RF MEASUREMENT REPORT

FCC ID:	2APPT-2821
Applicant:	Airthings ASA
Product:	Hub Cellular
Model No.:	2820
Brand Name:	Airthings
FCC Classification:	FCC Part 15 Spread Spectrum Transmitter (DSS)
FCC Rule Part(s):	Part15 Subpart C (Section 15.247)
Result:	Complies
Received Date:	2023-03-09
Test Date:	2023-03-11 ~ 2023-06-08

Reviewed By: Sunny Sun

Approved By: Robin Wu

ACCREDITED
TESTING LABORATORY
CERTIFICATE #3628.01

The test results relate only to the samples tested.
The test results shown in the test report are traceable to the national/international standards through the calibration of the equipment and evaluated measurement uncertainty herein.
The test report shall not be reproduced except in full without the written approval of MRT Technology (Suzhou) Co., Ltd.

Revision History

Report No.	Version	Description	Issue Date	Note
2303RSU022-U2	V01	Initial Report	2023-06-15	Invalid
2303RSU022-U2	V02	Revise the Calibration Date of Equipment	2023-07-23	Valid

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1. General Information

1.1. Applicant

Airthings ASA

Wergelandsveien 7, 0167 Oslo, Norway

1.2. Manufacturer

Crow Electronic Engineering Ltd.

12 Kineret St. Airport City, Zip: 70100, Israel

1.3. Testing Facility

☒	**Test Site – MRT Suzhou Laboratory**				
	Laboratory Location (Suzhou - Wuzhong) D8 Building, No.2 Tian'edang Rd., Wuzhong Economic Development Zone, Suzhou, China **Laboratory Location (Suzhou - SIP)** 4b Building, Liando U Valley, No.200 Xingpu Rd., Shengpu Town, Suzhou Industrial Park, China				
	Laboratory Accreditations				
	A2LA: 3628.01		CNAS: L10551		
	FCC: CN1166		ISED: CN0001		
	VCCI:	☐R-20025	☐G-20034	☐C-20020	☐T-20020
		☐R-20141	☐G-20134	☐C-20103	☐T-20104
☐	**Test Site – MRT Shenzhen Laboratory**				
	Laboratory Location (Shenzhen) 1G, Building A, Junxiangda Building, Zhongshanyuan Road West, Nanshan District, Shenzhen, China				
	Laboratory Accreditations				
	A2LA: 3628.02		CNAS: L10551		
	FCC: CN1284		ISED: CN0105		
☐	**Test Site – MRT Taiwan Laboratory**				
	Laboratory Location (Taiwan) No. 38, Fuxing 2nd Rd., Guishan Dist., Taoyuan City 333, Taiwan (R.O.C.)				
	Laboratory Accreditations				
	TAF: L3261-190725				
	FCC: 291082, TW3261		ISED: TW3261		

1.4. Product Information

Product	Hub Cellular
Model No.	2820
EUT Identification No.	CERT_HUB_21, CERT_HUB_23 for Conducted measurement CERT_ HUB_23, CERT_ HUB_30 for Radiated measurement
SmartLink Specification	905.6 ~ 926 MHz
GSM	GSM 850, GSM 1900
LTE Cat M1	Band 2, 4, 5, 12, 13, 26
Antenna Information	Refer to 1.5.
Operating Temp.	0 ~ 45°C
Integrated Modular	
FCC ID	XMR201707BG96
IC	10224A-201709BG96
Model	BG96
Company Name	Quectel Wireless Solution Co., Ltd
Accessories	
Adapter	Model No.: MP12-050160-AX Input: 100V-240V~50/60Hz, 0.4A Max Output: 5.0V⎓1.6A
Note: The information of EUT was provided by the manufacturer, and the accuracy of the information shall be the responsibility of the manufacturer.	

1.5. Radio Specification under Test

Frequency Range	905.6 ~ 926 MHz
Channel Number	52
Type of modulation	FHSS
Antenna Type	PCB Antenna
Antenna Gain	2.77 dBi

1.6. Working Frequencies

Channel	Frequency	Channel	Frequency	Channel	Frequency
1	905.6MHz	2	906.0MHz	3	906.4MHz
4	906.8MHz	5	907.2MHz	6	907.6MHz
7	908.0MHz	8	908.4MHz	9	908.8MHz
10	909.2MHz	11	909.6MHz	12	910.0MHz
13	910.4MHz	14	910.8MHz	15	911.2MHz
16	911.6MHz	17	912.0MHz	18	912.4MHz
19	912.8MHz	20	913.2MHz	21	913.6MHz
22	914.0MHz	23	914.4MHz	24	914.8MHz
25	915.2MHz	26	915.6MHz	27	916.0MHz
28	916.4MHz	29	916.8MHz	30	917.2MHz
31	917.6MHz	32	918.0MHz	33	918.4MHz
34	918.8MHz	35	919.2MHz	36	919.6MHz
37	920.0MHz	38	920.4MHz	39	920.8MHz
40	921.2MHz	41	921.6MHz	42	922.0MHz
43	922.4MHz	44	922.8MHz	45	923.2MHz
46	923.6MHz	47	924.0MHz	48	924.4MHz
49	924.8MHz	50	925.2MHz	51	925.6MHz
52	926.0MHz	-	-	-	-

2. Test Configuration

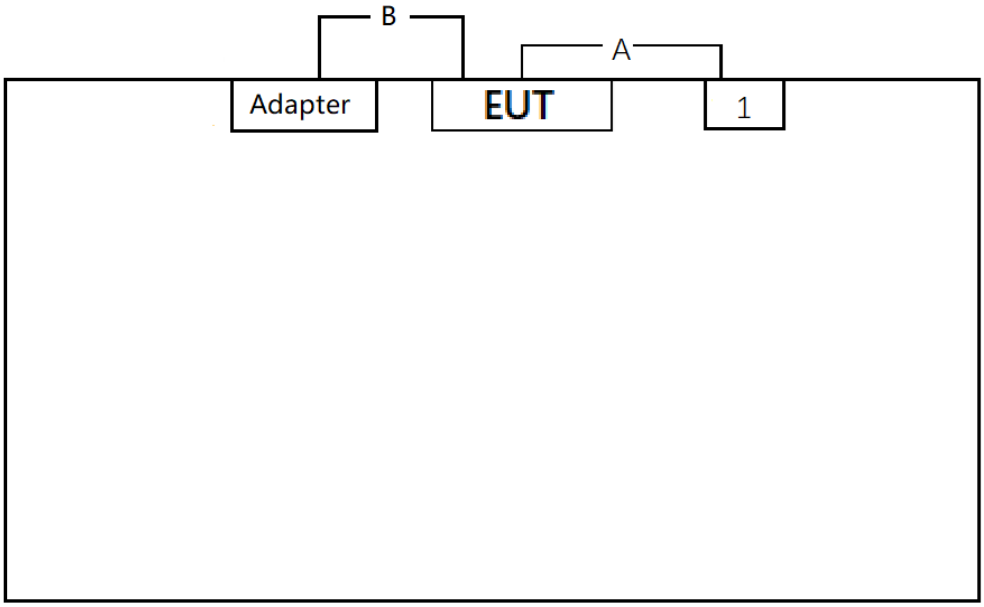
2.1. Test Mode

Mode 1: Transmit by SmartLink

2.2. Test System Connection Diagram

The device was tested per the guidance ANSI C63.10: 2013 was used to reference the appropriate EUT setup for radiated emissions testing and AC line conducted testing.

Connection Diagram – Radiated Emission testing & AC conducted Emissions



Cable Type		Cable Spec.	Length
A	USB Cable	Shielding	1m
B	Power Cable	Non-shielding	1.5 m
Product		**Manufacturer**	**Model No.**
1	Notebook	DELL	DELL Inspiron 5359

2.3. Test Software

The test utility software used during testing was “IPOP”, and the version was 4.1.

2.4. Applied Standards

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

- FCC Part 15.247
- KDB 558074 D01v05r02
- ANSI C63.10-2013

2.5. Test Environment Condition

Ambient Temperature	15 ~ 35 °C
Relative Humidity	20 ~ 75 %RH

3. Antenna Requirement

Excerpt from §15.203 of the FCC Rules/Regulations:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. 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 provisions of this section."

- The antenna of the device is **permanently attached.**

Conclusion:

The unit complies with the requirement of §15.203.

4. Measuring Instrument

Instrument	Manufacturer	Model No.	Asset No.	Cali. Interval	Cali. Due Date	Test Site
EMI Test Receiver	R&S	ESR7	MRTSUE06001	1 year	2023-12-28	WZ-AC1
Horn Antenna	Schwarzbeck	BBHA 9120D	MRTSUE06023	1 year	2023-08-22	WZ-AC1
Preamplifier	Agilent	83017A	MRTSUE06076	1 year	2023-05-08	WZ-AC1
Preamplifier	Agilent	83017A	MRTSUE06076	1 year	2024-05-07	WZ-AC1
TRILOG Antenna	Schwarzbeck	VULB 9168	MRTSUE06172	1 year	2023-06-21	WZ-AC1
Anechoic Chamber	TDK	WZ-AC1	MRTSUE06212	1 year	2023-04-21	WZ-AC1
Anechoic Chamber	TDK	WZ-AC1	MRTSUE06212	1 year	2024-04-20	WZ-AC1
Thermohygrometer	testo	608-H1	MRTSUE06403	1 year	2023-06-01	WZ-AC1
Thermohygrometer	testo	608-H1	MRTSUE06403	1 year	2024-05-31	WZ-AC1
Signal Analyzer	Keysight	N9010B	MRTSUE06607	1 year	2023-12-28	WZ-AC1
Thermohygrometer	testo	608-H1	MRTSUE11039	1 year	2023-11-01	WZ-AC1
Loop Antenna	Schwarzbeck	FMZB 1519	MRTSUE06025	1 year	2023-09-29	WZ-AC1/AC2
TRILOG Antenna	Schwarzbeck	VULB 9162	MRTSUE06022	1 year	2023-05-16	WZ-AC2
TRILOG Antenna	Schwarzbeck	VULB 9162	MRTSUE06022	1 year	2024-05-15	WZ-AC2
EMI Test Receiver	Agilent	N9038A	MRTSUE06125	1 year	2023-05-24	WZ-AC2
EMI Test Receiver	Agilent	N9038A	MRTSUE06125	1 year	2024-05-23	WZ-AC2
Thermohygrometer	Mingle	ETH529	MRTSUE06170	1 year	2023-11-27	WZ-AC2
Horn Antenna	Schwarzbeck	BBHA 9120D	MRTSUE06171	1 year	2023-10-13	WZ-AC2
Preamplifier	Schwarzbeck	BBV 9718	MRTSUE06176	1 year	2023-05-08	WZ-AC2
Preamplifier	Schwarzbeck	BBV 9718	MRTSUE06176	1 year	2024-05-07	WZ-AC2
Anechoic Chamber	RIKEN	WZ-AC2	MRTSUE06213	1 year	2023-04-21	WZ-AC2
Anechoic Chamber	RIKEN	WZ-AC2	MRTSUE06213	1 year	2024-04-20	WZ-AC2
Thermohygrometer	testo	608-H1	MRTSUE11038	1 year	2023-11-01	WZ-AC2
Signal Analyzer	Keysight	N9010B	MRTSUE06457	1 year	2023-05-24	WZ-SR5
Signal Analyzer	Keysight	N9010B	MRTSUE06457	1 year	2024-05-23	WZ-SR5
Thermohygrometer	testo	608-H1	MRTSUE06402	1 year	2023-06-01	WZ-SR5
Thermohygrometer	testo	608-H1	MRTSUE06402	1 year	2024-05-31	WZ-SR5
Shielding Room	HUAMING	WZ-SR5	MRTSUE06442	N/A	N/A	WZ-SR5
Attenuator	MVE	MVE2213	MRTSUE11093	1 year	2023-06-09	WZ-SR5
Signal Analyzer	Agilent	N9020A	MRTSUE06106	1 year	2024-02-29	WZ-SR5
Oscilloscope	Agilent	DSO-X 6002A	MRTSUE06107	1 year	2024-02-29	WZ-SR5
Two-Line V-Network	R&S	ENV216	MRTSUE06002	1 year	2023-05-24	WZ-SR2
Two-Line V-Network	R&S	ENV216	MRTSUE06002	1 year	2024-05-23	WZ-SR2
Symmetrical Attenuator	Schwarzbeck	SYMAT 40	MRTSUE06117	1 year	2023-04-10	WZ-SR2
Symmetrical Attenuator	Schwarzbeck	SYMAT 40	MRTSUE06117	1 year	2024-04-09	WZ-SR2

Instrument	Manufacturer	Model No.	Asset No.	Cali. Interval	Cali. Due Date	Test Site
Shielding Room	MIX-BEP	WZ-SR2	MRTSUE06215	5 years	2026-12-20	WZ-SR2
Thermohygrometer	testo	608-H1	MRTSUE06404	1 year	2023-06-01	WZ-SR2
Thermohygrometer	testo	608-H1	MRTSUE06404	1 year	2024-05-31	WZ-SR2
EMI Test Receiver	R&S	ESR3	MRTSUE06909	1 year	2023-10-27	WZ-SR2

Software	Version	Function
EMI Software	V3.0.0	EMI Test Software
Controller_MF 7802	2.03C	RE Antenna & Turntable
Controller_MF 7802	1.02	RE Antenna & Turntable

5. Decision Rules and Measurement Uncertainty

5.1. Decision Rules

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4: 2012 Clause 8.2.

(Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

5.2. Measurement Uncertainty

Where relevant, the following test uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k = 2.

AC Conducted Emission Measurement
The maximum measurement uncertainty is evaluated as: 9kHz~150kHz: 3.58dB 150kHz~30MHz: 3.20dB
Radiated Disturbance
The maximum measurement uncertainty is evaluated as: Coaxial: 9kHz~30MHz: 2.59dB Coplanar: 9kHz~30MHz: 2.60dB Horizontal: 30MHz~200MHz: 3.85dB 200MHz~1GHz: 4.36dB 1GHz~10GHz: 4.98dB Vertical: 30MHz~200MHz: 4.06dB 200MHz~1GHz: 5.28dB 1GHz~10GHz: 4.91dB
Spurious Emissions, Conducted
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 2.30dB
Output Power
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 2.30dB
Occupied Bandwidth
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 3.20%

6. Test Result

6.1. Summary

FCC Section(s)	Test Description	Test Condition	Verdict
15.247(a)(1)(i)	20dB Bandwidth	Conducted	Pass
15.247(b)(2)	Output Power		Pass
15.247(a)(1)(i)	Carrier Frequency Separation		Pass
15.247(a)(1)(i)	Number of Channels		Pass
15.247(a)(1)(i)	Time of Occupancy		Pass
15.247(d)	Band Edge / Out- of-Band Emissions		Pass
15.205, 15.209	General Field Strength (Restricted Bands and Radiated Emission)	Radiated	Pass
15.207	AC Conducted Emissions 150kHz - 30MHz	Line Conducted	Pass

Notes:

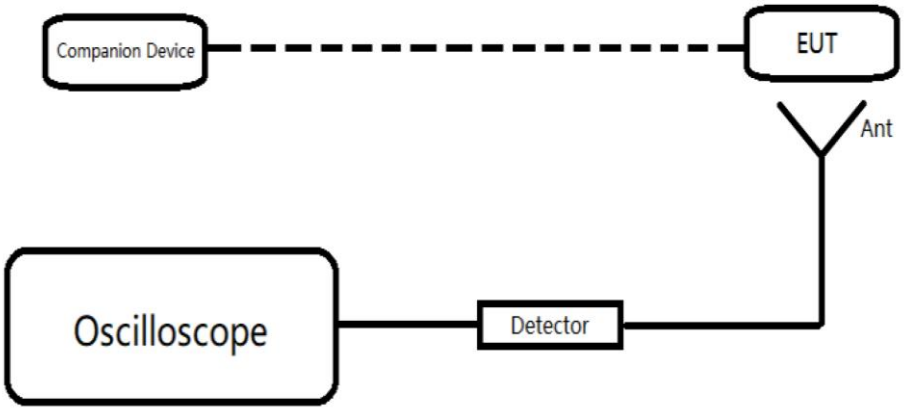
1. The analyzer plots shown in this section were all taken with a correction table loaded into the analyzer. The correction table was used to account for the losses of the cables and attenuators used as part of the system to connect the EUT to the analyzer at all frequencies of interest.
2. For radiated emission test, every axis (X, Y, Z) was also verified. The test results shown in the following sections represent the worst-case emissions.

6.2. Duty Cycle

6.2.1. Test Limit

N/A

6.2.2. Test Setup



6.2.3. Test Procedure

In normal use, the EUT connects to companion device via SRD. The hub cellular will send signal only when it detects the signal sent by the companion device.

Due to the signal is hopping signal, so we use oscilloscope to test the signal.

1. Connect the EUT to the companion device, companion device is set to transmit signal once a minute (the minimum transmit time)

2. Use oscilloscope to test signal via crystal detector. The crystal detector can convert RF power levels applied to the 50-Ω input connector into proportional values of DC voltage. The output voltage polarity is negative.

6.2.4. Test Result

Refer to Appendix A.1.

6.3. 20dB Bandwidth Measurement

6.3.1. Test Limit

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

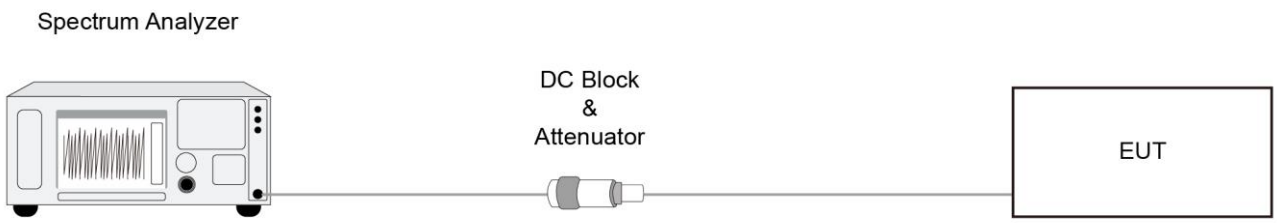
6.3.2. Test Procedure

ANSI C63.10-2013 - Section 6.9.2 (20dB Bandwidth)

6.3.3. Test Setting

1. Set RBW = 1% to 5% of the 20dB bandwidth
2. VBW = approximately three times RBW
3. Span = approximately 2 to 5 times the 20dB bandwidth, centered on a hopping channel
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. Allow the trace to stabilize
8. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 20 dB relative to the maximum level measured in the fundamental emission.

6.3.4. Test Setup



6.3.5. Test Result

Refer to Appendix A.2.

6.4. Output Power Measurement

6.4.1. Test Limit

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

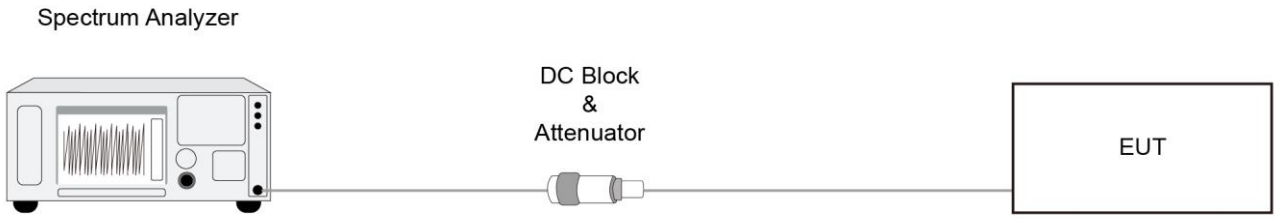
6.4.2. Test Procedure

ANSI C63.10-2013 - Section 7.8.5

6.4.3. Test Setting

1. Set RBW ≥ the 20 dB bandwidth of the emission being measured.
2. VBW ≥ RBW
3. Span = approximately five times the 20dB bandwidth, centered on a hopping channel
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. Allow the trace to stabilize, Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power (don't forget added the external attenuation and cable loss)

6.4.4. Test Setup



6.4.5. Test Result

Refer to Appendix A.3.

6.5. Carrier Frequency Separation Measurement

6.5.1. Test Limit

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.

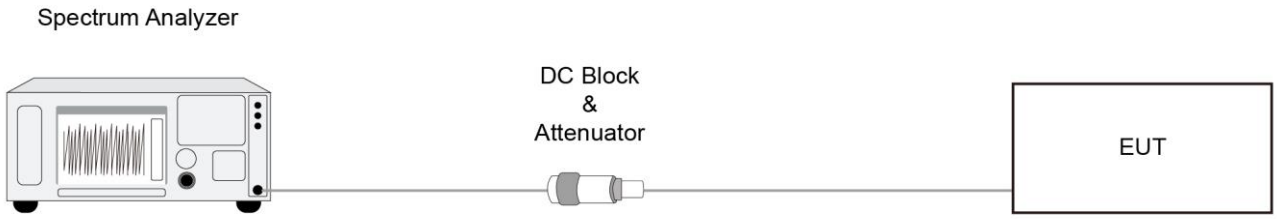
6.5.2. Test Procedure

ANSI C63.10-2013 - Section 7.8.2.

6.5.3.Test Setting

1. Span = wide enough to capture the peaks of two adjacent channels.
2. Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
3. VBW ≥ RBW
4. Sweep time = Auto couple
5. Detector = Peak
6. Trace mode = Max hold
7. Allowed the trace to stabilize
8. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

6.5.4. Test Setup



6.5.5. Test Result

Refer to Appendix A.4.

6.6. Number of Hopping Channels Measurement

6.6.1. Test Limit

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; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies.

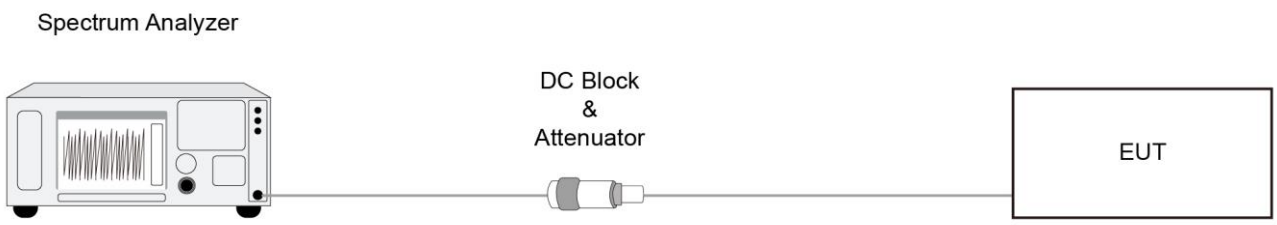
6.6.2. Test Procedure

ANSI C63.10-2013 - Section 7.8.3.

6.6.3. Test Settitng

1. Span = the frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
2. To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3. VBW ≥ RBW
4. Sweep time = Auto couple
5. Detector = Peak
6. Trace mode = Max hold
7. Allow the trace to stabilize

6.6.4. Test Setup



6.6.5. Test Result

Refer to Appendix A.5.

6.7. Time of Occupancy Measurement

6.7.1. Test Limit

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 average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

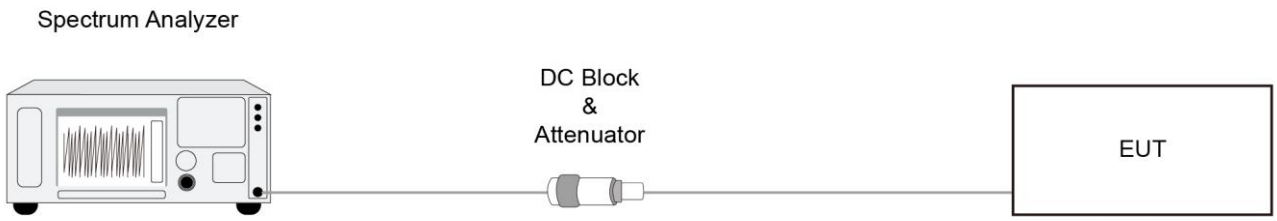
6.7.2. Test Procedure

ANSI C63.10-2013 - Section 7.8.4.

6.7.3. Test Settitng

1. Span = zero span, centered on a hopping channel.
2. RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
3. VBW ≥ RBW
4. Sweep time = as necessary to capture the entire dwell time per hopping channel
5. Detector = Peak
6. Trace mode = max hold
7. Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time. An oscilloscope may be used instead of a spectrum analyzer. The EUT shall show compliance with the appropriate regulatory limit for the number of hopping channels. A plot of the data shall be included in the test report.

6.7.4. Test Setup



6.7.5. Test Result

Refer to Appendix A.6.

6.8. Band-edge Compliance Measurement

6.8.1. Test Limit

The maximum permissible emission level is 20dBc. Any emissions were lying outside of the emission bandwidth and in authorized band edges to a field strength limit specified in Section 15.209 of the Title 47 CFR.

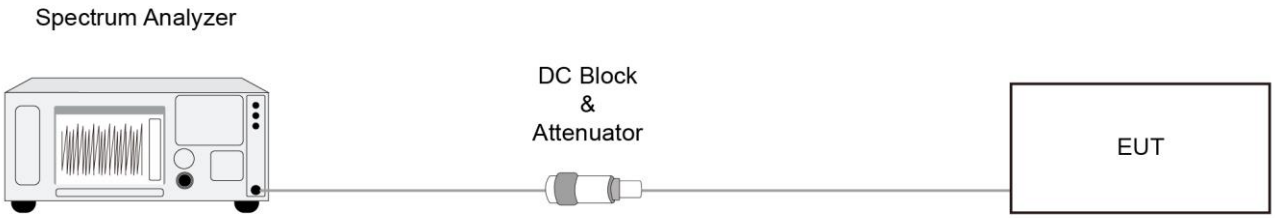
6.8.2. Test Procedure

ANSI C63.10-2013 - Section 6.10.4.

6.8.3. Test Setting

1. Span = wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.
2. RBW = 100kHz
3. VBW = 300kHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize
8. Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission.

6.8.4. Test Setup



6.8.5. Test Result

Refer to Appendix A.7.

6.9. Conducted Spurious Emissions Measurement

6.9.1. Test Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

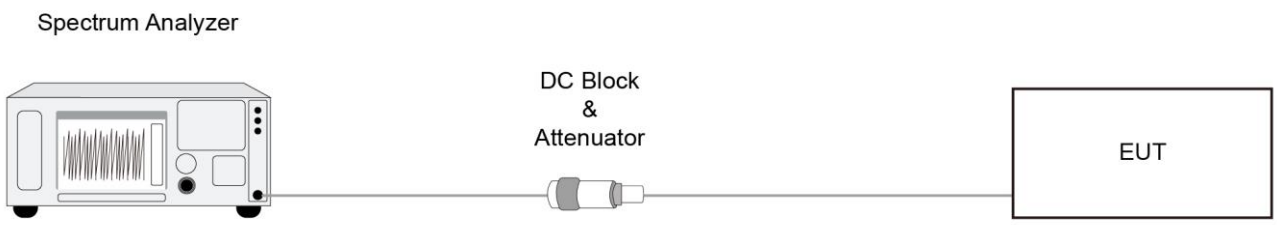
6.9.2. Test Procedure

ANSI C63.10-2013 - Section 7.8.8.

6.9.3. Test Setting

1. Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
2. RBW = 100kHz
3. VBW = 300kHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize
8. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the limit specified in this section.

6.9.4. Test Setup



6.9.5. Test Result

Refer to Appendix A.8.

6.10. Radiated Spurious Emission Measurement

6.10.1. Test Limit

All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47 CFR must not exceed the limits shown in Table per Section 15.209.

FCC Part 15 Subpart C Paragraph 15.209		
Frequency [MHz]	Field Strength [uV/m]	Measured Distance [Meters]
0.009 - 0.490	2400/F (kHz)	300
0.490 - 1.705	24000/F (kHz)	30
1.705 - 30	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

6.10.2. Test Procedure

ANSI C63.10 Section 6.3 (General Requirements)

ANSI C63.10 Section 6.4 (Standard test method below 30MHz)

ANSI C63.10 Section 6.5 (Standard test method above 30MHz to 1GHz)

ANSI C63.10 Section 6.6 (Standard test method above 1GHz)

6.10.3. Test Setting

Table 1 - RBW as a function of frequency

Frequency	RBW
9 ~ 150 kHz	200 ~ 300 Hz
0.15 ~ 30 MHz	9 ~ 10 kHz
30 ~ 1000 MHz	100 ~ 120 kHz
> 1000 MHz	1 MHz

Quasi-Peak Measurements below 1GHz

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. Span was set greater than 1MHz
3. RBW = as specified in Table 1
4. Detector = CISPR quasi-peak
5. Sweep time = auto couple
6. Trace was allowed to stabilize

Peak Measurements above 1GHz

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

Average Measurements above 1GHz (Method VB)

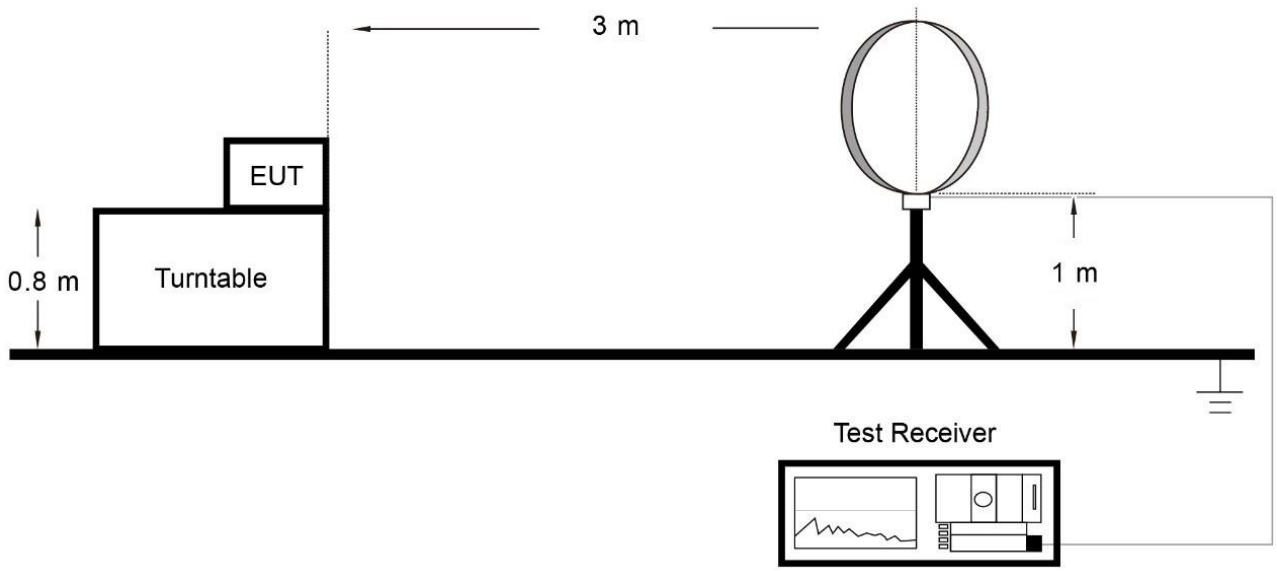
1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW; If the EUT is configured to transmit with duty cycle ≥ 98%, set VBW = 10 Hz.

If the EUT duty cycle is < 98%, set VBW ≥ 1/T. T is the minimum transmission duration.

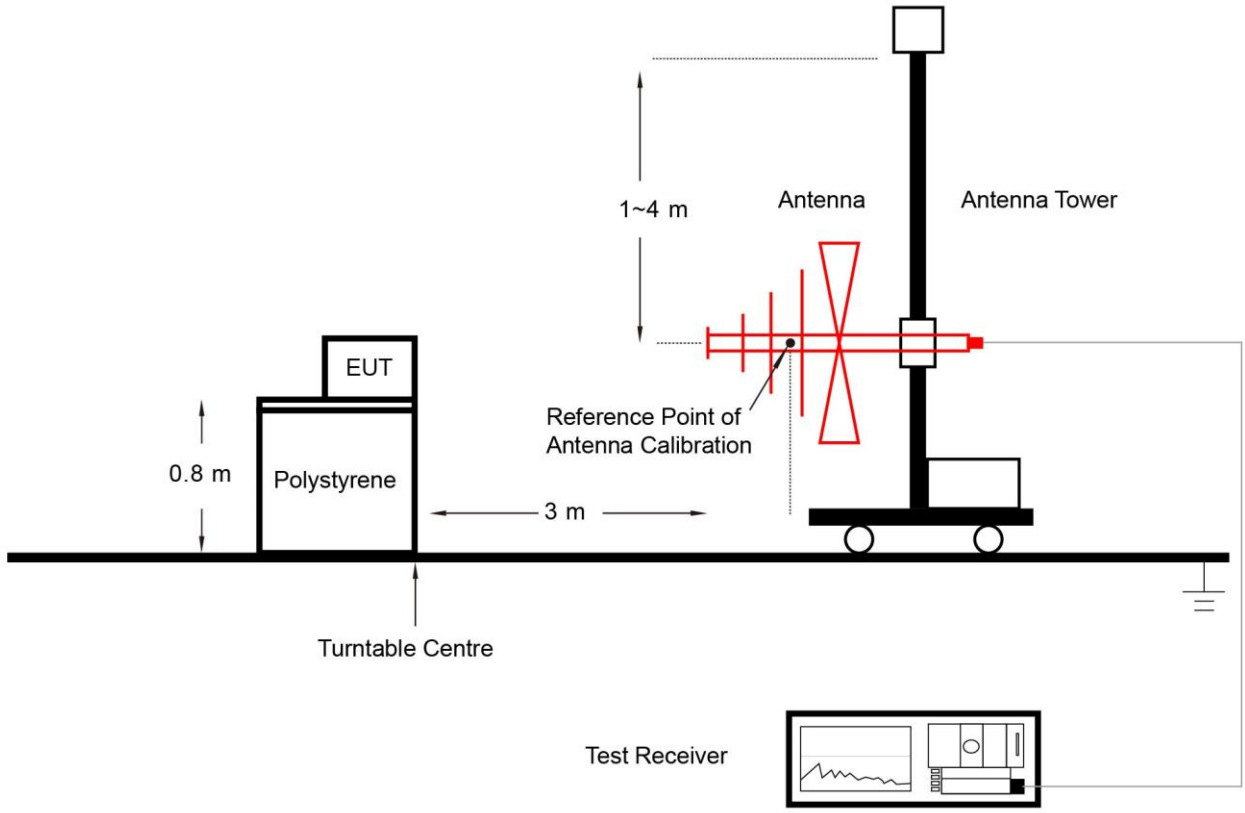
4. Detector = Peak
5. Sweep time = auto
6. Trace mode = max hold
7. Trace was allowed to stabilize

6.10.4. Test Setup

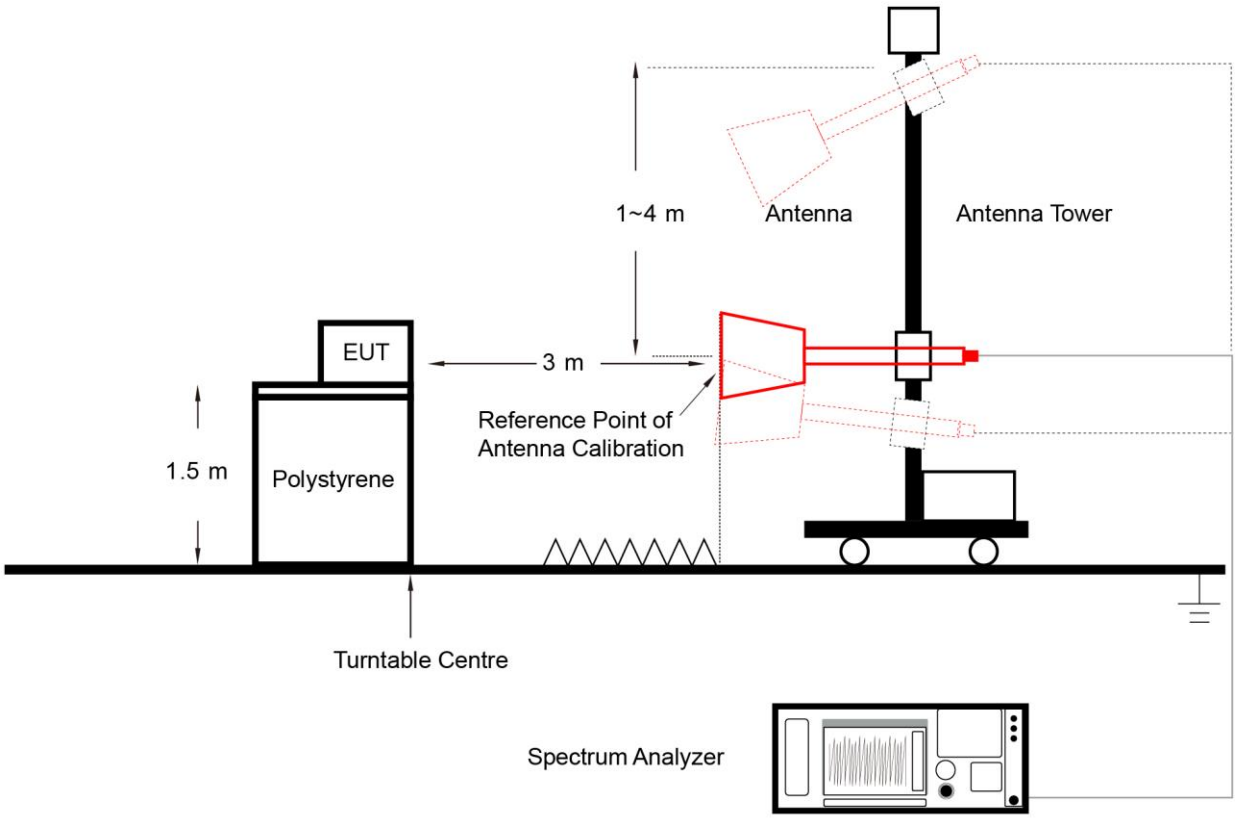
Below 30MHz Test Setup:



Below 1GHz Test Setup:



Above 1GHz Test Setup:



6.10.5. Test Result

Refer to Appendix A.9.

6.11. Radiated Restricted Band Edge Measurement

6.11.1. Test Limit

For 15.205 requirement:

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a) of FCC part 15, must also comply with the radiated emission limits specified in Section 15.209(a).

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)	Frequency (GHz)
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1] 0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41	--	--	--

All out of band emissions appearing in a restricted band as specified in Section 15.205 of the Title 47CFR must not exceed the limits shown in Table per Section 15.209.

FCC Part 15 Subpart C Paragraph 15.209		
Frequency [MHz]	Field Strength [uV/m]	Measured Distance [Meters]
0.009 - 0.490	2400/F (kHz)	300
0.490 - 1.705	24000/F (kHz)	30
1.705 - 30	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

6.11.2. Test Procedure

ANSI C63.10 Section 6.3 (General Requirements)

ANSI C63.10 Section 6.6 (Standard test method above 1GHz)

6.11.3. Test Setting

Peak Field Strength Measurements

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

Average Measurements above 1GHz (Method VB)

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest

2. RBW = 1MHz

3. VBW; If the EUT is configured to transmit with duty cycle ≥ 98%, set VBW = 10 Hz.

   If the EUT duty cycle is < 98%, set VBW ≥ 1/T. T is the minimum transmission duration.

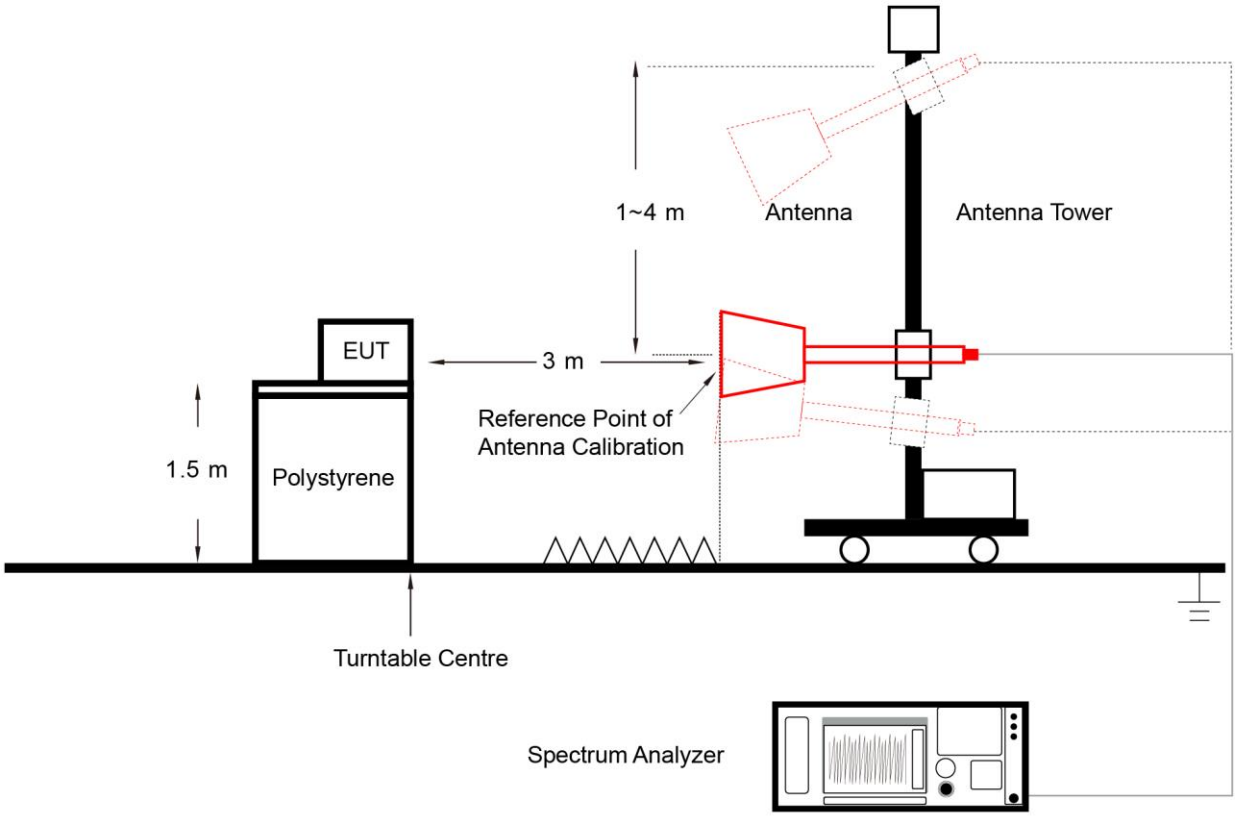
4. Detector = Peak

5. Sweep time = auto

6. Trace mode = max hold

7. Trace was allowed to stabilize

6.11.4. Test Setup



6.11.5. Test Result

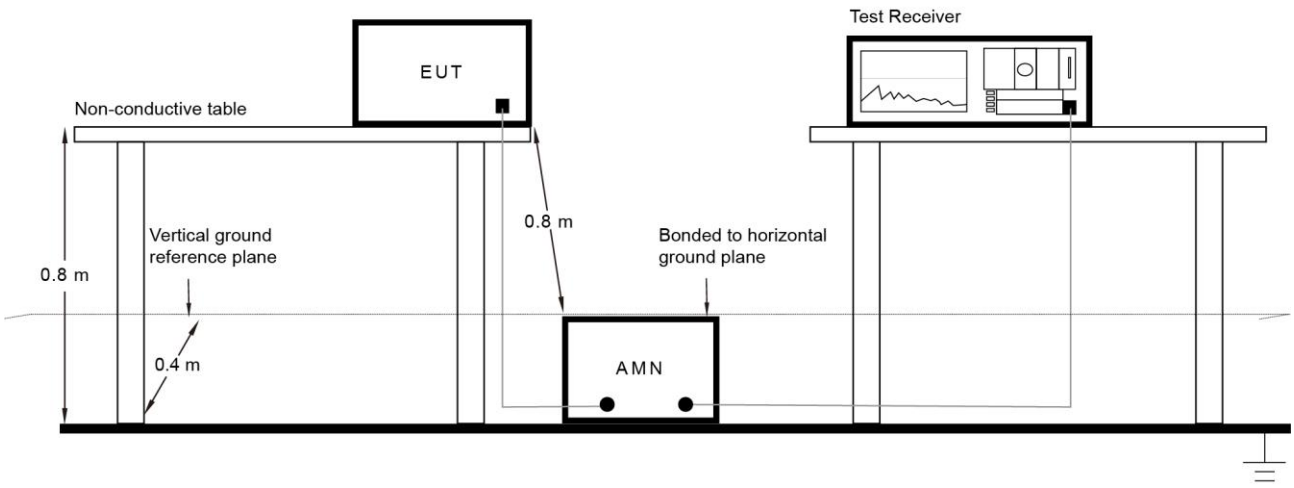
Refer to Appendix A.10.

6.12. AC Conducted Emissions Measurement

6.12.1. Test Limit

FCC Part 15 Subpart C Paragraph 15.207 Limits		
Frequency (MHz)	QP (dBμV)	Average (dBμV)
0.15 - 0.50	66 - 56	56 - 46
0.50 - 5.0	56	46
5.0 - 30	60	50
Note 1: The lower limit shall apply at the transition frequencies. Note 2: The limit decreases linearly with the logarithm of the frequency in the range 0.15MHz to 0.5MHz.		

6.12.2. Test Setup



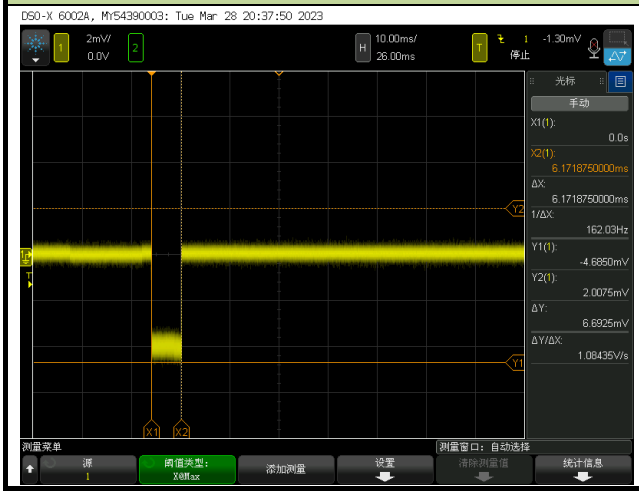
6.12.3. Test Result

Refer to Appendix A.11.

Appendix A - Test Result

A.1 Duty Cycle Test Result

Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-28		

Duty Cycle (T = Transmission Duration)	
905.6MHz	6.17%
905.6MHz (T = 6.17 ms)	
	

Note: As the minimum transmit time interval is one minute declared by manufacturer, so 100ms was used as the observation period, maximum Duty Cycle = T / observation period * 100%=6.17ms / 100ms * 100% = 6.17%.

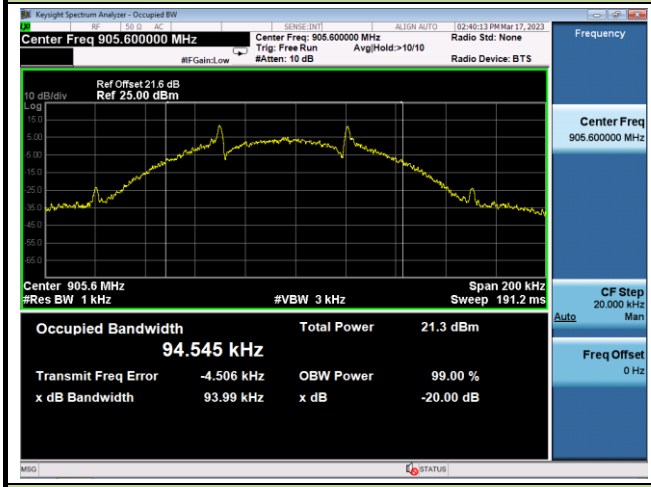
A.2 20dB Bandwidth Test Result

Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-17		

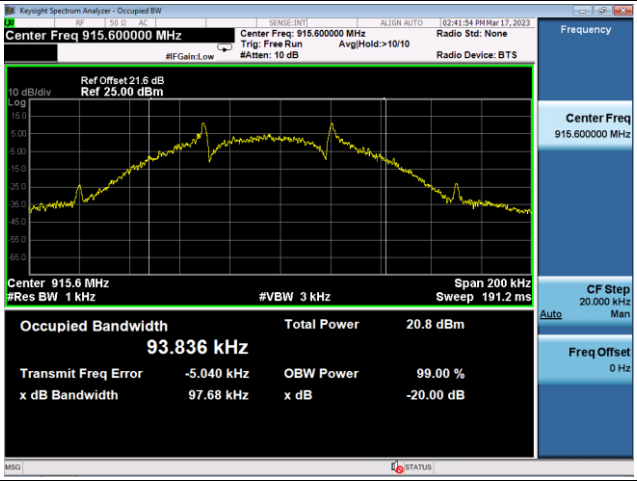
Channel No.	Frequency (MHz)	20dB Bandwidth (kHz)	Limit (kHz)
01	905.6	93.99	≤ 500
26	915.6	97.68	≤ 500
52	926.0	95.60	≤ 500

20dB Bandwidth

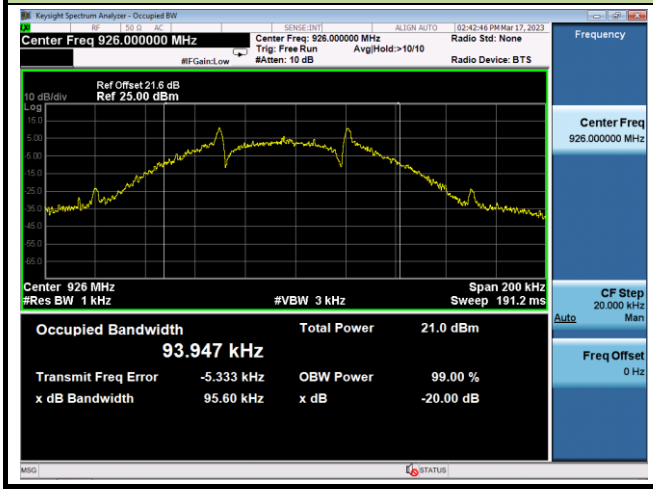
Channel 01 (905.6MHz)



Channel 26 (915.6MHz)



Channel 52 (926.0MHz)



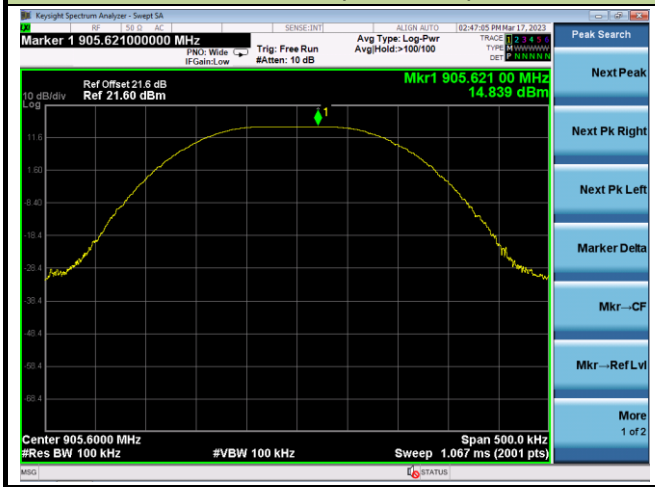
A.3 Output Power Test Result

Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-17		

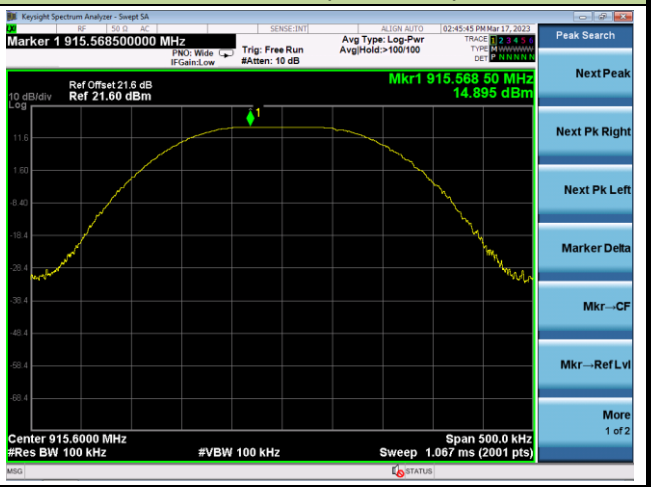
Channel No.	Frequency (MHz)	Output Power (dBm)	Power Limit (dBm)
01	905.6	14.839	≤ 30.00
26	915.6	14.895	≤ 30.00
52	926.0	14.775	≤ 30.00

Output Power

Channel 01 (905.6MHz)



Channel 26 (915.6MHz)



Channel 52 (926.0MHz)

A.4 Carrier Frequency Separation Test Result

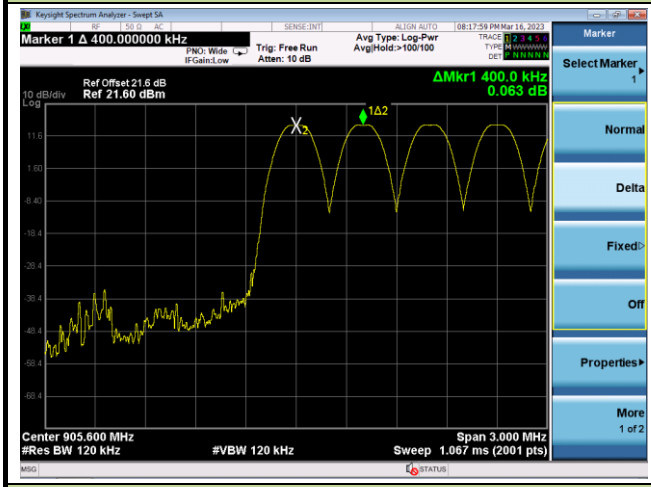
Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-16		

Channel No.	Frequency (MHz)	Carrier Frequency Separation (kHz)	Limit (kHz)	Result
01	905.6	400	≥ 93.99	Pass
26	915.6	400	≥ 97.68	Pass
52	926.0	400	≥ 95.60	Pass

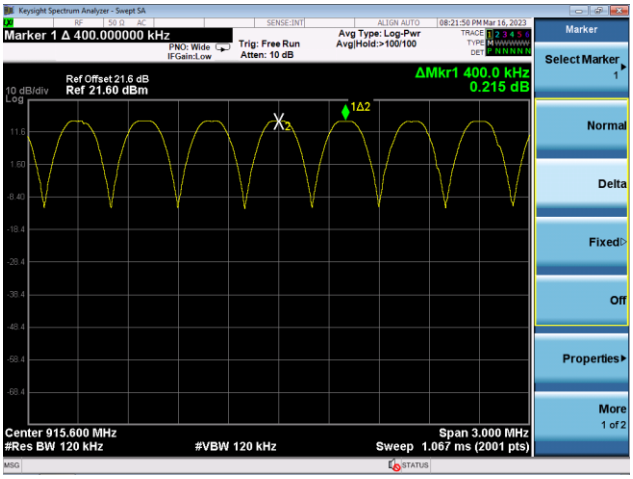
Note: The Limit is the value of the 20dB BW.

Carrier Frequency Separation

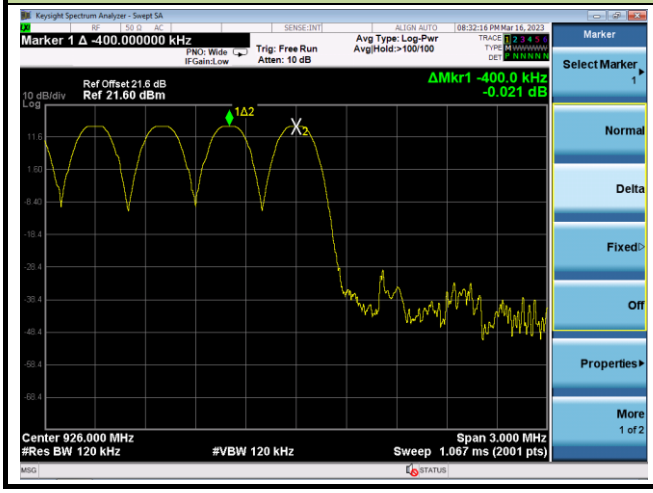
Channel 01 (905.6MHz)



Channel 26 (915.6MHz)



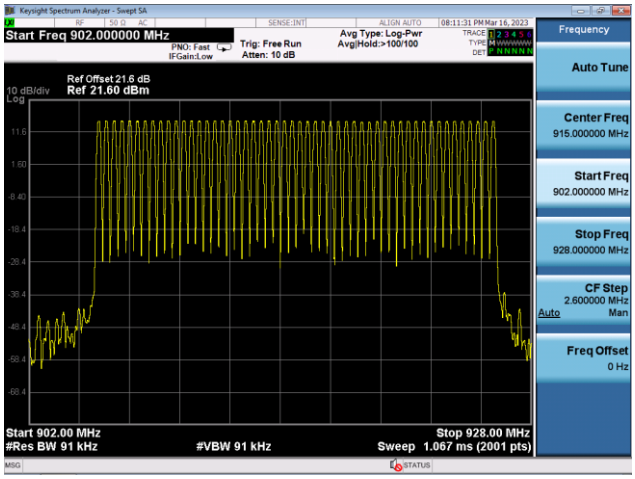
Channel 52 (926.0MHz)



A.5 Number of Hopping Channels Test Result

Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-16		

Channel Numbers	Frequency (MHz)	Limit (Hopping Channels)	Result
52	905.6~926.0	≥ 50	Pass

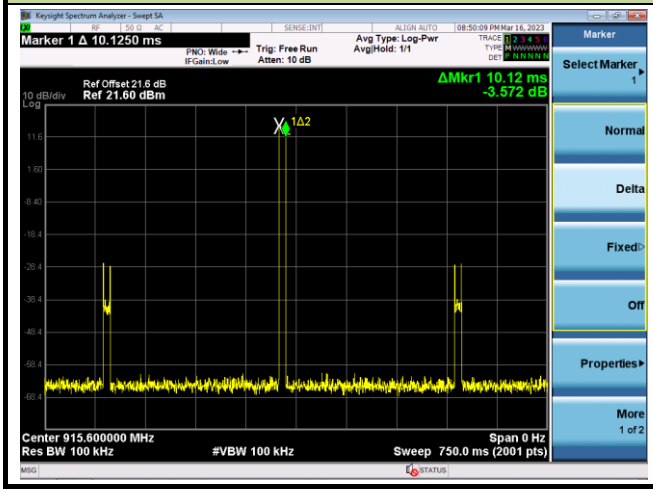
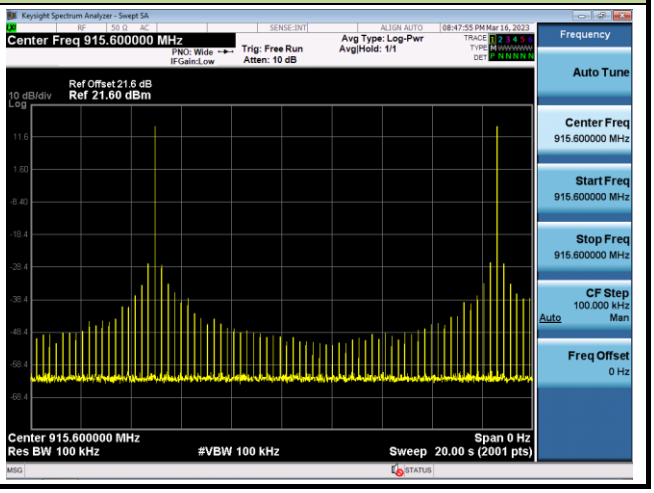
Number of Hopping Channels	
902.0~928.0MHz	
	

A.6 Time of Occupancy Test Result

Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-16		

Channel No.	Frequency (MHz)	Transmit Time Per Hop (ms)	Observation Period (s)	Number of Hops in Observation Period	Time of Occupancy (ms)	Limit (ms)	Result
01~52	905.6~926.0	10.12	20	2	20.24	≤ 400	Pass

Note: Time of Occupancy (ms) = Transmit Time Per Hop (ms) * Number of Hops in Observation Period

Transmit Time Per Hop	Number of Hops in Observation Period
	

A.7 Band-edge Compliance Test Result

Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-03-17		

Channel No.	Frequency (MHz)	Limit	Result
01	905.6	20dBc	Pass
52	926.0	20dBc	Pass

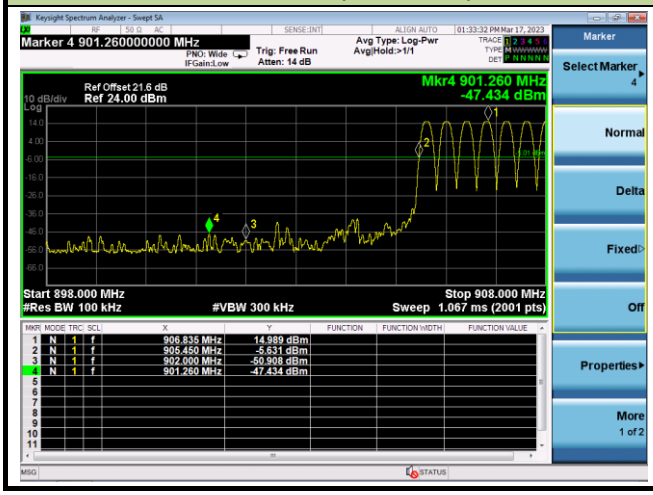
Band-edge Compliance

Channel 01 (905.6MHz)

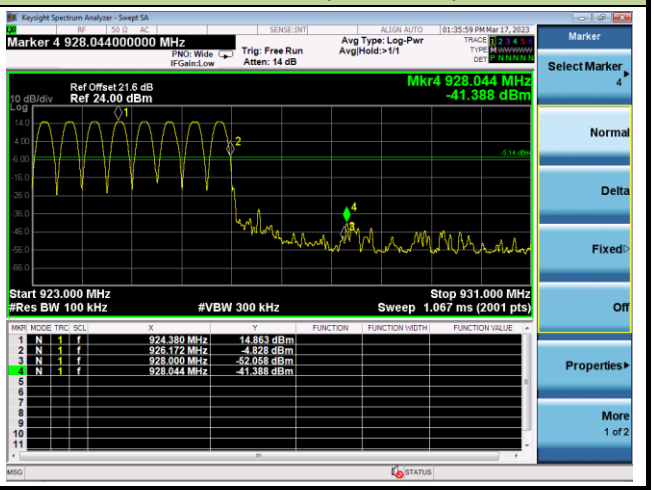
Channel 52 (926.0MHz)

Operation Frequency Range of 20dB Bandwidth within Hopping Mode

Channel 01 (905.6MHz)



Channel 52 (926.0MHz)



A.8 Conducted Spurious Emissions Test Result

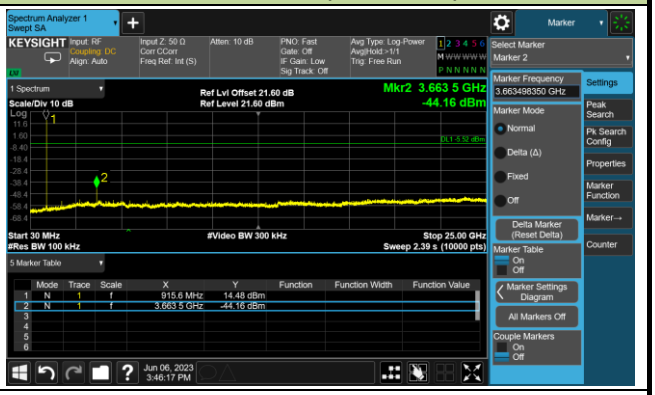
Test Site	WZ-SR5	Test Engineer	Lynn Yang
Test Date	2023-06-06		

Channel No.	Frequency (MHz)	Limit (MHz)	Result
01	905.6	20dBc	Pass
26	915.6	20dBc	Pass
52	926.0	20dBc	Pass

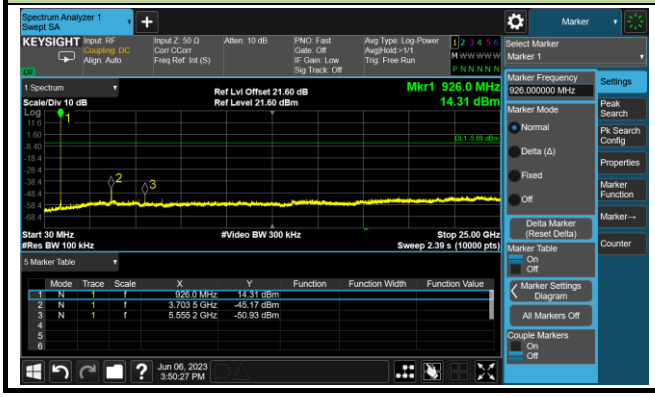
Conducted Spurious Emissions

Channel 01 (905.6MHz)

Channel 26 (915.6MHz)



Channel 52 (926.0MHz)



A.9 Radiated Spurious Emission Test Result

Test Site	WZ-AC1/WZ-AC2	Test Engineer	Charles Zhang/ Bob Zhang
Test Date	2023-05-03~2023-06-08		
Remark:	1. Average measurement was not performed if peak level lower than average limit. 2. Other frequency was 20dB below limit line within 1-10GHz, there is not show in the report.		

Test Channel	Frequency (MHz)	Reading Level (dBμV)	Factor (dB/m)	Measure Level (dBμV/m)	Duty Cycle Factor (dB)	Limit (dBμV/m)	Margin (dB)	Detector	Polarization
01	2714.5	66.2	-2.6	63.6	N/A	74.0	-10.4	Peak	Horizontal
	2714.5	66.2	-2.6	39.4	-24.2	54.0	-14.6	Average	Horizontal
	3623.5	58.3	-0.3	58.0	N/A	74.0	-16.0	Peak	Horizontal
	3623.5	58.3	-0.3	33.8	-24.2	54.0	-20.2	Average	Horizontal
	4528.0	45.6	2.0	47.6	N/A	74.0	-26.4	Peak	Horizontal
	2719.0	67.7	-2.6	65.1	N/A	74.0	-8.9	Peak	Vertical
	2719.0	67.7	-2.6	40.9	-24.2	54.0	-13.1	Average	Vertical
	3623.5	57.0	-0.3	56.7	N/A	74.0	-17.3	Peak	Vertical
	3623.5	57.0	-0.3	32.5	-24.2	54.0	-21.5	Average	Vertical
	4528.0	43.5	2.0	45.5	N/A	74.0	-28.5	Peak	Vertical
26	2746.0	67.4	-2.5	64.9	N/A	74.0	-9.1	Peak	Horizontal
	2746.0	67.4	-2.5	40.7	-24.2	54.0	-13.3	Average	Horizontal
	3664.0	61.1	-0.3	60.8	N/A	74.0	-13.2	Peak	Horizontal
	3664.0	61.1	-0.3	36.6	-24.2	54.0	-17.4	Average	Horizontal
	4577.5	44.9	2.0	46.9	N/A	74.0	-27.1	Peak	Horizontal
	2746.0	64.2	-2.5	61.7	N/A	74.0	-12.3	Peak	Vertical
	2746.0	64.2	-2.5	37.5	-24.2	54.0	-16.5	Average	Vertical
	3664.0	58.3	-0.3	58.0	N/A	74.0	-16.0	Peak	Vertical
	3664.0	58.3	-0.3	33.8	-24.2	54.0	-20.2	Average	Vertical
	4577.5	41.9	2.0	43.9	N/A	74.0	-30.1	Peak	Vertical

Note:

Peak Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m)

Average Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m) + Duty Cycle Factor(dB)

Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m) – Pre_Amplifier Gain (dB)

Duty Cycle Factor(dB) = 20 * Log_{10}(Duty Cycle) = -24.2 (dB)

Test Channel	Frequency (MHz)	Reading Level (dBμV)	Factor (dB/m)	Measure Level (dBμV/m)	Duty Cycle Factor (dB)	Limit (dBμV/m)	Margin (dB)	Detector	Polarization
52	2777.5	68.5	-2.4	66.1	N/A	74.0	-7.9	Peak	Horizontal
	2777.5	68.5	-2.4	41.9	-24.2	54.0	-12.1	Average	Horizontal
	3704.5	60.2	-0.1	60.1	N/A	74.0	-13.9	Peak	Horizontal
	3704.5	60.2	-0.1	35.9	-24.2	54.0	-18.1	Average	Horizontal
	4631.5	44.4	2.6	47.0	N/A	74.0	-27.0	Peak	Horizontal
	2777.5	65.5	-2.4	63.1	N/A	74.0	-10.9	Peak	Vertical
	2777.5	65.5	-2.4	38.9	-24.2	54.0	-15.1	Average	Vertical
	3704.5	59.0	-0.1	58.9	N/A	74.0	-15.1	Peak	Vertical
	3704.5	59.0	-0.1	34.7	-24.2	54.0	-19.3	Average	Vertical
	4631.5	42.2	2.6	44.8	N/A	74.0	-29.2	Peak	Vertical

Note:

Peak Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m)

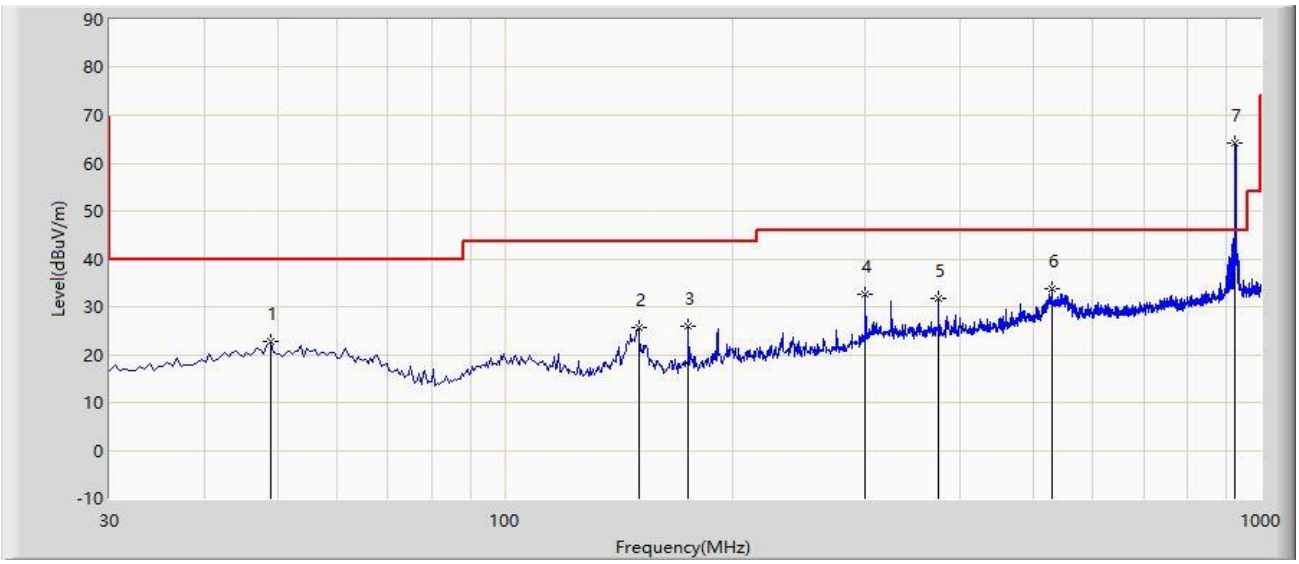
Average Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m) + Duty Cycle Factor(dB)

Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m) - Pre_Amplifier Gain (dB)

Duty Cycle Factor(dB) = 20 * Log_{10}(Duty Cycle) = -24.2 (dB)

The Result of Radiated Emission below 1GHz:

Site: WZ-AC2	Test Date: 2023-06-08
Limit: FCC_Part15.209_RSE(3m)	Engineer: Bob Zhang
Probe: VULB9162_30-7000MHz	Polarity: Horizontal
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 926MHz	



No	Mark	Frequency (MHz)	Measure Level (dBμV/m)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV/m)	Factor (dB/m)	Type
1		48.915	22.788	2.386	-17.212	40.000	20.402	PK
2		150.280	25.796	10.445	-17.704	43.500	15.351	PK
3		175.015	25.817	9.539	-17.683	43.500	16.278	PK
4		300.145	32.659	11.726	-13.341	46.000	20.933	PK
5		374.835	31.668	8.851	-14.332	46.000	22.817	PK
6	*	530.035	33.767	8.290	-12.233	46.000	25.477	PK
7		925.795	64.194	33.100	N/A	N/A	31.094	PK

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m).

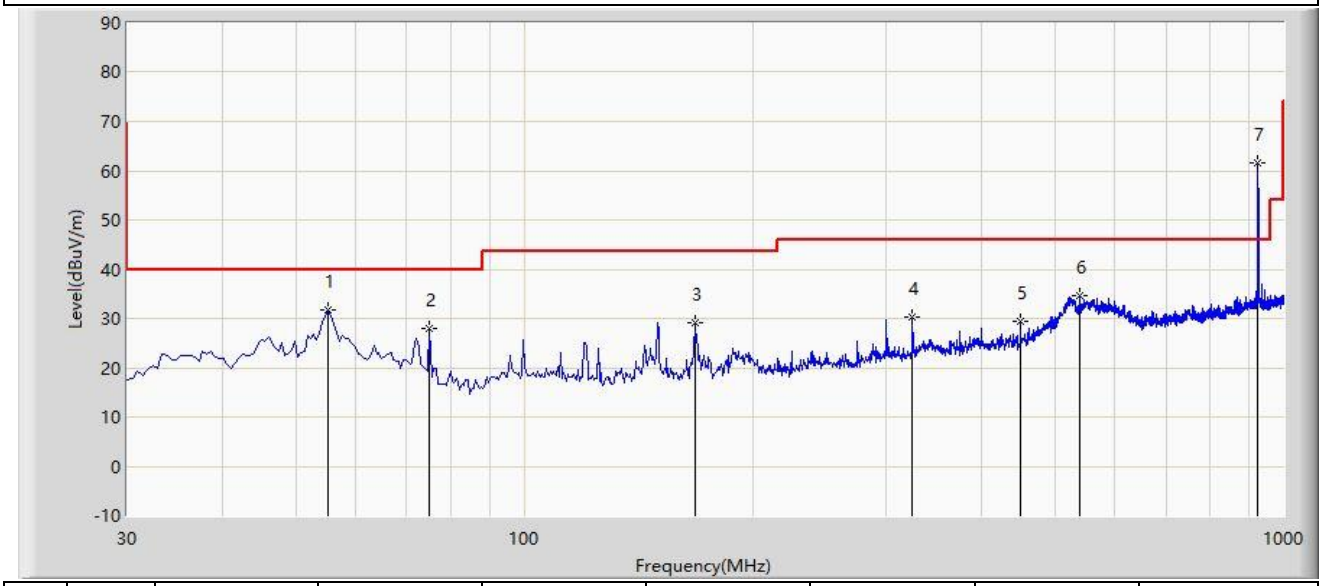
Note 3: Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m).

Note 4: Quasi-Peak measurement was not performed when peak measure level was lower than the quasi-peak limit.

Note 5: The point (7) is SmartLink fundamental frequency, which was evaluated during Radiated Restricted Band Edge Test.

Note 6: The amplitude of radiated emissions (frequency range from 9kHz to 30MHz) is that proximity to ambient noise, which also are attenuated more than 20 dB below the permissible value. Therefore, the data is not presented in the report

Site: WZ-AC2	Test Date: 2023-06-08
Limit: FCC_Part15.209_RSE(3m)	Engineer: Bob Zhang
Probe: VULB9162_30-7000MHz	Polarity: Vertical
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 926MHz	



No	Mark	Frequency (MHz)	Measure Level (dBμV/m)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV/m)	Factor (dB/m)	Type
1	*	55.220	31.867	11.586	-8.133	40.000	20.281	PK
2		75.105	27.887	12.777	-12.113	40.000	15.110	PK
3		167.740	29.094	13.092	-14.406	43.500	16.002	PK
4		324.880	30.408	8.797	-15.592	46.000	21.611	PK
5		450.010	29.329	5.145	-16.671	46.000	24.184	PK
6		539.735	34.742	8.866	-11.258	46.000	25.876	PK
7		925.795	61.646	30.552	N/A	N/A	31.094	PK

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m).

Note 3: Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m).

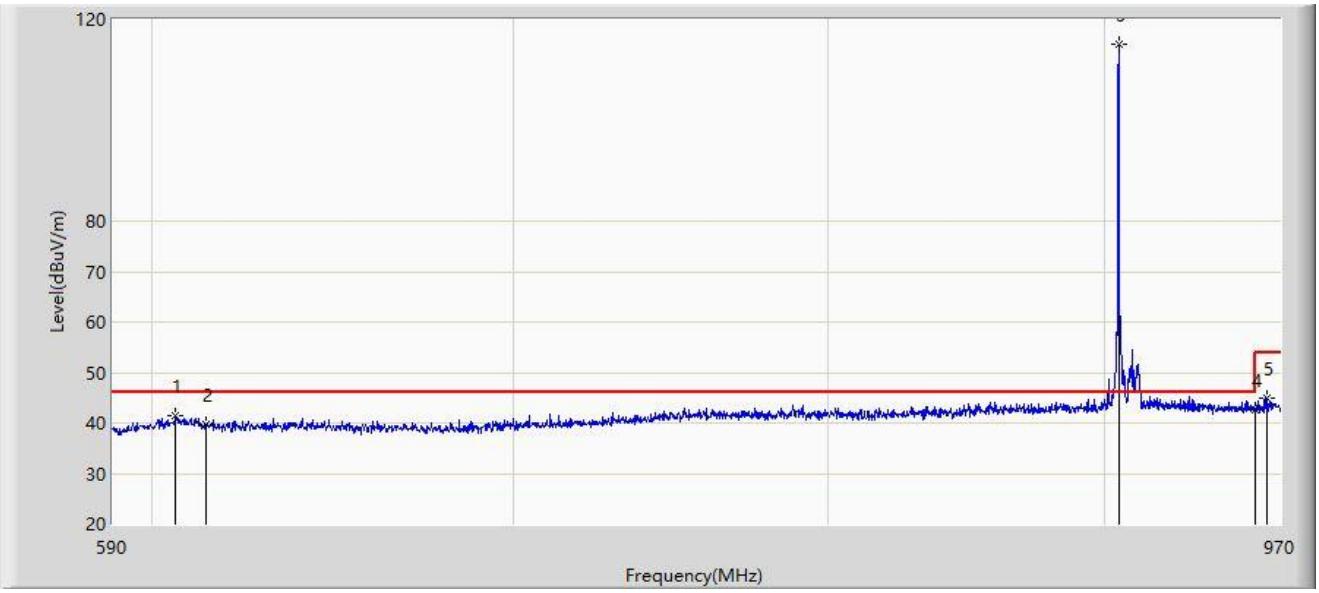
Note 4: Quasi-Peak measurement was not performed when peak measure level was lower than the quasi-peak limit.

Note 5: The point (7) is SmartLink fundamental frequency, which was evaluated during Radiated Restricted Band Edge Test.

Note 6: The amplitude of radiated emissions (frequency range from 9kHz to 30MHz) is that proximity to ambient noise, which also are attenuated more than 20 dB below the permissible value. Therefore, the data is not presented in the report.

A.10 Radiated Restricted Band Edge Test Result

Site: WZ-AC1	Test Date: 2023-03-11
Limit: FCC_Part15.209_RSE(3m)	Engineer: Charles Zhang
Probe: VULB 9168_25-2000MHz	Polarity: Horizontal
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 905.6MHz	



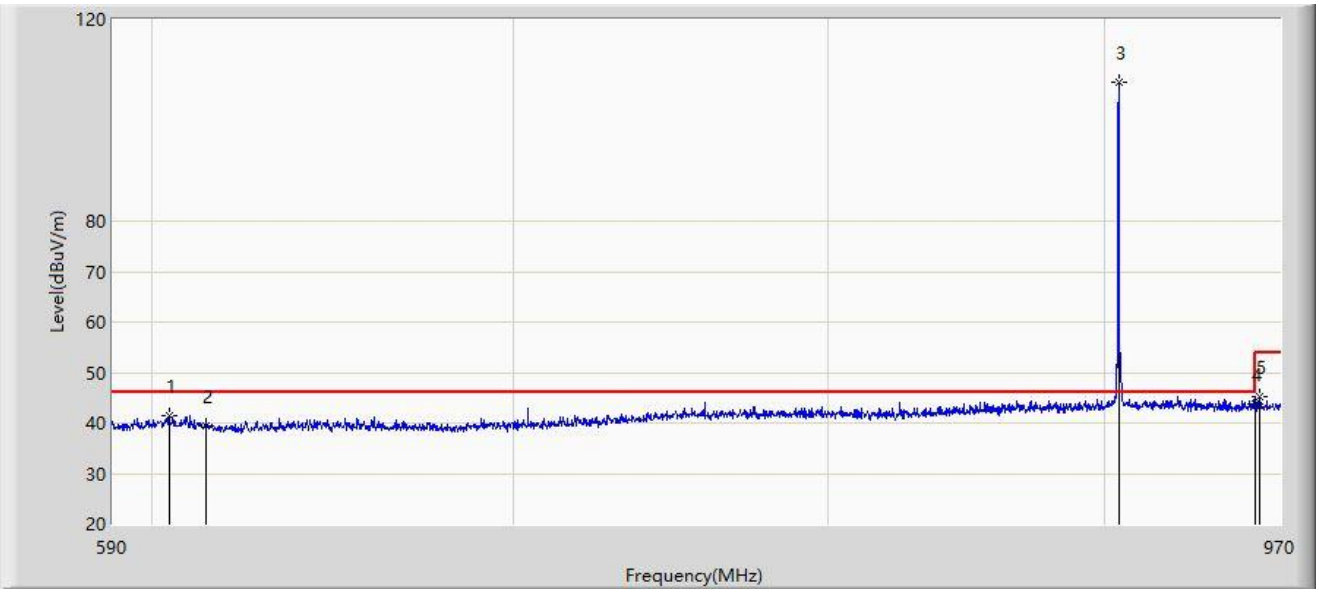
No	Mark	Frequency (MHz)	Measure Level (dBμV/m)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV/m)	Factor (dB/m)	Type
1		606.150	41.443	15.800	-4.557	46.000	25.643	PK
2		614.000	39.845	14.113	-6.155	46.000	25.732	PK
3		905.590	114.953	85.423	N/A	N/A	29.529	PK
4	*	960.000	42.667	12.888	-3.333	46.000	29.779	PK
5		964.680	45.054	15.183	-8.946	54.000	29.871	PK

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m).

Note 3: Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m).

Site: WZ-AC1	Test Date: 2023-03-11
Limit: FCC_Part15.209_RSE(3m)	Engineer: Charles Zhang
Probe: VULB 9168_25-2000MHz	Polarity: Vertical
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 905.6MHz	



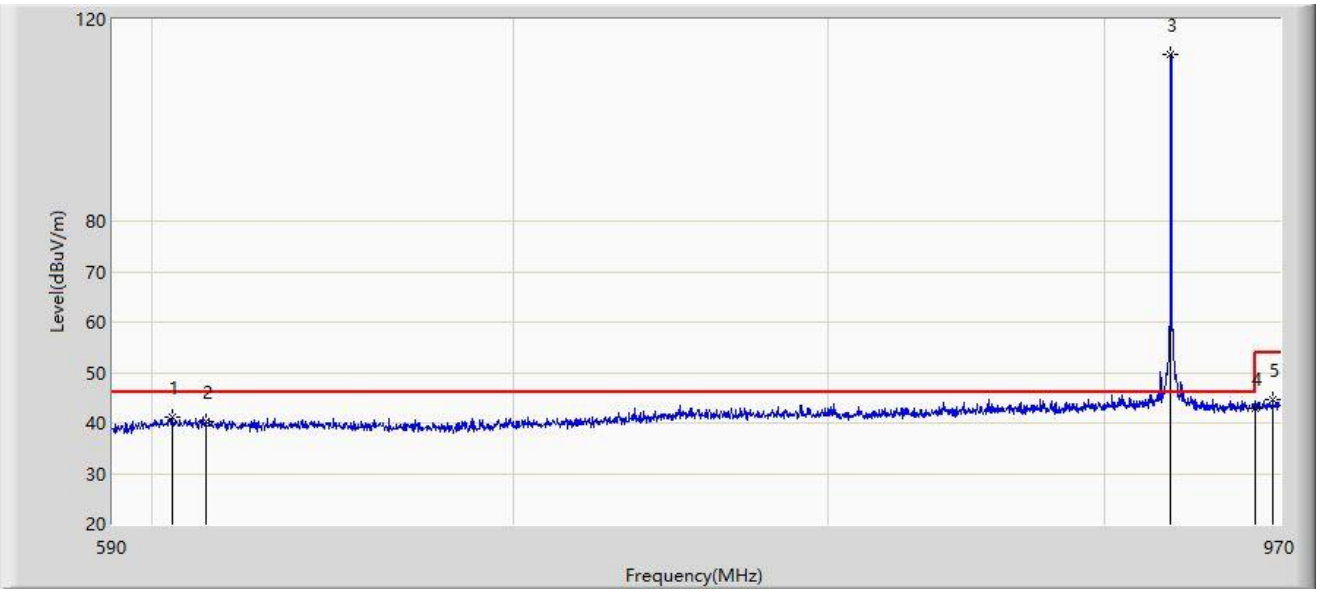
No	Mark	Frequency (MHz)	Measure Level (dBµV/m)	Reading Level (dBµV)	Margin (dB)	Limit (dBµV/m)	Factor (dB/m)	Type
1		604.440	41.465	15.859	-4.535	46.000	25.605	PK
2		614.000	39.563	13.831	-6.437	46.000	25.732	PK
3		905.590	107.566	78.036	N/A	N/A	29.529	PK
4	*	960.000	43.898	14.119	-2.102	46.000	29.779	PK
5		961.450	45.151	15.337	-8.849	54.000	29.814	PK

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBµV/m) = Reading Level (dBµV) + Factor (dB/m).

Note 3: Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m).

Site: WZ-AC1	Test Date: 2023-03-11
Limit: FCC_Part15.209_RSE(3m)	Engineer: Charles Zhang
Probe: VULB 9168_25-2000MHz	Polarity: Horizontal
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 926MHz	



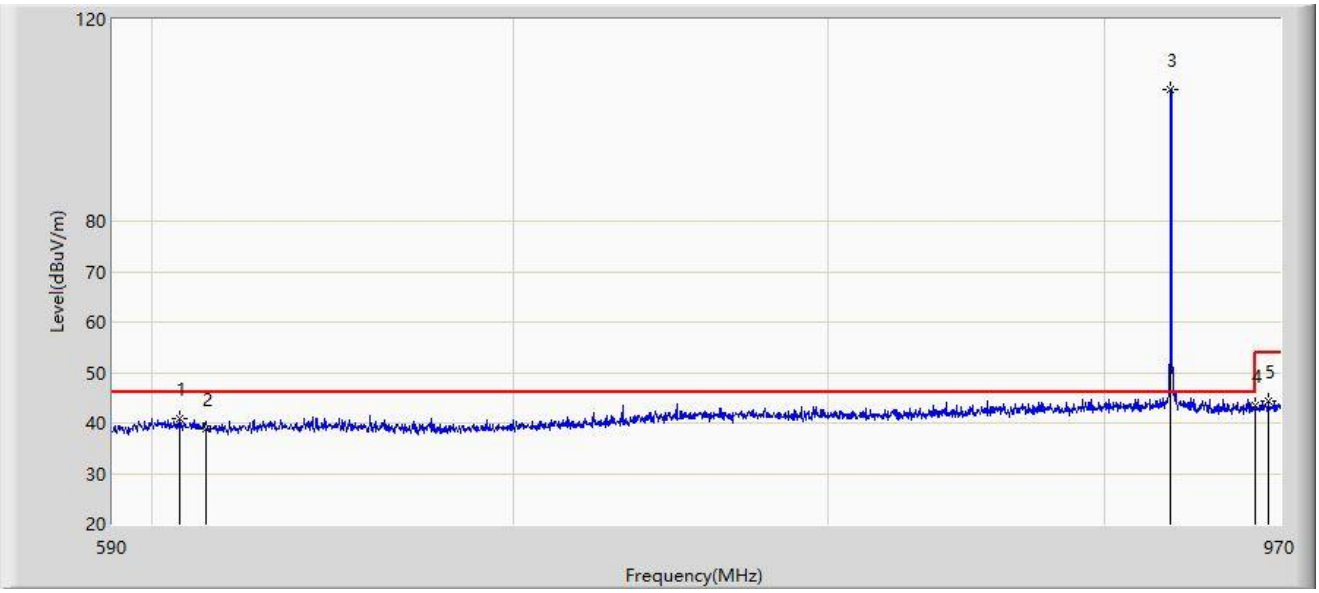
No	Mark	Frequency (MHz)	Measure Level (dBμV/m)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV/m)	Factor (dB/m)	Type
1		605.390	41.095	15.461	-4.905	46.000	25.634	PK
2		614.000	40.235	14.503	-5.765	46.000	25.732	PK
3		925.920	113.150	83.204	N/A	N/A	29.946	PK
4	*	960.000	42.998	13.219	-3.002	46.000	29.779	PK
5		966.960	44.596	14.692	-9.404	54.000	29.904	PK

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m).

Note 3: Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m).

Site: WZ-AC1	Test Date: 2023-03-11
Limit: FCC_Part15.209_RSE(3m)	Engineer: Charles Zhang
Probe: VULB 9168_25-2000MHz	Polarity: Vertical
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 926MHz	



No	Mark	Frequency (MHz)	Measure Level (dBμV/m)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV/m)	Factor (dB/m)	Type
1		607.100	41.003	15.349	-4.997	46.000	25.654	PK
2		614.000	38.961	13.229	-7.039	46.000	25.732	PK
3		925.920	106.196	76.250	N/A	N/A	29.946	PK
4	*	960.000	43.362	13.583	-2.638	46.000	29.779	PK
5		965.250	44.289	14.408	-9.711	54.000	29.880	PK

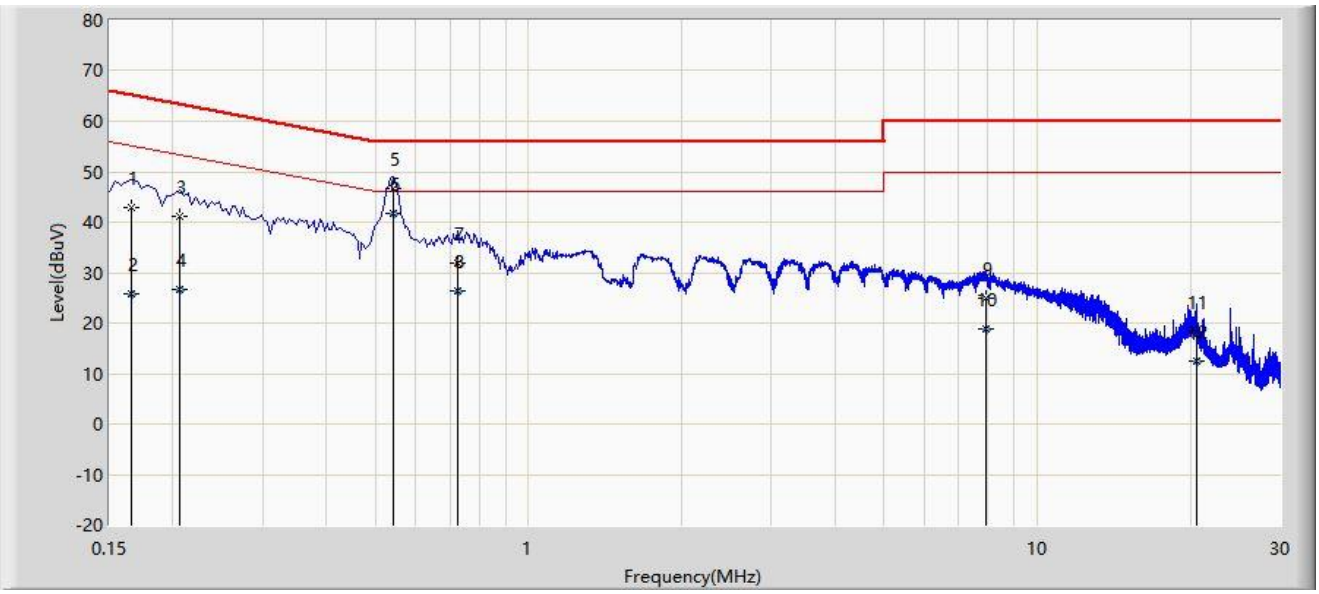
Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV/m) = Reading Level (dBμV) + Factor (dB/m).

Note 3: Factor (dB/m) = Cable Loss (dB) + Antenna Factor (dB/m).

A.11 AC Conducted Emissions Test Result

Site: WZ-SR2	Test Date: 2023-03-31
Temperature: 22.3°C	Humidity: 49.5%
Limit: FCC_Part15.207_CE_AC Power	Engineer: Alin Zhou
Probe: ENV216_101683_Filter Off_E	Polarity: Line
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 926MHz	



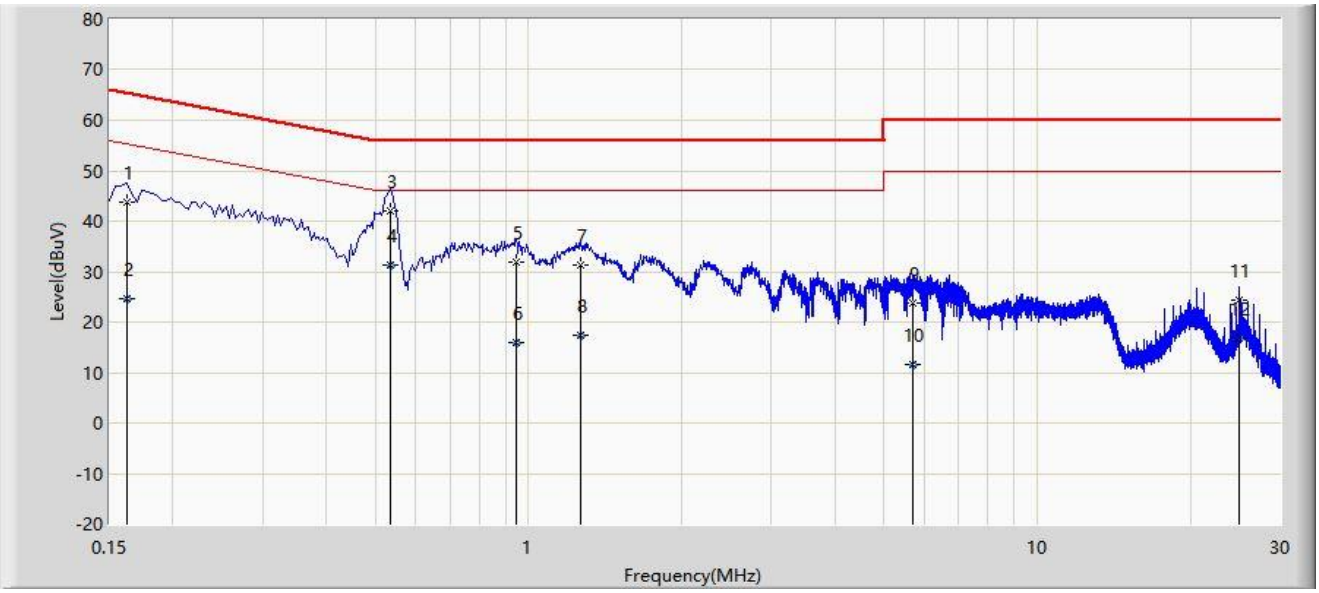
No	Mark	Frequency (MHz)	Measure Level (dBμV)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV)	Factor (dB)	Type
1		0.166	42.849	33.141	-22.309	65.158	9.708	QP
2		0.166	25.876	16.169	-29.282	55.158	9.708	AV
3		0.206	41.115	31.396	-22.250	63.365	9.720	QP
4		0.206	26.710	16.991	-26.655	53.365	9.720	AV
5		0.542	46.759	36.860	-9.241	56.000	9.899	QP
6	*	0.542	41.603	31.704	-4.397	46.000	9.899	AV
7		0.726	31.901	21.924	-24.099	56.000	9.977	QP
8		0.726	26.285	16.309	-19.715	46.000	9.977	AV
9		7.914	24.949	14.415	-35.051	60.000	10.534	QP
10		7.914	18.877	8.343	-31.123	50.000	10.534	AV
11		20.502	18.200	6.687	-41.800	60.000	11.512	QP
12		20.502	12.465	0.953	-37.535	50.000	11.512	AV

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV) = Reading Level (dBμV) + Factor (dB).

Note 3: Factor (dB) = Cable Loss (dB) + LISN Factor (dB).

Site: WZ-SR2	Test Date: 2023-03-31
Temperature: 22.3°C	Humidity: 49.5%
Limit: FCC_Part15.207_CE_AC Power	Engineer: Alin Zhou
Probe: ENV216_101683_Filter Off_E	Polarity: Neutral
EUT: Hub Cellular	Power: AC 120V/60Hz
Test Mode: Transmit at 926MHz	



No	Mark	Frequency (MHz)	Measure Level (dBμV)	Reading Level (dBμV)	Margin (dB)	Limit (dBμV)	Factor (dB)	Type
1		0.162	43.702	33.972	-21.659	65.361	9.730	QP
2		0.162	24.641	14.912	-30.720	55.361	9.730	AV
3	*	0.534	41.991	32.082	-14.009	56.000	9.909	QP
4		0.534	31.162	21.253	-14.838	46.000	9.909	AV
5		0.946	31.991	21.877	-24.009	56.000	10.113	QP
6		0.946	15.861	5.748	-30.139	46.000	10.113	AV
7		1.266	31.316	21.168	-24.684	56.000	10.148	QP
8		1.266	17.249	7.101	-28.751	46.000	10.148	AV
9		5.690	23.746	13.345	-36.254	60.000	10.400	QP
10		5.690	11.485	1.084	-38.515	50.000	10.400	AV
11		25.002	24.282	12.511	-35.718	60.000	11.771	QP
12		25.002	16.950	5.179	-33.050	50.000	11.771	AV

Note 1: " * ", means this data is the worst emission level.

Note 2: Measure Level (dBμV) = Reading Level (dBμV) + Factor (dB).

Note 3: Factor (dB) = Cable Loss (dB) + LISN Factor (dB).

Appendix B - Test Setup Photograph

Refer to “2303RSU022-UT” file.

Appendix C - EUT Photograph

Refer to “ 2303RSU022-UE” file.

The End