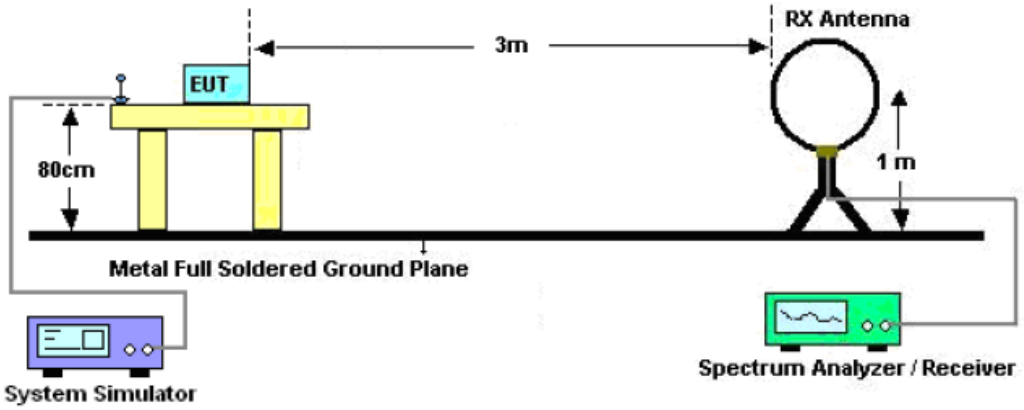
10. RADIATED EMISSION

10.1. MEASUREMENT PROCEDURE

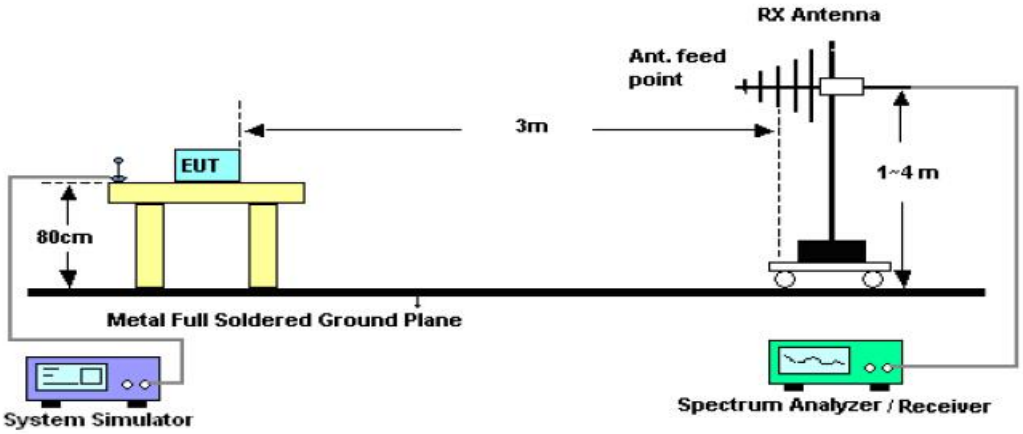
1. The EUT was placed on the top of the turntable 0.8 or 1.5 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 3 meters far away from the turntable.
2. Power on the EUT and all the supporting units. The turntable was rotated 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.

10.2. TEST SETUP

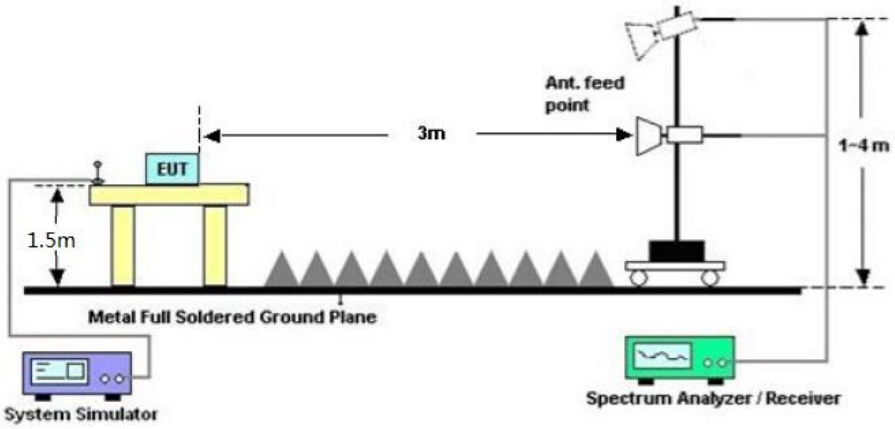
Radiated Emission Test-Setup Frequency Below 30MHz



RADIATED EMISSION TEST SETUP 30MHz-1000MHz



RADIATED EMISSION TEST SETUP ABOVE 1000MHz



10.3. 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

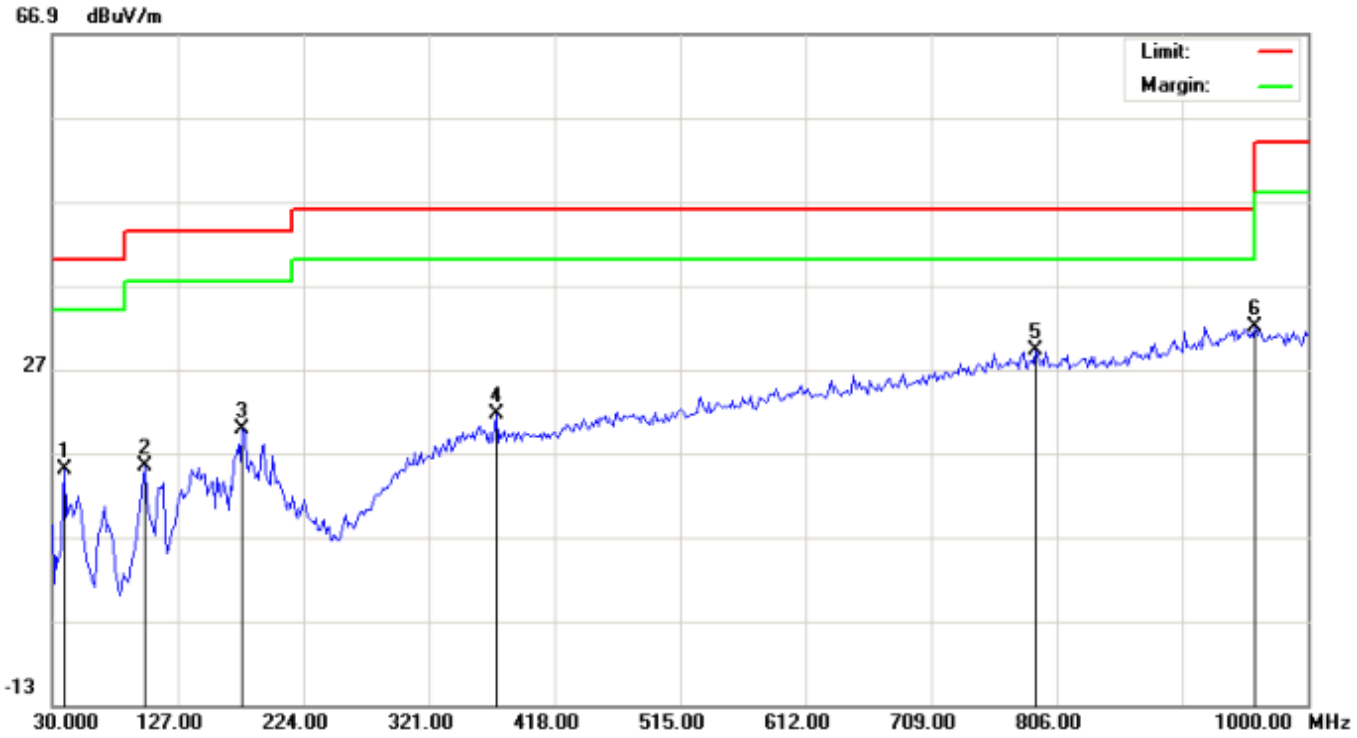
10.4. TEST RESULT

RADIATED EMISSION BELOW 30MHZ

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

RADIATED EMISSION BELOW 1GHZ

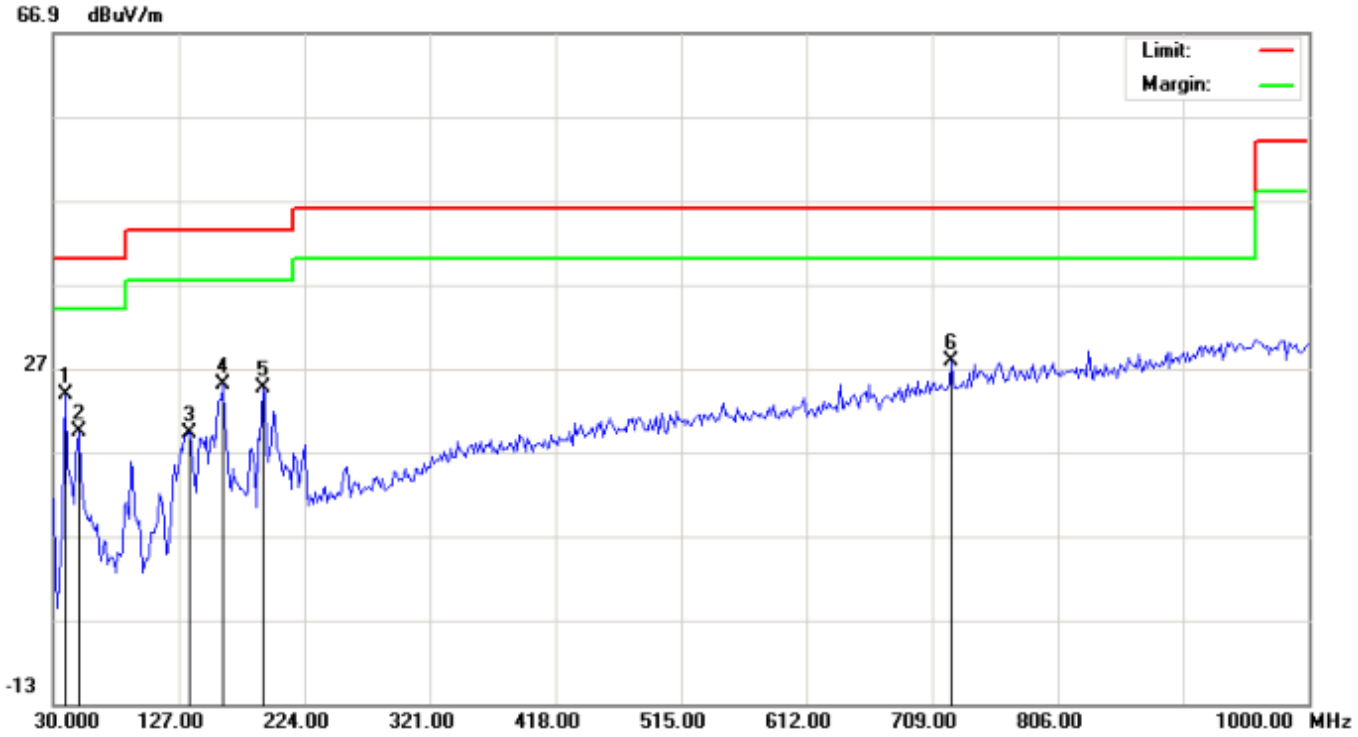
RADIATED EMISSION TEST- (30MHZ-1GHZ) -HORIZONTAL



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		39.7000	3.58	11.51	15.09	40.00	-24.91	peak			
2		101.1333	5.26	10.22	15.48	43.50	-28.02	peak			
3		177.1167	8.75	10.96	19.71	43.50	-23.79	peak			
4		372.7333	2.62	18.89	21.51	46.00	-24.49	peak			
5		789.8333	2.03	27.18	29.21	46.00	-16.79	peak			
6	*	959.5833	2.08	29.91	31.99	46.00	-14.01	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	*	39.7000	15.36	8.51	23.87	40.00	-16.13	peak			
2		49.4000	11.20	8.28	19.48	40.00	-20.52	peak			
3		135.0833	6.05	13.15	19.20	43.50	-24.30	peak			
4		160.9500	9.66	15.27	24.93	43.50	-18.57	peak			
5		191.6667	13.47	11.11	24.58	43.50	-18.92	peak			
6		723.5500	1.99	25.87	27.86	46.00	-18.14	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 worst mode for the worst EUT recorded in the report.

RADIATED EMISSION TEST- (ABOVE 1GHZ)

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector	Comment
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	Type	
Low Channel (2402 MHz)							
4804	63.56	-3.62	59.94	74	-14.06	Pk	Vertical
4804	42.34	-3.62	38.72	54	-15.28	AV	Vertical
4804	62.88	-3.64	59.24	74	-14.76	Pk	Horizontal
4804	45.37	-3.64	41.73	54	-12.27	AV	Horizontal
Mid Channel (2441 MHz)							
4882	63.74	-3.65	60.09	74	-13.91	Pk	Vertical
4882	43.51	-3.65	39.86	54	-14.14	AV	Vertical
4882	63.02	-3.68	59.34	74	-14.66	Pk	Horizontal
4882	42.83	-3.68	39.15	54	-14.85	AV	Horizontal
High Channel (2480 MHz)							
4960	61.49	-3.59	57.90	74	-16.10	pk	Vertical
4960	43.50	-3.59	39.91	54	-14.09	AV	Vertical
4960	59.86	-3.59	56.27	74	-17.73	pk	Horizontal
4960	41.45	-3.59	37.86	54	-16.14	AV	Horizontal

Note:

1) 30MHz~25GHz:(Scan with GFSK, π/4-DQPSK,8DPSK, the worst casw is GFSK Mode)
2) Factor = Antenna Factor + Cable Loss – Pre-amplifier.
   Emission Level = Meter Reading + Factor
   Margin = Emission Leve - Limit

RESULT: PASS

11. BAND EDGE EMISSION

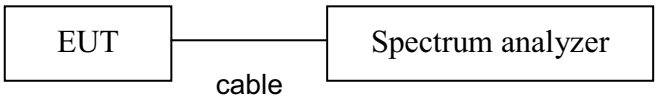
11.1. MEASUREMENT PROCEDURE

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.

11.2. TEST SET-UP

Radiated same as 10.2

Conducted set up



11.3. Radiated TEST RESULT

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector	Comment
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	Type	
GFSK							
2399.9	62.31	-12.99	49.32	74	-24.68	peak	Vertical
2399.9	53.60	-12.99	40.61	54	-13.39	AVG	Vertical
2399.9	66.65	-12.99	53.66	74	-20.34	peak	Horizontal
2399.9	47.43	-12.99	34.44	54	-19.56	AVG	Horizontal
2483.6	61.27	-12.78	48.49	74	-25.51	peak	Vertical
2483.6	52.13	-12.78	39.35	54	-14.65	AVG	Vertical
2483.6	63.01	-12.78	50.23	74	-23.77	peak	Horizontal
2483.6	53.82	-12.78	41.04	54	-12.96	AVG	Horizontal
π/4-DQPSK							
2399.9	60.03	-12.99	47.04	74	-26.96	peak	Vertical
2399.9	54.27	-12.99	41.28	54	-12.72	AVG	Vertical
2399.9	63.42	-12.99	50.43	74	-23.57	peak	Horizontal
2399.9	53.86	-12.99	40.87	54	-13.13	AVG	Horizontal
2483.6	61.98	-12.78	49.20	74	-24.80	peak	Vertical
2483.6	51.47	-12.78	38.69	54	-15.31	AVG	Vertical
2483.6	61.33	-12.78	48.55	74	-25.45	peak	Horizontal
2483.6	50.35	-12.78	37.57	54	-16.43	AVG	Horizontal
8DPSK							
2399.9	62.86	-12.99	49.87	74	-24.13	peak	Vertical
2399.9	55.45	-12.99	42.46	54	-11.54	AVG	Vertical
2399.9	63.91	-12.99	50.92	74	-23.08	peak	Horizontal
2399.9	50.56	-12.99	37.57	54	-16.43	AVG	Horizontal
2483.6	60.69	-12.78	47.91	74	-26.09	peak	Vertical
2483.6	53.43	-12.78	40.65	54	-13.35	AVG	Vertical
2483.6	62.01	-12.78	49.23	74	-24.77	peak	Horizontal
2483.6	56.20	-12.78	43.42	54	-10.58	AVG	Horizontal

RESULT: PASS

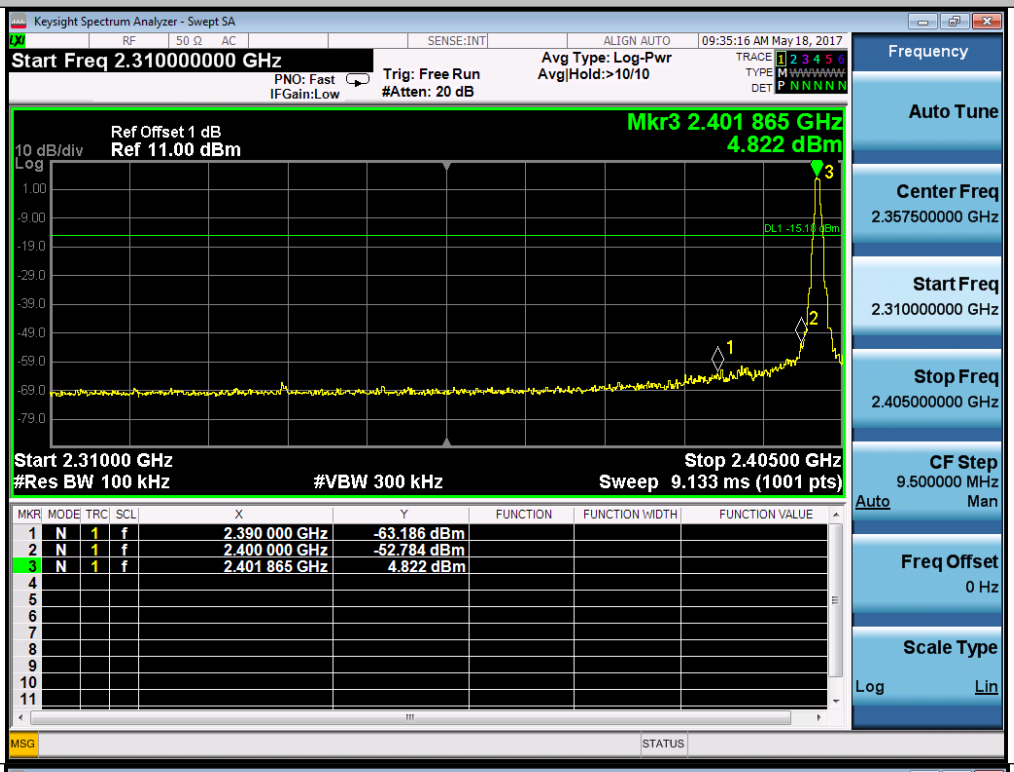
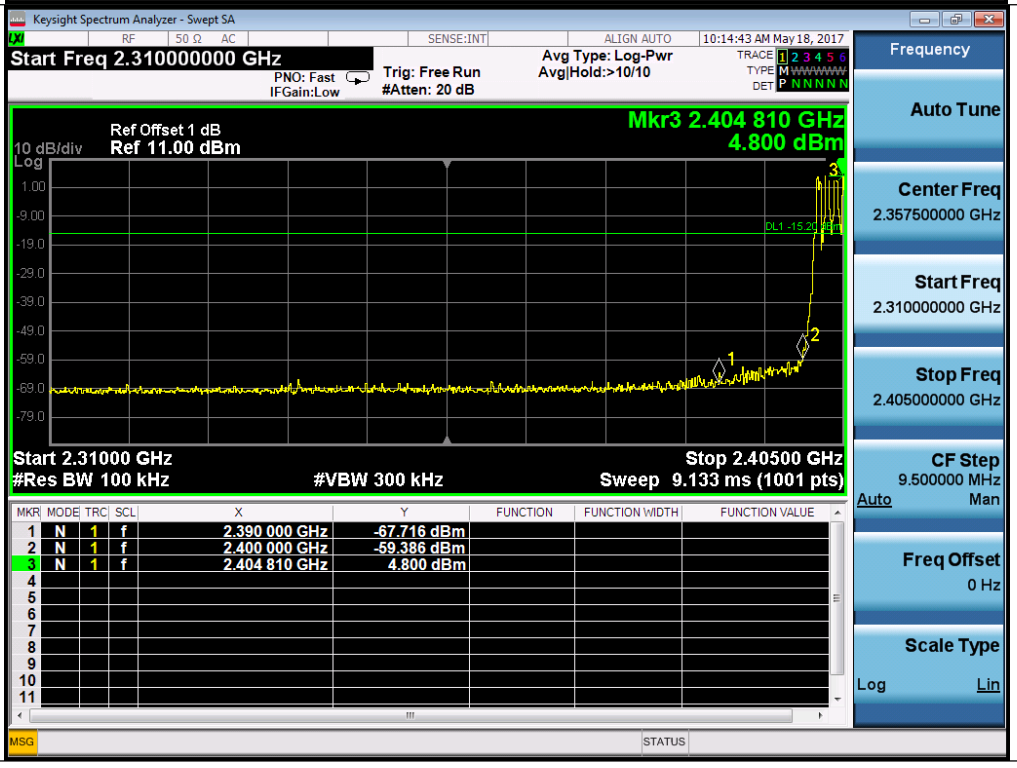
Note: The other modes radiation emission have enough 20dB margin.

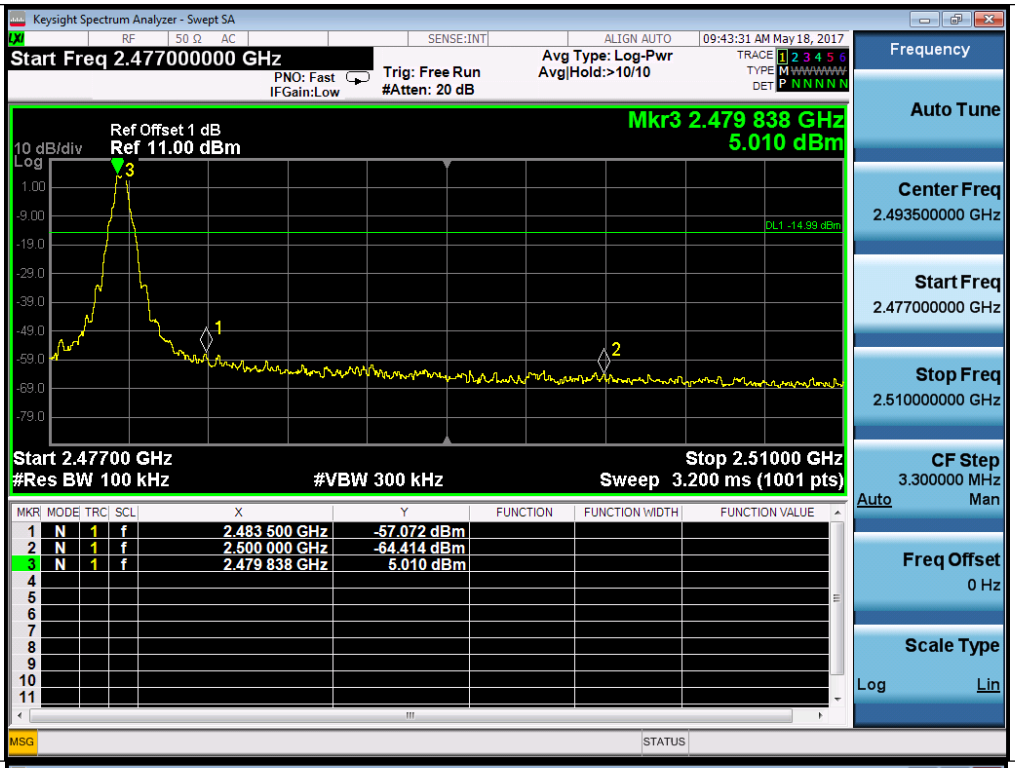
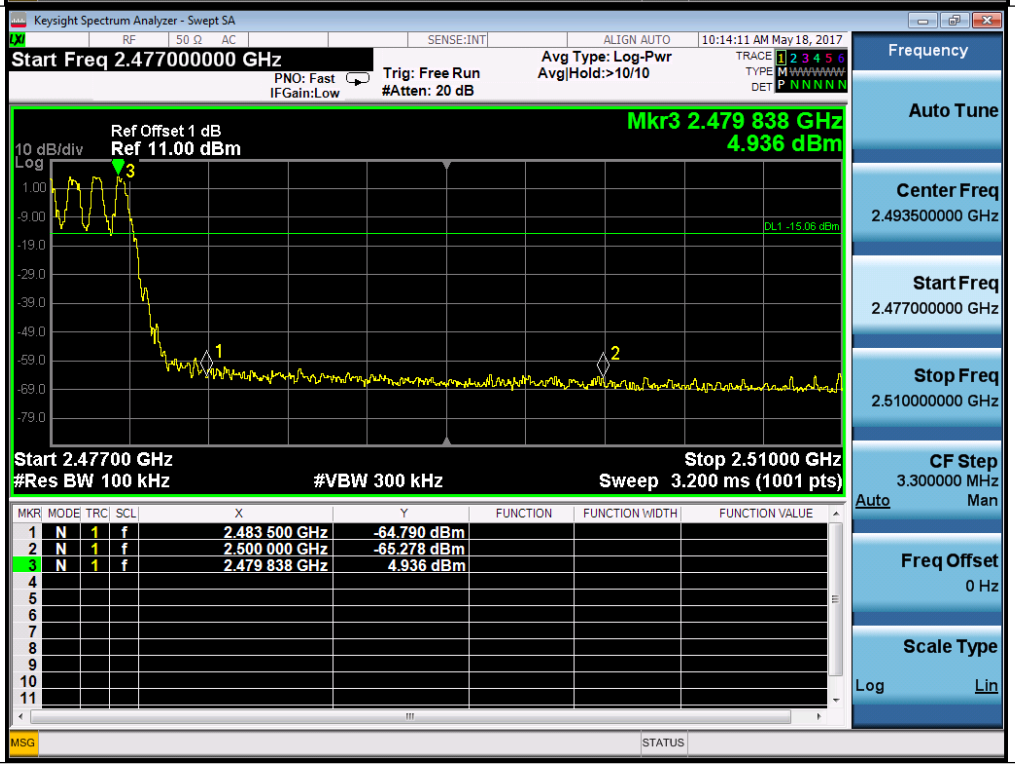
Factor=Antenna Factor + Cable loss - Amplifier gain, Over=Measure-Limit.

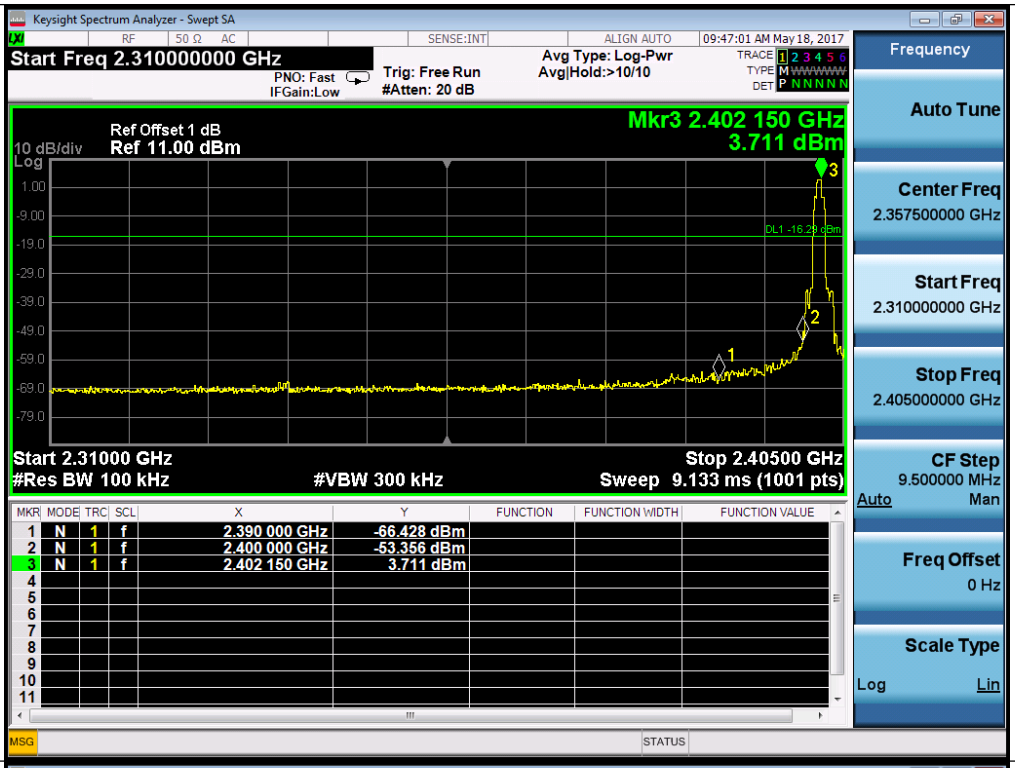
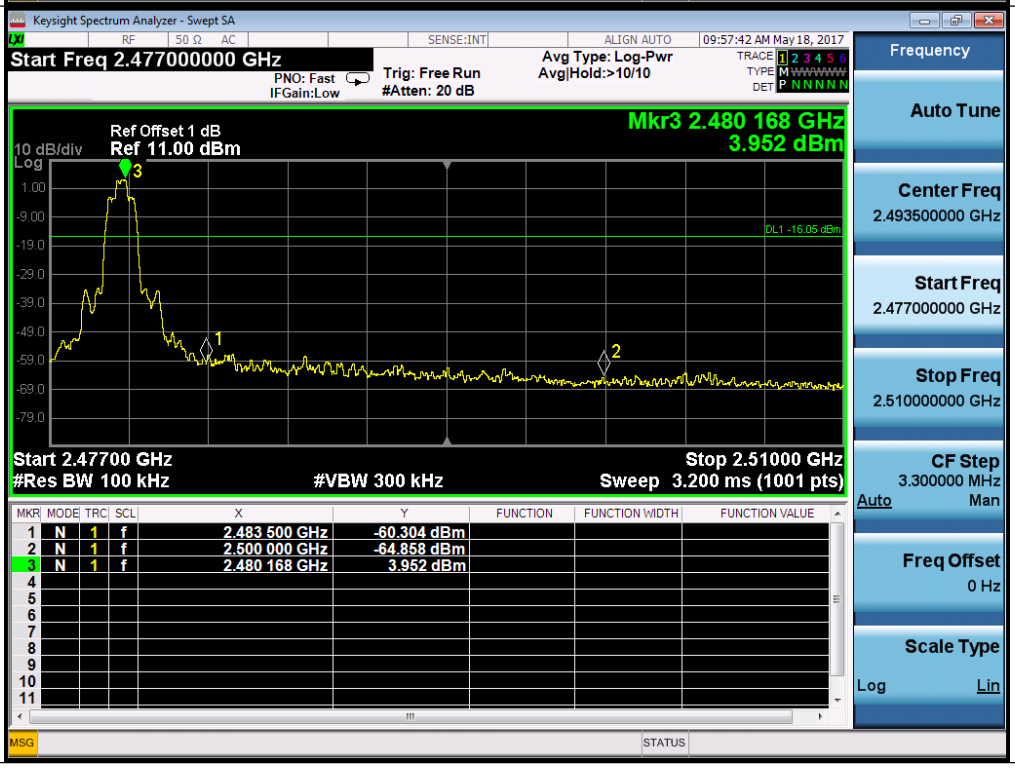
The “Factor” value can be calculated automatically by software of measurement system.

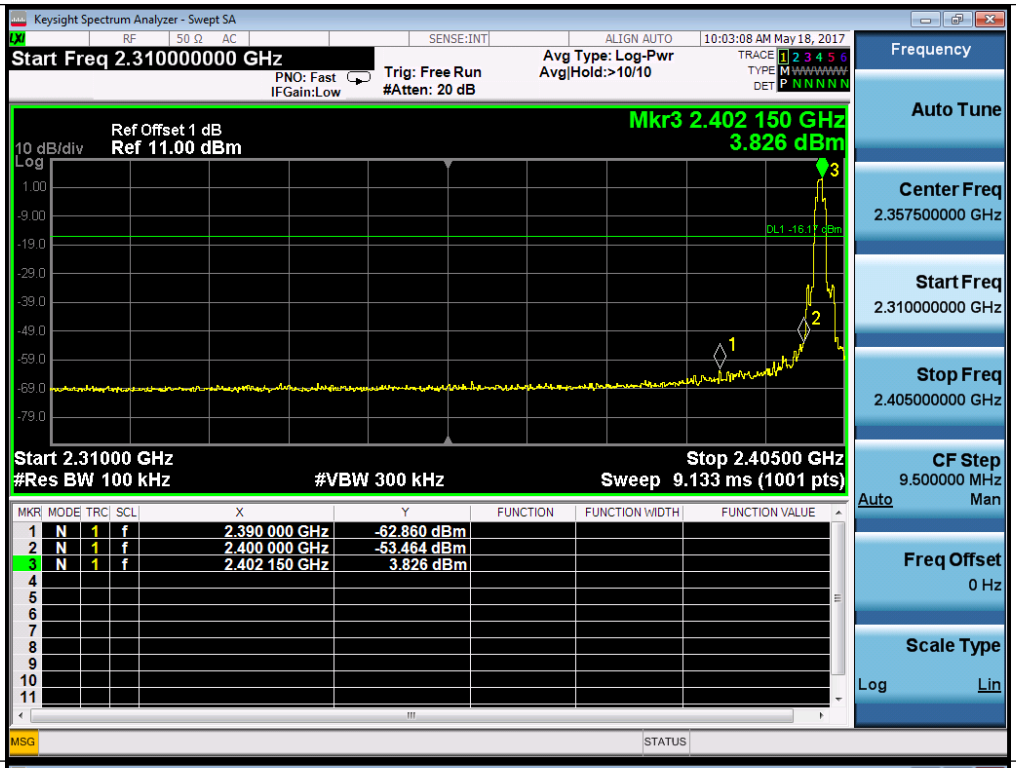
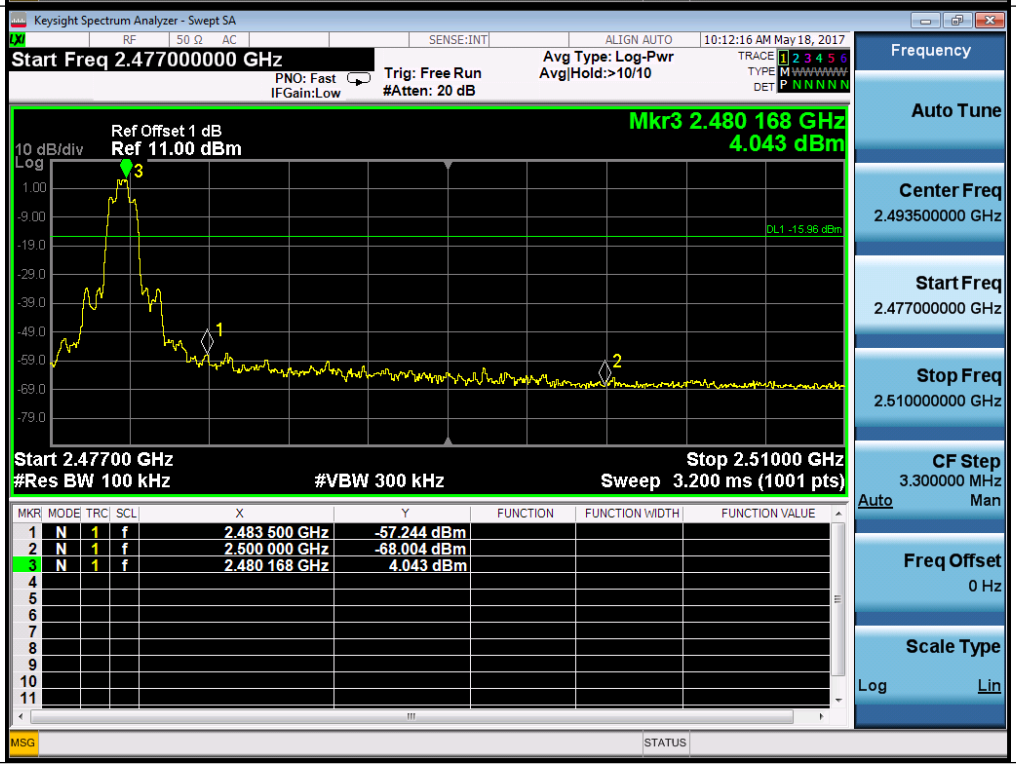
11.4 Conducted TEST RESULT

Test Graph

Graphs		
GFSK/LCH/No Hop		
GFSK/LCH/ Hop		

GFSK/HCH/No 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.

12. NUMBER OF HOPPING FREQUENCY

12.1. 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.

12.2. TEST SETUP (BLOCK DIAGRAM OF CONFIGURATION)

Same as described in section 8.2

12.3. MEASUREMENT EQUIPMENT USED

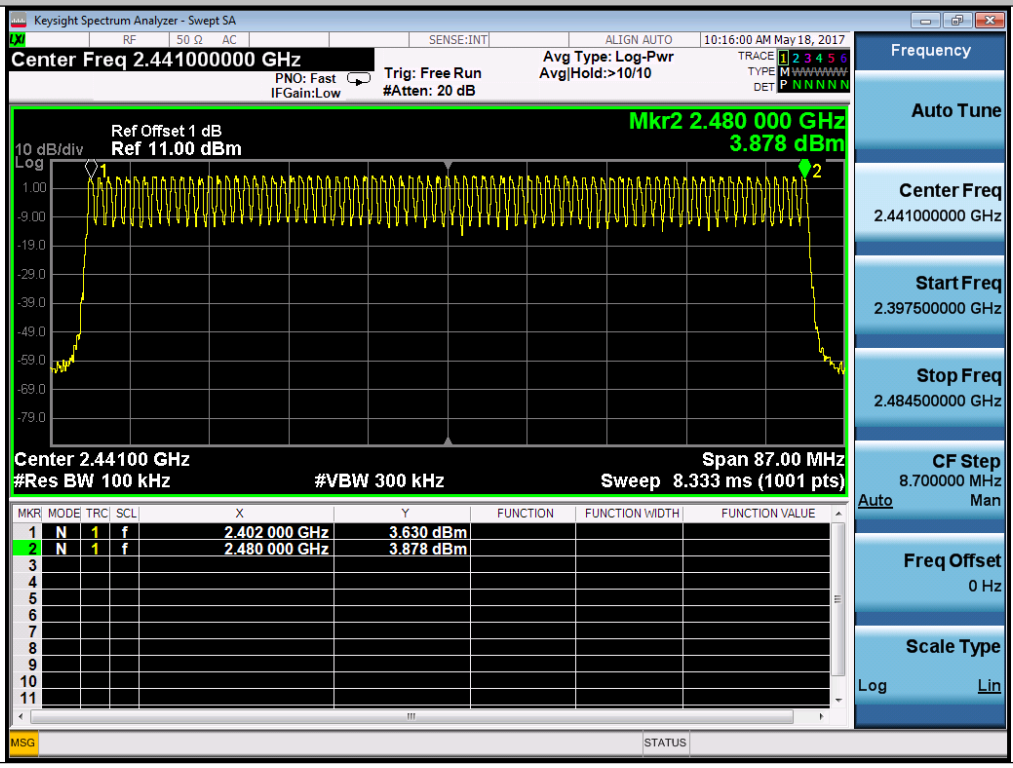
The same as described in section 6

12.4. LIMITS AND MEASUREMENT RESULT

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	

13. TIME OF OCCUPANCY (DWELL TIME)

13.1. 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; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
4. Detector function: Peak. Trace: Max hold.
5. Use the marker-delta function to determine the transmit time per hop.
6. Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:
(Number of hops in the period specified in the requirements) = (number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)
7. The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements.

13.2. TEST SETUP (BLOCK DIAGRAM OF CONFIGURATION)

Same as described in section 8.2

13.3. MEASUREMENT EQUIPMENT USED

The same as described in section 6

13.4. LIMITS AND MEASUREMENT RESULT

Channel.	Burst Width [ms/hop/ch]	Dwell Time[ms]	Verdict	Limit (ms)
LCH	2.900	309.3372	PASS	400
MCH	2.900	309.3372	PASS	400
HCH	2.900	309.3372	PASS	400

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

The dwell time is calculated with the following formula:

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

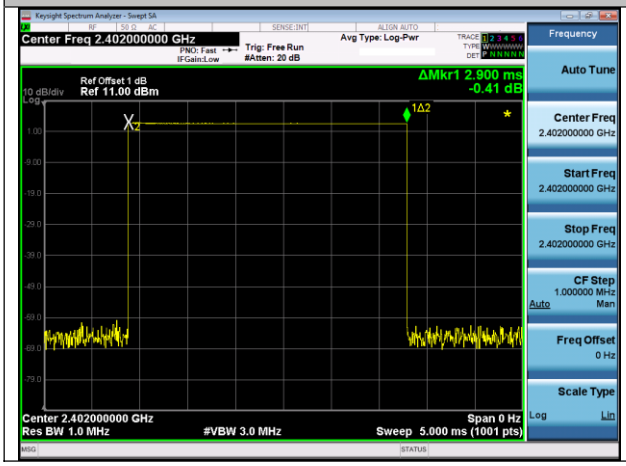
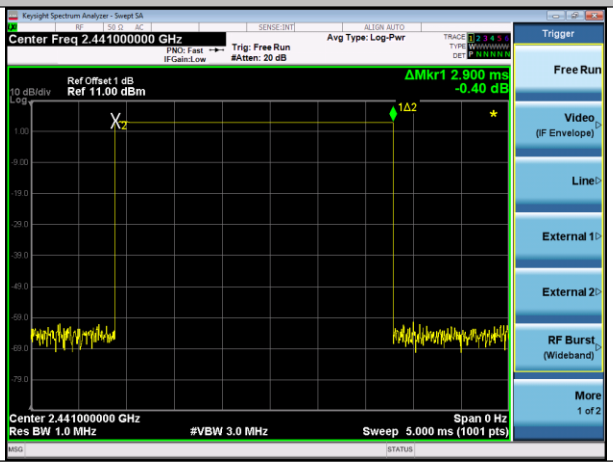
Where:

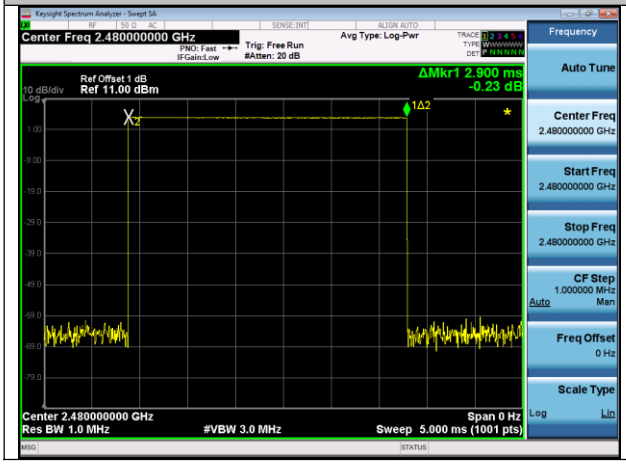
t_{pulse} is the measured pulse time (pls. refer the plots of the spectrum analyser above) [s],
n_{hops} is the number of hops per second in the actual operating mode of the transmitter [1/s].

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)

Test Graph

GFSK-LCH	GFSK-MCH
	

GFSK-HCH	
	

14. FREQUENCY SEPARATION

14.1. 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

14.2. TEST SETUP (BLOCK DIAGRAM OF CONFIGURATION)

Same as described in section 6.2

14.3. MEASUREMENT EQUIPMENT USED

The same as described in section 6.3

14.4. 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	

15. FCC LINE CONDUCTED EMISSION TEST

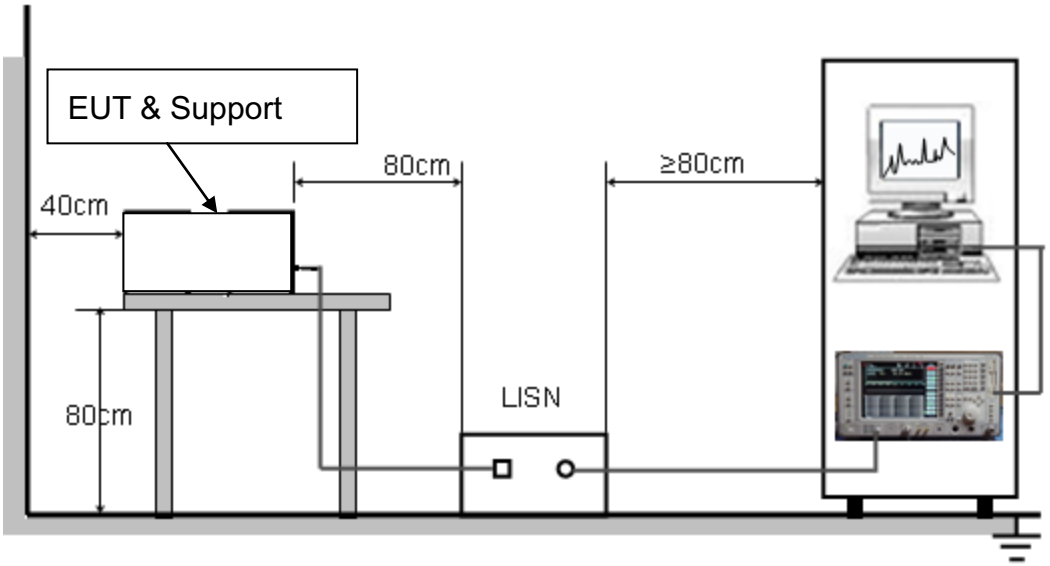
15.1. LIMITS OF LINE CONDUCTED EMISSION TEST

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.

15.2. BLOCK DIAGRAM OF LINE CONDUCTED EMISSION TEST



15.3. 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.

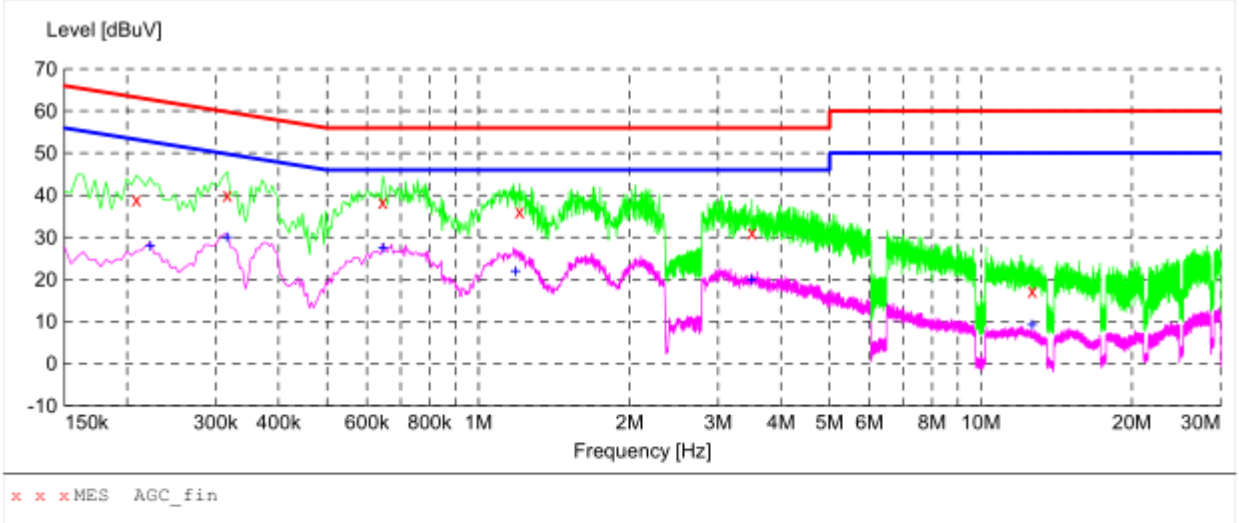
Then, the EUT configuration and cable configuration of the above highest emission level were recorded for reference of final testing.

15.4. 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.

15.5. TEST RESULT OF LINE CONDUCTED EMISSION TEST

Line Conducted Emission Test Line 1-L



MEASUREMENT RESULT: "AGC_fin"

2017/5/20 10:32

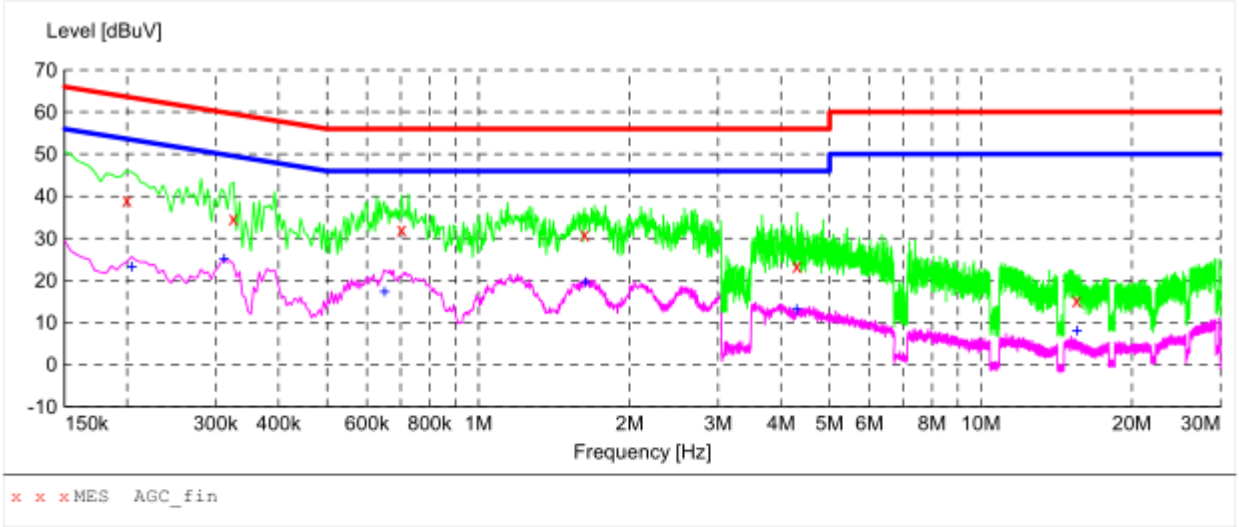
Frequency	Level	Transd	Limit	Margin	Detector	Line	PE	AUX STATE
MHz	dBuV	dB	dBuV	dB				
0.208500	39.00	10.3	63	24.3	QP	L1	FLO	ON
0.316500	40.10	10.3	60	19.7	QP	L1	FLO	ON
0.645000	38.40	10.3	56	17.6	QP	L1	FLO	ON
1.207500	36.20	10.4	56	19.8	QP	L1	FLO	ON
3.502500	31.10	10.5	56	24.9	QP	L1	FLO	ON
12.651000	17.30	11.0	60	42.7	QP	L1	FLO	ON

MEASUREMENT RESULT: "AGC_fin2"

2017/5/20 10:32

Frequency	Level	Transd	Limit	Margin	Detector	Line	PE	AUX STATE
MHz	dBuV	dB	dBuV	dB				
0.222000	27.90	10.3	53	24.8	AV	L1	FLO	ON
0.316500	30.00	10.3	50	19.8	AV	L1	FLO	ON
0.645000	27.50	10.3	46	18.5	AV	L1	FLO	ON
1.185000	21.90	10.4	46	24.1	AV	L1	FLO	ON
3.502500	19.90	10.5	46	26.1	AV	L1	FLO	ON
12.651000	9.20	11.0	50	40.8	AV	L1	FLO	ON

Line Conducted Emission Test Line 2-N



MEASUREMENT RESULT: "AGC_fin"

2017/5/20 10:20

Frequency	Level	Transd	Limit	Margin	Detector	Line	PE	AUX STATE
MHz	dBuV	dB	dBuV	dB				
0.199500	39.10	10.3	64	24.5	QP	N	FLO	ON
0.325500	34.70	10.3	60	24.9	QP	N	FLO	ON
0.703500	32.10	10.3	56	23.9	QP	N	FLO	ON
1.626000	30.90	10.4	56	25.1	QP	N	FLO	ON
4.303500	23.40	10.5	56	32.6	QP	N	FLO	ON
15.504000	15.20	11.2	60	44.8	QP	N	FLO	ON

MEASUREMENT RESULT: "AGC_fin2"

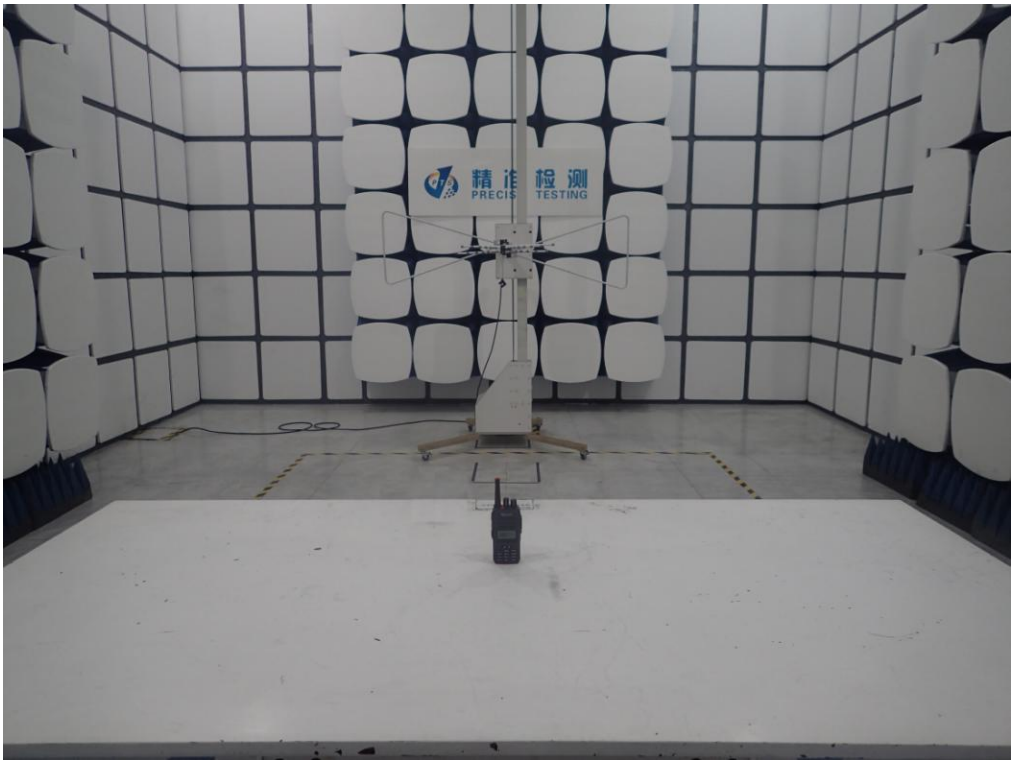
2017/5/20 10:20

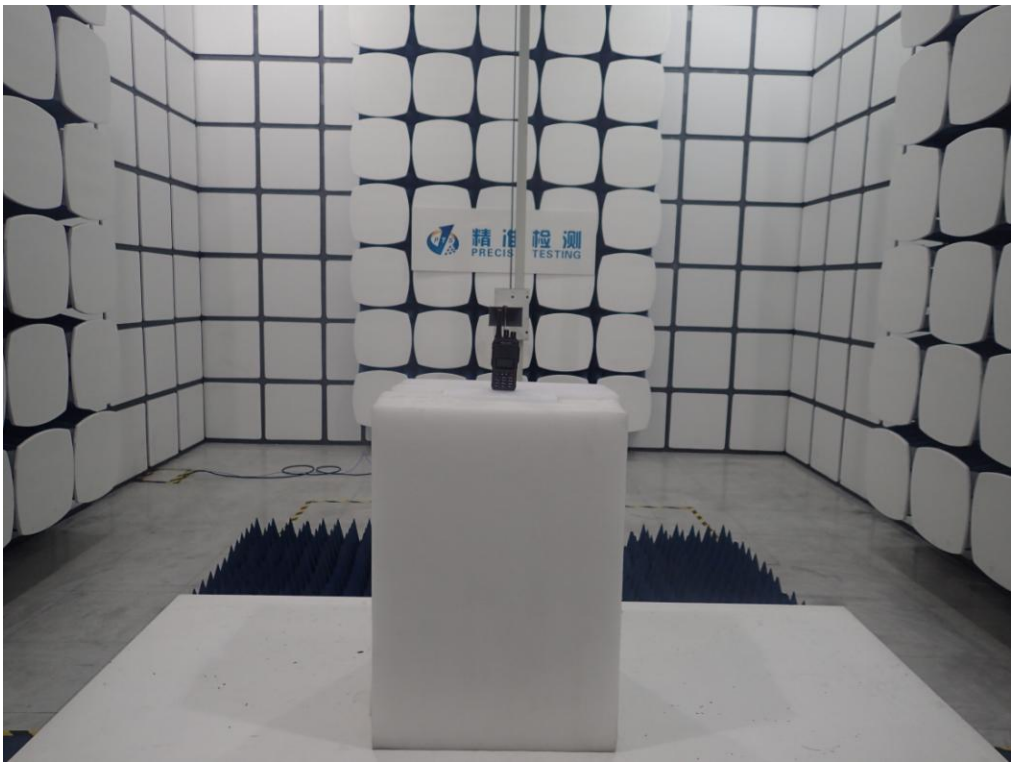
Frequency	Level	Transd	Limit	Margin	Detector	Line	PE	AUX STATE
MHz	dBuV	dB	dBuV	dB				
0.204000	23.20	10.3	53	30.2	AV	N	FLO	ON
0.312000	25.10	10.3	50	24.8	AV	N	FLO	ON
0.649500	17.30	10.3	46	28.7	AV	N	FLO	ON
1.630500	19.60	10.4	46	26.4	AV	N	FLO	ON
4.303500	13.10	10.5	46	32.9	AV	N	FLO	ON
15.544500	8.00	11.2	50	42.0	AV	N	FLO	ON

APPENDIX A: PHOTOGRAPHS OF TEST SETUP

FCC LINE CONDUCTED EMISSION TEST SETUP

FCC RADIATED EMISSION TEST SETUP





----END OF REPORT----