RF Test Report

Project Number:	**5028090**	**Offer Number:**	**SUW-202302004095**
Report Number:	**5028090EMC09**	**Revision Level:**	**1**
Client:	**UTEC, Inc.**		

Equipment Under Test:	**Refrigerated Shipping Container Controller**
Product Name:	**Micro-Link 5 Controller**
Model:	**MICROLINK5B**
FCC ID:	**2AK6N-MICROLINK5B**
IC:	**703A-MICROLINK5B**

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:	**17 November 2023**
Test Result:	**Compliant**

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER: 3212.01
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: Daniel Alvarez, RF/EMC Sr. Staff Engineer

Reviewed by: Martin Taylor, Sr RF/EMC Engineer

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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	Compliant
Antenna Requirement	15.203	RSS-GEN S6.8	Compliant (1)

(1) The device uses a PCB trace PIFA antenna which cannot be replaced by the end user.

1.1 *Modifications Required for Compliance*

None

2 General Information

2.1 *Client Information*

Name:	UTEC, Inc.
Address:	111 E. Wayne Street, Suite 800
City, State, Zip, Country:	Fort Wayne, IN 46802, USA

2.2 *Test Laboratory*

Name:	SGS North America, Inc.
Address:	620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country:	Suwanee, GA 30024, USA
Accrediting Body:	A2LA
Type of lab:	Testing Laboratory
Certificate Number:	3212.01
Designation Number:	US1126
CAB Identifier:	US0186

2.3 *General Information of EUT*

Equipment Under Test:	Refrigerated Shipping Container Controller
Product Name:	Micro-Link 5 Controller
Model:	MICROLINK5B
Serial Numbers:	4120W008381 (Conducted Sample) 3821W039479 (Radiated Sample)
FCC ID:	2AK6N-MICROLINK5B
IC:	703A-MICROLINK5B
Frequency Range:	2412 – 2462 MHz
Data Modes:	WLAN 802.11b, 802.11g, 802.11nHT20, 802.11nHT40
Antenna Gain*:	ANT1: PCB Trace PIFA Antenna (WLAN & Bluetooth); 4.54dBi ANT2: PCB Trace PIFA Antenna (WLAN MIMO only); 4.54dBi
Rated Voltage:	$5V_{DC}$ to Micro Board USB port or Dual phase $18V_{AC}$ to IO Board
Test Voltage:	$5V_{DC}$ to Micro Board USB port (for Conducted Measurements) Dual phase $18V_{AC}$ to IO Board (for Radiated Measurements)
Sample Received Date:	03 February 2023
Dates of testing:	4-13 April 2023

*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.

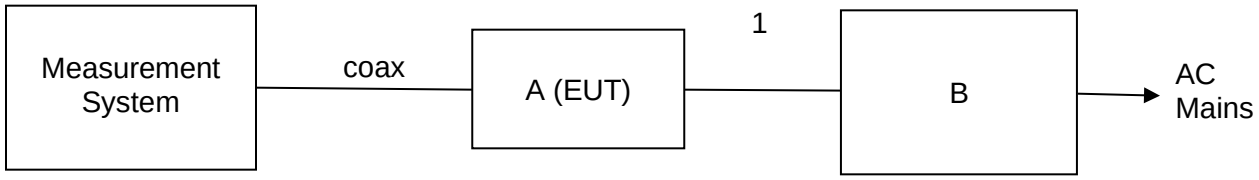
2.4 *Operating Modes and Conditions*

The EUT was running test mode firmware with TI tools 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:

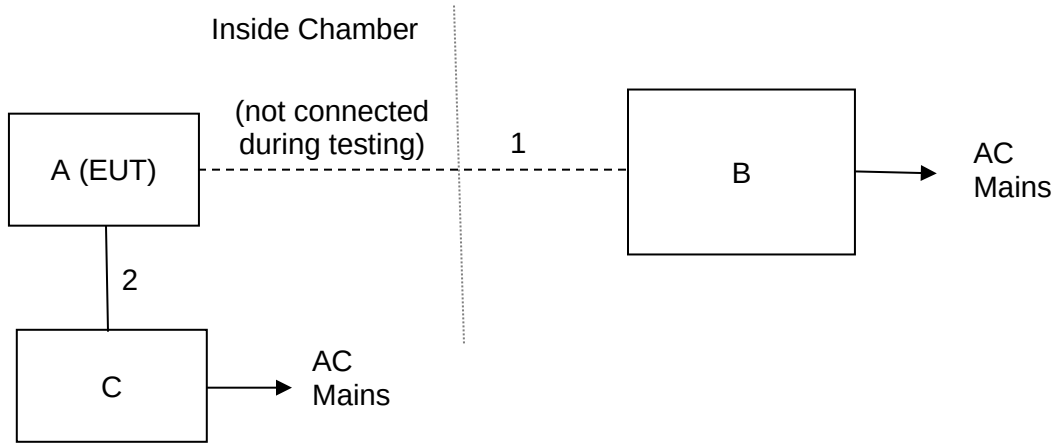
- 802.11b, 5Mbps
- 802.11g, 6Mbps
- 802.11nHT20, MCS6
- 802.11nHT40, MCS4

The commanded power setting for all testing was 20000.

2.5 *EUT Connection Block Diagram – Conducted Measurements*



2.6 *EUT Connection Block Diagram – Radiated Measurements*



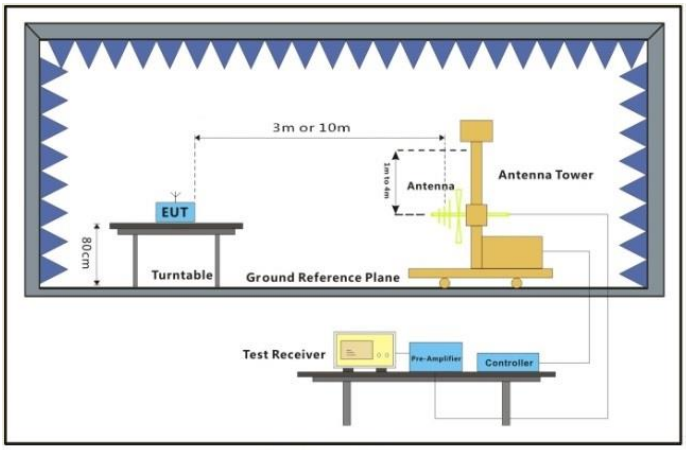
2.7 *System Configurations*

Device Reference	Manufacturer	Description	Model Number	Serial Number
A	UTEC, Inc.	Micro-Link 5 Controller (EUT)	MICROLINK5B	4120W008381 3821W039479
B	Lenovo	Laptop Computer	T420	R8-X9XFV
C	UTEC, Inc.	Transformer Box	(none)	(none)

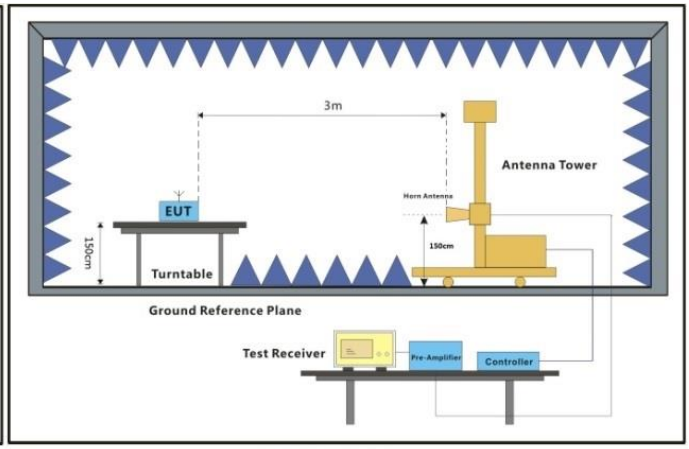
2.8 *Cable List*

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
1	USB	EUT	Laptop Computer	1.0	N	N
2	AC Power (5-wire harness)	EUT	Transformer Box	0.7	N	N

2.9 *Test Setup Diagrams (Radiated)*



30MHz-1GHz



Above 1GHz

3 Bandwidth

3.1 *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

3.2 *Test Method*

The procedures from ANSI C63.10: 2013 clause 11.8 and 558074 D01 DTS Meas Guidance v05r02 were used to determine the 6 dB bandwidth.

The procedures from ANSI C63.10: 2013 clause 6.9.2 were used to measure the 99% Occupied Bandwidth.

3.3 *Test Site*

EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	20.3 °C
Relative Humidity:	33.6 %
Atmospheric Pressure:	98.2 kPa

3.4 *Test Equipment*

Test End Date: 11-Apr-2023 Tester: DA

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	7-Dec-2022	7-Dec-2023
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	13-Mar-2023	13-Mar-2024
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20109	13-Mar-2023	13-Mar-2024
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	CNR	CNR

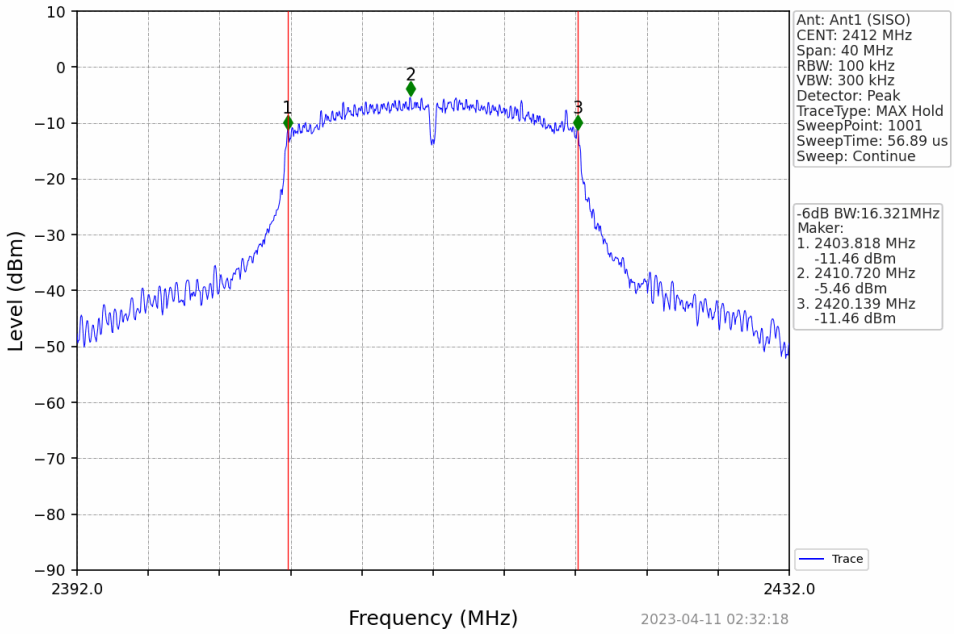
Software Profile:
TSTPASS Version: 2.0

3.5 *Test Data – 6dB Bandwidth*

Mode	TX Type	Frequency (MHz)	ANT	6dB Bandwidth (MHz)		Verdict
				Result	Limit	
802.11b	SISO	2412	1	10.091	>=0.5	Pass
		2437	1	10.100	>=0.5	Pass
		2462	1	10.075	>=0.5	Pass
802.11g	SISO	2412	1	16.321	>=0.5	Pass
		2437	1	16.320	>=0.5	Pass
		2462	1	15.136	>=0.5	Pass
802.11n (HT20)	SISO	2412	1	15.444	>=0.5	Pass
		2437	1	15.437	>=0.5	Pass
		2462	1	15.151	>=0.5	Pass
802.11n (HT40)	SISO	2422	1	35.120	>=0.5	Pass
		2437	1	33.924	>=0.5	Pass
		2452	1	35.091	>=0.5	Pass
802.11n (HT20)	MIMO	2412	1	15.154	>=0.5	Pass
		2437	1	15.145	>=0.5	Pass
		2462	1	15.196	>=0.5	Pass

Sample Plot

Low Channel – 802.11g (2412MHz)

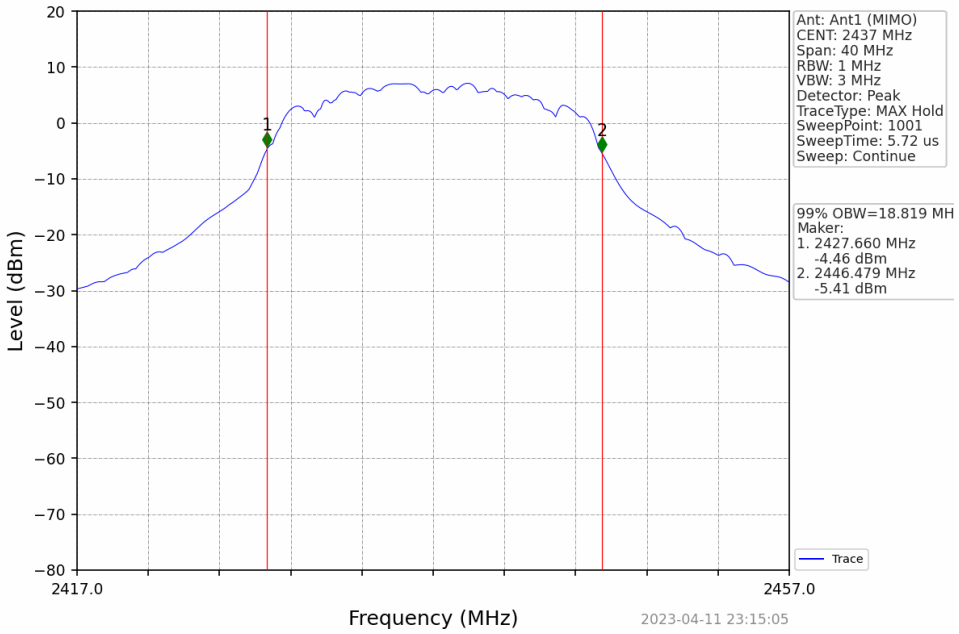


3.6 *Test Data – 99% Bandwidth*

Mode	TX Type	Frequency (MHz)	ANT	99% Occupied Bandwidth (MHz) Result	Verdict
802.11b	SISO	2412	1	14.674	Pass
		2437	1	14.645	Pass
		2462	1	14.626	Pass
802.11g	SISO	2412	1	17.291	Pass
		2437	1	19.648	Pass
		2462	1	17.277	Pass
802.11n (HT20)	SISO	2412	1	18.433	Pass
		2437	1	18.971	Pass
		2462	1	18.071	Pass
802.11n (HT40)	SISO	2422	1	37.448	Pass
		2437	1	38.817	Pass
		2452	1	37.426	Pass
802.11n (HT20)	MIMO	2412	1	18.078	Pass
		2437	1	18.819	Pass
		2462	1	18.185	Pass

Sample Plot

Low Channel – 802.11n (HT20) MIMO (2412MHz)



4 Output Power

4.1 *Test Result*

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

4.2 *Test Method*

Fundamental peak 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)

4.3 *Test Site*

EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	20.3 °C
Relative Humidity:	33.6 %
Atmospheric Pressure:	98.2 kPa

4.4 *Test Equipment*

Test End Date: 11-Apr-2023 Tester: DA

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	7-Dec-2022	7-Dec-2023
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	13-Mar-2023	13-Mar-2024
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20109	13-Mar-2023	13-Mar-2024
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	CNR	CNR

Software Profile:
TSTPASS Version: 2.0

4.5 *Test Data - SISO*

Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
802.11b	SISO	2412	12.67	<=30	Pass
		2437	13.48	<=30	Pass
		2462	14.00	<=30	Pass
802.11g	SISO	2412	14.49	<=30	Pass
		2437	18.69	<=30	Pass
		2462	15.37	<=30	Pass
802.11n (HT20)	SISO	2412	14.38	<=30	Pass
		2437	15.25	<=30	Pass
		2462	15.06	<=30	Pass
802.11n (HT40)	SISO	2422	12.91	<=30	Pass
		2437	14.55	<=30	Pass
		2452	13.79	<=30	Pass
Note1: Antenna Gain: Ant1: 4.54dBi					

4.6 *Test Data - MIMO*

Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)				Verdict
			ANT1	ANT2	MIMO	Limit	
802.11n (HT20)	MIMO	2412	14.72	16.24	18.56	<=30	Pass
		2437	16.23	19.38	21.09	<=30	Pass
		2462	16.03	15.86	18.96	<=30	Pass
Note1: Antenna Gain: Ant1: 4.54dBi; Ant2: 4.54dBi Note2: Directional Gain: Uncorrelated (Directional Gain = Ant Gain) Note3: HT40 MIMO is not supported							

Directional gain for ANT1 and ANT2 is 4.54 dBi (Uncorrelated)

Formulas below are referenced from KDB 662911 DO1 Multiple Transmitter Output

(i) If transmit signals are *correlated*, then

Directional gain = $10 \log[(10^{G_1/20} + 10^{G_2/20} + \ldots + 10^{G_N/20})^2 / N_{ANT}]$ dBi [Note the "20"s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.]

(ii) If all transmit signals are *completely uncorrelated*, then

Directional gain = $10 \log[(10^{G_1/10} + 10^{G_2/10} + \ldots + 10^{G_N/10})/N_{ANT}]$ dBi

5 Power Spectral Density

5.1 *Test Result*

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

5.2 *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.

Limit
The limit is 8 dBm.

5.3 *Test Site*

Environmental Conditions

Temperature:	20.3 °C
Relative Humidity:	33.6 %
Atmospheric Pressure:	98.2 kPa

5.4 *Test Equipment*

Test End Date: 11-Apr-2023 Tester: DA

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	7-Dec-2022	7-Dec-2023
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	13-Mar-2023	13-Mar-2024
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20109	13-Mar-2023	13-Mar-2024
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	CNR	CNR

Software Profile: TSTPASS Version: 2.0

5.5 *Test Data - SISO*

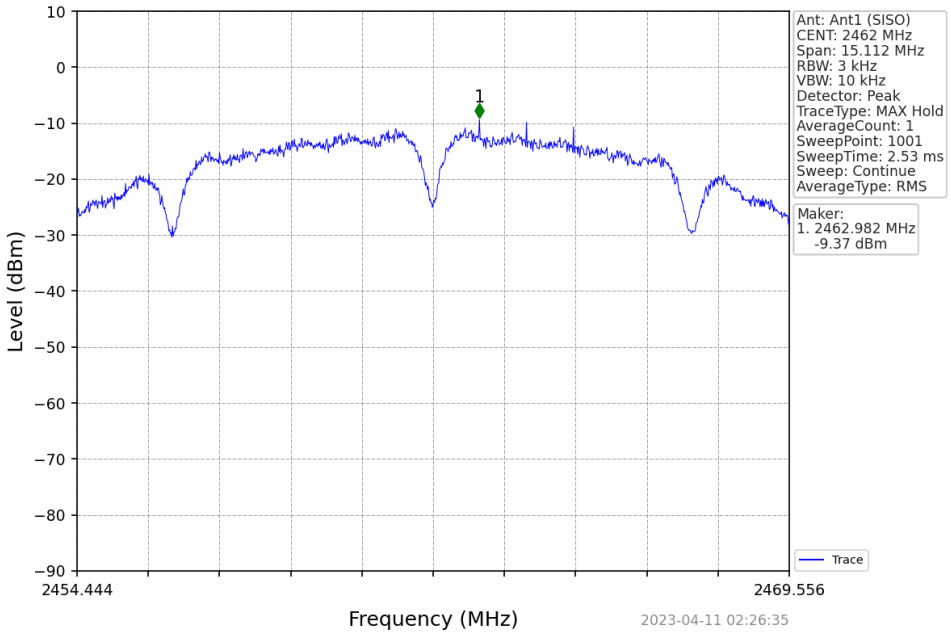
Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)		Verdict
			ANT1	Limit	
802.11b	SISO	2412	-10.65	<=8	Pass
		2437	-9.67	<=8	Pass
		2462	-9.37	<=8	Pass
802.11g	SISO	2412	-15.71	<=8	Pass
		2437	-12.44	<=8	Pass
		2462	-15.38	<=8	Pass
802.11n (HT20)	SISO	2412	-17.84	<=8	Pass
		2437	-16.66	<=8	Pass
		2462	-16.08	<=8	Pass
802.11n (HT40)	SISO	2422	-21.51	<=8	Pass
		2437	-20.40	<=8	Pass
		2452	-21.13	<=8	Pass
Note1: Antenna Gain: Ant1: 4.54dBi;					

5.6 *Test Data - MIMO*

Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)				Verdict
			ANT1	ANT2	MIMO	Limit	
802.11n (HT20)	MIMO	2412	-16.43	-14.37	-12.97	<=8	Pass
		2437	-15.21	-11.88	-10.52	<=8	Pass
		2462	-15.28	-15.57	-12.91	<=8	Pass
Note1: Antenna Gain: Ant1: 4.54dBi; Ant2: 4.54dBi; Note2: Directional Gain: Uncorrelated (Directional Gain = Ant Gain)							

Sample Plot

Mid Channel – 802.11b, Port ANT1 (2462MHz)



6 Conducted Spurious Emissions / Band Edge

6.1 *Test Result*

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

6.2 *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.

6.3 *Test Site*

Environmental Conditions

Temperature:	20.3 °C
Relative Humidity:	33.6 %
Atmospheric Pressure:	98.2 kPa

6.4 *Test Equipment*

Test End Date: 11-Apr-2023 Tester: DA

Equipment	Model	Manufacturer	Asset	Cal Date	Cal Due Date
SIGNAL ANALYZER (TS8997)	FSV30	ROHDE & SCHWARZ	B085749	7-Dec-2022	7-Dec-2023
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20108	13-Mar-2023	13-Mar-2024
RF CABLE SMA TO SMA, 0.01-40GHZ	084-0505-059	TELEDYNE STORM MICROWAVE	20109	13-Mar-2023	13-Mar-2024
TSTPASS SWITCHBOX	SB2	TSTPASS	23009	CNR	CNR

Software Profile:
TSTPASS Version: 2.0

6.5 *Test Data - SISO*

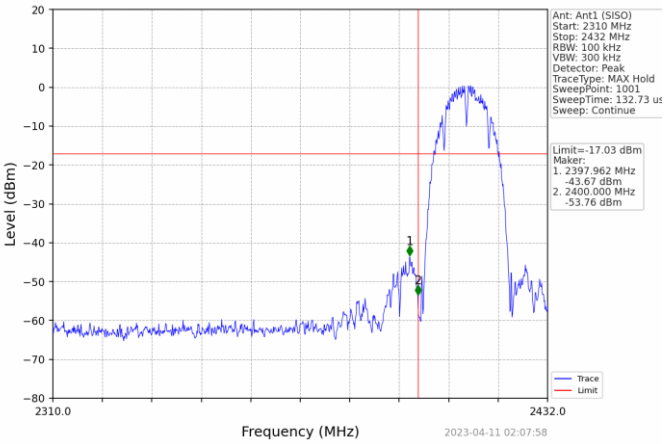
Mode	TX Type	Frequency (MHz)	ANT	Level of Reference (dBm)	Limit (dBm)	Verdict
802.11b	SISO	2412	1	2.97	-17.03	Pass
		2437	1	2.97	-17.03	Pass
		2462	1	2.97	-17.03	Pass
802.11g	SISO	2412	1	0.92	-19.08	Pass
		2437	1	0.92	-19.08	Pass
		2462	1	0.92	-19.08	Pass
802.11n (HT20)	SISO	2412	1	-1.87	-21.87	Pass
		2437	1	-1.87	-21.87	Pass
		2462	1	-1.87	-21.87	Pass
802.11n (HT40)	SISO	2422	1	-5.13	-25.13	Pass
		2437	1	-5.13	-25.13	Pass
		2452	1	-5.13	-25.13	Pass
Note1: Refer to FCC Part 15.247 (d) and ANSI C63.10-2013, the channel contains the maximum PSD level was used to establish the reference level.						

6.6 *Test Data - MIMO*

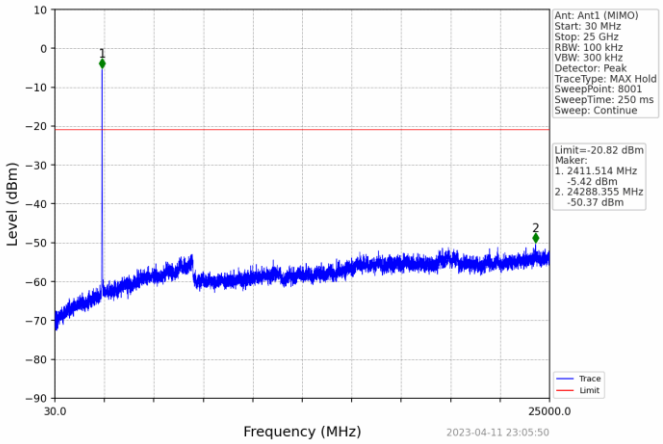
Mode	TX Type	Frequency (MHz)	ANT	Level of Reference (dBm)	Limit (dBm)	Verdict
802.11n (HT20)	MIMO	2412	1	-0.82	-20.82	Pass
			2	2.46	-17.54	Pass
		2437	1	-0.82	-20.82	Pass
			2	2.46	-17.54	Pass
		2462	1	-0.82	-20.82	Pass
			2	2.46	-17.54	Pass
Note1: Refer to FCC Part 15.247 (d) and ANSI C63.10-2013, the channel contains the maximum PSD level was used to establish the reference level.						

802.11b – (ANT1)

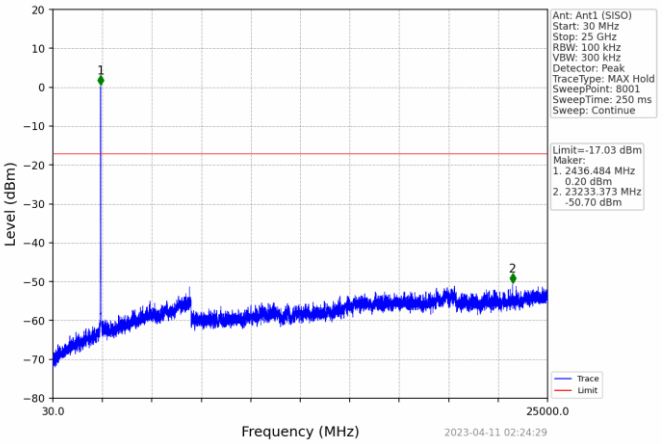
Lower Band Edge - Low Channel (2412MHz)



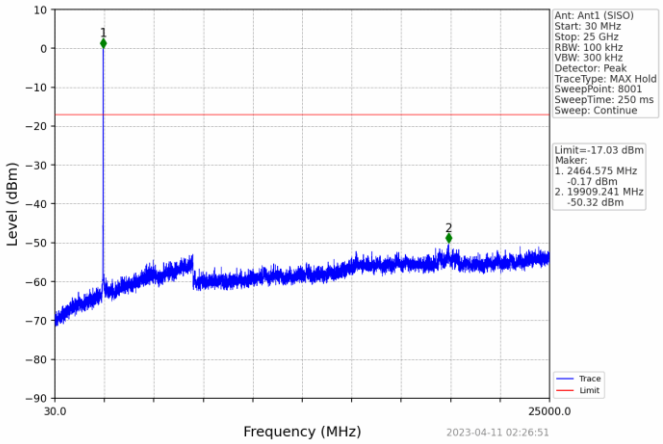
Full Spectrum - Low Channel (2412MHz)



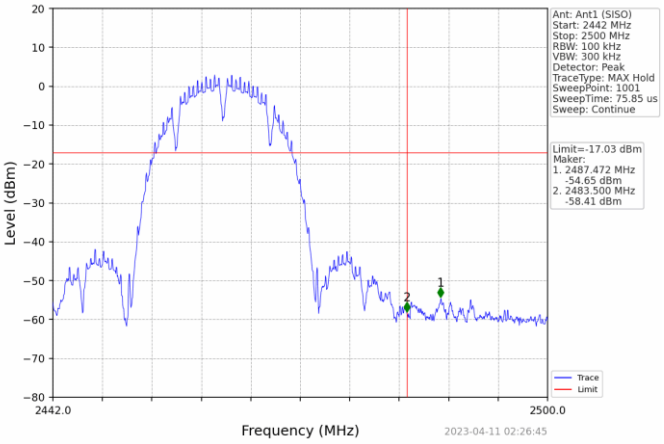
Full Spectrum - Mid Channel (2437MHz)



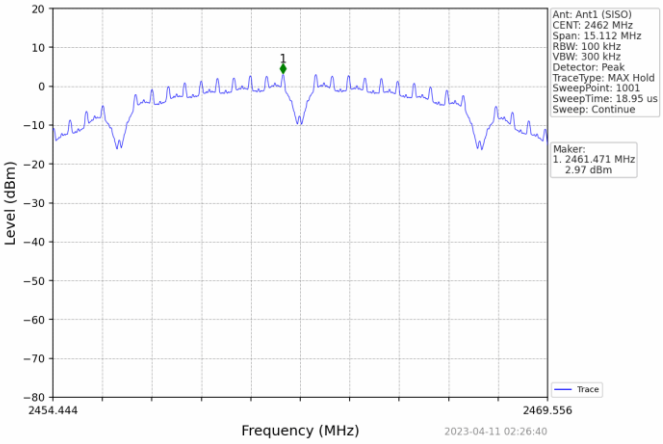
Full Spectrum - High Channel (2462MHz)



Upper Band Edge – High Channel (2462MHz)

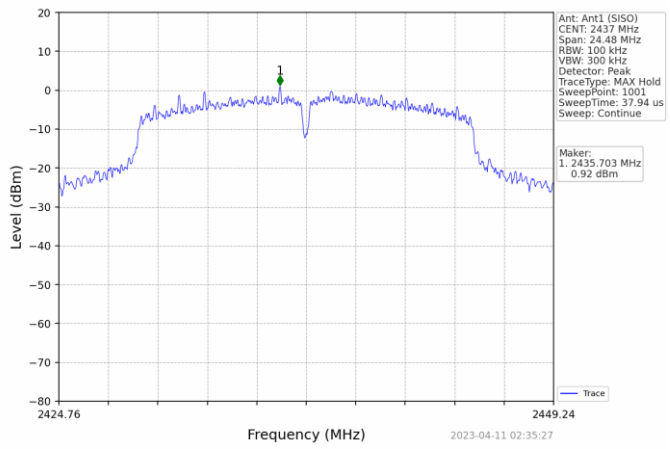


In-Band Reference – 2462MHz

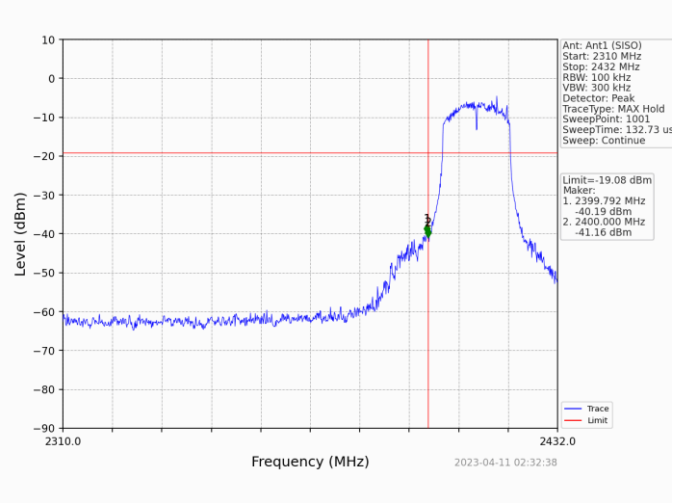


802.11g – (ANT1)

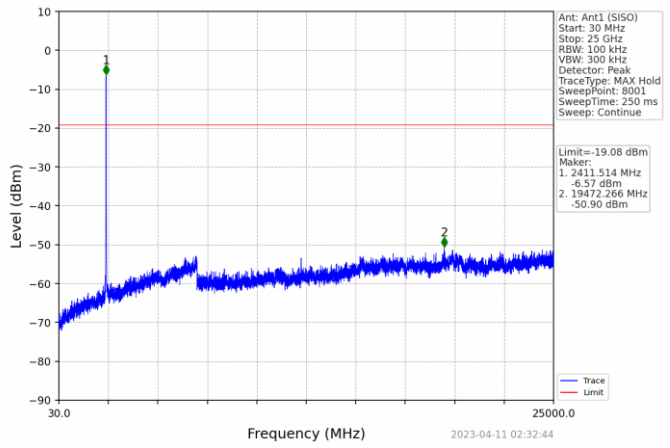
In-Band Reference – 2437MHz



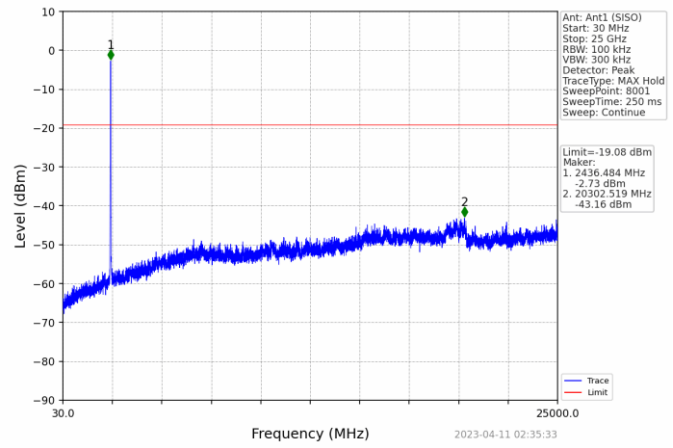
Lower Band Edge - Low Channel (2412MHz)



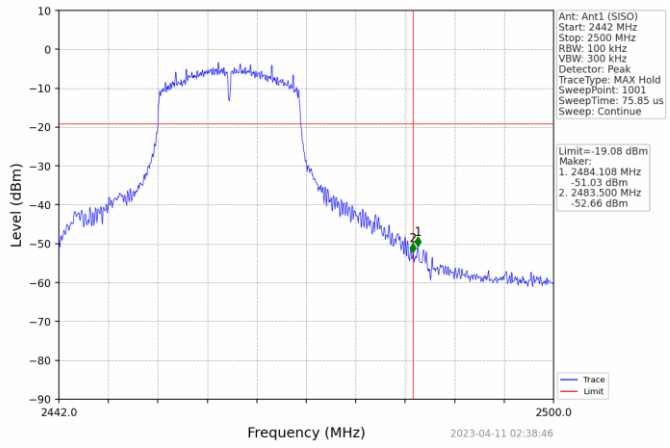
Full Spectrum - Low Channel (2412MHz)



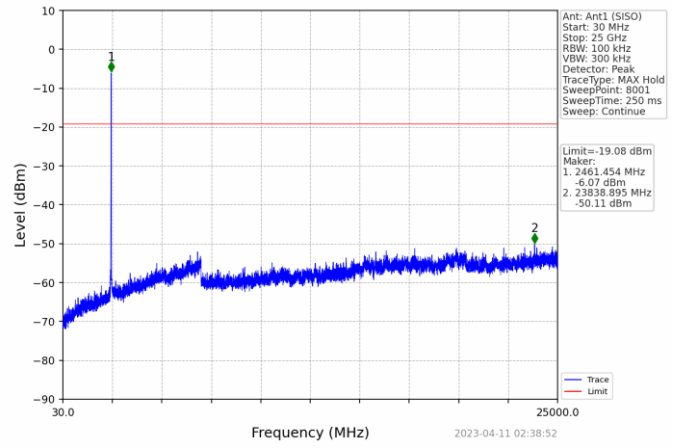
Full Spectrum - Mid Channel (2437MHz)



Upper Band Edge – High Channel (2462MHz)

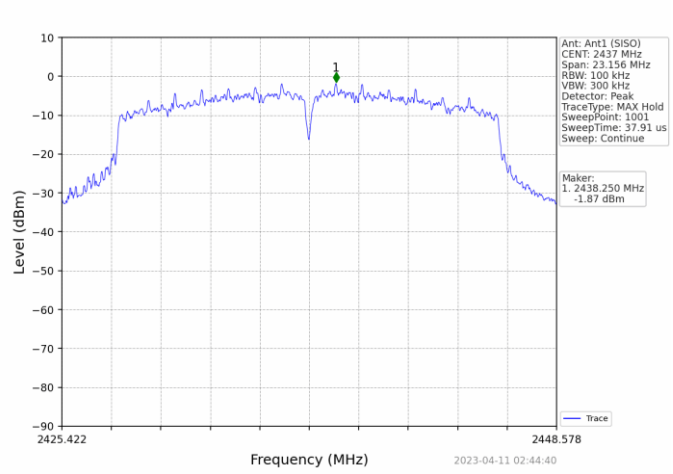


Full Spectrum - High Channel (2462MHz)

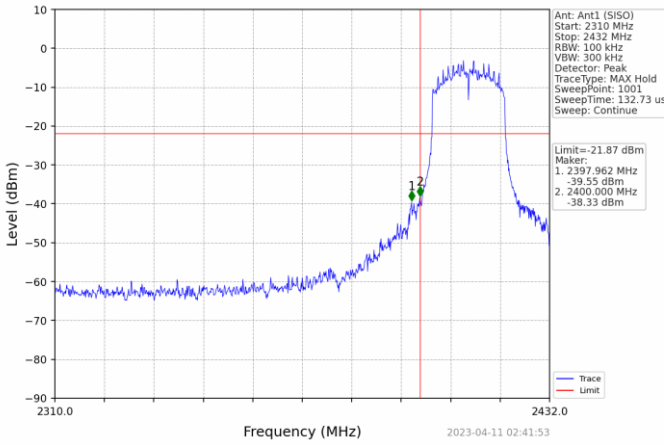


802.11n(HT20) – (ANT1)

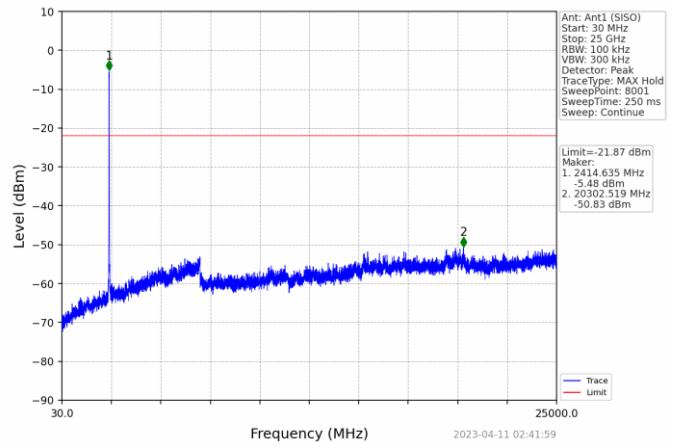
In-Band Reference – 2437MHz



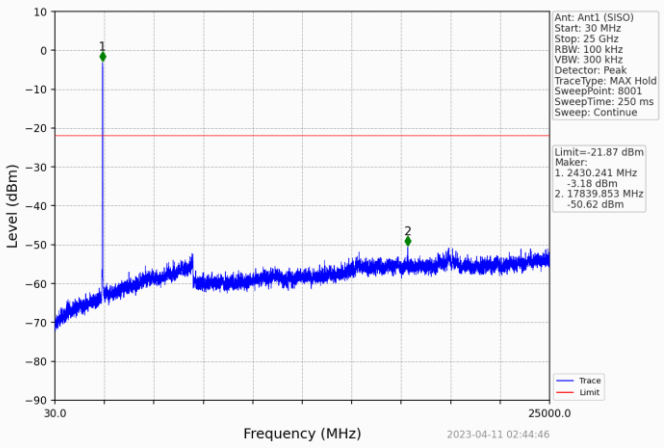
Lower Band Edge - Low Channel (2412MHz)



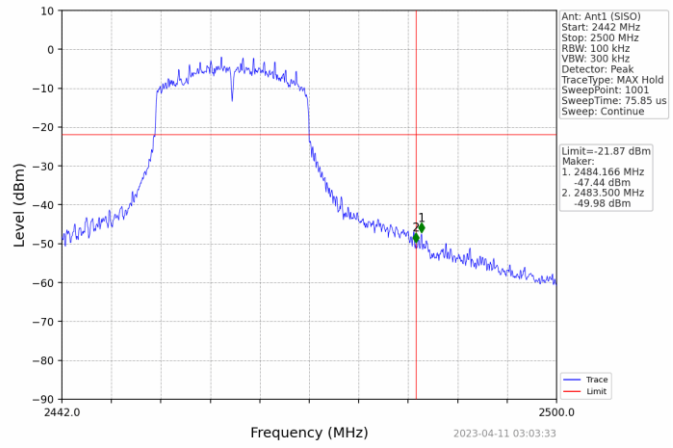
Full Spectrum - Low Channel (2412MHz)



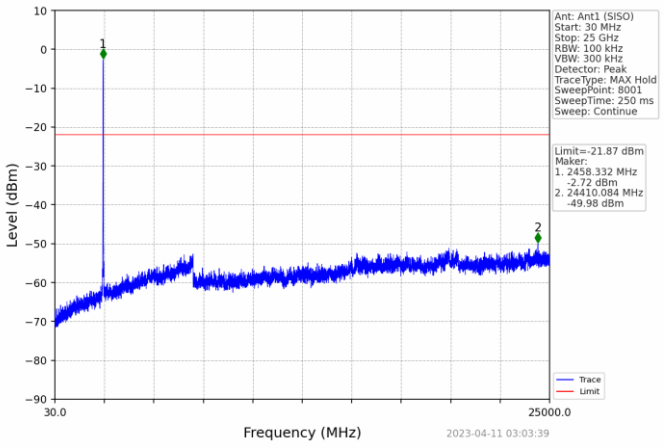
Full Spectrum - Mid Channel (2437MHz)



Upper Band Edge – High Channel (2462MHz)

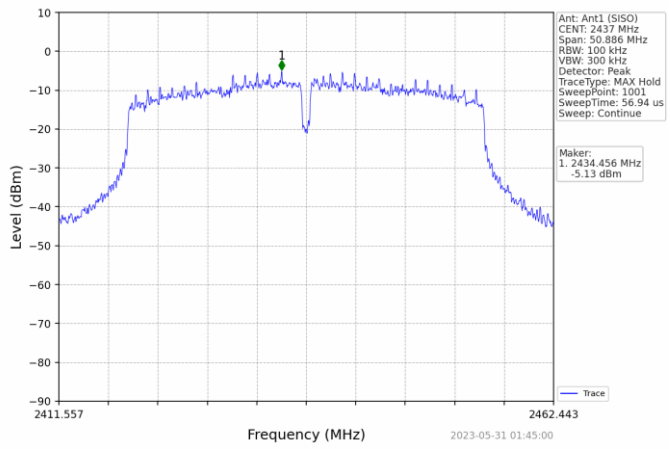


Full Spectrum - High Channel (2462MHz)

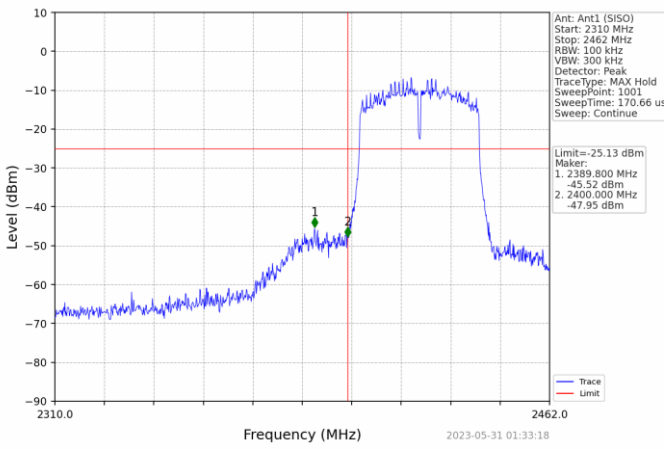


802.11n(HT40) – (ANT1)

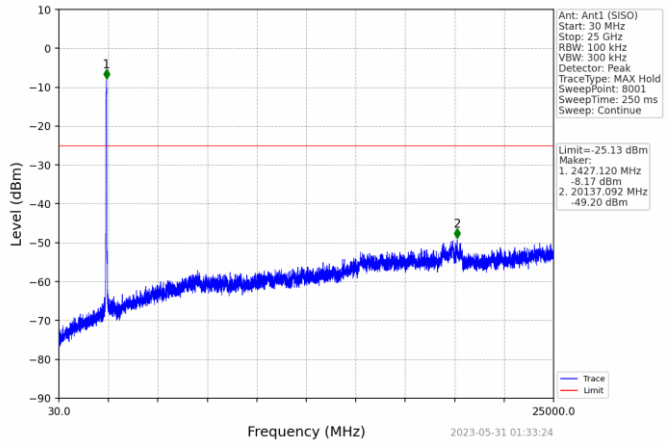
In-Band Reference – 2437MHz



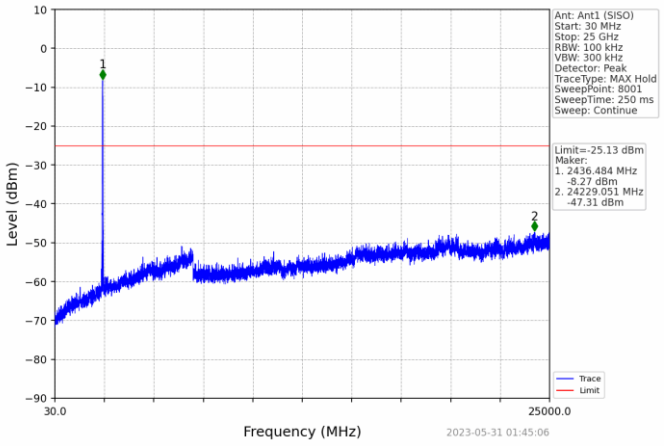
Lower Band Edge - Low Channel (2422MHz)



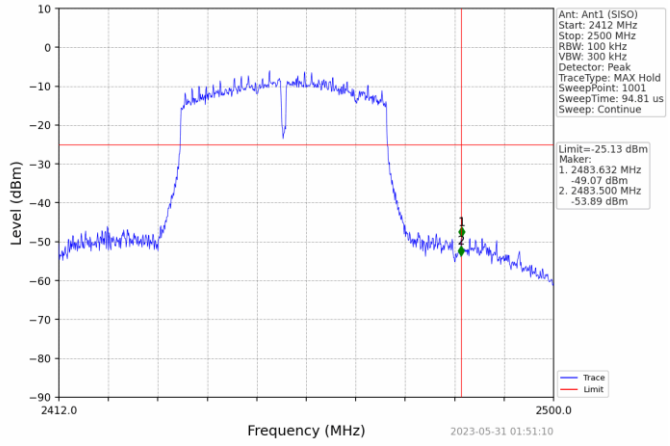
Full Spectrum - Low Channel (2422MHz)



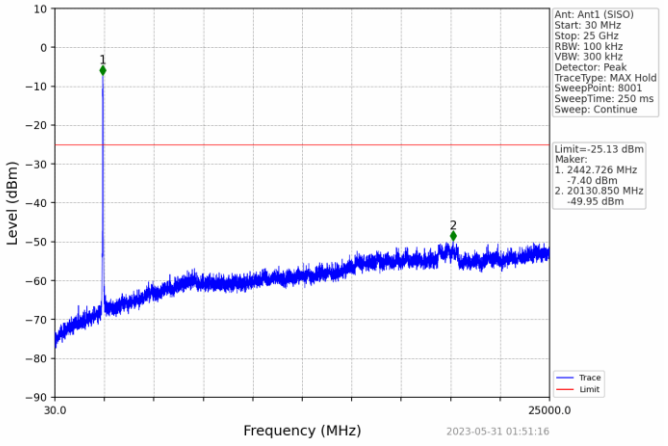
Full Spectrum - Mid Channel (2437MHz)



Upper Band Edge – High Channel (2452MHz)

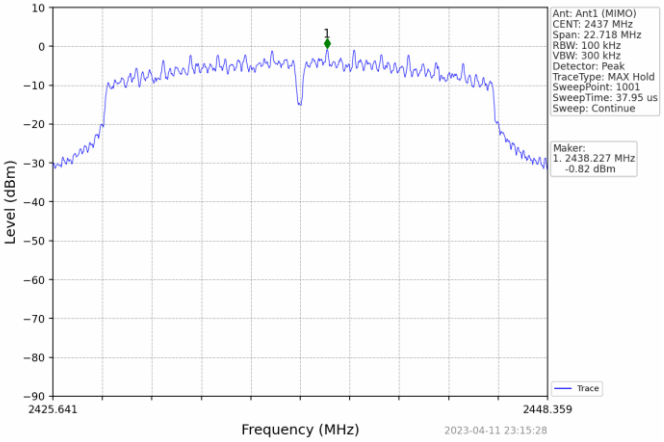


Full Spectrum - High Channel (2452MHz)

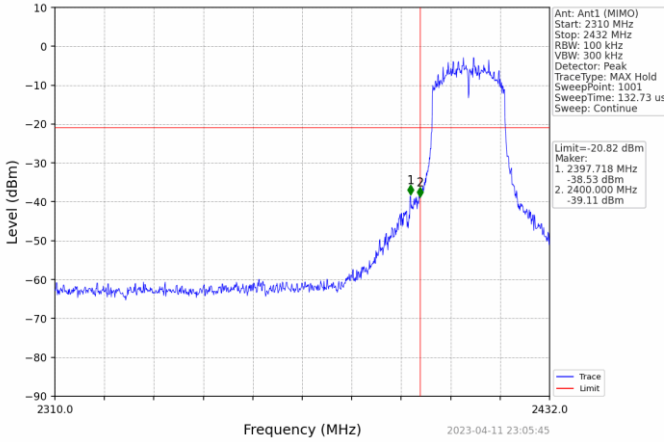


802.11n(HT20) – ANT1 + ANT2 (MIMO)

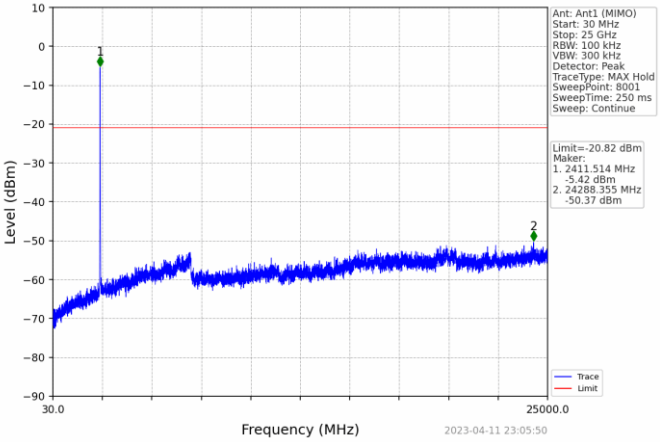
In-Band Reference – 2437MHz – Ant1



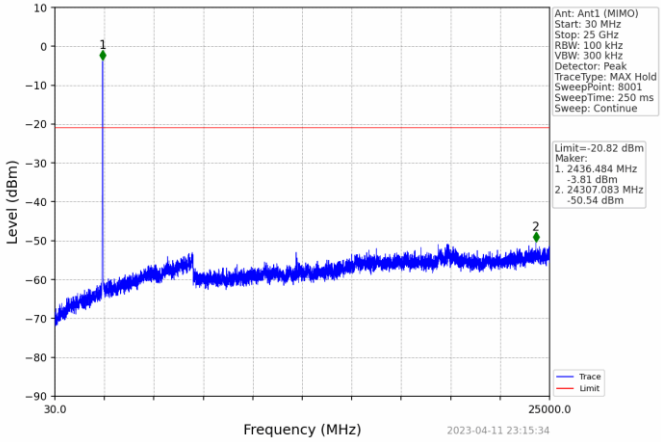
Lower Band Edge - LCH (2412MHz) – Ant1



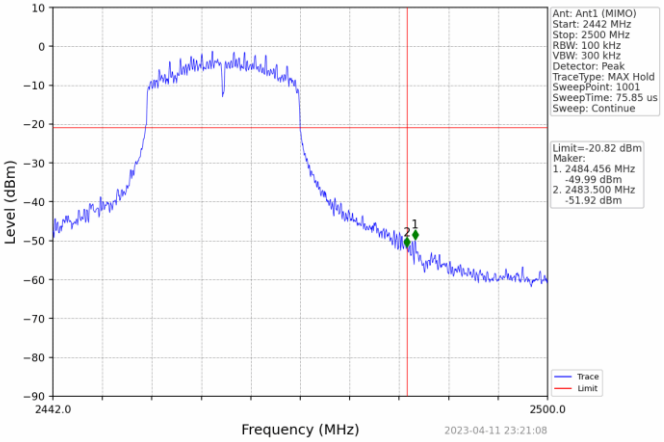
Full Spectrum - LCH (2412MHz) – Ant1



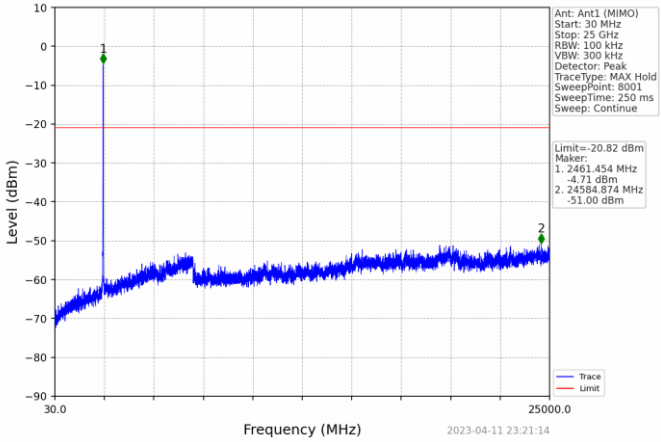
Full Spectrum – MCH (2437MHz) – Ant1



Upper Band Edge - HCH (2462MHz) – Ant1

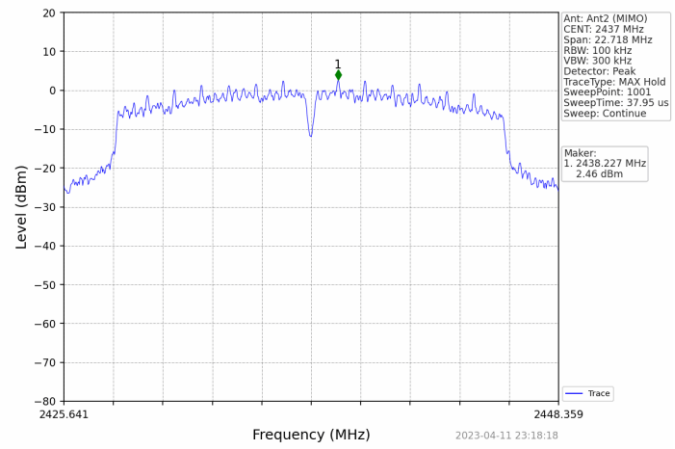


Full Spectrum – HCH (2462MHz) – Ant1

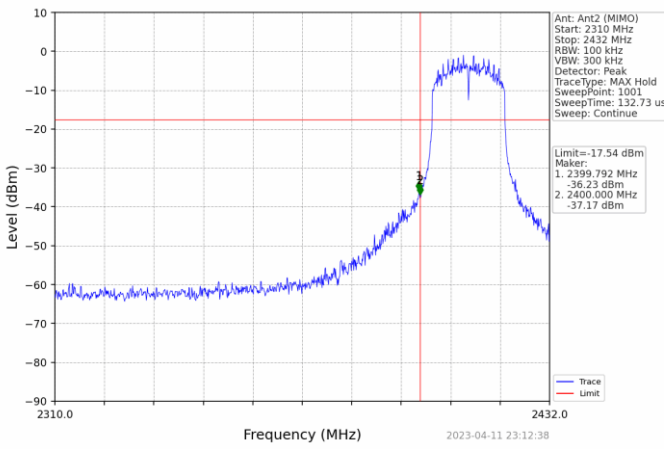


802.11n(HT20) – ANT2 + ANT1 (MIMO)

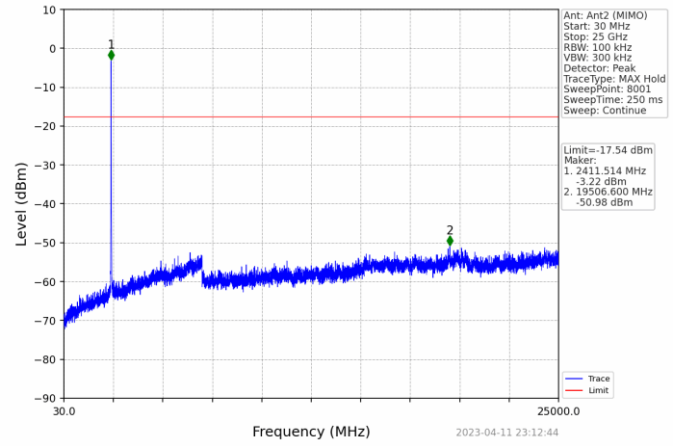
In-Band Reference - 2437MHz – Ant2



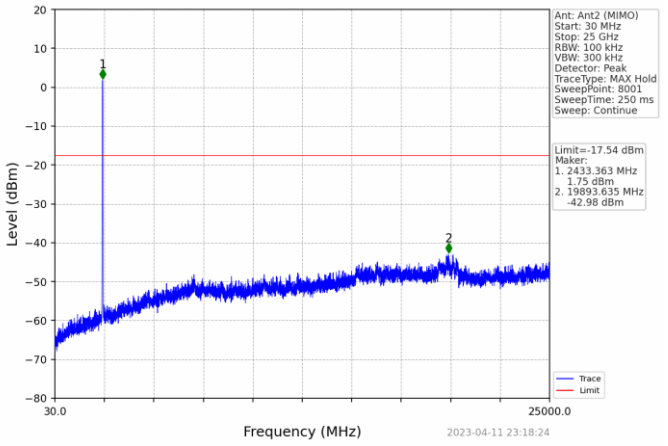
Lower Band Edge – LCH (2412MHz) – Ant2



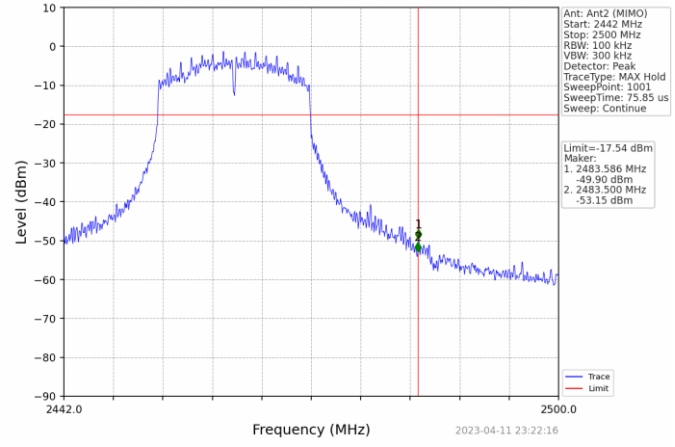
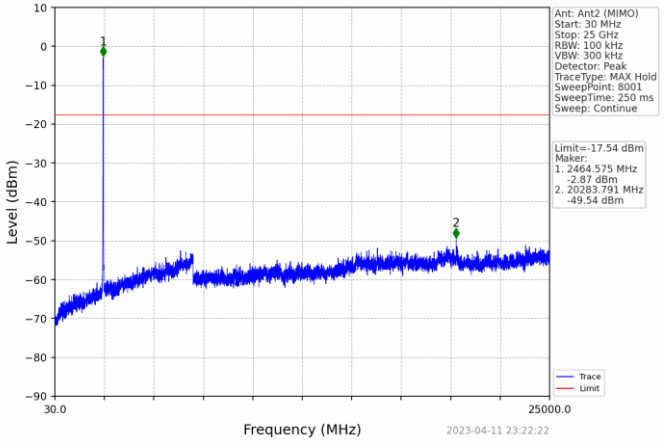
Full Spectrum - Low Channel (2412MHz) – Ant2



Full Spectrum - Mid Channel (2437MHz) – Ant2



Upper Band Edge – HCH (2462MHz) – Ant2



Full Spectrum - High Channel (2462MHz) – Ant2