



University of New Hampshire  
**InterOperability  
Laboratory**

**WLAN Consortium**  
802.11 Wireless Station Performance Test Suite  
Version 0.4

TECHNICAL DOCUMENT

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## REVISION & CHANGE HISTORY

REVISION	DATE	AUTHOR	EXPLANATION
0.1	Dec. 2021	Eason Su	Initial Draft Version
0.2	Oct. 2022	Eason Su	Metrics Update
0.3	Mar. 2023	Justin Nelson	<p>Added references to 802.11b &amp; g where necessary.</p> <p>Changed name and text of Receiver Sensitivity Test to more accurately reflect the result of the test.</p> <p>Added text to Maximum Working Inserted Attenuation Test to clarify that the AP remains at a constant transmit power for the duration of the test.</p> <p>Added text to Table A to clarify that only supported configurations shall be tested.</p> <p>Updated header in Table 1.1.2 to more clearly describe the test traffic load column.</p>
0.4	Mar. 2023	Justin Nelson	<p>Many editorial updates.</p> <p>Added values for 802.11b to table 1.1.2.</p>

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# INTRODUCTION

## Overview

The University of New Hampshire's InterOperability Laboratory (UNH-IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard.

Note that successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other compliant devices. However, combined with satisfactory operation in the UNH-IOL's interoperability test bed, these tests provide a reasonable level of confidence that the Device Under Test (DUT) will function well in most environments.

## Organization of Tests

The tests contained in this document are organized to simplify the identification of information related to a test and to facilitate the actual testing process. Each test contains an identification that describes the test and provides cross-reference information. The discussion section covers background information and specifies why the test is to be performed. Tests are grouped in order to reduce setup time in the lab environment. Each test contains the following information:

### Test Number

The Test Number associated with each test follows a simple grouping structure. Listed first is the Test Group Number followed by the test's number within the group. This allows for the addition of future tests to the appropriate groups of the test suite without requiring the renumbering of the subsequent tests.

### Purpose

The purpose is a brief statement outlining what the test attempts to achieve. The test is written at the functional level. The section may also cover the assumptions made in the design or implementation of the test, as well as known limitations. Other items specific to the test are covered here.

### References

This test was made with references to the following external specifications:

- [1] The Broadband Forum's *TR398-Issue 2 Corrigendum 1: Wi-Fi Residential & SOHO Performance Testing (2021, September)*.  
<https://www.broadband-forum.org/technical-reports>
- [2] 802.11-2020 - IEEE Standard for Information technology — Telecommunications and information exchange between systems Local and metropolitan area networks — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

## Test Configuration & Setup

The setup section describes the initial configuration of the test environment. Small changes in the configuration may be included in the test procedure.

### Procedure

The procedure section of the test description contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing and may be interspersed with observable results.

### Metrics (pass / fail criteria)

This section lists the specific observables that can be examined by the tester in order to verify that the DUT is operating properly. When multiple values for an observable are possible, this section provides a short discussion on how to interpret them. The determination of a pass or fail outcome for a particular test is often based on the successful (or unsuccessful) detection of a certain observable.

### Definitions

The following terms are used throughout this document.

AP	Access Point
DUT	Device Under Test
PTL	Percentage Throughput Lost
RSSI	Received Signal Strength Indicator

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# TEST SETUP & CONFIGURATION

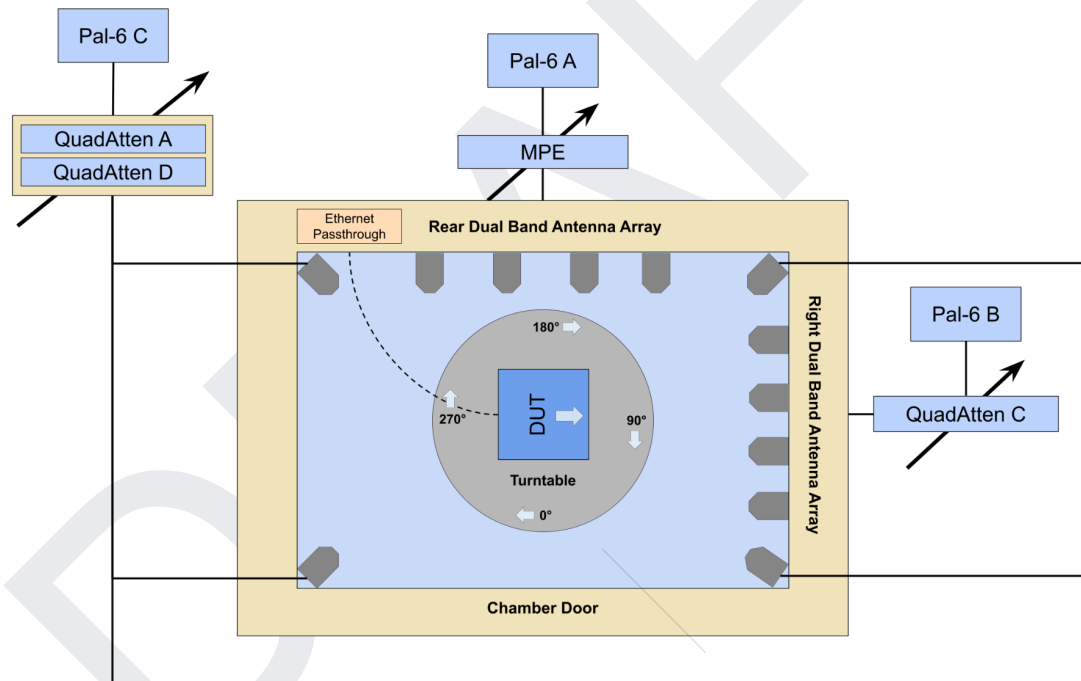
This section provides general information about test setups, configurations, and other information that may be common across the test plan. Individual test cases may include additional information, changes, or diagrams, as required for the specific test case.

## Physical Test Setup

Figure 1 below shows the test setup used throughout the test plan. Each test may not require use of all three Pal-6 simulated APs simultaneously.

Each Pal-6 device is connected to an attenuator used to simulate distance in various tests and is denoted with an arrow across a blue box.

**Figure 1: Top-down representation of the testing environment.**





## Default Test Configuration

The default test configuration is defined as any valid combination of the values below. A test configuration is chosen by the party requesting testing and must be provided in advance of the test. Individual test cases may update or alter these configurations as required for the specific testing scenario.

**Table A: Default Test Configuration Options**

Band	Modulation	Channel Bandwidth	Spatial Streams
2.4 GHz	802.11a	20 MHz	1
5 GHz	802.11b	40 MHz	2
	802.11g	80 MHz	3
	802.11n	160 MHz	4
	802.11ac		
	802.11ax		

## Test Metric Calculations

This section explains the process for calculating throughput requirements for devices depending on various configuration settings and the operational mode of the DUT chosen by the vendor at the time of reservation.

### Calculation of Throughput Requirements

For each test, a baseline requirement is given based on a device set to one of the following configurations specified in Table B. The baseline throughput requirement corresponding to the band and modulation selection from Table A shall apply to all testing.

**Table B: Baseline Configuration for Throughput Requirements**

Band	Modulation	Channel Width	NSS
2.4 GHz	802.11b	N/A	1
2.4 GHz	802.11g	N/A	1
2.4 GHz	802.11n	20 MHz	1
2.4 GHz	802.11ax	20 MHz	1

5 GHz	802.11a	N/A	1
5 GHz	802.11n	20 MHz	1
5 GHz	802.11ac	20 MHz	1
5 GHz	802.11ax	20 MHz	1

The following formula is used to calculate the actual throughput requirement as a function of the baseline requirement:

$$\text{Requirement} = (\text{Baseline}) * (\text{SpatialStreamModifier}) * (\text{ChannelWidth Modifier})$$

Refer to Table C to calculate the modifier value for each corresponding setting. For each setting on the left hand column, replace its modifier variable in the above formula with the corresponding modifier formula in the right hand column.

**Table C: Formula Modifiers for Throughput Metrics**

Setting	Abbreviation	Possible Values	Modifier Formula
Channel Width (MHz)	CW	20, 40, 80, 160	TBD
Number of Spatial Streams	SS	1, 2, 4	TBD * SS

For example, a test with a baseline requirement of 100 Mbps in the default configuration for a device operating in 802.11ac in the 5GHz band with 2 spatial streams and a channel width of 80 would have an adjusted requirement of:

$$(100) * (2) * (\text{TBD}) = \text{TBD Mbps}$$

## Attenuation Settings

This test uses the following pre-set attenuation values for sections which refer to devices at “Short”, “Medium”, and “Long” ranges in both the 2.4 and 5GHz bands.

**Table D: Definition of Attenuation Ranges**

Configuration	Wi-Fi Band	Short Attenuation	Medium Attenuation	Long Attenuation

		(dB)	(dB)	(dB)
1	2.4GHz	0	20	40
2	5GHz	0	20	32

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## Running Traffic with iPerf

Where the open source program iPerf3 is used to implement the traffic throughput measurements within this test plan, a predetermined set of command line flags shall be used to start and run the iPerf3 program as documented below, unless a specific test case provides alternate commands, to ensure consistency within testing.

The iPerf3 program runs as either a client or server process, where the server acts as a traffic reflector/recipient, while the client is responsible for the definition of specific tests/measurements to perform between the client and server processes. For the purposes of definitions below, the commands assume the iPerf3 server process is running on the STA side and the client process is running on the AP side of the Wi-Fi link. The processes MAY be run on either side of the link during testing, provided the uplink/downlink definitions are consistently maintained.

The iPerf3 server shall be started with the command `iPerf3 --server`. Specific client commands for each test scenario are located below. An explanation of the commands follows, for information only.

```
iPerf3 --client SERVER_IP --time TEST_TIME --bitrate 0 --parallel 10 --reverse --omit 2
```

```
iPerf3 --client SERVER_IP --time --bitrate --reverse --udp --omit 2
```

SERVER\_IP address is the IP address of the system where the server is running.

TEST\_TIME is the length of time the measurement will run for. This is set within each test case below.

The bitrate parameter is set to zero, to instruct iPerf3 to attempt to determine (measure) the maximum throughput between the client and server.

The parallel parameter instructs iPerf3 to run five measurement streams in parallel between the client and server. This improves the overall accuracy of the measurement. The individual bandwidth used by each stream can vary, and the summation/average is used to calculate the overall measurement.

The reverse parameter instructs iPerf3 to measure the bandwidth from the server to the client. The default behavior performs the measurement from the client to the server.

The udp parameter instructs iPerf3 to use the UDP transport for traffic. When not specified, TCP traffic is used instead.

The omit 2 parameter instructs iPerf3 to “discard” the first 2 seconds of the measurement, to avoid inclusion of TCP slow start, etc.

Additional commands MAY be used to alter/direct logging or format of results, such as the `--logfile` or `--json` options. However, any additional command shall NOT alter the operation or measurement traffic used by the program.

The iPerf3 programs shall be run on a Linux based system, using a kernel version of 4.14 or newer. The system shall include at least one processor, with two cores, of at least 2 GHz. The processor compute power available on the DUT may impact the performance results. To avoid this impact, it might be possible to run the iPerf3 process separately from the STA device, if the DUT can perform IP routing between a wired Ethernet interface and the Wi-Fi interface being tested.

*This section has been modified from BBF TR-398 Issue 2 Corrigendum 1 (Ref[1])*

## **Reporting RSSI Values**

For each throughput traffic measurement, a corresponding RSSI measurement is also taken from the AP. These values are reported alongside each throughput measurement in each section.

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# 1. Radio Frequency Capability

## 1.1 Maximum Working Inserted Attenuation Test

### Purpose:

The Maximum Working Inserted Attenuation Test measures the DUT's ability to receive increasingly weak signals. Distance is simulated between the DUT and AP using increasing attenuation until the connection begins to degrade. This point is measured as the maximum working inserted attenuation and repeated through multiple coding schemes to ensure consistency.

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 AP. Note, this total attenuation includes both the "air-gap" between the STA and the test setup antennas, as well as the additional attenuation inserted by the programmable attenuator. During the test, the AP is limited to a single coding scheme and maintains a constant transmission power. The point at which the connection degrades represents the receiver's approximate sensitivity. The test is repeated with multiple coding schemes, ensuring the DUT should smoothly transition between coding schedules as the attenuation increases in normal operation. This is an approximate measurement only, where a detailed receiver sensitivity measurement would typically be performed in a controlled test environment with calibrated transmitter power levels.

### Test Configuration & Setup:

1. This test uses the physical setup shown in Figure 1.
2. This test shall be run under one configuration specified in Table 1.1.1.

**Table 1.1.1: Wi-Fi Test Configurations for Maximum Working Inserted Attenuation Test**

Test Configuration	Wi-Fi configuration (specification / band)
1	802.11b / 2.4 GHz / 20MHz
2	802.11g / 2.4 GHz / 20MHz
3	802.11n / 2.4 GHz / 20MHz
4	802.11ac / 5 GHz / 80 MHz
5	802.11ax / 2.4 GHz / 20 MHz
6	802.11ax / 5 GHz / 80 MHz

**NOTE:** All configurations shall use an access point supporting one spatial stream (Nss=1).

**Procedure:**

1. Set the rotation angle to 0 degrees.
2. Configure the AP to the correct MCS rate as defined in table 1.1.2 for the current configuration.
3. Configure the Traffic Generator to use the applicable test data rate from table 1.1.2.
4. Allow the DUT to associate with the AP.
5. Configure the attenuator to 0dB.
6. Enable packet generation from the AP to the DUT for 20 seconds.
7. Record the PTL.
8. Increase the attenuator by 1dB.
9. Repeat steps 6-8 until the PTL is greater than 10%. Record the final attenuation value as the maximum working inserted attenuation.
10. Increase the rotation angle by 45 degrees
11. Repeat steps 5-10 until the DUT has been rotated by 360 degrees. Calculate the average maximum working inserted attenuation.
12. Repeat steps 1-11 for each MCS test index applicable to the test configuration from Table 1.1.2.

**Table 1.1.2: MCS Rate and Traffic Test Configurations**

Test Index	MCS Index	Modulation	Data Rates (Mbps) Nss = 1	
			Theoretical	Test Data Rate
20 MHz Channel in 802.11b				
1	0	DBPSK	1	0.4
2	3	DQPSK	11	4.4
20 MHz Channel in 802.11g				
3	0	BPSK	6	2.4
4	7	64-QAM	54	21.6
20 MHz Channel in 802.11n				
5	0	BPSK	6.5	4.23
6	7	64-QAM	65	42.25

80 MHz Channel in 802.11ac				
7	0	BPSK	29.3	19.05
8	9	256-QAM	390	253.5
20 MHz Channel in 802.11ax 2.4 GHz				
9	0	BPSK	8	5.2
10	11	1024-QAM	135	87.75
80 MHz Channel in 802.11ax 5GHz				
11	0	BPSK	34	22.1
12	11	1024-QAM	567	374.4
<b>Note 1:</b> The MCS rates are defined in Ref [2].				

**Metrics (pass/fail criteria):**

1. The measured average (between all rotation points) maximum working inserted attenuation (inserted attenuation) in the test shall reach the minimum required working inserted attenuation outlined in Table 1.1.3.

**Table 1.1.3: Required Inserted Attenuation**

Test Index	MCS Index	Modulation	Inserted Attenuation
1	0	DBPSK	TBD
2	3	DQPSK	TBD
3	0	BPSK	TBD
4	7	64-QAM	TBD
5	0	BPSK	56
6	7	64-QAM	38
7	0	BPSK	46



8	9	256-QAM	21
9	0	BPSK	56
10	11	1024-QAM	33
11	0	BPSK	46
12	11	1024-QAM	21

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## 2. Baseline Performance

### 2.1 Maximum Throughput Test

#### Purpose:

The Maximum Throughput Test is designed to measure the maximum throughput performance of the DUT over an ideal channel (i.e. a short distance).

#### Test Configuration & Setup:

1. This test uses the physical setup shown in Figure 1.
2. This test shall be run under one configuration specified in Table B.

#### Procedure:

1. Allow the DUT to associate with the AP.
2. Measure the downlink TCP throughput to the STA using a test time of 120 seconds.
3. Measure the uplink TCP throughput to the STA using a test time of 120 seconds.

#### Metrics (pass/fail criteria):

1. The measured average throughput shall meet the performance requirement determined by the baseline requirement outlined in Table 2.1.2 adjusted for the current configuration.

**Table 2.1.2: Baseline Throughput Requirements**

Modulation	Operating Band	NSS	Bandwidth (MHz)	Downlink throughput requirement (Mbps)	Uplink throughput requirement (Mbps)
802.11b	2.4Ghz	1	20	TBD	TBD
802.11g	2.4Ghz	1	20	TBD	TBD
802.11n	2.4Ghz	1	20	50	50
802.11ax	2.4Ghz	1	20	100	100
802.11a	5Ghz	1	20	TBD	TBD
802.11n	5GHz	1	20	TBD	TBD
802.11ac	5Ghz	1	20	50	50

802.11ax	5Ghz	1	20	TBD	TBD
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## 2.2 Bidirectional Throughput Test

### Purpose:

The Bidirectional Throughput Test measures the uplink and downlink throughput achieved simultaneously through the DUT and an AP.

### Test Configuration & Setup:

1. This test uses the physical setup shown in Figure 1.
2. This test shall be run under the configuration as chosen from Table A.
3. This test requires two instances of iPerf servers running on the DUT, each with the same IP address on separate ports.

### Procedure:

1. Allow the DUT to associate with the AP.
2. Measure the baseline uplink TCP throughput to the AP for 120 seconds. Record these results as Baseline\_UL\_Throughput
3. Measure the baseline downlink TCP throughput to the AP for 120 seconds. Record these results as Baseline\_DL\_Throughput
4. Set the downlink data rate for the bidirectional UDP traffic streams at 45% of Baseline\_DL\_Throughput. Record this as DL\_Throughput
5. Set the uplink data rate for the bidirectional UDP traffic streams at 45% of Baseline\_UL\_Throughput. Record this as DL\_Throughput
6. Run bidirectional traffic for a test time of 120 seconds, recording the number of packets sent, received, and dropped in both directions.
7. Record the PTL as the number of packets lost in both the downlink and uplink directions divided by the total number of packets sent by the DUT and AP in both directions.
8. Repeat steps 2-7 for each attenuation as outlined in Table D.

### Metrics (pass/fail criteria):

1. The measured PTL shall not exceed  $1E-2$  for all points in each selected configuration.

## 3. Coverage

### 3.1 Range Versus Rate Test

#### Purpose:

The Range versus Rate Test intends to measure the baseband and RF chain performance of a Wi-Fi device. The attenuation of signals due to range increase is achieved by using an attenuator between the DUT and the AP. The increase of attenuation can approximate the distance between the DUT and AP, according to the freespace loss for the given band (i.e. 2.4 or 5 GHz). This assumes a line-of-sight channel between the DUT and AP.

#### Test Configuration & Setup:

1. This test uses the physical setup shown in Figure 1.
2. This test shall be run under the configuration as chosen from Table A.

**Table 3.1.1: Attenuation Ranges for RF chain during the test**

Wifi Band	Attenuation range (dB)
2.4 GHz	0-80
5 GHz	0-64

#### Procedure:

1. Configure the attenuator setting to 0dB attenuation.
2. Allow the DUT to associate with the AP.
3. Measure the downlink TCP throughput to the DUT using a test time of 120 seconds.
4. Measure the uplink TCP throughput to the AP using a test time of 120 seconds.
5. Repeat steps 3-4, increasing the attenuation by 4dB for each step until reaching the max attenuation as outlined in Table 3.1.1 or until the DUT can no longer associate with the AP.

#### Metrics (pass/fail criteria):

1. The measured average throughput shall meet the performance requirements calculated according to the corresponding baseline in Table 3.1.2 or 3.1.3 for each selected configuration. For each configuration, the test allows no more than 2 testing points to fall below the throughput requirement.

**Table 3.1.2: Range Versus Rate Test Baseline Throughput Requirements 2.4GHz**

Attenuation (dB)	Baseline Throughput Requirements (Mbps)							
	802.11b		802.11g		802.11n 2.4GHz		802.11ax 2.4GHz	
	DL	UL	DL	UL	DL	UL	DL	UL
0	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
4	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
8	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
12	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
16	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
20	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
24	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
28	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
32	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
36	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
40	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
44	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
48	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
52	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
56	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
60	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
64	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
68	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
72	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
76	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
80	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

**Table 3.1.3: Range Versus Rate Test Baseline Throughput Requirements 5GHz**

Attenuation (dB)	Baseline Throughput Requirements (Mbps)							
	802.11a		802.11n 5GHz		802.11ac		802.11ax 5GHz	
	DL	UL	DL	UL	DL	UL	DL	UL

0	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
4	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
8	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
12	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
16	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
20	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
24	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
28	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
32	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
36	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
40	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
44	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
48	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
52	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
56	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
60	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
64	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

## 3.2 Spatial Consistency Test

### Purpose:

The Spatial consistency Test intends to verify the Wi-Fi signal radiation pattern of the DUT is consistent (omnidirectional). This is achieved across a single plane, through the use of directional antennas within the test setup, while rotating the DUT relative to the antenna.

### Test Configuration & Setup:

1. This test uses the physical setup shown in Figure 1.
2. This test shall be run under the configuration as chosen from Table A.

### Procedure:

1. Establish the LAN connection and allow the DUT to associate with the AP.
2. Set the attenuation setting to the short attenuation for the current band in accordance with Table D.
3. Measure the downlink TCP throughput to the DUT using a test time of 60 seconds.
4. Wait for 10 seconds.
5. Measure the uplink TCP throughput to the AP using a test time of 60 seconds.
6. Rotate the DUT platform by 30°.
7. Repeat steps 3-6 until the DUT has been rotated by 360°.
8. Repeat steps 3-7 for the medium and long attenuation settings for the current band in accordance with Table D.

### Metrics (pass/fail criteria):

1. The average throughput measured at each angle shall meet the calculated throughput requirement based on Table 3.2.1 and the current configuration for 10 out of 12 points at each attenuation setting.

**Table 3.2.1: Baseline Throughput requirements for Spatial Consistency Test**

Modulation	Operating Band	Throughput (Mbps)					
		Short		Medium		Long	
		DL	UL	DL	UL	DL	UL
802.11b	2.4Ghz	TBD	TBD	TBD	TBD	TBD	TBD
802.11g	2.4Ghz	TBD	TBD	TBD	TBD	TBD	TBD
802.11n	2.4Ghz	TBD	TBD	TBD	TBD	TBD	TBD



802.11ax	2.4Ghz	TBD	TBD	TBD	TBD	TBD	TBD
802.11a	5Ghz	TBD	TBD	TBD	TBD	TBD	TBD
802.11ac	5Ghz	TBD	TBD	TBD	TBD	TBD	TBD
802.11ax	5Ghz	TBD	TBD	TBD	TBD	TBD	TBD

2. The maximum variation<sup>1</sup> during rotation shall not exceed 30% in the 2.4Ghz band or 40% in the 5Ghz band for each attenuation setting.

1: The variation at each 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.

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## 4. Stability and Robustness

### 4.1 Long Term Stability Test

#### Purpose:

The Long Term Stability Test measures the DUT's ability to handle heavy user loads over long periods of time. The DUT must maintain a stable connection for the duration of the test without significant drops in throughput.

#### Test Configuration & Setup:

1. This test uses the physical setup shown in Figure 1.
2. This test shall be run under the configuration as chosen from Table A.

#### Procedure:

1. Configure the attenuator setting to 0dB attenuation.
2. Allow the DUT to associate with the AP.
3. Wait for 60 seconds for the system to stabilize.
4. Measure the downlink TCP throughput to the DUT using a test time of 120 seconds. Record this value as "baseline\_tcp".
5. Configure a downlink UDP transmission through the DUT lasting 15 minutes using a bandwidth target of 45% of the baseline\_tcp measurement.
6. Record the PTL
7. Repeat steps 5-6 for 16 measurements for a total of 4 hours of traffic.

#### Metrics (pass/fail criteria):

1. For each measurement, the PTL shall not exceed  $1E-2$ .

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