



TESTING LABORATORY
CERTIFICATE#4323.01



FCC PART 15.247 TEST REPORT

For

Murata Manufacturing Co., Ltd.

10-1, Higashikotari 1-chome, Nagaokakyo-shi, Kyoto 617-8555, Japan

FCC ID: VPYLB1SJ

Report Type: Original Report	Product Type: LoRa Module
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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Applicant	Murata Manufacturing Co., Ltd.
Tested Model	LBAA0QB1SJ
Product Type	LoRa Module
Power Supply	DC 3.3V
RF Function	LoRa (125kHz)
Operating Frequency	902.3-914.9MHz
Channel Number	64
Channel Separation	200kHz
Modulation Type	LoRa
Antenna Type	PCB antenna, FPC antenna with IPEX connector
Maximum Antenna Gain	PCB antenna/ FPC antenna: 1dBi
Firmware Version	Test FW V0.0.15

**All measurement and test data in this report was gathered from production sample serial number: 20190916001.
(Assigned by the BACL. The EUT supplied by the applicant was received on 2019-09-16)*

Objective

This test report is prepared on behalf of *Murata Manufacturing Co., Ltd.* in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions rules.

The tests were performed in order to determine Compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

Related Submittal(s)/Grant(s)

Part 15.247 DTS submissions with FCC ID: VPYLB1SJ.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed and Bay Area Compliance Laboratories Corp. (Kunshan). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Item		Uncertainty
AC Power Lines Conducted Emissions		3.19dB
RF conducted test with spectrum		0.9dB
RF Output Power with Power meter		0.5dB
Radiated emission	30MHz~1GHz	6.11dB
	1GHz~6GHz	4.45dB
	6GHz~18GHz	5.23dB
	18GHz~40GHz	5.65dB
Occupied Bandwidth		0.5kHz
Temperature		1.0℃
Humidity		6%

Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the No.248 Chenghu Road, Kunshan, Jiangsu province, China.

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01), the FCC designation No. CN1185 under the FCC KDB 974614 D01 and CAB identifier CN0004 under the ISED requirement. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-2014.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The frequencies is $F(\text{MHz})=902.3+0.2*n$ ($0 \leq n \leq 63$). The lowest, middle, highest channel numbers of the EUT used and tested in this report are below:

Channel	Frequency (MHz)
0	902.3
32	908.7
63	914.9

EUT Exercise Software

RF test software: FSKLoRaCmd.

Power level: 18.

Data rate: SF10.

Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
Murata Manufacturing Co., Ltd.	Base plate 1	JS-0909 Type1SJ EVB_PCB Antenna	/
Molex	FPC antenna	2111400100	/
ZHAOXIN	DC Power Supply	RXN-605D	DC002

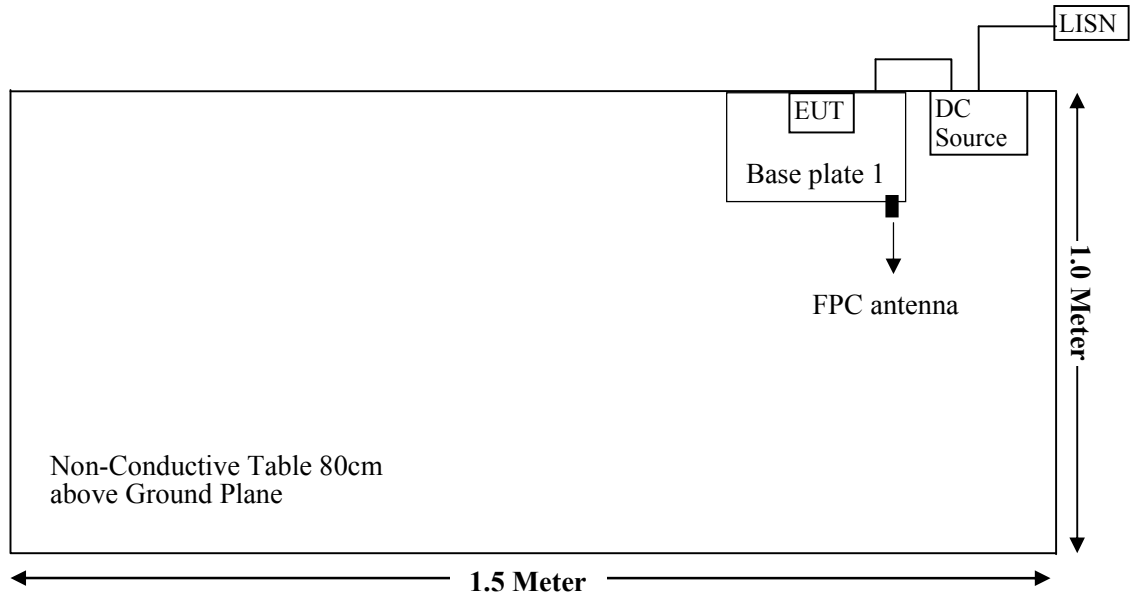
External I/O Cable

Cable Description	Length (m)	From Port	To
DC Cable	1.0	EUT	DC Source

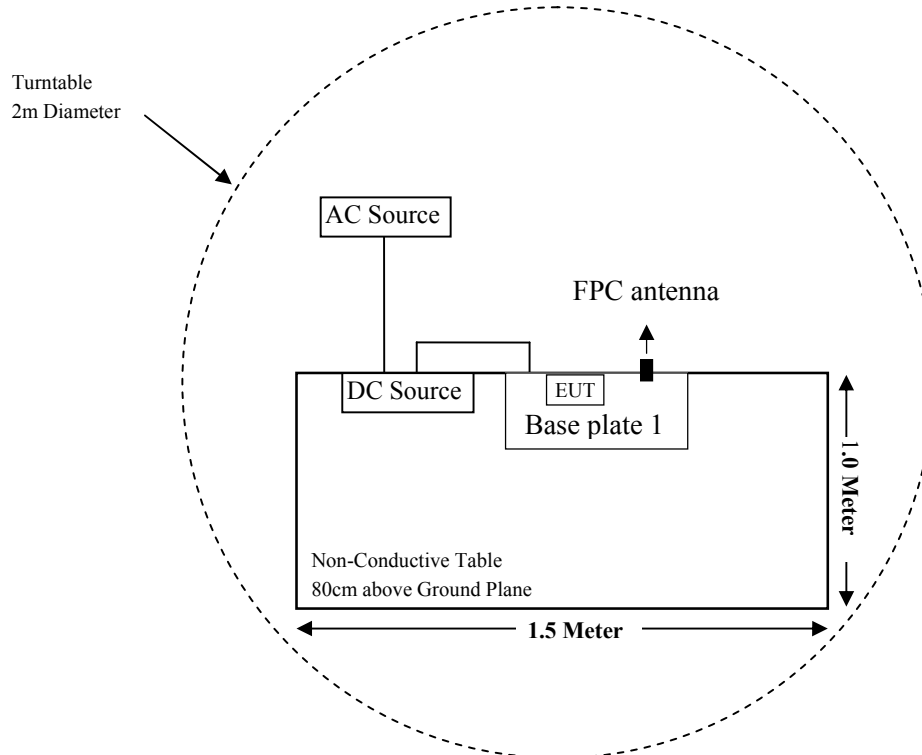
Block Diagram of Test Setup

For FPC antenna:

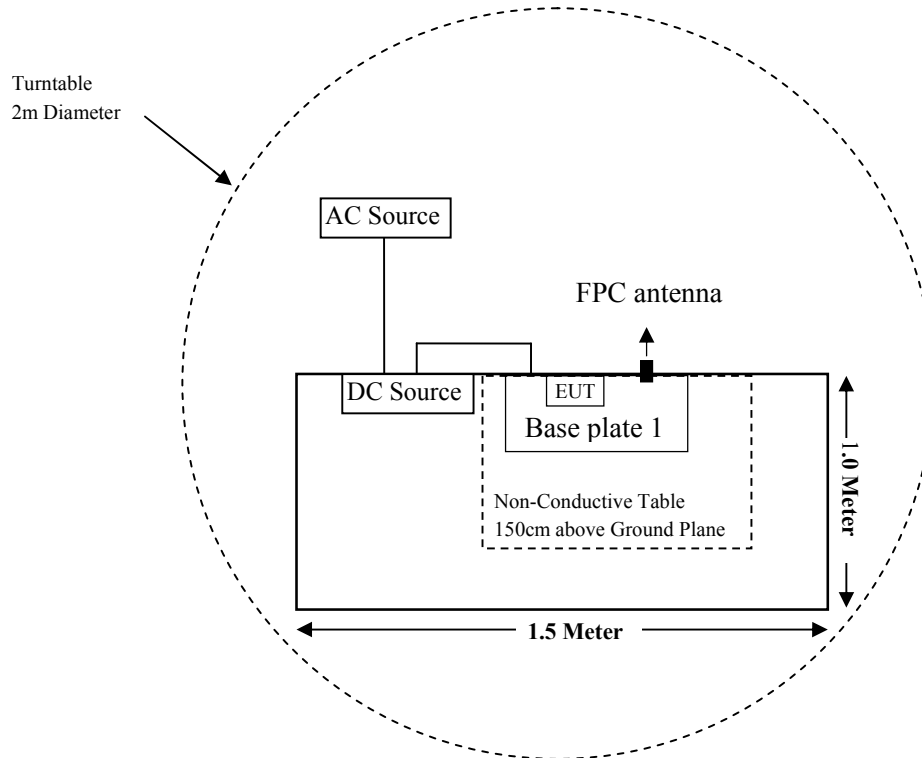
For Conducted Emissions:



For Radiated Emissions(Below 1GHz):

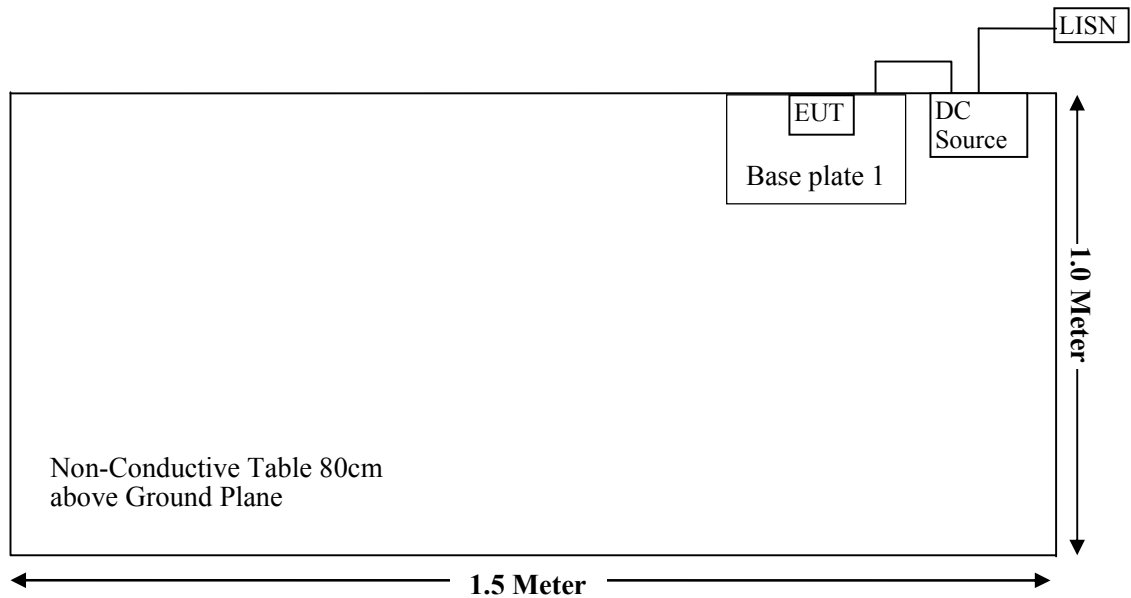


For Radiated Emissions(Above 1GHz):

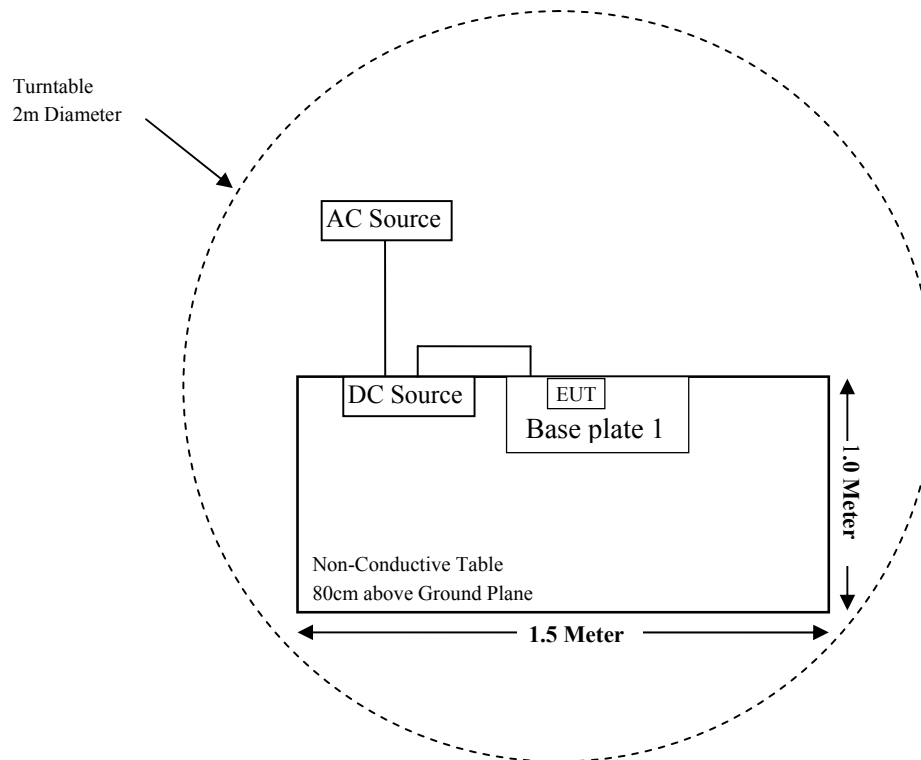


For PCB antenna:

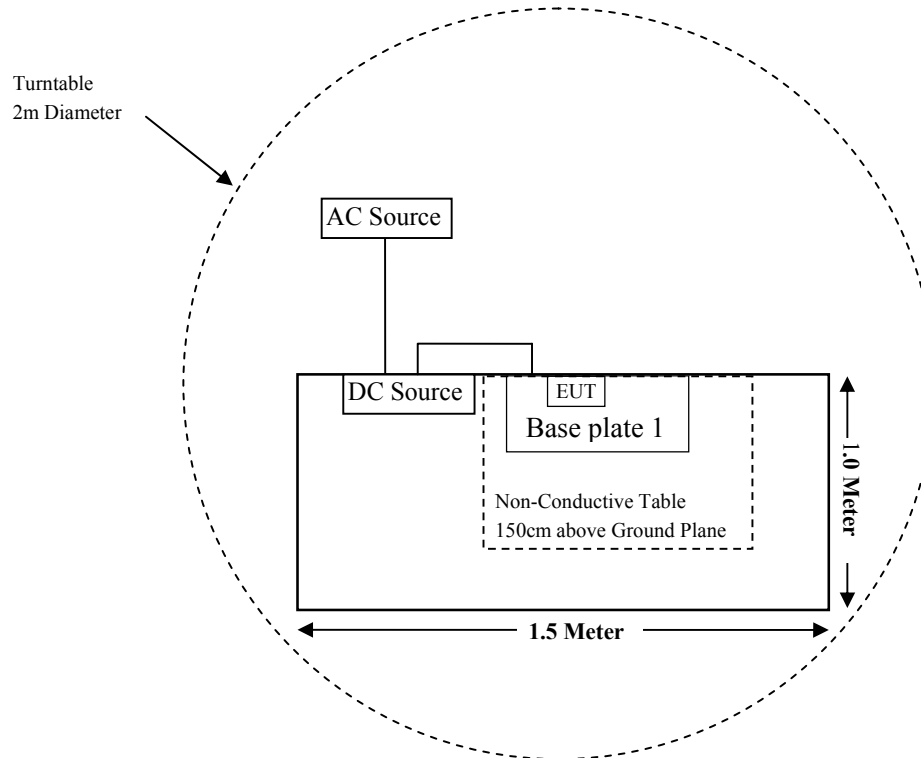
For Conducted Emissions:



For Radiated Emissions(Below 1GHz):



For Radiated Emissions(Above 1GHz):



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC §1.1310& §2.1091	Maximum Permissible Exposure (MPE)	Compliant
§15.203	Antenna Requirement	Compliant
§15.207(a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliant
§15.247(a)(1)	Channel Separation Test	Compliant
§15.247(a)(1)(i)	20 dB Emission Bandwidth	Compliant
§15.247(a)(1)(i)	Quantity of Hopping Channel Test	Compliant
§15.247(f)	Time of Occupancy (Dwell Time) of hybrid systems	Compliant (See Note)
§15.247(f)	Power Spectral Density of hybrid systems	Compliant (See Note)
§15.247(b)(3)	Maximum conducted(average) output power	Compliant
§15.247(d)	Band edges Testing	Compliant

Note: The EUT use a hybrid systems in the band.

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Radiated Emission Test (Chamber 3#)					
Rohde & Schwarz	EMI Test Receiver	ESR	102454	2019-12-14	2020-12-13
Sunol Sciences	Broadband Antenna	JB3	A060217	2017-08-04	2020-08-03
Sonoma Instrument	Pre-amplifier	310N	171205	2019-08-14	2020-08-13
Audix	Test Software	e3	V9	/	/
MICRO-COAX	Coaxial Cable	Cable-8	008	2019-08-15	2020-08-14
MICRO-COAX	Coaxial Cable	Cable-9	009	2019-08-15	2020-08-14
MICRO-COAX	Coaxial Cable	Cable-10	010	2019-08-15	2020-08-14
Radiated Emission Test (Chamber 2#)					
Rohde & Schwarz	EMI Test Receiver	ESU40	100207	2019-05-30	2020-05-29
ETS-LINDGREN	Horn Antenna	3115	9207-3900	2017-07-15	2020-07-14
A.H.Systems, inc	Amplifier	2641-1	491	2020-02-20	2021-02-19
Narda	Attenuator	10dB	010	2019-08-15	2020-08-14
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-6	006	2019-08-15	2020-08-14
MICRO-COAX	Coaxial Cable	Cable-11	011	2019-08-15	2020-08-14
MICRO-COAX	Coaxial Cable	Cable-12	012	2019-08-15	2020-08-14
MICRO-COAX	Coaxial Cable	Cable-13	013	2019-08-15	2020-08-14
RF Conducted Test					
Rohde & Schwarz	Signal Analyzer	FSIQ26	836131/009	2019-11-30	2020-11-29
Agilent	Power Meter	N1912A	MY5000492	2019-11-18	2020-11-17
Agilent	Power Sensor	N1921A	MY54210024	2019-11-18	2020-11-17
Rohde & Schwarz	Signal Analyzer	FSV40	101116	2019-08-05	2020-08-04
Narda	Attenuator	10dB	010	2019-08-15	2020-08-14
Murata	RF Cable	Murata C01	C01	Each Time	/
Conducted Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESR	1316.3003K03-101746-zn	2019-07-11	2020-07-10
Audix	Test Software	e3	V9	/	/
Rohde & Schwarz	LISN	ENV216	3560655016	2019-11-30	2020-11-29
Rohde & Schwarz	Pulse limiter	ESH3-Z2	0357.8810.54	2019-08-15	2020-08-14
MICRO-COAX	Coaxial Cable	Cable-15	015	2019-08-15	2020-08-14

* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §1.1310& §2.1091 - MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247(i) and subpart §1.1310, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guidelines.

Limits for Maximum Permissible Exposure (MPE) (§1.1310, §2.1091)

(B) Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm²)	Averaging Time (minutes)
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/		f/1500	30
1500-100,000	/		1.0	30

f = frequency in MHz; * = Plane-wave equivalent power density;

According to §1.1310 and §2.1091 RF exposure is calculated.

Calculated Formulary:

Predication of MPE limit at a given distance

$S = PG/4\pi R^2$ = power density (in appropriate units, e.g. mW/cm²);

P = power input to the antenna (in appropriate units, e.g., mW);

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain;

R = distance to the center of radiation of the antenna (appropriate units, e.g., cm);

Calculated Data:**For worst case:**

Mode	Frequency Range (MHz)	Antenna Gain		Tune-up Conducted average Power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
LoRa (125kHz)	902.3-914.9	1	1.26	18.00	63.10	20	0.0158	0.60
LoRa (500kHz)	903-914.2	1	1.26	21.50	141.25	20	0.0354	0.60

Conclusion: The device meets FCC MPE at 20 cm distance.

FCC §15.203 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 15.203, 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.

Antenna Connector Construction

The EUT has been tested with two antennas for Lora, one FPC antenna with IPEX connector which the antenna gain is 1dBi and one PCB antenna which the antenna gain is 1dBi, fulfill the requirement of this section. Please refer to the EUT photos.

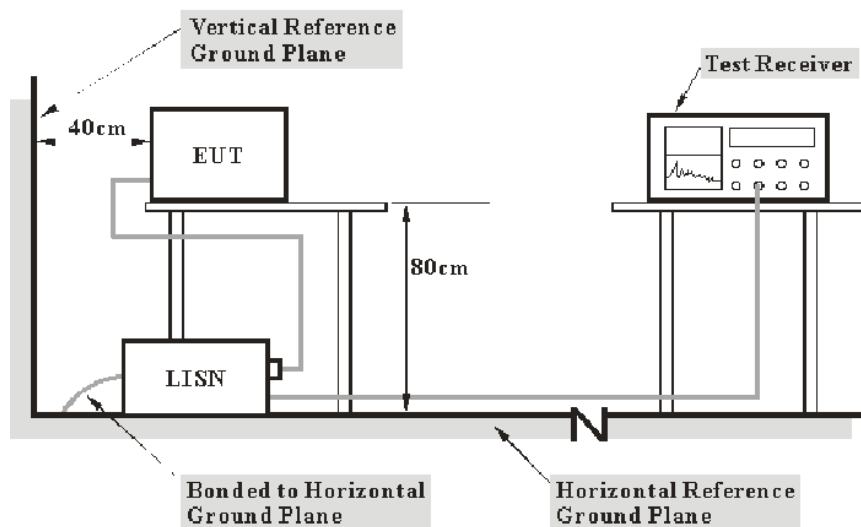
Result: Compliant.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the DC Source was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Corrected Factor & Over Limit Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

$$\text{Factor (dB)} = \text{LISN VDF (dB)} + \text{Cable Loss (dB)} + \text{Transient Limiter Attenuation (dB)}$$

The “**Over Limit**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an over limit of 7dB means the emission is 7 dB above the limit. The equation for over limit calculation is as follows:

$$\text{Over Limit (dB)} = \text{Read level (dB}\mu\text{V)} + \text{Factor (dB)} - \text{Limit (dB}\mu\text{V)}$$

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207.

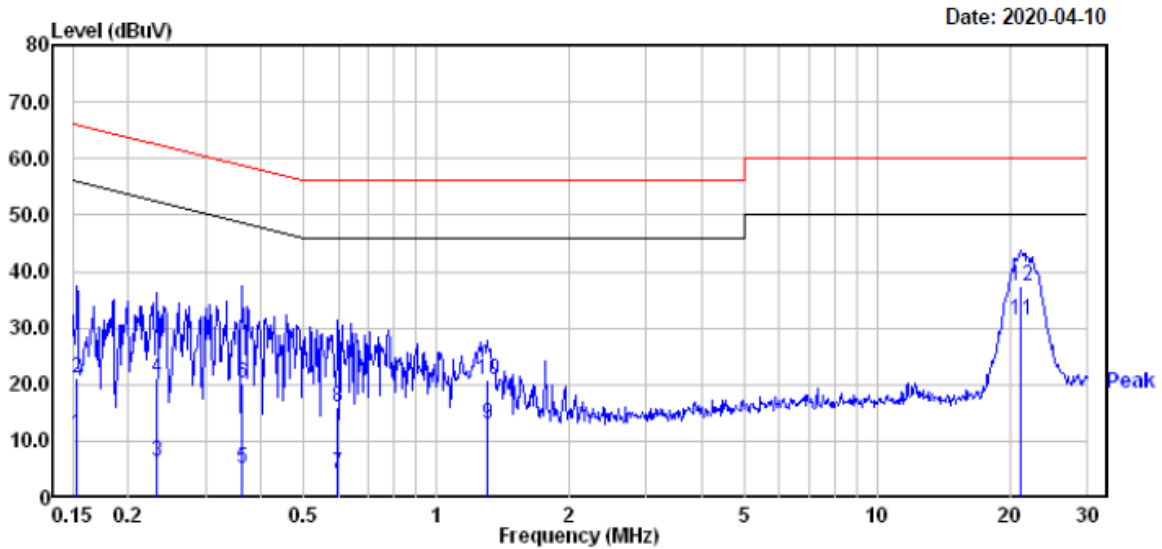
Test Data

Environmental Conditions

Temperature:	22 °C
Relative Humidity:	50 %
ATM Pressure:	101.3 kPa

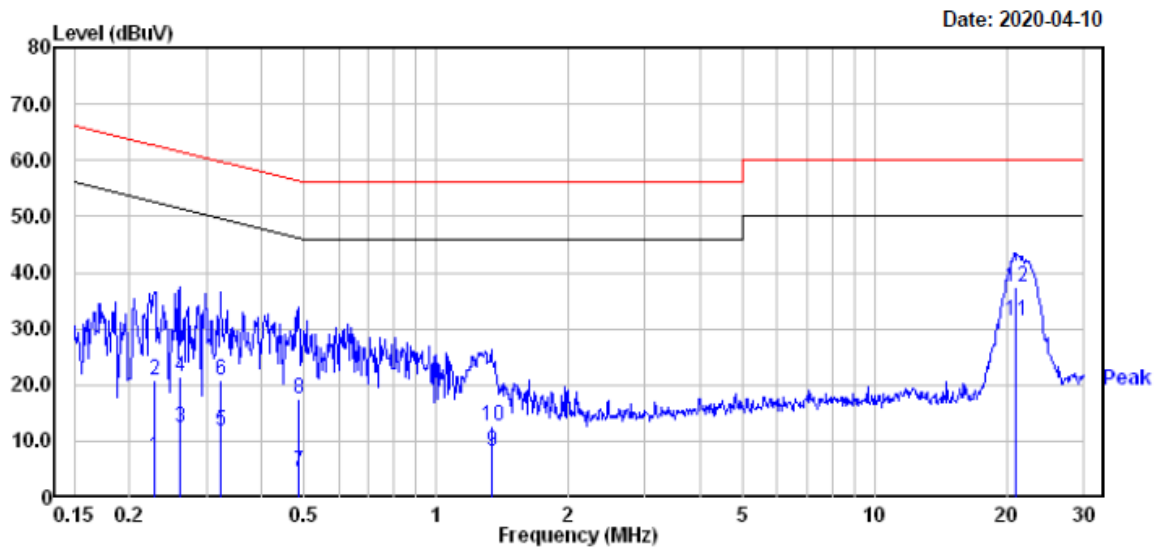
The testing was performed by Chao Gao on 2020-04-10.

EUT operation mode: Transmitting in low channel (worst case)

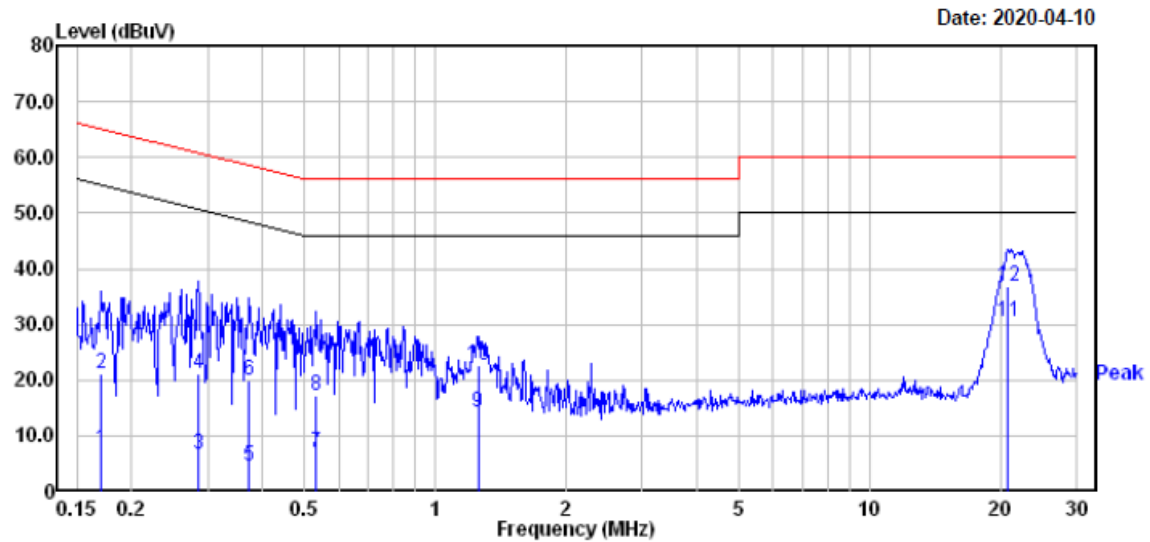
For FPC antenna**AC 120V/60 Hz, Line**

	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBUV	dB	dBUV	dBUV	dB	
1	0.153	-8.60	19.82	11.22	55.82	-44.60	Average
2	0.153	1.20	19.82	21.02	65.82	-44.80	QP
3	0.233	-13.40	19.82	6.42	52.35	-45.93	Average
4	0.233	1.20	19.82	21.02	62.35	-41.33	QP
5	0.363	-14.60	19.79	5.19	48.65	-43.46	Average
6	0.363	0.30	19.79	20.09	58.65	-38.56	QP
7	0.598	-15.50	19.75	4.25	46.00	-41.75	Average
8	0.598	-3.80	19.75	15.95	56.00	-40.05	QP
9	1.303	-6.70	19.82	13.12	46.00	-32.88	Average
10	1.303	1.10	19.82	20.92	56.00	-35.08	QP
11	21.260	11.59	19.89	31.48	50.00	-18.52	Average
12	21.260	17.59	19.89	37.48	60.00	-22.52	QP

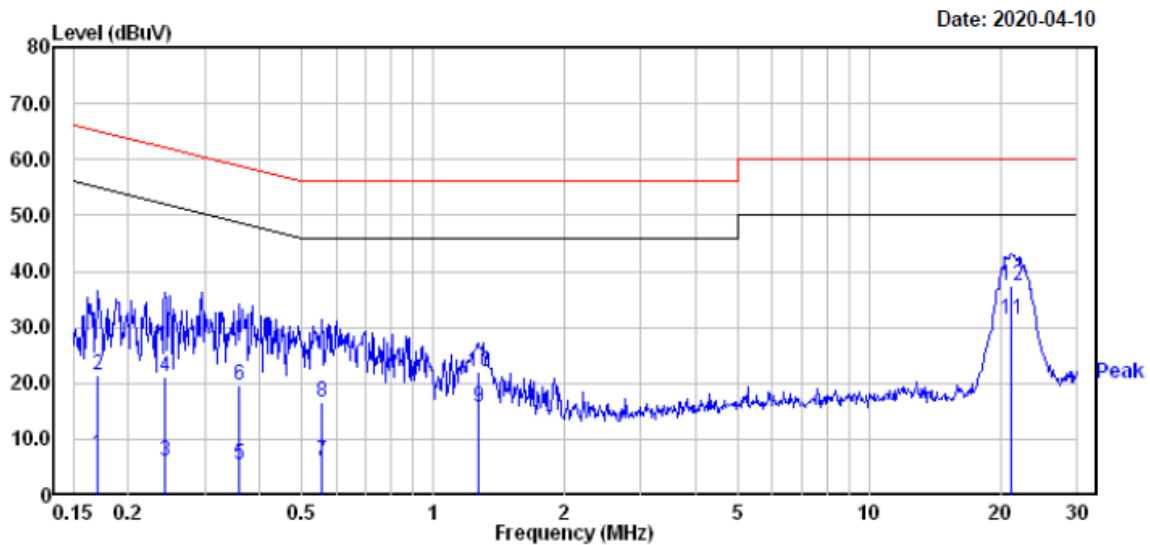
AC 120V/60 Hz, Neutral



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.228	-12.50	19.82	7.32	52.52	-45.20	Average
2	0.228	1.00	19.82	20.82	62.52	-41.70	QP
3	0.260	-7.30	19.82	12.52	51.42	-38.90	Average
4	0.260	1.70	19.82	21.52	61.42	-39.90	QP
5	0.322	-8.10	19.82	11.72	49.66	-37.94	Average
6	0.322	0.90	19.82	20.72	59.66	-38.94	QP
7	0.486	-15.20	19.76	4.56	46.23	-41.67	Average
8	0.486	-2.40	19.76	17.36	56.23	-38.87	QP
9	1.338	-11.79	19.82	8.03	46.00	-37.97	Average
10	1.338	-7.19	19.82	12.63	56.00	-43.37	QP
11	21.035	11.60	19.90	31.50	50.00	-18.50	Average
12	21.035	17.50	19.90	37.40	60.00	-22.60	QP

For PCB antenna**AC 120V/60 Hz, Line**

	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.169	-12.30	19.83	7.53	54.99	-47.46	Average
2	0.169	1.30	19.83	21.13	64.99	-43.86	QP
3	0.285	-13.20	19.82	6.62	50.68	-44.06	Average
4	0.285	1.30	19.82	21.12	60.68	-39.56	QP
5	0.373	-15.21	19.78	4.57	48.43	-43.86	Average
6	0.373	0.19	19.78	19.97	58.43	-38.46	QP
7	0.532	-12.69	19.75	7.06	46.00	-38.94	Average
8	0.532	-2.49	19.75	17.26	56.00	-38.74	QP
9	1.255	-5.50	19.82	14.32	46.00	-31.68	Average
10	1.255	2.70	19.82	22.52	56.00	-33.48	QP
11	20.814	10.61	19.90	30.51	50.00	-19.49	Average
12	20.814	16.91	19.90	36.81	60.00	-23.19	QP

AC 120V/60 Hz, Neutral

	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.170	-12.60	19.83	7.23	54.94	-47.71	Average
2	0.170	1.70	19.83	21.53	64.94	-43.41	QP
3	0.243	-13.80	19.82	6.02	52.00	-45.98	Average
4	0.243	1.20	19.82	21.02	62.00	-40.98	QP
5	0.360	-14.51	19.80	5.29	48.74	-43.45	Average
6	0.360	-0.31	19.80	19.49	58.74	-39.25	QP
7	0.555	-13.70	19.75	6.05	46.00	-39.95	Average
8	0.555	-3.20	19.75	16.55	56.00	-39.45	QP
9	1.269	-4.20	19.82	15.62	46.00	-30.38	Average
10	1.269	2.20	19.82	22.02	56.00	-33.98	QP
11	21.147	11.40	19.89	31.29	50.00	-18.71	Average
12	21.147	17.40	19.89	37.29	60.00	-22.71	QP

Note:

1) Factor (dB) = LISN VDF (dB) + Cable Loss (dB) + Transient Limiter Attenuation (dB)

2) Over Limit (dB) = Read level (dBuV) + Factor (dB) - Limit (dBuV)

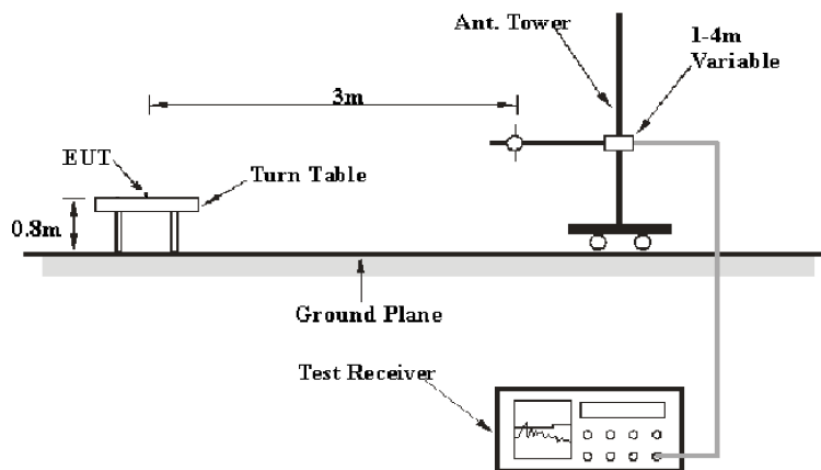
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

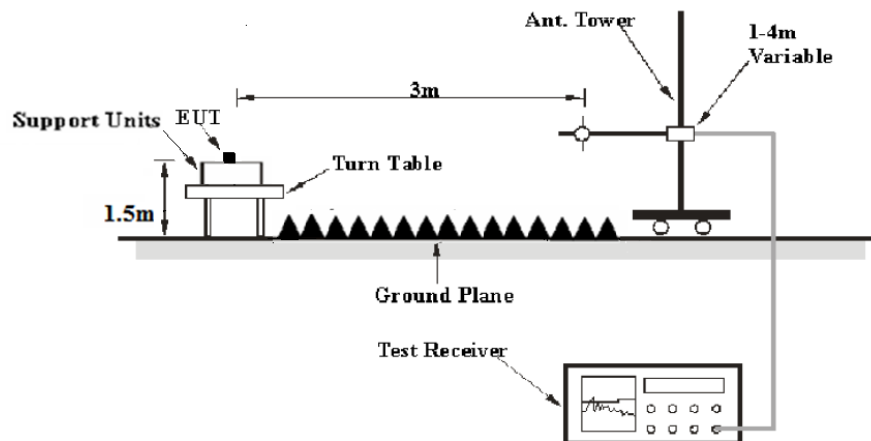
FCC §15.205; §15.209; §15.247(d)

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

EMI Test Receiver Setup

The system was investigated from 30 MHz to 10 GHz.

During the radiated emission test, the EMI test receiver Setup was set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Detector
30 MHz – 1000 MHz	120 kHz	300 kHz	120 kHz	QP
Above 1GHz	1MHz	3 MHz	/	PK
	1MHz	3 MHz	/	Ave.

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter Reading. The basic equation is as follows:

Corrected Amplitude (dBμV/m) = Meter Reading (dBμV) + Antenna Factor (dB/m) + Cable Loss (dB) - Amplifier Gain (dB)

The “**Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin (dB) = Limit (dBμV/m) - Corrected Amplitude (dBμV/m)

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

Test Data**Environmental Conditions**

Temperature:	21.8~23.2 °C
Relative Humidity:	48~50 %
ATM Pressure:	101.2~101.3 kPa

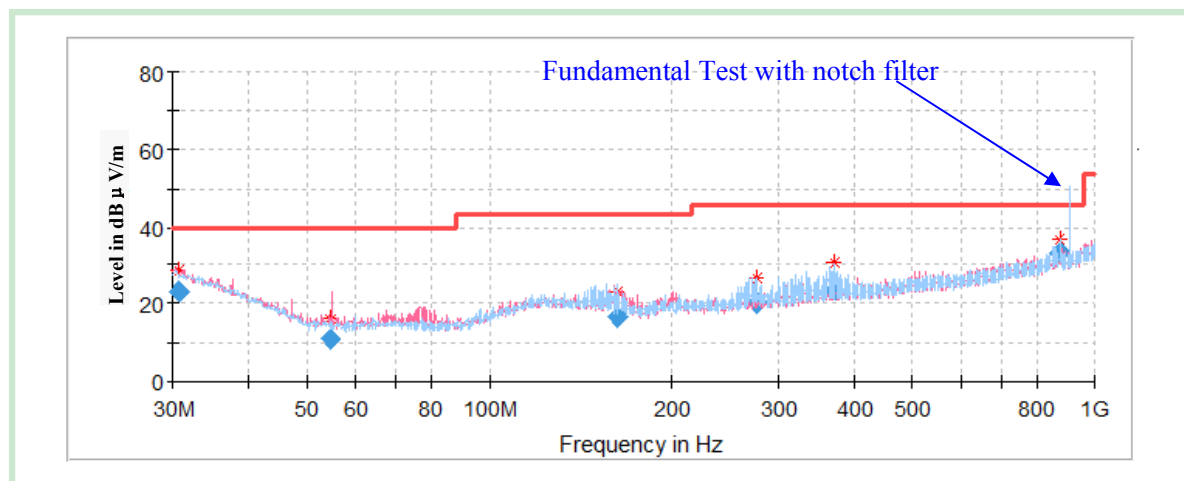
The testing was performed by Chao Gao from 2020-03-28 to 2020-05-11.

EUT operation mode: Transmitting

For FPC antenna:

Spurious Emission Test:**30MHz-1GHz**

Pre-scan with low, middle, high channel of operation in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded



Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
	QuasiPeak (dBµV/m)	Height (cm)	Polar (H/V)				
30.560705	22.96	200.0	V	6.0	-4.3	40.00	17.04
54.460000	10.92	100.0	V	187.0	-17.7	40.00	29.08
163.152350	16.64	200.0	H	241.0	-12.9	43.50	26.86
276.477800	20.32	100.0	H	11.0	-11.2	46.00	25.68
371.542350	23.78	100.0	H	268.0	-8.8	46.00	22.22
876.775800	33.11	100.0	H	186.0	-0.5	46.00	12.89

1GHz-10GHz

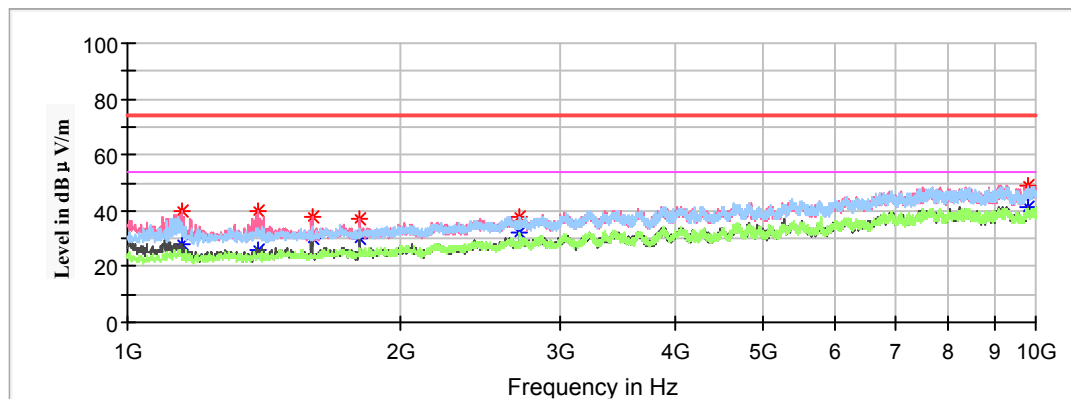
Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.

Note:

1. The test was performed with a 10dB Attenuator.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB) + Attenuator(dB)
 Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)
 Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV/m)

Low Channel: 902.3MHz

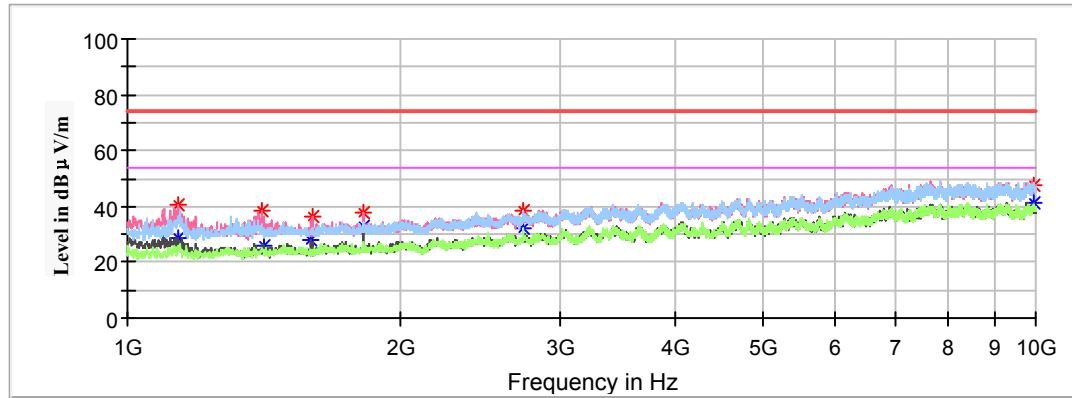
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1146.700000	---	27.90	150.0	V	232.0	-18.3	54.00	26.10
1146.700000	39.73	---	150.0	V	232.0	-18.3	74.00	34.27
1393.300000	---	26.01	200.0	V	247.0	-16.9	54.00	27.99
1393.300000	39.72	---	200.0	V	247.0	-16.9	74.00	34.28
1597.600000	---	30.19	150.0	V	278.0	-16.0	54.00	23.81
1597.600000	37.56	---	150.0	V	278.0	-16.0	74.00	36.44
1804.600000	---	30.17	150.0	V	301.0	-15.2	54.00	23.83
1804.600000	36.77	---	150.0	V	301.0	-15.2	74.00	37.23
2706.900000	37.42	---	150.0	V	207.0	-11.5	74.00	36.58
2706.900000	---	32.43	150.0	V	207.0	-11.5	54.00	21.57
9814.600000	---	41.24	150.0	V	301.0	2.0	54.00	12.76
9814.600000	48.78	---	150.0	V	301.0	2.0	74.00	25.22

Middle Channel: 908.7MHz

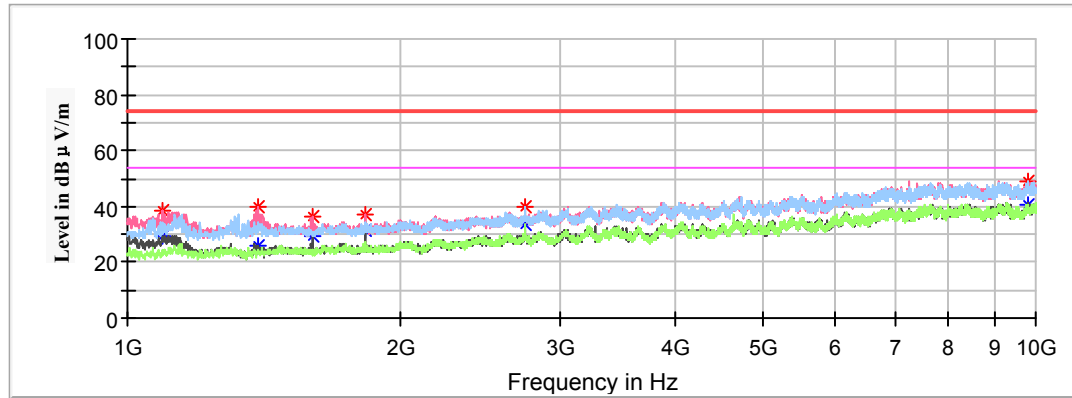
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1135.000000	40.42	---	150.0	V	230.0	-18.3	74.00	33.58
1135.000000	---	28.61	150.0	V	230.0	-18.3	54.00	25.39
1405.000000	38.54	---	200.0	V	255.0	-16.9	74.00	35.46
1405.000000	---	26.03	200.0	V	255.0	-16.8	54.00	27.97
1593.100000	---	28.31	150.0	V	277.0	-16.0	54.00	25.69
1593.100000	36.29	---	150.0	V	277.0	-16.0	74.00	37.71
1817.400000	37.59	---	150.0	V	277.0	-15.2	74.00	36.41
1817.400000	---	32.77	150.0	V	277.0	-15.2	54.00	21.23
2726.100000	38.12	---	200.0	V	199.0	-11.4	74.00	35.88
2726.100000	---	32.12	200.0	V	199.0	-11.4	54.00	21.88
9947.800000	47.89	---	200.0	H	176.0	1.9	74.00	26.11
9947.800000	---	41.36	200.0	H	176.0	1.9	54.00	12.64

High Channel: 914.9MHz

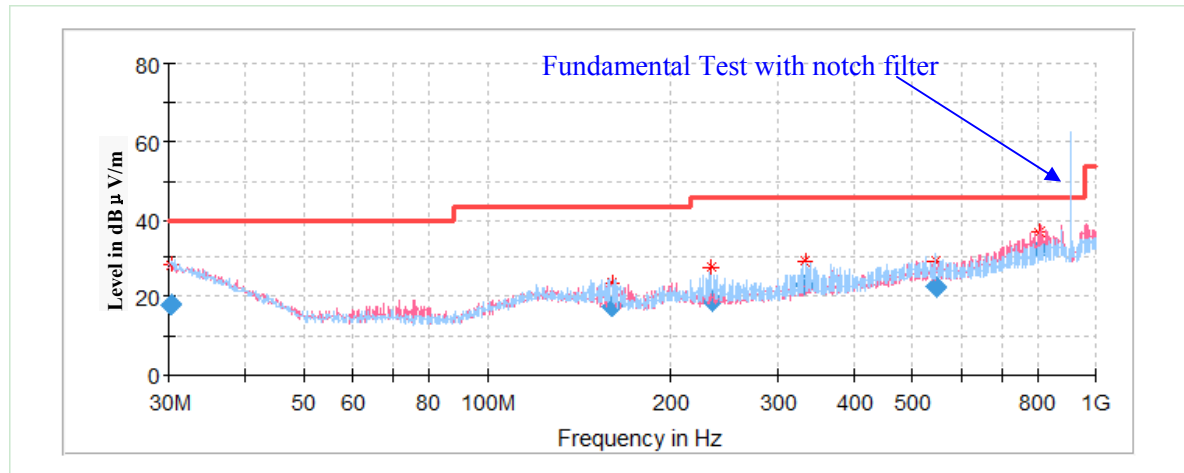
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1093.600000	38.76	---	150.0	V	230.0	-18.6	74.00	35.24
1093.600000	---	29.07	150.0	V	230.0	-18.6	54.00	24.93
1393.300000	---	26.22	200.0	V	254.0	-16.9	54.00	27.78
1393.300000	39.62	---	200.0	V	254.0	-16.9	74.00	34.38
1598.500000	---	29.10	150.0	V	277.0	-16.0	54.00	24.90
1598.500000	36.69	---	150.0	V	277.0	-16.0	74.00	37.31
1829.800000	---	31.17	150.0	V	300.0	-15.1	54.00	22.83
1829.800000	37.17	---	150.0	V	300.0	-15.1	74.00	36.83
2744.700000	---	33.73	150.0	V	206.0	-11.3	54.00	20.27
2744.700000	40.19	---	150.0	V	206.0	-11.3	74.00	33.81
9820.000000	---	40.67	150.0	H	159.0	2.0	54.00	13.33
9820.000000	48.93	---	150.0	H	159.0	2.0	74.00	25.07

For PCB antenna:**Spurious Emission Test:****30MHz-1GHz**

*Pre-scan with low, middle, high channel of operation in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded*



Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	QuasiPeak (dBμV/m)	Height (cm)	Polar (H/V)				
30.208893	18.21	100.0	H	307.0	-4.1	40.00	21.79
159.911200	17.50	200.0	H	211.0	-12.7	43.50	26.00
233.313750	18.91	100.0	H	251.0	-12.2	46.00	27.09
332.325300	23.39	100.0	H	287.0	-9.8	46.00	22.61
546.579550	22.48	200.0	H	47.0	-5.7	46.00	23.52
809.485200	32.40	100.0	V	77.0	-1.5	46.00	13.60

1GHz-10GHz

Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.

Note:

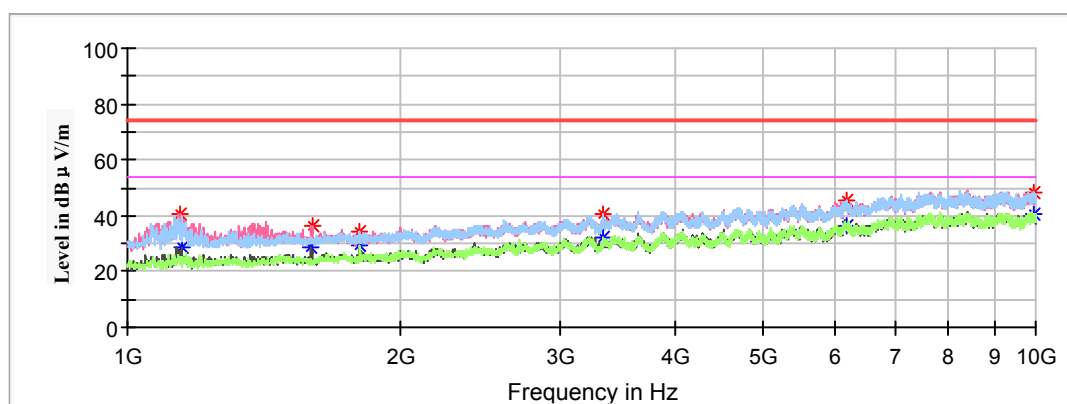
1. The test was performed with a 10dB Attenuator.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) – Amplifier Factor (dB) + Attenuator(dB)

Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)

Margin (dB) = Limit (dBμV/m) – Corrected Amplitude (dBμV/m)

Low Channel: 902.3MHz

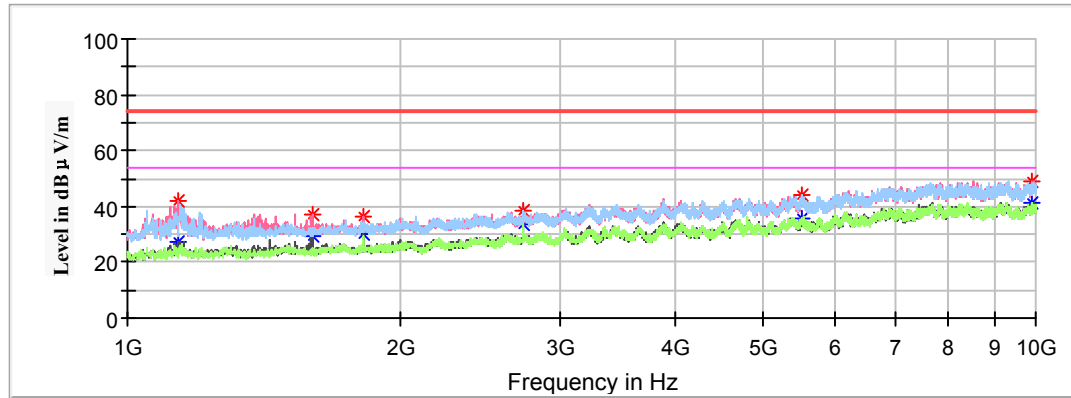
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1144.900000	40.78	---	150.0	V	232.0	-18.3	74.00	33.22
1144.900000	---	28.90	150.0	V	232.0	-18.3	54.00	25.10
1593.100000	---	28.60	150.0	V	278.0	-16.0	54.00	25.40
1593.100000	36.14	---	150.0	V	278.0	-16.0	74.00	37.86
1804.600000	34.49	---	150.0	H	46.0	-15.2	74.00	39.51
1804.600000	---	29.24	150.0	H	46.0	-15.2	54.00	24.76
3344.500000	---	32.20	200.0	H	247.0	-9.2	54.00	21.80
3344.500000	40.90	---	200.0	H	247.0	-9.2	74.00	33.10
6189.400000	45.63	---	150.0	H	14.0	-2.3	74.00	28.37
6189.400000	---	36.60	150.0	H	14.0	-2.3	54.00	17.40
9959.500000	---	40.41	150.0	H	137.0	1.9	54.00	13.59
9959.500000	48.47	---	150.0	H	137.0	1.9	74.00	25.53

Middle Channel: 908.7MHz

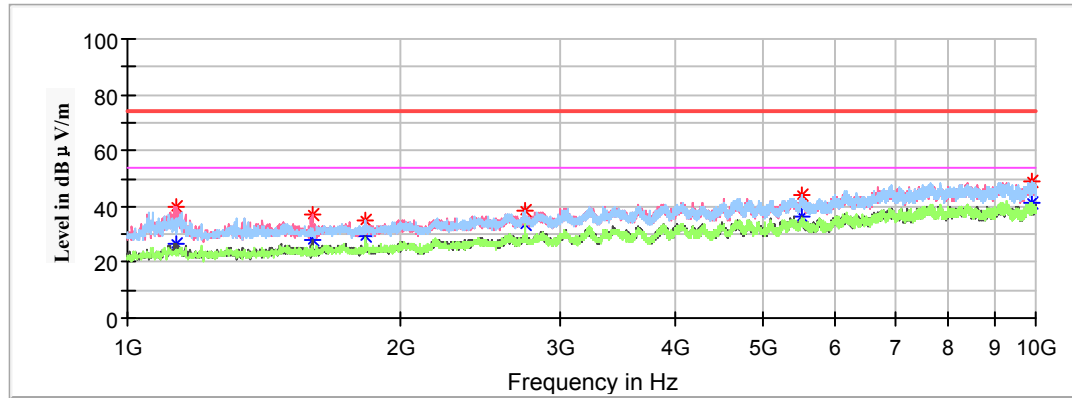
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBµV/m)	Margin (dB)
	MaxPeak (dBµV/m)	Average (dBµV/m)	Height (cm)	Polar (H/V)				
1138.600000	41.74	---	150.0	V	232.0	-18.3	74.00	32.26
1138.600000	---	27.01	150.0	V	232.0	-18.3	54.00	26.99
1597.600000	37.40	---	200.0	V	296.0	-16.0	74.00	36.60
1597.600000	---	29.07	200.0	V	296.0	-16.0	54.00	24.93
1817.400000	36.63	---	200.0	V	230.0	-15.2	74.00	37.37
1817.400000	---	30.04	200.0	V	230.0	-15.2	54.00	23.96
2726.100000	---	33.34	200.0	V	199.0	-11.4	54.00	20.66
2726.100000	38.50	---	200.0	V	199.0	-11.4	74.00	35.50
5519.800000	44.29	---	150.0	V	70.0	-3.9	74.00	29.71
5519.800000	---	35.40	150.0	V	70.0	-3.9	54.00	18.60
9917.200000	---	41.43	200.0	H	269.0	1.9	54.00	12.57
9917.200000	49.17	---	200.0	H	269.0	1.9	74.00	24.83

High Channel: 914.9MHz

Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1130.500000	40.14	---	200.0	V	186.0	-18.4	74.00	33.86
1130.500000	---	26.74	200.0	V	186.0	-18.4	54.00	27.26
1596.700000	37.06	---	200.0	V	272.0	-16.0	74.00	36.94
1596.700000	---	28.13	200.0	V	272.0	-16.0	54.00	25.87
1829.800000	---	29.49	200.0	V	229.0	-15.1	54.00	24.51
1829.800000	35.00	---	200.0	V	229.0	-15.1	74.00	39.00
2744.700000	38.55	---	200.0	V	193.0	-11.3	74.00	35.45
2744.700000	---	33.54	200.0	V	193.0	-11.3	54.00	20.46
5525.200000	---	36.13	200.0	V	142.0	-3.9	54.00	17.87
5525.200000	44.06	---	200.0	V	142.0	-3.9	74.00	29.94
9922.600000	---	41.27	200.0	V	343.0	1.9	54.00	12.73
9922.600000	49.10	---	200.0	V	343.0	1.9	74.00	24.90

Bandedge Emissions Test:

(Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.)

Note:

1. The test is performed with a 10dB Attenuator.
2. Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor+ Attenuator
Corrected Amplitude = Corrected Factor + Reading
Margin = Limit - Corrected. Amplitude

For FPC antenna:

Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	QuasiPeak (dBμV/m)	Height (cm)	Polar (H/V)				
902.3MHz							
902.00	36.18	150	H	128	0.2	46	9.82
902.00	35.32	200	V	206	0.2	46	10.68
914.9MHz							
928.00	35.50	200	H	130	1.2	46	10.50
928.00	34.09	200	V	245	1.2	46	11.91

For PCB antenna:

Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	QuasiPeak (dBμV/m)	Height (cm)	Polar (H/V)				
902.3MHz							
902.00	35.60	150	H	111	0.2	46	10.40
902.00	34.36	200	V	252	0.2	46	11.64
914.9MHz							
928.00	36.23	100	H	105	1.3	46	9.77
928.00	35.77	200	V	343	1.3	46	10.23

FCC §15.247(a) (1) - CHANNEL SEPARATION TEST

Applicable Standard

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

Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a. Span: Wide enough to capture the peaks of two adjacent channels.
- b. RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- c. Video (or average) bandwidth (VBW) $\geq$ RBW.
- d. Sweep: Auto.
- e. Detector function: Peak.
- f. Trace: Max hold.
- g. Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Test Data**Environmental Conditions**

Temperature:	23.2 °C
Relative Humidity:	49 %
ATM Pressure:	101.2 kPa

The testing was performed by Chao Gao on 2020-05-08.

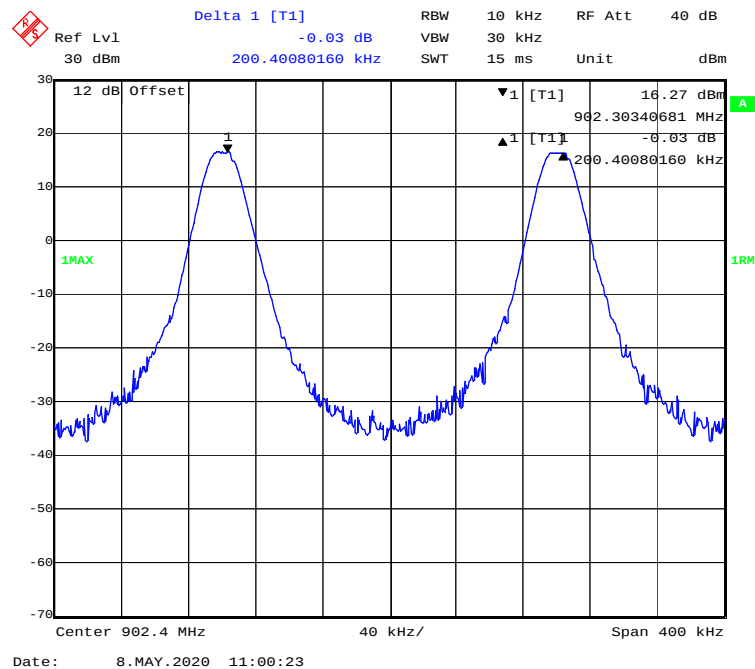
EUT operation mode: Transmitting

Test Result: Compliant.

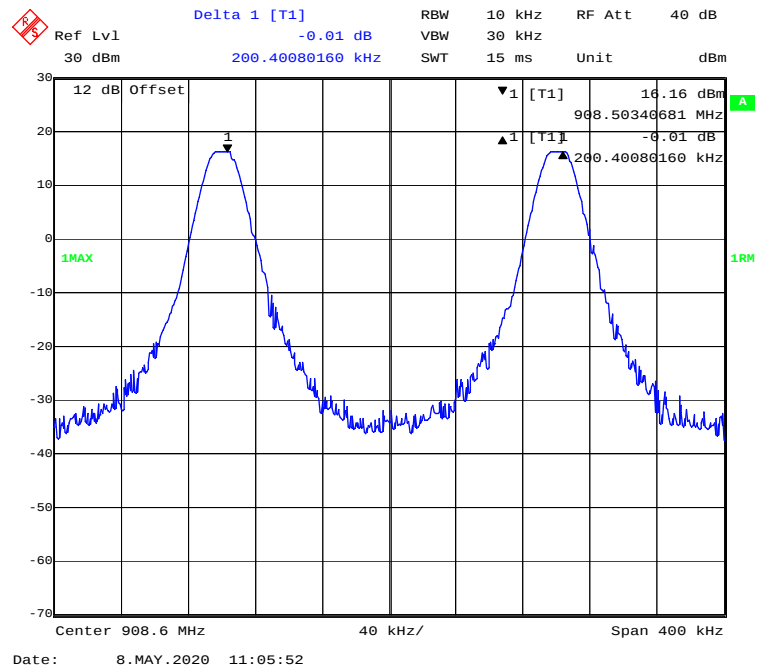
Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
Low	902.3	0.200	0.139	Pass
Adjacent	902.5			
Middle	908.7	0.200	0.138	Pass
Adjacent	908.5			
High	914.9	0.201	0.140	Pass
Adjacent	914.7			

Note: Limit = 20 dB bandwidth

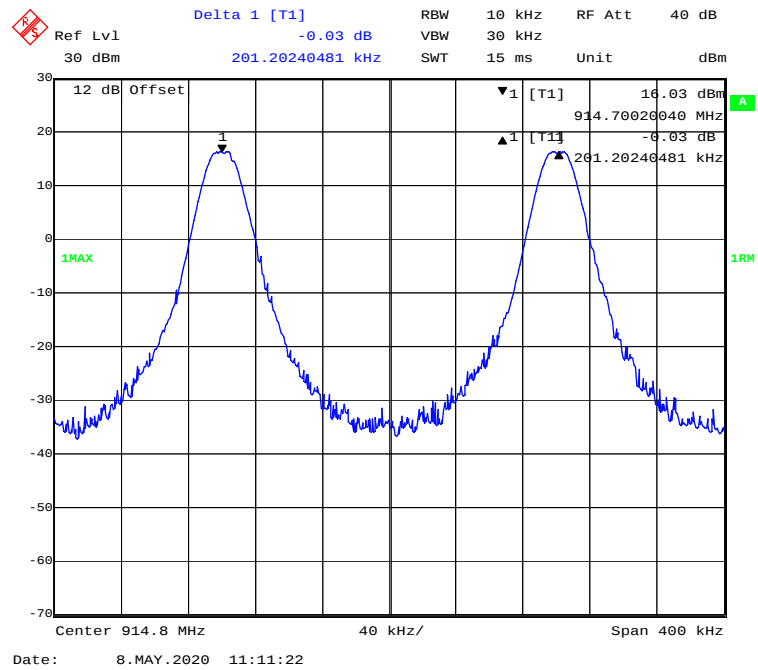
Low Channel



Middle Channel



High Channel



FCC §15.247(a) (1) (i)– 20 dB EMISSION BANDWIDTH

Applicable Standard

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

Test Data

Environmental Conditions

Temperature:	23.2 °C
Relative Humidity:	48 %
ATM Pressure:	101.2 kPa

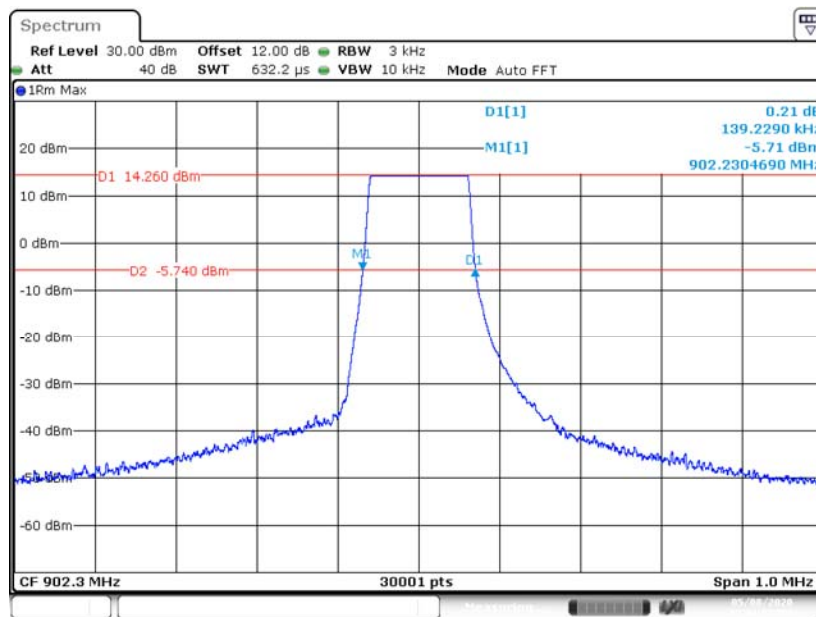
The testing was performed by Chao Gao on 2020-05-08.

EUT operation mode: Transmitting

Test Result: Compliant.

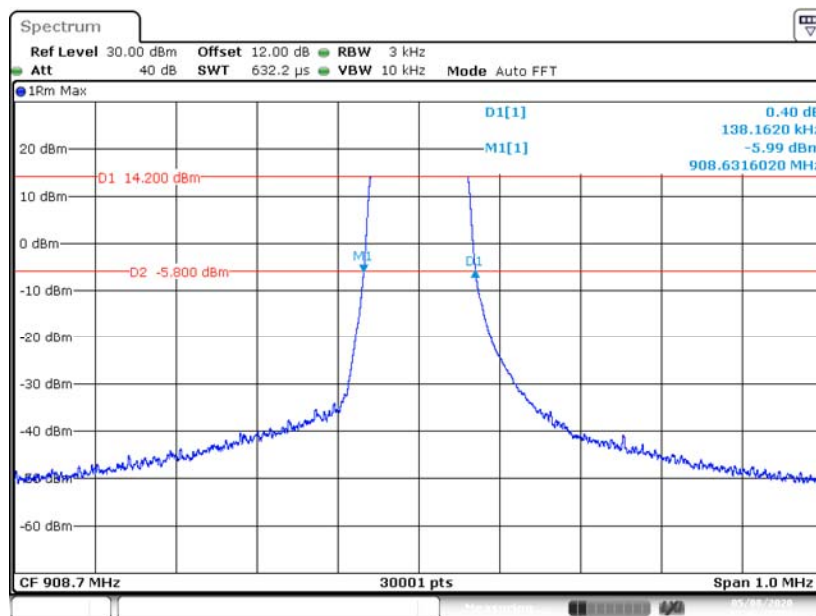
Channel	Frequency (MHz)	20 dB Emission Bandwidth (MHz)	Limit (MHz)
Low	902.3	0.139	≤0.25
Middle	908.7	0.138	≤0.25
High	914.9	0.140	≤0.25

Low Channel



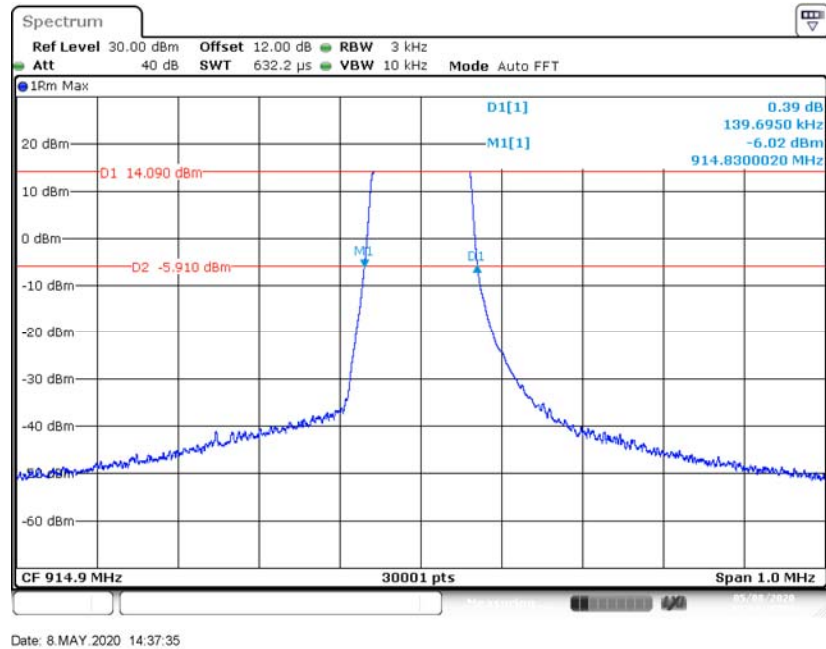
Date: 8 MAY.2020 14:41:53

Middle Channel



Date: 8 MAY.2020 14:40:18

High Channel



FCC §15.247(a) (1) (i) - QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a. Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b. RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c. VBW $\geq$ RBW.
- d. Sweep: Auto.
- e. Detector function: Peak.
- f. Trace: Max hold.
- g. Allow the trace to stabilize.

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies.

Test Data

Environmental Conditions

Temperature:	24.0 °C
Relative Humidity:	49 %
ATM Pressure:	101.6 kPa

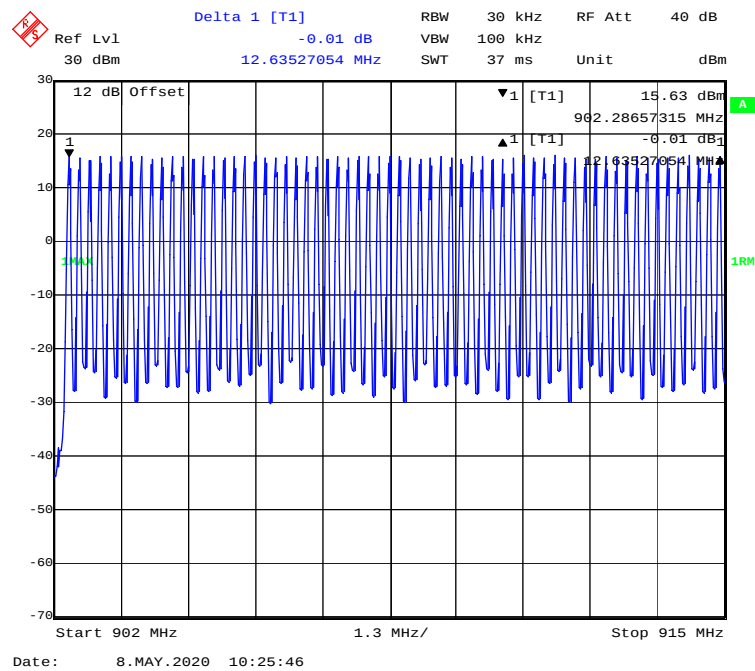
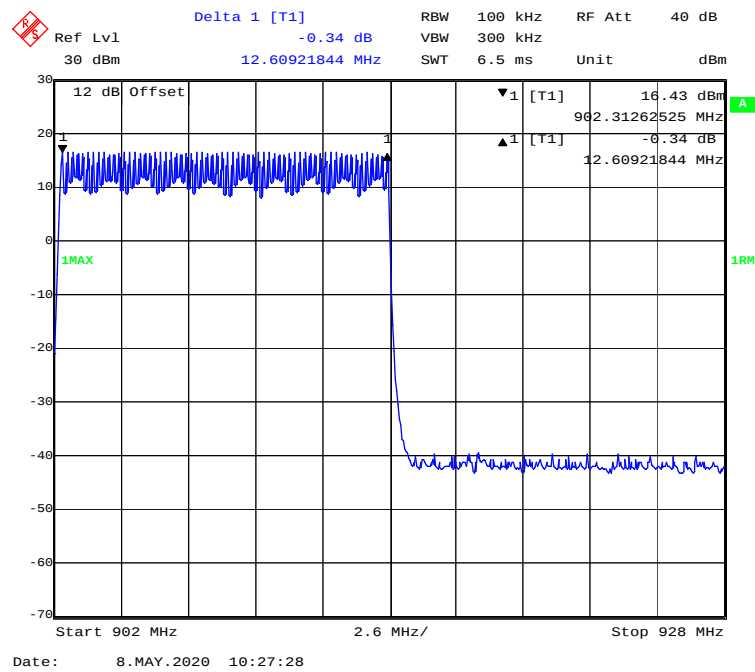
The testing was performed by Chao Gao on 2020-05-08.

EUT operation mode: Hopping

Test Result: Compliant.

Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
902~928MHz	64	≥ 50

Number of Hopping Channels



FCC §15.247(f) - TIME OF OCCUPANCY (DWELL TIME) OF HYBRID SYSTEMS

Applicable Standard

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

- a Span: Zero span, centered on a hopping channel.
- b RBW shall be $\leq$ channel spacing and where possible RBW should be set $\geq 1 / T$, where T is the expected dwell time per channel.
- c 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.
- d Detector function: Peak.
- e Trace: Max hold.

Test Data

Environmental Conditions

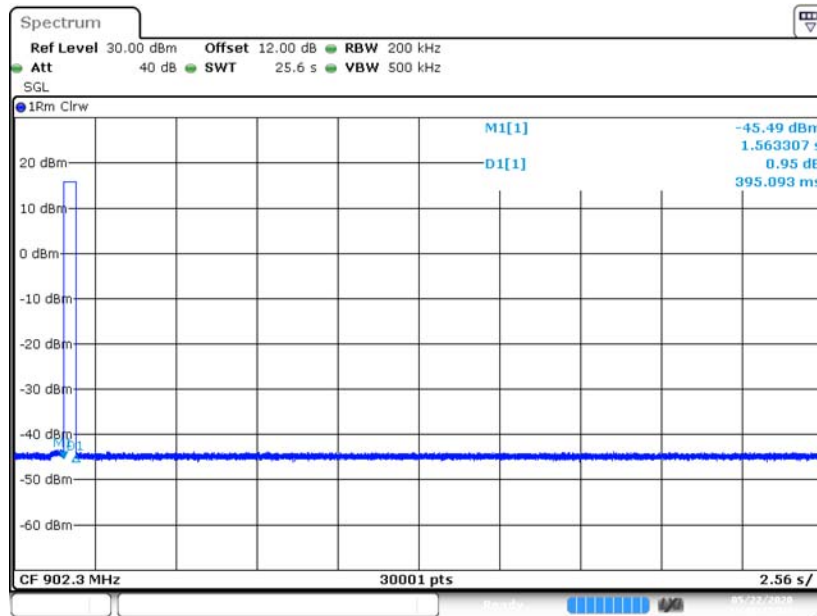
Temperature:	23.8°C~24.2 °C
Relative Humidity:	48 %~53%
ATM Pressure:	101.1kPa~101.3 kPa

The testing was performed by Chao Gao on 2020-05-08 and 2020-05-22.

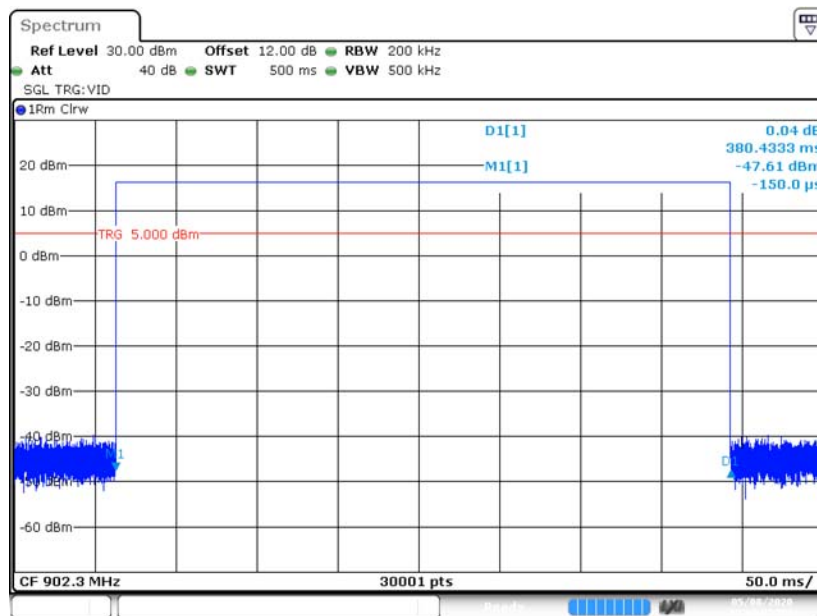
EUT operation mode: Hopping

Channel	Dwell Time (s)	Limit (s)	Result
Low	0.380	0.4	Pass
Middle	0.381	0.4	Pass
High	0.381	0.4	Pass

Low Channel

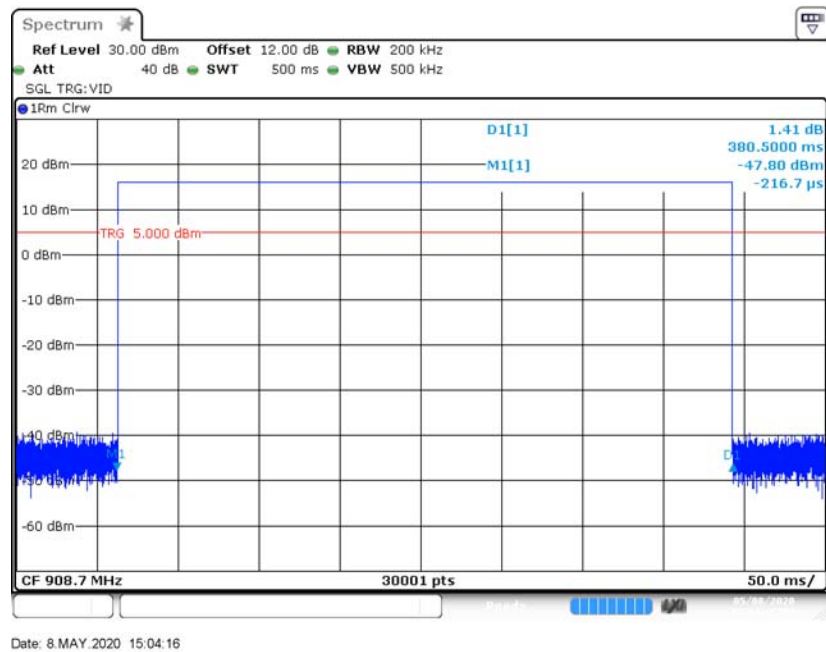
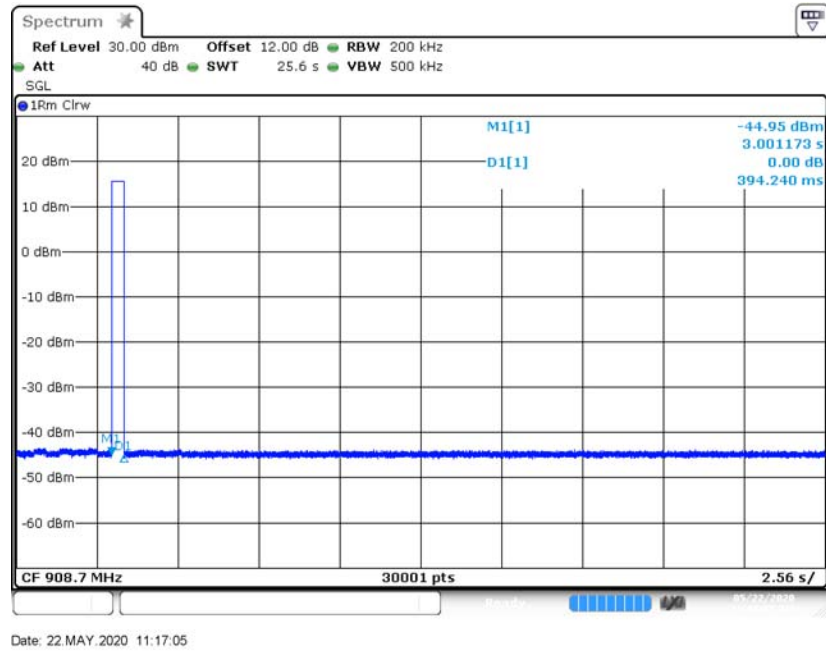


Date: 22 MAY 2020 11:12:42

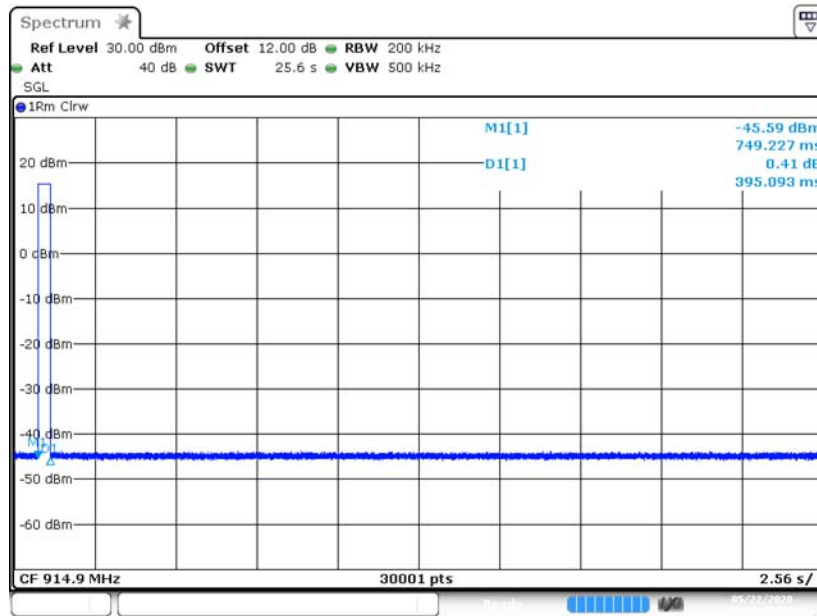


Date: 8 MAY 2020 15:02:03

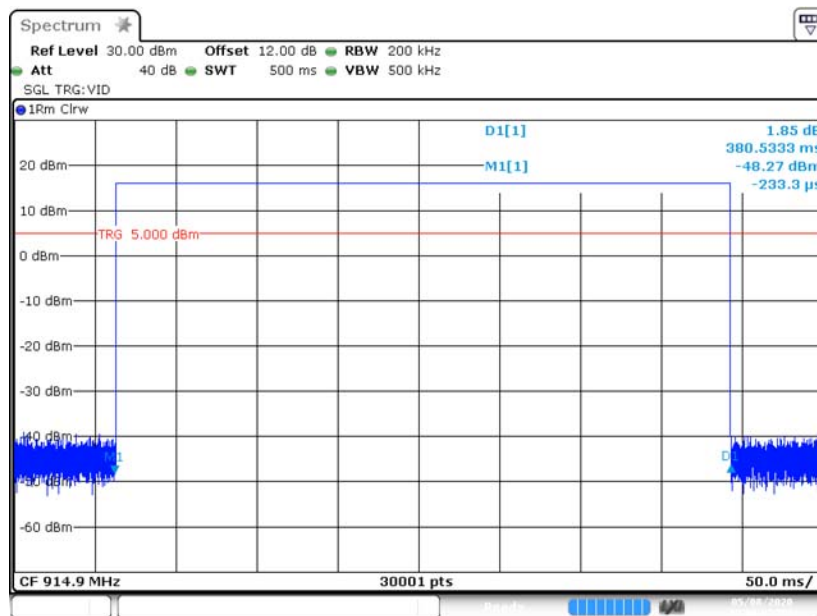
Middle Channel



High Channel



Date: 22 MAY.2020 11:20:49



Date: 8 MAY.2020 15:06:03

FCC §15.247(f) - POWER SPECTRAL DENSITY OF HYBRID SYSTEMS

Applicable Standard

The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure

- Set instrument center frequency to DTS channel center frequency.
- Set span to at least 1.5 times the OBW.
- Set RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- Set VBW $\geq [3 \times \text{RBW}]$.
- Detector = power averaging (rms)
- Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span} / \text{RBW}]$.
- Sweep time = auto couple.
- Employ trace averaging (rms) mode over a minimum of 100 traces.
- Use the peak marker function to determine the maximum amplitude level.
- If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced).

Test Data

Environmental Conditions

Temperature:	24.2 °C
Relative Humidity:	49 %
ATM Pressure:	101.2 kPa

The testing was performed by Chao Gao on 2020-05-22.

EUT operation mode: Transmitting

Test Result: Compliant.

Channel	Frequency (MHz)	PSD (dBm/3kHz)	Limit (dBm/3kHz)
Low	902.3	7.12	≤ 8
Middle	908.7	7.05	≤ 8
High	914.9	6.96	≤ 8

Low Channel



Middle Channel



High Channel



Date: 22 MAY 2020 13:51:59

FCC §15.247(b)(3)-MAXIMUM CONDUCTED (AVERAGE) OUTPUT POWER

Applicable Standard

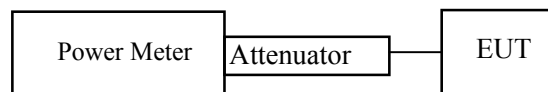
According to FCC §15.247(b) (3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, Compliant with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

Test Procedure

According to ANSI C63.10-2013 sub-clause 11.9.2.3.1

The maximum average conducted output power may be measured using a wideband RF average power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall use a fast-responding diode detector.

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add duty factor to the display.



Test Data

Environmental Conditions

Temperature:	23.2 °C
Relative Humidity:	49 %
ATM Pressure:	101.2 kPa

The testing was performed by Chao Gao on 2020-05-08.

EUT operation mode: Transmitting

Channel	Frequency (MHz)	Average Output Power (dBm)	Limit (dBm)	Result
Low	902.3	17.58	30	Pass
Middle	908.7	17.51	30	Pass
High	914.9	17.36	30	Pass

Note: The antenna gain is 1dBi for FPC antenna and 1dBi for PCB antenna.

FCC §15.247(d) - BAND EDGES TESTING

Applicable Standard

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, provided the transmitter demonstrates Compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated 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) (see §15.205(c)).

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.

Test Data

Environmental Conditions

Temperature:	23.2 °C
Relative Humidity:	49 %
ATM Pressure:	101.2 kPa

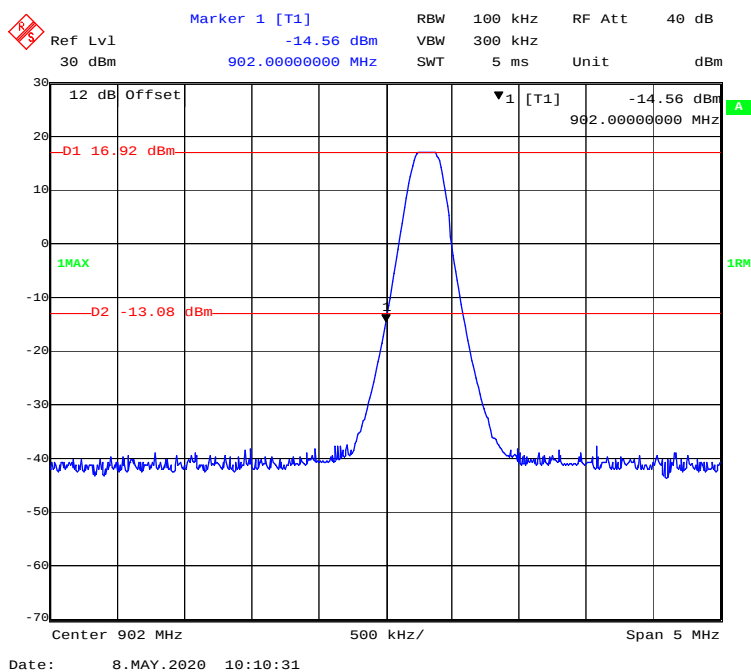
The testing was performed by Chao Gao on 2020-05-08.

EUT operation mode: Transmitting & Hopping

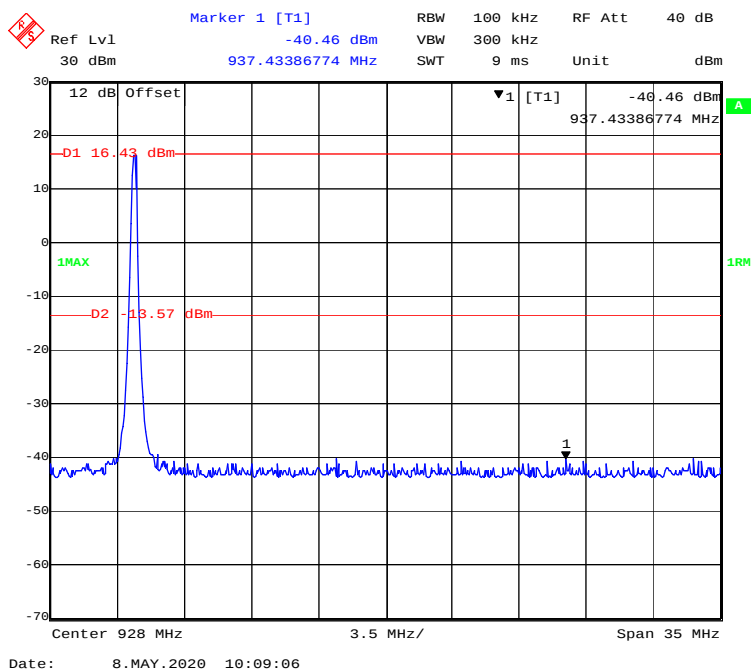
Test Result: Compliant.

Band Edge

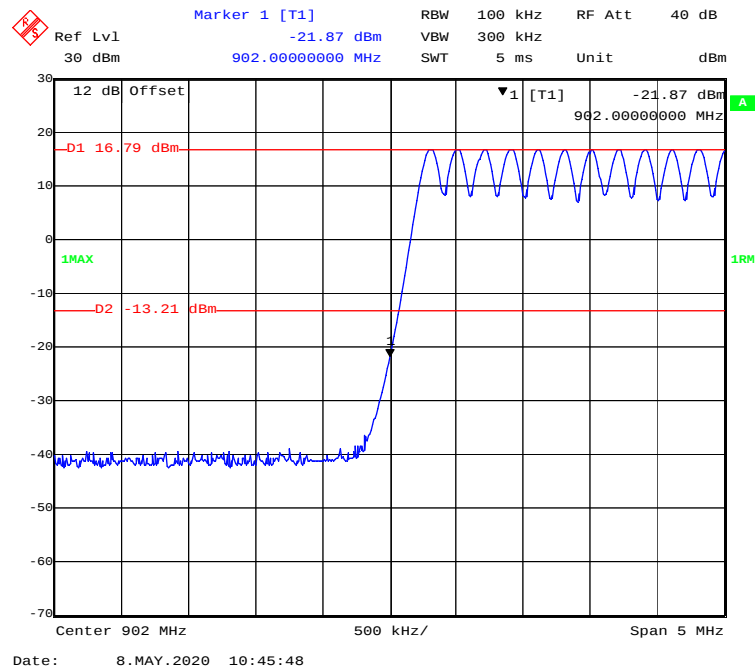
Left Side - Transmitting



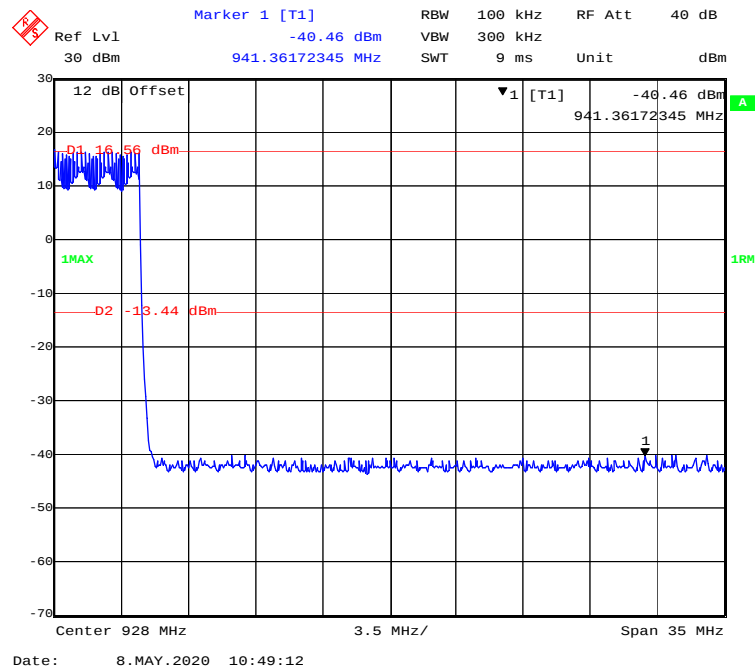
Right Side - Transmitting



Left Side - Hopping



Right Side- Hopping



***** END OF REPORT *****