



FCC RF Test Report

APPLICANT : Ring LLC
EQUIPMENT : Test Kit
BRAND NAME : ring
MODEL NAME : 5UM3E5
FCC ID : 2AEUP-BHAGF001
STANDARD : FCC Part 15 Subpart C §15.247
CLASSIFICATION : (DTS) Digital Transmission System
TEST DATE(S) : Nov. 03, 2020 ~ Mar. 21, 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

Reviewed by: Jason Jia / Supervisor

Alex Wang

Approved by: Alex Wang / Manager



Sporton International Inc. (Kunshan)

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



TABLE OF CONTENTS

REVISION HISTORY.....	3
SUMMARY OF TEST RESULT	4
1 GENERAL DESCRIPTION.....	5
1.1 Applicant.....	5
1.2 Product Feature of Equipment Under Test.....	5
1.3 Product Specification of Equipment Under Test.....	5
1.4 Modification of EUT	6
1.5 Testing Location	6
1.6 Test Software.....	6
1.7 Applicable Standards.....	6
2 TEST CONFIGURATION OF EQUIPMENT UNDER TEST.....	7
2.1 Carrier Frequency 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	10
2.5 EUT Operation Test Setup	10
2.6 Measurement Results Explanation Example.....	10
3 TEST RESULT	11
3.1 6dB and 99% Bandwidth Measurement	11
3.2 Output Power Measurement.....	30
3.3 Power Spectral Density Measurement	31
3.4 Conducted Band Edges and Spurious Emission Measurement	50
3.5 Radiated Band Edges and Spurious Emission Measurement	75
3.6 AC Conducted Emission Measurement.....	79
3.7 Antenna Requirements.....	81
4 LIST OF MEASURING EQUIPMENT.....	82
5 UNCERTAINTY OF EVALUATION.....	84
APPENDIX A. CONDUCTED TEST RESULTS	
APPENDIX B. AC CONDUCTED EMISSION TEST RESULT	
APPENDIX C. RADIATED SPURIOUS EMISSION	
APPENDIX D. DUTY CYCLE PLOTS	



REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR151806D	Rev. 01	Initial issue of report	May 16, 2022

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(2)	6dB Bandwidth	$\geq 0.5\text{MHz}$	Pass	-
3.1	-	99% Bandwidth	-	Pass	-
3.2	15.247(b)(3)	Output Power	$\leq 30\text{dBm}$	Pass	-
3.3	15.247(e)	Power Spectral Density	$\leq 8\text{dBm}/3\text{kHz}$	Pass	-
3.4	15.247(d)	Conducted Band Edges and Spurious Emission	$\leq 30\text{dBc}$	Pass	-
3.5	15.247(d)	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 7.43 dB at 2489.080 MHz
3.6	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 10.27 dB at 0.442 MHz
3.7	15.203 & 15.247(b)	Antenna Requirement	N/A	Pass	-

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

1523 26th Street, Santa Monica CA 90404, USA

1.2 Product Feature of Equipment Under Test

Product Feature	
Equipment	Test Kit
Brand Name	ring
Model Name	5UM3E5
FCC ID	2AEUP-BHAGF001
EUT supports Radios application	Bluetooth LE LoRa FSK GPS WIFI sniffing
HW Version	D-SS-A35-01A-A-V2.2
SW Version	nordic-diagnostics-images-1.2.0.5
EUT Stage	Identical Prototype

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

1.3 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 / 5, 7, 8, 9, 10 11
Maximum Output Power to Antenna	LoRa DTS SF5 : 20.16 dBm (0.1038 W) LoRa DTS SF7 : 26.59 dBm (0.4560 W) LoRa DTS SF8 : 26.18 dBm (0.4150 W) LoRa DTS SF9 : 26.25 dBm (0.4217 W) LoRa DTS SF10 : 26.21 dBm (0.4178 W) LoRa DTS SF11 : 26.50 dBm (0.4467 W)
99% Occupied Bandwidth	LoRa DTS SF5 : 0.507MHz LoRa DTS SF7 : 0.527MHz LoRa DTS SF8 : 0.515MHz LoRa DTS SF9 : 0.518MHz LoRa DTS SF10 : 0.524MHz LoRa DTS SF11 : 0.541MHz
Antenna Type / Gain	IFA stamping Antenna with gain -1.20 dBi
Type of Modulation	LoRa



1.4 Modification of EUT

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

1.5 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.
	TH01-KS CO01-KS 03CH04-KS 03CH06-KS	CN1257	314309

1.6 Test Software

Item	Site	Manufacture	Name	Version
1.	03CH04-KS	AUDIX	E3	6.2009-8-24a
2.	03CH06-KS	AUDIX	E3	6.2009-8-24a1
3.	CO01-KS	AUDIX	E3	6.2009-8-24

1.7 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

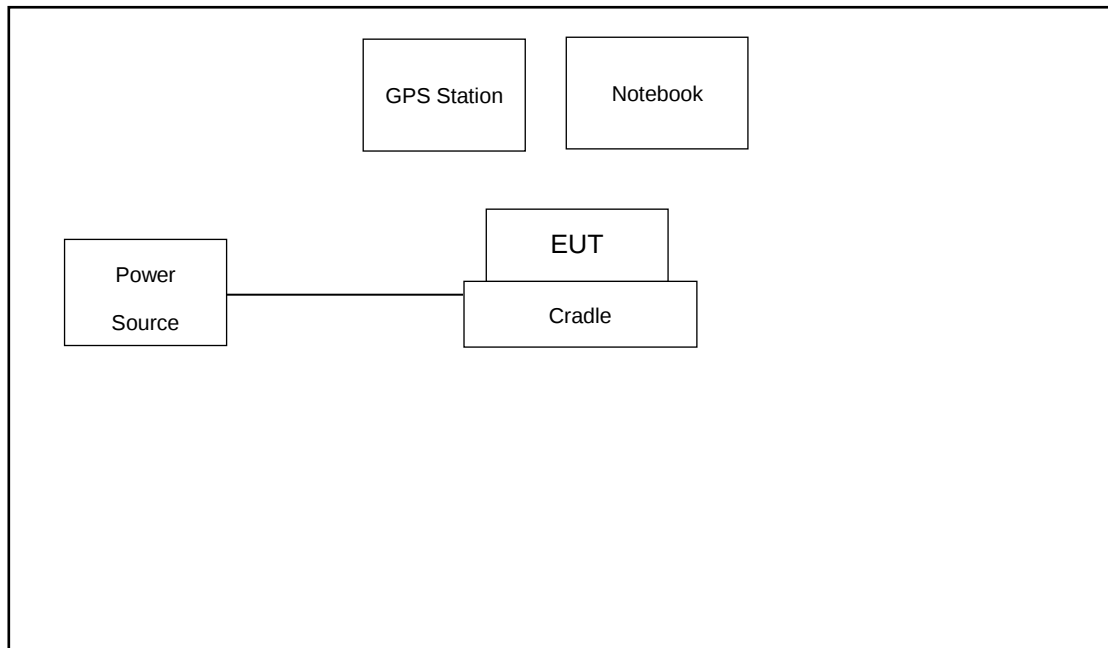
- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (X plane) were recorded in this report.
- b. AC power line Conducted Emission was tested under maximum output power.

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

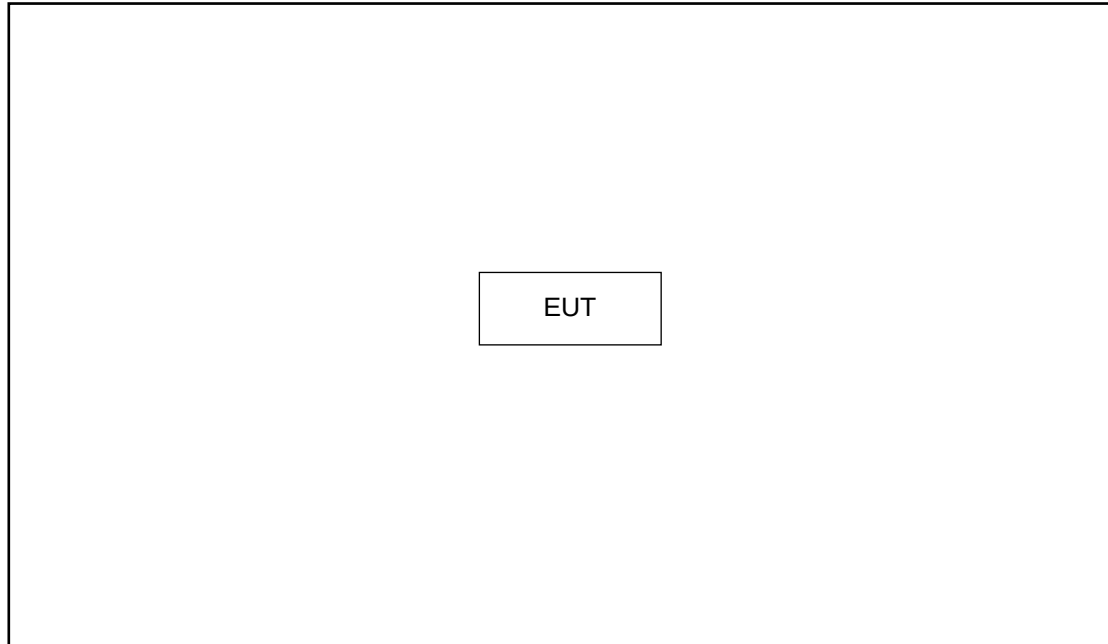
Summary table of Test Cases	
Test Item	Data Rate / Modulation
	Lora DTS
Conducted TCs	Mode 1: LoRa Tx CH01_902.5 MHz Mode 2: LoRa Tx CH16_914.5 MHz Mode 3: LoRa Tx CH31_926.5 MHz
Radiated TCs	Mode 1: LoRa Tx CH01_902.5 MHz Mode 2: LoRa Tx CH16_914.5 MHz Mode 3: LoRa Tx CH31_926.5 MHz
AC Conducted Emission	Mode 1 : Lora Tx + Bluetooth Tx + GPS RX + Cradle + Charging from Adapter
Co-location	Mode 1: Bluetooth LE Tx CH39_2480 MHz + LoRa DTS SF8 Tx_926.5 MHz

2.3 Connection Diagram of Test System

For Conducted Emission:



For Radiated Emission:



2.4 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	GPS Station	RACELOGIC	RLLS03-2RP	N/A	N/A	Unshielded, 1.8m
2.	Adapter	chenyang	C-P56	N/A	N/A	N/A
3.	Notebook	Lenovo	G480	QDS-BRCM1050I	N/A	AC I/P: Unshielded, 1.8 m DC O/P: Shielded, 1.8 m

2.5 EUT Operation Test Setup

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

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 4.5 dB and 10dB attenuator.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 4.5 + 10 = 14.5 \text{ (dB)}\end{aligned}$$

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



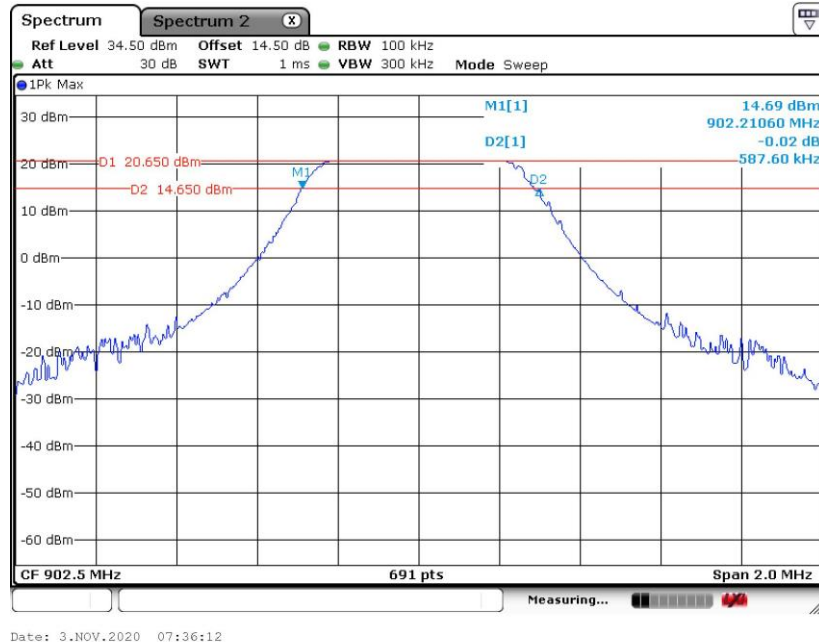


3.1.5 Test Result of 6dB Bandwidth

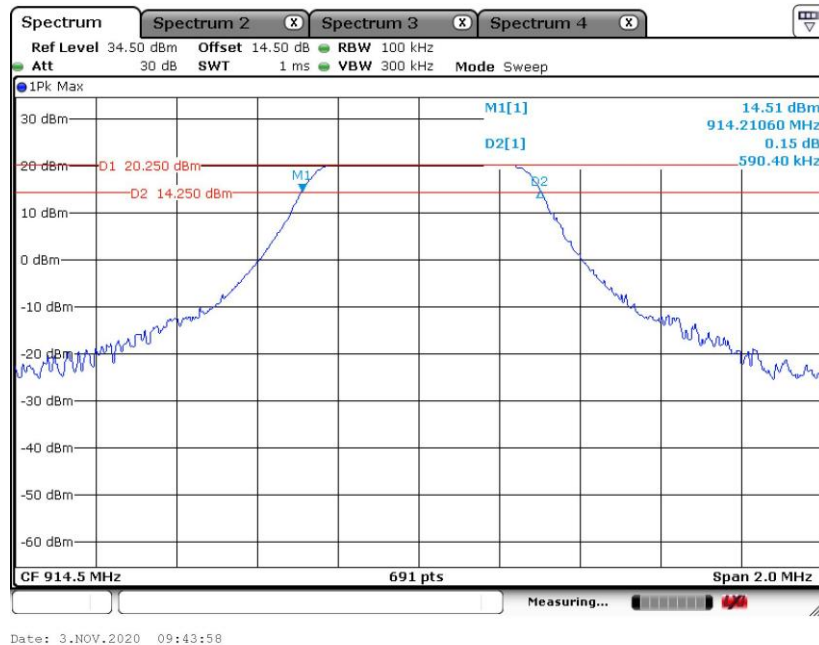
Please refer to Appendix A.

For SF5:

6 dB Bandwidth Plot on 902.5MHz

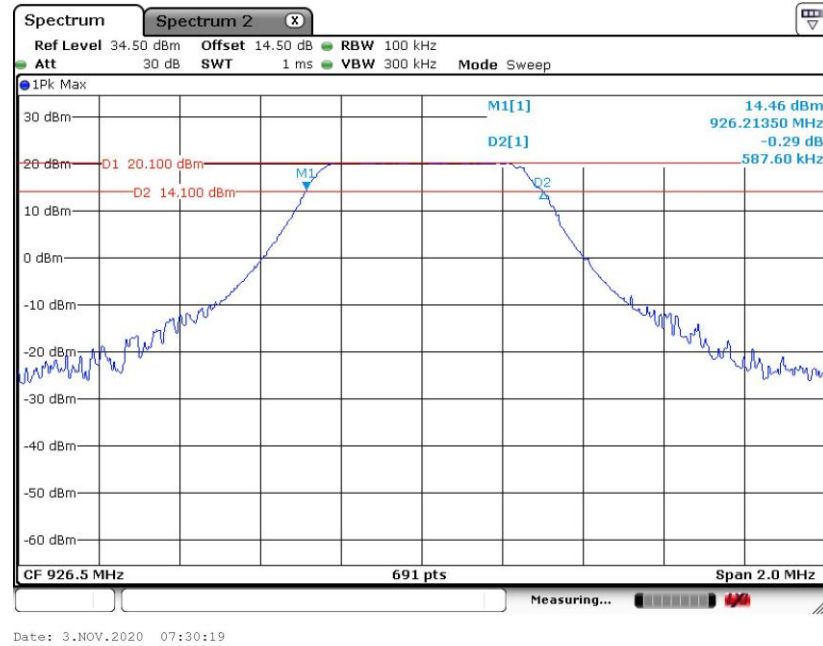


6 dB Bandwidth Plot on 914.5 MHz



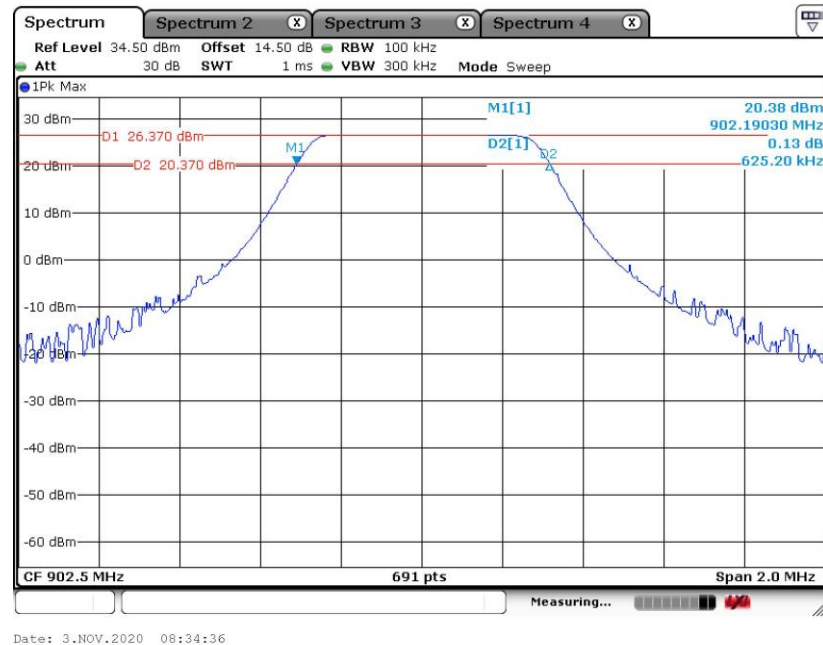


6 dB Bandwidth Plot on 926.5 MHz



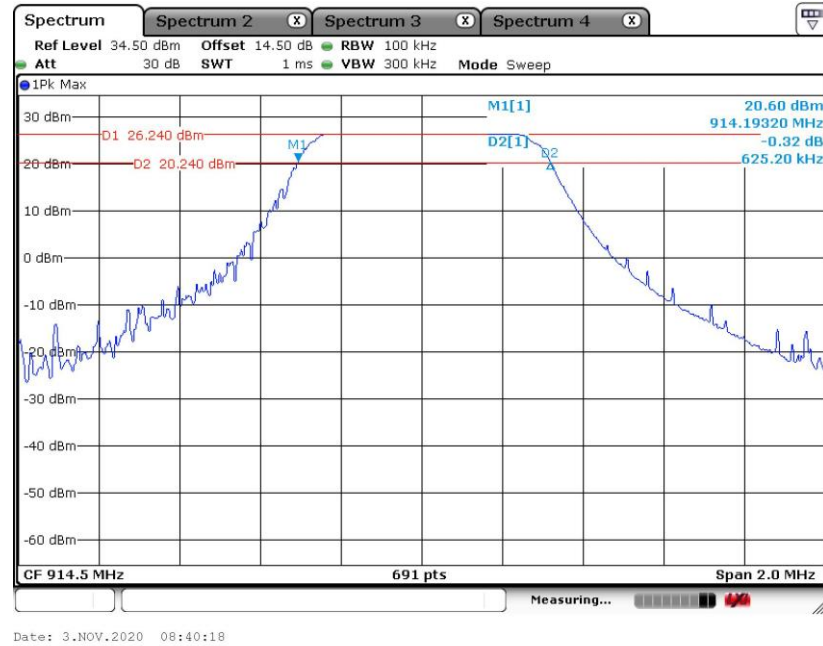
For SF7:

6 dB Bandwidth Plot on 902.5 MHz

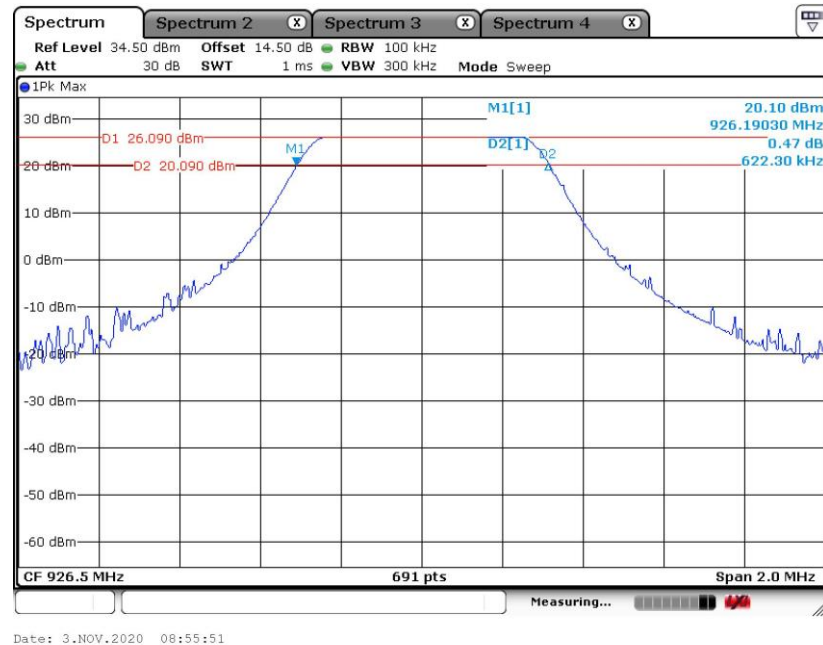




6 dB Bandwidth Plot on 914.5 MHz



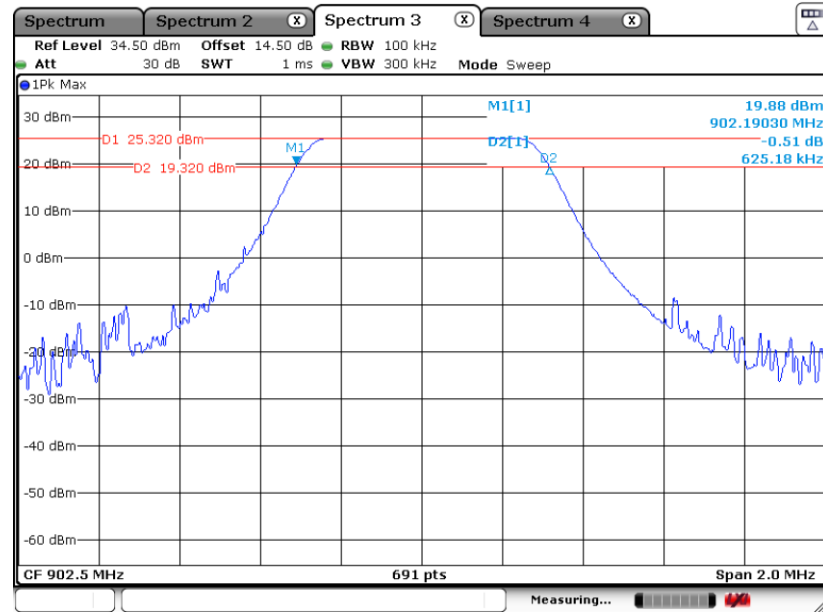
6 dB Bandwidth Plot on 926.5 MHz





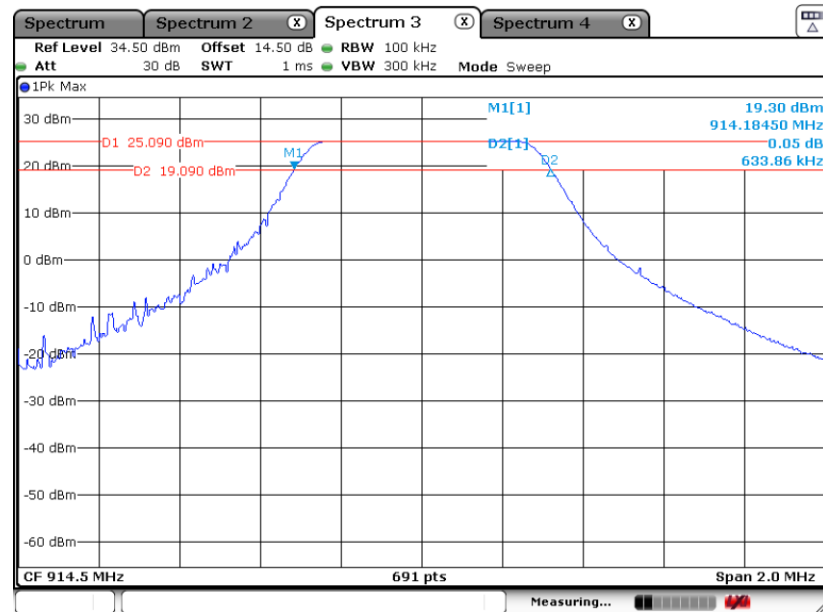
For SF8:

6 dB Bandwidth Plot on 902.5MHz



Date: 25.FEB.2022 18:54:42

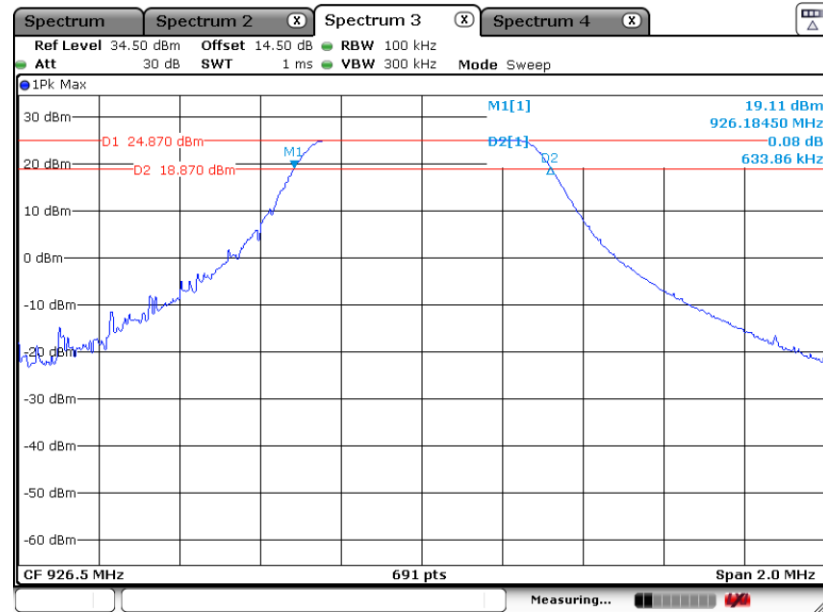
6 dB Bandwidth Plot on 914.5 MHz



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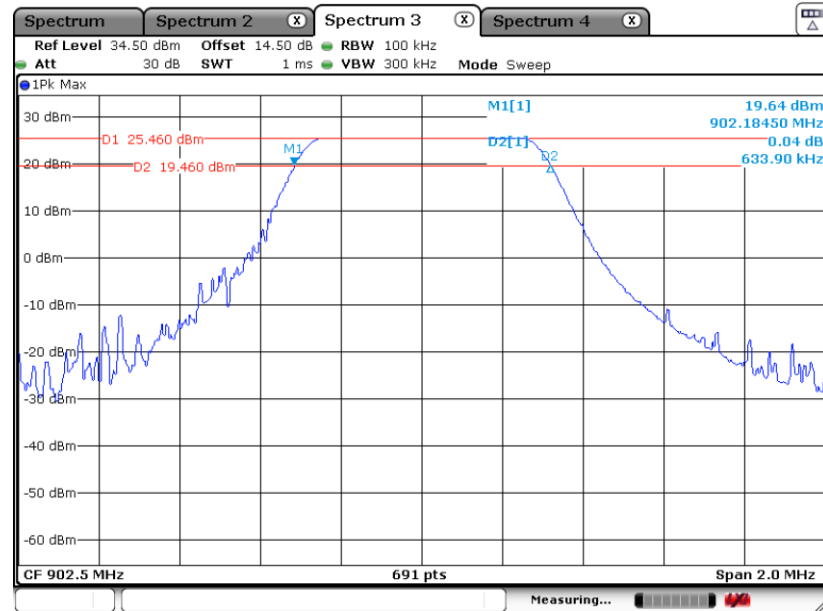
6 dB Bandwidth Plot on 926.5 MHz



Date: 25.FEB.2022 19:02:54

For SF9:

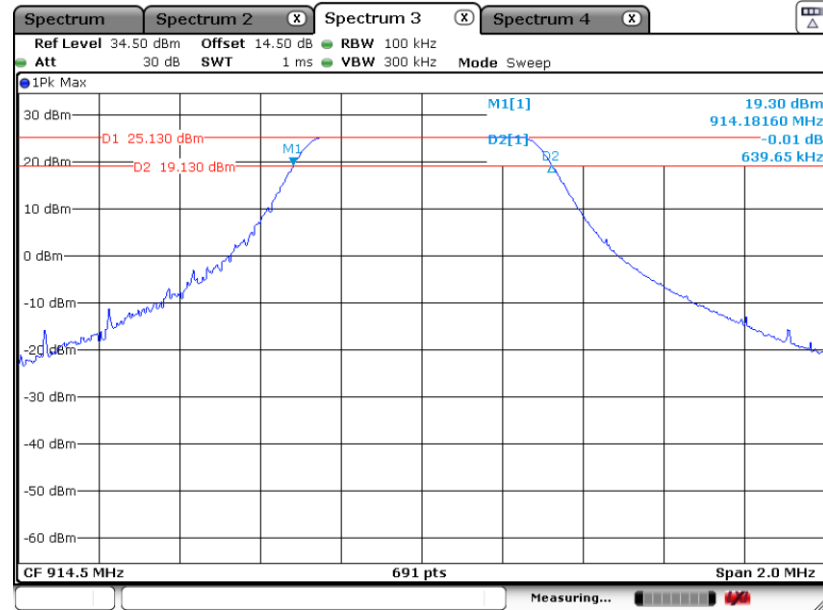
6 dB Bandwidth Plot on 902.5 MHz



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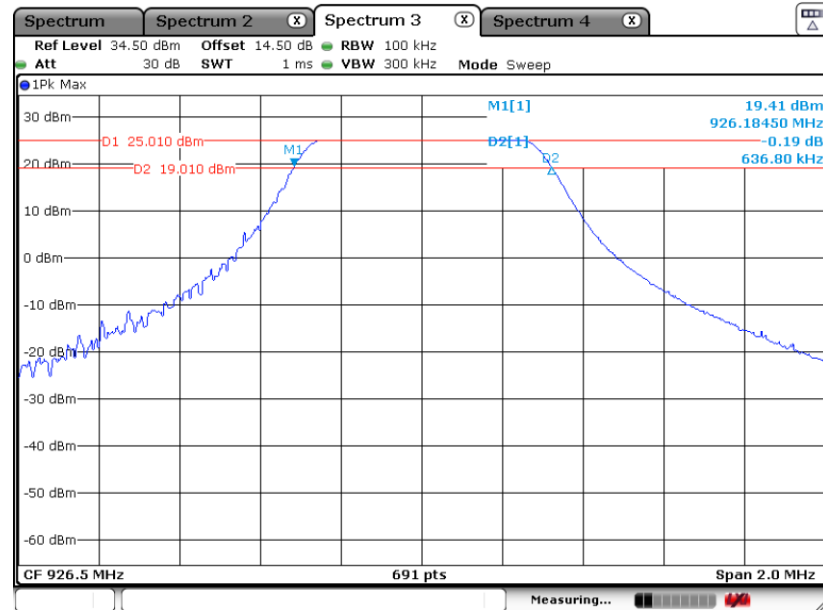


6 dB Bandwidth Plot on 914.5 MHz



Date: 25.FEB.2022 19:19:43

6 dB Bandwidth Plot on 926.5 MHz

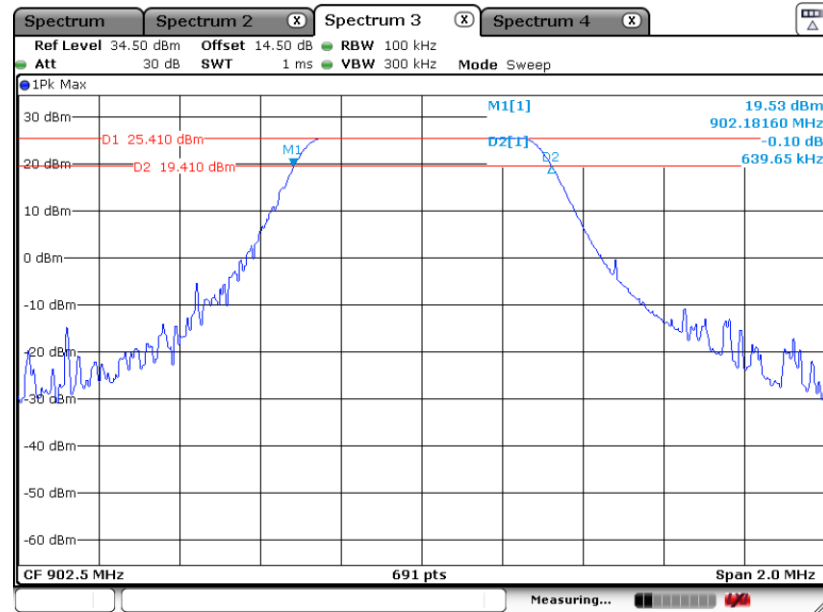


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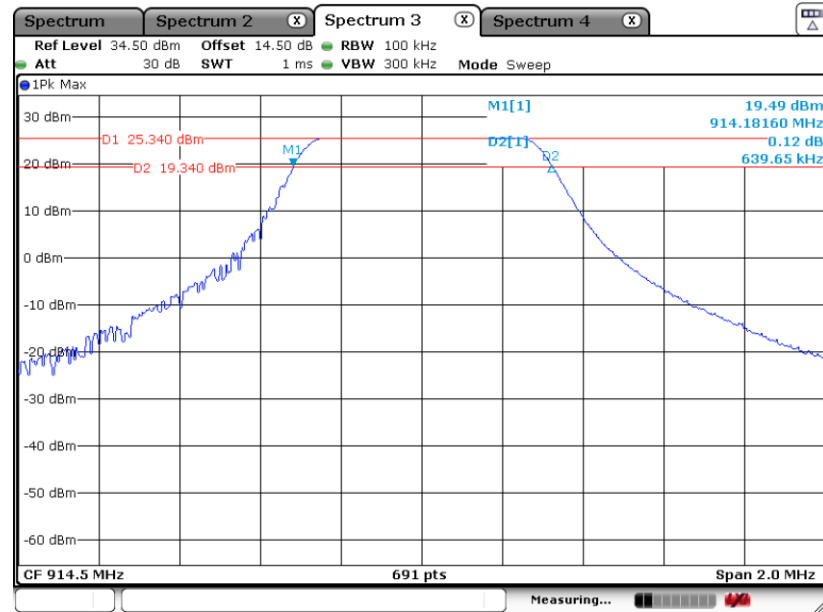
For SF10:

6 dB Bandwidth Plot on 902.5 MHz



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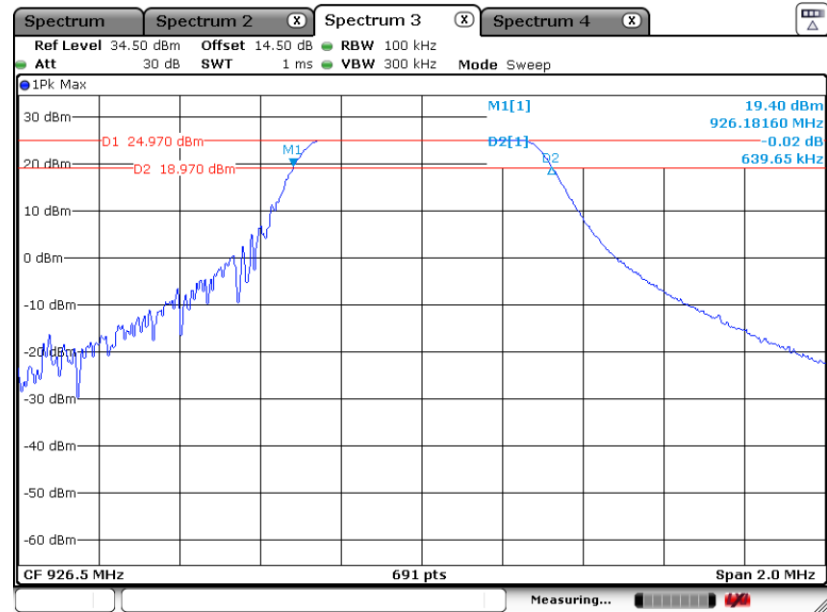
6 dB Bandwidth Plot on 914.5 MHz



Date: 25.FEB.2022 20:12:22



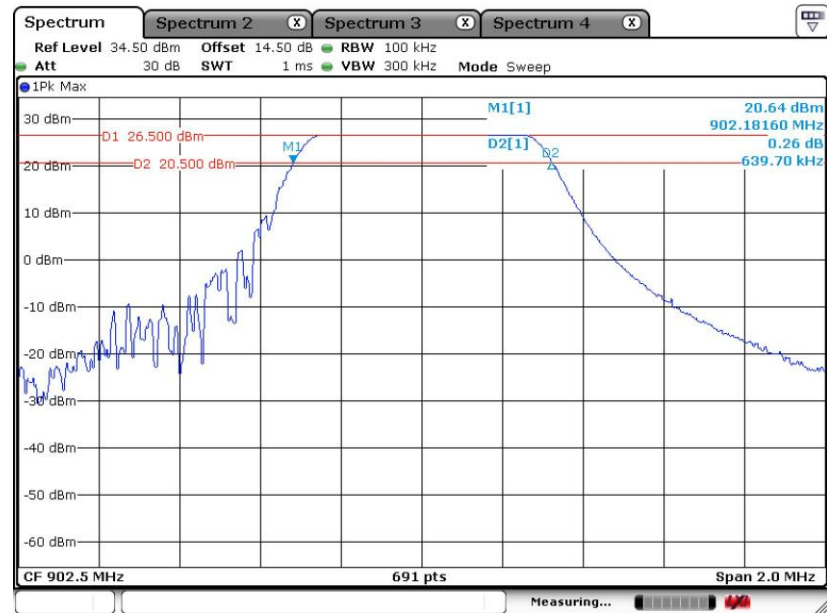
6 dB Bandwidth Plot on 926.5 MHz



Date: 25.FEB.2022 20:06:13

For SF11:

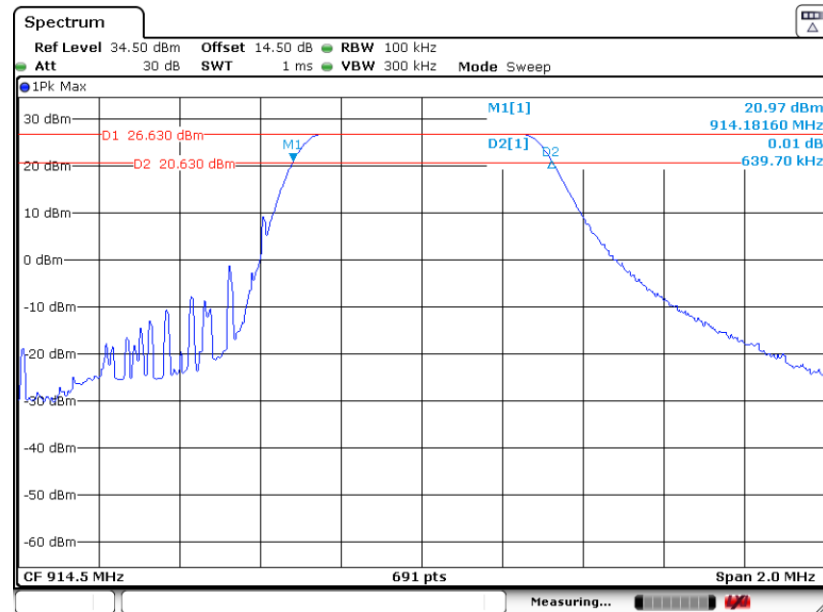
6 dB Bandwidth Plot on 902.5 MHz



Date: 3.NOV.2020 10:57:04

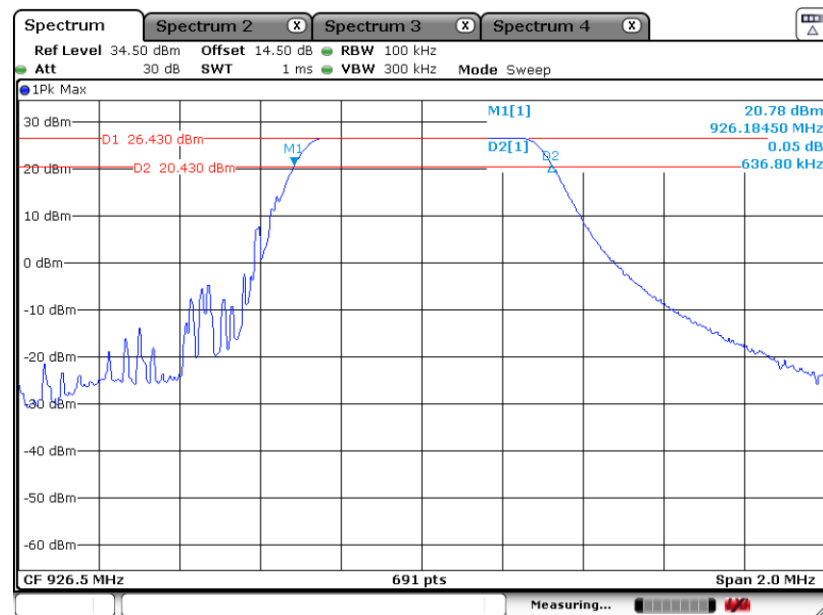


6 dB Bandwidth Plot on 914.5 MHz



Date: 3.NOV.2020 18:26:33

6 dB Bandwidth Plot on 926.5 MHz



Date: 3.NOV.2020 18:37:29

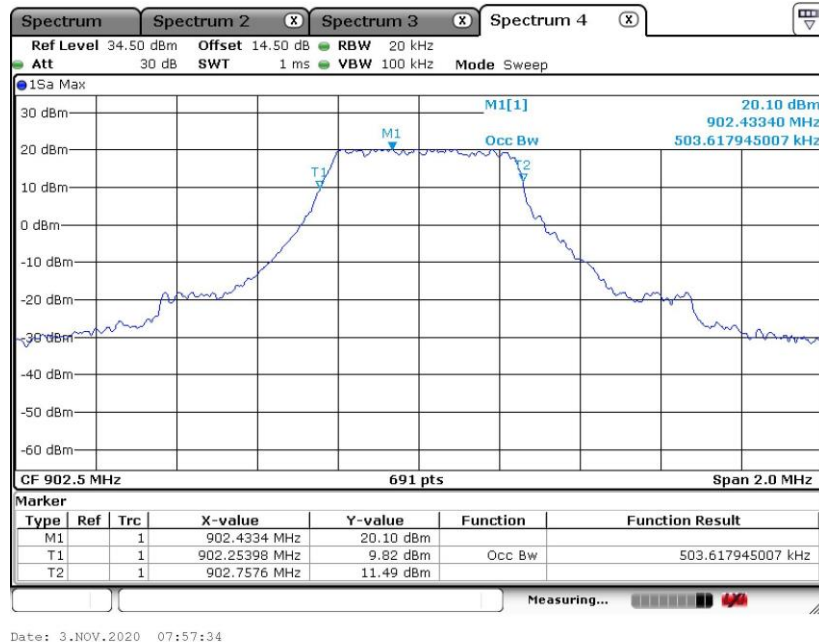


3.1.6 Test Result of 99% Occupied Bandwidth

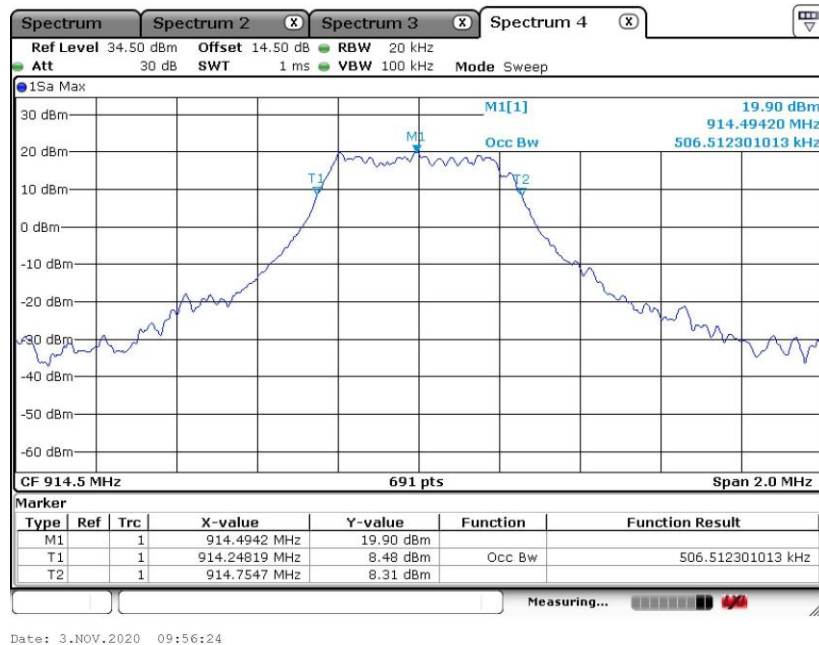
Please refer to Appendix A.

For SF5:

99% Bandwidth Plot on 902.5 MHz

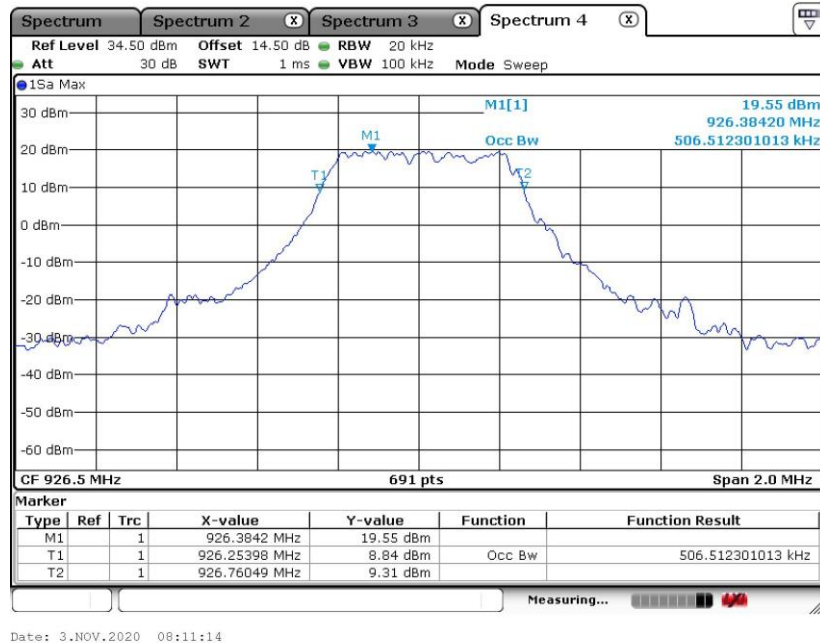


99% Occupied Bandwidth Plot on 914.5 MHz



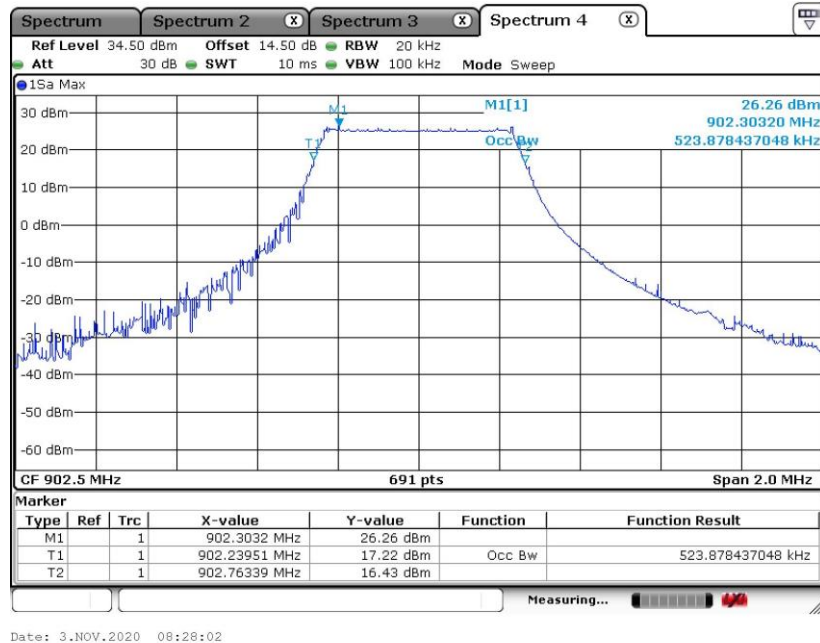


99% Occupied Bandwidth Plot on 926.5 MHz



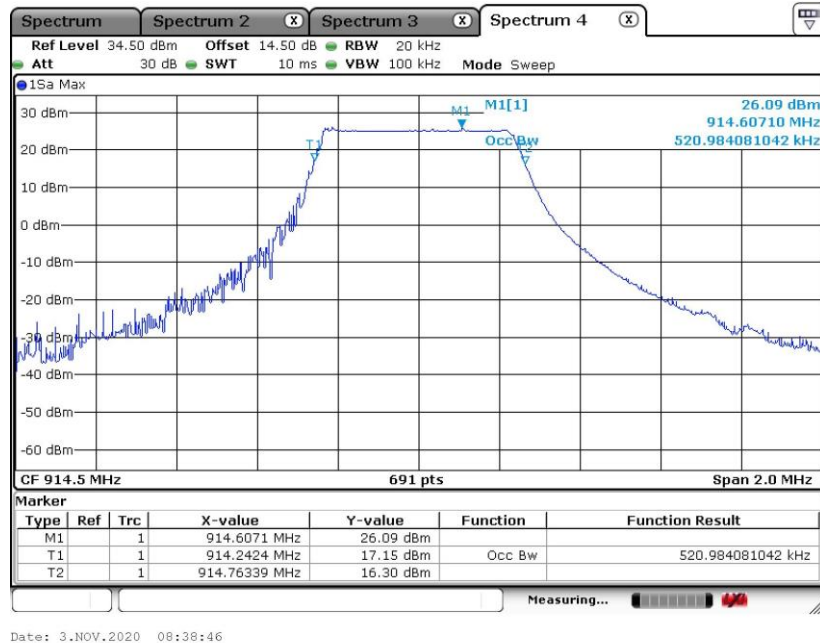
For SF7:

99% Bandwidth Plot on 902.5 MHz

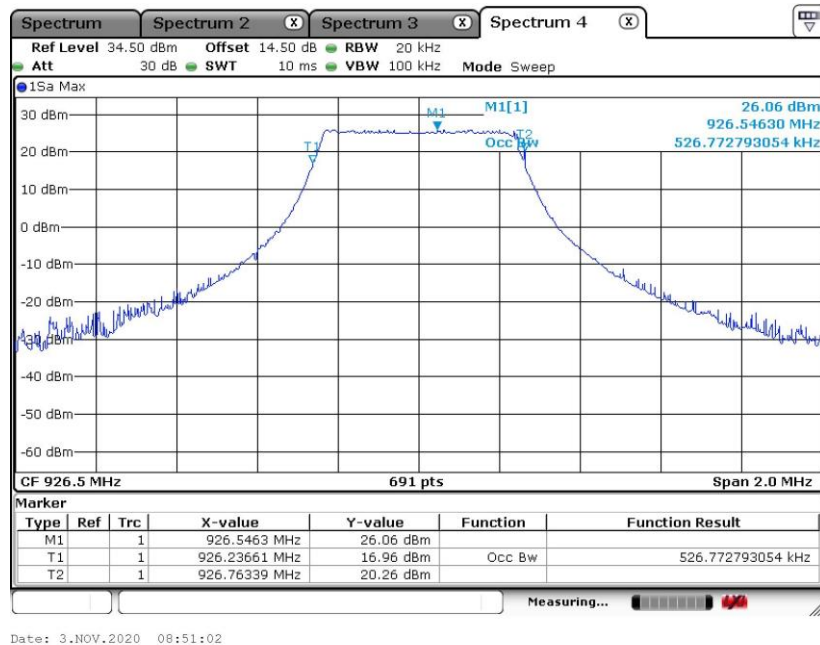




99% Occupied Bandwidth Plot on 914.5 MHz



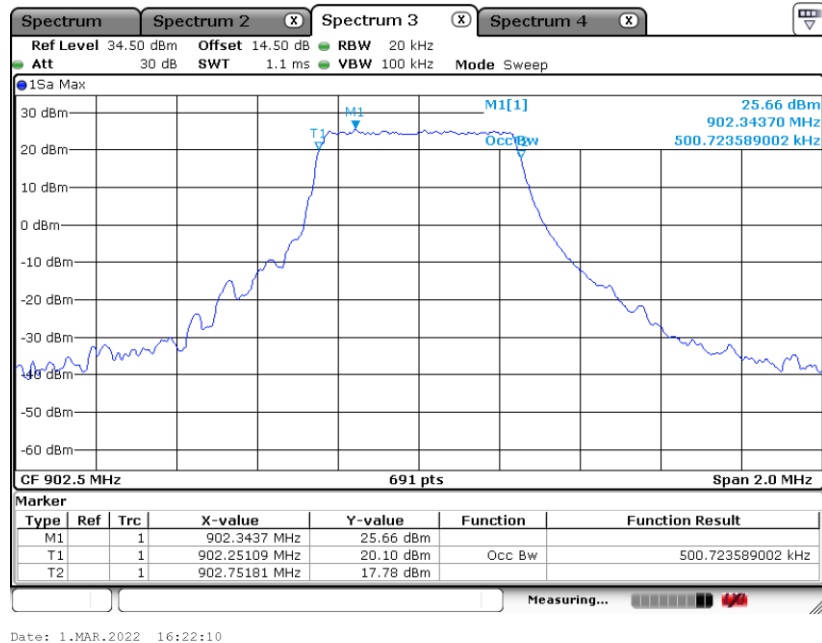
99% Occupied Bandwidth Plot on 926.5 MHz



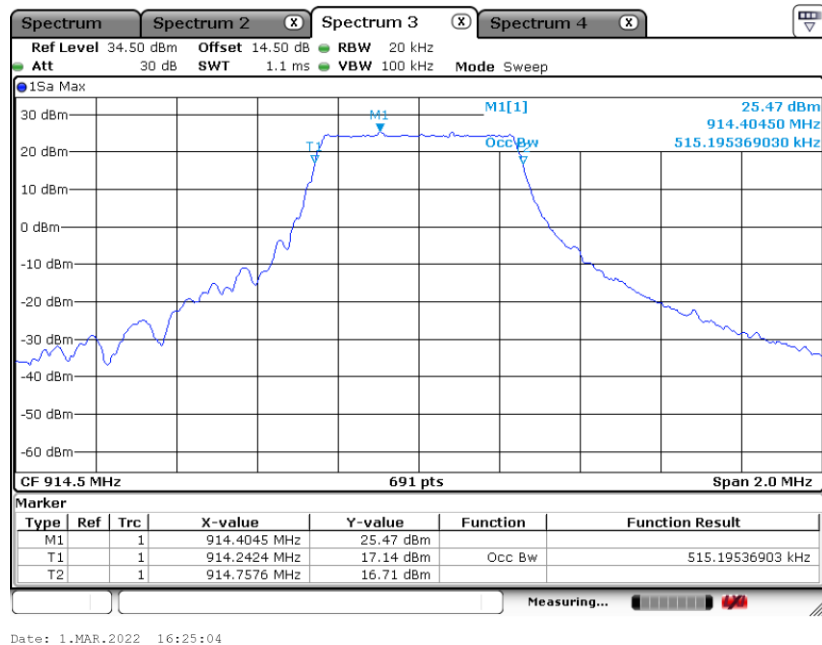


For SF8:

99% Bandwidth Plot on 902.5MHz

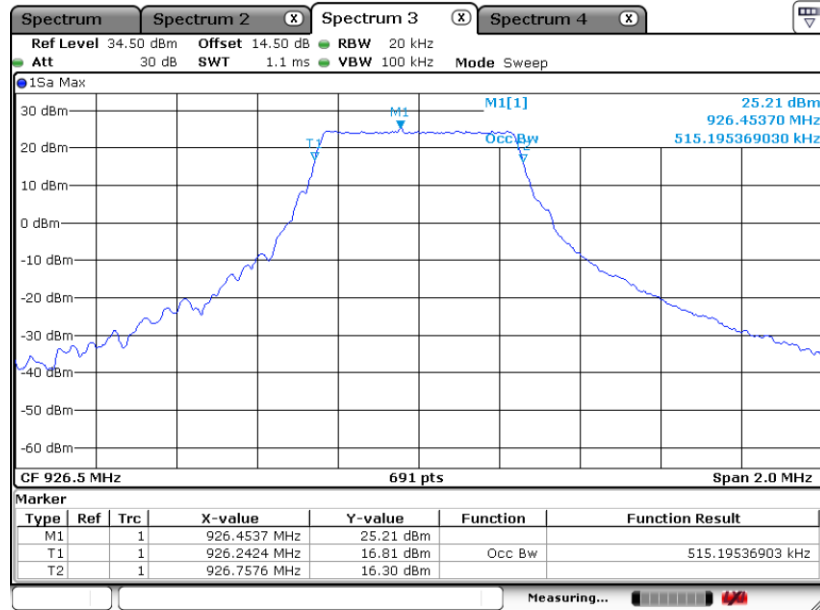


99% Bandwidth Plot on 914.5 MHz





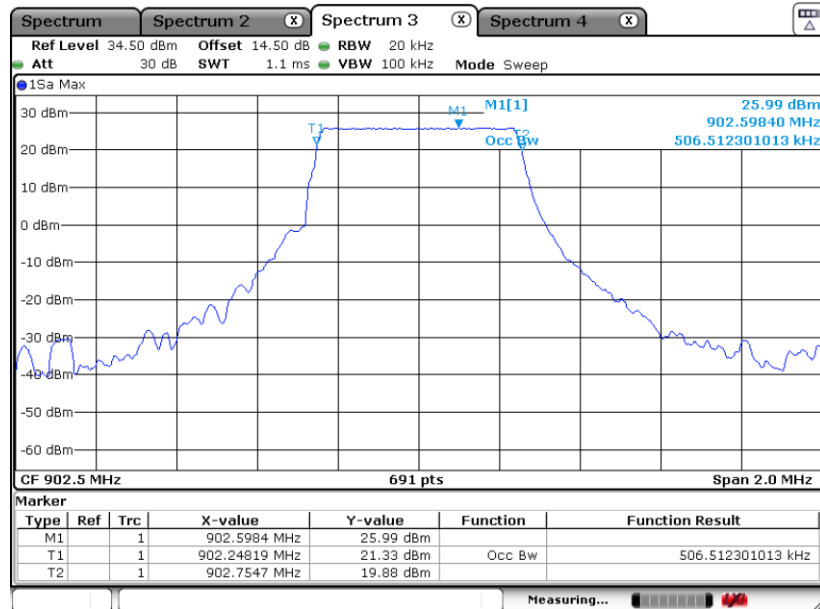
99% Bandwidth Plot on 926.5 MHz



Date: 1.MAR.2022 16:28:37

For SF9:

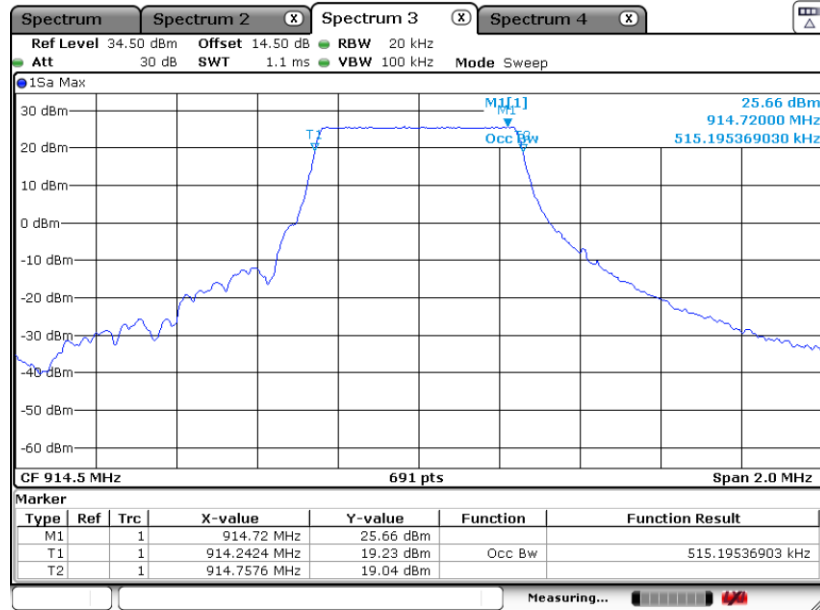
99% Bandwidth Plot on 902.5 MHz



Date: 1.MAR.2022 16:33:04

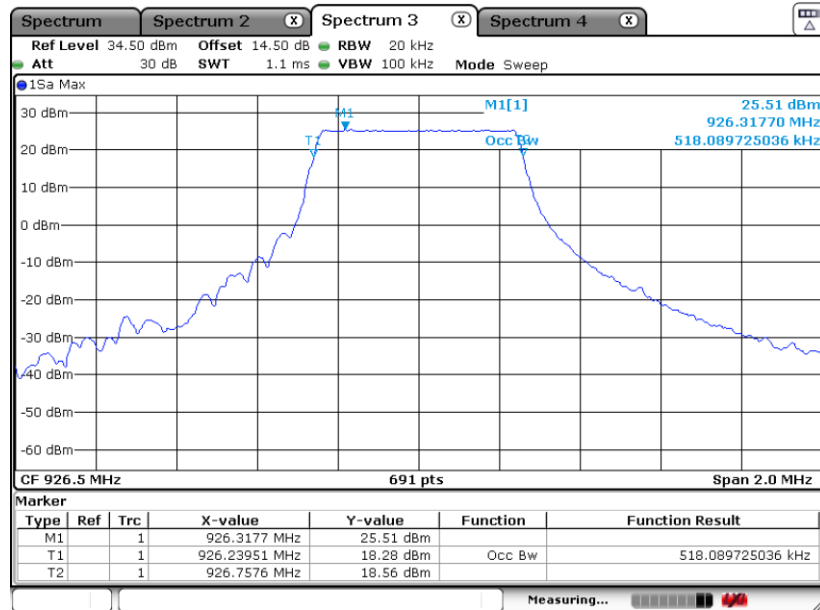


99% Bandwidth Plot on 914.5 MHz



Date: 1.MAR.2022 16:35:52

99% Bandwidth Plot on 926.5 MHz

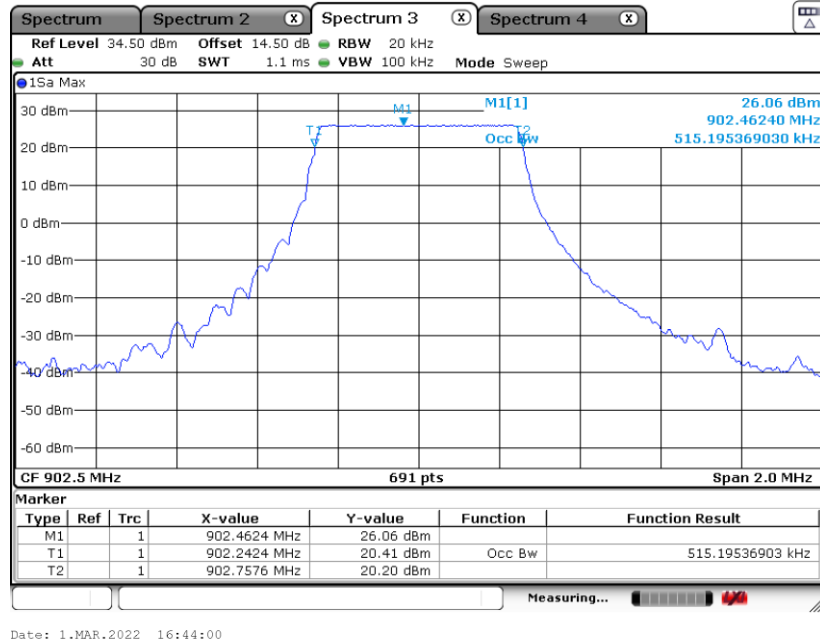


Date: 1.MAR.2022 16:39:52

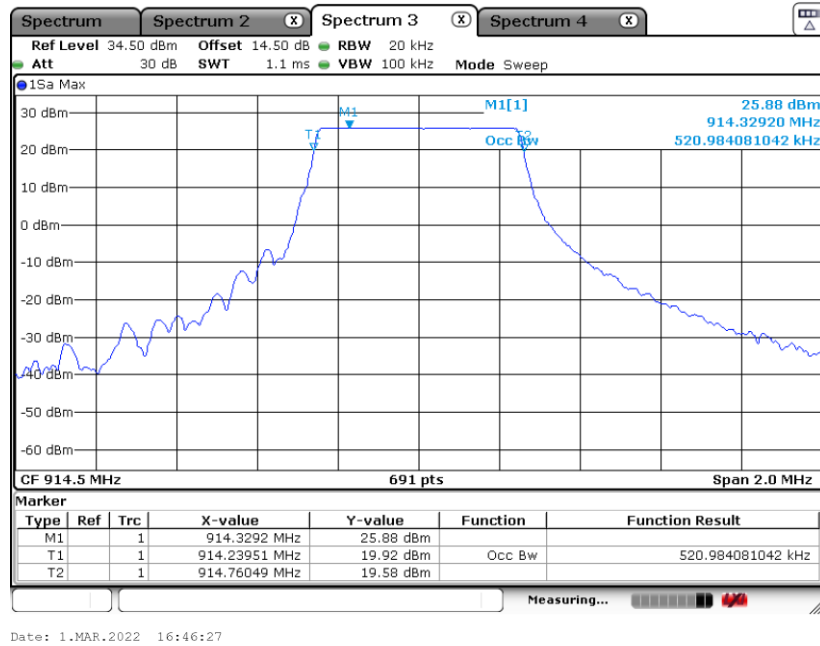


For SF10:

99% Bandwidth Plot on 902.5 MHz

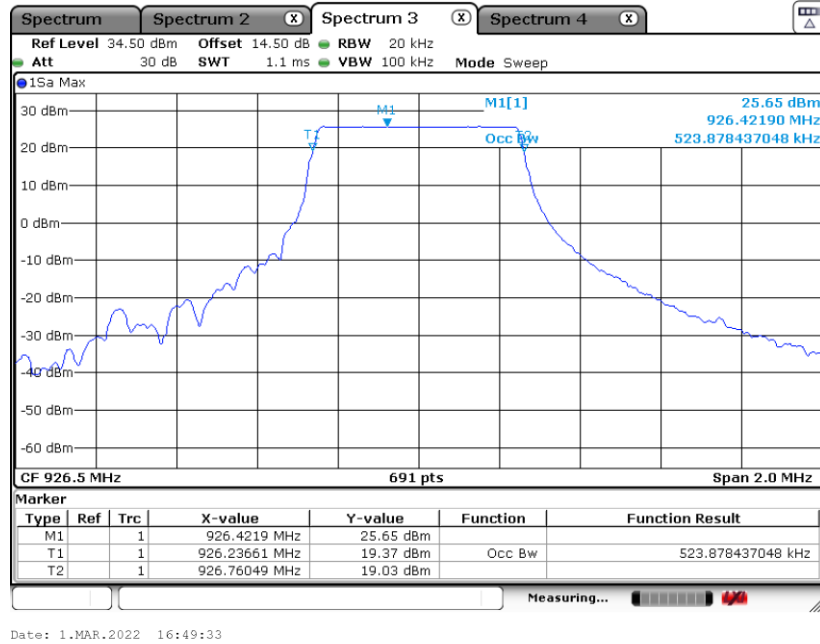


99% Bandwidth Plot on 914.5 MHz



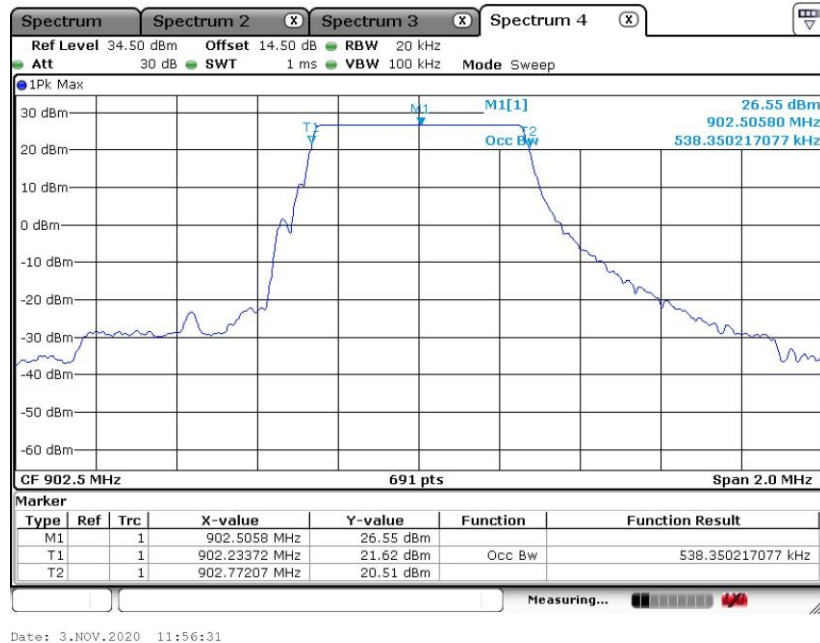


99% Bandwidth Plot on 926.5 MHz



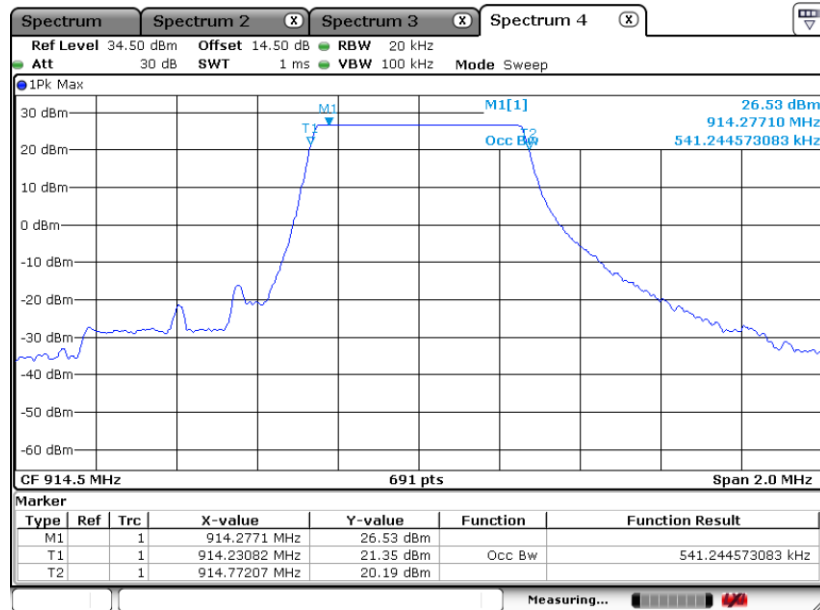
For SF11:

99% Bandwidth Plot on 902.5 MHz



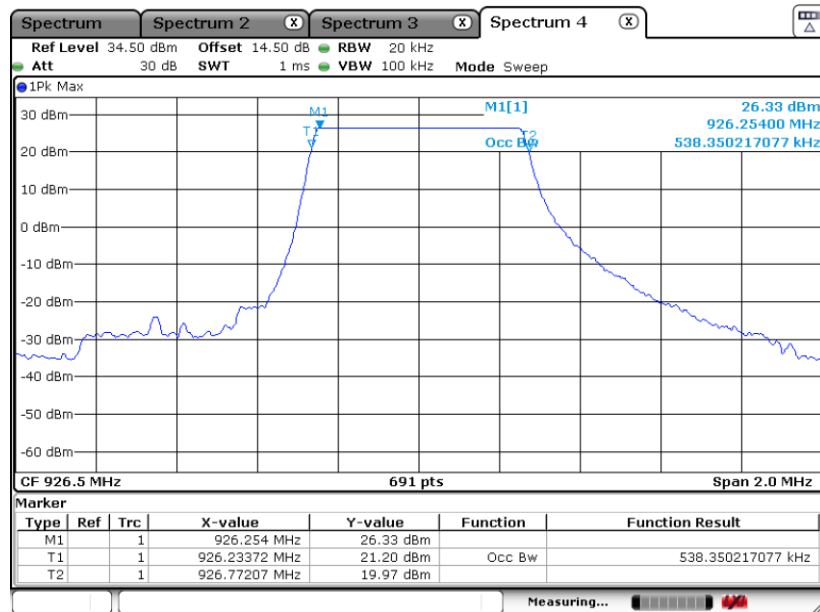


99% Occupied Bandwidth Plot on 914.5 MHz



Date: 3.NOV.2020 18:34:43

99% Occupied Bandwidth Plot on 926.5 MHz



Date: 3.NOV.2020 18:44:04

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.

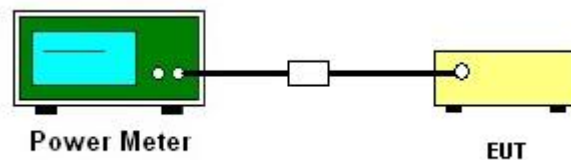
3.2.2 Measuring Instruments

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 11.9.1.3 PKPM1 Peak power meter or 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.

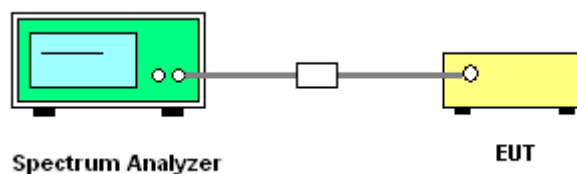
3.3.2 Measuring Instruments

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.



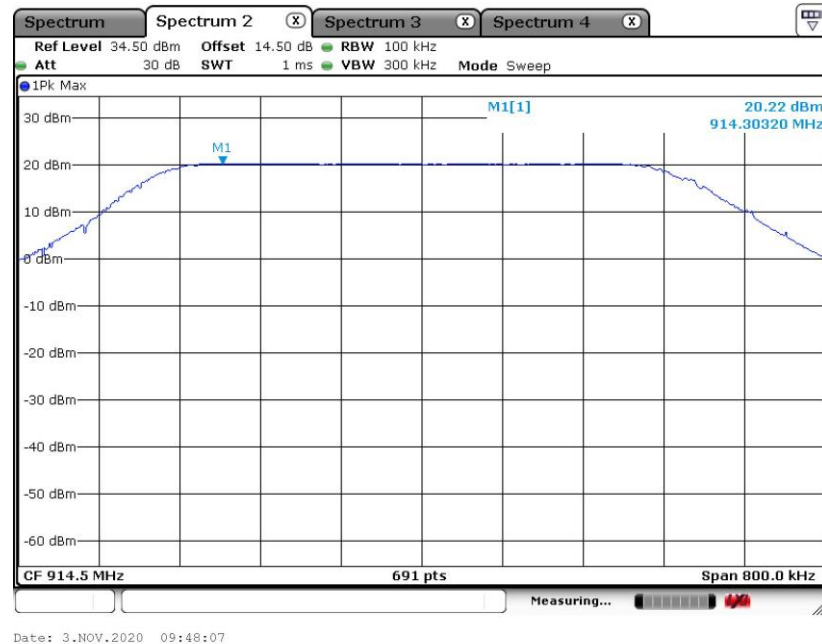
3.3.6 Test Result of Power Spectral Density Plots (100kHz)

For SF5:

PSD 100kHz Plot on 902.5 MHz

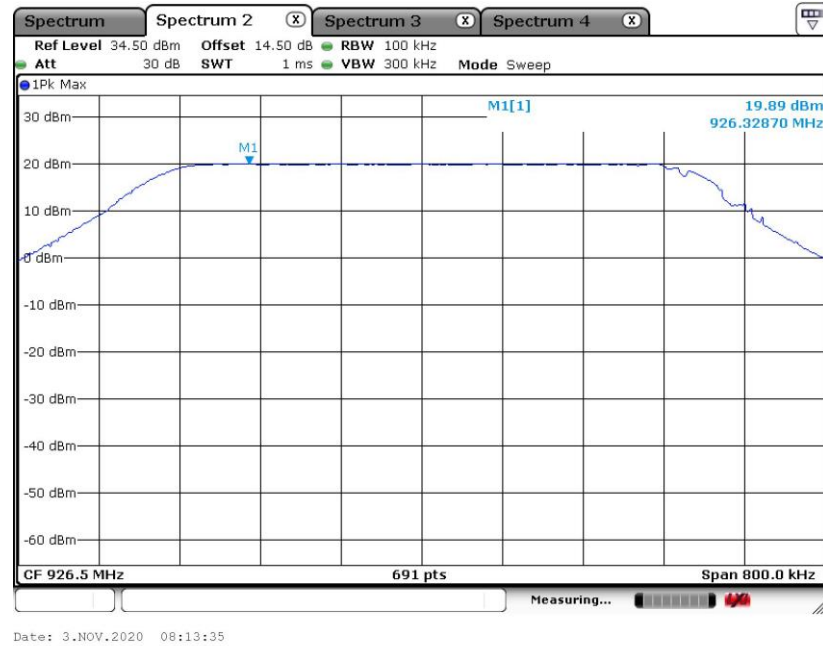


PSD 100kHz Plot on 914.5 MHz



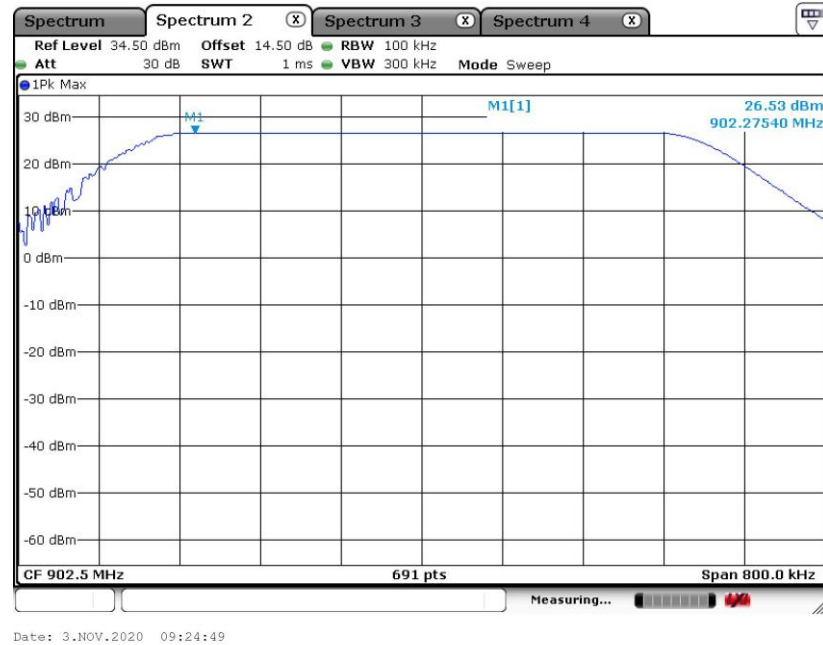


PSD 100kHz Plot on 926.5 MHz



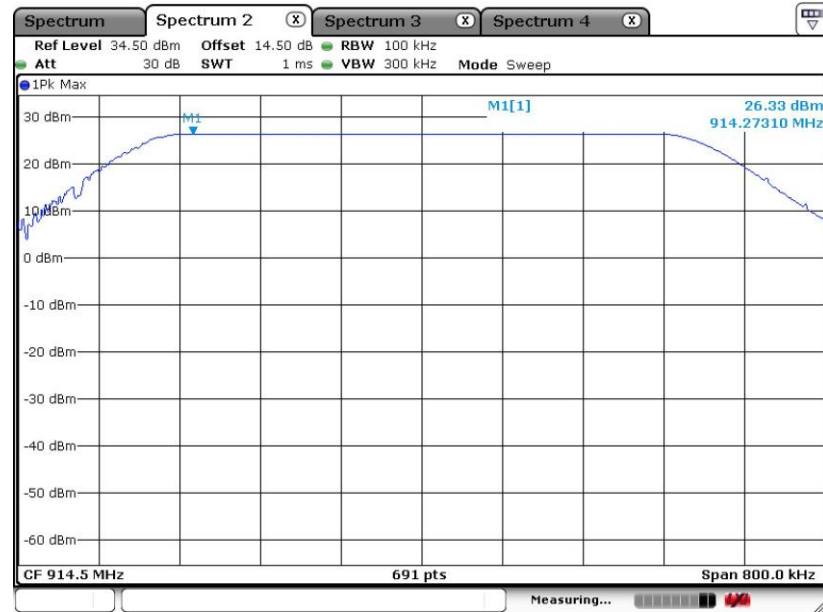
For SF7:

PSD 100kHz Plot on 902.5 MHz



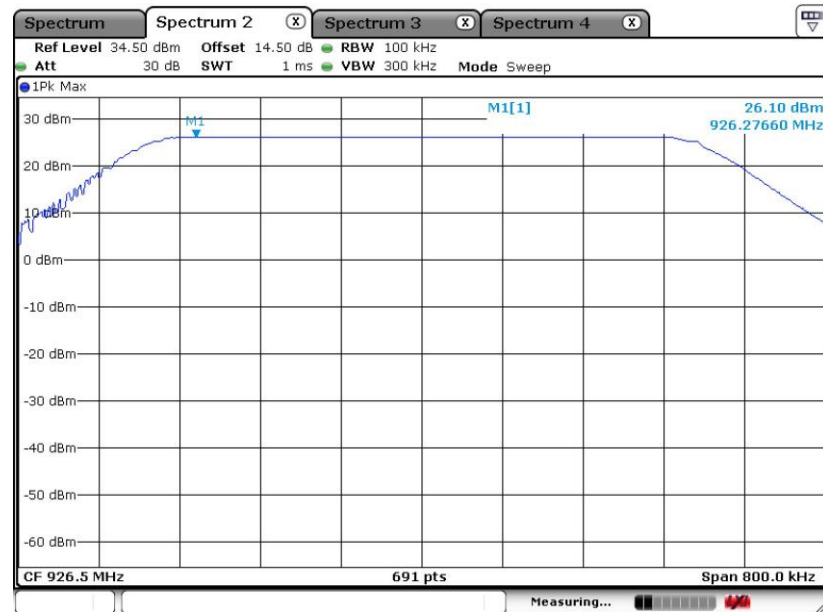


PSD 100kHz Plot on 914.5 MHz



Date: 3.NOV.2020 09:21:50

PSD 100kHz Plot on 926.5 MHz

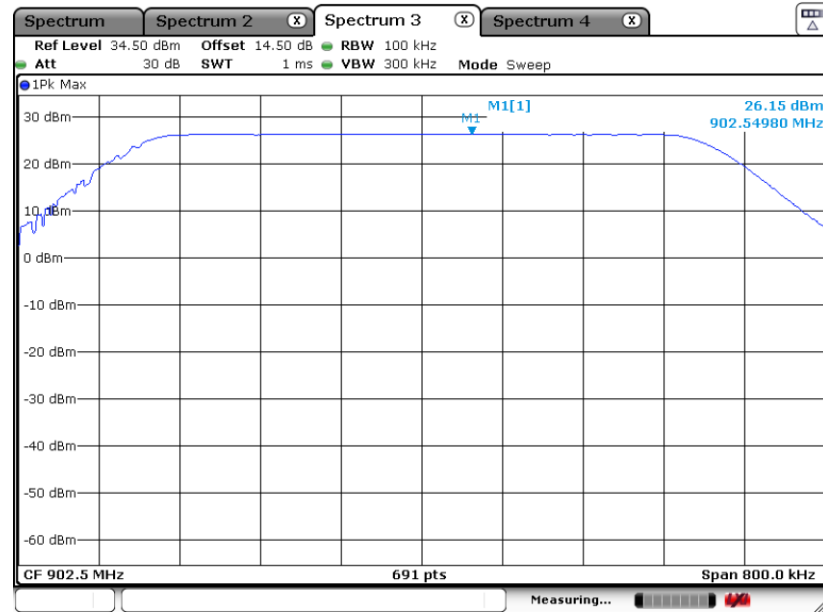


Date: 3.NOV.2020 09:00:32



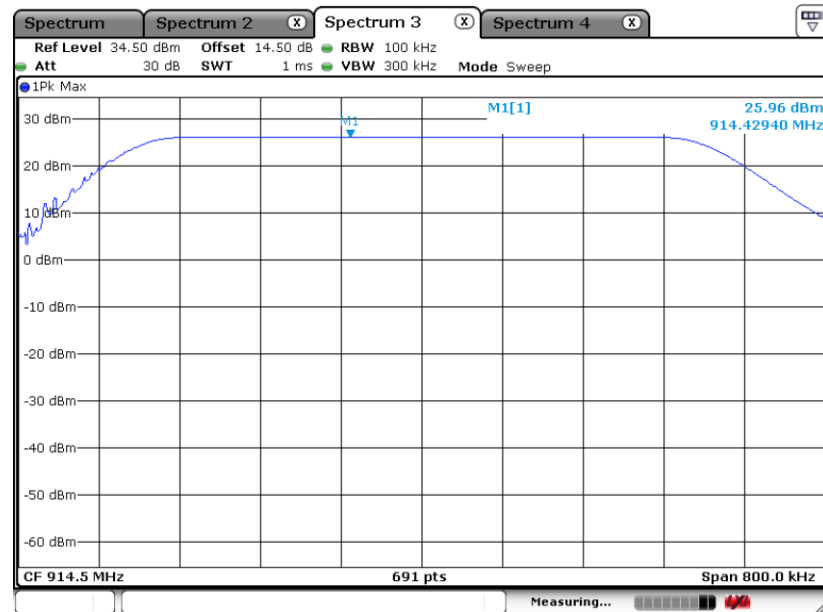
For SF8:

PSD 100kHz Plot on 902.5 MHz



Date: 1.MAR.2022 16:20:35

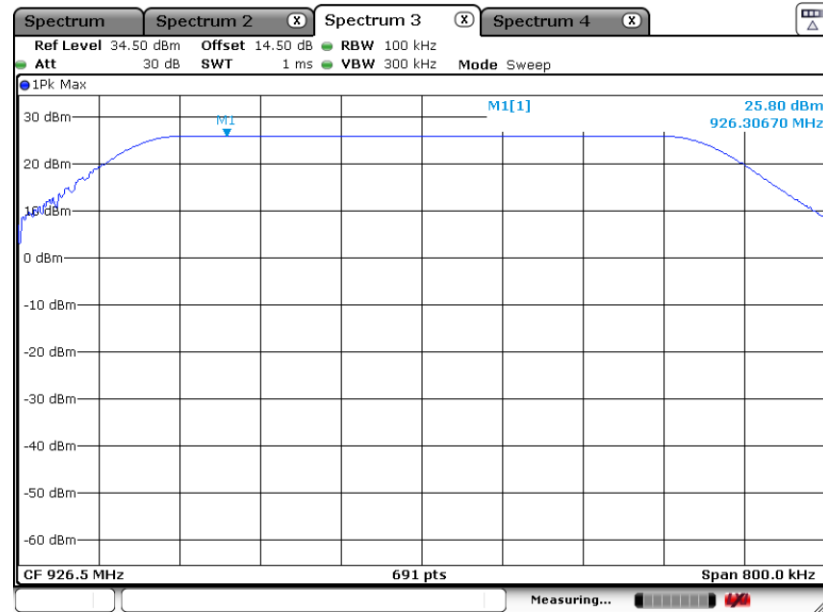
PSD 100kHz Plot on 914.5 MHz



Date: 1.MAR.2022 16:24:04



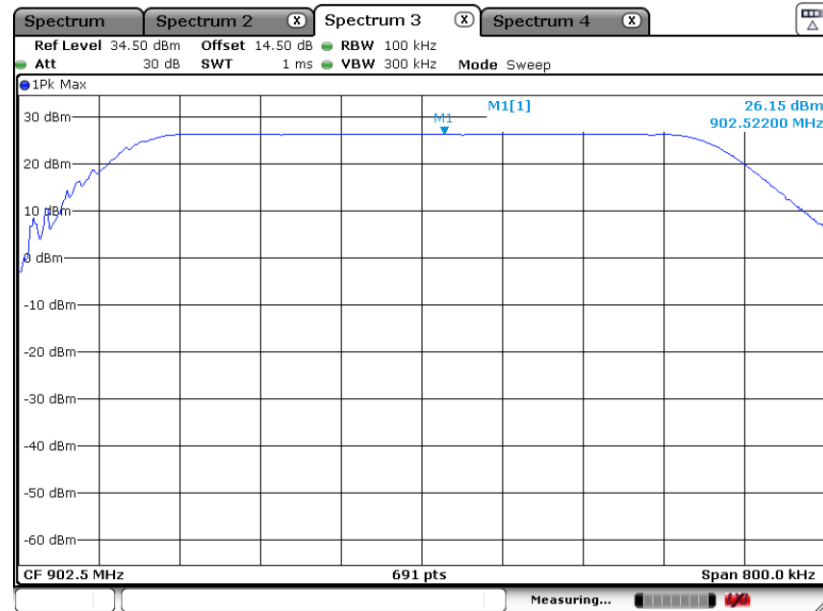
PSD 100kHz Plot on 926.5 MHz



Date: 1.MAR.2022 16:27:13

For SF9:

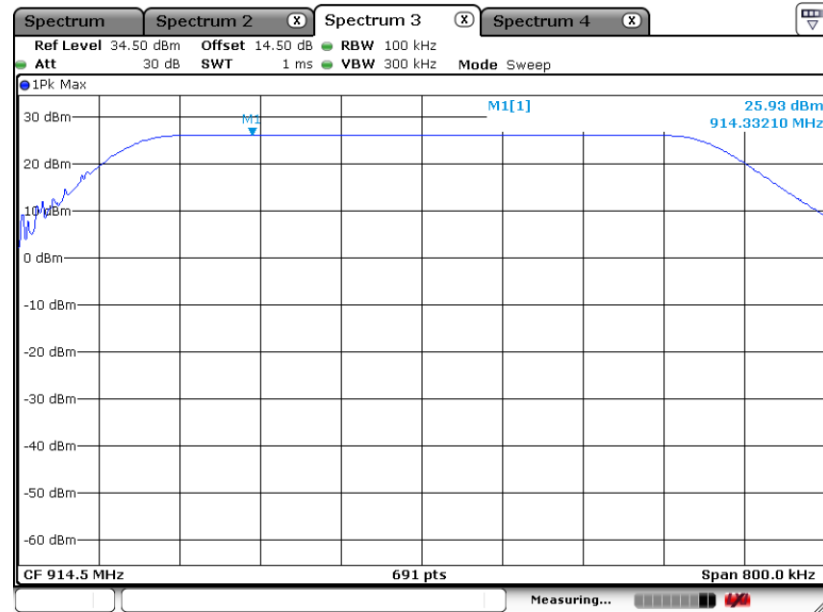
PSD 100kHz Plot on 902.5 MHz



Date: 1.MAR.2022 16:31:42

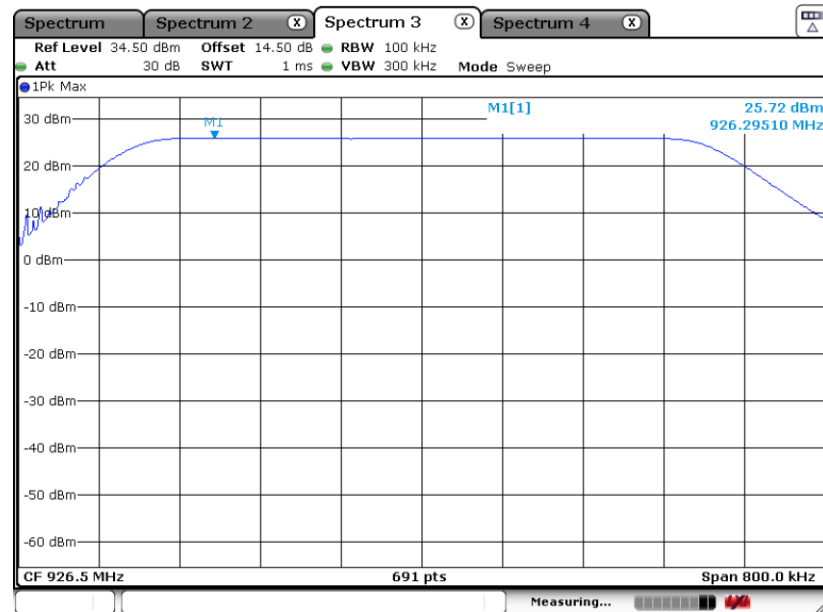


PSD 100kHz Plot on 914.5 MHz



Date: 1.MAR.2022 16:35:23

PSD 100kHz Plot on 926.5 MHz

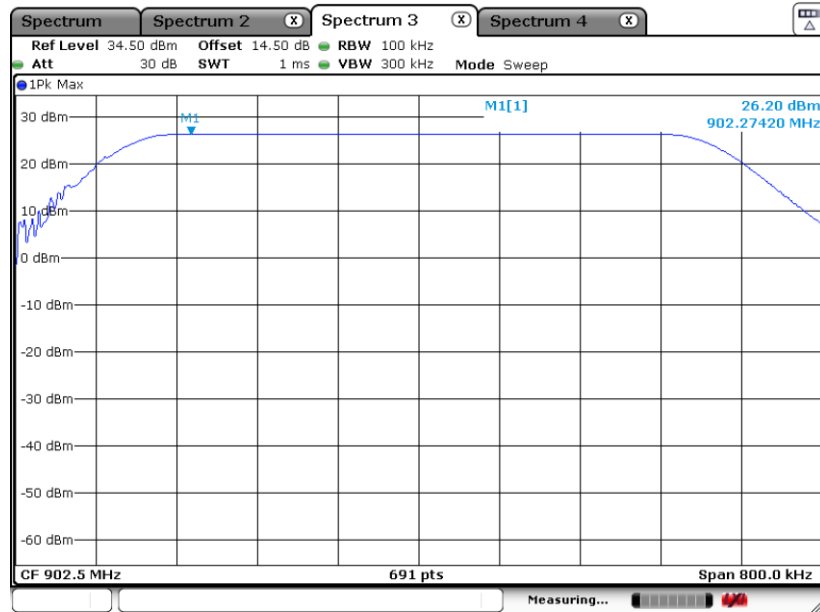


Date: 1.MAR.2022 16:37:52

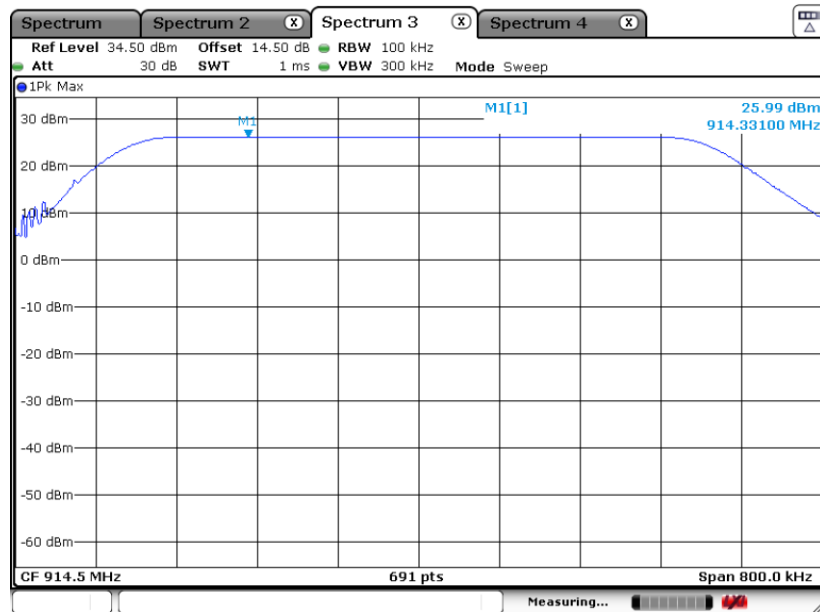


For SF10:

PSD 100kHz Plot on 902.5 MHz

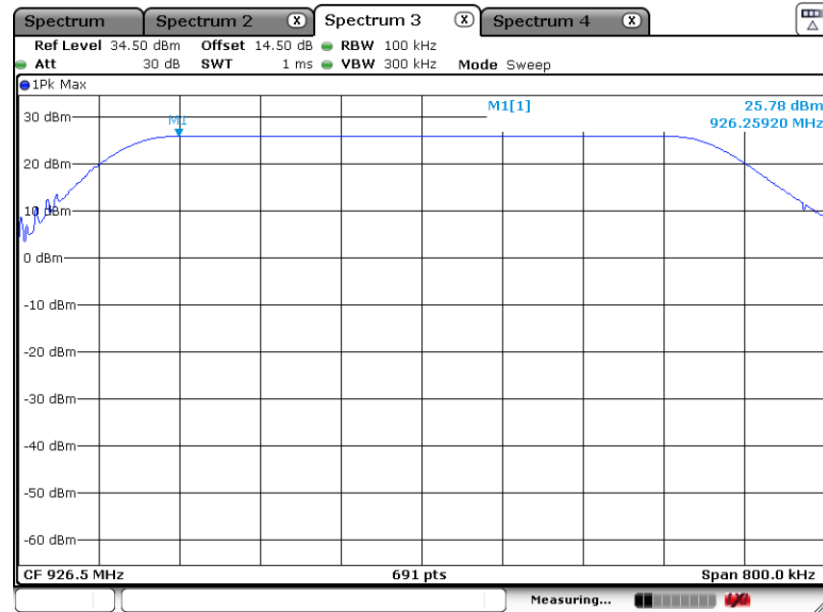


PSD 100kHz Plot on 914.5 MHz





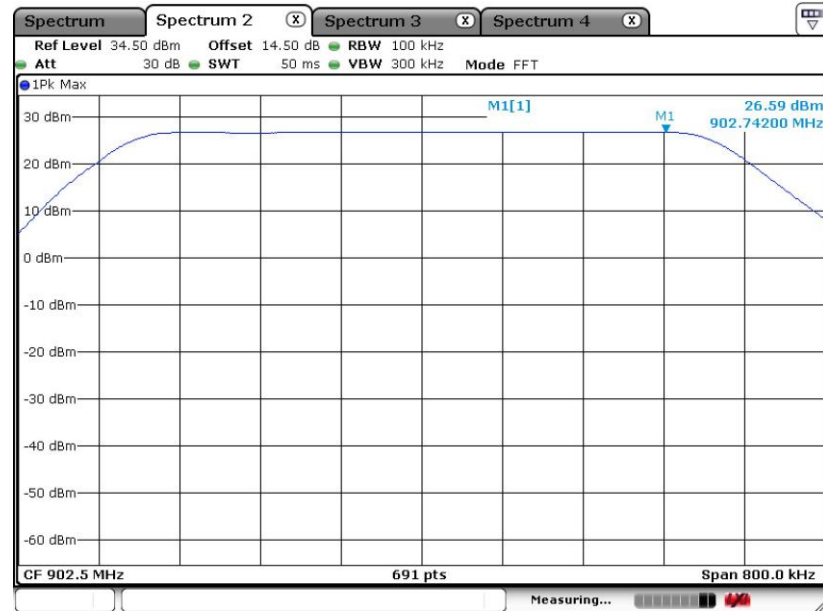
PSD 100kHz Plot on 926.5 MHz



Date: 1.MAR.2022 16:48:21

For SF11:

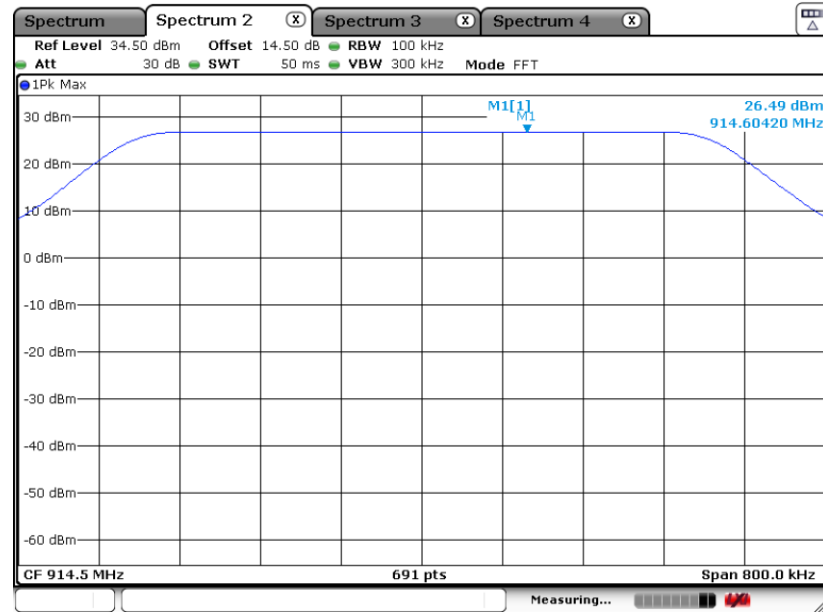
PSD 100kHz Plot on 902.5 MHz



Date: 3.NOV.2020 11:05:28

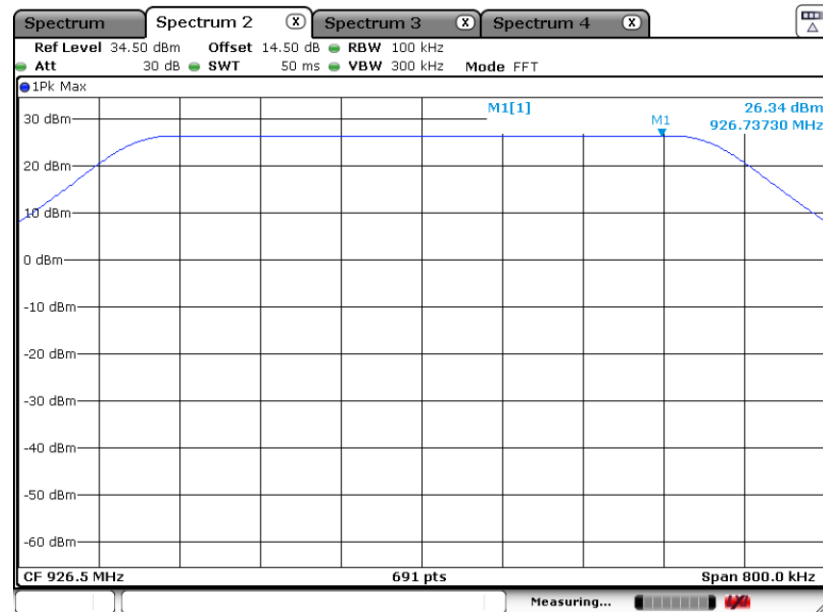


PSD 100kHz Plot on 914.5 MHz



Date: 3.NOV.2020 18:46:45

PSD 100kHz Plot on 926.5 MHz



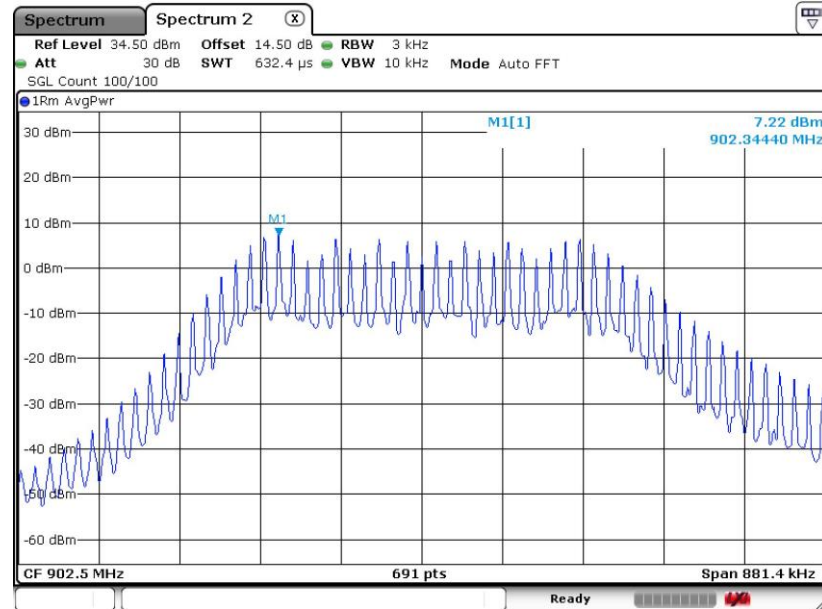
Date: 3.NOV.2020 18:40:53



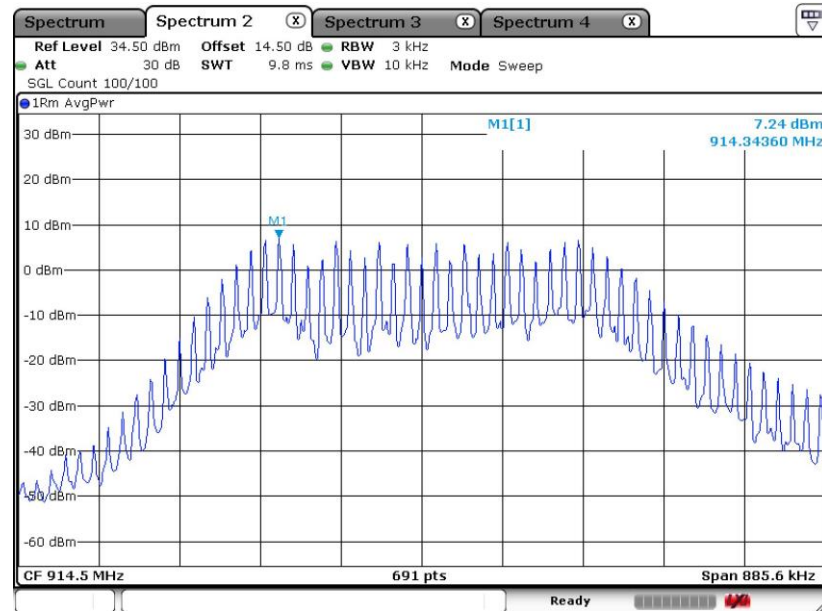
3.3.7 Test Result of Power Spectral Density Plots (3kHz)

For SF5:

PSD 3kHz Plot on 902.5 MHz

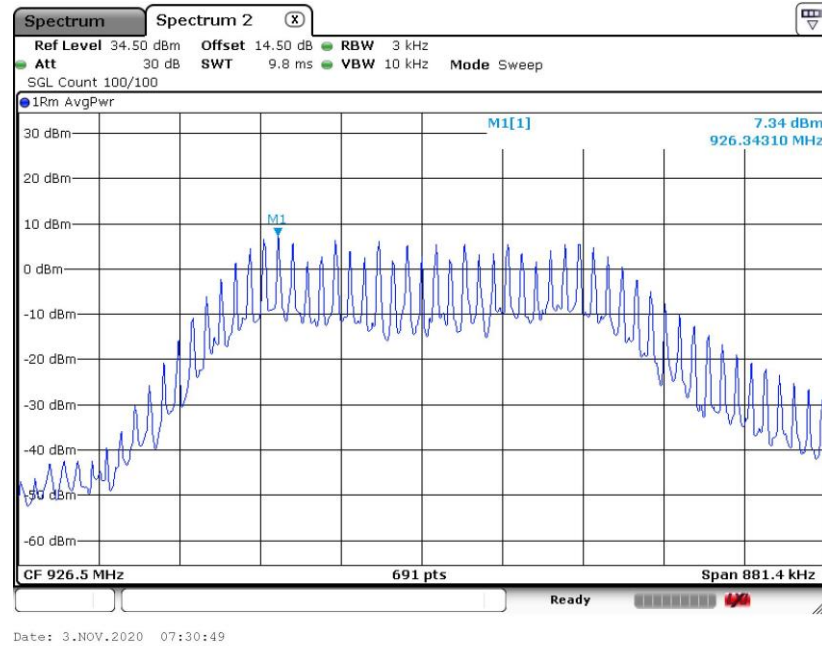


PSD 3kHz Plot on 914.5 MHz



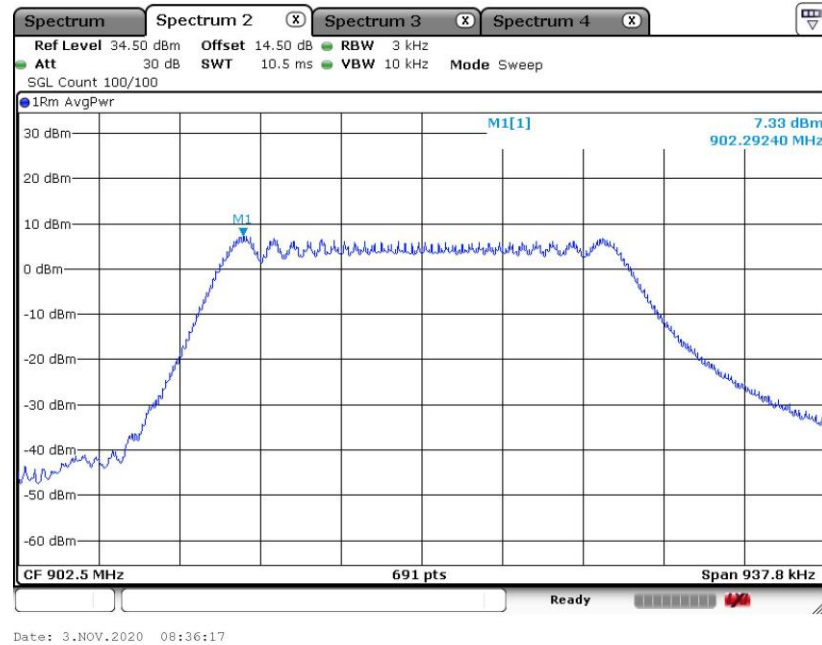


PSD 3kHz Plot on 926.5 MHz



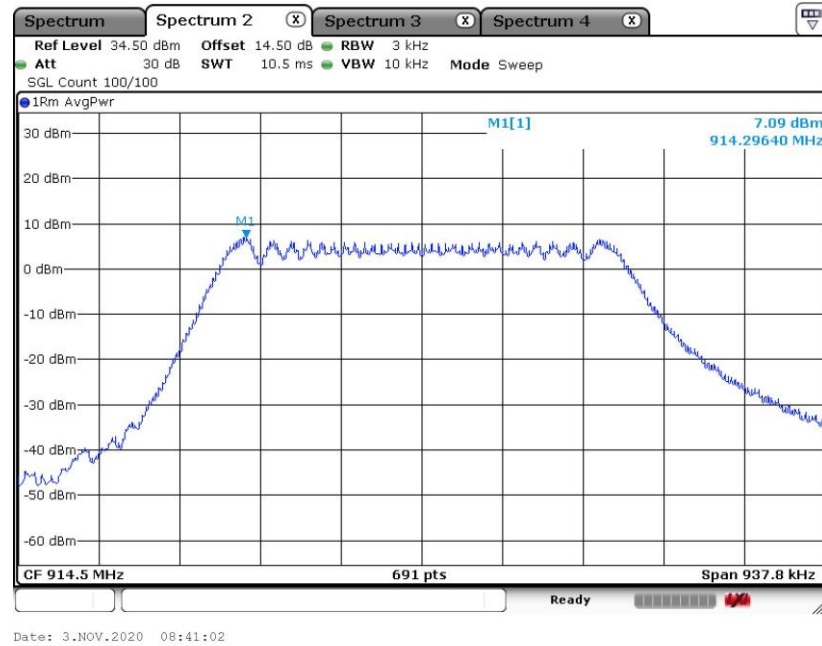
For SF7:

PSD 3kHz Plot on 902.5 MHz

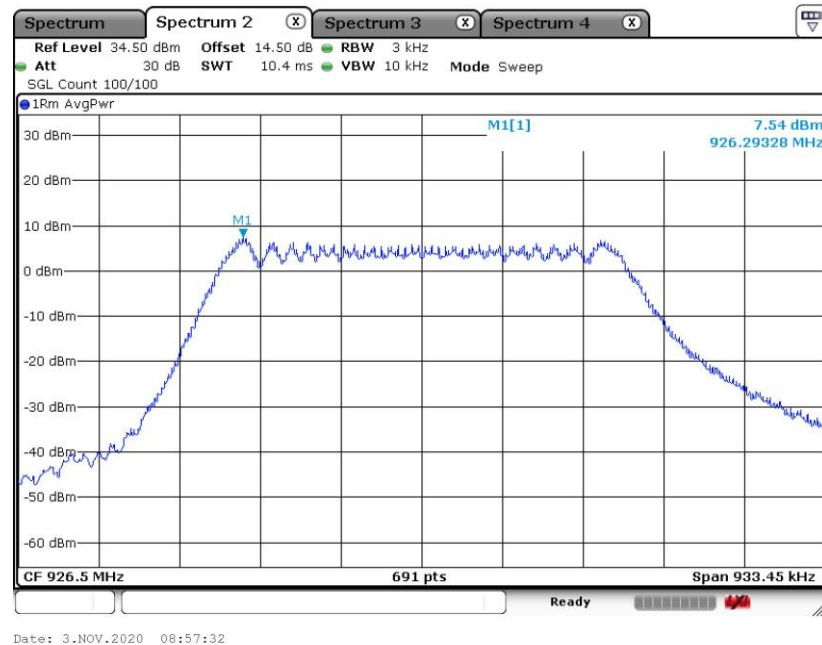




PSD 3kHz Plot on 914.5 MHz



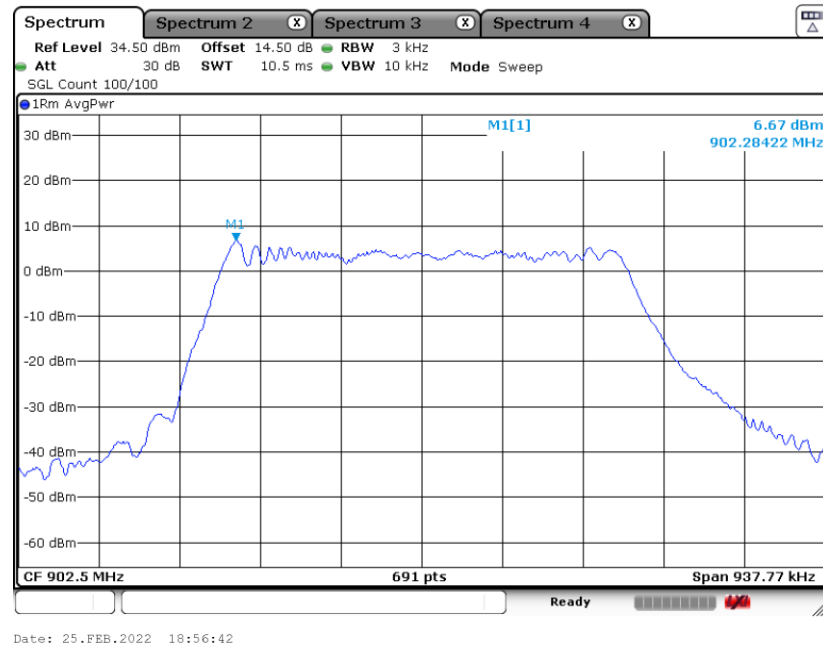
PSD 3kHz Plot on 926.5 MHz



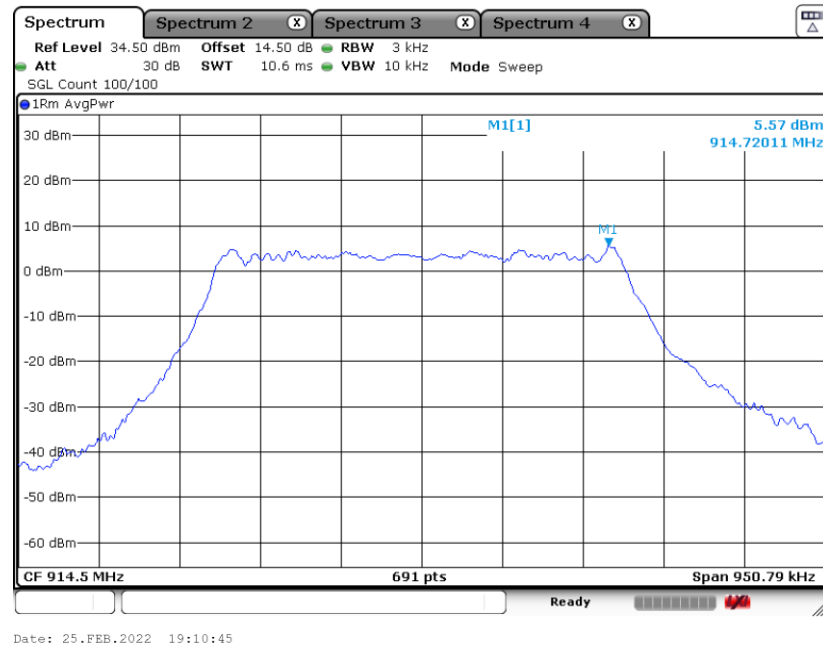


For SF8:

PSD 3kHz Plot on 902.5 MHz

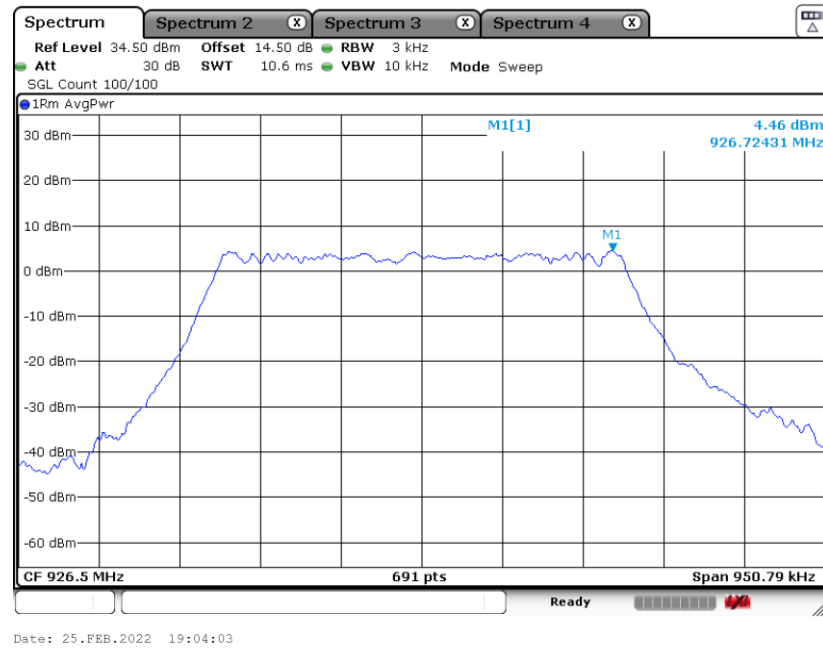


PSD 3kHz Plot on 914.5 MHz



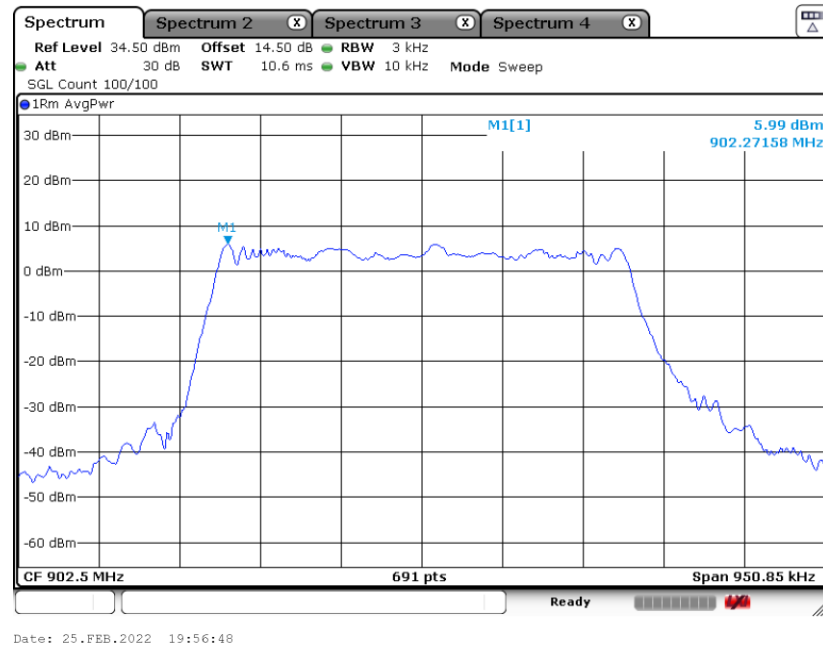


PSD 3kHz Plot on 926.5 MHz



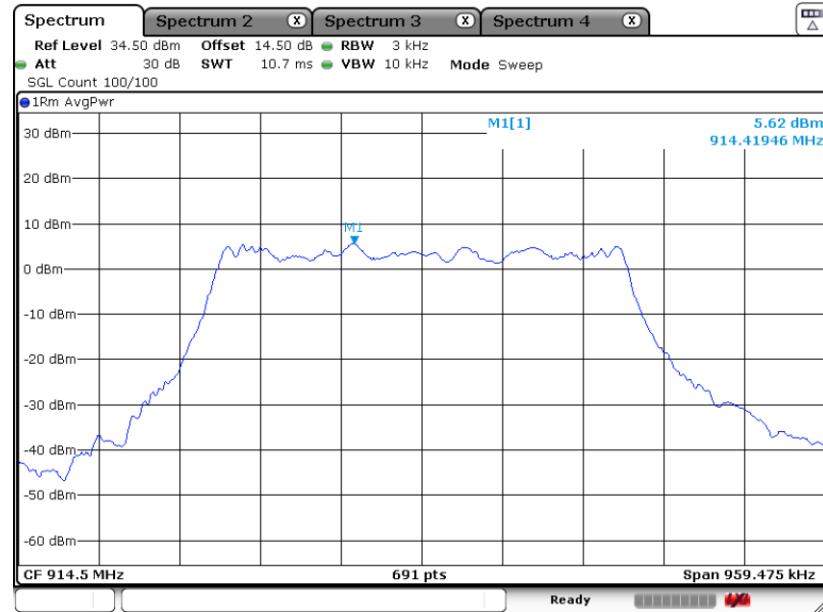
For SF9:

PSD 3kHz Plot on 902.5 MHz



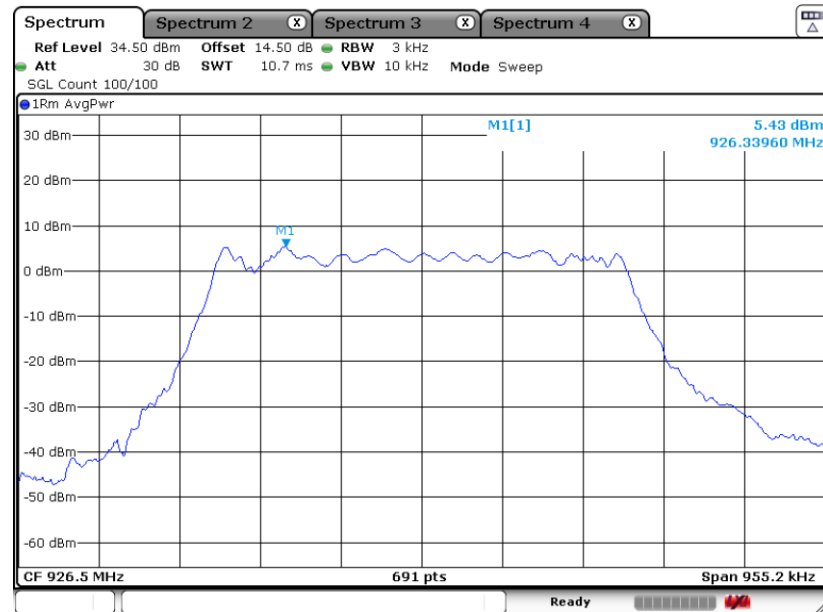


PSD 3kHz Plot on 914.5 MHz



Date: 25.FEB.2022 19:21:26

PSD 3kHz Plot on 926.5 MHz



Date: 25.FEB.2022 19:51:57



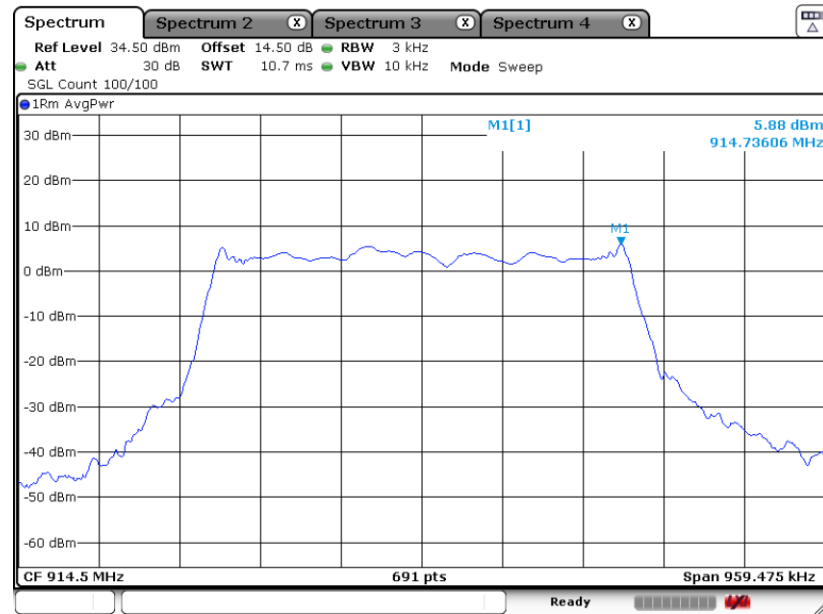
For SF10:

PSD 3kHz Plot on 902.5 MHz



Date: 25.FEB.2022 20:01:55

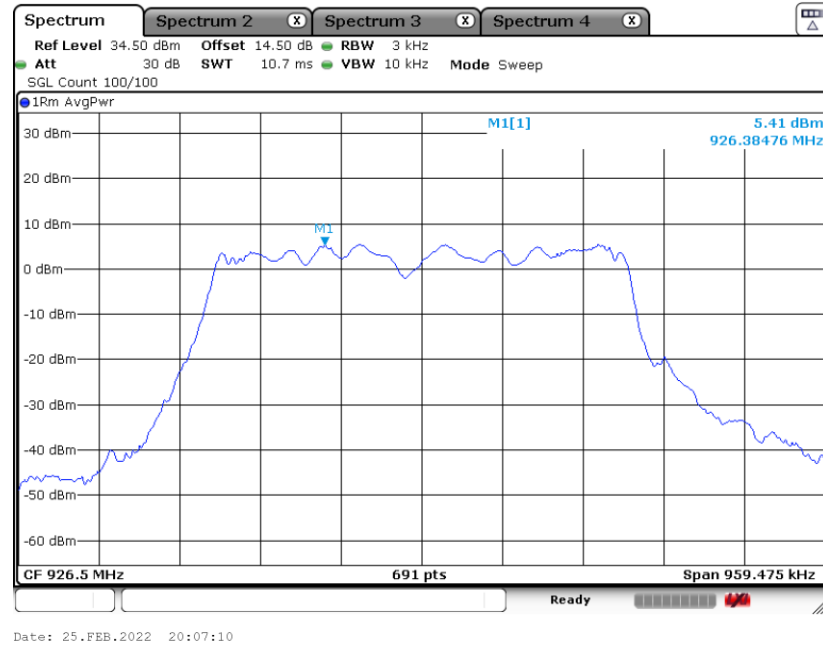
PSD 3kHz Plot on 914.5 MHz



Date: 25.FEB.2022 20:13:03

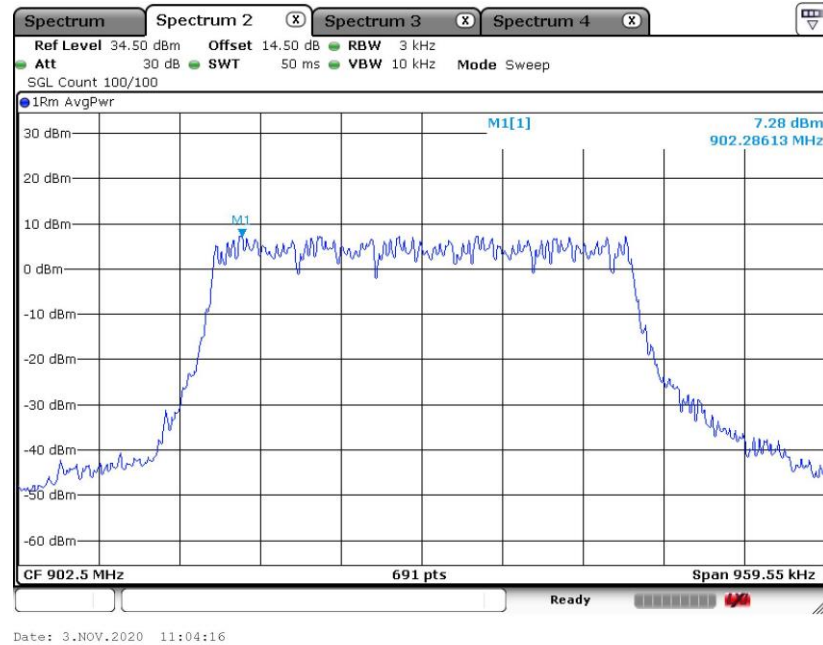


PSD 3kHz Plot on 926.5 MHz



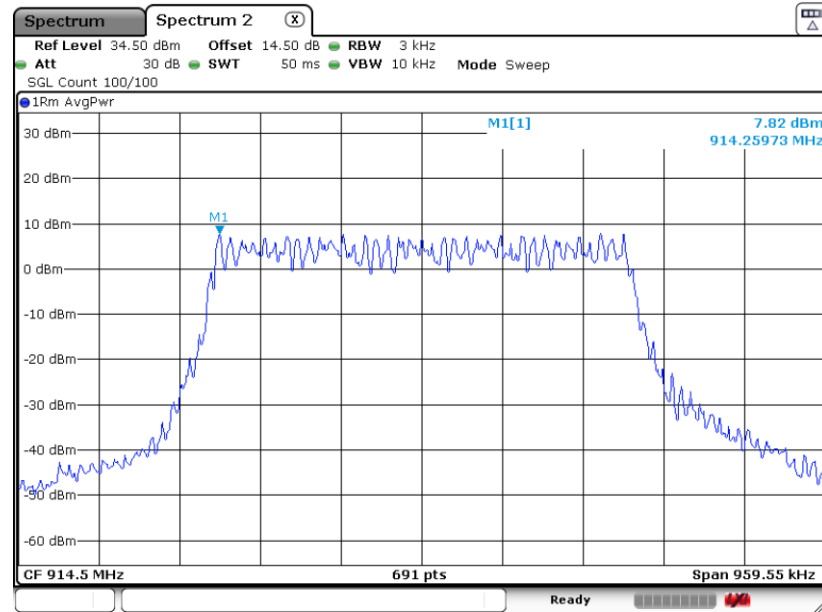
For SF11:

PSD 3kHz Plot on 902.5 MHz



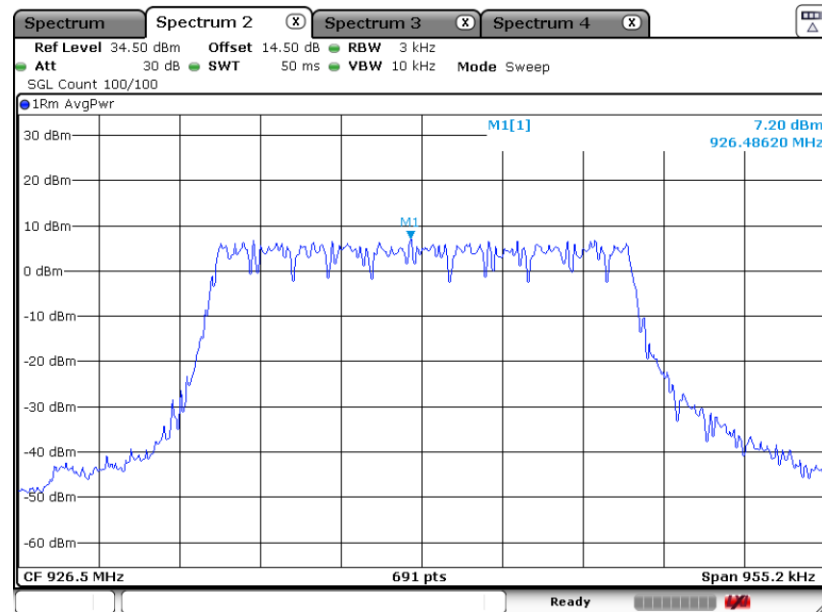


PSD 3kHz Plot on 914.5 MHz



Date: 3.NOV.2020 18:29:01

PSD 3kHz Plot on 926.5 MHz



Date: 3.NOV.2020 18:39:41

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.

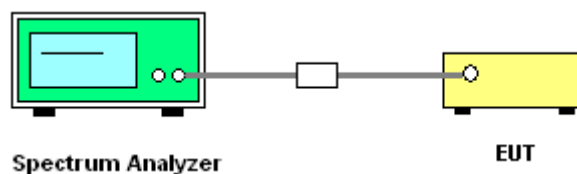
3.4.2 Measuring Instruments

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

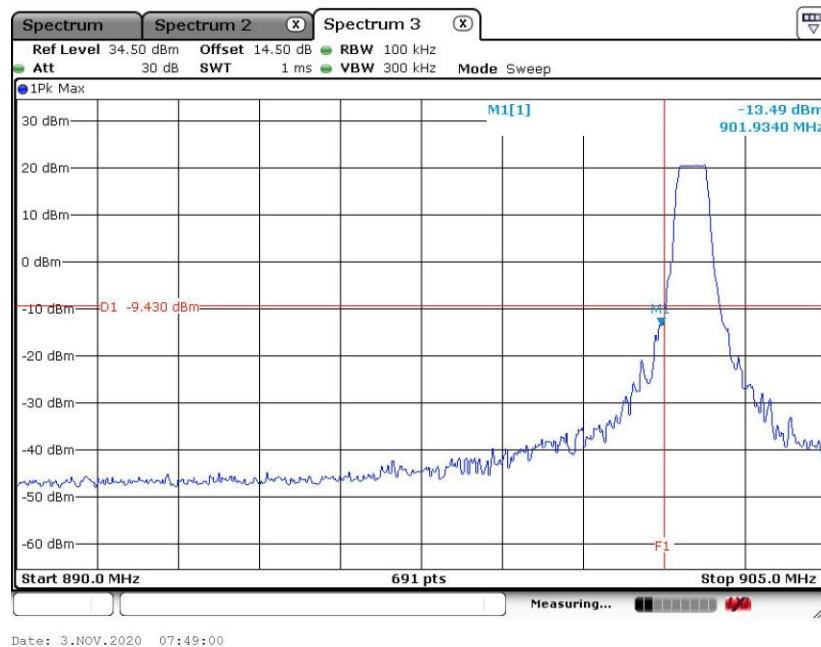




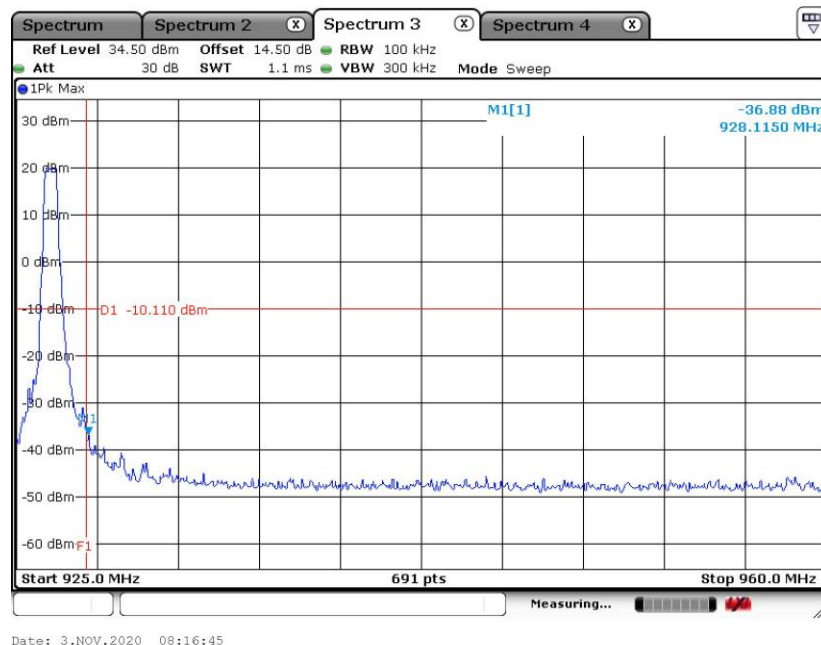
3.4.5 Test Result of Conducted Band Edges Plots

For SF5:

Low Band Edge Plot on 902.5 MHz



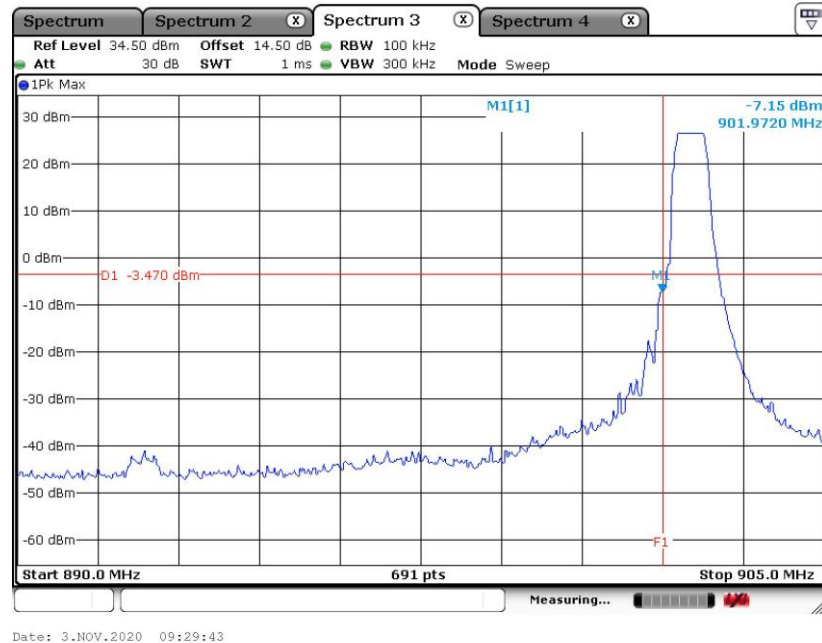
High Band Edge Plot on 926.5 MHz





For SF7:

Low Band Edge Plot on 902.5 MHz



High Band Edge Plot on 926.5 MHz

