Test Report of FCC CFR 47 Part 15 Subpart C and Industry Canada RSS-247 Issue 2

On Behalf of

Graupner CO., Ltd.

202Dong 8th F,18, Bucheon-ro 198beon-gil, Wonmi-gu, Bucheon-si, Gyeonggi-do, South Korea

Product Name:	**2.4GHz Radio Controller**
Model/Type No.:	**MC-28, MC-28 4D**
FCC ID:	**SNL-16007100**
IC:	**20961-16007100**
Prepared By:	**Shenzhen Hongcai Testing Technology Co., Ltd.** 1st-3rd Floor, Building C, Shuanghuan Xin Yi Dai Hi-Tech Industrial Park, No.8 Baoqing Road, Baolong Industrial Zone, Longgang District, Shenzhen, Guangdong, China Tel: +86-755-86337020 Fax:+86-755-86337028
Report Number:	HCT17CR065E-1
Tested Date:	March 25~April 17, 2017
Issued Date:	April 17, 2017
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1. GENERAL INFORMATION

1.1 Product Description for Equipment Under Test (EUT)

Client Information

Applicant:	**Graupner CO.,Ltd.**
Address of applicant:	202Dong 8th F,18, Bucheon-ro 198beon-gil, Wonmi-gu, Bucheon-si, Gyeonggi-do, South Korea
Manufacturer :	**SJ Technology(Shenzhen)Co.,Ltd**
Address of manufacturer:	F6, 1 Bldg, A Area, Yintianxifa Industrial Area, Xixiang Town, Baoan District Shenzhen, Guangdong Province, China

General Description of E.U.T

Items	Description
EUT Description:	2.4GHz Radio Controller
Model No.:	MC-28
Supplementary Model:	MC-28 4D
Trade Name:	HoTT
Frequency Band:	2404.056~2474.044MHz
Mini Channel Spacing:	1.014MHz
Number of Channels:	70
Type of Modulation:	FHSS
Antenna Gain	0.5dBi
Antenna Type:	2.4GHz Ceramic Patch Antenna
Rated Voltage:	DC 3.8V from battery, the battery can be charged from USB port

Remark: ** The test data gathered are from the production sample provided by the manufacturer.*
** Supplementary Model have the same circuit, but different appearance.*

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Hopping Channels:

Number	Channel	Frequency	Number	Channel	Frequency
[0]	51	2455.772	[35]	43	2447.660
[1]	63	2467.940	[36]	67	2471.997
[2]	1	2405.070	[37]	13	2417.239
[3]	20	2424.337	[38]	17	2421.295
[4]	36	2440.562	[39]	31	2435.491
[5]	46	2450.702	[40]	47	2451.716
[6]	64	2468.955	[41]	60	2464.898
[7]	12	2416.225	[42]	9	2413.182
[8]	23	2427.379	[43]	22	2426.365
[9]	39	2443.604	[44]	33	2437.519
[10]	53	2457.800	[45]	45	2449.688
[11]	56	2460.842	[46]	69	2474.044
[12]	7	2411.154	[47]	6	2410.140
[13]	25	2429.407	[48]	19	2423.323
[14]	34	2438.550	[49]	32	2436.505
[15]	55	2459.828	[50]	48	2452.730
[16]	61	2465.912	[51]	58	2462.870
[17]	10	2414.197	[52]	3	2407.098
[18]	18	2422.309	[53]	27	2431.435
[19]	41	2445.632	[54]	28	2432.449
[20]	49	2453.744	[55]	50	2454.758
[21]	59	2463.884	[56]	57	2461.856
[22]	4	2408.112	[57]	11	2415.210
[23]	15	2419.267	[58]	26	2430.421
[24]	40	2444.618	[59]	30	2434.477
[25]	54	2458.814	[60]	52	2456.786
[26]	66	2470.983	[61]	62	2466.927
[27]	8	2412.169	[62]	0	2404.056
[28]	21	2425.351	[63]	16	2420.281
[29]	38	2442.590	[64]	29	2433.463
[30]	44	2448.674	[65]	42	2446.646
[31]	65	2469.969	[66]	68	2473.011
[32]	2	2406.084	[67]	5	2409.126
[33]	14	2418.253	[68]	24	2428.393
[34]	37	2441.575	[69]	35	2439.547

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1.2 Related Submittal(s) / Grant (s) and Test Methodology

FCC Rules Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.

DA 00-705: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

RSS-GEN Issue 4: General Requirements for Compliance of Radio Apparatus.

RSS-247, Issue 2: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test Facility

All measurement required was performed at laboratory of Shenzhen CTL Testing Technology Co., Ltd.

Floor 1-A, Baisha Technology Park, No. 3011, Shahexi Road, Nanshan, Shenzhen 518055 China

There is one 3m semi-anechoic chamber and two line conducted labs for final test. The Test Sites meet the requirements in documents ANSI C63.4 and CISPR 22/EN 55022 requirements.

FCC – Registration No.: 970318
Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration 970318, December, 2013.

IC Registration No.: 9618B
The 3m alternate test site of Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered by Certification and Engineer Bureau of Industry Canada for the performance of with Registration No.: 9618B on November 13, 2013.

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2. SYSTEM TEST CONFIGURATION

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

The calibrated antennas used to sample the radiated field strength are mounted on a non-conductive, motorized antenna mast 3 or 10 meters from the leading edge of the turntable.

2.3 General Test Procedures

Conducted Emissions: The EUT is placed on the table, which is 0.8 m above ground plane According to the requirements in ANSI C63.10-2013 Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-Peak detector mode.

Radiated Emissions: The EUT is a placed on as turntable, which is 0.8 m above ground plane. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna, which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the maximum emissions, exploratory radiated emission measurements were made according to the requirements in ANSI C63.10-2013.

2.4 Measurement Uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16 - 4 “Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements“ and is documented in the Shenzhen CTL Testing Technology Co., Ltd. quality system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Transmitter power conducted	+/- 0.57 dB
Transmitter power Radiated	+/- 2.20 dB
Conducted spurious emission 9KHz-40 GHz	+/- 2.20 dB
Power Line Conducted Emission	+/- 3.20 dB
Radiated Emission	+/- 4.32 dB

Note: This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

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2.5 Measure Results Explanation Example

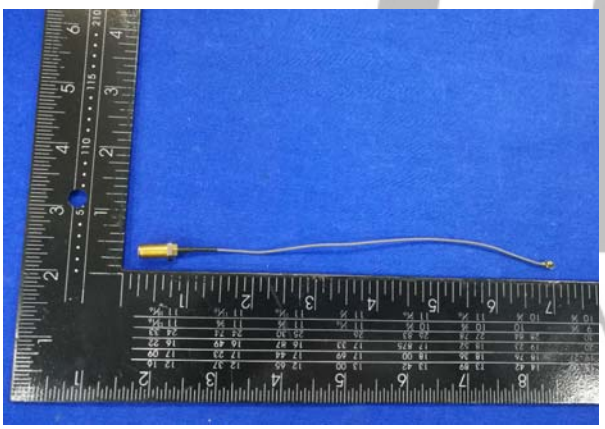
For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

The spectrum analyzer offset is derived from RF cable less and attenuator factor.
Offset= RF cable less+ attenuator factor.

Note: Using a temporary antenna connector for the EUT when the conducted measurements are performed.

Equipment	Manufacturer	Model No.	Frequency range(GHz)	Attenuation values(dBm)
Line	Zhenjiang south electronic	RG316	1-12	0.07
			<1G	0.02
			>12G	0.95
Connector	Zhenjiang south electronic	SMA-K/N-J	1-12	0.01
			<1G	0.005
			>12G	0.03



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2.6 List of Measuring Equipments Used

No.	Equipment	Manufacturer	Model No.	S/N	Last Calculator	Due Calculator
1	EMI Test Receiver	R&S	ESCI	100687	2016-7-25	2017-7-24
2	EMI Test Receiver	R&S	ESPI	100097	2016-10-1	2017-10-31
3	Amplifier	HP	8447D	1937A02492	2016-7-25	2017-7-24
4	TRILOG Broadband Test-Antenna	SCHWARZBECK	VULB9163	9163-324	2016-7-25	2017-7-24
5	Triple-Loop Antenna	EVERFINE	LLA-2	711002	2016-10-1	2017-10-31
6	RF POWER AMPLIFIER	FRANKONIA	FLL-75	1020A1109	2016-7-25	2017-7-24
7	6DB Attenuator	FRANKONIA	N/A	1001698	2016-7-25	2017-7-24
8	10dB attenuator	ELECTRO-METRICS	EM-7600	836	2016-7-25	2017-7-24
9	Spectrum Analyzer	R&S	FSP	100397	2016-10-1	2017-10-31
10	Broadband preamplifier	SCH WARZBECK	BBV9718	9718-182	2016-7-25	2017-7-24
11	Horn Antenna	SCHWARZBECK	BBHA 9120D	0437	2016-7-25	2017-7-24
12	Horn Antenna	SCHWARZBECK	BBHA9170	0483	2016-7-25	2017-7-24

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3. SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC §15.207 IC RSS-GEN Clause 8.8	AC Power Line Conducted Emission	Pass
FCC §15.247(a)(1) IC RSS-247 Issue2 Clause 5.1	Hopping Channel Bandwidth	Pass
RSS-Gen Clause 6.6	Occupied Bandwidth	Pass
FCC §15.247(a)(1) IC RSS-247 Issue2 Clause 5.1	Hopping Channel Separation	Pass
FCC §15.247(a)(1) IC RSS-247 Issue2 Clause 5.1	Number of Hopping Frequency Used	Pass
FCC §15.247(a)(1)(iii) IC RSS-247 Issue2 Clause 5.1	Dwell Time of Each Frequency	Pass
FCC §15.247(b)(1) IC RSS-247 Issue2 Clause 5.4	Maximum Peak Output Power	Pass
FCC §15.247(d) IC RSS-247 Issue2 Clause 5.5	Band Edges Emission	Pass
FCC §15.247(d) IC RSS-247 Issue2 Clause 5.5	Spurious Radiated Emission	Pass
FCC §15.203/15.247(b)/(c) IC RSS-GEN Clause 8.3	Antenna Requirement	Pass

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4. TEST OF AC POWER LINE CONDUCTED EMISSION

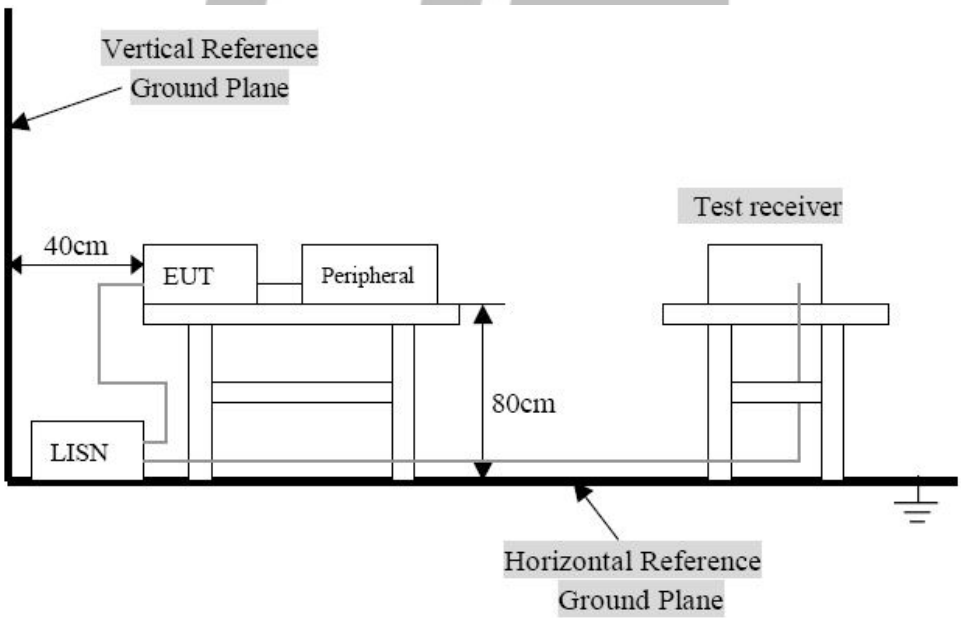
4.1 Applicable Standard

Refer to FCC §15.207, RSS-GEN Clause 8.8.

For a Low-power Radio-frequency Device is designed to be connected to the AC power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed below limits table.

Frequency Range (MHz)	Limits (dBuV)	
	Quasi-Peak	Average
0.150～0.500	66～56	56～46
0.500～5.000	56	46
5.000～30.00	60	50

4.2 Test Setup Diagram



Remark: The EUT was connected to a 120VAC/ 60Hz power source.

4.3 Test Result

PASS

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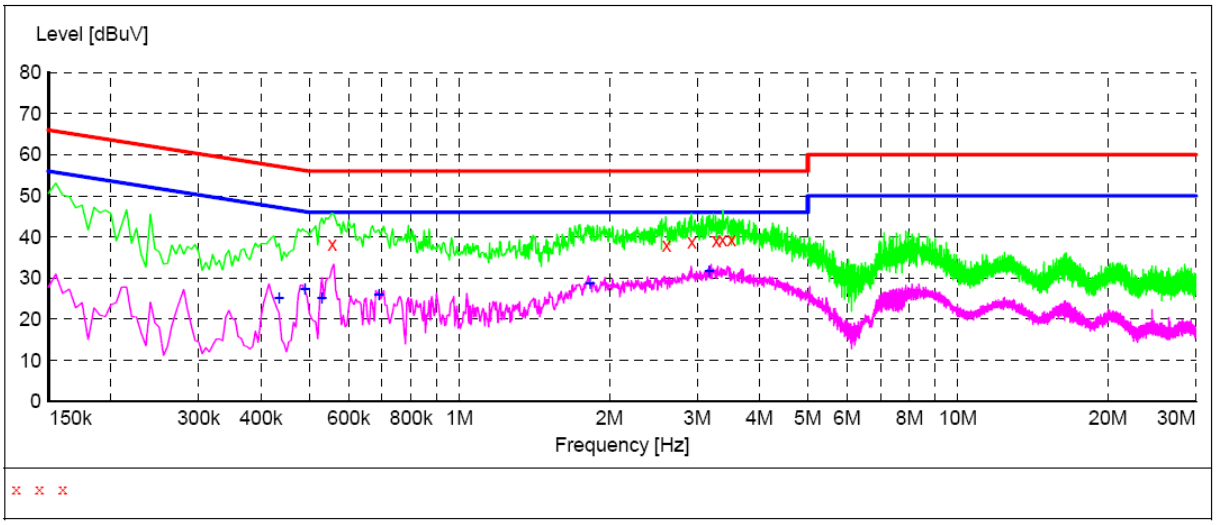
Conducted Emission Test Data

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	Tx Mode
Test Site:	Shielded Room
Operator:	Li
Test Specification:	DC 3.8V from battery
Comment:	Live Line
Start of Test:	Tem:25℃ Hum:50%

SCAN TABLE: "Voltage(150K-30M)FIN"

Short Description: 150K-30M Voltage



MEASUREMENT RESULT:

Frequency MHz	Level dBuV	Transd dB	Limit dBuV	Margin dB	Detector	Line	PE
0.555000	38.20	10.4	56	17.8	QP	L1	GND
2.605000	38.10	12.6	56	17.9	QP	L1	GND
2.925000	38.90	12.4	56	17.1	QP	L1	GND
3.275000	39.10	12.6	56	16.9	QP	L1	GND
3.370000	39.40	12.7	56	16.6	QP	L1	GND
3.515000	39.40	12.8	56	16.6	QP	L1	GND

MEASUREMENT RESULT:

Frequency MHz	Level dBuV	Transd dB	Limit dBuV	Margin dB	Detector	Line	PE
0.435000	25.30	11.0	47	21.9	AV	L1	GND
0.490000	27.30	10.5	46	18.9	AV	L1	GND
0.530000	25.30	10.4	46	20.7	AV	L1	GND
0.690000	26.10	10.3	46	19.9	AV	L1	GND
1.830000	28.60	12.9	46	17.4	AV	L1	GND
3.170000	31.60	12.5	46	14.4	AV	L1	GND

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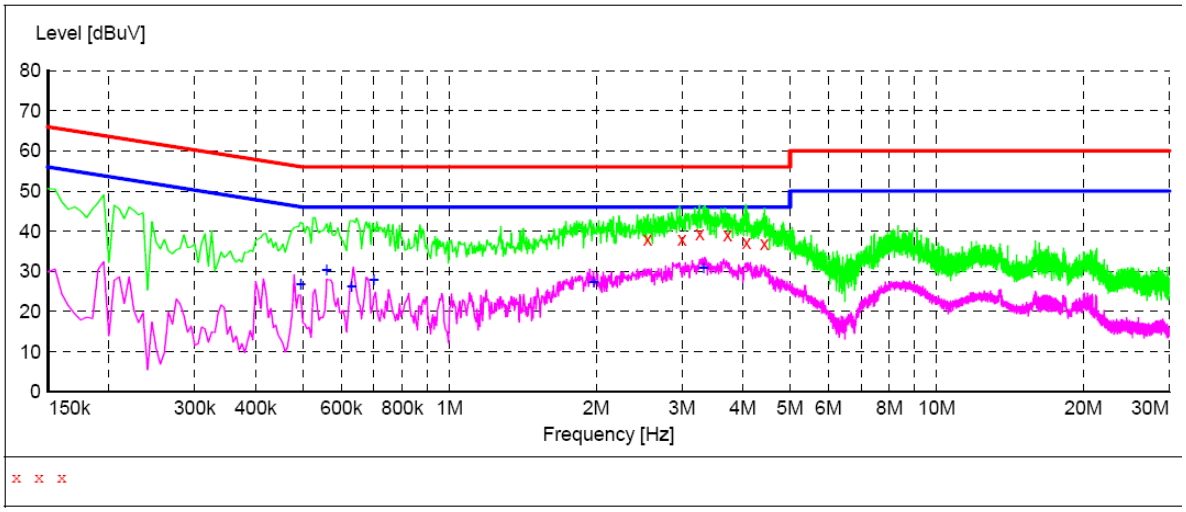
Conducted Emission Test Data

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	Tx Mode
Test Site:	Shielded Room
Operator:	Li
Test Specification:	DC 3.8V from battery
Comment:	Neutral Line
Start of Test:	Tem:25℃ Hum:50%

SCAN TABLE: "Voltage(150K-30M)FIN"

Short Description: 150K-30M Voltage



MEASUREMENT RESULT:

Frequency MHz	Level dBuV	Transd dB	Limit dBuV	Margin dB	Detector	Line	PE
2.550000	37.90	12.7	56	18.1	QP	N	GND
3.000000	38.10	12.3	56	17.9	QP	N	GND
3.260000	39.30	12.6	56	16.7	QP	N	GND
3.720000	39.00	13.0	56	17.0	QP	N	GND
4.070000	37.20	13.3	56	18.8	QP	N	GND
4.425000	36.90	13.4	56	19.1	QP	N	GND

MEASUREMENT RESULT:

Frequency MHz	Level dBuV	Transd dB	Limit dBuV	Margin dB	Detector	Line	PE
0.495000	26.80	10.4	46	19.3	AV	N	GND
0.560000	30.20	10.4	46	15.8	AV	N	GND
0.630000	26.30	10.4	46	19.7	AV	N	GND
0.700000	27.90	10.3	46	18.1	AV	N	GND
1.980000	27.20	13.2	46	18.8	AV	N	GND
3.325000	31.00	12.6	46	15.0	AV	N	GND

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5. Test of Hopping Channel Bandwidth

5.1 Applicable Standard

Section 15.247(a)(1), RSS-247 Issue2 Clause 5.1, RSS-Gen Clause 6.6:
FHSS 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, FHSS operating in the band 2400-2483.5 MHz 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

5.2 EUT Setup

Spectrum Analyzer

5.3 Test Equipment List and Details

See section 2.5.

5.4 Test Procedure

1. Use the following spectrum analyzer settings:

   Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel

   RBW ⩾ 1% of the 20 dB bandwidth

   VBW ⩾ RBW

   Sweep = Auto

   Detector function = peak

   Trace = max hold

2. The spectrum width with level higher than 20dB below the peak level.

3. Repeat above 1~3 points for the middle and highest channel of the EUT.

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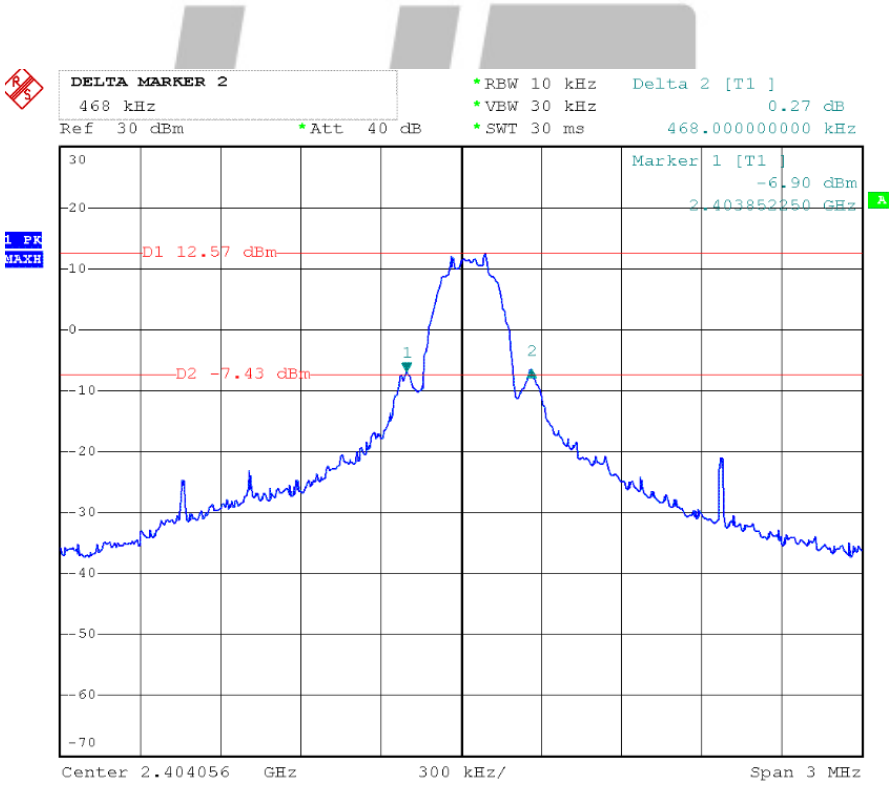
5.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: Tx Mode

Modulation Type	Channel No.	Frequency (MHz)	99%OBW (MHz)	20dB Bandwidth (kHz)	Min. Limit (kHz)
FHSS	Low	2404.056	0.552	468	>25
FHSS	Middle	2438.550	0.540	474	>25
FHSS	High	2474.044	0.552	462	>25

Channel Low：



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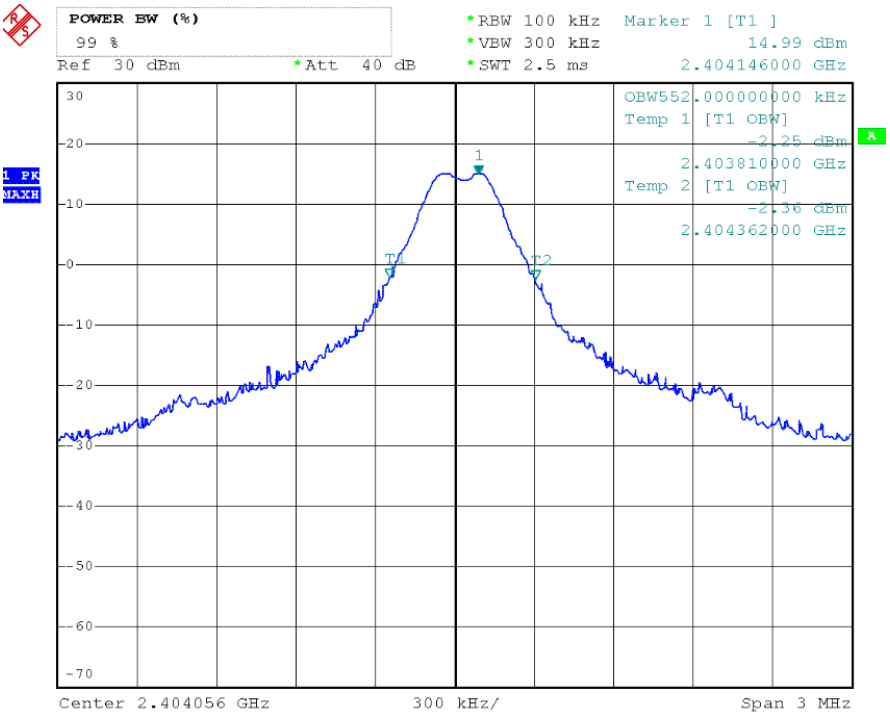
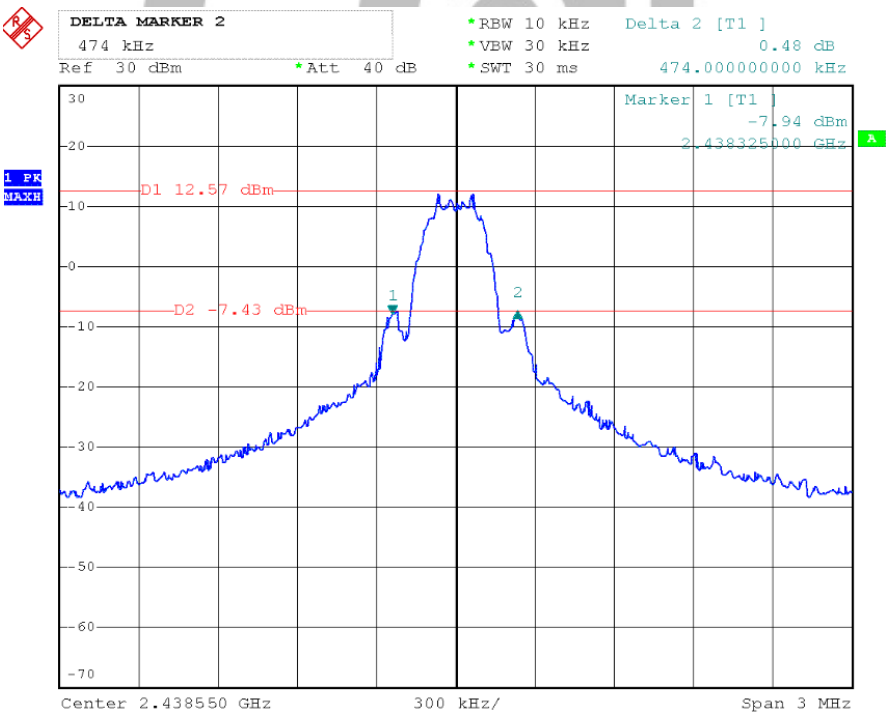
99%OBW(CH Low):



Channel Middle：



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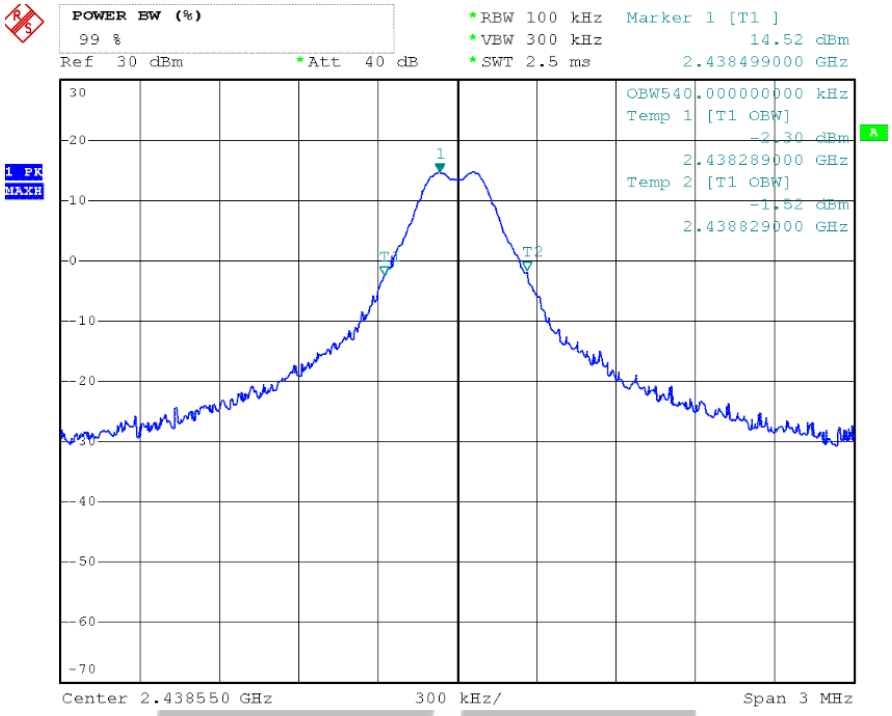
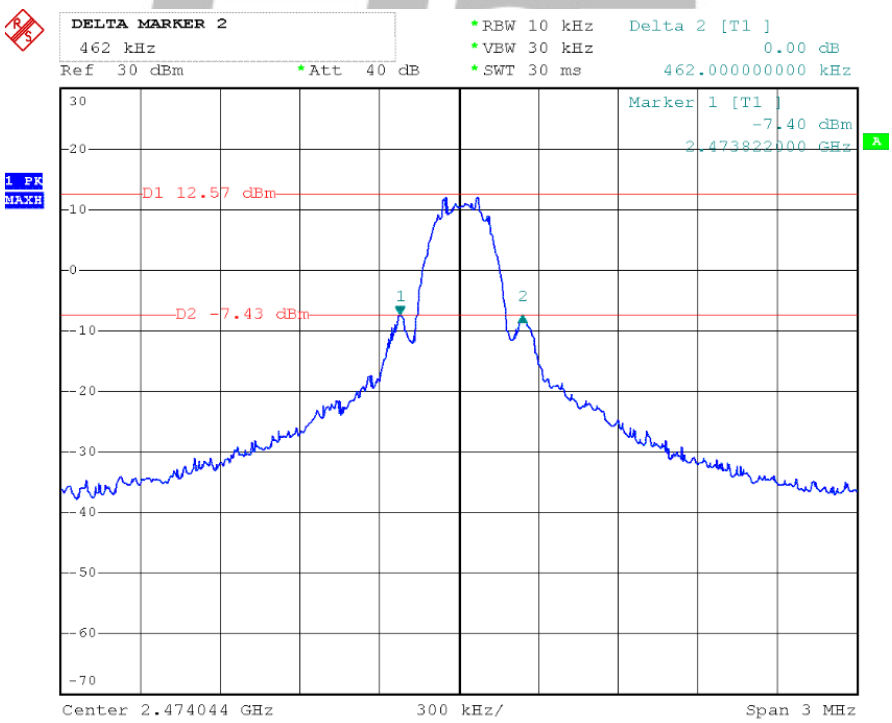
99%OBW(CH Middle):



Channel High：



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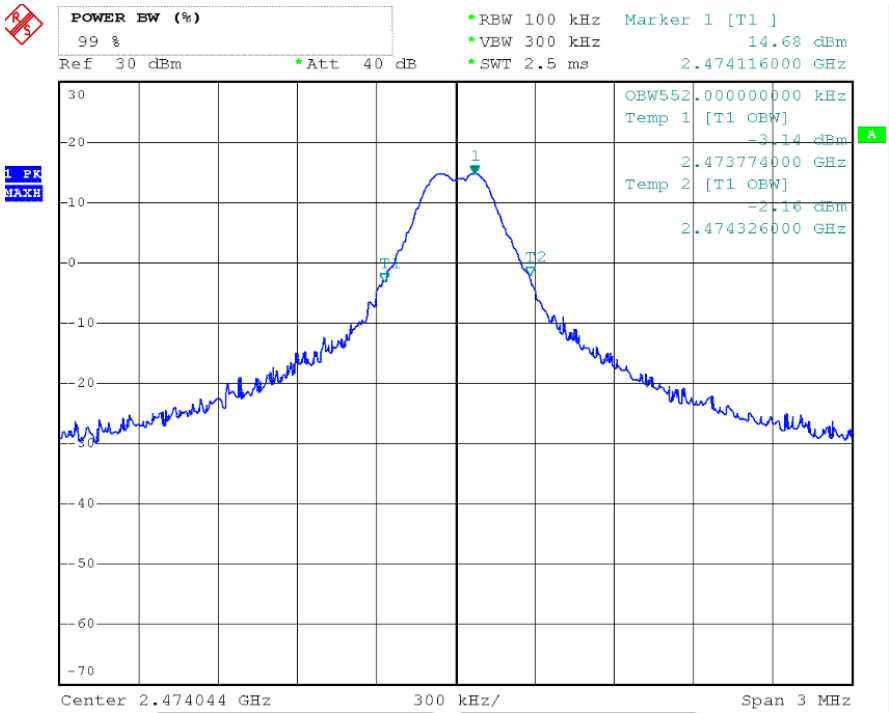
99%OBW(CH High):



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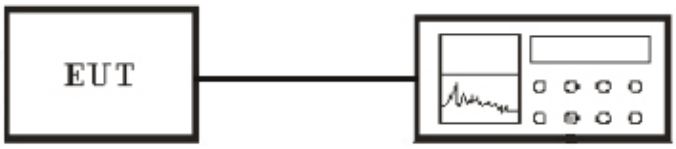
6. Test of Hopping Channel Separation

6.1 Applicable Standard

Section 15.247(a)(1), RSS-247 Issue2 Clause 5.1: FHSS 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, FHSS operating in the band 2400-2483.5 MHz 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

6.2 EUT Setup



Spectrum Analyzer

6.3 Test Equipment List and Details

See section 2.5.

6.4 Test Procedure

1. The EUT must have its hopping function enabled.

2. Use the following spectrum analyzer settings:

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

4. The Hopping Channel Separation is defined as the separation between 2 neighboring hopping frequencies.

5. Repeat above 1~3 points for the middle and highest channel of the EUT.

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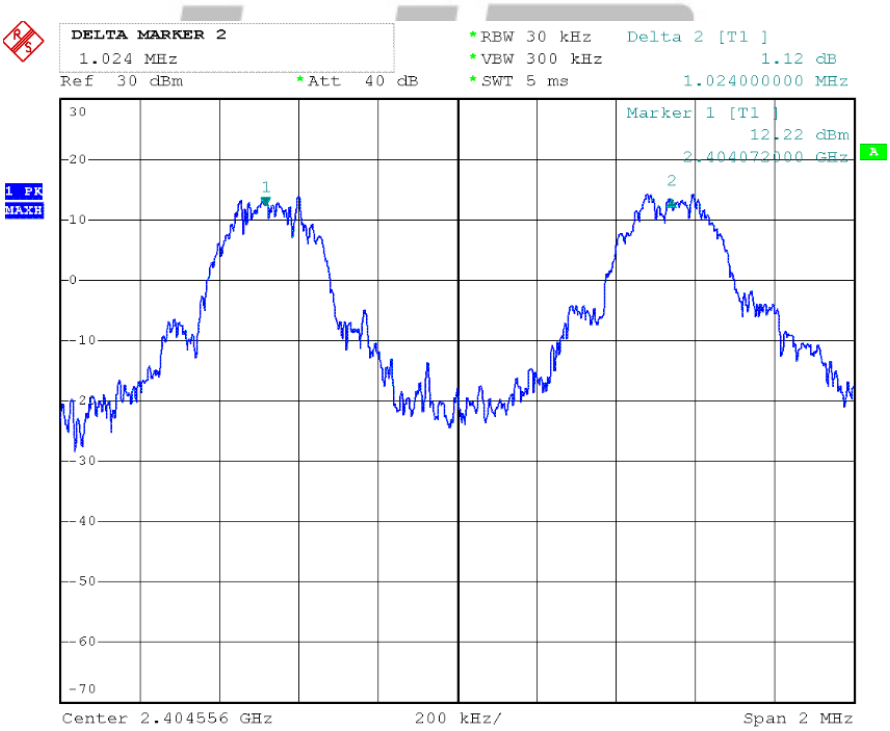
6.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: Tx Mode

Modulation Type	Frequency (MHz)	Channel Separation (MHz)
FHSS	2404.056~2405.056	1.024
FHSS	2438.550~2441.061	0.956
FHSS	2478.595~2474.044	0.992

Channel Low：



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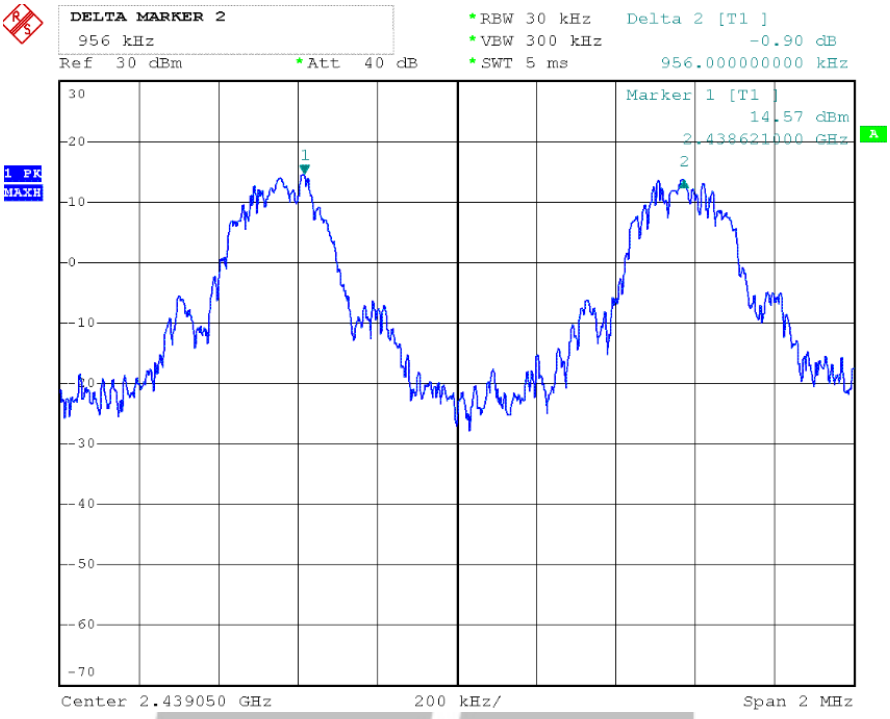
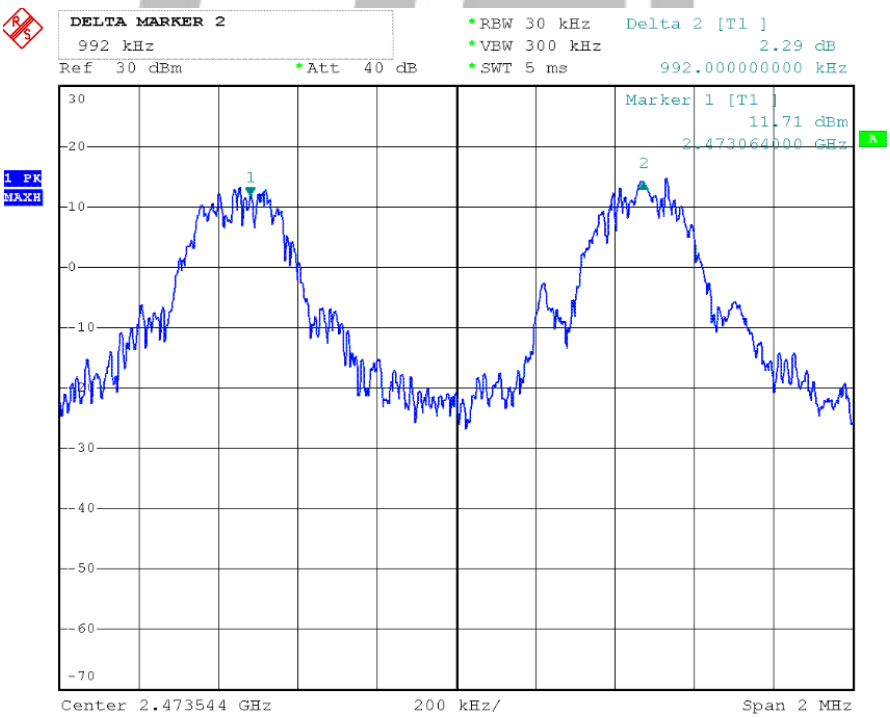
Channel Middle:



Channel High:



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7. Test of Number of Hopping Frequency

7.1 Applicable Standard

Section 15.247(a)(1)(iii), RSS-247 Issue2 Clause 5.1: For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 15 non-overlapping hopping channels. Frequency hopping system which use fewer than 75 hopping frequencies may employ intelligent hopping techniques to avoid interference to other transmissions. Frequency hopping system may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 non-overlapping channels are used.

7.2 EUT Setup

Spectrum Analyzer

7.3 Test Equipment List and Details

See section 2.5.

7.4 Test Procedure

1. The EUT must have its hopping function enabled.
2. Use the following spectrum analyzer settings:

   Span = the frequency band of operation

   RBW ⩾ 1% of the span

   VBW ⩾ RBW

   Sweep = Auto

   Detector function = peak

   Trace = max hold
3. Observe frequency hopping in 2400MHz~2483.5MHz, there are at least 32 non-overlapping channels.
4. Repeat above 1~3 points for the middle and highest channel of the EUT.

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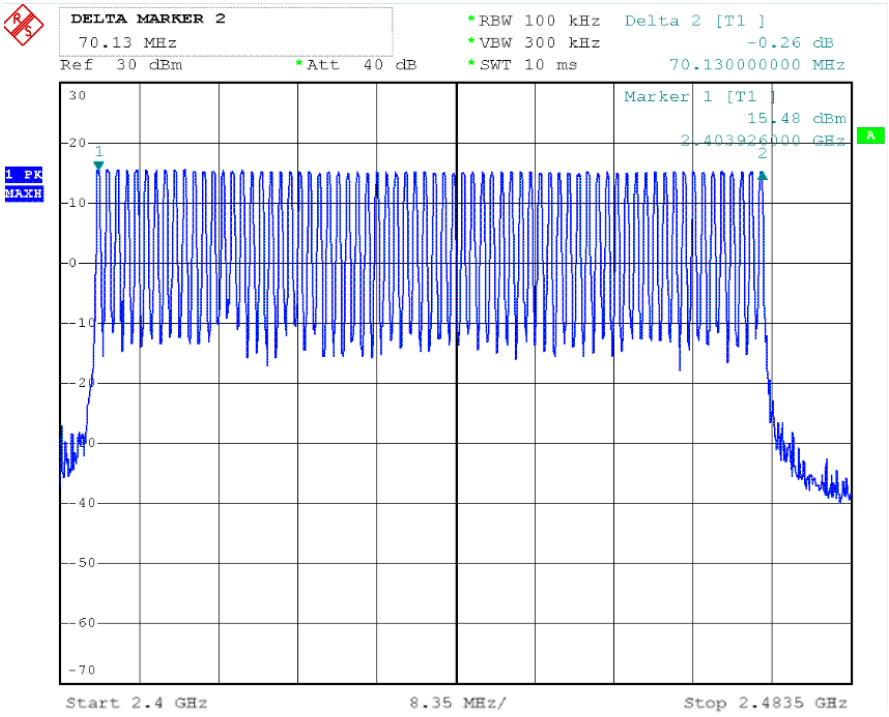
7.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: Tx Mode

Modulation Type	Frequency (MHz)	Number of Hopping Channels	Min. Limit
FHSS	2404.056~2474.044	70	⩾15



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8. Test of Dwell Time of Each Frequency

8.1 Applicable Standard

Section 15.247(a)(1)(iii), RSS-247 Issue2 Clause 5.1: For frequency hopping systems operating in the 2400-2483.5 MHz band The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4seconds multiplied by the number of hopping channels employed.

8.2 EUT Setup

Spectrum Analyzer

8.3 Test Equipment List and Details

See section 2.5.

8.4 Test Procedure

1. The EUT must have its hopping function enabled.
2. Use the following spectrum analyzer settings:

   Span = zero span, centered on a hopping channel

   RBW = 1 MHz

   VBW ⩾ RBW

   Sweep = as necessary to capture the entire dwell time per hopping channel

   Detector function = peak

   Trace = max hold

3. Measure the maximum time duration of one single pulse.

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8.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: Tx Mode

Test Result: PASS

Modulation Type	Channel No.	Frequency (MHz)	Dwell Time (ms)	Limit (ms)
FHSS	Low	2404.056	153.72	400
FHSS	Middle	2440.056	160.992	400
FHSS	High	2474.044	159.96	400

A period time = 0.4 (s) * 70= 28 (s)

CH Low:
N=42

Time slot =3.66(ms)
Dwell time=N*T= 42*3.718=153.72 (ms)

CH Mid:
N=43

Time slot =3.744(ms)
Dwell time=N*T= 43*3.744=160.992(ms)

CH High:
N=43

Time slot =3.72(ms)
Dwell time=N*T= 43*3.72=159.96(ms)

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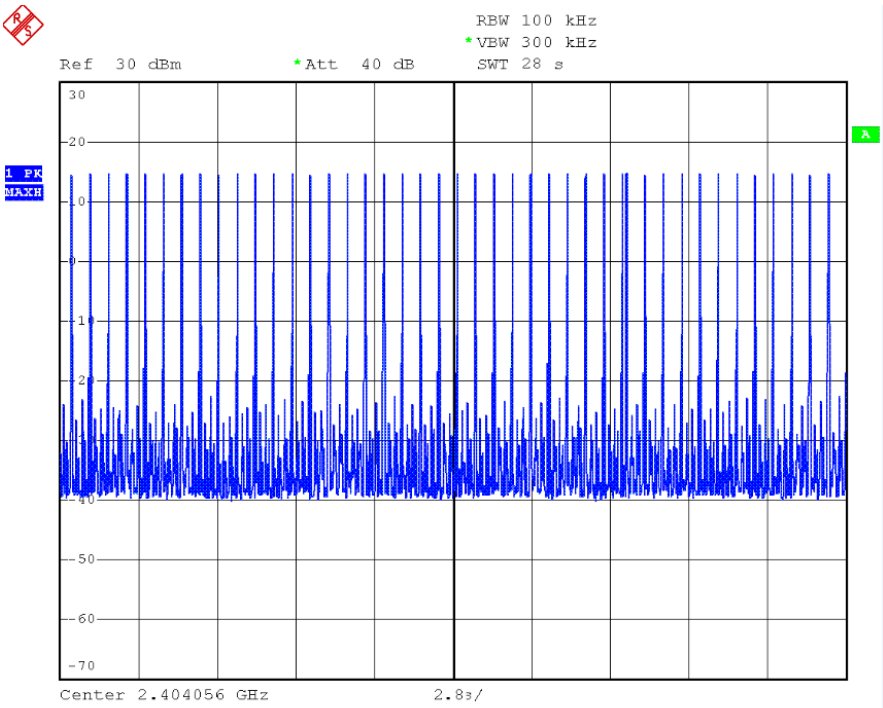
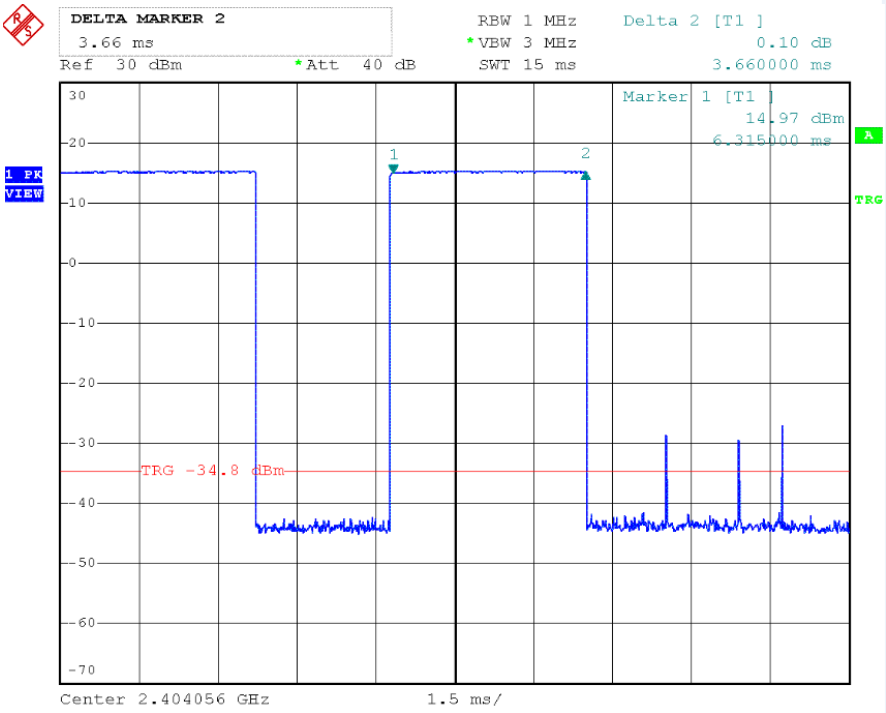
Channel Low：





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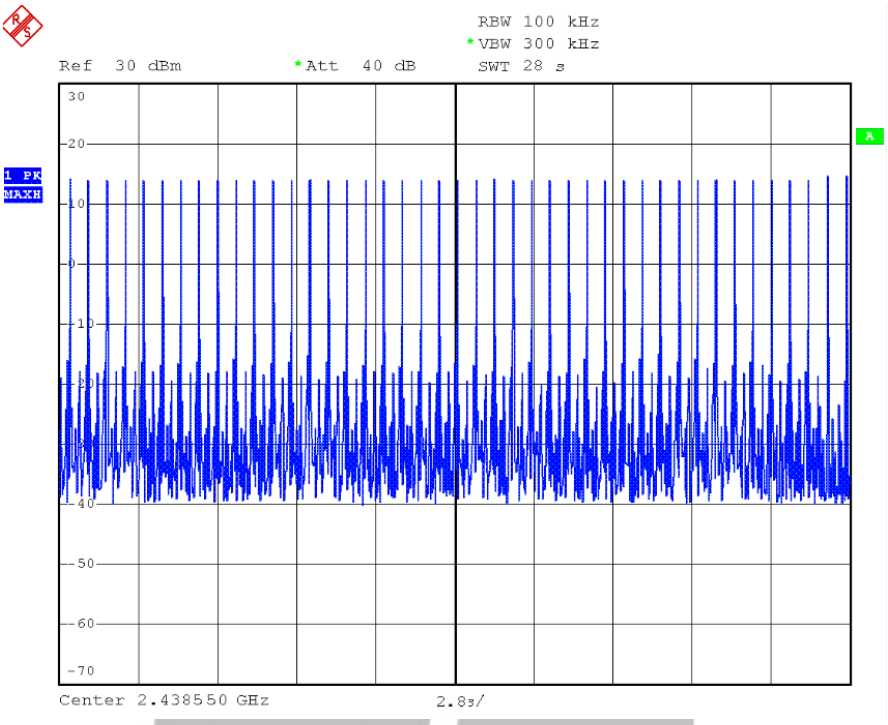
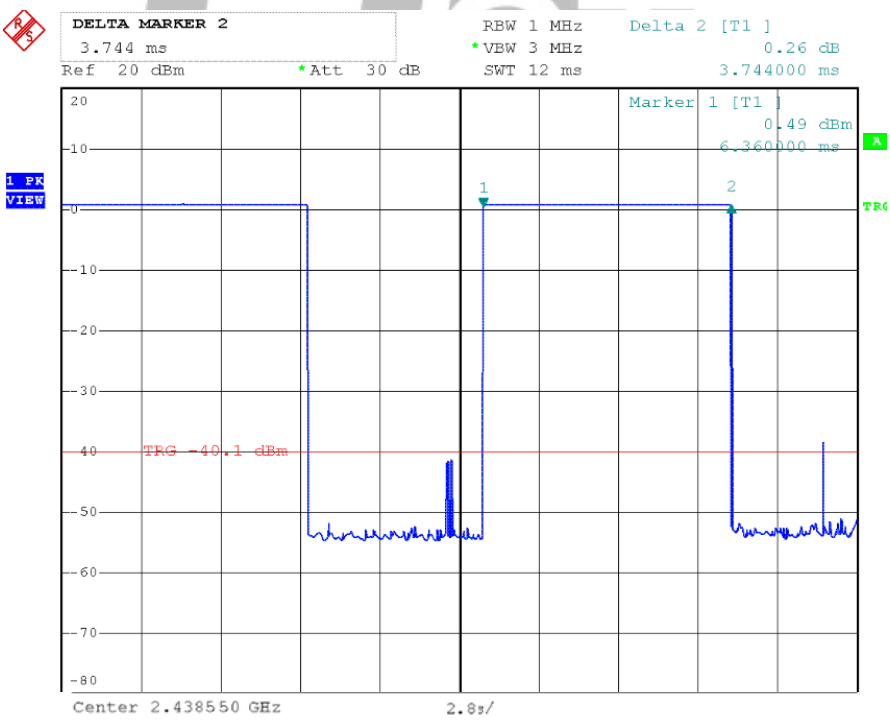
Channel Middle：





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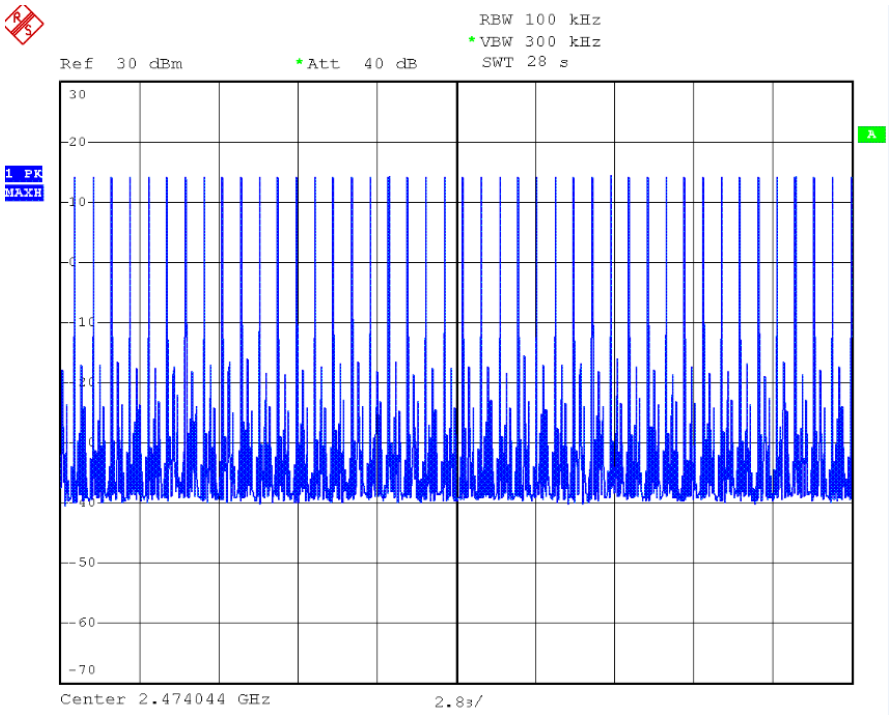
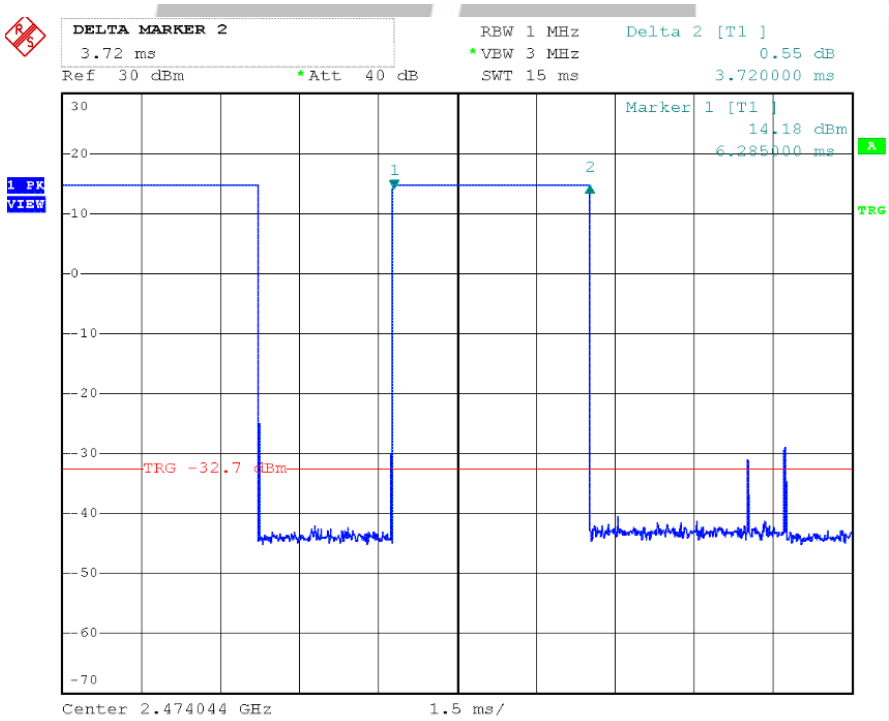
Channel High：





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9. Test of Maximum Peak Output Power

9.1 Applicable Standard

Section 15.247(b)(1), RSS-247 Issue2 Clause 5.4: For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels and The maximum peak output power shall not exceed 1 watt. For all other frequency hopping systems in this frequency band, The maximum peak output power shall not exceed 0.125 watt.

9.2 EUT Setup

Spectrum Analyzer

9.3 Test Equipment List and Details

See section 2.5.

9.4 Test Procedure

1. The transmitter output was connected to the peak power meter and recorded the peak value.
2. Peak power meter parameter set to auto attenuator and filter is the same as.
3. Repeated the 1 for the middle and highest channel of the EUT.

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9.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: Tx Mode

Modulation Type	Channel No.	Frequency (MHz)	Output Power (dBm)	Limit (dBm)	Result
FHSS	Low	2404.056	14.94	30	Pass
FHSS	Middle	2438.550	14.39	30	Pass
FHSS	High	2474.044	14.59	30	Pass

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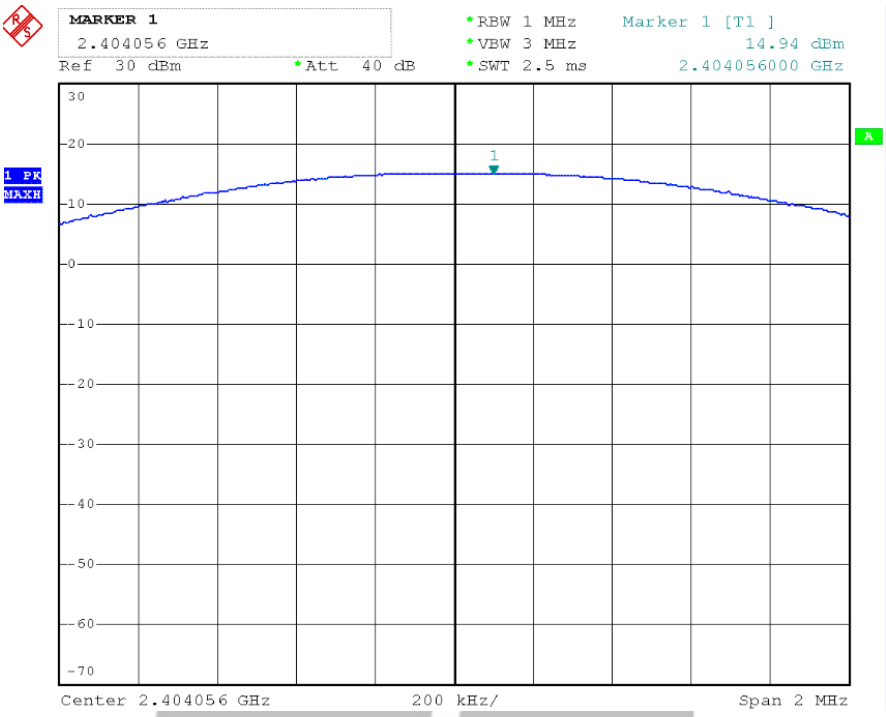
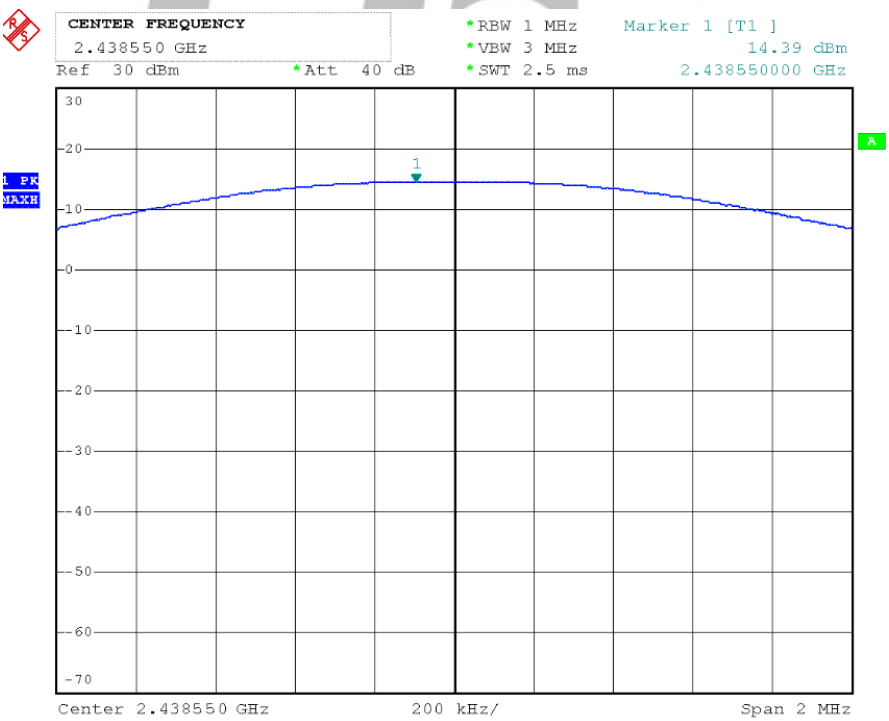
Channel Low：



Channel Middle：



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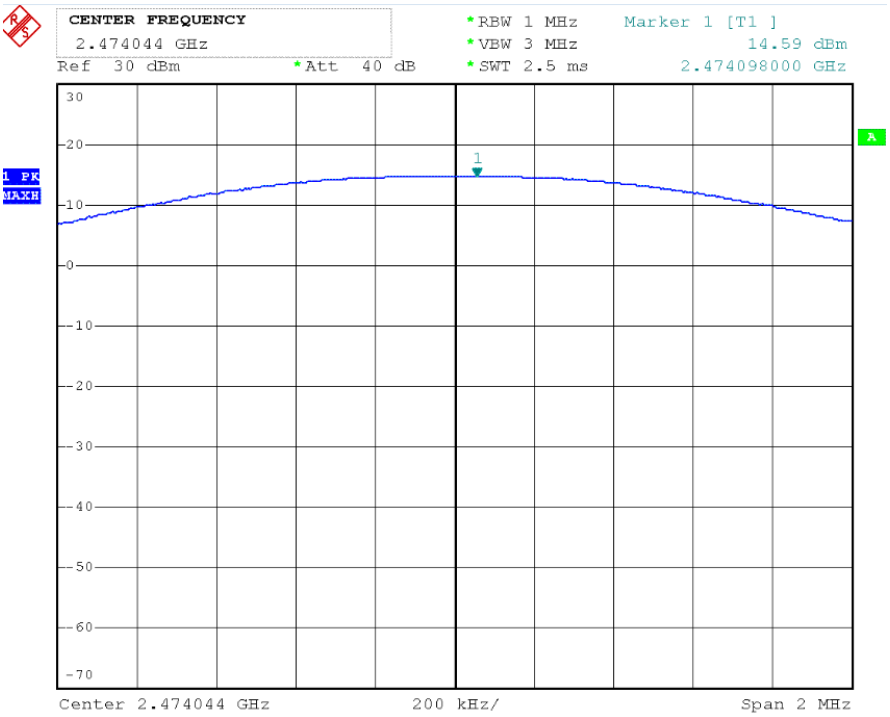
Channel High：



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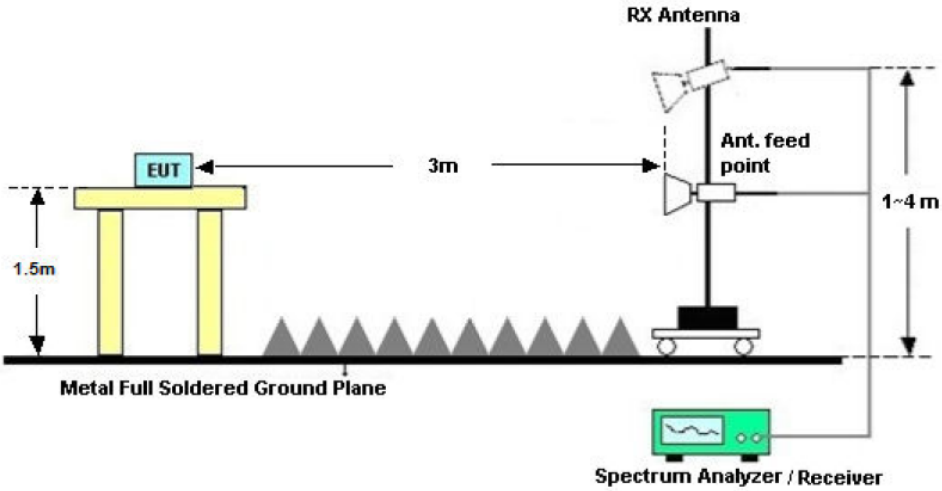
10. Test of Band Edges Emission

10.1 Applicable Standard

Section 15.247(d), RSS-247 Issue1 Clause 5.5: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated 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. In addition, radiated emissions that fall in the restricted bands, as defined in Section 15.205, must also comply with the radiated emission limits specified in Section 15.209.

10.2 EUT Setup

Radiated Measurement Setup



HONGCAI TESTING

Conducted Measurement Setup

Spectrum Analyzer

10.3 Test Equipment List and Details

See section 2.5.

10.4 Test Procedure

Conducted Measurement

1. Span = wide enough to capture the peak level of the emission operating on the channel closest to the bandedge, as well as any modulation products which fall outside of the authorized band of operation.
2. Set the RBW⩾ 1% of the span
3. Set the VBW ≥ RBW.
4. Detector = peak.

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5. Sweep time = auto
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use the peak marker function to determine the maximum amplitude level.

Radiated Measurement

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest

2. Set RBW = 1 MHz for f ⩾ 1 GHz, 100 kHz for f < 1 GHz

3. Set VBW ⩾ RBW

4. Detector = Peak

5. Trace Mode = max hold.

6. Sweep = auto couple.

7. Trace was allowed to stabilize

Average Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest

2. Set RBW = 1 MHz for f ⩾ 1 GHz, 100 kHz for f < 1 GHz

3. Set VBW ⩾ RBW

4. Detector = power average (RMS)

5. Sweep = auto couple.

6. Trace (RMS) averaging was performed over at least 100 traces

NOTE :

1. Configure the EUT according to ANSI C63.10-2013

2. 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 emission field strength of both horizontal and vertical polarization.

4. For band edge emission, the antenna tower was scan (from 1 M to 4 M) and then the turn table was rotated (from 0 degree to 360 degrees) to find the maximum reading.

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10.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: Tx Mode

Radiated Test Result

Frequency (MHz)	Antenna Polarization	Emission Read Value (dBμV/m)	Limits (dBμV/m)	REMARK PK/AV
2400.00	H	37.05	54	PK
2400.00	V	37.55	54	PK
2483.5.00	H	41.69	54	PK
2483.5.00	V	41.98	54	PK

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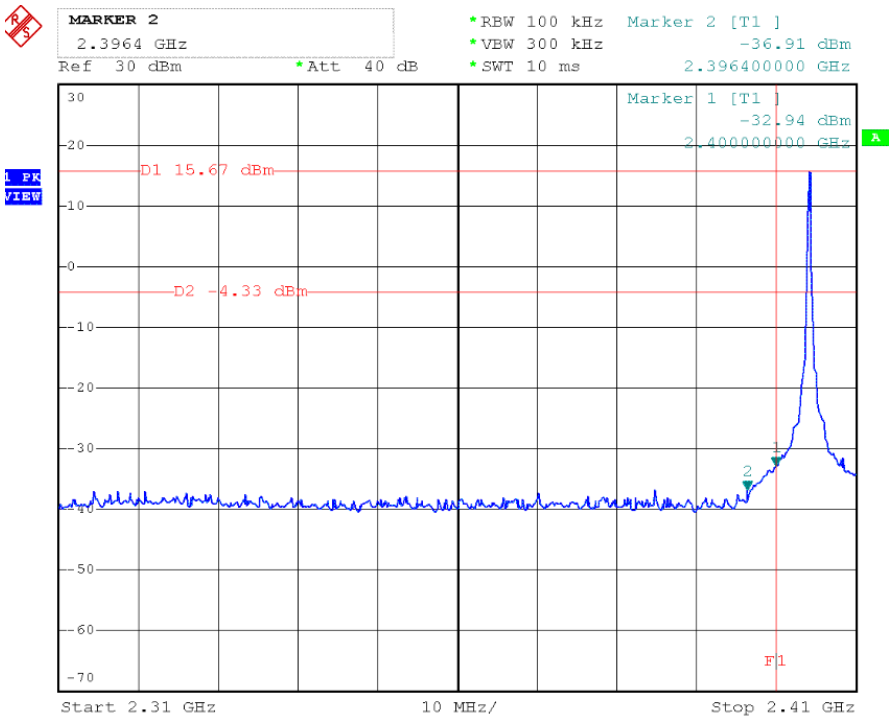
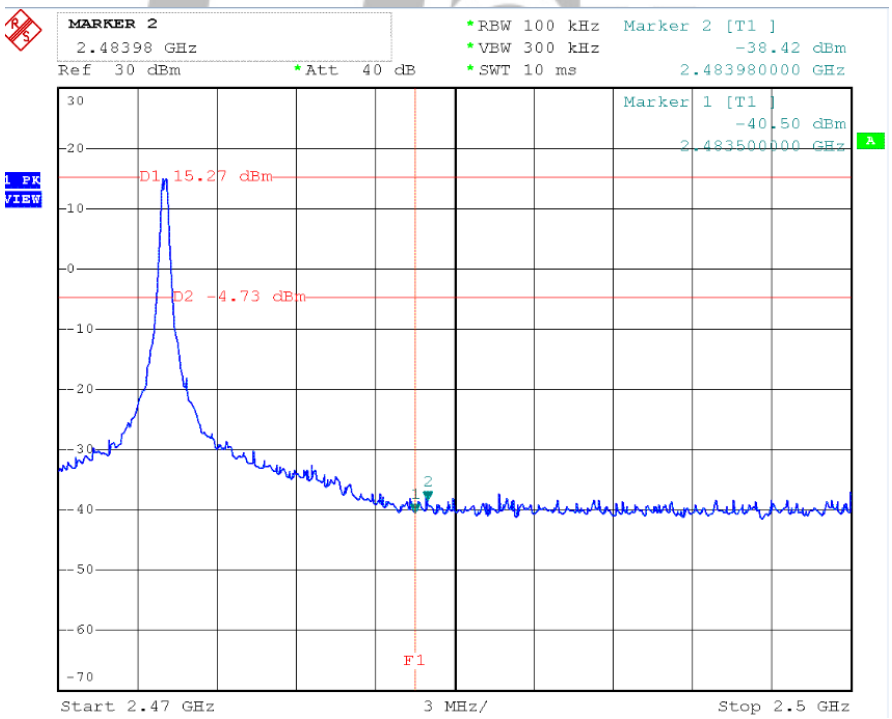
Conducted Test Result

Low Channel



High Channel



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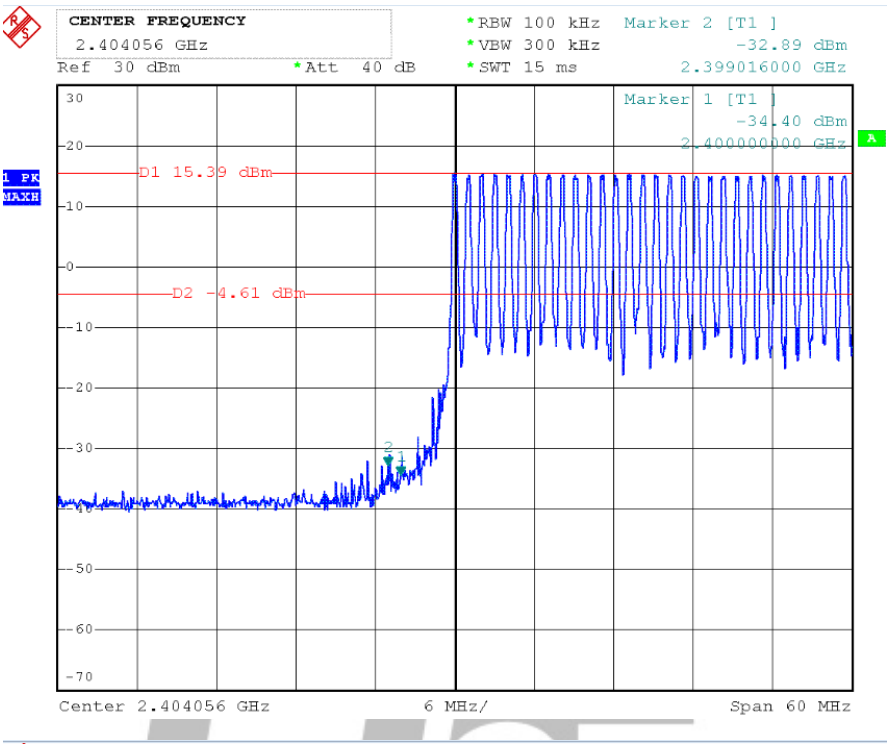
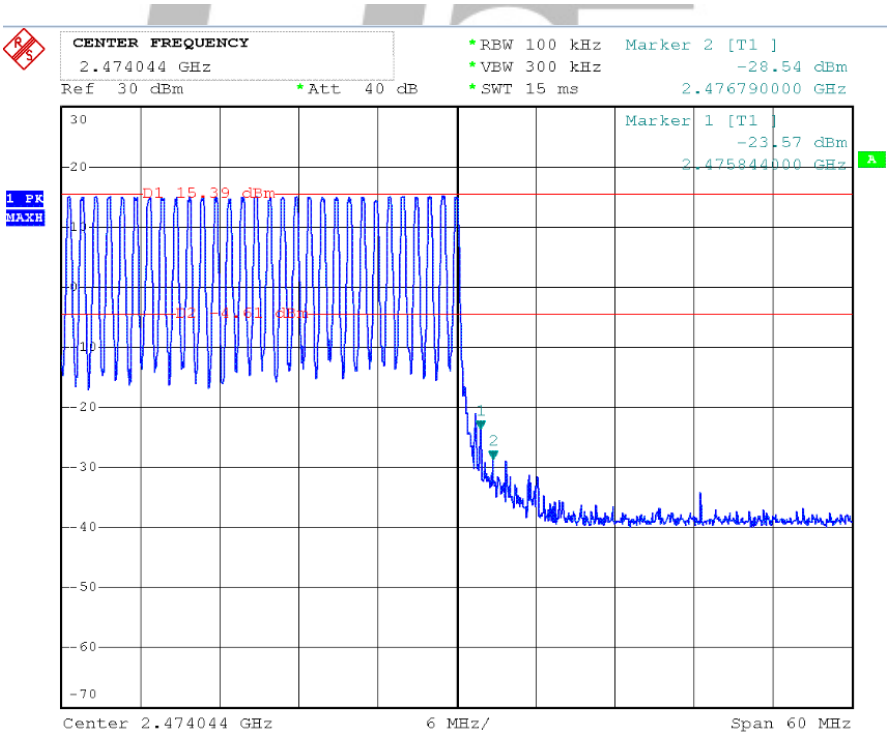
Hopping Conducted Test Result

Low Channel



High Channel



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11. Test of Spurious Radiated Emission

11.1 Applicable Standard

Refer to FCC §15.205 and §15.209, RSS-247 Issue2 Clause 5.5.

11.1.2 Limits

Section 15.247(d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated 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. In addition, radiated emissions that fall in the restricted bands, as defined in Section 15.205, must also comply with the radiated emission limits specified in Section 15.209.

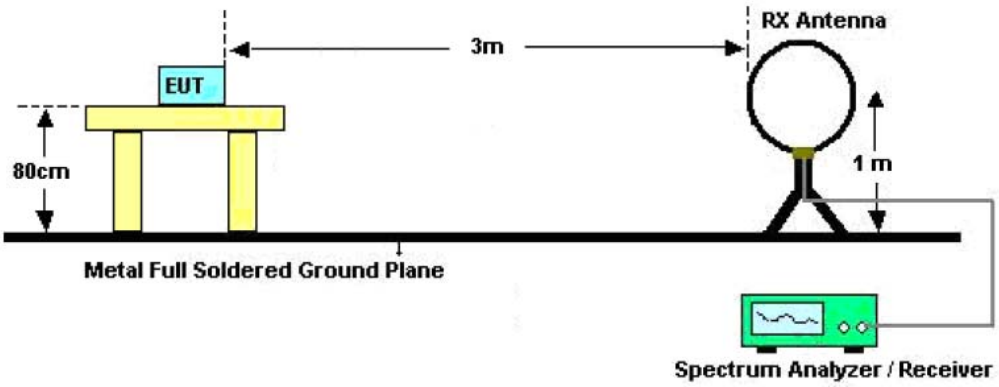
All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47 CFR must not exceed the limits shown in Table per Section 15.209.

Frequency (MHz)	Field Strength (microvolts/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

11.2 EUT Setup

Radiated Measurement Setup

For radiated emission below 30MHz



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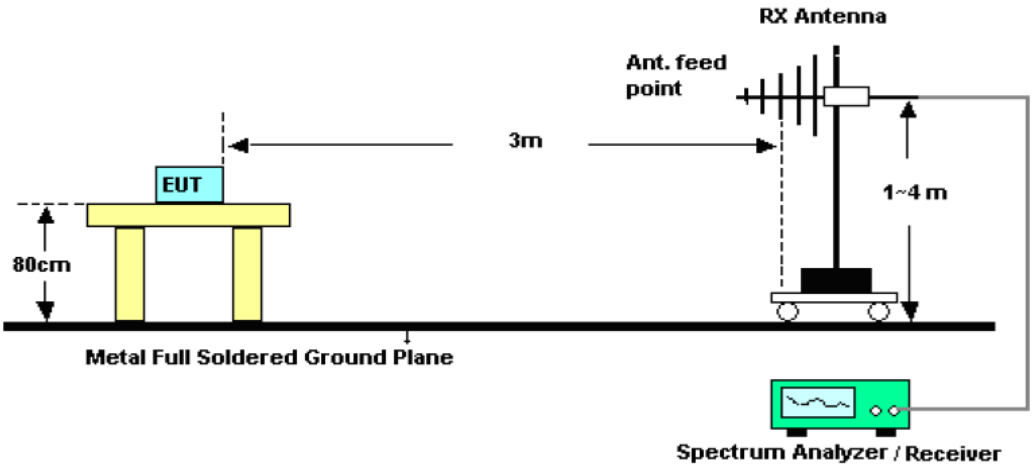
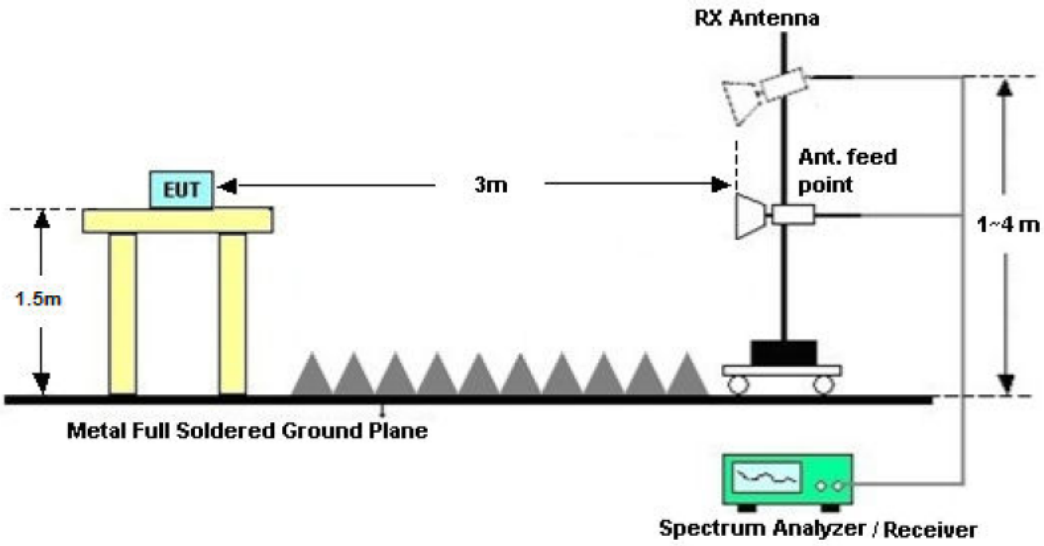
For radiated emission from 30MHz to1GHz



For radiated emission from above1GHz



Conducted Measurement Setup

Spectrum Analyzer

11.3 Test Equipment List and Details

See section 2.5.

11.4 Test Procedure

Conducted Measurement

1. Set the center frequency and span to encompass frequency range to be measured.
2. Set the RBW = 100 kHz.
3. Set the VBW ≥ RBW.

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4. Detector = peak.
5. Sweep time = auto couple.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use the peak marker function to determine the maximum amplitude level.

Radiated Measurement

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest

2. Set RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz

3. Set VBW ≥ RBW

4. Detector = Peak

5. Trace Mode = max hold.

6. Sweep = auto couple.

7. Trace was allowed to stabilize

Average Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest

2. Set RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz

3. Set VBW ≥ RBW

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4. Detector = power average (RMS)

5. Sweep = auto couple.

6. Trace (RMS) averaging was performed over at least 100 traces

NOTE: 1. Configure the EUT according to ANSI C63.10-2013

2. 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 emission field strength of both horizontal and vertical polarization.

4. For band edge emission, the antenna tower was scan (from 1 M to 4 M) and then the turn table was rotated (from 0 degree to 360 degrees) to find the maximum reading.

11.5 Test Result

Temperature (℃) : 22~23	EUT: 2.4GHz Radio Controller
Humidity (%RH): 50~54	M/N: MC-28
Barometric Pressure (mbar): 950~1000	Operation Condition: TX Mode/ simulatneous transmission

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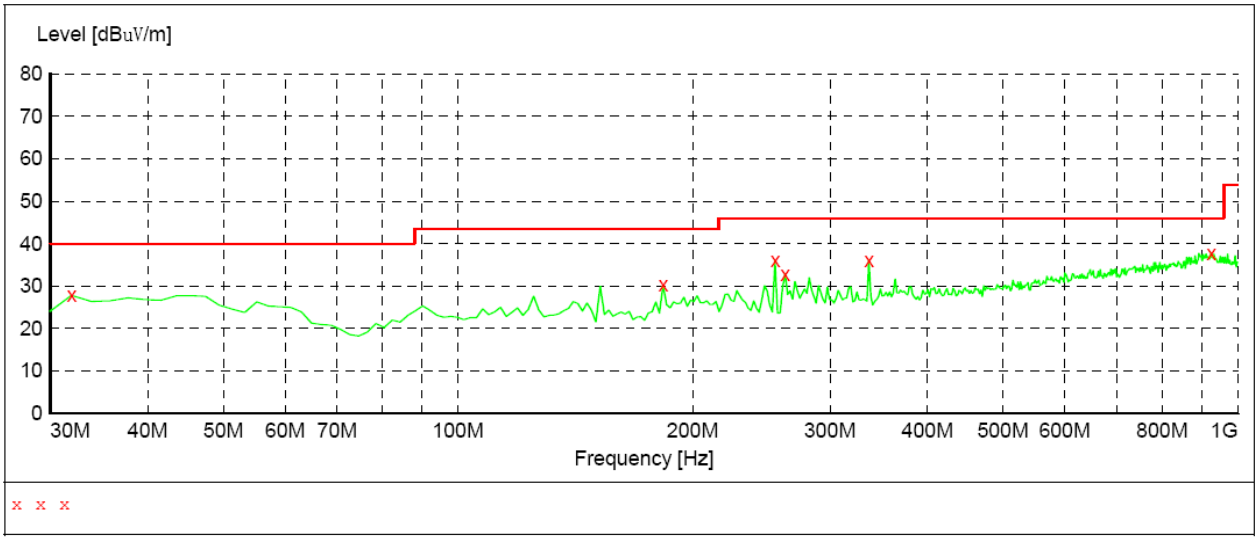
Test Result: PASS

Radiated Spurious Emission Data Below 1GHz Channel Low:

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	TX Mode
Test Site:	3m CHAMBER
Operator:	Chen
Test Specification:	DC 3.8V from battery
Comment:	Polarization: Horizontal

SWEEP TABLE: "test (30M-1G)"

Short Description:			Field Strength		
Start Frequency	Stop Frequency	Detector	Meas. Time	IF Bandw.	Transducer
30.0 MHz	1.0 GHz	MaxPeak	Coupled	100 kHz	9163-2015



MEASUREMENT RESULT:

Frequency MHz	Level dBuV/m	Transd dB	Limit dBuV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
31.940000	27.80	14.0	40.0	12.2	QP	300.0	0.00	HORIZONTAL
183.260000	30.20	12.7	43.5	13.3	QP	300.0	0.00	HORIZONTAL
255.040000	36.00	13.8	46.0	10.0	QP	100.0	0.00	HORIZONTAL
262.800000	32.90	14.4	46.0	13.1	QP	100.0	0.00	HORIZONTAL
336.520000	36.10	16.0	46.0	9.9	QP	100.0	0.00	HORIZONTAL
924.340000	37.80	25.8	46.0	8.2	QP	100.0	0.00	HORIZONTAL

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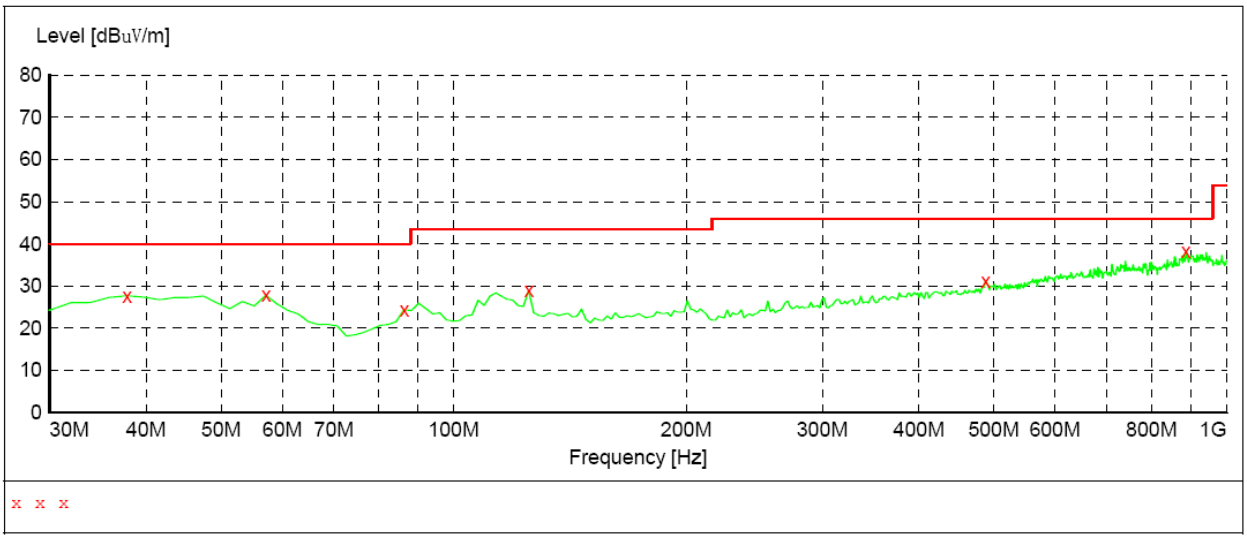
Radiated Spurious Emission Data Below 1GHz Channel Low:

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	TX Mode
Test Site:	3m CHAMBER
Operator:	Chen
Test Specification:	DC 3.8V from battery
Comment:	Polarization: Vertical

SWEEP TABLE: "test (30M-1G)"

Short Description:			Field Strength		
Start Frequency	Stop Frequency	Detector	Meas. Time	IF Bandw.	Transducer
30.0 MHz	1.0 GHz	MaxPeak	Coupled	100 kHz	9163-2015



MEASUREMENT RESULT:

Frequency MHz	Level dBuV/m	Transd dB	Limit dBuV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
37.760000	27.70	13.7	40.0	12.3	QP	100.0	0.00	VERTICAL
57.160000	27.80	15.7	40.0	12.2	QP	100.0	0.00	VERTICAL
86.260000	24.40	12.9	40.0	15.6	QP	100.0	0.00	VERTICAL
125.060000	28.90	13.0	43.5	14.6	QP	100.0	0.00	VERTICAL
487.840000	31.20	19.3	46.0	14.8	QP	100.0	0.00	VERTICAL
885.540000	38.30	25.4	46.0	7.7	QP	100.0	0.00	VERTICAL

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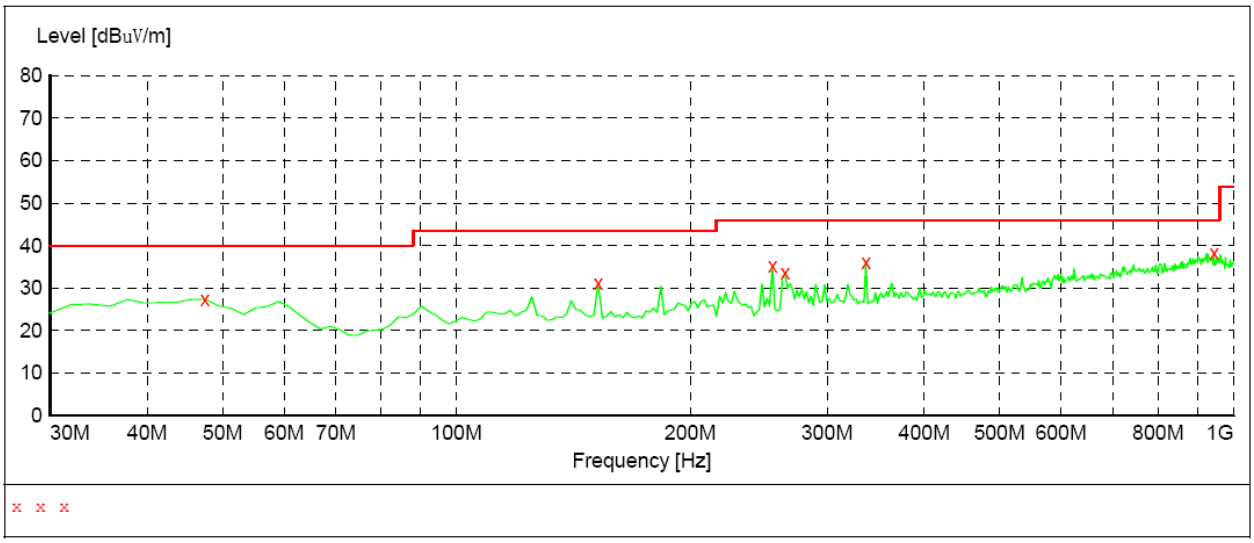
Radiated Spurious Emission Data Below 1GHz Channel Middle:

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	TX Mode
Test Site:	3m CHAMBER
Operator:	Chen
Test Specification:	DC 3.8V from battery
Comment:	Polarization: Horizontal

SWEEP TABLE: "test (30M-1G)"

Short Description:			Field Strength		
Start Frequency	Stop Frequency	Detector	Meas. Time	IF Bandw.	Transducer
30.0 MHz	1.0 GHz	MaxPeak	Coupled	100 kHz	9163-2015



MEASUREMENT RESULT:

Frequency MHz	Level dBuV/m	Transd dB	Limit dBuV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
47.460000	27.40	16.7	40.0	12.6	QP	300.0	0.00	HORIZONTAL
152.220000	31.10	11.4	43.5	12.4	QP	300.0	0.00	HORIZONTAL
255.040000	35.20	13.8	46.0	10.8	QP	100.0	0.00	HORIZONTAL
264.740000	33.70	14.7	46.0	12.3	QP	100.0	0.00	HORIZONTAL
336.520000	36.00	16.0	46.0	10.0	QP	100.0	0.00	HORIZONTAL
943.740000	38.20	25.3	46.0	7.8	QP	100.0	0.00	HORIZONTAL

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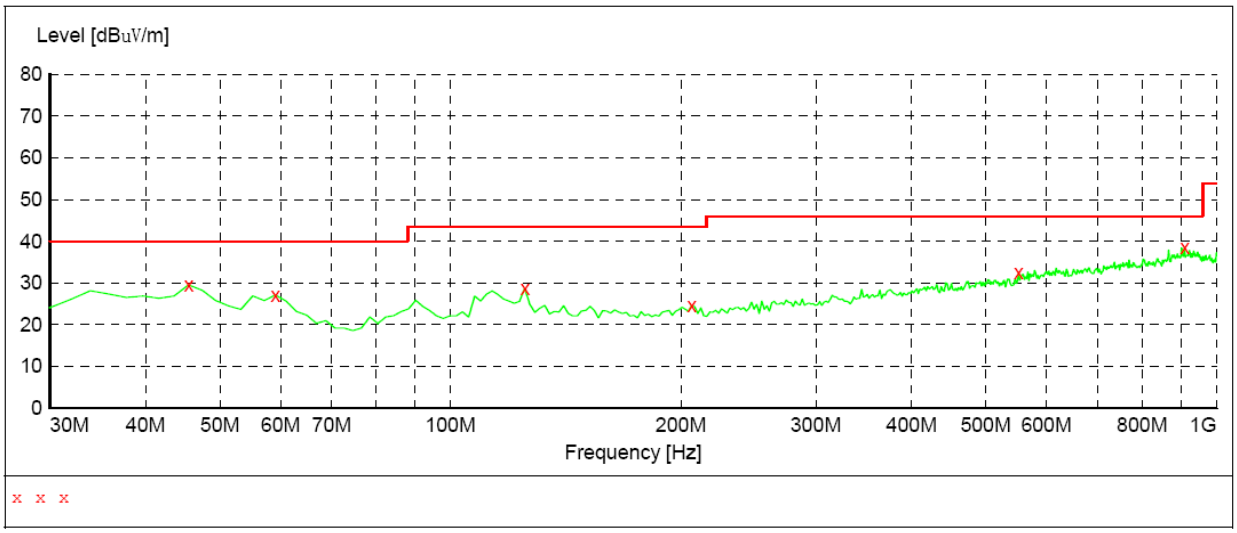
Radiated Spurious Emission Data Below 1GHz Channel Middle:

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	TX Mode
Test Site:	3m CHAMBER
Operator:	Chen
Test Specification:	DC 3.8V from battery
Comment:	Polarization: Vertical

SWEEP TABLE: "test (30M-1G)"

Short Description:			Field Strength		
Start Frequency	Stop Frequency	Detector	Meas. Time	IF Bandw.	Transducer
30.0 MHz	1.0 GHz	MaxPeak	Coupled	100 kHz	9163-2015



MEASUREMENT RESULT:

Frequency MHz	Level dBuV/m	Transd dB	Limit dBuV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
45.520000	29.50	16.8	40.0	10.5	QP	100.0	0.00	VERTICAL
59.100000	27.10	15.7	40.0	12.9	QP	100.0	0.00	VERTICAL
125.060000	28.70	13.0	43.5	14.8	QP	100.0	0.00	VERTICAL
206.540000	24.70	14.1	43.5	18.8	QP	100.0	0.00	VERTICAL
551.860000	32.50	20.5	46.0	13.5	QP	100.0	0.00	VERTICAL
908.820000	38.50	25.8	46.0	7.5	QP	100.0	0.00	VERTICAL

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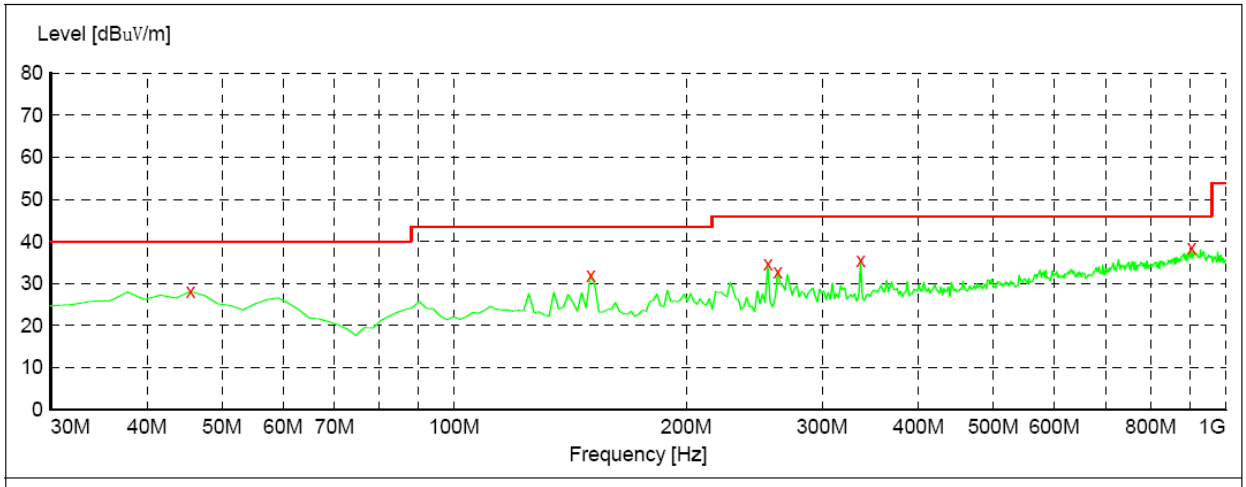
Radiated Spurious Emission Data Below 1GHz Channel High:

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	TX Mode
Test Site:	3m CHAMBER
Operator:	Chen
Test Specification:	DC 3.8V from battery
Comment:	Polarization: Horizontal

SWEEP TABLE: "test (30M-1G)"

Short Description:			Field Strength		
Start Frequency	Stop Frequency	Detector	Meas. Time	IF Bandw.	Transducer
30.0 MHz	1.0 GHz	MaxPeak	Coupled	100 kHz	9163-2015



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MEASUREMENT RESULT:

Frequency MHz	Level dBuV/m	Transd dB	Limit dBuV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
45.520000	28.10	16.8	40.0	11.9	QP	300.0	0.00	HORIZONTAL
150.280000	31.90	11.5	43.5	11.6	QP	100.0	0.00	HORIZONTAL
255.040000	34.70	13.8	46.0	11.3	QP	300.0	0.00	HORIZONTAL
262.800000	32.90	14.4	46.0	13.1	QP	100.0	0.00	HORIZONTAL
336.520000	35.50	16.0	46.0	10.5	QP	100.0	0.00	HORIZONTAL
903.000000	38.40	25.8	46.0	7.6	QP	100.0	0.00	HORIZONTAL

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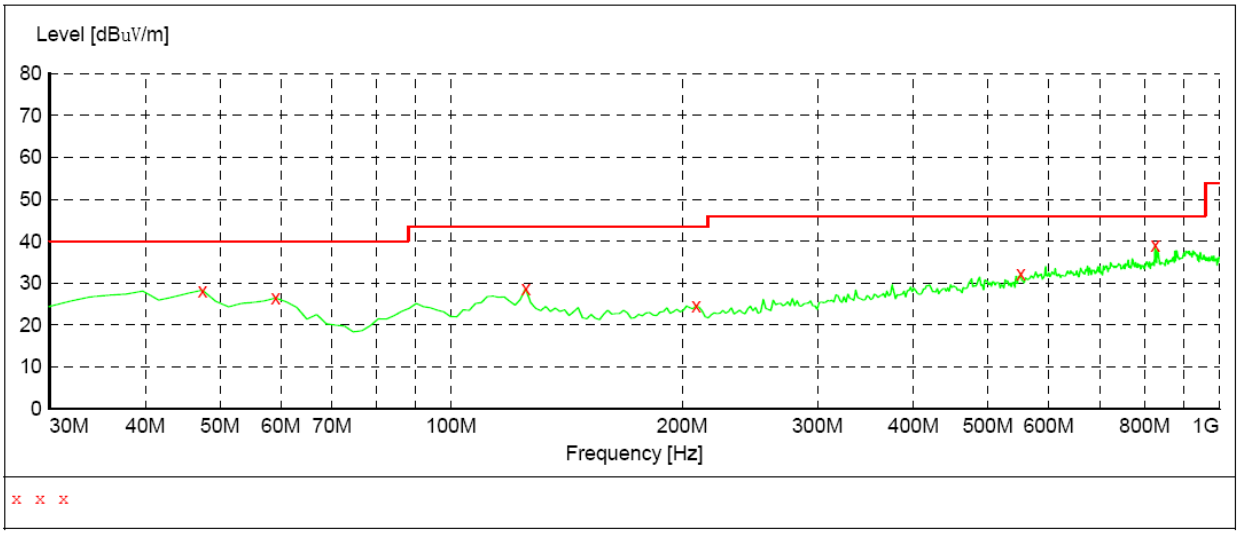
Radiated Spurious Emission Data Below 1GHz Channel High:

EUT:	2.4GHz Radio Controller
M/N:	MC-28
Operating Condition:	TX Mode
Test Site:	3m CHAMBER
Operator:	Chen
Test Specification:	DC 3.8V from battery
Comment:	Polarization: Vertical

SWEEP TABLE: "test (30M-1G)"

Short Description: Field Strength

Start Frequency	Stop Frequency	Detector	Meas. Time	IF Bandw.	Transducer
30.0 MHz	1.0 GHz	MaxPeak	Coupled	100 kHz	9163-2015



MEASUREMENT RESULT:

Frequency MHz	Level dBuV/m	Transd dB	Limit dBuV/m	Margin dB	Det.	Height cm	Azimuth deg	Polarization
47.460000	28.30	16.7	40.0	11.7	QP	100.0	0.00	VERTICAL
59.100000	26.50	15.7	40.0	13.5	QP	100.0	0.00	VERTICAL
125.060000	28.70	13.0	43.5	14.8	QP	100.0	0.00	VERTICAL
208.480000	24.60	14.1	43.5	18.9	QP	100.0	0.00	VERTICAL
551.860000	32.30	20.5	46.0	13.7	QP	100.0	0.00	VERTICAL
825.400000	39.10	24.0	46.0	6.9	QP	100.0	0.00	VERTICAL

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Radiated Spurious Emission Test Data Above 1GHz

Channel Low

Channel Low（2404.056MHz）								
Maximum Frequency (MHz)	Polarity and Level					Limit (dBμV/m)	Margin (dBμV/m)	Mark (P/Q/A)
	Polarity	Height (m)	Reading dBμV	Transd	Result dBμV/m			
2404.056	H	1	113.97	-6.94	107.03	N/A	N/A	P
			104.49	-6.94	97.55	N/A	N/A	A
2404.056	V	1	117.47	-6.94	110.53	N/A	N/A	P
			106	-6.94	99.06	N/A	N/A	A
4808.112	H	1	47.95	0.36	48.31	74	-25.69	P
			37.57	0.36	37.93	54	-16.07	A
4808.112	V	1	48.77	0.36	49.13	74	-24.87	P
			37.48	0.36	37.84	54	-16.16	A
7205	H	1	47.85	7.25	55.1	74	-18.9	P
			37.94	7.25	45.19	54	-8.81	A
7205	V	1	48.64	7.25	55.89	74	-18.11	P
			38.05	7.25	45.3	54	-8.7	A
9613.33	H	1	47.91	9.77	57.68	74	-16.32	P
			39.18	9.77	48.95	54	-5.05	A
9613.33	V	1	50.38	6.86	57.24	74	-16.76	P
			39.19	6.86	46.05	54	-7.95	A
12021.67	H	1	47.91	13.49	61.4	74	-12.6	P
			39.63	13.49	53.12	54	-0.88	A
12021.67	V	1	49.54	13.49	63.03	74	-10.97	P
			39.8	13.49	53.29	54	-0.71	A
----	----	----	----	----	----	----	----	----

Remark: 1. Transd.=Antenna Factor+Cable Loss-Pre-amplifier
Margin = Level-Limit
Mark: P means Peak Value, Q means Quasi Peak Value, A means Average Value
2. 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.
3. Spectrum analyzer setting P(Peak): RBW=1MHz, VBW=3MHz, A(Average): RBW=1MHz, VBW=3MHz.
4. The test limit distance is 3m limit

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Channel Mid

Channel Mid（2438.550MHz）								
Maximum Frequency (MHz)	Polarity and Level					Limit (dBμV/m)	Margin (dBμV/m)	Mark (P/Q/A)
	Polarity	Height (m)	Reading dBμV	Transd	Result dBμV/m			
2438.550	H	1	110.56	-6.53	104.03	N/A	N/A	P
			101.08	-6.53	94.55	N/A	N/A	A
2438.550	V	1	114.06	-6.53	107.53	N/A	N/A	P
			102.59	-6.53	96.06	N/A	N/A	A
4877.10	H	1	49.75	0.59	50.34	74	-23.66	P
			39.06	0.59	39.65	54	-14.35	A
4877.10	V	1	49.88	0.59	50.47	74	-23.53	P
			39.08	0.59	39.67	54	-14.33	A
7321.68	H	1	48.95	7.32	56.27	74	-17.73	P
			38.59	7.32	45.91	54	-8.09	A
7321.68	V	1	49.06	7.32	56.38	74	-17.62	P
			38.97	7.32	46.29	54	-7.71	A
9754.20	H	1	48.24	9.95	58.19	74	-15.81	P
			39.33	9.95	49.28	54	-4.72	A
9754.20	V	1	49.14	9.95	59.09	74	-14.91	P
			39.24	9.95	49.19	54	-4.81	A
12342.75	H	1	49.52	13.58	63.1	74	-10.9	P
			39.43	13.58	53.01	54	-0.99	A
12342.75	V	1	49.5	13.58	63.08	74	-10.92	P
			39.24	13.58	52.82	54	-1.18	A
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Remark: 1. Transd.=Antenna Factor+Cable Loss-Pre-amplifier
Margin = Level-Limit
Mark: P means Peak Value, Q means Quasi Peak Value, A means Average Value
2. 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.
3. Spectrum analyzer setting P(Peak): RBW=1MHz, VBW=3MHz, A(Average): RBW=1MHz, VBW=3MHz.
4. The test limit distance is 3m limit

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Channel High

Channel High（2474.044MHz）								
Maximum Frequency (MHz)	Polarity and Level					Limit (dBμV/m)	Margin (dBμV/m)	Mark (P/Q/A)
	Polarity	Height (m)	Reading dBμV	Transd	Result dBμV/m			
2474.044	H	1	109.75	-6.44	103.31	N/A	N/A	P
			99.86	-6.44	93.42	N/A	N/A	A
2474.044	V	1	112.75	-6.44	106.31	N/A	N/A	P
			100.79	-6.44	94.35	N/A	N/A	A
4948.088	H	1	48.78	0.81	49.59	74	-24.41	P
			38.59	0.81	39.4	54	-14.6	A
4948.088	V	1	51.58	0.81	52.39	74	-21.61	P
			39.9	0.81	40.71	54	-13.29	A
7422.132	H	1	49.79	7.4	57.19	74	-16.81	P
			38.86	7.4	46.26	54	-7.74	A
7422.132	V	1	48.64	7.4	56.04	74	-17.96	P
			38.59	7.4	45.99	54	-8.01	A
9896.176	H	1	47.61	9.77	57.38	74	-16.62	P
			38.88	9.77	48.65	54	-5.35	A
9896.176	V	1	50.08	6.86	56.94	74	-17.06	P
			38.89	6.86	45.75	54	-8.25	A
12370.22	H	1	47.61	13.49	61.1	74	-12.9	P
			39.33	13.49	52.82	54	-1.18	A
12370.22	V	1	49.24	13.49	62.73	74	-11.27	P
			39.5	13.49	52.99	54	-1.01	A
25381.35	----	----	----	----	----	----	----	----

Remark: 1. Transd.=Antenna Factor+Cable Loss-Pre-amplifier
Margin = Level-Limit
Mark: P means Peak Value, Q means Quasi Peak Value, A means Average Value
2. 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.
3. Spectrum analyzer setting P(Peak): RBW=1MHz, VBW=3MHz, A(Average): RBW=1MHz, VBW=3MHz.
4. The test limit distance is 3m limit

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Radiated Emission Below 30 MHz TX (CH Low)

Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Emission Levels (dBuV/m)	Limit (dBμV/m)	Margin (dB)	Detector Mode
0.52	24.68	8.14	-1.03	31.79	73.2	-41.41	QP
21.36	23.32	8.68	1.24	33.24	69.5	-36.26	QP
26.06	25.43	8.86	1.13	35.42	69.5	-34.08	QP
27.33	26.48	8.04	1.71	36.23	69.5	-33.27	QP

Note:

1. The pre-test have done for the EUT in three axes and found the worst emission at position shown in test setup photos. The worst case data is recorded in the report.
2. Emission level (dBuV/m) =Raw Value (dBuV) + Correction Factor (dB/m)
3. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
4. The other emission levels were very low against the limit.
5. Margin value = Emission level.- Limit value

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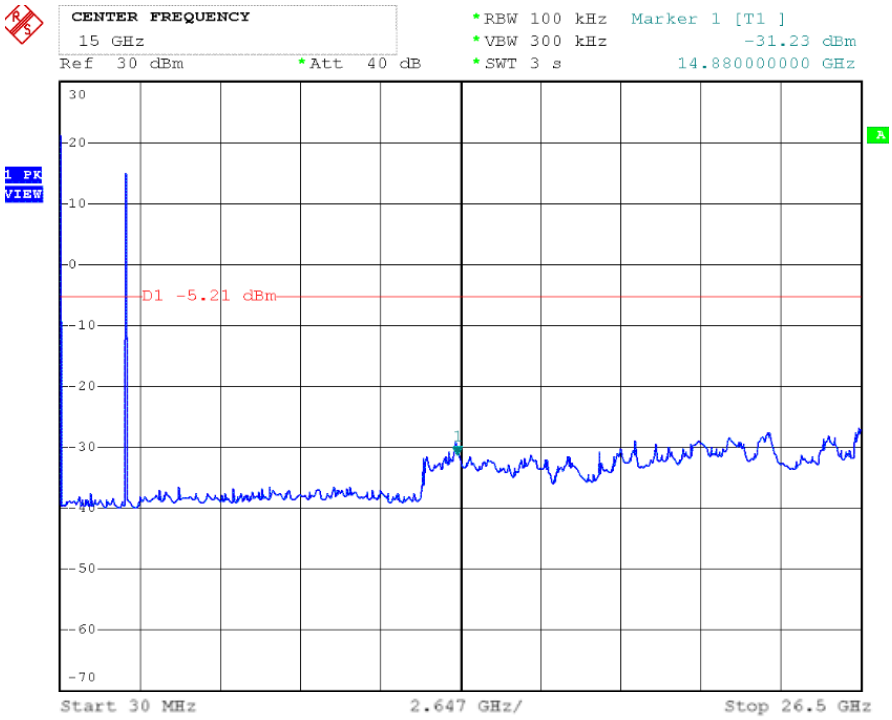
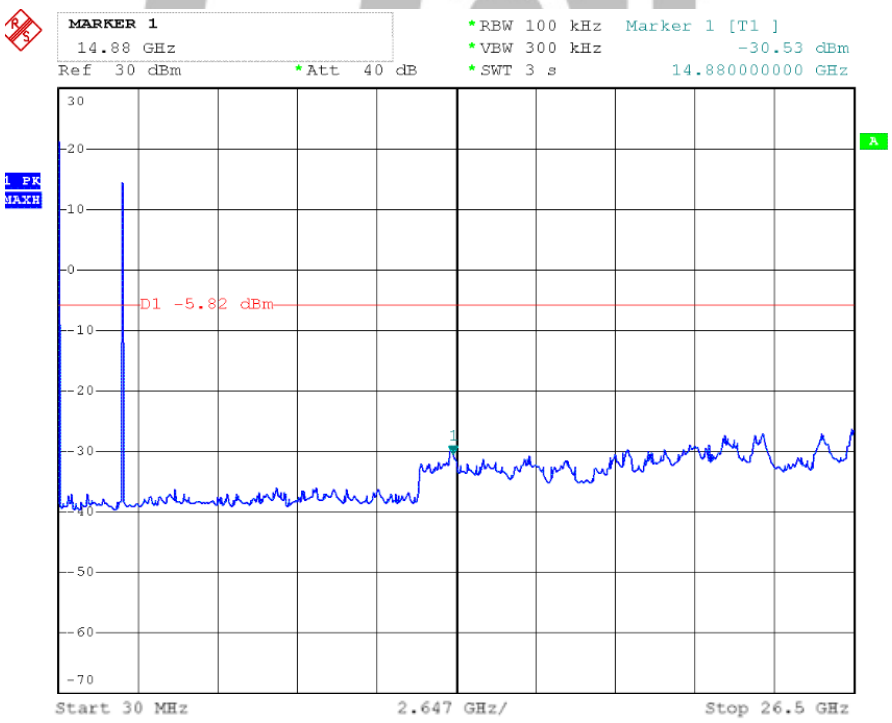
Conducted Spurious Emission Test Data 30MHz-26.5GHz

Channel Low



Channel Mid



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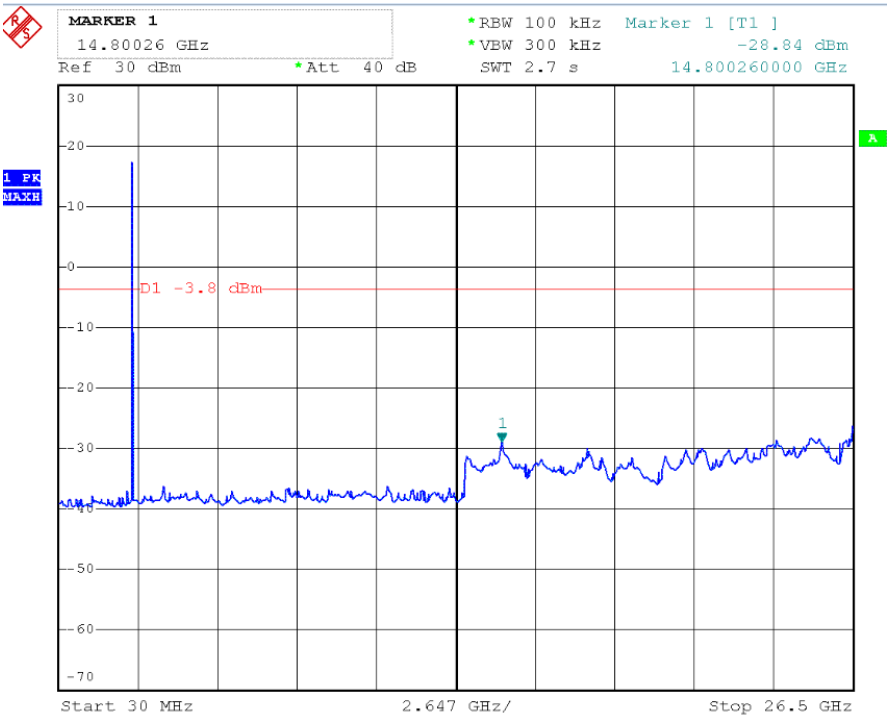
Channel High



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12. ANTENNA REQUIREMENT

12.1 Standard Applicable

Section 15.203, RSS-GEN Clause 8.3:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Section 15.247(b)/(c):

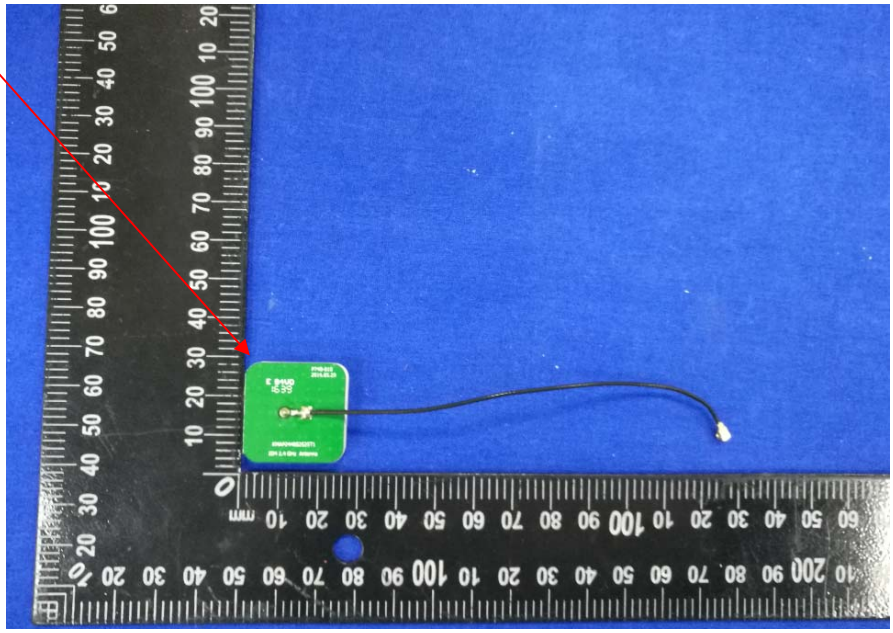
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

If the intentional radiator is used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

12.2 Antenna Connected Construction

The antenna connector is designed with permanent attachment and no consideration of replacement. The antenna used in this product is complied with Standard. The maximum Gain of the antenna lower than 6.0dBi and have the definite antenna Specification.

Antenna



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