FCC RF Test Report

APPLICANT	:	Nauto
EQUIPMENT	:	In-vehicle camera
BRAND NAME	:	Nauto
MODEL NAME	:	N4
FCC ID	:	2AKJ5-N4
STANDARD	:	FCC Part 15 Subpart C §15.247
CLASSIFICATION	:	(DSS) Spread Spectrum Transmitter
TEST DATE(S)	:	Mar. 31, 2024 ~ Apr. 01, 2024

We, Sporton International Inc. (Kunshan), would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International Inc. (Kunshan), the test report shall not be reproduced except in full.

Jason Jia

Approved by: Jason Jia

ACCREDITED
Cert #5145.02

Sporton International Inc. (Kunshan)
No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR3D2618A	Rev. 01	Initial issue of report	May 14, 2024

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(1)	Number of Channels	≥ 15Chs	Pass	-
3.2	15.247(a)(1)	Hopping Channel Separation	≥ 2/3 of 20dB BW	Pass	-
3.3	15.247(a)(1)	Dwell Time of Each Channel	≤ 0.4sec in 31.6sec period	Pass	-
3.4	15.247(a)(1)	20dB Bandwidth	-	Report only	-
3.4	-	99% Bandwidth	-	Report only	-
3.5	15.247(b)(1)	Peak Output Power	≤ 125 mW	Pass	-
3.6	15.247(d)	Conducted Band Edges	≤ 20dBc	Pass	-
3.7	15.247(d)	Conducted Spurious Emission	≤ 20dBc	Pass	-
3.8	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 16.80 dB at 2483.66 MHz
-	15.207	AC Conducted Emission	15.207(a)	Not Applicable	-
3.9	15.203 & 15.247(b)	Antenna Requirement	15.203 & 15.247(b)	Pass	-

Conformity Assessment Condition:

1. The test results (PASS/FAIL) with all measurement uncertainty excluded are presented against the regulation limits or in accordance with the requirements stipulated by the applicant/manufacturer who shall bear all the risks of non-compliance that may potentially occur if measurement uncertainty is taken into account.
2. The measurement uncertainty please refer to each test result in the section “Measurement Uncertainty”

Disclaimer:

The product specifications of the EUT presented in the test report that may affect the test assessments are declared by the manufacturer who shall take full responsibility for the authenticity.

1 General Description

1.1 Applicant

Nauto
1259 Reamwood Ave, Sunnyvale, CA 94089, USA

1.2 Manufacturer

Nauto
1259 Reamwood Ave, Sunnyvale, CA 94089, USA

1.3 Product Feature of Equipment Under Test

Product Feature	
Equipment	In-vehicle camera
Brand Name	Nauto
Model Name	N4
FCC ID	2AKJ5-N4
SN Code	Conducted: N40HTV6E1000E5L Radiation: N40HTV6E10011BS
HW Version	V4
SW Version	NautoN4
EUT Stage	Identical Prototype

Remark: The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

1.4 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Frequency Range	2402 MHz ~ 2480 MHz
Number of Channels	79
Carrier Frequency of Each Channel	2402+n*1 MHz; n=0~78
Maximum Output Power to Antenna	Bluetooth BR(1Mbps) : 13.97 dBm (0.0249 W) Bluetooth EDR (2Mbps) : 13.24 dBm (0.0211 W) Bluetooth EDR (3Mbps) : 13.59 dBm (0.0229 W)
99% Occupied Bandwidth	Bluetooth BR(1Mbps) : 0.842 MHz Bluetooth EDR (2Mbps) : 1.169 MHz Bluetooth EDR (3Mbps) : 1.154 MHz
Antenna Type / Gain	monopole Antenna with gain -0.4 dBi
Type of Modulation	Bluetooth BR (1Mbps) : GFSK Bluetooth EDR (2Mbps) :π/4-DQPSK Bluetooth EDR (3Mbps) : 8-DPSK

1.5 Modification of EUT

No modifications are made to the EUT during all test items.

1.6 Testing Location

Sporton International Inc. (Kunshan) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Test Firm	Sporton International Inc. (Kunshan)		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	03CH05-KS TH01-KS	CN1257	314309

1.7 Test Software

Item	Site	Manufacturer	Name	Version
1.	TH01-KS	Tonscend	JS1120-3 test system China_210602	3.3.10
2.	03CH05-KS	AUDIX	E3	210616

1.8 Applicable Standards

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

- 47 CFR Part 15 Subpart C §15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- ANSI C63.10-2013

Remark:

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

2 Test Configuration of Equipment Under Test

2.1 Carrier Frequency Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
2400-2483.5 MHz	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	-	-

2.2 Test Mode

a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated:, radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (Y plane) were recorded in this report, and the worst mode of radiated spurious emissions is Bluetooth 1Mbps mode, and recorded in this report.

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

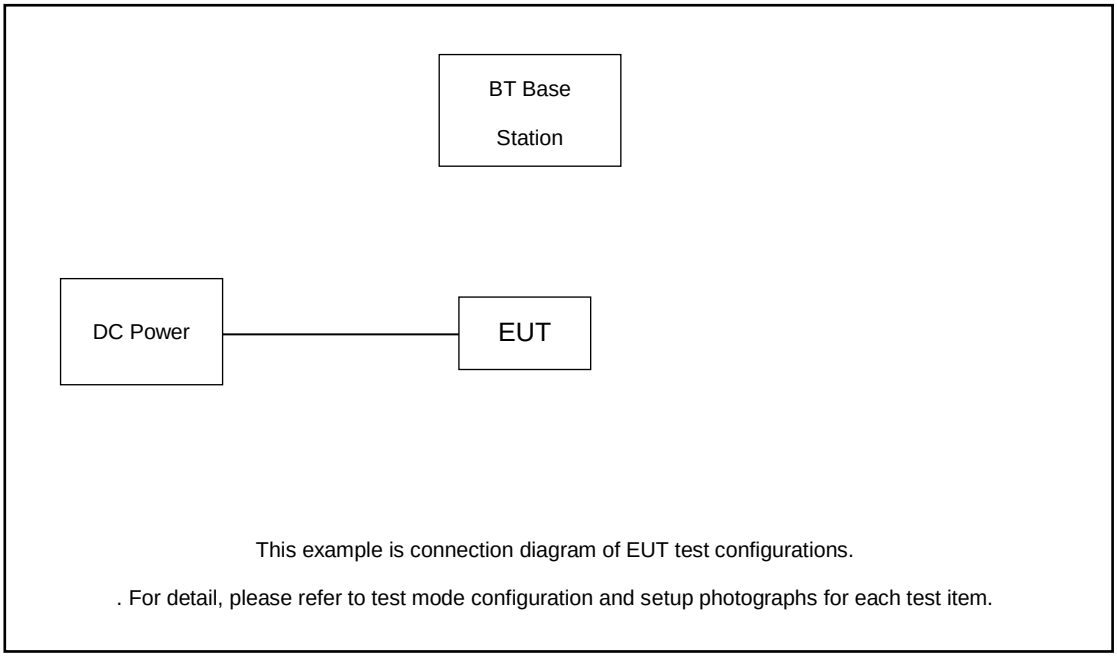
The following summary table is showing all test modes to demonstrate in compliance with the standard.

Summary table of Test Cases			
Test Item	**Data Rate / Modulation**		
	Bluetooth BR 1Mbps GFSK	**Bluetooth EDR 2Mbps π/4-DQPSK**	**Bluetooth EDR 3Mbps 8-DPSK**
Conducted Test Cases	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz	Mode 4: CH00_2402 MHz Mode 5: CH39_2441 MHz Mode 6: CH78_2480 MHz	Mode 7: CH00_2402 MHz Mode 8: CH39_2441 MHz Mode 9: CH78_2480 MHz
Radiated Test Cases	**Bluetooth BR 1Mbps GFSK**		
	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz		

Remark:

1. For radiated test cases, the worst mode data rate 1Mbps was reported only, because this data rate has the highest RF output power at preliminary tests, and no other significantly frequencies found in conducted spurious emission.
2. For Radiated Test Cases, The tests were performed with DC Power.

2.3 Connection Diagram of Test System



2.4 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	BT Base Station	R&S	CBT	N/A	N/A	Unshielded, 1.8m
2.	DC Power	TIANNENG	A6-DZF-12V	N/A	N/A	N/A

2.5 EUT Operation Test Setup

For Bluetooth function, the engineering test program was provided and enabled to make EUT connect with Bluetooth base station to continuous transmit.

2.6 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example :

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 2.19 dB and 10dB attenuator.

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

= 2.19 + 10 = 12.19 (dB)

3 Test Result

3.1 Number of Channel Measurement

3.1.1 Limits of Number of Hopping Frequency

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

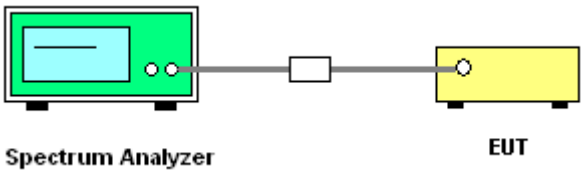
3.1.2 Measuring Instruments

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

3.1.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = the frequency band of operation; RBW = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. The number of hopping frequency used is defined as the number of total channel.
7. Record the measurement data derived from spectrum analyzer.

3.1.4 Test Setup



3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.

3.2 Hopping Channel Separation Measurement

3.2.1 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.

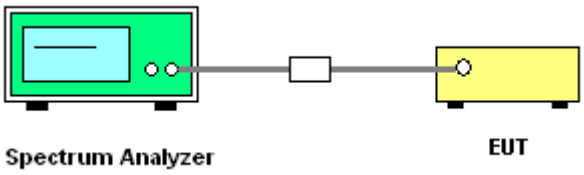
3.2.2 Measuring Instruments

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

3.2.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.2.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings:
   Span = wide enough to capture the peaks of two adjacent channels;
   RBW = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.2.4 Test Setup



3.2.5 Test Result of Hopping Channel Separation

Please refer to Appendix A.

3.3 Dwell Time Measurement

3.3.1 Limit of Dwell Time

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

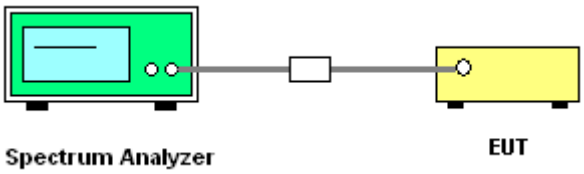
3.3.2 Measuring Instruments

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

3.3.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.4.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW = 1 MHz; VBW ≥ RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.3.4 Test Setup



3.3.5 Test Result of Dwell Time

Please refer to Appendix A.

3.4 20dB and 99% Bandwidth Measurement

3.4.1 Limit of 20dB and 99% Bandwidth

Reporting only

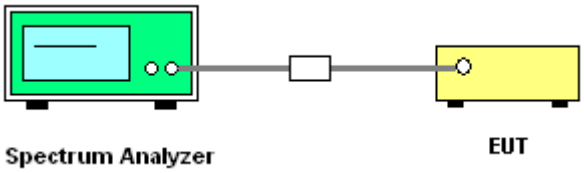
3.4.2 Measuring Instruments

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

3.4.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 6.9.2 and 6.9.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Use the following spectrum analyzer settings for 20dB Bandwidth measurement.
   Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel;
   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.

3.4.4 Test Setup



3.4.5 Test Result of 20dB & 99% Occupied Bandwidth

Please refer to Appendix A.

3.5 Output Power Measurement

3.5.1 Limit of Output Power

The maximum peak conducted output power of the intentional radiator shall not exceed the following: For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band 0.125 watts. The power limit for 1Mbps, 2Mbps, 3Mbps and AFH modes are 0.125 watts.

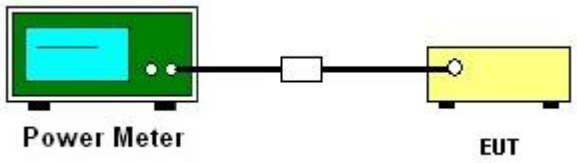
3.5.2 Measuring Instruments

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

3.5.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.5.
2. The RF output of EUT was connected to the power meter by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Measure the conducted output power with cable loss and record the results in the test report.
5. Measure and record the results in the test report.

3.5.4 Test Setup



3.5.5 Test Result of Peak Output Power

Please refer to Appendix A.

3.6 Conducted Band Edges Measurement

3.6.1 Limit of Band Edges

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

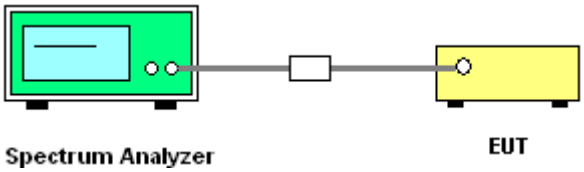
3.6.2 Measuring Instruments

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

3.6.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.6.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Set RBW = 100kHz, VBW = 300kHz. Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used.
4. Enable hopping function of the EUT and then repeat step 2. and 3.
5. Measure and record the results in the test report.

3.6.4 Test Setup



3.6.5 Test Result of Conducted Band Edges

Please refer to Appendix A.

3.6.6 Test Result of Conducted Hopping Mode Band Edges

Please refer to Appendix A.

3.7 Conducted Spurious Emission Measurement

3.7.1 Limit of Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

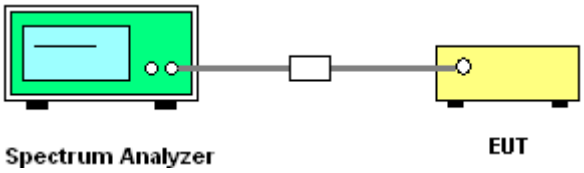
3.7.2 Measuring Instruments

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

3.7.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.8.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

3.7.4 Test Setup



3.7.5 Test Result of Conducted Spurious Emission

Please refer to Appendix A.

3.8 Radiated Band Edges and Spurious Emission Measurement

3.8.1 Limit of Radiated Band Edges and Spurious Emission

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. In addition, radiated emissions which fall in the restricted bands must also comply with the limits as below.

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 - 960	200	3
Above 960	500	3

3.8.2 Measuring Instruments

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

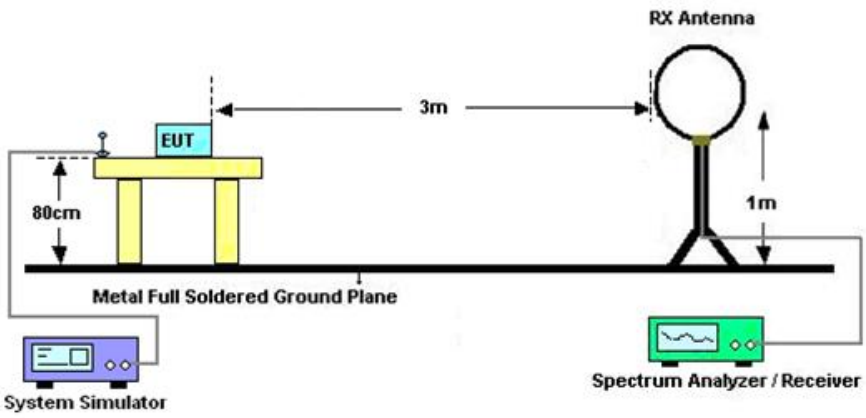
3.8.3 Test Procedures

1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
4. Set to the maximum power setting and enable the EUT transmit continuously.
5. Use the following spectrum analyzer settings:
   (1) Span shall wide enough to fully capture the emission being measured;
   (2) Set RBW=100 kHz for f < 1 GHz, RBW=1MHz for f>1GHz ; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
   (3) For average measurement: use duty cycle correction factor method per 15.35(c).
   Duty cycle = On time/100 milliseconds
   On time = $N_1*L_1+N_2*L_2+...+N_{n-1}*LN_{n-1}+N_n*L_n$
   Where N_1 is number of type 1 pulses, L_1 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 - Preamp Factor = Level
7. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
8. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than 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.

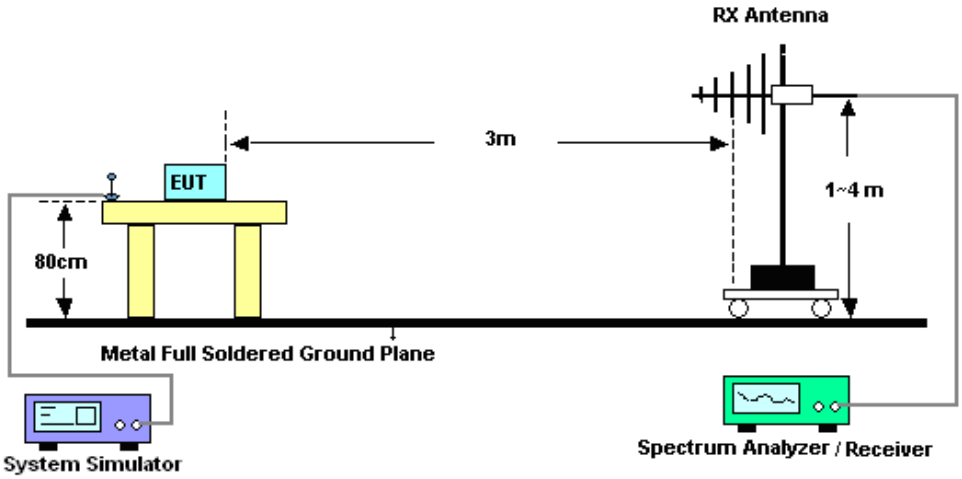
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.79dB) derived from 20log (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent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

3.8.4 Test Setup

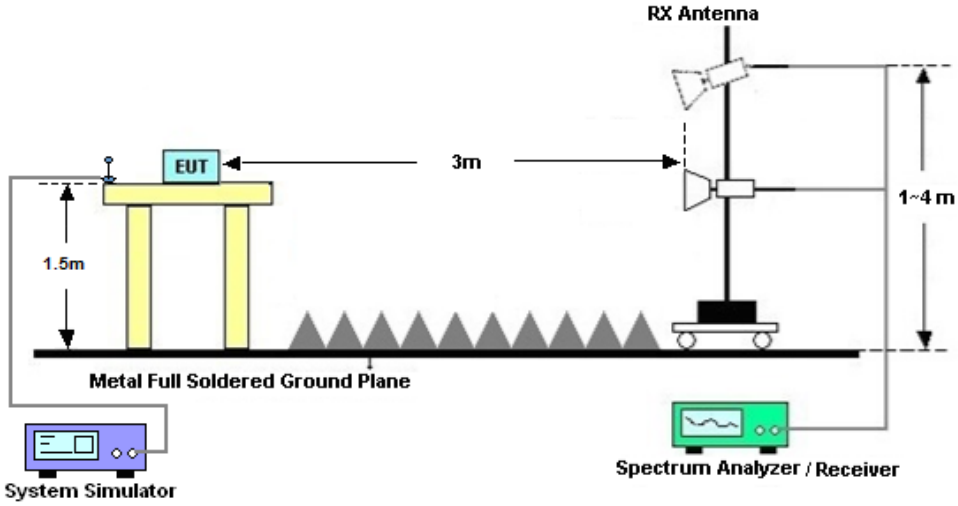
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



3.8.5 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.8.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B.

3.8.7 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic or 40GHz, whichever is lower)

Please refer to Appendix B.

3.8.8 Duty cycle correction factor for average measurement

Please refer to Appendix C.

3.9 Antenna Requirements

3.9.1 Standard Applicable

If directional gain of transmitting antennas is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the rule.

3.9.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.9.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
EMI Test Receiver	Keysight	N9038A	MY56400004	3Hz~8.5GHz;Max 30dBm	Oct. 10, 2023	Apr. 01, 2024	Oct. 09, 2024	Radiation (03CH05-KS)
EXA Spectrum Analyzer	Keysight	N9010A	MY55150244	10Hz-44G,MAX 30dB	Mar. 24, 2024	Apr. 01, 2024	Mar. 23, 2025	Radiation (03CH05-KS)
Loop Antenna	R&S	HFH2-Z2	100321	9kHz~30MHz	Oct. 10, 2023	Apr. 01, 2024	Oct. 09, 2024	Radiation (03CH05-KS)
Bilog Antenna	TeseQ	CBL6111D	49922	30MHz-1GHz	Apr. 09, 2023	Apr. 01, 2024	Apr. 08, 2024	Radiation (03CH05-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	00218642	1GHz~18GHz	Apr. 06, 2023	Apr. 01, 2024	Apr. 05, 2024	Radiation (03CH05-KS)
SHF-EHF Horn	Com-power	AH-840	101093	18GHz~40GHz	Jan. 05, 2024	Apr. 01, 2024	Jan. 04, 2025	Radiation (03CH05-KS)
Amplifier	SONOMA	310N	380826	9KHz-1GHz	Jul. 06, 2023	Apr. 01, 2024	Jul. 05, 2024	Radiation (03CH05-KS)
Amplifier	EM	EM18G40GA	060852	18~40GHz	Jan. 05, 2024	Apr. 01, 2024	Jan. 04, 2025	Radiation (03CH05-KS)
high gain Amplifier	EM	EM01G18GA	060839	1Ghz-18Ghz	Oct. 10, 2023	Apr. 01, 2024	Oct. 09, 2024	Radiation (03CH05-KS)
Amplifier	EM	EM01G18GA	060833	1Ghz-18Ghz	Jan. 03, 2024	Apr. 01, 2024	Jan. 02, 2025	Radiation (03CH05-KS)
AC Power Source	Chroma	61601	F104090004	N/A	NCR	Apr. 01, 2024	NCR	Radiation (03CH05-KS)
Turn Table	ChamPro	EM 1000-T	060762-T	0~360 degree	NCR	Apr. 01, 2024	NCR	Radiation (03CH05-KS)
Antenna Mast	ChamPro	EM 1000-A	060762-A	1 m~4 m	NCR	Apr. 01, 2024	NCR	Radiation (03CH05-KS)
Spectrum Analyzer	R&S	FSV40	101040	10Hz~40GHz	Oct. 11, 2023	Mar. 31, 2024	Oct. 10, 2024	Conducted (TH01-KS)
Pulse Power Senor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 02, 2024	Mar. 31, 2024	Jan. 01, 2025	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 02, 2024	Mar. 31, 2024	Jan. 01, 2025	Conducted (TH01-KS)

NCR: No Calibration Required

5 Measurement Uncertainty

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI 63.10-2013. All the measurement uncertainty value were shown with a coverage K=2 to indicate 95% level of confidence. The measurement data show herein meets or exceeds the CISPR measurement uncertainty values specified in CISPR 16-4-2 and can be compared directly to specified limit to determine compliance.

Uncertainty of Conducted Measurement

Conducted Spurious Emission & Bandedge	**±2.26 dB**
Occupied Channel Bandwidth	**±0.1%**
Conducted Power	**±0.46 dB**
Conducted Power Spectral Density	**±0.88 dB**
Frequency	**±0.4 Hz**

Uncertainty of Radiated Emission Measurement (9 KHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**3.30 dB**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**6.28 dB**

Uncertainty of Radiated Emission Measurement (1 GHz ~ 18 GHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**4.88 dB**

Uncertainty of Radiated Emission Measurement (18 GHz ~ 40 GHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.26 dB**

---------- THE END ----------

Appendix A. Conducted Test Results

Ambient Condition: 25 ℃, 45 %RH	
Test Date: 2024.3.31	**Test Engineer:** Jiang Jun

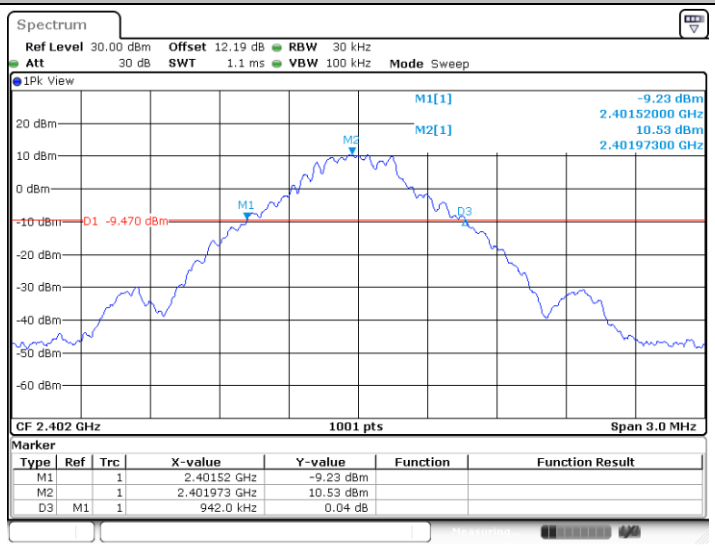
20dB Emission Bandwidth

Test Result

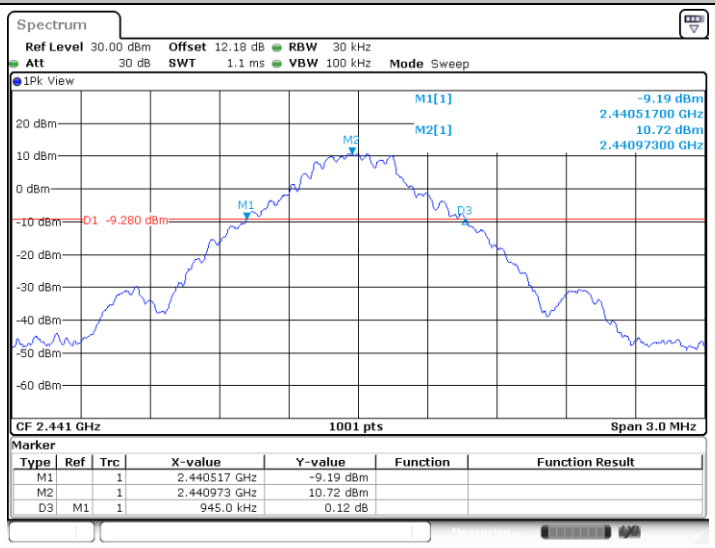
TestMode	Freq(MHz)	20dB EBW[MHz]	FL[MHz]	FH[MHz]
DH5	2402	0.94	2401.52	2402.46
	2441	0.95	2440.52	2441.46
	2480	0.94	2479.52	2480.46
2DH1	2402	1.29	2401.32	2402.61
	2441	1.29	2440.33	2441.62
	2480	1.29	2479.33	2480.61
3DH1	2402	1.24	2401.38	2402.62
	2441	1.24	2440.38	2441.62
	2480	1.24	2479.38	2480.62

Test Graphs

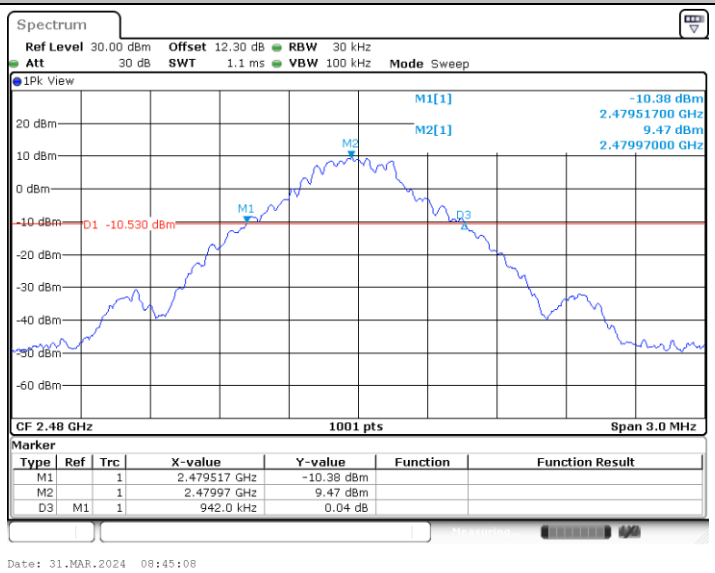
DH5_2402



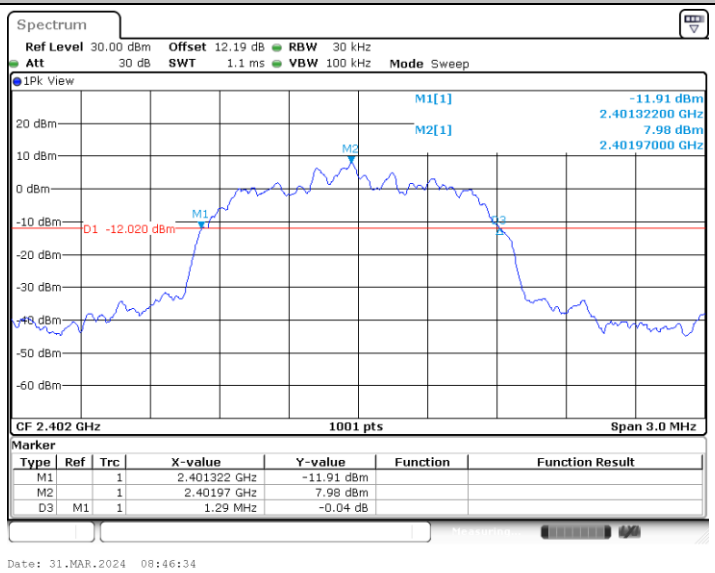
DH5_2441



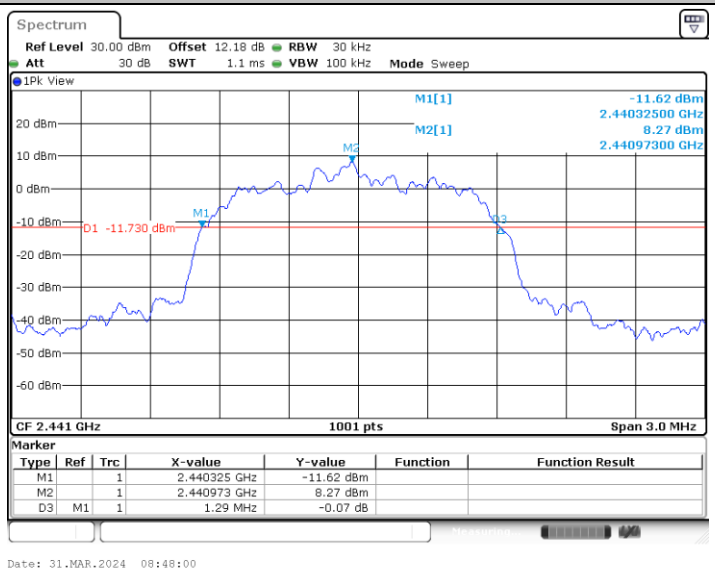
DH5_2480



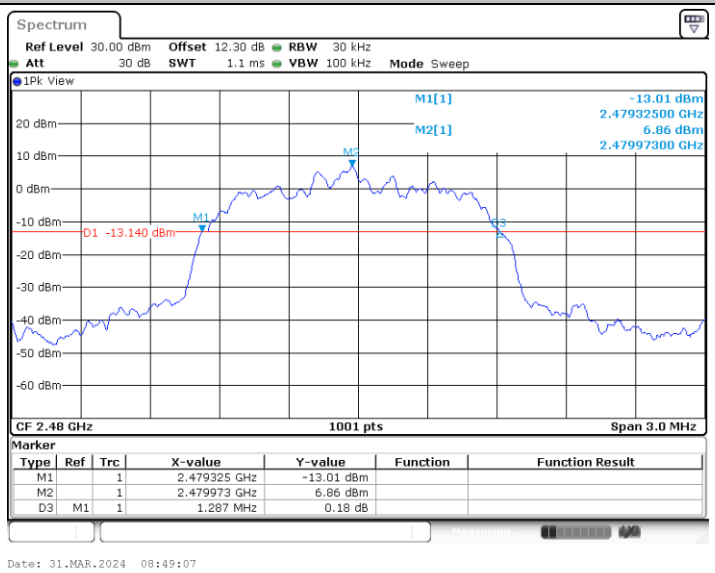
2DH1_2402



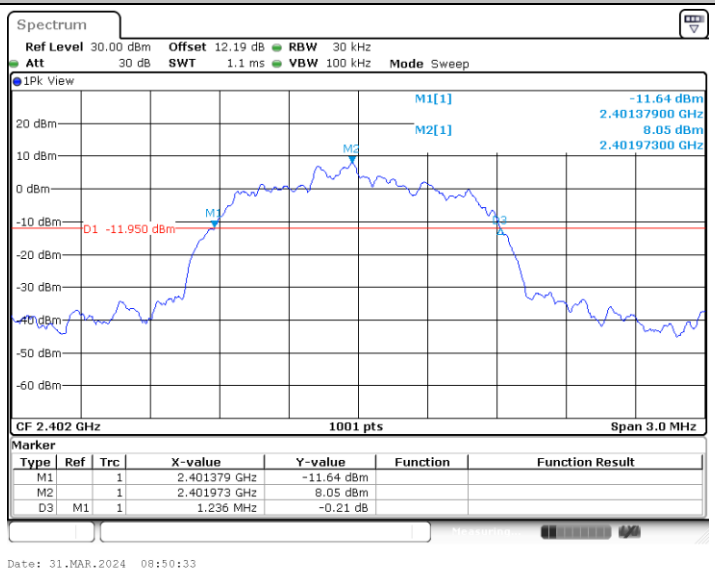
2DH1_2441



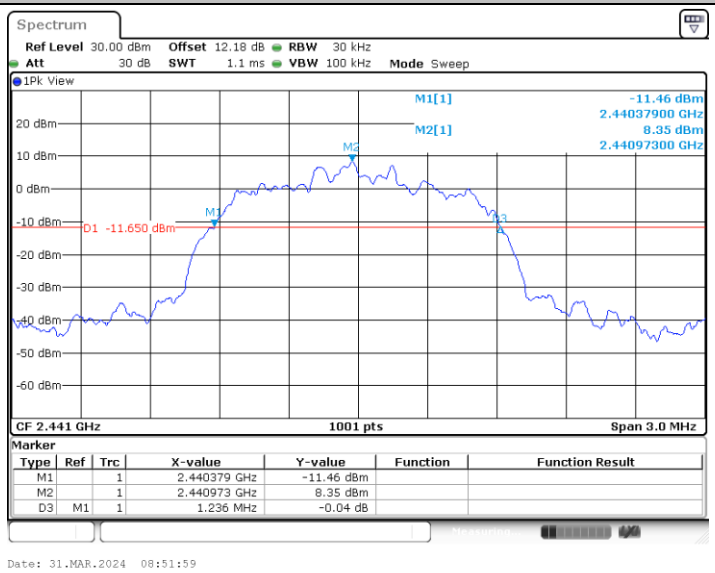
2DH1_2480



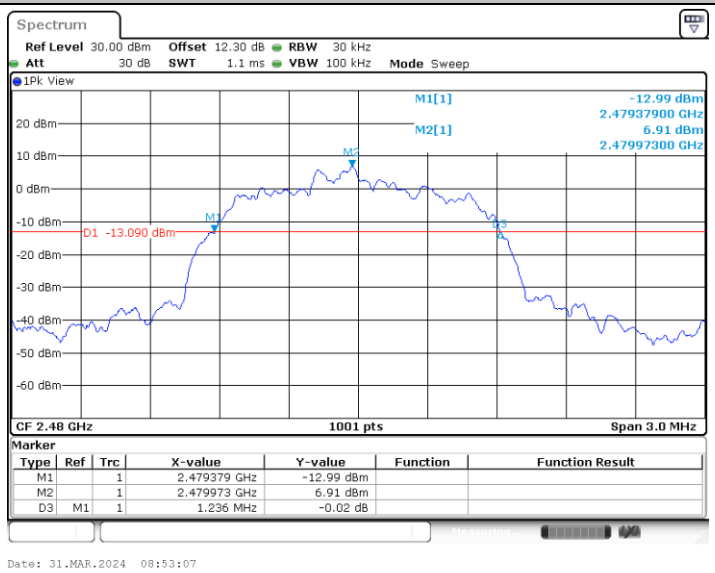
3DH1_2402



3DH1_2441



3DH1_2480


Spectrum
Ref Level 30.00 dBm Offset 12.30 dB RBW 30 kHz
Att 30 dB SWT 1.1 ms VBW 100 kHz Mode Sweep
1Pk View
M1[1] -12.99 dBm
2.47937900 GHz
M2[1] 6.91 dBm
2.47997300 GHz
D1 -13.090 dBm
CF 2.48 GHz 1001 pts Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.479379 GHz -12.99 dBm
M2 1 2.479973 GHz 6.91 dBm
D3 M1 1 1.236 MHz -0.02 dB
Date: 31.MAR.2024 08:53:07

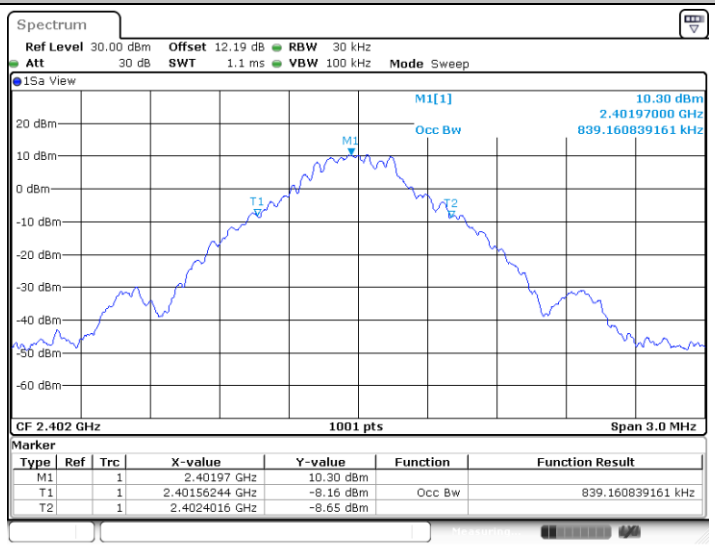
Occupied Channel Bandwidth

Test Result

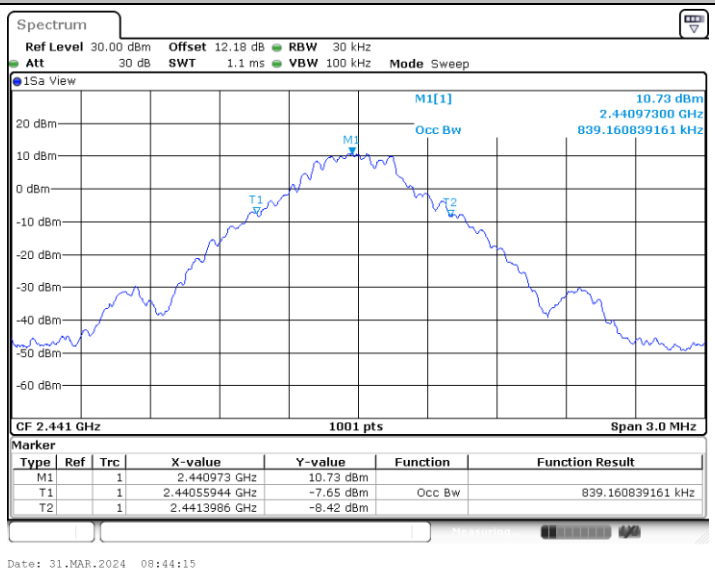
TestMode	Freq(MHz)	OCB [MHz]	FL[MHz]	FH[MHz]
DH5	2402	0.839	2401.5624	2402.4016
	2441	0.839	2440.5594	2441.3986
	2480	0.842	2479.5564	2480.3986
2DH1	2402	1.169	2401.3886	2402.5574
	2441	1.166	2440.3916	2441.5574
	2480	1.166	2479.3916	2480.5574
3DH1	2402	1.154	2401.4186	2402.5724
	2441	1.151	2440.4186	2441.5694
	2480	1.151	2479.4186	2480.5694

Test Graphs

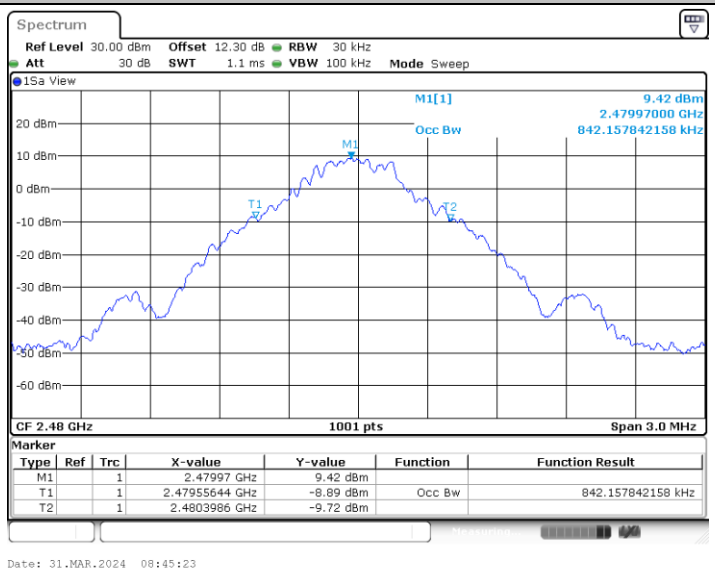
DH5_2402



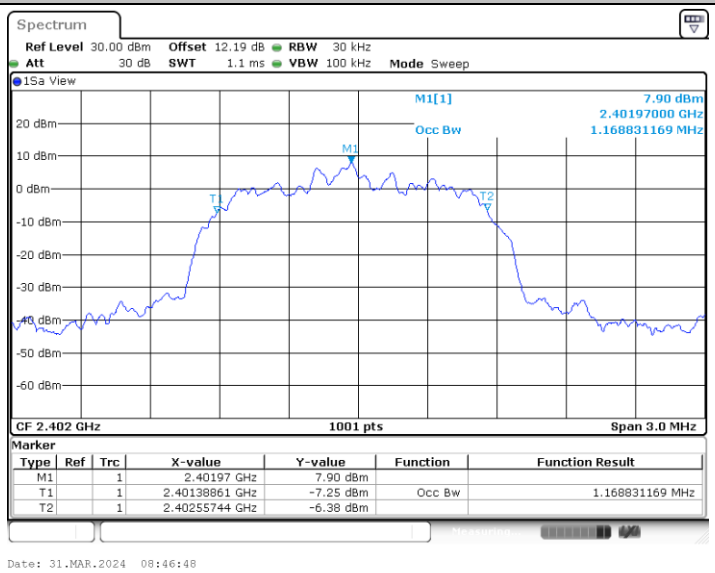
DH5_2441



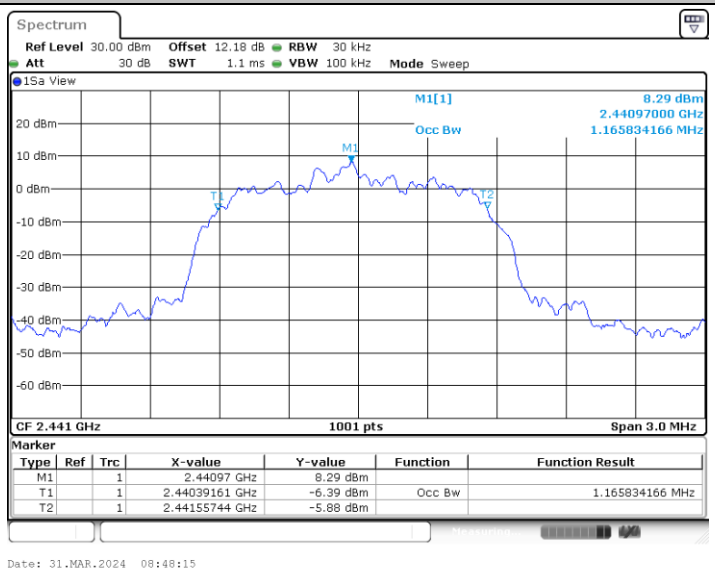
DH5_2480



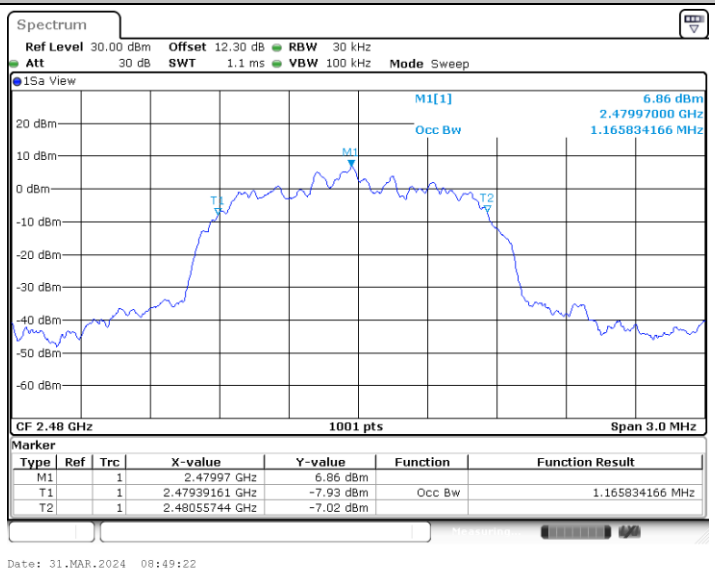
2DH1_2402



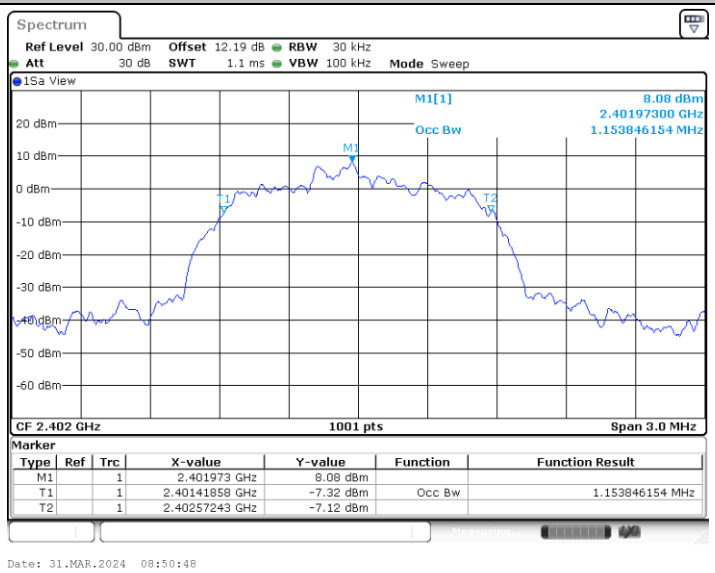
2DH1_2441



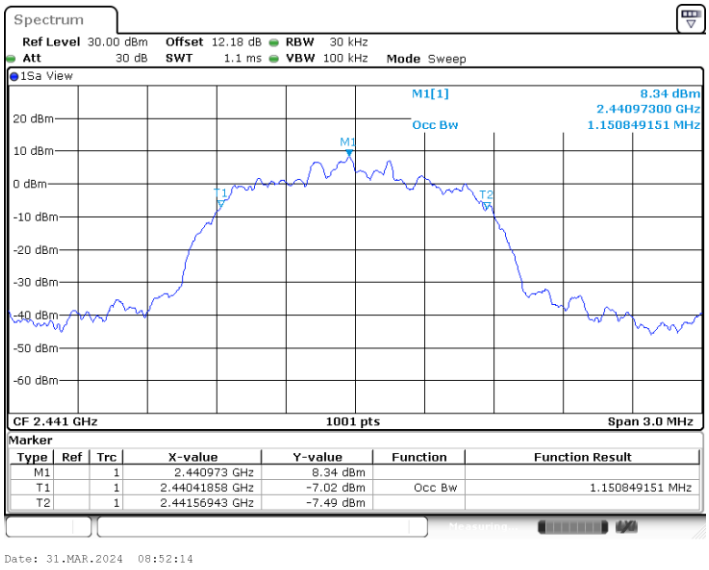
2DH1_2480



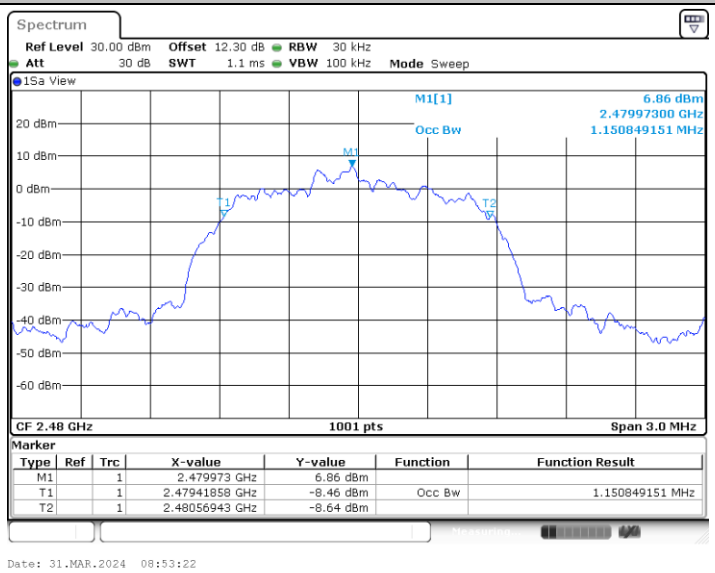
3DH1_2402



3DH1_2441



3DH1_2480


Spectrum
Ref Level 30.00 dBm Offset 12.30 dB RBW 30 kHz
Att 30 dB SWT 1.1 ms VBW 100 kHz Mode Sweep
1Sa View
M1[1] 6.86 dBm
2.47997300 GHz
Occ Bw 1.150849151 MHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
CF 2.48 GHz
1001 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.479973 GHz 6.86 dBm
T1 1 2.47941858 GHz -8.46 dBm Occ Bw 1.150849151 MHz
T2 1 2.48056943 GHz -8.64 dBm
Date: 31.MAR.2024 08:53:22

Maximum conducted output power

Test Result Peak

TestMode	CH.	Peak Power (dBm)	Power Limit (dBm)	Pass/Fail
DH5	0	13.78	20.97	Pass
	39	**13.97**	20.97	Pass
	78	12.44	20.97	Pass
2DH5	0	13.03	20.97	Pass
	39	**13.24**	20.97	Pass
	78	11.69	20.97	Pass
3DH5	0	13.41	20.97	Pass
	39	**13.59**	20.97	Pass
	78	12.06	20.97	Pass

Remark： Power setting is the AUTO(AUTO is the default).

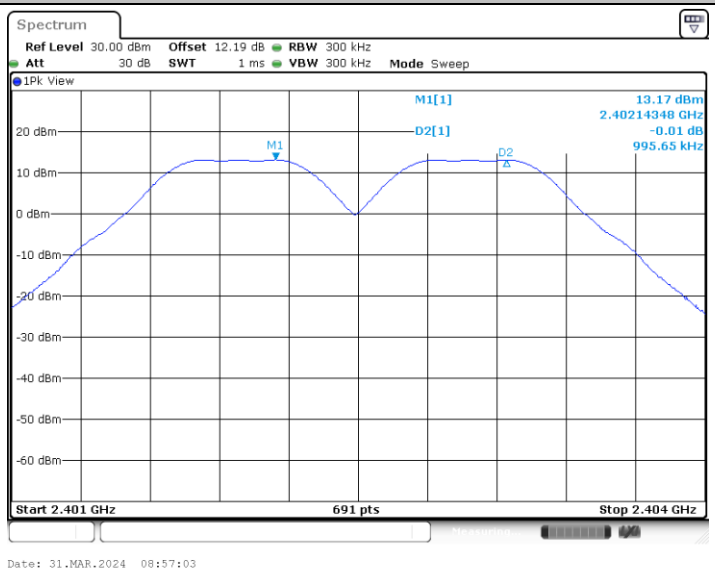
Carrier frequency separation

Test Result

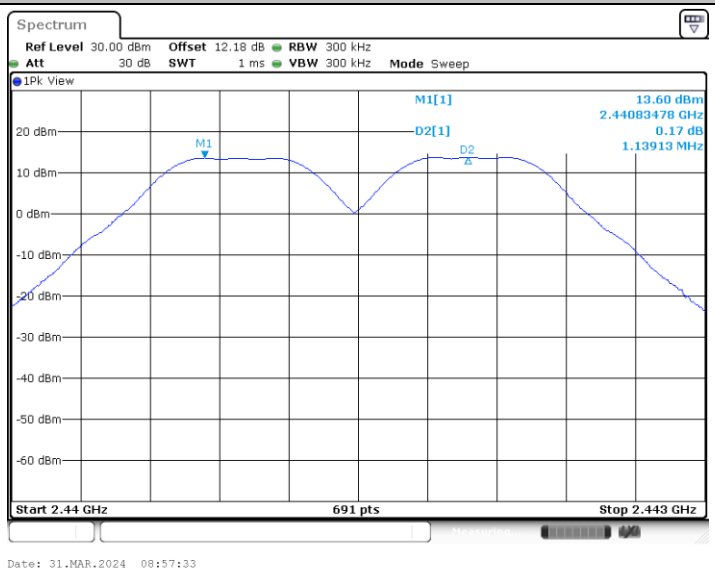
TestMode	Freq(MHz)	Result[MHz]	Limit[MHz]	Verdict
DH5	2402	0.996	≥0.627	PASS
	2441	1.139	≥0.633	PASS
	2480	1	≥0.627	PASS
2DH1	2402	1.009	≥0.860	PASS
	2441	1.017	≥0.860	PASS
	2480	1.009	≥0.860	PASS
3DH1	2402	1.004	≥0.827	PASS
	2441	1	≥0.827	PASS
	2480	1.165	≥0.827	PASS

Test Graphs

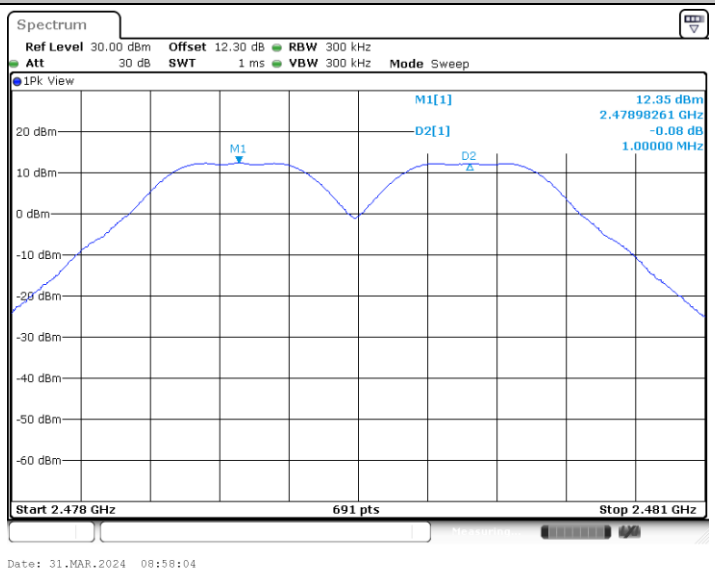
DH5_2402



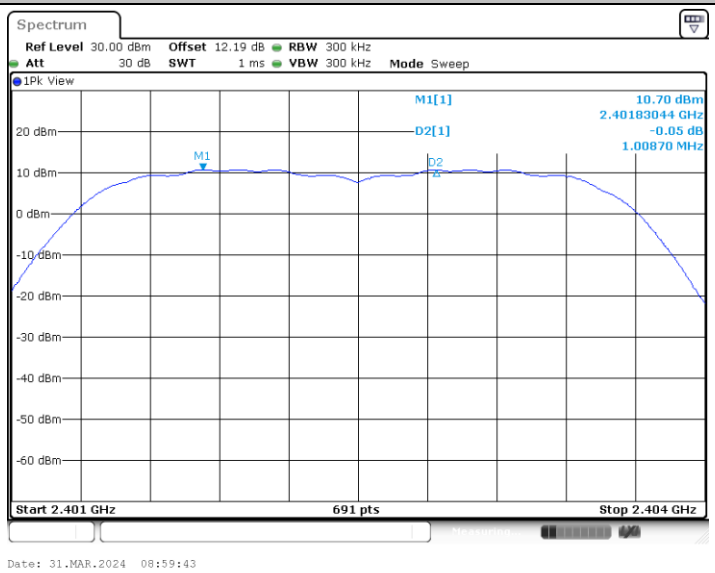
DH5_2441



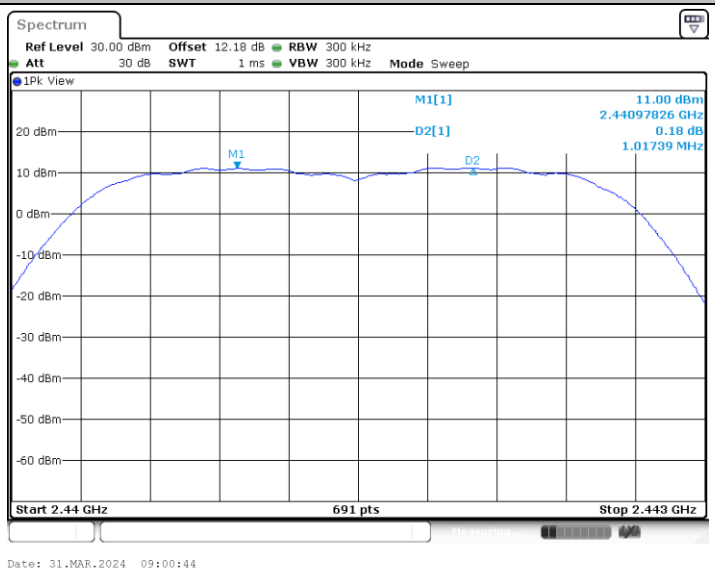
DH5_2480



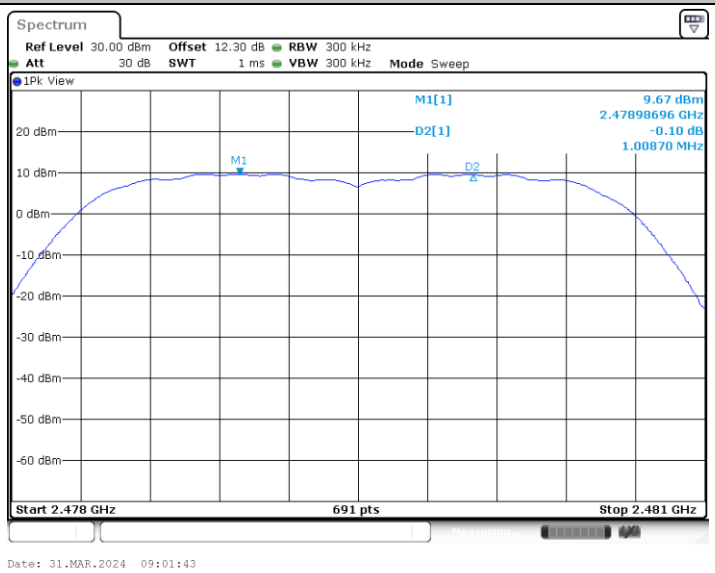
2DH1_2402



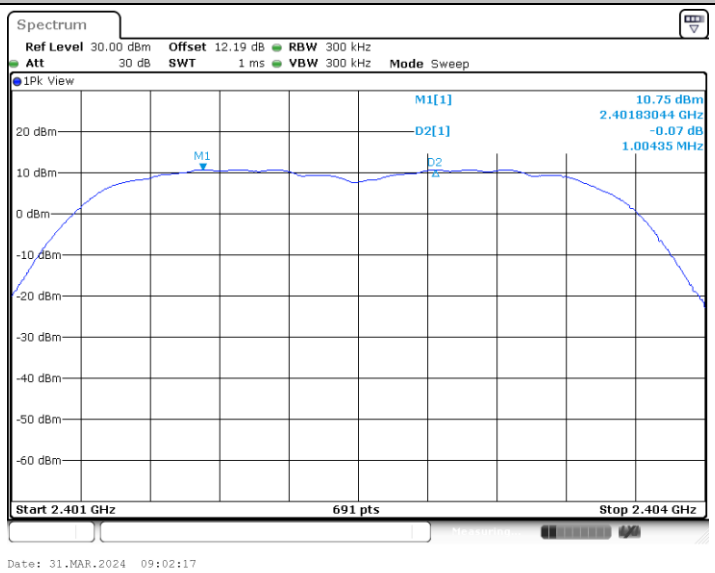
2DH1_2441



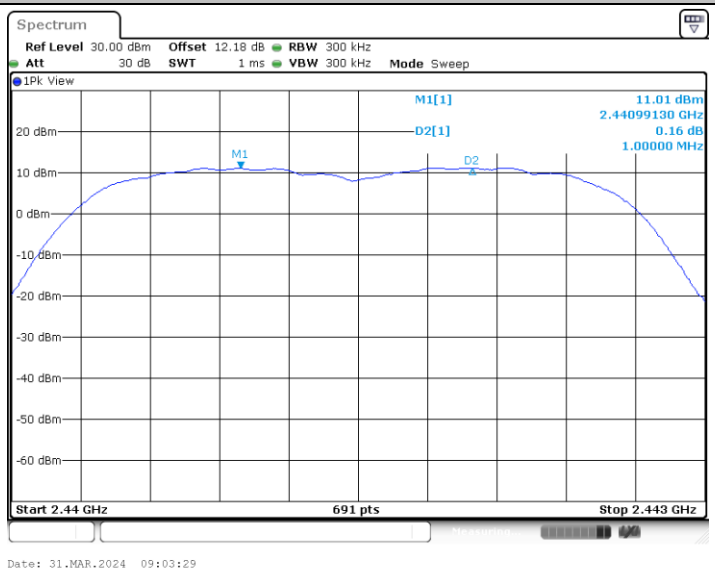
2DH1_2480



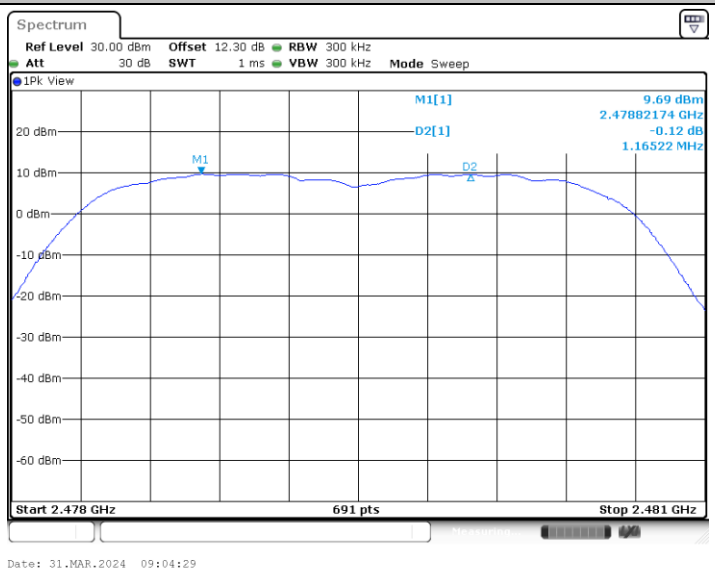
3DH1_2402



3DH1_2441



3DH1_2480


Spectrum
Ref Level 30.00 dBm Offset 12.30 dB RBW 300 kHz
Att 30 dB SWT 1 ms VBW 300 kHz Mode Sweep
1Pk View
M1[1] 9.69 dBm
2.47882174 GHz
D2[1] -0.12 dB
1.16522 MHz
20 dBm
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
Start 2.478 GHz 691 pts Stop 2.481 GHz
Date: 31.MAR.2024 09:04:29

Time of occupancy

Test Result

TestMode	Hopping Channel Number Rate	Hops Over Occupancy Time(hops)	Package Transfer Time (msec) (MHz)	Dwell Time (sec)	Limits (sec)	Pass/Fail
Normal	79	106.67	2.9029	0.31	0.4	Pass
AFH	20	53.33	2.9029	0.15	0.4	Pass

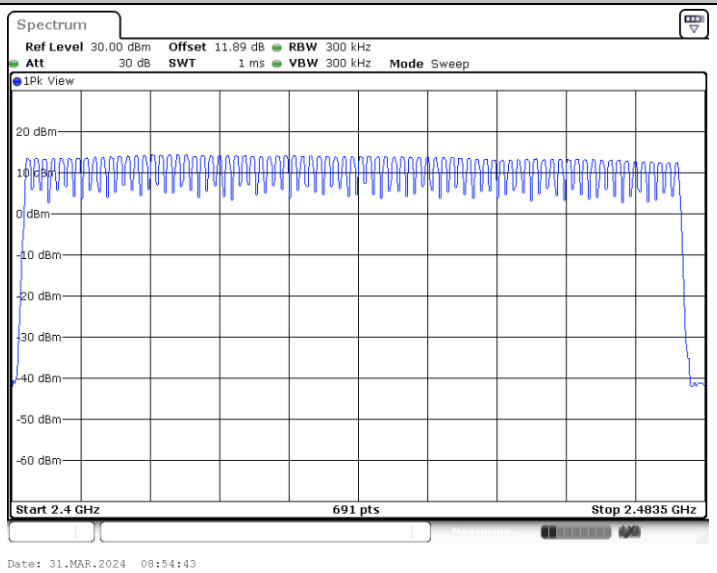
Number of hopping channels

Test Result

TestMode	Freq(MHz)	Result[Num]	Limit[Num]	Verdict
DH5	Hop	79	≥15	PASS

Test Graphs

DH5_Hop



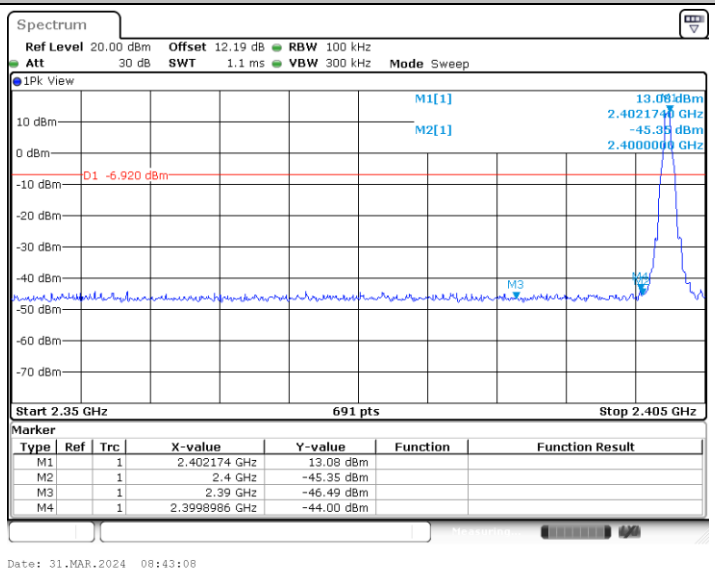
Band edge measurements

Test Result

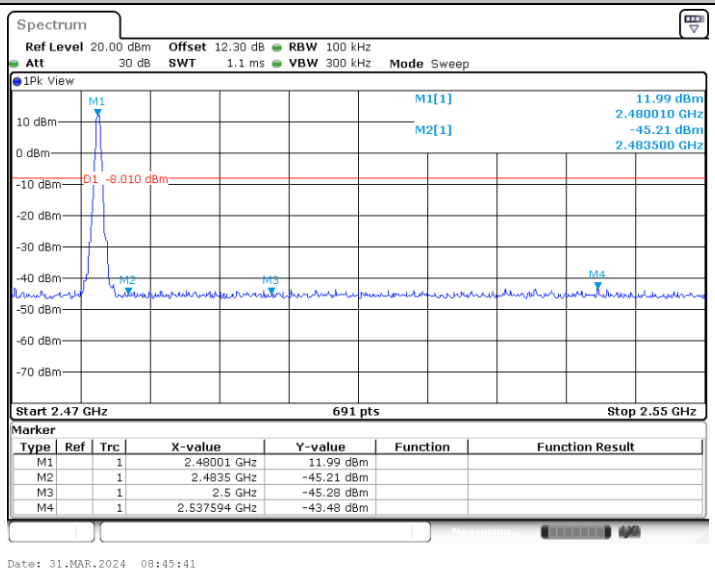
TestMode	ChName	Freq(MHz)	RefLevel [dBm]	Result [dBm]	Limit [dBm]	Verdict
DH5	Low	2402	13.08	-44	≤-6.92	PASS
	High	2480	11.99	-43.48	≤-8.01	PASS
	Low	Hop_2402	12.67	-44.04	≤-7.33	PASS
	High	Hop_2480	12.70	-43.2	≤-7.3	PASS
2DH1	Low	2402	10.46	-43.23	≤-9.54	PASS
	High	2480	9.40	-43.73	≤-10.6	PASS
	Low	Hop_2402	10.18	-44.73	≤-9.82	PASS
	High	Hop_2480	9.91	-43.18	≤-10.09	PASS
3DH1	Low	2402	10.66	-43.22	≤-9.34	PASS
	High	2480	9.51	-43.09	≤-10.49	PASS
	Low	Hop_2402	10.32	-44.69	≤-9.68	PASS
	High	Hop_2480	9.97	-43.18	≤-10.03	PASS

Test Graphs

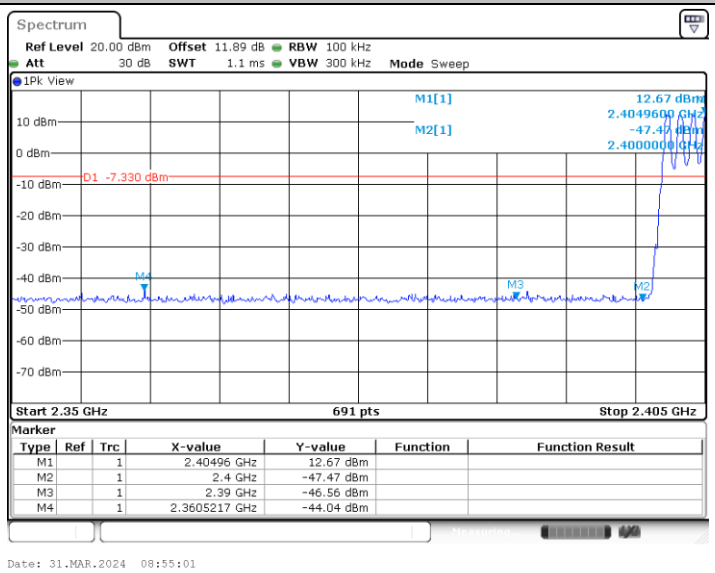
DH5_Low_2402



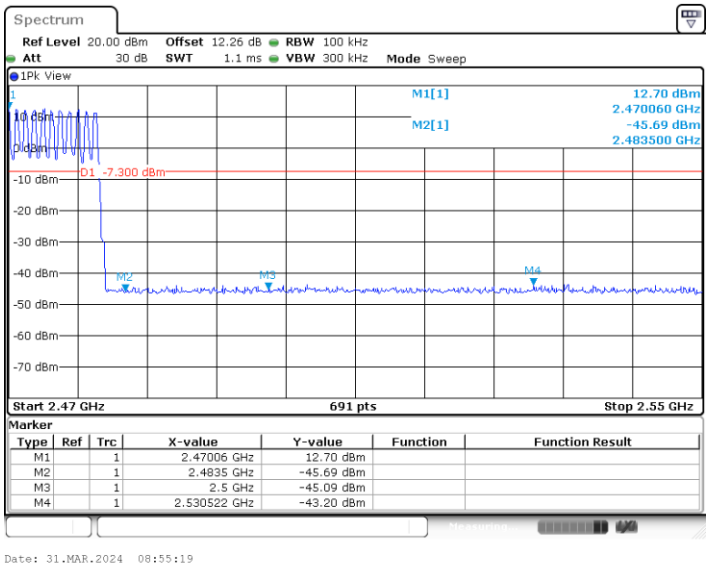
DH5_High_2480



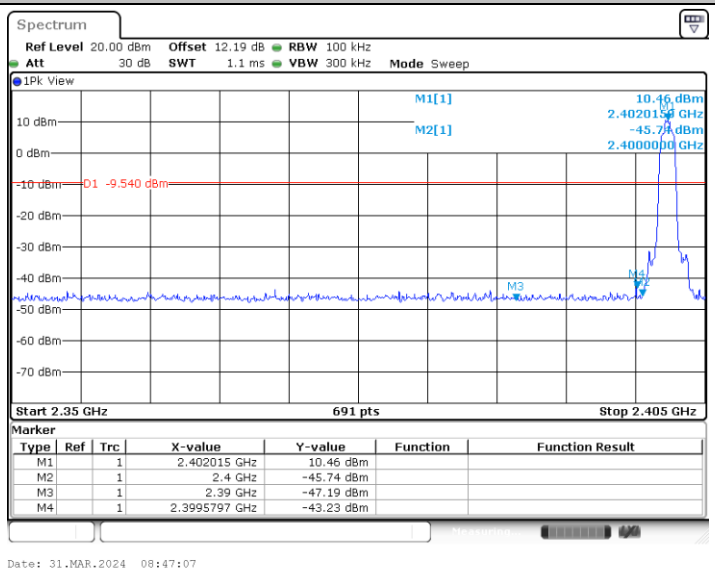
DH5_Low_Hop_2402



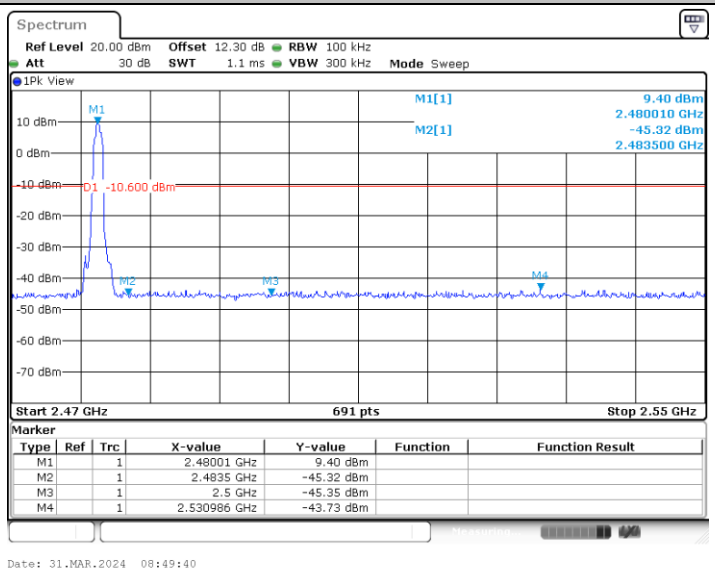
DH5_High_Hop_2480



2DH1_Low_2402



2DH1_High_2480



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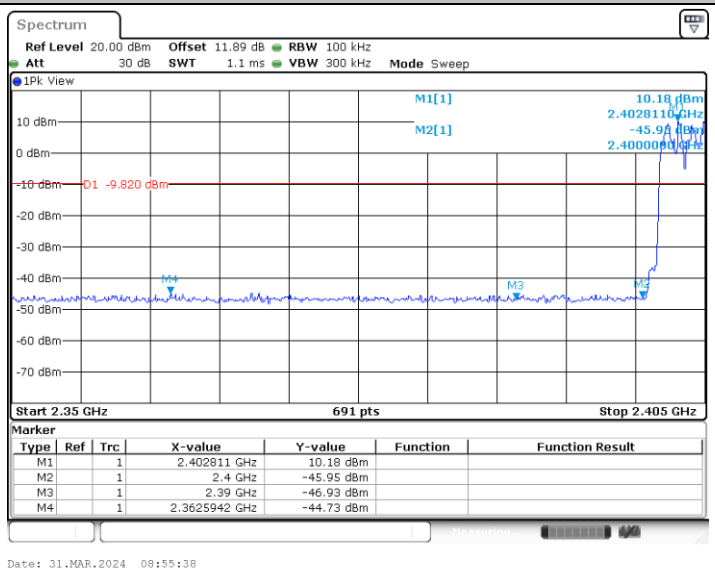
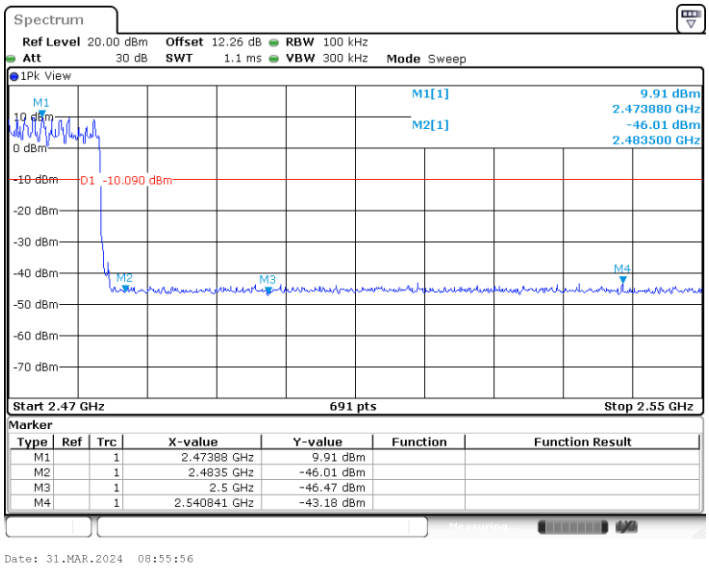
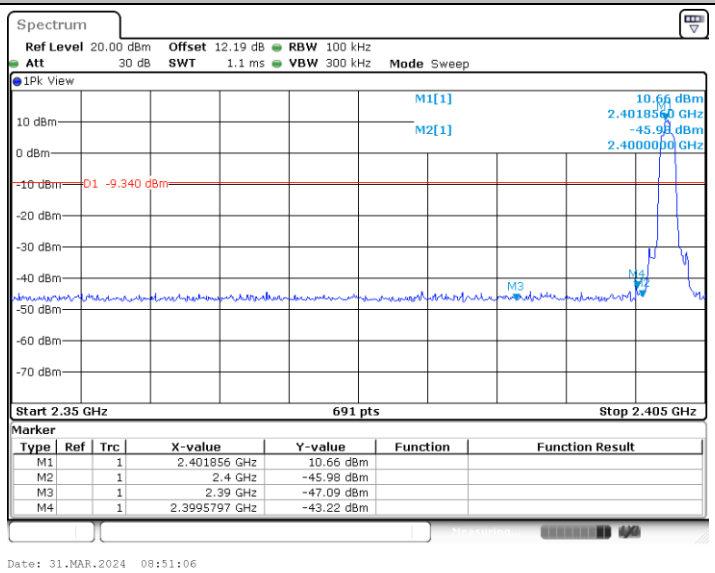


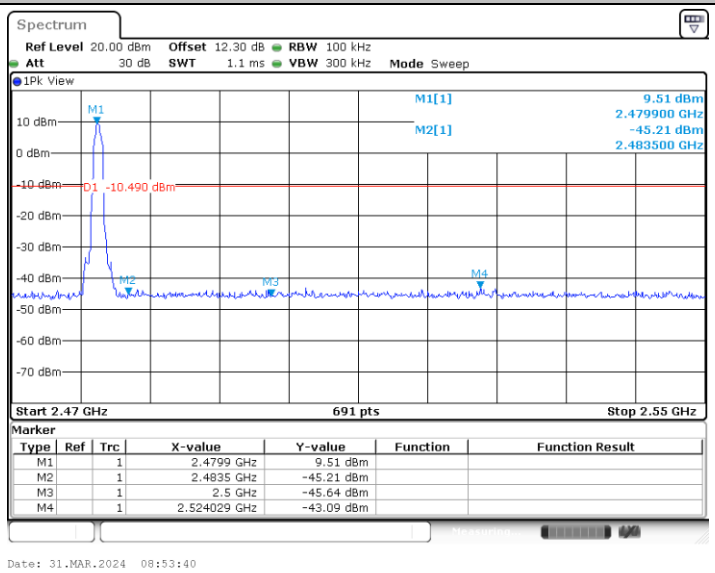
2DH1_High_Hop_2480



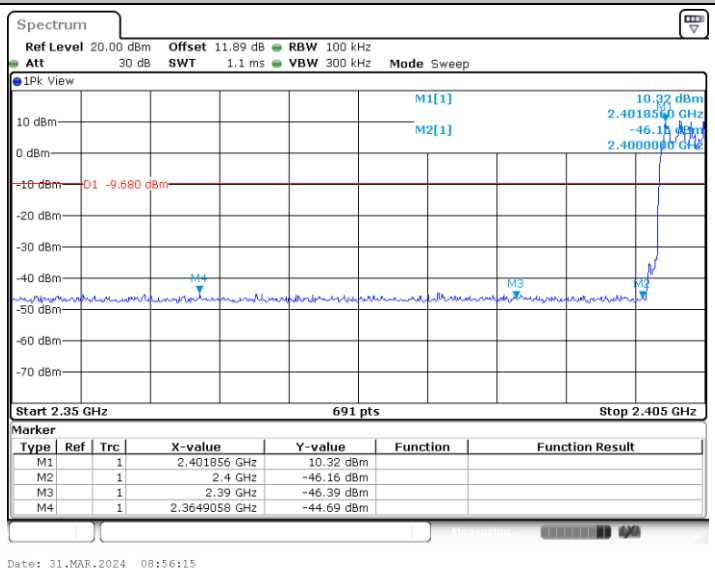
3DH1_Low_2402



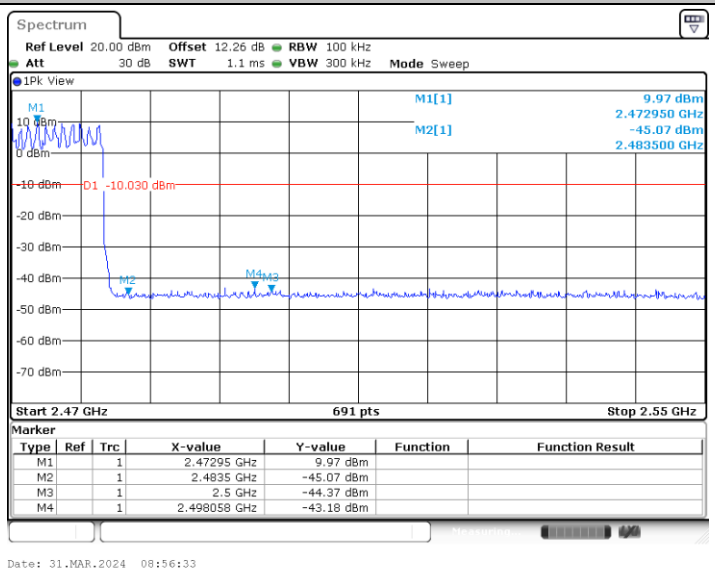
3DH1_High_2480



3DH1_Low_Hop_2402



3DH1_High_Hop_2480



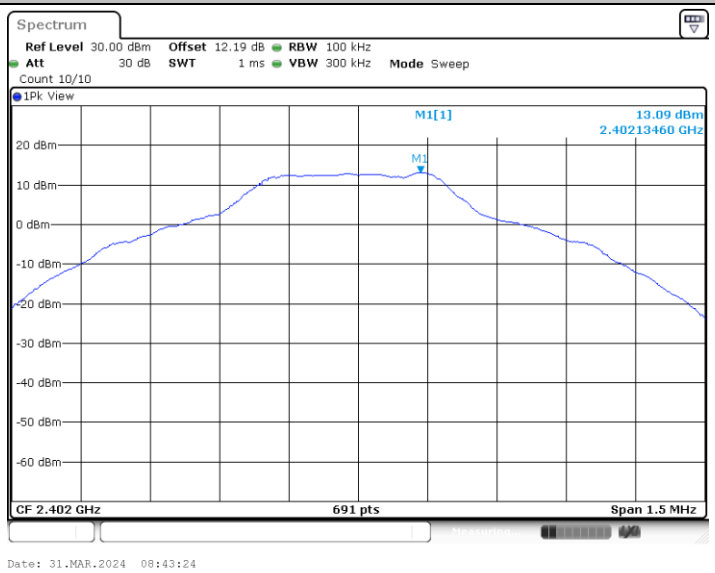
Conducted Spurious Emission

Test Result

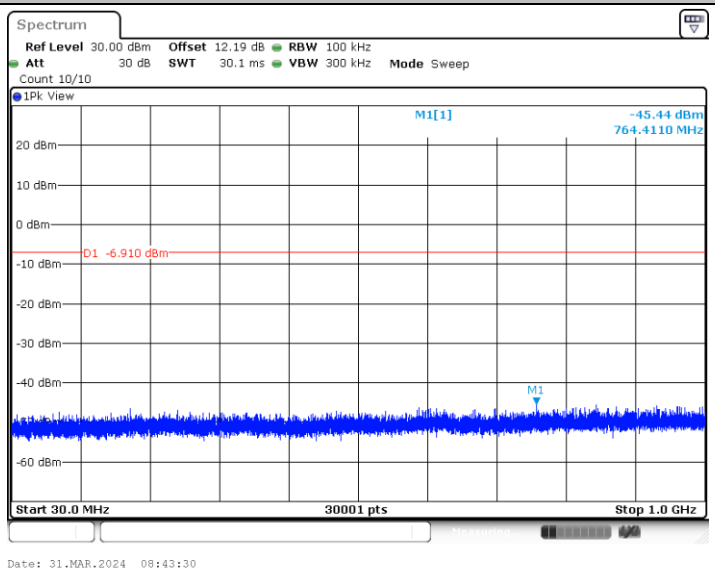
TestMode	Freq(MHz)	FreqRange [MHz]	RefLevel [dBm]	Result [dBm]	Limit [dBm]	Verdict
DH5	2402	Reference	13.09	13.09	---	PASS
		30~1000	13.09	-45.44	≤-6.91	PASS
		1000~26500	13.09	-36.39	≤-6.91	PASS
	2441	Reference	13.37	13.37	---	PASS
		30~1000	13.37	-45.67	≤-6.63	PASS
		1000~26500	13.37	-36.37	≤-6.63	PASS
	2480	Reference	11.96	11.96	---	PASS
		30~1000	11.96	-44.44	≤-8.04	PASS
		1000~26500	11.96	-36.25	≤-8.04	PASS
2DH1	2402	Reference	10.38	10.38	---	PASS
		30~1000	10.38	-45.27	≤-9.62	PASS
		1000~26500	10.38	-35.33	≤-9.62	PASS
	2441	Reference	10.71	10.71	---	PASS
		30~1000	10.71	-45	≤-9.29	PASS
		1000~26500	10.71	-35.58	≤-9.29	PASS
	2480	Reference	9.30	9.30	---	PASS
		30~1000	9.30	-45.47	≤-10.7	PASS
		1000~26500	9.30	-35.82	≤-10.7	PASS
3DH1	2402	Reference	10.61	10.61	---	PASS
		30~1000	10.61	-44.99	≤-9.39	PASS
		1000~26500	10.61	-36.21	≤-9.39	PASS
	2441	Reference	10.91	10.91	---	PASS
		30~1000	10.91	-45.43	≤-9.09	PASS
		1000~26500	10.91	-36.82	≤-9.09	PASS
	2480	Reference	9.47	9.47	---	PASS
		30~1000	9.47	-45.39	≤-10.53	PASS
		1000~26500	9.47	-36.33	≤-10.53	PASS

Test Graphs

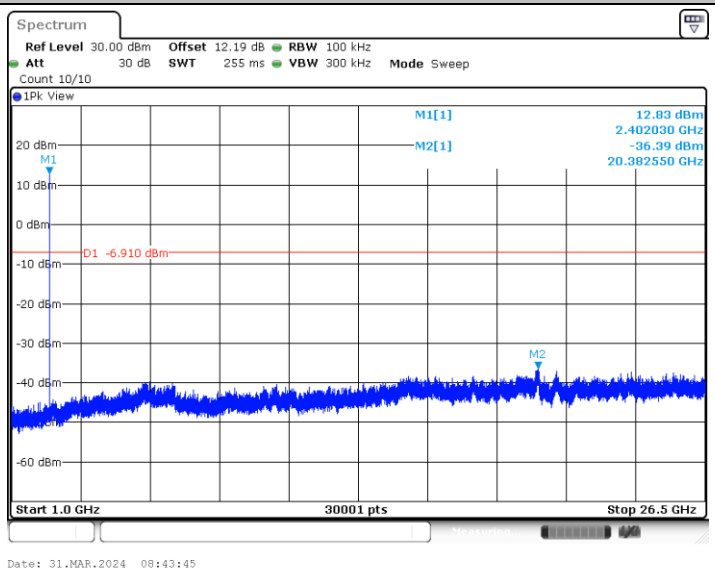
DH5_2402_0~Reference



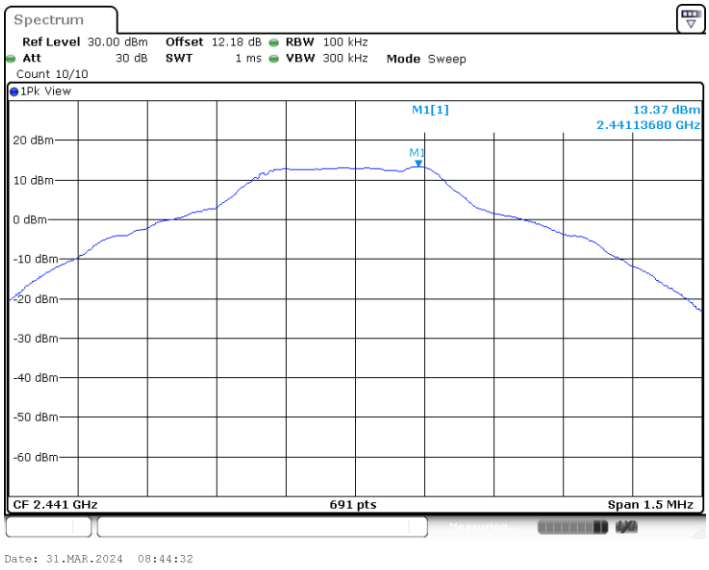
DH5_2402_30~1000



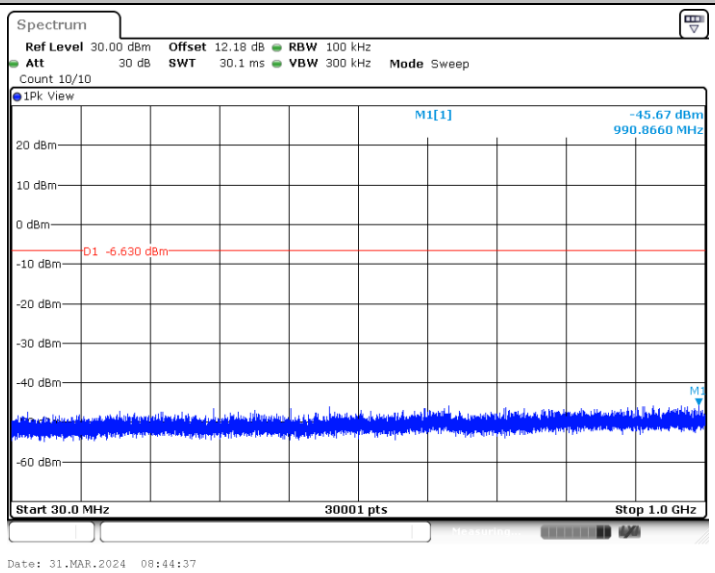
DH5_2402_1000~26500



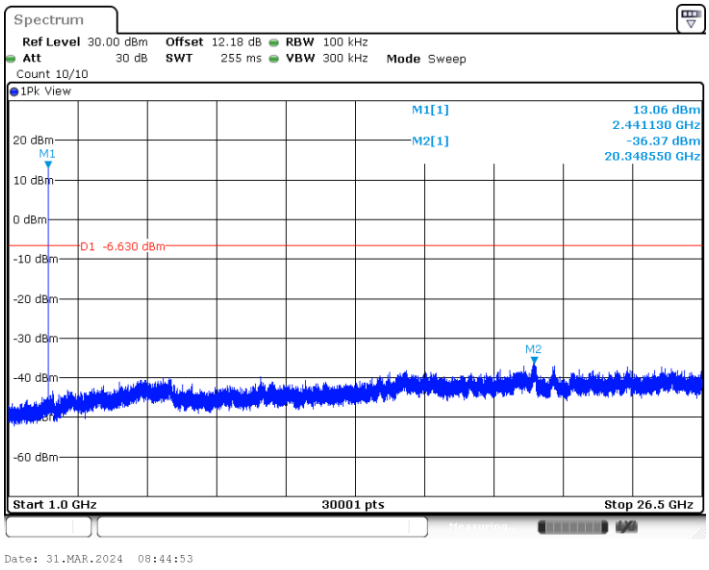
DH5_2441_0~Reference



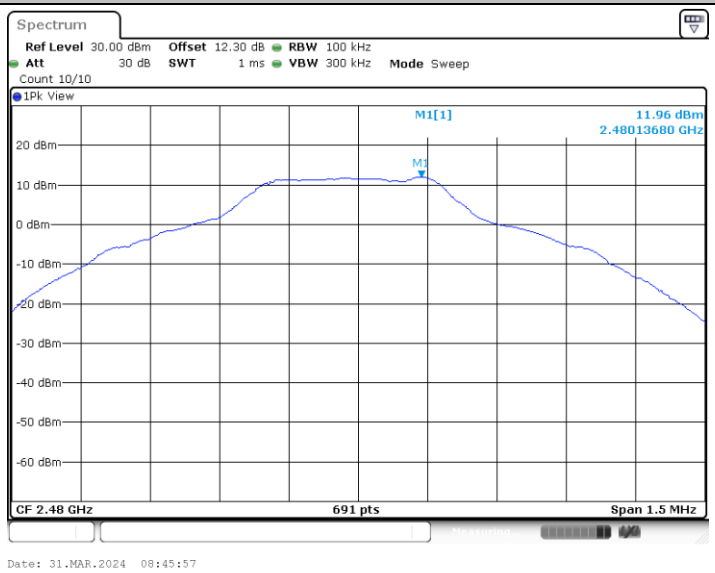
DH5_2441_30~1000



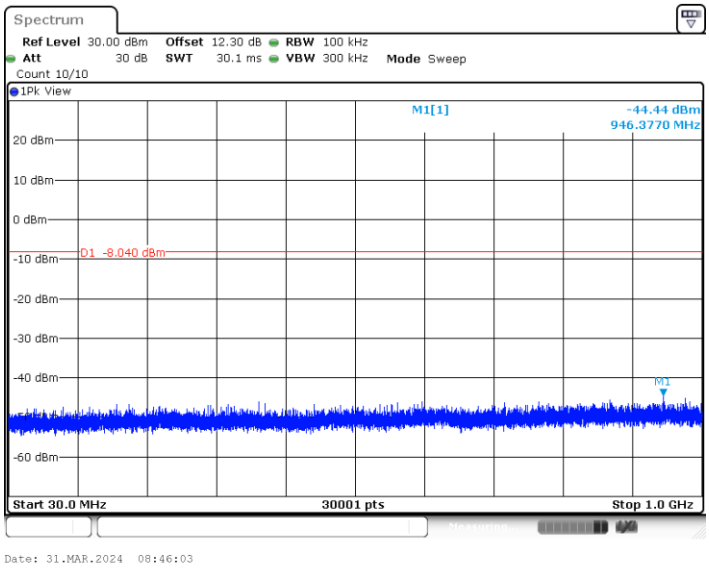
DH5_2441_1000~26500



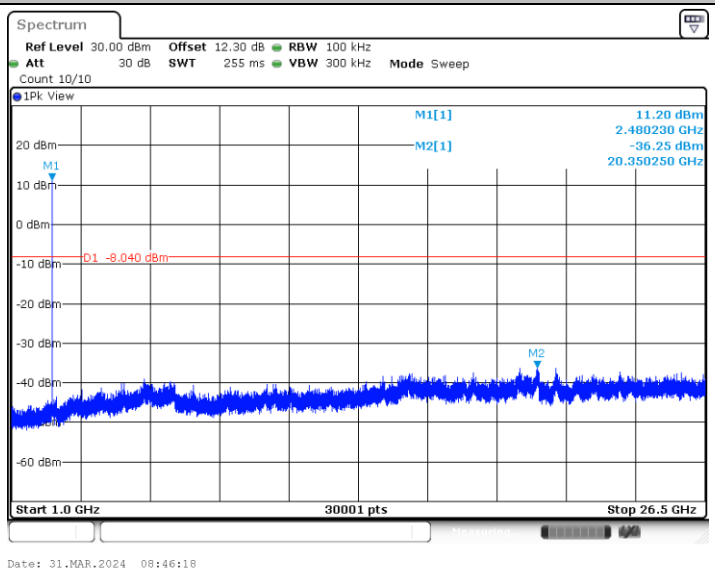
DH5_2480_0~Reference



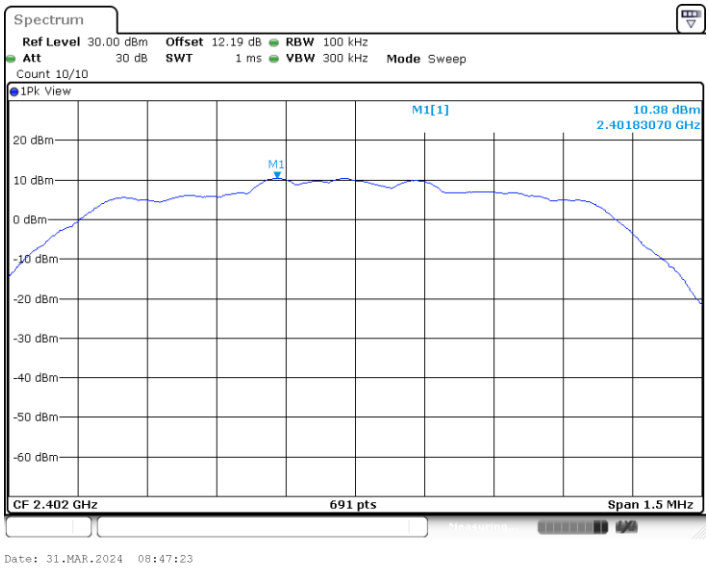
DH5_2480_30~1000



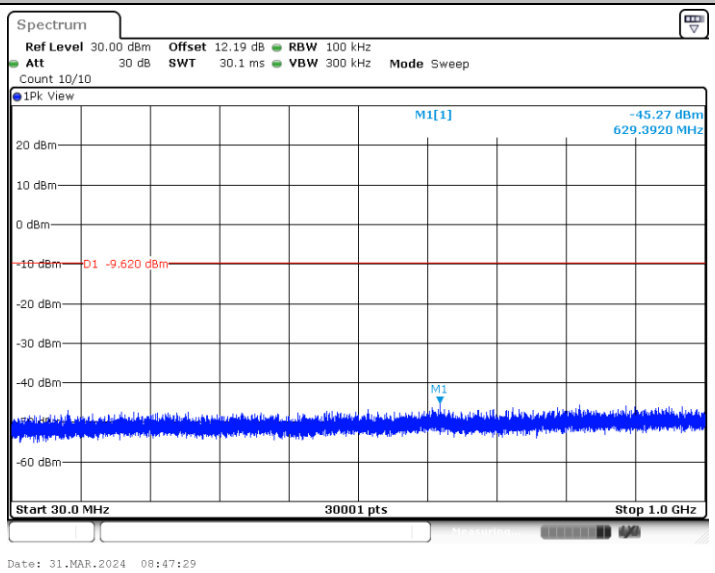
DH5_2480_1000~26500



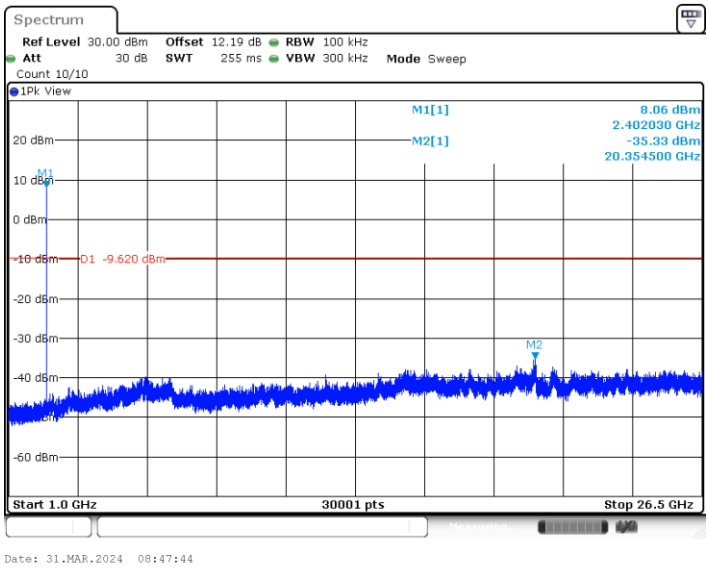
2DH1_2402_0~Reference



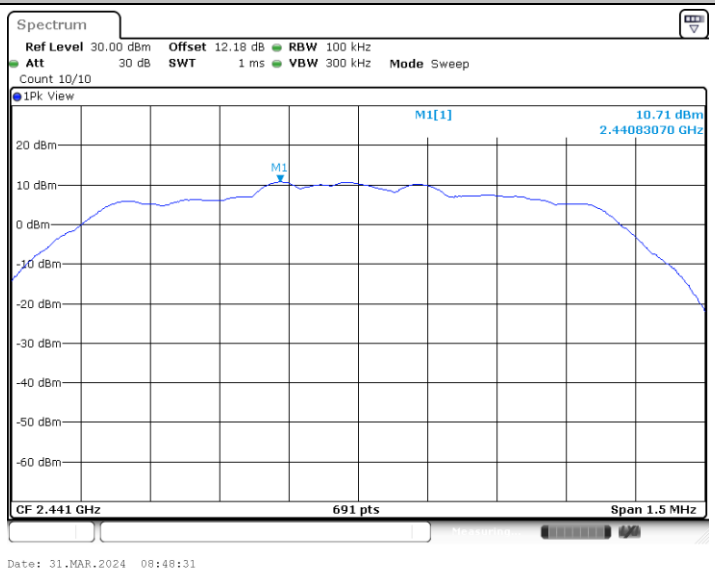
2DH1_2402_30~1000



2DH1_2402_1000~26500



2DH1_2441_0~Reference



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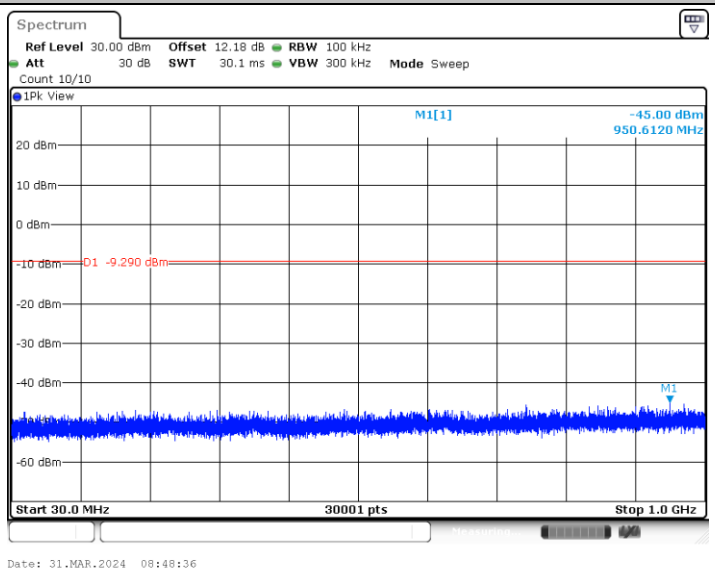
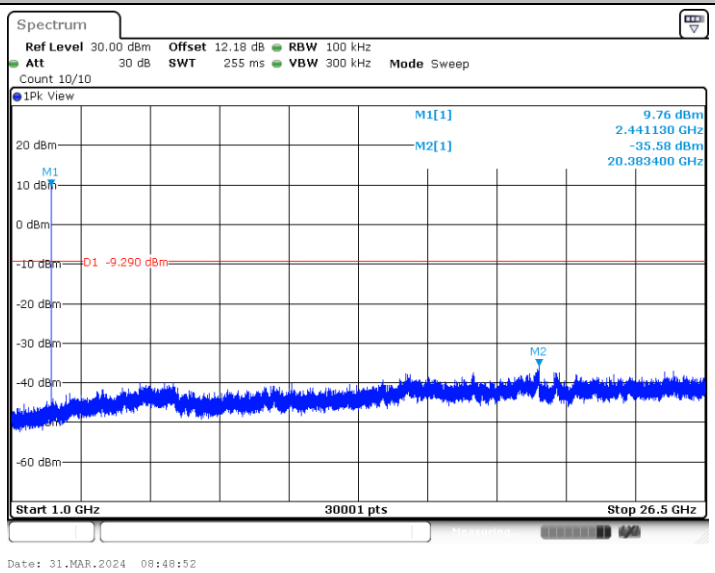
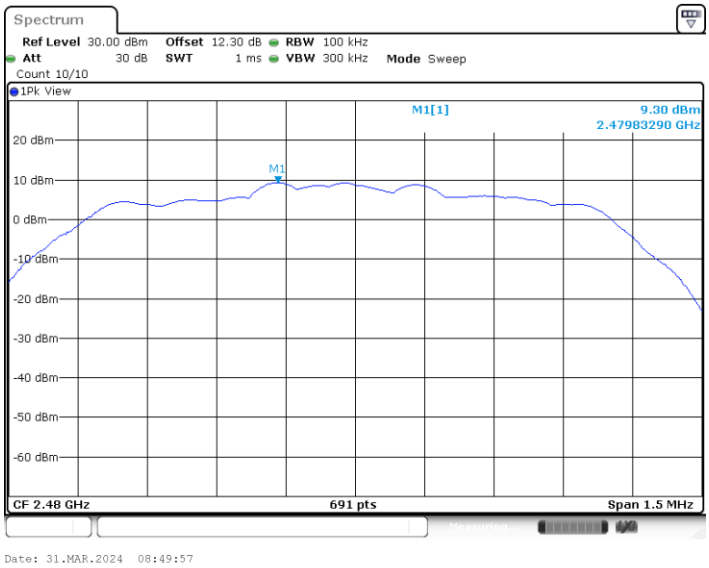


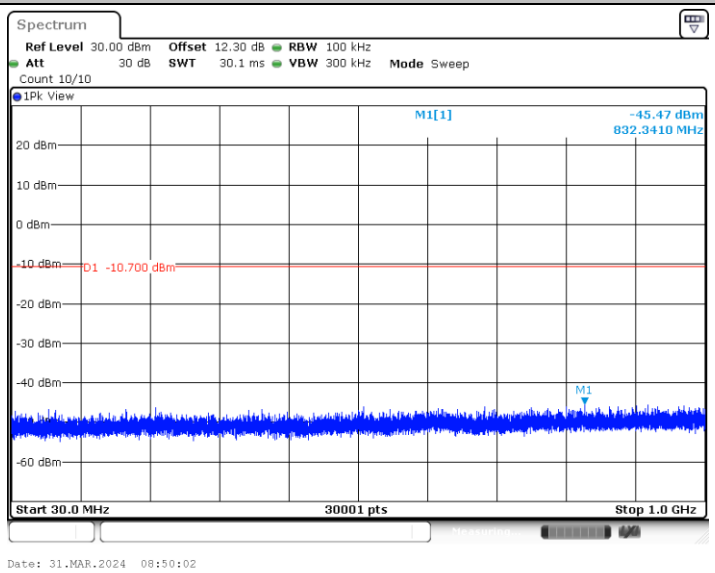
2DH1_2441_1000~26500



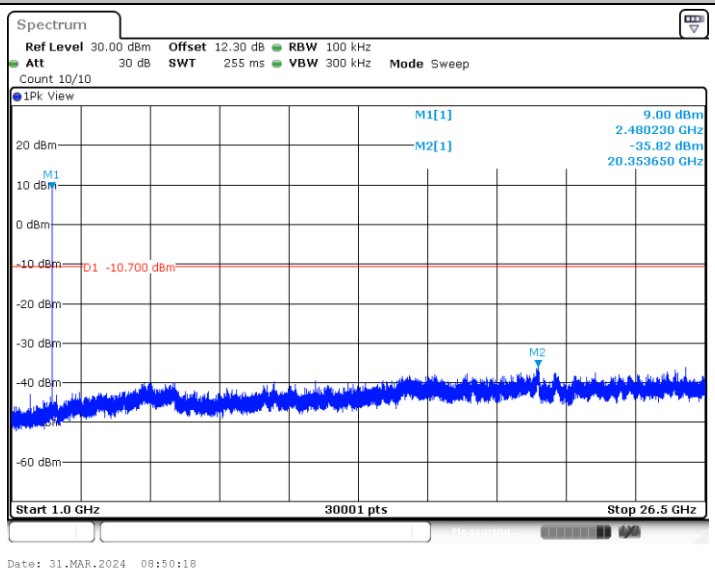
2DH1_2480_0~Reference



2DH1_2480_30~1000



2DH1_2480_1000~26500



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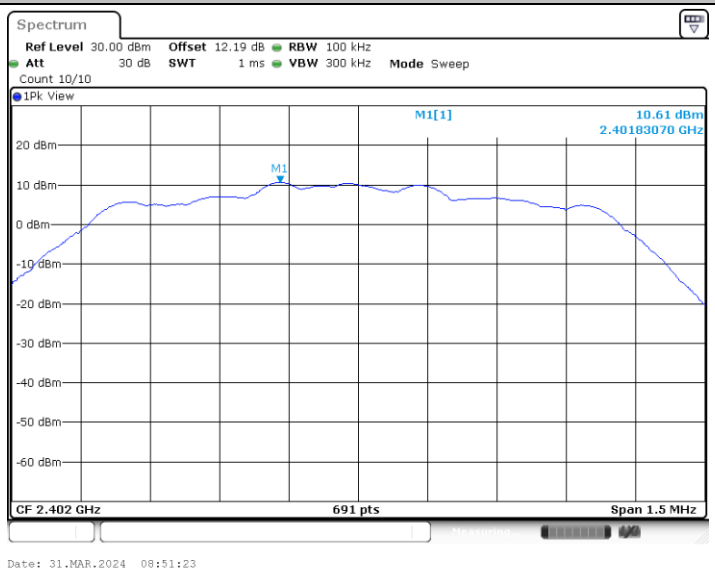

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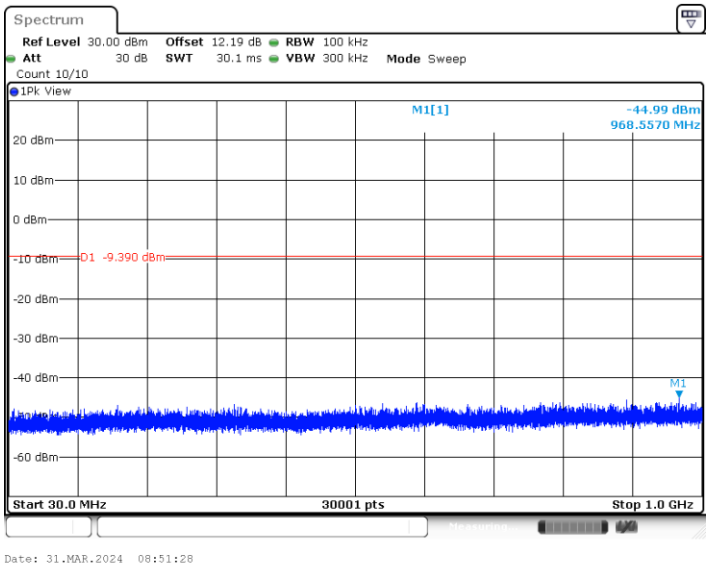
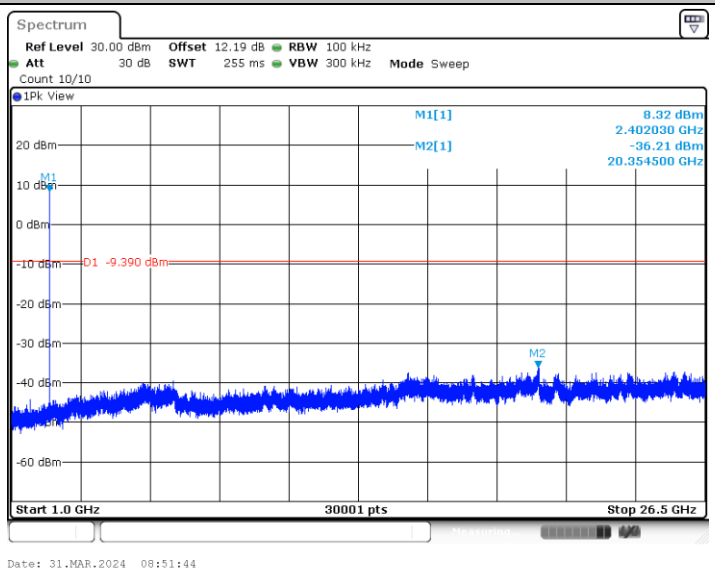


3DH1_2402_1000~26500



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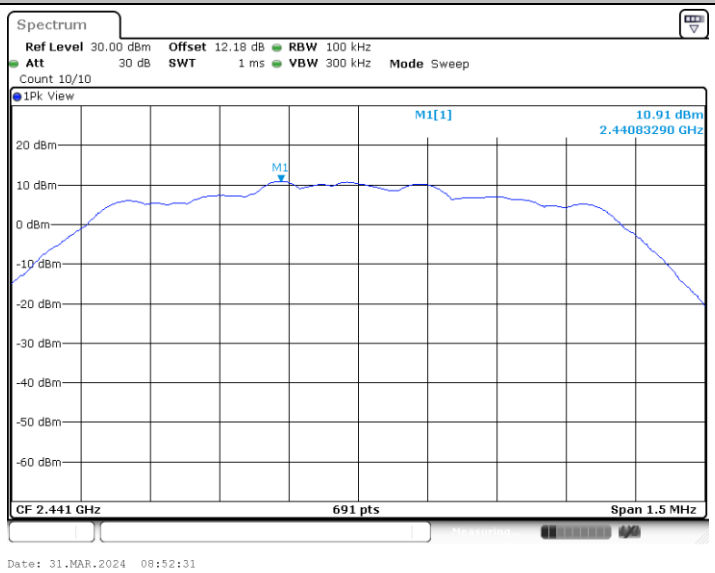
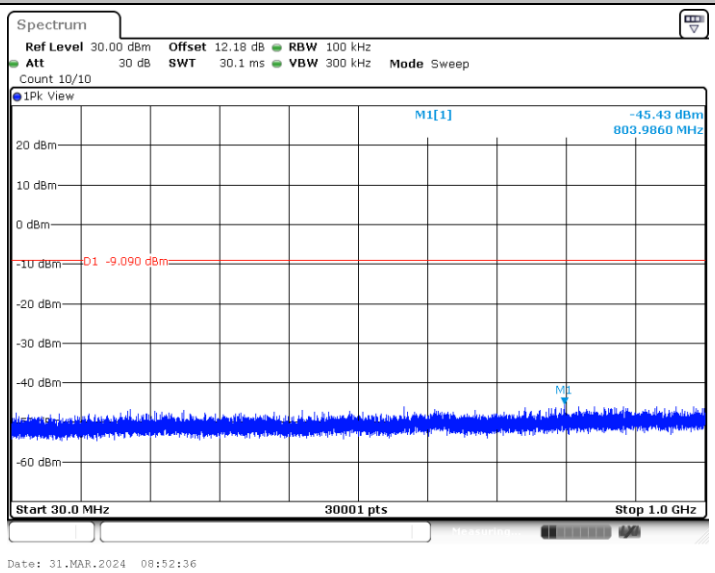
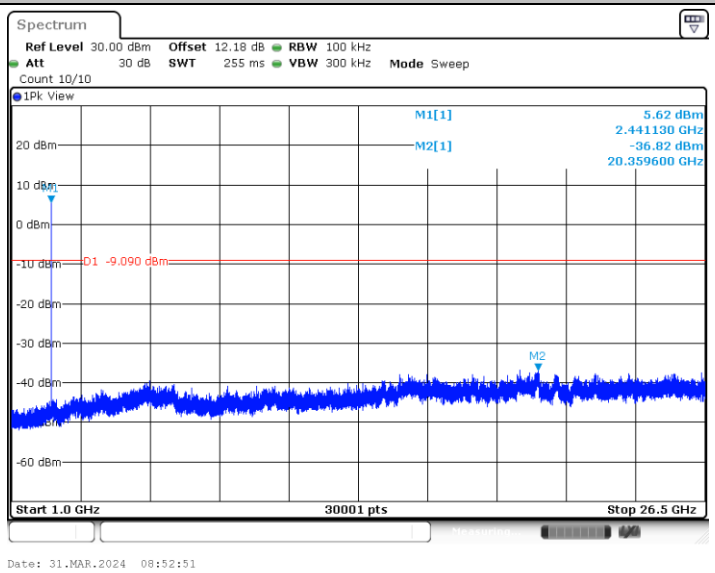


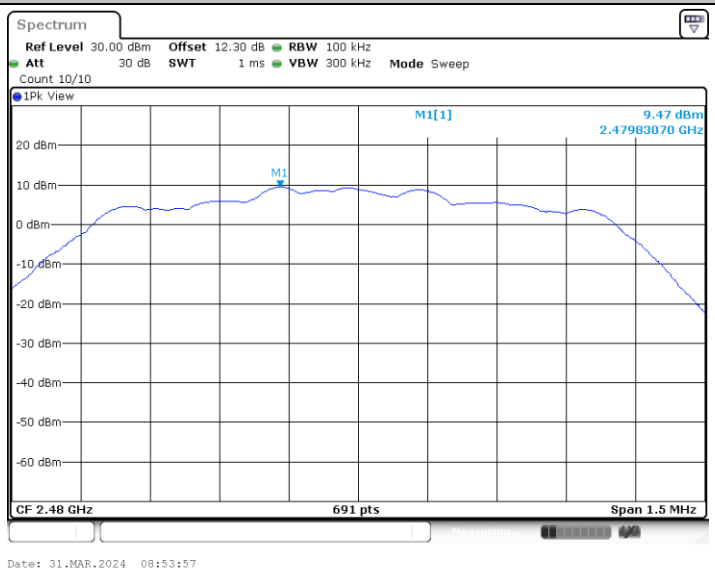
3DH1_2441_30~1000



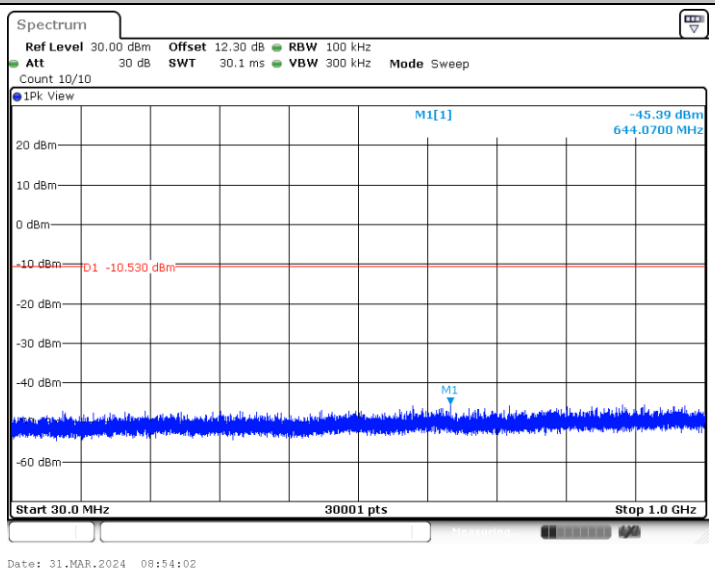
3DH1_2441_1000~26500



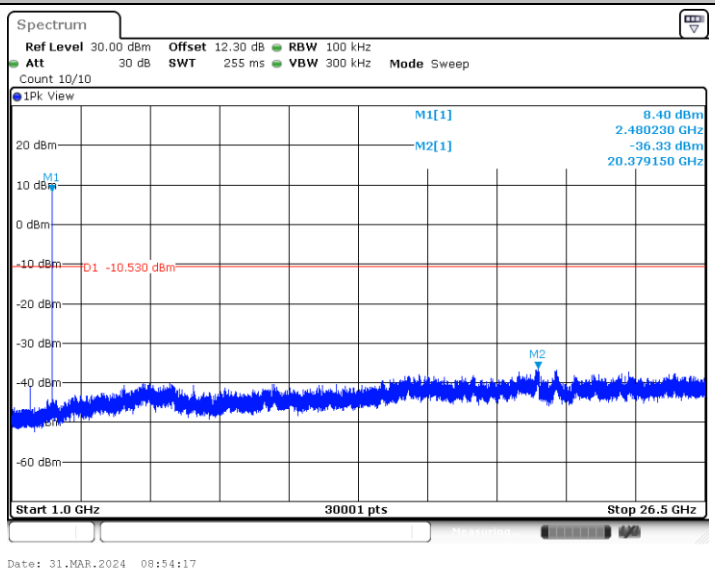
3DH1_2480_0~Reference



3DH1_2480_30~1000



3DH1_2480_1000~26500



Appendix B. Radiated Spurious Emission Test Data

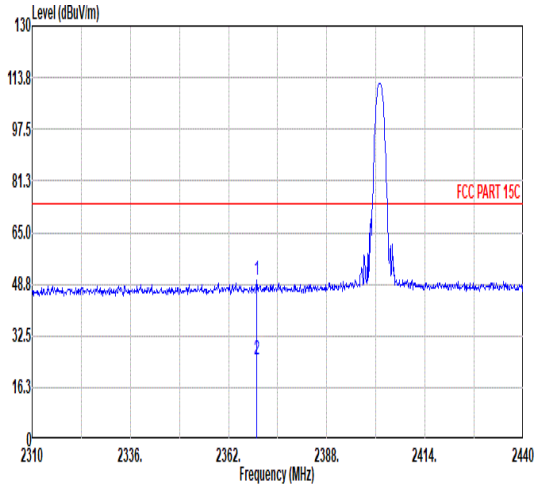
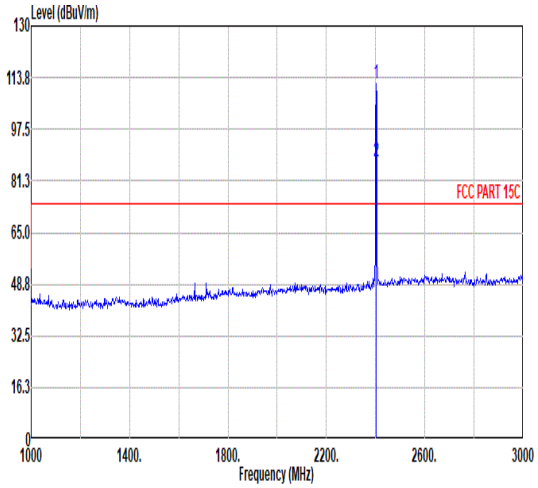
Test Engineer :	Carry	**Relative Humidity :**	41~42%
		Temperature :	22~23℃

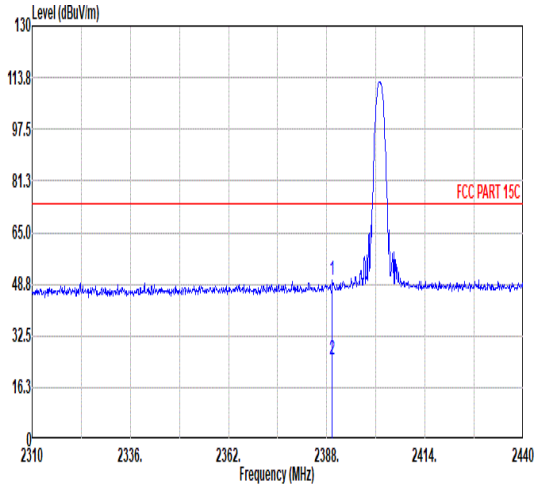
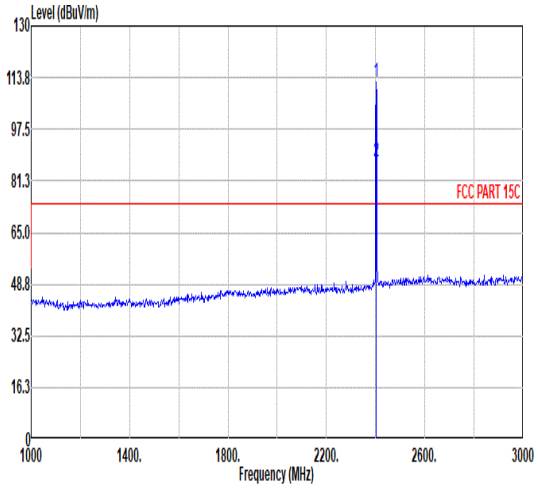
Radiated Spurious Emission Test Modes

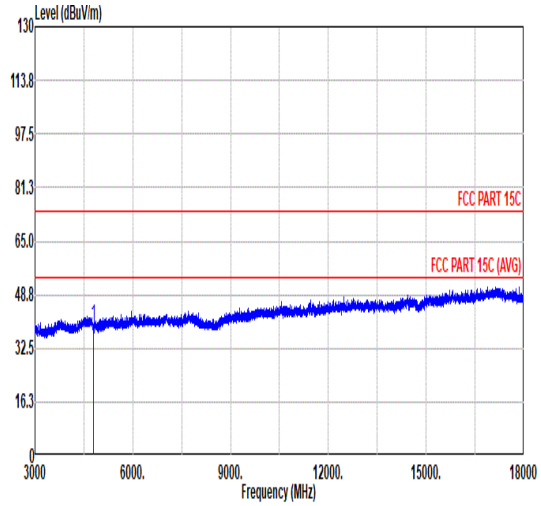
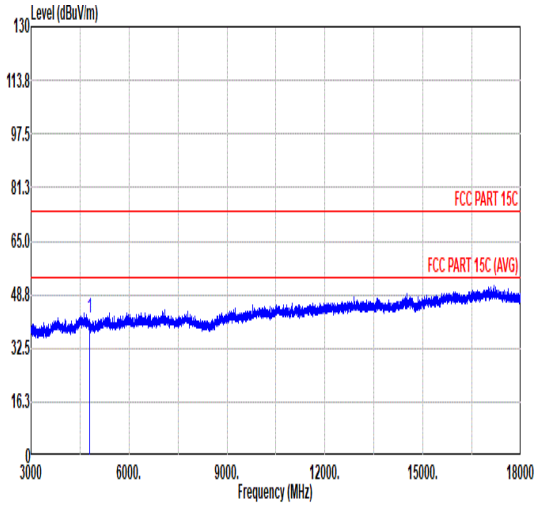
Mode	Band (MHz)	Modulation	Channel	Frequency	Data Rate	Remark
Mode 1	2400-2483.5	Bluetooth BR_GFSK	00	2402	1Mbps	-
Mode 2	2400-2483.5	Bluetooth BR_GFSK	39	2441	1Mbps	-
Mode 3	2400-2483.5	Bluetooth BR_GFSK	78	2480	1Mbps	-

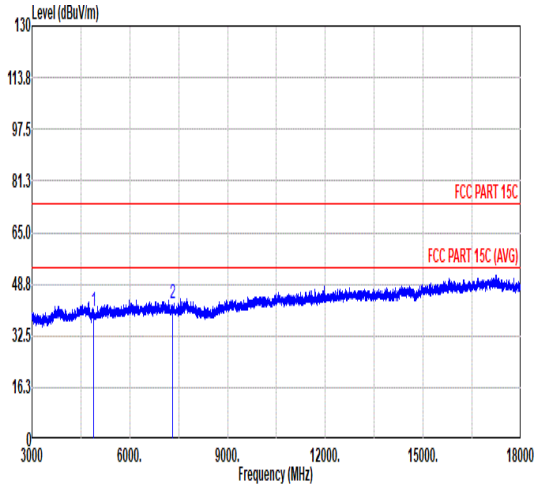
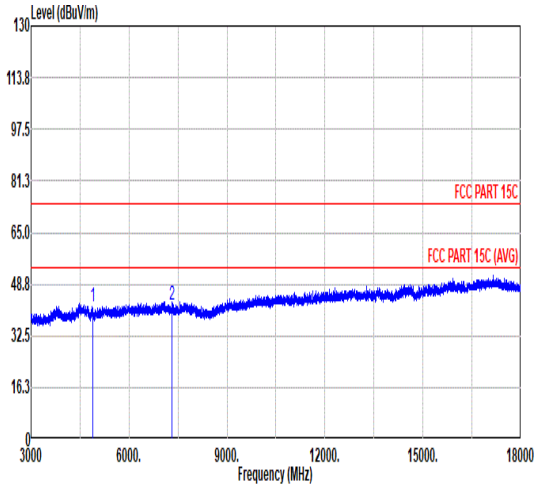
Summary of each worse mode

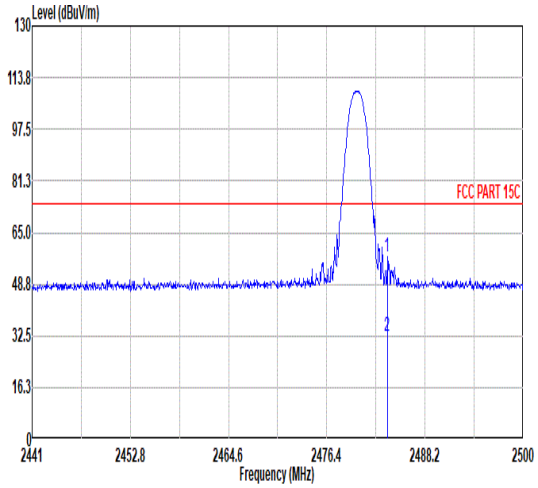
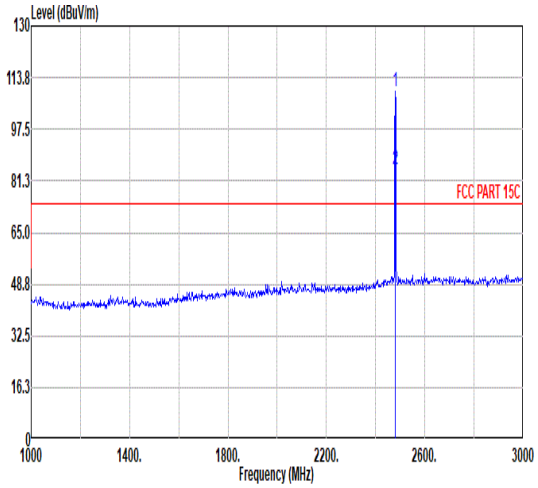
Mode	Modulation	Ch.	Freq. (MHz)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Pol.	Peak Avg.	Result	Remark
1	Bluetooth BR_GFSK	00	2369.41	50.04	74.00	-23.96	H	PEAK	Pass	Band Edge
1	Bluetooth BR_GFSK	00	4804.00	41.68	74.00	-32.32	V	PEAK	Pass	Harmonic
2	Bluetooth BR_GFSK	39	-	-	-	-	-	-	-	Band Edge
2	Bluetooth BR_GFSK	39	7323.00	42.83	74.00	-31.17	H	PEAK	Pass	Harmonic
3	Bluetooth BR_GFSK	78	2483.66	57.20	74.00	-16.80	H	PEAK	Pass	Band Edge
3	Bluetooth BR_GFSK	78	7440.00	42.48	74.00	-31.52	V	PEAK	Pass	Harmonic

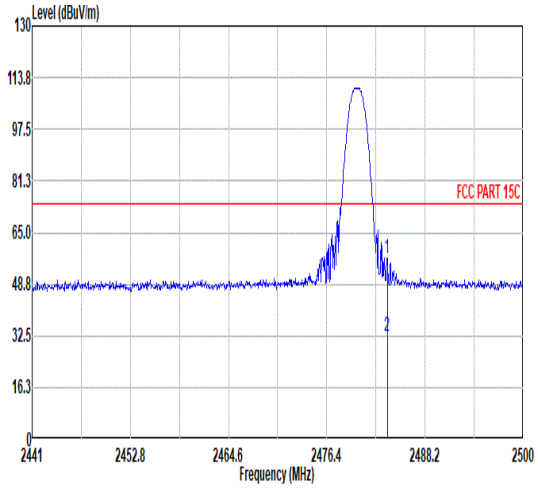
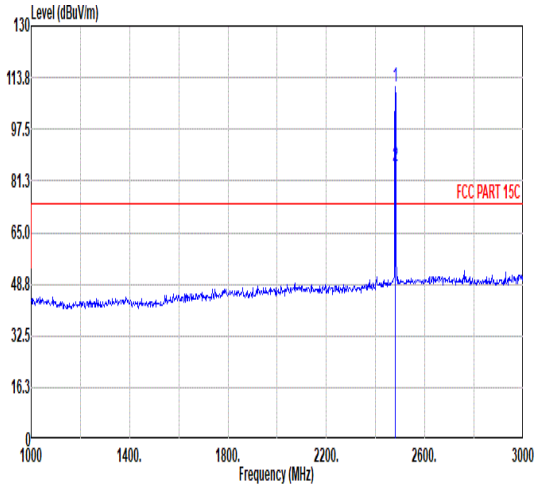
Mode	1	
	Band Edge	
	2400-2483.5_Bluetooth BR_GFSK_CH00_2402MHz	
Pol.	Horizontal	Fundamental
Peak	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2369.41 50.04 74.00 -23.96 41.84 32.19 7.07 37.06 6.00 300 350 PEAK 2 2369.41 25.25 54.00 -28.75 17.05 32.19 7.07 37.06 6.00 300 350 AVERAGE	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2402.00 112.00 ------ ------ 103.51 32.41 7.12 37.04 6.00 300 350 PEAK 2 2402.00 87.21 ------ ------ 78.72 32.41 7.12 37.04 6.00 300 350 AVERAGE

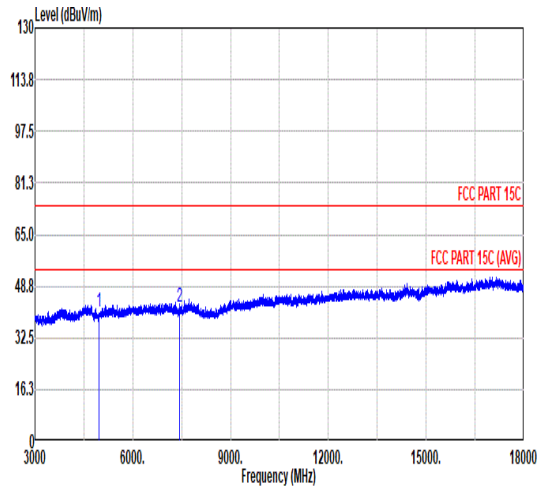
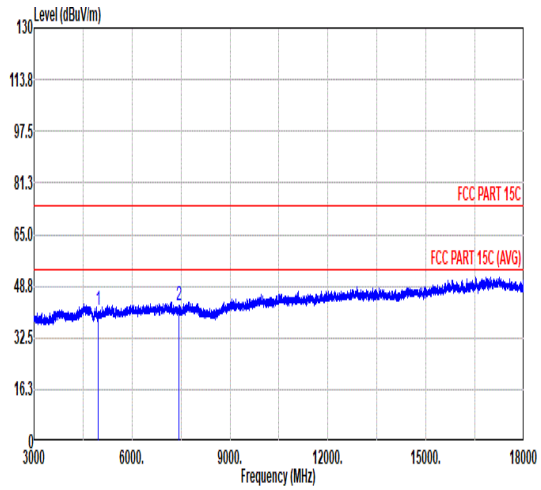
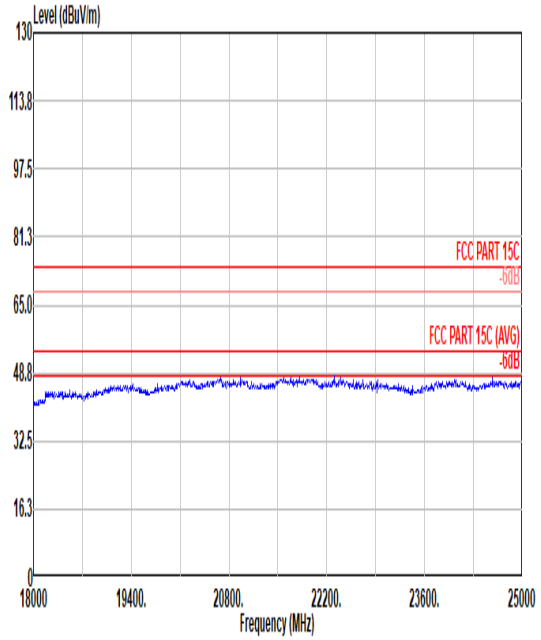
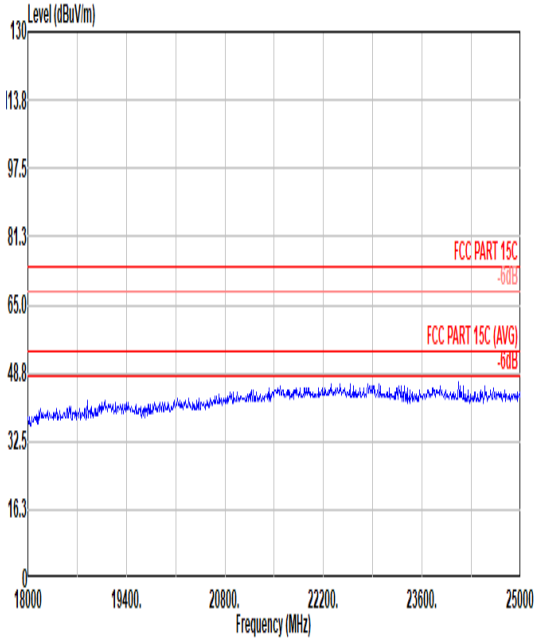
Mode	1	
	Band Edge	
	2400-2483.5_Bluetooth BR_GFSK_CH00_2402MHz	
Pol.	Vertical	Fundamental
Peak	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2389.43 50.02 74.00 -23.98 41.64 32.33 7.10 37.05 6.00 113 274 PEAK 2 2389.43 25.23 54.00 -28.77 16.85 32.33 7.10 37.05 6.00 113 274 AVERAGE	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2402.00 112.19 ------ ------ 103.70 32.41 7.12 37.04 6.00 113 274 PEAK 2 2402.00 87.40 ------ ------ 78.91 32.41 7.12 37.04 6.00 113 274 AVERAGE

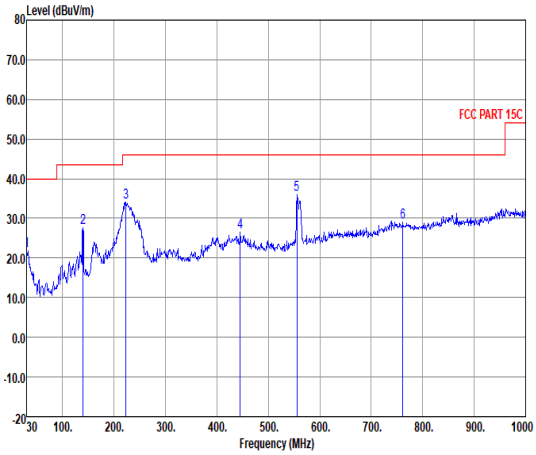
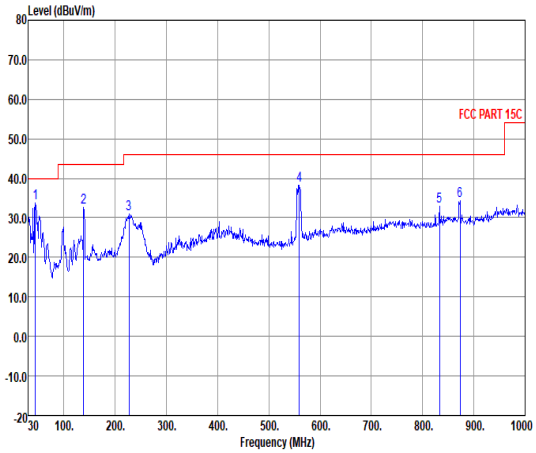
Mode	1	
	Harmonic	
	2400-2483.5_Bluetooth BR_GFSK_CH00_2402MHz	
Pol.	Horizontal	Vertical
Peak Avg	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 4804.00 39.59 74.00 -34.41 60.47 34.40 10.20 65.48 0.00 -- -- PEAK	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 4804.00 41.68 74.00 -32.32 62.56 34.40 10.20 65.48 0.00 -- -- PEAK

Mode	2	
	Harmonic	
	2400-2483.5_Bluetooth BR_GFSK_CH39_2441MHz	
Pol.	Horizontal	Vertical
Peak Avg	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 4882.00 40.22 74.00 -33.78 61.13 34.32 10.30 65.53 0.00 -- -- PEAK 2 7323.00 42.83 74.00 -31.17 60.46 35.98 12.72 66.33 0.00 -- -- PEAK	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 4882.00 41.49 74.00 -32.51 62.40 34.32 10.30 65.53 0.00 -- -- PEAK 2 7323.00 42.10 74.00 -31.90 59.73 35.98 12.72 66.33 0.00 -- -- PEAK

Mode	3	
	Band Edge	
	2400-2483.5_Bluetooth BR_GFSK_CH78_2480MHz	
Pol.	Horizontal	Fundamental
Peak	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2483.66 57.20 74.00 -16.80 47.80 32.99 7.26 36.85 6.00 100 209 PEAK 2 2483.66 32.41 54.00 -21.59 23.01 32.99 7.26 36.85 6.00 100 209 AVERAGE	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2480.00 109.56 ------ ------ 100.21 32.96 7.25 36.86 6.00 100 209 PEAK 2 2480.00 84.77 ------ ------ 75.42 32.96 7.25 36.86 6.00 100 209 AVERAGE

Mode	3	
	Band Edge	
	2400-2483.5_Bluetooth BR_GFSK_CH78_2480MHz	
Pol.	Vertical	Fundamental
Peak	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2483.66 57.12 74.00 -16.88 47.72 32.99 7.26 36.85 6.00 182 261 PEAK 2 2483.66 32.33 54.00 -21.67 22.93 32.99 7.26 36.85 6.00 182 261 AVERAGE	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 2480.00 110.63 ------ ------ 101.28 32.96 7.25 36.86 6.00 182 261 PEAK 2 2480.00 85.84 ------ ------ 76.49 32.96 7.25 36.86 6.00 182 261 AVERAGE

Mode	3	
	Harmonic	
	2400-2483.5_Bluetooth BR_GFSK_CH78_2480MHz	
Pol.	Horizontal	Vertical
Peak	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 4960.00 40.49 74.00 -33.51 61.44 34.24 10.40 65.59 0.00 -- -- PEAK 2 7440.00 42.19 74.00 -31.81 60.10 35.94 12.78 66.63 0.00 -- -- PEAK	 Freq Level Limit Line Margin Read Level Ant Factor Cable Loss Preamp Factor Aux Factor APos TPos Remark MHz dBuV/m dBuV/m dB dBuV dB/m dB dB dB cm deg 1 4960.00 41.10 74.00 -32.90 62.05 34.24 10.40 65.59 0.00 -- -- PEAK 2 7440.00 42.48 74.00 -31.52 60.39 35.94 12.78 66.63 0.00 -- -- PEAK
Avg		

Mode	3	
	30-1G	
	2400-2483.5_Bluetooth BR_GFSK_CH78_2480MHz	
Pol.	Horizontal	Vertical
QP		

Horizontal:

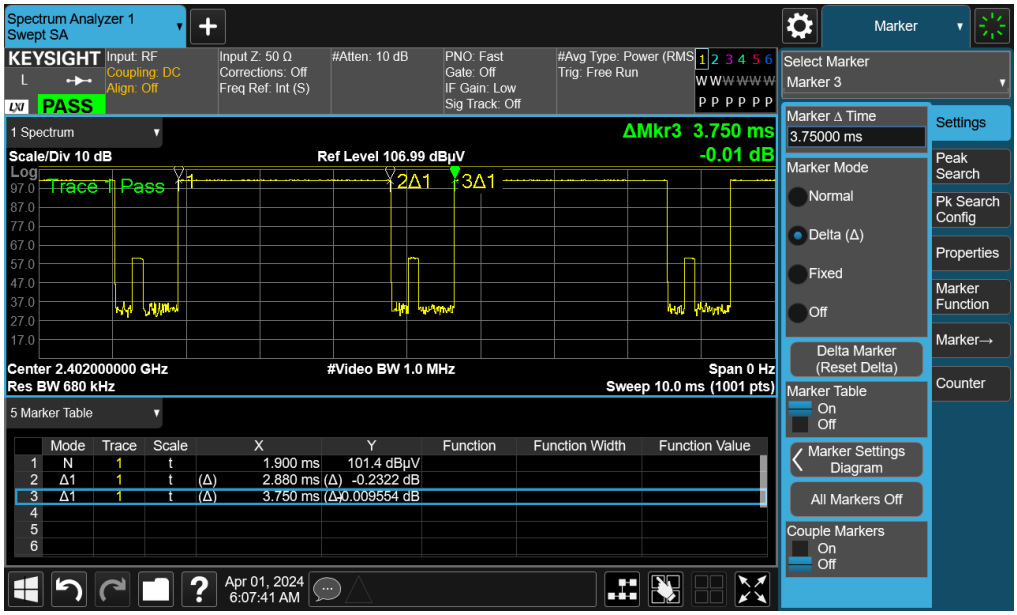
	Freq	Level	Over Limit	Limit Line	Read Level	Cable Loss	Antenna Factor	Preamp Factor	A/Pos	T/Pos	Remark
	MHz	dBuV/m	dB	dBuV/m	dBuV	dB	dB/m	dB	cm	deg	
1	30.00	21.79	-18.21	40.00	29.53	0.71	24.57	33.02	---	---	Peak
2	139.61	27.62	-15.88	43.50	42.11	1.78	16.56	32.83	---	---	Peak
3	223.03	34.11	-11.89	46.00	47.85	2.27	16.80	32.81	---	---	Peak
4	445.16	26.65	-19.35	46.00	34.02	3.22	22.45	33.04	---	---	Peak
5	555.74	36.03	-9.97	46.00	40.45	3.60	25.09	33.11	---	---	Peak
6	761.38	29.12	-16.88	46.00	31.75	4.22	25.93	32.78	---	---	Peak

Vertical:

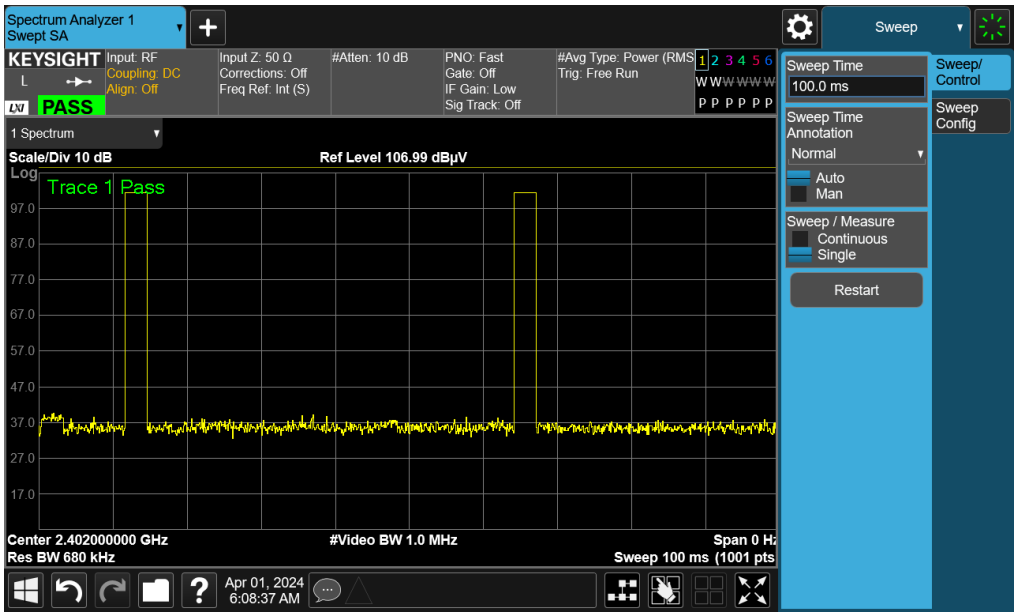
	Freq	Level	Over Limit	Limit Line	Read Level	Cable Loss	Antenna Factor	Preamp Factor	A/Pos	T/Pos	Remark
	MHz	dBuV/m	dB	dBuV/m	dBuV	dB	dB/m	dB	cm	deg	
1	44.55	33.71	-6.29	40.00	49.26	0.96	16.47	32.98	---	---	Peak
2	138.64	32.78	-10.72	43.50	47.27	1.77	16.57	32.83	---	---	Peak
3	226.91	30.85	-15.15	46.00	44.32	2.30	17.03	32.80	---	---	Peak
4	559.62	38.31	-7.69	46.00	42.72	3.61	25.08	33.10	---	---	Peak
5	833.16	33.06	-12.94	46.00	34.67	4.41	26.48	32.50	---	---	Peak
6	872.93	34.29	-11.71	46.00	35.27	4.51	26.63	32.12	---	---	Peak

Appendix C. Duty Cycle Plots

DH5 on time (One Pulse) Plot on Channel 39



DH5 on time (Count Pulses) Plot on Channel 39



Note:

1. Worst case Duty cycle = on time/100 milliseconds = 2 * 2.88 / 100 = 5.76 %
2. Worst case Duty cycle correction factor = 20*log(Duty cycle) = -24.79 dB
3. DH5 has the highest duty cycle worst case and is reported.