FCC Part 15.247

TEST REPORT

For

Pycom Ltd

Surrey Technology Park 2 Huxley Road, Guildford Surrey GU2 7RE, United Kingdom

FCC ID: 2AJMTPYGATE

Report Type:	**Product Type:**
Original Report	gateway

Report Producer : **Coco Lin** Coco Lin

Report Number : **RXZ211104002RF02**

Report Date : **2022-01-06**

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Revision History

Revision	No.	Report Number	Issue Date	Description	Author/ Revised by
0.0	RXZ211104002	RXZ211104002RF02	2022-01-06	Original Report	Coco Lin

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1. General Information

1.1. Product Description for Equipment under Test (EUT)

Applicant	Pycom Ltd
	Surrey Technology Park 2 Huxley Road, Guildford Surrey GU2 7RE, United Kingdom
Manufacturer	Pycom Ltd
	Surrey Technology Park 2 Huxley Road, Guildford Surrey GU2 7RE, United Kingdom
Brand(Trade) Name	N/A
Product (Equipment)	gateway
Main Model Name	Pygate
Series Model Name	N/A
Model Discrepancy	N/A
Frequency Range	LoRa (125kHz): 902.3 ~ 927.7 MHz LoRa (250kHz): 902.3 ~ 927.5 MHz
Transmit Power	LoRa (125kHz): 23.84 dBm LoRa (250kHz): 23.92 dBm
Modulation Technique	LoRa (125kHz) LoRa (250kHz)
Power Operation (Voltage Range)	DC 5V from USB Port, DC 3.6V-4.2V from Li-Po Battery and DC 48V from PoE via the optional adapter board (PyEthernet)
Received Date	Nov. 04, 2021
Date of Test	Nov. 12, 2021 ~ Dec. 24, 2021

*All measurement and test data in this report was gathered from production sample serial number: RXZ211104002-01 (Assigned by BACL, New Taipei Laboratory).

1.2. Objective

This report is prepared on behalf of *Pycom Ltd* in accordance with Part 2, Subpart J, Part 15, Subparts A and C of the Federal Communication Commission's rules.

The tests were performed in order to determine the compliance of the EUT with FCC Rules Part 15-Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

1.3. Related Submittal(s)/Grant(s)

N/A.

1.4. 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.

KDB 558074 D01 15.247 Meas Guidance v05r02

1.5. Statement of Compliance

Decision Rule: No, (The test results do not include MU judgment)

Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.

The determination of the test results does not require consideration of the uncertainty of the measurement, unless the assessment is required by customer agreement, regulation or standard document specification.

Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) is not responsible for the authenticity of the information provided by the applicant that affects the test results.

1.6. Measurement Uncertainty

Parameter		Uncertainty
AC Mains		+/- 2.36 dB
RF output power, conducted		+/- 0.93 dB
Occupied Bandwidth		+/- 0.35 MHz
Unwanted Emissions, conducted		+/- 1.69 dBm
Emissions, radiated	30MHz~1GHz	+/- 5.22 dB
	1GHz~18GHz	+/- 6.12 dB
	18GHz~40GHz	+/- 4.99 dB
Temperature		+/- 1.27 °C
Humidity		+/- 3 %

1.7. Environmental Conditions

Test Site	Test Data	Temperature (℃)	Relative Humidity (%)	ATM Pressure (hPa)	Test Engineer
AC Line Conducted Emissions	2021/12/01-13	21.6	67	1010	Ken Yu
Radiation Spurious Emissions	2021/11/12-12/24	22.9-23.6	56-74	1010	David Lee
Conducted Spurious Emissions	2021/11/29	24.5	52	1010	Howard Ho
20 dB Emission Bandwidth	2021/11/17	24.7	55	1010	Howard Ho
Channel Separation Test	2021/11/17	24.7	55	1010	Howard Ho
Maximum Output Power	2021/11/17	24.7	55	1010	Howard Ho
100 kHz Bandwidth of Frequency Band Edge	2021/11/23	24.2	53	1010	Howard Ho
Power Spectral Density	2021/11/16	24.6	53	1010	Howard Ho
Time of Occupancy (Dwell Time)	2021/11/17	24.7	55	1010	Howard Ho
Quantity of hopping channel Test	2021/11/17	24.7	55	1010	Howard Ho

1.8. Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) to collect test data is located on

☒70, Lane 169, Sec. 2, Datong Road, Xizhi Dist., New Taipei City 22183, Taiwan, R.O.C.

Bay Area Compliance Laboratories Corp. (New Taipei Laboratory) is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 3732) and the FCC designation No.TW3732 under the Mutual Recognition Agreement (MRA) in FCC Test.

2. System Test Configuration

2.1. Description of Test Configuration

The system was configured for testing in engineering mode, which was provided by manufacturer.

For LoRa (125kHz) mode, 128 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)		
1	902.3	27	907.5	53	912.7	79	917.9	105	923.1
2	902.5	28	907.7	54	912.9	80	918.1	106	923.3
3	902.7	29	907.9	55	913.1	81	918.3	107	923.5
4	902.9	30	908.1	56	913.3	82	918.5	108	923.7
5	903.1	31	908.3	57	913.5	83	918.7	109	923.9
6	903.3	32	908.5	58	913.7	84	918.9	110	924.1
7	903.5	33	908.7	59	913.9	85	919.1	111	924.3
8	903.7	34	908.9	60	914.1	86	919.3	112	924.5
9	903.9	35	909.1	61	914.3	87	919.5	113	924.7
10	904.1	36	909.3	62	914.5	88	919.7	114	924.9
11	904.3	37	909.5	63	914.7	89	919.9	115	925.1
12	904.5	38	909.7	64	914.9	90	920.1	116	925.3
13	904.7	39	909.9	65	915.1	91	920.3	117	925.5
14	904.9	40	910.1	66	915.3	92	920.5	118	925.7
15	905.1	41	910.3	67	915.5	93	920.7	119	925.9
16	905.3	42	910.5	68	915.7	94	920.9	120	926.1
17	905.5	43	910.7	69	915.9	95	921.1	121	926.3
18	905.7	44	910.9	70	916.1	96	921.3	122	926.5
19	905.9	45	911.1	71	916.3	97	921.5	123	926.7
20	906.1	46	911.3	72	916.5	98	921.7	124	926.9
21	906.3	47	911.5	73	916.7	99	921.9	125	927.1
22	906.5	48	911.7	74	916.9	100	922.1	126	927.3
23	906.7	49	911.9	75	917.1	101	922.3	127	927.5
24	906.9	50	912.1	76	917.3	102	922.5	128	927.7
25	907.1	51	912.3	77	917.5	103	922.7	/	/
26	907.3	52	912.5	78	917.7	104	922.9	/	/

Were tested with channel 1, 65 and 128.

For LoRa (250kHz) mode, 64 channels are provided to testing:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	902.3	14	907.5	27	912.7	40	917.9	53	923.1
2	902.7	15	907.9	28	913.1	41	918.3	54	923.5
3	903.1	16	908.3	29	913.5	42	918.7	55	923.9
4	903.5	17	908.7	30	913.9	43	919.1	56	924.3
5	903.9	18	909.1	31	914.3	44	919.5	57	924.7
6	904.3	19	909.5	32	914.7	45	919.9	58	925.1
7	904.7	20	909.9	33	915.1	46	920.3	59	925.5
8	905.1	21	910.3	34	915.5	47	920.7	60	925.9
9	905.5	22	910.7	35	915.9	48	921.1	61	926.3
10	905.9	23	911.1	36	916.3	49	921.5	62	926.7
11	906.3	24	911.5	37	916.7	50	921.9	63	927.1
12	906.7	25	911.9	38	917.1	51	922.3	64	927.5
13	907.1	26	912.3	39	917.5	52	922.7	/	/

Were tested with channel 1, 33 and 64.

2.2. Equipment Modifications

No modification was made to the EUT.

2.3. EUT Exercise Software

The test software was used “ATOM, LoRa-net picoGW_hal”

Test Frequency		Low	Mid	High
Power Level Setting	LoRa (125kHz)	13	13	14
	LoRa (250kHz)	13	13	14

2.4. Support Equipment List and Details

Description	Manufacturer	Model	Maximum Antenna Gain
NB	DELL	E6410	N/A
Fixture Board	Uses Technology	B+	N/A
AC Adapter	SOS	SOS-PS-25A	N/A
Gateway module (Development Board)	Pycom Ltd	Wipy3, Lopy4, GPy	N/A
Antenna-0: Internal WiFi/BT/BLE SMD Antenna	Johanson Technology	2450AT43B100	-0.5 dBi (WiPy3) 1.3 dBi (LoPy4/GPy)
Antenna-1: External WiFi/BT/BLE Monopole Antenna	Pycom Ltd	External WiFi/BT Antenna	2.0 dBi (WiPy3)
Antenn-A: LTE External PCB Antenna with Plastic Case	Pycom Ltd	NEW External LTE-M Antenna Kit	2.0 dBi (GPy)
Antenn-B: LTE External PCB Antenna	Pycom Ltd	External LTE-M Antenna Kit	2.2 dBi (GPy)
Raspberry pi 3	Rasbperry Pi	B+	N/A

2.5. External Cable List and Details

Cable Description	Length (m)	From	To
USB type-C Cable	1.5	EUT	NB

2.6. Test Mode

Pre-scan

Radiated Spurious Emissions:

Model 1: Pygate, DC 5V from USB Port

Model 2: Pygate, DC 3.6V from Li-Po Battery

Model 3: Pygate, DC 48V from PoE

AC Line Conducted Emissions:

Model 1: Pygate, DC 5V from USB Port

Model 3: Pygate, DC 48V from PoE

Worst case is the Pygate, DC 5V from USB Port.

Full System (model: Pygate, DC 5V from USB Port) for all test item.

Transmitting simultaneously test

AC Line Conducted Emissions and Radiated Spurious Emissions

	Combination	Transmitting simultaneously Mode	Antenna Use
Model 1	Pygate, DC 5V from USB Port + Wipy3.0 (FCC ID: 2AJMTWIPY3R)	LoRa + WIFI 2.4G/BLE/BT	Wi-Fi Antenna-0/1 LoRa Antenna
Model 2	Pygate, DC 5V from USB Port + LoPy4 1.0 (FCC ID: 2AJMTLOPY4R)	LoRa + WIFI 2.4G/BLE/BT	Wi-Fi Antenna-0 LoRa Antenna
Model 3	Pygate, DC 5V from USB Port + GPy 1.0 (FCC ID: 2AJMTGPY01R)	LoRa + WIFI 2.4G/BLE/BT/LTE	LTE Antenna-A/B Wi-Fi Antenna-0 LoRa Antenna

Note: All the antenna combination had been evaluated, The worst case had been recorded in the report.

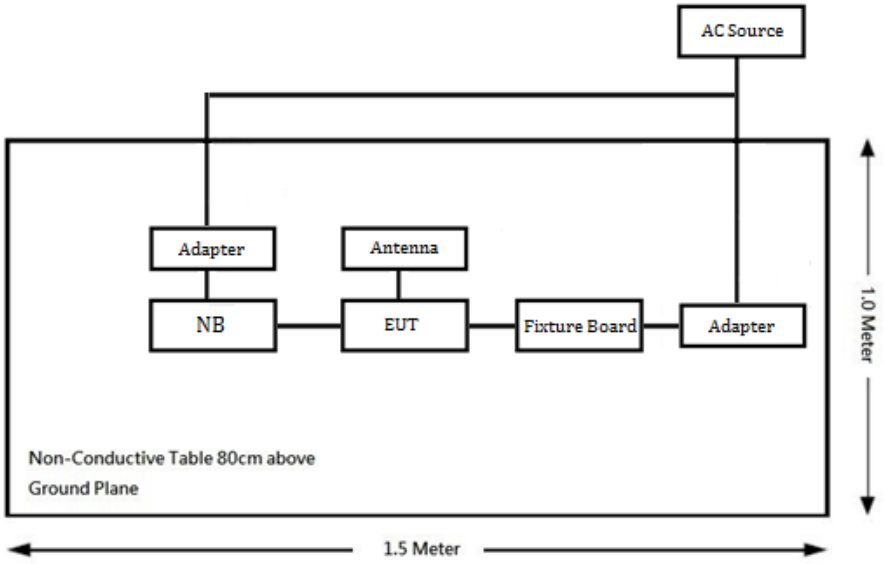
2.7. Block Diagram of Test Setup

See test photographs attached in annex setup photos for the actual connections between EUT and support equipment.

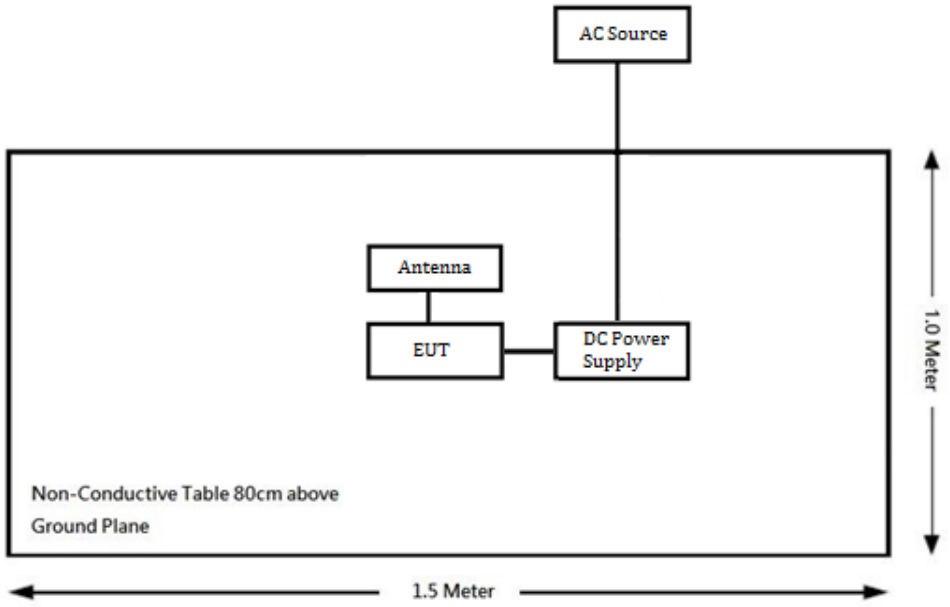
Radiation

Below 1GHz:

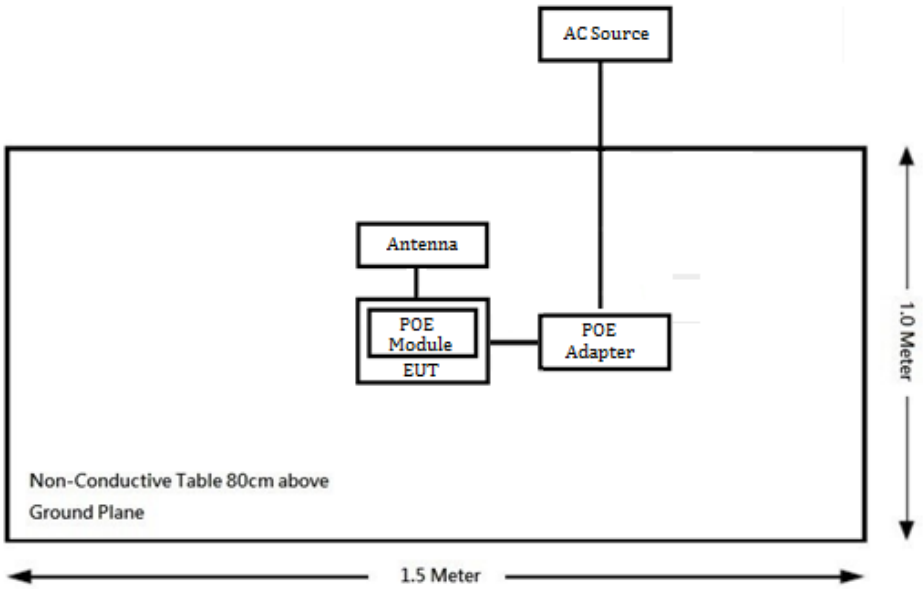
Pygate, DC 5V from USB Port



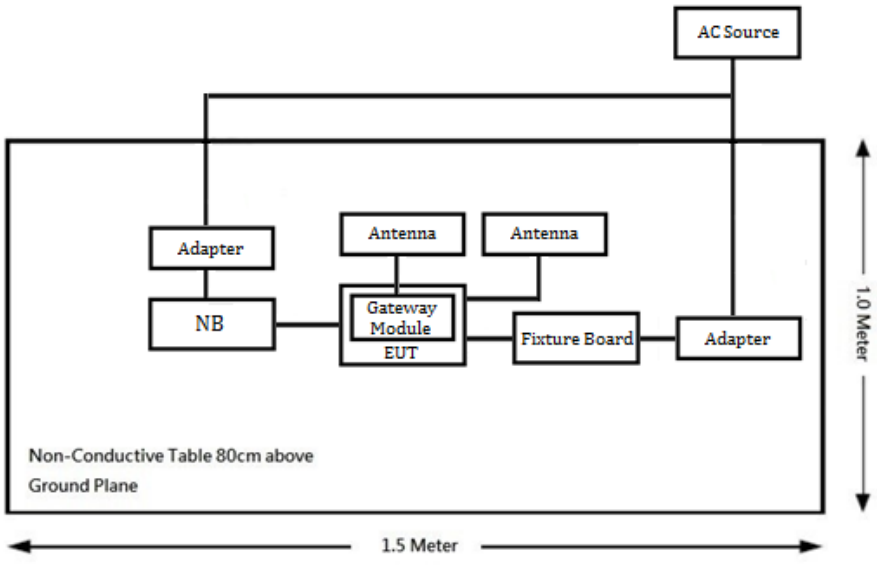
Pygate, DC 3.6V from Li-Po Battery



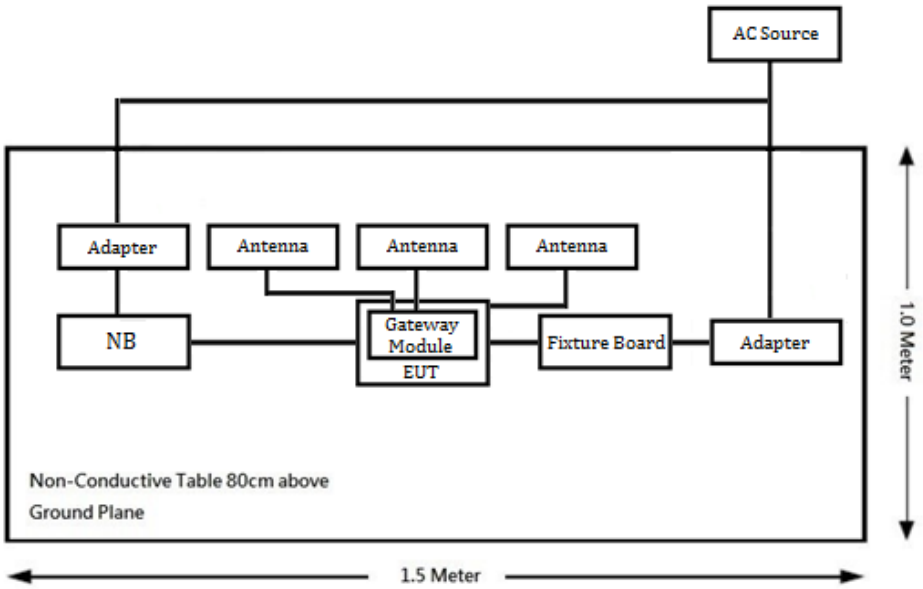
Pygate, DC 48V from PoE



Pygate, DC 5V from USB Port + Gateway Module (Wipy3.0 / LoPy4 1.0)

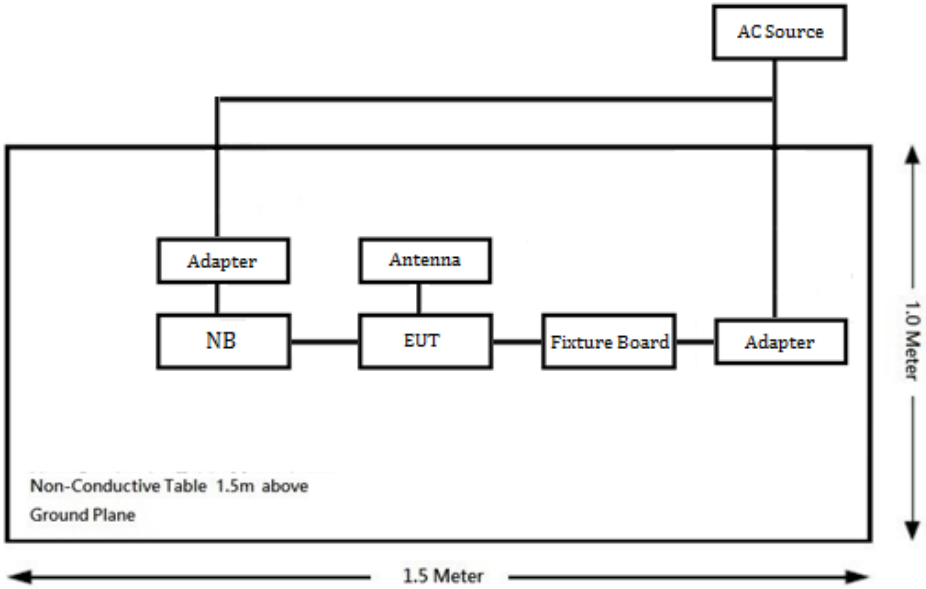


Pygate, DC 5V from USB Port + Gateway Module (GPy 1.0)

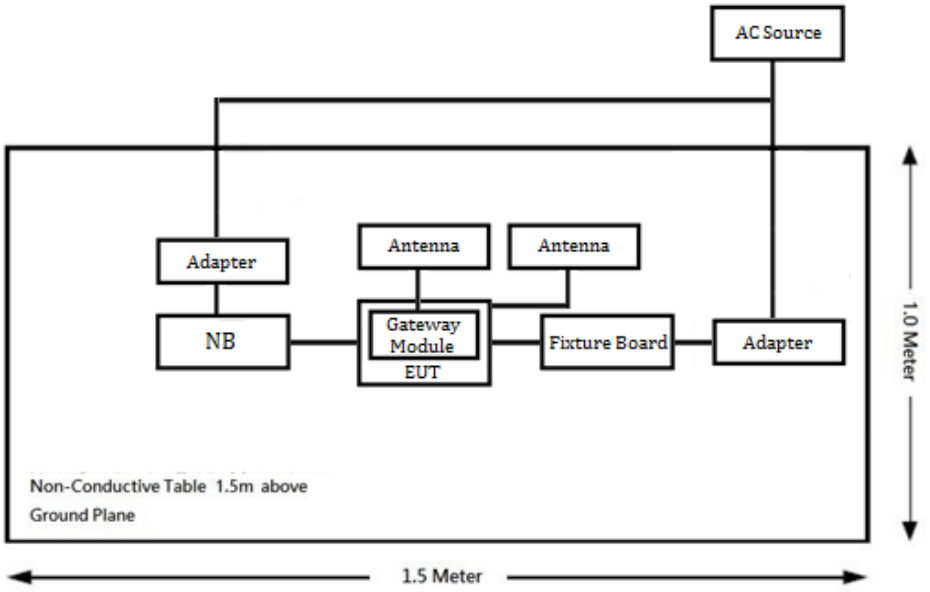


Above 1GHz:

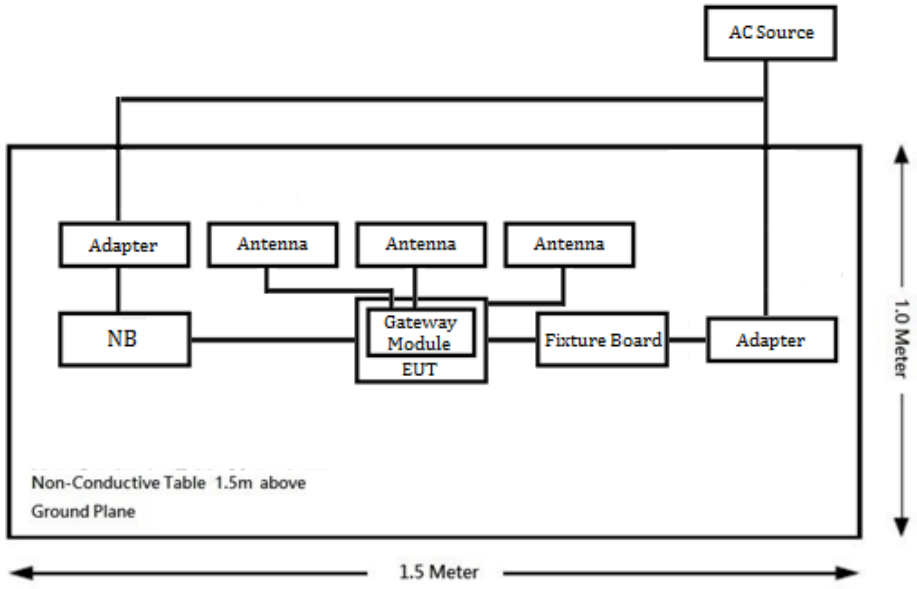
Pygate, DC 5V from USB Port



Pygate, DC 5V from USB Port + Gateway Module (Wipy3.0 / LoPy4 1.0)

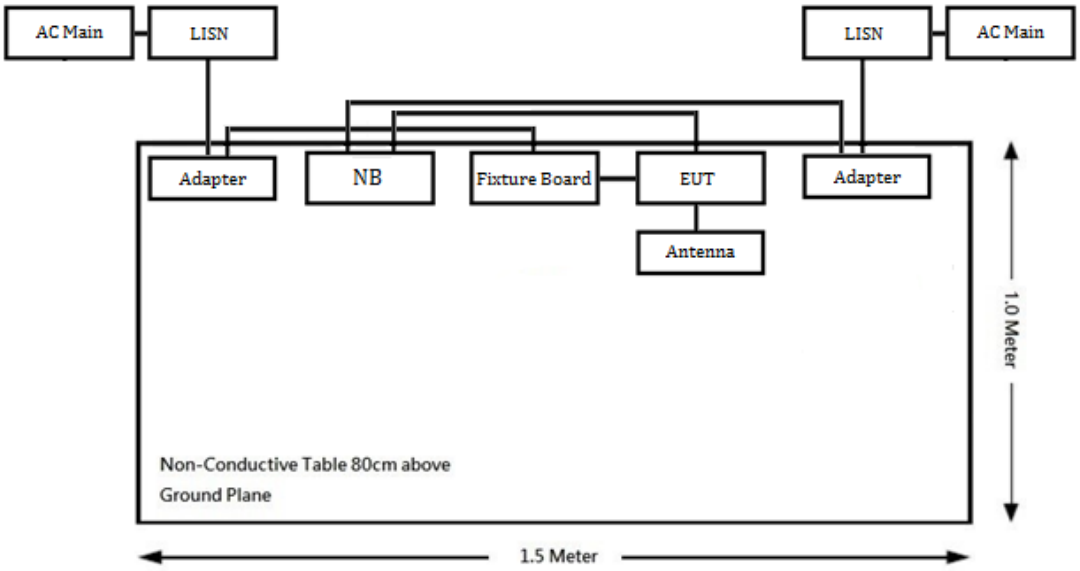


Pygate, DC 5V from USB Port + Gateway Module (GPy 1.0)

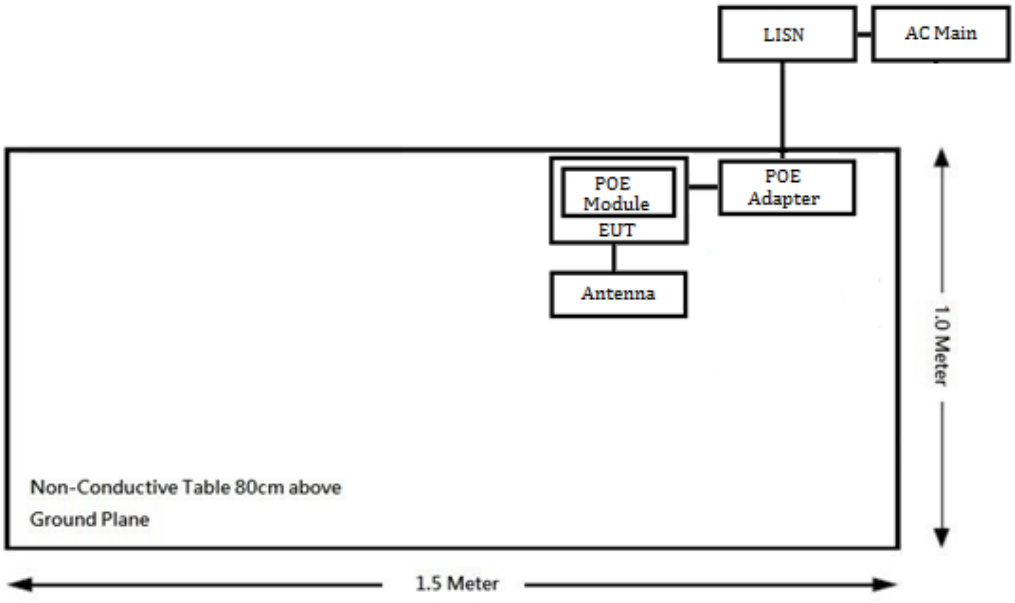


Conduction:

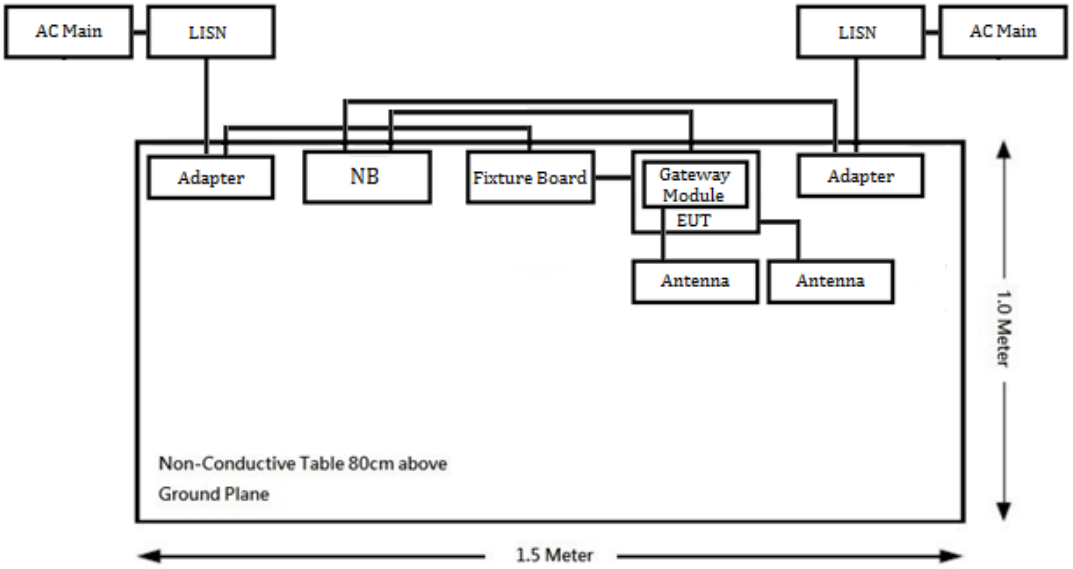
Pygate, DC 5V from USB Port



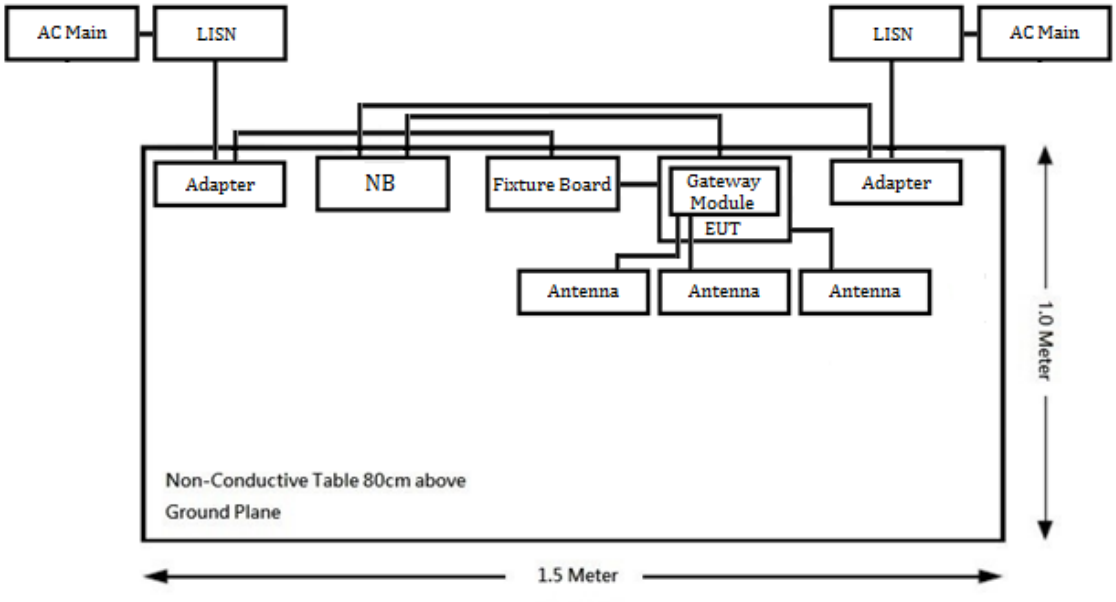
Pygate, DC 48V from PoE



Pygate, DC 5V from USB Port + Gateway Module (Wipy3.0 / LoPy4 1.0)



Pygate, DC 5V from USB Port + Gateway Module (GPy 1.0)



2.8. Duty Cycle

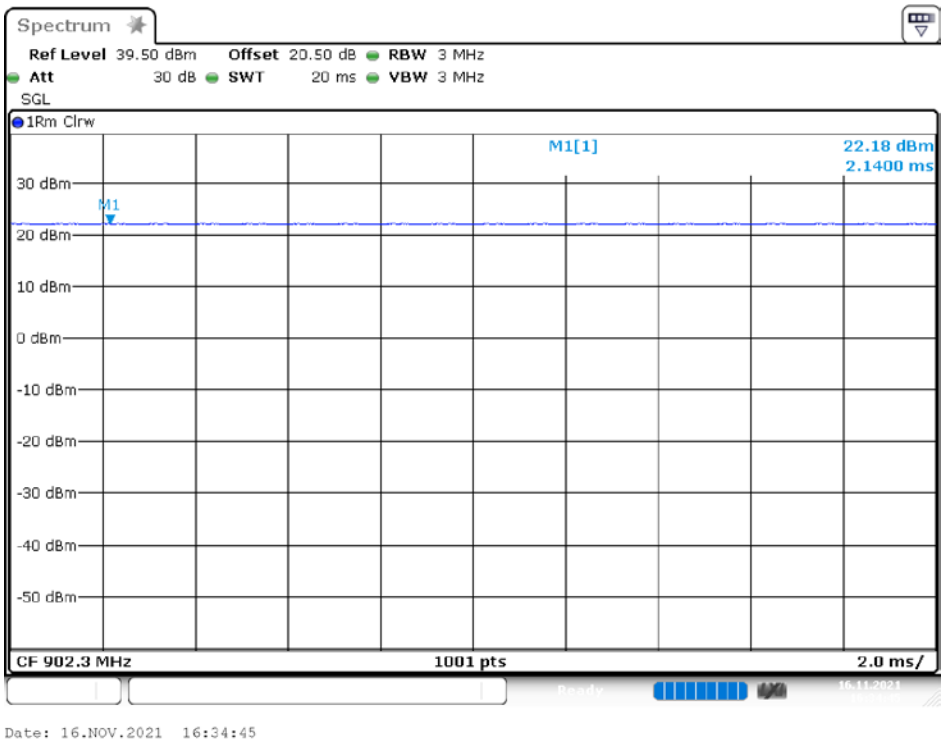
The duty cycle as below:

Mode	On Time (ms)	Off Time (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
LoRa (125kHz)	/	/	100	0
LoRa (250kHz)	/	/	100	0

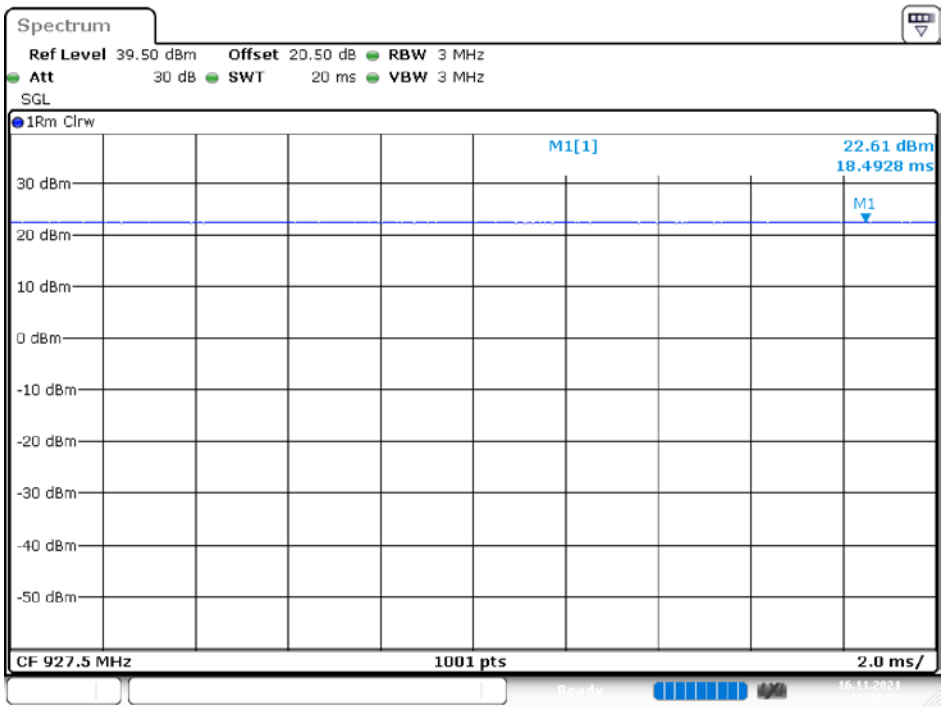
Note: Duty Cycle Correction Factor = 10*log(1/duty cycle)

Please refer to the following plots.

For 125kHz



For 250kHz:



Date: 16.NOV.2021 16:08:55

3. Summary of Test Results

FCC Rules	Description of Test	Results
§15.247(i), §1.1310,§2.1091	Maximum Permissible Exposure (MPE)	Compliance
§15.203	Antenna Requirement	Compliance
§15.207(a)	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d)	Spurious Emissions	Compliance
§15.247(a)(1)(i)	20 dB Emission Bandwidth	Compliance
§15.247(a)(1)	Channel Separation Test	Compliance
§15.247(f)	Time of Occupancy (Dwell Time)	Compliance
§15.247(f)	Power Spectral Density of hybrid systems	Compliance
§15.247(a)(1)(i)	Quantity of hopping channel Test	Compliance
§15.247(b)(3)	Maximum Peak Output Power	Compliance
§15.247(d)	100 kHz Bandwidth of Frequency Band Edge	Compliance

4. Test Equipment List and Details

Description	Manufacturer	Model	Serial Number	Calibration Date	Calibration Due Date
AC Line Conduction Room (CON-A)					
LISN	Rohde & Schwarz	ENV216	101612	2020/12/30	2021/12/29
LISN	Rohde & Schwarz	ENV216	101248	2021/06/08	2022/06/07
EMI Test Receiver	Rohde & Schwarz	ESR3	102099	2021/6/9	2022/6/8
Pulse Limiter	Rohde & Schwarz	ESH3Z2	TXZEM104	2021/7/29	2022/7/29
RF Cable	EMEC	EM-CB5D	001	2021/6/11	2022/6/11
Software	AUDIX	E3	V9.150826k	N.C.R	N.C.R
Radiated Room (966-A)					
Bilog Antenna with 6 dB Attenuator	SUNOL SCIENCES & MINI-CIRCUITS	JB6/UNAT-6+	A050115/15542_01	2021/01/19	2022/01/18
Horn Antenna	EMCO	SAS-571	1020	2021/4/23	2022/4/22
Preamplifier	Sonoma	310N	130602	2021/06/08	2022/06/07
Preamplifier	A.H. system Inc.	PAM-0118P	470	2021/03/15	2022/03/14
EMI Test Receiver	Rohde & Schwarz	ESR7	101419	2021/11/09	2022/11/08
Spectrum Analyzer	Rohde & Schwarz	FSV40	101435	2021/01/07	2022/01/06
Micro flex Cable	UTIFLEX	UFB197C-1-2362-70U-70U	225757-001	2021/2/1	2022/1/31
Coaxial Cable	COMMATE	PEWC	8Dr	2020/12/25	2021/12/24
Coaxial Cable	UTIFLEX	UFB311A-Q-1440-300300	220490-006	2021/2/1	2022/1/31
Coaxial Cable	JUNFLON	J12J102248-00-B-5	AUG-07-15-044	2020/12/25	2021/12/24
Cable	EMC	EMC105-SM-SM-10000	201003	2021/2/3	2022/2/2
Software	Farad	EZ_EMC	BACL-03A1	N.C.R	N.C.R
Conducted Room					
Spectrum Analyzer	Rohde & Schwarz	FSV40	101140	2021/01/07	2022/01/06
Cable	UTIFLEX	UFA210A	9435	2021/10/05	2022/10/04
Attenuator	MCL	BW-S10W5+	1419	2021/01/28	2022/01/27
Power Sensor	KEYSIGHT	U2021XA	MY54080018	2021/01/28	2022/01/27

***Statement of Traceability:** BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to the SI System of Units via the R.O.C. Center for Measurement Standards of the Electronics Testing Center, Taiwan (ETC) or to another internationally recognized National Metrology Institute (NMI), and were compliant with the current Taiwan Accreditation Foundation (TAF) requirements

5. FCC §15.247(i), §1.1310, § 2.1091 - Maximum Permissible Exposure (MPE)

5.1. 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/cm^2)**	**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/cm^2);

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);

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

5.2. RF Exposure Evaluation Result

Calculated Data (worst case):

Model 1

Mode	Frequency Range (MHz)	Antenna Gain		Target Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
LoRa (125kHz)	902.3-927.7	0.87	1.222	24	251.189	20	0.0611	0.602
LoRa (250kHz)	902.3-927.5	0.87	1.222	24	251.189	20	0.0611	0.602
LoRa (500kHz)	903-927.5	0.87	1.222	23.5	223.87	20	0.0544	0.602
WIFI (Internal Antenna)	2412-2462	-0.5	0.891	18	63.096	20	0.0112	1
BLE (Internal Antenna)	2402-2480	-0.5	0.891	3.5	2.239	20	0.0004	1
BT2.1+EDR (Internal Antenna)	2402-2480	-0.5	0.891	5.5	3.548	20	0.0006	1
WIFI (External Antenna)	2412-2462	2	1.585	18	63.096	20	0.0199	1
BLE (External Antenna)	2402-2480	2	1.585	3.5	2.239	20	0.0007	1
BT2.1+EDR (External Antenna)	2402-2480	2	1.585	5.5	3.548	20	0.0011	1

Note: WIFI 2.4G/BLE/BT (FCC ID: 2AJMTWIPY3R) and LoRa can transmit simultaneously; the worst condition as below:

$\sum_i \frac{S_i}{S_{Limit,i}}$ = 0.0611/0.602+0.0199/1.00= 0.1213 < 1.0

Model 2

Mode	Frequency Range (MHz)	Antenna Gain		Target Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
LoRa (125kHz)	902.3-927.7	0.87	1.222	24	251.189	20	0.0611	0.602
LoRa (250kHz)	902.3-927.5	0.87	1.222	24	251.189	20	0.0611	0.602
LoRa (500kHz)	903-927.5	0.87	1.222	23.5	223.87	20	0.0544	0.602
WIFI	2412-2462	1.3	1.349	23	199.526	20	0.0535	1
BLE	2402-2480	1.3	1.349	3	1.995	20	0.0005	1
BT3.0	2402-2480	1.3	1.349	6	3.981	20	0.0011	1
Sigfox	902-928	0.87	1.222	20	100.000	20	0.0243	0.601

Note: WIFI 2.4G/BLE/BT (FCC ID: 2AJMTLOPY4R) and LoRa can transmit simultaneously; the worst condition as below:

$\sum_i \frac{S_i}{S_{Limit,i}}$ = 0.0611/0.602+0.0535/1.00= 0.1549 < 1.0

Model 3

Mode	Frequency Range (MHz)	Antenna Gain		Target Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
LoRa (125kHz)	902.3-927.7	0.87	1.222	24	251.189	20	0.0611	0.602
LoRa (250kHz)	902.3-927.5	0.87	1.222	24	251.189	20	0.0611	0.602
LoRa (500kHz)	903-927.5	0.87	1.222	23.5	223.87	20	0.0544	0.602
WIFI	2412-2462	1.3	1.35	23	199.526	20	0.0535	1
BLE	2402-2480	1.3	1.35	5	3.16	20	0.0008	1
BT3.0	2402-2480	1.3	1.35	6.5	4.47	20	0.0012	1
FDD Band4	1710-1755	7	5.012	23	199.53	20	0.1989	1
FDD Band12	699-716	9.4	8.710	23.5	223.87	20	0.3879	0.466
FDD Band13	777-787	10.4	10.965	23	199.53	20	0.4352	0.518

Note: WIFI 2.4G/BLE/BT, LTE (FCC ID: 2AJMTGPY01R) and LoRa can transmit simultaneously; the worst condition as below:

$\sum_i \frac{S_i}{S_{Limit,i}}$ =0.0611/0.602+0.0535/1.00+0.4352/0.518= 0.995 < 1.0

Result: MPE evaluation of single and simultaneous transmission meet **20cm** the requirement of standard.

7. FCC §15.203 – Antenna Requirements

7.1. Applicable Standard

According to § 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 user of a standard antenna jack or electrical connector is prohibited.

And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

7.2. Antenna Information

Function	Manufacturer	Type	Model	Antenna Gain
LoRa External	Pycom Ltd	Monopole	LoRa (865MHz/915MHz) & Sigfox Antenna Kit	0.87 dBi (Pygate)

Result: Compliance

8. FCC §15.207(a) – AC Line Conducted Emissions

8.1. Applicable Standard

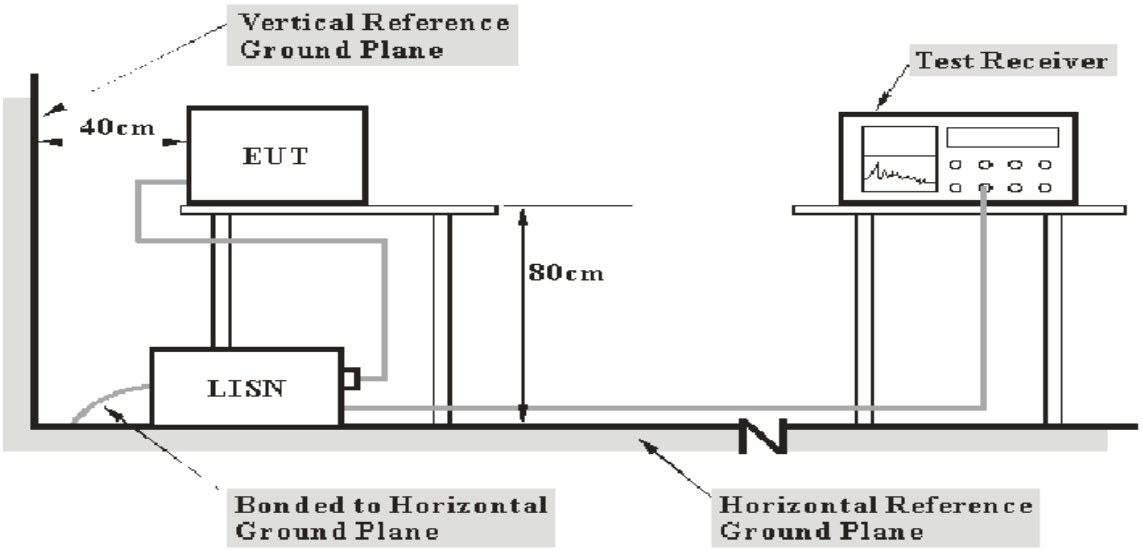
According to §15.207

For an intentional radiator that is designed to be connected to the public utility (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 the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequencies ranges.

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 Note 1	56 to 46 Note 1
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency.

8.2. 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 setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 limits.

8.3. EMI Test Receiver Setup

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

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

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

8.4. Test Procedure

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

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

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

8.5. Corrected Factor & Margin Calculation

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

Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

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

Over Limit = Level – Limit Line

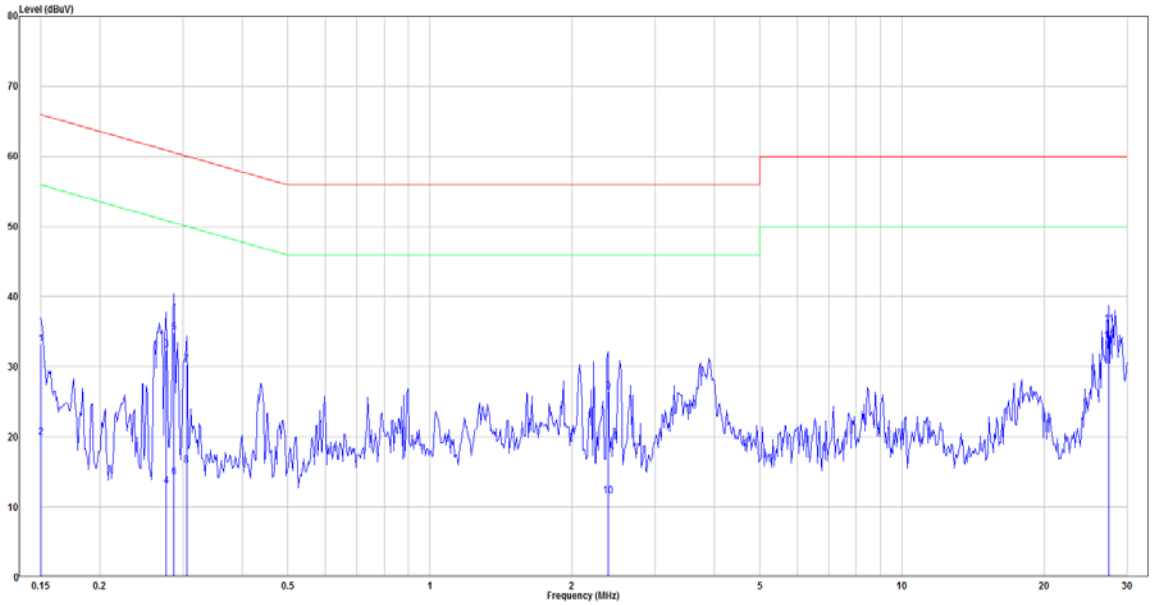
8.6. Test Results

Test Mode: Transmitting

For 125kHz

Pygate, DC 5V from USB Port

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.150	13.66	19.60	33.26	66.00	-32.74	QP
2	0.150	0.28	19.60	19.88	56.00	-36.12	Average
3	0.276	12.87	19.58	32.45	60.94	-28.49	QP
4	0.276	-6.59	19.58	12.99	50.94	-37.95	Average
5	0.286	15.33	19.58	34.91	60.63	-25.72	QP
6	0.286	-5.28	19.58	14.30	50.63	-36.33	Average
7	0.305	10.64	19.58	30.22	60.10	-29.88	QP
8	0.305	-3.69	19.58	15.89	50.10	-34.21	Average
9	2.384	6.74	19.65	26.39	56.00	-29.61	QP
10	2.384	-8.13	19.65	11.52	46.00	-34.48	Average
11	27.416	16.13	19.94	36.07	60.00	-23.93	QP
12	27.416	13.81	19.94	33.75	50.00	-16.25	Average

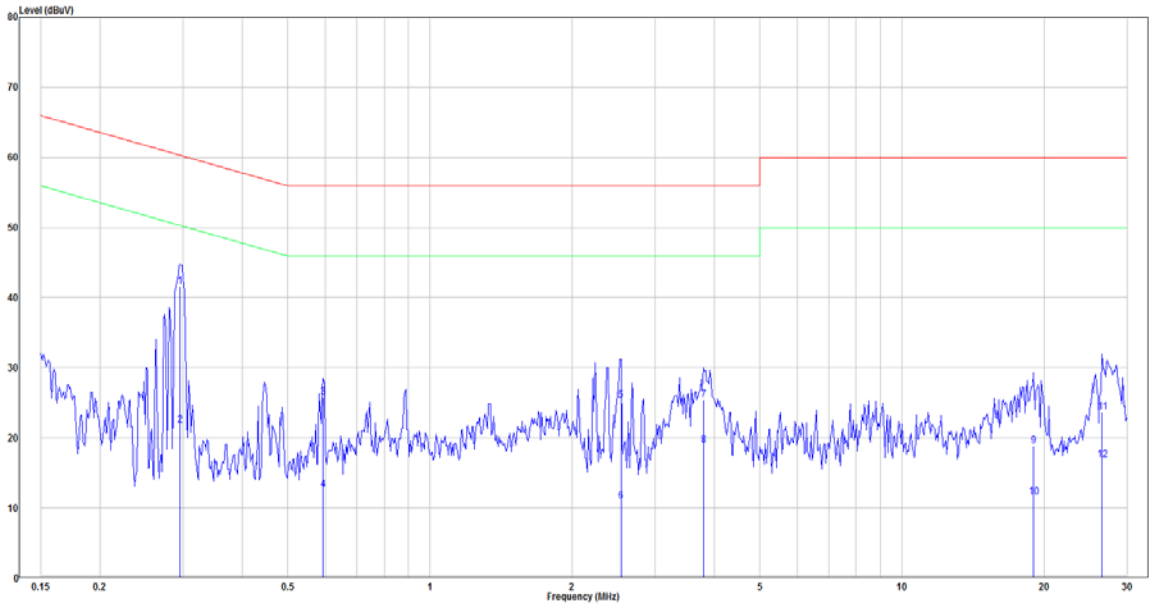
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.296	22.05	19.58	41.63	60.37	-18.74	QP
2	0.296	2.23	19.58	21.81	50.37	-28.56	Average
3	0.595	6.20	19.59	25.79	56.00	-30.21	QP
4	0.595	-7.01	19.59	12.58	46.00	-33.42	Average
5	2.540	5.64	19.65	25.29	56.00	-30.71	QP
6	2.540	-8.73	19.65	10.92	46.00	-35.08	Average
7	3.799	5.80	19.68	25.48	56.00	-30.52	QP
8	3.799	-0.71	19.68	18.97	46.00	-27.03	Average
9	19.021	-1.04	19.90	18.86	60.00	-41.14	QP
10	19.021	-8.31	19.90	11.59	50.00	-38.41	Average
11	26.558	3.71	19.98	23.69	60.00	-36.31	QP
12	26.558	-3.12	19.98	16.86	50.00	-33.14	Average

Note:

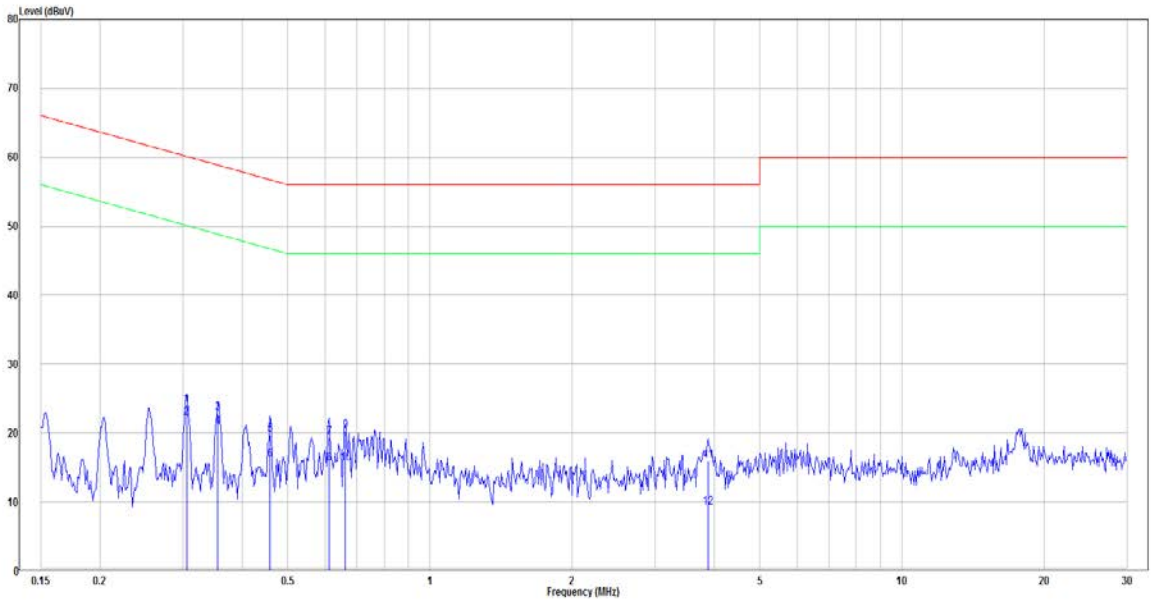
Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Pygate, DC 48V from PoE

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.305	4.53	19.58	24.11	60.10	-35.99	QP
2	0.305	2.64	19.58	22.22	50.10	-27.88	Average
3	0.356	3.33	19.58	22.91	58.83	-35.92	QP
4	0.356	1.30	19.58	20.88	48.83	-27.95	Average
5	0.459	0.16	19.59	19.75	56.71	-36.96	QP
6	0.459	-3.51	19.59	16.08	46.71	-30.63	Average
7	0.611	-0.25	19.60	19.35	56.00	-36.65	QP
8	0.611	-4.08	19.60	15.52	46.00	-30.48	Average
9	0.661	0.67	19.60	20.27	56.00	-35.73	QP
10	0.661	-4.08	19.60	15.52	46.00	-30.48	Average
11	3.881	-3.75	19.69	15.94	56.00	-40.06	QP
12	3.881	-10.46	19.69	9.23	46.00	-36.77	Average

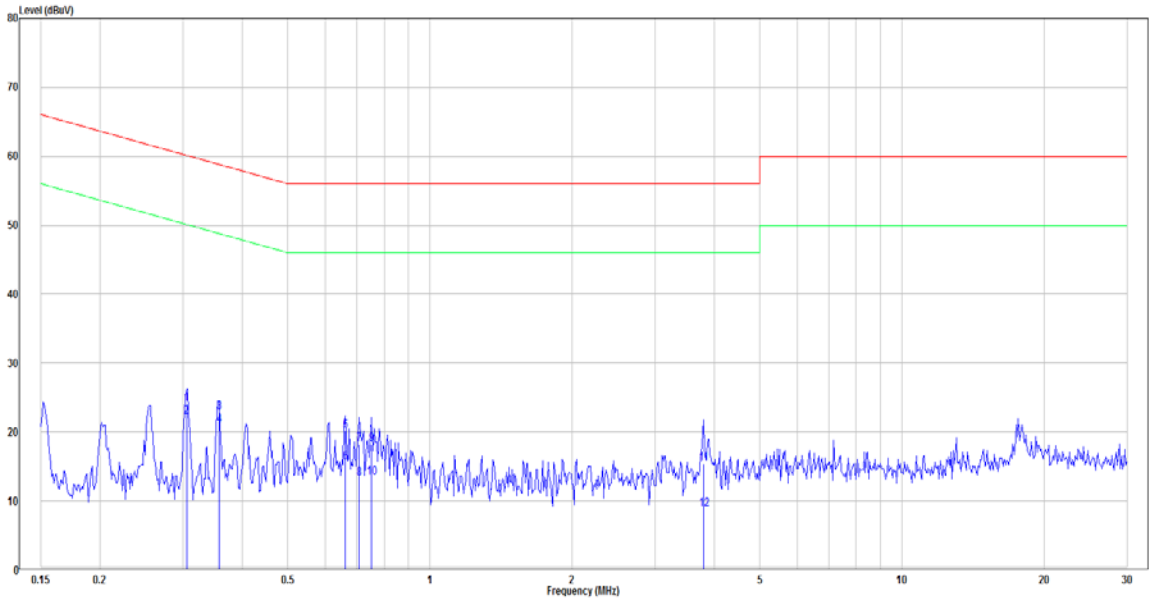
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.305	4.49	19.58	24.07	60.10	-36.03	QP
2	0.305	2.66	19.58	22.24	50.10	-27.86	Average
3	0.358	3.31	19.58	22.89	58.78	-35.89	QP
4	0.358	1.47	19.58	21.05	48.78	-27.73	Average
5	0.661	0.55	19.59	20.14	56.00	-35.86	QP
6	0.661	-4.09	19.59	15.50	46.00	-30.50	Average
7	0.708	-1.36	19.59	18.23	56.00	-37.77	QP
8	0.708	-6.37	19.59	13.22	46.00	-32.78	Average
9	0.751	-1.31	19.60	18.29	56.00	-37.71	QP
10	0.751	-6.13	19.60	13.47	46.00	-32.53	Average
11	3.799	-4.26	19.68	15.42	56.00	-40.58	QP
12	3.799	-10.92	19.68	8.76	46.00	-37.24	Average

Note:

Level = Read Level + Factor

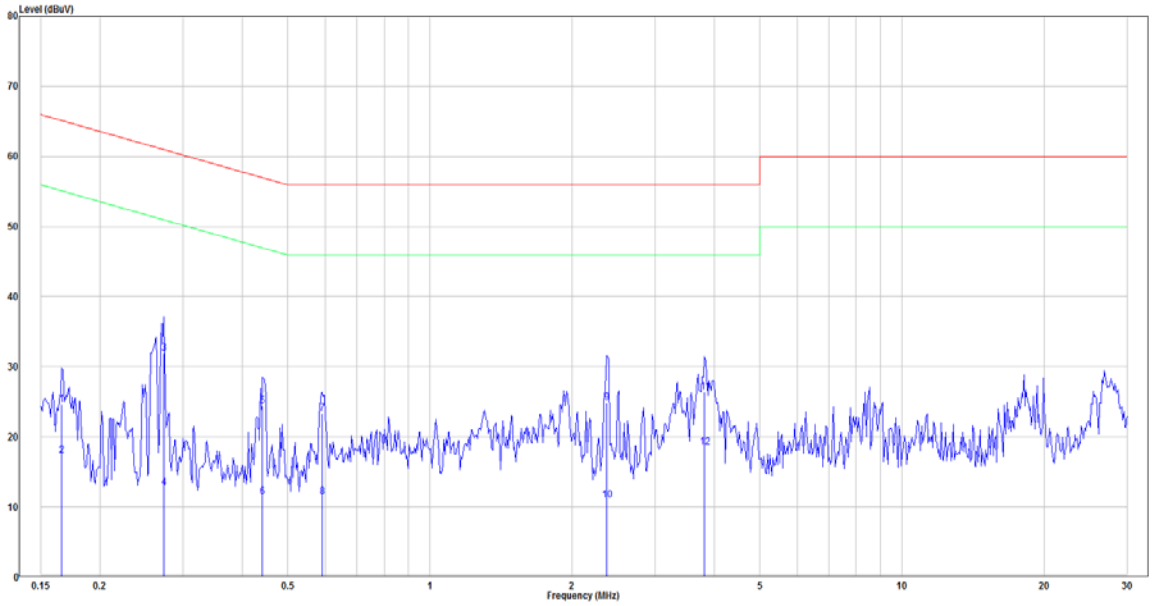
Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

For 250kHz

Pygate, DC 5V from USB Port

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.166	5.01	19.59	24.60	65.16	-40.56	QP
2	0.166	-2.31	19.59	17.28	55.16	-37.88	Average
3	0.273	12.33	19.58	31.91	61.03	-29.12	QP
4	0.273	-6.85	19.58	12.73	51.03	-38.30	Average
5	0.442	4.85	19.59	24.44	57.02	-32.58	QP
6	0.442	-8.16	19.59	11.43	47.02	-35.59	Average
7	0.592	3.79	19.60	23.39	56.00	-32.61	QP
8	0.592	-8.12	19.60	11.48	46.00	-34.52	Average
9	2.371	5.21	19.65	24.86	56.00	-31.14	QP
10	2.371	-8.70	19.65	10.95	46.00	-35.05	Average
11	3.820	6.68	19.69	26.37	56.00	-29.63	QP
12	3.820	-1.18	19.69	18.51	46.00	-27.49	Average

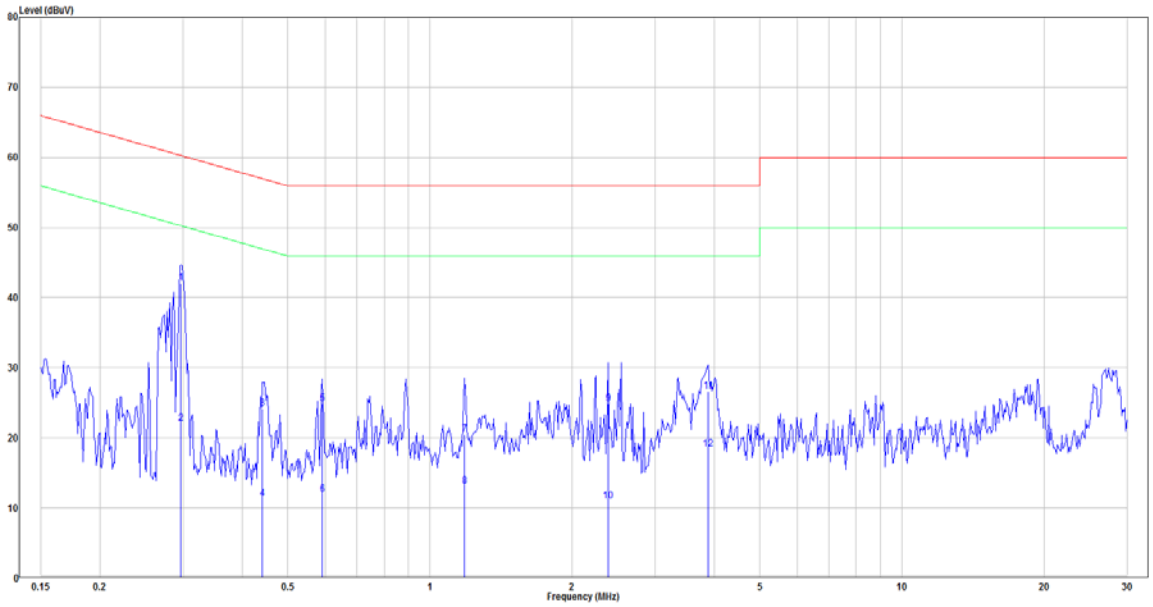
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.297	22.52	19.58	42.10	60.32	-18.22	QP
2	0.297	2.44	19.58	22.02	50.32	-28.30	Average
3	0.442	4.55	19.59	24.14	57.02	-32.88	QP
4	0.442	-8.30	19.59	11.29	47.02	-35.73	Average
5	0.592	5.30	19.59	24.89	56.00	-31.11	QP
6	0.592	-7.74	19.59	11.85	46.00	-34.15	Average
7	1.184	0.88	19.61	20.49	56.00	-35.51	QP
8	1.184	-6.52	19.61	13.09	46.00	-32.91	Average
9	2.384	5.21	19.65	24.86	56.00	-31.14	QP
10	2.384	-8.71	19.65	10.94	46.00	-35.06	Average
11	3.881	6.94	19.69	26.63	56.00	-29.37	QP
12	3.881	-1.30	19.69	18.39	46.00	-27.61	Average

Note:

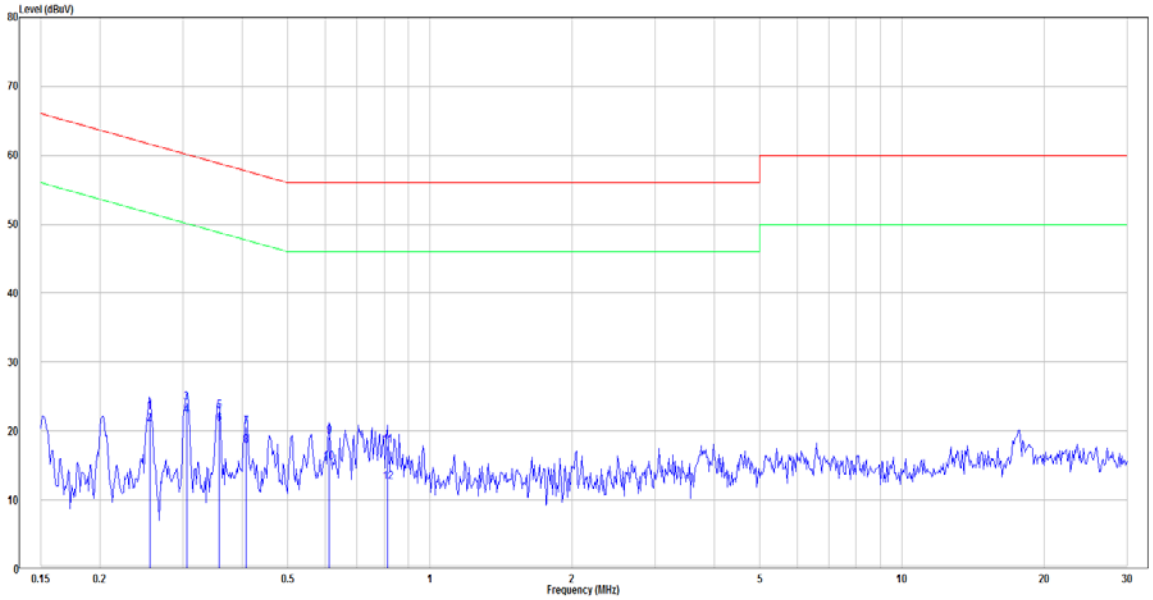
Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Pygate, DC 48V from PoE

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.255	3.18	19.58	22.76	61.60	-38.84	QP
2	0.255	1.42	19.58	21.00	51.60	-30.60	Average
3	0.305	4.54	19.58	24.12	60.10	-35.98	QP
4	0.305	2.63	19.58	22.21	50.10	-27.89	Average
5	0.358	3.31	19.58	22.89	58.78	-35.89	QP
6	0.358	1.46	19.58	21.04	48.78	-27.74	Average
7	0.408	0.96	19.58	20.54	57.68	-37.14	QP
8	0.408	-1.65	19.58	17.93	47.68	-29.75	Average
9	0.611	-0.33	19.60	19.27	56.00	-36.73	QP
10	0.611	-4.18	19.60	15.42	46.00	-30.58	Average
11	0.813	-1.73	19.60	17.87	56.00	-38.13	QP
12	0.813	-6.99	19.60	12.61	46.00	-33.39	Average

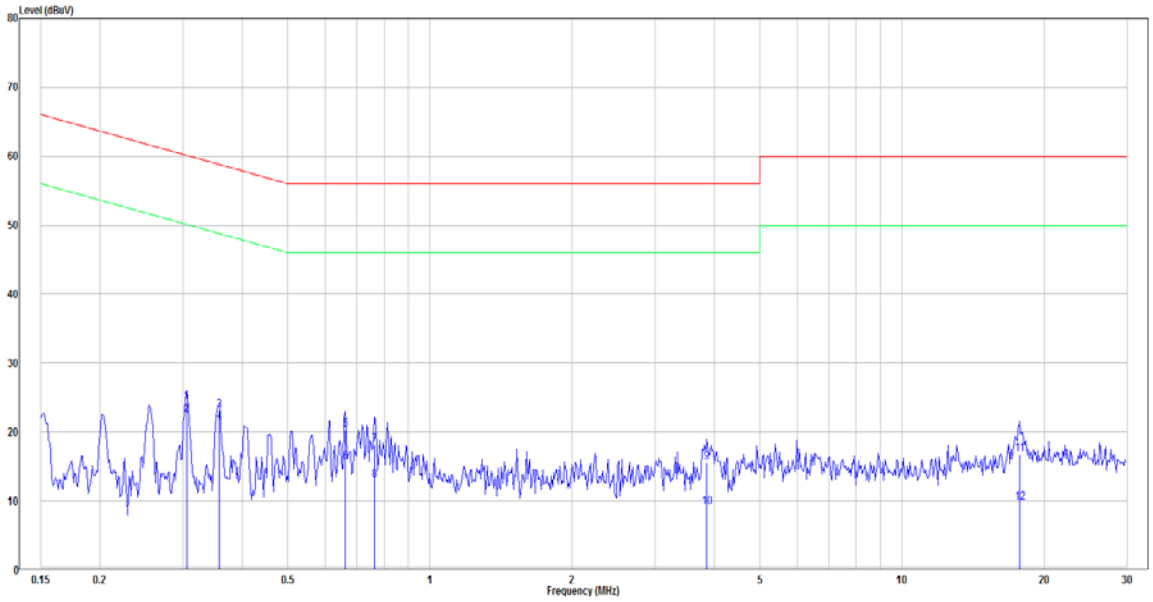
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.305	4.73	19.58	24.31	60.10	-35.79	QP
2	0.305	2.94	19.58	22.52	50.10	-27.58	Average
3	0.358	3.57	19.58	23.15	58.78	-35.63	QP
4	0.358	1.77	19.58	21.35	48.78	-27.43	Average
5	0.661	0.67	19.59	20.26	56.00	-35.74	QP
6	0.661	-4.02	19.59	15.57	46.00	-30.43	Average
7	0.763	-1.46	19.60	18.14	56.00	-37.86	QP
8	0.763	-6.56	19.60	13.04	46.00	-32.96	Average
9	3.860	-4.12	19.69	15.57	56.00	-40.43	QP
10	3.860	-10.65	19.69	9.04	46.00	-36.96	Average
11	17.755	-3.10	19.89	16.79	60.00	-43.21	QP
12	17.755	-10.10	19.89	9.79	50.00	-40.21	Average

Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

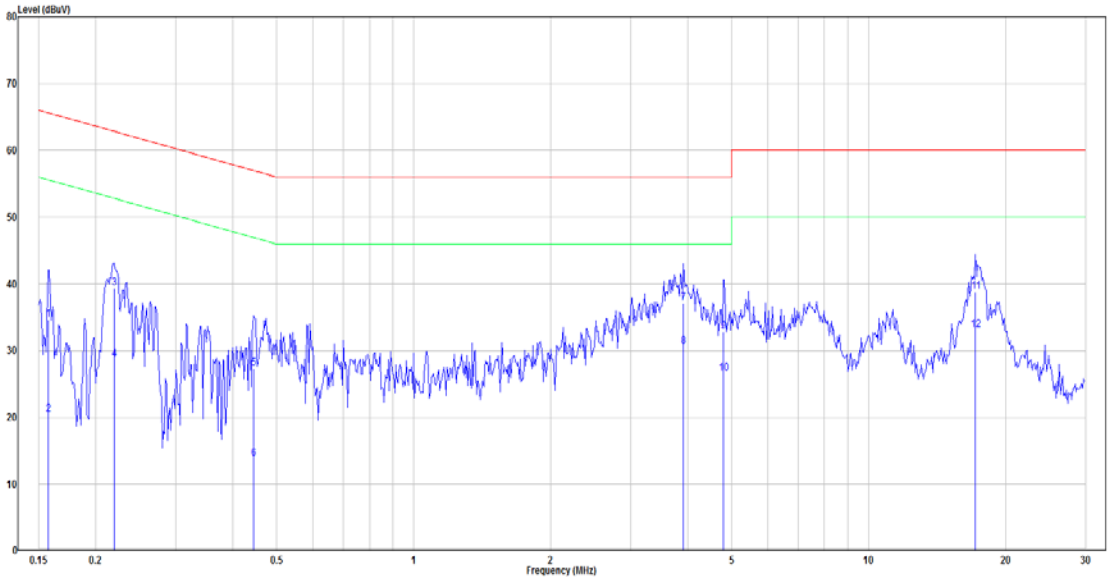
Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Transmitting simultaneously test:

Model 1

The worst case of LoRa and WIFI mode transmitting simultaneously was recorded

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.157	15.08	19.59	34.67	65.60	-30.93	QP
2	0.157	0.81	19.59	20.40	55.60	-35.20	Average
3	0.220	19.72	19.58	39.30	62.83	-23.53	QP
4	0.220	9.11	19.58	28.69	52.83	-24.14	Average
5	0.444	7.76	19.59	27.35	56.98	-29.63	QP
6	0.444	-5.74	19.59	13.85	46.98	-33.13	Average
7	3.922	17.42	19.69	37.11	56.00	-18.89	QP
8	3.922	10.94	19.69	30.63	46.00	-15.37	Average
9	4.797	13.11	19.71	32.82	56.00	-23.18	QP
10	4.797	6.81	19.71	26.52	46.00	-19.48	Average
11	17.199	18.90	19.86	38.76	60.00	-21.24	QP
12	17.199	13.25	19.86	33.11	50.00	-16.89	Average

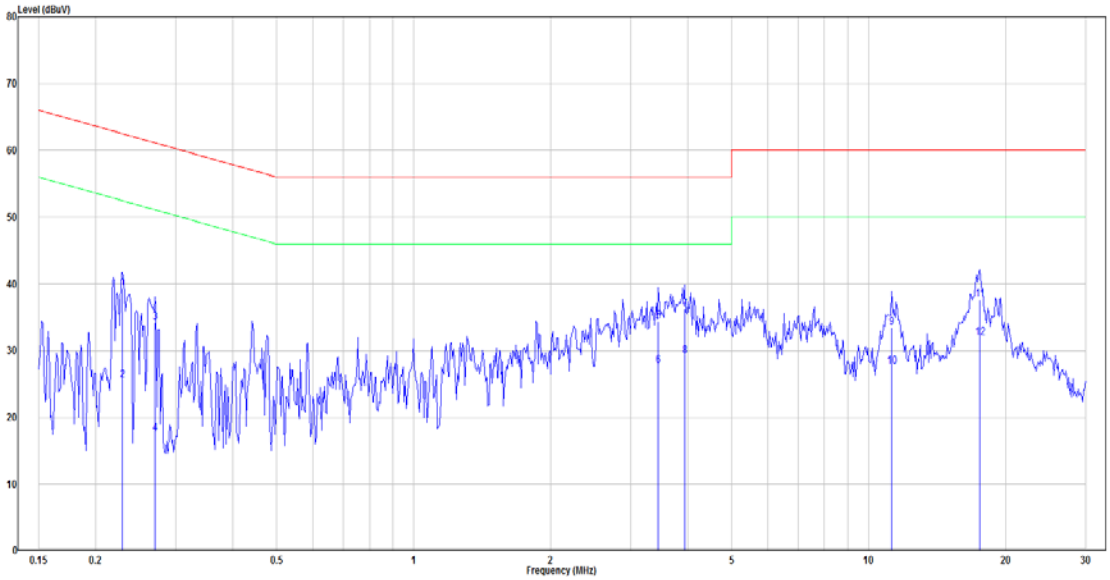
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.229	19.76	19.58	39.34	62.48	-23.14	QP
2	0.229	5.99	19.58	25.57	52.48	-26.91	Average
3	0.270	14.73	19.58	34.31	61.12	-26.81	QP
4	0.270	-2.03	19.58	17.55	51.12	-33.57	Average
5	3.454	14.73	19.68	34.41	56.00	-21.59	QP
6	3.454	8.13	19.68	27.81	46.00	-18.19	Average
7	3.943	16.48	19.69	36.17	56.00	-19.83	QP
8	3.943	9.53	19.69	29.22	46.00	-16.78	Average
9	11.257	13.60	19.82	33.42	60.00	-26.58	QP
10	11.257	7.76	19.82	27.58	50.00	-22.42	Average
11	17.568	17.77	19.89	37.66	60.00	-22.34	QP
12	17.568	11.99	19.89	31.88	50.00	-18.12	Average

Note:

Level = Read Level + Factor

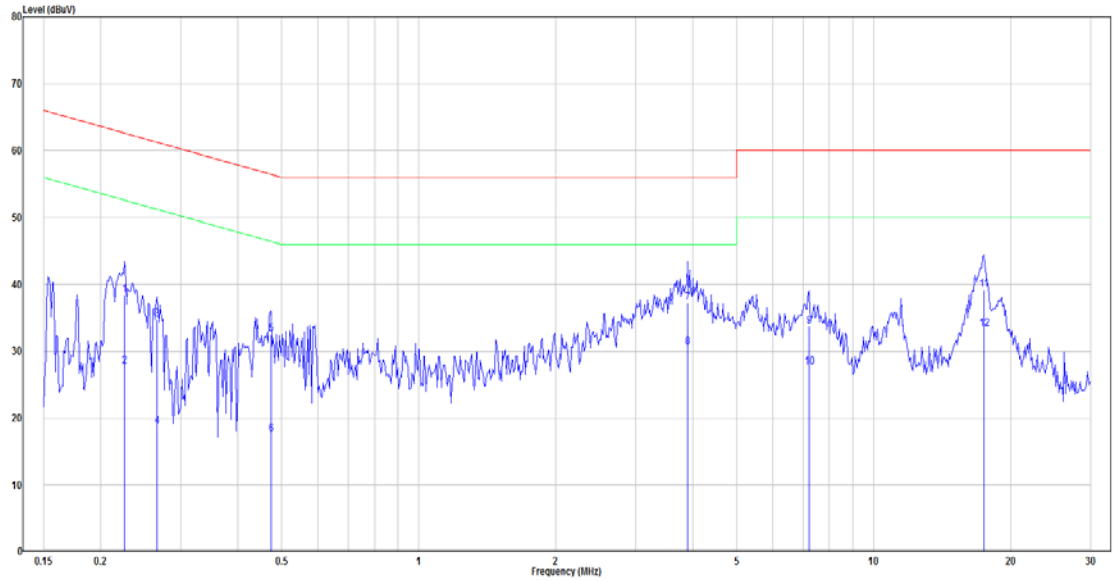
Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Model 2

The worst case of LoRa and WIFI mode transmitting simultaneously was recorded

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.226	18.80	19.58	38.38	62.61	-24.23	QP
2	0.226	8.18	19.58	27.76	52.61	-24.85	Average
3	0.266	15.15	19.58	34.73	61.25	-26.52	QP
4	0.266	-0.84	19.58	18.74	51.25	-32.51	Average
5	0.474	13.03	19.59	32.62	56.45	-23.83	QP
6	0.474	-1.97	19.59	17.62	46.45	-28.83	Average
7	3.901	17.62	19.69	37.31	56.00	-18.69	QP
8	3.901	10.91	19.69	30.60	46.00	-15.40	Average
9	7.213	14.04	19.76	33.80	60.00	-26.20	QP
10	7.213	7.86	19.76	27.62	50.00	-22.38	Average
11	17.475	19.30	19.86	39.16	60.00	-20.84	QP
12	17.475	13.45	19.86	33.31	50.00	-16.69	Average

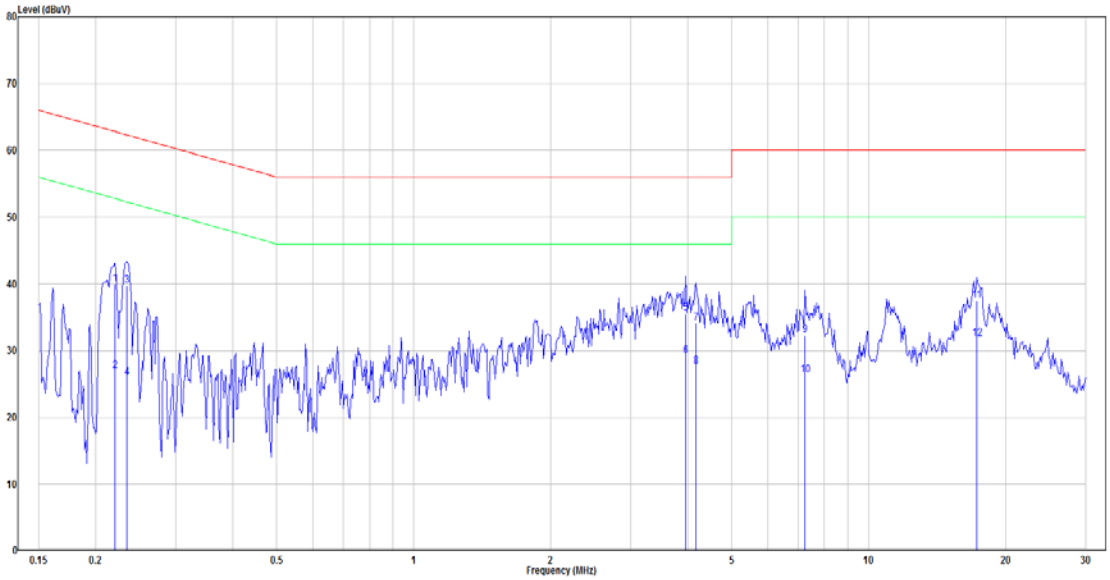
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.221	20.47	19.58	40.05	62.79	-22.74	QP
2	0.221	7.45	19.58	27.03	52.79	-25.76	Average
3	0.234	20.20	19.58	39.78	62.30	-22.52	QP
4	0.234	6.36	19.58	25.94	52.30	-26.36	Average
5	3.964	15.83	19.69	35.52	56.00	-20.48	QP
6	3.964	9.53	19.69	29.22	46.00	-16.78	Average
7	4.180	14.39	19.70	34.09	56.00	-21.91	QP
8	4.180	7.96	19.70	27.66	46.00	-18.34	Average
9	7.252	12.54	19.76	32.30	60.00	-27.70	QP
10	7.252	6.62	19.76	26.38	50.00	-23.62	Average
11	17.291	17.60	19.89	37.49	60.00	-22.51	QP
12	17.291	11.92	19.89	31.81	50.00	-18.19	Average

Note:

Level = Read Level + Factor

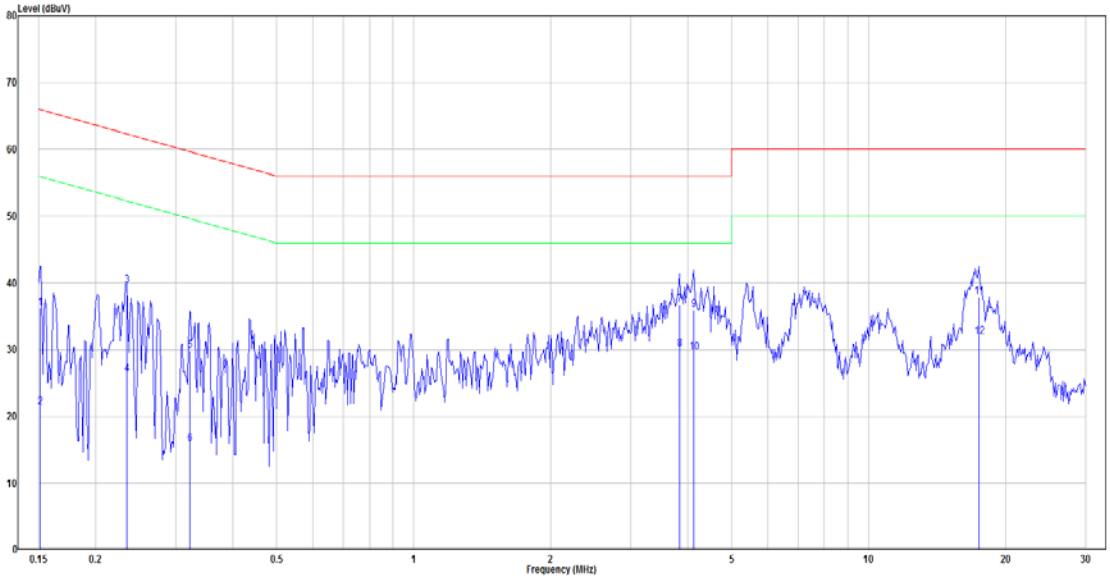
Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Model 3

The worst case of LoRa and WIFI, LTE mode transmitting simultaneously was recorded

Main: AC120 V, 60 Hz, Line



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.151	16.60	19.59	36.19	65.96	-29.77	QP
2	0.151	1.71	19.59	21.30	55.96	-34.66	Average
3	0.234	20.09	19.58	39.67	62.30	-22.63	QP
4	0.234	6.68	19.58	26.26	52.30	-26.04	Average
5	0.322	10.21	19.58	29.79	59.66	-29.87	QP
6	0.322	-3.67	19.58	15.91	49.66	-33.75	Average
7	3.840	17.07	19.69	36.76	56.00	-19.24	QP
8	3.840	10.39	19.69	30.08	46.00	-15.92	Average
9	4.136	16.24	19.69	35.93	56.00	-20.07	QP
10	4.136	9.92	19.69	29.61	46.00	-16.39	Average
11	17.475	18.02	19.86	37.88	60.00	-22.12	QP
12	17.475	12.07	19.86	31.93	50.00	-18.07	Average

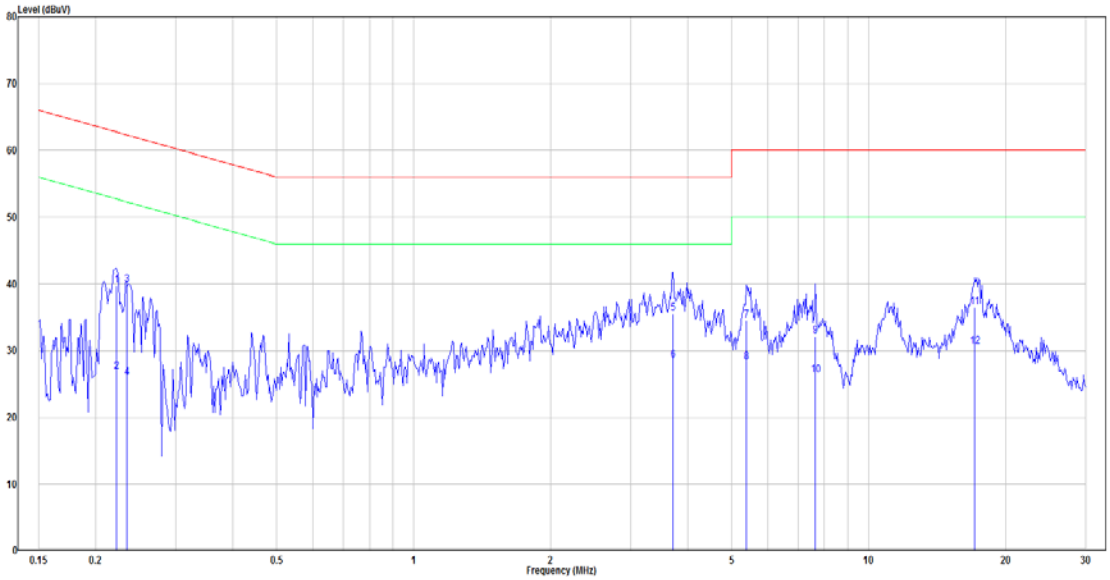
Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

Main: AC120 V, 60 Hz, Neutral



No.	Frequency	Reading	Correct	Result	Limit	Over limit	Remark
	(MHz)	(dBµV)	Factor(dB)	(dBµV)	(dBµV)	(dB)	
1	0.222	20.16	19.58	39.74	62.74	-23.00	QP
2	0.222	7.28	19.58	26.86	52.74	-25.88	Average
3	0.234	20.32	19.58	39.90	62.30	-22.40	QP
4	0.234	6.30	19.58	25.88	52.30	-26.42	Average
5	3.720	15.83	19.68	35.51	56.00	-20.49	QP
6	3.720	8.79	19.68	28.47	46.00	-17.53	Average
7	5.390	14.78	19.73	34.51	60.00	-25.49	QP
8	5.390	8.51	19.73	28.24	50.00	-21.76	Average
9	7.646	12.41	19.76	32.17	60.00	-27.83	QP
10	7.646	6.59	19.76	26.35	50.00	-23.65	Average
11	17.109	16.62	19.86	36.48	60.00	-23.52	QP
12	17.109	10.82	19.86	30.68	50.00	-19.32	Average

Note:

Level = Read Level + Factor

Over Limit = Level – Limit Line

Factor = (LISN, ISN, PLC or current probe) Factor + Cable Loss + Attenuator

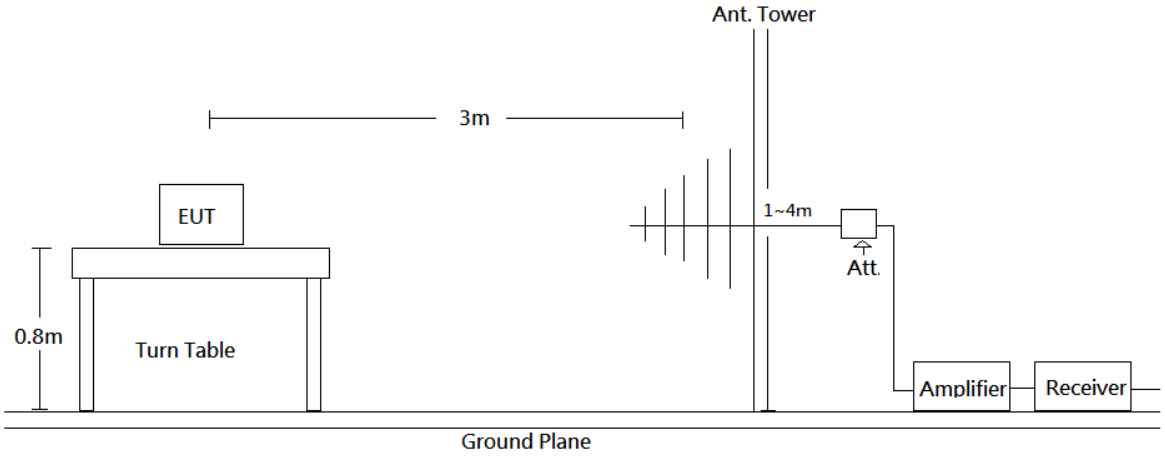
9. FCC §15.209, §15.205 , §15.247(d) – Spurious Emissions

9.1. Applicable Standard

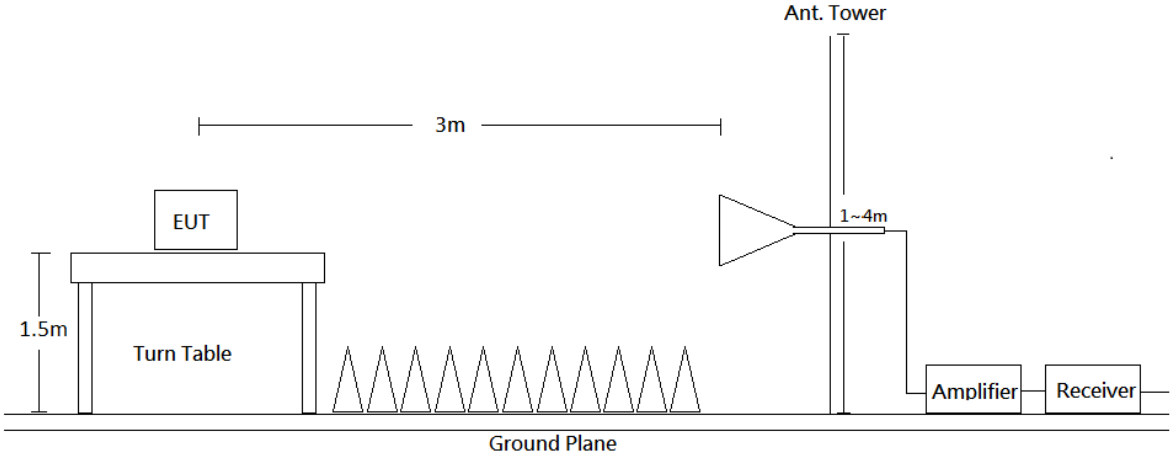
FCC §15.205; §15.209; §15.247(d)

9.2. EUT Setup

Below 1 GHz:



Above 1 GHz:



Radiated emission tests were performed in the 3 meters chamber test site, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC Part 15.209 and FCC 15.247 Limits.

9.3. EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 10 GHz. During the radiated emission test, the EMI test receiver was set with the following configurations measurement method 6.3 in ANSI C63.10.

Frequency Range	RBW	VBW	Measurement method
30-1000 MHz	120 kHz	/	QP
Above 1 GHz	1 MHz	3 MHz	PK
	1 MHz	10 Hz	Ave

9.4. Test Procedure

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

All data was recorded in the Quasi-peak detector mode from 30 MHz to 1 GHz and PK and average detector modes for frequencies above 1 GHz.

9.5. Corrected Factor & Margin Calculation

The Correct Factor 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:

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

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

Margin = Result – Limit

9.6. Test Results

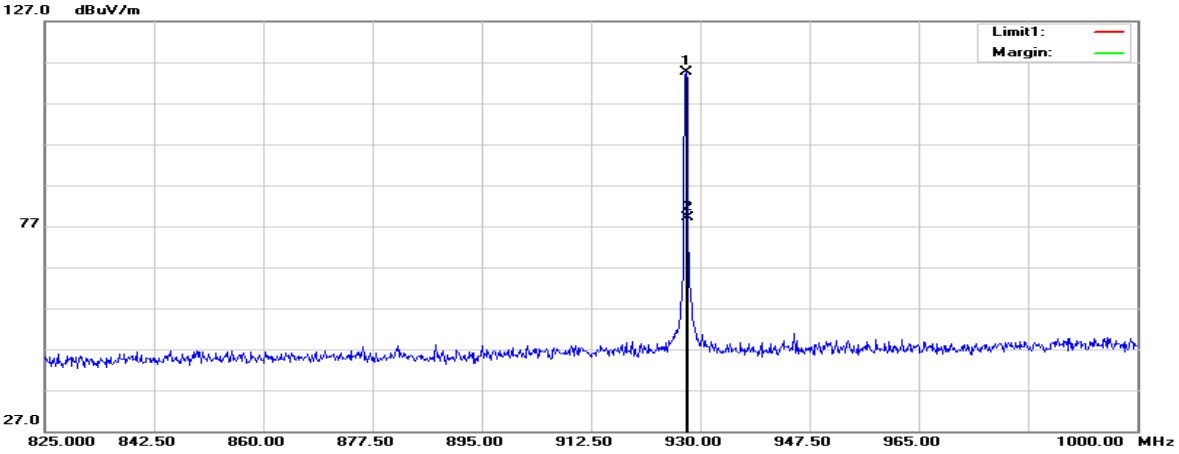
Test Mode: Transmitting

For 125kHz (Pre-scan with three orthogonal axis, and worse case as Y axis.)

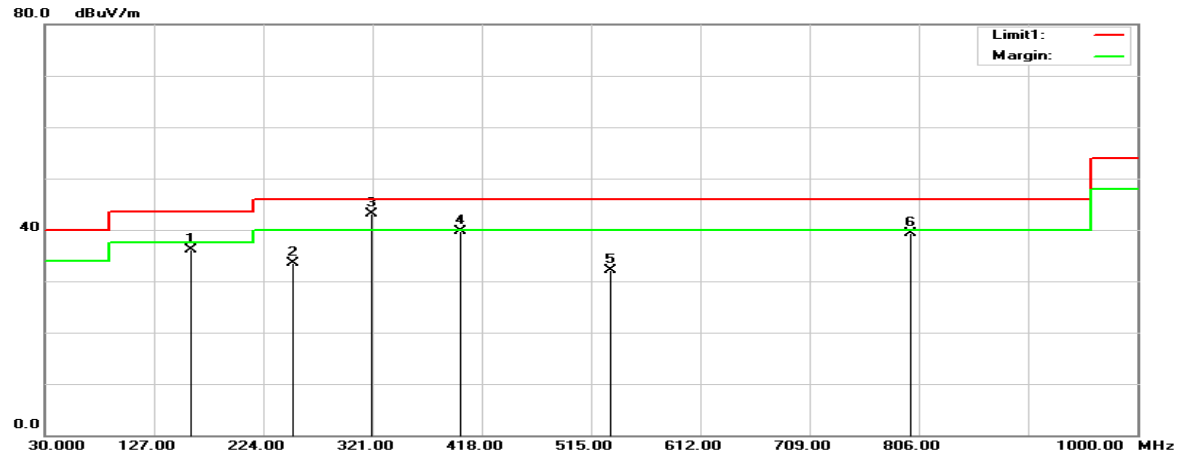
Pygate, DC 5V from USB Port

Horizontal (worst case is high channel)

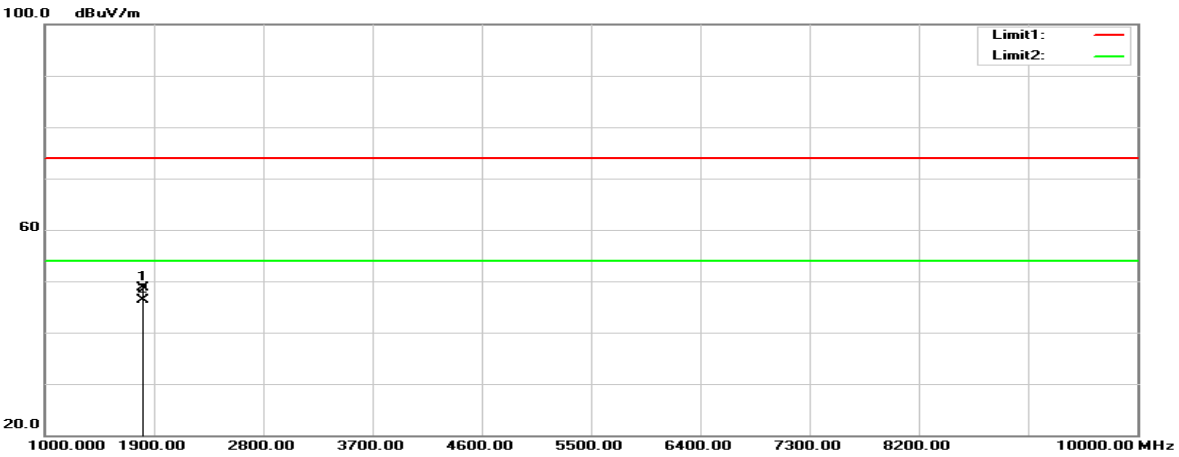
Fundamental:



30MHz-1GHz:

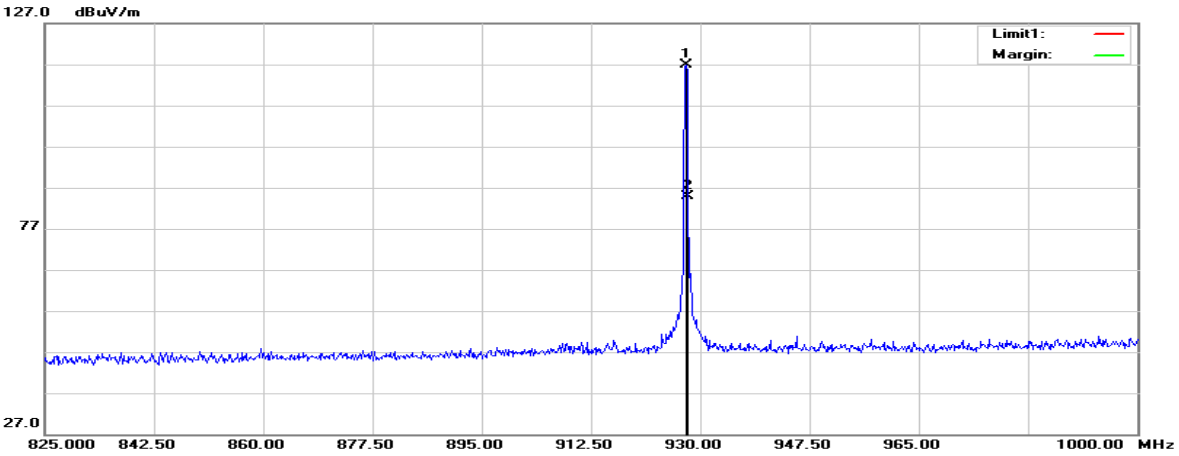


1GHz-10GHz:

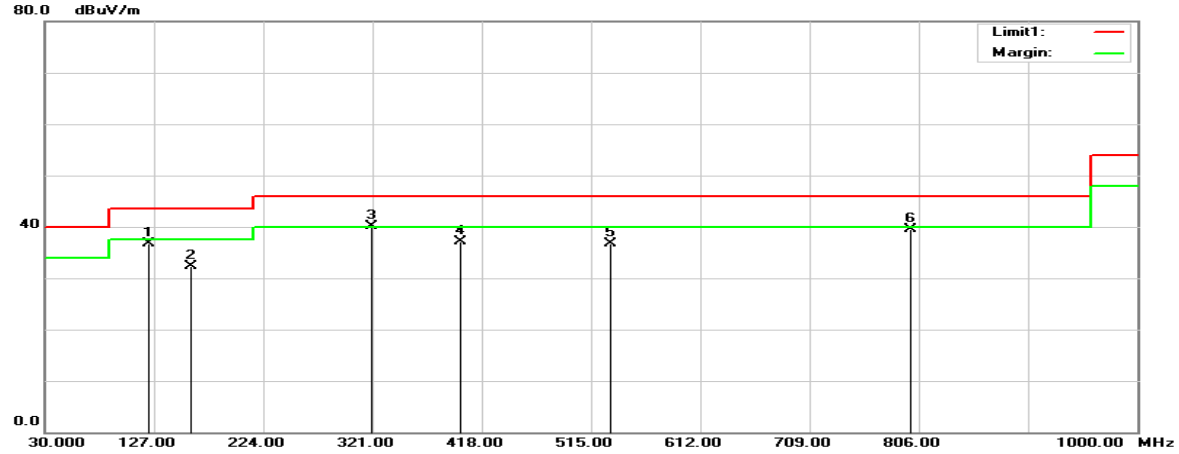


Vertical

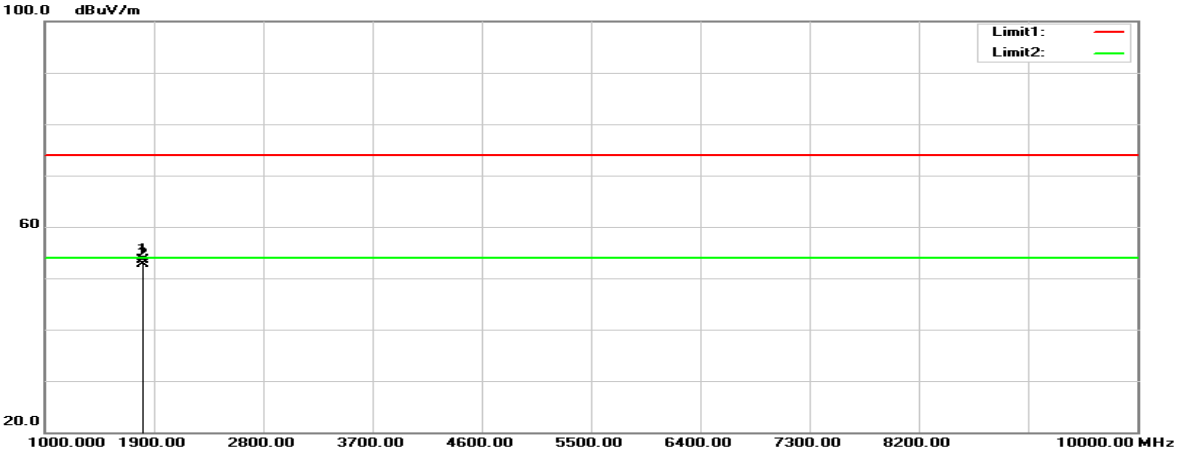
Fundamental:



30MHz-1GHz:



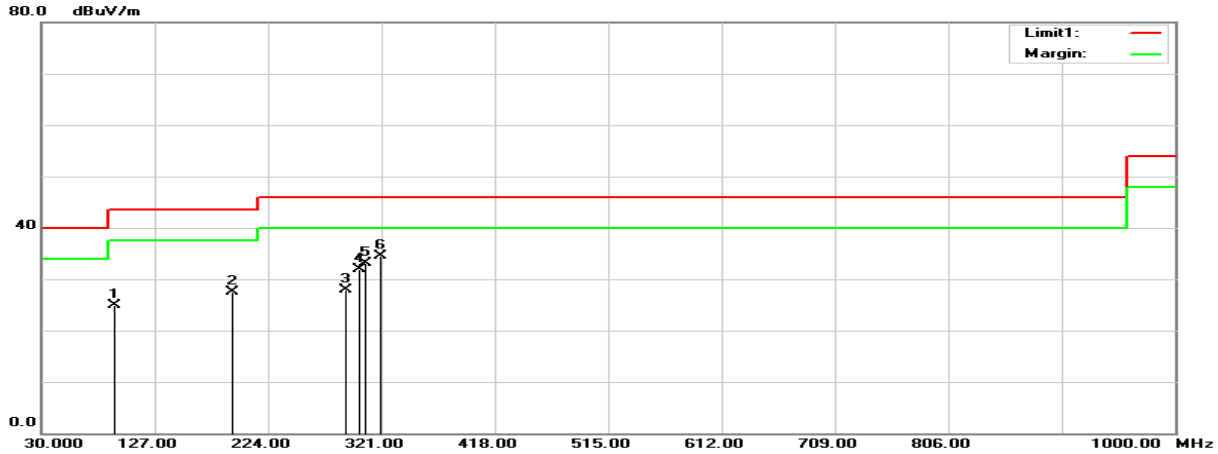
1GHz-10GHz:



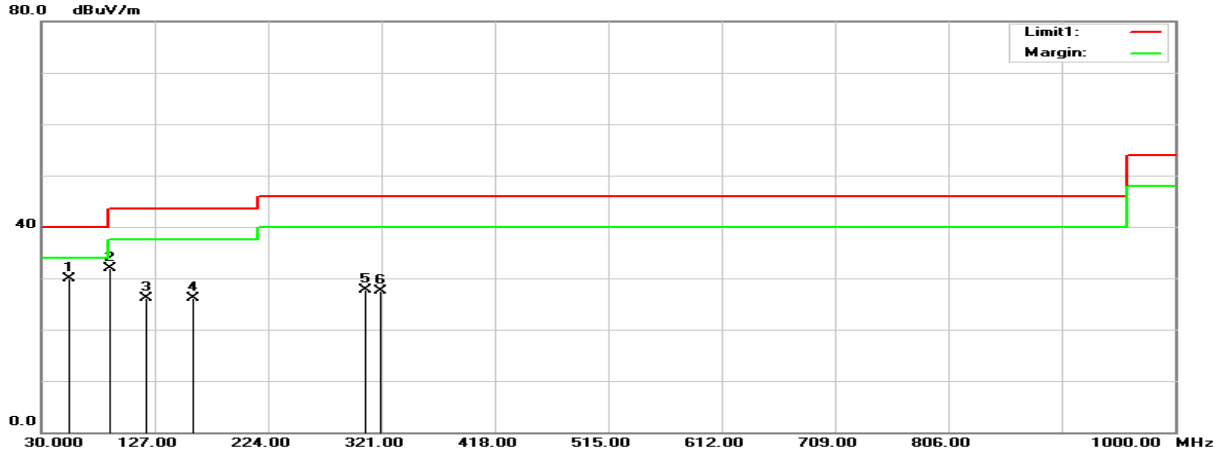
Pygate, DC 3.6V from Li-Po Battery

30MHz-1GHz:

Horizontal



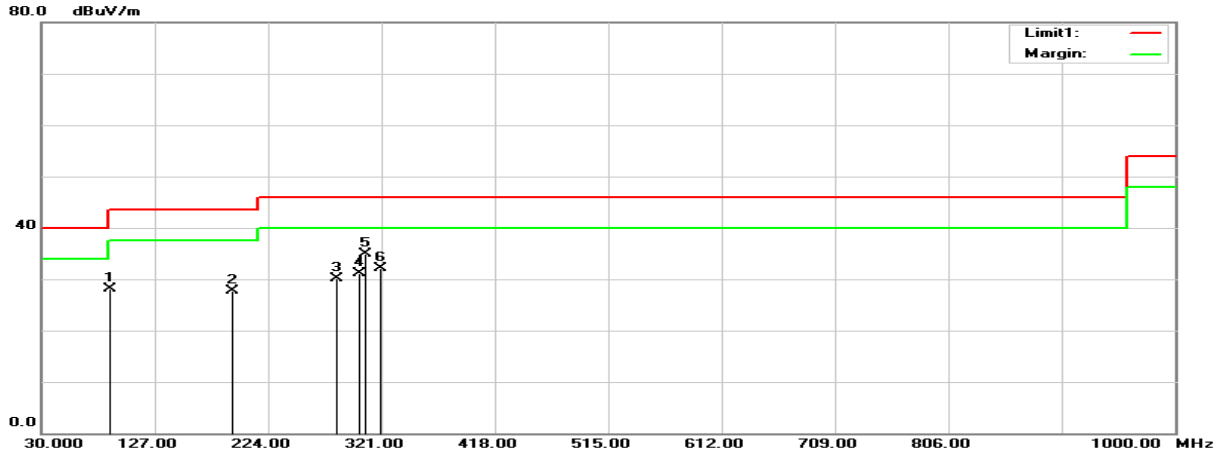
Vertical



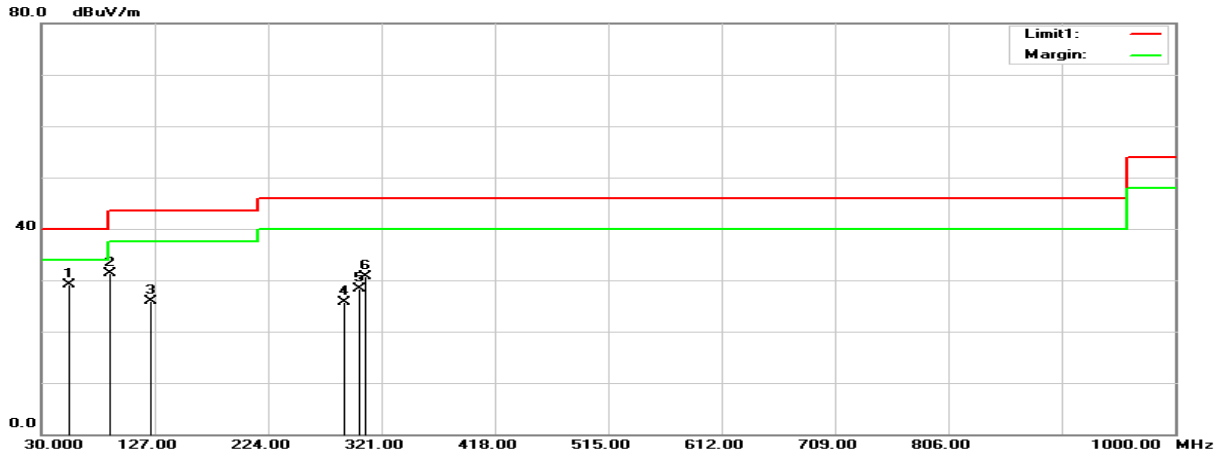
Pygate, DC 48V from PoE

30MHz-1GHz:

Horizontal



Vertical

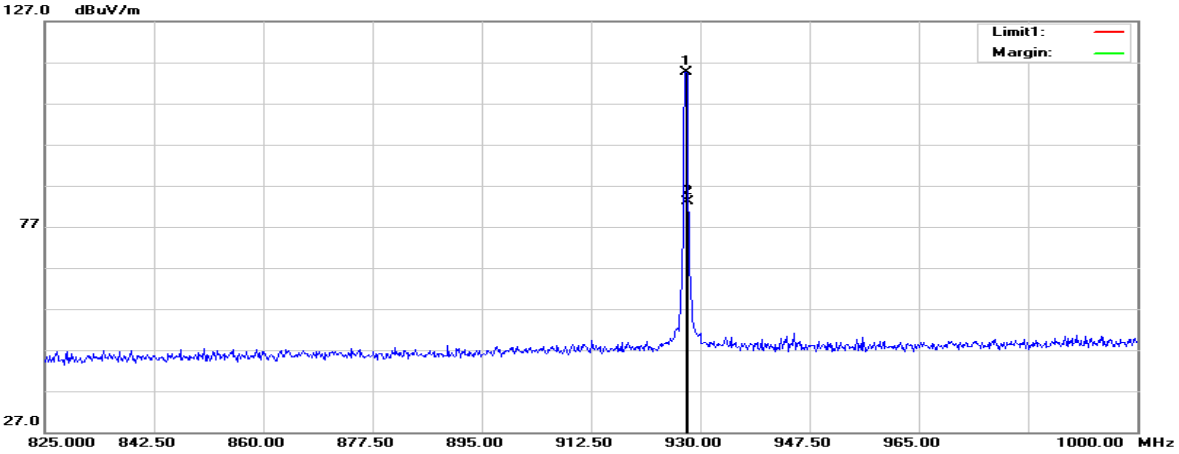


For 250 kHz

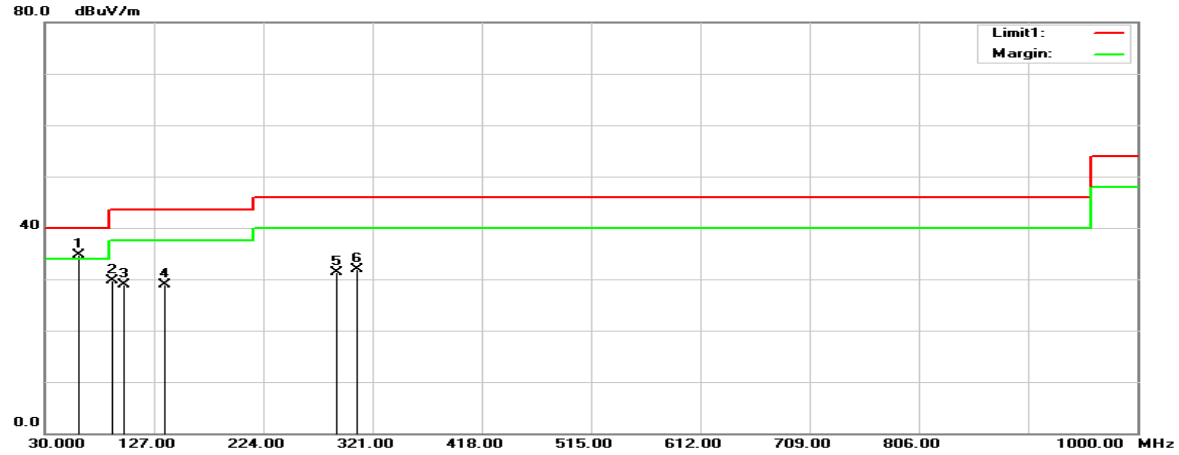
Pygate, DC 5V from USB Port

Horizontal (worst case is high channel)

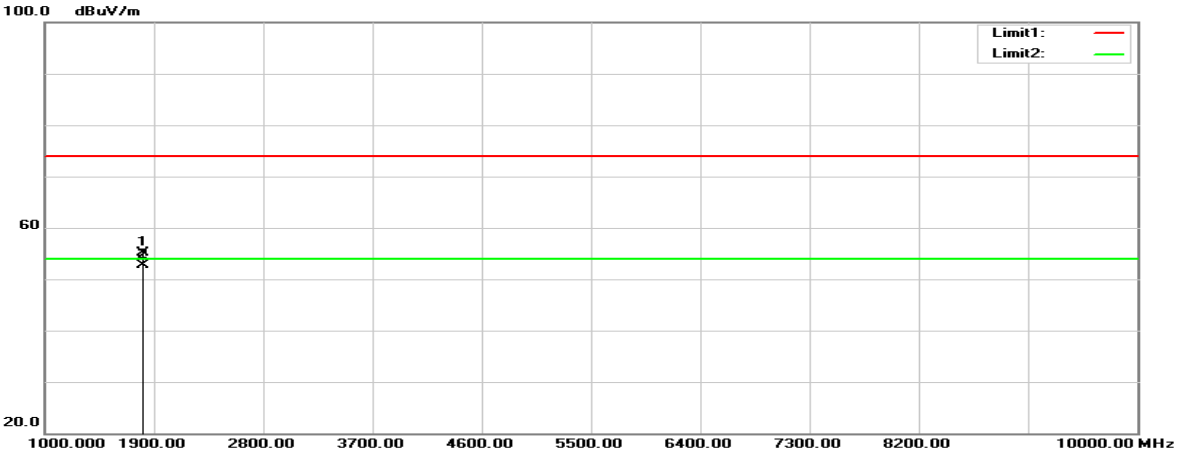
Fundamental:



30MHz-1GHz:

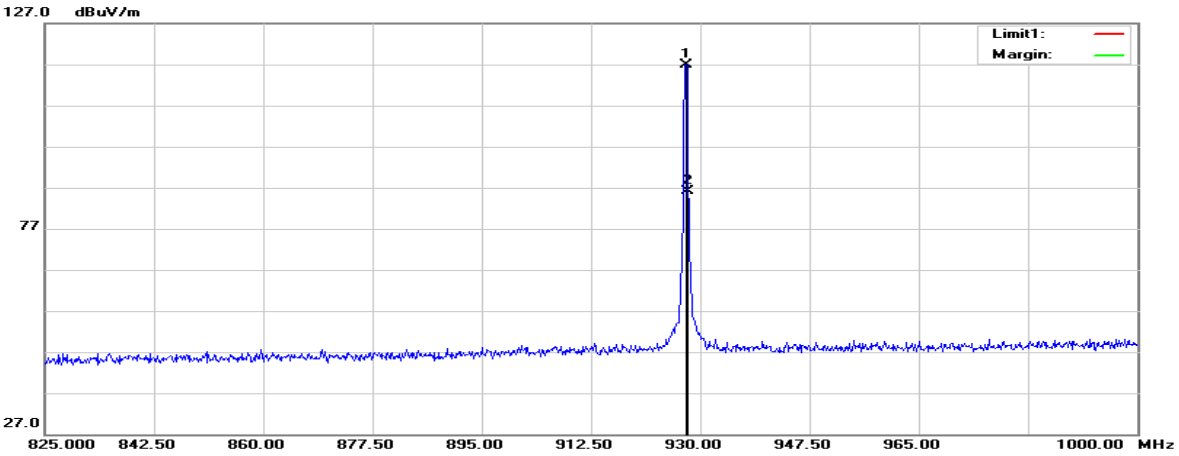


1GHz-10GHz:

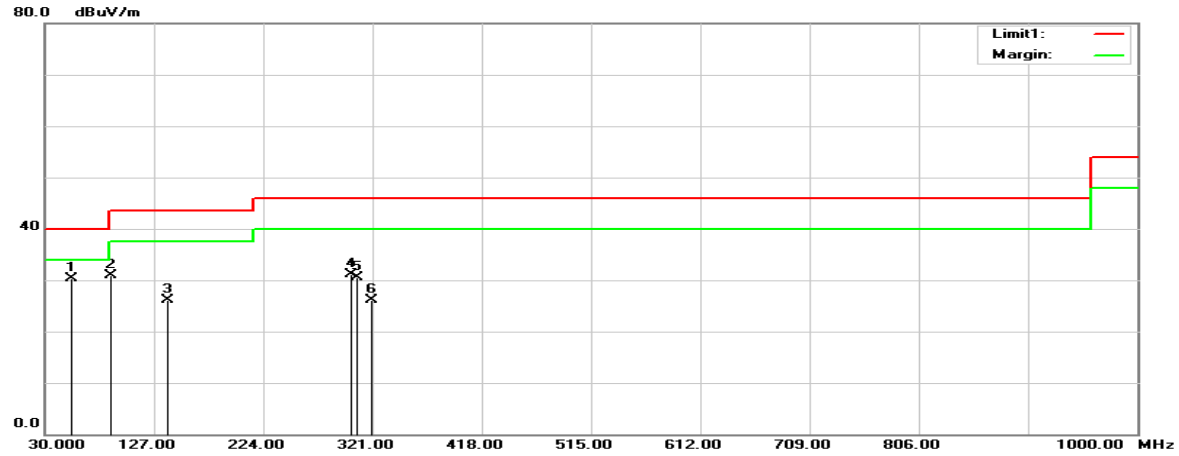


Vertical

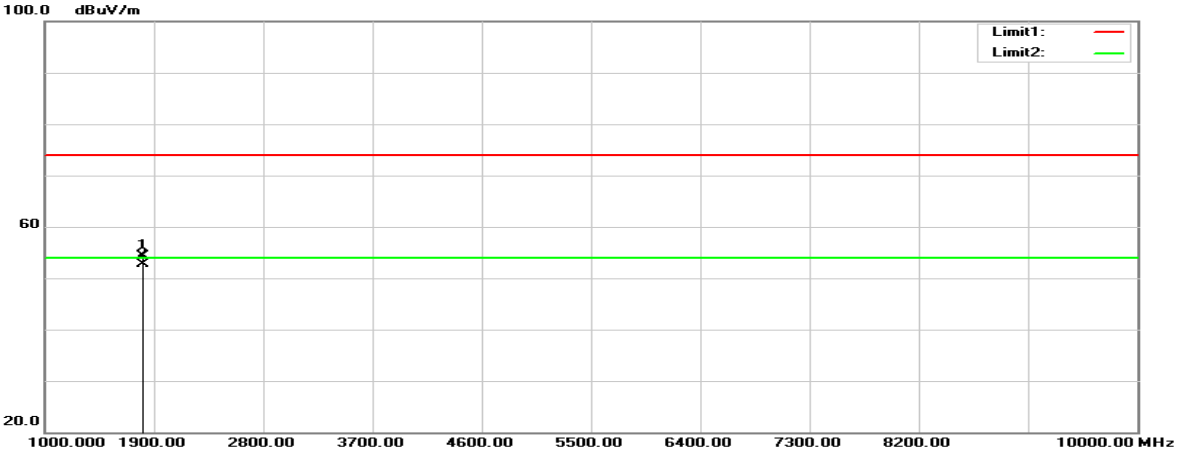
Fundamental:



30MHz-1GHz:



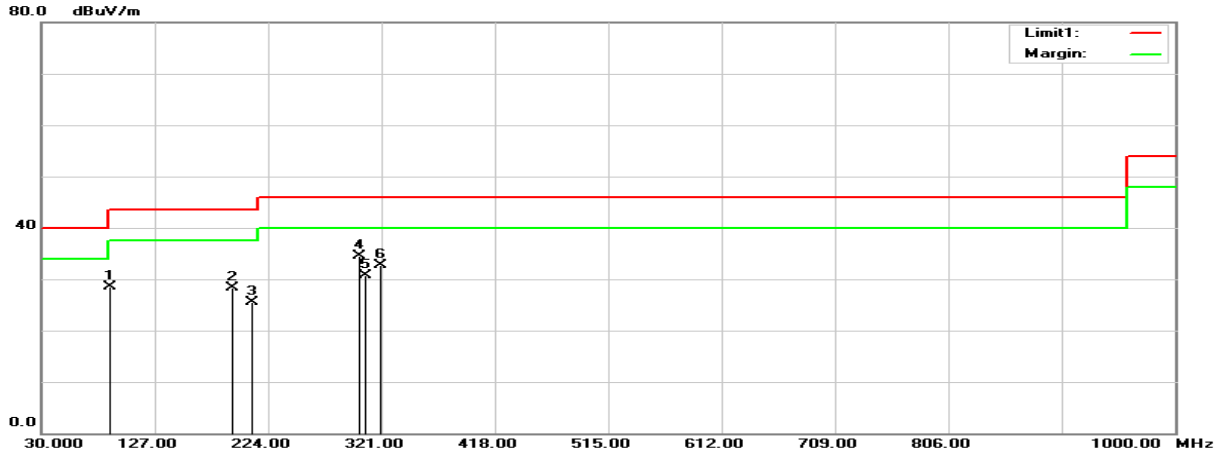
1GHz-10GHz:



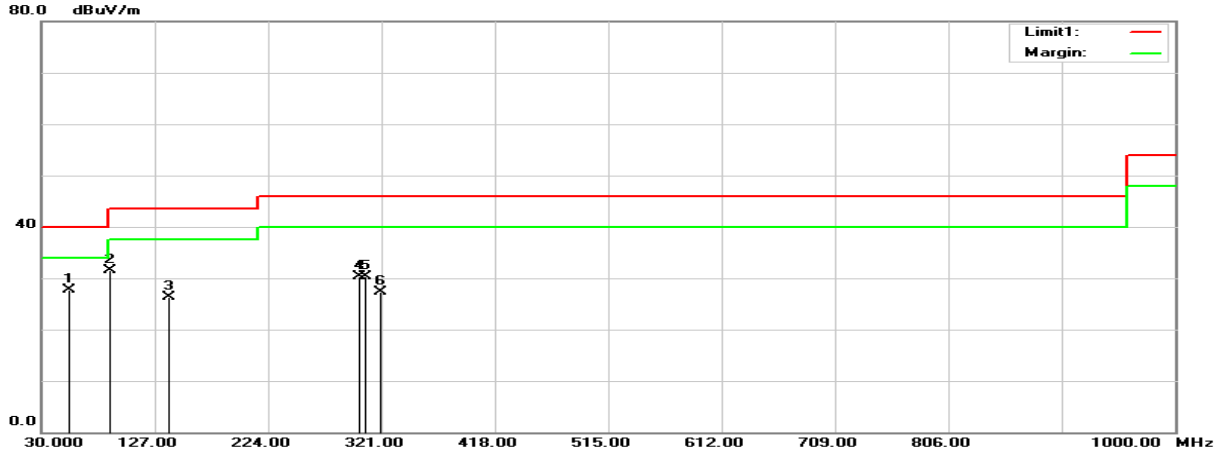
Pygate, DC 3.6V from Li-Po Battery

30MHz-1GHz:

Horizontal



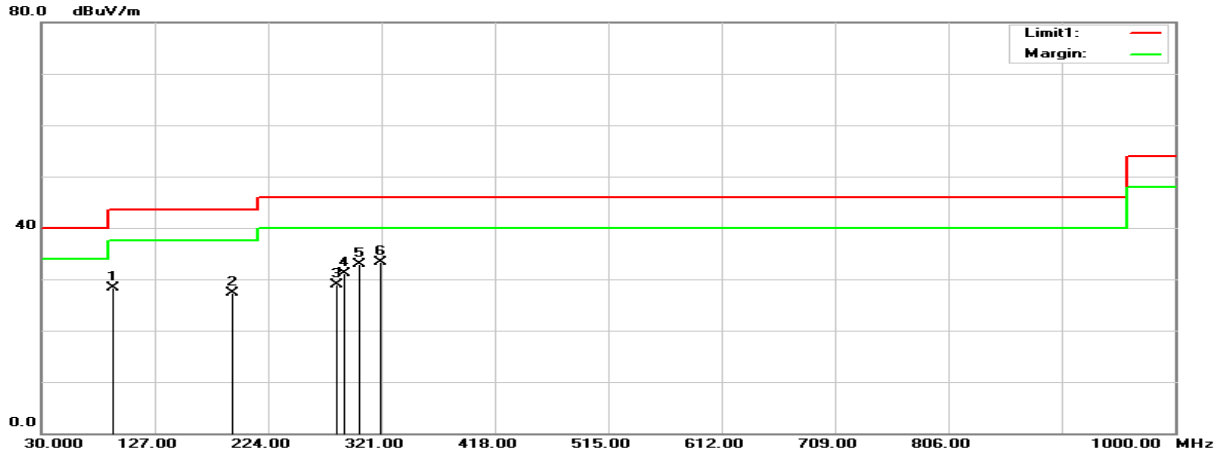
Vertical



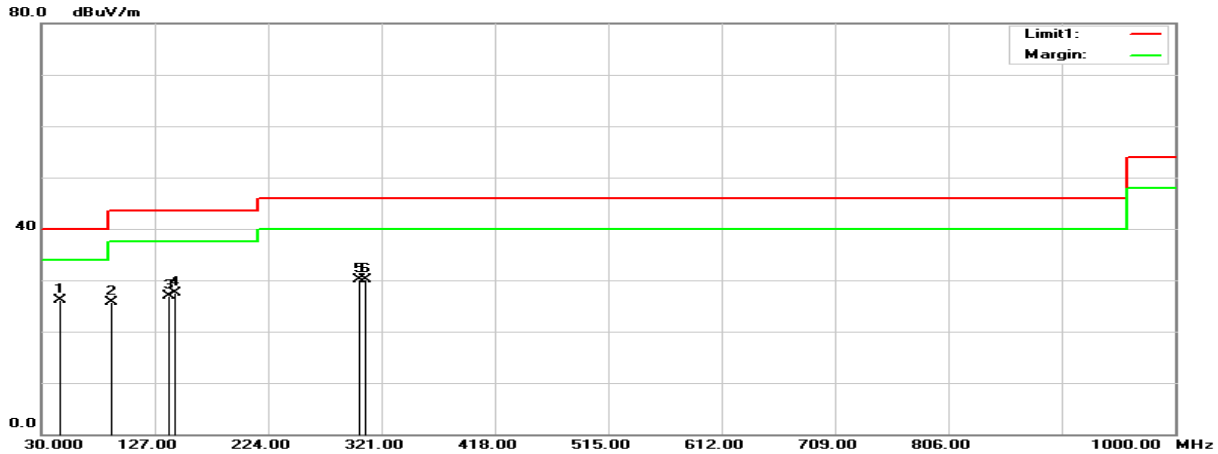
Pygate, DC 48V from PoE

30MHz-1GHz:

Horizontal



Vertical



For 125 kHz:

Pygate, DC 5V from USB Port
30MHz-10GHz
Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
902.0000	80.69	1.01	81.70	83.87	-2.17	108	236	QP
902.3000	112.85	1.02	113.87	N/A	N/A	108	236	QP
1804.600	61.32	-12.56	48.76	74.00	-25.24	150	134	peak
1804.600	58.79	-12.56	46.23	54.00	-7.77	150	134	AVG
Middle channel								
915.1000	111.95	1.57	113.52	N/A	N/A	110	240	QP
1830.200	62.44	-12.33	50.11	74.00	-23.89	145	289	peak
1830.200	60.72	-12.33	48.39	54.00	-5.61	145	289	AVG
High channel								
159.9800	47.22	-11.14	36.08	43.50	-7.42	100	300	peak
250.1900	45.75	-12.34	33.41	46.00	-12.59	100	27	peak
320.0300	52.80	-9.63	43.17	46.00	-2.83	100	286	peak
398.6000	47.53	-7.88	39.65	46.00	-6.35	100	269	peak
532.4600	37.75	-5.64	32.11	46.00	-13.89	100	307	peak
798.2400	40.42	-1.04	39.38	46.00	-6.62	100	91	peak
927.7000	112.75	1.78	114.53	N/A	N/A	110	244	QP
928.0000	77.28	1.79	79.07	84.53	-5.46	110	244	QP
1855.400	63.21	-12.11	51.10	74.00	-22.90	124	181	peak
1855.400	62.43	-12.11	50.32	54.00	-3.68	124	181	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
902.0000	82.67	1.01	83.68	86.00	-2.32	126	256	QP
902.3000	114.98	1.02	116.00	N/A	N/A	126	256	QP
1804.600	66.10	-12.56	53.54	74.00	-20.46	129	75	peak
1804.600	65.23	-12.56	52.67	54.00	-1.33	129	75	AVG
Middle channel								
915.1000	115.18	1.57	116.75	N/A	N/A	130	260	QP
1830.200	65.96	-12.33	53.63	74.00	-20.37	171	75	peak
1830.200	64.55	-12.33	52.22	54.00	-1.78	171	75	AVG
High channel								
122.1500	47.40	-10.72	36.68	43.50	-6.82	100	72	peak
159.9800	43.45	-11.14	32.31	43.50	-11.19	100	165	peak
320.0300	49.69	-9.63	40.06	46.00	-5.94	100	294	peak
399.5700	45.02	-7.89	37.13	46.00	-8.87	100	189	peak
532.4600	42.34	-5.64	36.70	46.00	-9.30	100	290	peak
798.2400	40.47	-1.04	39.43	46.00	-6.57	100	150	peak
927.7000	115.14	1.78	116.92	N/A	N/A	128	241	QP
928.0000	82.98	1.79	84.77	86.92	-2.15	128	241	QP
1855.400	64.33	-12.11	52.22	74.00	-21.78	123	283	peak
1855.400	63.43	-12.11	51.32	54.00	-2.68	123	283	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Pygate, DC 3.6V from Li-Po Battery

30MHz-1GHz

Horizontal

Frequency	Reading	Correct	Result	Limit	Margin	Height	Degree	Remark
(MHz)	(dBµV)	Factor(dB/m)	(dBµV/m)	(dBµV/m)	(dB)	(cm)	(°)	
92.0800	41.15	-16.27	24.88	43.50	-18.62	100	182	peak
192.9600	39.87	-12.29	27.58	43.50	-15.92	100	256	peak
289.9600	37.83	-9.95	27.88	46.00	-18.12	100	334	peak
301.6000	41.96	-10.06	31.90	46.00	-14.10	100	124	peak
307.4200	43.07	-9.93	33.14	46.00	-12.86	100	192	peak
320.0300	44.11	-9.63	34.48	46.00	-11.52	100	344	peak

Vertical

Frequency	Reading	Correct	Result	Limit	Margin	Height	Degree	Remark
(MHz)	(dBµV)	Factor(dB/m)	(dBµV/m)	(dBµV/m)	(dB)	(cm)	(°)	
53.2800	46.83	-16.91	29.92	40.00	-10.08	100	92	peak
88.2000	48.54	-16.73	31.81	43.50	-11.69	100	229	peak
120.2100	36.35	-10.27	26.08	43.50	-17.42	100	314	peak
159.9800	37.34	-11.14	26.20	43.50	-17.30	100	182	peak
307.4200	37.57	-9.93	27.64	46.00	-18.36	100	174	peak
320.0300	37.07	-9.63	27.44	46.00	-18.56	100	229	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Pygate, DC 48V from PoE

30MHz-1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
89.1700	44.89	-16.70	28.19	43.50	-15.31	100	335	peak
192.9600	39.99	-12.29	27.70	43.50	-15.80	100	123	peak
283.1700	40.41	-10.22	30.19	46.00	-15.81	100	254	peak
301.6000	41.16	-10.06	31.10	46.00	-14.90	100	96	peak
307.4200	44.83	-9.93	34.90	46.00	-11.10	100	147	peak
320.0300	41.69	-9.63	32.06	46.00	-13.94	100	241	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
53.2800	46.04	-16.91	29.13	40.00	-10.87	100	335	peak
89.1700	47.91	-16.70	31.21	43.50	-12.29	100	194	peak
124.0900	36.29	-10.35	25.94	43.50	-17.56	100	255	peak
288.9900	35.66	-10.00	25.66	46.00	-20.34	100	149	peak
301.6000	38.45	-10.06	28.39	46.00	-17.61	100	187	peak
307.4200	40.54	-9.93	30.61	46.00	-15.39	100	234	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

For 250 kHz:

Pygate, DC 5V from USB Port
30MHz-10GHz
Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
902.0000	80.56	1.01	81.57	83.89	-2.32	122	255	QP
902.3000	112.87	1.02	113.89	N/A	N/A	122	255	QP
1804.600	67.71	-12.56	55.15	74.00	-18.85	162	341	peak
1804.600	65.22	-12.56	52.66	54.00	-1.34	162	341	AVG
Middle channel								
915.1000	112.04	1.57	113.61	N/A	N/A	112	241	QP
1830.200	62.68	-12.33	50.35	74.00	-23.65	138	157	peak
1830.200	60.45	-12.33	48.12	54.00	-5.88	138	157	AVG
High channel								
60.0700	51.72	-17.10	34.62	40.00	-5.38	100	114	peak
90.1400	46.20	-16.53	29.67	43.50	-13.83	100	168	peak
99.8400	42.92	-14.06	28.86	43.50	-14.64	100	41	peak
136.7000	39.53	-10.66	28.87	43.50	-14.63	100	318	peak
288.9900	41.34	-10.00	31.34	46.00	-14.66	100	225	peak
307.4200	41.74	-9.93	31.81	46.00	-14.19	100	214	peak
927.5000	112.83	1.78	114.61	N/A	N/A	115	255	QP
928.0000	81.25	1.79	83.04	84.61	-1.57	115	255	QP
1855.400	63.64	-12.11	51.53	74.00	-22.47	126	284	peak
1855.400	62.07	-12.11	49.96	54.00	-4.04	126	284	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
Low channel								
902.0000	83.88	1.01	84.89	86.32	-1.43	124	226	QP
902.3000	115.30	1.02	116.32	N/A	N/A	124	226	QP
1804.600	66.83	-12.56	54.27	74.00	-19.73	142	81	peak
1804.600	65.27	-12.56	52.71	54.00	-1.29	142	81	AVG
Middle channel								
915.1000	115.13	1.57	116.70	N/A	N/A	135	277	QP
1830.200	64.96	-12.33	52.63	74.00	-21.37	144	86	peak
1830.200	63.45	-12.33	51.12	54.00	-2.88	144	86	AVG
High channel								
53.2800	47.22	-16.91	30.31	40.00	-9.69	100	343	peak
88.2000	47.73	-16.73	31.00	43.50	-12.50	100	325	peak
138.6400	36.74	-10.69	26.05	43.50	-17.45	100	144	peak
301.6000	41.17	-10.06	31.11	46.00	-14.89	100	158	peak
307.4200	40.52	-9.93	30.59	46.00	-15.41	100	229	peak
320.0300	35.80	-9.63	26.17	46.00	-19.83	100	247	peak
927.5000	115.10	1.78	116.88	N/A	N/A	136	288	QP
928.0000	84.24	1.79	86.03	86.88	-0.85	136	288	QP
1855.400	64.18	-12.11	52.07	74.00	-21.93	167	69	peak
1855.400	62.64	-12.11	50.53	54.00	-3.47	167	69	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Pygate, DC 3.6V from Li-Po Battery

30MHz-1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
89.1700	45.12	-16.70	28.42	43.50	-15.08	100	314	peak
192.9600	40.64	-12.29	28.35	43.50	-15.15	100	118	peak
210.4200	38.77	-13.31	25.46	43.50	-18.04	100	241	peak
301.6000	44.47	-10.06	34.41	46.00	-11.59	100	124	peak
307.4200	40.70	-9.93	30.77	46.00	-15.23	100	360	peak
320.0300	42.34	-9.63	32.71	46.00	-13.29	100	248	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
53.2800	44.70	-16.91	27.79	40.00	-12.21	100	224	peak
89.1700	48.13	-16.70	31.43	43.50	-12.07	100	148	peak
138.6400	36.92	-10.69	26.23	43.50	-17.27	100	68	peak
301.6000	40.33	-10.06	30.27	46.00	-15.73	100	321	peak
307.4200	40.23	-9.93	30.30	46.00	-15.70	100	125	peak
320.0300	36.85	-9.63	27.22	46.00	-18.78	100	119	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Pygate, DC 48V from PoE

30MHz-1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
91.1100	44.89	-16.49	28.40	43.50	-15.10	100	242	peak
192.9600	39.52	-12.29	27.23	43.50	-16.27	100	162	peak
283.1700	39.09	-10.22	28.87	46.00	-17.13	100	189	peak
288.9900	41.14	-10.00	31.14	46.00	-14.86	100	253	peak
301.6000	42.87	-10.06	32.81	46.00	-13.19	100	211	peak
320.0300	42.92	-9.63	33.29	46.00	-12.71	100	149	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
45.5200	40.20	-14.08	26.12	40.00	-13.88	100	178	peak
90.1400	42.28	-16.53	25.75	43.50	-17.75	100	249	peak
138.6400	37.54	-10.69	26.85	43.50	-16.65	100	331	peak
144.4600	38.41	-10.89	27.52	43.50	-15.98	100	148	peak
301.6000	40.12	-10.06	30.06	46.00	-15.94	100	251	peak
307.4200	39.97	-9.93	30.04	46.00	-15.96	100	44	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

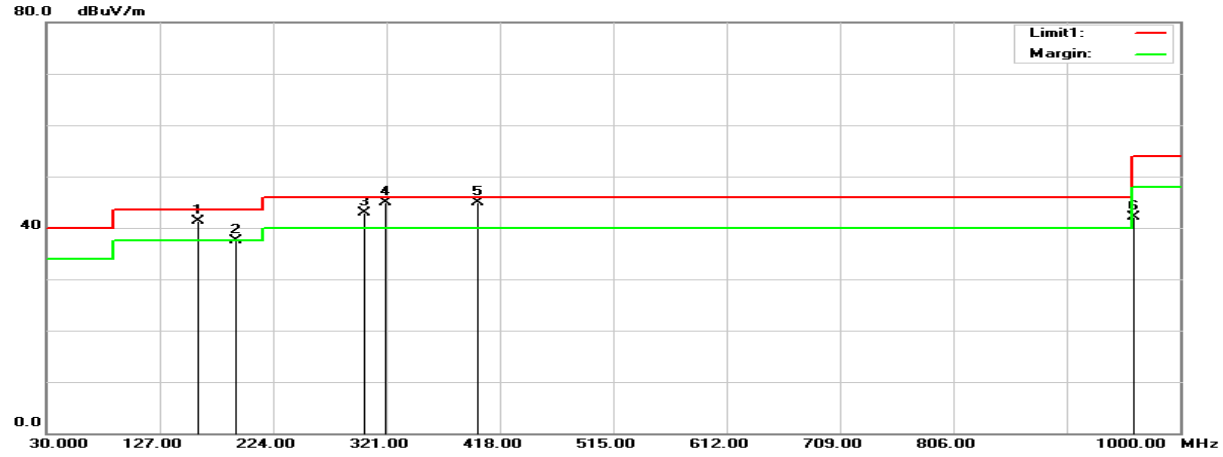
Transmitting simultaneously test:

Model 1

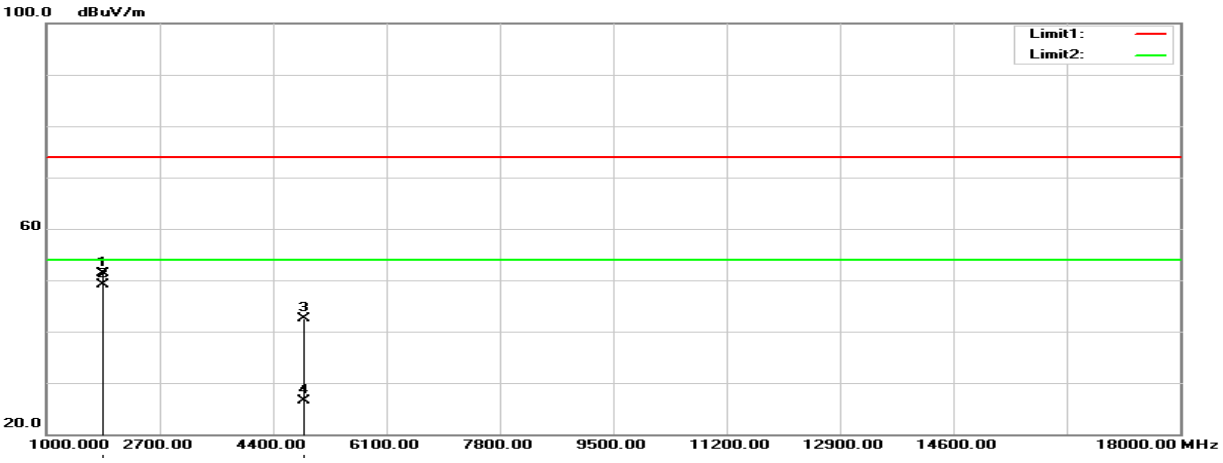
The worst case of LoRa (125kHz) and WIFI mode transmitting simultaneously was recorded

Horizontal

30MHz-1GHz

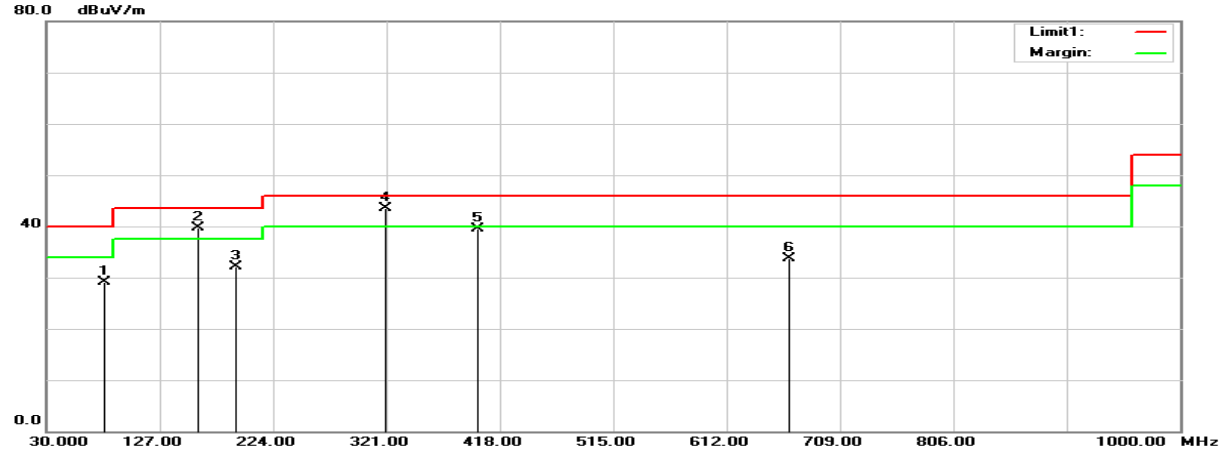


1GHz-18GHz

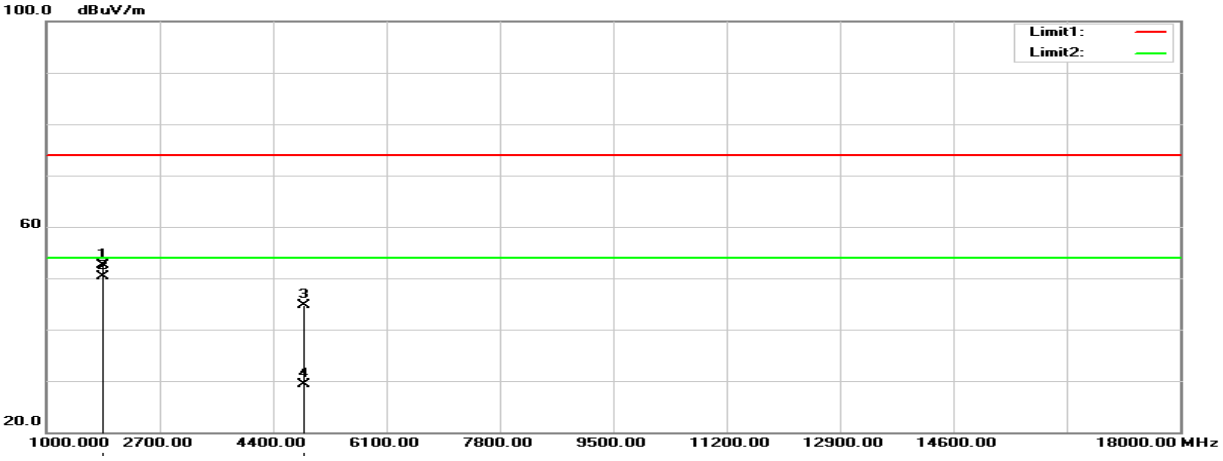


Vertical

30MHz-1GHz



1GHz-18GHz



Below 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
159.9800	52.36	-11.14	41.22	43.50	-2.28	100	241	peak
191.9900	49.91	-12.48	37.43	43.50	-6.07	100	111	peak
301.6000	52.91	-10.06	42.85	46.00	-3.15	100	96	peak
320.0300	54.55	-9.63	44.92	46.00	-1.08	100	85	peak
398.6000	52.75	-7.88	44.87	46.00	-1.13	100	62	QP
960.2300	39.72	2.35	42.07	54.00	-11.93	100	112	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
79.4700	45.50	-16.42	29.08	40.00	-10.92	100	25	peak
159.9800	50.82	-11.14	39.68	43.50	-3.82	100	124	peak
191.9900	44.56	-12.48	32.08	43.50	-11.42	100	112	peak
320.0300	53.08	-9.63	43.45	46.00	-2.55	100	52	peak
398.6000	47.31	-7.88	39.43	46.00	-6.57	100	96	peak
665.3500	37.05	-3.40	33.65	46.00	-12.35	100	111	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Above 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
1855.400	63.33	-12.11	51.22	74.00	-22.78	172	88	peak
1855.400	61.12	-12.11	49.01	54.00	-4.99	172	88	AVG
4874.000	44.36	-1.92	42.44	74.00	-31.56	121	78	peak
4874.000	28.43	-1.92	26.51	54.00	-27.49	121	78	AVG

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
1855.400	64.58	-12.11	52.47	74.00	-21.53	121	291	peak
1855.400	62.36	-12.11	50.25	54.00	-3.75	121	291	AVG
4874.000	46.68	-1.92	44.76	74.00	-29.24	150	190	peak
4874.000	31.21	-1.92	29.29	54.00	-24.71	150	190	AVG

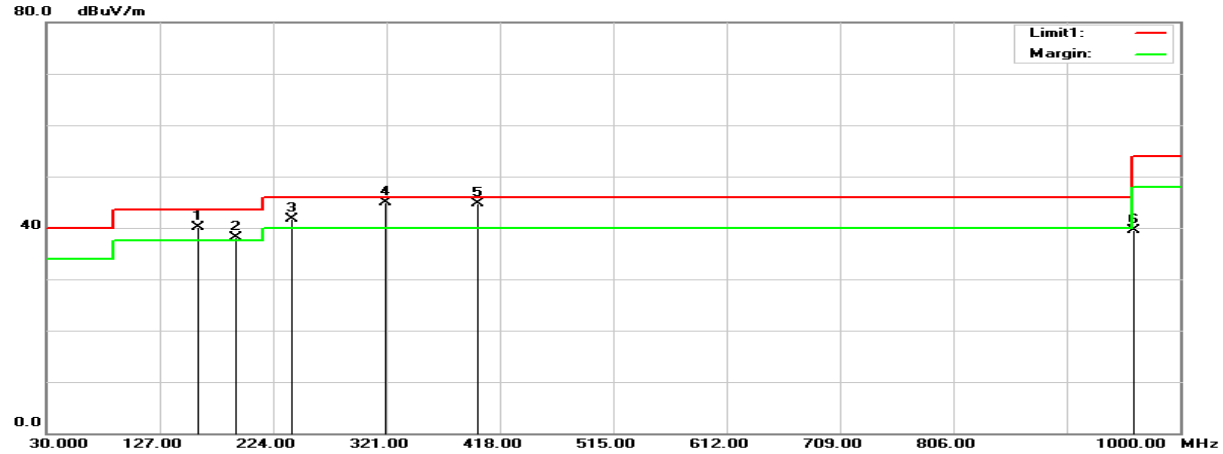
Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Model 2

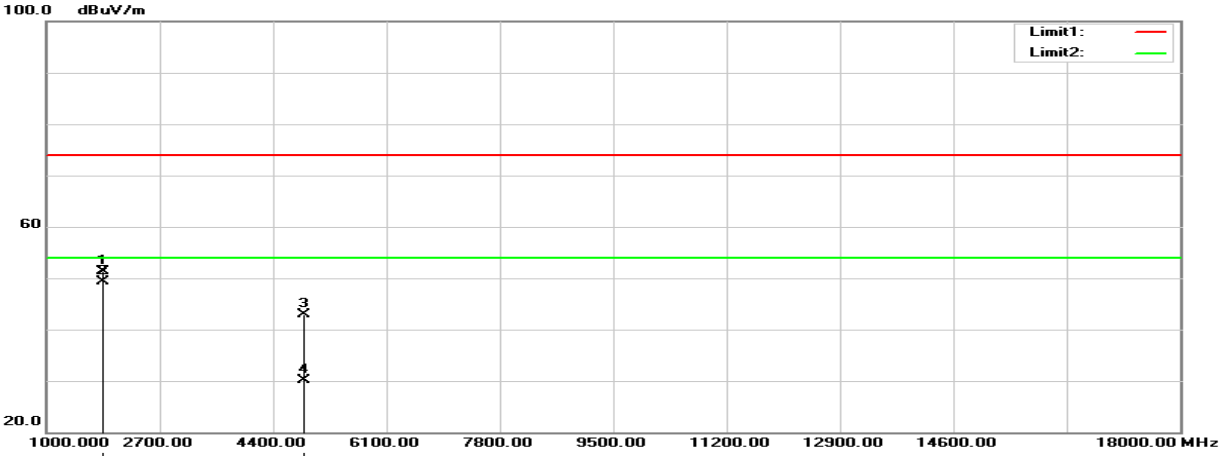
The worst case of LoRa (125kHz) and WIFI mode transmitting simultaneously was recorded

Horizontal

30MHz-1GHz

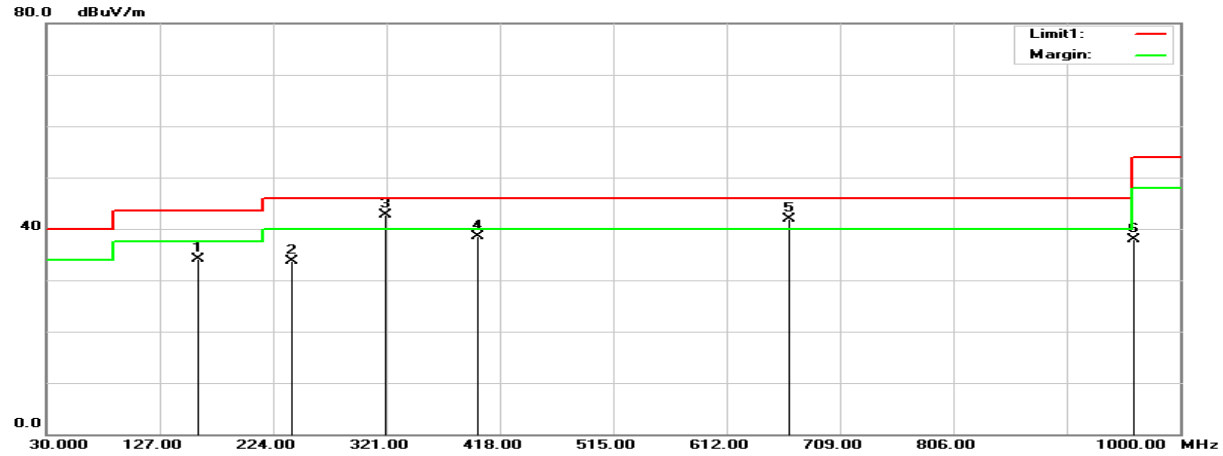


1GHz-18GHz

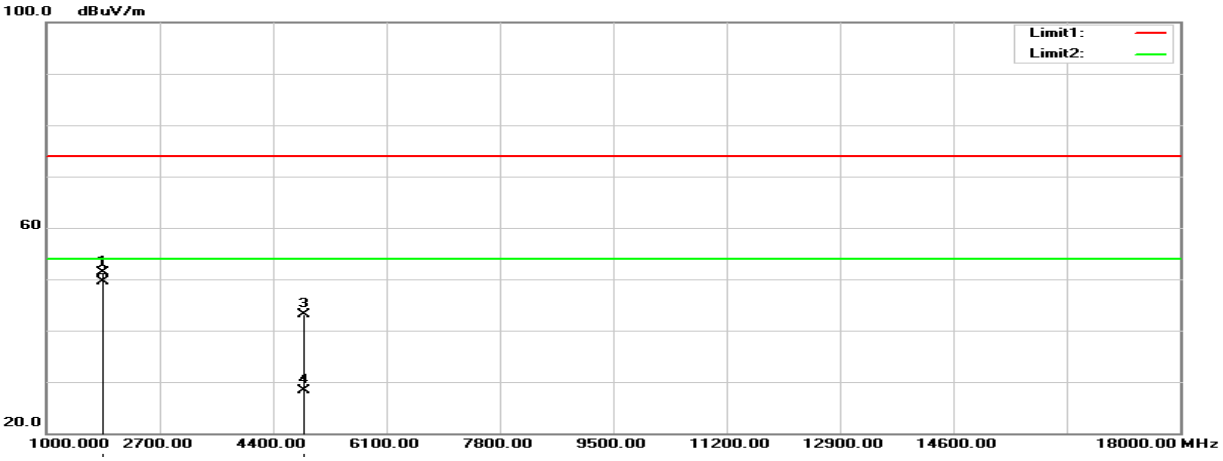


Vertical

30MHz-1GHz



1GHz-18GHz



Below 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
159.9800	51.30	-11.14	40.16	43.50	-3.34	100	52	peak
191.9900	50.56	-12.48	38.08	43.50	-5.42	100	62	peak
239.5200	53.95	-12.25	41.70	46.00	-4.30	100	147	peak
320.0300	54.52	-9.63	44.89	46.00	-1.11	100	123	QP
398.6000	52.55	-7.88	44.67	46.00	-1.33	100	111	peak
960.2300	37.19	2.35	39.54	54.00	-14.46	100	96	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
159.9800	45.27	-11.14	34.13	43.50	-9.37	100	125	peak
239.5200	45.90	-12.25	33.65	46.00	-12.35	100	41	peak
320.0300	52.32	-9.63	42.69	46.00	-3.31	100	125	peak
398.6000	46.39	-7.88	38.51	46.00	-7.49	100	96	peak
665.3500	45.31	-3.40	41.91	46.00	-4.09	100	64	peak
960.2300	35.51	2.35	37.86	54.00	-16.14	100	111	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Above 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
1855.400	63.36	-12.11	51.25	74.00	-22.75	169	89	peak
1855.400	61.35	-12.11	49.24	54.00	-4.76	169	89	AVG
4874.000	44.82	-1.92	42.90	74.00	-31.10	153	330	peak
4874.000	32.02	-1.92	30.10	54.00	-23.90	153	330	AVG

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
1855.400	63.41	-12.11	51.30	74.00	-22.70	125	276	peak
1855.400	61.58	-12.11	49.47	54.00	-4.53	125	276	AVG
4874.000	45.05	-1.92	43.13	74.00	-30.87	153	329	peak
4874.000	30.13	-1.92	28.21	54.00	-25.79	153	329	AVG

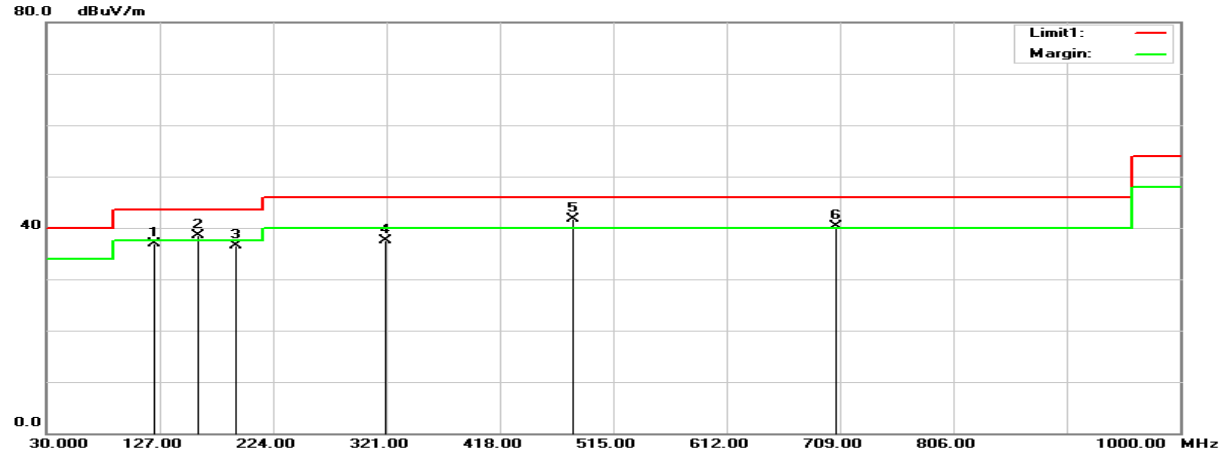
Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Model 3

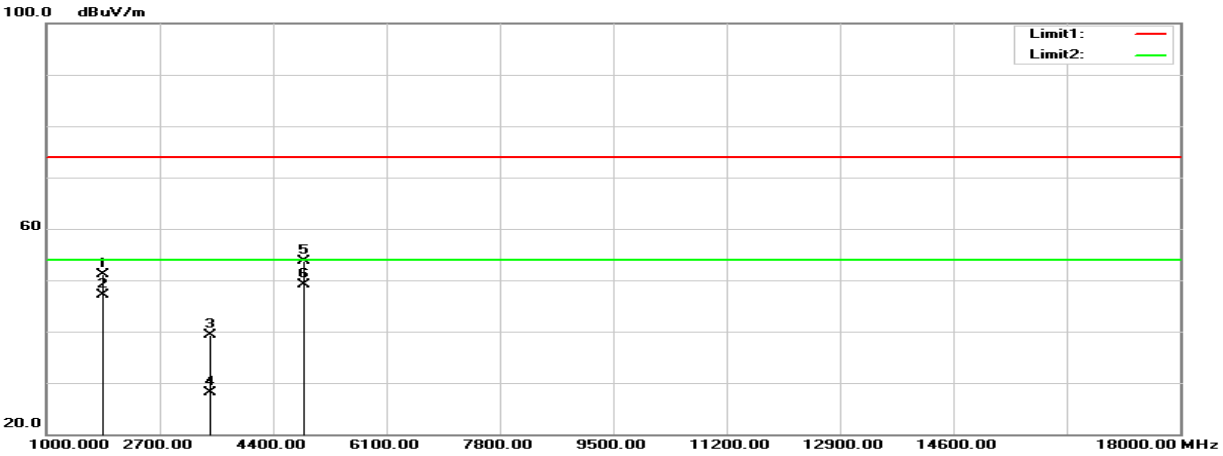
The worst case of LoRa (125kHz) and WIFI, LTE mode transmitting simultaneously was recorded

Horizontal

30MHz-1GHz

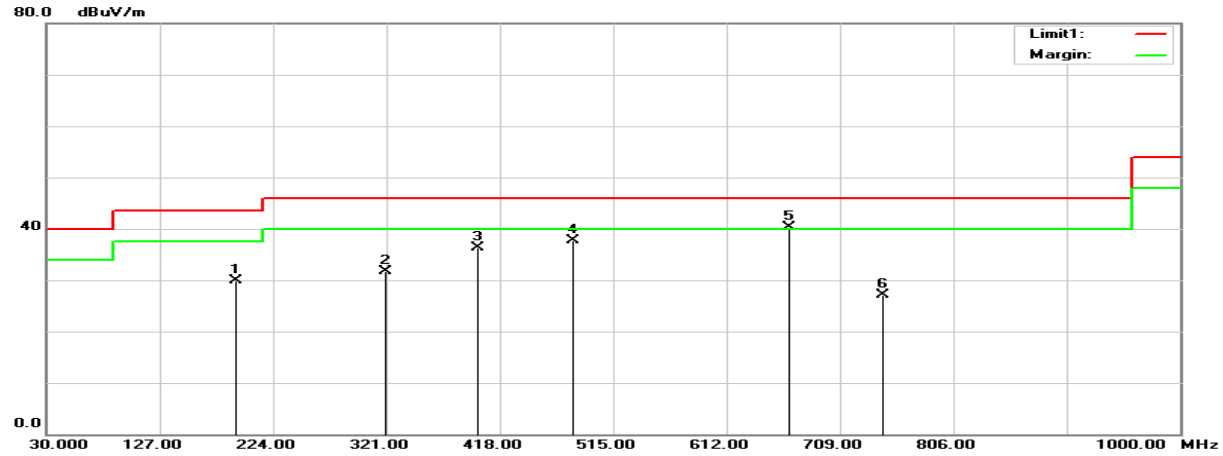


1GHz-18GHz

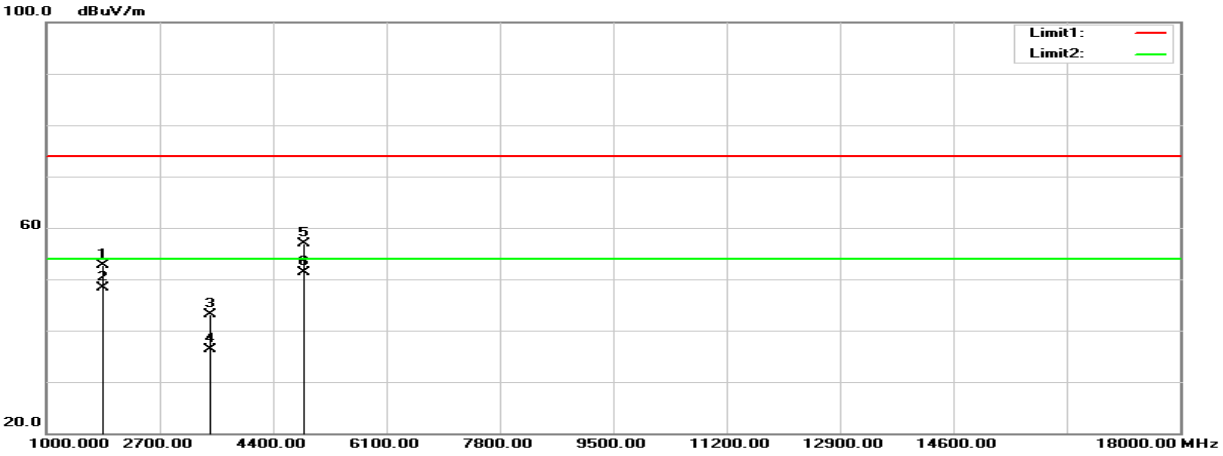


Vertical

30MHz-1GHz



1GHz-18GHz



Below 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
122.1500	47.60	-10.72	36.88	43.50	-6.62	100	125	peak
159.9800	49.62	-11.14	38.48	43.50	-5.02	100	52	peak
191.9900	48.94	-12.48	36.46	43.50	-7.04	100	62	peak
320.0300	47.04	-9.63	37.41	46.00	-8.59	100	136	peak
480.0800	47.65	-6.00	41.65	46.00	-4.35	100	68	peak
705.1200	43.15	-2.88	40.27	46.00	-5.73	100	96	peak

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
191.9900	42.43	-12.48	29.95	43.50	-13.55	100	78	peak
320.0300	41.29	-9.63	31.66	46.00	-14.34	100	154	peak
398.6000	44.19	-7.88	36.31	46.00	-9.69	100	123	peak
480.0800	43.70	-6.00	37.70	46.00	-8.30	100	15	peak
665.3500	43.62	-3.40	40.22	46.00	-5.78	100	166	peak
745.8600	29.35	-2.33	27.02	46.00	-18.98	100	65	peak

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Above 1GHz

Horizontal

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
1855.400	63.28	-12.11	51.17	74.00	-22.83	155	325	peak
1855.400	59.25	-12.11	47.14	54.00	-6.86	155	325	AVG
3465.000	45.21	-5.81	39.40	74.00	-34.60	178	189	peak
3465.000	33.87	-5.81	28.06	54.00	-25.94	178	189	AVG
4874.000	55.66	-1.92	53.74	74.00	-20.26	145	21	peak
4874.000	50.93	-1.92	49.01	54.00	-4.99	145	21	AVG

Vertical

Frequency (MHz)	Reading (dBµV)	Correct Factor(dB/m)	Result (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Degree (°)	Remark
1855.400	64.90	-12.11	52.79	74.00	-21.21	150	222	peak
1855.400	60.48	-12.11	48.37	54.00	-5.63	150	222	AVG
3465.000	48.98	-5.81	43.17	74.00	-30.83	158	124	peak
3465.000	42.19	-5.81	36.38	54.00	-17.62	158	124	AVG
4874.000	58.78	-1.92	56.86	74.00	-17.14	154	254	peak
4874.000	53.25	-1.92	51.33	54.00	-2.67	154	254	AVG

Result = Reading + Correct Factor
Margin = Result – Limit
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain
Spurious emissions more than 20 dB below the limit were not reported.

Conducted Spurious Emissions:

For 125 kHz:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Low	902.3	44.80	≥ 30	PASS
Middle	915.1	44.91	≥ 30	PASS
High	927.7	44.75	≥ 30	PASS

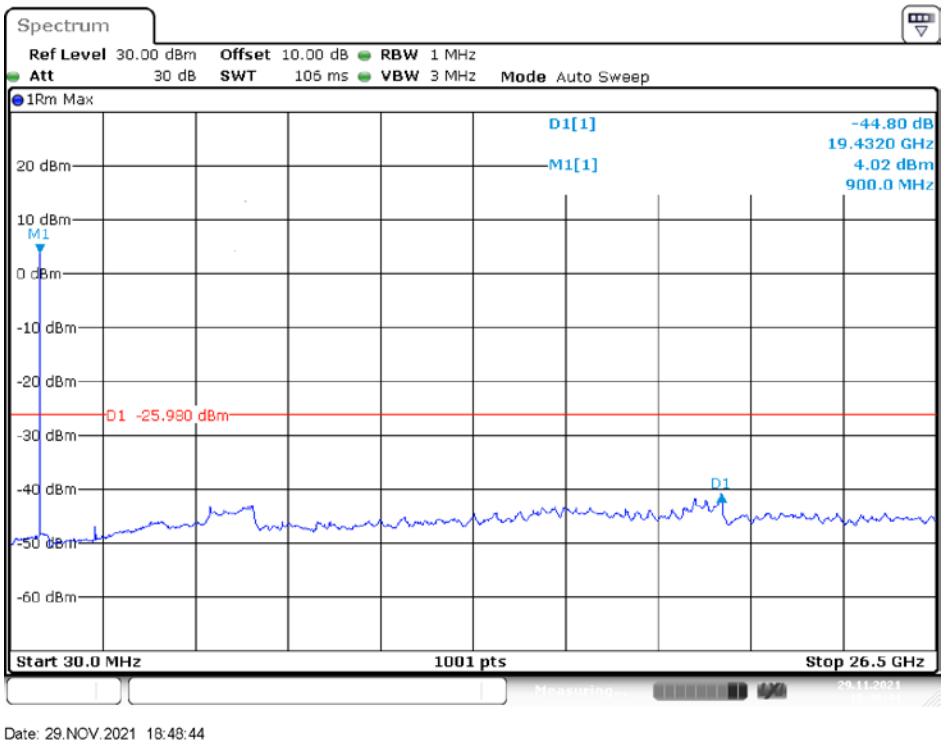
For 250 kHz:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Low	902.3	44.59	≥ 30	PASS
Middle	915.1	44.82	≥ 30	PASS
High	927.5	44.95	≥ 30	PASS

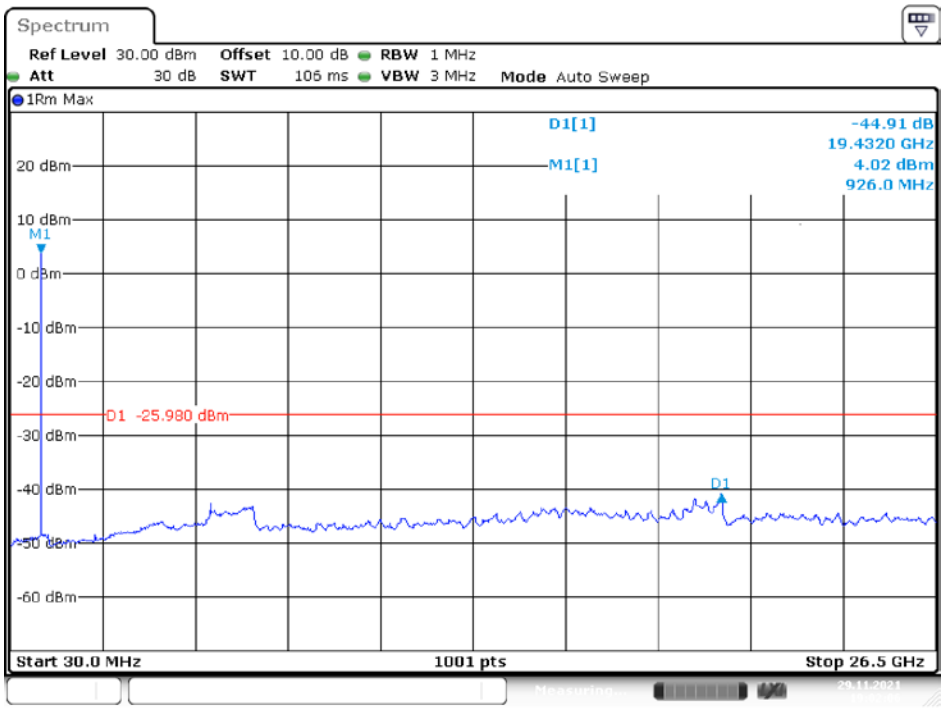
Please refer to the following plots.

For 125 kHz

Low Channel

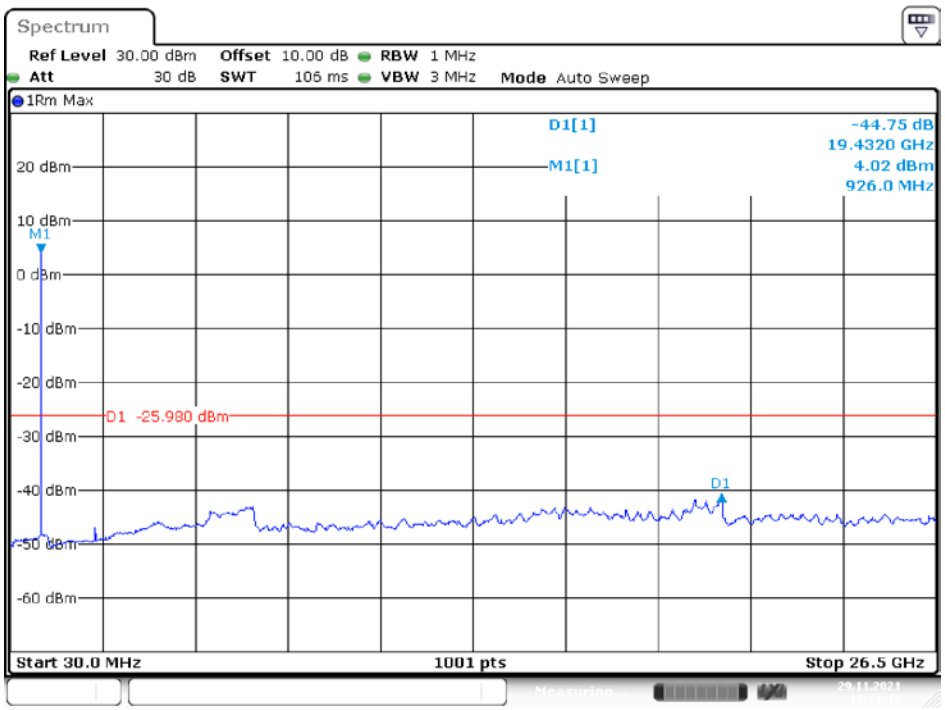


Middle Channel



Date: 29.NOV.2021 19:02:07

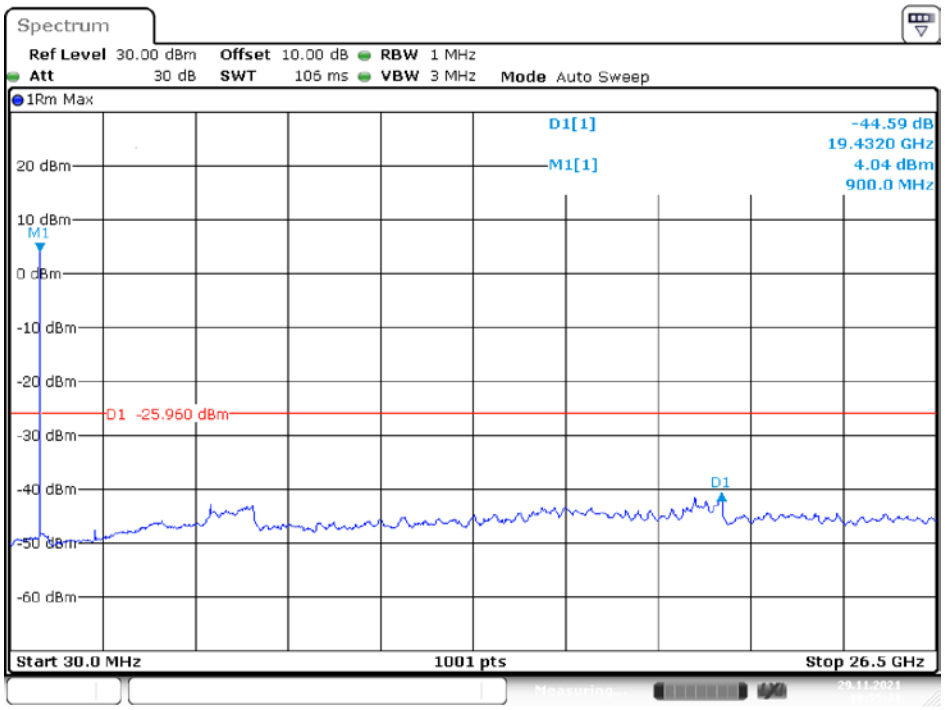
High Channel



Date: 29.NOV.2021 19:11:18

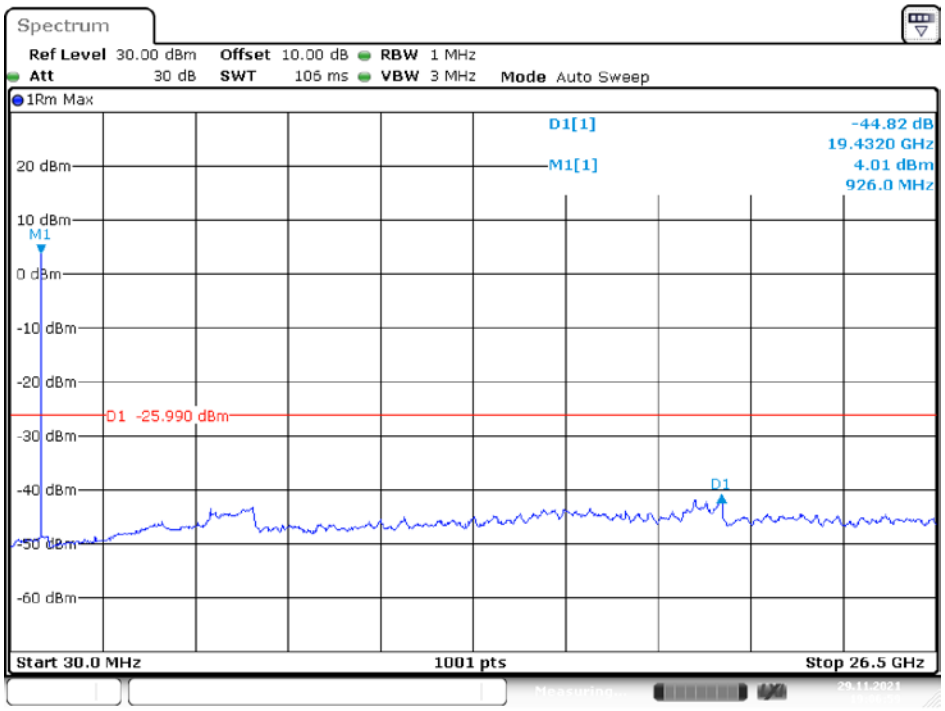
For 250 kHz

Low Channel



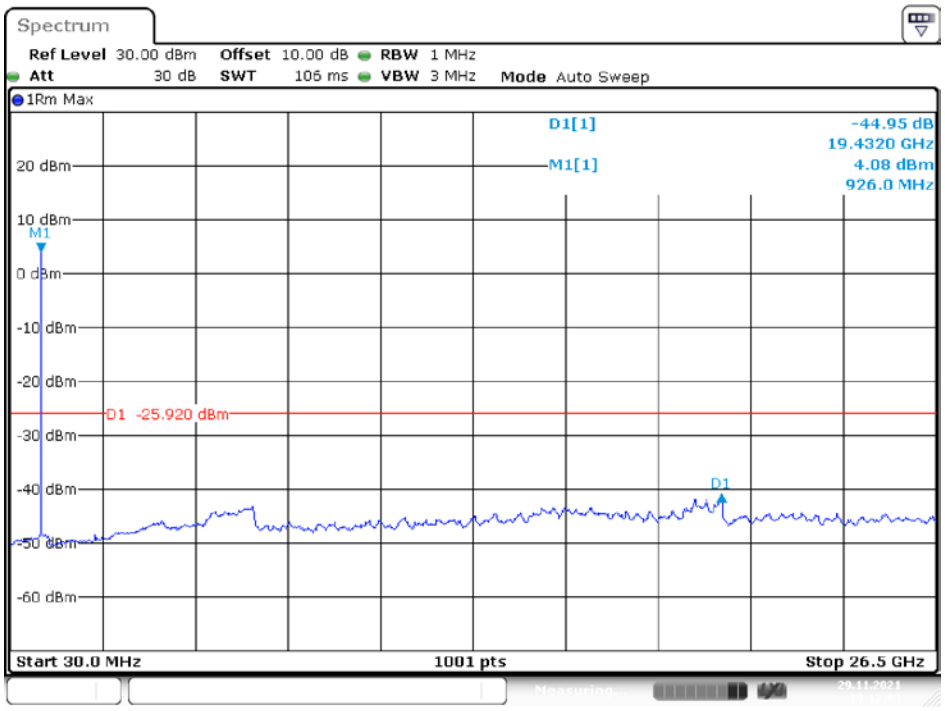
Date: 29.NOV.2021 18:55:31

Middle Channel



Date: 29.NOV.2021 19:07:00

High Channel



Date: 29.NOV.2021 19:12:03

10. FCC §15.247(a)(1)(i) – 20 dB Emission Bandwidth

10.1. Applicable Standard

According to FCC §15.247(a) (1) (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.

10.2. 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.

10.3. Test Results

For 125kHz:

Channel	Frequency (MHz)	20 dBc BW (MHz)	Result
Low	902.3	0.15	Compliance
Middle	915.1	0.15	Compliance
High	927.7	0.15	Compliance

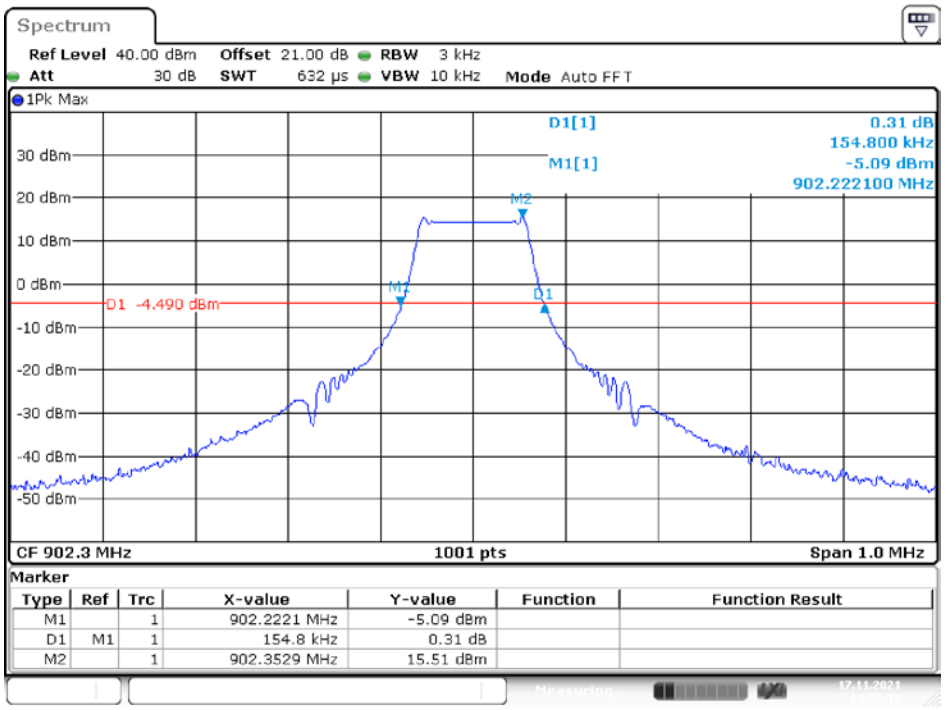
For 250kHz:

Channel	Frequency (MHz)	20 dBc BW (MHz)	Result
Low	902.3	0.30	Compliance
Middle	915.1	0.30	Compliance
High	927.5	0.30	Compliance

Please refer to the following plots

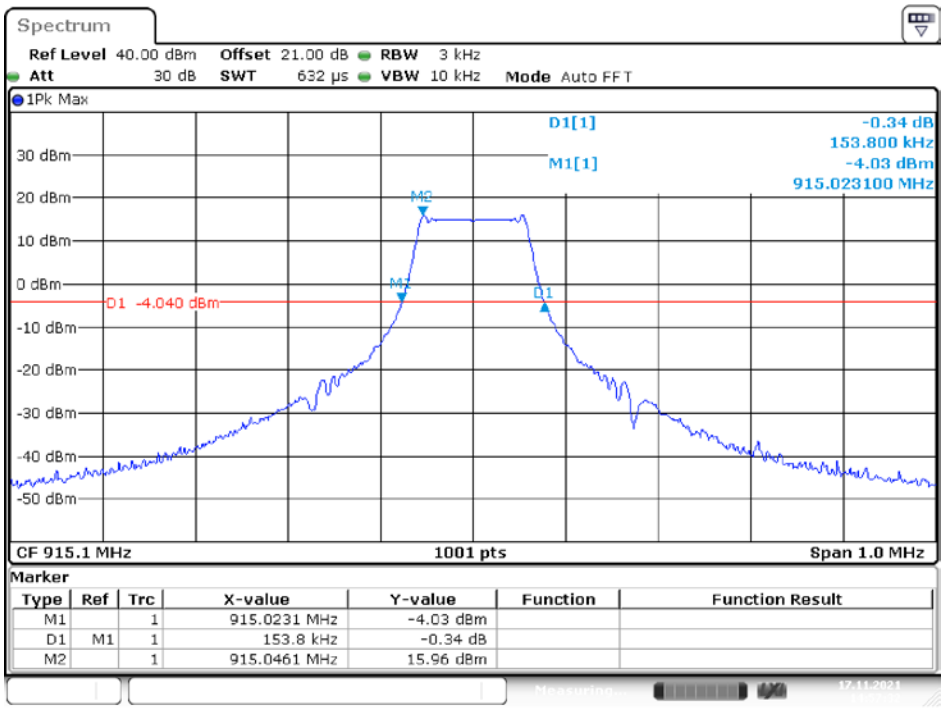
For 125kHz:

Low Channel



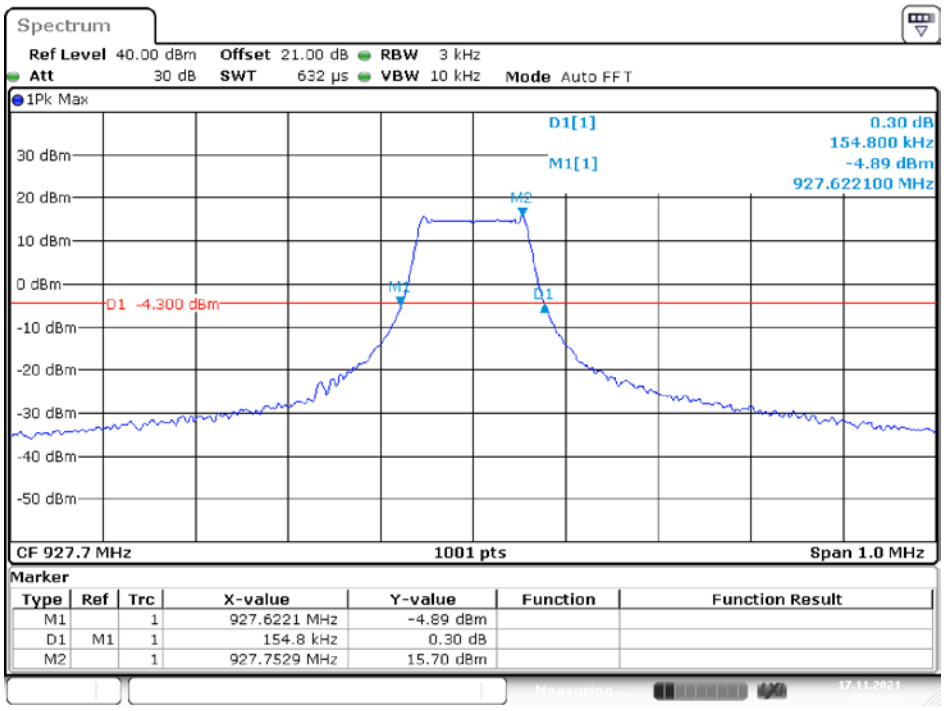
Date: 17.NOV.2021 14:55:16

Middle Channel



Date: 17.NOV.2021 14:57:32

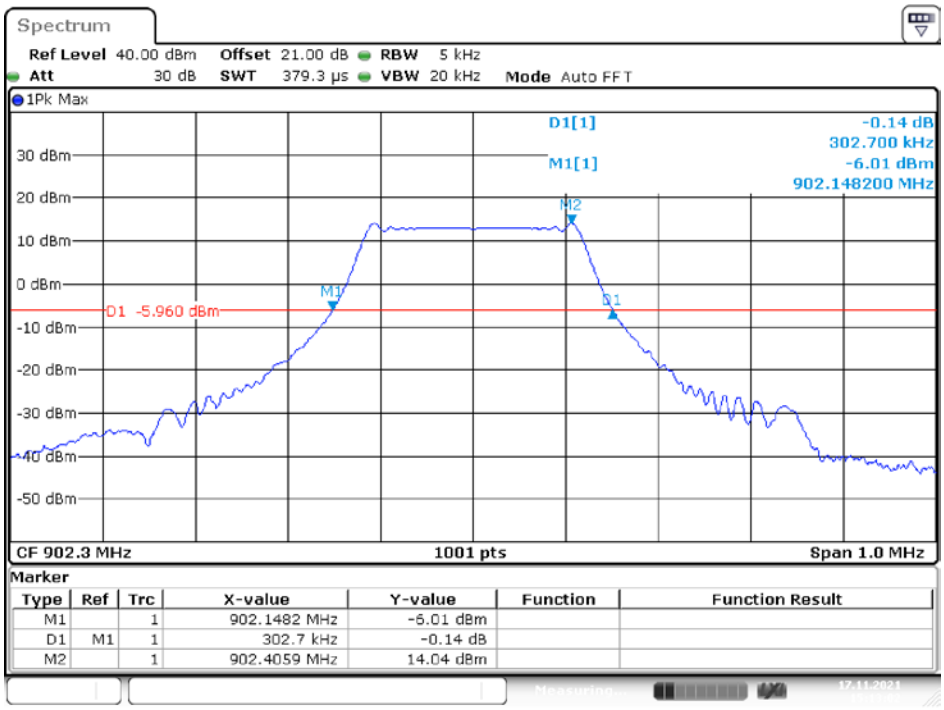
High Channel



Date: 17.NOV.2021 15:00:13

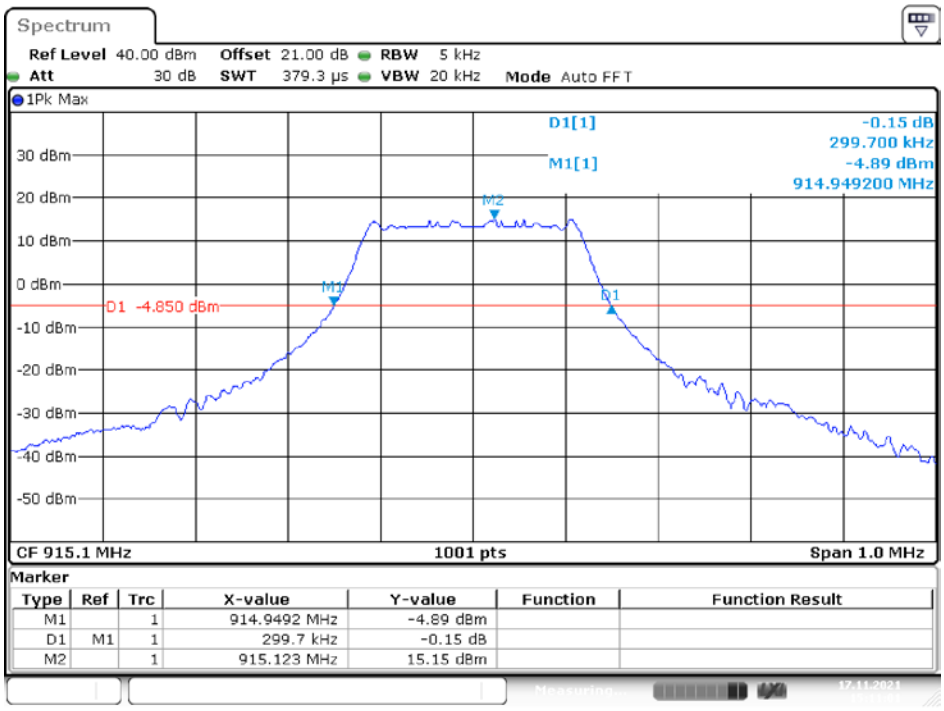
For 250kHz:

Low Channel



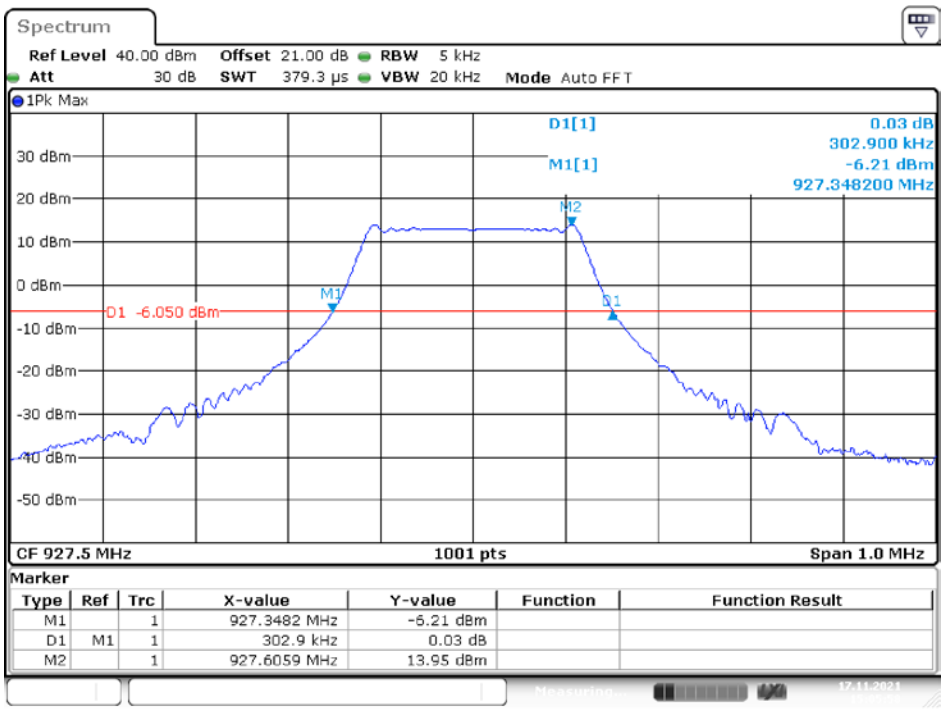
Date: 17.NOV.2021 15:13:01

Middle Channel



Date: 17.NOV.2021 15:11:00

High Channel



Date: 17.NOV.2021 15:05:58

11. FCC §15.247(a)(1) – Channel Separation Test

11.1. Applicable Standard

According to FCC §15.247(a) (1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

11.2. Test Procedure

1. Set the EUT in transmitting mode, max hold the channel.
2. Set the adjacent channel of the EUT and max hold another trace.
3. Measure the channel separation.

11.3. Test Results

For 125kHz:

Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
Low	902.3	0.2	0.15	Compliance
Middle	915.1	0.2	0.15	Compliance
High	927.7	0.2	0.15	Compliance

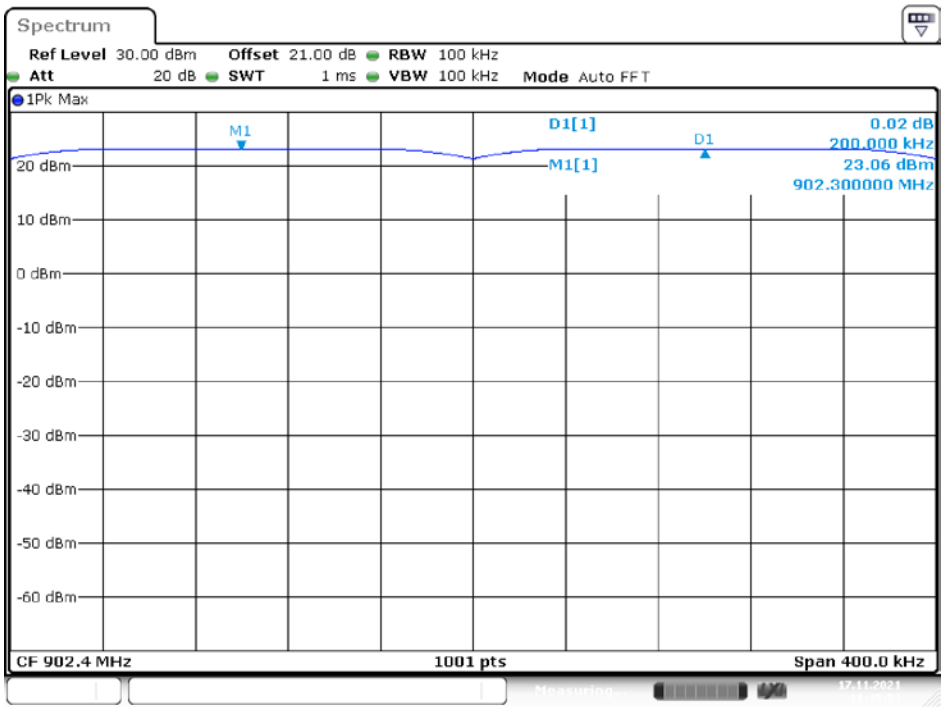
For 250kHz:

Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
Low	902.3	0.4	0.30	Compliance
Middle	915.1	0.4	0.30	Compliance
High	927.5	0.4	0.30	Compliance

Please refer to the following plots.

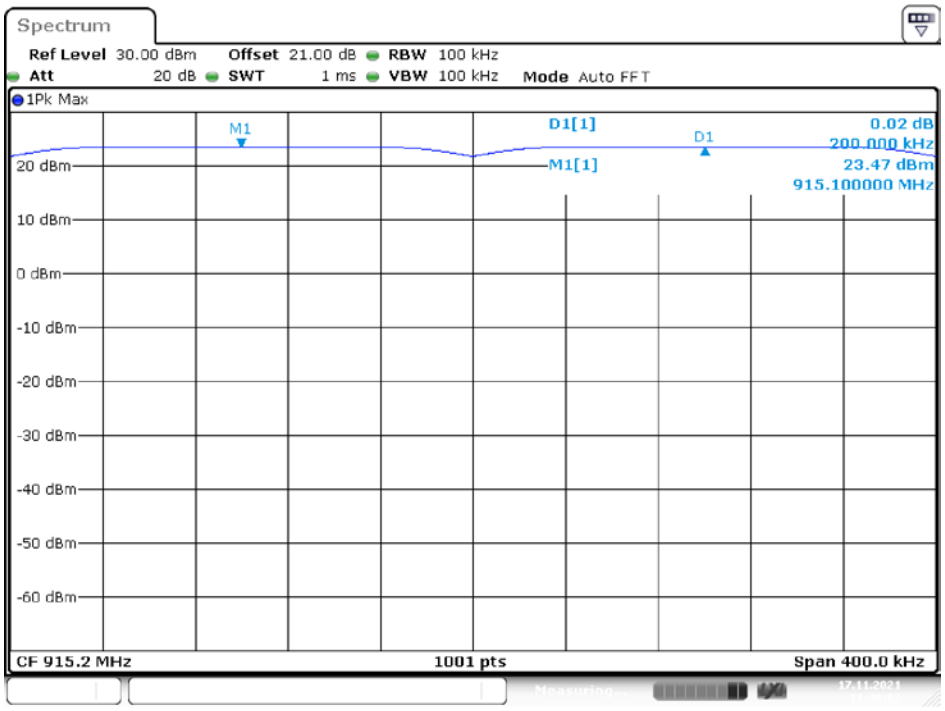
For 125kHz

Low Channel



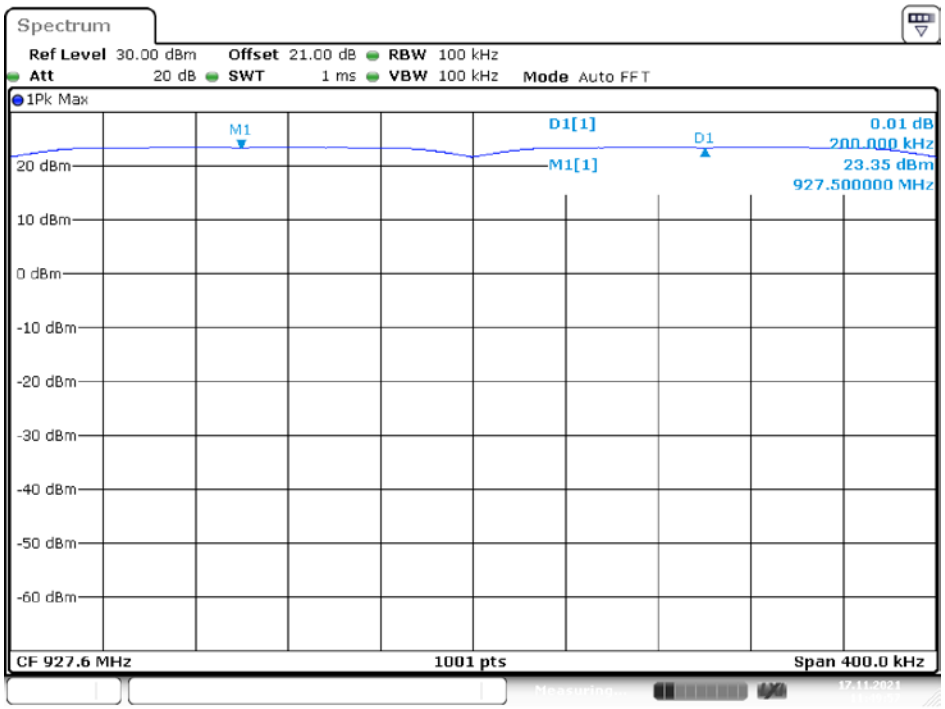
Date: 17.NOV.2021 11:45:53

Middle Channel



Date: 17.NOV.2021 11:48:02

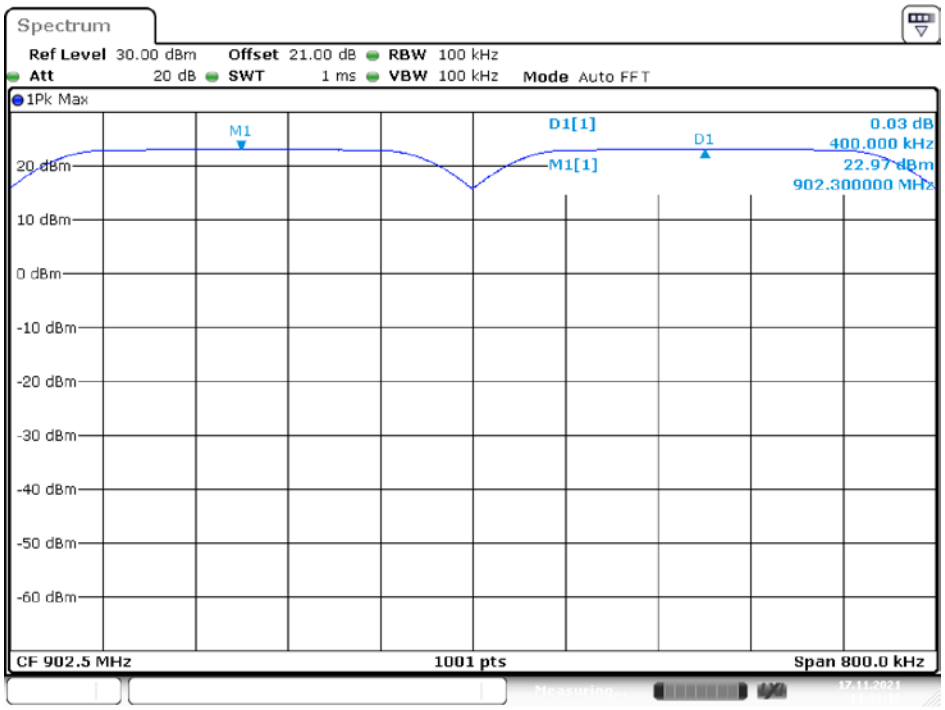
High Channel



Date: 17.NOV.2021 11:49:57

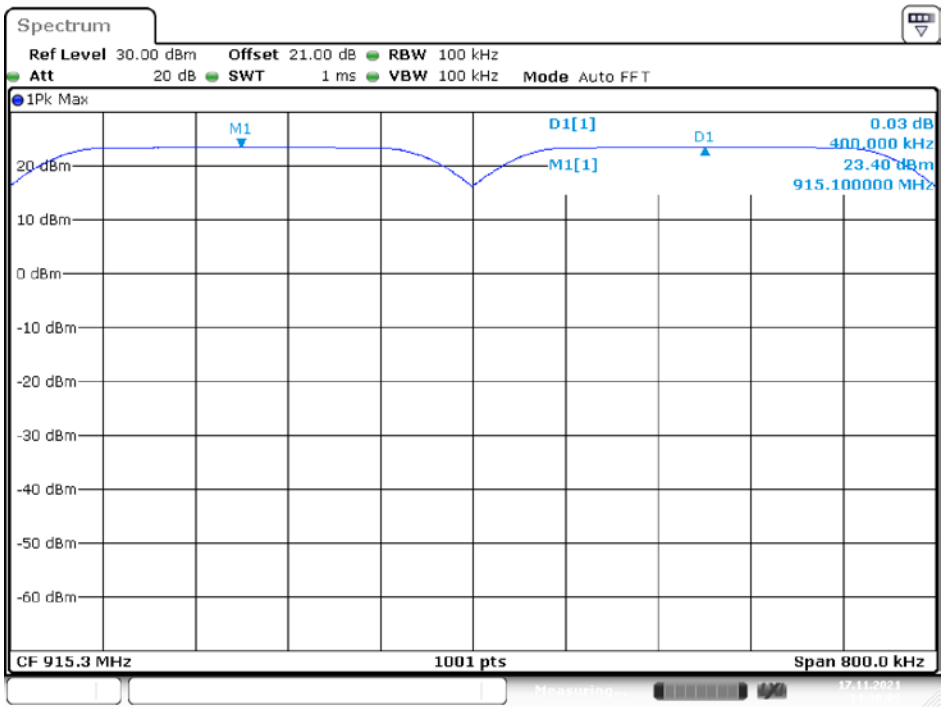
For 250kHz

Low Channel



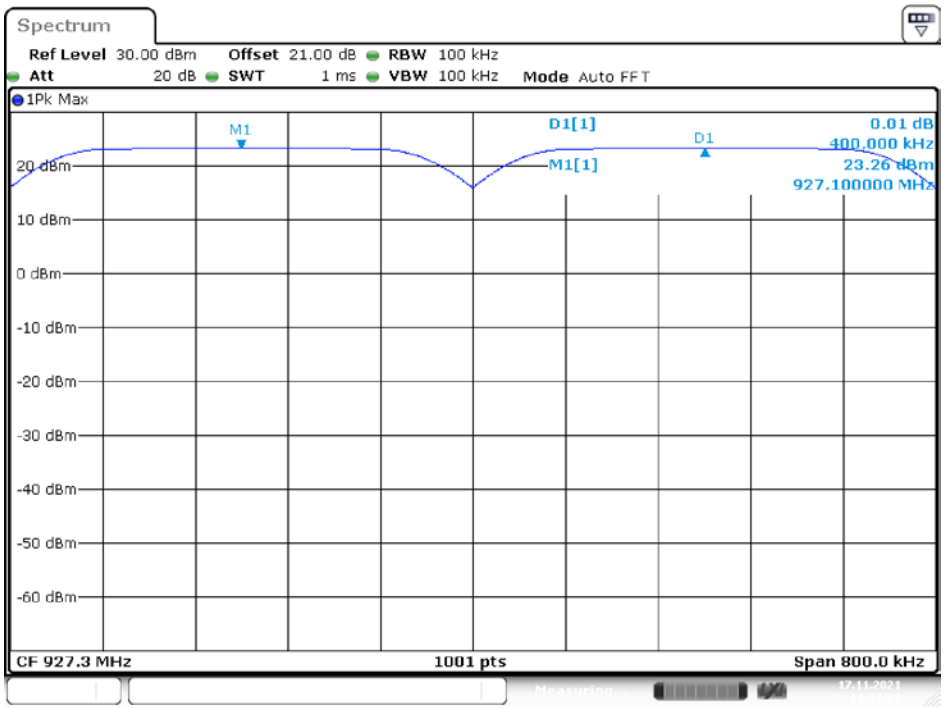
Date: 17.NOV.2021 14:32:16

Middle Channel



Date: 17.NOV.2021 14:30:09

High Channel



Date: 17.NOV.2021 14:24:02

12. FCC§15.247(f) –Time of Occupancy (Dwell Time)

12.1. Applicable Standard

According to FCC §15.247(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.

12.2. Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel RBW ≤ channel spacing and where possible RBW should be set >> 1/T, where T is the expected dwell time per channel Sweep = as necessary to capture the entire dwell time per hopping channel Detector function = peak Trace = max hold

12.3. Test Results

For 125kHz:

Frequency (MHz)	Pulse Time (ms)	Hopping Number	Period Time (s)	Total of Dwell (ms)	Limit (ms)	Result
915.1	67.4	2	51.2	134.80	<400	PASS

Note : period time = 0.4*128 = 51.2 (s), Total of Dwell=Pulse Time * Hopping Number

For 250kHz:

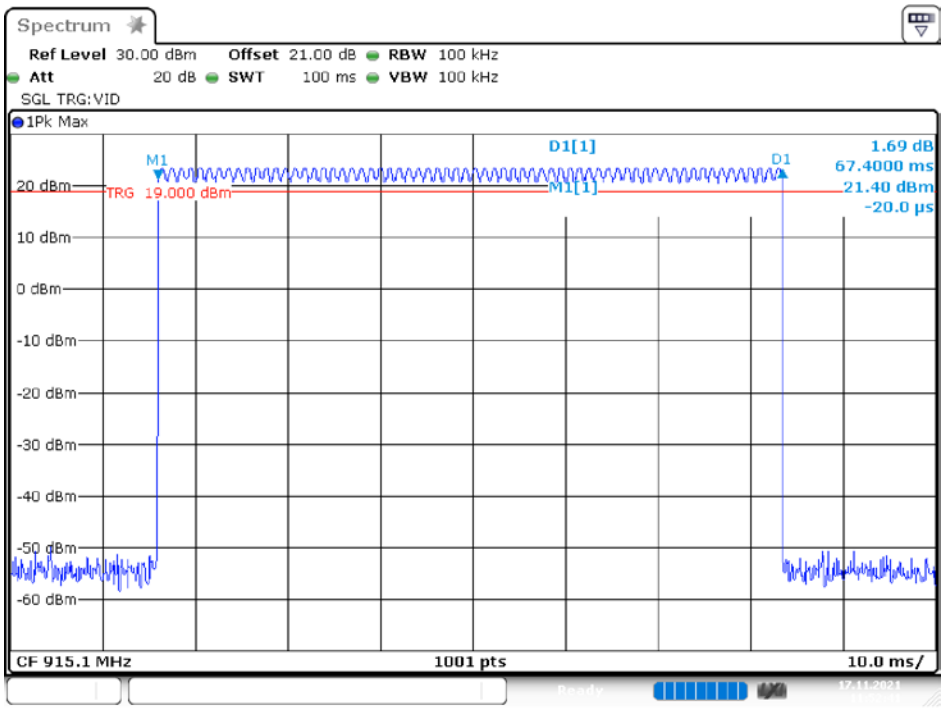
Frequency (MHz)	Pulse Time (ms)	Hopping Number	Period Time (s)	Total of Dwell (ms)	Limit (ms)	Result
915.1	67.9	2	25.6	135.80	<400	PASS

Note : period time = 0.4*64 = 25.6 (s), Total of Dwell=Pulse Time * Hopping Number

Please refer to the following plots

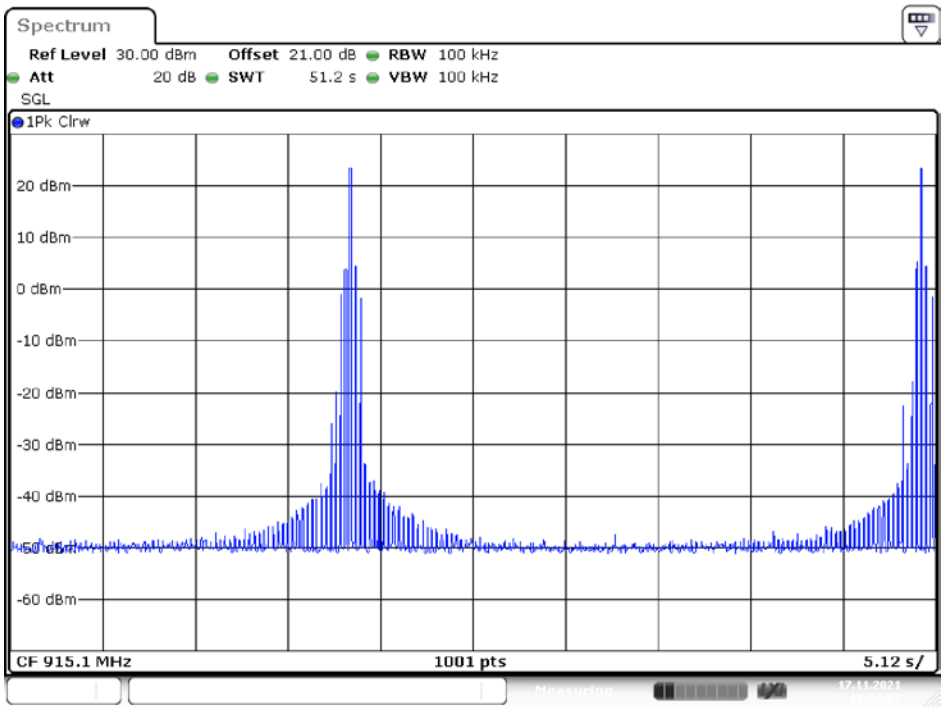
For 125kHz

Pulse Width



Date: 17.NOV.2021 11:52:40

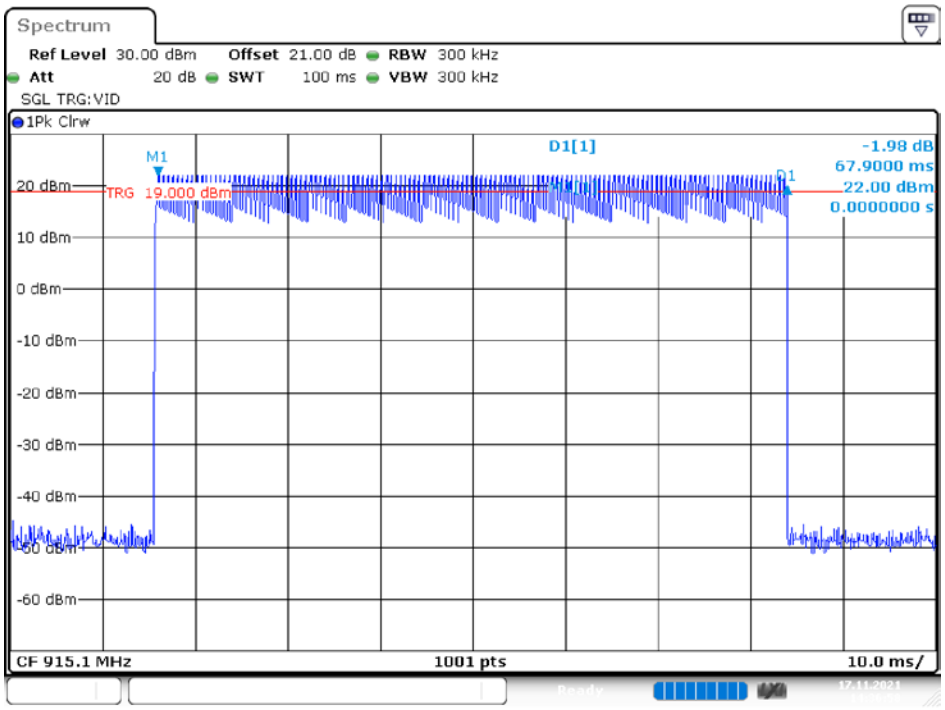
Hopping Number



Date: 17.NOV.2021 18:24:07

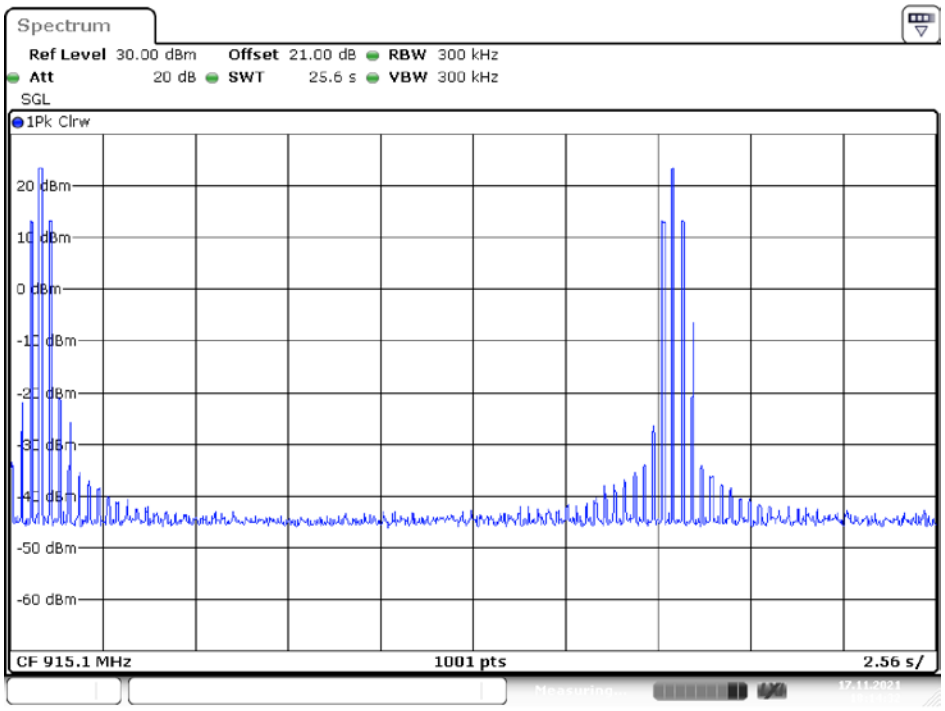
For 250kHz

Pulse Width



Date: 17.NOV.2021 14:36:58

Hopping Number



Date: 17.NOV.2021 18:14:32

13. FCC §15.247(a)(1)(i) –Quantity of hopping channel Test

13.1. Applicable Standard

According to FCC §15.247(a) (1) (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.

13.2. Test Procedure

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
2. Set the EUT in hopping mode from first channel to last.
3. By using the Max-Hold function record the Quantity of the channel.

13.3. Test Results

For 125kHz:

Frequency Range (MHz)	Number of Hopping Channel (CH)	Result
902-928	128	Compliance

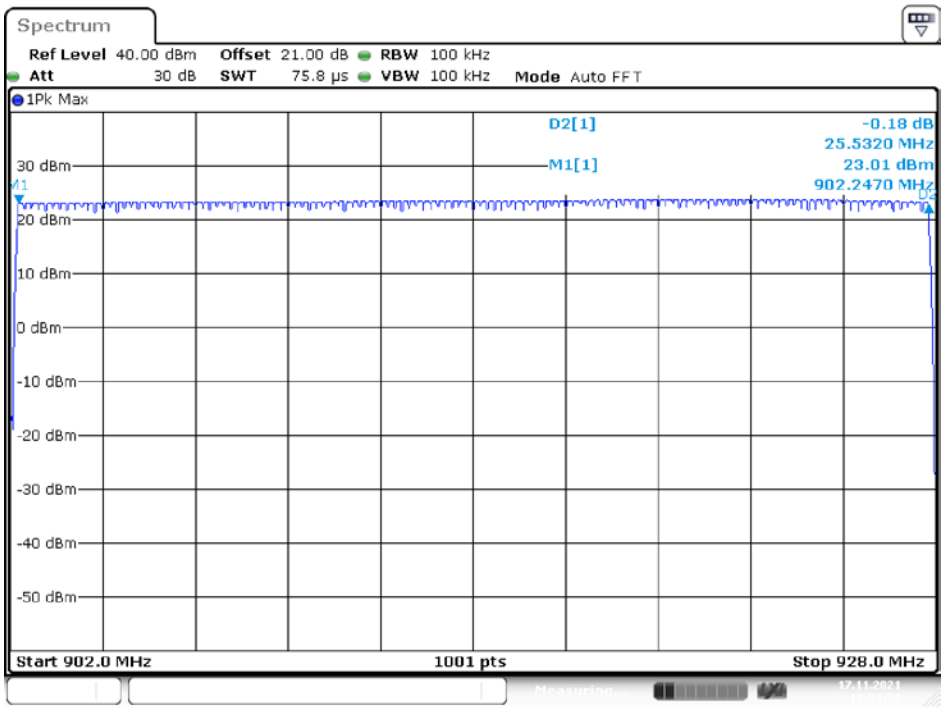
For 250kHz:

Frequency Range (MHz)	Number of Hopping Channel (CH)	Result
902-928	64	Compliance

Please refer to the following plots

For 125kHz

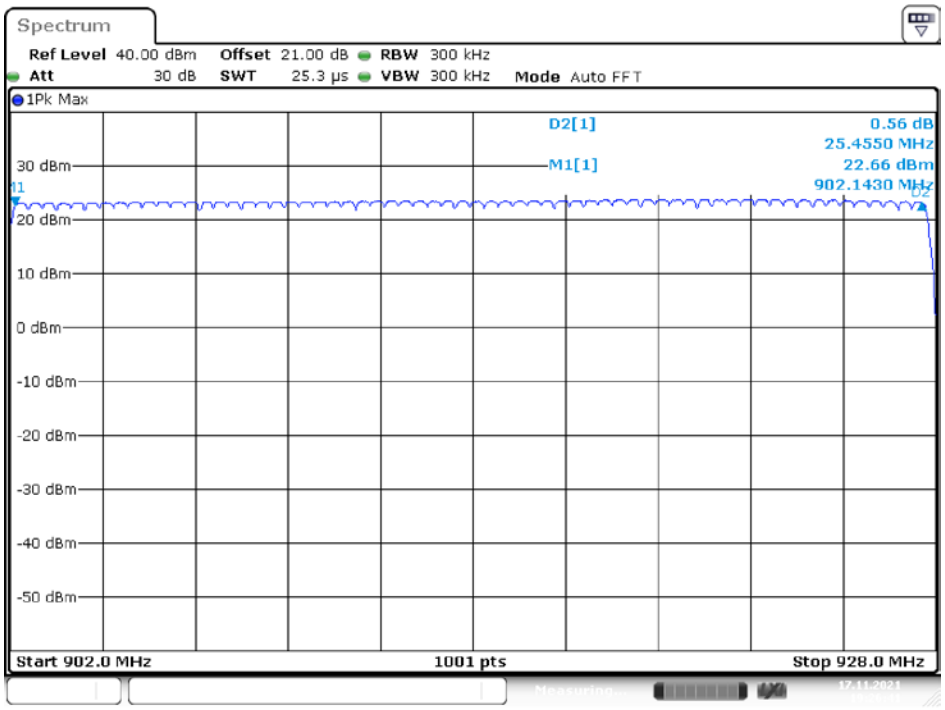
Number of Hopping Channels



Date: 17.NOV.2021 19:24:59

For 250kHz

Number of Hopping Channels



Date: 17.NOV.2021 19:26:41

14. FCC §15.247(b)(3) – Maximum Average Output Power

14.1. 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, compliance 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.

14.2. Test Procedure

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 measuring equipment.

14.3. Test Results

For 125kHz:

Channel	Frequency (MHz)	Average Conducted Output Power (dBm)	Limit (dBm)	Result
Low	902.3	23.25	30	PASS
Middle	915.1	23.59	30	PASS
High	927.7	23.84	30	PASS

For 250kHz:

Channel	Frequency (MHz)	Average Conducted Output Power (dBm)	Limit (dBm)	Result
Low	902.3	23.24	30	PASS
Middle	915.1	23.58	30	PASS
High	927.5	23.92	30	PASS

15. FCC §15.247(f) – POWER SPECTRAL DENSITY OF HYBRID SYSTEMS

15.1. 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.

15.2. Test Procedure

a) Set instrument center frequency to DTS channel center frequency.

b) Set span to at least 1.5 times the OBW.

c) Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.

d) Set VBW ≥ [3 × RBW].

e) Detector = power averaging (rms)

f) Ensure that the number of measurement points in the sweep ≥ [2 × span / RBW].

g) Manually set the sweep time to: ≥ [10 × (number of measurement points in sweep) × (transmission symbol period)], but no less than the auto sweep time.

h) Perform the measurement over a single sweep.

i) Use the peak marker function to determine the maximum amplitude level.

j) If 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)..

15.3. Test Results

For 125kHz:

Channel	Frequency (MHz)	Power Spectral Density (dBm/3 kHz)	Limit dBm/3 kHz)	Result
Low	902.3	7.38	8	PASS
Middle	915.1	7.71	8	PASS
High	927.7	7.99	8	PASS

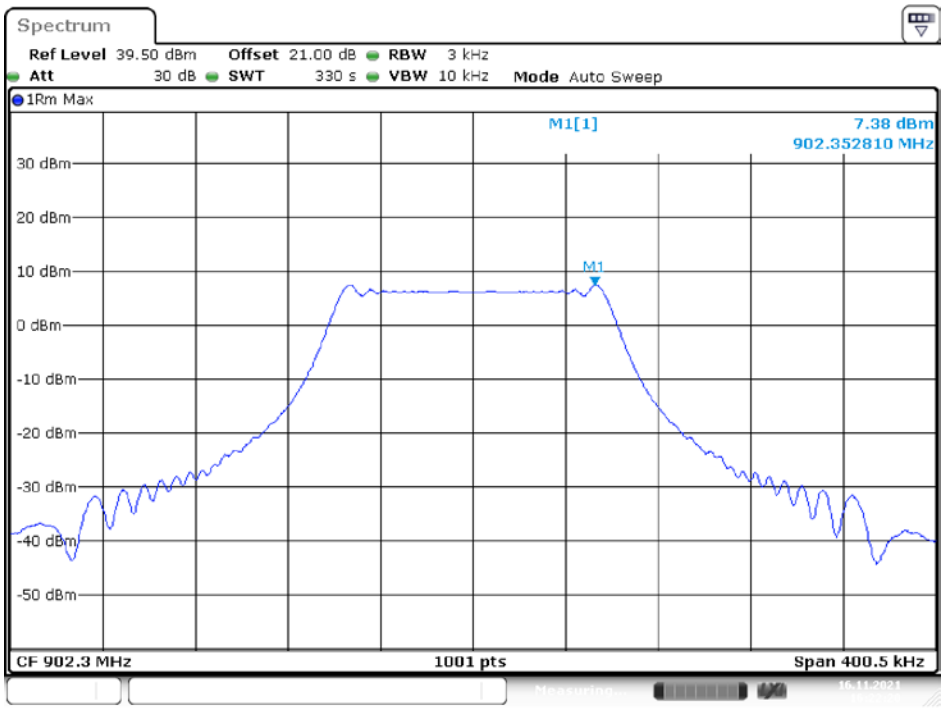
For 250kHz:

Channel	Frequency (MHz)	Power Spectral Density (dBm/3 kHz)	Limit dBm/3 kHz)	Result
Low	902.3	4.37	8	PASS
Middle	915.1	4.72	8	PASS
High	927.5	5.01	8	PASS

Please refer to the following plots

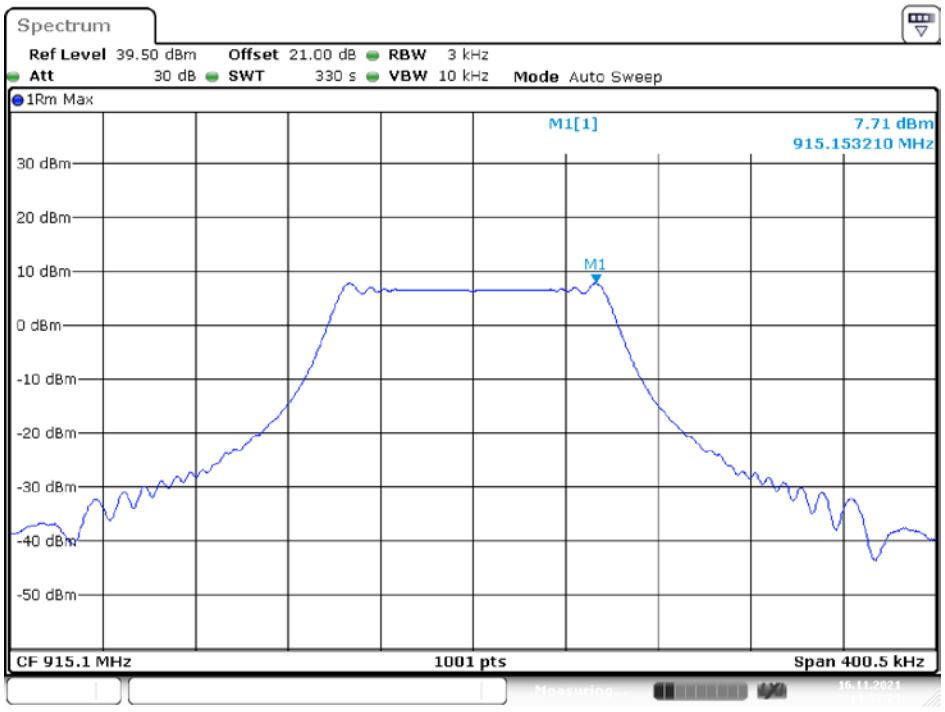
For 125kHz

Low Channel



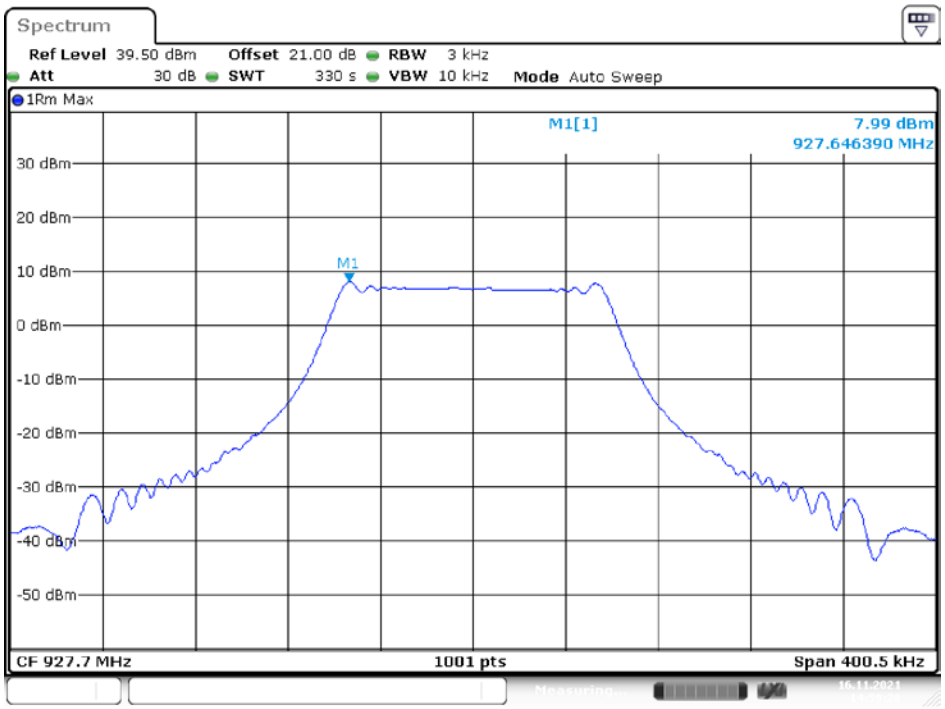
Date: 16.NOV.2021 16:22:20

Middle Channel



Date: 16.NOV.2021 14:52:29

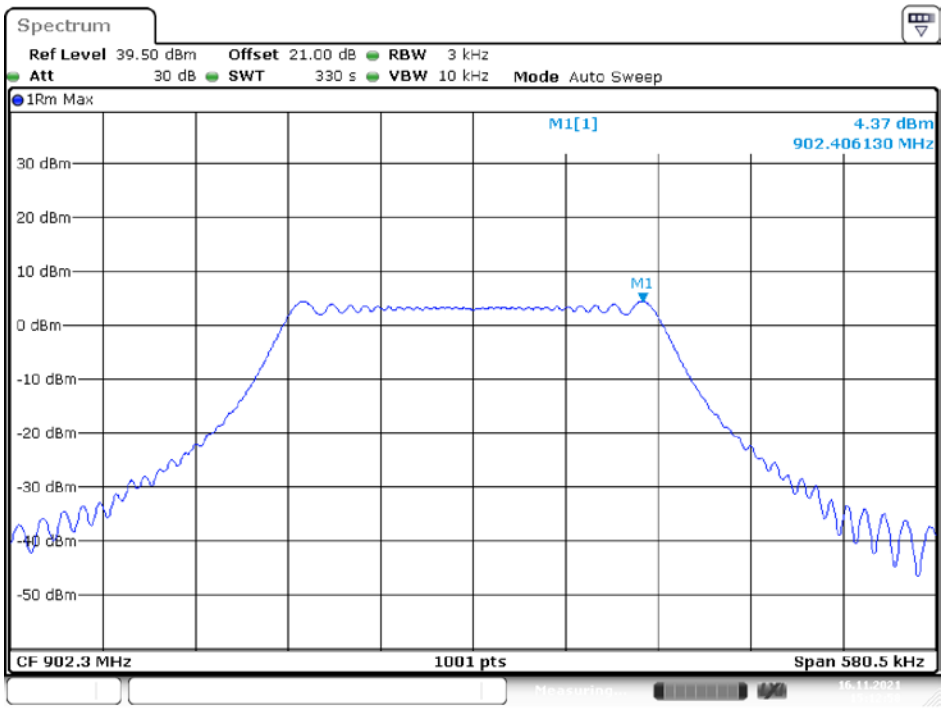
High Channel



Date: 16.NOV.2021 14:59:28

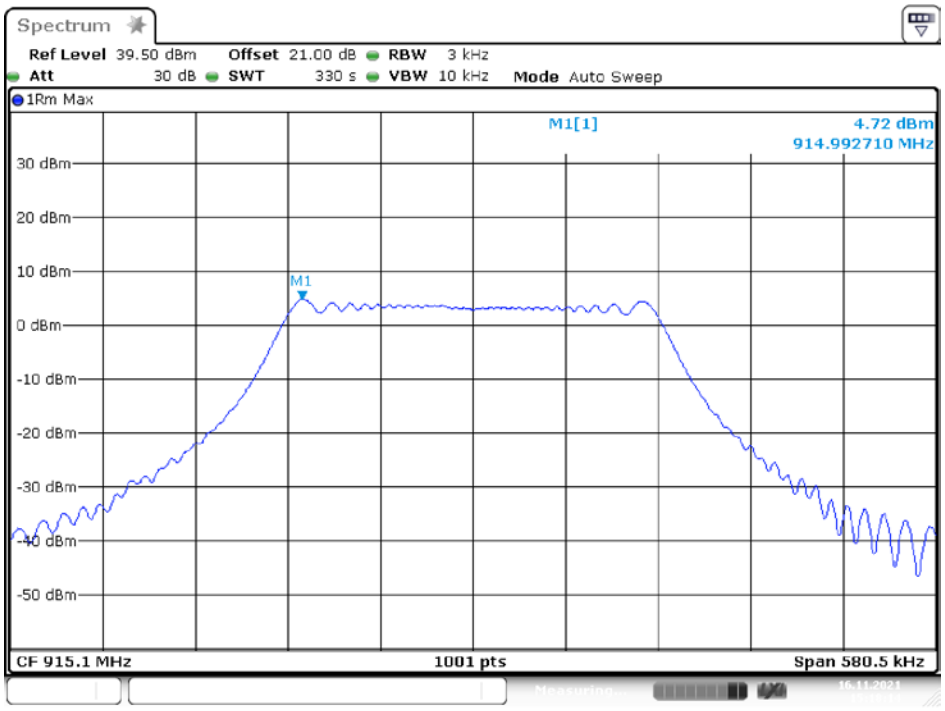
For 250kHz

Low Channel



Date: 16.NOV.2021 15:12:58

Middle Channel



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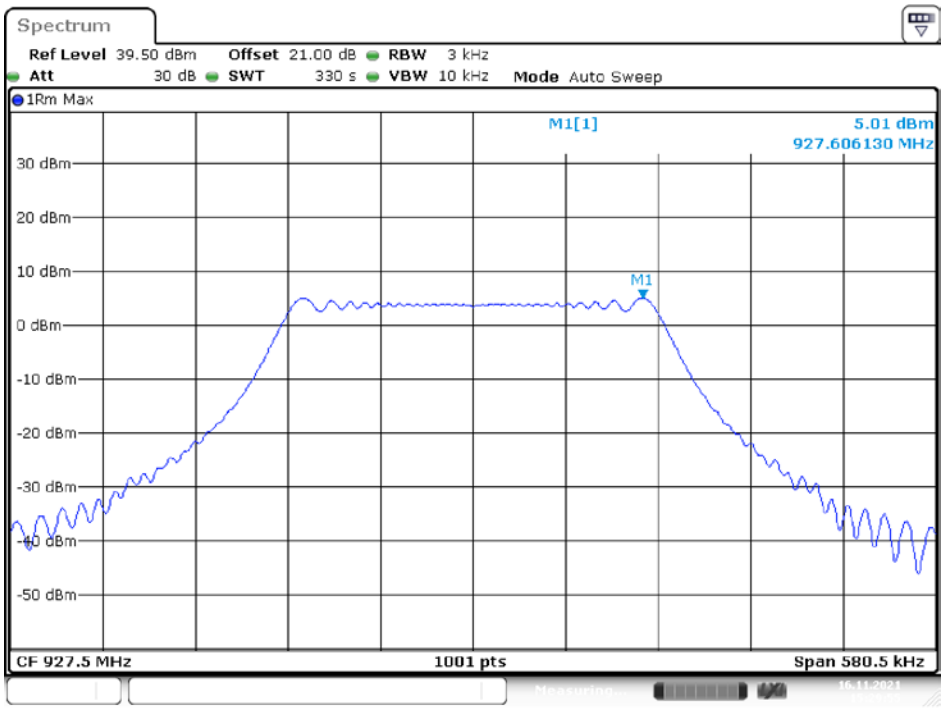
High Channel



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16. FCC §15.247(d) – 100 kHz Bandwidth of Frequency Band Edge

16.1. 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)).

16.2. 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 its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW to 100 kHz and VBW of spectrum analyzer to 300 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.

16.3. Test Results

For 125kHz:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Transmitting				
Low	902.3	34.23	≥ 30	PASS
High	927.7	37.36	≥ 30	PASS
Hopping Mode				
Low	902.3	52.38	≥ 30	PASS
High	927.7	50.95	≥ 30	PASS

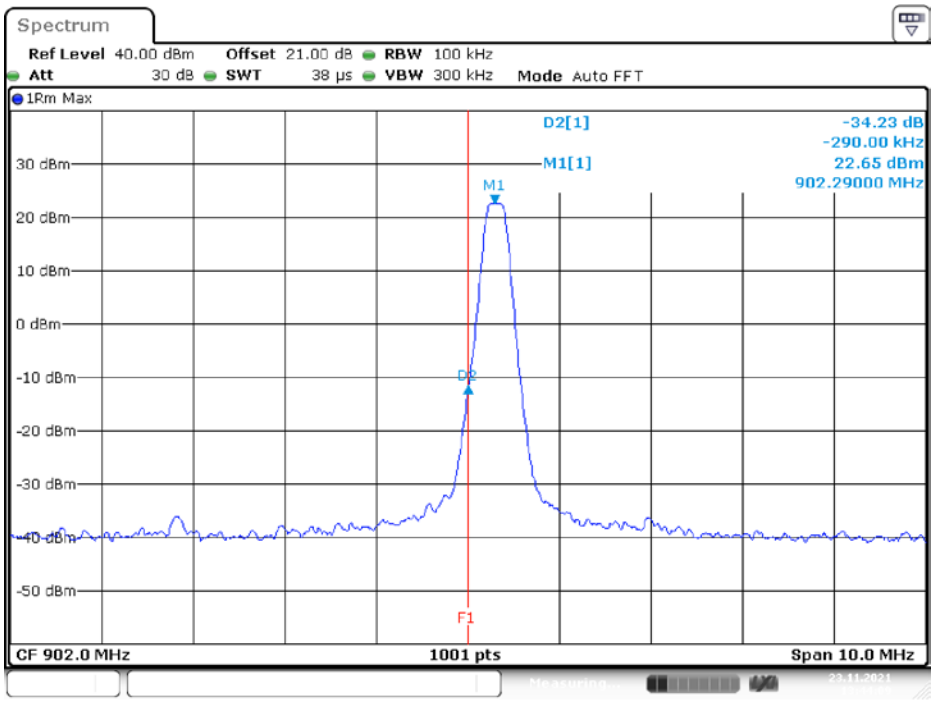
For 250kHz:

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Transmitting				
Low	902.3	33.18	≥ 30	PASS
High	927.5	48.70	≥ 30	PASS
Hopping Mode				
Low	902.3	46.06	≥ 30	PASS
High	927.5	55.89	≥ 30	PASS

Please refer to the following plots.

For 125kHz

Band Edge, CH Low



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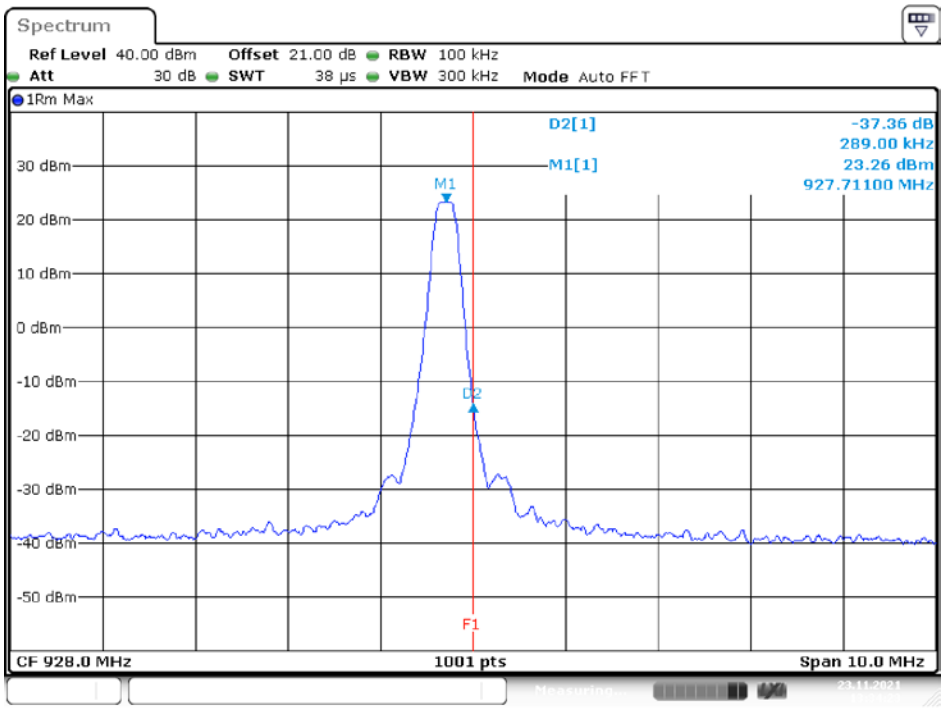
Band Edge, CH High



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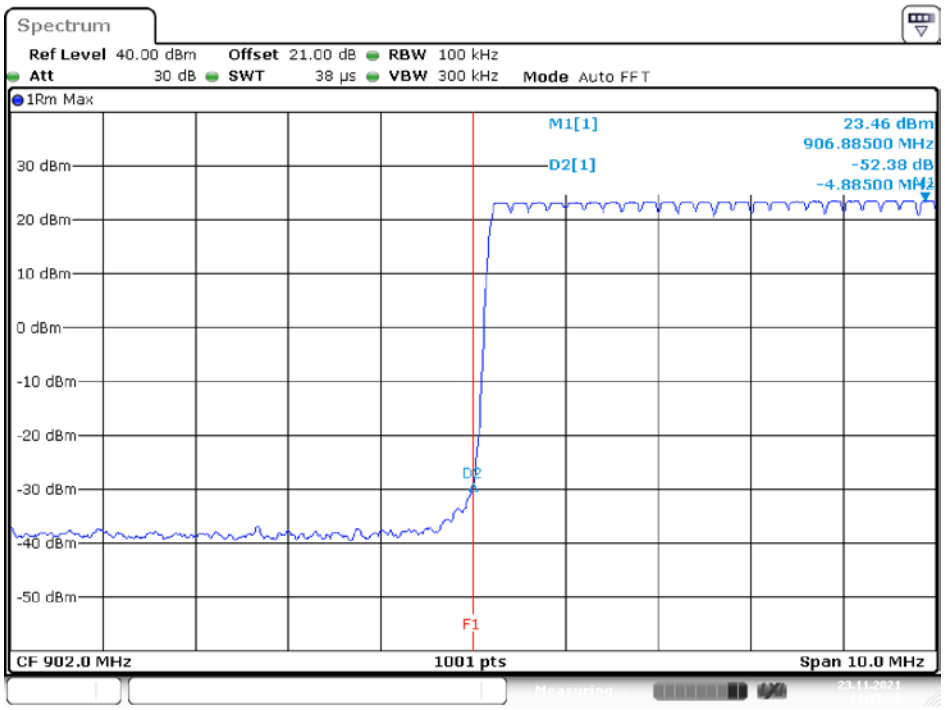
For 125kHz Hopping Mode

Band Edge, CH Low



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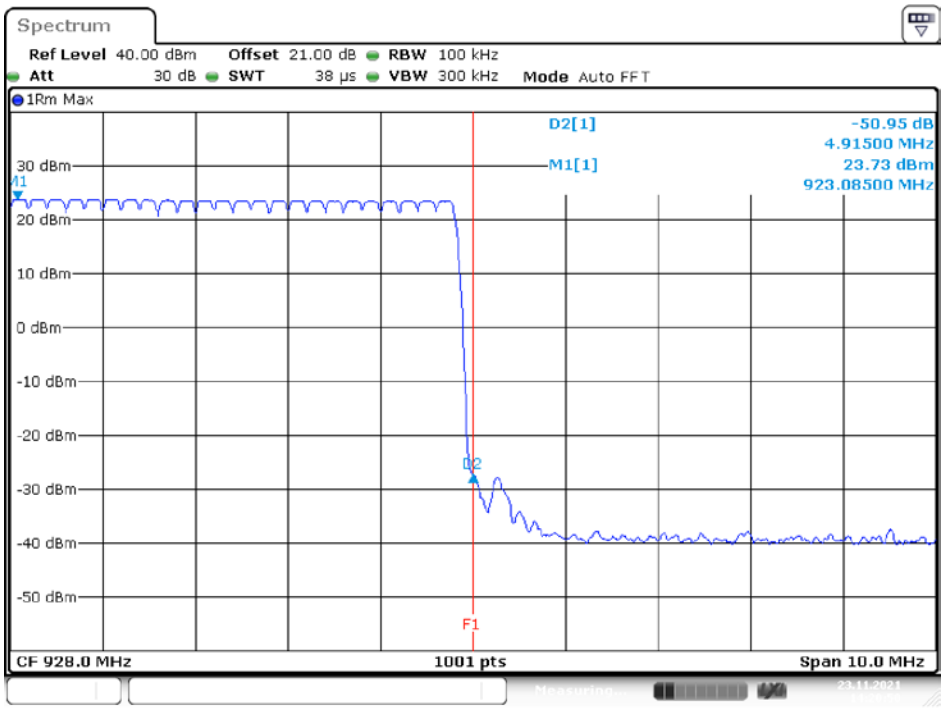
Band Edge, CH High



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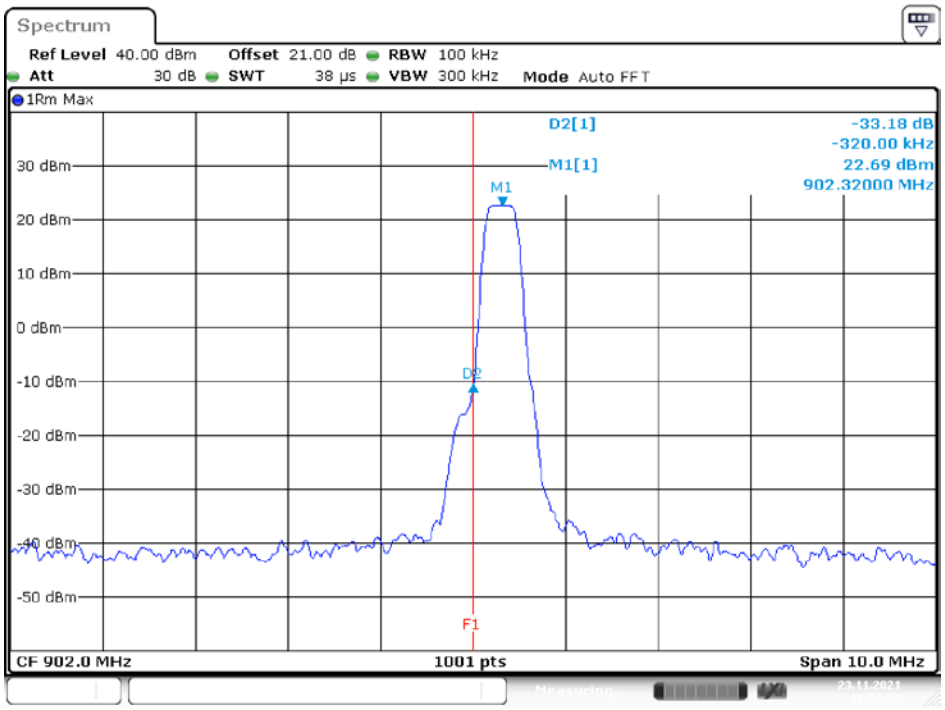
For 250kHz

Band Edge, CH Low



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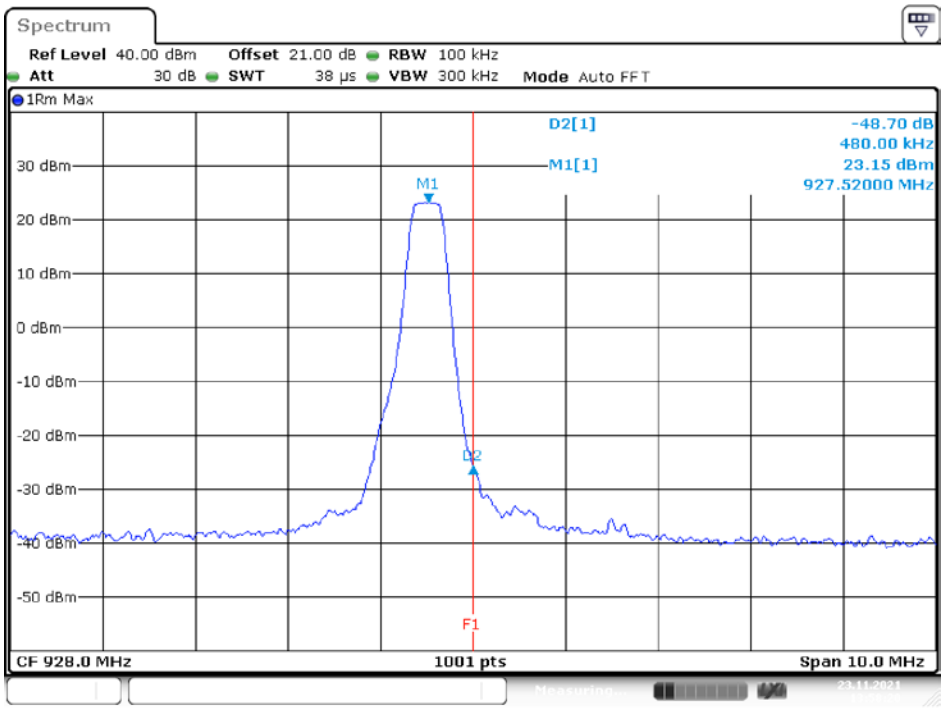
Band Edge, CH High



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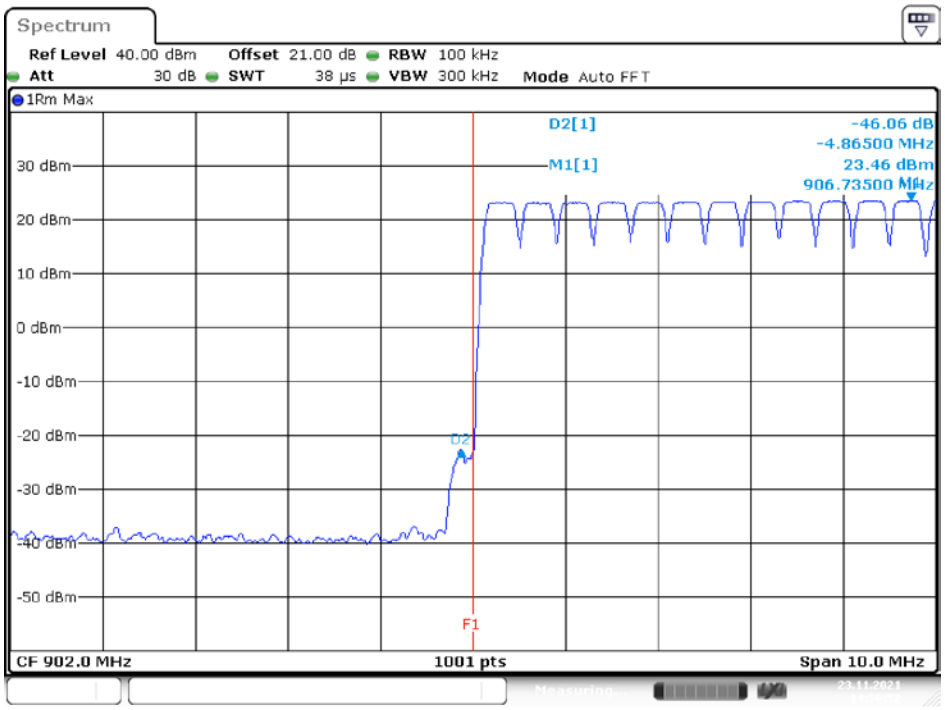
For 250kHz Hopping Mode

Band Edge, CH Low



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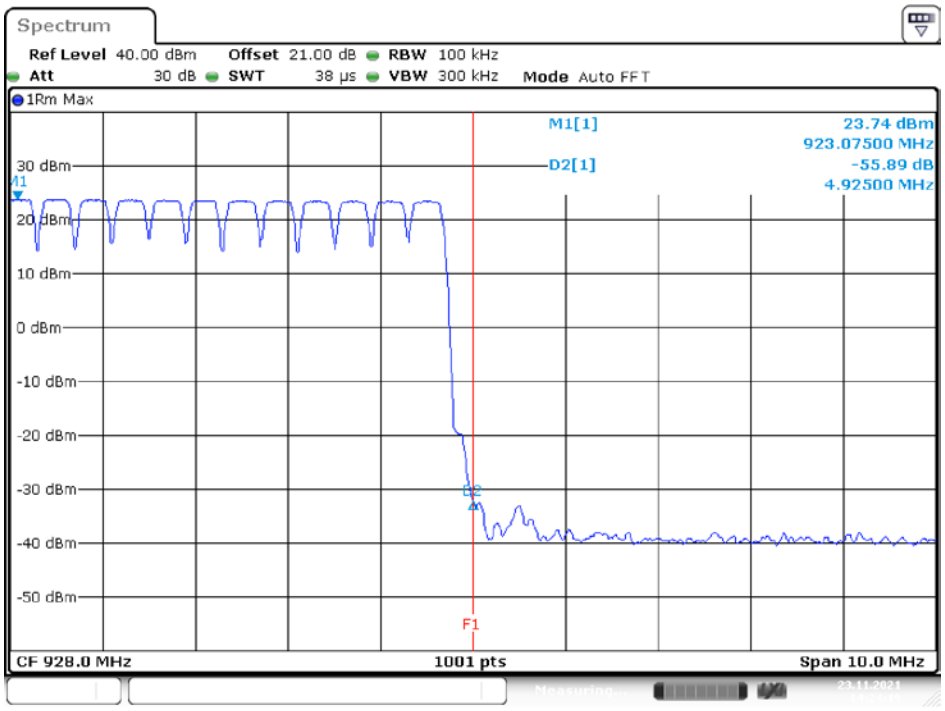
Band Edge, CH High



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