



FCC Part 15.247

RSS-247 Issue 2, Feb 2017; RSS-Gen Issue 5, Mar 2019

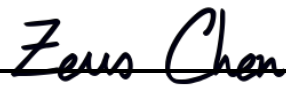
TEST REPORT

For

Redpine Signals Inc

2107 N First Street, Suite 540, San Jose, CA 95131-2019, USA

FCC ID: XF6-M4SB
IC: 8407A-M4SB

Report Type	Original Report
Product Name:	Single Band SIP Module, Small Form Factor Single Band 802.11b/g/n, Bluetooth 5.0, Zigbee Module
Model Name:	M4SB
Report Number :	RLK191015004-00B
Report Date :	2019/11/25
Reviewed By :	Zeus Chen 
Prepared By:	
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Note: This test report is prepared for the customer shown above and for the device described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp. (Linkou Laboratory)

Revision History

Revision	Report Number	Issue Date	Description
1.0	RLK191015004-00B	2019/11/25	Original Report

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1 General Information

1.1 Product Description for Equipment under Test (EUT)

Applicant	Redpine Signals Inc 2107 N First Street, Suite 540, San Jose, CA 95131-2019, USA
Manufacturer	Redpine Signals Inc 2107 N First Street, Suite 540, San Jose, CA 95131-2019, USA
Brand Name	 REDPINE SIGNALS DRIVING WIRELESS CONVERGENCE
Product (Equipment)	Single Band SIP Module, Small Form Factor Single Band 802.11b/g/n, Bluetooth 5.0, Zigbee Module
Model Name	M4SB
Frequency Range	2405 - 2480 MHz
Number of Channels	16 Channels
Output Power	1.8Vdc: 16.07 dBm (0.0405 W) 3.3Vdc: 19.58 dBm (0.0908 W)
Modulation Type	OQPSK
Related Submittal(s)/Grant(s)	FCC Part 15.247 DTS with FCC ID: XF6-M4SB FCC Part 15.247 DTS with FCC ID: XF6-M4SB
Received Date	Oct. 15, 2019
Date of Test	Oct. 22, 2019 ~ Nov. 21, 2019

**All measurement and test data in this report was gathered from production sample serial number: 190914002(Assigned by BACL, Linkou Laboratory).*

1.2 Operation Condition of EUT

Power Operation (Voltage Range)	<input type="checkbox"/> AC 120 V/60 Hz <input type="checkbox"/> Adapter <input type="checkbox"/> By Power Cord.
	<input checked="" type="checkbox"/> DC Type <input checked="" type="checkbox"/> DC Power Supply: 1.8V, 3.3V <input type="checkbox"/> Battery: <input type="checkbox"/> External from USB Cable <input type="checkbox"/> External DC Adapter
	<input type="checkbox"/> Host System

1.3 Objective and Test Methodology

The Objective of this Test Report was to document the compliance of the Redpine Signals Inc. Appliance (Model: M4SB) to the requirements of the following Standards:

- Part 2, Subpart J, Part 15, Subparts A and C, section 15.247 of the Federal Communication Commission's rules.
- ANSI C63.10-2013 of t American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- RSS-Gen Issue 5, Mar 2019— General Requirements for Compliance of Radio Apparatus
- RSS-247 Issue 2, Feb 2017— Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.4 Measurement Uncertainty

Parameter	Expanded Measurement uncertainty
RF output power	± 1.488 dB
Occupied Channel Bandwidth	± 453.927 Hz
RF Conducted Emission test	± 2.77 dB
AC Power Line Conducted Emission	± 2.66 dB
Radiated Below 1G	± 3.57 dB
Radiated Above 1G	± 5.32 dB

1.5 Environmental Conditions and Test Date

Test Site	Test Date	Temperature (°C)	Relative Humidity (% RH)	Test Engineer
Conduction (CON-01)	2019-11-21	22.3	54	Leo Cheng
Radiated (966A)	2019-10-21 - 2019-11-18	20 - 24.3	45-51	Leo Cheng
Conducted (TH-02)	2019-11-04 - 2019-11-21	21.3 - 24.7	57-61	Ethan Shao

1.6 Test Facility

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

No.6, Wende 2Rd., Guishan Dist., Taoyuan City 33382, Taiwan (R.O.C.).

Bay Area Compliance Laboratories Corp. (Linkou Laboratory) Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 3546) by Mutual Recognition Agreement (MRA). The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database. The FCC Registration No.: 0027578244. Designation No.: TW3546. The Test Firm Registration No.: 181430.

2 System Test Configuration

2.1 Test Channels and Description of Worst Test Configuration

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

No special accessory, No modification was made to the EUT and No special equipment used during test.

For Zigbee, there are totally 16 channels.

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2405	9	2445
1	2410	--	--
2	2415	--	--
3	2420	14	2470
--	--	15	2475
8	2440	16	2480

For BLE: Channel 0, 8 and 16 were tested.

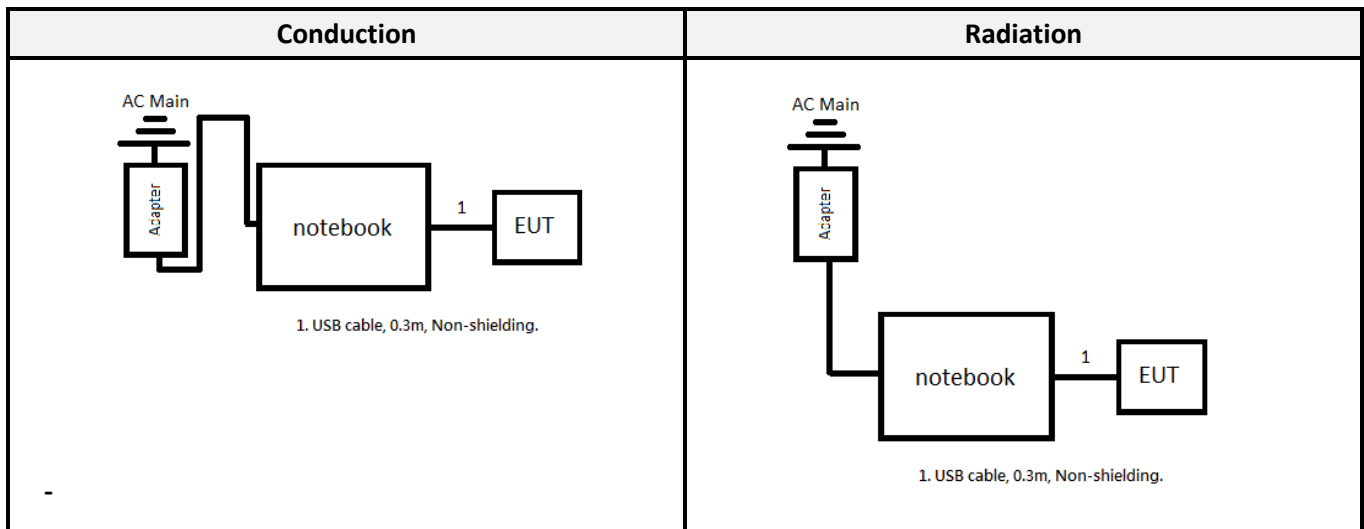
Worst Case of Power Setting				
EUT Exercise Software		FCC_PER_TEST_GUI.py		
Chip Antenna 1.8V				
Configuration	NTX	Low CH	Mid CH	High CH
Zigbee	1	18	18	18
Chip Antenna 3.3V				
Configuration	NTX	Low CH	Mid CH	High CH
Zigbee	1	18	17	13

2.2 Support Equipment List and External Cable List

No.	Description	Manufacturer	Model Number
A	Notebook	DELL	Inspiron 15
B	Adapter	Chicony Power	HA65NS5-00 (DELL)

No.	Cable Description	Shielding Type	Length (m)	From	To
1	USB Cable	Non-Shielded	1	EUT	NB

2.3 Block Diagram of Test Setup



2.4 Duty Cycle

All measurements are to be performed with the EUT transmitting at 100% duty cycle at its maximum power control level; however, if 100% duty cycle cannot be achieved, measurements of duty cycle, x, and maximum power transmission duration, T, are required for each tested mode of operation.

Configuration	On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Factor (dB)
Zigbee-1.8v	100	100	100	0.00
Zigbee-3.3v	100	100	100	0.00



*Note: Duty Factor = $10 \cdot \log(1/\text{Duty cycle})$

3 Summary of Test Results

FCC/ISED Rules	Description of Test	Result
§15.247(i), §1.1310, §2.1091	Maximum Permissible Exposure (MPE)	Compliance
ISED RSS-102 Sec 2.5.2	Exemption Limits for Routine Evaluation – RF Exposure Evaluation	Compliance
§15.203 ISED RSS-Gen Sec 6.8	Antenna Requirement	Compliance
§15.207(a) ISED RSS-Gen Sec 6.8	AC Line Conducted Emissions	Compliance
§15.205, §15.209, §15.247(d) ISED RSS-Gen Sec 8.9 and 8.10 ISED RSS-247 Sec 5.5	Spurious Emissions	Compliance
§15.247(a)(2) ISED RSS-247 Sec 5.2 ISED RSS-Gen Sec 6.7	6 dB Emission Bandwidth	Compliance
§15.247(b)(3) ISED RSS-247 Sec5.4(d)	Maximum Peak Output Power	Compliance
§15.247(d) ISED RSS-247 Sec 5.5	100 kHz Bandwidth of Frequency Band Edge	Compliance
§15.247(e) ISED RSS-247 Sec 5.2(b)	Power Spectral Density	Compliance

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

4.1 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/4πR² = 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);

4.2 RF Exposure Evaluation Result

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)			
BLE	2402-2480	1.00	1.2589	21.00	125.8925	20	0.0315	1
Zigbee	2405-2480	1.00	1.2589	20.00	100.0000	20	0.0397	1
Wi-Fi 2.4G	2412-2462	1.00	1.2589	22.00	158.4893	20	0.0251	1

Result: MPE evaluation meet 20 cm the requirement of standard.

5 RSS-102 Sec 2.5.2- Exemption Limits for Routine Evaluation – RF Exposure Evaluation

5.1 Applicable Standard

According to subpart RSS-102 Sec 2.5.2,

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz⁶ and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

5.2 RF Exposure Evaluation Result

BLE Max tune-up conducted output power is 21 dBm (125.8925 mW) at 2402 MHz, Antenna Gain = 1 dBi, EIRP = 22 dBm (0.1585 W), so the maximum conducted and E.I.R.P. source-based, time-averaged output is less than 2.68 W for general public use.

Zigbee Max tune-up conducted output power is 20 dBm (100.0000 mW) at 2405 MHz, Antenna Gain = 1 dBi, EIRP = 21 dBm (0.1259 W), so the maximum conducted and E.I.R.P. source-based, time-averaged output is less than 2.68 W for general public use.

Wi-Fi 2.4G Max tune-up conducted output power is 22 dBm (158.4893 mW) at 2437 MHz, Antenna Gain = 1 dBi, EIRP = 23 dBm (0.1995 W), so the maximum conducted and E.I.R.P. source-based, time-averaged output is less than 2.70 W for general public use.

Note: Wi-Fi, BT and Zigbee can't simultaneously.

Result: MPE test exempted.

6 FCC §15.203 and RSS-247 Sec 6.8 - Antenna Requirements

6.1 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 does not exceed 6dBi

According to RSS-Gen 6.3: Transmitter Antenna for Licence-Exempt Radio Apparatus

The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the licence-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.

Licence-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the licence-exempt apparatus.

Testing shall be performed using the highest gain antenna of each combination of licence-exempt transmitter and antenna type, with the transmitter output power set at the maximum level. Footnote8 When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device’s antenna shall be stated, based on a measurement or on data from the antenna manufacturer.

User manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:

This radio transmitter (identify the device by certification number) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi).

6.2 Antenna List and Details

Brand	Model	Antenna Type	Antenna Gain	Result
Redpine	Redpine Chip	Chip Antenna	1.00 dBi	Compliance

The EUT has an internal antenna arrangement, which was permanently attached, fulfill the requirement of this section.

7 FCC §15.207 and RSS-Gen Sec 6.8 - AC Line Conducted Emissions

7.1 Applicable Standard

According to FCC §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.

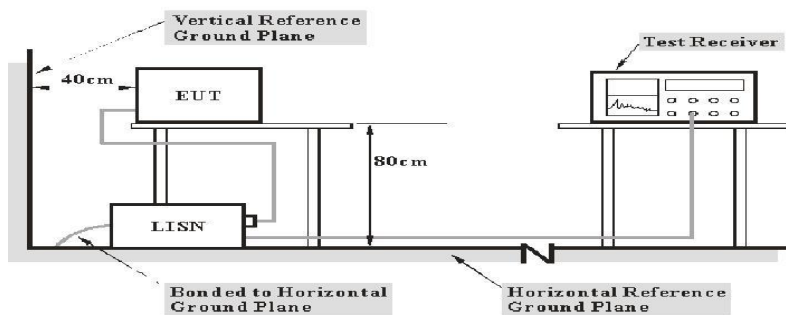
According to RSS-Gen 8.8 Conducted limits:

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 (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56 ^{Note 1}	56 to 46 ^{Note 2}
0.5-5	56	46
5-30	60	50

Note 1: Decreases with the logarithm of the frequency. Note 2: A linear average detector is required

7.2 EUT Setup and Test Procedure



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

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	Receiver RBW
150 kHz - 30 MHz	9 kHz

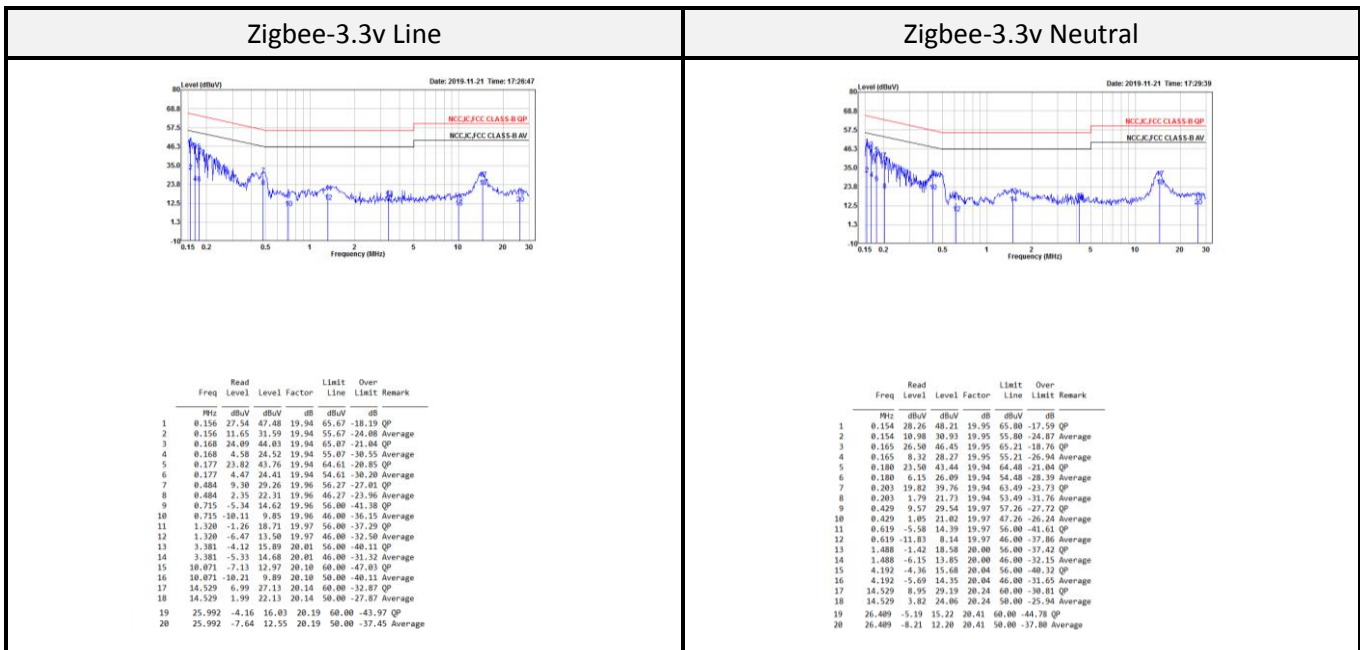
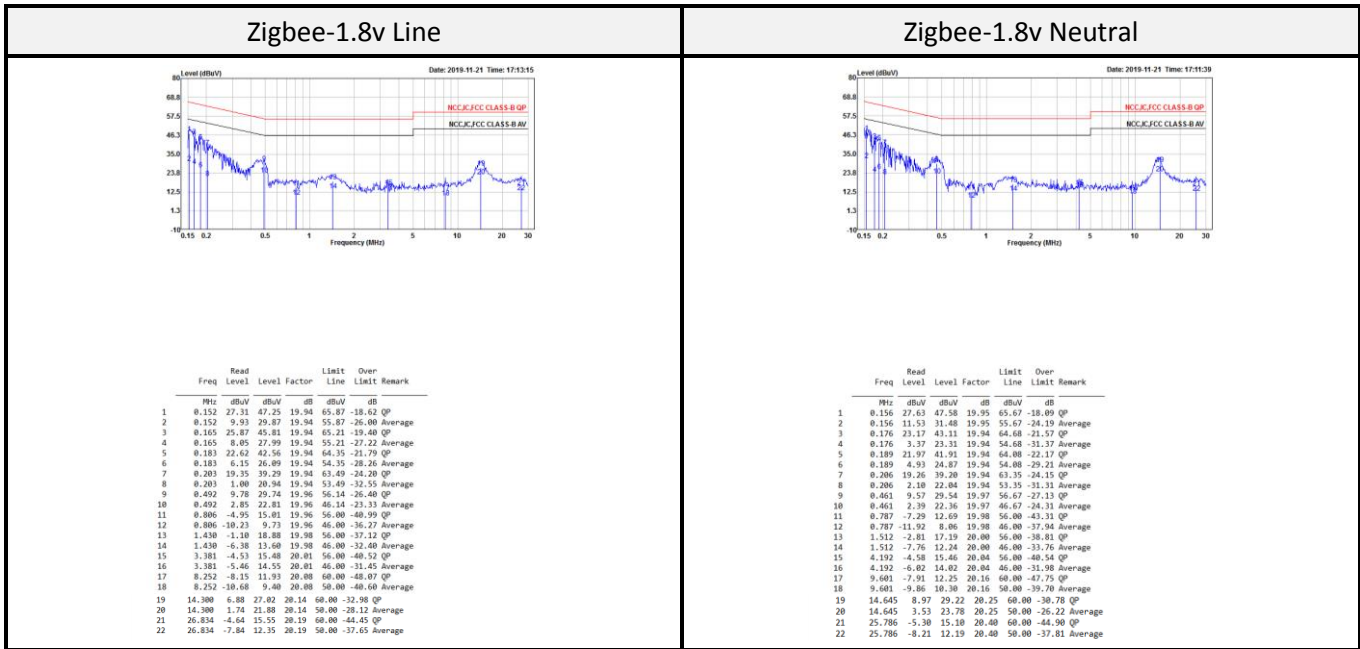
During the conducted emission test, the adapter was connected to the outlet of the LISN. Maximizing procedure was performed on the six (6) highest emissions of the EUT. All data was recorded in the Quasi-peak and average detection mode.

7.3 Test Equipment List and Details

Description	Manufacture	Model	Serial No.	Cal. Date.	Cal. Due.
AC Line Conduction Room (CON-01)					
Two-Line V-Network	Rohde & Schwarz	ENV216	100010	2019/09/02	2020/09/01
Pulse Limiter	SCHWARZBECK	VSTD 9561-F	00432	2019/08/28	2020/08/27
ESR EMI Test Receiver	Rohde & Schwarz	ESR3	102430	2019/03/27	2020/03/26
RF Cable	EMCI	EMCCFD300-BM-BM-8000	180526	2019/08/08	2020/08/07
Software	Audix	e3 v9	E3LK-03	N.C.R	N.C.R

***Statement of Traceability:** The testing equipment's listed above have finished the calibration by Electronics Testing Center, Taiwan (ETC) or other laboratories which were accredited by TAF or equivalent organizations. The calibration result could be traceable to the International System of Units (SI).

7.4 Test Data and Test Plot



Note:

Level = Reading Level + Correct Factor

Over Limit = Level – Limit

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

8 FCC §15.209, §15.205, §15.247(d) and RSS-Gen Sec 8.9, 8.10 and RSS-247 Sec 5.5– Spurious Emissions

8.1 Applicable Standard

As per FCC §15.35(d): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1MHz.

As Per FCC §15.205(a) except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	13.36-13.41	399.9-410	4.5-5.15
0.495-0.505	16.42-16.423	608-614	5.35-5.46
2.1735-2.1905	16.69475-16.69525	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per FCC §15.247 (d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, 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 20dB. 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)).

As per RSS-Gen 8.9,

Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits shown in Table 4 and Table 5 below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

Table 4 – General Field Strength Limits for Licence-Exempt Transmitters at Frequencies Above 30 MHz

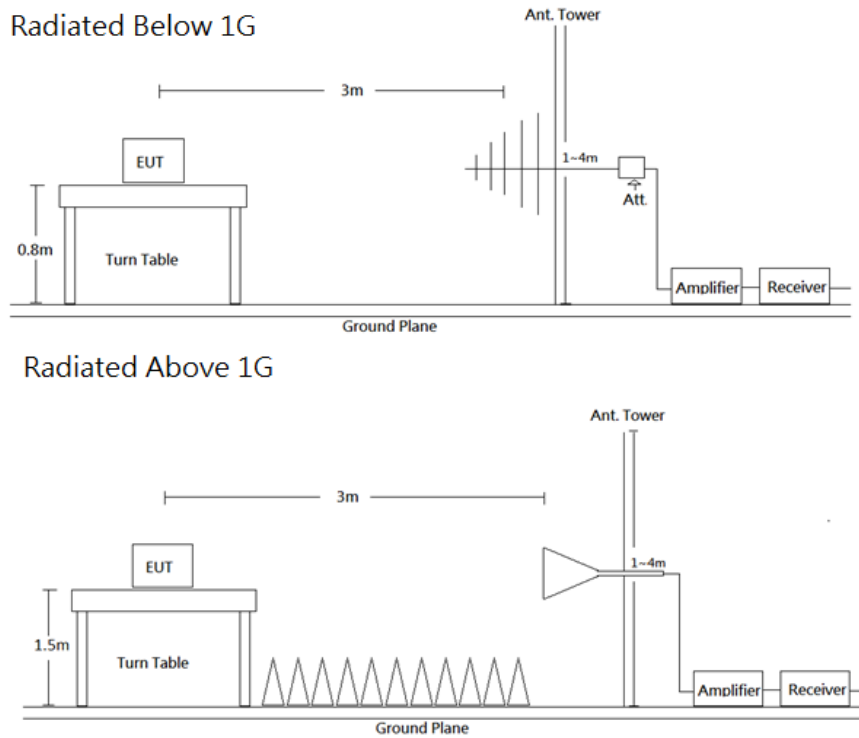
Frequency (MHz)	Field Strength ($\mu\text{v/m}$ at 3 metres)
30-88	100
88-216	150
216-960	200
Above 960*	500

* Unless otherwise specified, for all frequencies greater than 1 GHz, the radiated emission limits for licence-exempt radio apparatus stated in applicable RSSs (including RSS-Gen) are based on measurements using a linear average detector function having a minimum resolution bandwidth of 1 MHz. If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for such factors as pulse desensitization to ensure the peak emission is less than 20 dB above the average limit.

Note: Transmitting devices are not permitted in restricted frequency bands unless stated otherwise in the specific RSS.

As per RSS-247 §5.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

8.2 EUT Setup and Test Procedure



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.

The system was investigated from 30 MHz to 26.5 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	Duty cycle	Measurement method
30-1000 MHz	120 kHz	/	-	QP
Above 1 GHz	1 MHz	3 MHz	-	PK
	1 MHz	10 Hz	>98%	Ave
	1 MHz	1/T	<98%	Ave

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.

8.3 Test Equipment List and Details

Description	Manufacture	Model	Serial No.	Cal. Date.	Cal. Due.
Radiation 3M Room (966A)					
Active Loop	EMCO	6502	0001-3322	2019/03/15	2020/03/14
Bilog Antenna/6 dB Attenuator	SUNOL SCIENCES & EMEC /EMCI	JB3/N-6-06	A111513/AT-N0668	2019/03/29	2020/03/28
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	101434	2019/04/17	2020/04/16
Horn Antenna	ETS-Lindgren	3115	00109141	2019/07/05	2020/07/04
Horn Antenna	ETS-Lindgren	3160-09	00123852	2019/07/11	2020/07/10
Preamplifier	A.H. Systems	PAM-1840VH	174	2019/02/18	2020/02/17
Preamplifier	A.H. Systems	PAM-0118	478	2019/03/28	2020/03/27
Microflex Cable (1m)	EMCI	EMC106-SM-SM-2000	180515	2019/08/07	2020/08/06
Microflex Cable (2m)	MTJ	H0919	00000-MT28A-100	2019/08/07	2020/08/06
Microflex Cable (8m)	UTIFLEX	UFA210A-1-3149-300300	MFR 64639 232490-001	2019/08/07	2020/08/06
Turn Table	Chaintek	T-200-S-1	003501	N.C.R	N.C.R
Antenna Tower	Chaintek	MBD-400-1	003504	N.C.R	N.C.R
Controller	Chaintek	3000-1	003507	N.C.R	N.C.R
Software	Audix	e3 v9	E3LK-01	N.C.R	N.C.R
Conducted Room(TH-02)					
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	101457	2019/06/24	2020/06/23
Cable	MTJ	MT40S	620620-MT40S-100	2018/12/28	2019/12/27

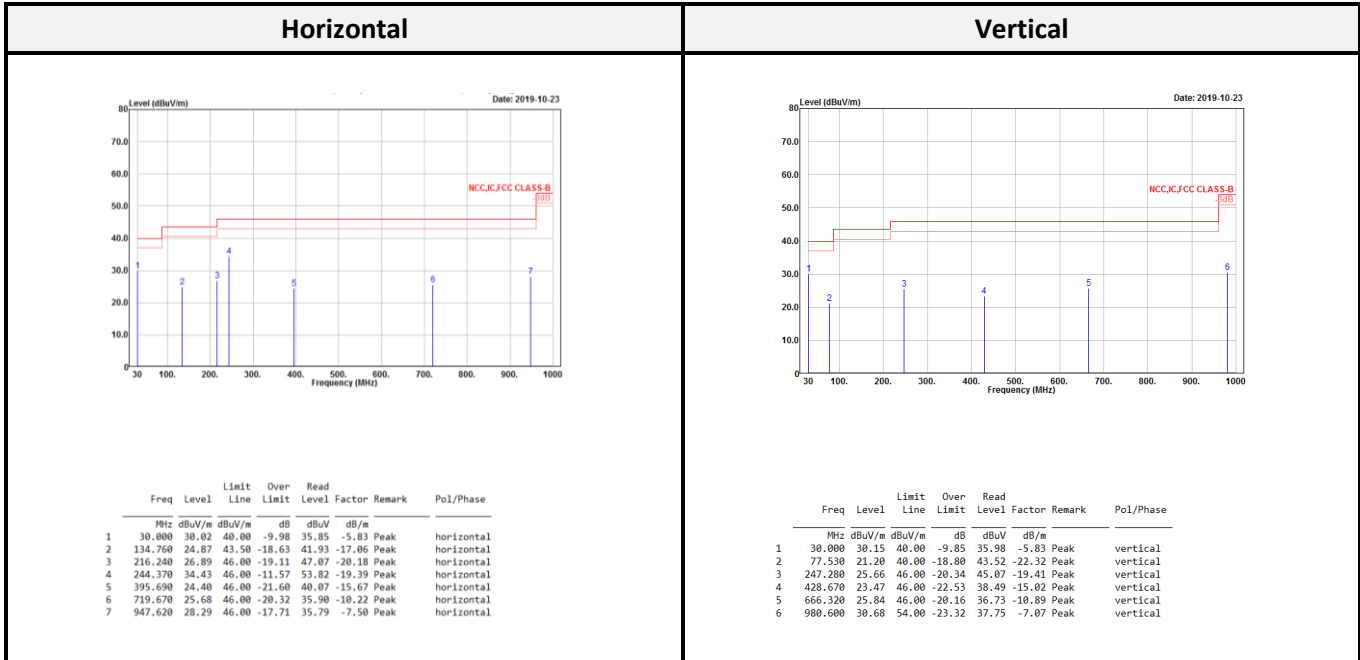
***Statement of Traceability:** The testing equipment's listed above have finished the calibration by Electronics Testing Center, Taiwan (ETC) or other laboratories which were accredited by TAF or equivalent organizations. The calibration result could be traceable to the International System of Units (SI).

8.4 Test Result

<Chip Antenna 1.8V>

Transmitting mode (Pre-scan with three orthogonal axis, and worse case as Z axis)

Below 1G (30 MHz-1 GHz) test the worst mode



Level = Reading Level + Correct Factor

Over Limit = Level – Limit

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

Spurious emissions more than 20 dB below the limit were not reported

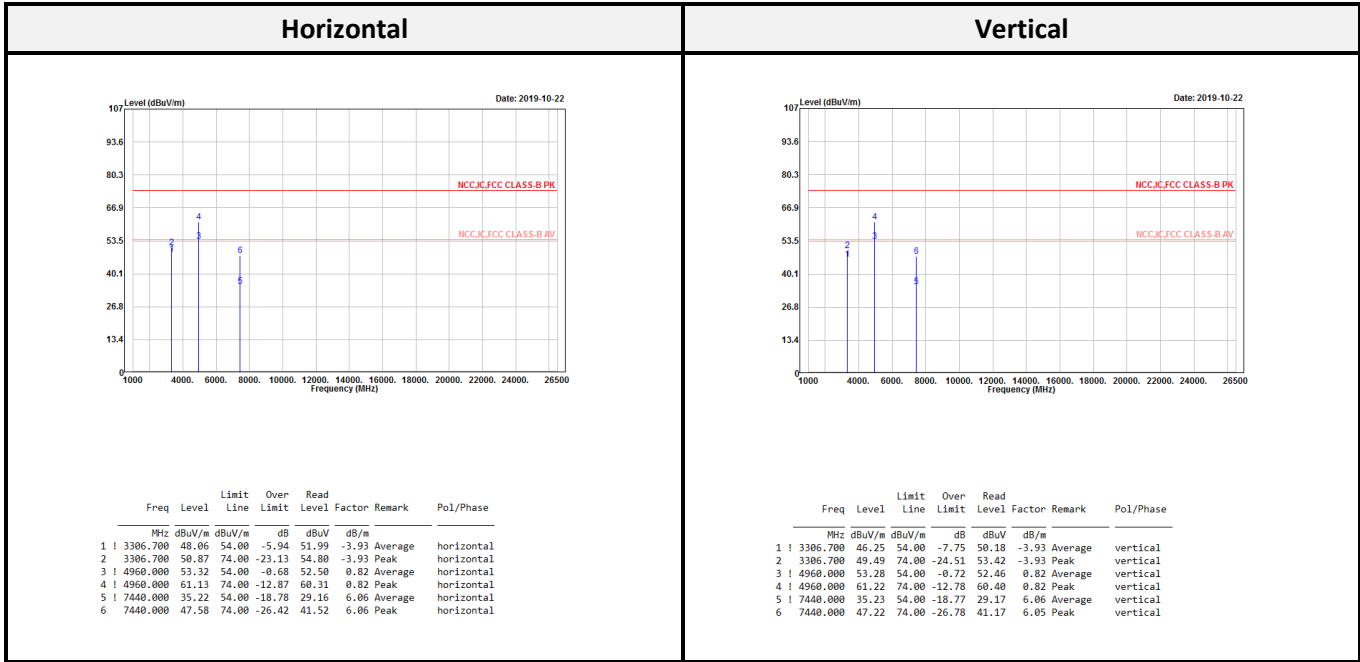
Above 1G (1 GHz-26.5 GHz)

Low CH													
Horizontal							Vertical						
Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark	Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark
MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m		MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m	
2365.488	49.01	54.00	-4.99	56.71	-7.70	Average	2364.570	42.06	54.00	-11.94	49.76	-7.70	Average
2365.488	59.02	74.00	-14.98	66.72	-7.70	Peak	2364.570	53.01	74.00	-20.99	60.71	-7.70	Peak
2404.656	107.49			115.10	-7.61	Average	2404.656	98.49			106.10	-7.61	Average
2404.656	111.86			119.47	-7.61	Peak	2404.656	102.95			110.56	-7.61	Peak
3206.600	49.62	54.00	-4.38	53.92	-4.30	Average	3206.600	45.57	54.00	-8.43	49.87	-4.30	Average
3206.600	51.26	74.00	-22.74	55.56	-4.30	Peak	3206.600	48.63	74.00	-25.37	52.93	-4.30	Peak
4810.000	47.37	54.00	-6.63	46.75	0.62	Average	4810.000	45.14	54.00	-8.86	44.52	0.62	Average
4810.000	55.29	74.00	-18.71	54.67	0.62	Peak	4810.000	53.28	74.00	-20.72	52.66	0.62	Peak
7315.000	35.08	54.00	-18.92	29.42	5.66	Average	7215.000	34.73	54.00	-19.27	29.44	5.29	Average
7315.000	46.75	74.00	-27.25	41.09	5.66	Peak	7215.000	47.73	74.00	-26.27	42.44	5.29	Peak

Middle CH													
Horizontal							Vertical						
Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark	Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark
MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m		MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m	
2383.084	40.48	54.00	-13.52	48.12	-7.64	Average	2370.258	37.52	54.00	-16.48	45.20	-7.68	Average
2383.084	53.51	74.00	-20.49	61.15	-7.64	Peak	2370.258	52.04	74.00	-21.96	59.72	-7.68	Peak
2439.712	106.41			113.93	-7.52	Average	2440.680	95.27			102.79	-7.52	Average
2439.712	110.93			118.45	-7.52	Peak	2440.680	99.81			107.33	-7.52	Peak
2485.208	39.61	54.00	-14.39	46.95	-7.34	Average	2518.604	37.71	54.00	-16.29	44.98	-7.27	Average
2485.208	52.55	74.00	-21.45	59.89	-7.34	Peak	2518.604	51.49	74.00	-22.51	58.76	-7.27	Peak
3253.300	48.30	54.00	-5.70	52.37	-4.07	Average	3253.300	46.69	54.00	-7.31	50.76	-4.07	Average
3253.300	50.22	74.00	-23.78	54.29	-4.07	Peak	3253.300	49.62	74.00	-24.38	53.69	-4.07	Peak
4880.000	51.81	54.00	-2.19	51.01	0.80	Average	4880.000	51.59	54.00	-2.41	50.79	0.80	Average
4880.000	59.16	74.00	-14.84	58.36	0.80	Peak	4880.000	59.70	74.00	-14.30	58.90	0.80	Peak
7320.000	35.08	54.00	-18.92	29.38	5.70	Average	7320.000	35.71	54.00	-18.29	30.01	5.70	Average
7320.000	47.47	74.00	-26.53	41.77	5.70	Peak	7320.000	47.73	74.00	-26.27	42.03	5.70	Peak

High CH													
Horizontal							Vertical						
Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark	Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark
MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m		MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m	
2479.440	104.96			112.31	-7.35	Average	2479.520	94.79			102.14	-7.35	Average
2479.440	109.76			117.11	-7.35	Peak	2479.520	99.19			106.54	-7.35	Peak
2483.520	50.29	54.00	-3.71	57.63	-7.34	Average	2483.500	41.97	54.00	-12.03	49.31	-7.34	Average
2483.520	62.44	74.00	-11.56	69.78	-7.34	Peak	2483.500	54.04	74.00	-19.96	61.38	-7.34	Peak
3306.700	48.06	54.00	-5.94	51.99	-3.93	Average	3306.700	46.25	54.00	-7.75	50.18	-3.93	Average
3306.700	50.87	74.00	-23.13	54.80	-3.93	Peak	3306.700	49.49	74.00	-24.51	53.42	-3.93	Peak
4960.000	53.32	54.00	-0.68	52.50	0.82	Average	4960.000	53.28	54.00	-0.72	52.46	0.82	Average
4960.000	61.13	74.00	-12.87	60.31	0.82	Peak	4960.000	61.22	74.00	-12.78	60.40	0.82	Peak
7440.000	35.22	54.00	-18.78	29.16	6.06	Average	7440.000	35.23	54.00	-18.77	29.17	6.06	Average
7440.000	47.58	74.00	-26.42	41.52	6.06	Peak	7440.000	47.22	74.00	-26.78	41.17	6.05	Peak

Above 1G (1 GHz-26.5 GHz): The worst mode



Level = Reading Level + Correct Factor

Over Limit = Level – Limit

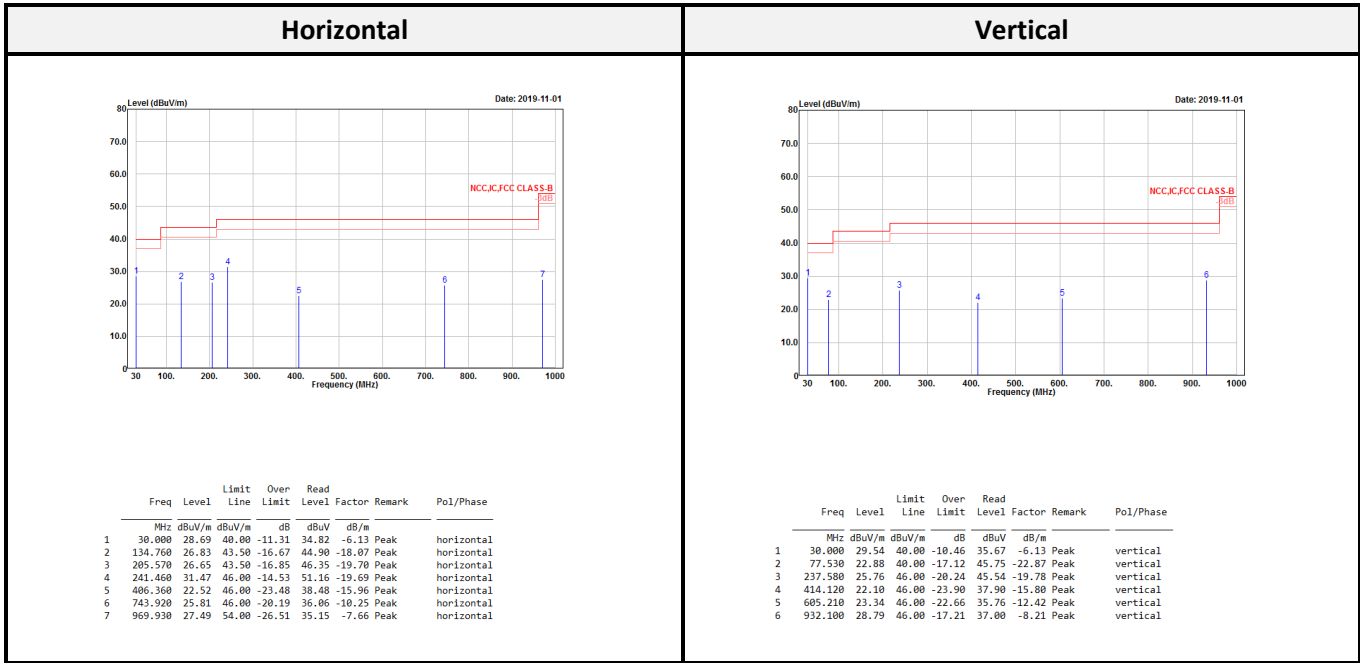
Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

Spurious emissions more than 20 dB below the limit were not reported

<Chip Antenna 3.3V>

Transmitting mode (Pre-scan with three orthogonal axis, and worse case as Z axis)

Below 1G (30 MHz-1 GHz) test the worst mode



Level = Reading Level + Correct Factor

Over Limit = Level – Limit

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

Spurious emissions more than 20 dB below the limit were not reported

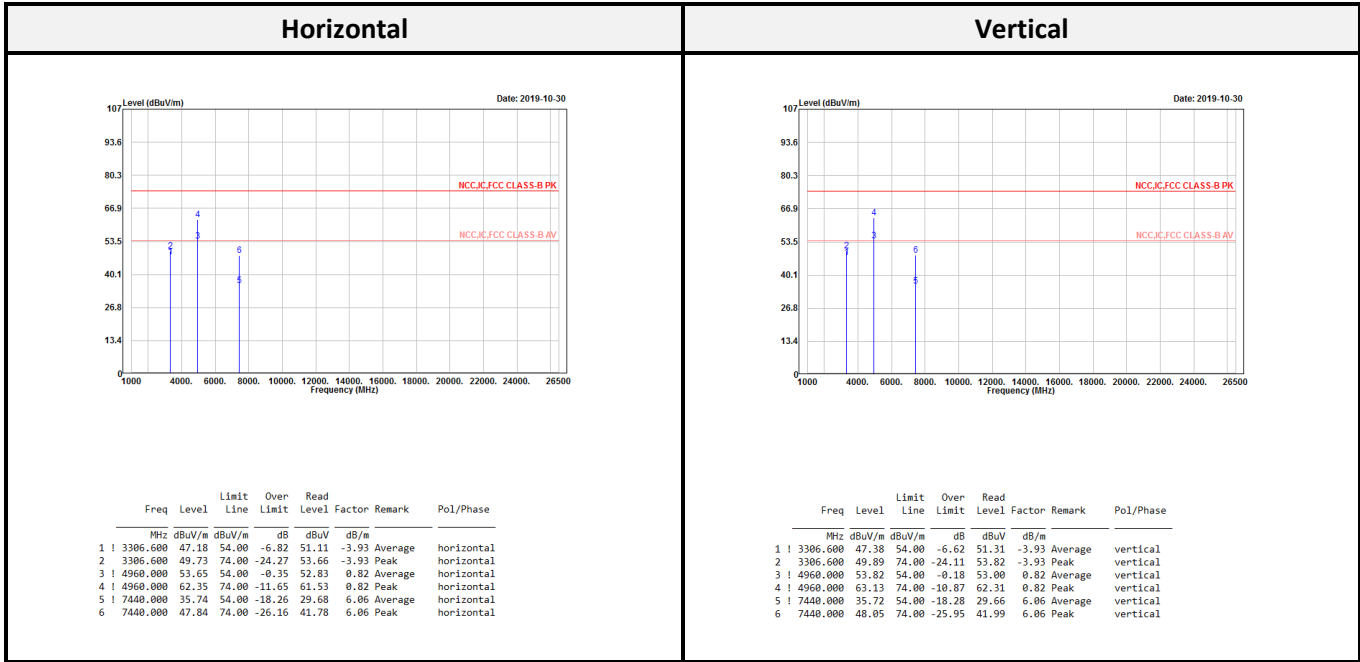
Above 1G (1 GHz-26.5 GHz)

Low CH													
Horizontal							Vertical						
Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark	Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark
MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m		MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m	
2364.468	49.94	54.00	-4.06	57.64	-7.70	Average	2365.386	42.04	54.00	-11.96	49.74	-7.70	Average
2364.468	59.56	74.00	-14.44	67.26	-7.70	Peak	2365.386	53.86	74.00	-20.14	61.56	-7.70	Peak
2404.554	108.66			116.27	-7.61	Average	2405.574	99.62			107.23	-7.61	Average
2404.554	113.38			120.99	-7.61	Peak	2405.574	104.45			112.06	-7.61	Peak
3206.600	49.26	54.00	-4.74	53.56	-4.30	Average	3206.600	46.98	54.00	-7.02	51.28	-4.30	Average
3206.600	51.20	74.00	-22.80	55.50	-4.30	Peak	3206.600	49.12	74.00	-24.88	53.42	-4.30	Peak
4810.000	50.20	54.00	-3.80	49.58	0.62	Average	4810.000	48.52	54.00	-5.48	47.90	0.62	Average
4810.000	58.43	74.00	-15.57	57.81	0.62	Peak	4810.000	57.16	74.00	-16.84	56.54	0.62	Peak
7215.000	40.40	54.00	-13.60	35.11	5.29	Average	7215.000	41.87	54.00	-12.13	36.58	5.29	Average
7215.000	52.20	74.00	-21.80	46.91	5.29	Peak	7215.000	52.90	74.00	-21.10	47.61	5.29	Peak

Middle CH													
Horizontal							Vertical						
Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark	Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark
MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m		MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m	
2386.230	42.19	54.00	-11.81	49.83	-7.64	Average	2341.702	37.56	54.00	-16.44	45.33	-7.77	Average
2386.230	56.25	74.00	-17.75	63.89	-7.64	Peak	2341.702	51.33	74.00	-22.67	59.10	-7.77	Peak
2440.680	107.18			114.70	-7.52	Average	2440.680	96.90			104.42	-7.52	Average
2440.680	112.03			119.55	-7.52	Peak	2440.680	101.82			109.34	-7.52	Peak
2497.792	40.61	54.00	-13.39	47.93	-7.32	Average	2525.622	37.86	54.00	-16.14	45.11	-7.25	Average
2497.792	54.13	74.00	-19.87	61.45	-7.32	Peak	2525.622	51.75	74.00	-22.25	59.00	-7.25	Peak
3253.300	48.47	54.00	-5.53	52.54	-4.07	Average	3253.300	47.50	54.00	-6.50	51.57	-4.07	Average
3253.300	50.76	74.00	-23.24	54.83	-4.07	Peak	3253.300	49.77	74.00	-24.23	53.84	-4.07	Peak
4880.000	53.78	54.00	-0.22	52.98	0.80	Average	4880.000	53.81	54.00	-0.19	53.01	0.80	Average
4880.000	63.13	74.00	-10.87	62.33	0.80	Peak	4880.000	62.91	74.00	-11.09	62.11	0.80	Peak
7320.000	35.80	54.00	-18.20	30.10	5.70	Average	7320.000	35.92	54.00	-18.08	30.22	5.70	Average
7320.000	48.60	74.00	-25.40	42.90	5.70	Peak	7320.000	48.29	74.00	-25.71	42.59	5.70	Peak

High CH													
Horizontal							Vertical						
Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark	Freq	Level	Limit Line	Over Limit	Read Level	Factor	Remark
MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m		MHz	dBuV/m	dBuV/m	dB	dBuV	dB/m	
2480.480	100.31			107.66	-7.35	Average	2480.480	90.42			97.77	-7.35	Average
2480.480	105.25			112.60	-7.35	Peak	2480.480	95.40			102.75	-7.35	Peak
2483.500	45.27	54.00	-8.73	52.61	-7.34	Average	2483.500	39.16	54.00	-14.84	46.50	-7.34	Average
2483.500	56.32	74.00	-17.68	63.66	-7.34	Peak	2483.500	51.44	74.00	-22.56	58.78	-7.34	Peak
3306.600	47.18	54.00	-6.82	51.11	-3.93	Average	3306.600	47.38	54.00	-6.62	51.31	-3.93	Average
3306.600	49.73	74.00	-24.27	53.66	-3.93	Peak	3306.600	49.89	74.00	-24.11	53.82	-3.93	Peak
4960.000	53.65	54.00	-0.35	52.83	0.82	Average	4960.000	53.82	54.00	-0.18	53.00	0.82	Average
4960.000	62.35	74.00	-11.65	61.53	0.82	Peak	4960.000	63.13	74.00	-10.87	62.31	0.82	Peak
7440.000	35.74	54.00	-18.26	29.68	6.06	Average	7440.000	35.72	54.00	-18.28	29.66	6.06	Average
7440.000	47.84	74.00	-26.16	41.78	6.06	Peak	7440.000	48.05	74.00	-25.95	41.99	6.06	Peak

Above 1G (1 GHz-26.5 GHz): The worst mode



Level = Reading Level + Correct Factor

Over Limit = Level – Limit

Correct Factor = Antenna Factor + Cable Loss – Amplifier Gain

Spurious emissions more than 20 dB below the limit were not reported

Conducted Spurious Emissions:

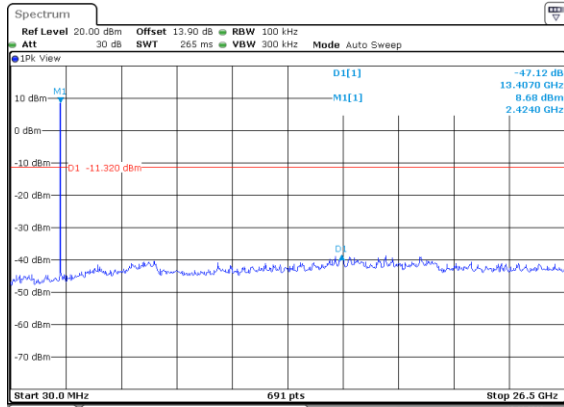
<Chip Antenna 1.8V>

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Zigbee mode				
Low	2405	47.12	≥ 20	Compliance
Mid	2440	46.14	≥ 20	Compliance
High	2480	45.82	≥ 20	Compliance

<Chip Antenna 3.3V>

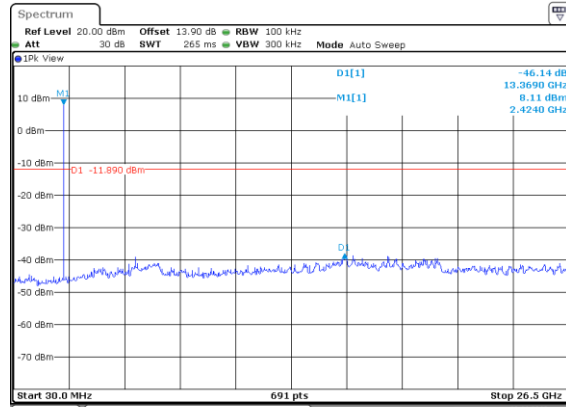
Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Zigbee mode				
Low	2405	50.18	≥ 20	Compliance
Mid	2440	48.76	≥ 20	Compliance
High	2480	41.75	≥ 20	Compliance

Zigbee-1.8v Low CH



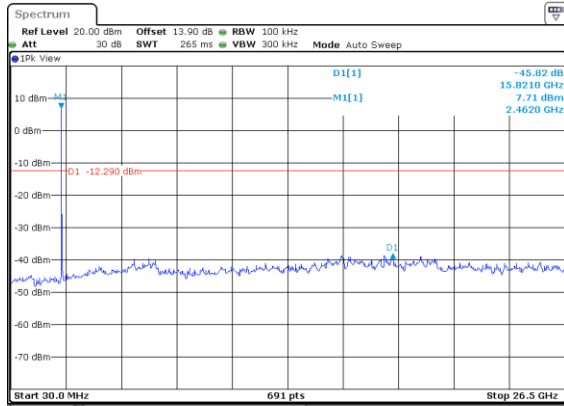
Date: 13.NOV.2019 18:03:33

Zigbee-1.8v Middle CH



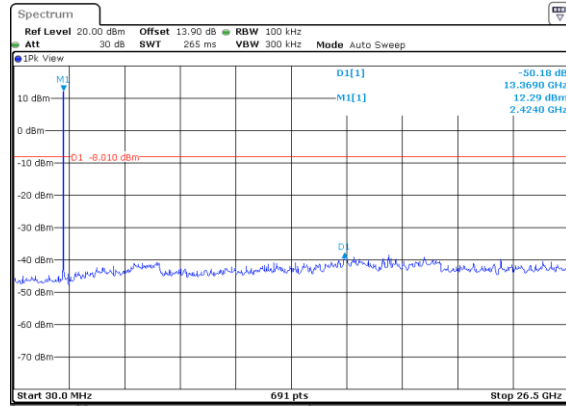
Date: 13.NOV.2019 18:06:00

Zigbee-1.8v High CH



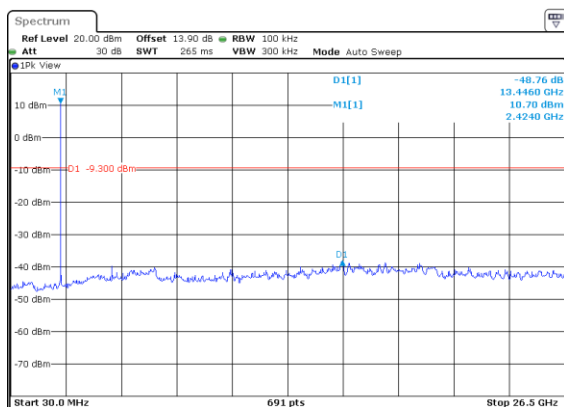
Date: 13.NOV.2019 18:07:57

Zigbee-3.3v Low CH



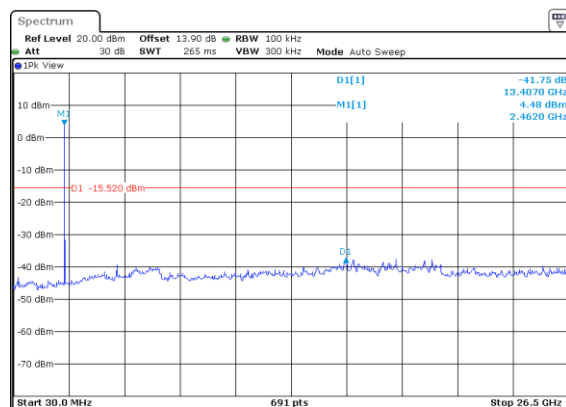
Date: 11.NOV.2019 19:17:53

Zigbee-3.3v Middle CH



Date: 11.NOV.2019 19:19:31

Zigbee-3.3v High CH



Date: 11.NOV.2019 19:22:33

9 FCC §15.247(a)(2) and RSS-247 Sec 5.2– 6 dB Emission Bandwidth and RSS-Gen Sec 6.7 99% OBW

9.1 Applicable Standard

According to FCC §15.247(a) (2),

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

According to RSS-247 §5.2 a),

The minimum 6 dB bandwidth shall be 500 kHz.

According to RSS-Gen §6.7,

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “x dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated x dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.
- The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

9.2 Test Procedure

6 dB Emission Bandwidth

According to ANSI C63.10-2013, the steps for the first option are as follows:

- (1) Set RBW = 100 kHz. (2) Set the VBW $\geq [3 \times \text{RBW}]$. (3) Detector = peak. (4) Trace mode = max hold.
- (5) Sweep = auto couple. (6) Allow the trace to stabilize. (7) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

99% Emission Bandwidth

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

The following procedure shall be used for measuring 99% power bandwidth:

- a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (\text{OBW}/\text{RBW})]$ below the reference level. Specific guidance is given in 4.1.5.2.
- d) Step a) through step c) might require iteration to adjust within the specified range.

- e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.
- f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.
- g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.
- h) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

9.3 Test Equipment List and Details

Description	Manufacture	Model	Serial No.	Cal. Date.	Cal. Due.
Conducted Room(TH-02)					
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	101457	2019/06/24	2020/06/23
Cable	MTJ	MT40S	620620-MT40S-100	2018/12/28	2019/12/27

***Statement of Traceability:** *The testing equipment's listed above have finished the calibration by Electronics Testing Center, Taiwan (ETC) or other laboratories which were accredited by TAF or equivalent organizations. The calibration result could be traceable to the International System of Units (SI).*

9.4 Test Results

<Chip Antenna 1.8V>

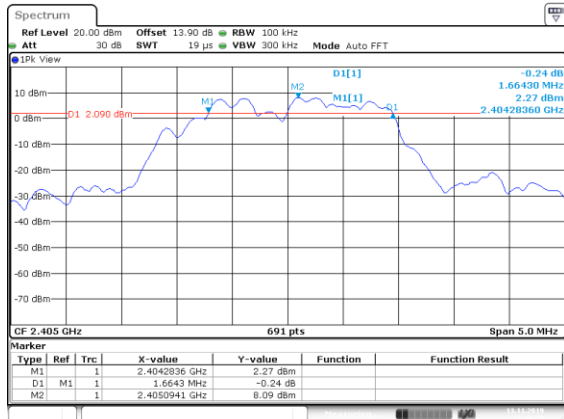
Channel	Frequency (MHz)	99% OBW (MHz)	6 dB BW (MHz)	6dB Limit (MHz)	Result
Zigbee mode					
Low	2405	2.0550	1.66	> 0.5	Compliance
Middle	2440	2.0550	1.66	> 0.5	Compliance
High	2480	2.0550	1.67	> 0.5	Compliance

<Chip Antenna 3.3V>

Channel	Frequency (MHz)	99% OBW (MHz)	6 dB BW (MHz)	6dB Limit (MHz)	Result
Zigbee mode					
Low	2405	2.0333	1.67	> 0.5	Compliance
Middle	2440	2.0333	1.65	> 0.5	Compliance
High	2480	2.0333	1.66	> 0.5	Compliance

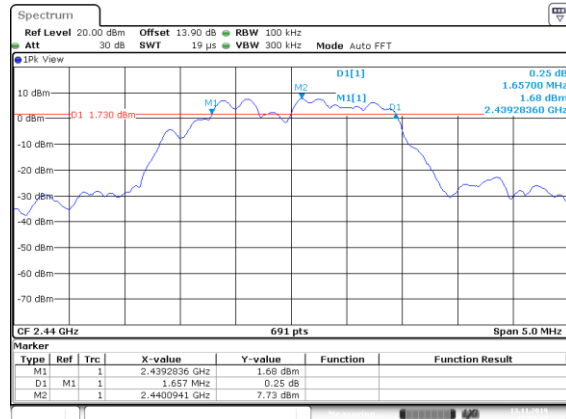
<6 dB BW>

Zigbee-1.8v Low CH



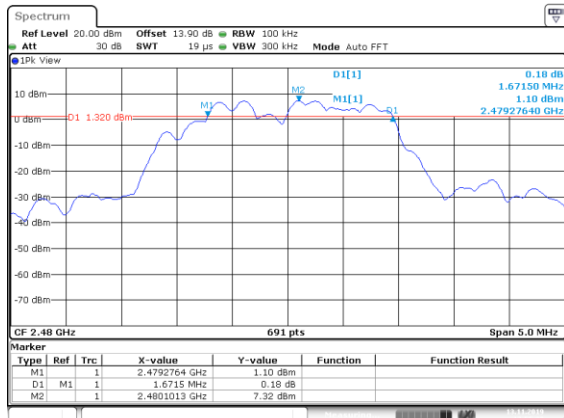
Date: 13.NOV.2019 17:49:50

Zigbee-1.8v Middle CH



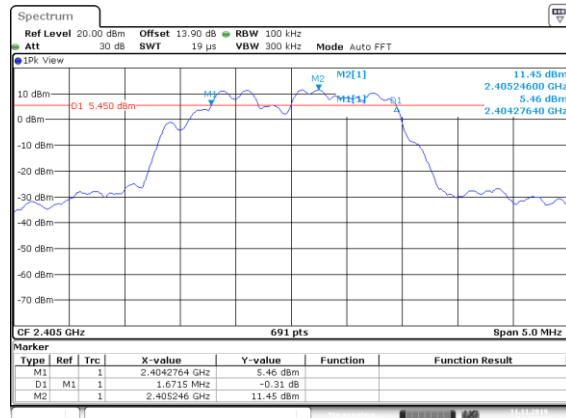
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Zigbee-1.8v High CH



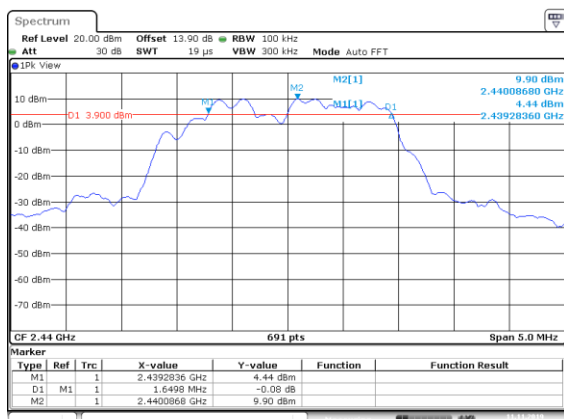
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Zigbee-3.3v Low CH



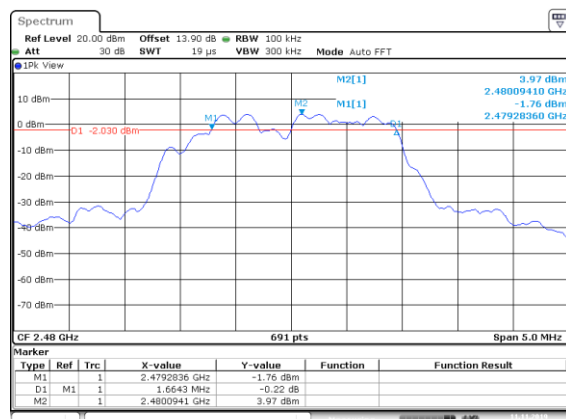
Date: 11.NOV.2019 19:06:05

Zigbee-3.3v Middle CH



Date: 11.NOV.2019 19:08:02

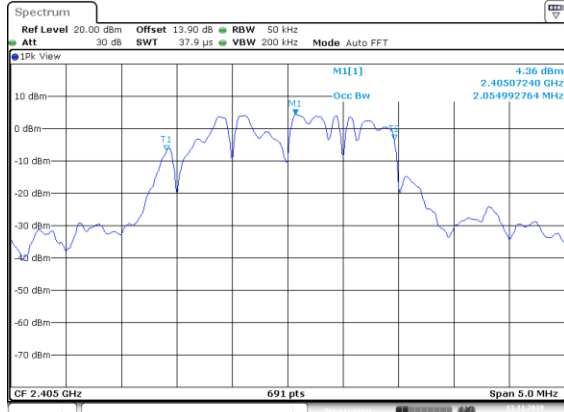
Zigbee-3.3v High CH



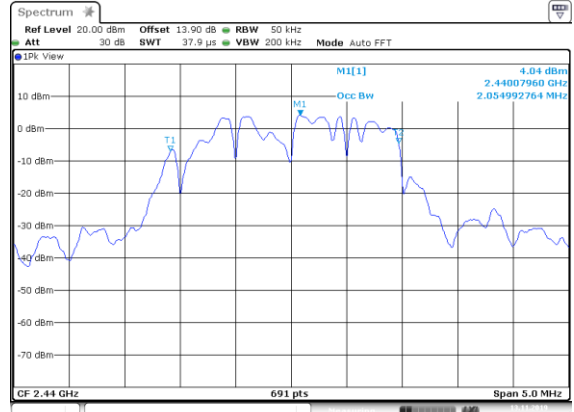
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<99% OBW>

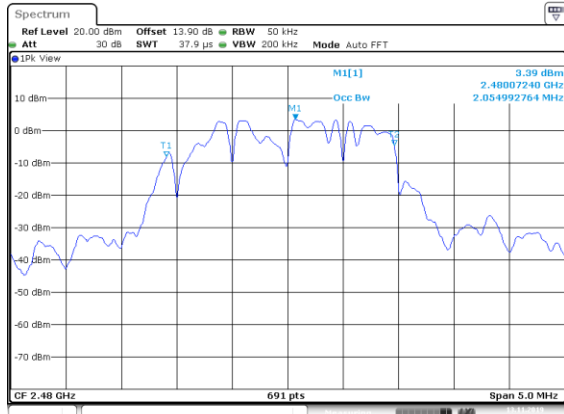
Zigbee-1.8v Low CH



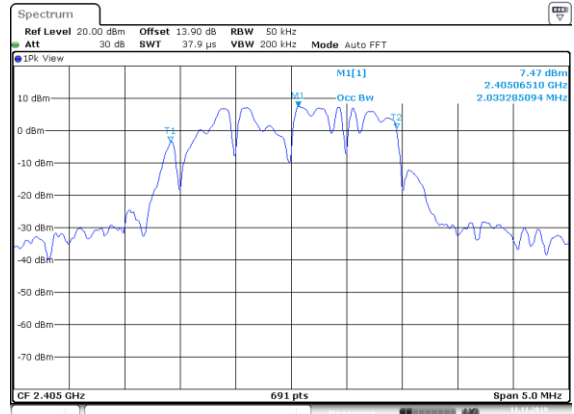
Zigbee-1.8v Middle CH



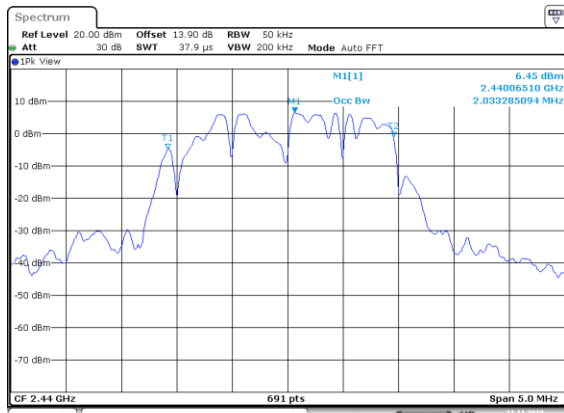
Zigbee-1.8v High CH



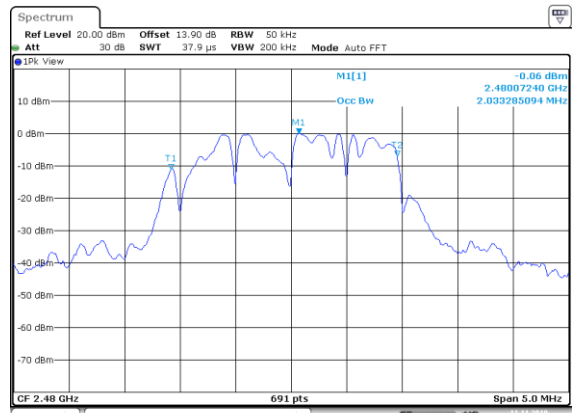
Zigbee-3.3v Low CH



Zigbee-3.3v Middle CH



Zigbee-3.3v High CH



10 FCC §15.247(b) (3) and RSS-247 Sec 5.4(d) – Maximum Output Power

10.1 Applicable Standard

According to FCC §15.247(b) (3),

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.

According to RSS-247 §5.4(d).

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

10.2 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.
- (3). Add a correction factor to the display.

10.3 Test Equipment List and Details

Description	Manufacture	Model	Serial No.	Cal. Date.	Cal. Due.
Conducted Room(TH-02)					
USB Wideband Power Sensor	Agilent	U2021XA	MY54250014	2018/11/22	2019/11/21
Cable	MTJ	MT40S	620620-MT40S-100	2018/12/28	2019/12/27

***Statement of Traceability:** The testing equipment's listed above have finished the calibration by Electronics Testing Center, Taiwan (ETC) or other laboratories which were accredited by TAF or equivalent organizations. The calibration result could be traceable to the International System of Units (SI).

10.4 Test Results

<Chip Antenna 1.8V>

Channel	Frequency (MHz)	Maximum Peak Output Power (dBm)	Maximum Peak Output Power (W)	Limit (dBm)	Result
Zigbee mode					
Low	2405	16.07	0.0405	30	Compliance
Middle	2440	15.85	0.0385	30	Compliance
High	2480	15.38	0.0345	30	Compliance

Channel	Frequency (MHz)	Average Output Power (dBm)	Average Output Power (W)	Limit (dBm)	Result
Zigbee mode					
Low	2405	15.34	0.0342	30	Compliance
Middle	2440	15.08	0.0322	30	Compliance
High	2480	14.56	0.0286	30	Compliance

**Note: Duty Cycle is 100% and Duty Factor is 0 dB.*

<Chip Antenna 3.3V>

Channel	Frequency (MHz)	Maximum Peak Output Power (dBm)	Maximum Peak Output Power (W)	Limit (dBm)	Result
Zigbee mode					
Low	2405	19.58	0.0908	30	Compliance
Middle	2440	18.37	0.0687	30	Compliance
High	2480	12.34	0.0171	30	Compliance

Channel	Frequency (MHz)	Average Output Power (dBm)	Average Output Power (W)	Limit (dBm)	Result
Zigbee mode					
Low	2405	17.75	0.0596	30	Compliance
Middle	2440	16.35	0.0432	30	Compliance
High	2480	10.15	0.0104	30	Compliance

**Note: Duty Cycle is 100% and Duty Factor is 0 dB.*

11 FCC §15.247(d) and RSS-247 Sec 5.5 – 100 kHz Bandwidth of Frequency Band Edge

11.1 Applicable Standard

According to FCC §15.247(d),

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, 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)).

According to RSS-247 §5.5. In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

11.2 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.

11.3 Test Equipment List and Details

Description	Manufacture	Model	Serial No.	Cal. Date.	Cal. Due.
Conducted Room(TH-02)					
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	101457	2019/06/24	2020/06/23
Cable	MTJ	MT40S	620620-MT40S-100	2018/12/28	2019/12/27

****Statement of Traceability:** The testing equipment's listed above have finished the calibration by Electronics Testing Center, Taiwan (ETC) or other laboratories which were accredited by TAF or equivalent organizations. The calibration result could be traceable to the International System of Units (SI).*

11.4 Test Results

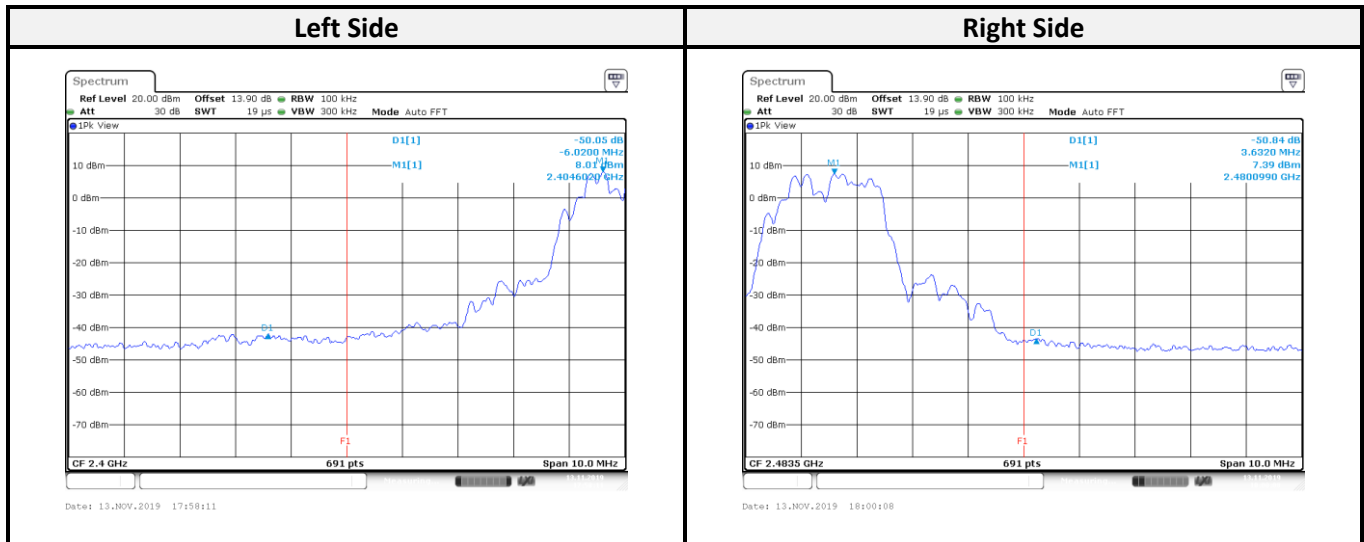
<Chip Antenna 1.8V>

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Zigbee mode				
Low	2405	50.05	≥ 20	Compliance
High	2480	50.84	≥ 20	Compliance

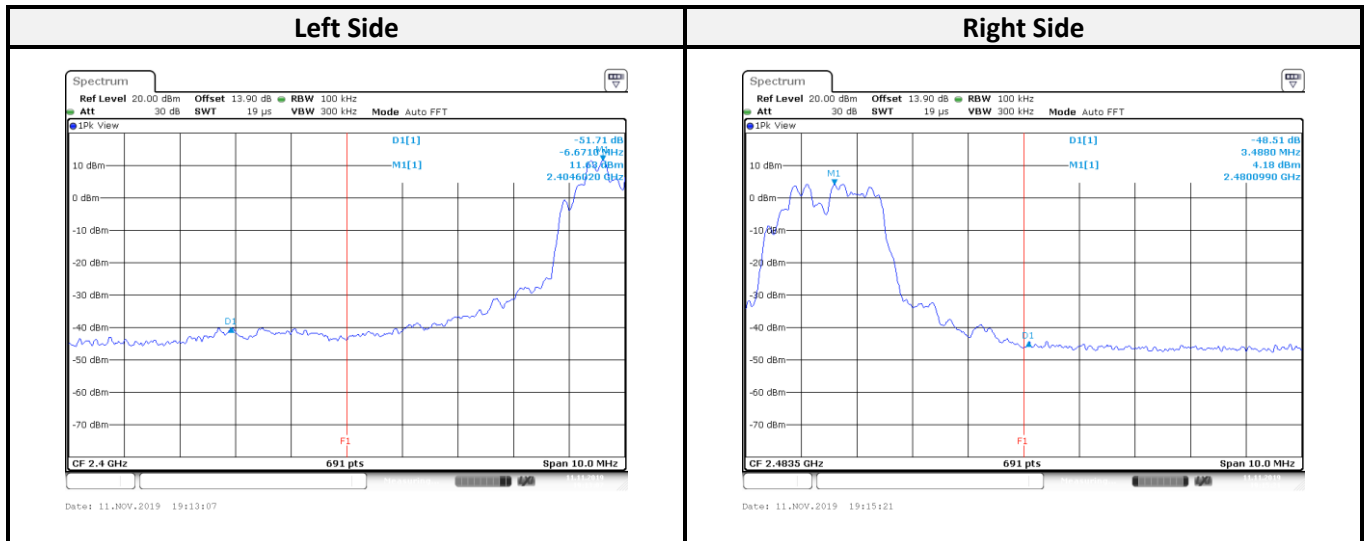
<Chip Antenna 3.3V>

Channel	Frequency (MHz)	Delta Peak to Band Emission (dBc)	Limit (dBc)	Result
Zigbee mode				
Low	2405	51.71	≥ 20	Compliance
High	2480	48.51	≥ 20	Compliance

<Chip Antenna 1.8V>



<Chip Antenna 3.3V>



12 FCC §15.247(e) and RSS-247 Sec 5.2(b) – Power Spectral Density

12.1 Applicable Standard

According to FCC §15.247(e),

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

According to RSS-247 §5.2(b).

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

12.2 Test Procedure

According to ANSI C63.10-2013,

- (1) Set analyzer center frequency to DTS channel center frequency.
- (2) Set the span to 1.5 times the DTS bandwidth. (3) Set the RBW to $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- (4) Set the VBW $\geq [3 \times \text{RBW}]$. (5) Detector = peak. (6) Sweep time = auto couple.
- (7) Trace mode = max hold. (8) Allow trace to fully stabilize.
- (9) Use the peak marker function to determine the maximum amplitude level within the RBW.
- (10) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

12.3 Test Equipment List and Details

Description	Manufacture	Model	Serial No.	Cal. Date.	Cal. Due.
Conducted Room(TH-02)					
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	101457	2019/06/24	2020/06/23
Cable	MTJ	MT40S	620620-MT40S-100	2018/12/28	2019/12/27

***Statement of Traceability:** The testing equipment's listed above have finished the calibration by Electronics Testing Center, Taiwan (ETC) or other laboratories which were accredited by TAF or equivalent organizations. The calibration result could be traceable to the International System of Units (SI).

12.4 Test Results

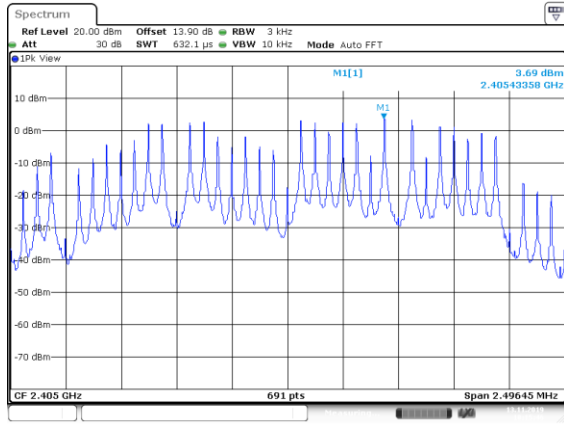
<Chip Antenna 1.8V>

Channel	Frequency (MHz)	PSD (dBm/3 kHz)	Limit (dBm/3 kHz)	Result
Zigbee-1Mbps				
Low	2405	3.69	8	Compliance
Middle	2440	3.21	8	Compliance
High	2480	2.78	8	Compliance

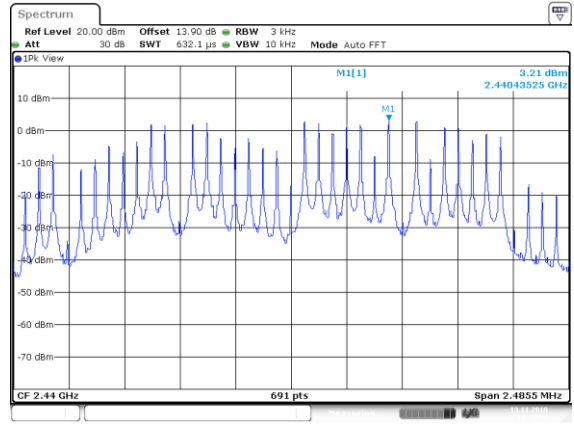
<Chip Antenna 3.3V>

Channel	Frequency (MHz)	PSD (dBm/3 kHz)	Limit (dBm/3 kHz)	Result
Zigbee-1Mbps				
Low	2405	7.22	8	Compliance
Middle	2440	5.67	8	Compliance
High	2480	-0.44	8	Compliance

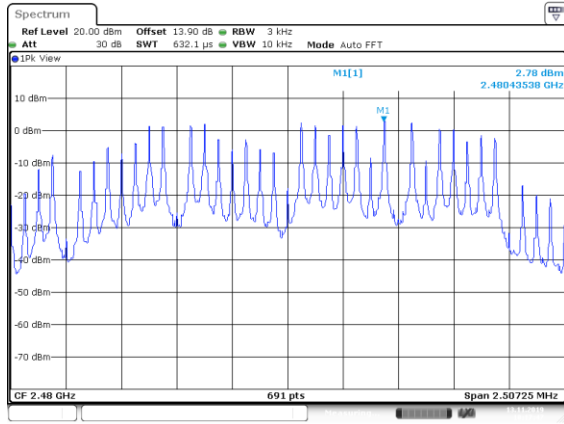
Zigbee-1.8v Low CH



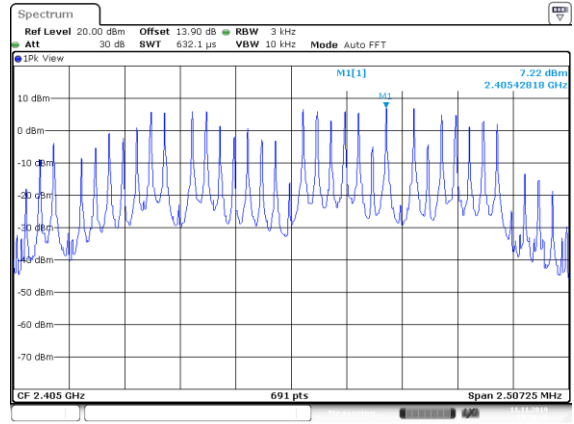
Zigbee-1.8v Middle CH



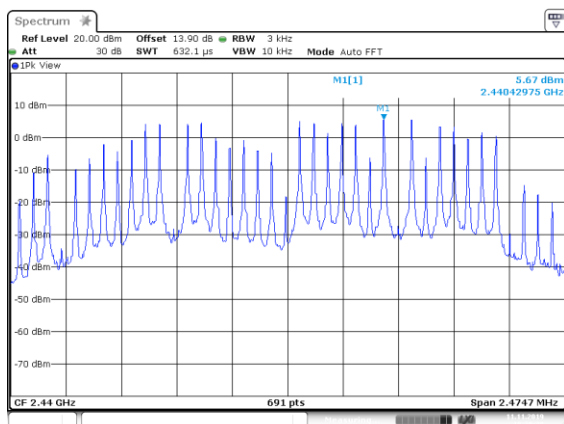
Zigbee-1.8v High CH



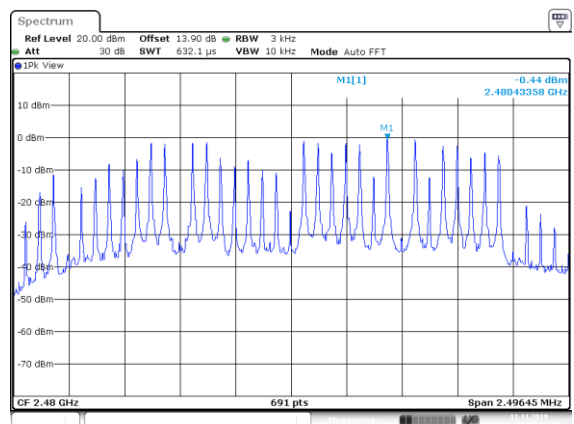
Zigbee-3.3v Low CH



Zigbee-3.3v Middle CH



Zigbee-3.3v High CH



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