



Test Report

Date : 2023-03-14

No. : HMD23020008

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Applicant : PIN Genie Inc, DBA LOCKLY.
676 Transfer Rd., St. Paul, MN 55114

Supplier / Manufacturer : Smart Electronic Industrial (Dongguan) Co., Ltd
Qing Long Road, Long Jian Tian Village, Huang Jiang Town, Dong
Guan, Guang Dong, China

Description of Sample(s) : Submitted sample(s) said to be
Product: Lockly Guard Vision
Brand Name: LOCKLY
Model No.: PGD698D
FCC ID: 2ASIVPGD698

Date Samples Received : 2023-02-24

Date Tested : 2023-02-24 to 2023-03-07

Investigation Requested : Perform Electro Magnetic Interference measurement in accordance
with FCC 47CFR [Codes of Federal Regulations] Part 15 and ANSI
C63.10:2013 for FCC Certification.

Conclusions : The submitted product COMPLIED with the requirements of Federal
Communications Commission [FCC] Rules and Regulations Part 15.
The tests were performed in accordance with the standards described
above and on Section 2.2 in this Test Report.

Remarks : 2.4G Wireless FHSS (GFSK)
For additional model(s) details, please see page 3.


Dr.CHAN Kwok Hung, Brian
Authorized Signatory

The Hong Kong Standards and Testing Centre Limited

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1.0 General Details

1.1 Test Laboratory

The Hong Kong Standards and Testing Centre Ltd.
EMC Laboratory
10 Dai Wang Street, Taipo Industrial Estate, New Territories, Hong Kong
Telephone: 852 2666 1888
Fax: 852 2664 4353

1.2 Equipment Under Test [EUT]

Description of Sample(s)

Product:	Lockly Guard Vision
Supplier:	Smart Electronic Industrial (Dongguan) Co., Ltd Qing Long Road, Long Jian Tian Village, Huang Jiang Town, Dong Guan, Guang Dong, China
Brand Name:	LOCKLY
Model Number:	PGD698D
Additional Model:	PGD698L
Rating:	6Vd.c.(“AA” battery x4) x2

1.2.1 Description of EUT Operation

The Equipment Under Test (EUT) is a Lockly Guard Vision (Interconnected Edition). The transmission signal is digital modulated with channel frequency range 2403.01-2471.01MHz. The R.F. signal was modulated by IC; the type of modulation used was frequency hopping spread spectrum Modulation.

1.3 Date of Order

2023-02-24

1.4 Submitted Sample(s):

1 Sample

1.5 Test Duration

2023-02-24 to 2023-03-07

1.6 Country of Origin

China

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1.7 RF Module Details

Module Model Number: N/A
Module FCC ID: N/A
Module Transmission Type: 2.4G Wireless
Modulation: FHSS (GFSK)
Data Rates: N/A
Frequency Range: 2400-2483.5MHz
Carrier Frequencies: 2403.01MHz – 2471.01MHz

Module Specification (specification provided by manufacturer)

1.8 Antenna Details

Antenna Type: Linear antenna
Antenna Gain: 2.69 dBi

1.9 Channel List

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2403.01		
2	2407.01		
3	2411.01		
4	2415.01		
5	2419.01		
6	2423.01		
7	2427.01		
8	2431.01		
9	2435.01		
10	2439.01		
11	2443.01		
12	2447.01		
13	2451.01		
14	2455.01		
15	2459.01		
16	2463.01		
17	2467.01		
18	2471.01		

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2.0 Technical Details

2.1 Investigations Requested

Perform Electromagnetic Interference measurements in accordance with FCC 47CFR [Codes of Federal Regulations] Part 15 Regulations and ANSI C63.10:2013 for FCC Certification.

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. All testing shall be performed under maximum output power condition, and to measure its highest possible emissions level.

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2.2 Test Standards and Results Summary Tables

EMISSION Results Summary						
Test Condition	Test Requirement	Test Method	Class / Severity	Test Result		
				Pass	Failed	N/A
Maximum Peak Conducted Output Power	FCC 47CFR 15.247(b)(1)	ANSI C63.10: 2013	N/A	☒	☐	☐
Radiated Spurious Emissions	FCC 47CFR 15.209, FCC 47CFR 15.205	ANSI C63.10: 2013	N/A	☒	☐	☐
AC Mains Conducted Emissions	FCC 47CFR 15.207	ANSI C63.10: 2013	N/A	☐	☐	☒
Conducted Spurious Emissions	FCC 47CFR 15.247(d)	ANSI C63.10: 2013	N/A	☒	☐	☐
Number of Hopping Frequency	FCC 47CFR 15.247 (b)(1)	ANSI C63.10: 2013	N/A	☒	☐	☐
20dB Bandwidth	FCC 47CFR 15.247(a)(2)	ANSI C63.10: 2013	N/A	☒	☐	☐
Hopping Channel Separation	FCC 47CFR 15.247(a)(1)	ANSI C63.10: 2013	N/A	☒	☐	☐
Band-edge measurement (Radiated)	FCC 47CFR 15.247(d)	ANSI C63.10: 2013	N/A	☒	☐	☐
Pseudorandom Hopping Algorithm	FCC 47CFR 15.247(a)(1)	N/A	N/A	☒	☐	☐
Time of Occupancy (Dwell Time)	FCC 47CFR 15.247(a)(1)(iii)	ANSI C63.10: 2013	N/A	☒	☐	☐
Antenna requirement	FCC 47CFR 15.203	N/A	N/A	☒	☐	☐

Note: N/A - Not Applicable



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2.3 Table for Test Modes

Preliminary tests were performed in different data rate to find the worst radiated emission. The data rate in the table below is the worst-case rate with respect to the specific test item.

Investigation has been done on all the possible configurations for searching the worst cases.

The following table is a list of the test modes shown in this test report.

Test Items	Mode	Data Rate
Maximum Peak Conducted Output Power	GFSK	/
Hopping Channel Separation	GFSK	/
Number of Hopping Frequency	GFSK	/
Time of Occupancy (Dwell Time)	GFSK	/
Radiated Spurious Emissions	GFSK	/
Band-edge compliance of Conducted Emission	GFSK	/

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3.0 Test Results

3.1 Emission

3.1.1 Maximum Peak Conducted Output Power

Test Requirement:	FCC 47CFR 15.247(b) (1)
Test Method:	ANSI C63.10: 2013
Test Date:	2023-03-02
Mode of Operation:	Tx mode

Ambient Temperature: 25°C Relative Humidity: 51% Atmospheric Pressure: 101 kPa

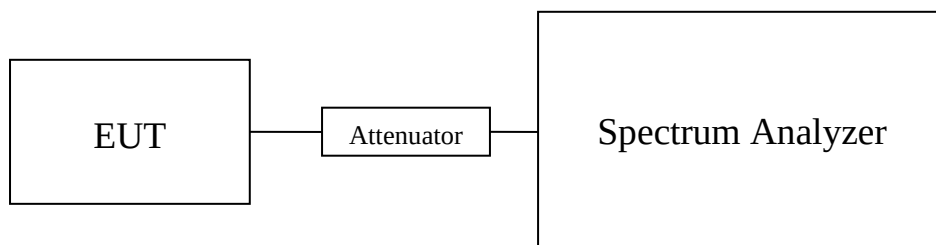
Test Method:

A temporary antenna connector was soldered to the RF output. The RF output of the EUT was connected to the spectrum analyzer. All the attenuation or cable loss will be added to the measured maximum output power. The results are recorded in Watt.

Spectrum Analyzer Setting:

RBW = 5 MHz, VBW= 5MHz, Sweep = Auto, Span: Approximately five times the 20 dB bandwidth
Detector = Peak, Trace = Max. hold

Test Setup:



Note: a temporary antenna connector was soldered to the RF output.



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Limits for Maximum Peak Conducted Output Power [FCC 47CFR 15.247]:

The maximum peak output power shall not exceeded the following limits:
For frequency hopping systems employing at least 75 hopping channels: 1 Watt
For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 Watts
For Digital Transmission systems in 2400-2483.5 MHz Band: 1 Watt

For FHSS systems in 2400-2483.5 MHz Band: 0.125Watt (20.9dBm)

Results of Tx Mode: Pass (TX Unit) (GFSK)					
Channel	Frequency (MHz)	Conducted power(dBm)	Antenna Gain(dBi)	E.I.R.P(dBm)	E.I.R.P (Watt)
Low	2403.01	17.39	2.69	20.08	0.1018591
Mid	2439.01	17.16	2.69	19.85	0.096605
High	2471.01	16.96	2.69	19.65	0.092257

Calculated measurement uncertainty : 30MHz to 1GHz 1.7dB
1GHz to 26GHz 1.7dB



Test Report

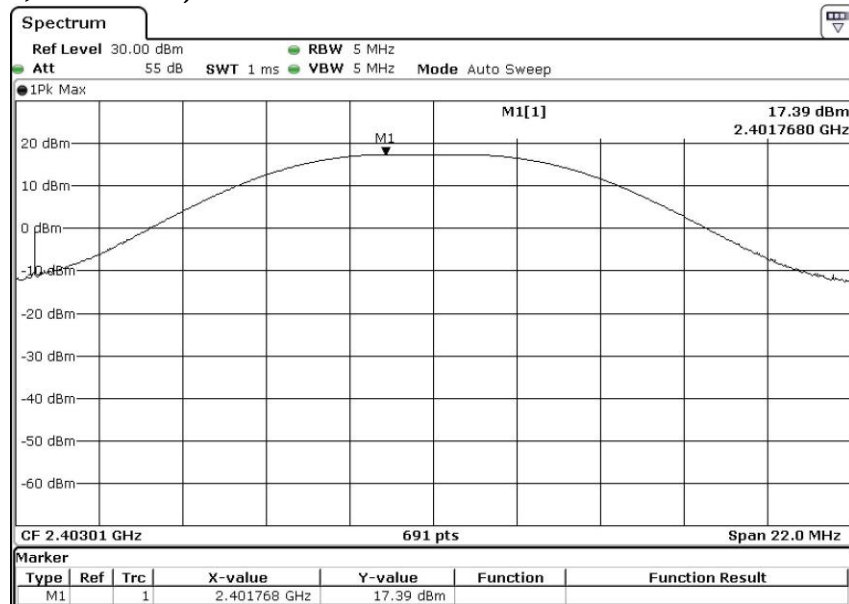
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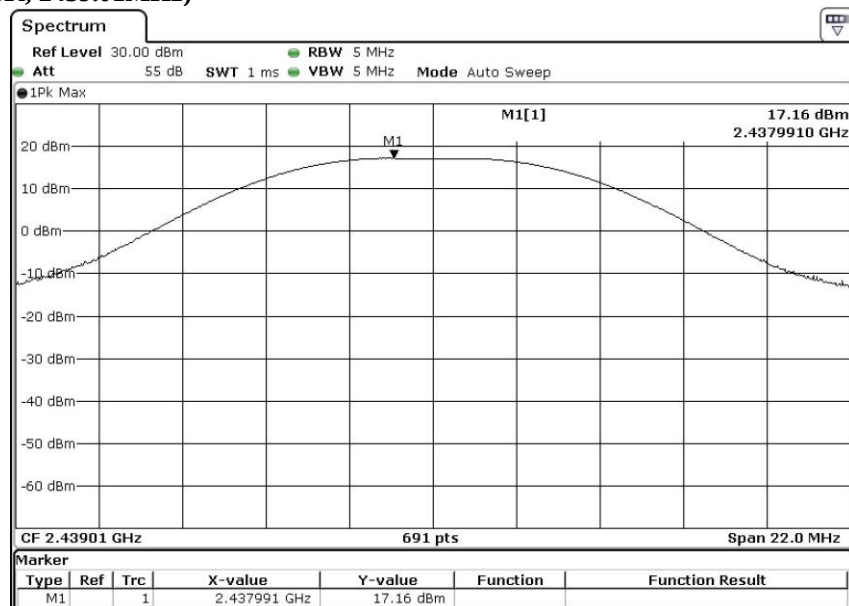
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Test plot of Maximum Peak Conducted Output Power:

TX mode (GFSK, 2403.01MHz)



TX mode (GFSK, 2439.01MHz)



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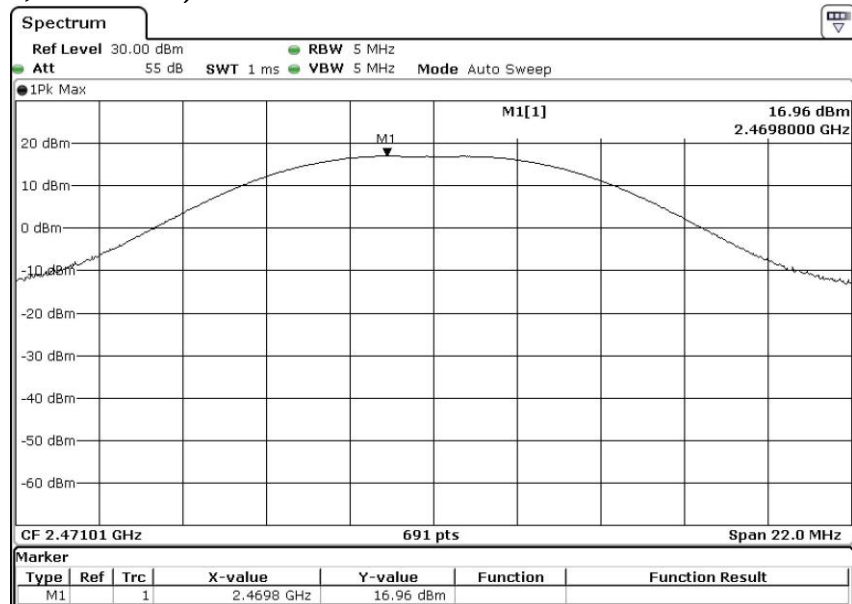


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TX mode (GFSK, 2471.01MHz)



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3.1.2 Radiated Spurious Emissions

Test Requirement:	FCC 47CFR 15.209
Test Method:	ANSI C63.10:2013
Test Date:	2023-03-02 to 2023-03-07
Mode of Operation:	Tx mode (GFSK)

Ambient Temperature: 26.8°C Relative Humidity: 43.9% Atmospheric Pressure: 100.8 kPa

Test Method:

For emission measurements at or below 1 GHz, the sample was placed 0.8m above the ground plane of semi-anechoic Chamber*. For emission measurements above 1 GHz, the sample was placed 1.5m above the ground plane of semi-anechoic Chamber*. Measurements in both horizontal and vertical polarities were performed. During the test, each emission was maximized by: having the EUT continuously working, investigated all operating modes, rotated about all 3 axis (X, Y & Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, rotating turntable, varying antenna height from 1m to 4m in both horizontal and vertical polarizations. The emissions worst-case are shown in Test Results of the following pages.

* Semi-Anechoic chamber located on the G/F of The Hong Kong Standards and Testing Centre Ltd. with
Registration Number: HK0001
Test Firm Registration Number: 367672

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Spectrum Analyzer Setting:

9KHz – 30MHz (Pk & AVG)

RBW: 10kHz
VBW: 30kHz
Sweep: Auto
Span: Fully capture the emissions being measured
Trace: Max. hold

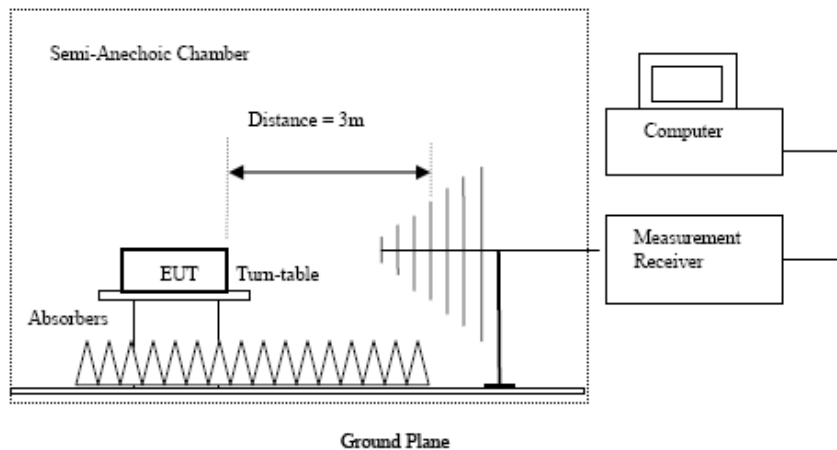
30MHz – 1GHz (QP)

RBW: 120kHz
VBW: 120kHz
Sweep: Auto
Span: Fully capture the emissions being measured
Trace: Max. hold

Above 1GHz (Pk & AVG)

RBW: 1MHz
VBW: 1MHz
Sweep: Auto
Span: Fully capture the emissions being measured
Trace: Max. hold

Test Setup:



- Absorbers placed on top of the ground plane are for measurements above 1000MHz only.
- Measurements between 30MHz to 1000MHz made with Bi-log antennas, above 1000MHz horn antennas are used, 9kHz to 30MHz loop antennas are used.

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Limits for Radiated Emissions FCC 47 CFR 15.247 Class B):

Frequency Range	Quasi-Peak Limits
[MHz]	[μ V/m]
0.009-0.490	2400/F (kHz)
0.490-1.705	24000/F (kHz)
1.705-30	30
30-88	100
88-216	150
216-960	200
Above960	500

The emission limits shown in the above table are based on measurement employing a CISPR quasi-peak detector and above 1000MHz are based on measurements employing an average detector.

Result of Tx mode (2403.01 MHz) (GFSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Field Strength μ V/m	Limit μ V/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2403.01 MHz) (GFSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
4806.02	59.3	0.8	60.1	74.0	13.9	Vertical
4806.02	57.4	0.5	57.9	74.0	16.1	Horizontal
7209.03	55.2	7.0	62.2	74.0	11.8	Vertical
7209.03	53.4	6.5	59.9	74.0	14.1	Horizontal
9612.04	47.1	8.5	55.6	74.0	18.4	Vertical
9612.04	46.3	8.3	54.6	74.0	19.4	Horizontal
12015.05	45.4	10.9	56.3	74.0	17.8	Vertical
12015.05	45.2	10.8	56.0	74.0	18.0	Horizontal

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Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
4806.02	45.1	0.8	45.9	54.0	8.1	Vertical
4806.02	43.3	0.5	43.8	54.0	10.2	Horizontal
7209.03	40.1	7.0	47.1	54.0	6.9	Vertical
7209.03	38.2	6.5	44.7	54.0	9.3	Horizontal
9612.04	31.2	8.5	39.7	54.0	14.3	Vertical
9612.04	32.0	8.3	40.3	54.0	13.7	Horizontal
12015.05	30.4	10.9	41.3	54.0	12.7	Vertical
12015.05	29.5	10.8	40.3	54.0	13.7	Horizontal

Result of Tx mode (2439.01 MHz) (GFSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2439.01 MHz) (GFSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
4878.02	57.8	0.8	58.6	74.0	15.4	Vertical
4878.02	55.3	0.5	55.8	74.0	18.2	Horizontal
7317.03	54.2	7.0	61.2	74.0	12.8	Vertical
7317.03	52.0	6.5	58.5	74.0	15.5	Horizontal
9756.04	48.1	8.5	56.6	74.0	17.4	Vertical
9756.04	47.3	8.3	55.6	74.0	18.4	Horizontal
12195.05	45.0	10.9	55.9	74.0	18.1	Vertical
12195.05	45.3	10.8	56.1	74.0	17.9	Horizontal

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Field Strength of Spurious Emissions						
Average Value						
Frequency MHz	Measured Level @3m dBuV	Correction Factor dB/m	Field Strength dBuV/m	Limit @3m dBuV/m	Margin dB	E-Field Polarity
4878.02	42.2	0.8	43.0	54.0	11.0	Vertical
4878.02	38.5	0.5	39.0	54.0	15.0	Horizontal
7317.03	40.1	7.0	47.1	54.0	6.9	Vertical
7317.03	38.5	6.5	45.0	54.0	9.0	Horizontal
9756.04	33.1	8.5	41.6	54.0	12.4	Vertical
9756.04	32.2	8.3	40.5	54.0	13.5	Horizontal
12195.05	30.5	10.9	41.4	54.0	12.6	Vertical
12195.05	30.1	10.8	40.9	54.0	13.1	Horizontal

Result of Tx mode (2471.01 MHz) (GFSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions						
Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2471.01 MHz) (GFSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions						
Peak Value						
Frequency MHz	Measured Level @3m dBuV	Correction Factor dB/m	Field Strength dBuV/m	Limit @3m dBuV/m	Margin dB	E-Field Polarity
4942.02	58.1	0.8	58.9	74.0	15.1	Vertical
4942.02	56.0	0.5	56.5	74.0	17.5	Horizontal
7413.03	54.4	7.0	61.4	74.0	12.6	Vertical
7413.03	52.3	6.5	58.8	74.0	15.2	Horizontal
9884.04	47.6	8.5	56.1	74.0	17.9	Vertical
9884.04	47.0	8.3	55.3	74.0	18.7	Horizontal
12355.05	45.5	10.9	56.4	74.0	17.6	Vertical
12355.05	45.3	10.8	56.1	74.0	17.9	Horizontal

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Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
4942.02	43.5	0.8	44.3	54.0	9.7	Vertical
4942.02	41.6	0.5	42.1	54.0	11.9	Horizontal
7413.03	40.5	7.0	47.5	54.0	6.5	Vertical
7413.03	38.5	6.5	45.0	54.0	9.0	Horizontal
9884.04	33.2	8.5	41.7	54.0	12.3	Vertical
9884.04	31.6	8.3	39.9	54.0	14.1	Horizontal
12355.05	30.2	10.9	41.1	54.0	12.9	Vertical
12355.05	30.1	10.8	40.9	54.0	13.1	Horizontal

Remarks:

No additional spurious emissions found between lowest internal used/generated frequency and 30 MHz

* Denotes restricted band of operation.

Measurements were made using a peak detector. Any emission less than 1000MHz and falling within the restricted bands of FCC Rules Part 15 Section 15.205 and the limits of FCC Rules Part 15 Section 15.209 were applied.

Correction Factor included Antenna Factor and Cable Attenuation.

Calculated measurement uncertainty
(9kHz-30MHz): 2.0dB
(30MHz -1GHz): 4.9dB
(1GHz -6GHz): 4.02dB
(6GHz -26.5GHz): 4.03dB

Emissions in the vertical and horizontal polarizations have been investigated and the worst-case test results are recorded in this report.

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Radiated Emissions Measurement:

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. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)).

Result: RF Radiated Emissions (Lowest)-GFSK

Field Strength of Band-edge Compliance						
Peak Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
2390.0	60.2	-4.8	55.4	74.0	18.6	Vertical
2390.0	56.6	-4.7	51.9	74.0	22.1	Horizontal

Field Strength of Band-edge Compliance						
Average Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
2390.0	53.6	-4.8	48.8	54.0	5.2	Vertical
2390.0	49.2	-4.7	44.5	54.0	9.5	Horizontal

Result: RF Radiated Emissions (Highest) -GFSK

Field Strength of Band-edge Compliance						
Peak Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
2483.5	60.2	-4.8	55.4	74.0	18.6	Vertical
2483.5	56.3	-4.7	51.6	74.0	22.4	Horizontal

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Field Strength of Band-edge Compliance						
Average Value						
Frequency MHz	Measured Level @3m dB μ V	Correction Factor dB/m	Field Strength dB μ V/m	Limit @3m dB μ V/m	Margin dB	E-Field Polarity
2483.5	51.1	-4.8	46.3	54.0	7.7	Vertical
2483.5	47.2	-4.7	42.5	54.0	11.5	Horizontal

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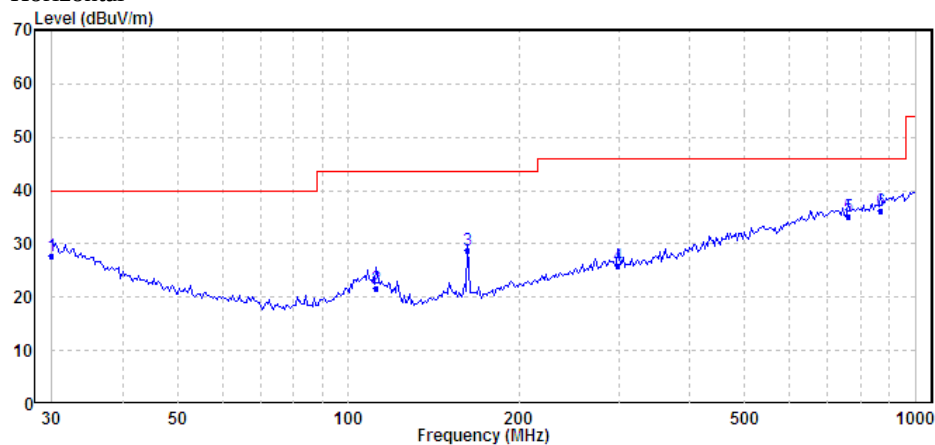
Limits for Radiated Emissions FCC 47 CFR 15.247 Class B):

Frequency Range	Quasi-Peak Limits
[MHz]	[μ V/m]
0.009-0.490	2400/F (kHz)
0.490-1.705	24000/F (kHz)
1.705-30	30
30-88	100
88-216	150
216-960	200
Above960	500

The emission limits shown in the above table are based on measurement employing a CISPR quasi-peak detector and above 1000MHz are based on measurements employing an average detector.

Results of TX mode (GFSK 2403.01 MHz) (30MHz – 1GHz): Pass

Horizontal



Ambient Temperature: 23.0C
Relative Humidity : 48.5%

	Freq	Level	Limit	Over		
	MHz	dBuV/m	dBuV/m	Limit	Remark	Pol/Phase
1	30.000	27.64	40.00	-12.36	QP	Horizontal
2	112.131	21.72	43.50	-21.78	QP	Horizontal
3	162.611	28.87	43.50	-14.63	QP	Horizontal
4	299.316	25.93	46.00	-20.07	QP	Horizontal
5	760.704	35.01	46.00	-10.99	QP	Horizontal
6	869.130	36.18	46.00	-9.82	QP	Horizontal

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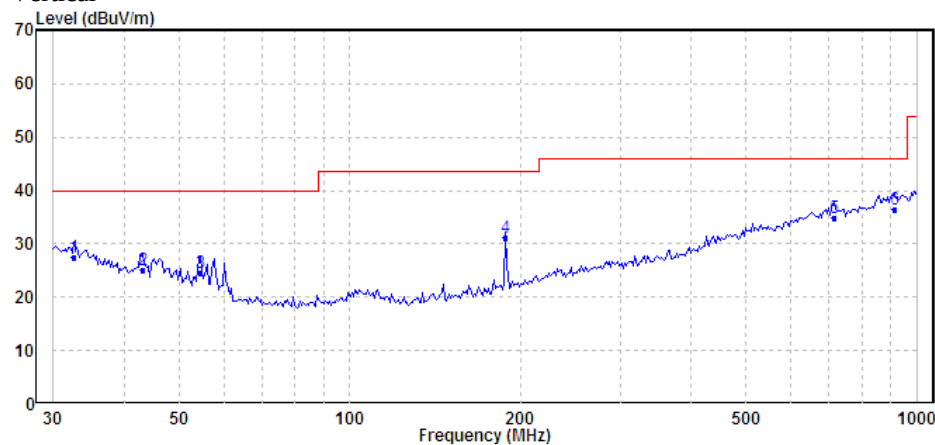
Limits for Radiated Emissions FCC 47 CFR 15.247 Class B1:

Frequency Range	Quasi-Peak Limits
[MHz]	[μ V/m]
0.009-0.490	2400/F (kHz)
0.490-1.705	24000/F (kHz)
1.705-30	30
30-88	100
88-216	150
216-960	200
Above960	500

The emission limits shown in the above table are based on measurement employing a CISPR quasi-peak detector and above 1000MHz are based on measurements employing an average detector.

Results of TX mode (GFSK 2403.01 MHz) (30MHz – 1GHz): Pass

Vertical



Ambient Temperature: 23.0C
Relative Humidity : 48.5%

	Freq	Level	Limit	Over		
	MHz	dBuV/m	Line	Limit	Remark	Pol/Phase
1	32.634	27.40	40.00	-12.60	QP	Vertical
2	43.202	25.19	40.00	-14.81	QP	Vertical
3	54.452	24.66	40.00	-15.34	QP	Vertical
4	188.413	31.20	43.50	-12.30	QP	Vertical
5	714.173	34.88	46.00	-11.12	QP	Vertical
6	912.862	36.49	46.00	-9.51	QP	Vertical

Remarks: Calculated measurement uncertainty (30MHz – 1GHz): 4.9dB

Emissions in the vertical and horizontal polarizations have been investigated and the worst-case test results are recorded in this report.

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3.1.4 Number of Hopping Frequency

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

Limit of Number of Hopping Frequency

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels

Test Method:

The RF output of the EUT was connected to the spectrum analyzer by a low loss cable.

Spectrum Analyzer Setting:

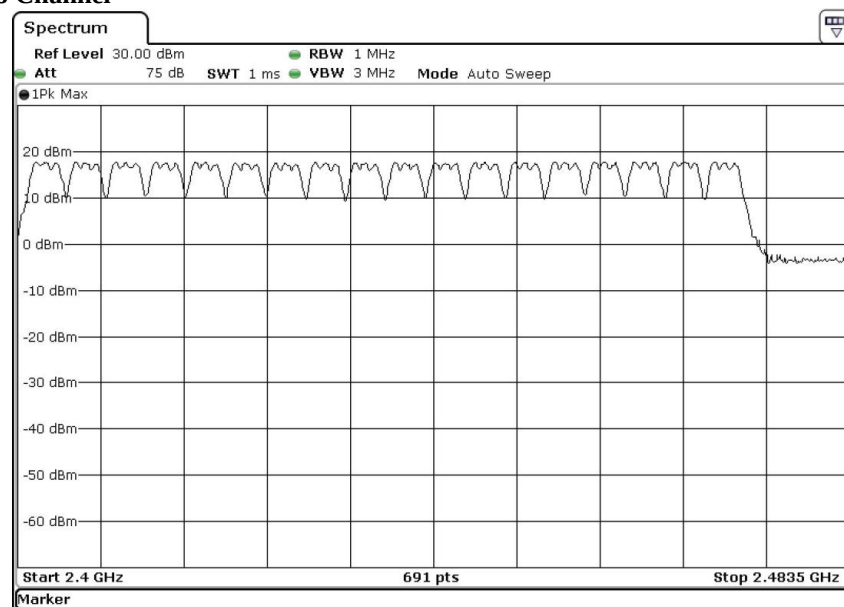
RBW = 1000kHz, VBW $\geq$ RBW, Sweep = Auto, Span = the frequency band of operation
Detector = Peak, Trace = Max. hold

Test Setup:

As Test Setup of clause 3.1.1 in this test report.

Measurement Data:

GFSK: 18 of 18 Channel



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3.1.5 20dB Bandwidth

Test Requirement: FCC 47CFR 15.247(a)(1)
Test Method: ANSI C63.10:2013
Test Date: 2023-03-03
Mode of Operation: Tx mode

Ambient Temperature: 25°C Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Remark:

The result has been done on all the possible configurations for searching the worst cases.

Test Method:

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency. Once the reference level is established, the equipment is conditioned with typical modulating signal to produce the worst-case (i.e. the widest) bandwidth.

Spectrum Analyzer Setting:

RBW = 100kHz, VBW $\geq$ RBW, Sweep = Auto, Span = two times and five times the OBW
Detector = Peak, Trace = Max. hold

Test Setup:

As Test Setup of clause 3.1.1 in this test report.

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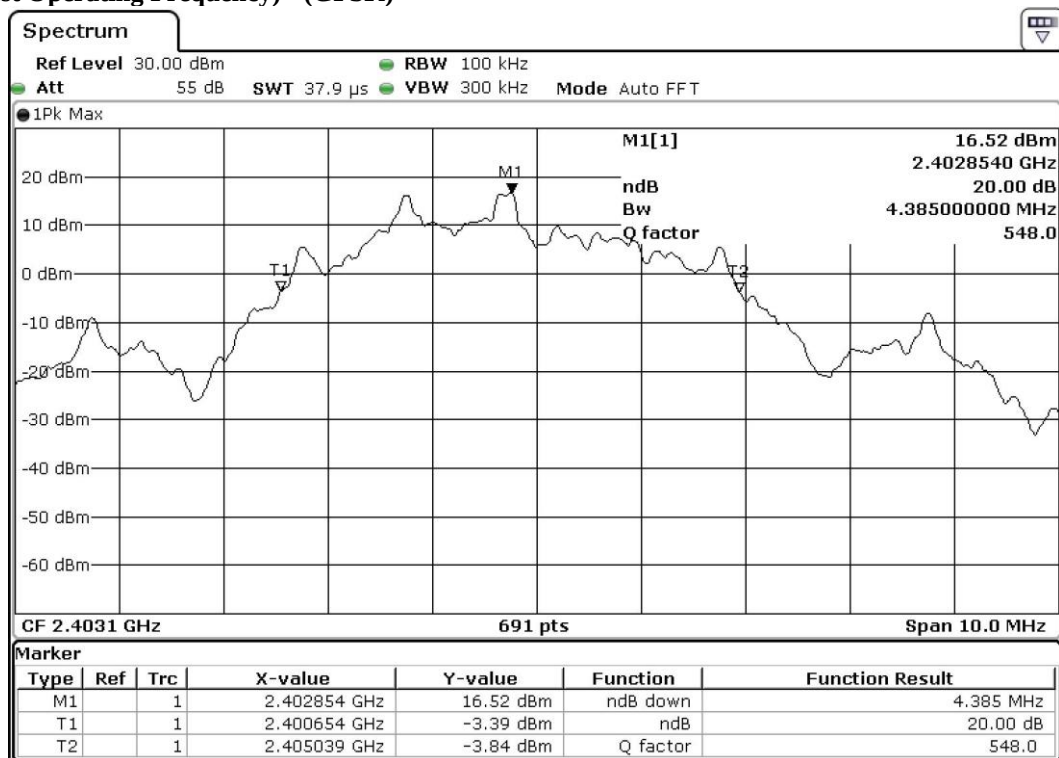
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Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2403.01	4.385	Within 2400-2483.5

(Lowest Operating Frequency) - (GFSK)



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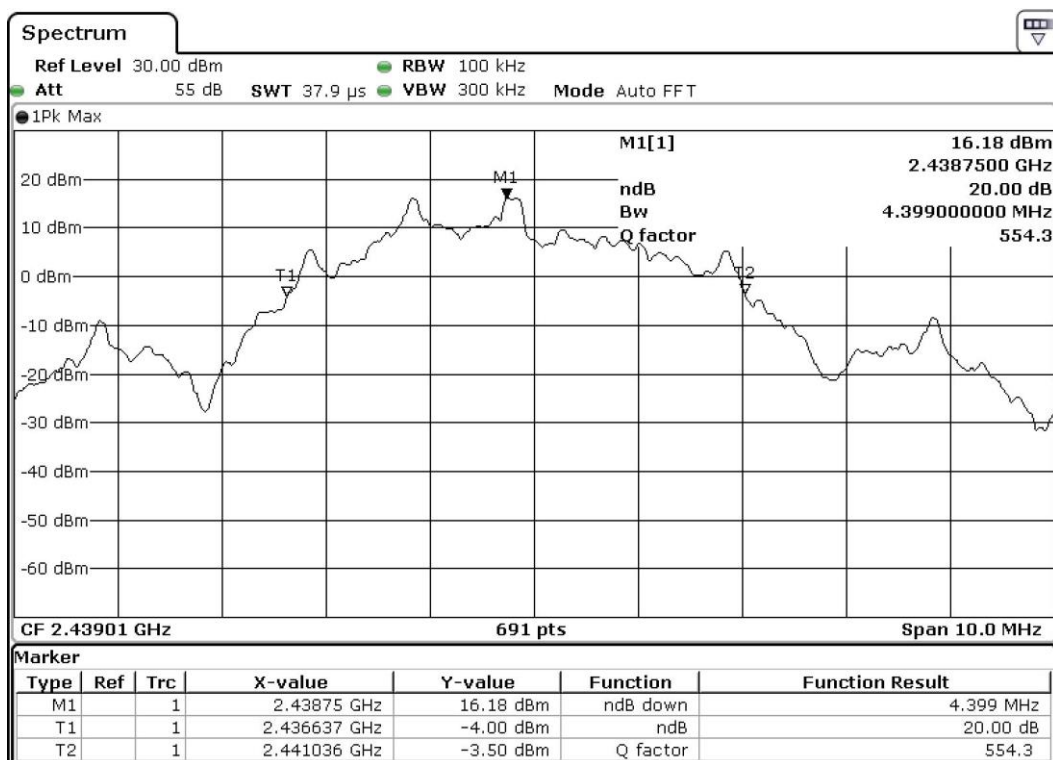
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Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2439.01	4.399	Within 2400-2483.5

(Middle Operating Frequency) - (GFSK)



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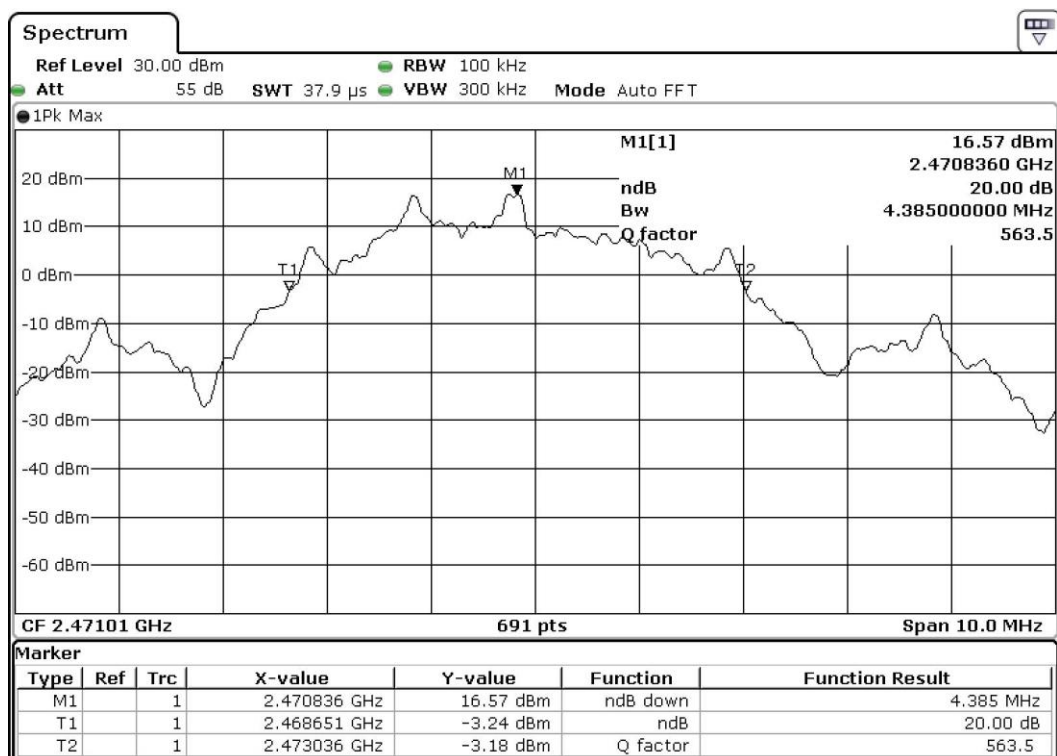
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Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2471.01	4.385	Within 2400-2483.5

(Highest Operating Frequency) - (GFSK)



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3.1.6 Hopping Channel Separation

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

Requirements:

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.

Spectrum Analyzer Setting:

RBW = 1000kHz, VBW $\geq$ RBW, Sweep = Auto,
Span = Wide enough to capture the peaks of two adjacent channels
Detector = Peak, Trace = Max. hold

Limit:

The measured maximum bandwidth=4399 kHz

The measured maximum bandwidth * 2/3 = 4399KHz * 2/3 = 2932.67kHz

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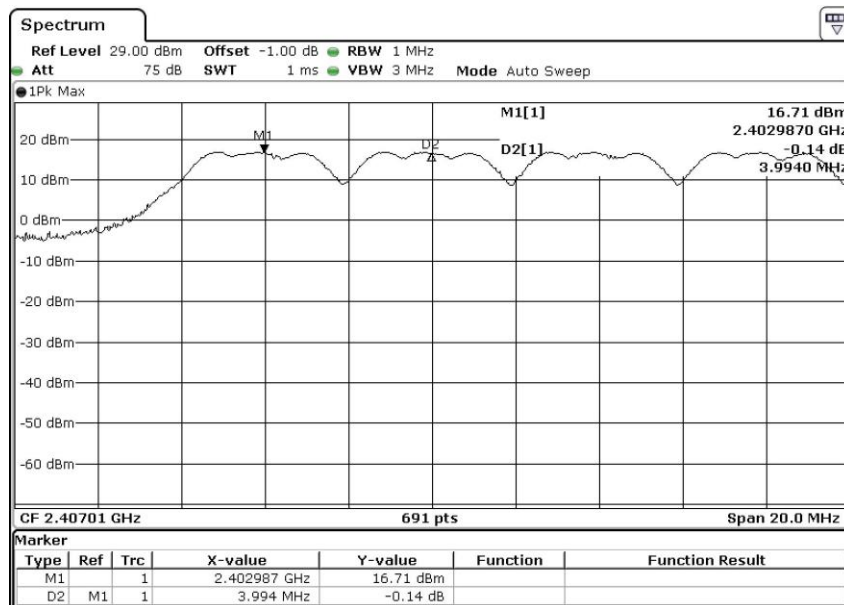


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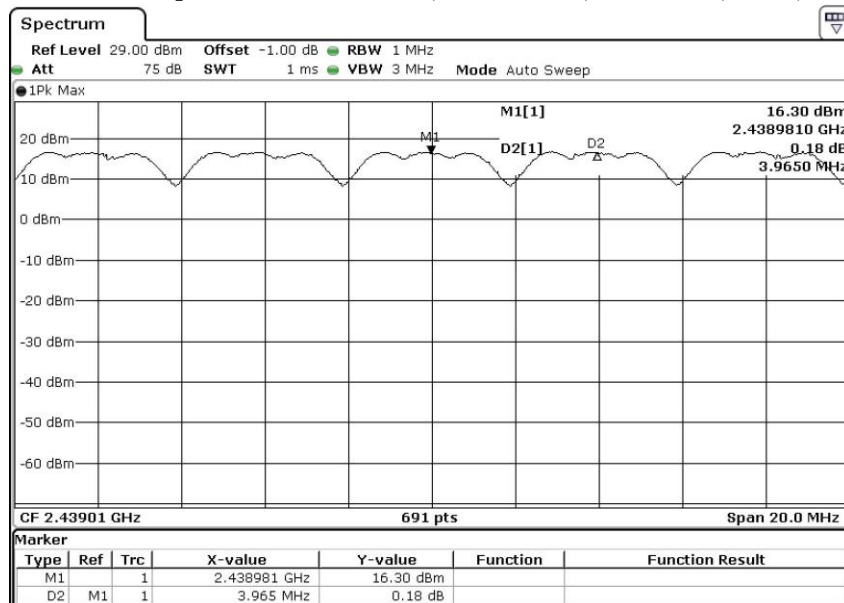
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Channel separation = 3.994MHz (>2932.67kHz) (Lowest) (GFSK)



Channel separation = 3.965MHz (>2932.67kHz) (Mid) (GFSK)



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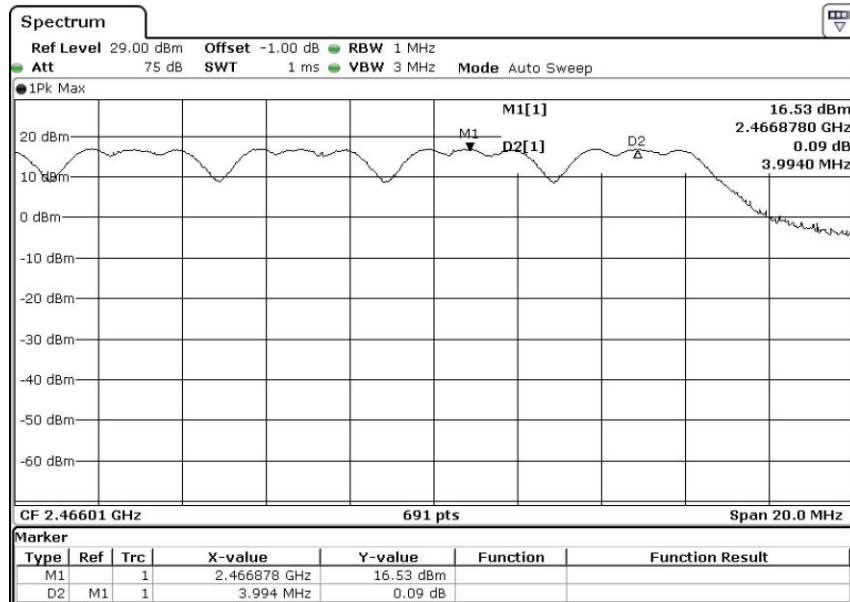


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Channel separation = 3.994MHz (>2932.67kHz) (Highest) (GFSK)



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3.1.7 Band-edge Compliance of RF Conducted Emissions Measurement:

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

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.

According to the test method DA 00-705.

Spectrum Analyzer Setting:

RBW = 100kHz, VBW= 300kHz, Sweep = Coupled,

Span = Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.

Detector = Peak, Trace = Max. hold

Remark: Emissions under the fixed frequency mode and hopping mode have been investigated, the worst-case measurement results were recorded in the test report

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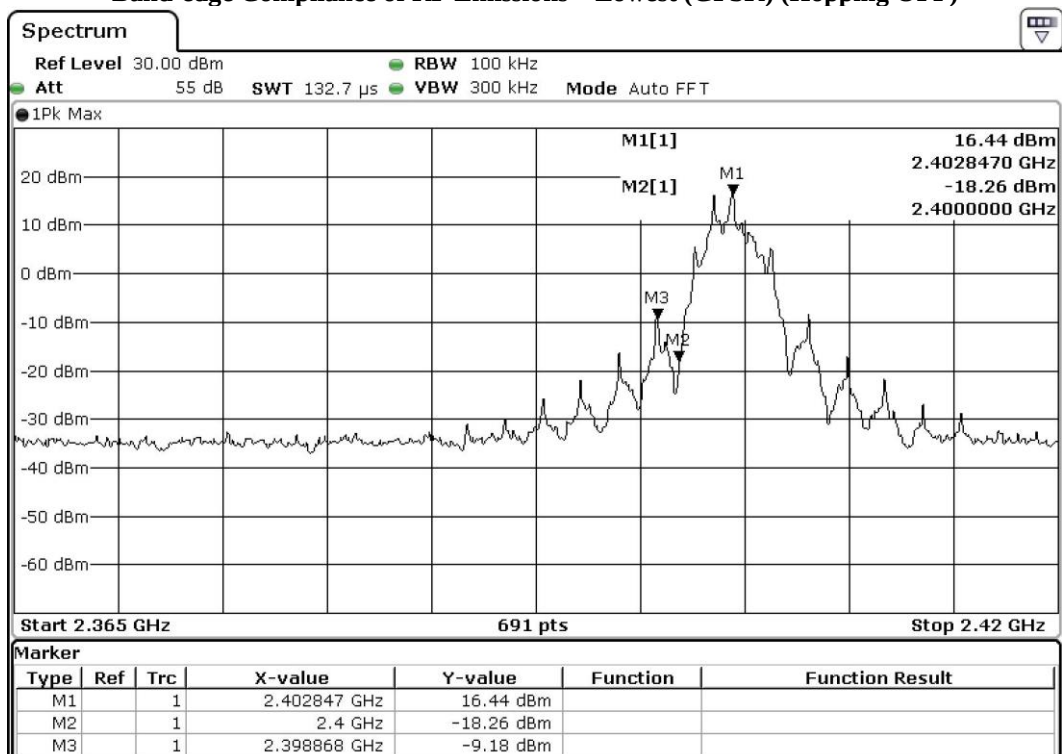
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Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBm]	[dBm]	[dBm]	
2400 – Lowest Fundamental	16.44	-3.56	-9.81	PASS

Band-edge Compliance of RF Emissions – Lowest (GFSK) (Hopping OFF)



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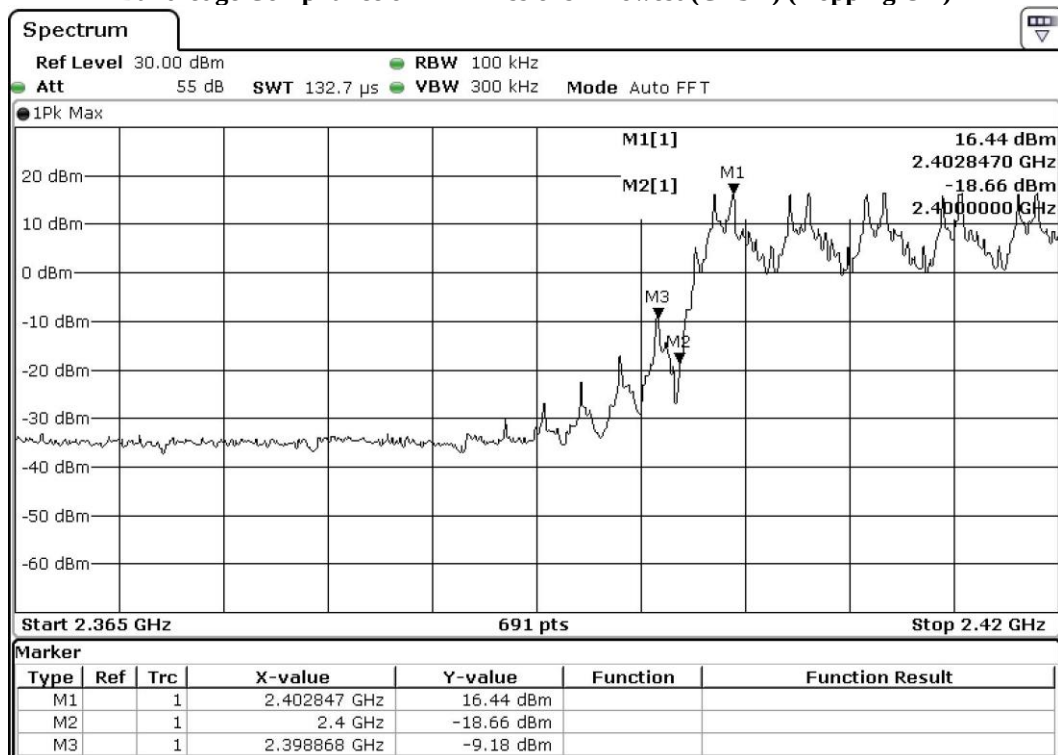
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Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBμV]	[dBμV]	[dBμV]	
2400 – Lowest Fundamental	16.44	-3.56	-9.81	PASS

Band-edge Compliance of RF Emissions – Lowest (GFSK) (Hopping ON)



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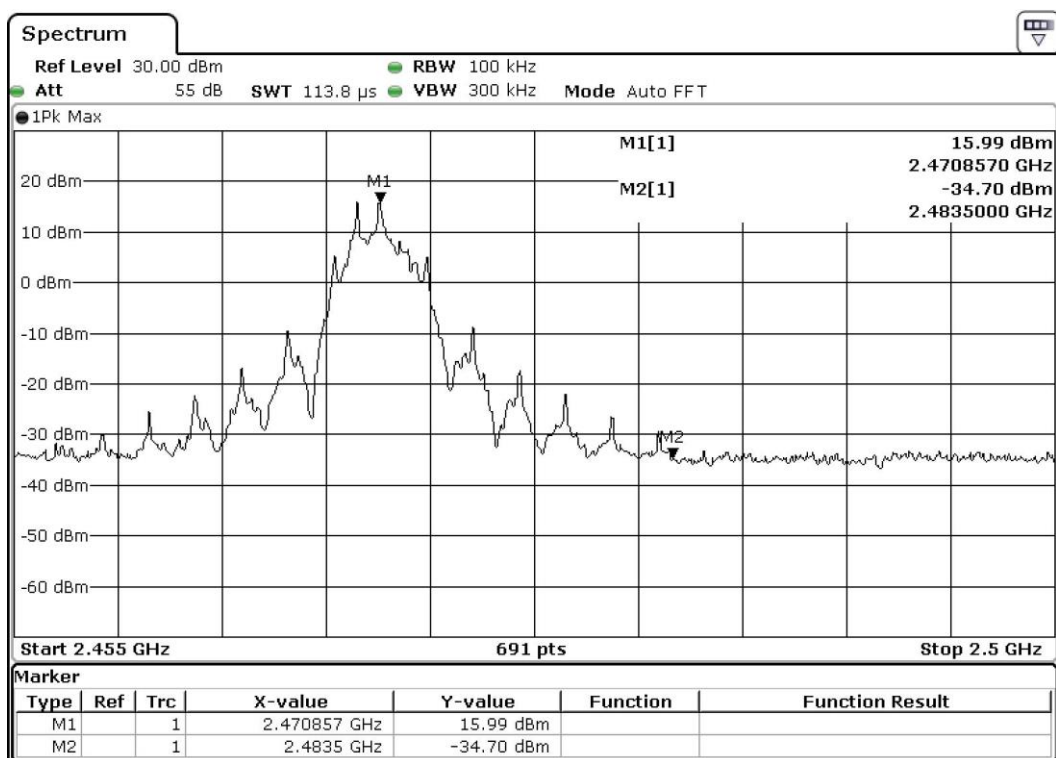
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Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBμV]	[dBμV]	[dBμV]	
2483.5 - Highest Fundamental	15.99	-4.01	-34.70	PASS

Band-edge Compliance of RF Emissions – Highest (GFSK) (Hopping OFF)



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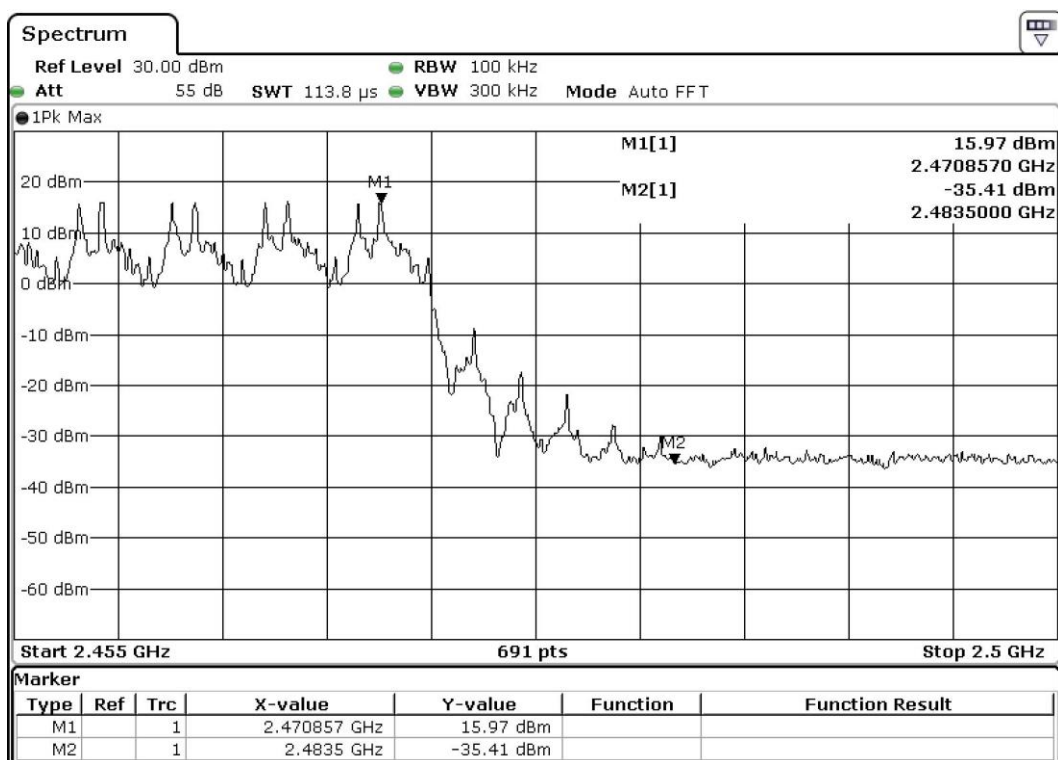
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Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBμV]	[dBμV]	[dBμV]	
2483.5 - Highest Fundamental	15.97	-4.03	-35.41	PASS

Band-edge Compliance of RF Emissions – Highest (GFSK) (Hopping ON)



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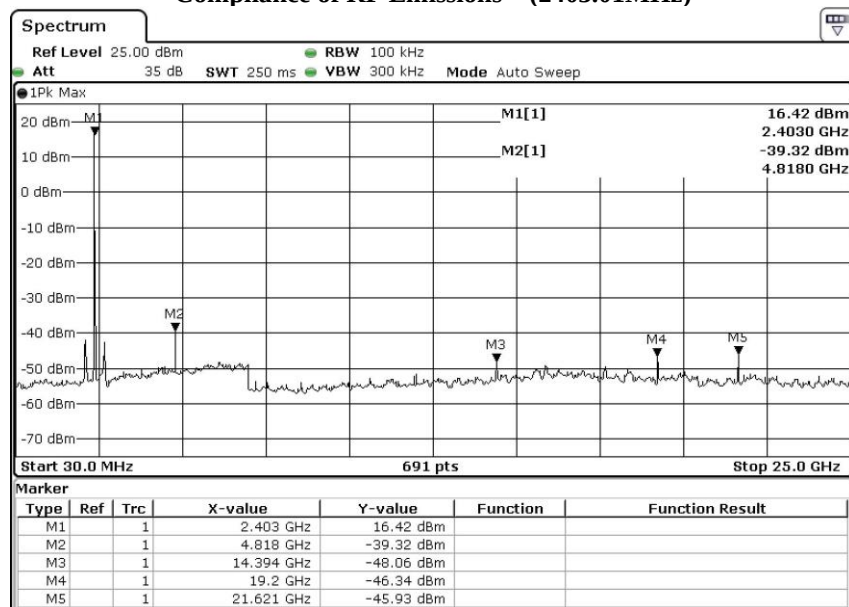
Compliance of RF Conducted Emissions Measurement:

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.

Remark: Emissions under the fixed frequency mode and hopping mode have been investigated, the worst-case measurement results were recorded in the test report

Compliance of RF Emissions – (2403.01MHz)



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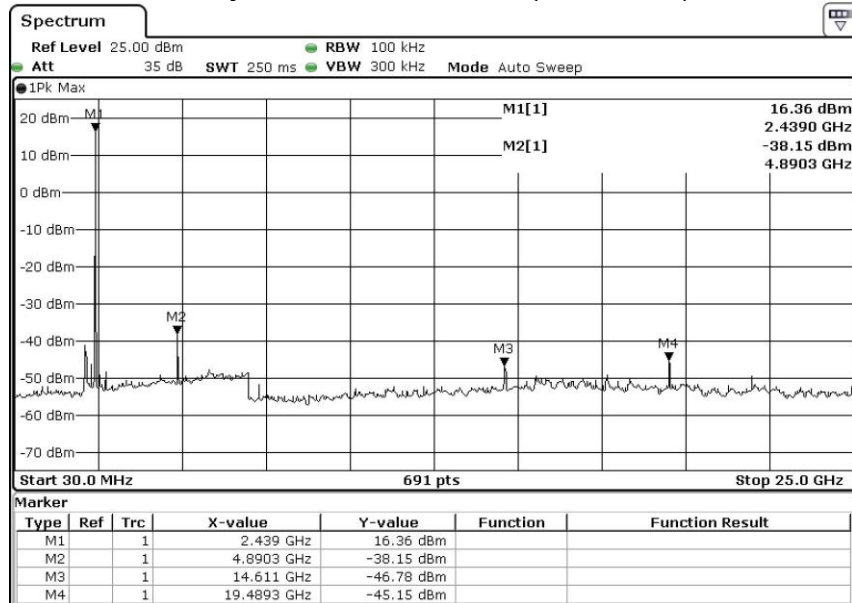


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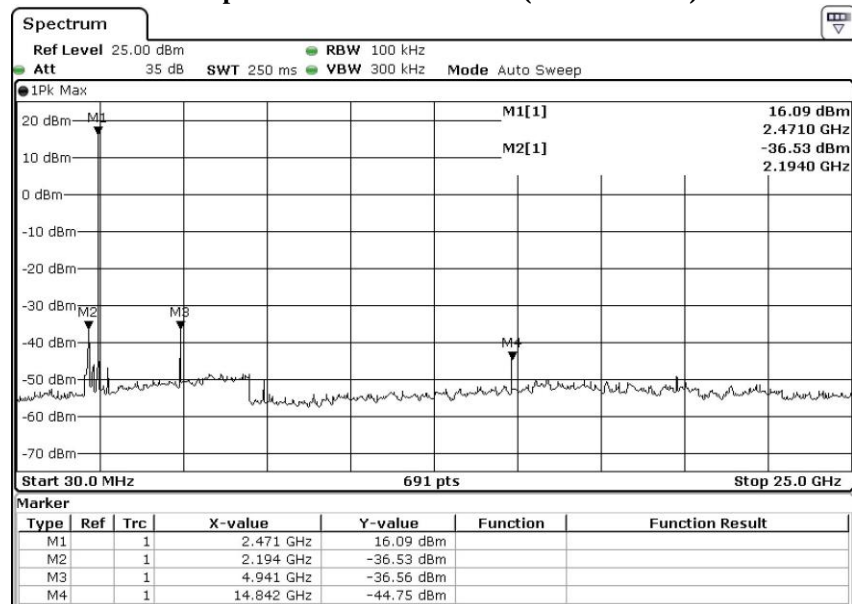
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Compliance of RF Emissions – (2439.01MHz)



Compliance of RF Emissions – (24071.01MHz)



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3.1.8 Time of Occupancy (Dwell Time)

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

Requirements:

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channel employed.

No requirements for Digital Transmission System.

Spectrum Analyzer Setting:

RBW = 1000kHz, VBW ≥ RBW,

Sweep = A longer sweep time to show two successive hops on a channel,

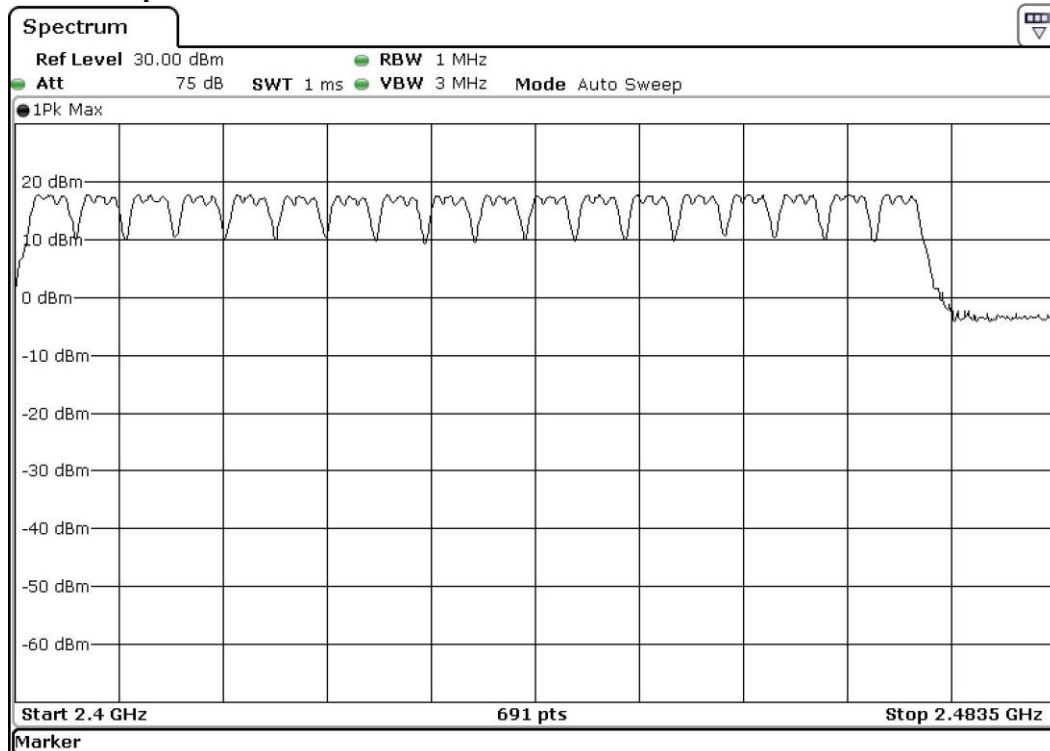
Span = Zero, Detector = Peak, Trace = Max. hold

Dwell Time = Pulse Duration * hop rate / number of channel * observation duration

Observed duration: 0.4s x 18 = 7.2s

Measurement Data:

Channel Occupied in GFSK: 18 of 18 Channel



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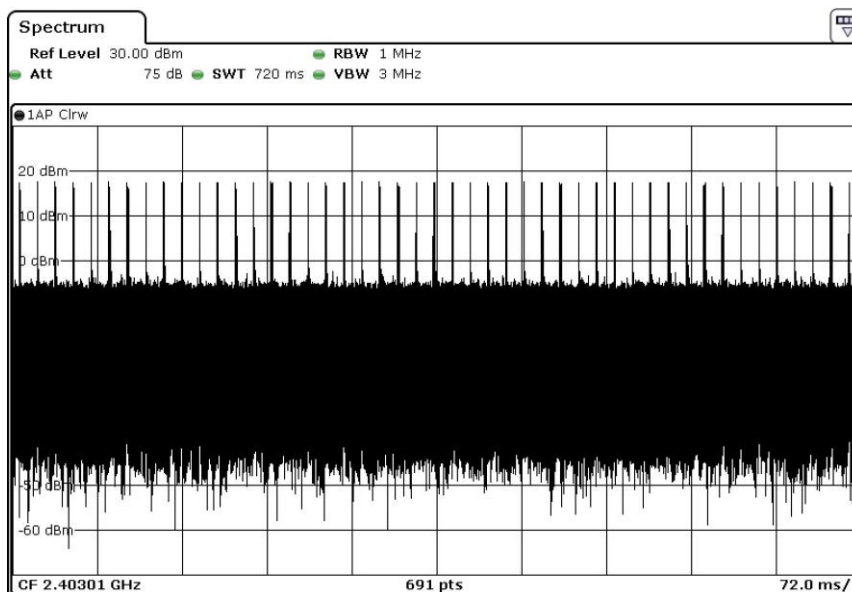
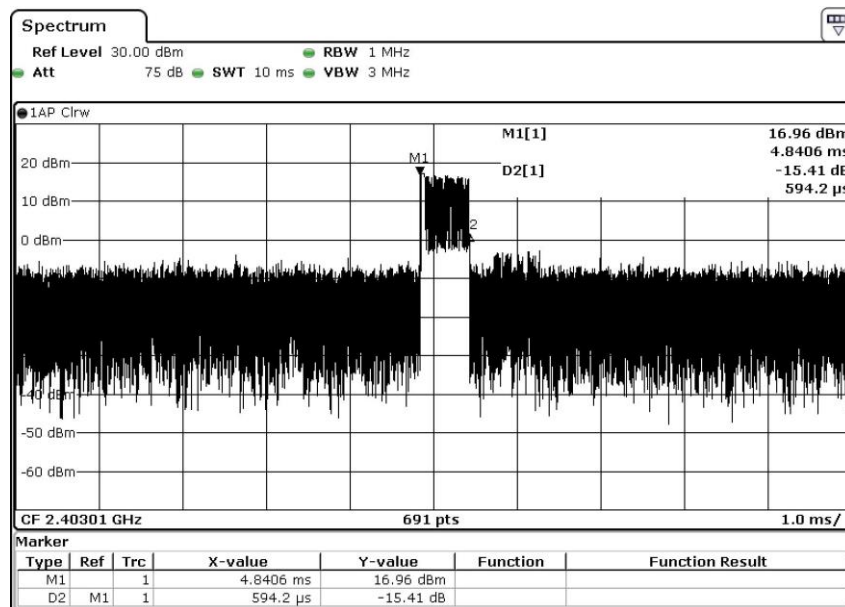
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The Dwell time is the time duration of the pulse times 470 within 7.2 seconds

Fig. A
[Pulse duration of Lowest Channel]



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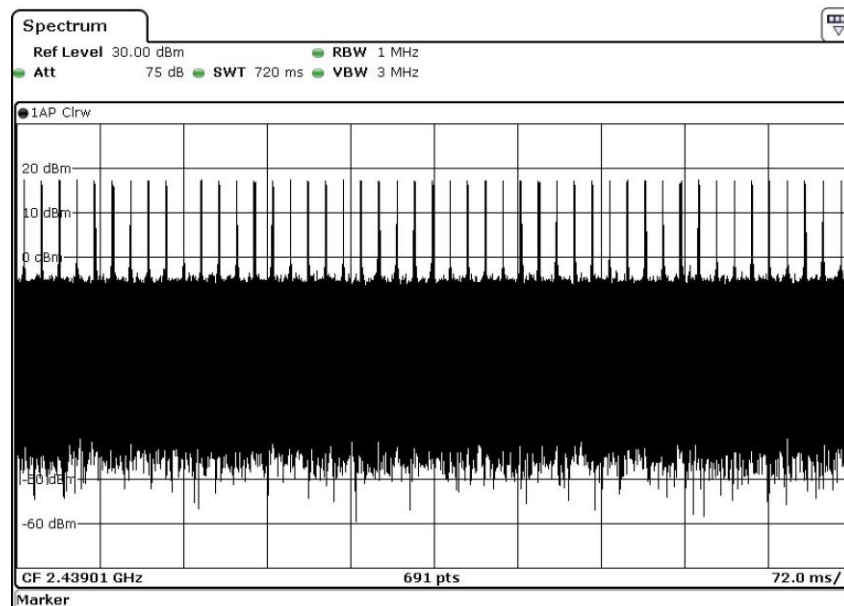
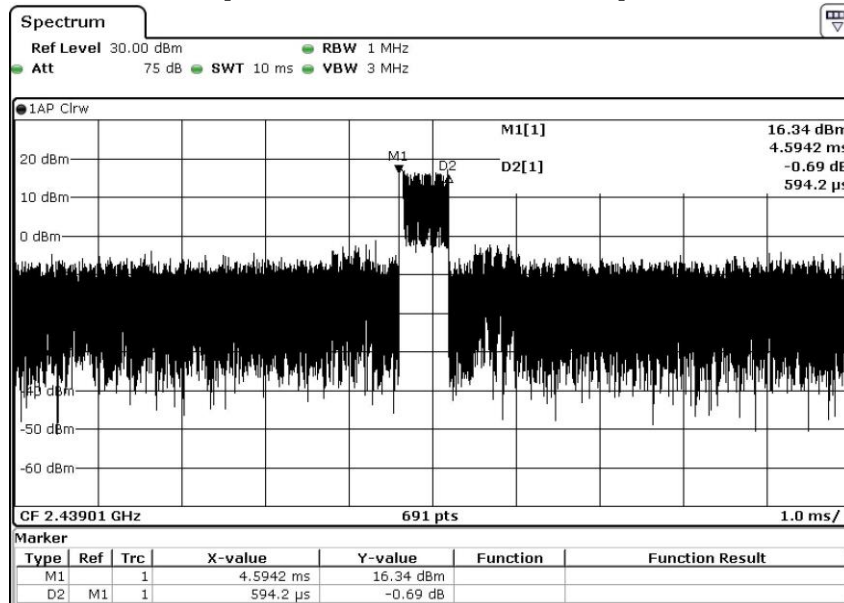


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Fig. B
[Pulse duration of Middle Channel]



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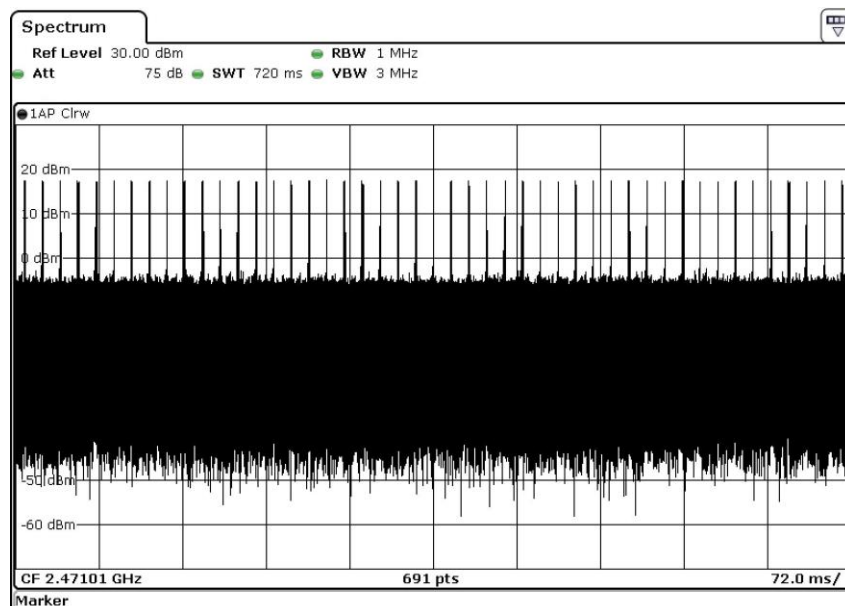
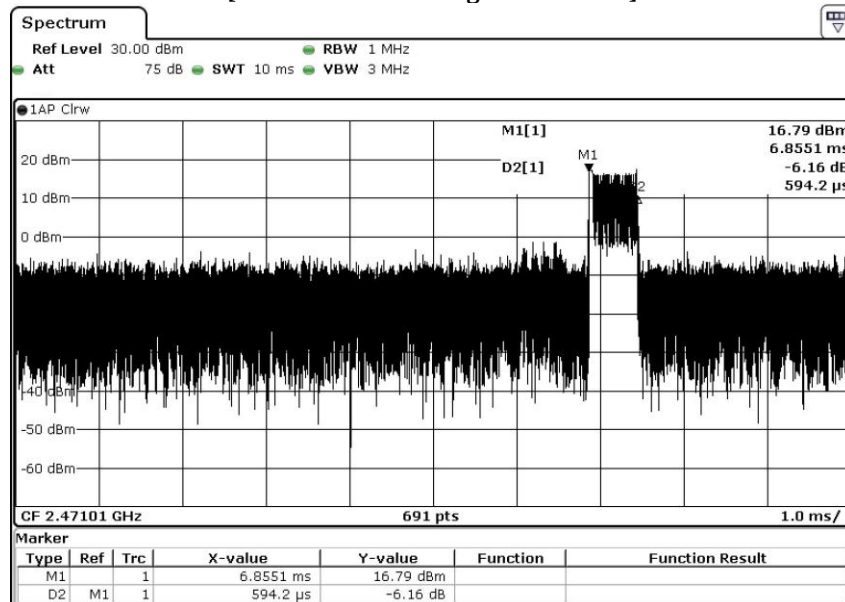


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Fig. C
[Pulse duration of Highest Channel]



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Time of occupancy (Dwell Time):

Frequency (MHz)	Pulse Duration (ms)	Dwell Time (s)	Limits (s)	Test Results
2403.01	0.5942	0.2793	0.400	Complies
2439.01	0.5942	0.2793	0.400	Complies
2471.01	0.5942	0.2793	0.400	Complies

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3.1.9 Channel Centre Frequency

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

Requirements:

Frequency hopping system in the 2400-2483.5MHz band shall use at least 15 (Channel 1 to 18) non-overlapping channels.

Pseudorandom Frequency Hopping Sequence Table as below:

Channel: 4, 10, 14, 15, 16, 14, 11, 15, 6, 8, 4, 1, 3, 13, 14, 17, 6, 14, 7, 18, 11, 6, 13, 12, 2, 11, 5, 3, 17, 11, 12, 18, 13, 7, 5, 2, 7, 6, 13, 14, 8, 10, 14, 15, 17, 4, 1, 11, 10, 11, 18, 6, 17, 11, 1, 4, 18, 5, 11, 12, 16, 15, 2, 17, 13, 9, 10, 15, 5, 1, 18, 12, 1, 6 etc.

The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

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3.1.10 Pseudorandom Hopping Algorithm

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

Requirements:

The channel frequencies shall be selected from a pseudorandom ordered list of hopping frequencies. Each frequency must be used equally by the transmitter.

EUT Pseudorandom Hopping Algorithm

The EUT is a 2.4G Wireless device, the Pseudo-random hopping pattern; hopping characteristics and algorithm are based on the 2.4G Wireless specification.

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3.1.11 Antenna Requirement

Ambient Temperature: 25°C

Relative Humidity: 51%

Atmospheric Pressure: 101 kPa

Test Requirements: § 15.203

Test Specification:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Test Results:

This is Linear antenna. There is no external antenna, the antenna gain = 2.69 dBi. User is unable to remove or changed the Antenna.

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Appendix A

List of Measurement Equipment

Radiated Emission

EQP NO.	DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CAL	DUE CAL
EM215	MULTIDEVICE CONTROLLER	EMCO	2090	00024676	N/A	N/A
EM217	ELECTRIC POWERED TURNTABLE	EMCO	2088	00029144	N/A	N/A
EM218	ANECHOIC CHAMBER	ETS-LINDGREN	FACT-3	--	2019/04/16	2024/04/16
EM356	ANTENNA POSITIONING TOWER	ETS-LINDGREN	2171B	00150346	N/A	N/A
EM293	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	N9020A	MY50510152	2022/11/25	2024/11/25
EM299	BROADBAND HORN ANTENNA	ETS-LINDGREN	3115	00114120	2022/11/24	2024/11/24
EM300	PYRAMIDAL STANDARD GAIN HORN ANTENNA	ETS-LINDGREN	3160-09	00130130	2022/11/25	2024/11/25
EM301	PYRAMIDAL STANDARD GAIN HORN ANTENNA	ETS-LINDGREN	3160-10	00130988	2022/11/25	2024/11/25
EM353	LOOP ANTENNA	ETS_LINDGREN	6502	00206533	2022/06/10	2024/09/10
EM355	Biconilog Antenna	ETS-Lindgren	3143B	00094856	2022/06/17	2024/09/17
EM200	DUAL CHANNEL POWER METER	R & S	NRVD	100592	2022/10/11	2025/10/11
EM012	PRE-AMPLIFIER	HP	HP8448B	3008A00262	2022/11/08	2025/11/08
EM215	MULTIDEVICE CONTROLLER	EMCO	2090	00024676	N/A	N/A

Remarks:-

CM CORRECTIVE MAINTENANCE
N/A NOT APPLICABLE
TBD TO BE DETERMINED

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Appendix B Photographs of EUT

View of the product



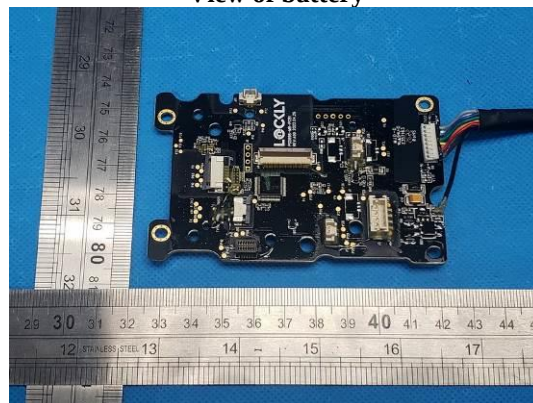
View of the product



Inner circuit view



View of battery



Inner circuit top view



Inner circuit bottom view



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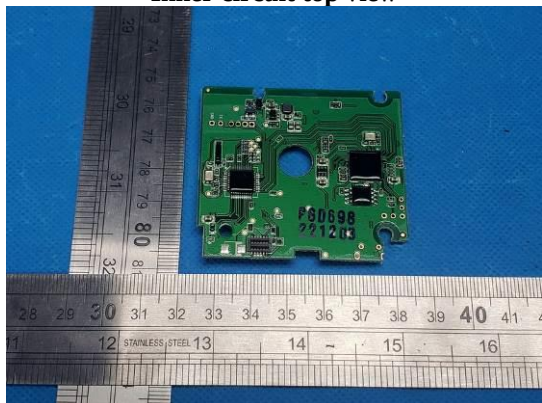
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Photographs of EUT

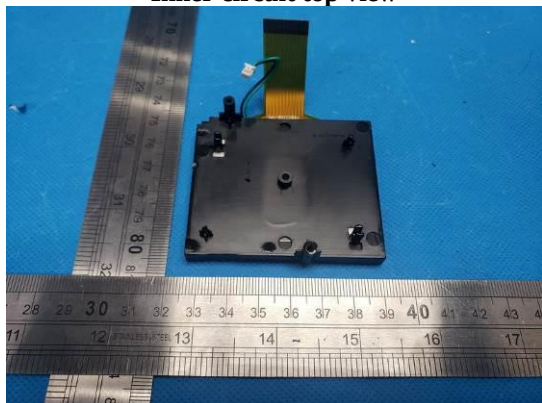
Inner circuit top view



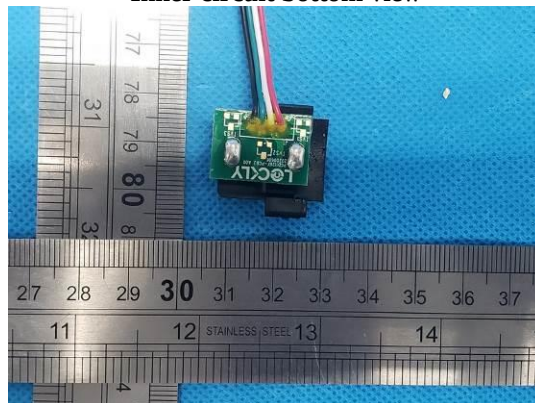
Inner circuit bottom view



Inner circuit top view



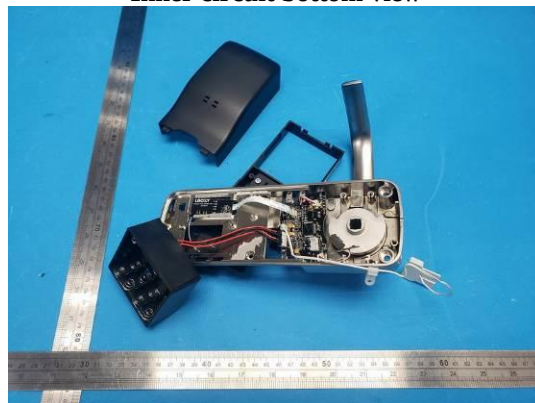
Inner circuit bottom view



Inner circuit top view



Inner circuit bottom view



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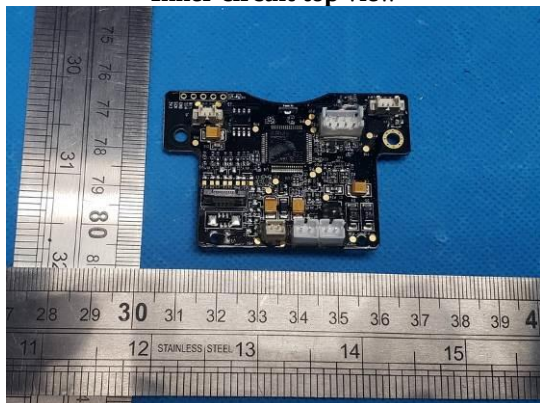
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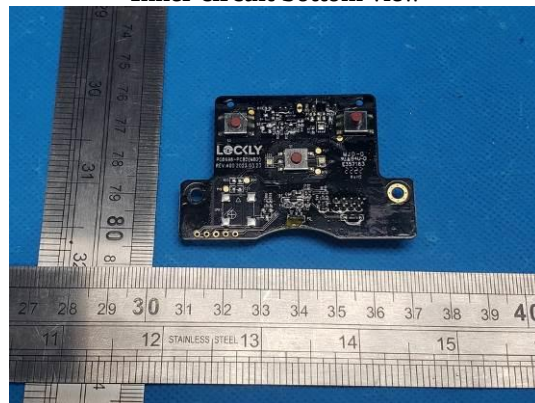
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Photographs of EUT

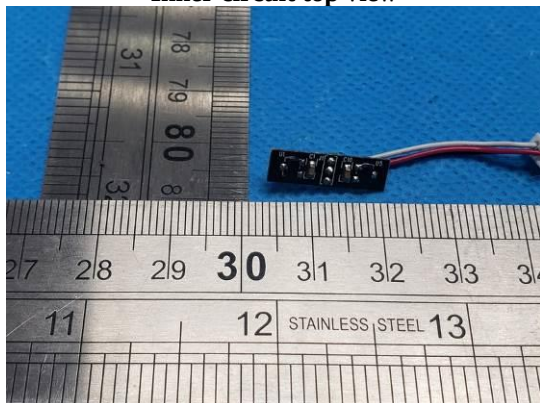
Inner circuit top view



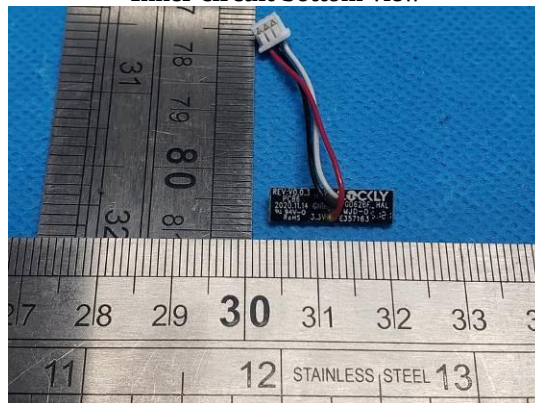
Inner circuit bottom view



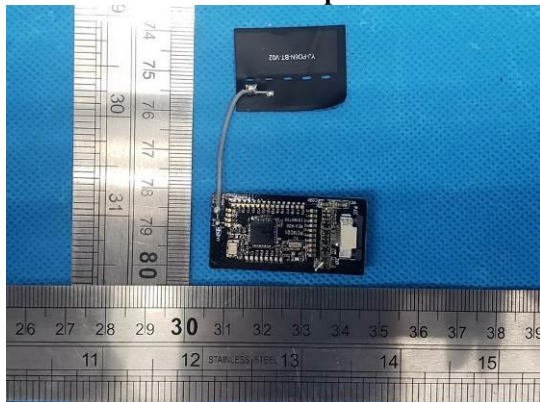
Inner circuit top view



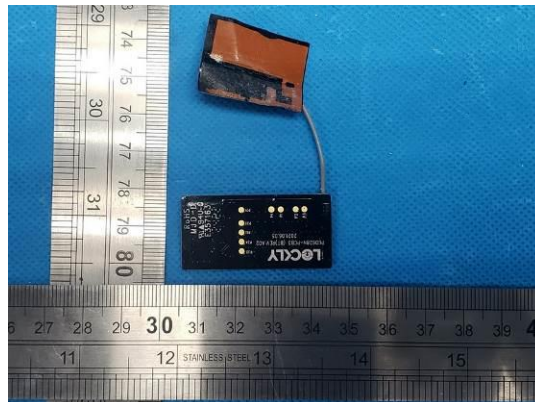
Inner circuit bottom view



Inner circuit top view



Inner circuit bottom view



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Photographs of EUT

Measurement of Radiated Emission Test Set Up (9kHz – 30MHz)



Measurement of Radiated Emission Test Set Up (30MHz to 1000MHz)



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Measurement of Radiated Emission Test Set Up (Above 1000MHz)



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