



# FCC RADIO TEST REPORT

**FCC ID** : 2AEUPBHARC011  
**Equipment** : Spotlight cam wired  
**Brand Name** : Ring  
**Model Name** : 5L5C4T  
**Applicant** : Ring LLC  
1523 26th St Santa Monica, CA 90404 USA  
**Manufacturer** : Ring LLC  
1523 26th St Santa Monica, CA 90404 USA  
**Standard** : FCC Part 15 Subpart C §15.247

The product was received on Aug. 31, 2021 and testing was performed from Jan. 28, 2022 to Apr. 24, 2022. We, Sporton International Inc. Wensan Laboratory, would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval from Sporton International Inc. Wensan Laboratory, the test report shall not be reproduced except in full.

Approved by: Louis Wu

**Sporton International Inc. Wensan Laboratory**

No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City 333010, Taiwan (R.O.C)



## Table of Contents

<b>History of this test report.....</b>	<b>3</b>
<b>Summary of Test Result.....</b>	<b>4</b>
<b>1 General Description .....</b>	<b>5</b>
1.1 Product Feature of Equipment Under Test.....	5
1.2 Modification of EUT .....	5
1.3 Testing Location .....	5
1.4 Applicable Standards.....	6
<b>2 Test Configuration of Equipment Under Test .....</b>	<b>7</b>
2.1 Carrier Frequency and Channel .....	7
2.2 Test Mode.....	8
2.3 Connection Diagram of Test System.....	9
2.4 Support Unit used in test configuration and system .....	9
2.5 EUT Operation Test Setup .....	9
2.6 Measurement Results Explanation Example.....	10
<b>3 Test Result .....</b>	<b>11</b>
3.1 6dB and 99% Bandwidth Measurement .....	11
3.2 Output Power Measurement.....	22
3.3 Power Spectral Density Measurement .....	23
3.4 Conducted Band Edges and Spurious Emission Measurement .....	29
3.5 Radiated Band Edges and Spurious Emission Measurement .....	45
3.6 AC Conducted Emission Measurement.....	49
3.7 Antenna Requirements.....	51
<b>4 List of Measuring Equipment.....</b>	<b>52</b>
<b>5 Uncertainty of Evaluation .....</b>	<b>54</b>
<b>Appendix A. Conducted Test Results</b>	
<b>Appendix B. AC Conducted Emission Test Result</b>	
<b>Appendix C. Radiated Spurious Emission</b>	
<b>Appendix D. Radiated Spurious Emission Plots</b>	
<b>Appendix E. Duty Cycle Plots</b>	
<b>Appendix F. Setup Photographs</b>	



## History of this test report

Report No.	Version	Description	Issue Date
FR240817B	01	Initial issue of report	Apr. 29, 2022
FR240817B	02	1. Revise Equipment Name 2. Add remark for Radiated Spurious Emission Plots	Sep. 23, 2022

## Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	15.247(a)(2)	6dB Bandwidth	Pass	-
3.1	2.1049	99% Occupied Bandwidth	Reporting only	-
3.2	15.247(b)(3)	Power Output Measurement	Pass	-
3.3	15.247(e)	Power Spectral Density	Pass	-
3.4	15.247(d)	Conducted Band Edges	Pass	-
		Conducted Spurious Emission	Pass	-
3.5	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	Pass	4.53 dB under the limit at 44.550 MHz
3.6	15.207	AC Conducted Emission	Pass	18.35 dB under the limit at 12.968 MHz
3.7	15.203 & 15.247(b)	Antenna Requirement	Pass	-

**Declaration of Conformity:**

- The test results (PASS/FAIL) with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers. It's means measurement values may risk exceeding the limit of regulation standards, if measurement uncertainty is include in test results.
- The measurement uncertainty please refer to this report "Uncertainty of Evaluation".

**Comments and Explanations:**

The product specifications of the EUT presented in the report are declared by the manufacturer who shall take full responsibility for the authenticity.

**Reviewed by: Keven Cheng**

**Report Producer: Vivian Hsu**

# 1 General Description

## 1.1 Product Feature of Equipment Under Test

LoRa

Product Feature		
Antenna Type	PIFA Antenna	
Antenna information		
902 MHz ~ 928 MHz	Peak Gain (dBi)	0.73

**Remark:** The above EUT's information was declared by manufacturer. Please refer to Comments and Explanations in report summary.

## 1.2 Modification of EUT

No modifications made to the EUT during the testing.

## 1.3 Testing Location

Test Site	Sporton International Inc. EMC & Wireless Communications Laboratory	
Test Site Location	No.52, Huaya 1st Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C.) TEL: +886-3-327-3456 FAX: +886-3-328-4978	
Test Site No.	Sporton Site No. TH02-HY (TAF Code: 1190)	
Remark	The Conducted test item subcontracted to Sporton International Inc. EMC & Wireless Communications Laboratory	
Test Site	Sporton International Inc. Wensan Laboratory	
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City 333010, Taiwan (R.O.C.) TEL: +886-3-327-0868 FAX: +886-3-327-0855	
Test Site No.	Sporton Site No. 03CH12-HY, CO07-HY	

**Note:** The test site complies with ANSI C63.4 2014 requirement.

FCC designation No.: TW1190 and TW3786



## 1.4 Applicable Standards

According to the specifications declared by the manufacturer, the EUT must comply with the requirements of the following standards:

- ♦ FCC Part 15 Subpart C §15.247
- ♦ FCC KDB Publication No. 558074 D01 15.247 Meas Guidance v05r02
- ♦ FCC KDB 414788 D01 Radiated Test Site v01r01.
- ♦ ANSI C63.10-2013

**Remark:**

1. All the test items were validated and recorded in accordance with the standards without any modification during the testing.
2. The TAF code is not including all the FCC KDB listed without accreditation.

## 2 Test Configuration of Equipment Under Test

- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, the measured emission level of the EUT was maximized by rotating the EUT on a turntable, adjusting the orientation of the EUT and EUT antenna in three orthogonal axis (X: flat, Y: portrait, Z: landscape), and adjusting the measurement antenna orientation, following C63.10 exploratory test procedures and find Z plane as worst plane.
- b. AC power line Conducted Emission was tested under maximum output power.

### 2.1 Carrier Frequency and Channel

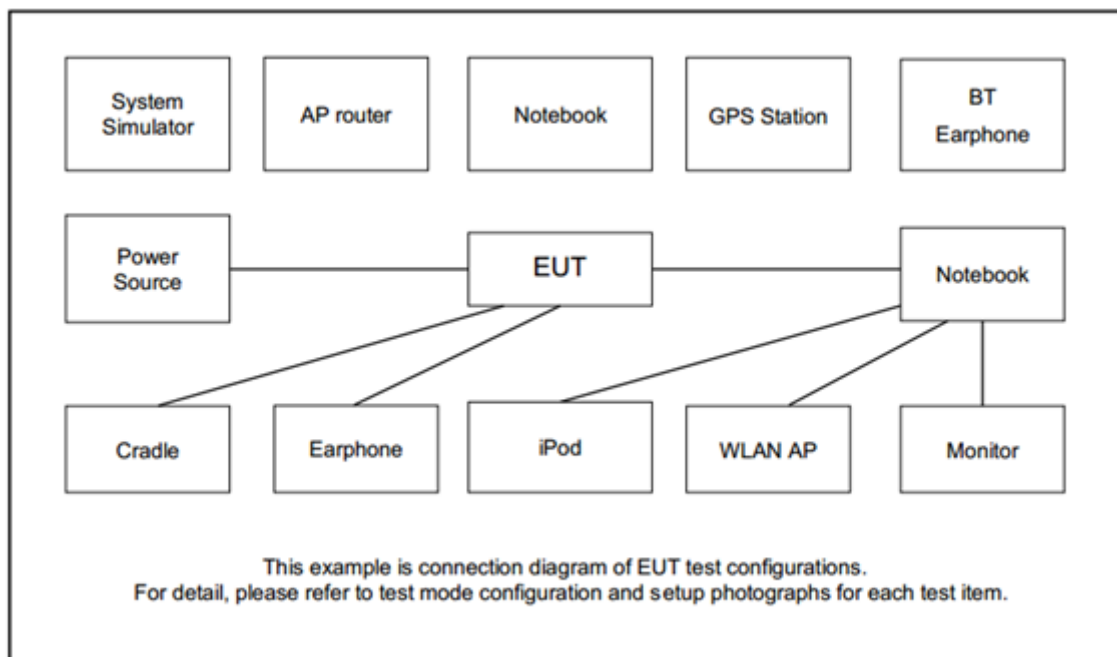
Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
902 – 928 MHz	1	902.5	17	915.3
	2	903.3	18	916.1
	3	904.1	19	916.9
	4	904.9	20	917.7
	5	905.7	21	918.5
	6	906.5	22	919.3
	7	907.3	23	920.1
	8	908.1	24	920.9
	9	908.9	25	921.7
	10	909.7	26	922.5
	11	910.5	27	923.3
	12	911.3	28	924.1
	13	912.1	29	924.9
	14	912.9	30	925.7
	15	913.7	31	926.5
	16	914.5		

## 2.2 Test Mode

Summary table of Test Cases		
Test Item	Feature	LoRa
<b>Conducted Test Cases</b>	<b>LoRa 500 KHz DTS_SF5</b>	Mode 1: CH01 Tx_902.50 MHz Mode 2: CH16 Tx_914.50 MHz Mode 3: CH31 Tx_926.50 MHz
	<b>LoRa 500 KHz DTS_SF8</b>	Mode 4: CH01 Tx_902.50 MHz Mode 5: CH16 Tx_914.50 MHz Mode 6: CH31 Tx_926.50 MHz
	<b>LoRa 500 KHz DTS_SF9</b>	Mode 7: CH01 Tx_902.50 MHz Mode 8: CH16 Tx_914.50 MHz Mode 9: CH31 Tx_926.50 MHz
	<b>LoRa 500 KHz DTS_SF10</b>	Mode 10: CH01 Tx_902.50 MHz Mode 11: CH16 Tx_914.50 MHz Mode 12: CH31 Tx_926.50 MHz
	<b>LoRa 500 KHz DTS_SF11</b>	Mode 13: CH01 Tx_902.50 MHz Mode 14: CH16 Tx_914.50 MHz Mode 15: CH31 Tx_926.50 MHz
<b>Radiated Test Cases</b>	<b>LoRa 500 KHz DTS_SF5</b>	Mode 1: CH01 Tx_902.50 MHz Mode 2: CH16 Tx_914.50 MHz Mode 3: CH31 Tx_926.50 MHz
<b>AC Conducted Emission</b>	Mode 1: LoRa Tx + USB Cable (Charging from Adapter)	



## 2.3 Connection Diagram of Test System



## 2.4 Support Unit used in test configuration and system

Item	Equipment	Brand Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Adapter	DVE	DSA-5PFM-05 FUS	FCC DoC	N/A	N/A
2.	USB Cable	NA	NA	N/A	N/A	N/A

## 2.5 EUT Operation Test Setup

The RF test items, utility “J-Link RTT Viewer V7.54a” was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to provide channel selection, power level, data rate and the application type and for continuous transmitting signals.

## 2.6 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

*Offset = RF cable loss + attenuator factor.*

Following shows an offset computation example with cable loss 4.2 dB and 10 dB attenuator.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 4.2 + 10 = 14.2 \text{ (dB)}\end{aligned}$$

### 3 Test Result

#### 3.1 6dB and 99% Bandwidth Measurement

##### 3.1.1 Limit of 6dB and 99% Bandwidth

The minimum 6 dB bandwidth shall be at least 500 kHz.

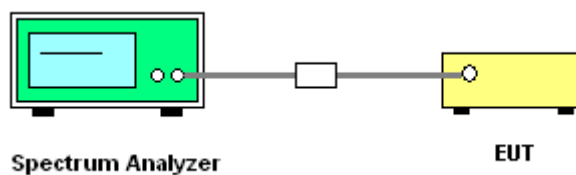
##### 3.1.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

##### 3.1.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 6.9.3 (OBW) and 11.8.1 (6dB BW).
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. Set the Video bandwidth (VBW) = 300 kHz. In order to make an accurate measurement. The 6 dB bandwidth must be greater than 500 kHz.
5. For 99% Bandwidth Measurement, the spectrum analyzer's resolution bandwidth (RBW) is set 1-5% of the emission bandwidth and set the Video bandwidth (VBW)  $\geq 3 * RBW$ .
6. Measure and record the results in the test report.

##### 3.1.4 Test Setup





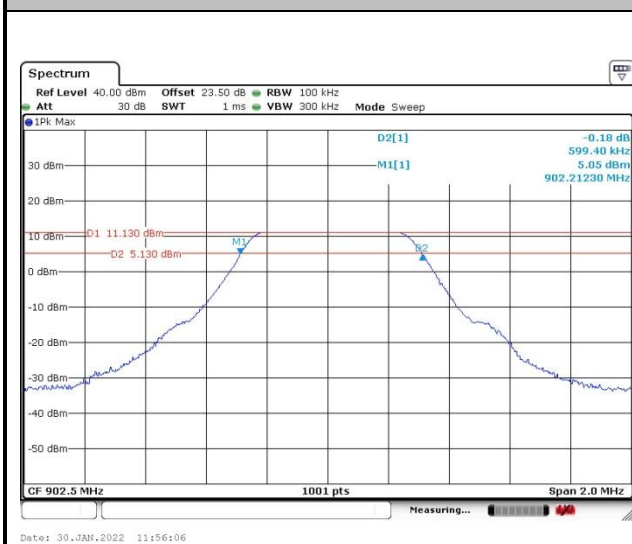
### 3.1.5 Test Result of 6dB and 99% Occupied Bandwidth

Please refer to Appendix A.

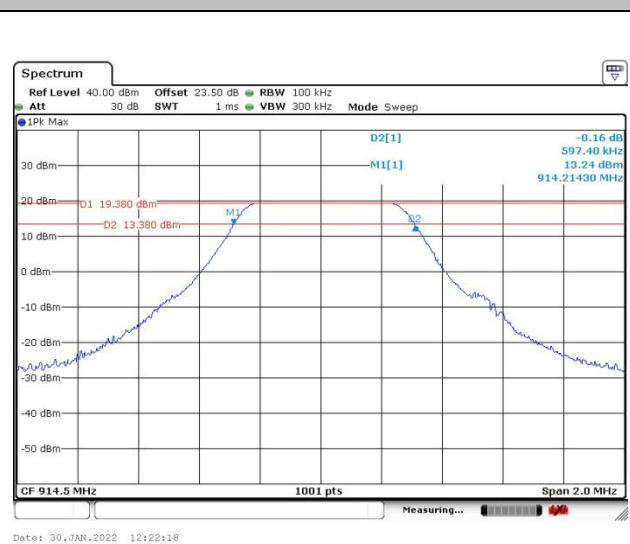
<LoRa 500kHz DTS>

<Data Rate: SF5>

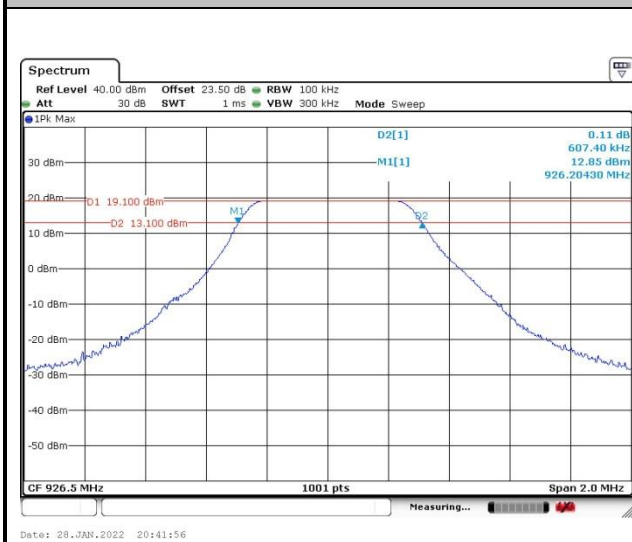
6 dB Bandwidth Plot on Channel 1



6 dB Bandwidth Plot on Channel 16



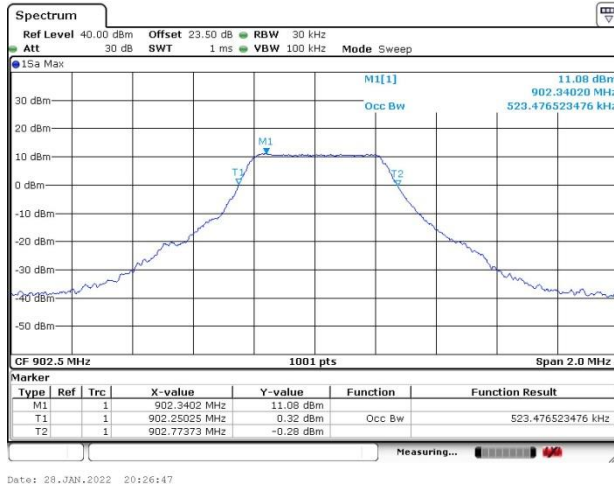
6 dB Bandwidth Plot on Channel 31



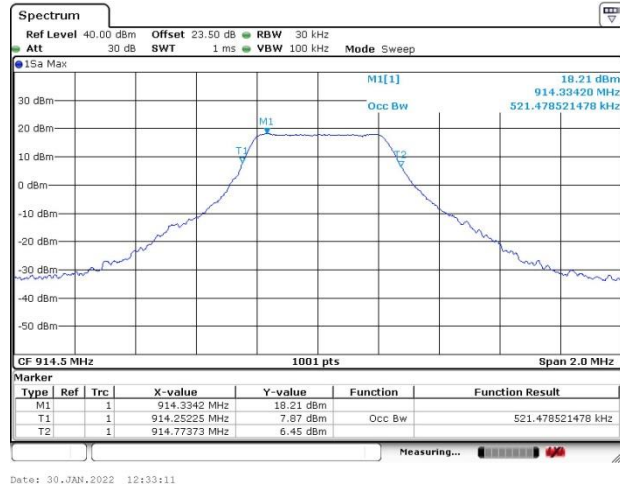
N/A



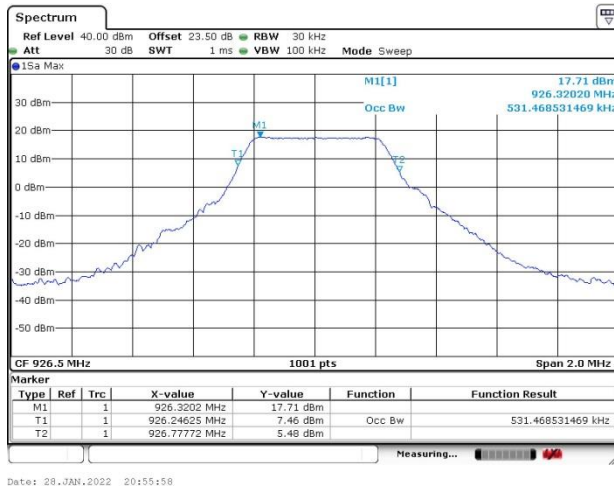
## 99% Occupied Bandwidth Plot on Channel 1



## 99% Occupied Plot Bandwidth on Channel 16



## 99% Occupied Bandwidth Plot on Channel 31



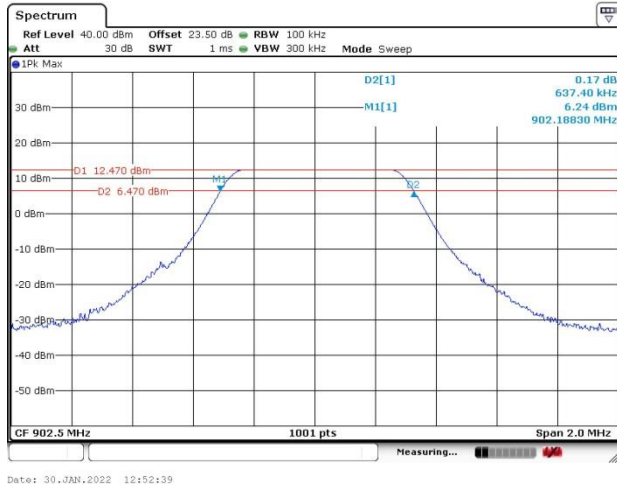
N/A

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

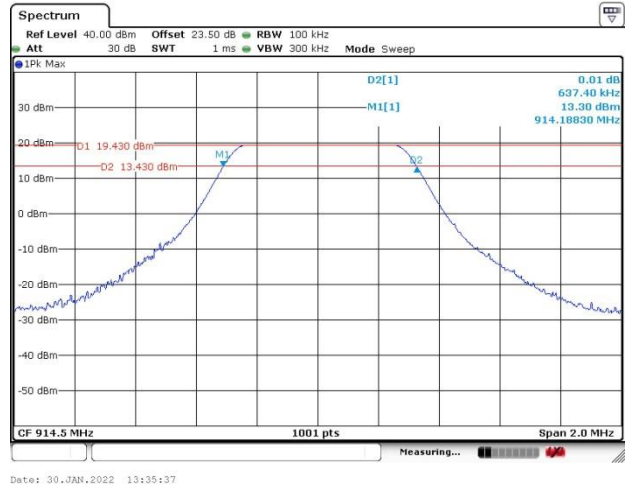


&lt;Data Rate: SF8&gt;

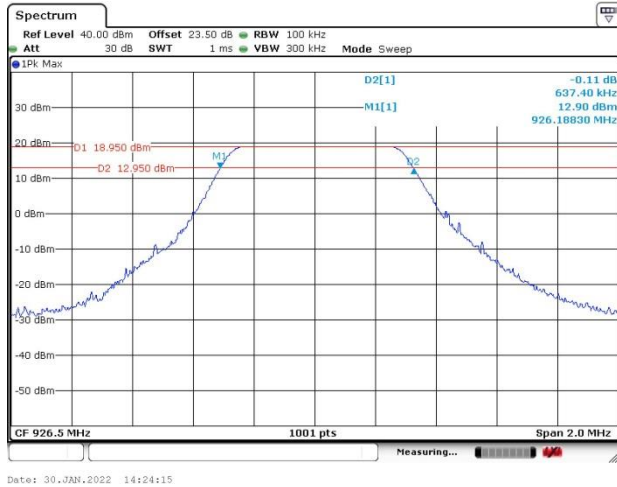
6 dB Bandwidth Plot on Channel 1



6 dB Bandwidth Plot on Channel 16



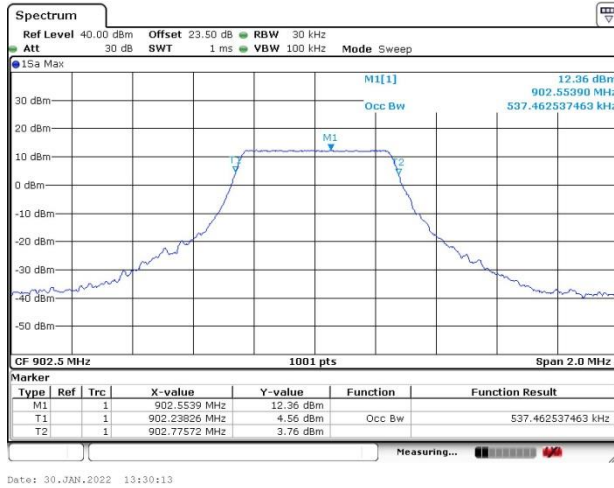
6 dB Bandwidth Plot on Channel 31



N/A



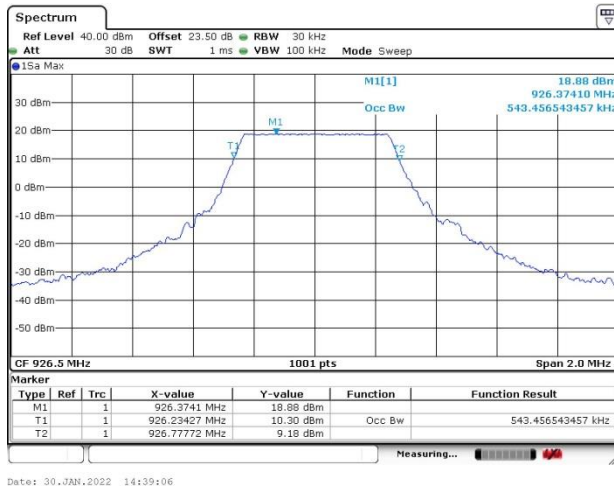
99% Occupied Bandwidth Plot on Channel 1



99% Occupied Plot Bandwidth on Channel 16



99% Occupied Bandwidth Plot on Channel 31



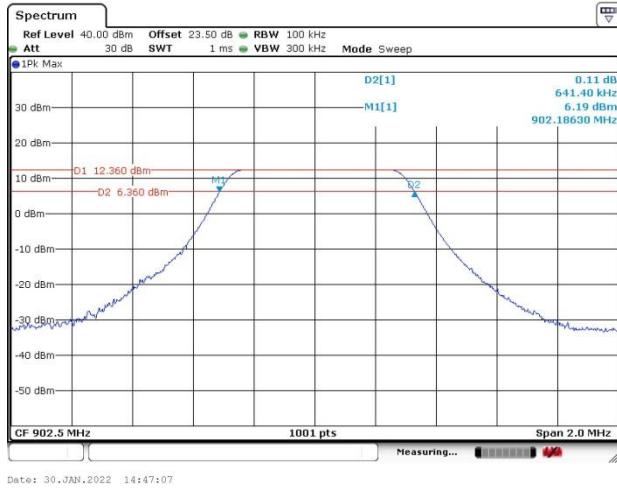
N/A

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

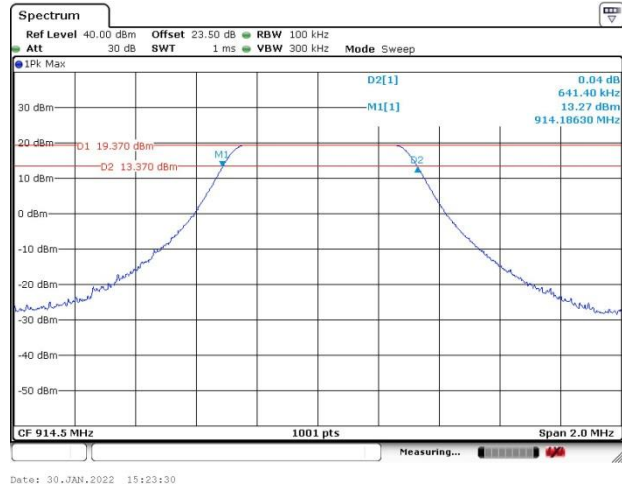


&lt;Data Rate: SF9&gt;

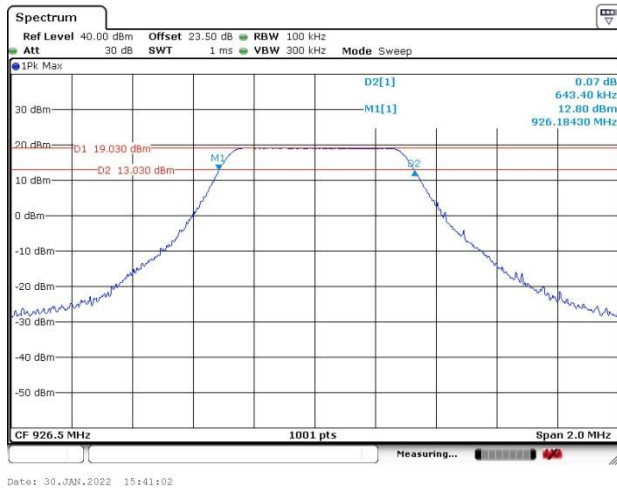
6 dB Bandwidth Plot on Channel 1



6 dB Bandwidth Plot on Channel 16



6 dB Bandwidth Plot on Channel 31

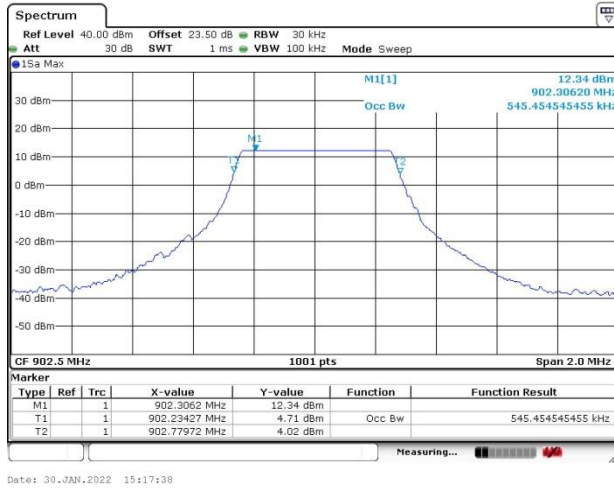


N/A

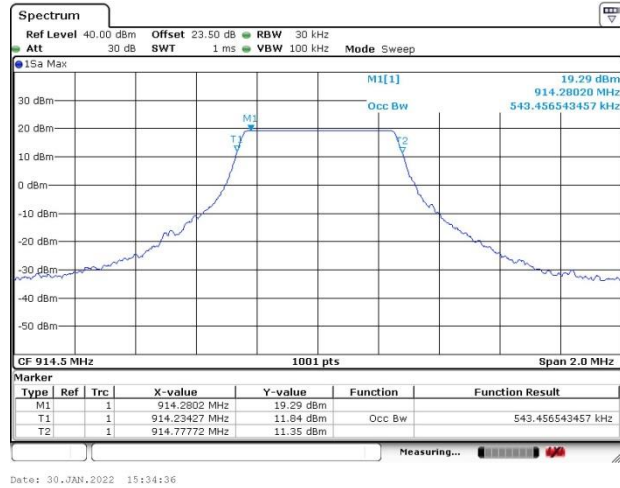




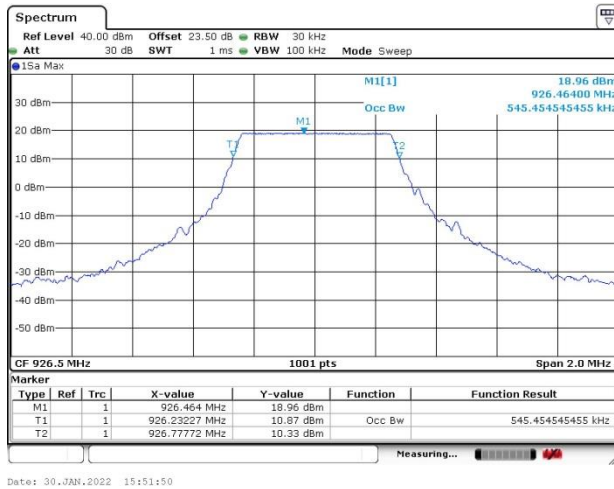
## 99% Occupied Bandwidth Plot on Channel 1



## 99% Occupied Plot Bandwidth on Channel 16



## 99% Occupied Bandwidth Plot on Channel 31



N/A

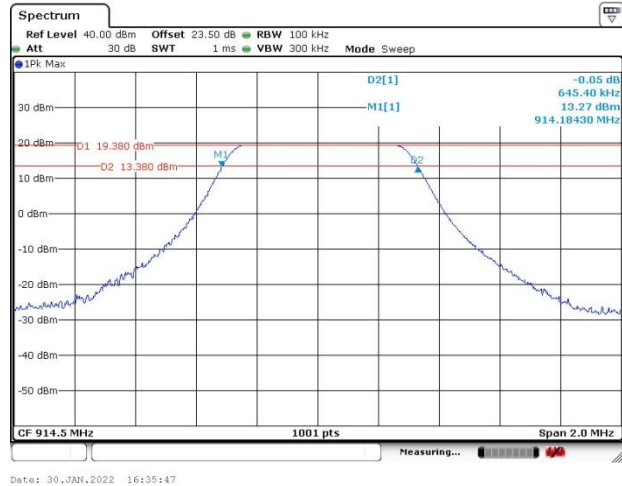
Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

**<Data Rate: SF10>**

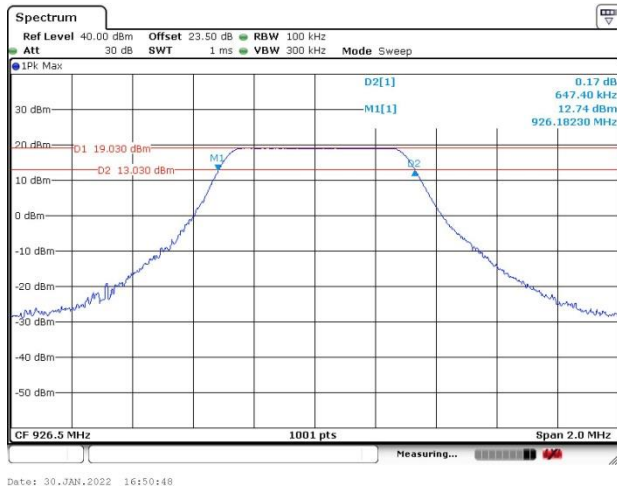
### 6 dB Bandwidth Plot on Channel 1



### 6 dB Bandwidth Plot on Channel 16



### 6 dB Bandwidth Plot on Channel 31



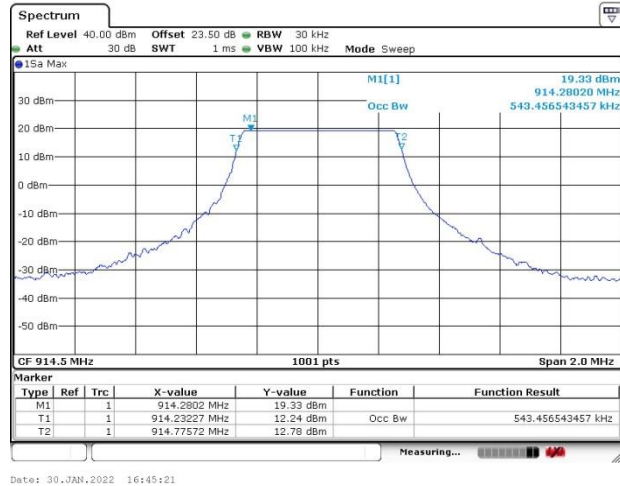
**N/A**



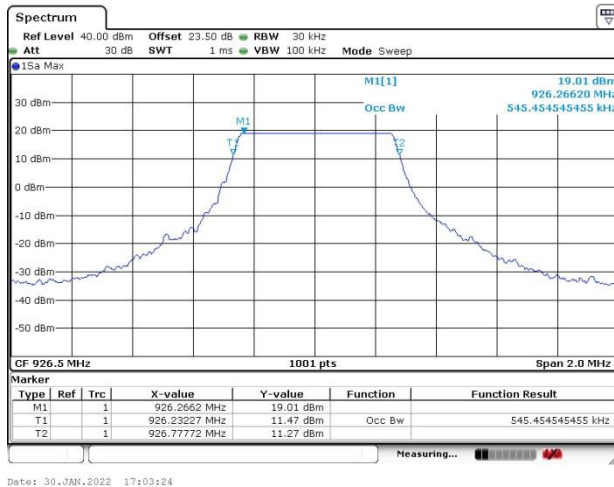
99% Occupied Bandwidth Plot on Channel 1



99% Occupied Plot Bandwidth on Channel 16



99% Occupied Bandwidth Plot on Channel 31



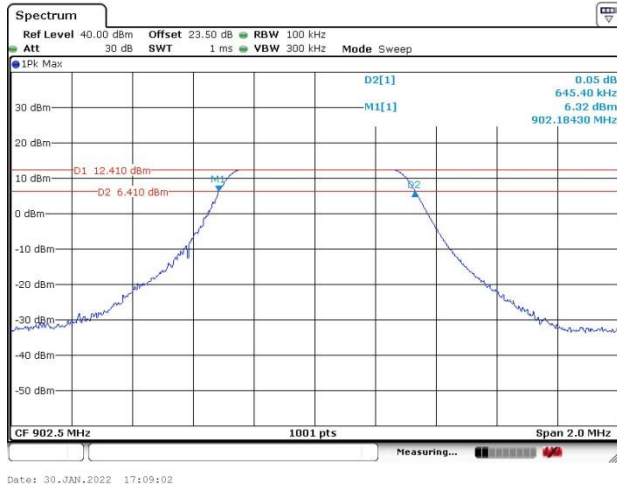
N/A

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

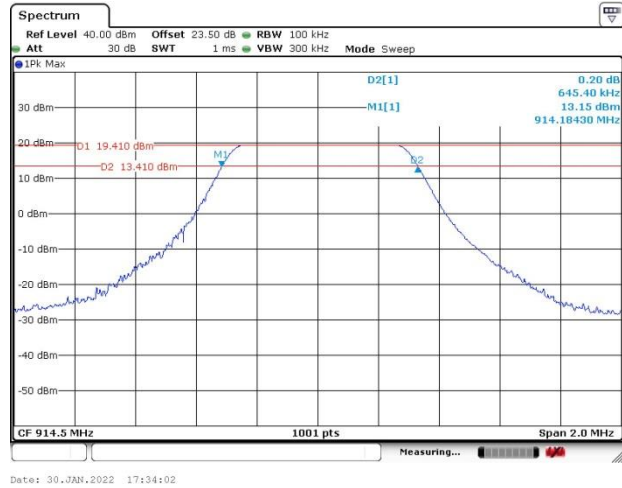


&lt;Data Rate: SF11&gt;

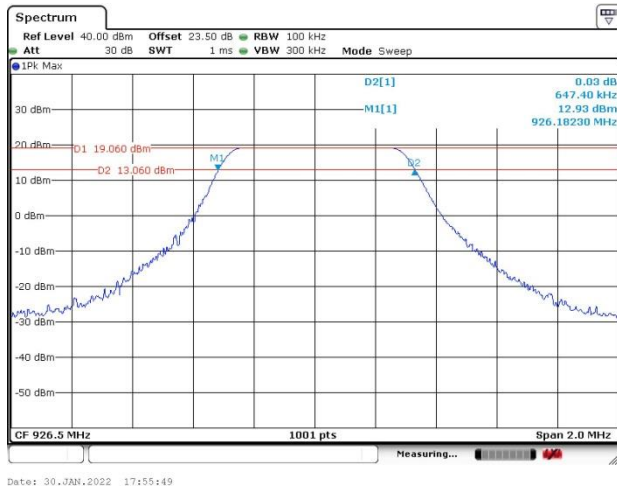
6 dB Bandwidth Plot on Channel 1



6 dB Bandwidth Plot on Channel 16



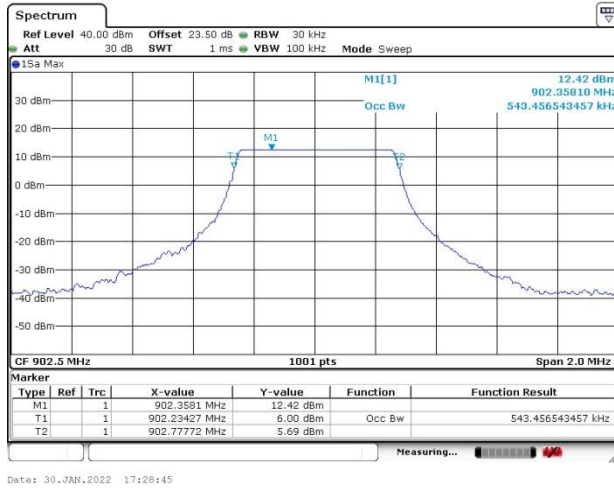
6 dB Bandwidth Plot on Channel 31



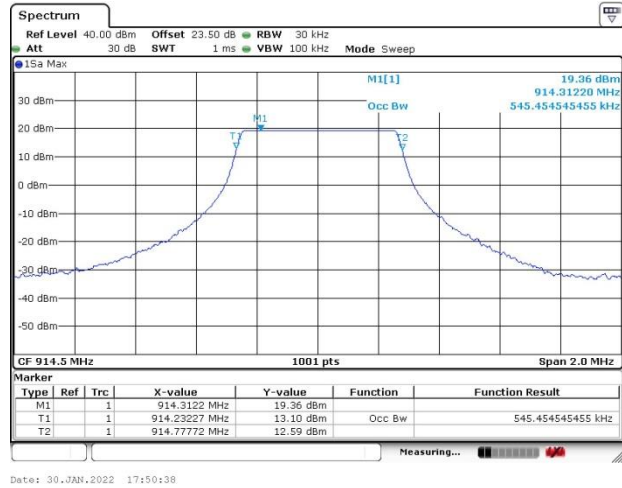
N/A



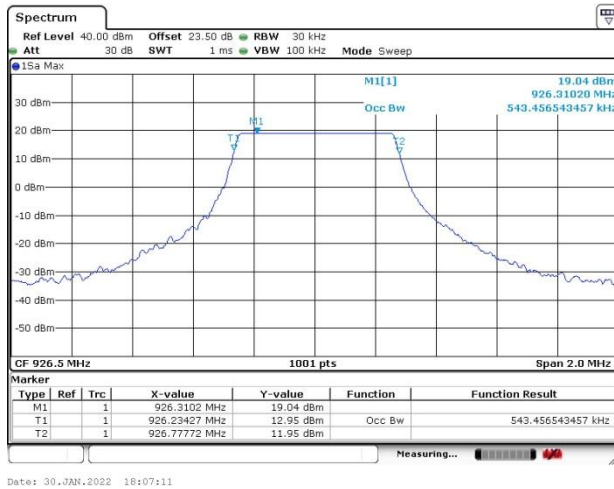
99% Occupied Bandwidth Plot on Channel 1



99% Occupied Plot Bandwidth on Channel 16



99% Occupied Bandwidth Plot on Channel 31



N/A

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

## 3.2 Output Power Measurement

### 3.2.1 Limit of Output Power

Section 15.247(b)(3) For systems using digital modulation in the 902-928 MHz, the limit for peak output power is 1 watt.

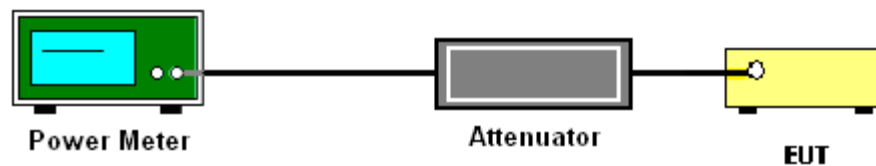
### 3.2.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

### 3.2.3 Test Procedures

1. For Average Power, the testing follows ANSI C63.10 Section 11.9.2.3.2 Method AVGPM-G
2. The RF output of EUT is connected to the power meter by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Measure the conducted output power and record the results in the test report.

### 3.2.4 Test Setup



### 3.2.5 Test Result of Average Output Power

Please refer to Appendix A.

### 3.3 Power Spectral Density Measurement

#### 3.3.1 Limit of Power Spectral Density

The peak power spectral density shall not be greater than 8 dBm in any 3 kHz band at any time interval of continuous transmission.

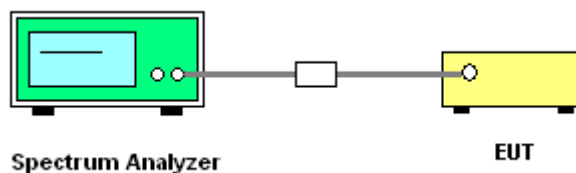
#### 3.3.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

#### 3.3.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 11.10.2 Method PKPSD.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 3 kHz. Video bandwidth VBW = 10 kHz In order to make an accurate measurement, set the span to 1.5 times DTS Channel Bandwidth. (6dB BW)
5. Detector = peak, Sweep time = auto couple, Trace mode = max hold, Allow trace to fully stabilize. Use the peak marker function to determine the maximum power level.
6. Measure and record the results in the test report.

#### 3.3.4 Test Setup



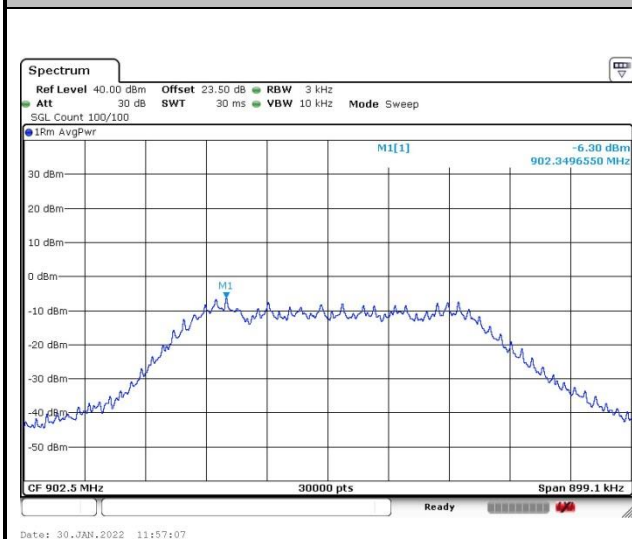


### 3.3.5 Test Result of Power Spectral Density

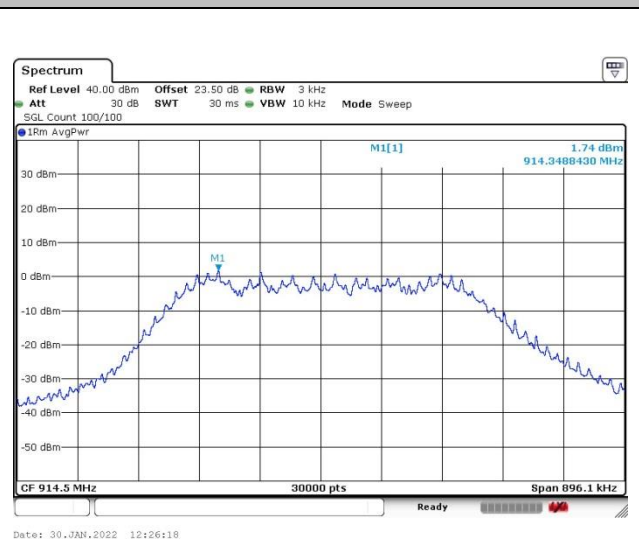
Please refer to Appendix A.

<Data Rate: SF5>

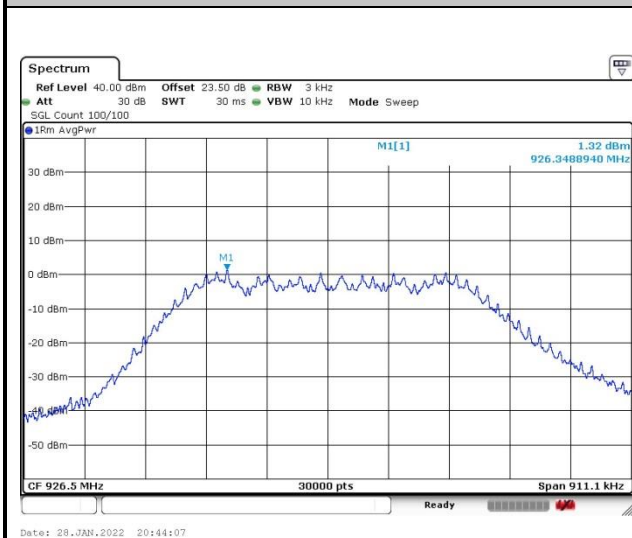
Power Density (dBm/3kHz) Plot Channel 1



Power Density (dBm/3kHz) Plot Channel 16



Power Density (dBm/3kHz) Plot Channel 31



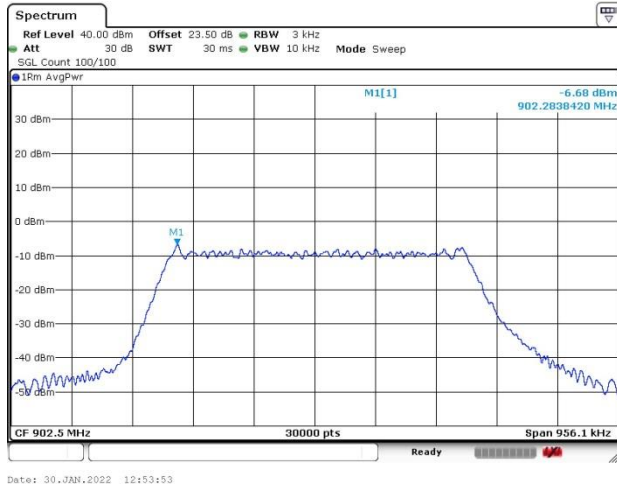
N/A



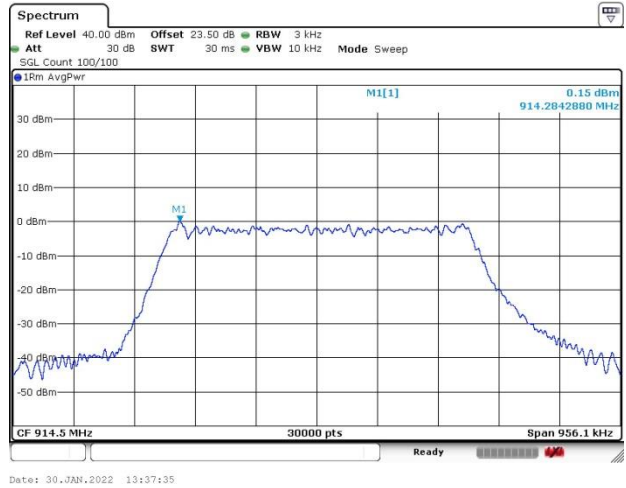


&lt;Data Rate: SF8&gt;

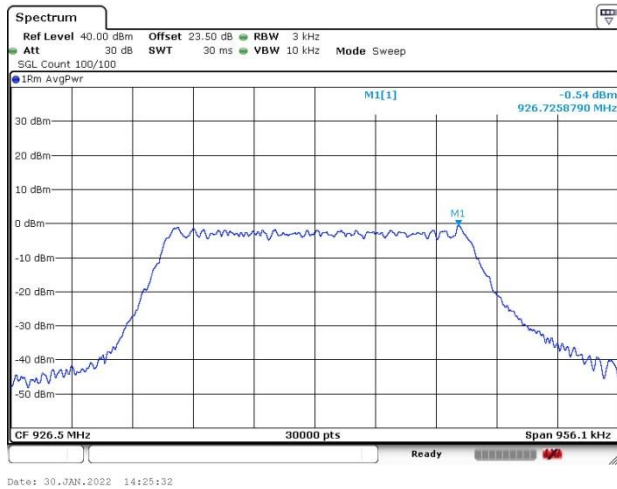
Power Density (dBm/3kHz) Plot Channel 1



Power Density (dBm/3kHz) Plot Channel 16



Power Density (dBm/3kHz) Plot Channel 31

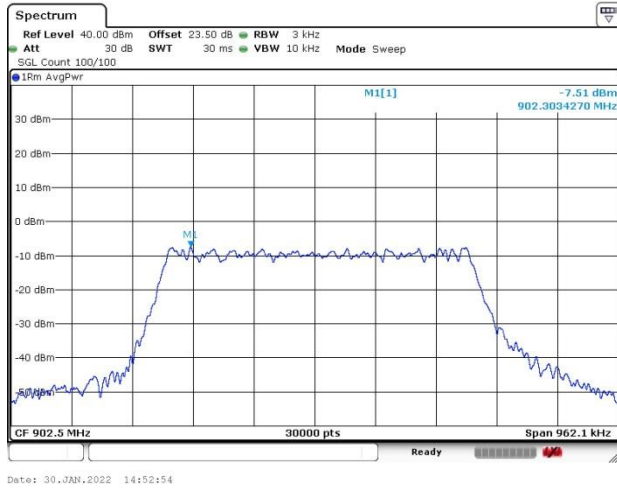


N/A

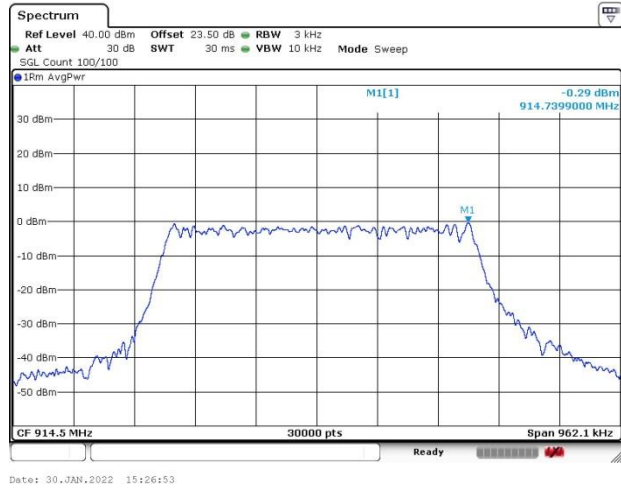


&lt;Data Rate: SF9&gt;

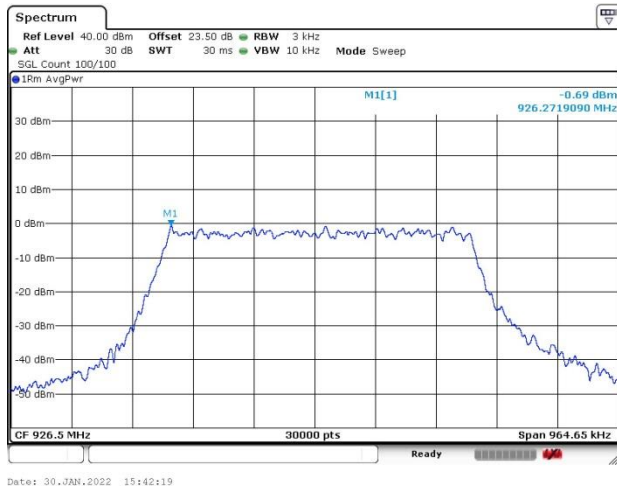
Power Density (dBm/3kHz) Plot Channel 1



Power Density (dBm/3kHz) Plot Channel 16



Power Density (dBm/3kHz) Plot Channel 31

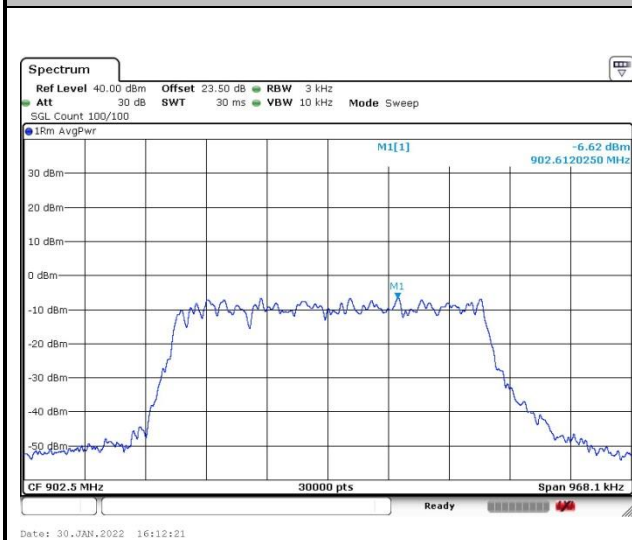


N/A

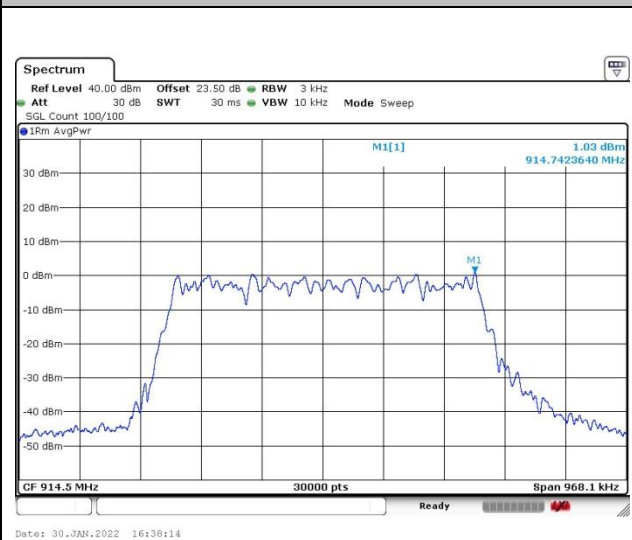


&lt;Data Rate: SF10&gt;

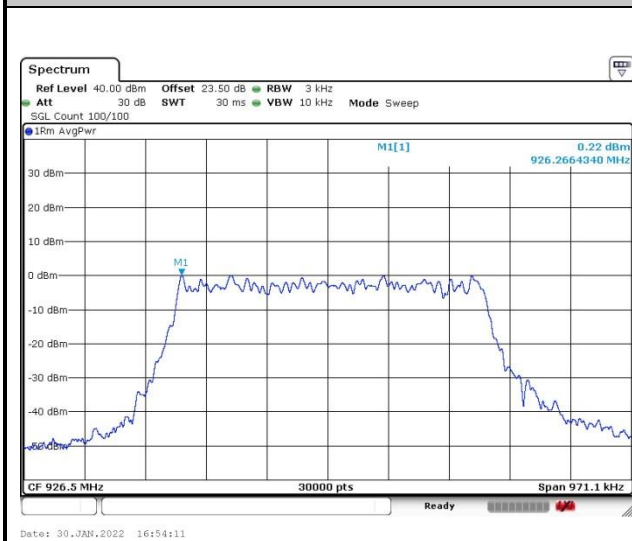
Power Density (dBm/3kHz) Plot Channel 1



Power Density (dBm/3kHz) Plot Channel 16



Power Density (dBm/3kHz) Plot Channel 31

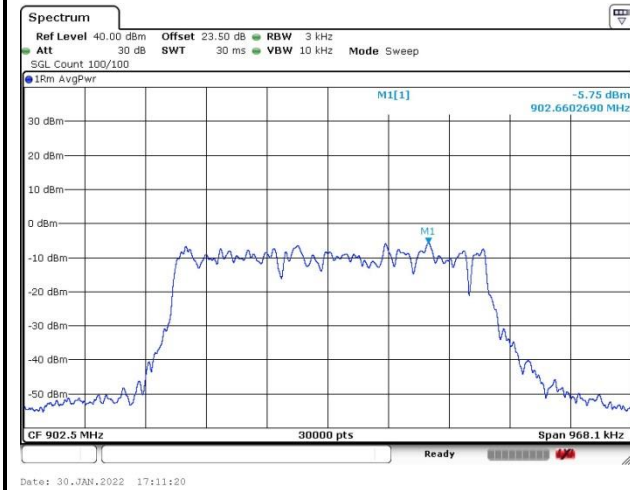


N/A

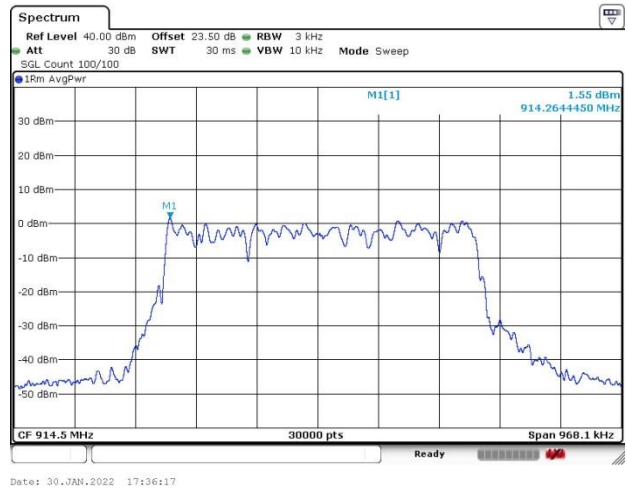


&lt;Data Rate: SF11&gt;

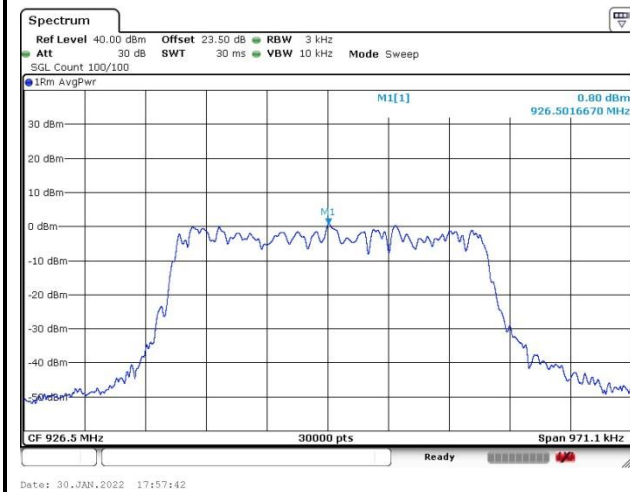
Power Density (dBm/3kHz) Plot Channel 1



Power Density (dBm/3kHz) Plot Channel 16



Power Density (dBm/3kHz) Plot Channel 31



N/A

### 3.4 Conducted Band Edges and Spurious Emission Measurement

#### 3.4.1 Limit of Conducted Band Edges and Spurious Emission Measurement

In any 100 kHz bandwidth outside of the authorized frequency band, the emissions which fall in the non-restricted bands shall be attenuated at least 20 dB / 30dB relative to the maximum PSD level in 100 kHz by RF conducted measurement.

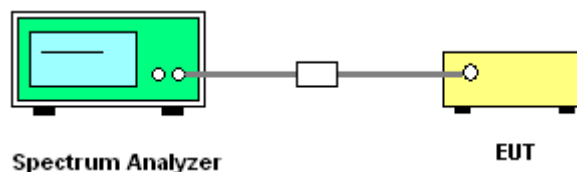
#### 3.4.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

#### 3.4.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 11.11.3 Emission level measurement.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Set RBW = 100 kHz, VBW=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB per 15.247(d).
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

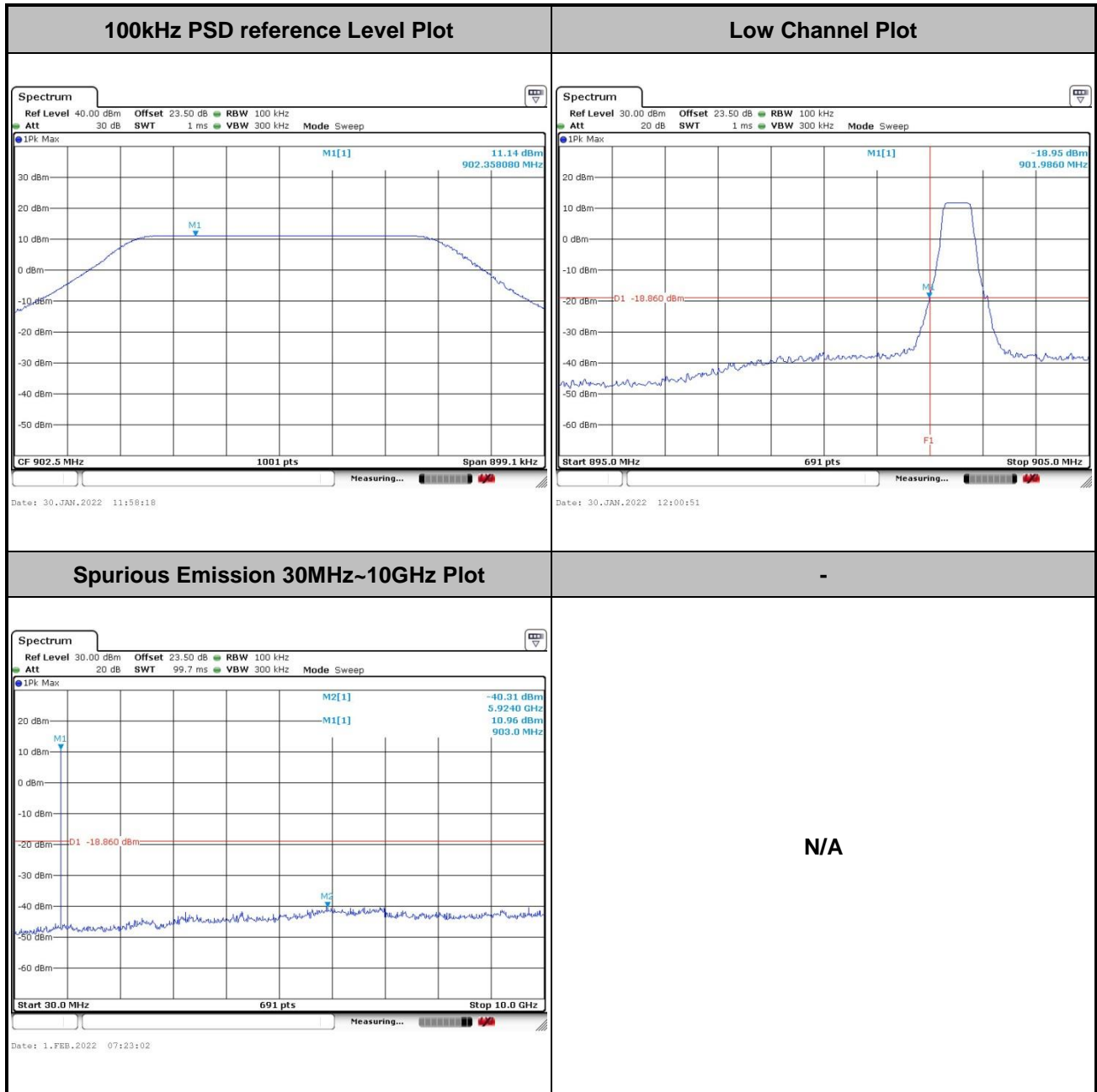
#### 3.4.4 Test Setup





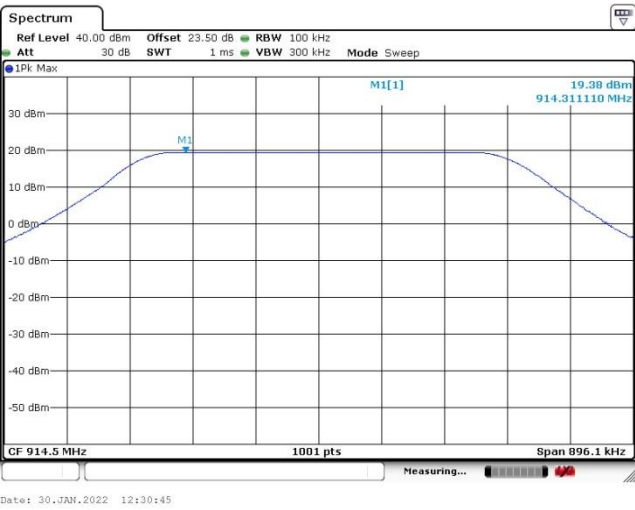
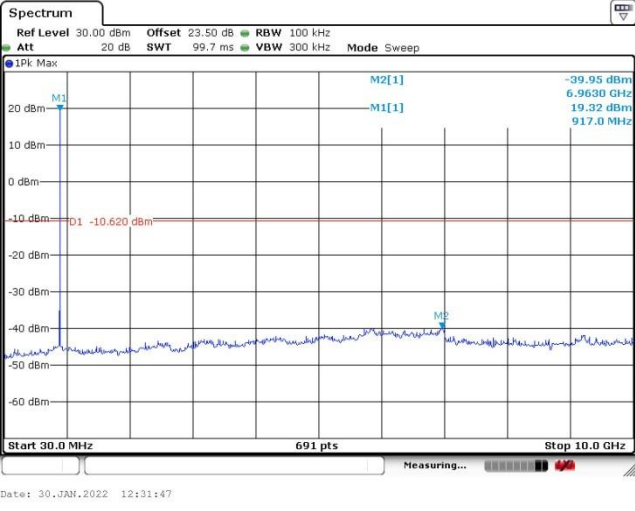
## 3.4.5 Test Result of Conducted Band Edges and Spurious Emission

&lt;Data Rate: SF5&gt;



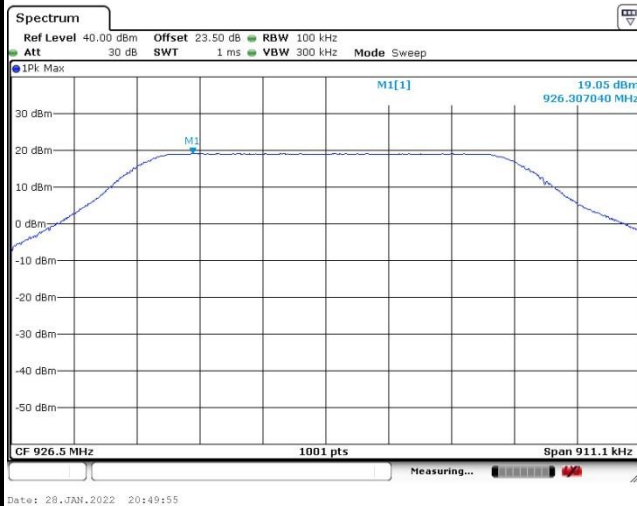
N/A



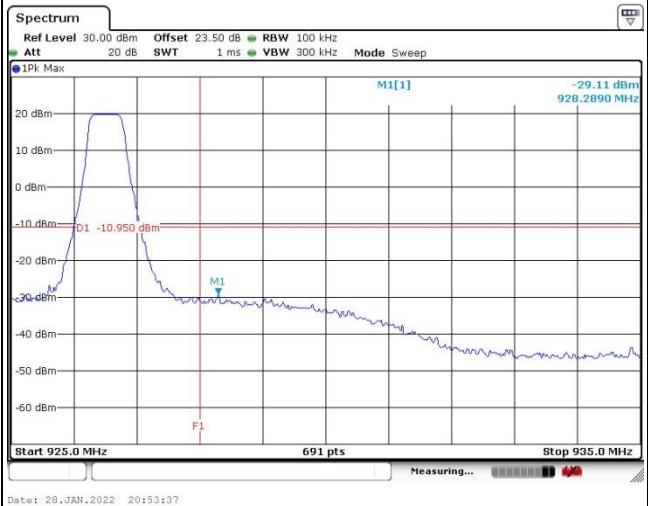
100kHz PSD reference Level Plot	Middle Channel Plot
	
Spurious Emission 30MHz~10GHz Plot	-
	N/A



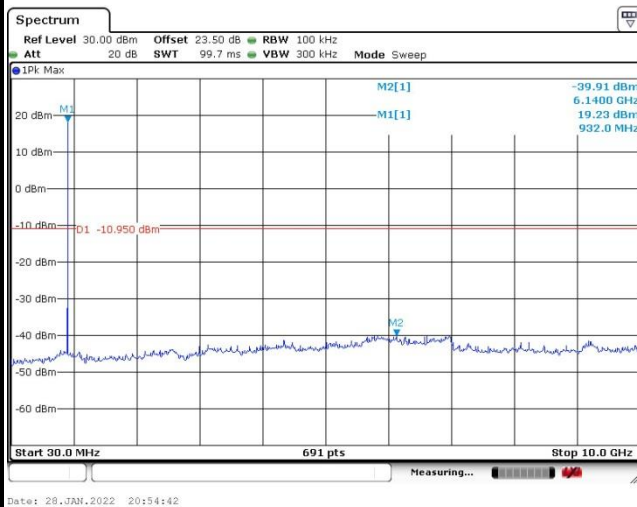
100kHz PSD reference Level Plot



High Channel Plot



Spurious Emission 30MHz~10GHz Plot

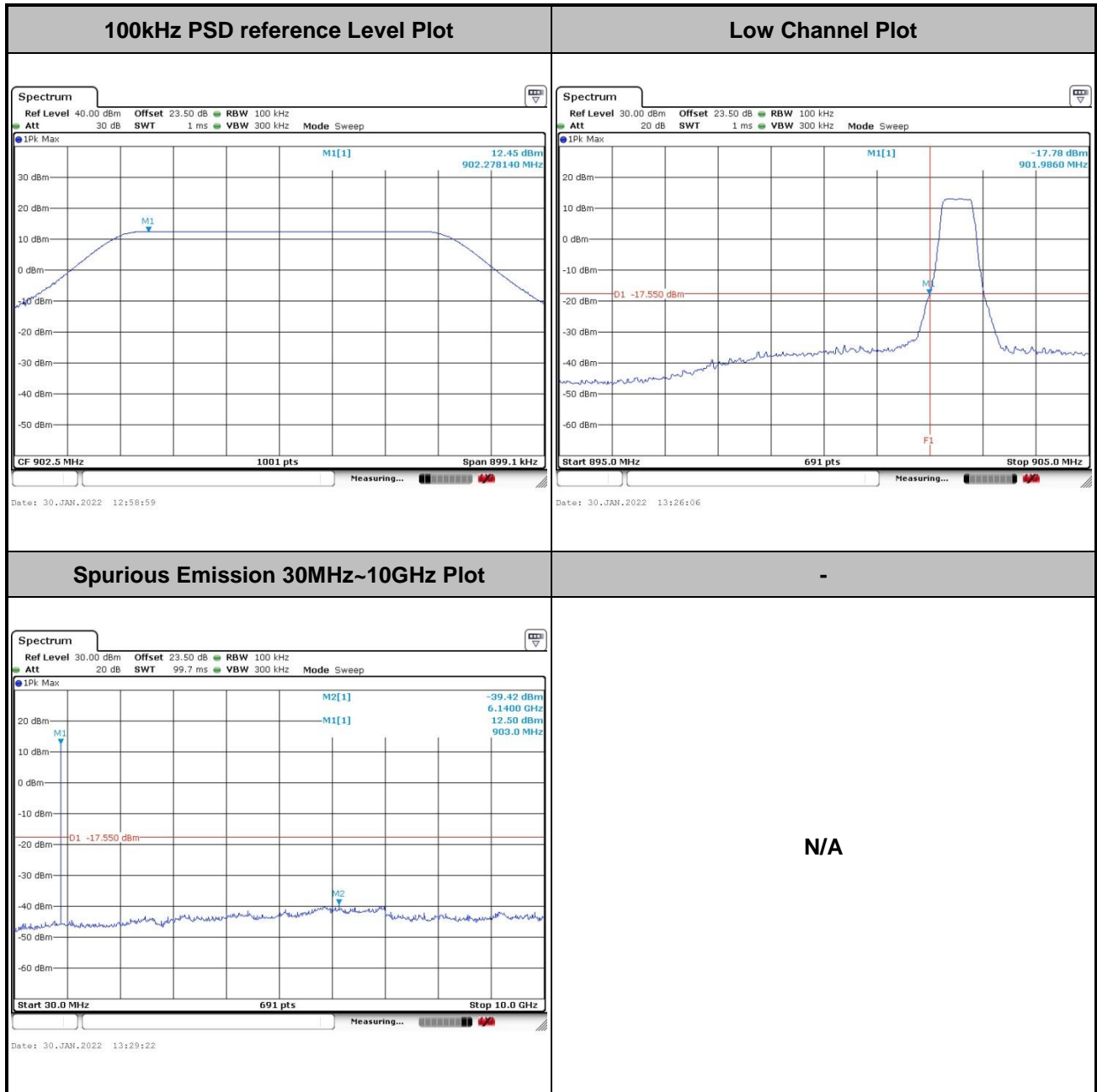


N/A

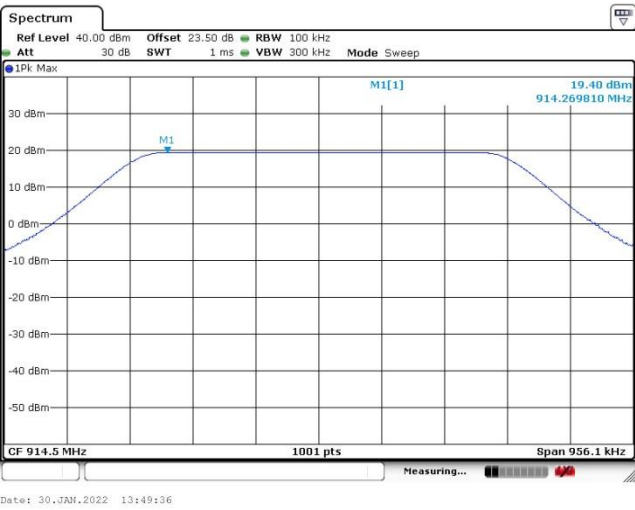
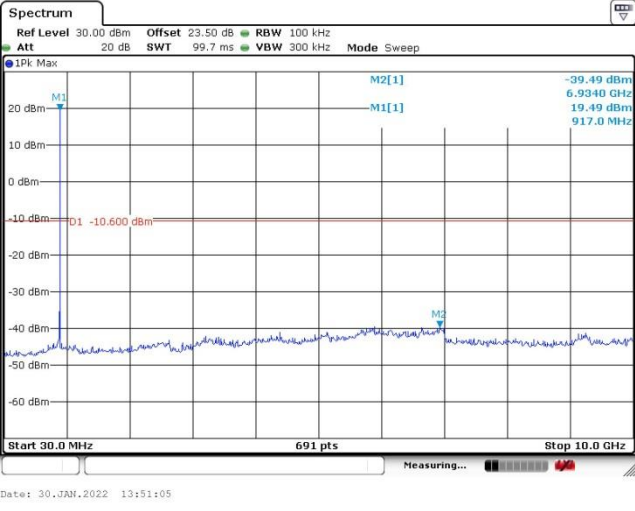




&lt;Data Rate: SF8&gt;

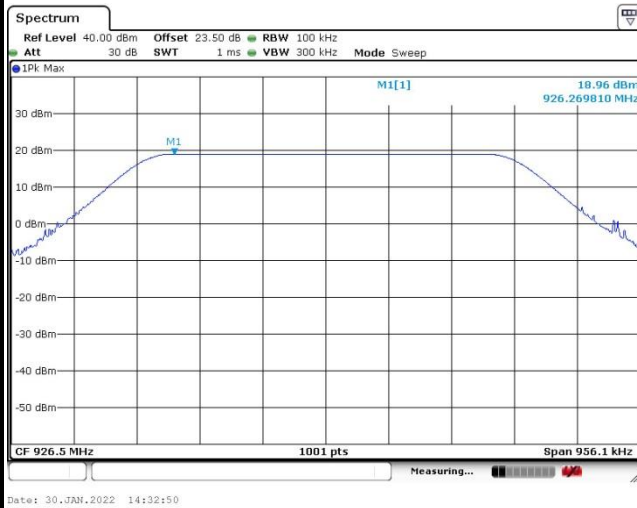




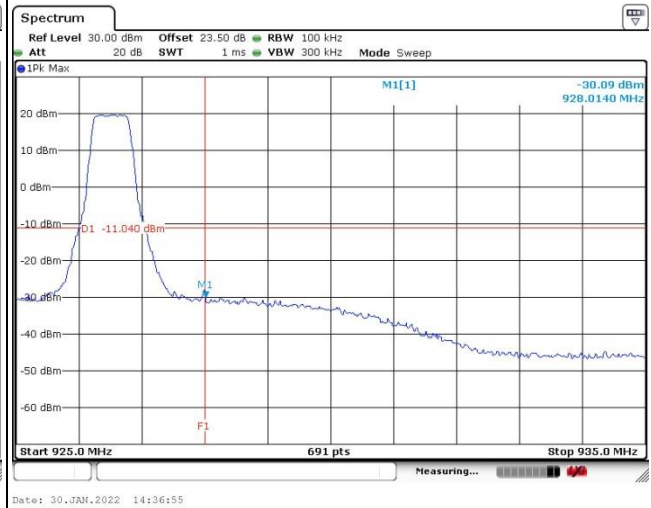
100kHz PSD reference Level Plot	Middle Channel Plot
 <p>100kHz PSD reference Level Plot</p>	
Spurious Emission 30MHz~10GHz Plot	-
 <p>Spurious Emission 30MHz~10GHz Plot</p>	N/A



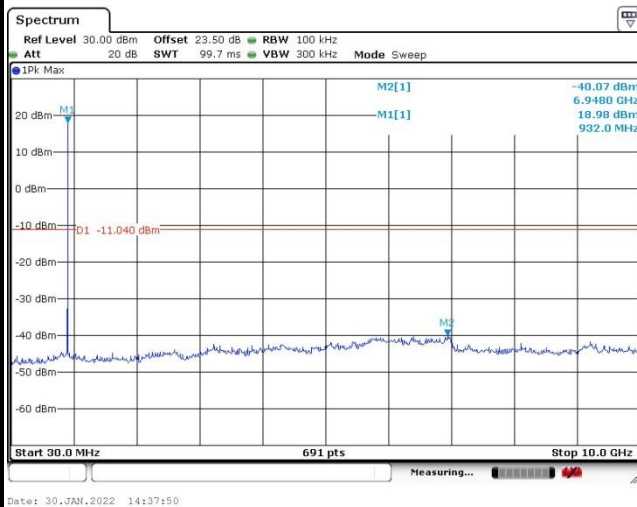
100kHz PSD reference Level Plot



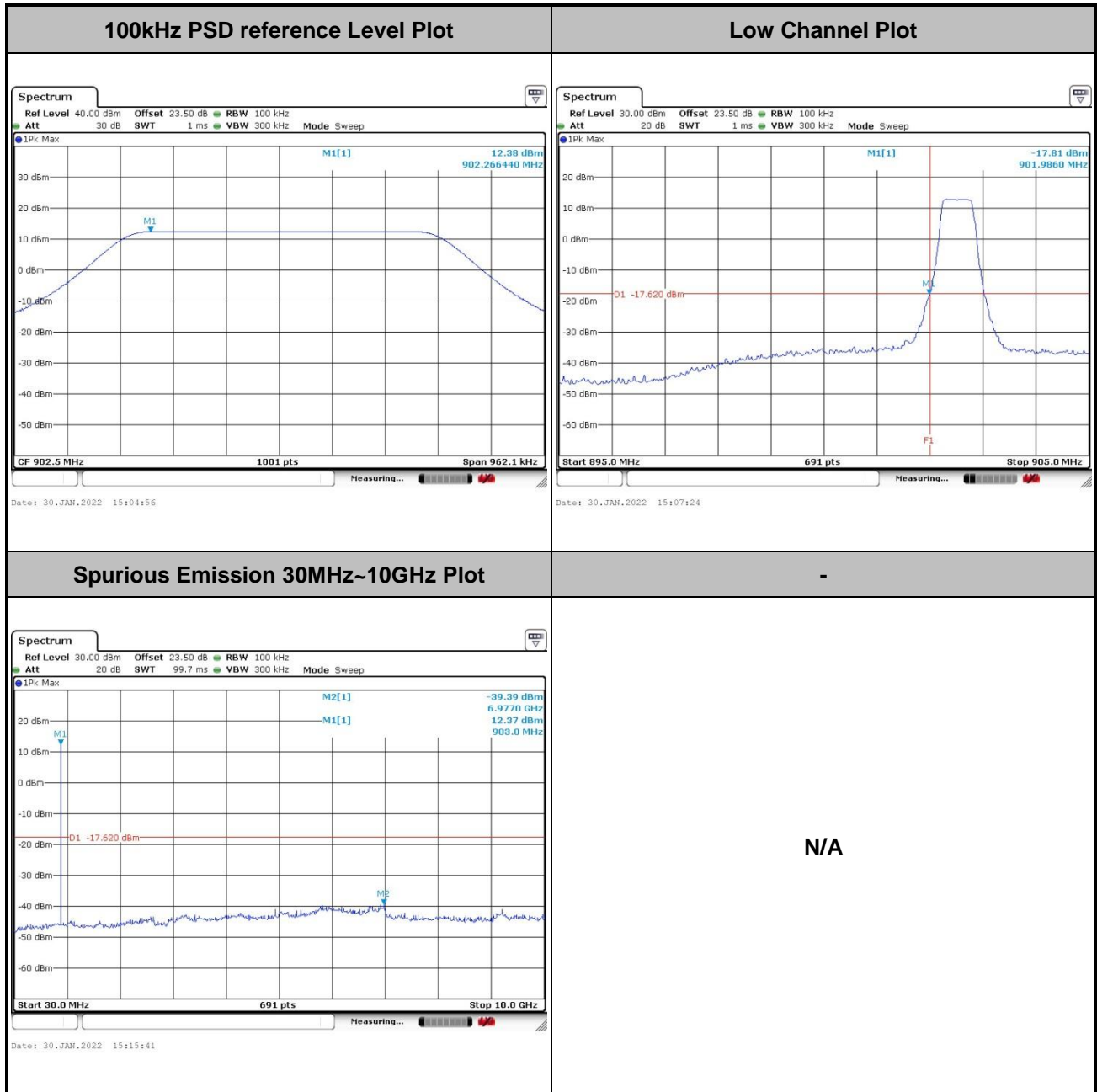
High Channel Plot



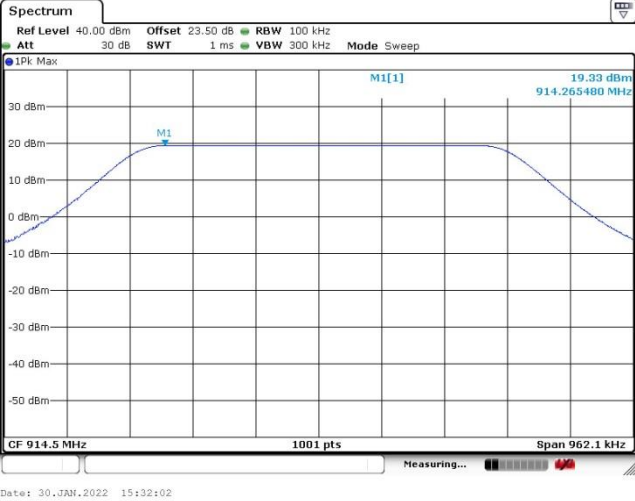
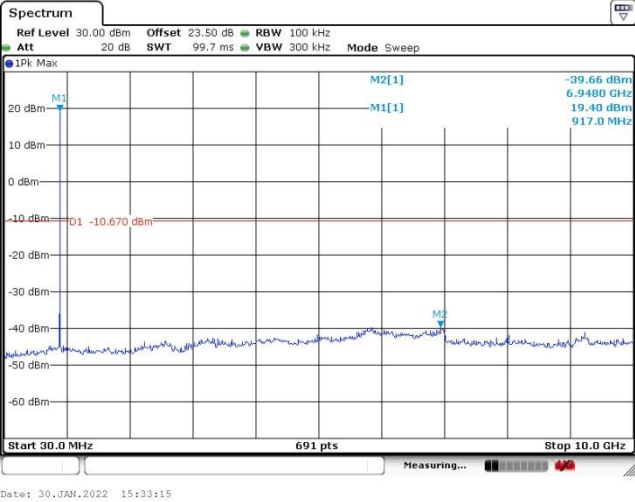
Spurious Emission 30MHz~10GHz Plot



N/A

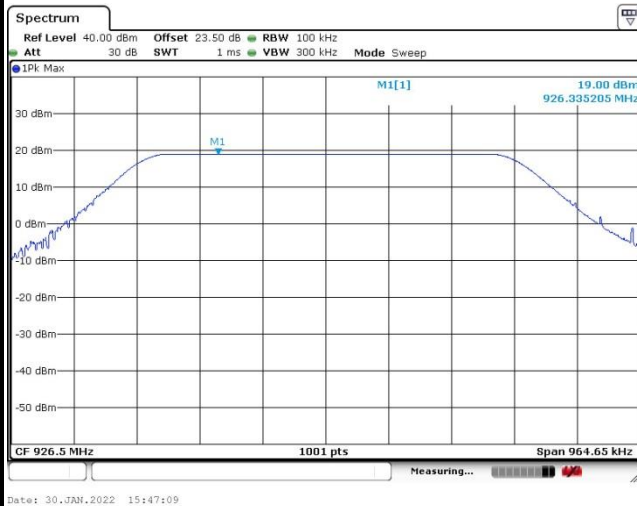
**<Data Rate: SF9>**




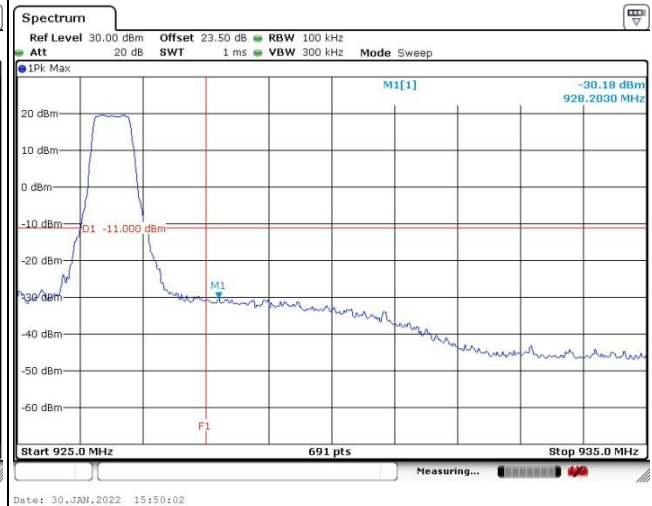
100kHz PSD reference Level Plot	Middle Channel Plot
 <p>100kHz PSD reference Level Plot</p>	
Spurious Emission 30MHz~10GHz Plot	-
 <p>Spurious Emission 30MHz~10GHz Plot</p>	N/A



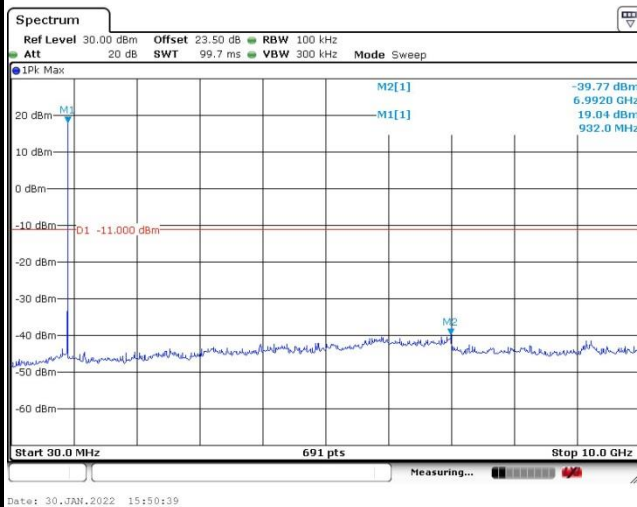
100kHz PSD reference Level Plot



High Channel Plot



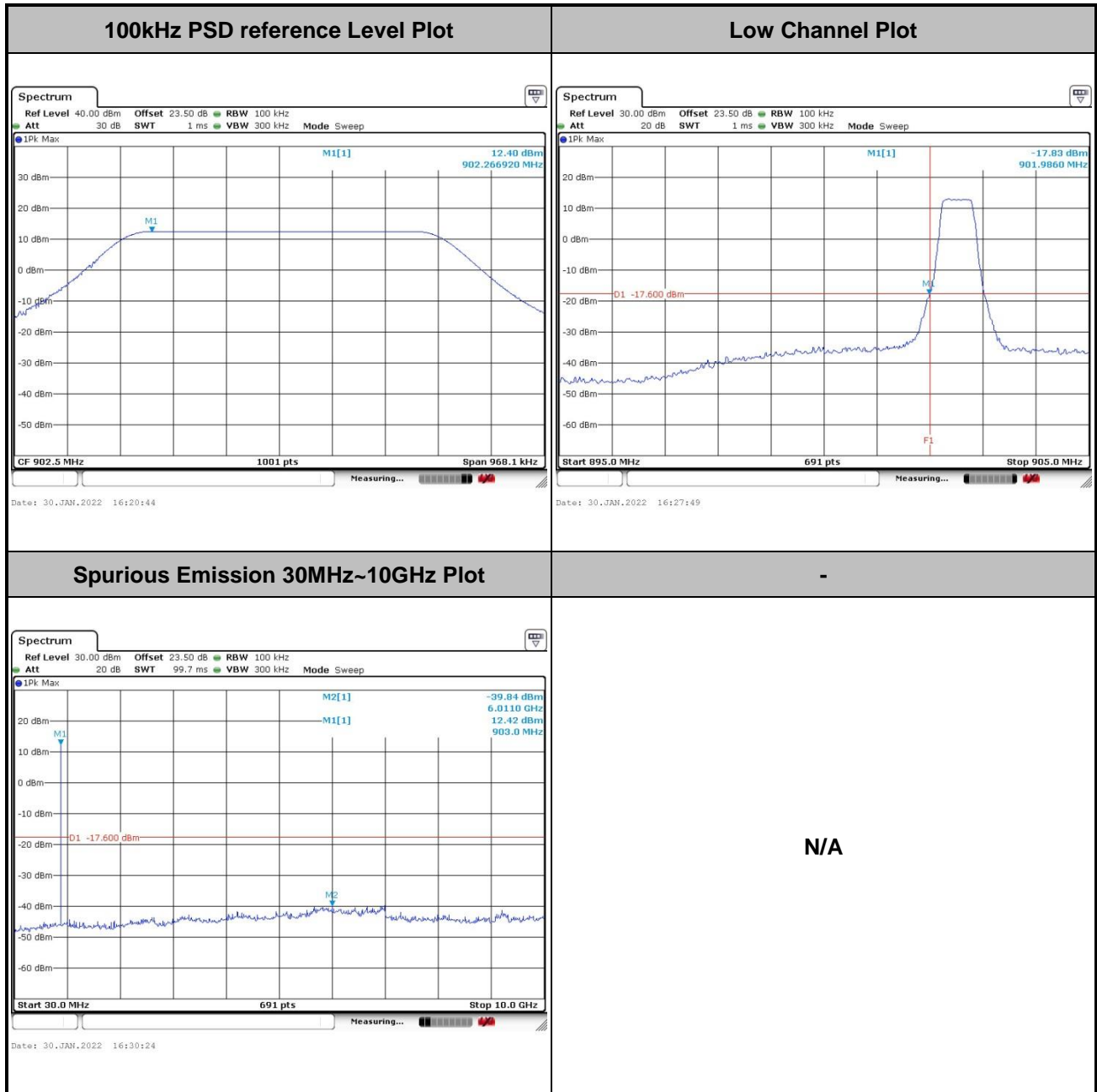
Spurious Emission 30MHz~10GHz Plot




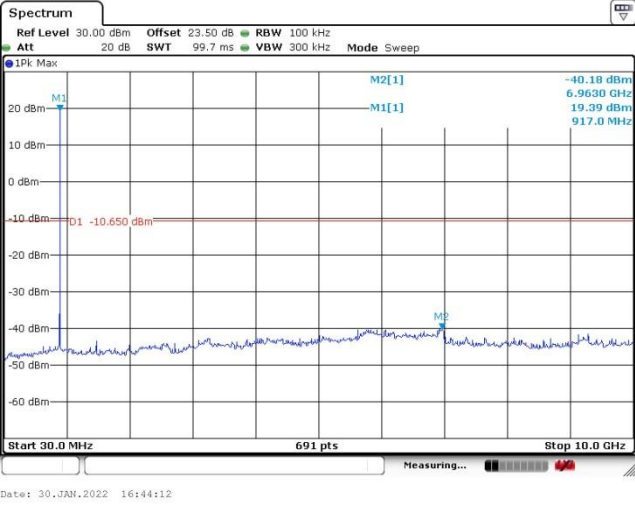
N/A



&lt;Data Rate: SF10&gt;



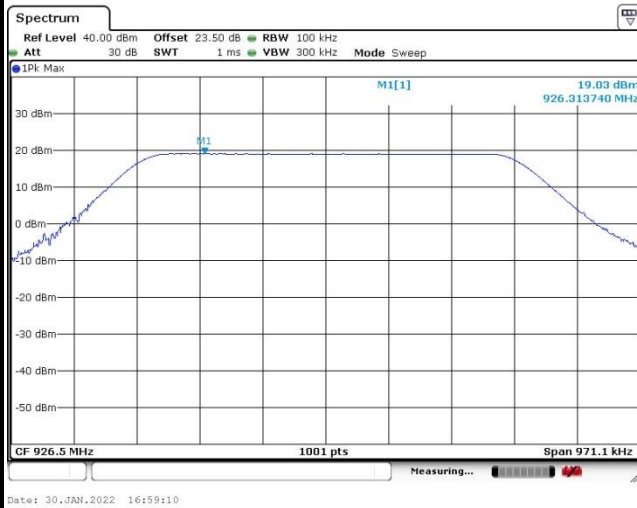


100kHz PSD reference Level Plot	Middle Channel Plot
	
Spurious Emission 30MHz~10GHz Plot	-
	N/A

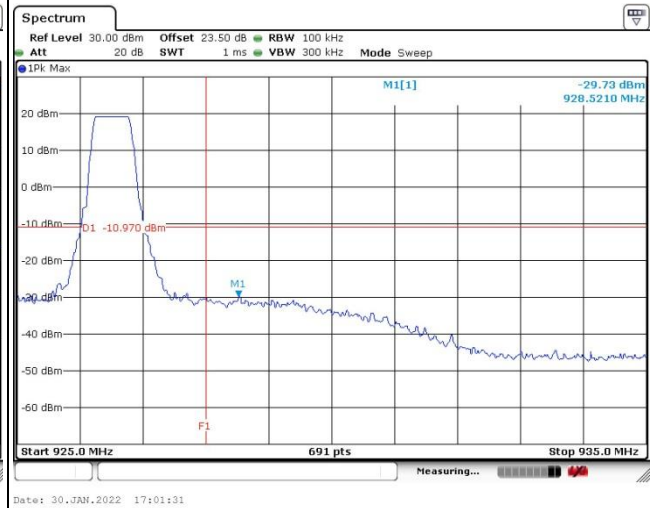




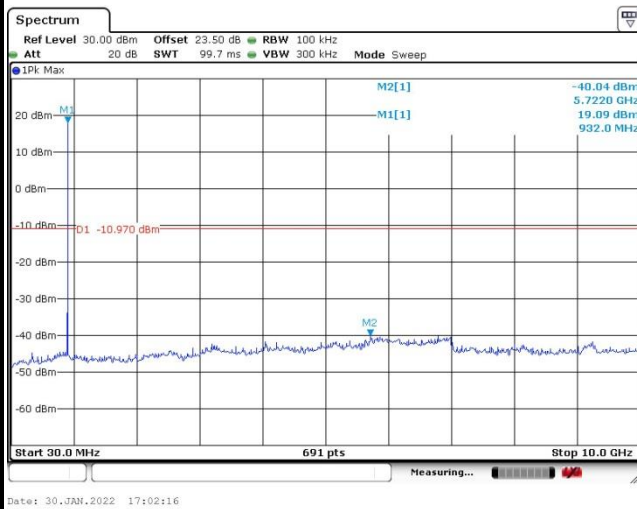
100kHz PSD reference Level Plot



High Channel Plot

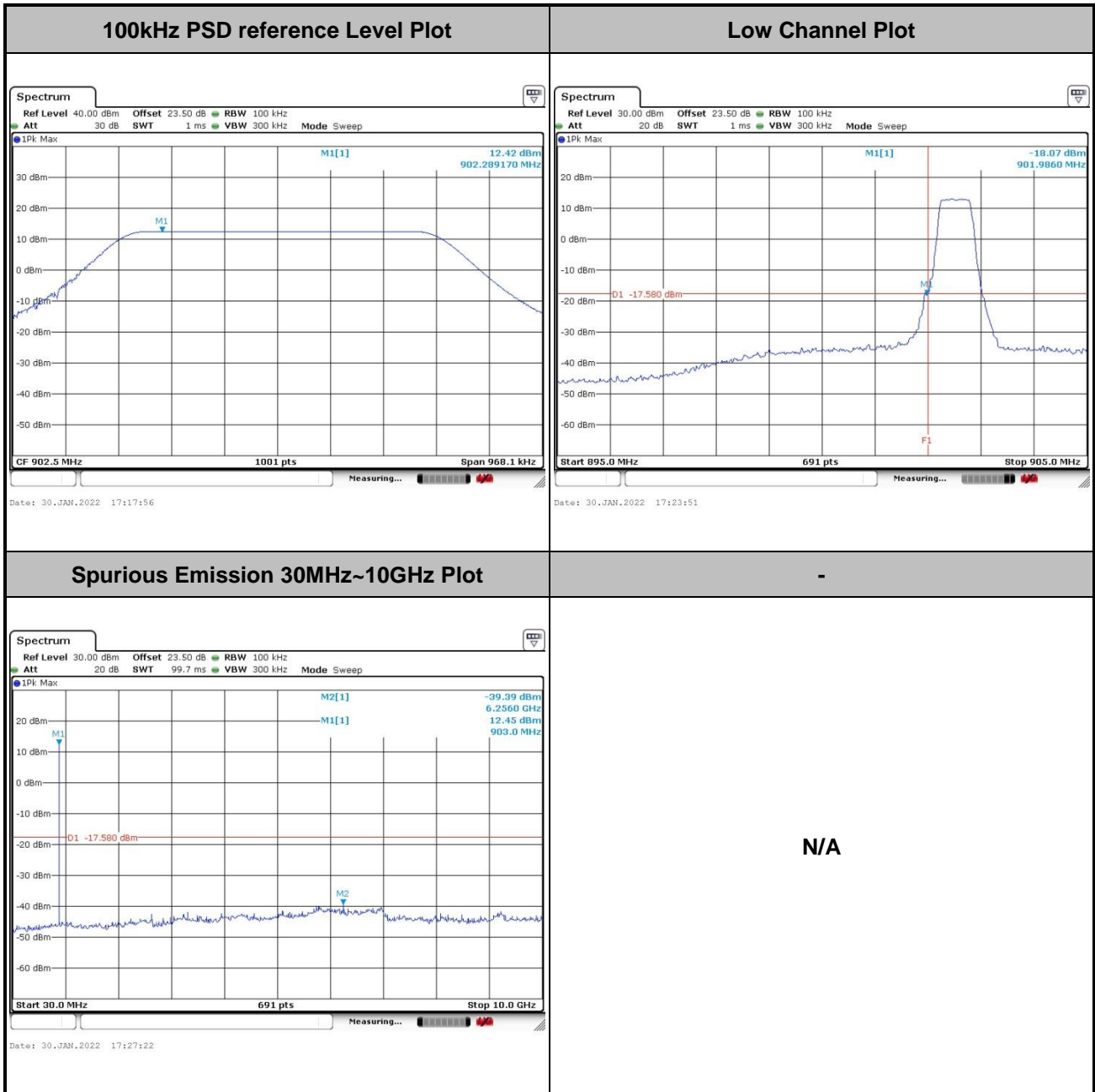


Spurious Emission 30MHz~10GHz Plot



N/A

<Data Rate: SF11>

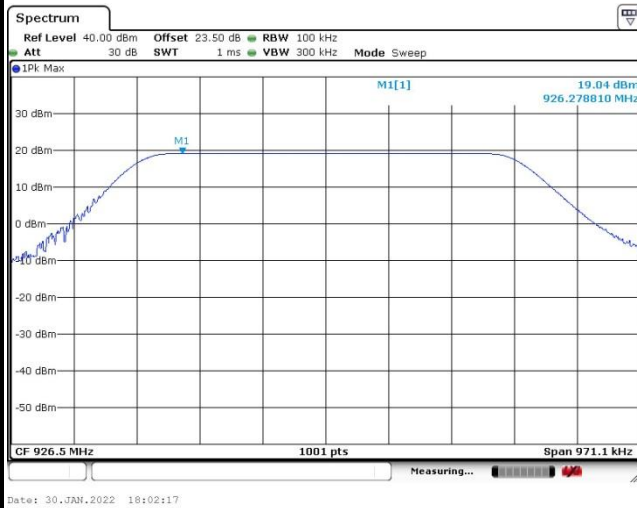




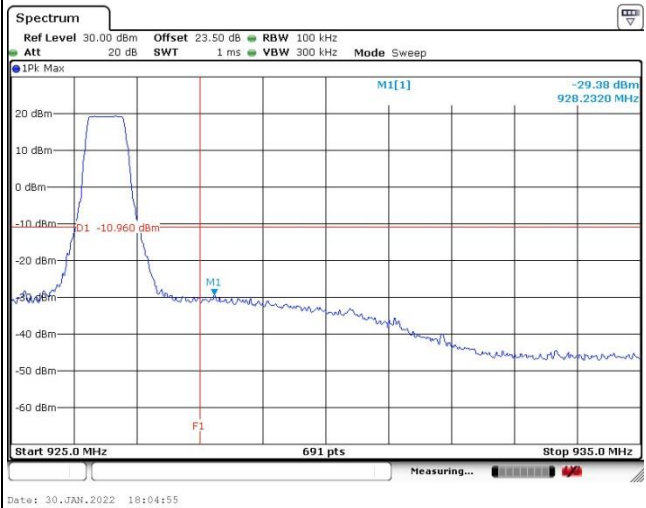
100kHz PSD reference Level Plot	Middle Channel Plot
<p>Spectrum</p> <p>Ref Level 40.00 dBm Offset 23.50 dB RBW 100 kHz Att 30 dB SWT 1 ms VBW 300 kHz Mode Sweep</p> <p>1Pk Max</p> <p>M1[1] 19.37 dBm 914.295930 MHz</p> <p>CF 914.5 MHz 1001 pts Span 968.1 kHz</p> <p>Date: 30.JAN.2022 17:42:47</p>	
Spurious Emission 30MHz~10GHz Plot	-
<p>Spectrum</p> <p>Ref Level 30.00 dBm Offset 23.50 dB RBW 100 kHz Att 20 dB SWT 99.7 ms VBW 300 kHz Mode Sweep</p> <p>1Pk Max</p> <p>M2[1] -38.99 dBm 6.1840 GHz M1[1] 19.41 dBm 917.0 MHz D1 -10.630 dBm</p> <p>Start 30.0 MHz 691 pts Stop 10.0 GHz</p> <p>Date: 30.JAN.2022 17:43:51</p>	N/A



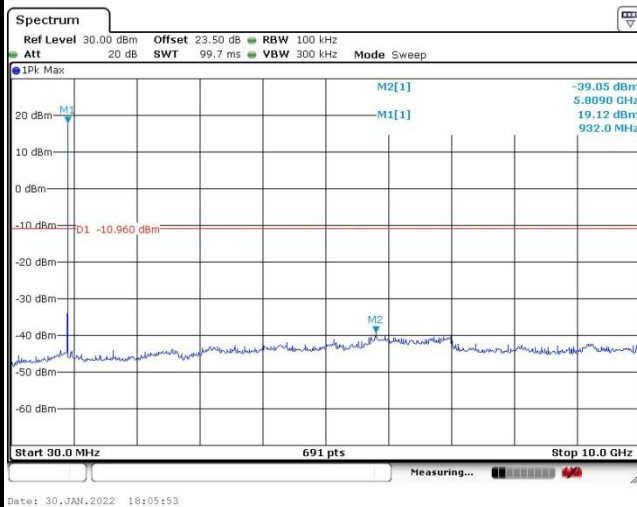
100kHz PSD reference Level Plot



High Channel Plot



Spurious Emission 30MHz~10GHz Plot



N/A

### 3.5 Radiated Band Edges and Spurious Emission Measurement

#### 3.5.1 Limit of Radiated band edge and Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. If the output power of this device is measured by spectrum analyzer, the attenuation under this paragraph shall be 30 dB instead of 20 dB. In addition, radiated emissions which fall in the restricted bands must also comply with the limits as below.

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 - 960	200	3
Above 960	500	3

#### 3.5.2 Measuring Instruments

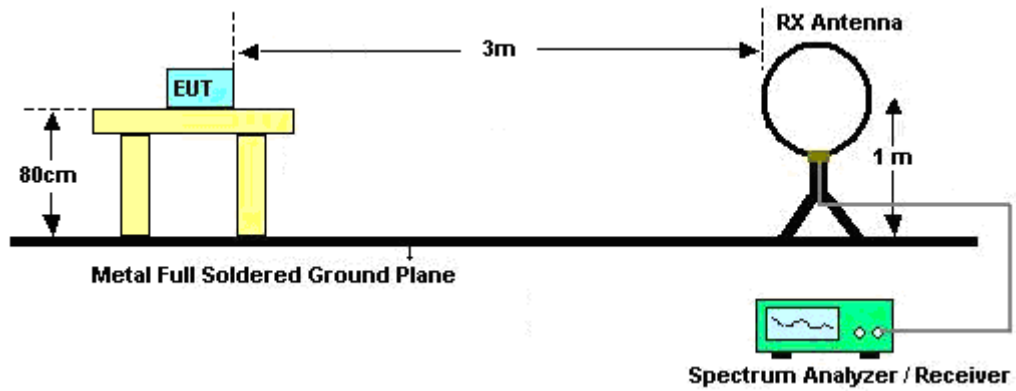
Please refer to the measuring equipment list in this test report.

### 3.5.3 Test Procedures

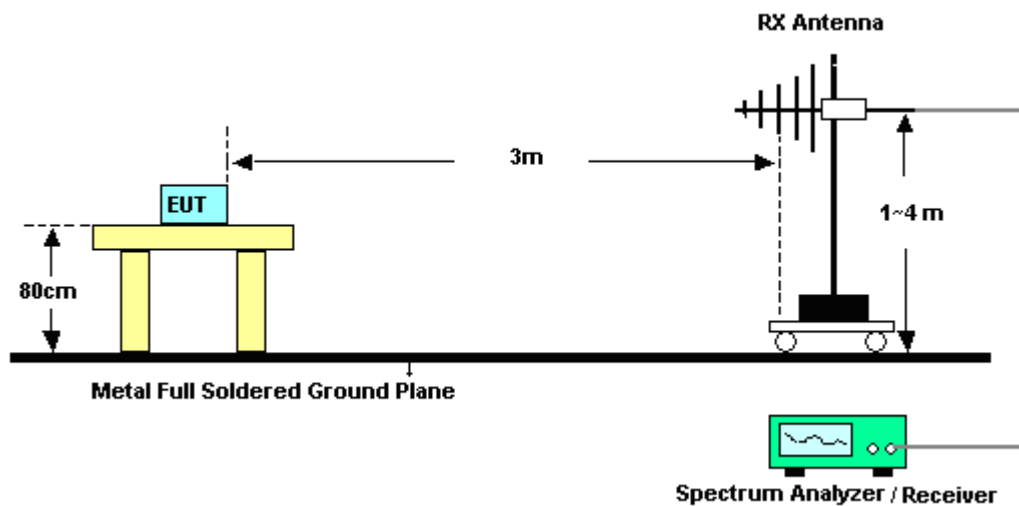
1. The testing follows the ANSI C63.10 Section 11.12.1 Radiated emission measurements.
2. The EUT is arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT is placed on a turntable with 0.8 meter for frequency below 1 GHz and 1.5 meter for frequency above 1 GHz respectively above ground.
4. The EUT is set 3 meters away from the receiving antenna, which is mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
6. Radiated testing below 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading. When there is no suspected emission found and the emission level is with at least 6 dB margin against QP limit line, the position is marked as “-”.
7. Radiated testing above 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading for scanning all frequencies. When there is no suspected emission found and the harmonic emission level is with at least 6 dB margin against average limit line, the position is marked as “-”.
8. Use the following spectrum analyzer settings:
  - (1) Span shall wide enough to fully capture the emission being measured;
  - (2) Set RBW = 100 kHz for  $f < 1$  GHz; VBW  $\geq$  RBW; Sweep = auto; Detector function = peak; Trace = max hold;
  - (3) Set RBW = 1 MHz, VBW= 3 MHz for  $f \geq 1$  GHz for peak measurement.For average measurement:
  - VBW = 10 Hz, when duty cycle is no less than 98 percent.
  - VBW  $\geq 1/T$ , when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

### 3.5.4 Test Setup

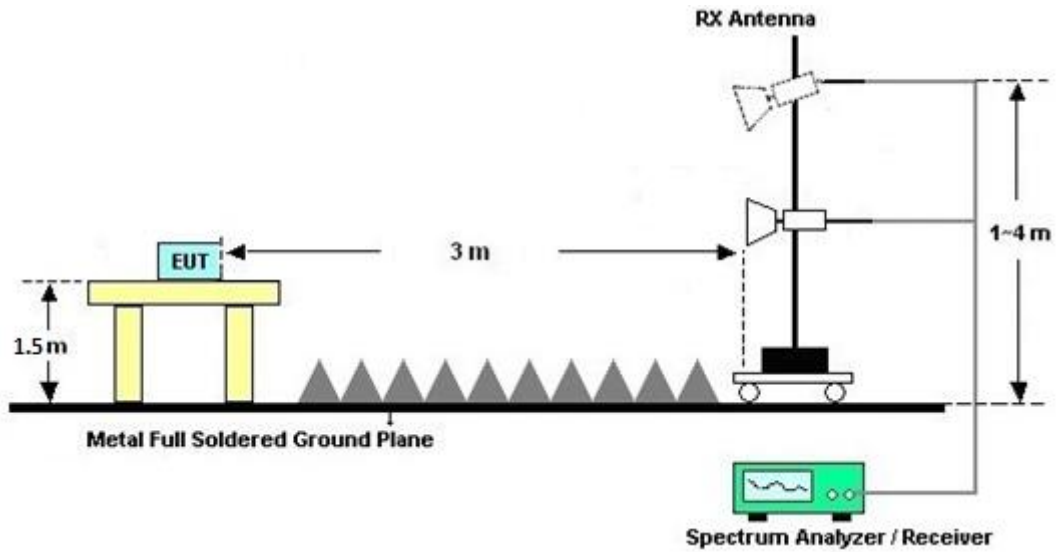
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated test above 1GHz



### 3.5.5 Test Results of Radiated Spurious Emissions (9kHz ~ 30MHz)

The low frequency, which starts from 9 kHz to 30 MHz, is pre-scanned and the result which is 20 dB lower than the limit line is not reported.

There is adequate comparison measurement of both open-field test site and alternative test site - semi-Anechoic chamber according to 414788 D01 Radiated Test Site v01r01, and the result comes out very similar.

### 3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C and D.

### 3.5.7 Duty Cycle

Please refer to Appendix E.

### 3.5.8 Test Result of Radiated Spurious Emission (30MHz ~ 10<sup>th</sup> Harmonic)

Please refer to Appendix C and D.



### 3.6 AC Conducted Emission Measurement

#### 3.6.1 Limit of AC Conducted Emission

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

Frequency of Emission (MHz)	Conducted Limit (dB $\mu$ V)	
	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.

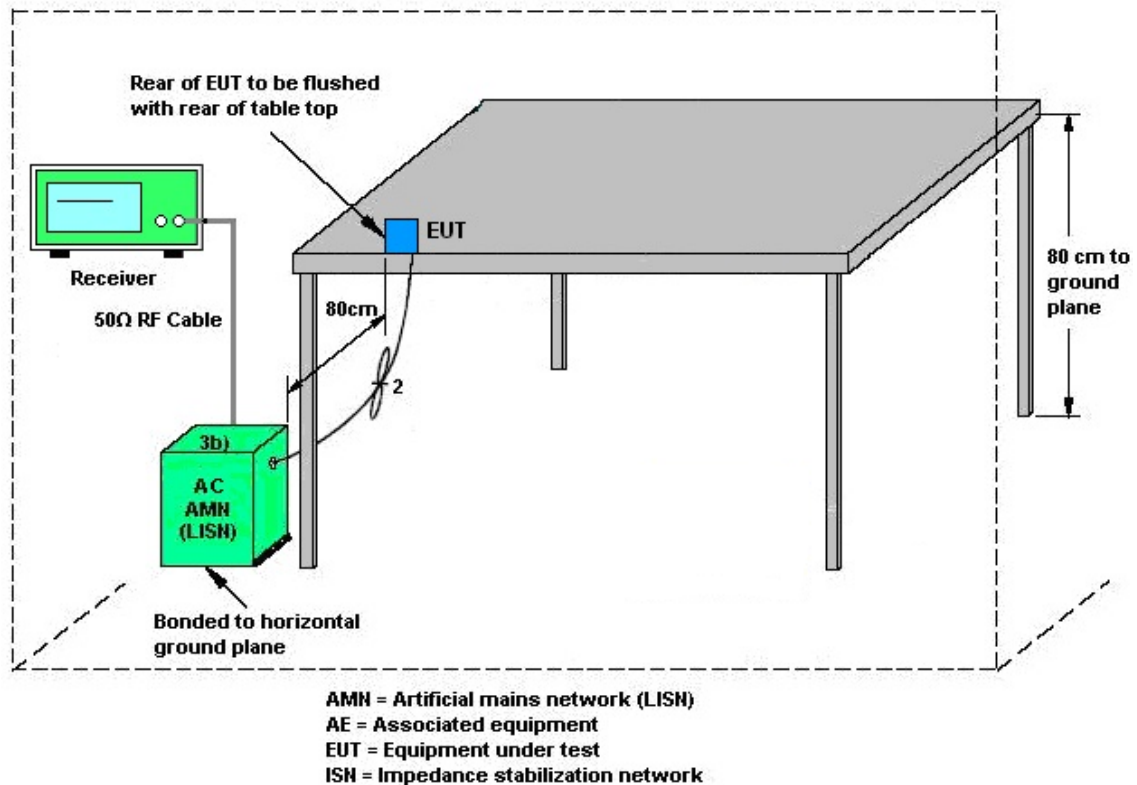
#### 3.6.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

#### 3.6.3 Test Procedures

1. The EUT is placed 0.4 meter away from the conducting wall of the shielding room, and is kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN shall be used.
6. Both Line and Neutral shall be tested in order to find out the maximum conducted emission.
7. The frequency range from 150 kHz to 30 MHz is scanned.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF bandwidth = 9kHz) with Maximum Hold Mode.

### 3.6.4 Test Setup



### 3.6.5 Test Result of AC Conducted Emission

Please refer to Appendix B.



## **3.7 Antenna Requirements**

### **3.7.1 Standard Applicable**

If directional gain of transmitting Antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. 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 rule.

### **3.7.2 Antenna Anti-Replacement Construction**

An embedded-in antenna design is used.

### **3.7.3 Antenna Gain**

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.



## 4 List of Measuring Equipment

Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Sep. 07, 2021	Feb. 17, 2022~ Mar. 04, 2022	Sep. 06, 2022	Radiation (03CH12-HY)
Bilog Antenna	TESEQ	CBL 6111D & 00800N1D01 N-06	37059 & 01	30MHz~1GHz	Oct. 09, 2021	Feb. 17, 2022~ Mar. 04, 2022	Oct. 08, 2022	Radiation (03CH12-HY)
Horn Antenna	SCHWARZBE CK	BBHA 9120 D	9120D-1328	1GHz~18GHz	Dec. 03, 2021	Feb. 17, 2022~ Mar. 04, 2022	Dec. 02, 2022	Radiation (03CH12-HY)
SHF-EHF Horn Antenna	SCHWARZBE CK	BBHA9170	00993	18GHz~40GHz	Nov. 30, 2021	Feb. 17, 2022~ Mar. 04, 2022	Nov. 29, 2022	Radiation (03CH12-HY)
Preamplifier	COM-POWER	PA-103	161075	10MHz~1GHz	Mar. 24, 2021	Feb. 17, 2022~ Mar. 04, 2022	Mar. 23, 2022	Radiation (03CH12-HY)
Preamplifier	Agilent	8449B	3008A02375	1GHz~26.5GHz	May 25, 2021	Feb. 17, 2022~ Mar. 04, 2022	May 24, 2022	Radiation (03CH12-HY)
Preamplifier	E-INSTRUME NT TECH LTD.	ERA-100M-1 8G-56-01-A7 0	EC1900270	1GHz~18GHz	Dec. 27, 2021	Feb. 17, 2022~ Mar. 04, 2022	Dec. 26, 2022	Radiation (03CH12-HY)
Preamplifier	EMEC	EM18G40G	060715	18GHz~40GHz	Dec. 24, 2021	Feb. 17, 2022~ Mar. 04, 2022	Dec. 23, 2022	Radiation (03CH12-HY)
SHF-EHF Horn Antenna	SCHWARZBE CK	BBHA9170	00993	18GHz~40GHz	Nov. 30, 2021	Feb. 17, 2022~ Mar. 04, 2022	Nov. 29, 2022	Radiation (03CH12-HY)
Spectrum Analyzer	Agilent	N9010A	MY53470118	10Hz~44GHz	Jan. 12, 2022	Feb. 17, 2022~ Mar. 04, 2022	Jan. 11, 2023	Radiation (03CH12-HY)
Filter	Wainwright	WLKS1200-1 2SS	SN2	1.2GHz Low Pass Filter	Mar. 17, 2021	Feb. 17, 2022~ Mar. 04, 2022	Mar. 16, 2022	Radiation (03CH12-HY)
Filter	Wainwright	WHKX12-27 00-3000-180 00-60ST	SN2	3GHz High Pass Filter	Jul. 12, 2021	Feb. 17, 2022~ Mar. 04, 2022	Jul. 11, 2022	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	MY9837/4PE	9kHz~30MHz	Mar. 11, 2021	Feb. 17, 2022~ Mar. 04, 2022	Mar. 10, 2022	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 126E	0058/126E	30MHz~18GHz	Dec. 10, 2021	Feb. 17, 2022~ Mar. 04, 2022	Dec. 09, 2022	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30MHz~40GHz	Feb. 22, 2021	Feb. 17, 2022~ Feb. 20, 2022	Feb. 21, 2022	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30MHz~40GHz	Feb. 21, 2022	Feb. 21, 2022~ Mar. 04, 2022	Feb. 20, 2023	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	800740/2	30MHz~40GHz	Feb. 22, 2021	Feb. 17, 2022~ Feb. 20, 2022	Feb. 21, 2022	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30MHz~40GHz	Feb. 21, 2022	Feb. 21, 2022~ Mar. 04, 2022	Feb. 20, 2023	Radiation (03CH12-HY)
Hygrometer	TECEPIL	DTM-303B	TP210090	N/A	Oct. 08, 2021	Feb. 17, 2022~ Mar. 04, 2022	Oct. 07, 2022	Radiation (03CH12-HY)
Controller	EMEC	EM1000	N/A	Control Turn table & Ant Mast	N/A	Feb. 17, 2022~ Mar. 04, 2022	N/A	Radiation (03CH12-HY)
Antenna Mast	EMEC	AM-BS-4500 -B	N/A	1m~4m	N/A	Feb. 17, 2022~ Mar. 04, 2022	N/A	Radiation (03CH12-HY)
Turn Table	EMEC	TT2000	N/A	0~360 Degree	N/A	Feb. 17, 2022~ Mar. 04, 2022	N/A	Radiation (03CH12-HY)
Software	Audix	E3 6.2009-8-24	RK-000989	N/A	N/A	Feb. 17, 2022~ Mar. 04, 2022	N/A	Radiation (03CH12-HY)



Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
AC Power Source	ACPOWER	AFC-11003G	F317040033	N/A	N/A	Mar. 08, 2022	N/A	Conduction (CO07-HY)
Software	Rohde & Schwarz	EMC32 V10.30	N/A	N/A	N/A	Mar. 08, 2022	N/A	Conduction (CO07-HY)
Pulse Limiter	SCHWARZBECK	VTSD 9561-F N	9561-F N00373	9kHz-200MHz	Oct. 29, 2021	Mar. 08, 2022	Oct. 28, 2022	Conduction (CO07-HY)
RF Cable	HUBER + SUHNER	RG 214/U	1358175	9kHz~30MHz	Mar. 17, 2021	Mar. 08, 2022	Mar. 16, 2022	Conduction (CO07-HY)
Two-Line V-Network	TESEQ	NNB 51	45051	N/A	Feb. 16, 2022	Mar. 08, 2022	Feb. 15, 2023	Conduction (CO07-HY)
EMI Test Receiver	Rohde & Schwarz	ESR3	102317	9kHz~3.6GHz	Oct. 21, 2021	Mar. 08, 2022	Oct. 20, 2022	Conduction (CO07-HY)
Hygrometer	TECPEL	TR-32	HE17XB2468	N/A	Mar. 09, 2021	Jan. 28, 2022~ Mar. 07, 2022	Mar. 08, 2022	Conducted (TH02-HY)
Hygrometer	TECPEL	TECPEL	TP210073	N/A	Nov. 16, 2021	Mar. 07, 2022~ Apr. 24, 2022	Nov. 15, 2022	Conducted (TH02-HY)
Signal Analyzer	Rohde & Schwarz	FSV40	101566	10Hz~40GHz	Aug. 30, 2021	Jan. 28, 2022~ Apr. 24, 2022	Aug. 29, 2022	Conducted (TH02-HY)
Power Meter	Anritsu	ML2495A	1036004	N/A	Aug. 01, 2021	Jan. 28, 2022~ Apr. 24, 2022	Jul. 31, 2022	Conducted (TH02-HY)
Power Sensor	Anritsu	MA2411B	1027253	300MHz~40GHz	Aug. 01, 2021	Jan. 28, 2022~ Apr. 24, 2022	Jul. 31, 2022	Conducted (TH02-HY)
Switch Box & RF Cable	Burgeon	ETF-058	EC1208321 (Box2)	N/A	Jun. 08, 2021	Jan. 28, 2022~ Apr. 24, 2022	Jun. 07, 2022	Conducted (TH02-HY)



## 5 Uncertainty of Evaluation

### Uncertainty of Conducted Emission Measurement (150 kHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	2.3 dB
--	--------

### Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	5.8 dB
--	--------

### Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	5.4 dB
--	--------

### Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	5.9 dB
--	--------

**Appendix A. Test Result of Conducted Test Items**

Test Engineer:	Tommy Lee	Temperature:	20~25	°C
Test Date:	2022/1/28~2022/3/28	Relative Humidity:	49~56	%

**<LoRa 500kHz>**

**TEST RESULTS DATA**  
**6dB and 99% Occupied Bandwidth**

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
LoRa 500kHz	SF5	1	1	902.5	0.523	0.599	0.50	Pass
LoRa 500kHz	SF5	1	16	914.5	0.521	0.597	0.50	Pass
LoRa 500kHz	SF5	1	31	926.5	0.531	0.607	0.50	Pass

**TEST RESULTS DATA**  
**Average Power Table**

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Average Conducted Power (dBm)	Conducted Power Limit (dBm)	DG (dBi)	EIRP Power (dBm)	EIRP Power Limit (dBm)	Pass /Fail
LoRa 500kHz	SF5	1	1	902.5	11.31	30.00	0.73	12.04	36.00	Pass
LoRa 500kHz	SF5	1	16	914.5	19.44	30.00	0.73	20.17	36.00	Pass
LoRa 500kHz	SF5	1	31	926.5	19.14	30.00	0.73	19.87	36.00	Pass

**TEST RESULTS DATA**  
**Average Power Density**

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Peak PSD (dBm /100kHz)	Average PSD (dBm /3kHz)	DG (dBi)	Average PSD Limit (dBm /3kHz)	Pass/Fail
LoRa 500kHz	SF5	1	1	902.5	11.14	-6.30	0.73	8.00	Pass
LoRa 500kHz	SF5	1	16	914.5	19.38	1.74	0.73	8.00	Pass
LoRa 500kHz	SF5	1	31	926.5	19.05	1.32	0.73	8.00	Pass

Note: PSD (dBm/ 100kHz) is a reference level used for Conducted Band Edges and Conducted Spurious Emission 30dBc limit.