Shenzhen Huaxia Testing Technology Co., Ltd.

1F., Block A of Tongsheng Technology Building, Huahui Road, Dalang Street, Longhua District, Shenzhen, China

Telephone: +86-755-26648640
Fax: +86-755-26648637
Website: www.cqa-cert.com

Report Template Version: V05
Report Template Revision Date: 2021-11-03

Test Report

Report No. :	CQASZ20230200113E-01
Applicant:	Shenzhen Star Instrument Co., Ltd.
Address of Applicant:	Star Industrial Park, Baolong Industrial City, Longgang District, Shenzhen, China
Equipment Under Test (EUT):	
Product:	Wi-SUN Communication Module for Meter
Model No.:	MJ001-01
Test Model No.:	MJ001-01
Brand Name:	STAR INSTRUMENT
FCC ID:	2A2X4-MJ001-01
Standards:	47 CFR Part 15, Subpart C
Date of Receipt:	2023-02-06
Date of Test:	2023-02-06 to 2023-02-16
Date of Issue:	2023-02-24
Test Result :	**PASS***

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

Tested By: lewis zhou

(Lewis Zhou)

Reviewed By: Timo Lei

(Timo Lei)

Approved By:

(Jack Ai)

The test report is effective only with both signature and specialized stamp, The result(s) shown in this report refer only to the sample(s) tested. Without written approval of CQA, this report can't be reproduced except in full.

1 Version

Revision History Of Report

Report No.	Version	Description	Issue Date
CQASZ20230200113E-01	Rev.01	Initial report	2023-02-24

2 Test Summary

Test Item	Test Requirement	Test method	Result
Antenna Requirement	47 CFR Part 15, Subpart C Section 15.203/15.247 (c)	ANSI C63.10 (2013)	PASS
AC Power Line Conducted Emission	47 CFR Part 15, Subpart C Section 15.207	ANSI C63.10 (2013)	PASS
Conducted Peak Output Power	47 CFR Part 15, Subpart C Section 15.247 (b)(2)	ANSI C63.10 (2013)	PASS
20dB Occupied Bandwidth	47 CFR Part 15, Subpart C Section 15.247 (a)(1)	ANSI C63.10 (2013)	PASS
Carrier Frequencies Separation	47 CFR Part 15, Subpart C Section 15.247 (a)(1)	ANSI C63.10 (2013)	PASS
Hopping Channel Number	47 CFR Part 15, Subpart C Section 15.247 (a)(1)	ANSI C63.10 (2013)	PASS
Dwell Time	47 CFR Part 15, Subpart C Section 15.247 (a)(1)	ANSI C63.10 (2013)	PASS
Pseudorandom Frequency Hopping Sequence	47 CFR Part 15, Subpart C Section 15.247(b)(4)	ANSI C63.10 (2013)	PASS
Band-edge for RF Conducted Emissions	47 CFR Part 15, Subpart C Section 15.247(d)	ANSI C63.10 (2013)	PASS
RF Conducted Spurious Emissions	47 CFR Part 15, Subpart C Section 15.247(d)	ANSI C63.10 (2013)	PASS
Radiated Spurious emissions	47 CFR Part 15, Subpart C Section 15.205/15.209	ANSI C63.10 (2013)	PASS
Restricted bands around fundamental frequency (Radiated Emission)	47 CFR Part 15, Subpart C Section 15.205/15.209	ANSI C63.10 (2013)	PASS

3 Contents

Page

1 VERSION 2
2 TEST SUMMARY 3
3 CONTENTS 4
4 GENERAL INFORMATION 5
4.1 CLIENT INFORMATION 5
4.2 GENERAL DESCRIPTION OF EUT 5
4.3 ADDITIONAL INSTRUCTIONS 7
4.4 TEST ENVIRONMENT 8
4.5 DESCRIPTION OF SUPPORT UNITS 8
4.6 STATEMENT OF THE MEASUREMENT UNCERTAINTY 9
4.7 TEST LOCATION 10
4.8 TEST FACILITY 10
4.9 ABNORMALITIES FROM STANDARD CONDITIONS 10
4.10 OTHER INFORMATION REQUESTED BY THE CUSTOMER 10
4.11 EQUIPMENT LIST 11
5 TEST RESULTS AND MEASUREMENT DATA 12
5.1 ANTENNA REQUIREMENT 12
5.2 CONDUCTED EMISSIONS 13
5.3 CONDUCTED PEAK OUTPUT POWER 17
5.4 20DB OCCUPY BANDWIDTH 21
5.5 CARRIER FREQUENCIES SEPARATION 24
5.6 HOPPING CHANNEL NUMBER 27
5.7 DWELL TIME 29
5.8 BAND-EDGE FOR RF CONDUCTED EMISSIONS 32
5.9 SPURIOUS RF CONDUCTED EMISSIONS 36
5.10 OTHER REQUIREMENTS FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM 42
5.11 RADIATED SPURIOUS EMISSION & RESTRICTED BANDS 44
5.11.1 Radiated Emission below 1GHz 47
5.11.2 Transmitter Emission above 1GHz 49
6 PHOTOGRAPHS - EUT TEST SETUP 50
6.1 RADIATED EMISSION 50
6.2 CONDUCTED EMISSION 51
7 PHOTOGRAPHS - EUT CONSTRUCTIONAL DETAILS 52

4 General Information

4.1 Client Information

Applicant:	Shenzhen Star Instrument Co., Ltd.
Address of Applicant:	Star Industrial Park, Baolong Industrial City, Longgang District, Shenzhen, China
Manufacturer:	Shenzhen Star Instrument Co., Ltd.
Address of Manufacturer:	Star Industrial Park, Baolong Industrial City, Longgang District, Shenzhen, China
Factory:	Shenzhen Star Instrument Co., Ltd.
Address of Factory:	Star Industrial Park, Baolong Industrial City, Longgang District, Shenzhen, China

4.2 General Description of EUT

Product Name:	Wi-SUN Communication Module for Meter
Model No.:	MJ001-01
Test Model No.:	MJ001-01
Trade Mark:	STAR INSTRUMENT
Software Version:	V1.2.2000
Hardware Version:	MJ001-01-A11
Operation Frequency:	915.2MHz~927.8MHz
Modulation Technique:	Frequency Hopping Spread Spectrum(FHSS)
Modulation Type:	GFSK
Number of Channel:	64
Hopping Channel Type:	Adaptive Frequency Hopping systems
Product Type:	☒ Mobile ☐ Portable
Test Software of EUT:	SSCOM V5.13.1
Antenna Type:	PCB antenna
Antenna Gain:	1.71dBi
Power Supply:	Power supply DC 5V form computer

Operation Frequency each of channel							
Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
0	915.2MHz	20	919.2MHz	40	923.2MHz	60	927.2MHz
1	915.4MHz	21	919.4MHz	41	923.4MHz	61	927.4MHz
2	915.6MHz	22	919.6MHz	42	923.6MHz	62	927.6MHz
3	915.8MHz	23	919.8MHz	43	923.8MHz	63	927.8MHz
4	916MHz	24	920MHz	44	924MHz		
5	916.2MHz	25	920.2MHz	45	924.2MHz		
6	916.4MHz	26	920.4MHz	46	924.4MHz		
7	916.6MHz	27	920.6MHz	47	924.6MHz		
8	916.8MHz	28	920.8MHz	48	924.8MHz		
9	917MHz	29	921MHz	49	925MHz		
10	917.2MHz	30	921.2MHz	50	925.2MHz		
11	917.4MHz	31	921.4MHz	51	925.4MHz		
12	917.6MHz	32	921.6MHz	52	925.6MHz		
13	917.8MHz	33	921.8MHz	53	925.8MHz		
14	918MHz	34	922MHz	54	926MHz		
15	918.2MHz	35	922.2MHz	55	926.2MHz		
16	918.4MHz	36	922.4MHz	56	926.4MHz		
17	918.6MHz	37	922.6MHz	57	926.6MHz		
18	918.8MHz	38	922.8MHz	58	926.8MHz		
19	919MHz	39	923MHz	59	927MHz		

Note:
In section 15.31(m), regards to the operating frequency range over 10 MHz, the Lowest frequency, the middle frequency, and the highest frequency of channel were selected to perform the test, and the selected channel see below:

Channel	Frequency
The Lowest channel	915.2MHz
The Middle channel	921.6MHz
The Highest channel	927.8MHz

4.3 Additional Instructions

EUT Test Software Settings:	
Mode:	☒ Special software is used. ☐ Through engineering command into the engineering mode. engineering command: *#*#3646633#*#*
EUT Power level:	Class2 (Power level is built-in set parameters and cannot be changed and selected)

Use test software to set the lowest frequency, the middle frequency and the highest frequency keep transmitting of the EUT.

Mode	Channel	Frequency(MHz)
GFSK	CH0	915.2
	CH32	921.6
	CH63	927.8

4.4 Test Environment

Operating Environment:	
Temperature:	25 °C
Humidity:	54% RH
Atmospheric Pressure:	1009mbar
Test Mode:	Use test software to set the lowest frequency, the middle frequency and the highest frequency keep transmitting of the EUT.

4.5 Description of Support Units

The EUT has been tested with associated equipment below.

Description	Manufacturer	Model No.	Remark	Supplied
/	/	/	/	/

4.6 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 **Shenzhen Huaxia Testing Technology Co., Ltd.** 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.

Hereafter the best measurement capability for CQA laboratory is reported:

No.	Item	Uncertainty
1	Radiated Emission (Below 1GHz)	5.12dB
2	Radiated Emission (Above 1GHz)	4.60dB
3	Conducted Disturbance (0.15~30MHz)	3.34dB
4	Radio Frequency	3×10^{-8}
5	Duty cycle	0.6 %
6	Occupied Bandwidth	1.1%
7	RF conducted power	0.86dB
8	RF power density	0.74
9	Conducted Spurious emissions	0.86dB
10	Temperature test	0.8℃
11	Humidity test	2.0%
12	Supply voltages	0.5 %
13	Frequency Error	5.5 Hz

4.7 Test Location

All tests were performed at:

Shenzhen Huaxia Testing Technology Co., Ltd.

1F., Block A of Tongsheng Technology Building, Huahui Road, Dalang Street, Longhua District, Shenzhen, China

4.8 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:
IC Registration No.: 22984-1
The 3m Semi-anechoic chamber of Shenzhen Huaxia Testing Technology Co., Ltd. has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing

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

- **CNAS (No. CNAS L5785)**

CNAS has accredited Shenzhen Huaxia Testing Technology 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. 4742.01)**

Shenzhen Huaxia Testing Technology Co., Ltd., Shenzhen EMC Laboratory is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 4742.01.

- **FCC Registration No.: 522263**

Shenzhen Huaxia Testing Technology Co., Ltd., Shenzhen EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration No.:522263

4.9 Abnormalities from Standard Conditions

None.

4.10 Other Information Requested by the Customer

None.

4.11 Equipment List

Test Equipment	Manufacturer	Model No.	Instrument No.	Calibration Date	Calibration Due Date
EMI Test Receiver	R&S	ESR7	CQA-005	2022/09/09	2023/09/08
Spectrum analyzer	R&S	FSU26	CQA-038	2022/09/09	2023/09/08
Spectrum analyzer	R&S	FSU40	CQA-075	2022/09/09	2023/09/08
Preamplifier	MITEQ	AFS4-00010300-18-10P-4	CQA-035	2022/09/09	2023/09/08
Preamplifier	MITEQ	AMF-6D-02001800-29-20P	CQA-036	2022/09/09	2023/09/08
Preamplifier	EMCI	EMC184055SE	CQA-089	2022/09/09	2023/09/08
Loop antenna	Schwarzbeck	FMZB1516	CQA-060	2021/09/16	2024/09/15
Bilog Antenna	R&S	HL562	CQA-011	2021/09/16	2024/09/15
Horn Antenna	R&S	HF906	CQA-012	2021/09/16	2024/09/15
Horn Antenna	Schwarzbeck	BBHA 9170	CQA-088	2021/09/16	2024/09/15
Coaxial Cable (Above 1GHz)	CQA	N/A	C007	2022/09/09	2023/09/08
Coaxial Cable (Below 1GHz)	CQA	N/A	C013	2022/09/09	2023/09/08
RF cable(9KHz~40GHz)	CQA	RF-01	CQA-079	2022/09/09	2023/09/08
Antenna Connector	CQA	RFC-01	CQA-080	2022/09/09	2023/09/08
Power Sensor	KEYSIGHT	U2021XA	CQA-30	2022/09/09	2023/09/08
N1918A Power Analysis Manager Power Panel	Agilent	N1918A	CQA-074	2022/09/09	2023/09/08
Power meter	R&S	NRVD	CQA-029	2022/09/09	2023/09/08
Power divider	MIDWEST	PWD-2533-02-SMA-79	CQA-067	2022/09/09	2023/09/08
EMI Test Receiver	R&S	ESR7	CQA-005	2022/09/09	2023/09/08
LISN	R&S	ENV216	CQA-003	2022/09/09	2023/09/08
Coaxial cable	CQA	N/A	CQA-C009	2022/09/09	2023/09/08
DC power	KEYSIGHT	E3631A	CQA-028	2022/09/09	2023/09/08

Note:

The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

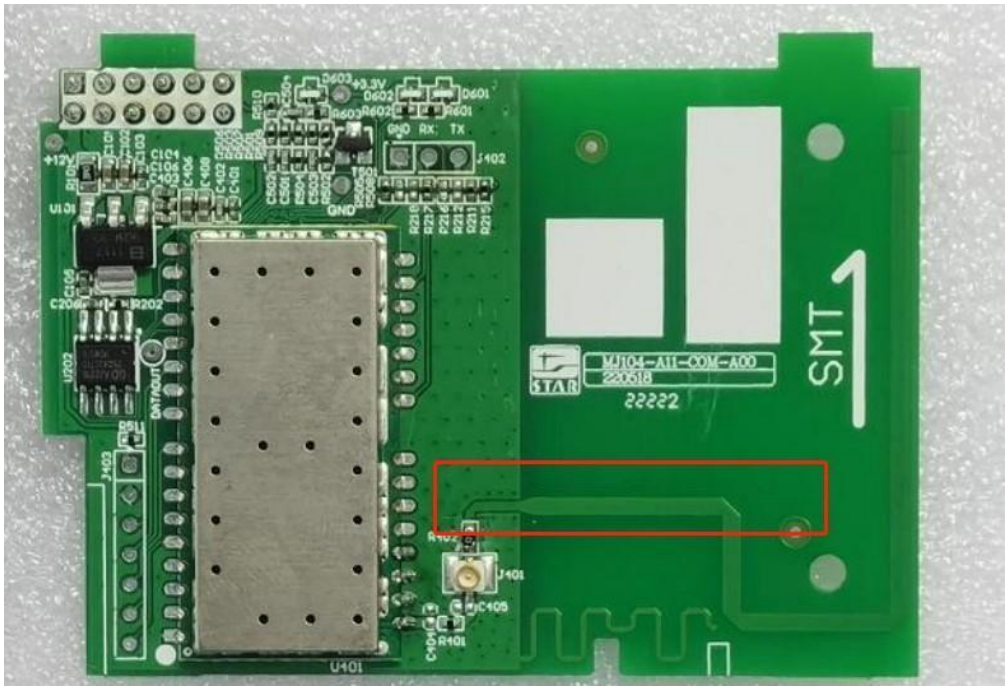
5 Test results and Measurement Data

5.1 Antenna Requirement

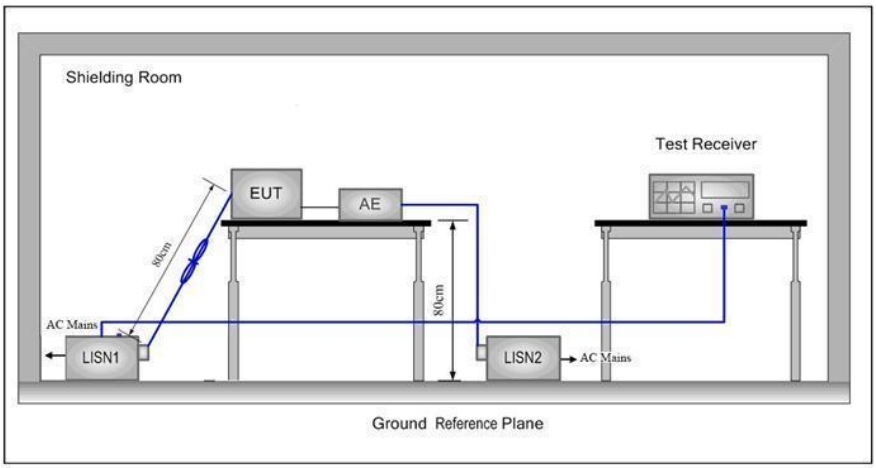
Standard requirement:	47 CFR Part 15C Section 15.203 /247(c)

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.
15.247(b) (4) requirement:
The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The antenna is PCB antenna. The best case gain of the antenna is 1.71 dBi.



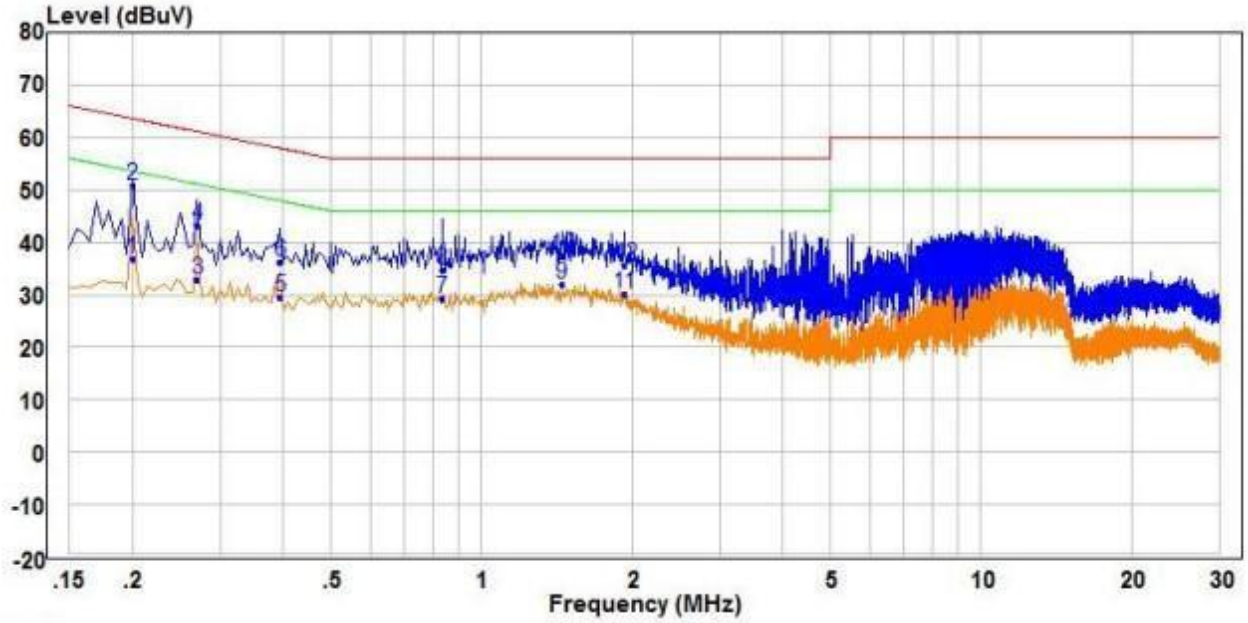
5.2 Conducted Emissions

Test Requirement:	47 CFR Part 15C Section 15.207
Test Method:	ANSI C63.10: 2013
Test Frequency Range:	150kHz to 30MHz
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 Procedure:	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 50Ω/50μH + 5Ω 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: 2013 on conducted measurement.
Test Setup:	

Exploratory Test Mode:	Non-hopping transmitting mode with all kind of modulation and all kind of data type at the lowest, middle, high channel.
Final Test Mode:	Through Pre-scan, find the GFSK modulation at the lowest channel is the worst case. Only the worst case is recorded in the report.
Test Voltage:	AC 120V/60Hz
Test Results:	Pass

Measurement Data

Live line:

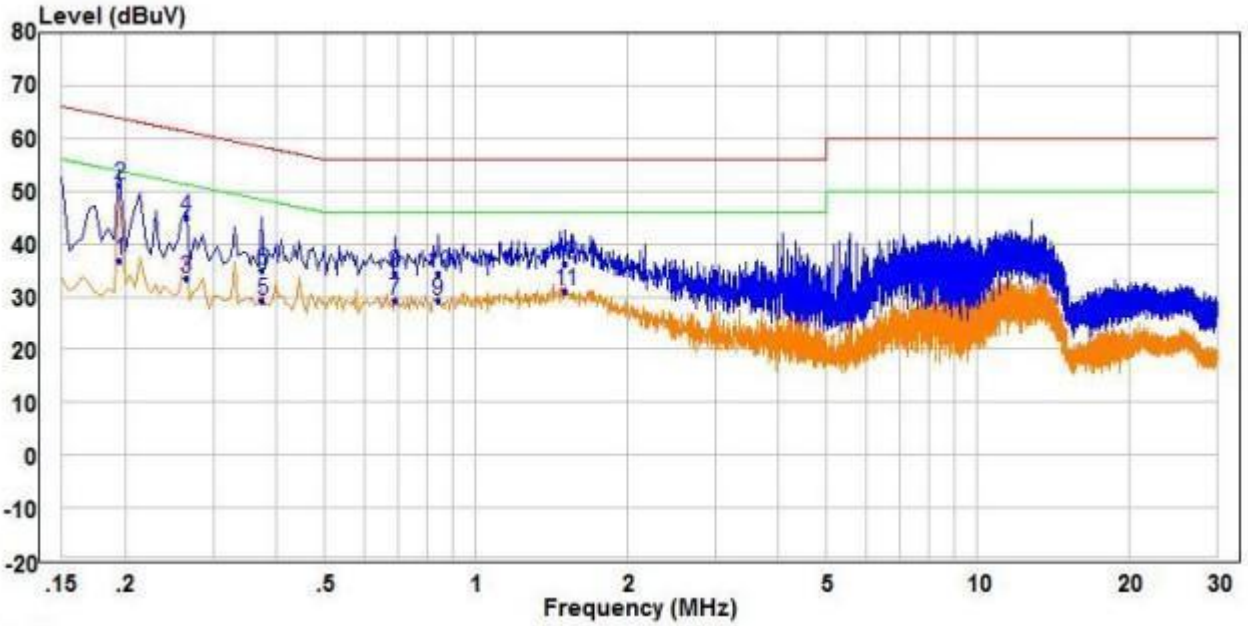


		Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark	Pol/Phase
		MHz	dBuV	dB	dBuV	dBuV	dB		
1		0.200	27.39	9.61	37.00	53.61	-16.61	Average	Line
2	PP	0.200	41.34	9.61	50.95	63.61	-12.66	QP	Line
3		0.270	23.35	9.52	32.87	51.12	-18.25	Average	Line
4		0.270	33.84	9.52	43.36	61.12	-17.76	QP	Line
5		0.395	20.00	9.60	29.60	47.96	-18.36	Average	Line
6		0.395	26.77	9.60	36.37	57.96	-21.59	QP	Line
7		0.835	19.47	9.81	29.28	46.00	-16.72	Average	Line
8		0.835	24.82	9.81	34.63	56.00	-21.37	QP	Line
9	AV	1.450	21.32	10.74	32.06	46.00	-13.94	Average	Line
10		1.450	26.72	10.74	37.46	56.00	-18.54	QP	Line
11		1.930	18.56	11.55	30.11	46.00	-15.89	Average	Line
12		1.930	23.95	11.55	35.50	56.00	-20.50	QP	Line

Remark:

1. The following Quasi-Peak and Average measurements were performed on the EUT:
2. Final Test Level =Receiver Reading + LISN Factor + Cable Loss.
3. If the Peak value under Average limit, the Average value is not recorded in the report.

Neutral line:



		Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark	Pol/Phase
		MHz	dBuV	dB	dBuV	dBuV	dB		
1		0.195	27.26	9.62	36.88	53.82	-16.94	Average	Neutral
2	PP	0.195	41.62	9.62	51.24	63.82	-12.58	QP	Neutral
3		0.265	24.08	9.52	33.60	51.27	-17.67	Average	Neutral
4		0.265	35.51	9.52	45.03	61.27	-16.24	QP	Neutral
5		0.375	19.79	9.58	29.37	48.39	-19.02	Average	Neutral
6		0.375	25.50	9.58	35.08	58.39	-23.31	QP	Neutral
7		0.690	19.29	9.89	29.18	46.00	-16.82	Average	Neutral
8		0.690	24.56	9.89	34.45	56.00	-21.55	QP	Neutral
9		0.840	19.57	9.81	29.38	46.00	-16.62	Average	Neutral
10		0.840	24.63	9.81	34.44	56.00	-21.56	QP	Neutral
11	AV	1.510	21.46	9.73	31.19	46.00	-14.81	Average	Neutral
12		1.510	26.54	9.73	36.27	56.00	-19.73	QP	Neutral

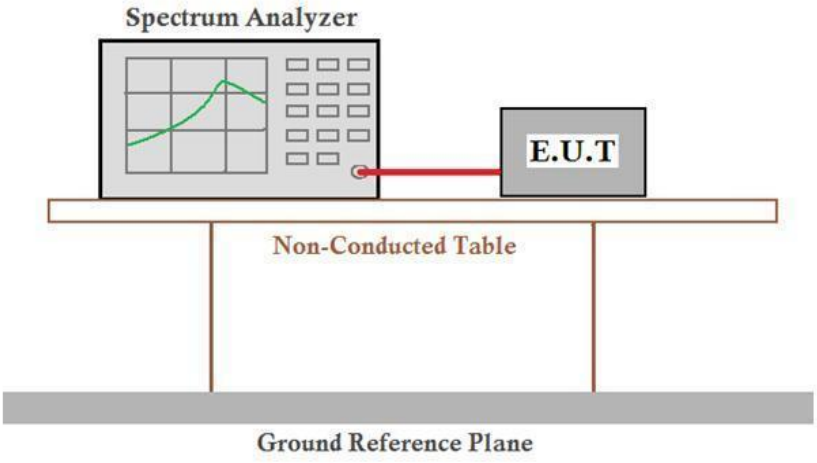
Remark:

1. The following Quasi-Peak and Average measurements were performed on the EUT:

2. Final Test Level =Receiver Reading + LISN Factor + Cable Loss.

3. If the Peak value under Average limit, the Average value is not recorded in the report.

5.3 Conducted Peak Output Power

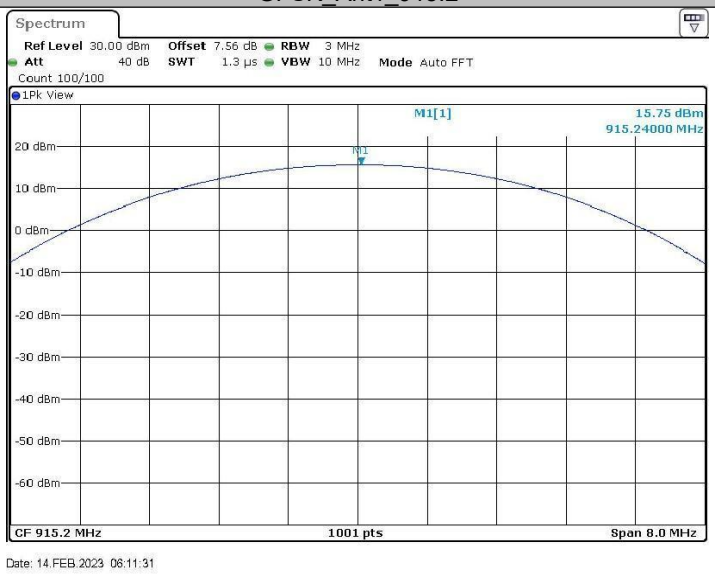
Test Requirement:	47 CFR Part 15C Section 15.247 (b)(2)
Test Method:	ANSI C63.10:2013
Test Setup:	 *Remark: Offset=Cable loss+ attenuation factor.*
Limit:	30dBm
Exploratory Test Mode:	Non-hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	GFSK modulation type Only the worst case is recorded in the report.
Test Results:	Pass

Measurement Data

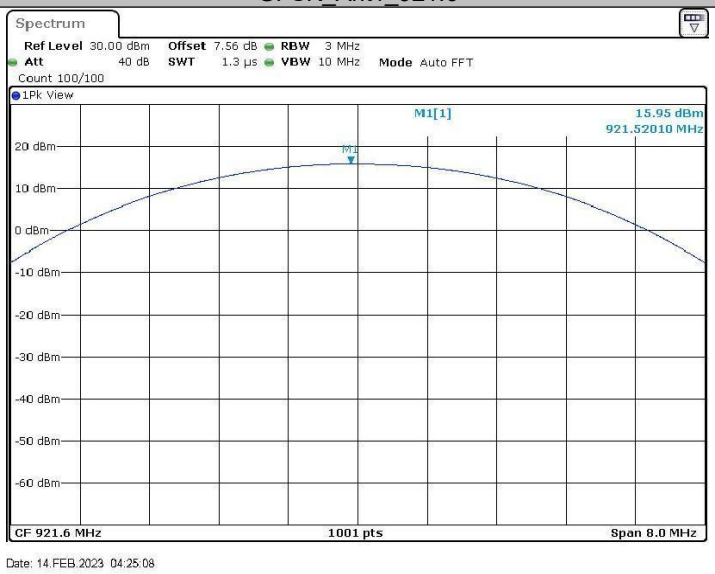
GFSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	15.75	30.00	Pass
Middle	15.95	30.00	Pass
Highest	15.27	30.00	Pass

Test plot as follows:

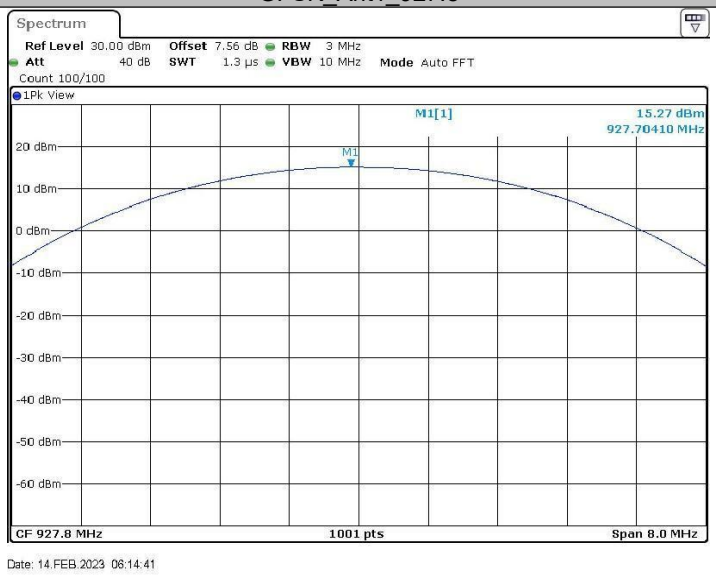
GFSK_Ant1_915.2



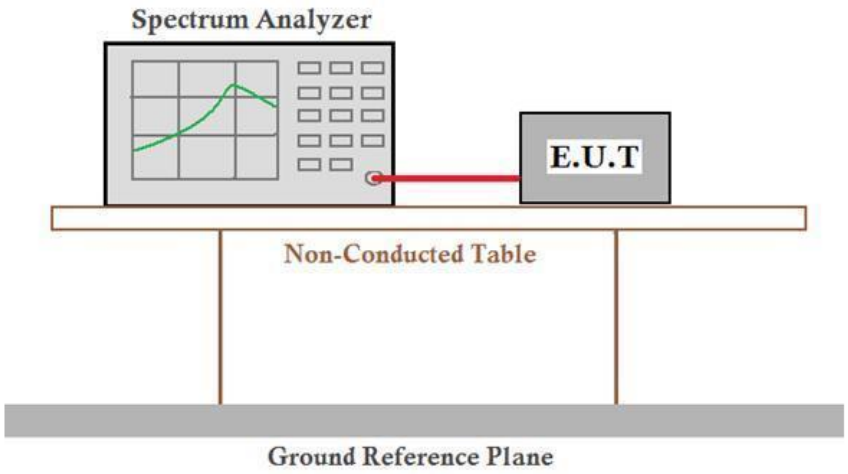
GFSK_Ant1_921.6



GFSK_Ant1_927.8



5.4 20dB Occupy Bandwidth

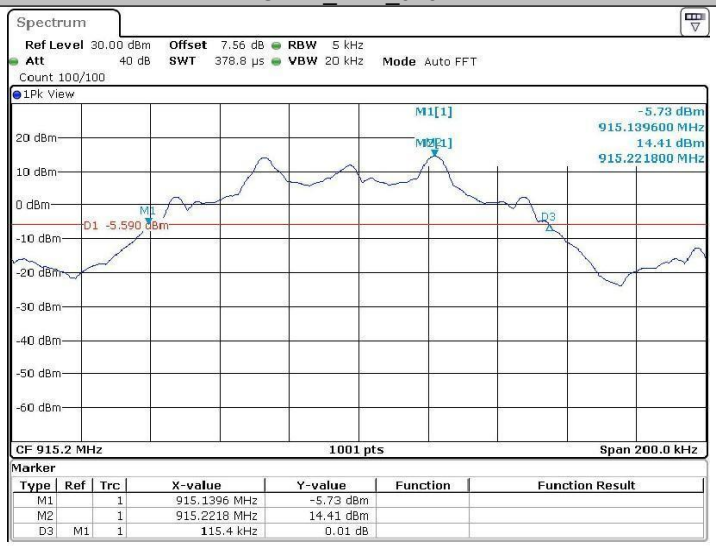
Test Requirement:	47 CFR Part 15C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Test Setup:	 Remark: Offset=Cable loss+ attenuation factor.
Limit:	NA
Exploratory Test Mode:	Non-hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	GFSK modulation type
Test Results:	Pass

Measurement Data

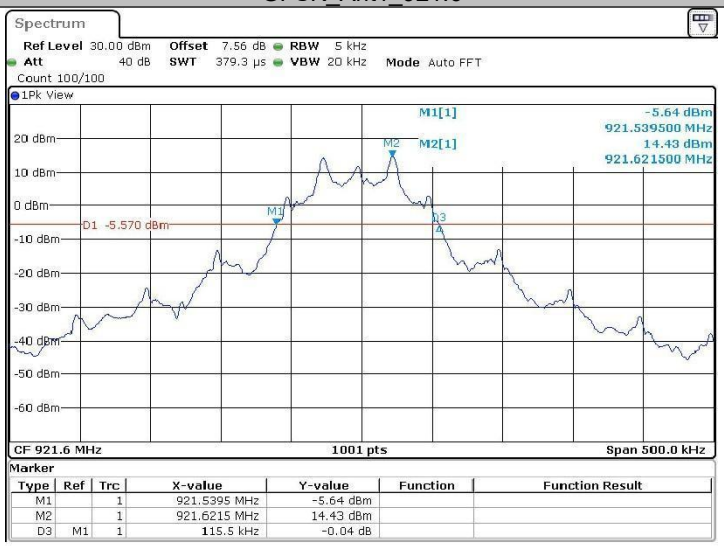
Test channel	20dB Occupy Bandwidth (MHz)
	GFSK
Lowest	0.12
Middle	0.12
Highest	0.12

Test plot as follows:

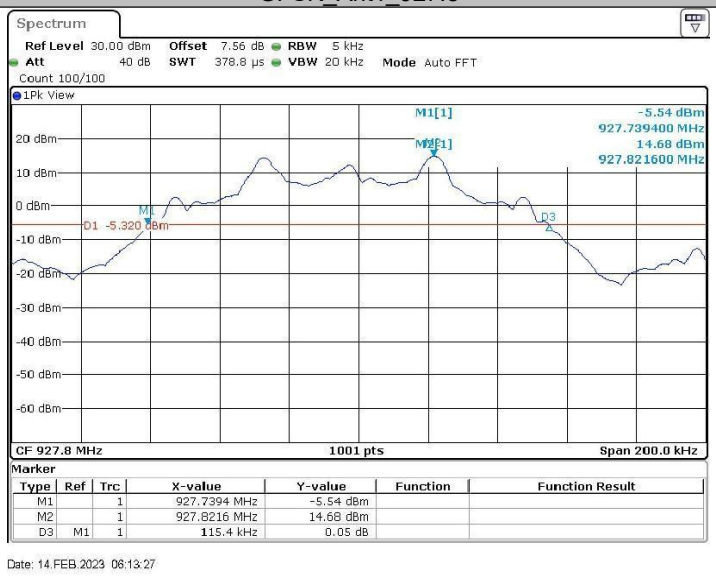
GFSK_Ant1_915.2



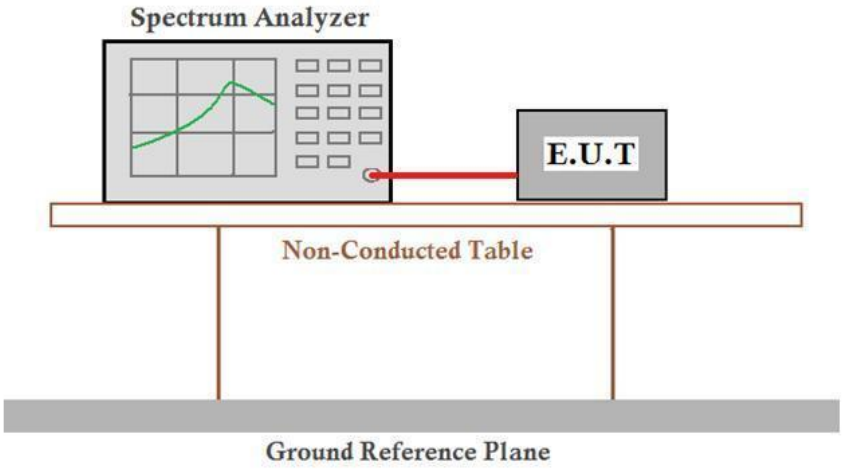
GFSK_Ant1_921.6



GFSK_Ant1_927.8



5.5 Carrier Frequencies Separation

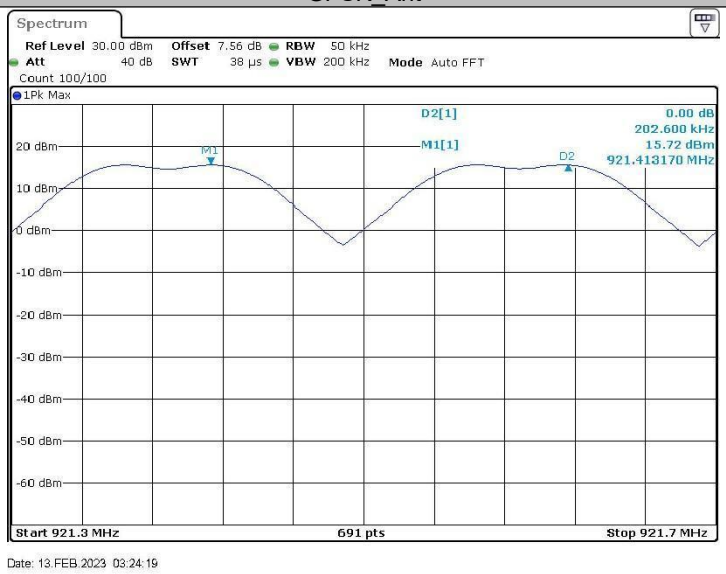
Test Requirement:	47 CFR Part 15C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Test Setup:	 Remark: Offset=Cable loss+ attenuation factor.
Limit:	20dB bandwidth
Exploratory Test Mode:	Hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	GFSK modulation type Only the worst case is recorded in the report.
Test Results:	Pass

Measurement Data

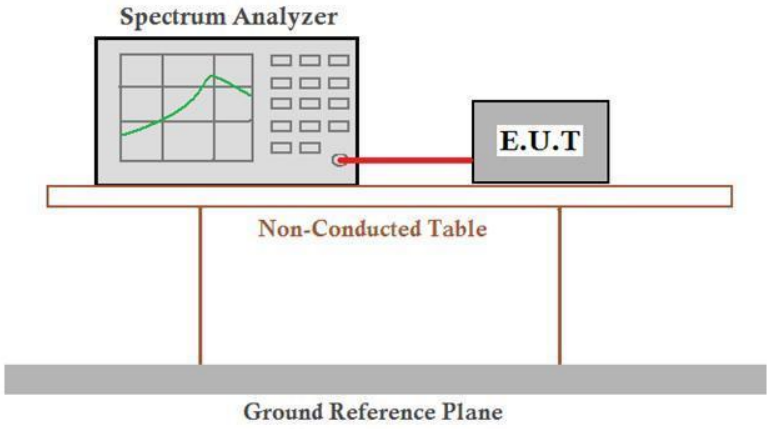
GFSK mode		
Carrier Frequencies Separation (MHz)	Limit (MHz)	Result
0.2	≥0.12	Pass

Test plot as follows:

GFSK_Ant



5.6 Hopping Channel Number

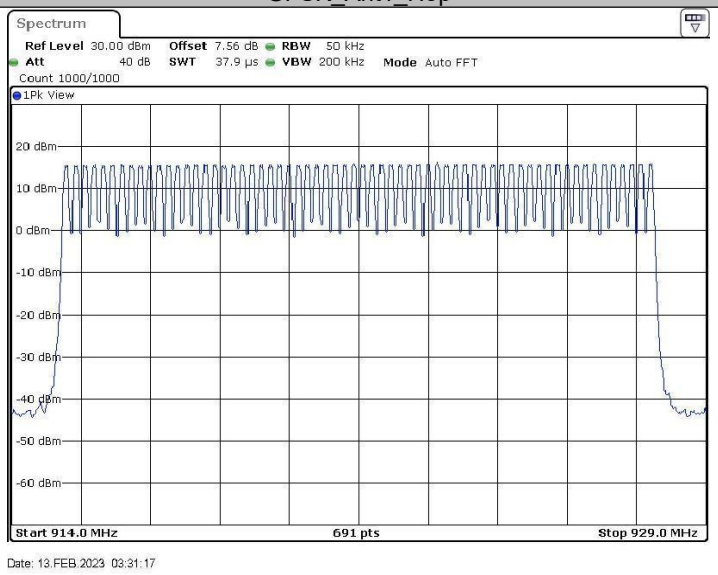
Test Requirement:	47 CFR Part 15C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Test Setup:	 *Remark: Offset=Cable loss+ attenuation factor.*
Limit:	At least 50 channels
Exploratory Test Mode:	hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	GFSK modulation type Only the worst case is recorded in the report.
Test Results:	Pass

Measurement Data

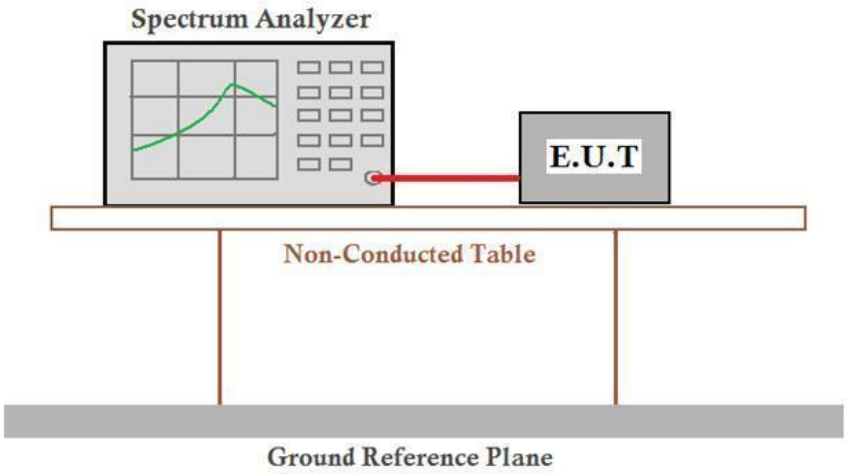
Mode	Hopping channel numbers	Limit
GFSK	64	≥50

Test plot as follows:

GFSK_Ant1_Hop



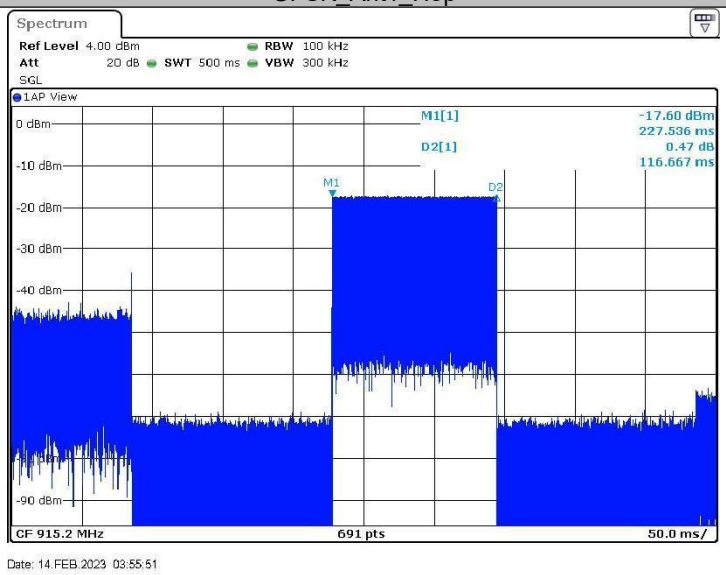
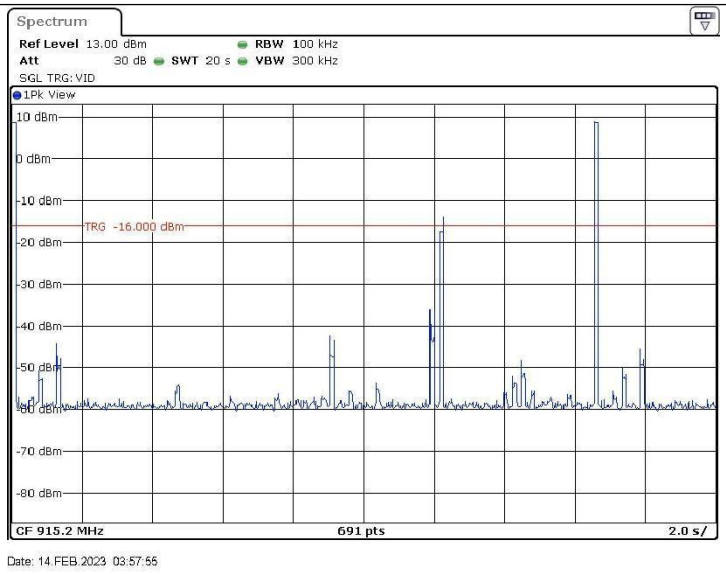
5.7 Dwell Time

Test Requirement:	47 CFR Part 15C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Test Setup:	 *Remark: Offset=Cable loss+ attenuation factor.*
Test Mode:	Hopping transmitting with all kind of modulation and all kind of data type.
Limit:	0.4 Second
Test Results:	Pass

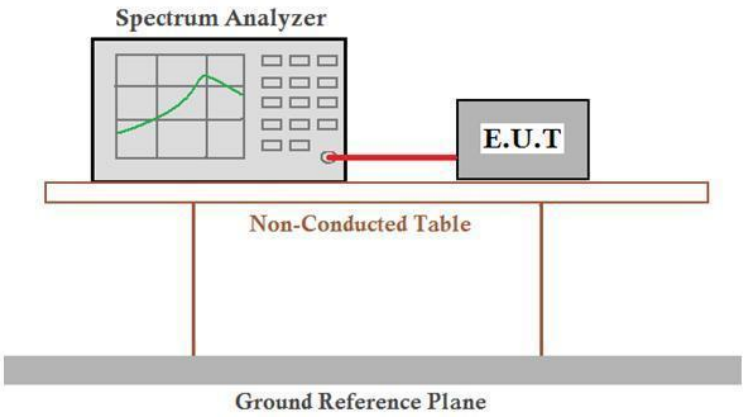
Measurement Data

Mode	Burst Width [ms/hop/ch]	Dwell Time[s]	Limit (second)
GFSK	116.67	0.233	≤0.4

Test plot as follows:

GFSK_Ant1_Hop



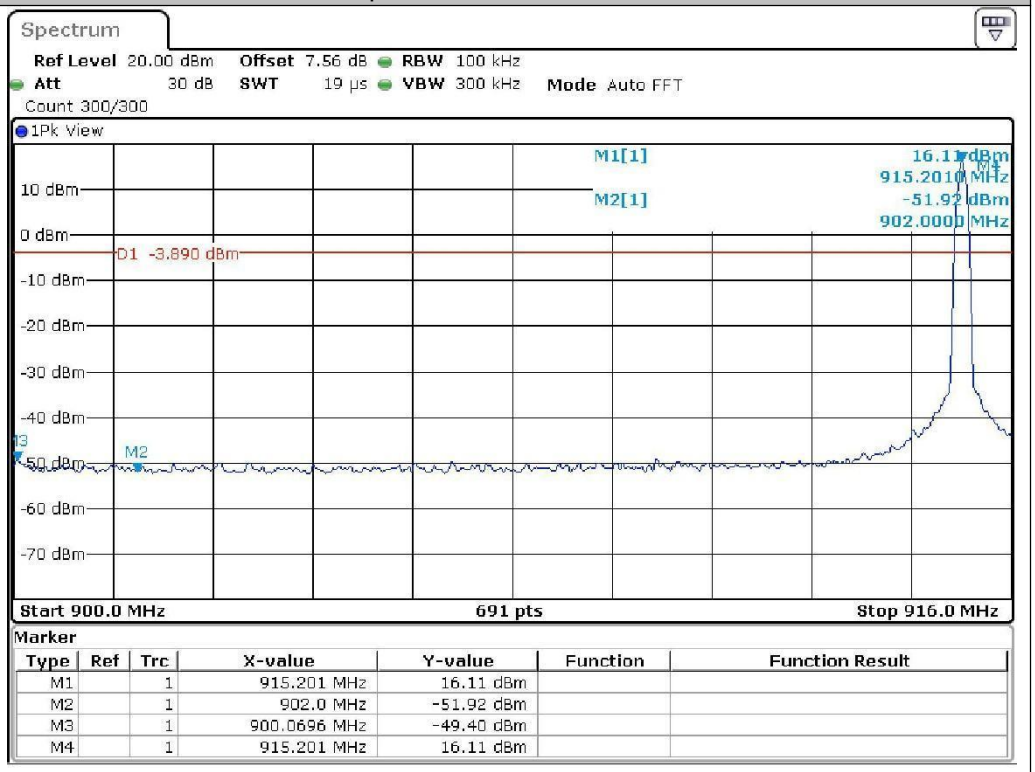
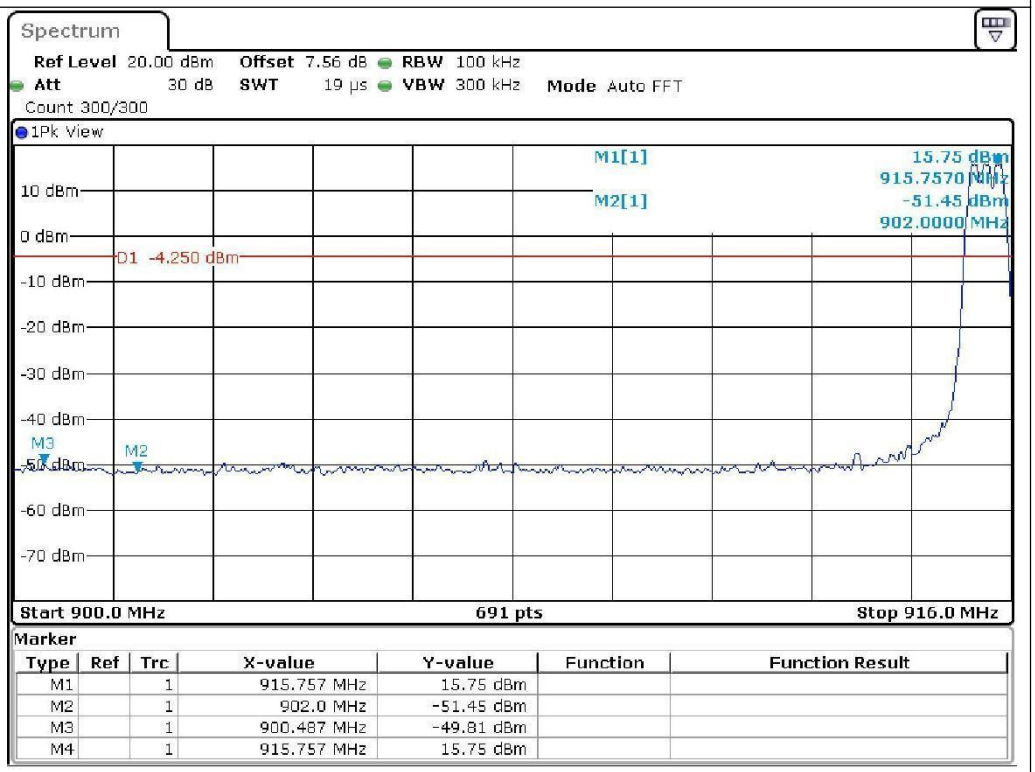
5.8 Band-edge for RF Conducted Emissions

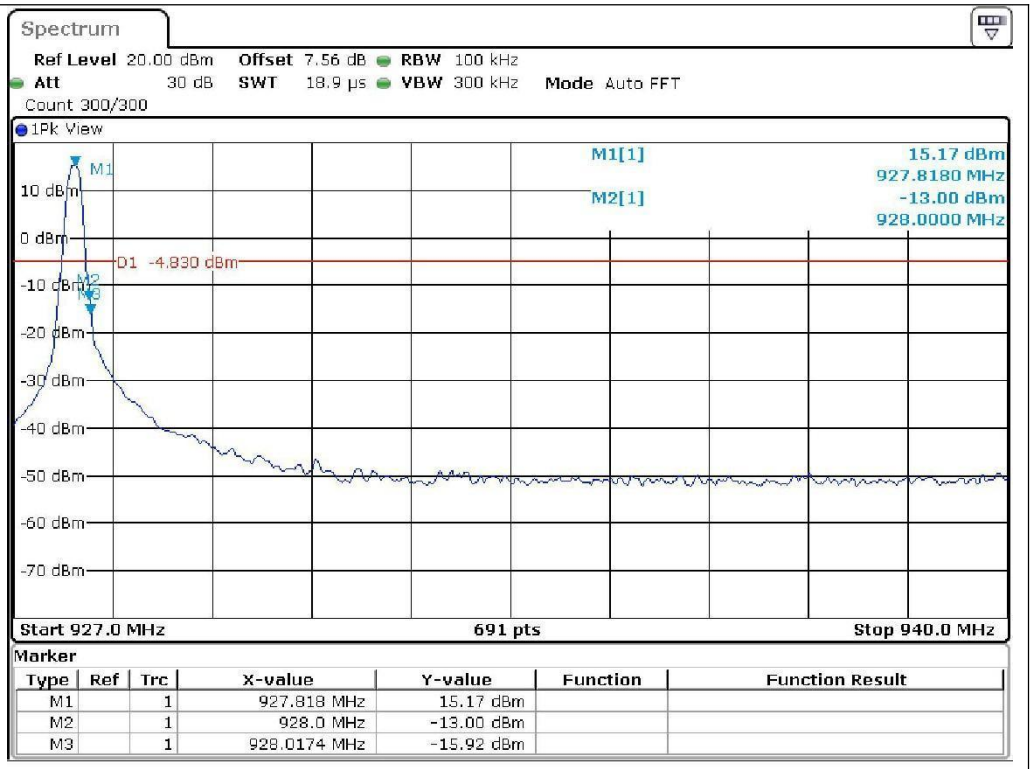
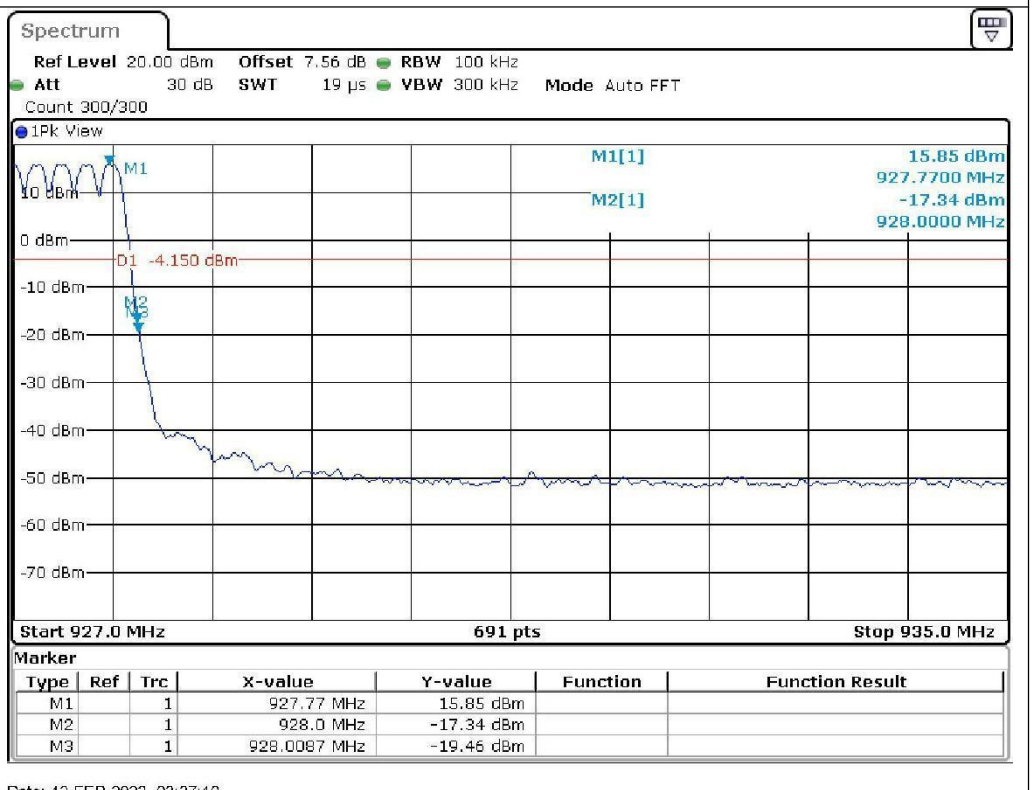
Test Requirement:	47 CFR Part 15C Section 15.247 (d)
Test Method:	ANSI C63.10:2013
Test Setup:	 *Remark: Offset=cable loss+ attenuation factor.*
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is 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.
Exploratory Test Mode:	Hopping and Non-hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	Through Pre-scan, find the GFSK modulation type Only the worst case is recorded in the report.
Test Results:	Pass

Measurement Data

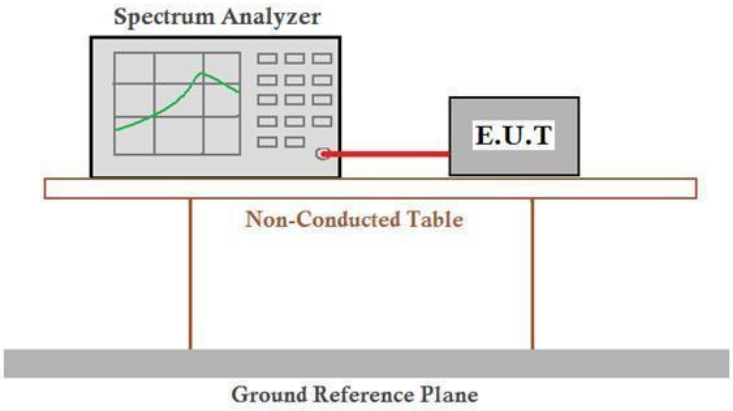
Mode	Test Channel	Frequency [MHz]	Frequency Hopping	Emission Level [dBm]	Limit [dBm]	Result
GFSK	LCH	902	Off	-49.4	-3.89	PASS
			On	-49.81	-4.25	PASS
GFSK	HCH	928	Off	-53.160	-13	PASS
			On	-51.430	-17.34	PASS

Test plot as follows:

Graphs	
GFSK/LCH/No Hop	 Marker Type Ref Trc X-value Y-value Function Function Result M1 1 915.201 MHz 16.11 dBm M2 1 902.0 MHz -51.92 dBm M3 1 900.0696 MHz -49.40 dBm M4 1 915.201 MHz 16.11 dBm Date: 13.FEB.2023 02:02:44
GFSK/LCH/Hop	 Marker Type Ref Trc X-value Y-value Function Function Result M1 1 915.757 MHz 15.75 dBm M2 1 902.0 MHz -51.45 dBm M3 1 900.487 MHz -49.81 dBm M4 1 915.757 MHz 15.75 dBm Date: 13.FEB.2023 03:13:29

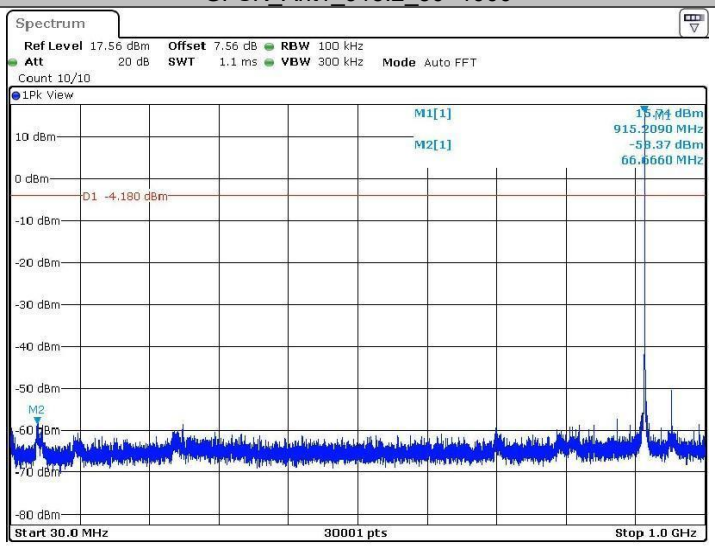
GFSK/HCH/No Hop	
GFSK/HCH/Hop	

5.9 Spurious RF Conducted Emissions

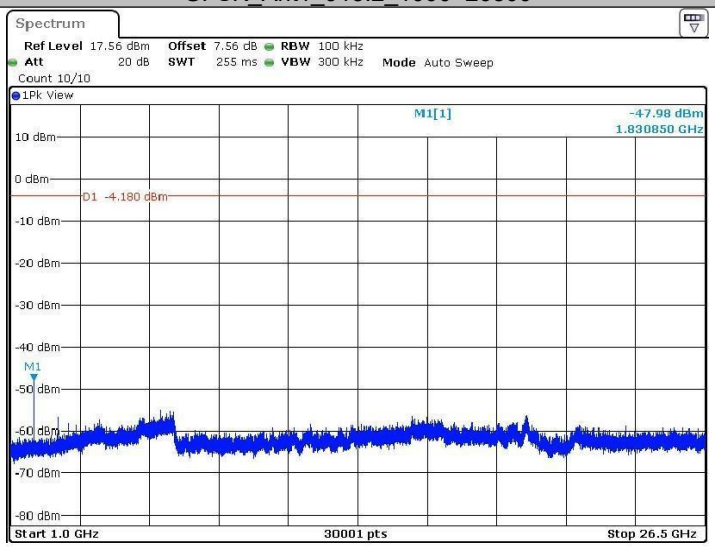
Test Requirement:	47 CFR Part 15C Section 15.247 (d)
Test Method:	ANSI C63.10:2013
Test Setup:	 *Remark: Offset=cable loss+ attenuation factor.*
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is 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.
Exploratory Test Mode:	Non-hopping transmitting with all kind of modulation and all kind of data type
Final Test Mode:	Through Pre-scan, find the GFSK modulation type
Test Results:	Pass

GFSK_Ant1_915.2_0~Reference

GFSK_Ant1_915.2_30~1000

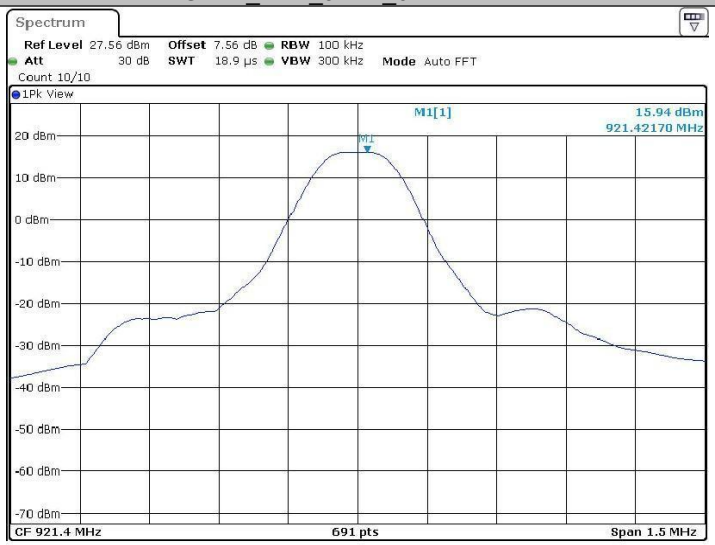


GFSK_Ant1_915.2_1000~26500



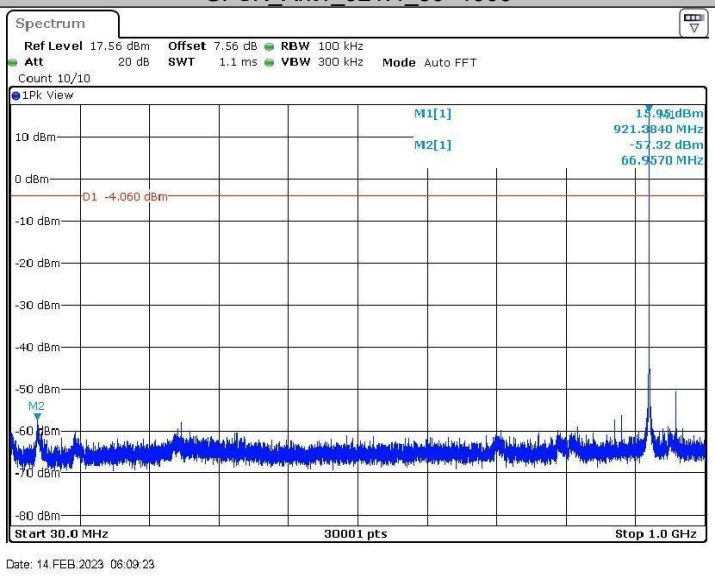
Date: 14.FEB.2023 06:11:22

GFSK_Ant1_921.4_0~Reference



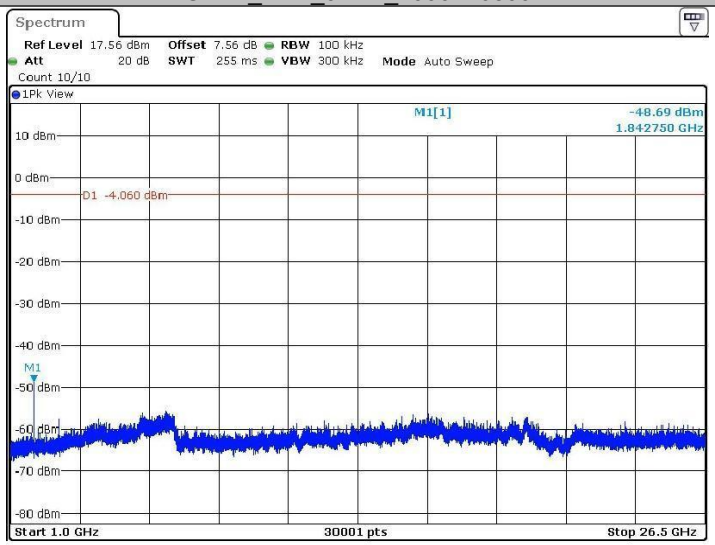
Date: 14.FEB.2023 06:09:16

GFSK_Ant1_921.4_30~1000



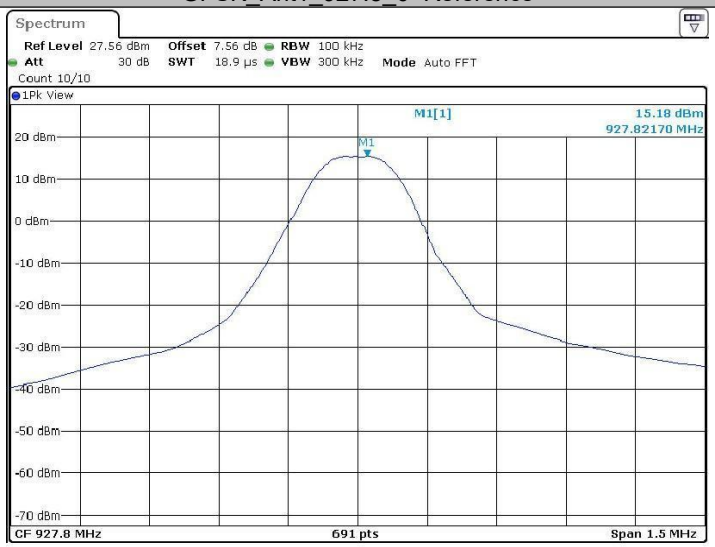
Date: 14.FEB.2023 06:09:23

GFSK_Ant1_921.4_1000~26500



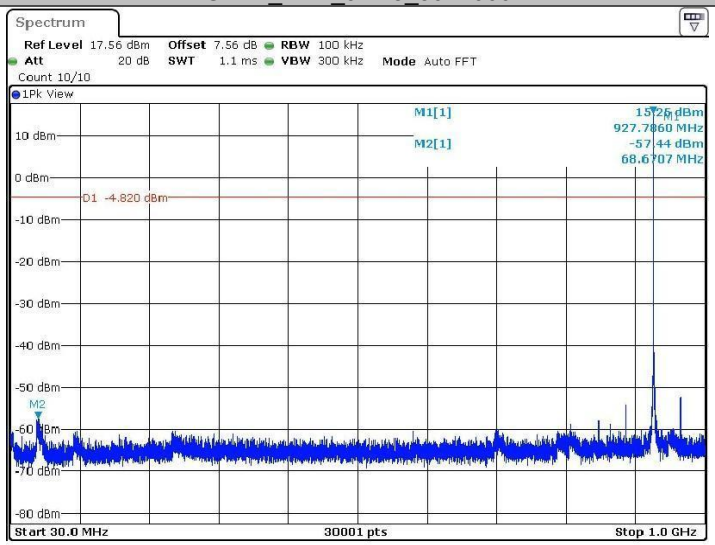
Date: 14.FEB.2023 06:09:44

GFSK_Ant1_927.8_0~Reference



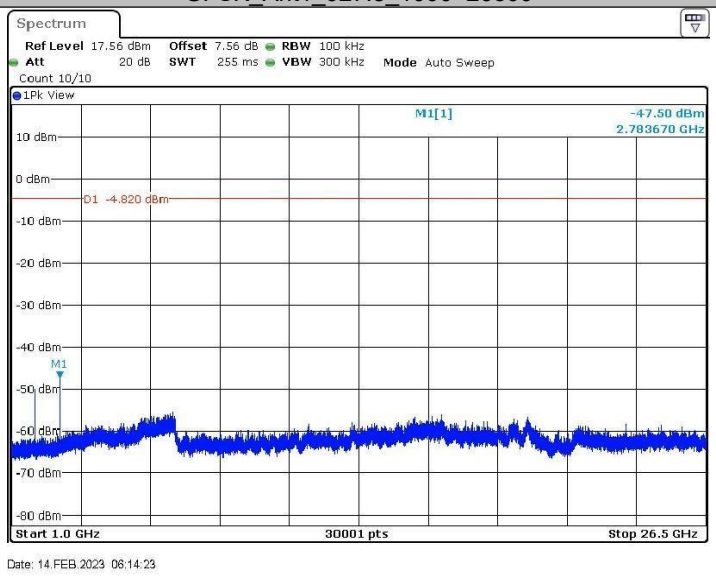
Date: 14.FEB.2023 06:13:54

GFSK_Ant1_927.8_30~1000



Date: 14.FEB.2023 06:14:02

GFSK_Ant1_927.8_1000~26500



Remark:

Pre test 9kHz to 25GHz, find the highest point when testing, so only the worst data were shown in the test report. Per FCC Part 15.33 (a) and 15.31 (o) ,The amplitude of spurious emissions from intentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in this part.

5.10 Other requirements Frequency Hopping Spread Spectrum System

Test Requirement:	47 CFR Part 15C Section 15.247 (a)(1), (h) requirement:

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.

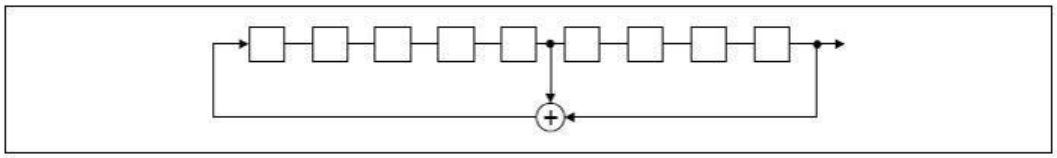
Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

Compliance for section 15.247(a)(1)

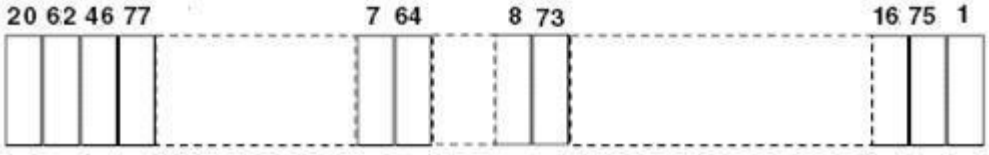
According to Bluetooth Core Specification, the pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage
outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs; i.e. the shift register is initialized with nine ones.

- Number of shift register stages: 9
- Length of pseudo-random sequence: 2^9 -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 follow:



Each frequency used equally on the average by each transmitter.

According to Bluetooth Core Specification, Bluetooth receivers are designed to have input and IF bandwidths that match the hopping channel bandwidths of any Bluetooth transmitters and shift frequencies in synchronization with the transmitted signals.

Compliance for section 15.247(g)

According to Bluetooth Core Specification, the Bluetooth system transmits the packet with the pseudorandom hopping frequency with a continuous data and the short burst transmission from the Bluetooth system is also transmitted under the frequency hopping system with the pseudorandom hopping frequency system.

Compliance for section 15.247(h)
According to Bluetooth Core specification, the Bluetooth system incorporates with an adaptive system to detect other user within the spectrum band so that it individually and independently to avoid hopping on the occupied channels. According to the Bluetooth Core specification, the Bluetooth system is designed not have the ability to coordinated with other FHSS System in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitter.

5.11 Radiated Spurious Emission & Restricted bands

Test Requirement:	47 CFR Part 15C Section 15.209 and 15.205
Test Method:	ANSI C63.10: 2013
Test Site:	Measurement Distance: 3m (Semi-Anechoic Chamber)
Receiver Setup:	

Frequency	Detector	RBW	VBW	Remark
0.009MHz-0.090MHz	Peak	10kHz	30kHz	Peak
0.009MHz-0.090MHz	Average	10kHz	30kHz	Average
0.090MHz-0.110MHz	Quasi-peak	10kHz	30kHz	Quasi-peak
0.110MHz-0.490MHz	Peak	10kHz	30kHz	Peak
0.110MHz-0.490MHz	Average	10kHz	30kHz	Average
0.490MHz -30MHz	Quasi-peak	10kHz	30kHz	Quasi-peak
30MHz-1GHz	Peak	120 kHz	300kHz	Peak
Above 1GHz	Peak	1MHz	3MHz	Peak
	Peak	1MHz	10Hz	Average

Limit:

Frequency	Field strength (microvolt/meter)	Limit (dBuV/m)	Remark	Measurement distance (m)
0.009MHz-0.490MHz	2400/F(kHz)	-	-	300
0.490MHz-1.705MHz	24000/F(kHz)	-	-	30
1.705MHz-30MHz	30	-	-	30
30MHz-88MHz	100	40.0	Quasi-peak	3
88MHz-216MHz	150	43.5	Quasi-peak	3
216MHz-960MHz	200	46.0	Quasi-peak	3
960MHz-1GHz	500	54.0	Quasi-peak	3
Above 1GHz	500	54.0	Average	3

Note: 15.35(b), Unless otherwise specified, the limit on peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device.

Test Setup:	

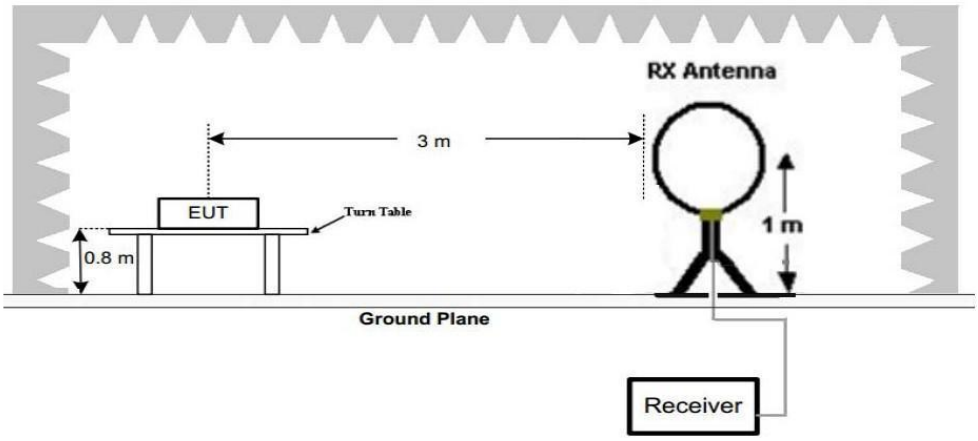


Figure 1. Below 30MHz

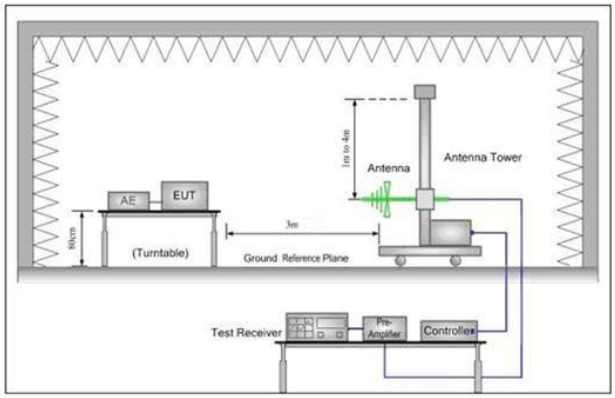


Figure 2. 30MHz to 1GHz

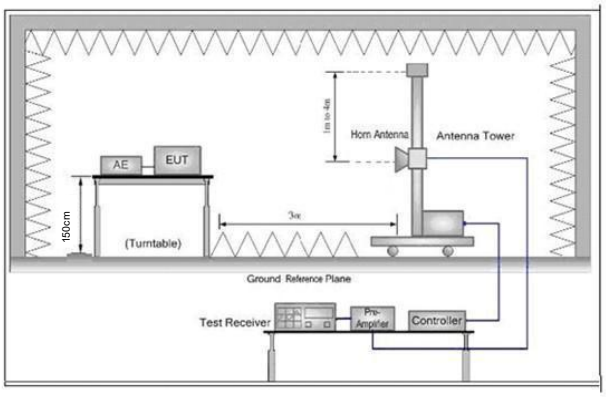


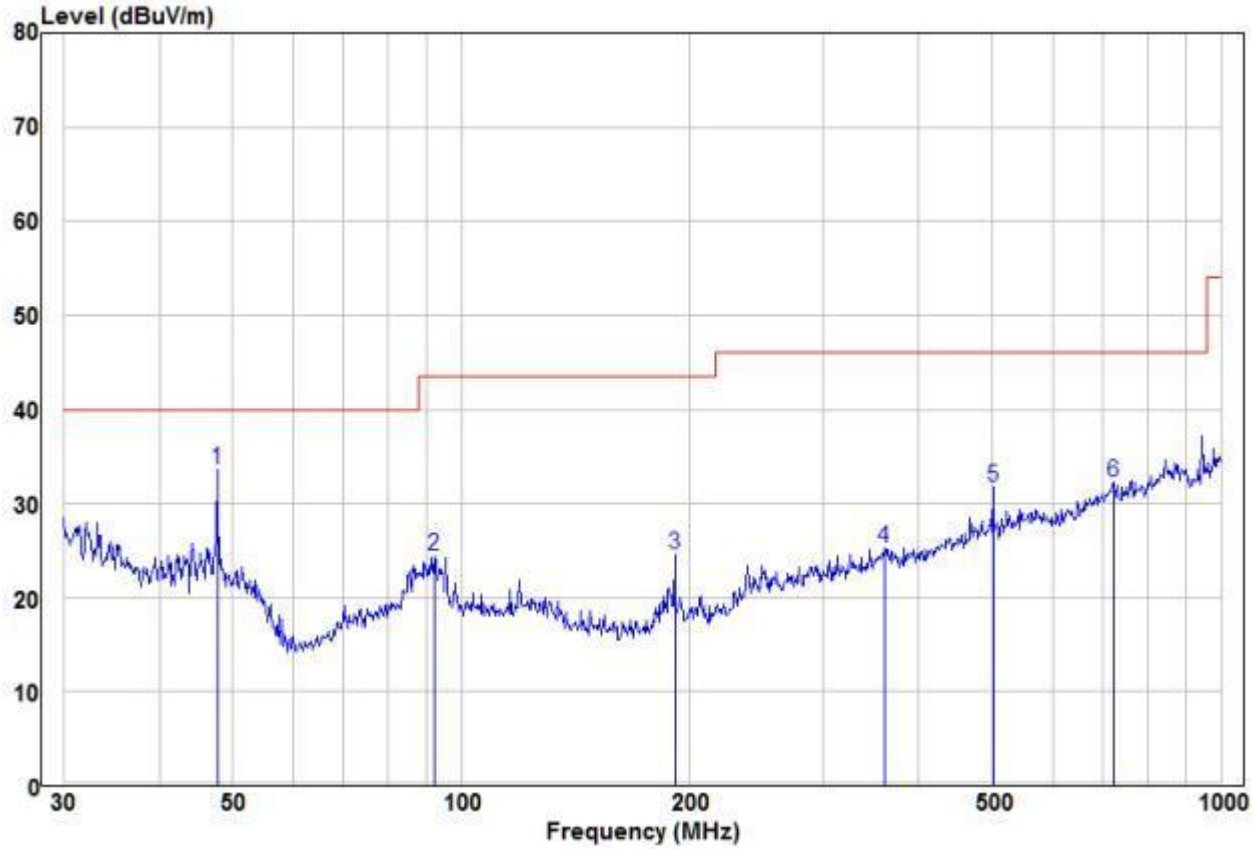
Figure 3. Above 1 GHz

Test Procedure:	a. 1) Below 1G: The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter semi-anechoic camber. The table was rotated 360 degrees to determine the position of the highest radiation. 2) Above 1G: The EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter semi-anechoic camber. The table was rotated 360 degrees to determine the position of the highest radiation. Note: For the radiated emission test above 1GHz: Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane. b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower. c. 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.

	d. 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. e. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode. f. 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. g. Test the EUT in the lowest channel (2402MHz),the middle channel (2441MHz),the Highest channel (2480MHz) h. 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. i. Repeat above procedures until all frequencies measured was complete.
Exploratory Test Mode:	Non-hopping transmitting mode with all kind of modulation and all kind of data type Transmitting mode
Final Test Mode:	Through Pre-scan, find the GFSK modulation is the worst case. For below 1GHz part, through pre-scan, the worst case is the lowest channel. Only the worst case is recorded in the report.
Test Results:	Pass

5.11.1 Radiated Emission below 1GHz

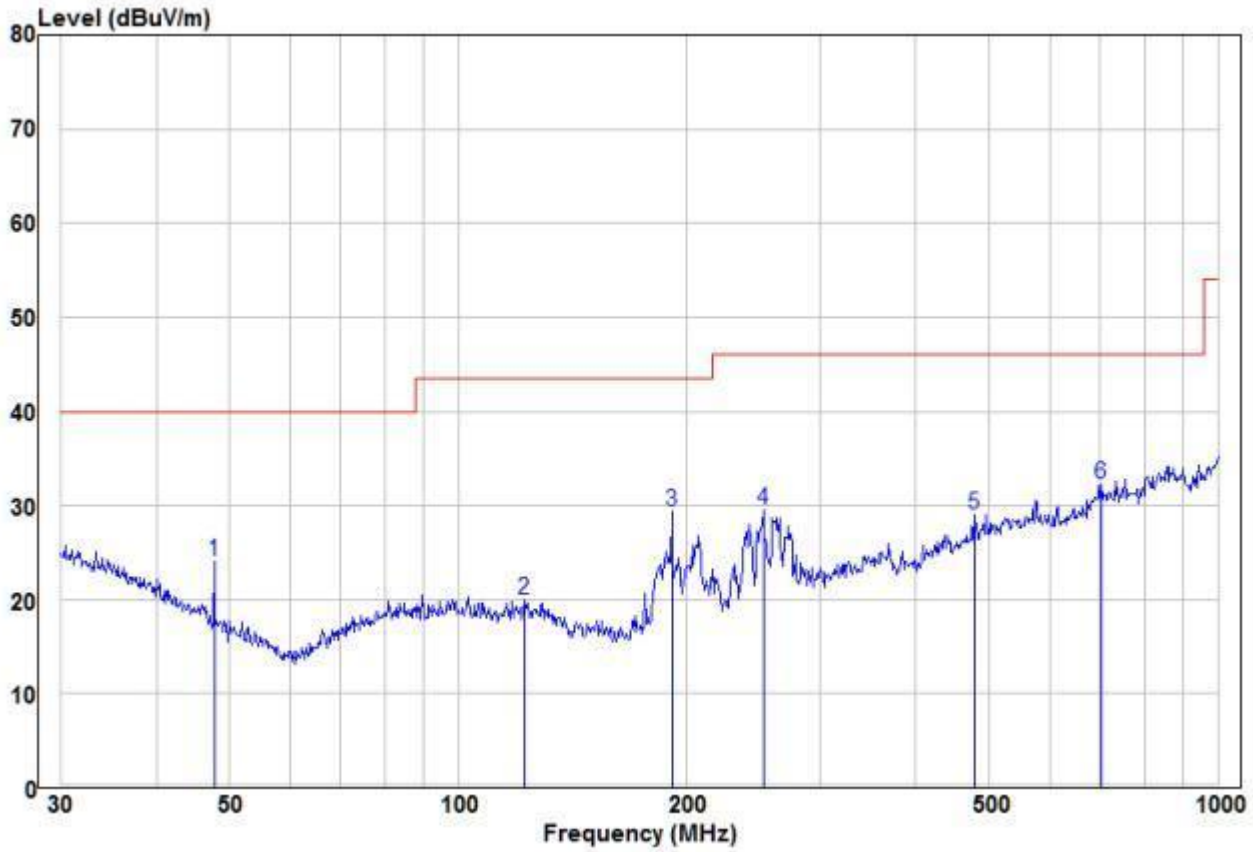
30MHz~1GHz		
Test mode:	Transmitting	Vertical



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark	Pol/Phase
	MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB		
1 pp	47.66	24.50	9.19	33.69	40.00	-6.31	Peak	VERTICAL
2	92.14	14.17	10.15	24.32	43.50	-19.18	Peak	VERTICAL
3	191.07	16.46	8.02	24.48	43.50	-19.02	Peak	VERTICAL
4	360.45	10.06	15.20	25.26	46.00	-20.74	Peak	VERTICAL
5	501.18	13.43	18.29	31.72	46.00	-14.28	Peak	VERTICAL
6	724.26	11.06	21.25	32.31	46.00	-13.69	Peak	VERTICAL

Remark:
The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:
Factor= Antenna Factor + Cable Factor – Preamplifier Factor,
Level = Read Level + Factor,
Over Limit=Level-Limit Line.

Test mode:	Transmitting	Horizontal



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark	Pol/Phase
	MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB		
1	47.66	14.89	9.19	24.08	40.00	-15.92	Peak	HORIZONTAL
2	122.40	9.38	10.60	19.98	43.50	-23.52	Peak	HORIZONTAL
3	191.07	21.24	8.02	29.26	43.50	-14.24	Peak	HORIZONTAL
4	252.06	17.33	12.14	29.47	46.00	-16.53	Peak	HORIZONTAL
5	477.17	11.43	17.57	29.00	46.00	-17.00	Peak	HORIZONTAL
6 pp	701.76	11.15	21.10	32.25	46.00	-13.75	Peak	HORIZONTAL

Remark:
The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:
Factor= Antenna Factor + Cable Factor – Preamplifier Factor,
Level = Read Level + Factor,
Over Limit=Level-Limit Line.

5.11.2 Transmitter Emission above 1GHz

Worse case mode:		GFSK		Test channel:		Lowest	
Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Over (dB)	Detector Type	Ant. Pol. H/V
902	55.57	-9.39	46.18	74	-27.82	Peak	H
1830.4	51.86	-4.33	47.53	74	-26.47	Peak	H
2745.6	50.93	1.01	51.94	74	-22.06	Peak	H
902	55.76	-9.39	46.37	74	-27.63	Peak	V
1830.4	54.10	-4.33	49.77	74	-24.23	Peak	V
2745.6	50.12	1.01	51.13	74	-22.87	Peak	V

Worse case mode:		GFSK		Test channel:		Middle	
Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Over (dB)	Detector Type	Ant. Pol. H/V
1843.2	50.40	-4.11	46.29	74	-27.71	peak	H
2764.8	50.60	1.51	52.11	74	-21.89	peak	H
1843.2	52.19	-4.11	48.08	74	-25.92	peak	V
2764.8	51.04	1.51	52.55	74	-21.45	peak	V

Worse case mode:		GFSK		Test channel:		Highest	
Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Over (dB)	Detector Type	Ant. Pol. H/V
928	55.00	-9.29	45.71	74	-28.29	**Peak**	**H**
1855.6	51.35	-4.04	47.31	74	-26.69	Peak	H
2783.4	50.87	1.57	52.44	74	-21.56	Peak	H
928	55.25	-9.29	45.96	74	-28.04	**Peak**	**V**
1855.6	49.45	-4.04	45.41	74	-28.59	Peak	V
2783.4	50.87	1.57	52.44	74	-21.56	Peak	V

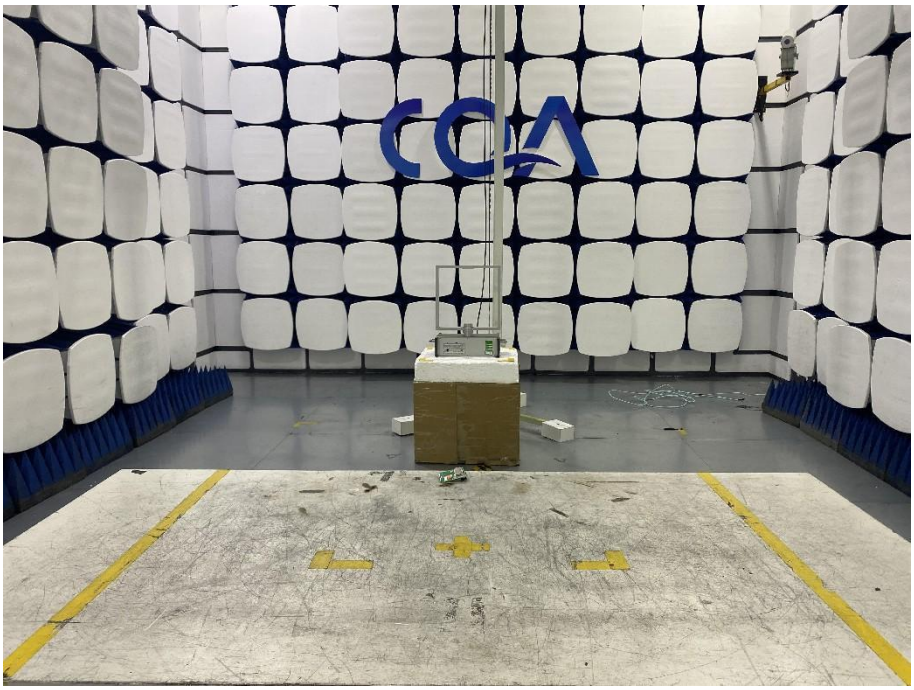
Remark:

1) The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:
   Final Test Level =Receiver Reading + Antenna Factor + Cable Factor – Preamplifier Factor
2) Scan from 9kHz to 25GHz, the disturbance above 10GHz and below 30MHz was very low. As shown in this section, for frequencies above 1GHz, the field strength limits are based on average limits. However, 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. So, only the peak measurements were shown in the report.

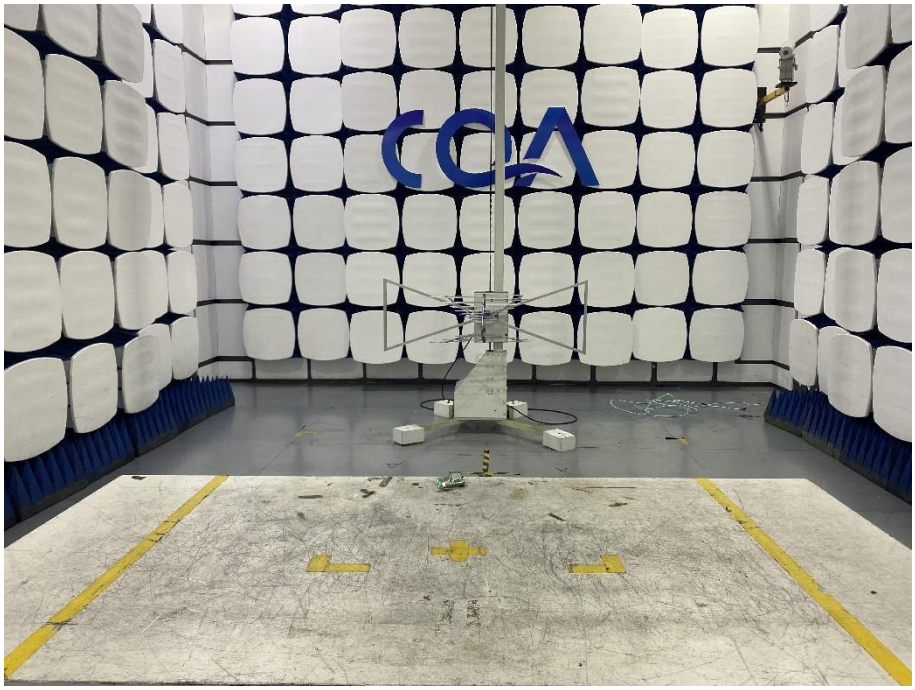
6 Photographs - EUT Test Setup

6.1 Radiated Emission

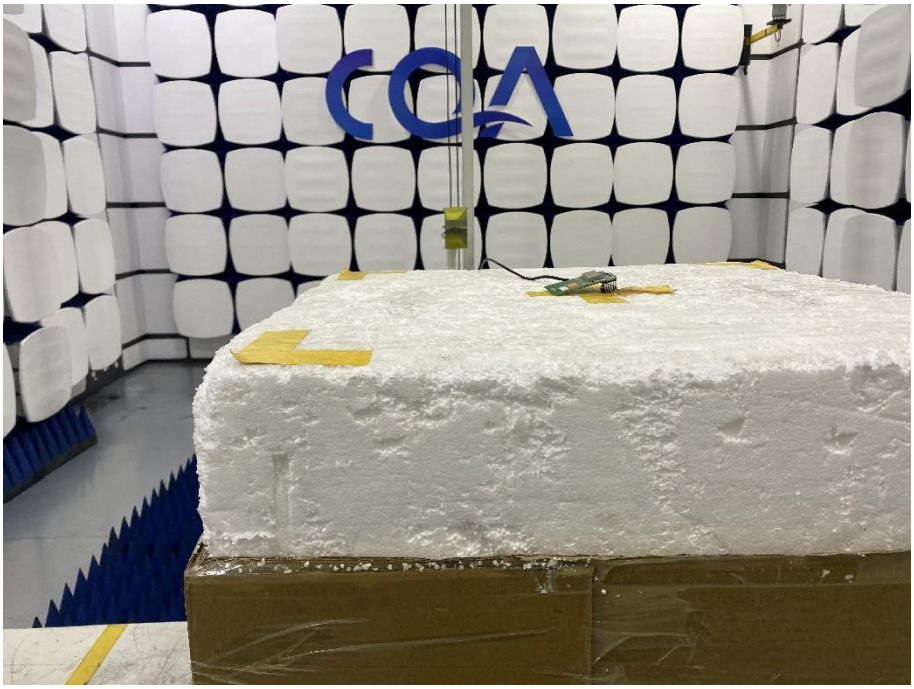
9KHz~30MHz:



30MHz~1GHz:

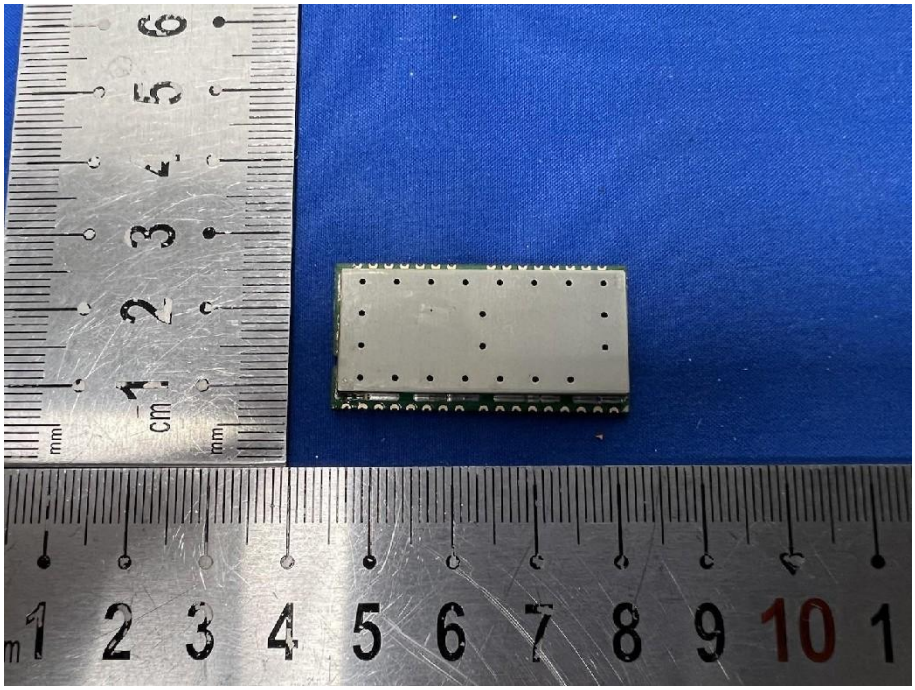


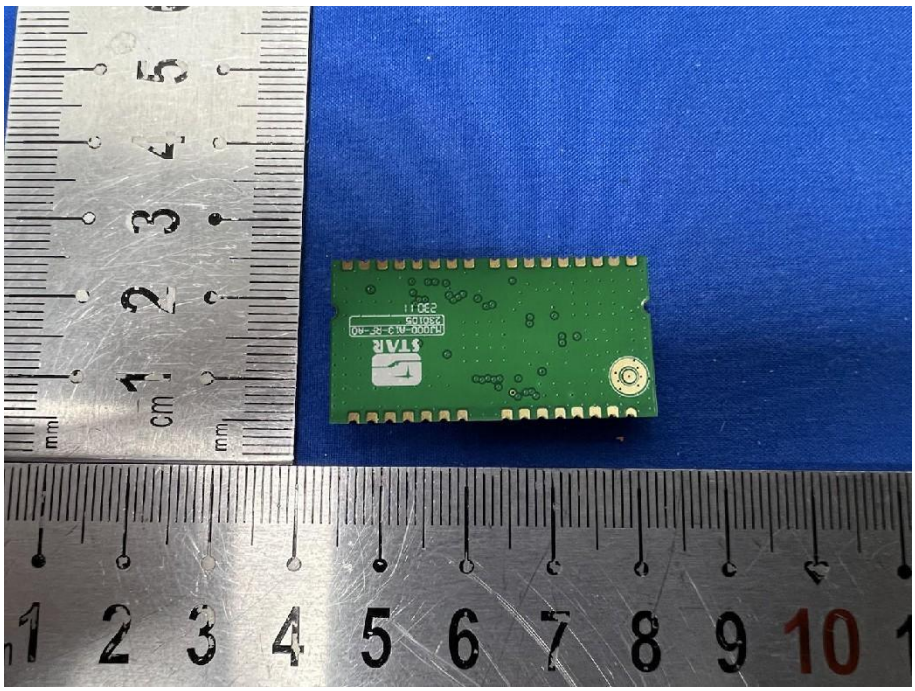
Above 1GHz:

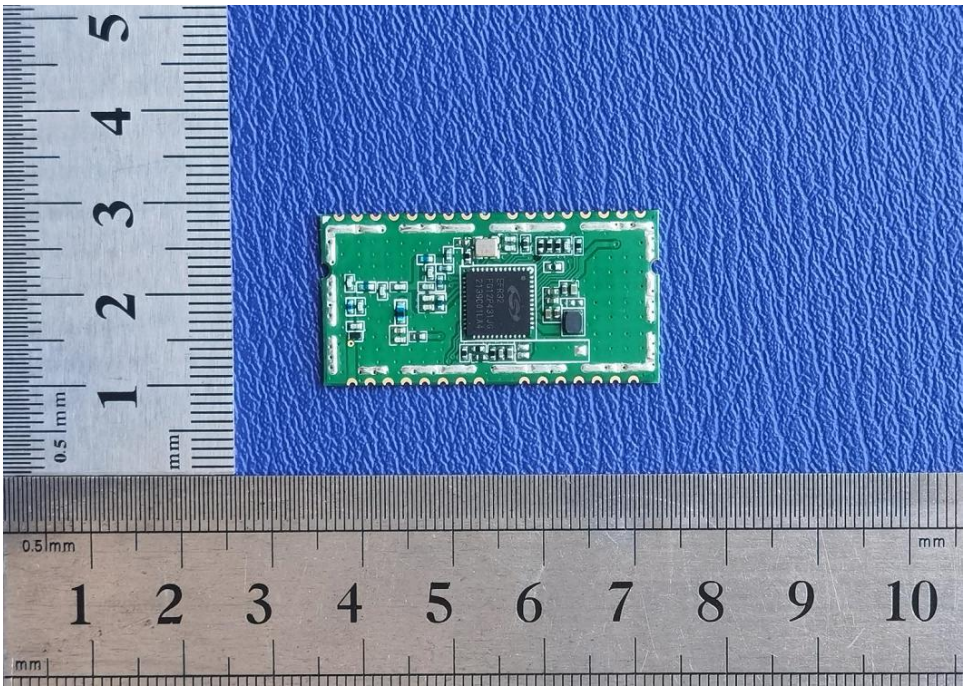


6.2 Conducted Emission

7 Photographs - EUT Constructional Details







*** END OF REPORT ***