RF Test Report

Report Number:	**208726-1** **Revision Level: 1**
Client:	**Comma.ai, inc.**
	3900 Harney St., San Diego, CA92110
Equipment Under Test:	**2.4/5 GHz WiFi module**
Product Name:	**LightningHard SOM**
Model:	**LightningHard SOM**
FCC ID:	**2BFC6-LIGHTNINGH**
IC:	**32232-LIGHTNINGH**
Applicable Standards:	**FCC Part 15 Subpart C, § 15.247**
	RSS-247, Issue 3, August 2023
	RSS-GEN, Issue 5, February 2021, Amendment 2
	ANSI C63.10:2013
Report issued on:	**June 26, 2024**
Test Result:	**Compliant**

A2LA Cert. No. 1935.01

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER: 1935.01
Report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.

Prepared by: Andreas Gillmeier, Sr. Wireless Engineer

Reviewed by: Alex Chang, Sr. Regulatory Laboratory Manager – EMC/RF

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1 Summary of Test Results

Test Description	Test Specification		Test Result
Bandwidth	15.247(a)(2)	RSS-247 S5.2(a) RSS-GEN S6.7	Compliant
Output Power	15.247(b)(3)	RSS-247 S5.4(d)	Compliant
Power Spectral Density	15.247(e)	RSS-247 S5.2(b)	Compliant
Conducted Spurious Emissions / Band Edge	15.247(d)	RSS-247 S5.5	Compliant
Field Strength of Spurious Radiation (Restricted Bands)	15.247(d) 15.205, 15.209	RSS-247 S5.5 RSS-GEN S8.9, S8.10	Compliant
Band Edge Emissions in Restricted Frequency Bands	15.205, 15.209	RSS-GEN S8.9, S8.10	Compliant
AC Powerline Conducted Emissions	15.207	RSS-GEN S8.8	Not Applicable(1)
Antenna Requirement	15.203	RSS-GEN S6.8	Compliant

(1) The device is a module, power via DC power source

1.1 *Modifications Required for Compliance*

The I/Q samples for both chains are generated inside of the modem of the main SOC (the SDM845). These samples are then transmitted to the WCN3990 chip, which does the upconverting to the right channel carrier frequency, as well as regulating the output power. From there, both 5GHz and 2.4GHz signals are combined in the discrete frontend before being sent to the MHF4 connectors up top.

An unrelated clock signal (38.4MHz) on the SOM that is routed in the vicinity to one of the I/Q differential signals from chain 1 in between the SDM and WCN chips is upconverted by the WCN, which results in these symmetric peaks 38.4MHz away from the carrier frequency.

The change that we would make results in the reduction of the amplitude of this clock signal, which reduces the amount of 38.4MHz noise coupled into the I/Q lines of chain 1.

We changed C184 from 33pF to 100pF as a mitigation, since this reduces the output signal's amplitude (WL_BB_PLL_REF_CLK_OUT).

General Information

1.2 *Client Information*

Name:	Comma.ai, inc.
Address:	3900 Harney St.
City, State, Zip, Country:	San Diego, CA92110, USA

1.3 *Test Laboratory*

Name:	SGS North America, Inc.
Address:	12310 World Trade Drive, Suite 106/107
City, State, Zip, Country:	San Diego, CA 92128, USA
Accrediting Body:	A2LA
Type of lab:	Testing Laboratory
Certificate Number:	1935.01
Designation Number:	US1346
CAB Identifier:	US0236

1.4 *General Information of EUT*

Equipment Under Test:	2.4/5 GHz WiFi module
Product Name:	LightningHard SOM
Model:	LightningHard SOM
Serial Numbers:	N/A
FCC ID:	2BFC6-LIGHTNINGH
IC:	32232-LIGHTNINGH
Frequency Range:	2412 – 2462 MHz
Data Modes:	WLAN 802.11b, 802.11g, 802.11nHT20, 802.11nHT40
Antenna Gain*:	ANT1: PCB Omnidirectional Antenna (TE 2344654-7); peak gain 1.5dBi*
Rated Voltage:	3.6 to 4.8V_{DC} to module PCB
Test Voltage:	12V_{DC} to Dev Board via AC/DC adapter or DC power supply
Sample Received Date:	January 30, 2024
Dates of testing:	February 9 – March 26, 2024

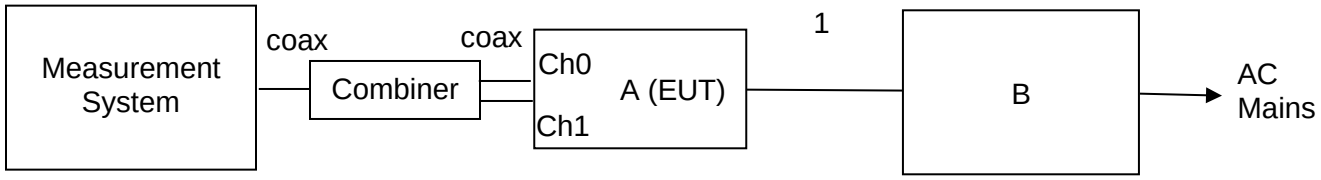
*Data was not measured by SGS laboratory and therefore SGS is not responsible for accuracy. Data obtained via customer, specification sheet, previous filing or other.

1.5 *Operating Modes and Conditions*

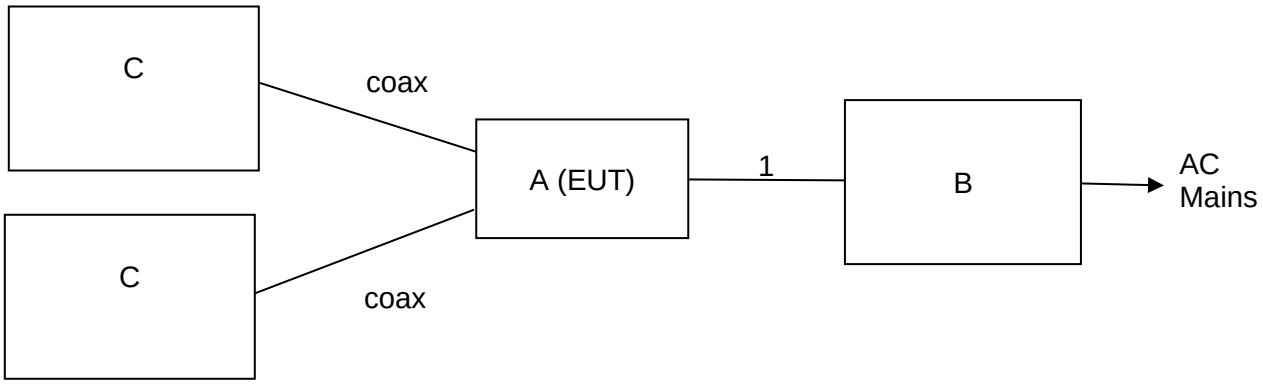
The EUT was mounted on an evaluation board running test mode firmware which allowed commands to be sent to transmit on low, middle and high channels in all necessary modulation and modes of operation. The worst-case data rates were determined to be:

- 802.11b (NOHT), 1 and 11 Mbps, Power Level 15
- 802.11b (CCK), 11 Mbps, Power Level 15
- 802.11g, 6 and 9 and 12 Mbps, Power Level 12 and 15
- 802.11nHT20, MCS 8 and 10 and 11, Power Level 13 and 15
- 802.11nHT40, MCS 0, Power Level 15

1.6 *EUT Connection Block Diagram – Conducted Measurements*



1.7 *EUT Connection Block Diagram – Radiated Measurements*



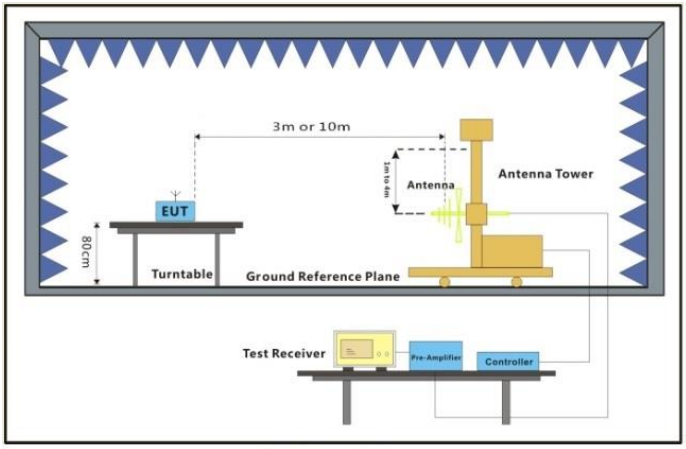
1.8 *System Configurations*

Device Reference	Manufacturer	Description	Model Number	Serial Number
A	Comma.ai	Test Board	LightningHard Test Board 10/19/2023	N/A
B	TMEZON	AC/DC power adapter	MZ-12V2A-2.4M	N/A
C	TE	Dual Band WLAN antenna	2344654-7	N/A

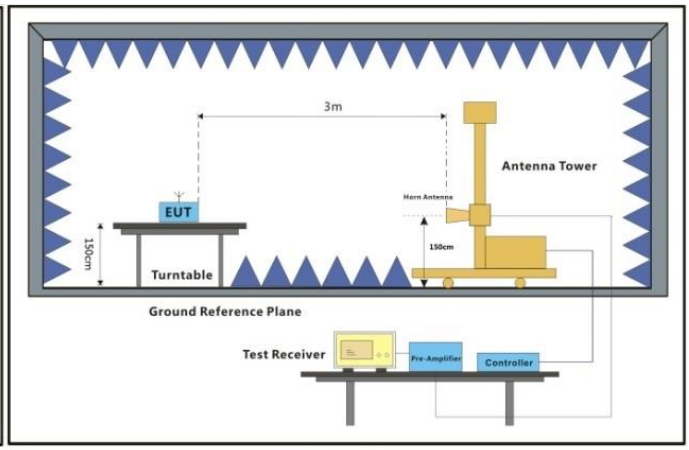
1.9 *Cable List*

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
1	DC out	AC/DC power adapter	DC plug	2.3	No	No

1.10 *Test Setup Diagrams (Radiated)*



30MHz-1GHz



Above 1GHz

2 Bandwidth

2.1 *Test Result*

Test Description	Test Specification		Test Result
6 dB Bandwidth 99% Occupied Bandwidth	15.247(a)(2)	RSS-247 S5.2(a) RSS-GEN S6.7	Compliant

2.2 *Test Method*

1. Place the EUT on the table and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

FCC measurement

1. The testing follows the Measurement Procedure from ANSI C63.10: 2013 clause 11.8 and KDB 558074 D01.
2. Set the spectrum analyzer as
   RBW= 100 kHz ,
   VBW = 3 X RBW,
   Span= 2 to 5 times of the OBW,
   Sweep=auto, Detector = Peak, and Max hold.
3. Mark the upper and lower frequencies of -6dB.
4. Repeat above procedures until all test default channel is completed.

ISED measurements

1. The testing follows the Measurement Procedure from ANSI C63.10: 2013 clause 6.9.2 and RSS-Gen section 6.7.
2. Set the spectrum analyzer as
   RBW= 1 % to 5% of 99% and -6dB Bandwidth ,
   VBW ≥ 3 X RBW,
   Span= large enough to capture all products of the modulation process
   Sweep=auto, Detector = Peak, and Max hold.
3. Mark the upper and lower frequencies of 99% and -6dB.
4. Repeat above procedures until all test default channel is completed.

2.3 *Test Site*

EMC Laboratory, San Diego, CA

Environmental Conditions

Temperature: 18 – 23.3 °C
Relative Humidity: 45 - 62 %

2.4 *Test Equipment*

Test Dates: Feb. 21 – March 8, 2024 Tester: Andreas Gillmeier

Asset No.	Type of Equipment	Model	Serial No.	Manufacturer	Cal Date	Cal Due Date
Conducted Testing						
2003	Signal Analyzer	N9030B	MY61330812	Keysight	01/29/2024	01/29/2025
-	Test Software	Radio Test Software	v.23	SGS Taiwan	N/A	-
2036	Temp/Humidity Data Logger	GSP-8	CMA231100002	Elitech	05/24/2023	

2.5 *Test Setup Photographs*

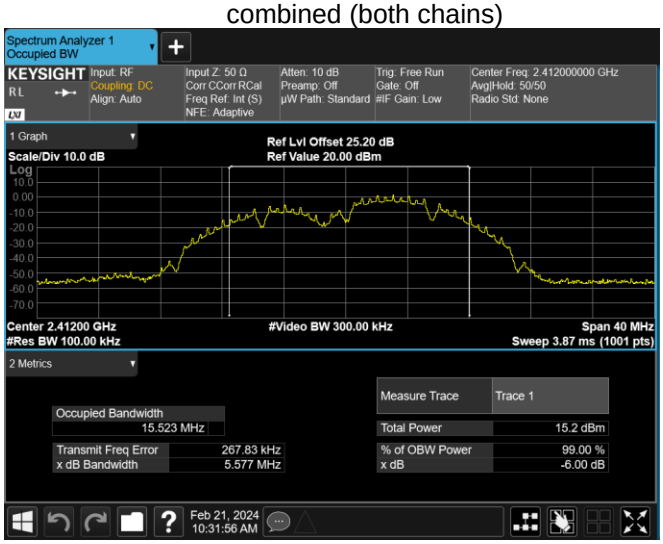
Test setup photographs are located in a separate exhibit.

2.6 *Test Data – 6dB Bandwidth*

Mode	Frequency (MHz)	Power Level	Data Rate (Mbps) / Modulation	6dB Bandwidth (MHz)		Verdict
				Both Antennas Combined	Limit	
802.11b NOHT	2412	15	1	5.577	>=0.5	Pass
	2437	15	11	6.04	>=0.5	Pass
	2462	15	11	5.596	>=0.5	Pass
802.11b CCK	2412	15	11	5.358	>=0.5	Pass
	2437	15	11	6.04	>=0.5	Pass
	2462	15	11	5.607	>=0.5	Pass
802.11g	2412	15	9	16.1	>=0.5	Pass
	2437	12	12	16.19	>=0.5	Pass
	2462	15	6	15.82	>=0.5	Pass
802.11n (HT20)	2412	13	mcs11	17.61	>=0.5	Pass
	2437	13	mcs8	17.62	>=0.5	Pass
	2462	15	mcs10	16.07	>=0.5	Pass
802.11n (HT40)	2422	13	mcs0	35.77	>=0.5	Pass
	2437	13	mcs0	36.05	>=0.5	Pass
	2452	13	mcs0	35.23	>=0.5	Pass

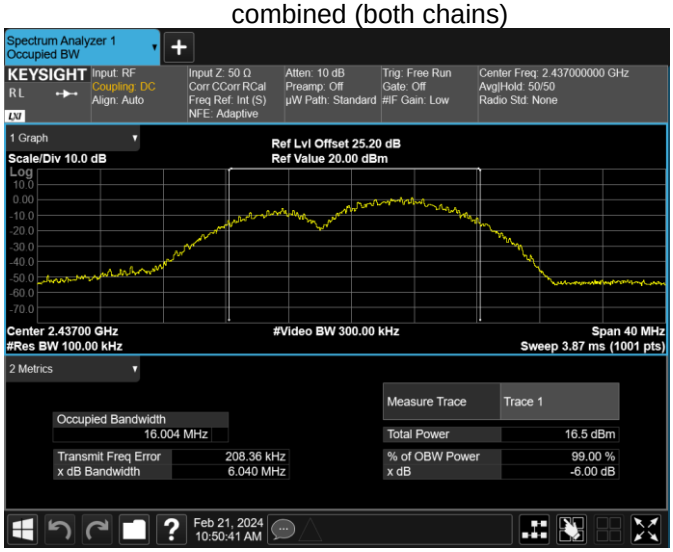
Low Channel – 802.11b NOHT, (2412MHz)

combined (both chains)



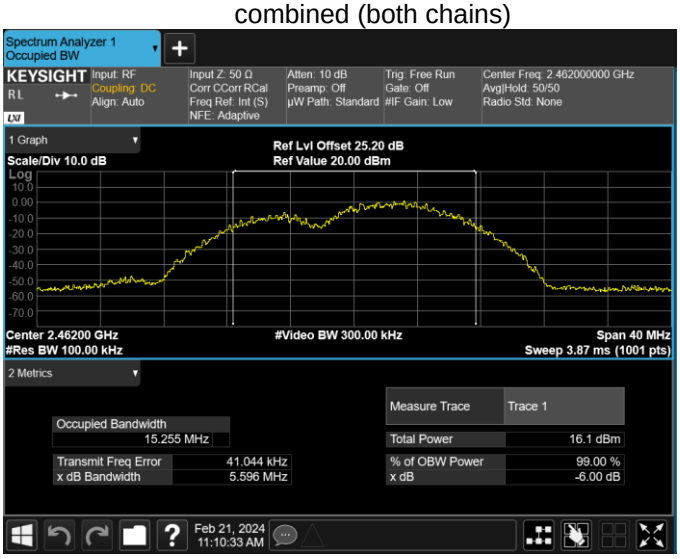
Mid Channel – 802.11b NOHT, (2437MHz)

combined (both chains)



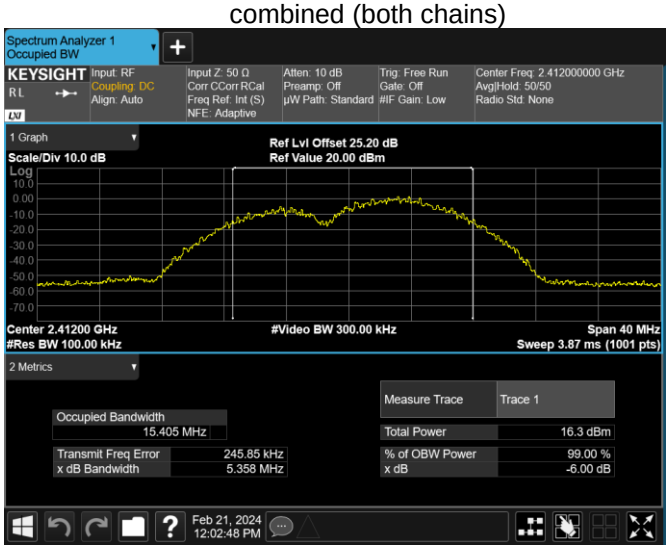
High Channel – 802.11b NOHT, (2462MHz)

combined (both chains)



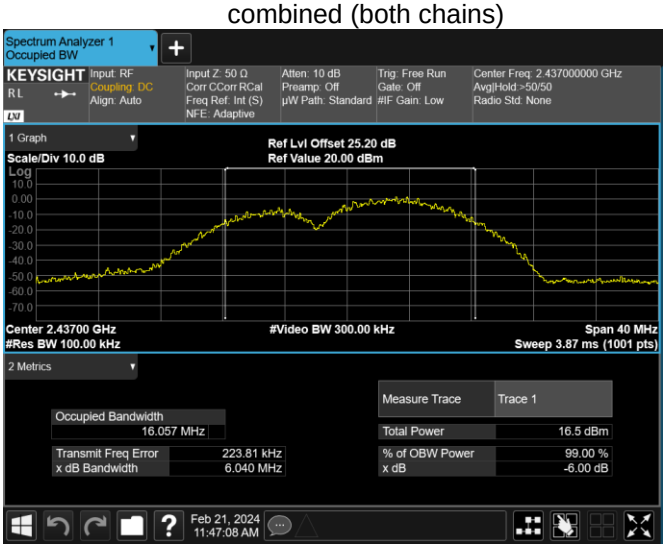
Low Channel – 802.11b CCK, (2412MHz)

combined (both chains)



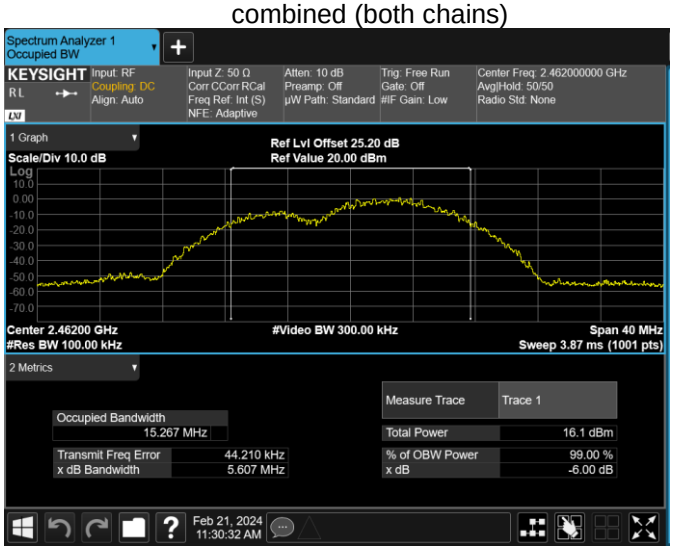
Mid Channel – 802.11b CCK, (2437MHz)

combined (both chains)



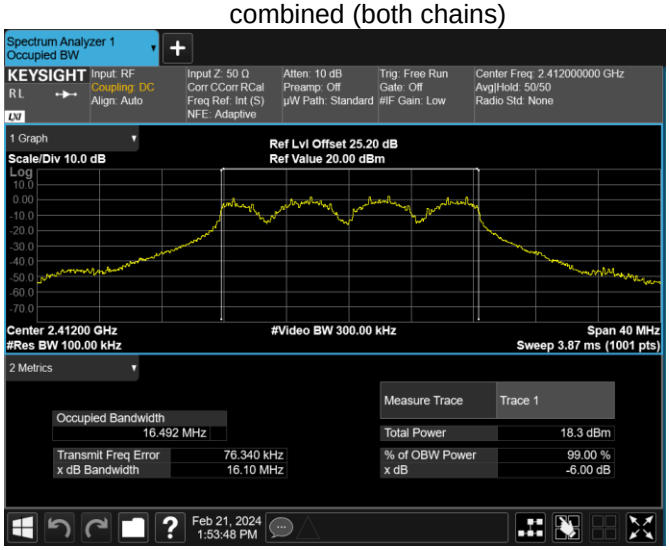
High Channel – 802.11b CCK, (2462MHz)

combined (both chains)



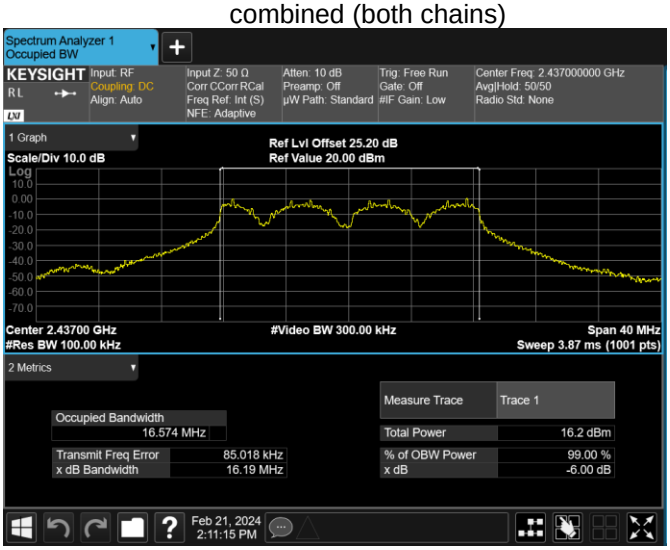
Low Channel – 802.11g NOHT, (2412MHz)

combined (both chains)



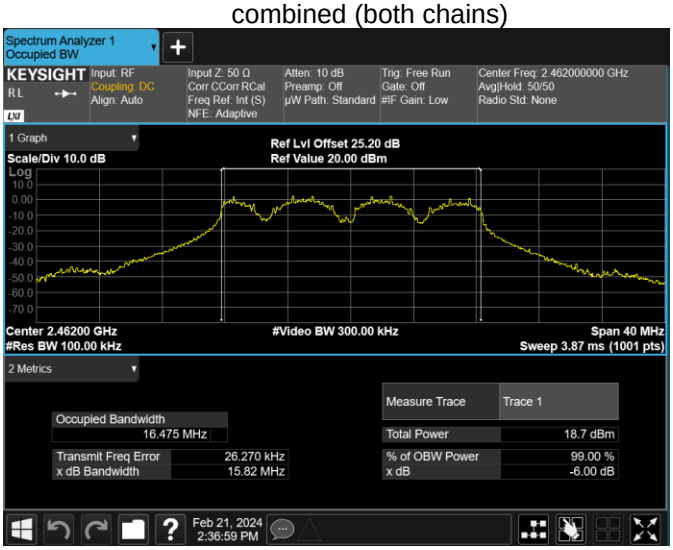
Mid Channel – 802.11g NOHT, (2437MHz)

combined (both chains)



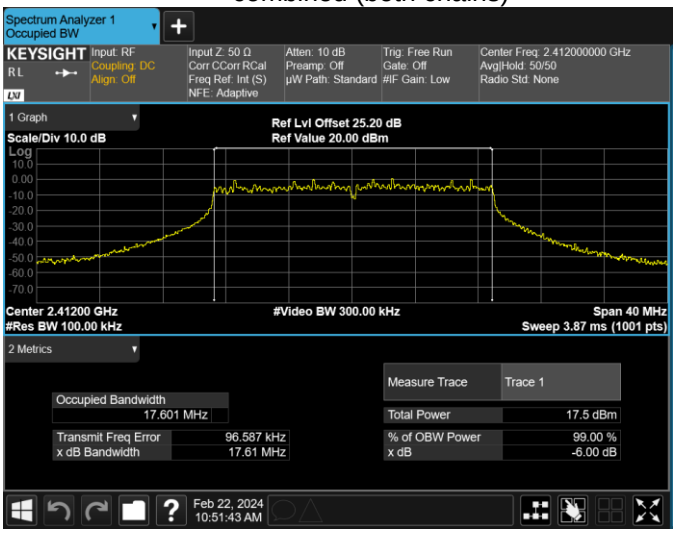
High Channel – 802.11g NOHT, (2462MHz)

combined (both chains)



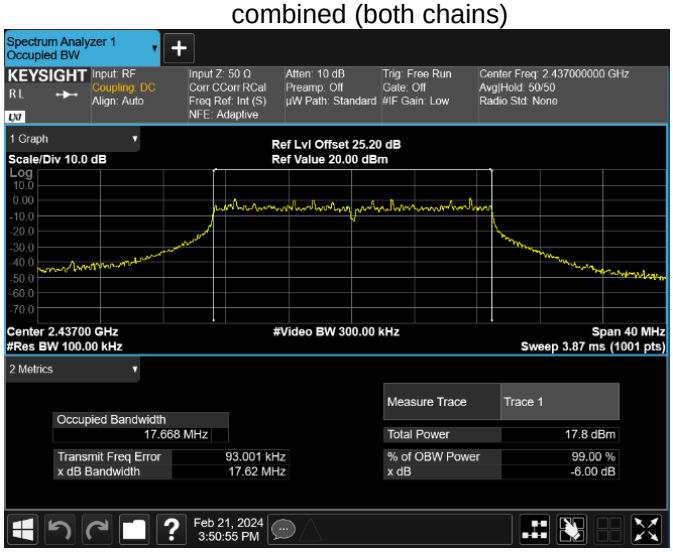
Low Channel – 802.11n HT20, (2412MHz)

combined (both chains)



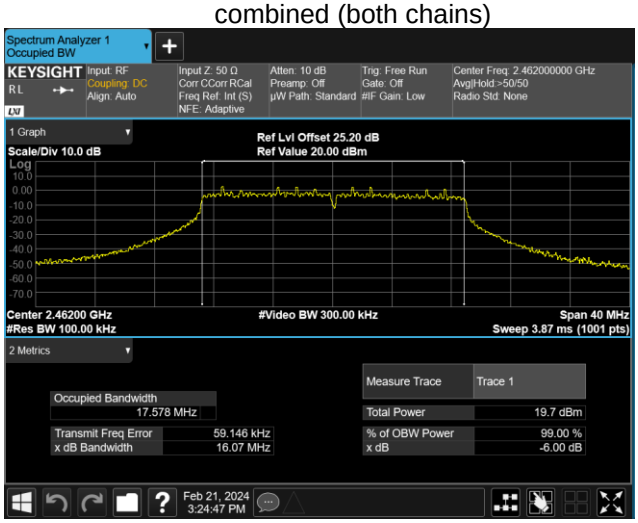
Mid Channel – 802.11n HT20, (2437MHz)

combined (both chains)



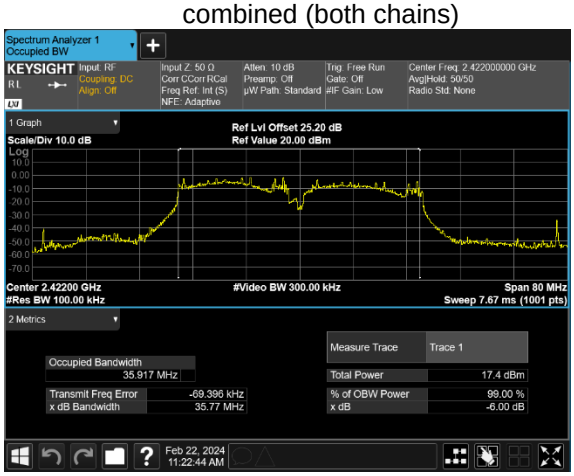
High Channel – 802.11n HT20, (2462MHz)

combined (both chains)



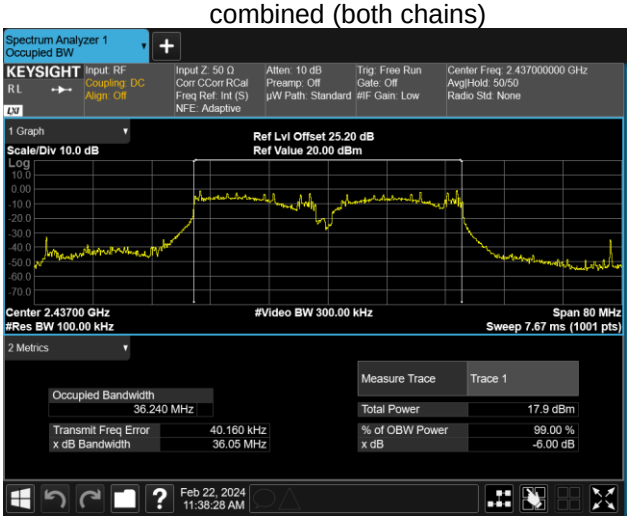
Low Channel – 802.11n HT40, (2422MHz)

combined (both chains)



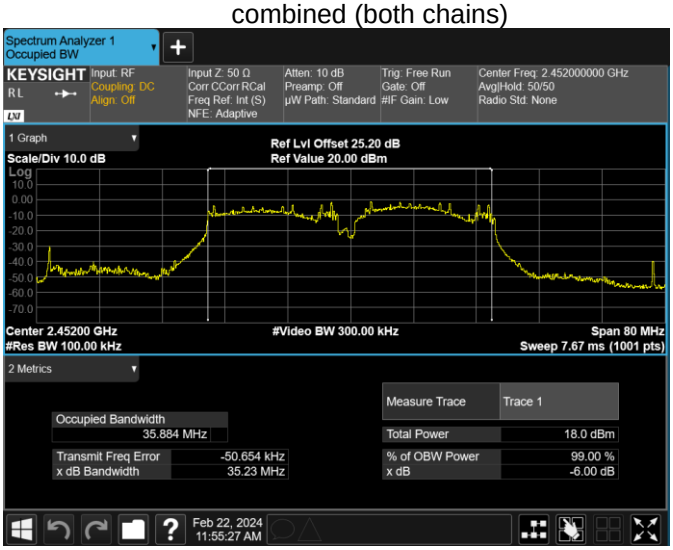
Mid Channel – 802.11n HT40, (2437MHz)

combined (both chains)



High Channel – 802.11n HT40, (2452MHz)

combined (both chains)

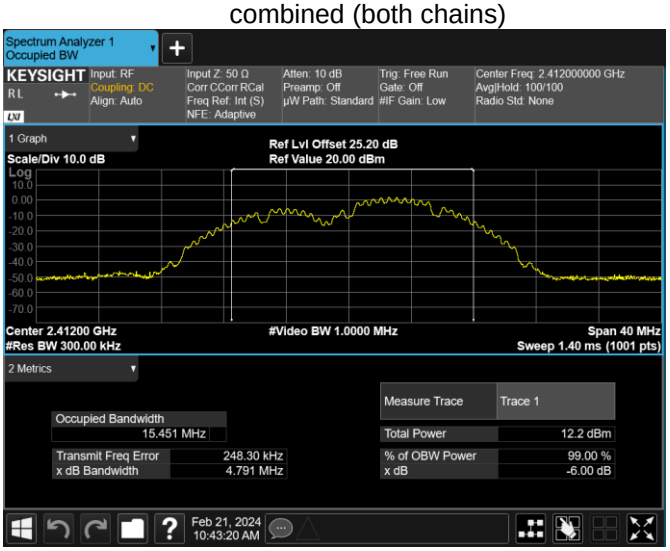


2.7 *Test Data – 99% Bandwidth*

Mode	Frequency (MHz)	Power Level	Data Rate (Mbps) / Modulation	99% Bandwidth (MHz) Both Antennas Combined	Verdict
802.11b NOHT	2412	15	1	15.451	For Information Only
	2437	15	11	15.998	
	2462	15	11	15.163	
802.11b CCK	2412	15	11	15.254	
	2437	15	11	15.994	
	2462	15	11	15.166	
802.11g	2412	15	9	16.921	
	2437	12	12	17.115	
	2462	15	6	16.85	
802.11n (HT20)	2412	13	mcs11	17.789	
	2437	13	mcs8	17.946	
	2462	15	mcs10	17.733	
802.11n (HT40)	2422	13	mcs0	36.227	
	2437	13	mcs0	36.604	
	2452	13	mcs0	36.166	

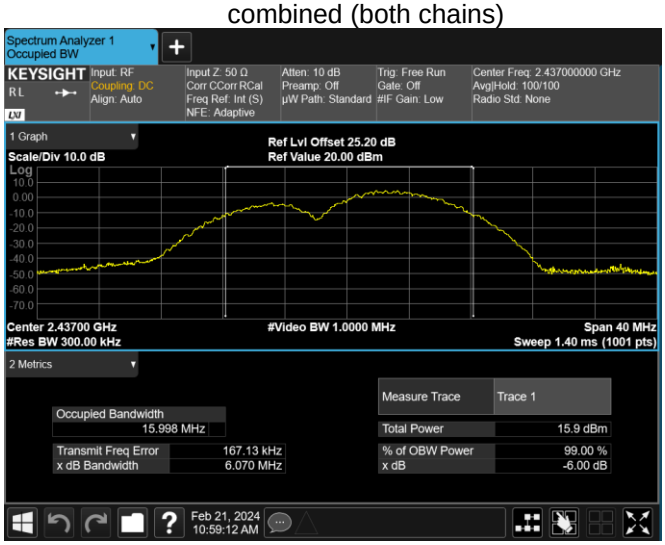
Low Channel – 802.11b NOHT, (2412MHz)

combined (both chains)



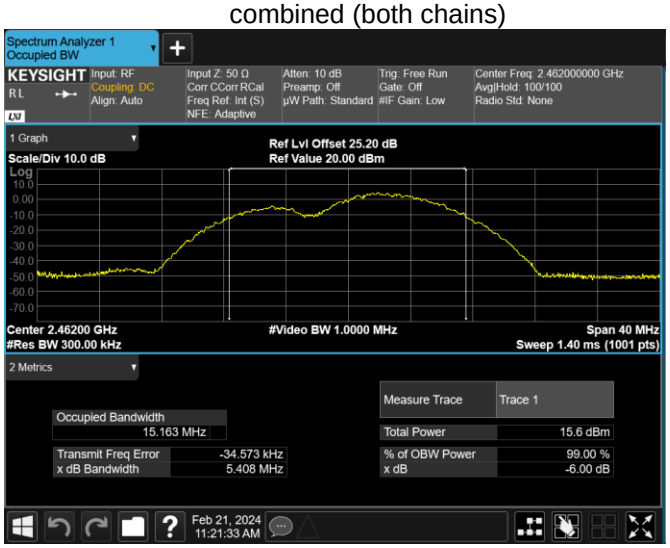
Mid Channel – 802.11b NOHT, (2437MHz)

combined (both chains)



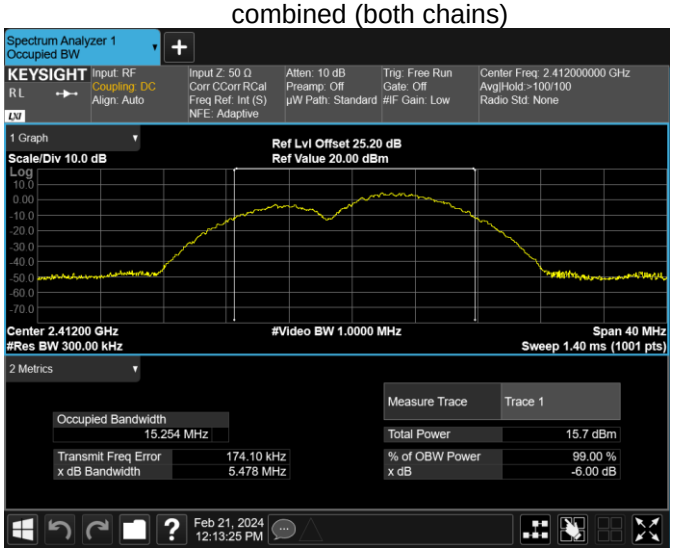
High Channel – 802.11b NOHT, (2462MHz)

combined (both chains)



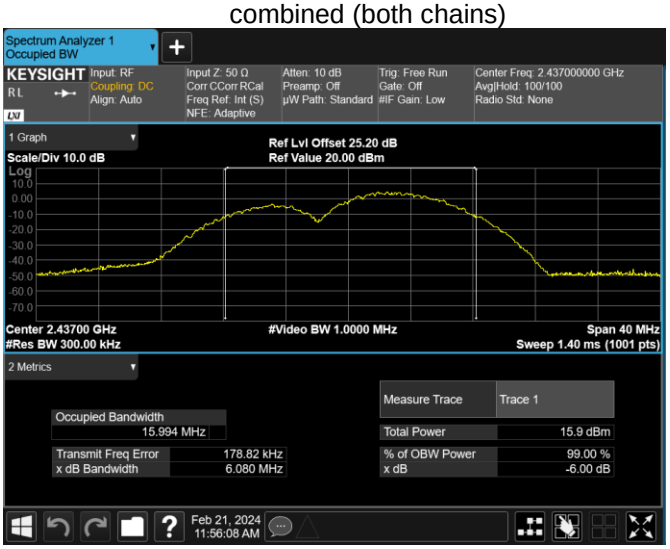
Low Channel – 802.11b CCK, (2412MHz)

combined (both chains)



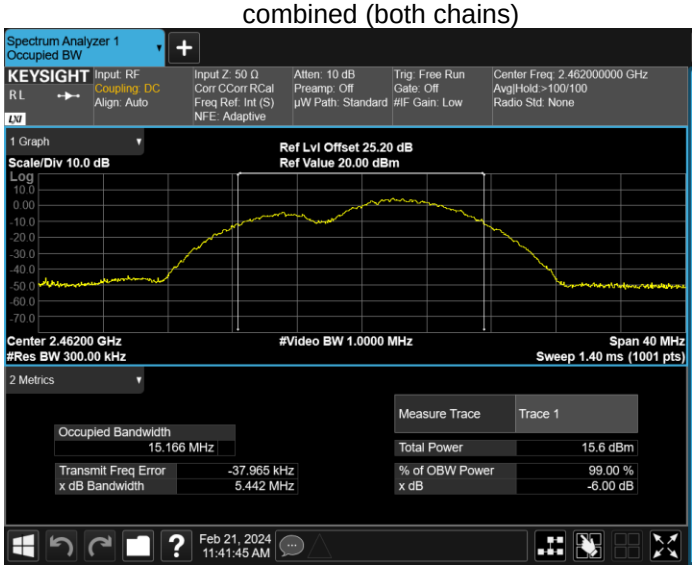
Mid Channel – 802.11b CCK, (2437MHz)

combined (both chains)



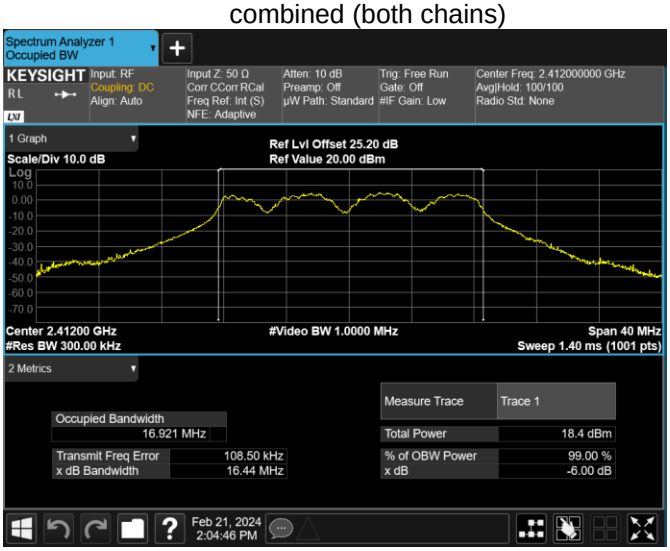
High Channel – 802.11b CCK, (2462MHz)

combined (both chains)



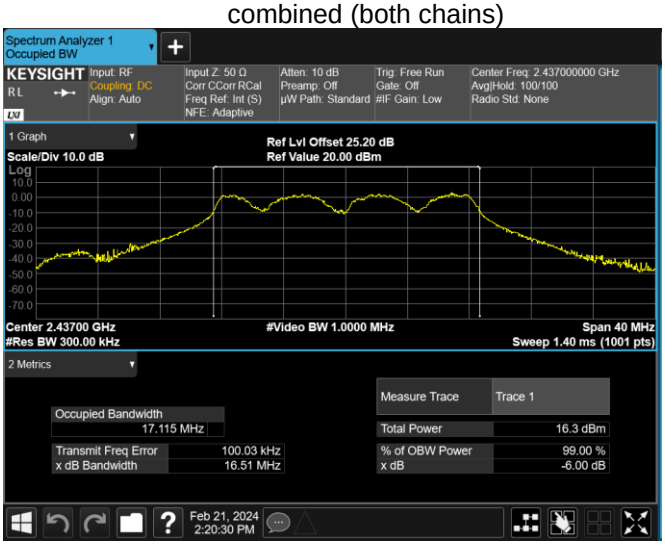
Low Channel – 802.11g NOHT, (2412MHz)

combined (both chains)



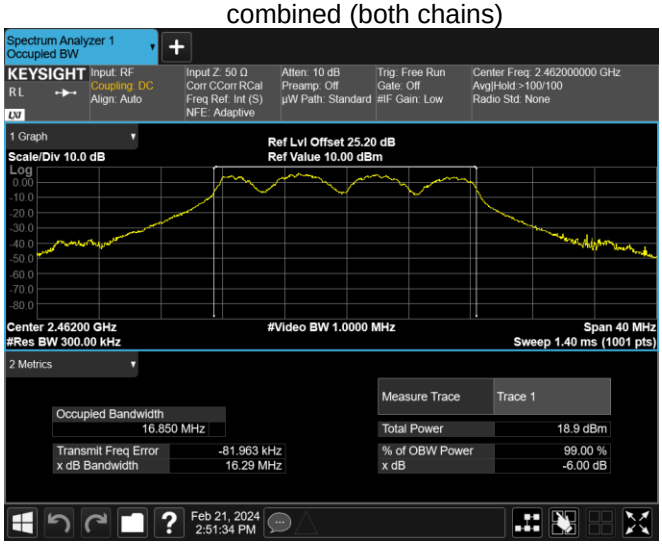
Mid Channel – 802.11g NOHT, (2437MHz)

combined (both chains)



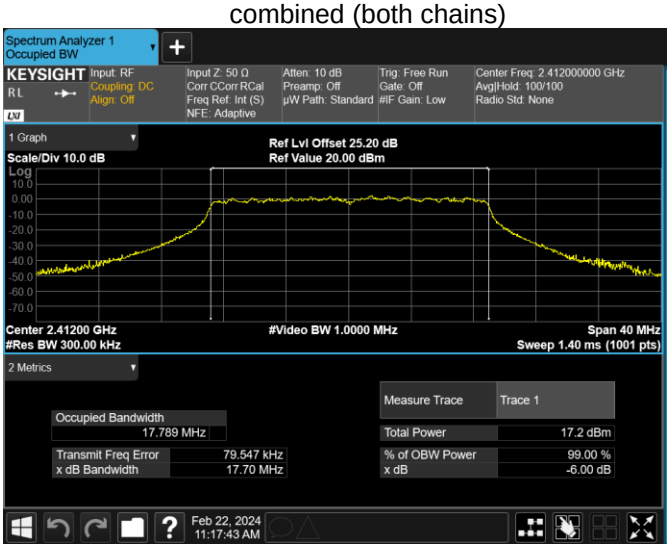
High Channel – 802.11g NOHT, (2462MHz)

combined (both chains)



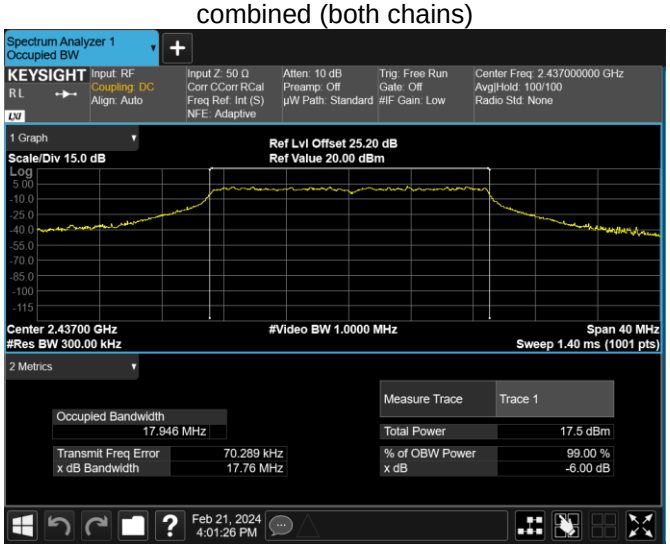
Low Channel – 802.11n HT20, (2412MHz)

combined (both chains)



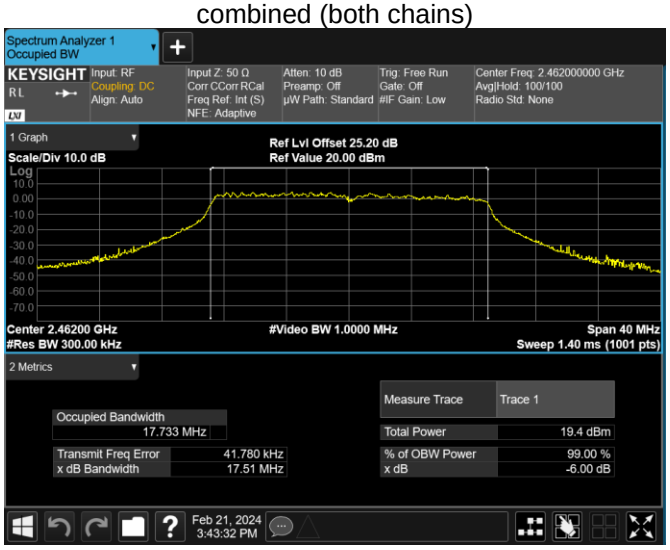
Mid Channel – 802.11n HT20, (2437MHz)

combined (both chains)



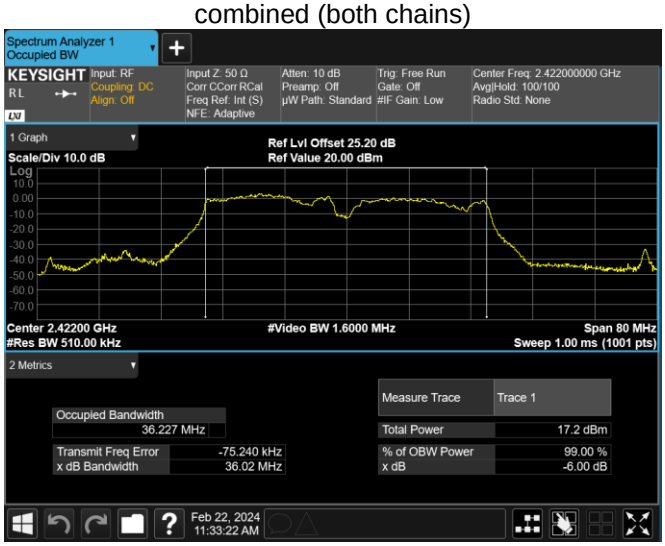
High Channel – 802.11n HT20, (2462MHz)

combined (both chains)



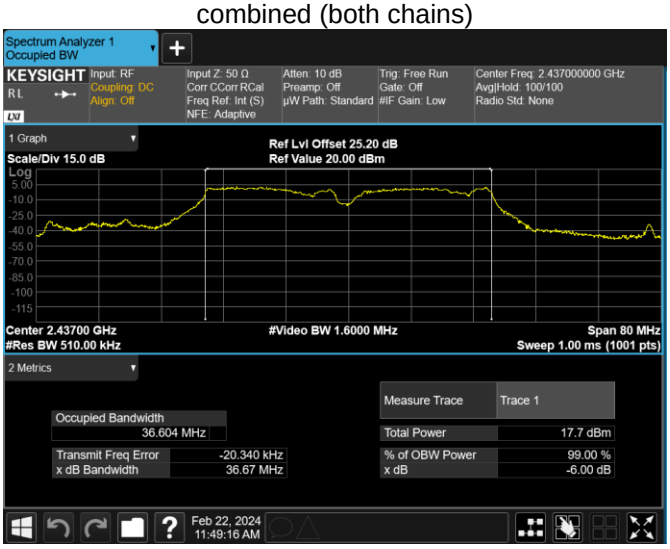
Low Channel – 802.11n HT40, (2422MHz)

combined (both chains)



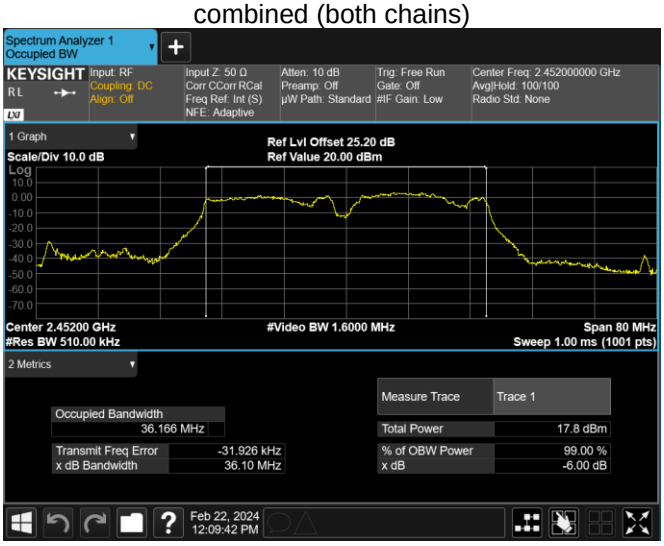
Mid Channel – 802.11n HT40, (2437MHz)

combined (both chains)



High Channel – 802.11n HT40, (2452MHz)

combined (both chains)



3 Output Power

3.1 *Test Result*

Test Description	Test Specification		Test Result
Peak Output Power	15.247(b)(3)	RSS-247 S5.4(d)	Compliant

3.2 *Test Method*

Fundamental average power measurements were recorded using the procedures from ANSI C63.10: 2013 clause 11.9 and KDB 558074 D01 Measurement Guidance v05r02.

Limit
(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. For using antennas with greater than 6dBi of gain, the limit is reduced in dB by the amount the gain exceeds 6dBi (e.g. for a 7.4dBi antenna, the limit is reduced from 30dBm to 28.6dBm)

3.3 *Test Site*

EMC Laboratory, San Diego, CA

Environmental Conditions

Temperature: 12.7 -27.9 °C
Relative Humidity: 27 – 64 %

3.4 *Test Equipment*

Test End Date: Jan. 30 – Feb. 23, 2024 Tester: Minsung Kang

Asset No.	Type of Equipment	Model	Serial No.	Manufacturer	Cal Date	Cal Due Date
Conducted Testing						
2013	Power Meter	N1911A	MY62310007	Keysight	01/29/2024	01/29/2025
2015	Wideband Power Sensor	N1921A	MY62220017	Keysight	01/29/2024	01/29/2025
2036	Temp/Humidity Data Logger	GSP-8	CMA231100002	Elitech	05/24/2023	

3.5 *Test Setup Photographs*

Test setup photographs are located in a separate exhibit.

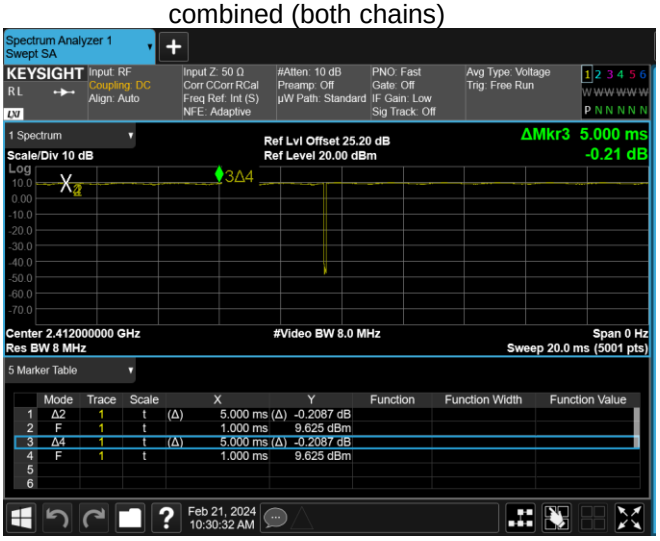
3.6 *Duty Cycle Test Data*

The test system reported the following duty-cycles used for correcting the average measurements:
Only worst-case scenario reported as both antennas combined

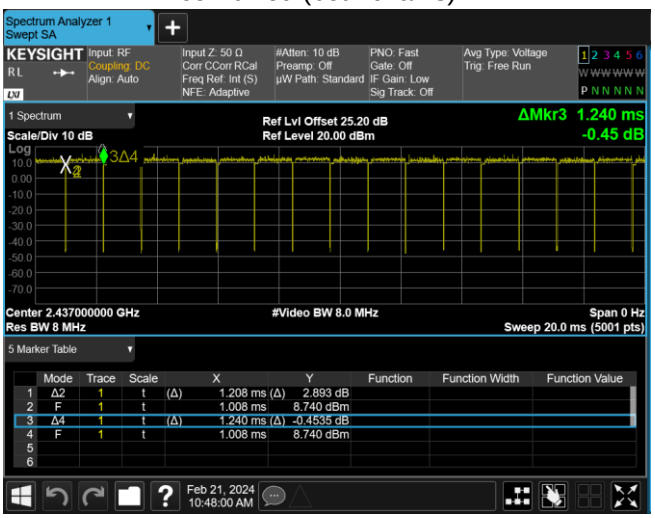
Antennas Combined							
Mode	**Power Level Setting**	**Data Rate (Mbps)/**	**Frequency (MHz)**	**T_on (ms)**	**T_on + T_off (ms)**	**Duty Cycle (%)**	**Duty Cycle Correction Factor (dB)**
802.11b NOHT	15	1	2412	5.000	5.000	100	0.00
	15	11	2437	1.208	1.240	97.42	0.11
	15	11	2462	1.208	1.240	97.42	0.11
802.11b CCK	15	11	2412	1.208	1.240	97.42	0.11
	15	11	2437	1.208	1.240	97.42	0.11
	15	11	2462	1.208	1.240	97.42	0.11
802.11g	15	9	2412	1.384	1.420	97.46	0.11
	12	12	2437	1.044	1.080	96.67	0.15
	15	6	2462	2.064	2.100	98.29	0.00
802.11n (HT20)	13	mcs11	2412	0.276	0.312	88.46	0.53
	13	mcs8	2437	0.984	1.019	96.47	0.16
	15	mcs10	2462	0.356	0.392	90.82	0.42
802.11n (HT40)	13	mcs0	2422	0.948	0.999	94.89	0.23
	13	mcs0	2437	0.948	0.999	94.89	0.23
	13	mcs0	2452	0.947	0.999	94.79	0.23

Duty Cycle measurement

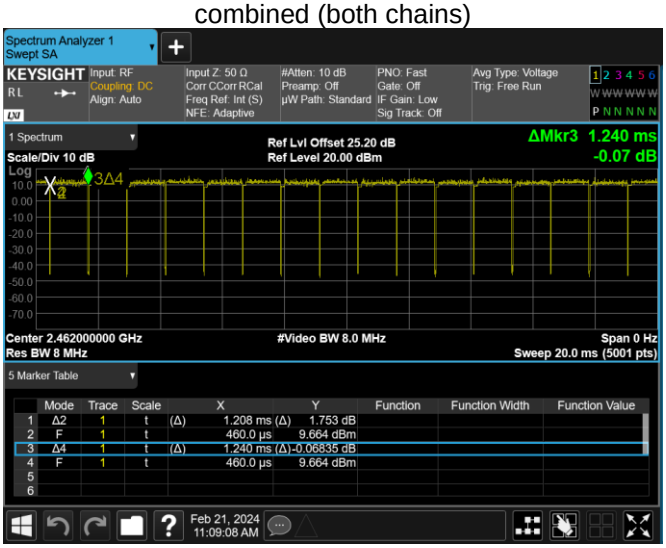
Low Channel – 802.11b NOHT, (2412MHz)
combined (both chains)



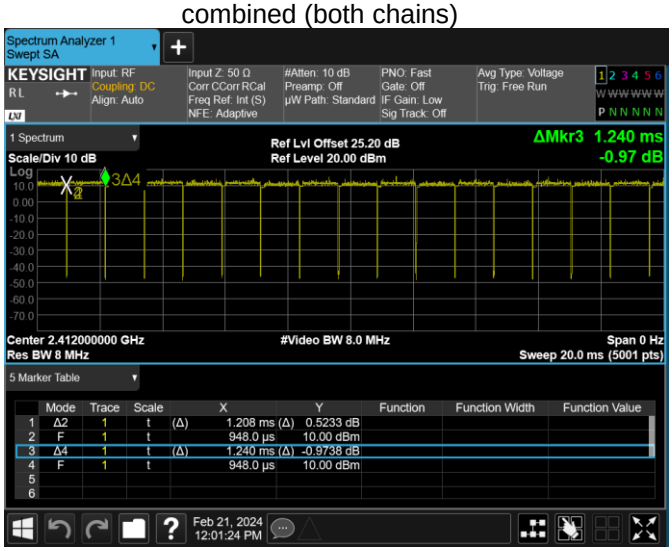
Mid Channel – 802.11b NOHT, (2437MHz)
combined (both chains)



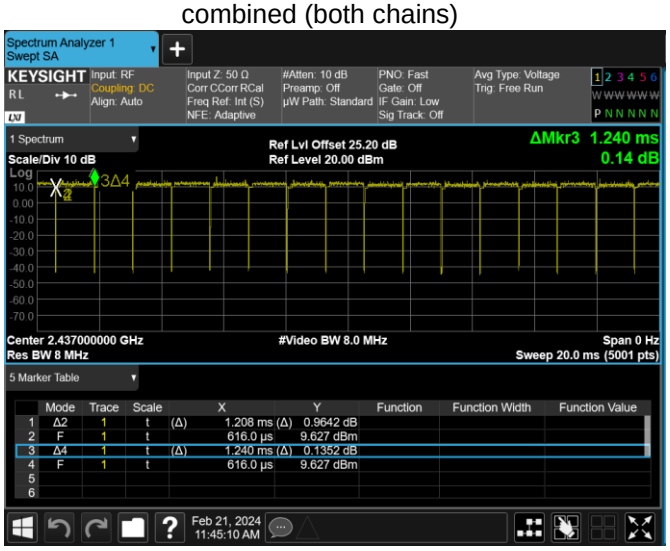
High Channel – 802.11b NOHT, (2462MHz)
combined (both chains)



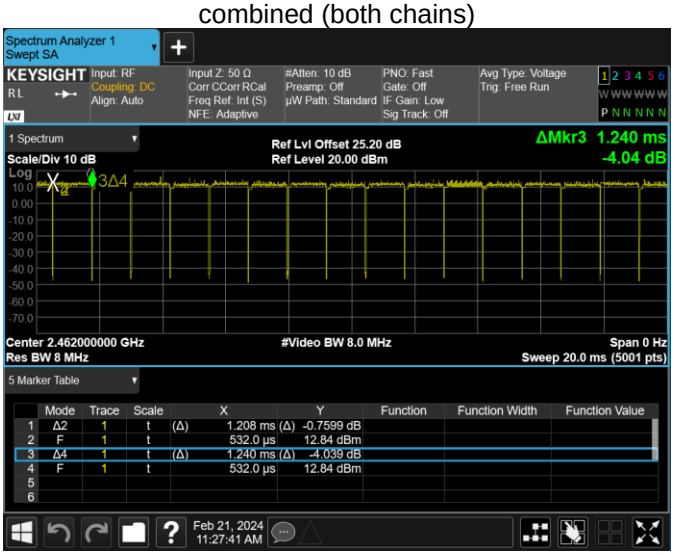
Low Channel – 802.11b CCK, (2412MHz)
combined (both chains)



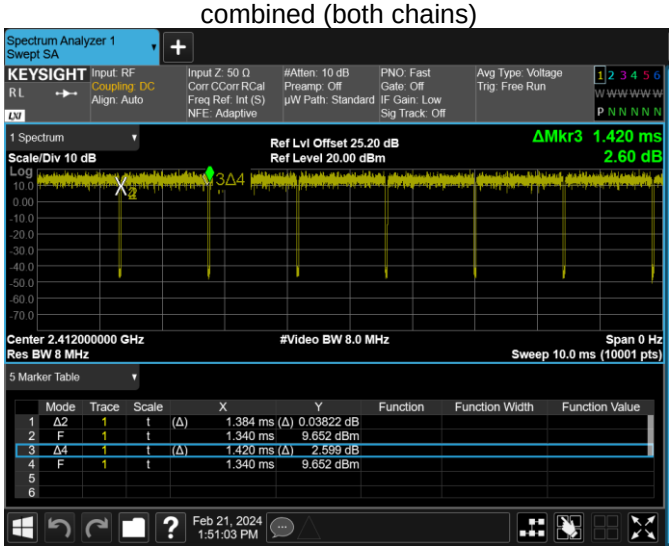
Mid Channel – 802.11b CCK, (2437MHz)
combined (both chains)



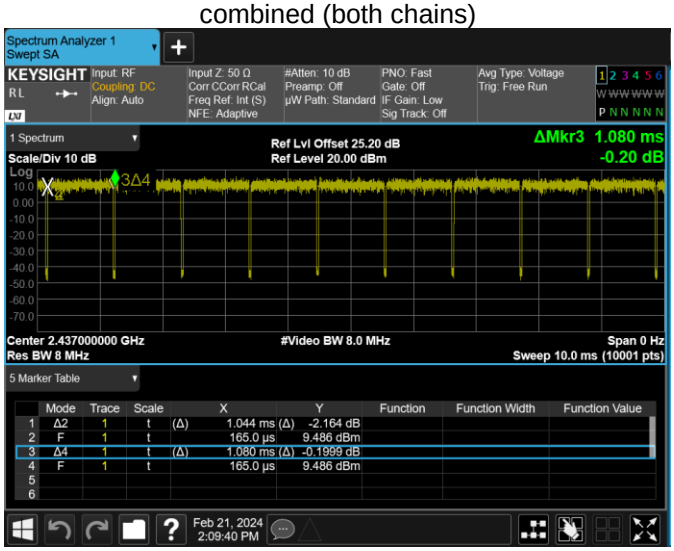
High Channel – 802.11b CCK, (2462MHz)
combined (both chains)



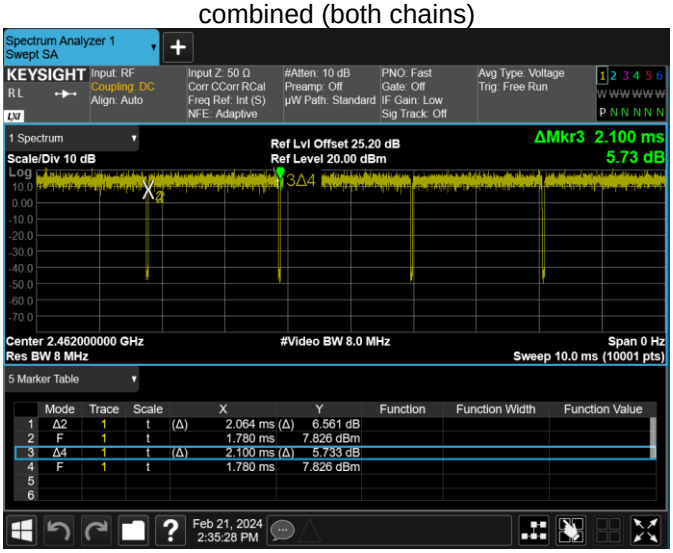
Low Channel – 802.11g NOHT, (2412MHz)
combined (both chains)



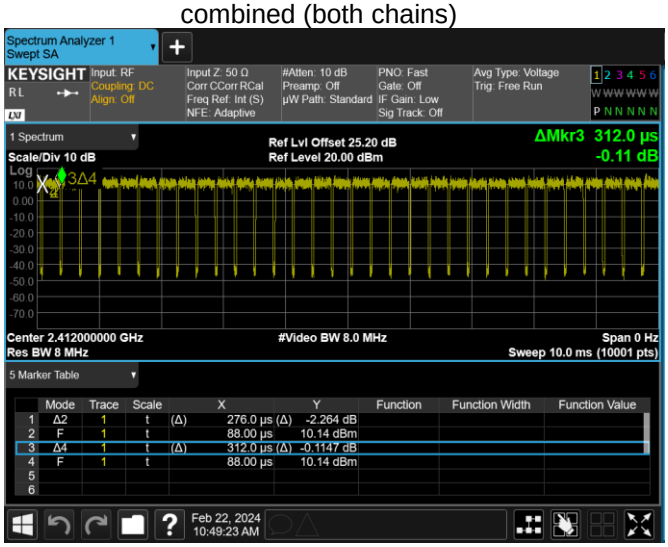
Mid Channel – 802.11g NOHT, (2437MHz)
combined (both chains)



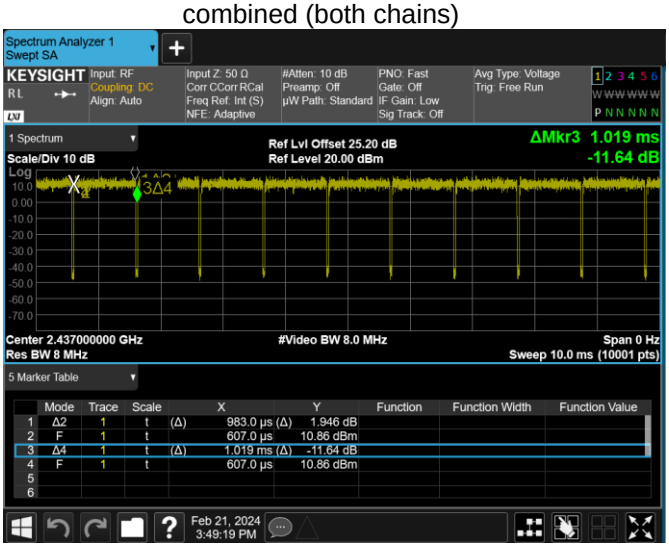
High Channel – 802.11g NOHT, (2462MHz)
combined (both chains)



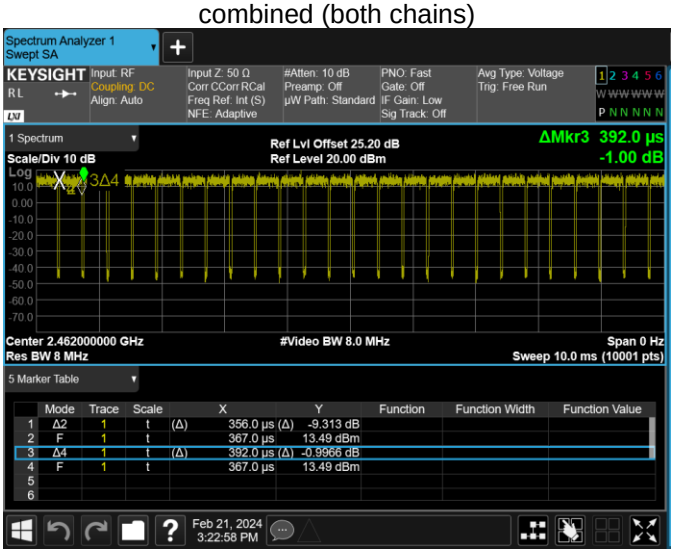
Low Channel – 802.11n HT20, (2412MHz)
combined (both chains)



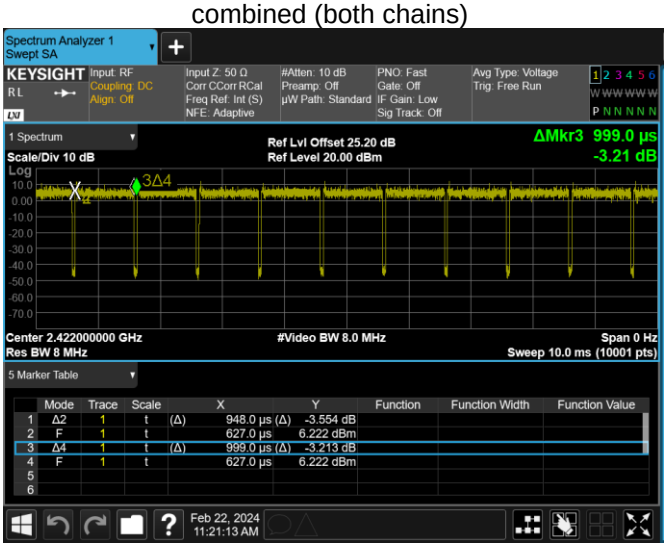
Mid Channel – 802.11n HT20, (2437MHz)
combined (both chains)



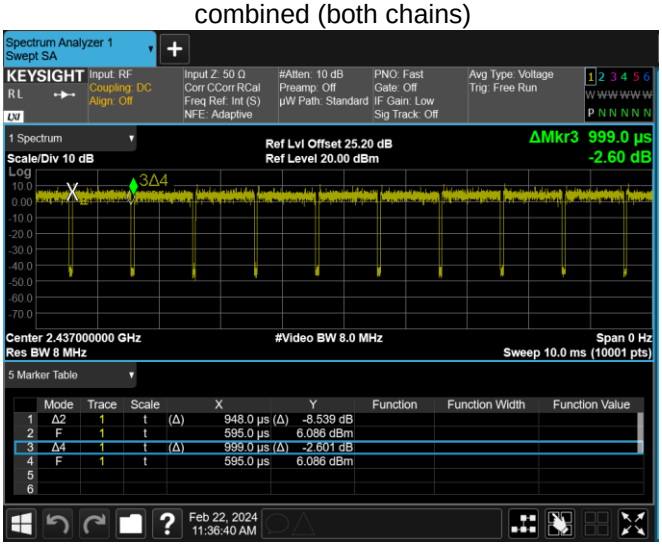
High Channel – 802.11n HT20, (2462MHz)
combined (both chains)



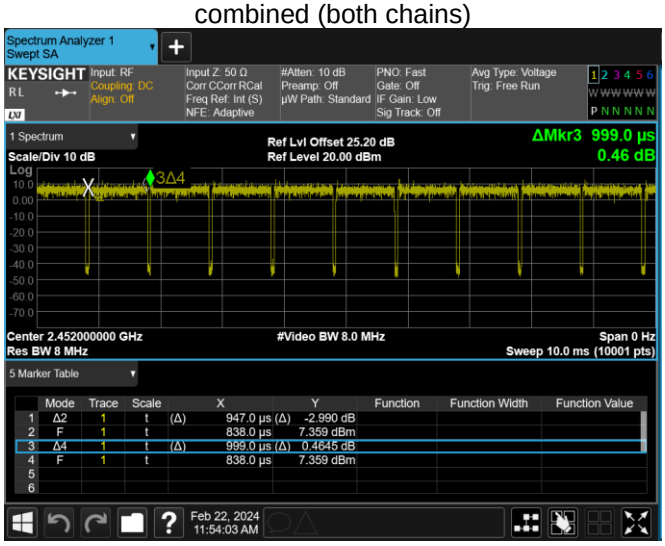
Low Channel – 802.11n HT40, (2422MHz)
combined (both chains)



Mid Channel – 802.11n HT40, (2437MHz)
combined (both chains)



High Channel – 802.11n HT40, (2452MHz)
combined (both chains)



Mode	Channel/ Frequency (MHz)	Data Rate (Mbps)	PWR Level Setting	Duty Cycle Correction (dB)	Mode	Antenna Gain (max.) (dBi)	Calculated EIRP (dBm)	Limit (dBm)	Verdict
802.11b NOHT	2412 MHz	1	15	0.00	8.22	1.50	9.72	30	Pass
		11	**15**	**0.11**	**8.32**	**1.50**	**9.82**	30	Pass
	2437 MHz	1	15	0.00	8.61	1.50	10.11	30	Pass
		11	**15**	**0.11**	**8.93**	**1.50**	**10.43**	30	Pass
	2462 MHz	1	15	0.00	8.43	1.50	9.93	30	Pass
		11	**15**	**0.11**	**8.61**	**1.50**	**10.11**	30	Pass
802.11b CCK	2412 MHz	1	15	0.00	8.29	1.50	9.79	30	Pass
		11	**15**	**0.11**	**8.57**	**1.50**	**10.07**	30	Pass
	2437 MHz	1	15	0.00	8.79	1.50	10.29	30	Pass
		11	**15**	**0.11**	**10.02**	**1.50**	**11.52**	30	Pass
	2462 MHz	1	15	0.00	8.40	1.50	9.90	30	Pass
		11	**15**	**0.11**	**8.56**	**1.50**	**10.06**	30	Pass
802.11g NOHT	2412 MHz	6	15	0.07	11.64	1.50	13.14	30	Pass
		9	15	0.11	11.73	1.50	13.23	30	Pass
		12	15	0.15	11.66	1.50	13.16	30	Pass
		18	**15**	**0.53**	**12.08**	**1.50**	**13.58**	30	Pass
		24	15	0.53	11.95	1.50	13.45	30	Pass
		36	15	0.53	11.82	1.50	13.32	30	Pass
		48	15	0.53	11.80	1.50	13.30	30	Pass
		54	15	0.53	11.73	1.50	13.23	30	Pass
	2437 MHz	6	12	0.07	9.41	1.50	10.91	30	Pass
		9	12	0.11	9.53	1.50	11.03	30	Pass
		12	12	0.15	9.61	1.50	11.11	30	Pass
		18	**12**	**0.53**	**9.86**	**1.50**	**11.36**	30	Pass
		24	12	0.53	9.75	1.50	11.25	30	Pass
		36	12	0.53	9.64	1.50	11.14	30	Pass
		48	12	0.53	9.65	1.50	11.15	30	Pass
		54	12	0.53	9.55	1.50	11.05	30	Pass
	2462 MHz	6	15	0.07	12.14	1.50	13.64	30	Pass
		9	15	0.11	12.17	1.50	13.67	30	Pass
		12	15	0.15	12.18	1.50	13.68	30	Pass
		18	**15**	**0.53**	**12.48**	**1.50**	**13.98**	30	Pass
		24	15	0.53	12.39	1.50	13.89	30	Pass
		36	15	0.53	12.37	1.50	13.87	30	Pass
		48	15	0.53	12.12	1.50	13.62	30	Pass
		54	15	0.53	12.08	1.50	13.58	30	Pass

Mode	Channel/ Frequency (MHz)	Data Rate (Mbps)	PWR Level Setting	Duty Cycle Correction (dB)	Mode	Antenna Gain (max.) (dBi)	Calculated EIRP (dBm)	Limit (dBm)	Verdict
802.11n HT20	2412 MHz	mcs0	13	0.23	9.42	1.50	10.92	30	Pass
		mcs1	13	0.53	9.55	1.50	11.05	30	Pass
		mcs2	13	0.53	9.63	1.50	11.13	30	Pass
		mcs3	13	0.53	9.50	1.50	11.00	30	Pass
		mcs4	13	0.53	9.55	1.50	11.05	30	Pass
		mcs5	13	0.53	9.55	1.50	11.05	30	Pass
		mcs6	13	0.53	9.61	1.50	11.11	30	Pass
		mcs7	13	0.53	9.62	1.50	11.12	30	Pass
		mcs8	13	0.16	9.50	1.50	11.00	30	Pass
		mcs9	13	0.53	9.83	1.50	11.33	30	Pass
		mcs10	13	0.42	9.73	1.50	11.23	30	Pass
		mcs11	**13**	**0.53**	**9.95**	**1.50**	**11.45**	30	Pass
		mcs12	13	0.53	9.78	1.50	11.28	30	Pass
		mcs13	13	0.53	9.69	1.50	11.19	30	Pass
		mcs14	13	0.53	9.54	1.50	11.04	30	Pass
	2437 MHz	mcs0	13	0.23	10.07	1.50	11.57	30	Pass
		mcs1	13	0.53	10.23	1.50	11.73	30	Pass
		mcs2	13	0.53	10.38	1.50	11.88	30	Pass
		mcs3	13	0.53	10.20	1.50	11.70	30	Pass
		mcs4	13	0.53	10.37	1.50	11.87	30	Pass
		mcs5	13	0.53	10.22	1.50	11.72	30	Pass
		mcs6	13	0.53	10.28	1.50	11.78	30	Pass
		mcs7	13	0.53	10.19	1.50	11.69	30	Pass
		mcs8	13	0.16	10.36	1.50	11.86	30	Pass
		mcs9	**13**	**0.53**	**10.68**	**1.50**	**12.18**	30	Pass
		mcs10	13	0.42	10.42	1.50	11.92	30	Pass
		mcs11	13	0.53	10.53	1.50	12.03	30	Pass
		mcs12	13	0.53	10.62	1.50	12.12	30	Pass
		mcs13	13	0.53	10.12	1.50	11.62	30	Pass
		mcs14	13	0.53	9.78	1.50	11.28	30	Pass

Mode	Channel/ Frequency (MHz)	Data Rate (Mbps)	PWR Level Setting	Duty Cycle Correction (dB)	Mode	Antenna Gain (max.) (dBi)	Calculated EIRP (dBm)	Limit (dBm)	Verdict
802.11n HT20	2462 MHz	mcs0	15	0.23	11.38	1.50	12.88	30	Pass
		mcs1	15	0.53	11.65	1.50	13.15	30	Pass
		mcs2	15	0.53	11.68	1.50	13.18	30	Pass
		mcs3	15	0.53	11.57	1.50	13.07	30	Pass
		mcs4	15	0.53	11.59	1.50	13.09	30	Pass
		mcs5	15	0.53	11.67	1.50	13.17	30	Pass
		mcs6	15	0.53	11.75	1.50	13.25	30	Pass
		mcs7	15	0.53	11.61	1.50	13.11	30	Pass
		mcs8	15	0.16	11.96	1.50	13.46	30	Pass
		mcs9	**15**	**0.53**	**12.34**	**1.50**	**13.84**	30	Pass
		mcs10	15	0.42	12.26	1.50	13.76	30	Pass
		mcs11	15	0.53	12.13	1.50	13.63	30	Pass
		mcs12	15	0.53	11.77	1.50	13.27	30	Pass
		mcs13	15	0.53	11.61	1.50	13.11	30	Pass
		mcs14	15	0.53	11.66	1.50	13.16	30	Pass
80211n HT40	2422 MHz	mcs0	13	0.23	10.25	1.50	11.75	30	Pass
		mcs1	13	0.53	10.42	1.50	11.92	30	Pass
		mcs2	13	0.53	10.40	1.50	11.90	30	Pass
		mcs3	13	0.53	10.45	1.50	11.95	30	Pass
		mcs4	**13**	**0.53**	**10.52**	**1.50**	**12.02**	30	Pass
		mcs5	13	0.53	10.08	1.50	11.58	30	Pass
		mcs6	13	0.53	9.84	1.50	11.34	30	Pass
		mcs7	13	0.53	9.53	1.50	11.03	30	Pass
		mcs8	13	0.16	9.77	1.50	11.27	30	Pass
		mcs9	13	0.53	10.04	1.50	11.54	30	Pass
		mcs10	13	0.42	9.94	1.50	11.44	30	Pass
		mcs11	13	0.53	9.96	1.50	11.46	30	Pass
		mcs12	13	0.53	8.86	1.50	10.36	30	Pass
		mcs13	13	0.53	8.51	1.50	10.01	30	Pass
		mcs14	13	0.53	8.59	1.50	10.09	30	Pass

Mode	Channel/ Frequency (MHz)	Data Rate (Mbps)	PWR Level Setting	Duty Cycle Correction (dB)	Mode	Antenna Gain (max.) (dBi)	Calculated EIRP (dBm)	Limit (dBm)	Verdict
802.11n HT40	2437 MHz	mcs0	13	0.23	10.58	1.50	12.08	30	Pass
		mcs1	13	0.53	10.87	1.50	12.37	30	Pass
		mcs2	**13**	**0.53**	**10.88**	**1.50**	**12.38**	30	Pass
		mcs3	13	0.53	10.81	1.50	12.31	30	Pass
		mcs4	13	0.53	10.86	1.50	12.36	30	Pass
		mcs5	13	0.53	10.52	1.50	12.02	30	Pass
		mcs6	13	0.53	10.30	1.50	11.80	30	Pass
		mcs7	13	0.53	9.97	1.50	11.47	30	Pass
		mcs8	13	0.16	10.13	1.50	11.63	30	Pass
		mcs9	13	0.53	10.43	1.50	11.93	30	Pass
		mcs10	13	0.42	10.48	1.50	11.98	30	Pass
		mcs11	13	0.53	10.29	1.50	11.79	30	Pass
		mcs12	13	0.53	9.19	1.50	10.69	30	Pass
		mcs13	13	0.53	8.97	1.50	10.47	30	Pass
		mcs14	13	0.53	9.02	1.50	10.52	30	Pass
	2452 MHz	mcs0	13	0.23	10.96	1.50	12.46	30	Pass
		mcs1	**13**	**0.53**	**11.17**	**1.50**	**12.67**	30	Pass
		mcs2	13	0.53	11.12	1.50	12.62	30	Pass
		mcs3	13	0.53	11.12	1.50	12.62	30	Pass
		mcs4	13	0.53	11.09	1.50	12.59	30	Pass
		mcs5	13	0.53	10.70	1.50	12.20	30	Pass
		mcs6	13	0.53	10.74	1.50	12.24	30	Pass
		mcs7	13	0.53	10.17	1.50	11.67	30	Pass
		mcs8	13	0.16	10.38	1.50	11.88	30	Pass
		mcs9	13	0.53	10.76	1.50	12.26	30	Pass
		mcs10	13	0.42	10.51	1.50	12.01	30	Pass
		mcs11	13	0.53	10.45	1.50	11.95	30	Pass
		mcs12	13	0.53	9.39	1.50	10.89	30	Pass
		mcs13	13	0.53	9.21	1.50	10.71	30	Pass
		mcs14	13	0.53	9.22	1.50	10.72	30	Pass

Example screen shots from the power meter:
Low Channel – 802.11b NOHT, (2412MHz)

combined (both chains)

4 Power Spectral Density

4.1 *Test Result*

Test Description	Test Specification		Test Result
Power Spectral Density	15.247(e)	RSS-247 S5.2(b)	Compliant

4.2 *Test Method*

Power spectral density measurements were recorded using the procedures from ANSI C63.10: 2013 clause 11.10 and KDB 558074 D01 Measurement Guidance v05r02.

1. Set analyzer center frequency to DTS channel center frequency.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance .
3. Set the span to 1.5 times the DTS channel bandwidth.
4. Set the RBW = 3 kHz & VBW = 10 kHz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level.

Limit
The limit is 8 dBm.

4.3 *Test Site*

Environmental Conditions

Temperature: 18 – 22.4 °C
Relative Humidity: 47 - 62 %

4.4 *Test Equipment*

Test Dates: Feb. 21 – 22, 2024 Tester: Andreas Gillmeier

Asset No.	Type of Equipment	Model	Serial No.	Manufacturer	Cal Date	Cal Due Date
Conducted Testing						
2003	Signal Analyzer	N9030B	MY61330812	Keysight	01/29/2024	01/29/2025
-	Test Software	Radio Test Software	v.23	SGS Taiwan	N/A	-
2036	Temp/Humidity Data Logger	GSP-8	CMA231100002	Elitech	05/24/2023	

4.5 *Test Setup Photographs*

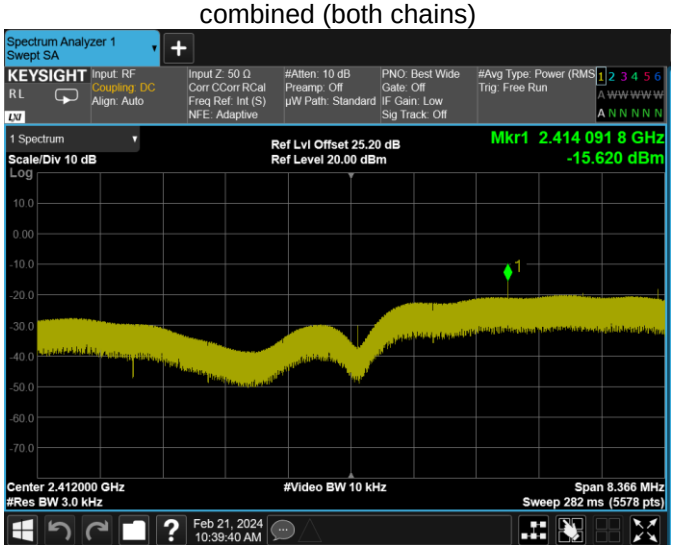
Test setup photographs are located in a separate exhibit.

4.6 *Test Data*

Mode	Frequency (MHz)	Power Level	Data Rate (Mbps)	Duty Cycle Correction (dB)	Power Spectral Density (dBm/3 kHz) (including Duty Cycle Correction)		Verdict
					Both Antennas Combined	Limit	
802.11b NOHT	2412	15	1	0	-15.62	8	Pass
	2437	15	11	0.11	-15.39	8	Pass
	2462	15	11	0.11	-15.36	8	Pass
802.11b CCK	2412	15	11	0.11	-15.74	8	Pass
	2437	15	11	0.11	-15.61	8	Pass
	2462	15	11	0.11	-15.35	8	Pass
802.11g	2412	15	9	0.11	-19.52	8	Pass
	2437	12	12	0.15	-20.84	8	Pass
	2462	15	6	0	-17.97	8	Pass
802.11n (HT20)	2412	13	mcs11	0.53	-13.32	8	Pass
	2437	13	mcs8	0.16	-20.83	8	Pass
	2462	15	mcs10	0.42	-18.38	8	Pass
802.11n (HT40)	2422	13	mcs0	0.23	-21.36	8	Pass
	2437	13	mcs0	0.23	-22.77	8	Pass
	2452	13	mcs0	0.23	-21.24	8	Pass

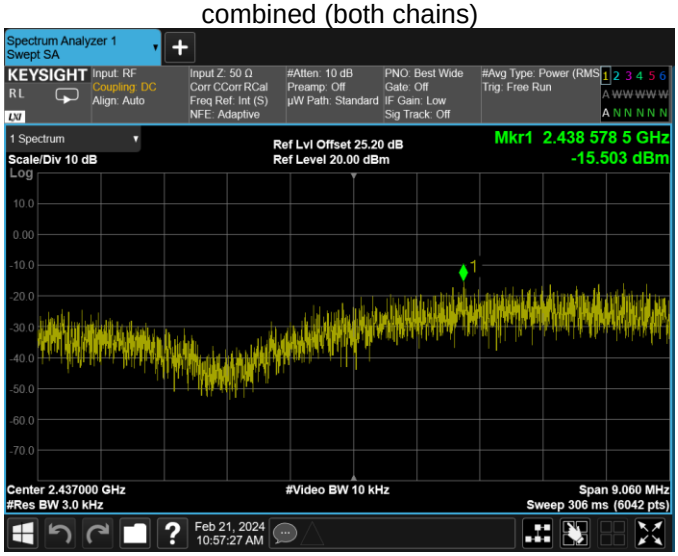
Low Channel – 802.11b NOHT, (2412MHz)

combined (both chains)



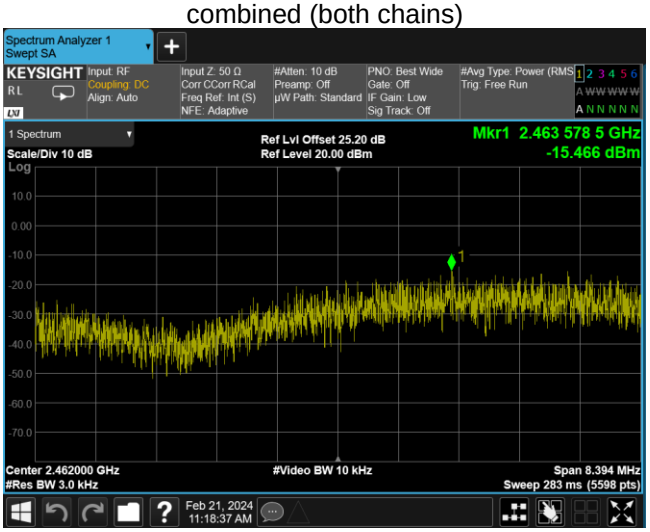
Mid Channel – 802.11b NOHT, (2437MHz)

combined (both chains)



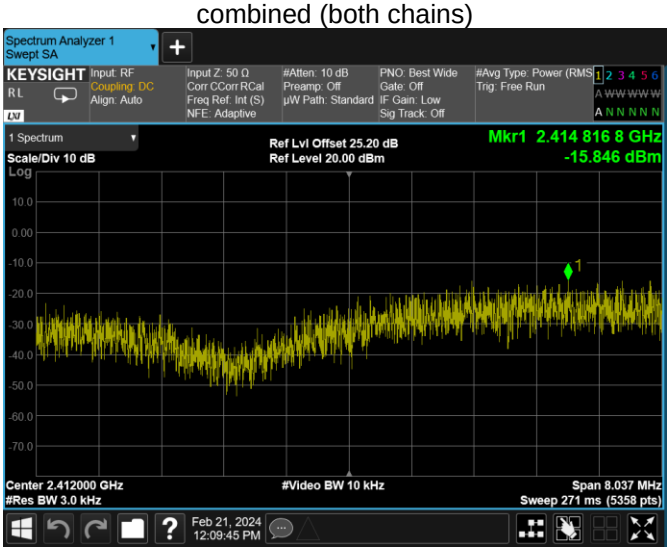
High Channel – 802.11b NOHT, (2462MHz)

combined (both chains)



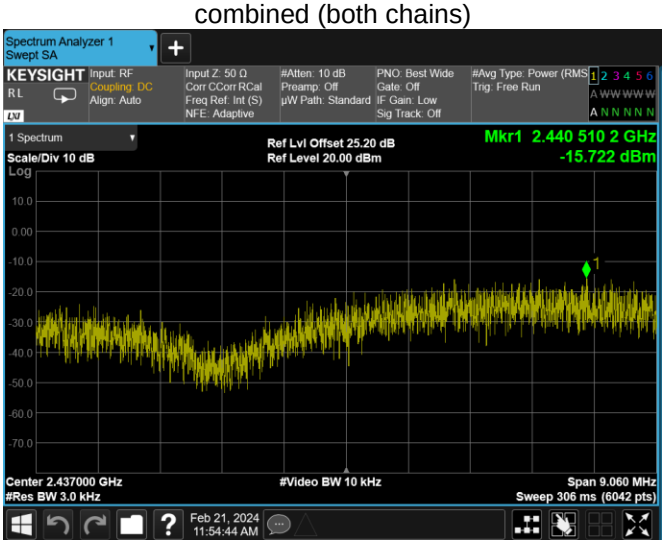
Low Channel – 802.11b CCK, (2412MHz)

combined (both chains)



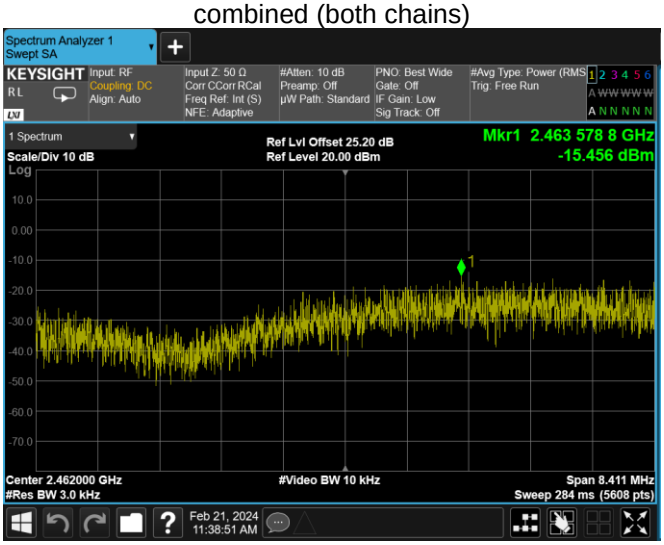
Mid Channel – 802.11b CCK, (2437MHz)

combined (both chains)



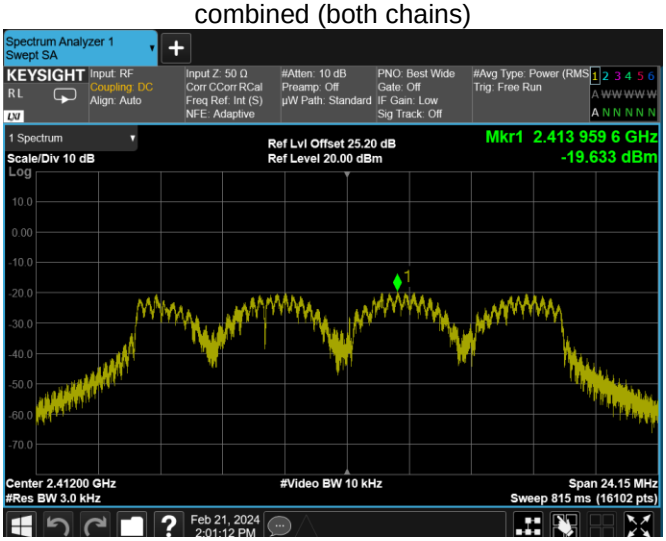
High Channel – 802.11b CCK, (2462MHz)

combined (both chains)



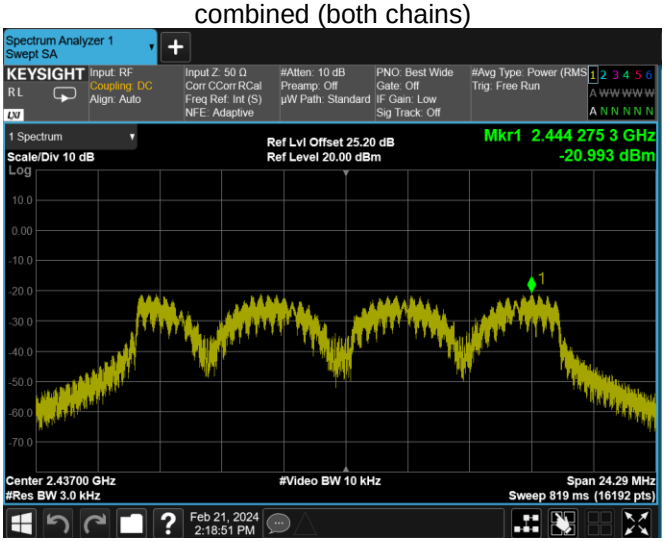
Low Channel – 802.11g NOHT, (2412MHz)

combined (both chains)



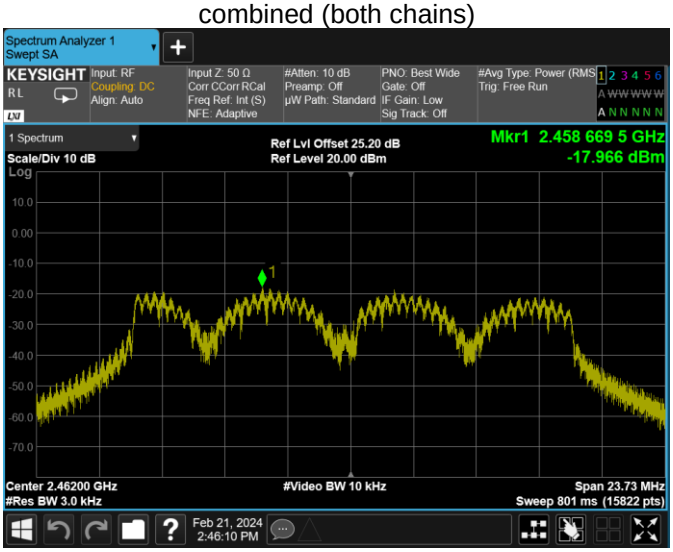
Mid Channel – 802.11g NOHT, (2437MHz)

combined (both chains)



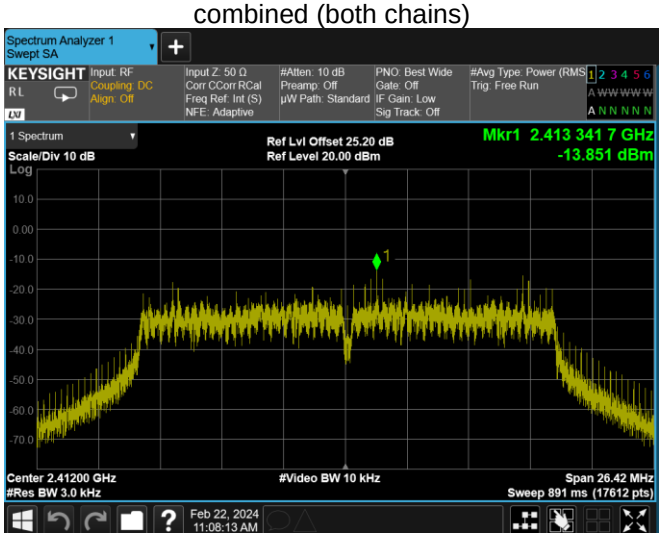
High Channel – 802.11g NOHT, (2462MHz)

combined (both chains)



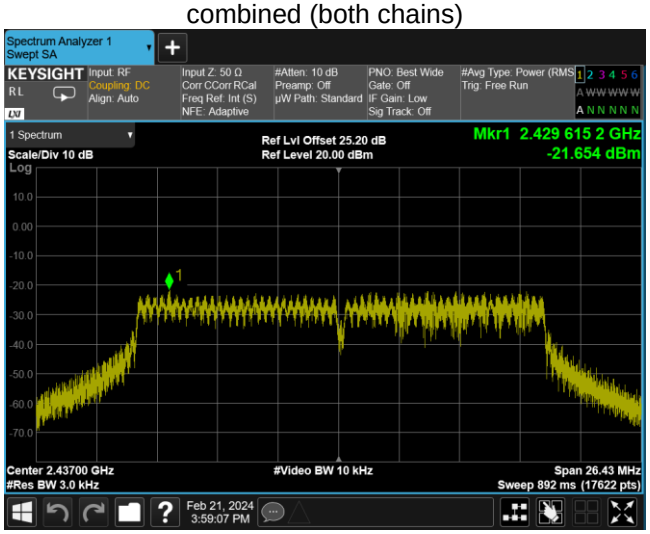
Low Channel – 802.11n HT20, (2412MHz)

combined (both chains)



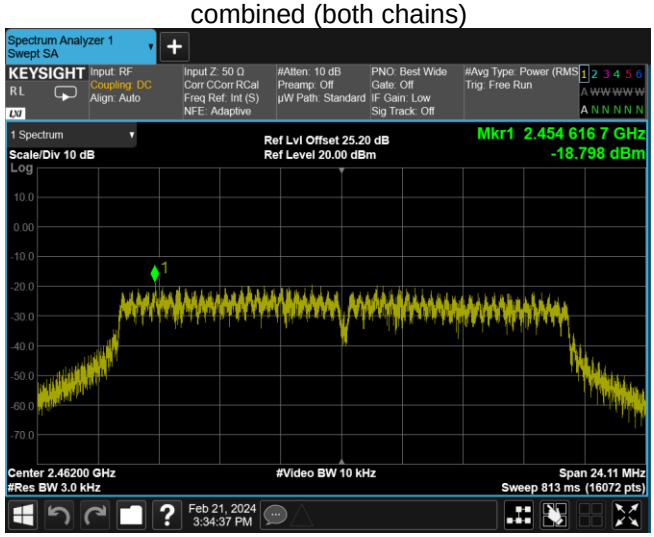
Mid Channel – 802.11n HT20, (2437MHz)

combined (both chains)



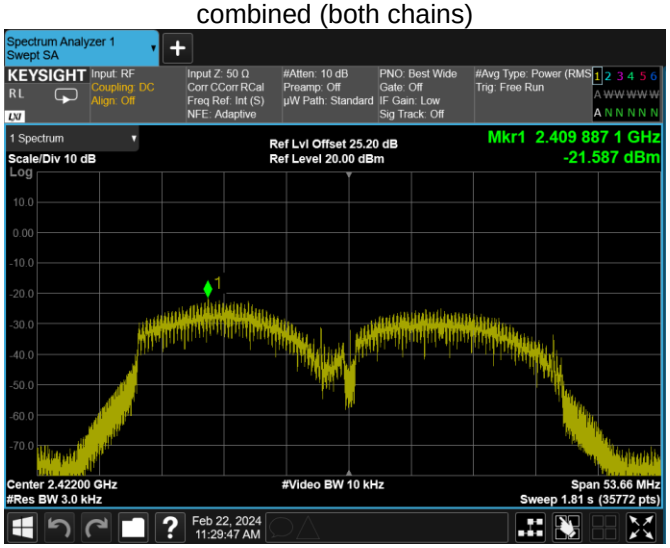
High Channel – 802.11n HT20, (2462MHz)

combined (both chains)



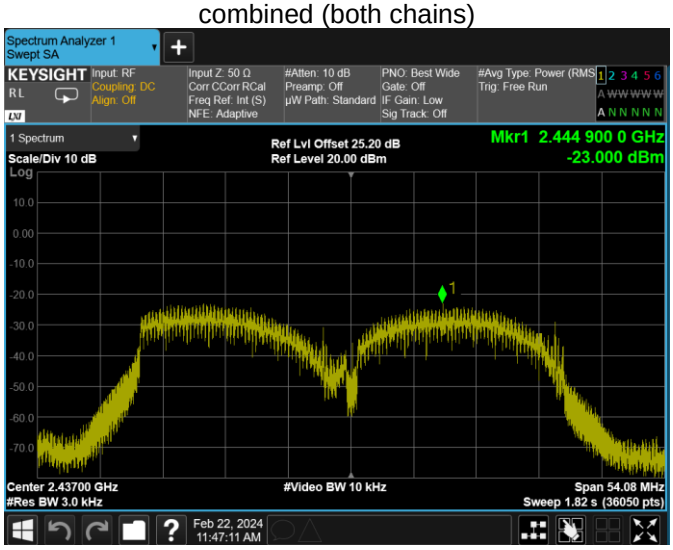
Low Channel – 802.11n HT40, (2422MHz)

combined (both chains)



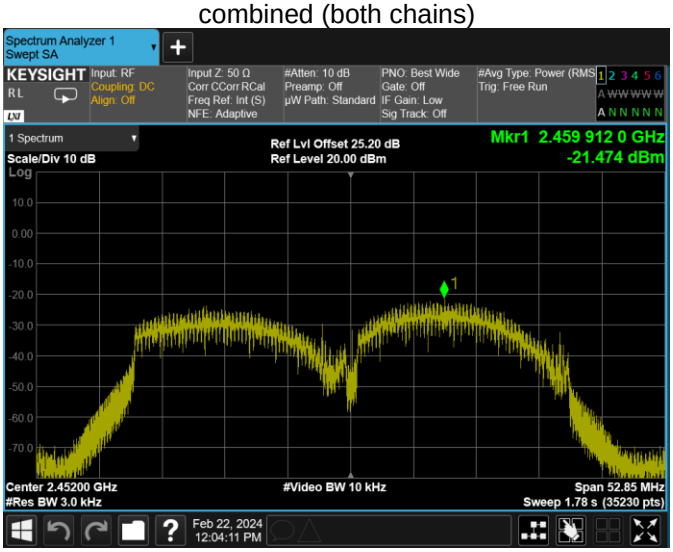
Mid Channel – 802.11n HT40, (2437MHz)

combined (both chains)



High Channel – 802.11n HT40, (2452MHz)

combined (both chains)



5 Conducted Spurious Emissions / Band Edge

5.1 *Test Result*

Test Description	Test Specification		Test Result
Conducted Spurious Emissions / Band Edge	15.247(d)	RSS-247 S5.5	Compliant

5.2 *Test Method*

Spurious emissions in non-restricted frequency bands were recorded using the methods defined in ANSI C63.10: 2013 clause 11.11 and KDB 558074 D01 Measurement Guidance v05r02.

Lowest, middle, and highest channels were investigated.

Because the maximum conducted peak output power was used to determine compliance with the output power limits, the limit in any 100 kHz band outside of the authorized band is 20 dB below the maximum in-band peak level.

Reference Level of Emission Limit:

1. Set analyzer center frequency to DTS channel center frequency.
2. The testing follows the Measurement Procedure of FCC KDB 558074 D01 DTS Meas. Guidance .
3. Set the span to 1.5 times the DTS channel bandwidth.
4. Set the RBW = 100kHz & VBW = 300 kHz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level.

5.3 *Test Site*

Environmental Conditions

Temperature: 18 – 23.3 °C
Relative Humidity: 45 - 62 %

5.4 *Test Equipment*

Test Dates: Feb. 21 – March 8, 2024 Tester: Andreas Gillmeier

Asset No.	Type of Equipment	Model	Serial No.	Manufacturer	Cal Date	Cal Due Date
Conducted Testing						
2003	Signal Analyzer	N9030B	MY61330812	Keysight	01/29/2024	01/29/2025
-	Test Software	Radio Test Software	v.23	SGS Taiwan	N/A	-
2036	Temp/Humidity Data Logger	GSP-8	CMA231100002	Elitech	05/24/2023	

5.5 *Test Data*

Mode	Frequency (MHz)	Power Level	Data Rate (Mbps)	Level of Reference (dBm)				Verdict
				Ch0	Limit Ch 0 (dBm)	Ch1	Limit Ch 1 (dBm)	
802.11b NOHT	2412	15	1	0.44	-29.56	1.10	-28.9	Pass
	2437	15	11	0.89	-29.11	1.74	-28.26	Pass
	2462	15	11	0.48	-29.52	1.58	-28.42	Pass
802.11b CCK	2412	15	11	0.41	-29.59	1.61	-28.39	Pass
	2437	15	11	0.83	-29.17	1.85	-28.15	Pass
	2462	15	11	0.17	-29.83	1.71	-28.29	Pass
802.11g	2412	15	9	-3.08	-33.08	-2.3	-32.3	Pass
	2437	12	12	-2.9	-32.9	-4.37	-34.37	Pass
	2462	15	6	-5.33	-35.33	-1.29	-31.29	Pass
802.11n (HT20)	2412	13	mcs11	-4.95	-34.95	-4.15	-34.15	Pass
	2437	13	mcs8	-4.53	-34.53	-3.64	-33.64	Pass
	2462	15	mcs10	-2.72	-32.72	-0.99	-30.99	Pass
802.11n (HT40)	2422	13	mcs0	-6.84	-36.84	-6.48	-36.48	Pass
	2437	13	mcs0	-5.88	-35.88	-5.88	-35.88	Pass
	2452	13	mcs0	-6.51	-36.51	-6.51	-36.51	Pass