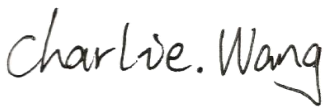
RF Test Report

Applicant:	Quectel Wireless Solutions Co., Ltd.
Address:	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233
Product:	Smart Module
Model No.:	SG560D-WF
Brand Name:	QUECTEL
FCC ID:	XMR2023SG560DWF
Standards:	FCC CFR47 Part 15C
Report No.:	PD20230213RF01
Issue Date:	2024/01/15
Test Result:	PASS *

* **The above equipment has been tested and compliance with the requirement of the relative standards by Hefei Panwin Technology Co., Ltd.**



Reviewed By: Charlie Wang **Approved By:** Alec Yang

Hefei Panwin Technology Co., Ltd.

Floor 1, Zone E, Plant 2#, Mingzhu Industrial Park, No.106 Chuangxin Avenue, High-tech Zone, Hefei City, Anhui Province,China

TEL: 0551-63811775

Revision History

Report No.	Version	Description	Issue Date	Note
PD20230213RF01	01	Initial Report	2024/01/15	Valid

Remark:

The customer claimed that the clocking scheme of the module's WiFi unit had been updated, and the old clock scheme continues to provide the clock signal for the entire system except WiFi. After the update, the module is the same everywhere except for the difference in the clock scheme of WiFi. The new XO solution has no RF impact.Therefore, this report verifies the 20dB and 99% Bandwidth, Hopping Channel Separation, Radiated Band Edges and Radiated Spurious Emission, and other data can be referred to in the original report(Report No.: SEWA2303000041RG01) released by SGS on 2023/05/24.

CONTENTS

Summary of Test Results

No.	Test Case	FCC Rules	Verdict
1	20dB and 99% Bandwidth	15.247(a)(1)	Report only
2	Hopping Channel Separation	15.247(a)(1)	PASS
3	Radiated Band Edges and Radiated Spurious Emission	15.247(d)	PASS
4	Antenna Requirement	15.203 & 15.247(b)	PASS
Date of Testing:2023/12/07 to 2024/01/11 Date of Sample Received: 2023/12/04			
Note：All indications of PASS/FAIL in this report are opinions expressed by Hefei Panwin Technology Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.			

Remark:

We, Hefei Panwin Technology Co., Ltd., would like to declare that the tested sample has been evaluated in accordance with the procedures given in ANSI C63.10-2013 and shown compliance with the applicable technical standards.

1 General Information

1.1 Notes of the Test Report

This report is invalid without signature of auditor and approver or with any alterations. The report shall not be partially reproduced without written approval of the testing company. Entrusted test results are only responsible for incoming samples. If there is any objection to the testing report, it shall be raised to the testing company within 15 days from the date of receiving the report. In the test results, "NA" means "not applicable", and the test items marked with "Δ" are subcontracted projects.

1.2 Test Facility

FCC (Designation number: CN1361, Test Firm Registration Number: 473156)

Hefei Panwin Technology Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform measurements.

A2LA (Certificate Number: 6849.01)

Hefei Panwin Technology Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform measurement.

1.3 Testing Laboratory

Company Name	Hefei Panwin Technology Co., Ltd.
Address	Floor 1, Zone E, Plant 2#, Mingzhu Industrial Park, No.106 Chuangxin Avenue, High-tech Zone, Hefei City, Anhui Province,China
Telephone	+86-0551-63811775
Post Code	230031

2 General Description of Equipment under Test

2.1 Details of Application

Applicant	Quectel Wireless Solutions Co., Ltd.
Applicant Address	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233
Manufacturer	Quectel Wireless Solutions Co., Ltd.
Manufacturer Address	Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233

2.2 General Information

Product	Smart Module
Model	SG560D-WF
SN	1. P1Y23141B000037 2. P1Y23123V000012
Hardware Version	R1.1
Software Version	SG560DWFPARO2A04
Antenna Type	External Antenna
Antenna Gain	0.47dBi
Operating voltage range	Typical 4.0Vdc
Modulation Type	Frequency Hopping Spread Spectrum (FHSS):GFSK, π/4-DQPSK, 8-DPSK
Operating Frequency Range(s)	Bluetooth : 2402 ~ 2480 MHz
Number of channels	79
Carrier Frequency of Each Channel	2402+n*1 MHz; n=0~78
Note: The declared of product specification for EUT and/or Antenna presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.	

2.3 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 S15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- ANSI C63.10-2013

3 Test Condition

3.1 Test Configuration

Test mode

Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data rates and antenna ports (if EUT with antenna diversity architecture). The worst cases were recorded in this report.

Radiated measurements are performed by rotating the EUT in three different orthogonal test planes (Z, X, Y axis), receiver antenna polarization (horizontal and vertical), the worst emission was found in Z position and the worst case was recorded.

3.2 Carrier Frequency Channel

Frequency Band	Channel	Freq（MHz）	Channel	Freq（MHz）	Channel	Freq（MHz）
2400-2483.5MHz	0	2402	27	2429	54	2456
	1	2403	28	2430	55	2457
	2	2404	29	2431	56	2458
	3	2405	30	2432	57	2459
	4	2406	31	2433	58	2460
	5	2407	32	2434	59	2461
	6	2408	33	2435	60	2462
	7	2409	34	2436	61	2463
	8	2410	35	2437	62	2464
	9	2411	36	2438	63	2465
	10	2412	37	2439	64	2466
	11	2413	38	2440	65	2467
	12	2414	39	2441	66	2468
	13	2415	40	2442	67	2469
	14	2416	41	2443	68	2470
	15	2417	42	2444	69	2471
	16	2418	43	2445	70	2472
	17	2419	44	2446	71	2473
	18	2420	45	2447	72	2474
	19	2421	46	2448	73	2475
	20	2422	47	2449	74	2476
	21	2423	48	2450	75	2477
	22	2424	49	2451	76	2478
	23	2425	50	2452	77	2479
	24	2426	51	2453	78	2480
	25	2427	52	2454	-	-
	26	2428	53	2455	-	-

3.3 Equipment List

Instrument	Manufacturer	Model	Asset No.	Cal. Interval	Cal. Due Date
EMI Test Receiver	R&S	ESR7	PWB0023	1 Year	2024/10/11
Spectrum Analyzer	R&S	FSV3044	PWB0024	1 Year	2024/10/11
Loop Antenna	R&S	HFH2-Z2E	PWB0026	1 Year	2024/10/21
TRILOG Broadband Antenna	Schwarzbeck	VULB9162	PWB0029	1 Year	2024/10/14
Double-Ridged Guide Antenna	ETS-Lindgren	3117	PWB0031	1 Year	2024/10/12
k Type Horn Antenna	Steatite Antennas	QMS-00880	PWB0035	1 Year	2024/10/17
Spectrum Analyzer	KEYSIGHT	N9020B	PWC0055	1 Year	2024/10/11
DC Power	KEYSIGHT	E3640A	PWC0046	1 Year	2024/10/11
Anechoic Chamber	ETS.LINDGREN	Fact 3-2m	PWB0003	3 Years	2024/08/28
Shielded Chamber	Maorui	MR543	PWC0041	3 Years	2026/08/26
Pre-Amplifier	R&S	SCU18F	PWB0034	1 Year	2024/10/11
Pre-Amplifier	R&S	SCU40F1	PWB0036	1 Year	2024/10/11
Pre-Amplifier	COM-MW	DLNA8	PWB0094	1 Year	2024/11/08
Test Software	Tonseced	JS1120-3 V3.2.22	/	/	/
Test Software	R&S	ELEKTRA 4.20.2	/	/	/

3.4 Support Equipment List

Equipment	Manufacturer	Description	Model	Serial Number
EVB	QUECTEL	NA	NA	NA
USB Cable	NA	NA	NA	NA
Adapter	Xiamen Xinsenhai Electronics Co., Ltd	Output:12V 60W	P60EB120500	NA

3.5 Test Uncertainty

No.	Parameter	Uncertainty
1	20dB Emission Bandwidth	1.9%
2	Occupied channel bandwidth	1.9%
3	Carrier Frequency Separation	1.9%
4	Band-edge Spurious Emission	1.21dB
5	Conducted RF Spurious Emission	9kHz-7GHz:1.21dB 7GHz-40GHz: 3.31dB
6	Temperature	3℃
7	Humidity	1.3 %
8	Supply voltages	0.006 V

4 Test Items Description

Ambient condition

Shielded Chamber

Temperature [°C]	20.4 to 25.6
Humidity [%RH]	29 to 40
Pressure [kPa]	100.8 to 102.7

Anechoic Chamber

Temperature [°C]	20.1 to 27.1
Humidity [%RH]	30 to 49
Pressure [kPa]	100.8 to 104.1

4.1 20dB and 99% Bandwidth Measurement

4.1.1 Limit of 20dB and 99% Bandwidth

Reporting only

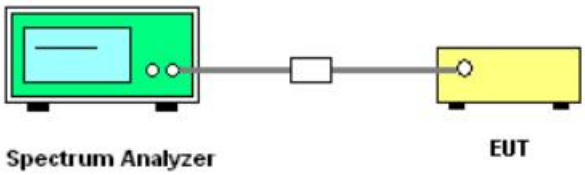
4.1.2 Measuring Instruments

The measuring equipment is listed in the section 3.3 of this test report.

4.1.3 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;
   The RBW is set to 1% to 5% of the 99% OBW, the VBW is set to 3 times the 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;
   The RBW is set to 1% to 5% of the 99% OBW,the VBW is set to 3 times the RBW;
   Sweep = auto; Detector function = peak;
   Trace = max hold.
6. Measure and record the results in the test report.

4.1.4 Test Setup



4.1.5Test Results

See Appendix A.1.

4.2 Hopping Channel Separation Measurement

4.2.1 Limit of Hopping Channel Separation

Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

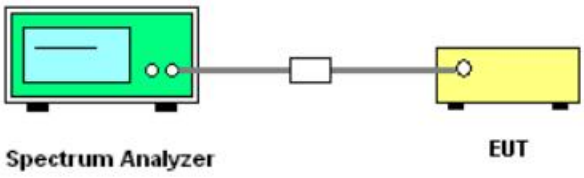
4.2.2 Measuring Instruments

The measuring equipment is listed in the section 3.3 of this test report.

4.2.3 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 = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak;
   Trace = max hold.
6. Measure and record the results in the test report.

4.2.4 Test Setup



4.2.5 Test Results

See Appendix A.2.

4.3 Radiated Band Edges and Spurious Emission Measurement

4.3.1 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 of emission (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
Above960	500	3

4.3.2 Measuring Instruments

The measuring equipment is listed in the section 3.3 of this test report.

4.3.3 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 GH, RBW=1MHz for f>1GHz ; VBW ≥ RBW; Sweep = auto;Detector function = peak;Trace = max hold for peak.
   (3) For average measurement: use duty cycle correction factor method per 15.35(c).
   Duty cycle = On time/100 milliseconds

On time = $N_1*L_1+N_2*L_2+...+N_{n-1}*L_{n-1}+N_n*L_n$

Where N_1 is number of type 1 pulses, L, is length of type 1 pulses, etc.

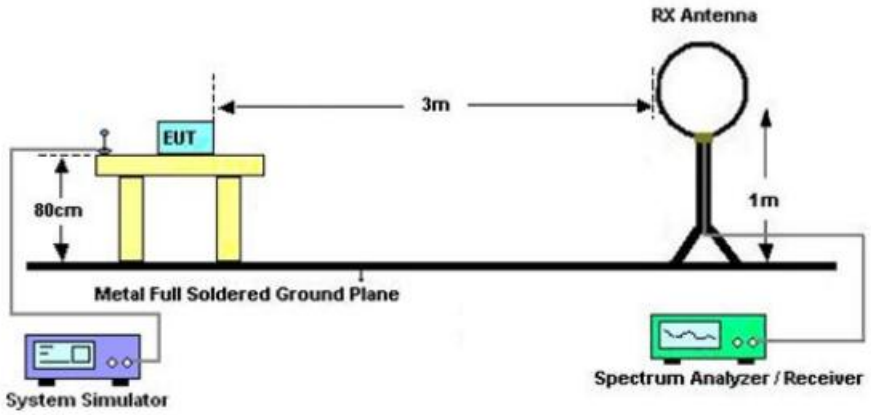
Average Emission Level = Peak Emission Level + 20*log(Duty cycle).

6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Pre-amp 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 peak 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.

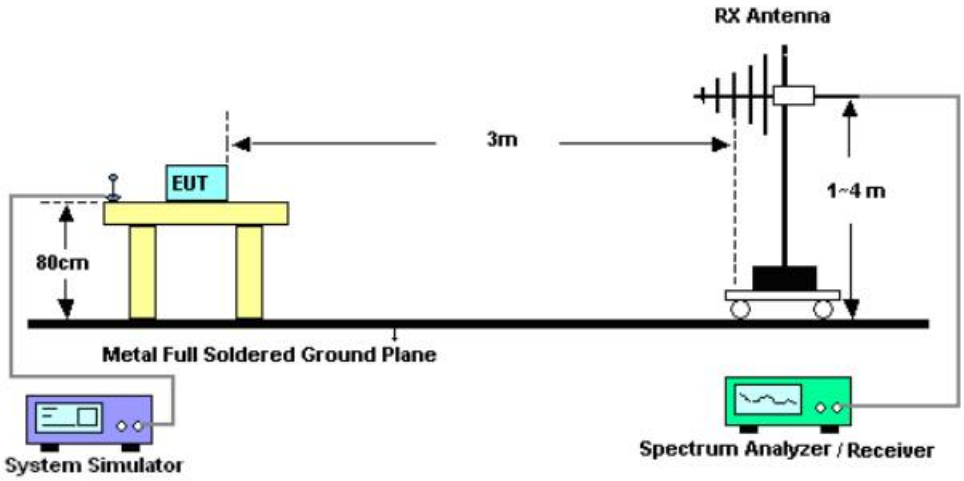
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.79dB) derived from 20log (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.

4.3.4 Test Setup

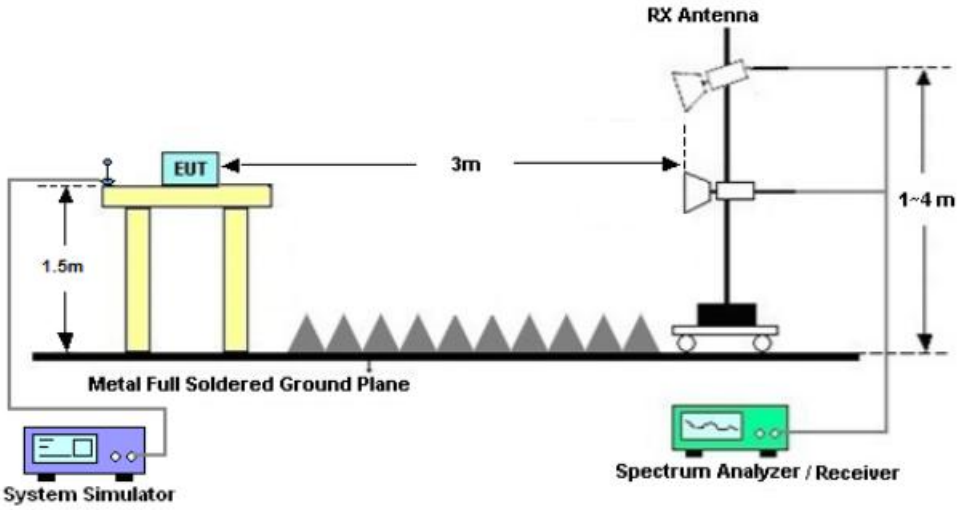
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



4.3.5 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 was20dB 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.

4.3.6Test Result of Radiated Spurious at Band Edges

See Appendix B.1.

4.3.7 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic or40GHz, whichever is lower)

See Appendix B.1.

4.4 Antenna Requirements

4.4.1 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.

4.4.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

4.4.3 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.

Appendix A – Test Results of Conducted Test

A.1 20dB and 99% Bandwidth Measurement

Test Result

20dB Bandwidth

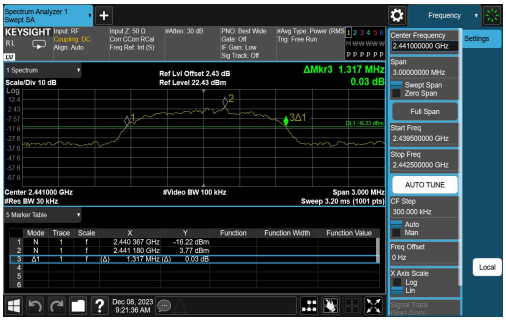
Test Mode	Antenna	Frequency[MHz]	20db EBW[MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
DH5	Ant1	2402	0.942	2401.565	2402.507	---	---
DH5	Ant1	2441	0.933	2440.571	2441.504	---	---
DH5	Ant1	2480	0.933	2479.568	2480.501	---	---
2DH5	Ant1	2402	1.287	2401.391	2402.678	---	---
2DH5	Ant1	2441	1.311	2440.367	2441.678	---	---
2DH5	Ant1	2480	1.308	2479.367	2480.675	---	---
3DH5	Ant1	2402	1.302	2401.376	2402.678	---	---
3DH5	Ant1	2441	1.317	2440.367	2441.684	---	---
3DH5	Ant1	2480	1.302	2479.373	2480.675	---	---

99% Bandwidth

Test Mode	Antenna	Frequency[MHz]	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
DH5	Ant1	2402	0.83211	2401.6047	2402.4368	---	---
DH5	Ant1	2441	0.83463	2440.6036	2441.4382	---	---
DH5	Ant1	2480	0.83149	2479.6013	2480.4328	---	---
2DH5	Ant1	2402	1.1928	2401.4278	2402.6206	---	---
2DH5	Ant1	2441	1.1957	2440.4263	2441.6220	---	---
2DH5	Ant1	2480	1.1919	2479.4253	2480.6172	---	---
3DH5	Ant1	2402	1.2043	2401.4182	2402.6225	---	---
3DH5	Ant1	2441	1.2048	2440.4175	2441.6223	---	---
3DH5	Ant1	2480	1.2069	2479.4135	2480.6204	---	---

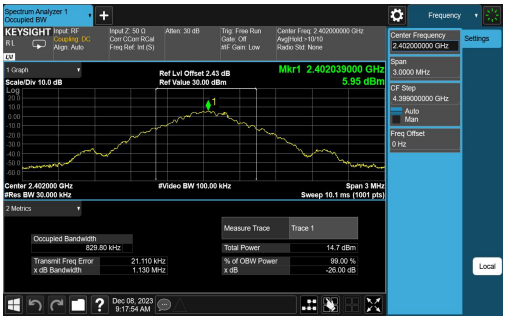
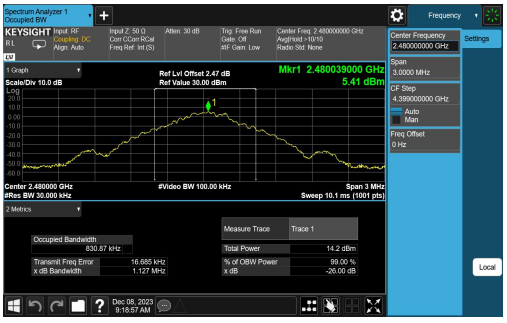
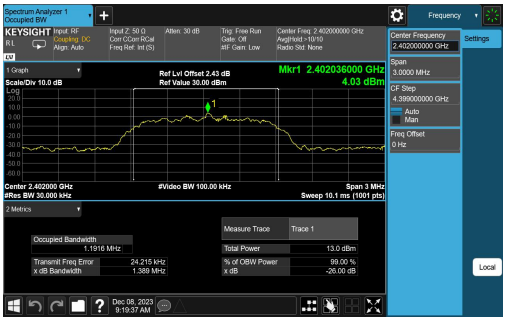
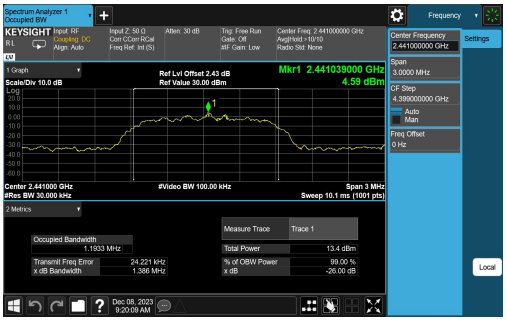
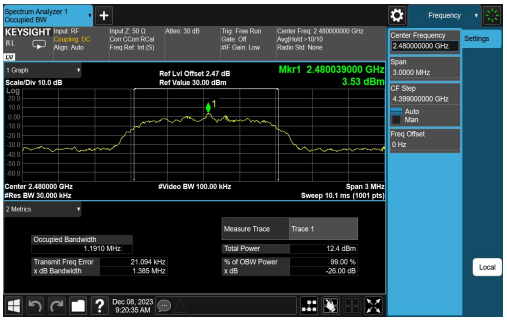
Test Graphs

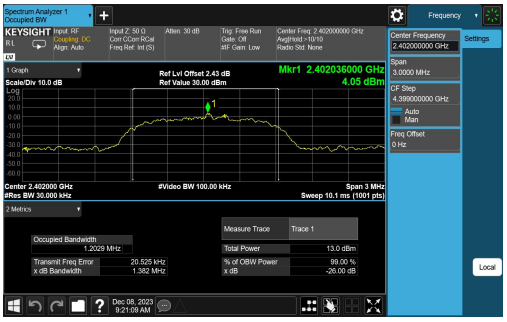
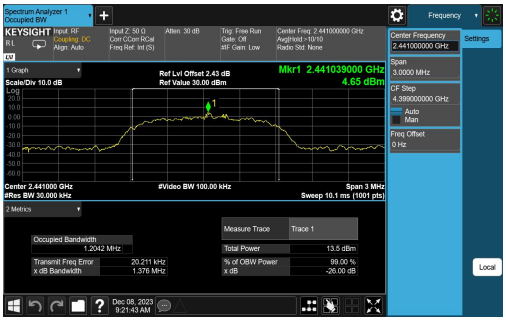
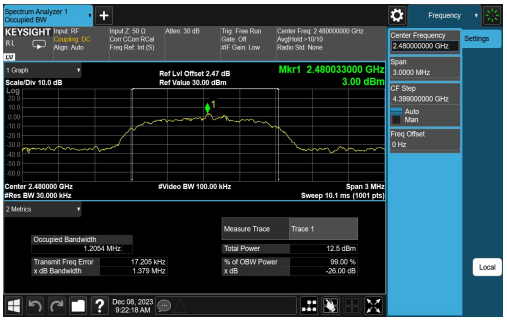
20dB Bandwidth

DH5-Ant1-2402	DH5-Ant1-2441
	
DH5-Ant1-2480	2DH5-Ant1-2402
	
2DH5-Ant1-2441	2DH5-Ant1-2480
	
3DH5-Ant1-2402	3DH5-Ant1-2441
	
3DH5-Ant1-2480	/

	/

99% Bandwidth

DH5-Ant1-2402	DH5-Ant1-2441
	
DH5-Ant1-2480	**2DH5-Ant1-2402**
	
2DH5-Ant1-2441	**2DH5-Ant1-2480**
	

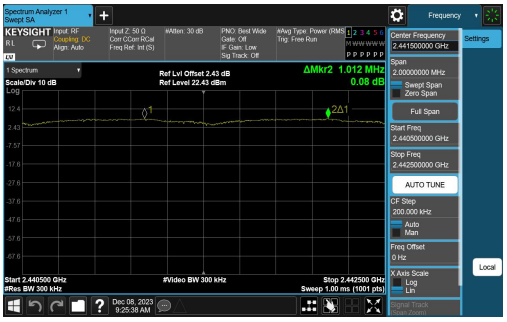
3DH5-Ant1-2402	3DH5-Ant1-2441
	
3DH5-Ant1-2480	**/**
	/

A.2 Hopping Channel Separation

Test Result

Test Mode	Antenna	Frequency[MHz]	Result[MHz]	Limit[MHz]	Verdict
DH5	Ant1	Hop	1.006	≥0.942	PASS
2DH5	Ant1	Hop	1.022	≥0.874	PASS
3DH5	Ant1	Hop	1.012	≥0.878	PASS

Test Graphs

DH5-Ant1-Hop-PASS	2DH5-Ant1-Hop-PASS
	
3DH5-Ant1-Hop-PASS	/
	/

Appendix B – Test Results of Radiated Test

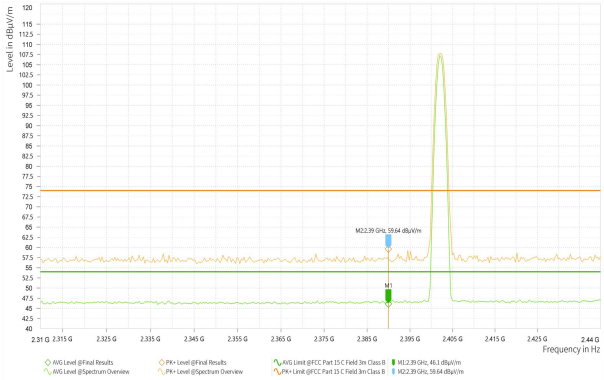
B.1 Radiated Band Edges and Spurious Emission

Test Result_Band Edges

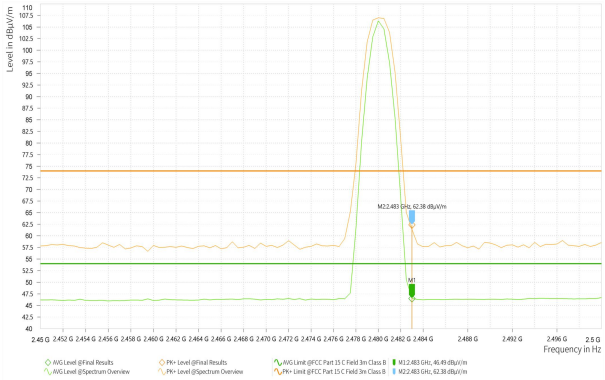
Test Mode & Test Freq.[MHz]	Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AVG Level [dBμV/m]	AVG Limit dBμV/m]	AVG Margin [dB]	Polarization	Azimuth [deg]
BT_DH5_2402_edge	2,389.950	59.64	74.00	14.36	46.10	54.00	7.90	V	303.3
BT_DH5_2480_edge	2,483.000	62.38	74.00	11.62	46.49	54.00	7.51	V	165.8
BT_2DH5_2402_edge	2,389.950	59.26	74.00	14.74	46.03	54.00	7.97	H	20.4
BT_2DH5_2480_edge	2,483.500	59.58	74.00	14.42	46.34	54.00	7.66	V	0.8
BT_3DH5_2402_edge	2,389.950	59.82	74.00	14.18	46.05	54.00	7.95	H	0
BT_3DH5_2480_edge	2,483.000	60.82	74.00	13.18	46.62	54.00	7.38	V	115.7

Test Graphs_Band Edges

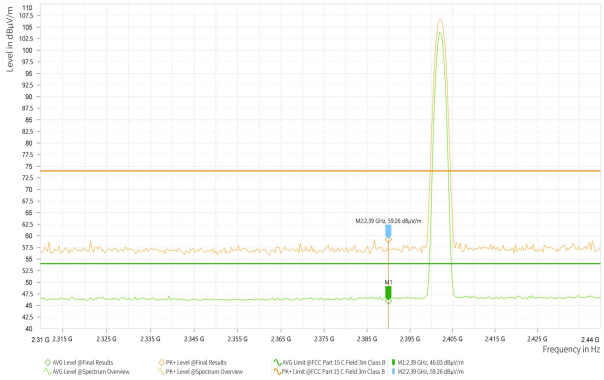
BT_DH5_2402_edge



BT_DH5_2480_edge



BT_2DH5_2402_edge



BT_2DH5_2480_edge