



FCC/ISED - TEST REPORT

Report Number : **709502403822-00E Rev1** Date of Issue: October 31, 2024

Model : **Lime-CCU23**

Product Type : CCU

Applicant : Neutron Holdings, Inc.

Address : 85 2nd St, San Francisco, CA 94105 USA

Production Facility : Quectel Wireless Solutions Co., Ltd.

Address : Building 5, Shanghai Business Park Phase III (Area B), No.1016
Tianlin Road.Minhang District, Shanghai 200233, China

Test Result : ☒ **Positive** ☐ **Negative**

Total pages including
Appendices : 71



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This revised report replaced all the version issued before.



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2 Details about the Test Laboratory

Details about the Test Laboratory

Test Site 1

Company name: TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
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FCC Registration No.: 820234

FCC Designation Number: CN1183

ISED CAB identifier: CN0101

IC Registration No.: 31668



3 Description of the Equipment Under Test

Product:	CCU
Model no.:	Lime-CCU23
Hardware Version Identification No. (HVIN)	Lime-CCU23
Product Marketing Name (PMN)	Lime-CCU23
FCC ID:	2APB2-LIME-CCU23
IC:	32977-LIMECCU23
Options and accessories:	NA
Rating:	DC 42V/54V
RF Transmission Frequency:	For 2.4G Wi-Fi: For 802.11b/g/n-HT20: 2412~2462 MHz For 5G Wi-Fi: 5180~5240 MHz (U-NII-1) 5260~5320 MHz (U-NII-2A) 5500~5720 MHz (U-NII-2C) 5745~5825 MHz (U-NII-3) The device shall not be capable of transmitting in the 5600-5650 MHz band. For BLE (Module1): 2402~2480 MHz For EDR (Module1): 2402~2480 MHz For BLE (Module2): 2402~2480 MHz For EDR (Module2): 2402~2480 MHz
No. of Operated Channel:	For 2.4G Wi-Fi: 11 for 802.11b/802.11g/802.11n(H20) For 5G Wi-Fi: 5180~5240 MHz (U-NII-1) 5260~5320 MHz (U-NII-2A)



5500~5700 MHz (U-NII-2C)
5745~5825 MHz (U-NII-3)

For BLE (Module1): 40

For EDR (Module1): 79

For BLE (Module2): 40

For EDR (Module2): 79

Modulation:

For 2.4G Wi-Fi:

Direct Sequence Spread Spectrum (DSSS) for 802.11b

Orthogonal Frequency Division Multiplexing (OFDM) for 802.11g/n

For 5G Wi-Fi:

Orthogonal Frequency Division Multiplexing (OFDM) for 802.11a/n/ac

For BLE (Module1): GFSK

For EDR (Module1): GFSK, $\pi/4$ DQPSK, 8DPSK

For BLE (Module2): GFSK

For EDR (Module2): GFSK, $\pi/4$ DQPSK, 8DPSK

Hardware Version:

EG21GGFR07A01M4G_OCPCU_NCFG_QDM549_01.200.01.002

Software Version:

V1.2

Data speed:

For 2.4G Wi-Fi:

11b 1-11Mbps

11g 6-54Mbps

11n(H20) 6.5-72.2Mbps

For 5G Wi-Fi:

11a 6 ~ 54Mbps,

11n HT20 6.5 ~ 72.2Mbps,

11ac VHT20 6.5 ~ 86.7Mbps, 11ac VHT40 13.5 ~ 200Mbps,

11ac VHT80 29.3 ~ 433.3Mbps

For BLE (Module1): 1Mbps

For EDR (Module1): 1Mbps, 2Mbps, 3Mbps

For BLE (Module2): 1Mbps, 2Mbps

For EDR (Module2): 1Mbps, 2Mbps, 3Mbps

Channel list:

For 2.4G Wi-Fi:

802.11b/g/n(HT20)			
Ch	Fre(MHz)	Ch	Fre(MHz)
1	2412	7	2442
2	2417	8	2447
3	2422	9	2452
4	2427	10	2457
5	2432	11	2462
6	2437		

For 5G Wi-Fi:

Band (GHz)	Operating Channel Number	Channel center frequencies for 20MHz bandwidth (MHz)
5.15GHz~5.25GHz	36	5180
	40	5200
	44	5220
	48	5240
5.25GHz~5.35GHz	52	5260
	56	5280
	60	5300
	64	5320
5.5GHz~5.7GHz	100	5500
	104	5520
	108	5540
	112	5560
	116	5580
	132	5660
	136	5680
	140	5700
5.725GHz~5.825GHz	144	5720
	149	5745
	153	5765
	157	5785
	161	5805
	165	5825

Band (GHz)	Operating Channel Number	Channel center frequencies for 40MHz
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		bandwidth (MHz)
5.15GHz~5.25GHz	38	5190
	46	5230
5.25GHz~5.35GHz	54	5270
	62	5310
5.5GHz~5.7GHz	102	5510
	110	5550
	118	5590
	134	5670
	142	5710
5.725GHz~5.825GHz	151	5755
	159	5795

Band (GHz)	Operating Channel Number	Channel center frequencies for 80MHz bandwidth (MHz)
5.15GHz~5.25GHz	42	5210
5.25GHz~5.35GHz	58	5290
5.5GHz~5.7GHz	106	5530
	138	5690
5.725GHz~5.825GHz	155	5775

For BLE

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

For EDR

Ch	Fre (MH)	Ch	Fre (MH)	Ch	Fre (MH)	Ch	Fre (MH)	Ch	Fre (MHz)
1	2402	17	2418	33	2434	49	2450	65	2466
2	2403	18	2419	34	2435	50	2451	66	2467
3	2404	19	2420	35	2436	51	2452	67	2468
4	2405	20	2421	36	2437	52	2453	68	2469
5	2406	21	2422	37	2438	53	2454	69	2470



6	2407	22	2423	38	2439	54	2455	70	2471
7	2408	23	2424	39	2440	55	2456	71	2472
8	2409	24	2425	40	2441	56	2457	72	2473
9	2410	25	2426	41	2442	57	2458	73	2474
10	2411	26	2427	42	2443	58	2459	74	2475
11	2412	27	2428	43	2444	59	2460	75	2476
12	2413	28	2429	44	2445	60	2461	76	2477
13	2414	29	2430	45	2446	61	2462	77	2478
14	2415	30	2431	46	2447	62	2463	78	2479
15	2416	31	2432	47	2448	63	2464	79	2480
16	2417	32	2433	48	2449	64	2465		

Antenna Type: For 2.4G Wi-Fi: FPC

For 5G Wi-Fi: FPC

For BLE (Module1): FPC

For EDR (Module1): FPC

For BLE (Module2): FPC

For EDR (Module2): FPC

Antenna Gain: For 2.4G Wi-Fi: 1.96 dBi

For 5G Wi-Fi: 3.52 dBi

For BLE (Module1): 1.96 dBi

For EDR (Module1): 1.96 dBi

For BLE (Module2): 3.16 dBi

For EDR (Module2): 3.16 dBi

Description of the EUT: The Equipment Under Test (EUT) is a CCU with Wi-Fi Module, BLE/EDR Module and LTE Module. The EUT support Wi-Fi operated at 2.4GHz and 5GHz.

Test sample no.: SHA-843416-2 (Radiated sample)
SHA-843416-3 (Conducted sample)



The sample's mentioned in this report is/are submitted/ supplied/ manufactured by client. The laboratory therefore assumes no responsibility for accuracy of information on the brand name, model number, origin of manufacture, consignment, antenna gain or any information supplied.



4 Summary of Test Standards

Test Standards	
FCC Part 15 Subpart C 10-1-2023 Edition	PART 15 - RADIO FREQUENCY DEVICES Subpart C - Intentional Radiators
RSS-Gen Issue 5, April 2018 Amendment 1, March 2019 + Amendment 2, February 2021	General Requirements for Compliance of Radio Apparatus
RSS-247 Issue 3 August 2023	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSS) and License-Exempt Local Area Network (LE- LAN) Devices

All the test methods were according to KDB 558074 D01 15.247 Measurement Guidance v05r02 and ANSI C63.10-2013.



5 Summary of Test Results

Technical Requirements							
FCC Part 15 Subpart C & RSS-247 Issue 3/RSS-Gen Issue 5							
Test Condition			Pages	Test Site	Test Result		
					Pass	Fail	N/A
§15.207	RSS-GEN 8.8	Conducted emission AC power port	---	Site 1	☒	☐	☐
§15.247 (b) (1)	RSS-247 5.4(d)	Conducted peak output power	18-22	Site 1	☒	☐	☐
	RSS-247 5.4(d)	Equivalent Isotropic Radiated Power	18-22	Site 1	☒	☐	☐
§15.247(a)(1)	RSS-247 5.1(a) & RSS-Gen 6.7	20dB bandwidth and 99% Occupied Bandwidth	23-30	Site 1	☒	☐	☐
§15.247(a)(1)	RSS-247 5.1(b)	Carrier frequency separation	31-33	Site 1	☒	☐	☐
§15.247(a)(1)(iii)	RSS-247 5.1(d)	Number of hopping frequencies	34-35	Site 1	☒	☐	☐
§15.247(a)(1)(iii)	RSS-247 5.1(d)	Dwell Time - Average Time of Occupancy	36-40	Site 1	☒	☐	☐
§15.247(a)(2)	RSS-247 5.2(a) & RSS-GEN 6.7	6dB bandwidth and 99% Occupied Bandwidth	---	---	☐	☐	☒
§15.247(e)	RSS-247 5.2(b)	Power spectral density	---	---	☐	☐	☒
§15.247(e)	RSS-247 5.5	Spurious RF conducted emissions	41-47	Site 1	☒	☐	☐
§15.247(d)	RSS-247 5.5	Band edge	48-60	Site 1	☒	☐	☐
§15.247(d) & §15.209 & §15.205	RSS-247 5.5 & RSS-Gen 6.13	Spurious radiated emissions for transmitter	61-67	Site 1	☒	☐	☐
§15.203	RSS-Gen 6.8	Antenna requirement	See note 1		☒	☐	☐

Remark 1: N/A – Not Applicable.

Remark 2: The EUT only operation at 2.4G Wi-Fi and 5G Wi-Fi UNII Band (5180MHz-5240MHz, 5745MHz-5825MHz).

Note 1: The EUT uses a FPC antenna, which gain is 1.96 dBi for 2.4G Wi-Fi, 3.52 dBi for 5G Wi-Fi. In accordance to §15.203 and RSS-Gen 6.8, It is considered sufficiently to comply with the provisions of this section.

15.203 requirement: An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall 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, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna



jack or electrical connector is prohibited. 15.247(c) (1)(i) requirement: (i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi



6 General Remarks

Remarks

This submittal(s) (test report) is intended for FCC ID: 2APB2-LIME-CCU23, IC: 32977-LIMECCU23 complies with Section 15.207, 15.209, 15.247 of the FCC Part 15, Subpart C Rules and RSS-247, RSS-GEN.

This report is only for the EDR (Module1) test report, for the 5GHz Wi-Fi test report please refer to 709502403822-00A, for the 2.4GHz Wi-Fi test report please refer to 709502403822-00C, for the BLE (Module1) test report please refer to 709502403822-00D, for the BLE (Module2) test report please refer to 709502403822-00F, for the EDR (Module2) test report please refer to 709502403822-00G.

SUMMARY:

All tests according to the regulations cited on page 5 were

■ - Performed

□ - **Not** Performed

The Equipment Under Test

■ - **Fulfills** the general approval requirements.

□ - **Does not** fulfill the general approval requirements.

Sample Received Date: July 12, 2024

Testing Start Date: August 6, 2024

Testing End Date: August 22, 2024

TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch

Reviewed by:

Prepared by:

Tested by:



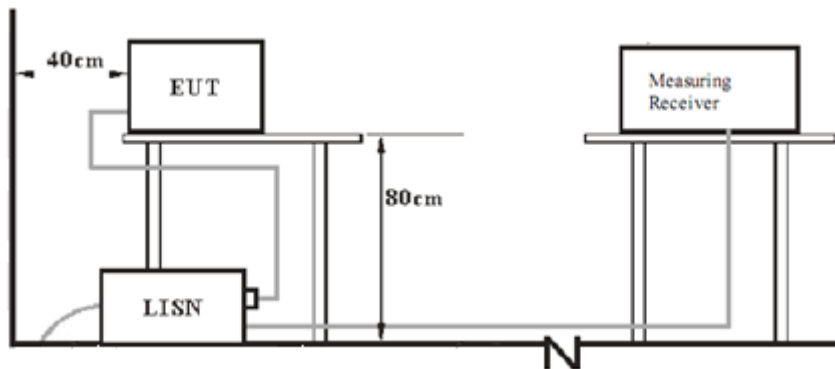
Hui TONG
Review Engineer

Wenqiang LU
Project Engineer

Chengjie GUO
Test Engineer

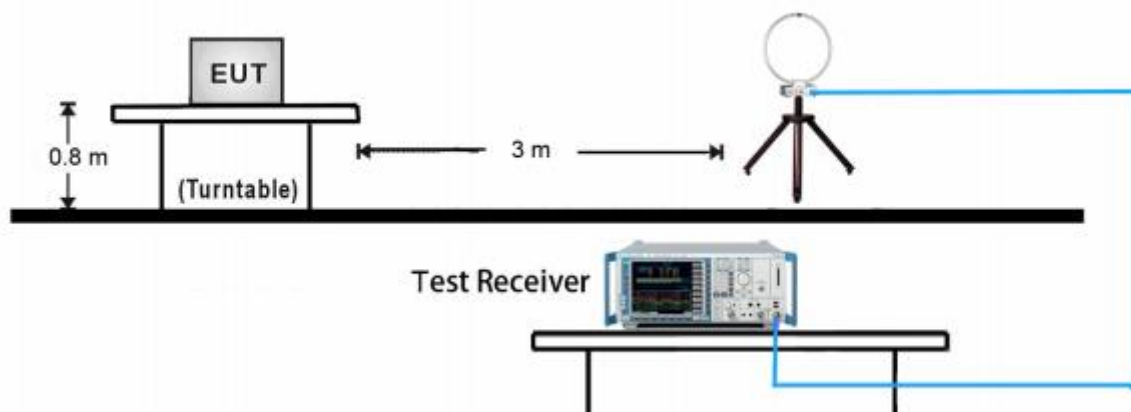
7 Test Setups

7.1 AC Power Line Conducted Emission test setups

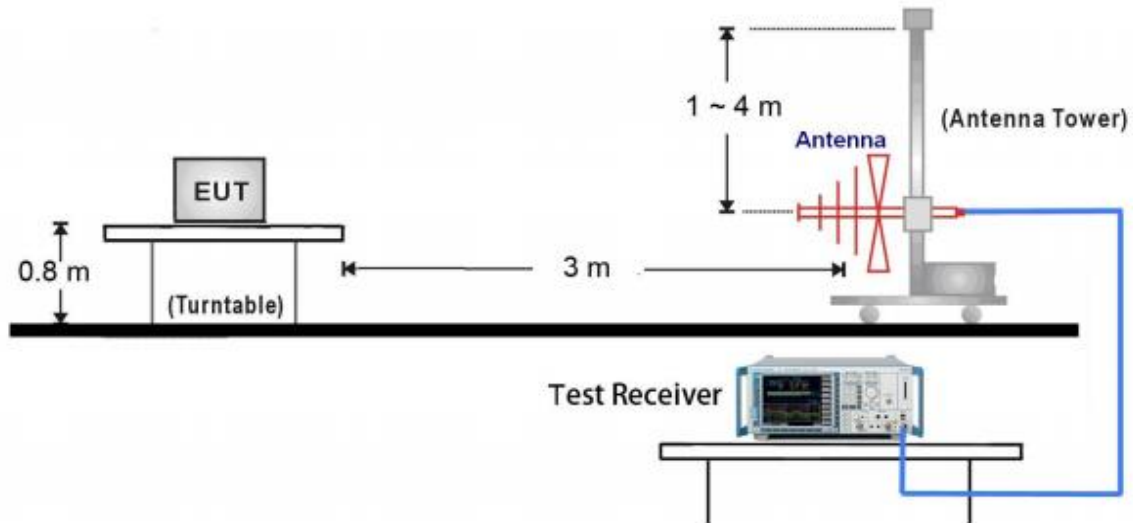


7.2 Radiated test setups

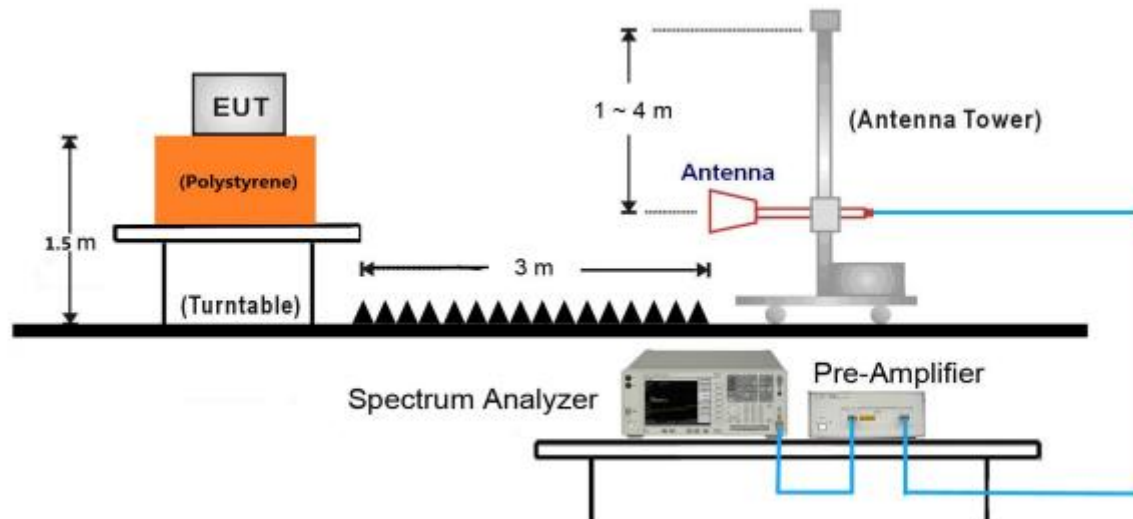
9kHz ~ 30MHz Test Setup:



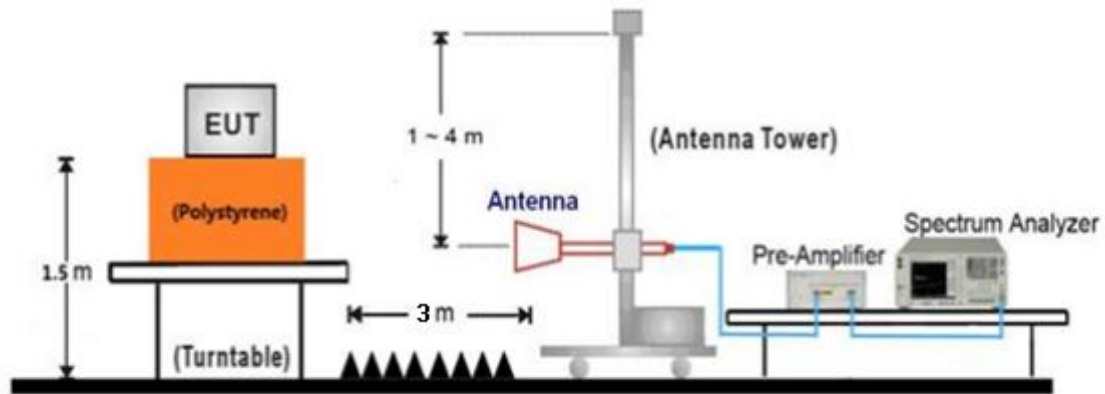
30MHz ~ 1GHz Test Setup:



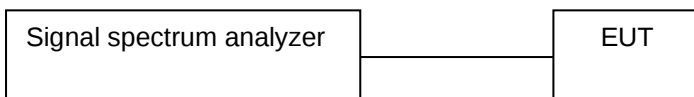
1GHz ~ 18GHz Test Setup:



18GHz ~ 25GHz Test Setup:



7.3 Conducted RF test setups



8 Systems test configuration

Auxiliary Equipment Used during Test:

DESCRIPTION	MANUFACTURER	MODEL NO.(SHIELD)	S/N(LENGTH)
Notebook	Lenove	E470	PF-OU5TS7 17/09

Test software: adb.exe, which used to control the EUT in continues transmitting mode.

The system was configured to hopping mode and non-hopping mode.

Hopping mode: typical working mode (normal hopping status)

Mode	Tested Channel	Modulation	Index Value (Power level setting)
DH5	0	GFSK	Default
	40	GFSK	Default
	78	GFSK	Default
2DH5	0	$\pi/4$ -DQPSK	Default
	40	$\pi/4$ -DQPSK	Default
	78	$\pi/4$ -DQPSK	Default
3DH5	0	8DPSK	Default
	40	8DPSK	Default
	78	8DPSK	Default

The system was configured to hopping mode and non-hopping mode.

Hopping mode: typical working mode (normal hopping status)

Non-hopping mode: The system was configured to operate at a signal channel transmitting. The test software allows the configuration and operation at the worst-case duty and the highest transmit power



9 Technical Requirement

9.1 Conducted Peak Output Power & EIRP

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously
3. Use the following test receiver settings:
Span = approximately 5 times the 20dB bandwidth, centered on a hopping channel
RBW > the 20dB bandwidth of the emission being measured, VBW ≥ RBW,
Sweep = auto, Detector function = peak, Trace = max hold
4. 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 and record the results in the test report.
5. Repeat above procedures until all frequencies measured were complete.

Limits

According to §15.247 (b) (1) & RSS-247 5.4(b), conducted peak output power limit as below:

Frequency Range MHz	Limit W	Limit dBm
2400-2483.5	≤1	≤30

According to & RSS-247 5.4(b), EIRP limit as below:

Frequency Range MHz	Limit W	Limit dBm
2400-2483.5	≤4	≤36

Remark: EIRP=Conducted output power + Antenna Gain



Conducted Peak Output Power & EIRP

Bluetooth Mode GFSK modulation Test Result

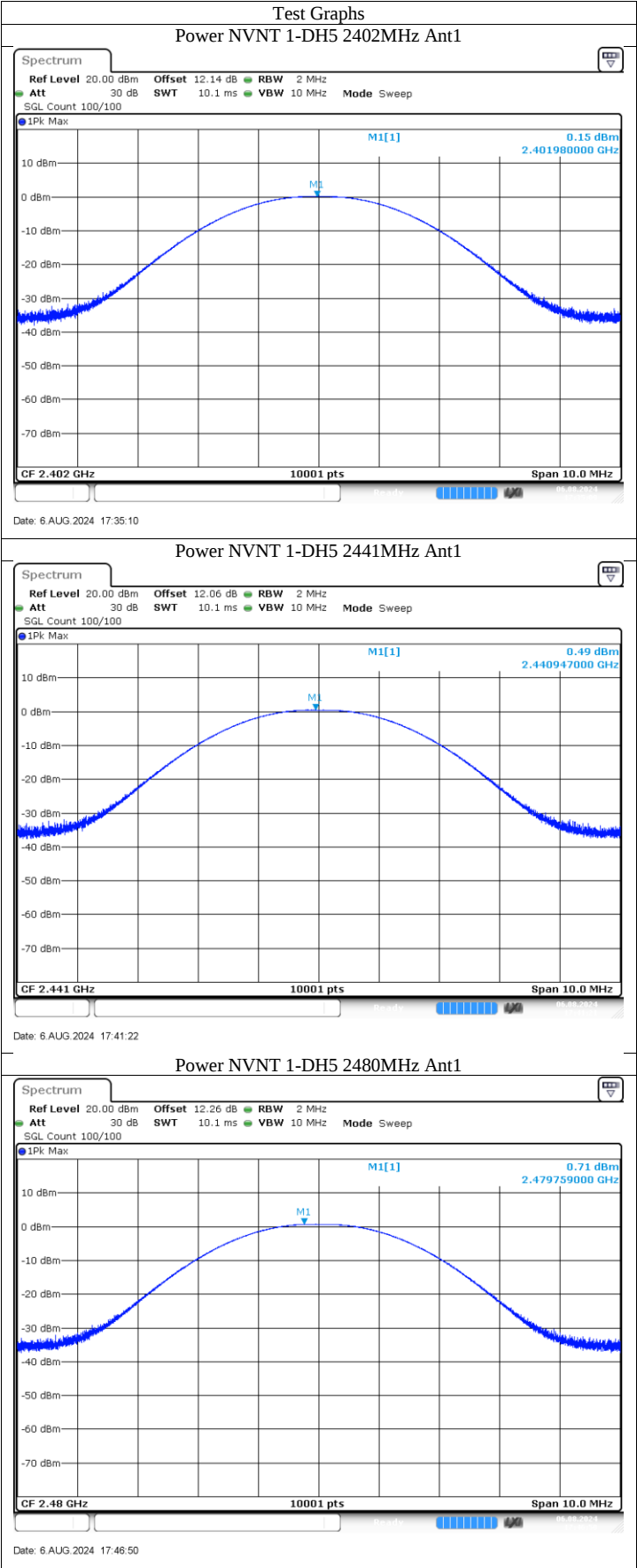
Frequency MHz	Conducted Peak Output Power dBm	Antenna Gain dBi	EIRP dBm	Result
Low channel 2402MHz	0.15	1.96	2.11	Pass
Middle channel 2441MHz	0.49	1.96	2.45	Pass
High channel 2480MHz	0.71	1.96	2.67	Pass

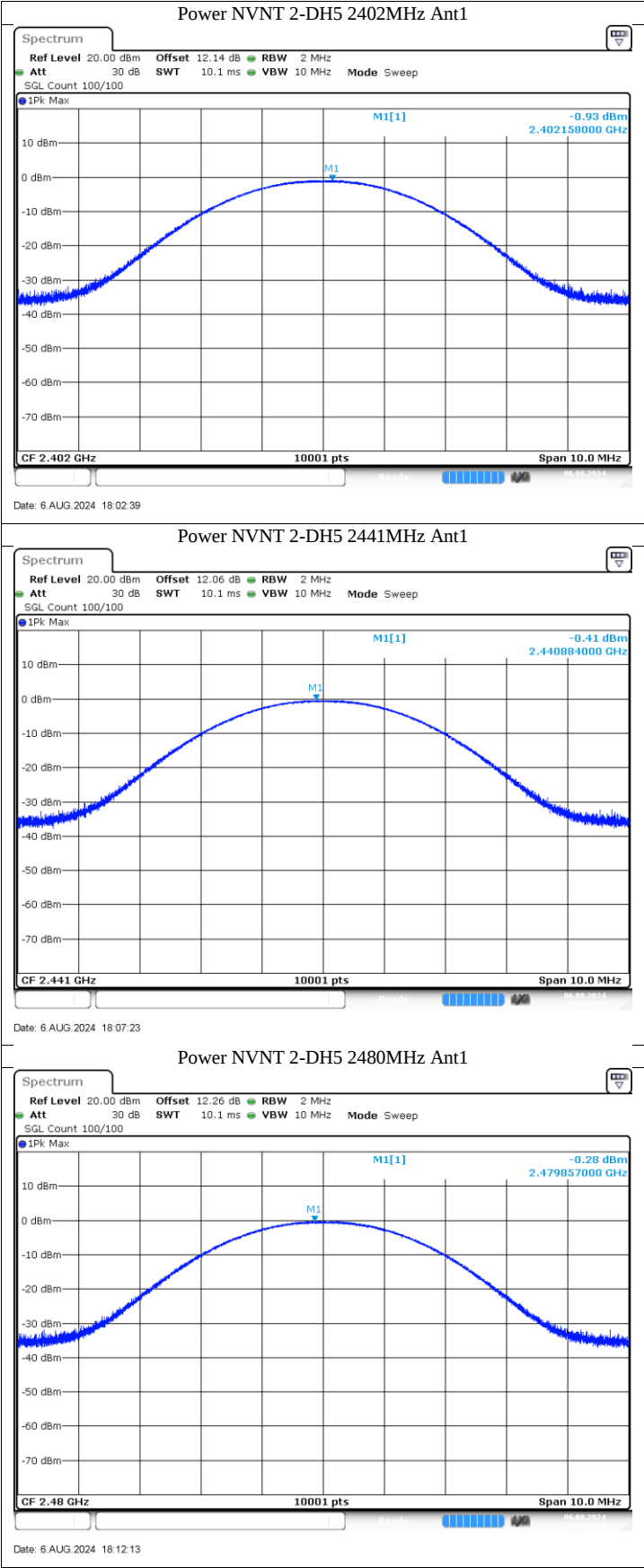
Bluetooth Mode $\pi/4$ -DQPSK modulation Test Result

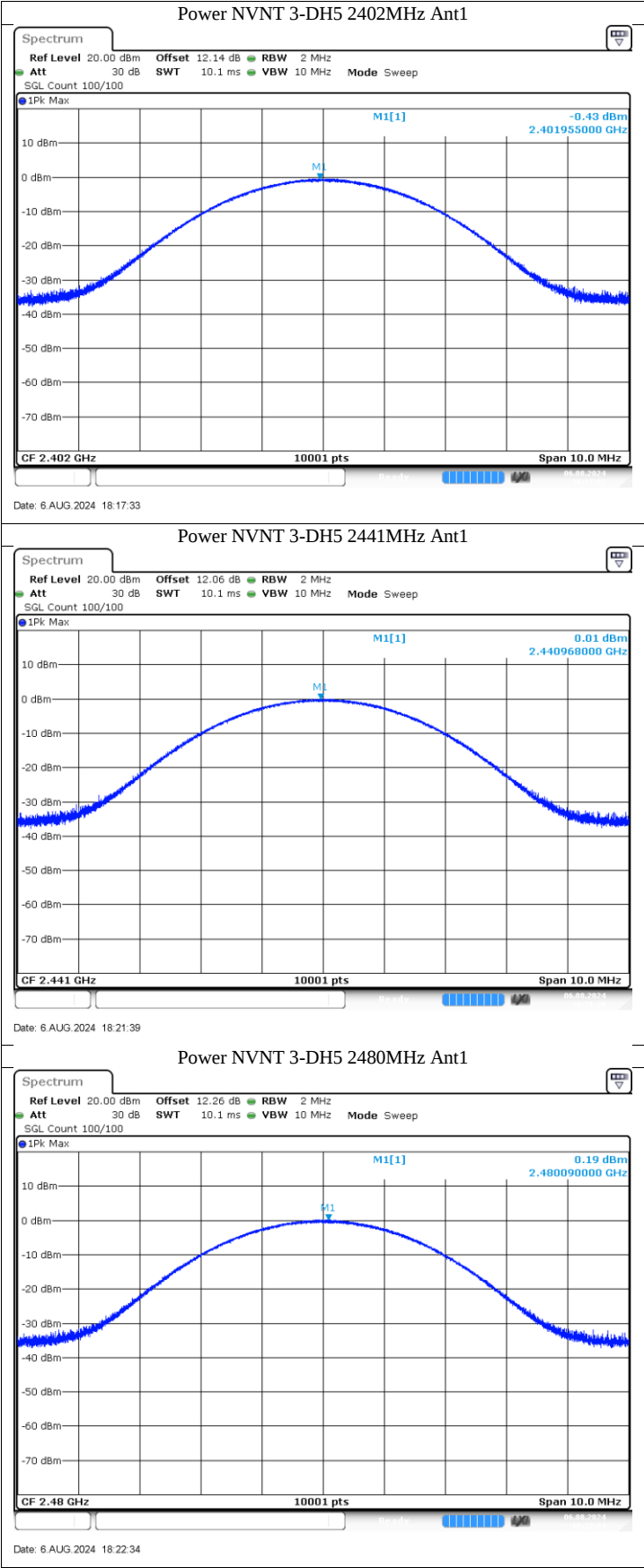
Frequency MHz	Conducted Peak Output Power dBm	Antenna Gain dBi	EIRP dBm	Result
Low channel 2402MHz	-0.93	1.96	1.03	Pass
Middle channel 2441MHz	-0.41	1.96	1.55	Pass
High channel 2480MHz	-0.28	1.96	1.68	Pass

Bluetooth Mode 8DPSK modulation Test Result

Frequency MHz	Conducted Peak Output Power dBm	Antenna Gain dBi	EIRP dBm	Result
Low channel 2402MHz	-0.43	1.96	1.53	Pass
Middle channel 2441MHz	0.01	1.96	1.97	Pass
High channel 2480MHz	0.19	1.96	2.15	Pass









9.2 20 dB bandwidth and 99% Occupied Bandwidth

Test Method

- 1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
- 2. Set to the maximum power setting and enable the EUT transmit continuously.
- 3. Use the following test receiver settings:
Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
RBW ≥ 1% to 5% of the 20 dB bandwidth/99% OBW, VBW≥3RBW,
Sweep = auto, Detector function = peak, Trace = max hold
- 4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Measure the frequency difference of two frequencies that were attenuated 20 dB/99% OBW from the reference level. Record the frequency difference as the emission bandwidth. Record the results.
- 5. Repeat above procedures until all frequencies measured were complete.

Limit

Limit [kHz]

N/A



20 dB bandwidth and 99% Occupied Bandwidth

Bluetooth Mode GFSK Modulation test result

Frequency MHz	20 dB Bandwidth kHz	99% Bandwidth kHz	Limit kHz	Result
2402	951	902	--	Pass
2441	947	910	--	Pass
2480	960	911	--	Pass

20 dB bandwidth and 99% Occupied Bandwidth

Bluetooth Mode $\pi/4$ -DQPSK Modulation test result

Frequency MHz	20 dB Bandwidth kHz	99% Bandwidth kHz	Limit kHz	Result
2402	1286	1185	--	Pass
2441	1278	1197	--	Pass
2480	1282	1190	--	Pass

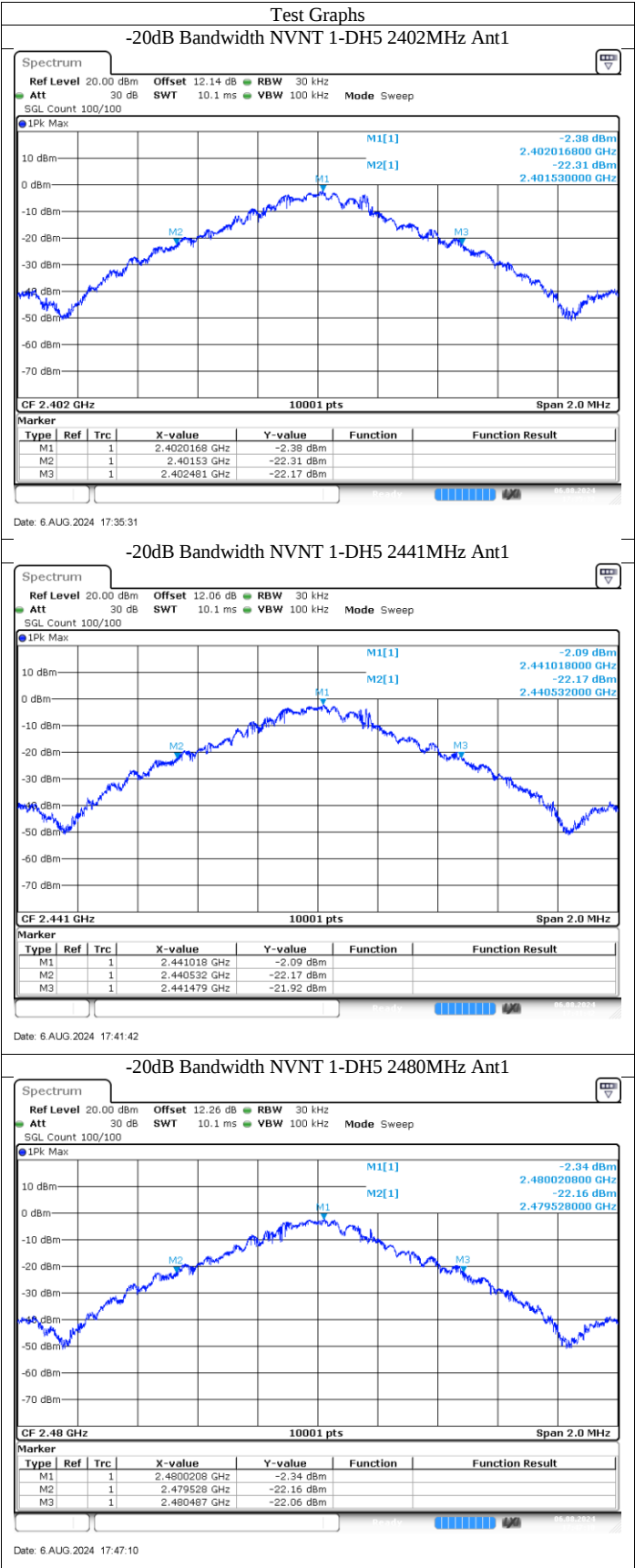
20 dB bandwidth and 99% Occupied Bandwidth

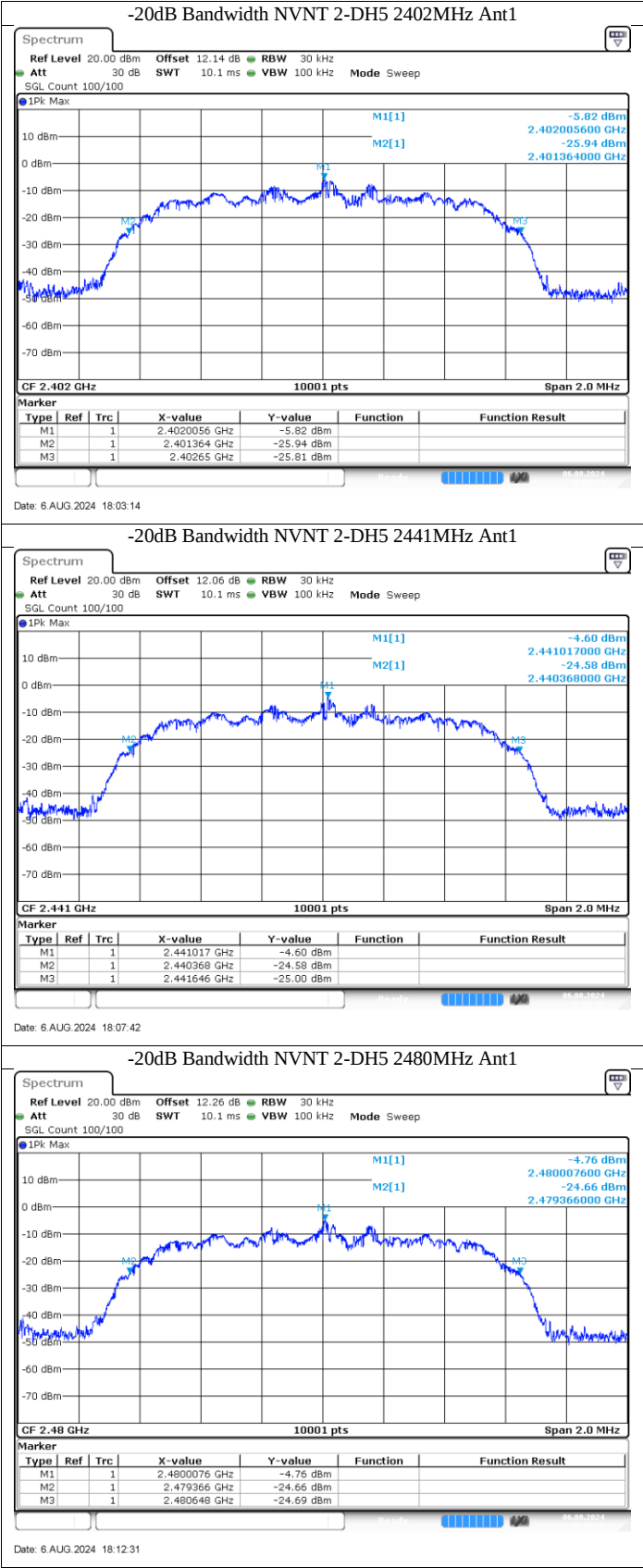
Bluetooth Mode 8DPSK Modulation test result

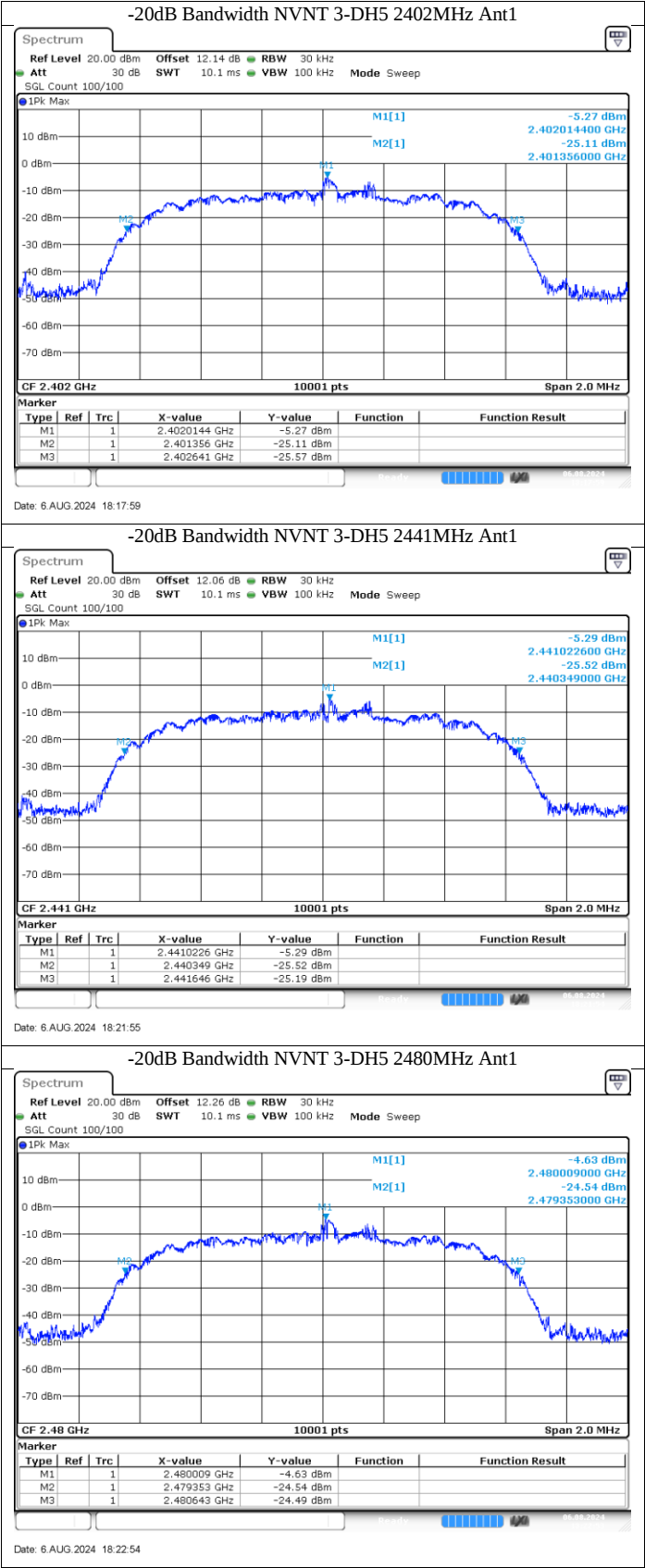
Frequency MHz	20 dB Bandwidth kHz	99% Bandwidth kHz	Limit kHz	Result
2402	1285	1195	--	Pass
2441	1297	1196	--	Pass
2480	1290	1192	--	Pass



-20dB Bandwidth

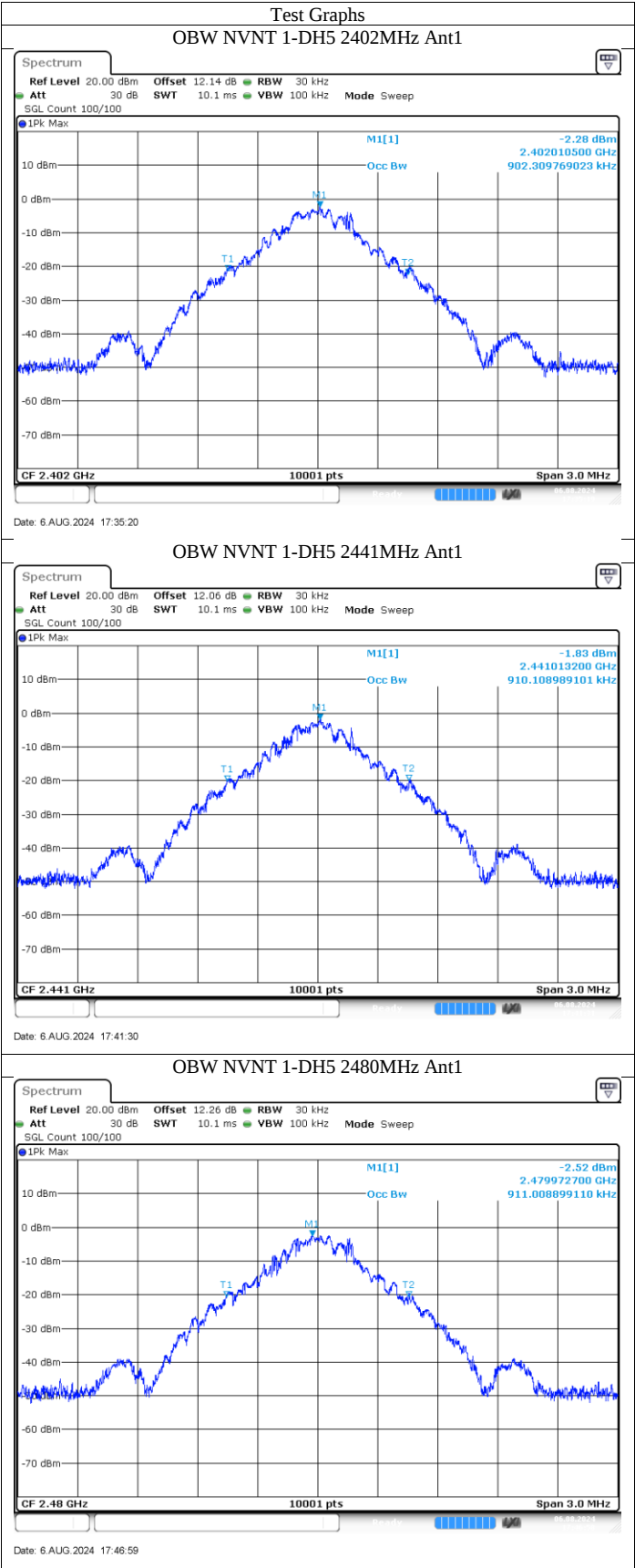


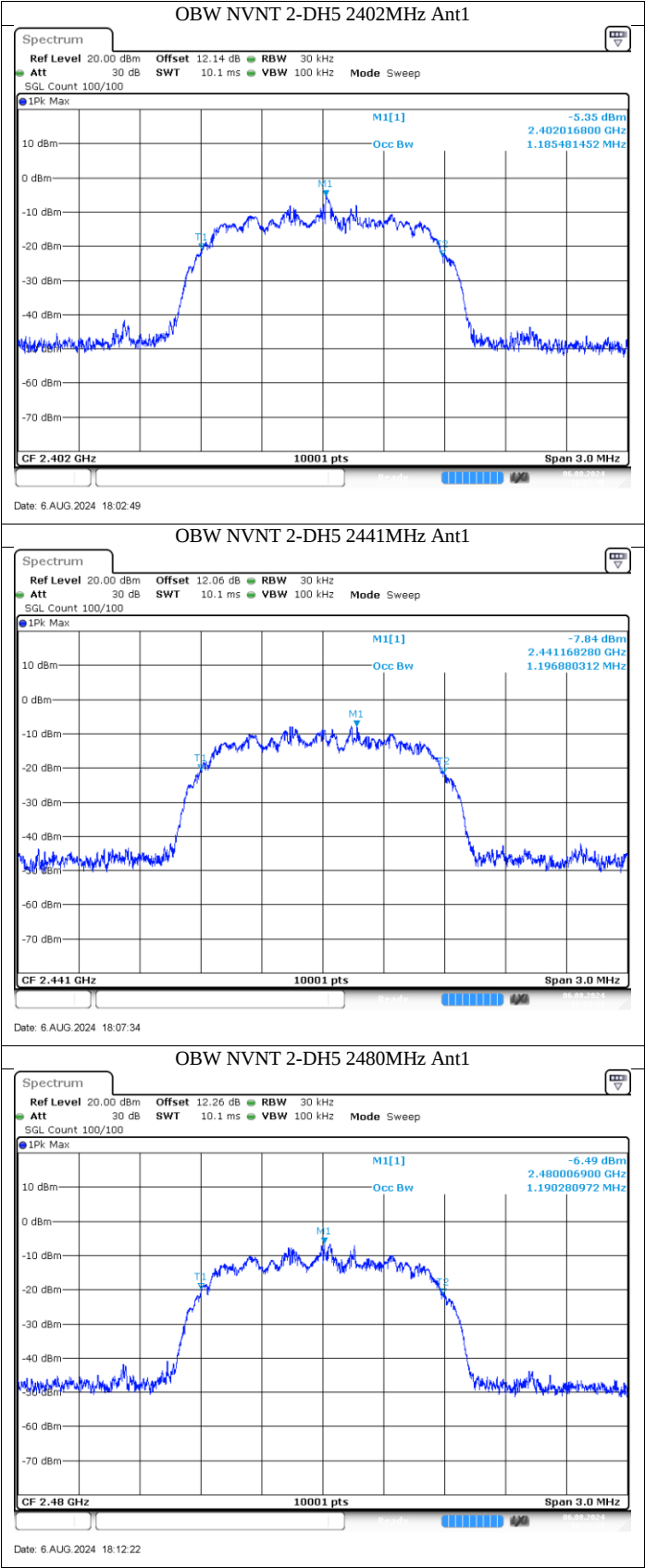


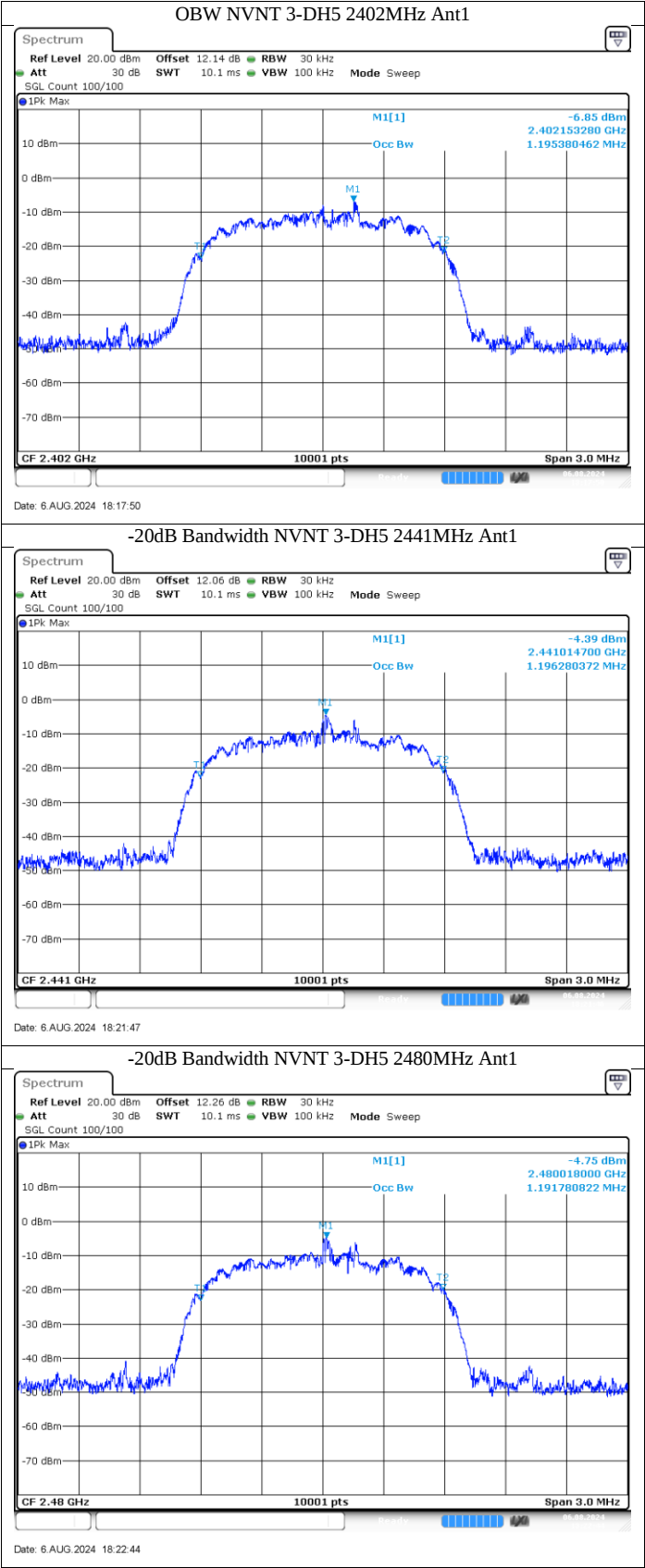




99% Occupied Bandwidth







9.3 Carrier Frequency Separation

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Use the following spectrum analyzer settings:
Span = wide enough to capture the peaks of two adjacent channels, RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel. VBW $\geq$ RBW, Sweep = auto, Detector function = peak.
4. By using the Max-Hold function record the separation of two adjacent channels.
5. Measure the frequency difference of these two adjacent channels by spectrum analyzer marker function. Record the results.
6. Repeat above procedures until all frequencies measured were complete.

Limit

Limit kHz
$\geq 25\text{kHz}$ or $2/3$ of the 20 dB bandwidth which is greater

Limit

Modulation	Frequency MHz	2/3 of 20 dB Bandwidth kHz
GFSK	2441	631
$\pi/4$ -DQPSK	2441	852
8DPSK	2441	865

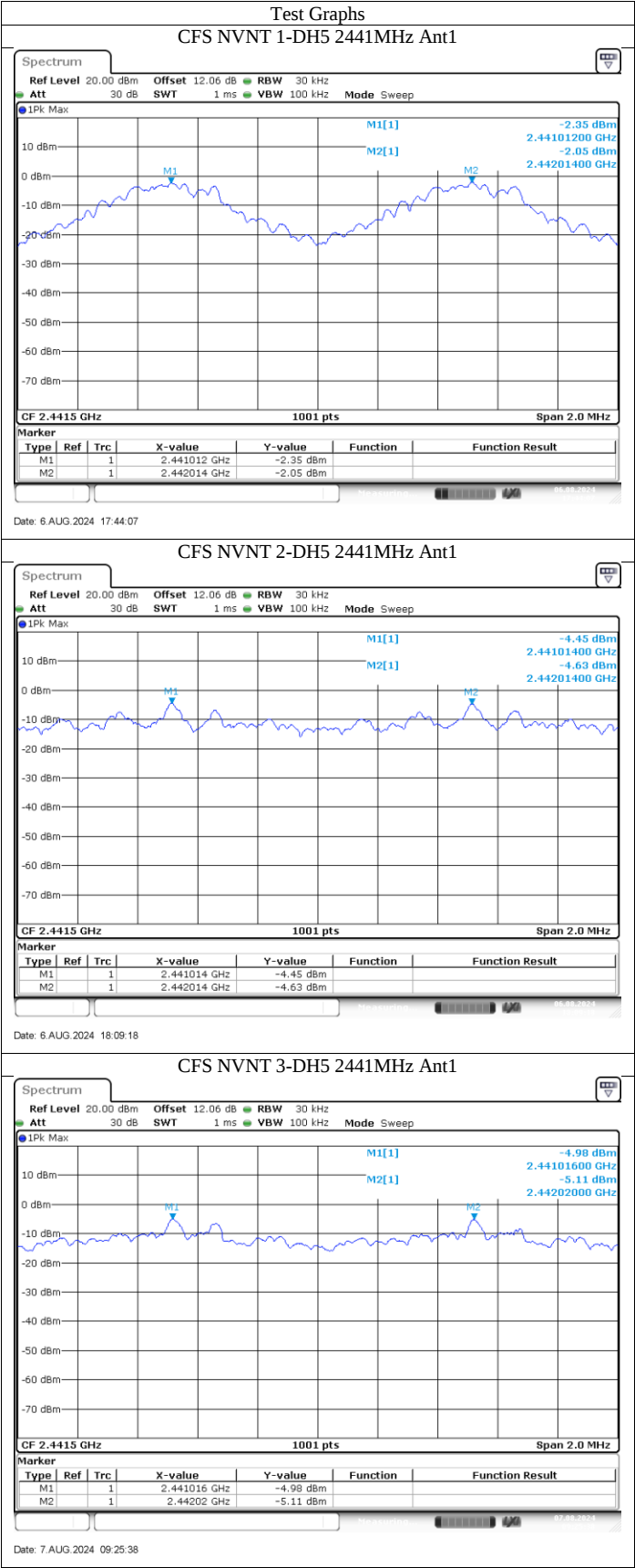


Carrier Frequency Separation

Test result: The measurement was performed with the typical configuration (normal hopping status), here GFSK, $\pi/4$ -DQPSK and 8DPSK modulation mode (low channel) was used to show compliance.

GFSK Modulation test result

Modulation	Frequency	Carrier Frequency Separation	Result
	MHz	kHz	
GFSK	2441	1002	Pass
$\pi/4$ -DQPSK	2441	1000	Pass
8DPSK	2441	1004	Pass





9.4 Number of hopping frequencies

Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Use the following spectrum analyzer settings:
Span = the frequency band of operation, RBW: 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, VBW $\geq$ RBW, Sweep = auto, Detector function = peak, Trace=Max hold.
4. Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

Limit

Limit
number

 ≥ 15