FCC RF Test Report

APPLICANT	:	**Ring LLC**
EQUIPMENT	:	**Spotlight Cam Plus**
BRAND NAME	:	**Ring**
MODEL NAME	:	**5E82E9**
FCC ID	:	**2AEUPBHASL001**
STANDARD	:	**FCC Part 15 Subpart C §15.247**
CLASSIFICATION	:	**(DSS) Spread Spectrum Transmitter**
TEST DATE(S)	:	**Jun. 26, 2022 ~ Jul. 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

ACCREDITED
Cert #5145.02

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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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR251809D	Rev. 01	Initial issue of report	Sep. 02, 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 12.14 dB at 984.48 MHz
3.9	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 8.57 dB at 0.255 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
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	Spotlight Cam Plus
Brand Name	Ring
Model Name	5E82E9
FCC ID	2AEUPBHASL001
SN	Radiation: G9D1UL032203001H Conducted: G9D1UL0322030019 Conduction: G9D1UL0322020008
HW Version	309000143062R0
SW Version	1.3.10500
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 MHz ~ 928 MHz
Number of Channels	129
Bandwidth / Spreading Factor	125kHz / 7, 8, 9
Maximum Output Power to Antenna	SF7 : 21.93 dBm (0.1560 W) SF8 : 21.91 dBm (0.1552 W) SF9 : 21.99 dBm (0.1581 W)
99% Occupied Bandwidth	SF7 : 0.131MHz SF8 : 0.131MHz SF9 : 0.132MHz
Antenna Type / Gain	PIFA Antenna with gain -1.81 dBi
Type of Modulation	LoRa-FHSS

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.**
	CO01-KS 03CH08-KS TH01-KS	CN1257	314309

1.7 Test Software

Item	Site	Manufacture	Name	Version
1.	03CH08-KS	AUDIX	E3	6.2009-8-24
2.	CO01-KS	AUDIX	E3	6.2009-8-24

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:

1. All test items were verified and recorded according to the standards and without any deviation during the test.
2. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

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: For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (Y plane) were recorded in this report.

b. AC power line Conducted Emission was tested under maximum output power.

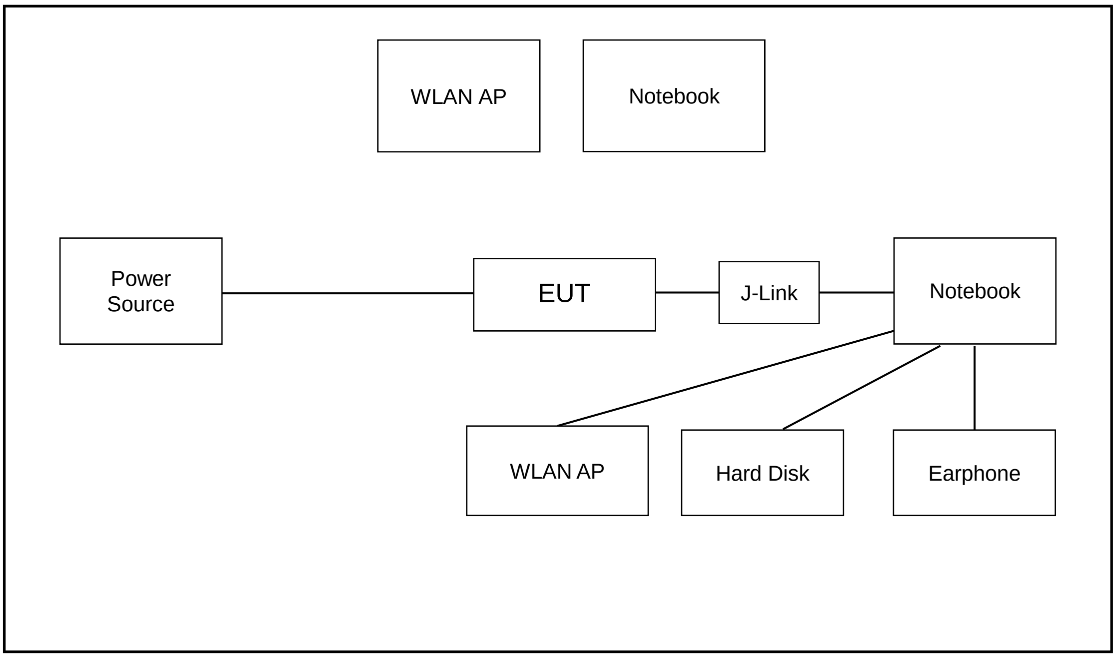
The following summary table is showing all test modes to demonstrate in compliance with the standard.

Summary table of Test Cases			
Test Item	Modulation / Spreading Factor		
	LoRa FHSS / SF7	LoRa FHSS / SF8	LoRa FHSS / SF9
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
Radiated 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
AC Conducted Emission	Mode 1 : Lora Tx + Bluetooth Link + WLAN Link(2.4G) + Adapter + Battery 3		

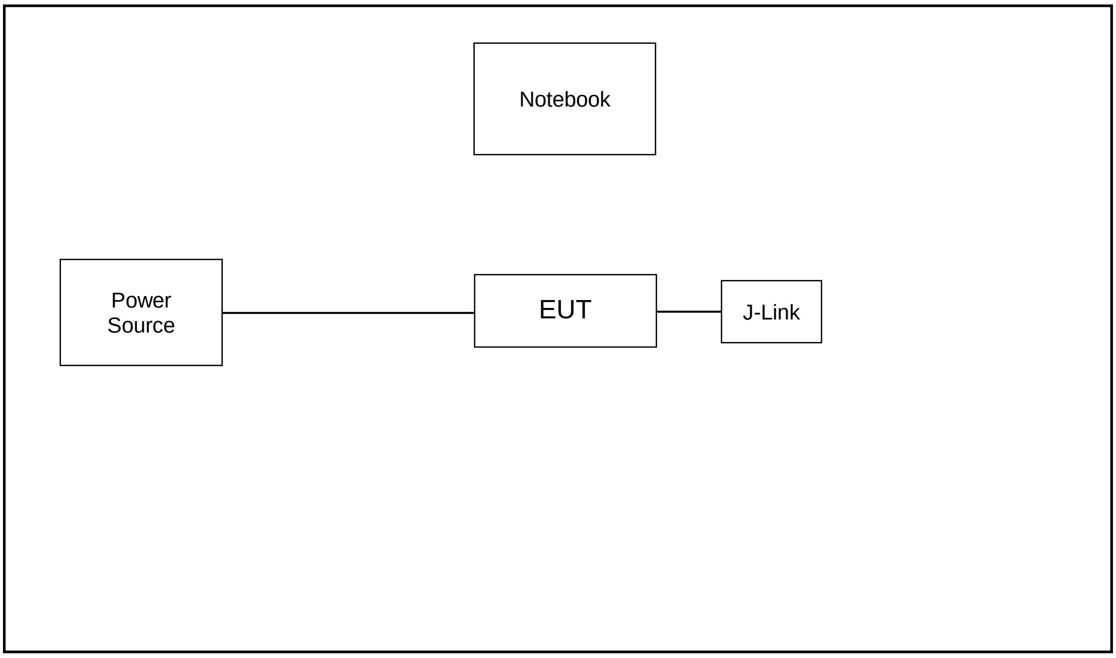
Note: The accessories are chosen from Part 15B worst cases.

2.3 Connection Diagram of Test System

For AC 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.	WLAN AP	LINKSYS	WRT1900ACSV2	N/A	N/A	Unshielded,1.8m
2.	Notebook	Honor	Magicbook 16	N/A	N/A	AC I/P: Unshielded, 1.8 m DC O/P: Shielded, 1.8 m
3.	Earphone	Lenovo	P121	N/A	N/A	Unshielded,1.2m
4.	Hard Disk	Lenovo	F310	DoC	Shielded, 1.2m	N/A
5.	J-Link	N/A	N/A	N/A	N/A	N/A

2.5 EUT Operation Test Setup

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

For AC power line conducted emissions, the EUT was set to connect with the WLAN AP under large package sizes transmission.

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 5.0 dB and 10dB attenuator.

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

= 5.0 + 10 = 15.0 (dB)

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

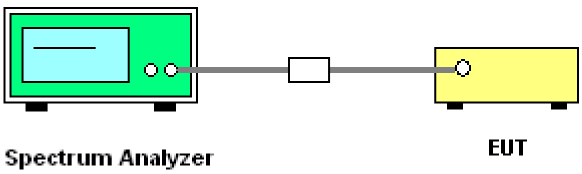
3.1.2 Measuring Instruments

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

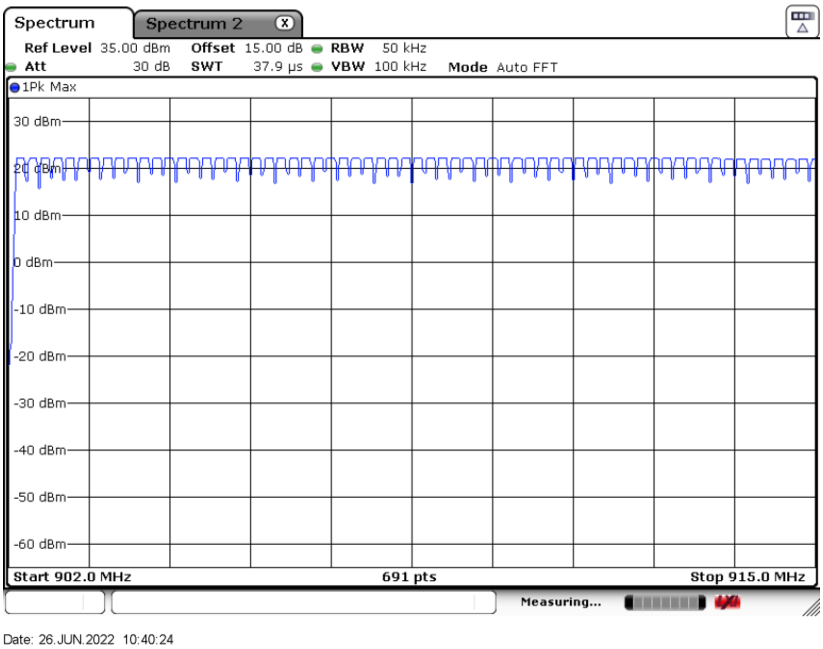


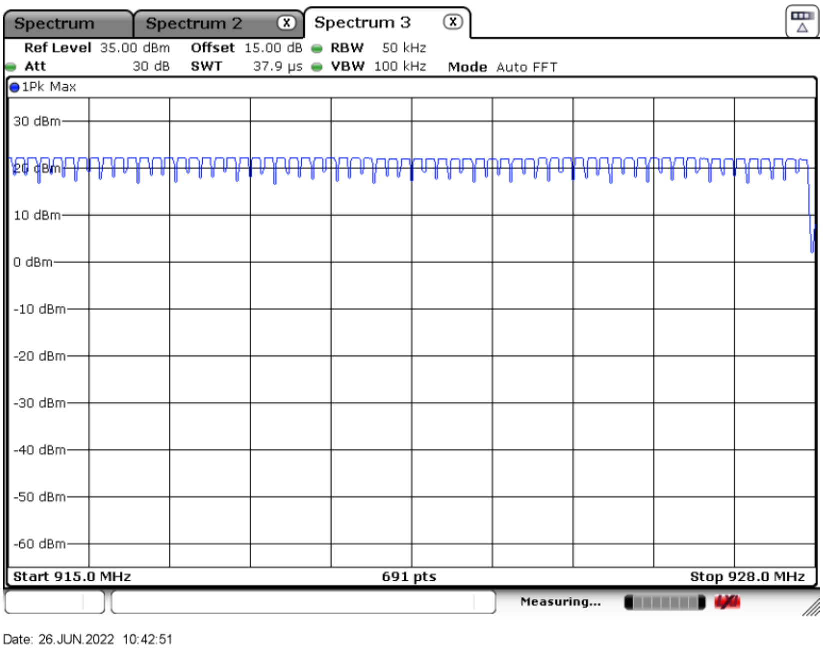
3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.

SF7:

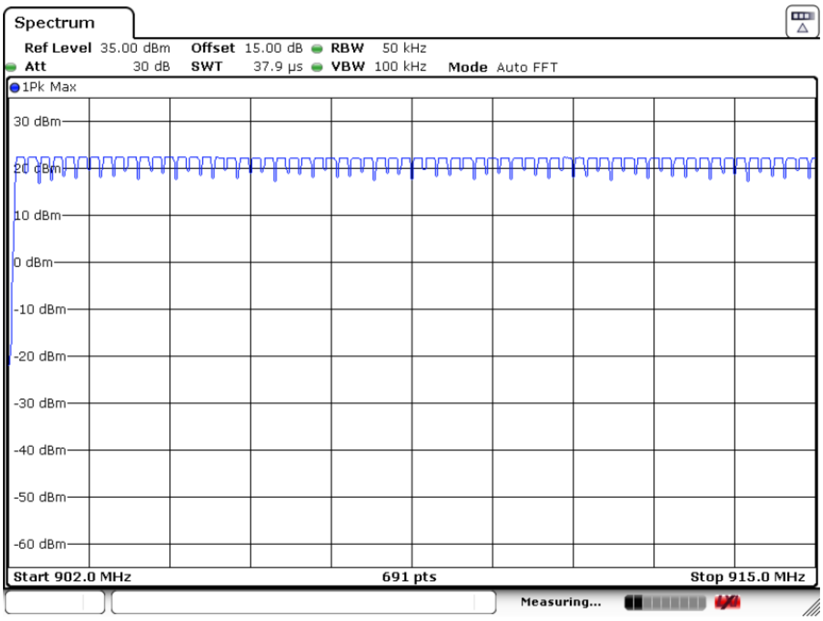
Number of Hopping Channel Plot on Channel 1 - 129



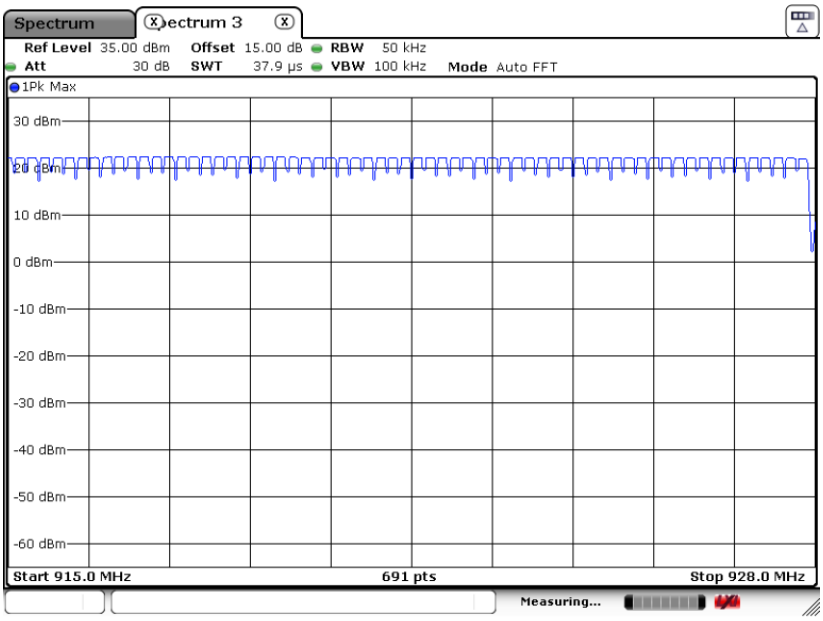


SF8:

Number of Hopping Channel Plot on Channel 1 - 129



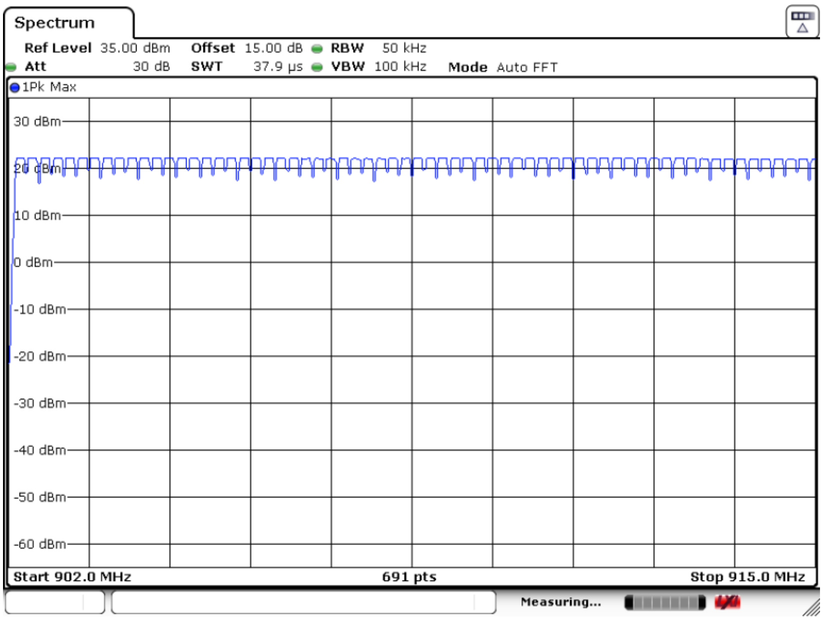
Date: 26.JUN.2022 11:31:35



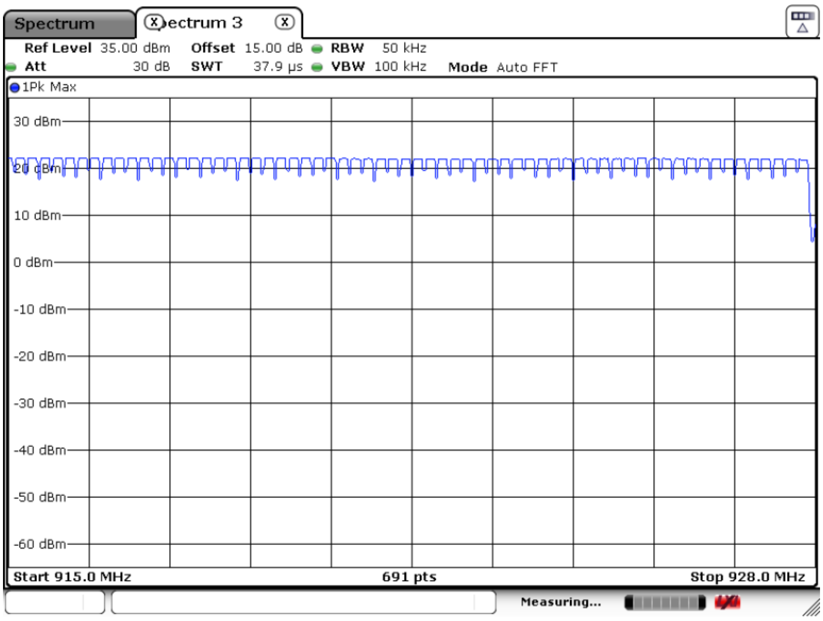
Date: 26.JUN.2022 11:33:58

SF9:

Number of Hopping Channel Plot on Channel 1 - 129



Date: 26.JUN.2022 13:25:22



Date: 26.JUN.2022 13:28:15

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.

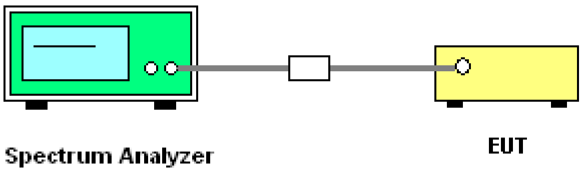
3.2.2 Measuring Instruments

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

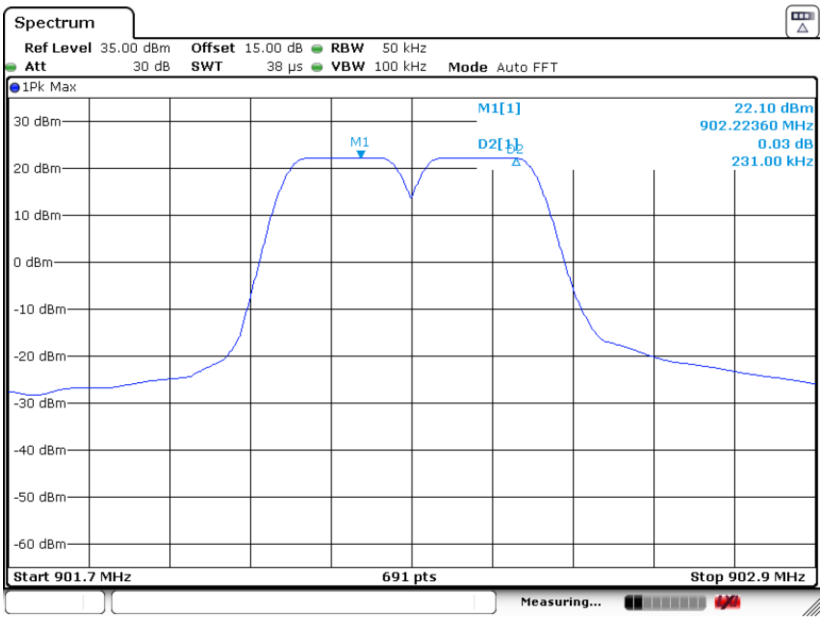


3.2.5 Test Result of Hopping Channel Separation

Please refer to Appendix A.

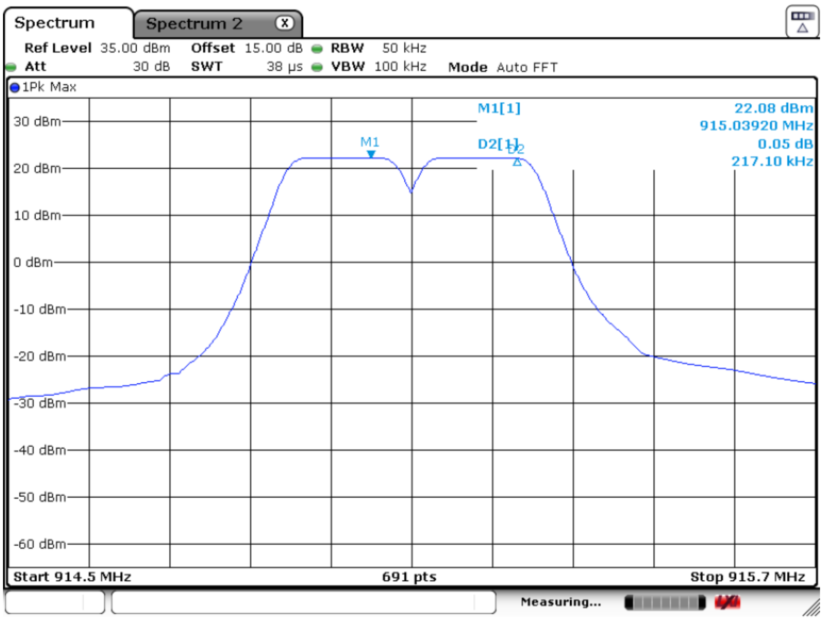
SF7:

Channel Separation Plot on Channel 1 - 2



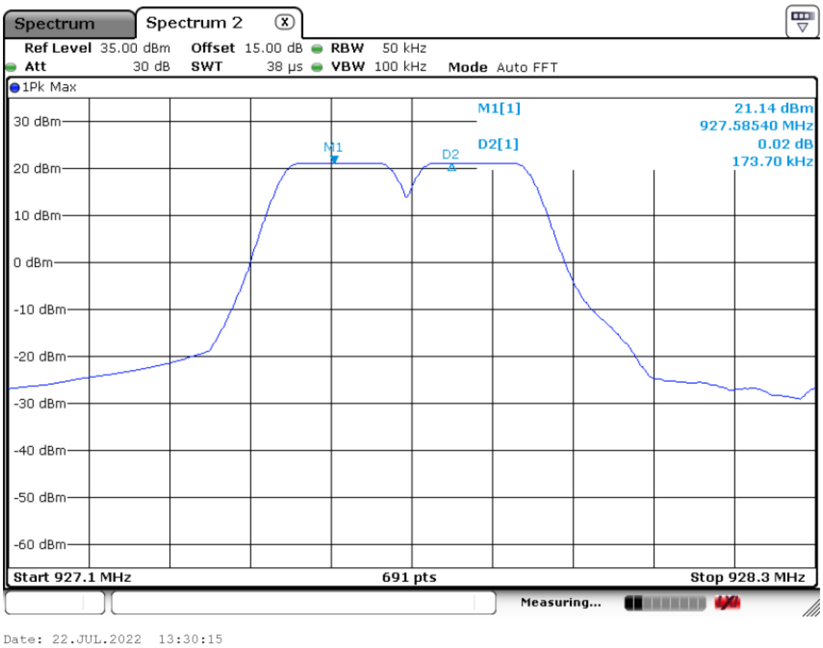
Date: 26.JUN.2022 10:06:23

Channel Separation Plot on Channel 64 - 65



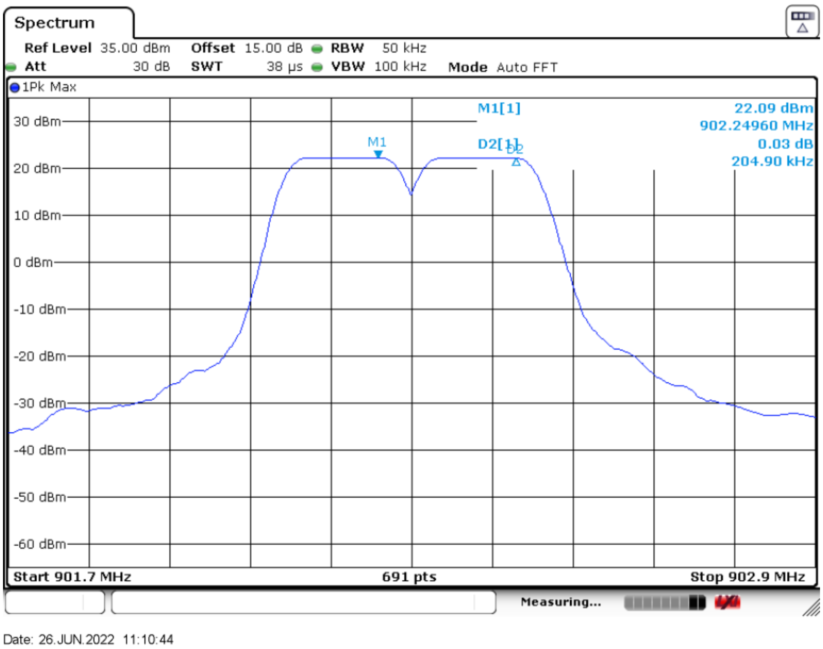
Date: 26.JUN.2022 10:13:32

Channel Separation Plot on Channel 128 - 129

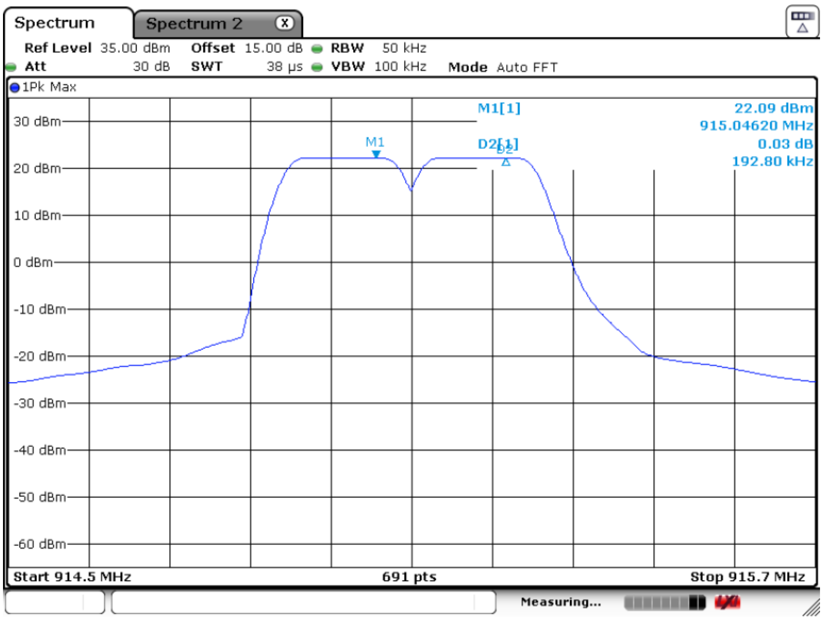


SF8:

Channel Separation Plot on Channel 1 - 2

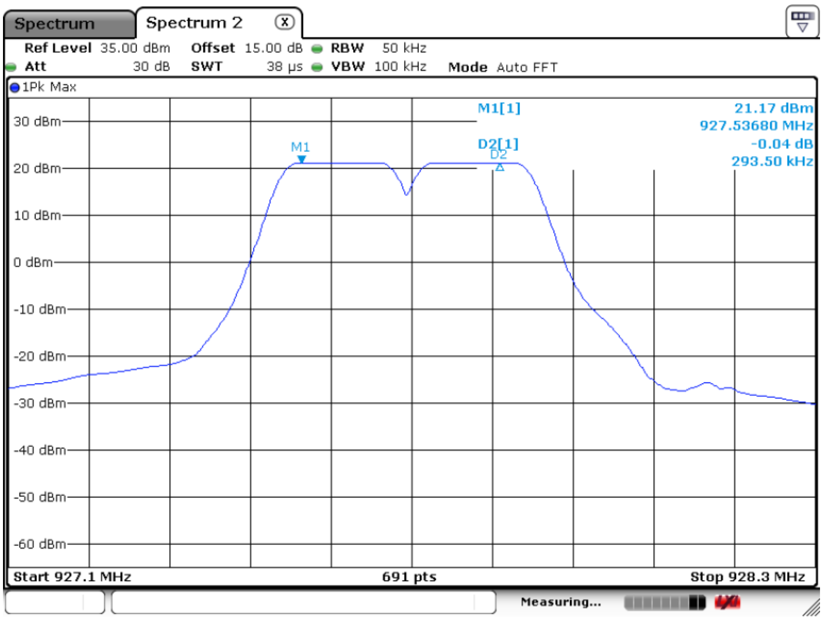


Channel Separation Plot on Channel 64 - 65



Date: 26.JUN.2022 11:15:36

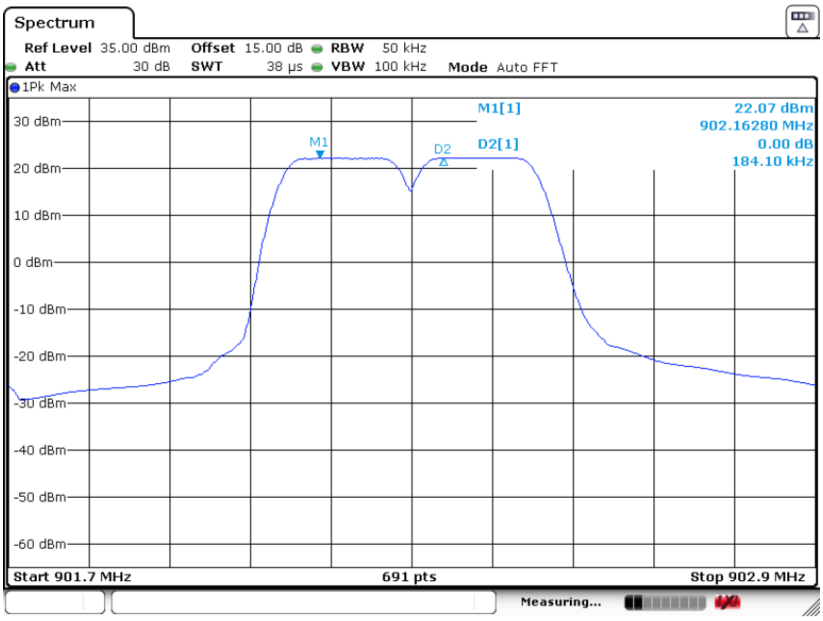
Channel Separation Plot on Channel 128 - 129



Date: 22.JUL.2022 13:33:21

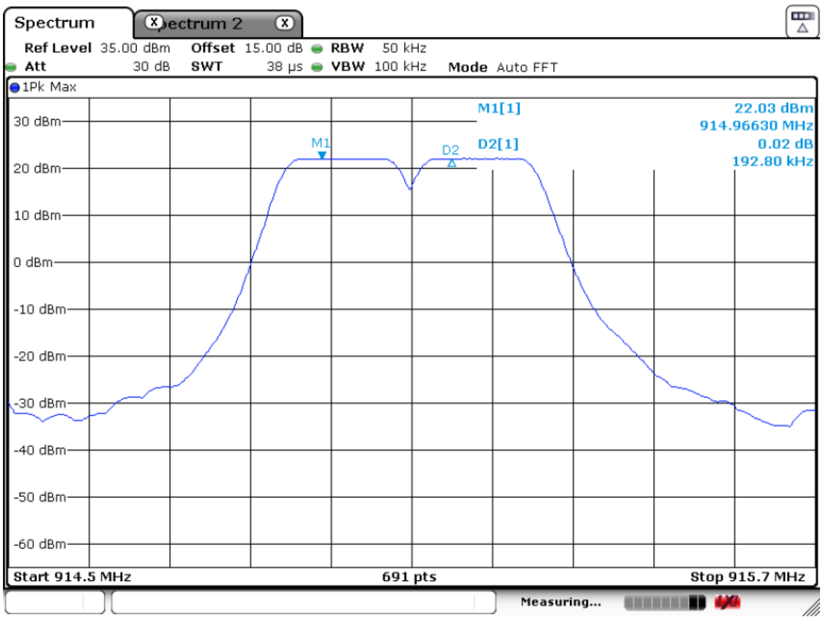
SF9:

Channel Separation Plot on Channel 1 - 2



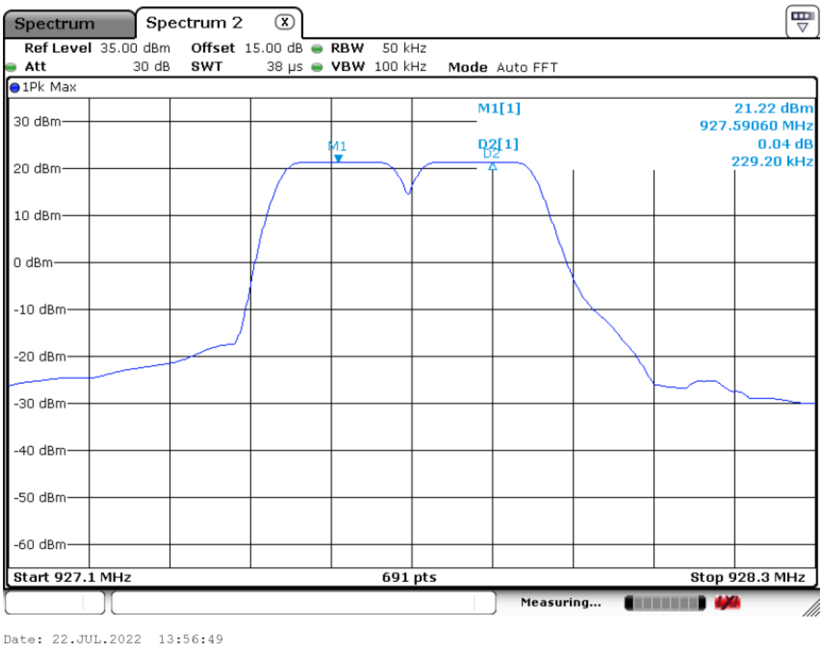
Date: 26.JUN.2022 13:08:56

Channel Separation Plot on Channel 64 - 65



Date: 26.JUN.2022 13:13:19

Channel Separation Plot on Channel 128 - 129



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.

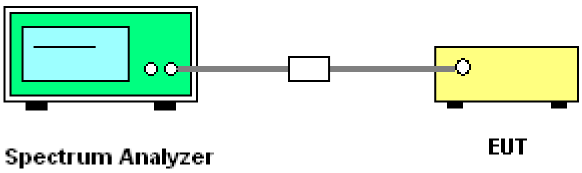
3.3.2 Measuring Instruments

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

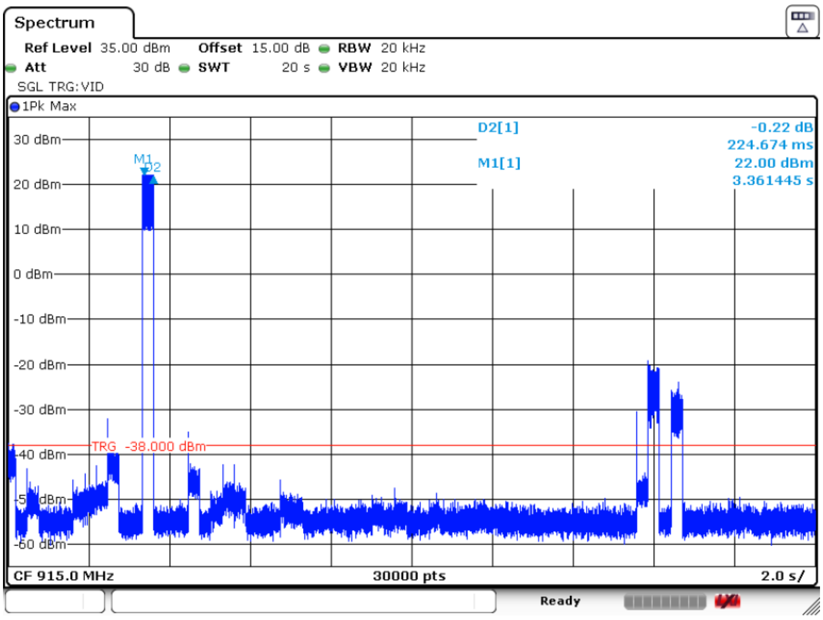


3.3.5 Test Result of Dwell Time

Please refer to Appendix A.

SF7:

DT on-time and Hops over 20 sec period



Date: 26.JUN.2022 10:48:25

Remark:

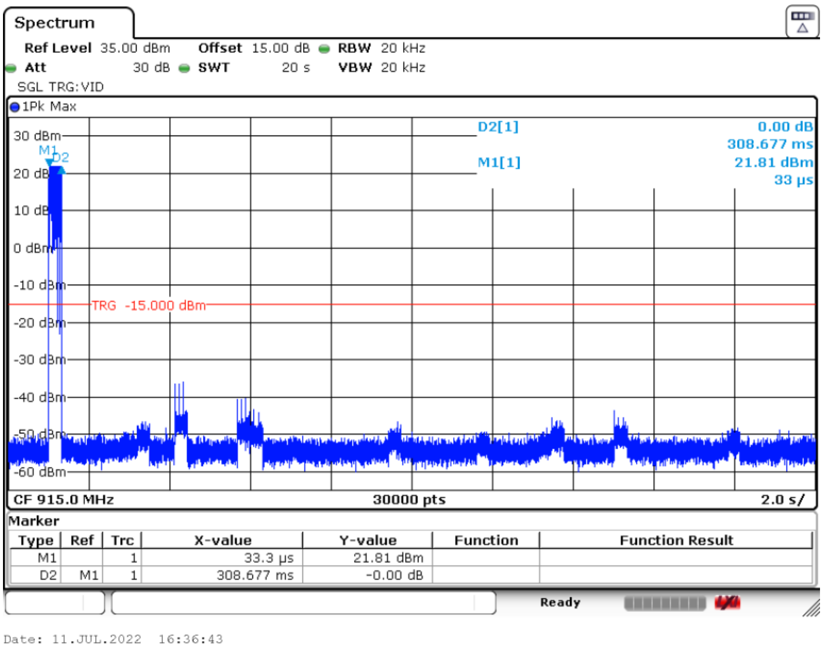
Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

= 1 (hop) x 224.674 (ms)

= 0.225 (sec)

SF8:

DT on-time and Hops over 20 sec period



Remark:

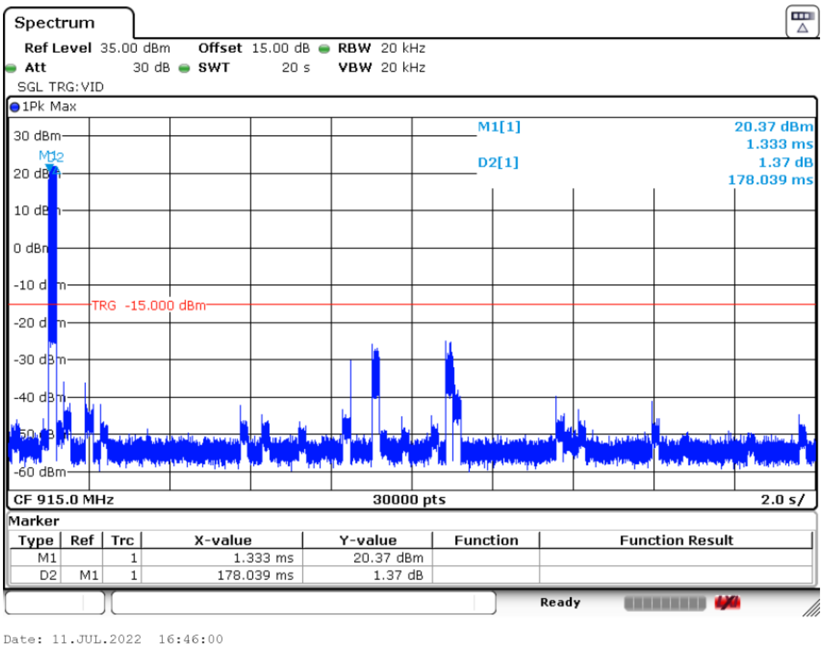
Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

= 1 (hop) x 308.677 (ms)

= 0.309 (sec)

SF9:

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 178.039 (ms)

= 0.178 (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.

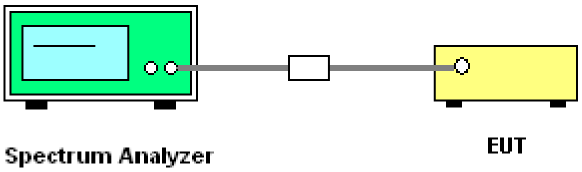
3.4.2 Measuring Instruments

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 ≥ 1% of the 20 dB bandwidth; VBW ≥ 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 ≥ 1% of the 99% bandwidth; VBW ≥ RBW; Sweep = auto; Detector function = sample;
   Trace = max hold.
6. Measure and record the results in the test report.

3.4.4 Test Setup

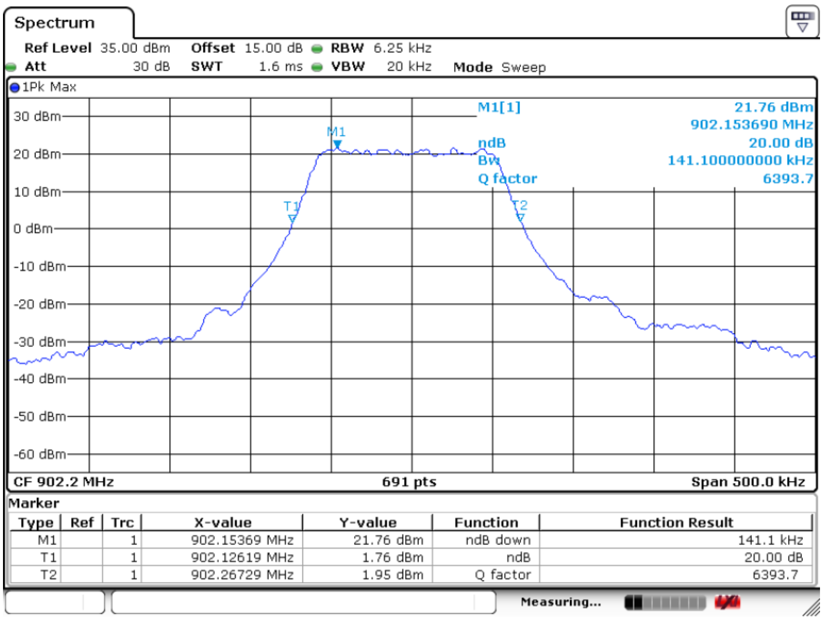


3.4.5 Test Result of 20dB Bandwidth

Please refer to Appendix A.

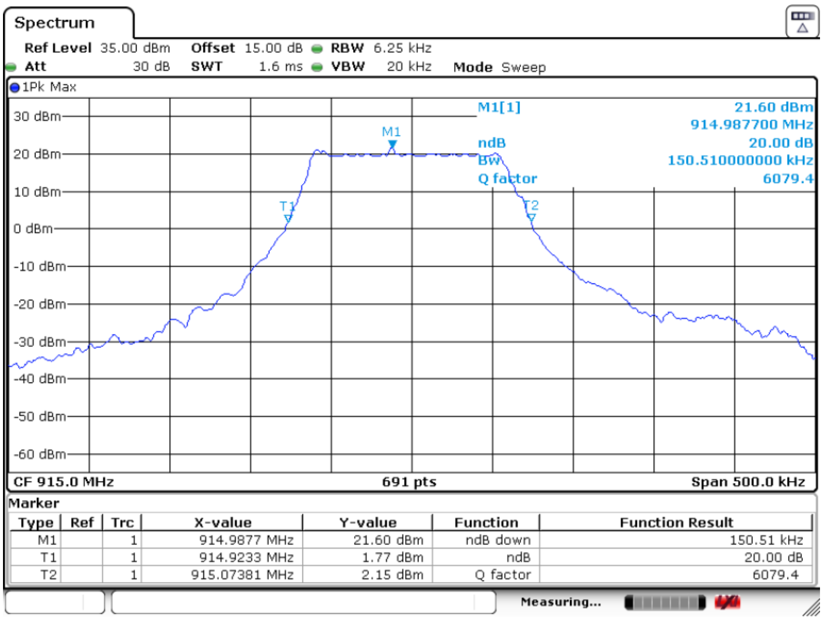
SF7:

20 dB Bandwidth Plot on Channel 1



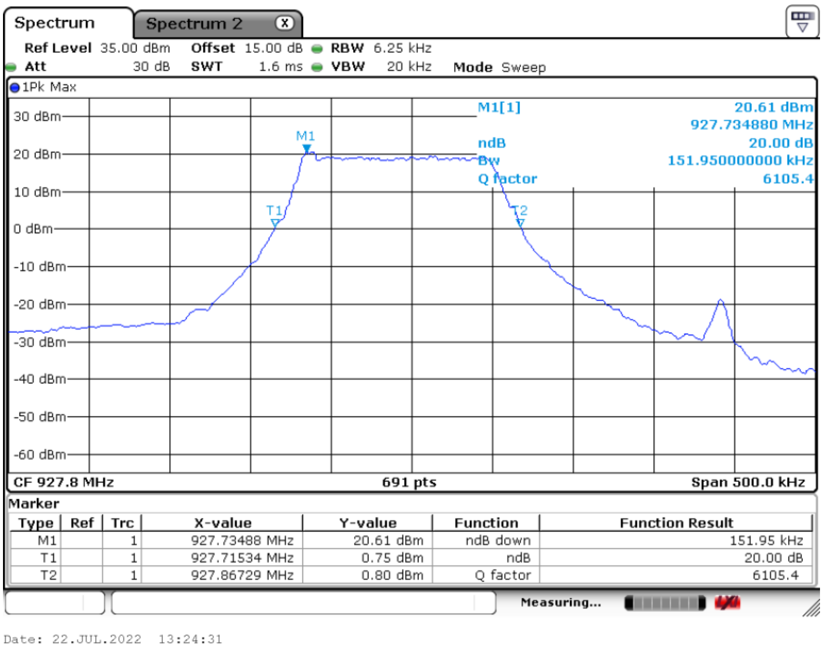
Date: 26.JUN.2022 09:32:37

20 dB Bandwidth Plot on Channel 65



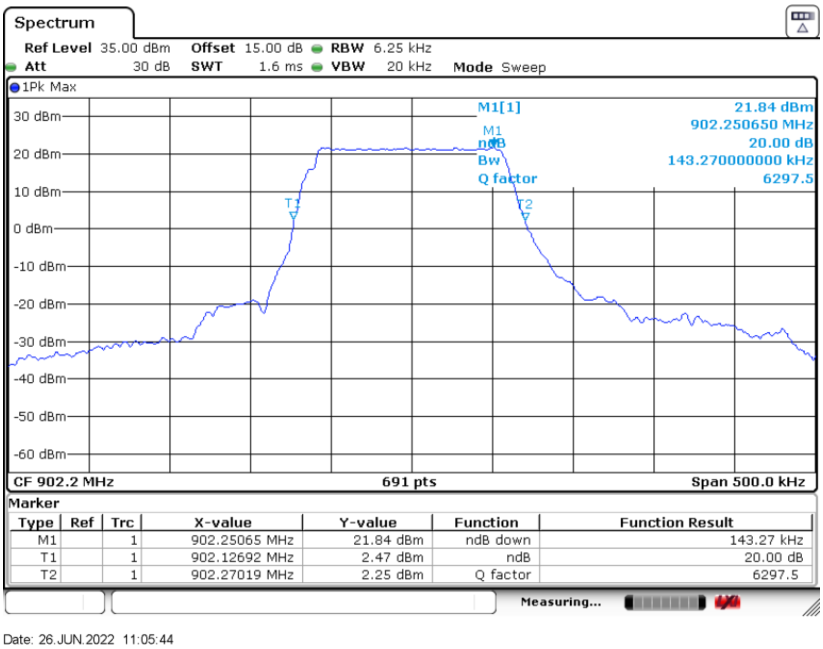
Date: 26.JUN.2022 10:14:39

20 dB Bandwidth Plot on Channel 129

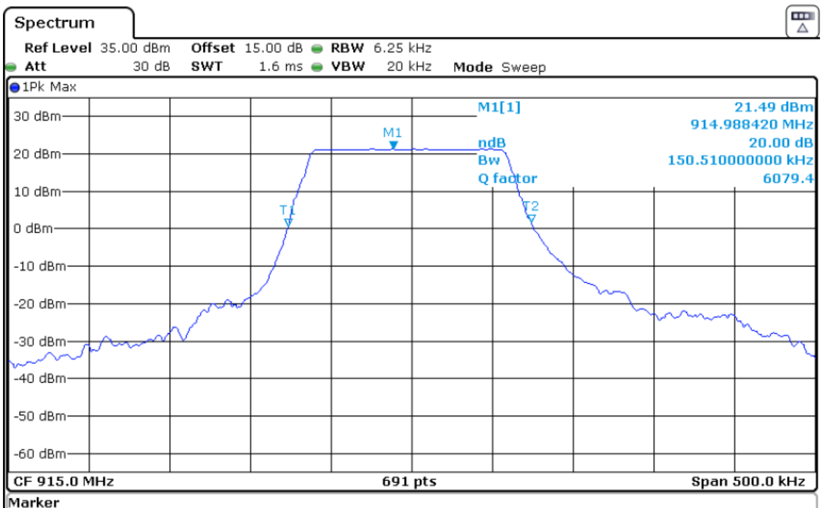


SF8:

20 dB Bandwidth Plot on Channel 1



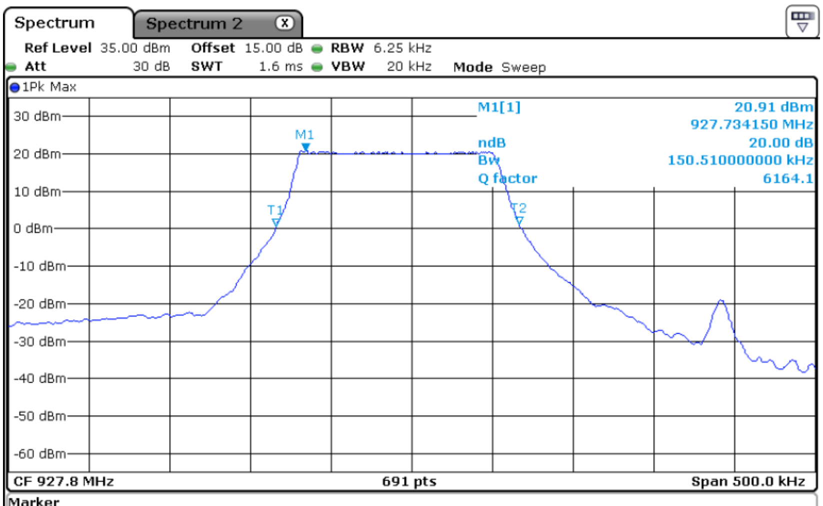
20 dB Bandwidth Plot on Channel 65



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	914.98842 MHz	21.49 dBm	ndB down	150.51 kHz
T1		1	914.9233 MHz	0.62 dBm	ndB	20.00 dB
T2		1	915.07381 MHz	1.77 dBm	Q factor	6079.4

Date: 26.JUN.2022 11:16:56

20 dB Bandwidth Plot on Channel 129

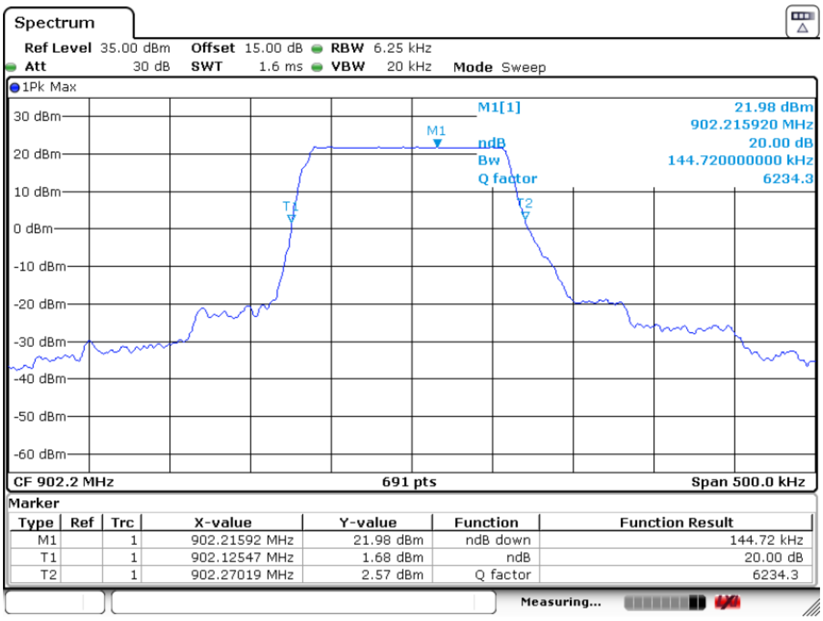


Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	927.73415 MHz	20.91 dBm	ndB down	150.51 kHz
T1		1	927.71606 MHz	0.63 dBm	ndB	20.00 dB
T2		1	927.86657 MHz	1.28 dBm	Q factor	6164.1

Date: 22.JUL.2022 13:34:28

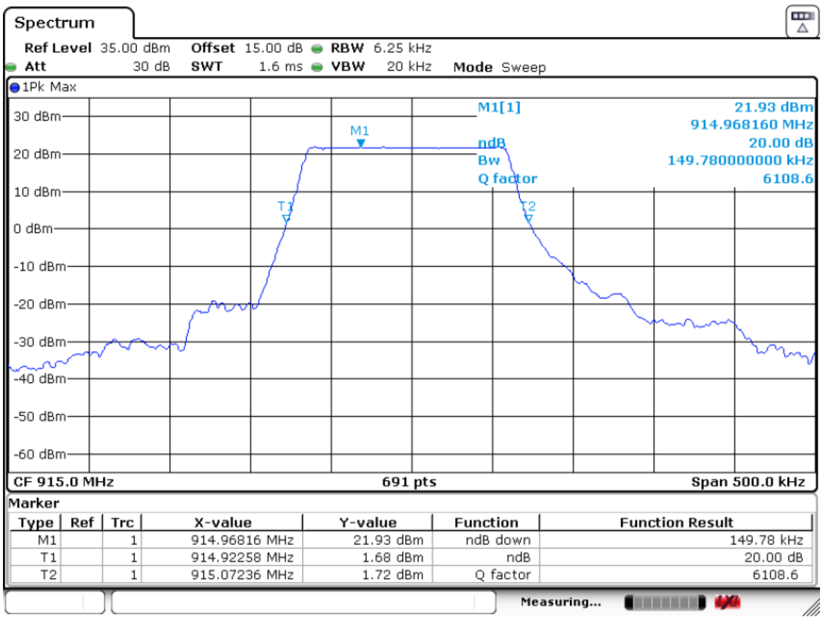
SF9:

20 dB Bandwidth Plot on Channel 1



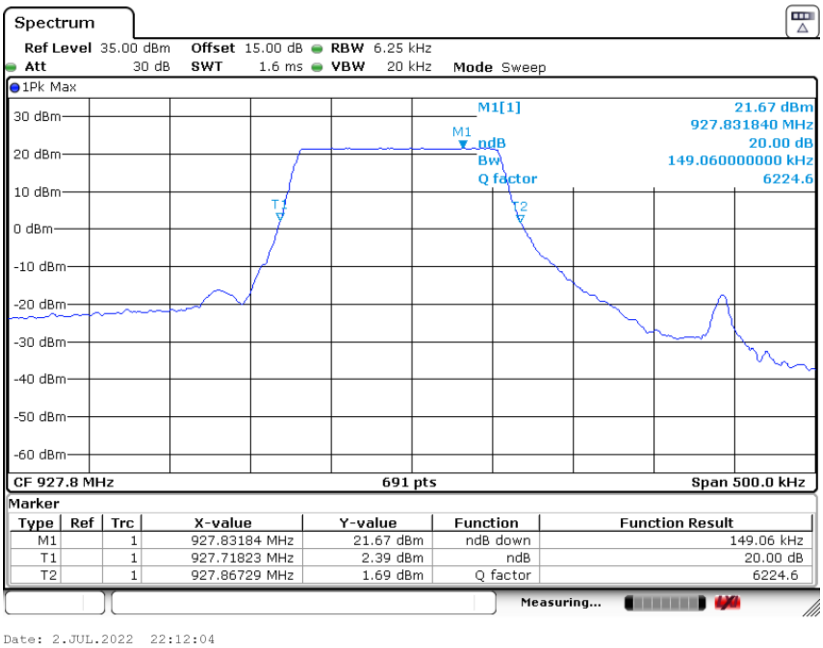
Date: 26.JUN.2022 13:04:47

20 dB Bandwidth Plot on Channel 65



Date: 26.JUN.2022 13:14:01

20 dB Bandwidth Plot on Channel 129

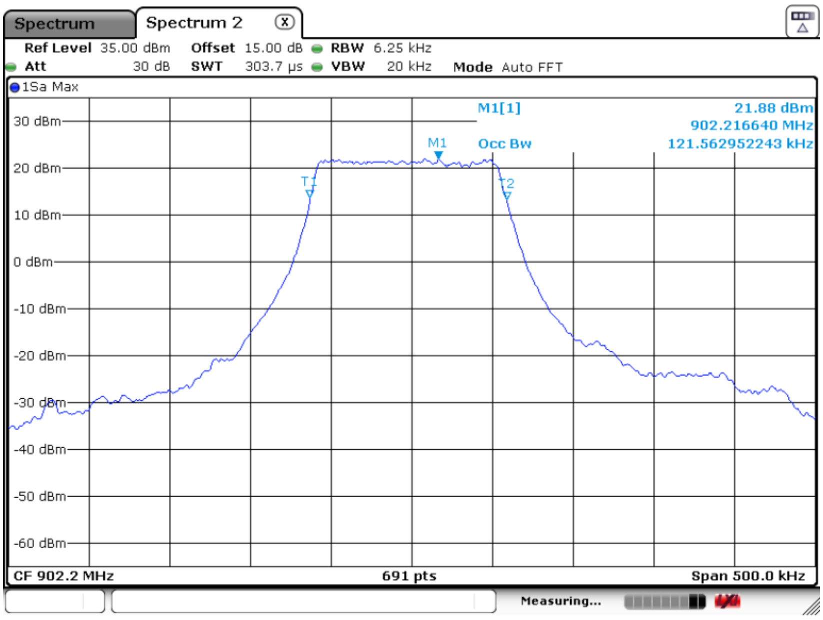


3.4.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

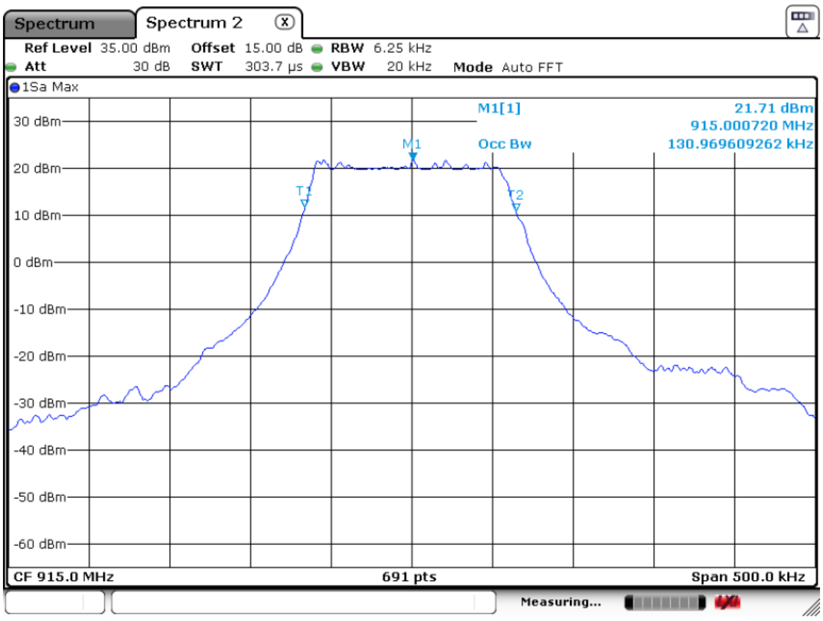
SF7:

99% Occupied Bandwidth Plot on Channel 1



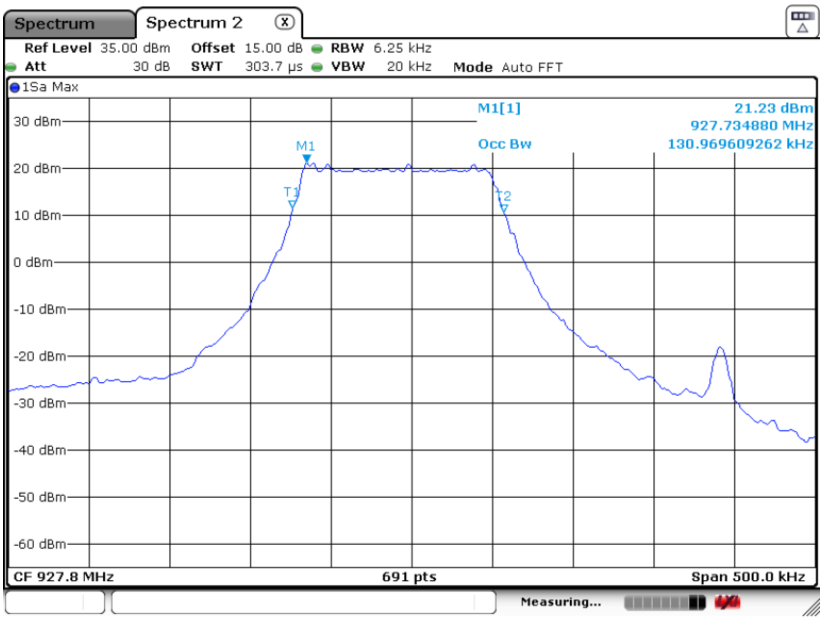
Date: 26.JUN.2022 10:10:04

99% Occupied Bandwidth Plot on Channel 65



Date: 26.JUN.2022 10:11:48

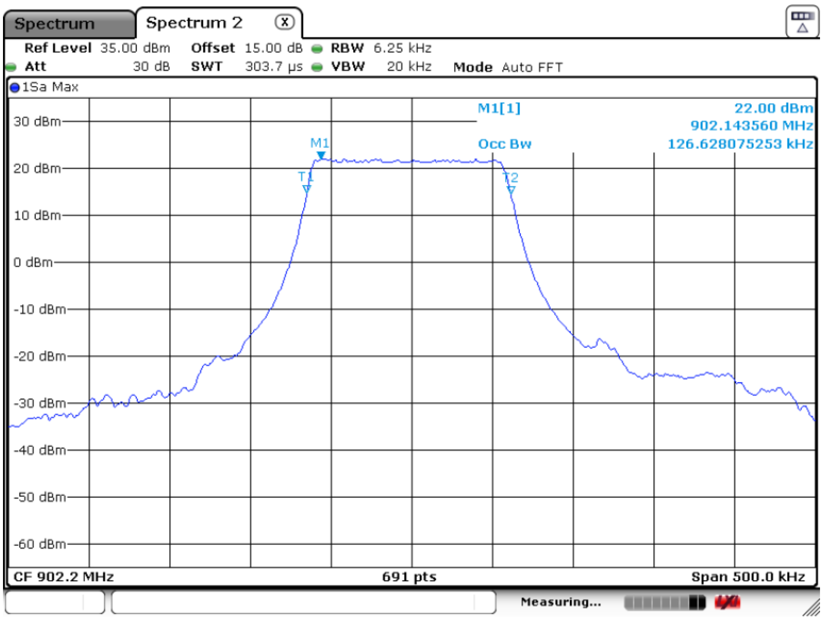
99% Occupied Bandwidth Plot on Channel 129



Date: 2.JUL.2022 21:40:01

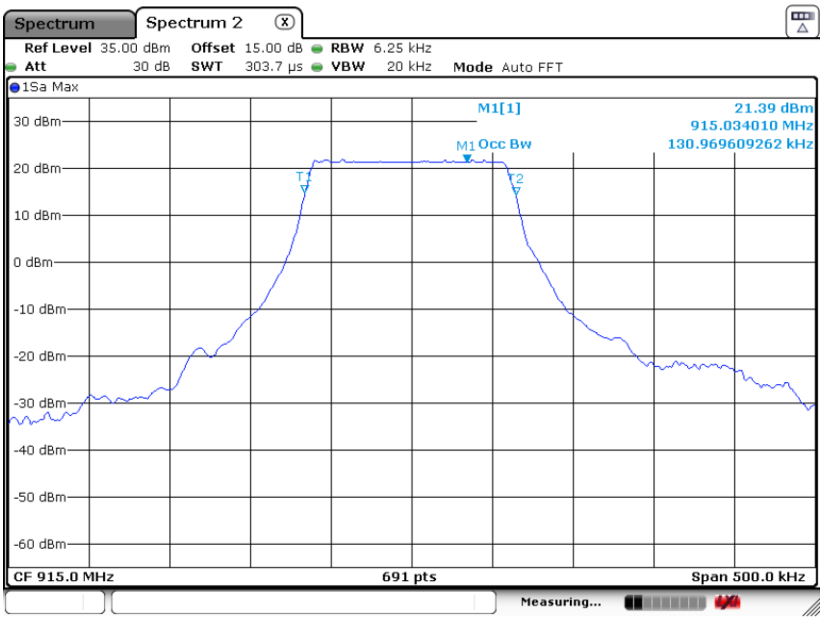
SF8:

99% Occupied Bandwidth Plot on Channel 1



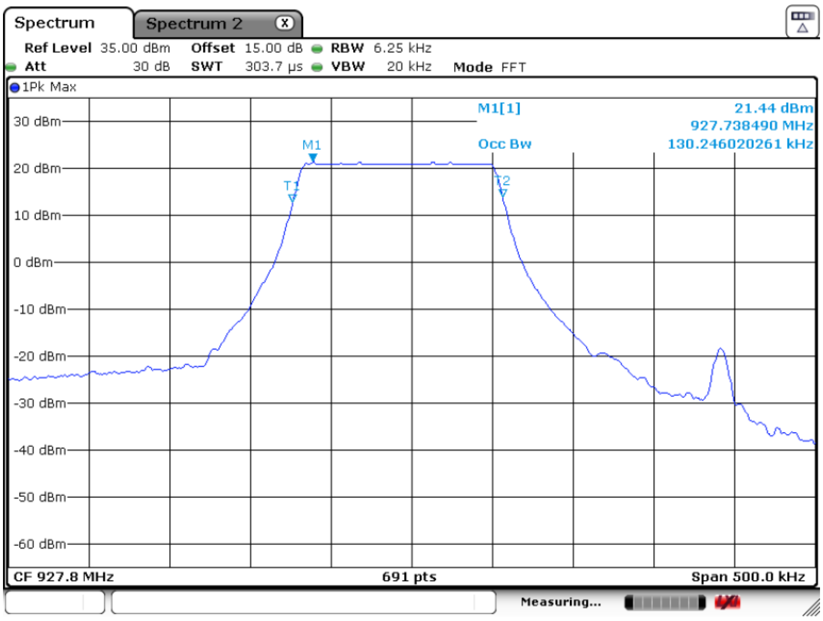
Date: 26.JUN.2022 11:11:58

99% Occupied Bandwidth Plot on Channel 65



Date: 26.JUN.2022 11:14:19

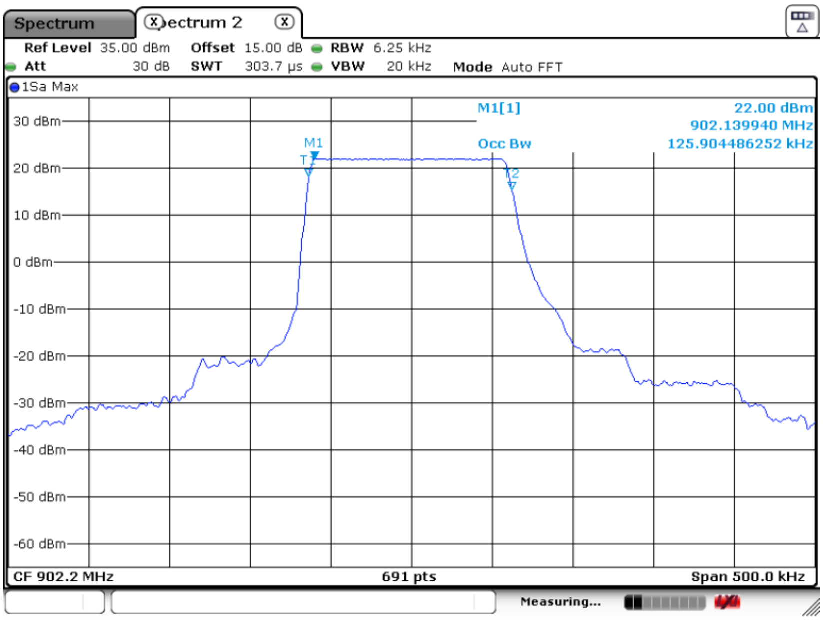
99% Occupied Bandwidth Plot on Channel 129



Date: 2.JUL.2022 21:09:33

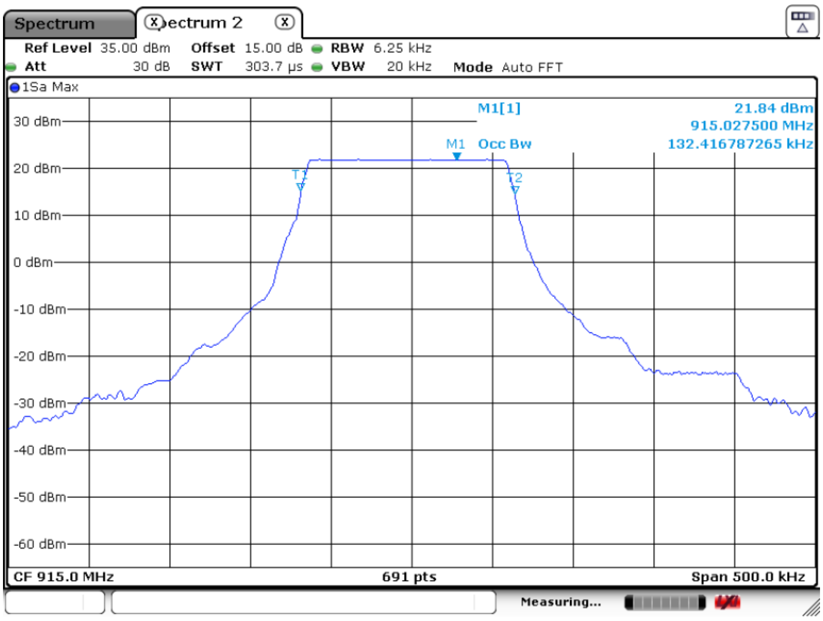
SF9:

99% Occupied Bandwidth Plot on Channel 1



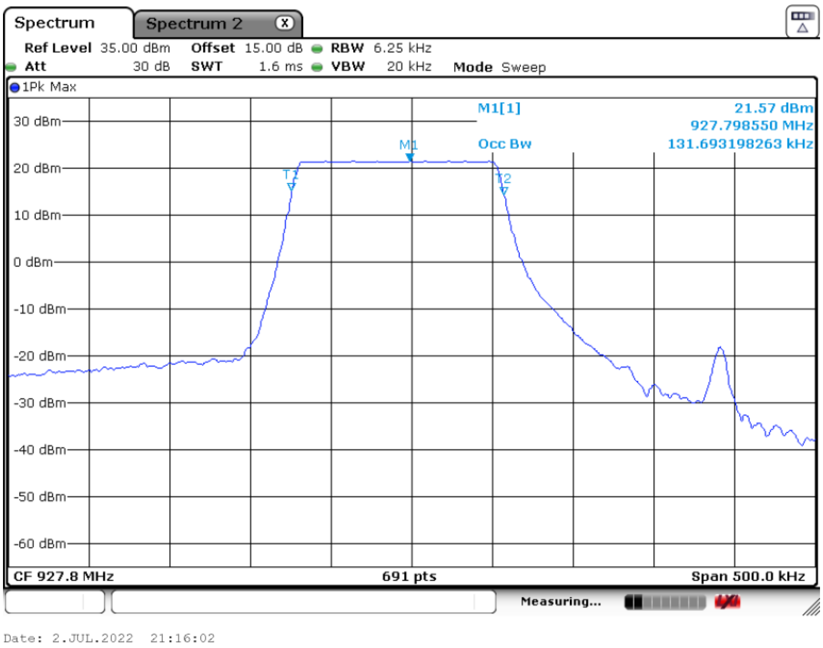
Date: 26.JUN.2022 13:09:48

99% Occupied Bandwidth Plot on Channel 65



Date: 26.JUN.2022 13:12:08

99% Occupied Bandwidth Plot on Channel 129



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.

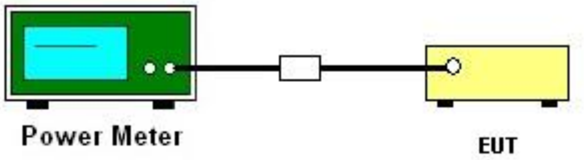
3.5.2 Measuring Instruments

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.

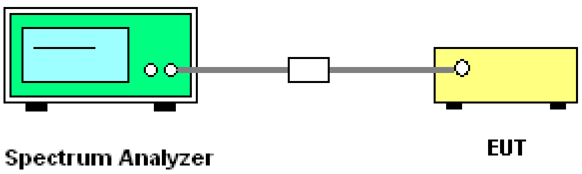
3.6.2 Measuring Instruments

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.

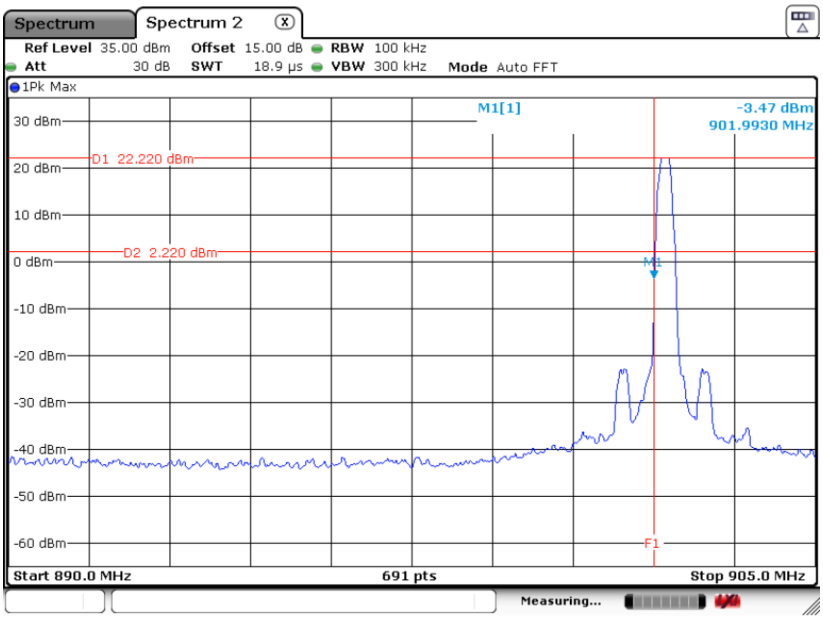
3.6.4 Test Setup



3.6.5 Test Result of Conducted Band Edges

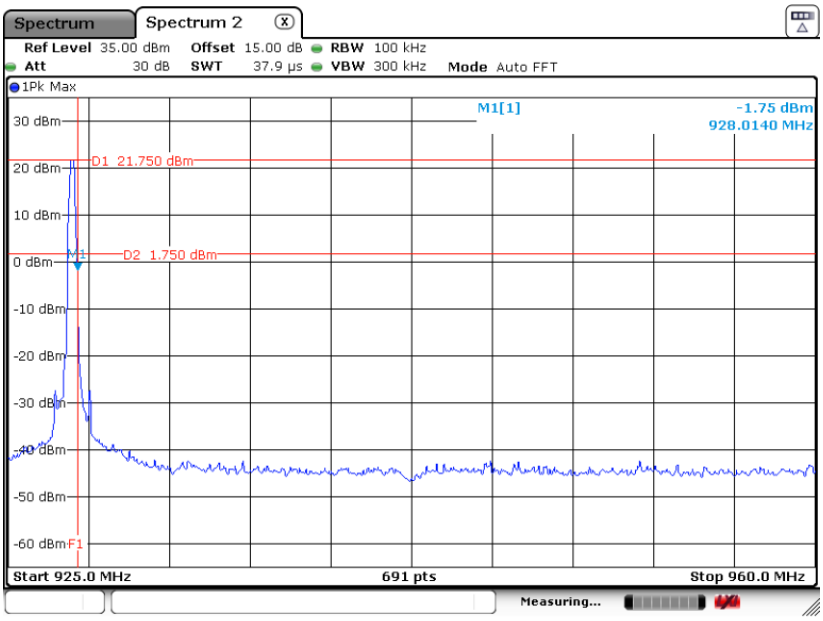
SF7:

Low Band Edge Plot on Channel 1



Date: 26.JUN.2022 09:36:37

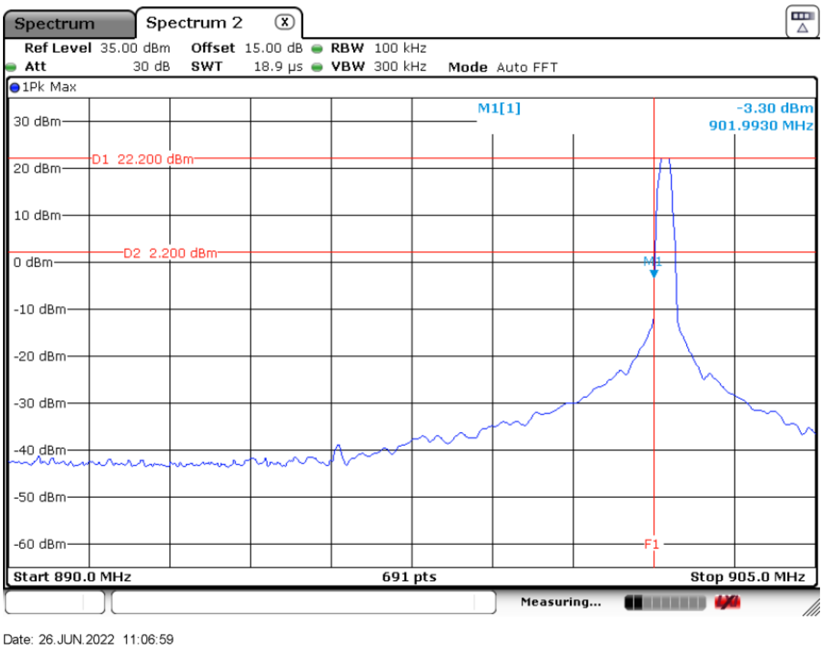
High Band Edge Plot on Channel 129



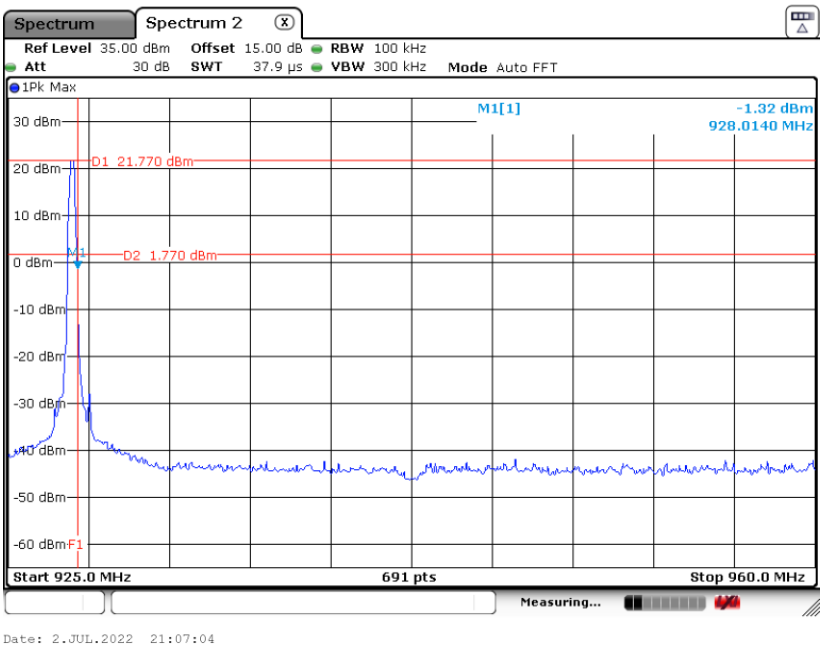
Date: 2.JUL.2022 21:40:45

SF8:

Low Band Edge Plot on Channel 1

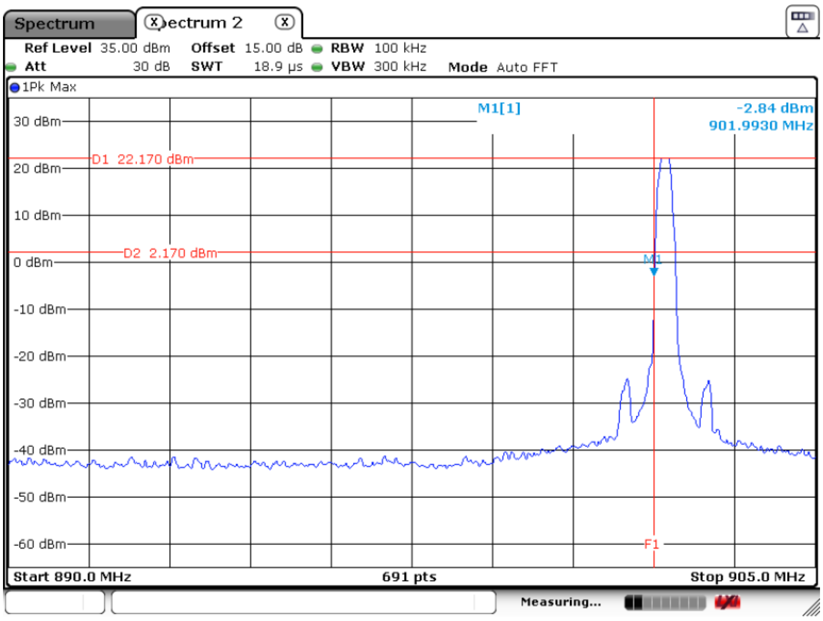


High Band Edge Plot on Channel 129



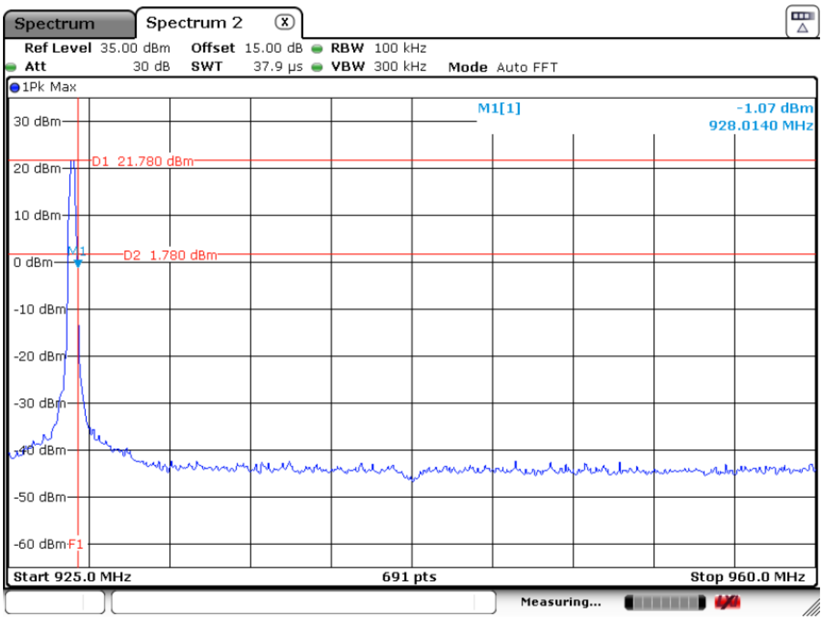
SF9:

Low Band Edge Plot on Channel 1



Date: 26.JUN.2022 13:05:30

High Band Edge Plot on Channel 129

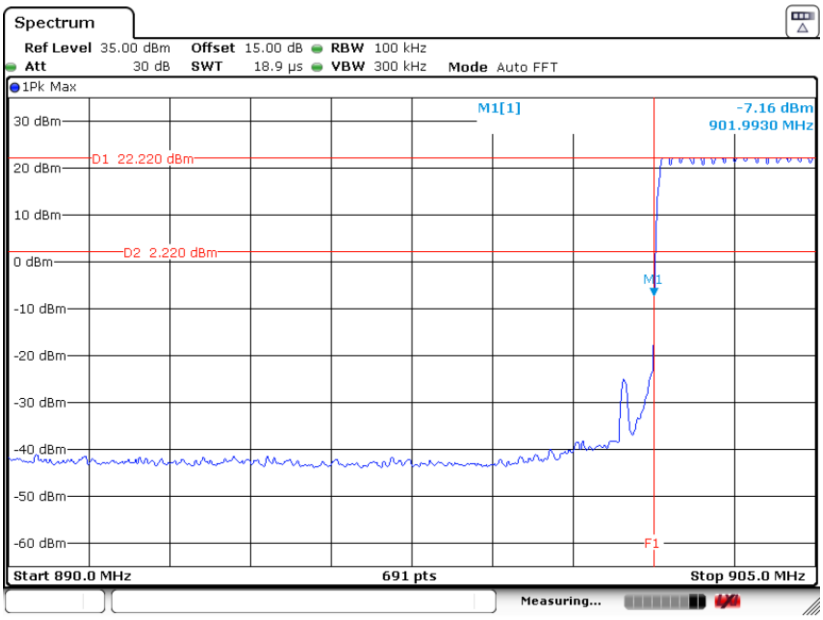


Date: 2.JUL.2022 21:15:18

3.6.6 Test Result of Conducted Hopping Mode Band Edges

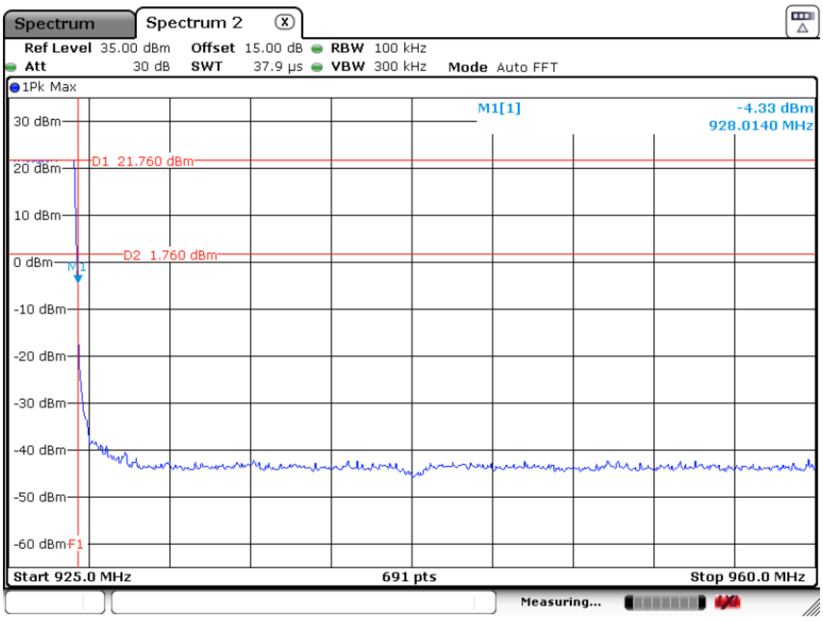
SF7:

Hopping Mode Low Band Edge Plot



Date: 26.JUN.2022 12:36:10

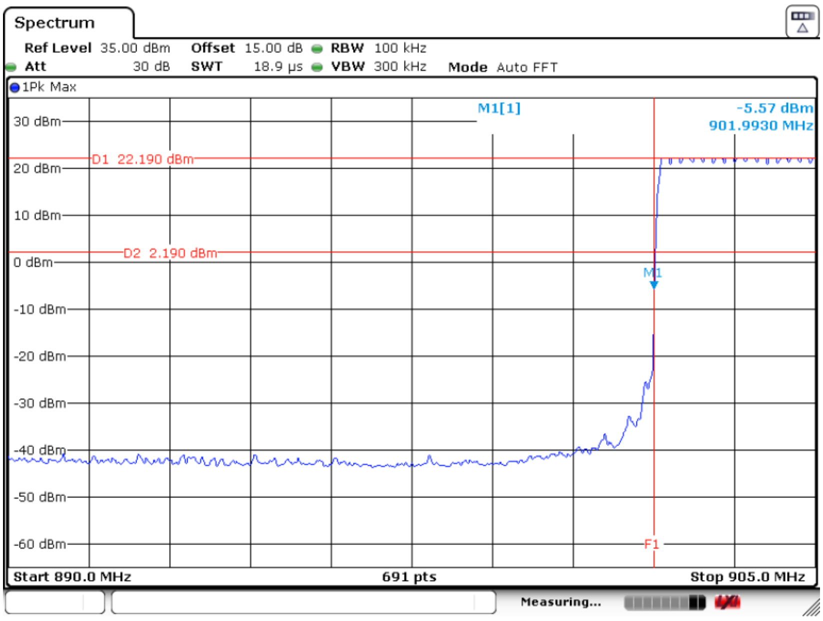
Hopping Mode High Band Edge Plot



Date: 2.JUL.2022 21:44:20

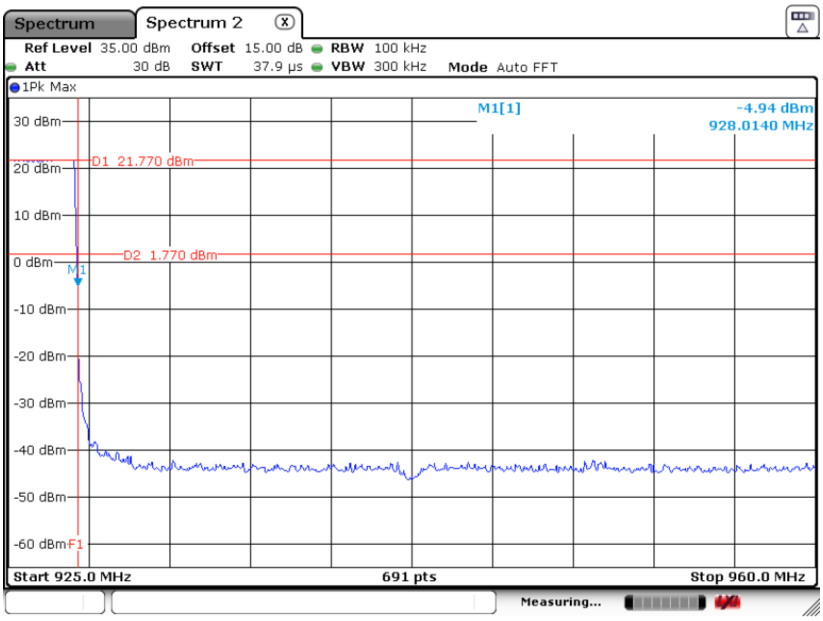
SF8:

Hopping Mode Low Band Edge Plot



Date: 26.JUN.2022 12:28:49

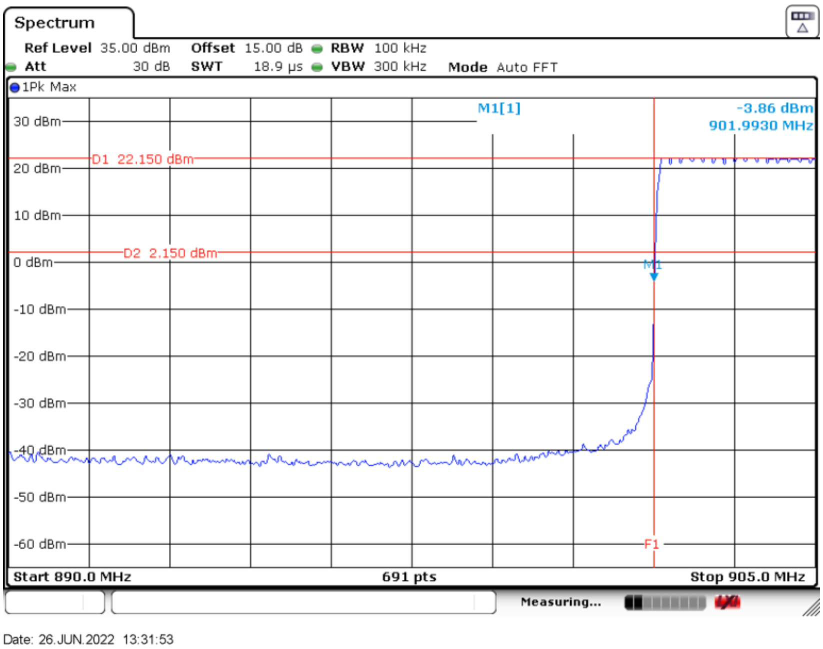
Hopping Mode High Band Edge Plot



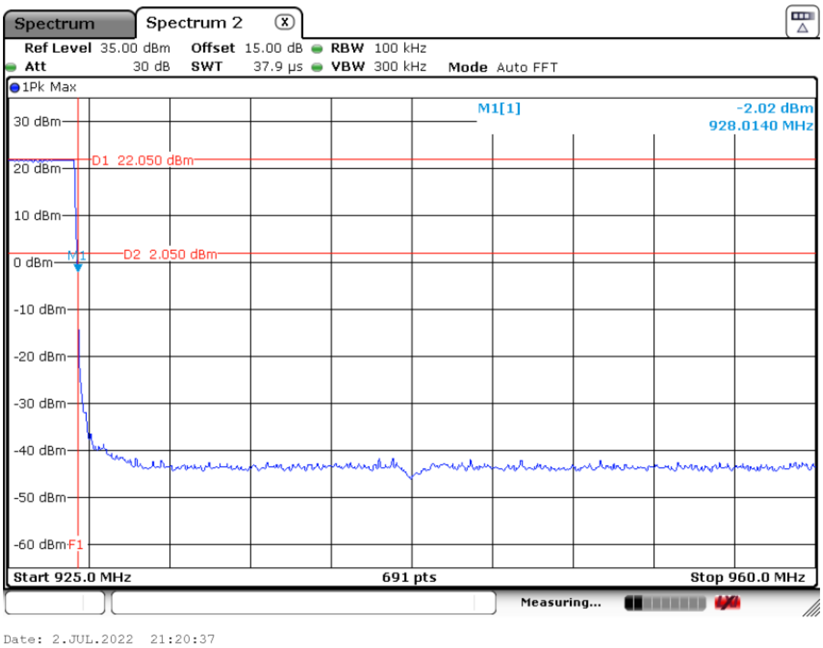
Date: 2.JUL.2022 21:11:45

SF9:

Hopping Mode Low Band Edge Plot



Hopping Mode High Band Edge Plot



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.

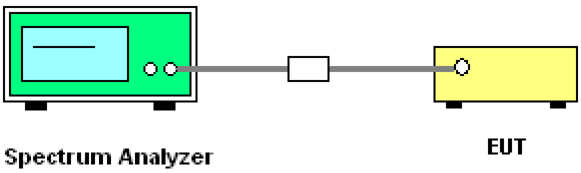
3.7.2 Measuring Instruments

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.

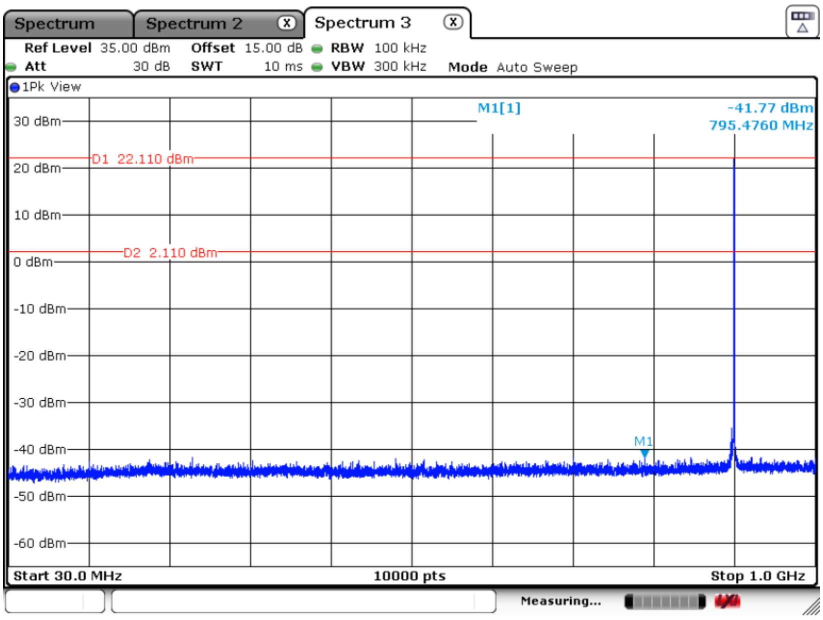
3.7.4 Test Setup



3.7.5 Test Result of Conducted Spurious Emission

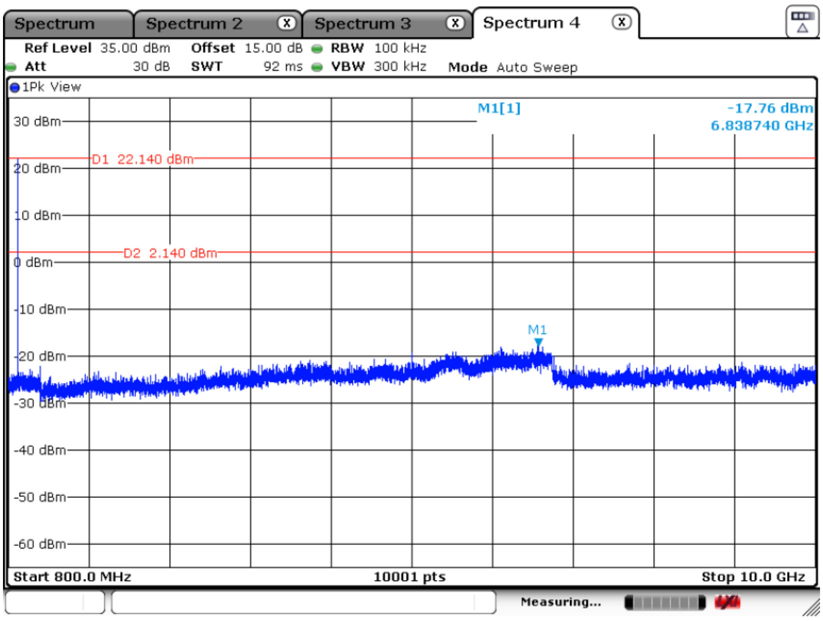
SF7:

CSE Plot on Ch 1 between 30MHz ~ 1 GHz



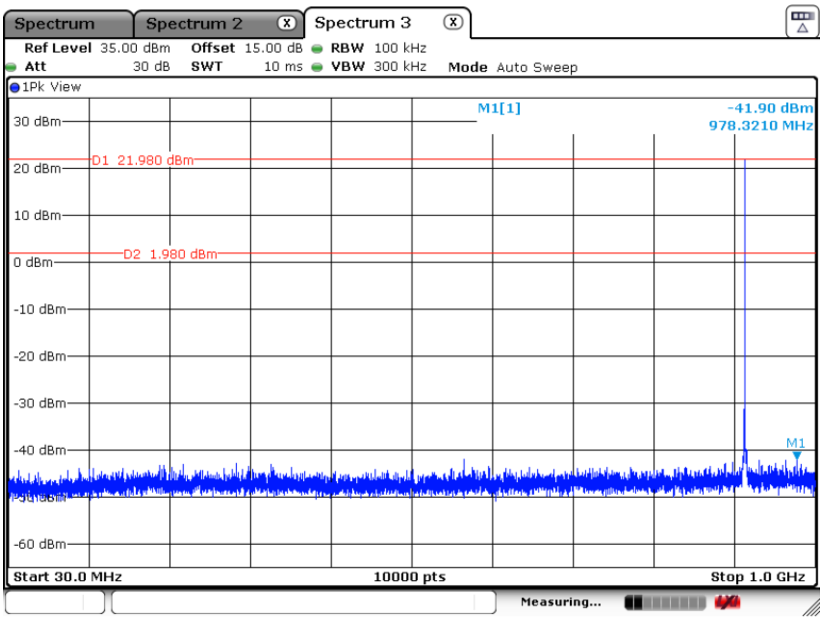
Date: 26.JUN.2022 09:40:50

CSE Plot on Ch 1 between 800 MHz ~ 10 GHz



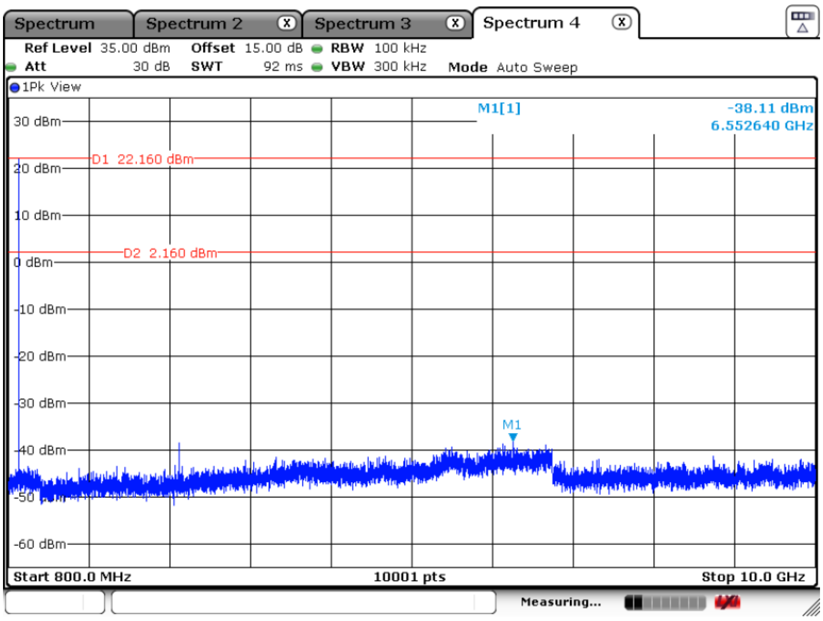
Date: 26.JUN.2022 09:44:01

CSE Plot on Ch 65 between 30MHz ~ 1 GHz



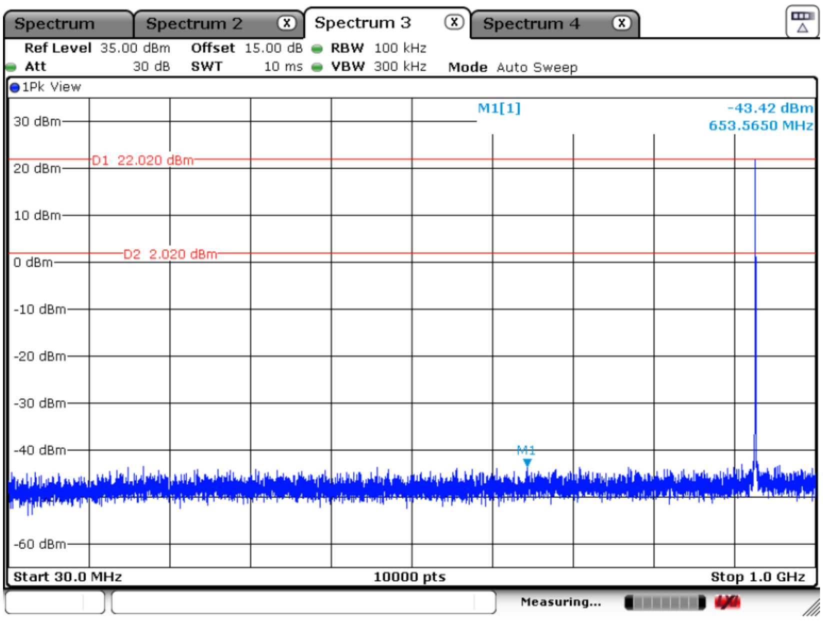
Date: 26.JUN.2022 10:15:52

CSE Plot on Ch 65 between 800 MHz ~ 10 GHz



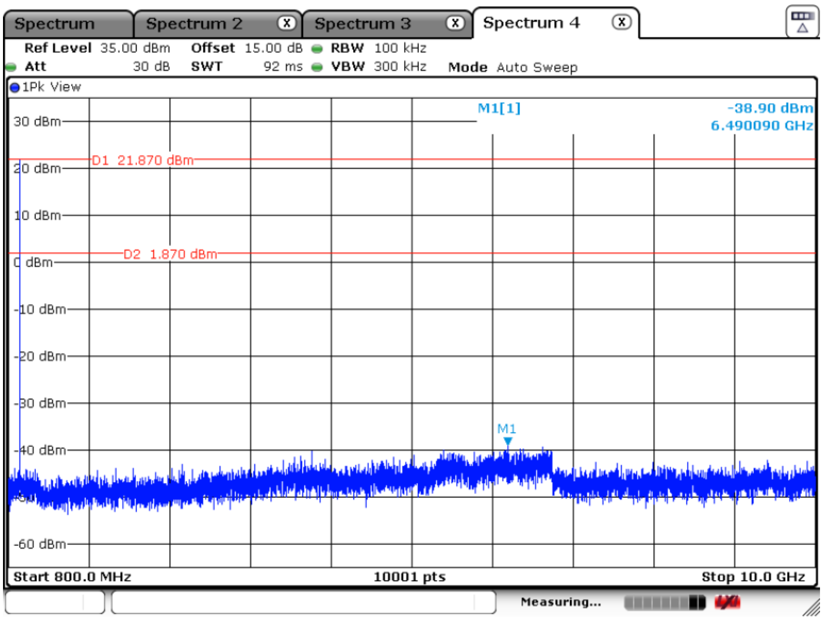
Date: 26.JUN.2022 10:16:52

CSE Plot on Ch 129 between 30MHz ~ 1 GHz



Date: 26.JUN.2022 10:24:57

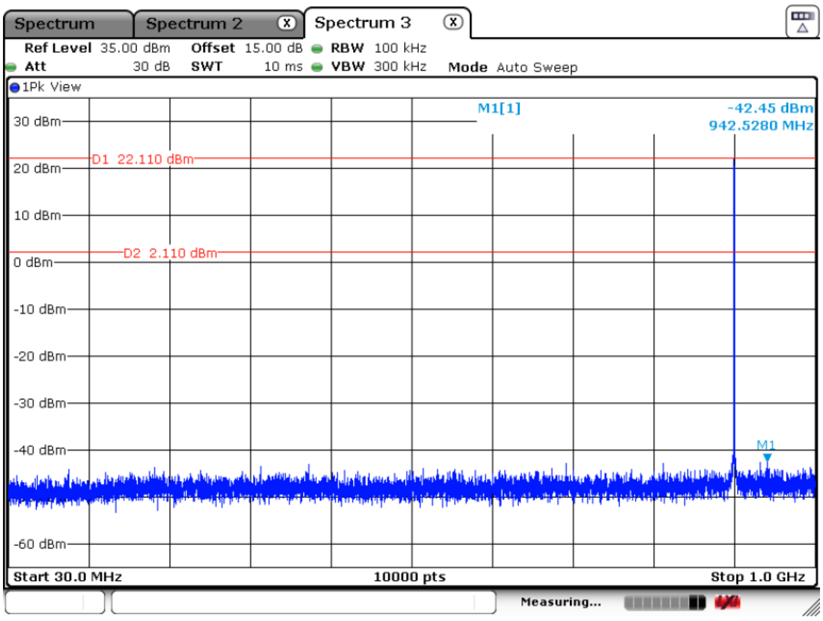
CSE Plot on Ch 129 between 800 MHz ~ 10 GHz



Date: 26.JUN.2022 10:26:35

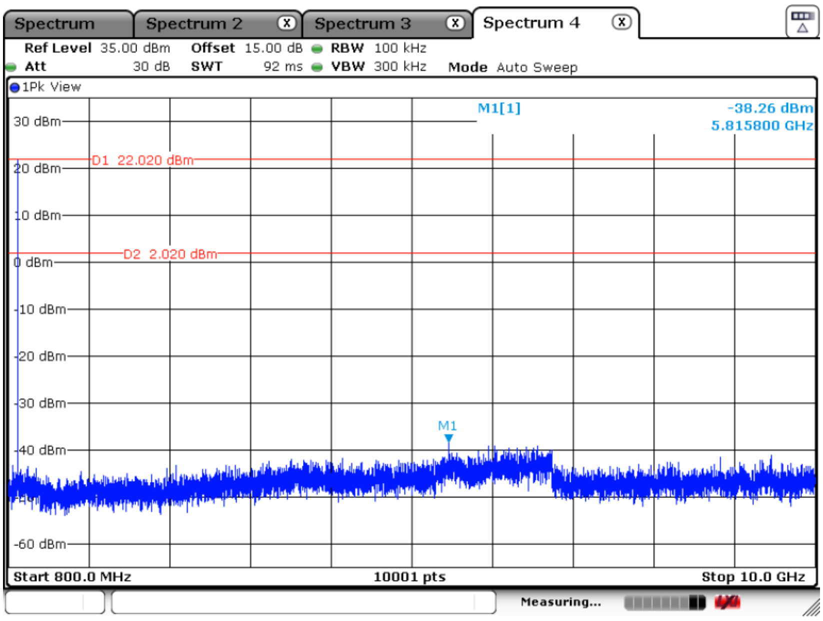
SF8:

CSE Plot on Ch 1 between 30MHz ~ 1 GHz



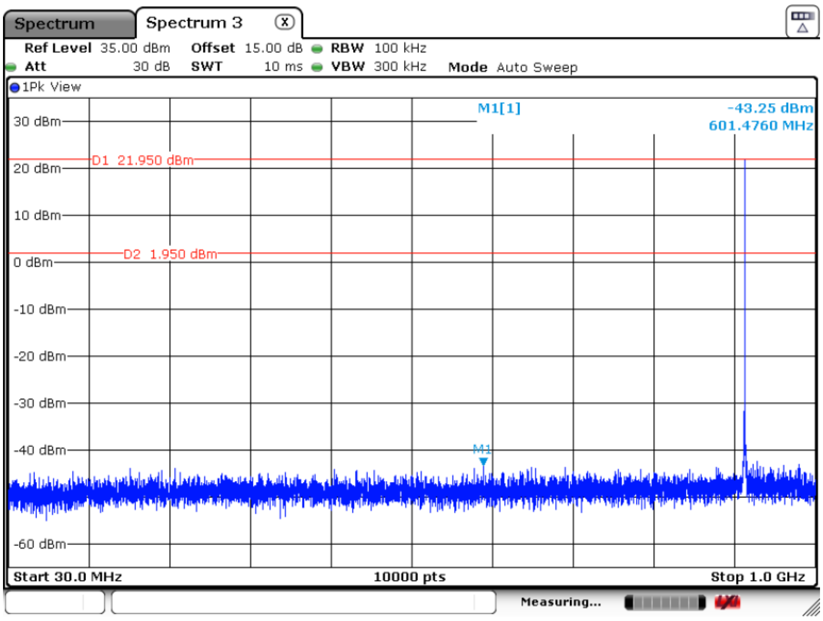
Date: 26.JUN.2022 11:07:57

CSE Plot on Ch 1 between 800 MHz ~ 10 GHz



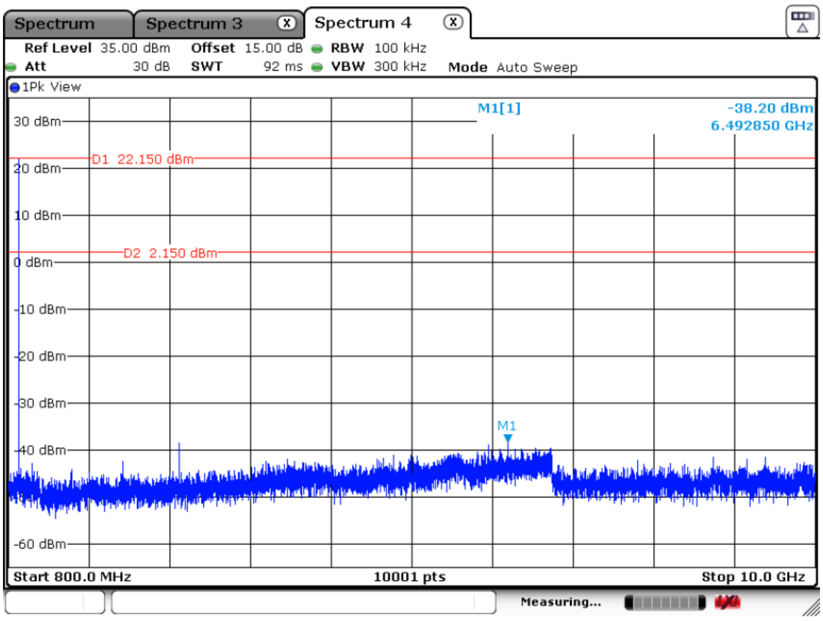
Date: 26.JUN.2022 11:08:58

CSE Plot on Ch 65 between 30MHz ~ 1 GHz



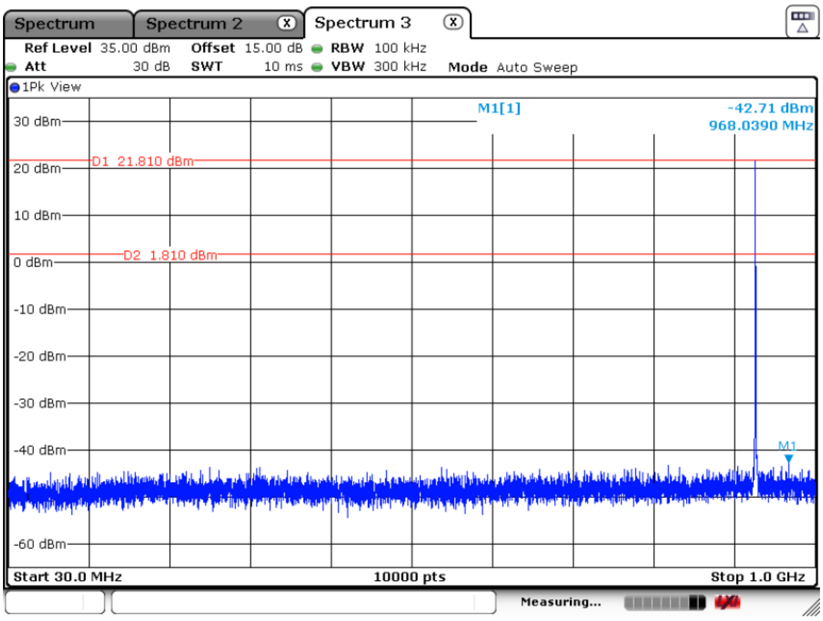
Date: 26.JUN.2022 11:17:55

CSE Plot on Ch 65 between 800 MHz ~ 10 GHz



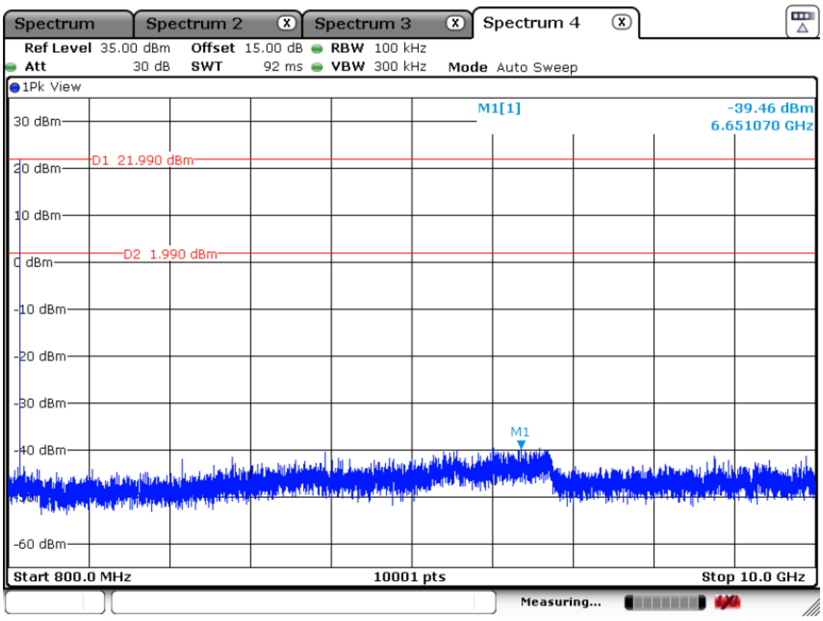
Date: 26.JUN.2022 11:18:35

CSE Plot on Ch 129 between 30MHz ~ 1 GHz



Date: 26.JUN.2022 11:22:31

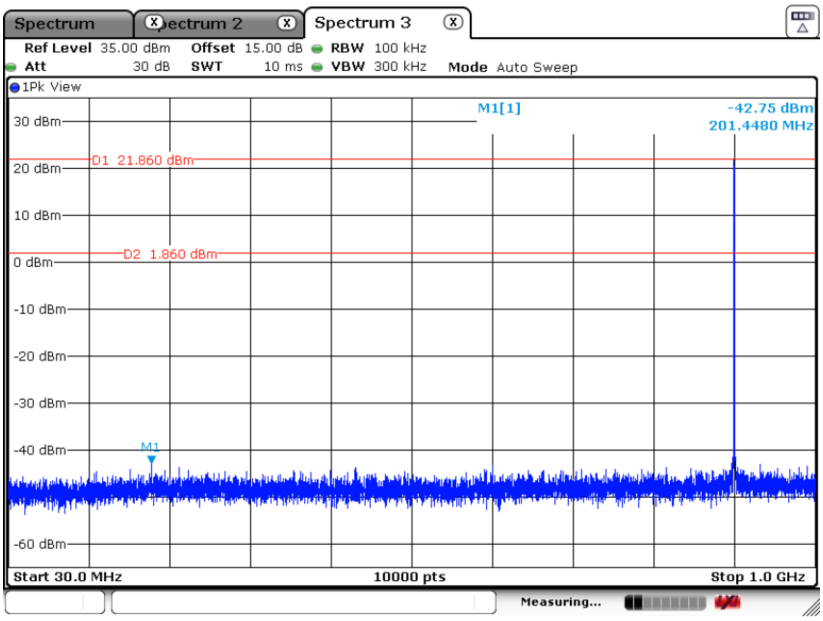
CSE Plot on Ch 129 between 800 MHz ~ 10 GHz



Date: 26.JUN.2022 11:23:47

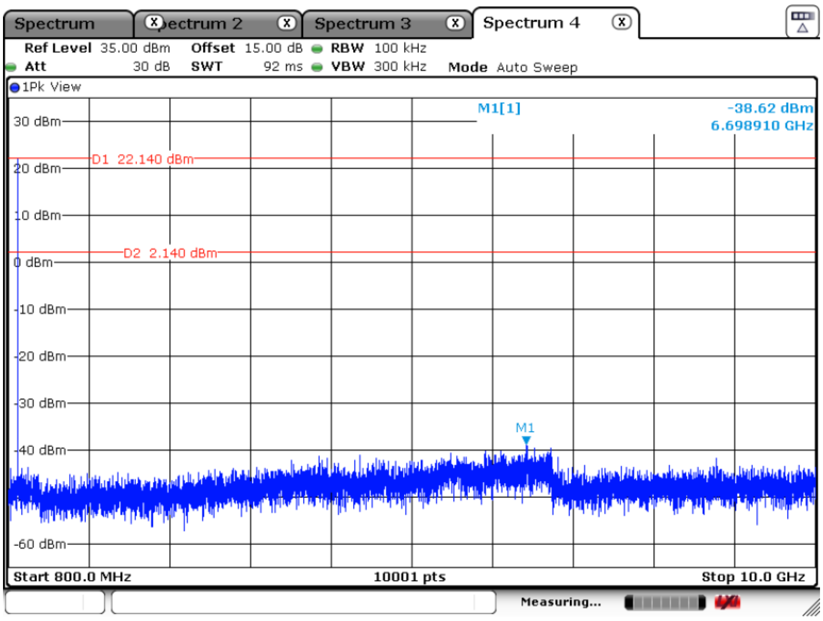
SF9:

CSE Plot on Ch 1 between 30MHz ~ 1 GHz



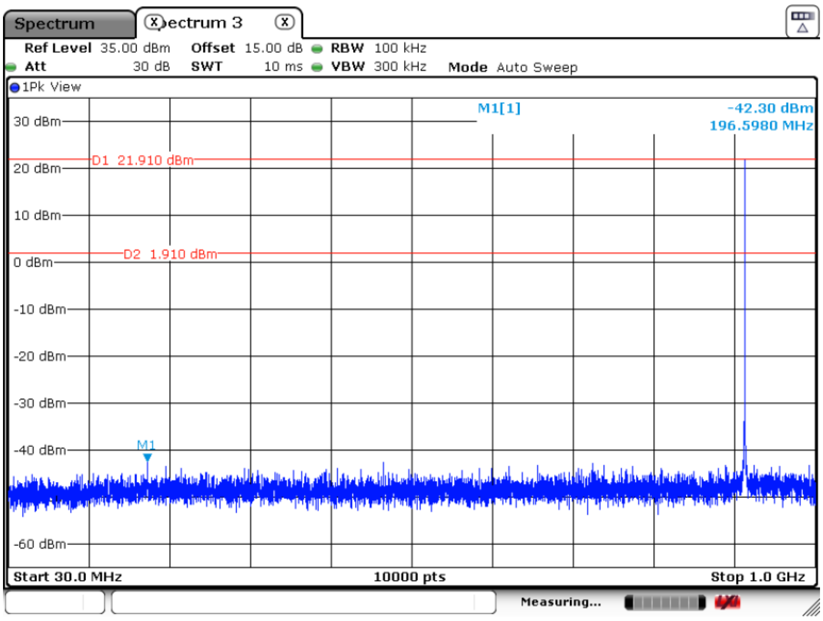
Date: 26.JUN.2022 13:06:10

CSE Plot on Ch 1 between 800 MHz ~ 10 GHz



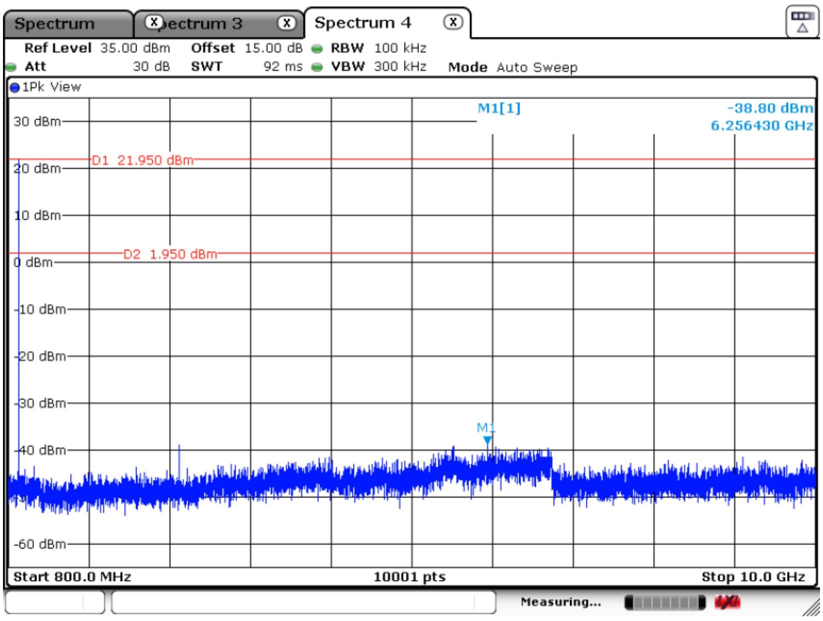
Date: 26.JUN.2022 13:06:53

CSE Plot on Ch 65 between 30MHz ~ 1 GHz



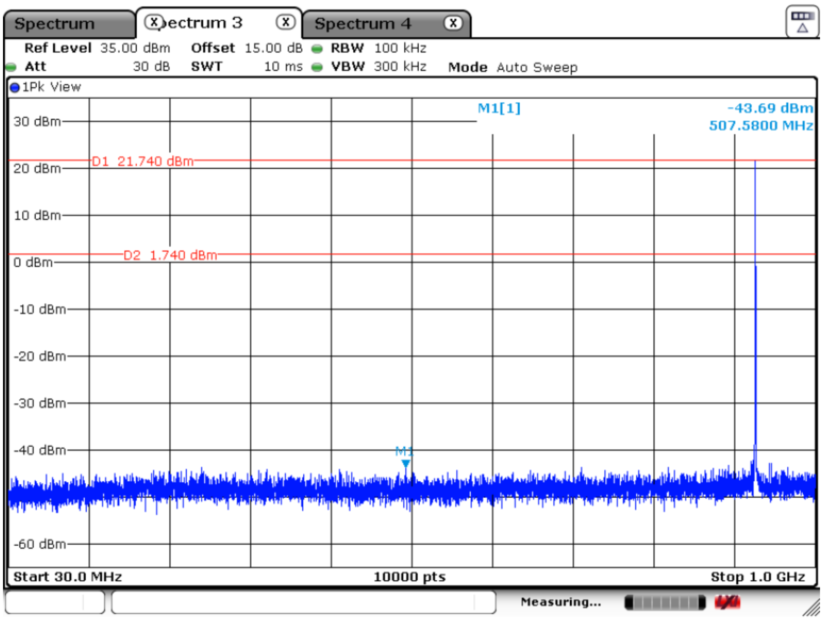
Date: 26.JUN.2022 13:14:52

CSE Plot on Ch 65 between 800 MHz ~ 10 GHz



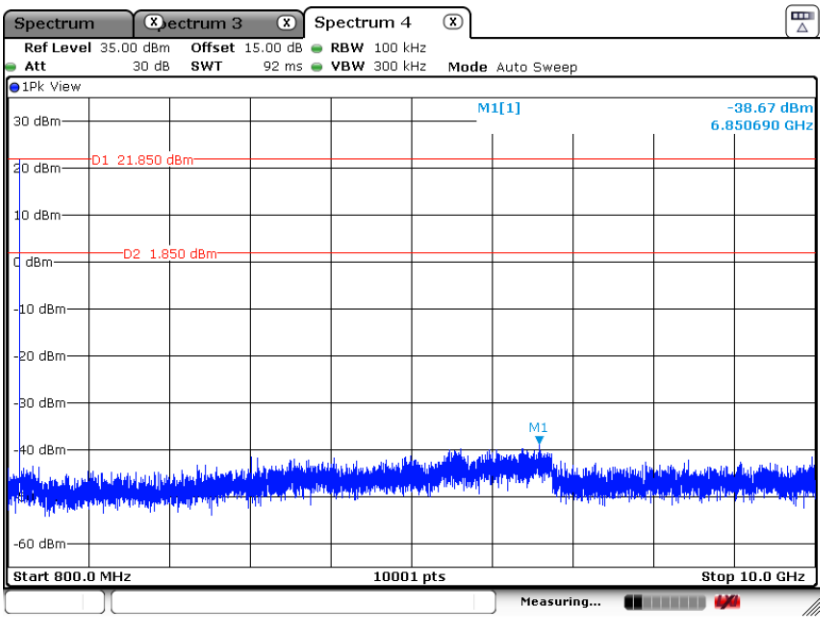
Date: 26.JUN.2022 13:15:38

CSE Plot on Ch 129 between 30MHz ~ 1 GHz



Date: 26.JUN.2022 13:18:01

CSE Plot on Ch 129 between 800 MHz ~ 10 GHz



Date: 26.JUN.2022 13:18:32

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

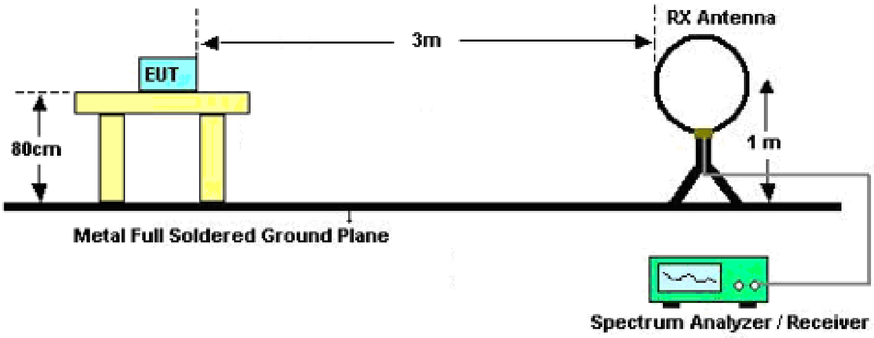
The measuring equipment is listed in the section 4 of this test report.

3.8.3 Test Procedures

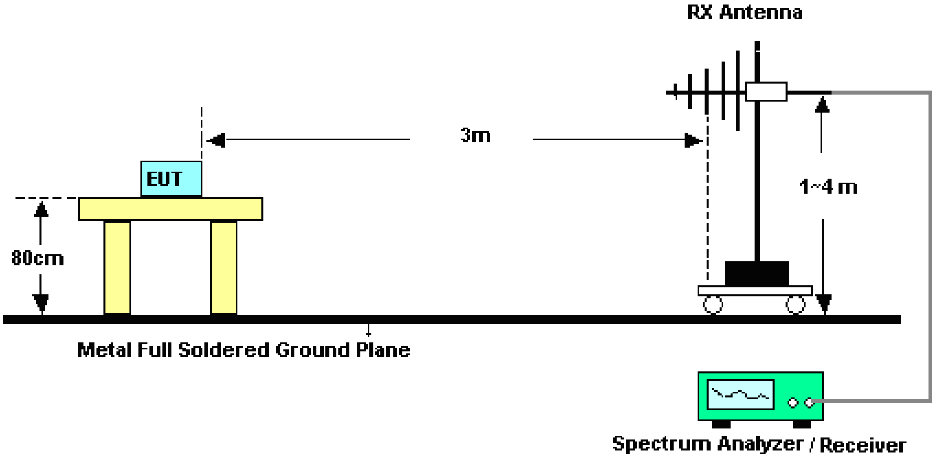
1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. For each suspected emission, 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 ≥ 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

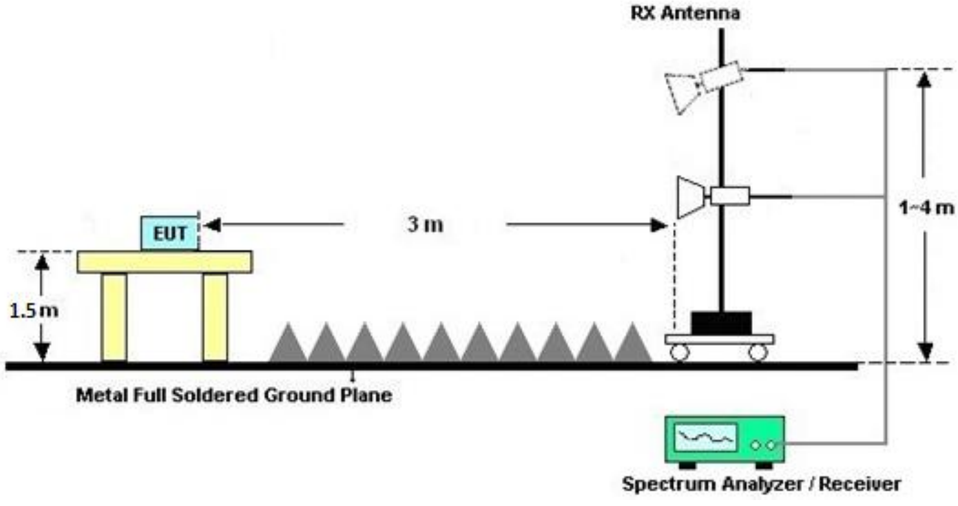
For radiated emissions below 30MHz



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.

3.9 AC Conducted Emission Measurement

3.9.1 Limit of AC Conducted Emission

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

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

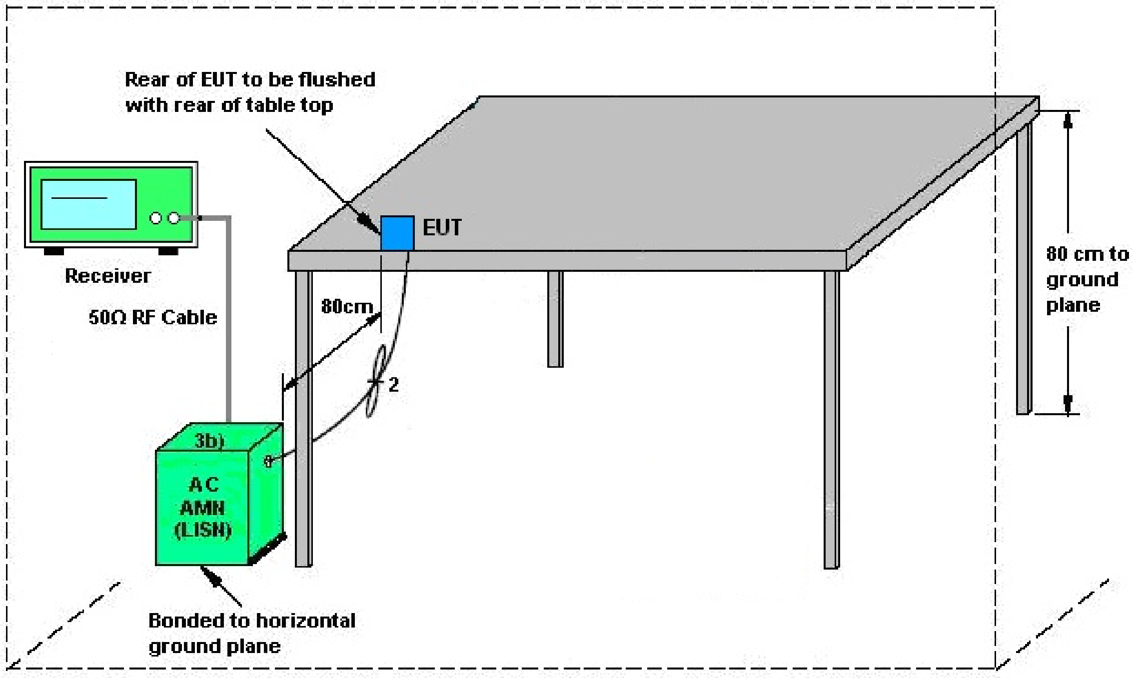
3.9.2 Measuring Instruments

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

3.9.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

3.9.4 Test Setup



AMN = Artificial mains network (LISN)
AE = Associated equipment
EUT = Equipment under test
ISN = Impedance stabilization network

3.9.5 Test Result of AC Conducted Emission

Please refer to Appendix B.

3.10 Antenna Requirements

3.10.1 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.

3.10.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.10.3 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	Jun. 26, 2022~ Jul. 22, 2022	Oct. 13, 2022	Conducted (TH01-KS)
Pulse Power Senor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 05, 2022	Jun. 26, 2022~ Jul. 22, 2022	Jan. 04, 2023	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 05, 2022	Jun. 26, 2022~ Jul. 22, 2022	Jan. 04, 2023	Conducted (TH01-KS)
EMI Test Receiver	R&S	ESR7	101403	9kHz~7GHz;Max 30dBm	Oct. 16, 2021	Jul. 23. 2022	Oct. 15, 2022	Radiation (03CH08-KS)
EXA Spectrum Analyzer	Keysight	N9010B	MY57471084	10Hz-44G,MAX 30dB	Jul. 11, 2022	Jul. 23. 2022	Jul. 10, 2023	Radiation (03CH08-KS)
Loop Antenna	R&S	HFH2-Z2	100321	9kHz~30MHz	Oct. 30, 2021	Jul. 23. 2022	Oct. 29, 2022	Radiation (03CH08-KS)
Bilog Antenna	TESEQ& VGT	CBL 61110	59915	30MHz-1GHz	Sep. 02, 2021	Jul. 23. 2022	Sep. 01, 2022	Radiation (03CH08-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	00240138	1GHz~18GHz	Jul. 18, 2022	Jul. 23. 2022	Jul. 17, 2023	Radiation (03CH08-KS)
high gain Amplifier	MITEQ	AMF-7D-00101800-30-10P	2025788	1Ghz-18Ghz	Jul. 30, 2021	Jul. 23. 2022	Jul. 29, 2022	Radiation (03CH08-KS)
SHF-EHF Horn	Com-power	AH-840	101070	18GHz~40GHz	Jan. 05, 2022	Jul. 23. 2022	Jan. 04, 2023	Radiation (03CH08-KS)
Amplifier	SONOMA	310N	413741	9KHz-1GHz	Jan. 05, 2022	Jul. 23. 2022	Jan. 04, 2023	Radiation (03CH08-KS)
Amplifier	Keysight	83017A	MY53270389	500MHz~26.5GHz	Jan. 05, 2022	Jul. 23. 2022	Jan. 04, 2023	Radiation (03CH08-KS)
Amplifier	MITEQ	EM18G40GGA	060728	18~40GHz	Jan. 05, 2022	Jul. 23. 2022	Jan. 04, 2023	Radiation (03CH08-KS)
AC Power Source	Chroma	61601	616010002473	N/A	NCR	Jul. 23. 2022	NCR	Radiation (03CH08-KS)
Turn Table	MF	MF7802	N/A	0~360 degree	NCR	Jul. 23. 2022	NCR	Radiation (03CH08-KS)
Antenna Mast	MF	MF7802	N/A	1 m~4 m	NCR	Jul. 23. 2022	NCR	Radiation (03CH08-KS)
EMI Receiver	R&S	ESCI7	100768	9kHz~7GHz;	May 24, 2022	Jul. 21, 2022	May 23, 2023	Conduction (CO01-KS)
AC LISN (for auxiliary equipment)	MessTec	AN3016	060103	9kHz~30MHz	Oct. 14, 2021	Jul. 21, 2022	Oct. 13, 2022	Conduction (CO01-KS)
AC LISN	MessTec	AN3016	060105	9kHz~30MHz	May 24, 2022	Jul. 21, 2022	May 23, 2023	Conduction (CO01-KS)
AC Power Source	Chroma	61602	ABP000000811	AC 0V~300V, 45Hz~1000Hz	Oct. 14, 2021	Jul. 21, 2022	Oct. 13, 2022	Conduction (CO01-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 Conducted Emission Measurement (150kHz ~ 30MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**2.94dB**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**4.9dB**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Appendix A. Conducted Test Results

Test Engineer:	Albert Shi	**Temperature:**	20~26°C
Test Date:	2022/6/26~2022/7/22	**Relative Humidity:**	40~51%

LoRa-FHSS-Spreading Factor 7

TEST RESULTS DATA
20dB and 99% Occupied Bandwidth and Hopping Channel Separation

Mod.	NTX	CH.	Freq. (MHz)	20db BW (MHz)	99% Bandwidth (MHz)	Hopping Channel Separation Measurement (MHz)	Hopping Channel Separation Measurement Limit (MHz)	Pass/Fail
SF7	1	1	902.2	0.141	0.122	0.231	0.141	Pass
SF7	1	65	915	0.151	0.131	0.217	0.151	Pass
SF7	1	129	927.8	0.152	0.131	0.174	0.152	Pass

TEST RESULTS DATA
Dwell Time

Mod.	CH.	DT On-time per hop (ms)	Total hops over 20sec	Dwell Time (sec)	Limits (sec)	Pass/Fail
SF7	hopping	224.674	1.00	0.22	0.4	Pass

TEST RESULTS DATA
Peak Power Table

mode	Freq. (MHz)	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
SF7	902.2	1	**21.93**	30.00	Pass
	915	1	21.90	30.00	Pass
	927.8	1	21.85	30.00	Pass

TEST RESULTS DATA
Number of Hopping Frequency

Number of Hopping (Channel)	Limits (Channel)	Pass/Fail
129	> 50	Pass

LoRa-FHSS-Spreading Factor 7

TEST RESULTS DATA
20dB and 99% Occupied Bandwidth and Hopping Channel Separation

Mod.	NTX	CH.	Freq. (MHz)	20db BW (MHz)	99% Bandwidth (MHz)	Hopping Channel Separation Measurement (MHz)	Hopping Channel Separation Measurement Limit (MHz)	Pass/Fail
SF8	1	1	902.2	0.143	0.127	0.205	0.143	Pass
SF8	1	65	915	0.151	0.131	0.193	0.151	Pass
SF8	1	129	927.8	0.151	0.130	0.294	0.151	Pass

TEST RESULTS DATA
Dwell Time

Mod.	CH.	DT On-time per hop (ms)	Total hops over 20sec	Dwell Time (sec)	Limits (sec)	Pass/Fail
SF8	hopping	308.677	1.00	0.31	0.4	Pass

TEST RESULTS DATA
Peak Power Table

mode	Freq. (MHz)	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
SF8	902.2	1	**21.91**	30.00	Pass
	915	1	21.89	30.00	Pass
	927.8	1	21.85	30.00	Pass

TEST RESULTS DATA
Number of Hopping Frequency

Number of Hopping (Channel)	Limits (Channel)	Pass/Fail
129	> 50	Pass