8. CONDUCTED SPURIOUS EMISSION

8.1. MEASUREMENT PROCEDURE

1. Connect EUT RF output port to the Spectrum Analyzer through an RF attenuator
2. Set the EUT Work on the top, the Middle and the bottom operation frequency individually.
3. Set the Span = wide enough to capture the peak level of the in-band emission and all spurious emissions from the lowest frequency generated in the EUT up through the 10th harmonic.
   RBW = 100 kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak.
4. Set SPA Trace 1 Max hold, then View.

Note: The EUT was tested according for compliance ANSI C63.10 (2013) requirements. Owing to satisfy the requirements of the number of measurement points, we set the RBW=1MHz, VBW＞RBW, scan up through 10th harmonic, and consider the tested results as the worst case, if the tested results conform to the requirement, we can deem that the real tested results(set the RBW=100KHz, VBW＞RBW) are conform to the requirement.

8.2. TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)

The same as described in section 8.2

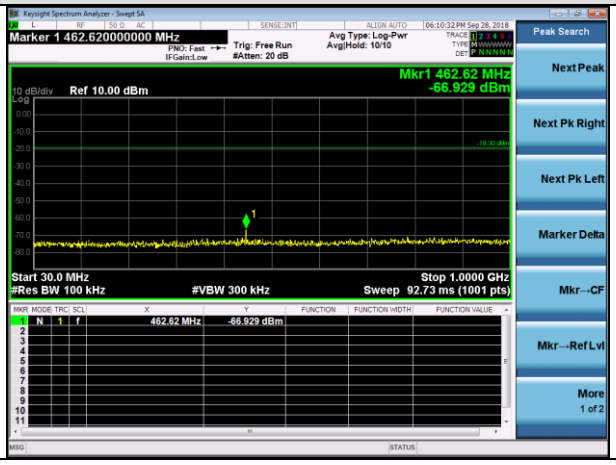
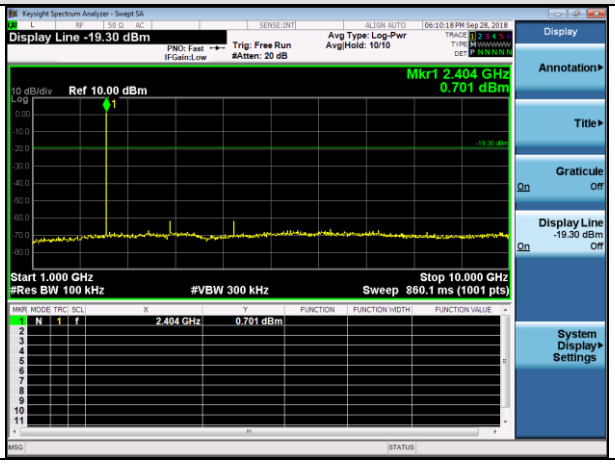
8.3. MEASUREMENT EQUIPMENT USED

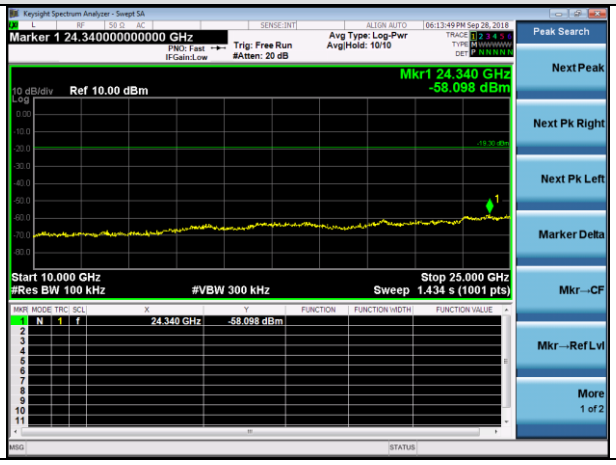
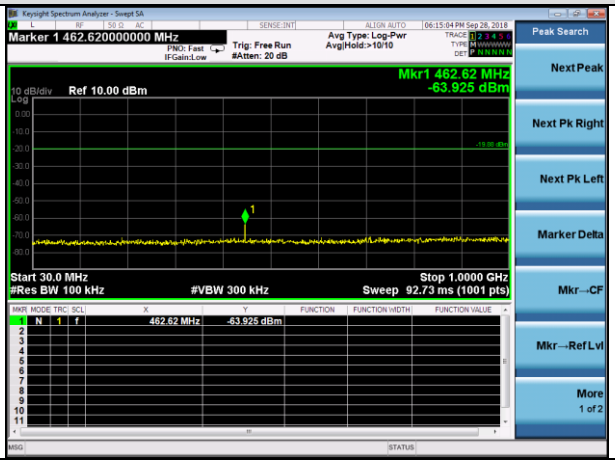
The same as described in section 6

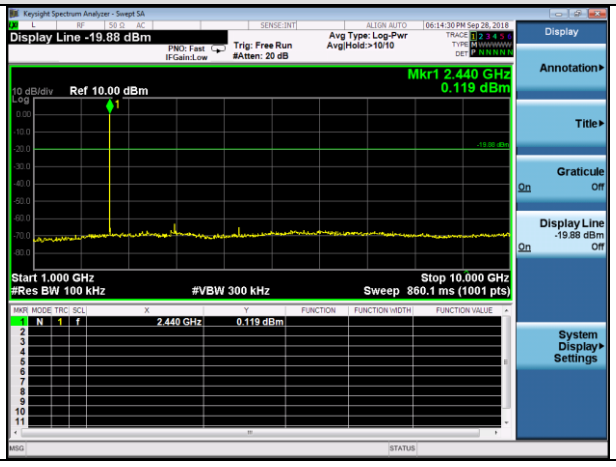
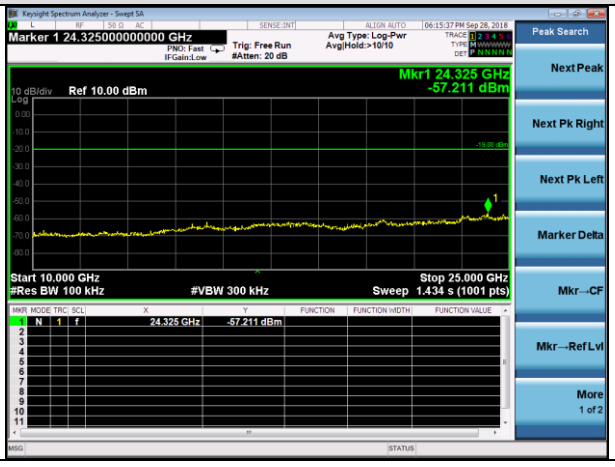
8.4. LIMITS AND MEASUREMENT RESULT

LIMITS AND MEASUREMENT RESULT		
Applicable Limits	Measurement Result	
	Test Data	Criteria
In any 100 KHz Bandwidth Outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produce by the intentional radiator shall be at least 20 dB below that in 100KHz bandwidth within the band that contains the highest level of the desired power. In addition, radiation emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in§15.209(a))	Refer Test Graph	PASS

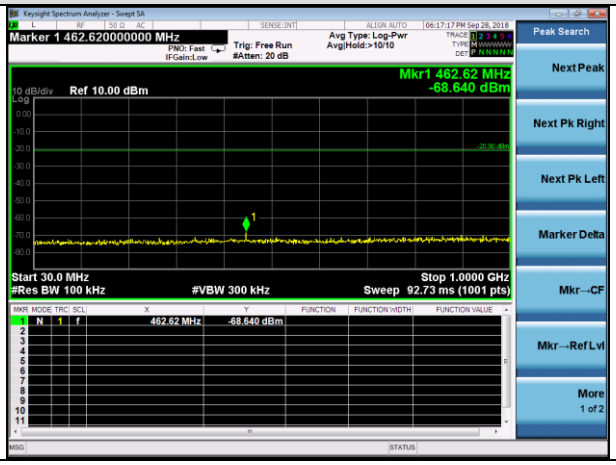
Test Graph

GFSK-LCH	GFSK-LCH
	

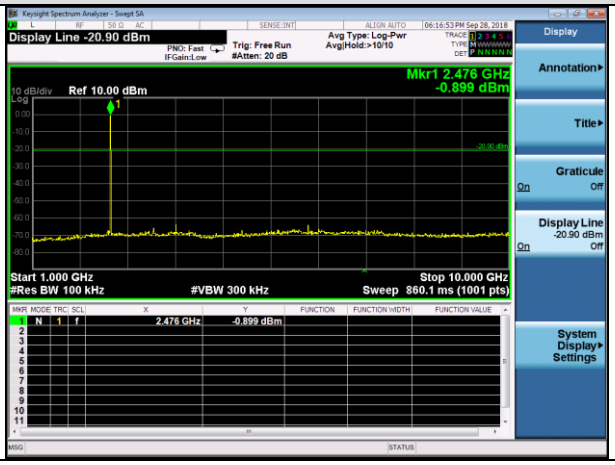
GFSK-LCH	GFSK-MCH
	

GFSK-MCH	GFSK-MCH
	

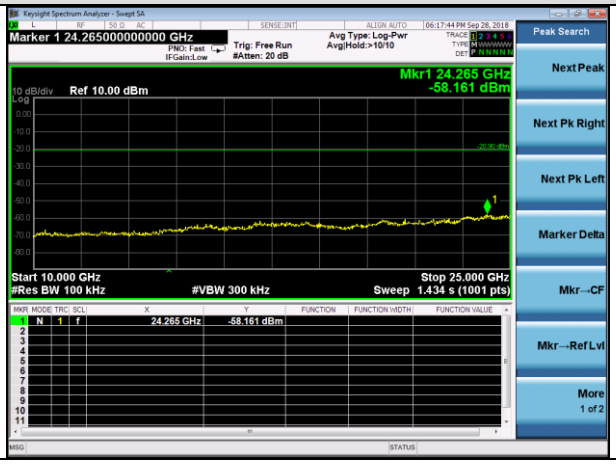
GFSK-HCH



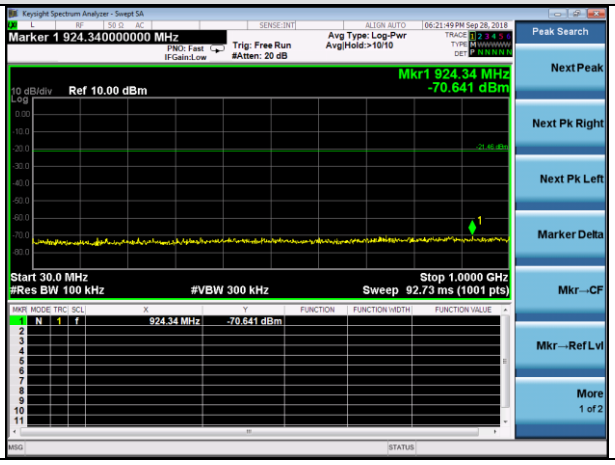
GFSK-HCH



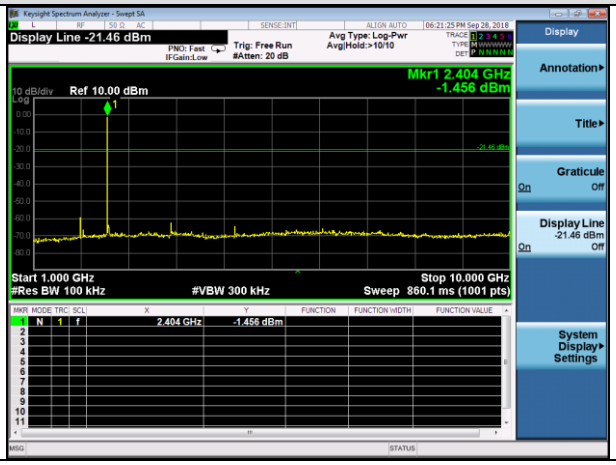
GFSK-HCH



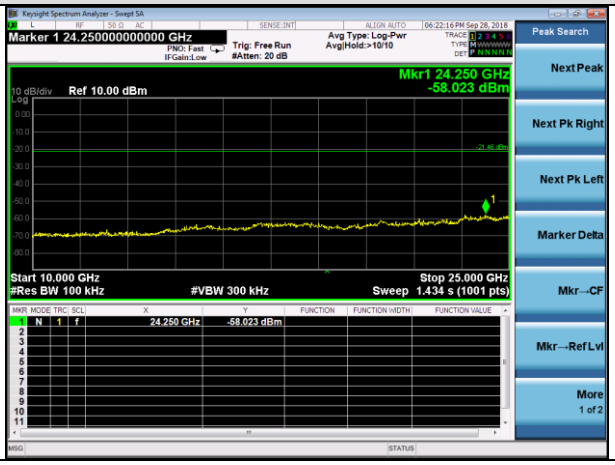
π/4DQPSK-LCH



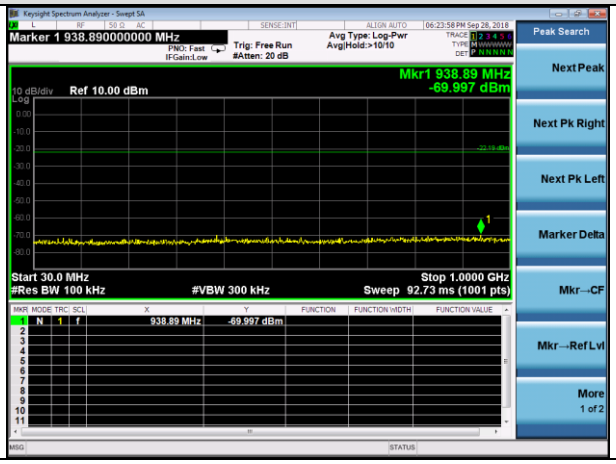
π/4DQPSK-LCH



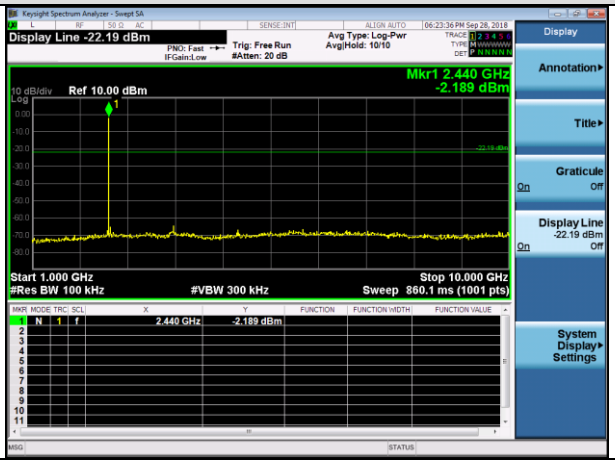
π/4DQPSK-LCH



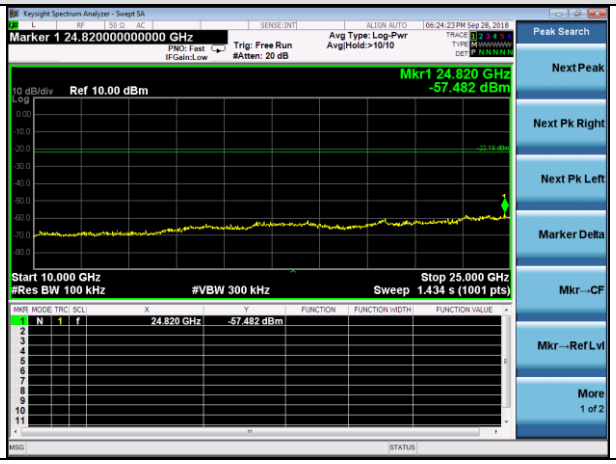
π/4DQPSK-MCH



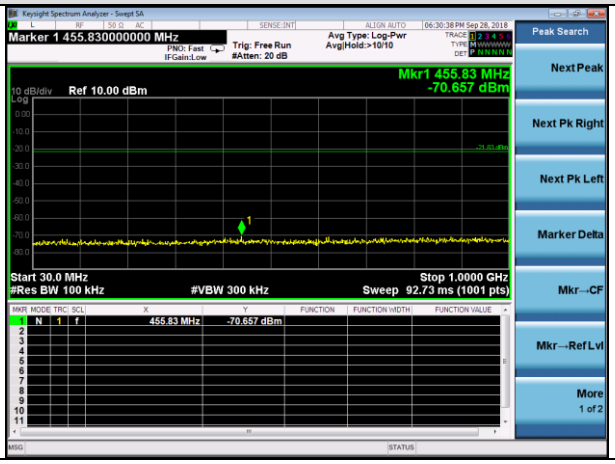
π/4DQPSK-MCH



π/4DQPSK-MCH



π/4DQPSK-HCH



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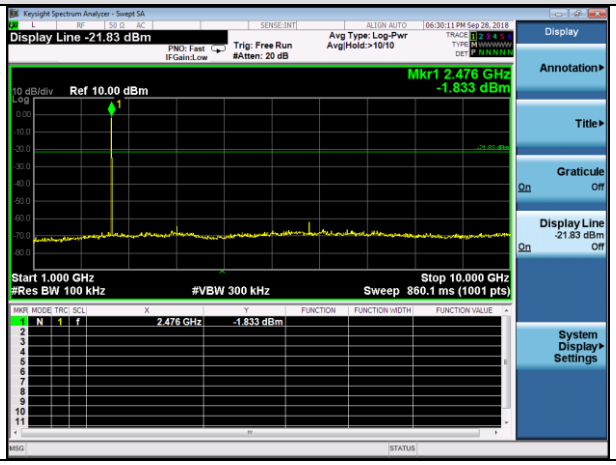

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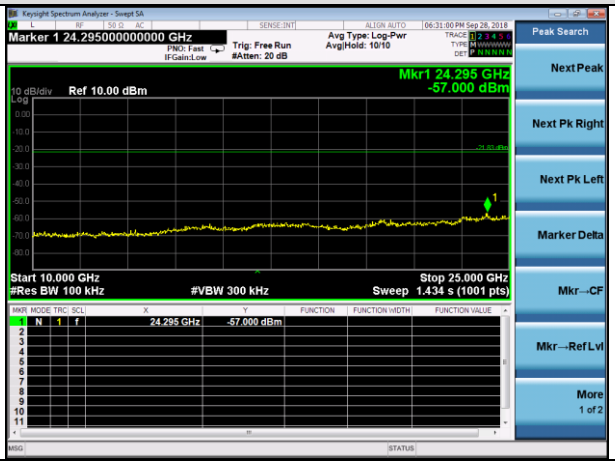
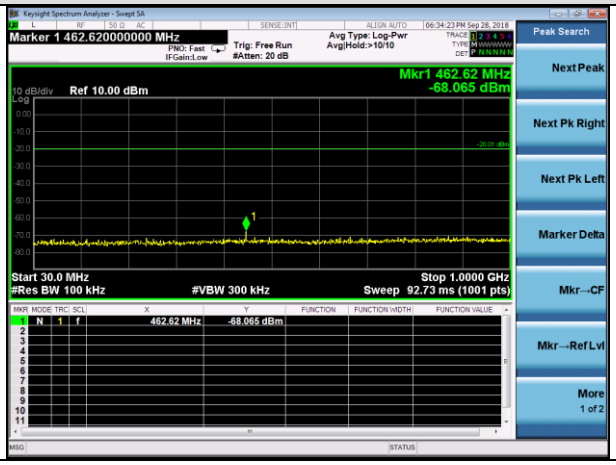
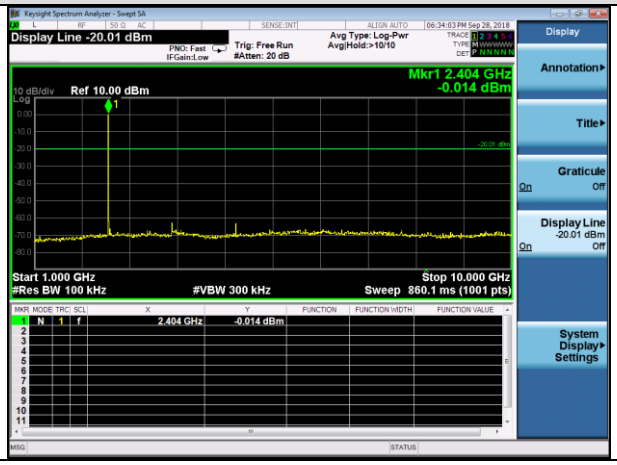
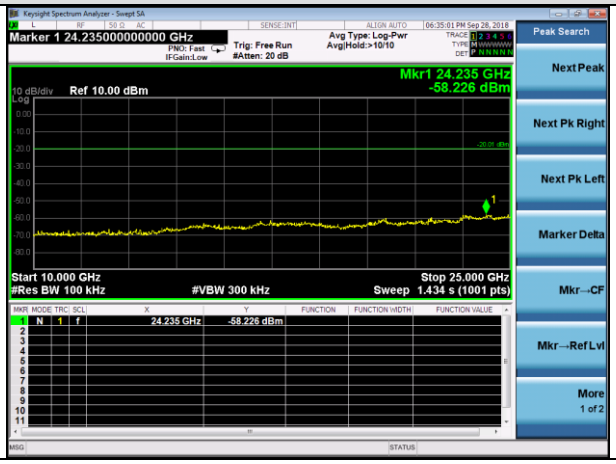
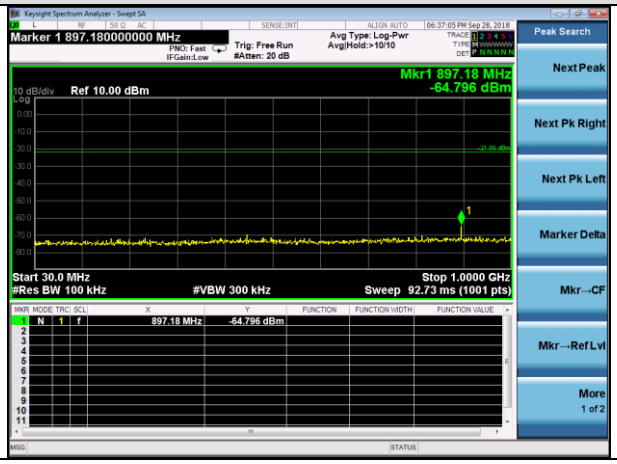
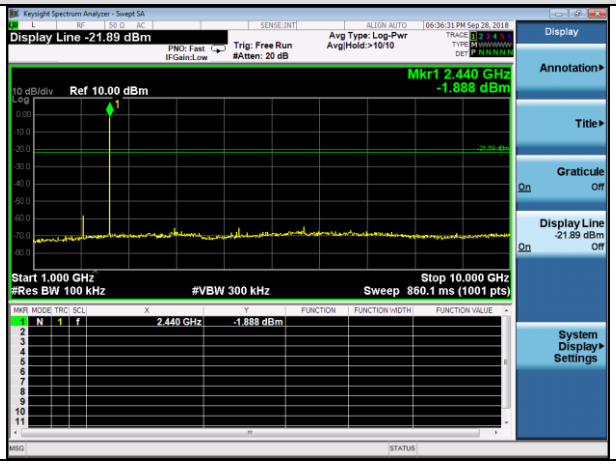
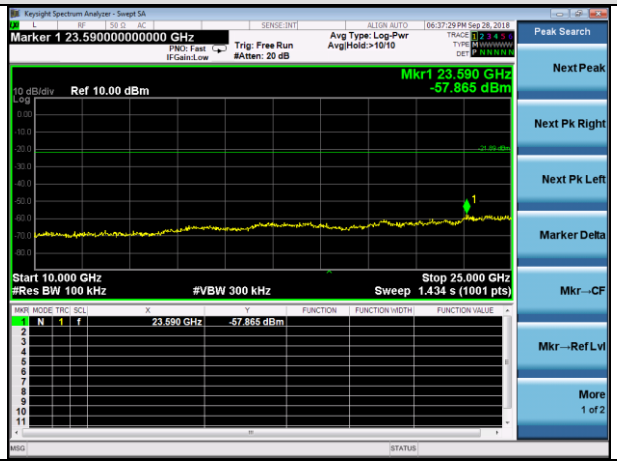
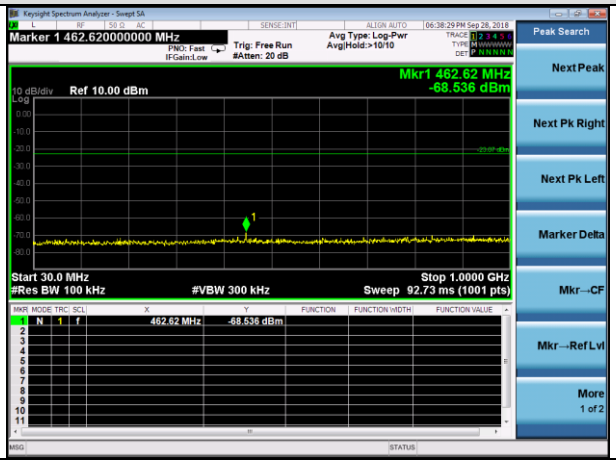
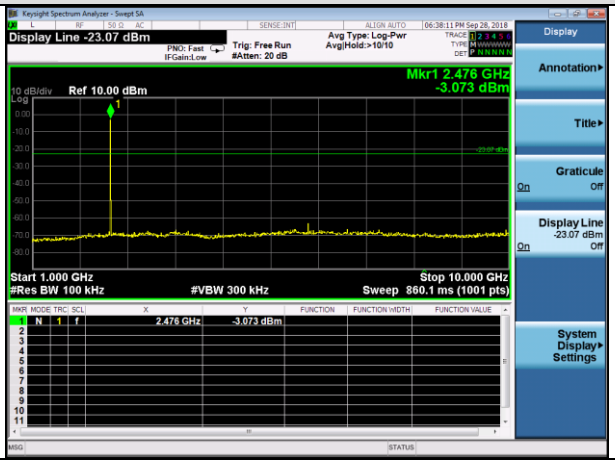


8DPSK-LCH	8DPSK-LCH
	

8DPSK-LCH	8DPSK-MCH
	

8DPSK-MCH	8DPSK-MCH
	

8DPSK-HCH	8DPSK-HCH
	

8DPSK-HCH	

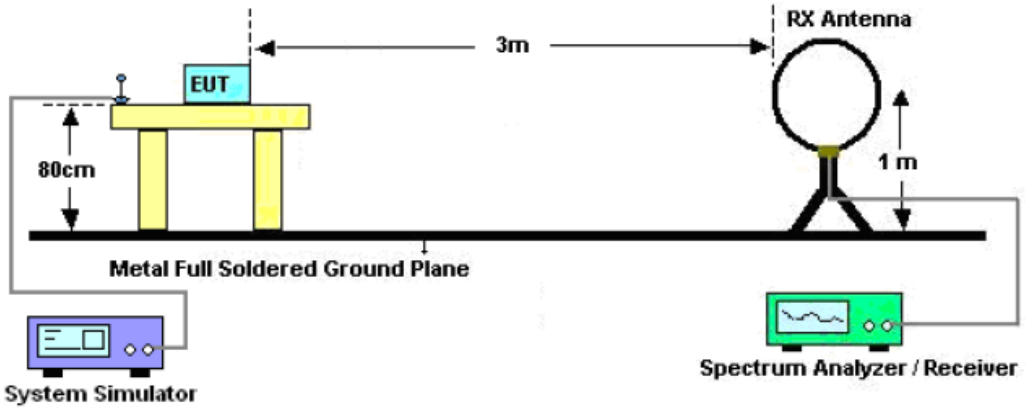
9. RADIATED EMISSION

9.1. MEASUREMENT PROCEDURE

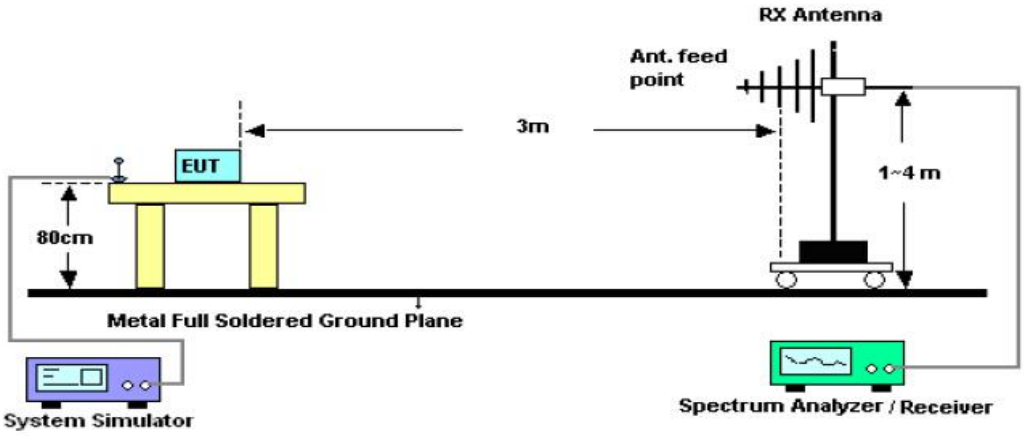
1. The EUT was placed on the top of the turntable 0.8 or 1.5 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 3 meters far away from the turntable.
2. Power on the EUT and all the supporting units. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization.
4. For each suspected emissions, the antenna tower was scan (from 1 M to 4 M) and then the turntable was rotated (from 0 degree to 360 degrees) to find the maximum reading.
5. Set the test-receiver system to Peak or CISPR quasi-peak Detect Function with specified bandwidth under Maximum Hold Mode.
6. For emissions above 1GHz, use 1MHz VBW and RBW for peak reading. Then 1MHz RBW and 10Hz VBW for average reading in spectrum analyzer. Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane.
7. When the radiated emissions limits are expressed in terms of the average value of the emissions, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum values.
8. If the emissions level of the EUT in peak mode was 3 dB lower than the average limit specified, then testing will be stopped and peak values of EUT will be reported, otherwise, the emissions which do not have 3 dB margin will be repeated one by one using the quasi-peak method for below 1GHz.
9. For testing above 1GHz, the emissions level of the EUT in peak mode was lower than average limit (that means the emissions level in peak mode also complies with the limit in average mode), then testing will be stopped and peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.
10. In case the emission is lower than 30MHz, loop antenna has to be used for measurement and the recorded data should be QP measured by receiver. High - Low scan is not required in this case.

9.2. TEST SETUP

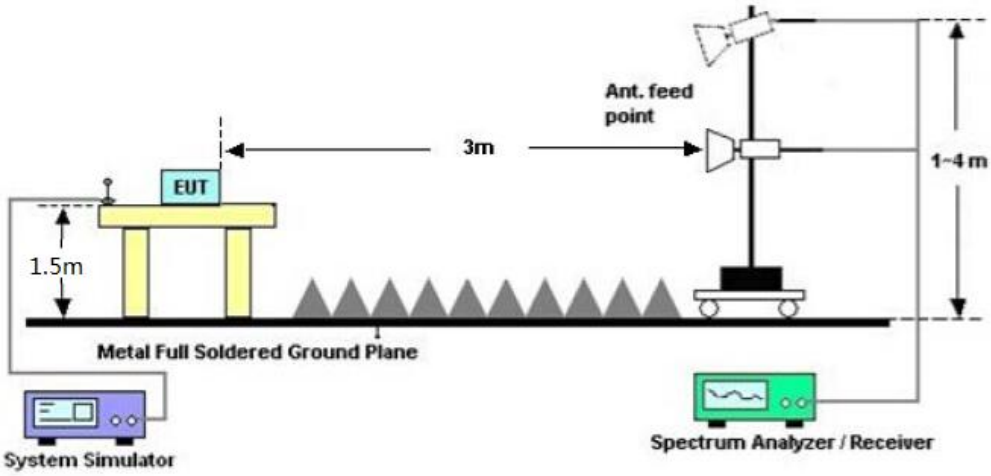
RADIATED EMISSION TEST-SETUP FREQUENCY BELOW 30MHZ



RADIATED EMISSION TEST SETUP 30MHz-1000MHz



RADIATED EMISSION TEST SETUP ABOVE 1000MHz



9.3. LIMITS AND MEASUREMENT RESULT

15.209(a) Limit in the below table has to be followed

Frequencies (MHz)	Field Strength (micorvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/F(KHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

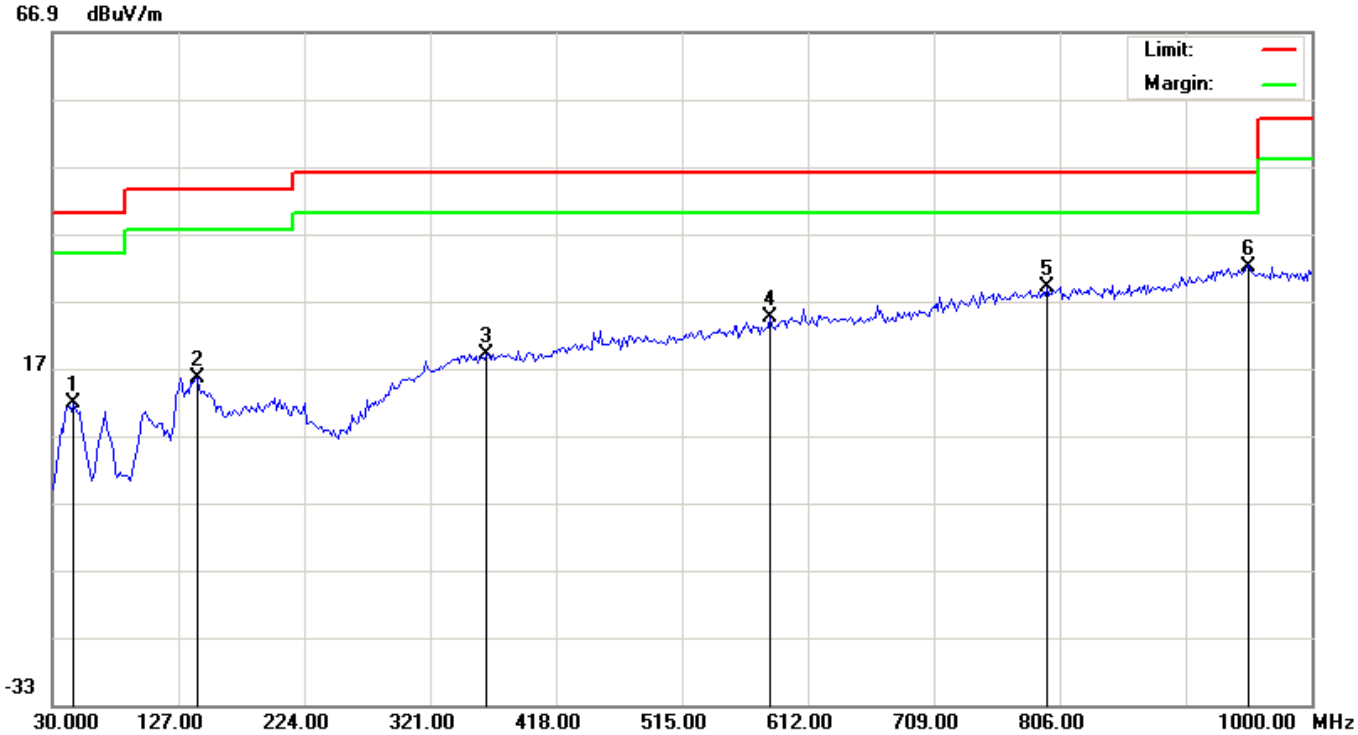
9.4. TEST RESULT

RADIATED EMISSION BELOW 30MHZ

No emission found between lowest internal used/generated frequencies to 30MHz.

RADIATED EMISSION BELOW 1GHZ

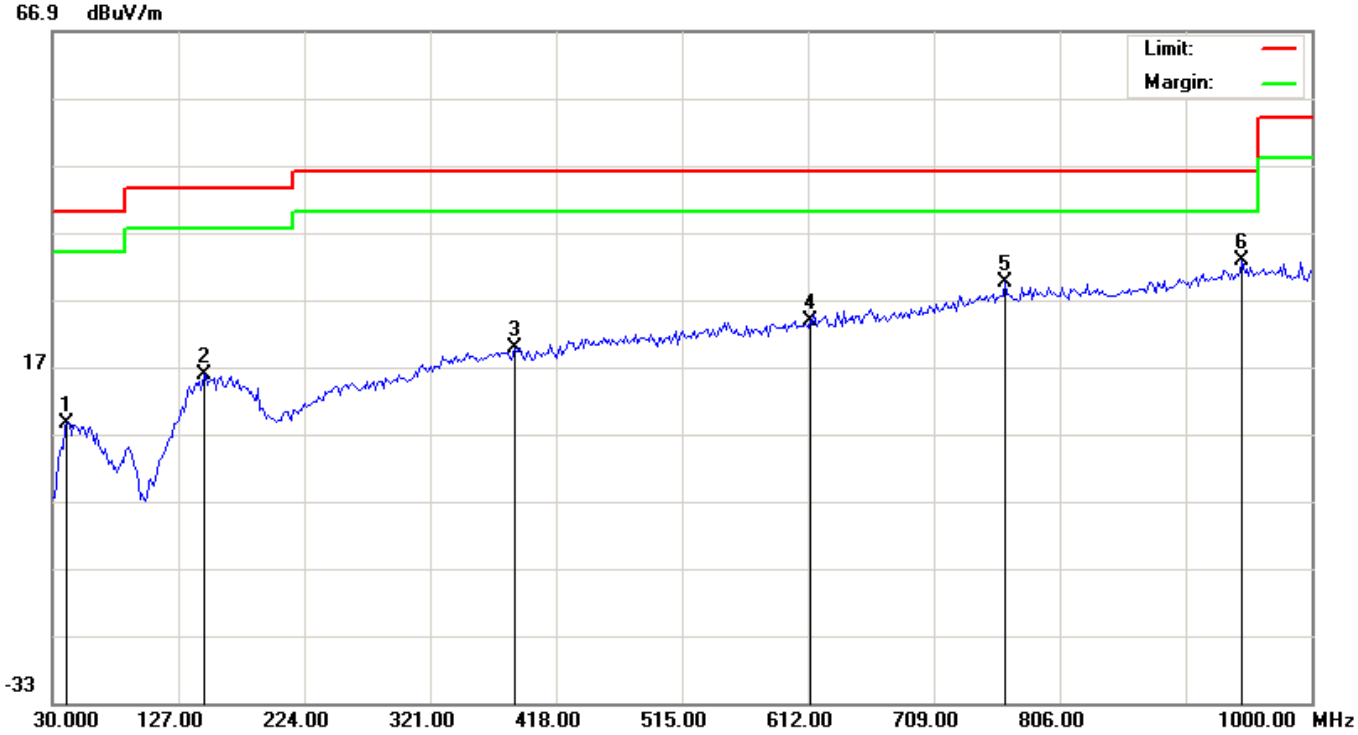
RADIATED EMISSION TEST- (30MHZ-1GHZ) -HORIZONTAL



No.	Mk	Freq.	Reading	Factor	Measurement	Limit	Over	Detector	Antenna Height	Table Degree	Comment
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB		cm	degree	
1		46.1667	0.40	11.49	11.89	40.00	-28.11	peak			
2		141.5500	0.72	14.82	15.54	43.50	-27.96	peak			
3		364.6500	0.21	18.84	19.05	46.00	-26.95	peak			
4		582.9000	1.24	23.30	24.54	46.00	-21.46	peak			
5		796.3000	1.83	27.27	29.10	46.00	-16.90	peak			
6	*	951.5000	2.16	29.99	32.15	46.00	-13.85	peak			

RESULT: PASS

RADIATED EMISSION TEST- (30MHZ-1GHZ) -VERTICAL



No.	Mk	Freq.	Reading	Factor	Measurement	Limit	Over	Detector	Antenna Height	Table Degree	Comment
	.	MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB		cm	degree	
1		41.3167	-0.27	8.81	8.54	40.00	-31.46	peak			
2		146.4000	0.59	15.24	15.83	43.50	-27.67	peak			
3		385.6667	0.85	18.98	19.83	46.00	-26.17	peak			
4		613.6167	0.84	23.04	23.88	46.00	-22.12	peak			
5		763.9667	2.75	26.82	29.57	46.00	-16.43	peak			
6	*	946.6500	2.75	29.91	32.66	46.00	-13.34	peak			

RESULT: PASS

Note: 1. Factor=Antenna Factor + Cable loss, Margin=Measurement-Limit.

2. The “Factor” value can be calculated automatically by software of measurement system.

3. All test modes for different EUT are pre-tested. The low channel for GFSK mode is the worst case and recorded in the report.

RADIATED EMISSION TEST- (ABOVE 1GHZ)

Frequency (MHz)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Detector Type	Comment
Low Channel (2402 MHz)					
4804	-22.26	-22.26	-22.26	Pk	Vertical
4804	-17.64	-17.64	-17.64	AV	Vertical
4804	-22.16	-22.16	-22.16	Pk	Horizontal
4804	-16.56	-16.56	-16.56	AV	Horizontal
Mid Channel (2441 MHz)					
4882	52.41	74	-21.59	Pk	Vertical
4882	38.25	54	-15.75	AV	Vertical
4882	51.25	74	-22.75	Pk	Horizontal
4882	37.42	54	-16.58	AV	Horizontal
High Channel (2480 MHz)					
4960	51.36	74	-22.64	pk	Vertical
4960	37.51	54	-16.49	AV	Vertical
4960	53.11	74	-20.89	pk	Horizontal
4960	41.34	54	-12.66	AV	Horizontal

RESULT: PASS

Note:

1. 1GHz~25GHz:(Scan with GFSK, π/4-DQPSK,8DPSK, the worst case is GFSK Mode, No recording in the test report at least have 20dB margin)
2. Margin = Emission Level - Limit

10. BAND EDGE EMISSION

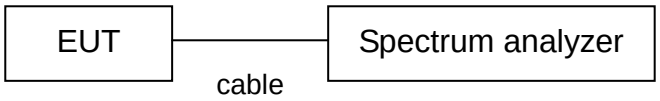
10.1. MEASUREMENT PROCEDURE

1. The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100kHz.The video bandwidth is set to 300kHz.
2. Transmitter set to the normal hopping mode at 2.4 and 2.4835 GHz.

10.2. TEST SET-UP

Radiated same as 10.2

Conducted set up



10.3. RADIATED TEST RESULT

Frequency (MHz)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Detector Type	Comment
GFSK					
2399.9	50.46	74	-23.54	peak	Vertical
2399.9	38.03	54	-15.97	AVG	Vertical
2399.9	49.44	74	-24.56	peak	Horizontal
2399.9	39.29	54	-14.71	AVG	Horizontal
2483.6	51.31	74	-22.69	peak	Vertical
2483.6	35.18	54	-18.82	AVG	Vertical
2483.6	51.22	74	-22.78	peak	Horizontal
2483.6	37.09	54	-16.91	AVG	Horizontal
π/4-DQPSK					
2399.9	51.11	74	-22.89	peak	Vertical
2399.9	40.32	54	-13.68	AVG	Vertical
2399.9	49.38	74	-24.62	peak	Horizontal
2399.9	39.42	54	-14.58	AVG	Horizontal
2483.6	51.69	74	-22.31	peak	Vertical
2483.6	35.43	54	-18.57	AVG	Vertical
2483.6	52.09	74	-21.91	peak	Horizontal
2483.6	38.43	54	-15.57	AVG	Horizontal
8DPSK					
2399.9	50.98	74	-23.02	peak	Vertical
2399.9	41.23	54	-12.77	AVG	Vertical
2399.9	50.39	74	-23.61	peak	Horizontal
2399.9	39.42	54	-14.58	AVG	Horizontal
2483.6	51.21	74	-22.79	peak	Vertical
2483.6	35.39	54	-18.61	AVG	Vertical
2483.6	52.10	74	-21.90	peak	Horizontal
2483.6	40.04	54	-13.96	AVG	Horizontal

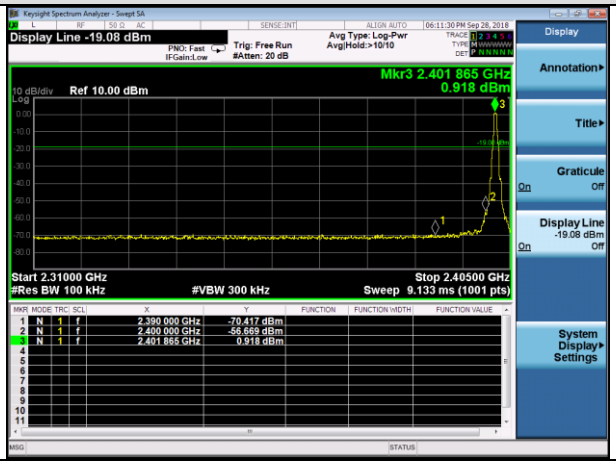
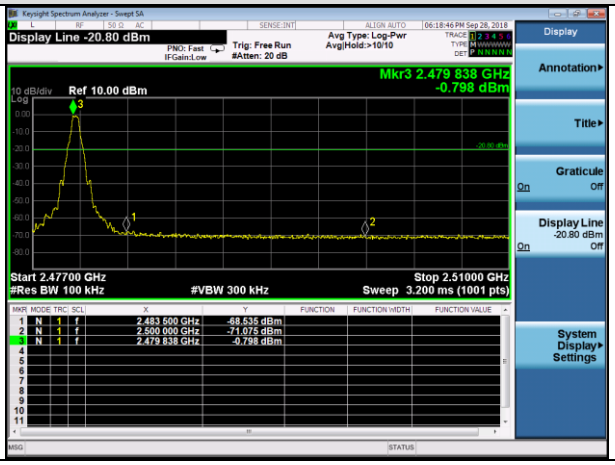
RESULT: PASS

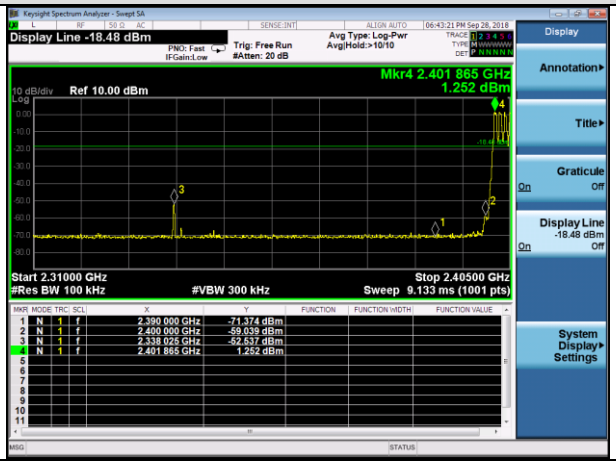
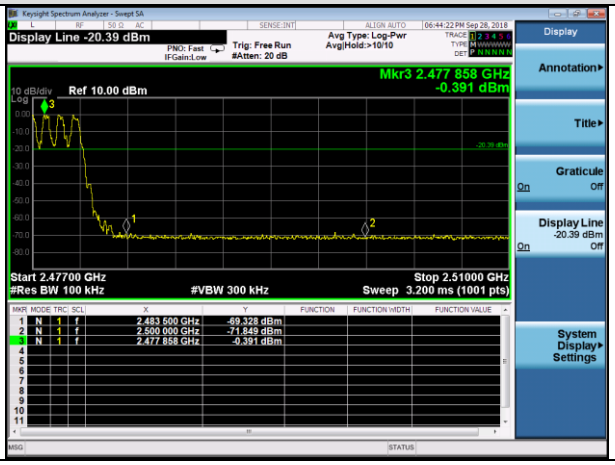
Note: The other modes radiation emission have enough 20dB margin.

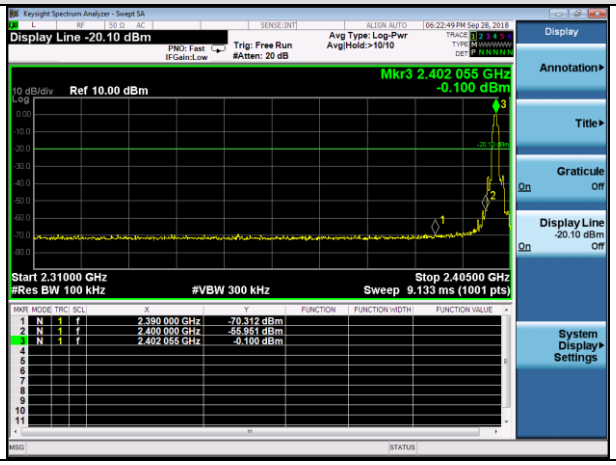
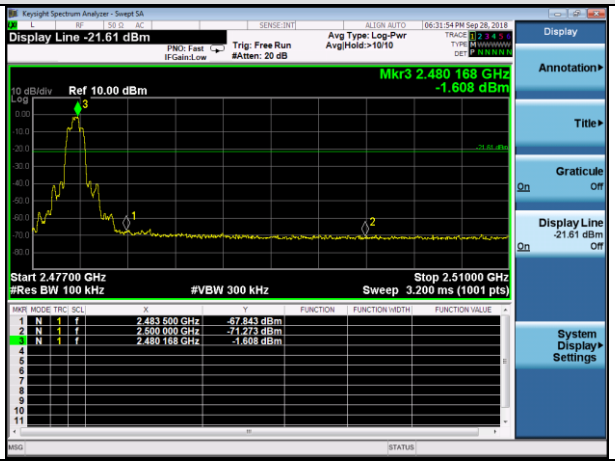
Margin = Emission Level – Limit

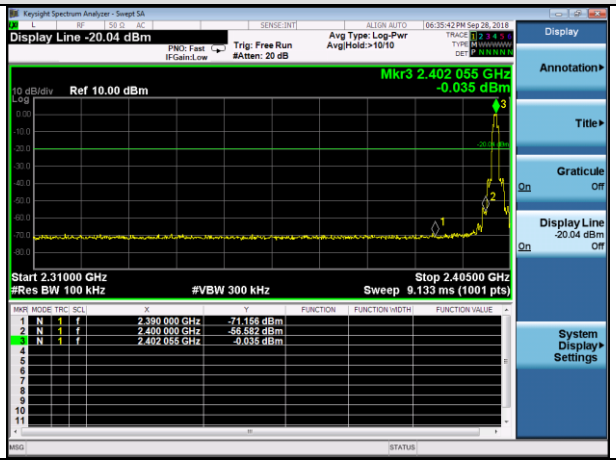
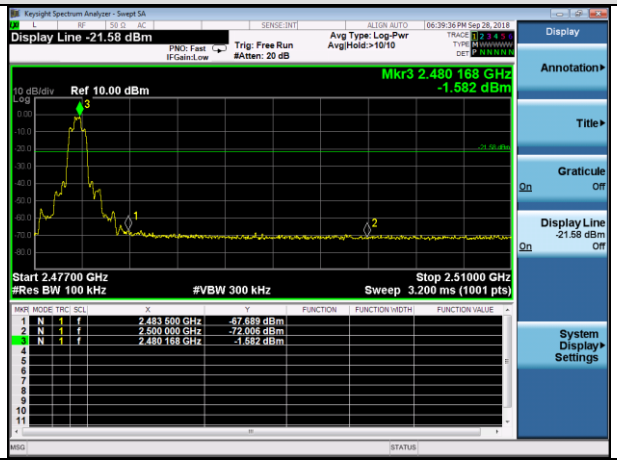
10.4 CONDUCTED TEST RESULT

Test Graph

GFSK/LCH/No Hop	GFSK/HCH/ No Hop
	

GFSK/LCH/Hop	GFSK/HCH/Hop
	

π/4DQPSK/LCH/No Hop	π/4DQPSK /HCH/No Hop
	

8DPSK/LCH/No Hop	8DPSK/HCH/No Hop
	

Note: All modes were tested, only the worst case record in the report.

11. NUMBER OF HOPPING FREQUENCY

11.1. MEASUREMENT PROCEDURE

1. Place the EUT on the table and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum analyzer.
3. Set the spectrum analyzer Start = 2.4GHz Stop = 2.4835GHz
4. Set the Spectrum Analyzer as RBW>=1%span, VBW>=RBW.

11.2. TEST SETUP (BLOCK DIAGRAM OF CONFIGURATION)

Same as described in section 8.2

11.3. MEASUREMENT EQUIPMENT USED

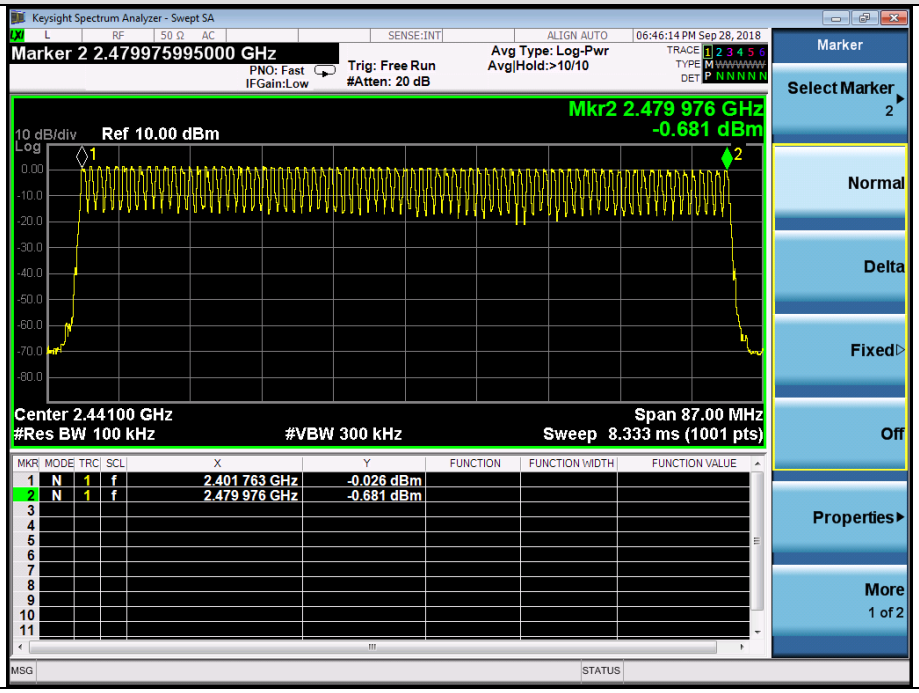
The same as described in section 6

11.4. LIMITS AND MEASUREMENT RESULT

Mode	Channel.	Number of Hopping Channel	Verdict
GFSK	Hop	79	PASS

Note: All modes were tested, only the worst case record in the report.

Test Graph

Graphs		
GFSK/Hop		

12. TIME OF OCCUPANCY (DWELL TIME)

12.1. MEASUREMENT PROCEDURE

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
1. Span: Zero span, centered on a hopping channel.
2. RBW shall be≤channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
3. Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel.
4. Detector function: Peak. Trace: Max hold.
5. Use the marker-delta function to determine the transmit time per hop.
6. Using the following equation:

The dwell time is calculated with the following formula:

Dwell time = t_{pulse} x n_{hops} / number of channels x 31.6 s

Where:

t_{pulse} is the measured pulse time (pls. refer the plots of the spectrum analyser above) [s],
n_{hops} is the number of hops per second in the actual operating mode of the transmitter [1/s].

The hopping rate of the system is 1600 hops per second and the system uses 79 channels. For this reason one time slot has a length of 625 µs.

With the used hopping mode (DH5) a packet need 5 timeslots for transmitting and the next timeslot for receiving. So the system makes in worst case 266,67 hops per second in transmit mode (n_{hops} = 266.667 1/s)

12.2. TEST SETUP (BLOCK DIAGRAM OF CONFIGURATION)

Same as described in section 8.2

12.3. MEASUREMENT EQUIPMENT USED

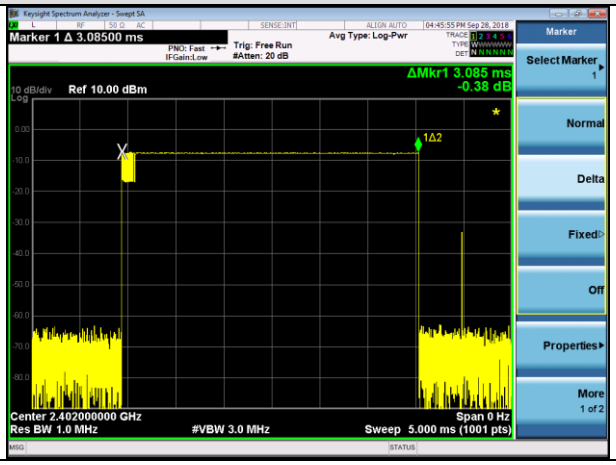
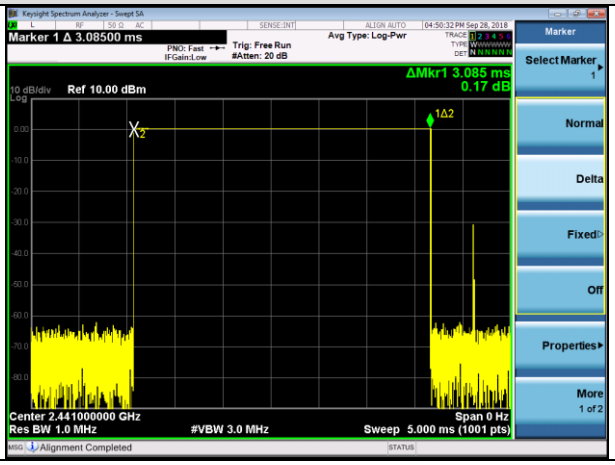
The same as described in section 6

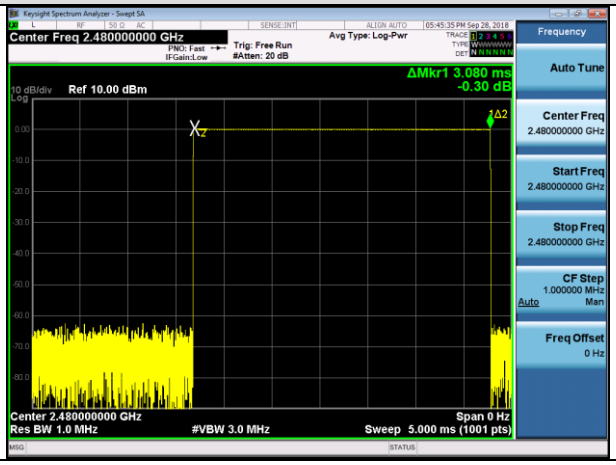
12.4. LIMITS AND MEASUREMENT RESULT

Channel.	Burst Width [ms/hop/ch]	Dwell Time[ms]	Verdict	Limit (ms)
LCH	3.085	329.0671	PASS	400
MCH	3.085	329.0671	PASS	400
HCH	3.080	328.5337	PASS	400

Note: The DH5 for GFSK modulation is the worst case and recorded in the report.

Test Graph

GFSK-LCH	GFSK-MCH
	

GFSK-HCH	
	

13. FREQUENCY SEPARATION

13.1. MEASUREMENT PROCEDURE

1. Place the EUT on the table and set it in transmitting mode
2. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum analyzer
3. Set Span = wide enough to capture the peaks of two adjacent channels Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span Video (or Average) Bandwidth (VBW) ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold

13.2. TEST SETUP (BLOCK DIAGRAM OF CONFIGURATION)

Same as described in section 6.2

13.3. MEASUREMENT EQUIPMENT USED

The same as described in section 6.3

13.4. LIMITS AND MEASUREMENT RESULT

Mode	Channel.	Carrier Frequency Separation [MHz]	Verdict
GFSK	Hop	0.999	PASS

Note: All modes were tested, only the worst case record in the report.

Test Graph

Graphs	
GFSK/Hop	

14. FCC LINE CONDUCTED EMISSION TEST

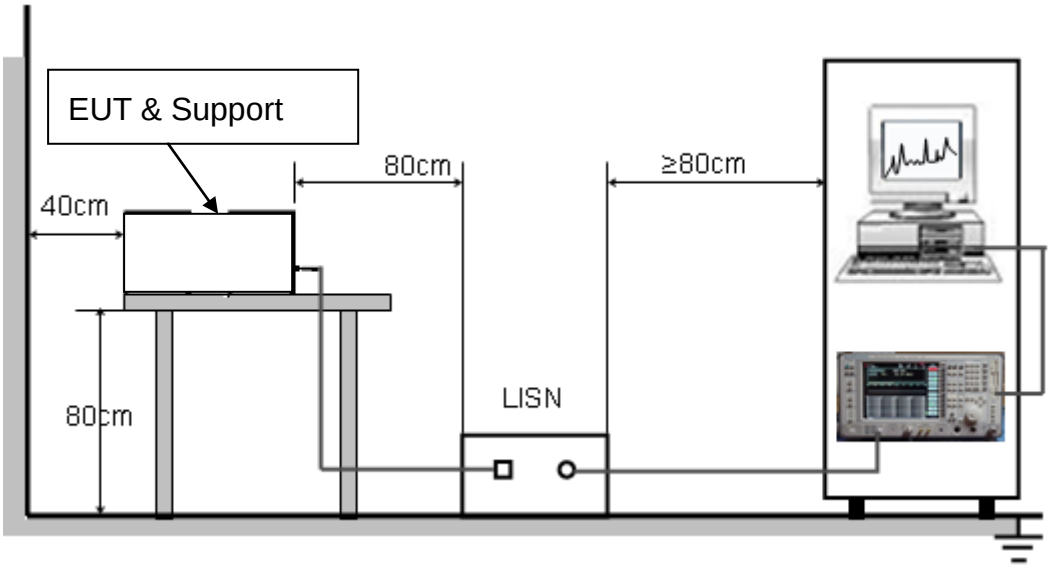
15.1. LIMITS OF LINE CONDUCTED EMISSION TEST

Frequency	Maximum RF Line Voltage	
	Q.P.(dBuV)	Average(dBuV)
150kHz~500kHz	66-56	56-46
500kHz~5MHz	56	46
5MHz~30MHz	60	50

Note:

1. The lower limit shall apply at the transition frequency.
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz.

14.2. BLOCK DIAGRAM OF LINE CONDUCTED EMISSION TEST



14.3. PRELIMINARY PROCEDURE OF LINE CONDUCTED EMISSION TEST

1. The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. When the EUT is a tabletop system, a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10 (see Test Facility for the dimensions of the ground plane used). When the EUT is a floor-standing equipment, it is placed on the ground plane which has a 3-12 mm non-conductive covering to insulate the EUT from the ground plane.
2. Support equipment, if needed, was placed as per ANSI C63.10.
3. All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10.
4. All support equipments received AC120V/60Hz power from a LISN, if any.
5. The EUT received DC charging voltage by adapter which received 120V/60Hzpower by a LISN..
6. The test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
7. Analyzer / Receiver scanned from 150 kHz to 30MHz for emissions in each of the test modes.
8. During the above scans, the emissions were maximized by cable manipulation.
9. The test mode(s) were scanned during the preliminary test.

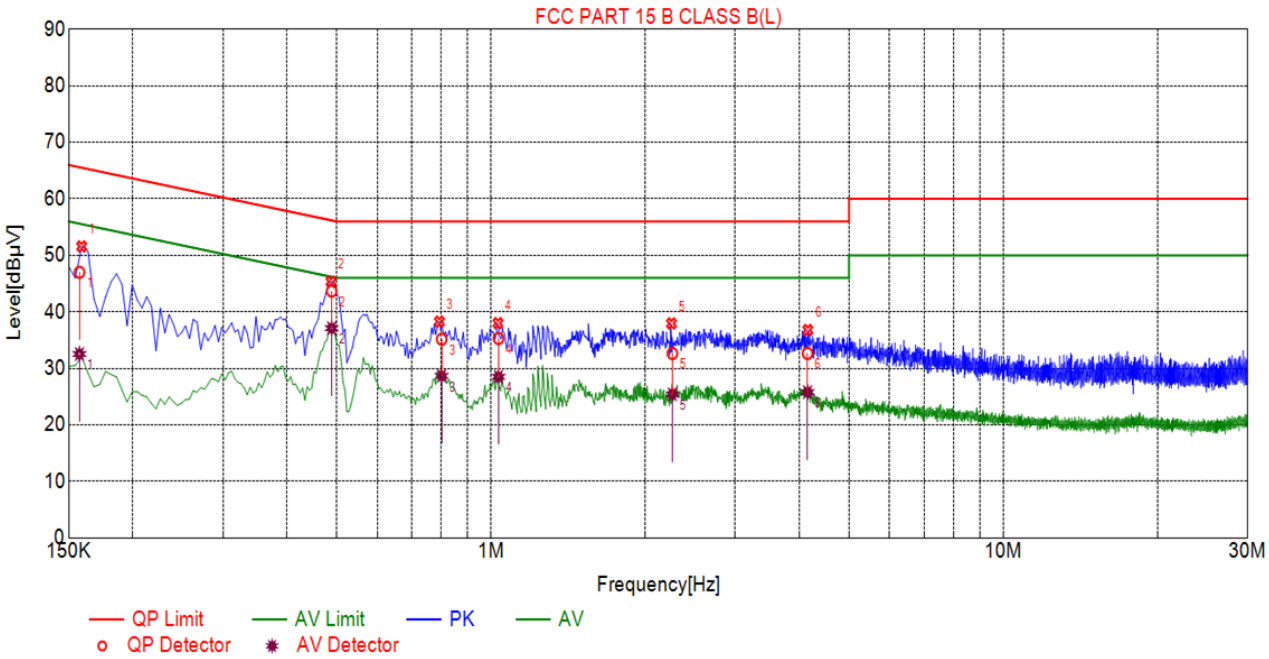
Then, the EUT configuration and cable configuration of the above highest emission level were recorded for reference of final testing.

14.4. FINAL PROCEDURE OF LINE CONDUCTED EMISSION TEST

1. EUT and support equipment was set up on the test bench as per step 2 of the preliminary test.
2. A scan was taken on both power lines, Line 1 and Line 2, recording at least the six highest emissions. Emission frequency and amplitude were recorded into a computer in which correction factors were used to calculate the emission level and compare reading to the applicable limit. If EUT emission level was less –2dB to the A.V. limit in Peak mode, then the emission signal was re-checked using Q.P and Average detector.
3. The test data of the worst case condition(s) was reported on the Summary Data page.

14.5. TEST RESULT OF LINE CONDUCTED EMISSION TEST

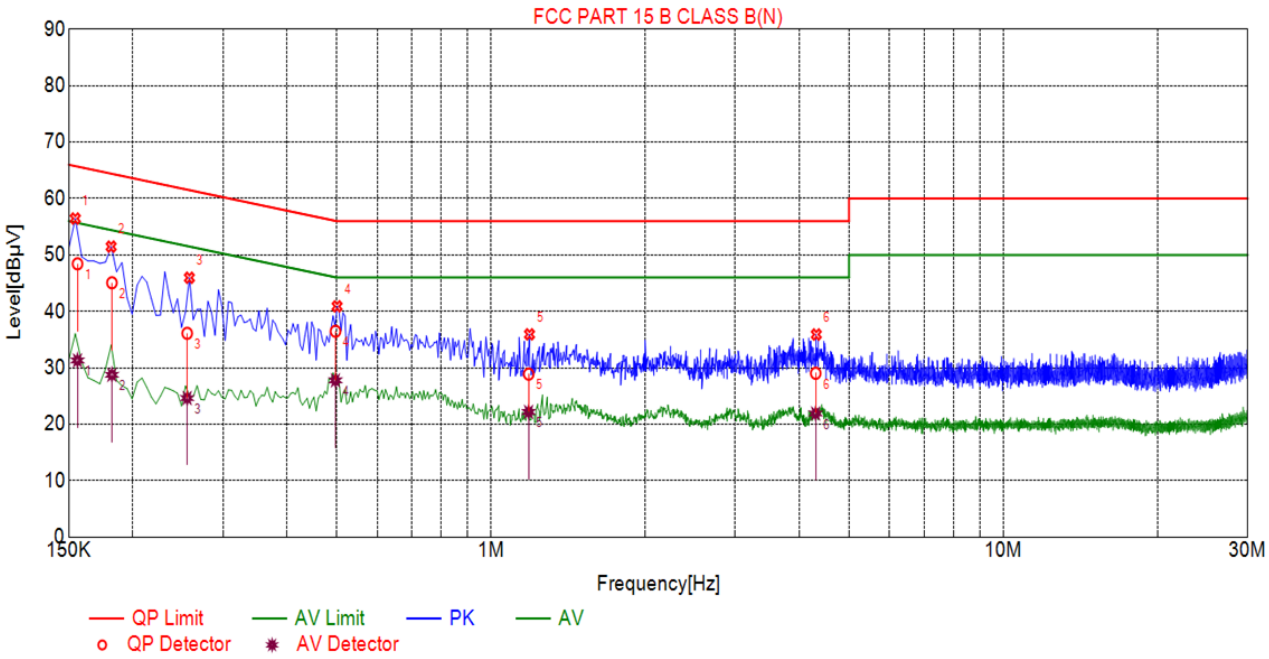
LINE CONDUCTED EMISSION TEST LINE 1-L



Suspected List						
NO.	Freq. [MHz]	Level [dBμV]	Factor [dB]	Limit [dBμV]	Margin [dB]	Detector
1	0.1590	51.58	10.01	65.52	13.94	PK
2	0.4875	45.34	10.04	56.21	10.87	PK
3	0.7935	38.27	10.05	56.00	17.73	PK
4	1.0320	37.99	10.07	56.00	18.01	PK
5	2.2515	37.95	10.18	56.00	18.05	PK
6	4.1550	36.78	10.25	56.00	19.22	PK

Final Data List								
NO.	Freq. [MHz]	Factor [dB]	QP Value [dBμV]	QP Limit [dBμV]	QP Margin [dB]	AV Value [dBμV]	AV Limit [dBμV]	AV Margin [dB]
1	0.1574	10.01	47.01	65.60	18.59	32.53	55.60	23.07
2	0.4889	10.04	43.69	56.19	12.50	37.10	46.19	9.09
3	0.8014	10.06	35.16	56.00	20.84	28.66	46.00	17.34
4	1.0344	10.07	35.29	56.00	20.71	28.50	46.00	17.50
5	2.2598	10.18	32.64	56.00	23.36	25.41	46.00	20.59
6	4.1491	10.25	32.64	56.00	23.36	25.79	46.00	20.21

LINE CONDUCTED EMISSION TEST LINE 2-N



Suspected List

NO.	Freq. [MHz]	Level [dBµV]	Factor [dB]	Limit [dBµV]	Margin [dB]	Detector
1	0.1545	56.46	10.03	65.75	9.29	PK
2	0.1815	51.48	10.06	64.42	12.94	PK
3	0.2580	45.96	10.04	61.50	15.54	PK
4	0.5010	40.89	10.04	56.00	15.11	PK
5	1.1895	35.93	10.09	56.00	20.07	PK
6	4.3170	35.90	10.25	56.00	20.10	PK

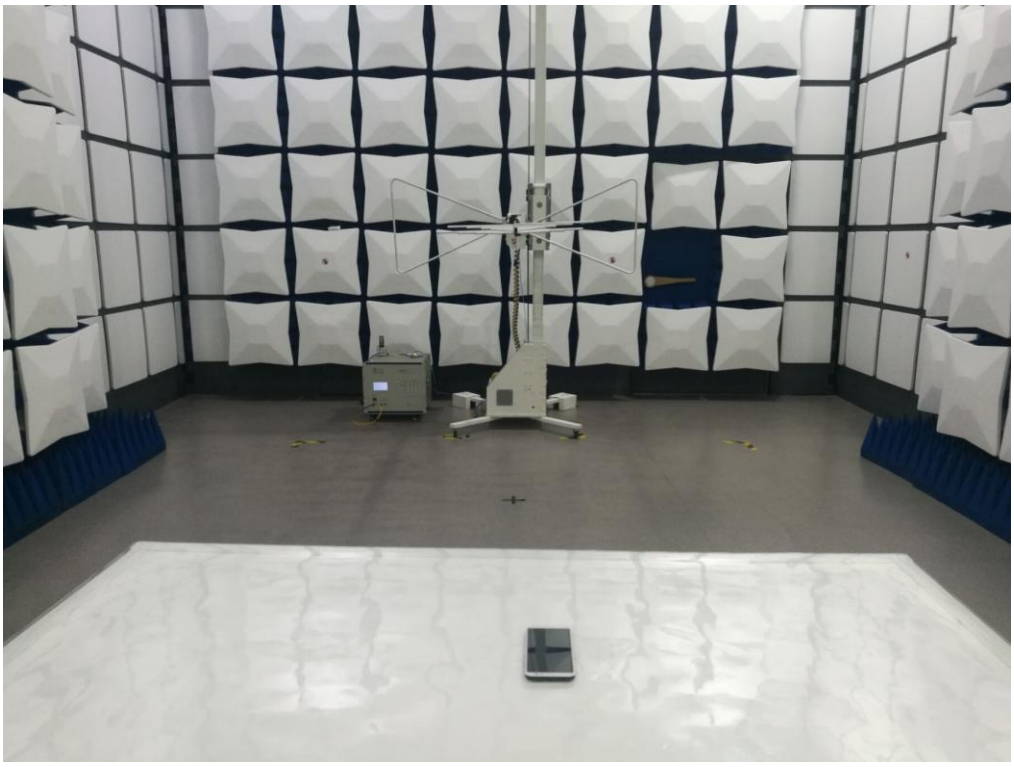
Final Data List

NO.	Freq. [MHz]	Factor [dB]	QP Value [dBµV]	QP Limit [dBµV]	QP Margin [dB]	AV Value [dBµV]	AV Limit [dBµV]	AV Margin [dB]
1	0.1560	10.02	48.44	65.67	17.23	31.30	55.67	24.37
2	0.1821	10.06	45.07	64.39	19.32	28.75	54.39	25.64
3	0.2554	10.04	36.12	61.58	25.46	24.63	51.58	26.95
4	0.4973	10.04	36.47	56.04	19.57	27.77	46.04	18.27
5	1.1849	10.09	28.88	56.00	27.12	22.17	46.00	23.83
6	4.3034	10.25	29.03	56.00	26.97	21.90	46.00	24.10

APPENDIX A: PHOTOGRAPHS OF TEST SETUP

LINE CONDUCTED EMISSION TEST SETUP

RADIATED EMISSION TEST SETUP



RADIATED EMISSION ABOVE 1G TEST SETUP

----END OF REPORT----