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	:	**(DSS) Spread Spectrum Transmitter**
TEST DATE(S)	:	**Nov. 03, 2020 ~ Mar. 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.

Reviewed by: Jason Jia / Supervisor

Approved by: Alex Wang / Manager

Cert #5145.02

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FCC ID: 2AEUP-BHAGF001

Page Number : 1 of 74
Report Issued Date : May 16, 2022
Report Version : Rev. 01
Report Template No.: BU5-FR15CLoRaFHSS Version 2.0

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR151806C	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)(1)(i)	Number of Channels	≥ 50Chs	Pass	-
3.2	15.247(a)(1)	Hopping Channel Separation	≥ 20dB Bandwidth	Pass	-
3.3	15.247(a)(1)(i)	Dwell Time of Each Channel	≤ 0.4sec in 20sec period	Pass	-
3.4	15.247(a)(1)(i)	20dB Bandwidth	≤ 500 kHz	Pass	-
3.4	-	99% Bandwidth	-	Pass	-
3.5	15.247(b)(2)	Peak Output Power	≤ 1 W	Pass	-
3.6	15.247(d)	Conducted Band Edges	≤ 20dBc	Pass	-
3.7	15.247(d)	Conducted Spurious Emission	≤ 20dBc	Pass	-
3.8	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 5.29 dB at 2483.500 MHz
3.9	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 10.27 dB at 0.442 MHz
3.10	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 MHz ~ 928 MHz
Number of Channels	129
Bandwidth / Spreading Factor	125kHz / 7, 8, 9, 10
Maximum Output Power to Antenna	SF7 : 26.73 dBm (0.4710 W) SF8 : 26.63 dBm (0.4603 W) SF9 : 26.65 dBm (0.4624 W) SF10 : 26.71 dBm (0.4688 W)
99% Occupied Bandwidth	SF7 : 0.130MHz SF8 : 0.132MHz SF9 : 0.131MHz SF10 : 0.132MHz
Antenna Type / Gain	IFA stamping Antenna with gain -1.20 dBi
Type of Modulation	LoRa-FHSS

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.**
	CO01-KS 03CH04-KS 03CH06-KS TH01-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	6.2009-8-24al
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.

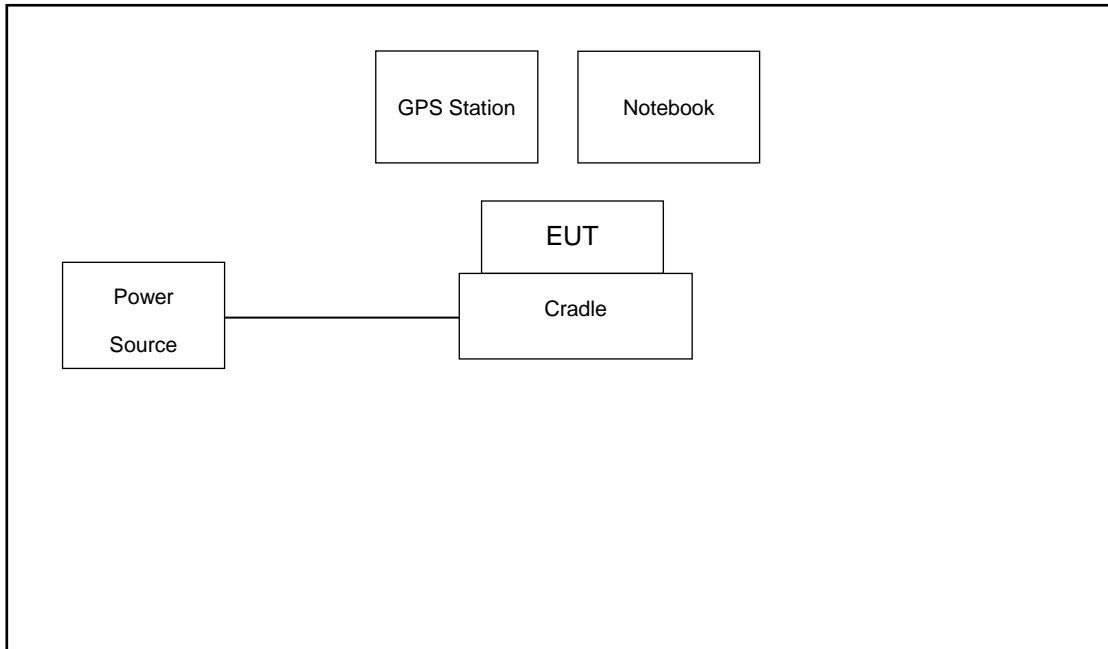# 2   Test Configuration of Equipment Under Test

2.1 Carrier Frequency Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
902-928 MHz	1	902.2	44	910.8	87	919.4
	2	902.4	45	911	88	919.6
	3	902.6	46	911.2	89	919.8
	4	902.8	47	911.4	90	920
	5	903	48	911.6	91	920.2
	6	903.2	49	911.8	92	920.4
	7	903.4	50	912	93	920.6
	8	903.6	51	912.2	94	920.8
	9	903.8	52	912.4	95	921
	10	904	53	912.6	96	921.2
	11	904.2	54	912.8	97	921.4
	12	904.4	55	913	98	921.6
	13	904.6	56	913.2	99	921.8
	14	904.8	57	913.4	100	922
	15	905	58	913.6	101	922.2
	16	905.2	59	913.8	102	922.4
	17	905.4	60	914	103	922.6
	18	905.6	61	914.2	104	922.8
	19	905.8	62	914.4	105	923
	20	906	63	914.6	106	923.2
	21	906.2	64	914.8	107	923.4
	22	906.4	65	915	108	923.6
	23	906.6	66	915.2	109	923.8
	24	906.8	67	915.4	110	924
	25	907	68	915.6	111	924.2
	26	907.2	69	915.8	112	924.4
	27	907.4	70	916	113	924.6
	28	907.6	71	916.2	114	924.8
	29	907.8	72	916.4	115	925
	30	908	73	916.6	116	925.2
	31	908.2	74	916.8	117	925.4
	32	908.4	75	917	118	925.6
	33	908.6	76	917.2	119	925.8
	34	908.8	77	917.4	120	926
	35	909	78	917.6	121	926.2
	36	909.2	79	917.8	122	926.4
	37	909.4	80	918	123	926.6
	38	909.6	81	918.2	124	926.8
	39	909.8	82	918.4	125	927
	40	910	83	918.6	126	927.2
	41	910.2	84	918.8	127	927.4
	42	910.4	85	919	128	927.6
	43	910.6	86	919.2	129	927.8

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	**Modulation / Spreading Factor**		
	LoRa FHSS / SF7	**LoRa FHSS / SF9**	**LoRa FHSS / SF10**
Conducted Test Cases	Mode 1: CH1_902.2 MHz Mode 2: CH65_915 MHz Mode 3: CH129_927.8 MHz	Mode 4: CH1_902.2 MHz Mode 5: CH65_915 MHz Mode 6: CH129_927.8 MHz	Mode 7: CH1_902.2 MHz Mode 8: CH65_915 MHz Mode 9: CH129_927.8 MHz
	LoRa FHSS / SF8		
	Mode 10: CH1_902.2 MHz Mode 11: CH65_915 MHz Mode 12: CH129_927.8 MHz		
Radiated Test Cases	**LoRa FHSS / SF7**	**LoRa FHSS / SF9**	**LoRa FHSS / SF10**
	Mode 1: CH1_902.2 MHz Mode 2: CH65_915 MHz Mode 3: CH129_927.8 MHz	Mode 4: CH1_902.2 MHz Mode 5: CH65_915 MHz Mode 6: CH129_927.8 MHz	Mode 7: CH1_902.2 MHz Mode 8: CH65_915 MHz Mode 9: CH129_927.8 MHz
	LoRa FHSS / SF8		
	Mode 10: CH1_902.2 MHz Mode 11: CH65_915 MHz Mode 12: CH129_927.8 MHz		
AC Conducted Emission	Mode 1 : Lora Tx + Bluetooth Tx + GPS RX + Cradle + Charging from Adapter		
Co-location	Mode 1: Bluetooth Tx CH39_2480 MHz + LoRa FHSS SF8 Tx_915 MHz		

2.3 Connection Diagram of Test System

For Conducted Emission:

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┌─────────────────────────────────────────────────────────────┐
│                                                               │
│              ┌──────────────┐    ┌──────────────┐             │
│              │              │    │              │             │
│              │ GPS Station  │    │   Notebook   │             │
│              │              │    │              │             │
│              └──────────────┘    └──────────────┘             │
│                             ┌──────────────┐                  │
│                             │     EUT      │                  │
│    ┌──────────────┐         ├──────────────┤                  │
│    │   Power      │─────────│    Cradle    │                  │
│    │              │         │              │                  │
│    │   Source     │         │              │                  │
│    └──────────────┘         └──────────────┘                  │
│                                                               │
│                                                               │
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└─────────────────────────────────────────────────────────────┘
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For Radiated Emission:

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│                                                               │
│                          ┌──────────────┐                     │
│                          │     EUT      │                     │
│                          └──────────────┘                     │
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│                                                               │
└─────────────────────────────────────────────────────────────┘
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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 FHSS 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.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).

     = 4.5 + 10 = 14.5 (dB)

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3   Test Result

3.1   Number of Channel Measurement

3.1.1 Limits of Number of Hopping Frequency

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

3.1.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.1.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.3.
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. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = the frequency band of operation; RBW = 50kHz; VBW = 100KHz; Sweep = auto; Detector function = peak; Trace = max hold.
6. The number of hopping frequency used is defined as the number of total channel.
7. Record the measurement data derived from spectrum analyzer.

3.1.4 Test Setup
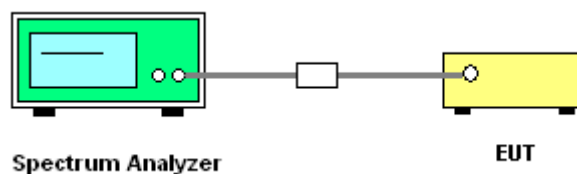
3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.

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SF7:

Number of Hopping Channel Plot on Channel 1 - 129
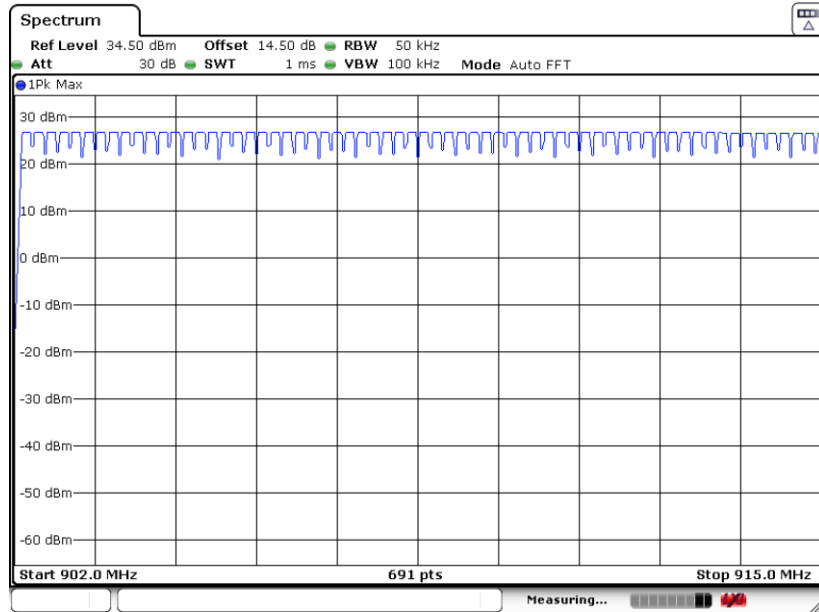
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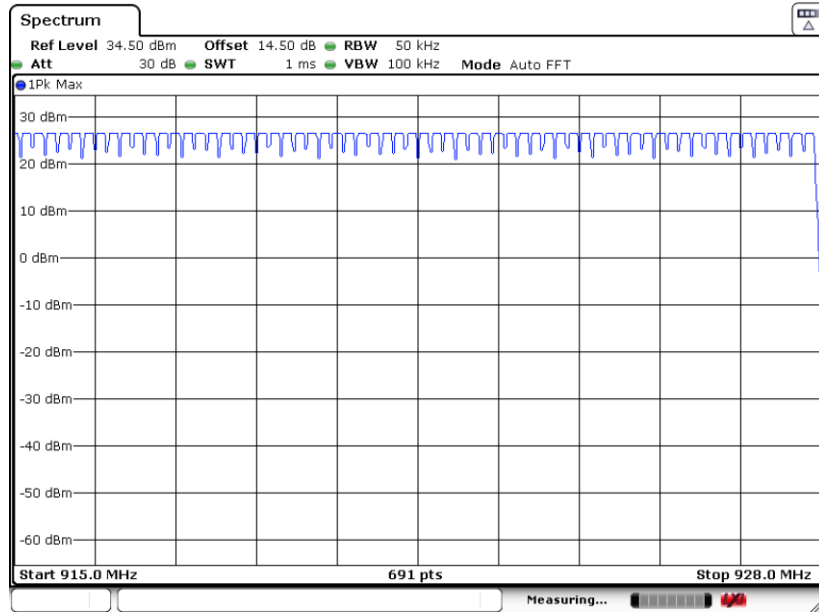
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SF8:

Number of Hopping Channel Plot on Channel 1 - 129
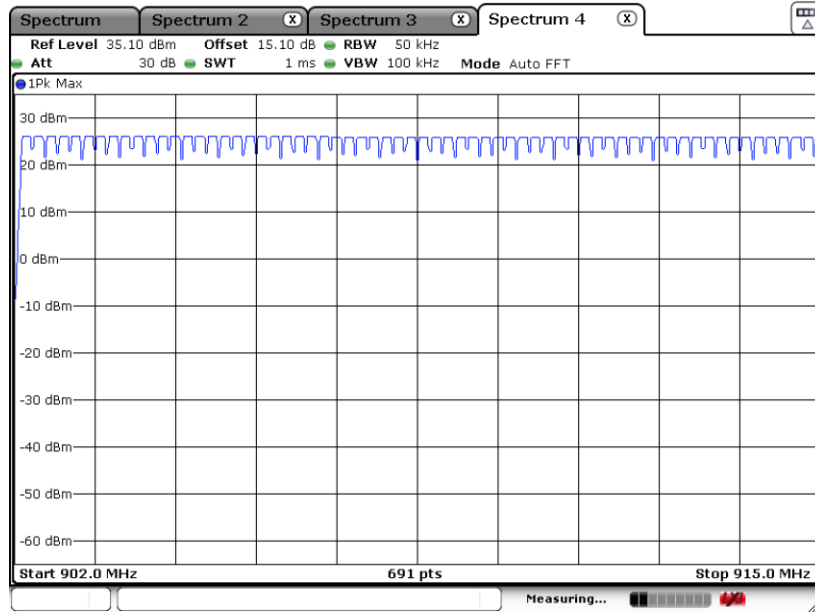
Date: 4.JAN.2022 15:45:47
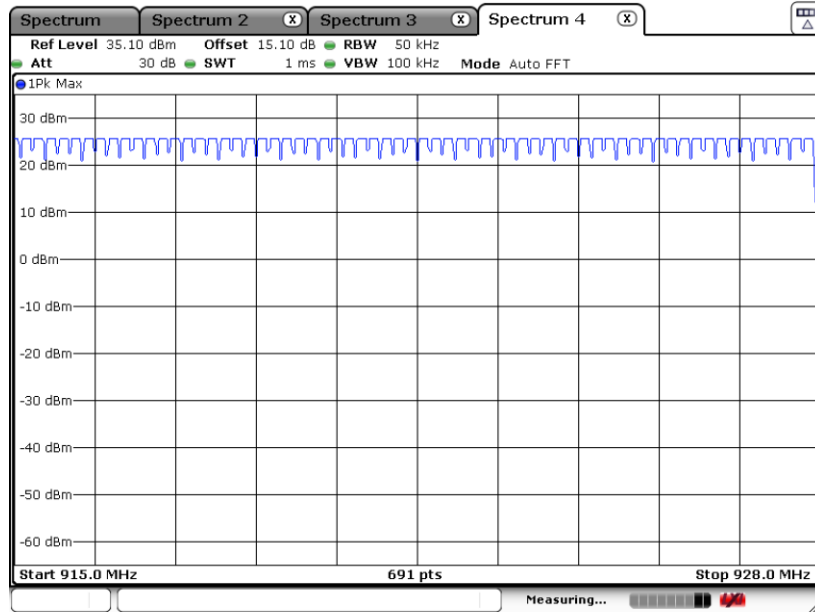
Date: 4.JAN.2022 15:47:34

SF9:

Number of Hopping Channel Plot on Channel 1 - 129
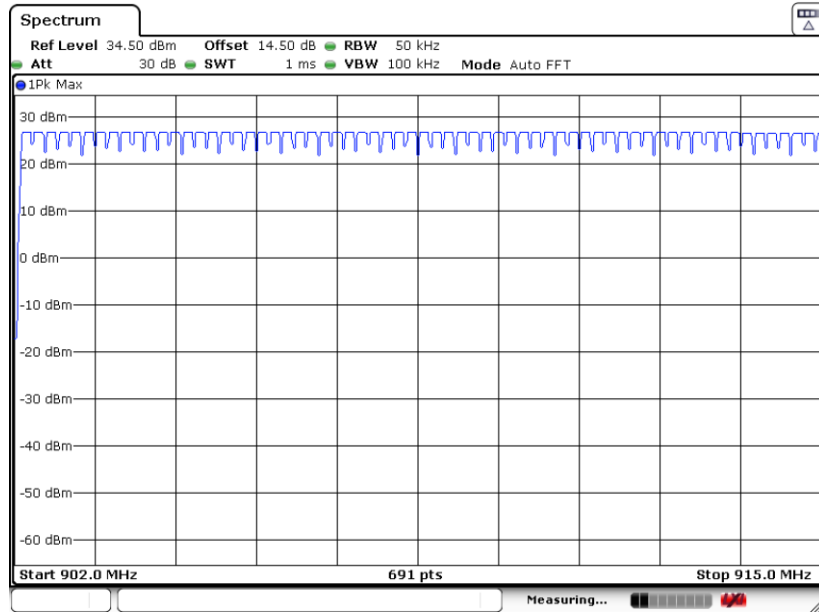
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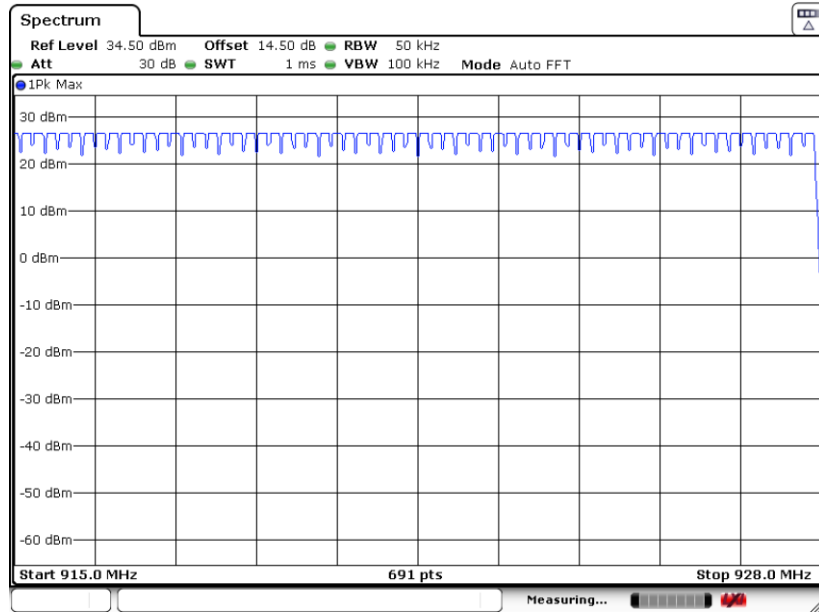
Date: 3.NOV.2020 21:26:34

SF10:

Number of Hopping Channel Plot on Channel 1 - 129
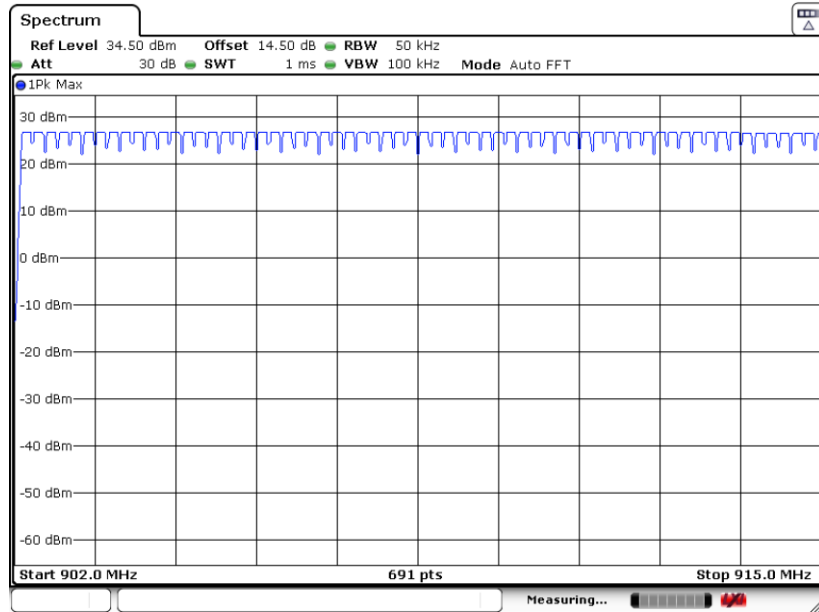
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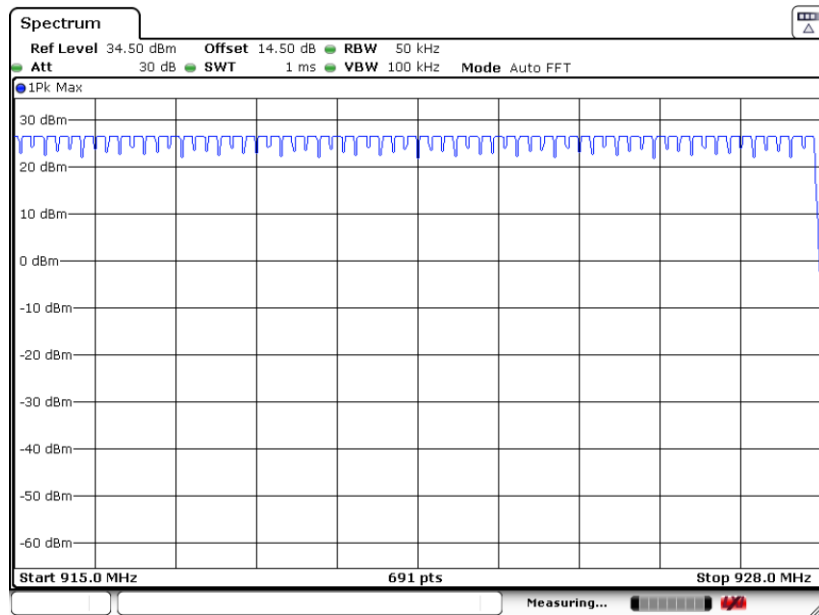
Date: 3.NOV.2020 23:02:43

3.2 Hopping Channel Separation Measurement

3.2.1 Limit of Hopping Channel Separation

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

3.2.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.2.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.2.
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. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings:
   Span = wide enough to capture the peaks of two adjacent channels;
   RBW = 50kHz; VBW = 100KHz; Sweep = auto; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.2.4 Test Setup

Spectrum Analyzer   EUT
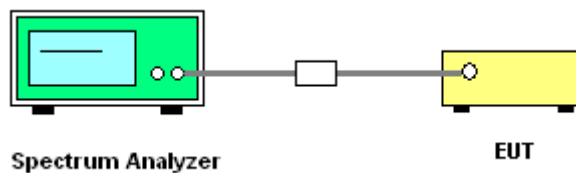
3.2.5 Test Result of Hopping Channel Separation

Please refer to Appendix A.

SF7:

Channel Separation Plot on Channel 1 - 2
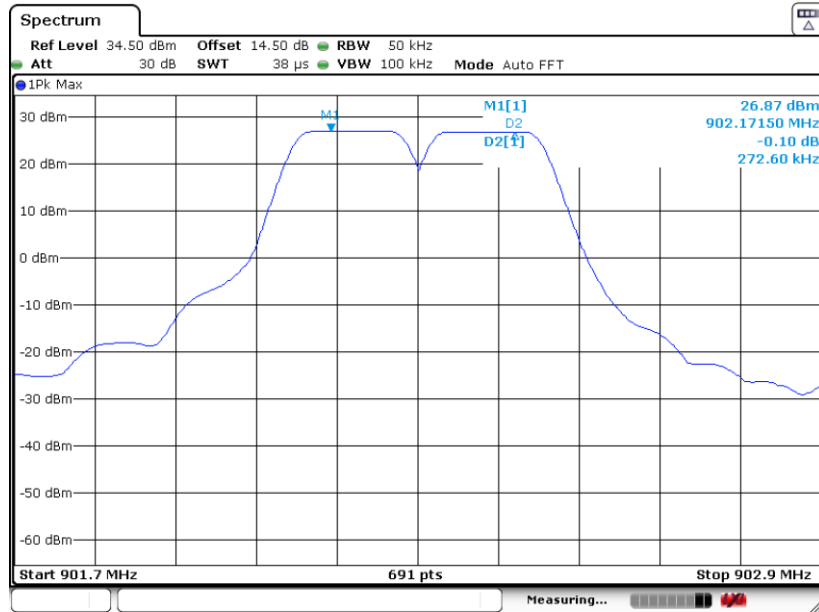
Date: 3.NOV.2020 19:22:29

Channel Separation Plot on Channel 64 - 65

Date: 3.NOV.2020 20:10:03

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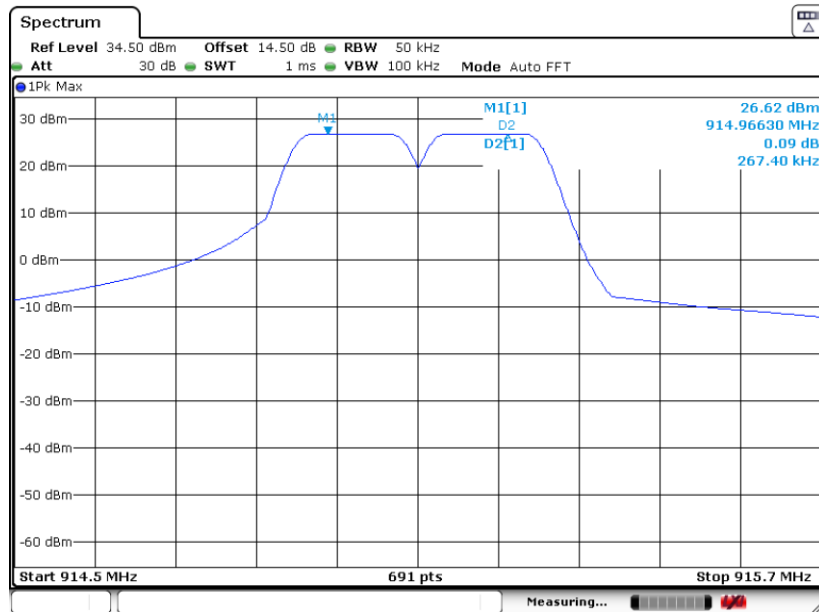
Channel Separation Plot on Channel 128 - 129
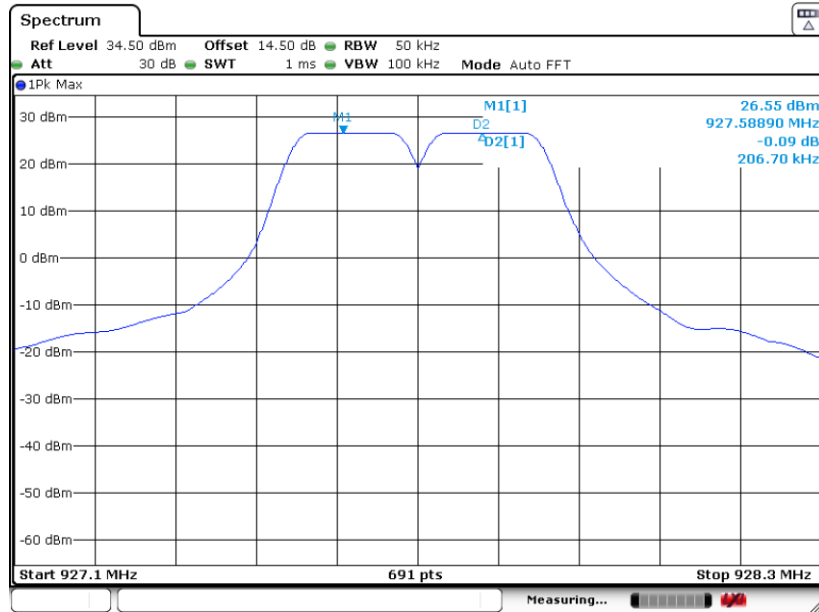
Date: 3.NOV.2020 20:39:21

SF8:

Channel Separation Plot on Channel 1 - 2
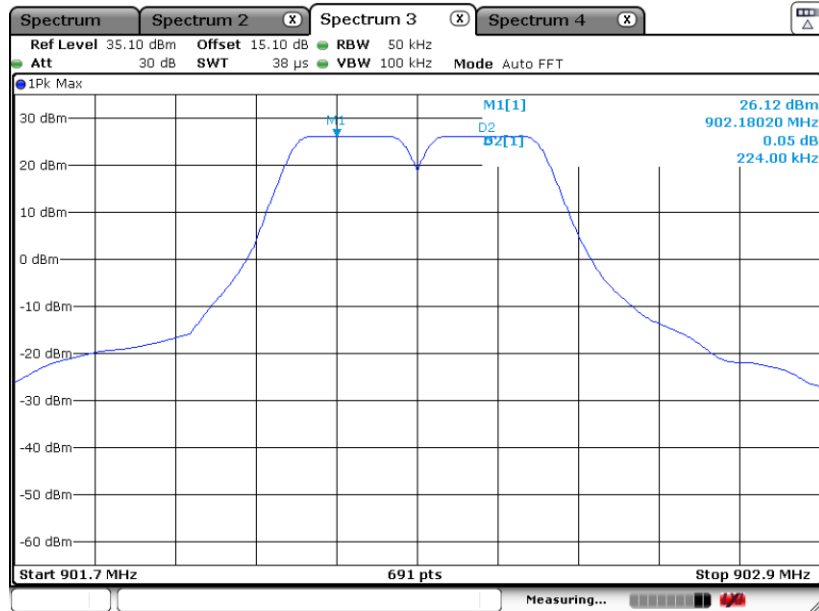
Date: 4.JAN.2022 14:45:50

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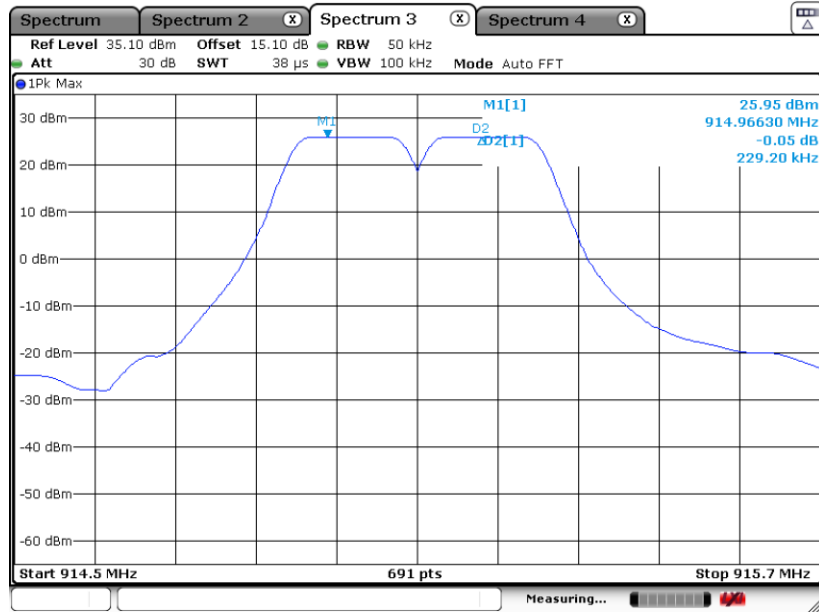
Date: 4.JAN.2022 14:52:04

Channel Separation Plot on Channel 128 - 129

Date: 4.JAN.2022 15:00:47

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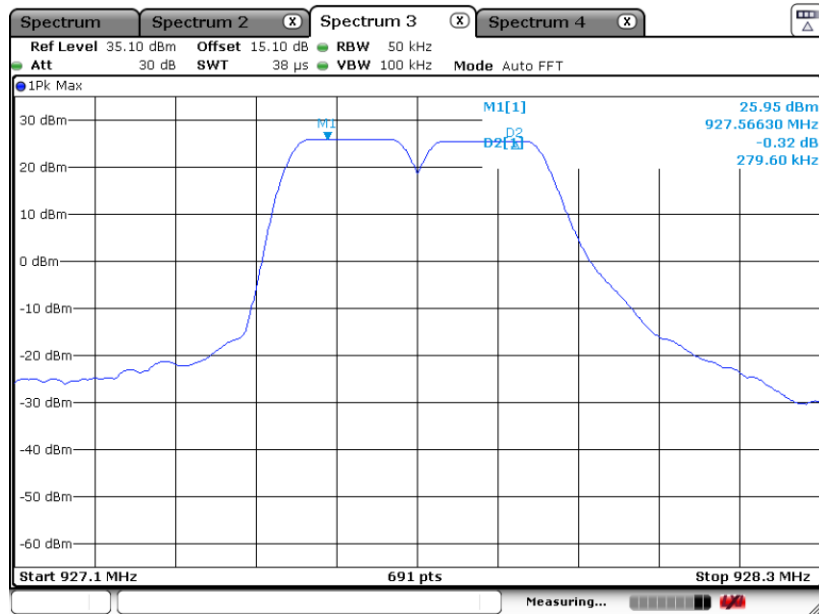
SF9:

Channel Separation Plot on Channel 1 - 2

Date: 3.NOV.2020 22:03:02

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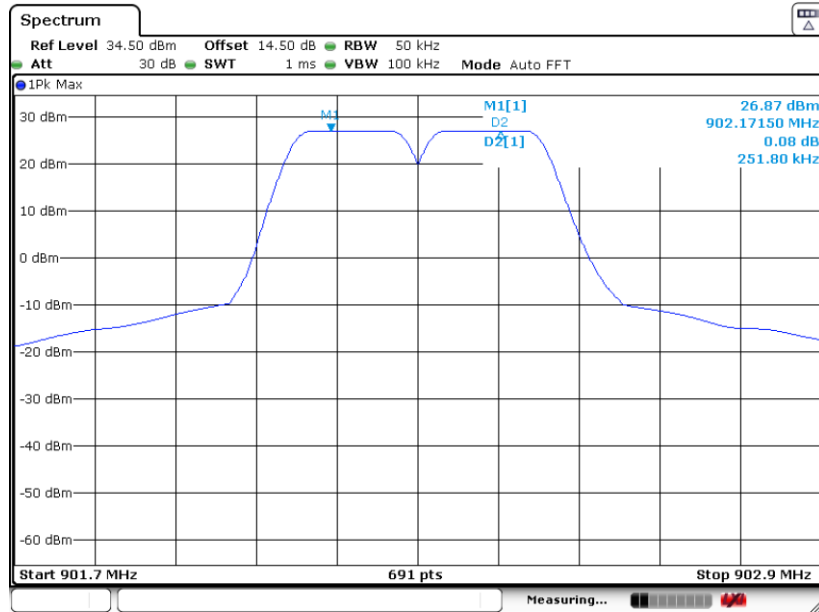
Channel Separation Plot on Channel 64 - 65
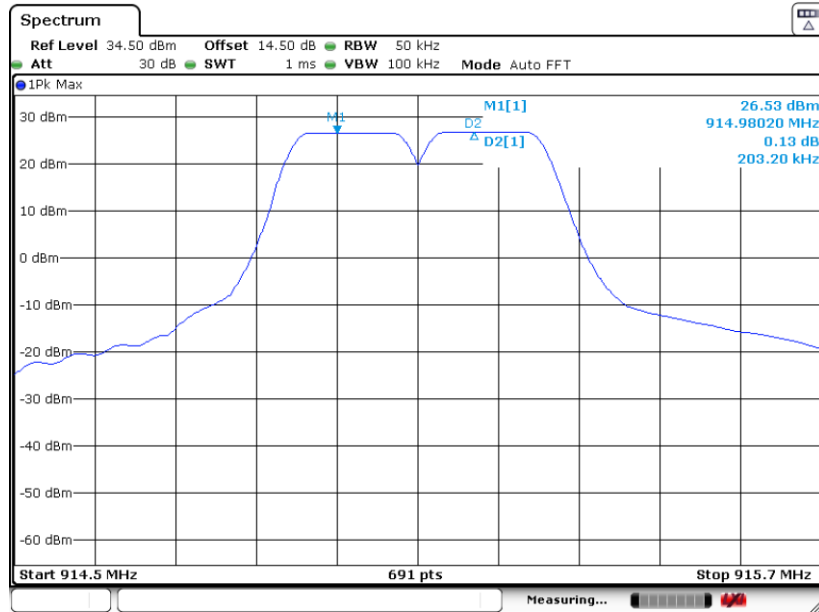
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Channel Separation Plot on Channel 128 - 129
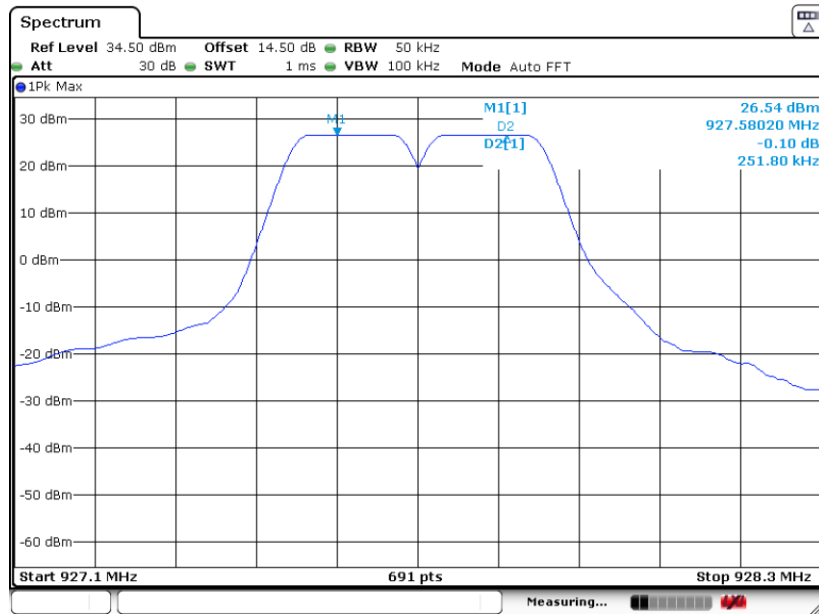
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SF10:

Channel Separation Plot on Channel 1 - 2
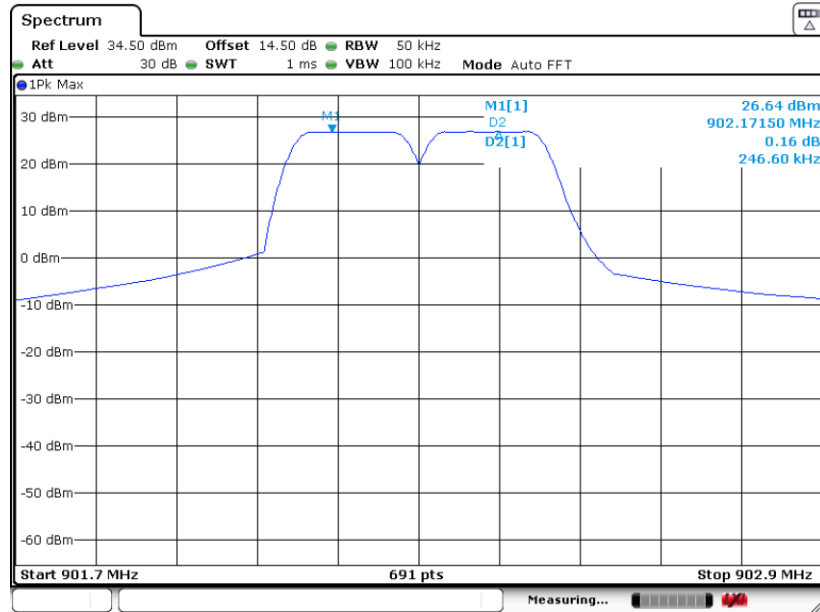
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Channel Separation Plot on Channel 64 - 65
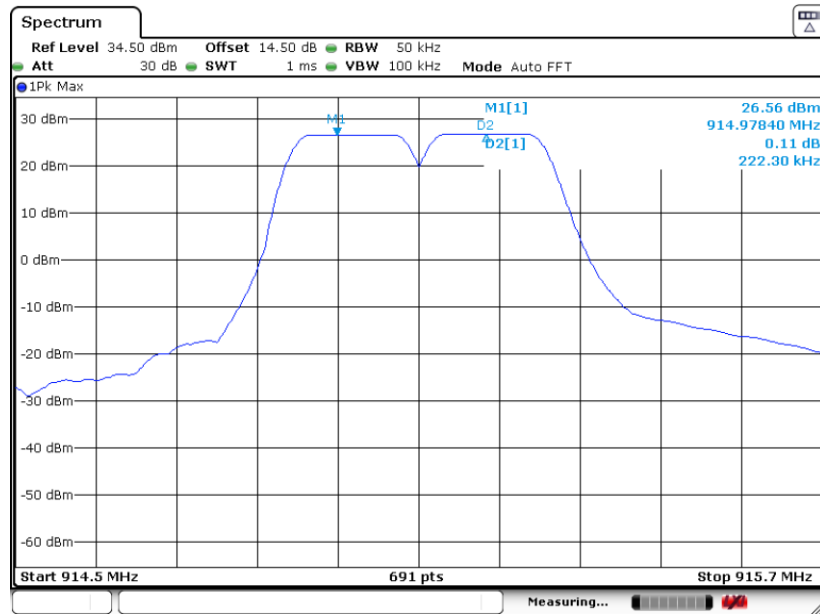
Date: 3.NOV.2020 23:32:15

Channel Separation Plot on Channel 128 - 129
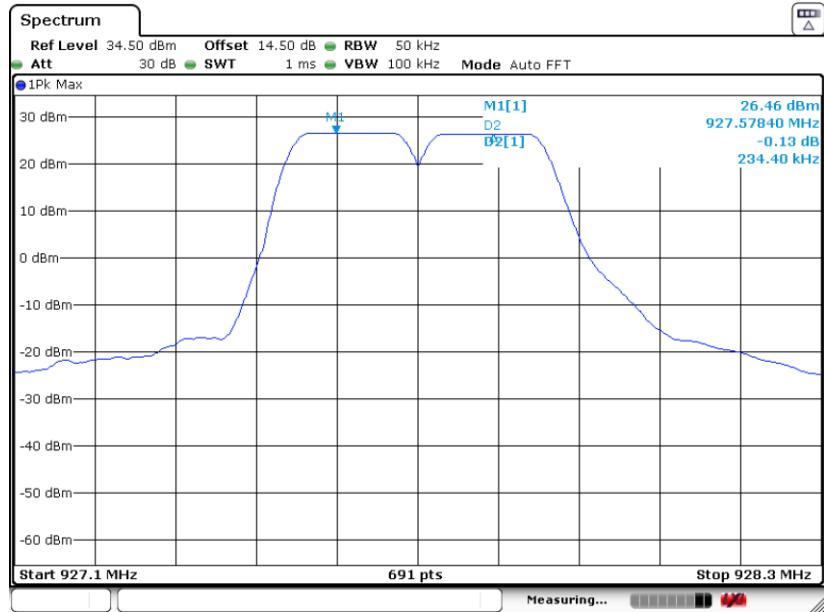
Date: 3.NOV.2020 23:30:28

3.3 Dwell Time Measurement

3.3.1 Limit of Dwell Time

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

3.3.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.3.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.4.
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. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW = 20 KHz; VBW = 20KHz; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.3.4 Test Setup

Spectrum Analyzer   EUT
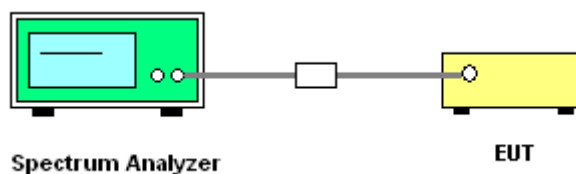
3.3.5 Test Result of Dwell Time

Please refer to Appendix A.

SF7:

DT on-time and Hops over 20 sec period
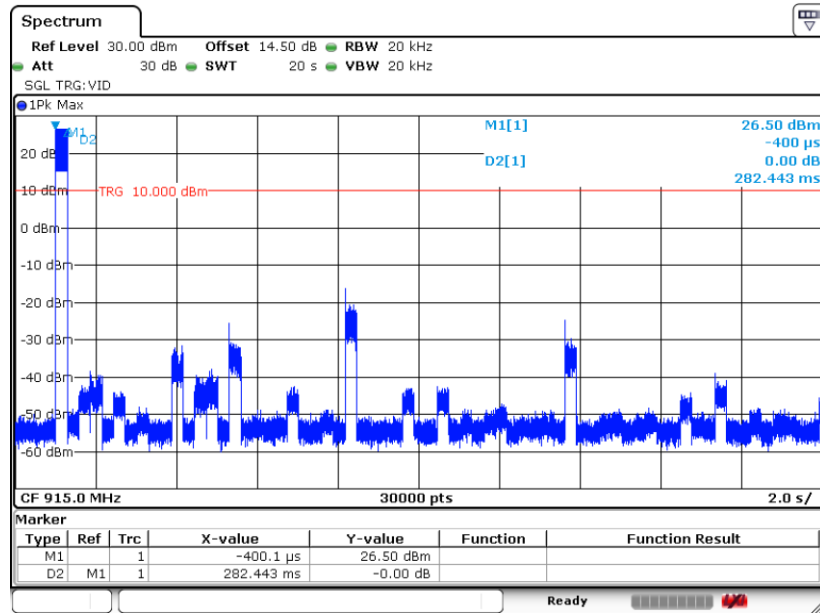
Date: 4.NOV.2020 09:59:40

Remark:

Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

= 1 (hop) x 282.443 (ms)

= 0.282 (sec)

SF8:

DT on-time and Hops over 20 sec period
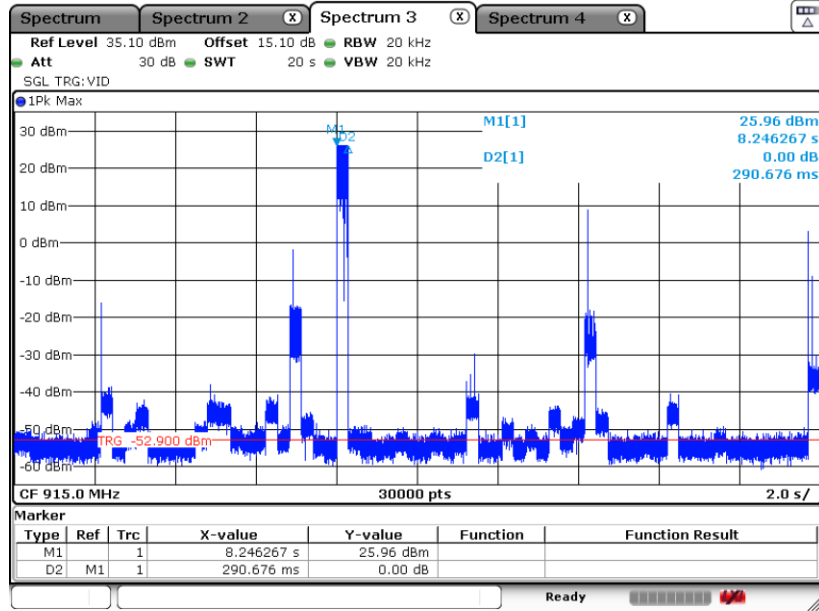
Date: 4.JAN.2022 15:38:54

Remark:

Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

= 1 (hop) x 290.676 (ms)

= 0.291 (sec)

SF9:

DT on-time and Hops over 20 sec period
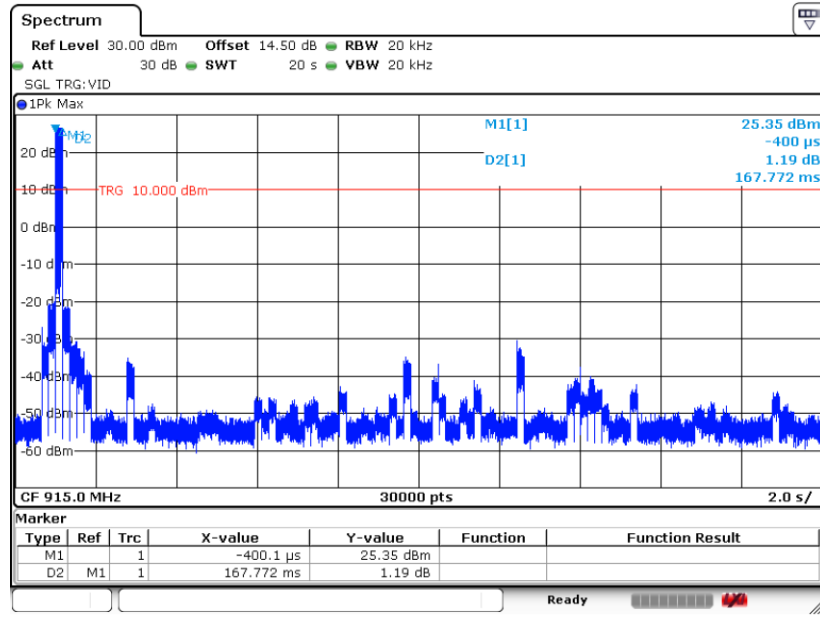
Date: 4.NOV.2020 09:53:54

Remark:

Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

= 1 (hop) x 167.772 (ms)

= 0.168 (sec)

SF10:

DT on-time and Hops over 20 sec period
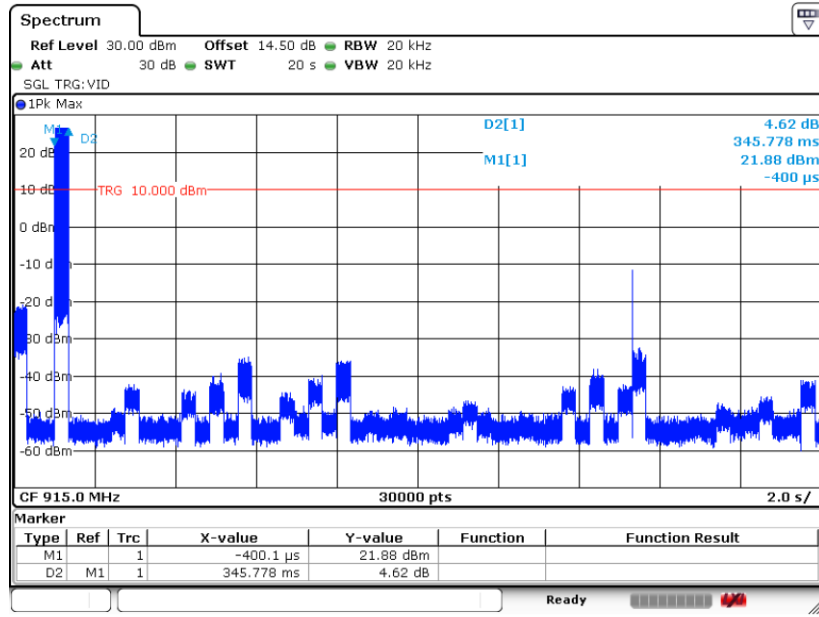
Remark:

Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

= 1 (hop) x 345.778 (ms)

= 0.346 (sec)

3.4 20dB and 99% Bandwidth Measurement

3.4.1 Limit of 20dB and 99% Bandwidth

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

3.4.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.4.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 6.9.2 and 6.9.3.
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. Use the following spectrum analyzer settings for 20dB Bandwidth measurement.
   Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel;
   RBW $\geq$ 1% of the 20 dB bandwidth; VBW $\geq$ RBW; Sweep = auto; Detector function = peak;
   Trace = max hold.
5. Use the following spectrum analyzer settings for 99 % Bandwidth measurement.
   Span = approximately 1.5 to 5 times the 99% bandwidth, centered on a hopping channel;
   RBW $\geq$ 1% of the 99% bandwidth; VBW $\geq$ RBW; Sweep = auto; Detector function = sample;
   Trace = max hold.
6. Measure and record the results in the test report.

3.4.4 Test Setup
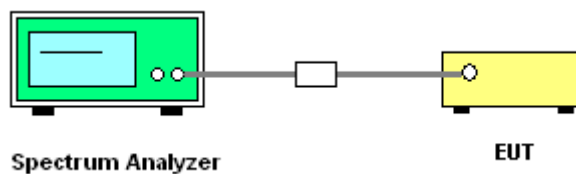
3.4.5 Test Result of 20dB Bandwidth

Please refer to Appendix A.

SF7:

20 dB Bandwidth Plot on Channel 1

```
Spectrum                                                                           [⊞△]
  Ref Level  34.50 dBm    Offset  14.50 dB ● RBW  6.25 kHz
● Att         30 dB       SWT     1.6 ms ● VBW    20 kHz    Mode Sweep
●1Pk Max
 30 dBm                              M1           M1[1]                  26.08 dBm
                                                                  902.165990 MHz
 20 dBm                                           ndB                    20.00 dB
                                                  Bw              146.160000000 kHz
 10 dBm                            T1             Q factor                  6172.2
                                   ▽                    T2
  0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
CF 902.2 MHz                              691 pts                    Span 500.0 kHz
Marker
 Type | Ref | Trc |   X-value    |  Y-value  | Function  |  Function Result
  M1  |     |  1  | 902.16599 MHz| 26.08 dBm | ndB down  |       146.16 kHz
  T1  |     |  1  | 902.12836 MHz|  5.77 dBm |    ndB    |        20.00 dB
  T2  |     |  1  | 902.27453 MHz|  6.22 dBm | Q factor  |          6172.2
                                                      Measuring... ▮▮▮▮▮▮▮▮▯ ▞▞
```

Date: 3.NOV.2020 19:09:16

20 dB Bandwidth Plot on Channel 65

```
Spectrum                                                                           [⊞△]
  Ref Level  34.50 dBm    Offset  14.50 dB ● RBW  6.25 kHz
● Att         30 dB       SWT     1.6 ms ● VBW    20 kHz    Mode Sweep
●1Pk Max
 30 dBm                              M1           M1[1]                  24.80 dBm
                                                                  914.946450 MHz
 20 dBm                                           ndB                    20.00 dB
                                                  Bw              147.610000000 kHz
 10 dBm                                           Q factor                  6198.3
                                   T1                  T2
  0 dBm                            ▽
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
CF 915.0 MHz                              691 pts                    Span 500.0 kHz
Marker
 Type | Ref | Trc |   X-value    |  Y-value  | Function  |  Function Result
  M1  |     |  1  | 914.94645 MHz| 24.80 dBm | ndB down  |       147.61 kHz
  T1  |     |  1  | 914.92836 MHz|  4.28 dBm |    ndB    |        20.00 dB
  T2  |     |  1  | 915.07598 MHz|  4.76 dBm | Q factor  |          6198.3
                                                      Measuring... ▮▯▯▯▯▯▯▯▯ ▞▞
```

Date: 3.NOV.2020 20:03:34

20 dB Bandwidth Plot on Channel 129
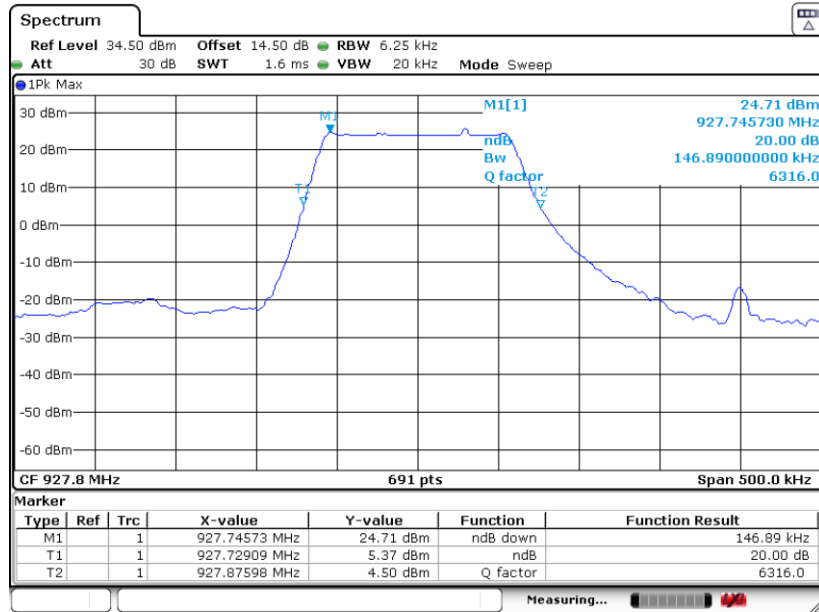
Date: 3.NOV.2020 20:34:17

SF8:

20 dB Bandwidth Plot on Channel 1
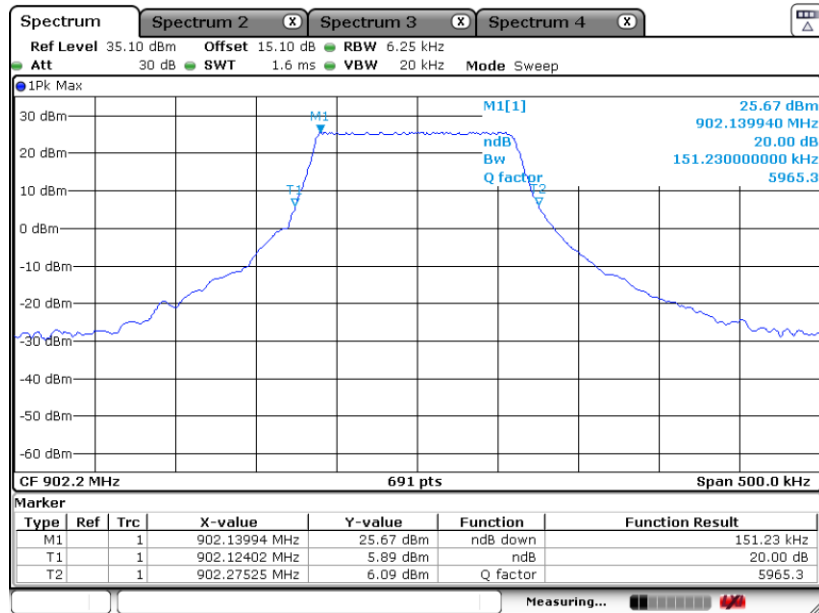
Date: 4.JAN.2022 14:38:20

20 dB Bandwidth Plot on Channel 65
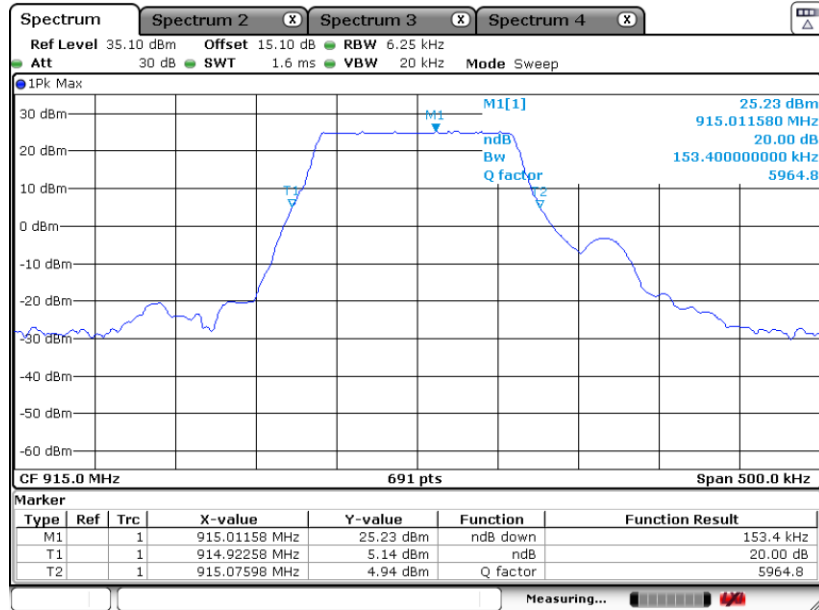
Date: 4.JAN.2022 14:49:17
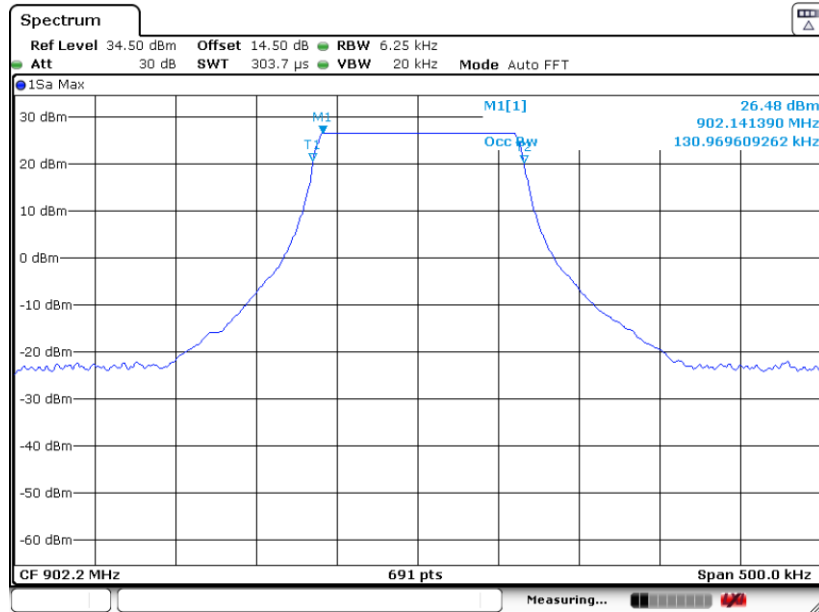
20 dB Bandwidth Plot on Channel 129
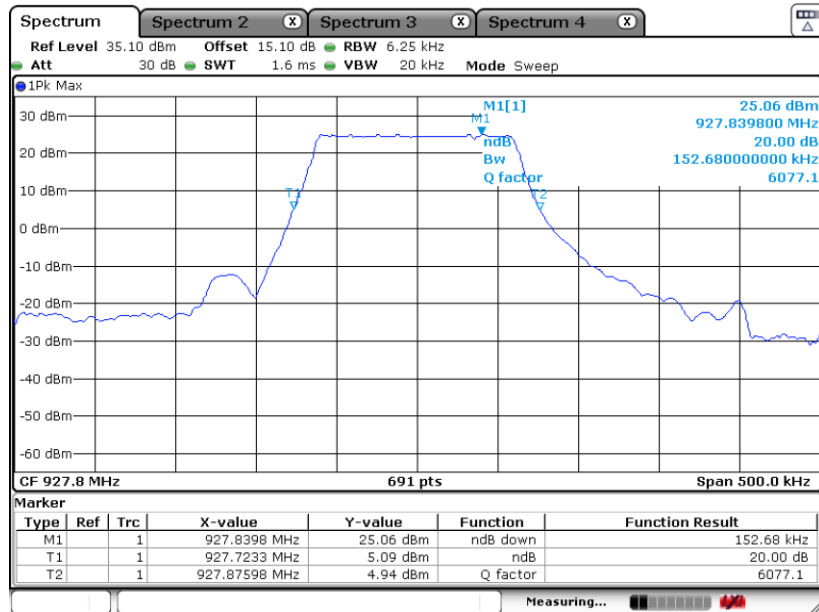
Date: 4.JAN.2022 14:54:02

SF9:

20 dB Bandwidth Plot on Channel 1
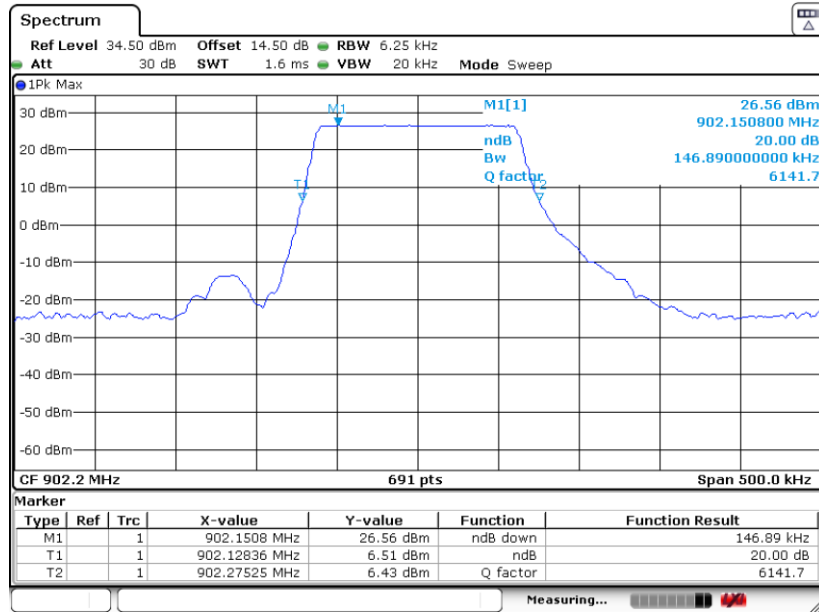
Date: 3.NOV.2020 20:53:41

20 dB Bandwidth Plot on Channel 65

Date: 3.NOV.2020 21:31:23

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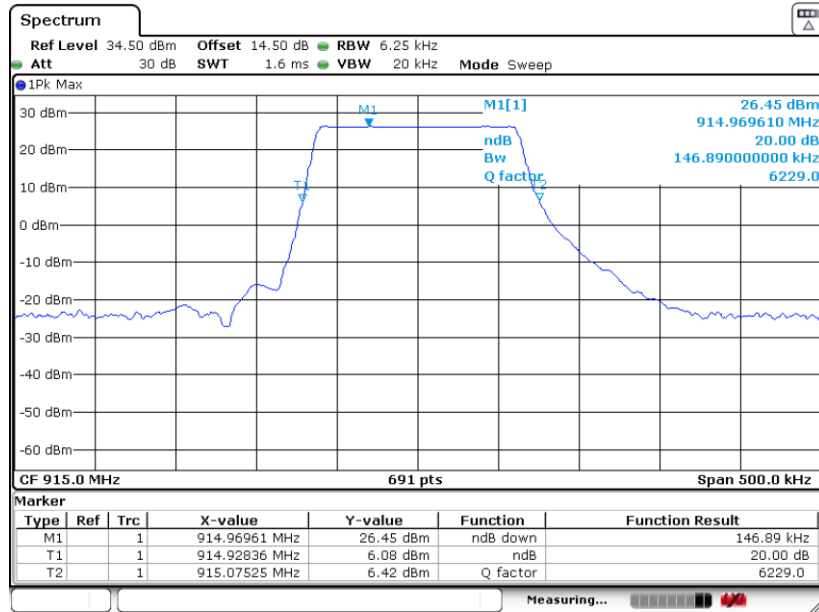
20 dB Bandwidth Plot on Channel 129
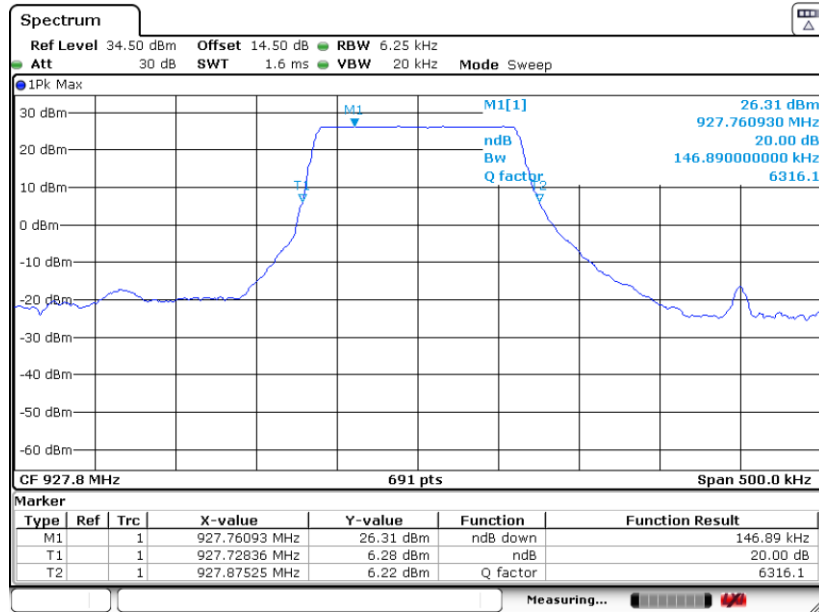
Date: 3.NOV.2020 21:35:27

SF10:

20 dB Bandwidth Plot on Channel 1
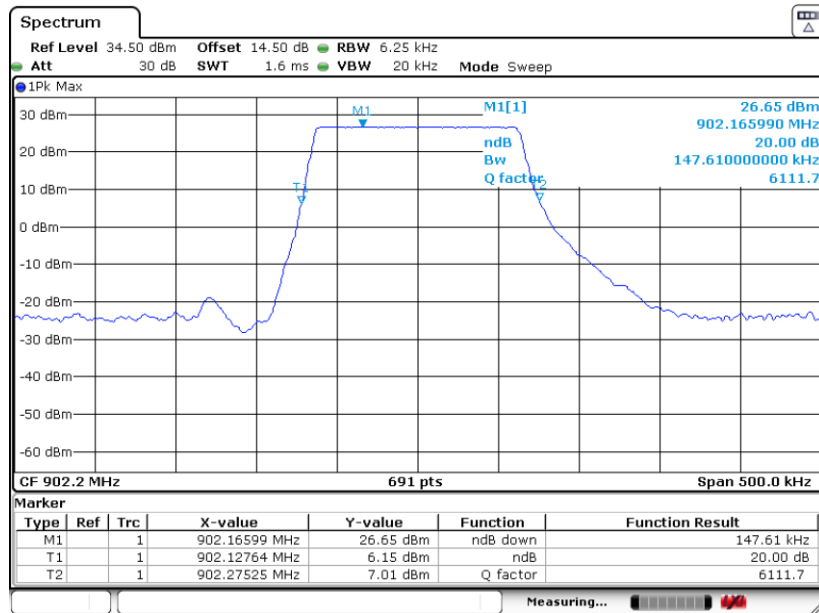
Date: 3.NOV.2020 23:09:19

20 dB Bandwidth Plot on Channel 65
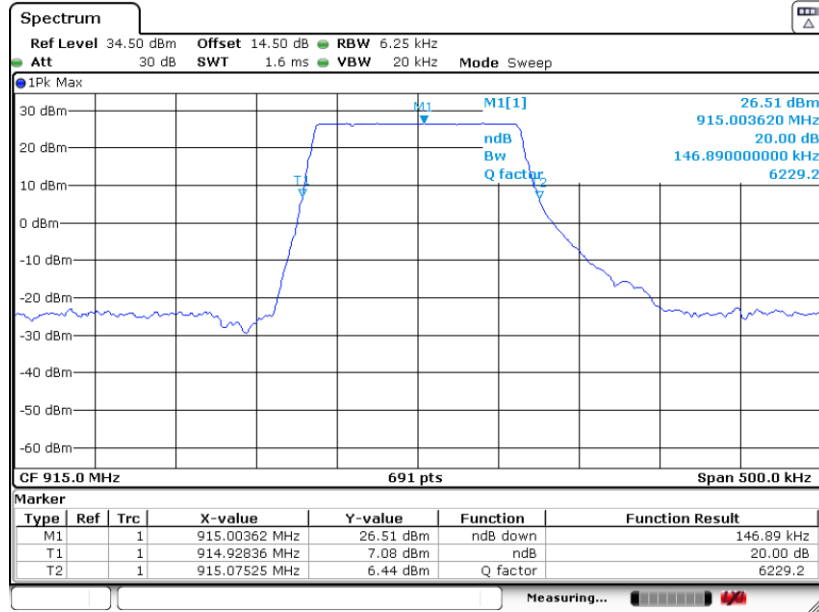
Date: 3.NOV.2020 23:23:30

20 dB Bandwidth Plot on Channel 129
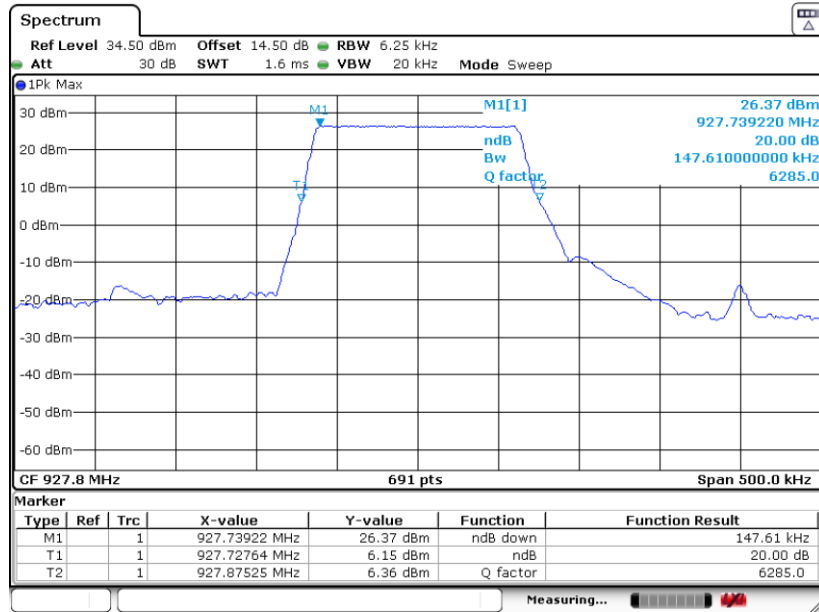
Date: 3.NOV.2020 23:25:57

3.4.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

SF7:

99% Occupied Bandwidth Plot on Channel 1
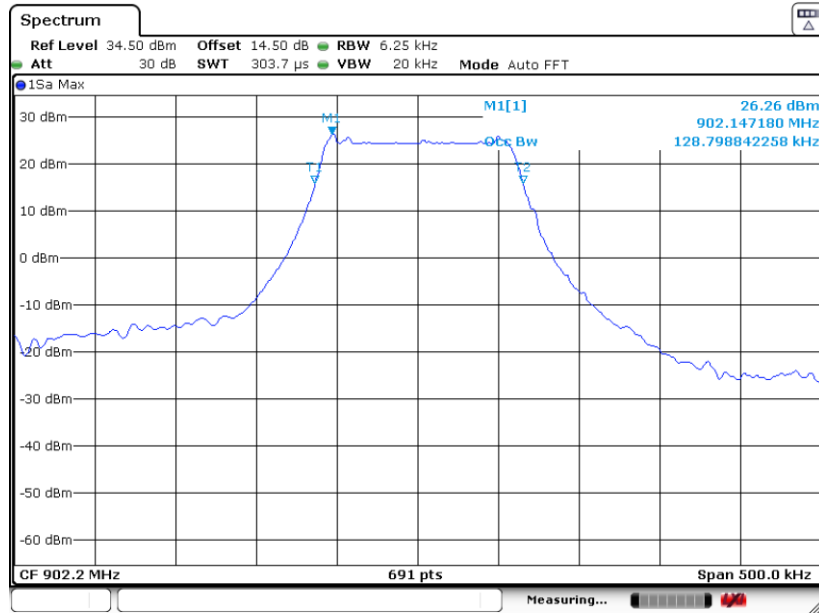
Date: 3.NOV.2020 19:24:15

99% Occupied Bandwidth Plot on Channel 65
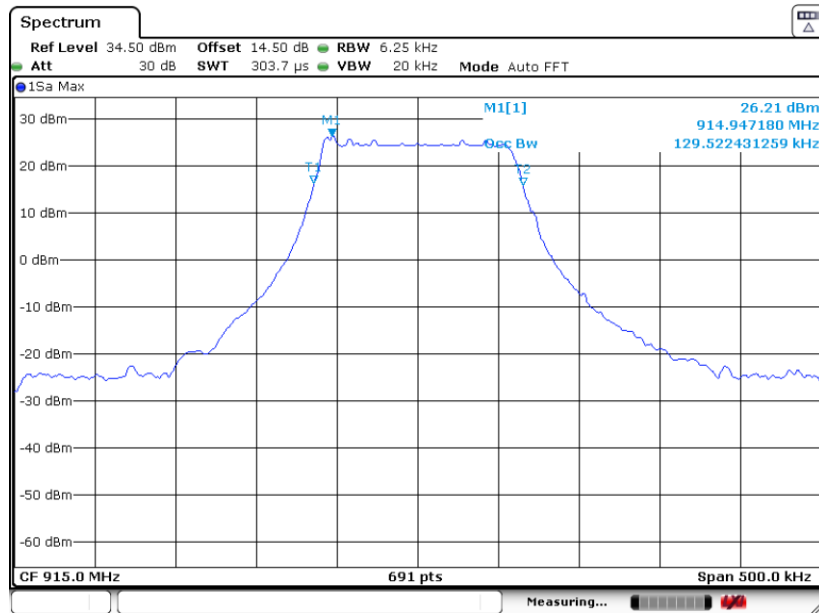
Date: 3.NOV.2020 20:04:06

99% Occupied Bandwidth Plot on Channel 129

Date: 3.NOV.2020 20:35:49
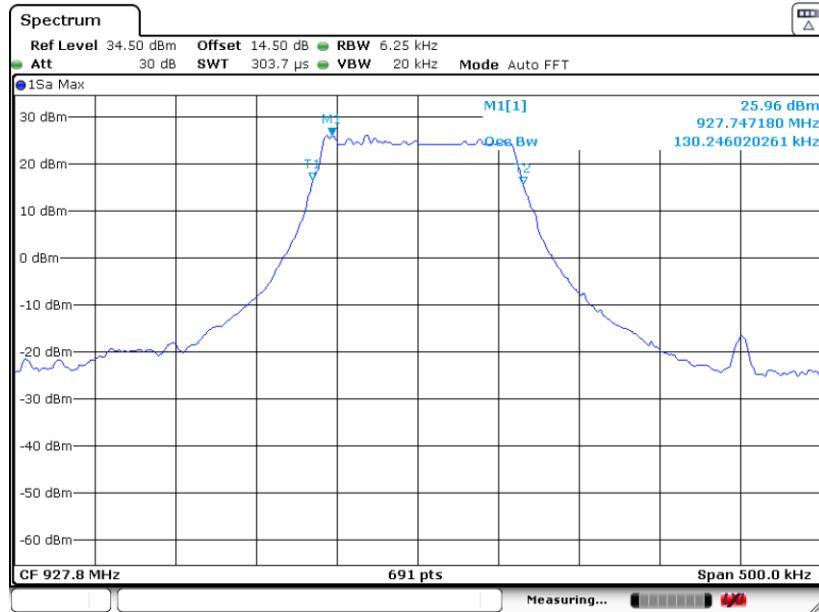
SF8:

99% Occupied Bandwidth Plot on Channel 1

Date: 4.JAN.2022 14:47:18
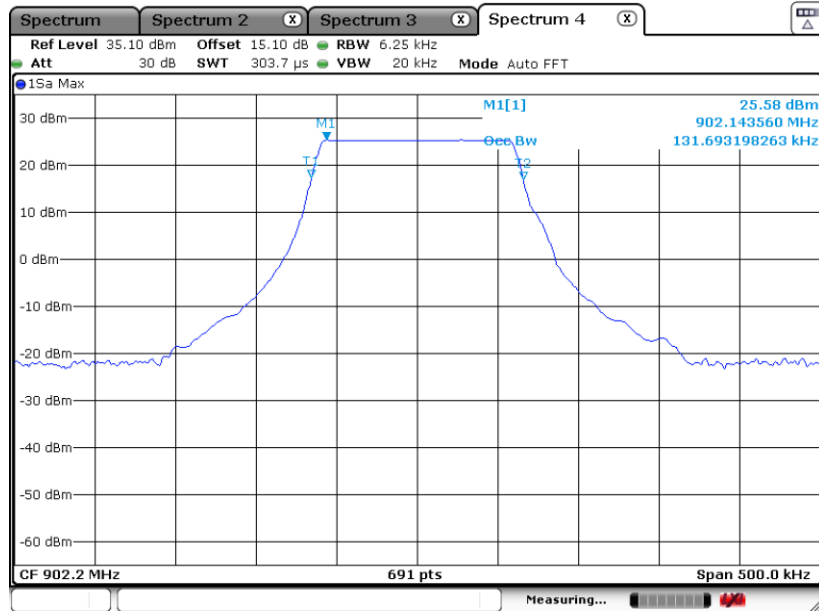
99% Occupied Bandwidth Plot on Channel 65
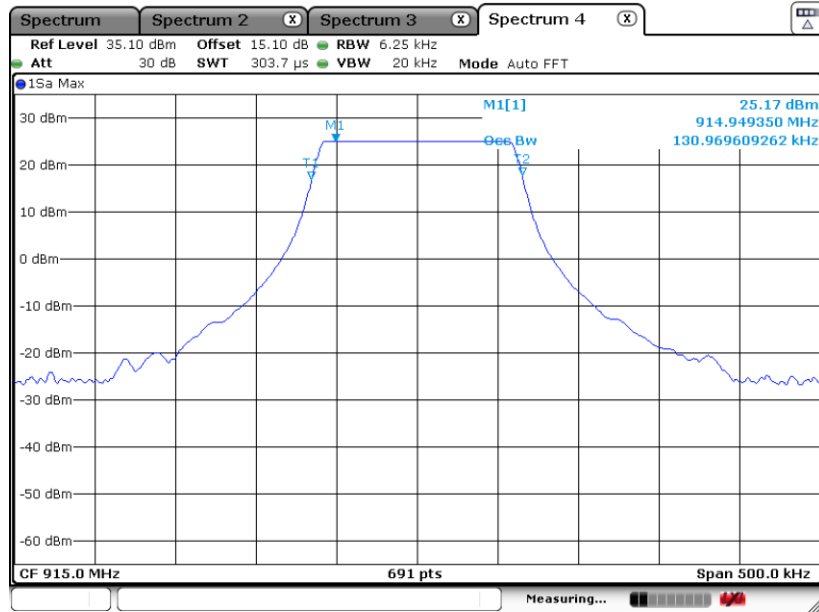
Date: 4.JAN.2022 14:48:41

99% Occupied Bandwidth Plot on Channel 129

Date: 4.JAN.2022 14:53:24

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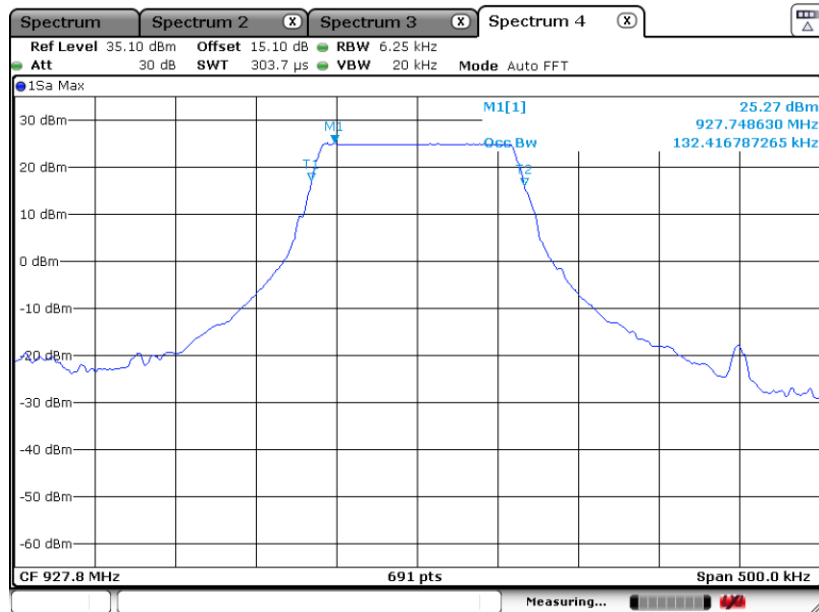
SF9:

99% Occupied Bandwidth Plot on Channel 1

Date: 3.NOV.2020 20:54:44

99% Occupied Bandwidth Plot on Channel 65
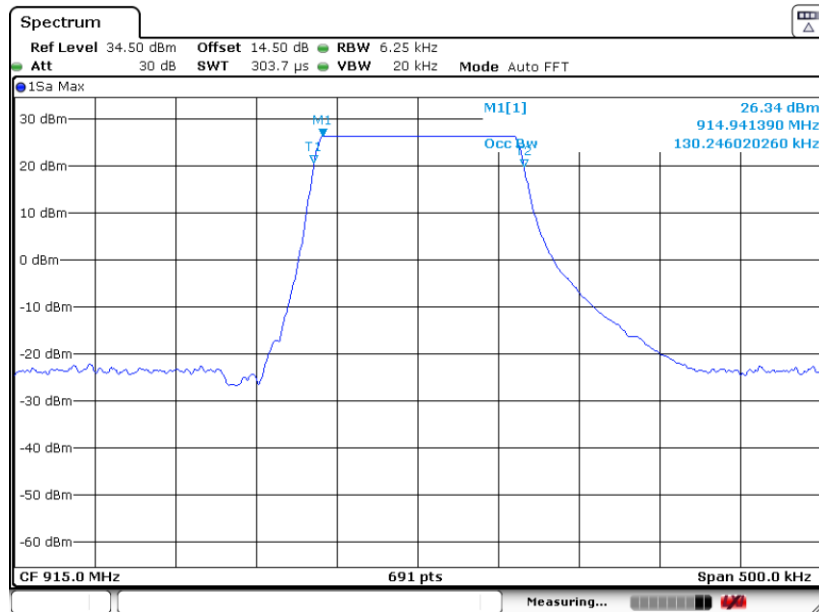
Date: 3.NOV.2020 21:31:57

99% Occupied Bandwidth Plot on Channel 129
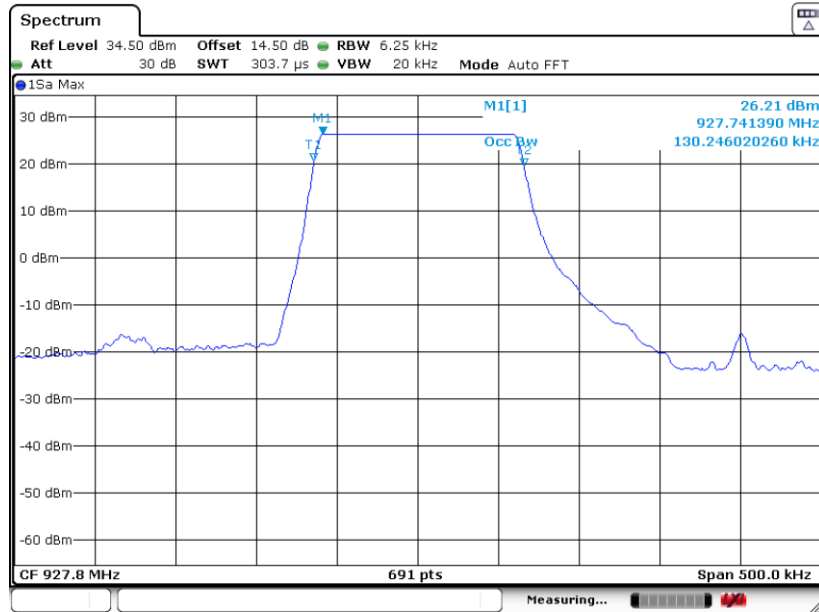
Date: 3.NOV.2020 21:35:43

SF10:

99% Occupied Bandwidth Plot on Channel 1
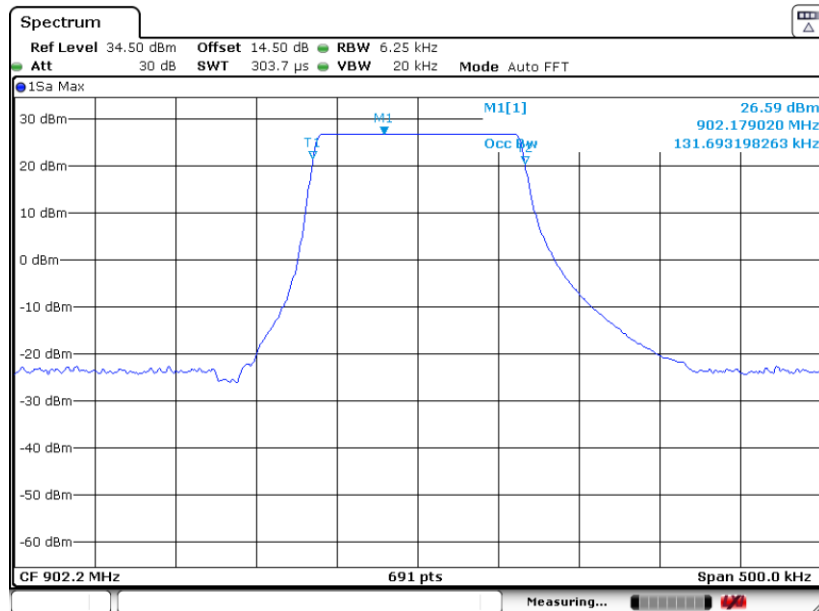
Date: 3.NOV.2020 23:10:32

99% Occupied Bandwidth Plot on Channel 65

Date: 3.NOV.2020 23:23:52

99% Occupied Bandwidth Plot on Channel 129

Date: 3.NOV.2020 23:26:44
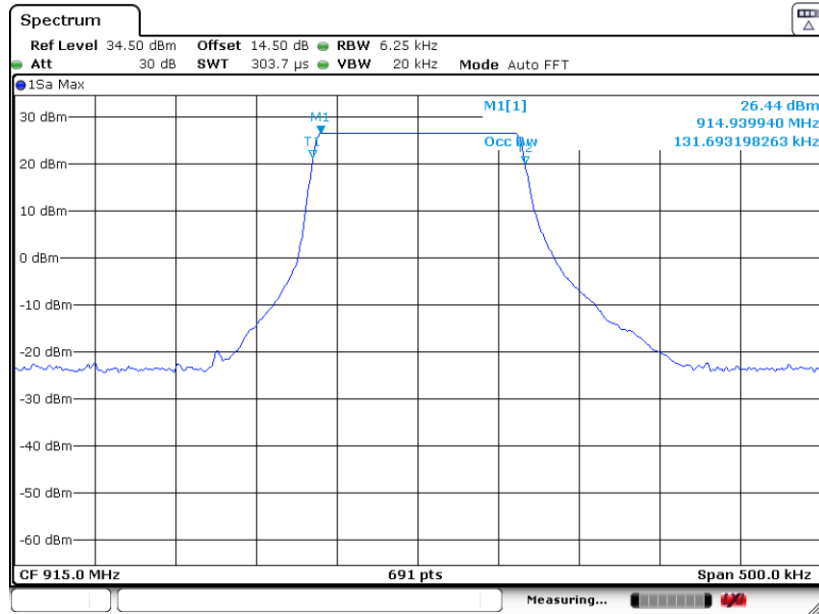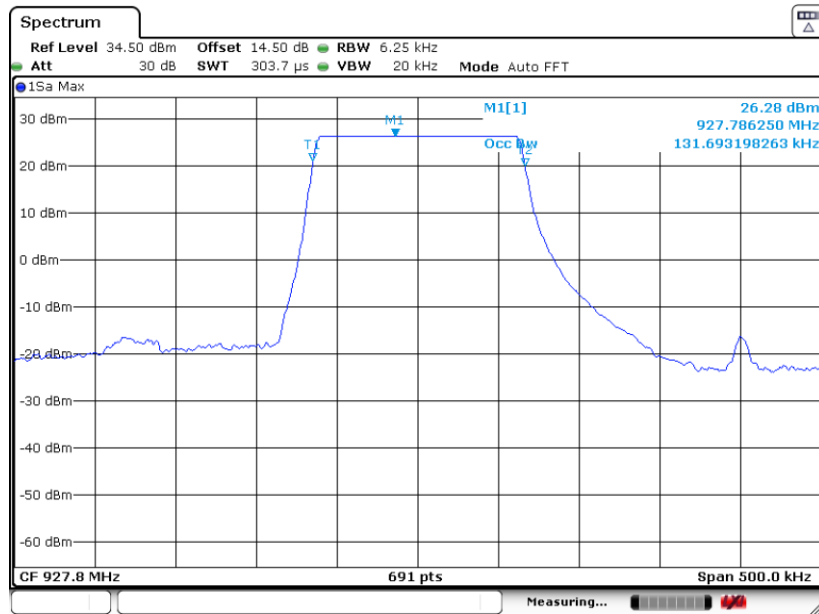
Note : The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

3.5 Output Power Measurement

3.5.1 Limit of Output Power

The maximum peak conducted output power of the intentional radiator shall not exceed the following: For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

3.5.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.5.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.5.
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 with cable loss and record the results in the test report.
5. Measure and record the results in the test report.

3.5.4 Test Setup
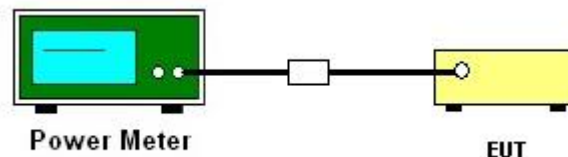
3.5.5 Test Result of Peak Output Power

Please refer to Appendix A.

3.6 Conducted Band Edges Measurement

3.6.1 Limit of Band Edges

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

3.6.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.6.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.6.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Set RBW = 100kHz, VBW = 300kHz. Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used.
4. Enable hopping function of the EUT and then repeat step 2. and 3.
5. Measure and record the results in the test report.

3.6.4 Test Setup

Spectrum Analyzer   EUT
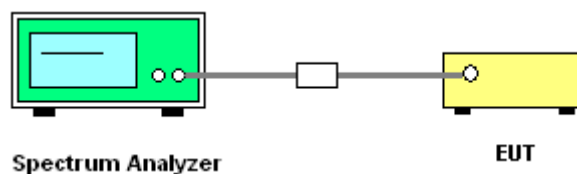
3.6.5 Test Result of Conducted Band Edges

SF7:

Low Band Edge Plot on Channel 1
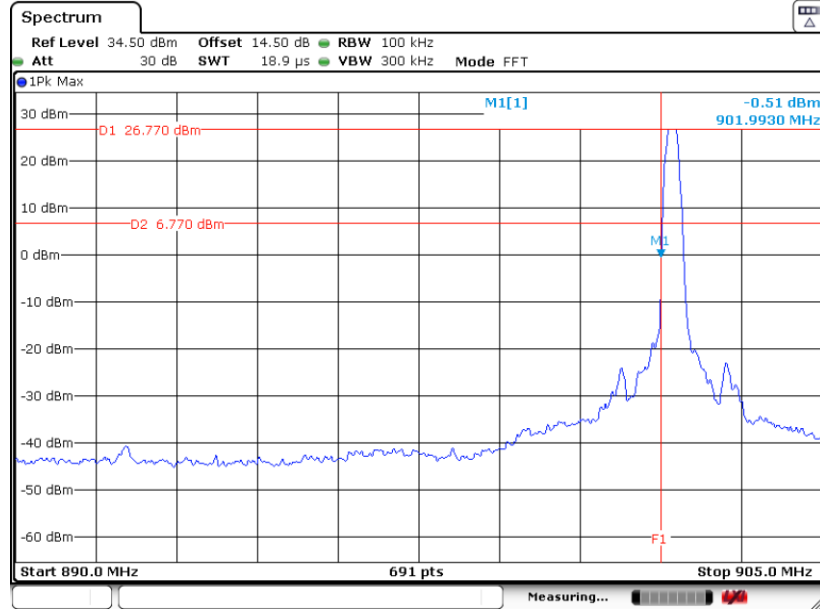
Date: 3.NOV.2020 19:11:58

High Band Edge Plot on Channel 129
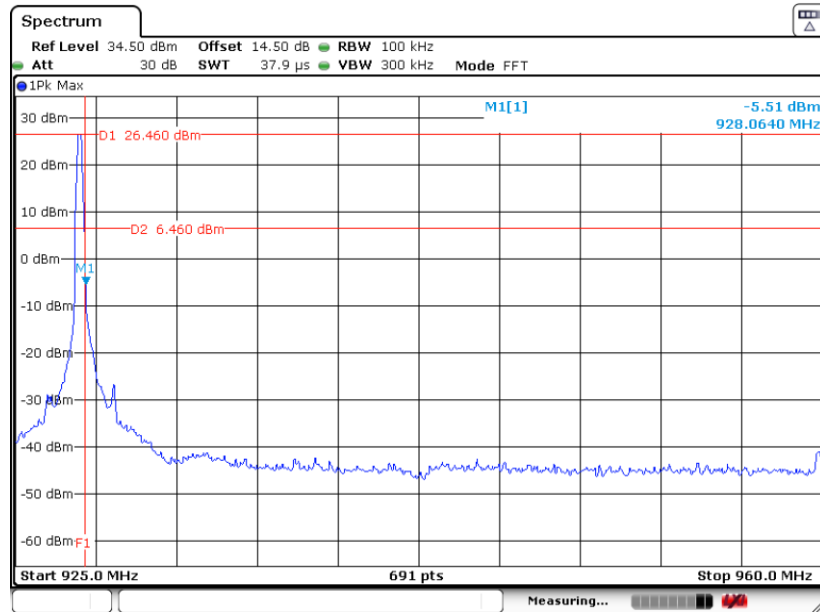
Date: 3.NOV.2020 20:35:13

SF8:

Low Band Edge Plot on Channel 1

Date: 4.JAN.2022   14:40:13

High Band Edge Plot on Channel 129

Date: 4.JAN.2022   15:55:44
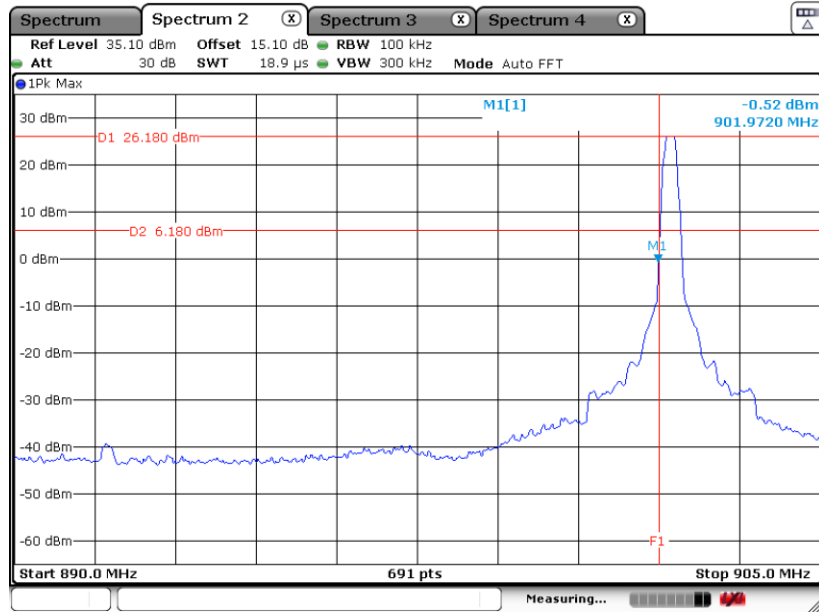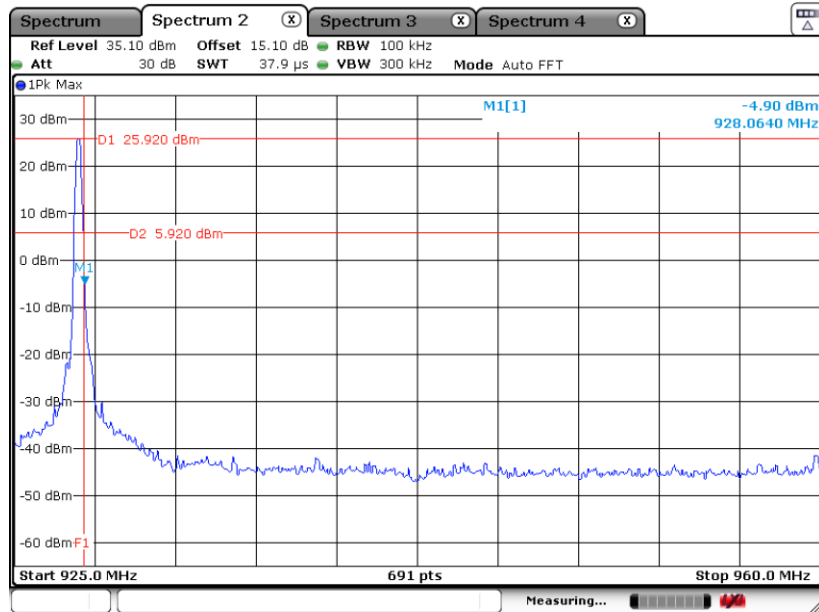
SF9:

Low Band Edge Plot on Channel 1
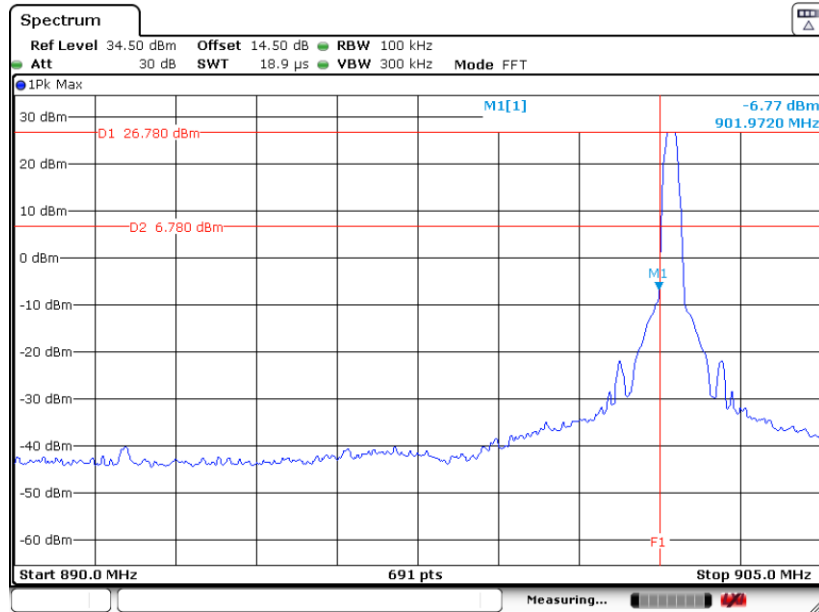
Date: 3.NOV.2020 20:54:15

High Band Edge Plot on Channel 129
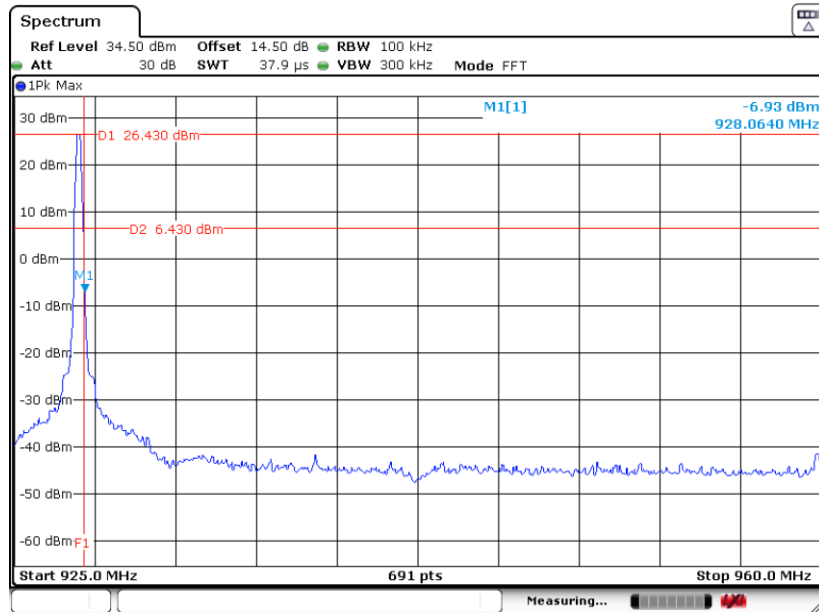
Date: 3.NOV.2020 21:40:04

SF10:

Low Band Edge Plot on Channel 1
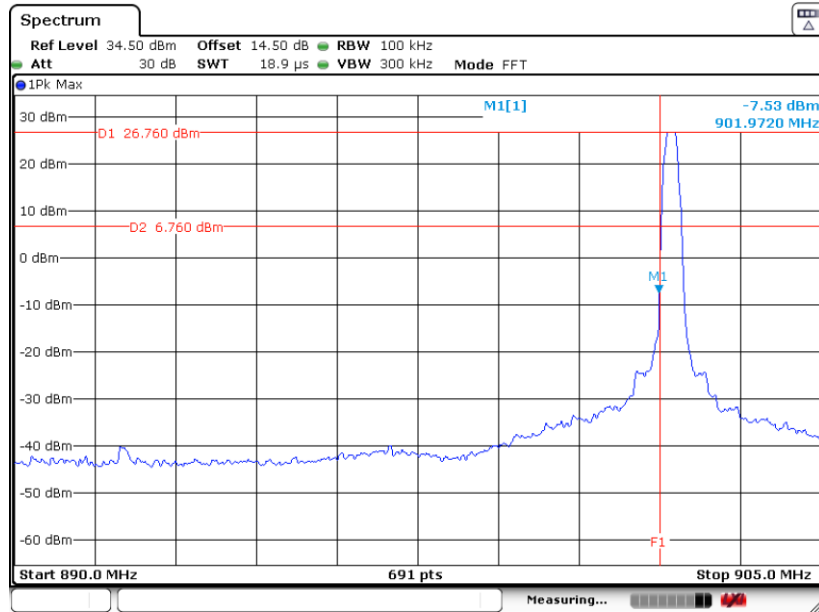
Date: 3.NOV.2020 23:09:53

High Band Edge Plot on Channel 129
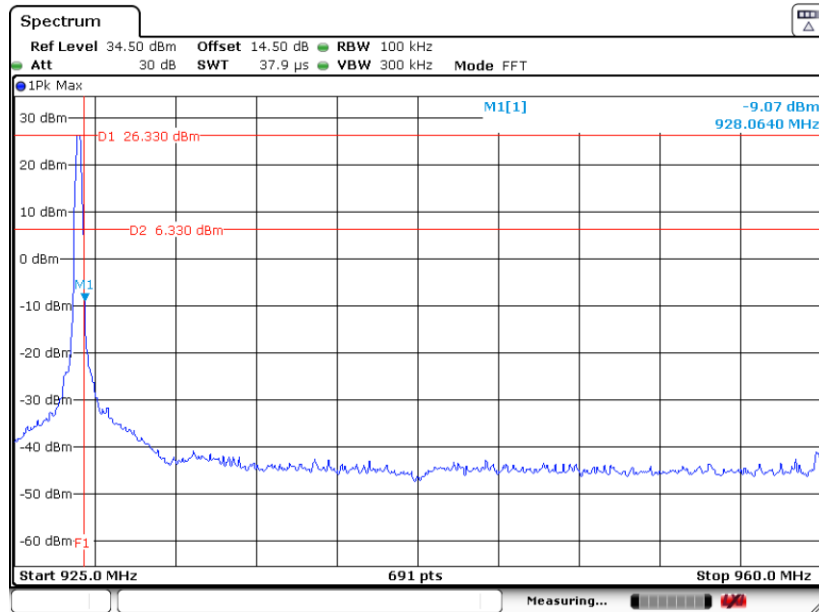
Date: 3.NOV.2020 23:29:11

3.6.6 Test Result of Conducted Hopping Mode Band Edges

SF7:

Hopping Mode Low Band Edge Plot
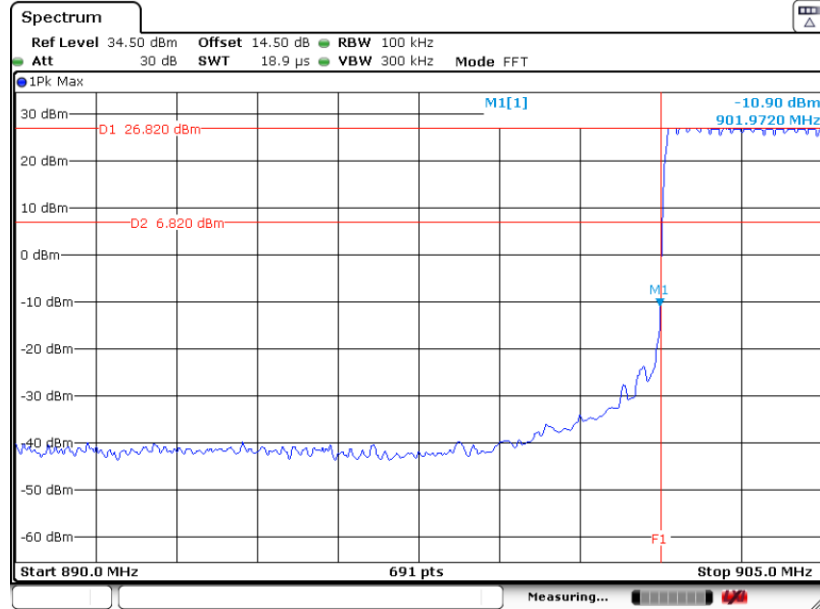
Date: 3.NOV.2020 19:30:54

Hopping Mode High Band Edge Plot
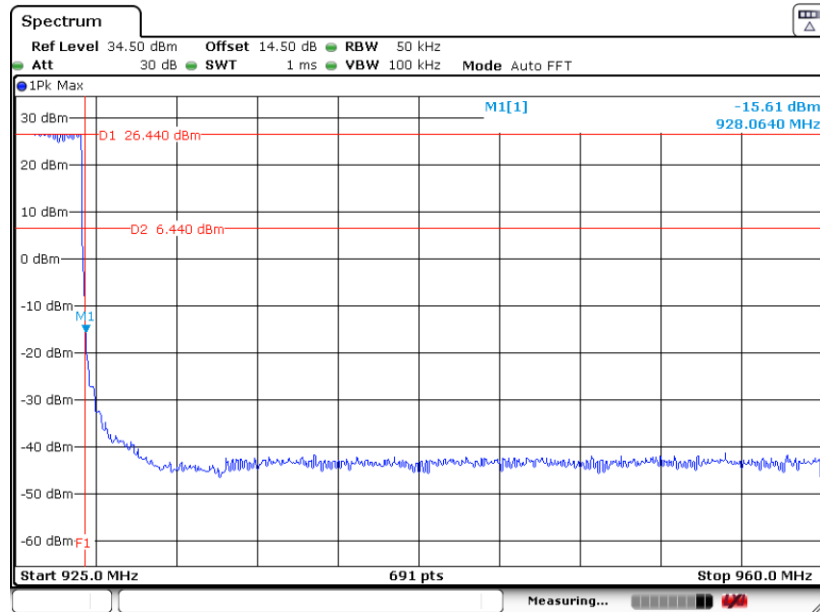
Date: 3.NOV.2020 20:40:59

SF8:

Hopping Mode Low Band Edge Plot
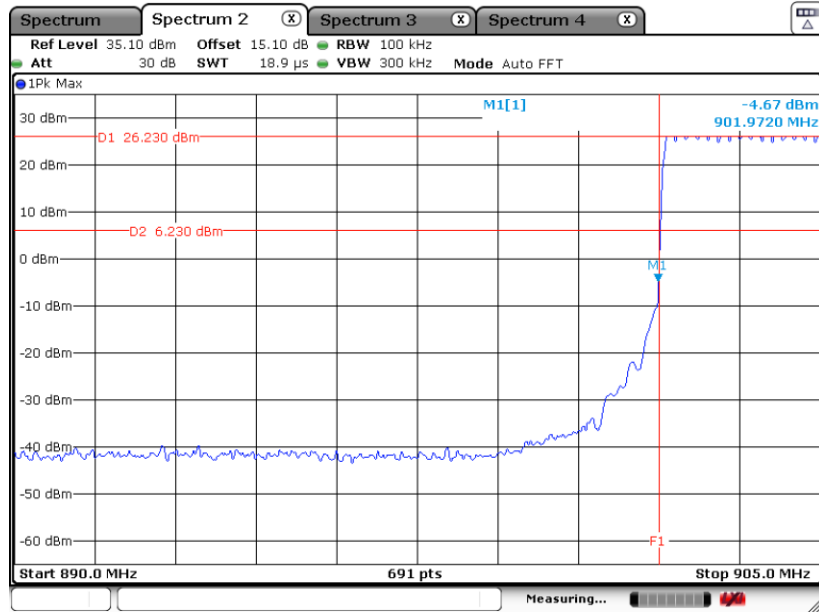
Date: 4.JAN.2022 15:50:00

Hopping Mode High Band Edge Plot
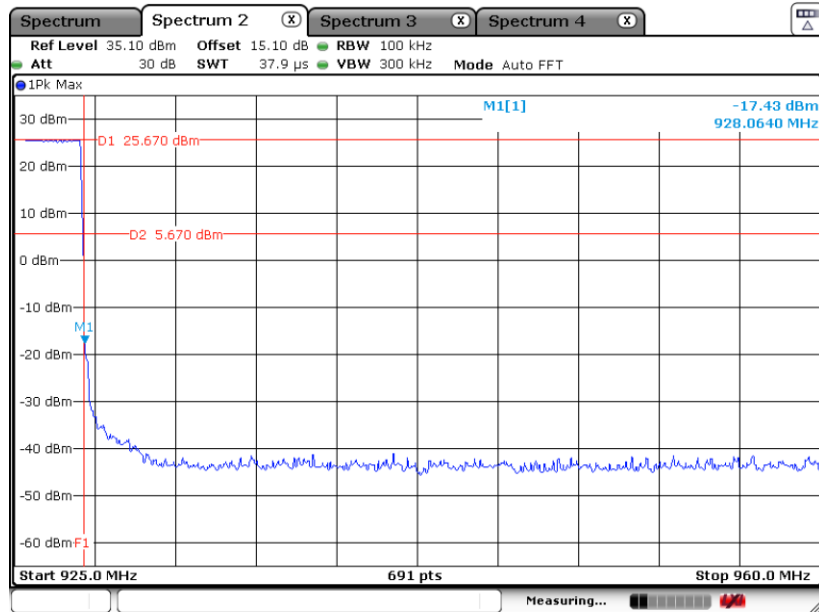
Date: 4.JAN.2022 15:51:49

SF9:

Hopping Mode Low Band Edge Plot
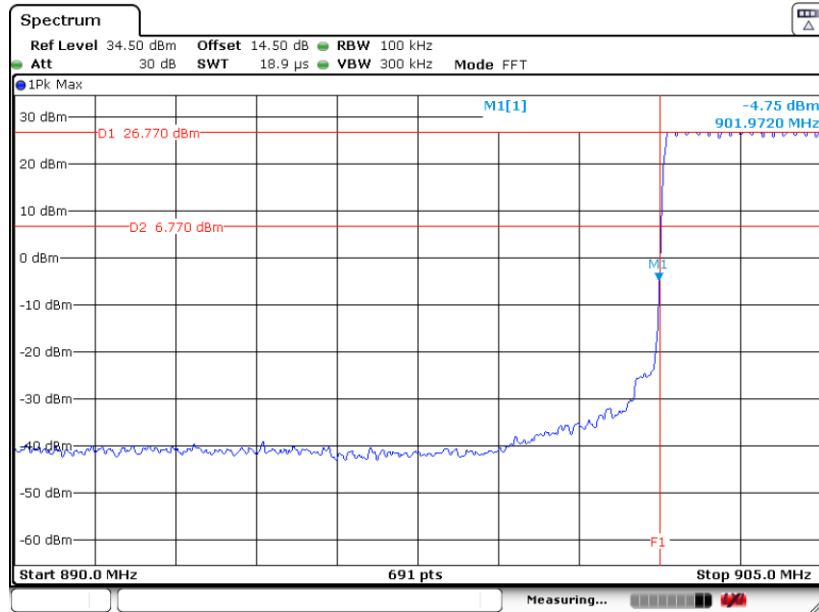
Date: 3.NOV.2020 21:57:54

Hopping Mode High Band Edge Plot
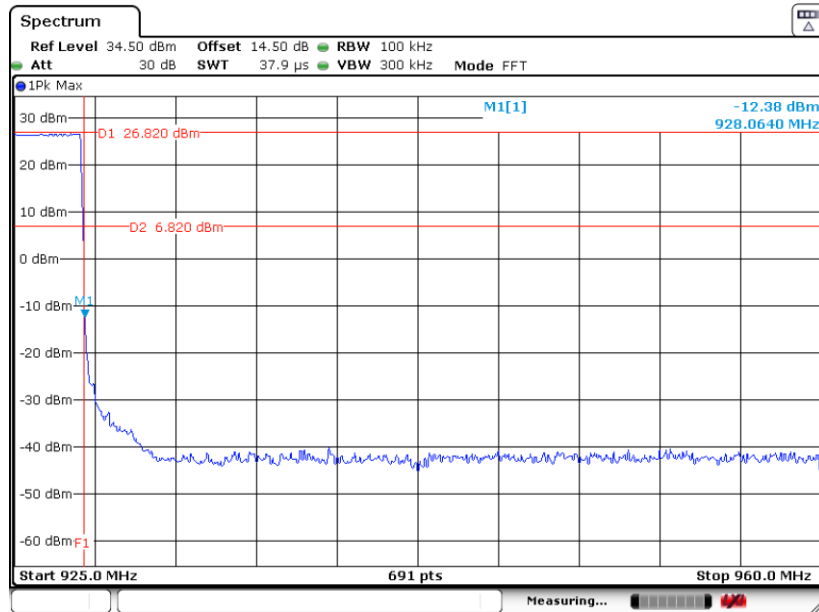
Date: 3.NOV.2020 21:23:46

SF10:

Hopping Mode Low Band Edge Plot
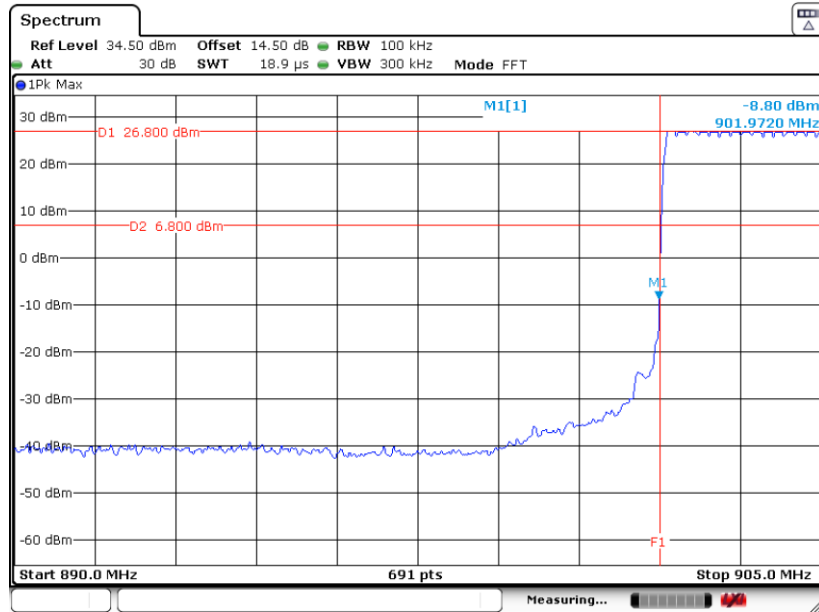
Date: 3.NOV.2020 22:14:14

Hopping Mode High Band Edge Plot

Date: 3.NOV.2020 23:20:34

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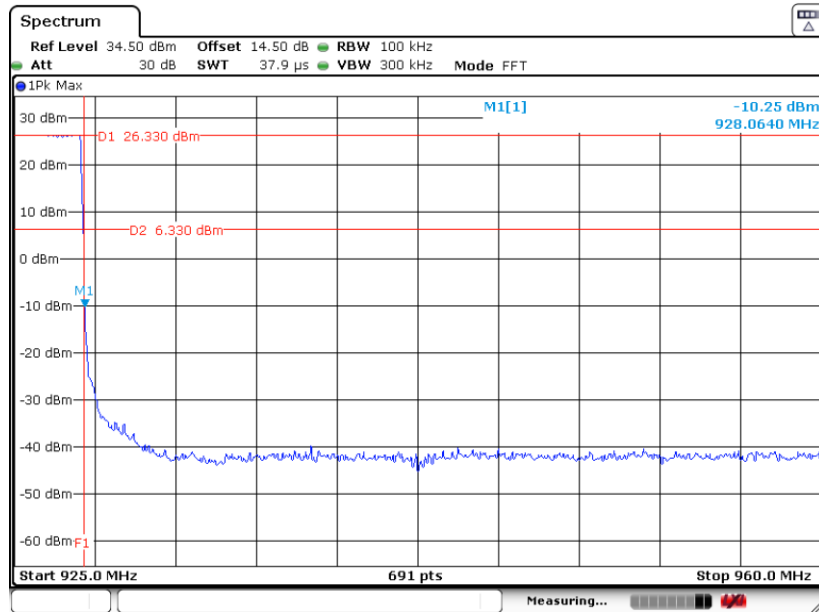
3.7 Conducted Spurious Emission Measurement

3.7.1 Limit of Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

3.7.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.7.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.8.
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. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.
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.

3.7.4 Test Setup

Spectrum Analyzer   EUT
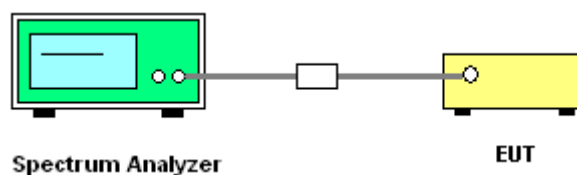
3.7.5 Test Result of Conducted Spurious Emission

SF7:

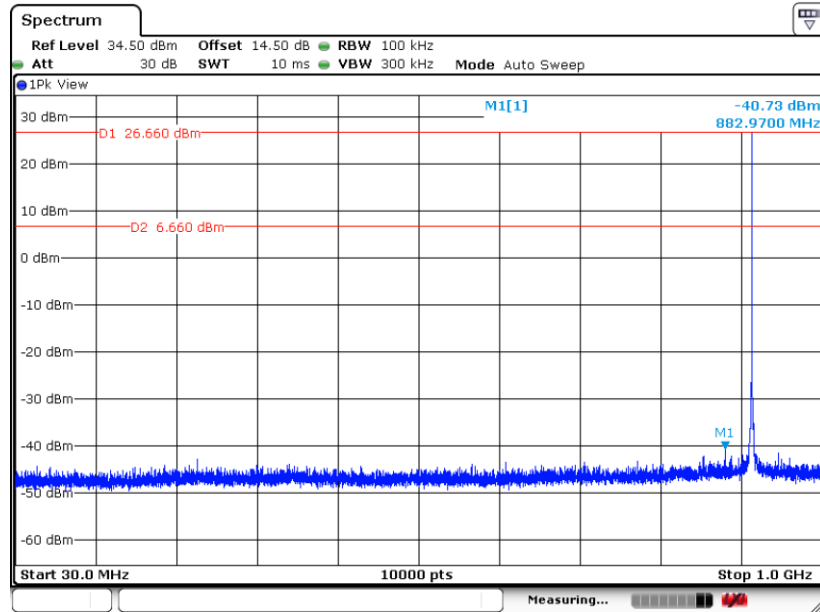### CSE Plot on Ch 1 between 30MHz ~ 1 GHz
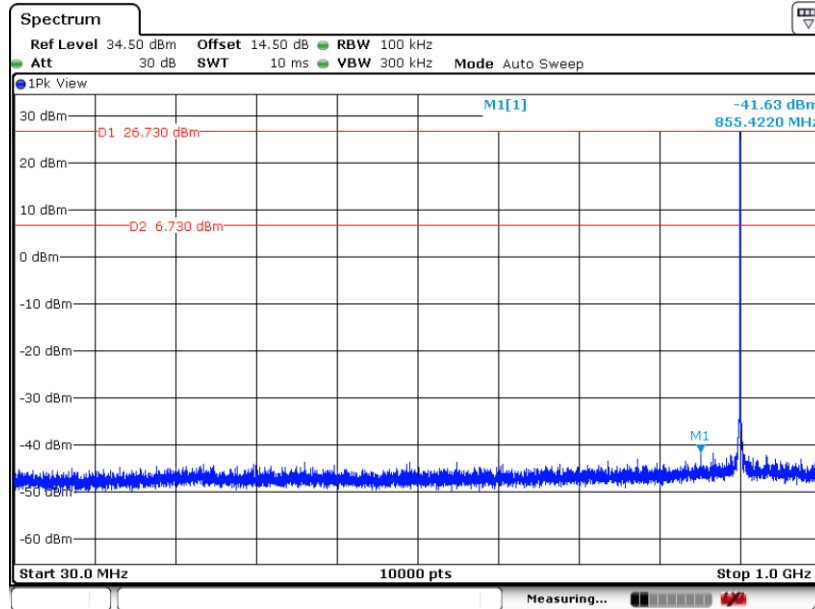
Date: 4.NOV.2020 14:46:59

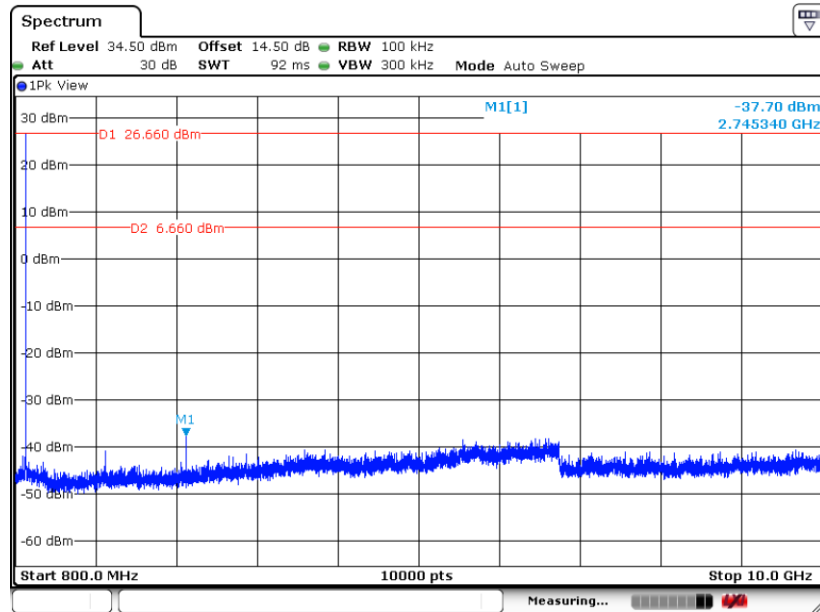### CSE Plot on Ch 1 between 800 MHz ~ 10 GHz
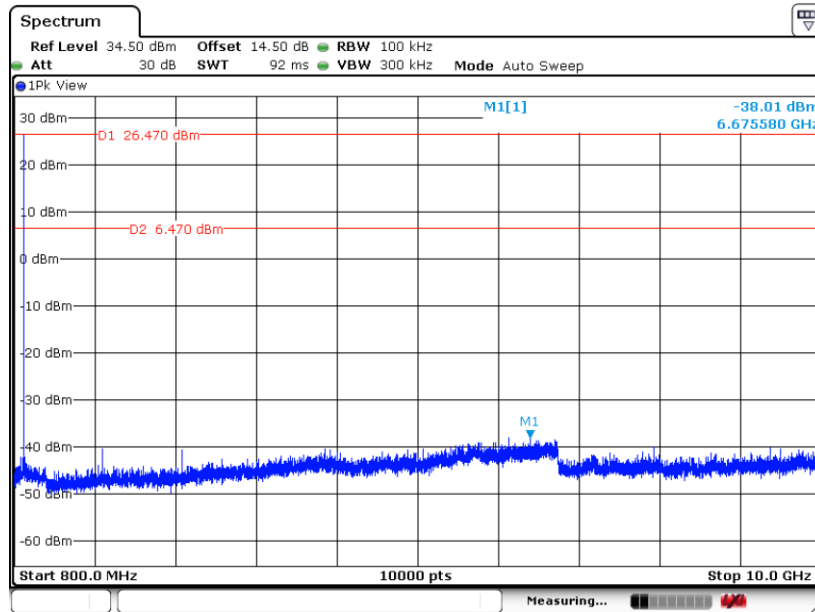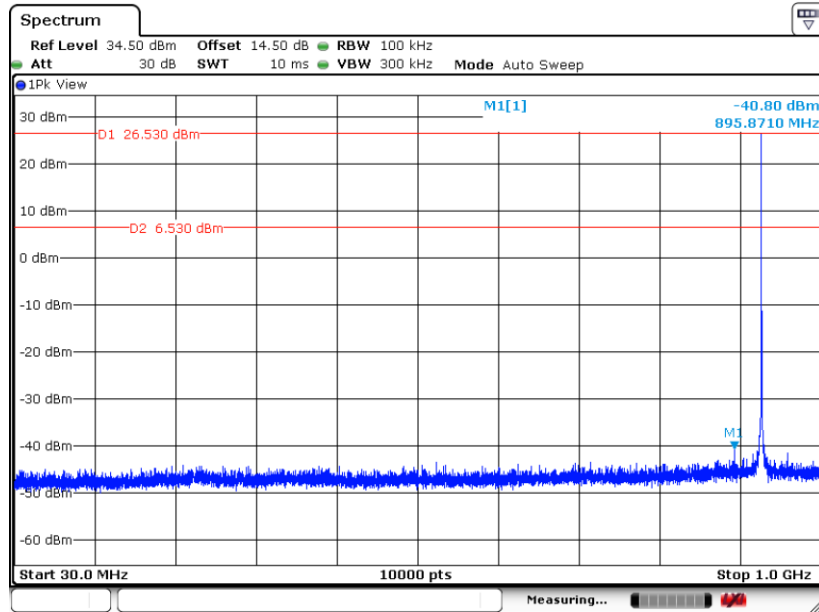

Date: 4.NOV.2020 14:48:09

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CSE Plot on Ch 65 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 14:50:52

CSE Plot on Ch 65 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 14:50:09

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CSE Plot on Ch 129 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 14:51:54

CSE Plot on Ch 129 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 14:52:34

SF8:

CSE Plot on Ch 1 between 30MHz ~ 1 GHz
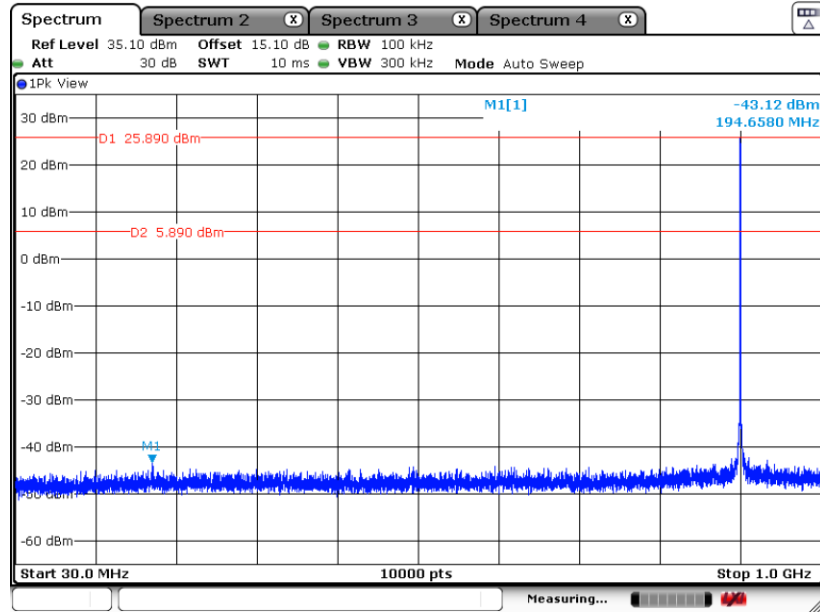
Date: 4.JAN.2022 15:13:30

CSE Plot on Ch 1 between 800 MHz ~ 10 GHz
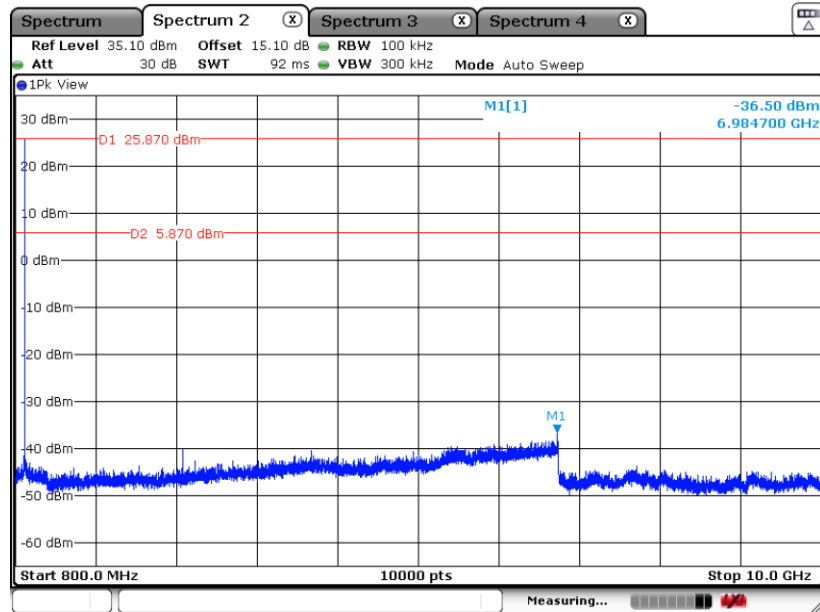
Date: 4.JAN.2022 15:14:52

CSE Plot on Ch 65 between 30MHz ~ 1 GHz

Date: 4.JAN.2022 15:10:38
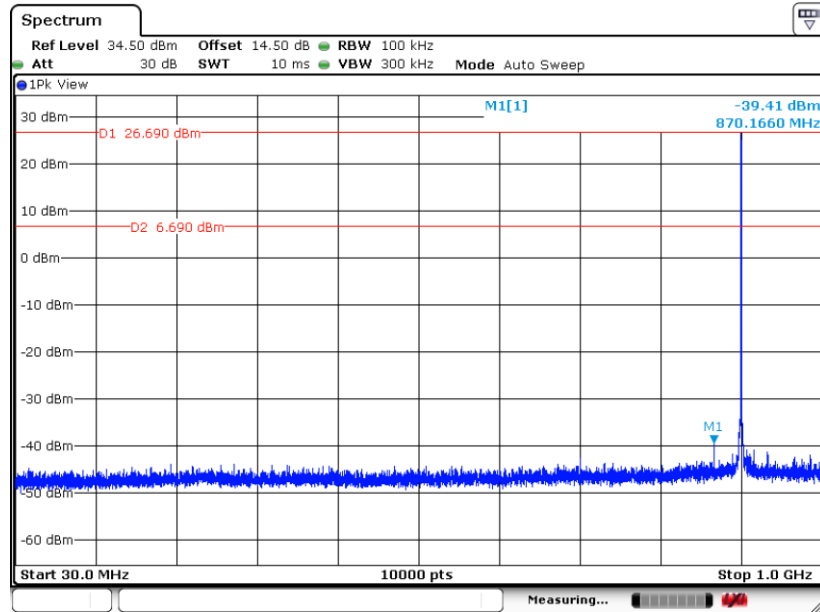
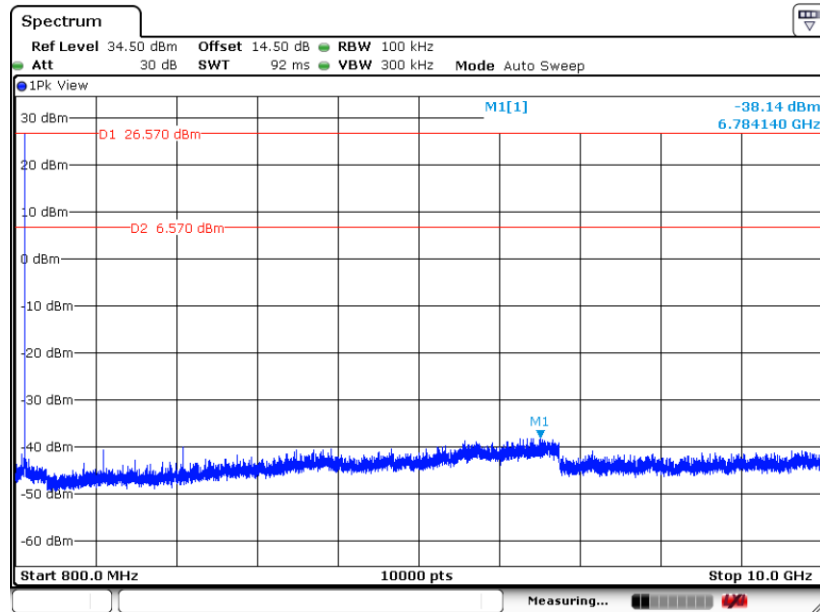## CSE Plot on Ch 65 between 800 MHz ~ 10 GHz

Date: 4.JAN.2022 15:11:23

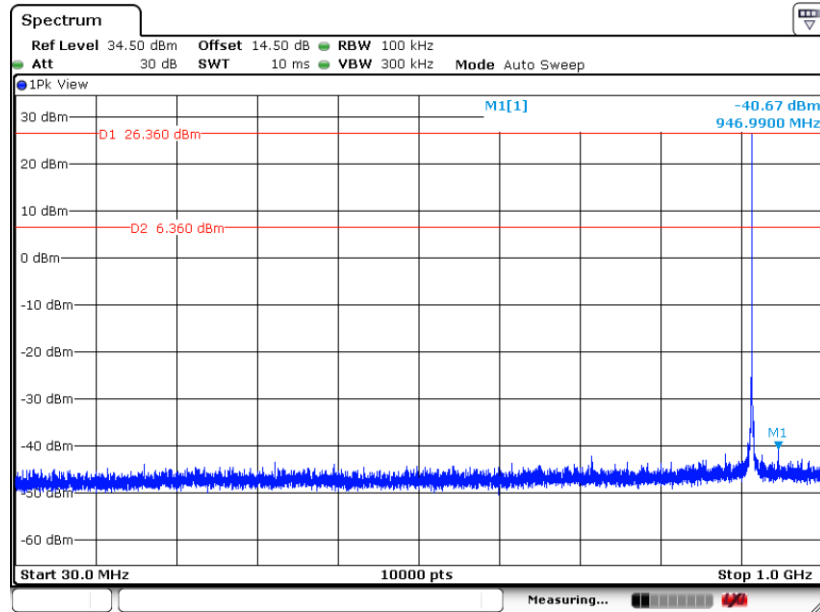### CSE Plot on Ch 129 between 30MHz ~ 1 GHz
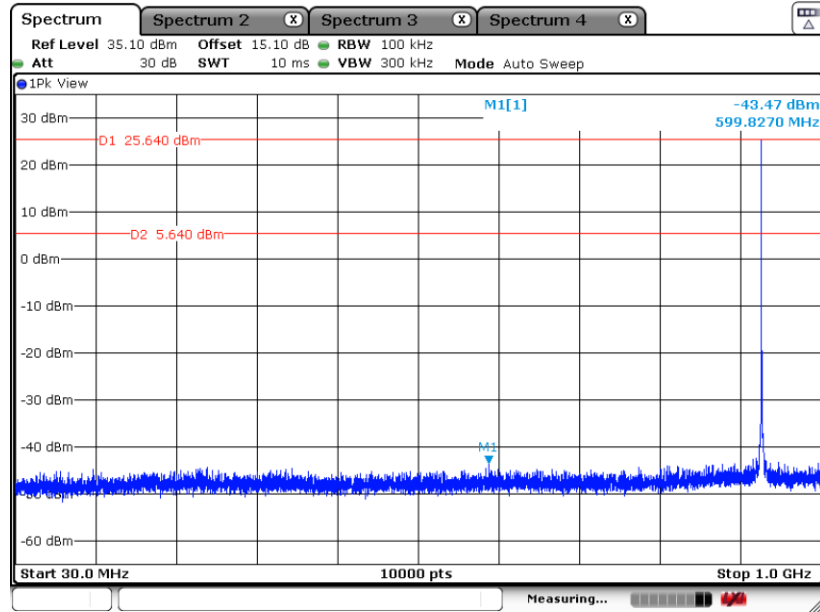
Date: 4.JAN.2022 15:08:14

CSE Plot on Ch 129 between 800 MHz ~ 10 GHz
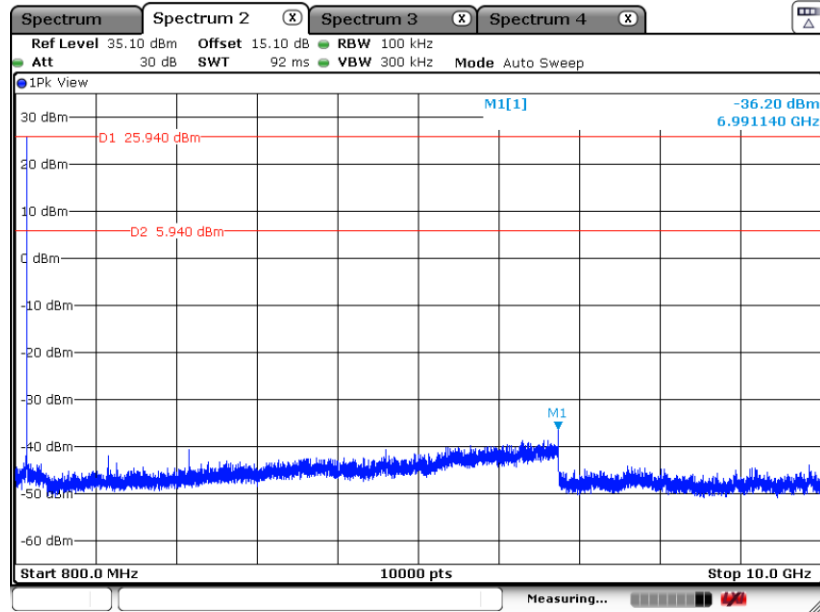
Date: 4.JAN.2022 15:07:11

SF9:

CSE Plot on Ch 1 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 14:55:02

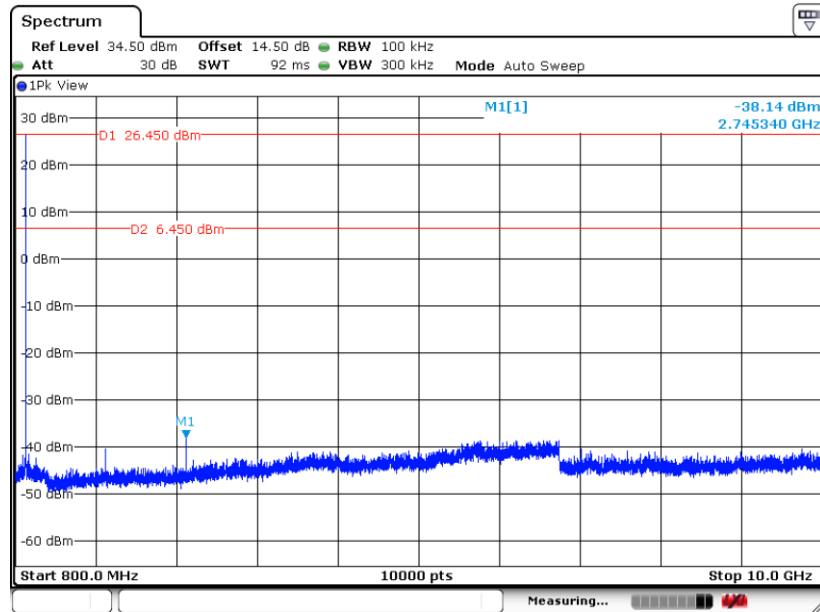### CSE Plot on Ch 1 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 14:54:25

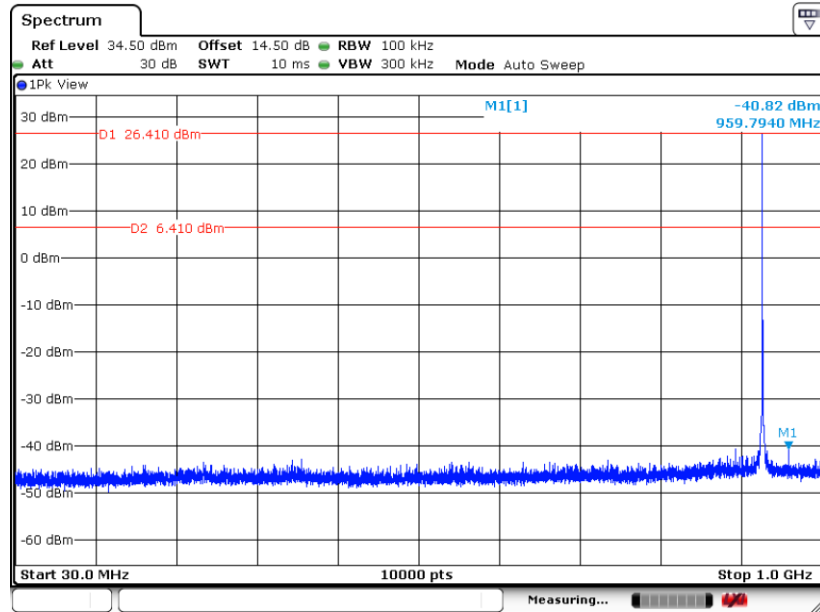### CSE Plot on Ch 65 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 14:58:08

CSE Plot on Ch 65 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 14:59:00

CSE Plot on Ch 129 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 15:01:12

CSE Plot on Ch 129 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 15:00:22

SF10:

CSE Plot on Ch 1 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 15:03:06

CSE Plot on Ch 1 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 15:03:47

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CSE Plot on Ch 65 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 15:05:21

CSE Plot on Ch 65 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 15:04:47

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Report Version   : Rev. 01
Report Template No.: BU5-FR15CLoRaFHSS Version 2.0

CSE Plot on Ch 129 between 30MHz ~ 1 GHz

Date: 4.NOV.2020 15:06:11

CSE Plot on Ch 129 between 800 MHz ~ 10 GHz

Date: 4.NOV.2020 15:06:47
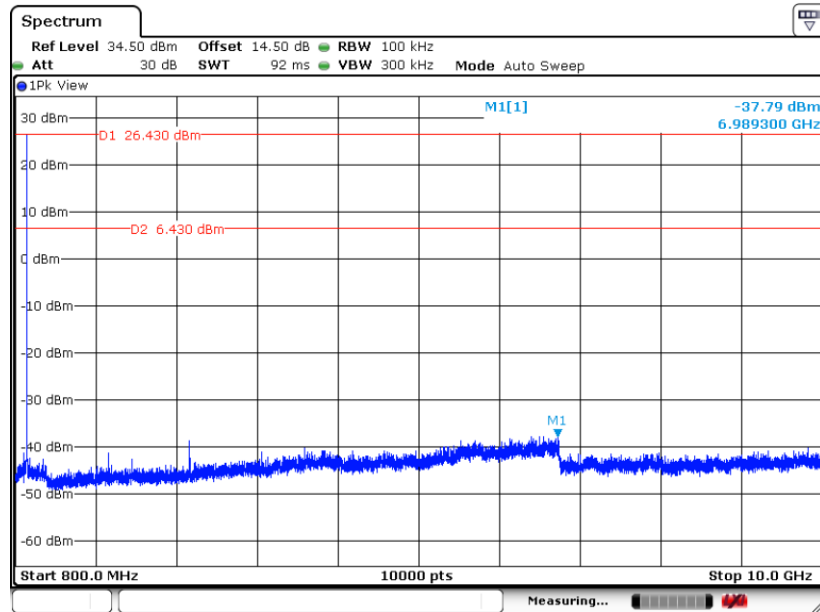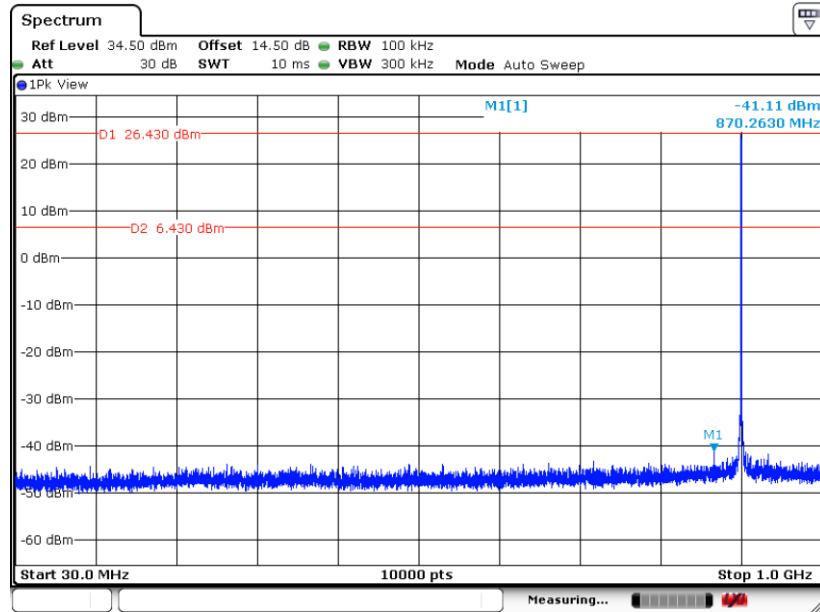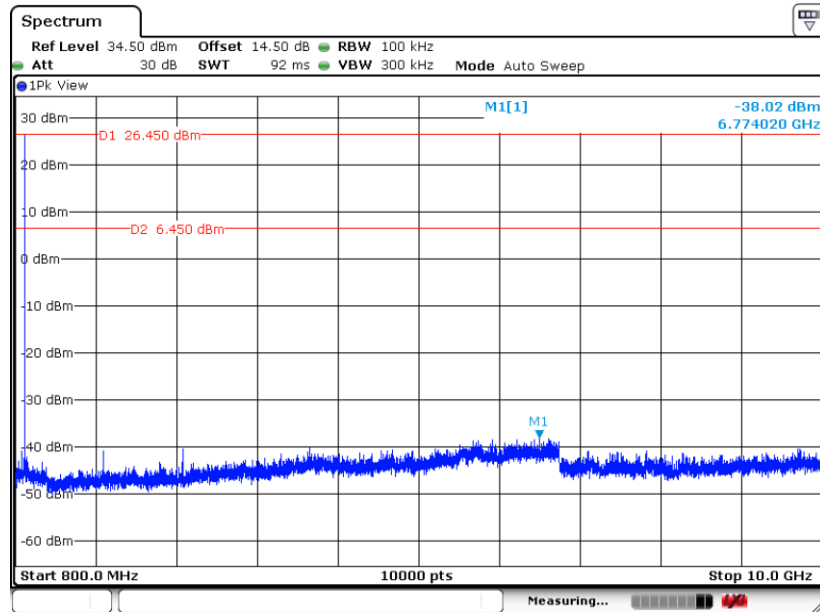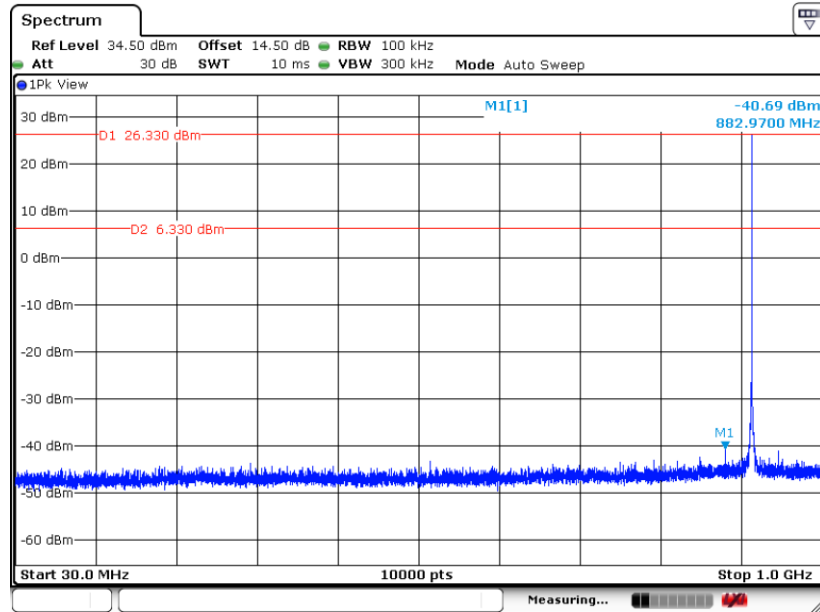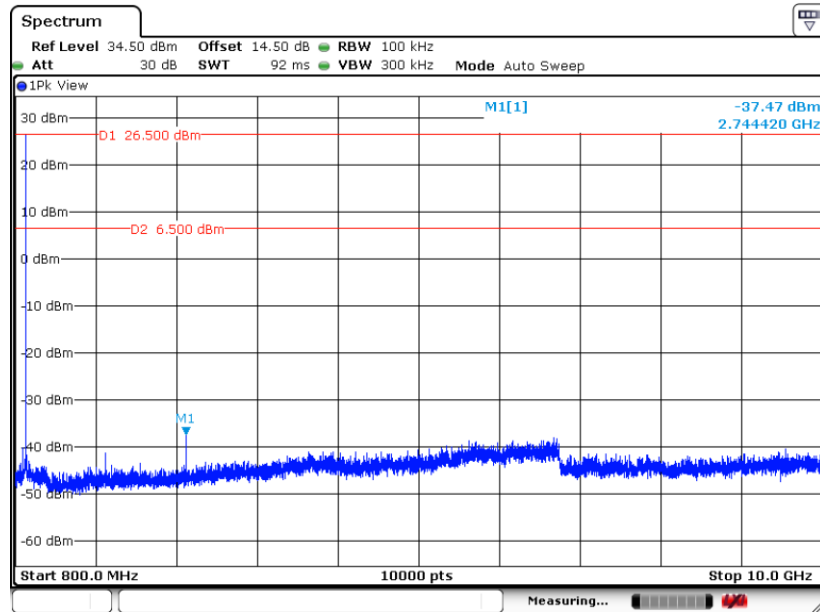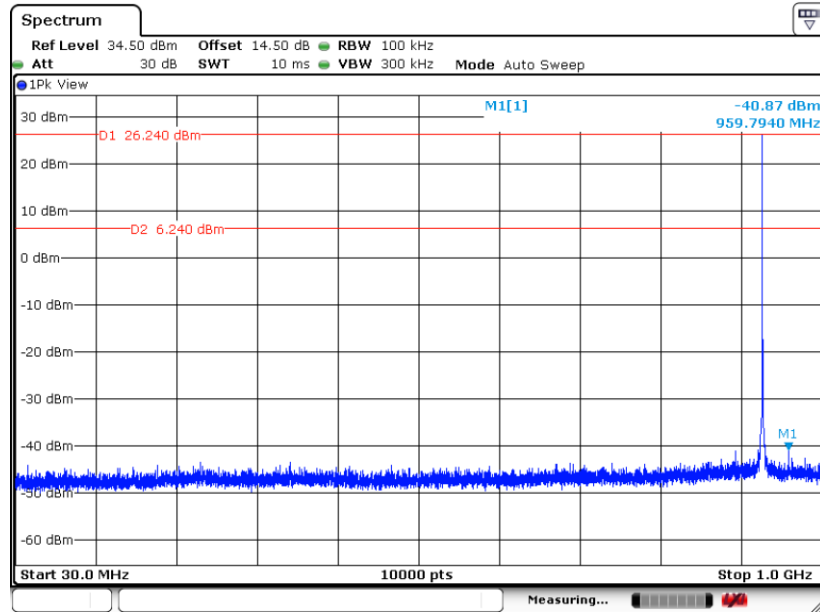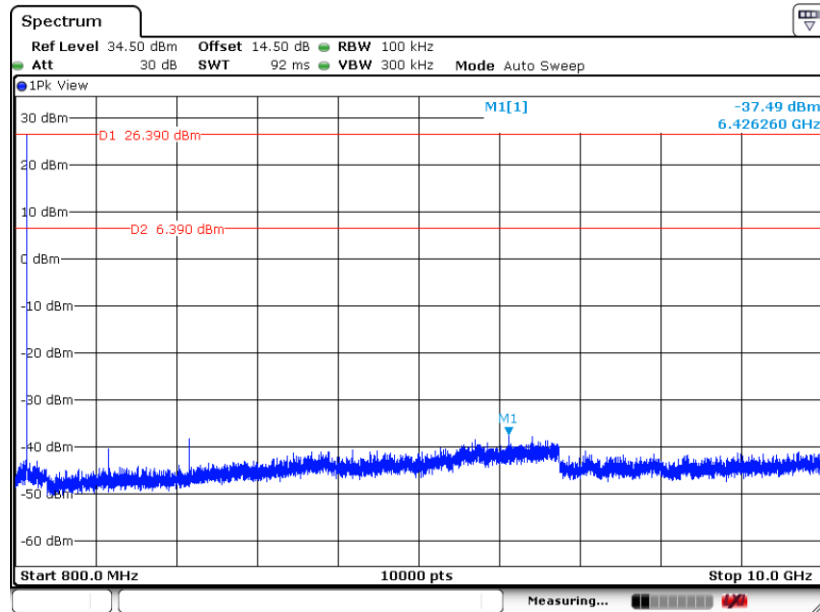
3.8 Radiated Band Edges and Spurious Emission Measurement

3.8.1 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. 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

3.8.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.8.3 Test Procedures

1. 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.

2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.

3. For each suspected emission, 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 to comply with the guidelines.

4. Set to the maximum power setting and enable the EUT transmit continuously.

5. 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, RBW=1MHz for f>1GHz ; VBW $\geq$ RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak

6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

7. 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.

8. 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.
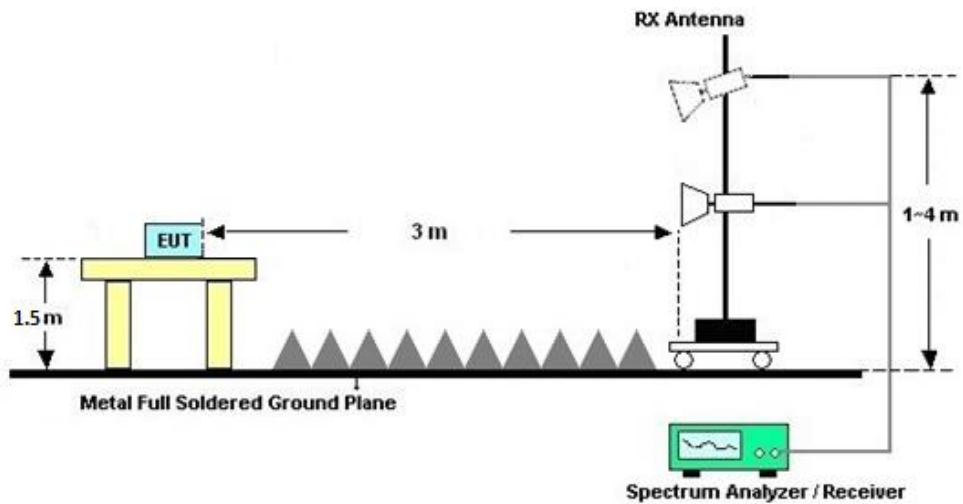
3.8.4 Test Setup

For radiated emissions below 30MHz
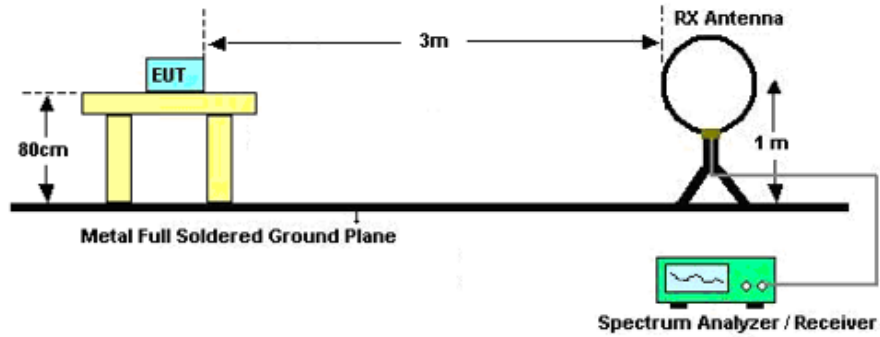
For radiated emissions from 30MHz to 1GHz
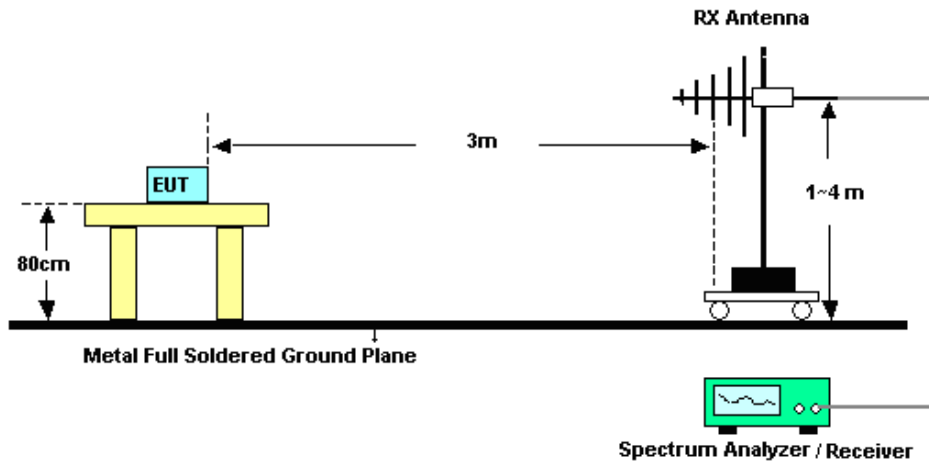
For radiated emissions above 1GHz

3.8.5 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.

3.8.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C.

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

Please refer to Appendix C.