FCC RF Test Report

FCC ID	:	UZ7WS5012
EQUIPMENT	:	WS501 Wearable Computer
BRAND NAME	:	Zebra
MODEL NAME	:	WS5012
APPLICANT	:	Zebra Technologies Corporation 3 Overlook Point, Lincolnshire, IL 60069, USA
MANUFACTURER		Zebra Technologies Corporation 3 Overlook Point, Lincolnshire, IL 60069, USA
STANDARD	:	FCC Part 15 Subpart C §15.247
CLASSIFICATION	:	(DTS) Digital Transmission System
TEST DATE(S)	:	Feb. 13, 2025 ~ Mar. 13, 2025

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.

This report contains data that were produced under subcontract by Sporton International Inc. (Shenzhen)

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)
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APPENDIX A. CONDUCTED TEST RESULTS

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR512204C	Rev. 01	Initial issue of report	Apr. 15, 2025

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(a)(2)	6dB Bandwidth	≥ 0.5MHz	Pass	-
3.1	-	99% Bandwidth	-	Report Only	-
3.2	15.247(b)	Power Output Measurement	≤ 30dBm	Pass	-
3.3	15.247(e)	Power Spectral Density	≤ 8dBm/3kHz	Pass	-
3.4	15.247(d)	Conducted Band Edges	≤ 30dBc	Pass	-
		Conducted Spurious Emission		Pass	-
3.5	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 1.30 dB at 2389.95 MHz
3.6	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 16.05 dB at 0.17 MHz
3.7	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 Product Feature of Equipment Under Test

Product Feature	
Equipment	WS501 Wearable Computer
Brand Name	Zebra
Model Name	WS5012
FCC ID	UZ7WS5012
SN Code	Conducted: 250145247E0026 Conduction: 250175247E0088 Radiation: 250175247E0073
HW Version	EV1
SW Version	14-02-11.00-UN-U00-PRD-APL-04
MFD	05FEB25
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.

Specification of Accessory				
Battery	**Brand Name**	Zebra	**Model**	BT-000446B

Supported Unit used in test configuration and system				
USB Cable	**Brand Name**	Zebra	**Part Number**	CBL-WS5X-USBA-01
AC Adapter	**Brand Name**	Zebra	**Part Number**	PWR-WUA5V12W0US
WS50 Two Finger Trigger Mount	**Brand Name**	Zebra	**Part Number**	SG-WS5X-TRGA-01
Replacement protective shell for WS50 Scan	**Brand Name**	Zebra	**Part Number**	SG-WS5X-SHLCS-01
Replacement protective deflector for WS50 Scan	**Brand Name**	Zebra	**Part Number**	SG-WS5X-DFLTC-01
WS50 Scan Back of Hand Mount	**Brand Name**	Zebra	**Part Number**	SG-WS5X-BHMT-01
Spare Hand Wrap for WS50 Back of Hand Mount (right hand medium size)	**Brand Name**	Zebra	**Part Number**	SG-WEAR-HNWPRM-01
Spare Hand Wrap for WS50 Back of Hand Mount (left hand large size)	**Brand Name**	Zebra	**Part Number**	SG-WEAR-HNWPLL-01

1.2 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Channel Frequency Range	2412 MHz ~ 2462 MHz
Maximum (Average) Output Power to antenna	**<MIMO Ant 0+1>** 802.11b : 23.56 dBm (0.2270 W) 802.11g : 21.99 dBm (0.1581 W) 802.11n HT20 : 21.30 dBm (0.1349 W) 802.11ac VHT20 : 21.37 dBm (0.1371 W) 802.11ax HE20 : 21.48 dBm (0.1406 W)
99% Occupied Bandwidth	802.11b : 11.429 MHz 802.11g : 22.298 MHz 802.11ac VHT20 : 19.181 MHz 802.11ax HE20 : 19.421 MHz
Antenna Type / Gain	**<Ant 0>** IFA Antenna type with gain 0.4 dBi **<Ant 1>** IFA Antenna type with gain 0.8 dBi
Type of Modulation	802.11b : DSSS (DBPSK / DQPSK / CCK) 802.11g/n : OFDM (BPSK / QPSK / 16QAM / 64QAM) 802.11ac : OFDM (BPSK / QPSK / 16QAM / 64QAM / 256QAM) 802.11ax : OFDM (BPSK / QPSK / 16QAM / 64QAM / 256QAM / 1024QAM)

Note:

1. The device supports WLAN MIMO CDD mode for 11b/g/n/ac/ax and Tx Beamforming mode for 11ax.
2. For WLAN SISO & MIMO mode, the whole testing has assessed only MIMO mode by referring to the higher normal output power.
3. For CDD and Beamforming modes, the CDD mode is the worst case, Beamforming power is set 3dB lower than CDD power. Thus only CDD mode was evaluated in this report by referring to their maximum conducted power.
4. For 802.11n/11ac mode, the whole testing have assessed only 802.11ac VHT20 by referring to the higher output power for conducted test items.
5. 802.11ax support OFDMA full RU tone and partial RU tone, both full RU and partial RU-left (for low CH) and partial RU-right (for high CH) test output power, the full RU power/PSD > partial RU, therefore the full RU perform full test, and partial RU verify bandedge/spurious.

1.3 Modification of EUT

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

1.4 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.**
	03CH08-KS TH01-KS	CN1257	314309

Sporton International Inc. (ShenZhen) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.01.

Test Firm	Sporton International Inc. (ShenZhen)		
Test Site Location	101, 1st Floor, Block B, Building 1, No. 2, Tengfeng 4th Road, Fenghuang Community, Fuyong Street, Baoan District, Shenzhen City, Guangdong Province 518103 People's Republic of China TEL: +86-755-86066985		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	CO02-SZ	CN1256	421272

Test data subcontracted: Conducted Emission test case in section 3.6 of this report.

1.5 Test Software

Item	Site	Manufacturer	Name	Version
1.	TH01-KS	Tonscend	JS1120-3 test system China_210602	3.3.10
2.	03CH08-KS	AUDIX	E3	210616
3.	CO02-SZ	AUDIX	E3	6.120613b

1.6 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
- FCC KDB 662911 D01 Multiple Transmitter Output v02r01.
- 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

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: conduction emission (150 kHz to 30 MHz), 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 (X plane) were recorded in this report.

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

2.1 Carrier Frequency and Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
2400-2483.5 MHz	1	2412	7	2442
	2	2417	8	2447
	3	2422	9	2452
	4	2427	10	2457
	5	2432	11	2462
	6	2437	-	-

2.2 Test Mode

Final test modes are considering the modulation and worse data rates as below table.

MIMO Antenna

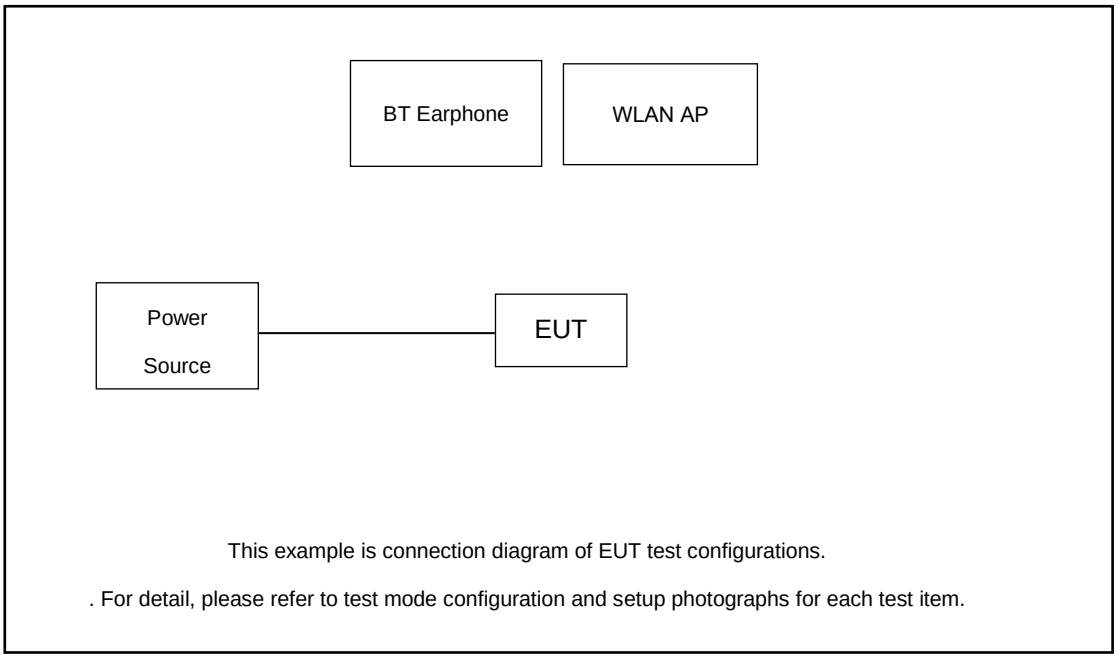
Modulation	Data Rate
802.11b	**1 Mbps**
802.11g	**6 Mbps**
802.11ax HE20	**MCS0**

RSE Co-location mode
802.11g CH06 MIMO Tx + NFC on

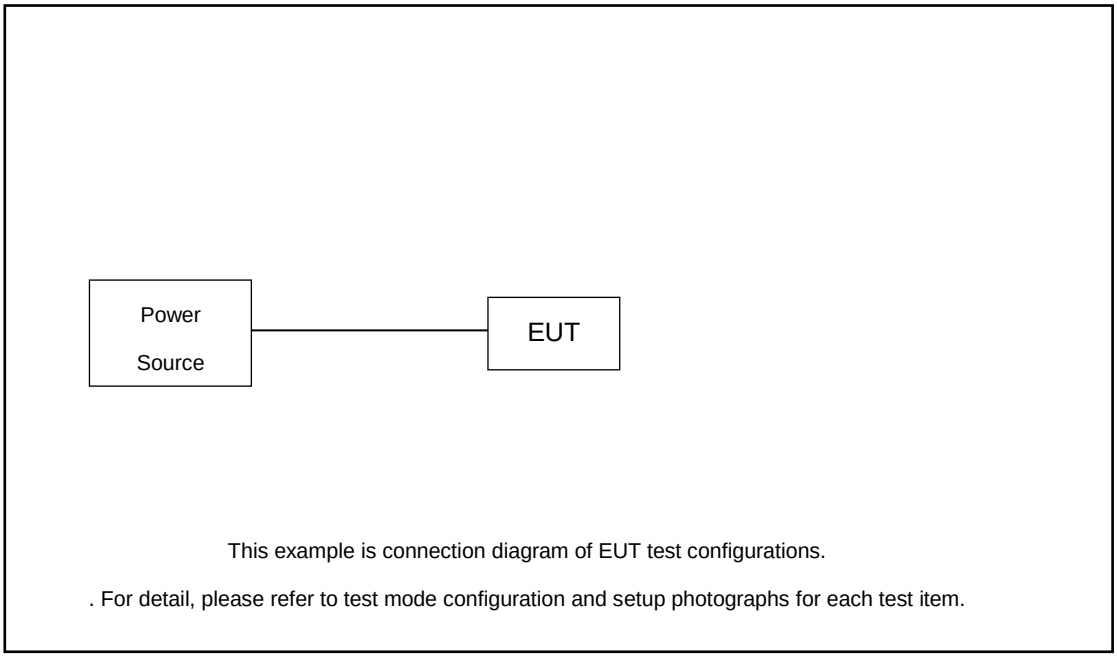
Test Cases	
AC Conducted Emission	Mode 1 : WLAN 2.4G Link + BT Link + USB Cable(Charging from Adapter) + Battery
Remark: For Radiated Test Cases, The tests were performed with Adapter and USB Cable.	

2.3 Connection Diagram of Test System

AC Conducted Emission:



Radiated Emission:



2.4 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	BT Earphone	Samsung	EO-MG900	PYAHS-107W	N/A	N/A
2.	WLAN AP	Dlink	DIR-820L	KA2IR820LA1	N/A	Unshielded,1.8m

2.5 EUT Operation Test Setup

For WLAN RF test items, an engineering test program was provided and enabled to make EUT continuous transmit.

For AC power line conducted emissions, the EUT was set to connect with the WLAN AP under large package sizes transmission.

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 2.11 dB and 20dB attenuator.

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

= 2.11 + 20 =22.11 (dB)

3 Test Result

3.1 6dB and 99% Bandwidth Measurement

3.1.1 Limit of 6dB and 99% Bandwidth

The minimum 6 dB bandwidth shall be at least 500 kHz.

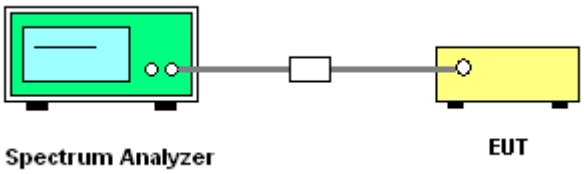
3.1.2 Measuring Instruments

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

3.1.3 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) ≥ 3*RBW. 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) = 1%~5% of OBW and set the Video bandwidth (VBW) approximately three times the RBW.
6. Measure and record the results in the test report.

3.1.4 Test Setup



3.1.5 Test Result of 6dB and 99% Occupied Bandwidth

Please refer to Appendix A.

3.2 Output Power Measurement

3.2.1 Limit of Output Power

For systems using digital modulation in the 2400-2483.5MHz, the limit for output power is 30dBm. If transmitting antenna with directional gain greater than 6dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

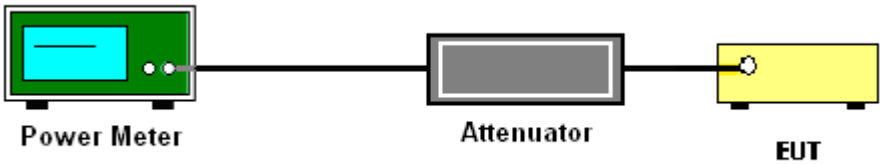
3.2.2 Measuring Instruments

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

3.2.3 Test Procedures

1. The testing follows the Measurement Procedure of ANSI C63.10-2013 clause 11.9.1.3 PKPM1 Peak power meter or ANSI C63.10-2013 clause 11.9.2.3.1 Method AVGPM method.
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 and record the results in the test report.
5. For MIMO mode, calculation method follows FCC KDB 662911 D01 Multiple Transmitter Output v02r01.

3.2.4 Test Setup



3.2.5 Test Result of Average Output Power

2.4GHz Band MIMO																		
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Duty Factor (dB)		Average Conducted Power with duty factor (dBm)			Conducted Power Limit (dBm)		DG (dBi)		EIRP Power (dBm)		EIRP Power Limit (dBm)		Pass /Fail	Power Setting
					Ant0	Ant1	Ant0	Ant1	SUM	Ant0	Ant1	Ant0	Ant1	Ant0	Ant1	Ant0	Ant1		
11b	5.5Mbps	2	1	2412	0.24	0.24	19.02	18.84	21.94	30.00		0.80		22.74		36.00		Pass	18.50
11b	5.5Mbps	2	6	2437	0.24	0.24	20.63	20.47	23.56	30.00		0.80		24.36		36.00		Pass	20.00
11b	5.5Mbps	2	11	2462	0.24	0.24	18.62	18.53	21.59	30.00		0.80		22.39		36.00		Pass	18.00
11g	6Mbps	2	1	2412	0.30	0.28	15.13	15.08	18.12	30.00		0.80		18.92		36.00		Pass	14.50
11g	6Mbps	2	2	2417	0.30	0.28	16.36	16.62	19.50	30.00		0.80		20.30		36.00		Pass	16.00
11g	6Mbps	2	6	2437	0.30	0.28	18.94	19.01	21.99	30.00		0.80		22.79		36.00		Pass	18.50
11g	6Mbps	2	9	2452	0.30	0.28	16.41	16.54	19.49	30.00		0.80		20.29		36.00		Pass	16.00
11g	6Mbps	2	10	2457	0.30	0.28	15.44	15.74	18.60	30.00		0.80		19.40		36.00		Pass	15.00
11g	6Mbps	2	11	2462	0.30	0.28	14.99	15.00	18.01	30.00		0.80		18.81		36.00		Pass	14.50
HT20	MCS0	2	1	2412	0.32	0.32	15.07	15.07	18.08	30.00		0.80		18.88		36.00		Pass	14.50
HT20	MCS0	2	2	2417	0.32	0.32	15.74	16.07	18.92	30.00		0.80		19.72		36.00		Pass	15.00
HT20	MCS0	2	6	2437	0.32	0.32	18.39	18.19	21.30	30.00		0.80		22.10		36.00		Pass	18.00
HT20	MCS0	2	9	2452	0.32	0.32	16.01	16.29	19.16	30.00		0.80		19.96		36.00		Pass	15.50
HT20	MCS0	2	10	2457	0.32	0.32	14.96	15.55	18.28	30.00		0.80		19.08		36.00		Pass	14.50
HT20	MCS0	2	11	2462	0.32	0.32	14.37	14.50	17.45	30.00		0.80		18.25		36.00		Pass	14.00
VHT20	MCS0	2	1	2412	0.32	0.32	15.13	15.17	18.16	30.00		0.80		18.96		36.00		Pass	14.50
VHT20	MCS0	2	2	2417	0.32	0.32	15.79	16.15	18.98	30.00		0.80		19.78		36.00		Pass	15.00
VHT20	MCS0	2	6	2437	0.32	0.32	18.47	18.25	21.37	30.00		0.80		22.17		36.00		Pass	18.00
VHT20	MCS0	2	9	2452	0.32	0.32	16.04	16.41	19.24	30.00		0.80		20.04		36.00		Pass	15.50
VHT20	MCS0	2	10	2457	0.32	0.32	15.07	15.63	18.37	30.00		0.80		19.17		36.00		Pass	14.50
VHT20	MCS0	2	11	2462	0.32	0.32	14.45	14.55	17.51	30.00		0.80		18.31		36.00		Pass	14.00

2.4GHz Band MIMO																				
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	RU Config.	Duty Factor (dB)		Average Conducted Power with duty factor (dBm)			Conducted Power Limit (dBm)		DG (dBi)		EIRP Power (dBm)		EIRP Power Limit (dBm)		Pass /Fail	Power Setting
						Ant0	Ant1	Ant0	Ant1	SUM	Ant0	Ant1	Ant0	Ant1	Ant0	Ant1	Ant0	Ant1		
HE20	MCS0	2	1	2412	Full	0.40	0.40	15.26	15.29	18.29	30.00		0.80		19.09		36.00		Pass	14.50
HE20	MCS0	2	1	2412	26/0	0.07	0.07	7.32	6.97	10.16	30.00		0.80		10.96		36.00		Pass	8.00
HE20	MCS0	2	1	2412	52/37	0.05	0.05	8.89	9.78	12.37	30.00		0.80		13.17		36.00		Pass	10.50
HE20	MCS0	2	1	2412	106/53	0.00	0.00	11.76	12.15	14.97	30.00		0.80		15.77		36.00		Pass	12.50
HE20	MCS0	2	2	2417	Full	0.40	0.40	15.93	16.26	19.11	30.00		0.80		19.91		36.00		Pass	15.00
HE20	MCS0	2	6	2437	Full	0.40	0.40	18.58	18.35	21.48	30.00		0.80		22.28		36.00		Pass	18.00
HE20	MCS0	2	6	2437	26/0	0.07	0.07	10.91	12.33	14.69	30.00		0.80		15.49		36.00		Pass	10.50
HE20	MCS0	2	6	2437	52/37	0.05	0.05	13.47	14.09	16.80	30.00		0.80		17.60		36.00		Pass	12.50
HE20	MCS0	2	6	2437	106/53	0.00	0.00	15.41	15.75	18.59	30.00		0.80		19.39		36.00		Pass	14.50
HE20	MCS0	2	9	2452	Full	0.40	0.40	16.16	16.53	19.36	30.00		0.80		20.16		36.00		Pass	15.50
HE20	MCS0	2	10	2457	Full	0.40	0.40	15.17	15.74	18.47	30.00		0.80		19.27		36.00		Pass	14.50
HE20	MCS0	2	11	2462	Full	0.40	0.40	14.57	14.69	17.64	30.00		0.80		18.44		36.00		Pass	14.00
HE20	MCS0	2	11	2462	26/8	0.07	0.07	8.30	8.39	11.36	30.00		0.80		12.16		36.00		Pass	7.50
HE20	MCS0	2	11	2462	52/40	0.05	0.05	9.79	11.59	13.79	30.00		0.80		14.59		36.00		Pass	10.00
HE20	MCS0	2	11	2462	106/54	0.00	0.00	12.68	13.34	16.03	30.00		0.80		16.83		36.00		Pass	12.00

3.2.6 Test Result of Peak Output Power (Reporting Only)

2.4GHz Band MIMO							
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	Peak Conducted Power (dBm)		
					Ant0	Ant1	SUM
11b	5.5Mbps	2	1	2412	21.89	21.87	24.89
11b	5.5Mbps	2	6	2437	23.67	23.38	26.54
11b	5.5Mbps	2	11	2462	21.59	21.45	24.53
11g	6Mbps	2	1	2412	24.07	24.21	27.15
11g	6Mbps	2	2	2417	24.75	25.06	27.92
11g	6Mbps	2	6	2437	25.36	25.61	28.50
11g	6Mbps	2	9	2452	24.76	25.05	27.92
11g	6Mbps	2	10	2457	24.69	24.78	27.75
11g	6Mbps	2	11	2462	24.21	24.27	27.25
HT20	MCS0	2	1	2412	24.48	24.24	27.37
HT20	MCS0	2	2	2417	24.56	24.02	27.31
HT20	MCS0	2	6	2437	25.49	25.54	28.53
HT20	MCS0	2	9	2452	24.51	24.69	27.61
HT20	MCS0	2	10	2457	24.49	24.65	27.58
HT20	MCS0	2	11	2462	24.35	24.28	27.33
VHT20	MCS0	2	1	2412	24.55	24.32	27.45
VHT20	MCS0	2	2	2417	24.61	24.07	27.36
VHT20	MCS0	2	6	2437	25.52	25.58	28.56
VHT20	MCS0	2	9	2452	24.57	24.73	27.66
VHT20	MCS0	2	10	2457	24.55	24.68	27.63
VHT20	MCS0	2	11	2462	24.41	24.35	27.39

2.4GHz Band MIMO								
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	RU Config.	Peak Conducted Power (dBm)		
						Ant0	Ant1	SUM
HE20	MCS0	2	1	2412	Full	24.61	24.49	27.56
HE20	MCS0	2	1	2412	26/0	17.14	17.63	20.40
HE20	MCS0	2	1	2412	52/37	19.62	19.94	22.79
HE20	MCS0	2	1	2412	106/53	21.82	23.49	25.75
HE20	MCS0	2	2	2417	Full	24.66	25.14	27.92
HE20	MCS0	2	6	2437	Full	25.59	25.66	28.64
HE20	MCS0	2	6	2437	26/0	20.68	22.35	24.61
HE20	MCS0	2	6	2437	52/37	23.63	23.55	26.60
HE20	MCS0	2	6	2437	106/53	24.63	25.58	28.14
HE20	MCS0	2	9	2452	Full	24.63	24.78	27.72
HE20	MCS0	2	10	2457	Full	24.58	24.72	27.66
HE20	MCS0	2	11	2462	Full	24.47	24.45	27.47
HE20	MCS0	2	11	2462	26/8	17.43	18.16	20.82
HE20	MCS0	2	11	2462	52/40	19.52	21.37	23.55
HE20	MCS0	2	11	2462	106/54	22.64	22.89	25.78

3.3 Power Spectral Density Measurement

3.3.1 Limit of Power Spectral Density

The peak power spectral density shall not be greater than 8dBm in any 3kHz band at any time interval of continuous transmission.

3.3.2 Measuring Instruments

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

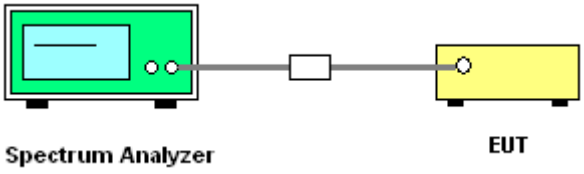
3.3.3 Test Procedures

1. The testing follows Measurement Procedure of ANSI C63.10-2013 clause 11.10.2 Method PKPSD.
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) = 3 kHz. Video bandwidth VBW = 10 kHz In order to make an accurate measurement, set the span to 1.5 times DTS Channel Bandwidth. (6dB BW)
5. Detector = peak, Sweep time = auto couple, Trace mode = max hold, Allow trace to fully stabilize. Use the peak marker function to determine the maximum power level.
6. Measure and record the results in the test report.
7. For MIMO mode, calculation method follows FCC KDB 662911 D01 Multiple Transmitter Output v02r01:

   Method (b): Measure and sum spectral maxima across the outputs.

   The measurement on each individual output were performed with the same span and number on each individual output. The maximum value (peak) of each spectrum is determined. These maximum values are then summed mathematically in linear power units across the outputs.

3.3.4 Test Setup



3.3.5 Test Result of Power Spectral Density

Please refer to Appendix A.

3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission Measurement

In any 100 kHz bandwidth outside of the authorized frequency band, the emissions which fall in the non-restricted bands shall be attenuated at least 30dB relative to the maximum PSD level in 100 kHz by RF conducted measurement.

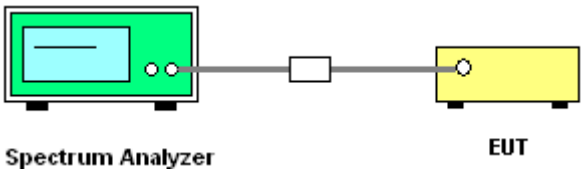
3.4.2 Measuring Instruments

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 11.11
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=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB per 15.247(d).
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.

3.4.4 Test Setup



3.4.5 Test Result of Conducted Band Edges and Spurious Emission

Please refer to Appendix A.

3.5 Radiated Band Edges and Spurious Emission Measurement

3.5.1 Limit of Radiated band edge and Spurious Emission Measurement

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

3.5.2 Measuring Instruments

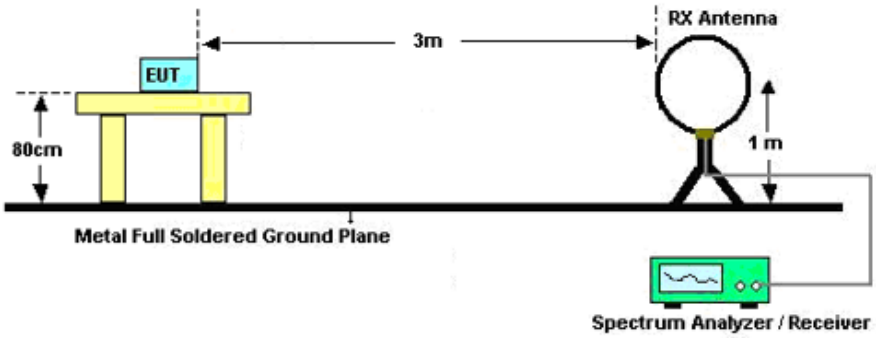
The measuring equipment is listed in the section 4 of this test report.

3.5.3 Test Procedures

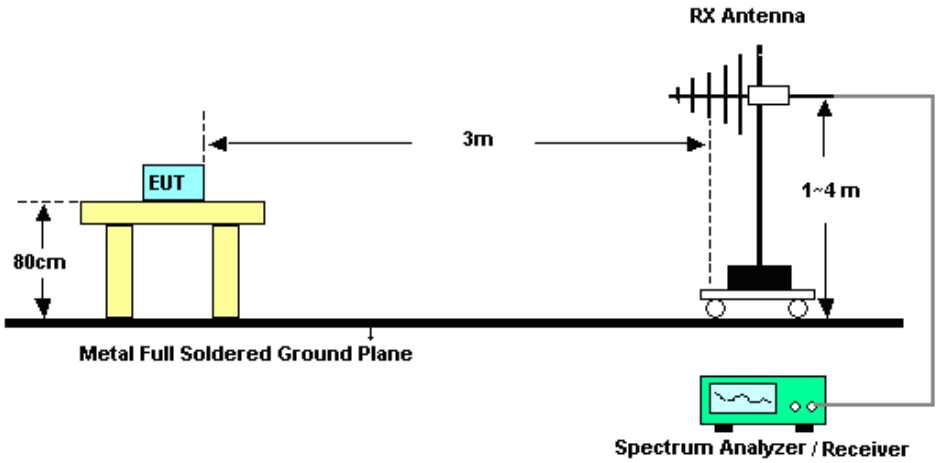
1. The testing follows ANSI C63.10-2013 clause 11.11 & 11.12
2. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better 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 f ≥ 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.

3.5.4 Test Setup

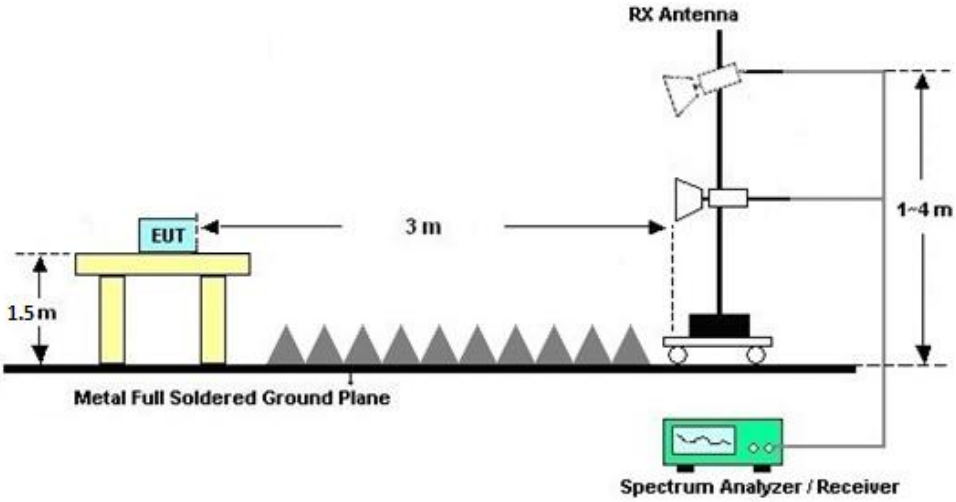
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



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

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.

3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C.

3.5.7 Duty Cycle

Please refer to Appendix D.

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

Please refer to Appendix C.

3.6 AC Conducted Emission Measurement

3.6.1 Limit of AC Conducted Emission

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-Peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

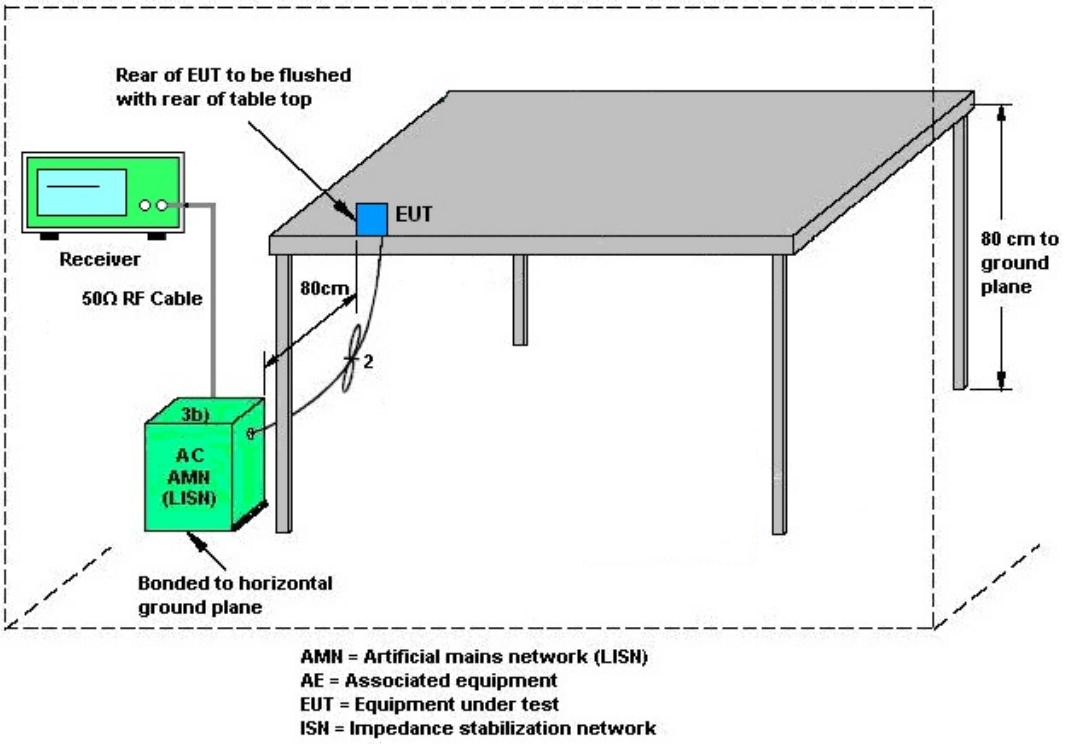
3.6.2 Measuring Instruments

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

3.6.3 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room, and it was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF bandwidth = 9kHz) with Maximum Hold Mode.

3.6.4 Test Setup



3.6.5 Test Result of AC Conducted Emission

Please refer to Appendix B.

3.7 Antenna Requirements

3.7.1 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.

3.7.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.7.3 Antenna Gain

<CDD Modes >

FCC KDB 662911 D01 Multiple Transmitter Output v02r01

For CDD transmissions, directional gain is calculated as

Directional gain = G_{ANT} + Array Gain, where Array Gain is as follows.

For power spectral density (PSD) measurements on all devices,

Array Gain = 10 log(N_{ANT}/N_{SS}=1) dB.

For power measurements on IEEE 802.11 devices,

Array Gain = 0 dB (i.e., no array gain) for $N_{ANT} \leq 4$.

Directional gain may be calculated by using the formulas applicable to equal gain antennas with G_{ANT} set equal to the gain of the antenna having the highest gain;

The EUT supports CDD mode.

For power, the directional gain G_{ANT} is set equal to the antenna having the highest gain, i.e., F)2)f)i).

For PSD, the directional gain calculation is following F)2)f)ii) of KDB 662911 D01 v02r01.

The power and PSD limit should be modified if the directional gain of EUT is over 6 dBi,

The directional gain “DG” is calculated as following table.

<CDD Modes>

	Ant. 0 (dBi)	Ant. 1 (dBi)	DG for Power (dBi)	DG for PSD (dBi)	Power Limit Reduction (dB)	PSD Limit Reduction (dB)
2.4 GHz	0.40	0.80	0.80	3.61	0.00	0.00

Power Limit Reduction = DG(Power) – 6dBi, (min = 0)

PSD Limit Reduction = DG(PSD) – 6dBi, (min = 0)

TXBF modes

The EUT supports TXBF mode for 11ax.

FCC KDB 662911 D01 Multiple Transmitter Output v02r01, directional gain is calculated as

$$DirectionalGain = 10 \cdot \log \left[\frac{\sum_{j=1}^{N_{SS}} \left\{ \sum_{k=1}^{N_{ANT}} g_{j,k} \right\}^2}{N_{ANT}} \right]$$

where

Each antenna is driven by no more than one spatial stream;

N_{SS} = the number of independent spatial streams of data;

N_{ANT} = the total number of antennas

$g_{j,k} = 10^{G_k/20}$ if the kth antenna is being fed by spatial stream j, or zero if it is not;

G_k is the gain in dBi of the kth antenna.

The directional gain calculation is following F)2)e)ii) of KDB 662911 D01 v02r01.

The power and PSD limit should be modified if the directional gain of EUT is over 6 dBi,

The directional gain "DG" is calculated as following table.

	Ant 0 (dBi)	Ant 1 (dBi)	DG for Power (dBi)	DG for PSD (dBi)	Power Limit Reduction (dB)	PSD Limit Reduction (dB)
2.4 GHz	0.40	0.80	3.61	3.61	0.00	0.00

Power Limit Reduction = DG(Power) – 6dBi, (min = 0)

PSD Limit Reduction = DG(PSD) – 6dBi, (min = 0)

4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV40	101040	10Hz~40GHz	Oct. 10, 2024	Feb. 13, 2025~ Mar. 13, 2025	Oct. 09, 2025	Conducted (TH01-KS)
Pulse Power Senor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 02, 2025	Feb. 13, 2025~ Mar. 13, 2025	Jan. 01, 2026	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 02, 2025	Feb. 13, 2025~ Mar. 13, 2025	Jan. 01, 2026	Conducted (TH01-KS)
EMI Test Receiver	Keysight	N9038A	MY57290151	3Hz~8.5GHz;Max 30dBm	Jul. 04, 2024	Mar. 12, 2025~ Mar. 13, 2025	Jul. 03, 2025	Radiation (03CH08-KS)
EXA Spectrum Analyzer	Keysight	N9010B	MY57441079	10Hz-44GHz	Oct. 09, 2024	Mar. 12, 2025~ Mar. 13, 2025	Oct. 08, 2025	Radiation (03CH08-KS)
Loop Antenna	R&S	HFH2-Z2E	101125	9kHz~30MHz	Sep. 08, 2024	Mar. 12, 2025~ Mar. 13, 2025	Sep. 07, 2025	Radiation (03CH08-KS)
Bilog Antenna	TESEQ	CBL 6111D	59915	30MHz-1GHz	Aug. 18, 2024	Mar. 12, 2025~ Mar. 13, 2025	Aug.17, 2025	Radiation (03CH08-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	00240138	1GHz~18GHz	Jul. 06, 2024	Mar. 12, 2025~ Mar. 13, 2025	Jul. 05, 2025	Radiation (03CH08-KS)
high gain Amplifier	EM	EM01G18GA	060890	1Ghz-18Ghz	Jul. 23, 2024	Mar. 12, 2025~ Mar. 13, 2025	Jul. 22, 2025	Radiation (03CH08-KS)
SHF-EHF Horn	Com-power	AH-840	101116	18GHz~40GHz	Oct. 22, 2024	Mar. 12, 2025~ Mar. 13, 2025	Oct. 21, 2025	Radiation (03CH08-KS)
Amplifier	SONOMA	310N	380826	9KHz-1GHz	Jul. 03, 2024	Mar. 12, 2025~ Mar. 13, 2025	Jul. 02, 2025	Radiation (03CH08-KS)
Amplifier	Keysight	83017A	MY53270417	500MHz~26.5GHz	Oct. 09, 2024	Mar. 12, 2025~ Mar. 13, 2025	Oct. 08, 2025	Radiation (03CH08-KS)
Amplifier	EM	EM18G40GGA	060737	18~40GHz	Jan. 03, 2025	Mar. 12, 2025~ Mar. 13, 2025	Jan. 02, 2026	Radiation (03CH08-KS)
AC Power Source	Chroma	61601	616010002473	N/A	NCR	Mar. 12, 2025~ Mar. 13, 2025	NCR	Radiation (03CH08-KS)
Turn Table	EM	EM 1000-T	N/A	0~360 degree	NCR	Mar. 12, 2025~ Mar. 13, 2025	NCR	Radiation (03CH08-KS)
Antenna Mast	EM	EM 1000-A	N/A	1 m~4 m	NCR	Mar. 12, 2025~ Mar. 13, 2025	NCR	Radiation (03CH08-KS)
EMI Receiver	R&S	ESR7	102297	9kHz~7GHz;	Jul. 03, 2024	Mar. 12, 2025	Jul. 02, 2025	Conduction (CO02-SZ)
AC LISN	R&S	ENV216	101499	9kHz~30MHz	Jul. 03, 2024	Mar. 12, 2025	Jul. 02, 2025	Conduction (CO02-SZ)
AC Power Source	CHROMA	61601	616010002470	100Vac~250Vac	Dec. 25, 2024	Mar. 12, 2025	Dec. 24, 2025	Conduction (CO02-SZ)

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	**±2.22dB**
Occupied Channel Bandwidth	**±0.1%**
Conducted Power	**±0.50 dB**
Conducted Power Spectral Density	**±0.90 dB**
Frequency	**±0.04 ppm**

Uncertainty of AC Conducted Emission Measurement (0.15 MHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**2.5dB**

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

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

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**6.04dB**

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

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

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.40dB**

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

Appendix A. Conducted Test Results

Ambient Condition: 25 ℃, 45 %RH	
Test Date: 2025.2.13~2025.3.13	**Test Engineer:** Jiang Jun

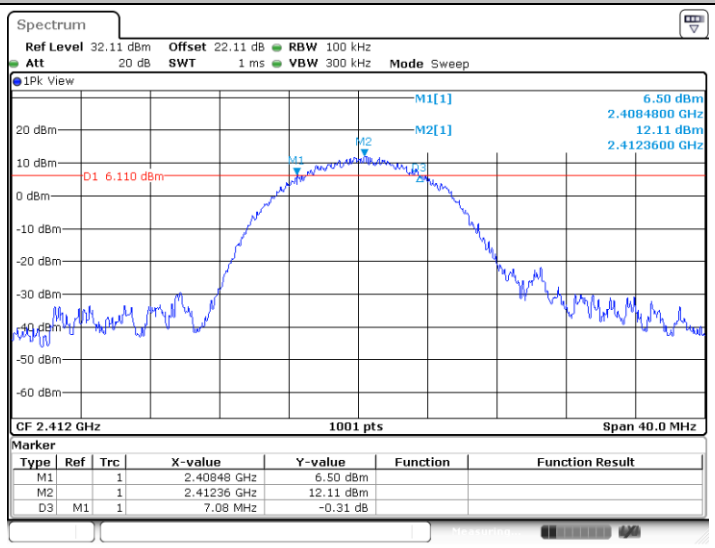
DTS Bandwidth

Test Result

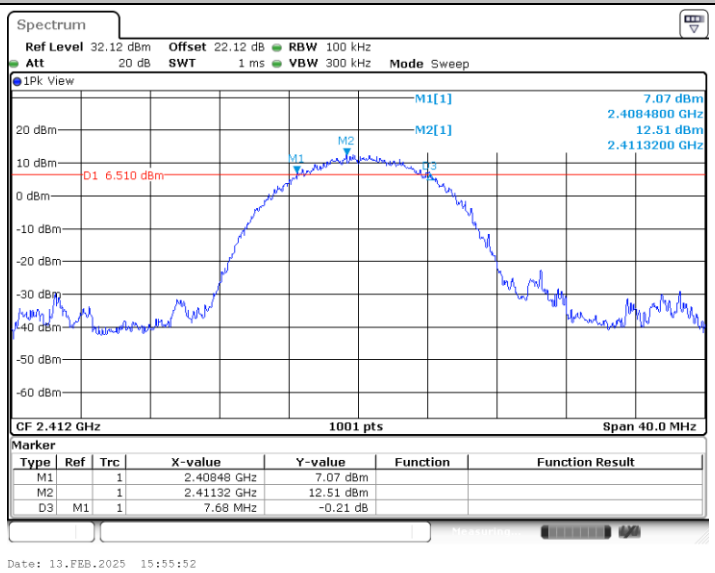
TestMode	Antenna	Freq(MHz)	DTS BW [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
11B-CDD	Ant0	2412	7.08	2408.48	2415.56	0.5	PASS
	Ant1	2412	7.68	2408.48	2416.16	0.5	PASS
	Ant0	2437	7.04	2433.48	2440.52	0.5	PASS
	Ant1	2437	6.96	2433.44	2440.40	0.5	PASS
	Ant0	2462	7.12	2458.40	2465.52	0.5	PASS
	Ant1	2462	7.52	2458.48	2466.00	0.5	PASS
11G-CDD	Ant0	2412	15.68	2404.48	2420.16	0.5	PASS
	Ant1	2412	15.72	2404.44	2420.16	0.5	PASS
	Ant0	2417	14.52	2410.68	2425.20	0.5	PASS
	Ant1	2417	15.76	2409.44	2425.20	0.5	PASS
	Ant0	2437	16.32	2428.84	2445.16	0.5	PASS
	Ant1	2437	16.36	2428.80	2445.16	0.5	PASS
	Ant0	2452	16.32	2443.84	2460.16	0.5	PASS
	Ant1	2452	16.36	2443.80	2460.16	0.5	PASS
	Ant0	2457	16.32	2448.84	2465.16	0.5	PASS
	Ant1	2457	16.32	2448.84	2465.16	0.5	PASS
	Ant0	2462	16.32	2453.84	2470.16	0.5	PASS
	Ant1	2462	15.76	2454.40	2470.16	0.5	PASS
11AC20MIMO	Ant0	2412	16.36	2404.44	2420.80	0.5	PASS
	Ant1	2412	13.88	2406.92	2420.80	0.5	PASS
	Ant0	2417	16.36	2409.44	2425.80	0.5	PASS
	Ant1	2417	16.36	2409.44	2425.80	0.5	PASS
	Ant0	2437	17.60	2428.20	2445.80	0.5	PASS
	Ant1	2437	17.60	2428.20	2445.80	0.5	PASS
	Ant0	2452	17.60	2443.20	2460.80	0.5	PASS
	Ant1	2452	17.60	2443.20	2460.80	0.5	PASS
	Ant0	2457	17.56	2448.24	2465.80	0.5	PASS
	Ant1	2457	17.56	2448.24	2465.80	0.5	PASS
	Ant0	2462	17.52	2453.24	2470.76	0.5	PASS
	Ant1	2462	16.92	2453.84	2470.76	0.5	PASS
11AX20MIMO	Ant0	2412	17.00	2404.44	2421.44	0.5	PASS
	Ant1	2412	16.80	2404.44	2421.24	0.5	PASS
	Ant0	2417	16.48	2409.88	2426.36	0.5	PASS
	Ant1	2417	15.60	2410.68	2426.28	0.5	PASS
	Ant0	2437	18.52	2427.72	2446.24	0.5	PASS
	Ant1	2437	17.96	2427.64	2445.60	0.5	PASS
	Ant0	2452	18.68	2442.72	2461.40	0.5	PASS
	Ant1	2452	18.52	2442.80	2461.32	0.5	PASS
	Ant0	2457	18.84	2447.64	2466.48	0.5	PASS
	Ant1	2457	18.64	2447.80	2466.44	0.5	PASS
	Ant0	2462	17.04	2454.08	2471.12	0.5	PASS
	Ant1	2462	17.00	2453.96	2470.96	0.5	PASS

Test Graphs

11B-CDD_Ant0_2412



11B-CDD_Ant1_2412



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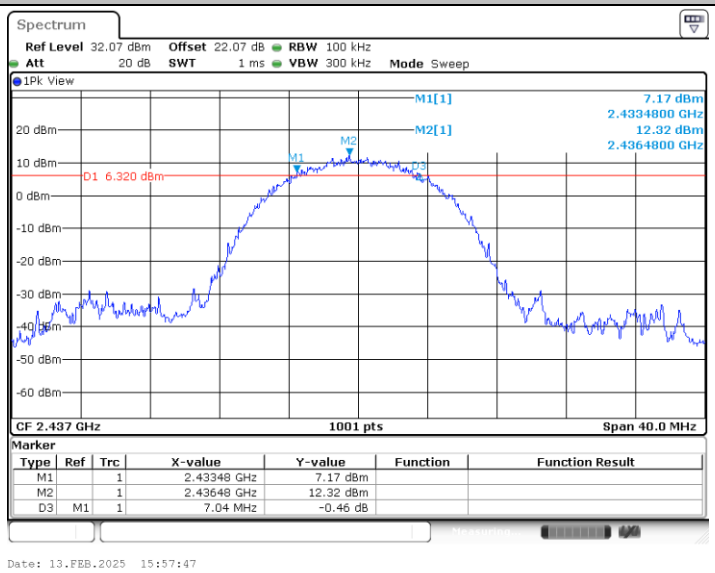
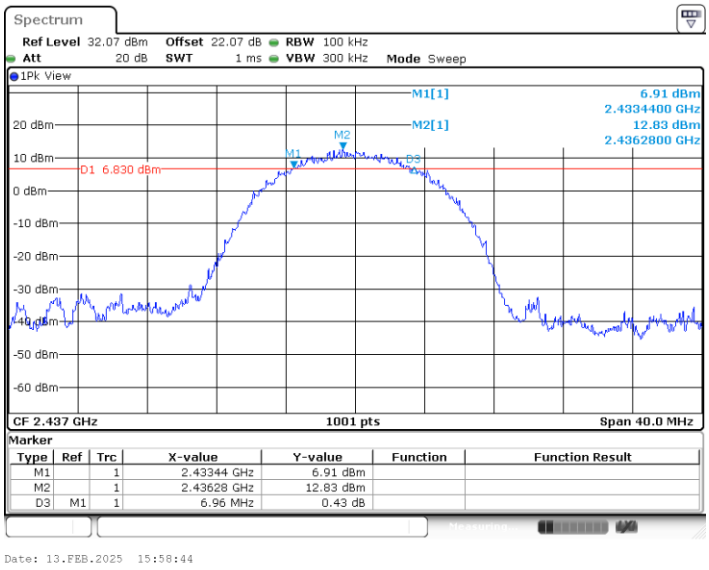
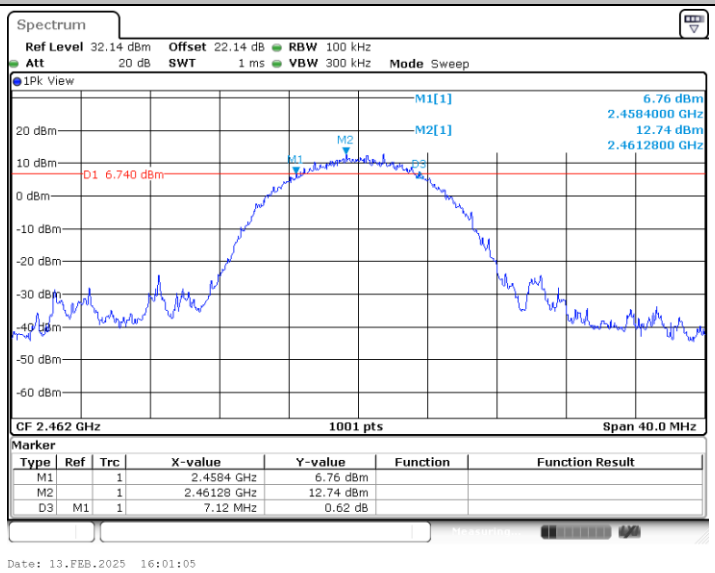


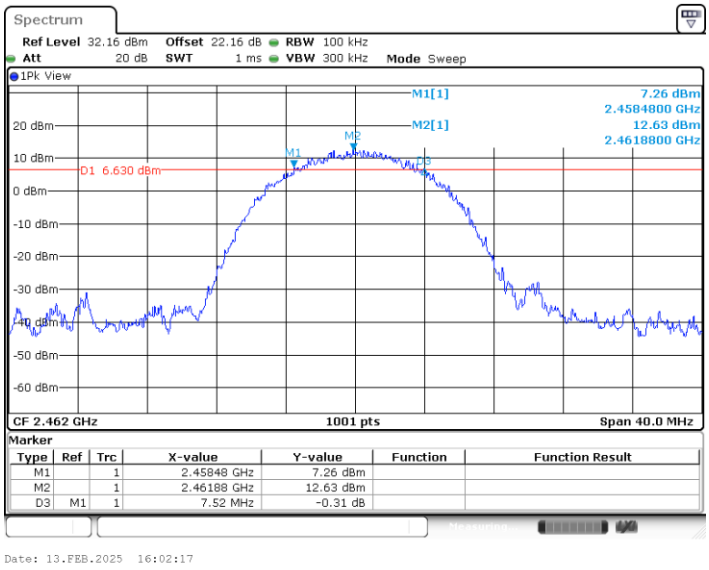
11B-CDD_Ant1_2437



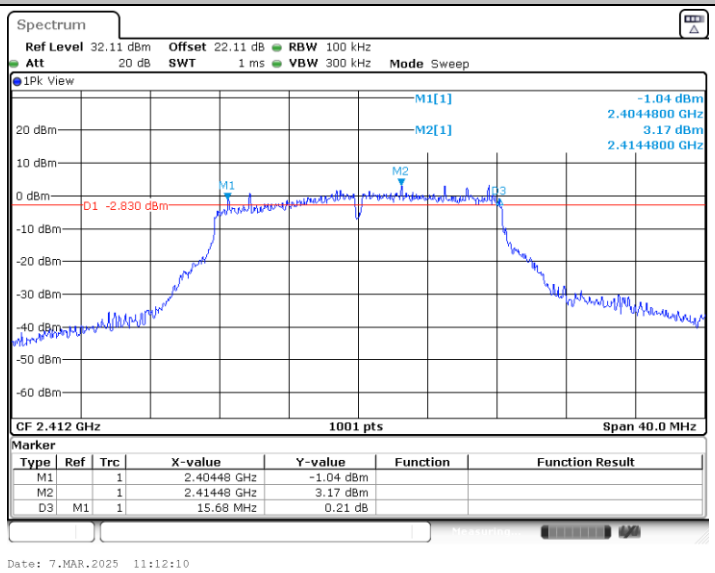
11B-CDD_Ant0_2462



11B-CDD_Ant1_2462



11G-CDD_Ant0_2412



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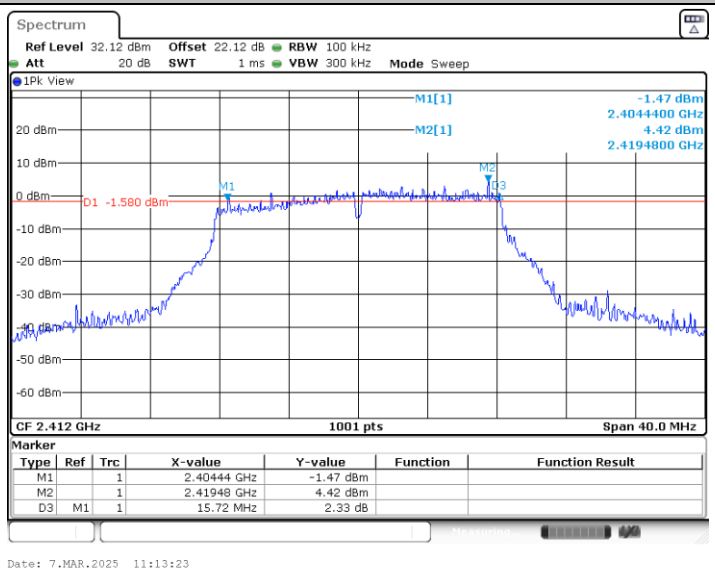

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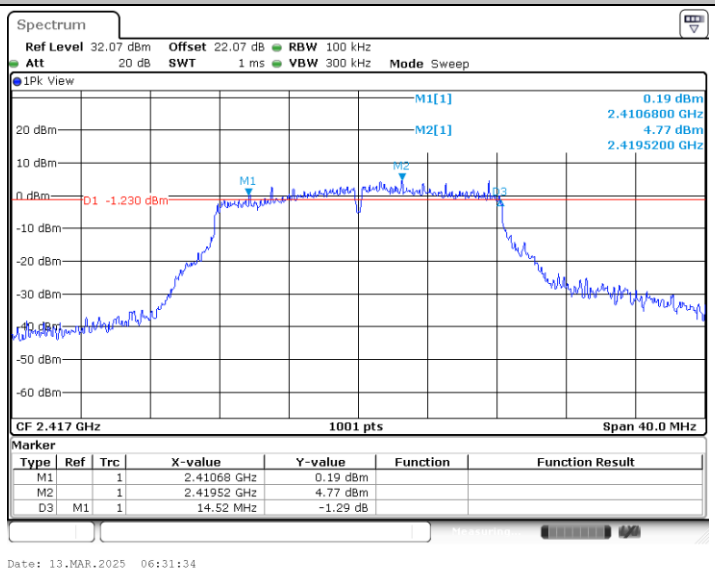

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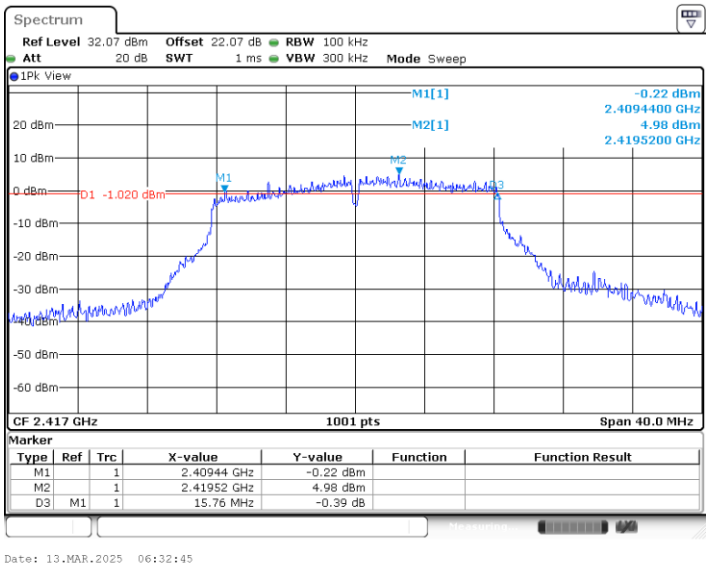

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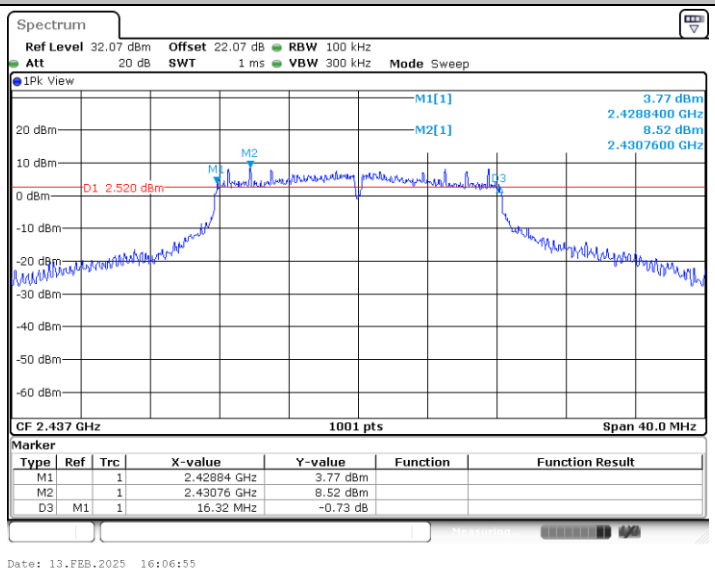

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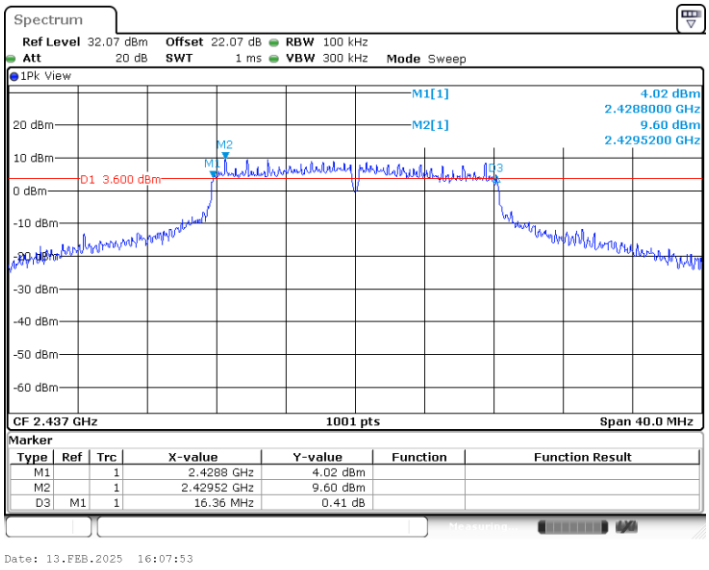

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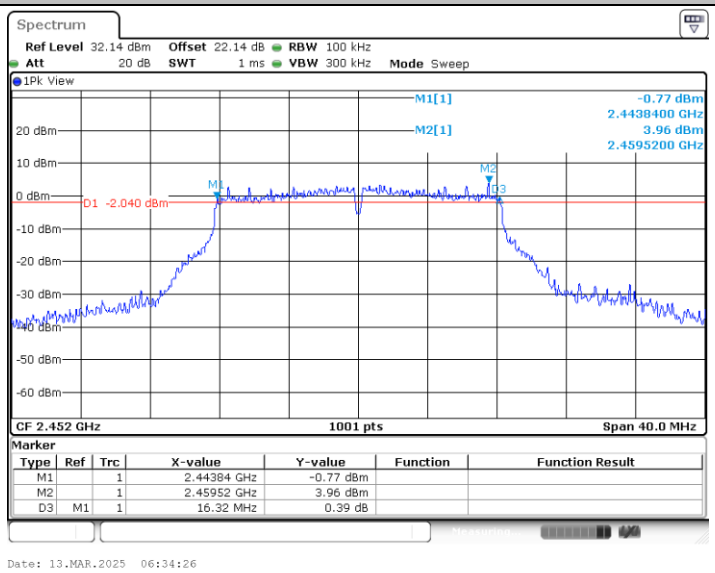

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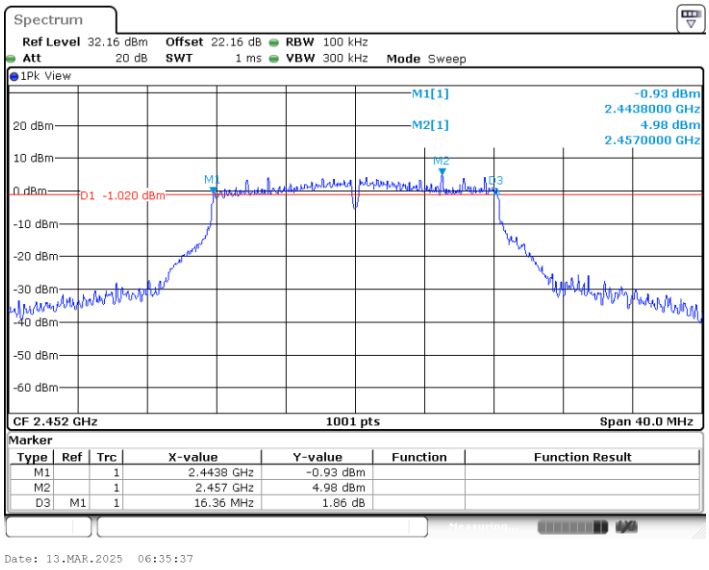

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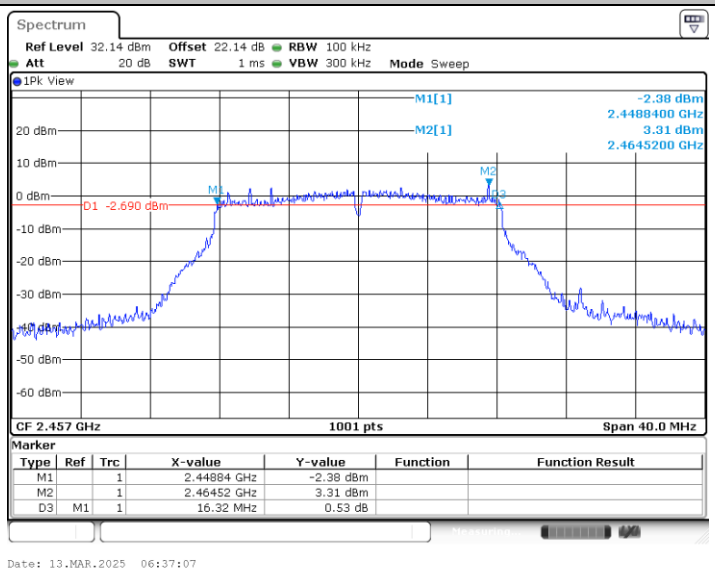

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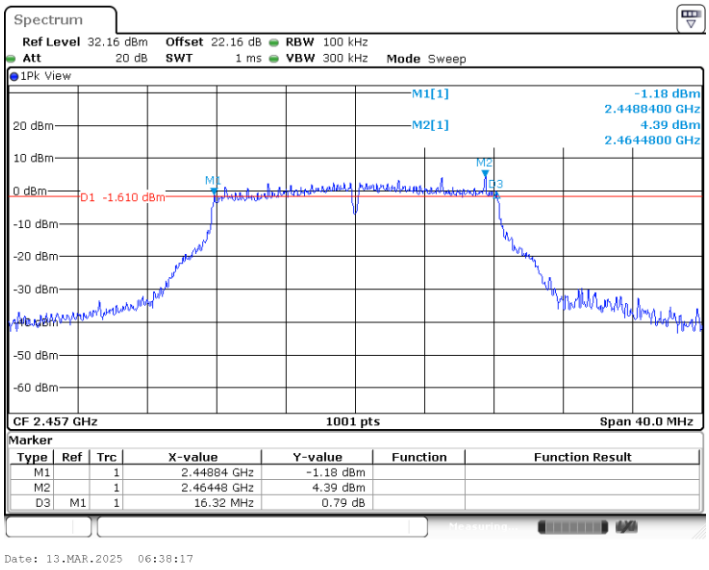

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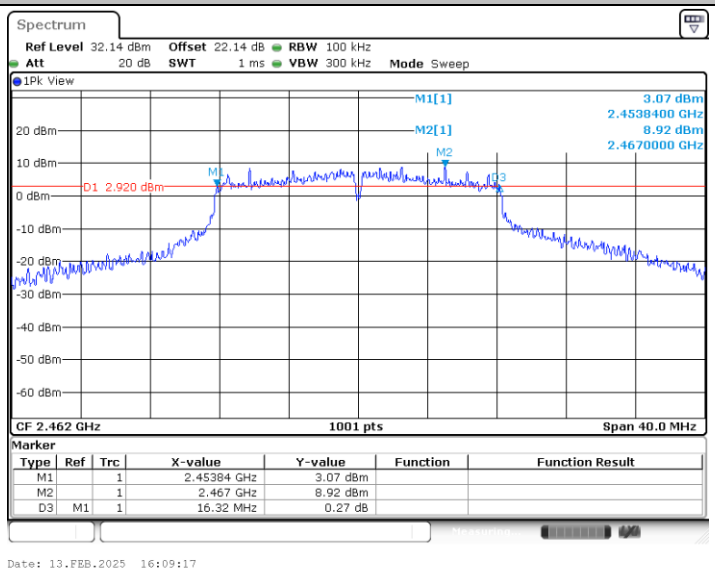

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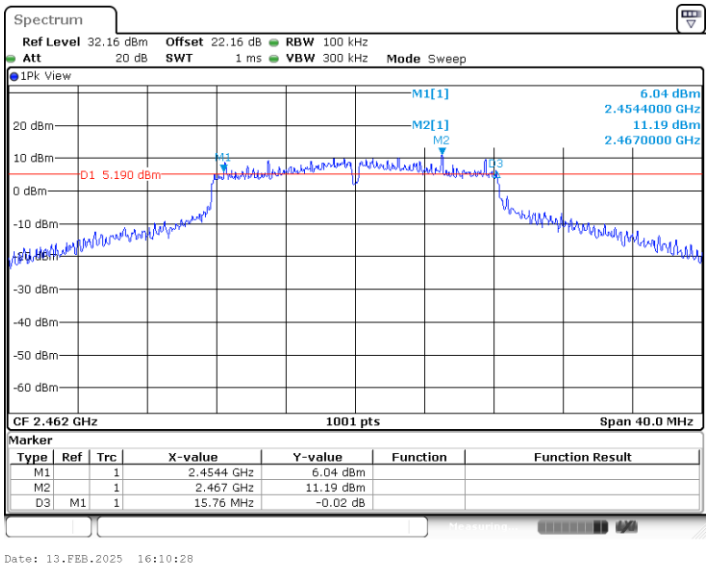
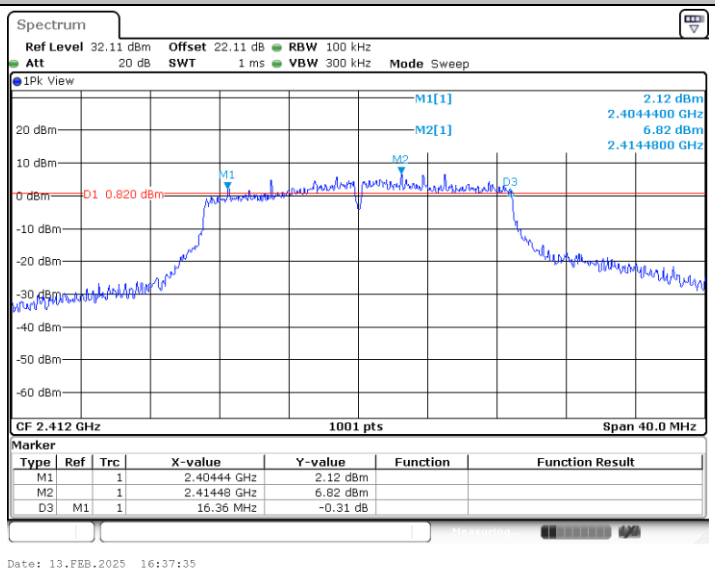


11AC20MIMO_Ant0_2412



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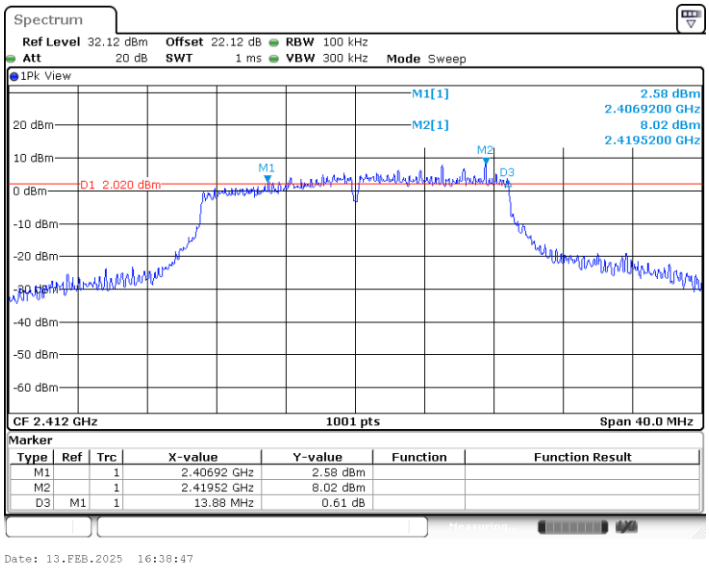

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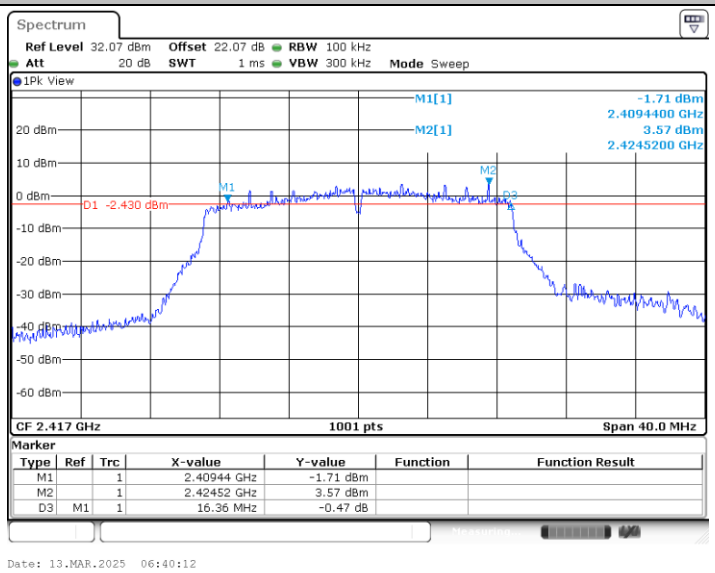

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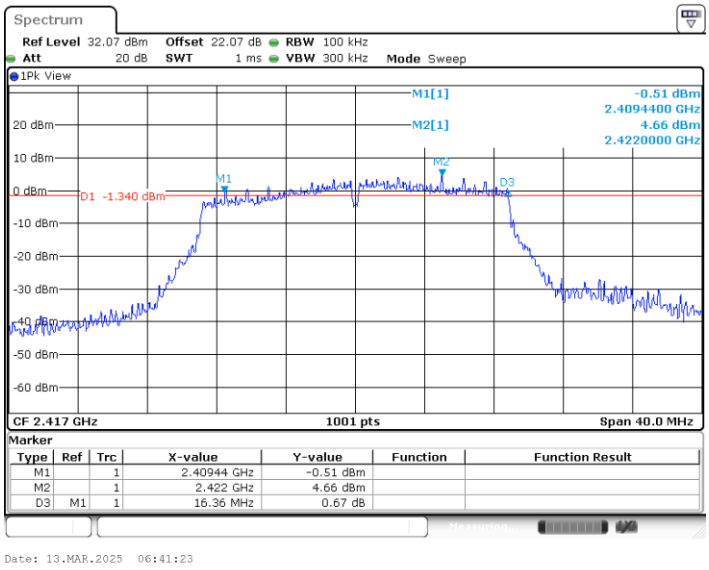

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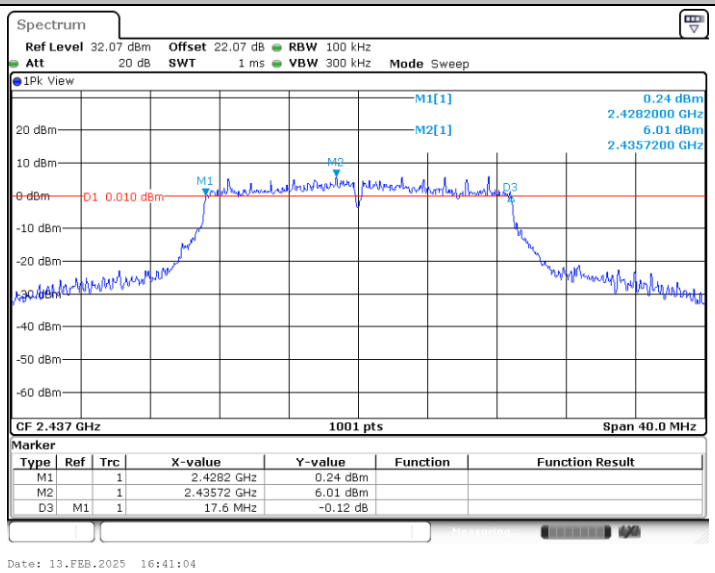

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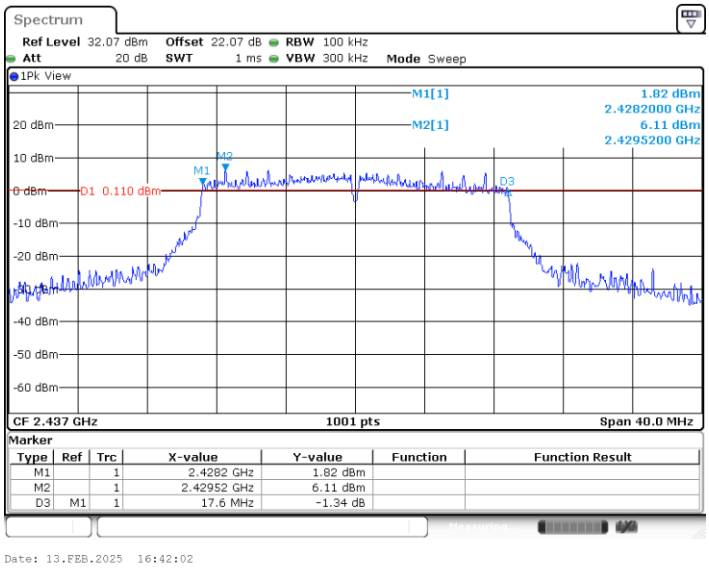

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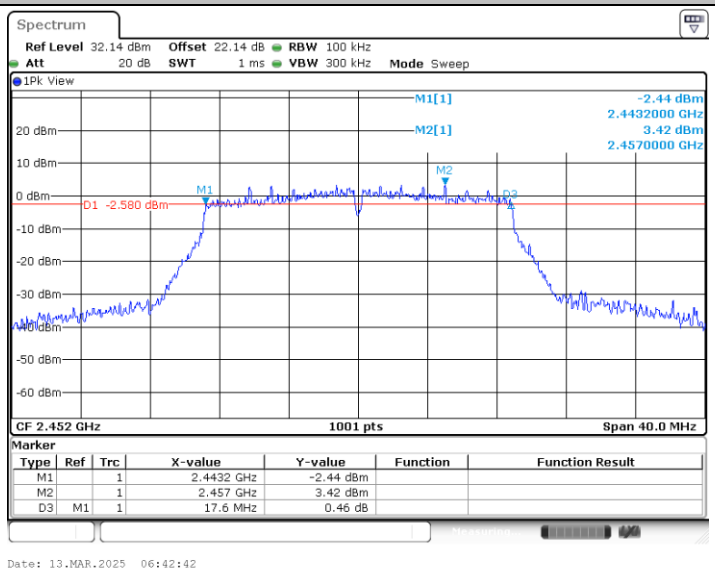

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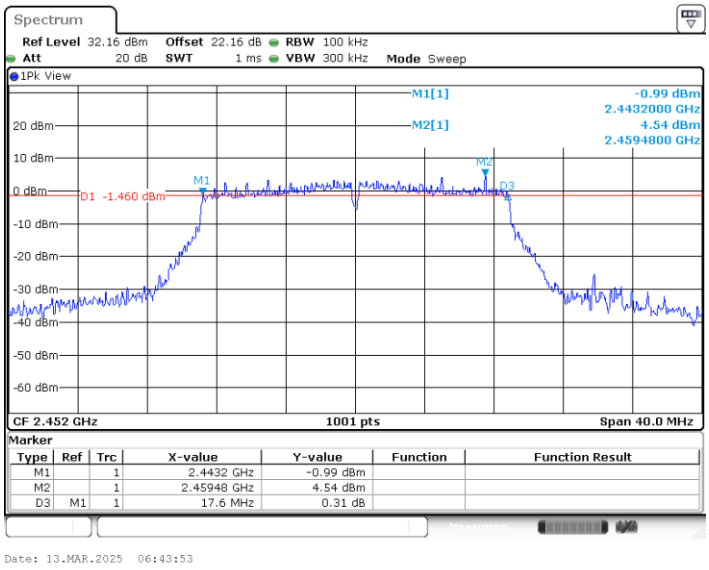

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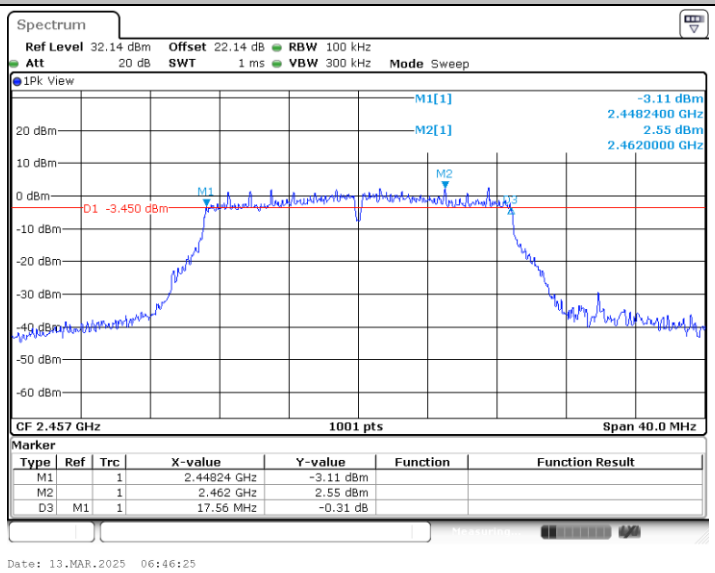

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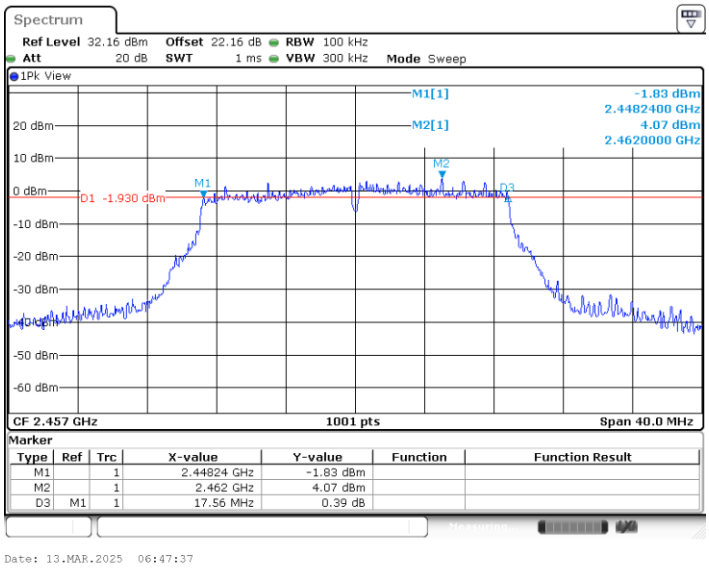

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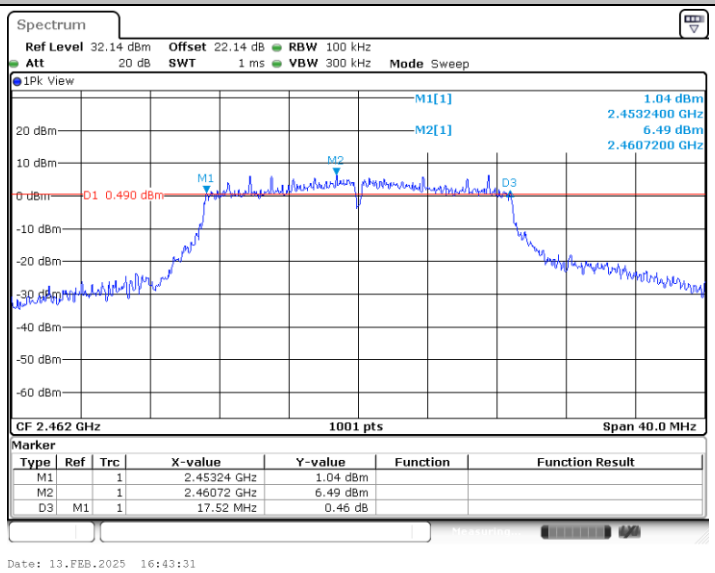

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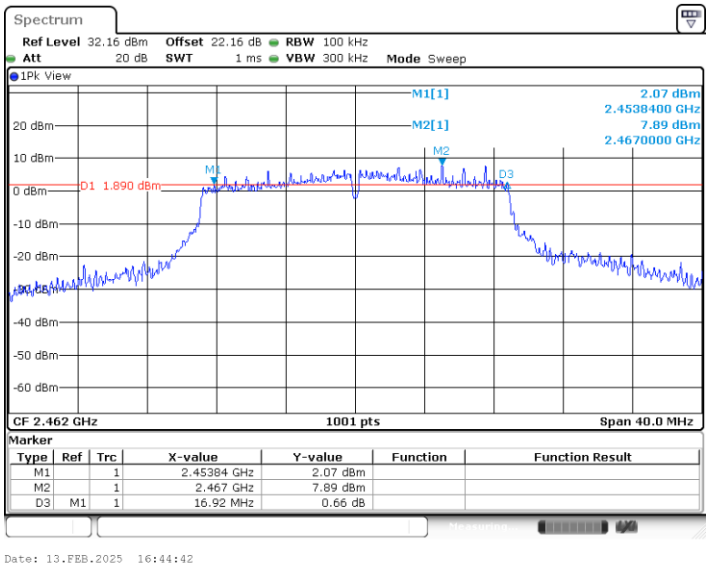

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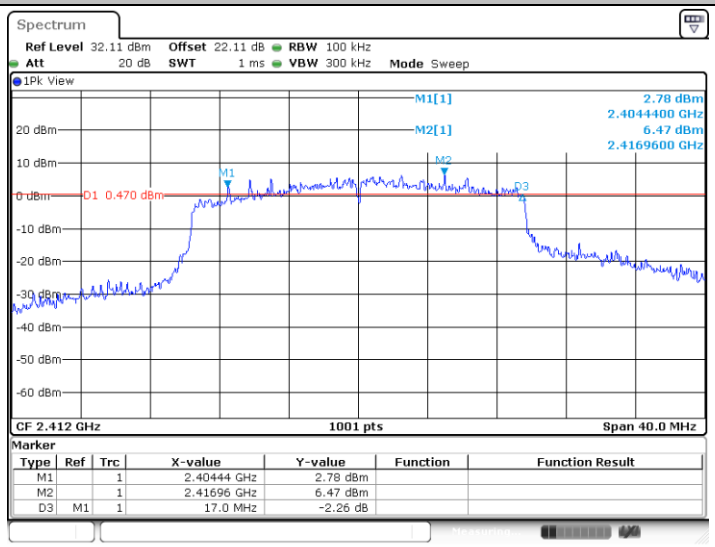

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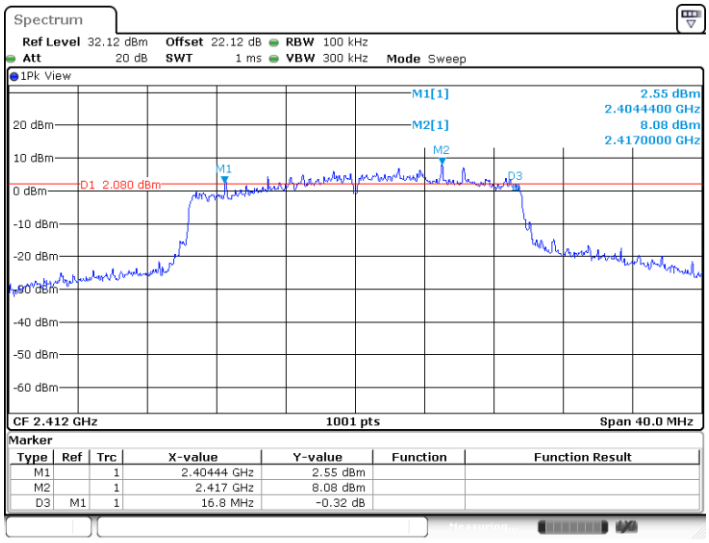

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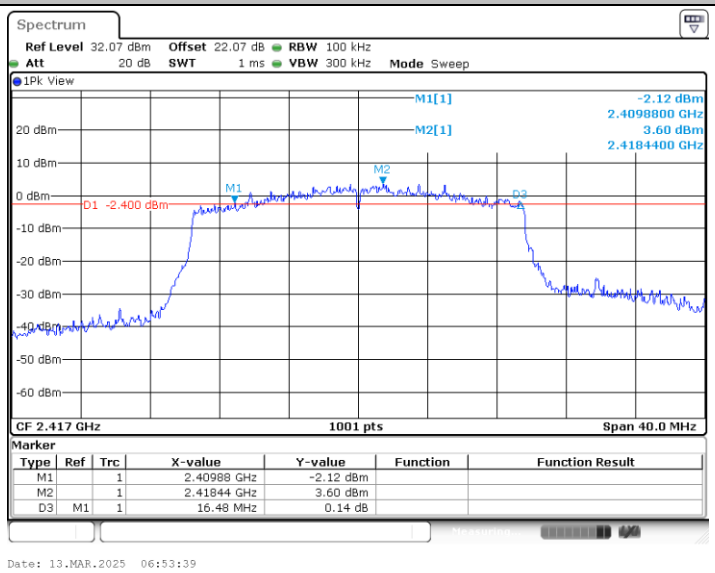

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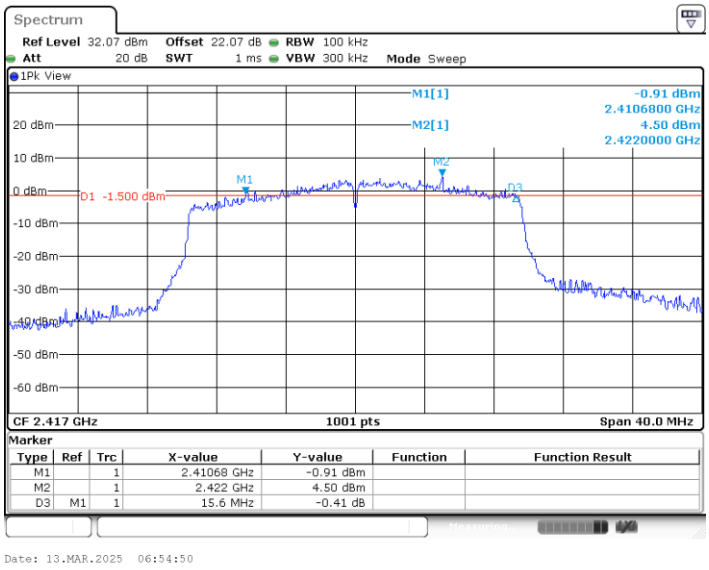

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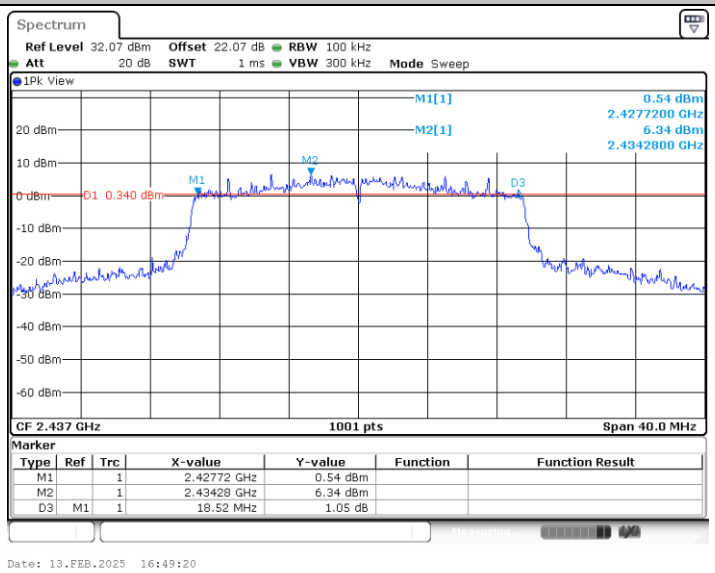

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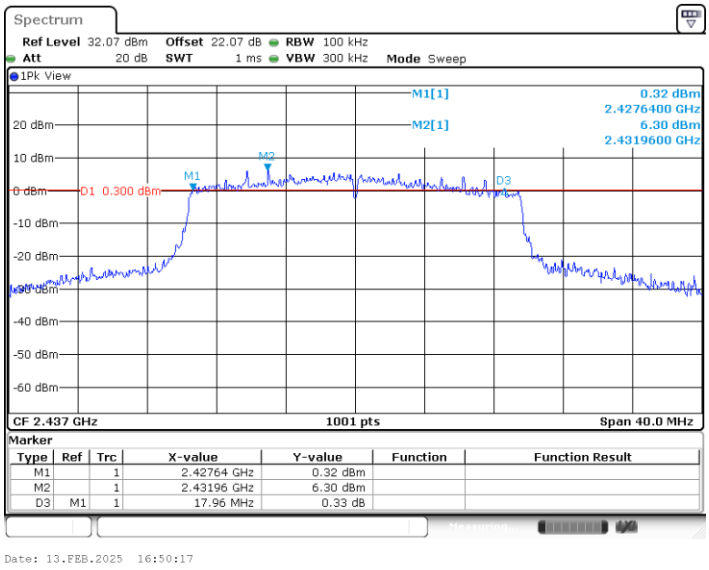

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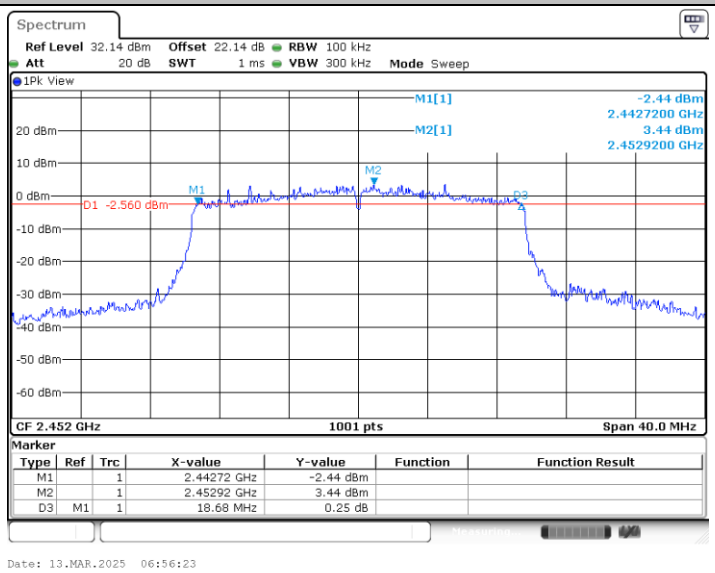

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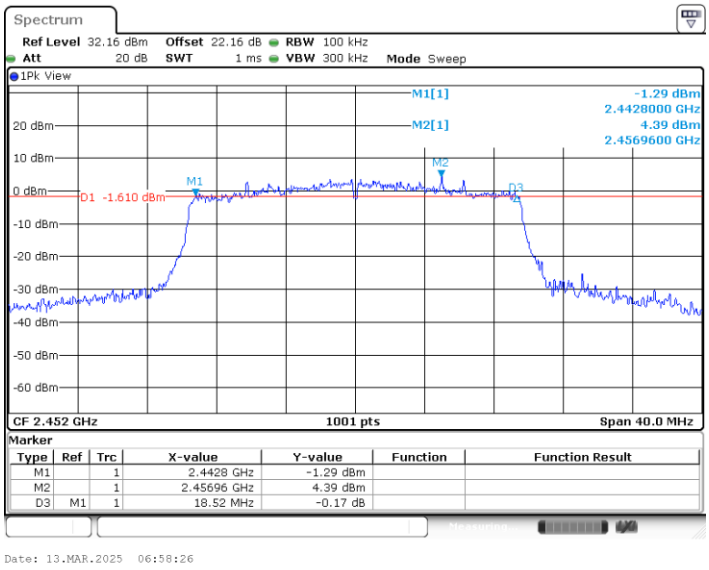

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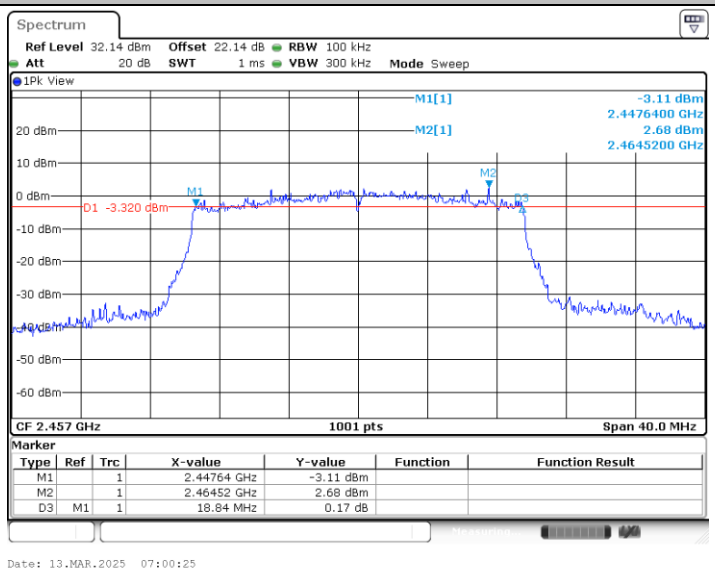

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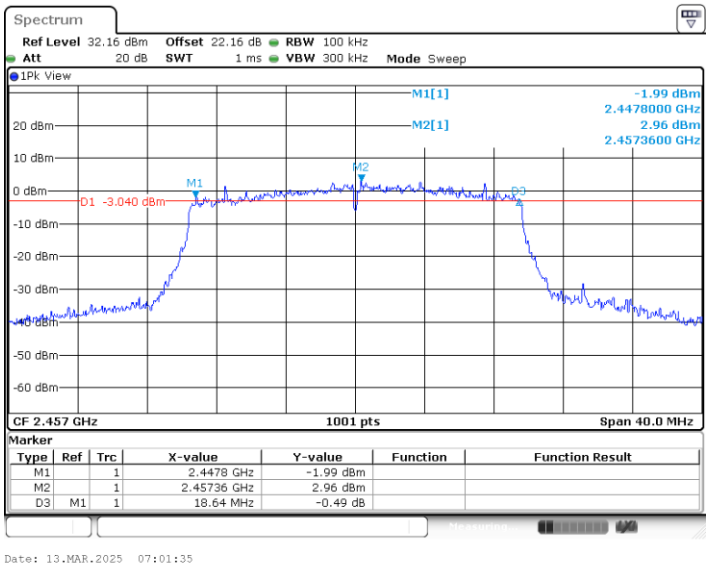

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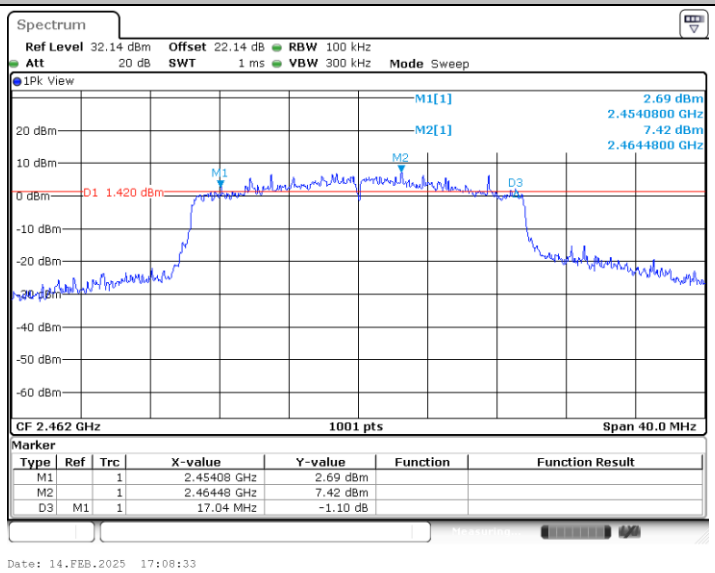

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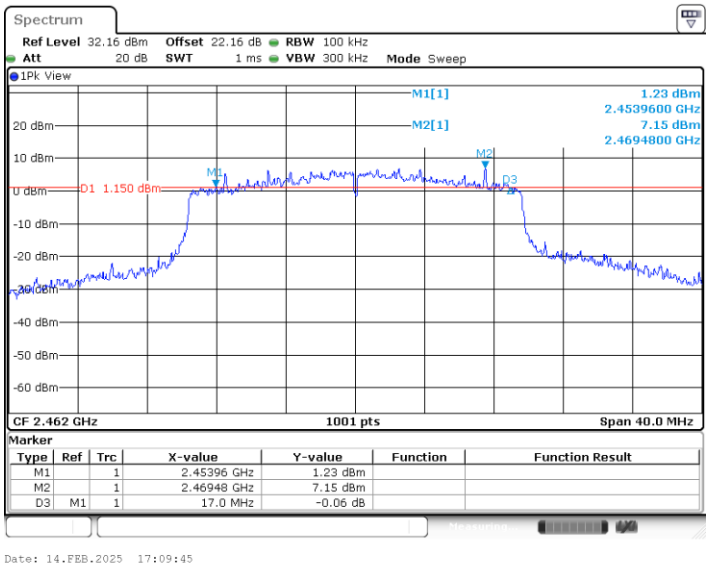


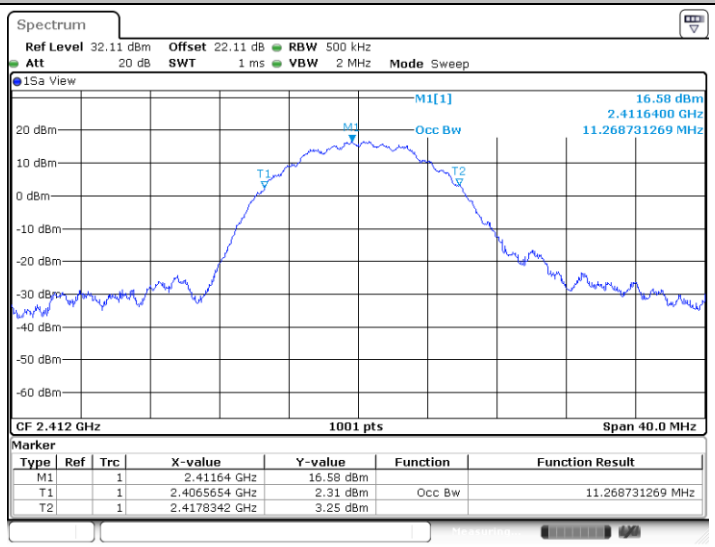
Occupied Channel Bandwidth

Test Result

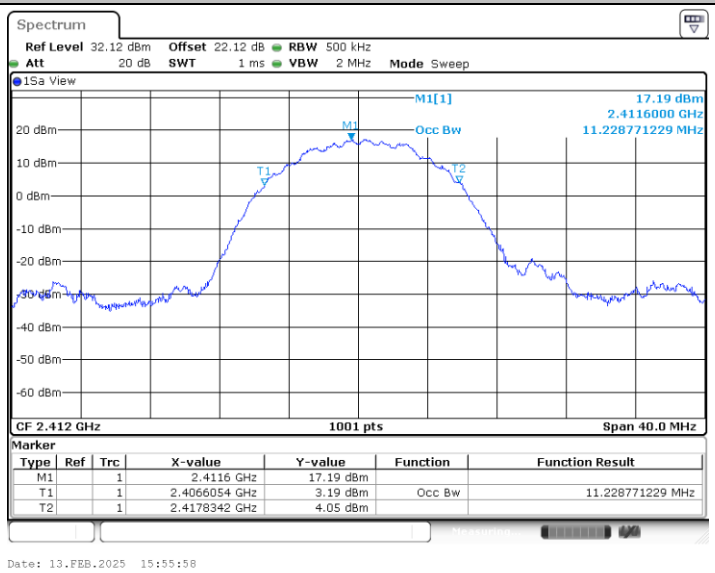
TestMode	Antenna	Freq(MHz)	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
11B-CDD	Ant0	2412	11.269	2406.5654	2417.8342	---	---
	Ant1	2412	11.229	2406.6054	2417.8342	---	---
	Ant0	2437	11.429	2431.2458	2442.6743	---	---
	Ant1	2437	11.389	2431.2058	2442.5944	---	---
	Ant0	2462	11.269	2456.4056	2467.6743	---	---
	Ant1	2462	11.229	2456.4855	2467.7143	---	---
11G-CDD	Ant0	2412	17.582	2403.4885	2421.0709	---	---
	Ant1	2412	17.343	2403.6484	2420.9910	---	---
	Ant0	2417	17.463	2408.5285	2425.9910	---	---
	Ant1	2417	17.103	2408.6883	2425.7912	---	---
	Ant0	2437	19.82	2427.5694	2447.3896	---	---
	Ant1	2437	20.579	2426.8102	2447.3896	---	---
	Ant0	2452	17.742	2443.2488	2460.9910	---	---
	Ant1	2452	17.423	2443.4086	2460.8312	---	---
	Ant0	2457	17.622	2448.2488	2465.8711	---	---
	Ant1	2457	17.263	2448.4885	2465.7512	---	---
	Ant0	2462	21.179	2452.5295	2473.7083	---	---
	Ant1	2462	22.298	2451.8102	2474.1079	---	---
11AC20MIMO	Ant0	2412	19.181	2402.8891	2422.0699	---	---
	Ant1	2412	18.541	2403.0889	2421.6304	---	---
	Ant0	2417	18.302	2408.0090	2426.3107	---	---
	Ant1	2417	17.942	2408.1688	2426.1109	---	---
	Ant0	2437	18.821	2427.6094	2446.4306	---	---
	Ant1	2437	18.302	2427.7293	2446.0310	---	---
	Ant0	2452	18.581	2442.8092	2461.3906	---	---
	Ant1	2452	18.222	2442.9690	2461.1908	---	---
	Ant0	2457	18.541	2447.7692	2466.3107	---	---
	Ant1	2457	18.182	2448.0090	2466.1908	---	---
	Ant0	2462	18.861	2452.7293	2471.5904	---	---
	Ant1	2462	18.462	2452.9690	2471.4306	---	---
11AX20MIMO	Ant0	2412	19.421	2402.5694	2421.9900	---	---
	Ant1	2412	19.381	2402.5295	2421.9101	---	---
	Ant0	2417	18.981	2407.6094	2426.5904	---	---
	Ant1	2417	18.941	2407.6494	2426.5904	---	---
	Ant0	2437	19.261	2427.3696	2446.6304	---	---
	Ant1	2437	19.181	2427.3696	2446.5504	---	---
	Ant0	2452	19.061	2442.5295	2461.5904	---	---
	Ant1	2452	19.181	2442.4496	2461.6304	---	---
	Ant0	2457	19.061	2447.4895	2466.5504	---	---
	Ant1	2457	19.101	2447.4895	2466.5904	---	---
	Ant0	2462	19.221	2452.4496	2471.6703	---	---
	Ant1	2462	19.141	2452.4895	2471.6304	---	---

Test Graphs

11B-CDD_Ant0_2412



11B-CDD_Ant1_2412



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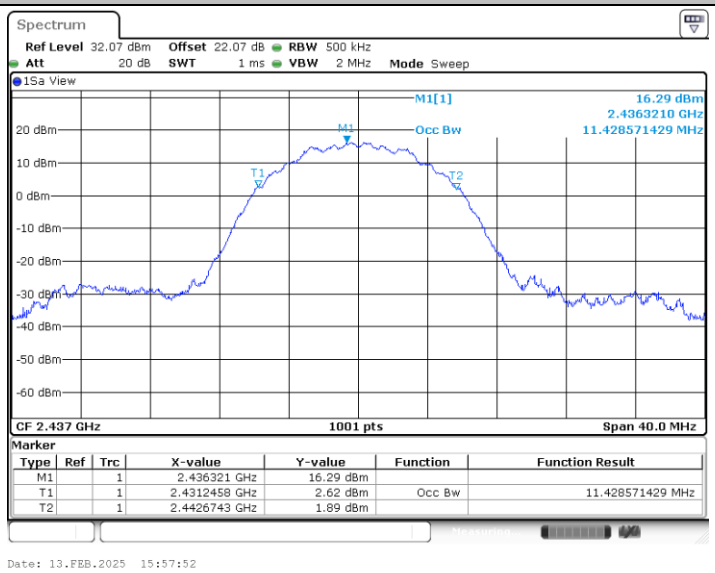

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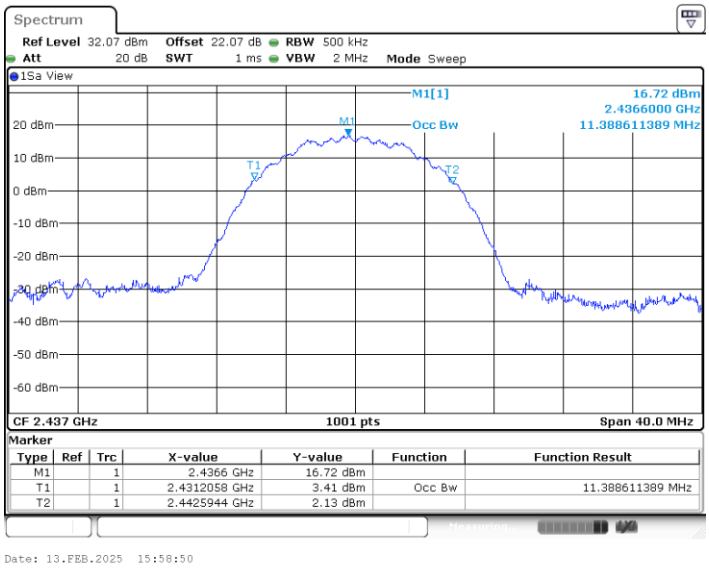

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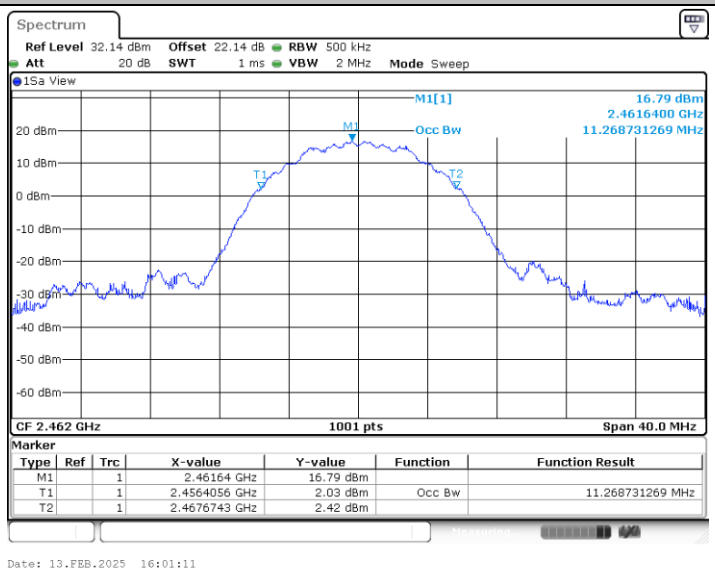

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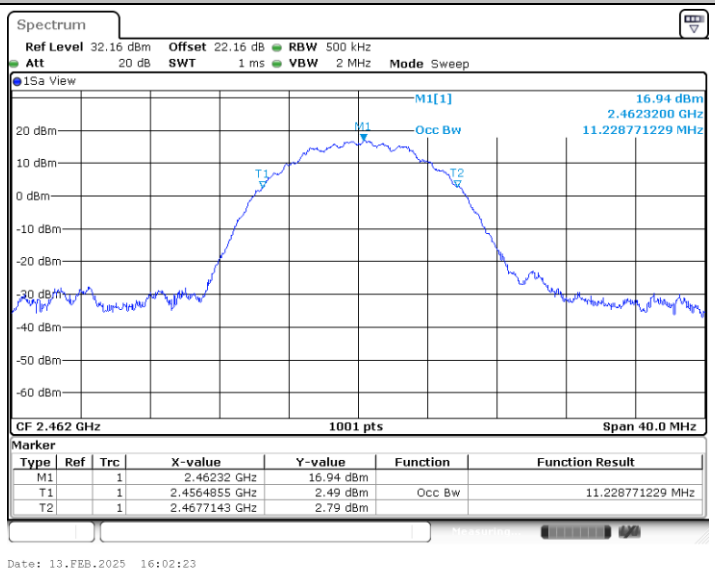

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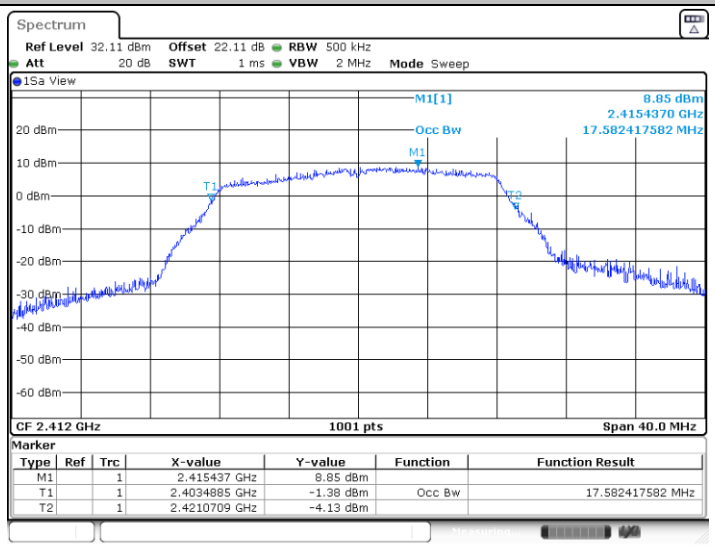
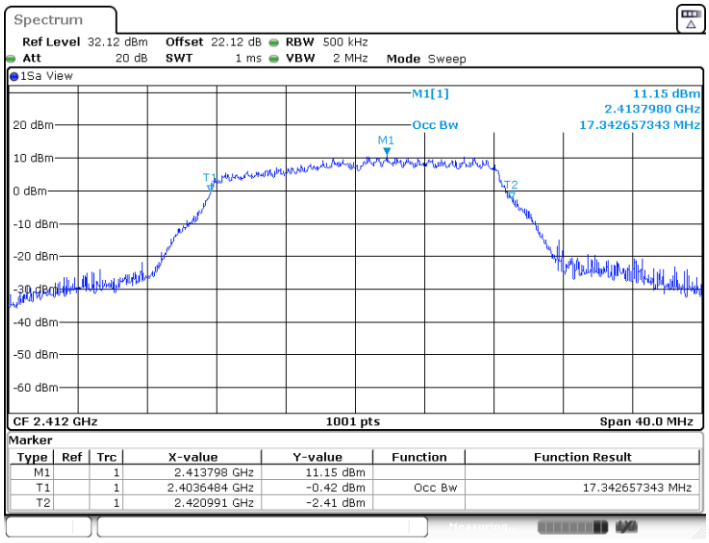


11G-CDD_Ant1_2412



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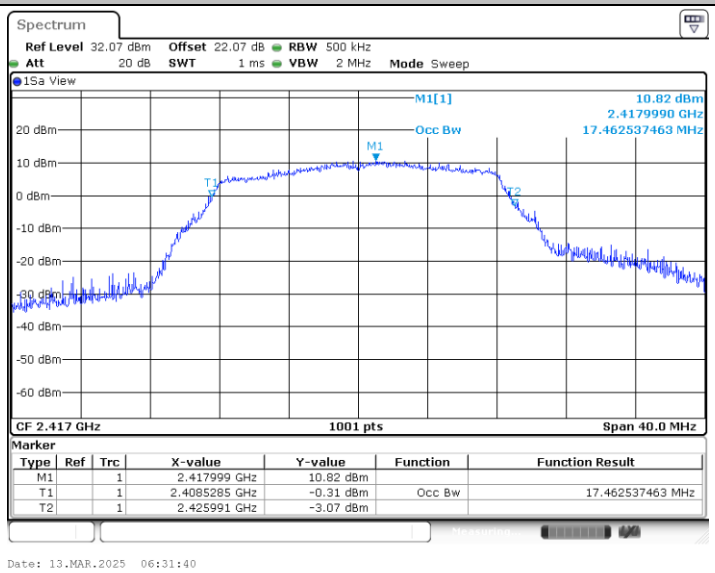

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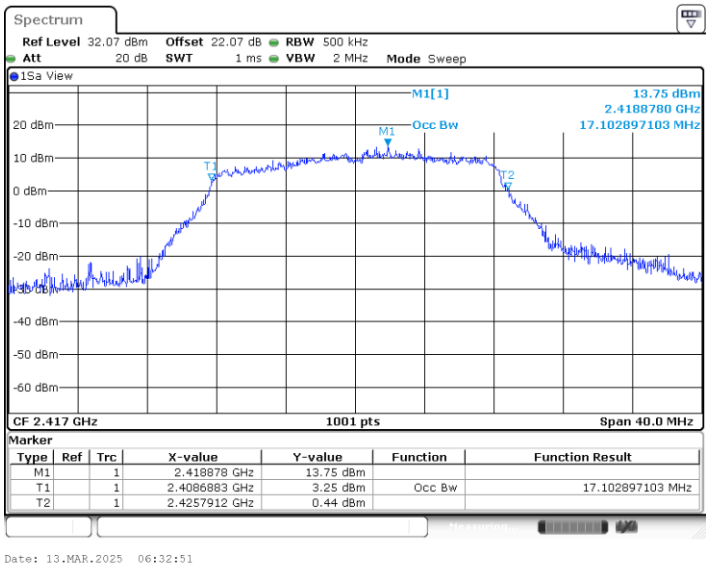

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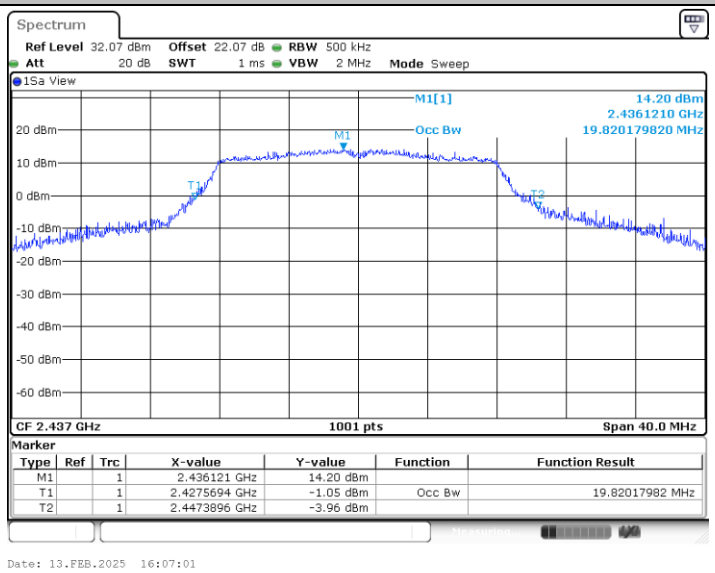

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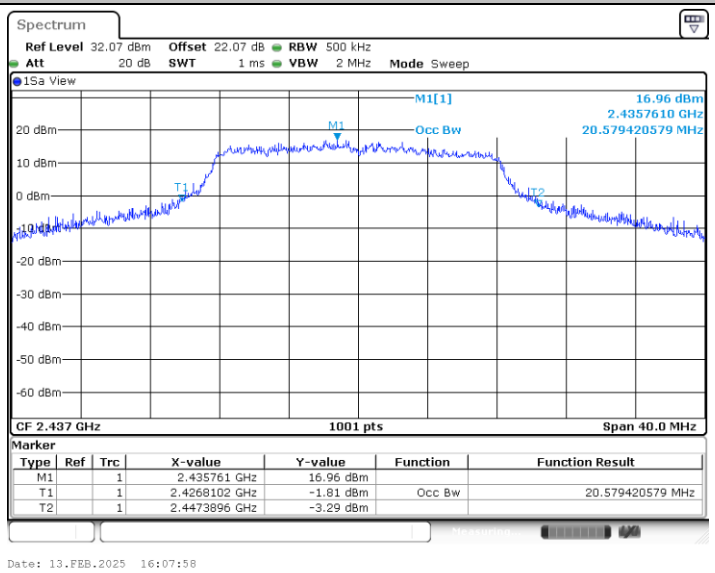

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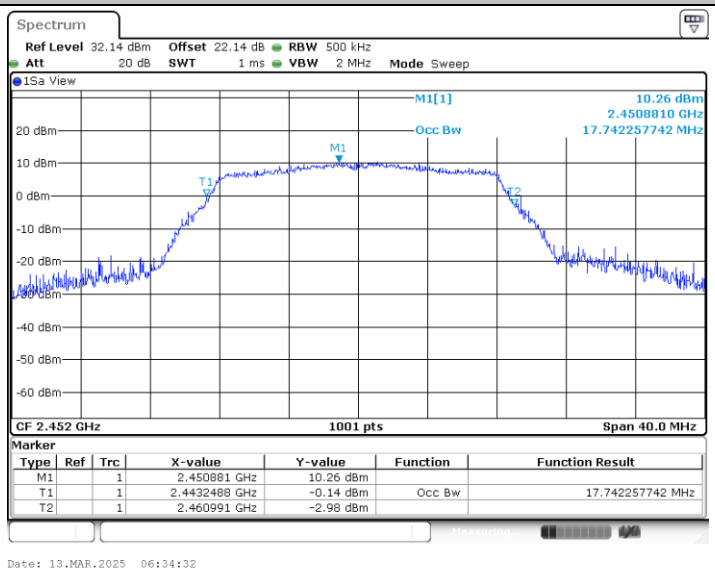

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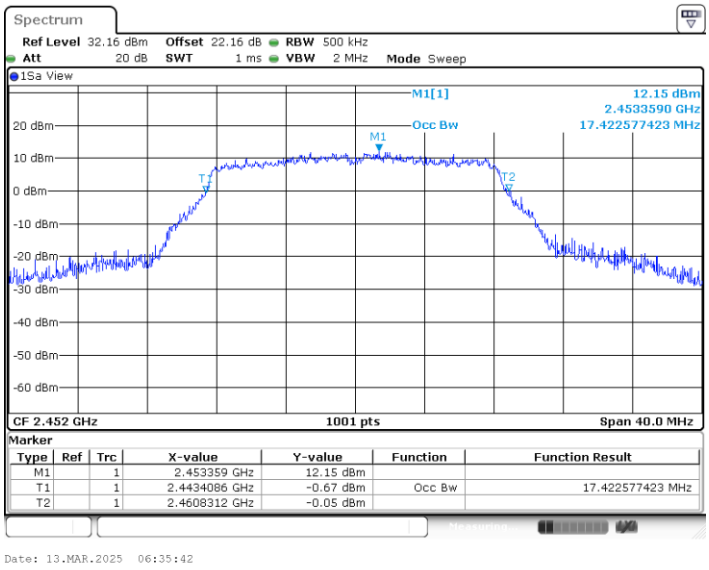

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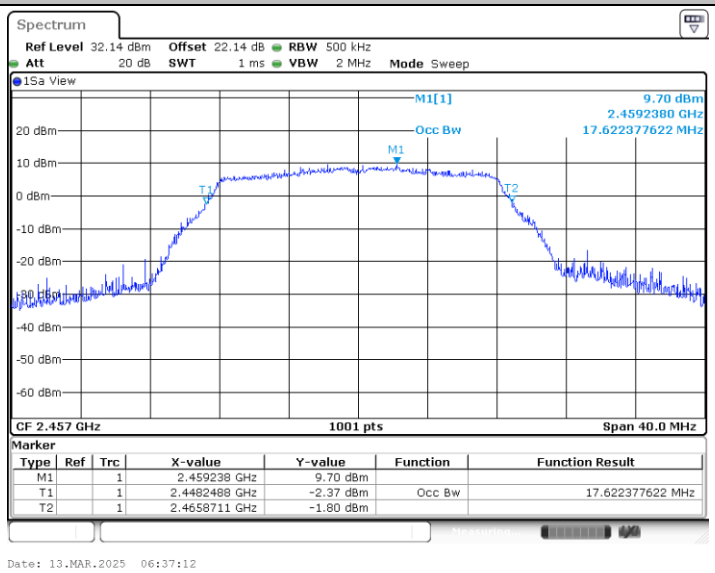

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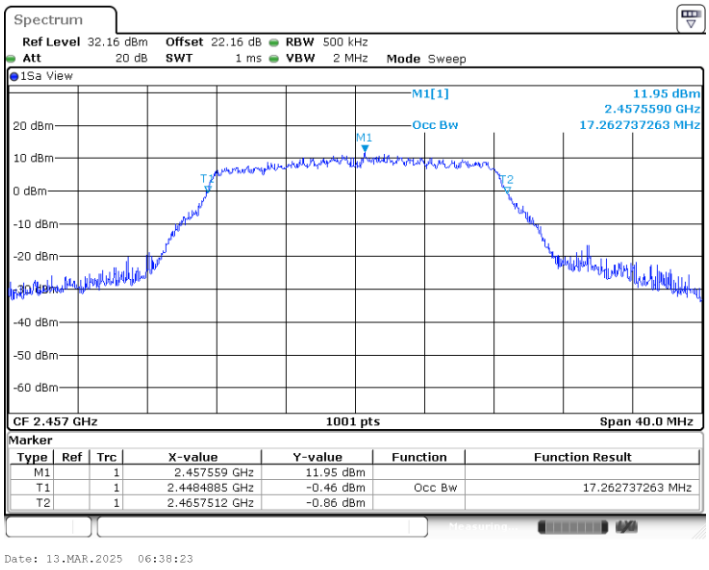

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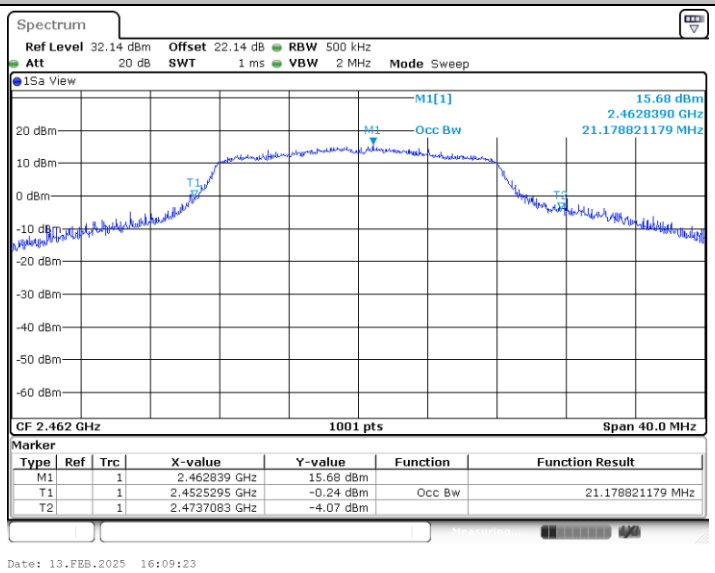

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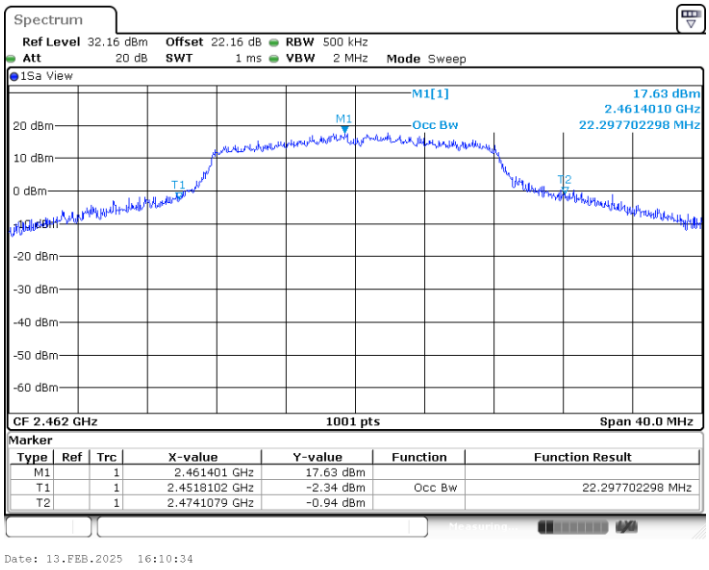

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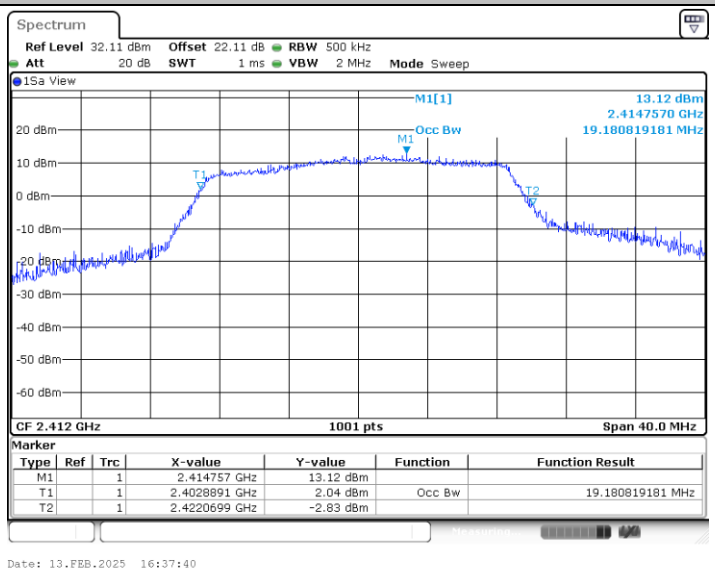

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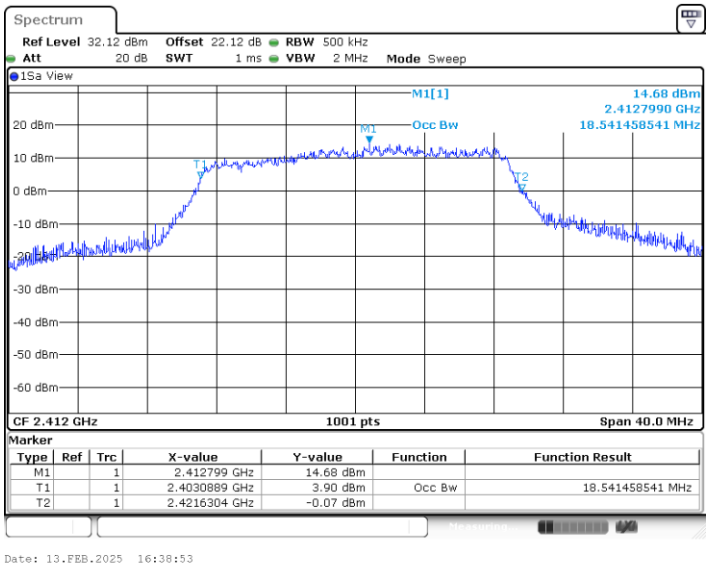

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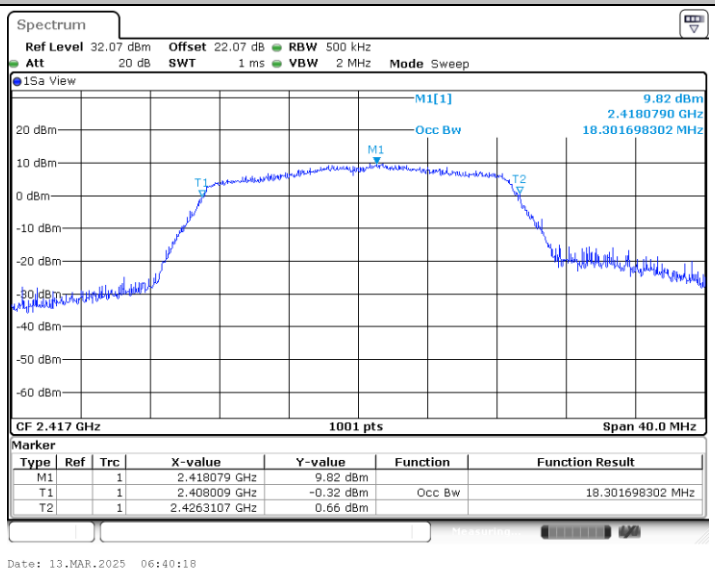

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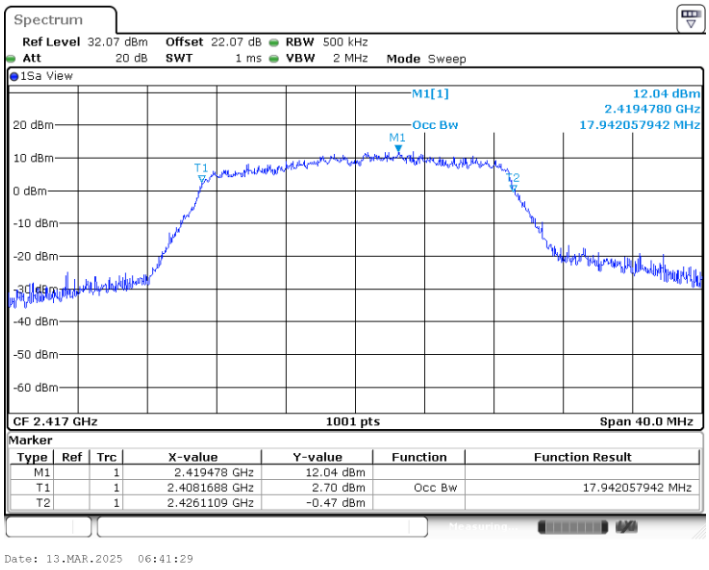

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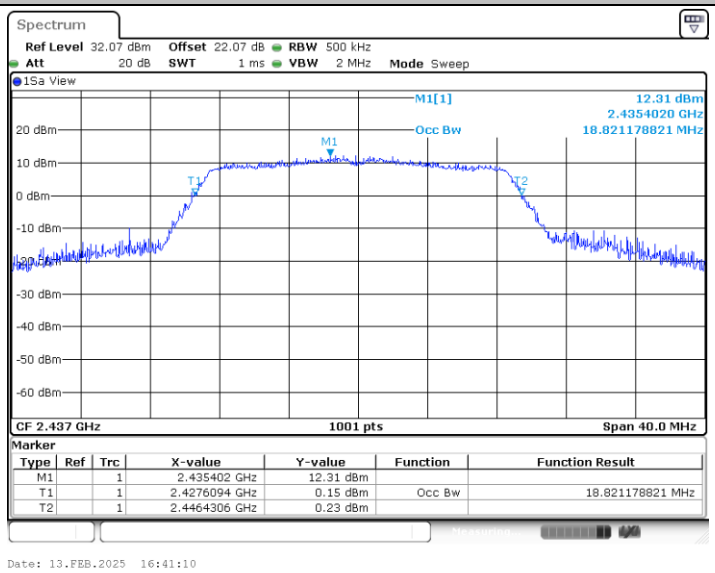

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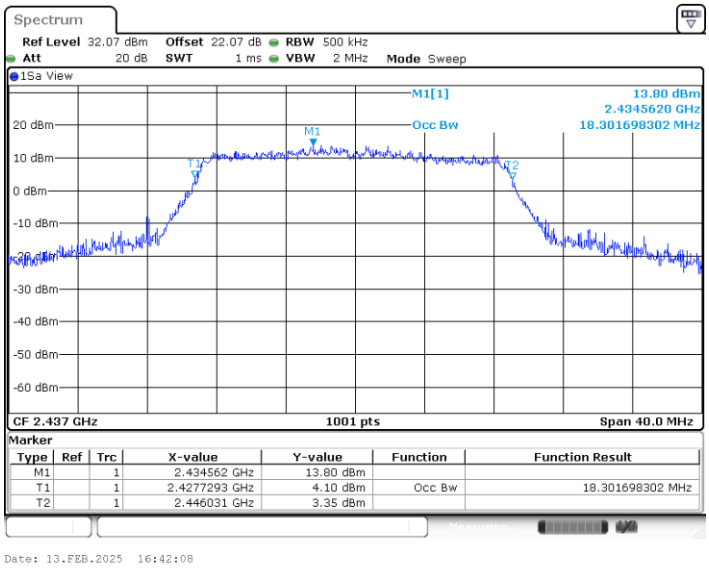

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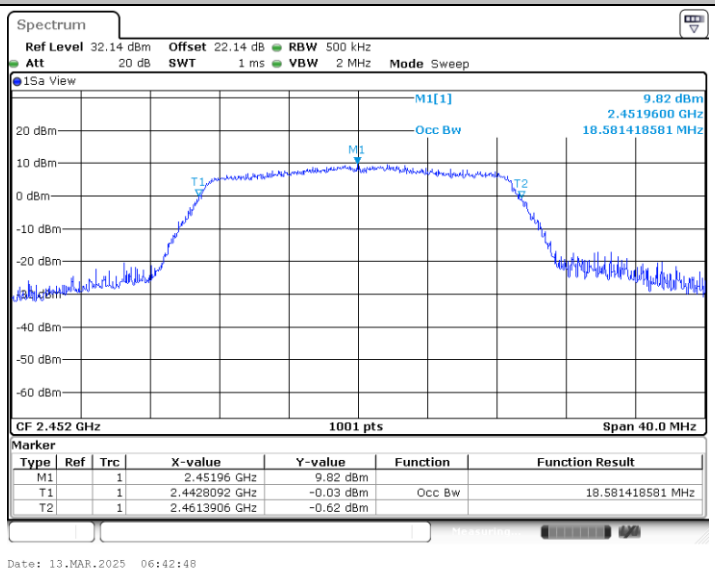

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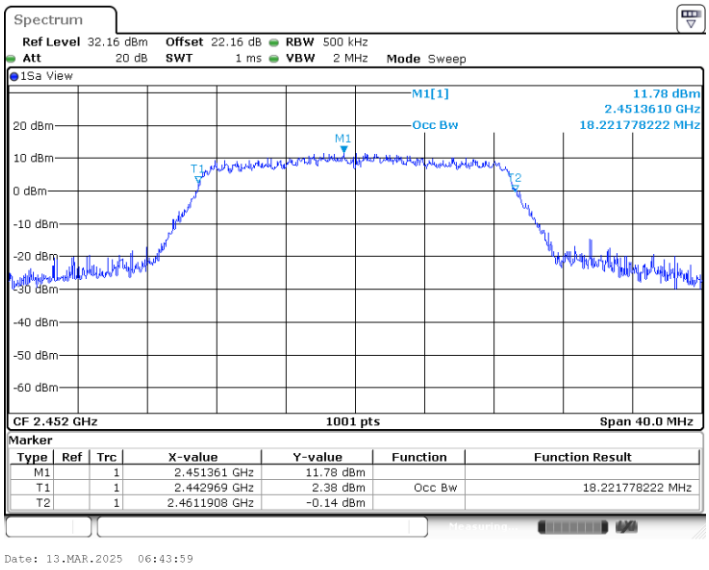

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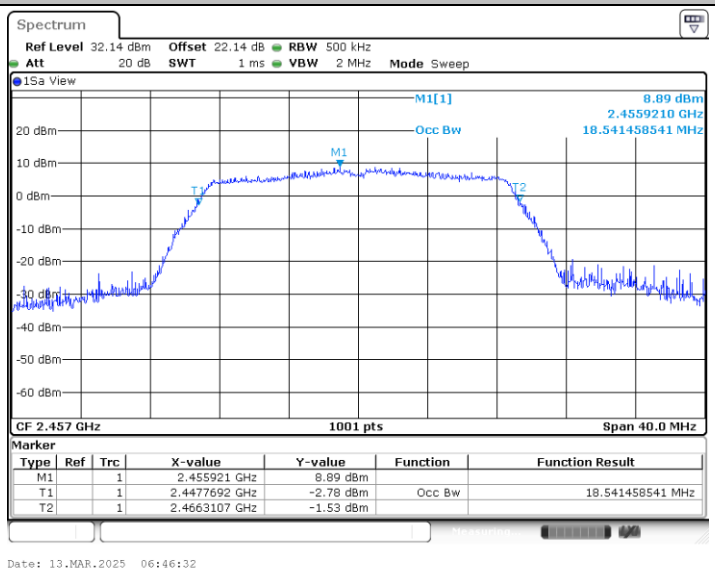

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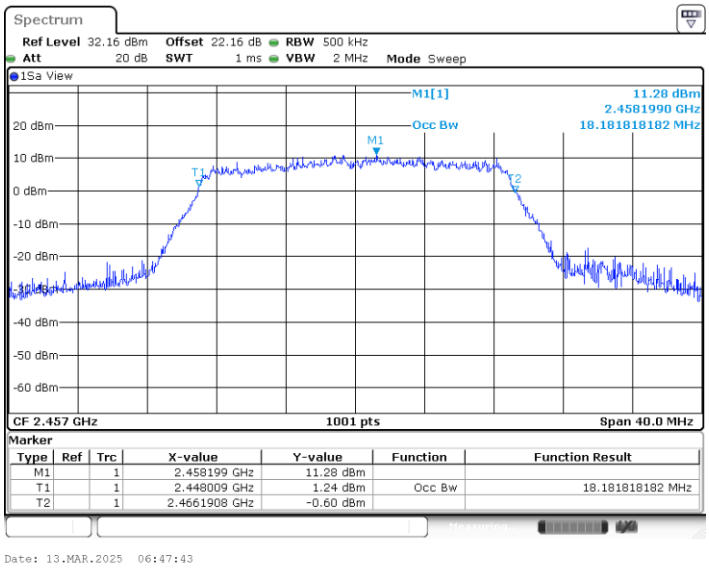

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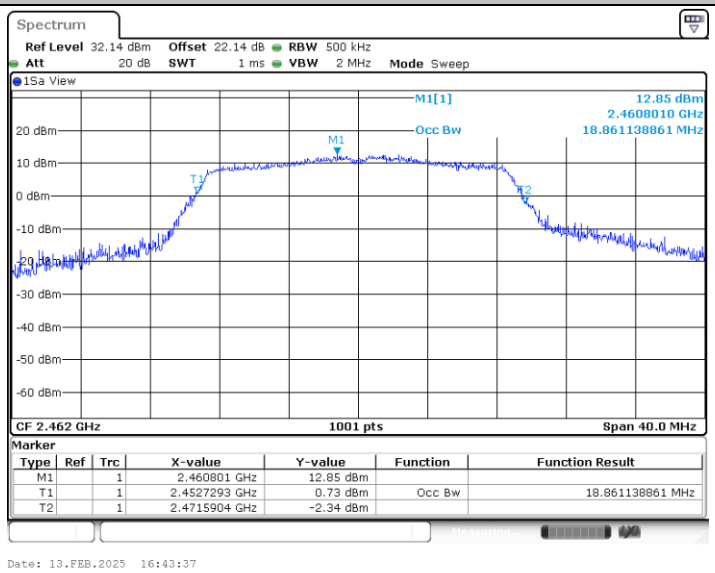

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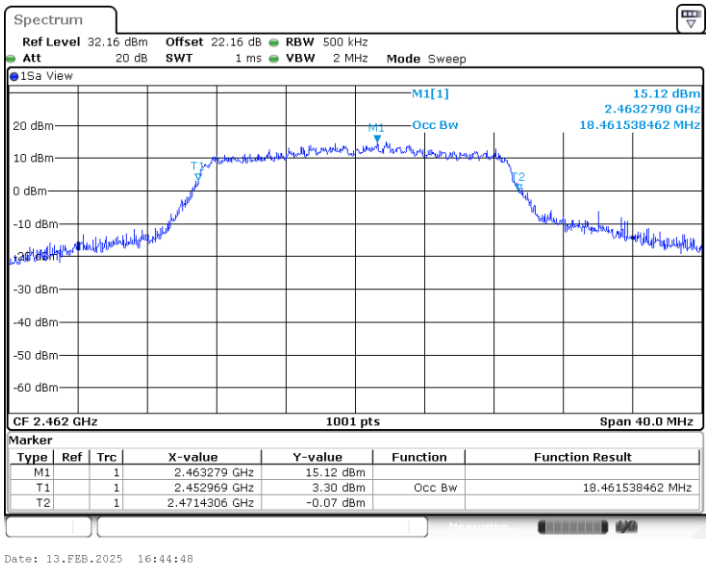

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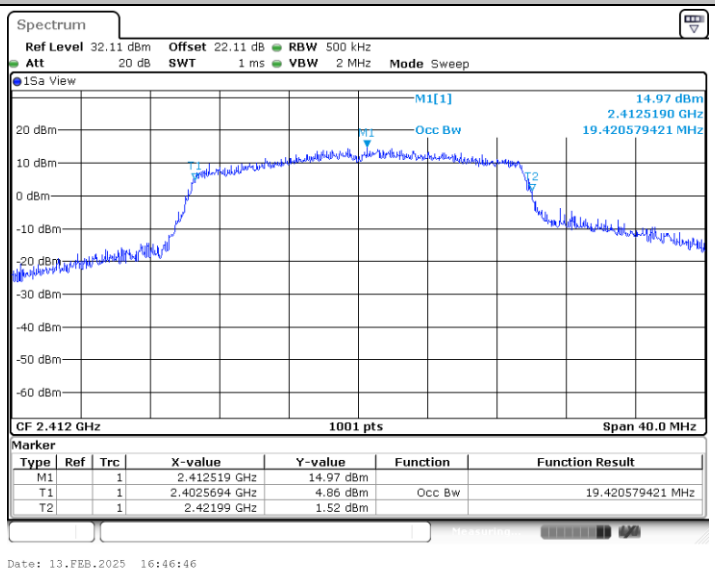

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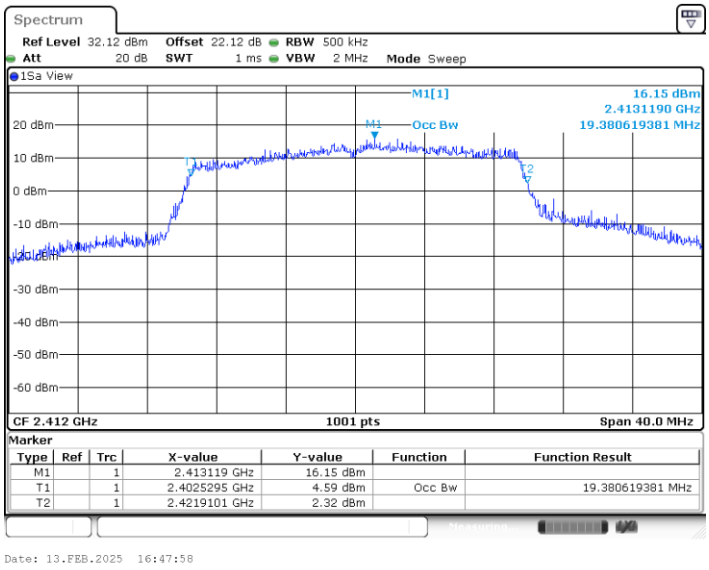

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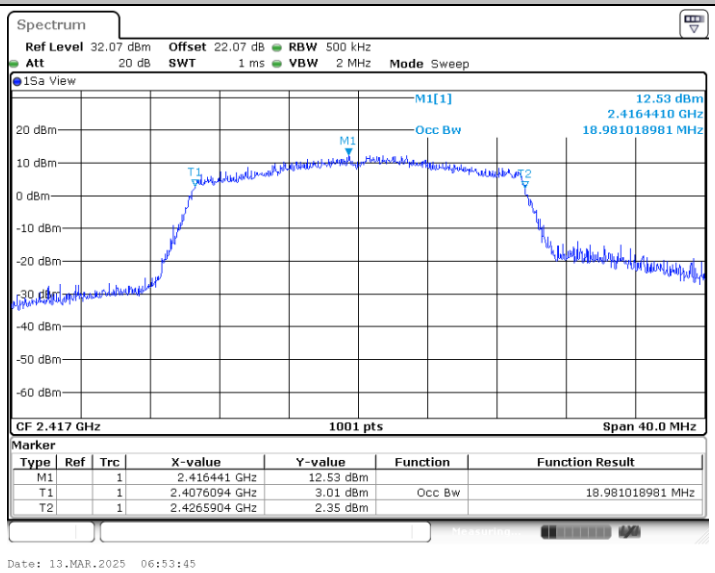

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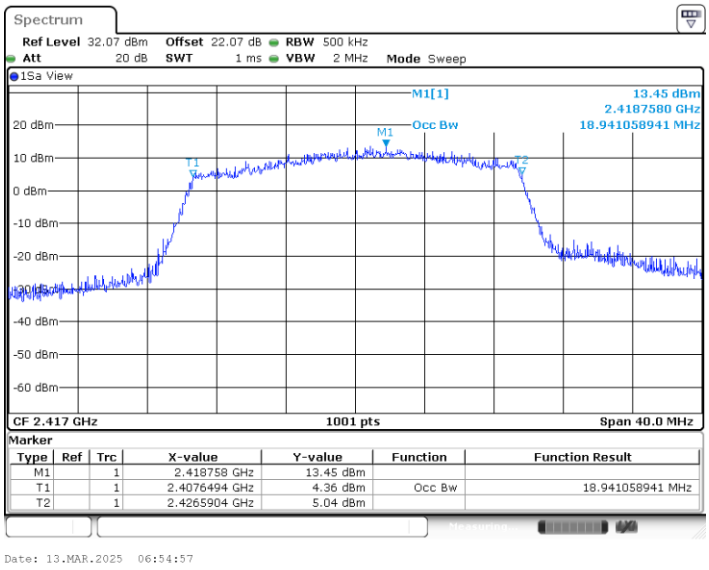

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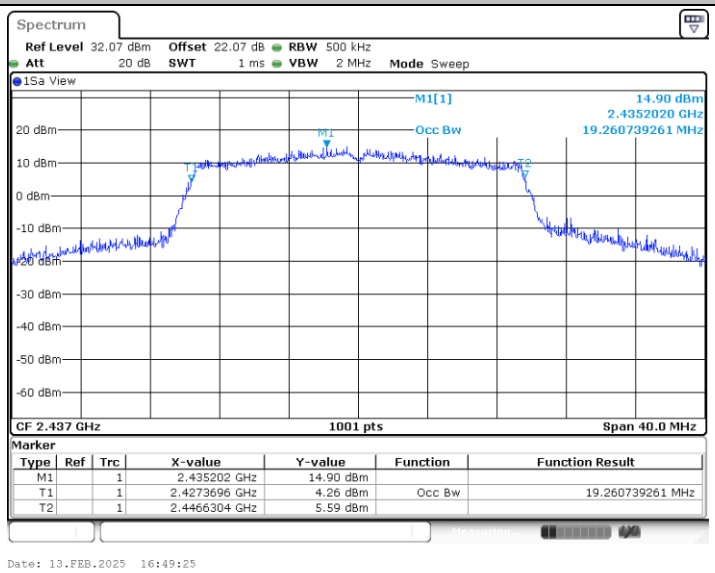
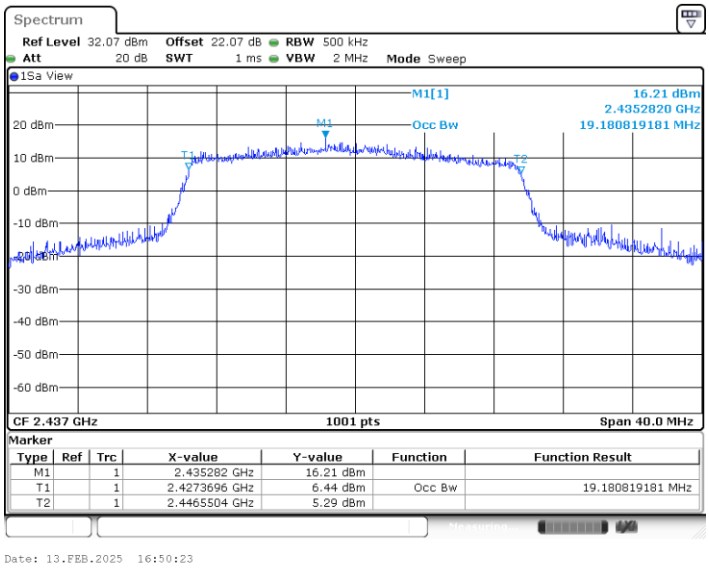
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