



FCC REPORT

Applicant: Shenzhen Friendcom Technology Development Co., Ltd.

Address of Applicant: 5-6 Floor, Building 17, Guangqian Industrial Park, Xili, Nanshan District, Shenzhen, Guangdong Province, China

Equipment Under Test (EUT)

Product Name: LoRaWAN Module

Model No.: WSL05-A0

Trade Mark: Friendcom

FCC ID: UU3FCWSL05-A0

Applicable standards: FCC CFR Title 47 Part 15 Subpart C Section 15.247

Date of sample receipt: 02 Mar., 2021

Date of Test: 02 Mar., to 16 Apr., 2021

Date of report issued: 16 Apr., 2021

Test Result: PASS *

* In the configuration tested, the EUT complied with the standards specified above.

Authorized Signature:



Bruce Zhang
Laboratory Manager

This report details the results of the testing carried out on one sample. The results contained in this test report do not relate to other samples of the same product and does not permit the use of the CCIS product certification mark. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

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2 Version

Version No.	Date	Description
00	31 Mar., 2021	Original
01	16 Apr., 2021	Update Page 5, 12, 14, 16, 18, 20, 21

Tested by:

Yanyo Wu

Date:

16 Apr., 2021

Test Engineer

Reviewed by:

Winner Zhang

Date:

16 Apr., 2021

Project Engineer

3 Contents

	Page
1 COVER PAGE	1
2 VERSION	2
3 CONTENTS	3
4 TEST SUMMARY	4
5 GENERAL INFORMATION	5
5.1 CLIENT INFORMATION	5
5.2 GENERAL DESCRIPTION OF E.U.T.	5
5.3 TEST ENVIRONMENT AND MODE	6
5.4 DESCRIPTION OF SUPPORT UNITS	6
5.5 MEASUREMENT UNCERTAINTY.....	6
5.6 ADDITIONS TO, DEVIATIONS, OR EXCLUSIONS FROM THE METHOD	6
5.7 LABORATORY FACILITY	6
5.8 LABORATORY LOCATION	6
5.9 TEST INSTRUMENTS LIST.....	7
6 TEST RESULTS AND MEASUREMENT DATA	8
6.1 ANTENNA REQUIREMENT.....	8
6.2 CONDUCTED EMISSIONS	9
6.3 CONDUCTED OUTPUT POWER	12
6.4 20dB OCCUPY BANDWIDTH	14
6.5 CARRIER FREQUENCIES SEPARATION.....	16
6.6 HOPPING CHANNEL NUMBER.....	18
6.7 DWELL TIME	20
6.8 PSEUDORANDOM FREQUENCY HOPPING SEQUENCE	22
6.9 BAND EDGE.....	23
6.9.1 Conducted Emission Method	23
6.9.2 Radiated Emission Method	25
6.10 SPURIOUS EMISSION.....	30
6.10.1 Conducted Emission Method.....	30
6.10.2 Radiated Emission Method.....	32
7 TEST SETUP PHOTO	37
8 EUT CONSTRUCTIONAL DETAILS	38

4 Test Summary

Test Items	Section in CFR 47	Result
Antenna Requirement	15.203 & 15.247 (c)	Pass
AC Power Line Conducted Emission	15.207	Pass
Conducted Peak Output Power	15.247 (b)(2)	Pass
20dB Occupied Bandwidth	15.247 (a)(1) (i)	Pass
Carrier Frequencies Separation	15.247 (a)(1)	Pass
Hopping Channel Number	15.247 (a)(1) (i)	Pass
Dwell Time	15.247 (a)(1) (i)	Pass
Spurious Emission	15.205 & 15.209	Pass
<p>Remark:</p> <ol style="list-style-type: none"> 1. Pass: The EUT complies with the essential requirements in the standard. 2. N/A: Not Applicable. 3. The cable insertion loss used by "RF Output Power" and other conduction measurement items is 0.5dB (provided by the customer). 		
Test Method:	ANSI C63.10-2013 KDB 558074 D01 15.247 Meas Guidance v05r02	

5 General Information

5.1 Client Information

Applicant:	Shenzhen Friendcom Technology Development Co., Ltd.
Address:	5-6 Floor, Building 17, Guangqian Industrial Park, Xili, Nanshan District, Shenzhen, Guangdong Province, China
Manufacturer:	Shenzhen Friendcom Technology Development Co., Ltd.
Address:	5-6 Floor, Building 17, Guangqian Industrial Park, Xili, Nanshan District, Shenzhen, Guangdong Province, China
Factory:	Shenzhen Friendcom Technology Development Co., Ltd.
Address:	Building 20, Zhubaocheng industry park, 568 Huanchang North Road, Changping Town, Dongguan, Guangdong Province, China

5.2 General Description of E.U.T.

Product Name:	LoRaWAN Module
Model No.:	WSL05-A0
Operation Frequency:	902 MHz~928MHz
Number of channel:	Upward : 902MHz~915MHz for 64 Down : 923MHz~928MHz for 8
Modulation type:	LoRaWAN
Modulation technology:	FHSS
Antenna Type:	Rod antenna
Antenna gain:	2.0 dBi
Power supply:	DC 5.0V
Test Sample Condition:	The test samples were provided in good working order with no visible defects.

Operation Frequency							
Upward:							
Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
0	902.3MHz	7	903.7MHz	14	905.1MHz	57	913.7MHz
1	902.5MHz	8	903.9MHz	15	905.3MHz	58	913.9MHz
2	902.7MHz	9	904.1MHz	...	...	59	914.1MHz
3	902.9MHz	10	904.3MHz	...	...	60	914.3MHz
4	903.1MHz	11	904.5MHz	...	...	61	914.5MHz
5	903.3MHz	12	904.7MHz	...	...	62	914.7MHz
6	903.5MHz	13	904.9MHz	...	...	63	914.9MHz
Down:							
0	923.3MHz	2	924.5MHz	4	925.7MHz	6	926.9MHz
1	923.9MHz	3	925.1MHz	5	926.3MHz	7	927.5MHz
Remark:							
1. Channel 0, 32 &63 selected for test.							
2. Down channel only receives data.							

5.3 Test environment and mode

Operating Environment:	
Temperature:	24.0 °C
Humidity:	54 % RH
Atmospheric Pressure:	1010 mbar
Test Modes:	
Non-hopping mode:	Keep the EUT in continuous transmitting mode with worst case data rate.
Hopping mode:	Keep the EUT in hopping mode.
<p>The sample was placed 0.8m (below 1GHz)/1.5m (above 1GHz) above the ground plane of 3m chamber*. Measurements in both horizontal and vertical polarities were performed. During the test, each emission was maximized by: having the EUT continuously working with a fresh battery, investigated all operating modes, rotated about all 3 axis (X, Y & Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, rotating the turntable, varying antenna height from 1m to 4m in both horizontal and vertical polarizations. The emissions worst-case are shown in Test Results of the following pages.</p>	

5.4 Description of Support Units

The EUT has been tested as an independent unit.

5.5 Measurement Uncertainty

Parameters	Expanded Uncertainty
Conducted Emission (9kHz ~ 30MHz)	±1.60 dB (k=2)
Radiated Emission (9kHz ~ 30MHz)	±3.12 dB (k=2)
Radiated Emission (30MHz ~ 1000MHz)	±4.32 dB (k=2)
Radiated Emission (1GHz ~ 18GHz)	±5.16 dB (k=2)
Radiated Emission (18GHz ~ 40GHz)	±3.20 dB (k=2)

5.6 Additions to, deviations, or exclusions from the method

No

5.7 Laboratory Facility

The test facility is recognized, certified, or accredited by the following organizations:

- **FCC - Designation No.: CN1211**
JianYan Testing Group Shenzhen Co., Ltd. has been accredited as a testing laboratory by FCC(Federal Communications Commission). The test firm Registration No. is 727551.
- **ISED – CAB identifier.: CN0021**
The 3m Semi-anechoic chamber of JianYan Testing Group Shenzhen Co., Ltd. has been Registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 10106A-1.
- **A2LA - Registration No.: 4346.01**
This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories. The test scope can be found as below link: <https://portal.a2la.org/scopepdf/4346-01.pdf>

5.8 Laboratory Location

JianYan Testing Group Shenzhen Co., Ltd.
 Address: No.101, Building 8, Innovation Wisdom Port, No.155 Hongtian Road, Huangpu Community, Xinqiao Street, Bao'an District, Shenzhen, Guangdong, People's Republic of China.
 Tel: +86-755-23118282, Fax: +86-755-23116366
 Email: info@ccis-cb.com, Website: http://www.ccis-cb.com

5.9 Test Instruments list

Radiated Emission:					
Test Equipment	Manufacturer	Model No.	Serial No.	Cal. Date (mm-dd-yy)	Cal. Due date (mm-dd-yy)
3m SAC	ETS	9m*6m*6m	966	01-19-2021	01-18-2024
BiConiLog Antenna	SCHWARZBECK	VULB9163	497	03-03-2021	03-02-2022
Biconical Antenna	SCHWARZBECK	VUBA9117	359	06-18-2020	06-17-2021
Horn Antenna	SCHWARZBECK	BBHA9120D	916	03-03-2021	03-02-2022
Horn Antenna	SCHWARZBECK	BBHA9120D	1805	06-18-2020	06-17-2021
Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170582	11-18-2020	11-17-2021
EMI Test Software	AUDIX	E3	Version: 6.110919b		
Pre-amplifier	HP	8447D	2944A09358	03-03-2021	03-02-2022
Pre-amplifier	CD	PAP-1G18	11804	03-03-2021	03-02-2022
Spectrum analyzer	Rohde & Schwarz	FSP30	101454	03-03-2021	03-02-2022
Spectrum analyzer	Rohde & Schwarz	FSP40	100363	11-18-2020	11-17-2021
EMI Test Receiver	Rohde & Schwarz	ESRP7	101070	03-03-2021	03-02-2022
Cable	ZDECL	Z108-NJ-NJ-81	1608458	03-03-2021	03-02-2022
Cable	MICRO-COAX	MFR64639	K10742-5	03-03-2021	03-02-2022
Cable	SUHNER	SUCOFLEX100	58193/4PE	03-03-2021	03-02-2022
RF Switch Unit	MWRFTTEST	MW200	N/A	N/A	N/A
Test Software	MWRFTTEST	MTS8200	Version: 2.0.0.0		

Conducted Emission:					
Test Equipment	Manufacturer	Model No.	Serial No.	Cal. Date (mm-dd-yy)	Cal. Due date (mm-dd-yy)
EMI Test Receiver	Rohde & Schwarz	ESCI	101189	03-03-2021	03-02-2022
Pulse Limiter	SCHWARZBECK	OSRAM 2306	9731	03-03-2021	03-02-2022
LISN	CHASE	MN2050D	1447	03-03-2021	03-02-2022
LISN	Rohde & Schwarz	ESH3-Z5	8438621/010	06-18-2020	06-17-2021
Cable	HP	10503A	N/A	03-03-2021	03-02-2022
EMI Test Software	AUDIX	E3	Version: 6.110919b		

6 Test results and measurement data

6.1 Antenna Requirement

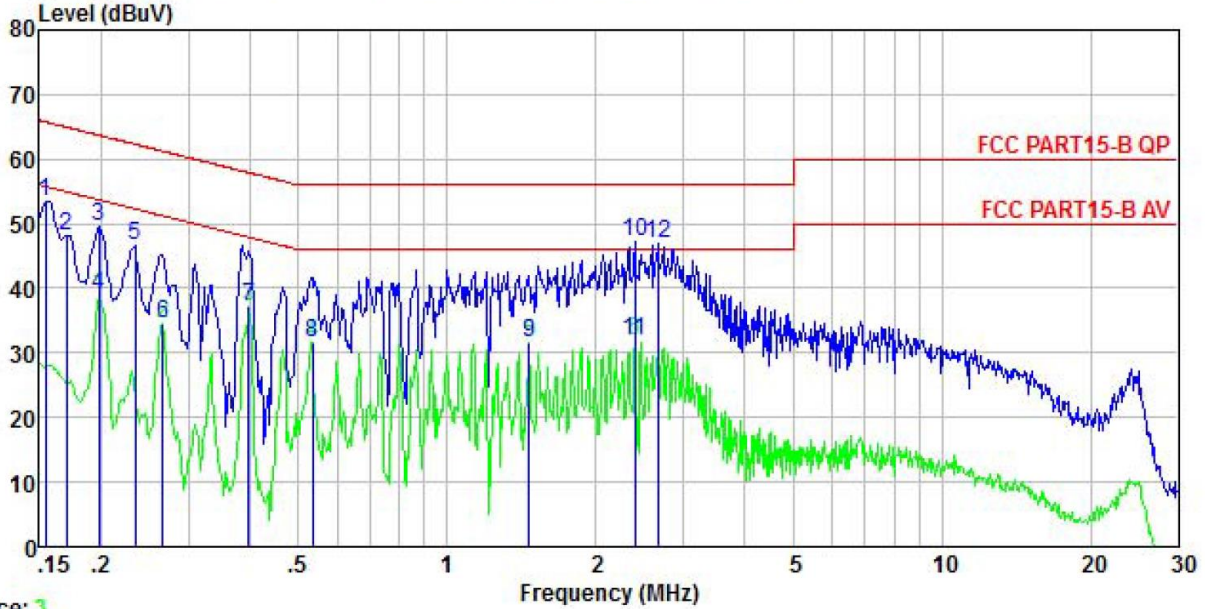
Standard requirement:	FCC Part 15 C Section 15.203 & 247(c)
<p>15.203 requirement: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.</p> <p>15.247(c) (1)(i) requirement: (i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.</p>	
E.U.T Antenna:	
<p>The antenna is a Rod antenna which permanently attached, and the best case gain of the antenna is 2.0 dBi.</p>	

6.2 Conducted Emissions

Test Requirement:	FCC Part 15 C Section 15.207		
Test Frequency Range:	150 kHz to 30 MHz		
Class / Severity:	Class B		
Receiver setup:	RBW=9 kHz, VBW=30 kHz, Sweep time=auto		
Limit:	Frequency range (MHz)	Limit (dBuV)	
		Quasi-peak	Average
	0.15-0.5	66 to 56*	56 to 46*
	0.5-5	56	46
	5-30	60	50
* Decreases with the logarithm of the frequency.			
Test setup:	<p><i>Remark</i> E.U.T: Equipment Under Test LISN: Line Impedance Stabilization Network Test table height=0.8m</p>		
Test procedure:	<ol style="list-style-type: none"> 1. The E.U.T and simulators are connected to the main power through a line impedance stabilization network (L.I.S.N.). This provides a 50ohm/50uH coupling impedance for the measuring equipment. 2. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm/50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs). 3. Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4-2014 on conducted measurement. 		
Test Instruments:	Refer to section 5.9 for details		
Test mode:	Hopping mode		
Test results:	Pass		

Measurement Data:

Product name:	LoRaWAN Module	Product model:	WSL05-A0
Test by:	Yaro	Test mode:	BT Tx mode
Test frequency:	150 kHz ~ 30 MHz	Phase:	Line
Test voltage:	AC 120 V/60 Hz	Environment:	Temp: 22.5°C Humi: 55%



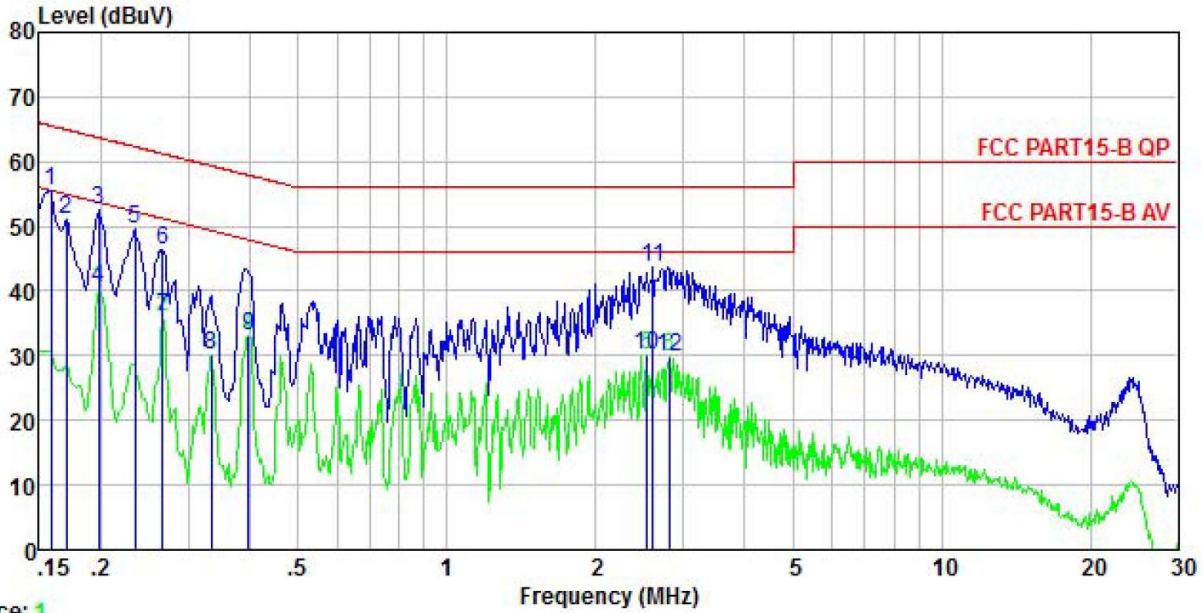
Trace: 3

	Freq	Read Level	LISN Factor	Aux Factor	Cable Loss	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dB	dB	dBuV	dBuV	dB	
1	0.154	54.10	-0.57	-0.06	0.01	53.48	65.78	-12.30	QP
2	0.170	48.93	-0.58	-0.10	0.01	48.26	64.94	-16.68	QP
3	0.198	50.33	-0.59	-0.16	0.04	49.62	63.71	-14.09	QP
4	0.198	39.57	-0.59	-0.16	0.04	38.86	53.71	-14.85	Average
5	0.234	47.46	-0.57	-0.20	0.02	46.71	62.30	-15.59	QP
6	0.266	35.44	-0.56	-0.23	0.02	34.67	51.25	-16.58	Average
7	0.398	37.33	-0.48	0.40	0.04	37.29	47.90	-10.61	Average
8	0.535	32.29	-0.45	-0.36	0.03	31.51	46.00	-14.49	Average
9	1.464	31.87	-0.56	0.03	0.14	31.48	46.00	-14.52	Average
10	2.396	47.79	-0.47	-0.27	0.15	47.20	56.00	-8.80	QP
11	2.396	32.55	-0.47	-0.27	0.15	31.96	46.00	-14.04	Average
12	2.664	47.58	-0.45	-0.24	0.11	47.00	56.00	-9.00	QP

Notes:

1. An initial pre-scan was performed on the line and neutral lines with peak detector.
2. Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission.
3. Final Level = Receiver Read level + LISN Factor + Cable Loss.

Product name:	LoRaWAN Module	Product model:	WSL05-A0
Test by:	Yaro	Test mode:	BT Tx mode
Test frequency:	150 kHz ~ 30 MHz	Phase:	Neutral
Test voltage:	AC 120 V/60 Hz	Environment:	Temp: 22.5°C Humi: 55%



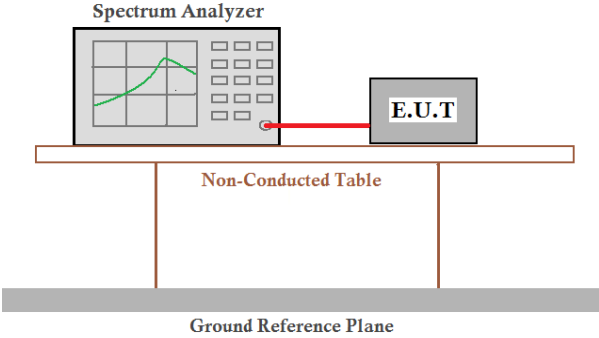
Trace: 1

	Read Freq	Read Level	LISN Factor	Aux Factor	Cable Loss	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dB	dB	dBuV	dBuV	dB	
1	0.158	56.20	-0.69	0.01	0.01	55.53	65.56	-10.03	QP
2	0.170	51.69	-0.68	0.01	0.01	51.03	64.94	-13.91	QP
3	0.198	53.07	-0.67	0.00	0.04	52.44	63.71	-11.27	QP
4	0.198	41.08	-0.67	0.00	0.04	40.45	53.71	-13.26	Average
5	0.234	50.24	-0.67	0.00	0.02	49.59	62.30	-12.71	QP
6	0.266	47.03	-0.67	0.01	0.02	46.39	61.25	-14.86	QP
7	0.266	36.59	-0.67	0.01	0.02	35.95	51.25	-15.30	Average
8	0.334	30.90	-0.66	-0.02	0.02	30.24	49.35	-19.11	Average
9	0.398	33.73	-0.63	-0.06	0.04	33.08	47.90	-14.82	Average
10	2.540	30.37	-0.67	0.25	0.13	30.08	46.00	-15.92	Average
11	2.608	44.09	-0.67	0.26	0.12	43.80	56.00	-12.20	QP
12	2.809	30.00	-0.66	0.29	0.09	29.72	46.00	-16.28	Average

Notes:

1. An initial pre-scan was performed on the line and neutral lines with peak detector.
2. Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission.
3. Final Level = Receiver Read level + LISN Factor + Cable Loss.

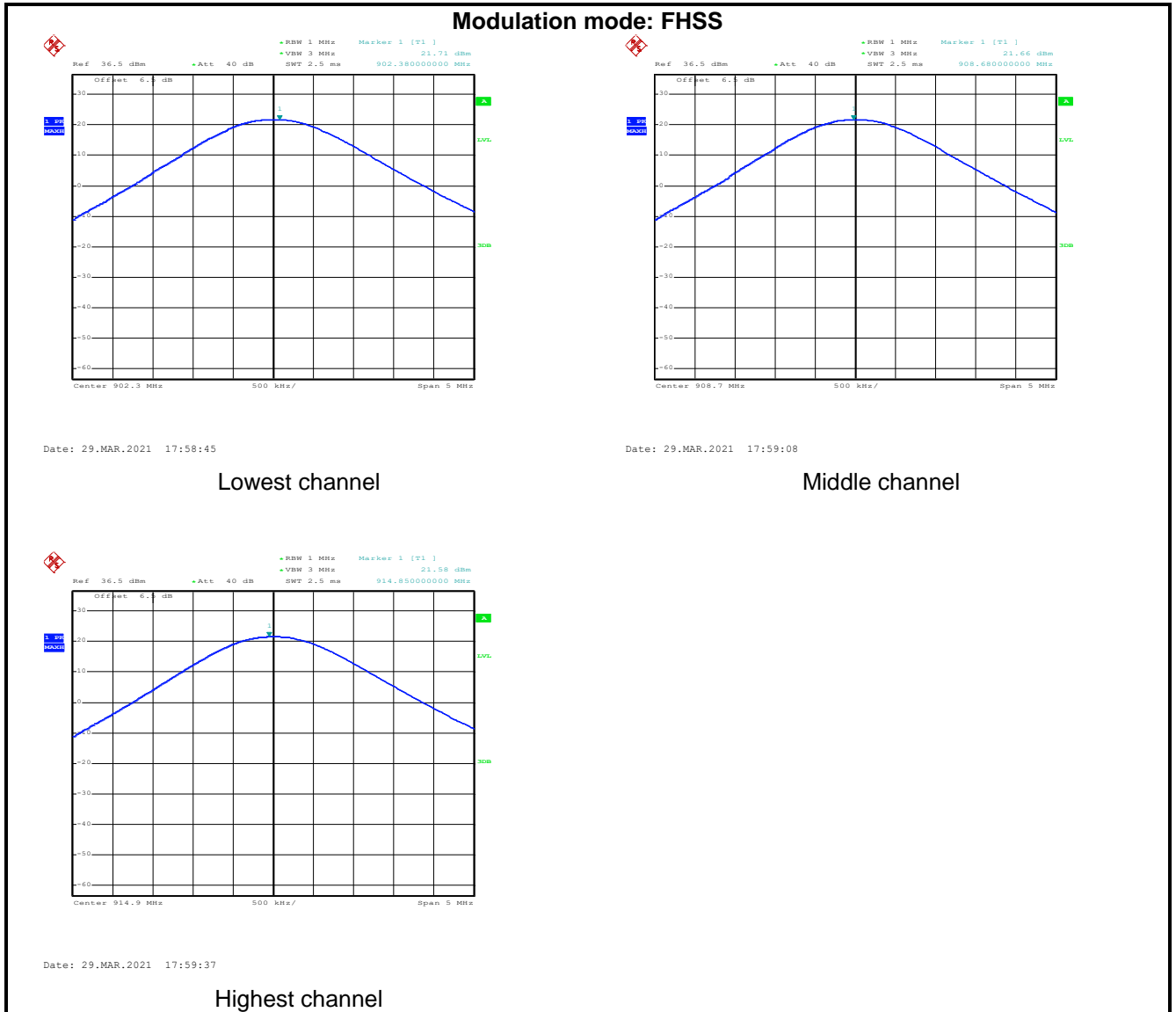
6.3 Conducted Output Power

Test Requirement:	FCC Part 15 C Section 15.247 (b)(2)
Receiver setup:	RBW=1MHz, VBW=3MHz, Detector=Peak
Limit:	For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.
Test setup:	 <p>The diagram illustrates the test setup. A Spectrum Analyzer is connected via a red cable to an E.U.T. (Equipment Under Test). Both are placed on a Non-Conducted Table. Below the table is a Ground Reference Plane.</p>
Test Instruments:	Refer to section 5.9 for details
Test mode:	Non-hopping mode
Test results:	Pass

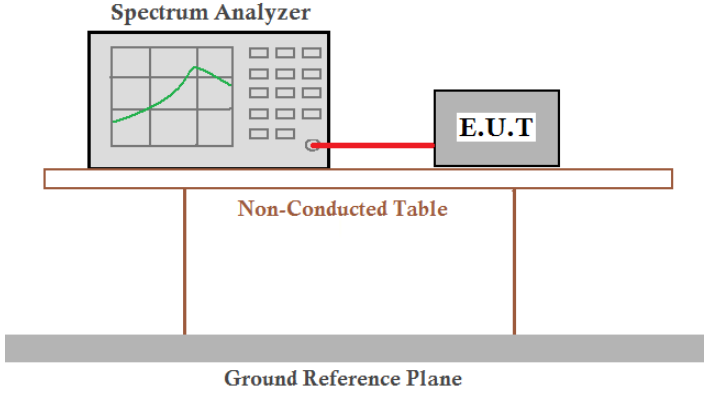
Measurement Data:

Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
FHSS mode			
Lowest channel	21.71	30.00	Pass
Middle channel	21.66	30.00	Pass
Highest channel	21.58	30.00	Pass

Test plot as follows:



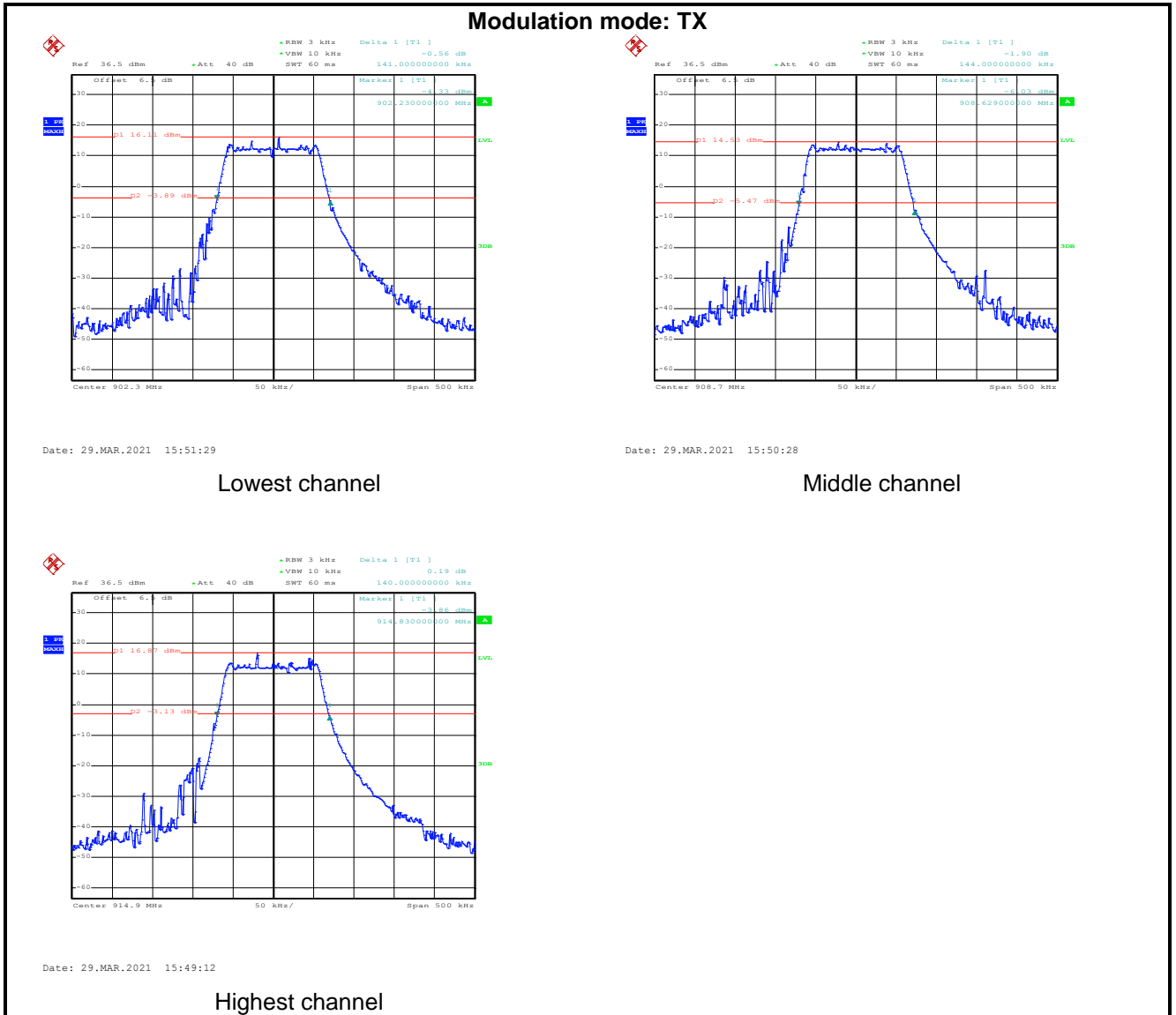
6.4 20dB Occupy Bandwidth

Test Requirement:	FCC Part 15 C Section 15.247 (a)(1)(i)
Receiver setup:	RBW=30 kHz, VBW=100 kHz, detector=Peak
Limit:	< 250KHz
Test setup:	
Test Instruments:	Refer to section 5.9 for details
Test mode:	Non-hopping mode
Test results:	Pass

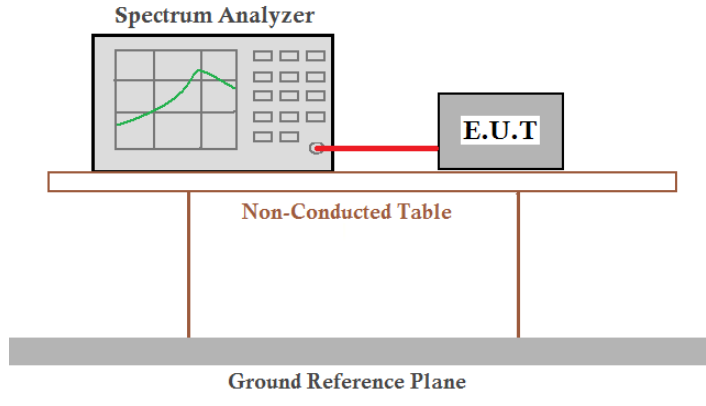
Measurement Data:

20dB Occupy Bandwidth (kHz)			
Lowest	Middle	Highest	Result
141	144	140	PASS

Test plot as follows:



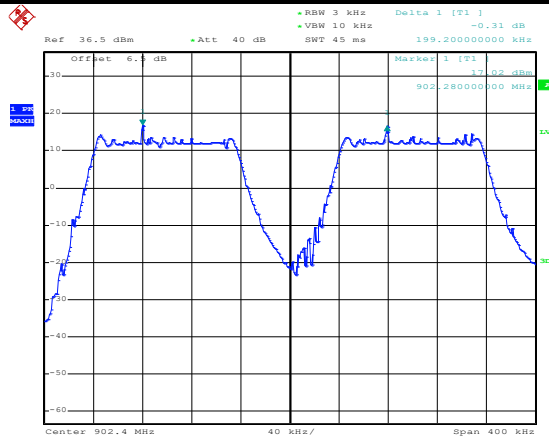
6.5 Carrier Frequencies Separation

Test Requirement:	FCC Part 15 C Section 15.247 (a)(1)
Receiver setup:	RBW=100 kHz, VBW=300 kHz, detector=Peak
Limit:	Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater
Test setup:	 <p>The diagram illustrates the test setup. A Spectrum Analyzer is connected via a red cable to an E.U.T. (Equipment Under Test). Both are placed on a Non-Conducted Table. Below the table is a Ground Reference Plane.</p>
Test Instruments:	Refer to section 5.9 for details
Test mode:	Hopping mode
Test results:	Pass

Measurement Data

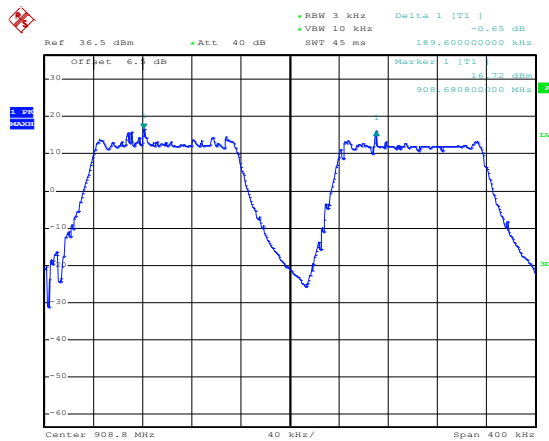
Test channel	Carrier Frequencies Separation (kHz)	Limit (kHz)	Result
FHSS			
Lowest	199.2	144	Pass
Middle	189.6	144	Pass
Highest	198.4	144	Pass

Test plot as follows:



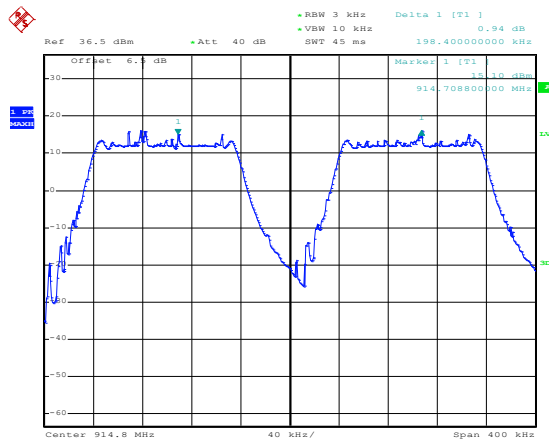
Date: 29.MAR.2021 15:55:03

Lowest channel



Date: 29.MAR.2021 15:56:48

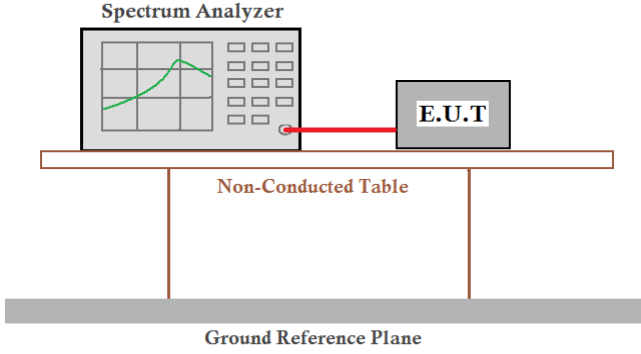
Middle channel



Date: 29.MAR.2021 16:00:03

Highest channel

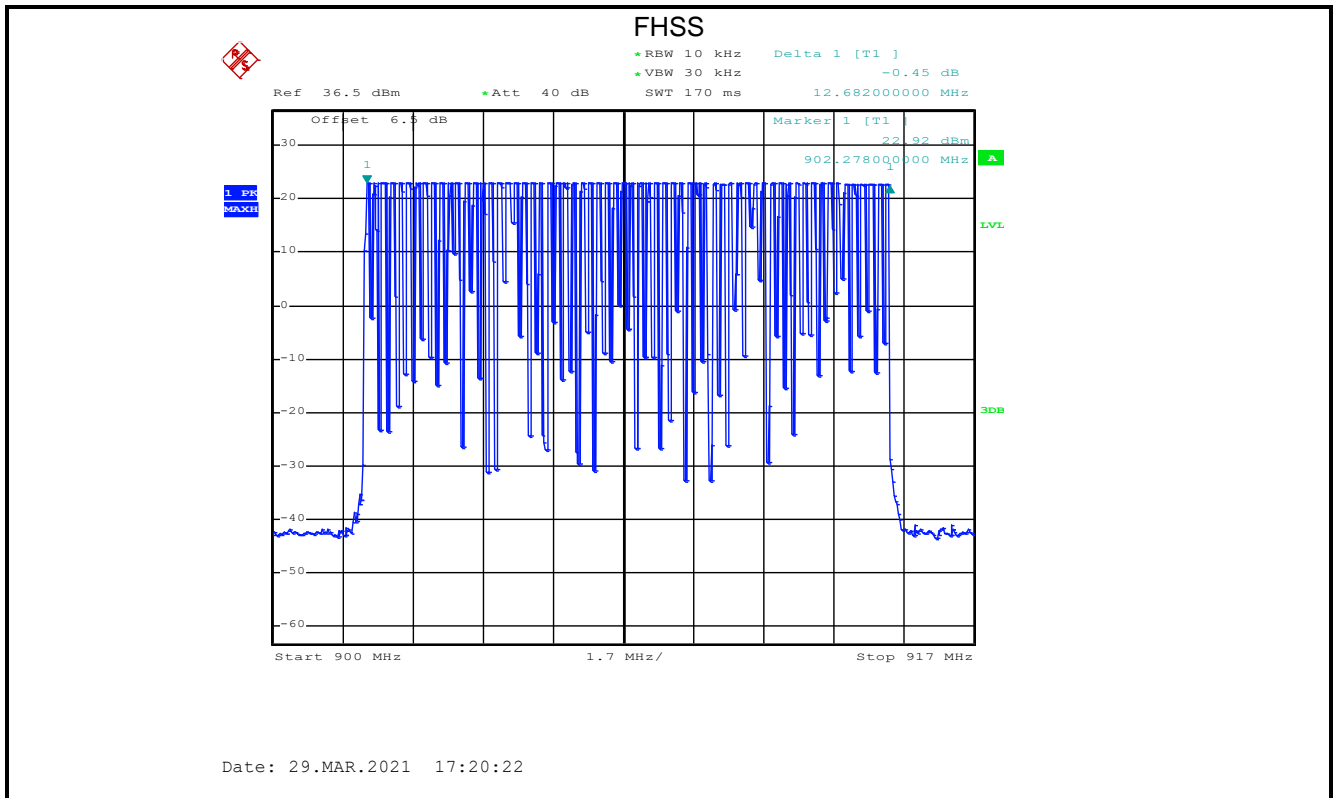
6.6 Hopping Channel Number

Test Requirement:	FCC Part 15 C Section 15.247 (a)(1)(i)
Receiver setup:	RBW=100 kHz, VBW=300 kHz, Detector=Peak
Limit:	50 channels
Test setup:	 <p>The diagram illustrates the test setup. A Spectrum Analyzer is connected via a red cable to an E.U.T. (Equipment Under Test). Both are placed on a Non-Conducted Table. Below the table is a Ground Reference Plane.</p>
Test Instruments:	Refer to section 5.9 for details
Test mode:	Hopping mode
Test results:	Pass

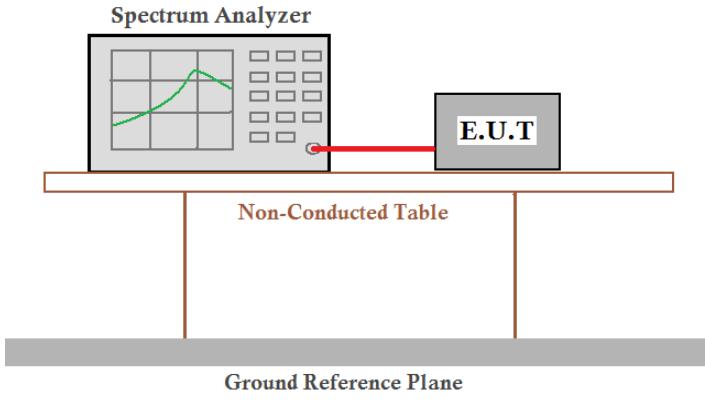
Measurement Data:

Mode	Hopping channel numbers	Limit	Result
FHSS	64	50	Pass

Test plot as follows:



6.7 Dwell Time

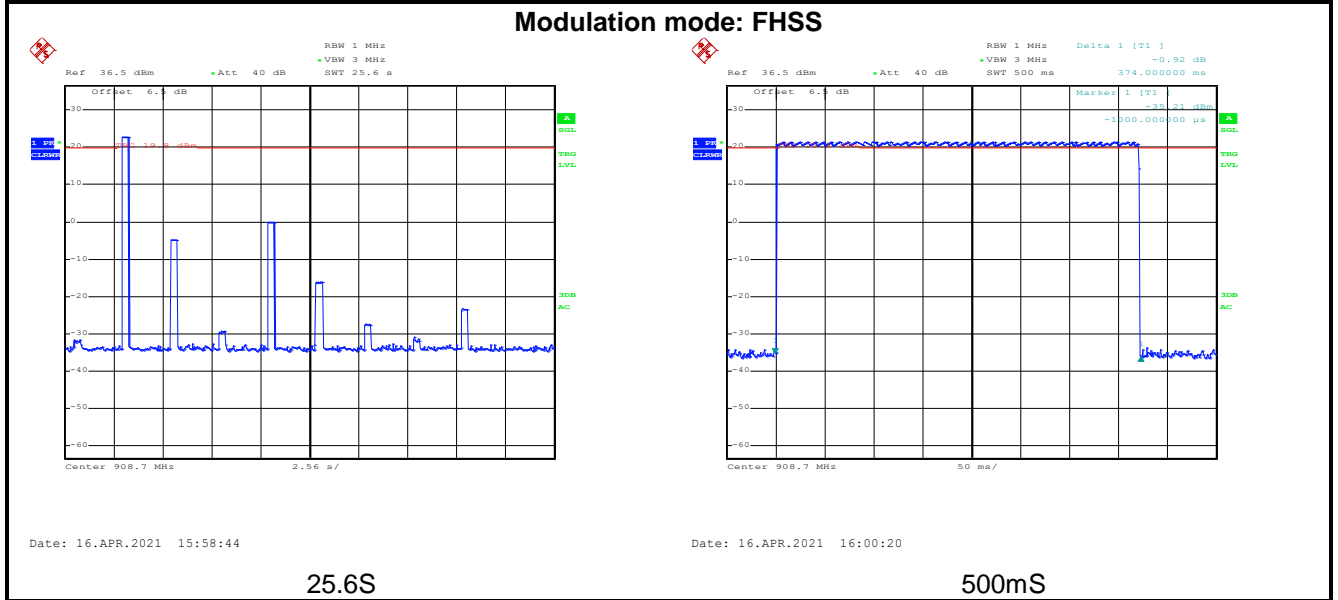
Test Requirement:	FCC Part 15 C Section 15.247 (a)(1)(i)
Receiver setup:	RBW=1 MHz, VBW=1 MHz, Span=0 Hz, Detector=Peak
Limit:	Occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period
Test setup:	 <p>The diagram illustrates the test setup. A Spectrum Analyzer is connected via a red cable to an E.U.T. (Equipment Under Test). Both are placed on a Non-Conducted Table. Below the table is a Ground Reference Plane.</p>
Test Instruments:	Refer to section 5.9 for details
Test mode:	Hopping mode
Test results:	Pass

Measurement Data:

Mode	25.6 second period (numbers)	Dwell time (second)	Limit (second)	Result
FHSS	1	0.374	0.4	Pass

Note:
 Calculation Formula: Dwell time = Ton time per hop * Hopping numbers
 For example:
 Time slot=0.374*1 =0.374ms

Test plot as follows:

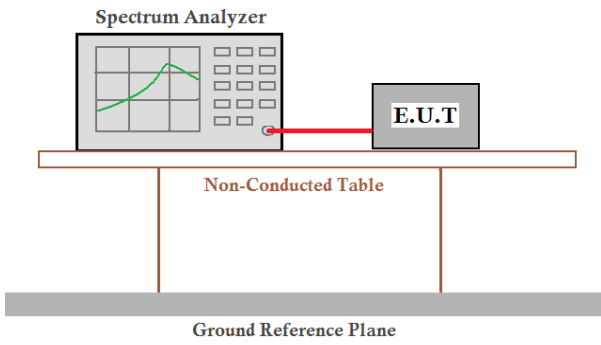


6.8 Pseudorandom Frequency Hopping Sequence

Test Requirement:	FCC Part 15 C Section 15.247 (a)(1) requirement:
<p>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.</p> <p>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 Pseudorandom 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.</p>	
EUT Pseudorandom Frequency Hopping Sequence	
<p>The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONES; i.e. the shift register is initialized with nine ones.</p> <ul style="list-style-type: none"> • Number of shift register stages: 9 • Length of pseudo-random sequence: $2^9 - 1 = 511$ bits • Longest sequence of zeros: 8 (non-inverted signal) <div data-bbox="264 864 1302 1010" style="text-align: center;"> </div> <p style="text-align: center;"><i>Linear Feedback Shift Register for Generation of the PRBS sequence</i></p> <p>An example of Pseudorandom Frequency Hopping Sequence as follow:</p> <div data-bbox="264 1111 1246 1249" style="text-align: center;"> </div> <p>Each frequency used equally on the average by each transmitter.</p> <p>The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.</p>	

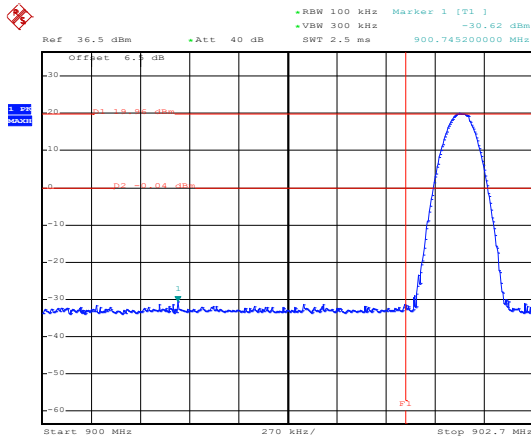
6.9 Band Edge

6.9.1 Conducted Emission Method

Test Requirement:	FCC Part 15 C Section 15.247 (d)
Receiver setup:	RBW=100 kHz, VBW=300 kHz, Detector=Peak
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.
Test setup:	 <p>The diagram illustrates the test setup. A Spectrum Analyzer is connected to an E.U.T. (Equipment Under Test) via a red cable. Both are placed on a Non-Conducted Table, which is supported by a Ground Reference Plane.</p>
Test Instruments:	Refer to section 5.9 for details
Test mode:	Non-hopping mode and hopping mode
Test results:	Pass

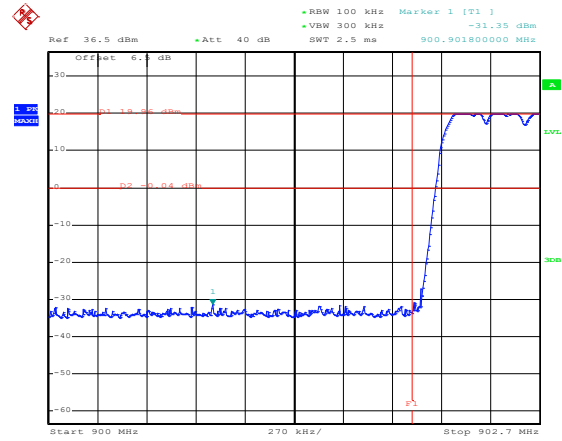
Test plot as follows:

FHSS Lowest Channel



Date: 29.MAR.2021 17:38:28

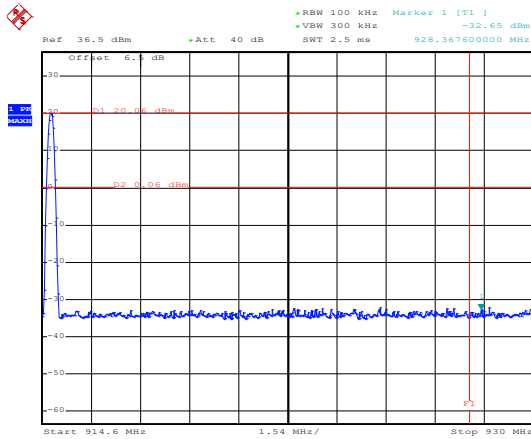
No-hopping mode



Date: 29.MAR.2021 17:39:12

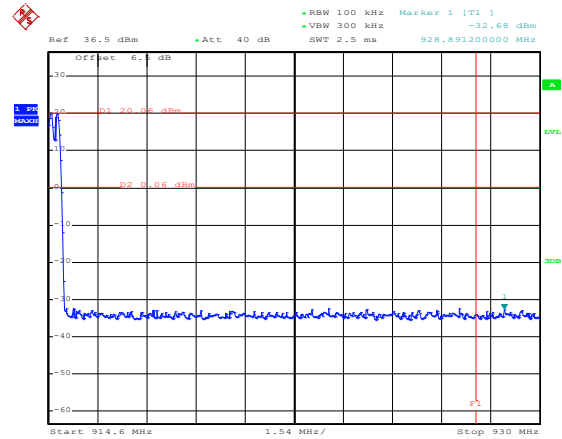
Hopping mode

Highest Channel



Date: 29.MAR.2021 17:40:28

No-hopping mode



Date: 29.MAR.2021 17:41:03

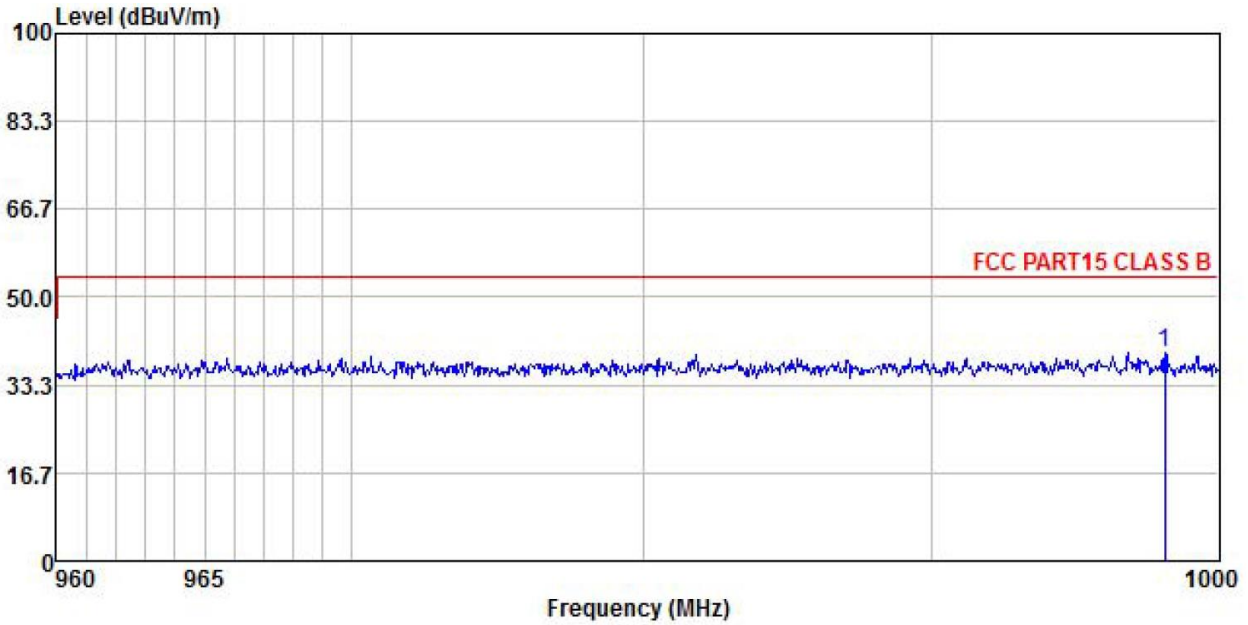
Hopping mode

6.9.2 Radiated Emission Method

Test Requirement:	FCC Part 15 C Section 15.209 and 15.205				
Test Frequency Range:	960MHz to1240MHz				
Test Distance:	3m				
Receiver setup:	Frequency	Detector	RBW	VBW	Remark
	Above 1GHz	Peak	1MHz	3MHz	Peak Value
		RMS	1MHz	3MHz	Average Value
Limit:	Frequency	Limit (dBuV/m @3m)		Remark	
	Above 1GHz	54.00		Average Value	
		74.00		Peak Value	
Test setup:					
Test Procedure:	<ol style="list-style-type: none"> 1. The EUT was placed on the top of a rotating table 1.5meters above the ground at a 3 meter camber. The table was rotated 360 degrees to determine the position of the highest radiation. 2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower. 3. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement. 4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rota table was turned from 0 degrees to 360 degrees to find the maximum reading. 5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode. 6. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet. 				
Test Instruments:	Refer to section 5.9 for details				
Test mode:	Non-hopping mode				
Test results:	Passed				

Below 1GHz:

Product Name:	LoRaWAN Module	Product Model:	WSL05-A0
Test By:	Yaro	Test mode:	Tx mode
Test Channel:	Lowest channel	Polarization:	Vertical
Test Voltage:	AC 120/60Hz	Environment:	Temp: 24°C Humi: 57%

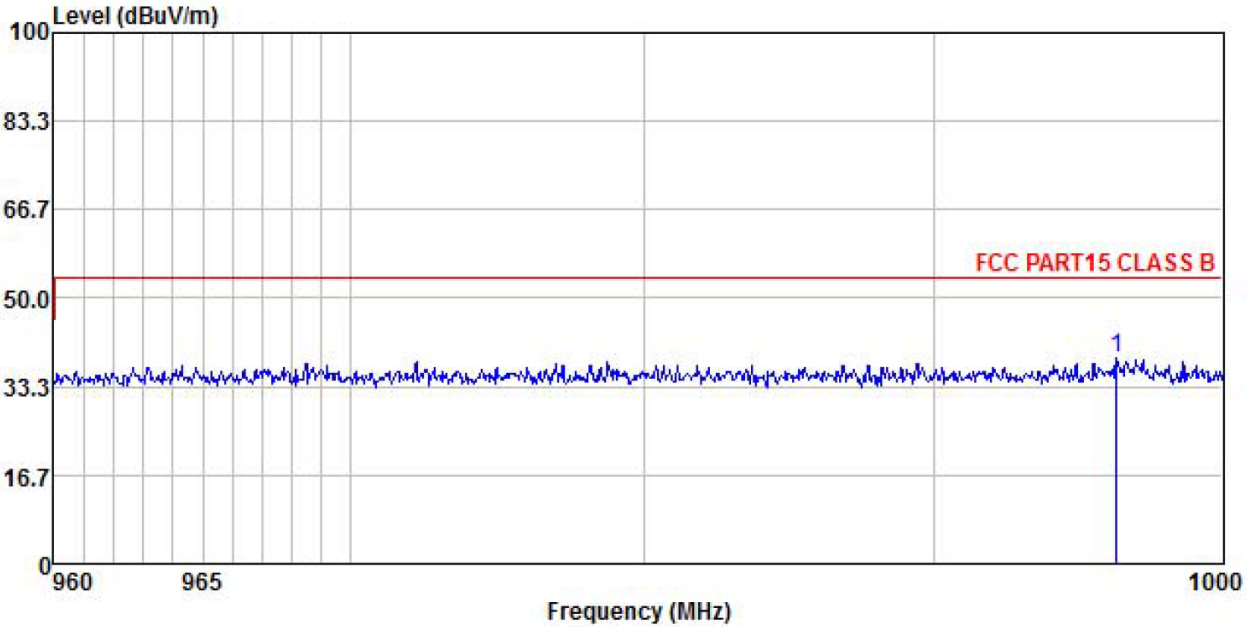


	ReadAntenna	Cable	Preamp	Limit	Over			
Freq	Level	Factor	Loss	Factor	Level	Line		
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m		
1	998.124	12.73	23.08	3.67	0.00	39.48	54.00	-14.52

Remark:

1. Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.
2. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product Name:	LoRaWAN Module	Product Model:	WSL05-A0
Test By:	Yaro	Test mode:	Tx mode
Test Channel:	Lowest channel	Polarization:	Horizontal
Test Voltage:	AC 120/60Hz	Environment:	Temp: 24°C Huni: 57%



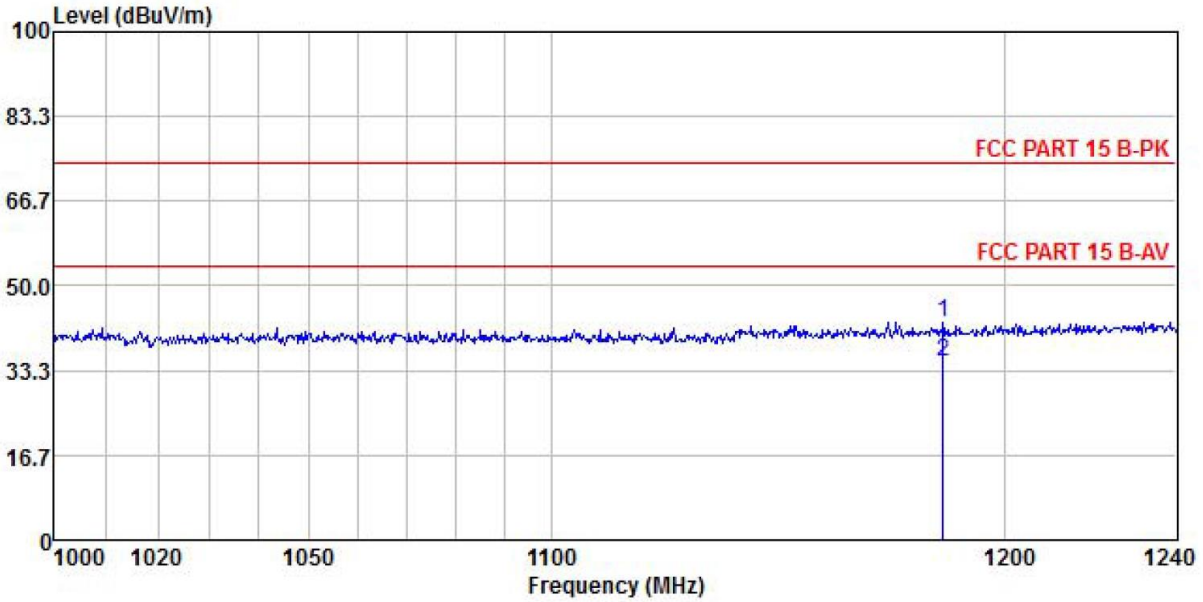
	Read	Antenna	Cable	Preamp	Limit	Over	
Freq	Level	Factor	Loss	Factor	Level	Line	Limit
-----	-----	-----	-----	-----	-----	-----	-----
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB
1 996.292	12.08	23.08	3.67	0.00	38.83	54.00	-15.17

Remark:

1. Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.
2. The emission levels of other frequencies are very lower than the limit and not show in test report.

Above 1GHz:

Product Name:	LoRaWAN Module	Product Model:	WSL05-A0
Test By:	Yaro	Test mode:	Tx mode
Test Channel:	Highest channel	Polarization:	Vertical
Test Voltage:	AC 120/60Hz	Environment:	Temp: 24°C Humi: 57%

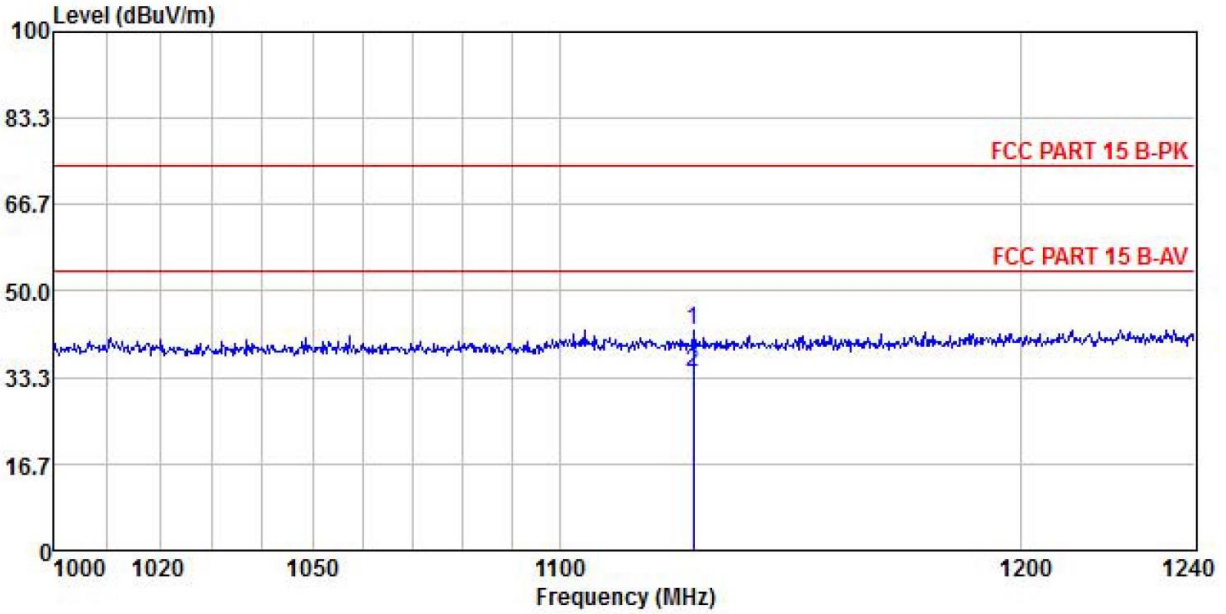


	Read	Antenna	Cable	Preamp	Level	Limit	Over	
-----	Level	Factor	Loss	Factor	Level	Line	Limit	Remark
-----	MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB
1	1185.741	12.60	24.29	6.05	0.00	42.94	74.00	-31.06 Peak
2	1185.741	4.78	24.29	6.05	0.00	35.12	54.00	-18.88 Average

Remark:

1. Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.
2. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product Name:	LoRaWAN Module	Product Model:	WSL05-A0
Test By:	Yaro	Test mode:	Tx mode
Test Channel:	Highest channel	Polarization:	Horizontal
Test Voltage:	AC 120/60Hz	Environment:	Temp: 24°C Huni: 57%



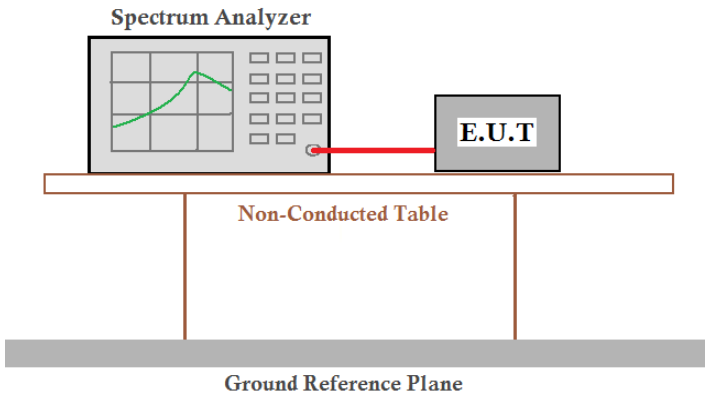
	ReadAntenna	Cable	Preamp	Limit	Over				
Freq	Level	Factor	Loss	Factor	Level	Line			
-----	-----	-----	-----	-----	-----	-----			
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m			
1	1128.018	12.23	24.27	5.91	0.00	42.41	74.00	-31.59	Peak
2	1128.018	4.25	24.27	5.91	0.00	34.43	54.00	-19.57	Average

Remark:

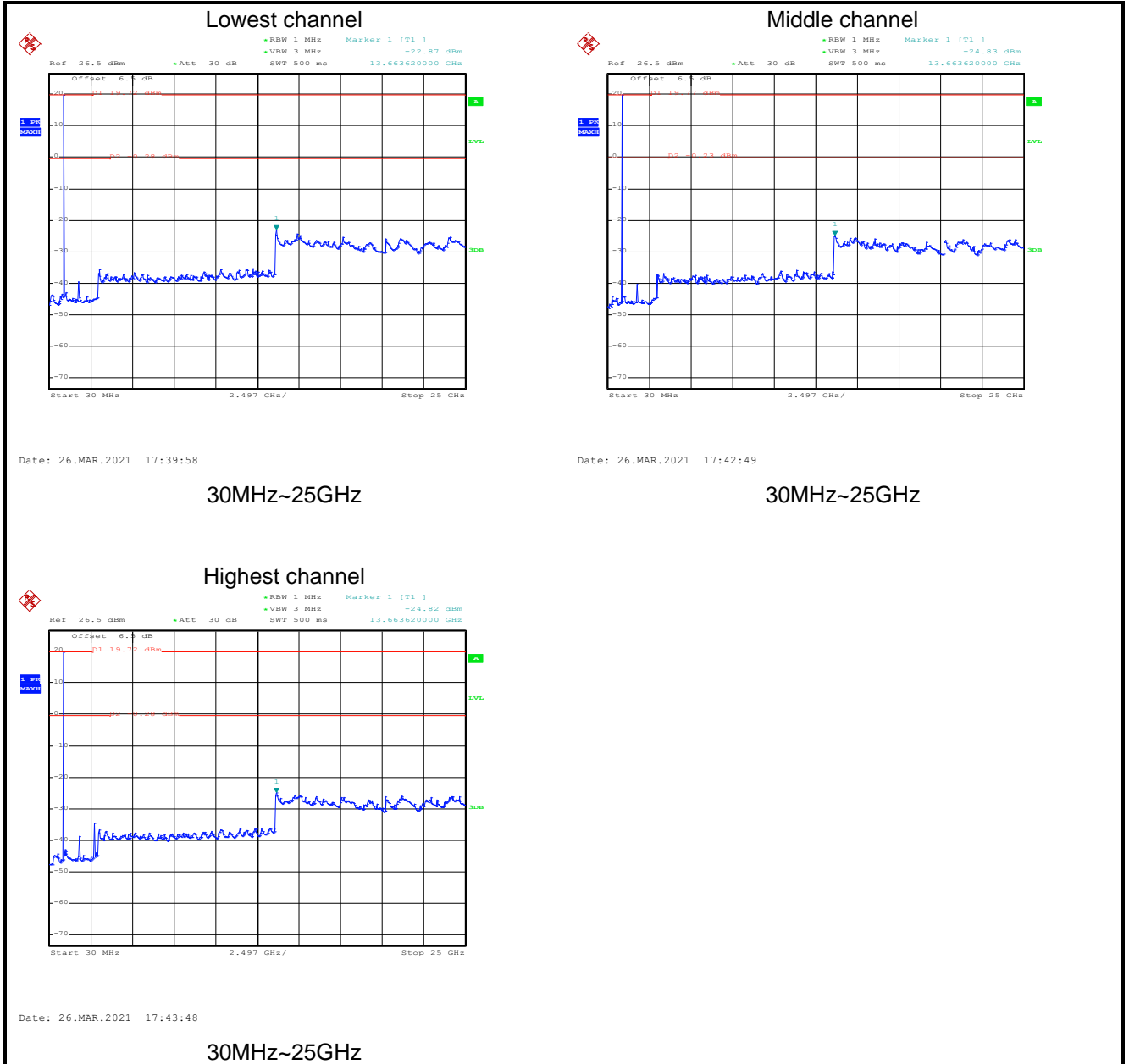
- Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.
- The emission levels of other frequencies are very lower than the limit and not show in test report.

6.10 Spurious Emission

6.10.1 Conducted Emission Method

Test Requirement:	FCC Part 15 C Section 15.247 (d)
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.
Test setup:	 <p>The diagram illustrates the test setup. A Spectrum Analyzer is connected to an E.U.T. (Equipment Under Test) via a red cable. Both are placed on a Non-Conducted Table, which is supported by two legs. Below the table is a Ground Reference Plane.</p>
Test Instruments:	Refer to section 5.9 for details
Test mode:	Non-hopping mode
Test results:	Pass

Test plot as follows:



6.10.2 Radiated Emission Method

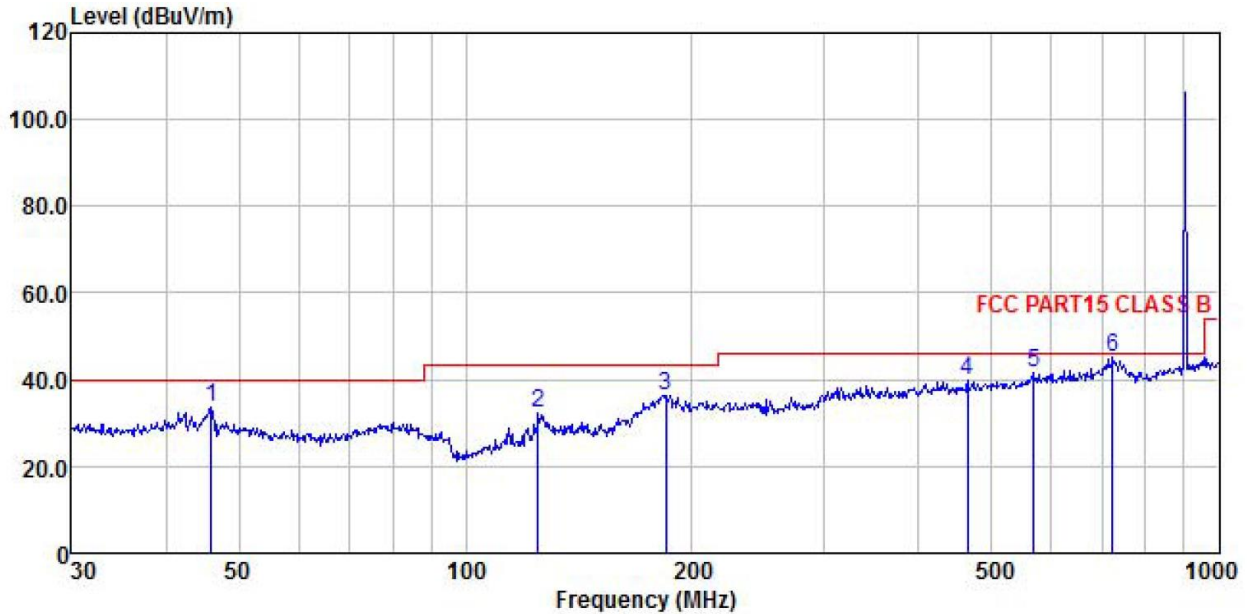
Test Requirement:	FCC Part 15 C Section 15.209				
Test Frequency Range:	9 kHz to 10 GHz				
Test Distance:	3m				
Receiver setup:	Frequency	Detector	RBW	VBW	Remark
	30MHz-1GHz	Quasi-peak	120kHz	300kHz	Quasi-peak Value
	Above 1GHz	Peak	1MHz	3MHz	Peak Value
		RMS	1MHz	3MHz	Average Value
Limit:	Frequency	Limit (dBuV/m @3m)		Remark	
	30MHz-88MHz	40.0		Quasi-peak Value	
	88MHz-216MHz	43.5		Quasi-peak Value	
	216MHz-960MHz	46.0		Quasi-peak Value	
	960MHz-1GHz	54.0		Quasi-peak Value	
	Above 1GHz	54.0		Average Value	
		74.0		Peak Value	
Test setup:	Below 1GHz				
	Above 1GHz				
Test Procedure:	<ol style="list-style-type: none"> 1. The EUT was placed on the top of a rotating table 0.8m(below 1GHz) /1.5m(above 1GHz) above the ground at a 3 meter chamber. The table was rotated 360 degrees to determine the position of the highest radiation. 2. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna 				

	<p>tower.</p> <ol style="list-style-type: none"> 3. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement. 4. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rota table was turned from 0 degrees to 360 degrees to find the maximum reading. 5. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode. 6. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
Test Instruments:	Refer to section 5.9 for details
Test mode:	Non-hopping mode
Test results:	Pass
Remark:	<ol style="list-style-type: none"> 1. Pre-scan all kind of the place mode (X-axis, Y-axis, Z-axis), and found the Y-axis is the worst case. 2. 9 kHz to 30 MHz is noise floor, so only shows the data of above 30MHz in this report.

Measurement Data (worst case):

Below 1GHz:

Product Name:	LoRaWAN Module	Product Model:	WSL05-A0
Test By:	Yaro	Test mode:	Tx mode
Test Frequency:	30 MHz ~ 1 GHz	Polarization:	Vertical
Test Voltage:	AC 120/60Hz	Environment:	Temp: 24°C Humi: 57%

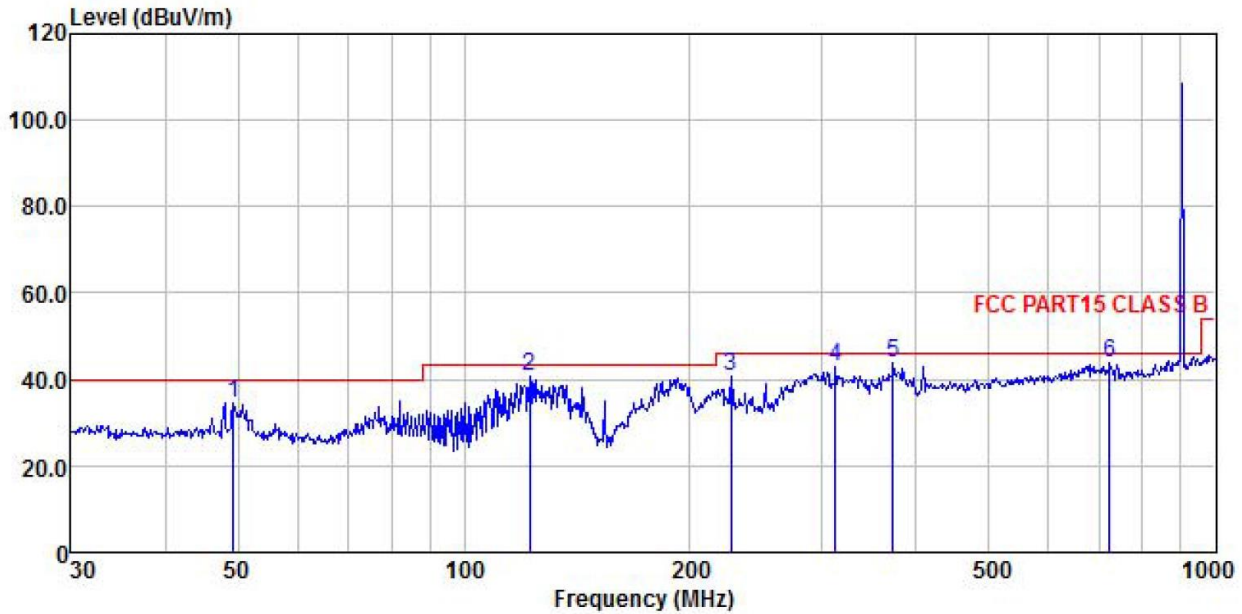


	Read	Antenna	Cable	Preamp	Limit	Over			
Freq	Level	Factor	Loss	Factor	Level	Line	Limit		
-----	-----	-----	-----	-----	-----	-----	-----		
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB		
1	46.016	20.01	12.96	0.48	0.00	33.45	40.00	-6.55	QP
2	125.007	20.07	11.40	0.92	0.00	32.39	43.50	-11.11	QP
3	184.490	18.01	17.16	1.32	0.00	36.49	43.50	-7.01	QP
4	463.970	18.52	19.26	2.24	0.00	40.02	46.00	-5.98	QP
5	568.613	19.30	19.71	2.51	0.00	41.52	46.00	-4.48	QP
6	724.261	21.80	20.55	2.91	0.00	45.26	46.00	-0.74	QP

Remark:

1. Final Level = Receiver Read level + Antenna Factor + Cable Loss – Pre-amplifier Factor.
2. The emission levels of other frequencies are very lower than the limit and not show in test report.

Product Name:	LoRaWAN Module	Product Model:	WSL05-A0
Test By:	Yaro	Test mode:	Tx mode
Test Frequency:	30 MHz ~ 1 GHz	Polarization:	Horizontal
Test Voltage:	AC 120/60Hz	Environment:	Temp: 24°C Huni: 57%



	ReadAntenna	Cable Preamp	Limit	Over				
Freq	Level	Factor	Loss	Factor	Level	Line	Limit	Remark
-----	-----	-----	-----	-----	-----	-----	-----	-----
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
1	49.359	21.07	13.16	0.48	0.00	34.71	40.00	-5.29 QP
2	122.404	28.57	11.05	0.91	0.00	40.53	43.50	-2.97 QP
3	226.894	20.66	18.41	1.50	0.00	40.57	46.00	-5.43 QP
4	312.179	22.30	18.73	1.79	0.00	42.82	46.00	-3.18 QP
5	372.005	22.99	18.93	1.95	0.00	43.87	46.00	-2.13 QP
6	724.261	20.50	20.55	2.91	0.00	43.96	46.00	-2.04 QP

Remark:

1. Final Level = Receiver Read level + Antenna Factor + Cable Loss – Preamplifier Factor.
2. The emission levels of other frequencies are very lower than the limit and not show in test report.

Above 1GHz:

Test channel: Lowest channel									
Detector: Peak Value									
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
1804.60	72.72	25.22	7.92	0.00	54.72	51.14	74.00	-22.86	Vertical
1804.60	70.12	25.22	7.92	0.00	54.72	48.54	74.00	-25.46	Horizontal
Detector: Average Value									
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
1804.60	63.15	25.22	7.92	0.00	54.72	41.57	54.00	-12.43	Vertical
1804.60	61.26	25.22	7.92	0.00	54.72	39.68	54.00	-14.32	Horizontal
Test channel: Middle channel									
Detector: Peak Value									
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
1817.40	69.11	25.29	7.94	0.00	54.71	47.63	74.00	-26.37	Vertical
1817.40	68.17	25.29	7.94	0.00	54.71	46.69	74.00	-27.31	Horizontal
Detector: Average Value									
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
1817.40	60.23	25.33	7.82	0.00	54.71	38.67	54.00	-15.33	Vertical
1817.40	59.71	25.33	7.82	0.00	54.71	38.15	54.00	-15.85	Horizontal
Test channel: Highest channel									
Detector: Peak Value									
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
1829.80	71.08	25.33	7.96	0.00	54.71	49.66	74.00	-24.34	Vertical
1829.80	72.73	25.33	7.96	0.00	54.71	51.31	74.00	-22.69	Horizontal
Detector: Average Value									
Frequency (MHz)	Read Level (dBuV)	Antenna Factor (dB/m)	Cable Loss (dB)	Aux Factor (dB)	Preamp Factor (dB)	Level (dBuV/m)	Limit Line (dBuV/m)	Over Limit (dB)	Polarization
1829.80	61.88	25.33	7.82	0.00	54.71	40.32	54.00	-13.68	Vertical
1829.80	63.34	25.33	7.82	0.00	54.71	41.78	54.00	-12.22	Horizontal
Remark: 1. Final Level = Receiver Read level + Antenna Factor + Cable Loss + Aux Factor – Preamplifier Factor. 2. The emission levels of other frequencies are lower than the limit 20dB and not show in test report.									