FCC TEST REPORT

FOR
Kar-Tech, Inc.

MCT247

Test Model: MCT247

Prepared for	:	Kar-Tech, Inc.
Address	:	111 Enterprise Road, P.O.Box 180606,Delafield, Wisconsin 53018,United States
Prepared by	:	Shenzhen LCS Compliance Testing Laboratory Ltd.
Address	:	101, 201 Bldg A & 301 Bldg C, Juji Industrial Park Shajing Street, Baoan District, Shenzhen, China
Tel	:	(+86)755-82591330
Fax	:	(+86)755-82591332
Web	:	www.LCS-cert.com
Mail	:	webmaster@LCS-cert.com
Date of receipt of test sample	:	June 17, 2020
Number of tested samples	:	1
Serial number	:	Prototype
Date of Test	:	June 17, 2020 ~ June 24, 2020
Date of Report	:	June 30, 2020

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

FCC TEST REPORT

FCC CFR 47 PART 15 C(15.247)

Report Reference No.	**:**	**LCS200612004AEA**
Date of Issue.....	:	June 30, 2020
Testing Laboratory Name.....	**:**	**Shenzhen LCS Compliance Testing Laboratory Ltd.**
Address.....	:	101, 201 Bldg A & 301 Bldg C, Juji Industrial Park Shajing Street, Baoan District, Shenzhen, China
Testing Location/ Procedure.....	:	Full application of Harmonised standards ■ Partial application of Harmonised standards □ Other standard testing method □
Applicant's Name.....	**:**	**Kar-Tech, Inc.**
Address.....	:	111 Enterprise Road, P.O.Box 180606,Delafield, Wisconsin 53018,United States
Test Specification		
Standard.....	:	FCC CFR 47 PART 15 C(15.247)
Test Report Form No.....	:	LCSEMC-1.0
TRF Originator.....	:	Shenzhen LCS Compliance Testing Laboratory Ltd.
Master TRF.....	:	Dated 2011-03

Shenzhen LCS Compliance Testing Laboratory Ltd. All rights reserved.

This publication may be reproduced in whole or in part for non-commercial purposes as long as the Shenzhen LCS Compliance Testing Laboratory Ltd. is acknowledged as copyright owner and source of the material. Shenzhen LCS Compliance Testing Laboratory Ltd. takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.

Test Item Description.....	**:**	**MCT247**
Trade Mark.....	:	Kar-Tech
Test Model.....	:	MCT247
Ratings.....	:	DC 3.3V
Result	**:**	**Positive**

Compiled by:	**Supervised by:**	**Approved by:**
Jack Liu	Jin Wang	Gavin Liang
Jack Liu/ Administrators	Jin Wang/ Technique principal	Gavin Liang/ Manager

FCC -- TEST REPORT

Test Report No. : **LCS200612004AEA**	June 30, 2020 Date of issue

Test Model.....	: MCT247
EUT.....	: MCT247
Applicant.....	**: Kar-Tech, Inc.**
Address.....	: 111 Enterprise Road, P.O.Box 180606,Delafield, Wisconsin 53018,United States
Telephone.....	: /
Fax.....	: /
Manufacturer.....	**: Kar-Tech, Inc.**
Address.....	: 111 Enterprise Road, P.O.Box 180606,Delafield, Wisconsin 53018,United States
Telephone.....	: /
Fax.....	: /
Factory.....	: **/**
Address.....	: /
Telephone.....	: /
Fax.....	: /

Test Result	**Positive**

The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test result without the written permission of the test laboratory.

Revision History

Revision	Issue Date	Revisions	Revised By
000	June 30, 2020	Initial Issue	Gavin Liang

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

TABLE OF CONTENTS

Description Page

1.GENERAL INFORMATION..... 6
1.1 Description of Device (EUT)..... 6
1.2 Support equipment List..... 7
1.3 External I/O Cable..... 7
1.4 Description of Test Facility..... 7
1.5 Statement of the Measurement Uncertainty..... 8
1.6 Measurement Uncertainty..... 8
1.7 Description of Test Modes..... 8
2. TEST METHODOLOGY..... 9
2.1 EUT Configuration..... 9
2.2 EUT Exercise..... 9
2.3 General Test Procedures..... 9
2.4. Test Sample..... 9
3. SYSTEM TEST CONFIGURATION..... 10
3.1 Justification..... 10
3.2 EUT Exercise Software..... 10
3.3 Special Accessories..... 10
3.4 Block Diagram/Schematics..... 10
3.5 Equipment Modifications..... 10
3.6 Test Setup..... 10
4. SUMMARY OF TEST RESULTS..... 11
5. SUMMARY OF TEST EQUIPMENT..... 12
6. MEASUREMENT RESULTS..... 13
6.1 Peak Power..... 13
6.2 Frequency Separation and 20 dB Bandwidth..... 14
6.3 Number of Hopping Frequency..... 15
6.4 Time of Occupancy (Dwell Time)..... 16
6.5 Conducted Spurious Emissions and Band Edges Test..... 17
6.6 Restricted Band Emission Limit..... 18
6.7. AC Power Line Conducted Emissions..... 27
6.8. Band-edge Measurements for Radiated Emissions..... 30
6.9. Pseudorandom Frequency Hopping Sequence..... 32
6.10. Antenna Requirement..... 33
7. TEST SETUP PHOTOGRAPHS OF EUT..... 34
8. EXTERIOR PHOTOGRAPHS OF THE EUT..... 34
9. INTERIOR PHOTOGRAPHS OF THE EUT..... 34

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

1.GENERAL INFORMATION

1.1 Description of Device (EUT)

EUT	: MCT247
Test Model	: MCT247
Power Supply	: DC 3.3V
Hardware Version	: A
Software Version	: A
SRD	:
Operation frequency	: 2407MHz-2470MHz
Channel Number	: 64 Channels 2407~2467MHz for Hop one； 2408~2468MHz for Hop two； 2409~2469MHz for Hop three； 2410~2470MHz for Hop four；
Channel Spacing	: 1MHz
Modulation Type	: GFSK
Antenna Description	: WIP Monopole antenna, 1.1dBi(Max.)

1.2 Support equipment List

Manufacturer	Description	Model	Serial Number	Certificate
Lenovo	PC	YogaDuet	--	FCC ID

1.3 External I/O Cable

I/O Port Description	Quantity	Cable
--	--	--

1.4 Description of Test Facility

FCC Registration Number is 254912.
Industry Canada Registration Number is 9642A.
EMSD Registration Number is ARCB0108.
UL Registration Number is 100571-492.
TUV SUD Registration Number is SCN1081.
TUV RH Registration Number is UA 50296516-001.
NVLAP Accreditation Code is 600167-0.
FCC Designation Number is CN5024
CAB identifier: CN0071

The 3m-Semi anechoic test site fulfils CISPR 16-1-4 according to ANSI C63.10:2013 and CISPR 16-1-4:2010 SVSWR requirement for radiated emission above 1GHz.

1.5 Statement of the Measurement Uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. To CISPR 16 – 4 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements" and is documented in the LCS quality system acc. To DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

1.6 Measurement Uncertainty

Test Item		Frequency Range	Uncertainty	Note
Radiation Uncertainty	:	9KHz~30MHz	3.10dB	(1)
		30MHz~200MHz	2.96dB	(1)
		200MHz~1000MHz	3.10dB	(1)
		1GHz~26.5GHz	3.80dB	(1)
		26.5GHz~40GHz	3.90dB	(1)
Conduction Uncertainty	:	150kHz~30MHz	1.63dB	(1)
Power disturbance	:	30MHz~300MHz	1.60dB	(1)

(1). This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

1.7 Description of Test Modes

MCT247 operates in the unlicensed ISM Band at 2.4GHz. With basic data rate feature, the data rates can be up to 1 Mb/s by modulating the RF carrier using GFSK techniques. The EUT works in the X-axis, Y-axis, Z-axis. The following operating modes were applied for the related test items. All test modes were tested, only the result of the worst case was recorded in the report.

Mode of Operations	Frequency Range (MHz)	Data Rate (Mbps)
FHSS	2407	1Mbps
	2438	1Mbps
	2470	1Mbps
For Conducted Emission		
Test Mode	TX Mode	
For Radiated Emission		
Test Mode	TX Mode	

Worst-case mode and channel used for 9 KHz-1000 MHz radiated emissions was the mode and channel with the highest output power, that was determined to be TX(1Mbps-Middle Channel).

Channel List:

Channel	Frequency(MHz)	Channel	Frequency(MHz)
1	2407	17	---
2	2408	18	---
3	2409	19	---
4	2410	20	---
5	---	21	---
6	---	62	2468
7	---	63	2469
8	---	64	2470
9	---	---	---

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2013, FCC CFR PART 15C 15.207, 15.209, 15.247 and DA 00-705.

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

The EUT was operated in the normal operating mode for Hopping Numbers and Dwell Time test and a continuous transmits mode for other tests.

According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209, 15.247 under the FCC Rules Part 15 Subpart C.

2.3 General Test Procedures

2.3.1 Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane.. According to the requirements in Section 6.2.1 of ANSI C63.10-2013 Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using Quasi-peak and average detector modes.

2.3.2 Radiated Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane.The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna, which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the maximum emissions, exploratory radiated emission measurements were made according to the requirements in Section 6.3 of ANSI C63.10-2013

2.4. Test Sample

The application provides 2 samples to meet requirement;

Sample Number	Description
Sample 1	Engineer sample – continuous transmit
Sample 2	Normal sample – Intermittent transmit

3. SYSTEM TEST CONFIGURATION

3.1 Justification

The system was configured for testing in a continuous transmits condition.

3.2 EUT Exercise Software

The system was configured for testing in a continuous transmits condition and change test channels manually switch the frequency points by pressing a key.

3.3 Special Accessories

N/A.

3.4 Block Diagram/Schematics

Please refer to the related document.

3.5 Equipment Modifications

Shenzhen LCS Compliance Testing Laboratory Ltd. has not done any modification on the EUT.

3.6 Test Setup

Please refer to the test setup photo.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

4. SUMMARY OF TEST RESULTS

Applied Standard: FCC Part 15 Subpart C				
FCC Rules	Description of Test	Test Sample	Result	Remark
§15.247(b)	Maximum Conducted Output Power	Sample 1	Compliant	Appendix A.1
§15.247(a)	20dB Bandwidth	Sample 1	Compliant	Appendix A.2
§15.247(a)	Frequency Separation	Sample 1	Compliant	Appendix A.3
§15.247(a)	Number Of Hopping Frequency	Sample 2	Compliant	Appendix A.4
§15.247(a)	Time Of Occupancy (Dwell Time)	Sample 2	Compliant	Appendix A.5
§15.205, §15.247(d)	Conducted Spurious Emissions and Band Edges Emissions	Sample 1	Compliant	Appendix A.6 Appendix A.7
§15.209, §15.247(d)	Radiated Spurious Emissions	Sample 1	Compliant	Note 1
§15.205	Emissions at Restricted Band	Sample 1	Compliant	Appendix A.8
§15.207(a)	AC Mains Conducted Emissions	Sample 1	Compliant	Note 1
§15.203	Antenna Requirements	Sample 1	Compliant	Note 1
§15.247(i)§2.1091	RF Exposure	N/A	Compliant	Note 2

Remark:

Note 1 --- Test results inside test report.

Note 2 --- Test results in other test report (RF Exposure Evaluation).

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

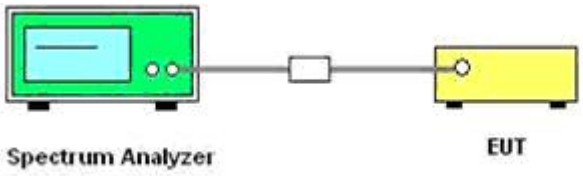
5. SUMMARY OF TEST EQUIPMENT

Item	Equipment	Manufacturer	Model No.	Serial No.	Cal Date	Due Date
1	Power Meter	R&S	NRVS	100444	2020-06-10	2021-06-09
2	Power Sensor	R&S	NRV-Z81	100458	2020-06-10	2021-06-09
3	Power Sensor	R&S	NRV-Z32	10057	2020-06-10	2021-06-09
4	Test Software	Tonscend	JS1120-2	/	N/A	N/A
5	RF Control Unit	Tonscend	JS0806-2	N/A	2020-06-10	2021-06-09
6	MXA Signal Analyzer	Agilent	N9020A	MY50510140	2019-11-22	2020-11-21
7	DC Power Supply	Agilent	E3642A	N/A	2019-11-14	2020-11-13
8	EMI Test Software	AUDIX	E3	/	N/A	N/A
9	3m Fully Anechoic Chamber	MRDIANZI	FAC-3M	MR009	2019-09-27	2020-09-26
10	Positioning Controller	MF	MF-7082	N/A	2020-06-11	2021-06-10
11	Active Loop Antenna	SCHWARZBECK	FMZB 1519B	00005	2018-07-26	2021-07-25
12	By-log Antenna	SCHWARZBECK	VULB9163	9163-470	2018-07-26	2021-07-25
13	Horn Antenna	SCHWARZBECK	BBHA 9120D	9120D-1925	2018-07-02	2021-07-01
14	Broadband Horn Antenna	SCHWARZBECK	BBHA 9170	791	2017-09-21	2020-09-20
15	Broadband Preamplifier	SCHWARZBECK	BBV 9719	9719-025	2020-06-16	2021-06-15
16	EMI Test Receiver	R&S	ESR 7	101181	2020-06-11	2021-06-10
17	RS SPECTRUM ANALYZER	R&S	FSP40	100503	2019-11-14	2020-11-13
18	Broadband Preamplifier	/	BP-01M18G	P190501	2019-07-01	2020-06-30
19	RF Cable-R03m	Jye Bao	RG142	CB021	2020-06-11	2021-06-10
20	RF Cable-HIGH	SUHNER	SUCOFLEX 106	03CH03-HY	2020-06-11	2021-06-10
21	6dB Attenuator	/	100W/6dB	1172040	2020-06-10	2021-06-09
22	3dB Attenuator	/	2N-3dB	/	2020-06-10	2021-06-09
23	EMI Test Receiver	R&S	ESPI	101840	2020-06-10	2021-06-09
24	Artificial Mains	R&S	ENV216	101288	2020-06-11	2021-06-10
25	10dB Attenuator	SCHWARZBECK	MTS-IMP-136	261115-001-0032	2020-06-10	2021-06-09
Note: All equipment is calibrated through CHINA CEPREI LABORATORY and GUANGZHOU LISAI CALIBRATION AND TEST CO., LTD.						

6. MEASUREMENT RESULTS

6.1 Peak Power

6.1.1 Block Diagram of Test Setup



6.1.2 Limit

According to §15.247(b)(1), For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

6.1.3 Test Procedure

The transmitter output is connected to the spectrum.

6.1.4. Test Procedures

1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.

2) RBW > 20 dB bandwidth of the emission being measured.

3) VBW ⩾ RBW.

4) Sweep: Auto.

5) Detector function: Peak.

6) Trace: Max hold.

6.1.5 Test Results

PASS

Please refer to Appendix A.1

Remark:

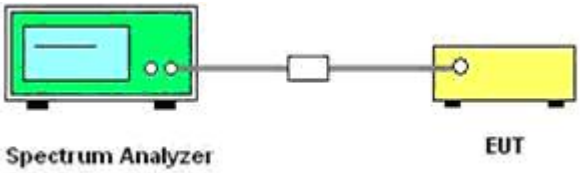
1. *Test results including cable loss;*
2. *Measured output power at difference Packet Type for each mode and recorded worst case for each mode.*

6.2 Frequency Separation and 20 dB Bandwidth

6.2.1 Limit

According to §15.247(a) (1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

6.2.2 Block Diagram of Test Setup



6.2.3 Test Procedure

Frequency separation test procedure：

1). Place the EUT on the table 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 the Spectrum Analyzer.

3). Set center frequency of Spectrum Analyzer = middle of hopping channel.

4). Set the Spectrum Analyzer as RBW = 300 kHz, VBW =1MHz, Span = wide enough to capture the peaks of two adjacent channels, Sweep = auto.

5). Max hold, mark 2 peaks of hopping channel and record the 2 peaks frequency.

20dB bandwidth test procedure：

1). Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel.

2). RBW ≥1% of the 20 dB bandwidth, VBW ≥RBW.

3). Detector function = peak.

4). Trace = max hold.

6.2.4 Test Results

PASS

Please refer to Appendix A.2 for 20 dB bandwidth

Please refer to Appendix A.3 for Frequency separation

Remark:

1). Test results including cable loss;

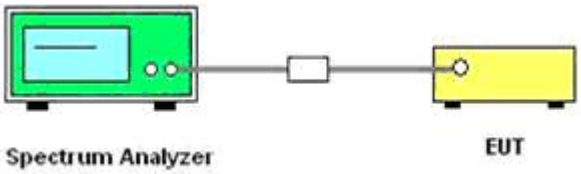
2). Measured at difference Packet Type for each mode and recorded worst case for each mode.

6.3 Number of Hopping Frequency

6.3.1 Limit

According to §15.247(a)(1)(ii), Frequency hopping systems operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels.

6.3.2 Block Diagram of Test Setup



6.3.3 Test Procedure

1). Place the EUT on the table 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 the Spectrum Analyzer.

3). Set Spectrum Analyzer Start=2400MHz, Stop = 2483.5MHz, Sweep = auto.

4). Set the Spectrum Analyzer as RBW/VBW=300KHz/1MHz.

5). Max hold, view and count how many channel in the band.

6.3.4 Test Results

PASS

Please refer to Appendix A.4

Remark:

1). Test results including cable loss;

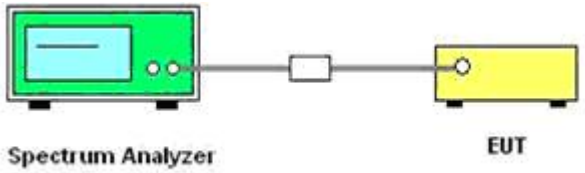
2). Measured at difference Packet Type for each mode and recorded worst case for each mode.

6.4 Time of Occupancy (Dwell Time)

6.4.1 Limit

According to §15.247(a)(1)(iii), Frequency hopping systems operating in the 2400MHz- 2483.5 MHz bands. The average time of occupancy on any channels shall not greater than 0.4 s within a period 0.4 s multiplied by the number of hopping channels employed.

6.4.2 Block Diagram of Test Setup



6.4.3 Test Procedure

1). Place the EUT on the table 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 the Spectrum Analyzer.

3). Set center frequency of Spectrum Analyzer = operating frequency.

4). Set the Spectrum Analyzer as RBW=1MHz, VBW=3MHz, Span = 0Hz, Sweep = auto.

5). Repeat above procedures until all frequency measured was complete.

6.4.4 Test Results

PASS

Please refer to Appendix A.5

Remark::

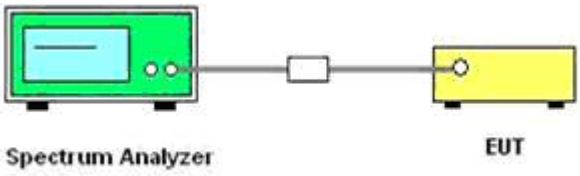
1. *Dwell time=Pulse width (ms) *hop number*
2. *Measured at low, middle and high channel, recorded the worst case.*

6.5 Conducted Spurious Emissions and Band Edges Test

6.5.1 Limit

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. Attenuation below the general limits specified in Section 15.209(a) is not required.

6.5.2 Block Diagram of Test Setup



6.5.3 Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 100 KHz. The video bandwidth is set to 300 KHz.

Measurements are made over the 9kHz to 25GHz range with the transmitter set to the lowest, middle, and highest channels.

6.5.4 Test Results of Conducted Spurious Emissions

No non-compliance noted. Only record the worst test result in this report. The test data refer to the following page.

PASS

Please refer to Appendix A.6 for conducted spurious emission.

Please refer to Appendix A.7 for conducted band edge.

Remark:

1. *Test results including cable loss;*
2. *"---"means that the fundamental frequency not for 15.209 limits requirement.*
3. *Not recorded emission from 9 KHz to 30 MHz as emission level at least 20dBc lower than emission limit.*

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

6.6 Restricted Band Emission Limit

6.6.1. Standard Applicable

15.205 (a) Except as shown 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	16.42-16.423	399.9-410	4.5-5.15
\1\ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	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	(\2\)
13.36-13.41			

\1\ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

\2\ Above 38.6

According to §15.247 (d): 20dBc in any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequencies (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

6.6.2. Measuring Instruments and Setting

Please refer to of equipment list in this report. The following table is the setting of spectrum analyzer and receiver.

Spectrum Parameter	Setting
Attenuation	Auto
Start Frequency	1000 MHz
Stop Frequency	10th carrier harmonic
RB / VB (Emission in restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average
RB / VB (Emission in non-restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average

Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~150kHz / RB/VB 200Hz/1KHz for QP/AVG
Start ~ Stop Frequency	150kHz~30MHz / RB/VB 9kHz/30KHz for QP/AVG
Start ~ Stop Frequency	30MHz~1000MHz / RB/VB 120kHz/1MHz for QP

6.6.3. Test Procedures

1) Sequence of testing 9 kHz to 30 MHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna height is 0.8 meter.

--- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

--- Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).

--- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QPK detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

2) Sequence of testing 30 MHz to 1 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height changes from 1 to 3 meter.

--- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter.

--- The final measurement will be done with QP detector with an EMI receiver.

--- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

3) Sequence of testing 1 GHz to 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height scan range is 1 meter to 2.5 meter.

--- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.

--- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

4) Sequence of testing above 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 1 meter.

--- The EUT was set into operation.

Premeasurement:

--- The antenna is moved spherical over the EUT in different polarizations of the antenna.

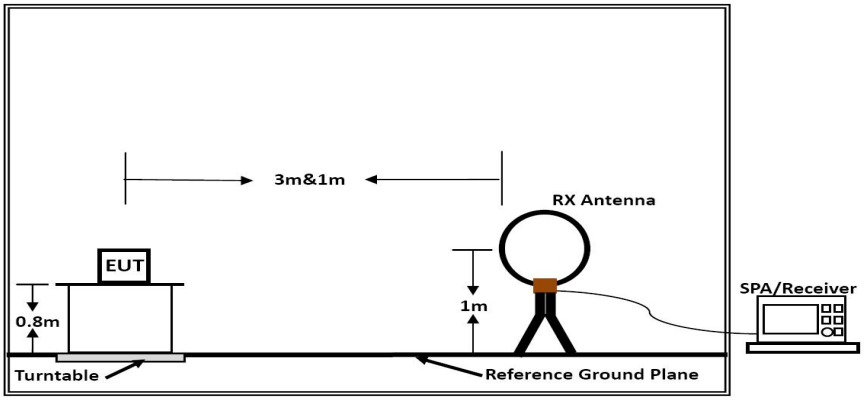
Final measurement:

--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.

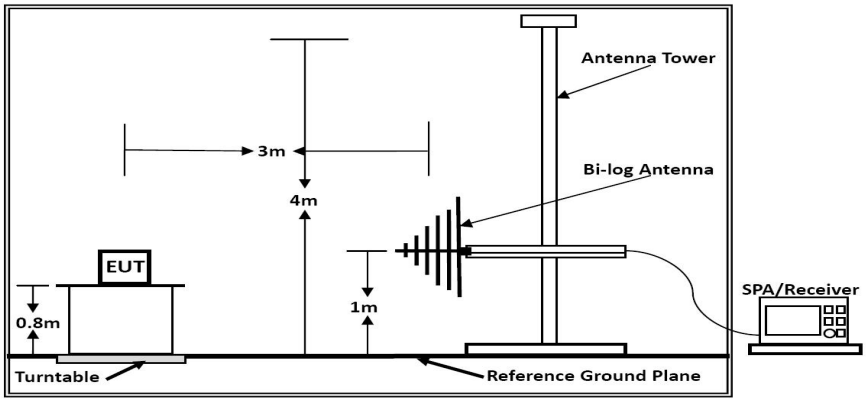
--- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

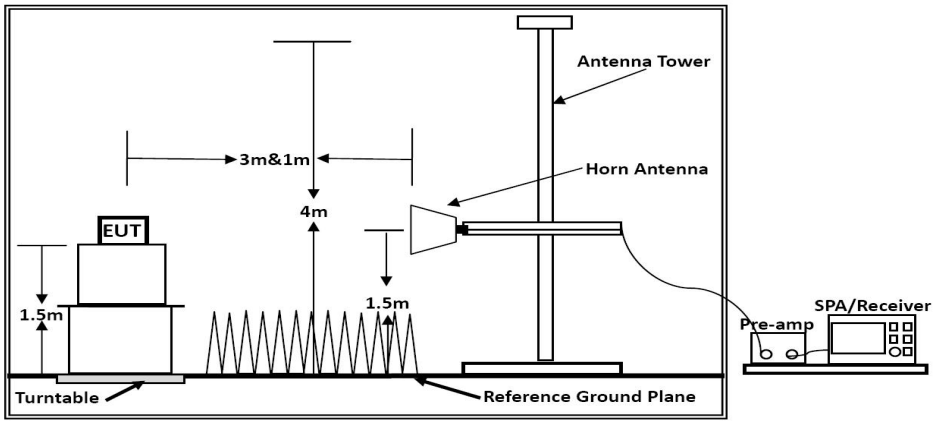
6.6.4. Test Setup Layout



Below 30MHz



Below 1GHz



Above 1GHz

Above 10 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1.5m.

Distance extrapolation factor = 20 log (specific distanc [3m] / test distance [1.5m]) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor [6 dB].

6.6.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

6.6.6. Results of Radiated Emissions (9 KHz~30MHz)

Temperature	24.3℃	Humidity	54.3%
Test Engineer	Diamond Lu	Configurations	GFSK

Freq. (MHz)	Level (dBuV)	Over Limit (dB)	Over Limit (dBuV)	Remark
-	-	-	-	See Note

Note:

The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = 40 log (specific distance / test distance) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor.

6.6.7. Results of Radiated Emissions (30 MHz~1000 MHz)

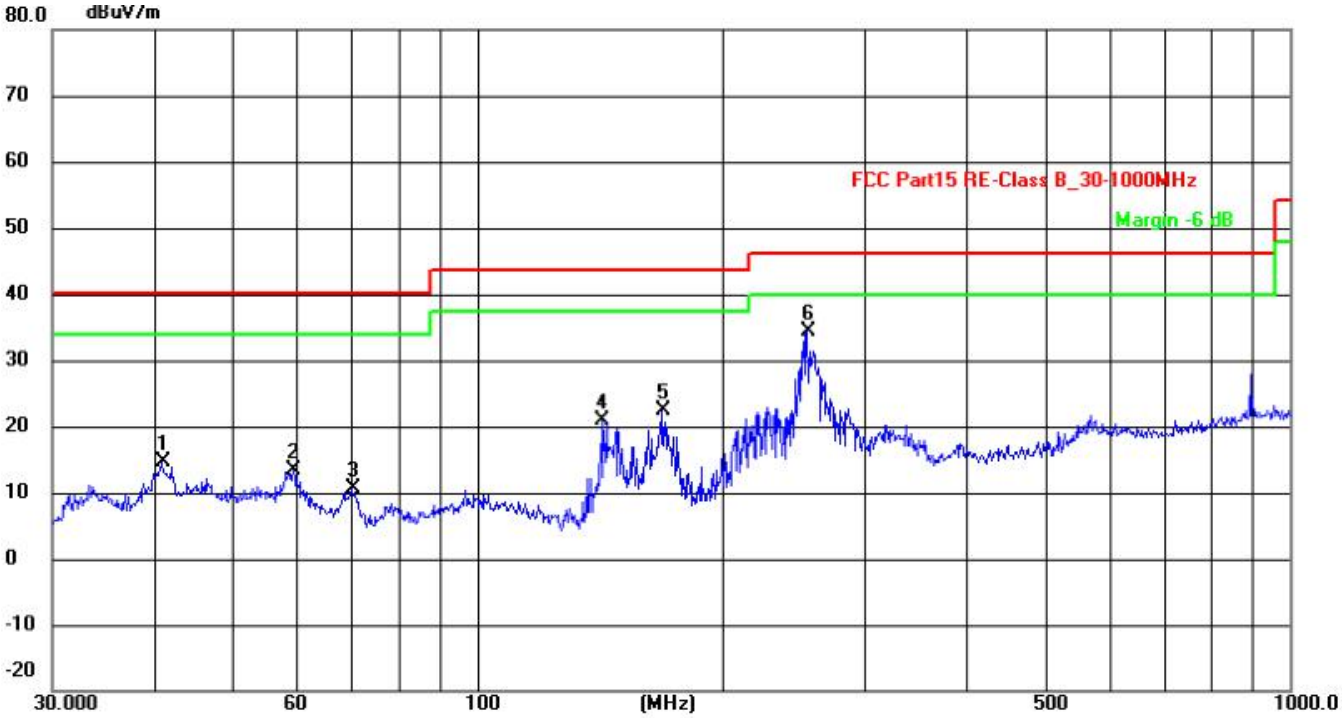
PASS.

Only record the worst test result in this report.

The test data please refer to following page.

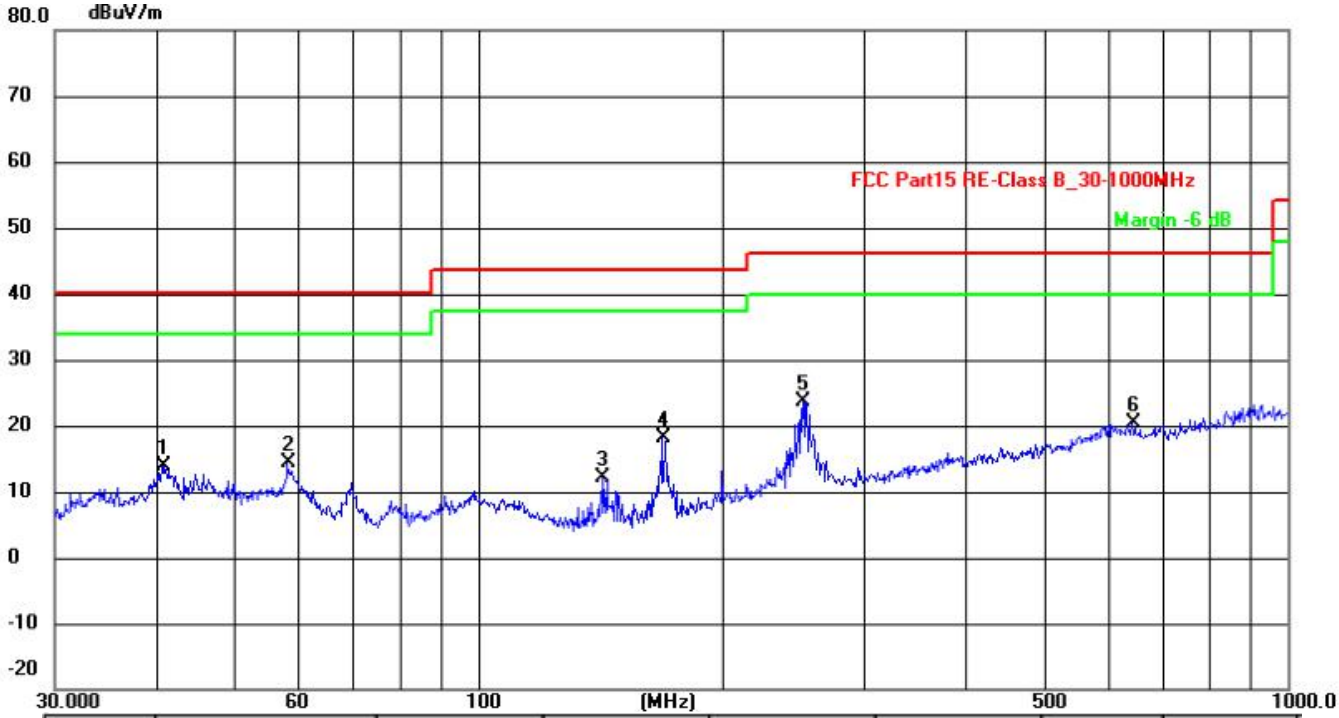
Below 1GHz (Middle Channel)

Horizontal



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	40.9881	30.98	-16.24	14.74	40.00	-25.26	QP
2	59.4405	30.12	-16.73	13.39	40.00	-26.61	QP
3	70.0903	30.57	-20.02	10.55	40.00	-29.45	QP
4	142.8243	42.48	-21.51	20.97	43.50	-22.53	QP
5	169.0054	42.67	-20.24	22.43	43.50	-21.07	QP
6	254.7284	49.93	-15.51	34.42	46.00	-11.58	QP

Vertical



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector
1	40.8446	30.23	-16.27	13.96	40.00	-26.04	QP
2	58.2030	30.87	-16.58	14.29	40.00	-25.71	QP
3	142.8243	33.66	-21.51	12.15	43.50	-31.35	QP
4	169.0054	38.45	-20.24	18.21	43.50	-25.29	QP
5	252.0627	39.09	-15.56	23.53	46.00	-22.47	QP
6	642.8613	28.78	-8.39	20.39	46.00	-25.61	QP

****Note:*

1). Pre-scan all modes and recorded the worst case results in this report (GFSK TX (1Mbps)).

2). Emission level (dBuV/m) = 20 log Emission level (uV/m).

3). Corrected Reading: Antenna Factor + Cable Loss + Read Level = Level.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

6.6.8. Results of Radiated Emissions (1 GHz~26 GHz)

Note: All the modes have been tested and recorded worst mode in the report.

The worst test result for GFSK, Channel 0 / 2407 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab. Los dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4814.00	54.54	33.06	35.04	3.94	56.50	74.00	-17.50	Peak	Horizontal
4814.00	43.77	33.06	35.04	3.94	45.73	54.00	-8.27	Average	Horizontal
4814.00	55.00	33.06	35.04	3.94	56.96	74.00	-17.04	Peak	Vertical
4814.00	44.21	33.06	35.04	3.94	46.17	54.00	-7.83	Average	Vertical

The worst test result for GFSK, Channel 31 / 2438 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab. Los dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4876.00	60.68	33.16	35.15	3.96	62.65	74.00	-11.35	Peak	Horizontal
4876.00	44.61	33.16	35.15	3.96	46.58	54.00	-7.42	Average	Horizontal
4876.00	60.70	33.16	35.15	3.96	62.67	74.00	-11.33	Peak	Vertical
4876.00	40.47	33.16	35.15	3.96	42.44	54.00	-11.56	Average	Vertical

The worst test result for GFSK, Channel 63 / 2470 MHz

Freq. MHz	Reading dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab. Los dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4940.00	60.00	33.26	35.14	3.98	62.10	74.00	-11.90	Peak	Horizontal
4940.00	43.00	33.26	35.14	3.98	45.10	54.00	-8.90	Average	Horizontal
4940.00	59.15	33.26	35.14	3.98	61.25	74.00	-12.75	Peak	Vertical
4940.00	42.72	33.26	35.14	3.98	44.82	54.00	-9.18	Average	Vertical

Notes:

1). Measuring frequencies from 9 KHz - 10th harmonic (ex. 26GHz), No emission found between lowest internal used/generated frequency to 30 MHz.

2). Radiated emissions measured in frequency range from 9 KHz - 10th harmonic (ex. 26GHz) were made with an instrument using Peak detector mode.

3). 18~25GHz at least have 20dB margin. No recording in the test report.

6.7. AC Power Line Conducted Emissions

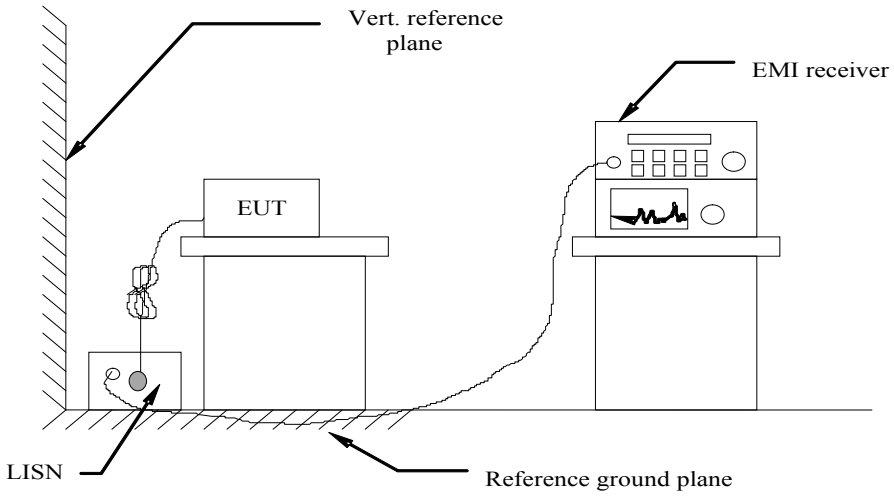
6.7.1 Standard Applicable

According to §15.207 (a): For an intentional radiator which 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 250 microvolts (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range is listed as follows:

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

* Decreasing linearly with the logarithm of the frequency

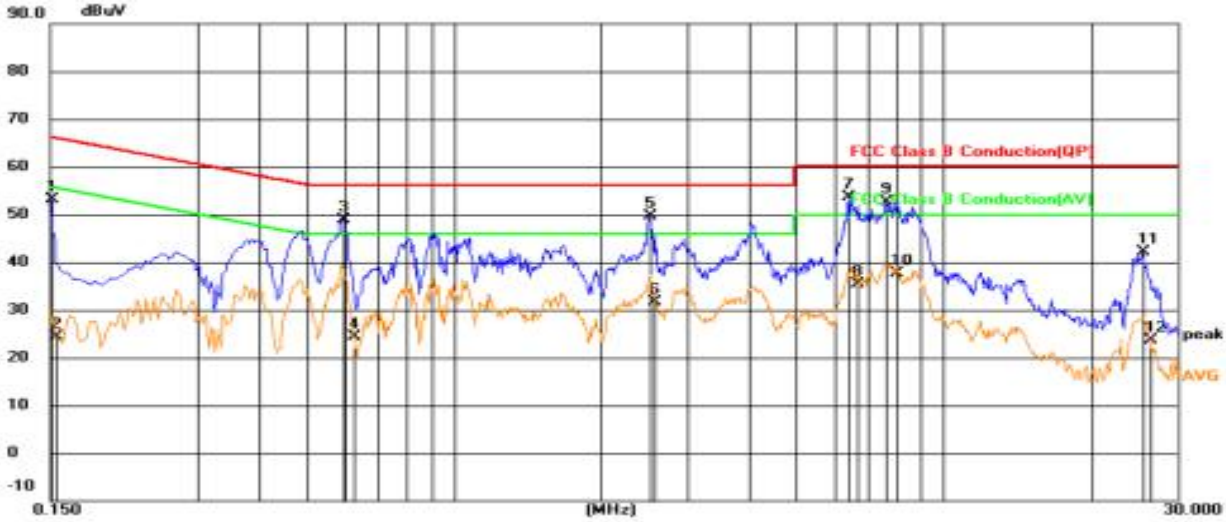
6.7.2 Block Diagram of Test Setup



6.7.3 Test Results

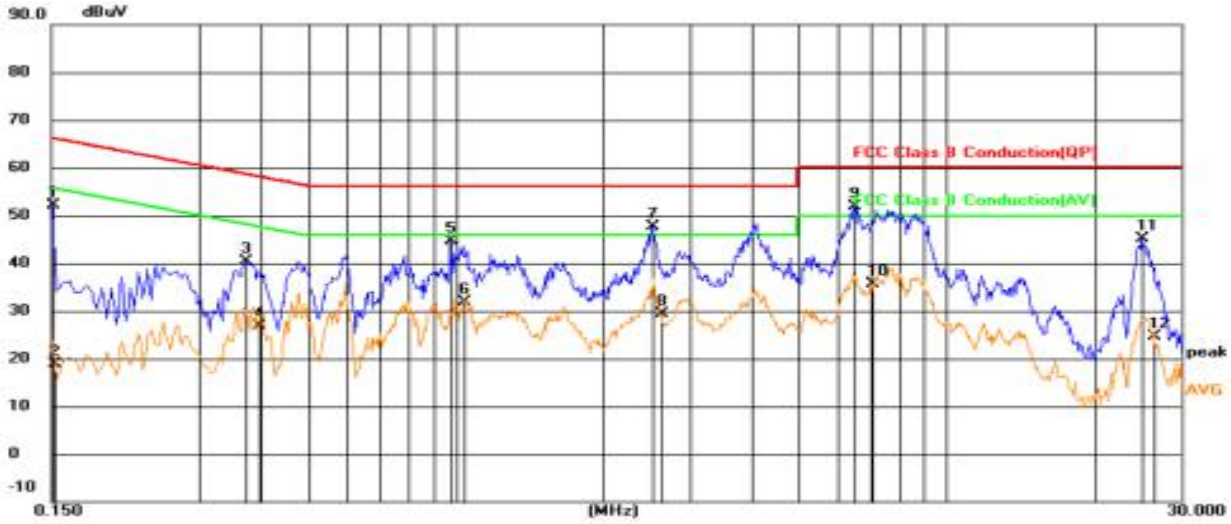
AC Conducted Emission of GFSK middle channel @ AC 120V/60Hz @ GFSK (worst case)

Line



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Margin		
		MHz	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1		0.1508	34.00	19.14	53.14	65.96	-12.82	QP	
2		0.1545	5.22	19.14	24.36	55.75	-31.39	AVG	
3		0.5955	29.64	19.18	48.82	56.00	-7.18	QP	
4		0.6270	5.21	19.21	24.42	46.00	-21.58	AVG	
5	*	2.5080	30.25	19.45	49.70	56.00	-6.30	QP	
6		2.5800	12.25	19.45	31.70	46.00	-14.30	AVG	
7		6.4140	33.99	19.56	53.55	60.00	-6.45	QP	
8		6.6795	15.91	19.56	35.47	50.00	-14.53	AVG	
9		7.6290	33.12	19.62	52.74	60.00	-7.26	QP	
10		8.0160	17.96	19.64	37.60	50.00	-12.40	AVG	
11		25.4580	22.02	20.20	42.22	60.00	-17.78	QP	
12		26.3400	3.42	20.15	23.57	50.00	-26.43	AVG	

Neutral



	MHz	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1	0.1508	33.09	19.14	52.23	65.96	-13.73	QP	
2	0.1524	-0.18	19.14	18.96	55.87	-36.91	AVG	
3	0.3750	21.11	19.31	40.42	58.39	-17.97	QP	
4	0.3976	7.58	19.31	26.89	47.90	-21.01	AVG	
5	0.9780	25.49	19.26	44.75	56.00	-11.25	QP	
6	1.0410	12.60	19.26	31.86	46.00	-14.14	AVG	
7	2.5170	28.20	19.43	47.63	56.00	-8.37	QP	
8	2.6115	10.04	19.43	29.47	46.00	-16.53	AVG	
9 *	6.4725	32.22	19.55	51.77	60.00	-8.23	QP	
10	7.0260	16.06	19.57	35.63	50.00	-14.37	AVG	
11	25.0395	25.08	20.13	45.21	60.00	-14.79	QP	
12	26.3400	4.47	20.08	24.55	50.00	-25.45	AVG	

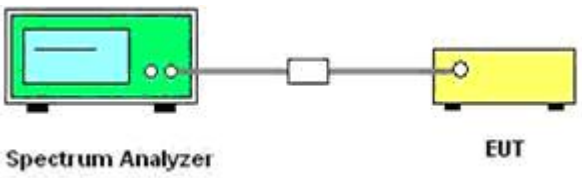
****Note: Pre-scan all modes and recorded the worst case results in this report (GFSK).*

6.8. Emissions at Restricted Band

6.8.1 Standard Applicable

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)).

6.8.2. Test Setup Layout



6.8.3. Measuring Instruments and Setting

Please refer to equipment list in this report. The following table is the setting of Spectrum Analyzer.

6.8.4. Test Procedures

According to KDB 412172 section 1.1 Field Strength Approach (linear terms):

$eirp = p_t \times g_t = (E \times d)^2/30$

Where:

p_t = transmitter output power in watts,

g_t = numeric gain of the transmitting antenna (unitless),

E = electric field strength in V/m,

d = measurement distance in meters (m).

$erp = eirp/1.64 = (E \times d)^2/(30 \times 1.64)$

Where all terms are as previously defined.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz for peak detector and RBW=1MHz, VBW=1/T for AV detector.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
   Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

6. Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
7. Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).
8. For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
9. Compare the resultant electric field strength level to the applicable regulatory limit.
10. Perform radiated spurious emission test duress until all measured frequencies were complete.

6.8.5. Test Results

PASS

Please refer to Appendix A.8

Remark:

1.Measured at Hopping and Non-Hopping mode, recorded worst at Non-Hopping mode.
2.The other emission levels were very low against the limit.
3.The average measurement was not performed when the peak measured data under the limit of average detection.
4.Detector AV is setting spectrum/receiver. RBW=1MHz/VBW=330Hz/Sweep time=Auto/Detector=Peak;
5.Since the out-of-band characteristics of the EUT transmit antenna will often be unknown, the use of a conservative antenna gain value is necessary. Thus, when determining the EIRP based on the measured conducted power, the upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands, or 2 dBi, whichever is greater. However, for devices that operate in multiple frequency bands while using the same transmit antenna, the highest gain of the antenna within the operating band nearest in frequency to the restricted band emission being measured may be used in lieu of the overall highest gain when the emission is at a frequency that is within 20 percent of the nearest band edge frequency, but in no case shall a value less than 2 dBi be used.

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.

6.9. Pseudorandom Frequency Hopping Sequence

6.9.1 Standard Applicable

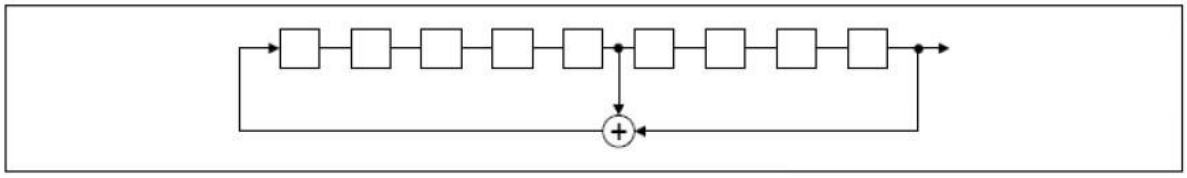
For 47 CFR Part 15C sections 15.247 (a) (1) requirement:

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

6.9.2 EUT Pseudorandom Frequency Hopping Sequence Requirement

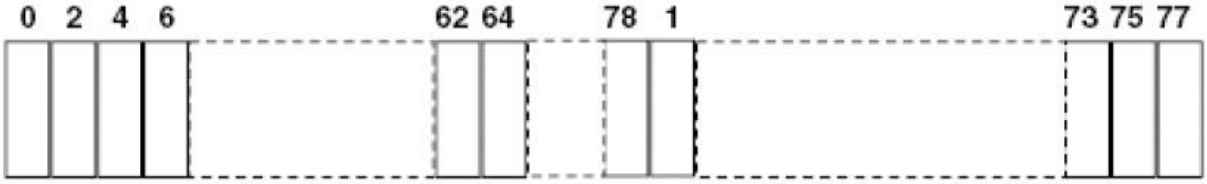
The pseudorandom frequency hopping sequence may be generated in a nice-stage shift register whose 5th first stage. The sequence begins with the first one of 9 consecutive ones, for example: the shift register is initialized with nine ones.

- Number of shift register stages:9
- Length of pseudo-random sequence:29-1=511 bits
- Longest sequence of zeros:8(non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of pseudorandom frequency hopping sequence as follows:



Each frequency used equally one the average by each transmitter.
The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitter and shift frequencies in synchronization with the transmitted signals.

6.10. Antenna Requirement

6.10.1 Standard Applicable

According to antenna requirement of §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 re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

And according to §15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

6.10.2 Antenna Connected Construction

6.10.2.1. Standard Applicable

According to § 15.203 & RSS-Gen, 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.

6.10.2.2. Antenna Connector Construction

The directional gains of antenna used for transmitting is 1.1dBi(Max), and the antenna is an Internal Antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details.

6.10.2.3. Results: Compliance.

7. TEST SETUP PHOTOGRAPHS OF EUT

Please refer to separated files for Test Setup Photos of the EUT.

8. EXTERIOR PHOTOGRAPHS OF THE EUT

Please refer to separated files for External Photos of the EUT.

9. INTERIOR PHOTOGRAPHS OF THE EUT

Please refer to separated files for Internal Photos of the EUT.

----------THE END OF TEST REPORT----------

This report shall not be reproduced except in full, without the written approval of Shenzhen LCS Compliance Testing Laboratory Ltd.