

7.8 Pseudorandom Frequency Hopping Sequence

Test Requirement:

FCC Part15 C Section 15.247 (a)(1)g/h requirement:

a(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Alternatively. Frequency hopping systems operating in the 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.

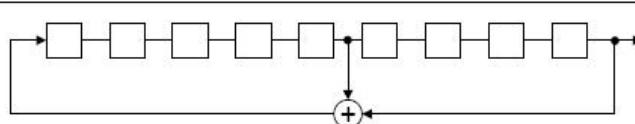
(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

EUT Pseudorandom Frequency Hopping Sequence

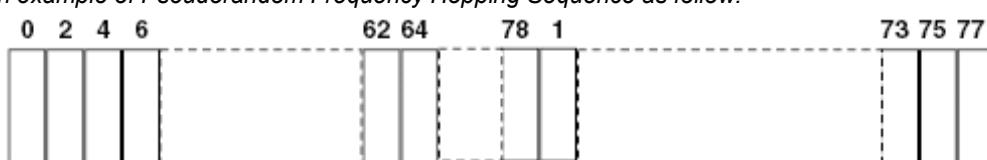
The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized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



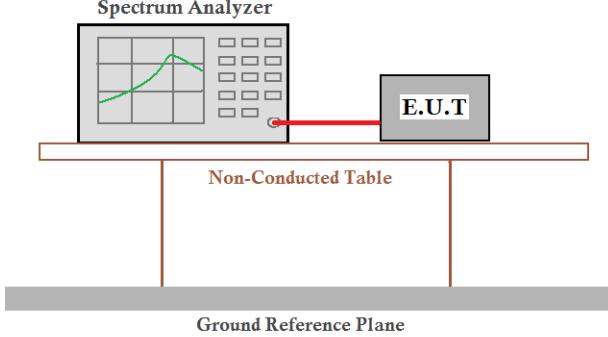
Each frequency used equally on the average by each transmitter.

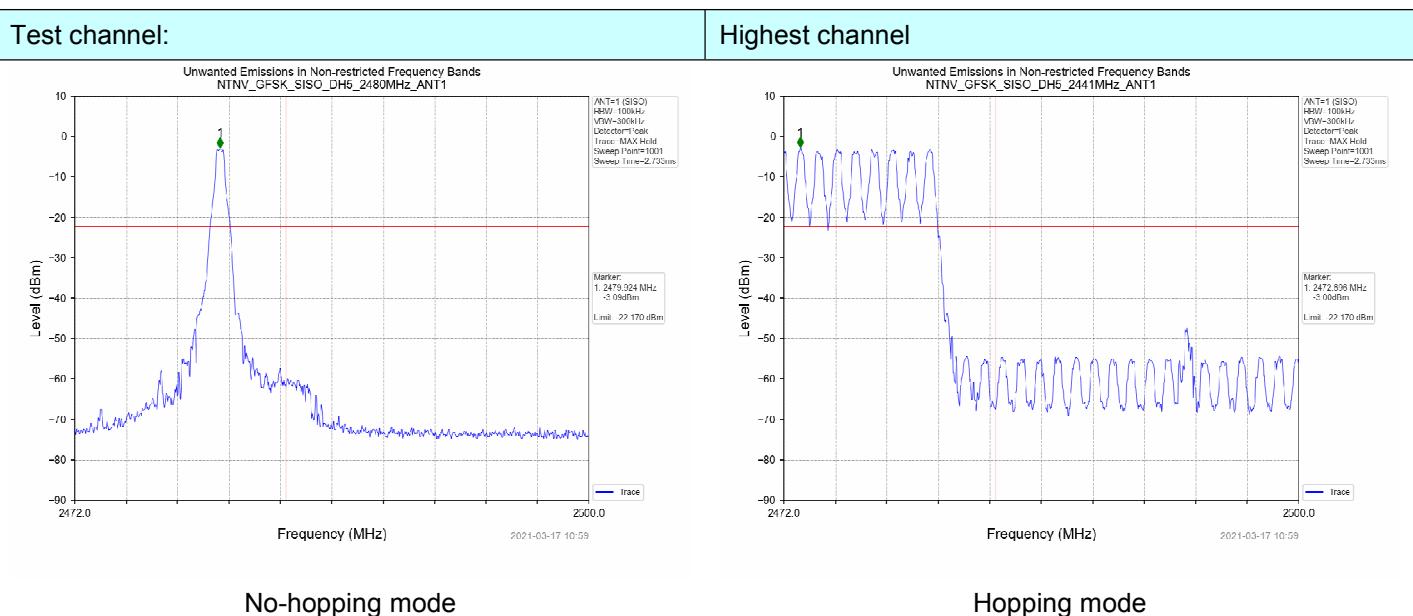
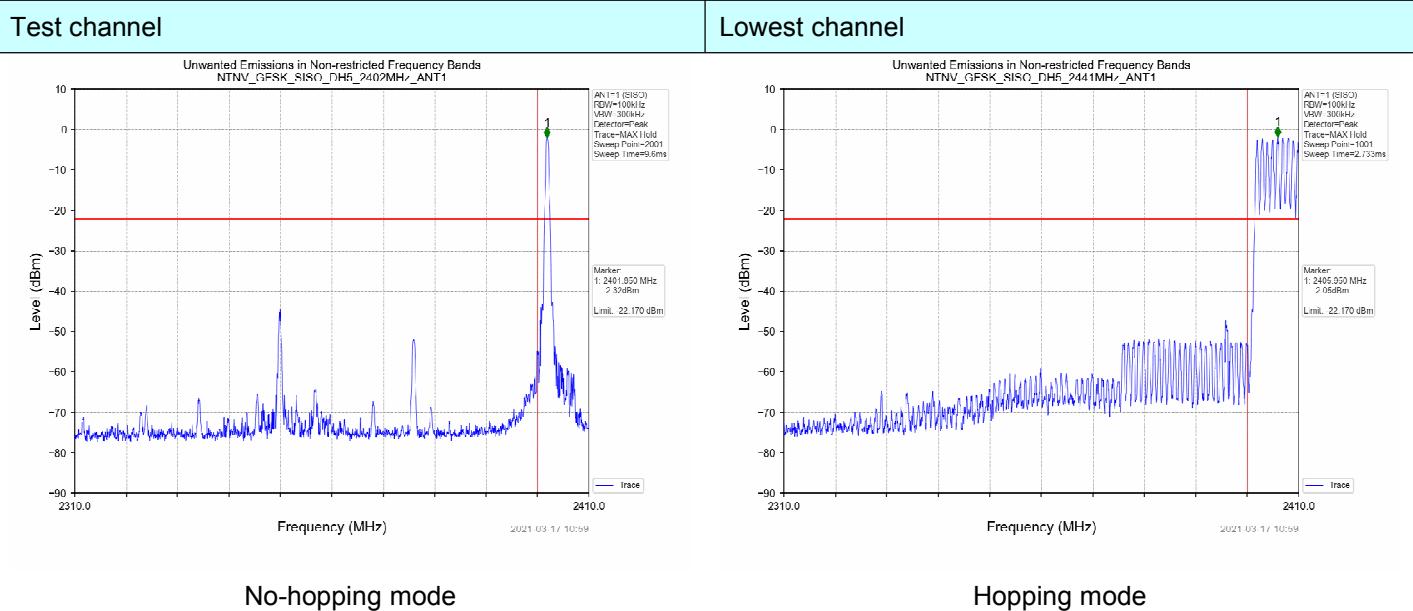
The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

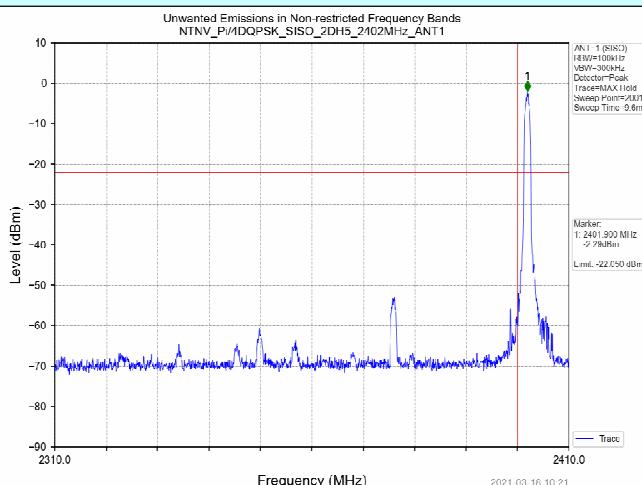
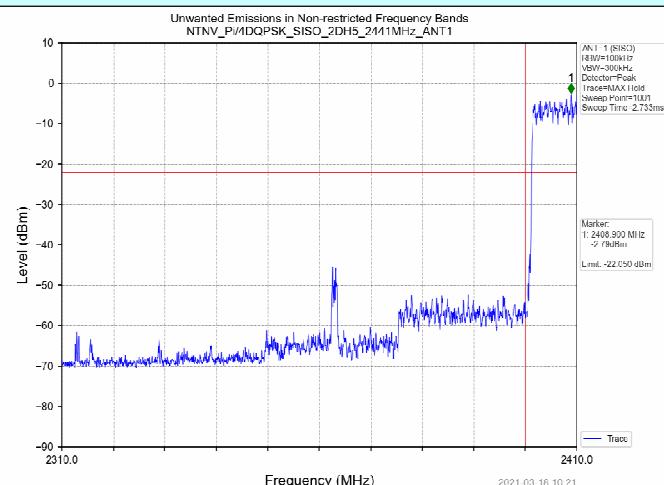
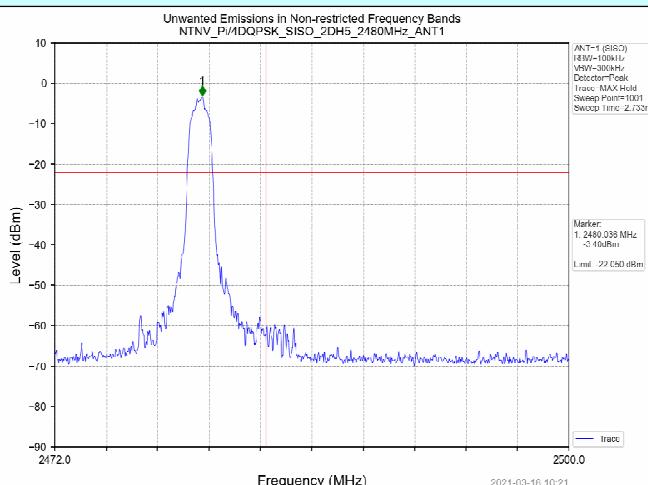
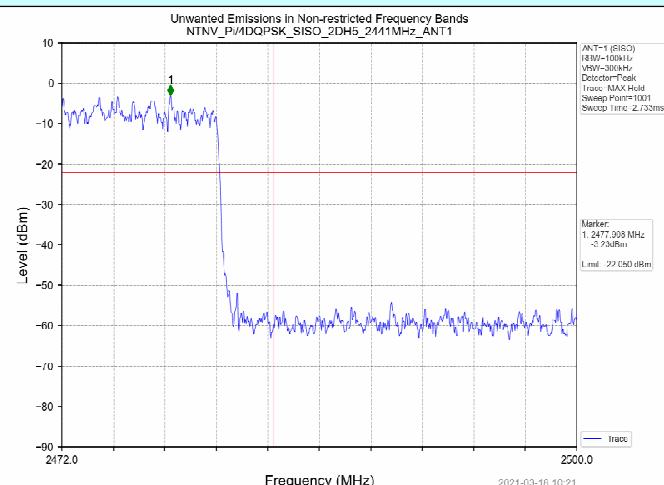
it permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted.

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 environment:	Temp.:	25 °C	Humid.:	52%	Press.:	1012mbar

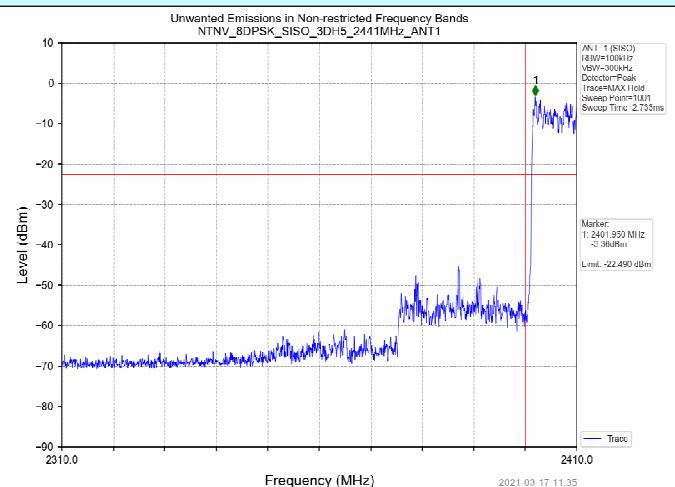
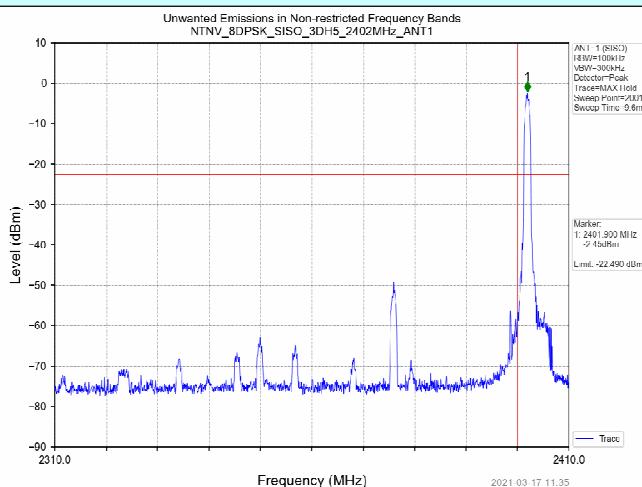
Test plot as follows:
GFSK Mode:


π/4-DQPSK Mode:
Test channel
Lowest channel

No-hopping mode

Hopping mode
Test channel:
Highest channel

No-hopping mode

Hopping mode

8-DPSK Mode:

Test channel

Lowest channel

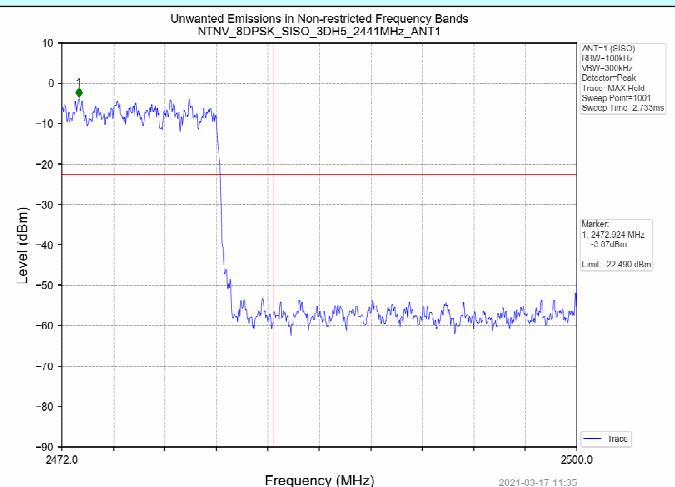
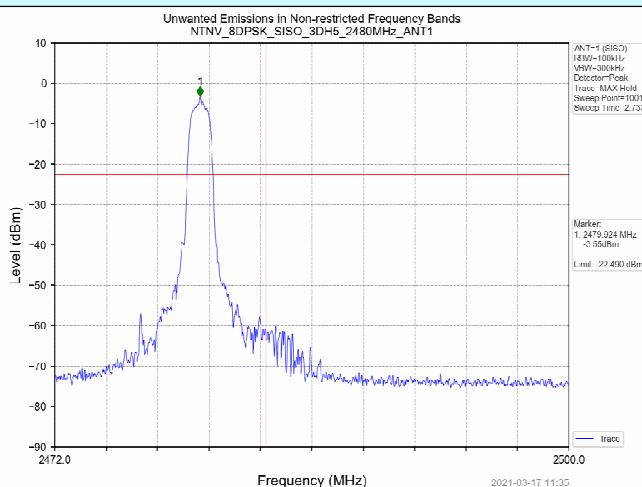


No-hopping mode

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 of the restrict bands were tested, only the worst band's (2310MHz to 2500MHz) data was showed.								
Test site:	Measurement Distance: 3m								
Receiver setup:	Frequency	Detector	RBW	VBW	Remark				
	Above 1GHz	Peak	1MHz	3MHz	Peak Value				
Limit:	Frequency	Limit (dBuV/m @3m)		Remark					
	Above 1GHz	54.00		Average Value					
Test setup:									
Test Procedure:	<ol style="list-style-type: none"> 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. The EUT was set 3 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 and the rota 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 Bandwidth with Maximum Hold Mode. 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								
Test results:	Pass								
Test environment:	Temp.:	25 °C	Humid.:	52%	Press.:	1012mbar			

Measurement Data

Remark: GFSK, Pi/4 DQPSK and 8DPSK all have been tested, only worse case GFSK is reported.

Operation Mode: GFSK TX Low channel(2402MHz)

Horizontal (Worst case)

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
2390	59.75	-5.68	54.07	74	-19.93	peak
2390	43.59	-5.68	37.91	54	-16.09	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
2390	63.12	-5.68	57.44	74	-16.56	peak
2390	44.98	-5.68	39.3	54	-14.7	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Operation Mode: GFSK TX High channel (2480MHz)

Horizontal (Worst case)

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits	Margin (dB)	Detector Type
2483.5	61.03	-5.85	55.18	74	-18.82	peak
2483.5	43.72	-5.85	37.87	54	-16.13	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

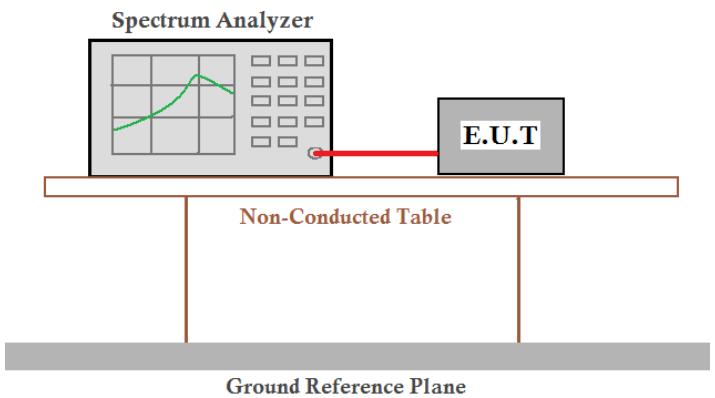
Vertical:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits	Margin (dB)	Detector Type
2483.5	62.67	-5.85	56.82	74	-17.18	peak
2483.5	45.89	-5.85	40.04	54	-13.96	AVG

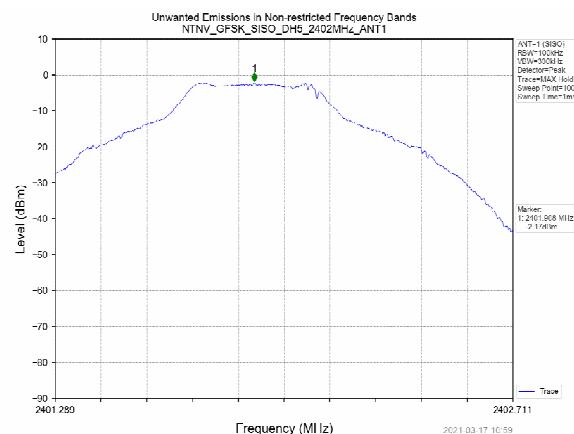
Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

7.10 Spurious Emission

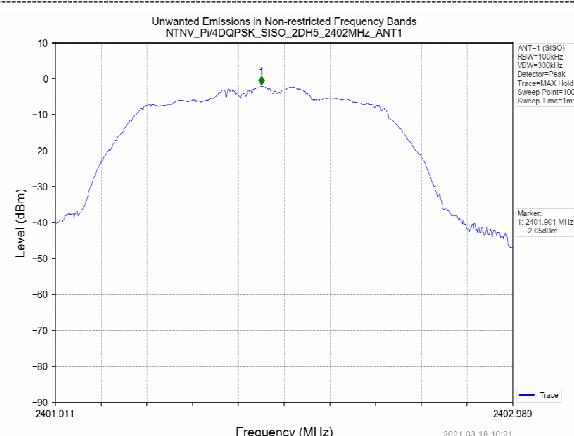
7.10.1 Conducted Emission Method

Test Requirement:	FCC Part15 C Section 15.247 (d)					
Test Method:	ANSI C63.10:2013					
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:	 <p>The diagram illustrates the test setup for conducted emission. A Spectrum Analyzer is connected to the E.U.T (Equipment Under Test) via a cable. The E.U.T is placed on a Non-Conducted Table. The entire setup is positioned above a Ground Reference Plane.</p>					
Test Instruments:	Refer to section 6.0 for details					
Test mode:	Refer to section 5.2 for details					
Test results:	Pass					
Test environment:	Temp.:	25 °C	Humid.:	52%	Press.:	1012mbar

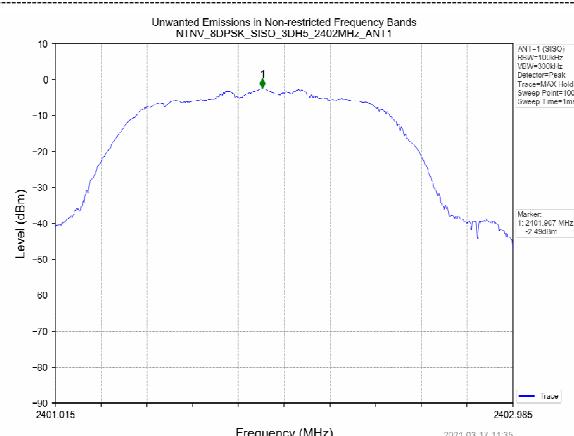
Reference



GFSK

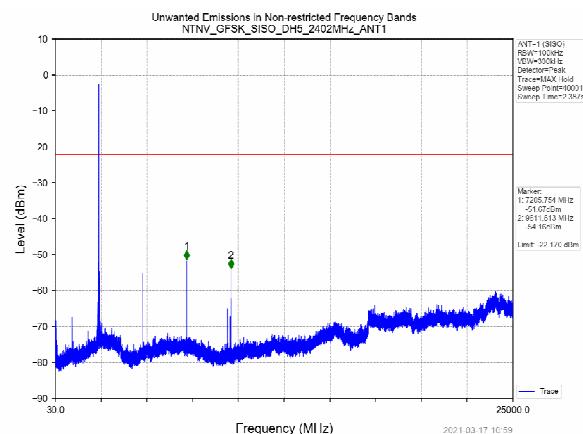


$\pi/4$ DQPSK

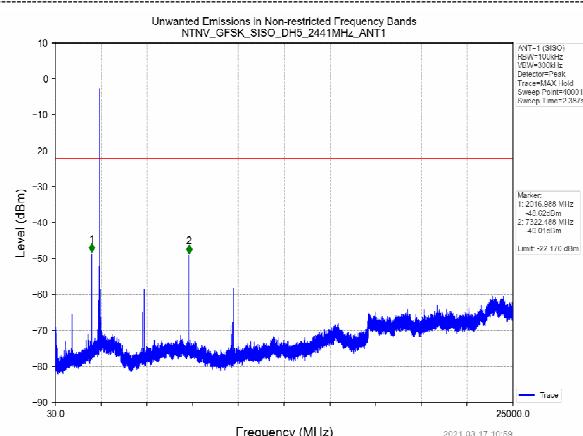


8-DPSK

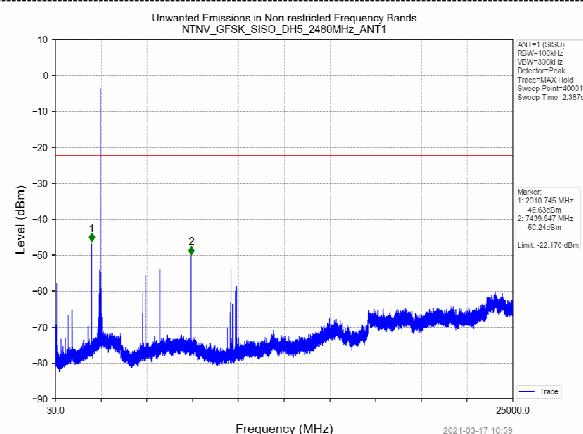
GFSK



CH00

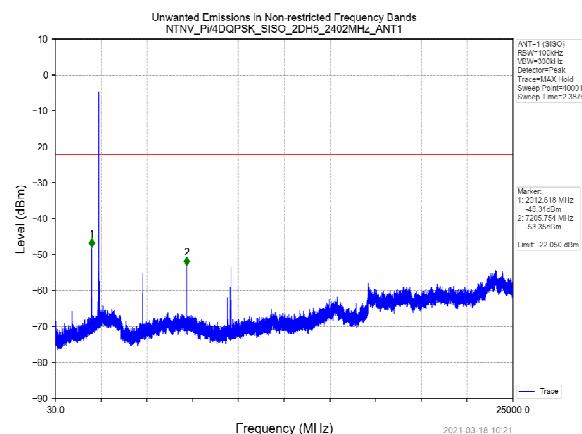


CH39

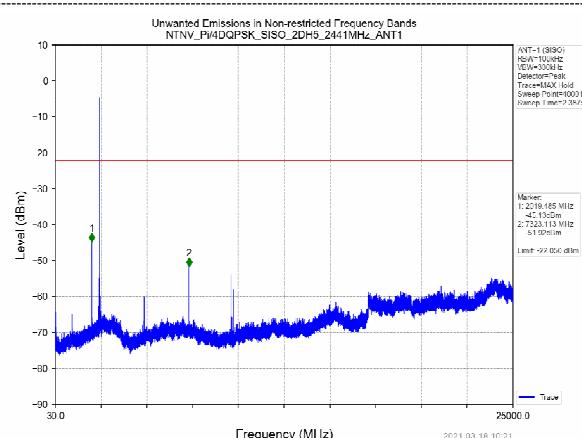


CH78

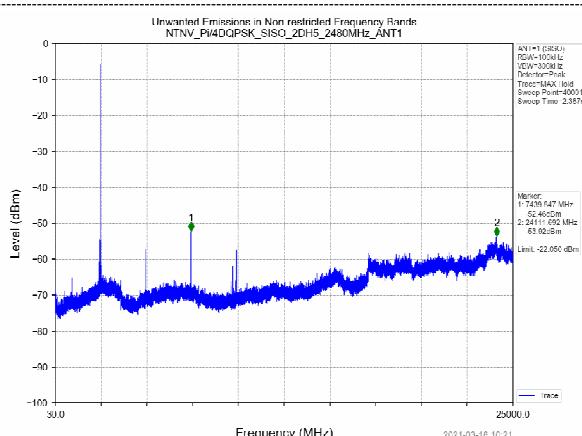
$\pi/4$ DQPSK



CH00

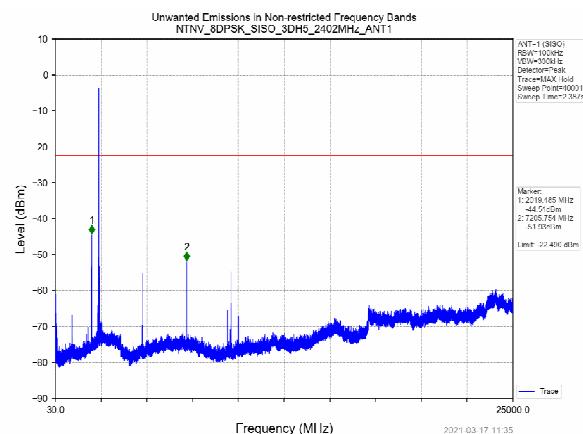


CH39

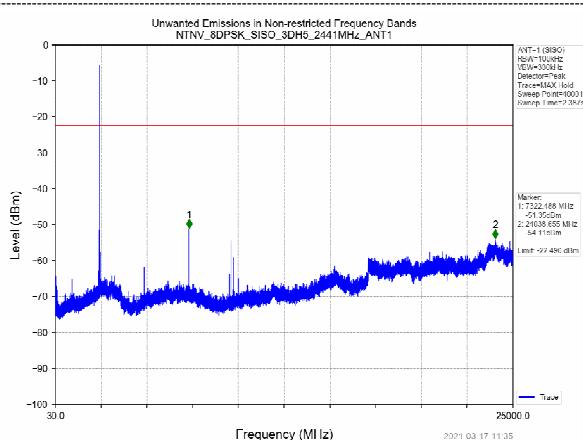


CH78

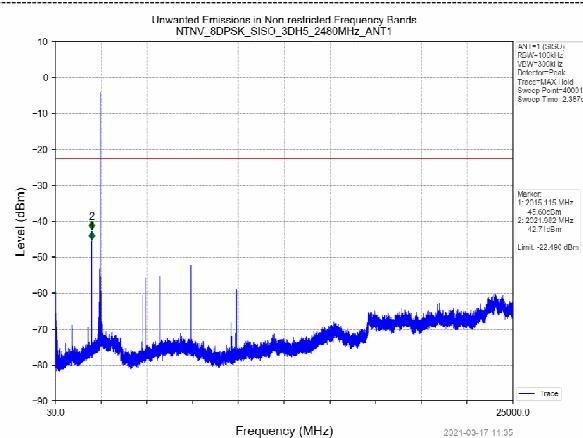
8-DPSK



CH00

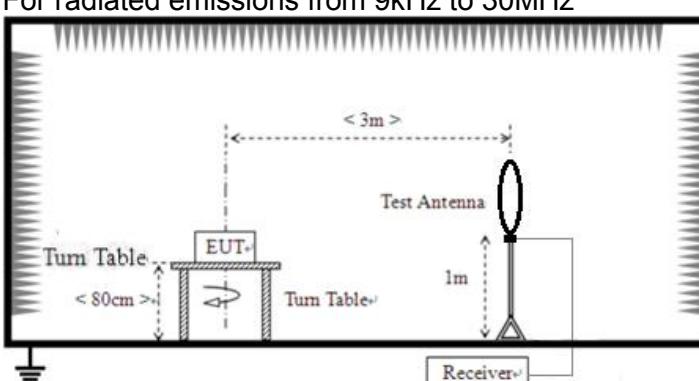


CH39

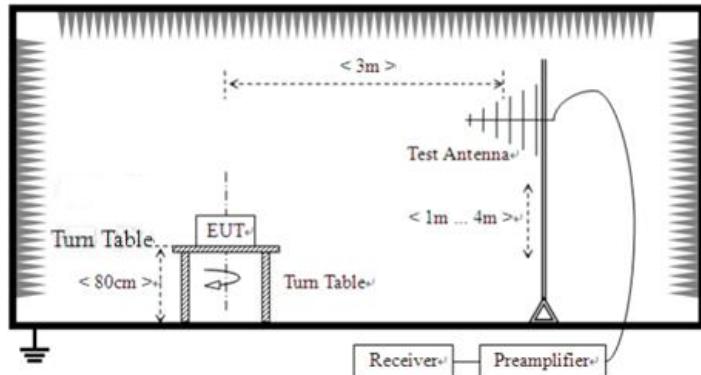


CH78

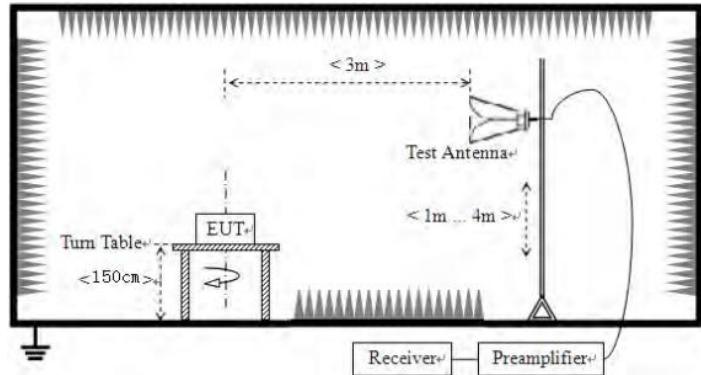
7.10.2 Radiated Emission Method

Test Requirement:	FCC Part15 C Section 15.209						
Test Method:	ANSI C63.10:2013						
Test Frequency Range:	9kHz to 25GHz						
Test site:	Measurement Distance: 3m						
Receiver setup:	Frequency	Detector	RBW	VBW	Value		
	9KHz-150KHz	Quasi-peak	200Hz	600Hz	Quasi-peak		
	150KHz-30MHz	Quasi-peak	9KHz	30KHz	Quasi-peak		
	30MHz-1GHz	Quasi-peak	120KHz	300KHz	Quasi-peak		
	Above 1GHz	Peak	1MHz	3MHz	Peak		
	Above 1GHz	Peak	1MHz	10Hz	Average		
Limit:	Frequency	Limit (uV/m)	Value	Measurement Distance 3m			
	0.009MHz-0.490MHz	2400/F(KHz)	QP				
	0.490MHz-1.705MHz	24000/F(KHz)	QP				
	1.705MHz-30MHz	30	QP				
	30MHz-88MHz	100	QP				
	88MHz-216MHz	150	QP				
	216MHz-960MHz	200	QP				
	960MHz-1GHz	500	QP				
	Above 1GHz	500	Average				
	Above 1GHz	5000	Peak				
Test setup:	For radiated emissions from 9kHz to 30MHz						
							

For radiated emissions from 30MHz to1GHz



For radiated emissions above 1GHz



Test Procedure:

1. The EUT was placed on the top of a rotating table (0.8m for below 1G and 1.5m for 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

Test environment:	Temp.:	25 °C	Humid.:	52%	Press.:	1012mbar
Test voltage:	AC 120V, 60Hz					
Test results:	Pass					

Measurement data:

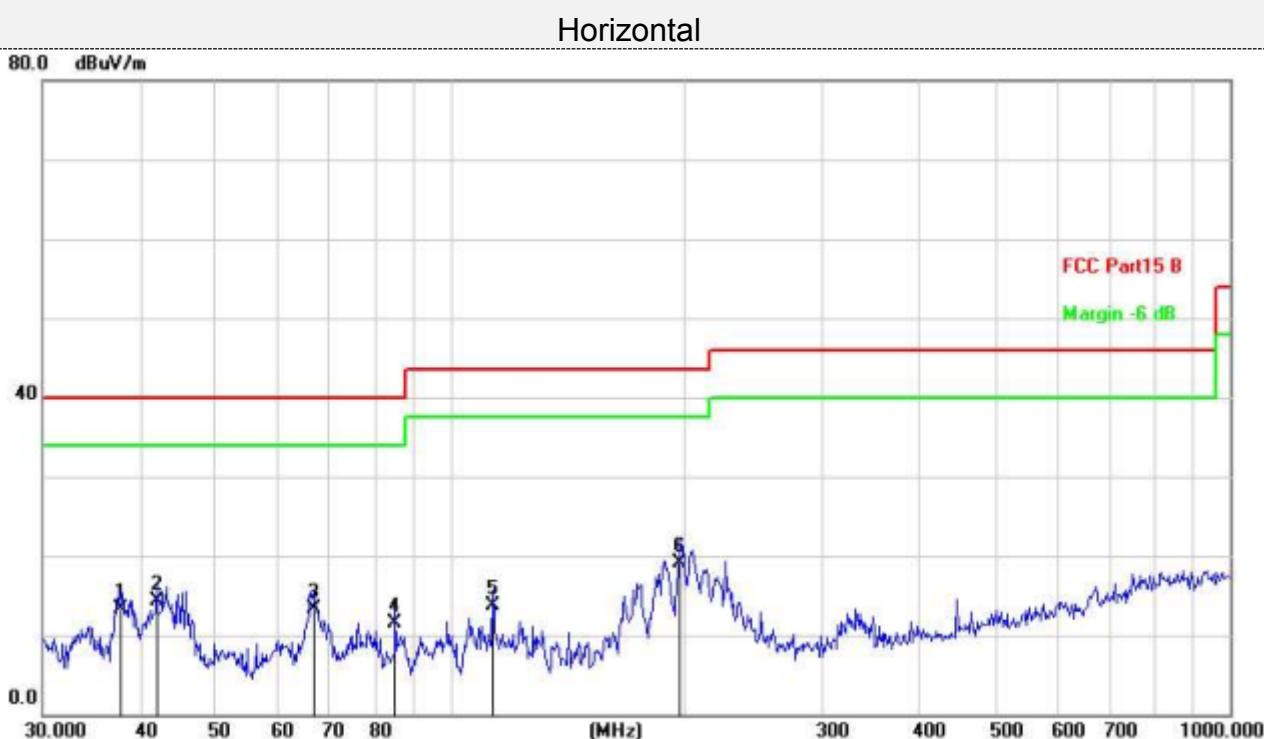
Remarks:

1. During the test, pre-scan the GFSK, $\pi/4$ -DQPSK, 8-DPSK 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.

9kHz~30MHz

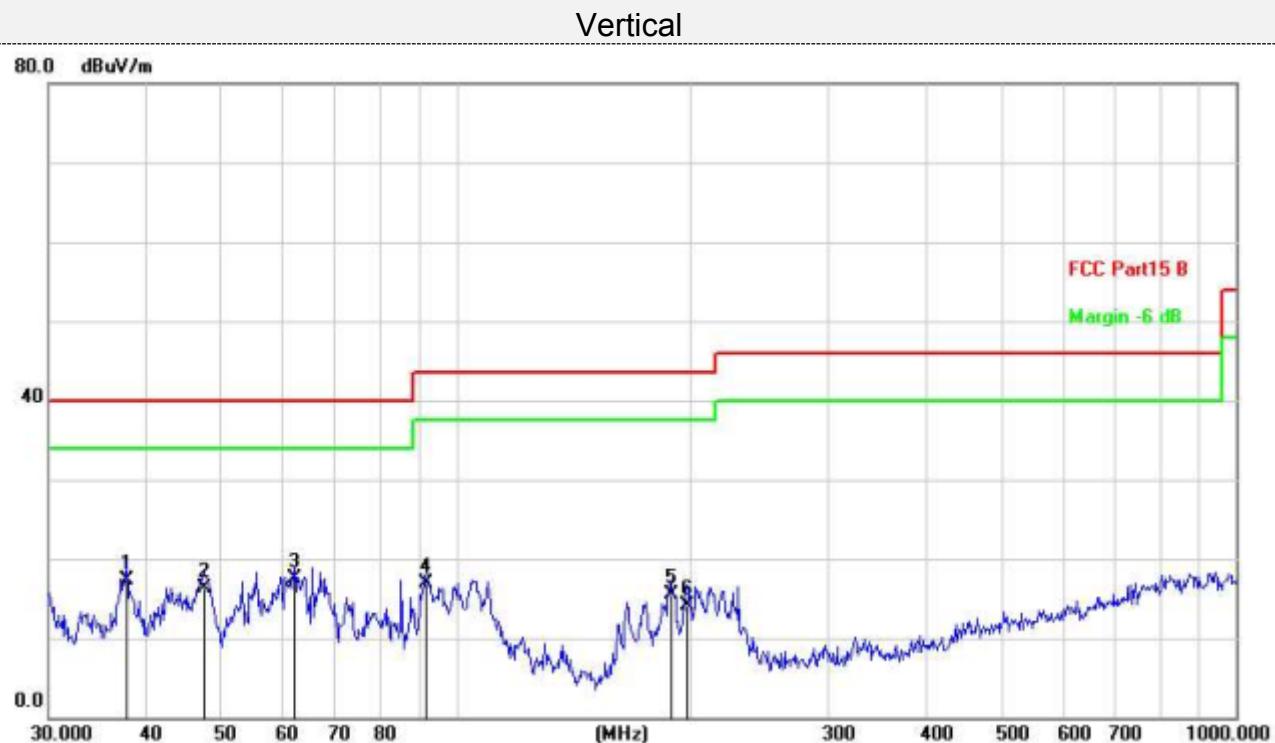
The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.

For 30MHz-1GHz



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB	dBuV/m	dB/m	dB	Detector
1		37.8121	31.36	-18.11	13.25	40.00	-26.75	QP
2		42.0066	32.15	-17.94	14.21	40.00	-25.79	QP
3		66.7325	32.88	-19.55	13.33	40.00	-26.67	QP
4		84.9995	32.65	-21.06	11.59	40.00	-28.41	QP
5		113.3163	33.86	-20.11	13.75	43.50	-29.75	QP
6	*	197.2001	39.19	-20.11	19.08	43.50	-24.42	QP

Final Level = Receiver Read level + Correct Factor



No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dB	Measure- ment dBuV/m	Limit dB/m	Over dB	Over Detector
1		37.8121	35.35	-18.11	17.24	40.00	-22.76	QP
2		47.4918	34.70	-18.37	16.33	40.00	-23.67	QP
3	*	61.9951	36.57	-18.99	17.58	40.00	-22.42	QP
4		91.4949	38.15	-21.19	16.96	43.50	-26.54	QP
5		188.4125	35.02	-19.57	15.45	43.50	-28.05	QP
6		197.8928	34.21	-20.13	14.08	43.50	-29.42	QP

Final Level = Receiver Read level + Correct Factor

For 1GHz to 25GHz

Remark: For test above 1GHz GFSK and Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK was reported as below:

CH Low (2402MHz)

Horizontal:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
4804	61.72	-3.61	58.11	74	-15.89	peak
4804	46.11	-3.61	42.5	54	-11.5	AVG
7206	57.59	-0.85	56.74	74	-17.26	peak
7206	44.46	-0.85	43.61	54	-10.39	AVG
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Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
4804	60.37	-3.61	56.76	74	-17.24	peak
4804	47.85	-3.61	44.24	54	-9.76	AVG
7206	56.36	-0.85	55.51	74	-18.49	peak
7206	45.16	-0.85	44.31	54	-9.69	AVG
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Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

CH Middle (2441MHz)

Horizontal:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
4882	61.73	-3.49	58.24	74	-15.76	peak
4882	46.59	-3.49	43.1	54	-10.9	AVG
7326	59.71	-0.8	58.91	74	-15.09	peak
7326	44.84	-0.8	44.04	54	-9.96	AVG
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Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
4882	61.09	-3.49	57.6	74	-16.4	peak
4882	45.37	-3.49	41.88	54	-12.12	AVG
7326	55.55	-0.80	54.75	74	-19.25	peak
7326	43.44	-0.8	42.64	54	-11.36	AVG
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Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

CH High (2480MHz)

Horizontal:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
4960	61.26	-3.41	57.85	74	-16.15	peak
4960	46.79	-3.41	43.38	54	-10.62	AVG
7440	57.03	-0.72	56.31	74	-17.69	peak
7440	44.19	-0.8	43.39	54	-10.61	AVG
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Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency (MHz)	Meter Reading (dB μ V)	Factor (dB)	Emission Level (dB μ V/m)	Limits (dB μ V/m)	Margin (dB)	Detector Type
4960	62.37	-3.41	58.96	74	-15.04	peak
4960	46.59	-3.41	43.18	54	-10.82	AVG
7440	56.13	-0.72	55.41	74	-18.59	peak
7440	43.26	-0.8	42.46	54	-11.54	AVG
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Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Remark:

- (1) Data of measurement within this frequency range shown “---” in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.
- (2) When the test results of Peak Detected below the limits of Average Detected, the Average Detected is not need completed.

8 Test Setup Photo

Reference to the **appendix I** for details.

9 EUT Constructional Details

Reference to the **appendix II** for details.

-----End-----