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.:	PD20230213RF02
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.**

Charlie. Wang

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

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Revision History

Report No.	Version	Description	Issue Date	Note
PD20230213RF02	1	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 6dB and 99% Bandwidth and Radiated Band Edges and Radiated Spurious Emission, and other data can be referred to in the original report(Report No.: SEWA2303000041RG02) released by SGS on 2023/05/24.

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Test Summary

No.	Test Case	FCC Rules	Verdict
1	6dB and 99% Bandwidth Measurement	15.247(a)(2)	PASS
2	Radiated Band Edges and Spurious Emission Measurement	15.247(d)	PASS
3	Antenna Requirements	15.203 & 15.247(b)	PASS

Date of Testing:2023/12/07 to 2024/01/11
Date of Sample Received: 2023/12/04

- We, Hefei Panwin Technology Co., Ltd., would like to declare that the tested sample has been evaluated in accordance with the procedures given in applied standard(s) in **Section 2.3** of this report and shown compliance with the applicable technical standards.
- All indications of PASS/FAIL in this report are based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.

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
Additional Beamforming Gain	NA
Operating voltage range	Typical 4.0Vdc
Rates Type	1M PHY, 2M PHY
Type of Modulation	Bluetooth LE 5.0: GFSK
Operating Frequency Range(s)	Bluetooth LE: 2402 to 2480MHz
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 Standard(s)

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

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.

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

Test Mode	Data Rate
Bluetooth LE	1Mbps
	2Mbps

3.2 Carrier Frequency and Channel

Frequency Band	Channel	Freq.(MHz)	Channel	Freq.(MHz
2400-2483.5 MHz	0	2402	21	2444
	1	2404	22	2446
	2	2406	23	2448
	3	2408	24	2450
	4	2410	25	2452
	5	2412	26	2454
	6	2414	27	2456
	7	2416	28	2458
	8	2418	29	2460
	9	2420	30	2462
	10	2422	31	2464
	11	2424	32	2466
	12	2426	33	2468
	13	2428	34	2470
	14	2430	35	2472
	15	2432	36	2474
	16	2434	37	2476
	17	2436	38	2478
	18	2438	39	2480
	19	2440	-	-
	20	2442	-	-

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	DTS Bandwidth	1.9 %
2	Occupied channel bandwidth	1.9 %
3	Unwanted Emissions In Non-restricted Frequency Bands	9kHz-7GHz: 1.21 dB 7GHz-40GHz: 3.31 dB
4	Radiated Spurious Emission	4.46 dB
5	Temperature	3 °C
6	Humidity	1.3 %
7	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 6dB and 99% Bandwidth Measurement

4.1.1 Limit of 6dB and 99% Bandwidth

The minimum 6 dB bandwidth shall be at least 500 kHz

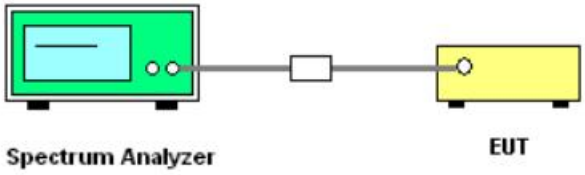
4.1.2 Measuring Instruments

The section 3.3 of List of Measuring Equipment of this test report is used for test.

4.1.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 11.8.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. Set the Video bandwidth (VBW) = 300 kHz. In order to make an accurate measurement. The 6 dB bandwidth must be greater than 500 kHz.
5. For 99% Bandwidth Measurement, the spectrum analyzer's resolution bandwidth (RBW) is set 1% to 5% of the 99% OBW and the VBW is set to 3 times of the RBW.
6. Measure and record the results in the test report.

4.1.4 Test Setup



4.1.5 Test Results

See Appendix A.1.

4.2 Radiated Band Edges and Spurious Emission Measurement

4.2.1 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. If the output power of this device was measured by spectrum analyzer, the attenuation under this paragraph shall be 30 dB instead of 20 dB. 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

4.2.2 Measuring Instruments

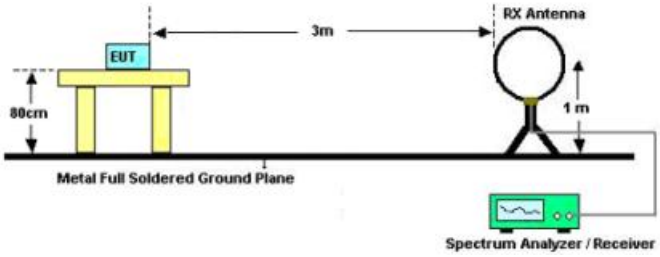
The section 3.3 of List of Measuring Equipment of this test report is used for test.

4.2.3 Test Procedures

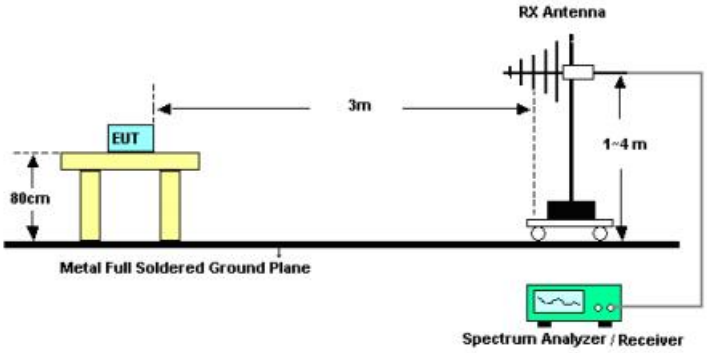
1. The testing follows ANSI C63.10-2013 clause 11.11 & 11.12
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. 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.
4. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level -Preamp Factor = Level
6. 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.
7. 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.
8. 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; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
   (3) Set RBW = 1 MHz, VBW= 3MHz for ≥ 1 GHz for peak measurement
   For average measurement:
   VBW= 10 Hz, when duty cycle is no less than 98 percent.
   VBW ≥ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

4.2.4 Test Setup

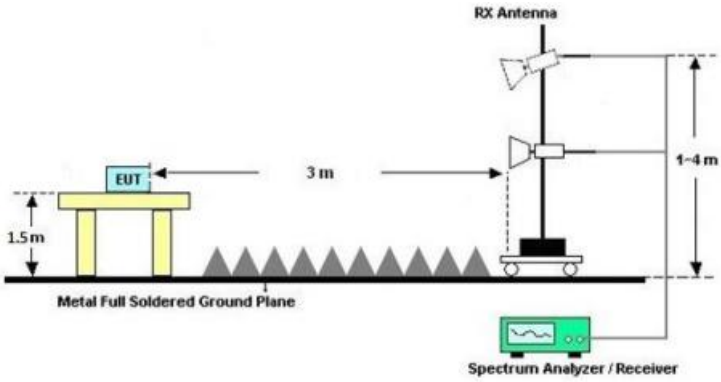
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



4.2.5 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.

4.2.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B.1.

4.2.7 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic or 40GHzwhichever is lower)

Please refer to Appendix B.1.

4.3 Antenna Requirements

4.3.1 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.

4.3.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

4.3.3 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 6dB and 99% Bandwidth

Test Result 6dB Bandwidth

Test Mode	Antenna	Frequency[MHz]	DTS BW [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	0.676	2401.688	2402.364	0.5	PASS
BLE_1M	Ant1	2440	0.680	2439.684	2440.364	0.5	PASS
BLE_1M	Ant1	2480	0.676	2479.684	2480.360	0.5	PASS
BLE_2M	Ant1	2402	1.140	2401.468	2402.608	0.5	PASS
BLE_2M	Ant1	2440	1.148	2439.460	2440.608	0.5	PASS
BLE_2M	Ant1	2480	1.152	2479.452	2480.604	0.5	PASS

Test Result 99% Bandwidth

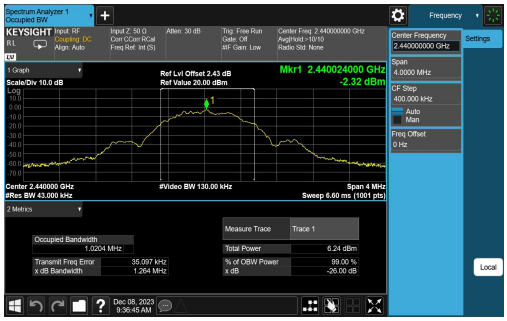
Test Mode	Antenna	Frequency[MHz]	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	1.0181	2401.5263	2402.5444	---	---
BLE_1M	Ant1	2440	1.0205	2439.5248	2440.5453	---	---
BLE_1M	Ant1	2480	1.0177	2479.5239	2480.5416	---	---
BLE_2M	Ant1	2402	2.0108	2401.0423	2403.0531	---	---
BLE_2M	Ant1	2440	2.0113	2439.0414	2441.0527	---	---
BLE_2M	Ant1	2480	2.0126	2479.0328	2481.0454	---	---

Test Graphs_6dB Bandwidth

BLE_1M-Ant1-2402-PASS	BLE_1M-Ant1-2440-PASS

BLE_1M-Ant1-2480-PASS	BLE_2M-Ant1-2402-PASS
BLE_2M-Ant1-2440-PASS	**BLE_2M-Ant1-2480-PASS**

Test Graphs_99% Bandwidth

BLE_1M-Ant1-2402	BLE_1M-Ant1-2440
	
BLE_1M-Ant1-2480	**BLE_2M-Ant1-2402**

BLE_2M-Ant1-2440	BLE_2M-Ant1-2480

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]
BLE_1M_2402_edge	2,389.950	59.47	74.00	14.53	46.02	54.00	7.98	V	43.6
BLE_1M_2480_edge	2,483.000	59.68	74.00	14.32	46.24	54.00	7.76	H	70.2
BLE_2M_2402_edge	2,390.275	59.30	74.00	14.70	46.03	54.00	7.97	H	104.9
BLE_2M_2480_edge	2,483.500	59.67	74.00	14.33	46.41	54.00	7.59	V	191

Test Result_Spurious Emission

Note1: Test result Sweep the whole frequency band through the range from 9kHz to the 10th harmonic of the carrier the Emissions in the frequency band 9kHz-30MHz and 18GHz-26.5GHz are more than 20dB below the limit are not reported.

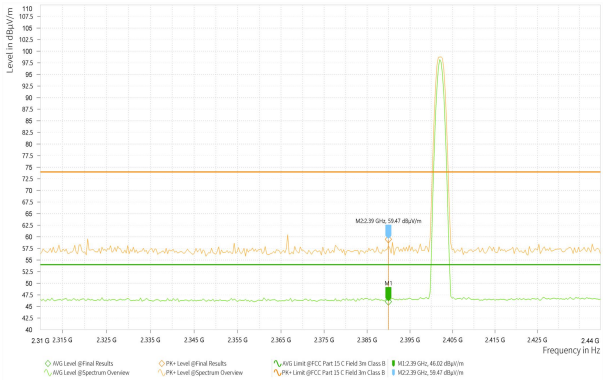
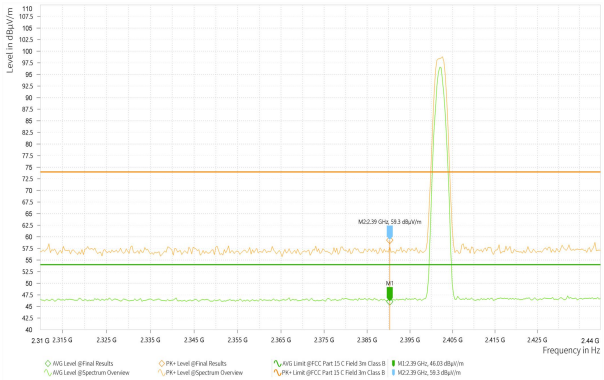
Note2: 'Low' indicates a frequency range below 1GHz, and 'High' indicates a frequency range above 1GHz.

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]
BLE_1M_2402_High	4,804.000	53.23	74.00	20.77	40.55	54.00	13.45	H	305.7
	7,206.000	55.80	74.00	18.20	43.43	54.00	10.57	H	253.1
	9,608.000	47.20	74.00	26.80	34.75	54.00	19.25	H	71.4
	12,010.000	49.04	74.00	24.96	36.25	54.00	17.75	H	200.6
	14,412.000	49.44	74.00	24.56	37.21	54.00	16.79	V	138.3
	16,814.000	53.59	74.00	20.41	41.12	54.00	12.88	H	360
BLE_1M_2440_High	4,880.000	53.67	74.00	20.33	40.79	54.00	13.21	H	101.2
	7,320.000	56.44	74.00	17.56	43.65	54.00	10.35	H	0.2
	9,760.000	48.37	74.00	25.63	35.29	54.00	18.71	H	360
	12,200.000	49.12	74.00	24.88	36.21	54.00	17.79	H	199.3
	14,640.000	49.84	74.00	24.16	37.51	54.00	16.49	H	360
	17,080.000	53.46	74.00	20.54	40.85	54.00	13.15	H	11
BLE_1M_2480_High	4,960.000	53.52	74.00	20.48	40.96	54.00	13.04	H	327
	7,440.000	56.45	74.00	17.55	43.91	54.00	10.09	H	251.9
	9,920.000	47.57	74.00	26.43	35.34	54.00	18.66	V	70.2
	12,400.000	49.03	74.00	24.97	36.74	54.00	17.26	V	10.2
	14,880.000	49.70	74.00	24.30	37.51	54.00	16.49	H	160.8
	17,360.000	52.52	74.00	21.48	39.74	54.00	14.26	H	8.9
BLE_2M_2402_High	4,804.000	53.78	74.00	20.22	40.65	54.00	13.35	H	305.6

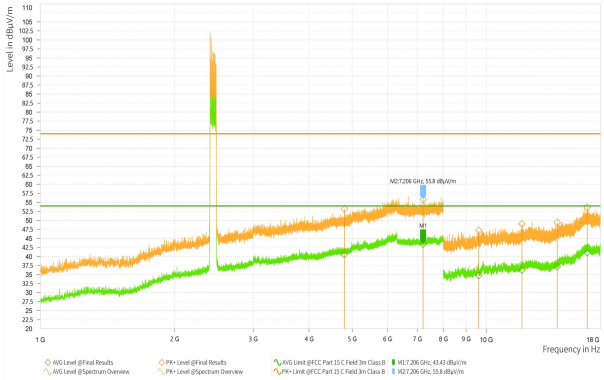
	7,206.000	56.27	74.00	17.73	43.40	54.00	10.60	H	360
	9,608.000	47.21	74.00	26.79	34.71	54.00	19.29	H	0
	12,010.000	48.64	74.00	25.36	36.12	54.00	17.88	H	135.9
	14,412.000	49.64	74.00	24.36	37.35	54.00	16.65	H	351.8
	16,814.000	53.20	74.00	20.80	40.46	54.00	13.54	V	67.8
BLE_2M_2440_High	4,880.000	53.36	74.00	20.64	40.85	54.00	13.15	H	329.4
	7,320.000	56.13	74.00	17.87	43.79	54.00	10.21	V	86.8
	9,760.000	47.87	74.00	26.13	35.38	54.00	18.62	H	71.4
	12,200.000	49.05	74.00	24.95	36.17	54.00	17.83	V	349.8
	14,640.000	49.96	74.00	24.04	37.21	54.00	16.79	H	225.3
	17,080.000	52.98	74.00	21.02	40.86	54.00	13.14	V	360
BLE_2M_2480_High	4,960.000	54.02	74.00	19.98	40.96	54.00	13.04	H	360
	7,440.000	56.58	74.00	17.42	44.00	54.00	10.00	H	0
	9,920.000	48.14	74.00	25.86	35.21	54.00	18.79	H	360
	12,400.000	49.15	74.00	24.85	36.70	54.00	17.30	H	360
	14,880.000	49.62	74.00	24.38	36.96	54.00	17.04	H	138.3
	17,360.000	52.13	74.00	21.87	39.90	54.00	14.10	H	162

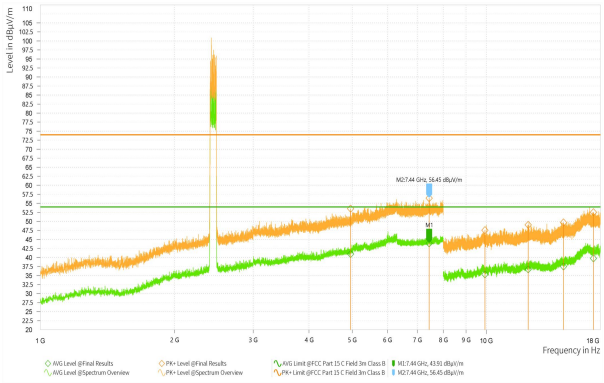
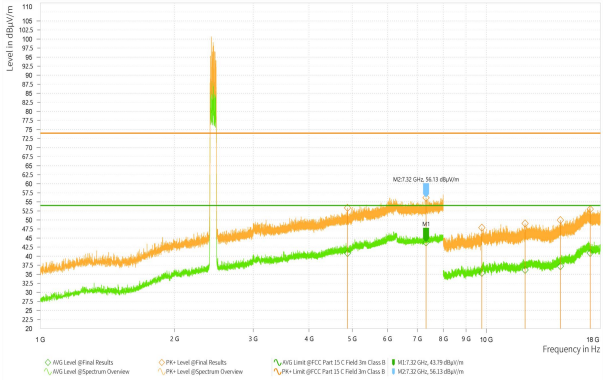
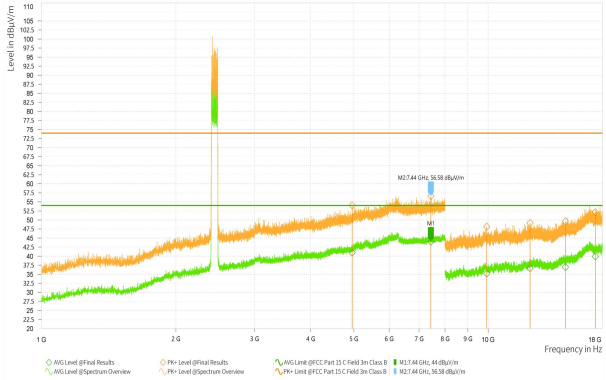
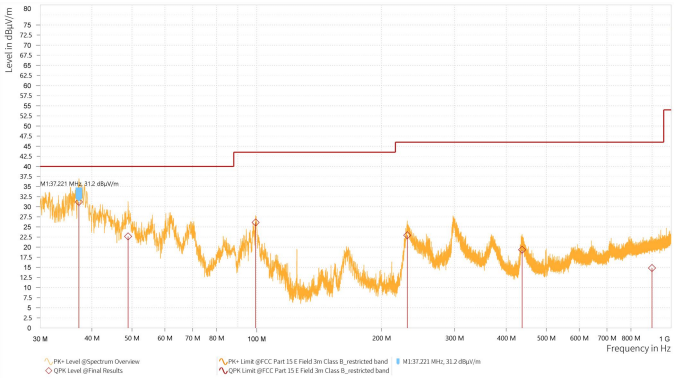
Test Mode & Test Freq.[MHz]	Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Pol.	Azimuth [deg]
BLE_1M_2402_Low	37.221	31.20	40.00	8.80	V	317.4
	48.915	22.68	40.00	17.32	V	358.6
	99.355	26.11	43.50	17.39	V	358.6
	230.790	22.94	46.00	23.06	H	236.3
	436.753	19.37	46.00	26.63	H	188.2
	899.389	14.83	46.00	31.17	H	59.1

Test Graphs_Band Edges

BLE_1M_2402_edge	BLE_1M_2480_edge
	
BLE_2M_2402_edge	**BLE_2M_2480_edge**
	

Test Graphs_Spurious Emission

BLE_1M_2402_High	BLE_1M_2440_High
	

BLE_1M_2480_High	BLE_2M_2402_High
	
BLE_2M_2440_High	**BLE_2M_2480_High**
	
BLE_1M_2402_Low	**/**
	/

Appendix C – The EUT Appearance

Refer to “Attachment 1: External Photograph” and “ Attachment 2: Internal Photograph” file.

Appendix D – Test Setup Photograph

Refer to “Attachment 5: RF Test Setup Photograph” file.

******End of the Report******