



RADIO TEST REPORT

Report No.: SHATBL2203027W01

Applicant:

FrSky Electronic Co., Ltd.

Address:

F-4, Building C, Zhongxiu Technology Park, No.3 Yuanxi Road, Wuxi,
214125, Jiangsu, China

Product Name : Tandem digital radio system

Brand Name : FRSKY

Model Name : TANDEM X18

Series Model : TANDEM X18S, TANDEM X18SE, TANDEM X18PRO

Test Standard : FCC Part 15.247

FCC ID : XYFTDX18HDSP

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TEST RESULT CERTIFICATION

Applicant's Name.....: FrSky Electronic Co., Ltd.
Address.....: F-4, Building C, Zhongxiu Technology Park, No.3 Yuanxi Road, Wuxi, 214125, Jiangsu, China
Manufacturer's Name.....: FrSky Electronic Co., Ltd.
Address.....: F-4, Building C, Zhongxiu Technology Park, No.3 Yuanxi Road, Wuxi, 214125, Jiangsu, China

Product Description

Product Name.....: Tandem digital radio system
Brand Name.....: FRSKY
Model Name.....: TANDEM X18
SeriesModel.....: TANDEM X18S, TANDEM X18SE, TANDEM X18PRO
Test Standards.....: FCC Part15.247

Test Procedure.....: ANSI C63.10-2013

This device described above has been tested by ATBL, the test results show that the equipment under test (EUT) is in compliance with the FCC/IC requirements. And it is applicable only to the tested sample identified in the report.

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Date of Test.....:

Date of receipt of test item.....: 23 Mar. 2022

Date (s) of performance of tests.: 23 Mar. 2022~24 Apr. 2022

Date of Issue.....: 24 Apr. 2022

Test Result.....: Pass

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Authorized Signatory :

Terry yang

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Revision History

Rev.	Issue Date	Report NO.	Effect Page	Contents
00	24 Apr. 2022	SHATBL2203027W01	ALL	Initial Issue

1. SUMMARY OF TEST RESULTS

Test procedures according to the technical standards:
KDB 558074 D01 15.247 Meas Guidance v05r02.

FCC Part15.247,Subpart C			
Standard Section	Test Item	Judgment	Remark
15.207	Conducted Emission	PASS	--
15.247(a)(1)	Hopping Channel Separation	PASS	--
15.247(b)(2)	Output Power	PASS	--
15.209	Radiated Spurious Emission	PASS	--
15.247(d)	Conducted Spurious & Band Edge Emission	PASS	--
15.247(a)(1)(i)	Number of Hopping Frequency	PASS	--
15.247(f)	Dwell Time	PASS	--
15.247(a)(1)	20dB Bandwidth 99% Bandwidth	PASS	--
15.205	Restricted bands of operation	PASS	--
Part 15.247(d)/part 15.209(a)	Band Edge Emission	PASS	--
15.203	Antenna Requirement	PASS	--

NOTE:

- (1) 'N/A' denotes test is not applicable in this Test Report.
- (2)All tests are according to ANSI C63.10-2013.

2. GENERAL INFORMATION

2.1 GENERAL DESCRIPTION OF THE EUT

Product Name	Tandem digital radio system
Trade Name	FRSKY
Model Name	TANDEM X18
Series Model	TANDEM X18S, TANDEM X18SE, TANDEM X18PRO
Model Difference	Different product models only represent different appearance and color of products
Channel List	Please refer to the Note 2.
Frequency range	902~928MHz
Modulation Type	LoRa
Power Rating	N/A
Battery	Model: GRP9240078-1C-7.4V 4000mAh Brand: SHENZHEN GREPOW BATTERY CO., LTD Rated Voltage: 7.4v 29.6Wh Charge Limit Voltage: 8.4v Capacity: 4000mAh
Hardware version number	1.0.0
Software versionnumber	ETHOS 1.1.1
Connecting I/O Port(s)	Please refer to the Note 1.

Note:

1. For a more detailed features description, please refer to the manufacturer's specifications or the User Manual.

2.

Channel List					
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	904	/	/	/	/
2	904.5	21	914	/	/
3	905	22	914.5	/	/
/	/	23	915	/	/
/	/	/	/	41	924
/	/	/	/	42	924.5
/	/	/	/	43	925

3. Table for Filed Antenna

Ant.	Brand	Model Name	Antenna Type	Connector	Gain (dBi)	NOTE
1	FRSKY	TANDEM X18	Single-band Antenna	N/A	1.8	Antenna

2.2 DESCRIPTION OF THE TEST MODES

To investigate the maximum EMI emission characteristics generated from EUT, the test system was pre-scanning tested based on the consideration of following EUT operation mode or test configuration mode which possibly have effect on EMI emission level. Each of these EUT operation mode(s) or test configuration mode(s) mentioned above was evaluated respectively.

Worst Mode	Description	Modulation
Mode 1	TX CH01	LoRa
Mode 2	TX CH22	LoRa
Mode 3	TX CH43	LoRa

Note:

(1) The measurements are performed at all Bit Rate of Transmitter, the worst data was reported.

(2) We have been tested for all available U.S. voltage and frequencies (For 120V, 50/60Hz and 240V, 50/60Hz) for which the device is capable of operation, and the worst case of 120V/ 60Hz is shown in the report.

For Conducted Emission

Test Case	
Conducted Emission	Mode4 : Keeping EUT TX

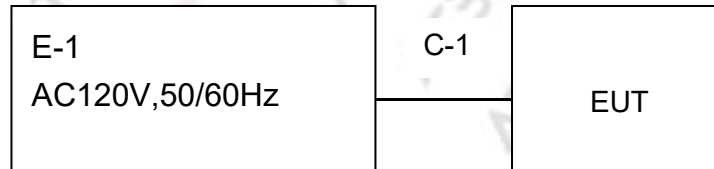
2.3 TEST SOFTWARE AND POWER LEVEL

During testing channel & power controlling software provided by the customer was used to control the operating channel as well as the output power level.

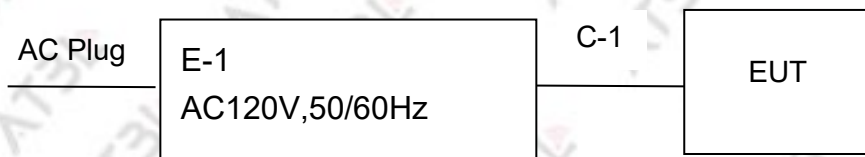
RF Function	Type	Mode Or Modulation type	Ant Gain(dBi)	Power Class	Software For Testing
LORA	500KHz	LORA	1.8	default	frsk

2.4 BLOCK DIGRAM SHOWING THE CONFIGURATION OF SYSTEM TESTED

Radiated Spurious EmissionTest



Conducted Emission Test



2.5 DESCRIPTION OF NECESSARY ACCESSORIES AND SUPPORT UNITS

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

Necessary accessories

Item	Equipment	Mfr/Brand	Model/Type No.	Length	Note
N/A	N/A	N/A	N/A	N/A	N/A

Support units

Item	Equipment	Mfr/Brand	Model/Type No.	Length	Note
N/A	N/A	N/A	N/A	N/A	N/A

Note:

- (1) For detachable type I/O cable should be specified the length in cm in 『Length』 column.

2.6 LABORATORY INFORMATION

Company Name:	Shanghai ATBL Technology Co., Ltd.
Address:	Building 8, No. 160 Basheng Road, Waigaoqiao Free Trade Zone, Pudong New Area, Shanghai
Telephone:	+86(0)21-51298625
A2LA Number:	6184.01
CNAS Number:	CNAS L14531

2.7 MEASUREMENT UNCERTAINTY

The reported uncertainty of measurement $y \pm U$, where expanded uncertainty U is based on a standard uncertainty multiplied by a coverage factor of $k=2$, providing a level of confidence of approximately 95 %.

No.	Item	Uncertainty
1	RF output power, conducted	$\pm 0.962\text{dB}$
2	Conducted spurious emissions	$\pm 2.986\text{dB}$
3	All emissions, radiated 30MHz-1GHz	$\pm 2.49\text{dB}$
4	All emissions, radiated 1GHz-18GHz	$\pm 3.50\text{dB}$
5	Occupied bandwidth	$\pm 2.336\text{dB}$
6	Power spectral density	$\pm 0.866\text{dB}$

2.8 EQUIPMENTS LIST

Radiation Test equipment

Kind of Equipment	Manufacturer	Type No.	Serial No.	Management number	Calibrated until
Test Receiver	R&S	ESCI	100469	SHATBL-E003	2022.07.13
Spectrum Analyzer	Agilent	N9020A	MY50200811	SHATBL-E017	2022.07.13
Bilog Antenna	SCHWARZBECK	VLUB 9168	01174	SHATBL-E008	2023.09.27
Horn Antenna	SCHWARZBECK	BBHA 9120D	02014	SHATBL-E009	2023.09.27
Pre-Amplifier (0.1M-3GHz)	JPT	JPA-10M1G35	21010100035001	SHATBL-E005	2022.10.07
Pre-Amplifier (1G-18GHz)	JPT	JPA0118-55-303A	1910001800055000	SHATBL-E006	2022.07.13
Temperature & Humidity	DeLi	DeLi	N/A	SHATBL-E016	2022.10.08
Antenna/Turntable Controller	Brilliant	N/A	N/A	SHATBL-E007	N/A
Test SW	FALA	EMC-RI(Ver.4A2)		SHATBL-E046	N/A

RF Connected Test

Kind of Equipment	Manufacturer	Type No.	Serial No.	equipment number	Calibrated until
MIMO Power measurement test Set	DARE	RPR3006W	16I00054SN016	SHATBL-W006	2022.10.07
			RPR6W-20001005	SHATBL-W013	2022.10.07
Signal Analyzer	Agilent	N9020A	MY57300196	SHATBL-W004	2022.10.07
Signal Generator	Agilent	N5182B	MY46240556	SHATBL-W005	2022.10.07
Wireless Communications Test Set	R&S	CMW500	101331	SHATBL-W007	2022.10.07
Temperature & Humidity	Deli	deli	N/A	SHATBL-W011	2022.10.07
Attenuator	Agilent	8494B	DC-18G	SHATBL-W009	2022.10.07
Attenuator	Agilent	8496B	DC-18G	SHATBL-W010	2022.10.07
power splitter	MNK	MPD-DC/6-2S	62315 G51	SHATBL-W015	2022.10.07
			62315 G52	SHATBL-W016	2022.10.07
Filter	Chengdu kangmaiwei	ZBSF-C2400-2483.5-T3	N/A	SHATBL-W021	N/A
Constant temperature and humidity box	KSON	THS-B6C-150	6159K	SHATBL-W019	2023.01.17
Test SW	FALA	LZ-RF(Ver.LzRF-03A3.1)		SHATBL-W020	N/A

3. EMC EMISSION TEST

3.1 CONDUCTED EMISSION MEASUREMENT

3.1.1 POWER LINE CONDUCTED EMISSION LIMITS

Operating frequency band. In case the emission fall within the restricted band specified on art 207(a)&RSS-Genlimit in the table below has to be followed.

FREQUENCY (MHz)	Conducted Emissionlimit (dBUV)	
	Quasi-peak	Average
0.15 -0.5	66 - 56 *	56 - 46 *
0.50 -5.0	56.00	46.00
5.0 -30.0	60.00	50.00

Note:

- (1) The tighter limit applies at the band edges.
- (2) The limit of “ * ” marked band means the limitation decreases linearly with the logarithm of the frequency in the range.

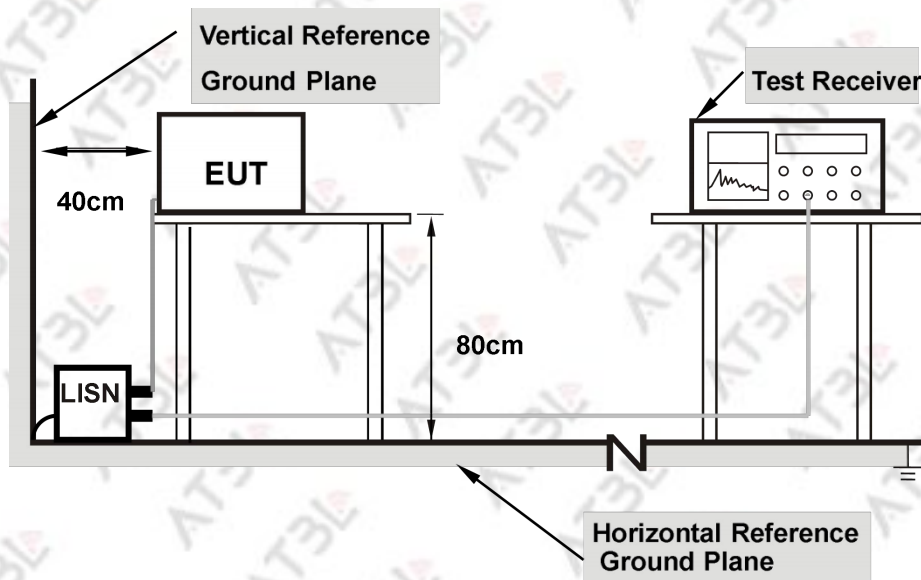
The following table is the setting of the receiver

Receiver Parameters	Setting
Attenuation	10 dB
Start Frequency	0.15 MHz
Stop Frequency	30 MHz
IF Bandwidth	9 kHz

3.1.2 TEST PROCEDURE

- The EUT was 0.8 meters from the horizontal ground plane and 0.4 meters from the vertical ground plane with EUT being connected to the power mains through a line impedance stabilization network (LISN). All other support equipments powered from additional LISN(s). The LISN provide 50 Ohm/ 50uH of coupling impedance for the measuring instrument.
- Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 to 40 cm long.
- I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m.
- LISN at least 80 cm from nearest part of EUT chassis.
- For the actual test configuration, please refer to the related Item –EUT Test Photos.

3.1.3 TEST SETUP



Note: 1.Support units were connected to second LISN.

2.Both of LISNs (AMN) are 80 cm from EUT and at least 80 cm from other units and other metal planes

3.1.4 EUT OPERATING CONDITIONS

The EUT was configured for testing in a typical fashion (as a customer would normally use it). The EUT has been programmed to continuously transmit during test. This operating condition was tested and used to collect the included data.

3.1.5 TEST RESULT

Temperature:	23.3(C)	Relative Humidity:	50%RH
Test Voltage:	N/A	Phase:	N/A
Test Mode:	N/A		

Note: The EUT is power by DC, this test item is not apply.

3.2 RADIATED EMISSION MEASUREMENT

3.2.1 RADIATED EMISSION LIMITS

In any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the Restricted band specified on Part15.205(a)&209(a), RSS-Gen Issue 5 and RSS-247 Issue 2, February 2017 (5.5) limit in the table and according to ANSI C63.10-2013 below has to be followed.

LIMITS OF RADIATED EMISSION MEASUREMENT (0.009MHz - 1000MHz)

Frequencies (MHz)	Field Strength (micorvolts/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

LIMITS OF RADIATED EMISSION MEASUREMENT (1GHz-25 GHz)

FREQUENCY (MHz)	(dBuV/m) (at 3M)	
	PEAK	AVERAGE
Above 1000	74	54

Notes:

- (1) The limit for radiated test was performed according to FCC PART 15C.
- (2) The tighter limit applies at the band edges.
- (3) Emission level (dBuV/m)=20log Emission level (uV/m).

LIMITS OF RESTRICTED FREQUENCY BANDS

FCC:

FREQUENCY (MHz)	FREQUENCY (MHz)	FREQUENCY (MHz)	FREQUENCY (GHz)
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
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	Above 38.6
13.36-13.41			

For Radiated Emission

Spectrum Parameter	Setting
Attenuation	Auto
Detector	Peak/QP/AV
Start Frequency	9 KHz/150KHz(Peak/QP/AV)
Stop Frequency	150KHz/30MHz(Peak/QP/AV)
RB / VB (emission in restricted band)	200Hz (From 9kHz to 0.15MHz)/ 9KHz (From 0.15MHz to 30MHz); 200Hz (From 9kHz to 0.15MHz)/ 9KHz (From 0.15MHz to 30MHz)

Spectrum Parameter	Setting
Attenuation	Auto
Detector	Peak/QP
Start Frequency	30 MHz(Peak/QP)
Stop Frequency	1000 MHz (Peak/QP)
RB / VB (emission in restricted band)	120 KHz / 300 KHz

Spectrum Parameter	Setting
Attenuation	Auto
Detector	Peak/AV
Start Frequency	1000 MHz(Peak/AV)
Stop Frequency	10th carrier hamonic(Peak/AV)
RB / VB (emission in restricted band)	1MHz / 3MHz(Peak) 1 MHz/ 3 MHz(AVG)

For Band Edge

Note: The EUT main frequency is too far away from the restricted band, so the band edge of the radiation method is not tested.

Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~90kHz / RB 200Hz for PK & AV
Start ~ Stop Frequency	90kHz~110kHz / RB 200Hz for QP
Start ~ Stop Frequency	110kHz~490kHz / RB 200Hz for PK & AV
Start ~ Stop Frequency	490kHz~30MHz / RB 9kHz for QP
Start ~ Stop Frequency	30MHz~1000MHz / RB 120kHz for QP

3.2.2 TEST PROCEDURE

- The measuring distance of at 3 m shall be used for measurements at frequency 0.009MHz up to 1GHz, and above 1GHz.
- The EUT was placed on the top of a rotating table 0.8 meters (above 1GHz is 1.5 m) above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
- The height of the equipment shall be 0.8 m (above 1GHz is 1.5 m); the height of the test antenna shall vary between 1 m to 4 m. horizontal and vertical polarizations of the antenna are set to make the measurement.
- The initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then QuasiPeak detector mode re-measured.
- If the Peak Mode measured value compliance with and lower than Quasi Peak Mode Limit, the EUT shall be deemed to meet QP Limits and then no additional QP Mode measurement performed.
- For the actual test configuration, please refer to the related Item –EUT Test Photos.

Note:

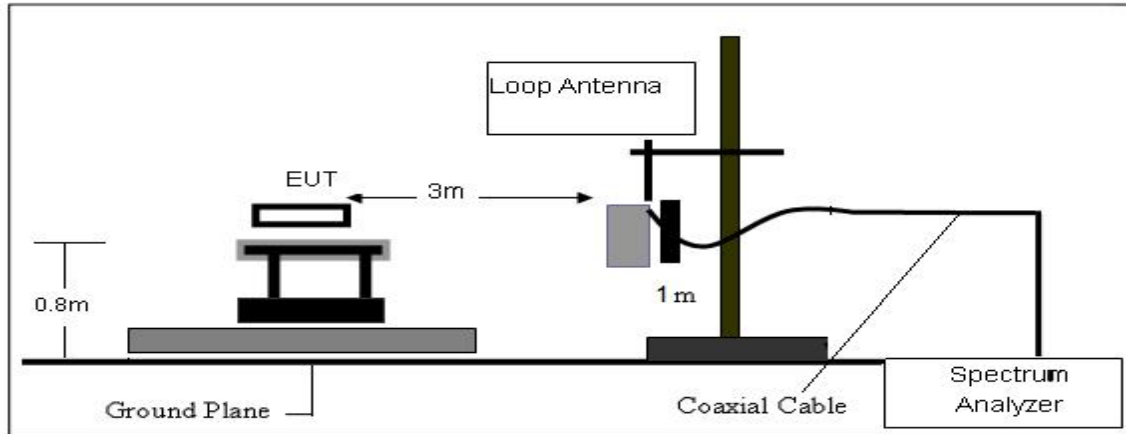
Both horizontal and vertical antenna polarities were tested and performed pretest to three orthogonal axis. The worst case emissions were reported.

3.2.3 DEVIATION FROM TEST STANDARD

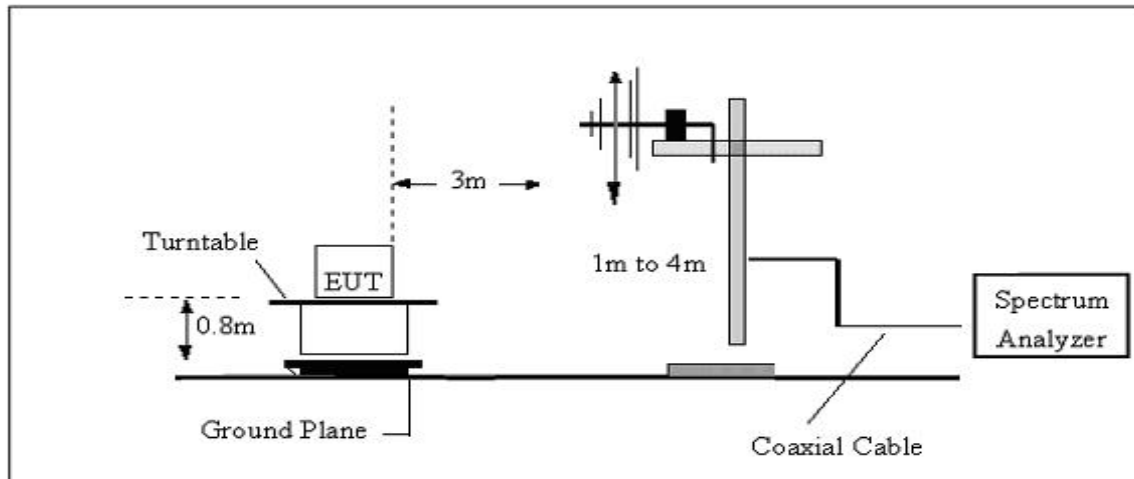
No deviation.

3.2.4 TESTSETUP

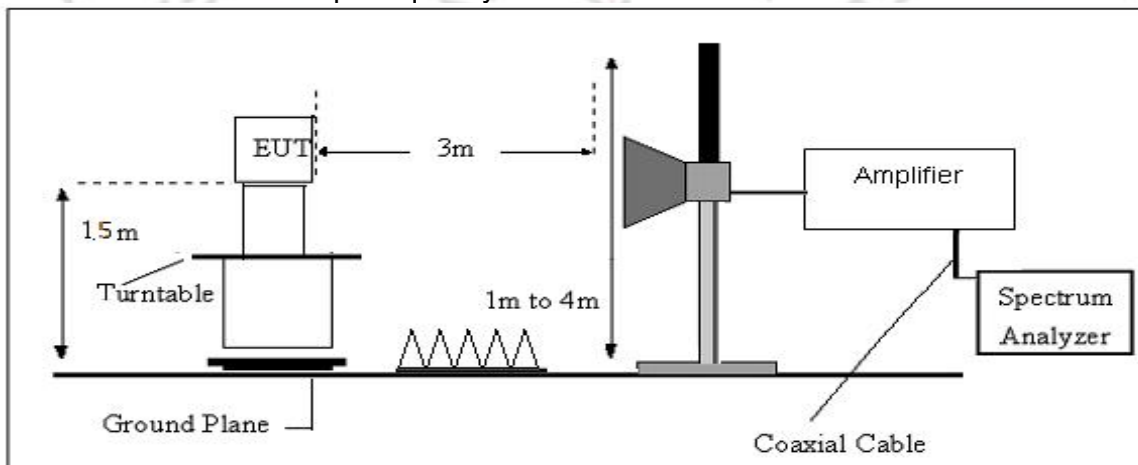
(A) Radiated Emission Test-Up Frequency Below 30MHz



(B) Radiated Emission Test-Up Frequency 30MHz~1GHz



(C) Radiated Emission Test-Up Frequency Above 1GHz



3.2.5 EUT OPERATING CONDITIONS

The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

3.2.6 FIELD STRENGTH CALCULATION

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF + CL - AG$$

Where

FS = Field Strength

CL = Cable Attenuation Factor (Cable Loss)

RA = Reading Amplitude

AG = Amplifier Gain

AF = Antenna Factor

For example

Frequency (MHz)	FS (dBμV/m)	RA (dBμV/m)	AF (dB)	CL (dB)	AG (dB)	Factor (dB)
300	40	58.1	12.2	1.6	31.9	-18.1

$$\text{Factor} = \text{AF} + \text{CL} - \text{AG}$$

3.2.7 TEST RESULTS

(9KHz-30MHz)

Temperature:	25(C)	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Test Mode:	TX Mode

Freq.	Reading	Limit	Margin	State	Test Result
(MHz)	(dBuV/m)	(dBuV/m)	(dB)	P/F	
--	--	--	--	--	PASS
--	--	--	--	--	PASS

Note:

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

Distance extrapolation factor = $40 \log (\text{specific distance/test distance})$ (dB);

Limit line = specific limits(dBuv) + distance extrapolation factor.

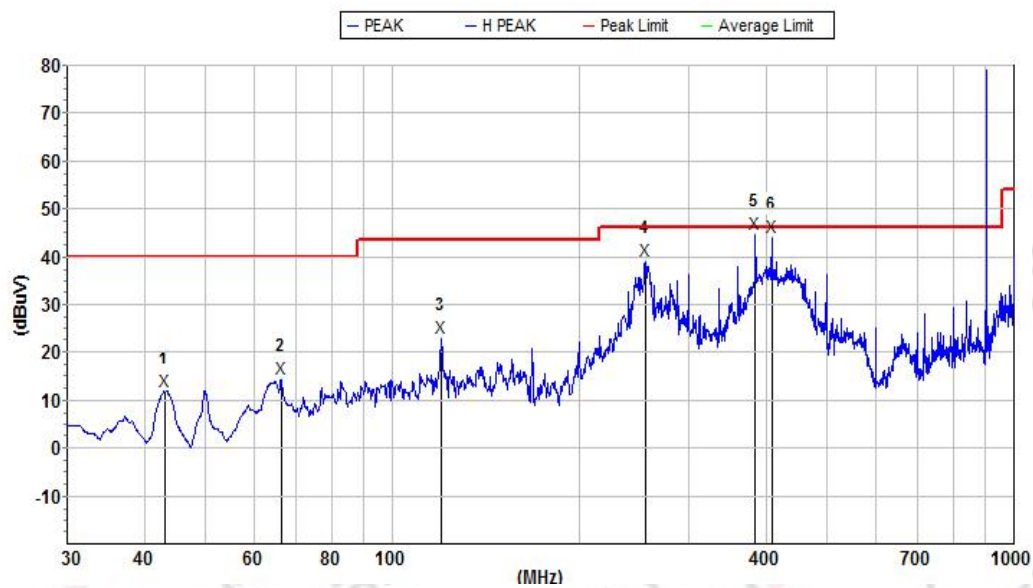
(30MHz-1000MHz)

Temperature:	25℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Horizontal
Test Mode:	Mode 1		

Remark:

1. Margin = Result (Result =Reading + Factor)-Limit
2. Factor= Antenna factor+Cable attenuation factor(cable loss)-Amplifier gain

904MHz Horizontal

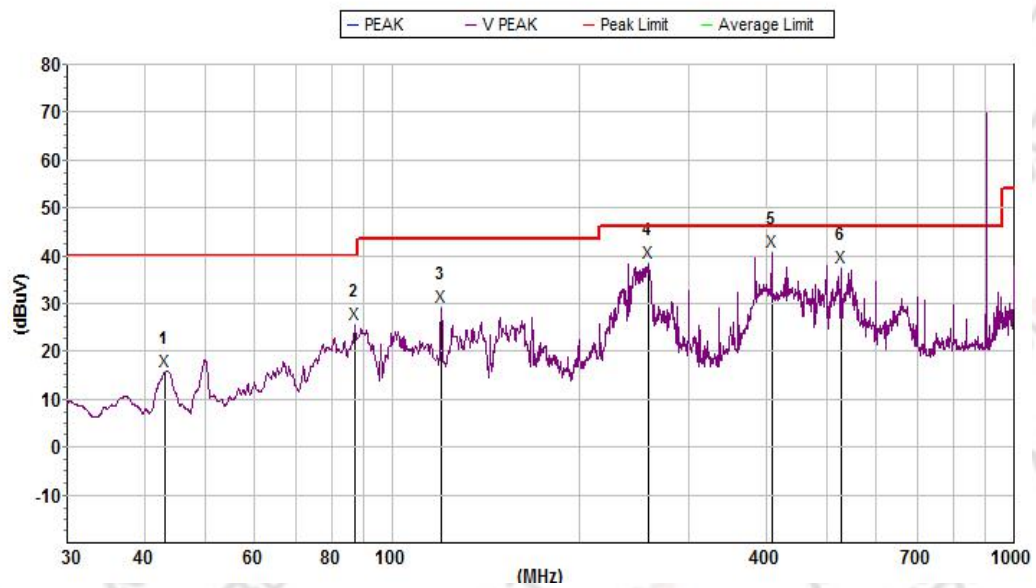


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
1	43.050457	11.9	40.0	28.1	13.9	32.4	0.8	H
2	66.266167	14.6	40.0	25.4	11.5	32.8	0.8	H
3	120.065933	23.2	43.5	20.3	12.2	32.9	1.4	H
4	256.071713	39.2	46.0	6.8	11.7	32.7	2.6	H
5	383.931815	44.7	46.0	1.3	13.7	32.4	2.7	H
6	407.514477	44.1	46.0	1.9	13.9	32.3	2.7	H

(30MHz-1000MHz)

Temperature:	25°C	Relative Humidity:	50%RH
DC 7.4V	DC 7.4V	Phase:	Vertical
Test Mode:	Mode 1		

904MHz Vertical

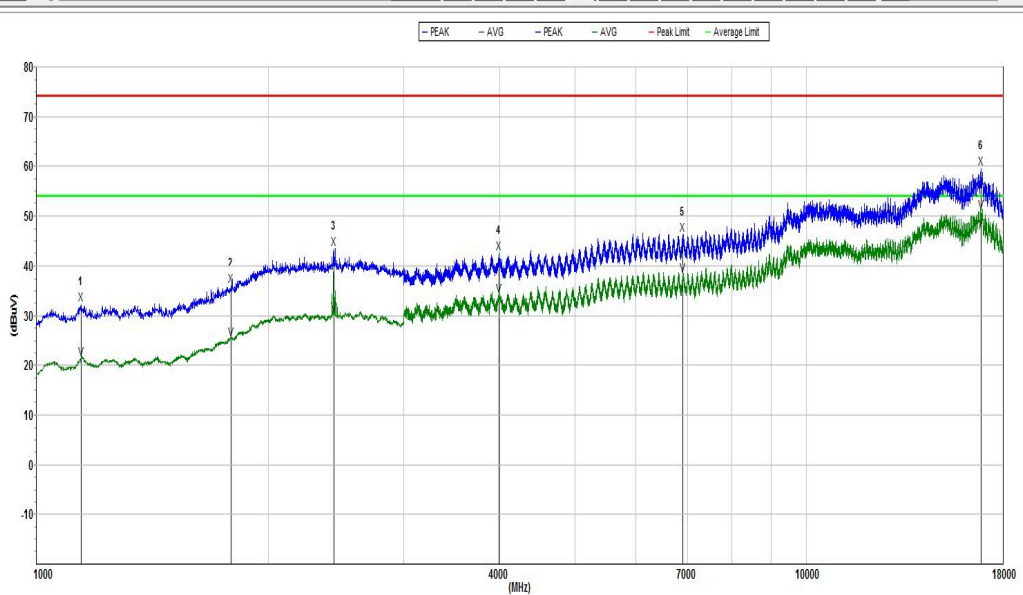


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
1	43.050457	15.9	40.0	24.1	13.9	32.5	0.8	V
2	87.111681	25.6	40.0	14.4	9.4	32.9	1.1	V
3	120.065933	29.3	43.5	14.2	12.2	32.9	1.4	V
4	257.873886	38.6	46.0	7.4	11.7	32.8	2.6	V
5	407.514477	40.7	46.0	5.3	14.9	32.3	2.7	V
6	527.320468	37.6	46.0	8.4	17.0	32.4	3.0	V

1000MHz-18000MHz)

Temperature:	25℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Horizontal
Test Mode:	Mode 1		

904MHz Horizontal

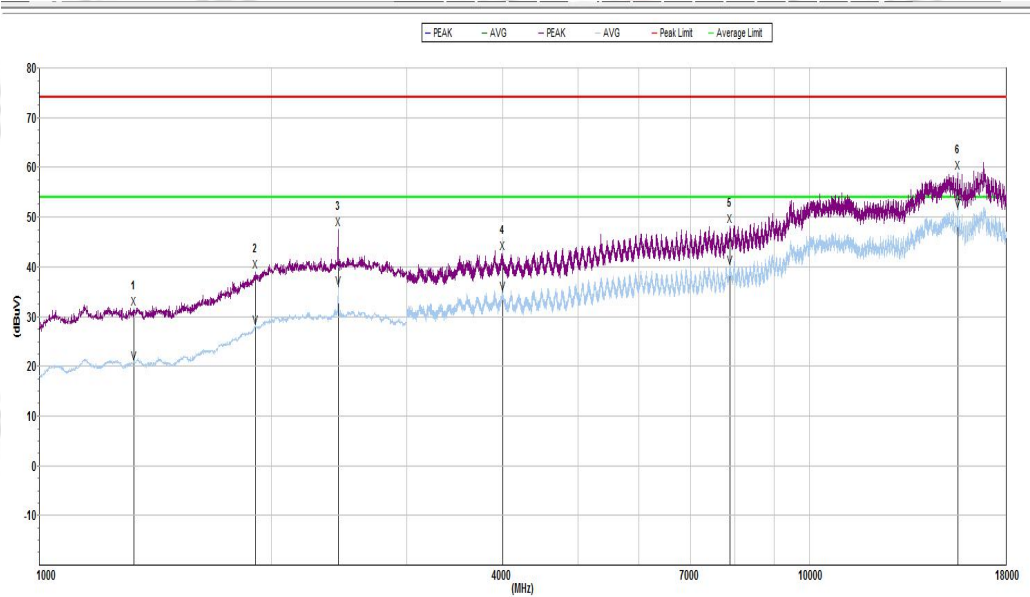


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
Peak:								
1	1144.000000	32.2	74.0	41.8	20.7	57.3	2.2	H
2	1791.000000	36.1	74.0	37.9	21.7	53.1	2.6	H
3	2434.000000	43.4	74.0	30.6	22.8	50.2	2.8	H
4	3988.500000	42.5	74.0	31.5	24.3	50.1	3.3	H
5	6911.250000	46.4	74.0	27.6	25.5	48.9	4.3	H
6	16838.250000	59.6	74.0	14.4	30.9	47.4	6.8	H
Avg								
1	1144.000000	21.3	54.0	32.7	20.7	57.3	2.2	H
2	1791.000000	25.4	54.0	28.6	21.7	53.1	2.6	H
3	2434.000000	30.3	54.0	23.7	22.8	50.2	2.8	H
4	3988.500000	34.0	54.0	20.0	24.3	50.1	3.3	H
5	6911.250000	38.1	54.0	15.9	25.5	48.9	4.3	H
6	16838.250000	51.0	54.0	3.0	30.9	47.4	6.8	H

(1000MHz-18000MHz)

Temperature:	25°C	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Vertical
Test Mode:	Mode 1		

904MHz Vertical

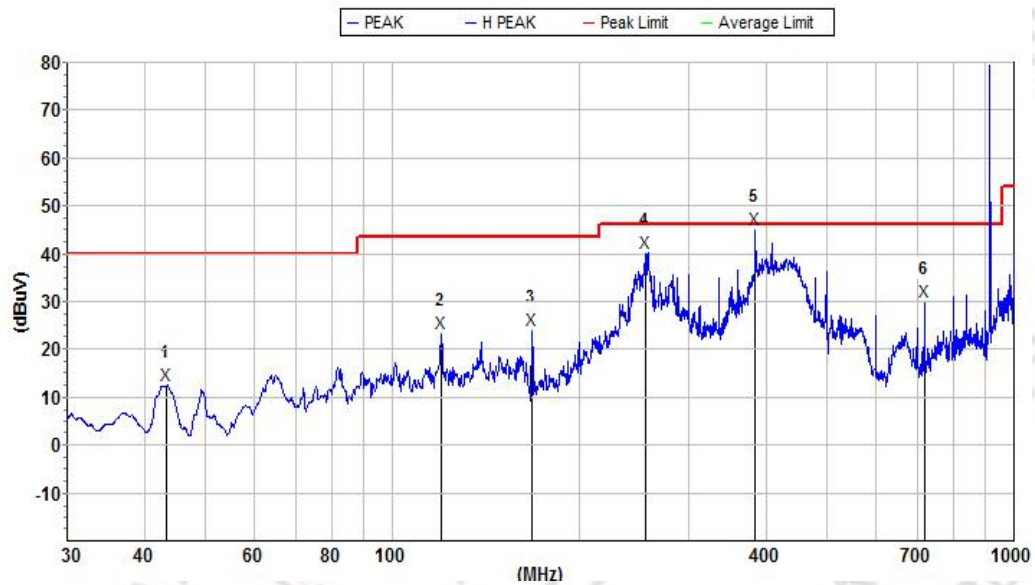


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
Peak:								
1	1326.000000	31.7	74.0	42.3	20.8	57.3	2.3	V
2	1909.000000	39.1	74.0	34.9	21.8	51.4	2.6	V
3	2444.000000	47.7	74.0	26.3	23.2	50.2	2.8	V
4	3995.250000	42.7	74.0	31.3	24.8	50.1	3.3	V
5	7879.500000	48.2	74.0	25.8	26.8	48.6	4.8	V
6	15569.250000	59.0	74.0	15.0	31.2	47.8	6.5	V
Avg								
1	1326.000000	20.7	54.0	33.3	20.8	57.3	2.3	V
2	1909.000000	27.9	54.0	26.1	21.8	51.4	2.6	V
3	2444.000000	35.8	54.0	18.2	23.2	50.2	2.8	V
4	3995.250000	34.8	54.0	19.2	24.8	50.1	3.3	V
5	7879.500000	40.0	54.0	14.0	26.8	48.6	4.8	V
6	15569.250000	51.4	54.0	2.6	31.2	47.8	6.5	V

(30MHz-1000MHz)

Temperature:	25℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Horizontal
Test Mode:	Mode 2		

914.5MHz Horizontal

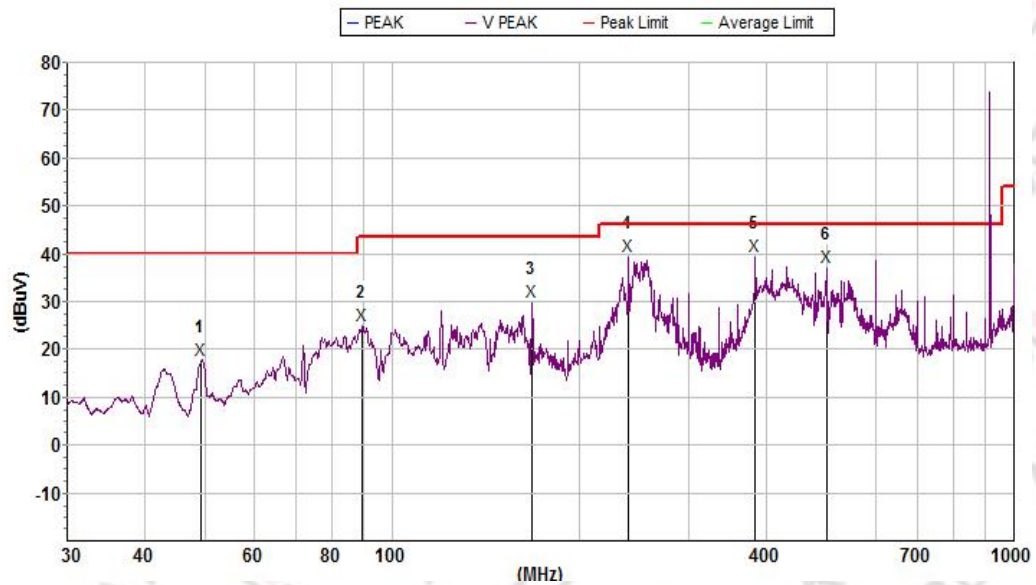


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
1	43.277492	12.5	40.0	27.5	13.9	32.4	0.8	H
2	120.065933	23.4	43.5	20.1	12.2	32.9	1.4	H
3	168.118752	24.1	43.5	19.4	13.4	32.8	1.7	H
4	256.071713	40.3	46.0	5.7	11.7	32.7	2.6	H
5	383.931815	45.1	46.0	0.9	13.7	32.4	2.7	H
6	719.199535	30.1	46.0	15.9	16.8	32.3	3.5	H

(30MHz-1000MHz)

Temperature:	25°C	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Vertical
Test Mode:	Mode 2		

914.5MHz Vertical

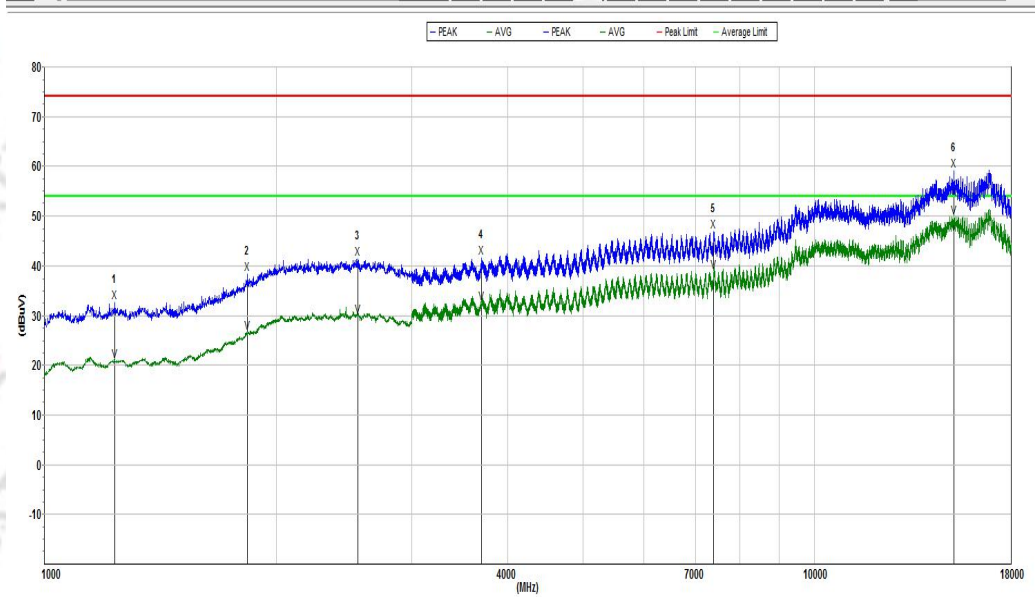


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
1	49.359419	17.9	40.0	22.1	13.6	32.6	0.8	V
2	89.589977	25.2	43.5	18.3	9.4	32.9	1.1	V
3	168.118752	29.9	43.5	13.6	13.4	32.9	1.7	V
4	239.987350	39.5	46.0	6.5	11.4	32.8	2.5	V
5	383.931815	39.5	46.0	6.5	14.4	32.4	2.7	V
6	499.424690	37.2	46.0	8.8	16.5	32.5	2.8	V

(1000MHz-18000MHz)

Temperature:	25℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Horizontal
Test Mode:	Mode 2		

914.5MHz Horizontal

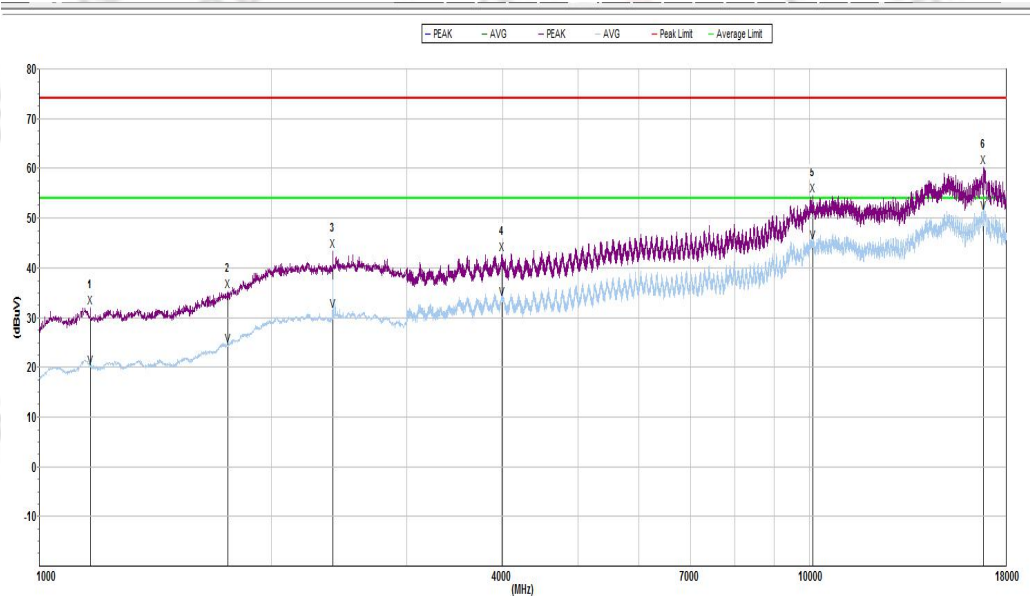


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
Peak:								
1	1235.000000	32.8	74.0	41.2	20.7	57.3	2.3	H
2	1834.000000	38.4	74.0	35.6	21.7	52.5	2.6	H
3	2551.000000	41.5	74.0	32.5	23.0	50.4	2.9	H
4	3692.250000	41.8	74.0	32.2	24.3	50.3	3.2	H
5	7396.500000	47.0	74.0	27.0	25.7	48.8	4.6	H
6	15168.000000	59.2	74.0	14.8	30.5	47.1	6.4	H
Avg								
1	1235.000000	21.0	54.0	33.0	20.7	57.3	2.3	H
2	1834.000000	26.5	54.0	27.5	21.7	52.5	2.6	H
3	2551.000000	29.9	54.0	24.1	23.0	50.4	2.9	H
4	3692.250000	32.6	54.0	21.4	24.3	50.3	3.2	H
5	7396.500000	38.9	54.0	15.1	25.7	48.8	4.6	H
6	15168.000000	49.7	54.0	4.3	30.5	47.1	6.4	H

(1000MHz-18000MHz)

Temperature:	25°C	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Vertical
Test Mode:	Mode 2		

914.5MHz Vertical

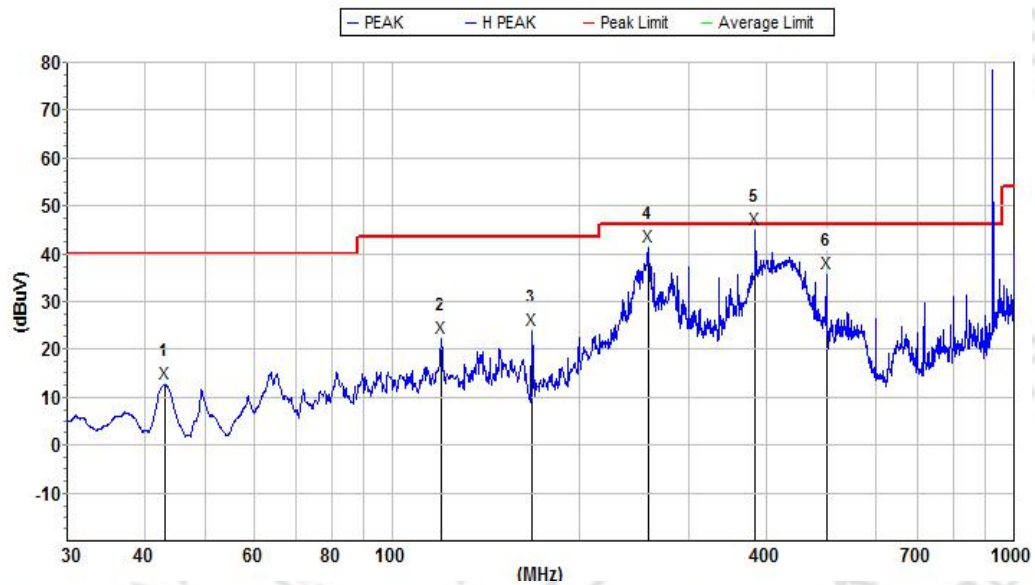


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
Peak:								
1	1166.000000	32.0	74.0	42.0	20.7	57.3	2.2	V
2	1757.000000	35.3	74.0	38.7	21.6	53.6	2.6	V
3	2406.000000	43.4	74.0	30.6	23.2	50.2	2.8	V
4	3987.000000	42.7	74.0	31.3	24.8	50.1	3.3	V
5	10101.750000	54.7	74.0	19.3	28.5	48.5	5.4	V
6	16830.750000	60.4	74.0	13.6	31.4	47.4	6.8	V
Avg								
1	1166.000000	20.1	54.0	33.9	20.7	57.3	2.2	V
2	1757.000000	24.4	54.0	29.6	21.6	53.6	2.6	V
3	2406.000000	31.4	54.0	22.6	23.2	50.2	2.8	V
4	3987.000000	33.8	54.0	20.2	24.8	50.1	3.3	V
5	10101.750000	45.1	54.0	8.9	28.5	48.5	5.4	V
6	16830.750000	51.2	54.0	2.8	31.4	47.4	6.8	V

(30MHz-1000MHz)

Temperature:	25℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Horizontal
Test Mode:	Mode 3		

925MHz Horizontal

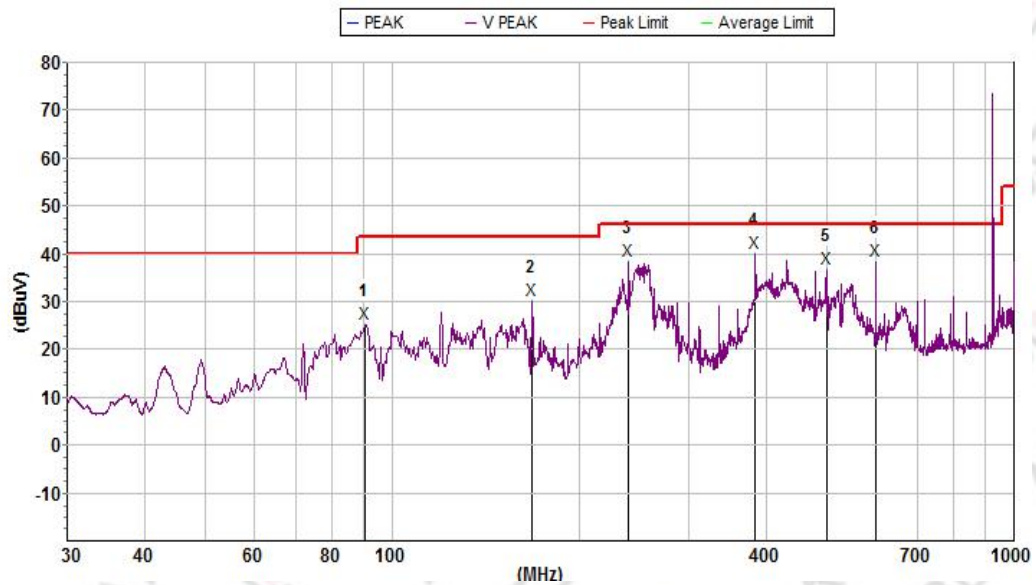


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
1	43.050457	12.8	40.0	27.2	13.9	32.4	0.8	H
2	120.065933	22.5	43.5	21.0	12.2	32.9	1.4	H
3	167.824251	24.2	43.5	19.3	13.4	32.8	1.7	H
4	257.873886	41.6	46.0	4.4	11.8	32.7	2.6	H
5	383.931815	45.0	46.0	1.0	13.7	32.4	2.7	H
6	499.424690	35.9	46.0	10.1	14.7	32.5	2.8	H

(30MHz-1000MHz)

Temperature:	235℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Vertical
Test Mode:	Mode 3		

925MHz Vertical

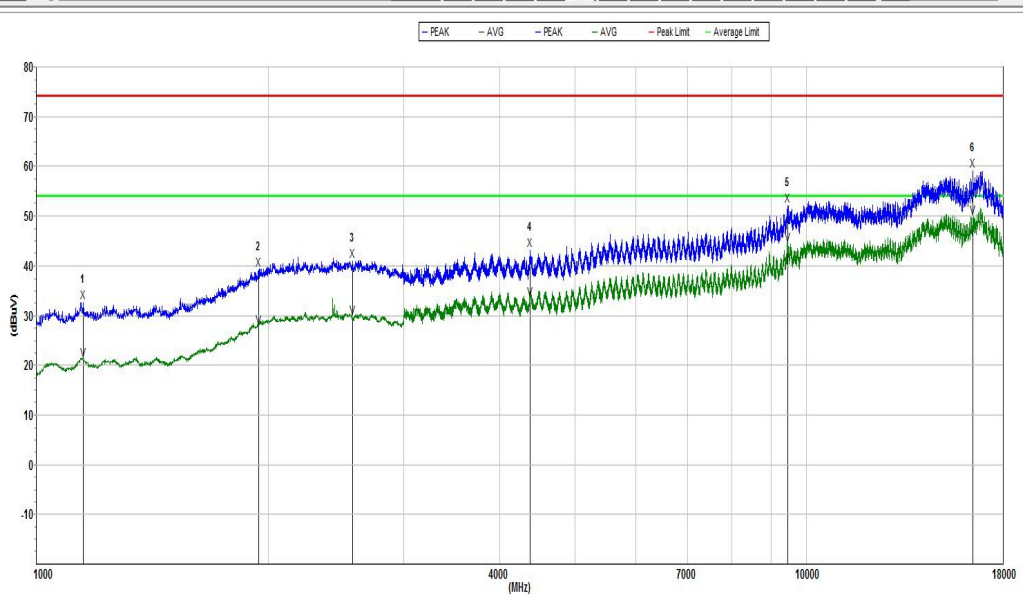


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
1	90.537409	25.4	43.5	18.1	9.5	32.9	1.1	V
2	168.118752	30.3	43.5	13.2	13.4	32.9	1.7	V
3	239.987350	38.4	46.0	7.6	11.4	32.8	2.5	V
4	383.931815	40.2	46.0	5.8	14.4	32.4	2.7	V
5	499.424690	36.8	46.0	9.2	16.5	32.5	2.8	V
6	599.321287	38.6	46.0	7.4	18.3	32.4	3.3	V

(1000MHz-18000MHz)

Temperature:	25℃	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Horizontal
Test Mode:	Mode 3		

925MHz Horizontal

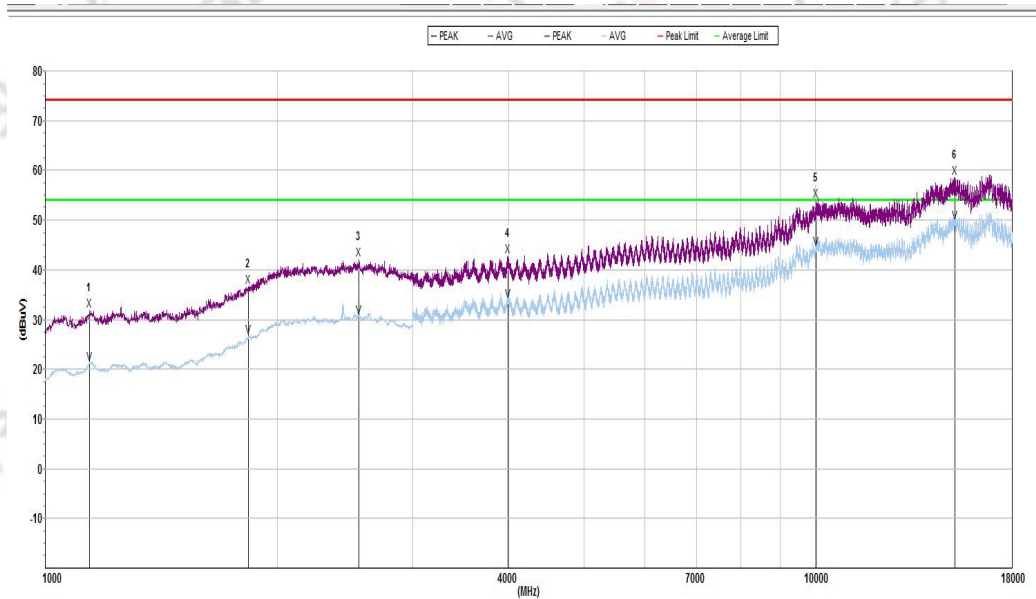


Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
Peak:								
1	1151.000000	32.7	74.0	41.3	20.8	57.3	2.2	H
2	1944.000000	39.2	74.0	34.8	21.8	50.9	2.6	H
3	2572.000000	41.1	74.0	32.9	23.1	50.4	2.9	H
4	4377.750000	43.3	74.0	30.7	24.6	50.1	3.5	H
5	9452.250000	52.2	74.0	21.8	27.2	48.6	5.4	H
6	16442.250000	59.3	74.0	14.7	30.8	47.9	6.7	H
Avg								
1	1151.000000	21.2	54.0	32.8	20.8	57.3	2.2	H
2	1944.000000	27.8	54.0	26.2	21.8	50.9	2.6	H
3	2572.000000	29.6	54.0	24.4	23.1	50.4	2.9	H
4	4377.750000	33.5	54.0	20.5	24.6	50.1	3.5	H
5	9452.250000	44.3	54.0	9.7	27.2	48.6	5.4	H
6	16442.250000	49.7	54.0	4.3	30.8	47.9	6.7	H

(1000MHz-18000MHz)

Temperature:	25°C	Relative Humidity:	50%RH
Test Voltage:	DC 7.4V	Phase:	Vertical
Test Mode:	Mode 3		

925MHz Vertical



Mk.	Freq.(MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L. (dB)	Pol.
Peak:								
1	1142.000000	31.8	74.0	42.2	20.7	57.3	2.2	V
2	1833.000000	36.6	74.0	37.4	21.7	52.5	2.6	V
3	2554.000000	42.2	74.0	31.8	23.5	50.4	2.9	V
4	3990.750000	42.7	74.0	31.3	24.8	50.1	3.3	V
5	10017.000000	53.9	74.0	20.1	28.4	48.5	5.4	V
6	15168.000000	58.6	74.0	15.4	31.1	47.1	6.4	V
Avg								
1	1142.000000	21.2	54.0	32.8	20.7	57.3	2.2	V
2	1833.000000	26.5	54.0	27.5	21.7	52.5	2.6	V
3	2554.000000	30.6	54.0	23.4	23.5	50.4	2.9	V
4	3990.750000	33.8	54.0	20.2	24.8	50.1	3.3	V
5	10017.000000	44.4	54.0	9.6	28.4	48.5	5.4	V
6	15168.000000	49.6	54.0	4.4	31.1	47.1	6.4	V

Note: 1.Other 18G-25G Emission detected are more than 20dB below the limit.

Restricted Bands Requirements

LoRa

Frequency (MHz)	Level (dBuV/ m)	Limit (dBuV/m)	Margin (dB)	Ant.F/G. (dB/m)	Amp.G. (dB)	Cbl.L.	Detector	Polarity
902.00	55.21	74.0	-18.79	22.95	39.02	4.91	PK	Horizontal
902.00	41.76	54.0	-12.24	22.95	39.02	4.91	AV	Horizontal
902.00	57.96	74.0	-16.04	22.95	39.02	4.91	PK	Vertical
902.00	40.84	54.0	-13.16	22.95	39.02	4.91	AV	Vertical
928.00	57.12	74.0	-16.88	22.95	39.02	5.12	PK	Horizontal
928.00	40.81	54.0	-13.19	22.95	39.02	5.12	AV	Horizontal
928.00	58.97	74.0	-15.03	22.95	39.02	5.12	PK	Vertical
928.00	41.63	54.0	-12.37	22.95	39.02	5.12	AV	Vertical

Remark: Low measurement frequencies is range from 2300 to 2403 MHz,high measurement frequencies is range from 2479 to 2500 MHz.Only show the worst point data of the emissions in the frequency 2300-2403 MHz and 2479-2500 MHz.

4. CONDUCTED SPURIOUS & BAND EDGE EMISSION

4.1 LIMIT

According to FCC section 15.247(d)&RSS-247 Issue 2, February 2017 (5.5), in any 100kHz 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 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

4.2 TEST PROCEDURE

Spectrum Parameter	Setting
Detector	Peak
Start/Stop Frequency	30 MHz to 10th carrier harmonic
RB / VB (emission in restricted band)	100 KHz/300 KHz
Trace-Mode:	Max hold

For Band edge

Spectrum Parameter	Setting
Detector	Peak
Start/Stop Frequency	Lower Band Edge: 890 – 905 MHz Upper Band Edge: 912 – 940MHz
RB / VB (emission in restricted band)	100 KHz/300 KHz
Trace-Mode:	Max hold

For Hopping Band edge

Spectrum Parameter	Setting
Detector	Peak
Start/Stop Frequency	Lower Band Edge: 890 – 905 MHz Upper Band Edge: 925 – 940 MHz
RB / VB (emission in restricted band)	100 KHz/300 KHz
Trace-Mode:	Max hold

4.3 TEST SETUP



The EUT is connected to the Spectrum Analyzer; the RF load attached to the EUT antenna terminal is 50Ohm; the path loss as the factor is calibrated to correct the reading. Make the measurement with the spectrum analyzer's resolution bandwidth(RBW) = 100 kHz. In order to make an accurate measurement, set the span greater than RBW.

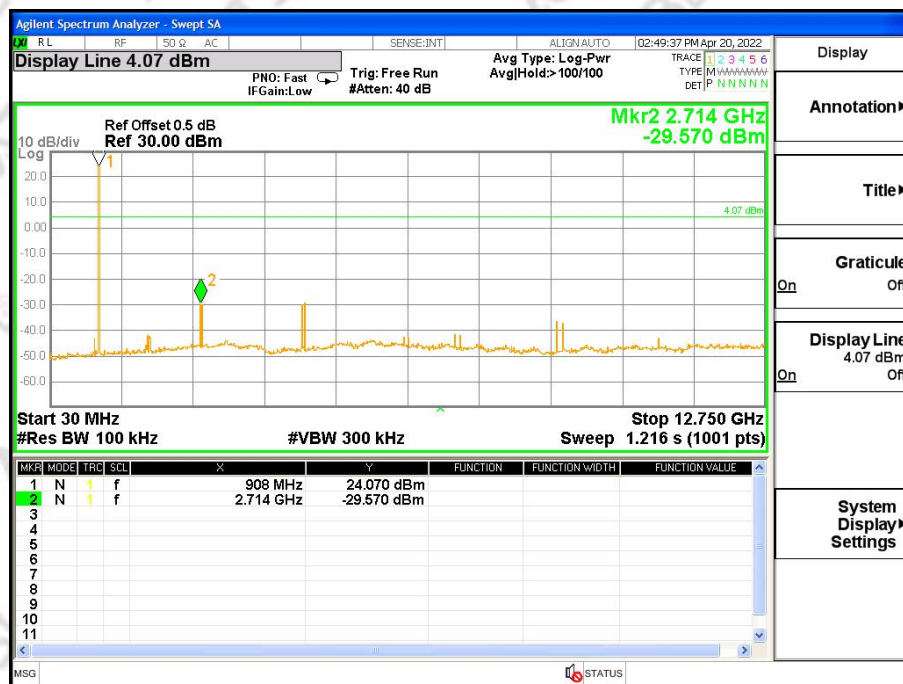
4.4 EUT OPERATION CONDITIONS

The EUT tested system was configured as the statements of 2.3 Unless otherwise a special operating condition is specified in the follows during the testing.

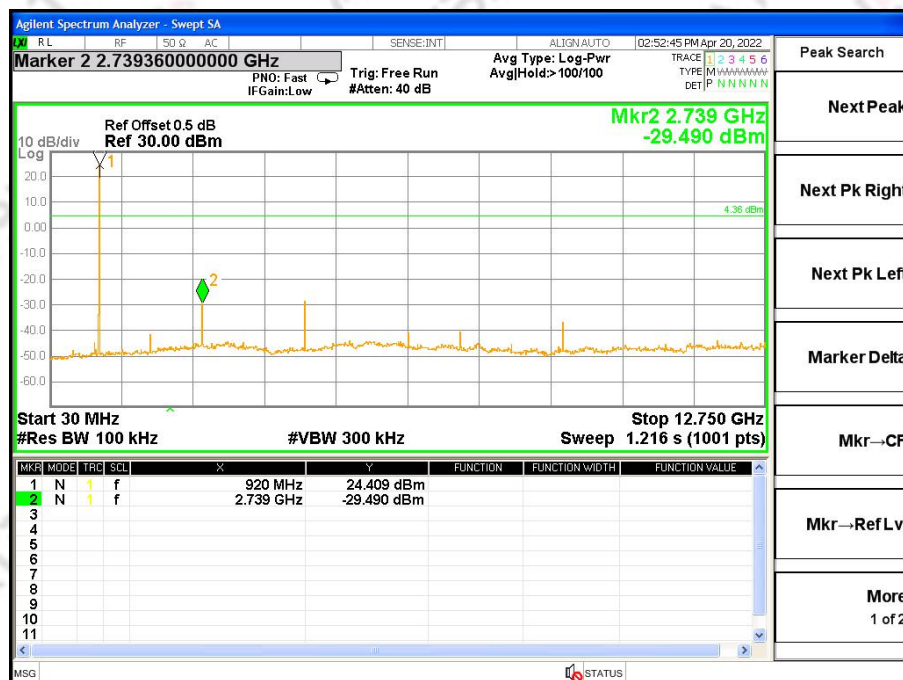
4.5 TEST RESULTS

Temperature:	25°C	Relative Humidity:	50%
Test Mode:	LoRa-01/22/43 CH	Test Voltage:	DC 5V

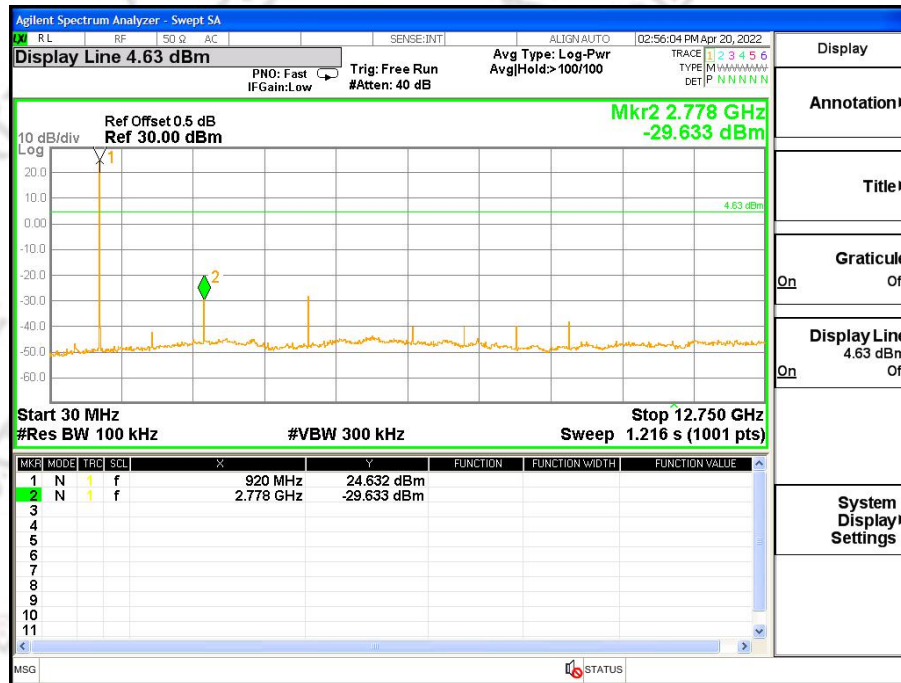
01 CH



22 CH

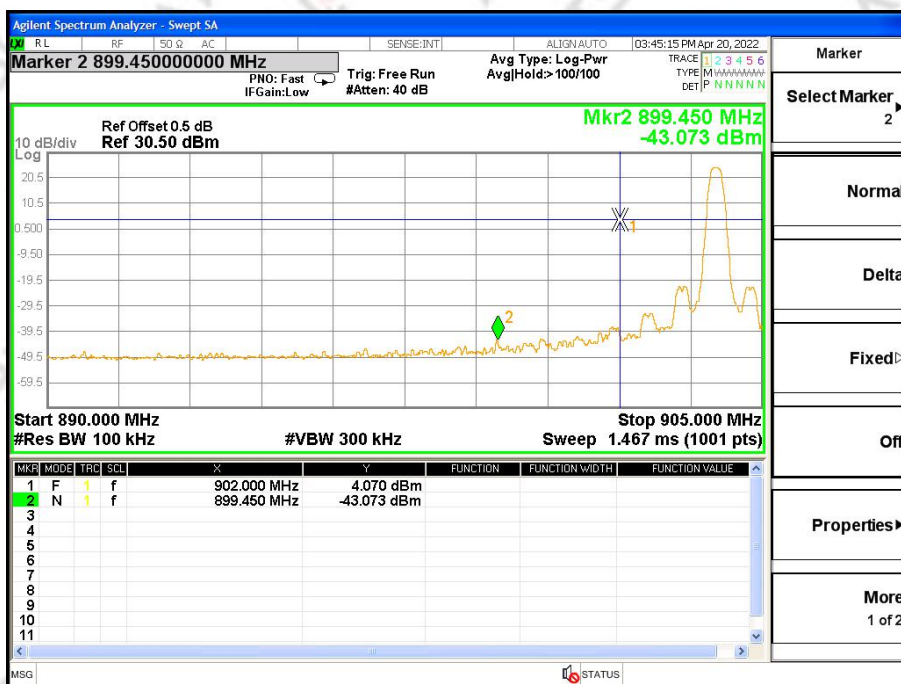


43 CH

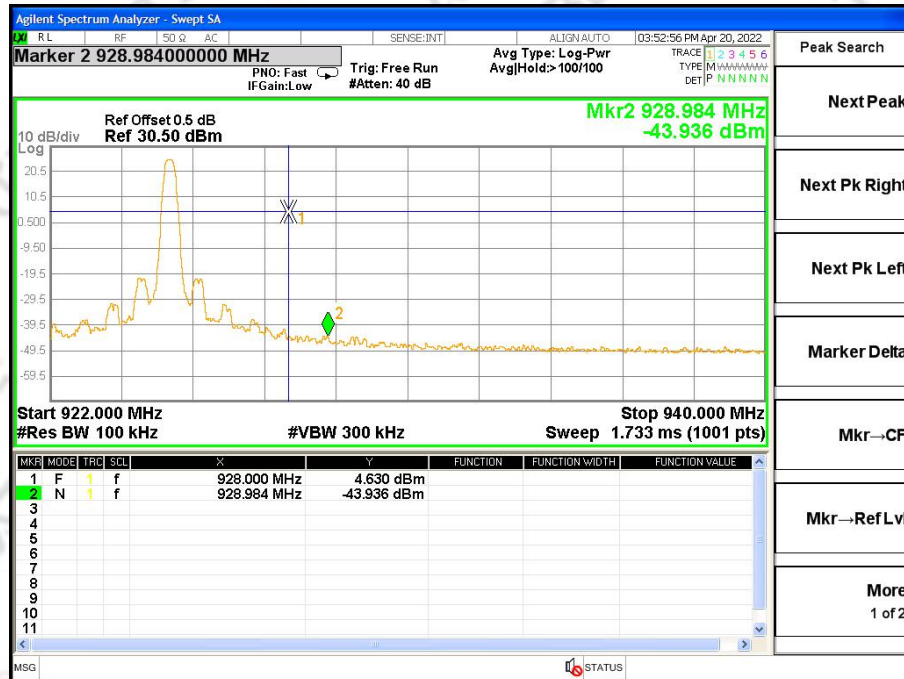


For Band edge(it's also the reference level for conducted spurious emission)

01 CH

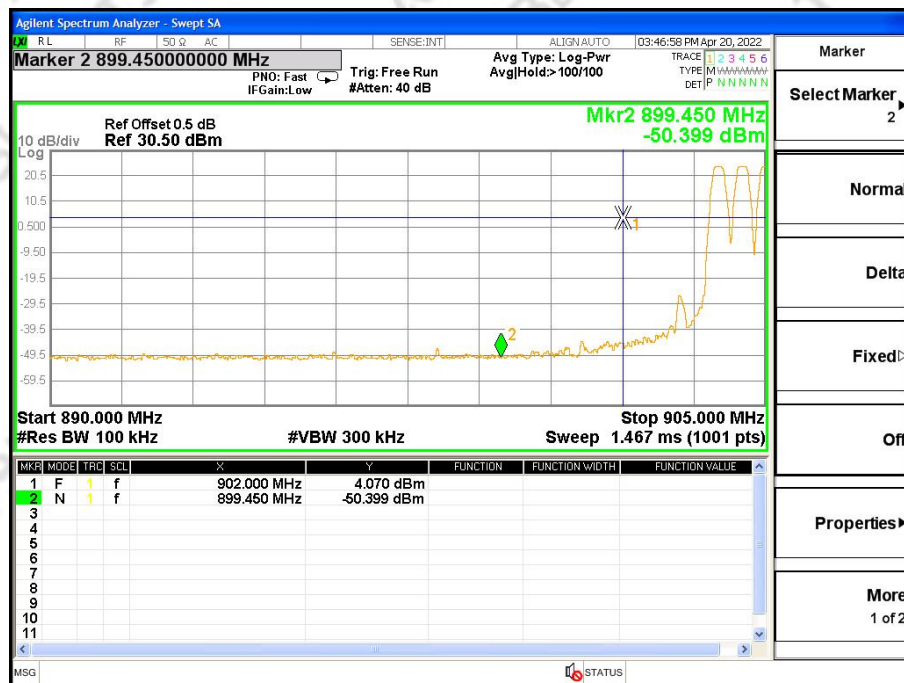


43 CH

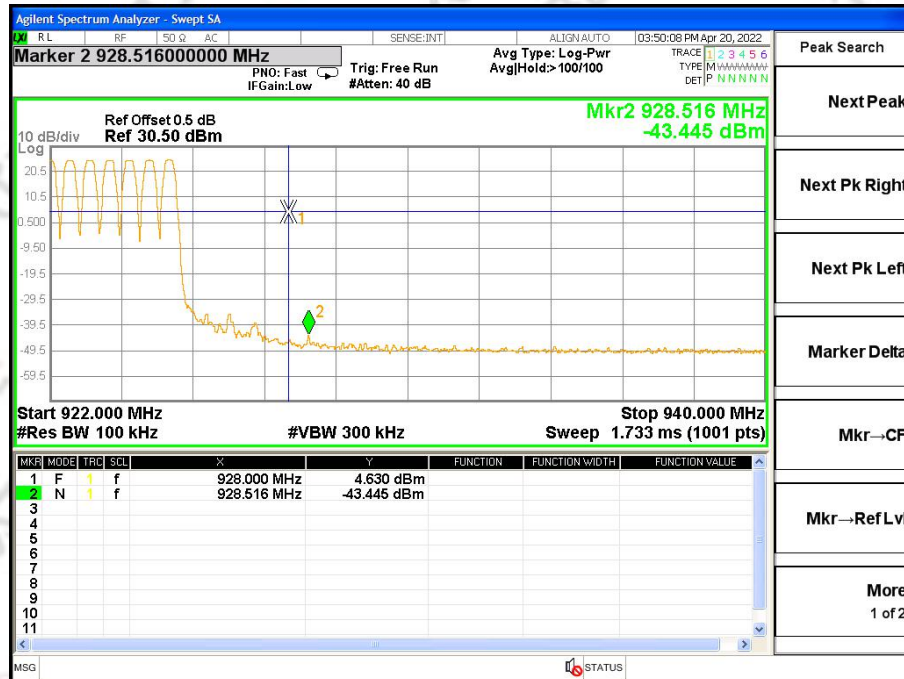


For Hopping Band edge

01 CH



43 CH



5. NUMBER OF HOPPING CHANNEL

5.1 LIMIT

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

EUT 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50.

Spectrum Parameters	Setting
Attenuation	Auto
Span Frequency	> Operating FrequencyRange
RB	100KHz
VB	300KHz
Detector	Peak
Trace	Max Hold
Sweep Time	Auto

5.2 TEST PROCEDURE

- The EUT was directly connected to the spectrum analyzer and antenna output port as show in the block diagram below.
- Spectrum Setting: RBW= 100KHz, VBW=300KHz, Sweep time = Auto.

5.3 TEST SETUP



5.4 EUT OPERATION CONDITIONS

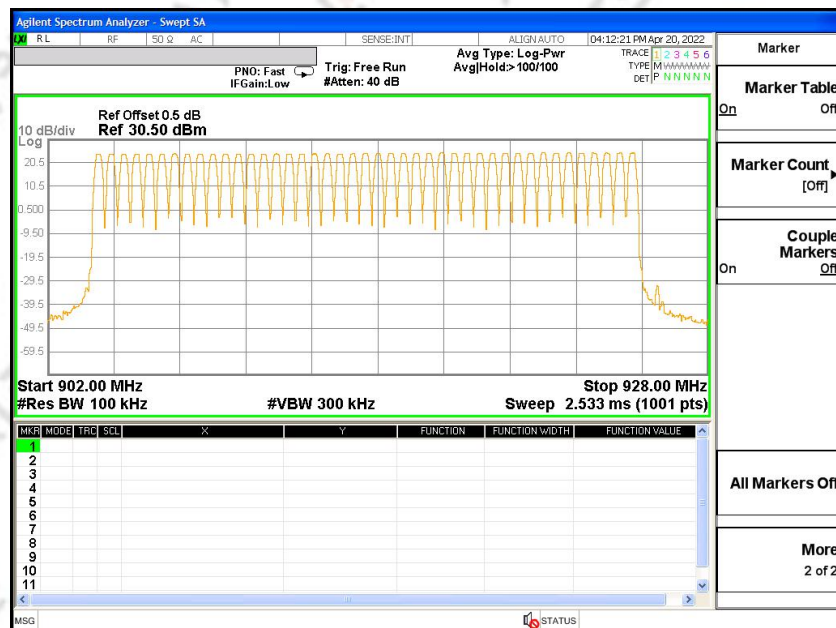
The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

5.5 TEST RESULTS

Temperature:	25°C	Relative Humidity:	50%
Test Mode:	Hopping Mode -LoRa Mode	Test Voltage:	DC 5V

Number of Hopping Channel: 43

Hopping channel



6. AVERAGE TIME OF OCCUPANCY

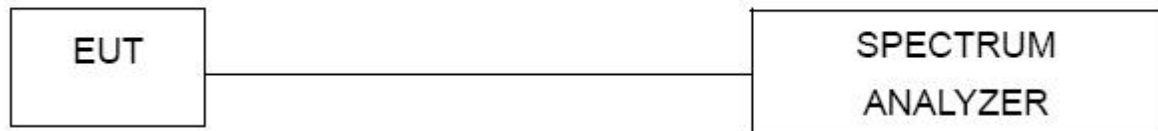
6.1 LIMIT

FCC Part 15.247, Subpart C				
Section	Test Item	Limit	Frequency Range (MHz)	Result
15.247(f)	Average Time of Occupancy	< 0.4sec	902-928	PASS

6.2 TEST PROCEDURE

- The transmitter output (antenna port) was connected to the spectrum analyzer.
- Set RBW =100KHz/VBW =300KHz.
- Use a video trigger with the trigger level set to enable triggering only on full pulses.
- Sweep Time is 0.4* channel number.
- Set the center frequency on any frequency would be measure and set the frequency span to zero span.
- Measure the maximum time duration of one single pulse.

6.3 TEST SETUP



6.4 EUT OPERATION CONDITIONS

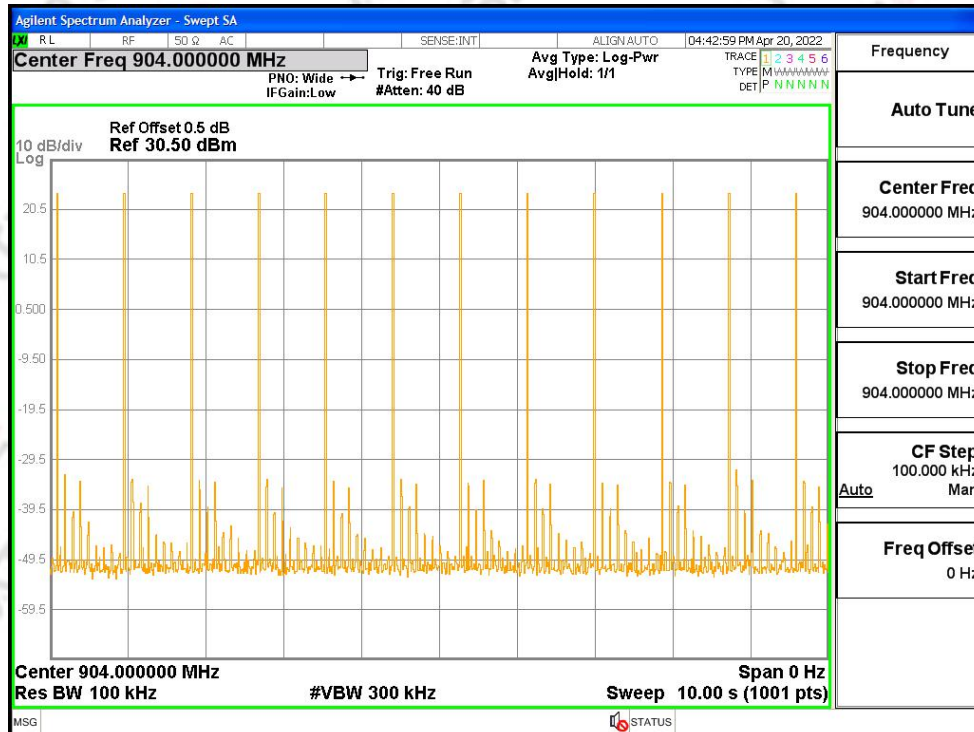
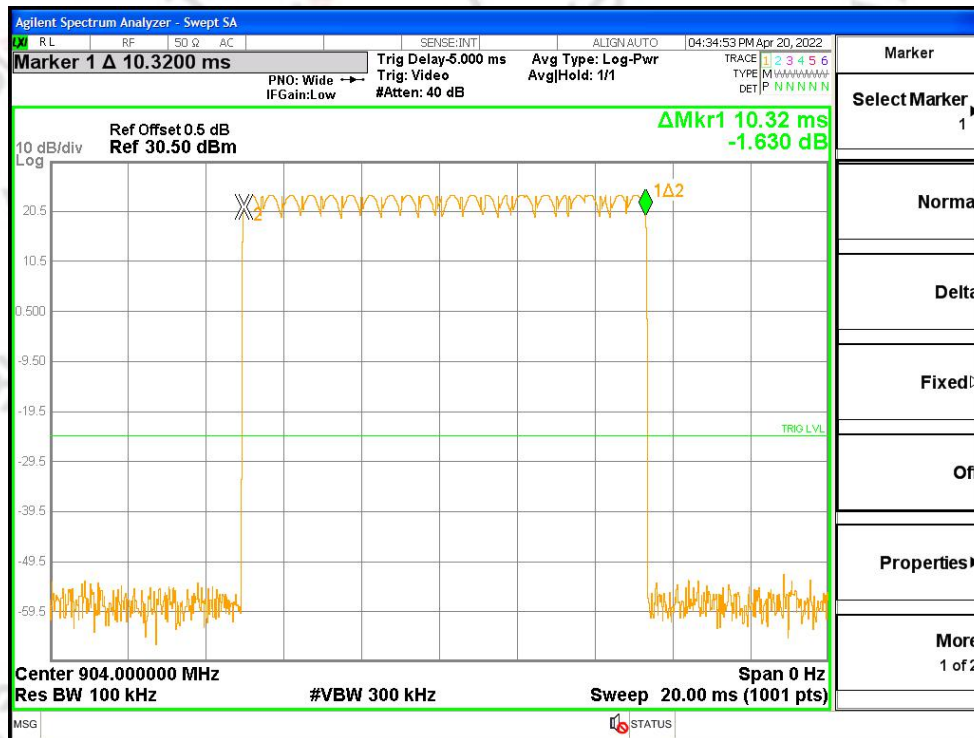
The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

6.5 TEST RESULTS

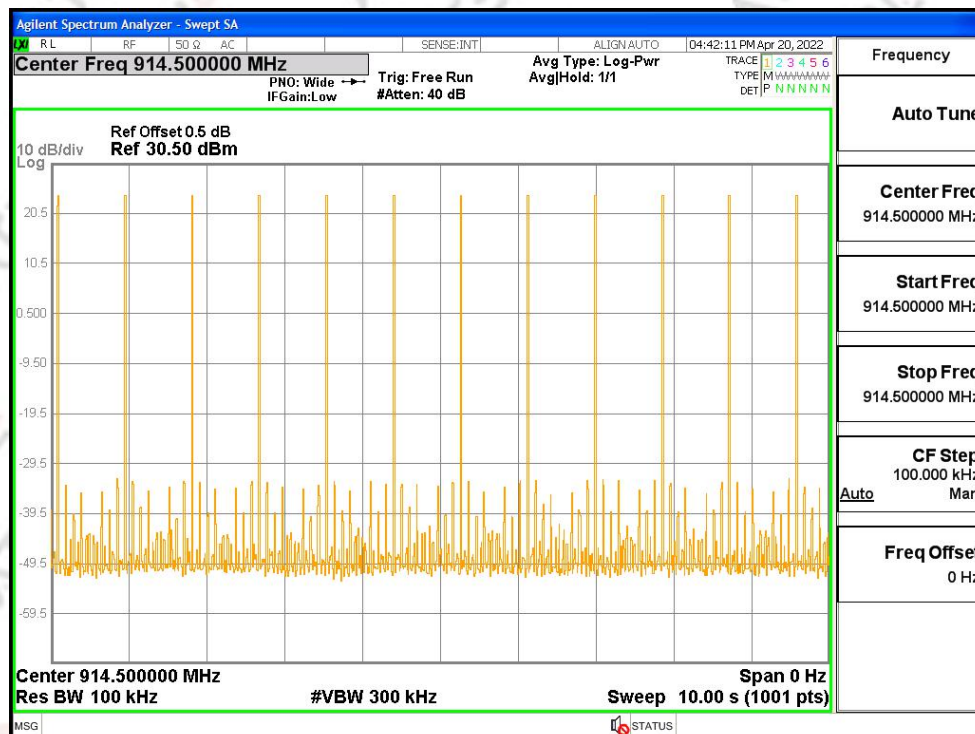
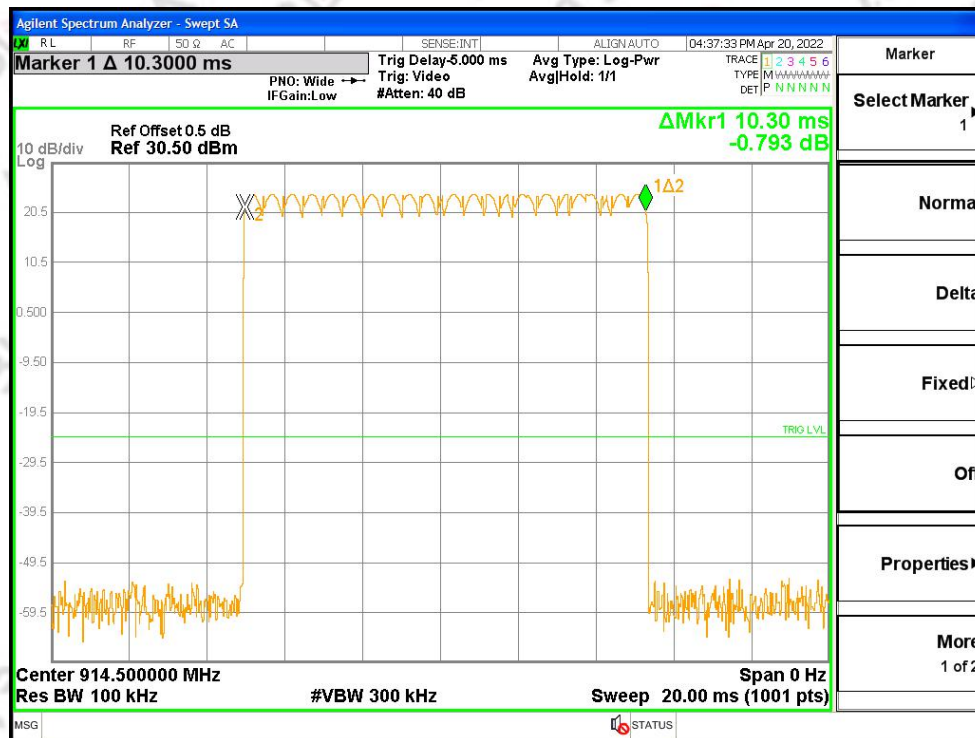
Temperature:	25°C	Relative Humidity:	50%
Test Mode:	LoRa	Test Voltage:	DC 5V

Frequency (MHz)	Pulse time(ms)	Number of pulses	Dwell Time(s)	Limits(s)
904	10.32	12	0.124	0.4
914.5	10.30	12	0.123	0.4
925	10.34	12	0.124	0.4

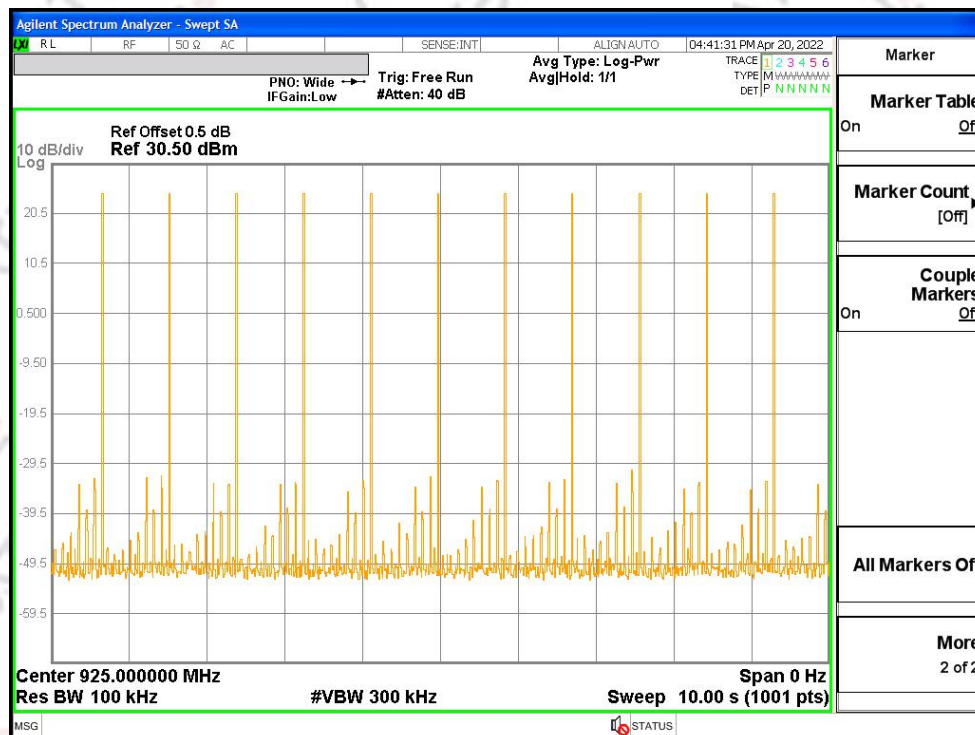
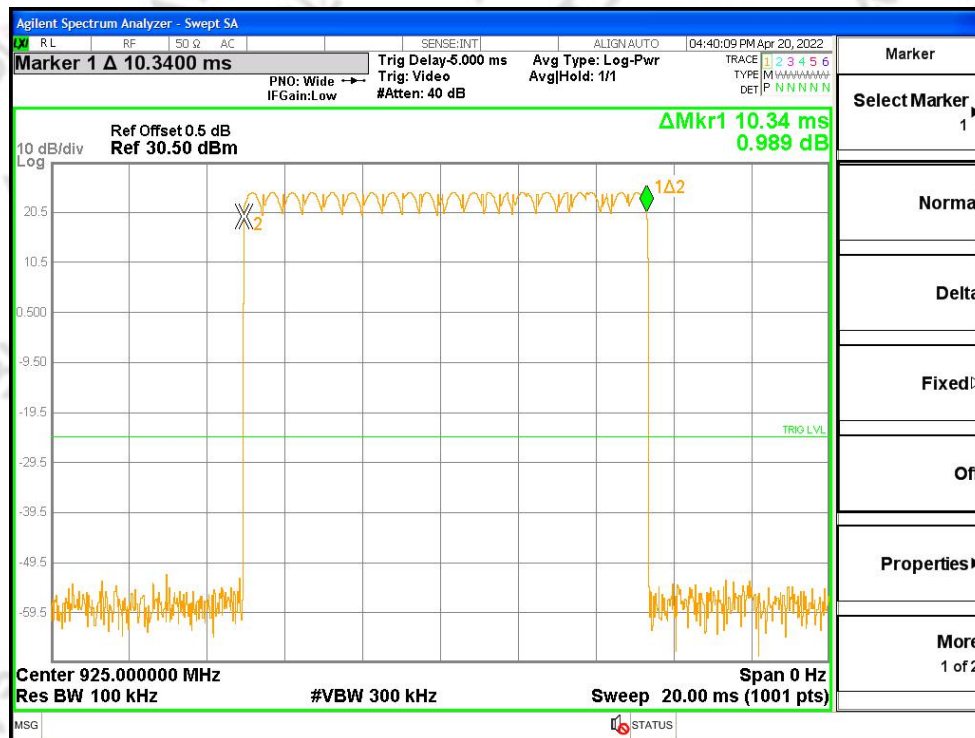
Mode 1



Mode 2



Mode 3



7. HOPPING CHANNEL SEPARATION MEASUREMENT

7.1 LIMIT

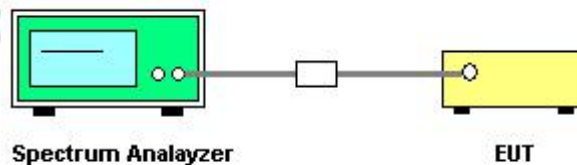
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that 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 hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Spectrum Parameter	Setting
Attenuation	Auto
Span	1MHz
RB	100 KHz
VB	300KHz
Detector	Peak
Trace	Max Hold
Sweep Time	Auto

7.2 TEST PROCEDURE

- The transmitter output (antenna port) was connected to the spectrum analyser in peak hold mode.
- Spectrum Setting: RBW= 100KHz, VBW= 300KHz, Sweep time = Auto.

7.3 TEST SETUP



7.4 EUT OPERATION CONDITIONS

The EUT was programmed to be in continuously transmitting mode.

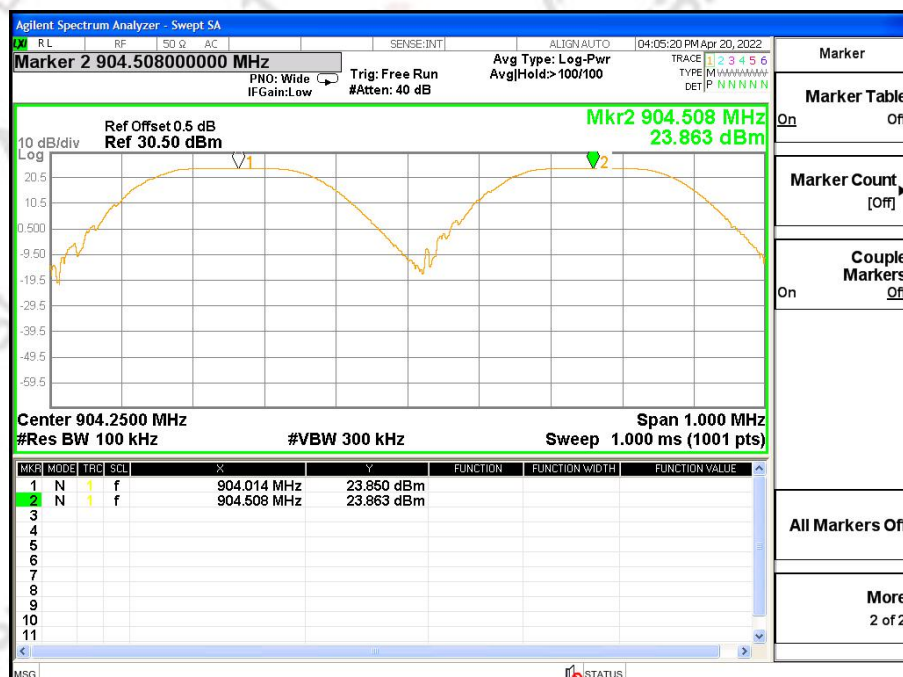
7.5 TEST RESULTS

Temperature:	25°C	Relative Humidity:	50%
Test Mode:	CH01 / CH22 / CH43	Test Voltage:	DC 5V

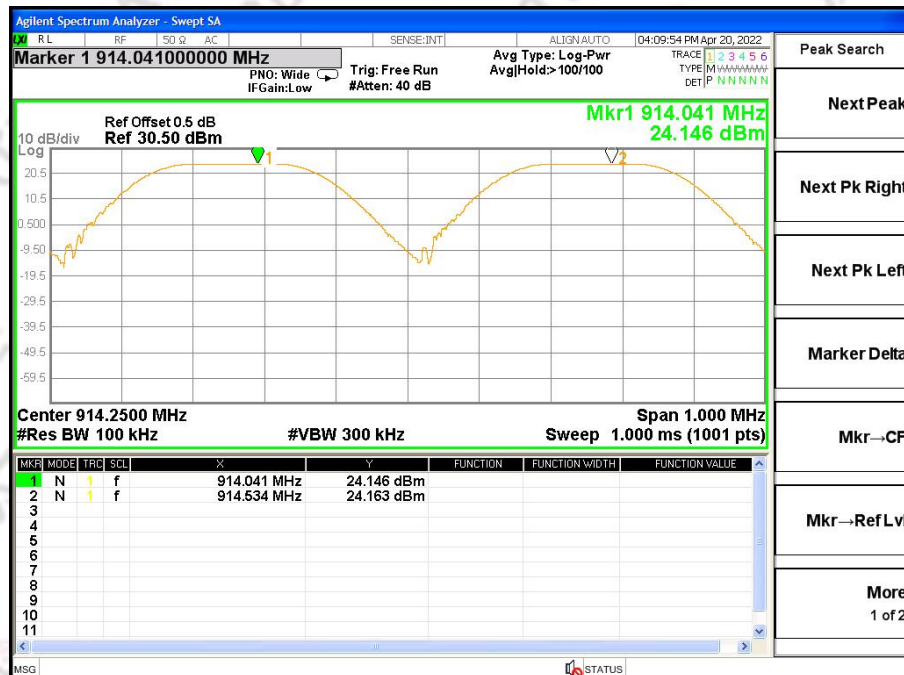
Frequency (MHz)	Mark1 Frequency (MHz)	Mark2 Frequency (MHz)	Ch. Separation (MHz)	Limit (MHz)	Result
904	904.014	904.508	0.494	0.143	Complies
914.5	914.041	914.534	0.493	0.142	Complies
925	924.566	924.973	0.407	0.141	Complies

For LoRa: Ch. Separation Limits: > 20dB bandwidth

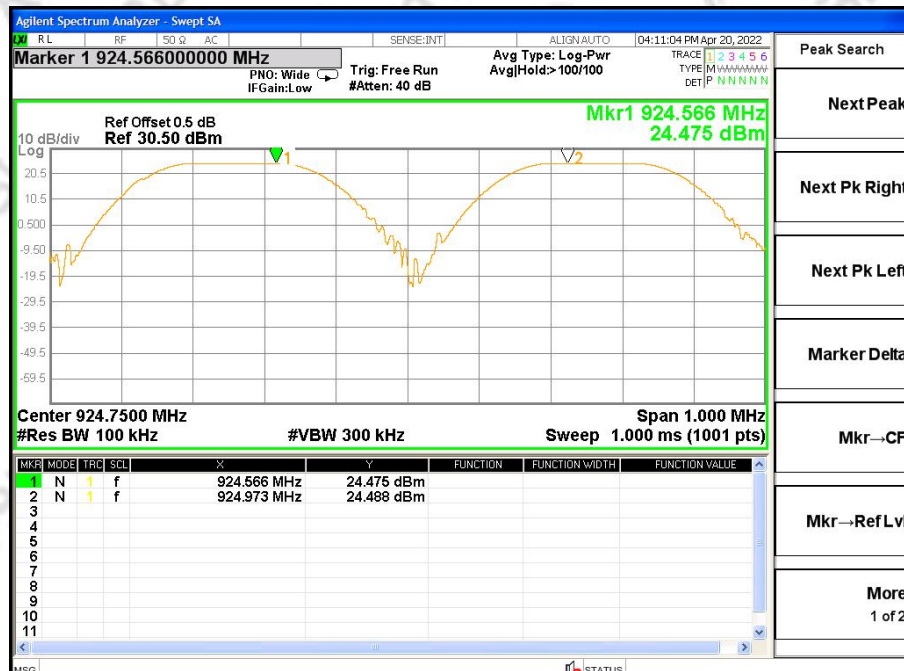
CH01



CH22



CH43



8. BANDWIDTH TEST

8.1 LIMIT

FCC Part15 15.247,Subpart C				
Section	Test Item	Limit	FrequencyRange (MHz)	Result
15.247(a)(1)	Bandwidth	< 250kHz	902-928	PASS

Spectrum Parameter	Setting
Attenuation	Auto
Span	500KHz
RB	3 kHz
VB	10 kHz
Detector	Peak
Trace	Max Hold
Sweep Time	Auto

8.2 TEST PROCEDURE

- The EUT was directly connected to the spectrum analyzer and antenna output port as show in the block diagram below.
- Spectrum Setting: RBW= 3KHz, VBW=10KHz, Sweep time = Auto.

8.3 TEST SETUP



8.4 EUT OPERATION CONDITIONS

The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

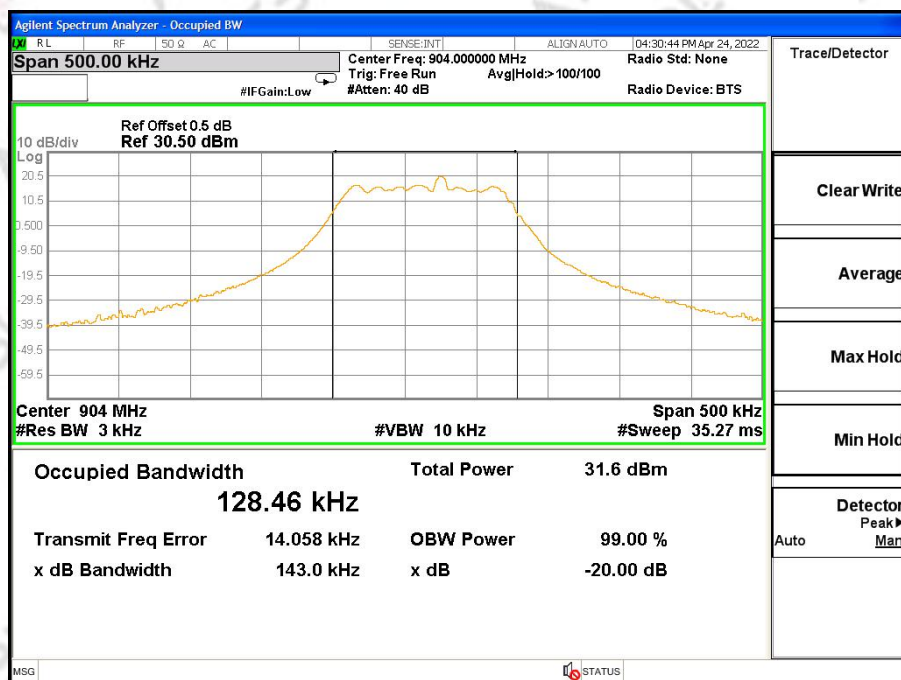
8.5 TEST RESULTS

Temperature:	25°C	Relative Humidity:	50%
Test Mode:	CH01 / CH22 / CH43	Test Voltage:	DC 7.4V

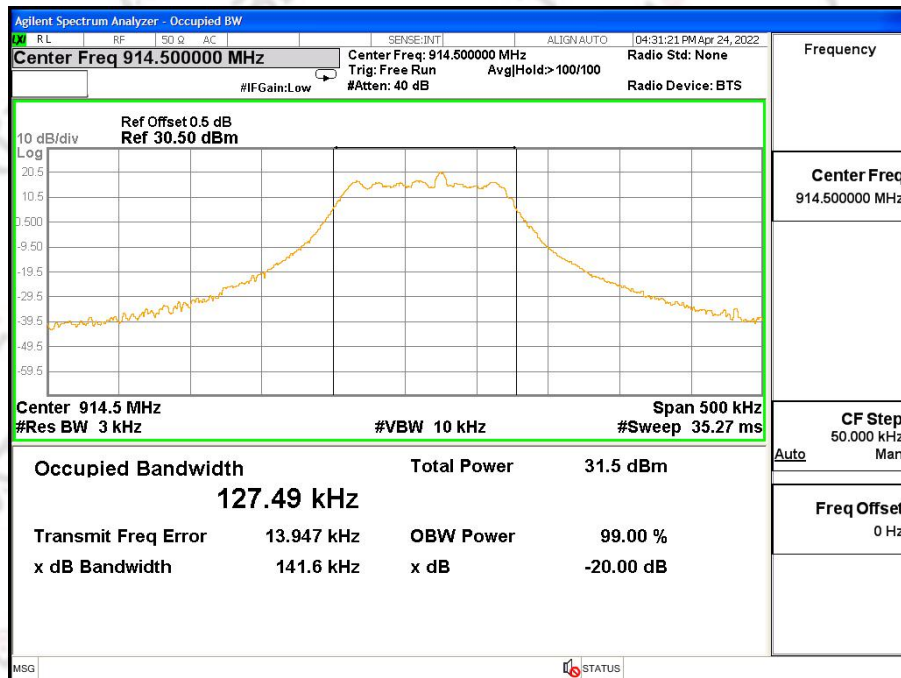
Frequency	20dB Bandwidth (MHz)	99% Bandwidth (MHz)	Result
904	0.381	0.128	PASS
914.5	0.379	0.127	PASS
925	0.381	0.127	PASS

99% Bandwidth

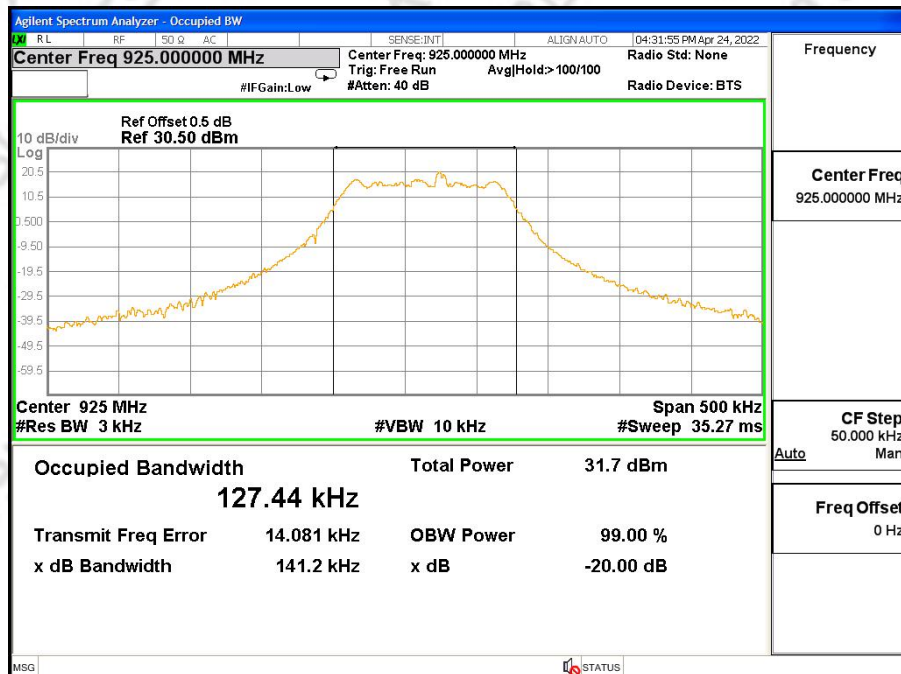
CH01



CH22

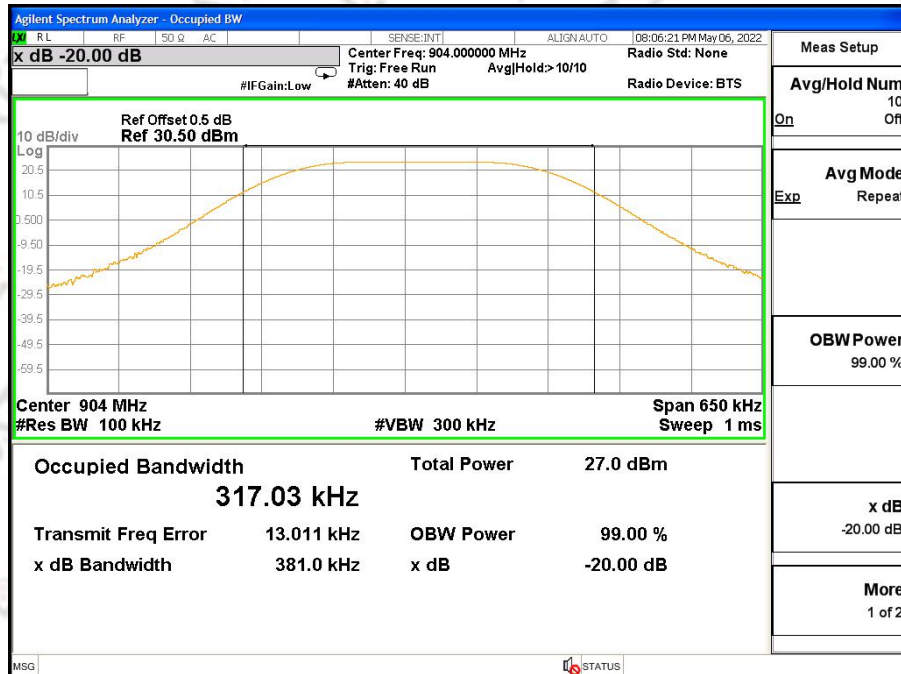


CH43

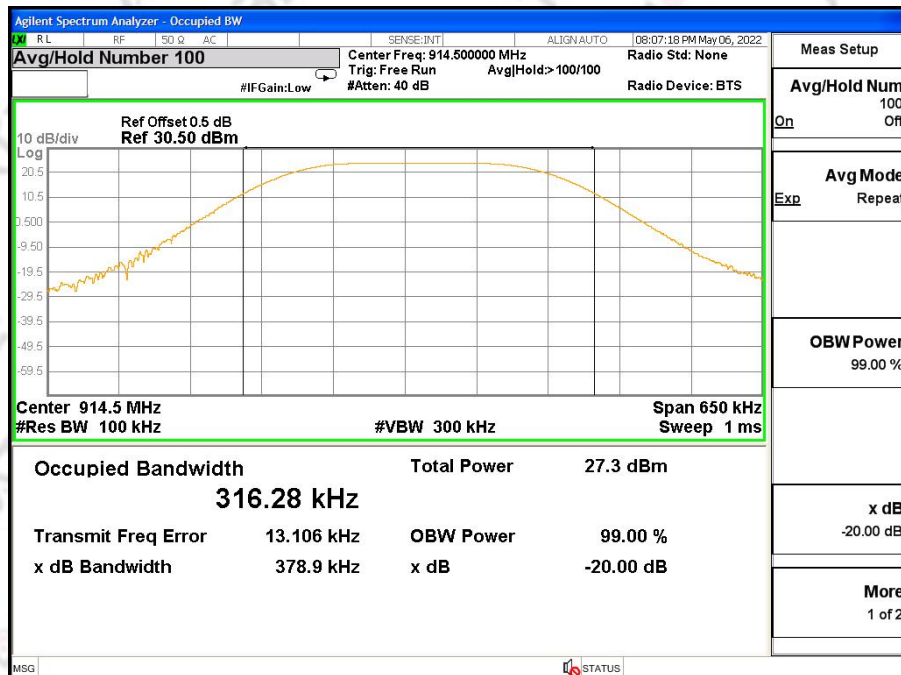


20dB Bandwidth

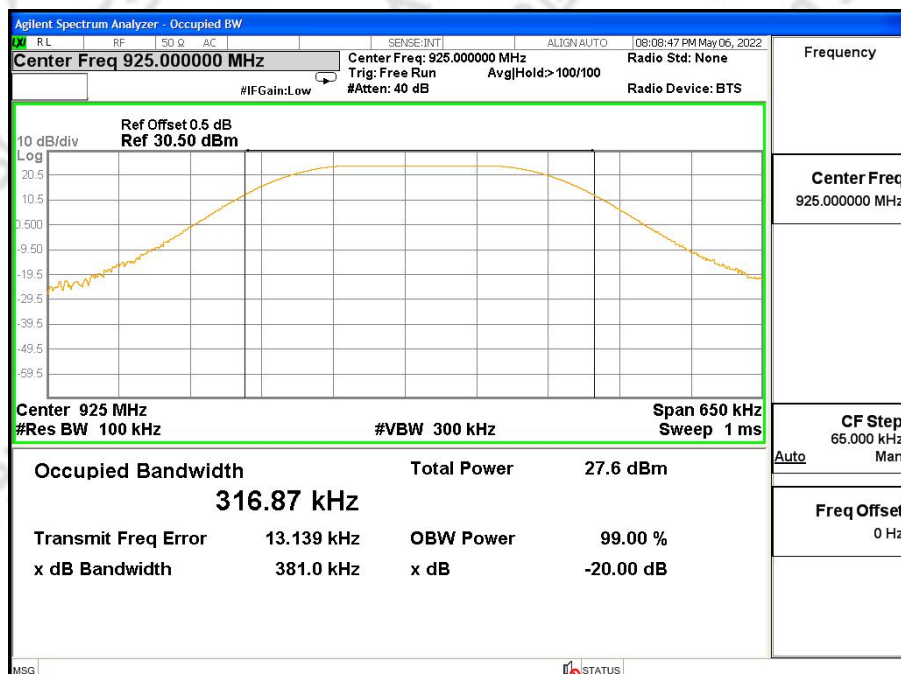
CH01



CH22



CH43



9. OUTPUT POWER TEST

9.1 LIMIT

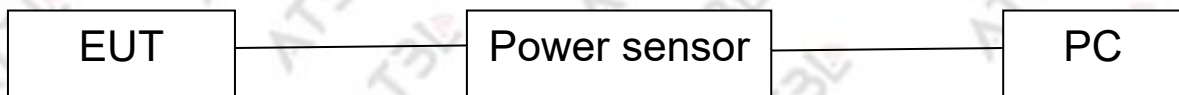
FCC Part15.247,Subpart C				
Section	Test Item	Limit	FrequencyRange (MHz)	Result
15.247(b)(2)	Output Power	250mW	902-928	PASS

9.2 TEST PROCEDURE

PKPM1 Peak power meter method:

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DSSS bandwidth and shall use a fast-responding diode detector.

9.3 TEST SETUP



9.4 EUT OPERATION CONDITIONS

The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

9.5 TEST RESULTS

Temperature:	25°C	Relative Humidity:	50%
Test Voltage:	DC 5V		

Test mode	Frequency	Peak Conducted Output Power	AVG Conducted Output Power	LIMIT
	(MHz)	(dBm)	(dBm)	dBm
Mode 1	904	23.07	21.13	24
Mode 2	914.5	23.38	20.61	24
Mode 3	925	23.65	20.53	24

EIRP Power

Test mode	Frequency	Peak Conducted Output Power	Antenna Gain	ERP Power	EIRP Power	LIMIT
	(MHz)	(dBm)	(dBi)	(dBm)	(dBm)	dBm
Mode 1	904	23.07	1.8	22.72	24.87	30
Mode 2	914.5	23.38	1.8	23.03	25.18	30
Mode 3	925	23.65	1.8	23.3	25.45	30

Note: EIRP = ERP+2.15dB.

10. ANTENNA REQUIREMENT

10.1 STANDARD REQUIREMENT

15.203&RSS-Gen Issue 5 requirement: For intentional device, according to 15.203&RSS-Gen Issue 5: 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.

10.2 EUT ANTENNA

Antenna Type	Frequency range	Gain (dBi)
Single-band Antenna	902MHz-928MHz	1.8

It comply with the standard requirement.

APPENDIX-PHOTOS OF TEST SETUP

Note: See test photos in setup photo document for the actual connections between Product and support equipment.

Conducted for RF



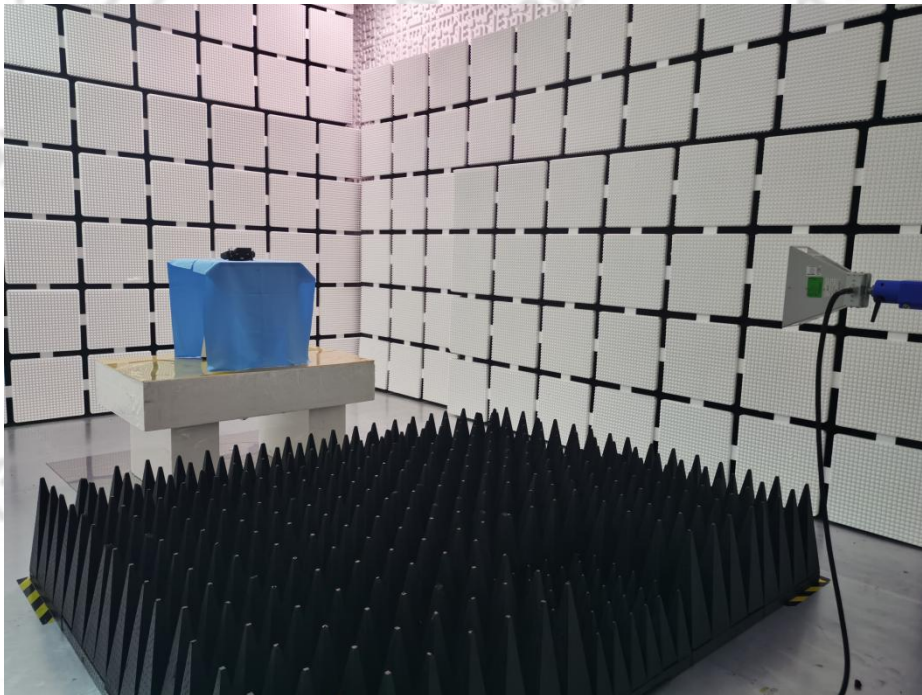
Radiation Emission
30MHz-1000MHz



Radiated Spurious Emission
30MHz-1000MHz



1GHz-18GHz



*****END OF THE REPORT*****