CONFIDENTIAL TRADE SECRET

FOR USE ONLY BY AUTHORIZED WI-FI ALLIANCE® MEMBERS

– DO NOT COPY –

Wi-Fi CERTIFIED™ ac Interoperability Test Plan

Version 2.4

10900-B Stonelake Boulevard, Suite 126
Austin, TX 78759

Phone: 512.498.9434 • Fax: 512.498.9435 • Email: certifications@wi-fi.org
www.wi-fi.org

Latest version available at **https://www.wi-fi.org/members/certification-program**

WI-FI ALLIANCE PROPRIETARY AND CONFIDENTIAL – SUBJECT TO CHANGE WITHOUT NOTICE

Table of Contents

1. OVERVIEW 11

1.1 SCOPE AND PURPOSE 11
1.2 CERTIFICATION GENERAL REQUIREMENTS 11
1.3 REFERENCES 12
1.4 TERMS AND DEFINITIONS 13
1.5 DEVICES UNDER TEST (DUT) 15
1.5.1 Applicability of Tests 15
1.5.2 APUT Tests 16
1.5.3 STAUT Tests 18

2. TEST TOOLS, METHODOLOGY AND APPROACH 20

3. IMPLEMENTATION REQUIREMENTS FOR WI-FI ALLIANCE CERTIFICATION 21

3.1 GENERAL REQUIREMENTS 21
3.2 SECURITY REQUIREMENTS 21

4. WI-FI CERTIFIED AC APUT TESTING 22

4.1 CONFIGURABILITY TESTS 22
4.1.1 General Configurability Tests 22
4.1.2 Security Configurability Tests 22
4.1.3 Wi-Fi CERTIFIED n Configurability Tests 22
4.2 APUT TEST CASES 23
4.2.1 AP Out of the Box (OOB) 23
4.2.2 AP WPA2 Initial Ping Interoperability Test 25
4.2.3 AP and STA Association and Throughput, Honoring NAV and PLCP 26
4.2.4 AP and STA Association and Throughput using WPA2-Enterprise with TLS 26
4.2.5 AP and STA Association and Throughput using WPA2-PSK 27
4.2.6 AP and STA Association and Throughput using Replay Counter Processing 31
4.2.7 AP and STA Association and Throughput using Mixed Mode WPA/WPA2 Enterprise with TLS and Message 3 Validation 31
4.2.8 AP and STA Association and Throughput using Mixed Mode WPA/WPA2-PSK 31
4.2.9 Reassociation/Bridging Tests 31
4.2.10 Multicast with WPA2-PSK Only Mode and WPA/WPA2-PSK Mixed Mode 31
4.2.11 Pre-authentication 31
4.2.12 PMK Caching 31
4.2.13 WPA Specific Countermeasures 31
4.2.14 WPA Negative Tests – No Association with a WEP or No Encryption STA 31
4.2.15 WPA Negative Test Cases – No Association with a WPA2-Enterprise with TLS and WPA-PSK Configured Access Point 31
4.2.16 802.11d and 802.11h Testing 32
4.2.17 (Removed Wi-Fi CERTIFIED n test) 34
4.2.18 Extended EAP Tests (Enterprise APs Only) 34
4.2.19 Dual Band APs 35
4.2.20 Basic WMM Association and Transmission 37
4.2.21 Traffic Differentiation in a Single BSS with Two 802.11n STAs 40
4.2.22 Traffic Differentiation in a Single BSS with WMM STA 42
4.2.23 Traffic Differentiation in a Single BSS with Legacy Non-WMM STA 42
4.2.24 APUT "No Acknowledgement" Test 42
4.2.25 Traffic Forwarding in Single BSS 43
4.2.26 Basic Association in 802.11n Environment 45
4.2.27 Ability to Receive 1 and 2 Spatial Streams 49
4.2.28 Spatial Multiplexing Power Save Operation 50

4.2.29 A-MPDU Aggregation when the AP is the Recipient with and without WPA2-PSK 51
4.2.30 A-MSDU Aggregation when AP is the Recipient 53
4.2.31 Overlapping BSS – 2.4 GHz 54
4.2.32 Overlapping BSS – 5 GHz 54
4.2.33 HT-Greenfield Operation 54
4.2.34 Short GI Operation 55
4.2.35 Overlapping BSS on Extension Channel 57
4.2.36 HT Duplicate Mode (MCS Index = 32) 57
4.2.37 AP Concurrent Operation in 2.4 and 5 GHz Frequency Bands 57
4.2.38 RIFS Test 57
4.2.39 STBC Transmit (2x1) Test 58
4.2.40 A-MPDU Aggregation when the AP is the Transmitter 60
4.2.41 AP 20/40 MHz Coexistence 62
4.2.42 Ability to Receive 3 Spatial Streams 62
4.2.43 AP Transmitting to STA using Supported Number of Spatial Streams 64
4.2.44 Disallow TKIP with HT Rates Test 65
4.2.45 AP Negative tests to ensure WEP is not used with HT associations in 11n devices 67
4.2.46 Negative tests to ensure WEP is not used with Associations at VHT Rates 68
4.2.47 AP Receiving 256-QAM MCSs 69
4.2.48 AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU 73
4.2.49 Ability to Receive A-MPDU with A-MSDU 74
4.2.50 Clear Channel Assessment on Secondary Channel 75
4.2.51 CTS with BW signaling in response to RTS with BW signaling 77
4.2.52 Single User Transmit beamforming when AP is the beamformer 79
4.2.53 LDPC where the AP is the Transmitter 81
4.2.54 LDPC where the AP is the Receiver 83
4.2.55 Operating Mode Notification Testing 84
4.2.56 APUT acting as MU Beamformer 86
4.2.57 Ability to Receive 4 Spatial Streams at APUT 91
4.2.58 Ability to Receive 160 MHz at APUT 93
4.2.59A RTS with Static Bandwidth Signaling 95
4.2.59B RTS with Dynamic Bandwidth Signaling 97
4.2.60 Extended 5 GHz Channel Support on APUT 99

5. WI-FI CERTIFIED AC STATION TESTING 101

5.1 CONFIGURABILITY OF TESTS 101
5.1.1 General Configurability Tests 101
5.1.2 Security Configurability Tests 101
5.2 INFRASTRUCTURE STAUT TEST CASES 102
5.2.1 STA Out of Box (OOB) 102
5.2.2 STA WPA2 Initial Ping Interoperability Test 104
5.2.3 AP and STA Association and Throughput, Honoring NAV 105
5.2.4 AP and STA Association and Throughput using Fragmentation 105
5.2.5 Mixed 802.11b/g Interoperabilty STA Testing 105
5.2.6 Mixed 802.11b/g Interoperabilty STA Testing with WPA-PSK 105
5.2.7 Mixed 802.11b/g Interoperabilty STA Testing with WEP or PSK Security 105
5.2.8 Mixed 802.11b/g Interoperabilty STA Testing with WPA-Enterprise 105
5.2.9 AP and STA Association and Throughput using WPA2-PSK 106
5.2.10 AP and STA Association and Throughput using WPA2-Enterprise 109
5.2.11 AP and STA Association and Throughput with Replay Counter Processing 111
5.2.12 AP and STA Association and Throughput using WEP 111
5.2.13 AP and STA Association and Throughput using WPA2 with Fragmentation 111
5.2.14 Broadcast/Multicast Transmission/Reception with WPA/WPA2-PSK Mixed Mode 111
5.2.15 Pre-authentication 111
5.2.16 PMK Caching 111

5.2.17 WPA Specific Countermeasures – Legacy WPA Only Mode 111
5.2.18 WPA Specific Countermeasures – WPA2/WPA Mixed Mode 111
5.2.19 WPA2 Negative Tests – Non-association with an AP not using WPA2 111
5.2.20 WPA2 Negative Tests – Non-association with PSK-Configured Station 111
5.2.21 WPA2 Negative Tests – Non-association with a TLS-Configured Station 111
5.2.22 802.11h Testing – Spectrum Management Bit 112
5.2.23 802.11h Testing — Channel Switch Test 113
5.2.24 Extended EAP Tests (Enterprise STAs Only) 114
5.2.25 (Removed from Wi-Fi CERTIFIED n Test Plan) 114
5.2.26 Roaming Test for Dual Band STAs with WPA-PSK 115
5.2.27 Traffic Differentiation in Single BSS with 802.11n STA 118
5.2.28 Traffic Differentiation in Single BSS with 2 802.11n STAs 121
5.2.29 Traffic Differentiation in Single BSS with WMM STA 123
5.2.30 Traffic Differentiation in Single BSS with Legacy non-WMM STA 123
5.2.31 Test ACM Bit Conformance 123
5.2.32 Test the AC Parameter Modification 124
5.2.33 TXOP Limit Test 126
5.2.34 STAUT "No Acknowledgement" Test 128
5.2.35 Basic Association in 802.11n Environment 130
5.2.36 Ability to Receive 1 and 2 Spatial Streams 133
5.2.37 A-MPDU Aggregation when the STA is the Recipient with and without WPA2-PSK 135
5.2.38 A-MSDU Aggregation when the STA is the Recipient 137
5.2.39 Overlapping BSS – 2.4 GHz 138
5.2.40 Overlapping BSS – 5 GHz 139
5.2.41 HT Greenfield Operation 140
5.2.42 Short GI Operation 141
5.2.43 Overlapping BSS on the Extension Channel 142
5.2.44 HT Duplicate Mode (MCS Index = 32) 142
5.2.45 RIFS Test 142
5.2.46 STBC Receive Test 143
5.2.47 A-MPDU Aggregation when the STA is the Transmitter 145
5.2.48 STA 20/40 MHz Coexistence 146
5.2.49 Ability to Receive 3 Spatial Streams 147
5.2.50 STAUT Transmitting to AP using Supported Number of Spatial Streams 149
5.2.51 Disallow TKIP with HT Rates Test 151
5.2.52 STA Negative tests to ensure WEP is not used with HT associations in 802.11n devices 152
5.2.53 Support for AES if TKIP is supported 153
5.2.54 STA Receiving 256-QAM MCSs 154
5.2.55 STA Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU 159
5.2.56 Ability to Receive A-MPDU with A-MSDU 160
5.2.57 CTS with BW signaling in response to RTS with BW signaling 161
5.2.58 Single User Transmit Beamforming when STA is the Beamformee 163
5.2.59 LDPC where STA is the transmitter 166
5.2.60 LDPC where STA is the Receiver 167
5.2.61 Clear Channel Assessment on Secondary Channel 168
5.2.62 Operating Mode Notification Testing 171
5.2.63 STAUT acting as MU Beamformee 173
5.2.64 Ability to Receive 4 Spatial Streams at STAUT 180
5.2.65 Ability to Receive 160 MHz at STAUT 182
5.2.66 Extended 5 GHz Channel Support on STAUT 184
5.2.67A RTS with Static Bandwidth Signaling 186
5.2.67B RTS with Dynamic Bandwidth Signaling 188
5.3 IBSS STAUT TEST CASES 189
5.3.1 IBSS Active or Passive Scanning Test 189
5.3.2 IBSS WEP On and Off Test 189

5.3.3 IBSS Rejoin Test 189
ANNEX A: TEST BED PRODUCTS 190
ANNEX B: TESTING NOTES 192
ANNEX C: DEFAULT WMM AC PARAMETERS 193
ANNEX D: THRESHOLD VALUES 194
ANNEX E: TEST BED DEFAULT MODES 196
ANNEX F: DEVICE UNDER TEST (DUT) DEFAULT CONFIGURATION FOR TEST PROCEDURES 199
ANNEX G: TRAFFIC STREAMS 201
ANNEX H: SCRIPT FILES 202
APPENDIX A: TEST PLAN CHANGE HISTORY 204

List of Tables

Table 1: General Capabilities Declaration 16
Table 2: APUT Tests 18
Table 3: STAUT Tests 19
Table 4: AP Initial 5 GHz Operation Test Configuration 23
Table 5: AP Initial 5 GHz Operation Procedure and Expected Results 24
Table 6: AP WPA2 Initial Ping Test Configuration 25
Table 7: AP WPA2 Initial Ping Test Procedure and Results 26
Table 8: AP and STA Association and Throughput using WPA2-Personal Configuration 27
Table 9: AP and STA Association and Throughput using WPA2-Personal Procedure and Results 29
Table 10: AP and STA Association without Security: Configuration 30
Table 11: AP and STA Association without Security: Procedure and Results 30
Table 12: Country code, TPC, and Channel Switching Test Configuration 32
Table 13: Two octet Country code, TPC and Channel Switching Test Procedure and Results 33
Table 14: Dual Band AP Configuration 35
Table 15: Dual Band AP Procedure and Results 36
Table 16: Basic WMM Association and Transmission Configuration 37
Table 17: Basic WMM Association and Transmission Procedure and Results 39
Table 18: Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs Configuration 40
Table 19: Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs: Procedure and Results 42
Table 20: Traffic Forwarding in Single BSS Configuration 43
Table 21: Traffic Forwarding in Single BSS Procedure and Results 44
Table 22: Basic Association in Wi-Fi CERTIFIED ac Environment Configuration 45
Table 23: Basic Association in Wi-Fi CERTIFIED ac Environment Procedure and Results 48
Table 24: Ability to Receive 1 and 2 Spatial Streams Configuration 49
Table 25: Ability to Receive 1 and 2 Spatial Stream Procedure and Results 50
Table 26: A-MPDU Aggregation Single Stream when AP is the Receiver with and without WPA2-Personal Configuration 51
Table 27: A-MPDU Aggregation Single Stream when AP is the Receiver with and without WPA2-Personal Procedure and Results 52
Table 28: A-MSDU Aggregation when AP is the Receiver Configuration 53
Table 29: A-MSDU Aggregation when AP is the Receiver Procedures and Results 54
Table 30: Receive Short GI for 80 MHz Operation Configuration 55
Table 31: Receive Short GI for 80 MHz Operation Procedure and Results 56
Table 32: STBC Tx (2x1) Test Configuration 58
Table 33: STBC Tx (2x1) Test Procedure and Results 59
Table 34: A-MPDU Aggregation when the AP is the Transmitter Configuration 60
Table 35: A-MPDU Aggregation when the AP is the Transmitter Procedure and Results 61
Table 36: Ability to Receive 3 Spatial Streams Configuration 62
Table 37: Ability to Receive 3 Spatial Stream Procedure and Results 63
Table 38: AP Transmitting to STA using Implmented Number of Spatial Streams Configuration 64
Table 39: AP Transmitting to STA using Implemented Number of Spatial Streams Procedure and Results 65
Table 40: Disallow TKIP with VHT Rates Test Configuration 66
Table 41: Disallow TKIP with VHT Rates (2) Test Procedure and Results 66
Table 42: AP Negative WEP Test Configuration 68
Table 43: AP Negative WEP Test Procedure and Results 68
Table 44: AP Receiving 256-QAM MCSs Configuration 69
Table 45: AP Receiving 256-QAM MCSs Procedure and Results 72
Table 46: AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Configuration 73
Table 47: AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Procedure and Results 73
Table 48: Receive A-MPDU with A-MSDU Test Configuration 74

Table 49: Receive A-MPDU with A-MSDU Test Procedure and Results 74
Table 50: CCA on Secondary Channel Configuration 75
Table 51: CCA on Secondary Channel Configuration Procedure and Results 76
Table 52: CTS with BW signaling in response to RTS with BW signaling Configuration 77
Table 53: CTS with BW Signaling in Response to RTS with BW Signaling: Procedure 78
Table 54: Single User Transmit Beamforming Test Configuration 79
Table 55: SU Transmit Beamforming where APUT is the beamformer 80
Table 56: LDPC where the AP is the Transmitter Test Configuration 81
Table 57: LDPC where the AP is the Transmitter Test Procedure and Results 82
Table 58: LDPC where the AP is the Receiver Test Configuration 83
Table 59: LDPC where the AP is the Receiver Test Procedure and Results 83
Table 60: Operation Mode Notification Test Configuration 84
Table 61: Operation Mode Notification Test Procedure and Results 85
Table 62: AP MU Beamformer Test Configuration 87
Table 63: AP acting as MU Beamformer Procedure and Results 90
Table 64: Ability to Receive 4 Spatial Streams at AP Test Configuration 91
Table 65: Ability to Receive 4 Spatial Streams at AP Procedure and Results 92
Table 66: Ability to Receive 160 MHz at AP Test Configuration 93
Table 67: Ability to Receive 160 MHz at AP Procedure and Results 94
Table 68: RTS with Static Bandwidth Signaling Test Configuration 95
Table 69: RTS with Static Bandwidth Signaling Procedure and Results 96
Table 70: RTS with Dynamic Bandwidth Signaling Test Configuration 97
Table 71: RTS with Dynamic Bandwidth Signaling Procedure and Results 98
Table 72: Extended 5 GHz Channel Support APUT Test Configuration 99
Table 73: Extended 5 GHz Channel Support APUT Procedure and Results 100
Table 74: STA Initial 5 GHz Operation Test Configuration 102
Table 75: STA Initial 5 GHz Operation Procedure and Expected Results 103
Table 76: STA WPA2 Initial Ping Interoperability Test Configuration 104
Table 77: EAP Priority Order 104
Table 78: STA WPA2 Initial Ping Interoperability Procedure and Expected Results 105
Table 79: AP and STA Association and Throughput using WPA2-Personal Configuration 106
Table 80: AP and STA Association and Throughput using WPA2-Personal Procedure and Results 107
Table 81: AP and STA Association and Throughput without Security: Configuration 108
Table 82: AP and STA Association and Throughput without Security: Procedure and Results 108
Table 83: AP and STA Association and Throughput using WPA2-Enterprise Configuration 109
Table 84: Priority, EAP Types, Supplicant, and Servers 109
Table 85: AP and STA Association and Throughput using WPA2-Enterprise Procedure and Results 110
Table 86: 802.11h Testing – Spectrum Management Configuration 112
Table 87: 802.11h Testing – Spectrum Management Bit Procedure and Results 112
Table 88: Channel Switch Test Configuration 113
Table 89: Channel Switch Test Procedure and Results 114
Table 90: Dual Band Roaming Test for Dual Band STAs with WPA-Personal Configuration 116
Table 91: Dual Band Roaming Test for Dual Band STAs with WPA-Personal Procedure and Results 117
Table 92: Traffic Differentiation in a Single BSS with Wi-Fi CERTIFIED ac STA Configuration 118
Table 93: Traffic Differentiation in a Single BSS with Wi-Fi CERTIFIED ac STA Procedure and Results (80 MHz) 120
Table 94: Traffic Differentiation with Two Wi-Fi CERTIFIED ac STA Configuration 121
Table 95: Traffic Differentiation with 2 Wi-Fi CERTIFIED ac STAs Procedure and Results 122
Table 96: Test the AC Parameter Modification Configuration 124
Table 97: Test the AC Parameter Modification Procedure and Results 125
Table 98: TXOP Test Limit Configuration 126
Table 99: Test the AC Parameter Modification Procedure and Results 127
Table 100: STAUT “No Acknowledgement” Test Configuration 128
Table 101: STAUT “No Acknowledgement” Test Procedure and Results 129
Table 102: Basic Association in Wi-Fi CERTIFIED ac Environment Configuration 130

Table 103: Basic Association in Wi-Fi CERTIFIED ac Environment Procedure and Results 132
Table 104: Ability to Receive 1 and 2 Spatial Streams Configuration 133
Table 105: Ability to Receive 1 and 2 Spatial Streams Procedure and Results 134
Table 106: A-MPDU Aggregation when the STA is the Receiver Configuration 135
Table 107: A-MPDU Aggregation when the STA is the Receiver Procedure and Results 136
Table 108: A-MSDU Aggregation when the STA is the Receiver Configuration 137
Table 109: A-MSDU Aggregation when the STA is the Receiver Procedure and Results 138
Table 110: Overlapping BSS – 5 GHz Configuration 139
Table 111: Overlapping BSS – 5 GHz Procedures and Results 140
Table 112: Short GI Operation Configuration 141
Table 113: Receive Short GI for 80 MHz Operation Procedure and Results 142
Table 114: STBC Receive Test Configuration 143
Table 115: STBC Receive Test Procedure and Results 143
Table 116: A-MPDU Aggregation when the STA is the Transmitter Configuration 145
Table 117: A-MPDU Aggregation when the STA is the Transmitter Procedure and Results 146
Table 118: Ability to Receive 3 Spatial Streams Configuration 147
Table 119: Ability to Receive 3 Spatial Stream Procedure and Results 148
Table 120: STAUT Transmitting to AP using Supported Number of Spatial Streams Configuration 149
Table 121: STAUT Transmitting to AP using Supported Number of Spatial Streams Procedure and Results 150
Table 122: Disallow TKIP with VHT Rates Test Configuration 151
Table 123: Disallow TKIP with VHT Rates Test Procedure and Results 151
Table 124: STA Negative WEP Test Configuration 152
Table 125: STA Negative WEP Test Procedure and Results 152
Table 126: STA Receiving 256-QAM MCSs Configuration 154
Table 127: STA Receiving 256-QAM MCSs Procedure and Results 158
Table 128: STA Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Configuration 159
Table 129: STA Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Procedure and Results 159
Table 130: Receive A-MPDU with A-MSDU Test Configuration 160
Table 131: Receive A-MPDU with A-MSDU Test Procedure and Results 160
Table 132: CTS with BW signaling in response to RTS with BW signaling Configuration 161
Table 133: CTS with BW signaling in response to RTS with BW signaling Procedure 162
Table 134: SU Transmit beamforming Test Configuration 163
Table 135: SU Transmit Beamforming where STAUT is the Beamformee Procedure 164
Table 136: LDPC Test Configuration 166
Table 137: LDPC Test Procedure and Results 166
Table 138: LDPC Test Configuration 167
Table 139: LDPC Test Procedure and Results 167
Table 140: CCA on Secondary Channel Configuration 168
Table 141: CCA Mechanism Configuration Procedure and Results 170
Table 142: Operation Mode Notification Test Configuration 171
Table 143: Testing Procedure and Results 172
Table 144: STA acting as MU Beamformee Test Configuration 173
Table 145: STAUT acting as MU Beamformee Procedure and Results Test Configuration 177
Table 146: Expected size of VHT Compressed Beamforming Report field for codebook=0 178
Table 147: Expected size of VHT Compressed Beamforming Report field for codebook=1 178
Table 148: Expected size of MU Exclusive Beamforming Report field 179
Table 149: Ability to Receive 4 Spatial Streams at STA Test Configuration 180
Table 150: Ability to Receive 4 Spatial Streams at STA Procedure and Results 181
Table 151 Ability to Receive 160 MHz at STA Test Configuration 182
Table 152 Ability to Receive 160 MHz at STA Procedure and Results 183
Table 153: Extended 5 GHz Channel Support Test Configuration 184
Table 154: Extended 5 GHz Channel Support Procedure and Results 185
Table 155: RTS with Bandwidth Signaling Test Configuration 186

Table 156: RTS with Bandwidth Signaling Procedure and Results 187
Table 157: RTS with Dynamic Bandwidth Signaling Test Configuration 188
Table 158: RTS with Dynamic Bandwidth Signaling Procedure and Results 188
Table 159: Test bed Stations 190
Table 160: Release 2 Test bed Access Points 191
Table 161: Servers 191
Table 162: Supplicants 191
Table 163: Test Tools 191
Table 164: Test bed Default Mode—AP 196
Table 165: Test bed Default Mode—STA 197
Table 166: Test bed Default Mode—11n Device, or 11ac Device Operating as an 11n Device 197
Table 167: Test bed Default Mode—11a Device, or 11ac Device Operating as an 11a Device 198
Table 168: APUT Default Mode 199
Table 169: STAUT Default Mode 200

List of Figures

Figure 1: Sigma System Test Configuration 20
Figure 2: MU beamformer test setup 86
Figure 3: Dual Band Roaming Test for Dual Band STAs with WPA-Personal Network Diagram 115
Figure 4: MU beamformee test setup 173

1. Overview

1.1 Scope and Purpose

A primary goal of Wi-Fi Alliance is to ensure interoperability among Wi-Fi CERTIFIED™ ac products from multiple manufacturers, and to promote this technology within both the business and consumer markets. This test plan specifies the the tests conducted in conjunction with an authorized test lab to provide the Wi-Fi CERTIFIED ac vendor product certification.

The test plan exercises various combinations of PHY layer, MAC layer, and security features. IEEE 802.11ac adds a number of mandatory and optional PHY and MAC features to the features of IEEE Std 802.11 (which includes IEEE Std 802.11n). The interoperability of the 802.11n features is tested according to the Wi-Fi CERTIFIED n Test Plan. The interoperability of the 802.11ac features is tested according to §4.8 of the Wi-Fi CERTIFIED ac MRD.

This test plan includes test cases from the first and second releases of Wi-Fi CERTIFIED ac, referred to as R1 and R2 in this document.

This test plan is modeled on the Wi-Fi CERTIFIED™ n System Interoperability Test Plan ("Wi-Fi CERTIFIED n Test Plan") version 2.0.22. All references, definitions, acronyms, and abbreviations of the Wi-Fi CERTIFIED n Test Plan are incorporated herein by reference. Section numbers in this document are based on the Wi-Fi CERTIFIED n Test Plan, and, if a particular test is not appropriate for this document, it is marked as "Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document".

1.2 Certification General Requirements

Wi-Fi CERTIFIED ac has three general requirements:

1. The first necessary condition of the Wi-Fi CERTIFIED ac certification:
   The DUT shall pass all mandatory tests in the Wi-Fi CERTIFIED n Test Plan and all tests in the Wi-Fi CERTIFIED n Test Plan for the optional features that are implemented, supported or declared by the vendor. This condition may be met by obtaining Wi-Fi CERTIFIED n certification of the DUT.
2. The second necessary condition of the Wi-Fi CERTIFIED ac certification:
   The DUT shall pass all mandatory tests in this test plan, the Wi-Fi CERTIFIED ac Test Plan, and all tests in this test plan for the optional features that are implemented, supported or declared by the vendor. Further details are in §1.5.

   The relevant version of the test plan for Wi-Fi CERTIFIED n System Interoperability Test Plan is the current one, whatever version that is. Therefore, whenever a new version of the Wi-Fi CERTIFIED n Test Plan becomes effective, it automatically becomes the relevant source test plan for the first condition of this Wi-Fi CERTIFIED ac Test Plan, without requiring any explicit change to this Test Plan.
3. The third necessary condition of the Wi-Fi CERTIFIED ac certification:
   The DUT shall pass all mandatory tests in the Wi-Fi CERTIFIED Protected Management Frame Test Plan and all tests in the Wi-Fi CERTIFIED Protected Management Frame Test Plan for the optional features that are implemented, supported, or declared by the vendor. This condition may be met by obtaining Wi-Fi Protected Management Frame certification of the DUT. A dual band DUT shall pass all applicable tests using the prescribed band for each applicable test, either 5GHz or 2.4GHz, as given in table of section 4 of PMF certification test plan.

Note: In the future the Wi-Fi CERTIFIED ac and Wi-Fi CERTIFIED n test plans may be merged. The provision for possible future exceptions is included because there is or may be duplication of effort between

the two components. It is desirable to allow for rationalization and streamlining of the test plan over time and to provide a migration path to a test plan in which the total number of test bed devices is minimized. During the period of sepearte Wi-Fi CERTIFIED ac and Wi-Fi CERTIFIED n test plans, to obtain “11n” on the certificate, a DUT must register for and successfully complete Wi-Fi CERTIFIED n explicitly.

1.3 References

The documents listed in this subclause are included in requirements made in the body of this test plan. Knowledge of their contents is required for the understanding and implementation of this test plan. If a listing includes a date, only that specific version of the document is required. If the listing does not include a date, the latest version of the document is required.

IEEE 802.1X: IEEE Std 802.1X™-2010, IEEE Standard for Local and Metropolitan Area Networks: Port-Based Network Access Control, Institute of Electrical and Electronics Engineers, Inc., February 2010.

IEEE 802.11-2012: IEEE Std 802.11™-2012, IEEE Standard for Local and Metropolitan Area Networks –Specific requirements, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, Institute of Electrical and Electronics Engineers, Inc., December 2012.

IEEE 802.11ac: 802.11ac-2013 - IEEE Standard for Information technology-- Telecommunications and information exchange between systems—Local and metropolitan area networks-- Specific requirements-- Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications-- Amendment 4: Enhancements for Very High Throughput for Operation in Bands below 6 GHz.

IEEE Draft Standard 802.11-REVmc/D5.2, accessible from the IEEE 802.11 member area.

RFC 2285: IETF RFC 2285, Benchmarking Terminology for LAN Switching Devices, Internet Engineering Task Force, February 1998.

IETF MS PEAP: IETF draft-kamath-pppext-peapv0-00.txt, Microsoft’s PEAP version 0 (Implementation in Windows XP SP1) (PEAP0), Internet Engineering Task Force, 25 October 2002.

IETF EAP: IETF draft-josefsson-pppext-eap-tls-eap-00 through draft-josefsson-pppext-eap-tls-eap-05.txt (PEAP1), Internet Engineering Task Force, August 2001 through September 2002.

RFC 4186: IETF RFC 4186, Extensible Authentication Protocol Method for Global System for Mobile Communications (GSM) Subscriber Identity Modules (EAP-SIM), Internet Engineering Task Force, January 2006.

RFC 4187: IETF RFC 4187, Extensible Authentiction Protocol Method for 3rd Generation Authentication and Key Agreementt (EAP-AKA), Internet Engineering Task Force, January 2006.

RFC 4851: IETF RFC 4851, The Flexible Authenticatin via Secure Tunnelling Extensible Authentiction Protocol Method (EAP-FAST), Internet Engineering Task Force, Internet Engineering Task Force, May 2007.

RFC 5246: IETF RFC 5246, TheTransport Layer Security (TLS) Protocol, Version 1.2, Internet Engineering Task Force, August 2008.

RFC 5281: IETF RFC 5281, Extensible Authentication Protocol Tunneled Transport Layer Security Authenticated Protocol version 0 (EAP-TTLSv0), Internet Engineering Task Force, August 2008.

Wi-Fi CERTIFIED n Test Plan: Wi-Fi CERTIFIED n System Interoperability Test Plan. Wi-Fi Alliance, Latest Version.

Wi-Fi CERTIFIED ac MRD: Wi-Fi Alliance Marketing Requirements Document for Interoperability Testing of Approved VHT5G Products, Version 1.1, Wi-Fi Alliance, WFA_MRD_VHT5G_v1.1.docx, Wi-Fi Alliance, February 2013.

Wi-Fi WMM® Test Plan: WMM System Interoperability Test Plan with Test Engine, v2.2, Wi-Fi Alliance, January 2011.

Wi-Fi CERTIFIED ac R2 MRD: Marketing Requirement Document for Interoperability Testing of Wi-Fi CERTIFIEDTM ac R2, Version 1.2.1, VHT5G MTG -- Wi-Fi CERTIFIED ac R2 MRD v1 2.1.docx, Wi-Fi Alliance, March 2016

1.4 Terms and Definitions

The following terms and definitions are used throughout this document.

Acronym	Definition
AC	access category
AC_BE	access category best effort
AC_BK	access category background
AC_VI	access category video
AC_V0	access category voice
ACI	Access category index
ACK	Acknowledgement
ACM	access category mandatory
ADDBA	add block acknowledgement
AES	advanced encryption standard
A-MPDU	aggregated medium access control protocol data unit
A-MSDU	aggregated medium access control service data unit
AP	access point
APUT	access point under test
AS	authentication server
ASCII	American Standard Code for Information Interchange
AV	audio video
BA	block acknowledgement
BSS	basic service set
BSSID	basic service set identifier
BW	bandwidth
CCMP	counter mode with cipher block chaining message authentication code protocol
CTS	clear to send
DA	destination address
DELBA	delete block acknowledgement
DTIM	delivery traffic indication map
DUT	device under test
EAP	Extensible Authentication Protocol (IETF)
ESS	extended service set
ESSID	extended service set identifier
GHz	GigaHertz
GI	guard interval

Acronym	Definition
GUI	graphical user interface
HT	high throughput
HT rates	any physical layer protocol data unit (PPDU) rate specified in subclause 20.6 of IEEE Std 802.11
IBSS	independent basic service set
IE	information element
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISO	Intenational Organization for Standardization
LAN	Local area network
LDPC	low density parity check
MAC	medium access control
MAP	moble access point Note: "AP" stands for a non-mobile AP, so there is a strict distinction between "AP" and "MAP".
MCS	modulation and coding scheme
MHz	MegaHertz
MIC	message integrity check
MIMO	multiple input, multiple output
MPDU	medium access control protocol data unit
MRD	market requirements document
MSDU	medium access control service data unit
MU	multi-user
NAV	network allocation vector
OBSS	overlapping basic service set
OOB	out of box
PC	personal computer
PCI	peripheral component interconnect
PHY	physical layer
PPDU	physical layer protocol data unit
RTS	request to send
Rx	receive
SS	spatial stream
SSID	service set identifier
STA	Station
STAUT	station under test
STBC	space-time block code
SU	single user
TKIP	temporal key integrity protocol
TPT	throughput
Tx	transmit
TXOP	transmission opportunity
VHT	very high throughput (used in this test plan to distinguish 802.11ac rates or capabilities)
VHT rates	any physical layer protocol data unit (PPDU) rate specified in subclause 22.5 of IEEE 802.11ac
WEP	wired equivalent privacy
Wi-Fi CERTIFIED™ ac	Wi-Fi Alliance certification program whose test plan is this document

Acronym	Definition
Wi-Fi CERTIFIED™ n	Wi-Fi Alliance certification program whose test plan in the Wi-Fi CERTIFIED n Test Plan
WMM®	Wi-Fi Multimedia™
WPA™	Wi-Fi Protected Access®
WPA2™	Wi-Fi Protected Access® 2

1.5 Devices Under Test (DUT)

1.5.1 Applicability of Tests

The applicable tests for certification are the tests of mandatory features and tests of optional features that a vendor chooses to implement, support, or declare. The general characteristics of the DUT are entered in the Wi-Fi Alliance Web registration system and are summarized in Table 1. Table 2 and Table 3 list the tests for APUT and STAUT respectively.

The “Applicability” column in Table 2 and Table 3 indicates whether a feature and its associated tests are either mandatory or optional to implement. Mandatory (M) tests are required for certification. Optional (O) tests are not required for certification, but are performed if the vendor implements, supports, or declares them, or the test technicial discovers them. Conditional (C) tests are mandatory if certain specified conditions pertain to the DUT (again, as declared by the vendor during the submission or discovered by the test technician), and are optional otherwise.

If the feature requires information, in particular if the vendor implements or supports an optional feature, the fourth column contains a “Y” if the vendor must provide information in the DUT Information spreadsheet. (A copy of the spreadsheet is accessible through the online Wi-Fi Alliance Certification System.) If a vendor implements or supports an optional feature, that feature must be indicated in the capabilities fields of the Beacon and must also be declared in the appropriate Wi-Fi Alliance registration and DUT Information spreadsheet at the time of submission. Each vendor shall fill out the DUT Information spreadsheet completely. Test labs will verify that the list of implemented or supported optional features is correctly declared. The information determines which tests and which test parameters apply to the certification.

A “Y” in the last column indicates the certain subset of optional capabilities that will be indicated on the interoperability certificate if they are declared by the vendor.

Even if a vendor declared more than 3 Spatial Streams, all tests are performed using 1, 2, or 3 Spatial Streams, as stated in the description of each test case. The Certificate will only list a maximum of 3 Spatial Streams.

If the declaration indicates the DUT does not support WPA2-Enterprise, then all tests that specify WPA2-Enterprise shall be replaced with WPA2-Personal, and the ASCII string “12345678” shall be used for the pass phrase.

If the declaration indicates an optional feature is present in the DUT, then that feature shall be tested, and, if that test fails, the DUT shall fail the Wi-Fi CERTIFIED ac certification.

Item	Vendor Answer
DUT Type	STA/AP
Primary Product Category	
Secondary Product Category	
Device Serial Number	
Device Firmware Version	
Is 802.11a Device	Yes/No
Is 802.11b Device	Yes/No
Is 802.11g Device	Yes/No
Is 802.11n Device	Yes/No
Is 802.11ac Device	Yes/no
Is the DUT an access point powered by an internal battery? (Mobile AP (MAP))	Yes/No
Does the APUT Beacon at 5 GHz out of box (OOB)?	Yes/No
Is a channel width of 160 MHz supported	Yes/No
Is channel width of 80+80 MHz supported?	Yes/No
Maximum Tx Spatial Streams in 2.4 GHz	0/1/2/3
Maximum Rx Spatial Streams in 2.4 GHz	0/1/2/3
Maximum Tx Spatial Streams in 5.0 GHz 11n	1/2/3/4
Maximum Rx Spatial Streams in 5.0 GHz 11n	1/2/3/4
Maximum Tx Spatial Streams in 11ac	1/2/3/4/5/6/7/8
Maximum Rx Spatial Streams in 11ac	1/2/3/4/5/6/7/8
Please provide user instructions to configure the following parameters: • SSID • Wireless Operational Mode, a/n/ac • Channel • Local IP Address and Netmask • Security: WPA2 or open • WPA2-Personal pass phrase	
Is the DUT security enabled in OOB mode? If Yes, provide the passphrase.	(passphrase)
Does the DUT support WPA2-Enterprise?	Yes/No
Does the DUT support WEP?	Yes/No
Is 802.11d Device	Yes/No
Is 802.11h Device	Yes/No
List the two letter Country Codes (CC) supported	
Is Transmit Power Control (TPC) supported?	Yes/No
Is Channel Switching supported?	Yes/No
Does the DUT support RTS with bandwidth signaling TA?	Yes/No
If yes to above, does the DUT support dynamic bandwidth signaling?	Yes/No
Does the DUT support MU-MIMO?	Yes/No
Does the DUT support 5 GHz extended channels?	Yes/No
Does the DUT support 160 MHz bandwidth?	Yes/No

Table 1: General Capabilities Declaration

1.5.2 APUT Tests

Table 2 lists the APUT tests.

Name	Test case	Applicability Mandatory / Optional / Conditional (M/O/C)	If implemented in submission, then Vendor must indicate	If implemented, displayed in certificate as "11ac Capability"
General Configurability	4.1.1	M		
Security Configurability	4.1.2	M	(See Table 1)	
In Initial Configuration AP Associates only with Wi-Fi CERTIFIED ac Stations	4.2.1.1	M	Y	
AP WPA2 Initial Ping Interoperability Test using Security	4.2.2.1	M		
AP and STA Association and Throughput using WPA2-Personal	4.2.5.1	M		
AP and STA Association without Security	4.2.5.2	C (if Open security supported)		
802.11d and 802.11h Country Code, TPC, and Channel Switching	4.2.16.1	O	(See Table 1)	
Concurrent Dual Band AP (2.4 GHz and 5 GHz operation)	4.2.19.1	O	Y	
Basic WMM Association and Transmission	4.2.20.1	M		
Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs	4.2.21.1	M		
Traffic Forwarding in a Single BSS	4.2.25.1	M		
Basic Association in a Wi-Fi CERTIFIED ac Environment	4.2.26.1	M		
Ability to Receive 1 and 2 Spatial Streams [Rx 1-2 tested Spatial Streams]	4.2.27.1	1 SS MAP: M 2 SS MAP: O 2 SS AP: M	(See Table 1)	Y
A-MPDU Aggregation when the AP is the Receiver with and without WPA2-Personal	4.2.29.1	M		
A-MSDU Aggregation when AP is the Receiver	4.2.30.1	M		
Receive Short GI for 80 MHz Operation [Rx Short Guard Interval]	4.2.34.1	M		
STBC Transmission for 80 MHz [Tx STBC 2x1]	4.2.39.1	O	Y	Y
A-MPDU Aggregation when the AP is the Transmitter	4.2.40.1	M		
Ability to Receive 3 Spatial Streams [Rx 3 tested Spatial Streams]	4.2.42.1	O	(See Table 1)	Y
AP Transmitting to STA using Supported Number of Spatial Streams [Tx 1-3 tested Spatial Streams]	4.2.43.1	M	(See Table 1)	Y
Disallow TKIP with VHT Rates	4.2.44.1	C (if WPA2/WPA mixed mode supported: M)		
Negative tests to ensure WEP is not used with Associations at VHT Rates	4.2.46	C (if WEP supported: M)	(See Table 1)	
AP Receiving 256-QAM MCSs [Rx MCS 8 (256-QAM)] or [Rx MCS 8-9 (256-QAM)]	4.2.47	O	Y (2 questions: MCS 8? MCS 8-9?)	Y
AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU	4.2.48	M		
Ability to Receive A-MPDU with A-MSDU [Rx A-MPDU of A-MSDU]	4.2.49	O	Y	Y
Clear Channel Assessment on Secondary Channel	4.2.50	M		
CTS with BW signaling in response to RTS with BW signaling	4.2.51	M		
Single User (SU) Transmit beamforming when AP is the beamformer [Tx SU beamformer]	4.2.52	O	Y	Y
LDPC where the AP is the Transmitter [Tx LDPC]	4.2.53	O	Y	Y
LDPC where the AP is the Receiver [Rx LDPC]	4.2.54	O	Y	Y
Operating Mode Notification Testing	4.2.55	M (for receive)		
AP acting as MU Beamformer	4.2.56	O	Y	Y
Ability to Receive 4 Spatial Streams at AP	4.2.57	O	Y	Y

Name	Test case	Applicability Mandatory / Optional / Conditional (M/O/C)	If implemented in submission, then Vendor must indicate	If implemented, displayed in certificate as "11ac Capability"
Ability to Receive 160 MHz at AP	4.2.58	O	Y	Y
RTS with static Bandwidth Signaling	4.2.59A	O	Y	Y
RTS with dynamic Bandwidth Signaling	4.2.59B	O	Y	N
Extended 5 GHz Channel Support on APUT	4.2.60	O	Y	Y

Table 2: APUT Tests

1.5.3 STAUT Tests

Table 3 lists the STAUT tests.

Name	Test case	Applicability Mandatory / Optional / Conditional (M/O/C)	If implemented in submission, then Vendor must indicate	If implemented, displayed in certificate as 11ac Capability
General Configurability Tests	5.1.1	M		
Security Configurability Tests	5.1.2	M		
STA Initial 5 GHz Operation	5.2.1.1	M	(See Table 1)	
STA WPA2 Initial Ping Interoperability Test using Security	5.2.2.1	M		
AP and STA Association and Throughput using WPA2-Personal	5.2.9.1	M		
AP and STA Association and Throughput without Security	5.2.9.2	O		
AP and STA Association and Throughput using WPA2-Enterprise	5.2.10.1	M		
802.11h Testing – Spectrum Management Bit	5.2.22.1	O	Y	
802.11h Testing – Channel Switch Test	5.2.23.1	O	Y	
Roaming Test for Single and Dual Band STAs with WPA-Personal	5.2.26.1	M	(See Table 1)	
Traffic Differentiation in Single BSS with Wi-Fi CERTIFIED ac STA	5.2.27.1	M		
Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs	5.2.28.1	M		
Test the AC Parameter Modification	5.2.32.1	M		
TXOP Limit Test	5.2.33.1	M		
STAUT "No Acknowledgement" Test	5.2.34.1	M		
Basic Association in the Wi-Fi CERTIFIED ac Environment	5.2.35.1	M		
Ability to Receive 1 and 2 Spatial Streams [Rx 1-2 tested Spatial Streams]	5.2.36.1	1 SS: M 2 SS: O	(See Table 1)	Y
A-MPDU Aggregation when the STA is the Receiver with and without WPA2-Personal	5.2.37.1	M		
A-MSDU Aggregation when the STA is the Receiver	5.2.38.1	M		
Overlapping BSS – 5 GHz	5.2.40.1	M		
Receive Short GI for 80 MHz Operation [Rx Short Guard Interval]	5.2.42.1	M		
STBC Receive Test [Rx STBC 2x1]	5.2.46.1	O	Y	Y
A-MPDU Aggregation when the STA is the Transmitter	5.2.47.1	M		
Ability to Receive 3 Spatial Streams [Rx 3 tested Spatial Streams]	5.2.49.1	O	(See Table 1)	Y
STA Transmitting to AP using Supported Number of Spatial Streams [Tx 1-3 tested Spatial Streams]	5.2.50.1	M	(See Table 1)	Y
Disallow TKIP with VHT Rates Test	5.2.51.1	M		
Negative tests to ensure WEP is not used with VHT associations in Wi-Fi CERTIFIED ac devices	5.2.52.1	C (if WEP supported: M)	(See Table 1	
STA Receiving 256-QAM MCSs [Rx MCS 8 (256-QAM)] or [Rx MCS 8-9 (256-QAM)]	5.2.54	O	Y	Y

Name	Test case	Applicability Mandatory / Optional / Conditional (M/O/C)	If implemented in submission, then Vendor must indicate	If implemented, displayed in certificate as 11ac Capability
STAUT Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU	5.2.55	M		
Ability to Receive A-MPDU with A-MSDU [Rx A-MPDU of A-MSDU]	5.2.56	O	Y	Y
CTS with BW signaling in response to RTS with BW signaling	5.2.57	M		
Single User (SU)Transmit Beamforming when STA is the Beamformee [Tx SU beamformee]	5.2.58	O	Y	Y
LDPC Test where STA is the Transmitter [Tx LDPC]	5.2.59	O	Y	Y
LDPC Test where STA is the Receiver [Rx LDPC]	5.2.60	O	Y	Y
Clear Channel Assessment on Secondary Channel	5.2.61	M		
Operating Mode Notification Testing	5.2.62	M (for receive)		
STA acting as MU Beamformee	5.2.63	O	Y	Y
Ability to Receive 4 Spatial Streams at STA	5.2.64	O	Y	Y
Ability to Receive 160 MHz at STA	5.2.65	O	Y	Y
Extended 5GHz Channel Support	5.2.66	O	Y	Y
RTS with Bandwidth Signaling	5.2.67A	O	Y	Y
RTS with Dynamic Bandwidth Signaling	5.2.67B	O	Y	N

Table 3: STAUT Tests

2. Test Tools, Methodology and Approach

The methodology and approach employed in the Wi-Fi CERTIFIED ac tests shall be the same as those specified in the Wi-Fi CERTIFIED n Test Plan.

The tools employed in the Wi-Fi CERTIFIED ac tests are updated from those used in the Wi-Fi CERTIFIED n tests.

The Wi-Fi Alliance Sigma Automation Suite will be used as much as possible. This tool suite provides configuration, test control, traffic generation, and results analysis services. The test plan, in its entirety, can be executed in a fully automated manner through the Wi-Fi Alliance distributed Sigma Command Scripts and the Sigma Unified CAPI Console.

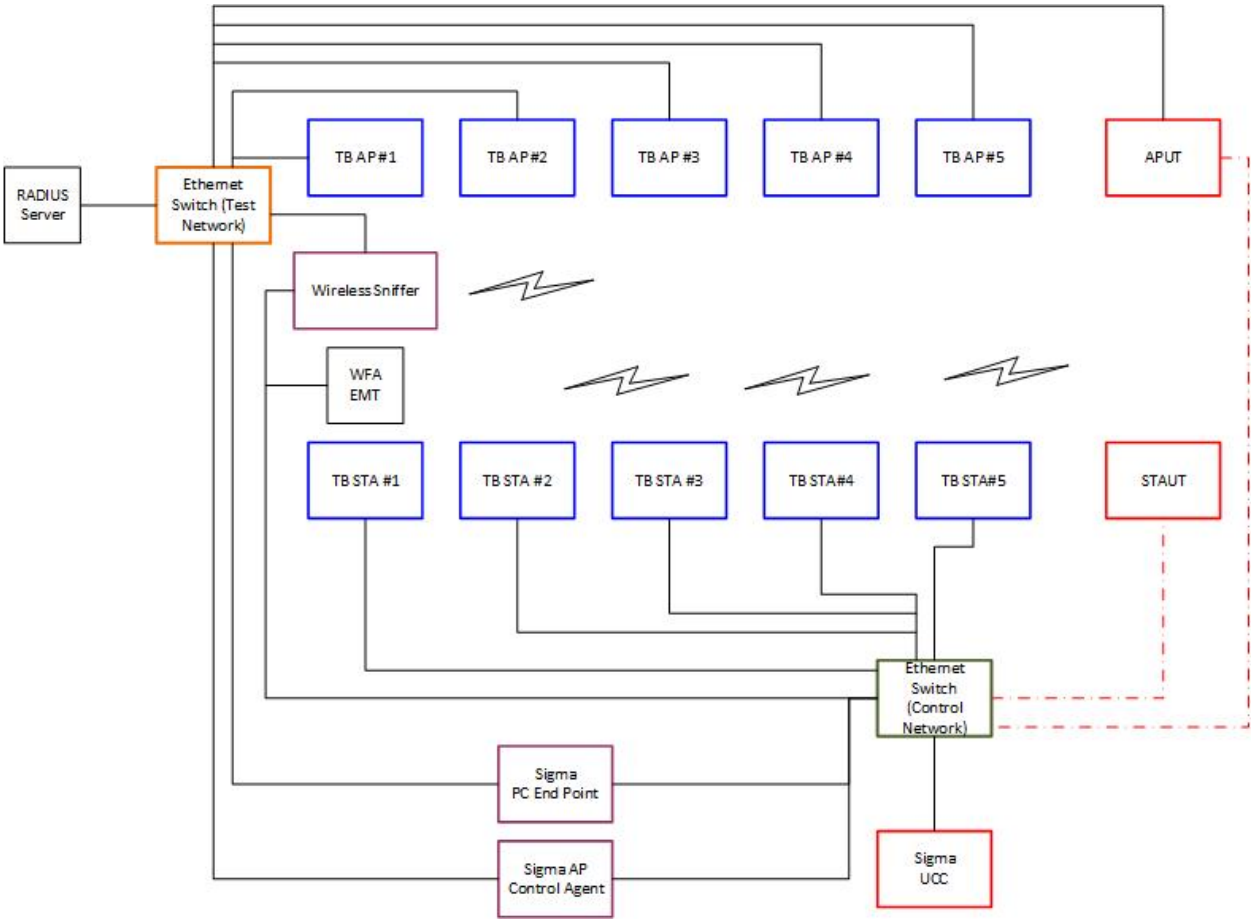

Figure 1: Sigma System Test Configuration

Annex G lists the data stream description files and Annex H lists the script files that control the test tools.

Additional information is available through the test tools page on the member website: https://www.wi-fi.org/members/certifications-testing/sigma-test-environment

3. Implementation Requirements for Wi-Fi Alliance Certification

The following items describe the necessary features that are required for a DUT to pass Wi-Fi CERTIFIED ac

3.1 General Requirements

The DUT shall comply with all requirements of the Wi-Fi CERTIFIED n Test Plan.

3.2 Security Requirements

All security required for implementation of HT rates in the Wi-Fi CERTIFIED n Test Plan are also required for implementation of VHT rates for Wi-Fi CERTIFIED ac certification.

4. Wi-Fi CERTIFIED ac APUT Testing

Default Testing Rules:

(1) Unless explicitly stated otherwise in a test case, all test bed devices have Channel Width set to 80 MHz in each test case of this clause 4.

(2) Unless explicitly stated otherwise in a test case, all test bed STAs operate in 1 SS mode in each test case of this clause 4.

(3) If the APUT fails a test, no further testing will be performed until the vendor addresses the problems and has updated the device.

(4) Every device (both test bed and DUT) is configured with an IP address before testing.

(5) "Test bed Default Mode" is specified in Annex E. APUT default configuration for test procedures is specified in Annex F.

4.1 Configurability Tests

4.1.1 General Configurability Tests

The APUT shall be capable of being manually configured with the following parameters:
1. SSID
2. Wireless operational mode, a/n/ac
3. Channel
4. Local IP address and subnet mask.

If any of the above items cannot be configured through the user interface, then the APUT fails.

4.1.2 Security Configurability Tests

If the vendor has declared support for WPA2-Enterprise and WPA2-Enterprise running EAP methods cannot be configured, then the APUT fails.

If the WPA2-Personal pass phrase "12345678" cannot be configured, then the APUT fails.

4.1.3 Wi-Fi CERTIFIED n Configurability Tests

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2 APUT Test Cases

4.2.1 AP Out of the Box (OOB)

4.2.1.1 In Initial Configuration the AP Associates only with Wi-Fi CERTIFIED ac Stations

Purpose and Description
Test the APUT for the SSID, open authentication mode or WPA2-Personal, and the channel width.

Applicability
Mandatory

Reference
Test case 4.2.1 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
STA2: Test bed Wi-Fi CERTIFIED n
STA3: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
STA4: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	STA3 Values	STA4 Values	APUT Values
Vendor	Broadcom	Qualcomm	Quantenna	Intel	-
SSID	wi-fi	wi-fi	wi-fi	wi-fi	wi-fi
Security	None	WEP	WPA-Personal	WPA2-Personal	
Encryption Key	-	0x9876543210	12345678	Reference the APUT factory default pass phrase in the vendor declaration.	-
Channel Width	80 MHz	20 MHz	40 MHz	80 MHz	80 MHz
Spatial Streams Implemented	2	2	2	2	Default per Annex F
AP Control Channel	-	-	-	-	36

Table 4: AP Initial 5 GHz Operation Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2, operating in 11a mode	Test bed Wi-Fi CERTIFIED n STA3	Test bed Wi-Fi CERTIFIED ac STA4	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (11a).	Configure STA3 to Test bed Default Mode (11n).	Configure STA4 to Test bed Default Mode (STA) and APUT default pass phrase		
2					If not configured for 5 GHz operation OOB, configure for 5 GHz operation	If not possible, then fail.
3					Beacon	
4	Association Request			Association Request		
5					Association Response	If STA1 or STA4 associates but not both associate, then pass
6		Association Request	Association Request			If STA2 associates, then fail. If STA3 associates, then fail.
7					RUN: PING <STA1_IP_ADDR> CONTINUOUS=YES Or RUN: PING <STA4_IP_ADDR> CONTINUOUS=YES	If pings time out, then fail

Table 5: AP Initial 5 GHz Operation Procedure and Expected Results

4.2.2 AP WPA2 Initial Ping Interoperability Test

4.2.2.1 AP WPA2 Initial Ping Interoperability Test using Security

Purpose and Description
Verifies that the APUT is able to authenticate, associate and support pings to a wired authentication server on a subnet connected to the test configuration.

Applicability
Mandatory

Reference
Test case 4.2.2 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
STA2: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
STA3: Test bed Wi-Fi CERTIFIED ac
STA4: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed. If the APUT has an embedded authentication server (AS) that does not implement TLS, the EAP method shall be chosen in priority order, according to Table 75.

Parameter	STA1 Values	STA2 Values	STA3 Values	STA4 Values	APUT Values
Vendor	Intel	Marvell	Intel	Marvell	-
Security	WPA2-Enterprise	WPA2-Enterprise	WPA2-Enterprise	WPA2-Enterprise	WPA2-Enterprise
Supplicant/Server	-	-	-	-	HostAPD
EAP Method (see note)	TLS	TLS	TLS	TLS	TLS
AP Control Channel	-	-	-	-	36
Channel Width	40 MHz	40 MHz	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	1	2	1	1	Default per Annex F

Table 6: AP WPA2 Initial Ping Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED n STA1	Test bed Wi-Fi CERTIFIED n STA2	Test bed Wi-Fi CERTIFIED ac STA3	Test bed Wi-Fi CERTIFIED ac STA4	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Configure STA1 to support WPA2-Enterprise.	Configure STA2 to Test bed Default Mode (11n). Configure STA2 to support WPA2-Enterprise.	Configure STA3 to Test bed Default Mode (STA). Configure STA3 to support WPA2-Enterprise.	Configure STA4 to Test bed Default Mode (STA). Configure STA4 to support WPA2-Enterprise.		
2					Beacon	
3	Association Request					
4					Association Response	
5	RUN: PING <APUT IP_ADDR> COUNT=90					If the pings do not continue for the whole 90 seconds, then fail.
6	Disassociate					
7		Association Request				
8					Association Response	
9		RUN: PING <APUT IP_ADDR> COUNT=90				If the pings do not continue for the whole 90 seconds, then fail.
10		Disassociate				
11			Association Request			
12					Association Response	
13			RUN: PING <APUT IP_ADDR> COUNT=90			If the pings do not continue for the whole 90 seconds, then fail.
14			Disassociate			
15				Association Request		
16					Association Response	
17				RUN: PING <APUT IP_ADDR> COUNT=90		If the pings do not continue for the whole 90 seconds, then fail.
18				Disassociate		

Table 7: AP WPA2 Initial Ping Test Procedure and Results

4.2.3 AP and STA Association and Throughput, Honoring NAV and PLCP

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.4 AP and STA Association and Throughput using WPA2-Enterprise with TLS

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.5 AP and STA Association and Throughput using WPA2-PSK

4.2.5.1 AP and STA Association and Throughput using WPA2-Personal

Purpose and Description
Verify that the AP can pass traffic using WPA2-Personal security mode.

Applicability
Mandatory. The steps specified in Table 9 shall be followed, up to 3 spatial streams regardless of what was declared by the vendor to be implemented by the APUT.

Reference
Test case 4.2.5 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac, capable of implementing 2 SS, and capable of being configured to implement 1 SS (disabling 2 SS)
STA2: Test bed Wi-Fi CERTIFIED ac, capable of implementing 3 SS
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Qualcomm	Broadcom	-
Power Save	None	None	Disabled
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678	12345678
Spatial Streams Implemented	See test procedure	See test procedure	Default
AP Control Channel	-	-	36
Channel Width	80 MHz	80 MHz	Configure the APUT to 160 MHz channel width if capable of supporting 160 MHz feature. If not, configure the APUT to 80 MHz channel width

Table 8: AP and STA Association and Throughput using WPA2-Personal Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac 2 SS STA1, configurable as 1 SS	Test bed Wi-Fi CERTIFIED ac 3 SS STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Configure STA1 to implement 1 SS only (disabling 2 SS).	Configure STA2 to Test bed Default Mode (STA). Configure STA2 to implement 3 SS.		
2			Beacon	If the Channel Width is set to 80 MHz, continue to step 3. If the Channel Width is set to 160 MHz check the following: Check VHT Capabilities element in Beacon/Probe Response. If Supported Channel Width Set is not equal to 1 or 2 (the AP supports 160 MHz or the AP supports 160 MHz and 80+80 MHz) then fail. Check VHT Operation element in Beacon/Probe Response to verify that: • Channel Width subfield is set to 1. • Channel Center Frequency Segment 0 is set to 42 • Channel Center Frequency Segment 1 is set to 50 If any of these conditions is not met, then fail.
3	Association Request		Association Response	If the Association Response does not contain a SUCCESS status, then fail.
4			Run script DT1-APUT-STA1 to STA1.	If the test runs to completion without error, then pass. Check using the sniffer that PPDUs transmitted by APUT contain VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is '2'.
5	Run script DT2-ST1-APUT to the APUT.			If the test runs to completion without error, then pass. Measure throughput, = X1. If X1 > 4.2.5.1A1DT2, then pass.
6			Run script DT3-APUT-STA1 to STA1.	If the test runs to completion without error, then pass. Measure throughput, = X2. If X2 > 4.2.5.1A1DT3, then pass
If the vendor declared that the APUT implements only 1 SS and the APUT is a not a MAP, then fail. If the vendor declared that the APUT implements only 1 SS and is a MAP, then pass, and stop the test. If the vendor declared that the APUT implements more than 1 SS, continue with the steps below.				
7	Disassociate			
8	Reconfigure STA1 to implement 2 SS (i.e., change the configuration from step 1)			
9	Association Request, signaling Nss = 2 in VHT		Association Response	If the Association Response does not contain a SUCCESS status, then fail

	Capabilities information element.			
10	Run script DT2-STA1-APUT to the APUT.			If the test runs to completion without error, then pass. Measure throughput, = X3. If X3 > 4.2.5.1A2DT2, then pass
11			Run script DT1-APUT-STA1 to STA1.	If the test runs to completion without error, then pass. Measure throughput, = X4. If X4 > 4.2.5.1A2DT1, then pass
If the vendor declared that the APUT implements only 2 SS, then pass, and stop the test. If the vendor declared that the APUT implements 3 SS or more, continue with the steps below.				
12		Association Request, signaling Nss = 3 in the VHT Capabilities IE	Association Response	If the Association Response does not contain a SUCCESS status, then fail.
13		Run script DT2-STA1-APUT to the APUT.		If the test runs to completion without error, then pass. Measure throughput, = X5. If X5 > 4.2.5.1A3DT2, then pass
14			Run script DT1-APUT-STA1 to STA2.	If the test runs to completion without error, then pass. Measure throughput, = X6. If X6 > 4.2.5.1A3DT1, then pass

Table 9: AP and STA Association and Throughput using WPA2-Personal Procedure and Results

4.2.5.2 AP and STA Association without Security

Purpose and Description
Verify that the APUT can pass traffic without security.

Applicability
Optional. Skip if Open security is not supported.

Reference
Test case 4.2.5 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
Security	None	None
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	1	Default

Table 10: AP and STA Association without Security: Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).		
2		Beacon	
3	Association Request	Association Response	If the Association Response does not contain a SUCCESS status then fail.
4		Run script DT1-APUT-STA1 to STA1.	If the test runs to completion without error, then pass. Check using the sniffer that PPDUs transmitted by APUT contain VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is '2'.
5	Run script DT2-STA1-APUT to the APUT.		If the test runs to completion without error, then pass.
6		Run script DT3-APUT-STA1 to STA1.	If the test runs to completion without error, then pass.

Table 11: AP and STA Association without Security: Procedure and Results

4.2.6 AP and STA Association and Throughput using Replay Counter Processing

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.7 AP and STA Association and Throughput using Mixed Mode WPA/WPA2 Enterprise with TLS and Message 3 Validation

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.8 AP and STA Association and Throughput using Mixed Mode WPA/WPA2-PSK

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.9 Reassociation/Bridging Tests

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.10 Multicast with WPA2-PSK Only Mode and WPA/WPA2-PSK Mixed Mode

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.11 Pre-authentication

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.12 PMK Caching

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.13 WPA Specific Countermeasures

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.14 WPA Negative Tests – No Association with a WEP or No Encryption STA

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.15 WPA Negative Test Cases – No Association with a WPA2-Enterprise with TLS and WPA-PSK Configured Access Point

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.16 802.11d and 802.11h Testing

4.2.16.1 802.11d and 802.11h Country Code, TPC, and Channel Switching

Purpose and Description
This test verifies support of:

- Two octet country code
- TPC
- Channel switching.

Applicability
Optional

References
Test cases 4.9.1, 4.9.2, and 4.10 in "Wi-Fi 802.11 with WPA2, WPA, and WEP System Interoperability Test Plan for IEEE 802.11a, b & g Devices"
Test case 4.2.16 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode), 802.11h+d capable
STA2: Test bed Wi-Fi CERTIFIED ac, 802.11h+d capable
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Qualcomm	Quantenna	-
AP Control Channel / Bandwidth	-	-	CH = 52 (if supported by APUT; else 36) / BW = 80 MHz
New Control Channel / Bandwidth	-	-	CH = 100 (if supported by APUT; else 149)/ BW = 80 MHz
Spatial Streams Implemented	2	2	Default

Table 12: Country code, TPC, and Channel Switching Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

If the vendor declared that the APUT supports:

- The two octet country code: perform steps 1 through 5
- TPC but not channel switching: perform step 6
- Channel switching but not TPC: perform steps 7 through 9
- Both TPC and channel switching: perform steps 10 through 12.

Steps	Test bed Wi-Fi CERTIFIED n STA1	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
1	Repeat the process (steps 2 through 5) for 4 additional countries for those APs that support 5 or more countries. For those that support fewer than 5 countries, repeat the procedure for all the countries supported.			
2	Configure STA1 to Test bed Default Mode (11n). Enable 802.11d capability if not already enabled.	Configure STA2 to Test bed Default Mode (STA). Enable 802.11d capability if not already enabled.		
3			Select one country from the list supplied by the APUT vendor.	
4			Beacon/Probe Response	Use the sniffer to check for IE=7 in the Beacon and the Probe Response. If the Country information element (Country name field) is identical in both the Beacon and Probe Response, and the first two octets of the Country String in the Country information element in the Beacon correspond to the code specified for the configured country in the ISO list, then pass.
5	Association Request		Association Response	If STA1 associates, then pass.
6		Association Request	Association Response	If STA2 associates, then pass.
7			Beacon/Probe Response	Use the sniffer to check for the Subband Triplet in the Country information element, the Power Constraint IE=32, and the VHT Transmit Power Envelope IE=195 in the Beacon and the Probe Response; if the Beacon and Probe Response messages contain all three, then the APUT passes this test.
8			Use the APUT-supplied command to force a channel switch (New Control Channel / Bandwidth).	Watch the sniffer until no more Beacons are seen from the APUT, or 15 seconds elapse after the issuance of the command to change the APUT's channel. If the AP fails to stop beaconing on this channel within 15 seconds, then fail.
9	Find at least the last five Beacons sent by the APUT and verify that all contain the CSA information element, Channel Switch Wrapper information element and the Wide Bandwidth Channel Switch sub-element in the Channel Switch Wrapper information element. If the last five Beacons are missing any of the following information elements and subelements, then the APUT fails this test: CSA information element, the Channel Switch Wrapper information element or the Wide Bandwidth Channel Switch sublement.			
10	Start the rest of the test steps from the initial test configuration (AP Control Channel / Bandwidth)			
11			Use the APUT supplied command to force a channel switch and bandwidth switch (New Control Channel / Bandwidth).	Watch the sniffer until no more Beacons are seen from the APUT, or 15 seconds elapse from the issuance of the command to change the channel of the APUT. Using the sniffer watch APUT switch to the new channel and confirm the new bandwidth. If the AP fails to stop beaconing on the initial channel within 15 seconds, then fail.
12	Find at least the last five Beacons sent by the APUT and verify that all contain the CSA IE, Channel Switch Wrapper IE and both the Wide Bandwidth Channel Switch and VHT Transmit Power Envelope subelements in the Channel Switch Wrapper IE. If the last five Beacons are missing any of the following information elements or subelements, then the APUT fails this test: CSA IE, Channel Wrapper IE, Wide Bandwidth Channel Switch subelement or the VHT Transmit Power subelement and VHT Transmit Power Envelope sub-element.			

Table 13: Two octet Country code, TPC and Channel Switching Test Procedure and Results

4.2.17 (Removed Wi-Fi CERTIFIED n test)

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.18 Extended EAP Tests (Enterprise APs Only)

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.19 Dual Band APs

4.2.19.1 Concurrent Dual Band AP (2.4 GHz and 5 GHz operation)

Purpose and Description
Test ability of AP to operate in 2.4 GHz and 5 GHz band concurrently.

This test is performed with two stations, each associated to the APUT, but in different bands. Data are transmitted between the stations to verify that the APUT supports two BSSes in different bands concurrently and bridges between them.

Applicability
Optional

Reference
Test case 4.2.19 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
STA2: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode), capable of 40 MHz channel width operation

Test Configuration
The following table defines the parameter values for the devices in the test bed. Note: single band and single radio DUTs skip this test.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Intel	Marvell	-
Security	WPA2-Enterprise running TLS	WPA2-Enterprise running TLS	WPA2-Enterprise running TLS
Supplicant/Server	-	-	HostAPD
AP Control Channel	36	6	6 and 36
Channel Width	80 MHz	20/40 MHz	80 MHz
Spatial Streams Implemented	1	1	Default

Table 14: Dual Band AP Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED n STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Configure STA1 to support WPA2-Enterprise running TLS.	Configure STA2 to Test bed Default Mode (STA). Configure STA2 to support WPA2-Enterprise running TLS.		
2			Beacon/Probe Response	If both STA1 and STA2 associate, then pass
3	Run script DT1-STA1-STA2 to STA2.			If STA1 → STA2 throughput is greater than 4.2.19A1DT1, then pass.
4		Run script DT2-STA2-STA1 to STA1.		If STA2 → STA1 throughput is greater than 4.2.19A1DT2, then pass.

Table 15: Dual Band AP Procedure and Results

4.2.20 Basic WMM Association and Transmission

4.2.20.1 Basic WMM Association and Transmission

Purpose and Description
Test WMM capability negotiation.
Verify internal and distributed traffic differentiation between different traffic classes and various PHY rates between a single pair.

This test is performed between a single APUT and a single STA to show that a DUT correctly differentiates packets. Two streams with different AC values are transmitted from a DUT and the throughputs are compared in the same manner as they are in the differentiation tests specified below.

Applicability
Mandatory

Reference
Test case 4.2.20 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac, implementing a maximum of 1 SS, or configurable to implement only 1 SS.
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed. Run tests for 30 seconds.

Parameter	STA1 Values	APUT Values
Vendor	Quantenna	-
Security	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678
AP Control Channel	-	36
AIFS	Default (see Annex C)	Default (see Annex C)
CWmin	Default (see Annex C)	Default (see Annex C)
CWmax	Default (see Annex C)	Default (see Annex C)
TXOPLimit	Default (see Annex C)	Default (see Annex C)
ACM: AC_VO	-	0
ACM: AC_VI	-	0
ACM: AC_BE	-	0
ACM: AC_BK	-	0
AC Tagging	DSCP	Default for AP
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	1	Default

Table 16: Basic WMM Association and Transmission Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).		
2		Beacon	Use the sniffer to check the Beacons. If each Beacon contains the VHT Operation information element, then pass. If each Beacon contains a WMM parameter element or a WMM information element, then pass. If the WMM Parameter information element is present, if ACI, ACm, AIFS, CWmin, CWmax and TXOP are set according to the configuration specified in Table 16, then pass. Record the ParamCount value.
3	Probe Request	Probe Response	Use the sniffer to check the Probe Request frames. If a Probe Request occurs and the Probe Response contains a VHT Operation information element and a WMM parameter element with ParamCount matching the ParamCount in the Beacon (step 2) and ACI, ACm, AIFS, CWmin, CWmax and TXOP are set according to Table 16, then pass.
4	Association Request	Association Response	Use the siffer to check the Association Response frame. If the Association Response contains a VHT Operation information element and a WMM parameter element with ParamCount matching the ParamCount in the Beacon/Probe Response (step 2 and 3) and ACI, ACm, AIFS, CWmin, CWmax and TXOP set tothe test configuration specified in Table 16, and the STA is associated, then pass.
5	Run script VHT-prereq-APUT-STA1	Run script VHT-prereq-APUT-STA1	Total TPT > 110 Mbps If not - check for environmental interference before continuing. Set TPT_X_Param = Total TPT
6	Run script VHT-4.2.20-6.	Run script VHT-4.2.19-6.	Use the sniffer to verify: In a UDP1_BE QoS Data frame, if QoS Control Field UP=000_2, EOSP=0_2, ACKPOLICY=00 and the frame type=10_2, subtype=1000_2, then pass. Use the sniffer to verify: In a UDP2_VI QoS Data frame, if QoS Control Field UP=101_2 or 100_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=10_2, subtype=1000_2, then pass. Use the sniffer to verify: In a UDP3_BE QoS Data frame, if QoS Control Field UP=000_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=10_2, subtype=1000_2, then pass. Receive Data UDP1, UDP2, UDP3. Check that: - UDP2 in second phase (31~60s) >= 80% of UDP2 in first phase (1~30s) If so, then pass.
7	Run script VHT-4.2.20-7.	Run script VHT-4.2.19.7.	Receive Data UDP1, UDP2, UDP3 Check that: UDP2 in second phase (31~60s) >= 80% of UDP2 in first phase (1~30s) If so, then pass.
8	Run script VHT-4.2.20-8.	Run script VHT-4.2.19-8.	Receive Data UDP1, UDP2, UDP3 Check that: UDP2 in second phase (31~60s) >= 70% of UDP2 in first phase (1~30s) If so, then pass.
9	Run script VHT-4.2.20-9.	Run script VHT-4.2.19-9.	Receive Data UDP1, UDP2, UDP3 Check that:

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
			UDP2 in second phase (31~60s) >= 60% of UDP2 in first phase (1~30s) If so, then pass.
10	Run script VHT-4.2.20-10	Run script VHT-4.2.19-10	Receive Data UDP1, UDP2, UDP3 Check that: UDP2 in second phase (31~60s) >= 80% of UDP2 in first phase (1~30s) If so, then pass.

Table 17: Basic WMM Association and Transmission Procedure and Results

4.2.21 Traffic Differentiation in a Single BSS with Two 802.11n STAs

4.2.21.1 Traffic Differentiation in a Single BSS with Two Wi-Fi CERTIFIED ac STAs

Purpose and Description
Verify internal and distributed traffic differentiation between different traffic classes at various PHY rates involving an AP and two STAs with downstream and upstream traffic.

The general approach is to run traffic streams using only two different priorities for any one test. Several of the tests use two streams of the lower priority to clearly show the differentiation. The intended load (load – for definition see Section 3.5.1 of RFC 2285) of the higher priority stream does not exceed the link capacity. The background traffic stream provides enough additional traffic to saturate the wireless link. This is true regardless of whether the priority of the background traffic is higher or lower than the DUT's traffic. Thus the total intended load of the two streams exceeds the link capacity. In this situation it is simple to compare the backoff algorithms of two devices – the higher priority stream should always get the bandwidth it needs to achieve its intended load, while the lower priority stream gets whatever is left over. The PHY rates of the DUT and the test bed source do not matter.

Applicability
Mandatory

Reference
Test case 4.2 in the "WMM System Interoperability Test Plan – version 1.4"

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
STA2: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Marvell	Qualcomm	-
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678	12345678
AP Control Channel	-	-	36
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	1	1	Default
AIFS	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
CWmin	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
CWmax	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
TXOPLimit	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
ACM: AC_VO	-	-	0
ACM: AC_VI	-	-	0
ACM: AC_BE	-	-	0
ACM: AC_BK	-	-	0
AC Tagging	DSCP	DSCP	Default for AP

Table 18: Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (STA).		
2	-	-	Beacon	
3	Probe Request	Probe Request	Probe Response	Use the sniffer to verify: If a Probe Request occurs and Probe Response contains WMM parameter information element, then pass
4	Association Request	Association Request	Association Responses	Use the sniffer to verify: If Association Responses contains WMM parameter information element and STA1 and STA2 associated, then pass.
5	Receive UDP1		Prerequisite step: Transmit UDP1	Total TPT > 110 Mbps. If not - check for environmental interference before continuing. Set TPT_X = Total TPT.
6		Receive UDP1	Prerequisite step: Transmit UDP1	Total TPT > 110 Mbps. If not - check for environmental interference before continuing. Set TPT_Y = Total TPT. Set TPT_X_Param = min(Total TPT_X, Total_Y).
7	Receive UDP1_BE, UDP2_VI	Receive UDP3_BE	Transmit UDP1_BE UDP2_VI UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Receive Data UDP1, UDP2, UDP3. Check that: - UDP2 in second phase (31~60s) >= 80 % UDP2 in first phase (1~30s) If so, then pass.
8	Receive UDP1_BE, UDP2_VI	Transmit UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Transmit UDP1_BE UDP2_VI Receive UDP3_BE	Receive Data UDP1, UDP2, UDP3. Check that: - UDP2 in second phase (31~60s) >= 80 **%** UDP2 in first phase (1~30s) If so, then pass.
9	Transmit UDP1_BE, UDP2_VI	Receive UDP3_BE	Receive UDP1_BE UDP2_VI Transmit UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Receive Data UDP1, UDP2, UDP3. Check that: - UDP2 in second phase (31~60s) >= 80 **%** UDP2 in first phase (1~30s) If so, then pass.
10	Receive UDP1_VI, UDP2_VO	Receive UDP3_VI	Transmit UDP1_VI UDP2_VO UDP3_VI (note that UDP3 traffic starts by definition after a 30 second delay)	Receive Data UDP1, UDP2, UDP3. Check that: - UDP2 in second phase (31~60s) >= 80 **%** UDP2 in first phase (1~30s) If so, then pass.
11	Receive UDP1_VI, UDP2_VO	Transmit UDP3_VI (note that UDP3 traffic starts by definition after a 30 second delay)	Transmit UDP1_VI UDP2_VO Receive UDP3_VI	Receive Data UDP1, UDP2, UDP3. Check that: - If UDP2 in second phase (31~60s) >= 80 % UDP2 in first phase (1~30s) If so, then pass.
12	Receive	Receive	Transmit	Receive Data UDP1, UDP2, UDP3.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
	UDP1_BK, UDP2_BE	UDP3_BK	UDP1_BK UDP2_BE UDP3_BK (note that UDP3 traffic starts by definition after a 30 second delay)	Check that: - UDP2 in second phase (31~60s) >= 80 **%** UDP2 in first phase (1~30s) If so, then pass.
13	Receive UDP1_BK, UDP2_BE	Transmit UDP3_BK (note that UDP3 traffic starts by definition after a 30 second delay)	Transmit UDP1_BK UDP2_BE Receive UDP3_BK	Receive Data UDP1, UDP2, UDP3. Check that: - UDP2 in second phase (31~60s) >= 80**%** UDP2 in first phase (1~30s) If so, then pass.

Table 19: Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs: Procedure and Results

4.2.22 Traffic Differentiation in a Single BSS with WMM STA

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document

4.2.23 Traffic Differentiation in a Single BSS with Legacy Non-WMM STA

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.24 APUT "No Acknowledgement" Test

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.25 Traffic Forwarding in Single BSS

4.2.25.1 Traffic Forwarding in a Single BSS

Purpose and Description
Verify that traffic sent by the legacy STA to the WMM STA is transmitted as AC_BE (best effort) traffic from the APUT.
Verify that traffic sent in any QoS access category from the WMM STA to the legacy STA is transmitted as legacy traffic.

In a given BSS with both Wi-Fi CERTIFIED ac and non WMM associated STAs, it is imperative that traffic between those two types of stations is forwarded correctly through the AP. A first Endpoint is setup on an Wi-Fi CERTIFIED ac STA and a second Endpoint is setup on a non-WMM STA. Traffic between the two endpoints shall pass through the AP. The test passes if the packets are correctly formatted to the two STA and if throughput is suitable.

Applicability
Mandatory

Reference
Test case 4.2.25 in Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
STA2: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac), operating in 11a mode with WMM off
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Broadcom	Qualcomm	-
AP Control Channel	-	-	36
AIFS	-	-	Default (see Annex C)
CWmin	-	-	Default (see Annex C)
CWmax	-	-	Default (see Annex C)
TXOP Limit	-	-	Default (see Annex C)
ACM: AC_VO	-	-	0
ACM: AC_VI	-	-	0
ACM: AC_BE	-	-	0
ACM: AC_BK	-	-	0
AC Tagging	DSCP	DSCP	Default for AP
Channel Width	80 MHz	20 MHz	80 MHz
Spatial Streams Implemented	1	1	Default

Table 20: Traffic Forwarding in Single BSS Configuration

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED n STA2 operating in 11a mode with WMM off	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (11n).		
2	Association Request	Association Request	Association Responses	
3	RUN: PING <STA2_IP_ADDR> COUNT=10	-	-	If at least one ping reply is received then pass
4	-	RUN: PING <STA1_IP_ADDR> COUNT=10	-	If at least one ping reply is received then pass
5	Receive UDP1		Prerequisite step: Transmit UDP1	Total TPT > 150Mbps. If not - check for environmental interferences before continuing.
6	Receive UDP2_BE	Transmit: UDP2_BE	-	Use the sniffer to verify: In a UDP2_BE QoS Data frame with STA1 as the destination, if QoS Control Field UP=000_2 or 011_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=10_2, subtype 1000 $_2$ then pass. Traffic to STA2 shall not have QoS framing. If the traffic has QoS framing, then fail. Check: If Receive Data UDP2, then pass.
7	Transmit UDP2_BK	Receive: UDP2_BK	-	Use the sniffer to verify: In a UDP2 Data frame with STA2 as the destination, if QoS Data Framing is not being used, then pass. Check: If Receive Data UDP2, then pass.
8	Transmit UDP2_BE	Receive UDP2_BE	-	Use the sniffer to verify: In a UDP2 Data frame with STA2 as the destination, if QoS Data Framing is not being used, then pass. Check: If Receive Data UDP2, then pass.
9	Transmit UDP1_BE UDP2_VI	Receive UDP1_BE UDP2_VI	-	Check: Receive Data UDP1_BE, UDP2_VI If UDP2 is >= 100 % of UDP1, then pass.

Table 21: Traffic Forwarding in Single BSS Procedure and Results

4.2.26 Basic Association in 802.11n Environment

4.2.26.1 Basic Association in a Wi-Fi CERTIFIED ac Environment

Purpose and Description
Test Beacon/Probe Response and Association Response format and the existence of the information elements.

Test association of a Wi-Fi CERTIFIED ac station in a pure Wi-Fi CERTIFIED ac network as well as in a mixed network that contains stations that are not Wi-Fi CERTIFIED ac stations, and also test the ability of a Wi-Fi CERTIFIED ac station to exchange traffic with all station types.
Verify the VHT Protection Mode Operating Mode settings as advertised by the APUT.

Applicability
Mandatory

Reference
Test case 4.2.26 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
(Use a screen room)
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
STA2: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode) 20/40 MHz capable
STA3: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode) 20MHz only
STA4: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac) operating in 11a mode
STA5: Test bed Wi-Fi CERTIFIED ac that sets the VHT SIGB CRC to a fixed value (e.g. all “0”)
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	STA3 Values	STA4 Values	STA5 Values	APUT Values
Vendor	Intel	Quantenna	Qualcomm	Broadcom	MediaTek	-
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678	12345678	12345678	12345678	12345678
Spatial Streams Implemented	1	1	1	1	1	Default
AP Control Channel	-	-	-	-	-	36
Channel Width	80 MHz	20/40MHz	20 MHz	20 MHz	80 MHz	80 MHz

Table 22: Basic Association in Wi-Fi CERTIFIED ac Environment Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED n 20/40 MHz Capable STA2	Test bed Wi-Fi CERTIFIED n 20 MHz Mode STA3	Test bed Wi-Fi CERTIFIED n STA4 operating in 11a mode	Test bed Wi-Fi CERTIFIED ac STA5	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (11n). Enable 40 MHz operation. Configure STA2 to implement 1 SS only.	Configure STA3 to Test bed Default Mode (11n). Configure STA3 to implement 1 SS only.	Configure STA4 to Test bed Default Mode (11a).	Configure STA5 to Test bed Default Mode (STA).	Beacon	Check Beacon for the VHT Capability IE and record the Supported Features [VHT Capabilities element] a. Short GI for 80 MHz b. VHT Supported MCS Set (for 1 SS, 2 SS, and 3 SS) c. Tx STBC d. Rx STBC If the supported list from the beacon does not match the submission then fail.
2	Association Request					Association Response to STA1	If the Association Response does not contain a SUCCESS status then fail. Check the Association Response for the HT information element. If the HT Protection Field is not 0 (no protection mode) or 3 (non-HT mixed mode) then fail.
3						RUN: PING <STA1_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more than 10% ping failures, then fail. In the PingRequest transmitted by the APUT check using the sniffer that at least one PPDU transmitted by the APUT contains VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is '2'. If not then fail.
4					Association Request	Association Response to STA5	If the Association Response does not contain a SUCCESS status then fail.
5						RUN: PING <STA5_IP_ADDR>	If more than 5 consecutive ping

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED n 20/40 MHz Capable STA2	Test bed Wi-Fi CERTIFIED n 20 MHz Mode STA3	Test bed Wi-Fi CERTIFIED n STA4 operating in 11a mode	Test bed Wi-Fi CERTIFIED ac STA5	APUT	Expected Results
						SIZE=10000 CONTINUOUS=YES	timeouts occur, then fail. If more than 10% ping failures, then fail.
6		(After 30 seconds) Association Request				Association Response to STA2	
7						RUN: PING <STA2_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more than 10% ping failures, then fail. If the ping for STA1 is stopped then fail
8			(After 30 seconds) Association Request			Association Response to STA3	
9						RUN: PING <STA3_IP_ADDR> SIZE=10000 CONTINUOUS=YES	1. Using a sniffer check the Association Response frame. If it does not contain a SUCCESS status, then fail. 2. Using a sniffer check the HT information element. If the HT Protection Field is not 0 (no protection mode), 2 (20MHz protection) or 3 (non-HT mixed mode), then fail.
10				(After 30 seconds) Association Request		Association Response to STA4	If Association Response does not contain a SUCCESS status, then fail. Using a sniffer check the HT information element. If the HT Protection Field is not 3 (non-HT Mixed mode), then fail.
11						RUN: PING <STA4_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED n 20/40 MHz Capable STA2	Test bed Wi-Fi CERTIFIED n 20 MHz Mode STA3	Test bed Wi-Fi CERTIFIED n STA4 operating in 11a mode	Test bed Wi-Fi CERTIFIED ac STA5	APUT	Expected Results
							If the ping for STA1, STA2 and STA3 is stopped, then fail
12	(after 30 seconds) Disassociate					Stop pings to STA 1	Nothing should change
13		(after 30 seconds) Disassociate				Stop pings to STA 2	Nothing should change
14				(after 30 seconds) Disassociate		Stop pings to STA4	If the APUT HT Protection Field is not changed to 0 (no protection mode); 2 (20MHz protection mode) or 3 (non-HT Mixed mode), then fail
15			(after 30 seconds) Disassociate		Stop pinging to STA5	Stop pings to STA3	If the APUT HT Protection Field is not changed to 0 (no protection mode), 2 (20MHz protection mode) or 3 (non-HT Mixed mode) then fail

Table 23: Basic Association in Wi-Fi CERTIFIED ac Environment Procedure and Results

4.2.27 Ability to Receive 1 and 2 Spatial Streams

4.2.27.1 Ability to Receive 1 and 2 Spatial Streams

Purpose and Description
Confirm that the APUT implements 1 and 2 SS on Rx side.

Applicability
2 SS is mandatory for the APUT.
2 SS is optional for the MAP under test.
The test procedure specifies testing 1 SS on an AP that the vendor has declared to be a MAP. If the vendor declared that the MAP implements 2 SS, then 2 SS shall also be tested on the MAP.

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac, 2 SS capable

Test Configuration
The following table defines the parameter values for the devices in the test bed. An APUT that is a MAP is not required to execute the 2 SS portion of this test.

Parameter	STA1 Values	APUT Values
Vendor	Intel	-
Security	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678
AP Control Channel	-	36.
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	See test procedure	Default

Table 24: Ability to Receive 1 and 2 Spatial Streams Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac 2 SS Capable STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Configure STA1 to transmit only VHT MCS 7.		
2		Beacon	
3	Association Request	Association Response	
4	RUN: PING <APUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Verify that the STA1 PPDUs are 80 MHz VHT packets and not 11n. (Check using the sniffer that PPDUs transmitted by APUT contain VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is '2'.) If they are not 80 MHz VHT packets, then fail.
5	Disassociate		
If the vendor declared that the APUT implements only 1 SS and the declared primary product category is a not a MAP, then fail. Else if the vendor declared that the APUT implements only 1 SS and the vendor declared the APUT is not powered by an internal battery, then fail. Else if the vendor declared that the APUT implements only 1 SS and is a MAP, then pass, and stop the test. Else if the vendor declared that the APUT implements 2 SS, continue with the steps below.			
6	Configure STA1 to Test bed Default Mode. Enable 2 SS. Configure STA1 to transmit only VHT MCS 7, Nss = 2.		
7	RUN: PING <APUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Verify the STA1 PPDUs are 80 MHz VHT packets and not 11n. (Check using the sniffer that PPDUs transmitted by APUT contain VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is '2'.) If they are not 80 MHz VHT packets, then fail.

Table 25: Ability to Receive 1 and 2 Spatial Stream Procedure and Results

4.2.28 Spatial Multiplexing Power Save Operation

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.29 A-MPDU Aggregation when the AP is the Recipient with and without WPA2-PSK

4.2.29.1 A-MPDU Aggregation when the AP is the Receiver with and without WPA2-Personal

Purpose and Description
Test Block ACK stream and A-MPDU aggregation traffic in receive side.
Test A-MPDU aggregation with and without WPA2-Personal security mode.

Applicability
Mandatory for the APUT. Skip steps 1 through 4 if Open security is not supported.

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration and Procedure
The following table defines the parameter values for the devices in the test bed.
Run all tests in batch mode.

Parameter	STA1 Values	APUT Values
Vendor	Quantenna	-
Security	None and WPA2-Personal	None and WPA2-Personal
Encryption Key	None and 12345678	None and 12345678
Spatial Streams Implemented	1	Default
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz

Table 26: A-MPDU Aggregation Single Stream when AP is the Receiver with and without WPA2-Personal Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA)	Skip steps 1 through 4 if Open security is not supported. Configure APUT with no security. Beacon.	
2	Association Request	Association Response	If the association response of STA1 is with status different than success then fail
3	ADDBA Request	ADDBA Response	
4	Run script HT1-STA1-AP-TID-5-30 on TID 4 or TID 5 for 30 seconds.		If Uplink throughput is less than 4.2.29A1HT1 then fail Use the sniffer to verify: Check that there are Block ACKs.
5		Disassociate. Reconfigure APUT security mode to WPA2-Personal Beacon.	
6	Association Request	Association Response	If the association response of STA1 is with status different than success then fail
7	ADDBA Request	ADDBA response	
8	Run script HT1-STA1-AP-TID-5-30 on TID 4 or TID 5 for 30 seconds.		If Uplink throughput is less than 4.2.29A2HT1 then fail. Use the sniffer to verify: Check that there are Block ACKs.

Table 27: A-MPDU Aggregation Single Stream when AP is the Receiver with and without WPA2-Personal Procedure and Results

4.2.30 A-MSDU Aggregation when AP is the Recipient

4.2.30.1 A-MSDU Aggregation when the AP is the Receiver

Purpose and Description
Test the mechanism of the A-MSDU Aggregation when the APUT is the receiver. A-MSDU is transmitted using VHT single MPDU format.

Applicability
Mandatory for the APUT

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac capable STA that supports A-MSDU transmission and both 3839 byte and 7935 byte Maximum A-MSDU Size in transmission
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
Security	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678
Spatial Streams Implemented	1	Default
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz

Table 28: A-MSDU Aggregation when AP is the Receiver Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable Transmit A-MSDU. Decline any ADDBA Request from APUT.		
2	-	Beacon	
3	Association Request	Association Response	
4	Run script HT1-STA1-AP-90 from STA1 to APUT for 90 seconds.		Note: Use the sniffer to check that the STA1 MPDUs are > 2346 and 80 Mhz VHT packets, if not then check the test bed STA. If the APUT successfully receives the transmitted data, and the uplink throughput is greater than 4.2.30A1HT1, then pass. If not, then fail.

Table 29: A-MSDU Aggregation when AP is the Receiver Procedures and Results

4.2.31 Overlapping BSS – 2.4 GHz

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.32 Overlapping BSS – 5 GHz

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.33 HT-Greenfield Operation

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.34 Short GI Operation

4.2.34.1 Receive Short GI for 80 MHz Operation

Purpose and Description
Verify that the APUT is appropriately receiving Short GI for 80 MHz.
Verify that the APUT can communicate with stations that do and do not support Short GI for 80 MHz simultaneously.

Applicability
Mandatory for the APUT

Reference
Test case 4.2.34 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA, capable of supporting Short GI for 80 MHz
STA2: Test bed Wi-Fi CERTIFIED ac STA
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Intel	Marvell	—
AP Control Channel	-	-	36
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	1	1	Default
Short GI for 80 MHz	1	0 or 1	1

Table 30: Receive Short GI for 80 MHz Operation Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1 with Short GI for 80 MHz enabled	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable Short GI for 80 MHz.	Configure STA2 to Test bed Default Mode (STA).	Enable Short GI for 80 MHz if not otherwise enabled.	
2	-		Beacon/Probe responses	If the Short GI for 80 MHz subfield in the VHT Capabilities information element is not set, then fail
3	Association Request		Association Response to STA1	If the Short GI for 80 MHz subfield in the VHT Capabilities information element in Association Response is not set, then fail
4	Set VHT MCS to 7 and Nss=1. RUN: PING <APUT_IP_ADDR> CONTINUOUS=YES			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.
5	Set VHT MCS to 7 and Nss=1. RUN: PING <APUT_IP_ADDR> SIZE=1172 CONTINUOUS=YES			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.
6		Association Request	Association Response to STA2	
7	RUN: PING <APUT_IP_ADDR> SIZE=10000 COUNT=90	RUN: PING <APUT_IP_ADDR> SIZE=10000 COUNT=90		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.

Table 31: Receive Short GI for 80 MHz Operation Procedure and Results

4.2.35 Overlapping BSS on Extension Channel

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.36 HT Duplicate Mode (MCS Index = 32)

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.37 AP Concurrent Operation in 2.4 and 5 GHz Frequency Bands

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.38 RIFS Test

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.39 STBC Transmit (2x1) Test

4.2.39.1 STBC Transmission for 80 MHz

Purpose and Description
Verify that the APUT is appropriately supporting Transmit 2x1 STBC.
Verify that the APUT can simultaneously communicate with stations with and without Receive 2x1 STBC support.

Applicability
Optional for the APUT

Test Environment
(Use a screen room)
APUT
STA1: Test bed Wi-Fi CERTIFIED ac with Rx STBC disabled
STA2: Test bed Wi-Fi CERTIFIED ac with Rx STBC enabled
Wireless Wi-Fi CERTIFIED ac sniffer, STBC-capable

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Intel	Broadcom	-
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678	12345678
AP Control Channel	N/A	N/A	44 (if supported by APUT; else 36)
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	1	1	Default
VHT Supported MCS Set	0-9	0-9	N/A

Table 32: STBC Tx (2x1) Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2 Rx STBC Capable	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (STA). Enable Rx STBC on STA2.	Enable Tx STBC on AP1 if not otherwise enabled.	
2	-		Beacons / Probe Responses	Using the sniffer verify that the Tx STBC bit of the VHT Capability Info field in the Beacon is not set. Else fail.
3	Association Request		Association Response	If STA1 association fails, then fail
4		Association Request	Association Response	If STA2 association fails, then fail
5			RUN: PING <STA1_IP_ADDR> CONTINUOUS=YES	If ping request is not successful within 90 seconds, then fail– Ping Request – Using the sniffer verify that the STBC field of VHT-SIG-A is ‘00’.
6			RUN: PING <STA2_IP_ADDR> CONTINUOUS=YES.	If ping is not successful within 90 seconds, then fail– Ping Request – Using the sniffer verify that the STBC field of VHT-SIG-A is ‘1’.

Table 33: STBC Tx (2x1) Test Procedure and Results

4.2.40 A-MPDU Aggregation when the AP is the Transmitter

4.2.40.1 A-MPDU Aggregation when the AP is the Transmitter

Purpose and Description
Test A-MPDU Aggregation when the APUT is the transmitter.

Applicability
Mandatory for the APUT
The test procedure requires the steps to be run up to the number of SSs declared by the vendor

Reference
Test case 4.2.40 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac implementing 1 SS
STA2: Test bed Wi-Fi CERTIFIED ac implementing 2 SS
STA3: Test bed Wi-Fi CERTIFIED ac implementing 3 SS
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	STA3 Values	APUT Values
Vendor	Marvell	Qualcomm	Broadcom	-
Spatial Streams Implmented	1	2	3	Default
Channel Width	80 MHz	80 MHz	80 MHz	80 MHz
Short GI	Disabled	Disabled	Disabled	-
AP Control Channel	N/A	N/A	N/A	36

Table 34: A-MPDU Aggregation when the AP is the Transmitter Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	Test bed Wi-Fi CERTIFIED ac STA3	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (STA). Enable 2 SS on STA2.	Configure STA3 to Test bed Default Mode (STA). Enable 3 SS on STA3.		
2	Association Request			Association Response	
3	Send ADDBA response to APUT			Send ADDBA request to STA1 for TID0. Note: the APUT may do this automatically after association or it may be triggered by the data traffic in step 3.	
4				Run script HT1-AP-STA1-TID-0 using TID0 to STA1.	If the measured throughput is less than 4.2.40A1HT1 then fail Verify that the APUT is using VHT PPDUs and that STA1 responds with BA.
If the vendor declared that the APUT is a not a MAP and implements only 1 SS transmission, then fail. If the vendor declared that the APUT implements more than 1 SS transmission, then continue; else stop the test.					
5		Association Request		Association Response	
6		Send ADDBA response to APUT		Send ADDBA request to STA2 for TID0	
7				Run script HT1-AP-STA1-TID-0 using TID0 to STA2.	If the measured throughput is less than 4.2.40A2HT1 then fail Verify that the APUT is using VHT PPDUs and that STA2 responds with BA.
If the vendor declared that the APUT implements more than 2 SS transmission, then continue; else stop the test. Steps 8-10 are run only once – that is, even if the APUT implements more than 3SS, the test ends with step 10, which tests 3SS operation.					
8		Association Request		Association Response	
9			Send ADDBA response to APUT	Send ADDBA request to STA3 for TID0	
10				Run script HT1-AP-STA1-TID-0 using TID0 to STA3.	If the measured throughput is less than 4.2.40A3HT1 then fail Verify that the APUT is using VHT PPDUs and that STA3 responds with BA.

Table 35: A-MPDU Aggregation when the AP is the Transmitter Procedure and Results

4.2.41 AP 20/40 MHz Coexistence

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.42 Ability to Receive 3 Spatial Streams

4.2.42.1 Ability to Receive 3 Spatial Streams

Purpose and Description
Confirm that the APUT implements 3 SS on Rx side.

Applicability
Optional for the APUT

Test Environnent
APUT
STA1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode) implementing 3 SS configuration
STA2: Test bed Wi-Fi CERTIFIED ac implementing 3 SS configuration

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Quantenna	Qualcomm	-
Spatial Streams Implemented	3	3	Default
AP Control Channel	-	-	36
Channel Width	See test procedure	See test procedure	80 MHz

Table 36: Ability to Receive 3 Spatial Streams Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED n 3 SS 20/40 MHz Capable STA1	Test bed Wi-Fi CERTIFIED ac 3 SS STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (11n). Enable Tx A-MPDU, A-MSDU and 3 SS.	Configure STA2 to Test bed Default Mode (STA). Enable Tx A-MSDU and 3 SS.	Beacon/Probe responses	If the APUT's Rx MCS Map in the VHT Supported MCS Set field of VHT Capabilities IE contains '11' in the bitmap indexes B4-B5 (3 SS) then fail
2	Association Request		Association Response	
3	Configure STA1 to transmit only 20 MHz, (HT) MCS23 (195 Mbps)	Configure STA2 to transmit only 20 MHz, Nss = 3, VHT MCS = 7 (195 Mbps)		
4	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		If more than 5 consecutive ping timeouts from either STA1 or STA2 occur, then fail. If more than 10% of pings fail from either STA1 or STA2, then fail.
5	Configure STA1 to transmit only 40 MHz (HT) MCS23 (405 Mbps)	Configure STA2 to transmit only 40 MHz, Nss = 3, VHT MCS = 7 (405 Mbps)		
6	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		If more than 5 consecutive ping timeouts from either STA1 or STA2 occur, then fail. If more that 10% ping failures from either STA1 or STA2, then fail.
7		Configure STA2 to transmit only 80 MHz, Nss = 3, VHT MCS = 7 (877.5 Mbps)		
8		RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 CONTINUOUS=YES.		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.

Table 37: Ability to Receive 3 Spatial Stream Procedure and Results

4.2.43 AP Transmitting to STA using Supported Number of Spatial Streams

4.2.43.1 AP Transmitting to STA using Supported Number of Spatial Streams

Purpose and Description
Test that the APUT transmits using a number of spatial streams compatible with the advertised capability of the receiver STA. Test that the APUT does not use a VHT MCS not supported by the receiver STA.

Applicability
Mandatory for the APUT
(The test procedure requires the steps to be run up to the number of SSs implemented by the APUT.)

Reference
Test case 4.2.43 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac implementing 1 SS
STA2: Test bed Wi-Fi CERTIFIED ac implementing 2 SS
STA3: Test bed Wi-Fi CERTIFIED ac implementing 3 SS
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	STA3 Values	APUT Values
Vendor	Intel	Marvell	Broadcom	-
Spatial Streams Implemented	1	2	3	Default
AP Control Channel	N/A	N/A	N/A	36
Channel Width	80 MHz	80 MHz	80 MHz	80 MHz

Table 38: AP Transmitting to STA using Implmented Number of Spatial Streams Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	Test bed Wi-Fi CERTIFIED ac STA3	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (STA). Enable 2SS.	Configure STA3 to Test bed Default Mode (STA). Enable 3 SS.	Sends Beacon indicating number of spatial streams supported in the VHT Capabilities: VHT Supported MCS Set: Tx MCS Map field	Use the sniffer to check the values in the Beacon. If the spatial stream number in the Beacon's Tx MCS Map field does not match the number of supported spatial streams given in the vendor declaration, then fail.
2	Association Request			Association Response	
3				RUN: PING <STA1_IP_ADDR> COUNT=100 SIZE=1000	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail. If the APUT does not transmit at least 1 VHT PPDU, then fail. If the APUT transmitted a VHT PPDU using VHT MCS 8 or VHT MCS 9, then fail. Otherwise, pass.
If the maximum number of spatial streams implemented by the APUT as determined in step 1 is 1, then end the test. If the vendor declared that the APUT is not a MAP, then fail. If the maximum number of spatial streams implemented by the APUT as determined in step 1 is greater than 1, then proceed with steps 4 and 5.					
4		Association Request with (VHT) MCS Set: MCS0-7 for Nss=1 and MCS0-7 for Nss=2		Association Response	
5				RUN: PING <STA2_IP_ADDR> COUNT=100 SIZE=1000	If more than 5 consecutive ping timeouts occur, then fail. If more than 10% of pings fail, then fail. If the APUT does not transmit at least 1 VHT PPDU using 2 SS then fail. If the APUT transmitted a VHT PPDU using VHT MCS 8 or VHT MCS 9 then fail. Otherwise, pass.
If the maximum number of spatial streams implemented by the APUT as determined in step 1 is 2 then end test. Otherwise, proceed with steps 6 and 7.					
6			Association Request	Association Response	
7				RUN: PING <STA3_IP_ADDR> COUNT=100 SIZE=1000	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail. If the APUT does not transmit at least 1 VHT PPDUs using 3 SS then fail. If the APUT transmitted a VHT PPDU using VHT MCS 8 or VHT MCS 9 then fail. Otherwise, pass.

Table 39: AP Transmitting to STA using Implemented Number of Spatial Streams Procedure and Results

4.2.44 Disallow TKIP with HT Rates Test

4.2.44.1 Disallow TKIP with VHT Rates

Purpose and Description
Ensure that the APUT does not use VHT rates when using TKIP as the encryption cipher.

Applicability
Mandatory for the APUT that supports WPA2/WPA mixed mode.

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac with the capability of setting TKIP and VHT and ability to generate a probe request.
Wireless Wi-Fi CERTIFIED ac sniffer

Note: might require manual/visual verification of GUI.

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
AP Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	1	Default

Table 40: Disallow TKIP with VHT Rates Test Configuration

WPA2-Personal/WPA-Personal Mixed Mode Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Step	Action	Results
1	Set up the APUT with mixed WPA-Personal/WPA2-Personal	If the APUT prohibits the configuration of WPA-Personal/WPA2-Personal when VHT is enabled, then fail. Stop the test. (The APUT in mixed mode shall allow the use of WPA-Personal with TKIP, but no VHT rates are allowed in this case. VHT rates are only allowed with WPA2-Personal using AES (CCMP)).
2	Associate STA1 to the APUT forcing STA1 to use WPA-Personal with TKIP	
3	Using the sniffer, look at the Association Request and Association Response	1) Verify that the Association Request from STA1 contains IE 45 and that the pairwise cipher suite requested is TKIP. If not, there is a test bed problem. Correct the configuration and restart the test. 2) If the Association Response status code is non-zero, then pass. Stop the test. 3) If IE 191 is present in the Association Response and the status code is zero, then fail. Stop the test.
4	Run script APUT-STA1-10 from a PC on the wired Ethernet side of the APUT to STA1 for at least 10 seconds	
5	Using the sniffer, collect 10 seconds of data packets	If any of the APUT data packets are sent at VHT rates, then fail. Stop the test. Ignore all packets from the test bed station.
6		If the test reaches this point, then pass.

Table 41: Disallow TKIP with VHT Rates (2) Test Procedure and Results

4.2.45 AP Negative tests to ensure WEP is not used with HT associations in 11n devices

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

4.2.46 Negative tests to ensure WEP is not used with Associations at VHT Rates

Purpose and Description
The APUT shall reject an association with test bed devices that are using WEP and VHT rates.

Applicability
Mandatory for the APUT that implements WEP

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac with the capability of setting WEP and TKIP with VHT rates, and capability to generate a probe request.

Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 values	APUT values
Vendor	MediaTek	
Security	-	WEP
Encryption Key	-	0x9876543210
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	1	Default

Table 42: AP Negative WEP Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Action	Results
1	Set up the APUT with WEP	If the APUT prohibits the configuration of WEP when VHT is enabled, then pass. Stop the test.
2	Using the sniffer, look at the Beacons of the APUT	If either IEs 191 or 192 is present in Beacons, then fail. Stop the test.
3	Force STA1 to do an active scan	
4	Using the sniffer, look at the Probe Responses of the APUT	If either IEs 191 or 192 is present in Probe Responses, then fail. Stop the test.
5	Associate STA1 to the APUT with STA1 configured for WEP and VHT.	
6	Using the sniffer, check the Association Response from the APUT.	If IE 191 is present in the Association Response and the status code is zero, then fail. Stop the test.
7	Run script APUT-STA1-10 from a PC on the wired Ethernet side of the APUT to the associated STA1 for at least 10 seconds.	
8	Using the sniffer, collect 10 seconds of data packets.	If any of the APUT data packets are sent with PPDUs that include VHT-SIG-A, then fail. Stop the test. Ignore all packets from the test bed station.
9		If the test reaches this point, the APUT passes the test

Table 43: AP Negative WEP Test Procedure and Results

4.2.47 AP Receiving 256-QAM MCSs

Purpose and Description
Test that the APUT is capable of receiving 256-QAM MCSs (MCS 8 and 9), if claimed.

Applicability
Optional for the APUT
The test procedure requires the steps to be run up to 2 SS or 3 SS, depending on which number of SSs is implemented by the APUT.)

Reference
None

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac implementing 2 SS, capable of:
- MCS 8-9 (where valid) in each implemented spatial stream and supported bandwidth
- Being configured to fixed MCS, channel width, and Nss

STA2: Test bed Wi-Fi CERTIFIED ac implementing 3 SS, capable of:
- MCS 8-9 in 3 SS
- Being configured to fixed MCS, channel width, and Nss.

Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Intel	Broadcom	-
Spatial Streams Implemented	2	3	Default
AP Control Channel	N/A	N/A	36
Channel Width	80 MHz	80 MHz	80 MHz

Table 44: AP Receiving 256-QAM MCSs Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.
Note: For steps 3-6, 8, and 9, the “Expected Results” column contains text requiring the Beacon to be checked for APUT support of modes. The Beacon can be checked at any time, starting at step 1.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable {Nss = 1, VHT MCS 8-9} and {Nss =2, VHT MCS0-9}..	Configure STA2 to Test bed Default Mode (STA). Enable {Nss = 3, VHT MCS0-9}.	Beacon	
2	Association Request indicating support for MCS8-9 for Nss=1 and Nss=2: Max MCS for 1 SS and Max MCS for 2 SS in the Tx MCS Map field = 9, and Tx Highest Supported Long GI Data Rate subfield = 0		Association Response	
3				Check Beacon for APUT support for transmitted mode: If (i) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 351`for MCS 8 or 390 for MCS 9, then the APUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: proceed to step 5.
4	Configure STA1 to transmit only: BW=80, MCS=8, Nss=1 RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
5				Check Beacon APUT support for transmitted mode at step 3: If (i) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 390, then the APUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: proceed to next step 7.
6	Configure STA1 to transmit only BW=80, MCS=9, Nss=1 RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
If the vendor declared that the APUT implements only 1 SS and is a not a MAP, then fail.				

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
Else, if the vendor declared that the APUT implements only 1 SS and is a MAP, and the test reaches this point with no failures, then pass; stop the test. Else, if the vendor declared that the APUT implements 2 SS or more, then continue.				
7				Check Beacon for APUT support for transmitted mode at step 3: If (i) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 702 for MCS 8 or 780 for MCS 9, then the APUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: proceed to step 9.
8	Configure STA1 to transmit only: BW=80, MCS=8, Nss=2 RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
9				Check Beacon for APUT support for transmitted mode at step 3: If (i) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 780, then the APUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: proceed to step 11.
10	Configure STA1 to transmit only: BW=80, MCS=9, Nss=2 RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
If the vendor declared that the APUT implements only 2 SS, and test reaches this point with no failures, then pass; stop the test. Else if the vendor declared that the APUT implements 3 SS or more, then continue.				
11		Association Request indicating support for MCS8-9 for Nss=3: Max MCS for 3 SS in the Tx MCS Map field = 9, and Tx Highest Supported Long GI Data Rate subfield = 0	Association Response	
12				Check Beacon for APUT support for transmitted mode at step 3: If

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	APUT	Expected Results
				(i) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 1053 for MCS 8 or 1170 for MCS9, then the APUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: stop the test.
13		Configure STA2 to transmit only: BW=80, MCS=8, Nss=3 RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
14				Check Beacon for APUT support for transmitted mode at step 3: If (i) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 1170, then the APUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: stop the test.
15		Configure STA2 to transmit only: BW=80, MCS=9, Nss=3 RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
If the test reaches this point with no failures, then pass.				

Table 45: AP Receiving 256-QAM MCSs Procedure and Results

4.2.48 AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU

Purpose and Description
Test that the APUT is capable of transmitting and receiving VHT A-MPDU Delimiter for Single MPDU.

Applicability
Mandatory for the APUT

Reference
None

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Marvell	-
Spatial Streams Implemented	1	Default
AP Control Channel	N/A	36
Channel Width	80 MHz	80 MHz

Table 46: AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Disable BA (transmit and receive): do not send ADDBA Request; decline any ADDBA Request from APUT.		
2		Beacon	
3	Association Request	Association Response	
4	RUN: PING <APUT_IP_ADDR> COUNT=100 SIZE=1000		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.

Table 47: AP Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Procedure and Results

4.2.49 Ability to Receive A-MPDU with A-MSDU

Purpose and Description
The test verifies that the APUT can correctly receive A-MPDU with A-MSDU.

Applicability
Optional for the APUT

Reference
None

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	1	Default

Table 48: Receive A-MPDU with A-MSDU Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable Tx A-MSDU.		
2		Beacon	
3	Association Request		
4		Association Response	
5	ADDBA Request	ADDBA Response	Verify that the A-MSDU Supported subfield in the Block Ack Parameter Set field in the ADDBA Response is set to 1; if not, then fail
6	RUN: PING <APUT_IP_ADDR> SIZE=16384 COUNT=30		If the ping fails to continue for the whole 30 seconds then fail

Table 49: Receive A-MPDU with A-MSDU Test Procedure and Results

4.2.50 Clear Channel Assessment on Secondary Channel

Purpose and Description
Verify that the APUT correctly defers for secondary 40 MHz channel and secondary 20 MHz channel traffic.

A traffic stream is established between the APUT and a test bed STA. With no secondary channel activity this should occupy the full 80 MHz of channel bandwidth and achieve a certain throughput. The secondary 40 MHz channel is then loaded with OBSS traffic. The throughput experienced by the traffic stream should drop. The purpose of the test is to ensure that the throughput drop is is due to the APUT deferring or transmitting at a lower bandwidth and not due to packet collisions. The process is then repeated with OBSS traffic on the secondary 20 MHz channel: the secondary 20 MHz channel is loaded with OBSS traffic; the throughput experienced by the traffic stream should drop relative to the no-OBSS case; and a check is made to ensure that the throughput drop is is due to the APUT deferring or transmitting at a lower bandwidth and not due to packet collisions.

Applicability
Mandatory for the APUT

Reference
None

Test Environment
(Use a screen room, or any available clear channel)
APUT
AP1: Test bed Wi-Fi CERTIFIED ac AP (implementing 1 SS)
STA1: Test bed Wi-Fi CERTIFIED ac STA
STA2: Test bed Wi-Fi CERTIFIED ac STA
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	AP1 Values	APUT Values
Vendor	Intel	Marvell	Broadcom	-
Spatial Streams Implemented	1	1	1	Default
AP Control Channel	-	-	See test procedure	44 (if supported by APUT; else 36)
Channel Width	80 MHz	40 MHz, 20 MHz (see test procedure)	See test procedure	80 MHz

Table 50: CCA on Secondary Channel Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac STA2	Test bed Wi-Fi CERTIFIED ac AP1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA).	Configure STA2 to Test bed Default Mode (STA).	Configure AP1 to Test bed Default Mode. -	Beacon	Use the sniffer to verify: Verify that VHT Operation: Channel Width is 1 and that HT Operation: STA Channel Width is 1, indicating 80 MHz operation. If not, then fail.
2	Association Request to APUT			Association Response to STA1	
3				Run script HT1-AP-STA1-30 to STA1.	Note downlink throughput value from APUT to reference station (X Mbps)
4			Configure AP1 for 40 MHz operation with channel 36 as the primary channel (if the APUT is operating on AP Control Channel 44; else channel 40)		Note: AP1 is operating on the secondary 40 MHz channel of the APUT BSS.
5		Association Request to AP1	Association Response to STA2		
6			Run script HT2-AP1-STA2-30 to STA2.		Measure downlink throughput between AP1 and STA2 (Y Mbps).
7			Run script VHT-4.2.101-7 to STA2.	Run script VHT-4.2.49-7 to STA1.	Measure downlink throughput between AP1 and STA2 (Y' Mbps). Check that Y' > 25 % of Y. If not, then fail. Measure downlink throughput between APUT and STA1 (X' Mbps). Check that X' > 9 % of X. If not, then fail. (Note: the APUT is operated with 80 MHz bandwidth but defers for secondary 40 MHz channel traffic between AP1 and STA2.)
8			Configure AP1 for 20 MHz operation with channel 48 as the primary channel (if the APUT is operating on AP Control Channel 44;else channel 42)		Note: AP1 is operating on the Secondary 20 MHz channel of the APUT BSS.
9		Association Request to AP1	Association Response to STA2		
10			Run script HT2-AP1-STA2-30 to STA2.		Measure downlink throughput between AP1 and STA2 (Z Mbps).
11			Run script VHT-4.2.101-7 to STA2.	Run script VHT-4.2.49-7 to STA1.	Measure downlink throughput between AP1 and STA2 (Z' Mbps). Check that Z' > 22 % of Z. If not, then fail. Measure downlink throughput between APUT and STA1 (X"'Mbps). Check that X'' > 4 % of X. If not, then fail. (Note: the APUT is operated with 80 MHz bandwidth but defers for secondary 20 MHz channel traffic between AP1 and STA2.) (Note: no comparison is made between X' (throughput with 40 MHz OBSS) and X'' (throughput with 20 MHz OBSS): there are no requirements on how these numbers compare.)

Table 51: CCA on Secondary Channel Configuration Procedure and Results

4.2.51 CTS with BW signaling in response to RTS with BW signaling

Purpose and Description
Verify that the APUT correctly implements CTS with BW signaling by checking its response to RTS with static and dynamic BW signaling respectively.

Applicability
Mandatory for the APUT

Reference
None

Test Environment
(Use a screen room)
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA supporting the optional feature RTS with BW signaling
Wireless Wi-Fi CERTIFIED ac sniffer, with the capability of reading BW bits or deriving them from SERVICE field

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Qualcomm	-
Spatial Streams Implemented	1	Default
AP Control Channel	-	See test procedure
Channel Width	80 MHz, 40 MHz (see test procedure)	See test procedure

Table 52: CTS with BW signaling in response to RTS with BW signaling Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable RTS with BW Signaling.		
2		Power on the APUT	Note: APUT starts minimum initial scan
3		Configure the APUT for 80 MHz operation with the primary channel on channel 44 (if supported by the APUT; else channel 36) .	Verify that the APUT Beacon shows 80 MHz operation (VHT Operation: Channel Width is 1 and HT Operation: HT Operation Information: STA Channel Width is 1) and that the primary channel is channel 44 (or 36, as applicable) (HT Operation: Primary Channel is 44 (or 36, as applicable)). If not, then fail.
4	Association Request to APUT	Association Response to STA1	
5	Configure STA1 to send out RTS with static BW signaling (80 MHz). (This step can be carried out in parallel with any of steps 1-3.)		
6	RUN: PING <APUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		Verify that the APUT responds to RTS with CTS and that the BW bits in the SERVICE field of the PPDU carrying the CTS indicate 80 MHz. If not, then fail. Verify that the ratio of CTS responses to RTS is greater than 70%. If not, then fail.
7	Disassociate. If necessary (for step 8), reset STA1 to Test bed Default Mode (STA).		
8	Configure STA1 to send out RTS with dynamic BW signaling (80 MHz)		
9	Association Request	Association Response	
10	RUN: PING <APUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		Verify that the APUT responds to RTS with CTS and that the BW bits in the SERVICE field of the PPDU carrying the CTS indicate 80 MHz, 40 MHz or 20 MHz. If not, then fail. Verify that the ratio of CTS responses to RTS is greater than 70%. If not, then fail.
11	Disassociate. If necessary (from step 8), reset STA1 to Test bed Default Mode (STA).		
12	Configure STA1 to send out RTS with dynamic BW signaling (40 MHz)		
13	Association Request	Association Response	
14	RUN: PING <APUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES		Verify that the APUT responds to RTS with CTS and that the BW bits in the SERVICE field of the PPDU carrying the CTS indicate either 40 MHz or 20 MHz. If not, then fail. Verify that the ratio of CTS responses to RTS is greater than 70%. If not, then fail.

Table 53: CTS with BW Signaling in Response to RTS with BW Signaling: Procedure

4.2.52 Single User Transmit beamforming when AP is the beamformer

Purpose and Description
Verify that the APUT implements single user transmit beamforming correctly.

Applicability
Optional for the APUT

Test Environment
(Use a screen room)
APUT
STA1: Test bed Wi-Fi CERTIFIED ac with single user TxBF beamformee capability enabled
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
AP Control Channel	N/A	44 (if supported by APUT; else 36)
Channel Width	80 MHz	80 MHz
Spatial Streams Implmented	1	Default

Table 54: Single User Transmit Beamforming Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1 SU TxBF Beamformee Capable	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA) Enable SU TxBF beamformee capability on STA1.		
2		Beacon/Probe responses	If the SU Beamformer Capable bit of VHT Capability Info field in the Beacon/Probe Response is not set, then fail. If Number of Sounding Dimensions subfield in VHT Capability Info field in the Beacon is 0, then fail.
3	Association Request	Association Response	If STA1 association fails, then fail. If the SU Beamformer Capable bit of VHT Capability Info field in the Association Response is not set, then fail. If the Number of Sounding Dimensions subfield in VHT Capability Info field in the Association Response is 0, then fail.
4		RUN: PING <STA1_IP_ADDR> COUNT=90	If ping is not successful within 90 seconds, then fail. If STA1 does not receive any VHT NDP Announcement frame followed by a VHT NDP from APUT, then fail. Verify that the VHT NDP Announcement frame from APUT has RA set to STA 1's MAC address; if not, then fail. Verify using the sniffer the following VHT NDP SIG-A fields: — BW = 2 (80MHz) — GROUP_ID = 63; — 1 < SU NSTS <= the value indicated in the Compressed Steering Number of Beamformer Antennas Supported field in the VHT Capabilities information element transmitted by STA 1. If not, then fail. Alternatively, if the sniffer is not available to check NDP SIG-A, the fields in NDP SIG-A can be indirectly verified by checking the VHT MIMO Control field of the VHT Compressed Beamforming frame: — 1 < Nr <= the value indicated in the Compressed Steering Number of Beamformer Antennas Supported field in the VHT Capabilities information element transmitted by STA 1; — Channel Width = 2 (80 MHz); — Feedback Type = 0 (for SU). Verify using the sniffer that the Beamformed (B8) bit of VHT_SIG-A in at least one PPDU transmitted by APUT is set to '1' after APUT receives the VHT Compressed Beamforming frame. If not, then fail. If ping request is not successful after APUT receives the VHT Compressed Beamforming frame, then fail.

Table 55: SU Transmit Beamforming where APUT is the beamformer

4.2.53 LDPC where the AP is the Transmitter

Purpose and Description
Verify that the APUT is appropriately supporting LDPC transmit.
Verify that the APUT can simultaneously communicate with stations with and without LDPC.

Applicability
Optional
Mandatory if the APUT is capable of transmitting LDPC frames

Test Environment
(Use a screen room)
APUT
STA1: Test bed Wi-Fi CERTIFIED ac with LDPC disabled
STA2: Test bed Wi-Fi CERTIFIED ac with LDPC enabled
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Qualcomm	Marvell	-
AP Control Channel	N/A	N/A	44 (if supported by APUT;else 36)
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	1	1	Default
LDPC Supported	No	Yes	Yes

Table 56: LDPC where the AP is the Transmitter Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1 LDPC Disabled	Test bed Wi-Fi CERTIFIED ac STA2 LDPC Capable	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA)	Configure STA2to Test bed Default Mode (STA). Enable LDPC on STA2.		
2	-		Beacon/Probe responses	
3	Association Request		Association Response	If STA1 association fails, then fail
4		Association Request	Association Response	If STA2 association fails, then fail
5			RUN: PING <STA1_IP_ADDR> COUNT=90	If the ping request is not successful within 90 seconds, then fail. .– Ping Request – Using the sniffer verify that the SU/MU[0] Coding bit of VHT-SIG-A is ‘0’ in frames transmitted by the APUT.
6			RUN: PING <STA1_IP_ADDR> COUNT=90	If ping is not successful within 90 seconds, then fail. .– Ping Request – Using the sniffer verify that the SU/MU[0] Coding bit of VHT-SIG-A is ‘1’ in frames transmitted by the APUT.

Table 57: LDPC where the AP is the Transmitter Test Procedure and Results

4.2.54 LDPC where the AP is the Receiver

Purpose and Description
Verify that the APUT is appropriately supporting LDPC receive.
Verify that the APUT can simultaneously communicate with stations with and without LDPC.

Applicability
Optional
Mandatory if the APUT is capable of receiving LDPC frames

Test Environment
(Use a screen room)
APUT
STA1: Test bed Wi-Fi CERTIFIED ac with LDPC enabled
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
AP Control Channel	N/A	44 (if supported by APUT; else 36)
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	1	Default
LDPC Supported	Yes	Yes

Table 58: LDPC where the AP is the Receiver Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1 LDPC Capable	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable LDPC on STA1.		
2		Beacon/Probe responses	Using the sniffer verify in the Beacon transmitted by the APUT that Rx LDPC in VHT Capabilities is set to '1'. If not, then fail.
3	Association Request	Association Response	If STA1 association fails, then fail. Using the sniffer verify in the Association Response transmitted by the APUT that Rx LDPC in VHT Capabilities is set to '1'. If not, then fail.
4		RUN: PING <STA1_IP_ADDR> COUNT=90	If ping is not successful within 90 seconds, then fail. –Ping Response – Using the sniffer verify that the SU/MU[0] Coding bit of VHT-SIG-A is '1'in frames received by the APUT. If not, then fail.

Table 59: LDPC where the AP is the Receiver Test Procedure and Results

4.2.55 Operating Mode Notification Testing

Purpose and Description
Verify that the APUT can correctly receive the Operating Mode Notification information element or frame.

The Operating Mode Notification information element (IE=199) or frame is used to notify STAs that the transmitting STA is changing its operating channel width, the maximum number of spatial streams it can receive, or both. At association, the test bed STA uses the Operation Mode Notification information element to indicate a smaller bandwidth and number of spatial streams than the capability it announces. The test verifies that the APUT responds with the smaller bandwidth. Later the test bed STA notifies the APUT that it is increasing its operating channel width and number of spatial streams. The test verifies that the APUT responds accordingly.

Applicability
Mandatory (for receive) for the APUT

Reference
None

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac that supports transmitting Operating Mode Notification or frame, and implements 2 SS configuration
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Broadcom	-
AP Control Channel / Bandwidth , Nss	AP Control Channel: N/A Bandwidth and Nss: 80 MHz, 2 SS (VHT Capabilities information element); 20 MHz, 1 SS (Operating Mode Notification information element)	AP Control Channel: 56 (if supported by APUT; else 36) Bandwidth and Nss: 80 MHz / Default
New Channel / Bandwidth , Nss	New Channel: N/A Bandwidth andNss: 80 MHz, 2 SS (Operating Mode Notification frame)	

Table 60: Operation Mode Notification Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1 with support for 2 SS and Operation Mode Notification	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (STA). Enable 2SS and Operating Mode Notification.		
2		Sends out Beacons	If the Operating Mode Notification subfield in the Extended Capabilities information element in the Beacon is not set, then fail
3	Association Request with a) BW=80 MHz, Nss = 2 in the VHT Capabilities element, and (b) Operation Mode Notification element containing Nss=1 and BW=20 MHz	Association Response	If the Operating Mode Notification subfield in the Extended Capabilities information element in Association Response is not set, then fail
4	RUN: PING <APUT_IP_ADDR> COUNT=90 SIZE=10000		If the ping fails to continue then fail. Use the sniffer to verify: The ping response from the APUT is 20MHz and 1 SS. If not, then fail.
5	Use the STA1-supplied command to switch bandwidth and maximum number of SS (BW=80 MHz, Nss=2).		
6	RUN: PING <APUT_IP_ADDR> COUNT=90 SIZE=10000		If the ping fails to continue, then fail. If the vendor declared that the APUT implements 2 SS, check whether at least one ping response from the APUT is 80 MHz and 2 SS. If not, then fail. If the vendor declared that the APUT does not implement 2 SS and is not a MAP, then fail. If the vendor declared that the APUT is a MAP, check whether the ping response from the APUT is 80 MHz and 1 SS. If not, then fail

Table 61: Operation Mode Notification Test Procedure and Results

4.2.56 APUT acting as MU Beamformer

Purpose and Description
Verify that the APUT supports operation as MU Beamformer.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.1
IEEE 802.11ac-2013

Test Environment
Use a screen room
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA with MU beamformee capability enabled operating in 1x1 mode and supporting at least 4 sounding feedback streams
STA2: Test bed Wi-Fi CERTIFIED ac STA with MU beamformee capability enabled operating in 1x1 mode and supporting at least 4 sounding feedback streams
Wireless ac sniffer
All other test bed STA and AP devices shall be turned off
Position the sniffer, APUT, STA1, and STA2 as shown in Figure 2.

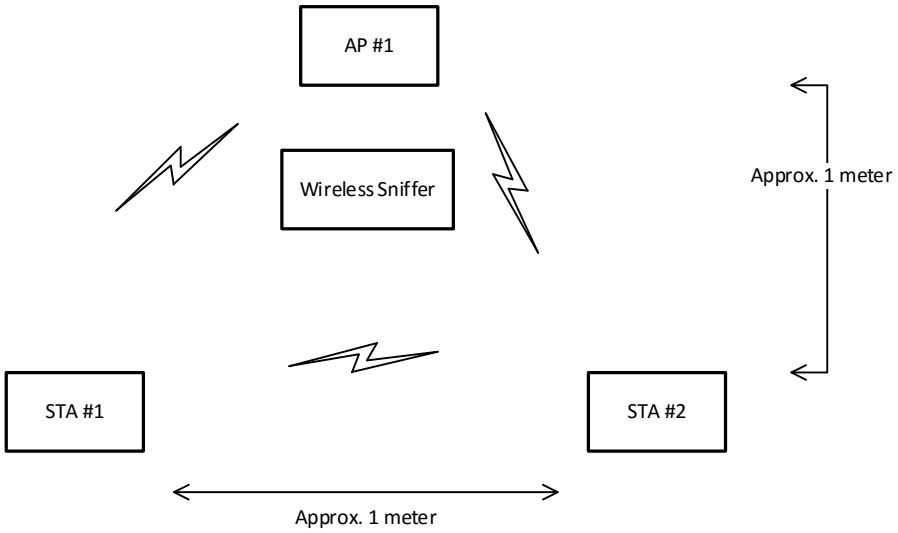

Figure 2: MU beamformer test setup

Prerequisites
APUT shall pass test 4.2.52.

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Quantenna	Qualcomm	-
Security	None	None	None
AP Control Channel	N/A	N/A	36
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Stream Support	1	1	Default

Table 62: AP MU Beamformer Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

PART 1: configuration and capabilities verification

Steps	Test bed Wi-Fi CERTIFIED ac STA1 MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac STA2 MU Beamformee Capable	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165 Enable MU beamformee capability on STA1. (operating in 1x1 mode)	Configure STA2 to Test bed Default Mode as per Table 165 Enable MU beamformee capability on STA2. (operating in 1x1 mode)	If not already enabled, enable MU Beamformer capability on APUT	
2	Configure STA1 to join APUT BSS	Configure STA2 to join APUT BSS	Beacon/Probe responses	SN: If the SU Beamformer Capable bit of VHT Capabilities Info field in the Beacon/Probe Response frames is set, then CONTINUE else FAIL. If MU Beamformer Capable bit of VHT Capabilities Info field in the Beacon/Probe Response frames is set, then CONTINUE else FAIL. If Number of Sounding Dimensions subfield in VHT Capabilities Info field in the Beacon frame is not 0 then CONTINUE else FAIL.
3	Association Request	Association Request	Association Response(s)	SN: If STA1 association fails, then FAIL. If STA2 association fails, then FAIL. Record the AssociationID for STA1 and STA2 Record Rx VHT-MCS Map subfield in the Supported VHT-MCS and NSS Set field in VHT Capabilities element in Association Request frame for STA1 and STA2 If the SU Beamformer Capable bit of VHT Capabilities Info field in the Association Response frame to either STA1 or STA2 is set, then CONTINUE else FAIL. If MU Beamformer Capable bit of VHT Capabilities Info field in the Association Response frame to either STA1 or STA2 is set, then CONTINUE else FAIL.

Steps	Test bed Wi-Fi CERTIFIED ac STA1 MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac STA2 MU Beamformee Capable	APUT	Expected Results
				If Number of Sounding Dimensions subfield in VHT Capability Info field in the Association Response frame to either STA1 or STA2 is not 0 then CONTINUE else FAIL.

PART 2: Group formation

Steps	Test bed Wi-Fi CERTIFIED ac STA1 MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac STA2 MU Beamformee Capable	APUT	Expected Results
4			MU Group Membership and User Position configuration. APUT sends Group ID management Action frames to STA1 and STA2. Transmit Parallel UDP1_BE, to STA1, STA2 for 60 Seconds	SN: Capture and parse the contents of the Group ID management Action frame. 1. IF STA1 and STA2 have at least 1 common bit set in the Membership Status bitmap within the range of [1:62] corresponding to a common groupID CONTINUE else FAIL. 2. Record all common groupIDs as GROUP_ID_LIST 3. For the identified common groupIDs, the User Position Array values should be distinct between STA1 and STA2 for at least one groupID else FAIL. Record these user positions as up1 for STA1 and up2 for STA2.

PART 3: MU sounding sequence

Steps	Test bed Wi-Fi CERTIFIED ac STA1 MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac STA2 MU Beamformee Capable	APUT	Expected Results
5			MU VHT Sounding sequence	SN: If APUT transmits a VHT NDP Announcement frame followed by a VHT NDP then CONTINUE else FAIL. Verify the following: 1. The VHT NDP Announcement frame RA is set to broadcast address: FF:FF:FF:FF:FF:FF 2. The VHT NDP Announcement frame contains two STA Info fields. Record STA Info 1 AID as STA_i1 and STA Info 2 AID as STA_i2 Each STA_info's a. AID12 field shall match with the AID values recorded in step 3 b. Feedback type field is set to 1: requesting MU-MIMO feedback c. Value of Nc (Nc Index field + 1) does not exceed the maximum number of supported spatial streams according to the Rx VHT-MCS Map subfield in the Supported VHT-MCS and NSS

Steps	Test bed Wi-Fi CERTIFIED ac STA1 MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac STA2 MU Beamformee Capable	APUT	Expected Results
				Set field in VHT Capabilities element of the STA as recorded in Step 3. 3. NDP Announcement frame uses BW=2 in VHT-SIG-A, or is sent in 80 MHz NON_HT_DUPLICATE format. If all are true, then CONTINUE else FAIL. SN: Verify the following VHT-SIG-A fields of the NDP: 1. BW = 80 MHz 2. GROUP_ID = 63 3. 1 < SU NSTS <= the value indicated in the Beamformee STS capability in VHT Capabilities Info field transmitted by STA 1. 4. 1 < SU NSTS <= the value indicated in the Beamformee STS capability in VHT Capabilities Info field transmitted by STA 2. If all are true, then CONTINUE else FAIL If the following are true in the VHT MIMO Control field of the VHT Compressed Beamforming frame: 1. 1 <= Nr Index <= the value indicated in the Beamformee STS Capability field in the VHT Capabilities information element transmitted by STA in position STA_i1 2. Channel Width = 2 (80 MHz); 3. Feedback Type = 1 (for MU). Then CONTINUE else FAIL.
6			BF report Poll	SN: If the APUT transmits BF report Poll frame to STA_i2 after APUT receives the VHT Compressed Beamforming frame from STA_i1 then CONTINUE else FAIL. If all the bits of the Feedback Segment Retransmission Bitmap field of the BF Report Poll are set to 1 then CONTINUE else FAIL.

PART4: Verify MU operation

Steps	Test bed Wi-Fi CERTIFIED ac STA1 MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac STA2 MU Beamformee Capable	APUT	Expected Results
7			APUT PPDU Verification	SN: Verify the following fields of VHT-SIG-A of the data frame from APUT: 1. The Beamformed (B8) bit in at least one PPDU transmitted by APUT is set to '1' after APUT receives the VHT Compressed Beamforming frames from STA_i1, STA_i2. 2. Group ID matches one of the group ID values in GROUP_ID_LIST established in Step 4. 3. MU[up1] NSTS and MU[up2] NSTS are equal to 1 (up1 and up2 are established in Step 4). If all above are TRUE then PASS else FAIL.

Table 63: AP acting as MU Beamformer Procedure and Results

4.2.57 Ability to Receive 4 Spatial Streams at APUT

Purpose and Description
Confirm that the APUT implements 4 SS on Rx side.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.4
IEEE 802.11ac-2013

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA operating in 11n mode implementing 4 SS configuration
STA2: Test bed Wi-Fi CERTIFIED ac STA implementing 4 SS configuration
Wireless ac Sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed

Parameter	STA1 Values	STA2 Values	APUT Values
Vendor	Broadcom	Qualcomm	-
Security	None	None	None
Spatial Streams Implemented	4	4	Default
AP Control Channel	-	-	36
Channel Width	40 MHz	80 MHz	80 MHz

Table 64: Ability to Receive 4 Spatial Streams at AP Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED n 4 SS 20/40 MHz Capable STA1	Test bed Wi-Fi CERTIFIED ac 4 SS STA2	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode (11n) as per Table 166 Enable Tx A-MPDU, A-MSDU and 4 SS.	Configure STA2 to Test bed Default Mode as per Table 165 Enable Tx A-MPDU, A-MSDU and 4 SS.	Beacon/Probe response frames	SN: If B6-B7 of the APUT Supported VHT-MCS and NSS Set field of the VHT capabilities IE in Beacon and Probe Response frames are not equal to 0b11 (4 SS not supported), then CONTINUE, else FAIL.
2	Association Request	Association Request	Association Response to STA1 and STA2	
3	Configure STA1 to transmit only 20 MHz, (HT) MCS31 (260 Mbps)	Configure STA2 to transmit only 20 MHz, Nss = 4, VHT MCS = 7(260 Mbps)		
4	RUN: PING <PC_ENDPOINT_IP_ADDR > SIZE=10000 Duration = 30 seconds	RUN: PING <PC_ENDPOINT_IP_ADDR > SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from either STA1 or STA2 occur, then FAIL, else CONTINUE.

				If more than 10% of pings fail from either STA1 or STA2, then FAIL, else CONTINUE.
5	Configure STA1 to transmit only 40 MHz (HT) MCS31 (540 Mbps)	Configure STA2 to transmit only 40 MHz, Nss = 4, VHT MCS = 7 (540 Mbps)		
6	RUN: PING <PC_ENDPOINT_IP_ADDR > SIZE=10000 Duration = 30 seconds	RUN: PING <PC_ENDPOINT_IP_ADDR > SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from either STA1 or STA2 occur, then FAIL, else CONTINUE. If more that 10% ping failures from either STA1 or STA2, then FAIL, else CONTINUE.
7		Configure STA2 to transmit only 80 MHz, Nss = 4, VHT MCS = 7 (1170 Mbps)		
8		RUN: PING <PC_ENDPOINT_IP_ADDR > SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts occur, then FAIL, else CONTINUE. If more that 10% ping failures, then FAIL, else PASS.

Table 65: Ability to Receive 4 Spatial Streams at AP Procedure and Results

4.2.58 Ability to Receive 160 MHz at APUT

Purpose and Description
Confirm that the APUT implements 160 MHz on Rx side.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.3
IEEE Draft Standard 802.11-REVmc/D5.2

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac implementing 160 MHz configuration
Wireless ac Sniffer
Use screen room
All other test bed STA and AP devices shall be turned off

Test Configuration
The following table defines the parameter values for the devices in the test bed

Parameter	STA1 Values	APUT Values
Vendor	Qualcomm	-
Security	None	None
Spatial Streams configured	Default	Default
AP Control Channel	-	36
Channel Width	160 MHz	160 MHz

Table 66: Ability to Receive 160 MHz at AP Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac 160 MHz STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165 Enable 160 MHz.	Configure APUT to enable 160 MHz bandwidth Beacon/Probe Response frames	SN: If Supported Channel Width Set of VHT Capabilities element in Beacon and Probe Response frame is equal to 1 or 2 (the AP supports 160 MHz or the AP supports 160 MHz and 80+80 MHz), then CONTINUE, else FAIL. SN: Verify the following in VHT Operation element in Beacon and Probe Response frame: 1. Channel Width subfield is set to 1. 2. Channel Center Frequency Segment 0 is set to 42 3. Channel Center Frequency Segment 1 is set to 50 IF all are true then CONTINUE, else FAIL.
2	Association Request	Association Response	SN: If the Association Response frame does not contain a SUCCESS status then fail, else CONTINUE.
3	Configure STA1 to transmit only: BW=160, MCS=7, Nss=1		

4	RUN: PING <APUT> SIZE=10000 Duration = 30		If more than 5 consecutive ping timeouts from STA1 occur, then FAIL, else CONTINUE. SN: • If the APUT transmits at least one BA or ACK in response to STA1's 160 MHz PPDU then Continue, else FAIL. • If no PPDUs from STA1 to APUT of bandwidth equal to 20 MHz or 40 MHz or 80 MHz are present then PASS else FAIL

Table 67: Ability to Receive 160 MHz at AP Procedure and Results

4.2.59A RTS with Static Bandwidth Signaling

Purpose and Description

Verify that the APUT correctly conforms to the operation of RTS with Static Bandwidth Signaling.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.6
IEEE 802.11ac-2013

Test Environment
Use a screen room
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA
Wireless ac Sniffer

The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Mediatek	-
Security	None	None
Spatial Stream Support	Default	Default
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz

Table 67: RTS with Static Bandwidth Signaling Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CRTIFIED ac STA1	APUT	Expected Results
1.	Configure test bed STA1 to Default Mode s per Table 165	Configure APUT to Default Mode as per Table 168	
2.		Beacon	SN: Verify the following in VHT Operation element in Beacon frame: 1. Channel Width subfield is set to 1 2. Channel Center Frequency Segment 0 is set to 42 3. Channel Center Frequency Segment 1 is set to 0 Verify the following in HT Operation element in Beacon frame: 1. Primary Channel is set to 36 2. Station Channel Width in VHT Operation Information subfield is set to 1 If all are true then CONTINUE, else FAIL.
3.	Association Request to APUT	Association Response to STA1	SN: If the Association Response frame contains a SUCCESS status then CONTINUE, else FAIL.
4.	Configure test bed STA1 to transmit 80 MHz CTS	Configure APUT to transmit RTS with static BW signaling (80 MHz)	

Steps	Test bed Wi-Fi CRTIFIED ac STA1	APUT	Expected Results
5.		Transmit UDP_1_BE to STA1 for 10 Seconds	SN: Verify the following: 1. The APUT transmits all RTS frames with static bandwidth signaling with BW field set to 80 MHz 2. Randomly select TXOP samples to perform the following check: • The APUT transmits all PPDUs with BW bits in the SERVICE field of the PPDU set to 80 MHz in the same TXOP as the CTS BW of 80 MHz • At least one or more PPDUs are sent during the TXOP duration If all are true then PASS, else FAIL. Note: For data gathering purpose, in WTS script check and print the value of the Individual/Group bit in the TA field of the RTS frame.

Table 68: RTS with Static Bandwidth Signaling Procedure and Results

4.2.59B RTS with Dynamic Bandwidth Signaling

Purpose and Description

Verify that the APUT correctly conforms to the operation of RTS with Dynamic Bandwidth Signaling.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.6
IEEE 802.11ac-2013

Test Environment
Use a screen room
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA
Wireless ac Sniffer

The following table defines the parameter values for the devices in the test bed.

Parameter	STA1 Values	APUT Values
Vendor	Quantenna	-
Security	None	None
Spatial Stream Support	Default	Default
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz

Table 69: RTS with Dynamic Bandwidth Signaling Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CRTIFIED ac STA1	APUT	Expected Results
1.	Configure test bed STA1 to Default Mode as per Table 165	Configure APUT to Default Mode as per Table 168	
2.		Beacon	SN: Verify the following in VHT Operation element in Beacon frame: 1. Channel Width is set to 1 Verify the following in HT Operation element in Beacon frame: 1. Primary Channel is set to 36 2. Station Channel Width in VHT Operation Information subfield is set to 1 If all are true then CONTINUE, else FAIL
3.	Association Request to APUT	Association Response to STA1	SN: If the Association Response frame does not contain a SUCCESS status then FAIL, else CONTINUE.
4.	Configure test bed STA1 to transmit 40 MHz CTS	Configure APUT to transmit RTS with dynamic BW signaling (80 MHz)	
5.		Transmit UDP1_BE to STA1 for 10 Seconds	SN: Verify the following:

Steps	Test bed Wi-Fi CRTIFIED ac STA1	APUT	Expected Results
			The APUT transmit at least one or more RTS with dynamic bandwidth signaling with BW field set to 80 MHz 1. PPDU of BW equal to 40 MHz or 20 MHz in the same TXOP as the CTS with BW_{CTS} equal to 40 APUT shall not transmit any PPDUs of BW equal to 80 MHz If all are true then PASS, else FAIL. Note: For data gathering purpose, in WTS script check and print the value of the Individual/Group bit in the TA field of the RTS frame.

Table 70: RTS with Dynamic Bandwidth Signaling Procedure and Results

4.2.60 Extended 5 GHz Channel Support on APUT

Purpose and Description
Confirm that the APUT implements extended 5 GHz channel support.

Applicability
Optional

Reference
IEEE 802.11ac-2013

Test Environment
APUT
STA1: Test bed Wi-Fi CERTIFIED ac STA, capable of operation in 5.15-5.35 and 5.47-5.85 GHz
Wireless ac Sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed

Parameter	STA1 Values	APUT Values
Vendor	Qualcomm	-
Security	None	None
Spatial Streams Implemented	Any	Default
AP Control Channel	-	64, 100, 140, 149, 165
Channel Width	80 MHz, 20 MHz (see test procedure)	80 MHz, 20 MHz (see test procedure)

Table 71: Extended 5 GHz Channel Support APUT Test Configuration

Note: Test Procedure may need to be run in a sealed container if APUT does not have any necessary regulatory approval for master mode operation (e.g. DFS) in the extended 5 GHz channels in the regulatory domain in which the tests are conducted.

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165	Configure APUT to Test bed Default Mode as per Table 168 on Channel 64 Beacon/Probe response frames	SN: If APUT is transmitting Beacon frames on Channel 64, then CONTINUE, else FAIL.
2	Association Request	Association Response	
3	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from STA1 occur, then FAIL, else CONTINUE.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165	Configure APUT to Test bed Default Mode as per Table 168 on Channel 100 Beacon/Probe response frames	SN: If APUT is transmitting Beacon frames on Channel 100, then CONTINUE, else FAIL.
2	Association Request	Association Response	
3	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from STA1 occur, then FAIL, else CONTINUE.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165	Configure APUT to Test bed Default Mode as per Table 168 on Channel 140. Configure APUT to 20 MHz operation only. Beacon/Probe response frames	SN: If APUT is transmitting Beacon frames on Channel 140, then CONTINUE, else FAIL.
2	Association Request	Association Response	
3	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from STA1 occur, then FAIL, else CONTINUE.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165	Configure APUT to Test bed Default Mode as per Table 168 on Channel 149 Beacon/Probe response frames	SN: If APUT is transmitting Beacon frames on Channel 149, then CONTINUE, else FAIL.
2	Association Request	Association Response	
3	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from STA1 occur, then FAIL, else CONTINUE.

Steps	Test bed Wi-Fi CERTIFIED ac STA1	APUT	Expected Results
1	Configure STA1 to Test bed Default Mode as per Table 165	Configure APUT to Test bed Default Mode as per Table 168 on Channel 165 Configure APUT to 20 MHz operation only. Beacon/Probe response frames	SN: If APUT is transmitting Beacon frames on Channel 165, then CONTINUE, else FAIL.
2	Association Request	Association Response	
3	RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 Duration = 30 seconds		If more than 5 consecutive ping timeouts from STA1 occur, then FAIL, else CONTINUE.

Table 72: Extended 5 GHz Channel Support APUT Procedure and Results

5. Wi-Fi CERTIFIED ac Station Testing

This section defines all the test cases for an STAUT for infrastructure and IBSS modes.

Default Testing Rules:

(1) Unless explicitly stated otherwise in a test case, all test bed devices have Channel Width set to 80 MHz in each test case of this Section 5.

(2) Unless explicitly stated otherwise in a test case, all test bed APs operate in 2 SS mode and all test bed STAs operate in 1 SS mode in each test case of this Section 5.

(3) If the STAUT fails a test, no further testing will be performed until the vendor addresses the problems and has updated the device.

(4) Every device (both test bed and DUT) is configured with an IP address before testing.

(5) “Test bed Default Mode” is specified in Annex E. STAUT default configuration for test procedures is specified in Annex F.

5.1 Configurability of Tests

5.1.1 General Configurability Tests

The STAUT shall be capable of being manually configured with the following parameters:
1. SSID
2. Local IP Address and subnet mask

If any of the above items cannot be configured through the user interface, then the STAUT fails.

5.1.2 Security Configurability Tests

If the vendor has declared support for WPA2-Enterprise and WPA2-Enterprise running EAP methods cannot be configured, then the STAUT fails.

If the WPA2-Personal pass phrase “12345678” cannot be configured, then the STAUT fails.

For Wi-Fi CERTIFIED ac interoperability the required security modes are:
- WPA2.

5.2 Infrastructure STAUT Test Cases

5.2.1 STA Out of Box (OOB)

5.2.1.1 STA Initial 5 GHz Operation

Purpose and Description
Test the STAUT for the SSID, open authentication mode or WPA2-Personal, and the channel width.

Applicability
Mandatory

Reference
Test case 5.2.1 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, implementing 3 SS, STBC, Short GI for 20 MHz, Short GI for 40 MHz, and Short GI for 80MHz
AP2: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac) operating as 802.11a
AP3: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac) operating as 802.11a
AP4: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration and Procedure
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values	AP2 Values	AP3 Values	AP4 Values
Vendor	-	Broadcom	Qualcomm	MediaTek	Quantenna
SSID	wi-fi	wi-fi	wi-fi	wi-fi	wi-fi
Security		None	WEP	WPA-Personal	WPA2-Personal
Encryption Key	-	-	0x9876543210	12345678	12345678
Beacon Interval (ms)	-	100	100	100	100
Channel	-	36	36	36	36
Channel Width	80 MHz	80 MHz	20 MHz	20 MHz	20 MHz
Spatial Streams Implemented	Default per Annex F	3	1	1	1

Table 73: STA Initial 5 GHz Operation Test Configuration

Test Procedure and Expected Results

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED n or Wi-Fi CERTIFIED ac AP2	Test bed Wi-Fi CERTIFIED n or Wi-Fi CERTIFIED ac AP3	Test bed Wi-Fi CERTIFIED ac AP4	Expected Results
1	If the vendor declared that the STAUT does not operate in 5 GHz OOB, configure for 5 GHz operation	Configure AP1 to Test bed Default Mode Enable 3 SS, STBC, Short GI for 20 MHz, Short GI for 40 MHz, Short GI for 80 MHz. Configure channel width to 80 MHz.	Configure AP2 to Test bed Default Mode (11a).	Configure AP3 to Test bed Default Mode (11a).	Configure AP4 to Test bed Default Mode Configure channel width to 20 MHz.	If not possible, fail
3		Beacon	Beacon	Beacon	Beacon	Check Beacons. If they do not match Table 72, reconfigure and restart test.
4	Association Request to AP1 or AP4	Association Response				The STAUT should connect to either AP1 or AP4 depending on its default security setting. If the STAUT did not associate, then fail. In the Association Request, look at the VHT Capabilities IE and record the Supported Features 1. Supported Channel Width (20/40/80 MHz only; or 20/40/80/160 MHz; or 20/40/80/160/80+80 MHz) 2. VHT Supported MCS Set (for 1 SS, 2 SS and 3 SS) 3. Short GI for 20 MHz 4. Short GI for 40 MHz 5. Short GI for 80 MHz 6. STBC If the supported features list does not match the submission declaration, then fail.
5	RUN: PING <AP1_IP_ADDR> Or RUN: PING <AP4_IP_ADDR>					If ping fails, then fail
6	Association Request to AP2					If the STAUT associates with AP2, then fail
7	Association Request to AP3					If the STAUT associates with AP3, then fail

Table 74: STA Initial 5 GHz Operation Procedure and Expected Results

5.2.2 STA WPA2 Initial Ping Interoperability Test

5.2.2.1 STA WPA2 Initial Ping Interoperability Test using Security

Purpose and Description
The initial ping test verifies that the STAUT can authenticate, associate and support pings to a wired authentication server on a subnet connected to the test configuration.

Applicability
Mandatory

Reference
Test case 5.2.2 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values
Vendor	-	MediaTek
SSID	-	wi-fi
Beacon Interval (ms)	-	100
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2
Security (see note bellow)	WPA2-Enterprise running TLS	WPA2-Enterprise running TLS
Supplicant/Server	-	HostAPd

Table 75: STA WPA2 Initial Ping Interoperability Test Configuration

Note: For the STAUT (vendor supplied supplicant) that does not support TLS, use the following table to choose the EAP method in priority order.

Priority	EAP
First	TTLS
Second	PEAP0
Third	PEAP1
Fourth	SIM
Fifth	FAST
Sixth	AKA

Table 76: EAP Priority Order

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode. Configure AP1 to support WPA2-Enterprise.	
2		Beacon	
3	Association Request	Association Response	If the STAUT fails to associate and authenticate to AP1, then fail.
4	RUN: PING <PC-ENDPOINT_IP_ADDR>		If the STAUT fails to receive ping responses from AP1 within 90 seconds, then fail.

Table 77: STA WPA2 Initial Ping Interoperability Procedure and Expected Results

5.2.3 AP and STA Association and Throughput, Honoring NAV

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.4 AP and STA Association and Throughput using Fragmentation

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.5 Mixed 802.11b/g Interoperabilty STA Testing

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.6 Mixed 802.11b/g Interoperabilty STA Testing with WPA-PSK

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.7 Mixed 802.11b/g Interoperabilty STA Testing with WEP or PSK Security

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.8 Mixed 802.11b/g Interoperabilty STA Testing with WPA-Enterprise

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.9 AP and STA Association and Throughput using WPA2-PSK

5.2.9.1 AP and STA Association and Throughput using WPA2-Personal

Purpose and Description
Verify that the STAUT can pass traffic using WPA2-Personal security mode.

Applicability
Mandatory

Reference
Test case 5.2.9 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac capable of being configured to support 1 SS (i.e., disabling 2 SS)
AP2: Test bed Wi-Fi CERTIFIED ac, implementing 3 SS
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values	AP2 Values
Vendor	-	Quantenna	Broadcom
SSID	-	wpa2	wpa2
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678	12345678
Spatial Streams Implmented	Default	See test procedure	3
Beacon Interval (ms)	-	100	100
AP Control Channel	-	36	36
Channel Width	80 MHz	80 MHz	80 MHz

Table 78: AP and STA Association and Throughput using WPA2-Personal Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	Expected Results
1		Configure AP1 to Test bed Default Mode Configure AP1 to 1 SS.	Configure AP2 to Test bed Default Mode Configure AP2 to 3 SS.	
2	Association Request	Association Response		If the Association Response does not contain a SUCCESS status, then fail. Check in Association Request: The Supported Channel Width in the VHT Capabilities Info Field of the VHT Capabilities IE should be ‘0’, ‘1’ or ‘2’. If not then fail.
3		Run script DT1-AP-DUT to the STAUT.		Measure throughput, = X1. If X1 < 5.2.9.1S1DT1, then fail
4	Run script DT1-DUT-AP to AP1.			Measure throughput, = X2. If X2 < 5.2.9.1S1DT2, then fail. Check using the sniffer that PPDUs transmitted by STAUT contain VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is ‘2’ and that throughput exceeds 5.2.9.1S1DT2. If both conditions are not satisfied, then fail.
If the vendor declared that the STAUT implements only 1 SS, then pass, and stop the test. If the vendor declared that the STAUT implements more than 1 SS, continue with the steps below.				
5	Disassociate			
6		Reconfigure AP1 to turn off special feature from step 1: i.e., enable 2 SS. Beacon, signaling Nss = 2.		If the Association Response does not contain a SUCCESS status, then fail. Check in Association Request: The Supported Channel Width in the VHT Capabilities Info Field of the VHT Capabilities IE should be ‘0’, ‘1’ or ‘2’. If not, then fail.
7	Association Request	Association Response		
8		Run script DT1-AP-DUT to STAUT		Measure throughput, = X3. If X3 < 5.2.9.1S2DT1, then fail.
9	Run script DT2-AP-DUT to AP1			Measure throughput, = X4. If X4 < 5.2.9.1S2DT2, then fail.
If the vendor declared that the STAUT implements only 2 SS, then pass, and stop the test. If the vendor declared that the STAUT implements more than 2 SS, continue with the steps below.				
10	Disassociate			
11			Beacon, signaling Nss = 3	
12	Association Request		Association Response	If the Association Response does not contain a SUCCESS status, then fail. Check in Association Request: The Supported Channel Width in the VHT Capabilities Info Field of the VHT Capabilities IE should be ‘0’, ‘1’ or ‘2’. If not, then fail.
13			Run script DT1-AP-DUT to STAUT	Measure throughput, = X5. If X5 < 5.2.9.1S3DT1, then fail.
14	Run script DT2-DUT-AP to AP2			Measure throughput, = X6. If X6 < 5.2.9.1S3DT2, then fail.

Table 79: AP and STA Association and Throughput using WPA2-Personal Procedure and Results

5.2.9.2 AP and STA Association and Throughput without Security

Purpose and Description
Verify that the STAUT can pass traffic without security.

Applicability
Optional. Skip if Open security is not supported.

Reference
Test case 5.2.9 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, configured to support 1 SS only
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values
Vendor	-	Quantenna
SSID	-	wpa2
Security	None	None
Beacon Interval (ms)	-	100
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	1

Table 80: AP and STA Association and Throughput without Security: Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode	
2		Beacon	Check Beacon. If it does not match Table 79, reconfigure and restart test..
3	Association Request	Association Response	If the Association Response does not contain a SUCCESS status, then fail. Check in Association Request: The Supported Channel Width in the VHT Capabilities Info Field of the VHT Capabilities IE should be ‘0’, ‘1’ or ‘2’.
4		Run script DT1-AP-DUT to STAUT	If recorded throughput is less than 5.2.9.2S1DT1, then fail
5	Run script DT2-DUT-AP to AP1		If recorded throughput is less than 5.2.9.2S1DT2, then fail

Table 81: AP and STA Association and Throughput without Security: Procedure and Results

5.2.10 AP and STA Association and Throughput using WPA2-Enterprise

5.2.10.1 AP and STA Association and Throughput using WPA2-Enterprise

Purpose and Description
Verify that the STAUT can pass traffic using WPA2-Enterprise security mode.

Applicability
Manadatory

Reference
Test case 5.2.10 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values
Vendor	-	Quantenna
SSID	-	wpa2
Security	WPA2-Enterprise running TLS	WPA2-Enterprise running TLS
Beacon Interval (ms)	-	100
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implmented	Default	1
Supplicant/Server	-	HostAPd

Table 82: AP and STA Association and Throughput using WPA2-Enterprise Configuration

Note: For the STAUT that does not support TLS, use the following table to choose the EAP method in priority order.

Priority	EAP
First	TTLS
Second	PEAP0
Third	PEAP1
Fourth	SIM
Fifth	FAST
Sixth	AKA

Table 83: Priority, EAP Types, Supplicant, and Servers

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode	
2		Beacon	
3	Association Request	Association Response	If the STAUT fails to associate, then fail.
4		Run script DT1-AP-DUT to STAUT	If recorded throughput is less than 5.2.10S1DT1**,** then fail.
5	Run script DT2-DUT-AP to AP1		If recorded throughput is less than 5.2.10S1DT2**,** then fail.
6		Run script DT3-AP-DUT to STAUT	If recorded throughput is less than 5.2.10S1DT3**,** then fail.

Table 84: AP and STA Association and Throughput using WPA2-Enterprise Procedure and Results

5.2.11 AP and STA Association and Throughput with Replay Counter Processing

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.12 AP and STA Association and Throughput using WEP

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.13 AP and STA Association and Throughput using WPA2 with Fragmentation

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.14 Broadcast/Multicast Transmission/Reception with WPA/WPA2-PSK Mixed Mode

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.15 Pre-authentication

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.16 PMK Caching

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.17 WPA Specific Countermeasures – Legacy WPA Only Mode

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.18 WPA Specific Countermeasures – WPA2/WPA Mixed Mode

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.19 WPA2 Negative Tests – Non-association with an AP not using WPA2

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.20 WPA2 Negative Tests – Non-association with PSK-Configured Station

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.21 WPA2 Negative Tests – Non-association with a TLS-Configured Station

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.22 802.11h Testing – Spectrum Management Bit

5.2.22.1 802.11h Testing – Spectrum Management Bit

Purpose and Description
Verify 802.11h operation with AP configuration as indicated.

Applicability
Optional

Reference
Test case 5.2.22 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode), supporting Spectrum Management Bit
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values
Vendor	-	MediaTek
SSID	-	80211h
Beacon Interval (ms)	-	100
Channel	-	56
Channel Width	80 MHz	40 MHz
Spatial Streams Implmented	Default	2
Minimum # Beacons with Switch Announcement information element after channel switch command	-	10
New Channel Number	-	36 (or any non DFS channel)
Channel Switch Mode	-	1 (silence STA)

Table 85: 802.11h Testing – Spectrum Management Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED n AP1	Expected Results
1		Configure AP1 to Test bed Default Mode (11n).	
2		Beacon/Probe Response	Set up the sniffer to capture the Association Request from the STAUT to AP1
3	Association Request	Association Response	Look in Capability Info section of the Association Request for the spectrum management bit. This test passes if the spectrum management bit is set to 1.

Table 86: 802.11h Testing – Spectrum Management Bit Procedure and Results

5.2.23 802.11h Testing — Channel Switch Test

5.2.23.1 802.11h Testing -- Channel Switch Test

Purpose and Description
Verify channel switching operation with AP configuration as indicated.

Applicability
Optional

Reference
Test case 5.2.23 in Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac supporting Channel Switch Announcement information element, Channel Wrapper IE and Wide Bandwidth Channel Switch subelement.
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameters	STAUT Values	AP1 Values
Vendor	-	Quantenna
SSID	-	80211h
Spatial Streams Implementedt	Default	2
Beacon Interval (ms)	-	100
AP Control Channel/Bandwidth	-	CH = 52 (if supported by APUT; else 36) / BW = 80 MHz
Minimum # Beacons with Switch Announcement information element after channel switch command	-	10
New Channel Number/Bandwidth	-	CH = 100 (if supported by APUT; else 149) / BW = 80 MHz
Channel Switch Mode	-	1 (silence STA)

Table 87: Channel Switch Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode.	
2		Beacon/Probe Response	
3	Association Request	Association Response	
4	RUN: PING <PC-ENDPOINT_IP_ADDR> CONTINUOUS=YES		Set up the sniffer to capture the traffic from the STAUT.
5		Use the AP1-supplied command to force a channel switch announcement. (AP1 transmits beacons which contain CSA IE, Channel Wrapper IE and Wide Bandwidth Channel Switch subelement.)	Sniff the wireless traffic, starting with initial Channel Switch Announcement and for an additional 15 seconds.
6		Wait until the STAUT switches to new channel, then RUN: PING <STAUT_IP_ADDR> .	Verify that at least the last 6 beacons as captured by the sniffer contain the Channel Switch Announcement IE, Channel Wrapper IE and Wide Bandwidth Channel Switch subelement. The test passes if the STAUT stops sending any frames, and no further frames are transmitted on the initial channel by the STAUT after AP1 has sent the last 6 beacons, with the Channel Switch Announcement information elements, Channel Wrapper IE and Wide Bandwidth Channel Switch subelement as seen with the sniffer. The test passes if AP1 receives ping response from STAUT in the new channel.

Table 88: Channel Switch Test Procedure and Results

5.2.24 Extended EAP Tests (Enterprise STAs Only)

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.25 (Removed from Wi-Fi CERTIFIED n Test Plan)

5.2.26 Roaming Test for Dual Band STAs with WPA-PSK

5.2.26.1 Roaming Test for Single and Dual Band STAs with WPA-Personal

Purpose and Description
This tests the ability of the station to roam between Wi-Fi CERTIFIED ac and Wi-Fi CERTIFIED n access points.

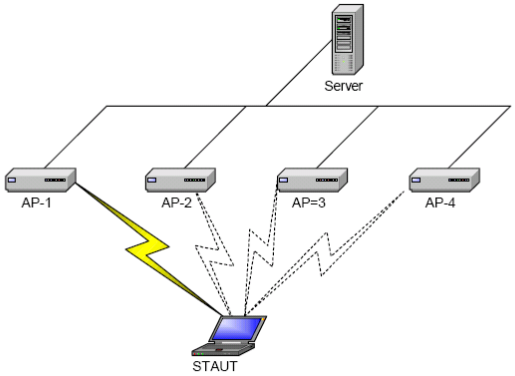

Figure 3: Dual Band Roaming Test for Dual Band STAs with WPA-Personal Network Diagram

The STAUT is forced to roam from AP1 to AP2 to AP3 to AP4 and back to AP1.
Pings shall not be lost for more than 90 seconds during a roam from one AP to the next.

Applicability
Mandatory

Reference
Test case 5.2.26 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
AP2: Test bed Wi-Fi CERTIFIED ac
AP3: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
AP4: Test bed Wi-Fi CERTIFIED ac

Test Configuration

The following table defines the parameter values for the devices in the test bed. If the STAUT does not support 2.4 GHz, configure all four test bed APs to 5 GHz.

Parameter	STAUT Values	AP1 Values	AP2 Values	AP3 Values	AP4 Values
Vendor	-	Qualcomm	Quantenna	Broadcom	Marvell
Beacon Interval ms	-	100	100	100	100
AP Control Channel	-	6 (36 if the STAUT does not support 2.4 GHz (0 SS))	36	6 (36 if the STAUT does not support 2.4 GHz (0 SS))	36
Channel Width	80 MHz	40 MHz	80 MHz	40 MHz	80 MHz
Spatial Streams Implemented	Default	2	2	2	2
ESSID	-	“012345678901234567890123456789 01”	“0123456789012345 6789012345678901”	“012345678901234567890123456789 01”	“01234567890123456789 012345678901”
Security	-	WPA2-AES Pass Phrase 12345678	WPA2-AES Pass Phrase 12345678	WPA2-AES Pass Phrase 12345678	WPA2-AES Pass Phrase 12345678

Table 89: Dual Band Roaming Test for Dual Band STAs with WPA-Personal Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Continuous pings at one second intervals are used to validate connectivity with the PC. Pings shall not be lost for more than 90 seconds during a roam from one AP to the next.

Steps	STAUT	Test bed Wi-Fi CERTIFIED n AP1	Test bed Wi-Fi CERTIFIED ac AP2	Test bed Wi-Fi CERTIFIED n AP3	Test bed Wi-Fi CERTIFIED ac AP4	Expected Results
1		Configure AP1 to Test bed Default Mode (11n). Enable 40 MHz.	Configure AP2 to Test bed Default Mode.	Configure AP3 to Test bed Default Mode (11n). Enable 40 MHz.	Configure AP4 to Test bed Default Mode..	
2		Beacon/Probe Response	Disable AP2	Disable AP3	Disable AP4	
3	The STAUT is associated to AP1.					If the STAUT is not associated to AP1, then fail.
4	RUN: PING <PC-ENDPOINT_IP_ADDR> CONTINUOUS=YES					If the pings are successful, then pass.
5		Disable AP1	Beacon/Probe Response	Disable AP3	Disable AP4	
6	Continue the pings to thePC-ENDPOINT.					If the STAUT roams within 90 seconds, then pass.
7		Disable AP1	Disable AP2	Beacon/Probe Response	Disable AP4	
8	Continue the pings to thePC-ENDPOINT.					If the STAUT roams within 90 seconds, then pass.
9		Disable AP1	Disable AP2	Disable AP3	Beacon/Probe Response	
10	Continue the pings to thePC-ENDPOINT.					If the STAUT roams within 90 seconds, then pass.
11		Beacon/Probe Response	Disable AP2	Disable AP3	Disable AP4	
12	Continue the pings to thePC-ENDPOINT.					If the STAUT roams within 90 seconds, then pass.

Table 90: Dual Band Roaming Test for Dual Band STAs with WPA-Personal Procedure and Results

5.2.27 Traffic Differentiation in Single BSS with 802.11n STA

5.2.27.1 Traffic Differentiation in Single BSS with Wi-Fi CERTIFIED ac STA

Purpose and Description
Test WMM capability negotiation.
Verify internal and distributed traffic differentiation between different traffic classes and various PHY rates between a single pair.

This test is performed between a single AP and a single STA to show that a DUT correctly differentiates packets. Two streams with different AC are transmitted from a DUT and the throughputs are compared in the same manner as the above differentiation tests. The background traffic stream provides enough additional traffic to saturate the wireless link.

Applicability
Mandatory

Reference
Test case 5.2.27 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Broadcom
Security	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678
AP Control Channel	-	36
AIFS	Default (see Annex C)	Default (see Annex C)
CWmin	Default (see Annex C)	Default (see Annex C)
CWmax	Default (see Annex C)	Default (see Annex C)
TXOPLimit	Default (see Annex C)	Default (see Annex C)
ACM: AC_VO	-	0
ACM: AC_VI	-	0
ACM: AC_BE	-	0
ACM: AC_BK	-	0
AC Tagging	Default for STAUT	DSCP
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	1

Table 91: Traffic Differentiation in a Single BSS with Wi-Fi CERTIFIED ac STA Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode	
2	-	Beacon	AP supports; - 80 MHz Channel Width - Rx SS1 - Tx SS1
3	Probe request	Probe Response	Use the sniffer to verify: If a Probe Request occurs and Probe Request contains WMM IE, then fail
4	Association Request	Association Response	Use the sniffer to verify: If Association Request contains WMM information element and STAUT associated, then pass
5	Prerequisite step: Transmit UDP1	Receive UDP1	Total TPT > 150 Mbps. If not - check for environmental interferences before continuing. Set TPT_X_Param = Total TPT (i.e., store the measured throughput value as TPT_X_Param)
6	Receive UDP1_BE, UDP2_VI Transmit UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Transmit UDP1_BE UDP2_VI Receive UDP3_BE	Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 75% UDP2 in first phase (1-30) If all conditions apply, then pass
7	Transmit UDP1_BE, UDP2_VI UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Receive UDP1_BE UDP2_VI UDP3_BE	Use the sniffer to verify: In a UDP1_BE QoS Data frame, if QoS Control Field UP=000_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=10_2, subtype=1000_2, then pass. Use the sniffer to verify: In a UDP2_VI QoS Data frame, if QoS Control Field UP=101_2 or 100_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=10_2, subtype=1000_2, then pass. Use the sniffer to verify: In a UDP3_BE QoS Data frame, if QoS Control Field UP=000_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=102, subtype=1000_2, then pass. Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30) If all conditions apply, then pass
8	Transmit UDP1_BE, UDP2_VI Receive UDP3_BE	Receive UDP1_BE UDP2_VI Transmit UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80% UDP2 in first phase (1-30) If all conditions apply, then pass
9	Transmit UDP1_BK, UDP2_BE Receive UDP3_BK	Receive UDP1_BK UDP2_BE Transmit UDP3_BK	Use the sniffer to verify: In a UDP2_BE QoS Data frame, if QoS Control Field UP=000_2 or 011_2, EOSP=0_2, ACKPOLICY=00_2 and the frame type=10_2, subtype 1000_2, then pass.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
		(note that UDP3 traffic starts by definition after a 30 second delay)	Use the sniffer to verify: In a UDP1_BK QoS Data frame, if QoS Control Field UP=010_2 or 0012, EOSP=02, ACKPOLICY=00_2 and the frame type=10_2, subtype=1000_2, then pass. Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30) If all conditions apply, then pass
10	Transmit UDP1_VI, UDP2_VO Receive UDP3_VI	Receive UDP1_VI UDP2_VO Transmit UDP3_VI (note that UDP3 traffic starts by definition after a 30 second delay)	Use the sniffer to verify: In a UDP2_VO QoS Data frame, if QoS Control Field UP=110_2 or 111_2, EOSP=0_2, ACKPOLICY=00 and the frame type=10_2, subtype=1000_2, then pass. Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30) If all conditions apply, then pass

Table 92: Traffic Differentiation in a Single BSS with Wi-Fi CERTIFIED ac STA Procedure and Results (80 MHz)

5.2.28 Traffic Differentiation in Single BSS with 2 802.11n STAs

5.2.28.1 Traffic Differentiation in Single BSS with Two Wi-Fi CERTIFIED ac STAs

Purpose and Description
Verify internal and distributed traffic differentiation between different traffic classes at various PHY rates involving an AP and two STAs with downstream/ upstream traffic.

For differentiation tests, the general approach is to run traffic streams using only two different priorities for any one test. Several of the tests use two streams of the lower priority to clearly show the differentiation. The intended load (load – for definition see section 3.5.1 of RFC2285) of the higher priority stream does not exceed the link capacity. The background traffic stream provides enough additional traffic to saturate the wireless link. This is true regardless of whether the priority of the background traffic is higher or lower than the DUT's traffic. Thus the total intended load of the two streams exceeds the link capacity. In this situation, it is simple to compare the backoff algorithms of two devices – the higher priority stream should always get the bandwidth it needs to achieve its intended load, while the lower priority stream gets whatever is left over.

Applicability
Mandatory

Reference
Test case 5.2.28 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
STA1: Test bed Wi-Fi CERTIFIED ac
AP1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	STA1 Values	AP1 Values
Vendor	-	Quantenna	Qualcomm
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	12345678	12345678	12345678
AP Control Channel	-	-	36
AIFS	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
CWmin	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
CWmax	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
TXOPLimit	Default (see Annex C)	Default (see Annex C)	Default (see Annex C)
ACM: AC_VO	-	-	0
ACM: AC_VI	-	-	0
ACM: AC_BE	-	-	0
ACM: AC_BK	-	-	0
AC Tagging	Default for STAUT	DSCP	DSCP
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	Default	1	1

Table 93: Traffic Differentiation with Two Wi-Fi CERTIFIED ac STA Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results

.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure STA1 to Test bed Default Mode.	Configure AP1 to Test bed Default Mode.	
2		-	Beacon	
3	Probe Request	Probe Request	Probe Response	Use the sniffer to verify: If a Probe Request occurs and STAUT Probe Request contains WMM IE, then fail.
4	Association Request	Association Request	Association Response	Use the sniffer to verify: If the STAUT Association Request contains an WMM information element and the STA is associated, then pass.
5	Prerequisite step: Transmit UDP1		Receive UDP1	Total TPT_X > 150 Mbps. If not, check for environmental interference before continuing.
6		Prerequisite step: Transmit UDP1	Receive UDP1	Total TPT _Y > 150 Mbps. If not, check for environmental interference before continuing. Set TPT_X_Param = min(Total TPT_X, Total_Y).
7	Transmit UDP1_BE,	Transmit UDP2_VI UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Receive UDP1_BE UDP2_VI UDP3_BE	Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30s) If all conditions apply, then pass.
8	Transmit UDP2_VI	Transmit UDP1_BE UDP3_BE (note that UDP3 traffic starts by definition after a 30 second delay)	Receive UDP1_BE UDP2_VI UDP3_BE	Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30s) If all conditions apply, then pass.
9	Transmit UDP1_BK,	Transmit UDP2_BE UDP3_BK (note that UDP3 traffic starts by definition after a 30 second delay)	Receive UDP1_BK UDP2_BE UDP3_BK	Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30s) If all conditions apply, then pass.
10	Transmit UDP1_VI,	Transmit UDP2_VO UDP3_VI (note that UDP3 traffic starts by definition after a 30 second delay)	Receive UDP1_VI UDP2_VO UDP3_VI	Check: - Total TPT > 90 % TPT_X_Param - UDP2 TPT >= 110 Mbps - UDP2 in second phase (31-60s) >= 80 % UDP2 in first phase (1-30s) If all conditions apply, then pass.

Table 94: Traffic Differentiation with 2 Wi-Fi CERTIFIED ac STAs Procedure and Results

5.2.29 Traffic Differentiation in Single BSS with WMM STA

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.30 Traffic Differentiation in Single BSS with Legacy non-WMM STA

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.31 Test ACM Bit Conformance

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.32 Test the AC Parameter Modification

5.2.32.1 Test the AC Parameter Modification

Purpose and Description
Test whether the STAUT honors AC Parameters by making a higher priority AC have "worse" AC parameters and then verify that its performance is degraded.

Determine whether the behavior of a STAUT conforms to the AC parameter settings (AIFSN, CWmin, TXOP) distributed in the Beacon. AC Parameter tests are only performed on STAUT. In one test, the test bed AP is configured to vary the AC parameters on a particular AC such that a higherpriority AC has "worse" AC parameters and then make sure that AC's performance is degraded compared to a lower number AC. Thus the measured throughput should be less than the reference streams.

Applicability
Mandatory

Reference
Test case 5.2.32 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
STA1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
STA2: Test bed Wi-Fi CERTIFIED ac
AP1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	STA1 Values	STA2 Values	AP1 Values
Vendor	-	Quantenna	Broadcom	Quantenna
AP Control Channel	-	-	-	36
Spatial Streams Implemented	Default	1	1	1
AIFS_VO	-	-	-	2
AIFS_VI	-	-	-	10
AIFS_BE	-	-	-	2
AIFs_BK	-	-	-	2
CWmin (for all 4 ACs)	-		-	7 (ECWMIN=3)
CWmax (for all 4 ACs)	-	-	-	15 (ECWMAX=4)
TXOP Limit: AC_VO	-	-	-	Default
TXOP Limit: AC_VI	-		-	Default
TXOP Limit: AC_BE	-	-	-	Default
TXOP Limit: AC_BK	-	-	-	Default
ACM: AC_VO	-	-	-	0
ACM: AC_VI	-	-	-	0
ACM: AC_BE	-	-	-	0
ACM: AC_BK	-	-	-	0
AC Tagging	Default for STAUT	DSCP	DSCP	DSCP
Channel Width	80 MHz	40 MHz	80 MHz	80 MHz

Table 95: Test the AC Parameter Modification Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED n STA1	Test bed Wi-Fi CERTIFIED ac STA2	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure STA1 to Test bed Default Mode - 11n.	Configure STA2 to Test bed Default Mode.	Configure AP1 to Test bed Default Mode. Configure AP1 to 1 SS.	
2	-	-	-	Beacon	
3	(Optional) Probe Request	(Optional) Probe request	(Optional) Probe request	Probe Response	
4	Association Request	Association Request	Association Request	Association Response	
5	Prerequisite step: Transmit UDP1			Receive UDP1	Total TPT > 150 Mbps. If not - check for environmental interference before continuing.
6	Transmit UDP2_VI UDP3_BE (Note that UDP3 traffic by definition starts after a 30 scond delay)	Transmit UDP4_BE	Transmit UDP1_BE	Receive UDP1_BE UDP2_VI UDP3_BE UDP4_BE	Check: Receive Data UDP1, UDP2, UDP3, UDP4. Verify that: - UDP2 in second phase <= 155**%** UDP1 in second phase (31~60s), - UDP2 in second phase (31~60s) <= 155**%** UDP3 in second phase (31~60s) - UDP2 in second phase (31~60s) <= 155 % UDP4 in second phase (31~60s) If all conditions apply, then pass.

Table 96: Test the AC Parameter Modification Procedure and Results

5.2.33 TXOP Limit Test

5.2.33.1 TXOP Limit Test

Purpose and Description
Determine whether the STAUT adheres to the TXOP limit rules broadcast from the AP.

The STAUT is tested to determine if its behavior conforms to the AC parameter settings (AIFSN, CWmin, TXOP) distributed in the Beacon. AC Parameter tests are only performed on STAUT. In this test, the TXOP limit for an AC is increased and the throughput is compared to a reference stream. The comparison threshold is directly proportional to the TXOP limit. If the STA is honoring the TXOP limit, its throughput will be less than the threshold.

Applicability
Mandatory

Reference
Test case 5.2.33 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
STA1: Test bed Wi-Fi CERTIFIED ac
AP1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	STA1 Values	AP1 Values
Vendor	-	Quantenna	Qualcomm
AP Control Channel	-	-	36
aIFS (for all ACs)	2	2	1
CWmin (for all 4 ACs)	7 (ECWMIN=3)	7 (ECWMIN=3)	7 (ECWMIN=3)
CWmax (for all 4 ACs)	15 (ECWMAX=4)	15 (ECWMAX=4)	15 (ECWMAX=4)
TXOPLimit: AC_VO	1 (32μS)	1 (32μS)	1 (32μS)
TXOPLimit: AC_VI	See steps 3, 5, and 7 Below	See steps 3, 5, and 7 Below	0 (one frame)
TXOP Limit: AC_BE	0 (one frame)	0 (one frame)	0 (one frame)
TXOP Limit: AC_BK	1 (32μS)	1 (32μS)	1 (32μS)
ACM: AC_VO	-	-	0
ACM: AC_VI	-	-	0
ACM: AC_BE	-	-	0
ACM: AC_BK	-	-	0
AC Tagging	Default for STAUT	DSCP	DSCP
Channel Width	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	Default	1	1

Table 97: TXOP Test Limit Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure STA1 to Test bed Default Mode. Configure STA1 to transmit only VHT MCS = 7 (292.5 Mbps)	Configure AP1 to Test bed Default Mode. Configure AP1 to 1 SS. Set TXOP limit: AC_VI = 0 (1 frame).	
2			Beacon	
3	Association Request	Association Request	Association Responses	
4	Prerequisite step: Transmit UDP1		Receive UDP1	Total TPT > 150 Mbps. If not - check for environmental interferences before continuing.
5	Transmit UDP1_VI	Transmit UDP2_BE	Receive UDP1_VI, UDP2_BE	Receive Data UDP1, UDP2 Check: UDP1 <= 177% UDP2 If so, then pass.
6	-	-	Set TXOP limit: AC_VI = 24 (768 µS)	
7	Transmit UDP1_VI	Transmit UDP2_BE	Receive UDP1_VI, UDP2_BE	Receive Data UDP1, UDP2 Check: UDP1 <= 261% UDP2 If so, then pass.
8	-	-	Set TXOP limit: AC_VI = 34 (1088 µS)	
9	Transmit UDP1_VI	Transmit UDP2_BE	Receive UDP1_VI, UDP2_BE	Receive Data UDP1, UDP2 Check: UDP1 <= 377% UDP2 If so, then pass.

Table 98: Test the AC Parameter Modification Procedure and Results

5.2.34 STAUT "No Acknowledgement" Test

5.2.34.1 STAUT "No Acknowledgement" Test

Purpose and Description
Verify that the STAUT operates correctly when it receives QoS packets with "No Acknowledgement".

The test bed transmitter is configured to set the ACK policy to "No Acknowledgement" in the QoS control field of a traffic stream. A sniffer is used to verify that Acknowledgement packets are not being sent by the STAUT. The throughput with the ACK policy set to "No Acknowledgement" is compared with the ACK Policy set to Acknowledgement. The test passes if the throughput is the same or higher.

Applicability
Mandatory

Reference
Test case 5.2.34 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode), 40 MHz capable
Wireless Wi-Fi CERTIFIED n Sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Broadcom
AP Control Channel	-	36
Channel Width	80 MHz	40 MHz
Spatial Streams Implemented	Default	2
AIFS	Default (see Annex C)	Default (see Annex C)
CWmin	Default (see Annex C)	Default (see Annex C)
CWmax	Default (see Annex C)	Default (see Annex C)
TXOPLimit	Default (see Annex C)	Default (see Annex C)
ACM: AC_VO	-	0
ACM: AC_VI	-	0
ACM: AC_BE	-	0
ACM: AC_BK	-	0
AC Tagging	Default for STAUT	DSCP

Table 99: STAUT "No Acknowledgement" Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED n AP1	Expected Results
1		Configure AP1 to Test bed Default Mode (AP (11n)). Enable 40 MHz capability.	
2	-	Beacon	
3	Probe request	Probe Response	(Probe requests are optional)
4	Association Request	Association Response	
5	Receive UDP1_BE, UDP2_VI	Transmit UDP1_BE UDP2_VI	Use the sniffer to verify: QoS Data frame Verify ACK policy bits are set to "Acknowledge" in packets from AP. If the STAUT generates ACK packets, then pass. Check: Receive Data UDP1 and UDP2. Record values of UDP1 and UDP2 throughput
6		Configure the test bed AP to set the "ACK policy"field to "012" (no acknowledgement) in QoS Control frames for all AC (see note to Test Case 5.2.34 in the Wi-Fi CERTIFIED n Test Plan).	
7	Receive UDP1_BE, UDP2_VI	Transmit UDP1_BE UDP2_VI	Use the sniffer to verify: QoS Data frame. Verify ACK policy bits are set to "No Acknowledge" in packets from AP. If the STAUT does not generate ACK packets, then pass. Check: Receive Data UDP1 and UDP2 If UDP1-T07 and UDP2-T07 are >= 88% of UDP1-T05 and UDP2-T05 respectively, then pass.

Table 100: STAUT "No Acknowledgement" Test Procedure and Results

5.2.35 Basic Association in 802.11n Environment

5.2.35.1 Basic Association in the Wi-Fi CERTIFIED ac Environment

Purpose and Description
Test Association Request frame format and the existence of the appropriate information elements.
Test adherence of STAUT to the operating mode advertisement and protection mechanism used.

Applicability
Mandatory

Reference
Test case 5.2.35 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac
AP2: Test bed Wi-Fi CERTIFIED ac that sets the VHT SIG-B CRC to a fixed value (e.g. all “0”)
STA1: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
STA2: Test bed Wi-Fi CERTIFIED n 20/40 MHz capable (or test bed Wi-Fi CERTIFIED ac operating in 11n mode)
STA3: Test bed Wi-Fi CERTIFIED n (or test bed Wi-Fi CERTIFIED ac) operating in 11a mode
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	STA1 Values	STA2 Values	STA3 Values	AP1 Values	AP2 Values
Vendor	-	Broadcom	Quantenna	Intel	Broadcom	Qualcomm
Security	WPA2-Personal	WPA2-Personal	WPA2-Personal	WPA2-Personal	WPA2-Personal	WPA2-Personal
Encryption Key	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
Channel Width	80 MHz	40 MHz	20 MHz	20 MHz	80 MHz	80 MHz
Spatial Streams Implemented	Default	2	2	2	2	2
AP Control Channel	-	-	-	-	36 (one test run in each channel)	36 (one test run in each channel)

Table 101: Basic Association in Wi-Fi CERTIFIED ac Environment Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED n STA1	Test bed Wi-Fi CERTIFIED n STA2	Test bed Wi-Fi CERTIFIED n STA3	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	Expected Results
1		Configure STA1 to Test bed Default Mode -11n. Enable 40 MHz capability.	Configure STA2 to Test bed Default Mode -11n.	Configure STA3 to Test bed Default Mode	Configure AP1 to Test bed Default Mode.	Configure AP2 to Test bed Default Mode. Configure AP2 to set the VHT SIG-B CRC field to a fixed value (e.g. all ”0”).	
2					Beacon		
3	Association Request to AP1	-	-	-	Association Response to STAUT		Check the Association Request for the VHT Capability IE and record the supported features: a. Short GI for 80 MHz b. VHT Supported MCS Set (1 SS, 2 SS, and 3 SS) c. Tx STBC d. Rx STBC If the supported list does not match the submission declaration, then fail.
4	RUN: PING <AP1_IP_ADDR> SIZE=10000 CONTINUOUS=YES						If more than 5 consecutive ping timeouts occur, then fail If more that 10% ping failures, then fail. In the PingRequest transmitted by the STAUT, check using the sniffer that at least one PPDU transmitted by the STAUT contains VHT-SIG-A and the BW bits (B0,B1) of VHT-SIG-A1 is ‘2’. If not, then fail.
5		Association Request to AP1 (After 30 seconds)	-	-	Association Response to STA1		If the ping from STAUT to AP is stopped, then fail.
6			Association Request to AP1 (After 30 seconds)		Association Response to STA2		If the ping from STAUT to AP is stopped then fail
7				Association Request to AP1 (After 30 seconds)	Association Response to STA3		If the ping from STAUT to AP is stopped, then fail.

Steps	STAUT	Test bed Wi-Fi CERTIFIED n STA1	Test bed Wi-Fi CERTIFIED n STA2	Test bed Wi-Fi CERTIFIED n STA3	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	Expected Results
8		(After 30 seconds) Disassociate					
9			(After 30 seconds) Disassociate				
10				(After 30 seconds) Disassociate			
11	Association Request to AP2					Association Response to STAUT	
12	RUN: PING <AP2_IP_ADDR> SIZE=10000 CONTINUOUS=YES						If more than 5 consecutive ping timeouts occur, then fail. If there are more than 20% ping failures, then fail.

Table 102: Basic Association in Wi-Fi CERTIFIED ac Environment Procedure and Results

5.2.36 Ability to Receive 1 and 2 Spatial Streams

5.2.36.1 Ability to Receive 1 and 2 Spatial Streams

Purpose and Description
Confirm that the STAUT implements 1 SS and, if implemented, 2 SS, in Rx side.

Applicability
Mandatory

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of being configured to support 1 SS only
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Qualcomm
AP Control Channel	-	36.
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2

Table 103: Ability to Receive 1 and 2 Spatial Streams Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode.	
2	-	Beacon/Probe responses	
3	Association Request	Association Response	If the STAUT VHT supported MCS Set field in the VHT Capabilities IE contains 11 in bits B0, B1, and/or contains 11 in bits B32, B33, then fail.
4		Configure AP1 to transmit only VHT MCS 7.	
5		RUN: PING <STAUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Verify that the AP1 PPDUs are 80 MHz VHT packets and not 11n. If they are not 80 MHz VHT packets, then fail.
If the vendor declared that the STAUT implements 2 SS, then continue. If not, then pass; stop the test.			
6			Check Association Request. If the STAUT VHT supported MCS Set field in the VHT Capabilities IE contains 11 in bits B2, B3, and/or contains 11 in bits B34 and B35, then fail.
7		Configure AP1 to transmit only VHT MCS 7.	
8		RUN: PING <STAUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Verify that the AP1 PPDUs are 80 MHz VHT packets and not 11n. If they are not 80 MHz VHT packets, then fail.

Table 104: Ability to Receive 1 and 2 Spatial Streams Procedure and Results

5.2.37 A-MPDU Aggregation when the STA is the Recipient with and without WPA2-PSK

5.2.37.1 A-MPDU Aggregation when the STA is the Receiver with and without WPA2-Personal

Purpose and Description
Test Block ACK stream and A-MPDU aggregation traffic in receive side.
Test Block ACK streams from the same AP on the receiver side.
Test A-MPDU aggregation with and without WPA2-Personal security mode

Applicability
Mandatory. Skip steps 1 through 5 if Open security is not supported.

Reference
Test case 5.2.37 in Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of 3 SS configuration
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.
Run all tests in batch mode.

Parameter	STAUT Values	AP1 Values
Vendor	-	Broadcom
Security	None and WPA2-Personal	None and WPA2-Personal
Encryption Key	None and 12345678	None and 12345678
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	See test procedure	3

Table 105: A-MPDU Aggregation when the STA is the Receiver Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.
Repeat test for all combinations of number of implemented streams on STAUT (Nss = 1, 2, and 3, as applicable) and security mode (encryption, no encryption).

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	-	Configure AP1 to Test bed Default Mode. Enable 3 SS. Change security mode to none.	
2	Association Request	Association Response	If the association response of STAUT is with status different than success then fail
3	Send ADDBA Response	Send ADDBA Request for TID 5	
4		Run script HT1-AP-DUT-TID-5 for TID 5	If Downlink throughput is less than 5.2.37S1HT1OPEN (for 1SS) 5.2.37S2HT1OPEN (for 2SS) 5.2.37S3HT1OPEN (for 3SS) , then fail (if the STAUT implements only 1 SS, use secondary thresholds that are listed in Annex D). Use the sniffer to verify that there are BAs
5	Disassociate		
6		Change security mode to WPA2-Personal. Beacon.	
7	Association Request	Association Response to STAUT	If the association response of STAUT is with status different than success then fail
8	Send ADDBA Response to AP1	Send ADDBA Request for TID 5	
9		Run script HT1-AP-DUT-TID-5 for TID 5	If Downlink throughput is less than 5.2.37S1HT1WPA2PSK (for 1SS) 5.2.37S2HT1WPA2PSK (for 2 SS) 5.2.37S3HT1WPA2PSK (for 3SS) , then fail (if the STAUT implements only 1 SS, use the secondary thresholds that are listed in Annex D). Use the sniffer to verify that there are Bas.
10	Disassociate		

Table 106: A-MPDU Aggregation when the STA is the Receiver Procedure and Results

5.2.38 A-MSDU Aggregation when the STA is the Recipient

5.2.38.1 A-MSDU Aggregation when the STA is the Receiver

Purpose and Description
Test the mechanism of A-MSDU Aggregation when the STAUT is the receiver. The A-MSDU is sent using VHT single MPDU format.

Applicability
Mandatory

Reference
None

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration and Procedure
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	MediaTek
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2

Table 107: A-MSDU Aggregation when the STA is the Receiver Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode. Enable VHT single MPDU format. Do not send ADDBA Request.	
2	-	Beacon	
3	Association Request	Association Response	
4		Run script HT1-AP-DUT to the STAUT.	If the vendor declared that the STAUT implements 2 SS and throughput is less than 5.2.38S1HT1, then fail. If the vendor declared that the STAUT implements only 1 SS and throughput is less than 5.2.38S2HT1, then fail. Note: Use the sniffer to check that: - AP1 MPDUs are > 2346; if not, then fail. - The AP PPDUs are 80 MHz VHT packets and not 11n. If not, then fail.

Table 108: A-MSDU Aggregation when the STA is the Receiver Procedure and Results

5.2.39 Overlapping BSS – 2.4 GHz

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.40 Overlapping BSS – 5 GHz

5.2.40.1 Overlapping BSS – 5 GHz

Purpose and Description
Verify that the STAUT will function correctly in an overlapping BSS environment in the 5 GHz frequency band.

Applicability
Mandatory

Reference
None

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of being set to 1 SS operation
AP2: Test bed Wi-Fi CERTIFIED ac, capable of being set to 1 SS operation)
STA1: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values	STA1 Values	AP2 Values
Vendor	-	Marvell	Intel	Broadcom
ESSID	VHT-5.2.40-AP1	VHT-5.2.40-AP1	VHT-5.2.40-AP2	VHT-5.2.40-AP2
AP Control Channel	-	36	-	36
Channel Width	80 MHz	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	Default per Annex F	1	1	1

Table 109: Overlapping BSS – 5 GHz Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac AP2	Expected Results
1		Configure AP1 to Test bed Default Mode. Configure AP1 to 1 SS.	Configure STA1 to Test bed Default Mode.	Configure AP2 to Test bed Default Mode. Configure AP2 to 1 SS.	
2	-	Beacon/Probe Responses		Beacon/Probe Responses	
3	Association Request to AP1	Association Response to STAUT	Association Request to AP2	Association Response to STA1	
4	Run script HT1-DUT-STA-AP-60 to AP1		Run script HT1-DUT-STA-AP-60 to AP2 for 1 minute		If the STAUT-AP1 throughput is less than 5.2.40S1HT1, then fail. If the STA1-AP2 throughput is less than 5.2.40S2HT1, then fail.

Table 110: Overlapping BSS – 5 GHz Procedures and Results

5.2.41 HT Greenfield Operation

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.42 Short GI Operation

5.2.42.1 Receive Short GI for 80 MHz Operation

Purpose and Description
Verify that the STAUT is appropriately receiving Short GI for 80 MHz.

Applicability
Mandatory

Reference
Test case 5.2.42 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac with 1 SS and Short GI for 80 MHz support
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor		MediaTek
AP Control Channel	-	36
Spatial Streams Implemented	Default per Annex F	1
Channel Width	80 MHz	80 MHz
Short GI for 80 MHz	Enabled	Enabled

Table 111: Short GI Operation Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Enable Short GI for 80 MHz, if not otherwise enabled	Configure AP1 to Test bed Default Mode. Configure AP1 to 1 SS. Enable Short GI for 80 MHz	
2	-	Beacon/Probe Responses	
3	Association Request	Association Response	If the Short GI for 80MHz subfield in the VHT Capabilities element in the association request is not set, then fail
4		Set VHT MCS to 7 and Nss=1. RUN: PING <STAUT_IP_ADDR> CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more than 10% ping failures, then fail.
5		Set VHT MCS to 7 and Nss=1 RUN: PING <STAUT_IP_ADDR> SIZE=1172 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more than 10% ping failures, then fail.
6		RUN: PING <STAUT_IP_ADDR> SIZE=10000 COUNT=90	If more than 5 consecutive ping timeouts occur, then fail. If more than 10% ping failures, then fail.

Table 112: Receive Short GI for 80 MHz Operation Procedure and Results

5.2.43 Overlapping BSS on the Extension Channel

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.44 HT Duplicate Mode (MCS Index = 32)

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.45 RIFS Test

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.46 STBC Receive Test

5.2.46.1 STBC Receive Test

Purpose and Description
Confirm that the STAUT supports STBC on Rx side.

Applicability
Optional

Reference
Test case 5.2.46 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac capable of STBC Transmit
Wireless Wi-Fi CERTIFIED ac sniffer
Run in clean environment (chamber)

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor		Quantenna
AP Control Channel	N/A	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz
Nss (number of spatial streams) ; Nsts (number of space-time streams)*	Default per Annex F	1 (one spatial stream); 2, (two space-time streams)

Table 113: STBC Receive Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Enable STBC Receive if not otherwise enabled	Configure AP1 to Test bed Default Mode Configure the test bed AP to use only STBC Transmit.	
2	-	Beacon	
3	Association Request	Association Response to STAUT	If the Rx STBC subfield value in Association Request is 0 then fail
4		RUN: PING <STAUT_IP_ADDR> CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.

Table 114: STBC Receive Test Procedure and Results

*Note: “STBC 2x1” refers to a mode in which transmission occurs from 2 transmit antennas, but can be received with 1 receive antenna. The signal transmitted from the second transmit antenna is a modified version of the signal transmitted from the first transmit antenna. This is not the same situation as a MIMO transmission, in which the transmit antennas can transmit independent signals, and in which there shall be at least as many receive antennas as independent signals transmitted. To distinguish STBC 2x1 from any MIMO configuration, the underlying (IEEE 802.11) standard defines the term “space-time stream”, a distinct concept from “spatial stream”. In “STBC 2x1”, there are 2 space-time streams transmitted, but only 1 spatial stream. See IEEE 802.11ac p.186, Table 22-1 (TXVECTOR and RXVECTOR parameters).

This distinction is not made in Test Case 5.2.46 in version 2.0.22 of the Wi-Fi CERTIFIED n Test Plan. The description in the Test Configuration table in that test case does not match the terminology used in the underlying IEEE standard.

5.2.47 A-MPDU Aggregation when the STA is the Transmitter

5.2.47.1 A-MPDU Aggregation when the STA is the Transmitter

Purpose and Description
Test A-MPDU Aggregation when the STAUT is the transmitter.

Applicability
Mandatory

Reference
Test case 5.2.47 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of 1 SS operation
AP2: Test bed Wi-Fi CERTIFIED ac, capable of 2 SS operation
AP3: Test bed Wi-Fi CERTIFIED ac, capable of 3 SS operation
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values	AP2 Values	AP3 Values
Vendor	-	Quantenna	Marvell	Broadcom
ESSID	-	VHT-5.2.47-AP1	VHT-5.2.47-AP2	VHT-5.2.47-AP3
AP Control Channel	-	36	36	36
Spatial Streams Implemented	-	1	2	3
Channel Width	80 MHz	80 MHz	80 MHz	80 MHz
Short GI	-	Disabled	Disabled	Disabled

Table 115: A-MPDU Aggregation when the STA is the Transmitter Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED acAP2	Test bed Wi-Fi CERTIFIED ac AP3	Expected Results
1		Configure AP1 to Test bed Default Mode. Configure AP1 to 1 SS.	Configure AP2 to Test bed Default Mode. Configure AP2 to 2 SS.	Configure AP3 to Test bed Default Mode. Configure AP3 to 3 SS.	
2		Disable A-MSDU Aggregation	Disable A-MSDU Aggregation	Disable A-MSDU Aggregation	
3	Association Request to AP1	Association Response			
4	Send ADDBA request to AP1 on TID0	Send ADDBA response to STAUT			
5	Run script HT2-DUT-APx4 on TID0 to AP1. Note: the STAUT may do this automatically after association or it may be triggered by the data traffic in step 4.				If the throughput is less than 5.2.47S1HT2 then fail. Using the sniffer, verify that STAUT is using VHT PPDUs and AP1 responds with BA.
6	Disassociate from AP1				
If the vendor declared that the STAUT implements more than 1 SS transmission, then continue.If not, then pass; stop the test.					
7	Association Request to AP2		Association Response		
8	Send ADDBA request to AP2 on TID0		Send ADDBA response to STAUT		
9	Run script HT2-DUT-APx4 for TID0 to AP2				If the throughput is less than 5.2.47S2HT2 then fail. Using the sniffer, verify that STAUT is using VHT PPDUs and AP1 responds with BA.
10	Disassociate from AP2				
If the vendor declared that the STAUT implements more than 2 SS transmission, then continue. If not, then pass; stop the test.					
11	Association Request to AP3			Association Response	
12	Send ADDBA request to AP3 for TID0			Send ADDBA response to STAUT	
13	Run script HT2-DUT-APx4 on TID0 to AP3				If the throughput is less than 5.2.47S3HT2 then fail. Using the sniffer, verify that STAUT is using VHT PPDUs and AP1 responds with BA.

Table 116: A-MPDU Aggregation when the STA is the Transmitter Procedure and Results

5.2.48 STA 20/40 MHz Coexistence

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.2.49 Ability to Receive 3 Spatial Streams

5.2.49.1 Ability to Receive 3 Spatial Streams

Purpose and Description
Confirm that the STAUT implements 3 SS receive.

Applicability
Optional

Test Environnent
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of 3 SS operation
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Quantenna
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	3	3

Table 117: Ability to Receive 3 Spatial Streams Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Enable 3SS if not otherwise enabled	Configure AP1 to Test bed Default Mode. Enable 3 SS.	-
2	-	Beacon/Probe Responses	
3	Association Request	Association Response	If the STAUT VHT Supported MCS set field in the VHT Supported MCS Set field of the VHT Capabilities IE does not contain 1 in the bitmap indexes B4-B5, then fail.
4		Configure AP1 to transmit only 20 MHz, Nss=3, VHT MCS = 7 (195 Mbps)	
5		RUN: PING <STAUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.
6		Configure AP1 to transmit only 40 MHz, Nss= 3, VHT MCS = 7 (405 Mbps)	
7		RUN: PING <STAUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.
8		Configure AP1 to transmit only 80 MHz, Nss= 3,VHT MCS = 7 (877.5 Mbps)	
9		RUN: PING <STAUT_IP_ADDR> SIZE=10000 CONTINUOUS=YES	If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail.

Table 118: Ability to Receive 3 Spatial Stream Procedure and Results

5.2.50 STAUT Transmitting to AP using Supported Number of Spatial Streams

5.2.50.1 STAUT Transmitting to AP using Supported Number of Spatial Streams

Purpose and Description
Confirm that the STAUT transmits using the correct number of spatial streams as advertised by the AP.

Applicability
Mandatory

Reference
Test case 5.2.50 in the Wi-Fi CERTIFIED n Test Plan

Test Environnent
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of 1 SS operation
AP2: Test bed Wi-Fi CERTIFIED ac
AP3: Test bed Wi-Fi CERTIFIED ac, capable of 3 SS operation
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values	AP2 Values	AP3 Values
Vendor	-	Broadcom	Quantenna	Qualcomm
AP Control Channel	-	36	36	36
Channel Width	80 MHz	80 MHz	80 MHz	80 MHz
Spatial Streams Implemented	Default	1	2	3

Table 119: STAUT Transmitting to AP using Supported Number of Spatial Streams Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	Test bed Wi-Fi CERTIFIED ac AP3	Expected Results
1	-	Configure AP1 to Test bed Default Mode Configure AP1 to 1 SS.	Configure AP2 to Test bed Default Mode.	Configure AP1 to Test bed Default Mode. Configure AP3 to 3 SS.	
2		Beacon/Probe Responses			
3	Association Request to AP1	Association Response			Record Supported Nss set of STAUT
4	RUN: PING <AP1_IP_ADDR> -COUNT=100 SIZE=1000				If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Use the sniffer to check that the STAUT transmitted at least 10 ping requests using 1 SS, then pass.
5	Disassociate from AP1				
If the vendor declared that the STAUT implements only 1SS, then pass; end the test. Otherwise proceed with steps 6 through 8.					
6	Enable 2 SS, if not otherwise enabled		Beacon/Probe responses with Nss=2		
7	Association Request to AP2		Association Response		
8	RUN: PING <AP2_IP_ADDR> -COUNT=100 SIZE=1000				If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Use the sniffer to check that the STAUT transmitted at least 10 ping requests using 2 SS then pass.
9	Disassociate from AP2				
If the vendor declared that the STAUT does not implement 3SS or more, then pass; end the test. Otherwise proceed with steps 10 through 12.					
10	Enable 3 SS if not otherwise enabled			Beacon/Probe responses with Nss=3	
11	Association Request			Association Response	
12	RUN: PING <AP3_IP_ADDR> -COUNT=100 SIZE=1000				If more than 5 consecutive ping timeouts occur, then fail. If more that 10% ping failures, then fail. Use the sniffer to check that the STAUT transmitted at least 10 ping requests using 3 SS then pass.

Table 120: STAUT Transmitting to AP using Supported Number of Spatial Streams Procedure and Results

5.2.51 Disallow TKIP with HT Rates Test

5.2.51.1 Disallow TKIP with VHT Rates Test

Purpose and Description
Ensure that the STAUT does not use VHT rates when using TKIP as the encryption cipher.

Applicability
Mandatory

Reference
Test case 5.2.51 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of association using TKIP with VHT. Note that this is a special capability, and is for testing purposes only.
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor		MediaTek
AP Control Channel	-	36

Table 121: Disallow TKIP with VHT Rates Test Configuration

WPA-Personal Only Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Action	Results
1	Configure API to Test bed Default Mode. Configure API with WPA-Personal (TKIP only).	
2	Force STAUT to do an active scan. Using the sniffer, check the Beacon and Probe Responses.	Verify that IE=191 is present in the Beacons and Probe Responses, and that TKIP is the only advertised pairwise cipher suite. If not, there is a test bed problem. Correct the configuration and restart the test.
3	Try to associate the STAUT to AP1.	
4	Using the sniffer, look at the Association Request from the STAUT.	1) If there is no Association Request from the STAUT, then pass. Stop the test. 2) If IE=191 is present in the Association Request, then fail. Stop the test.
5	Run script DUT-AP1-0 from the STAUT to a PC on the wired Ethernet side of AP1 for at least 10 seconds.	
6	Using the sniffer, collect 10 seconds of data packets.	If any of the STAUT data packets are sent at VHT rates, then fail. Stop the test. Ignore all packets from AP1.
7		If the test reaches this point, then pass.

Table 122: Disallow TKIP with VHT Rates Test Procedure and Results

5.2.52 STA Negative tests to ensure WEP is not used with HT associations in 802.11n devices

5.2.52.1 Negative tests to ensure WEP is not used with VHT associations in Wi-Fi CERTIFIED ac devices

Purpose and Description
Verify that the STAUT does not use WEP with VHT associations

Applicability
Mandatory if WEP is implemented on the STAUT

Reference
Test case 5.2.52 in the Wi-Fi CERTIFIED n Test Plan

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of association using WEP with VHT. Note that this is a special capability, and is for testing purposes only.
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 values
Vendor	-	Qualcomm
Security	-	WEP
Encryption Key	-	0x9876543210
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz

Table 123: STA Negative WEP Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	Action	Results
1	Configure AP1 to Test bed Default Mode. Configure AP1 with WEP.	
2	Force STAUT to do an active scan. Using the sniffer, check he Beacons and Probe Responses.	Verify that IE=191 is present in the Beacons and Probe Responses, and that only WEP is advertised. If not, there is a test bed problem. Correct the configuration and restart the test.
3	Try to associate the STAUT to AP1.	
4	Using the sniffer, look at the Association Request from the STAUT.	1) If there is no Association Request from the STAUT, then pass. Stop the test. 2) If IE=191 is present in the Association Request, then fail. Stop the test.
5	FROM PC-ENDPOINT, RUN: PING <STAUT_IP_ADDR> COUNT=10 SIZE=1000	
6	Using the sniffer, collect 10 seconds of ping data packets.	If any of the STAUT data packets are exchanged with PPDUs that include VHT-SIG-A, then fail. Stop the test. Ignore all packets from AP1.
7		If the test reaches this point, then the STAUT passes.

Table 124: STA Negative WEP Test Procedure and Results

5.2.53 Support for AES if TKIP is supported

Wi-Fi CERTIFIED n Test Plan v2.0.26 test. Intentionally left blank in this document.

5.2.54 STA Receiving 256-QAM MCSs

Purpose and Description
Test that the STAUT is capable of receiving 256-QAM MCSs (MCS 8 and 9).

Applicability
Optional
(The test procedure requires the steps to be run up to the number of spatial streams implemented by the STAUT.)

Reference
None

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of MCS 8-9 in each implemented number of spatial streams and bandwidth, and of being configured to fixed MCS, Channel Width, and Nss
AP2: Test bed Wi-Fi CERTIFIED ac implementing 3 SS, capable of MCS 8-9 in each supported number of spatial streams and bandwidth, and of being configured to fixed MCS, Channel Width, and Nss
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values	AP2 Values
Vendor	-	Qualcomm	Quantenna
Spatial Streams Implemented	Default	2	3
AP Control Channel	N/A	36	36
Channel Width	80 MHz	80 MHz	80 MHz

Table 125: STA Receiving 256-QAM MCSs Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	STAUT	Expected Results
1	Configure AP1 to Test bed Default Mode. Enable MCS8-9 in Nss=1 and Nss=2.	Configure AP2 to Test bed Default Mode. Enable 3SS. Enable MCS8-9 in Nss=3.		
2	Beacon, indicating support for MCS8-9 for Nss=1 and Nss=2: Max MCS for 1 SS, Max MCS for 2 SS in the Tx MCS Map field = 9, and Tx Highest Supported Long GI Data Rate subfield = 0			
3	Association Response		Association Request	Check STAUT support for transmit mode: If (i) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 351 for MCS 8 or 390 for MCS 9, then the STAUT is claiming support: proceed to the remainder of the steps. If not, the STAUT is not indicating support: proceed to step 5.
4	Configure AP1 to transmit only: BW=80, MCS=8, Nss=1 RUN: PING <STAUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.

Steps	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	STAUT	Expected Results
5				Check STAUT support for transmitted mode from step 3: If (i) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 1 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 390, then the STAUT is claiming support: proceed to the remainder of thes steps. If not, the STAUT is not indicating support: proceed to step 7.
6	Configure AP1 to transmit only: BW=80, MCS=9, Nss=1 RUN: PING <STAUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
If the vendor declared that the STAUT implements only 1 SS, and the test reaches this point with no failures, then pass; stop the test. Else if the vendor declared that the STAUT implements 2 SS or more, then continue.				
7				Check STAUT support for transmitted mode tep 2: If (i) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 702 for MCS 8 or 780 for MCS 9, then the STAUT is claiming support: proceed to the remainder of the steps. If not, the STAUT is not indicating support: proceed to step 9.
8	Configure AP1 to transmit only: BW=80, MCS=8, Nss=2 RUN: PING <STAUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
9				Check STAUT support for transmitted mode from step 3: If

Steps	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	STAUT	Expected Results
				(i) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 2 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 780, then the STAUT is claiming support: proceed to the remainder of the steps. If not, the APUT is not indicating support: proceed to step 11.
10	Configure AP1 to transmit only: BW=80, MCS=9, Nss=2 RUN: PING <STAUT_IP_ADDR> COUNT=100 SIZE=1000			If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail. If the STAUT does not transmit at least 1 VHT PPDU then fail.
If the vendor declared that the STAUT implements only 2 SS, and test reaches this point with no failures, then pass; stop the test. Else, if the vendor declared that the STAUT implements 3 SS or more, then continue.				
11			Disassociate from AP1	
12		Beacon, indicating support for MCS8-9 for Nss=1, Nss=2, and Nss=3: Max MCS for 1 SS, Max MCS for 2 SS, Max MCS for 3 SS in the Tx MCS Map field = 9, and Tx Highest Supported Long GI Data Rate subfield = 0		
13		Association Response	Association Request	Check STAUT support for transmit mode: If (i) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 8 or 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 1053 for MCS 8 or 1170 for MCS 9, then the STAUT is claiming support: proceed to the remainder of the steps. If not, the STAUT is not indicating support, then fail; stop the test.

Steps	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	STAUT	Expected Results
14		Configure AP2 to transmit only: BW=80, MCS=8, Nss=3 RUN: PING <STAUT_IP_ADDR> COUNT=100 SIZE=1000		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail. If the STAUT does not transmit at least 1 VHT PPDU, then fail.
15				Check STAUT support for transmitted mode from step 13: If (i) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield is 0, or (ii) the value of the Max MCS for 3 SS subfield in the Rx MCS Map field equals 9 and the value of the Rx Highest Supported Long GI Data Rate subfield equals 1170, then the STAUT is claiming support: proceed to the remainder of the steps. If not, the STAUT is not indicating support, then fail; stop the test.
16		Configure AP2 to transmit only: BW=80, MCS=9, Nss=3 RUN: PING <STAUT_IP_ADDR> COUNT=100 SIZE=1000		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.
If the test reaches this point with no failures, then pass.				

Table 126: STA Receiving 256-QAM MCSs Procedure and Results

5.2.55 STA Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU

Purpose and Description
Test that the STAUT is capable of transmitting and receiving VHT A-MPDU Delimiter for Single MPDU.

Applicability
Mandatory

Reference
None

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Marvell
Spatial Streams Implemented	Default	1 or 2
AP Control Channel	N/A	36
Channel Width	80 MHz	80 MHz

Table 127: STA Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode. Disable BA (transmit and receive): do not send ADDBA Request; decline any ADDBA Request from STAUT.	
2		Beacon	
3	Association Request	Association Response	
4	RUN: PING <AP1_IP_ADDR> COUNT=100 SIZE=1000		If more than 5 consecutive ping timeouts occur, then fail. If more that 10% of pings fail, then fail.

Table 128: STA Transmitting and Receiving VHT A-MPDU Delimiter for Single MPDU Procedure and Results

5.2.56 Ability to Receive A-MPDU with A-MSDU

Purpose and Description
The test verifies that the STAUT can correctly receive A-MPDU with A-MSDU.

Applicability
Optional

Reference
None

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	MediaTek
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2

Table 129: Receive A-MPDU with A-MSDU Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode.	
2		Enable Tx A-MSDU support	
3		Beacon	
4	Association Request		
5		Association Response	
6		ADDBA Request	
7	ADDBA Response		Verify that the A-MSDU Supported subfield in the Block Ack Parameter Set field in the ADDBA Response is set to 1; if not, then fail
8		RUN: PING <STAUT_IP_ADDR> SIZE=16384 COUNT=30	If the ping fails to continue for the whole 30 seconds then fail

Table 130: Receive A-MPDU with A-MSDU Test Procedure and Results

5.2.57 CTS with BW signaling in response to RTS with BW signaling

Purpose and Description
Verify that the STAUT correctly implements CTS with BW signaling by checking its response to RTS with static and dynamic BW signaling respectively.

Applicability
Mandatory

Reference
None

Test Environment
(Use a screen room)
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of RTS with BW signaling and 1 SS operation.
Note that this is a special test mode.
Wireless Wi-Fi CERTIFIED ac sniffer, with the capability of reading bandwidth bits or deriving them from the contents of the SERVICE field.

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Marvell
Spatial Streams Implmented	Default	1
AP Control Channel	-	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz

Table 131: CTS with BW signaling in response to RTS with BW signaling Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode. - Configure AP1 to 1 SS.	
2		Beacon	
3	Association Request	Association Response	
4		Configure AP1 to send out RTS with static BW signaling (80 MHz)	
5		Run script HT1-AP-SUT-30 to STAUT	Verify that the STAUT responds to RTS with CTS and that the BW bits in the SERVICE field of the PPDU carrying the CTS indicate 80 MHz. If not, then fail. Verify that the ratio of CTS responses to RTS is greater than 70%. If not then fail.
6	Disassociate		
7		Configure AP1 to send out RTS with dynamic BW signaling (80 MHz)	
8	Association Request	Association Response	
9		Run script HT1-AP-DUT-30 to STAUT	Verify that the STAUT responds to RTS with CTS and that the BW bits in the SERVICE field of the PPDU carrying the CTS indicate 80 MHz, 40 MHz, or 20 MHz. If not then fail. Verify that the ratio of CTS responses to RTS is greater than 70%. If not, then fail.
10	Disassociate		
11		Configure AP1 to send out RTS with dynamic BW signaling (40 MHz)	
12	Association Request	Association Response	
13		Run script HT1-AP-DUT-30 to STAUT	Verify that the APUT responds to RTS with CTS and that the BW bits in the SERVICE field of the PPDU carrying the CTS indicate either 40 MHz or 20 MHz. If not, then fail. Verify that the ratio of CTS responses to RTS is greater than 70%. If not then fail.

Table 132: CTS with BW signaling in response to RTS with BW signaling Procedure

5.2.58 Single User Transmit Beamforming when STA is the Beamformee

Purpose and Description
Verify that the STAUT supports SU Transmit beamformee capability correctly.

Applicability
Optional

Reference
None

Test Environment
(Use a screen room)
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of SU Transmit beamforming and 1 SS operation.
Note that this is a special test mode.
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor		Marvell
AP Control Channel	N/A	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2

Table 133: SU Transmit beamforming Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Enable SU Transmit beamforming Rx capability if not otherwise enabled	Configure AP1 to Test bed Default Mode. Configure AP1 to 2 SS. Enable SU Transmit beamformer capability. If applicable, disable MU beamformer and +HTC-VHT support.	
2	-	Beacon/Probe responses	
3	Association Request	Association Response	If the STAUT association fails, then fail. If SU Beamformee Capable bit of VHT Capability Info field in the Association Request is not set, then fail. If "Compressed Steering Number of Beamformer Antennas Supported" subfield in VHT Capability Info field in the Association Request is 0 then fail.
4		RUN: PING <STAUT_IP_ADDR> COUNT=90	If ping request is not successful within 90 seconds, then fail. If AP1 does not receive any VHT Compressed Beamforming frame, then fail. Verify the following subfields in the VHT MIMO Control field of the VHT Compressed Beamforming frame: - Nc <= Nr - Nr = value of SU NSTS field in transmitted NDP - Channel Width = value of BW field in transmitted NDP - Feedback = 0; - Remaining Feedback Segments = 0; - First Feedback Segment = 1; - Sounding Dialog Token Number = the value of the Sounding Dialog Token field in the transmitted NDP Announcement frame. If the values are not correct then fail. Verify the size of the VHT Compressed Beamforming frame according to Tables 124-A and 124-B. If the size is not correct then fail. If ping request is not successful after AP1 receives the VHT Compressed Beamforming frame then fail.

Table 134: SU Transmit Beamforming where STAUT is the Beamformee Procedure

Nr x Nc Codebook = 0	80 MHz, Ng=4 (bytes)	80 MHz, Ng=2 (bytes)	80 MHz, Ng=1 (bytes)
2x1	81	126	210
2x2	82	127	211
3x1	127	217	385
3x2	175	310	562
3x3	176	311	563
4x1	174	309	561

4x2	268	493	913
4x3	315	585	1089
4x4	316	586	1090

Table 124-A: VHT Compressed Beamforming frame size (including 28 bytes MAC header)

Nr x Nc Codebook = 1	80 MHz, Ng=4 (bytes)	80 MHz, Ng=2 (bytes)	80 MHz, Ng=1 (bytes)
2x1	112	187	327
2x2	113	188	328
3x1	189	339	619
3x2	268	493	913
3x3	269	494	914
4x1	267	492	912
4x2	423	798	1498
4x3	501	951	1791
4x4	502	952	1792

Table 124-B: VHT Compressed Beamforming frame size (including 28 bytes MAC header)

5.2.59 LDPC where STA is the transmitter

Purpose and Description
Verify that the STAUT is appropriately supporting LDPC transmit.

Applicability
Optional
Mandatory if the STA is capable of receiving LDPC frames

Reference
None

Test Environment
(Use a screen room)
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, LDPC capable
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Qualcomm
AP Control Channel	N/A	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2
LDPC Supported	Yes	Yes

Table 135: LDPC Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Enable LDPCTransmit if not otherwise enabled	Configure AP1 to Test bed Default Mode. Enable LDPC on AP1.	
2		Beacon/Probe responses	
3	Association Request		
4		Association Response	If the STAUT association fails, then fail
5		RUN: PING <STAUT_IP_ADDR> COUNT=90	If the ping request is not successful within 90 seconds, then fail. –Ping Response – Verify using the sniffer that the SU/MU[0] Coding bit of the VHT-SIG-A field is ‘1’ in at least one frame transmitted by the STAUT.

Table 136: LDPC Test Procedure and Results

5.2.60 LDPC where STA is the Receiver

Purpose and Description
Verify that the STAUT is appropriately supporting LDPC receive.

Applicability
Optional
Mandatory if the STA is capable of transmitting LDPC frames

Reference
None

Test Environment
(Use a screen room)
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, LDPC capable
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Quantenna
AP Control Channel	N/A	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	Default	2
LDPC Supported	Yes	Yes

Table 137: LDPC Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1 LDPC Capable	Expected Results
1	Enable LDPC Receive if not otherwise enabled.	Configure AP1 to Test bed Default Mode. Enable LDPC on AP1.	
2	Association Request		
3		Association Response	If the STAUT association fails, then fail. Using a sniffer verify in the Association Request transmitted by the STAUT that the Rx LDPC field in the VHT Capabilities information element is '1'.
4		Configure AP1 to transmit ping request using LDPC. RUN: PING <STAUT_IP_ADDR> COUNT=90	If ping is not successful within 90 seconds, then fail.

Table 138: LDPC Test Procedure and Results

5.2.61 Clear Channel Assessment on Secondary Channel

Purpose and Description
Determine whether the STAUT correctly defers for secondary 40 MHz channel and secondary 20 MHz channel traffic.

A traffic stream is established between the STAUT and a test bed AP. With no secondary channel activity this should occupy the full 80 MHz of channel bandwidth and achieve a certain throughput. The secondary 40 MHz channel is then loaded with OBSS traffic. The throughput experienced by the traffic stream should drop. A check is made to ensure that the throughput drop is due to the STAUT deferring or transmitting at a lower bandwidth and not due to packet collisions. The process is then repeated with OBSS traffic on the secondary 20 MHz channel: the secondary 20 MHz channel is loaded with OBSS traffic; the throughput experienced by the traffic stream should drop relative to the no-OBSS case; and a check is made to ensure that the throughput drop is due to the STAUT deferring or transmitting at a lower bandwidth and not due to packet collisions.

Applicability
Mandatory

Reference
None

Test Environment
(Use a screen room or any available clear channel)
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac, capable of 1 SS operation.
AP2: Test bed Wi-Fi CERTIFIED ac, capable of 1 SS operation.
STA2: Test bed Wi-Fi CERTIFIED ac
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	STA1 Values	AP1 Values	AP2 Values
Vendor		Broadcom	Qualcomm	Quantenna
Spatial Streams Implemented	Default	1	1	1
AP Control Channel	-	-	44 (if supported by AP1; else 36)	See test procedure
Channel Width	80 MHz	See test procedure	80 MHz	40 MHz

Table 139: CCA on Secondary Channel Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	Expected Results
1		Configure STA1 to Test bed Default Mode. Configure STA1 to 1 SS. Configure STA1 to 40 MHz mode.	Configure AP1 to Test bed Default Mode. Configure AP1 to 1 SS. Configure AP1 for 80 MHz with channel 44 as the primary channel (if supported by AP1; else 36).	Configure AP2 to Test bed Default Mode. Configure AP2 to 1 SS.	
2	Association Request to AP1		Association Response to STAUT		
3	Run script HT2-DUT-AP to AP1				Measure and record uplink throughput value (X Mbps)
4				Configure AP2 for 40 MHz with channel 36 as the primary channel if AP1 has AP Control Channel 44; else 40).	
5		Association Request to AP2		Association Response to STA2	
6		Run script HT1-STA1-AP-30 to AP2			Measure and record uplink throughput value (Y Mbps).
7	Run script HT1-5.2.105 to AP1	Run script HT1-5.2.61 to AP2			Measure uplink throughput between AP2 and STA1 (Y' Mbps). Check that Y' > 13 % of Y. If not, then fail. Measure uplink throughput between STAUT and AP1 (X' Mbps). Check that X' > 23 % of X. If not, then fail. (Note: the STAUT is operating with 80 MHz bandwidth but defers for secondary 40 MHz channel traffic between AP2 and STA1).
8				Configure AP2 for 20 MHz operation with with channel 48 as the primary channel (if AP1 has AP	

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac STA1	Test bed Wi-Fi CERTIFIED ac AP1	Test bed Wi-Fi CERTIFIED ac AP2	Expected Results
				Control Channel 44; else 42)	
9		Association Request to AP2		Association Response to STA1	
10		Run script HT1-STA1-AP-30 to AP2			Measure and record uplink throughput value between AP2 and STA1 (Z Mbps).
11	Run script HT1-5.2.105 to AP1	Run script HT1-5.2.61 to AP2			Measure uplink throughput between AP2 and STA1 (Z' Mbps). Check that Z' > 18 % of Z. If not, then fail. Measure uplink throughput between STAUT and AP1 (X" Mbps). Check that X' > 6 % of X. If not, then fail. (Note: the STAUT is operating with 80 MHz bandwidth but defers for secondary 20 MHz channel traffic between AP2 and STA1).

Table 140: CCA Mechanism Configuration Procedure and Results

5.2.62 Operating Mode Notification Testing

Purpose and Description
Verify that the STAUT can correctly receive and process the Operating Mode Notification information element.

In this test, the transmitting behavior is optional but receiving behavior is mandatory for STAUT.

The Operating Mode Notification information element (IE=199) or frame is used to notify STAs that the transmitting STA is changing its operating channel width, the maximum number of spatial streams it can receive, or both.

Applicability
Mandatory for receive; optional for transmit

Reference
None

Test Environment
STAUT
AP1: Wi-Fi CERTIFIED ac, capable of transmitting the Operation Mode Notification or frame
Wireless Wi-Fi CERTIFIED ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Broadcom
AP Control Channel / Bandwidth / NSS	-	56 (if supported by AP1; else 36) / 80 MHz / 2 SS
New Channel / Bandwidth / NSS	-	56 (if supported by AP1; else 36) / 20 MHz / 1 SS

Table 141: Operation Mode Notification Test Configuration

Test Procedure and Expected Results

The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode. Enable transmission of Operating Mode Notification.	
2		Beacon	
3	Association Request	Association Response	If the Operating Mode Notification subfield in the Extended Capabilities information element in Association Request is not set, then fail
4		RUN: PING <STAUT_IP_ADDR> COUNT=30	If the ping fails to continue then fail. Use the sniffer to verify: If the vendor declared that the STAUT implements 2 SS, check if at least one ping response from STAUT is 80 MHz and 2 SS. If the vendor declared that the STAUT does not implement 2 SS, check whether the ping response from the STAUT is 80 MHz and 1 SS. If not, then fail.
5		Use AP1- supplied command to force a bandwidth and maximum number of SS switch (BW=20 MHz, SS=1) within the Operation Notification information element in the beacon	
6		RUN: PING <STAUT_IP_ADDR> COUNT=30	If the ping does not continue, then fail. Use the sniffer to verify that the ping response from the STAUT is 20 MHz and 1 SS. If not, then fail.

Table 142: Testing Procedure and Results

5.2.63 STAUT acting as MU Beamformee

Purpose and Description
Verify that the STAUT supports operation as MU Beamformee.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.2
IEEE 802.11ac-2013

Test Environment
(Use a screen room)
STAUT
STA1: Test bed Wi-Fi CERTIFIED ac STA with MU Beamformee capability enabled
AP1: Test bed Wi-Fi CRTIFIED ac AP with MU Beamformer capability enabled
Wireless ac sniffer

Position the sniffer, STA1, AP1, and STAUT as shown in Figure 4.

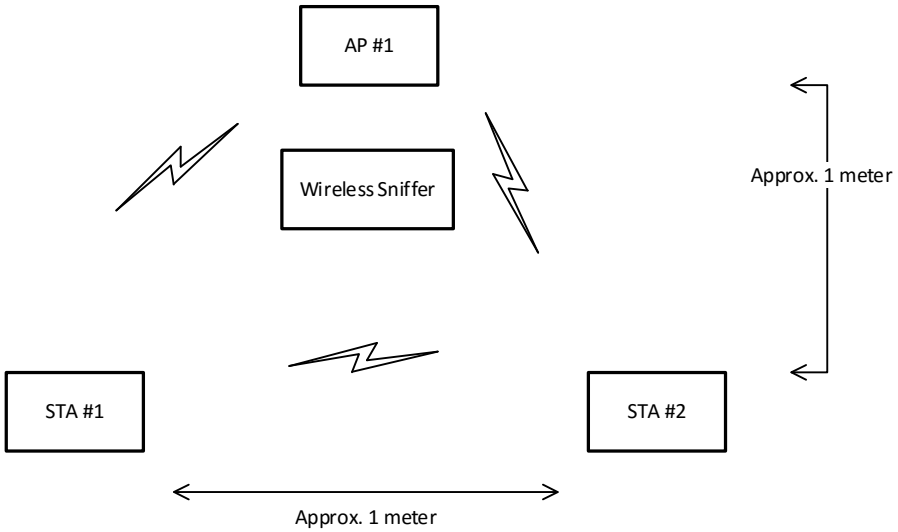

Figure 4: MU beamformee test setup

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	STA1 Values	AP1 Values
Vendor		Procedure A: Qualcomm Procedure B: Broadcom Procedure C: Quantenna	Procedure A: Quantenna Procedure B: Mediatek Procedure C: Qualcomm
Security	None	None	None
AP Control Channel	N/A	N/A	36
Channel Width	Default	80 MHz	80 MHz
Spatial Stream Support	Default	Default	Default

Table 143: STA acting as MU Beamformee Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

PART 1: configuration and capabilities verification

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac STA1, MU Beamformee Capable	Test bed Wi-Fi CERTIFIED ac AP1, MU Beamformer Capable	Expected Results
Procedure A				
1	Configure STAUT to DUT default mode as per Table 168 Enable MU Beamformee capability on STAUT	Configure STA1 to Test bed Default Mode as per Table 165 Enable MU Beamformee capability.	Configure AP1 to Test bed Default Mode Enable MU Beamformer capability. Configure AP1 to transmit NDP Announcement frames in VHT format with TA bit (Individual/Group bit) = 0	
2	Configure STAUT to associate to test bed AP1	Configure STA1 to associate to test bed AP1	Beacon/Probe Response frames	
3	Association Request	Association Request STA1 associates to AP1	Association Response to STAUT and test bed STA1	. SN: If STAUT does not associate successfully to test bed AP1 then FAIL, else CONTINUE. SN: Verify the following in VHT Capabilities Info field in Association Request frame from STAUT: 1. SU Beamformee Capable bit is set to 1 2. MU Beamformee Capable bit is set to 1 3. Beamformee STS Capability subfield set to >= 3 If all are true then CONTINUE, else FAIL.

PART 2: Group formation

4			Configure AP1 to ensure test bed STA1 will be the STA that transmits unsolicited CBF frame NOTE: This means that STA1 will send Compressed Beamforming Frame immediately following the NDP, while STAUT will send Compressed Beamforming Frame in response to	

			Beamforming Report Poll.	
5			AP1 sets GROUP_ID and USER_POSITION using Group ID Management Frame Transmit UDP1_BE to STAUT and STA1 for 60 Seconds	Using the sniffer, record GROUP_ID and USER_POSITION in Group ID Management Frames from test bed AP1 for STAUT and STA1 SN: If STAUT and STA1 have at least 1 common bit set in the Membership Status bitmap within the range of [1:62] corresponding to a common groupID, then CONTINUE, else FAIL. Record all common groupIDs as GROUP_ID_LIST For the identified common groupIDs, if the User Position Array values are distinct between STAUT and STA1 for at least one groupID, then CONTINUE, else FAIL. Record these user positions as up1 for STAUT and up2 for STA1.

PART 3: MU sounding sequence with STA1 as immediate responder

6			Sends NDP Announcement followed by the NDP frame.	Record Sounding Diaglog Token field value from NDP Announcement frame
7		Responds to NDP with Compressed Beamforming Frame (CBF).		
8	Responds to BF Report Poll frame from AP1 with CBF frame		Sends BF report Poll to STAUT following CBF from STA1.	SN: If the STAUT responds to BF report poll from test bed AP1 with Compressed Beamforming frame then CONTINUE, else FAIL. SN: Verify the following in the VHT MIMO Control field of the CBF frame from STAUT: 1. Nr index = Number of streams in NDP 2. Nc index <= Nr index 3. Channel Width <= value of BW field in transmitted NDP 4. Feedback Type = 1; 5. Remaining Feedback Segments = 0; 6. First Feedback Segment = 1; 7. Sounding Dialog Token Number = the value of the Sounding Dialog Token field in the transmitted NDP Announcement frame (as recorded in Step 6) If all are true then CONTINUE, else FAIL SN:

				Verify the size of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming Report field in the VHT Compressed Beamforming frame. If the size is correct then CONTINUE else FAIL.

PART 4: Verify MU operation

9			AP1 PPDU Verification	SN: Verify the following fields of VHT-SIG-A of the data frame to ensure MU session is established 1. The Beamformed (B8) bit of VHT-SIG-A in at least one PPDU transmitted to STAUT is set to '1'. If not then FAIL. 2. GROUP_ID matches one of the GROUP_ID values established in Step 4. If not then FAIL. 3. MU[up1] NSTS and MU[up2] NSTS are >= 1 (up1 and up2 are established in Step 5). If all above are true then CONTINUE, else FAIL.

PART 5: MU sounding sequence with STAUT as immediate responder

10			Configure AP1 to ensure STAUT will be the STA that transmits unsolicited CBF frame NOTE: This means that STAUT will send Compressed Beamforming Frame immediately following the NDP, while test bed STA1 will send Compressed Beamforming Frame in response to Beamforming Report Poll	
11	STAUT responds to NDP frame from AP1 with CBF frame		Sends NDP Announcement followed by the NDP frame	SN: If the STAUT responds to NDP frame from test bed AP1 with Compressed Beamforming frame then CONTINUE, else FAIL. SN: Verify the following in the VHT MIMO Control field of the CBF frame from STAUT: 1. Nr index = Number of streams in NDP 2. Nc index <= Nr index 3. Channel Width <= value of BW field in transmitted NDP 4. Feedback Type = 1; 5. Remaining Feedback Segments = 0; 6. First Feedback Segment = 1; 7. Sounding Dialog Token Number = the value of the Sounding Dialog Token field

				in the transmitted NDP Announcement frame (as recorded in Step 6) If all are true then CONTINUE, else FAIL Verify the size of the VHT Compressed Beamforming Report field and the MU Exclusive Beamforming field In the VHT Compressed Beamforming frame as per the Parts 3-5 in Table 143. If the sizes do not match then FAIL, else CONTINUE.
12		Responds to BF Report Poll with Compressed Beamforming Frame.	Sends BF report Poll to STA1	

PART 6: Verify MU operation

13			AP1 PPDU Verification	SN: Verify the following fields of VHT-SIG-A of the data frame from the test bed AP to ensure MU session is established 1. The Beamformed (B8) bit in at least one PPDU transmitted by AP to STAUT is set to '1' 2. Group ID matches one of the group ID values in GROUP_ID_LIST established in Step 4. 3. MU[up1] NSTS and MU[up2] NSTS are >= 1 (up1 and up2 are established in Step 5). If all above are TRUE then PASS else FAIL.
14	Procedure B: Repeat Steps 1 – 13 by configuring AP1 to transmit NDP Announcement frames in Non-HT Duplicate format with TA bit (Individual/Group bit) = 1			
15	Procedure C: Repeat Steps 1 – 13 by configuring AP1 to transmit NDP Announcement frames in Non-HT Duplicate format with TA bit (Individual/Group bit) = 0			

Table 144: STAUT acting as MU Beamformee Procedure and Results Test Configuration

The VHT Compressed Beamforming Report field is defined in Clause 8.4.1.48 of 802.11ac-2013. The expected number of bytes is shown in Table 144 and Table 145 for codebook=0 and for codebook=1 respectively.

		BW											
Nr	Nc	160 MHz			80 MHz			40 MHz			20 MHz		
		Ng			Ng			Ng			Ng		
		1	2	4	1	2	4	1	2	4	1	2	4
2	1	703	367	187	352	184	94	163	88	46	79	46	25
2	2	704	368	188	353	185	95	164	89	47	80	47	26
3	1	1405	733	373	703	367	187	325	175	91	157	91	49
3	2	2108	1100	560	1055	551	281	488	263	137	236	137	74
3	3	2109	1101	561	1056	552	282	489	264	138	237	138	75
4	1	2107	1099	559	1054	550	280	487	262	136	235	136	73
4	2	3512	1832	932	1757	917	467	812	437	227	392	227	122
4	3	4215	2199	1119	2109	1101	561	975	525	273	471	273	147
4	4	4216	2200	1120	2110	1102	562	976	526	274	472	274	148

Table 145: Expected size of VHT Compressed Beamforming Report field for codebook=0

		BW											
Nr	Nc	160 MHz			80 MHz			40 MHz			20 MHz		
		Ng			Ng			Ng			Ng		
		1	2	4	1	2	4	1	2	4	1	2	4
2	1	937	489	249	469	245	125	217	117	61	105	61	33
2	2	938	490	250	470	246	126	218	118	62	106	62	34
3	1	1873	977	497	937	489	249	433	233	121	209	121	65
3	2	2810	1466	746	1406	734	374	650	350	182	314	182	98
3	3	2811	1467	747	1407	735	375	651	351	183	315	183	99
4	1	2809	1465	745	1405	733	373	649	349	181	313	181	97
4	2	4682	2442	1242	2342	1222	622	1082	582	302	522	302	162
4	3	5619	2931	1491	2811	1467	747	1299	699	363	627	363	195
4	4	5620	2932	1492	2812	1468	748	1300	700	364	628	364	196

Table 146: Expected size of VHT Compressed Beamforming Report field for codebook=1

The MU Exclusive Beamforming Report field is defined in Clause 8.4.1.49 of 802.11ac-2013. The expected number of bytes is shown in Table 146.

		BW											
Nr	Nc	160 MHz			80 MHz			40 MHz			20 MHz		
		Ng			Ng			Ng			Ng		
		1	2	4	1	2	4	1	2	4	1	2	4
2	1	122	62	32	61	31	16	29	15	8	15	8	5
2	2	244	124	64	122	62	32	58	30	16	30	16	10
3	1	122	62	32	61	31	16	29	15	8	15	8	5
3	2	244	124	64	122	62	32	58	30	16	30	16	10
3	3	366	186	96	183	93	48	87	45	24	45	24	15
4	1	122	62	32	61	31	16	29	15	8	15	8	5
4	2	244	124	64	122	62	32	58	30	16	30	16	10
4	3	366	186	96	183	93	48	87	45	24	45	24	15
4	4	488	248	128	244	124	64	116	60	32	60	32	20

Table 147: Expected size of MU Exclusive Beamforming Report field

5.2.64 Ability to Receive 4 Spatial Streams at STAUT

Purpose and Description
Confirm that the STAUT implements 4 SS on Rx side.

Applicability
Optional for the STAUT

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.4
IEEE 802.11ac-2013

Test Environment
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac AP, capable of 4 SS operation
Wireless ac sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor	-	Broadcom
Security	None	None
AP Control Channel	-	36
Channel Width	80 MHz	80 MHz
Spatial Streams Implemented	4	4

Table 148: Ability to Receive 4 Spatial Streams at STA Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Enable 4SS if not otherwise enabled	Configure AP1 to Test bed Default Mode as per Table 164 Enable 4 SS.	
2	Configure STAUT to associate to test bed AP1	Beacon/Probe Response frames	
3	Association Request	Association Response	SN: If B6-B7 of the STAUT Supported VHT-MCS and NSS Set field in the VHT Capabilities IE are not equal to 0b11 (4 SS not supported), then CONTINUE, else FAIL.
4		Configure AP1 to transmit only 20 MHz, Nss = 4, VHT MCS = 7 (260 Mbps)	
5		RUN: PING <STAUT_IP_ADDR> SIZE=10000 ,Duration= 30 seconds	If more than 5 consecutive ping timeouts occur, then FAIL, else CONTINUE. If more that 10% ping failures, then FAIL, else CONTINUE.
6		Configure AP1 to transmit only 40 MHz, Nss = 4, VHT MCS = 7 (540 Mbps)	
7		RUN: PING <STAUT_IP_ADDR> SIZE=10000 ,Duration= 30 seconds	If more than 5 consecutive ping timeouts occur, then FAIL, else CONTINUE.

			If more that 10% ping failures, then FAIL, else CONTINUE.
8		Configure AP1 to transmit only 80 MHz, Nss = 4,VHT MCS = 7 (1170 Mbps)	
9		RUN: PING <STAUT_IP_ADDR> SIZE=10000 ,Duration= 30 seconds	If more than 5 consecutive ping timeouts occur, then FAIL, else CONTINUE. If more that 10% ping failures, then FAIL, else PASS.

Table 149: Ability to Receive 4 Spatial Streams at STA Procedure and Results

5.2.65 Ability to Receive 160 MHz at STAUT

Purpose and Description
Confirm that the STAUT implements 160 MHz on Rx side.

Applicability
Optional for the STAUT

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.3
IEEE Draft Standard 802.11-REVmc/D5.2

Test Environment
AP1: Test bed Wi-Fi CERTIFIED ac AP implementing 160 MHz configuration
STAUT
Wireless ac Sniffer
Use screen room
All other test bed STA and AP devices shall be turned off

Test Configuration
The following table defines the parameter values for the devices in the test bed

Parameter	STAUT Values	AP Values
Vendor	-	Qualcomm
Security	None	None
Spatial Streams Configured	Default	Default
AP Control Channel	-	36
Channel Width	160 MHz	160 MHz

Table 150 Ability to Receive 160 MHz at STA Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac 160 MHz AP1	Expected Results
1	Confgure STAUT to Default Mode as per Table 169. Configure STAUT to enable 160 MHz bandwidth	Configure AP1 to Test bed Default Mode as per Table 164. Enable 160 MHz. Configure AP1 to use 160 MHz BSS Operation Bandwidth by using the following configuration in the VHT Operation element: • Channel Width subfield is set to 1 • Channel Center Frequency Segment 0 is set to 42 • Channel Center Frequency Segment 1 is set to 50 Beacon/Probe Response frames	
2	Association Request	Association Response	SN:

			If Supported Channel Width Set in VHT capabilities element in the Association Request frame is not equal to 1 or 2 (the STA supports 160 MHz, or the STA supports 160 MHz and 80+80 MHz), then FAIL, else CONTINUE.
3		Configure AP1 to transmit only: BW=160,MCS=7, Nss=1	
4		RUN: PING <STAUT> SIZE=10000 , Duration = 30 seconds	If more than 5 consecutive ping timeouts from AP1 to STAUT occur, then FAIL, else CONTINUE. SN: • If the STAUT transmits at least one BA or ACK in response to AP1's 160 MHz PPDU then Continue, else FAIL • If no PPDUs from AP1 to STAUT of bandwidth equal to 20 MHz or 40 MHz or 80 MHz are present, then PASS else FAIL

Table 151 Ability to Receive 160 MHz at STA Procedure and Results

5.2.66 Extended 5 GHz Channel Support on STAUT

Purpose and Description
Confirm that the STAUT implements extended 5GHz channel support.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.5
IEEE 802.11ac-2013

Test Environment
AP1: Test bed AP (Wi-Fi CERTIFIED ac R1 or R2), capable of operation in 5.15-5.35 and 5.47-5.85 GHz
STAUT
Wireless ac Sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed

Parameter	STAUT Values	AP1 Values
Vendor	-	Marvell
Security	None	None
Spatial Streams Implemented	Default	Any
AP Control Channel	-	64,100, 140, 149, 165
Channel Width	80 MHz, 20 MHz (see test procedure)	80 MHz, 20 MHz (see test procedure)

Table 152: Extended 5 GHz Channel Support Test Configuration

Test Procedure and Expected Results
The following tables define the test procedures and expected results.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1	Configure STAUT to Default Mode as per Table 169	Configure AP1 to Test bed Default Mode as per Table 164 on Channel 64. Beacon/Probe Response frames	
2	Association Request	Association Response	
3		RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000 Duration = 30 seconds	If more than 5 consecutive ping timeouts from AP1 occur, then FAIL, else CONTINUE.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode (AP) on Channel 100. Beacon/Probe Response frames	
2	Association Request	Association Response	
3		RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000, framerate =10, Duration = 30 seconds	If more than 5 consecutive ping timeouts from AP1 occur, then FAIL, else CONTINUE.

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1		Configure AP1 to Test bed Default Mode (AP) on Channel 140. Configure AP1 to 20 MHz operation only.	

		Beacon/Probe Response frame	
2	Association Request	Association Response	
3		RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000, framerate =10, Duration = 30 seconds	If more than 5 consecutive ping timeouts from AP1 occur, then FAIL, else CONTINUE

Steps	**STAUT**	**Test bed Wi-Fi CERTIFIED ac AP1**	**Expected Results**
1		Configure AP1 to Test bed Default Mode (AP) on Channel 149. Beacon/Probe Response frames	
2	Association Request	Association Response	
3		RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000, framerate =10, Duration = 30 seconds	If more than 5 consecutive ping timeouts from AP1 occur, then FAIL, else CONTINUE

Steps	**STAUT**	**Test bed Wi-Fi CERTIFIED ac AP1**	**Expected Results**
1		Configure AP1 to Test bed Default Mode (AP) on Channel 165. Configure AP1 to 20 MHz operation only. Beacon/Probe Response frame	
2	Association Request	Association Response	
3		RUN: PING <PC_ENDPOINT_IP_ADDR> SIZE=10000, framerate =10, Duration = 30 seconds	If more than 5 consecutive ping timeouts from AP1 occur, then FAIL, else CONTINUE

Table 153: Extended 5 GHz Channel Support Procedure and Results

5.2.67A RTS with Static Bandwidth Signaling

Purpose and Description
Determine if the STAUT correctly conforms to RTS operation with Static Bandwidth Signaling.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.6
IEEE 802.11ac-2013

Test Environment
Use a screen room
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac AP
Wireless ac Sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor		Marvell
Security	None	None
Spatial Streams Support	Default	Default
AP Control Channel	-	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz

Table 154: RTS with Bandwidth Signaling Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1.	Configure STAUT to Default Mode as per Table 169	Configure AP1 to Test bed Default Mode as per Table 164	
2.	Association Request to test bed AP1	Association Response to STAUT	SN: If Association is successful then CONTINUE, else FAIL
3.	Configure RTS with static BW signaling (80 MHz)	Configure test bed AP1 to transmit 80 MHz CTS	
4.	Transmit UDP1_BE to AP1 for 10 Seconds		SN: Verify the following: 1. The STAUT transmits all RTS frames with static bandwidth signaling with BW field set to 80 MHz Randomly select TXOP samples to perform the following check: 1. The STAUT transmits all PPDUs with BW bits in the SERVICE field of the PPDU set to 80 MHz in the same TXOP as the CTS BW of 80 MHz 2. At least one or more PPDUs are sent during the TXOP duration If all are true then PASS, else FAIL. Note: For data gathering purpose, in WTS script check and print the value of the

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
			Individual/Group bit in the TA field of the RTS frame.

Table 155: RTS with Bandwidth Signaling Procedure and Results

5.2.67B RTS with Dynamic Bandwidth Signaling

Purpose and Description
Determine whether the STAUT correctly conforms to RTS operation with Dynamic Bandwidth signaling.

Applicability
Optional

Reference
Wi-Fi CERTIFIED ac R2 MRD, section 6.4.6
IEEE 802.11ac-2013

Test Environment
Use a screen room
STAUT
AP1: Test bed Wi-Fi CERTIFIED ac AP
Wireless ac Sniffer

Test Configuration
The following table defines the parameter values for the devices in the test bed.

Parameter	STAUT Values	AP1 Values
Vendor		Quantenna
Security	None	None
Spatial Streams Support	Default	Default
AP Control Channel	-	44 (if supported by AP1; else 36)
Channel Width	80 MHz	80 MHz

Table 156: RTS with Dynamic Bandwidth Signaling Test Configuration

Test Procedure and Expected Results
The following table defines the test procedures and expected results

Steps	STAUT	Test bed Wi-Fi CERTIFIED ac AP1	Expected Results
1.	Configure STAUT to Default Mode as per Table 169	Configure AP1 to Test bed Default Mode as per Table 164	
2.	Association Request to test bed AP1	Association Response to STAUT	SN: If Association is successful then CONTINUE, else FAIL
3.	Configure RTS with dynamic BW signaling (80 MHz)	Configure test bed AP1 to transmit 40MHz CTS	
4.	Transmit UDP1_BE to AP1 for 10 Seconds		SN: Verify the following: 1. The STAUT transmits at least one or more RTS with dynamic bandwidth signaling with BW field set to 80 MHz 2. PPDU of BW equal to 40 MHz or 20 MHz in the same TXOP as the CTS with BW equal to 40 3. STAUT shall not transmit any PPDUs of BW equal to 80 MHz If all are true then PASS, else FAIL. Note: For data gathering purpose, in WTS script check and print the value of the Individual/Group bit in the TA field of the RTS frame.

Table 157: RTS with Dynamic Bandwidth Signaling Procedure and Results

5.3 IBSS STAUT Test Cases

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.3.1 IBSS Active or Passive Scanning Test

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.3.2 IBSS WEP On and Off Test

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

5.3.3 IBSS Rejoin Test

Wi-Fi CERTIFIED n Test Plan test placeholder. Intentionally left blank in this document.

Annex A: Test Bed Products

(normative)

All vendor equipment is available exclusively from:

Tessco Technologies
11126 McCormick Road
Hunt Valley, Maryland 21031

Amber Buscemi buscemia@tessco.com
Melvin Simmons simmonsm@tessco.com

Note that the distributor does NOT supply technical support and cannot answer technical questions regarding this equipment. A contact person for each device is listed herein. They may be able to direct technical questions to the correct resource.

The current list of all test bed equipment for all Wi-Fi Alliance test beds can be accessed at the following ftp site:

ftp://wlabs.wi-fi.org
UN: test beds
PW: {this changes on a frequent basis, please visit http://www.wi-fi.org/testing_information.php}

Laptops for test bed stations should have the following:

- Microsoft Windows XP Professional with Service Pack 2
- Gigabit Ethernet port

Switches should have gigabit Ethernet ports

Test bed Stations

Vendor	Product	Version	Contact
Broadcom	BCM94709R4366AC	SigmaVHT5G-1.3.19.tar.bz2_2017	wfa-support-list@broadcom.com
Marvell	RD-88W-8997P-WiFi-S0	Mrvl-WFASigma_ver_M2.0_R0.09 (10:12:16 Oct 20 2016)	wifilab-support@marvell.com
MediaTek	MT663XR2TB	1.0	wfa-support@mediatek.com
Qualcomm	CA-65-Y9345	3.0.4_r00041.2	wfa.vht5gr2.support.external@qca.qualcomm.com
Quantenna	QV840C	wfa_pf4-cl56557-testbed-410	wfa-support@quantenna.com
Intel	7260.HMWG	16.0.1.22	wfa.external.support@intel.com

Table 158: Test bed Stations

Test bed Access Points

Vendor	Product	Version	Contact
Broadcom	BCM94709R4366AC	SigmaVHT5G-1.3.19.tar.bz2_2017	wfa-support-list@broadcom.com
Marvell	RD-88W-AP-8964-WIFI-R0	RD-88W-AP-8964-DR2-v9.0.6.0.p13_fw_9.1.7.111-WFA	wifilab-support@marvell.com
MediaTek	MT7615 R2TBV2	1.3.5.5(20 Jan 2017)	wfa-support@mediatek.com
Qualcomm	CA-65-Y9345	3.0.4_r00041.2	wfa.external.support@qti.qualcomm.com
Quantenna	QV840	wfa_pf4-cl56557-testbed-410	wfa-support@quantenna.com

Table 159: Release 2 Test bed Access Points

Servers

Vendor	Product	Version	Contact
Qualcomm	HostAPD	2.4	jouni.malinen@qualcomm.com

Table 160: Servers

Supplicants

Vendor	Product	Version	Contact

Table 161: Supplicants

Vendor	Product	Version	Contact
Broadcom (sniffer for R1 test bed)	BCM94360MC or BCM94360MC5_3	6.30 RC447.10552	wfa-support-list@broadcom.com
Quantenna (sniffer for R2 test bed)	QV840S	Install on sniffer device: • topaz-linux-sniffer-public-cl40841-410.lzma.img Install on control laptop: • quantenna-pcapmultiplexer_0.0.1build39997_amd64.deb • quantenna-sigmaca_0.0.1build39997_amd64.deb	wfa-support@quantenna.com

Table 162: Test Tools

Annex B: Testing Notes

(normative)

Test bed layout:

1. Place all APs on a shelf that can be about 12 inches above the bench where the STAs are positioned.
2. Ensure a line of sight between all APs and STAs. The distance between APs and STAs should not exceed 12 feet and should not be less than 1 foot.
3. If testing in an RF chamber, ensure that there is 25% or greater reflectivity.

Annex C: Default WMM AC Parameters

(normative**)**

Wi-Fi CERTIFIED ac shall use the 802.11a/g WMM parametrs as specified in the WMM specification.

Annex D: Threshold Values

(normative)

The values shown in each of these tables are the thresholds that are required to pass each throughput test.

	Sigma		
AP thresholds (Mbps)	1 SS	2 SS	3 SS
4.2.5.1A1DT1	110	N/A	N/A
4.2.5.1A1DT2	150	N/A	N/A
4.2.5.1A1DT3	5	N/A	N/A
4.2.5.1A2DT2	N/A	170	N/A
4.2.5.1A2DT1	N/A	150	N/A
4.2.5.1A3DT2	N/A	N/A	280
4.2.5.1A3DT1	N/A	N/A	210
4.2.19A1DT1	10	N/A	N/A
4.2.19A1DT2	10	N/A	N/A
4.2.29A1HT1	110	N/A	N/A
4.2.29A2HT1	110	N/A	N/A
4.2.30A1HT1	50	N/A	N/A
4.2.40A1HT1	110	N/A	N/A
4.2.40A2HT1	N/A	150	N/A
4.2.40A3HT1	N/A	N/A	210

	Sigma		
STA thresholds (Mbps)	1 SS	2 SS	3 SS
5.2.9.1S1DT1	110	N/A	N/A
5.2.9.1S1DT2	150	N/A	N/A
5.2.9.1S2DT1	N/A	150	N/A
5.2.9.1S2DT2	N/A	200	N/A
5.2.9.1S3DT1	N/A	N/A	210
5.2.9.1S3DT2	N/A	N/A	280
5.2.9.2S1DT1	110	N/A	N/A
5.2.9.2S1DT2	150	N/A	N/A
5.2.10S1DT1	110	N/A	N/A
5.2.10S1DT2	150	N/A	N/A
5.2.10S1DT3	5	N/A	N/A
5.2.37S1HT1OPEN	110	N/A	N/A
5.2.37S1HT1WPA2PSK	110	N/A	N/A
5.2.37S2HT1OPEN	N/A	150	N/A

5.2.37S2HT1WPA2PSK	N/A	150	N/A
5.2.37S3HT1OPEN	N/A	N/A	210
5.2.37S3HT1WPA2PSK	N/A	N/A	210
5.2.38S1HT1	N/A	60	N/A
5.2.38S2HT1	50	N/A	N/A
5.2.40S1HT1	60	N/A	N/A
5.2.40S2HT1	60	N/A	N/A
5.2.47S1HT2	150	N/A	N/A
5.2.47S2HT2	N/A	200	N/A
5.2.47S3HT2	N/A	N/A	280

Annex E: Test Bed Default Modes

(normative)

Many test cases include an instruction to configure a test bed device to “Test bed Default Mode”. The relevant settings are listed in the following tables.

Only optional modes are listed. All mandatory modes are required to be supported.

Additional configuration information (e.g., Security, AP Control Channel) is often given in the Test Configuration table in each test case.

Item	Mode name	Default	Notes
1	Spatial streams	2	
2	Bandwidth	80 MHz	
3	VHT MCS Set	0-7	MCS 8 off MCS 8-9 off
4	Short GI for 20 MHz	Off	Off for both transmit and receive
5	Short GI for 40 MHz	Off	Off for both transmit and receive
6	Short GI for 80 MHz	Off	Off for both transmit and receive
7	SU Transmit Beamformer	Off	
8	SUTransmit Beamformee	Off	
9	MU Transmit Beamformer	Off	
10	MU Transmit Beamformee	Off	
11	Transmit A-MSDU	Off	
12	Receive A-MPDU with A-MSDU	Off	
13	STBC 2x1 Transmit	Off	
14	STBC 2x1 Receive	Off	
15	LDPC	Off	
16	Operating Mode Notification (Transmit)	Off	
17	RTS with Bandwidth Signaling	Off	
18	Two-character Country Code	Any	
19	Transmit Power Control	Any	
20	Channel Switching	Any	
21	Short GI for 160 MHz	Off	Off for both transmit and receive

Table 163: Test bed Default Mode—AP

Item	Mode name	Default	Notes
1	Spatial streams	1	
2	Bandwidth	80 MHz	
3	VHT MCS Set	0-7	MCS 8 off MCS 8-9 off
4	Short GI for 20 MHz	Off	Off for both transmit and receive
5	Short GI for 40 MHz	Off	Off for both transmit and receive
6	Short GI for 80 MHz	Off	Off for both transmit and receive
7	SU Transmit Beamforming	Off	
8	SUTransmit Beamformee	Off	
9	MU Transmit Beamformer	Off	
10	MU Transmit Beamformee	Off	
11	Transmit A-MSDU	Off	
12	Receive A-MPDU with A-MSDU	Off	
13	STBC 2x1 Transmit	Off	
14	STBC 2x1 Receive	Off	
15	LDPC	Off	
16	Operating Mode Notification (Transmit)	Off	
17	RTS with Bandwidth Signaling	Off	
18	Two-character Country Code	Off	
19	Transmit Power Control	Off	

Item	Mode name	Default	Notes
20	Channel Switching	Off	
21	Short GI for 160 MHz	Off	Off for both transmit and receive
22	Extended 5 GHz Channel Support	OOB	

Table 164: Test bed Default Mode—STA

Item	Mode name	Default	Notes
1	Spatial streams	2	
2	Bandwidth	40 MHz	
3	(HT) MCS Set	0-15	
4	Short GI for 20 MHz	Off	Off for both transmit and receive
5	Short GI for 40 MHz	Off	Off for both transmit and receive
6	Short GI for 80 MHz	Not applicable (off)	
7	SU Transmit Beamforming	Off	
8	SU Transmit Beamformee	Off	
9	MU Transmit Beamformer	Off	
10	MU Transmit Beamformee	Off	
11	Transmit A-MPDU	Off	
12	Transmit A-MSDU	Off	
13	Receive A-MPDU with A-MSDU	Not applicable (off)	
14	STBC 2x1 Transmit	Off	
15	STBC 2x1 Receive	Off	
16	LDPC	Off	
17	Operating Mode Notification (Transmit)	Not applicable (off)	
18	RTS with Bandwidth Signaling	Not applicable (off)	
19	Two-character Country Code	Not applicable (off)	
20	Transmit Power Control	Off	
21	Channel Switching	Off	

Table 165: Test bed Default Mode—11n Device, or 11ac Device Operating as an 11n Device

Item	Mode name	Default	Notes
1	Spatial streams	1	
2	Bandwidth	20 MHz	
3	MCS Set	0-7	
4	Short GI for 20 MHz	Off	Off for both transmit and receive
5	Short GI for 40 MHz	Not applicable (off)	
6	Short GI for 80 MHz	Not applicable (off)	
7	SU Transmit Beamforming	Not applicable (off)	
8	SU Transmit Beamformee	Off	
9	MU Transmit Beamformer	Off	
10	MU Transmit Beamformee	Off	
11	Transmit A-MPDU	Off	
12	Transmit A-MSDU	Not applicable (off)	
13	Receive A-MPDU with A-MSDU	Not applicable (off)	
14	STBC 2x1 Transmit	Not applicable (off)	
15	STBC 2x1 Receive	Not applicable (off)	
16	LDPC	Not applicable (off)	
17	Operating Mode Notification (Transmit)	Not applicable (off)	
18	RTS with Bandwidth Signaling	Not applicable (off)	
19	Two-character Country Code	Not applicable (off)	
21	Transmit Power Control	Not applicable (off)	
20	Channel Switching	Not applicable (off)	

Table 166: Test bed Default Mode—11a Device, or 11ac Device Operating as an 11a Device

Annex F: Device Under Test (DUT) Default Configuration for Test Procedures

(normative)

This annex lists the values that a technician shall configure a DUT within a test procedure.. The default values for the APUT are in Table 168 and for the STAUT in Table 169.

Specific test cases may impose additional configuration requirements. For instance, test case 4.2.26 requires each APUT to turn off the modes RTS/CTS and CTS-to-Self.

Item	Mode name	Default	Notes
1	Spatial streams	4 SS if the vendor declared 4 SS; 3 SS if the vendor declared 3 SS; 1 SS if the vendor declared 1 SS; else 2 SS.	If the APUT permits different spatial stream configurations for 160 MHz bandwidth than for 80 MHzbandwidth, the configurations at left shall be those for 80 MHz bandwidth and below.
2	Bandwidth	160 MHz if supported; else 80 MHz	Configure APUT to use 160 MHz BSS Operation Bandwidth
3	VHT MCS Set	0-9 if supported; else 0-8 if supported; else 0-7.	
4	Short GI for 20 MHz	On	Mandatory for transmit and receive in VHT5G R2
5	Short GI for 40 MHz	On	Mandatory for transmit and receive in VHT5G R2
6	Short GI for 80 MHz	On	Mandatory for transmit and receive in VHT5G R2
7	Tx SU Beamformer	On (if supported)	
8	Tx SU Beamformee	On (if supported)	
9	Tx MU Beamformer	On (if supported)	
10	Tx MU Beamformee	On (if supported)	
11	Tx A-MSDU	On (if supported)	
12	Rx A-MPDU with A-MSDU	On (if supported)	
13	Tx STBC 2x1	On (if supported)	
14	Rx STBC 2x1	On (if supported)	
15	Tx LDPC	On (if supported)	
16	Rx LDPC		
17	Operating Mode Notification (Transmit)	On (if supported)	
18	RTS with Bandwidth Signaling	On (if supported)	
19	Two-character Country Code	On (if supported)	
20	Transmit Power Control	On (if supported)	
21	Channel Switching	On (if supported)	
22	Short GI for 160 MHz	On (if 160 MHz channels are supported)	Mandatory for “each supported bandwidth” in VHT5G R2
23	RTS with Bandwidth Signaling	On (if supported)	

Table 167: APUT Default Mode

Item	Mode name	Default	Notes
1	Spatial streams	4 SS if the vendor declared 4 SS; 3 SS if the vendor declared 3 SS; 2 SS if the vendor declared 2 SS; else 1 SS.	If the STAUT permits different spatial stream configurations for 160 MHz bandwidth than for 80 MHz bandwidth, the configurations at left shall be those for 80 MHz bandwidth and below.
2	Bandwidth	160 MHz if supported; else 80 MHz	
3	VHT MCS Set	0-9 if supported; else 0-8 if supported else 0-7	
4	Short GI for 20 MHz	On	Mandatory for transmit and receive in VHT5G R2
5	Short GI for 40 MHz	On	Mandatory for transmit and receive in VHT5G r2
6	Short GI for 80 MHz	On	Mandatory for transmit and receive in VHT5G r2
7	Tx Single User (SU) Beamformer	On (if supported)	
8	Tx Single User (SU) Beamformee	On (if supported)	
9	Tx Multiuser (MU) Beamformer	On (if supported)	
10	Tx Multiuser MU Beamformee	On (if supported)	
11	Transmit A-MSDU	On (if supported)	
12	Receive A-MPDU with A-MSDU	On (if supported)	
13	Tx STBC 2x1	On (if supported)	
14	Rx STBC 2x1	On (if supported)	
15	Tx LDPC	On (if supported)	
16	Rx LDPC	On (if supported)	
17	Operating Mode Notification (Transmit)	On (if supported)	
18	RTS with Bandwidth Signaling	On (if supported)	
19	802.11d Two-character Country Code	On (if supported)	
20	802.11d Transmit Power Control	On (if supported)	
21	802.11d Channel Switching	On (if supported)	
22	Short GI for 160 MHz	On (if 160 MHz channels are supported)	Mandatory for “each supported bandwidth” in VHT5G R2
23	RTS with Bandwidth Signaling	On (if supported)	
24	Extended 5 GHz Channel Support	On (if supported)	

Table 168: STAUT Default Mode

Annex G: Traffic Streams

(normative)

Stream Name	Frame Size	Num of Pairs	Throughput	Duration	Start Delay
UDP1	16K bytes	1	Unlimited	60 seconds	0
UDP2	16K bytes	1	Unlimited	60 seconds	0
UDP3	16K bytes	1	Unlimited	30 seconds	30 seconds
UDP4	16K bytes	1	Unlimited	60 seconds	0
UDP1_BK	1000 bytes	1	85 Mbps	60 seconds	0
UDP1_BE	1000 bytes	1	85 Mbps	60 seconds	0
UDP2_BE	1000 bytes	1	76 Mbps	60 seconds	0
UDP3_BE	1000 bytes	1	76 Mbps	30 seconds	30 seconds
UDP3_BK	1000 bytes	1	76 Mbps	30 seconds	30 seconds
UDP3_VI	1000 bytes	1	76 Mbps	30 seconds	30 seconds
UDP1_VI	1000 bytes	1	85 Mbps	60 aeconds	0
UDP2_VI	1000 bytes	1	76 Mbps	60 seconds	0
UDP2_VO	1000 bytes	1	76 Mbps	60 seconds	0
UDP4_BE	1000 bytes	1	85 Mbps	60 seconds	0

When multiple scripts are run in the same step of a test case, each has the same time reference.

For example:

1. In a step that specifies the running of UDP1 and UDP2 (even by different devices), the scripts start at the same time.
2. In a step that specifies the running of UDP1 amd UDP3 (even by different devices), the UDP3 script starts 30 seconds after the UDP1 script (i.e., the 30 second delay specified for UDP3 is with respect to the same nominal start time as for UDP1).
3. When two or more ping commands are run in the same step, they run simultaneously, unless specified otherwise.

Annex H: Script Files

(normative)

The table below lists the script files that command the actions toward the target device. Each script file also contains logic that checks the results.

File Name	Frame Size	Num of Pairs	Throughput	Duration	Start Delay
DT1-APUT-STA1	16K bytes	3	Unlimited	60 seconds	0 seconds
DT2-STA1-APUT	16K bytes	3	Unlimited	60 seconds	0 seconds
DT3-APUT-STA1	1000 bytes	1	11.5 Mbps	60 seconds	0 seconds
DT1-STA1-STA2	16K bytes	3	Unlimited	60 seconds	0 seconds
DT2-STA2-STA1	16K bytes	3	Unlimited	60 seconds	0 seconds
HT1-STA1-AP-TID-5-30	16K bytes	1	Unlimited	60 seconds	0 seconds
HT1-STA1-AP-90	16K bytes	3	Unlimited	90 seconds	0 seconds
HT1--AP-STA1-TID-0	16K bytes	4	Unlimited	60 seconds	0 seconds
HT1-AP-STA1-30	16K bytes	1	Unlimited	30 seconds	0 seconds
HT1-AP1-STA1-60	16K bytes	3	Unlimited	60 seconds	0 seconds
HT2-AP1-STA2-60	16K bytes	1	Unlimited	60 seconds	0 seconds
DT1-AP-DUT	16K bytes	3	Unlimited	60 seconds	0 seconds
DT2-DUT-AP	16K bytes	3	Unlimited	60 seconds	0 seconds
DT3-AP-DUT	1000 bytes	1	11.5 Mbps	60 seconds	0 seconds
HT1-AP-DUT-TID-5	16K bytes	3	Unlimited	60 seconds	0 seconds
HT1-AP-DUT	16K bytes	3	Unlimited	60 seconds	0 seconds
HT1-DUT-STA-AP-60	16K bytes	2	Unlimited	60 seconds	0 seconds
HT2-DUT-APx4	16K bytes	4	Unlimited	60 seconds	0 seconds
HT1-AP-DUT-30	16K bytes	1	Unlimited	30 seconds	0 seconds
HT2-DUT-AP	16K bytes	3	Unlimited	60 seconds	0 seconds
HT1-STA1-AP-90	16K bytes	3	Unlimited	90 seconds	0 seconds
HT1-5.2.61	16K bytes	6	Unlimited	60 seconds	0 seconds
VHT-prereq-APUT-STA1	16K bytes	3	Unlimited	60 seconds	0 seconds
VHT-4.2.20-6	Receive UDP1_BE – 1000 bytes UDP2_VI – 1000 bytes UDP3_BE – 1000 bytes	3	- - -	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.20-7	Receive UDP1_BE – 1000 bytes UDP2_VI – 1000 bytes Transmit UDP3_BE – 1000 bytes	3	- - 76 Mbps	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.20-8	Transmit UDP1_BE – 1000 bytes UDP2_VI – 1000 bytes Receive UDP3_BE – 1000 bytes	3	85 Mbps 76 Mbps -	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.20-9	Transmit UDP1_VI – 1000 bytes UDP2_VO – 1000 bytes Receive	3	85 Mbps 76 Mbps -	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds

	UDP3_VI – 1000 bytes				
VHT-4.2.20-10	Transmit UDP1_BK – 1000 bytes UDP2_BE – 1000 bytes Receive UDP3_BK – 1000 bytes	3	85 Mbps 76 Mbps -	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.19-6	Transmit UDP1_BE – 1000 bytes UDP2_VI – 1000 bytes UDP3_BE – 1000 bytes	3	85 Mbps 76 Mbps 76 Mbps	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.19-7	Transmit UDP1_BE – 1000 bytes UDP2_VI – 1000 bytes Receive UDP3_BE – 1000 bytes	3	85 Mbps 76 Mbps -	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.19-8	Receive UDP1_BE – 1000 bytes UDP2_VI – 1000 bytes Transmit UDP3_BE – 1000 bytes	3	- - 76 Mbps	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.19-9	Receive UDP1_VI – 1000 bytes UDP2_VO – 1000 bytes Transmit UDP3_VI – 1000 bytes	3	- - 76 Mbps	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds
VHT-4.2.19-10	Receive UDP1_BK – 1000 bytes UDP2_BE – 1000 bytes Transmit UDP3_BK – 1000 bytes	3	- - 76 Mbps	60 seconds 60 seconds 30 seconds	0 seconds 0 seconds 30 seconds

Appendix A: Test Plan Change History

(informative)

Version	Date dd/mm/yy	Remarks
1.0.0	11/06/13	Initial release
1.0.1	12/7/13 13/8/13	Changed title of section 3 to Implementation Requirements for WFA Certification. Clean up the usage of the words conformance and compliance. Merged with errata 0.1
1.0.2	30/8/13 10/10/13	Test case 4.2.52 – Replaced the Broadcom station with the Marvell station Test case 4.2.19 – Clarified that the 2.4 GHz station should use 20/40 MHz instead of 40 MHz.
1.0.3	18/10/13 25/10/13 1/11/13	Appendix A – Updated Broadcom's contact information to wfa-support-list@broadcom.com Appendix A – Corrected Atheros' contact information. Test case 4.2.52 – Reversed previous change. Put Broadcom station back in.
1.0.4	13/12/13	4.2.26 and 5.2.35 – Removed sniffer checks for protection.
1.0.5	24/1/14	4.2.1, 4.2.5, 4.2.25, 4.2.26, 4.2.27, 4.2.34, 4.2.40, 4.2.50, 4.2.53, 5.2.1, 5.2.9, 5.2.28, 5.2.37, 5.2.40, 5.2.42, 5.2.47, 5.2.49, 5.2.50, and 5.2.54 – Changed test bed devices. 4.2.26 and 5.2.35 – Temporarily reverted changes made in 1.0.4.
1.0.6	7/2/14 20/2/14 1/4/14	4.2.46 step 5 – Changed HT to VHT. 4.2.5.2 – Changed to optional. 4.2.29.1 – Made steps 1 through 4 optional. General – Removed instances of D3.0.
1.0.7	4/25/14	4.2.26 and 5.2.35 – Removed sniffer checks for protection.
1.0.8	4/28/14	4.2.26 – Reverted changes made in 1.0.7.
1.0.9	5/7/14 8/1/14 8/26/14	Renamed Ralink to MediaTek. Updated MediaTek's contact info. 4.2.29 – Allow TID 4 or TID 5 to be used. Annex A – Update MediaTek's RT8559XAP firmware to 4.0.1.0 (July 11 2014).
1.1	9/3/14 10/10/14 10/26/14	Annex A – Update MediaTek's RT3800PDAP2 firmware to 2.4.3.5. 4.2.44 – Removed the WPA-TKIP portion. The test is only mandatory for APUTs that support WPA2/WPA mixed mode. APUTs that support WPA2 only can skip this test. 4.2.26 – Remove APUT configuration to disable protection and remove checks for protection
1.2	10/27/14	5.2.58 – Replaced the Broadcom AP with the Marvell AP. Annex A – Replaced the Marvell RD-88W-8897-WIFI-R0 AP with the Marvell 8864 AP.
1.3	11/11/14 2/12/15 3/6/15	Section 1.2 – Added PMF as a mandatory requirement. Annex A – Updated the Realtek station's driver to version 20141215 4.2.20 – Changed WMM Paramater Information Element to WMM Parameter Element.

1.4	6/9/15	Annex A – Update HostAPD server.
1.5	5/6/15 6/22/15 Replaced the Atheros 11n station with existing test bed stations.	Annex A – Replace the Marvell RD-88W-8897-WIFI-R0 station with the Marvell RD-88W-8897-WIFI-S0. Replaced the Broadcom 11n station with the Broadcom BCM94360MC.
1.6	6/9/15 7/9/15 9/14/15 1/8/16 2/17/16	4.1.2, 4.2.16, 4.2.34, 4.2.40, 4.2.42, 4.2.43, 4.2.47 to 4.2.55 – Removed open as a security requirement/setting. For these cases, use the APUT's default security setting. 5.1.2, 5.2.1, 5.2.22, 5.2.23, 5.2.32, 5.2.33, 5.2.34, 5.2.36, 5.2.38, 5.2.40, 5.2.42, 5.2.46, 5.2.47, 5.2.49, 5.2.50, 5.2.54 to 5.2.59, 5.2.61, 5.2.62 – removed open as a security requirement/setting. For these test cases, use the STAUT's default security setting. 5.2.9.2 – skip if open security is not supported. 5.2.37 – skip steps 1 to 5 is open security is not supported. Annex A – Replaced the Broadcom BCM94360MC5_3 with the BCM94360MC. Owners of the BCM94360MC5_3 may continue to use it. Annex A – Corrected MediaTek AP's firmware version. Annex A – Updated Marvell AP's firmware version. 4.2.5.1 – Added additional checks for 160 Mhz signaling.
2.0	4/21/16	Merged the R2 Addendum into this document. Updated the 802.11ac Specification reference to the publically available Ammendment 4, released in 2013. Added the 802.11REVmc-D5.2 specification as a reference for test cases 5.2.65 and 4.2.58. Modifed the General Capabilities Table, APUT Tests Table, STAUT Tests Table, STAUT Tests Table as per the Addendum. Annex A: added R2 test bed STA and AP devices. Annex E – added Short GI for 160 MHx to Off for AP and STA, and added Extended 5 GHz Channel Support for STA. Annex F – Modified DUT Default Modes tables for APUT, STAUT per the Addendum. Test case 4.2.34 – changed to Mandatory for APUT. Test case 5.2.42 – changed to Mandatory for STAUT. Added test cases 4.2.34 through 4.2.59B. Added test cases 5.2.42 through 5.2.67B.
2.1	6/29/16 8/26/16 9/1/16 9/13/16	5.2.58 – Test bed AP changed from 1SS to 2SS. 4.2.55 – Corrected typo on ping recipient Annex A – Corrected MediaTek R1 AP's firmware version Annex A – Updated Broadcom R1, Realtek R1, Broadcom 11n, and Marvell 11n station software 4.2.44 – Replaced Marvell station with Broadcom station
2.2	10/19/16	Clarified prerequisite for PMF applies to 2.4 GHz in dual-band devices
2.3	2/13/17 2/20/17 3/28/17	Clarified that the PMF test plan does not require running all test cases in both 2.4 and 5 GHz for dual band devices. Added test case Extended 5 GHz Channel Support on APUT Annex A – Consolidated R1 and R2 devices. Affected test cases 4.2.1, 4.2.2, 4.2.5.1, 4.2.16, 4.2.19, 4.2.20, 4.2.21, 4.2.25, 4.2.26, 4.2.29, 4.2.40, 4.2.42, 4.2.43, 4.2.44, 4.2.51, 4.2.53, 5.2.1, 5.2.9.1, 5.2.9.2, 5.2.10, 5.2.22, 5.2.23, 5.2.26, 5.2.28, 5.2.32, 5.2.33, 5.2.34, 5.2.35, 5.2.36, 5.2.46, 5.2.47, 5.2.49, 5.2.50, 5.2.52, 5.2.54, 5.2.57, 5.2.59, 5.2.60, 5.2.61, 5.2.62

2.4	4/4/17	Annex A – Adjusted device names to match Tessco catalog.
	4/13/17	Corrected link on title page.
	6/14/17	Table 1 and 2 – Added test case 4.2.60 List of Tables – Corrected table numbering
	6/19/17	Annex A – Corrected the Marvell station's driver version
	8/25/17	Annex A – Updated Qualcomm's email address