7.8 Pseudorandom Frequency Hopping Sequence

Test Requirement:	FCC Part15 C Section 15.247 (a)(1) requirement:

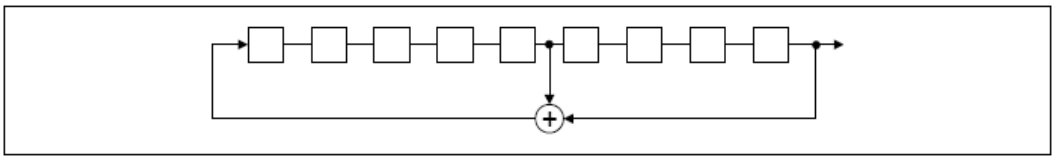
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Alternatively. Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a Pseudorandom ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

EUT Pseudorandom Frequency Hopping Sequence

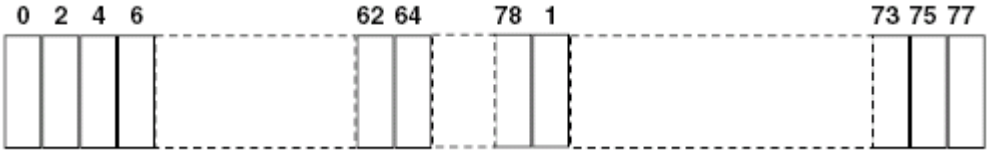
The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones.

- *Number of shift register stages: 9*
- *Length of pseudo-random sequence: 2^9 -1 = 511 bits*
- *Longest sequence of zeros: 8 (non-inverted signal)*



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of Pseudorandom Frequency Hopping Sequence as follow:

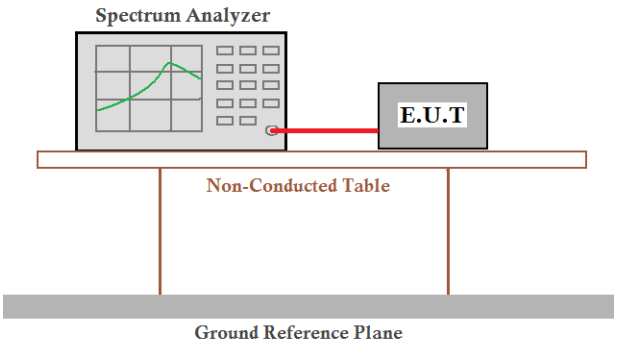


Each frequency used equally on the average by each transmitter.

The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

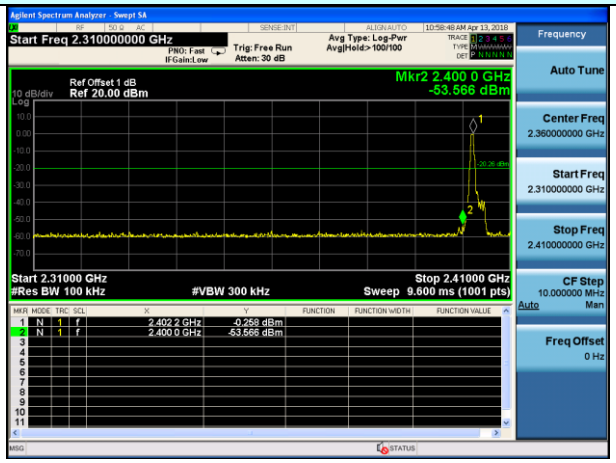
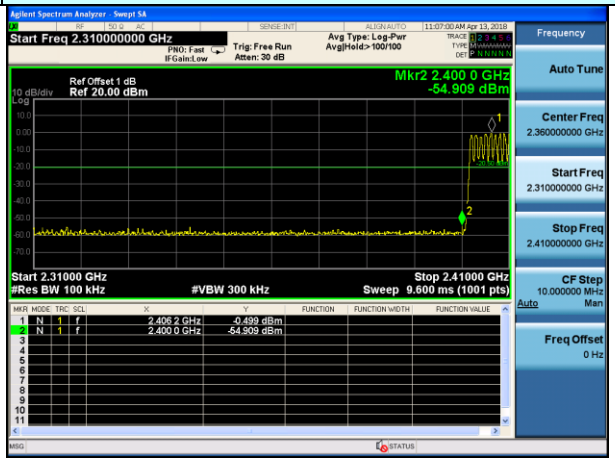
7.9 Band Edge

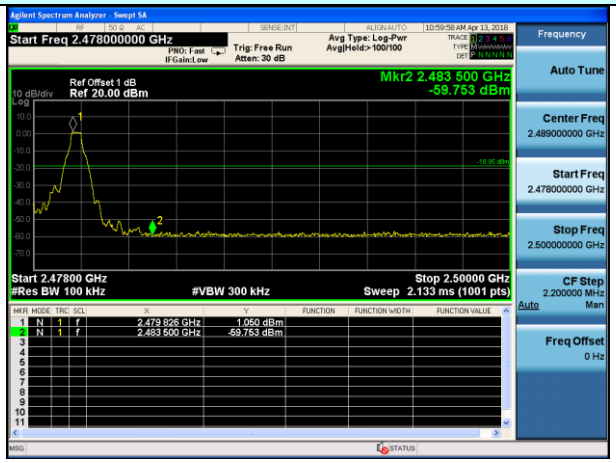
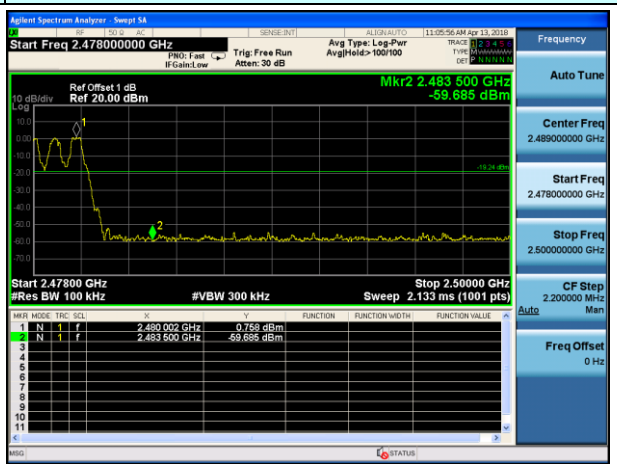
7.9.1 Conducted Emission Method

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2013
Receiver setup:	RBW=100kHz, VBW=300kHz, Detector=Peak
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 setup:	
Test Instruments:	Refer to section 6.0 for details
Test mode:	Refer to section 5.2 for details
Test results:	Pass

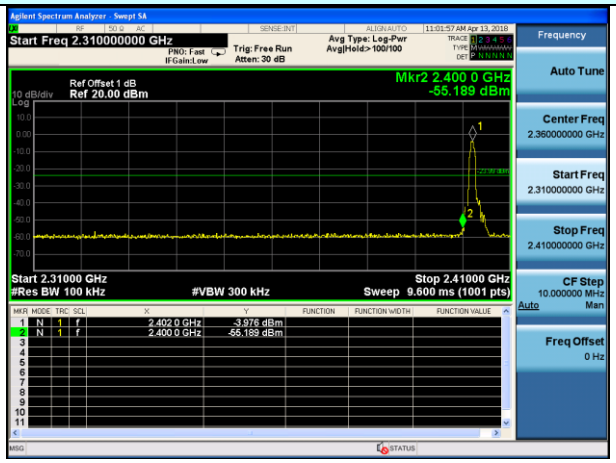
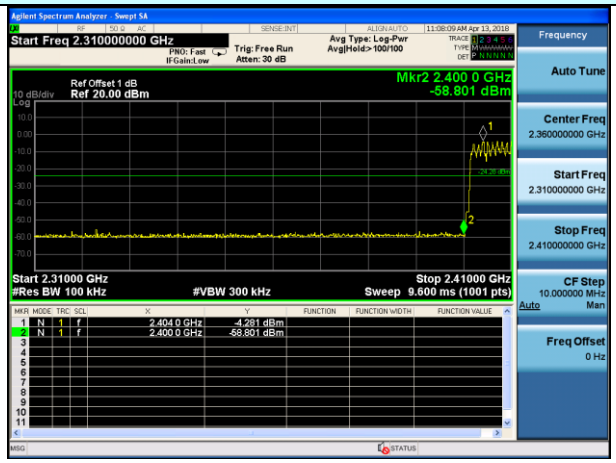
Test plot as follows:

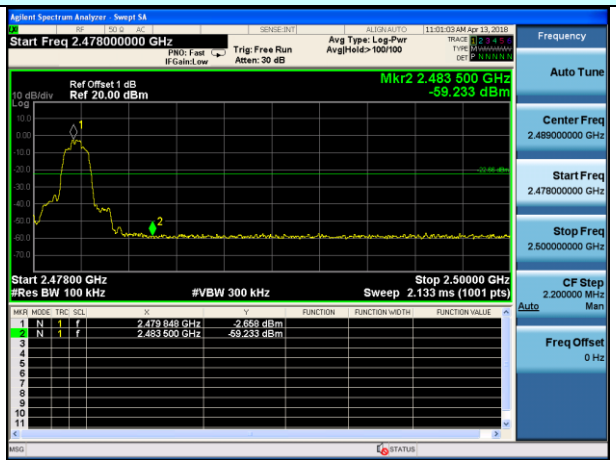
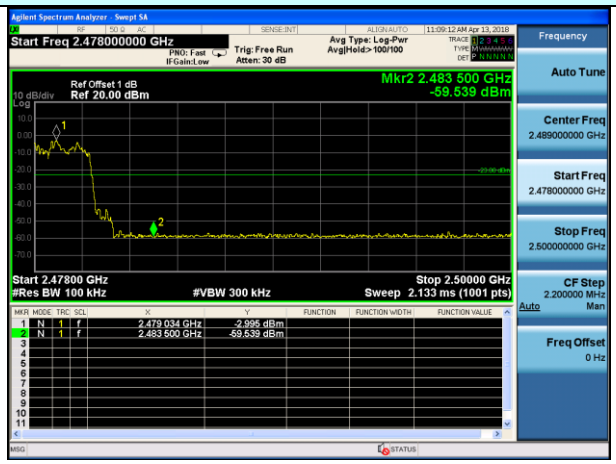
GFSK Mode:

Test channel:	Lowest channel
	
No-hopping mode	Hopping mode

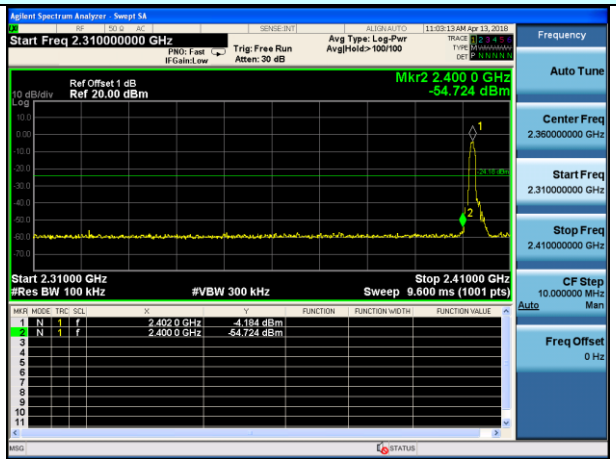
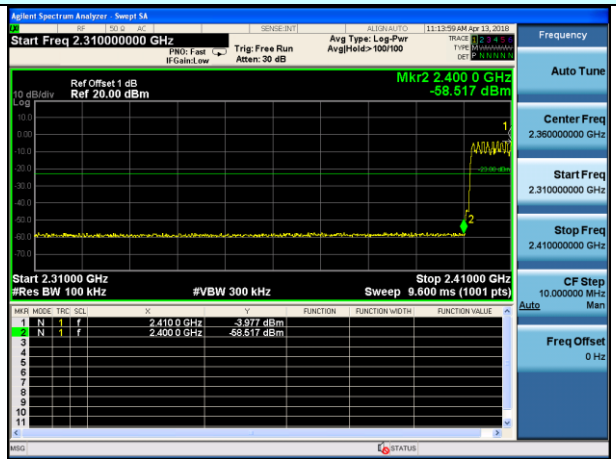
Test channel:	Highest channel
	
No-hopping mode	Hopping mode

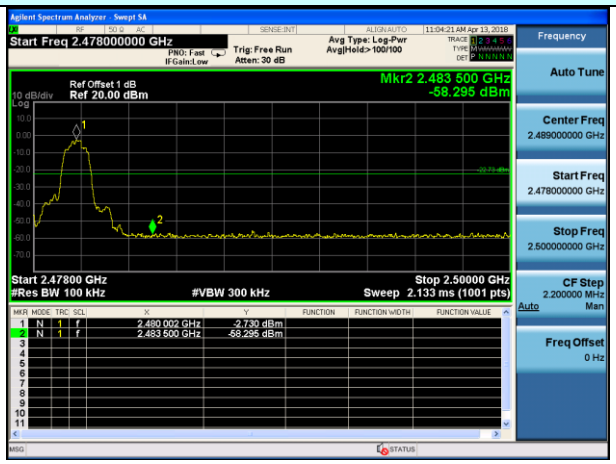
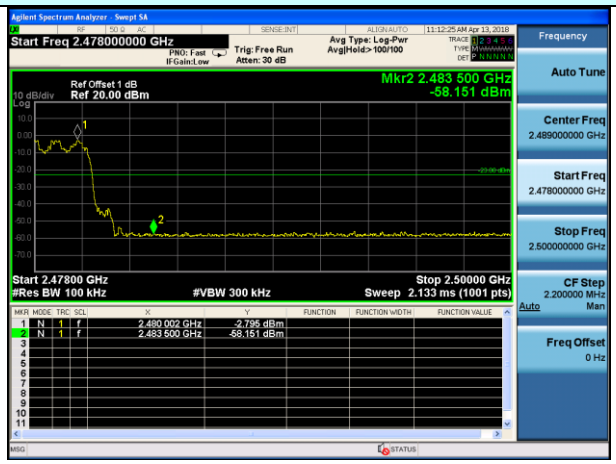
Pi/4QPSK Mode:

Test channel:	Lowest channel
	
No-hopping mode	Hopping mode

Test channel:	Highest channel
	
No-hopping mode	Hopping mode

8DPSK Mode:

Test channel:	Lowest channel
	
No-hopping mode	Hopping mode

Test channel:	Highest channel
	
No-hopping mode	Hopping mode

7.9.2 Radiated Emission Method

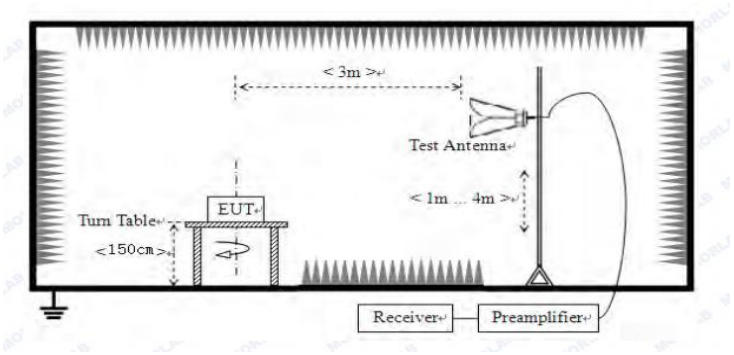
Test Requirement:	FCC Part15 C Section 15.209 and 15.205
Test Method:	ANSI C63.10:2013
Test Frequency Range:	All restriction band have been tested, and 2.3GHz to 2.5GHz band is the worse case
Test site:	Measurement Distance: 3m
Receiver setup:	

Frequency	Detector	RBW	VBW	Remark
Above 1GHz	Peak	1MHz	3MHz	Peak Value
	Peak	1MHz	10Hz	Average Value

Limit:

Frequency	Limit (dBuV/m @3m)	Remark
Above 1GHz	54.00	Average Value
	74.00	Peak Value

Test setup:



Test Procedure:

1. The EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter camber. The table was rotated 360 degrees to determine the position of the highest radiation.
2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
3. 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.
4. 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 rota table was turned from 0 degrees to 360 degrees to find the maximum reading.
5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
6. 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.

Test Instruments:	Refer to section 6.0 for details
Test mode:	Refer to section 5.2 for details 120VAC 60Hz

Test results:	Pass

Remark:

1. *During the test, pre-scan the GFSK, Pi/4QPSK,8DPSK modulation, and found the GFSK modulation which it is worse case.*

Test channel:	Lowest

Peak value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
2390	46.70	27.59	5.38	30.18	49.49	74	-24.51	Horizontal
2400	51.48	27.58	5.39	30.18	54.27	74	-19.73	Horizontal
2390	47.30	27.59	5.38	30.18	50.09	74	-23.91	Vertical
2400	50.50	27.58	5.39	30.18	53.29	74	-20.71	Vertical

Average value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
2390	36.31	27.59	5.38	30.18	39.10	54	-14.90	Horizontal
2400	37.89	27.58	5.39	30.18	40.68	54	-13.32	Horizontal
2390	36.23	27.59	5.38	30.18	39.02	54	-14.98	Vertical
2400	38.64	27.58	5.39	30.18	41.43	54	-12.57	Vertical

Test channel:	Highest

Peak value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
2483.5	48.48	27.53	5.47	29.93	51.55	74	-22.45	Horizontal
2500	47.41	27.55	5.49	29.93	50.52	74	-23.48	Horizontal
2483.5	50.10	27.53	5.47	29.93	53.17	74	-20.83	Vertical
2500	48.68	27.55	5.49	29.93	51.79	74	-22.21	Vertical

Average value:

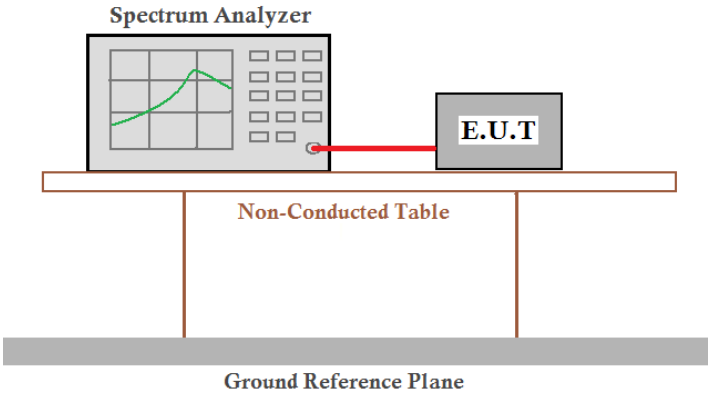
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
2483.5	38.48	27.53	5.47	29.93	41.55	54	-12.45	Horizontal
2500	36.72	27.55	5.49	29.93	39.83	54	-14.17	Horizontal
2483.5	40.59	27.53	5.47	29.93	43.66	54	-10.34	Vertical
2500	36.67	27.55	5.49	29.93	39.78	54	-14.22	Vertical

Remark:

1. *Final Level =Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor*
2. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

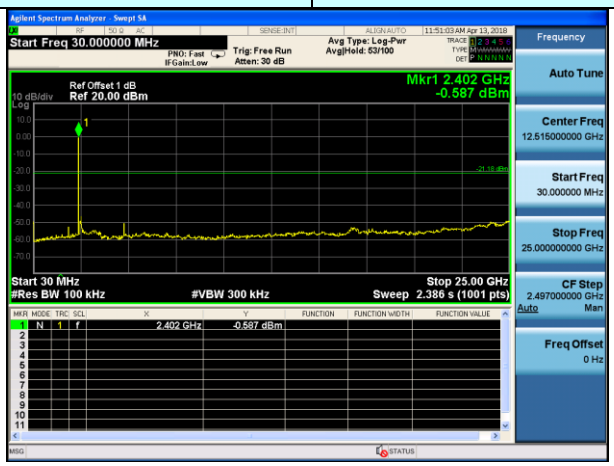
7.10 Spurious Emission

7.10.1 Conducted Emission Method

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2013 and KDB558074 D01 Meas Guidance V04
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 setup:	
Test Instruments:	Refer to section 6.0 for details
Test mode:	Refer to section 5.2 for details
Test results:	Pass

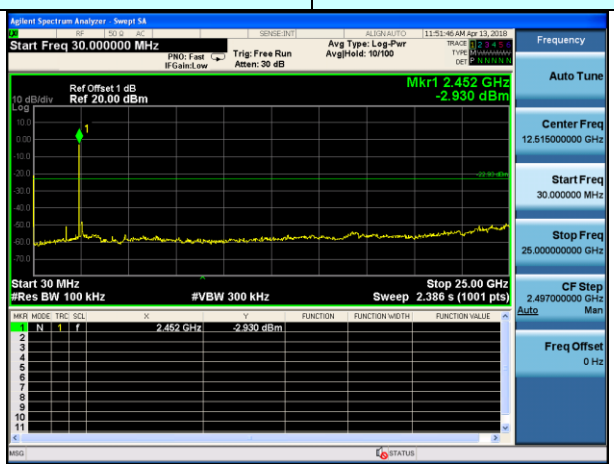
Remark:
During the test, pre-scan the GFSK, Pi/4QPSK, 8DPSK modulation, and found the GFSK modulation which it is worse case.

Test channel:	Lowest channel



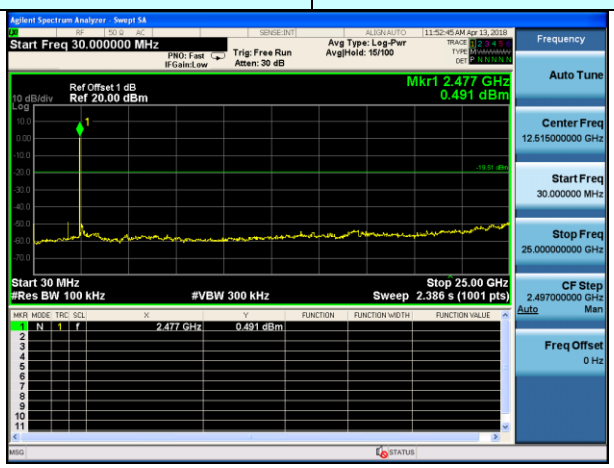
30MHz~25GHz

Test channel:	Middle channel



30MHz~25GHz

Test channel:	Highest channel



30MHz~25GHz

7.10.2 Radiated Emission Method

Test Requirement:	FCC Part15 C Section 15.209
Test Method:	ANSI C63.10:2013
Test Frequency Range:	30MHz to 25GHz
Test site:	Measurement Distance: 3m
Receiver setup:	

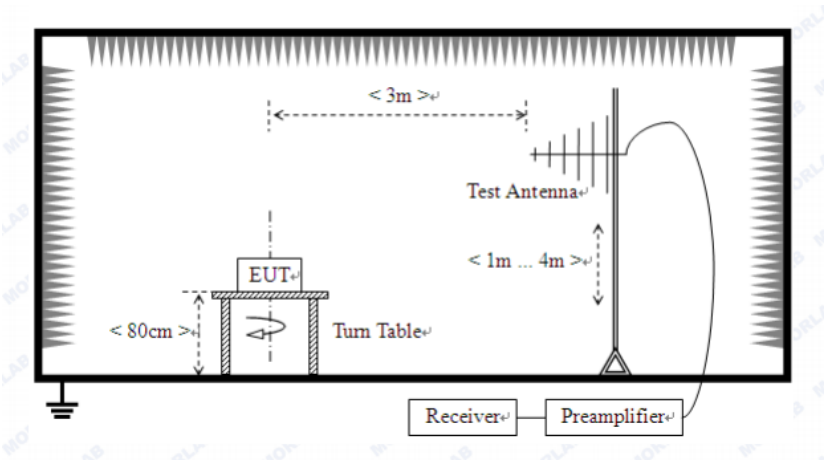
Frequency	Detector	RBW	VBW	Remark
30MHz-1GHz	Quasi-peak	120KHz	300KHz	Quasi-peak Value
Above 1GHz	Peak	1MHz	3MHz	Peak Value
	Peak	1MHz	10Hz	Average Value

Limit:

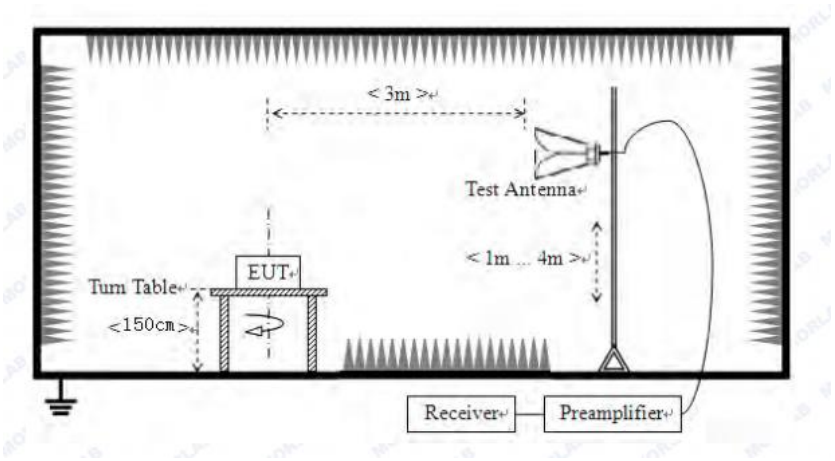
Frequency	Limit (dBuV/m @3m)	Remark
30MHz-88MHz	40.0	Quasi-peak Value
88MHz-216MHz	43.5	Quasi-peak Value
216MHz-960MHz	46.0	Quasi-peak Value
960MHz-1GHz	54.0	Quasi-peak Value
Above 1GHz	54.0	Average Value
	74.0	Peak Value

Test setup:

Below 1GHz



Above 1GHz

	
Test Procedure:	1. The EUT was placed on the top of a rotating table (0.8 meters below 1G and 1.5 meters above 1G) above the ground at a 3 meter camber. The table was rotated 360 degrees to determine the position of the highest radiation. 2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower. 3. 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. 4. 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 rota table was turned from 0 degrees to 360 degrees to find the maximum reading. 5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode. 6. 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.
Test Instruments:	Refer to section 6.0 for details
Test mode:	Refer to section 5.2 for details 120VAC 60Hz
Test results:	Pass

Remark:

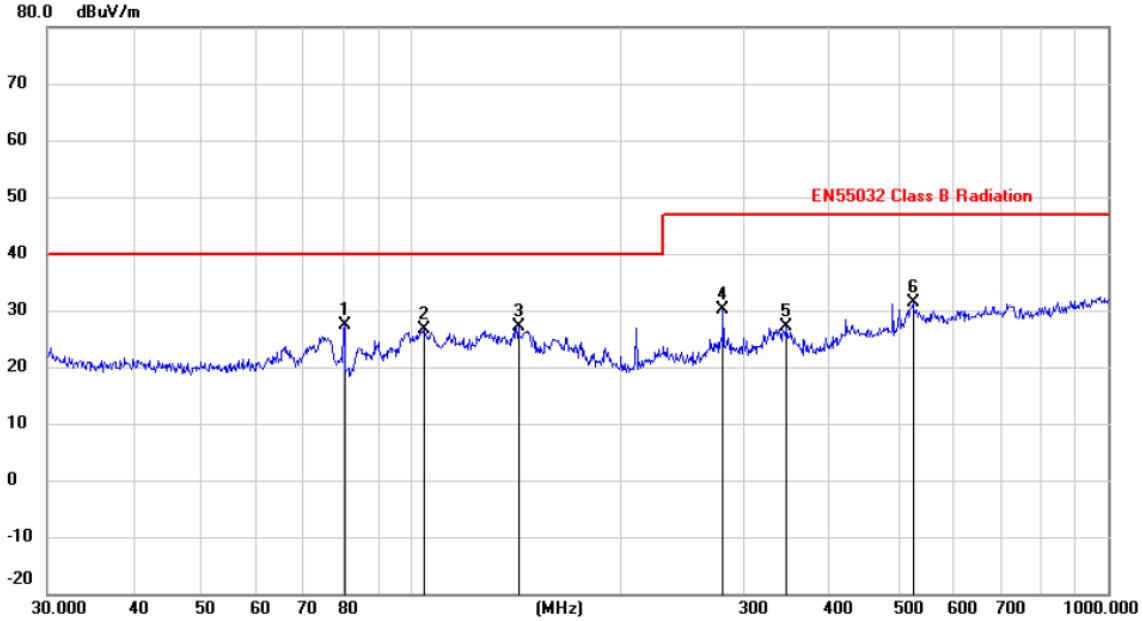
1. *During the test, pre-scan the GFSK, Pi/4QPSK modulation, and found the GFSK modulation which it is worse case.*
2. *Pre-scan all kind of the place mode (X-axis, Y-axis, Z-axis), and found the Y-axis which it is worse case.*

Measurement data:

Vertical:

Radiated Emission Measurement

File :201804012 Data :#1 Date: 2018/4/12 Time: 14:29:56



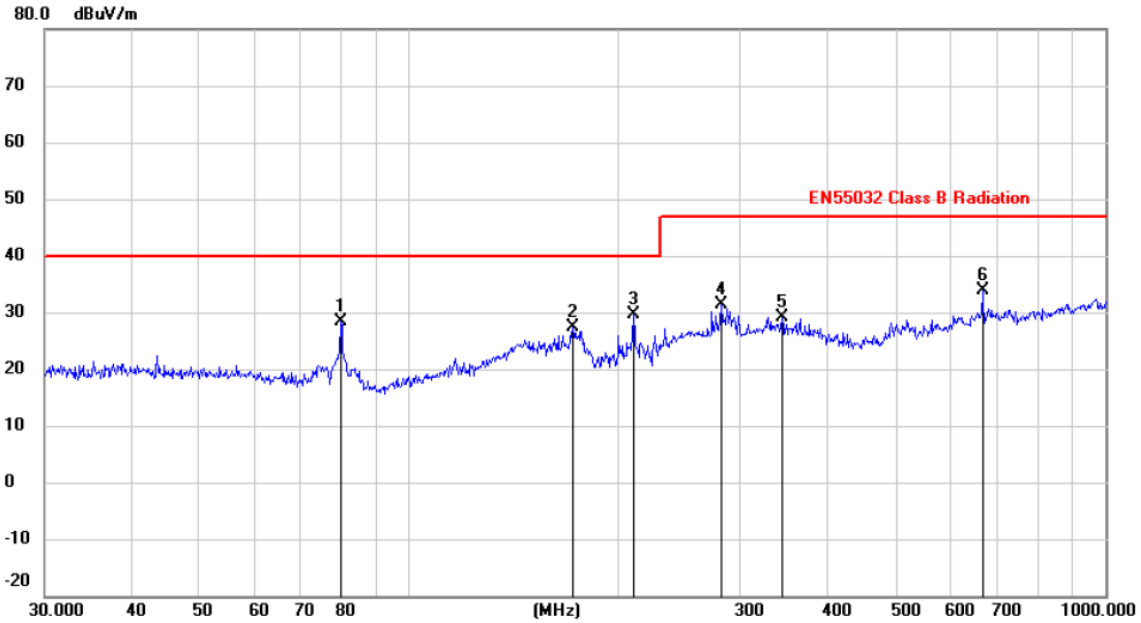
No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	80.3619	18.02	9.45	27.47	40.00	-12.53	peak			
2		104.1701	15.65	10.99	26.64	40.00	-13.36	peak			
3		142.3243	13.02	14.00	27.02	40.00	-12.98	peak			
4		280.0237	17.13	12.97	30.10	47.00	-16.90	peak			
5		345.5952	12.76	14.41	27.17	47.00	-19.83	peak			
6		524.5541	13.35	18.02	31.37	47.00	-15.63	peak			

Note:1. *:Maximum data; x:Over limit; !:over margin.
2.Measurement=Reading Level+Correct Factor; Correct Factor=Antenna Factor+Cable Loss.

Horizontal:

Radiated Emission Measurement

File :201804012 Data :#2 Date: 2018/4/12 Time: 14:31:28



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		80.0806	18.91	9.43	28.34	40.00	-11.66	peak			
2		171.9946	13.84	13.45	27.29	40.00	-12.71	peak			
3	*	210.0482	18.96	10.69	29.65	40.00	-10.35	peak			
4		281.9946	18.28	13.00	31.28	47.00	-15.72	peak			
5		343.1800	14.77	14.43	29.20	47.00	-17.80	peak			
6		668.1423	13.35	20.42	33.77	47.00	-13.23	peak			

Note:1. *:Maximum data; x:Over limit; !:over margin.
2.Measurement=Reading Level+Correct Factor; Correct Factor=Antenna Factor+Cable Loss.

■ **Above 1GHz**

Test channel:	Lowest

Peak value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
4804.00	38.11	31.78	8.6	32.09	46.40	74.00	-27.60	Vertical
7206.00	32.50	36.15	11.65	32	48.30	74.00	-25.70	Vertical
9608.00	32.57	37.95	14.14	31.62	53.04	74.00	-20.96	Vertical
12010.00	*					74.00		Vertical
14412.00	*					74.00		Vertical
4804.00	43.25	31.78	8.6	32.09	51.54	74.00	-22.46	Horizontal
7206.00	34.70	36.15	11.65	32	50.50	74.00	-23.50	Horizontal
9608.00	31.43	37.95	14.14	31.62	51.90	74.00	-22.10	Horizontal
12010.00	*					74.00		Horizontal
14412.00	*					74.00		Horizontal

Average value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
4804.00	27.35	31.78	8.6	32.09	35.64	54.00	-18.36	Vertical
7206.00	20.88	36.15	11.65	32	36.68	54.00	-17.32	Vertical
9608.00	20.49	37.95	14.14	31.62	40.96	54.00	-13.04	Vertical
12010.00	*					54.00		Vertical
14412.00	*					54.00		Vertical
4804.00	31.20	31.78	8.6	32.09	39.49	54.00	-14.51	Horizontal
7206.00	23.20	36.15	11.65	32	39.00	54.00	-15.00	Horizontal
9608.00	20.25	37.95	14.14	31.62	40.72	54.00	-13.28	Horizontal
12010.00	*					54.00		Horizontal
14412.00	*					54.00		Horizontal

Remark:

1. *Final Level =Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor*
2. *"*", means this data is the too weak instrument of signal is unable to test.*
3. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

Test channel:	Middle

Peak value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
4882.00	38.89	31.85	8.67	32.12	47.29	74.00	-26.71	Vertical
7323.00	32.42	36.37	11.72	31.89	48.62	74.00	-25.38	Vertical
9764.00	32.68	38.35	14.25	31.62	53.66	74.00	-20.34	Vertical
12205.00	*					74.00		Vertical
14646.00	*					74.00		Vertical
4882.00	42.34	31.85	8.67	32.12	50.74	74.00	-23.26	Horizontal
7323.00	35.47	36.37	11.72	31.89	51.67	74.00	-22.33	Horizontal
9764.00	32.34	38.35	14.25	31.62	53.32	74.00	-20.68	Horizontal
12205.00	*					74.00		Horizontal
14646.00	*					74.00		Horizontal

Average value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
4882.00	27.10	31.85	8.67	32.12	35.50	54.00	-18.50	Vertical
7323.00	21.08	36.37	11.72	31.89	37.28	54.00	-16.72	Vertical
9764.00	20.89	38.35	14.25	31.62	41.87	54.00	-12.13	Vertical
12205.00	*					54.00		Vertical
14646.00	*					54.00		Vertical
4882.00	31.98	31.85	8.67	32.12	40.38	54.00	-13.62	Horizontal
7323.00	23.43	36.37	11.72	31.89	39.63	54.00	-14.37	Horizontal
9764.00	19.85	38.35	14.25	31.62	40.83	54.00	-13.17	Horizontal
12205.00	*					54.00		Horizontal
14646.00	*					54.00		Horizontal

Remark:

1. *Final Level =Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor*
2. *"*", means this data is the too weak instrument of signal is unable to test.*
3. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

Test channel:	Highest

Peak value:

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
4960.00	38.68	31.93	8.73	32.16	47.18	74.00	-26.82	Vertical
7440.00	32.60	36.59	11.79	31.78	49.20	74.00	-24.80	Vertical
9920.00	32.73	38.81	14.38	31.88	54.04	74.00	-19.96	Vertical
12400.00	*					74.00		Vertical
14880.00	*					74.00		Vertical
4960.00	43.40	31.93	8.73	32.16	51.90	74.00	-22.10	Horizontal
7440.00	35.17	36.59	11.79	31.78	51.77	74.00	-22.23	Horizontal
9920.00	31.41	38.81	14.38	31.88	52.72	74.00	-21.28	Horizontal
12400.00	*					74.00		Horizontal
14880.00	*					74.00		Horizontal

Average value:

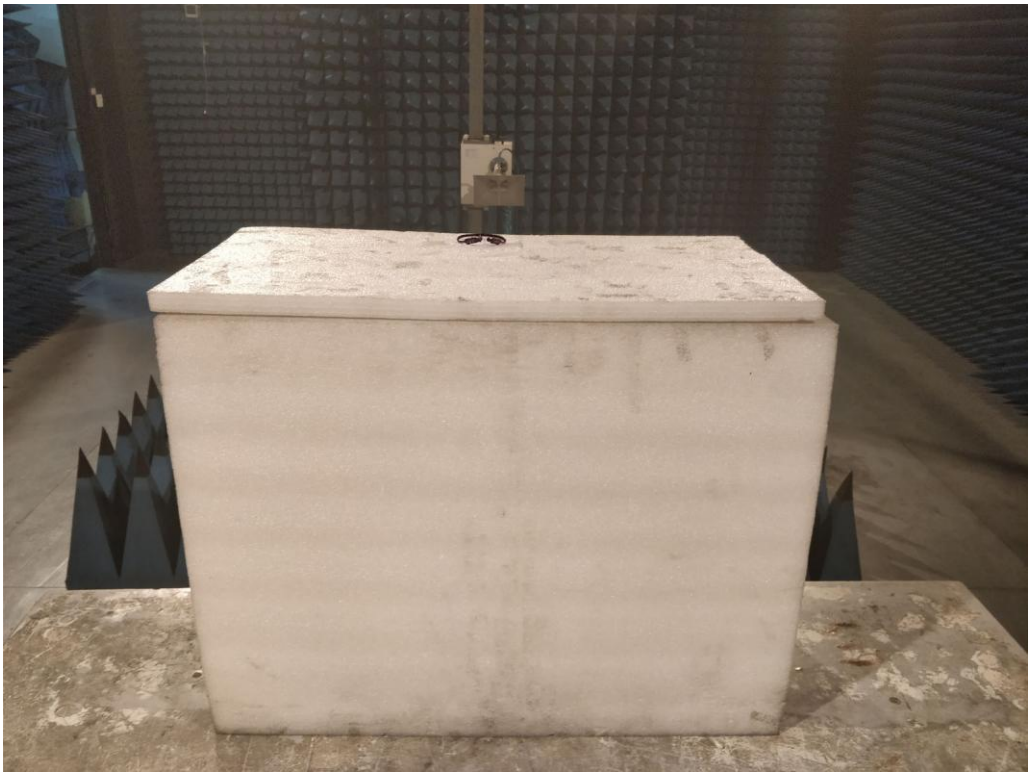
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
4960.00	27.53	31.93	8.73	32.16	36.03	54.00	-17.97	Vertical
7440.00	21.04	36.59	11.79	31.78	37.64	54.00	-16.36	Vertical
9920.00	20.42	38.81	14.38	31.88	41.73	54.00	-12.27	Vertical
12400.00	*					54.00		Vertical
14880.00	*					54.00		Vertical
4960.00	31.77	31.93	8.73	32.16	40.27	54.00	-13.73	Horizontal
7440.00	22.89	36.59	11.79	31.78	39.49	54.00	-14.51	Horizontal
9920.00	20.13	38.81	14.38	31.88	41.44	54.00	-12.56	Horizontal
12400.00	*					54.00		Horizontal
14880.00	*					54.00		Horizontal

Remark:

1. *Final Level =Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor*
2. *"*", means this data is the too weak instrument of signal is unable to test.*
3. *The emission levels of other frequencies are very lower than the limit and not show in test report.*

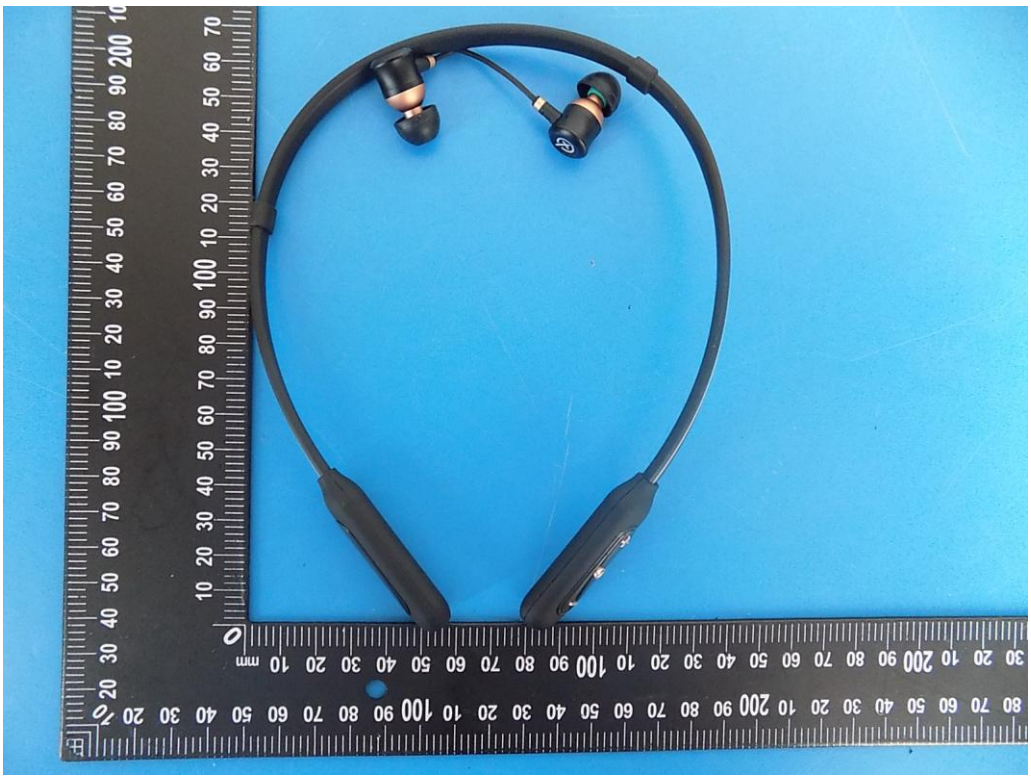
8 Test Setup Photo

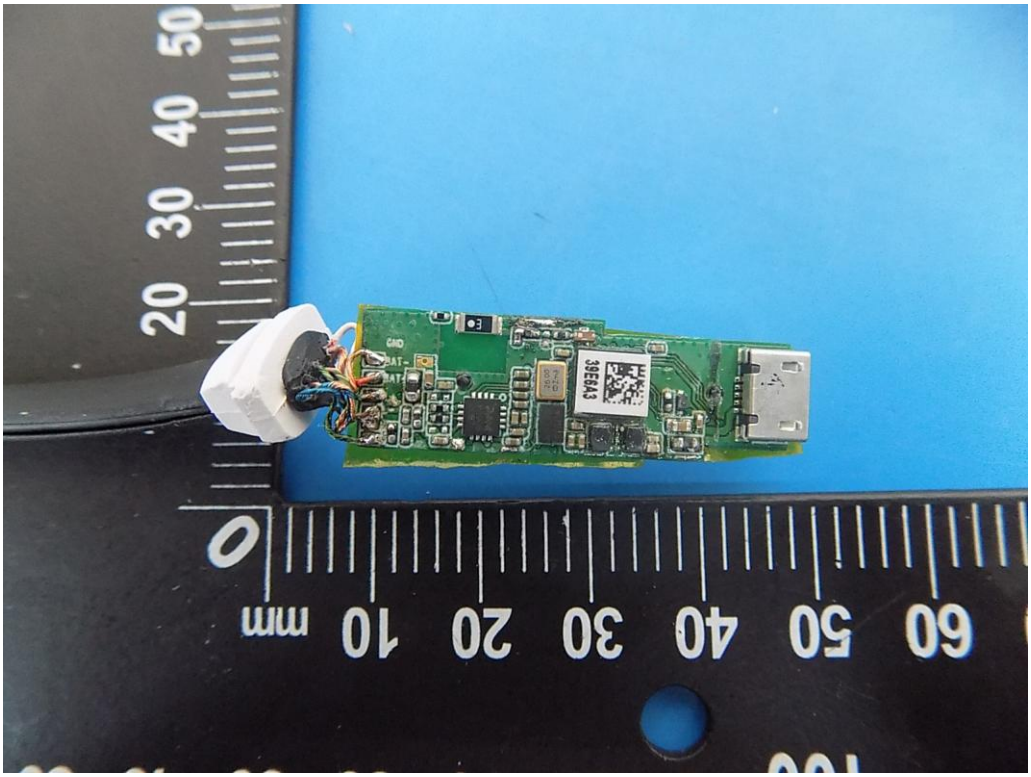
Radiated Emission

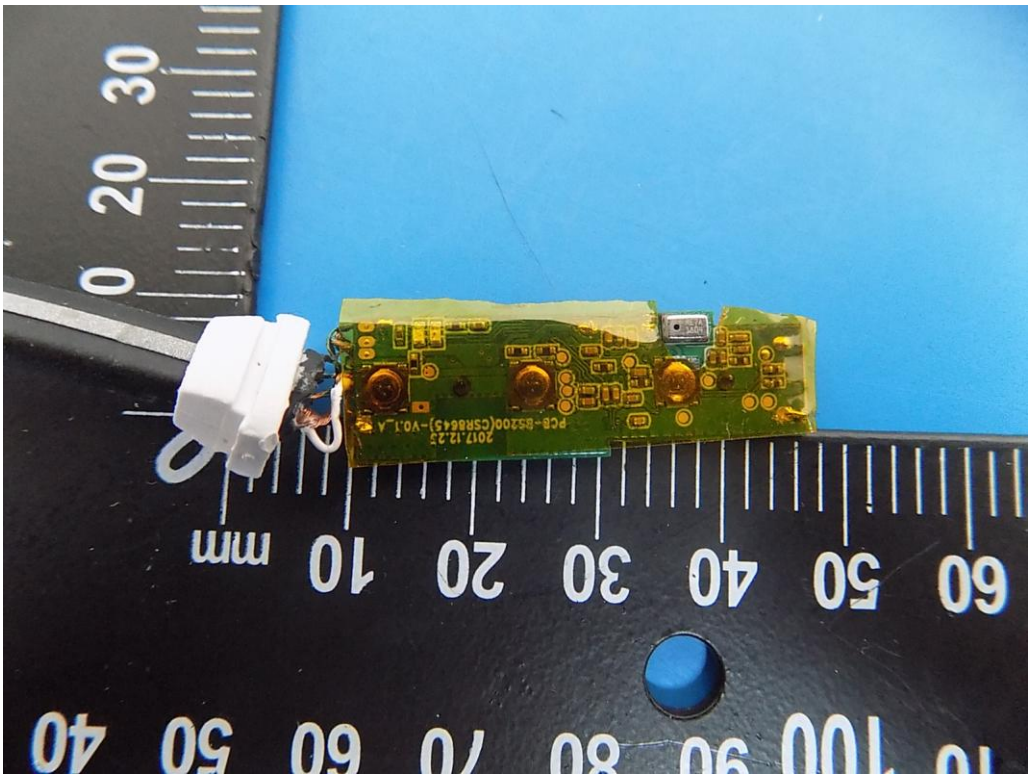


Conducted Emission

9 EUT Constructional Details



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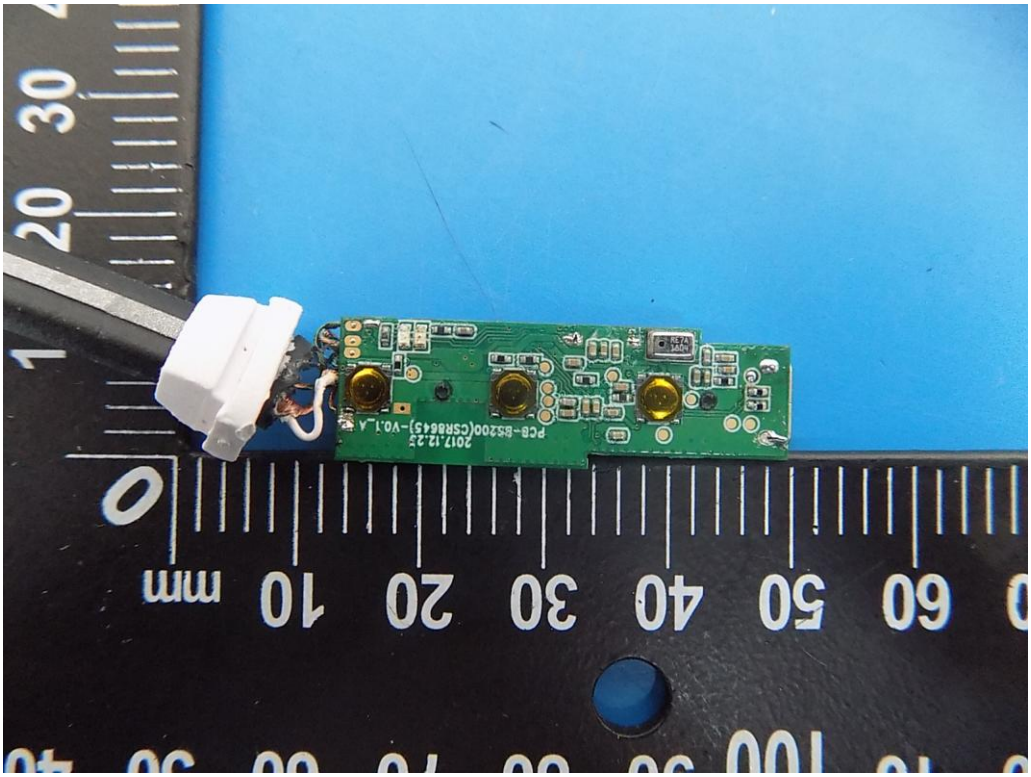
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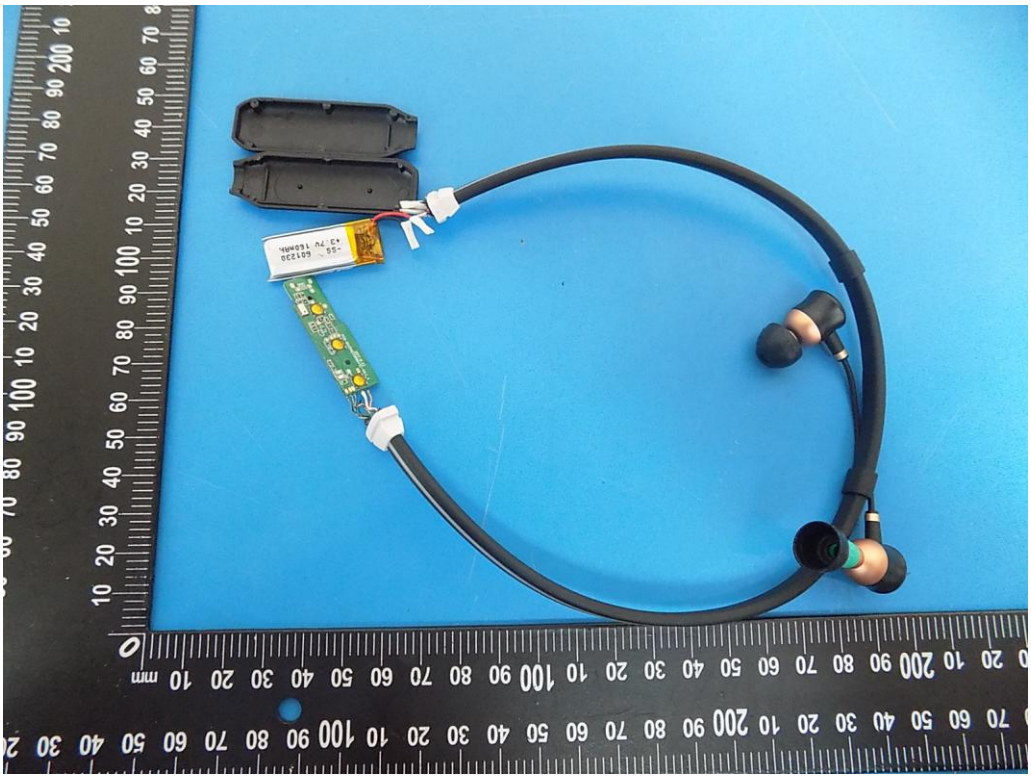

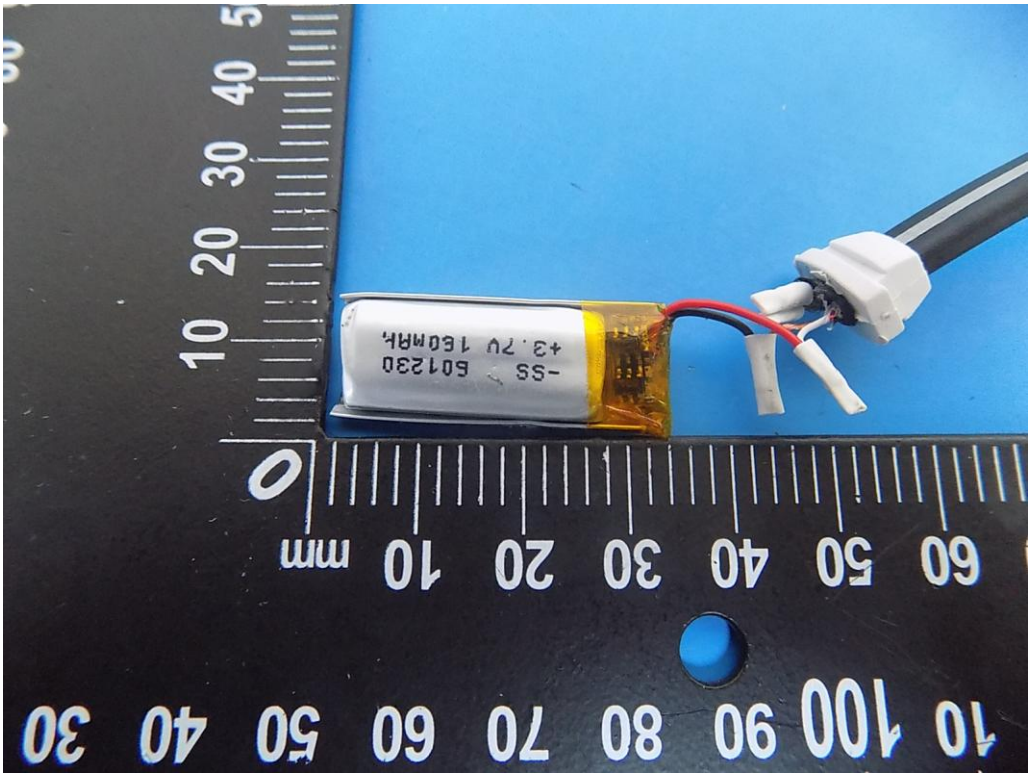

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