SGS-CSTC Standards Technical Services Co., Ltd.
Shenzhen Branch

No. 1 Workshop, M-10, Middle section, Science & Technology Park,
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TEST REPORT

Application No.:	SZEM1704003853CR
Applicant:	The Things Products.
Address of Applicant:	Herengracht 182, 1016BR Amsterdam, The Netherlands
Manufacturer:	The Things Products.
Address of Manufacturer:	Herengracht 182, 1016BR Amsterdam, The Netherlands
Factory:	EMBEST TECHNOLOGY CO., LTD
Address of Factory:	Tower B 4/F, Shanshui Building, Nanshan Yungu Innovation Industry Park, Liuxian Ave. No. 1183, Nanshan District, Shenzhen, Guangdong, China
Equipment Under Test (EUT):	
EUT Name:	THE THINGS GATEWAY
Model No.:	TTN-001-915-1.0
FCC ID:	2AJX4-GATEWAY
Standards:	47 CFR Part 15, Subpart C
Date of Receipt:	2017-05-04
Date of Test:	2017-06-15 to 2017-06-23
Date of Issue:	2017-08-29
Test Result :	**PASS***

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

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Jack Zhang
EMC Laboratory Manager

The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS International Electrical Approvals or testing done by SGS International Electrical Approvals in connection with, distribution or use of the product described in this report must be approved by SGS International Electrical Approvals in writing.

Revision Record				
Version	**Chapter**	**Date**	**Modifier**	**Remark**
01		2017-08-29		Original

Authorized for issue by:				
				
		Hank Yan /Project Engineer		
				
		Eric Fu /Reviewer		

2 Test Summary

Radio Spectrum Matter Part				
Item	**Standard**	**Method**	**Requirement**	**Result**
Conducted Emissions at AC Power Line (150kHz-30MHz)	47 CFR Part 15, Subpart C 15.207	ANSI C63.10 (2013) Section 6.2	47 CFR Part 15, Subpart C 15.207	Pass
Radiated Spurious Emissions	47 CFR Part 15, Subpart C 15.209	ANSI C63.10 (2013) Section 6.10.4	47 CFR Part 15, Subpart C 15.209	Pass

Note: The product uses three certified RF modules as below:

A) PCIE Radio Card (915MHz version), FCC ID: 2AJX4-GATEWAY; Granted Date: 08/03/2017

B) Bluetooth module, FCC ID: A8TBM71S2; Granted Date: 01/05/2016

C) 802.11BGN 1X1 MODULE, FCC ID: W7O24WN0; Granted Date: 08/27/2015

Based on this case, only the conducted emissions at AC Power Line and radiated spurious emission during three modules in simultaneously transmitting was re-evaluated in this report.

3 Contents

4 General Information

4.1 Details of E.U.T.

Power supply: DC 12V/2A

LoRa:

Frequency Range: 903MHz to 927.5MHz
Modulation Technique: LoRa
Antenna Type: Omni-Directional
Antenna Gain: 5.0dBi

BLE:

Frequency Range: 2402MHz to 2480MHz
Modulation Type: GFSK
Number of Channels: 40
Antenna Type: Chip Antenna
Antenna Gain: 0.1dBi

WiFi:

Operation Frequency: IEEE 802.11b/g/n(HT20): 2412MHz to 2472MHz
IEEE 802.11n(HT40): 2422MHz to 2462MHz
Modulation Type: IEEE for 802.11b: DSSS(CCK,DQPSK,DBPSK)
IEEE for 802.11g: OFDM(64QAM, 16QAM, QPSK, BPSK)
IEEE for 802.11n(HT20)/n(HT40): OFDM (BPSK, QPSK, 16QAM, 64QAM)
Channel Numbers: IEEE 802.11b/g, IEEE 802.11n HT20: 13 Channels
IEEE 802.11n(HT40): 9 Channels
Antenna Type: PCB Antenna
Antenna Gain: -1dBi

4.2 Description of Support Units

Description	Manufacturer	Model No.	Serial No.
AC/DC Adapter	Provided by client	DC 12V Output	--

4.3 Measurement Uncertainty

No.	Item	Measurement Uncertainty
1	Conduction emission	3.45dB (9kHz to 150kHz)
		3.0dB (150kHz to 30MHz)
2	Radiated Spurious emission test	4.5dB (30MHz-1GHz)
		4.8dB (1GHz-18GHz)
3	Temperature test	1℃
4	Humidity test	3%
5	Supply voltages	1.5%

4.4 Test Location

All tests were performed at:

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen Branch

No. 1 Workshop, M-10, Middle Section, Science & Technology Park, Shenzhen, Guangdong, China. 518057.

Tel: +86 755 2601 2053 Fax: +86 755 2671 0594

No tests were sub-contracted.

4.5 Test Facility

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

• **CNAS (No. CNAS L2929)**

CNAS has accredited SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC

Lab to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories (CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence in the field of testing.

• **A2LA (Certificate No. 3816.01)**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 3816.01.

• **VCCI**

The 10m Semi-anechoic chamber and Shielded Room of SGS-CSTC Standards Technical Services Co., Ltd. have been registered in accordance with the Regulations for Voluntary Control Measures with Registration No.: G-823, R-4188, T-1153 and C-2383 respectively.

• **FCC –Designation Number: CN1178**

SGS-CSTC Standards Technical Services Co., Ltd., Shenzhen EMC Laboratory has been recognized as an accredited testing laboratory.

Designation Number: CN1178. Test Firm Registration Number: 406779.

• **Industry Canada (IC)**

Two 3m Semi-anechoic chambers and the 10m Semi-anechoic chamber of SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen Branch EMC Lab have been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 4620C-1, 4620C-2, 4620C-3.

4.6 Deviation from Standards

None

4.7 Abnormalities from Standard Conditions

None

5 Equipment List

Conducted Emissions at AC Power Line (150kHz-30MHz)					
Equipment	**Manufacturer**	**Model No**	**Inventory No**	**Cal Date**	**Cal Due Date**
Shielding Room	ZhongYu Electron	GB-88	SEM001-06	2017-05-10	2018-05-10
Measurement Software	AUDIX	e3 V5.4.1221d	N/A	N/A	N/A
LISN	Rohde & Schwarz	ENV216	SEM007-01	2016-10-09	2017-10-09
LISN	ETS-LINDGREN	3816/2	SEM007-02	2017-04-14	2018-04-13
8 Line ISN	Fischer Custom Communications Inc.	FCC-TLISN-T8-02	EMC0120	2016-09-28	2017-09-28
4 Line ISN	Fischer Custom Communications Inc.	FCC-TLISN-T4-02	EMC0121	2016-09-28	2017-09-28
2 Line ISN	Fischer Custom	FCC-TLISN-T2-02	EMC0122	2016-09-28	2017-09-28

Radiated Spurious Emissions					
Equipment	**Manufacturer**	**Model No**	**Inventory No**	**Cal Date**	**Cal Due Date**
3m Semi-Anechoic Chamber	AUDIX	N/A	SEM001-02	2017-05-02	2020-05-01
Measurement Software	AUDIX	e3 V8.2014-6-27	N/A	N/A	N/A
Spectrum Analyzer	Rohde & Schwarz	FSU43	SEM004-08	2017-04-14	2018-04-13
BiConiLog Antenna (26-3000MHz)	ETS-Lindgren	3142C	SEM003-02	2017-03-05	2020-03-05
Horn Antenna (1-18GHz)	Rohde & Schwarz	HF907	SEM003-07	2015-06-14	2018-06-14
Horn Antenna(15GHz-40GHz)	Schwarzbeck	BBHA 9170	SEM003-14	2017-06-16	2020-06-15
Pre-amplifier (0.1-1300MHz)	HP	8447D	SEM005-02	2016-10-09	2017-10-09
Low Noise Amplifier(100MHz-18GHz)	Black Diamond Series	BDLNA-0118-352810	SEM005-05	2016-10-09	2017-10-09
Pre-amplifier(0.1-26.5GHz)	Compliance Directions Systems Inc.	PAP-0126	SEM004-10	2016-10-17	2017-10-17
Pre-amplifier(26GHz-40GHz)	Compliance Directions Systems Inc.	PAP-2640-50	SEM005-08	2017-04-14	2018-04-13
DC Power Supply	Zhao Xin	RXN-305D	SEM011-02	2016-10-09	2017-10-09
Active Loop Antenna	ETS-Lindgren	6502	SEM003-08	2015-08-14	2018-08-14
Band filter	N/A	N/A	SEM023-01	N/A	N/A

General used equipment					
Equipment	**Manufacturer**	**Model No**	**Inventory No**	**Cal Date**	**Cal Due Date**
Humidity/ Temperature Indicator	Shanghai Meteorological Industry Factory	ZJ1-2B	SEM002-03	2016-10-12	2017-10-12
Humidity/ Temperature Indicator	Shanghai Meteorological Industry Factory	ZJ1-2B	SEM002-04	2016-10-12	2017-10-12
Humidity/ Temperature Indicator	Mingle	N/A	SEM002-08	2016-10-12	2017-10-12
Barometer	Changchun Meteorological Industry Factory	DYM3	SEM002-01	2017-04-18	2018-04-18

6 Radio Spectrum Matter Test Results

6.1 Conducted Emissions at AC Power Line (150kHz-30MHz)

Test Requirement 47 CFR Part 15, Subpart C 15.207

Test Method: ANSI C63.10 (2013) Section 6.2

Limit:

Frequency of emission(MHz)	Conducted limit(dBμV)	
	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.		

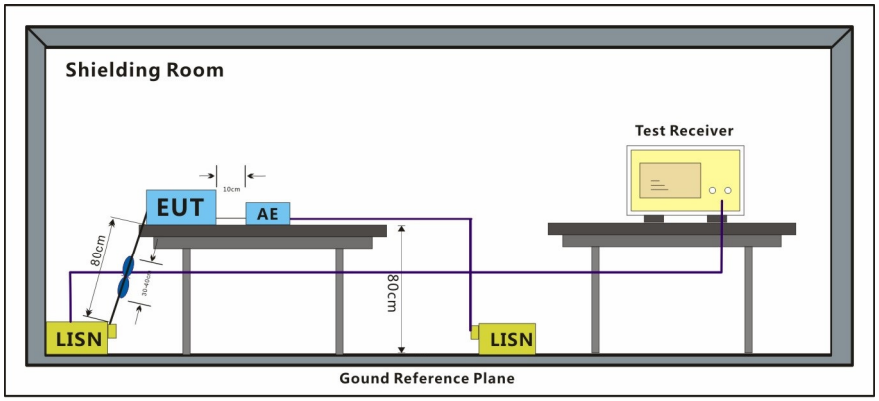
6.1.1 E.U.T. Operation

Operating Environment:

Temperature: 25 °C Humidity: 55 % RH Atmospheric Pressure: 1010 mbar

Test mode b:TX mode_Keep the EUT in WiFi, Bluetooth and Lora in simultaneously transmitting mode.

6.1.2 Test Setup Diagram



6.1.3 Measurement Procedure and Data

1) The mains terminal disturbance voltage test was conducted in a shielded room.

2) The EUT was connected to AC power source through a LISN 1 (Line Impedance Stabilization Network) which provides a 50ohm/50μH + 5ohm linear impedance. The power cables of all other units of the EUT were connected to a second LISN 2, which was bonded to the ground reference plane in the same way as the LISN 1 for the unit being measured. A multiple socket outlet strip was used to connect multiple power cables to a single LISN provided the rating of the LISN was not exceeded.

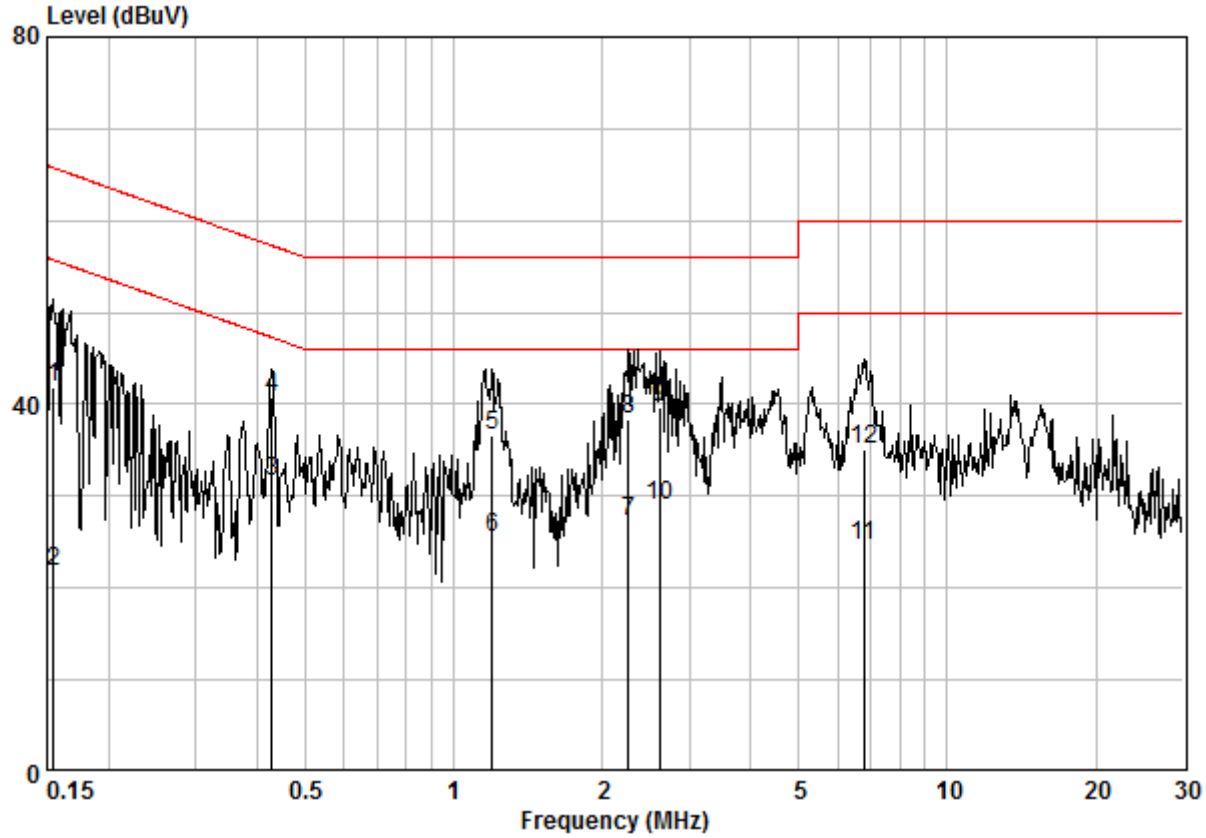
3) The tabletop EUT was placed upon a non-metallic table 0.8m above the ground reference plane. And for floor-standing arrangement, the EUT was placed on the horizontal ground reference plane,

4) The test was performed with a vertical ground reference plane. The rear of the EUT shall be 0.4 m from the vertical ground reference plane. The vertical ground reference plane was bonded to the horizontal ground reference plane. The LISN 1 was placed 0.8 m from the boundary of the unit under test and bonded to a ground reference plane for LISNs mounted on top of the ground reference plane. This distance was between the closest points of the LISN 1 and the EUT. All other units of the EUT and associated equipment was at least 0.8 m from the LISN 2.

5) In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10 on conducted measurement.

Remark: LISN=Read Level+ Cable Loss+ LISN Factor

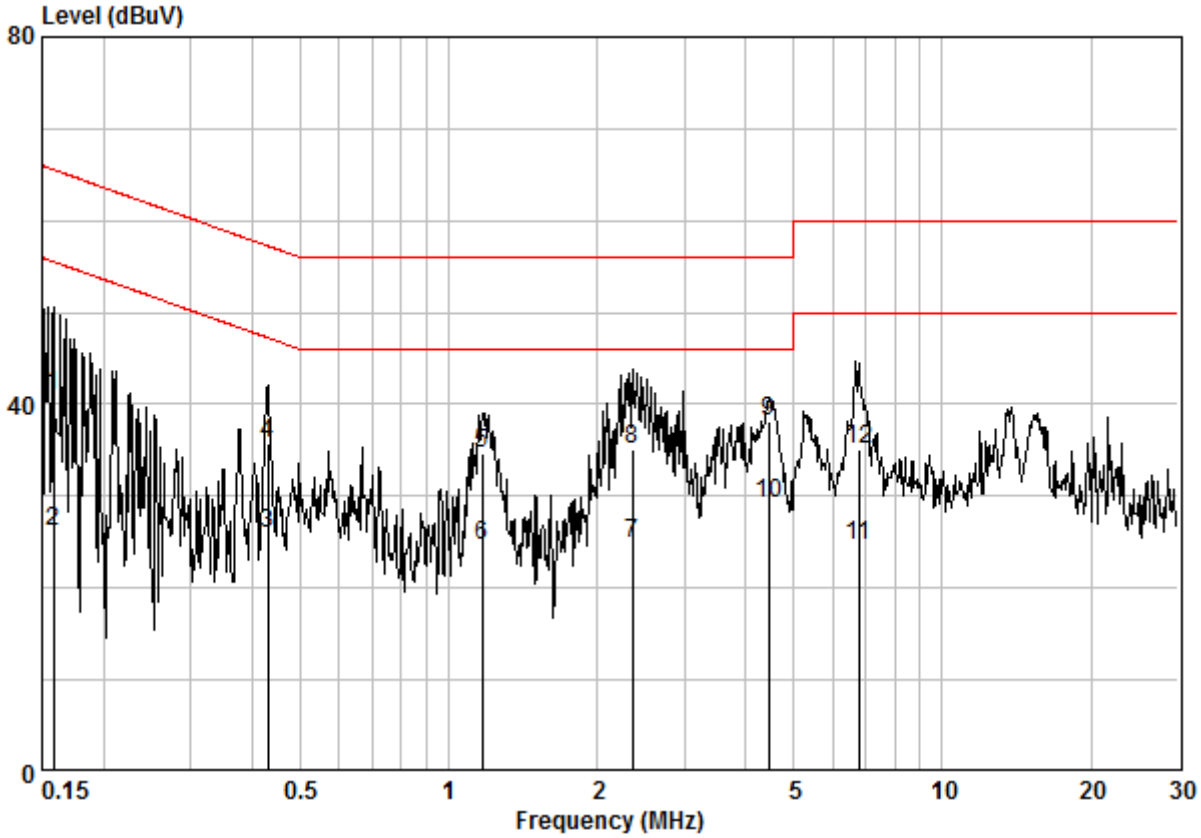
Mode:b; Line:Live Line



Site : Shielding Room
Condition : CE LINE
Job No. : 03853CR
Test Mode : b

		Freq	Cable Loss	LISN Factor	Read Level	Level	Limit Line	Over Limit	Remark
		MHz	dB	dB	dBuV	dBuV	dBuV	dB	
1		0.15485	0.02	9.64	32.13	41.79	65.74	-23.95	QP
2		0.15485	0.02	9.64	12.13	21.79	55.74	-33.94	AVERAGE
3	@	0.42825	0.02	9.64	21.99	31.65	47.29	-15.63	AVERAGE
4		0.42825	0.02	9.64	31.12	40.78	57.29	-16.51	QP
5		1.197	0.03	9.66	26.93	36.62	56.00	-19.38	QP
6		1.197	0.03	9.66	15.71	25.40	46.00	-20.60	AVERAGE
7		2.261	0.03	9.68	17.53	27.24	46.00	-18.76	AVERAGE
8		2.261	0.03	9.68	28.67	38.37	56.00	-17.63	QP
9		2.608	0.03	9.68	29.95	39.66	56.00	-16.34	QP
10		2.608	0.03	9.68	19.28	28.99	46.00	-17.01	AVERAGE
11		6.769	0.07	9.78	14.82	24.68	50.00	-25.32	AVERAGE
12		6.769	0.07	9.78	25.32	35.18	60.00	-24.82	QP

Mode:b; Line:Neutral Line



Site : Shielding Room
Condition : CE NEUTRAL
Job No. : 03853CR
Test Mode : b

	Freq	Cable Loss	LISN Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dB	dBuV	dBuV	dBuV	dB	
1	0.15816	0.02	9.64	31.28	40.94	65.56	-24.62	QP
2	0.15816	0.02	9.64	16.44	26.09	55.56	-29.47	AVERAGE
3	0.43052	0.02	9.63	16.39	26.04	47.24	-21.20	AVERAGE
4	0.43052	0.02	9.63	26.15	35.80	57.24	-21.44	QP
5	1.172	0.03	9.64	25.07	34.74	56.00	-21.26	QP
6	1.172	0.03	9.64	14.92	24.59	46.00	-21.41	AVERAGE
7	2.358	0.03	9.66	15.27	24.96	46.00	-21.04	AVERAGE
8	2.358	0.03	9.66	25.30	34.99	56.00	-21.01	QP
9	4.454	0.02	9.70	28.50	38.23	56.00	-17.77	QP
10	4.454	0.02	9.70	19.38	29.11	46.00	-16.89	AVERAGE
11	6.769	0.07	9.76	14.79	24.63	50.00	-25.37	AVERAGE
12	6.769	0.07	9.76	25.22	35.06	60.00	-24.94	QP

6.2 Radiated Spurious Emissions

Test Requirement 47 CFR Part 15, Subpart C 15.209 & 15.247(d)
Test Method: ANSI C63.10 (2013) Section 6.10.4
Measurement Distance: 3m
Limit:

Frequency(MHz)	Field strength(microvolts/meter)	Measurement distance(meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3
Remark: The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90kHz, 110-490kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.		

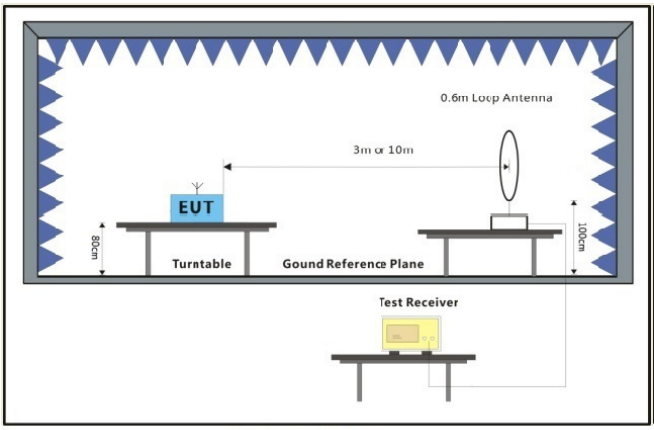
6.2.1 E.U.T. Operation

Operating Environment:

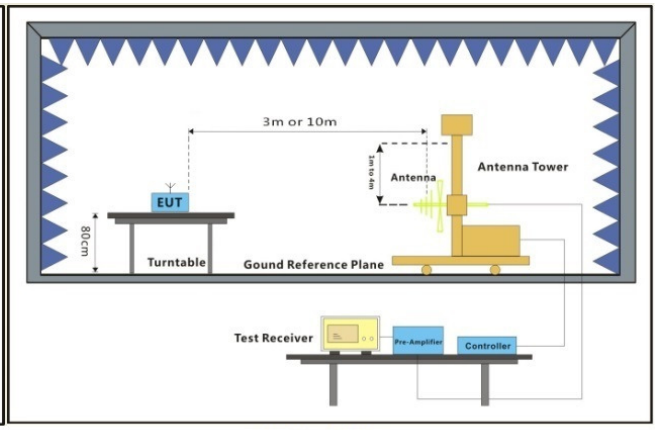
Temperature: 23 °C Humidity: 54 % RH Atmospheric Pressure: 1015 mbar

Test mode b:TX mode_Keep the EUT in WiFi, Bluetooth and Lora in simultaneously transmitting mode.

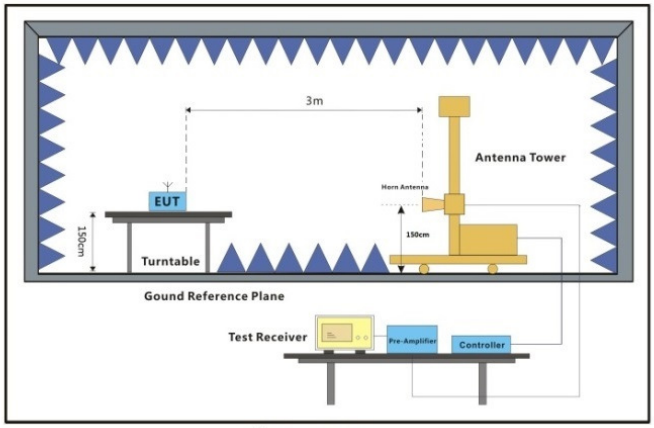
6.2.2 Test Setup Diagram



Below 30MHz



30MHz-1GHz



Above 1GHz

6.2.3 Measurement Procedure and Data

a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.

b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter fully-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.

c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

d. 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.

e. 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 (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.

f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.

g. 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.

h. Test the EUT in the lowest channel,the middle channel,the Highest channel.

i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.

j. Repeat above procedures until all frequencies measured was complete.

Remark: Level= Read Level+ Cable Loss+ Antenna Factor- Preamp Factor

Remark: Refer to the RF module report on radiated spurious emission test, the worst case for three modules are below:

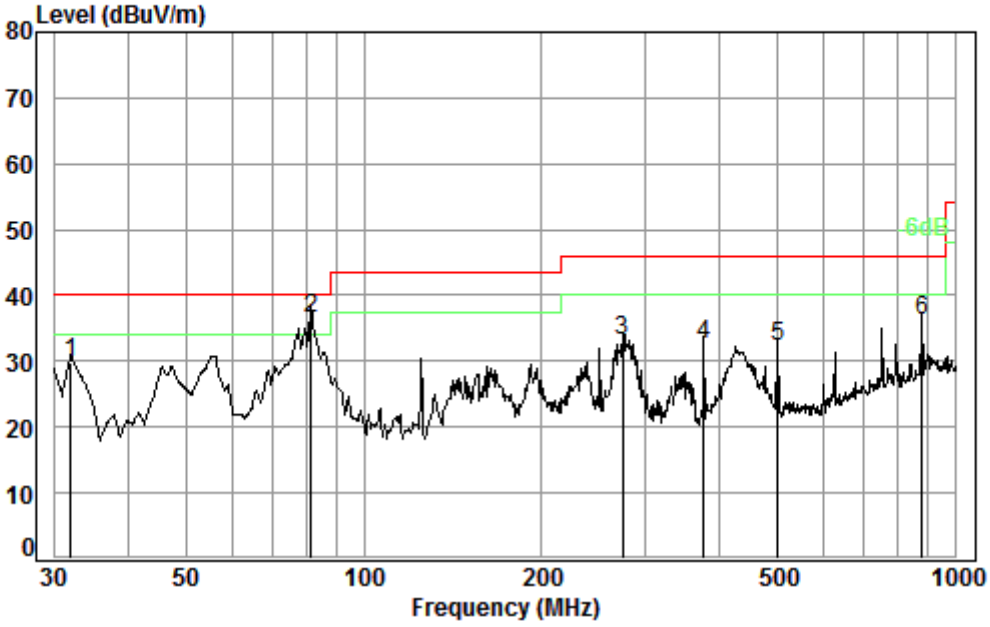
LoRa: lowest channel: 903MHz

BLE: Highest channel: 2480MHz

WiFi: 802.11b mode @ 2412MHz

So, the radiated spurious emission was tested under above three mode transmitting in simultaneously.

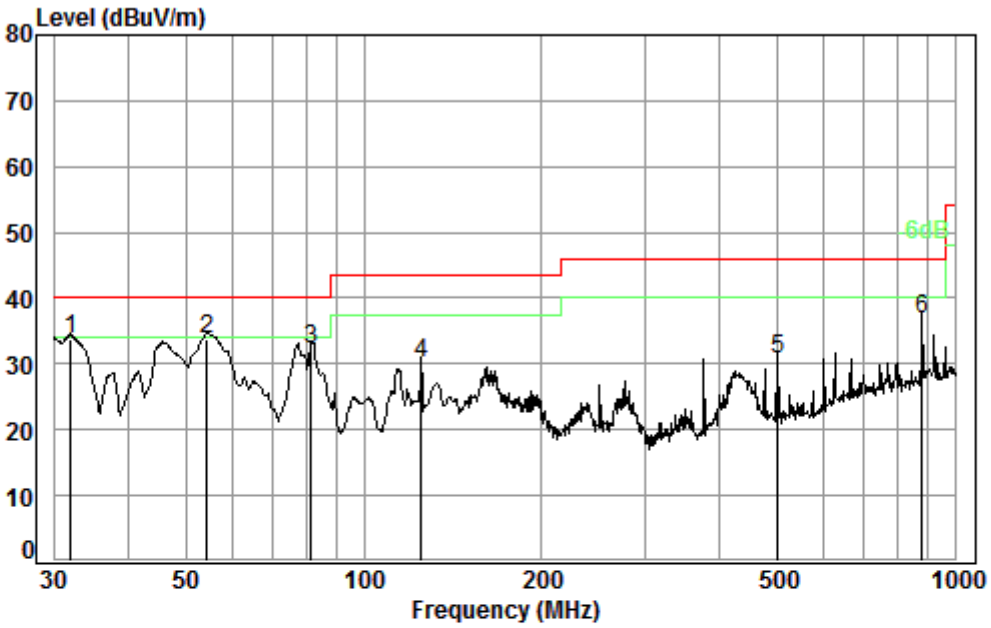
Mode:b; Polarization:Horizontal



Condition: 3m HORIZONTAL
Job No. : 3853CR
Test mode: b

	Freq	Cable Loss	Ant Factor	Preamp Factor	Read Level	Level	Limit Line	Over Limit
	MHz	dB	dB/m	dB	dBuV	dBuV/m	dBuV/m	dB
1	31.95	0.60	17.61	27.35	39.10	29.96	40.00	-10.04
2 pp	81.50	1.10	7.85	27.23	54.76	36.48	40.00	-3.52
3	273.23	1.78	12.76	26.47	45.23	33.30	46.00	-12.70
4	375.94	2.13	16.01	26.97	41.51	32.68	46.00	-13.32
5	501.18	2.60	17.83	27.69	39.52	32.26	46.00	-13.74
6	878.32	3.52	23.03	26.89	36.67	36.33	46.00	-9.67

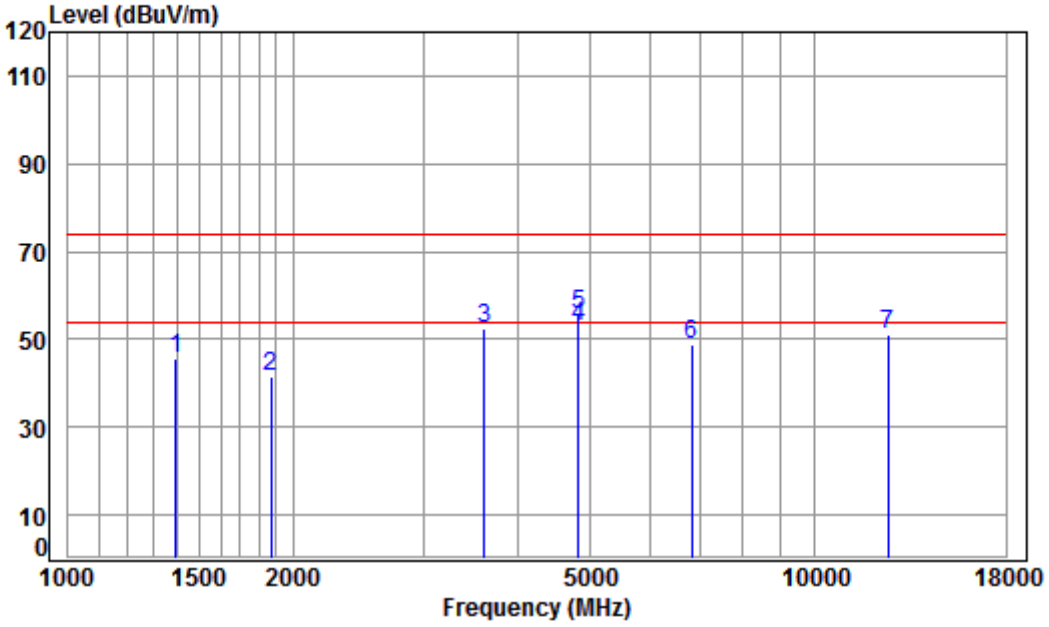
Mode:b; Polarization:Vertical



Condition: 3m VERTICAL
Job No. : 3853CR
Test mode: b

	Freq	Cable Loss	Ant Factor	Preamp Factor	Read Level	Level	Limit Line	Over Limit
	MHz	dB	dB/m	dB	dBuV	dBuV/m	dBuV/m	dB
1	31.95	0.60	17.61	27.35	42.76	33.62	40.00	-6.38
2 pp	54.26	0.80	8.06	27.28	52.30	33.88	40.00	-6.12
3	81.50	1.10	7.85	27.23	50.51	32.23	40.00	-7.77
4	125.01	1.26	7.80	27.04	48.09	30.11	43.50	-13.39
5	501.18	2.60	17.83	27.69	37.94	30.68	46.00	-15.32
6	878.32	3.52	23.03	26.89	37.28	36.94	46.00	-9.06

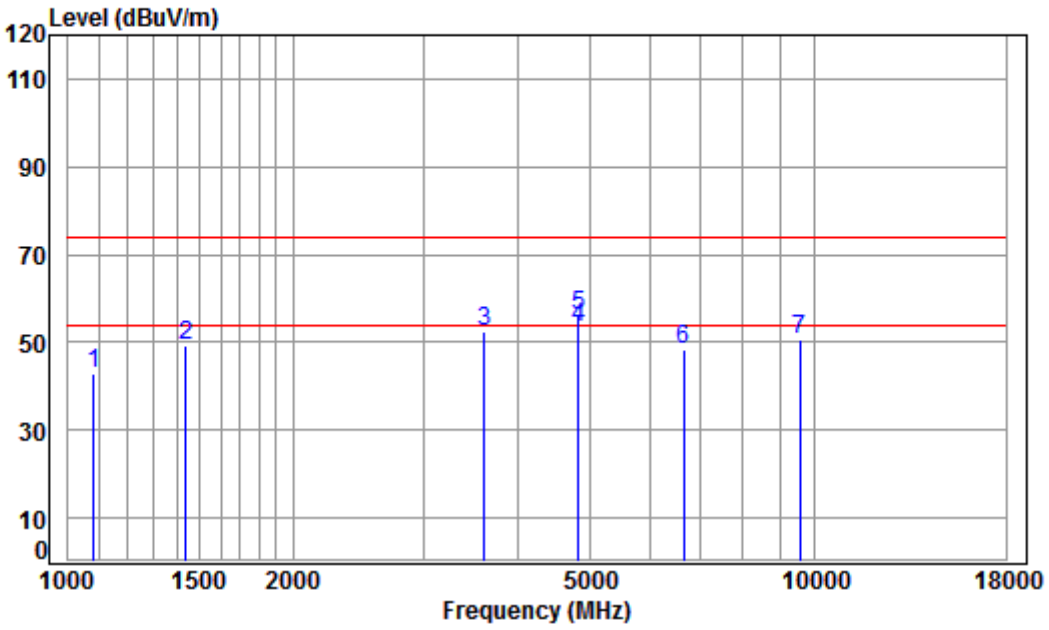
Mode:b; Polarization:Horizontal



Condition: 3m HORIZONTAL
Job No: : 03853CR
Mode: : WIFI+BT+Lora TX SE

	Freq	Cable Loss	Ant Factor	Preamp Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dB/m	dB	dBuV	dBuV/m	dBuV/m	dB	
1	1394.300	4.34	25.37	38.06	54.08	45.73	74.00	-28.27	peak
2	1872.381	4.89	27.34	38.01	47.46	41.68	74.00	-32.32	peak
3	3605.786	6.39	32.51	37.96	51.44	52.38	74.00	-21.62	Peak
4 pp	4824.000	7.77	34.21	38.42	49.42	52.98	54.00	-1.02	Average
5 pk	4824.000	7.77	34.21	38.42	51.90	55.46	74.00	-18.54	Peak
6	6835.278	9.37	36.05	37.46	40.95	48.91	74.00	-25.09	peak
7	12505.710	13.14	38.90	36.81	36.01	51.24	74.00	-22.76	peak

Mode:b; Polarization:Vertical



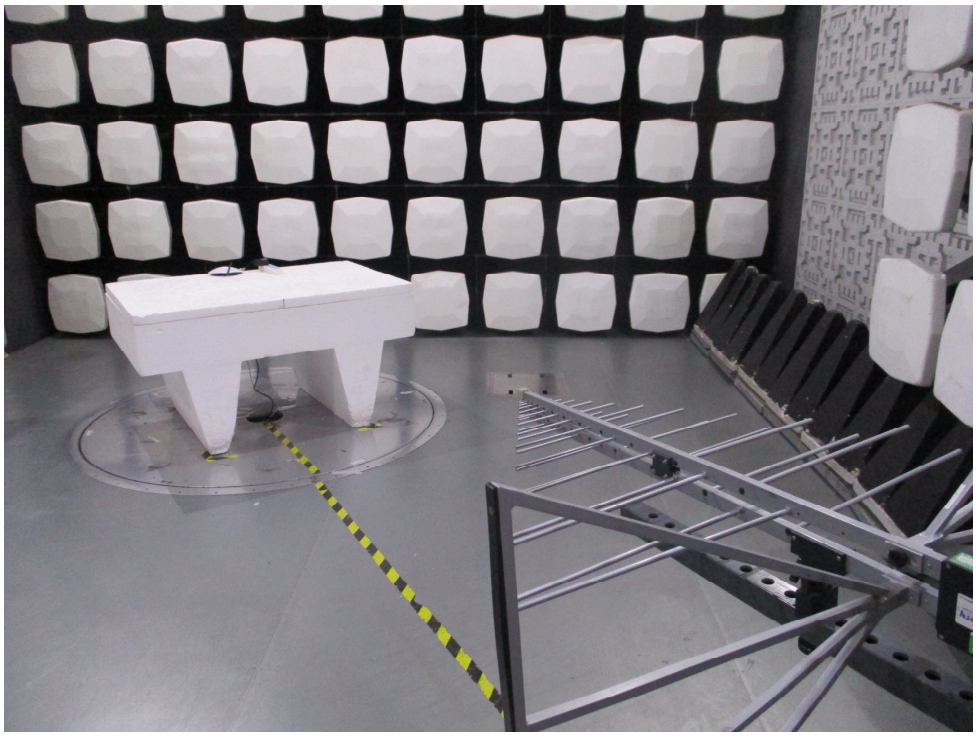
Condition: 3m Vertical
Job No: : 03853CR
Mode: : WIFI+BT+Lora TX SE

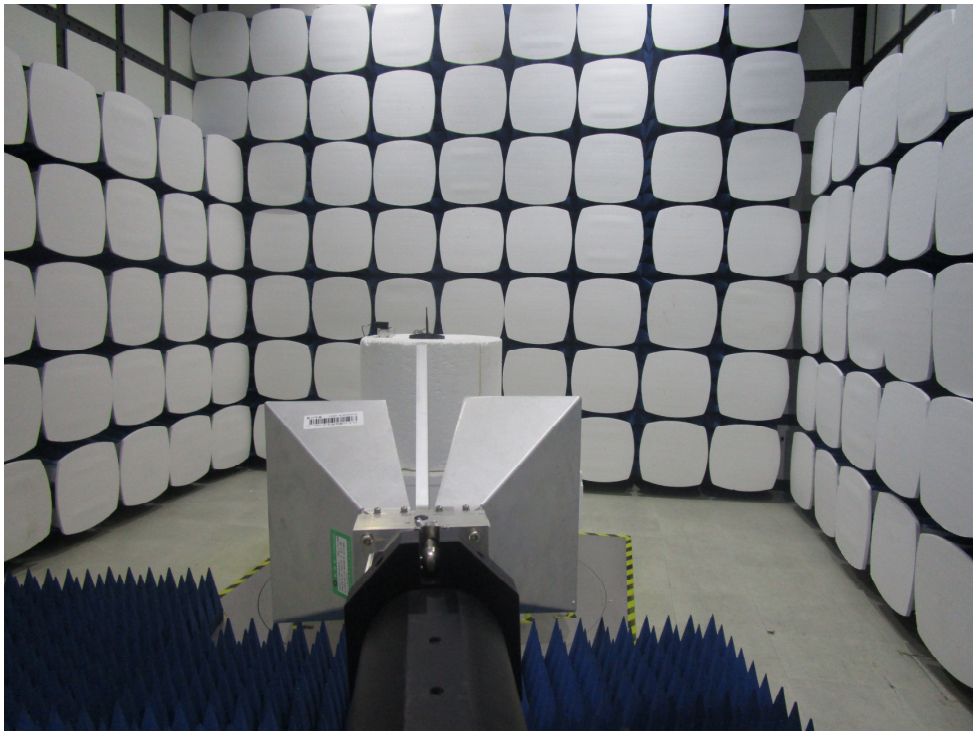
	Freq	Cable Loss	Ant Factor	Preamp Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dB/m	dB	dBuV	dBuV/m	dBuV/m	dB	
1	1081.166	3.90	23.86	38.09	53.30	42.97	74.00	-31.03	Peak
2	1439.343	4.40	25.56	38.06	57.51	49.41	74.00	-24.59	peak
3	3605.786	6.39	32.51	37.96	51.64	52.58	74.00	-21.42	Peak
4 pp	4824.000	7.77	34.21	38.42	49.73	53.29	54.00	-0.71	Average
5 pk	4824.000	7.77	34.21	38.42	52.47	56.03	74.00	-17.97	Peak
6	6659.763	9.21	35.56	37.64	41.18	48.31	74.00	-25.69	peak
7	9530.432	10.98	37.51	35.13	37.14	50.50	74.00	-23.50	peak

7 Photographs

7.1 Conducted Emissions at AC Power Line (150kHz-30MHz) Test Setup

7.2 Radiated Spurious Emissions Test Setup





7.3 EUT Constructional Details

Refer to Appendix A - Photographs of EUT Constructional Details for SZEM1704003853CR.