



FCC RF Test Report

APPLICANT : Ring LLC
EQUIPMENT : Video Doorbell Pro 2
BRAND NAME : Ring
MODEL NAME : 5AT2S2
FCC ID : 2AEUPBHALP032
STANDARD : FCC Part 15 Subpart C §15.247
CLASSIFICATION : (DTS) Digital Transmission System
TEST DATE(S) : Jul. 31, 2022 ~ Aug. 23, 2022

We, Sporton International Inc. (Kunshan), 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 of Sporton International Inc. (Kunshan), the test report shall not be reproduced except in full.

Jason Jia

Approved by: Jason Jia



Sporton International Inc. (Kunshan)

**No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300
People's Republic of China**



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SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(2)	6dB Bandwidth	≥ 0.5MHz	Pass	-
3.1	-	99% Bandwidth	-	Pass	-
3.2	15.247(b)(3)	Output Power	≤ 30dBm	Pass	-
3.3	15.247(e)	Power Spectral Density	≤ 8dBm/3kHz	Pass	-
3.4	15.247(d)	Conducted Band Edges and Spurious Emission	≤ 30dBc	Pass	-
3.5	15.247(d)	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 8.95 dB at 272.500 MHz
3.6	15.203 & 15.247(b)	Antenna Requirement	N/A	Pass	-

Note: This is a variant report for 5AT2S2. To add test results of LoRa DTS SF8/9/10 for RSE/ Conducted items on the basis from original report FR090815-03A.

Declaration of Conformity:

The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.

Comments and Explanations:

The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.



1 General Description

1.1 Applicant

Ring LLC
12515 Cerise Ave, Hawthorne, CA 90250, USA

1.2 Manufacturer

Goertek Inc.
No.268 Dongfang Road High-Tech Industrial Development District, Weifang Shandong, China

1.3 Product Feature of Equipment Under Test

Product Feature	
Equipment	Video Doorbell Pro 2
Brand Name	Ring
Model Name	5AT2S2
FCC ID	2AEUPBHALP032
EUT supports Radios application	WLAN 2.4GHz 802.11b/g/n HT20 WLAN 5GHz 802.11a/n HT20/HT40 WLAN 5GHz 802.11ac VHT20/VHT40/VHT80 Bluetooth BR/EDR/LE LoRa DTS/LoRa FHSS/FSK FHSS Radar
SN	Conducted: G9E1A814203200G5 Radiation: G9E1A814203200G5
HW Version	R6
SW Version	8.0.60
EUT Stage	Production Unit

Remark: The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

1.4 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Frequency Range	902.5 MHz ~ 926.5 MHz
Number of Channels	31
Bandwidth / Spread Factor	500kHz / 8, 9, 10
Maximum Output Power to Antenna	LoRa DTS SF8 : 14.74 dBm (0.0298 W) LoRa DTS SF9 : 14.93 dBm (0.0311 W) LoRa DTS SF10 : 15.05 dBm (0.0320 W)
99% Occupied Bandwidth	LoRa DTS SF8 : 0.515MHz LoRa DTS SF9 : 0.521MHz LoRa DTS SF10 : 0.521MHz
Antenna Type / Gain	IFA Antenna with gain -1.01 dBi
Type of Modulation	LoRa



1.5 Modification of EUT

No modifications are made to the EUT during all test items.

1.6 Testing Location

Sporton International Inc. (Kunshan) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Test Firm	Sporton International Inc. (Kunshan)		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	Sporton Site No.	FCC Designation No.	FCC Test Firm Registration No.
	03CH07-KS TH01-KS	CN1257	314309

1.7 Test Software

Item	Site	Manufacture	Name	Version
1.	03CH07-KS	AUDIX	E3	6.2009-8-24al

1.8 Applicable Standards

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

- 47 CFR Part 15 Subpart C §15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- ANSI C63.10-2013

Remark: All test items were verified and recorded according to the standards and without any deviation during the test.



2 Test Configuration of Equipment Under Test

2.1 Carrier Frequency Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
902.5-926.5 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	

Note: The above EUT's information was declared by manufacturer.



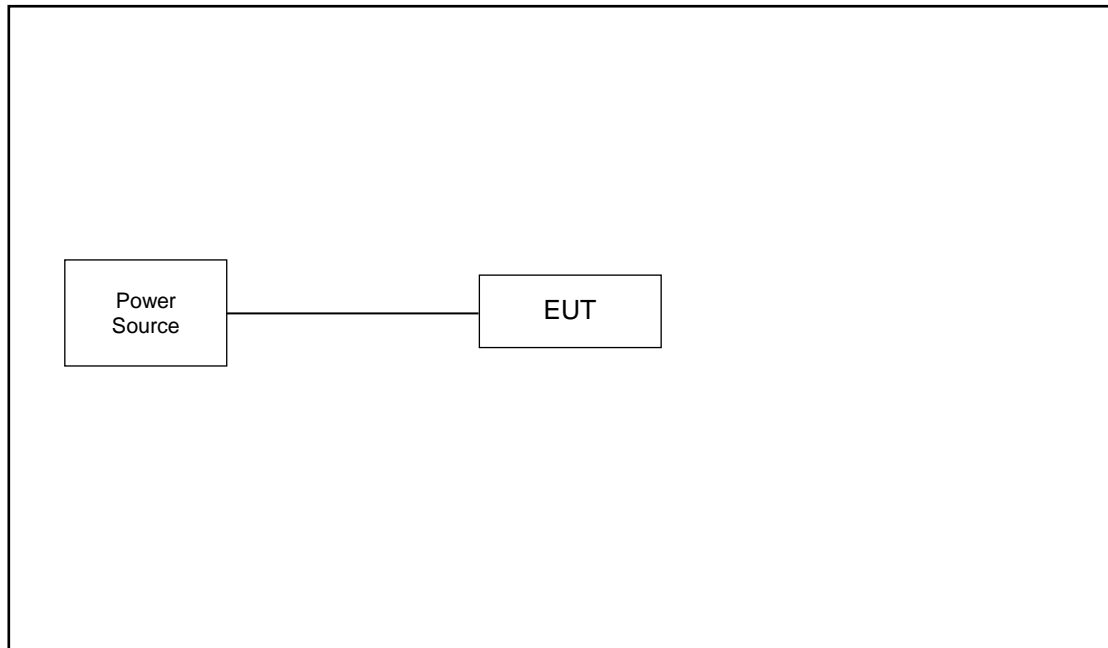
2.2 Test Mode

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: radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (X plane) were recorded in this report.

The following summary table is showing all test modes to demonstrate in compliance with the standard.

Summary table of Test Cases	
Test Item	Data Rate / Modulation
	Lora 500KHz DTS
Conducted TCs	Mode 1: LoRa Tx CH01_902.5 MHz
	Mode 2: LoRa Tx CH16_914.5 MHz
	Mode 3: LoRa Tx CH31_926.5 MHz
Radiated TCs	Mode 1: LoRa Tx CH01_902.5 MHz
	Mode 2: LoRa Tx CH16_914.5 MHz
	Mode 3: LoRa Tx CH31_926.5 MHz

2.3 Connection Diagram of Test System



2.4 EUT Operation Test Setup

For LoRa function, the engineering test program was provided and enabled to make EUT continuous transmit/receive.

2.5 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 4.8 dB and 10dB attenuator.

$$\begin{aligned} \text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)}. \\ &= 4.8 + 10 = 14.8 \text{ (dB)} \end{aligned}$$

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.

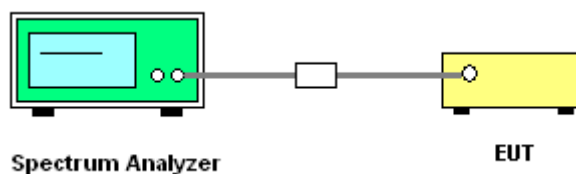
3.1.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.1.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 11.8
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT 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 20kHz and set the Video bandwidth (VBW) = 100kHz.
6. Measure and record the results in the test report.

3.1.4 Test Setup



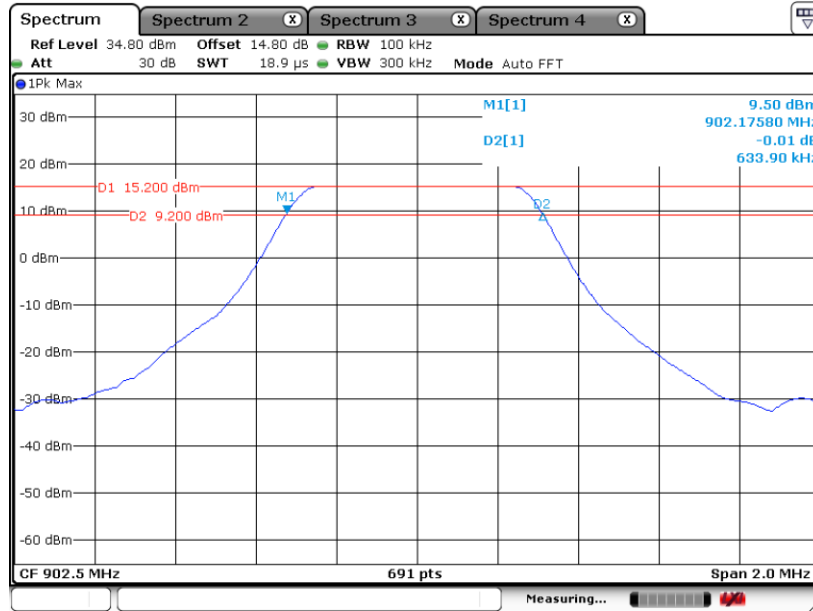


3.1.5 Test Result of 6dB Bandwidth

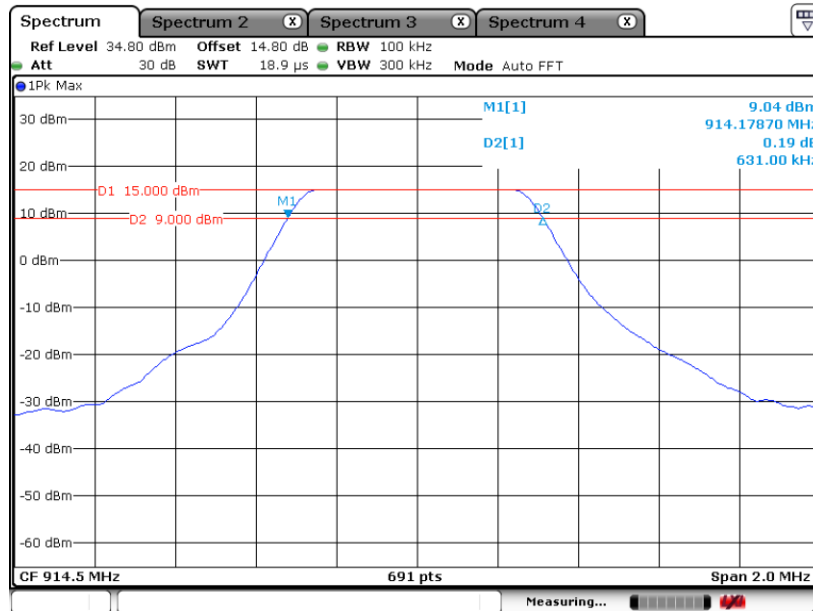
Please refer to Appendix A.

For SF8:

6 dB Bandwidth Plot on 902.5MHz

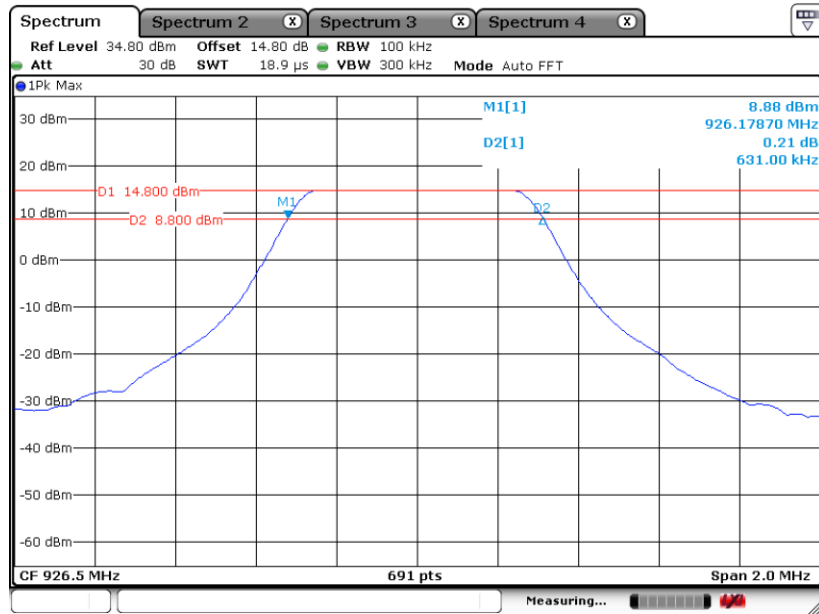


6 dB Bandwidth Plot on 914.5 MHz





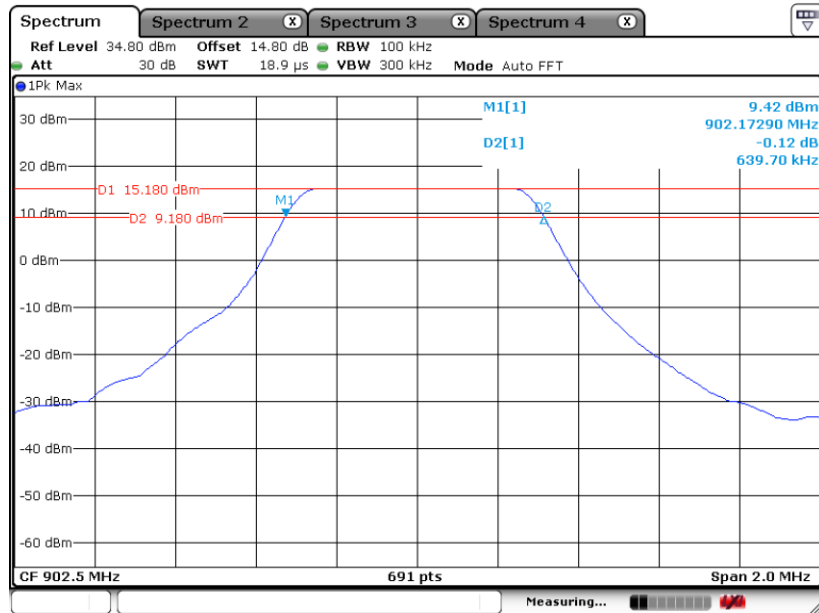
6 dB Bandwidth Plot on 926.5 MHz



Date: 31.JUL.2022 11:32:27

For SF9:

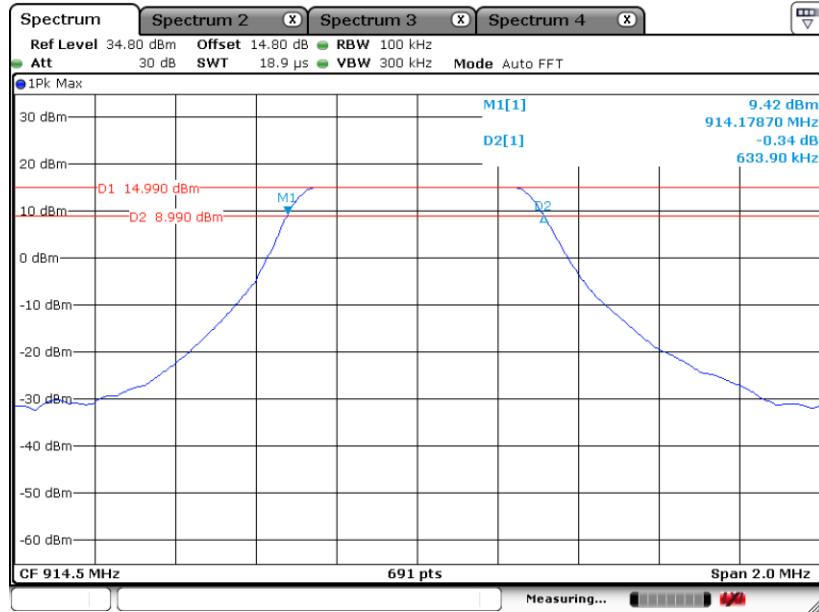
6 dB Bandwidth Plot on 902.5 MHz



Date: 31.JUL.2022 11:47:36

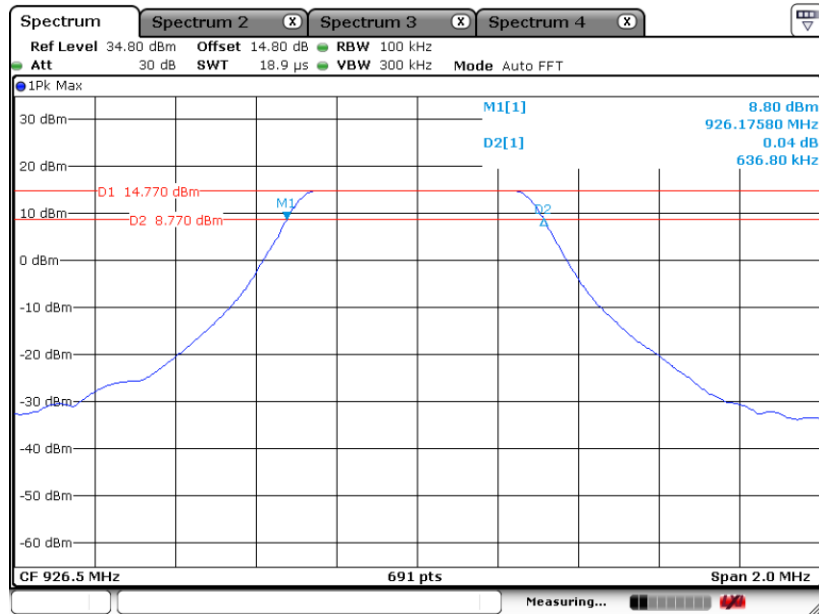


6 dB Bandwidth Plot on 914.5 MHz



Date: 31.JUL.2022 11:59:36

6 dB Bandwidth Plot on 926.5 MHz

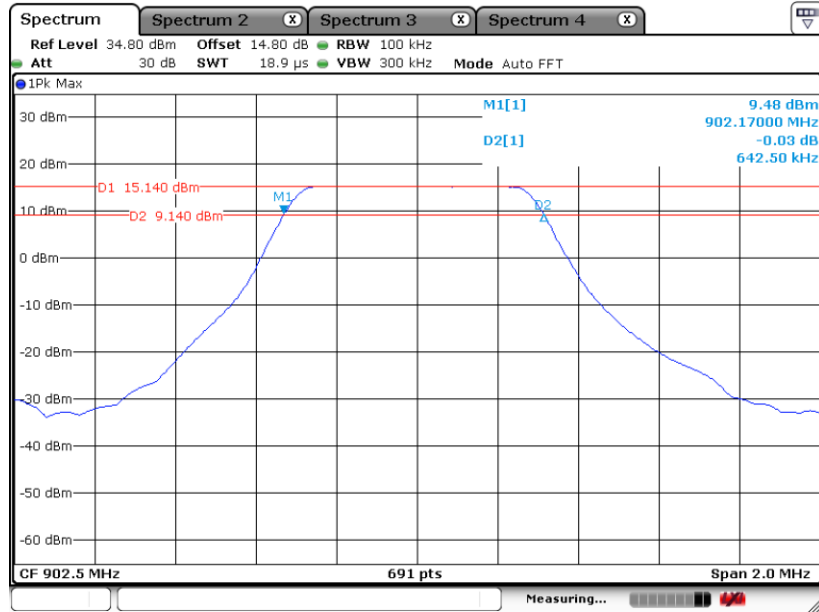


Date: 31.JUL.2022 12:03:35



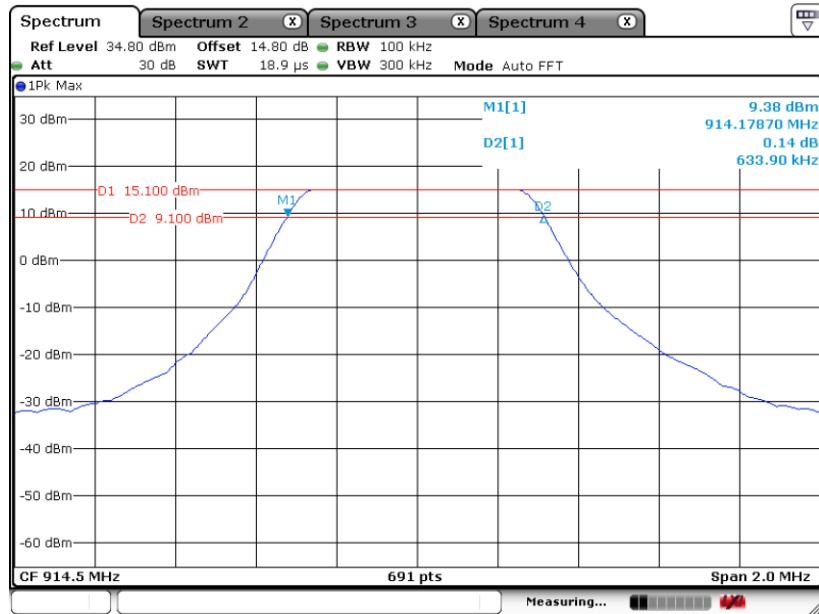
For SF10:

6 dB Bandwidth Plot on 902.5MHz



Date: 31.JUL.2022 12:40:43

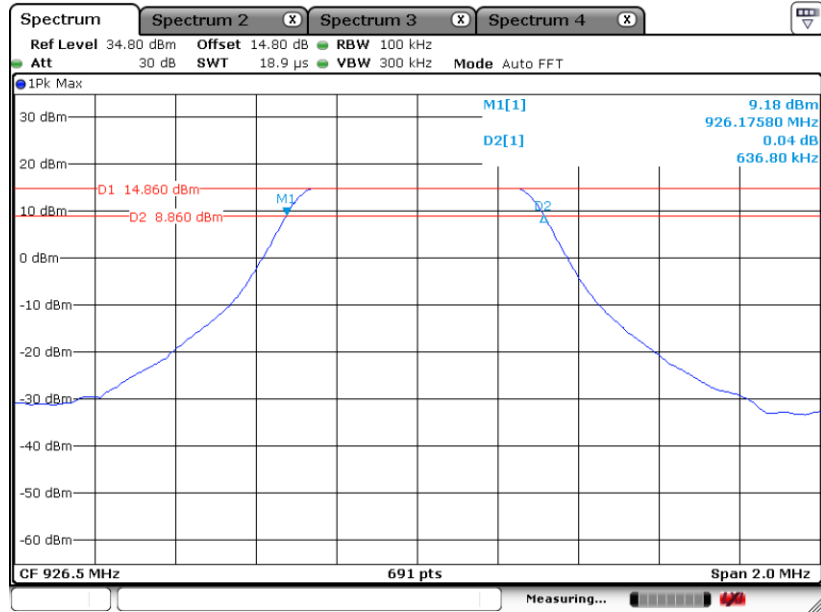
6 dB Bandwidth Plot on 914.5 MHz



Date: 31.JUL.2022 12:46:06



6 dB Bandwidth Plot on 926.5 MHz



Date: 31.JUL.2022 12:51:37

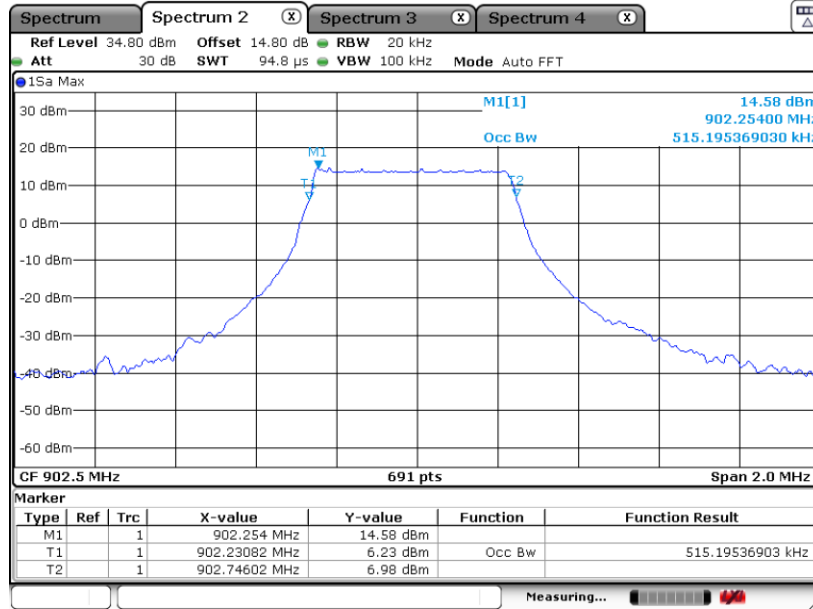


3.1.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

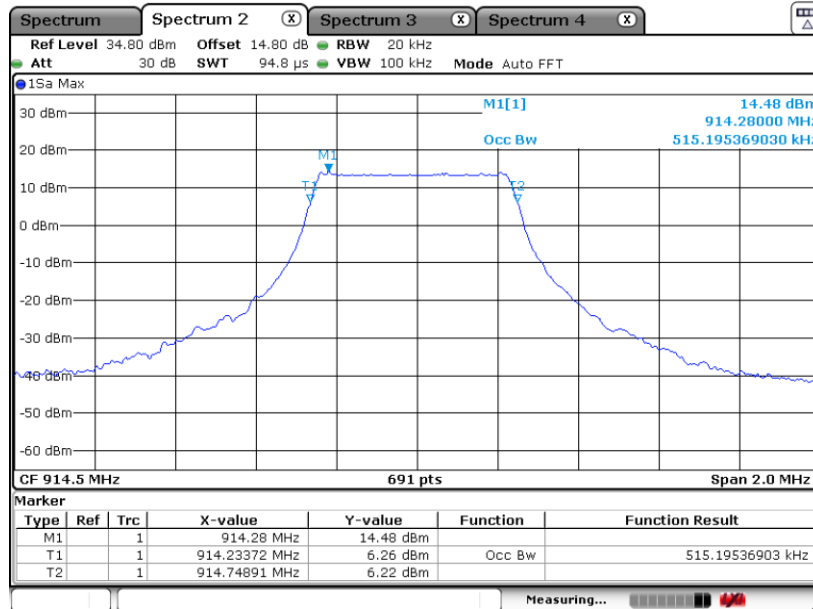
For SF8:

99% Bandwidth Plot on 902.5 MHz



Date: 3.AUG.2022 14:39:59

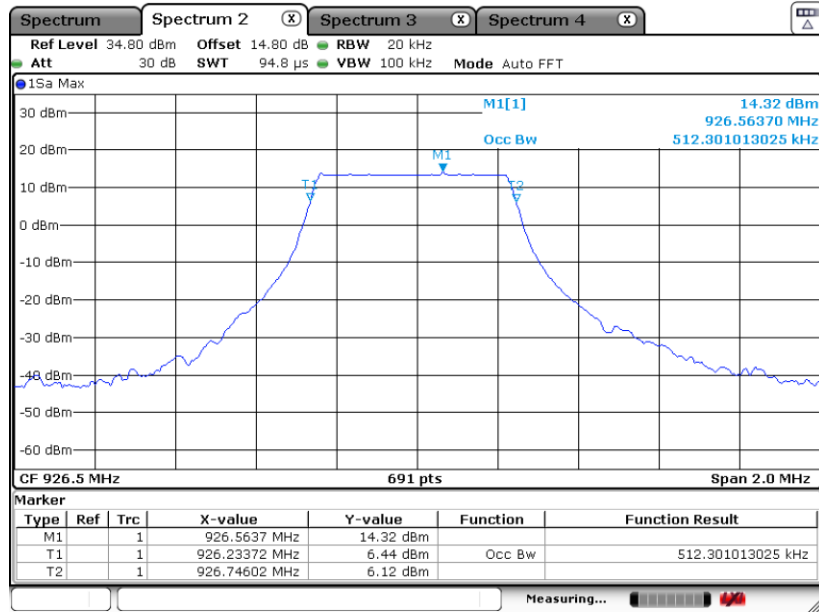
99% Occupied Bandwidth Plot on 914.5 MHz



Date: 3.AUG.2022 14:40:41



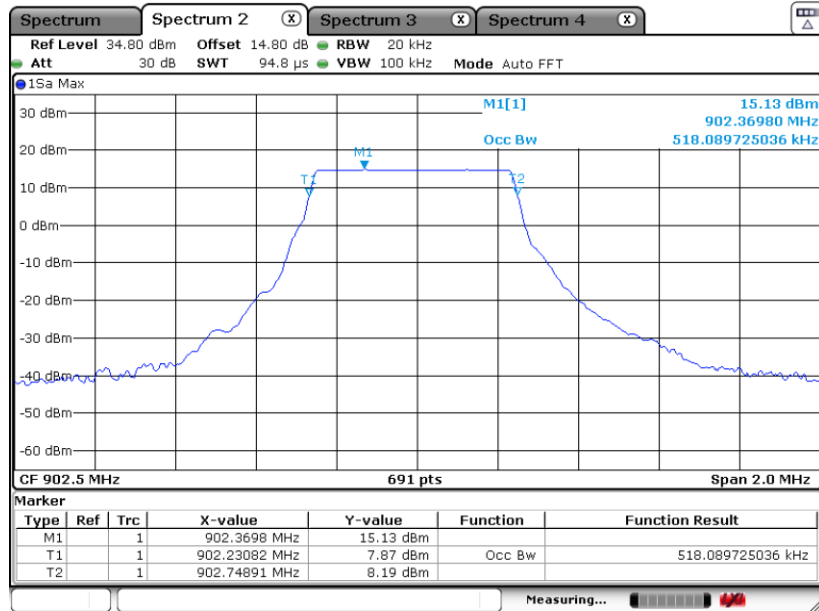
99% Occupied Bandwidth Plot on 926.5 MHz



Date: 3.AUG.2022 14:48:41

For SF9:

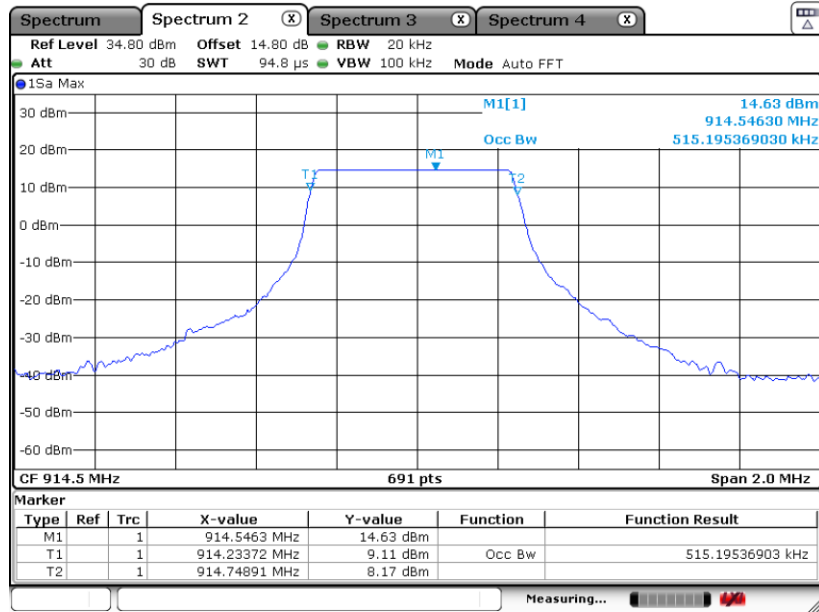
99% Bandwidth Plot on 902.5 MHz



Date: 3.AUG.2022 14:51:46

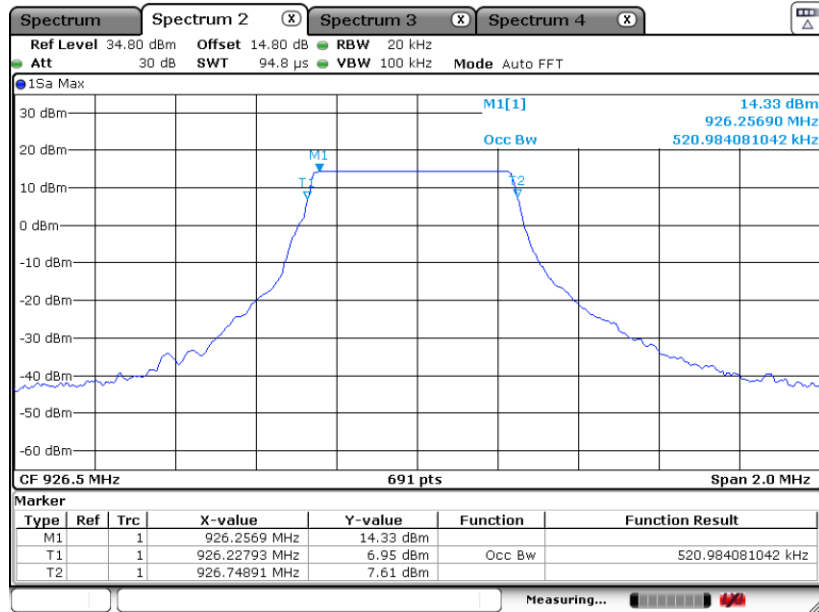


99% Occupied Bandwidth Plot on 914.5 MHz



Date: 3.AUG.2022 14:50:54

99% Occupied Bandwidth Plot on 926.5 MHz

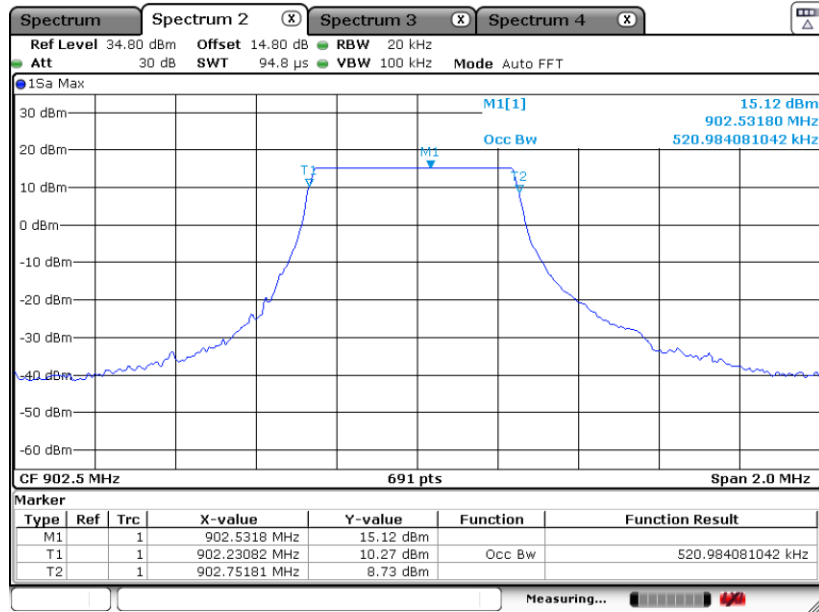


Date: 3.AUG.2022 14:49:11



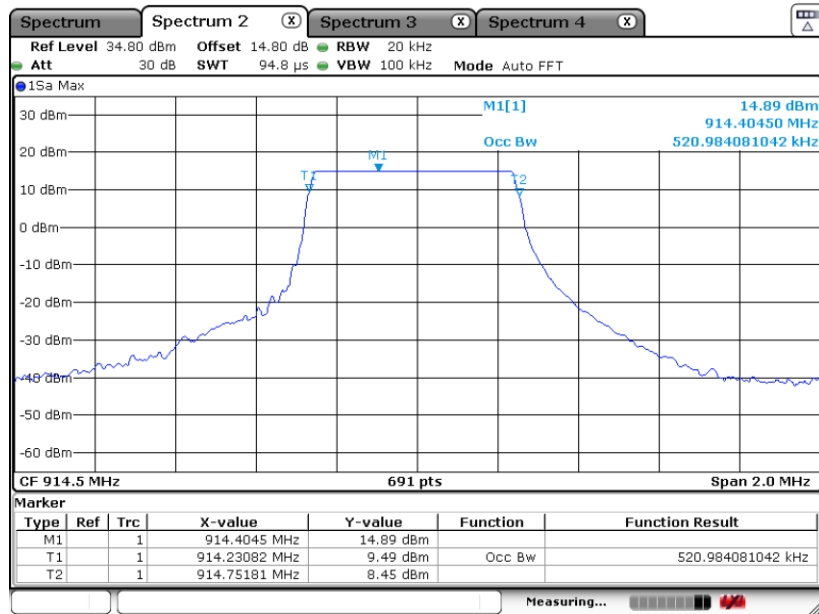
For SF10:

99% Bandwidth Plot on 902.5MHz



Date: 3.AUG.2022 14:52:18

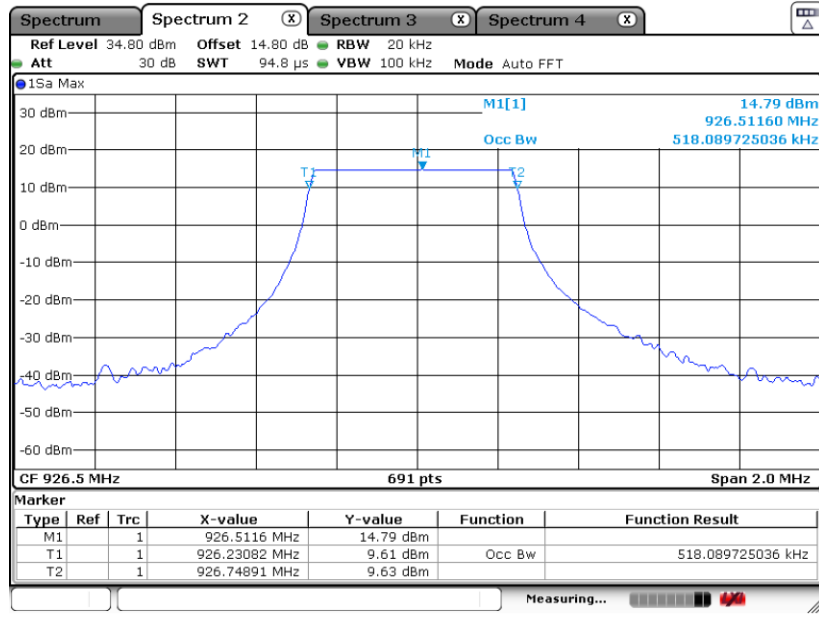
99% Bandwidth Plot on 914.5 MHz



Date: 3.AUG.2022 14:50:21



99% Bandwidth Plot on 926.5 MHz



Date: 3.AUG.2022 14:49:39

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

For systems using digital modulation in the 902-928MHz, the limit for output power is 30dBm. If transmitting antenna of directional gain greater than 6dBi is used, the output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

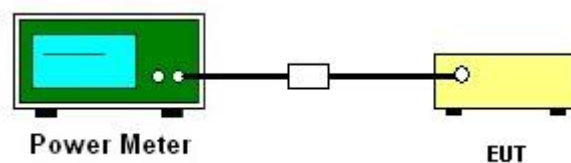
3.2.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.2.3 Test Procedures

1. The testing follows the Measurement Procedure of ANSI C63.10-2013 clause 11.9.2.3.1 Method AVGPM method.
2. The RF output of EUT was connected to the power meter by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT 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 8dBm in any 3kHz band at any time interval of continuous transmission.

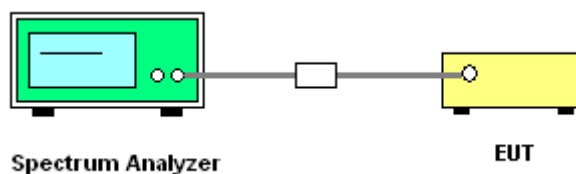
3.3.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.3.3 Test Procedures

1. The testing follows Measurement Procedure of ANSI C63.10-2013 clause 11.10.5 Method AVGPSD-2.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT 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 = power averaging (rms), Sweep time = auto couple. Use the peak marker function to determine the maximum power level.
6. Employ trace averaging (rms) mode over a minimum of 100 traces.
7. Ensure that the number of measurement points in the sweep $\geq [2 \times \text{span} / \text{RBW}]$.
8. Measure and record the results in the test report.
9. Add $[10 \log (1 / D)]$, where D is the duty cycle.
10. The Measured power density (dBm)/ 100kHz is a reference level and used as 30dBc down limit line for Conducted Band Edges and Conducted Spurious Emission.

3.3.4 Test Setup



3.3.5 Test Result of Power Spectral Density

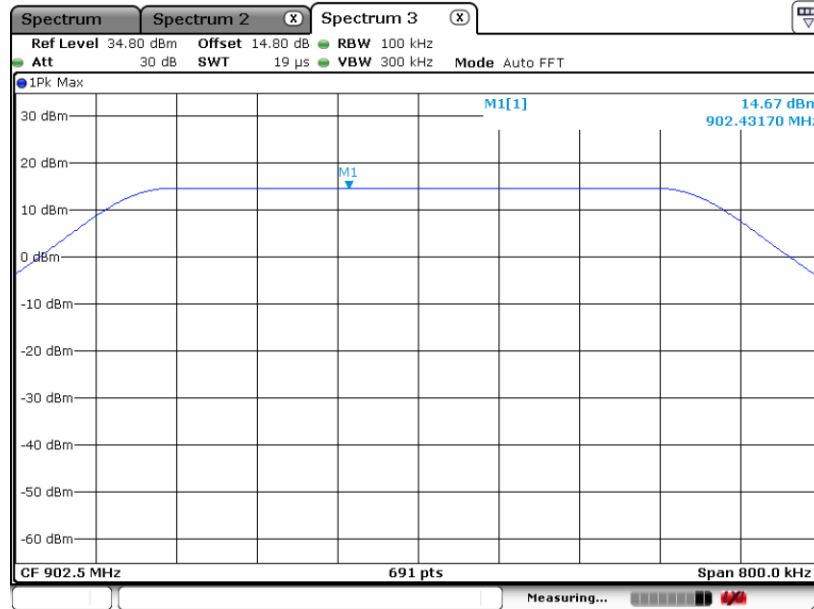
Please refer to Appendix A.



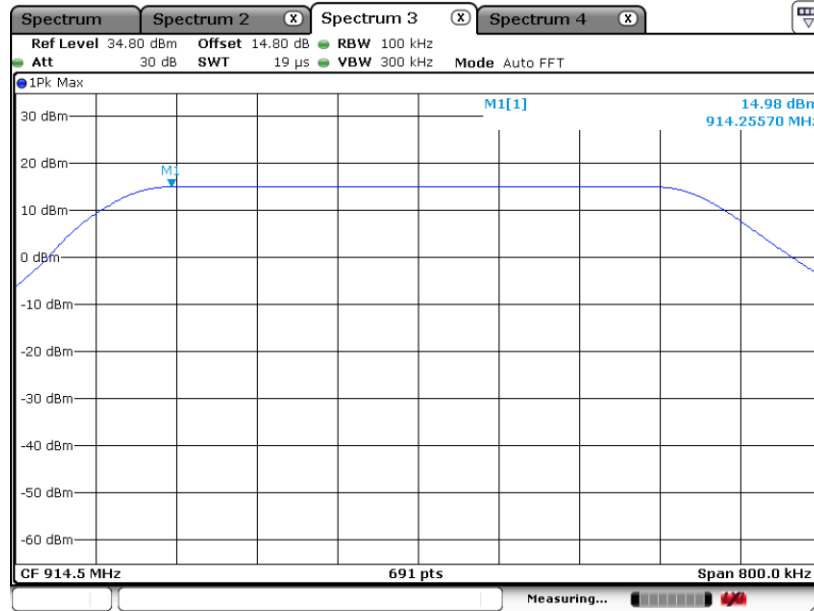
3.3.6 Test Result of Power Spectral Density Plots (100kHz)

For SF8:

PSD 100kHz Plot on 902.5 MHz

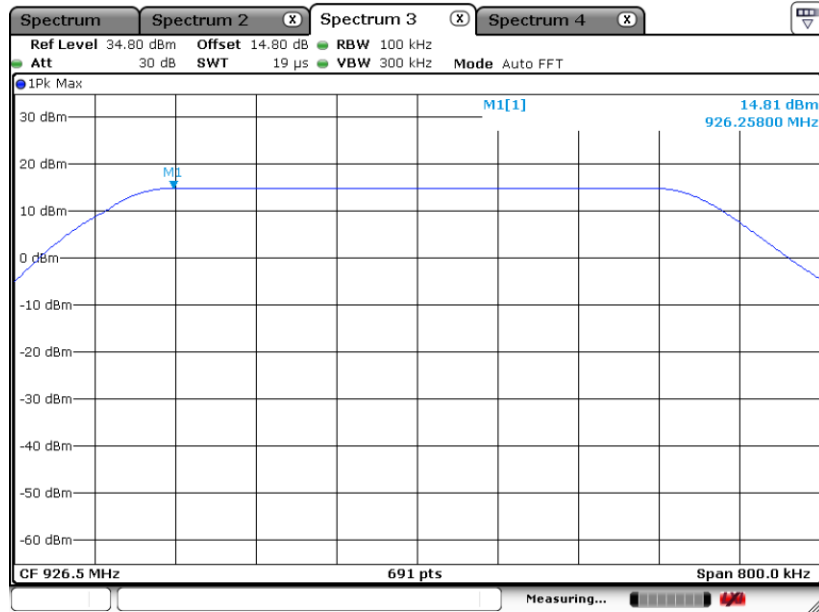


PSD 100kHz Plot on 914.5 MHz





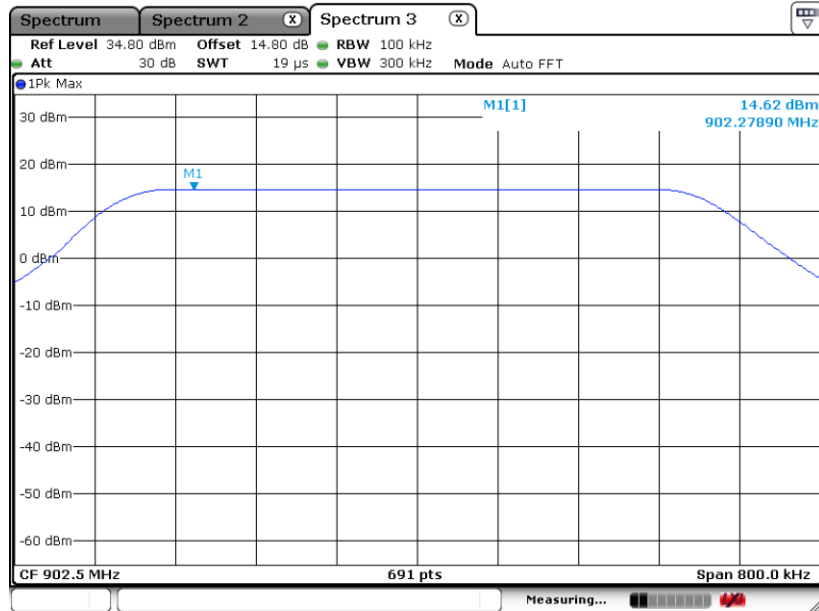
PSD 100kHz Plot on 926.5 MHz



Date: 31.JUL.2022 11:33:37

For SF9:

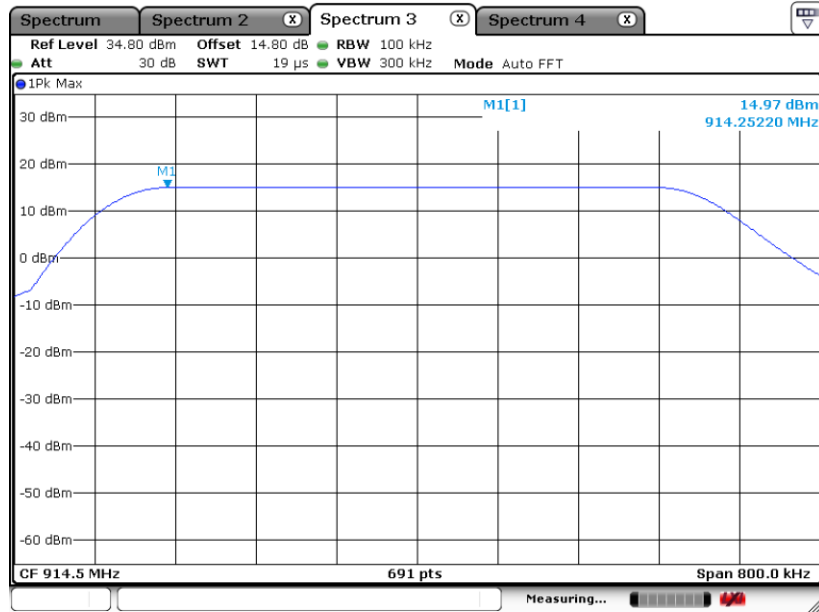
PSD 100kHz Plot on 902.5 MHz



Date: 23.AUG.2022 15:44:01

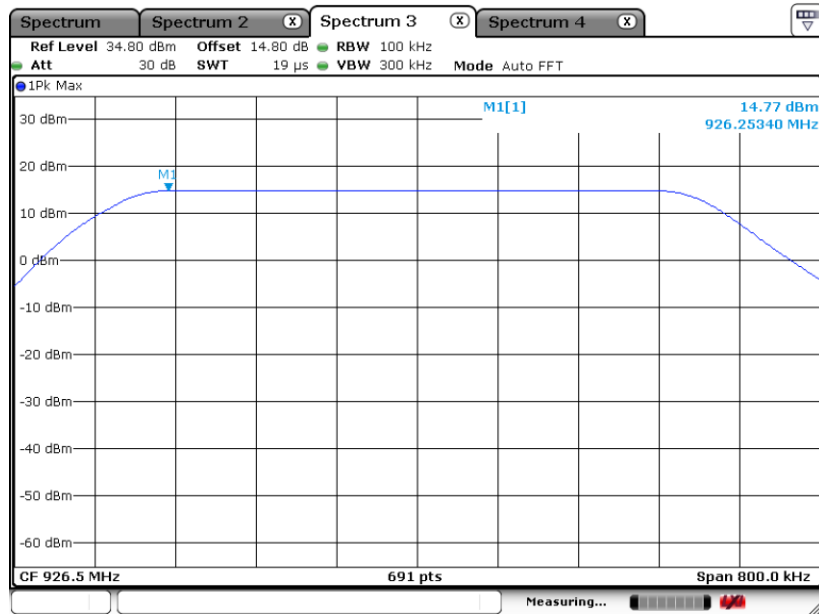


PSD 100kHz Plot on 914.5 MHz



Date: 31.JUL.2022 12:00:45

PSD 100kHz Plot on 926.5 MHz

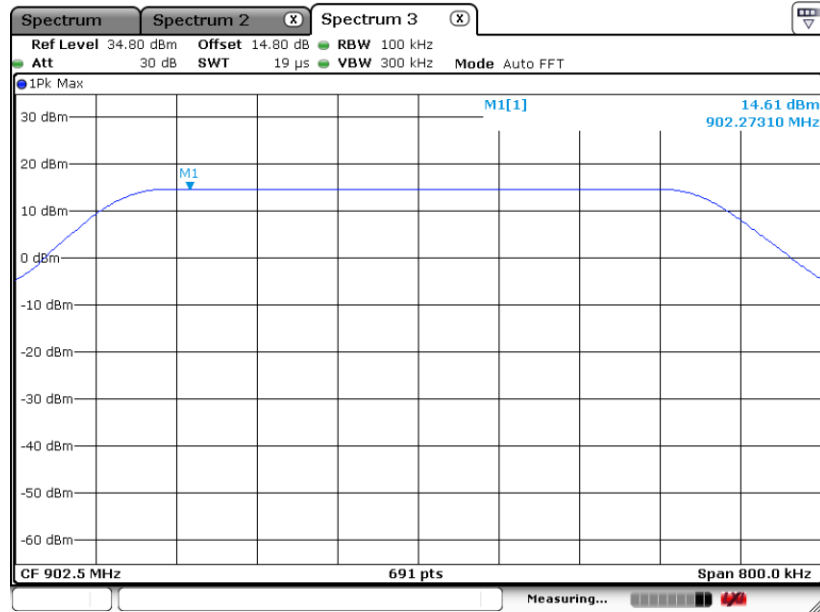


Date: 31.JUL.2022 12:04:38



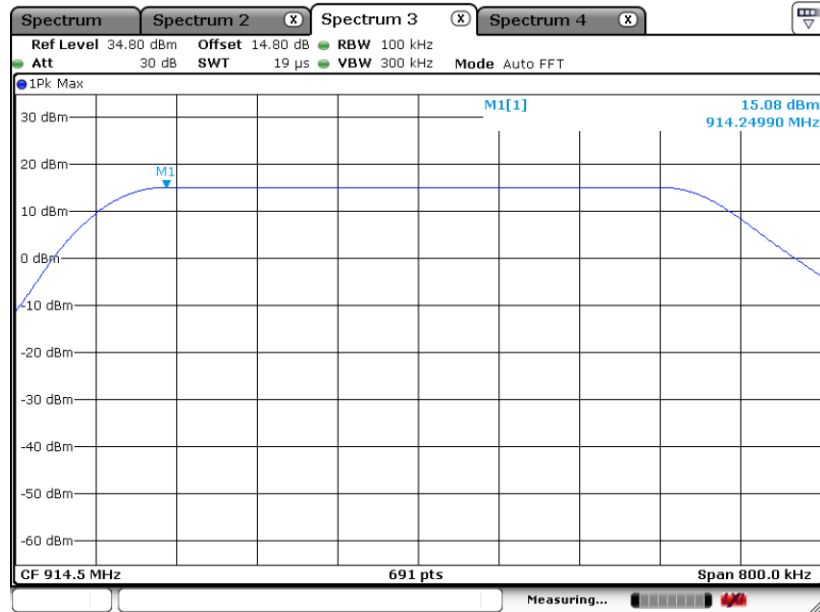
For SF10:

PSD 100kHz Plot on 902.5 MHz



Date: 23.AUG.2022 15:48:32

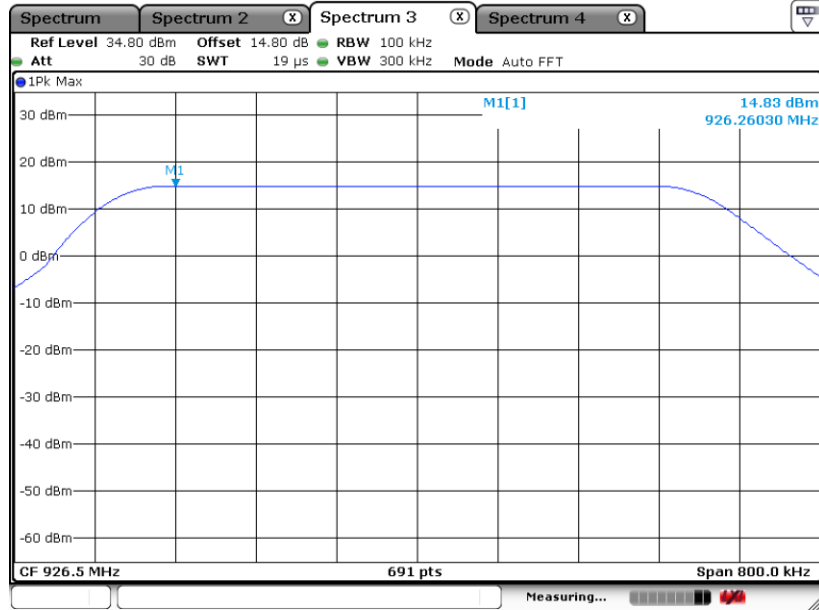
PSD 100kHz Plot on 914.5 MHz



Date: 31.JUL.2022 12:47:17



PSD 100kHz Plot on 926.5 MHz



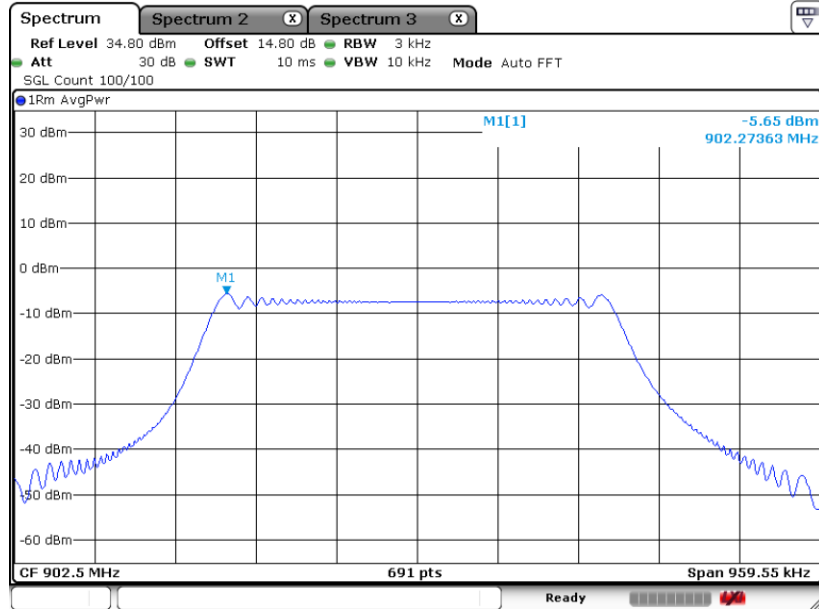
Date: 31.JUL.2022 12:52:25



3.3.7 Test Result of Power Spectral Density Plots (3kHz)

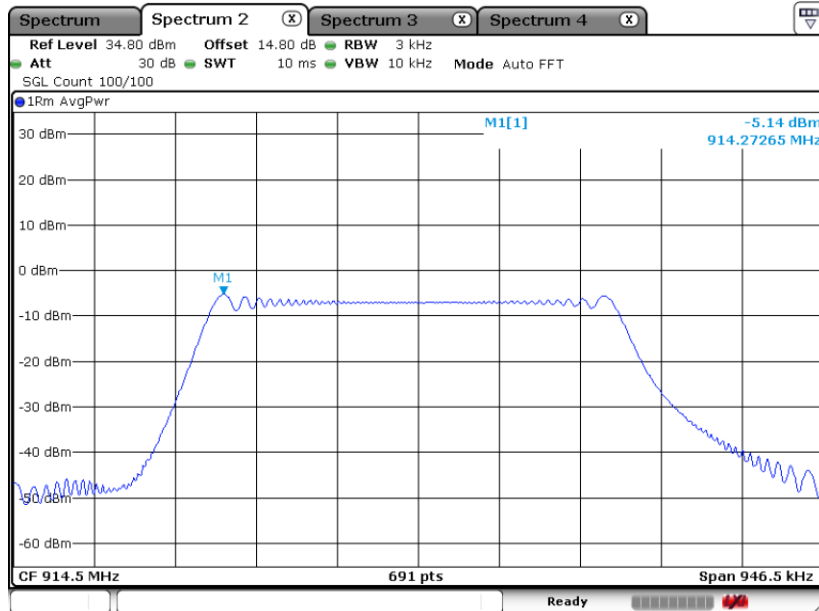
For SF8:

PSD 3kHz Plot on 902.5 MHz



Date: 23.AUG.2022 15:51:55

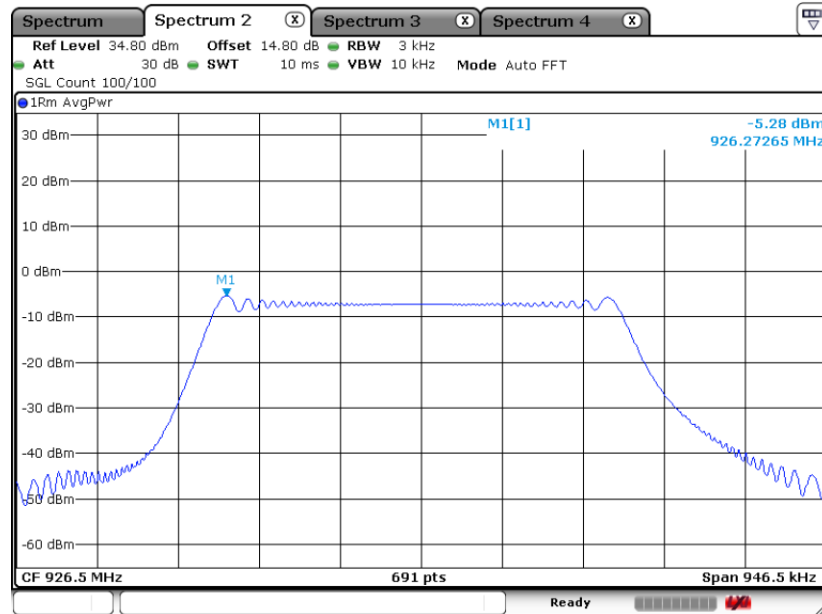
PSD 3kHz Plot on 914.5 MHz



Date: 31.JUL.2022 11:27:54



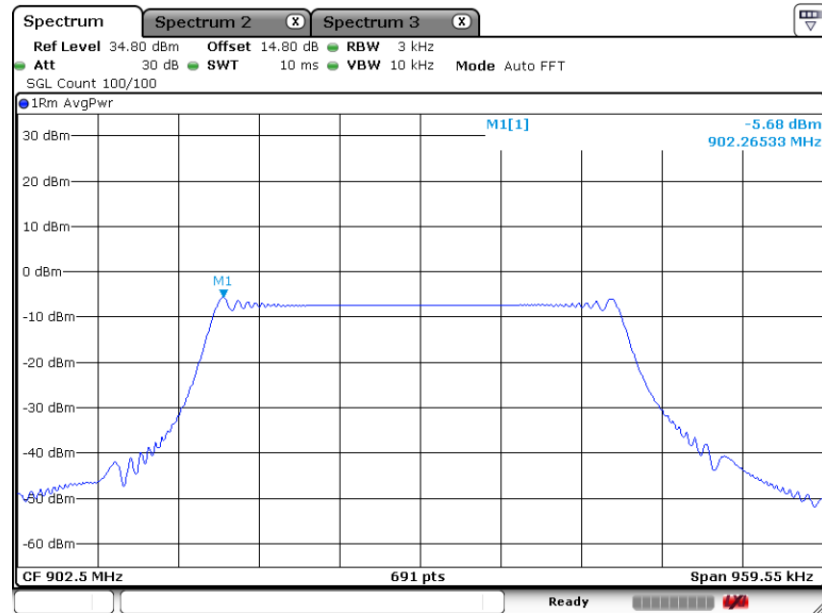
PSD 3kHz Plot on 926.5 MHz



Date: 31.JUL.2022 11:33:17

For SF9:

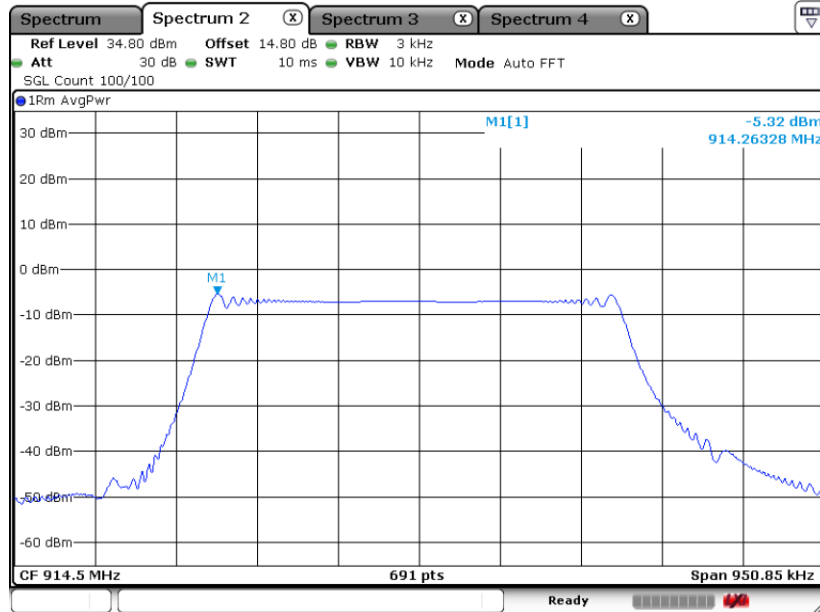
PSD 3kHz Plot on 902.5 MHz



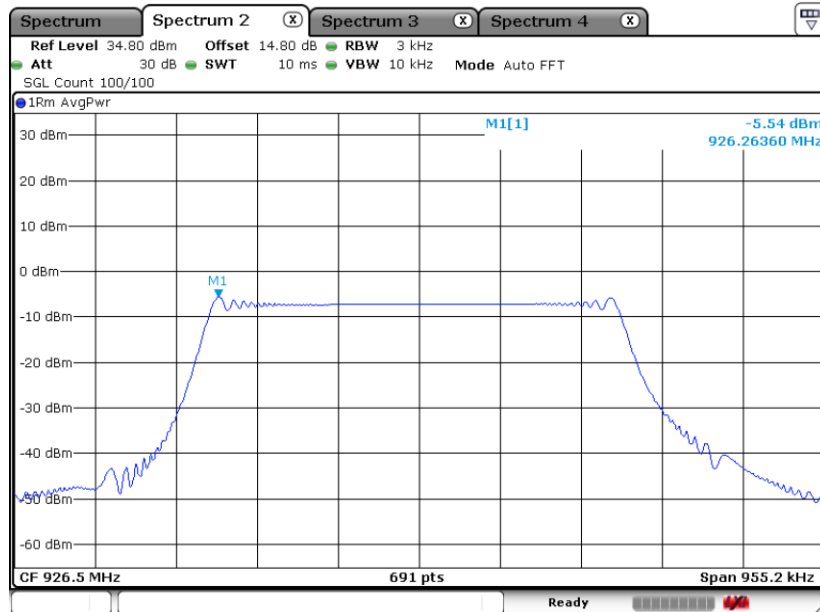
Date: 23.AUG.2022 15:51:20



PSD 3kHz Plot on 914.5 MHz



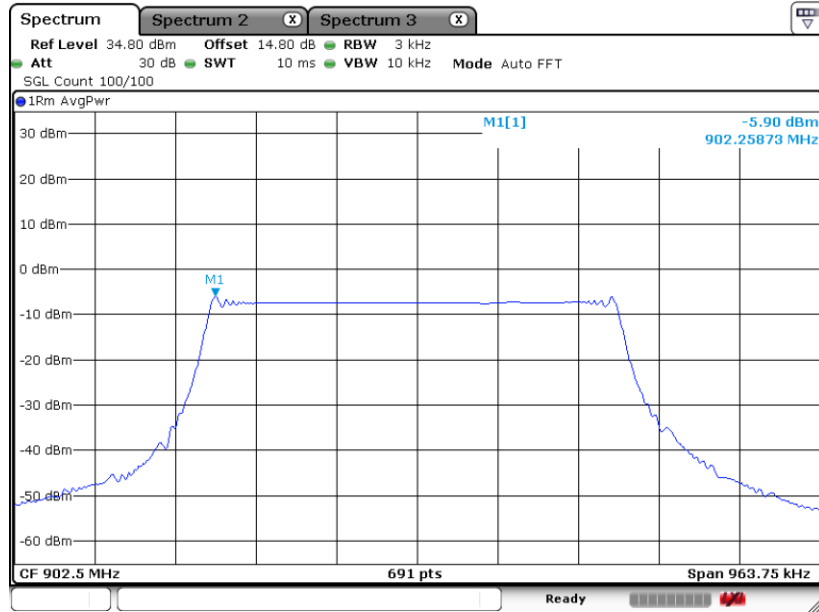
PSD 3kHz Plot on 926.5 MHz





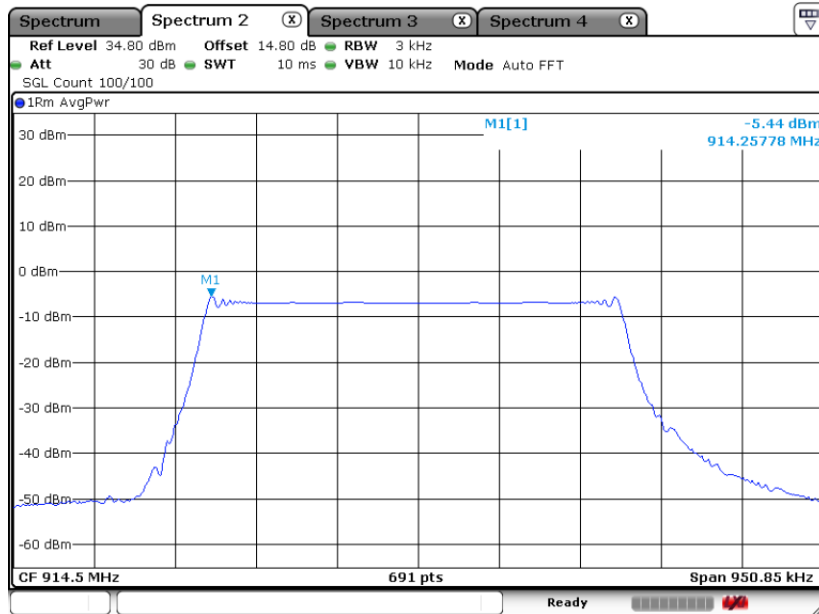
For SF10:

PSD 3kHz Plot on 902.5 MHz



Date: 23.AUG.2022 15:50:51

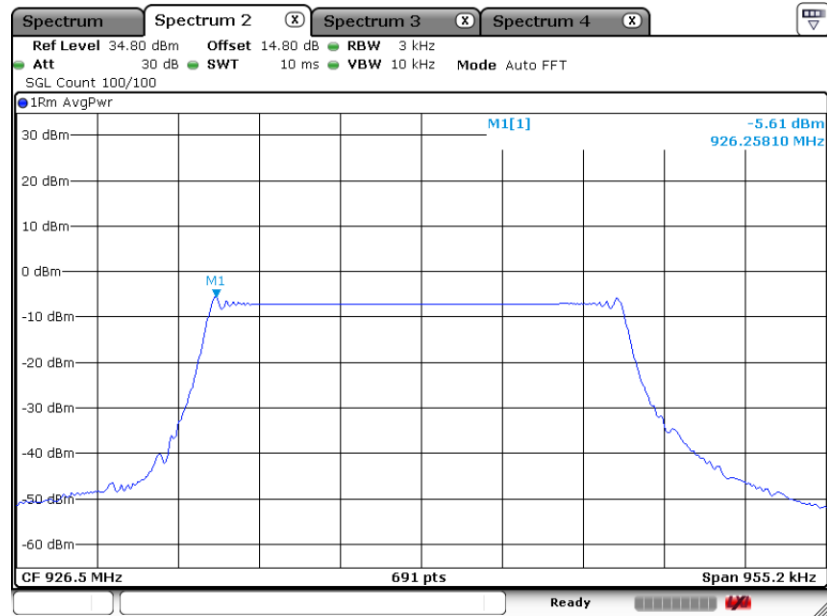
PSD 3kHz Plot on 914.5 MHz



Date: 31.JUL.2022 12:46:54



PSD 3kHz Plot on 926.5 MHz



Date: 31.JUL.2022 12:52:05

3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission

All harmonics/spurious must be at least 30 dB down from the highest emission level within the authorized band.

3.4.2 Measuring Instruments

The section 4.0 of List of Measuring Equipment of this test report is used for test.

3.4.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 11.13
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT 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.
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

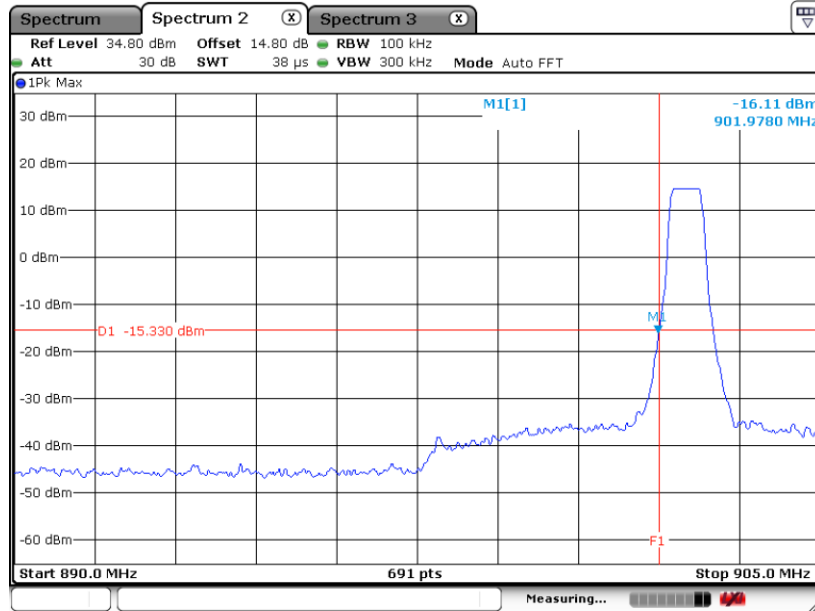




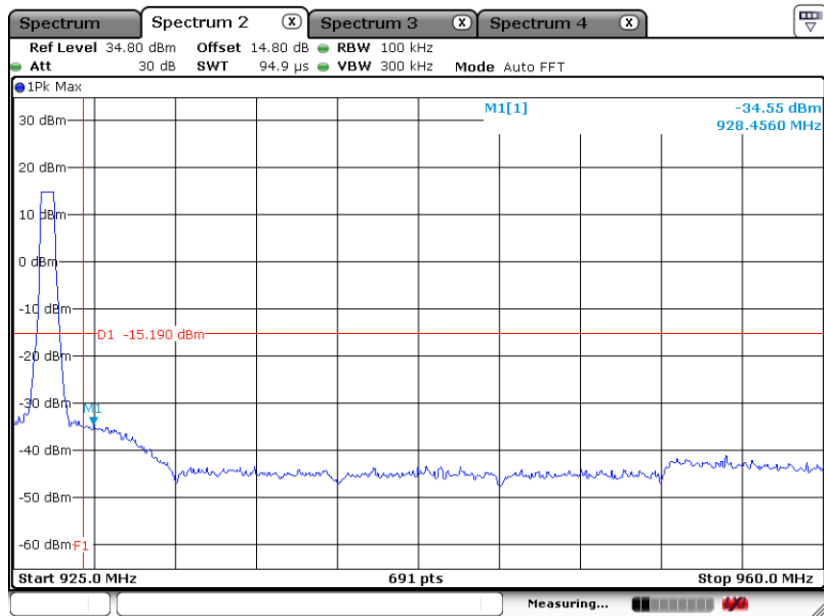
3.4.5 Test Result of Conducted Band Edges Plots

For SF8:

Low Band Edge Plot on 902.5 MHz



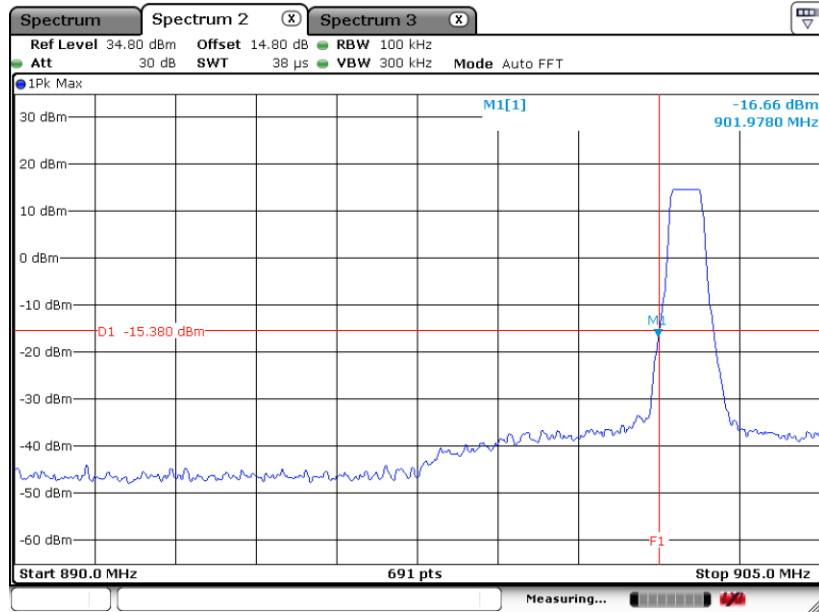
High Band Edge Plot on 926.5 MHz



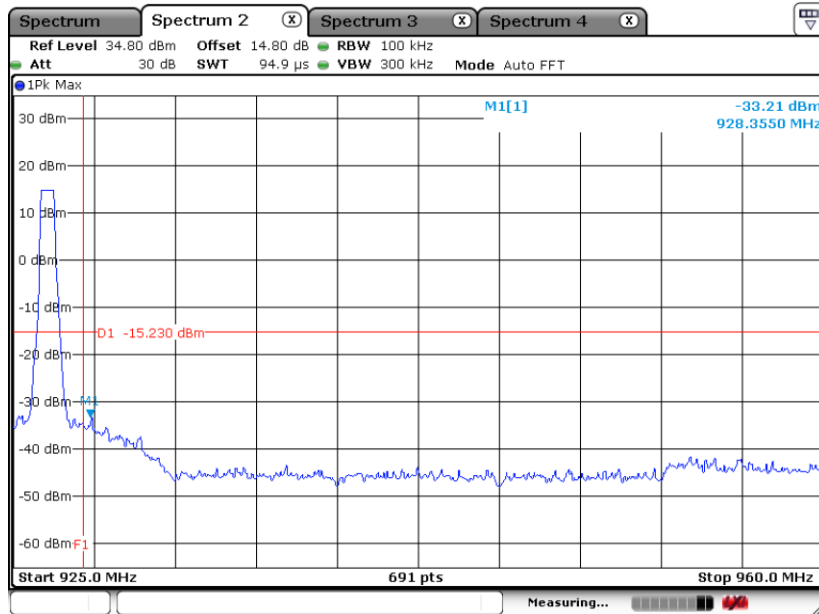


For SF9:

Low Band Edge Plot on 902.5 MHz



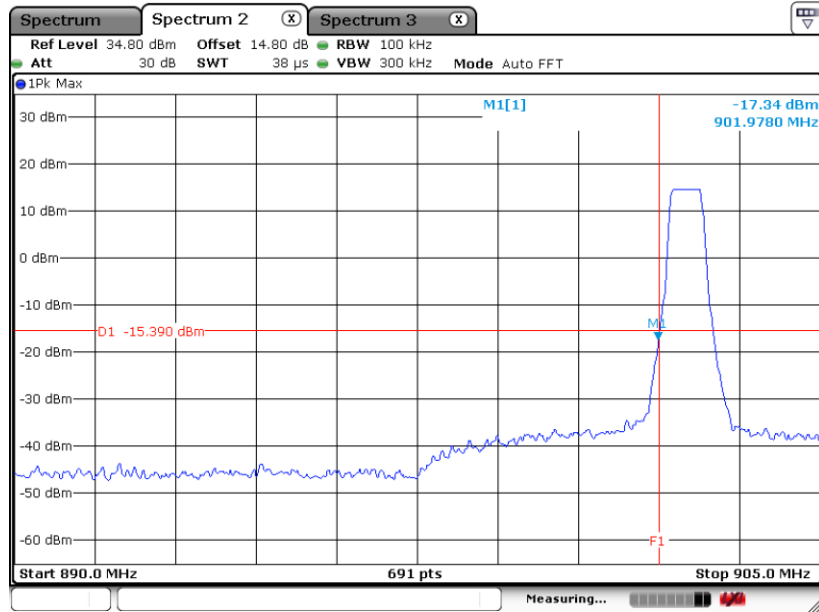
High Band Edge Plot on 926.5 MHz





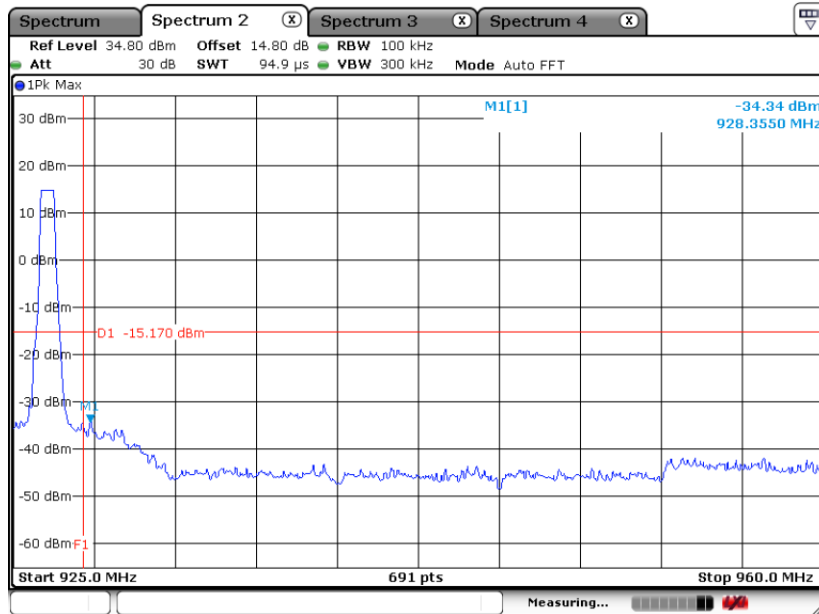
For SF10:

Low Band Edge Plot on 902.5 MHz



Date: 23.AUG.2022 15:49:28

High Band Edge Plot on 926.5 MHz



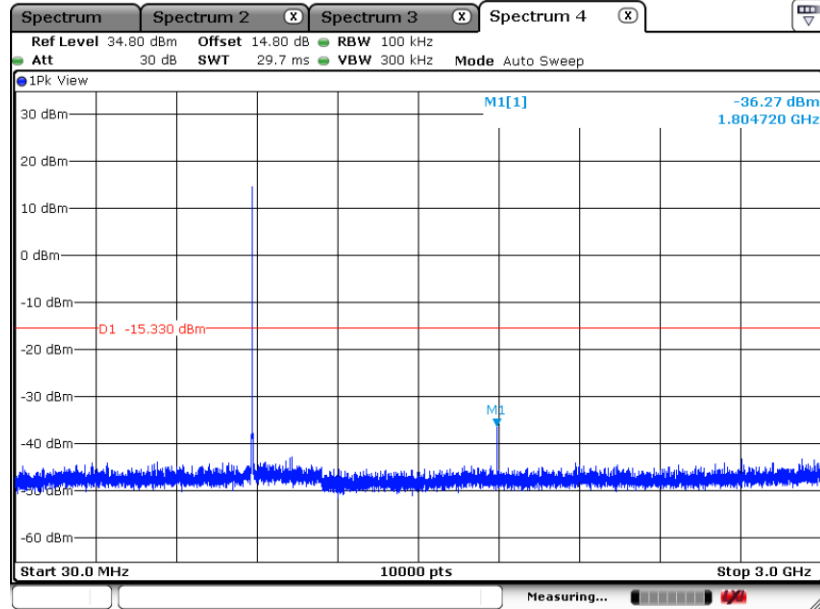
Date: 31.JUL.2022 12:53:29



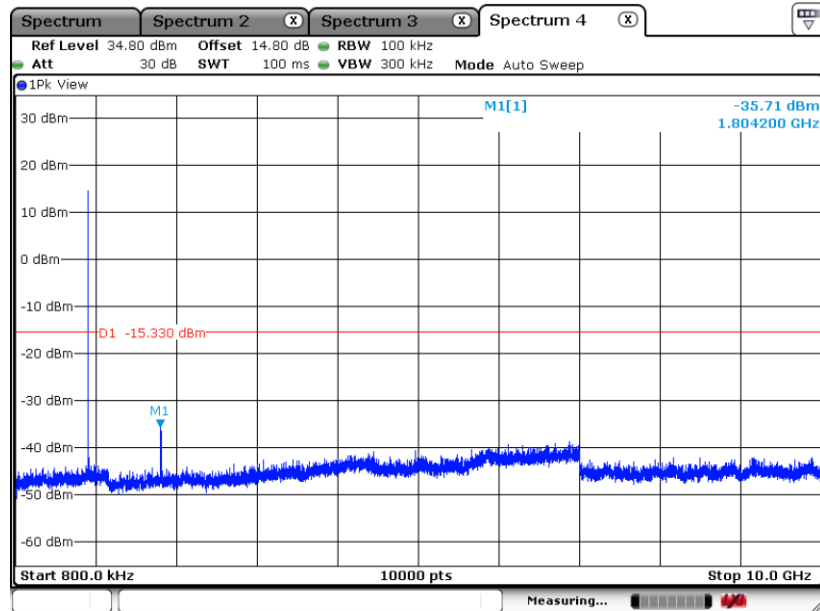
3.4.6 Test Result of Conducted Spurious Emission Plots

For SF8:

Conducted Spurious Emission Plot on 902.5 MHz

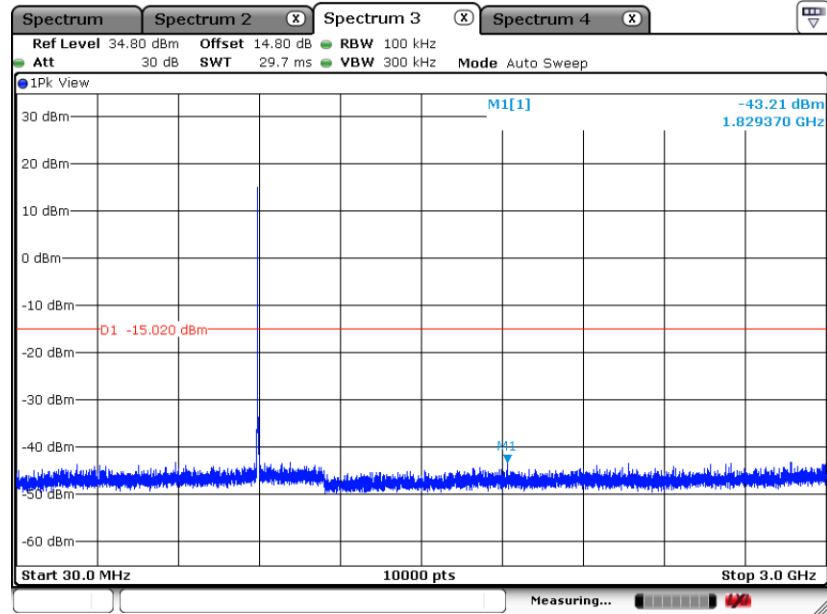


Conducted Spurious Emission Plot on 902.5 MHz

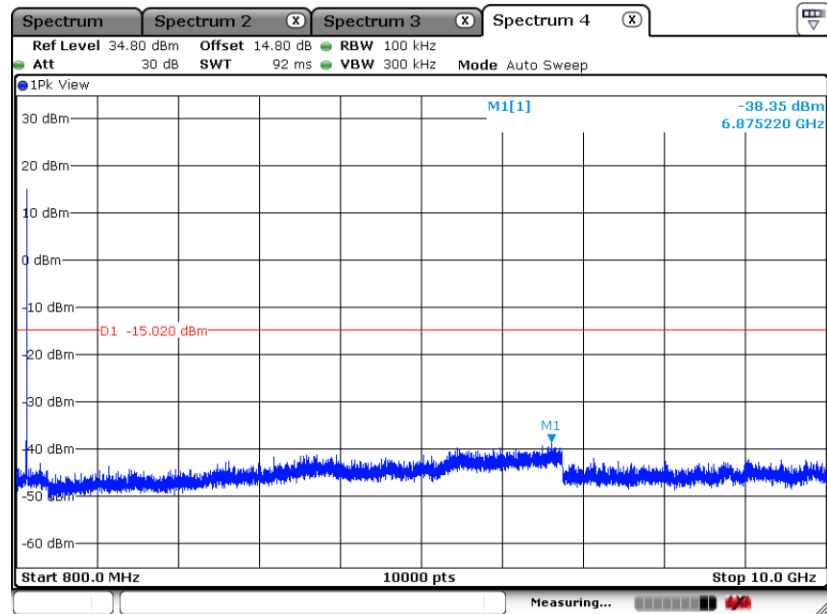




Conducted Spurious Emission Plot on 914.5 MHz

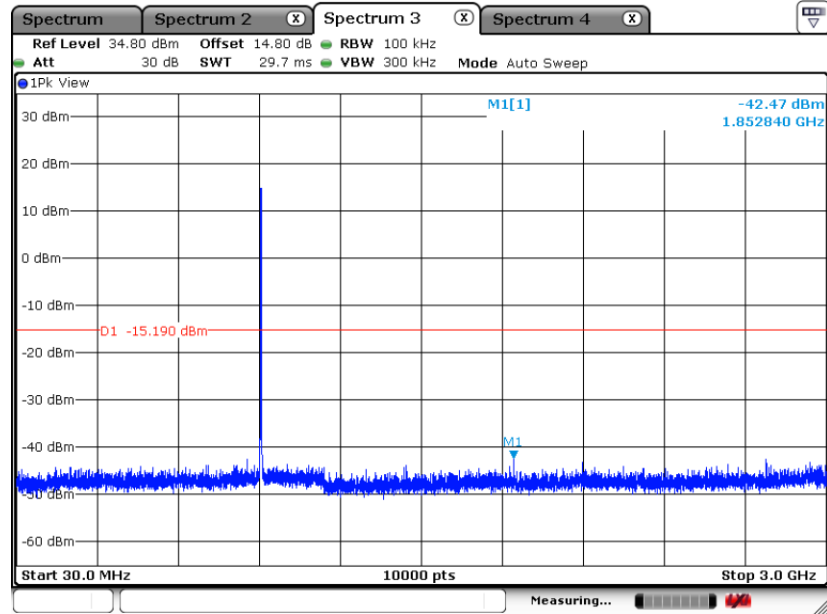


Conducted Spurious Emission Plot on 914.5 MHz

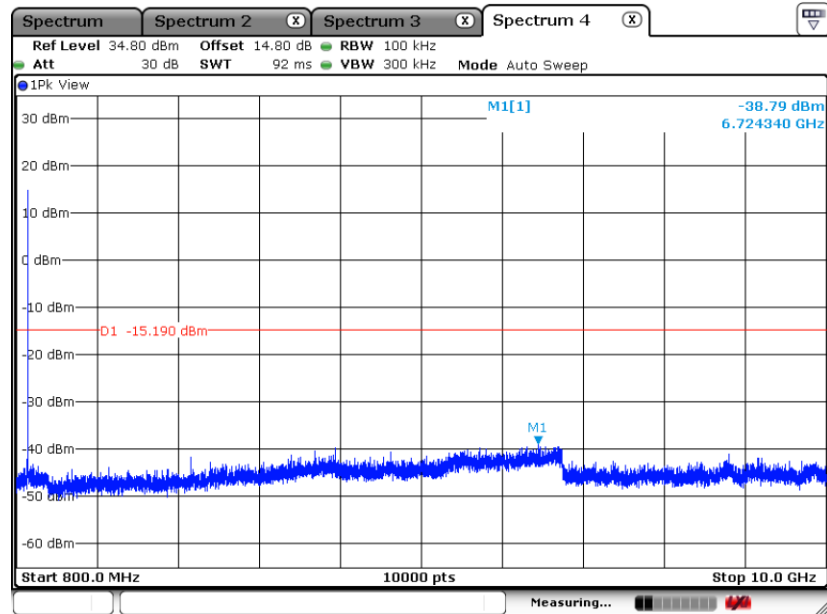




Conducted Spurious Emission Plot on 926.5 MHz



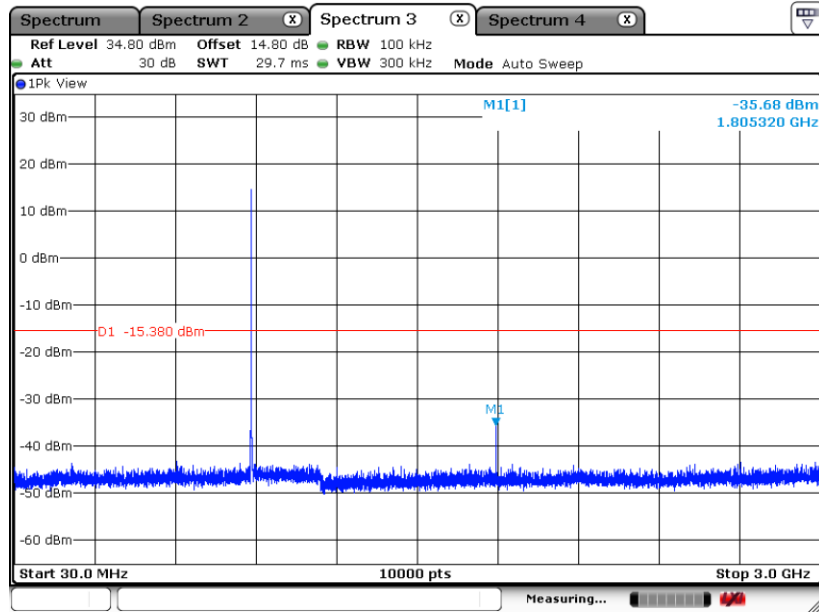
Conducted Spurious Emission Plot on 926.5 MHz





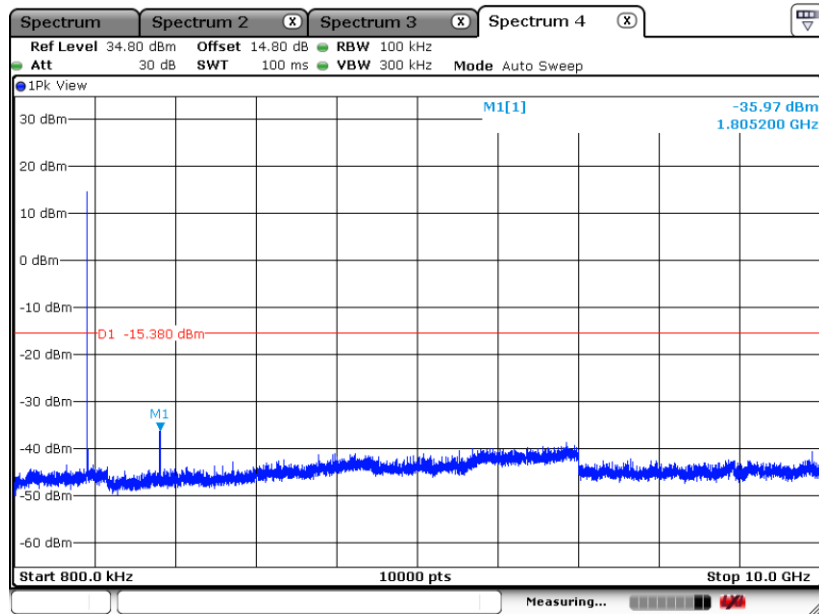
For SF9:

Conducted Spurious Emission Plot on 902.5 MHz



Date: 23.AUG.2022 15:57:53

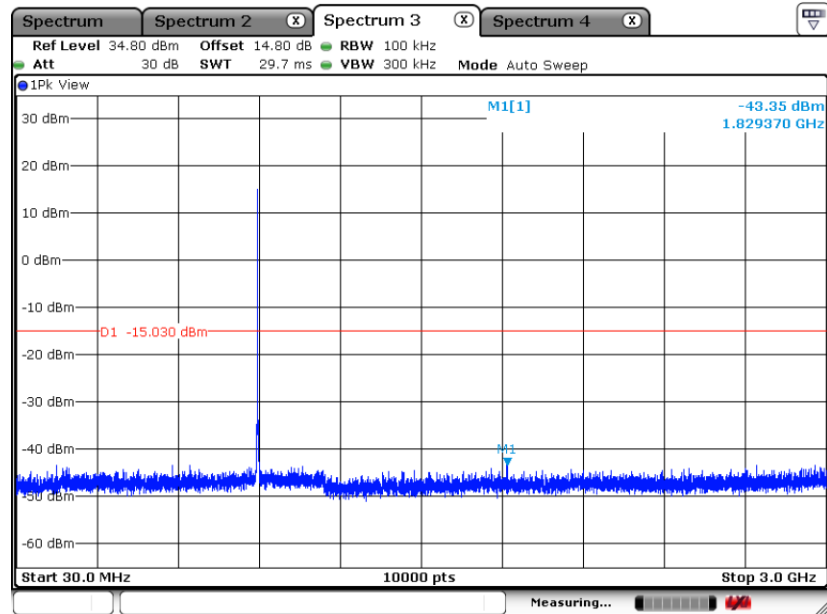
Conducted Spurious Emission Plot on 902.5 MHz



Date: 23.AUG.2022 15:58:44

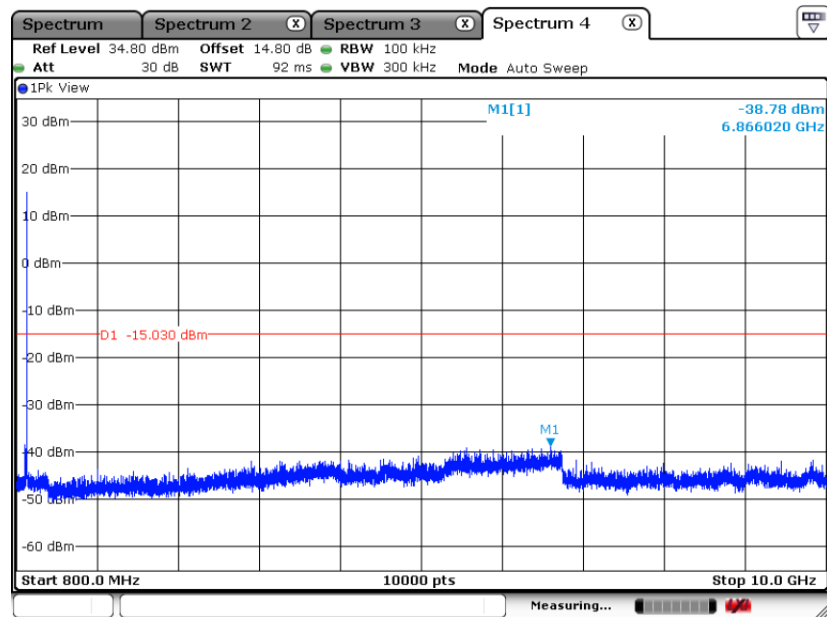


Conducted Spurious Emission Plot on 914.5 MHz



Date: 31.JUL.2022 12:01:47

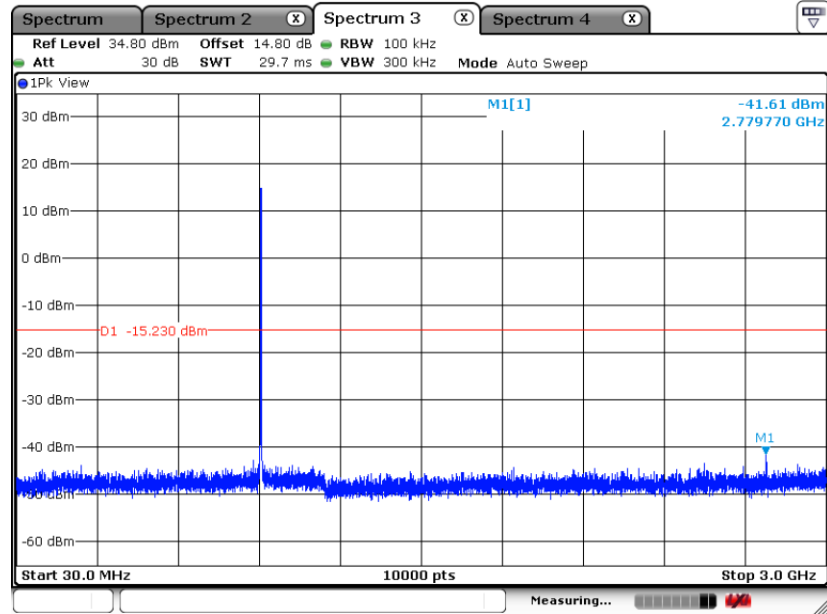
Conducted Spurious Emission Plot on 914.5 MHz



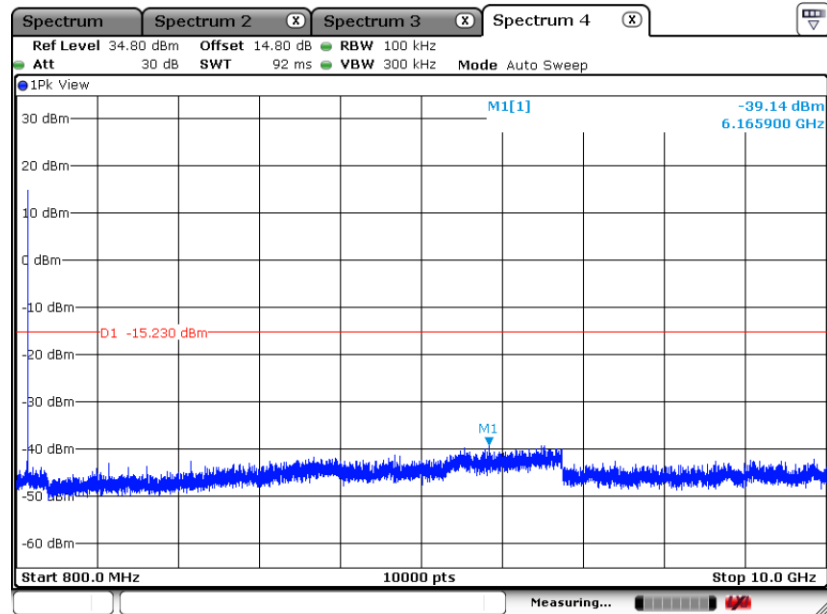
Date: 31.JUL.2022 12:02:14



Conducted Spurious Emission Plot on 926.5 MHz



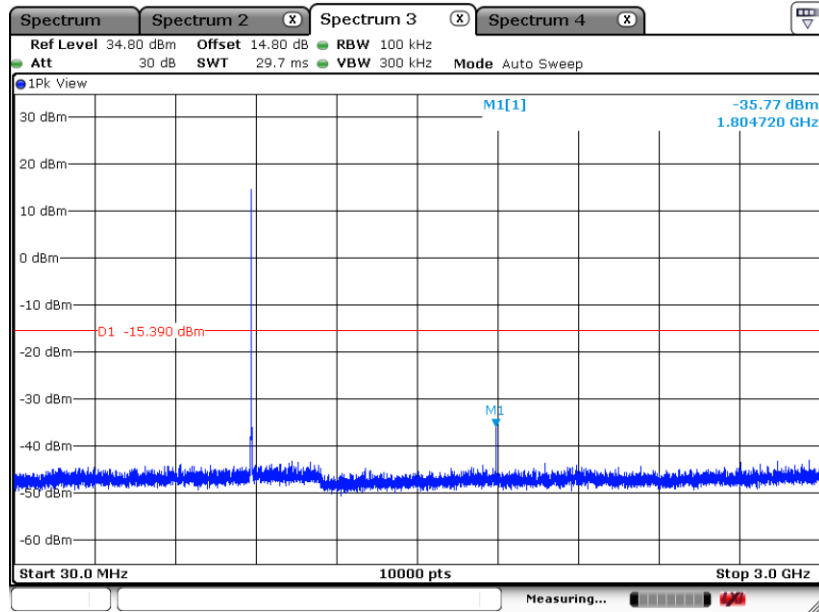
Conducted Spurious Emission Plot on 926.5 MHz





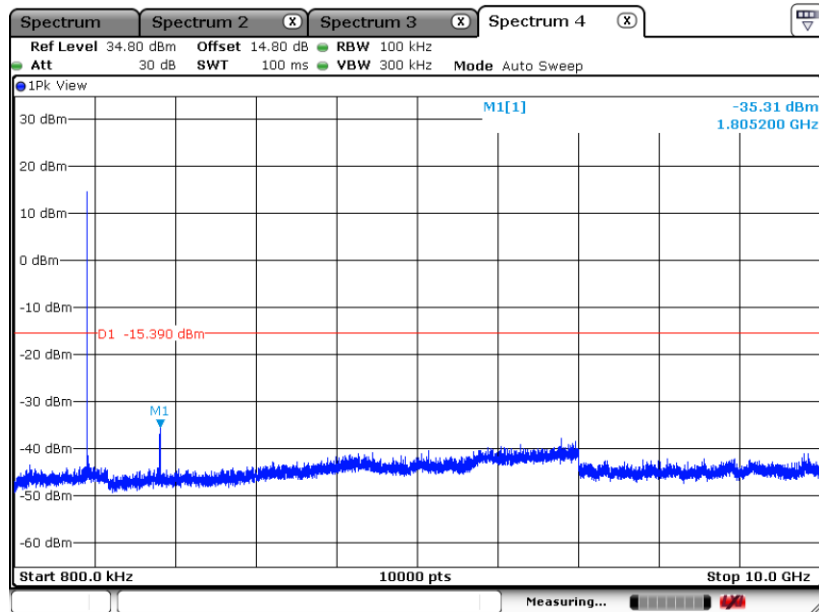
For SF10:

Conducted Spurious Emission Plot on 902.5 MHz



Date: 23.AUG.2022 15:59:38

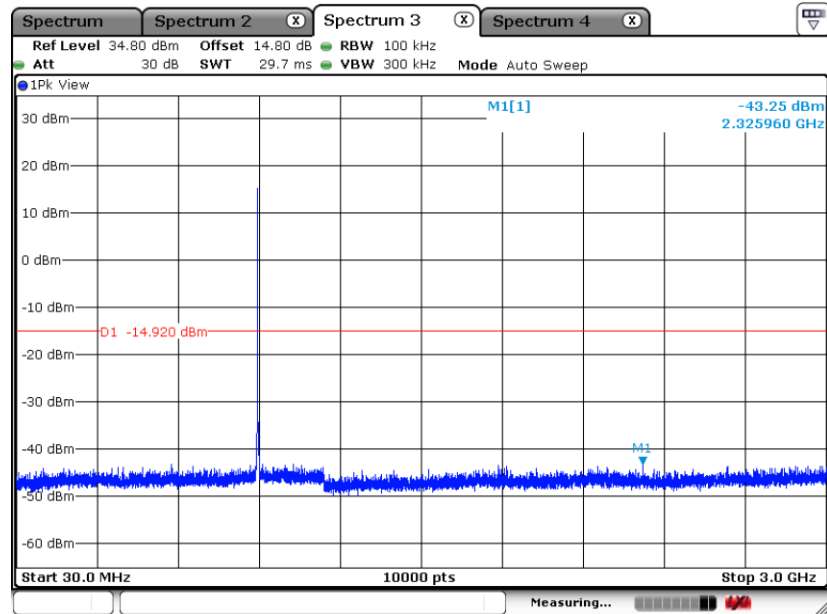
Conducted Spurious Emission Plot on 902.5 MHz



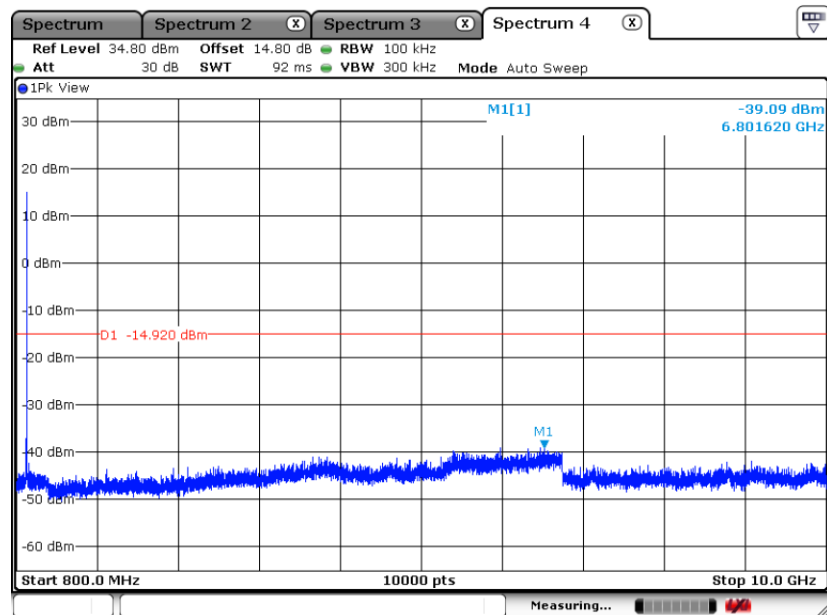
Date: 23.AUG.2022 16:00:52



Conducted Spurious Emission Plot on 914.5 MHz

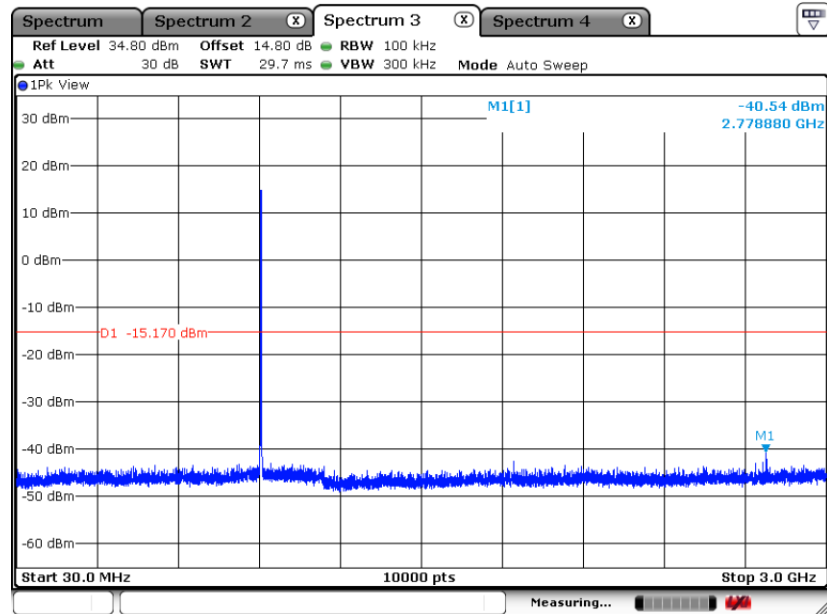


Conducted Spurious Emission Plot on 914.5 MHz



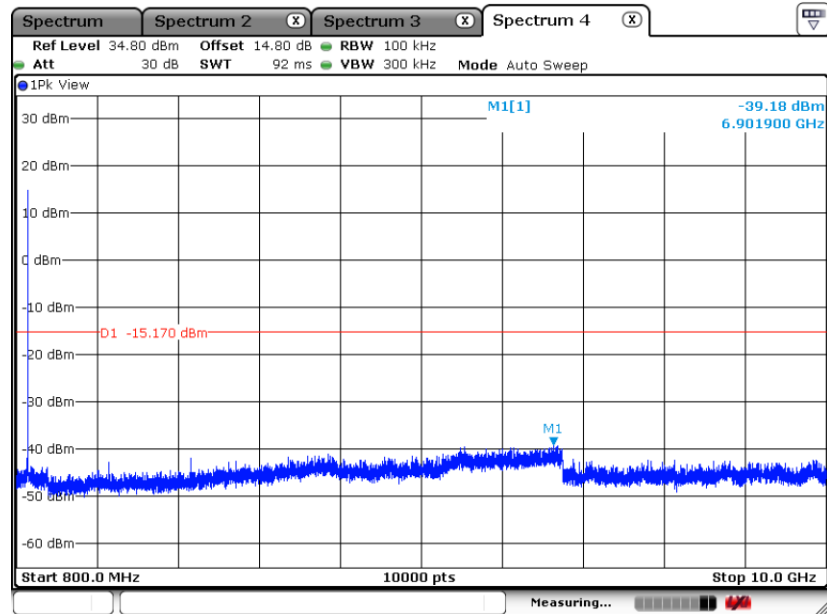


Conducted Spurious Emission Plot on 926.5 MHz



Date: 31.JUL.2022 12:54:26

Conducted Spurious Emission Plot on 926.5 MHz



Date: 31.JUL.2022 12:54:53



3.5 Radiated Band Edges and Spurious Emission Measurement

3.5.1 Limit of Radiated Band Edges and Spurious Emission

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 was 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

The section 4.0 of List of Measuring Equipment of this test report is used for test.

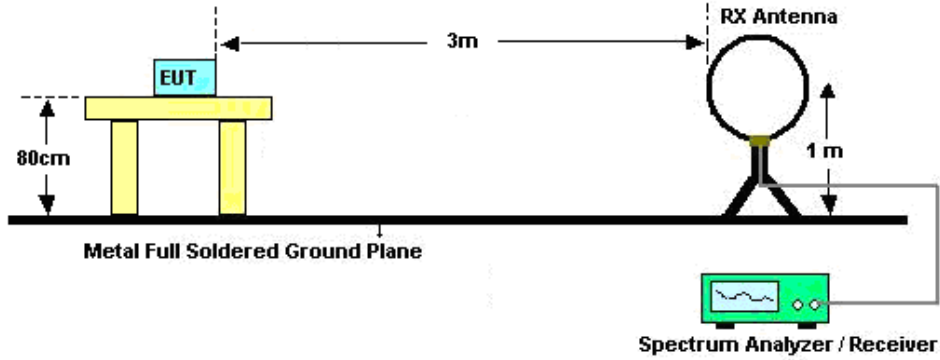


3.5.3 Test Procedures

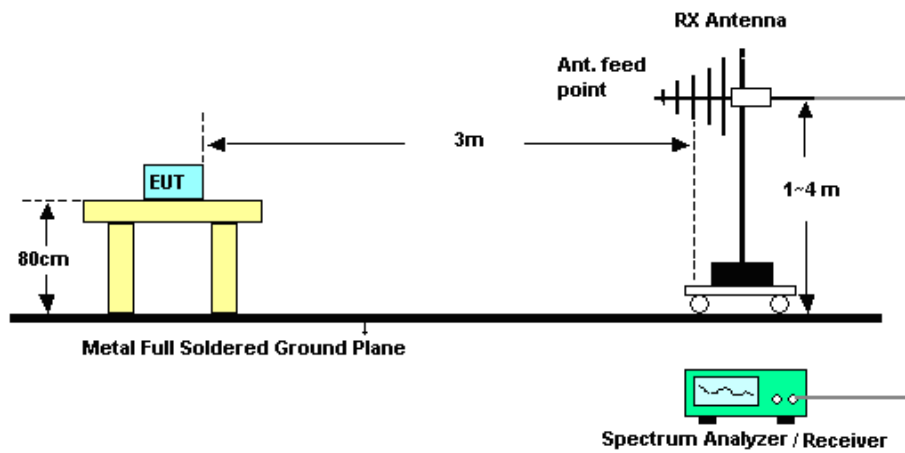
1. The testing follows ANSI C63.10-2013 clause 11.11 & 11.12
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
4. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
6. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
7. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than average limit (that means the emission level in average mode also complies with the limit in average mode), then peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.
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= 3MHz 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

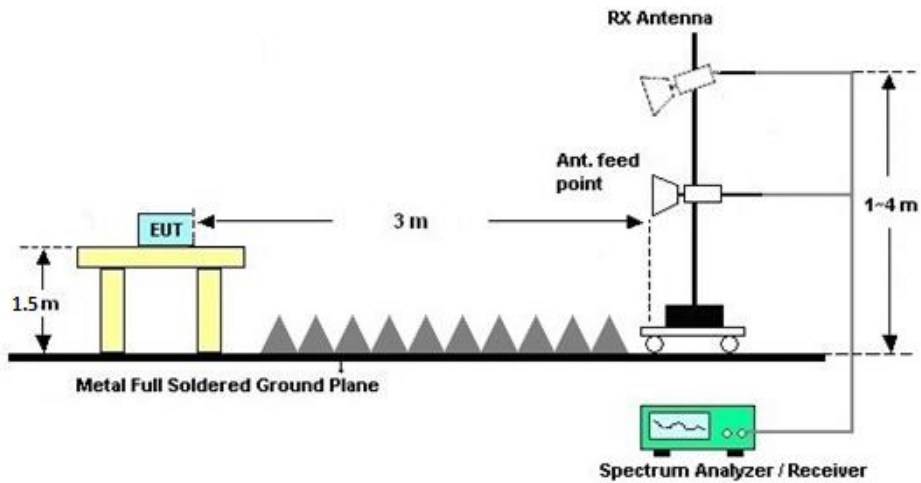
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz





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

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

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B.

3.5.7 Duty Cycle

Please refer to Appendix C.

3.5.8 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic)

Please refer to Appendix B.



3.6 Antenna Requirements

3.6.1 Standard Applicable

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

3.6.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.6.3 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	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV40	101040	10Hz~40GHz	Oct. 14, 2021	Jul. 31, 2022~ Aug. 23, 2022	Oct. 13, 2022	Conducted (TH01-KS)
Pulse Power Sensor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 05, 2022	Jul. 31, 2022~ Aug. 23, 2022	Jan. 04, 2023	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 05, 2022	Jul. 31, 2022~ Aug. 23, 2022	Jan. 04, 2023	Conducted (TH01-KS)
EMI Test Receiver	R&S	ESR7	101403	9kHz~7GHz;Max x 30dBm	Oct. 16, 2021	Aug. 15, 2022	Oct. 15, 2022	Radiation (03CH07-KS)
EXA Spectrum Analyzer	Keysight	N9010A	MY55370528	10Hz~44G,MAX 30dB	Oct. 16, 2021	Aug. 15, 2022	Oct. 15, 2022	Radiation (03CH07-KS)
Loop Antenna	R&S	HFH2-Z2	100321	9kHz~30MHz	Oct. 30, 2021	Aug. 15, 2022	Oct. 29, 2022	Radiation (03CH07-KS)
Bilog Antenna	TeseQ	CBL6111D	59913	30MHz-1GHz	Sep. 07, 2021	Aug. 15, 2022	Sep. 06, 2022	Radiation (03CH07-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	00218652	1GHz~18GHz	Apr. 06, 2022	Aug. 15, 2022	Apr. 05, 2023	Radiation (03CH07-KS)
high gain Amplifier	MITEQ	AMF-7D-0010 1800-30-10P	2025788	1Ghz-18Ghz	Jul. 30, 2022	Aug. 15, 2022	Jul. 29, 2023	Radiation (03CH07-KS)
Amplifier	SONOMA	310N	413740	9KHz-1GHz	Jan. 05, 2022	Aug. 15, 2022	Jan. 04, 2023	Radiation (03CH07-KS)
Amplifier	Keysight	83017A	MY53270316	500MHz~26.5GHz	Oct. 16, 2021	Aug. 15, 2022	Oct. 15, 2022	Radiation (03CH07-KS)
AC Power Source	Chroma	61601	616010002473	N/A	NCR	Aug. 15, 2022	NCR	Radiation (03CH07-KS)
Turn Table	MF	MF7802	N/A	0~360 degree	NCR	Aug. 15, 2022	NCR	Radiation (03CH07-KS)
Antenna Mast	MF	MF7802	N/A	1 m~4 m	NCR	Aug. 15, 2022	NCR	Radiation (03CH07-KS)

NCR: No Calibration Required



5 Uncertainty of Evaluation

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI 63.10-2013. All the measurement uncertainty value were shown with a coverage K=2 to indicate 95% level of confidence. The measurement data show herein meets or exceeds the CISPR measurement uncertainty values specified in CISPR 16-4-2 and can be compared directly to specified limit to determine compliance.

Uncertainty of Conducted Measurement

Test Item	Uncertainty
Conducted Power	±0.56 dB
Conducted Emissions	±0.92 dB
Occupied Channel Bandwidth	±0.03 %
Conducted Power Spectral Density	±0.54 dB

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	5.0dB
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Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	5.0dB
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Appendix A. Conducted Test Results

Test Engineer:	Jiang Jun	Temperature:	20~26	°C
Test Date:	2022.7.31~2022.8.23	Relative Humidity:	40~51	%

LoRa-DTS-Spreading Factor 8

TEST RESULTS DATA
6dB and 99% Occupied Bandwidth

Mod.	Channel	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
SF8	1	902.5Mhz	0.515	0.634	0.50	Pass
SF8	16	914.5Mhz	0.515	0.631	0.50	Pass
SF8	31	926.5Mhz	0.512	0.631	0.50	Pass

TEST RESULTS DATA
Average Power Table

Mod.	Channel	Freq. (MHz)	Duty Factor (dB)	Average Conducted Power (dBm)
SF8	1	902.5Mhz	0.02	14.74
SF8	16	914.5Mhz	0.02	14.66
SF8	31	926.5Mhz	0.02	14.54

TEST RESULTS DATA
Peak Power Density

Mod.	Channel	Freq. (MHz)	Peak PSD (dBm /100kHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
SF8	1	902.5Mhz	14.67	-5.65	1.01	8.00	Pass
SF8	16	914.5Mhz	14.98	-5.14	1.01	8.00	Pass
SF8	31	926.5Mhz	14.81	-5.28	1.01	8.00	Pass

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

LoRa-DTS-Spreading Factor 9**TEST RESULTS DATA**
6dB and 99% Occupied Bandwidth

Mod.	Channel	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
SF9	1	902.5Mhz	0.52	0.64	0.50	Pass
SF9	16	914.5Mhz	0.52	0.63	0.50	Pass
SF9	31	926.5Mhz	0.52	0.64	0.50	Pass

TEST RESULTS DATA
Average Power Table

Mod.	Channel	Freq. (MHz)	Duty Factor (dB)	Average Conducted Power (dBm)
SF9	1	902.5Mhz	0.00	14.93
SF9	16	914.5Mhz	0.00	14.66
SF9	31	926.5Mhz	0.00	14.44

TEST RESULTS DATA
Peak Power Density

Mod.	Channel	Freq. (MHz)	Peak PSD (dBm /100kHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
SF9	1	902.5Mhz	14.62	-5.68	1.01	8.00	Pass
SF9	16	914.5Mhz	14.97	-5.32	1.01	8.00	Pass
SF9	31	926.5Mhz	14.77	-5.54	1.01	8.00	Pass

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

LoRa-DTS-Spreading Factor 10**TEST RESULTS DATA**
6dB and 99% Occupied Bandwidth

Mod.	Channel	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
SF10	1	902.5Mhz	0.52	0.64	0.50	Pass
SF10	16	914.5Mhz	0.52	0.63	0.50	Pass
SF10	31	926.5Mhz	0.52	0.64	0.50	Pass

TEST RESULTS DATA
Average Power Table

Mod.	Channel	Freq. (MHz)	Duty Factor (dB)	Average Conducted Power (dBm)
SF10	1	902.5Mhz	0.00	15.05
SF10	16	914.5Mhz	0.00	14.97
SF10	31	926.5Mhz	0.00	14.85

TEST RESULTS DATA
Peak Power Density

Mod.	Channel	Freq. (MHz)	Peak PSD (dBm /100kHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
SF10	1	902.5Mhz	14.61	-5.90	1.01	8.00	Pass
SF10	16	914.5Mhz	15.08	-5.44	1.01	8.00	Pass
SF10	31	926.5Mhz	14.83	-5.61	1.01	8.00	Pass

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



Appendix B. Radiated Spurious Emission

902~928MHz

LORA DTS SF=8 (Band Edge @ 3m)

	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
902.5MHz		270.56	36.43	-9.57	46	46.24	19.27	2.4	31.48	200	77	P	H
		902.03	114.16	-	-	111.79	29.12	4.37	31.12	200	77	P	H
		268.62	29.72	-16.28	46	39.45	19.34	2.39	31.46	100	360	P	V
		902.03	105.06	-	-	102.69	29.12	4.37	31.12	100	360	P	V
914.5MHz		274.44	36.12	-9.88	46	46.07	19.13	2.42	31.5	200	360	P	H
		914.64	112.78	-	-	109.98	29.31	4.4	30.91	200	360	P	H
		273.47	29.24	-16.76	46	39.16	19.16	2.41	31.49	100	360	P	V
		914.64	105.43	-	-	102.63	29.31	4.4	30.91	100	360	P	V
926.5MHz		272.5	35.95	-10.05	46	45.83	19.2	2.41	31.49	200	360	P	H
		926.28	113.56	-	-	110.36	29.48	4.43	30.71	200	360	P	H
		272.5	28.96	-17.04	46	38.84	19.2	2.41	31.49	100	360	P	V
		926.28	105.34	-	-	102.14	29.48	4.43	30.71	100	360	P	V
Remark	<ol style="list-style-type: none"> No other spurious found. All results are PASS against Peak and Average limit line. Non-restricted band limit is 100kHz-PSD down 30dB. 												



LORA DTS SF=8 (Harmonic @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.5MHz		1801	44.19	-39.97	84.16	73.47	29.28	6.16	64.72	300	360	P	H
		2710	36.36	-37.64	74	62.75	31.06	7.65	65.1	300	360	P	H
		1801	40.07	-34.99	75.06	69.35	29.28	6.16	64.72	100	360	P	V
		2710	37.12	-36.88	74	63.51	31.06	7.65	65.1	100	360	P	V
914.5MHz		1828	45.02	-37.76	82.78	74.12	29.4	6.22	64.72	300	360	P	H
		2746	36.62	-37.38	74	62.99	31.04	7.7	65.11	300	360	P	H
		1828	40.95	-34.48	75.43	70.05	29.4	6.22	64.72	100	0	P	V
		2746	36.7	-37.3	74	63.07	31.04	7.7	65.11	100	0	P	V
926.5MHz		1855	46.17	-37.39	83.56	75.12	29.52	6.25	64.72	300	0	P	H
		2782	36.66	-37.34	74	63.03	31.01	7.74	65.12	300	0	P	H
		1855	40.71	-34.63	75.34	69.66	29.52	6.25	64.72	100	0	P	V
		2782	36.04	-37.96	74	62.41	31.01	7.74	65.12	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 30dB.												



LORA DTS SF=9 (Band Edge @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.5MHz		273.47	36.5	-9.5	46	46.42	19.16	2.41	31.49	100	360	P	H
		903	113.7	-	-	111.29	29.13	4.38	31.1	100	360	P	H
		265.71	28.17	-17.83	46	37.79	19.45	2.38	31.45	200	360	P	V
		902.03	106.53	-	-	104.16	29.12	4.37	31.12	200	360	P	V
914.5MHz		272.5	37.05	-8.95	46	46.93	19.2	2.41	31.49	200	360	P	H
		914.64	112.75	-	-	109.95	29.31	4.4	30.91	200	360	P	H
		240.2	29.52	-16.48	46	41.18	17.44	2.26	31.36	100	360	P	V
		914.64	106.22	-	-	103.42	29.31	4.4	30.91	100	360	P	V
926.5MHz		272.5	36.29	-9.71	46	46.17	19.2	2.41	31.49	100	360	P	H
		926.28	113.55	-	-	110.35	29.48	4.43	30.71	100	360	P	H
		404.42	34.46	-11.54	46	40.78	21.97	2.94	31.23	200	360	P	V
		926.28	105.41	-	-	102.21	29.48	4.43	30.71	200	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 30dB.												



LORA DTS SF=9 (Harmonic @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.5MHz		1801	44.58	-39.12	83.7	73.86	29.28	6.16	64.72	300	0	P	H
		2710	36.9	-37.1	74	63.29	31.06	7.65	65.1	300	0	P	H
		1801	40.66	-35.87	76.53	69.94	29.28	6.16	64.72	100	0	P	V
		2710	37.03	-36.97	74	63.42	31.06	7.65	65.1	100	0	P	V
914.5MHz		1828	43.63	-39.12	82.75	72.73	29.4	6.22	64.72	300	360	P	H
		2746	37.34	-36.66	74	63.71	31.04	7.7	65.11	300	360	P	H
		1828	39.31	-36.91	76.22	68.41	29.4	6.22	64.72	100	360	P	V
		2746	37.16	-36.84	74	63.53	31.04	7.7	65.11	100	360	P	V
926.5MHz		1855	44.77	-38.78	83.55	73.72	29.52	6.25	64.72	300	360	P	H
		2782	36.85	-37.15	74	63.22	31.01	7.74	65.12	300	360	P	H
		1855	42.73	-32.68	75.41	71.68	29.52	6.25	64.72	100	360	P	V
		2782	36.26	-37.74	74	62.63	31.01	7.74	65.12	100	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 30dB.												



LORA DTS SF=10 (Band Edge @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.5MHz		272.5	36.52	-9.48	46	46.4	19.2	2.41	31.49	200	360	P	H
		902.03	113.87	-	-	111.5	29.12	4.37	31.12	200	360	P	H
		267.65	28.91	-17.09	46	38.61	19.38	2.38	31.46	100	360	P	V
		902.03	106.14	-	-	103.77	29.12	4.37	31.12	100	360	P	V
914.5MHz		273.47	36.65	-9.35	46	46.57	19.16	2.41	31.49	100	360	P	H
		914.64	112.74	-	-	109.94	29.31	4.4	30.91	100	360	P	H
		272.5	29.15	-16.85	46	39.03	19.2	2.41	31.49	200	360	P	V
		914.64	106.2	-	-	103.4	29.31	4.4	30.91	200	360	P	V
926.5MHz		249.22	34.33	-11.67	46	44.95	18.44	2.3	31.36	200	360	P	H
		926.28	113.35	-	-	110.15	29.48	4.43	30.71	200	360	P	H
		267.65	30.78	-15.22	46	40.48	19.38	2.38	31.46	100	360	P	V
		926.28	105	-	-	101.8	29.48	4.43	30.71	100	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 30dB.												



LORA DTS SF=10 (Harmonic @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.5MHz		1801	43.99	-39.88	83.87	73.27	29.28	6.16	64.72	300	360	P	H
		2710	37.01	-36.99	74	63.4	31.06	7.65	65.1	300	360	P	H
		1801	40.24	-35.9	76.14	69.52	29.28	6.16	64.72	100	360	P	V
		2710	37	-37	74	63.39	31.06	7.65	65.1	100	360	P	V
914.5MHz		1828	34.5	-48.24	82.74	63.6	29.4	6.22	64.72	300	360	P	H
		2747.5	36.57	-37.43	74	62.94	31.04	7.7	65.11	300	360	P	H
		1828	34.21	-41.99	76.2	63.31	29.4	6.22	64.72	100	360	P	V
		2746	36.47	-37.53	74	62.84	31.04	7.7	65.11	100	360	P	V
926.5MHz		1855	34.89	-48.46	83.35	63.84	29.52	6.25	64.72	300	360	P	H
		2782	36.06	-37.94	74	62.43	31.01	7.74	65.12	300	360	P	H
		1855	36.08	-38.92	75	65.03	29.52	6.25	64.72	100	360	P	V
		2782	36.56	-37.44	74	62.93	31.01	7.74	65.12	100	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 30dB.												



Note symbol

*	Fundamental Frequency which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is over limit line.
P/A	Peak or Average
H/V	Horizontal or Vertical



A calculation example for radiated spurious emission is shown as below:

Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBμV/m) =
Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
3. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)
= 55.45 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 55.45(dBμV/m) – 74(dBμV/m)
= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)
= 43.54 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 43.54(dBμV/m) – 54(dBμV/m)
= -10.46(dB)

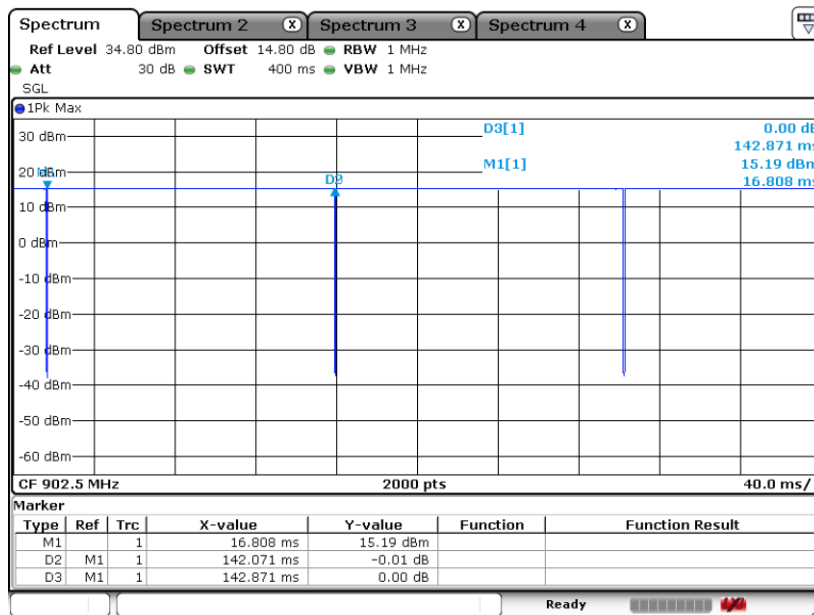
Both peak and average measured complies with the limit line, so test result is “PASS”.



Appendix C. Duty Cycle Plots

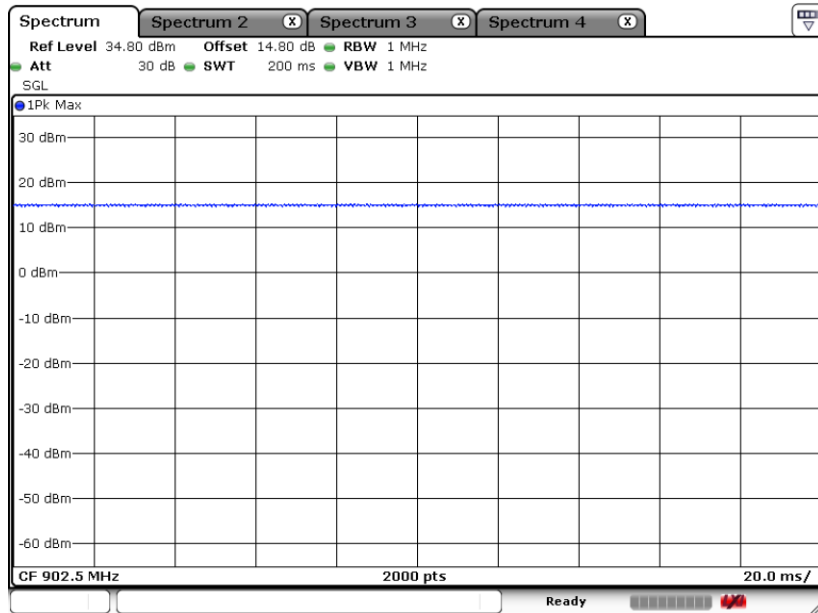
Band	Duty Cycle(%)	T(s)	1/T(kHz)	VBW Setting
LoRa DTS SF8	99.44	-	-	10Hz
LoRa DTS SF9	100	-	-	10Hz
LoRa DTS SF10	100	-	-	10Hz

LoRa DTS SF8





LoRa DTS SF9



LoRa DTS SF10

