



FCC TEST REPORT

Application No.: ZR/2019/50004
Applicant: Nauto, Inc.
Address of Applicant: 220 Portage Avenue, Palo Alto, California 94306
Manufacturer: Nauto, Inc.
Address of Manufacturer: 220 Portage Avenue, Palo Alto, California 94306
Factory: DongGuan HeQin Electronic CO.,LTD
Address of Factory: Santun Road,Santun Village PortAvenue,Houjie Town,Dong Guan City,Guang Dong Province,P.R.China
EUT Description: Mark Button, N3
Model No.: 810-00003-01
Trade Mark: Nauto
FCC ID: 2AKJ5-N3MB
Standards: 47 CFR FCC Part 2, Subpart J
 47 CFR Part 15, Subpart C
Test Method: KDB558074 D01 15.247 Meas Guidance v05r02
 ANSI C63.10 (2013)
Date of Receipt: 2019/5/15
Date of Test: 2019/5/16to 2019/5/28
Date of Issue: 2019/5/28

Test Result:	PASS *
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* In the configuration tested, the EUT complied with the standards specified above.

Authorized Signature:

Derek Yang
Wireless Laboratory Manager



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1 Version

Revision Record				
Version	Chapter	Date	Modifier	Remark
00		2019/5/28		Original

Authorized for issue by:			
Tested By		 _____ (Mike Hu) /Project Engineer	2019/5/28

Checked By		 _____ (David Chen) /Reviewer	2019/5/28



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2 Test Summary

Test Item	Test Requirement	Test method	Test Result	Result
Conducted Output Power	15.247 (b)(3)	ANSI C63.10 2013	Clause 4.3	PASS
DTS (6 dB) Bandwidth & 99% Occupied Bandwidth	15.247 (a)(2)	ANSI C63.10 2013	Clause 4.4	PASS
Power Spectral Density	15.247 (e)	ANSI C63.10 2013	Clause 4.5	PASS
Band-edge for RF Conducted Emissions	15.247(d)	ANSI C63.10 2013	Clause 4.6	PASS
RF Conducted Spurious Emissions	15.247(d)	ANSI C63.10 2013	Clause 4.7	PASS
Radiated Spurious Emissions	15.205/15.209	ANSI C63.10 2013	Clause 4.8	PASS
Restricted bands around fundamental frequency (Radiated Emission)	15.205/15.209	ANSI C63.10 2013	Clause 4.9	PASS



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Shenzhen Branch Testing Center, EEC Laboratory

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3 General Information

3.1 Client Information

Applicant:	Nauto, Inc.
Address of Applicant:	220 Portage Avenue, Palo Alto, California 94306
Manufacturer:	Nauto, Inc.
Address of Manufacturer:	220 Portage Avenue, Palo Alto, California 94306
Factory:	DongGuan HeQin Electronic CO.,LTD
Address of Factory:	Santun Road,Santun Village PortAvenue,Houjie Town,Dong Guan City,Guang Dong Province,P.R.China

3.2 Test Location

Company:	SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch
Address:	No. 1 Workshop, M-10, Middle section, Science & Technology Park, Shenzhen, Guangdong, China
Post code:	518057
Telephone:	+86 (0) 755 2601 2053
Fax:	+86 (0) 755 2671 0594
E-mail:	ee.shenzhen@sgs.com

3.3 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

• **CNAS (No. CNAS L2929)**

CNAS has accredited SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories (CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence in the field of testing.

• **A2LA (Certificate No. 3816.01)**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 3816.01.

• **VCCI**

The 3m Fully-anechoic chamber for above 1GHz, 10m Semi-anechoic chamber for below 1GHz, Shielded Room for Mains Port Conducted Interference Measurement and Telecommunication Port Conducted Interference Measurement of SGS-CSTC Standards Technical Services Co., Ltd. have been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: G-20026, R-14188, C-12383 and T-11153 respectively.

• **FCC –Designation Number: CN1178**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized as an accredited testing laboratory.

Designation Number: CN1178. Test Firm Registration Number: 406779.

• **Industry Canada (IC)**

Two 3m Semi-anechoic chambers and the 10m Semi-anechoic chamber of SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab have been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 4620C-1, 4620C-2, 4620C-3.



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3.4 General Description of EUT

EUT Description::	Mark Button, N3
Model No.:	810-00003-01
Trade Mark:	Nauto
Hardware Version:	Markbutton_V2.0
Software Version:	0x 02 55 3F F9 A1
Operation Frequency:	2400MHz~2483.5MHz $f_c = 2402 \text{ MHz} + N * 2 \text{ MHz}$, where: - f_c = "Operating Frequency" in MHz, - N = "Channel Number" with the range from 0 to 39.
Bluetooth Version:	Bluetooth V4.0 LE
Modulation Type:	GFSK
Number of Channel:	40
Sample Type:	<input type="checkbox"/> Portable Device, <input checked="" type="checkbox"/> Module
Antenna Type:	<input type="checkbox"/> External, <input checked="" type="checkbox"/> Integrated
Antenna Gain:	-1.0dBi
Power Supply	<input checked="" type="checkbox"/> AC/DC Adapter; <input type="checkbox"/> Battery; <input type="checkbox"/> PoE;; <input type="checkbox"/> Other:

Operation Frequency of each channel							
Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
0	2402MHz	10	2422MHz	20	2442MHz	30	2462MHz
1	2404MHz	11	2424MHz	21	2444MHz	31	2464MHz
2	2406MHz	12	2426MHz	22	2446MHz	32	2466MHz
3	2408MHz	13	2428MHz	23	2448MHz	33	2468MHz
4	2410MHz	14	2430MHz	24	2450MHz	34	2470MHz
5	2412MHz	15	2432MHz	25	2452MHz	35	2472MHz
6	2414MHz	16	2434MHz	26	2454MHz	36	2474MHz
7	2416MHz	17	2436MHz	27	2456MHz	37	2476MHz
8	2418MHz	18	2438MHz	28	2458MHz	38	2478MHz
9	2420MHz	19	2440MHz	29	2460MHz	39	2480MHz

Remark:

In section 15.31(m), regards to the operating frequency range over 10 MHz, the lowest frequency, the middle frequency, and the highest frequency of channel were selected to perform the test, and the selected channel see below:

Channel	Frequency
The lowest channel (CH0)	2402MHz
The middle channel (CH19)	2440MHz
The highest channel (CH39)	2480MHz





3.5 Test Environment

Operating Environment	
Temperature:	25.0 °C
Humidity:	50 % RH
Atmospheric Pressure:	101.32 KPa

3.6 Description of Support Units

The EUT has been tested independent unit.

4 Test results and Measurement Data

4.1 Antenna Requirement

Standard requirement:	47 CFR Part 15C Section 15.203 /247(c)
<p>15.203 requirement: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.</p> <p>15.247(b) (4) requirement: The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.</p> <p>The antenna is integrated on the main PCB and no consideration of replacement. The best case gain of the antenna is -1.0dBi.</p>	



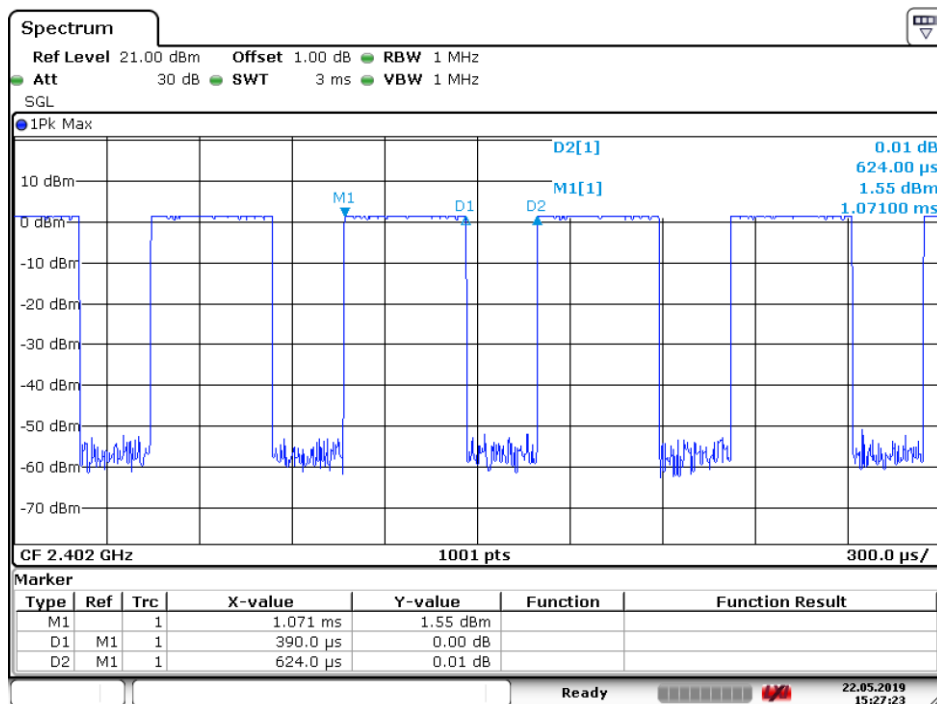
4.2 Duty Cycle

4.2.1 Test Results

Test Mode	TX Freq. [MHz]	Duty cycle [%]
BLE	CH0	62.50

4.2.1 Test Plots

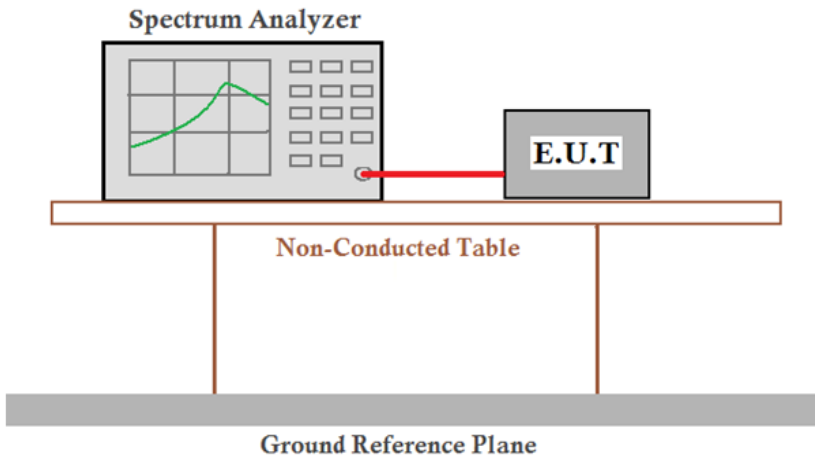
4.2.1.1 BLE



Date: 22.MAY.2019 15:27:24



4.3 Conducted Output Power

Test Requirement:	47 CFR Part 15C Section 15.247 (b)(3)
Test Method:	ANSI C63.10 :2013 Section 11.9.1.1
Test Setup:	
Limit:	30dBm
Test Mode:	Transmitting with GFSK modulation.
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass

4.3.1 Test Results

Measurement Data of Average Power

GFSK mode		
Test channel	Average Output Power (dBm)	Result
Lowest	0.21	Report purpose only
Middle	0.15	Report purpose only
Highest	0.03	Report purpose only

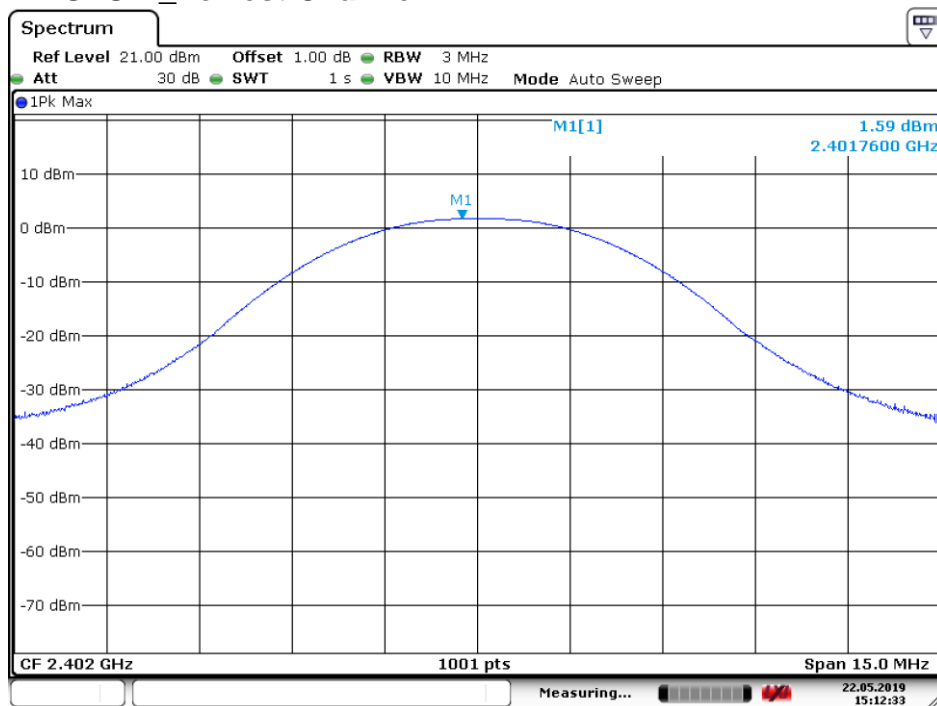
Measurement Data of Peak Power :

GFSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	1.59	30.00	Pass
Middle	1.53	30.00	Pass
Highest	1.36	30.00	Pass



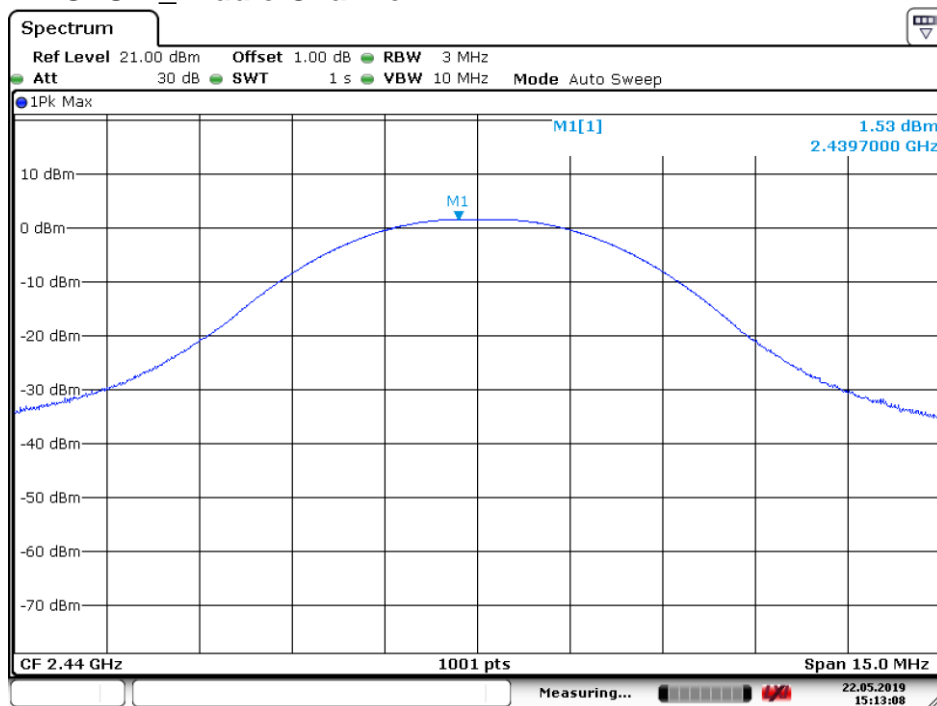
4.3.2 Test plots:

4.3.2.1 GFSK _Lowest Channel



Date: 22.MAY.2019 15:12:33

4.3.2.2 GFSK _Middle Channel



Date: 22.MAY.2019 15:13:08

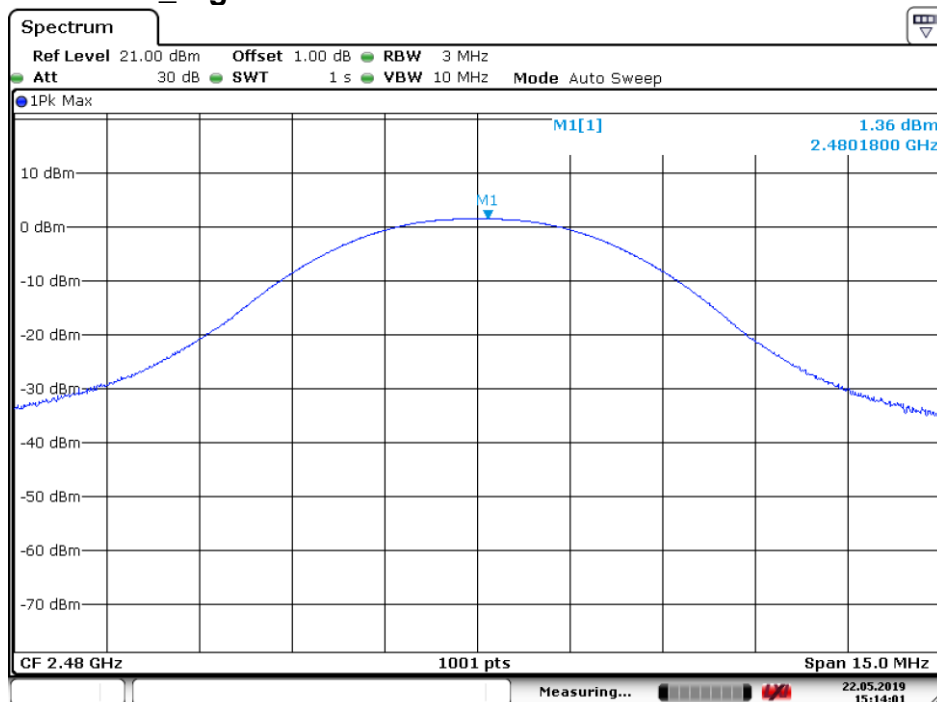


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4.3.2.3

GFSK_Highest Channel



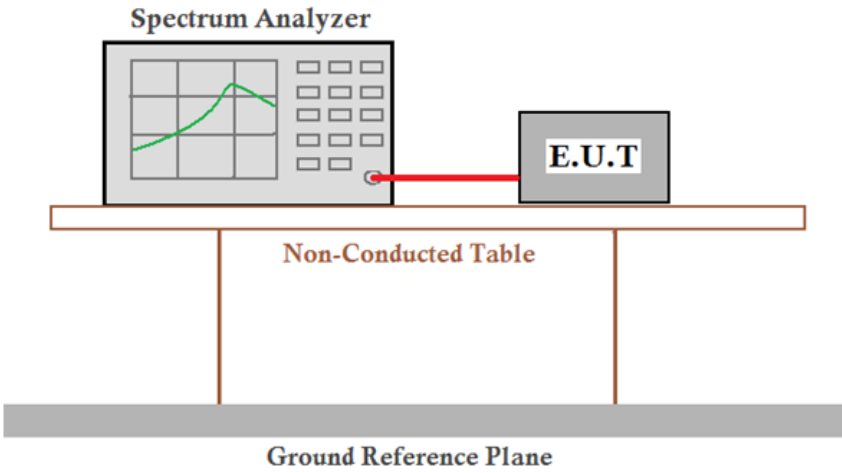
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4.4 DTS (6 dB) Bandwidth & 99% Occupied Bandwidth

Test Requirement:	47 CFR Part 15C Section 15.247 (a)(2)
Test Method:	ANSI C63.10: 2013 Section 11.8 Option 2
Test Setup:	
Limit:	≥ 500 kHz
Test Mode:	Transmitting with GFSK modulation.
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass

4.4.1 Test Results

Mode	Test Channel	99% Occupied Bandwidth (MHz)	6dB Emission Bandwidth (MHz)	Limit (kHz)	Result
GFSK	Lowest	1.04	0.69	≥500	Pass
	Middle	1.04	0.69	≥500	Pass
	Highest	1.04	0.69	≥500	Pass



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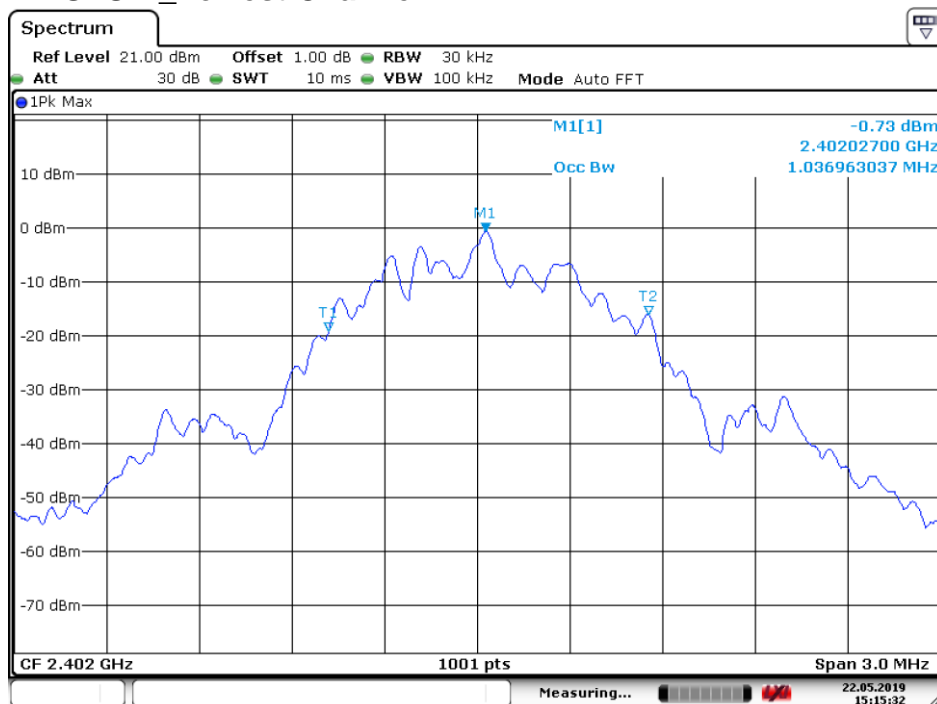
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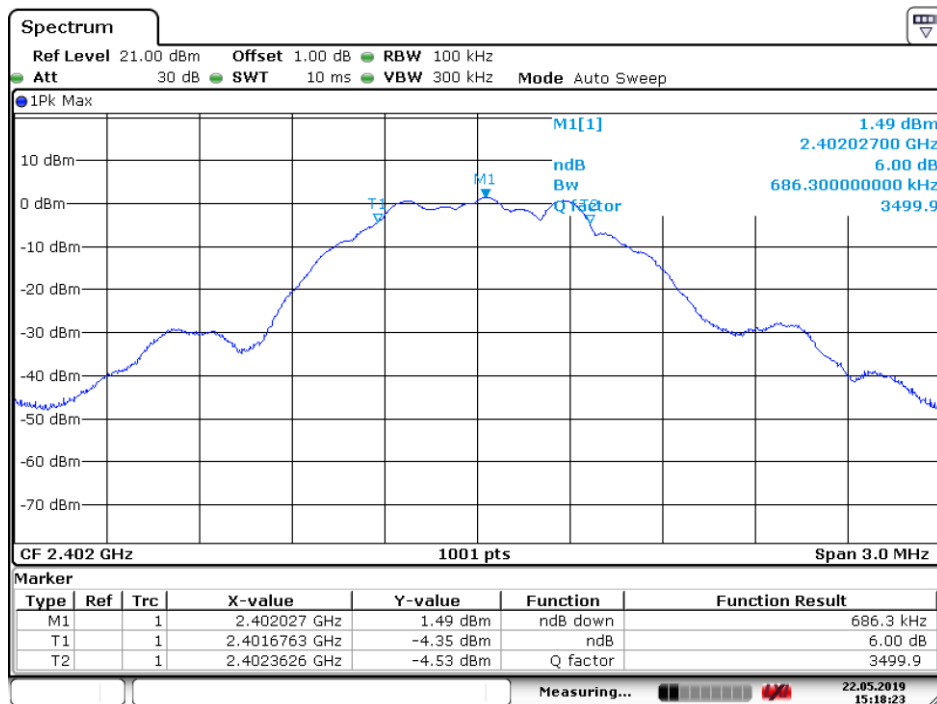
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4.4.2 Test plots

4.4.2.1 GFSK _Lowest Channel



Date: 22.MAY.2019 15:15:32



Date: 22.MAY.2019 15:18:24

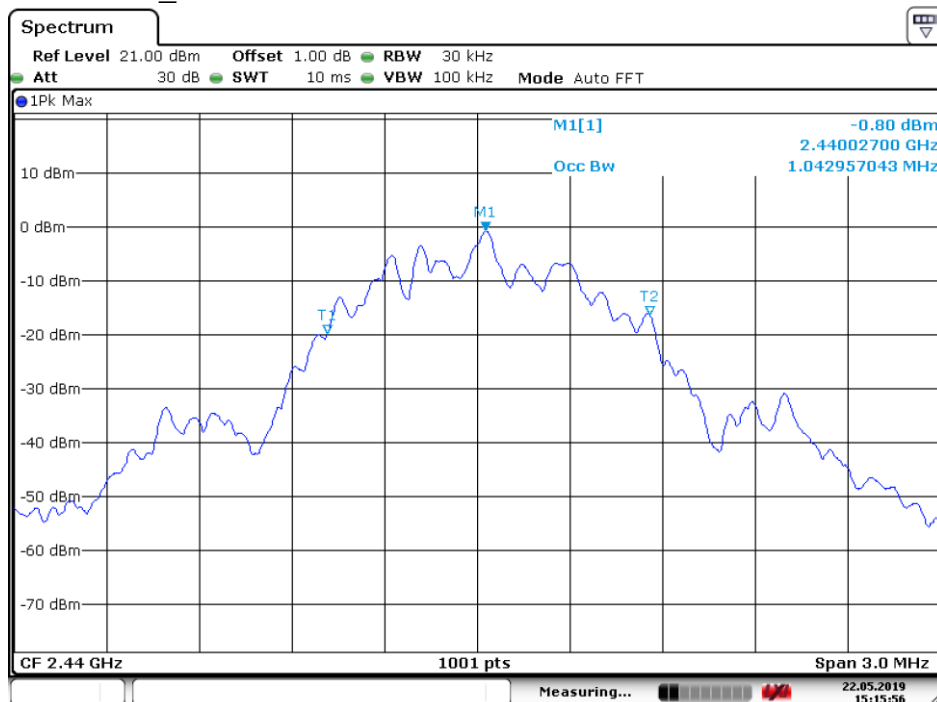


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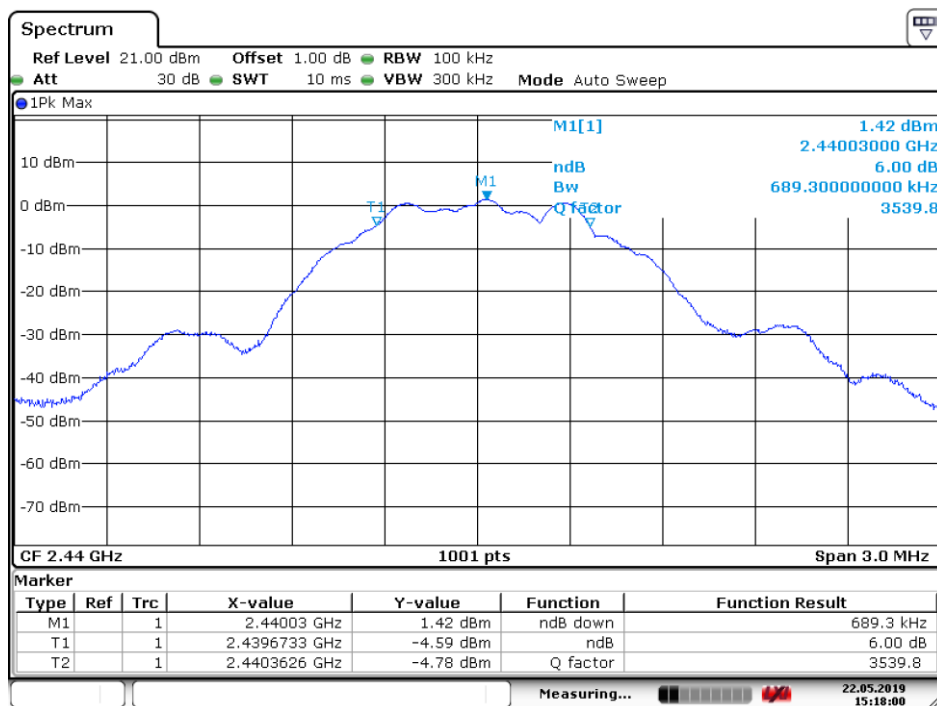
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4.4.2.2

GFSK_Middle Channel



Date: 22.MAY.2019 15:15:57



Date: 22.MAY.2019 15:18:01



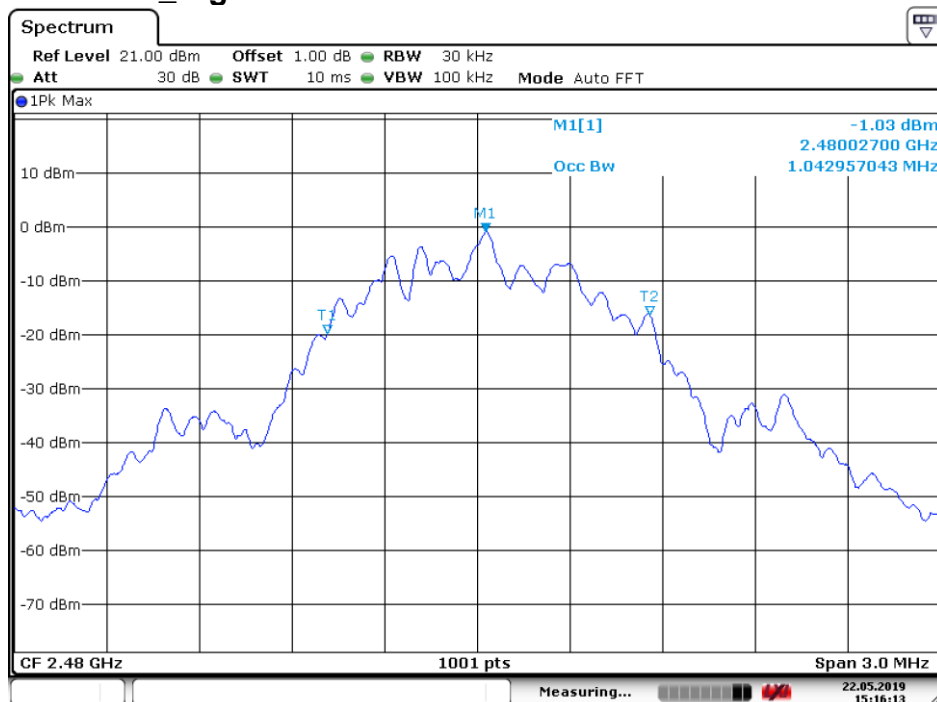
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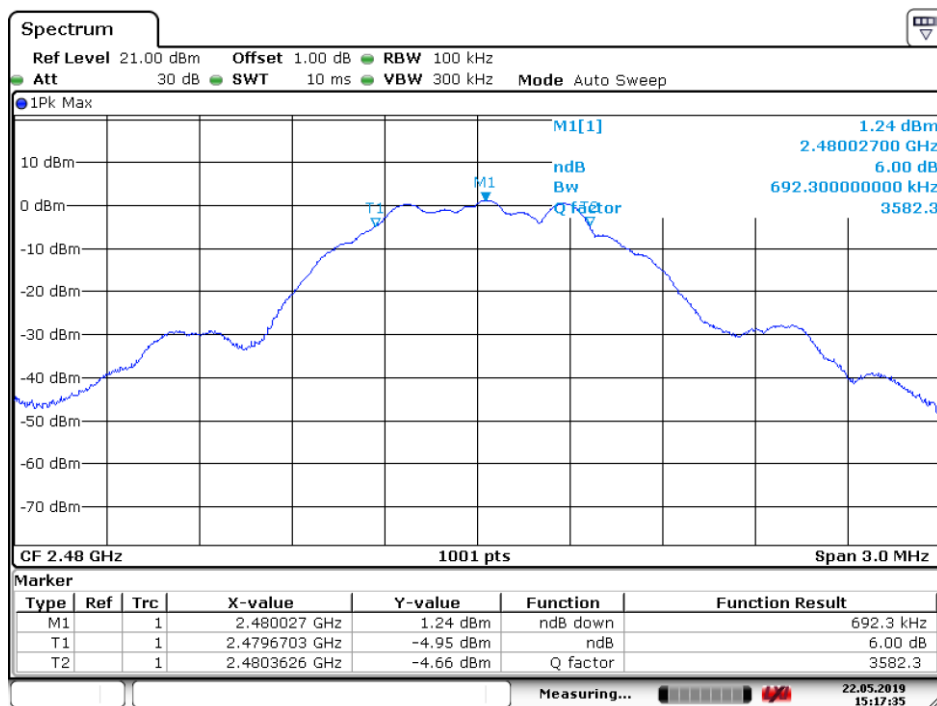
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4.4.2.3

GFSK_Highest Channel



Date: 22.MAY.2019 15:16:12



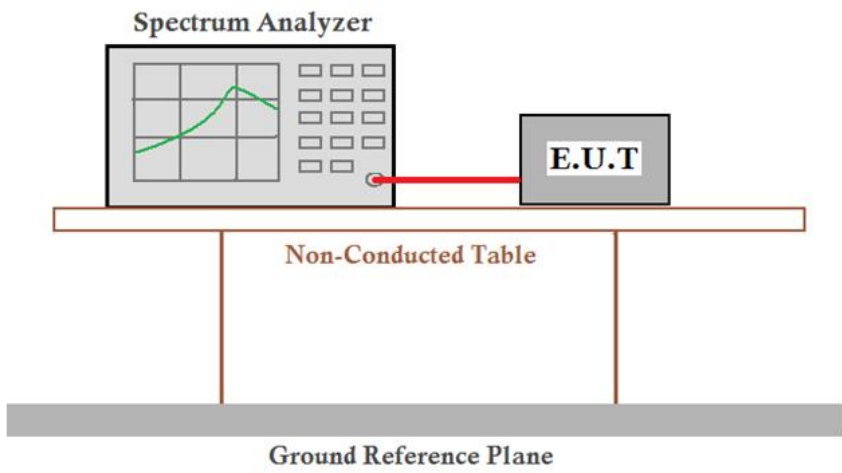
Date: 22.MAY.2019 15:17:35



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4.5 Power Spectral Density

Test Requirement:	47 CFR Part 15C Section 15.247 (e)
Test Method:	ANSI C63.10 :2013 Section 11.10.2
Test Setup:	
Limit:	≤8.00dBm/3kHz
Test Mode:	Transmitting with GFSK modulation.
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass

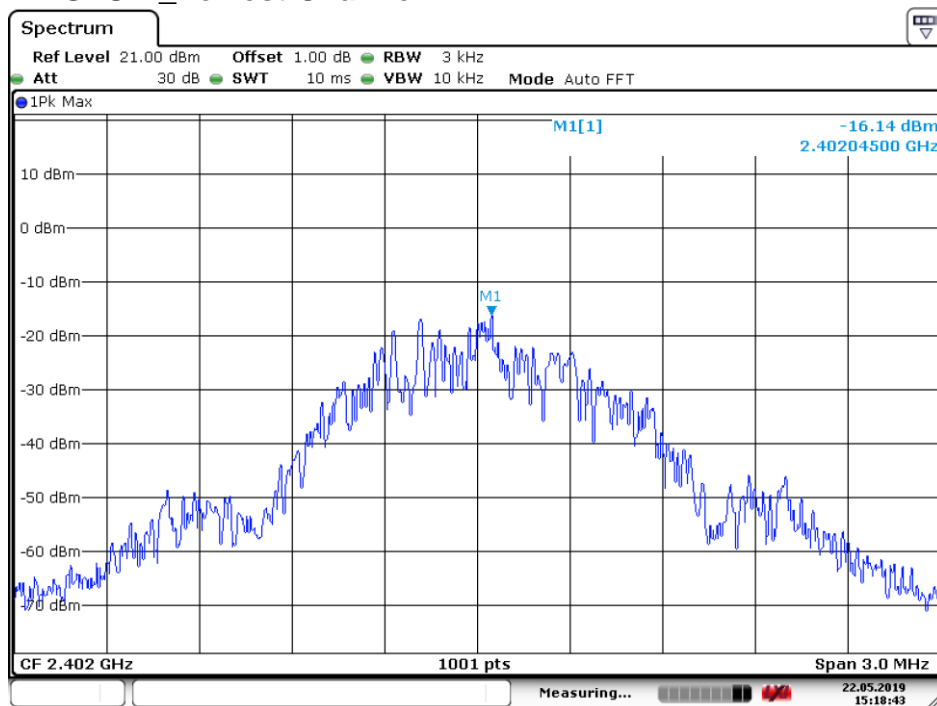
4.5.1 Test Results

Mode	Test Channel	Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)	Result
GFSK	Lowest	-16.14	≤8.00	Pass
	Middle	-16.18	≤8.00	Pass
	Highest	-16.36	≤8.00	Pass



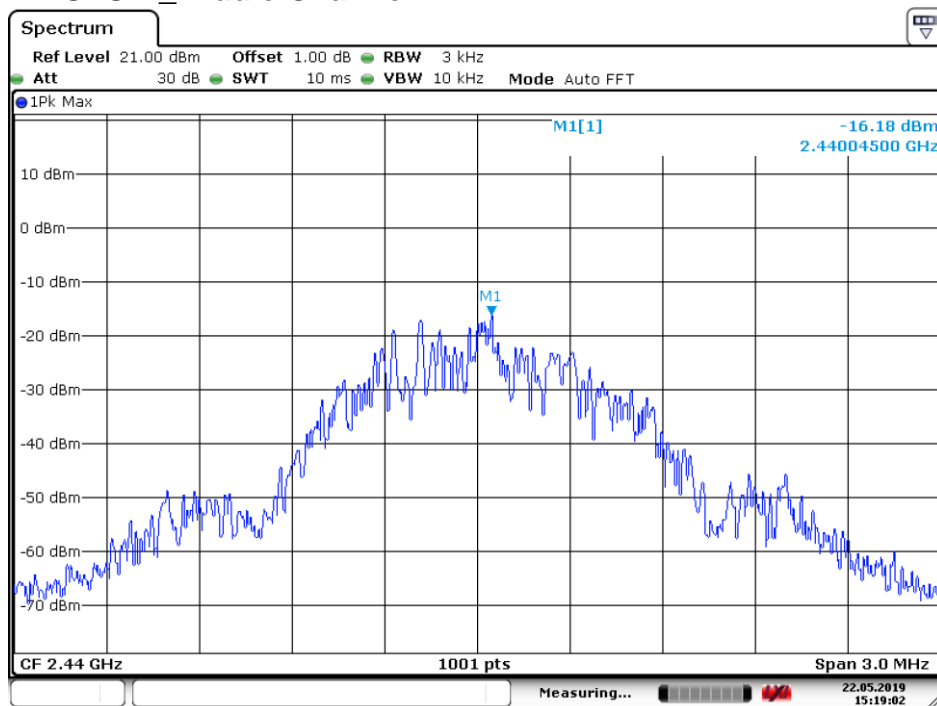
4.5.2 Test plots

4.5.2.1 GFSK_Lowest Channel



Date: 22.MAY.2019 15:18:43

4.5.2.2 GFSK_Middle Channel



Date: 22.MAY.2019 15:19:02



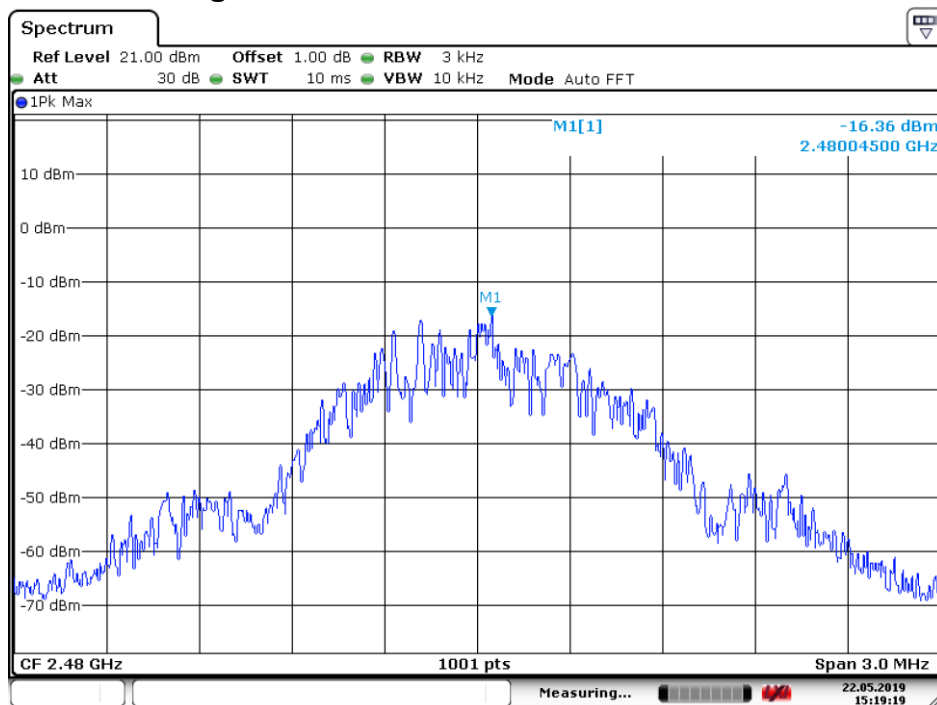
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4.5.2.3

GFSK_Highest Channel



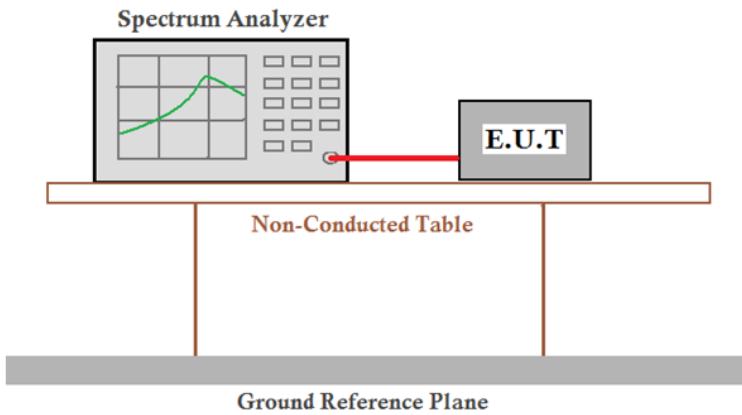
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4.6 Band-edge for RF Conducted Emissions

Test Requirement:	47 CFR Part 15C Section 15.247 (d)
Test Method:	ANSI C63.10: 2013 Section 11.13
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.
Test Mode:	Transmitting with GFSK modulation.
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass

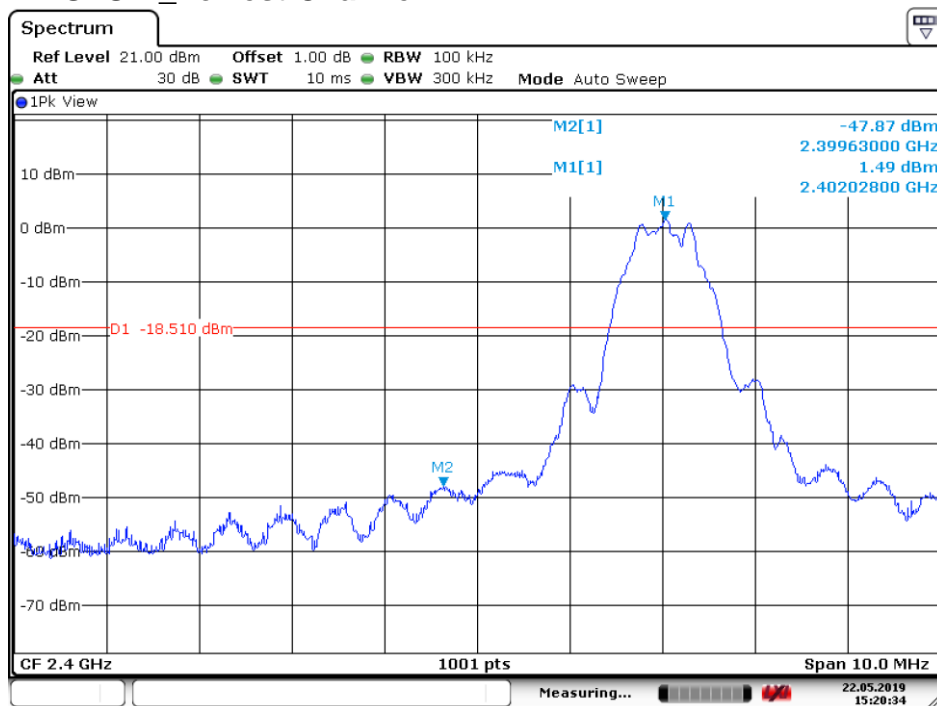


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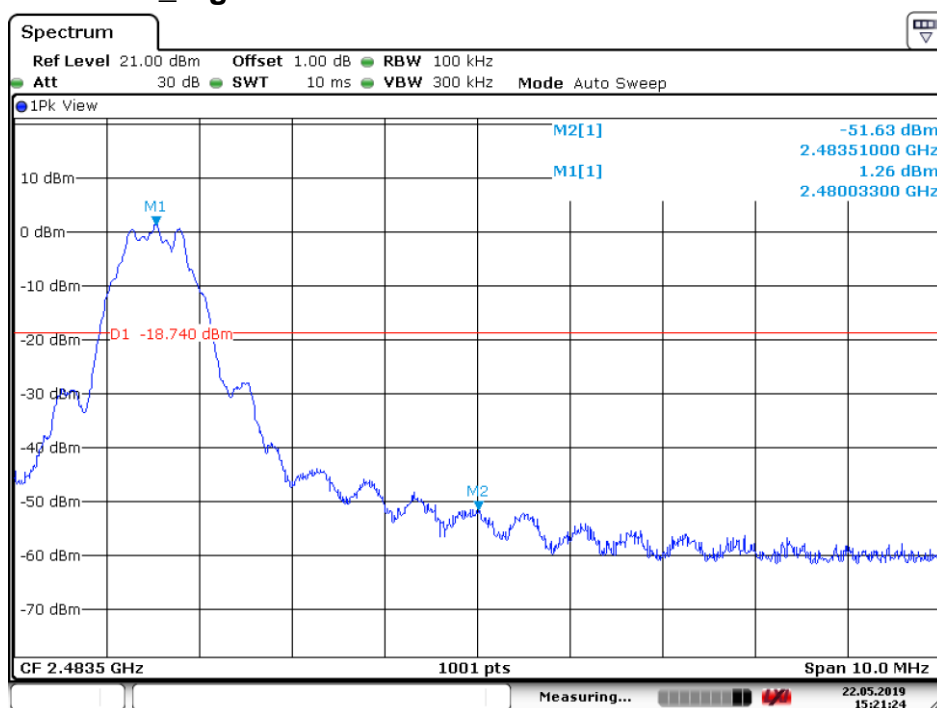
4.6.1 Test plots

4.6.1.1 GFSK_Lowest Channel



Date: 22.MAY.2019 15:20:35

4.6.1.2 GFSK_Highest Channel



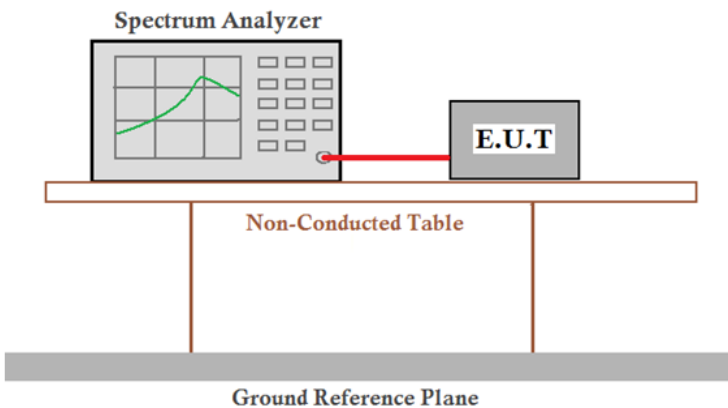
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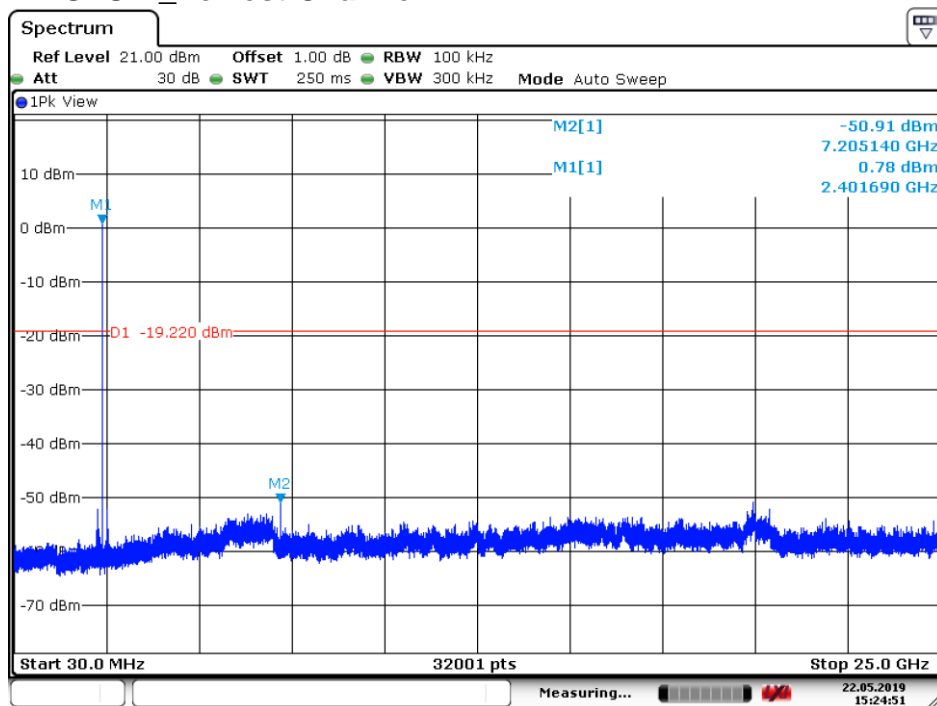
4.7 Spurious RF Conducted Emissions

Test Requirement:	47 CFR Part 15C Section 15.247 (d)
Test Method:	ANSI C63.10: 2013 Section 11.11
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.
Test Mode:	Transmitting with GFSK modulation.
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass



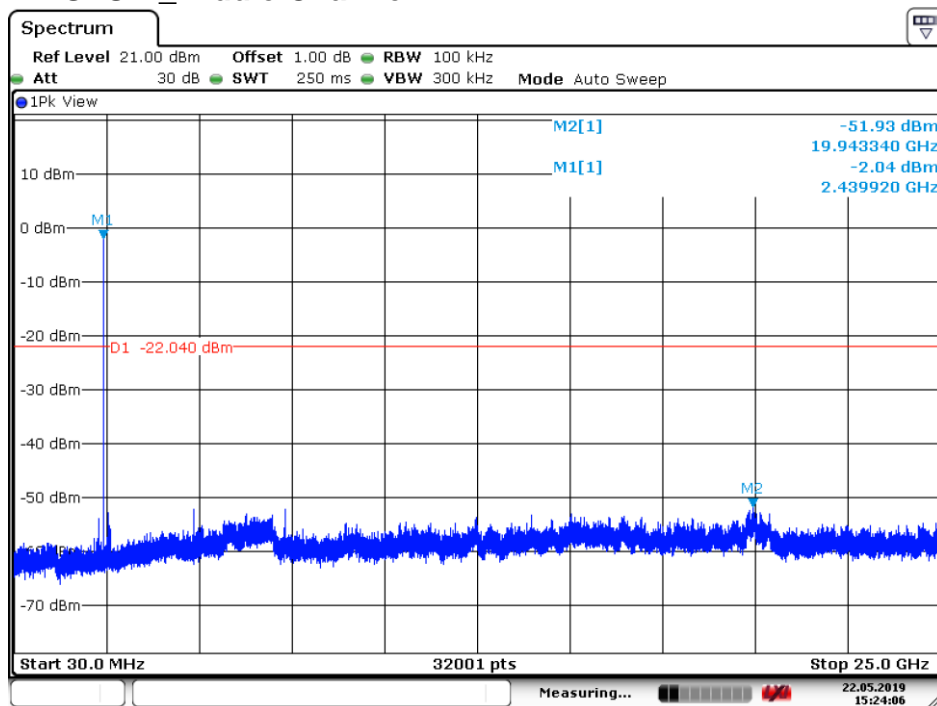
4.7.1 Test plots:

4.7.1.1 GFSK_Lowest Channel



Date: 22.MAY.2019 15:24:51

4.7.1.2 GFSK_Middle Channel



Date: 22.MAY.2019 15:24:07

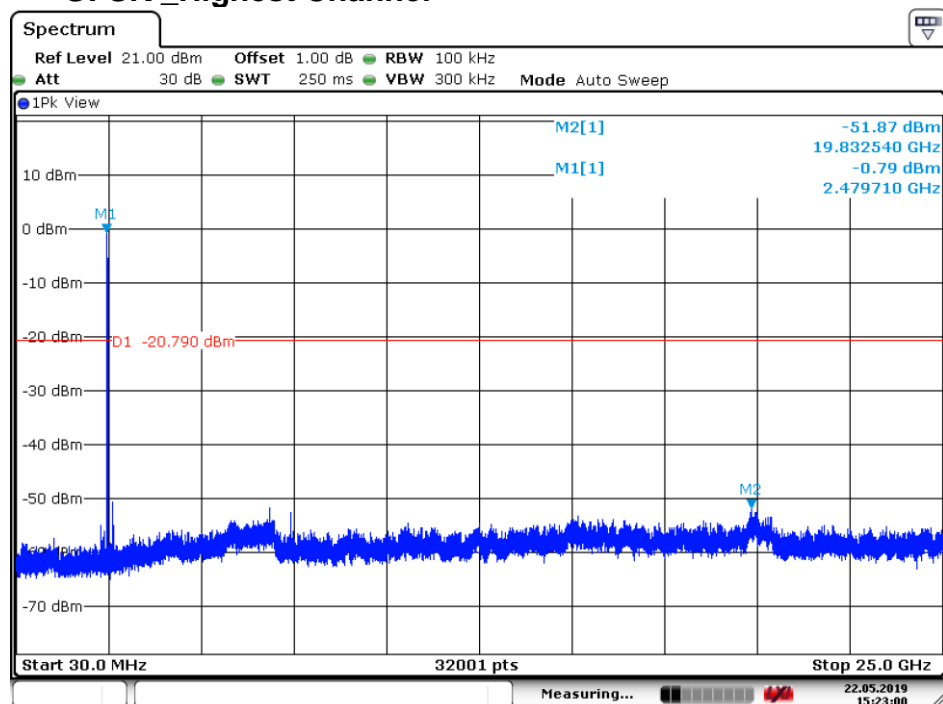


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4.7.1.3

GFSK_Highest Channel



Date: 22.MAY.2019 15:23:01

Remark:

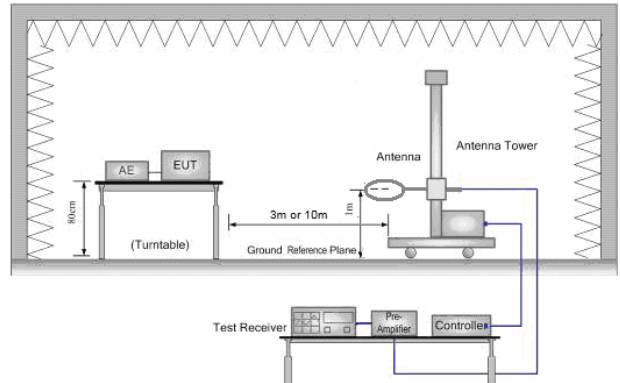
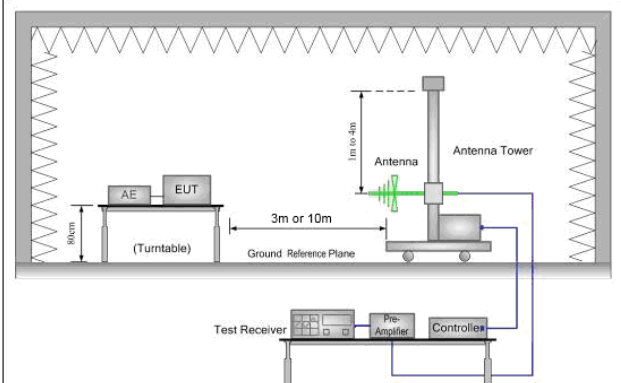
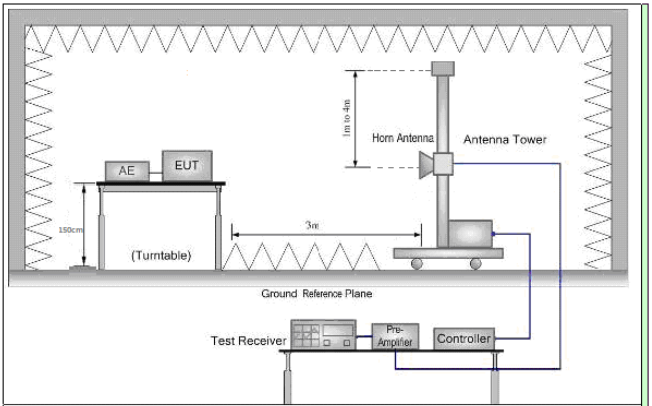
Scan from 9kHz to 25GHz, the disturbance between 9KHz to 30MHz was very low, and the above harmonics were the highest point could be found when testing, The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.



4.8 Radiated Spurious Emission

Test Requirement:	47 CFR Part 15C Section 15.209 and 15.205				
Test Method:	ANSI C63.10 :2013 Section 11.12				
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.				



Test Setup:	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Figure 1. Below 30MHz</p> </div> <div style="text-align: center;">  <p>Figure 2. 30MHz to 1GHz</p> </div> </div>
	<div style="text-align: center;">  <p>Figure 3. Above 1 GHz</p> </div>
Test Procedure:	<ol style="list-style-type: none"> 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. 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. 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. 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. 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. The test-receiver system was set to Peak Detect Function and Specified



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	<p>Bandwidth with Maximum Hold Mode.</p> <p>g. 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>h. Test the EUT in the lowest channel (2402MHz), the middle channel (2440MHz), the highest channel (2480MHz)</p> <p>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.</p> <p>j. Repeat above procedures until all frequencies measured was complete.</p>
Exploratory Test Mode:	<p>Transmitting with GFSK modulation.</p> <p>Charge + Transmitting mode.</p>
Final Test Mode:	<p>Transmitting with GFSK modulation.</p> <p>Pretest the EUT at Charge + Transmitting mode,</p> <p>For below 1GHz part, through pre-scan, the worst case is the lowest channel. Only the worst case is recorded in the report.</p>
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass

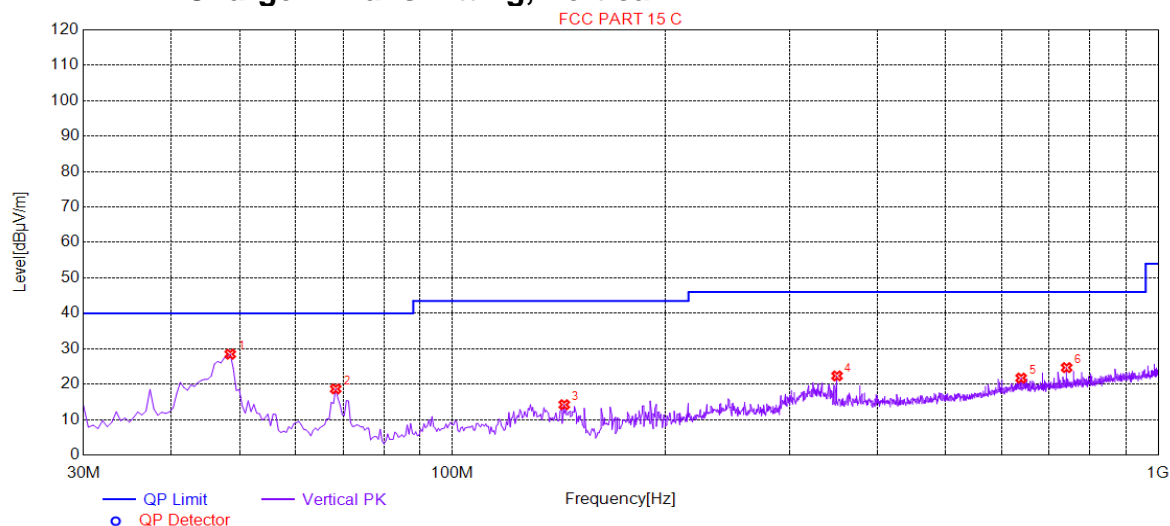


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4.8.1 Radiated Emission below 1GHz

4.8.1.1 Charge + Transmitting, Vertical

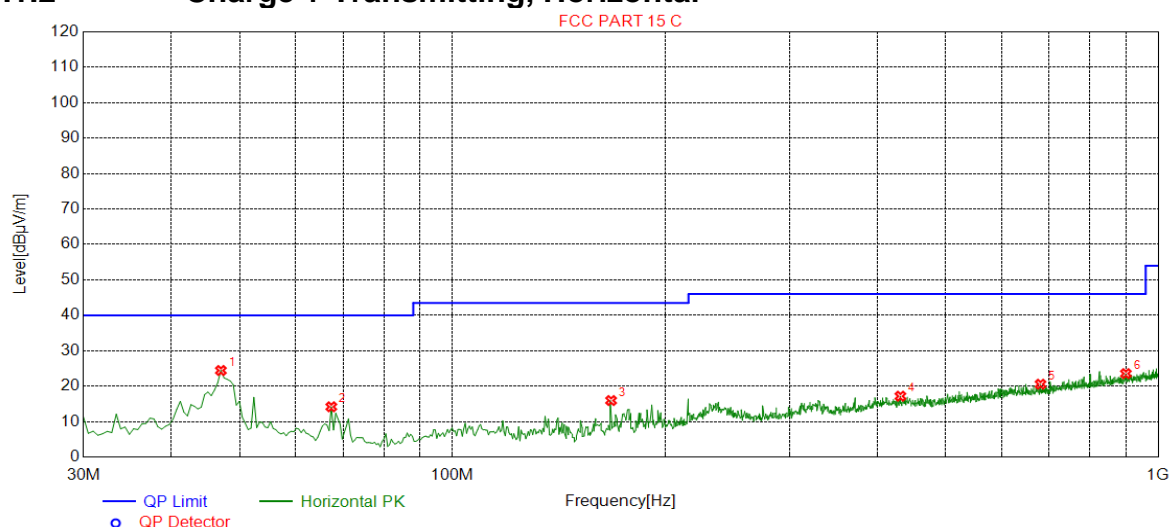


Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	48.4392	28.46	-30.19	40.00	11.54	100	75	Vertical
2	68.3342	18.66	-33.75	40.00	21.34	100	170	Vertical
3	144.0320	14.21	-35.04	43.50	29.29	200	177	Vertical
4	350.7454	22.34	-26.33	46.00	23.66	100	141	Vertical
5	639.4647	21.72	-19.53	46.00	24.28	100	307	Vertical
6	741.8509	24.67	-17.65	46.00	21.33	200	214	Vertical



4.8.1.2 Charge + Transmitting, Horizontal



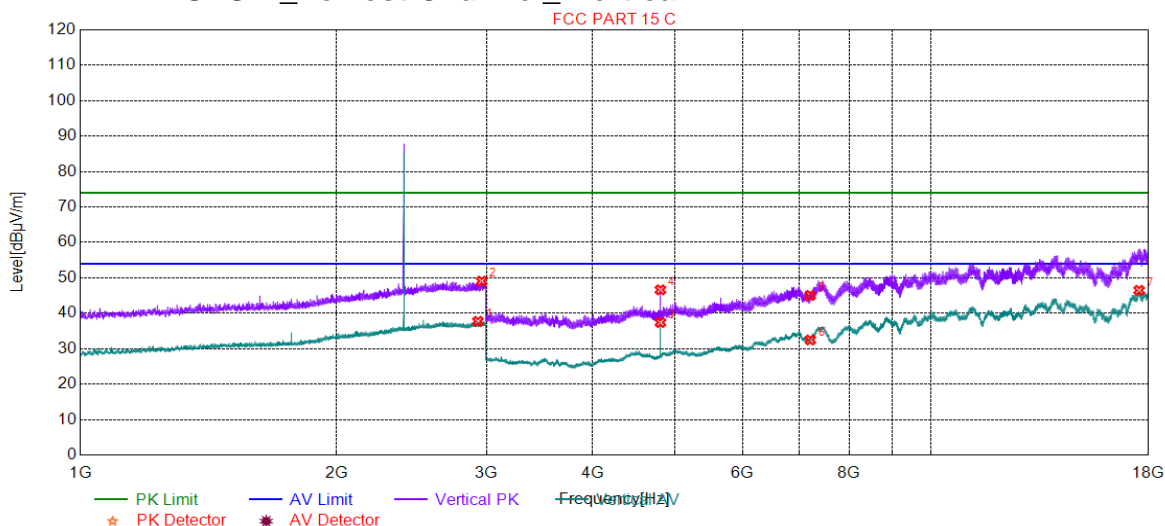
Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	46.9835	24.42	-30.20	40.00	15.58	200	131	Horizontal
2	67.3637	14.18	-33.51	40.00	25.82	100	312	Horizontal
3	167.808	15.95	-33.76	43.50	27.55	100	183	Horizontal
4	431.295	17.17	-24.23	46.00	28.83	100	255	Horizontal
5	681.195	20.56	-19.02	46.00	25.44	200	66	Horizontal
6	900.040	23.54	-15.23	46.00	22.46	100	268	Horizontal



4.8.2 Transmitter Emission above 1GHz

4.8.2.1 GFSK _Lowest Channel_ Vertical



Suspected List

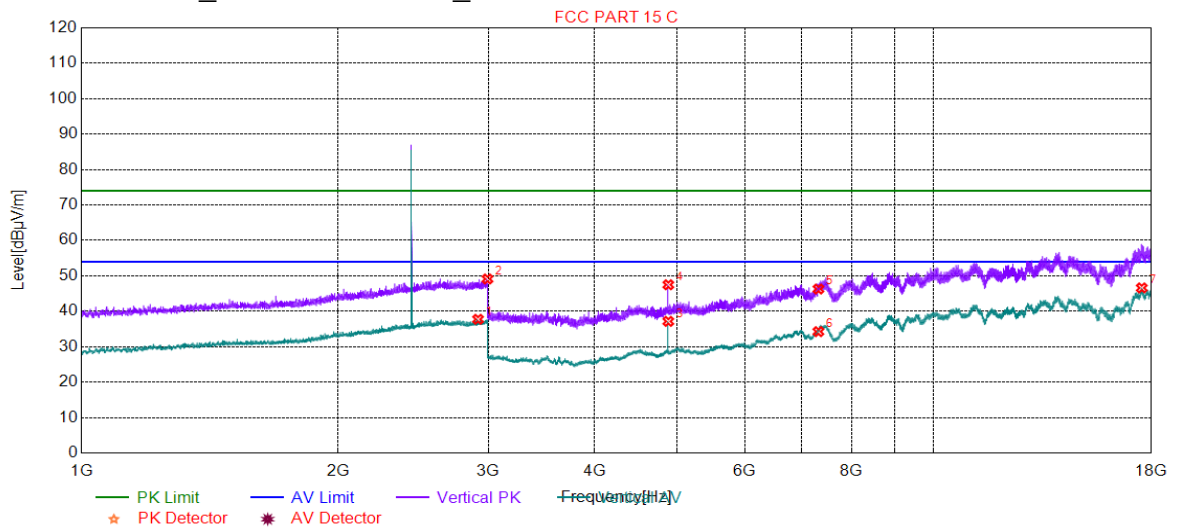
NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2932.48	37.73	2.28	54.00	16.27	150	118	Vertical
2	2961.99	49.08	2.30	74.00	24.92	150	332	Vertical
3	4804.00	37.40	-20.38	54.00	16.60	150	93	Vertical
4	4804.00	46.62	-20.38	74.00	27.38	150	60	Vertical
5	7206.00	45.02	-12.76	74.00	28.98	150	273	Vertical
6	7206.00	32.47	-12.76	54.00	21.53	150	28	Vertical
7	17542.9	46.48	0.90	54.00	7.52	150	133	Vertical



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4.8.2.2 GFSK _Middle Channel_ Vertical



Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2918.47	37.75	2.27	54.00	16.25	150	329	Vertical
2	2993.99	49.12	2.33	74.00	24.88	150	244	Vertical
3	4880.00	37.16	-19.29	54.00	16.84	150	51	Vertical
4	4880.00	47.49	-19.29	74.00	26.51	150	84	Vertical
5	7320.00	46.28	-11.41	74.00	27.72	150	84	Vertical
6	7320.00	34.26	-11.41	54.00	19.74	150	4	Vertical
7	17532.9	46.60	0.77	54.00	7.40	150	305	Vertical



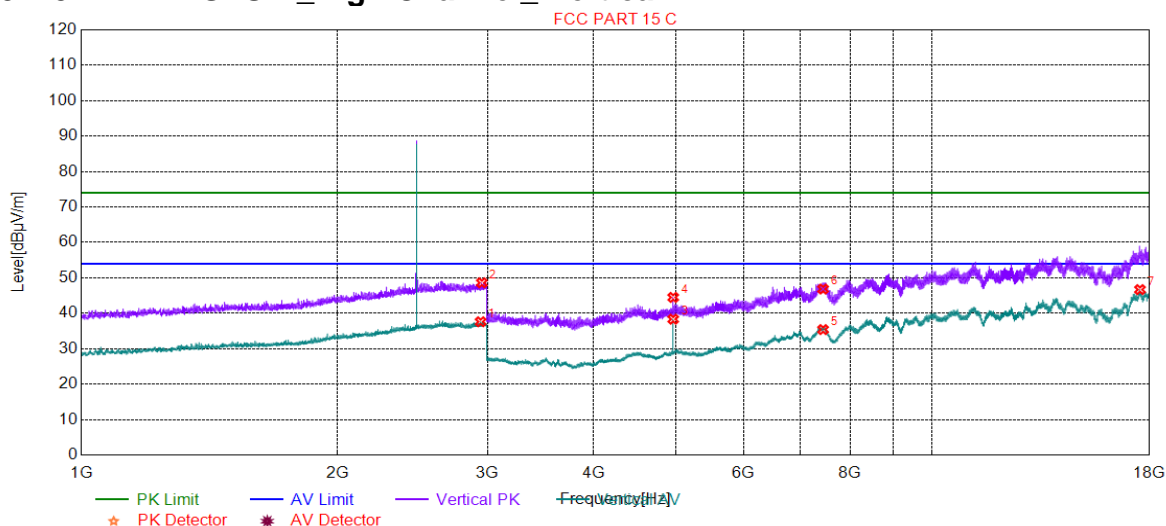
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4.8.2.3 GFSK _High Channel_ Vertical



Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2945.48	37.61	2.29	54.00	16.39	150	198	Vertical
2	2954.98	48.60	2.30	74.00	25.40	150	17	Vertical
3	4960.00	38.33	-18.67	54.00	15.67	150	147	Vertical
4	4960.00	44.49	-18.67	74.00	29.51	150	131	Vertical
5	7440.00	35.40	-10.72	54.00	18.60	150	131	Vertical
6	7440.00	46.85	-10.72	74.00	27.15	150	195	Vertical
7	17537.9	46.69	0.84	54.00	7.31	150	358	Vertical



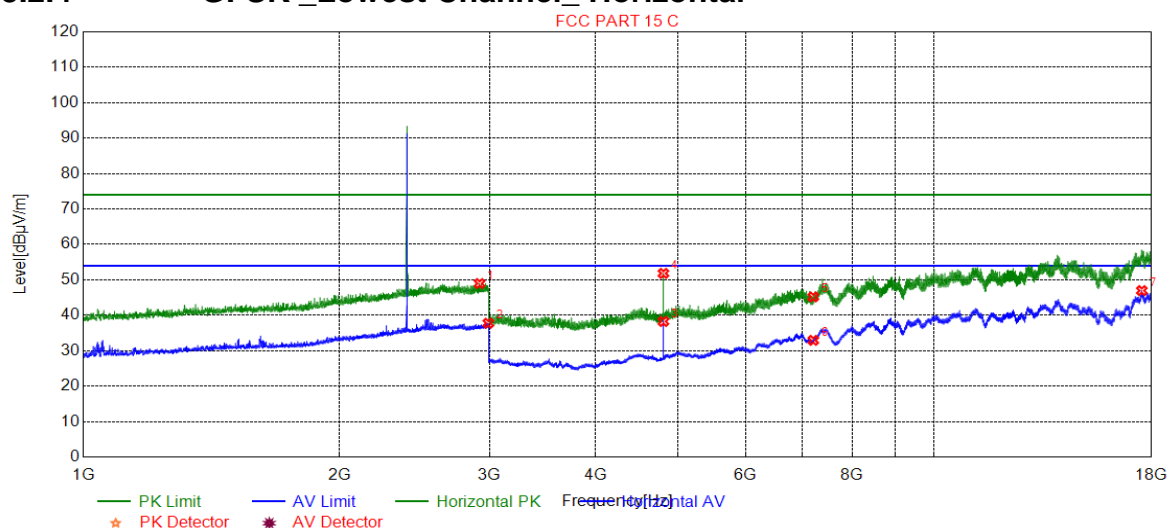
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4.8.2.4 GFSK _Lowest Channel_ Horizontal

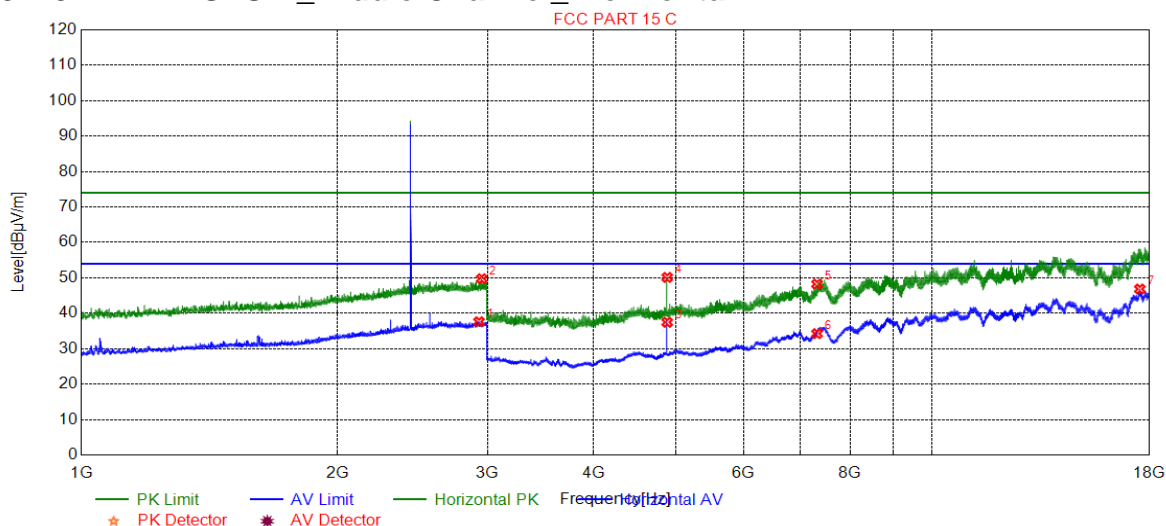


Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2921.48	48.97	2.28	74.00	25.03	150	218	Horizontal
2	2991.49	37.77	2.32	54.00	16.23	150	39	Horizontal
3	4804.00	38.26	-20.38	54.00	15.74	150	342	Horizontal
4	4804.00	51.83	-20.38	74.00	22.17	150	20	Horizontal
5	7206.00	45.19	-12.76	74.00	28.81	150	20	Horizontal
6	7206.00	32.93	-12.76	54.00	21.07	150	132	Horizontal
7	17528.9	46.97	0.72	54.00	7.03	150	76	Horizontal



4.8.2.5 GFSK _Middle Channel_ Horizontal



Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2932.98	37.61	2.28	54.00	16.39	150	311	Horizontal
2	2954.48	49.76	2.30	74.00	24.24	150	65	Horizontal
3	4880.00	37.47	-19.29	54.00	16.53	150	325	Horizontal
4	4880.00	50.13	-19.29	74.00	23.87	150	342	Horizontal
5	7320.00	48.24	-11.41	74.00	25.76	150	0	Horizontal
6	7320.00	34.26	-11.41	54.00	19.74	150	116	Horizontal
7	17529.4	46.85	0.73	54.00	7.15	150	304	Horizontal



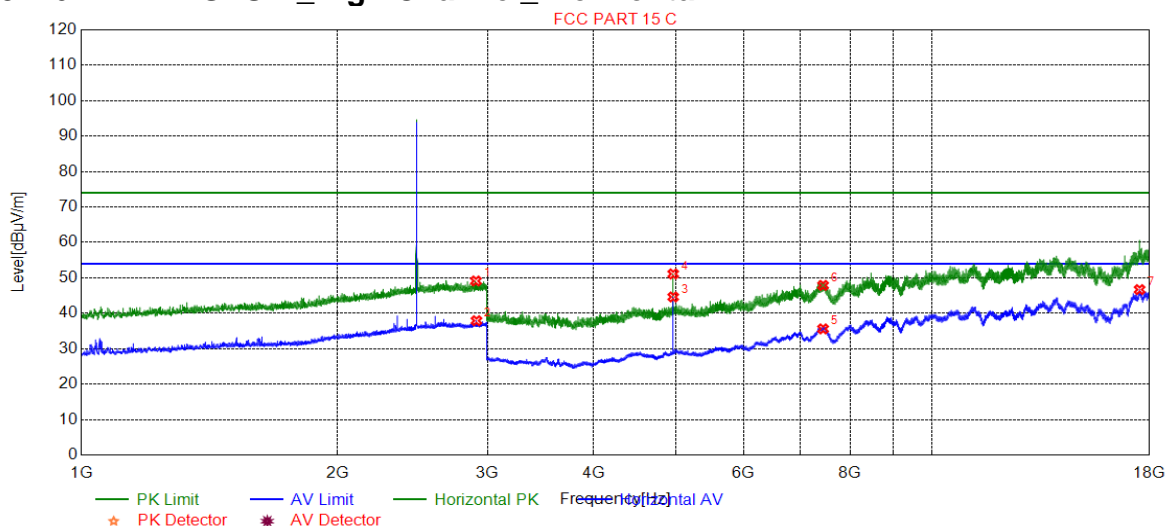
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4.8.2.6 GFSK _High Channel_ Horizontal



Suspected List								
NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2908.47	49.12	2.27	74.00	24.88	150	225	Horizontal
2	2912.47	37.91	2.27	54.00	16.09	150	77	Horizontal
3	4960.00	44.61	-18.67	54.00	9.39	150	4	Horizontal
4	4960.00	51.11	-18.67	74.00	22.89	150	4	Horizontal
5	7440.00	35.60	-10.72	54.00	18.40	150	174	Horizontal
6	7440.00	47.88	-10.72	74.00	26.12	150	52	Horizontal
7	17518.9	46.69	0.59	54.00	7.31	150	132	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:
Final Test Level = Receiver Reading + Antenna Factor + Cable Factor – Preamplifier Factor
- 2) 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.
- 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.

4.9 Restricted bands around fundamental frequency

Test Requirement:	47 CFR Part 15C Section 15.209 and 15.205		
Test Method:	ANSI C63.10: 2013 Section 11.12		
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:			

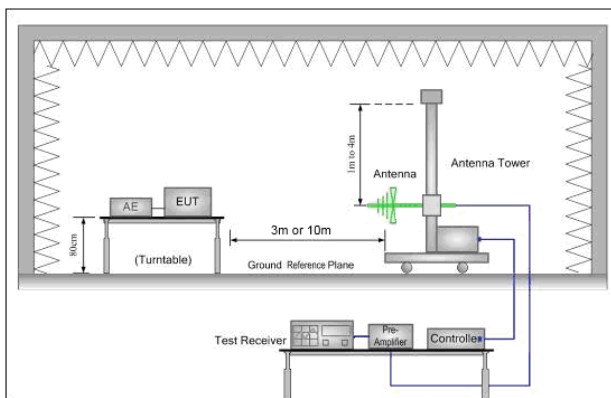


Figure 1. 30MHz to 1GHz

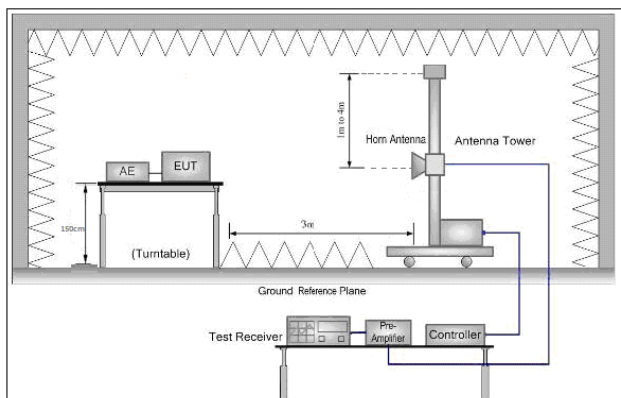


Figure 2. Above 1 GHz

Test Procedure:	<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. 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.</p> <p>f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.</p> <p>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</p> <p>h. Test the EUT in the lowest channel, the Highest channel</p>
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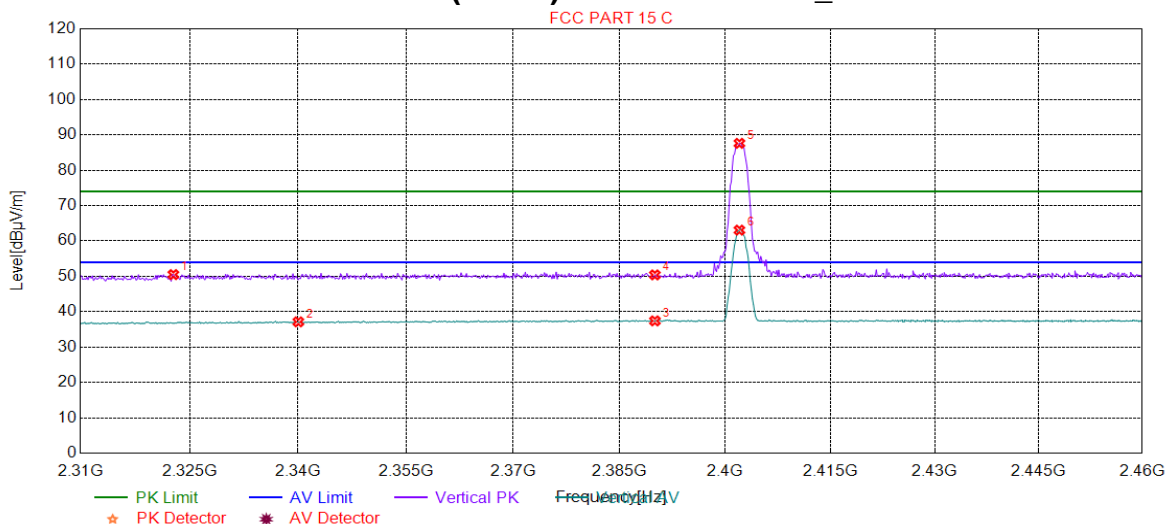
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	i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case. j. Repeat above procedures until all frequencies measured was complete.
Exploratory Test Mode:	Transmitting with GFSK modulation. Charge + Transmitting mode.
Final Test Mode:	Transmitting with GFSK modulation. Pretest the EUT at Charge + Transmitting mode. Only the worst case is recorded in the report.
Instruments Used:	Refer to section 5.10 for details.
Test Results:	Pass

4.9.1 Test plots

4.9.1.1 Worst Case Mode(GFSK) Lowest Channel_ Vertical

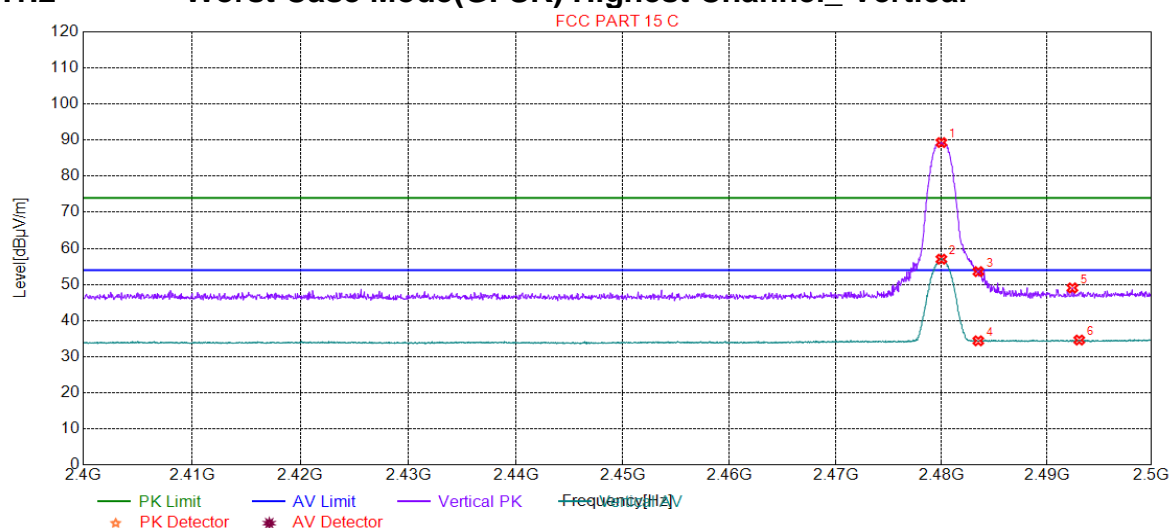


Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2322.7628	50.50	0.95	74.00	23.50	150	194	Vertical
2	2340.0300	37.14	1.03	54.00	16.86	150	341	Vertical
3	2390.0000	37.41	1.25	54.00	16.59	150	325	Vertical
4	2390.0000	50.41	1.25	74.00	23.59	150	282	Vertical
5	2402.0000	87.62	1.30	74.00	-13.62	150	338	Vertical
6	2402.0000	63.07	1.30	54.00	-9.07	150	338	Vertical



4.9.1.2 Worst Case Mode(GFSK) Highest Channel_ Vertical

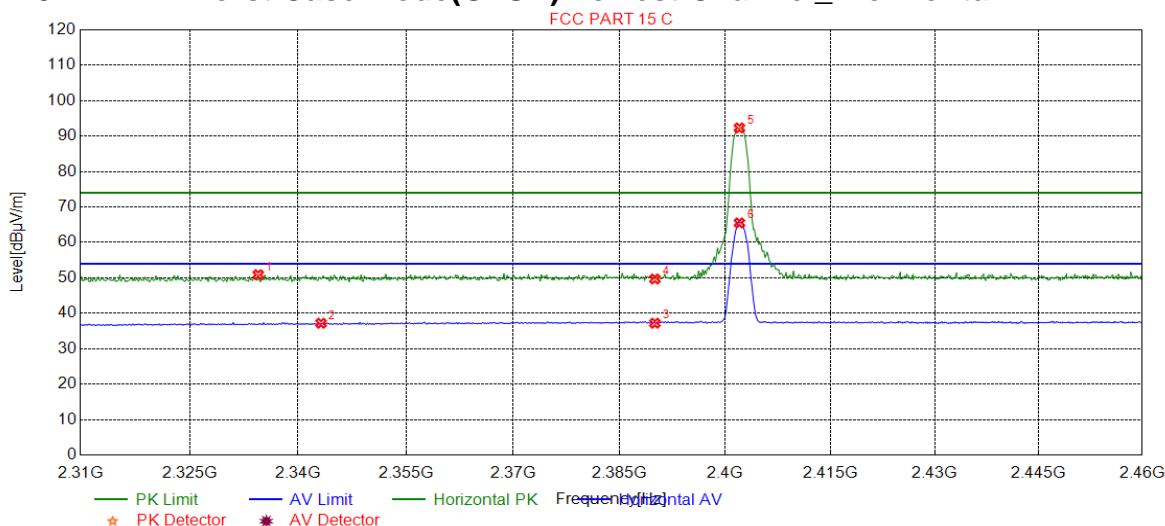


Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2480.0000	89.32	1.51	74.00	-15.32	150	339	Vertical
2	2480.0000	57.01	1.51	54.00	-3.01	150	297	Vertical
3	2483.5000	53.57	1.52	74.00	20.43	150	339	Vertical
4	2483.5000	34.39	1.52	54.00	19.61	150	17	Vertical
5	2492.4462	49.05	1.55	74.00	24.95	150	142	Vertical
6	2493.0965	34.61	1.55	54.00	19.39	150	248	Vertical



4.9.1.3 Worst Case Mode(GFSK) Lowest Channel_ Horizontal



Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2334.4745	50.91	1.00	74.00	23.09	150	87	Horizontal
2	2343.1832	37.20	1.04	54.00	16.80	150	132	Horizontal
3	2390.0000	37.21	1.25	54.00	16.79	150	343	Horizontal
4	2390.0000	49.69	1.25	74.00	24.31	150	177	Horizontal
5	2402.0000	92.32	1.30	74.00	-18.32	150	298	Horizontal
6	2402.0000	65.51	1.30	54.00	-11.51	150	244	Horizontal



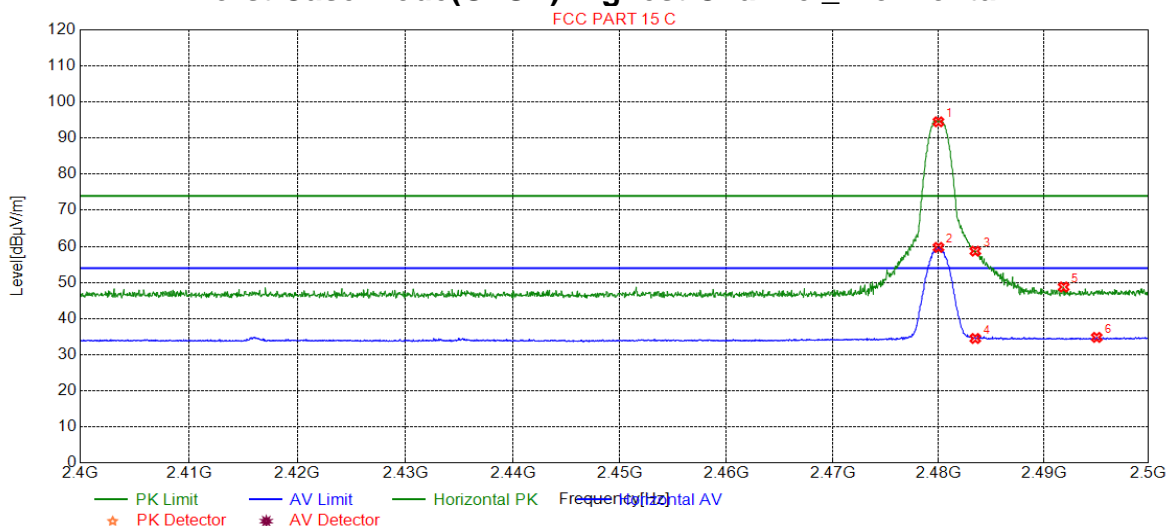
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4.9.1.4 Worst Case Mode(GFSK) Highest Channel_ Horizontal



Suspected List

NO.	Freq. [MHz]	Level [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	2480.0000	94.52	1.51	74.00	-20.52	150	248	Horizontal
2	2480.0000	59.72	1.51	54.00	-5.72	150	339	Horizontal
3	2483.5000	58.68	1.52	74.00	15.32	150	301	Horizontal
4	2483.5000	34.49	1.52	54.00	19.51	150	282	Horizontal
5	2491.8959	48.75	1.55	74.00	25.25	150	327	Horizontal
6	2495.0475	34.79	1.56	54.00	19.21	150	252	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	$\pm 0.75\text{dB}$
2	RF power density, conducted	$\pm 2.84\text{dB}$
3	Spurious emissions, conducted	$\pm 0.75\text{dB}$
4	Radiated Spurious emission test	$\pm 4.5\text{dB}$ (30MHz-1GHz)
		$\pm 4.8\text{dB}$ (1GHz-25GHz)
5	Conduct emission test	$\pm 3.12\text{ dB}$ (9KHz- 30MHz)
6	Temperature test	$\pm 1^{\circ}\text{C}$
7	Humidity test	$\pm 3\%$
8	DC and low frequency voltages	$\pm 0.5\%$



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6 Equipment List

Conducted Emission					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date (yyyy-mm-dd)	Cal. Due date (yyyy-mm-dd)
Shielding Room	ZhongYu Electron	GB-88	SEM001-06	2017/5/10	2020/5/9
LISN	Rohde & Schwarz	ENV216	SEM007-01	2018/9/2	2019/9/2
LISN	ETS-LINDGREN	Feb-16	SEM007-02	2018/4/2	2019/4/1
				2019/4/1	2020/3/31
Measurement Software	AUDIX	e3 V5.4.1221d	N/A	N/A	N/A
Coaxial Cable	SGS	N/A	SEM024-01	2018/7/12	2019/7/11
2 Line ISN	Fischer Custom Communications Inc.	FCC-TLISN-T2-02	EMC0122	2019/2/11	2020/2/10
EMI Test Receiver	Rohde & Schwarz	ESCI	SEM004-02	2019/3/2	2020/3/1
RF conducted test					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date (yyyy-mm-dd)	Cal. Due date (yyyy-mm-dd)
DC Power Supply	Agilent Technologies Inc	66311B	W009-09	2018/9/15	2019/9/15
Signal Analyzer	Rohde & Schwarz	FSV	W025-05	2019/1/13	2020/1/12
Coaxial Cable	SGS	N/A	SEM031-01	2018/7/13	2019/7/12
Attenuator	Weinschel Associates	WA41	SEM021-09	N/A	N/A
Signal Generator	KEYSIGHT	N5173B	SEM006-05	2018/9/2	2019/9/2
Temperature Chamber	GIANT FORCE	ICT-150-40-CP-AR	W027-03	2018/11/27	2019/11/27



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RE in Chamber					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date (yyyy-mm-dd)	Cal. Due date (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	2018/7/12	2019/7/11
MXE EMI Receiver (20Hz-8.4GHz)	Agilent Technologies	N9038A	SEM004-05	2018/9/2	2019/9/2
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	2019/3/2	2020/3/1

RE in Chamber					
Test Equipment	Manufacturer	Model No.	Inventory No.	Cal. date (yyyy-mm-dd)	Cal. Due date (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	2018/7/12	2019/7/11
EXA Signal Analyzer (10Hz-26.5GHz)	Agilent Technologies Inc	N9010A	SEM004-09	2019/3/12	2020/3/11
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	2018/9/2	2019/9/2
Low Noise Amplifier(100MHz-18GHz)	Black Diamond Series	BDLNA-0118-352810	SEM005-05	2018/9/27	2019/9/27
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	2019/3/2	2020/3/1

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	2019/3/2	2020/3/1
Trilog-Broadband Antenna(25M-2GHz)	Schwarzbeck	VULB9168	SEM003-18	2016/6/29	2019/6/28
Pre-amplifier (9k-1GHz)	Sonoma	310N	SEM005-03	2019/3/12	2020/3/11
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

7 Photographs - EUT Constructional Details

Refer to Appendix A - Photographs of EUT Constructional Details for ZR/2019/50004.

The End



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