

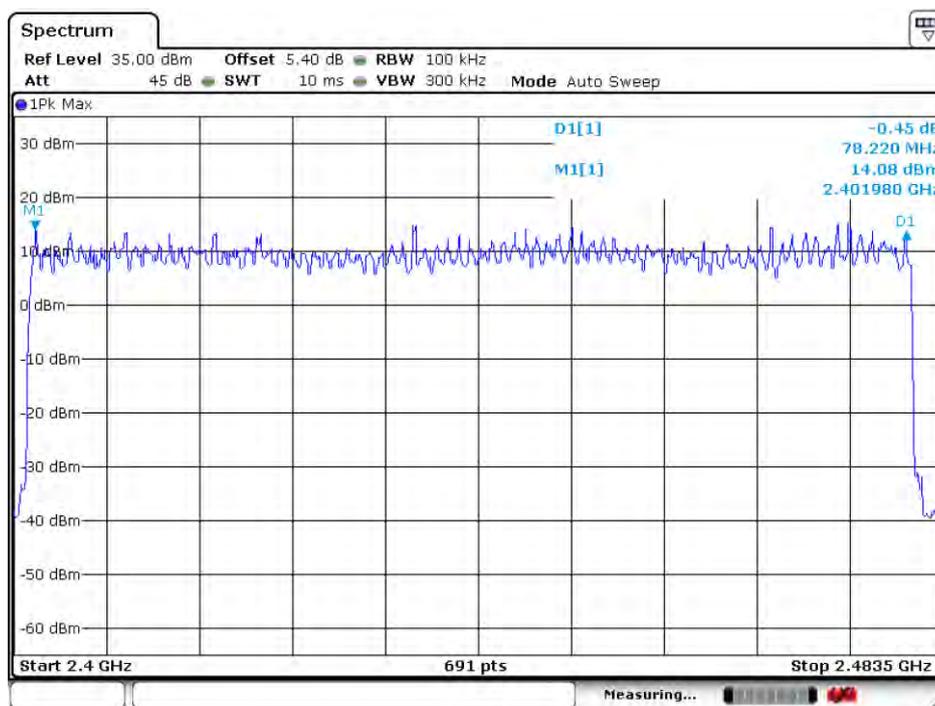
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### 4.7.2.6 8DPSK\_ANT2



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### 4.8 Dwell Time

Test Requirement:	47 CFR Part 15C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013 Section 7.8.4
Test Setup:	<p style="text-align: center;">Spectrum Analyzer</p> <p style="text-align: center;">E.U.T</p> <p style="text-align: center;">Non-Conducted Table</p> <p style="text-align: center;">Ground Reference Plane</p>
Instruments Used:	Refer to section 5.10 for details
Test Mode:	Hopping transmitting with all kind of modulation and all kind of data type.
Limit:	0.4 Second
Test Results:	Pass



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**4.8.1 Test Results**

Operation Modes	On time ( ms ) on one channel
DH1_ANT1	0.392
DH3_ANT1	1.655
DH5_ANT1	2.905
2-DH1_ANT1	0.398
2-DH3_ANT1	1.657
2-DH5_ANT1	2.905
3-DH1_ANT1	0.399
3-DH3_ANT1	1.654
3-DH5_ANT1	2.905
DH1_ANT2	0.386
DH3_ANT2	1.650
DH5_ANT2	2.906
2-DH1_ANT2	0.391
2-DH3_ANT2	1.652
2-DH5_ANT2	2.906
3-DH1_ANT2	0.392
3-DH3_ANT2	1.646
3-DH5_ANT2	2.906

**Bluetooth Time of Occupancy Calculation**

Typically, Bluetooth 1x/EDR mode has a channel hopping rate of 1600 hops/s, since 1x/EDR modes use 5 transmit and 1 receive slot, for a total of 6 slots, the Bluetooth transmitter is actually hopping at a rate of  $1600/6=266.67$  hops/slot

$400ms \times 79 \text{ Channel} = 31.6 \text{ s}$  (Time of Occupancy Limit)

Worst case BT has 266.67 hops/second (for 1x/EDR modes with 3-DH5 operation)

$266.67 \text{ hops/second} / 79 \text{ channels} = 3.38 \text{ hops/second}$  (# of hops/second on one channel)

$3.38 \text{ hops/second} / \text{channel} * 31.6 \text{ seconds} = 106.67 \text{ hops}$  (#hops over a 31.6 second period)

$106.67 \text{ hops} * 2.906 \text{ ms/channel} = 309.98 \text{ ms}$  (worst case dwell time for one channel in 1x/EDR modes)

With AFH, the number of channels is reduced to a minimum of 20 channels and the channel hopping rate is reduced by 50% to 800hops/s, AFH mode also uses 6 slots so the Bluetooth transmitter hops at a rate of  $800/6=133.3$  hops/s/slot

$400ms \times 20 \text{ Channel} = 8 \text{ s}$  (Time of Occupancy Limit)

Worst case BT has 133.3 hops/second/slot (for AFH mode with 3-DH5 operation)

$133.3 \text{ hops/second} / 20 \text{ channels} = 6.67 \text{ hops/second}$  (#hops/second on one channel)

$6.67 \text{ hops/second} * 8 \text{ seconds} = 53.34 \text{ hops}$  (#hops over a 8 seconds period)

$53.34 \text{ hops} \times 2.906 \text{ ms/channel} = 155.01 \text{ ms}$  (worst case dwell time for one channel in AFH mode)

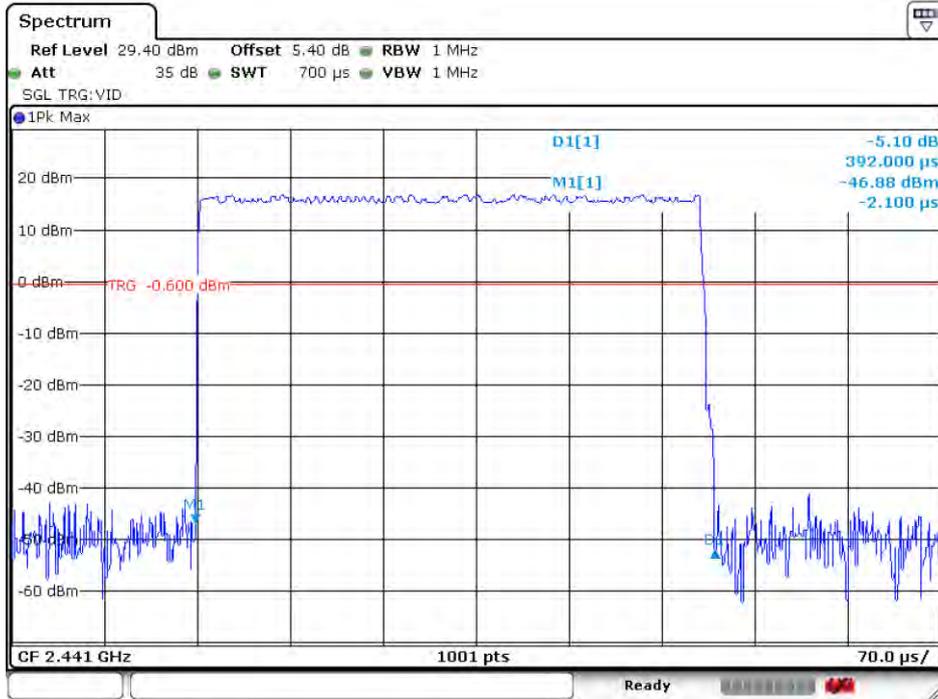


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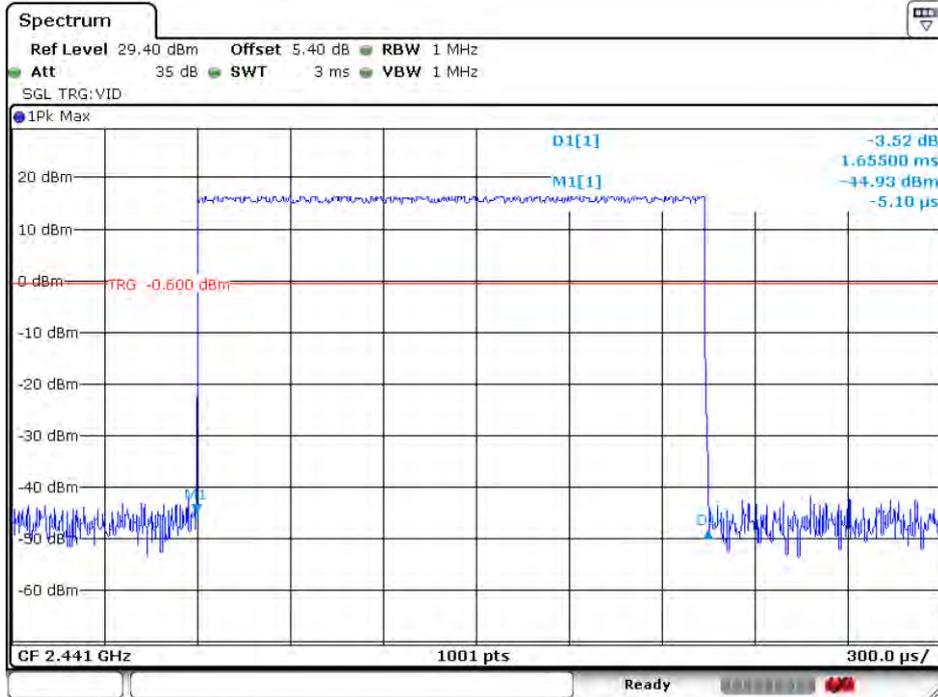
**4.8.2 Test plots**

**4.8.2.1 DH1\_Middle Channel\_ANT1**



Date: 30.MAR.2020 09:39:57

**4.8.2.2 DH3\_Middle Channel\_ANT1**

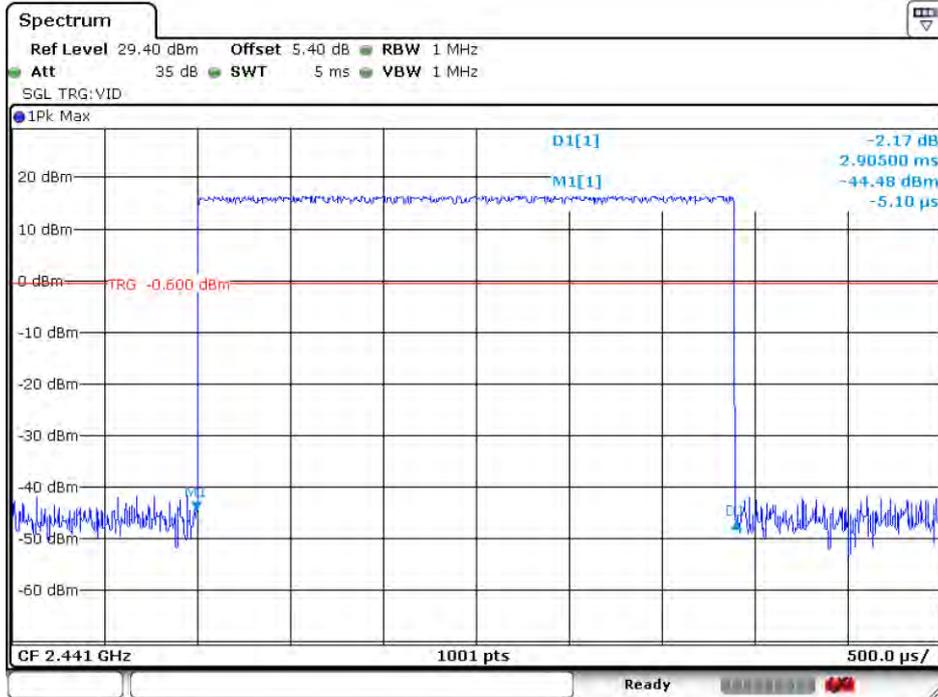


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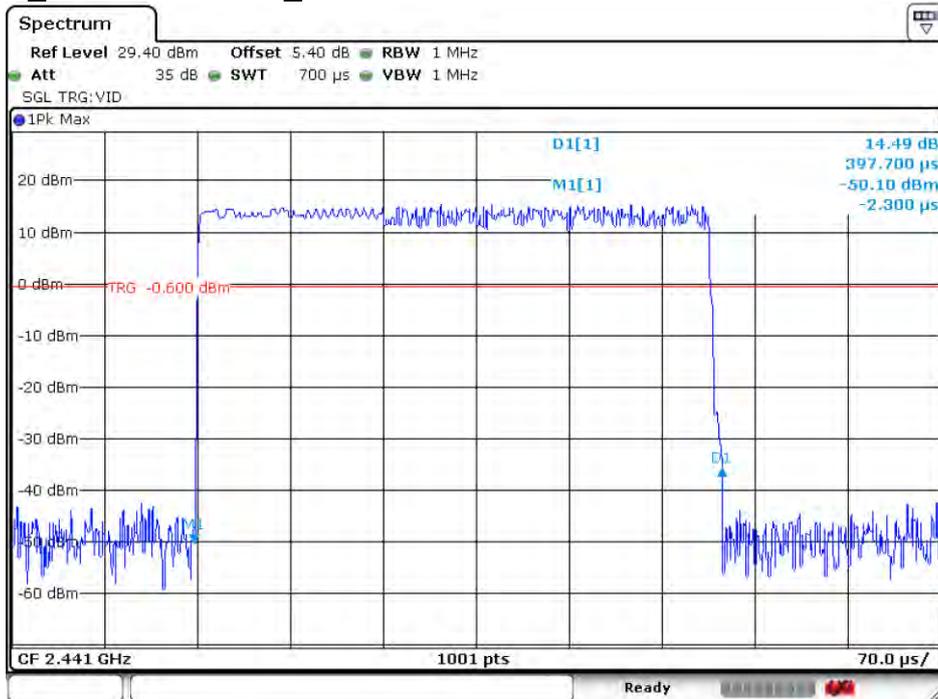
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**4.8.2.3 DH5 \_ Middle Channel\_ANT1**



Date: 30.MAR.2020 09:41:13

**4.8.2.4 2DH1 \_ Middle Channel\_ANT1**

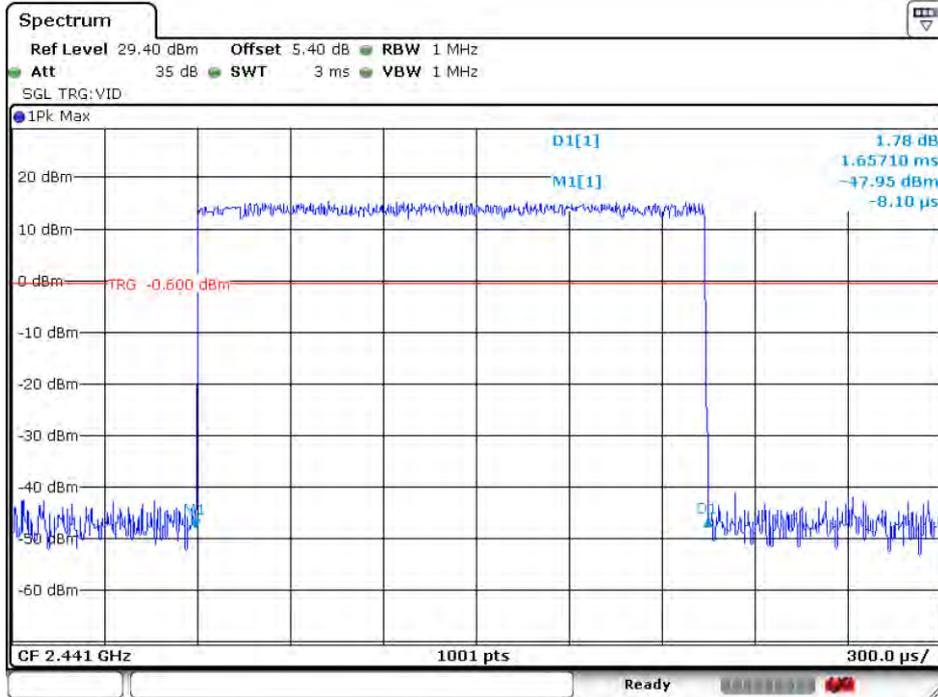


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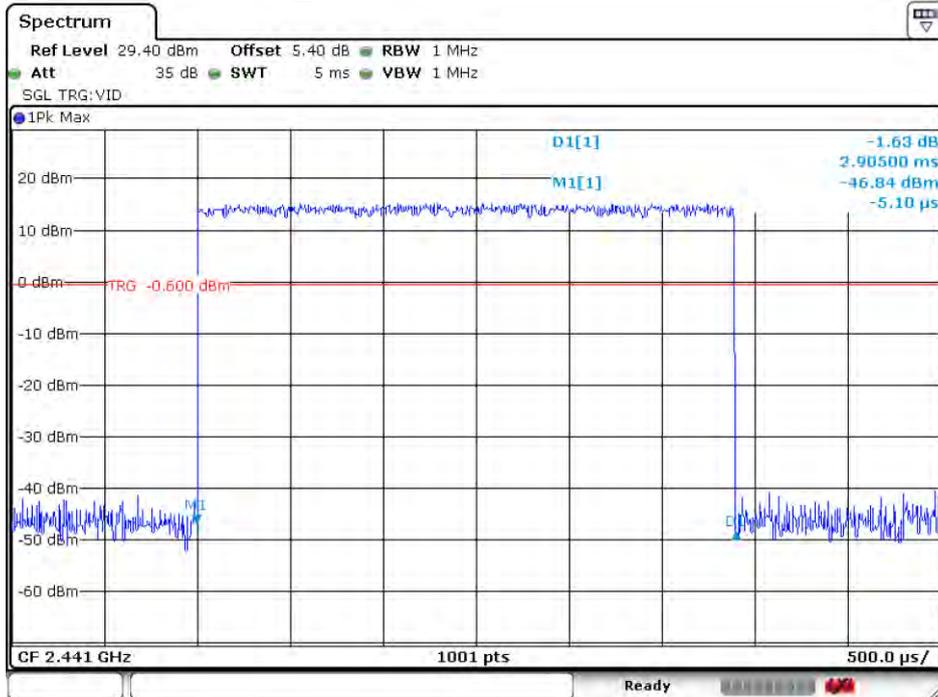
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**4.8.2.5 2DH3 \_ Middle Channel\_ANT1**



Date: 30.MAR.2020 09:42:34

**4.8.2.6 2DH5 \_ Middle Channel\_ANT1**

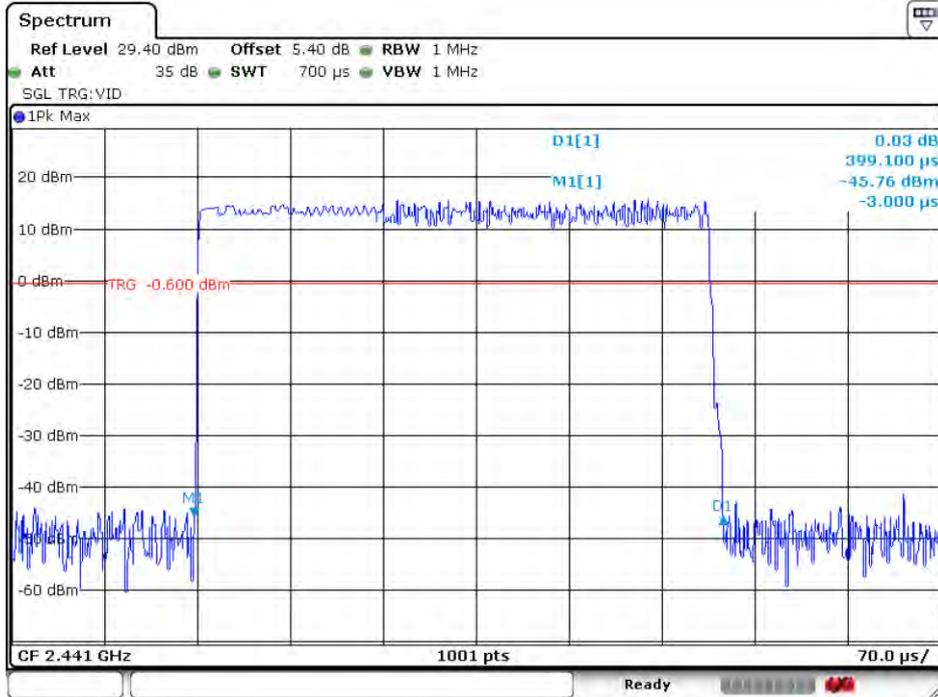


Date: 30.MAR.2020 09:41:59



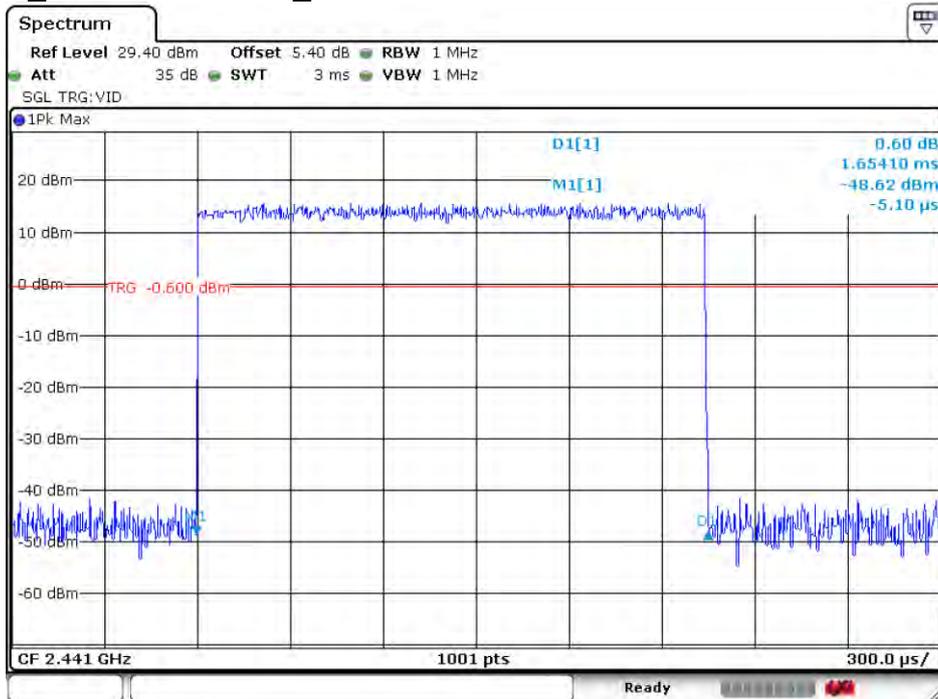
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4.8.2.7 3DH1\_Middle Channel\_ANT1



Date: 30.MAR.2020 09:43:31

4.8.2.8 3DH3\_Middle Channel\_ANT1

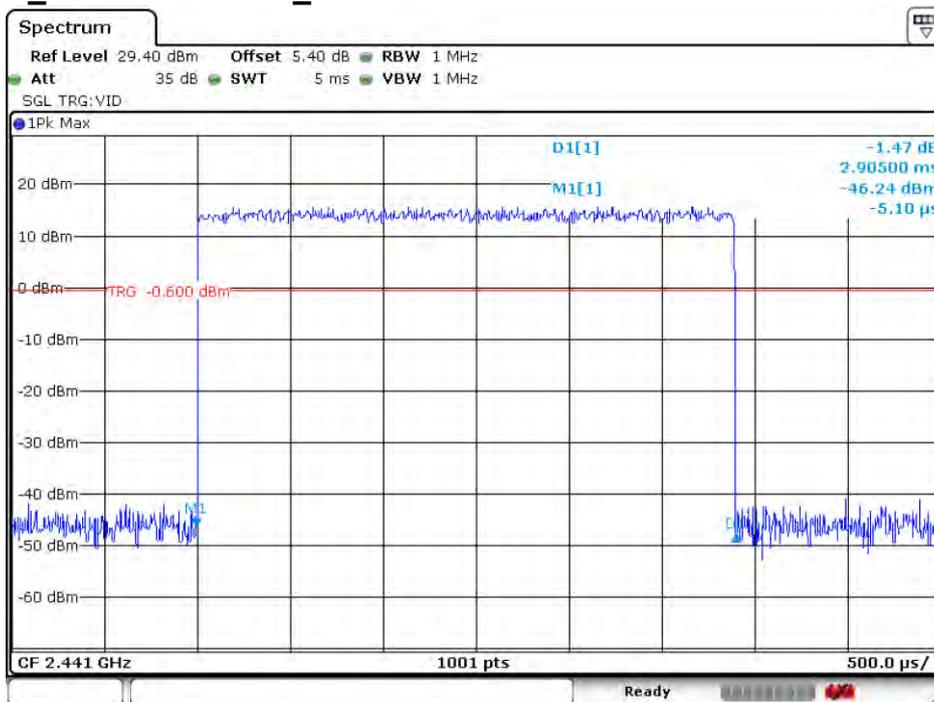


Date: 30.MAR.2020 09:42:57



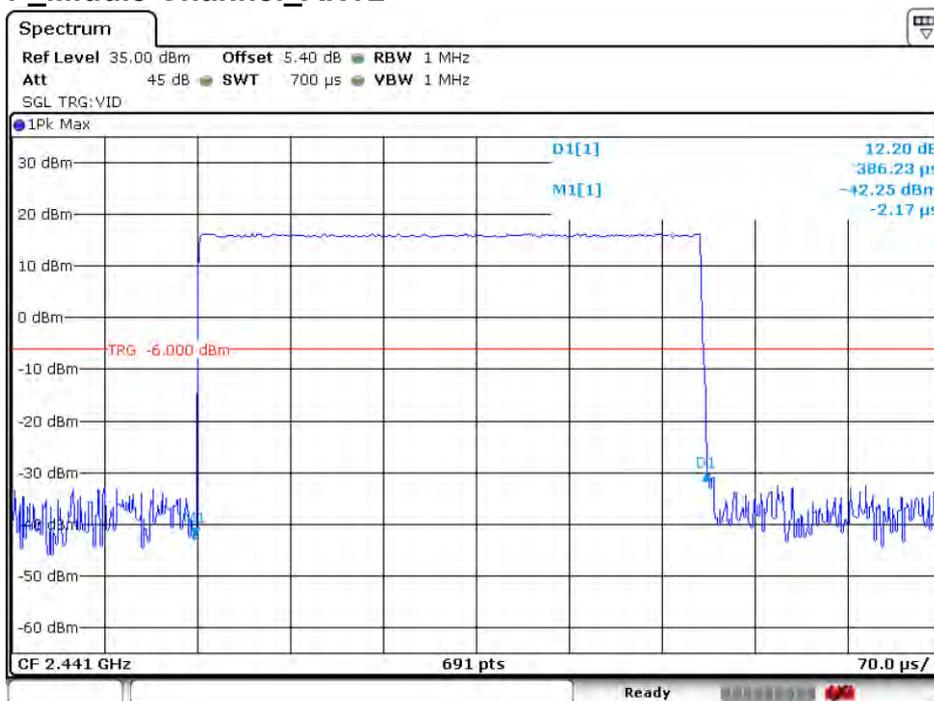
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### 4.8.2.9 3DH5 \_ Middle Channel\_ANT1



Date: 30.MAR.2020 09:41:39

### 4.8.2.10 DH1 \_ Middle Channel\_ANT2



Date: 17.APR.2020 10:34:10

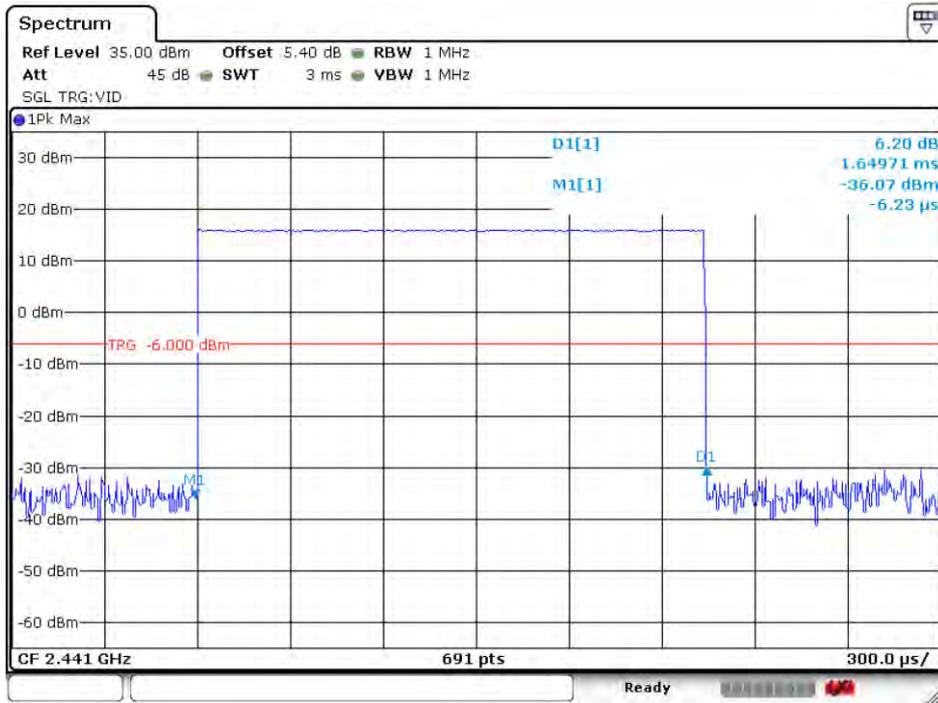
### 4.8.2.11 DH3 \_ Middle Channel\_ANT2



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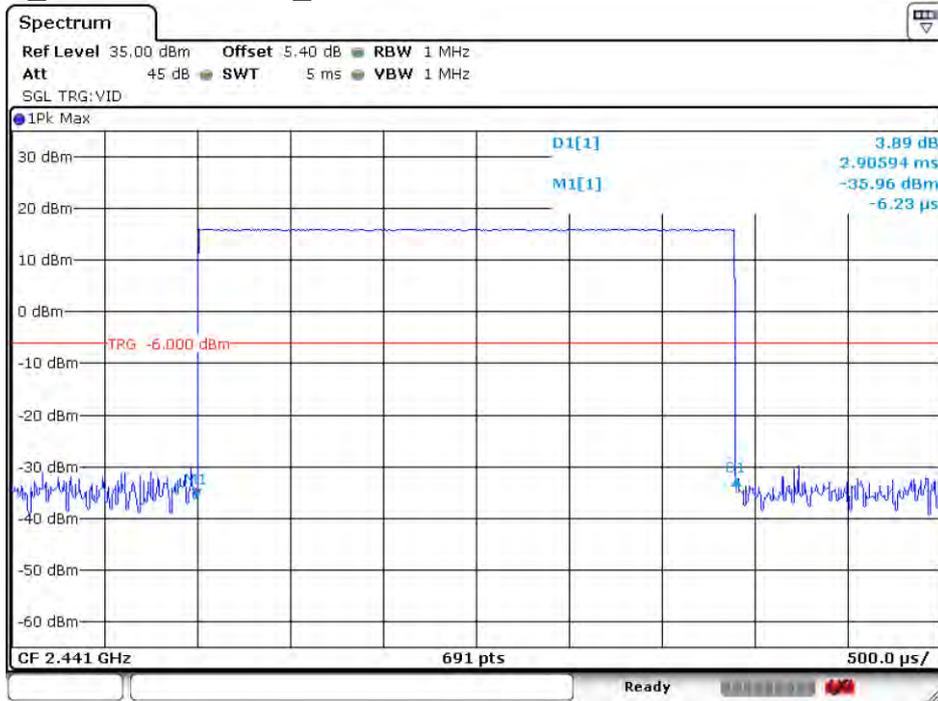
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Date: 17.APR.2020 10:33:39

**4.8.2.12 DH5\_Middle Channel\_ANT2**



Date: 17.APR.2020 10:33:04

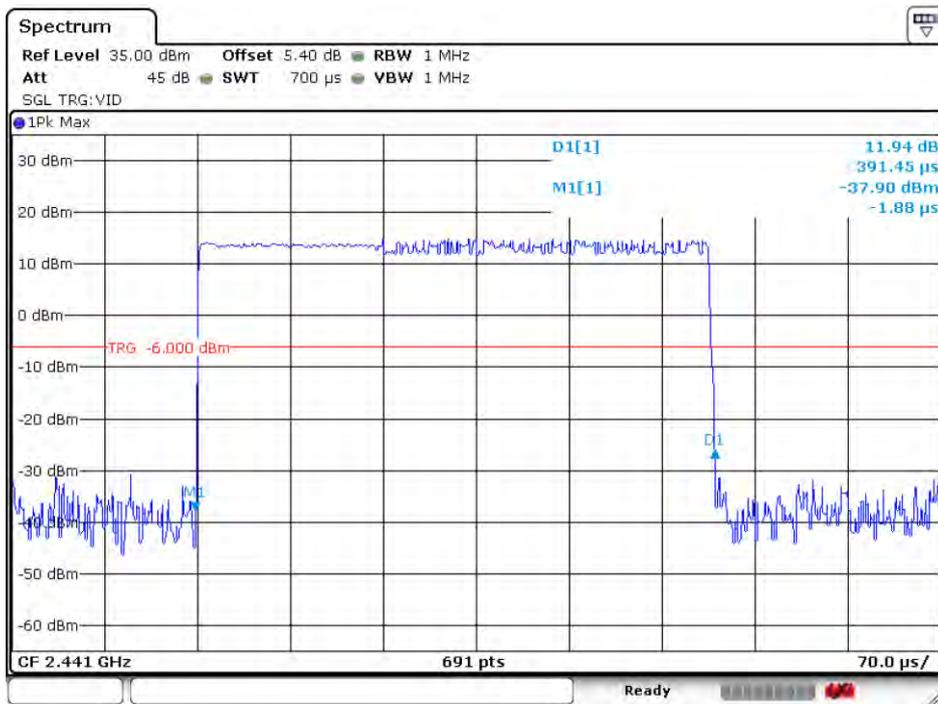
**4.8.2.13 2DH1\_Middle Channel\_ANT2**



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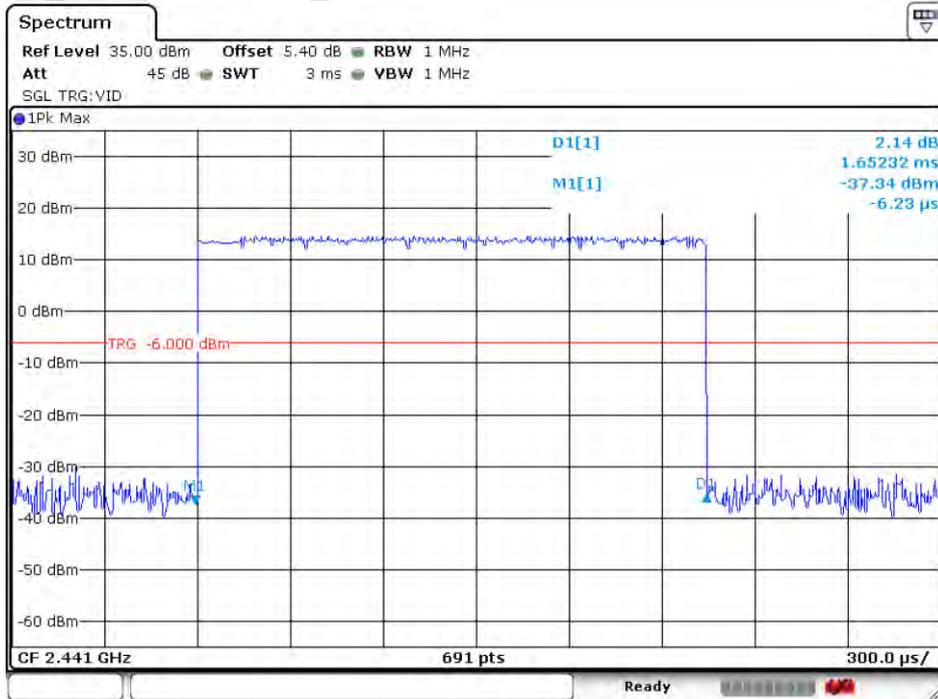


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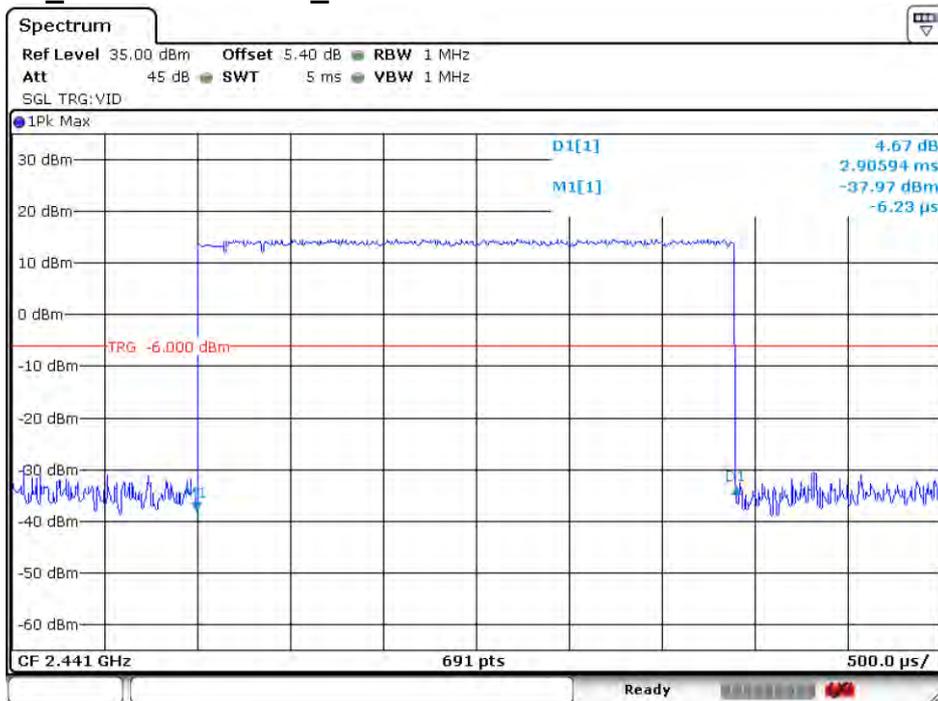
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**4.8.2.14 2DH3 \_ Middle Channel\_ANT2**



Date: 17.APR.2020 10:31:12

**4.8.2.15 2DH5 \_ Middle Channel\_ANT2**

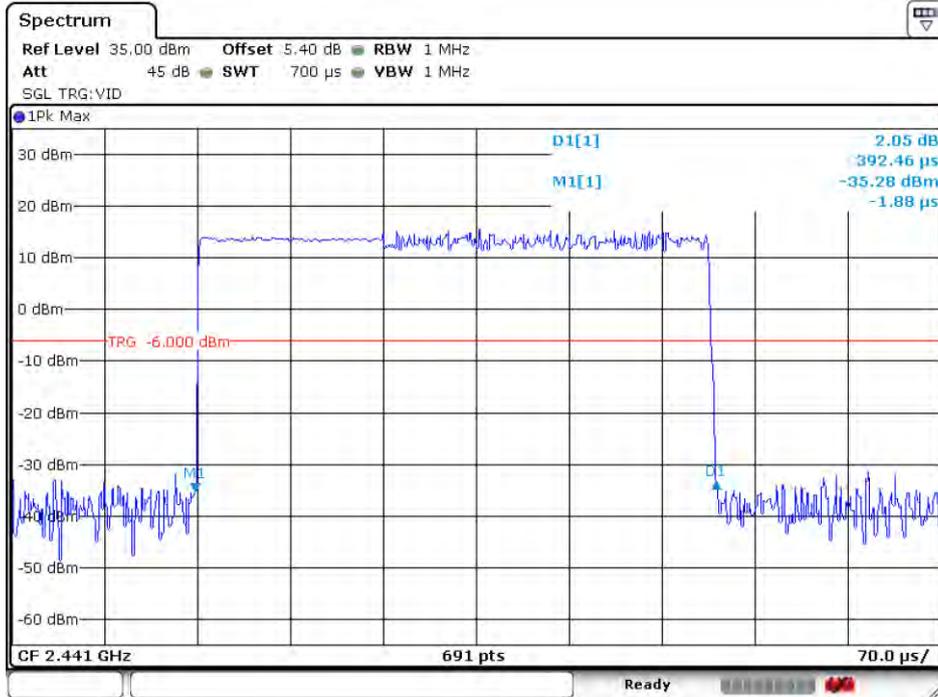


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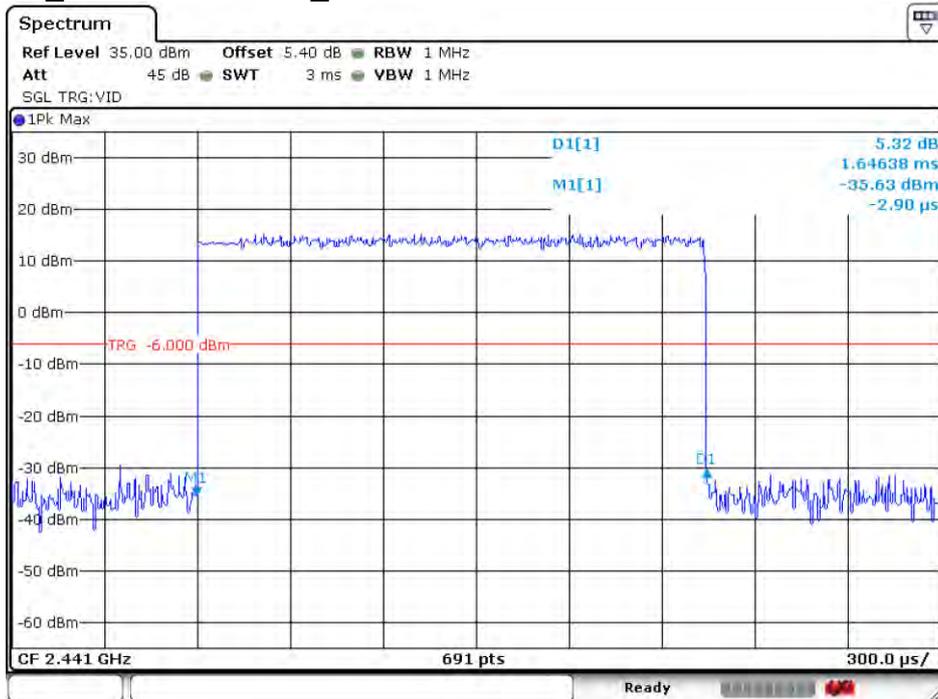
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**4.8.2.16 3DH1\_Middle Channel\_ANT2**



Date: 17.APR.2020 10:29:43

**4.8.2.17 3DH3\_Middle Channel\_ANT2**

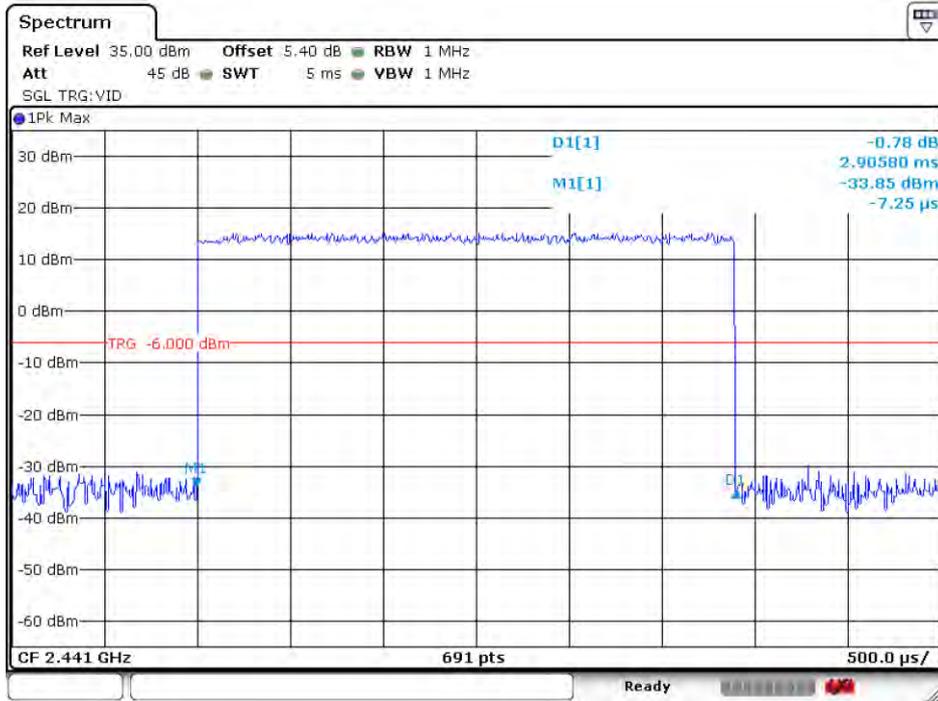


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**4.8.2.18 3DH5 \_ Middle Channel\_ANT2**



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### 4.9 Band-edge for RF Conducted Emissions

Test Requirement:	47 CFR Part 15C Section 15.247 (d)
Test Method:	ANSI C63.10:2013 Section 7.8.6
Test Setup:	<p>The diagram illustrates the test setup. A Spectrum Analyzer is connected via a red cable to an E.U.T. (Equipment Under Test). Both are placed on a Non-Conducted Table. Below the table is a Ground Reference Plane.</p>
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.
Exploratory Test Mode:	Hopping and Non-hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	Through Pre-scan, find the DH5 of data type is the worst case of GFSK modulation type, 2-DH5 of data type is the worst case of $\pi/4$ DQPSK modulation type, 3-DH5 of data type is the worst case of 8DPSK modulation type.
Instruments Used:	Refer to section 5.10 for details
Test Results:	Pass

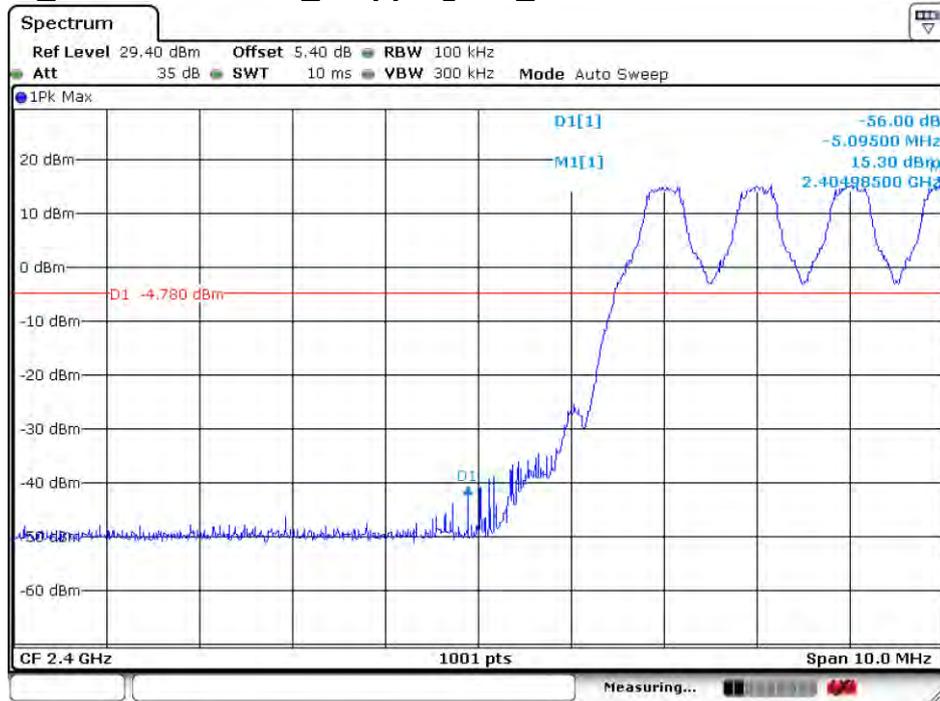


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### 4.9.1 Test plots

#### 4.9.1.1 GFSK\_Lowest Channel\_Hopping ON\_ANT1



Date: 30.MAR.2020 09:56:20

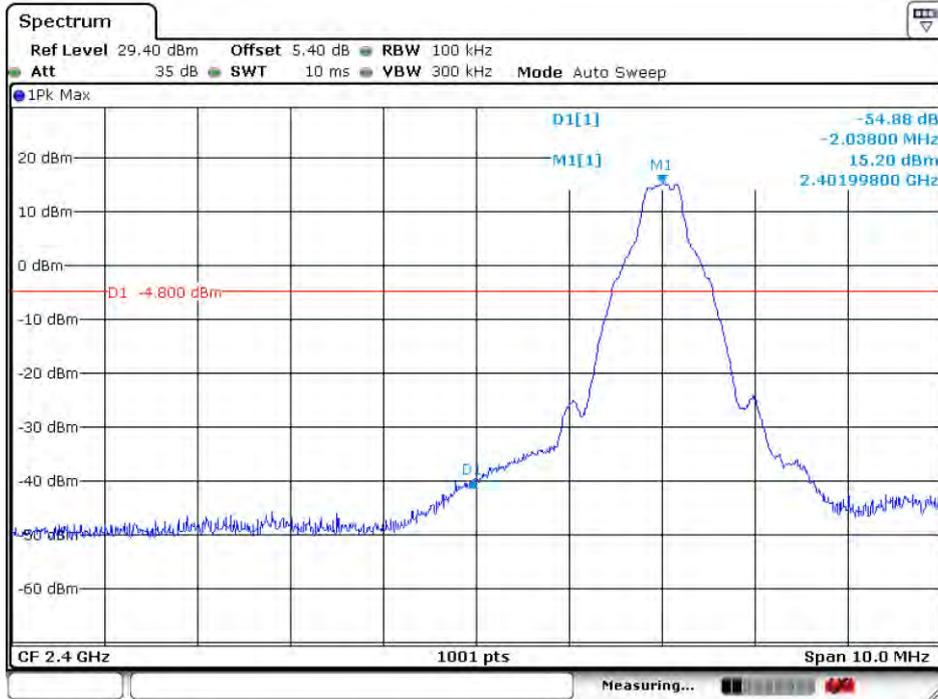


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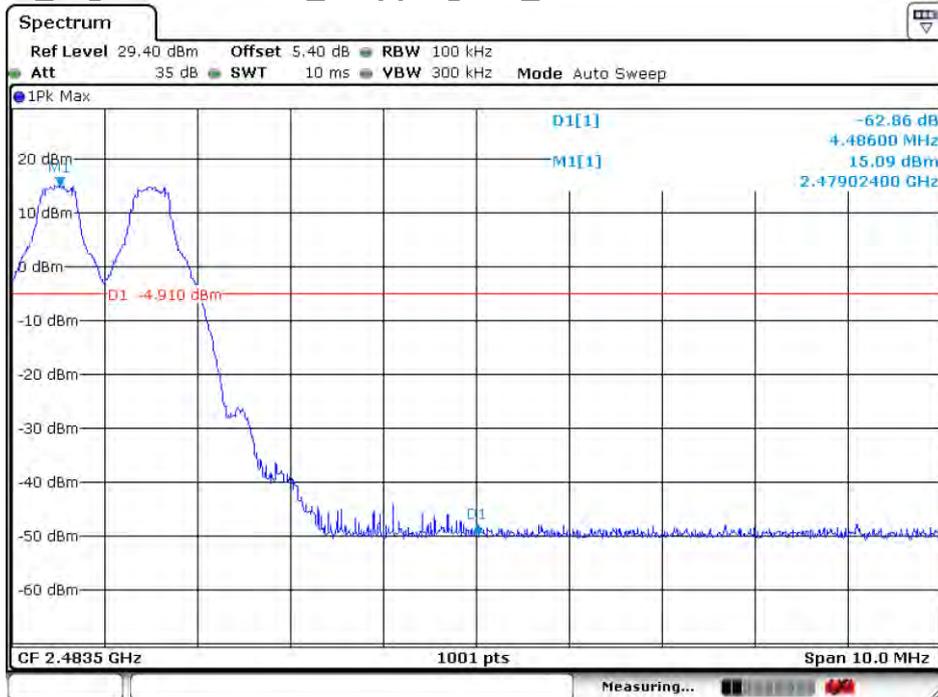
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 No.1 Workshop, M-10, Middle Section, Science & Technology Park, Shenzhen, China 518057 t (86-755) 26012053 f (86-755) 26710594 www.sgsgroup.com.cn  
 中国·深圳·科技园中区M-10栋一号厂房 邮编: 518057 t (86-755) 26012053 f (86-755) 26710594 sgs.china@sgs.com

**4.9.1.2 GFSK\_Lowest Channel\_Hopping OFF\_ANT1**



Date: 30.MAR.2020 09:59:39

**4.9.1.3 GFSK\_Highest Channel\_Hopping ON\_ANT1**



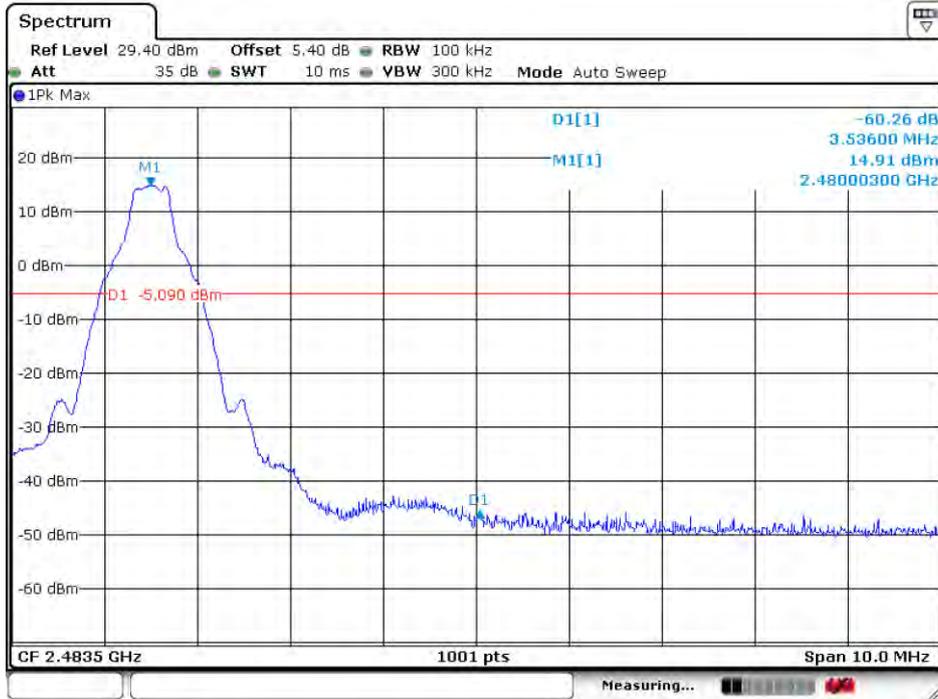
Date: 30.MAR.2020 09:57:50



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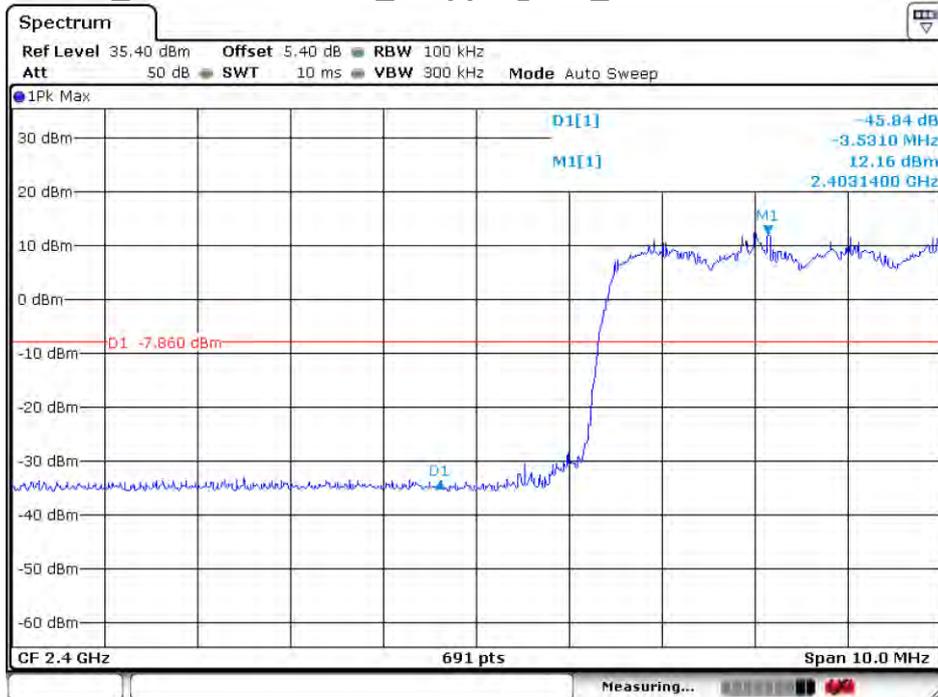
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**4.9.1.4 GFSK\_Highest Channel\_Hopping OFF\_ANT1**



Date: 30.MAR.2020 09:58:57

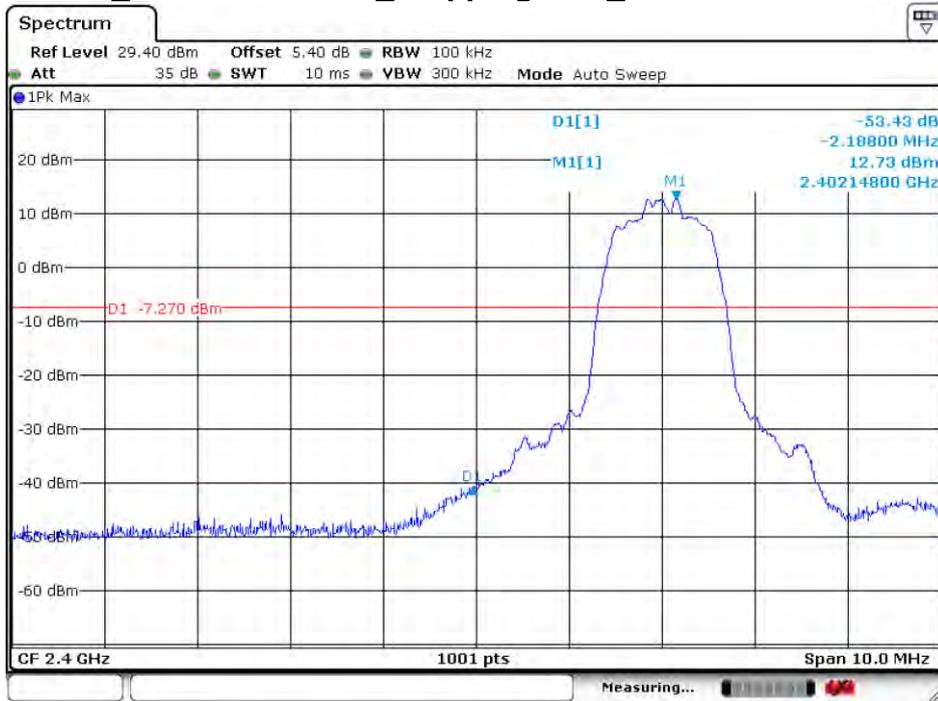
**4.9.1.5  $\pi/4$ DQPSK\_Lowest Channel\_Hopping ON\_ANT1**



Date: 28.APR.2020 13:01:30

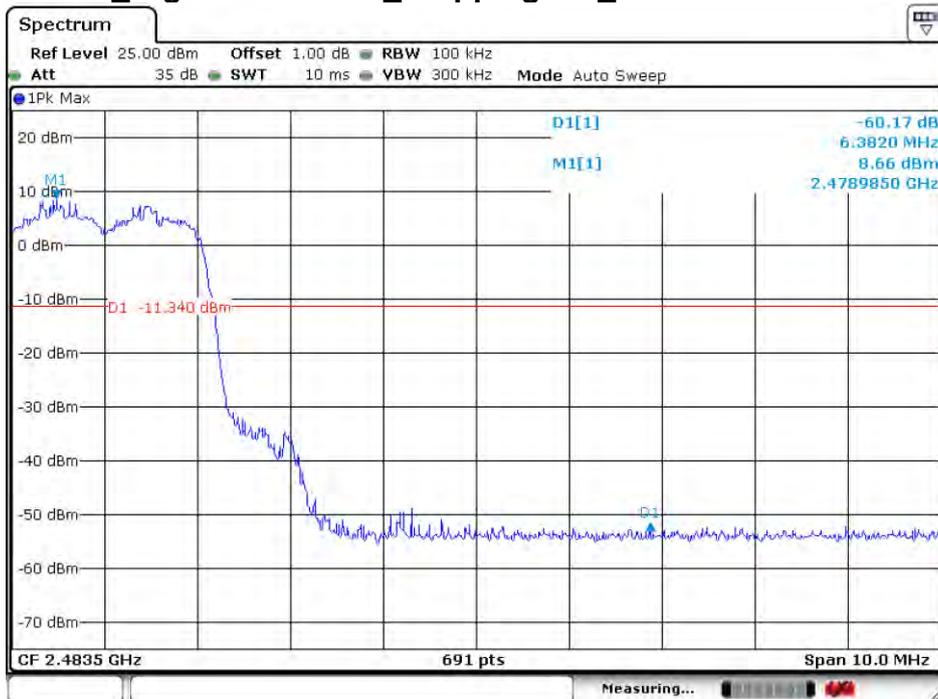


**4.9.1.6  $\pi/4$ DQPSK \_Lowest Channel\_ Hopping OFF\_ANT1**



Date: 30.MAR.2020 09:50:20

**4.9.1.7  $\pi/4$ DQPSK \_Highest Channel\_ Hopping ON\_ANT1**

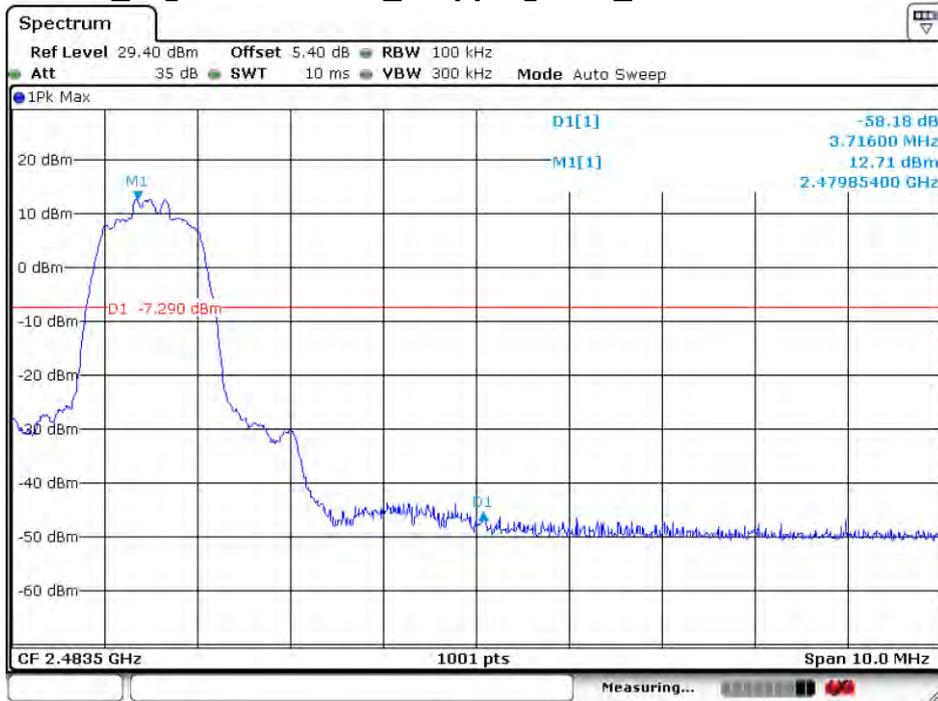


Date: 30.MAR.2020 08:36:41



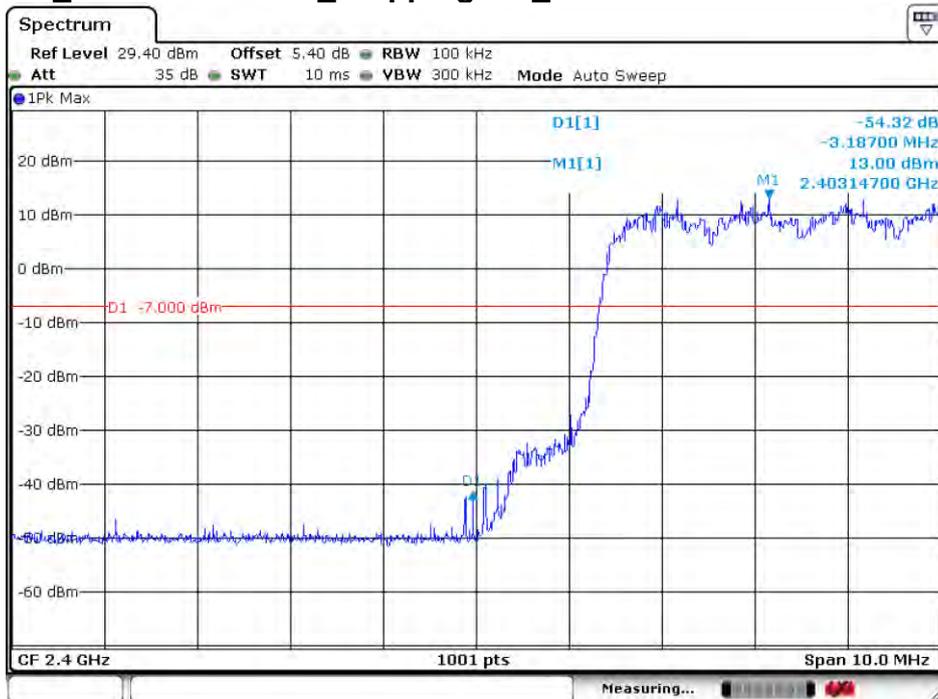
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**4.9.1.8  $\pi/4$ DQPSK \_Highest Channel\_ Hopping OFF\_ANT1**



Date: 30.MAR.2020 09:49:22

**4.9.1.9 8DPSK \_Lowest Channel\_ Hopping ON\_ANT1**



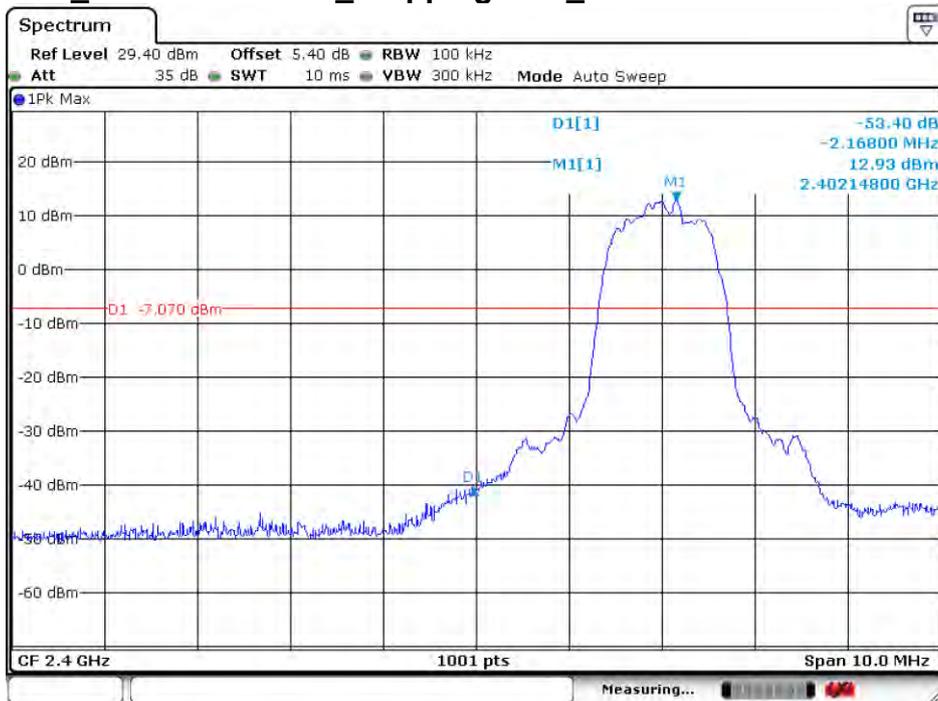
Date: 30.MAR.2020 09:54:11



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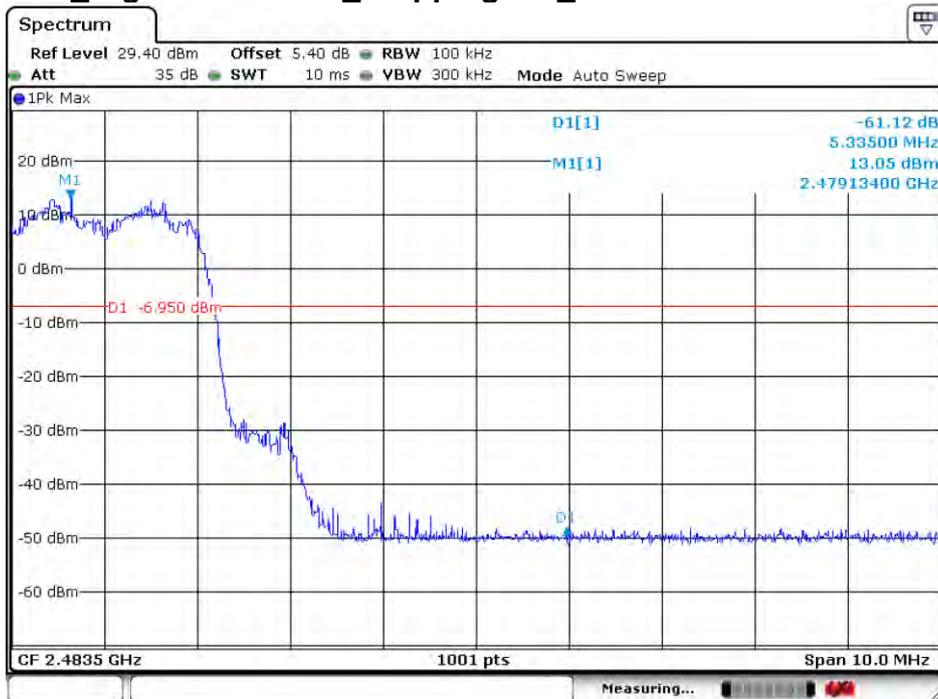
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**4.9.1.10 8DPSK\_Lowest Channel\_Hopping OFF\_ANT1**



Date: 30.MAR.2020 09:51:32

**4.9.1.11 8DPSK\_Highest Channel\_Hopping ON\_ANT1**

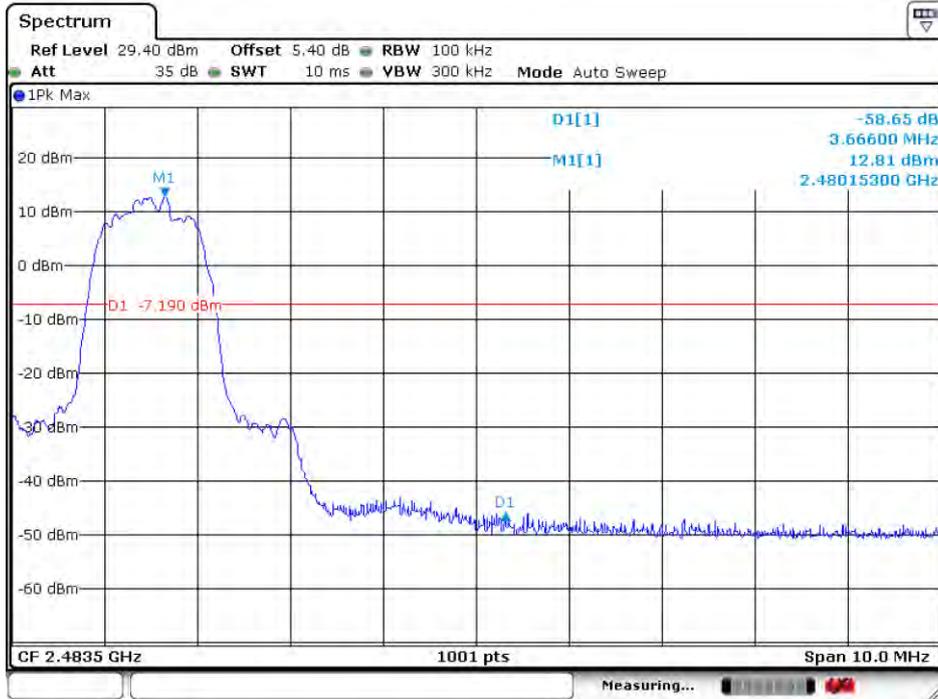


Date: 30.MAR.2020 09:53:07



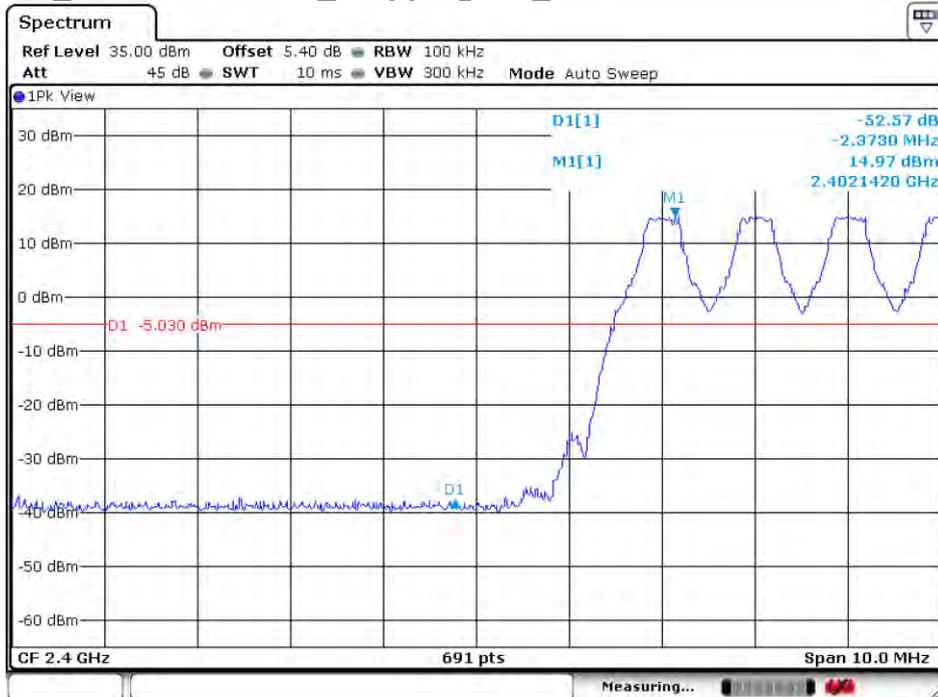
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**4.9.1.12 8DPSK\_Highest Channel\_Hopping OFF\_ANT1**



Date: 30.MAR.2020 09:52:19

**4.9.1.13 GFSK\_Lowest Channel\_Hopping ON\_ANT2**

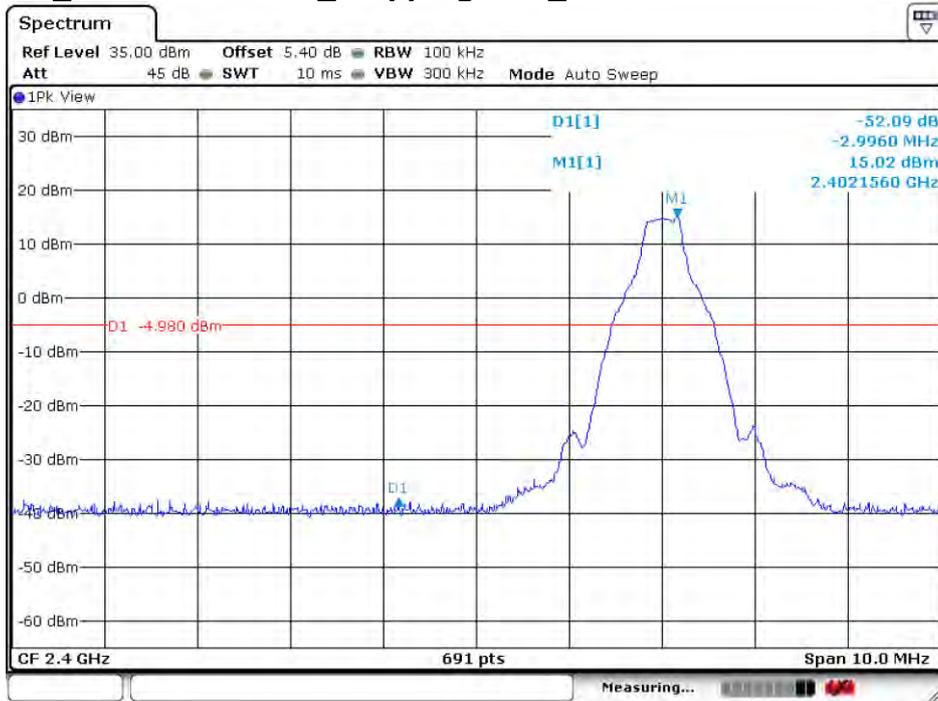


Date: 17.APR.2020 10:06:43



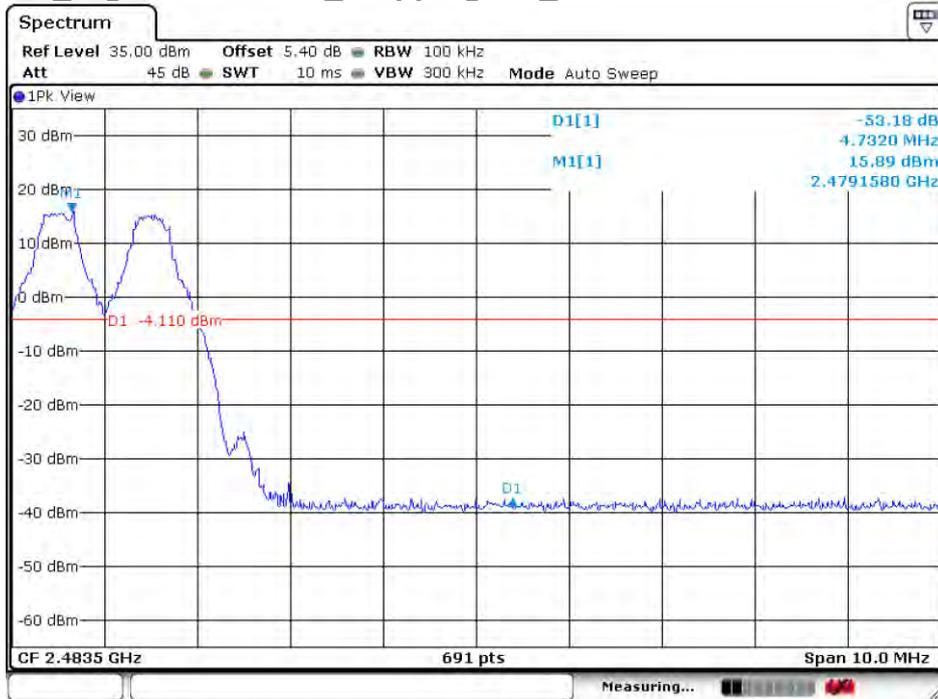
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**4.9.1.14 GFSK\_Lowest Channel\_Hopping OFF\_ANT2**



Date: 17.APR.2020 10:05:14

**4.9.1.15 GFSK\_Highest Channel\_Hopping ON\_ANT2**



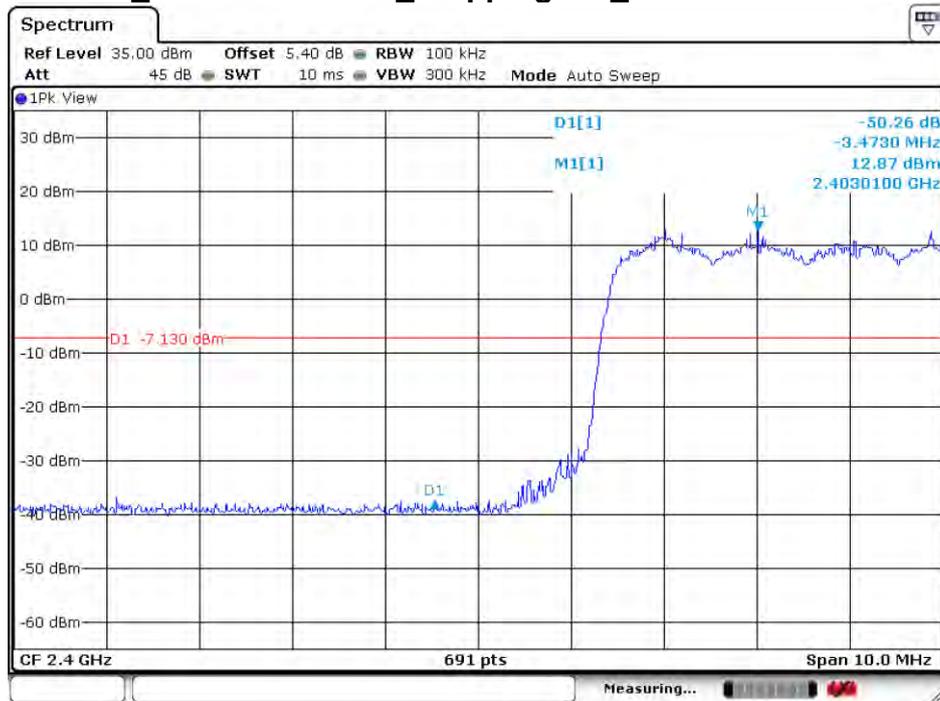
Date: 17.APR.2020 10:08:16



**4.9.1.16 GFSK\_Highest Channel\_Hopping OFF\_ANT2**



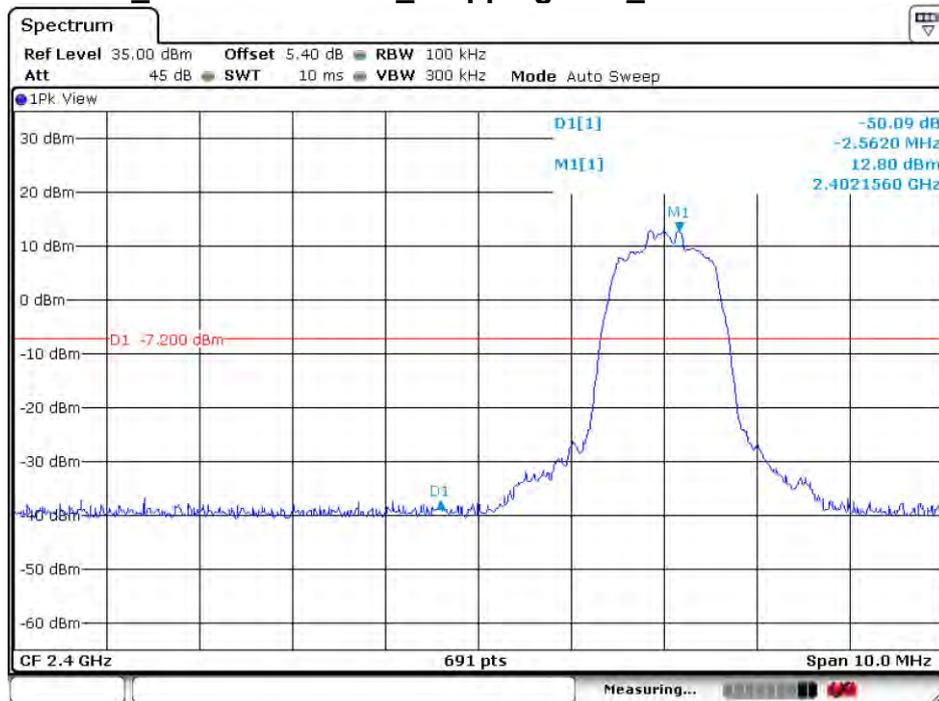
**4.9.1.17  $\pi/4$ DQPSK\_Lowest Channel\_Hopping ON\_ANT2**



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**4.9.1.18  $\pi/4$ DQPSK \_Lowest Channel\_ Hopping OFF\_ANT2**



Date: 17.APR.2020 10:10:51

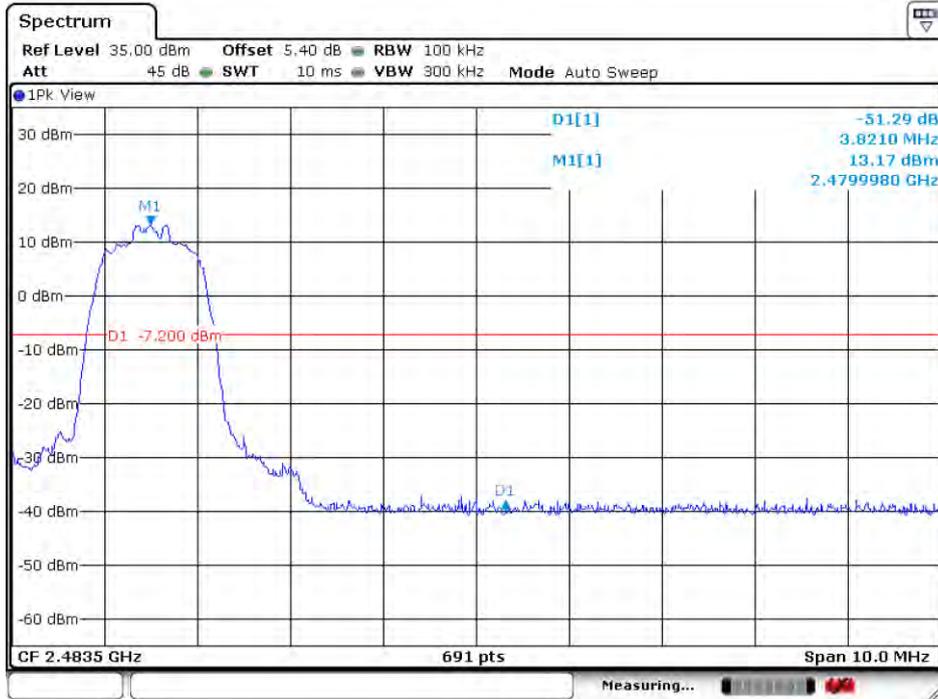
**4.9.1.19  $\pi/4$ DQPSK \_Highest Channel\_ Hopping ON\_ANT2**



Date: 17.APR.2020 10:09:20

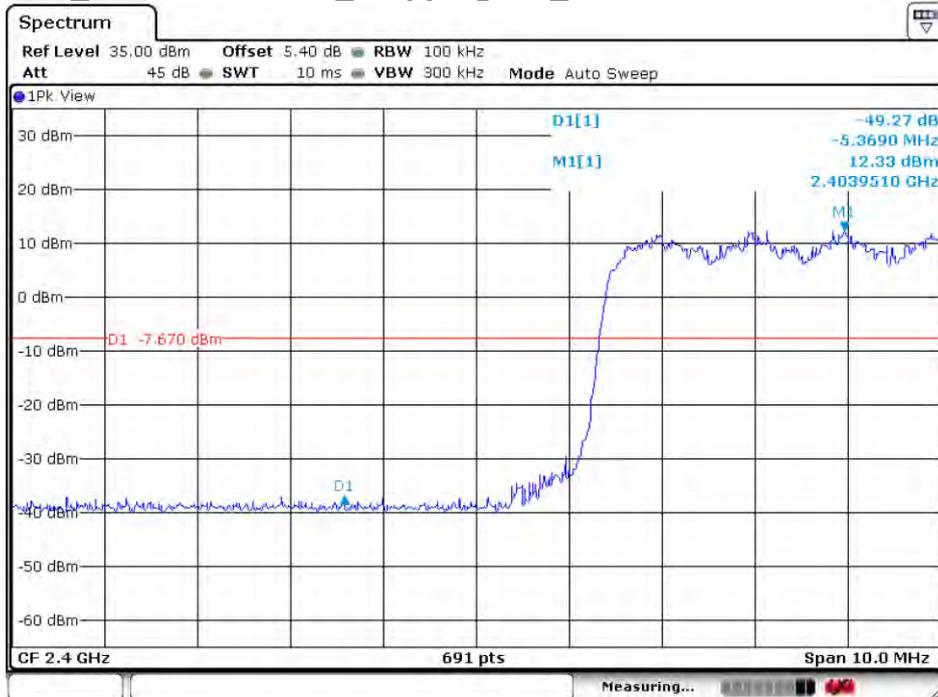


**4.9.1.20  $\pi/4$ DQPSK\_Highest Channel\_Hopping OFF\_ANT2**



Date: 17.APR.2020 10:11:43

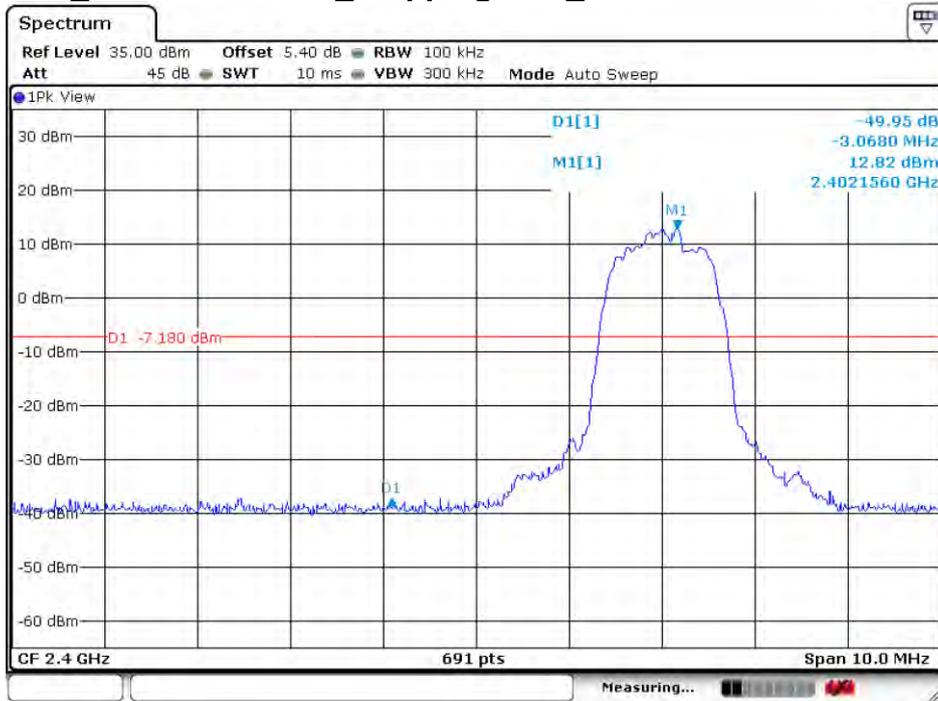
**4.9.1.21 8DPSK\_Lowest Channel\_Hopping ON\_ANT2**



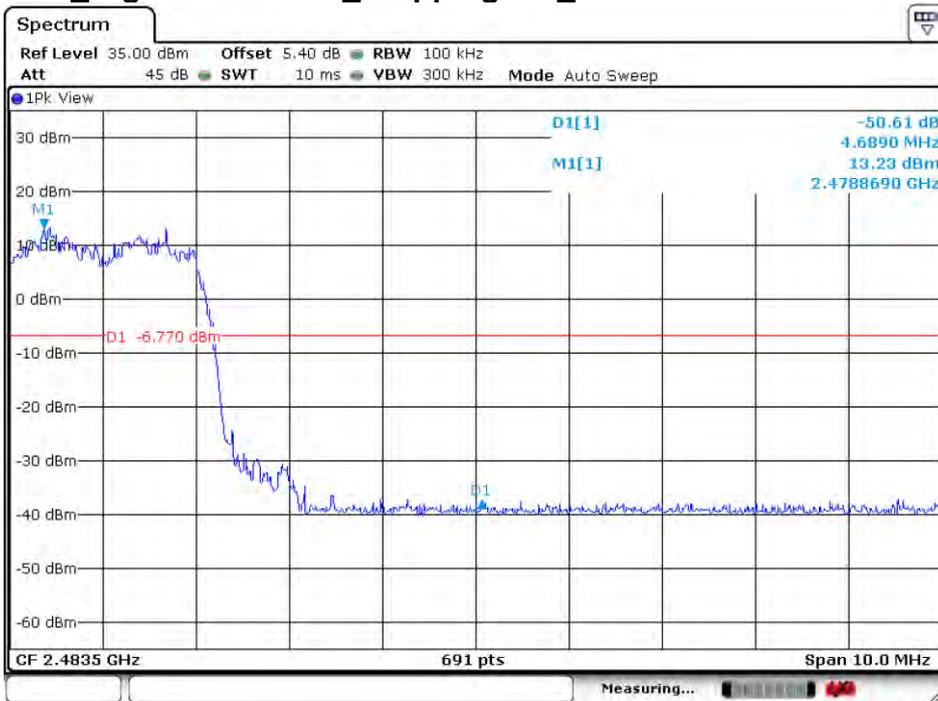
Date: 17.APR.2020 10:15:46



**4.9.1.22 8DPSK\_Lowest Channel\_Hopping OFF\_ANT2**



**4.9.1.23 8DPSK\_Highest Channel\_Hopping ON\_ANT2**



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**4.9.1.24 8DPSK \_Highest Channel\_ Hopping OFF\_ANT2**



Date: 17.APR.2020 10:12:45



### 4.10 Spurious RF Conducted Emissions

Test Requirement:	47 CFR Part 15C Section 15.247 (d)
Test Method:	ANSI C63.10:2013 Section 7.8.8
Test Setup:	
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.
Exploratory Test Mode:	Non-hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	Through Pre-scan, find the DH5 of data type is the worst case of GFSK modulation type, 2-DH5 of data type is the worst case of $\pi/4$ DQPSK modulation type, 3-DH5 of data type is the worst case of 8DPSK modulation type.
Instruments Used:	Refer to section 5.10 for details
Test Results:	Pass

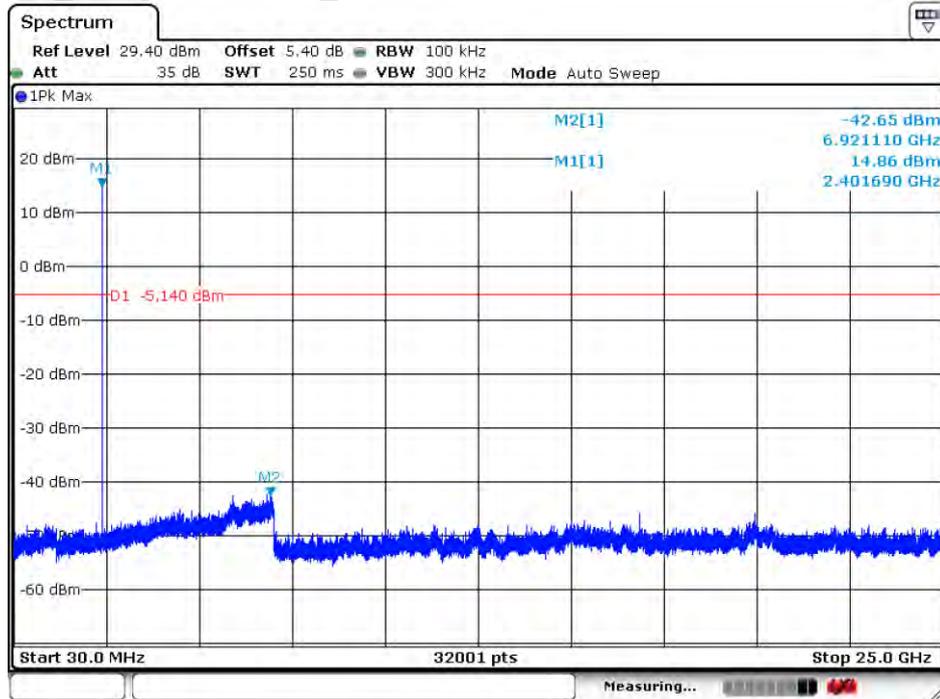


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### 4.10.1 Test plots

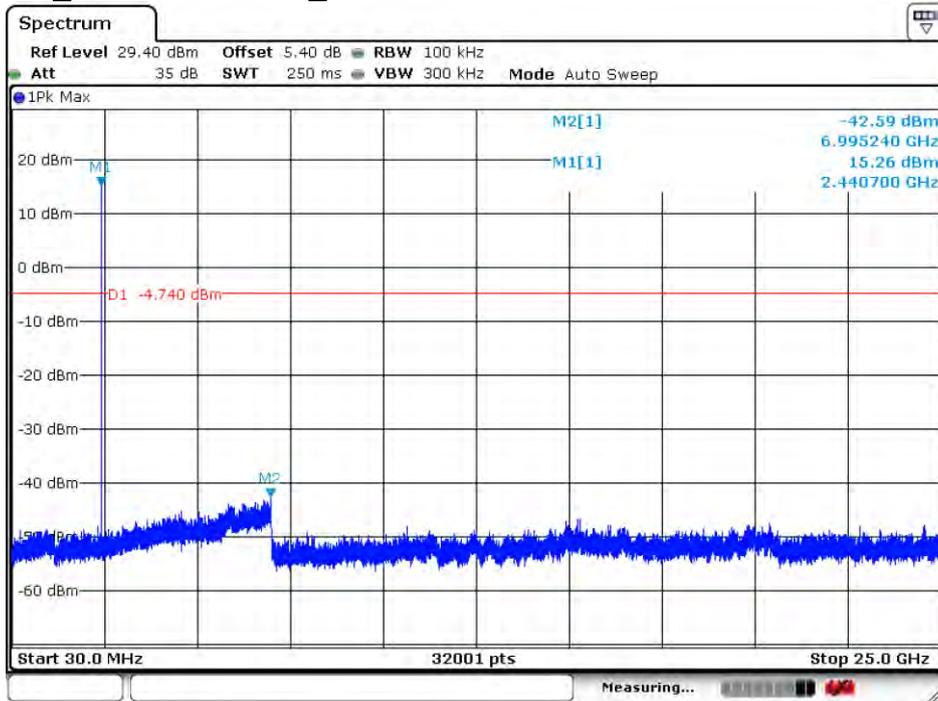
#### 4.10.1.1 GFSK\_Lowest Channel\_ANT1



Date: 30.MAR.2020 10:00:35

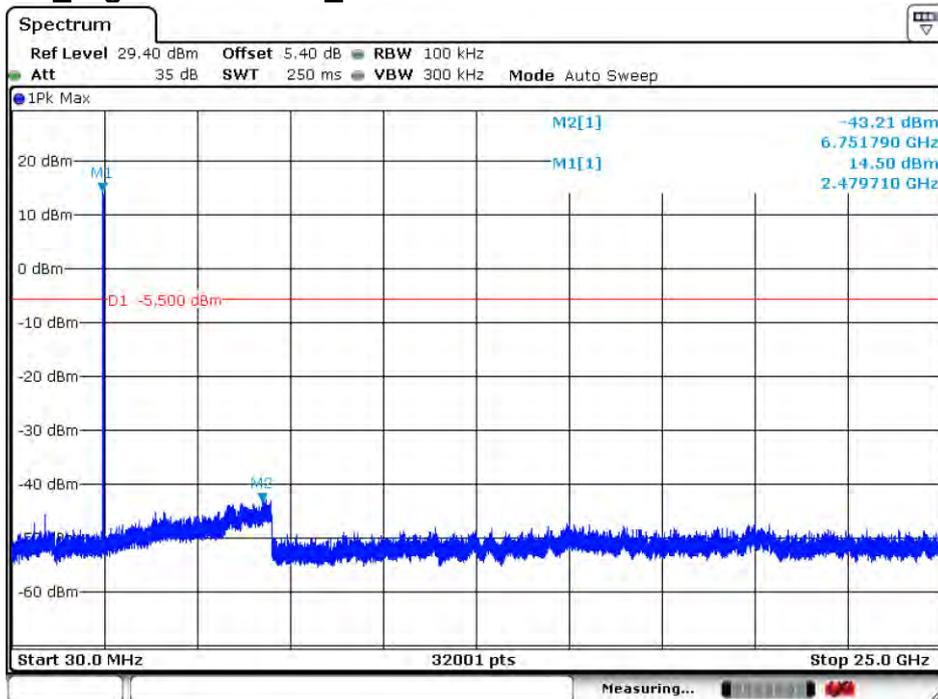


**4.10.1.2 GFSK\_Middle Channel\_ANT1**



Date: 30.MAR.2020 10:01:05

**4.10.1.3 GFSK\_Highest Channel\_ANT1**



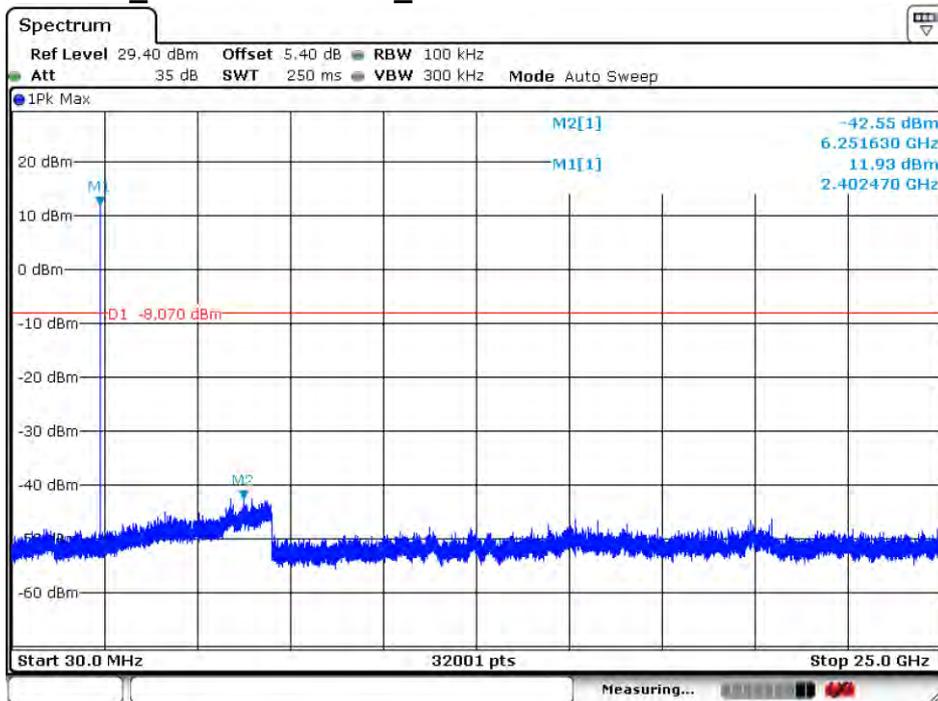
Date: 30.MAR.2020 10:01:45



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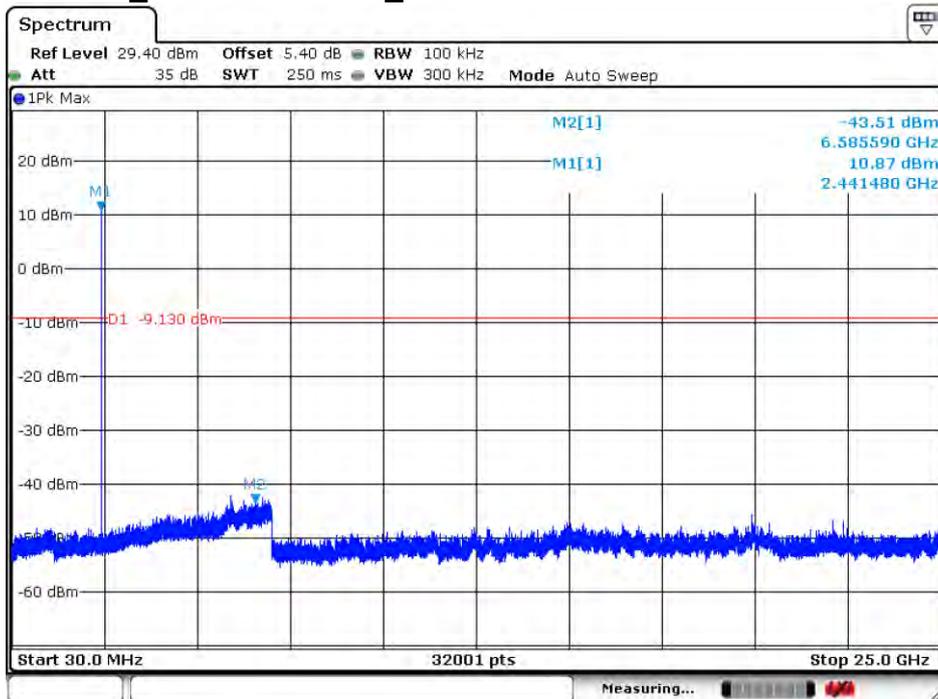
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**4.10.1.4  $\pi/4$ DQPSK\_Lowest Channel\_ANT1**



Date: 30.MAR.2020 10:06:30

**4.10.1.5  $\pi/4$ DQPSK\_Middle Channel\_ANT1**



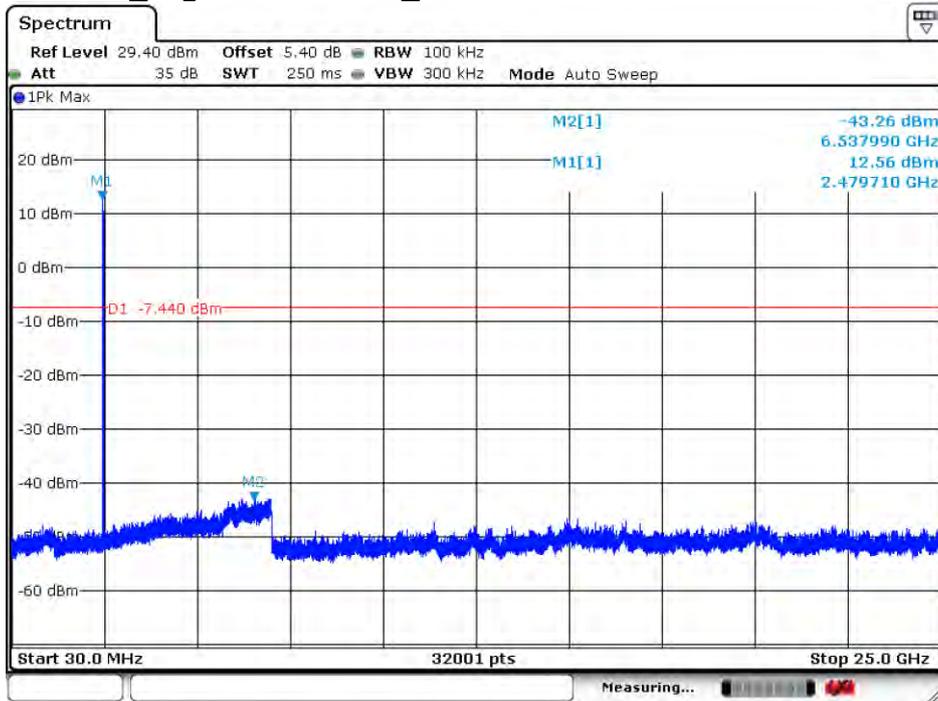
Date: 30.MAR.2020 10:07:18



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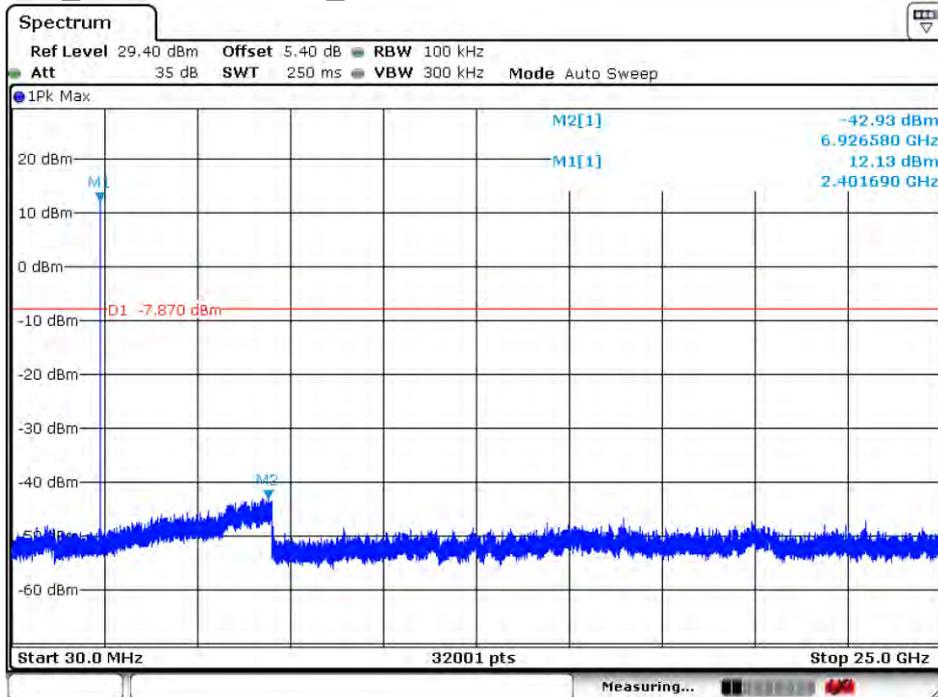
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**4.10.1.6  $\pi/4$ DQPSK\_Highest Channel\_ANT1**



Date: 30.MAR.2020 10:05:48

**4.10.1.7 8DPSK\_Lowest Channel\_ANT1**



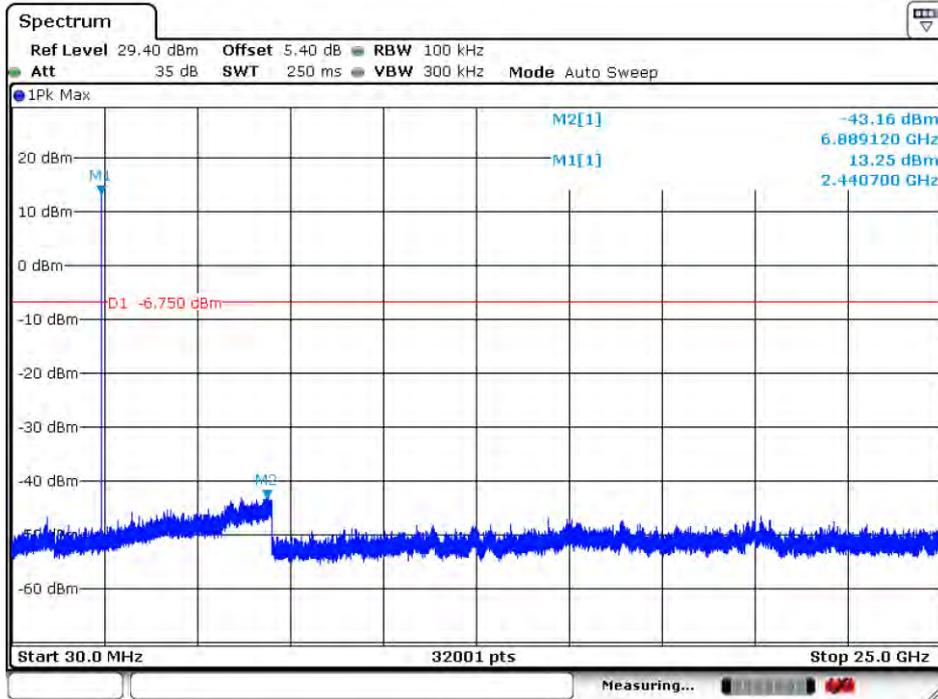
Date: 30.MAR.2020 10:03:15



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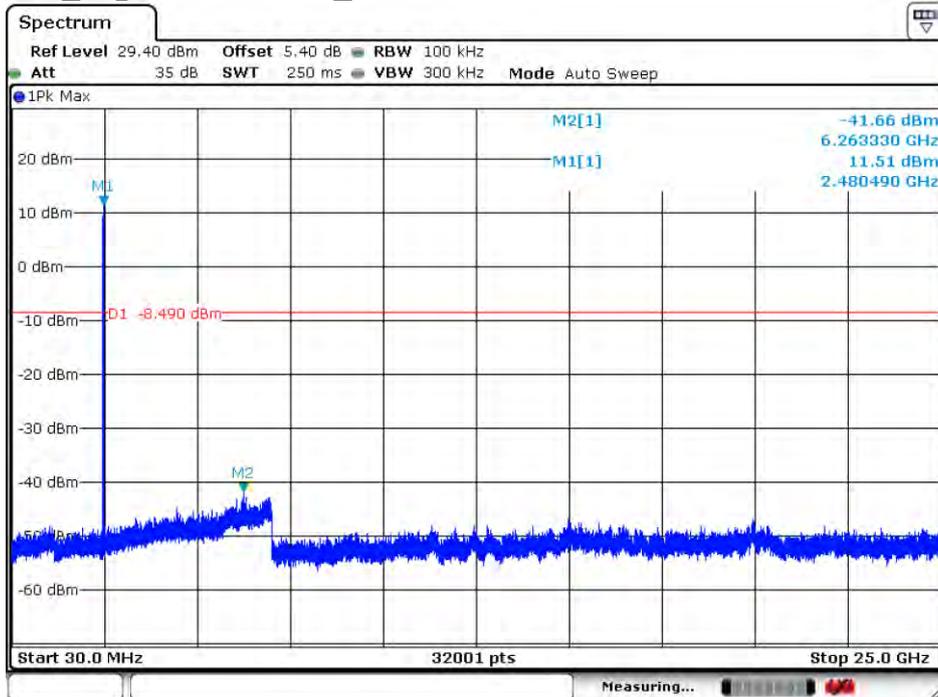
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**4.10.1.8 8DPSK\_Middle Channel\_ANT1**



Date: 30.MAR.2020 10:03:58

**4.10.1.9 8DPSK\_Highest Channel\_ANT1**



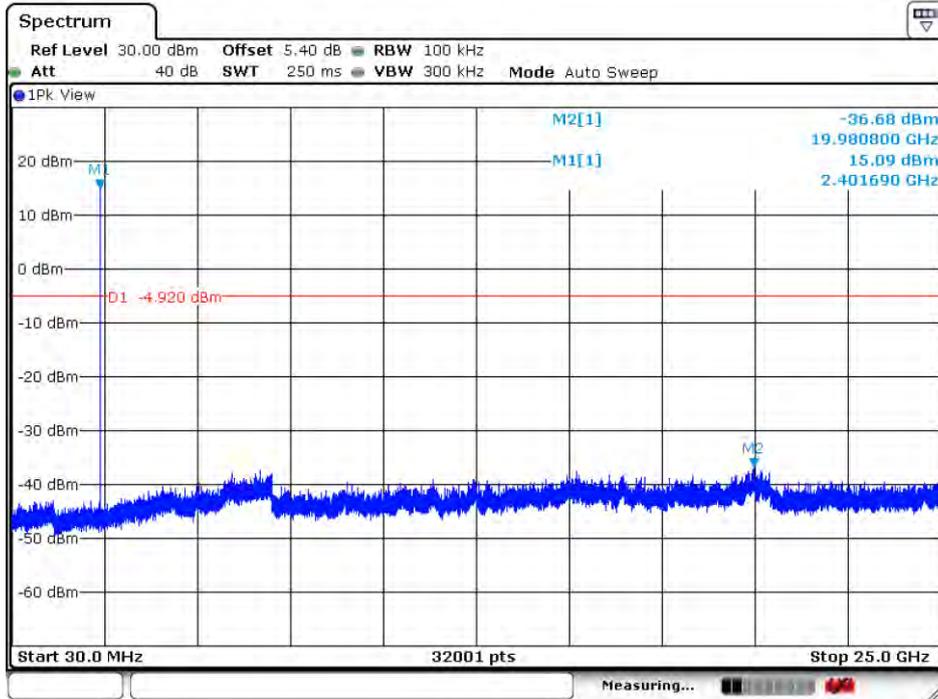
Date: 30.MAR.2020 10:04:41



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**4.10.1.10 GFSK\_Lowest Channel\_ANT2**



Date: 17.APR.2020 10:44:43



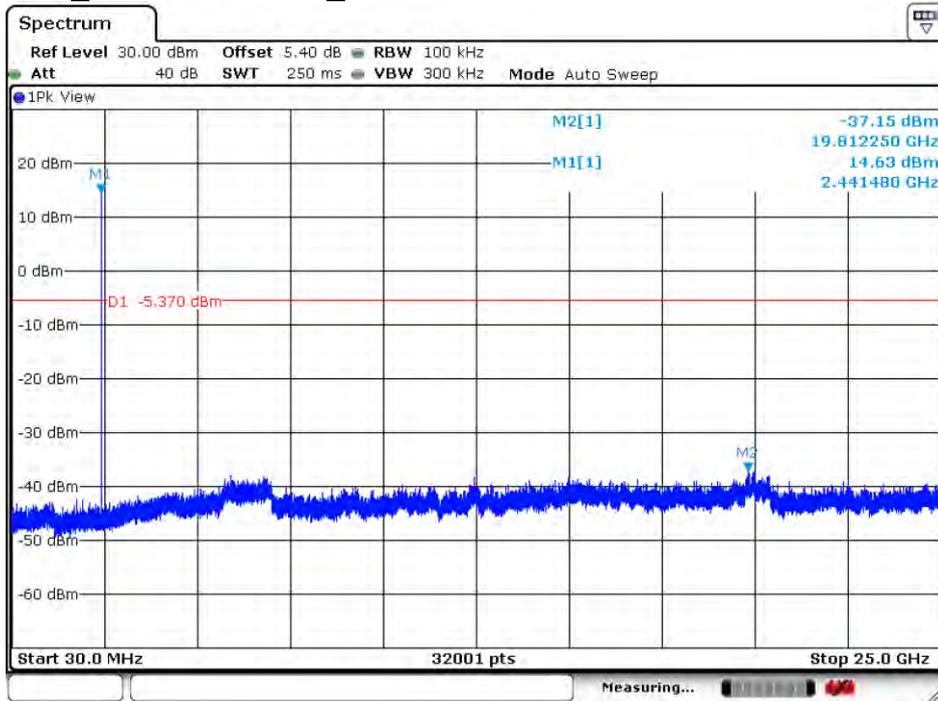
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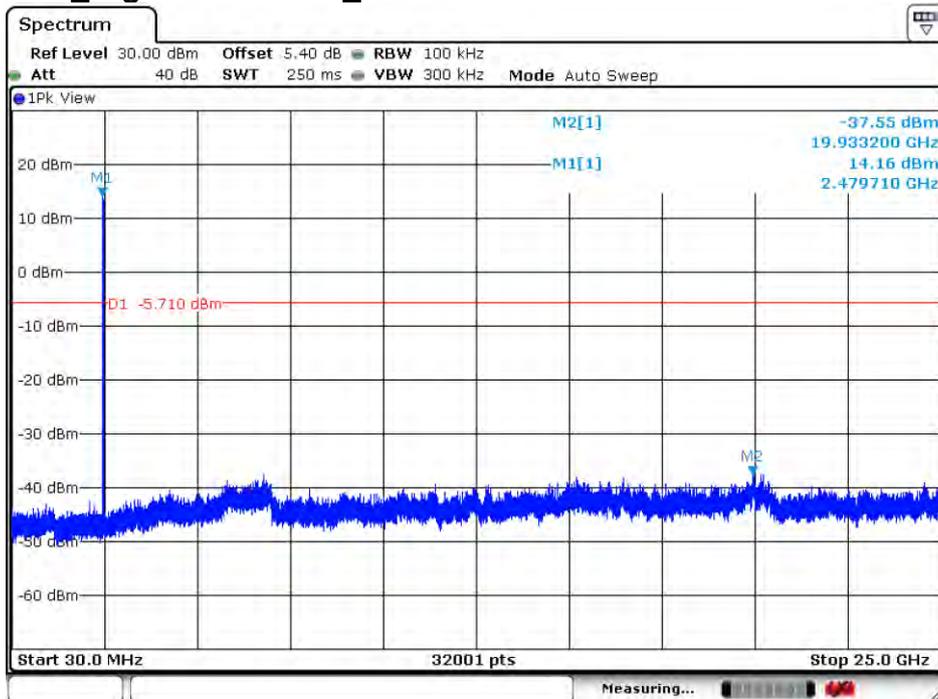
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 中国·深圳·科技园中区M-10栋一号厂房 邮编: 518057 t (86-755) 26012053 f (86-755) 26710594 sgs.china@sgs.com

**4.10.1.11 GFSK\_Middle Channel\_ANT2**



Date: 17.APR.2020 10:46:36

**4.10.1.12 GFSK\_Highest Channel\_ANT2**



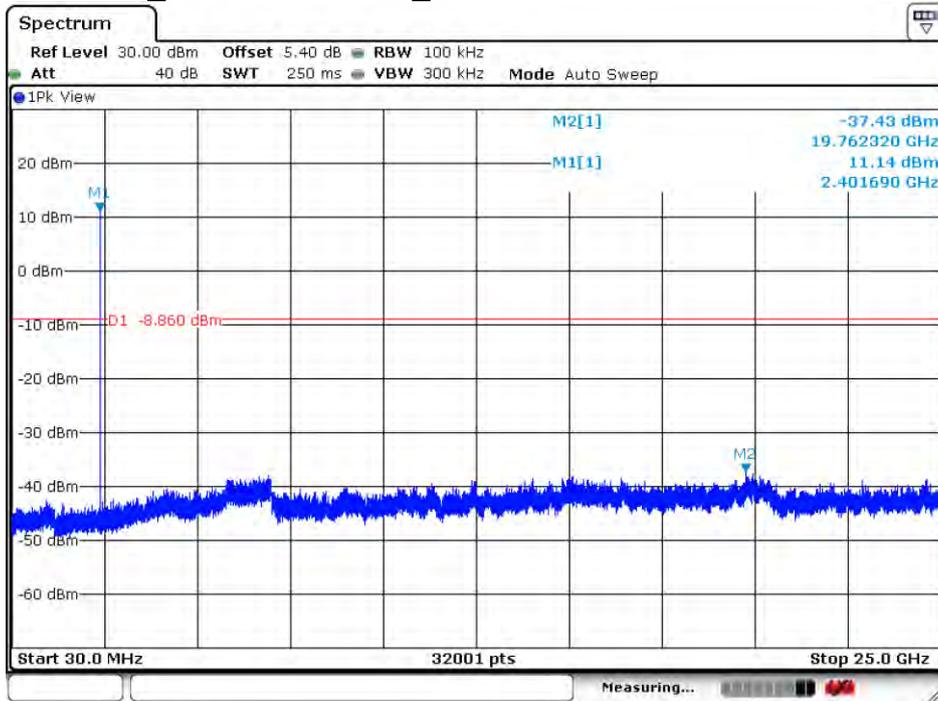
Date: 17.APR.2020 10:48:14



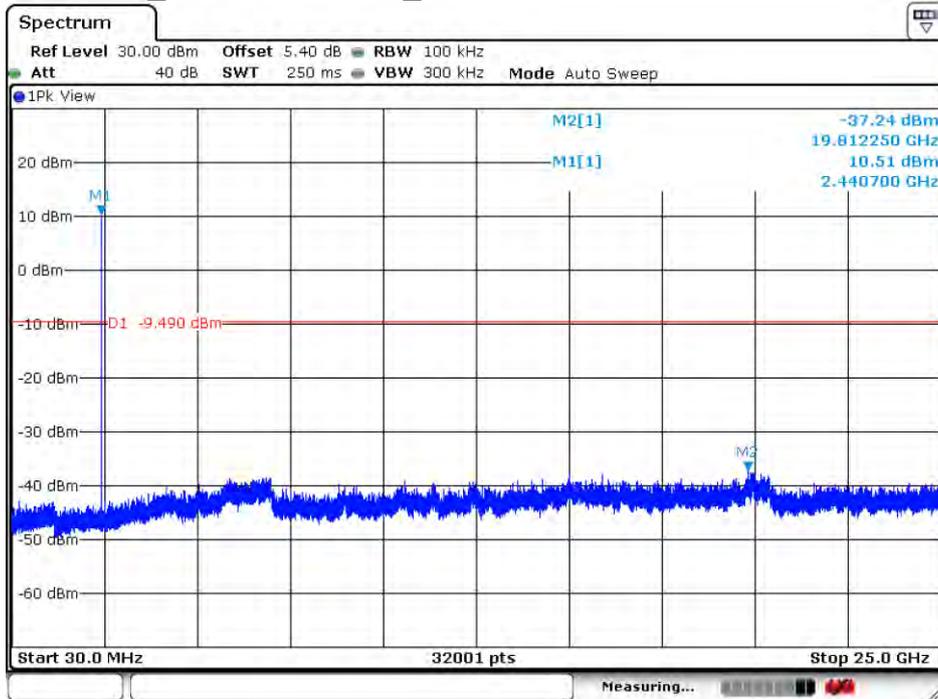
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**4.10.1.13  $\pi/4$ DQPSK\_Lowest Channel\_ANT2**



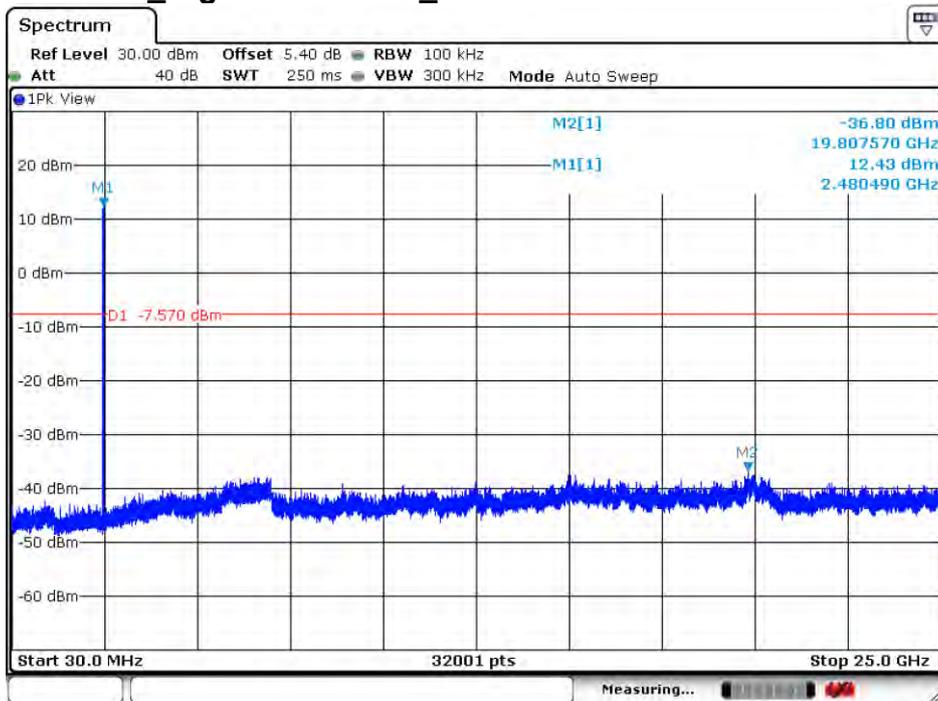
**4.10.1.14  $\pi/4$ DQPSK\_Middle Channel\_ANT2**



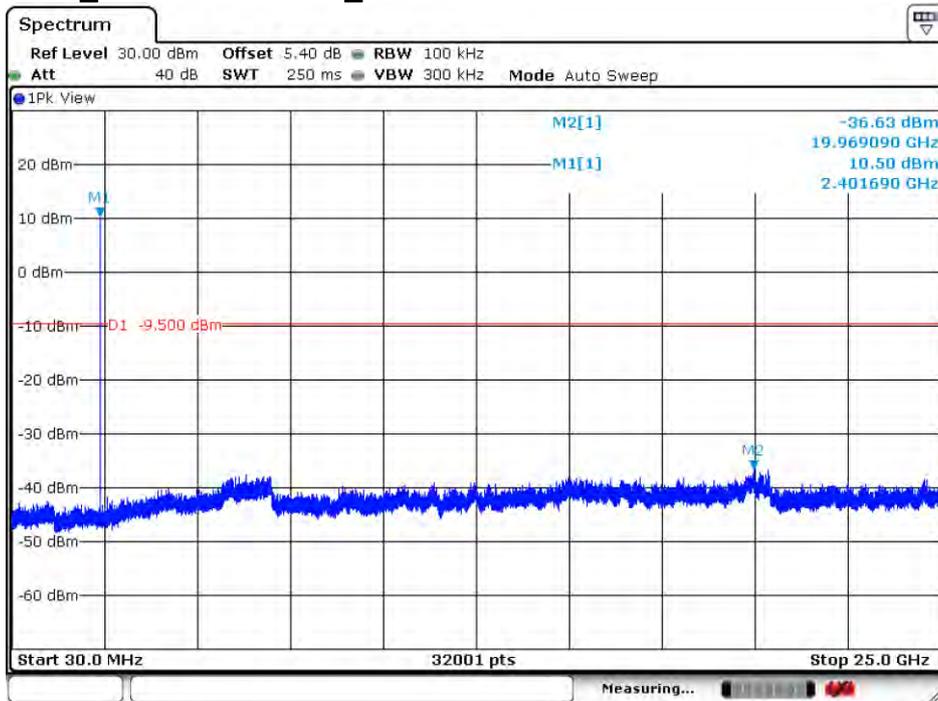
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**4.10.1.15  $\pi/4$ DQPSK\_Highest Channel\_ANT2**



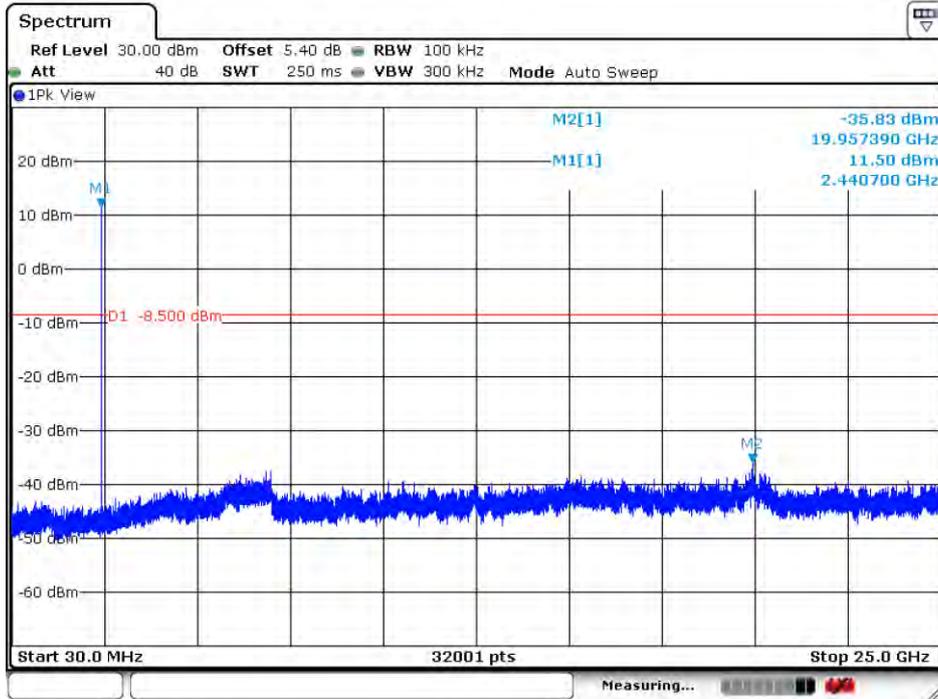
**4.10.1.16 8DPSK\_Lowest Channel\_ANT2**



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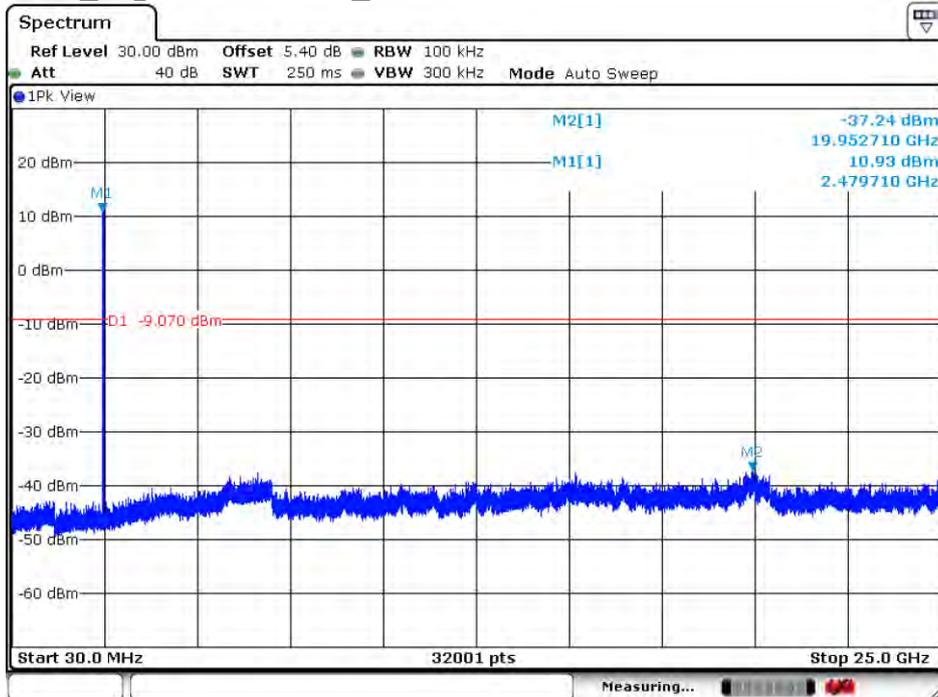
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**4.10.1.17 8DPSK\_Middle Channel\_ANT2**



Date: 17.APR.2020 11:08:38

**4.10.1.18 8DPSK\_Highest Channel\_ANT2**



Date: 17.APR.2020 11:07:14



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**Remark:**

Scan from 9kHz to 25GHz, the disturbance between 9KHz to 30MHz was very low, and the above harmonics were the highest point could be found when testing, The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.



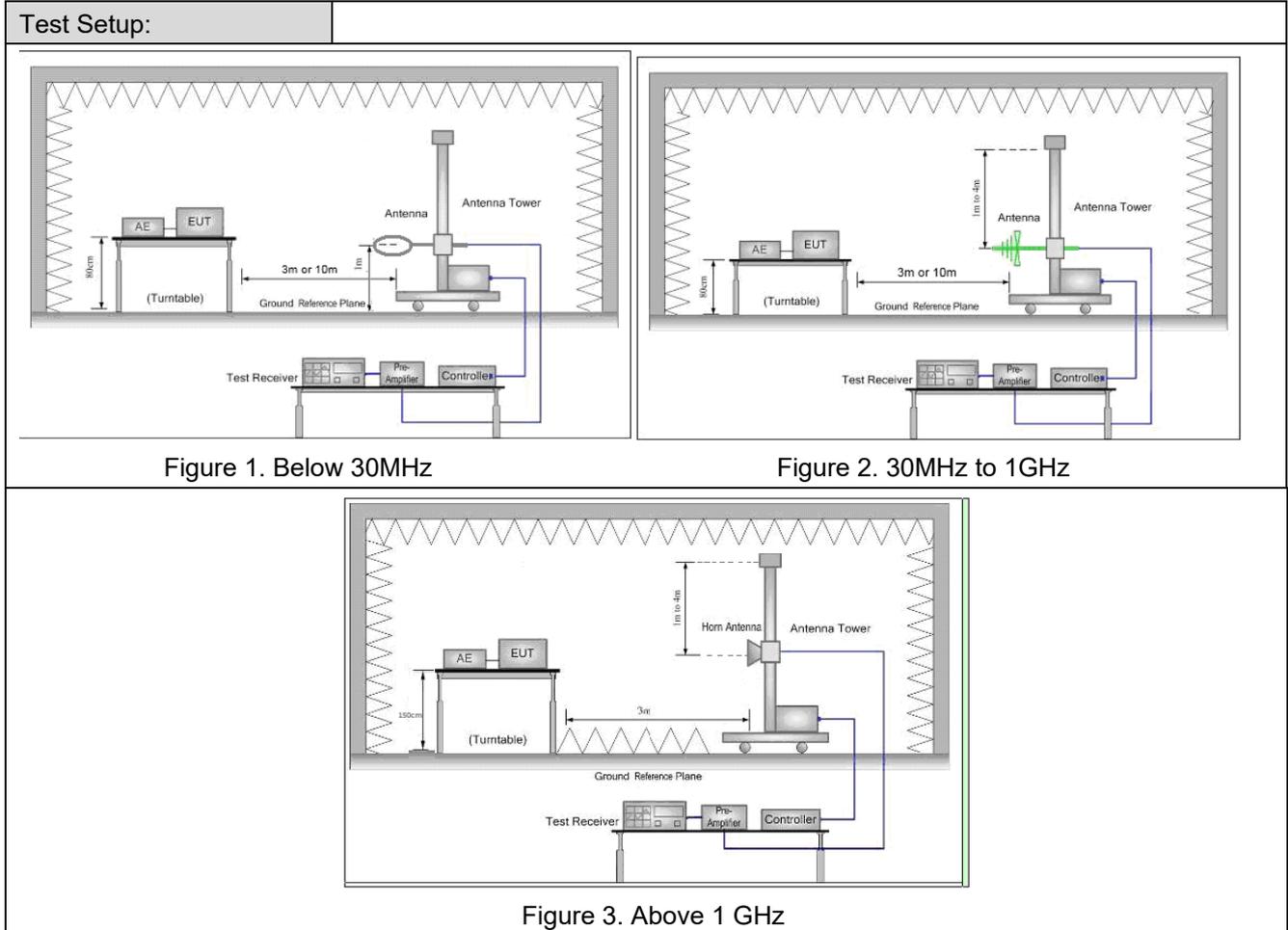
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### 4.11 Radiated Spurious Emission

Test Requirement:	47 CFR Part 15C Section 15.209 and 15.205				
Test Method:	ANSI C63.10: 2013				
Test Site:	Measurement Distance: 3m or 10m (Semi-Anechoic Chamber)				
Receiver Setup:	Frequency	Detector	RBW	VBW	Remark
	0.009MHz-0.090MHz	Peak	10kHz	30kHz	Peak
	0.009MHz-0.090MHz	Average	10kHz	30kHz	Average
	0.090MHz-0.110MHz	Quasi-peak	10kHz	30kHz	Quasi-peak
	0.110MHz-0.490MHz	Peak	10kHz	30kHz	Peak
	0.110MHz-0.490MHz	Average	10kHz	30kHz	Average
	0.490MHz -30MHz	Quasi-peak	10kHz	30kHz	Quasi-peak
	30MHz-1GHz	Quasi-peak	100 kHz	300kHz	Quasi-peak
	Above 1GHz	Peak	1MHz	3MHz	Peak
Peak		1MHz	10Hz	Average	
Limit:	Frequency	Field strength (microvolt/meter)	Limit (dBuV/m)	Remark	Measurement distance (m)
	0.009MHz-0.490MHz	2400/F(kHz)	-	-	300
	0.490MHz-1.705MHz	24000/F(kHz)	-	-	30
	1.705MHz-30MHz	30	-	-	30
	30MHz-88MHz	100	40.0	Quasi-peak	3
	88MHz-216MHz	150	43.5	Quasi-peak	3
	216MHz-960MHz	200	46.0	Quasi-peak	3
	960MHz-1GHz	500	54.0	Quasi-peak	3
	Above 1GHz	500	54.0	Average	3
Remark: 15.35(b), Unless otherwise specified, the limit on peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device.					





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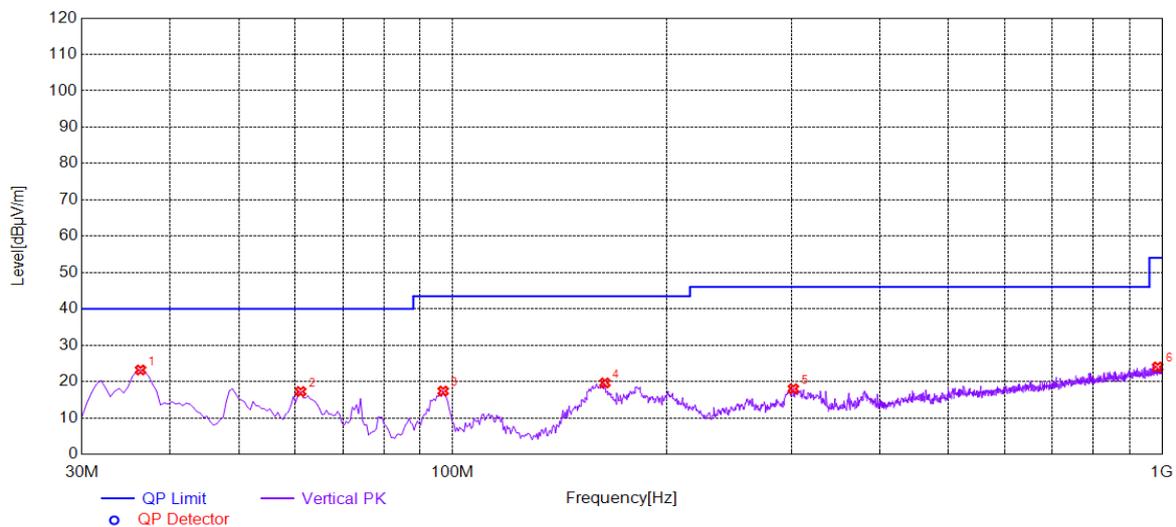
<p>Test Procedure:</p>	<p>a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.</p> <p>b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.</p> <p>c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.</p> <p>d. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.</p> <p>e. Use the following spectrum analyzer settings:</p> <p>(1) Span shall wide enough to fully capture the emission being measured;</p> <p>(2) Set RBW=100 kHz for <math>f &lt; 1 \text{ GHz}</math>, RBW=1MHz for <math>f &gt; 1\text{GHz}</math> ; VBW <math>\geq</math> RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak</p> <p>(3) For average measurement: use duty cycle correction factor method per 15.35(c). Duty cycle = On time/100 milliseconds On time = <math>N_1 * L_1 + N_2 * L_2 + \dots + N_{n-1} * L_{n-1} + N_n * L_n</math> Where <math>N_1</math> is number of type 1 pulses, <math>L_1</math> is length of type 1 pulses, etc. Average Emission Level = Peak Emission Level + <math>20 * \log(\text{Duty cycle})</math></p> <p>f. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.</p> <p>g. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.</p> <p>h. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.</p> <p>i. Test the EUT in the lowest channel (2402MHz), the middle channel (2441MHz), the Highest channel (2480MHz)</p> <p>j. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.</p> <p>k. Repeat above procedures until all frequencies measured was complete.</p>
<p>Exploratory Test Mode:</p>	<p>Non-hopping transmitting mode with all kind of modulation and all kind of data type</p>



	Charge + Transmitting mode.
Final Test Mode:	Through Pre-scan, find the DH5 of data type and GFSK modulation is the worst case. Pretest the EUT at Charge + Transmitting mode For below 1GHz part, through pre-scan, the worst case is the lowest channel. Only the worst case is recorded in the report.
Instruments Used:	Refer to section 5.10 for details
Test Results:	Pass

### 4.11.1 Radiated Emission below 1GHz

#### 4.11.1.1 Charge + Transmitting, Vertical



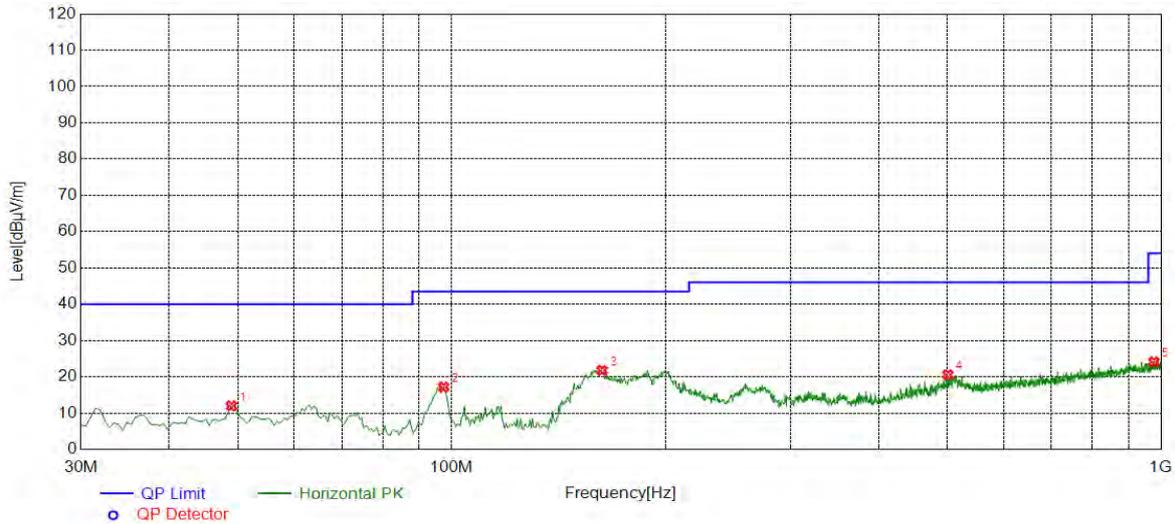
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	36.3082	23.19	-32.34	40.00	16.81	150	15	Vertical
2	61.0555	17.25	-31.91	40.00	22.75	150	292	Vertical
3	96.9635	17.39	-32.21	43.50	26.11	150	280	Vertical
4	163.927	19.63	-34.03	43.50	23.87	150	15	Vertical
5	302.221	18.00	-27.79	46.00	28.00	150	333	Vertical
6	985.928	24.03	-14.04	54.00	29.97	150	274	Vertical



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**4.11.1.2 Charge + Transmitting, Horizontal**



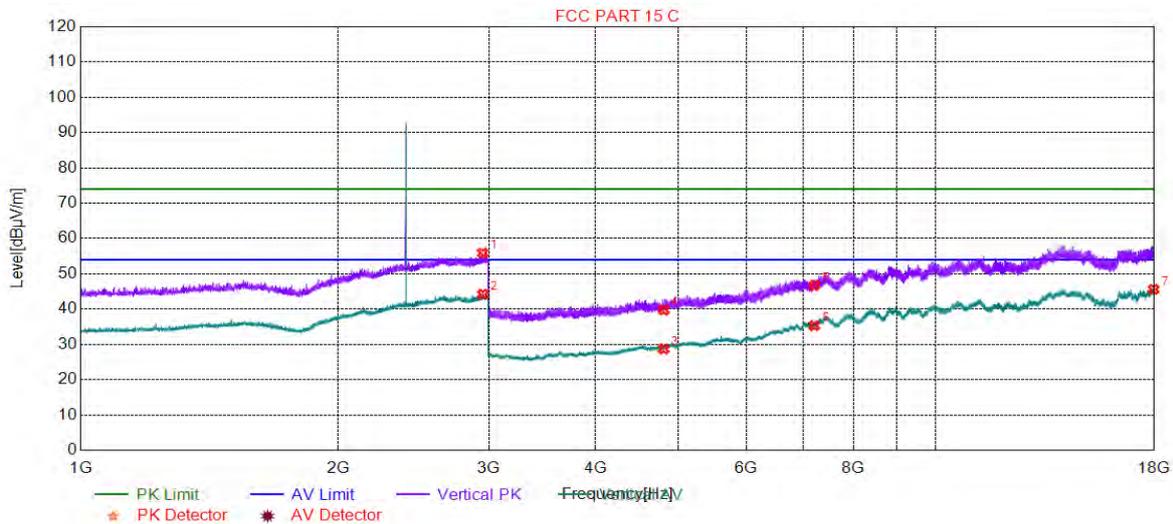
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	48.9245	11.95	-30.19	40.00	28.05	150	230	Horizontal
2	97.4487	17.17	-32.13	43.50	26.33	150	269	Horizontal
3	162.956	21.76	-34.10	43.50	21.74	150	237	Horizontal
4	500.685	20.58	-22.65	46.00	25.42	150	3	Horizontal
5	977.193	24.10	-14.14	54.00	29.90	150	162	Horizontal



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**4.11.2 Transmitter Emission above 1GHz**

**4.11.2.1 GFSK(DH5) \_Lowest Channel \_Vertical\_ANT1**



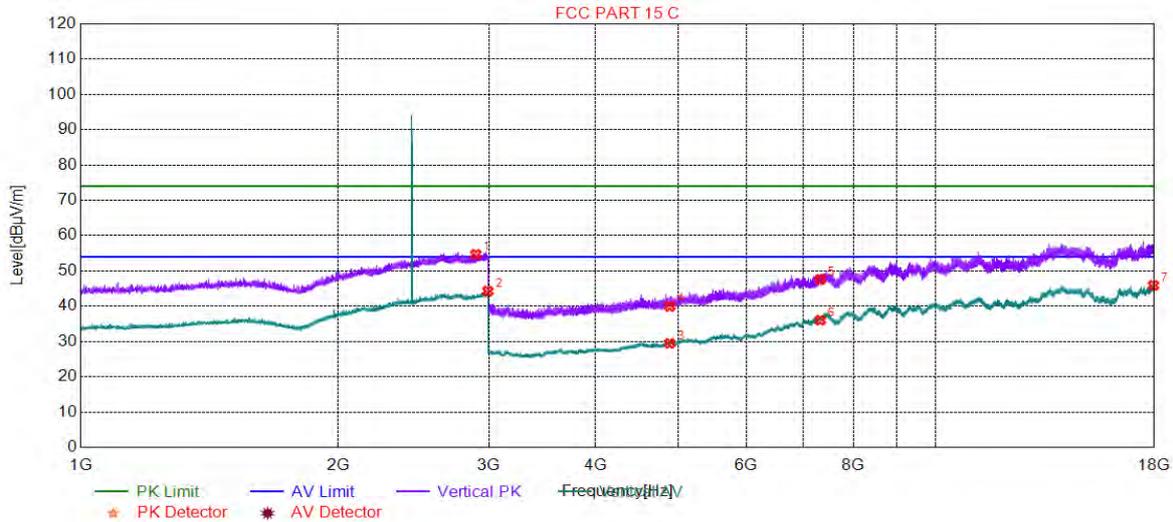
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2950.98	55.89	9.68	74.00	18.11	150	191	Vertical
2	2952.98	44.21	9.67	54.00	9.79	150	342	Vertical
3	4804.00	28.69	-18.30	54.00	25.31	150	260	Vertical
4	4804.00	39.76	-18.30	74.00	34.24	150	96	Vertical
5	7206.00	46.75	-10.09	74.00	27.25	150	18	Vertical
6	7206.00	35.30	-10.09	54.00	18.70	150	168	Vertical
7	17960.3	45.60	0.71	54.00	8.40	150	118	Vertical



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**4.11.2.2 GFSK(DH5) \_Middle Channel \_Vertical\_ANT1**



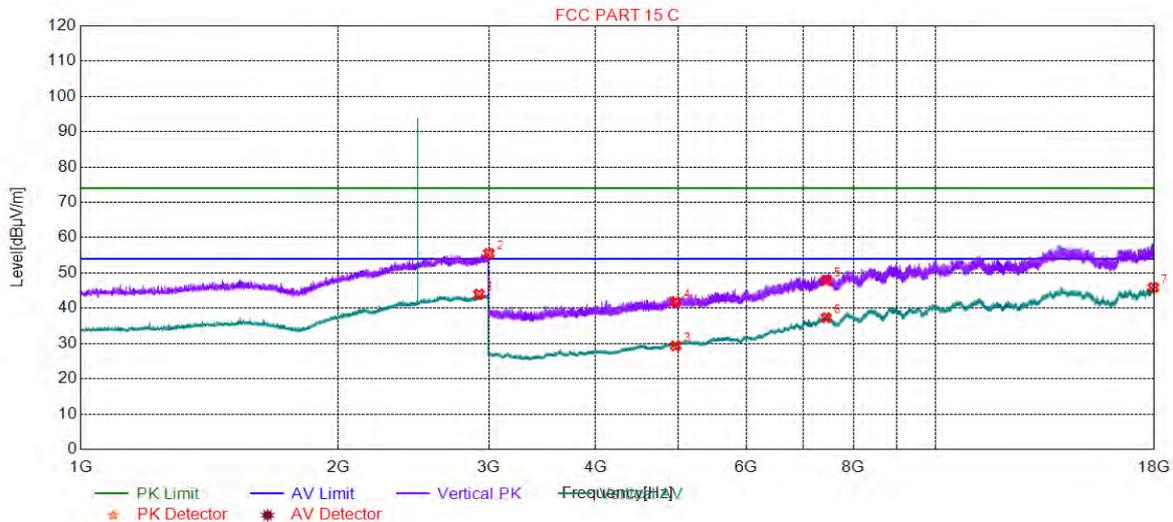
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2896.97	54.69	9.15	74.00	19.31	150	163	Vertical
2	2992.49	44.24	9.48	54.00	9.76	150	68	Vertical
3	4882.00	29.45	-17.96	54.00	24.55	150	101	Vertical
4	4882.00	39.95	-17.96	74.00	34.05	150	68	Vertical
5	7323.00	47.61	-9.71	74.00	26.39	150	219	Vertical
6	7323.00	36.03	-9.71	54.00	17.97	150	326	Vertical
7	17952.1	45.90	0.71	54.00	8.10	150	326	Vertical



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**4.11.2.3 GFSK(DH5) \_Highest Channel \_Vertical\_ANT1**



Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2921.98	43.97	9.38	54.00	10.03	150	68	Vertical
2	2999.49	55.52	9.45	74.00	18.48	150	205	Vertical
3	4960.00	29.32	-17.47	54.00	24.68	150	96	Vertical
4	4960.00	41.80	-17.47	74.00	32.20	150	150	Vertical
5	7440.00	47.89	-9.35	74.00	26.11	150	320	Vertical
6	7440.00	37.33	-9.35	54.00	16.67	150	320	Vertical
7	17948.8	45.86	0.70	54.00	8.14	150	18	Vertical

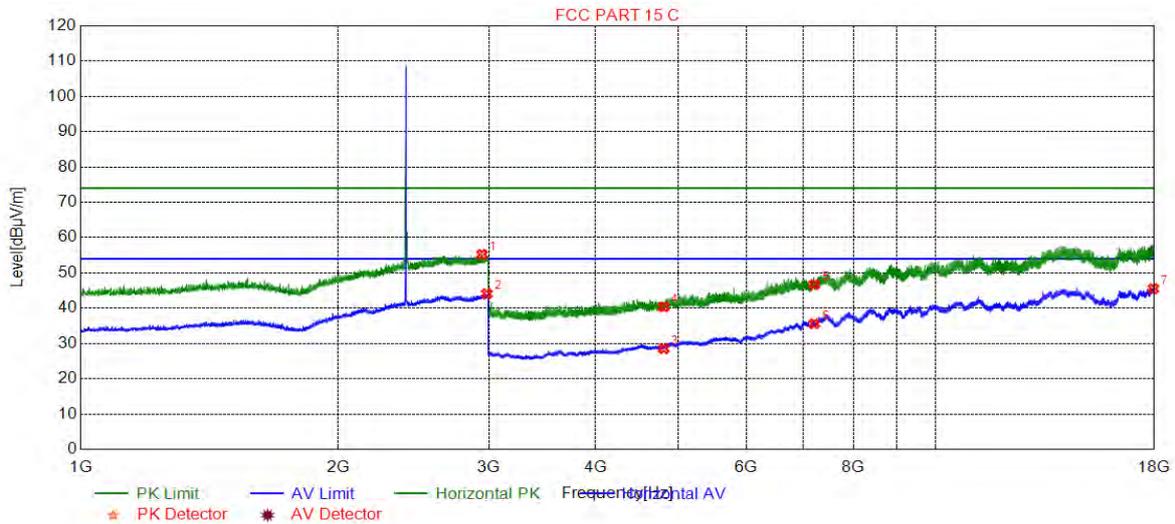


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**4.11.2.4 GFSK(DH5) \_Lowest Channel \_Horizontal\_ANT1**



Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2945.48	55.23	9.63	74.00	18.77	150	182	Horizontal
2	2983.99	44.10	9.52	54.00	9.90	150	210	Horizontal
3	4804.00	28.54	-18.30	54.00	25.46	150	259	Horizontal
4	4804.00	40.37	-18.30	74.00	33.63	150	314	Horizontal
5	7206.00	46.69	-10.09	74.00	27.31	150	73	Horizontal
6	7206.00	35.61	-10.09	54.00	18.39	150	18	Horizontal
7	17947.7	45.53	0.70	54.00	8.47	150	274	Horizontal



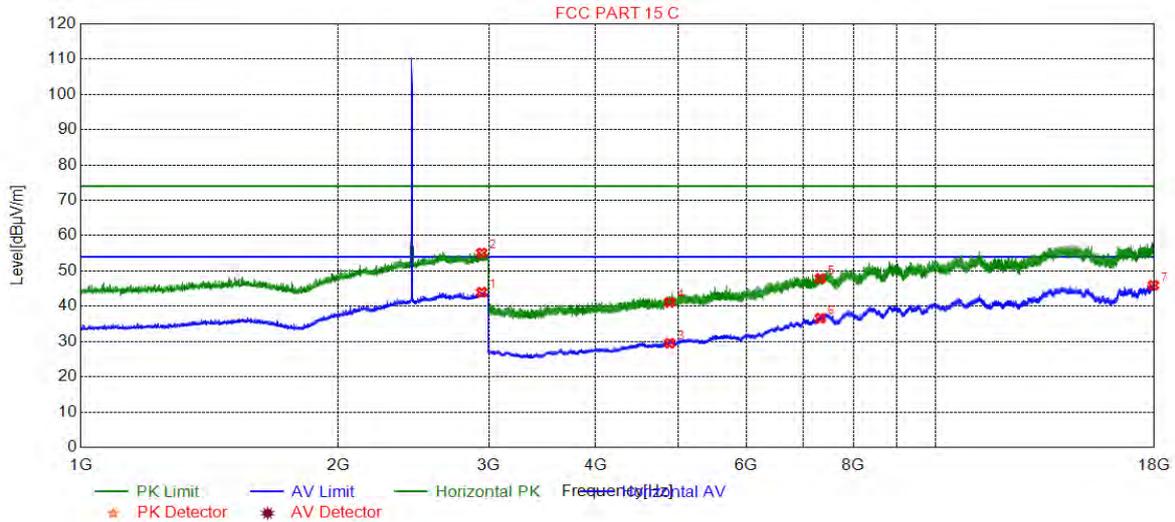
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**4.11.2.5 GFSK(DH5) \_Middle Channel \_Horizontal\_ANT1**



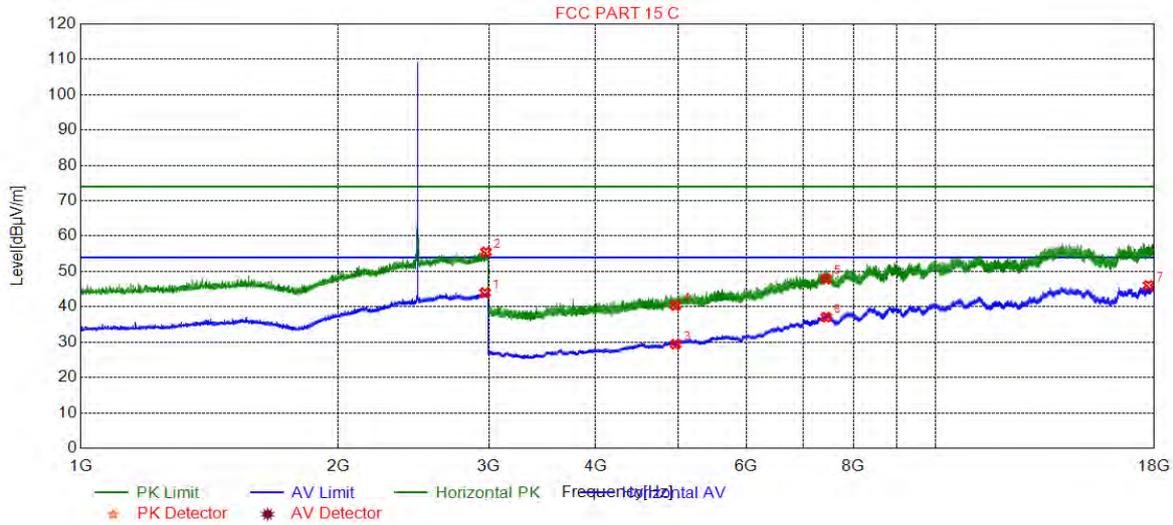
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2942.48	43.95	9.60	54.00	10.05	150	306	Horizontal
2	2942.98	55.11	9.60	74.00	18.89	150	358	Horizontal
3	4882.00	29.51	-17.96	54.00	24.49	150	314	Horizontal
4	4882.00	41.09	-17.96	74.00	32.91	150	314	Horizontal
5	7323.00	47.87	-9.71	74.00	26.13	150	275	Horizontal
6	7323.00	36.59	-9.71	54.00	17.41	150	360	Horizontal
7	17947.7	45.91	0.70	54.00	8.09	150	118	Horizontal



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**4.11.2.6 GFSK(DH5) \_Highest Channel \_Horizontal\_ANT1**



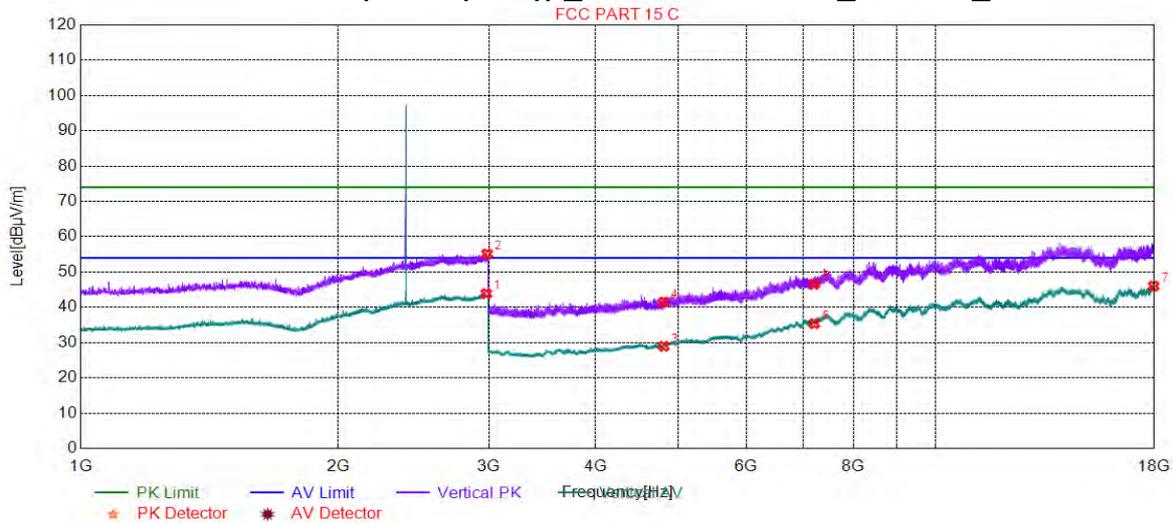
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2968.99	43.98	9.59	54.00	10.02	150	278	Horizontal
2	2976.99	55.51	9.56	74.00	18.49	150	32	Horizontal
3	4960.00	29.43	-17.47	54.00	24.57	150	286	Horizontal
4	4960.00	40.39	-17.47	74.00	33.61	150	204	Horizontal
5	7440.00	47.92	-9.35	74.00	26.08	150	18	Horizontal
6	7440.00	37.07	-9.35	54.00	16.93	150	318	Horizontal
7	17718.3	46.06	0.99	54.00	7.94	150	118	Horizontal



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**4.11.2.7 Worst Case Mode (GFSK(DH5)) \_Lowest Channel \_Vertical\_ANT2**



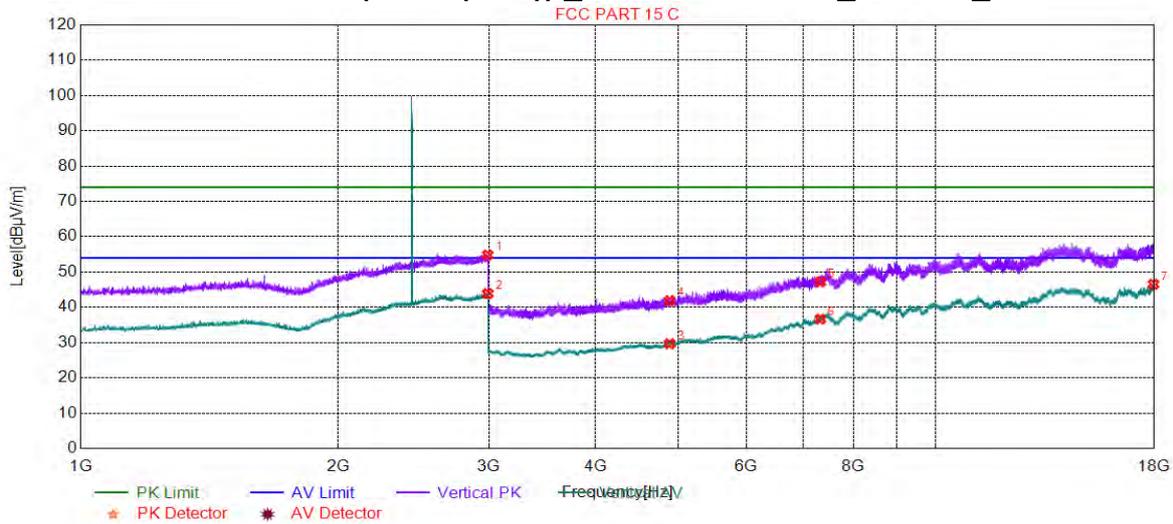
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2980.49	43.88	9.54	54.00	10.12	150	155	Vertical
2	2986.49	55.16	9.51	74.00	18.84	150	3	Vertical
3	4804.00	28.96	-18.30	54.00	25.04	150	243	Vertical
4	4804.00	41.50	-18.30	74.00	32.50	150	180	Vertical
5	7206.00	46.58	-10.09	74.00	27.42	150	324	Vertical
6	7206.00	35.35	-10.09	54.00	18.65	150	324	Vertical
7	17962.5	46.03	0.71	54.00	7.97	150	324	Vertical



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**4.11.2.8 Worst Case Mode (GFSK(DH5)) \_ Middle Channel \_ Vertical \_ ANT2**



Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2990.49	54.82	9.49	74.00	19.18	150	220	Vertical
2	2991.49	43.85	9.49	54.00	10.15	150	71	Vertical
3	4882.00	29.67	-17.96	54.00	24.33	150	289	Vertical
4	4882.00	41.89	-17.96	74.00	32.11	150	100	Vertical
5	7323.00	47.18	-9.71	74.00	26.82	150	43	Vertical
6	7323.00	36.64	-9.71	54.00	17.36	150	142	Vertical
7	17952.6	46.52	0.71	54.00	7.48	150	142	Vertical

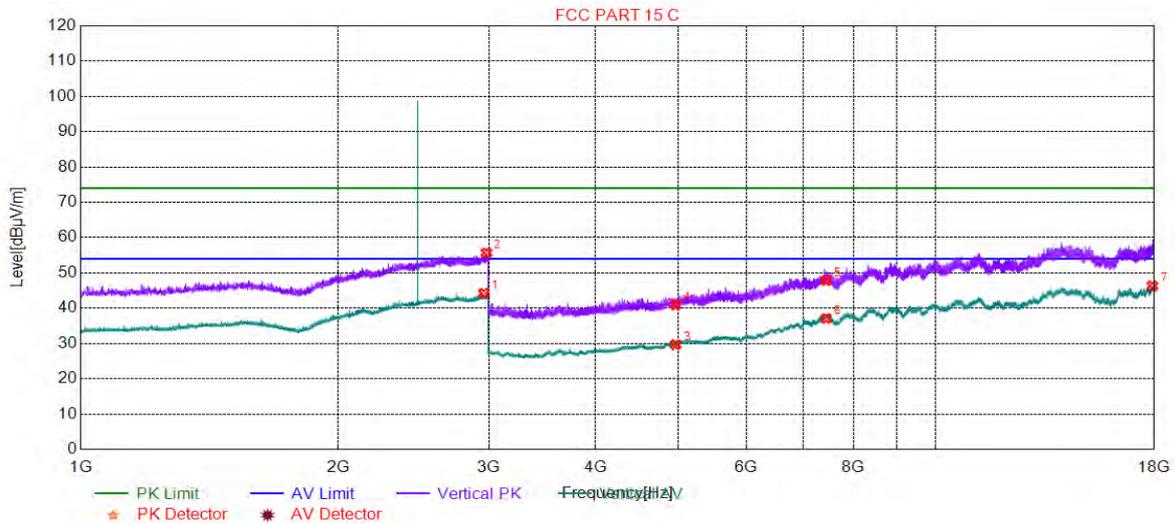


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4.11.2.9 Worst Case Mode (GFSK(DH5)) \_Highest Channel \_Vertical\_ANT2

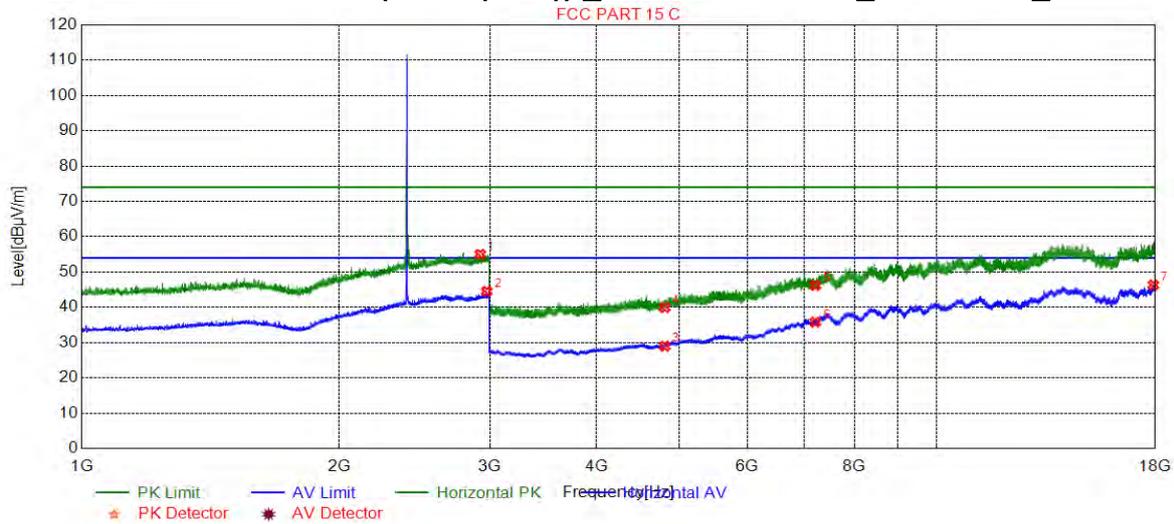


Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2959.48	44.21	9.64	54.00	9.79	150	148	Vertical
2	2980.99	55.70	9.54	74.00	18.30	150	106	Vertical
3	4960.00	29.66	-17.47	54.00	24.34	150	344	Vertical
4	4960.00	40.91	-17.47	74.00	33.09	150	208	Vertical
5	7440.00	47.84	-9.35	74.00	26.16	150	0	Vertical
6	7440.00	37.06	-9.35	54.00	16.94	150	342	Vertical
7	17905.9	46.32	0.69	54.00	7.68	150	342	Vertical



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**4.11.2.10 Worst Case Mode (GFSK(DH5)) \_Lowest Channel \_Horizontal\_ANT2**



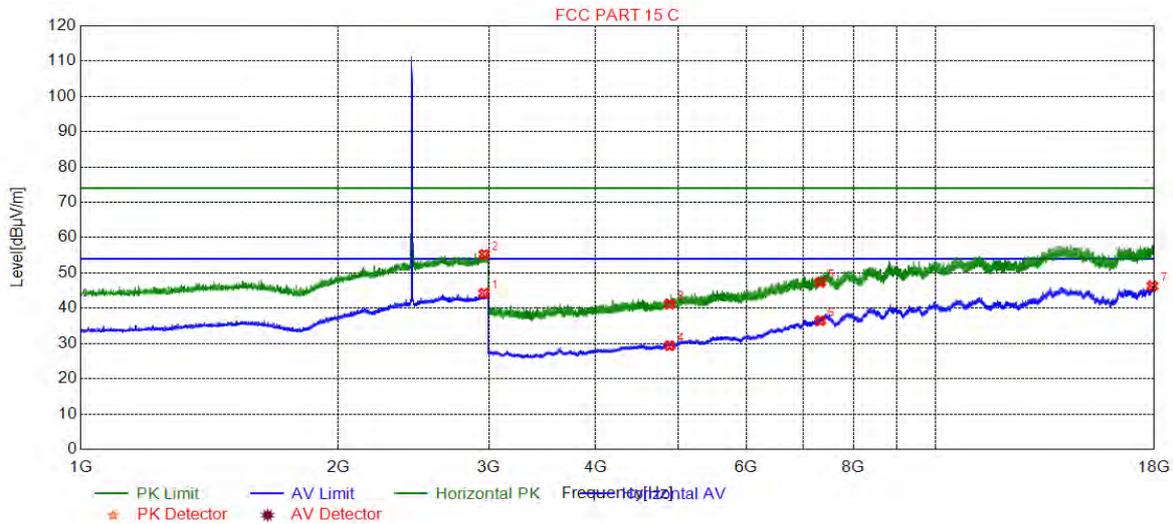
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2922.98	55.04	9.39	74.00	18.96	150	79	Horizontal
2	2974.99	44.53	9.57	54.00	9.47	150	31	Horizontal
3	4804.00	28.99	-18.30	54.00	25.01	150	89	Horizontal
4	4804.00	39.92	-18.30	74.00	34.08	150	182	Horizontal
5	7206.00	46.20	-10.09	74.00	27.80	150	130	Horizontal
6	7206.00	35.80	-10.09	54.00	18.20	150	290	Horizontal
7	17902.6	46.31	0.69	54.00	7.69	150	232	Horizontal



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**4.11.2.11 Worst Case Mode (GFSK(DH5)) \_Middle Channel \_Horizontal \_ANT2**



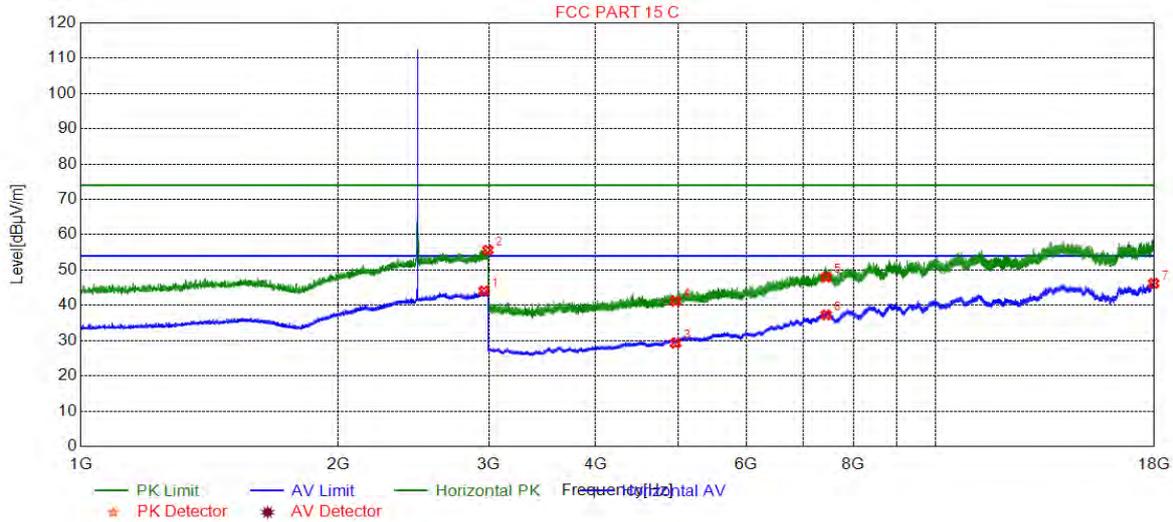
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2961.99	44.21	9.62	54.00	9.79	150	234	Horizontal
2	2962.99	55.24	9.62	74.00	18.76	150	152	Horizontal
3	4882.00	41.16	-17.96	74.00	32.84	150	294	Horizontal
4	4882.00	29.38	-17.96	54.00	24.62	150	46	Horizontal
5	7323.00	47.32	-9.71	74.00	26.68	150	143	Horizontal
6	7323.00	36.44	-9.71	54.00	17.56	150	1	Horizontal
7	17905.3	46.29	0.69	54.00	7.71	150	292	Horizontal



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**4.11.2.12 Worst Case Mode (GFSK(DH5)) \_Highest Channel \_ Horizontal \_ANT2**



Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2960.99	44.03	9.63	54.00	9.97	150	196	Horizontal
2	2990.99	55.62	9.49	74.00	18.38	150	168	Horizontal
3	4960.00	29.26	-17.47	54.00	24.74	150	154	Horizontal
4	4960.00	41.17	-17.47	74.00	32.83	150	209	Horizontal
5	7440.00	47.96	-9.35	74.00	26.04	150	342	Horizontal
6	7440.00	37.28	-9.35	54.00	16.72	150	242	Horizontal
7	17958.7	46.19	0.71	54.00	7.81	150	292	Horizontal

**Remark:**

1) The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:

$$\text{Final Test Level} = \text{Receiver Reading} + \text{Antenna Factor} + \text{Cable Factor} - \text{Preamplifier Factor}$$

2) Scan from 9kHz to 25GHz, the disturbance between 9KHz to 30MHz and 18GHz to 25GHz was very low, and the above harmonics were the highest point could be found when testing, The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.

3) As shown in this section, for frequencies above 1GHz, the field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. So, only the peak measurements were shown in the report.

4) All Modes have been tested, but only the worst case data displayed in this report.



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### 4.12 Restricted bands around fundamental frequency

Test Requirement:	47 CFR Part 15C Section 15.209 and 15.205		
Test Method:	ANSI C63.10: 2013		
Test Site:	Measurement Distance: 3m or 10m (Semi-Anechoic Chamber)		
Limit:	Frequency	Limit (dBuV/m @3m)	Remark
	30MHz-88MHz	40.0	Quasi-peak Value
	88MHz-216MHz	43.5	Quasi-peak Value
	216MHz-960MHz	46.0	Quasi-peak Value
	960MHz-1GHz	54.0	Quasi-peak Value
	Above 1GHz	54.0	Average Value
		74.0	Peak Value
Test Setup:			

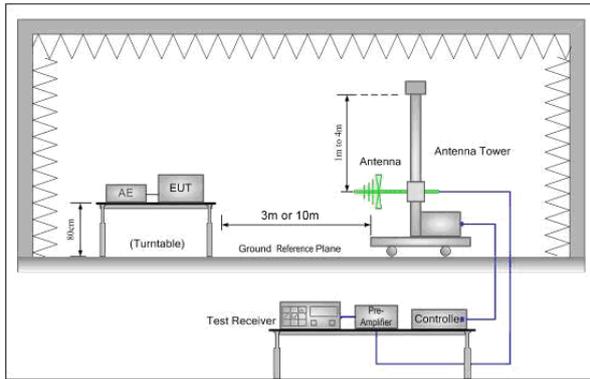


Figure 1. 30MHz to 1GHz

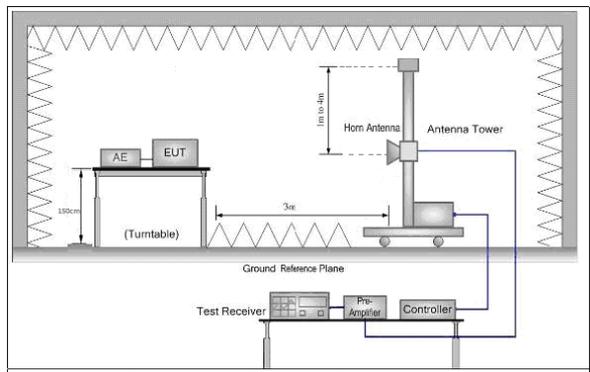


Figure 2. Above 1 GHz



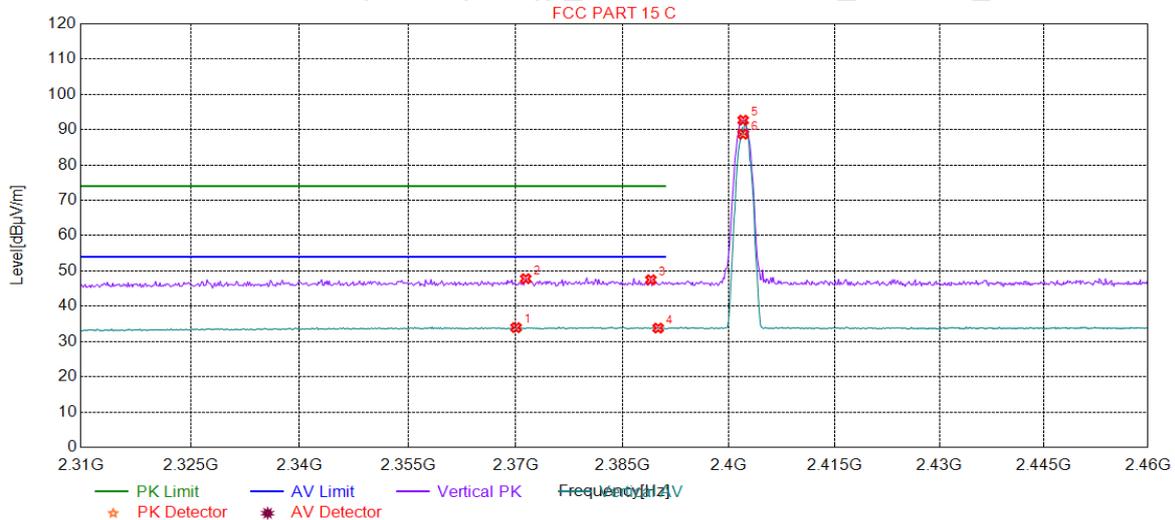
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<p>Test Procedure:</p>	<ol style="list-style-type: none"> <li>a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.</li> <li>b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.</li> <li>c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.</li> <li>d. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.</li> <li>e. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.</li> <li>f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.</li> <li>g. Place a marker at the end of the restricted band closest to the transmit frequency to show compliance. Also measure any emissions in the restricted bands. Save the spectrum analyzer plot. Repeat for each power and modulation for lowest and highest channel</li> <li>h. Test the EUT in the lowest channel , the Highest channel</li> <li>i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.</li> <li>j. Repeat above procedures until all frequencies measured was complete.</li> </ol>
<p>Exploratory Test Mode:</p>	<p>Non-hopping transmitting mode with all kind of modulation and all kind of data type Charge + Transmitting mode.</p>
<p>Final Test Mode:</p>	<p>Through Pre-scan, find the DH5 of data type and GFSK modulation is the worst case. Pretest the EUT at Charge + Transmitting mode, Only the worst case is recorded in the report.</p>
<p>Instruments Used:</p>	<p>Refer to section 5.10 for details</p>
<p>Test Results:</p>	<p>Pass</p>



### 4.12.1 Test plots

#### 4.12.1.1 Worst Case Mode (GFSK(DH5)) \_Lowest Channel \_Vertical\_ANT1



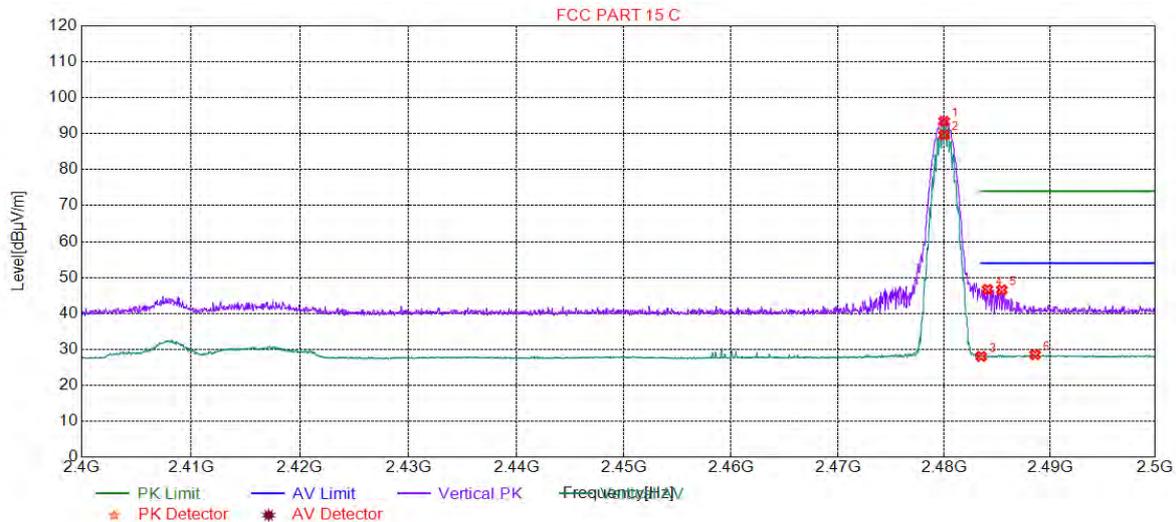
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2370.06	33.92	7.79	54.00	20.08	150	346	Vertical
2	2371.41	47.78	7.79	74.00	26.22	150	330	Vertical
3	2388.97	47.48	7.77	74.00	26.52	150	78	Vertical
4	2390.00	33.79	7.77	54.00	20.21	150	65	Vertical
5	2402.00	92.69	7.77	0.00	-92.69	150	302	Vertical
6	2402.00	88.74	7.77	0.00	-88.74	150	314	Vertical



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**4.12.1.2 Worst Case Mode (GFSK(DH5)) \_Highest Channel \_Vertical ANT1**



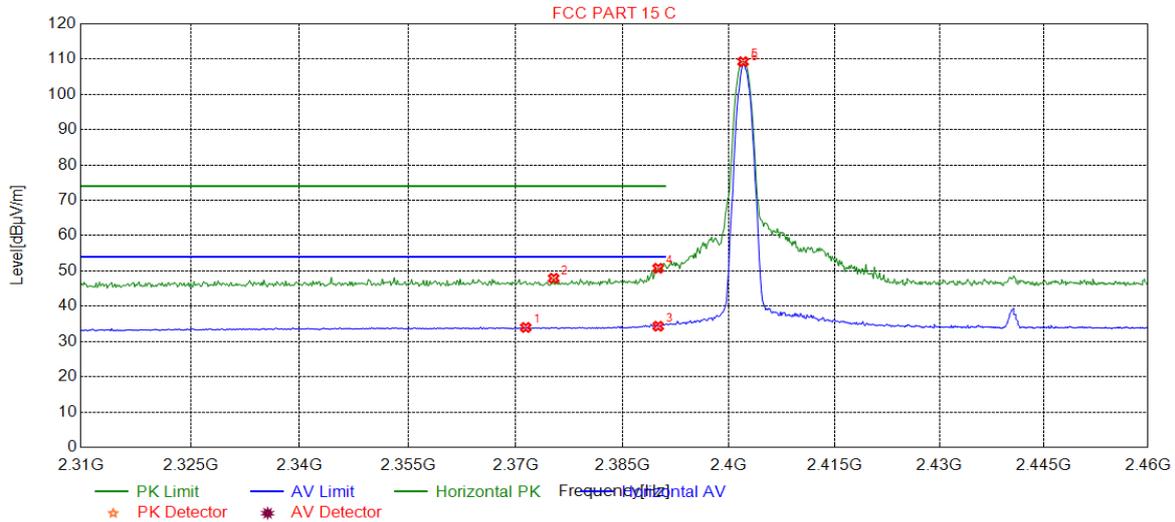
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2480.00	93.42	8.01	0.00	-93.42	150	302	Vertical
2	2480.00	89.66	8.01	0.00	-89.66	150	269	Vertical
3	2483.50	28.06	8.01	54.00	25.94	150	263	Vertical
4	2484.09	46.69	8.01	74.00	27.31	150	302	Vertical
5	2485.44	46.54	8.01	74.00	27.46	150	302	Vertical
6	2488.59	28.51	8.02	54.00	25.49	150	114	Vertical



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**4.12.1.3 Worst Case Mode (GFSK(DH5)) \_Lowest Channel \_Horizontal\_ANT1**



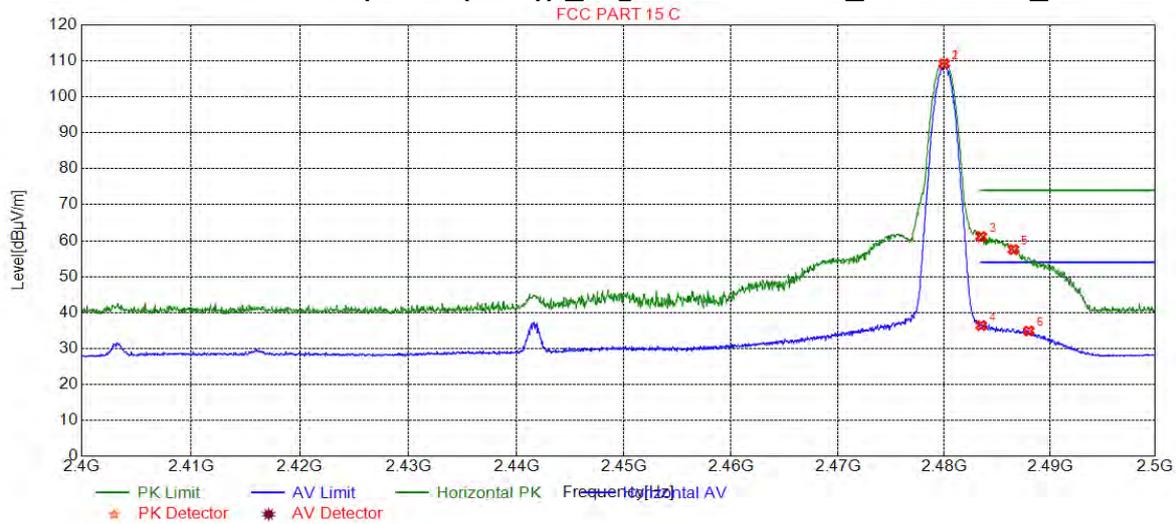
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2371.41	33.96	7.79	54.00	20.04	150	34	Horizontal
2	2375.31	47.90	7.78	74.00	26.10	150	313	Horizontal
3	2390.00	34.31	7.77	54.00	19.69	150	55	Horizontal
4	2390.00	50.74	7.77	74.00	23.26	150	63	Horizontal
5	2402.00	109.28	7.77	0.00	-109.28	150	55	Horizontal
6	2402.00	108.53	7.77	0.00	-108.53	150	55	Horizontal



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**4.12.1.4 Worst Case Mode (GFSK(DH5)) \_Highest Channel \_Horizontal\_ANT1**



Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2480.00	109.26	8.01	0.00	-109.26	150	57	Horizontal
2	2480.00	108.97	8.01	0.00	-108.97	150	57	Horizontal
3	2483.50	61.13	8.01	74.00	12.87	150	41	Horizontal
4	2483.50	36.38	8.01	54.00	17.62	150	57	Horizontal
5	2486.54	57.53	8.01	74.00	16.47	150	57	Horizontal
6	2487.99	34.86	8.02	54.00	19.14	150	62	Horizontal

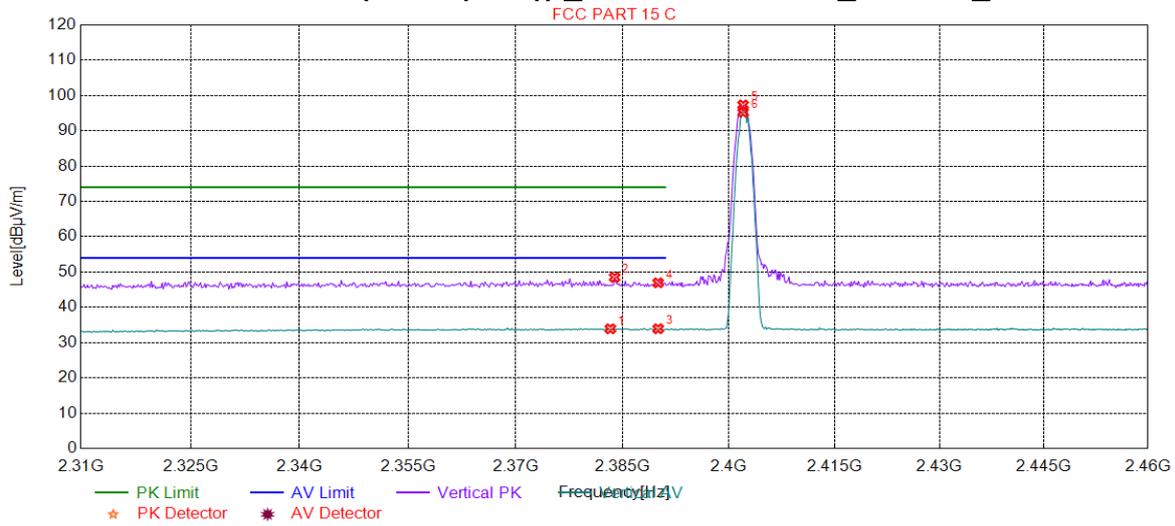


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**4.12.1.5 Worst Case Mode (GFSK(DH5)) \_Lowest Channel \_Vertical\_ANT2**



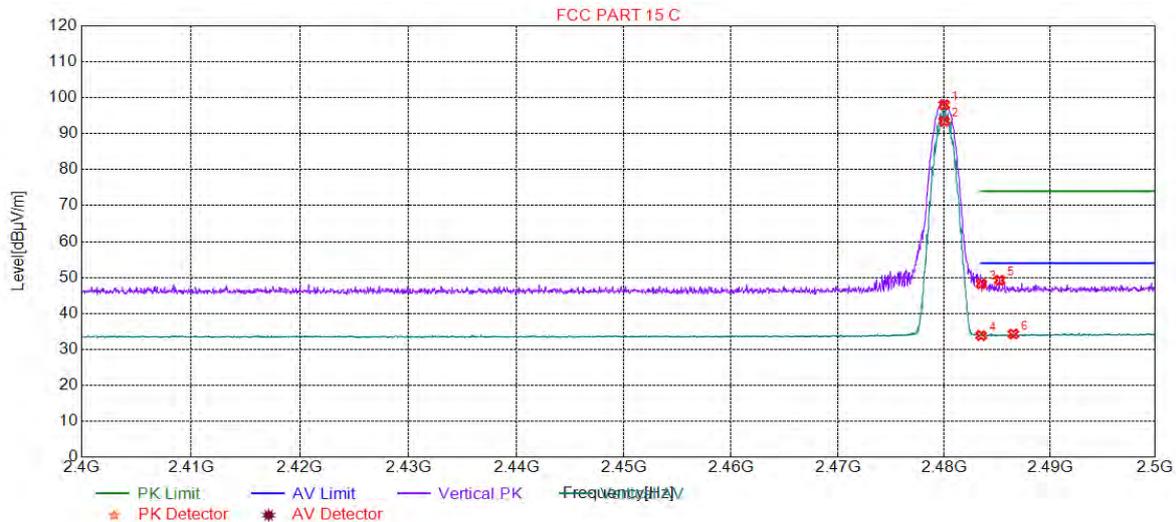
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2383.27	33.89	7.78	54.00	20.11	150	335	Vertical
2	2383.87	48.49	7.78	74.00	25.51	150	322	Vertical
3	2390.00	33.92	7.77	54.00	20.08	150	109	Vertical
4	2390.00	46.93	7.77	74.00	27.07	150	69	Vertical
5	2402.00	97.34	7.77	0.00	-97.34	150	189	Vertical
6	2402.00	95.25	7.77	0.00	-95.25	150	193	Vertical



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**4.12.1.6 Worst Case Mode (GFSK(DH5)) \_Highest Channel \_Vertical ANT2**



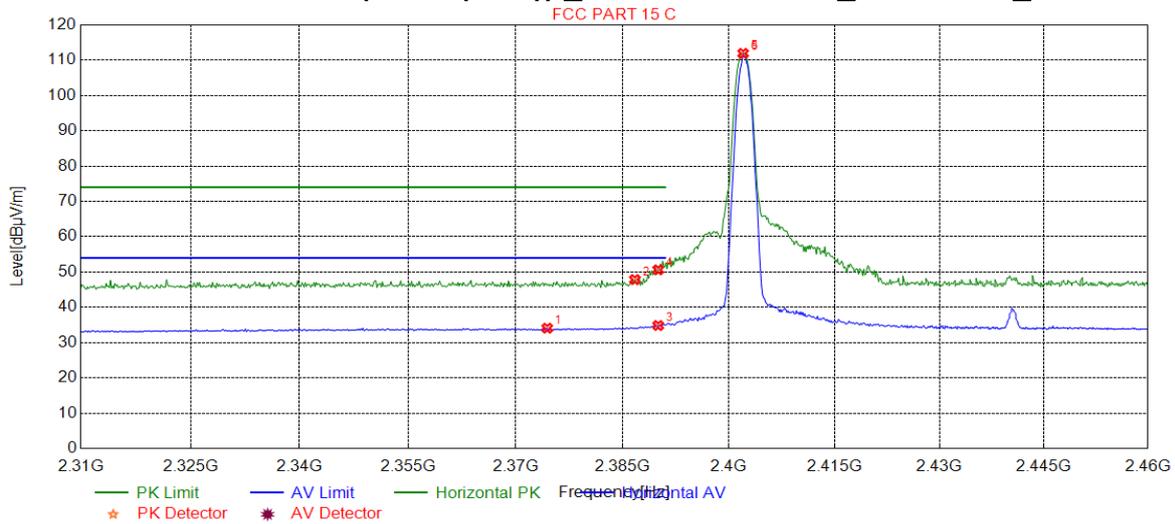
Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2480.00	98.06	8.01	0.00	-98.06	150	187	Vertical
2	2480.00	93.43	8.01	0.00	-93.43	150	119	Vertical
3	2483.50	48.25	8.01	74.00	25.75	150	187	Vertical
4	2483.50	33.85	8.01	54.00	20.15	150	233	Vertical
5	2485.24	49.22	8.01	74.00	24.78	150	193	Vertical
6	2486.54	34.26	8.01	54.00	19.74	150	167	Vertical



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**4.12.1.7 Worst Case Mode (GFSK(DH5)) \_Lowest Channel \_Horizontal\_ANT2**

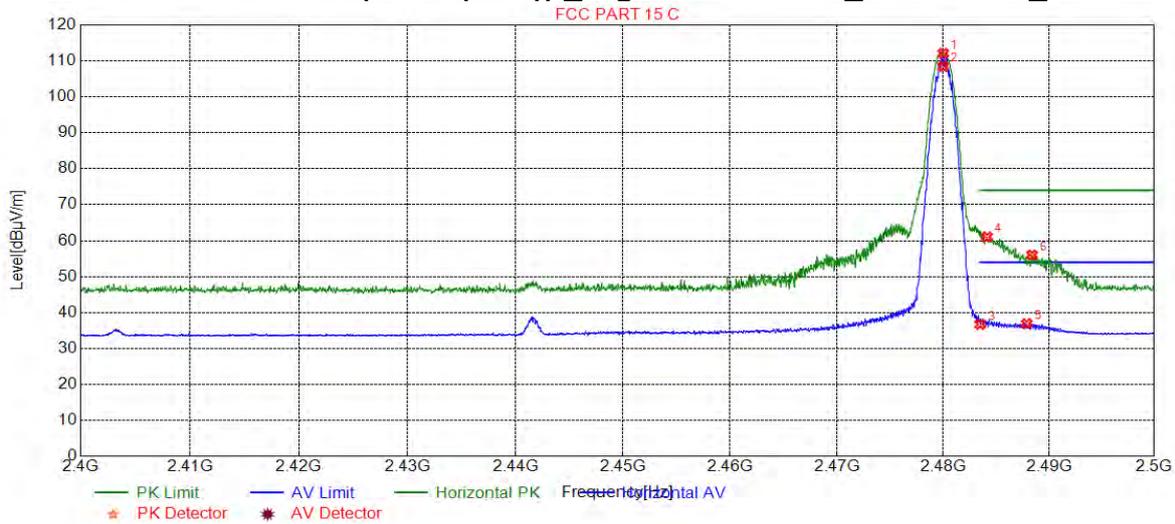


Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2374.41	34.07	7.79	54.00	19.93	150	192	Horizontal
2	2386.72	47.85	7.77	74.00	26.15	150	249	Horizontal
3	2390.00	34.83	7.77	54.00	19.17	150	212	Horizontal
4	2390.00	50.61	7.77	74.00	23.39	150	212	Horizontal
5	2402.00	111.95	7.77	0.00	-111.95	150	212	Horizontal
6	2402.00	111.68	7.77	0.00	-111.68	150	212	Horizontal



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**4.12.1.8 Worst Case Mode (GFSK(DH5)) \_Highest Channel \_ Horizontal\_ANT2**



Suspected List								
NO.	Freq. [MHz]	Level [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2480.00	112.10	8.01	0.00	-112.10	150	213	Horizontal
2	2480.00	108.43	8.01	0.00	-108.43	150	360	Horizontal
3	2483.50	36.72	8.01	54.00	17.28	150	248	Horizontal
4	2484.14	61.04	8.01	74.00	12.96	150	213	Horizontal
5	2487.89	36.91	8.02	54.00	17.09	150	202	Horizontal
6	2488.39	56.02	8.02	74.00	17.98	150	208	Horizontal

**Remark:**

The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:

*Final Test Level = Receiver Reading + Antenna Factor + Cable Factor – Preamplifier Factor*

All Modes have been tested, but only the worst case data displayed in this report.



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## 5 Measurement Uncertainty (95% confidence levels, k=2)

No.	Item	Measurement Uncertainty
1	Total RF power, conducted	±0.75dB
2	RF power density, conducted	±2.84dB
3	Spurious emissions, conducted	±0.75dB
4	Radiated Spurious emission test	±4.5dB (30MHz-1GHz)
		±4.8dB (1GHz-25GHz)
5	Conduct emission test	±3.12 dB(9KHz- 30MHz)
6	Temperature test	±1°C
7	Humidity test	±3%
8	DC and low frequency voltages	±0.5%



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## 6 Equipment List

Conducted Emission					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date	Cal.Duedate
				(yyyy-mm-dd)	(yyyy-mm-dd)
Shielding Room	ZhongYu Electron	GB-88	SEM001-06	2017/5/10	2020/5/9
LISN	Rohde & Schwarz	ENV216	SEM007-01	2019/7/14	2020/7/14
LISN	ETS-LINDGREN	Feb-16	SEM007-02	2020/4/13	2021/4/12
Measurement Software	AUDIX	e3 V5.4.1221d	N/A	N/A	N/A
Coaxial Cable	SGS	N/A	SEM024-01	2019/6/12	2020/6/11
2 Line ISN	Fischer Custom Communications Inc.	FCC-TLISN-T2-02	EMC0122	2020/2/11	2021/2/10
EMI Test Receiver	Rohde & Schwarz	ESCI	SEM004-02	2020/3/22	2021/3/21

RF conducted test					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date	Cal.Duedate
				(yyyy-mm-dd)	(yyyy-mm-dd)
DC Power Supply	Agilent Technologies Inc	66311B	W009-09	2019/7/15	2020/7/15
Signal Analyzer	Rohde & Schwarz	FSV	W025-05	2020/1/3	2021/1/2
Coaxial Cable	SGS	N/A	SEM031-01	2019/6/12	2020/6/11
Attenuator	Weinschel Associates	WA41	SEM021-09	N/A	N/A
Signal Generator	KEYSIGHT	N5173B	SEM006-05	2019/7/14	2020/7/14
Temperature Chamber	GIANT FORCE	ICT-150-40-CP-AR	W027-03	2019/10/27	2020/10/27
Power Meter	Rohde & Schwarz	NRVS	SEM014-02	2019/7/14	2020/7/14

RE in Chamber					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date	Cal.Due date
				(yyyy-mm-dd)	(yyyy-mm-dd)
3m Semi-Anechoic Chamber	AUDIX	N/A	SEM001-02	2018/3/13	2021/3/12
Measurement Software	AUDIX	e3V8.2014-6-27	N/A	N/A	N/A
Coaxial Cable	SGS	N/A	SEM026-01	2019/6/12	2020/6/11
EXA Signal Analyzer (10Hz-26.5GHz)	Agilent Technologies Inc	N9010A	SEM004-09	2020/3/22	2021/3/21



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BiConiLog Antenna (26-3000MHz)	ETS-Lindgren	3142C	SEM003-01	2017/6/27	2020/6/26
Horn Antenna (0.8-18GHz)	Rohde & Schwarz	HF907	SEM003-07	2018/4/13	2021/4/12
Pre-amplifier(0.1-1.3GHz)	HP	8447D	SEM005-02	2019/7/14	2020/7/14
Low Noise Amplifier(100MHz-18GHz)	Black Diamond Series	BDLNA-0118-352810	SEM005-05	2019/9/3	2020/9/2
Horn Antenna (15-40GHz)	Schwarzbeck	BBHA 9170	SEM003-15	2017/10/17	2020/10/16
Pre-amplifier(18-26GHz)	Rohde & Schwarz	CH14-H052	SEM005-17	2020/3/22	2021/3/21
Band filter	N/A	N/A	SEM023-01	N/A	N/A

**RE in Chamber**

Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date	Cal. Due date
				(yyyy-mm-dd)	(yyyy-mm-dd)
3m Semi-Anechoic Chamber	ETS-LINDGREN	N/A	SEM001-01	2017/8/5	2020/8/4
Measurement Software	AUDIX	e3 V8.2014-6-27	N/A	N/A	N/A
Coaxial Cable	SGS	N/A	SEM025-01	2019/6/12	2020/6/11
MXE EMI Receiver (20Hz-8.4GHz)	Agilent Technologies	N9038A	SEM004-05	2019/7/14	2020/7/14
BiConiLog Antenna (26-3000MHz)	ETS-LINDGREN	3142C	SEM003-01	2017/6/27	2020/6/26
Pre-amplifier (0.1-1.3GHz)	Agilent Technologies	8447D	SEM005-01	2020/3/22	2021/3/21

**RE in Chamber**

Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. Date (yyyy-mm-dd)	Cal. Due date (yyyy-mm-dd)
10m Semi-Anechoic Chamber	SAEMC	FSAC1018	SEM001-03	2018/3/31	2021/3/30
EMI Test Receiver (9k-7GHz)	Rohde & Schwarz	ESR	SEM004-03	2020/3/22	2021/3/21
Trilog-Broadband Antenna(25M-2GHz)	Schwarzbeck	VULB9168	SEM003-18	2020/3/22	2022/3/21
Pre-amplifier (9k-1GHz)	Sonoma	310N	SEM005-03	2020/3/22	2021/3/21
Loop Antenna (9kHz-30MHz)	ETS-Lindgren	6502	SEM003-08	2017/8/22	2020/8/21
Measurement Software	AUDIX	e3 V8.2014-6-27	N/A	N/A	N/A
Coaxial Cable	SGS	N/A	SEM029-01	2019/6/12	2020/6/11



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## 7 Photographs - EUT Constructional Details

Refer to Appendix A - Photographs of Set-Up for ZR/2020/30010

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The End



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