



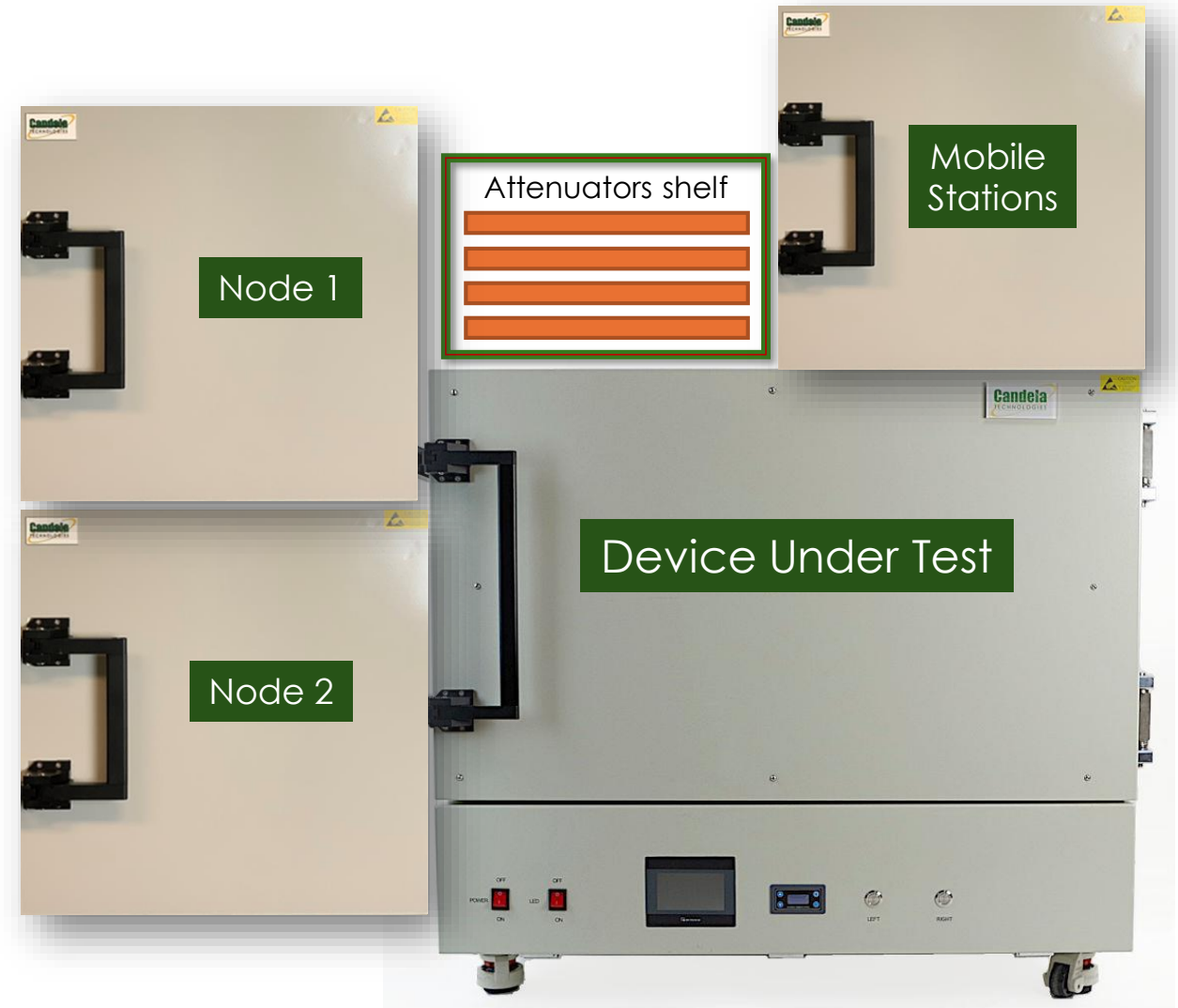
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Network
Testing &
Emulation
Solutions

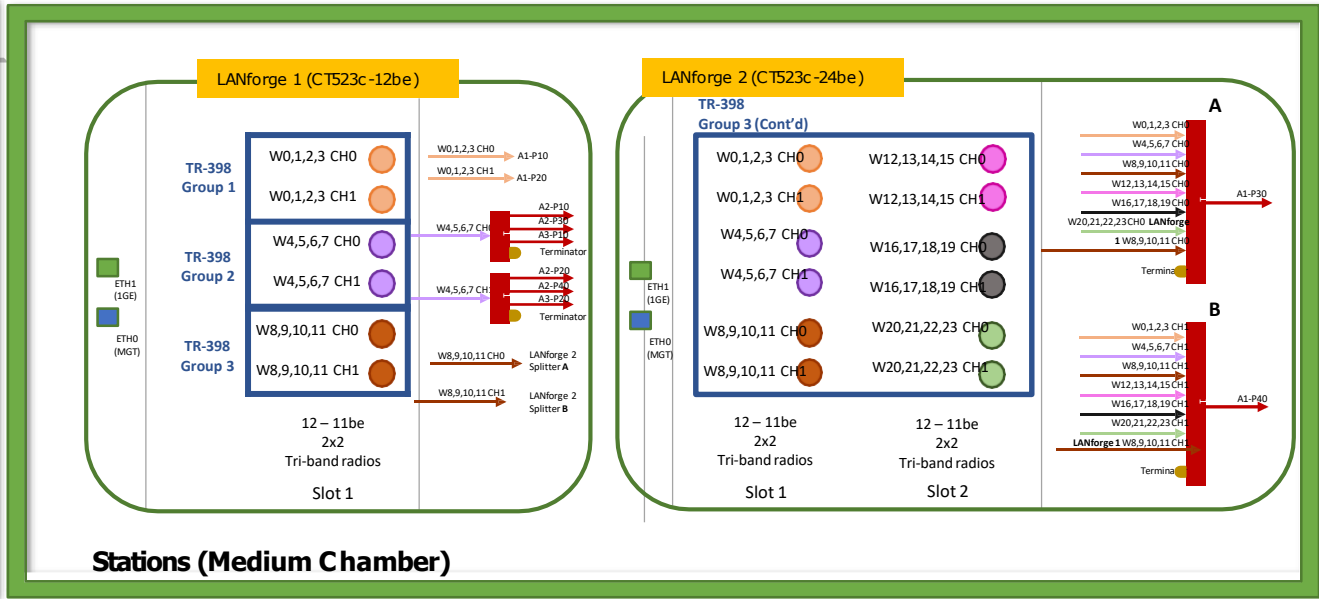
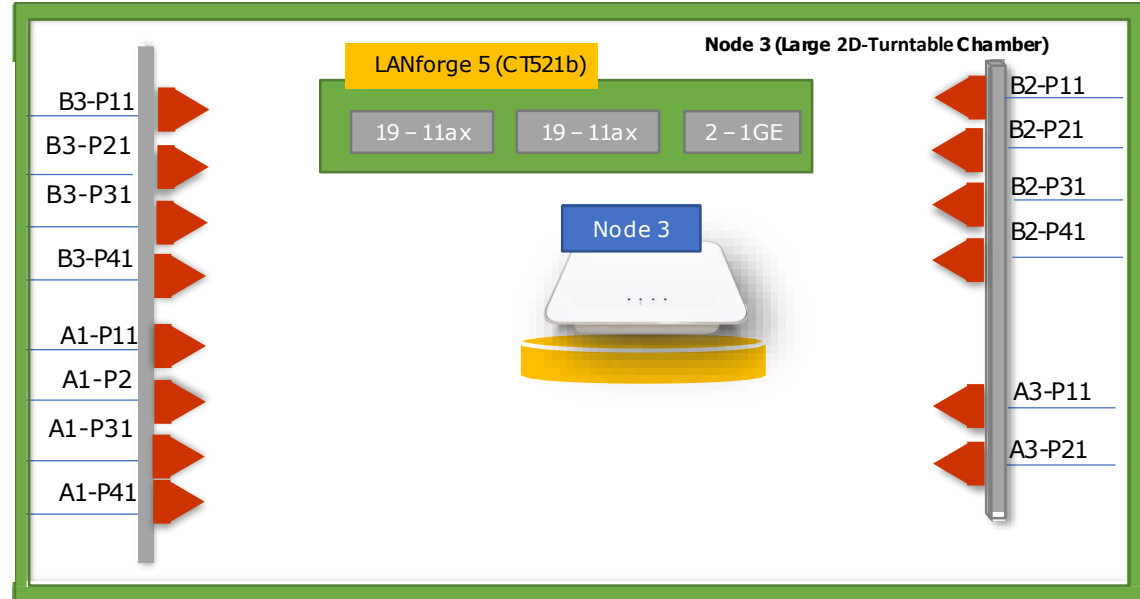
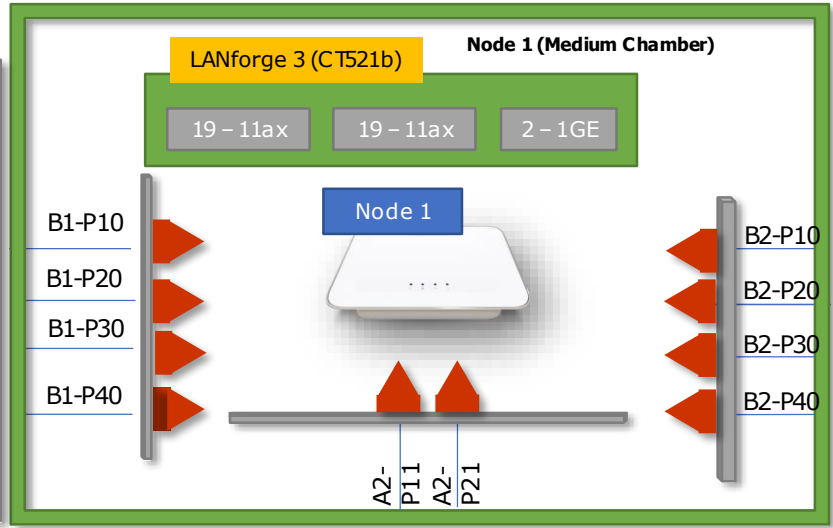
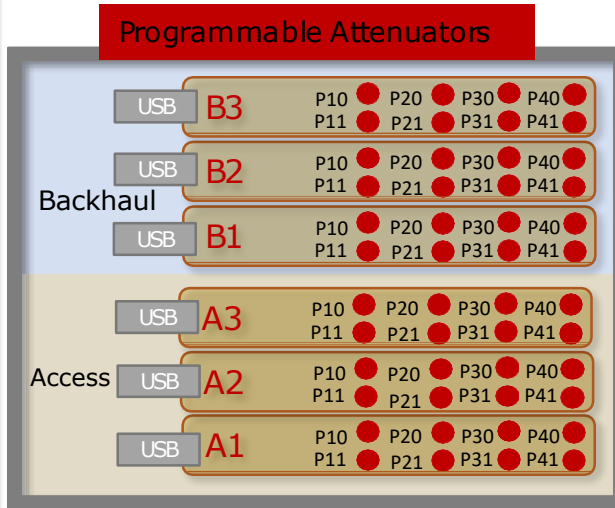
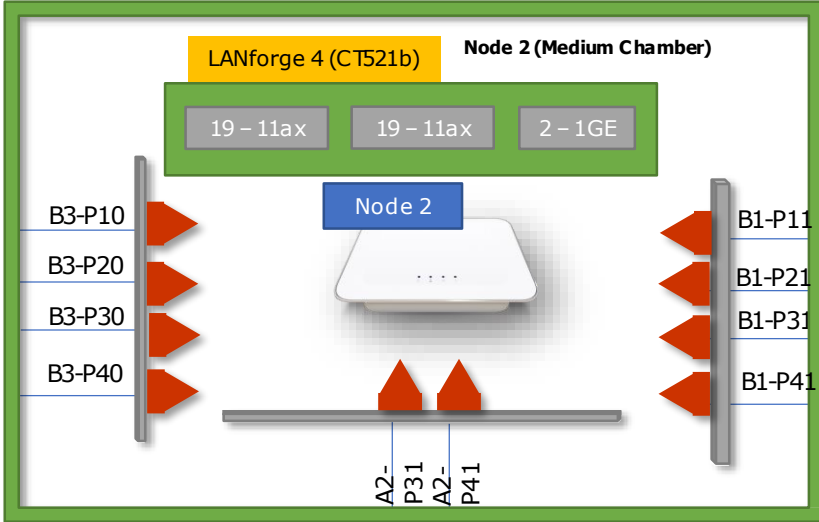
TR-398 Issue 4+Mesh Candela Solution

TR-398 Issue 4 Test Cases

- 6.1. RF capability
 - 6.1.1 Receiver Sensitivity Test
- 6.2. Baseline Performance
 - 6.2.1 Maximum Connection Test
 - 6.2.2 Maximum Throughput Test
 - 6.2.3 Airtime Fairness Test
 - 6.2.4 Dual-band Throughput Test
 - 6.2.5 Bidirectional Throughput Test
 - 6.2.6 Latency under Load Test
 - 6.2.7 Quality of Service
 - 6.2.8 Multi-Band Throughput Test
 - 6.2.9 OFDMA Throughput
- 6.3. Coverage
 - 6.3.1 Range Versus Rate Test
 - 6.3.2 Spatial consistency test -
 - 6.3.3 802.11ax Peak Performance Test
- 6.4. Multiple STAs Performance
 - 6.4.1 Multiple STAs Performance Test
 - 6.4.2 Multiple Association/Disassociation Stability Test
 - 6.4.3 Downlink MU-MIMO Performance Test
 - 6.4.4 Multicast Multi-Station
- 6.5. Stability/Robustness
 - 6.5.1 Long Term Stability Test
 - 6.5.2 AP Coexistence Test
 - 6.5.3 Automatic Channel Selection Test
 - 6.5.4 Puncturing
- 6.6 Mesh Performance
 - 6.6.1 Mesh Backhaul RVR
 - 6.6.2 Mesh Backhaul Node2 RVR
 - 6.6.3 Mesh Roam Time
- 7.1 Parameter Accuracies
 - 7.1.1 RSSI Accuracy
 - 7.1.2 Channel Utilization



TR398 issue 4 +Mesh Wiring Diagram



TR-398 Issue 4+ Mesh Testbed Images



Stackable Chambers Testbed Images



TR398 Issue 4 Lanforge GUI



TR-398 Issue 4 Automated Test (cv-inst-0)

Lat - OFDMA | RvR | Spatial - Long-Term | AP-Coex - Puncturing | RSSI, CH-UT | Advanced Configuration | Report Configuration | TR398-Issue4 | Report 1 ✖

Settings | Virtual Sta Radio Settings | 802.11AX Settings | 802.11AX Settings 2 | Mesh Settings | Mesh Settings 2 | Cal, Rx-Sens | Max-Cx, Max-Tput | ATF | DB, Bi-Dir

Selected DUT 5G: be800 GFiber-5G 70:f2:20:8f:09:41 (2) | Upstream Port: 1.3.2 LAN

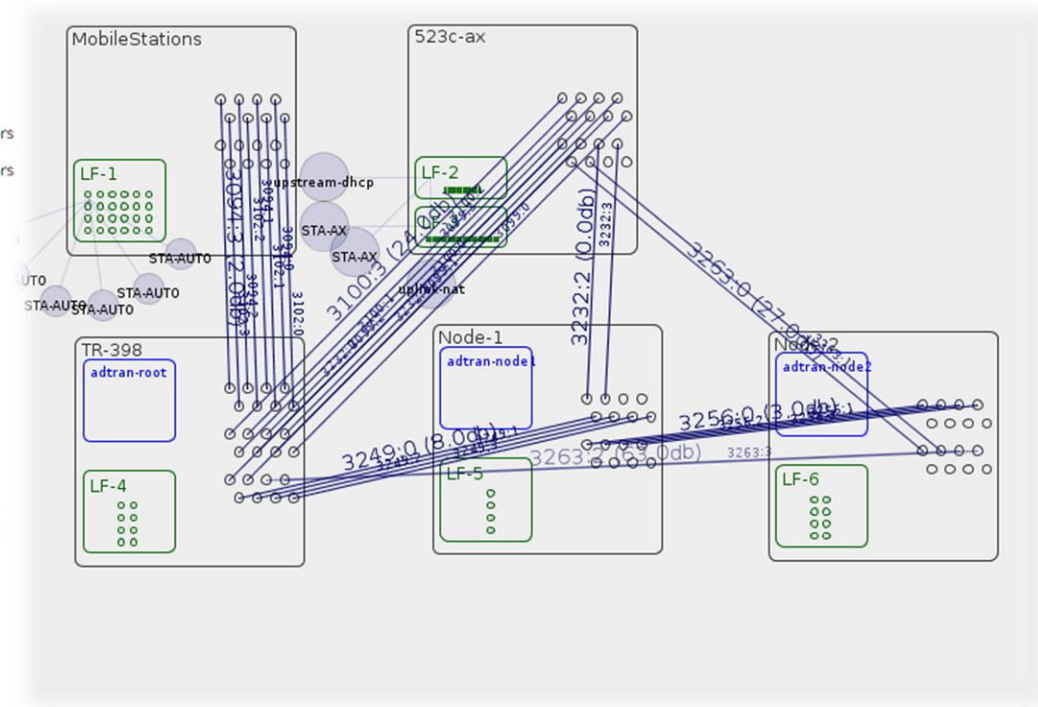
Selected DUT 2G: be800 GFiber-2G 70:f2:20:8f:09:39 (1) | Multicast Upstream Port: 1.1.2 eth2

Selected DUT 6G: be800 GFiber-6G 70:f2:20:8f:09:49 (3) | Turn-Table-Chamber: 840B-Default-Chamber

2.4Ghz 2m RSSI: -25 (Issue-3 default) (-25) | 5Ghz 2m RSSI: -30 (Issue-2/3) (-30)

Skip 2.4Ghz Tests | Skip 5Ghz Tests | Skip 6Ghz Tests | Skip N/A/C Tests | Skip AX Tests | Skip BE Tests

- TR-398 Tests to Run: Estimated Test Duration: 8.717 h
- Verify 802.11AX Radios
 - Calibrate 802.11AX Attenuators
 - Calibrate Mesh Sta to Root Attenuators
 - Calibrate Mesh Sta to Node-2 Attenuators
 - 6.1.1 Receiver Sensitivity
 - 6.2.1 Maximum Connection
 - 6.2.2 Maximum Throughput
 - 6.2.3 Airtime Fairness
 - 6.2.4 Dual-Band Throughput
 - 6.2.5 Bi-Directional Throughput
 - 6.2.8 Multi-Band Throughput
 - 6.2.9 OFDMA Throughput
 - 6.6.1 Mesh Backhaul RvR
 - Verify Virt-Sta Radios
 - Calibrate Virt-Sta Attenuators
 - Calibrate Mesh Sta to Node-1 Attenuators
 - Calibrate Mesh Node-1 to Node-2 Attenuators
 - 6.2.6 Latency
 - 6.2.7 Quality of Service
 - 6.3.1 Range Versus Rate
 - 6.3.2 Spatial Consistency
 - 6.3.3 Peak Performance
 - 7.1.1 RSSI Accuracy
 - 6.5.5 Puncturing
 - 6.6.2 Mesh Backhaul Node-2 RvR
 - Verify Group Throughput
 - Calibrate Mesh Root to Node-1 Attenuators
 - Calibrate Mesh Root to Node-2 Attenuators
 - 6.4.2 Multiple Assoc Stability
 - 6.4.3 Downlink MU-MIMO
 - 6.4.4 Multicast
 - 6.5.1 Long Term Stability
 - 6.5.2 AP Coexistence
 - 6.5.3 Automatic Channel Selection
 - 7.1.2 Channel Utilization
 - 6.6.3 Mesh Roam Time



TR-398 BOM Options



Tests	BOM1	BOM2	BOM3
6.1.1 Receiver Sensitivity Test	✓	✓	✓
6.2.1 Maximum Connection Test	✓	✓	✓
6.2.2 Maximum Throughput Test	✓	✓	✓
6.2.3 Airtime Fairness Test	✓	✓	✓
6.2.4 Dual-band Throughput Test	✓	✓	✓
6.2.5 Bidirectional Throughput Test	✓	✓	✓
6.2.6 Latency under Load Test	✓	✓	✓
6.2.7 Quality of service Test	✓	✓	✓
6.2.8 Multi-Band Throughput Test	✓	✓	✓
6.2.9 OFDMA Throughput	✓	✓	✓
6.3.1 Range Versus Rate Test	✓	✓	✓
6.3.2 Spatial consistency test	✓	✓	✓
6.3.3 802.11ax Peak Performance Test	✓	✓	✓
6.4.1 Multiple STAs Performance Test	✓	✓	✓
6.4.2 Multiple Association/Disassociation Stability Test	✓	✓	✓
6.4.3 Downlink MU-MIMO Performance Test	✓	✓	✓
6.4.4 Multicast Multi-Station	✓	✓	✓
6.5.1 Long Term Stability Test	✓	✓	✓
6.5.2 AP Coexistence Test	✓	✓	✓
6.5.3 Automatic Channel Selection Test	✓	✓	✓
6.5.4 Puncturing	✓	✓	✓
6.6.1 Mesh Backhaul RVR	✓	✓	
6.6.2 Mesh Backhaul Node2 RVR	✓		
6.6.3 Mesh Roam Time	✓	✓	
7.1.1 RSSI Accuracy	✓	✓	✓
7.1.2 Channel Utilization	✓	✓	✓

	Function	Testbed Components	BOM1	BOM2	BOM3
Hardware	Station Emulation/Traffic Generation/Test Automation	LANforge : CT-523c-20be-10GE	1 unit	1 unit	1 unit
		LANforge : CT-523c-12be-10GE	1 unit	1 unit	1 unit
		LANforge : CT-521a-2ax4	3 unit	2 unit	1 unit
	RF Isolation	CT820a Medium Chambers	3 units	2 units	1 units
		CT840a Large Chamber with Turntable	1 unit	1 unit	1 unit
	Distance Emulation	CT714 Programmable Attenuators	6units	4 units	3 units
	RF Connections	4x1 Splitters	2 units	X	X
		2x1 Splitters	10 unit	10 unit	10 units
		RF Cables	150 units	150 units	150 units
		RF Antennas	100 units	100 units	100 units
Software	Traffic Generation	SW1001m 1GE 1000 Traffic Stream Licenses	4 unit	3 units	2 units
		SW1100 10GE port licenses	1 unit	1 unit	1 unit
	Station Emulation	SW1001sta virtual station licenses	400 units	400 units	400 units
	Automation Software	SW-398 : TR-398 automation software license	1 unit	1 unit	1 unit
Support/Warranty		1-year hardware and software support	1 unit	1 unit	1 unit

- BOM1: Full TR-398 Issue 4 + Mesh setup
- BOM2: BOM1 without Node 2 chamber
- BOM3: BOM2 without Node 1 chamber

6.1.1 Receiver Sensitivity Test

- ❑ Receiver Sensitivity is a receiver's ability to receive and correctly demodulate weak signals. This test provides a simplified measurement of the receiver's sensitivity, relative to the total attenuation inserted between the DUT and the STA. As that attenuation is increased, the STA is limited to a single coding scheme, eventually causing the connection to degrade. The point at which the connection degrades represents the receiver's approximate sensitivity.
- ❑ This is an approximate measurement only, where a detailed receiver sensitivity measurement would typically be performed in a conducted test environment with calibrated transmitter power levels. The test is repeated with multiple coding schemes, ensuring the DUT should smoothly transition between coding schedules as the attenuation increases in normal operation

Operating Modes

- a) 802.11n
- b) 802.11ac
- c) 802.11ax over 2.4 GHz
- d) 802.11ax over 5 GHz
- e) 802.11ax over 6 GHz
- f) 802.11be over 2.4GHz
- g) 802.11be over 5 GHz
- h) 802.11be over 6 GHz

Test Procedure

1. Initialize attenuation to starting value (10 db stronger than passing value).
2. Configure the Traffic Generator to generate UDP traffic at 65% of theoretical rate.
3. Configure the attenuators to emulate 2-meter distance. This is considered 'zero' attenuation.
4. Increment attenuation by 1 dB each step. For each attenuation step, run traffic for 20 seconds. Record the packet-error rate (PER) at the UDP transport level (ignoring WiFi retries). If the PER is greater than 10%, then consider that the sensitivity cutoff and move to next iteration.
5. WiFi 5: These test steps are run for MCS 0 and 7 at 20Mhz on 2.4Ghz, and MCS 0 at 80Mhz, and mcs 9 at 80Mhz. All rates use 1 spatial stream.
6. WiFi 6: These test steps are run for MCS 0 and 11 at 20Mhz on 2.4Ghz, and MCS 0 and mcs 11 at 80Mhz. All rates use 1 spatial stream.
7. These test steps are run for each 45-degree spatial rotation.

Pass/Fail Criteria



a) 802.11n

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
1	0	BPSK	39
2	7	64-QAM	21

b) 802.11ac

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
3	0	BPSK	29
4	9	256-QAM	4

c) 802.11ax over 2.4Ghz

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
5	0	BPSK	39
6	11	1024-QAM	16

d) 802.11ax over 5Ghz

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
7	0	BPSK	29
8	11	1024-QAM	-3

e) 802.11ax over 6Ghz

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
9	0	BPSK	0
10	11	1024-QAM	0

f) 802.11be over 2.4Ghz

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
11	0	BPSK	39
12	11	1024-QAM	16

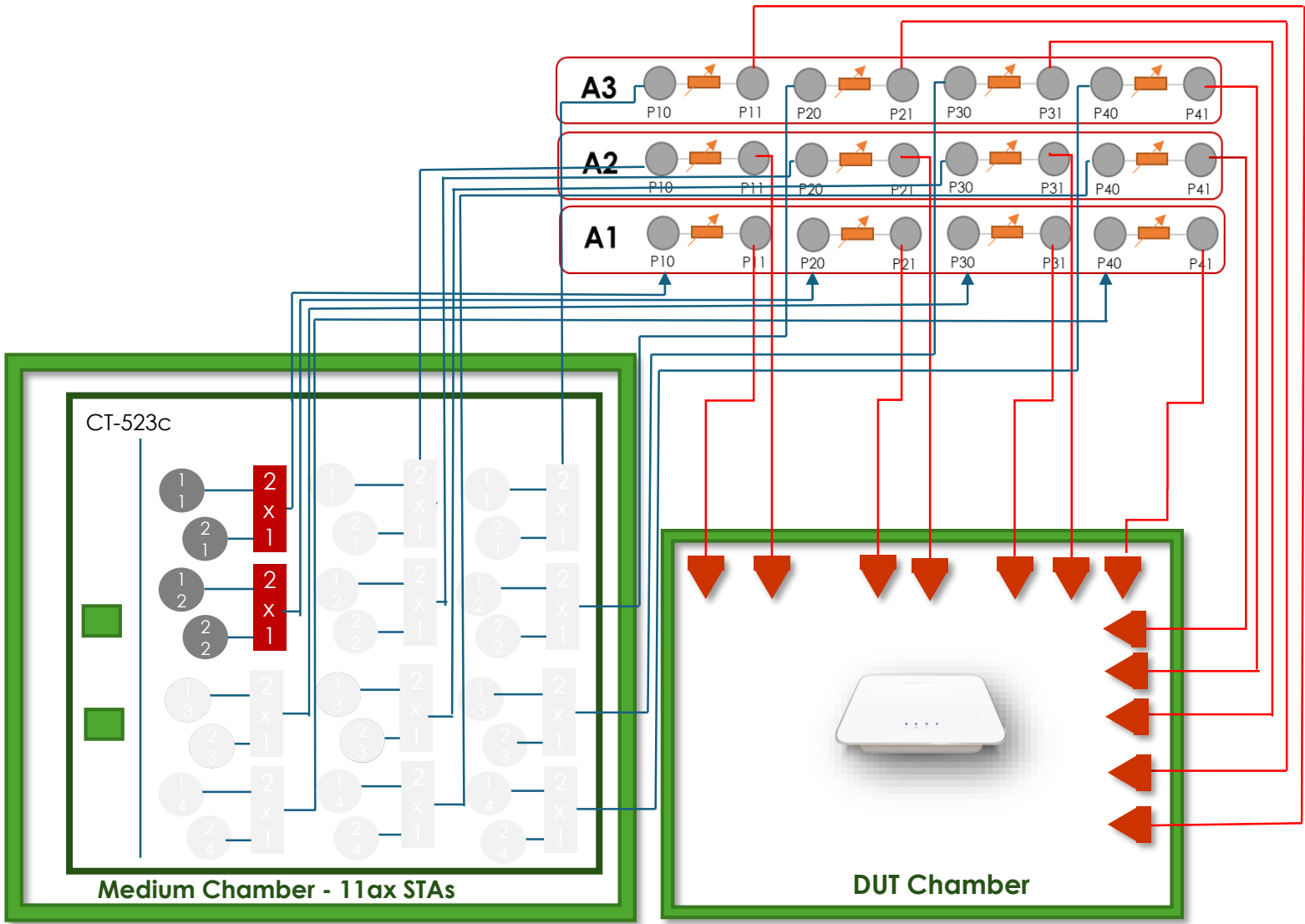
g) 802.11be over 5Ghz

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
13	0	BPSK	29
14	11	1024-QAM	-3

h) 802.11be over 6Ghz

Test Index	MCS index	Modulation	Approximate Receiver Sensitivity(dB)
			Required (Nss=1)
15	0	BPSK	0
16	11	1024-QAM	0

6.1.1 Wiring Diagram



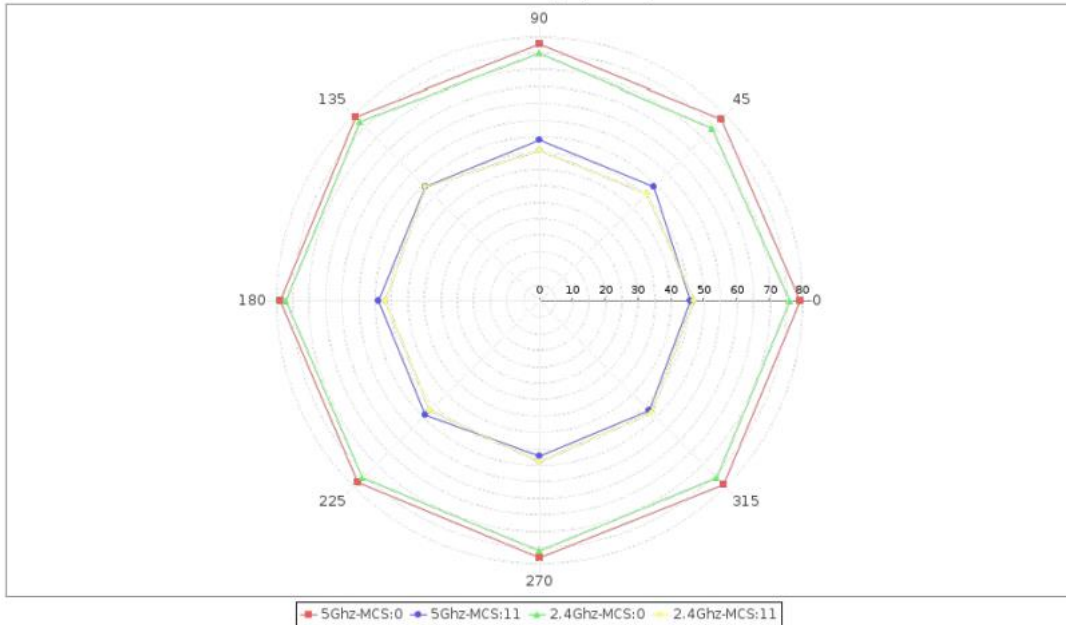
6.1.1 Example Results



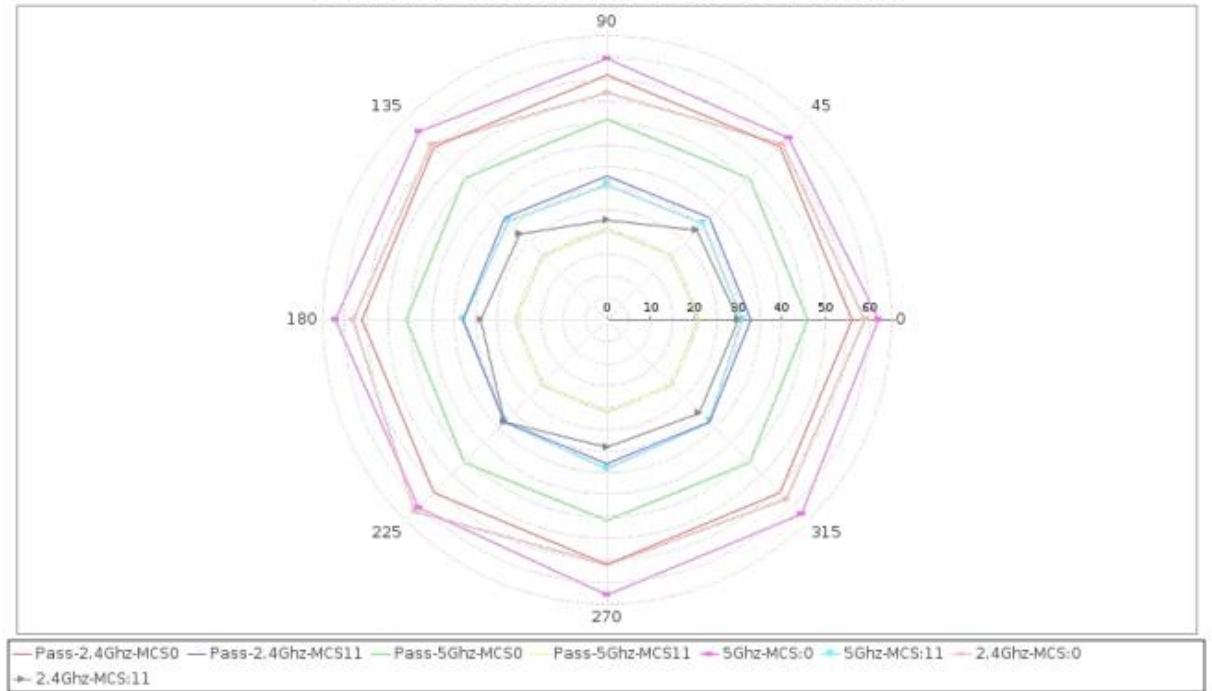
Summary Results

Test	Result	Candela Score	Elapsed	Info
6.1.1 Receiver Sensitivity Test	<div style="border: 1px solid red; padding: 2px;">2.4Ghz FAIL</div> <div style="border: 1px solid green; padding: 2px;">5Ghz PASS</div>	84	2.384 h	N 2.4Ghz passed 0 / 0 N 2.4Ghz Failed-by-steps: 0.0 Passed-by-steps: 0.0 AX 2.4Ghz passed 8 / 16 2.4 AX Fail-Avg: 4.6 2.4 AX Pass-Avg: 1.9 AX 2.4Ghz Failed-by-steps: 37.0 Passed-by-steps: 15.0 AC 5Ghz passed 0 / 0 AC 5Ghz Failed-by-steps: 0.0 Passed-by-steps: 0.0 AX 5Ghz passed 16 / 16 5Ghz AX Pass-Avg: 13.3 AX 5Ghz Failed-by-steps: 0.0 Passed-by-steps: 213.0

802.11AX Last Passing -(RSSI) vs Rotation



802.11AX Last Passing Value vs Rotation



6.2.1 Maximum Connection Test

- ❑ The Maximum Connection test intends to verify that the Wi-Fi AP can support 32 STAs simultaneously connected with minimal packet loss and no disassociations taking place.

Test Procedure

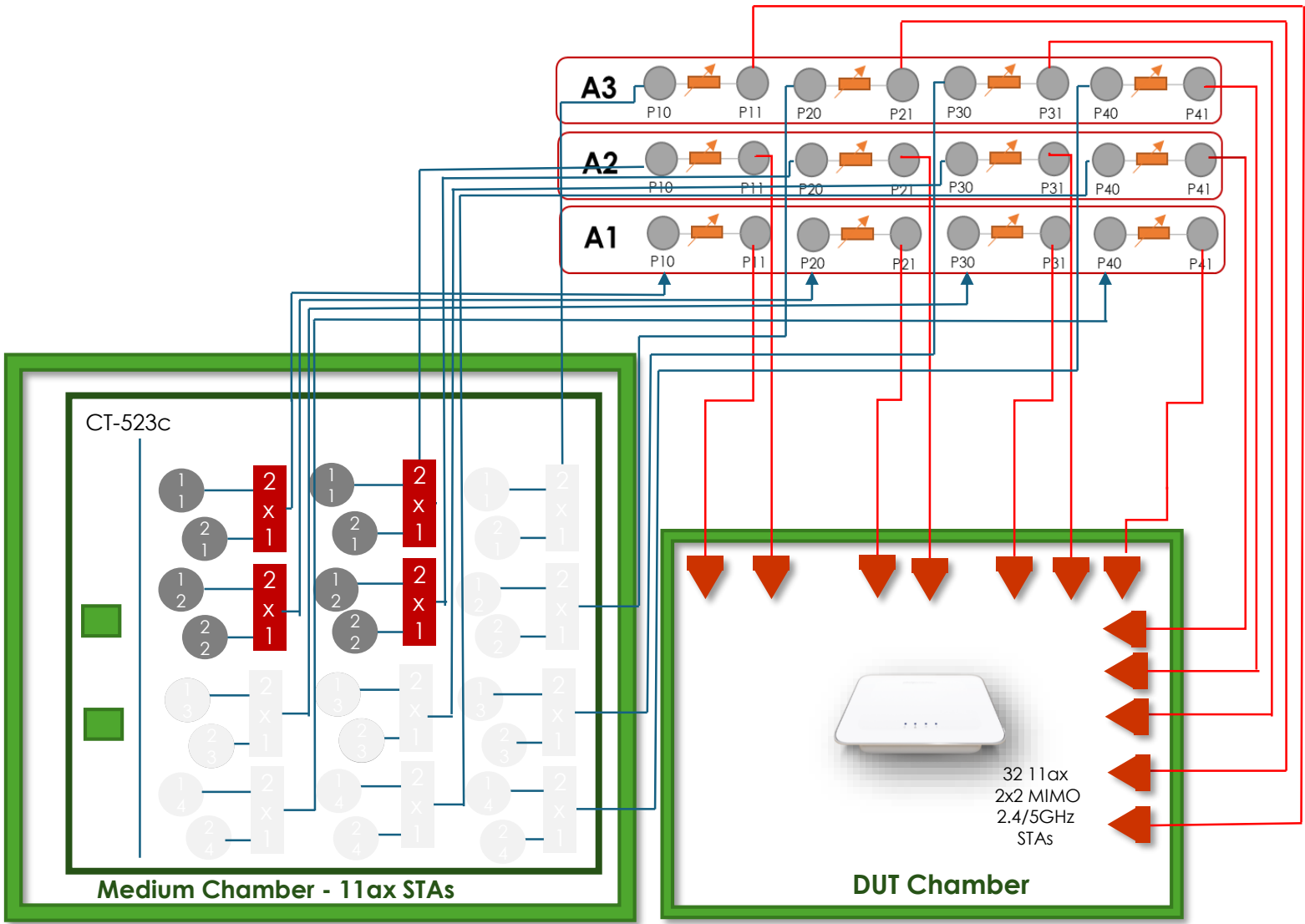
1. Configure the operating mode of the DUT to the first supported configuration listed in the above slide.
2. Allow the STA to associate with the DUT.
3. Simultaneously measure the downlink UDP packet loss, using a test time of 120 seconds and a traffic rate of 2 Mbps for 802.11n or 8 Mbps for 802.11ac, 3 Mbps for 802.11ax over 2.4 GHz, 10 Mbps for 802.11ax over 5 GHz, or 20 Mbps for 802.11ax over 6 GHz, 3.5Mbps for 802.11be over 2.4GHz, 12Mbps for 802.11be over 5GHz, 25Mbps for 802.11be over 6GHz through each STA. Record the number of packets transmitted and received to calculate the packet error rate.
4. Simultaneously measure the uplink UDP packet loss, using a test time of 120 seconds and a traffic rate of 2 Mbps for 802.11n or 8 Mbps for 802.11ac, 3 Mbps for 802.11ax over 2.4 GHz, 10 Mbps for 802.11ax over 5 GHz, or 20 Mbps for 802.11ax over 6 GHz, 3.5Mbps for 802.11be over 2.4GHz, 12Mbps for 802.11be over 5GHz, 25Mbps for 802.11be over 6GHz through each STA. Record the number of packets transmitted and received to calculate the packet error rate.
5. Repeat steps 2 through 4 for each additional configuration / operating mode supported by the DUT.

Pass/Fail Criteria



Wi-Fi Configuration	Downlink Throughput (Mbps)	Uplink Throughput (Mbps)
Config 1 :For 32 STA -11n - 64Mbps	63.36	63.36
Config 2 :For 32 STA – 11ac – 256Mbps	253.44	253.44
Config 3 :For 32 STA -11ax – 2.4Ghz -96 Mbps	95.04	95.04
Config 4 :For 32 STA – 11ax - 5Ghz – 320 Mbps	316.80	316.80
Config 5 :For 32 STA – 11ax - 6Ghz – 320 Mbps	633.60	633.60
Config 6 :For 32 STA -11be – 2.4Ghz -96 Mbps	110.88	110.88
Config 7 :For 32 STA – 11be - 5Ghz – 320 Mbps	380.16	380.16
Config 8 :For 32 STA – 11be - 6Ghz – 320 Mbps	792.00	792.00

6.2.1 Wiring Diagram

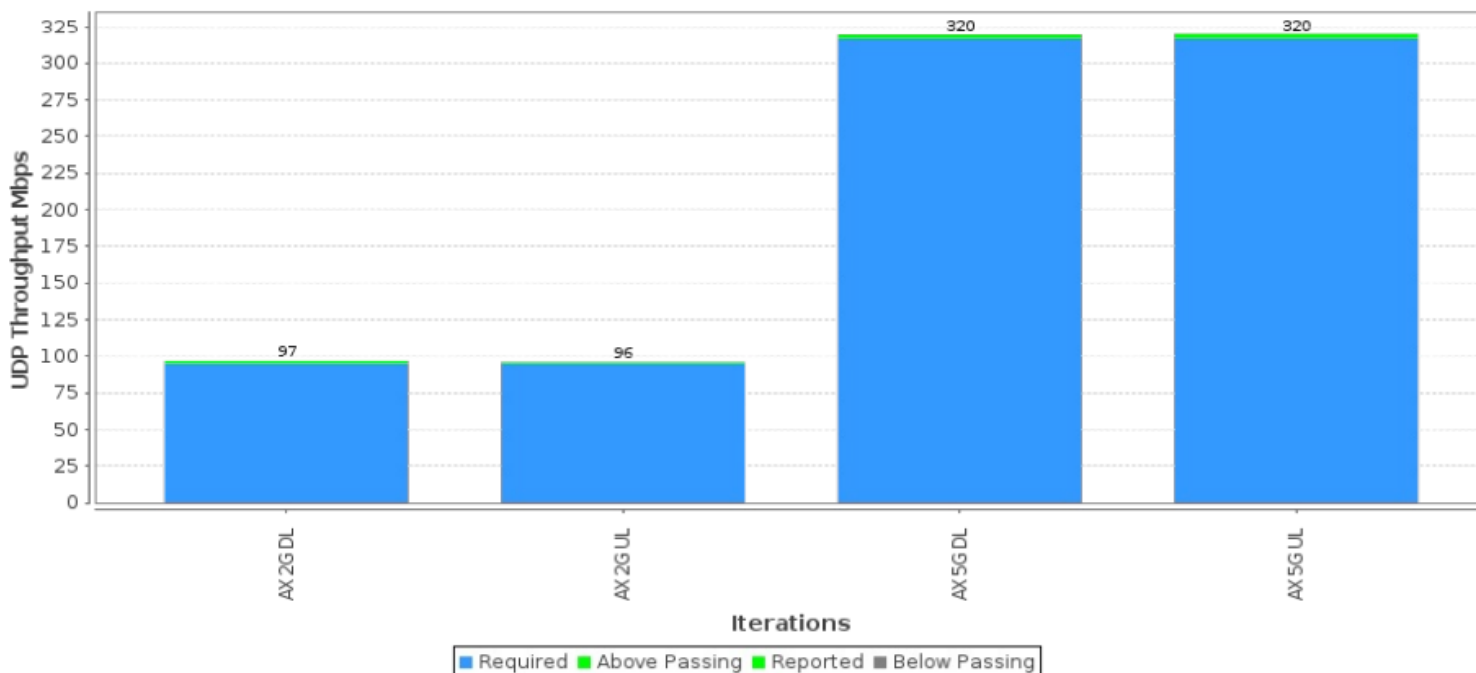


6.2.1 Example Results

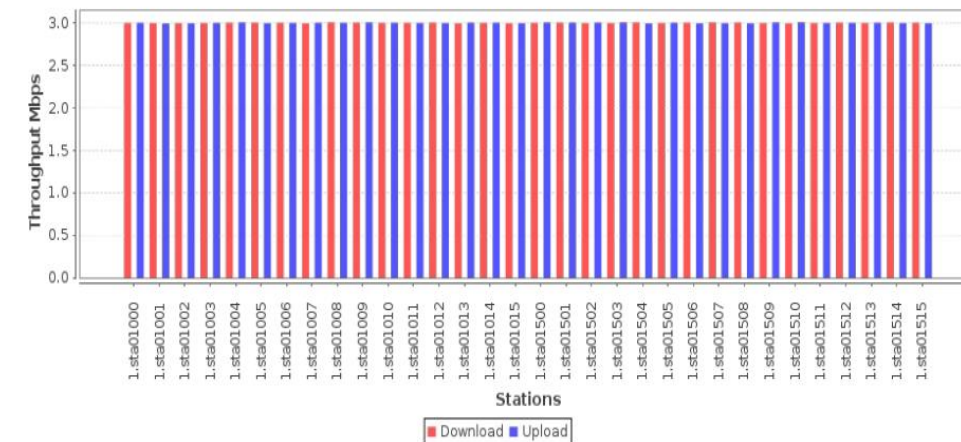
Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.1 Maximum Connection Test (32-STA)	2.4Ghz PASS 5Ghz PASS	100	9.38 m	Throughput: 2.4Ghz AX UL 101.13% DL 101.81% Throughput: 5Ghz AX UL 101.04% DL 100.87% Passed PER: 128 / 128

6.2.1 Maximum Connection Test (32-STA)



2.4Ghz Throughput



6.2.2 Maximum Throughput Test

- ❑ Maximum throughput test intends to measure the maximum throughput performance of the DUT. The test is conducted with connection by air interface in short distance (by considering the actual utilization of Wi-Fi).

Test Procedure

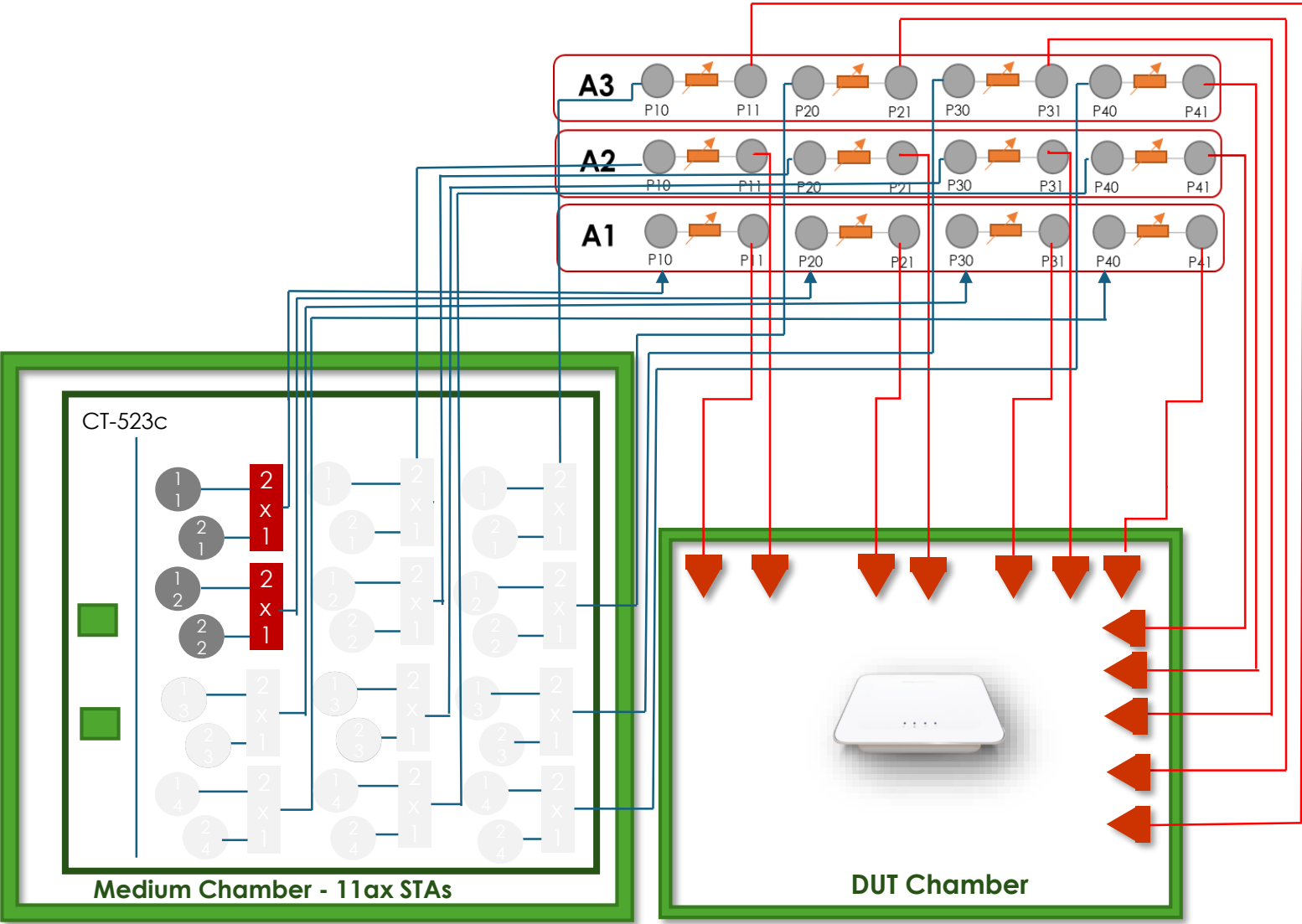
1. Configure the working mode of DUT to 802.11n with default configuration.
2. Establish the LAN connection and allow STA to associate with the DUT.
3. Measure the downlink TCP throughput to the STA, using a test time of 120 seconds.
4. Measure the uplink TCP throughput to the STA, using a test time of 120 seconds.
5. Set the working mode of DUT to 802.11ac and repeat steps 3-4 for bandwidth 80MHz.
6. Set the working mode of DUT to 802.11ax over 2.4 GHz and repeat steps 3-4.
7. Set the working mode of DUT to 802.11ax over 5 GHz and repeat steps 3-4.
8. Set the working mode of DUT to 802.11ax over 6 GHz, and repeat steps 3-4.
9. Set the working mode of DUT to 802.11be over 2.4 GHz, and repeat steps 3-4.
10. Set the working mode of DUT to 802.11be over 5 GHz, and repeat steps 3-4.
11. Set the working mode of DUT to 802.11be over 6 GHz, and repeat steps 3-4.

Pass/Fail Criteria



Wi-Fi Configuration (DUT) NSS-2	Wi-Fi Configuration(STA) NSS-2	BW	DL Throughput (Mbps)	UL Throughput (Mbps)
802.11n	802.11n (NSS-2)	20	100	100
802.11ac	802.11ac (NSS-2)	80	650	650
802.11ax (2.4Ghz)	802.11ax (2.4Ghz)	20	180	180
802.11ax (5 Ghz)	802.11ax (5 Ghz)	80	880	880
802.11ax (6 Ghz)	802.11ax (6 Ghz)	160	1500	1500
802.11be (2.4Ghz)	802.11be (2.4Ghz)	20	240	240
802.11be (5Ghz)	802.11be (5Ghz)	160	930	930
802.11be (6Ghz)	802.11be (6Ghz)	320	2500	2500

6.2.2 Wiring Diagram

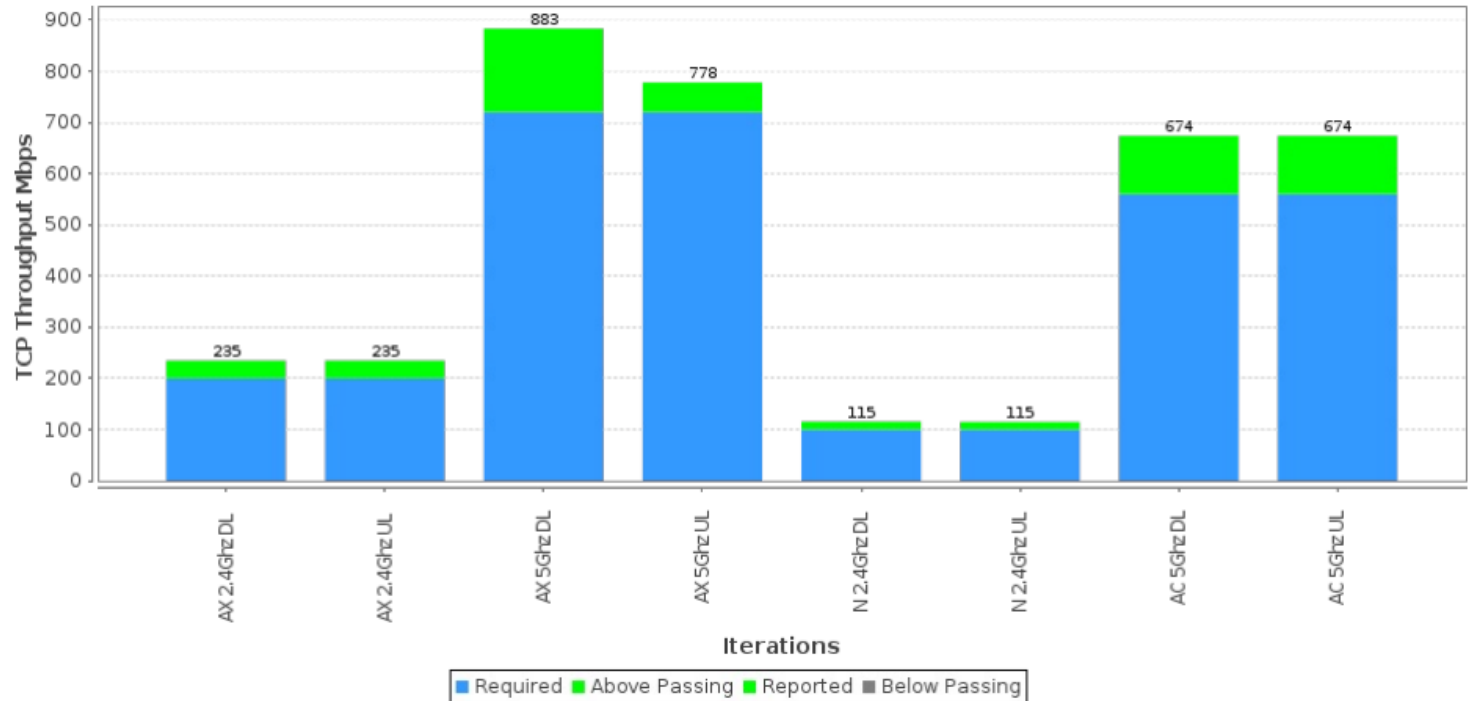


6.2.2 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.2 Maximum TCP Throughput Test	2.4Ghz PASS 5Ghz PASS	117	9.625 m	Throughput N 2.4Ghz UL 114.80% DL 115.48% Throughput AX 2.4Ghz UL 117.46% DL 117.44% Throughput AC 5Ghz UL 120.30% DL 120.30% Throughput AX 5Ghz UL 108.02% DL 122.65%

6.2.2 Maximum TCP Throughput Test



6.2.3 Airtime Fairness test

- ❑ Airtime Fairness Test intends to verify the capability of Wi-Fi device to ensure the fairness of airtime usage. This test uses two stations at a time, with one station running in optimum configuration. The second station varies between optimum configuration, weaker signal, and legacy mode configurations. In each setting, TCP traffic is used to determine maximum capacity of each station running by itself. Then, UDP traffic is created on STA1 to run at 75% of the TCP throughput and UDP traffic is created on the second station at 50% of the TCP throughput for that station. This overdrives the AP and causes it to drop frames. The pass/fail criteria is that each station gets at least 45% of the TCP throughput when both stations are running the prescribed UDP traffic.

Test Procedure

1. Establish the setup using default configuration for the 802.11n 2.4 GHz frequency band with Nss = 2 operating mode for STA1 and STA2. Use or configure a STA3 to only use 802.11b/g and single spatial stream.
2. Associate STA1 and STA2 with DUT. Establish the LAN connection and wait for 10 seconds. For 6Ghz mode, configure STA1 and STA2 to 160Mhz.
3. Measure the achievable downlink TCP throughput through STA1, using a test time of 120 seconds. Record this value as STA1_Throughput_Max_DL_1.
4. Measure the achievable downlink TCP throughput through STA2, using a test time of 120 seconds. Record this value as STA2_Throughput_Max_DL_1.
5. Configure the downlink UDP traffic streams to use a downlink data rate set to 75% of STA1_Throughput_Max_DL_1 for STA1 and 50% of STA2_Throughput_Max_DL_1 for STA2.
6. Simultaneously run the two UDP traffic streams for 120 seconds, recording the throughput for each stream. Record these values as STA1_Throughput_1 and STA2_Throughput_1 respectively.
7. Move STA2 to a medium distance to the DUT (equivalent to 35 dB@2.4GHz and 30 dB @5GHz attenuation between DUT and STA2, plus 2m calibrated distance). Wait for 10 seconds.
8. Establish Measure the achievable downlink TCP throughput through STA2, using a test time of 120 seconds. Record this value as STA2_Throughput_Max_DL_2.
9. Configure the downlink UDP traffic streams to use a downlink data rate set to 75% of STA1_Throughput_Max_DL_1 for STA1 and 50% of STA2_Throughput_Max_DL_2 for STA2.
10. Simultaneously run the two UDP traffic streams for 120 seconds, recording the throughput for each stream. Record these values as STA1_Throughput_2 and STA2_Throughput_2 respectively.

11. Disassociate STA2 with the DUT. Replace STA 2 with STA 3, configured for the specified Wi-Fi operating mode, and remove the attenuation. Establish the Wi-Fi connection between STA3 and DUT and wait for 10 seconds.
12. Measure the achievable downlink TCP throughput through STA3, using a test time of 120 seconds. Record this value as STA3_Throughput_Max_DL_3.
13. Configure the downlink UDP traffic streams to use a downlink data rate set to 75% of STA1_Throughput_Max_DL_1 for STA1 and 50% of STA3_Throughput_Max_DL_3 for STA3.
14. Simultaneously run the two UDP traffic streams for 120 seconds, recording the throughput for each stream. Record these values as STA1_Throughput_3 and STA3_Throughput_3 respectively.
15. Set the DUT to operating mode to 802.11ac 5 GHz frequency band with Nss = 2. Replace or reconfigure STA3 with a STA that uses only 802.11a and single spatial stream. Repeat steps 2 through 14.
16. Set the DUT to operating mode to 802.11ax 2.4 GHz frequency band with Nss = 2. Replace or reconfigure STA3 with a STA that uses only 802.11n and single spatial stream. Repeat steps 2 through 14.
17. Set the DUT to operating mode 802.11ax 5 GHz frequency band with Nss = 2. Replace or reconfigure STA3 with a STA that uses only 802.11ac and single spatial stream. Repeat steps 2 through 14.
18. Set the DUT to operating mode to 802.11ax 6 GHz frequency band with Nss = 2 and 160Mhz bandwidth. Ensure STA1 and STA2 are configured for 160Mhz. Replace or reconfigure STA3 with a STA that uses NSS1 and 80Mhz bandwidth. Repeat steps 2 through 14.
19. Set the DUT to operating mode to 802.11be 2.4 GHz frequency band with Nss = 2. Replace or reconfigure STA3 with a STA that uses only 802.11ax and single spatial stream. Repeat steps 2 through 14.
20. Set the DUT to operating mode to 802.11be 5 GHz frequency band with Nss = 2 and 160Mhz bandwidth. Ensure STA1 and STA2 are configured for 160Mhz. Replace or reconfigure STA3 with a STA that uses NSS1 and 80Mhz bandwidth. Repeat steps 2 through 14.
21. Set the DUT to operating mode to 802.11be 6 GHz frequency band with Nss = 2 and 320Mhz bandwidth. Ensure STA1 and STA2 are configured for 160Mhz. Replace or reconfigure STA3 with a STA that uses NSS1 and 160Mhz bandwidth. Repeat steps 2 through 14.

Pass/Fail Criteria

1. For each UDP measurement, the throughput shall be at least 45% of the TCP Throughput Max speeds reported on the station being tested. This ensures that the AP properly limits the over-driven STA1 connection and gives the other station a fair amount of airtime.

To verify over-all throughput while ensuring airtime fairness, the throughput of the DUT SHALL meet the requirements below.

1. For the test in 802.11n 2.4 GHz frequency band with Nss = 2:

- 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 100 Mbps.
- 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 85 Mbps.
- 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 60 Mbps.

2. For the test in 802.11ac 5 GHz frequency band with Nss = 2:

- 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 560 Mbps.
- 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 500 Mbps.
- 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 300 Mbps.

3. For the test in 802.11ax 2.4 GHz frequency band with Nss = 2:

- 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 200 Mbps.
- 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 150 Mbps.
- 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 95 Mbps.

4. For the test in 802.11ax 5 GHz frequency band with Nss = 2:

- 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 720 Mbps.
- 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 600 Mbps.
- 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 400 Mbps.

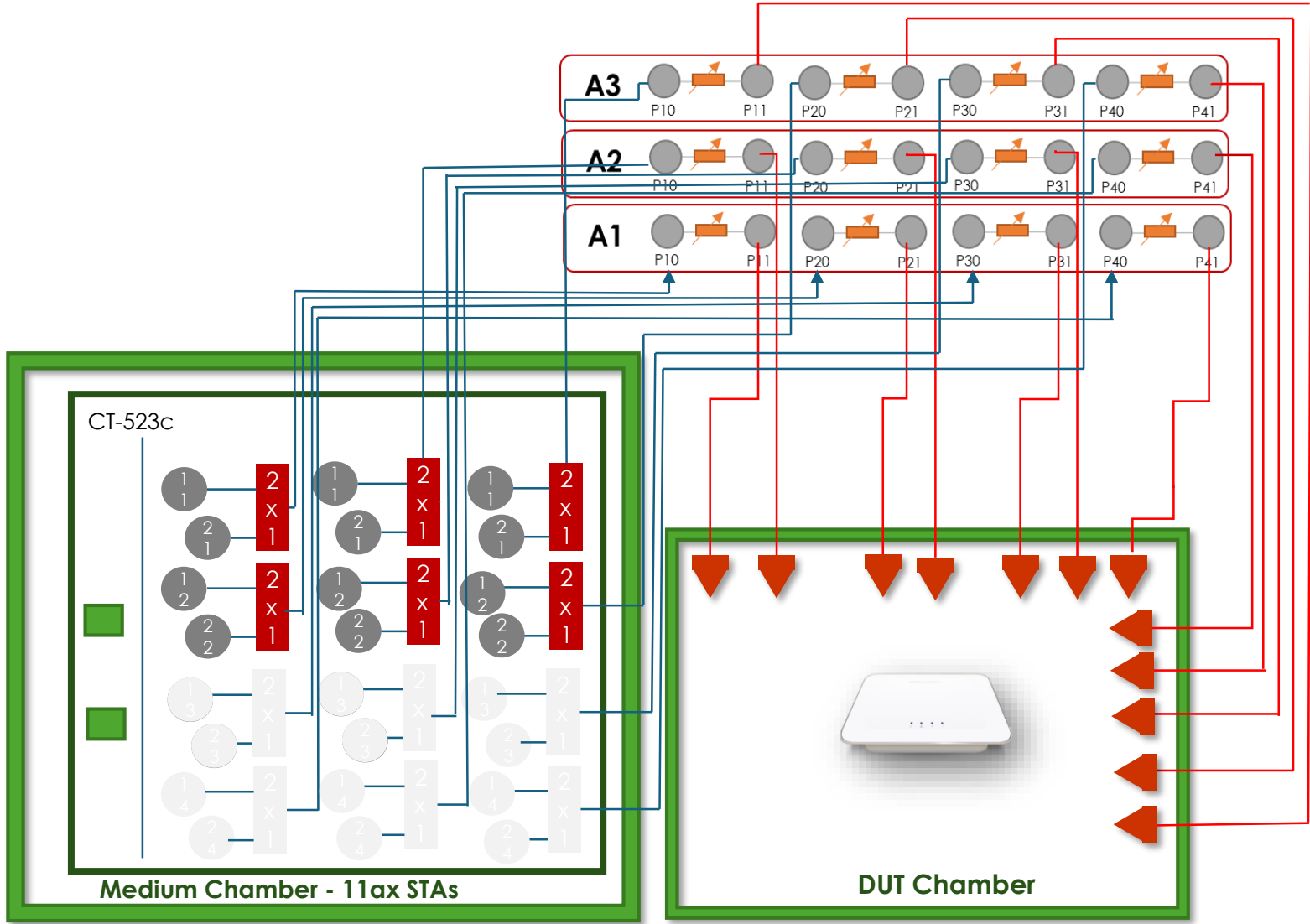
5. For the test in 802.11ax 6 GHz frequency band with Nss = 2:

- 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 1.44 Gbps.
- 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 1.2 Gbps.
- 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 800 Mbps.

Pass/Fail Criteria Contd.

3. For the test in 802.11be 2.4 GHz frequency band with Nss = 2:
 - 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 240 Mbps.
 - 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 150 Mbps.
 - 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 95 Mbps.
4. For the test in 802.11be 5 GHz frequency band with Nss = 2:
 - 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 820 Mbps.
 - 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 600 Mbps.
 - 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 400 Mbps.
5. For the test in 802.11be 6 GHz frequency band with Nss = 2:
 - 1.The summation of STA1_throughput_1 and STA2_throughput_1 SHALL be larger than 820 Gbps.
 - 2.The summation of STA1_throughput_2 and STA2_throughput_2 SHALL be larger than 700 Gbps.
 - 3.The summation of STA1_throughput_3 and STA3_throughput_3 SHALL be larger than 500 Mbps.

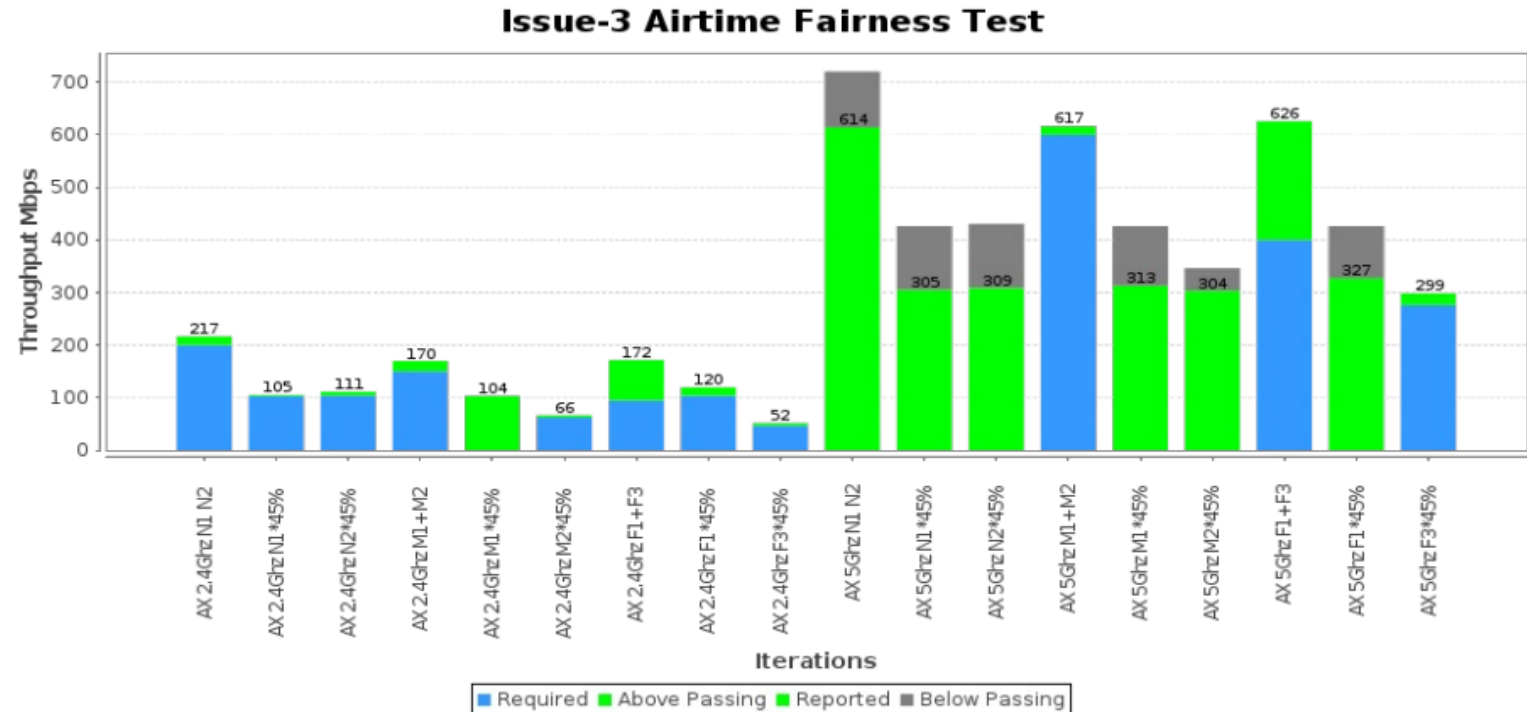
6.2.3 Wiring Diagram



6.2.3 Example Results

Summary Results

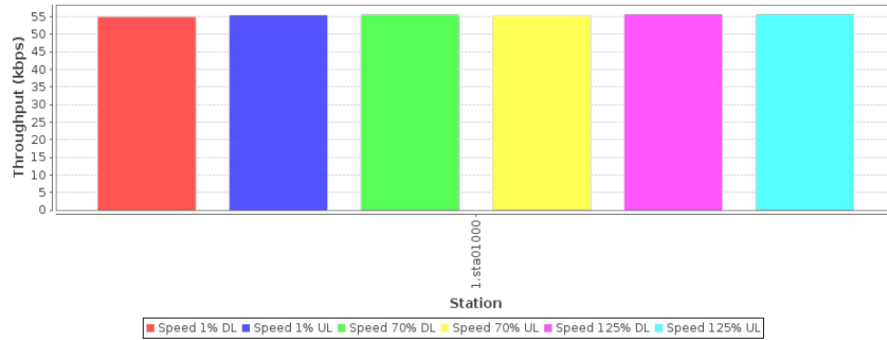
Test	Result	Candela Score	Elapsed	Info
Issue-3 Airtime Fairness Test	<u>2.4Ghz FAIL</u> <u>5Ghz FAIL</u>	80	17.739 m	AX 5Ghz passed 3 / 9 AX 2.4Ghz passed 8 / 9



Sample Test Results



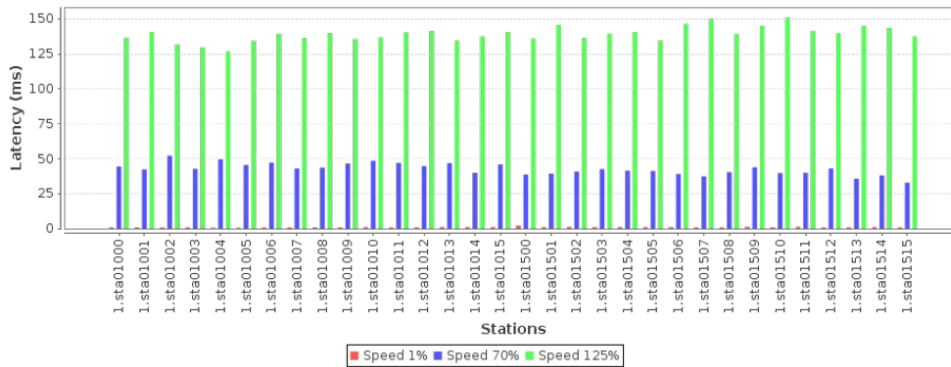
AX 2.4Ghz UDP Throughput for 1 station



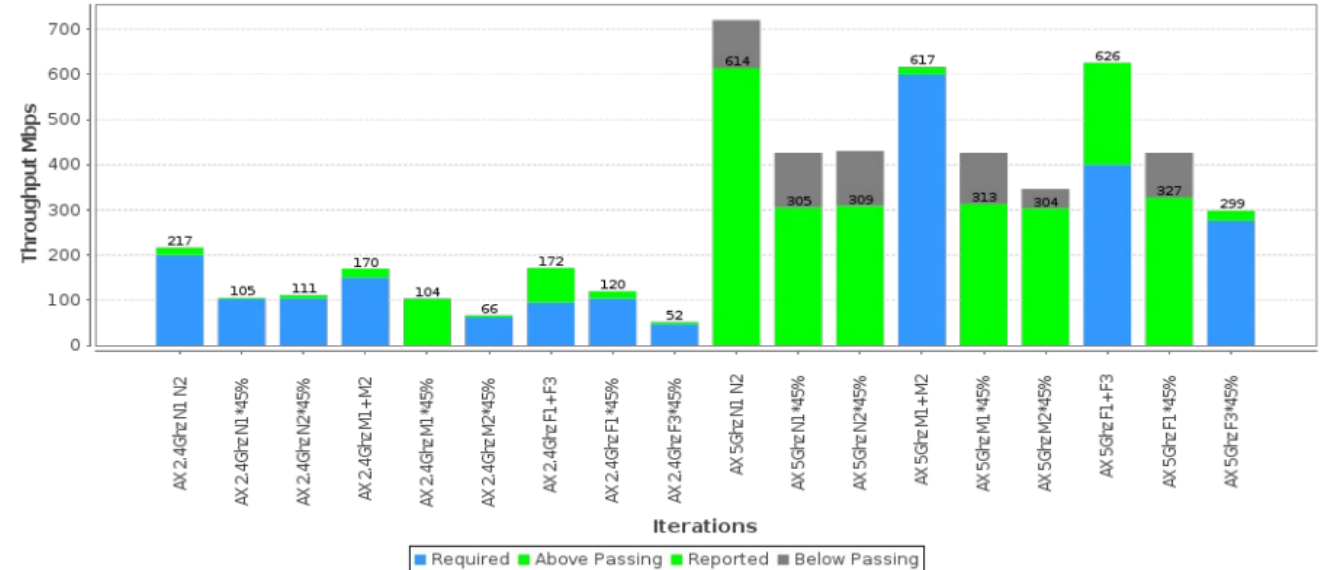
Summary Results

Test	Result	Candela Score	Elapsed	Info
Issue-3 Airtime Fairness Test	2.4Ghz FAIL 5Ghz FAIL	80	17.739 m	AX 5Ghz passed 3 / 9 AX 2.4Ghz passed 8 / 9

AX 2.4Ghz UDP Download Latency for 32 stations



Issue-3 Airtime Fairness Test



6.2.4 Dual Band Throughput Test

- The purpose of these test is to detect cross band interference of the DUT's transmitter on the receiver. The weak link is needed to ensure DUT, and STA are transmitting at the highest power and causing the most potential interference when the receiver is more susceptible to noise (low SNR).

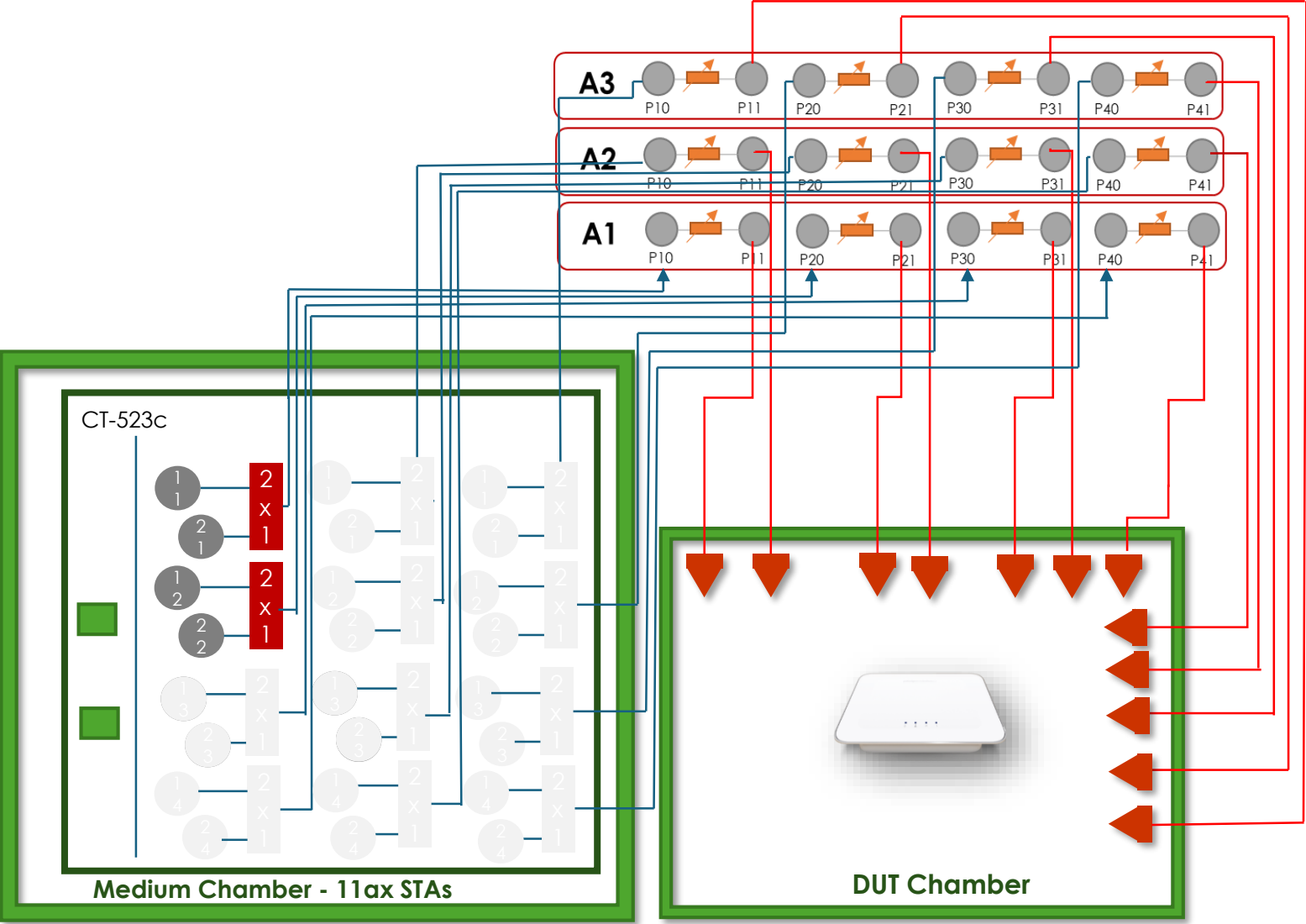
Test Procedure

1. Configure the system to emulate a 2-meter distance. This is the baseline '0' attenuation.
2. Set attenuation to 10db above 2m baseline.
3. Establish the LAN connection, create 1 on 2.4GHZ and one on 5 or 6Ghz and allow the stations to associate with the DUT.
4. Measure the downlink TCP throughput across both stations, with offered load as specified in the pass/fail table, using a test time of 120 seconds.
5. Measure the uplink TCP throughput across both stations, using a test time of 120 seconds.
6. Measure downlink on 2.4 station, uplink on 5 or 6Ghz station, using a test time of 120 seconds.
7. Measure uplink on 2.4 station, downlink on 5 or 6Ghz station, using a test time of 120 seconds.

Pass/Fail Criteria

Attenuation (dB)	Throughput Requirement(Mbps) 2.4 GHz	Throughput Requirement(Mbps) 5 GHz	Throughput Requirement(Mbps) 6 GHz
12/6 (n/ac)	60	390	N/A
30/24 (n/ac)	60	390	N/A
43/39 (n/ac)	15	115	N/A
12/6/0 (ax)	155	725	1400
30/24/15 (ax)	75	470	700
43/39/27 (ax)	20	115	75
12/6/0 (be)	218	950	N/A
30/24/15 (be)	190	570	N/A
43/39/27 (be)	N/A	950	2280

6.2.2 Wiring Diagram



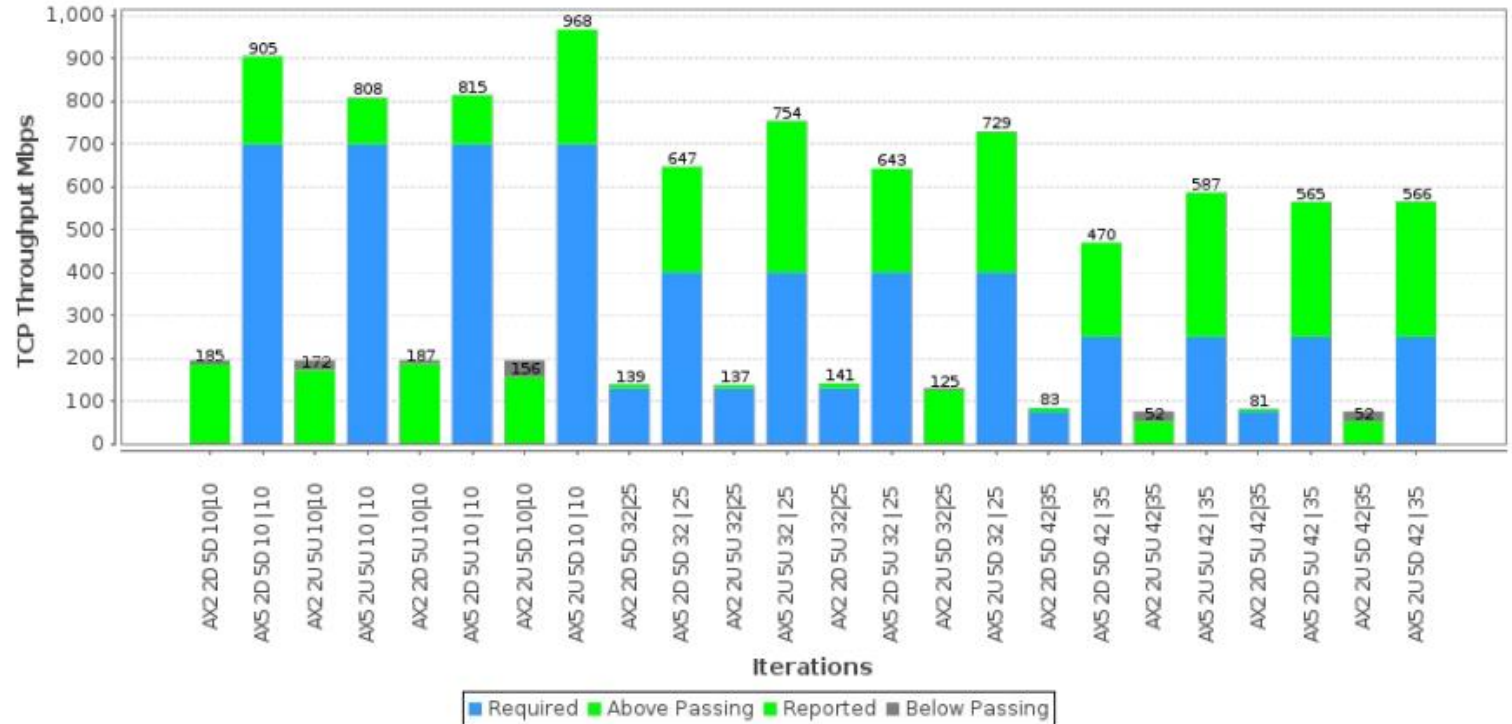
6.2.4 Example Results



Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.4 Dual-Band Throughput Test	2.4Ghz FAIL 5Ghz FAIL	85	7.252 m	2.4 AX 5 / 12 5Ghz AX 12 / 12

6.2.4 Dual-Band Throughput Test



6.2.5 Bidirectional Throughput test

- ❑ The Bidirectional Throughput Test measures the uplink and downlink simultaneously achieved through the DUT and a station

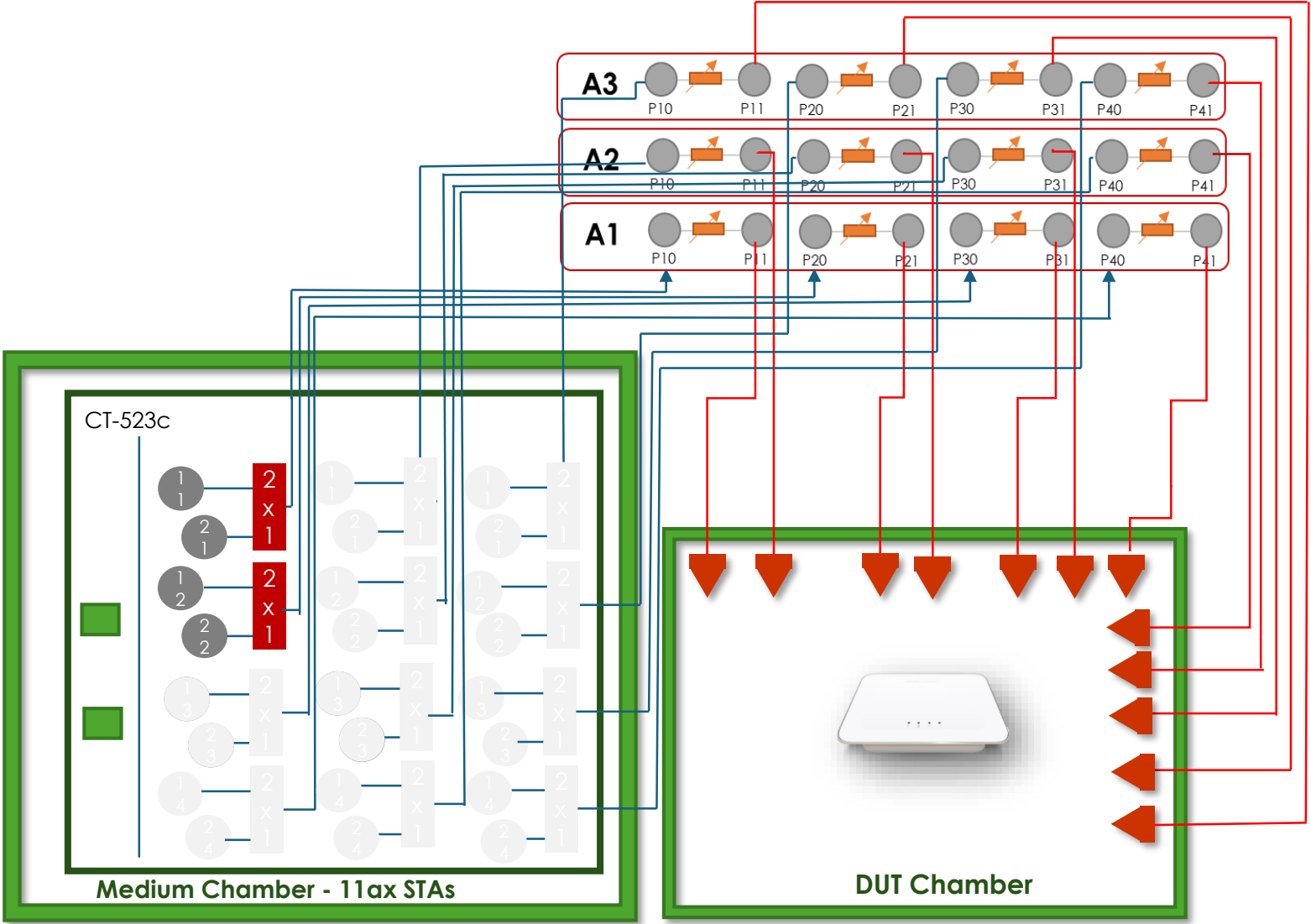
Test Procedure

1. Configure stations for N/AC mode.
2. Set attenuator to 12 for 2.4Ghz 'close' value.
3. Establish the LAN connection, create 1 station and allow the station to associate with the DUT.
4. Measure the downlink TCP throughput, using a test time of 120 seconds.
5. Measure the uplink TCP throughput, using a test time of 120 seconds.
6. Create bi-directional UDP connection that uses 45% of TCP throughput, using a test time of 120 seconds.
7. Record packet loss in each direction.
8. Repeat these steps for attenuation: 2m + 30, 43 for 2.4Ghz
9. Repeat these steps for attenuation: 2m + 6, 24, 39 for 5Ghz.
10. Repeat these steps for attenuation: 2m + 0, 15, 27 for 6Ghz.
11. Repeat these steps for AX mode.
12. Repeat these steps for BE mode.

PASS/FAIL Criteria

1. Each measured PACKET_LOSS_RATIO_DL and PACKET_LOSS_RATIO_UL SHALL be less than or equal to 1E-2

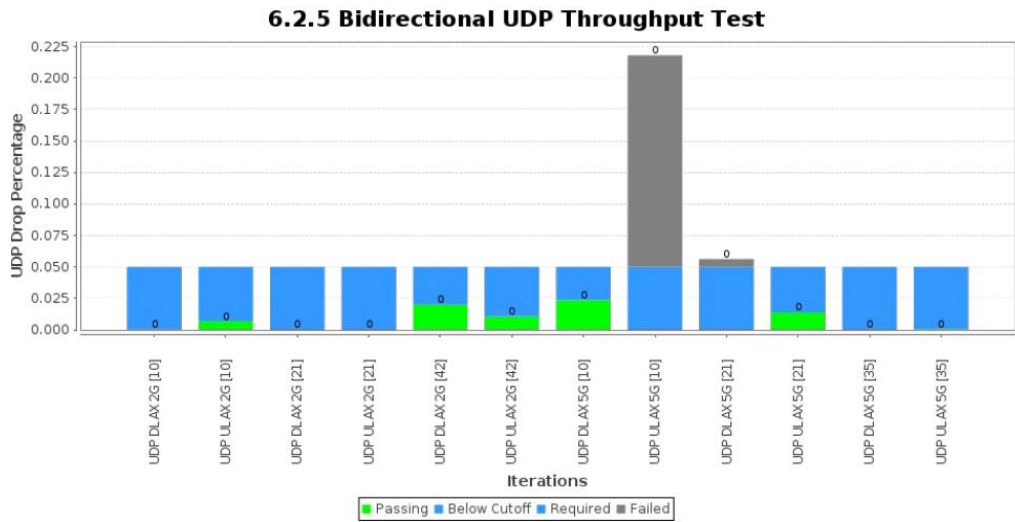
6.2.5 Wiring Diagram



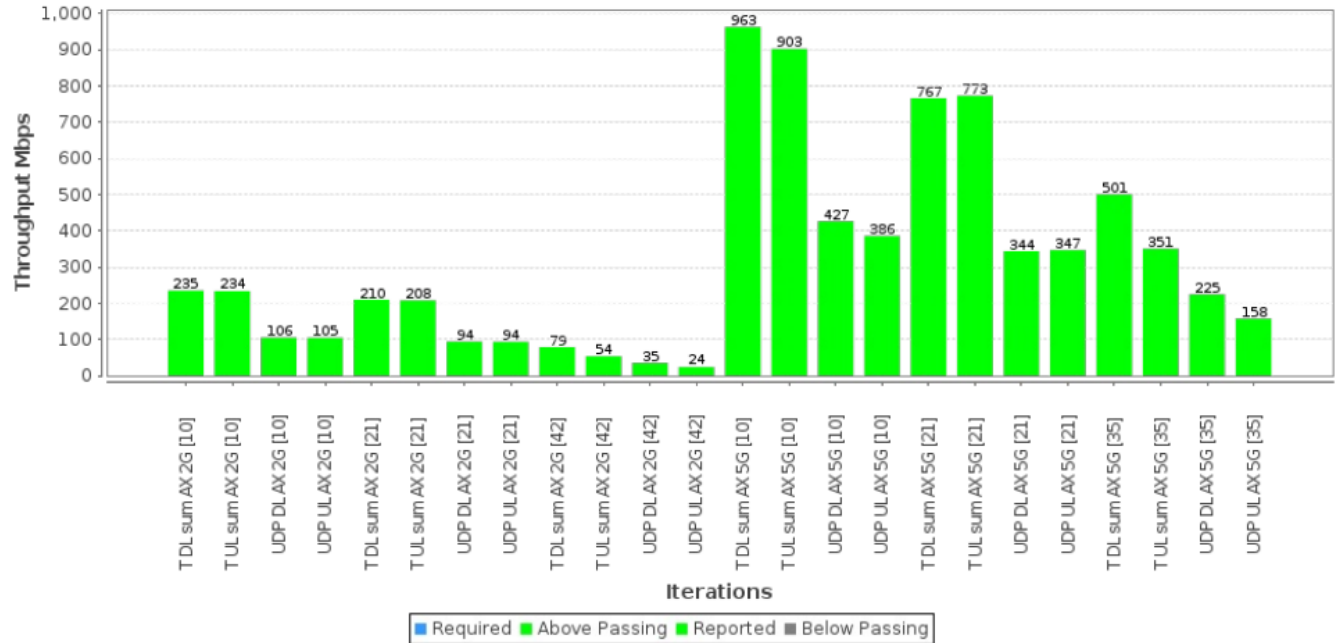
6.2.5 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.5 Bidirectional UDP Throughput Test	2.4Ghz PASS 5Ghz FAIL	83	20.249 m	AX 5Ghz passed 1 / 3 AX 2.4Ghz passed 3 / 3



6.2.5 Bidirectional UDP Throughput Test



6.2.6 Latency under Load Test

- ❑ The Latency test intends to verify latency under low, high, and maximum AP traffic load, with 1 and 32 stations. Traffic load is 4 bi-directional TCP streams for each station, plus a low speed UDP connection to probe latency.

Test Procedure

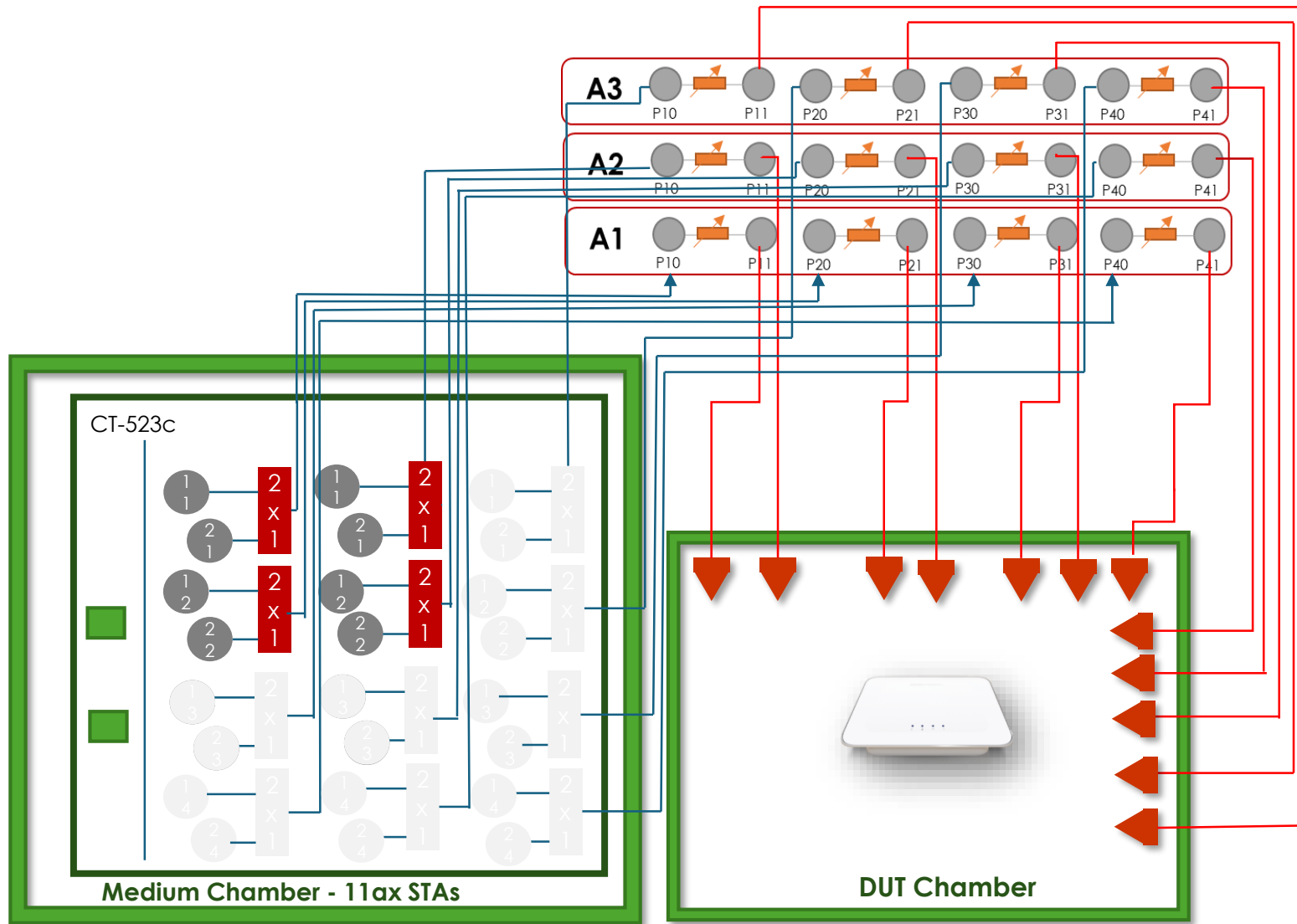
DUT should be configured for 20Mhz on 2.4Ghz, 80Mhz on 5Ghz for 802.11ax, 160MHz on 5GHz for 802.11be, and 160Mhz on 6Ghz for 802.11ax, 320MHz on 6GHz for 802.11be and stations should use two spatial streams. Ensure clocks between Eth and Sta devices are synchronized to within 5ms of each other. Standard NTP protocol should achieve this.

1. For each combination of: 2.4Ghz N, 5Ghz AC, 2.4Ghz AX, 5Ghz AX, 6Ghz AX,;
2. Configure attenuators to emulate 2-meter distance between stations and AP.
3. Create 32 stations and allow one to associate with the DUT. The other 31 are admin-down.
4. Create AP to Station (download) TCP stream, and run for 120 seconds, record throughput as 'maximum_load'. Stop this connection.
5. Calculate offered_load as 1% of maximum_load.
6. Create 4 TCP streams on each active station, each configured for Upload and Download rate of offered_load / (4 * active_station_count * 2).
7. Create 1 UDP stream on each active station, configured for 56kbps traffic Upload and 56kbps traffic Download.
8. Start all TCP and UDP connections. Wait 30 seconds to let traffic settle.
9. Every 10 seconds for 120 seconds, record one-way downloadlatency over the last 10 seconds for each UDP connection. Depending on test equipment features, this may mean you need to start/stop the UDP every 10 seconds or clear the UDP connection counters.
10. Calculate offered_load as 70% of maximum_load, and repeat steps 6 - 9 inclusive.
11. Calculate offered_load as 125% of maximum_load, and repeat steps 6 - 9 inclusive.
12. Allow the other 31 stations to associate, and repeat steps 5 - 11 inclusive with all 32 stations active.

Pass/Fail Criteria

1. For each test configuration running at 1% of maximum load, 1 station: Average of all UDP latency samples must be less than 15ms.
2. For each test configuration running at 1% of maximum load, 32 stations: Average of all UDP latency samples must be less than 25ms.
3. For each test configuration running at 70% of maximum load, 1 station: Average of all UDP latency samples must be less than 25ms.
4. For each test configuration running at 70% of maximum load, 32 stations: Average of all UDP latency samples must be less than 150ms.
5. For each test configuration running at 125% of maximum load, 1 station: Average of all UDP latency samples must be less than 55ms.
6. For each test configuration running at 125% of maximum load, 32 stations: Average of all UDP latency samples must be less than 250ms.
7. For each test configuration: Each UDP connection upload throughput must be at least 1/2 of requested UDP speed for final 10-second test interval.
8. For each test configuration: Each UDP connection download throughput must be at least 1/2 of requested UDP speed for final 10-second test interval.

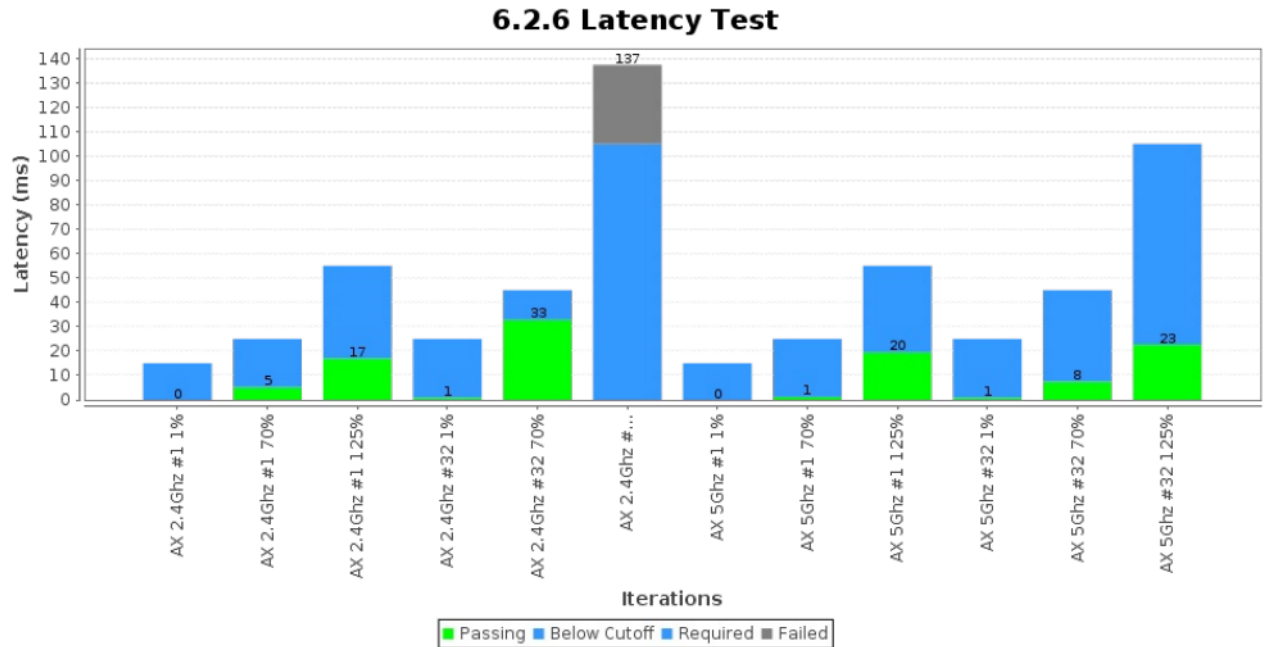
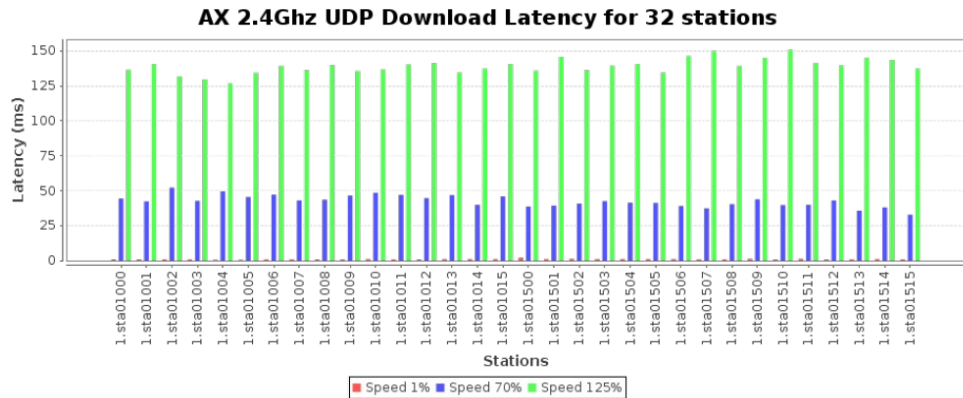
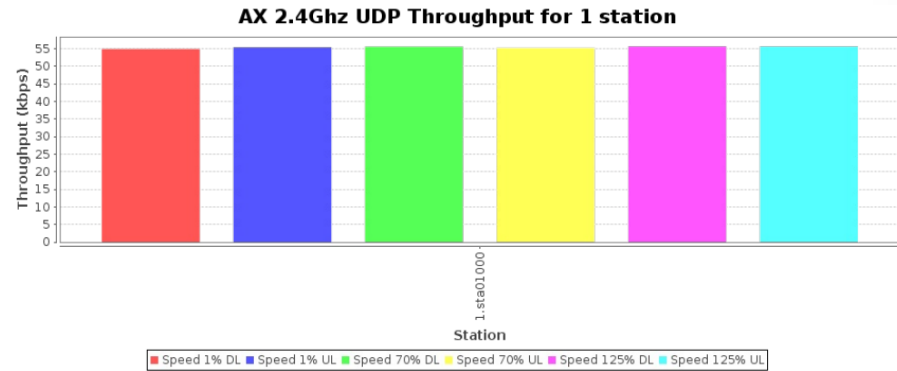
6.2.6 Wiring Diagram



6.2.6 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.6 Latency Test	2.4Ghz FAIL 5Ghz PASS	47	36.783 m	Total CX Passing Throughput: 198 / 198 100% Total CX Passing 2.4 AX: 58.0 / 99.0 58.586% Total CX Passing 5Ghz AX: 99.0 / 99.0 100%



6.2.7 Quality of Service

- ❑ Quality of Service Test intends to verify the capability of Wi-Fi device to ensure higher priority traffic gets prioritized over lower priority traffic. Best Effort QoS TCP traffic is used to determine maximum capacity of the station. Then combinations of VO, VI, BE, BK QoS UDP traffic is requested to run at 75% of the TCP throughput. This overdrives the AP and causes it to drop frames. The pass/fail criteria is that the higher QoS stream gets more priority (but not too much priority) than the lower QoS stream, while maintaining good over-all throughput.

Test Procedure

1. Establish the setup using default configuration for the 802.11n 2.4 GHz frequency band with Nss = 2 operating mode for STA1.
2. Associate STA1 with DUT. Establish the LAN connection and wait for 10 seconds.
3. Measure the achievable downlink Best Effort QoS TCP throughput through STA1, using a test time of 120 seconds. Record this value as STA1_Throughput_Max_DL_1. Stop the TCP traffic.
4. Configure the first downlink UDP traffic stream to use Voice QoS traffic.
5. Configure the second downlink UDP traffic stream to use Video QoS traffic.
6. Configure the first downlink UDP traffic stream to use a downlink data rate set to 75% of STA1_Throughput_Max_DL_1.
7. Configure the second downlink UDP traffic stream to use a downlink data rate set to 75% of STA1_Throughput_Max_DL_1.
8. Simultaneously run the two UDP traffic streams for 120 seconds, recording the throughput for each stream.
9. Repeat steps 6-8 for each other combination in the QoS Combinations table above.
10. Set the DUT to operating mode to 802.11ac 5 GHz frequency band. Repeat steps 2 through 9.
11. Set the DUT to operating mode to 802.11ax 2.4 GHz frequency band. Repeat steps 2 through 9.
12. Set the DUT to operating mode to 802.11ax 5 GHz frequency band. Repeat steps 2 through 9.
13. Set the DUT to operating mode to 802.11ax 6 GHz frequency band and 160Mhz. Repeat steps 2 through 9.

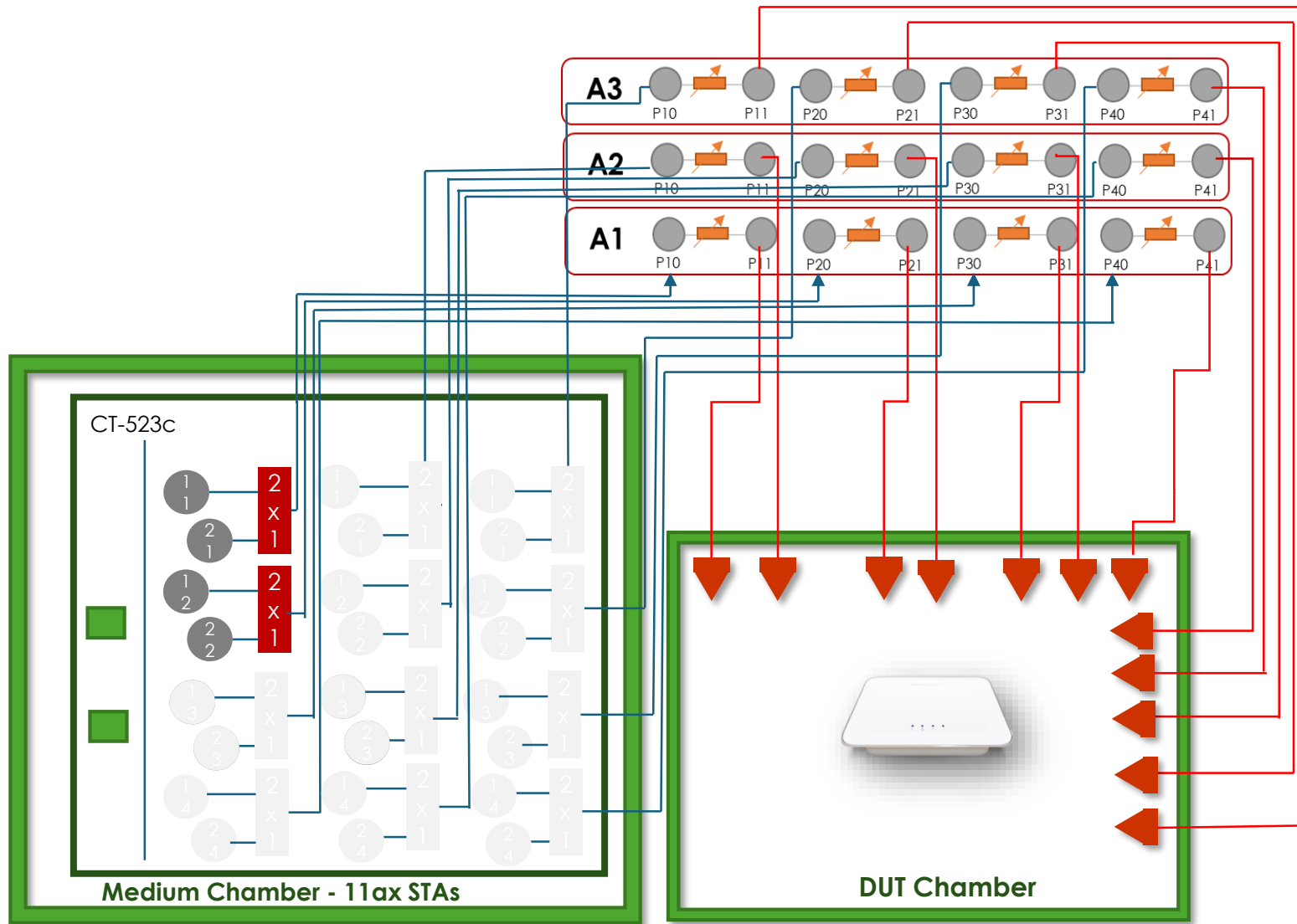
14. Set the DUT to operating mode to 802.11be 2.4 GHz frequency band. Repeat steps 2 through 9.
15. Set the DUT to operating mode to 802.11be 5 GHz frequency band and 160MHz. Repeat steps 2 through 9.
16. Set the DUT to operating mode to 802.11be 6 GHz frequency band and 320Mhz. Repeat steps 2 through 9.

Pass/Fail Criteria

For each combination of QoS, calculate the ratio of connection_1_throughput / connection_2_throughput:

1. For For Connection-2 Video & Best Effort: The ratio must be at least 1.1.
2. For Connection-2 Background: The ratio must be at least 1.2.
3. Combined throughput must be at least 90% of the STA1_throughput_Max_DL_1 measurement.

6.2.7 Wiring Diagram

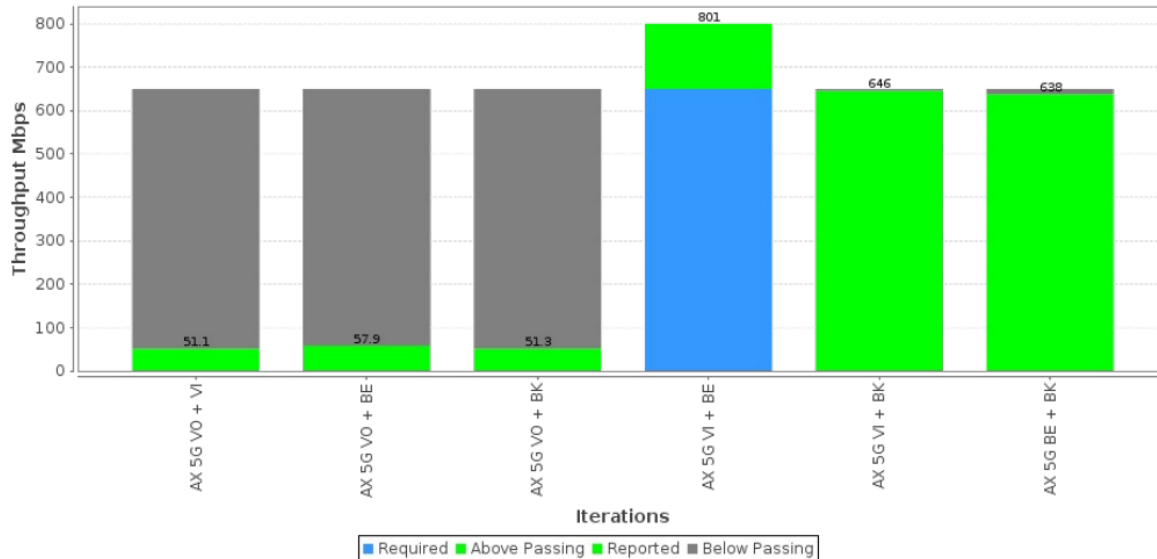


6.2.7 Example Results

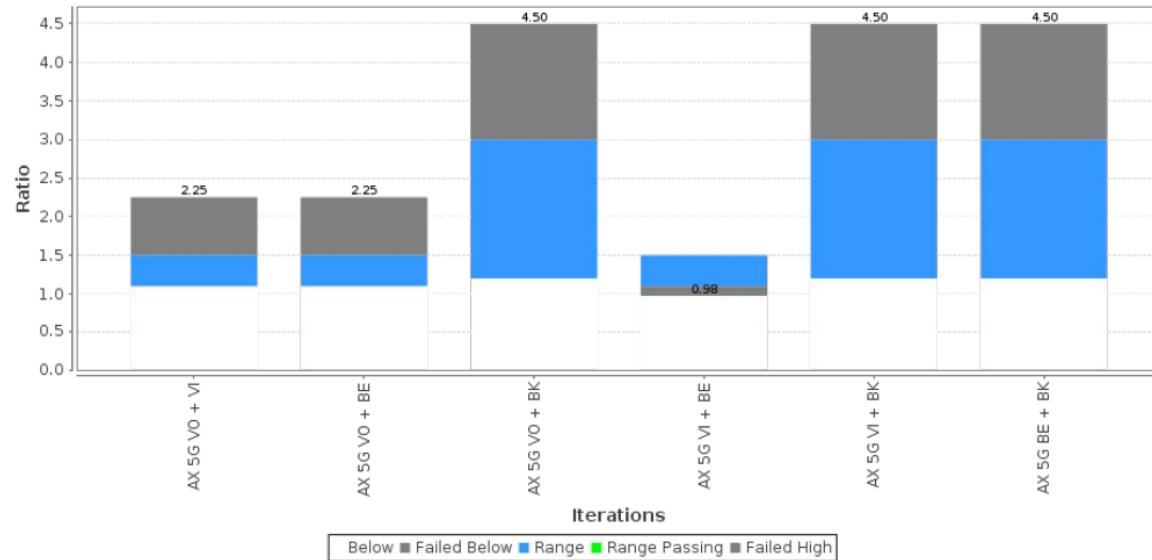
Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.7 Quality of Service Test	5Ghz FAIL	8	8.879 m	AX 5Ghz passed 1 / 12

6.2.7 Quality of Service Test: Throughput



6.2.7 Quality of Service Test: Ratio



6.2.8 Multi-band Throughput Test

- ❑ The Multi-band Throughput Test is intended to measure the throughput the DUT can support when concurrently connected to multiple stations on all the 2.4, 5 and 6 GHz bands, each operating with two spatial streams. The purpose of these additional test cases is to detect cross band interference of the DUT's transmitter on the receiver and to confirm the DUT has enough resources to serve multiple bands concurrently.

Test Procedure

These steps are done for AX stations, for the 3 attenuation steps (close, medium, far).

For the 2.4Ghz attenuation steps: 12 30 43.

For the 5Ghz attenuation steps: 6 24 39.

For the 6Ghz attenuation steps: 0 15 27.

TCP traffic offered load in this test should be configured 5Mbps above the pass/fail cutoff.

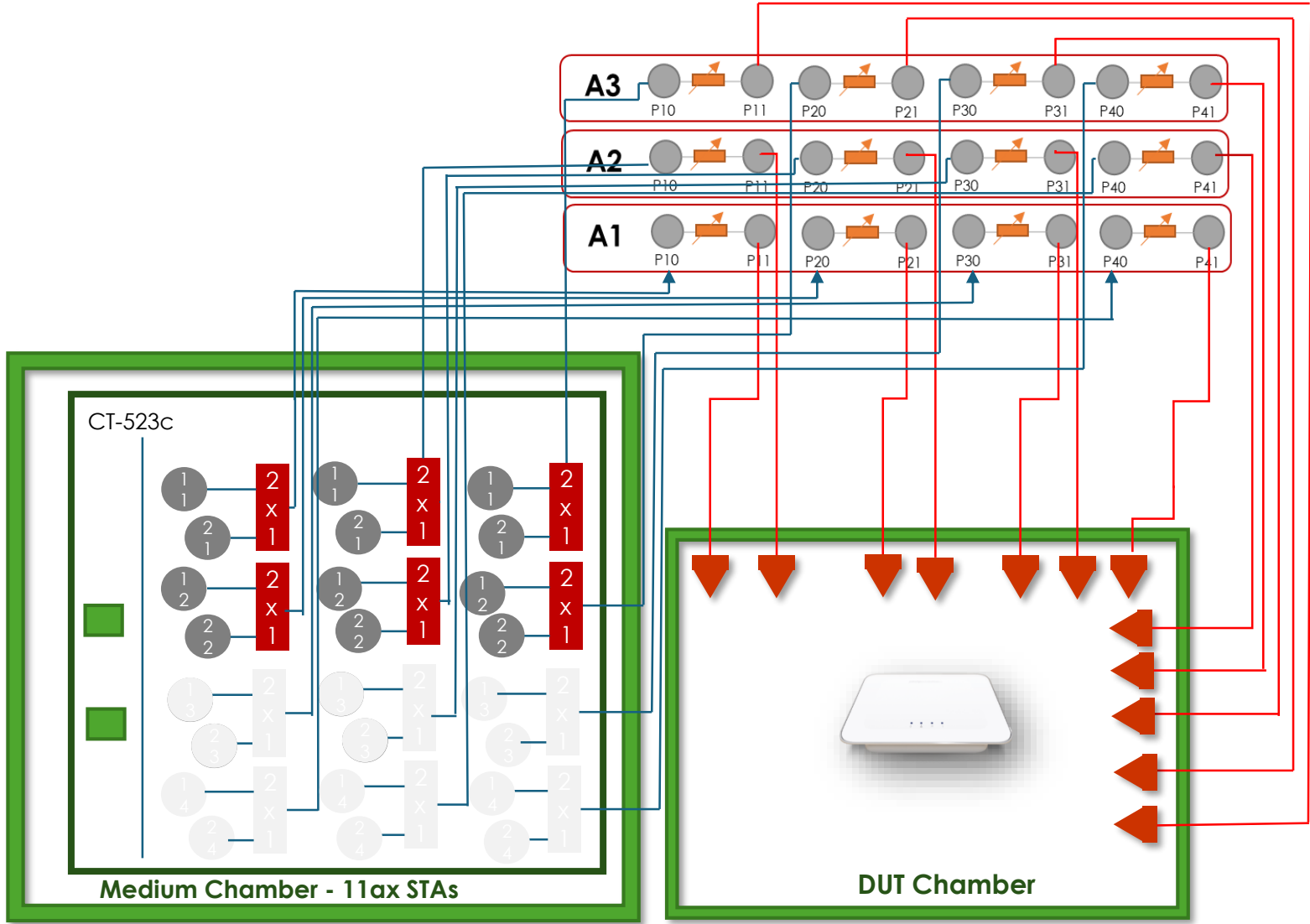
1. Configure the system to emulate a 2-meter distance. This is the baseline '0' attenuation.
2. Set attenuation to attenuator setting for respective band and close/medium/far distance.
3. Establish the LAN connection, create 1 STA on 2.4GHZ, one on 5Ghz, and one on 6Ghz and allow the stations to associate with the DUT.
4. Measure the downlink TCP throughput across all three stations, with offered load as shown in the pass/fail table, using a test time of 120 seconds.
5. Measure the uplink TCP throughput across all three stations, using a test time of 120 seconds.
6. Measure downlink on 2.4 and 5GHz station, uplink 6Ghz station, using a test time of 120 seconds.
7. Measure downlink on 2.4 and 6Ghz station, uplink on 5GHz station, using a test time of 120 seconds.

Pass/Fail Criteria

Each attenuation step must pass a certain amount of traffic to pass the test (units are Mbps). More than one failure per attenuation step means test failed.

1. Attenuation 12: 2.4Ghz STA 195 Mbps
2. Attenuation 30: 2.4Ghz STA 130 Mbps
3. Attenuation 43: 2.4Ghz STA 60 Mbps
4. Attenuation 6: 5Ghz STA 700 Mbps
5. Attenuation 24: 5Ghz STA 400 Mbps
6. Attenuation 39: 5Ghz STA 70 Mbps
7. Attenuation 0: 6Ghz STA 1400 Mbps
8. Attenuation 15: 6Ghz STA 700 Mbps
9. Attenuation 27: 6Ghz STA 70 Mbps

6.2.8 Wiring Diagram



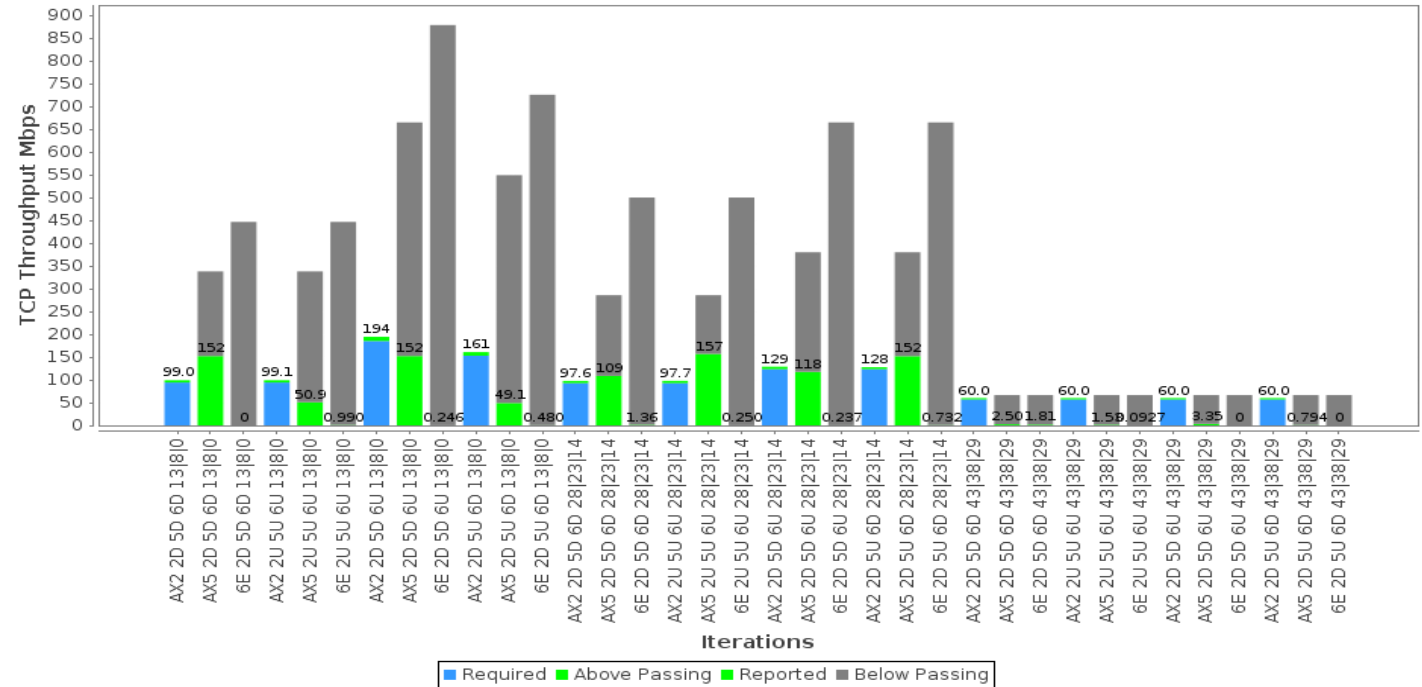
6.2.8 Example Results



Summary Results

Test	Result	Candela Score	Elapsed	Info
6.2.8 Multi-Band Throughput Test	2.4Ghz FAIL 5Ghz FAIL 6Ghz FAIL	33	15.221 m	AX-2.4 12 / 12 AX-5G 0 / 12 AX-6G 0 / 12

6.2.8 Multi-Band Throughput Test AX-2.4 + AX-5G



6.2.9 OFDMA Throughput Test

- ❑ The OFDMA test compares throughput with OFDMA enabled and disabled. The traffic load consists of 31 stations doing moderate speed download of 300 byte UDP payloads.

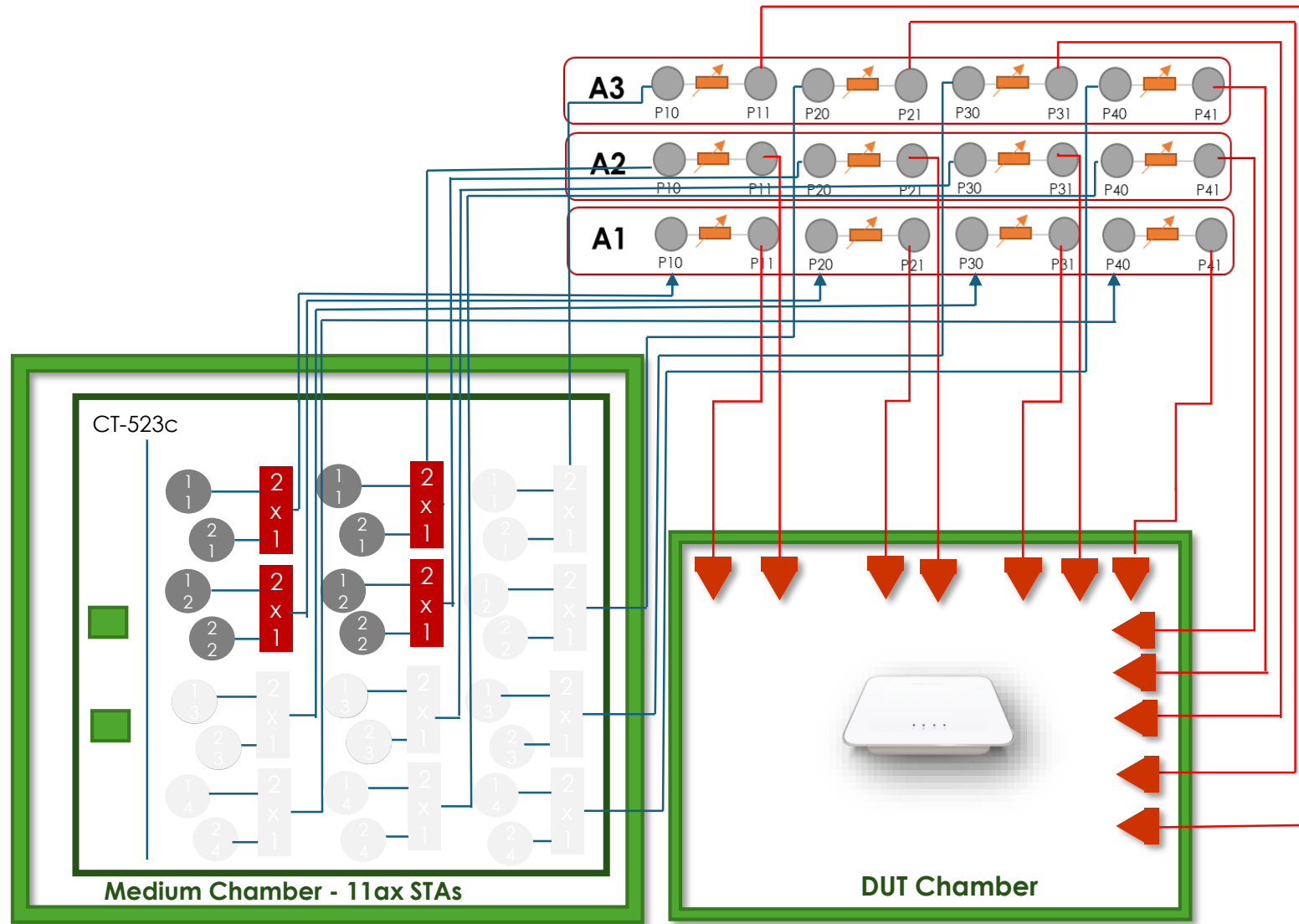
Test Procedure

1. Set to Medium AAV attenuation distance.
2. Set DUT AP to have OFDMA disabled.
3. Establish the LAN connection, create 32 stations and allow the 32 stations to associate with the DUT.
4. Create UDP download connections with 300 byte UDP payload on 31 of the stations.
5. Create 1 TCP Download connection set to run at maximum speed on the 32nd station.
6. Start all connections, let them ramp up traffic for 30 seconds.
7. Calculate total throughput of all 32 data connections over the next 2 minutes.
8. Record TCP throughput.
9. Record sum of UDP throughput.
10. Set DUT AP to have OFDMA enabled.
11. Repeat steps 3-9.

Pass/Fail Criteria

1. Total UDP + TCP throughput with OFDMA enabled must be at least 105% of non-OFDMA traffic total throughput.
2. Total UDP throughput with OFDMA enabled must be at least 95% of non-OFDMA traffic total throughput.

6.2.9 Wiring Diagram



6.3.1 Rate vs Range Test

- ❑ Range versus rate test intends to measure the baseband and RF chain performance of Wi-Fi device. The attenuation of signals due to increasing range is achieved by using attenuator(s) in the RF path between the AP and STA.

Test Procedure

These steps are done for 2.4Ghz, 5Ghz and 6Ghz, n/AC, AX and BE.

1. Configure the system to emulate a 2-meter distance in the appropriate band. This is the baseline '0' attenuation.
2. Establish the LAN connection, create 1 station and allow the station to associate with the DUT.
3. Measure the downlink TCP throughput, using a test time of 120 seconds.
4. Measure the uplink TCP throughput, using a test time of 120 seconds.
5. For each of these attenuations on top of the baseline attenuation, repeat the steps above:
 - For 2.4Ghz: 0, 6, 12, 18, 24, 30, 36, 39, 41, 43, 45, 47, 49
 - For 5Ghz: 0, 6, 12, 18, 24, 30, 36, 39, 41, 43, 45, 47, 49
 - For 6Ghz: 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30

Additional attenuation for test 802.11n and 802.11ax 2.4 GHz	0 dB (default), 6 dB, 12 dB, 18 dB, 24 dB, 30 dB, 36 dB, 39 dB, 41 dB, 43 dB, 45 dB, 47 dB, 49 dB
Additional attenuation for test of 802.11ac and 802.11ax 5Ghz	0 dB (default), 6 dB, 12 dB, 18 dB, 24 dB, 30 dB, 36 dB, 39 dB, 41 dB, 43 dB, 45 dB, 47 dB, 49 dB
Additional attenuation for test of 802.11ax 6 GHz	0 dB (default), 3 dB, 6 dB, 9 dB, 12 dB, 15 dB, 18 dB, 21 dB, 24 dB, 27 dB, 30 dB

6.3.1 Pass/Fail Criteria

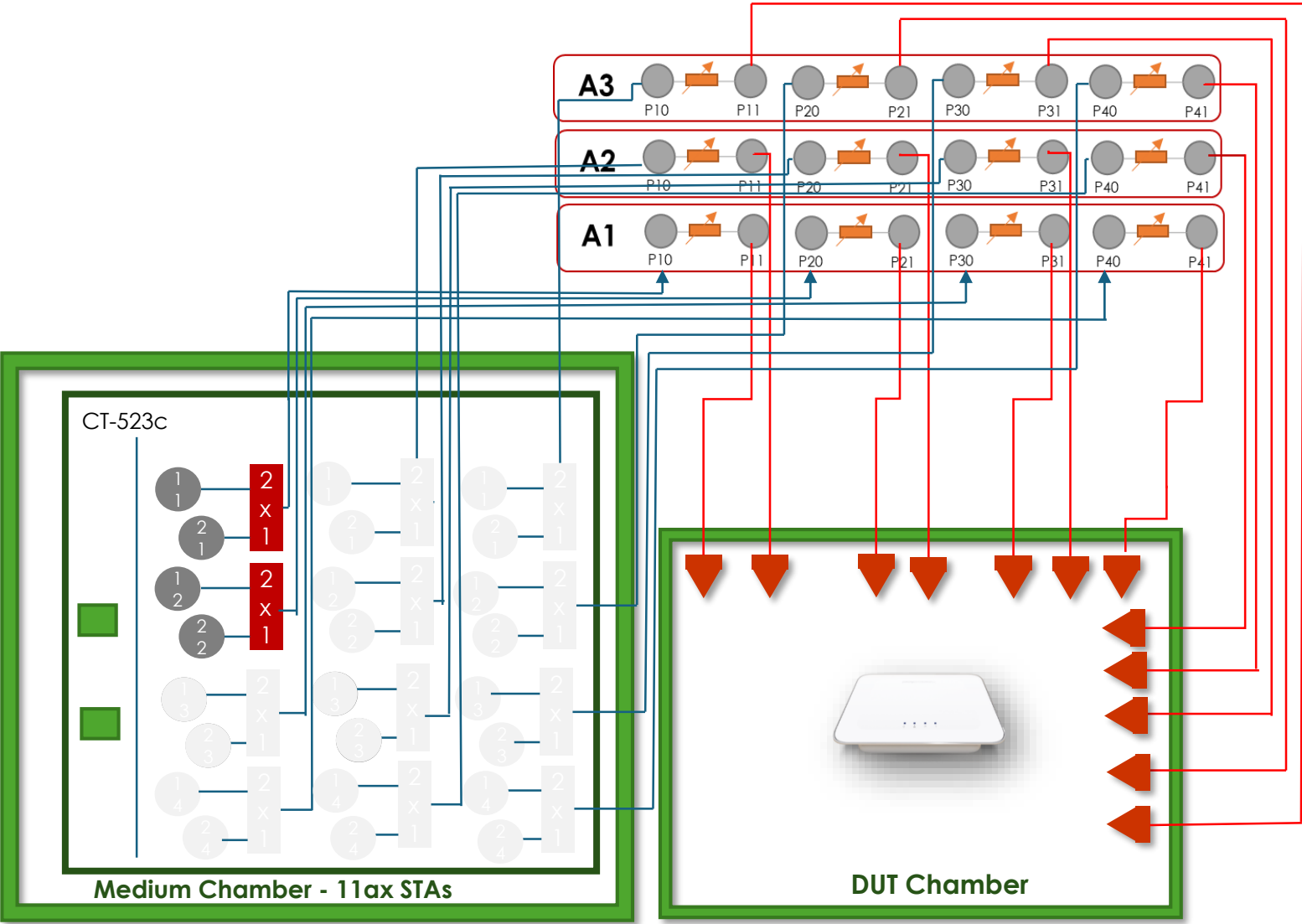
2.4Ghz-Attenuation	0	6	12	18	24	30	36	39	41	43	45	47	49
N 2.4G-Download(Mbps)	100	100	100	100	90	70	45	40	25	20	15	8	5
N 2.4G-Upload(Mbps)	100	100	100	100	90	70	45	40	25	20	15	8	5
AX 2.4G-Download(Mbps)	180	180	180	145	135	90	55	35	30	25	15	15	10
AX 2.4G-Upload(Mbps)	180	180	180	145	135	90	55	35	30	25	15	15	10
BE 2.4G-Download(Mbps)	240	200	150	120	90	85	65	55	30	25	15	10	4
BE 2.4G-Upload(Mbps)	240	200	150	120	90	85	65	50	25	20	10	5	4

5Ghz-Attenuation	0	6	12	18	24	30	36	39	41	43	45	47	49
AC 5G-Download(Mbps)	650	650	645	525	460	335	180	135	115	85	60	40	20
AC 5G-Upload(Mbps)	650	650	645	525	460	335	180	135	115	85	60	40	20
AX 5G-Download(Mbps)	880	855	820	700	555	395	215	150	135	85	75	45	40
AX 5G-Upload(Mbps)	880	855	820	700	555	395	215	150	135	85	75	45	40
BE 5G-Download(Mbps)	900	600	465	400	350	250	175	125	100	50	7	5	2
BE 5G-Upload(Mbps)	900	600	400	350	250	175	125	100	50	7	2	2	1

6Ghz-Attenuation	0	3	6	8	12	15	18	21	24	27	30
AX 6G- Download(Mbps)	1500	1400	1300	1200	1100	1000	900	800	700	600	400
AX 6G- Upload(Mbps)	1500	1400	1300	1200	1100	1000	900	800	700	600	400

6Ghz-Attenuation	0	3	6	8	12	15	18	21	24	27	30
BE 6G- Download(Mbps)	2400	1500	1000	750	300	200	175	150	50	7	2
BE 6G- Upload(Mbps)	2400	1500	1000	750	300	200	175	150	50	7	2

6.3.1 Wiring Diagram

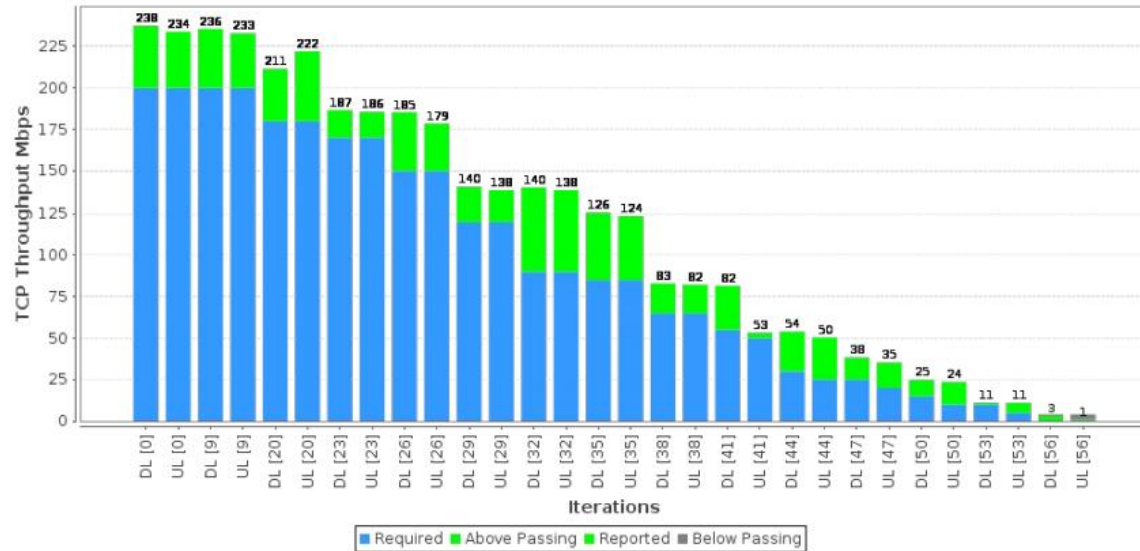


6.3.1 Example Results

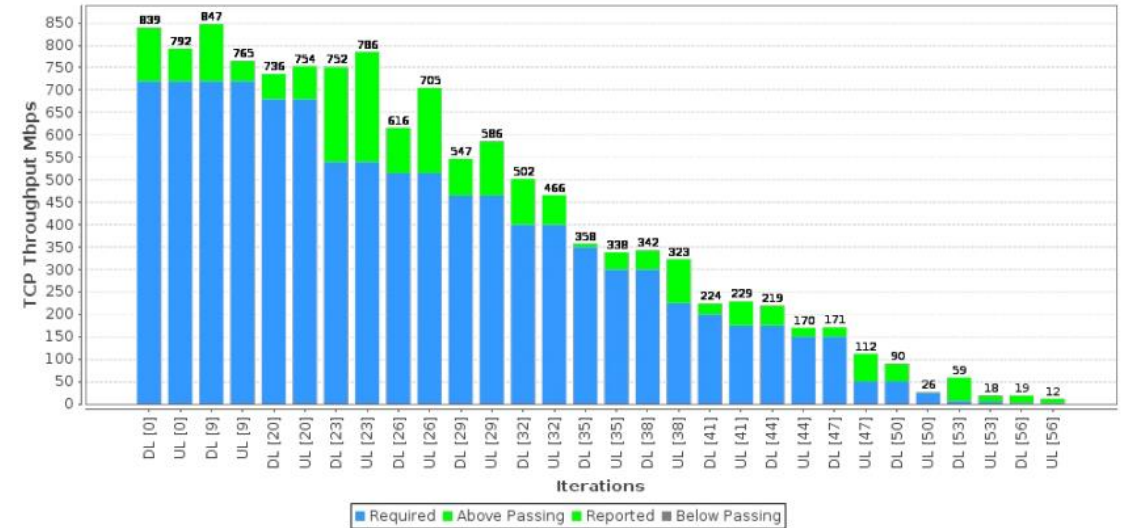
Summary Results

Test	Result	Candela Score	Elapsed	Info
6.3.1 Range Versus Rate Test	2.4Ghz PASS 5Ghz PASS	98	34.041 m	AX 5Ghz UL 15 / 15 DL 15 / 15 AX 2.4Ghz UL 14 / 15 DL 14 / 15

AX 2.4Ghz: 6.3.1 Range Versus Rate Test



AX 5Ghz: 6.3.1 Range Versus Rate Test



6.3.2 Spatial Consistency Test

- ❑ Spatial consistency test intends to verify the Wi-Fi signal consistency in spatial domain.

Test Procedure

These steps are done for 2.4, 5 and 6Ghz. 5Ghz uses 160Mhz in 802.11be and 6GHz uses 160MHz in 802.11ax, 320MHz in 802.11be

1. Configure the system to emulate a 2-meter distance.
2. Establish the LAN connection, create 1 station and allow the station to associate with the DUT.
3. Measure the downlink TCP throughput, using a test time of 60 seconds.
4. Measure the uplink TCP throughput, using a test time of 60 seconds.
5. Change attenuation by adding these values to the baseline 2-meter attenuation:
 - For 2.4 Ghz band: 12, 30, 43
 - For 5 Ghz band: 6, 24, 39
 - For 6 Ghz band: 0, 15, 27
6. Rotate the AP platform by 30 degrees and repeat steps above until the AP has been rotated a full 360 degrees.

Pass/Fail Criteria

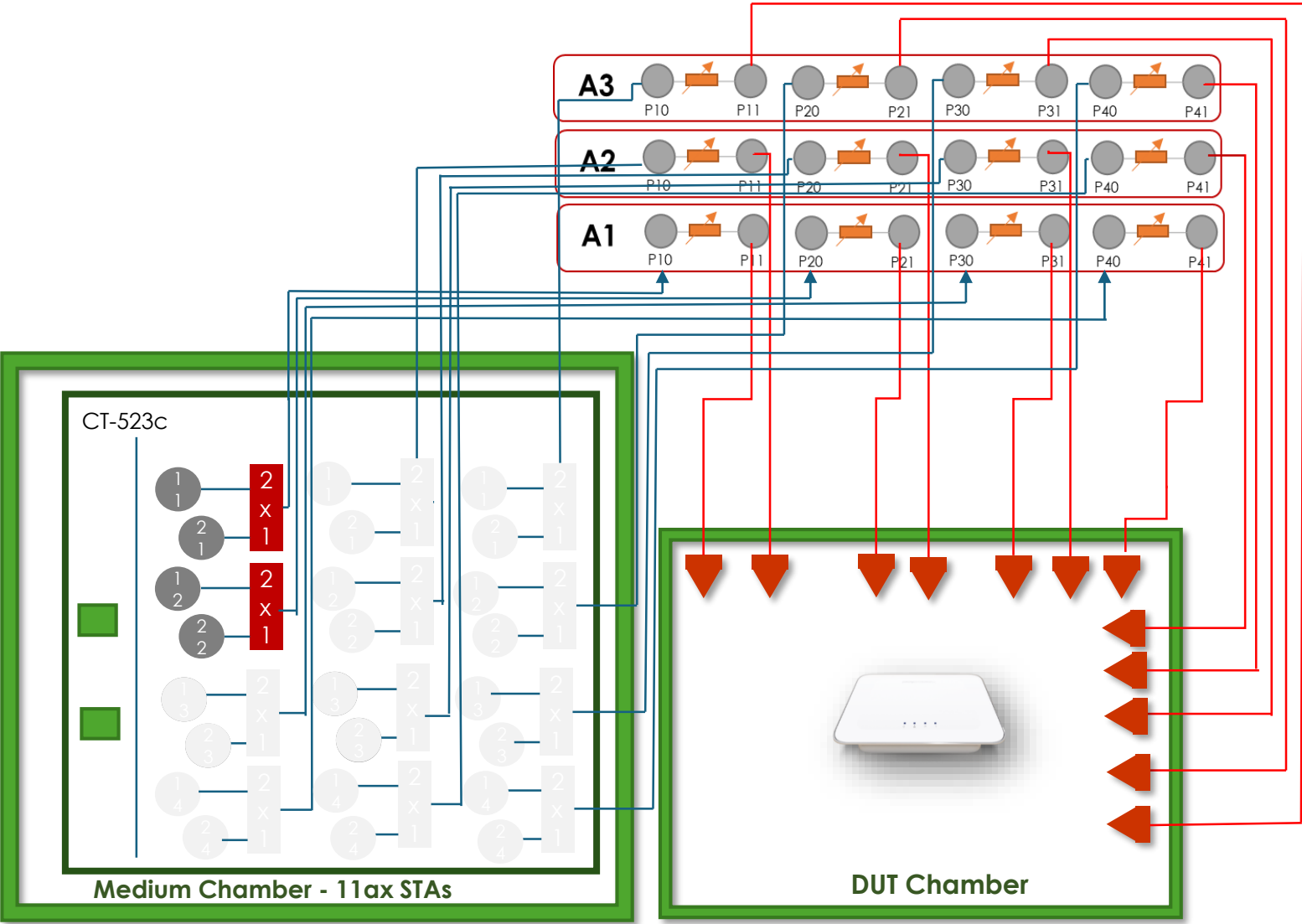
For each rotation, the variation in rates must be within a specified range. The variation at each specific attenuation is calculated as the difference between the minimum throughput value and the average throughput value, divided by the average throughput value over all rotations.

1. For 2.4Ghz, the range is 30%
2. For 5Ghz and 6GHz, the range is 40%

6.3.2 Pass/Fail Criteria

Wi-Fi Configuration (DUT)	Wi-Fi Configuration (STA)	Bandwidth	Throughput_S (Mbps)		Throughput_M (Mbps)		Throughput_L (Mbps)	
			DL	UL	DL	UL	DL	UL
802.11n (NSS-2)	802.11n (NSS-2)	20	90	90	70	70	35	35
802.11ac (NSS-2)	802.11ac (NSS-2)	80	500	500	400	400	300	300
802.11ax (2.4Ghz NSS-2)	802.11ax (2.4Ghz NSS-2)	20	150	150	100	100	35	35
802.11ax (5 Ghz, NSS-2)	802.11ax (5 Ghz, NSS-2)	80	700	700	400	400	200	200
802.11ax (6 Ghz, NSS-2)	802.11ax (6 Ghz, NSS-2)	160	1275	1275	850	850	510	510
802.11be (2.4Ghz NSS-2)	802.11be (2.4Ghz NSS-2)	20	200	200	100	100	35	35
802.11be (5 Ghz, NSS-2)	802.11be (5 Ghz, NSS-2)	160	1600	1600	800	800	200	200
802.11be (6 Ghz, NSS-2)	802.11be (6 Ghz, NSS-2)	320	2400	2400	800	800	200	200

6.3.2 Wiring Diagram

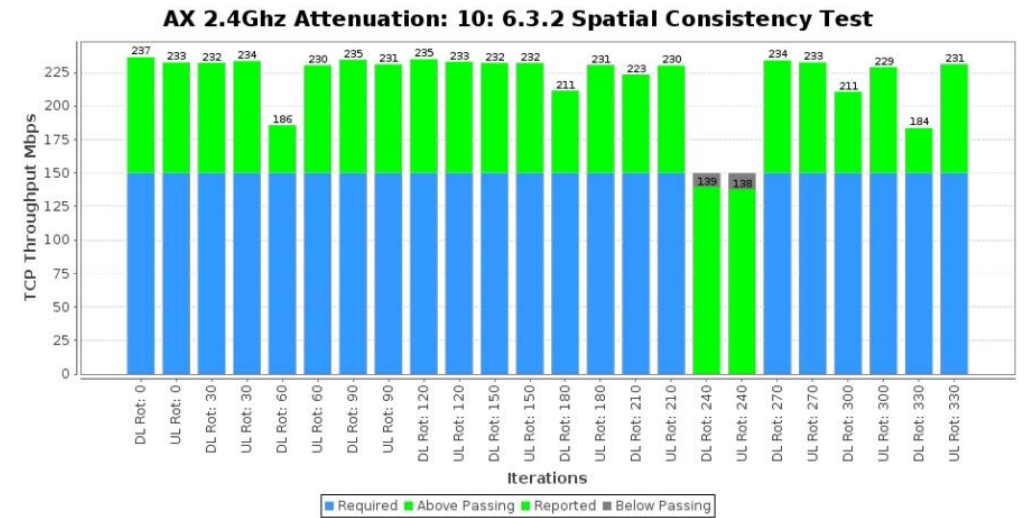
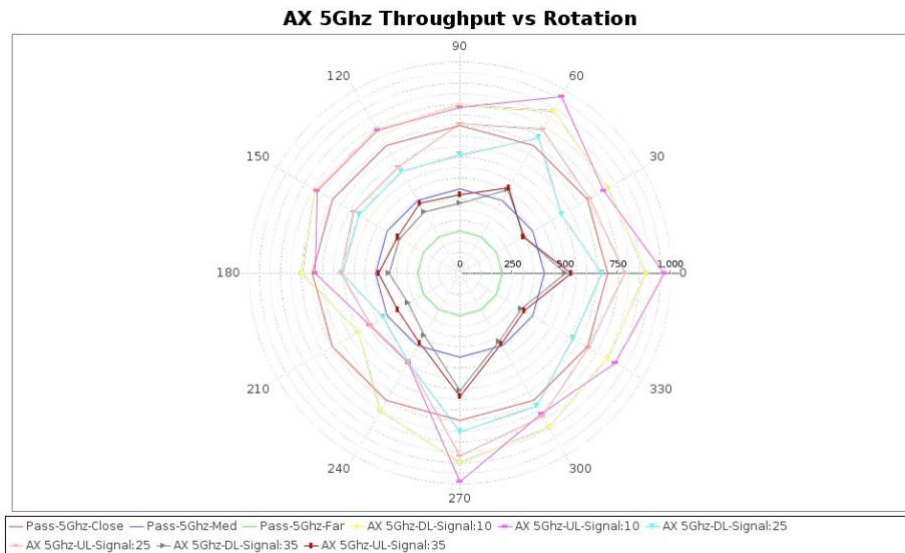


6.3.2 Example Results



Summary Results

Test	Result	Candela Score	Elapsed	Info
6.3.2 Spatial Consistency Test	2.4Ghz FAIL 5Ghz PASS	93	1.45 h	AX 5Ghz passed 12 / 12 N 2.4Ghz passed 9 / 12



6.3.3 802.11ax Peak Performance Test

- ❑ This test case examines the maximum performance expected from a DUT supporting 802.11ax and 802.11be

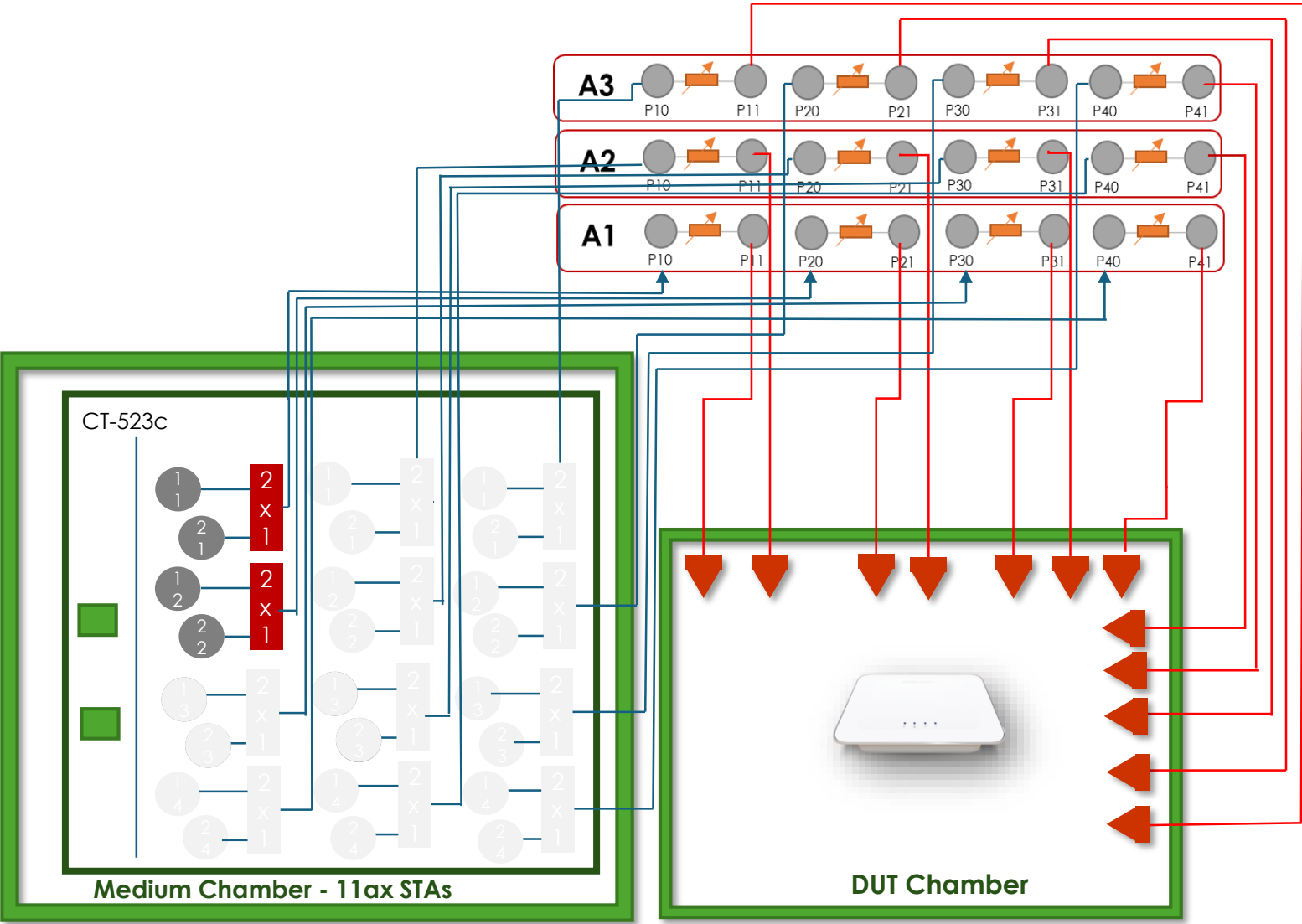
Test Procedure

1. Configure the operating mode of the DUT and STA.
2. Establish the LAN connection and allow STA to associate with the DUT.
3. Measure the downlink TCP throughput to the STA, using a test time of 120 seconds.
4. Measure the uplink TCP throughput to the STA, using a test time of 120 seconds.
5. Repeat steps 1 through 4 for each additional configuration in supported by the DUT.

Pass/Fail Criteria

Wi-Fi Configuration	Downlink Throughput (Mbps)	Uplink Throughput (Mbps)
Config 1: 802.11ax, 2.4 GHz, Nss = 2, BW = 40 MHz	300	300
Config 2 : 802.11ax, 5 GHz, Nss = 2, BW = 160 Mhz	1100	1100
Config 3: 802.11ax, 5 GHz, Nss = 4, BW = 160 Mhz	2400	2400
Config 4 : 802.11ax, 5 GHz, Nss = 8, BW = 160 Mhz	4800	4800
Config 5 : 802.11ax, 6 GHz, Nss = 2, BW = 160 Mhz	1100	1100
Config 6 : 802.11be, 5 GHz, Nss = 2, BW = 160 Mhz	1400	1400
Config 7 : 802.11be, 6 GHz, Nss = 2, BW = 320 Mhz	2400	2400

6.3.3 Wiring Diagram

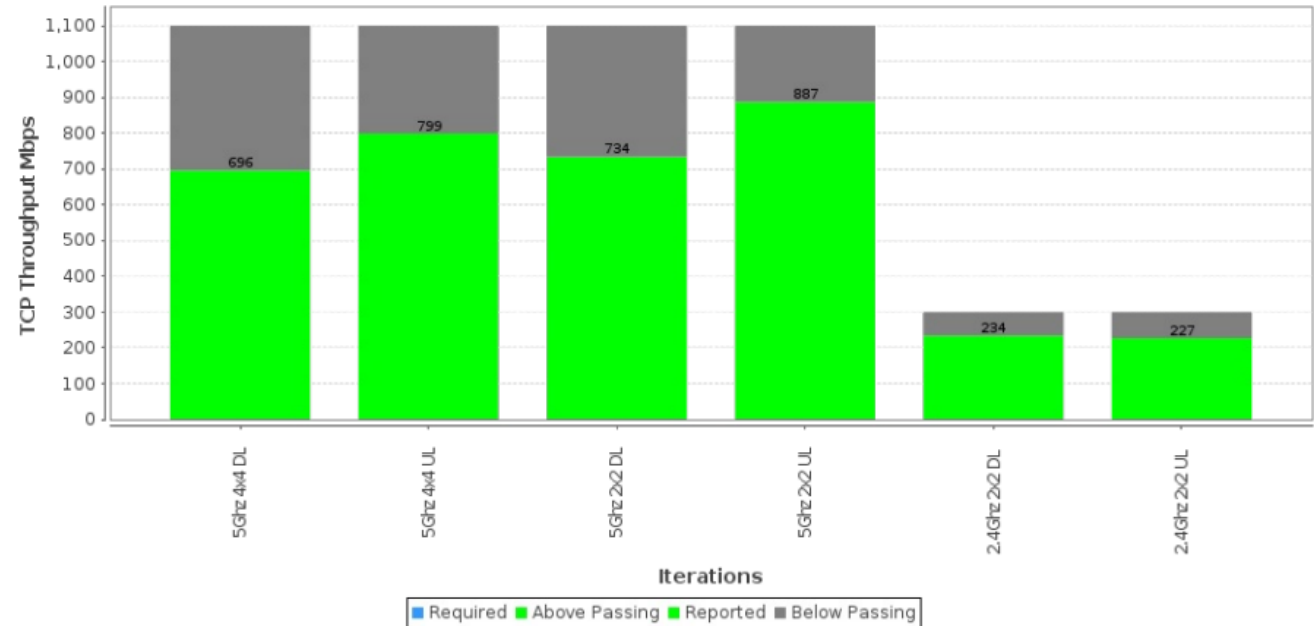


6.3.3 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.3.3 AX Peak Performance TCP Throughput Test	2.4Ghz FAIL 5Ghz FAIL	72	7.174 m	Throughput AX 2.4Ghz UL 75.63% DL 78.02% Throughput AX 2x2 5Ghz UL 80.63% DL 66.70% Throughput AX 4x4 5Ghz UL 72.62% DL 63.24%

6.3.3 AX Peak Performance TCP Throughput Test



6.4.1 Multiple STAs Performance Test

- ❑ Multiple STAs performance test intends to measure the performance of Wi-Fi device connected with multiple STAs simultaneously. To simulate a circumstance of real environment, various levels of signals reflecting various distance between Wi-Fi device and STA are considered in the test.

Test Procedure

These steps are done for 2.4, 5 and 6Ghz. 5Ghz uses 160Mhz in 802.11be, 6GHz uses 160MHz in 802.11ax and 320MHz in 802.11be bandwidth STA.

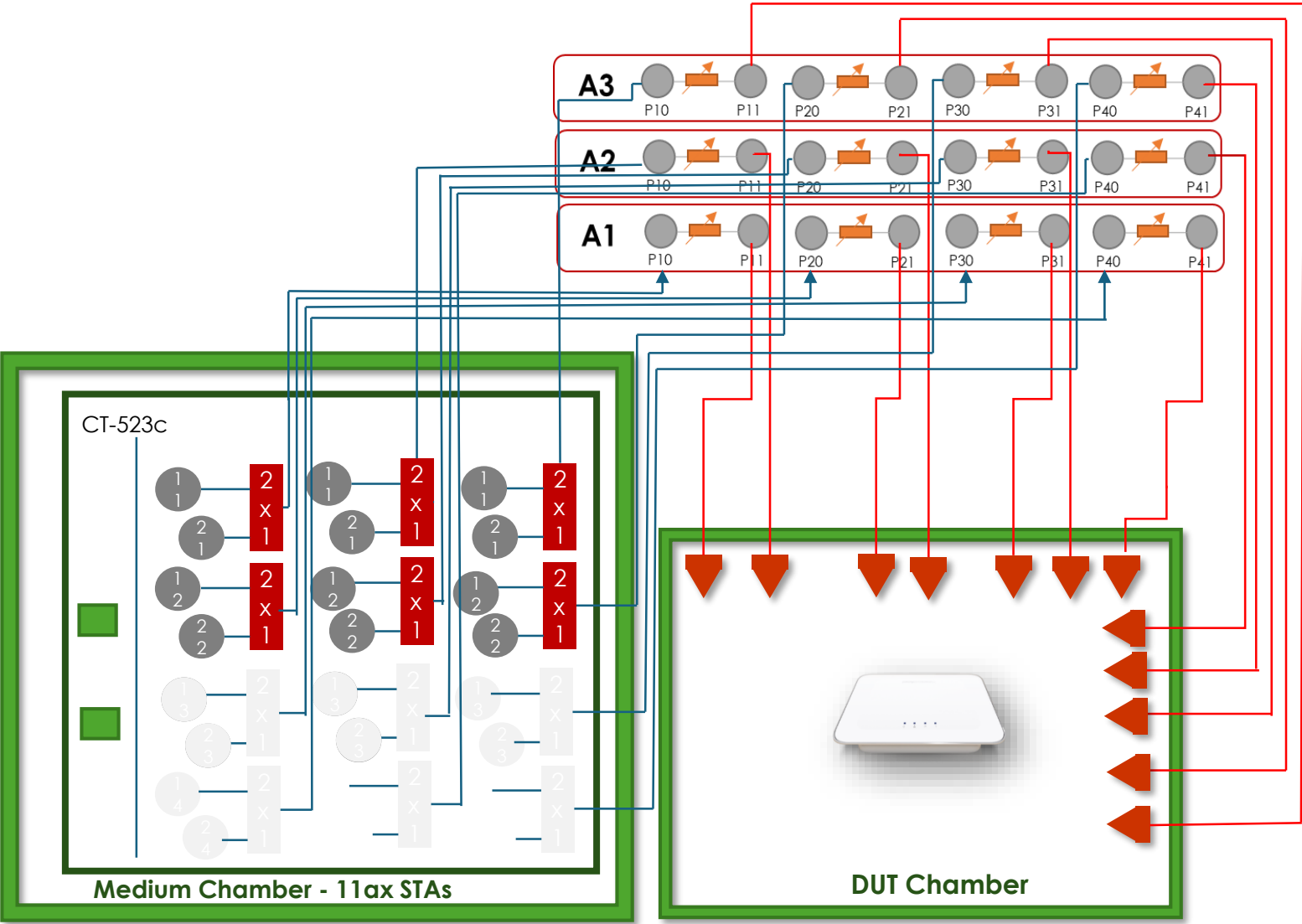
1. Configure the system to emulate a 2-meter distance. This is the baseline '0' attenuation.
2. Establish the LAN connection, create 3 sets of 3 stations.
3. Group 1 is set to short distance, Group 2 is set to medium distance, and Group 3 is set to long distance. The attenuations for 2.4Ghz are: 12, 30, 43 The attenuations for 5 Ghz are: 6, 24, 39 The attenuations for 6 Ghz are: 0, 15, 27
4. Measure the downlink TCP throughput to each short-distance STA, using a test time of 120 seconds. Calculate the summation of downlink TCP throughput of the three STA set to short distance. Wait for 10 seconds. Measure the uplink TCP throughput to each STA, using a test time of 120 seconds. Calculate the summation uplink TCP throughput of the three STA in short distance.
5. Enable the medium distance stations and allow them to associate with the DUT. Measure the downlink TCP throughput to each of the 6 stations, using a test time of 120 seconds. Calculate the summation of downlink TCP throughput of all STA (three short-distance STA and the three medium-distance STA). Wait for 10 seconds. Measure the uplink TCP throughput to each STA, using a test time of 120 seconds. Calculate the summation of uplink TCP throughput of all 6 stations.
6. Enable the long distance stations and allow them to associate with the DUT. Measure the downlink TCP throughput to each of the 9 stations, using a test time of 120 seconds. Calculate the summation of all STA (downlink TCP throughput of the three short-distance STA, the three medium-distance STA and the three long-distance STA). Wait for 10 seconds. Measure the uplink TCP throughput to each STA, using a test time of 120 seconds. Calculate the summation of uplink TCP throughput of all 9 stations.

6.4.1 Pass/Fail Criteria



Wi-Fi Configuration (DUT)	Wi-Fi Configuration (STA)	Bandwidth(MHz)	Throughput_S (Mbps)		Throughput_SM (Mbps)		Throughput_SML (Mbps)	
			DL	UL	DL	UL	DL	UL
802.11n (NSS-2)	802.11n (NSS-2)	20	70	70	60	60	50	50
802.11ac (NSS-2)	802.11ac (NSS-2)	80	500	500	500	500	400	400
802.11ax (2.4Ghz NSS-2)	802.11ax (2.4Ghz NSS-2)	20	140	140	120	120	100	100
802.11ax (5 Ghz, NSS-2)	802.11ax (5 Ghz, NSS-2)	80	680	600	600	250	500	200
802.11ax (6 Ghz, NSS-2)	802.11ax (6 Ghz, NSS-2)	160	1400	1400	1200	1200	1000	1000
802.11be (2.4Ghz NSS-2)	802.11be (2.4Ghz NSS-2)	20	240	240	160	160	100	100
802.11be (5 Ghz, NSS-2)	802.11be (5 Ghz, NSS-2)	160	1000	1000	680	680	550	550
802.11be (6 Ghz, NSS-2)	802.11be (6 Ghz, NSS-2)	320	2400	2400	1400	1400	750	750

6.4.1 Wiring Diagram

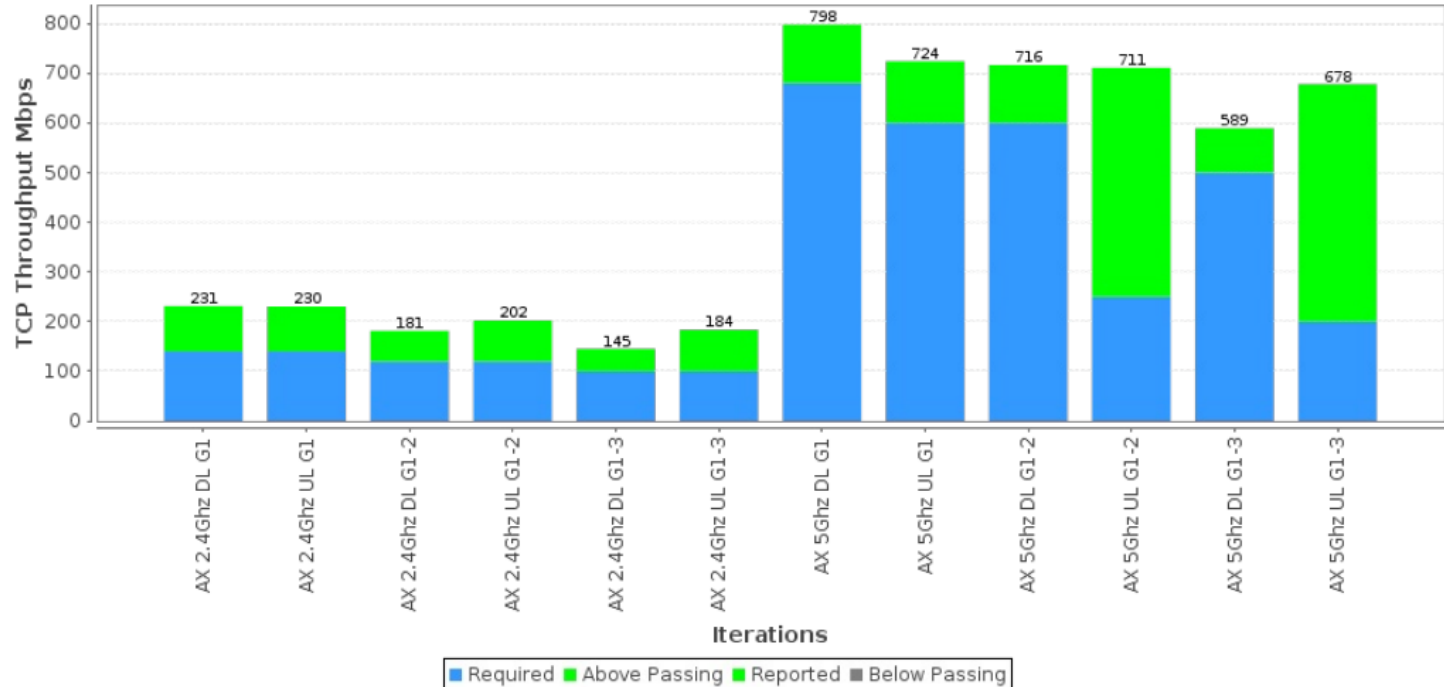


6.4.1 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.4.1 Multiple STAs Performance Test	2.4Ghz PASS 5Ghz PASS	100	16.909 m	AX 2.4Ghz Passed 6 / 6 AX 5Ghz Passed 6 / 6

6.4.1 Multiple STAs Performance Test



6.4.2 Multiple Association/Disassociation Stability Test

- ❑ Multiple association/disassociation stability test intends to measure stability of Wi-Fi device under a dynamic environment with frequent change of connection status.

Test Procedure

These steps are done for 2.4, 5 and 6Ghz.

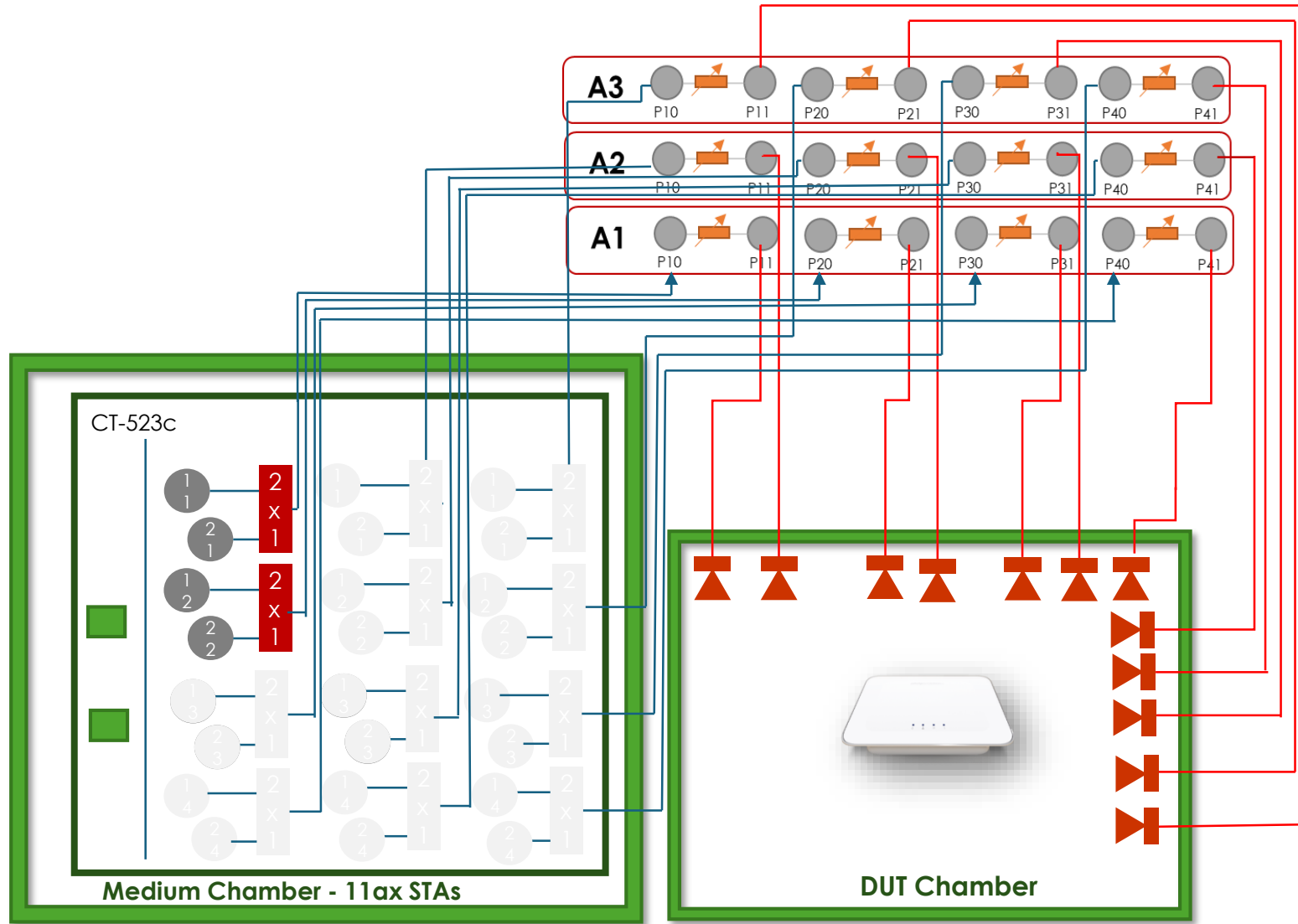
1. Configure the system to emulate the short distance for the respective band: 12 for 2.4Ghz, 6 for 5Ghz, and 0 for 6Ghz.
2. Establish the LAN connection, create 16 stations and associate all 16 to the DUT.
3. 8 STAs are picked for sending/receiving packets while the other 8 STAs are picked to do a dis-association/re-association process during the test.
4. Enable downlink UDP flow (4 Mbps @2.4GHz, 8 Mbps @5GHz and 16 Mbps @6Ghz) from DUT to each of the 8 traffic stations.
5. Run traffic for 30 seconds.
6. Disassociate the other 8 stations. Wait for 30 seconds. Re-associate the STAs simultaneously.
7. Stop traffic and record throughput and packet loss percentage.

Pass/Fail Criteria

In order to pass the test case, the recorded results SHALL meet the Pass/Fail Criteria, described as following:

1. UDP traffic rate is at least 99% of the configured rate for each STA.
2. UDP packet loss must be less than 0.01% over the duration of the test for each STA.
3. All stations must be connected with DHCP IP Address acquired at end of the test.

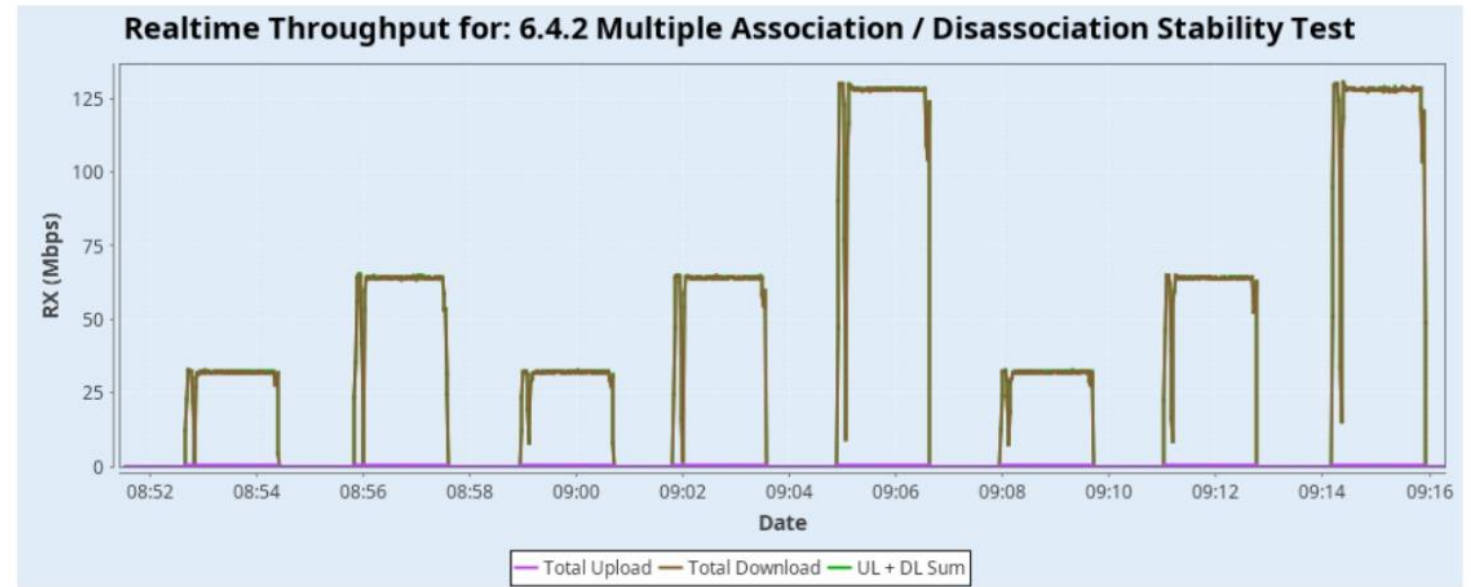
6.4.2 Wiring Diagram



6.4.2 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.4.2 Multiple Association / Disassociation Stability Test	2.4Ghz PASS 5Ghz PASS	100	12.67 m	N 2.4Ghz Passed 960 / 960 AX 2.4Ghz Passed 960 / 960 AC 5Ghz Passed 896 / 896 AX 5Ghz Passed 1128 / 1128



6.4.3 Downlink MU-MIMO Performance Test

- ❑ Downlink MU-MIMO Performance Test intends to verify the performance of Wi-Fi device when Downlink MUMIMO is applied. This best represents a typical deployment, where stations may only support 1x1 or 2x2 RF chain configurations. The test is only applicable to the Wi-Fi device supporting the 802.11ac/ax/be. Downlink MUMIMO capability is also sometimes referred

Test Procedure

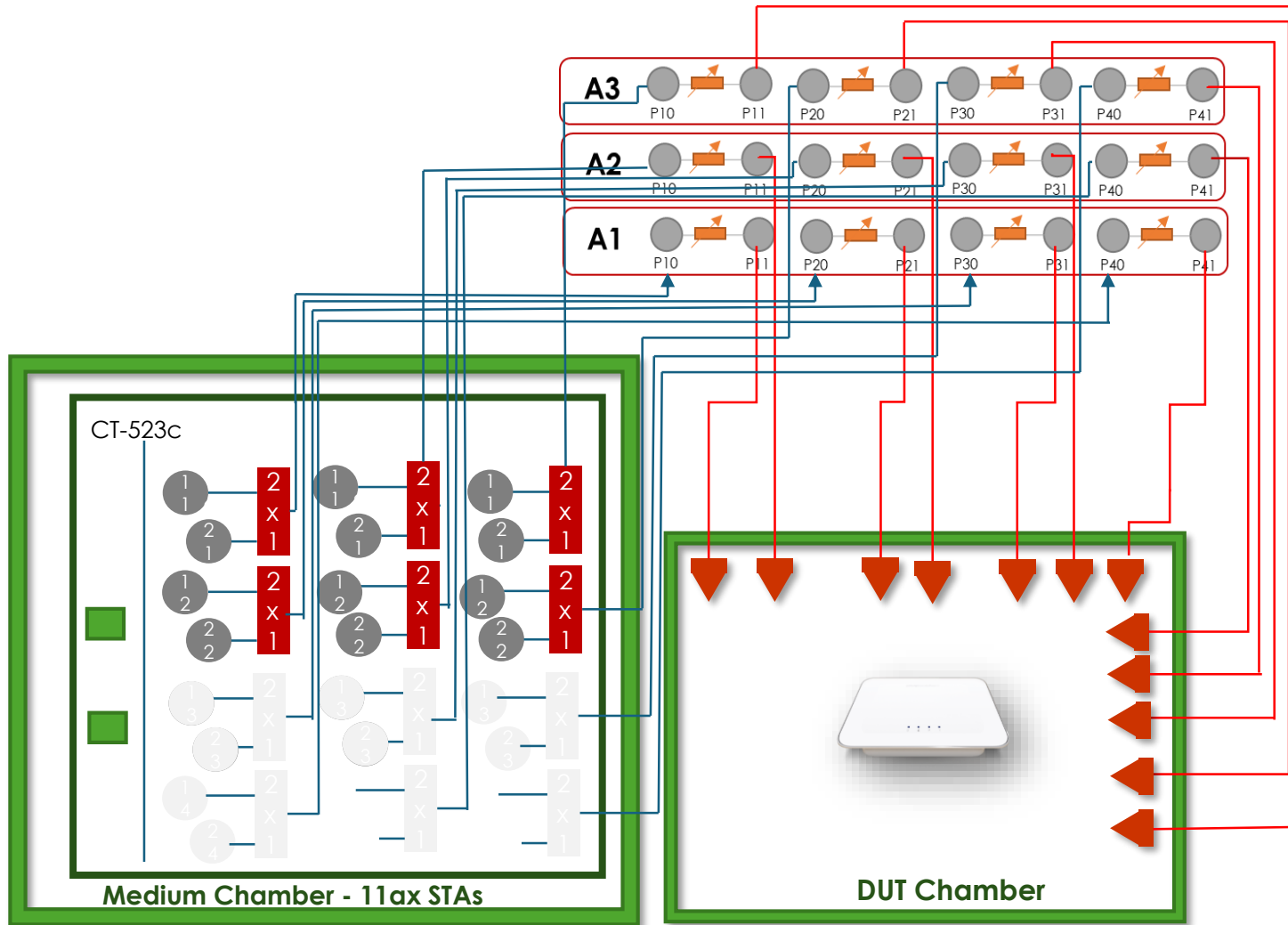
1. For each of the DUT configurations above.
2. Associate STA 1 with DUT. Establish the LAN connection and wait for 10 seconds.
3. Measure the downlink TCP throughput to STA1, using a test time of 120 seconds. Record this value as STA1_throughput_1.
4. Disassociate STA1. Wait for 10 seconds. Associate STA 2 with DUT. Wait for 10 seconds. Measure the downlink TCP throughput to STA2, using a test time of 120 seconds. Record this value as STA2_throughput_1.
5. Disassociate STA 2. Wait for 10 seconds. Associate STA 3 with DUT. Wait for 10 seconds. Measure the downlink TCP throughput to STA 3, using a test time of 120 seconds. Record this value as STA3_throughput_1.
6. Associate STA 1 and STA 2 with DUT (STA 3 remains associated). Simultaneously measure the downlink TCP throughput to all STA, using a test time of 120 seconds. Record these value as STA1_throughput_2, STA2_throughput_2 and STA3_throughput_2.
7. Repeat steps 1 through 6 for each DUT configuration.

Pass/Fail Criteria

In order to pass the test case, the recorded results SHALL meet the Pass/Fail Criteria, described as follows:

The sum of STA1_throughput_2, STA2_throughput_2, and STA3_throughput_2 SHALL be at least 45% of the sum of STA1_throughput_1, STA2_throughput_1, and STA3_throughput_1.

6.4.3 Wiring Diagram



6.4.3 Example Results

6.4.3 Downlink MU-MIMO Performance Test	2.4Ghz PASS 5Ghz PASS	106	25.431 m	AC 5Ghz Passed: 0 / 0 AX 2.4Ghz Passed: 3 / 3 AX 5Ghz Passed: 3 / 3 Single Throughput Sum: 1,779.83 Mbps SU-MIMO Throughput Sum: 626.70 Mbps MU-MIMO Throughput Sum: 1,280.20 Mbps
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6.4.4 Multicast Multi-station

- ❑ Multicast feature test intends to ensure that multicast works in the download direction with multiple STAs at different distances simultaneously. There are three sets of 3 stations, with each group at a different emulated distance. The different distances are to make sure the AP uses a reliable multicast encoding rate since there is no rate-control for multicast frames.

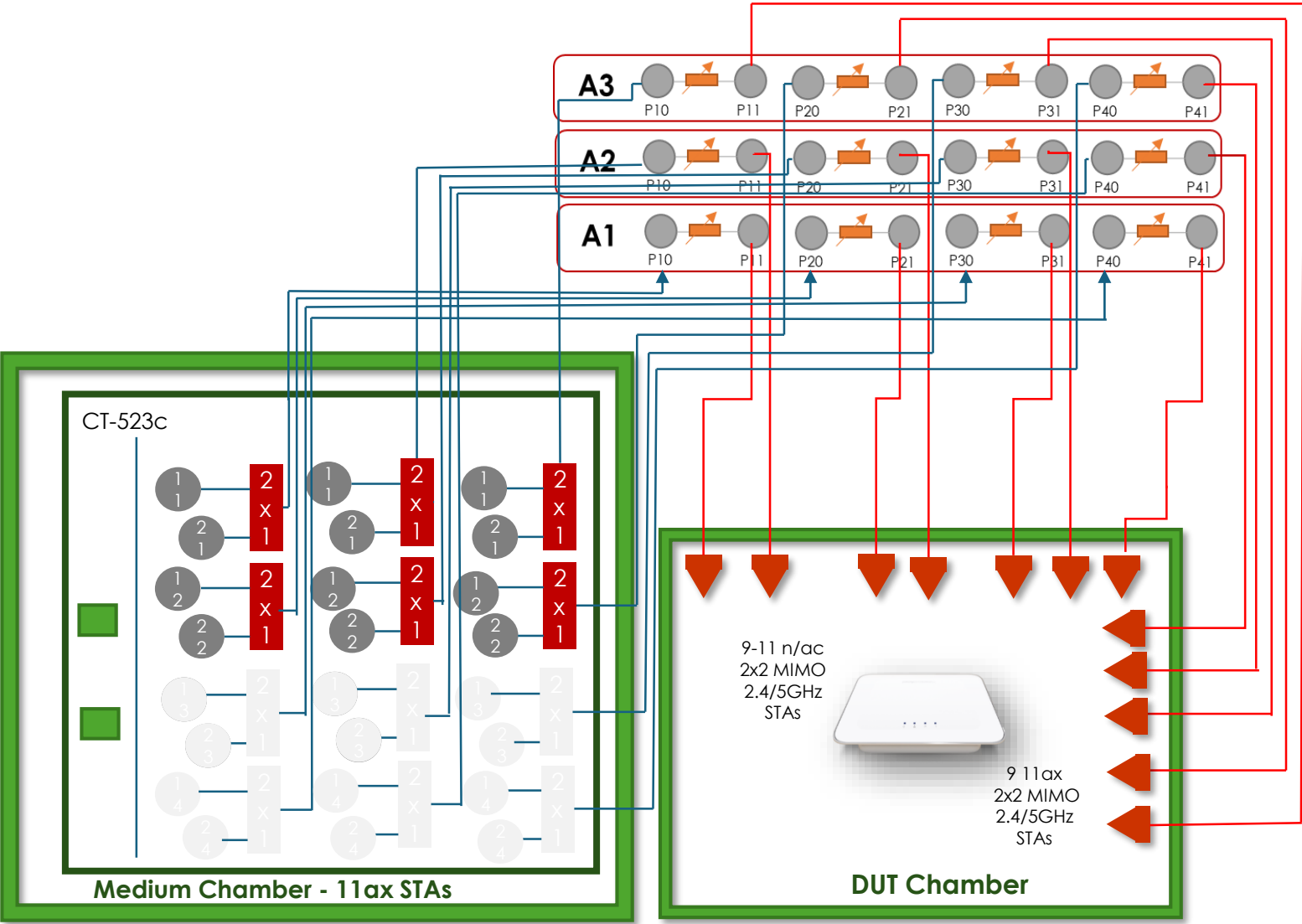
Test Procedure

1. Configure the system to emulate a 2-meter distance. This is the baseline '0' attenuation.
2. Establish the LAN connection.
3. Create 3 sets of 3 stations using 2.4Ghz N. Multicast transmitter speed is 500Kbps.
4. Group 1 is set to short distance, Group 2 is set to medium distance, and Group 3 is set to long distance. The attenuations for 2.4Ghz are: 12, 30, 43 The attenuations for 5 Ghz are: 6, 24, 39 The attenuations for 6 Ghz are: 0, 15, 27
5. Create one UDP IPv4 multicast transmitter on the Ethernet port, configured to send at requested speed for the band and mode.
6. Create one UDP IPv4 multicast receiver on each station. The multicast receiver must use the same multicast IP and port as the transmitter so that it can receive traffic from the transmitter.
7. Start multicast transmitter and receivers. Wait for 30 seconds to allow IGMP to propagate.
8. Allow multicast endpoints to run for another 120 seconds, record each receiver's throughput over the last 120 seconds.
9. Stop multicast endpoints and disassociate stations.
10. Create or reconfigured the 3 sets of 3 stations to use 5Ghz AC mode and/or configure the AP for 5Ghz AC mode. Multicast transmitter speed is 3Mbps. Repeat steps 4 - 9 inclusive.

Test Procedure Contd.

11. Create or reconfigured the 3 sets of 3 stations to use 2.4Ghz AX mode and/or configure the AP for 2.4Ghz AX mode. Multicast transmitter speed is 500Kbps. Repeat steps 4 - 9 inclusive.
12. Create or reconfigured the 3 sets of 3 stations to use 5Ghz AX mode and/or configure the AP for 5Ghz AX mode. Multicast transmitter speed is 3Mbps. Repeat steps 4 - 9 inclusive.
13. Create or reconfigured the 3 sets of 3 stations to use 6Ghz AX mode at 160Mhz bandwidth and/or configure the AP for 6Ghz AX mode at 160Mhz bandwidth. Multicast transmitter speed is 3Mbps. Repeat steps 4 - 9 inclusive.
14. Create or reconfigured the 3 sets of 3 stations to use 2.4Ghz BE mode and/or configure the AP for 2.4Ghz BE mode. Multicast transmitter speed is 500Kbps. Repeat steps 4 - 9 inclusive.
15. Create or reconfigured the 3 sets of 3 stations to use 5Ghz BE mode at 160MHz and/or configure the AP for 5Ghz BE mode at 160MHz. Multicast transmitter speed is 3Mbps. Repeat steps 4 - 9 inclusive.
16. Create or reconfigured the 3 sets of 3 stations to use 6Ghz BE mode at 320Mhz bandwidth and/or configure the AP for 6Ghz BE mode at 320Mhz bandwidth. Multicast transmitter speed is 3Mbps. Repeat steps 4 - 9 inclusive.

6.4.4 Wiring Diagram



Pass/Fail Criteria

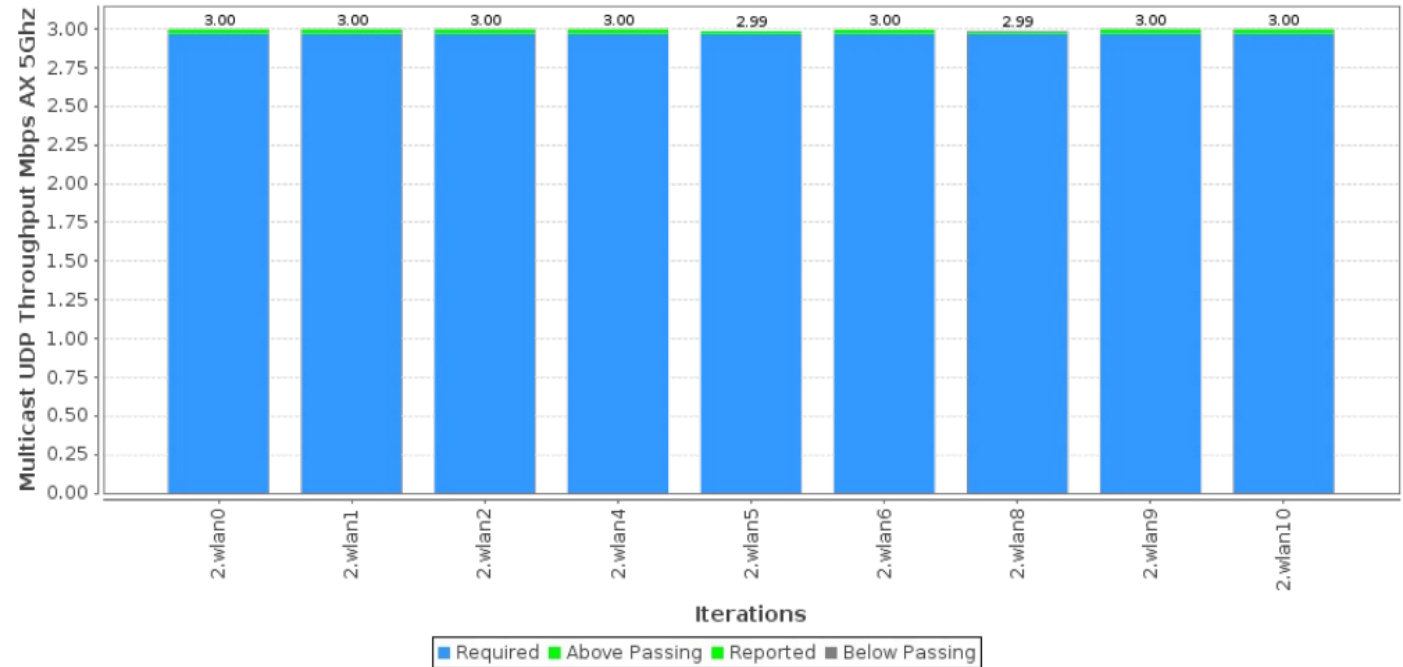
1. For each configuration, each multicast receiver endpoint must receive at at least 99% of the transmitted data rate.

6.4.4 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.4.4 Multiple STA Multicast Test	2.4Ghz PASS 5Ghz PASS	400	8.933 m	N 2.4Ghz Passed 9 / 9 AX 2.4Ghz Passed 9 / 9 AC 5Ghz Passed 9 / 9 AX 5Ghz Passed 9 / 9

6.4.4 Multiple STA Multicast Test



6.5.1 Long Term Stability test

- ❑ Long term stability test intends to measure the stability performance of Wi-Fi device under stresses that would typically be seen under heavy user load, such as watching multiple 4k video streams. Throughput and connection availability are continuously monitored over a period of 4 hours, during which time, the performance must remain steady. Testing is conducted in multiple bands (2.4 GHz, 5 GHz and 6GHz) simultaneously.

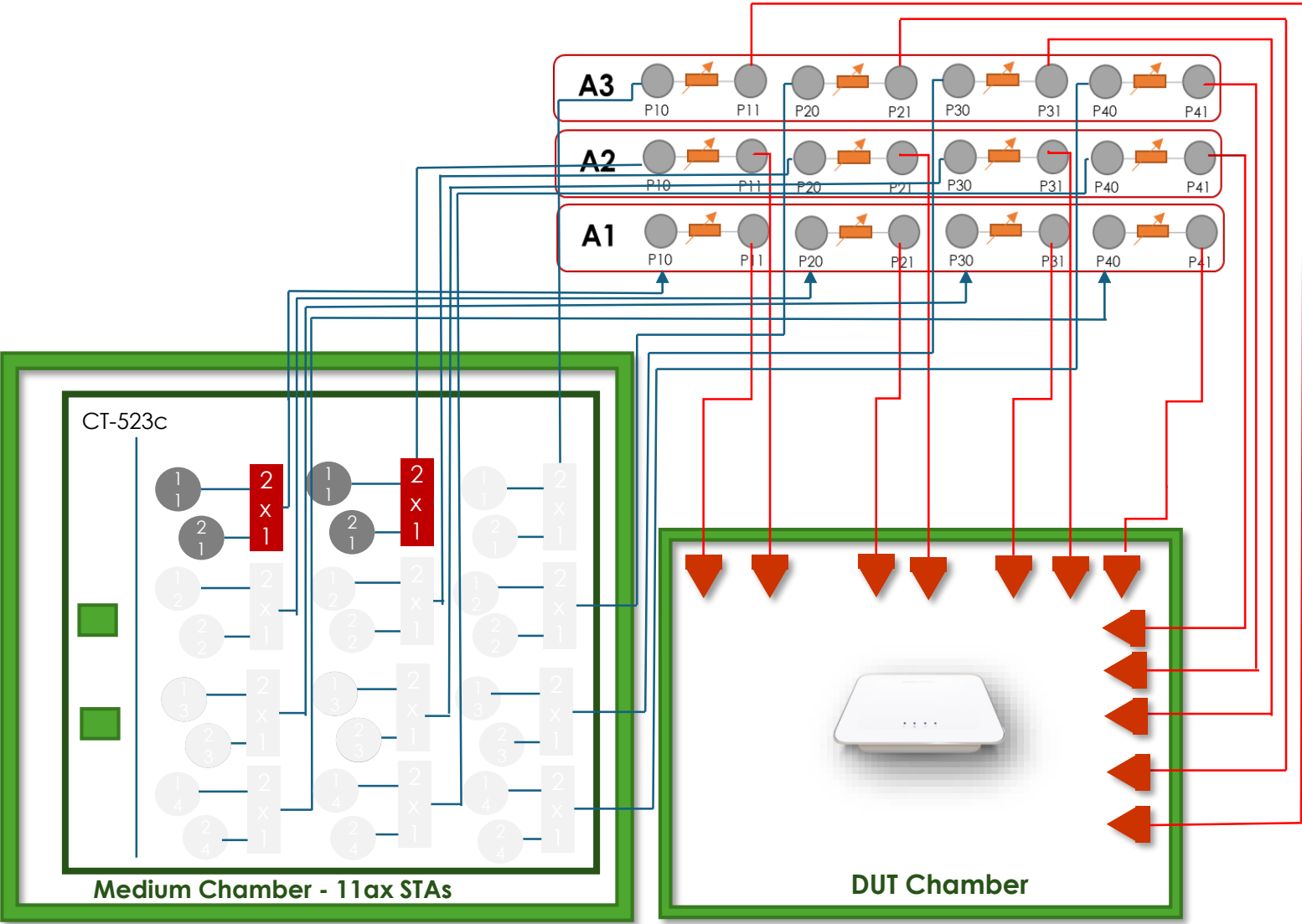
Test Procedure

1. These steps are done for 802.11ac, then for 802.11ax and then 802.11be stations. The test will optionally enable a third 6E radio if 6E testing is enabled.
2. Create 4 stations and set attenuation so that they are at a 2-meter distance.
3. If testing 6E, add 2 stations for 6E band as well. Set attenuation so that they are at a 2-meter distance.
4. One station on each band runs a 50Mbps UDP download.
5. A second station on each band associates for 5 minutes, then disconnects for 5 minutes, over and over.
6. UDP Packet loss is measured every 15 minutes and recorded for pass/fail reporting.

Pass/Fail Criteria

1. At end of each 15 minute interval, the packet loss must no more than 0.01%.

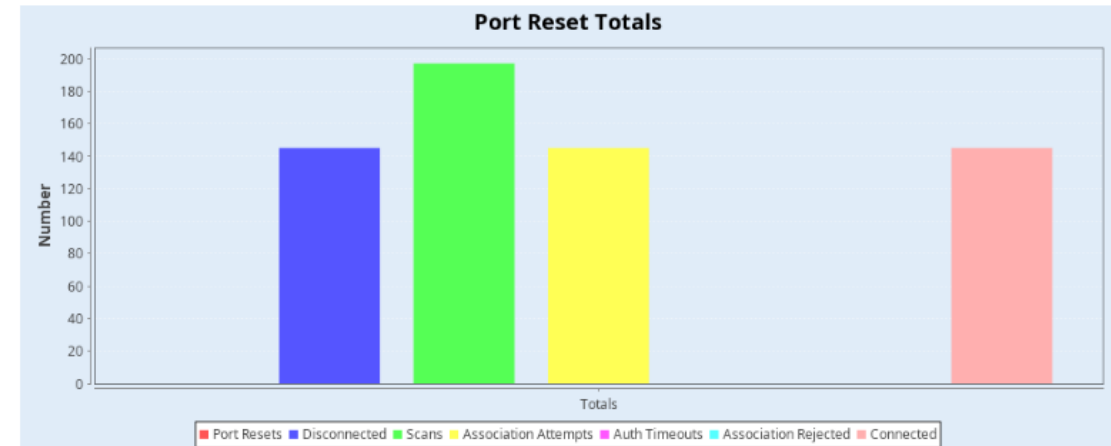
6.5.1 Wiring Diagram



6.5.1 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.5.1 Long Term Stability Test	2.4Ghz PASS 5Ghz PASS	100	4.311 h	AC 2.4Ghz Packet Error Rate Passed: 0 / 0 AC 5Ghz Packet Error Rate Passed: 0 / 0 AX 2.4Ghz Packet Error Rate Passed: 16 / 16 AX 5Ghz Packet Error Rate Passed: 16 / 16



6.5.2 AP Coexistence test

- ❑ AP coexistence test intends to verify Wi-Fi device performance with existence of alien AP. The alien AP in the test SHALL support the same Wi-Fi standard (802.11n/802.11ac/802.11ax/802.11be).

Test Procedure

1. Configure the system to emulate a 2-meter distance for all stations and APs.
2. NOTE: Alien AP radios should already be powered down at this point.
3. NOTE: DUT AP should already be enabled and set to default TR398 test settings.
4. Configure STA and alien STA to use proper mode (/n, AC, AX, BE) for this test iteration, or select appropriate STA devices that meet those requirements if STA cannot be set to specific wifi mode.
5. Measure the downlink TCP throughput, using a test time of 120 seconds. This is the baseline throughput. Record throughput as THROUGHPUT_SHORT_DUT.
6. If running on 5Ghz and using Alien DUT without DFS support, configure DUT AP for 40Mhz. Run TCP throughput test for 120 seconds and record throughput as THROUGHPUT_SHORT_DUT_40MHZ. This value is used for the adjoining channel test case.
7. Turn off DUT AP to allow clean test of the alien DUT performance.
8. Turn on alien AP, configure alien AP for DUT channel, and allow alien STA to connect.
9. Run TCP throughput test for 120 seconds and record throughput as THROUGHPUT_SHORT_ALIEN.
10. If running on 5Ghz, configure alien AP to 40Mhz, run TCP traffic, and record throughput as THROUGHPUT_SHORT_ALIEN_40MHZ.
11. Turn off alien AP and admin down the peer station.
12. Enable the alien network radios. The alien network shall be configured per Table 36 (Channel Configuration) above. No traffic is generated on the alien network for this step.
13. Measure the downlink TCP throughput, using a test time of 120 seconds. Record this measurement as THROUGHPUT_SHORT_DUT_1
14. Configure the alien network to transmit a UDP data stream at 40% of the measurement THROUGHPUT_SHORT_ALIEN or THROUGHPUT_SHORT_ALIEN_40MHZ, depending on the configuration of the alien AP bandwidth (80 MHz or 40 MHz).
15. Measure the downlink TCP throughput to peer STA, using a test time of 120 seconds. Record this measurement as THROUGHPUT_SHORT_DUT_2.
16. Repeat the steps above for each channel configuration in table 36.
17. Repeat the steps above for 5Ghz AC, 2.4Ghz AX, 5Ghz AX.

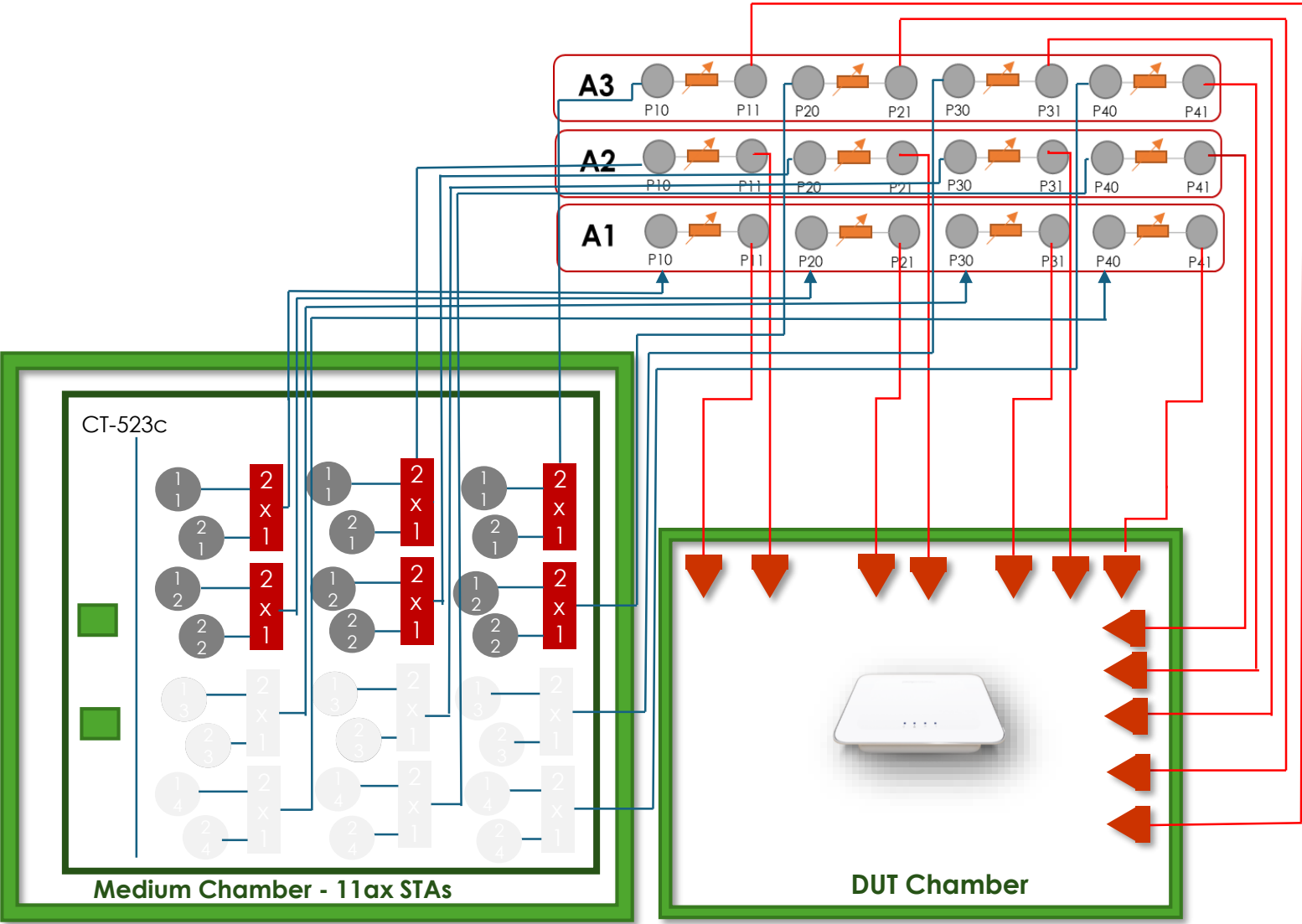
6.5.2 Pass/Fail Criteria



Wi-Fi Configuration (DUT)	Wi-Fi Configuration (STA)	Bandwidth	Throughput requirement referred to the No-Alien-device			
			Alien AP idle	Alien AP active on same channel	Alien AP active on overlapping channel	Alien AP active on adjacent channel
802.11n (NSS-2)	802.11n (NSS-2)	20	>=95%	>=40%	>=40%	>=90%
802.11ac (NSS-2)	802.11ac (NSS-2)	80	>=95%	>=40%	>=40%	>=90%
802.11ax (2.4Ghz NSS-2)	802.11ax (2.4Ghz NSS-2)	20	>=95%	>=40%	>=40%	>=90%
802.11ax (5 Ghz, NSS-2)	802.11ax (5 Ghz, NSS-2)	80	>=95%	>=40%	>=40%	>=90%

Note: Percentage indicates the performance deduction referred to the case with no alien device turned on.

6.5.2 Wiring Diagram

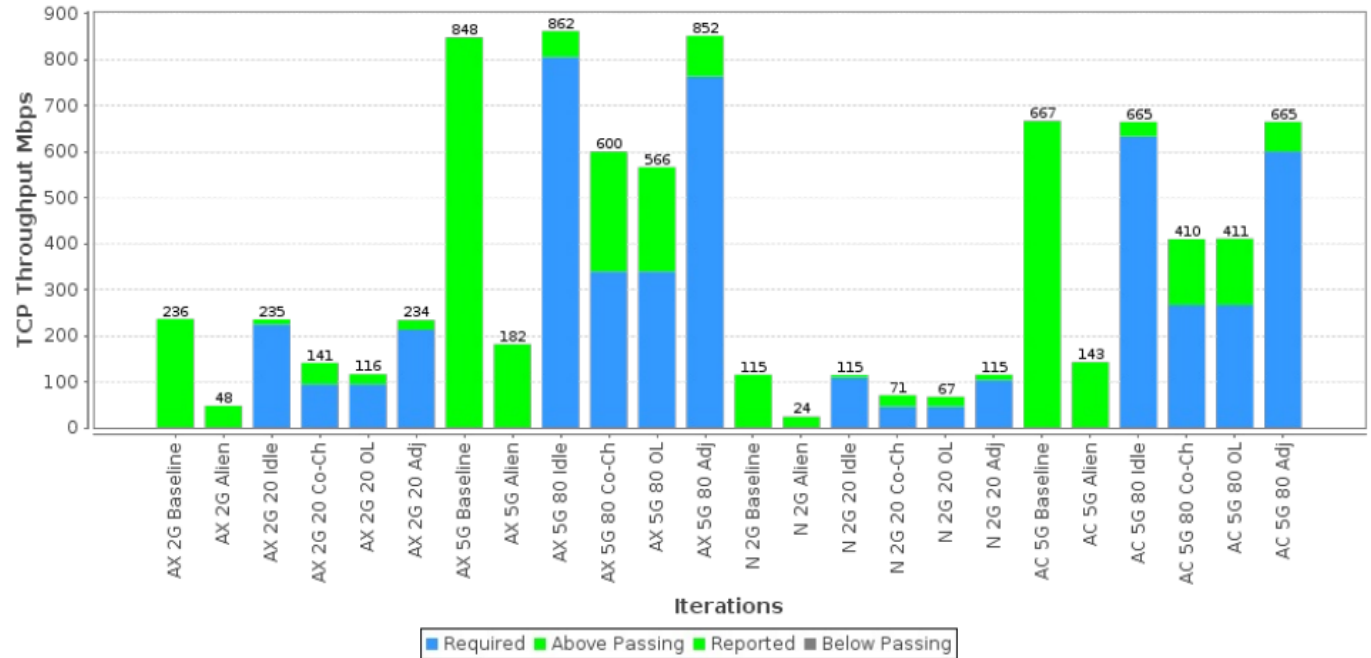


6.5.2 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.5.2 AP Coexistence Test	2.4Ghz PASS 5Ghz PASS	260	47.283 m	Passed 16 / 16 NOTE: Auto-Calibrated Interferer transmit rates: 5G-80Mhz-AC: 142.58 Mbps 5G-40Mhz-AC: 65.72 Mbps 2.4Ghz-20Mhz N: 24.00 Mbps 5G-80Mhz-AX: 181.65 Mbps 5G-40Mhz-AX: 96.62 Mbps 2.4Ghz-20Mhz AX: 47.74 Mbps

6.5.2 AP Coexistence Test



6.5.3 Automatic Channel Selection test

- ❑ The test verifies the DUT (AP) will select a Wi-Fi channel that is not presently utilized by other networks and will alter this channel on subsequent reboots, if the environment has changed (i.e. the channels utilized by the adjacent network has changed).

Test Procedure

1. Power off the DUT. Allow the second station to associate to the additional AP.
2. Configure the Ethernet traffic generator to run a continuous TCP throughput measurement, causing the devices to continuously transmit over the Wireless link between the second STA and AP.
3. Power on the DUT and allow the first station to associate with the DUT.
4. Record the channel used by the DUT.
5. Repeat steps 1 through 5, with the additional AP configured to use 2.4 GHz channels 1 and 11.
6. Repeat steps 1 through 5, with the additional AP configured to use 2.4 GHz channel 1 and 40 MHz bandwidth.
7. Repeat steps 1 through 5, using the 5 GHz band, with the additional AP configured to channels 42, 58, 106, and 122. The additional AP should be configured to use a channel bandwidth of 80 MHz.

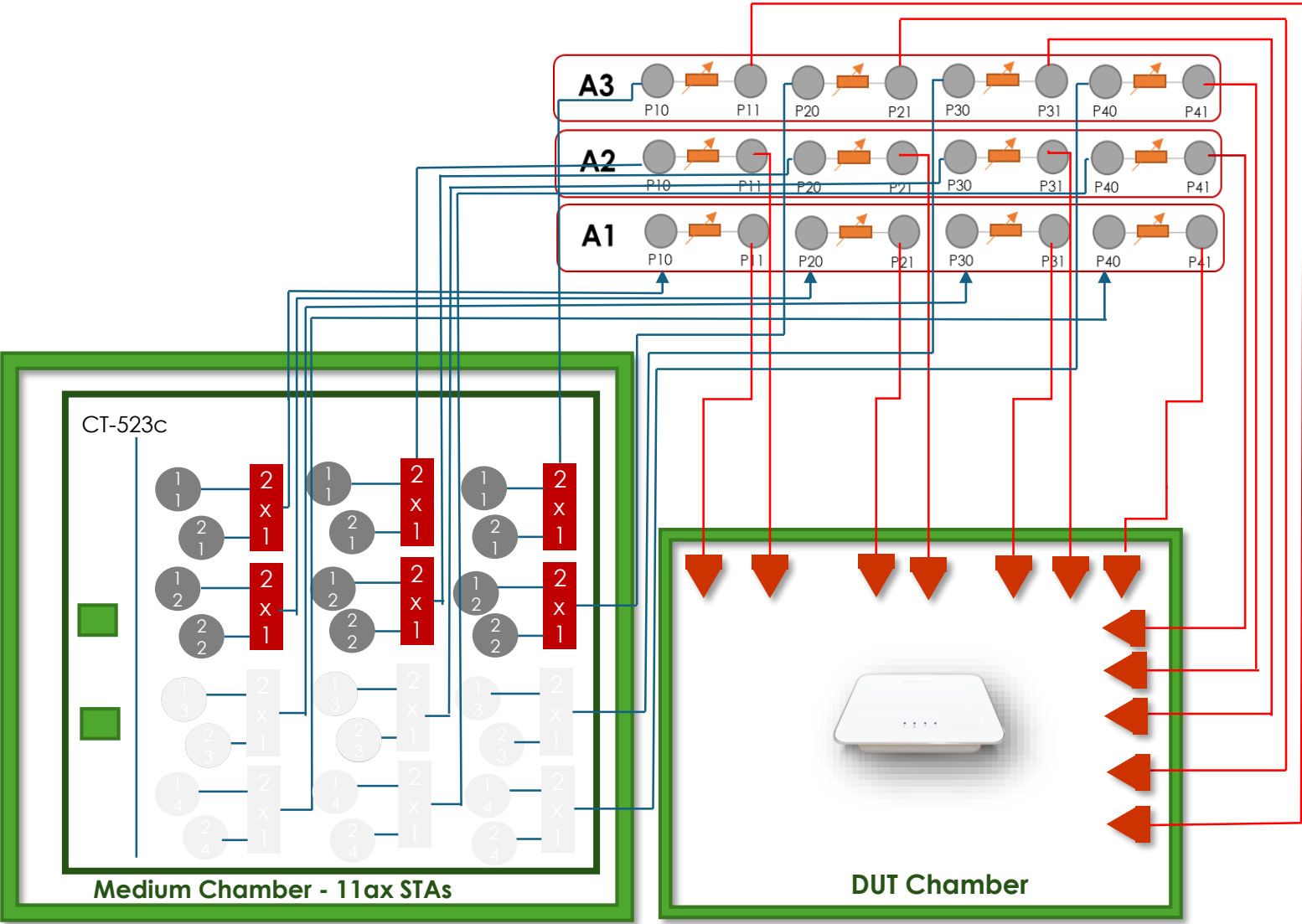
6.5.3 Pass/Fail Criteria



1. The DUT SHALL select a channel that is not the same as the channel the Additional AP is operating on and the selected channel SHALL not overlap with the channel the Additional AP is operating on. If the DUT selects the same, or an overlapping channel, the test point SHALL be considered a failure.

I	Additional AP Operating Band and Channel	Channel selected by DUT
1	2.4 GHz Channel 6, BW = 20 MHz	1, 11
2	2.4 GHz Channel 1, BW = 20 MHz	6, 11
3	2.4 GHz Channel 11, BW = 20 MHz	1, 6
4	5 GHz Channel 42, BW = 80 MHz	58, 106, 122
5	5 GHz Channel 58, BW = 80 MHz	42, 106, 122
6	5 GHz Channel 106, BW = 80 MHz	42, 58, 122
7	5 GHz Channel 122, BW = 80 MHz	42, 58, 106
8	2.4 GHz Channel 1, BW = 40 MHz	11

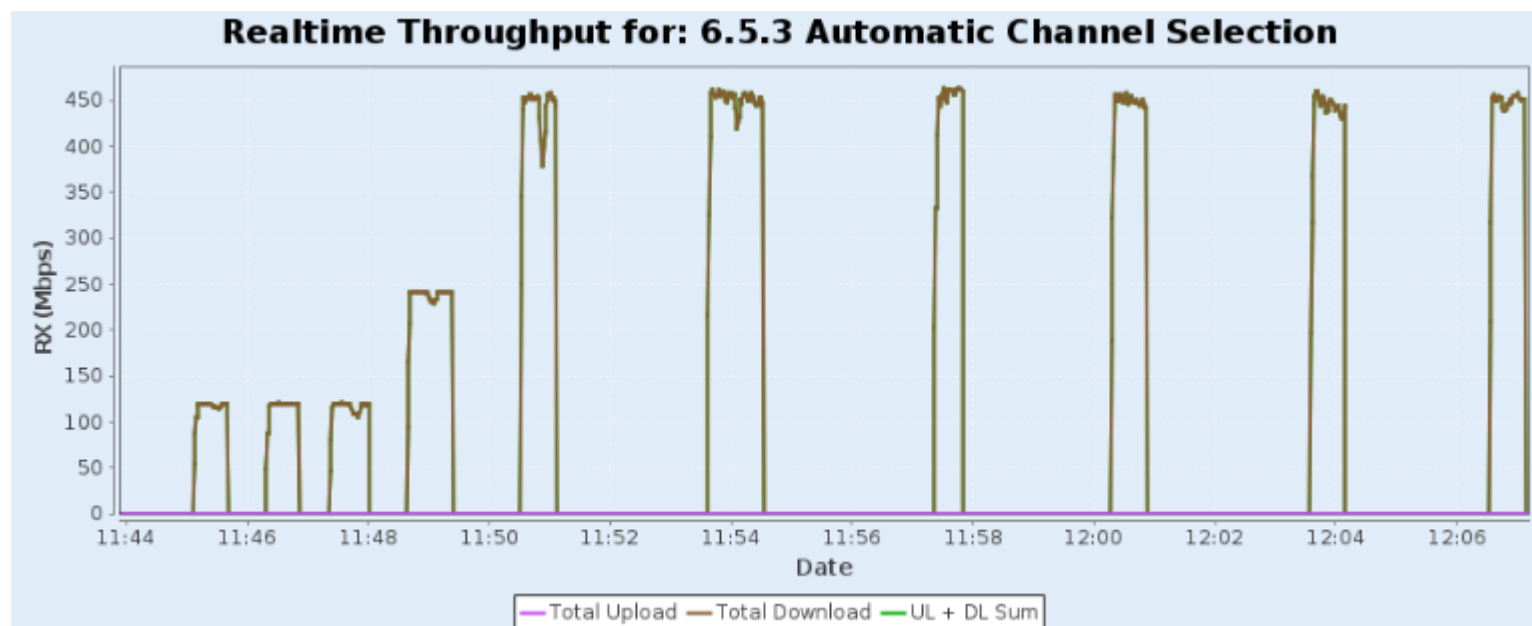
6.5.3 Wiring Diagram



6.5.3 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
6.5.3 Automatic Channel Selection	2.4Ghz PASS 5Ghz FAIL	90	23.314 m	Passed 9 / 10



6.5.4 Puncturing Test

- ❑ Puncturing test verifies DUT AP can use remaining bandwidth when 20Mhz of it is congested with interfering traffic.

Test Procedure

Interfering AP is used to create 20Mhz AP + STA on selected interfering channel. Interfering AP should have signal between -30 to -65 as heard by the DUT AP. Interfering AP must NOT use BSS Coloring. Interfering AP may use any wifi mode (n/ac/ax/be). Interfering AP should use 1 spatial stream. Interfering AP may be created by the Testbed, or may be an off-the-shelf AP

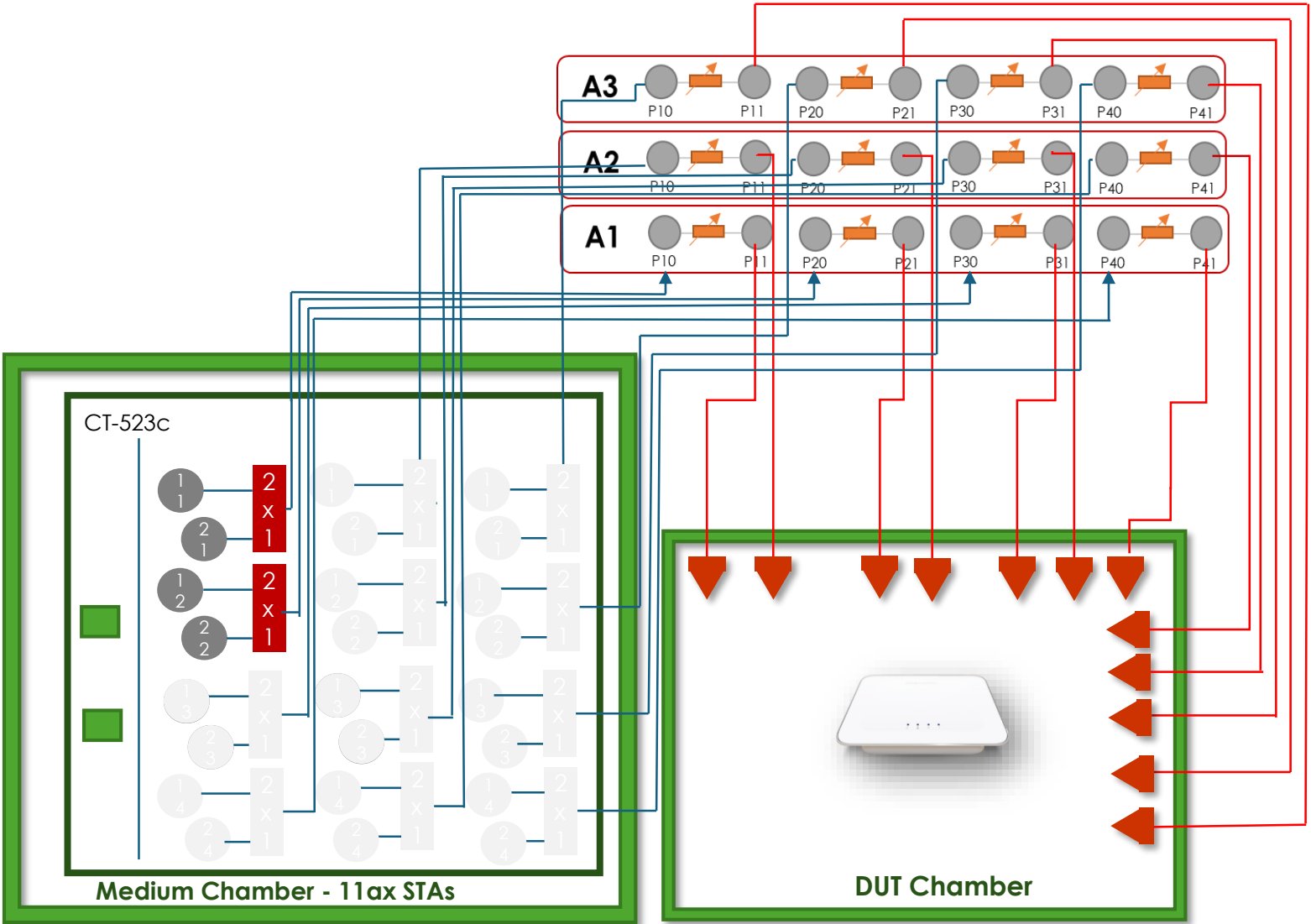
1. DUT AP is set to default TR398 test settings for 802.11BE, STA is configured for 5Ghz AP.
2. Configure 0 AAV attenuation between test STA and DUT AP.
3. Configure STA to connect to the DUT AP.
4. Alien AP and STA are set to be admin down.
5. Measure the STA downlink TCP throughput, using a test time of 120 seconds. This is the baseline throughput. Record throughput as THROUGHPUT_DUT and stop traffic.
6. Configure Alien AP for the first Alien Channel.
7. Configure Alien STA to connect to Alien AP.
8. Create TCP Downlink test between Alien AP and STA.
9. Measure the Alien STA downlink TCP Throughput, using a test time of 120 seconds and record throughput as THROUGHPUT_ALIEN and stop traffic.
10. Concurrently run STA TCP downlink at maximum speed, and Alien STA UDP Downlink at THROUGHPUT_ALIEN speed. for a period of 120 seconds. Record STA downlink traffic rate as THROUGHPUT_DUT_PUNC. Record Alien STA UDP Downlink traffic rate as THROUGHPUT_ALIEN_PUNC and stop traffic.
11. Repeat the steps 7 - 10 for Alien AP on each additional Alien Channel.
12. Repeat the steps 3 - 11 on the 6Ghz band

6.5.4 Pass/Fail Criteria

Passing values for this test require that the traffic be at least some percentage of the baseline throughput.

1. For 5Ghz 80Mhz:
 - THROUGHPUT_ALIEN_PUNC must be at least 40% of THROUGHPUT_ALIEN.
 - THROUGHPUT_DUT_PUNC must be at least 70% of THROUGHPUT_DUT.
2. For 6Ghz 320Mhz:
 - THROUGHPUT_ALIEN_PUNC must be at least 40% of THROUGHPUT_ALIEN.
 - THROUGHPUT_DUT_PUNC must be at least 90% of THROUGHPUT_DUT.

6.5.4 Wiring Diagram



6.6.1 Mesh Backhaul RVR

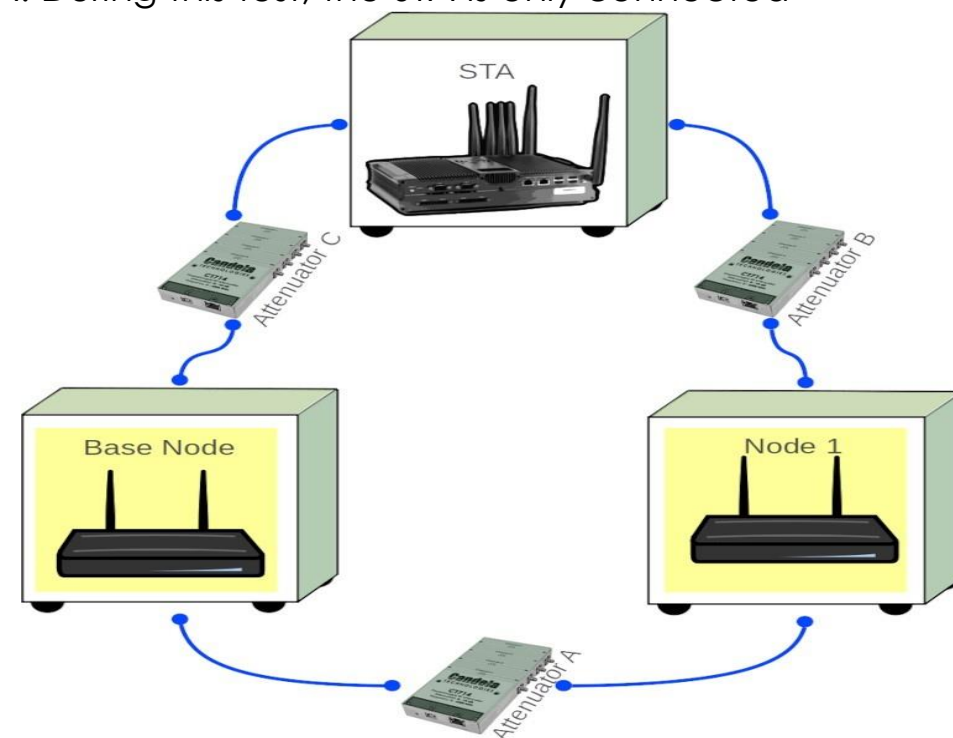
- This testcase measures the throughput performance of a mesh Wi-Fi system where the Wi-Fi Repeater is at different emulated distances from the base AP. The DUT considered to be the combination of a Base AP and a Wi-Fi repeater. The Base AP is defined as the AP devices connected to the wired network connection of the traffic generator and analyzer, while the Wi-Fi Repeater has only RF connections to both base AP and the STA. During this test, the STA is only connected to the Wi-Fi Repeater.

Setup

- This test uses 3 chambers. The Base AP is in chamber 1, Repeater is in chamber 2, and STA is in chamber 3. Attenuator A connects chamber 1 and 2, Attenuator B connects STA and chamber 2, and Attenuator C connects STA and chamber 1.
- The Ethernet traffic generator connects to the Base AP.
- The Attenuator A SHALL be configured to 5Ghz 2m calibrated distance plus 30dB.
- The Attenuator B SHALL be configured to 2m calibrated distance.
- The Attenuator C SHALL be configured to be at least 60dB to ensure the STA cannot talk to the root node.

Procedure

- Configure Attenuator A to 5Ghz 2m calibrated distance plus 30dB.
- Establish the LAN connection and allow STA to associate with the DUT.
- Measure the downlink TCP throughput to the STA, using a test time of 120 seconds.
- Measure the uplink TCP throughput to the STA, using a test time of 120 seconds.
- Set attenuator A to 5Ghz 2m calibrated distance plus 40, and repeat steps 2-4 inclusive.
- Set attenuator A to 5Ghz 2m calibrated distance plus 50, and repeat steps 2-4 inclusive.



6.1.1 Pass/Fail Criteria

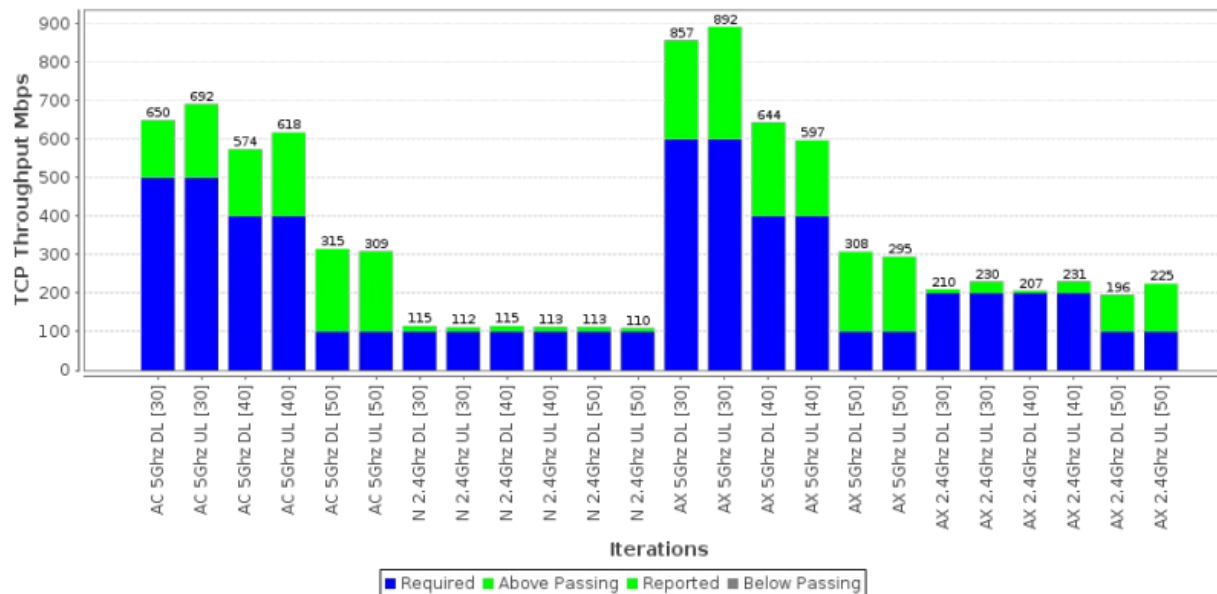
1. Pass/Fail criteria for each STA mode, at least 5 of the 6 tests must be at or above the throughput rate in the table below.

Wi-Fi Configuration (DUT)	Wi-Fi Configuration (STA)	Bandwidth	Attenuation 30dB		Attenuation 40dB		Attenuation 50dB	
			DL (Mbps)	UL (Mbps)	DL (Mbps)	UL (Mbps)	DL (Mbps)	UL (Mbps)
802.11n (2.4Ghz NSS-2)	802.11n (2.4Ghz NSS-2)	20	100	100	100	100	100	100
802.11ac (5Ghz NSS-2)	802.11ac (5Ghz NSS-2)	80	310	310	250	250	100	100
802.11ax (2.4Ghz NSS-2)	802.11ax (2.4Ghz NSS-2)	20	200	200	200	200	100	100
802.11ax (5Ghz NSS-2)	802.11ax (5Ghz NSS-2)	80	325	325	280	280	100	100

Summary Results

Test	Result	Candela Score	Elapsed	Info
8.1.1 Mesh Backhaul RvR	2.4Ghz PASS 5Ghz PASS	100	16.299 m	AC 5Ghz UL 3 / 3 DL 3 / 3 AX 5Ghz UL 3 / 3 DL 3 / 3 N 2.4Ghz UL 3 / 3 DL 3 / 3 AX 2.4Ghz UL 3 / 3 DL 3 / 3

8.1.1 Mesh Backhaul RvR

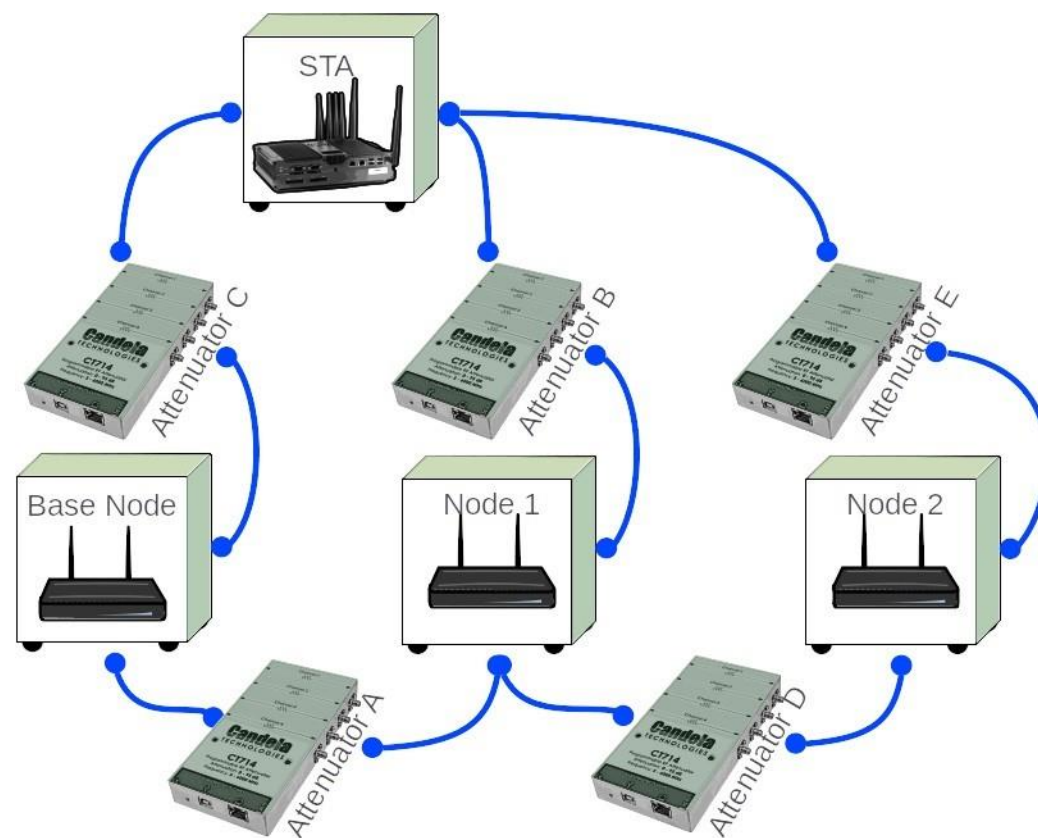


6.6.2 Mesh Backhaul Node2 RVR

- ❑ This testcase measures the throughput performance of a mesh Wi-Fi system where the Wi-Fi Repeaters are at different emulated distances from the base AP. The DUT considered to be the combination of a Base AP and two Wi-Fi repeaters. The Base AP is defined as the AP devices connected to the wired network connection of the traffic generator and analyzer, while the Wi-Fi Repeater has only RF connections to both base AP and the STA. During this test, the STA is only connected to the second Wi-Fi Repeater.

Setup

1. This test uses 4 chambers. The Base AP is in chamber 1, Repeater-1 is in chamber 2, and STA is in chamber 3, and Repeater-2 is in chamber 4. Attenuator A connects chamber 1 and 2, Attenuator B connects STA and chamber 2, and Attenuator C connects STA and chamber 1, Attenuator D connects chamber 2 and chamber 4, and Attenuator E connects STA and chamber 4 to chamber 3.
2. The Ethernet traffic generator connects to the Base AP.
3. The Attenuator A SHALL be configured to 5Ghz 2m calibrated distance plus 30dB.
4. The Attenuator B SHALL be configured to be at least 60dB to ensure the STA cannot talk to the root node.
5. The Attenuator C SHALL be configured to be at least 60dB to ensure the STA cannot talk to the root node.
6. The Attenuator D SHALL be configured to 5Ghz 2m calibrated distance plus 30dB.
7. The Attenuator E SHALL be configured to 5Ghz 2m calibrated distance.



Procedure

1. Configure Attenuator A and D to 5Ghz 2m calibrated distance plus 30dB.
2. Establish the LAN connection and allow STA to associate with the DUT.
3. Measure the downlink TCP throughput to the STA, using a test time of 120 seconds.
4. Measure the uplink TCP throughput to the STA, using a test time of 120 seconds.
5. Set attenuator A and D to 5Ghz 2m calibrated distance plus 40,and repeat steps 2-4 inclusive.
6. Set attenuator A and D to 5Ghz 2m calibrated distance plus 50,and repeat steps 2-4 inclusive.

Pass/Fail Criteria

1. Pass/Fail criteria for each STA mode, at least 5 of the 6 tests must be at or above the throughput rate in the table below.

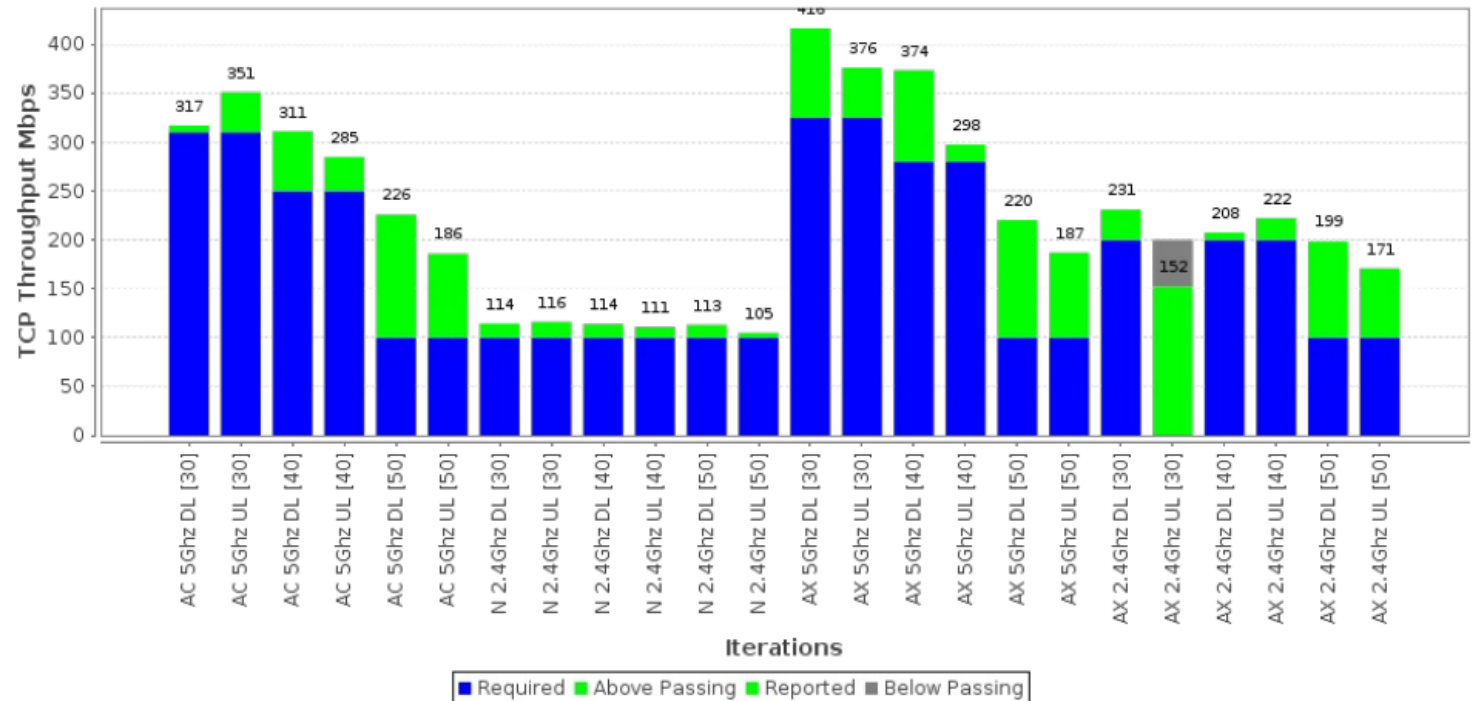
Wi-Fi Configuration (DUT)	Wi-Fi Configuration (STA)	Bandwidth	Attenuation 30dB		Attenuation 40dB		Attenuation 50dB	
			DL (Mbps)	UL (Mbps)	DL (Mbps)	UL (Mbps)	DL (Mbps)	UL (Mbps)
802.11n (2.4Ghz NSS-2)	802.11n (2.4Ghz NSS-2)	20	100	100	100	100	100	100
802.11ac (5Ghz NSS-2)	802.11ac (5Ghz NSS-2)	80	310	310	250	250	100	100
802.11ax (2.4Ghz NSS-2)	802.11ax (2.4Ghz NSS-2)	20	200	200	200	200	100	100
802.11ax (5Ghz NSS-2)	802.11ax (5Ghz NSS-2)	80	325	325	280	280	100	100

6.6.2 Example Results

Summary Results

Test	Result	Candela Score	Elapsed	Info
8.1.2 Mesh Backhaul Node-2 RvR	<u>2.4Ghz PASS</u> <u>5Ghz PASS</u>	95	16.418 m	AC 5Ghz UL 3 / 3 DL 3 / 3 AX 5Ghz UL 3 / 3 DL 3 / 3 N 2.4Ghz UL 3 / 3 DL 3 / 3 AX 2.4Ghz UL 2 / 3 DL 3 / 3

8.1.2 Mesh Backhaul Node-2 RvR

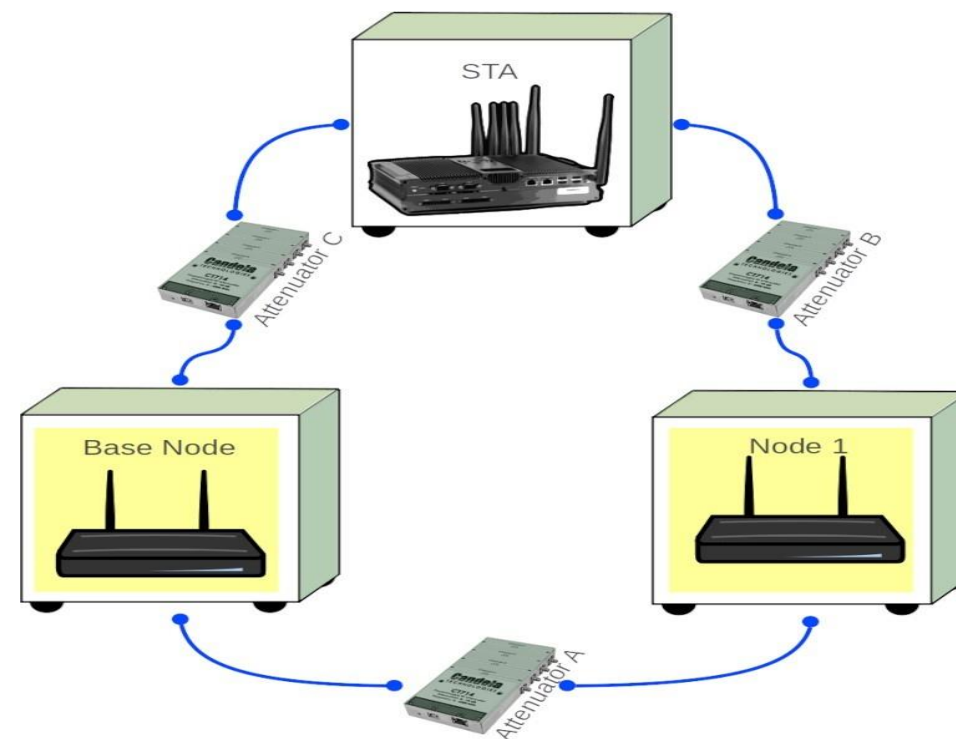


6.6.3 Mesh Roam Time

- ❑ This testcase measures the throughput performance of a mesh Wi-Fi system where the Wi-Fi Repeater is at different emulated distances from the base AP. The DUT considered to be the combination of a Base AP and a Wi-Fi repeater. The Base AP is defined as the AP devices connected to the wired network connection of the traffic generator and analyzer, while the Wi-Fi Repeater has only RF connections to both base AP and the STA. During this test, the STA is only connected to the Wi-Fi Repeater.

Setup

1. This test uses 3 chambers. The Base AP is in chamber 1, Repeater is in chamber 2, and STA is in chamber 3. Attenuator A connects chamber 1 and 2, Attenuator B connects STA and chamber 2, and Attenuator C connects STA and chamber 1.
2. The Ethernet traffic generator connects to the Base AP.
3. The Attenuator A SHALL be configured to 5Ghz 2m calibrated distance plus 30dB.
4. The Attenuator B SHALL be configured to 2m calibrated distance plus 30dB.
5. The Attenuator B SHALL be configured to 2m calibrated distance plus 70dB.



Procedure

1. Configure the Attenuator A to 5Ghz 2m calibrated distance plus 30dB.
2. Configure the Attenuator B to 5Ghz 2m calibrated distance plus 30dB.
3. Configure the Attenuator C to 5Ghz 2m calibrated distance plus 70dB.
4. Establish the LAN connection and allow STA to associate with the DUT.
5. Enable uplink UDP traffic at 1Mbps, 1250 byte payload frames (so that generator will generate 100 packers per second).
6. Decrease the value of Attenuator C by 1dB.
7. Increase the value of Attenuator B by 1dB.
8. Wait for 4 seconds.
9. Repeat steps 6-8 40 times, at which point attenuator B should be at 2m distance plus 70, and attenuator C should be at 2m distance plus 30dB.
10. Stop the UDP traffic and record the number of UDP packets that were transmitted by the STA and received by the receiver on ethernet port.
11. Restart the UDP traffic stream.
12. Decrease the value of Attenuator B by 1dB.
13. Increase the value of Attenuator C by 1dB.
14. Wait for 4 seconds.
15. Repeat steps 12-14 40 times, at which point attenuator C should be at 2m distance plus 70, and attenuator B should be at 2m distance plus 30dB.
16. Stop the UDP traffic and record the number of UDP packets that were transmitted by the STA and received by the traffic endpoint on the ethernet port.

Pass/Fail Criteria

1. Pass/Fail criteria for each STA mode and for each roam direction, there should be less than 200 dropped frames and the station should be disconnected for less than 2000ms wher

Summary Results

Test	Result	Candela Score	Elapsed	Info
8.2.1 Mesh Roam Time	2.4Ghz FAIL 5Ghz FAIL	79	27.137 m	AC 5Ghz 6 / 6 AX 5Ghz 4 / 6 N 2.4Ghz 4 / 6 AX 2.4Ghz 5 / 6

7.1.1 RSSI Accuracy Test

- ❑ This testcase verifies the relative accuracy of the DUT's RCPI (RSSI) reporting for different Station types and different attenuations

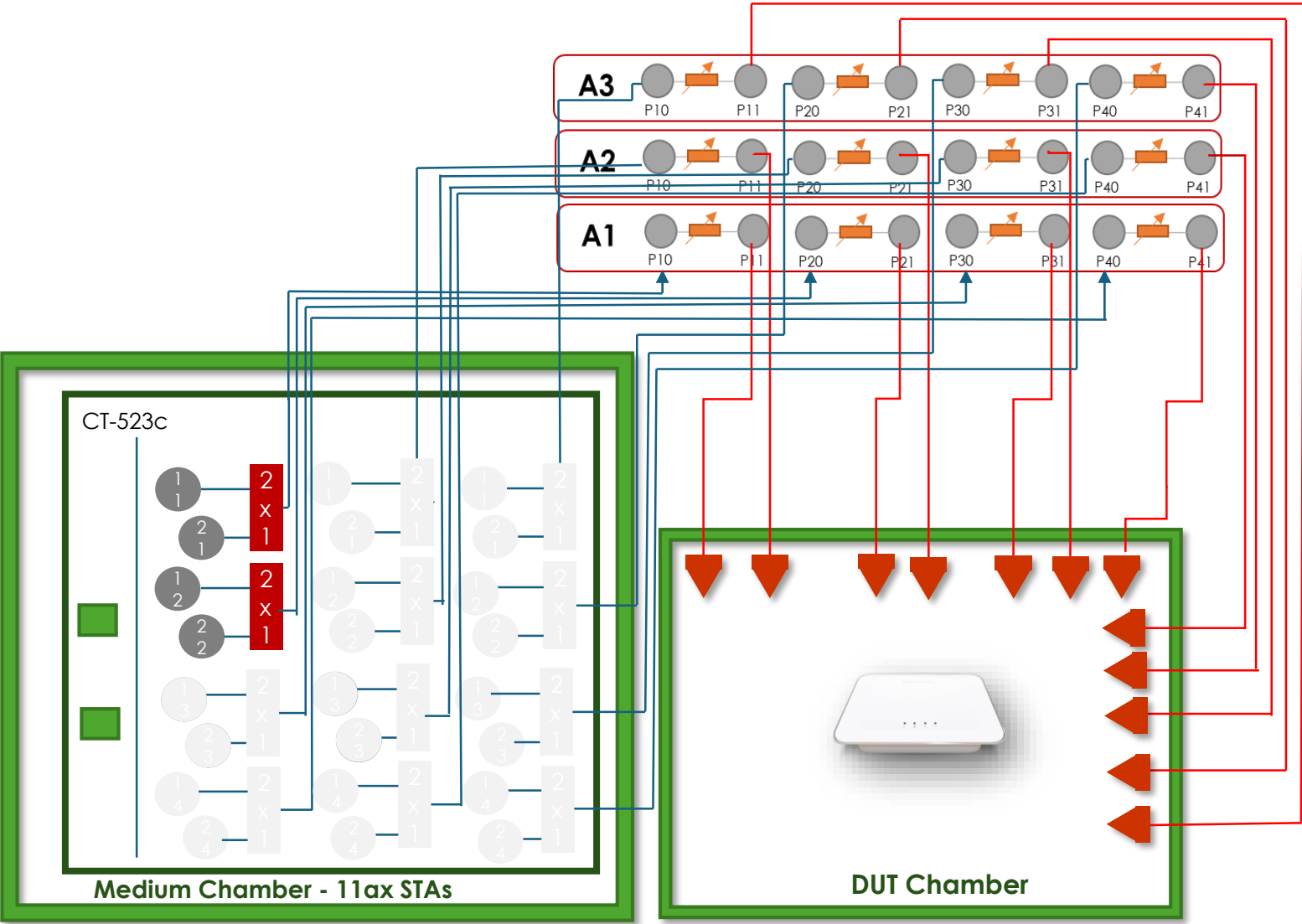
Test Procedure

1. For each combination of: 2.4Ghz N, 5Ghz AC, 2.4Ghz AX, 5Ghz AX, 6Ghz AX:
2. Set STA attenuator to calibrated 0 point. Set all other attenuators to maximum attenuation.
3. Create station with single spatial stream and allow it to associate with the DUT. Station is configured for 10dB txpower and 1 spatial stream.
4. Create 1 UDP stream, configured for 4Mbps traffic sent from STA to DUT and 512Kbps from DUT to STA. The 512Kbps downlink traffic ensures the STA can report accurate RSSI to help confirm testbed is working as expected in this test case.
5. Start UDP connection.
6. Every 10 seconds for 60 seconds, record DUT's reported RCPI/RSSI for the STA.
7. Stop connection, average the 6 RCPI/RSSI samples and record that averaged value.
8. Increase attenuation by 5, Repeat steps 2 - 5 until packet loss exceeds 5% or STA disconnects.

Pass/Fail Criteria

1. The lowest attenuation value is used to generate the expected RSSI at different attenuations.
2. Calculate average offset of the samples from the expected RSSI.
3. The absolute difference between the DUT reported RSSI and the expected RSSI plus offset must be no more than 2

7.1.1 Wiring Diagram



7.1.2 Channel Utilization Test

- ❑ This testcase provides a measurement of the accuracy of channel utilization as reported by the DUT. Several levels of traffic are injected to test different channel utilizations.

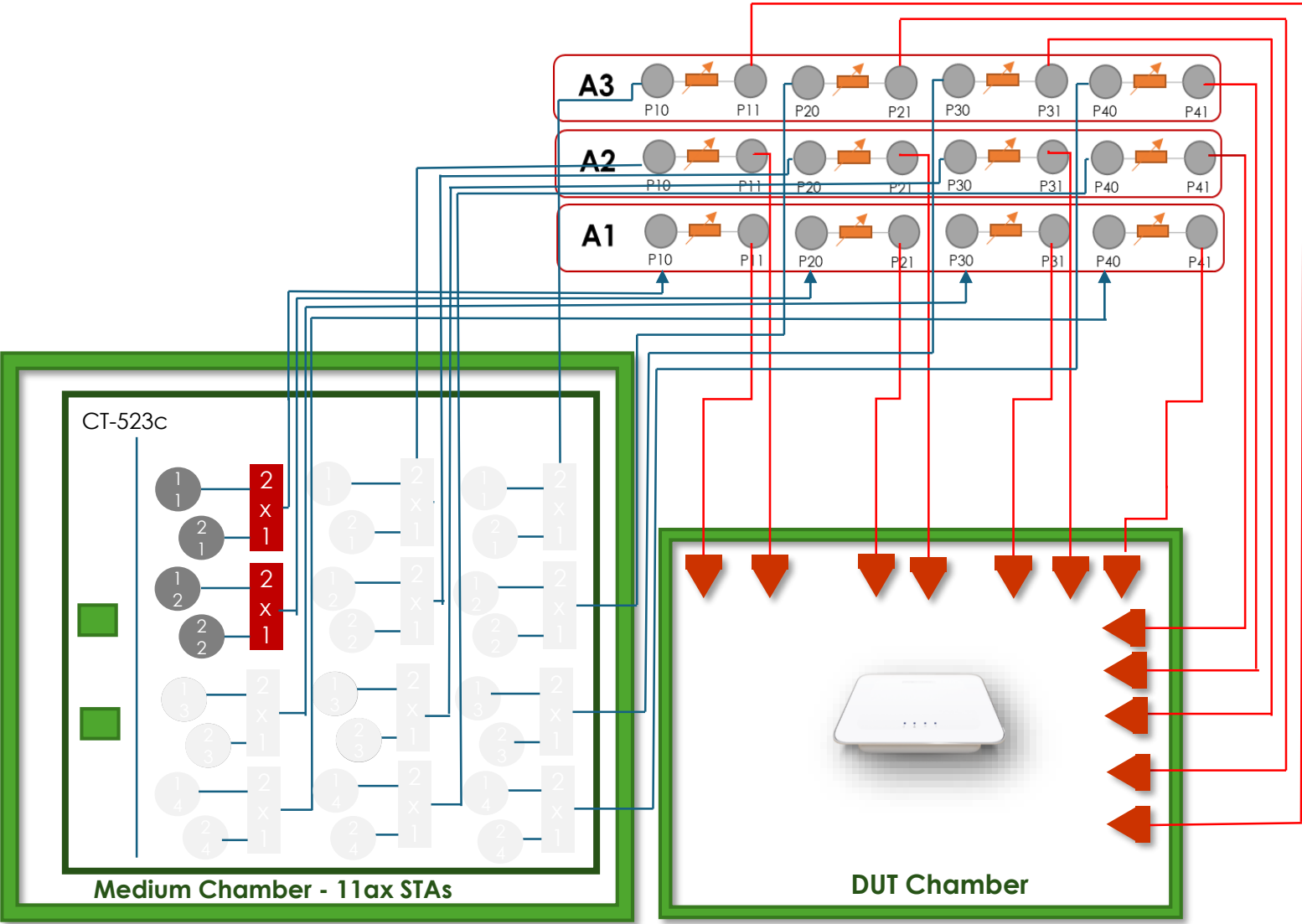
Test Procedure

1. For each combination of: 2.4Ghz N, 5Ghz AC, 2.4Ghz AX, 5Ghz AX, 6Ghz AX:
2. Create station with single spatial stream and allow it to associate with the DUT.
3. Create TCP traffic flow to determine max download rate. Store this as the load_100 and stop this traffic.
4. Create TCP traffic flow with requested rate at 75% of load_100, run traffic for 2 minutes.
5. At end of 2 minutes, and before traffic is stopped, query DUT's reported channel utilization.
6. Stop TCP connection.
7. Repeat steps 3-5 for 50% and 25% offered loads.

Pass/Fail Criteria

The reported channel utilization percentage must be within 4 of the testbed reported channel utilization. If the testbed cannot report channel utilization, then the value may be calculated based on the throughput percentage. For instance, if maximum throughput was 100Mbps, and actual throughput for the 50% step is 49Mbps, then expected channel utilization is 49%.

7.1.1 Wiring Diagram





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