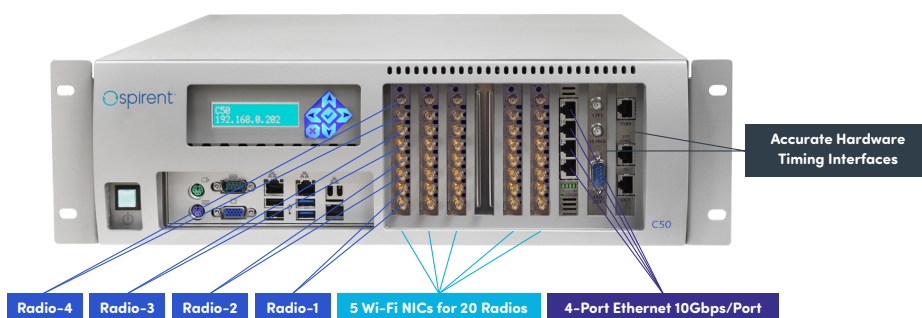


Spirent TestCenter WLAN

802.11ax 6GHz Wi-Fi 6/6E C50 High Radio Count (HRC) Appliance

802.11ax on the new 6GHz spectrum or Wi-Fi 6E comes alongside the latest 802.11ax standard and means devices can now operate on 6GHz band in addition to the existing 2.4GHz and 5GHz. Spirent TestCenter WLAN C50 High Radio Count (HRC) Wi-Fi 6E Appliance is a compact 3U appliance with a server-grade high performance process engine and rich interfaces. It combines Spirent's IEEE 802.11ax tri-band 2.4GHz/5GHz/6GHz HRC interface cards (NICs) with Spirent's 4-port IEEE 802.3bz BASE-T 100Mbps/1Gbps/2.5Gbps/5Gbps/10Gbps Ethernet cards on a copper interface. There are twenty (20) 802.11ax tri-band 2.4GHz/5GHz/6GHz client radios integrated with the appliance. This test instrument has the industry's highest integration in terms of radio counts within a single small appliance to realistically emulate multiple 802.11ax clients for Wi-Fi 6/6E support. This enables a new era of testing solutions for 802.11ax features and performance with Spirent's protocols, testing methodologies, automation capability, intelligent data mining, and testing results and report generation.

Orthogonal Frequency-Division Multiplexing Access (OFDMA) introduced in 802.11ax is a large step beyond OFDM, which is used by previous generation 802.11 standards. Testing tools and testing methodologies must be developed to offer the industry comprehensive testing strategies to cover the increased test cases due to new features in 802.11ax, without a significant increase in investment and test time. This development strategy must include a wide range of testing scenarios for the new 802.11ax features, such as OFDMA and Multi-User (MU) Multi-Input and Multi-Output (MIMO) in scale and performance. This requires emulating multiple 802.11ax clients, each with independent transmitters (TX) and receivers (RX) for testing. Each radio interface in the C50 appliance is operated independently with a dedicated process engine for control and data plane operation. Utilizing both the Ethernet and multiple WLAN cards installed in the appliance, users can emulate many realistic 802.11ax clients with traffic generation and analysis for both functional and performance testing.



Spirent 802.11ax C50 HRC Appliance

Applications

- Conductive or OTA testing
- Support 2.4GHz/5GHz/6GHz band
- Multi 802.11ax client testing scenarios
- OFDMA and MU-MIMO testing
- Single trip latency measure
- Functional, performance, and scalability testing
- Stability testing
- Security and authentication type testing
- AP interwork with legacy IEEE 802.11 mode
- Association processing and DHCP timing testing
- RFC2544 benchmark performance testing
- UDP stateless and TCP stateful traffic testing
- Application layer traffic testing
- 802.11ax feature testing
- Roaming, airtime fairness, band steering testing
- Test results and reports with Spirent TestCenter IQ

The C50 HRC Appliance enables users to emulate up to 20 fully featured 802.11ax clients to connect with an AP, either via cabled conductive connections or antennas installed Over-The-Air (OTA) link. Each radio stream path is characterized with the minimum internal RF signal path loss. This provides assurance for the typical 802.11ax use cases with a need to support the maximum achievable performance in radio interface level while used in OTA mode.

The appliance has an internal hardware-based clock crossing all radio and Ethernet interfaces with a high precision timing synchronization aimed at emulating realistic clients operating individually and for accurate latency measurements. This proprietary timing interface also allows inter-connection of multiple Spirent appliances and chassis to share a common Spirent signature timing clock. Consequently, two or more C50 Appliances can be easily inter-connected with an RJ45 cable to achieve an even higher OFDMA or MU client counts

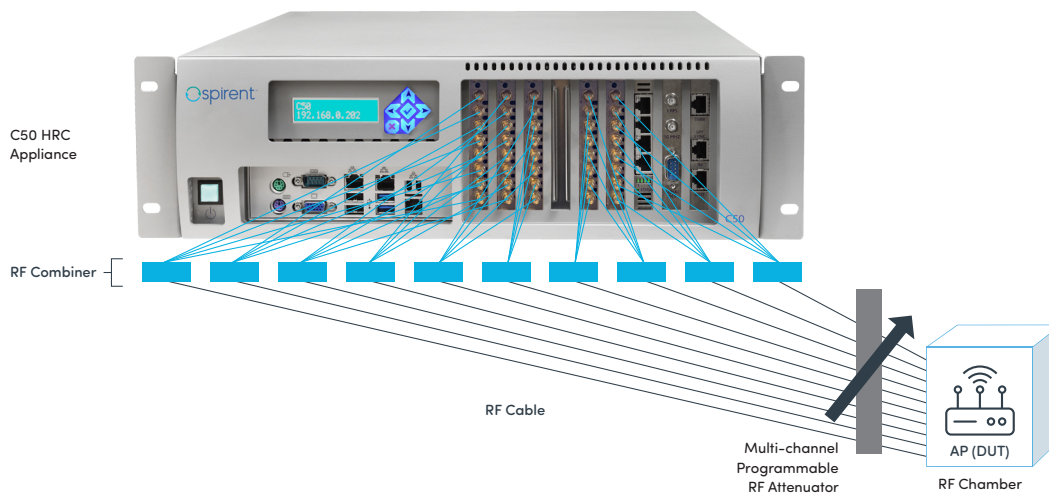
for higher scale test cases. Basic WLAN control plane and data plane features, along with the Spirent's signature L2-7 and rich set of protocols for timing, traffic, and throughput performance test cases, are supported over the WLAN network involving those Wi-Fi 6 clients and APs under test. These features meet the highly intensive testing requirements of new 802.11ax features such as OFDMA and MU-MIMO.

The C50 HRC Appliance can be set up with either RF cabled conductive or OTA mode. An example testbed setup is shown in the following diagram with several external RF combiners and a multiple channel programmable RF attenuator to connect a C50 to an RF chamber/enclosure. The required TX power level can be properly adjusted by using the programmable attenuator. This testbed can support multiple test cases such as OFDMA, MU-MIMO, maximum throughput, rate vs range, etc.



Port 1	(Group 1)	802.11, 2.4GHz/5GHz	Available
Port 2	(Group 1)	802.11, 2.4GHz/5GHz	Available
Port 3	(Group 1)	802.11, 2.4GHz/5GHz	Available
Port 4	(Group 1)	802.11, 2.4GHz/5GHz	Available
Port 5	(Group 5)	802.11, 2.4GHz/5GHz	Available
Port 6	(Group 5)	802.11, 2.4GHz/5GHz	Available
Port 7	(Group 5)	802.11, 2.4GHz/5GHz	Available
Port 8	(Group 5)	802.11, 2.4GHz/5GHz	Available
Port 9	(Group 9)	802.11, 2.4GHz/5GHz	Available
Port 10	(Group 9)	802.11, 2.4GHz/5GHz	Available
Port 11	(Group 9)	802.11, 2.4GHz/5GHz	Available
Port 12	(Group 9)	802.11, 2.4GHz/5GHz	Available
Port 13	(Group 13)	802.11, 2.4GHz/5GHz	Available
Port 14	(Group 13)	802.11, 2.4GHz/5GHz	Available
Port 15	(Group 13)	802.11, 2.4GHz/5GHz	Available
Port 16	(Group 13)	802.11, 2.4GHz/5GHz	Available
Port 17	(Group 17)	802.11, 2.4GHz/5GHz	Available
Port 18	(Group 17)	802.11, 2.4GHz/5GHz	Available
Port 19	(Group 17)	802.11, 2.4GHz/5GHz	Available
Port 20	(Group 17)	802.11, 2.4GHz/5GHz	Available
Port 21	(Group 21)	Link Up, Speed 10G	Available
Port 22	(Group 22)	Link Up, Speed 10G	Available
Port 23	(Group 23)	Link Up, Speed 10G	Available
Port 24	(Group 24)	Link Up, Speed 10G	Available

C50 HRC Physical Port Placement and Assignment
Example: 20 Radio Ports and 4 10Gbps Ethernet Ports



C50 HRC Appliance Testbed Setup Example

Each radio interface can be used to validate L2 to L7 traffic performance when it is associated with an AP. The example shown is for the maximum achievable L2 UDP throughput in an OTA mode, where a 2x2 radio interface can obtain over

1Gbps throughput with 1518-byte packets. The throughput history is presented in the graph generated in real time with the Spirent TestCenter IQ tool.

IEEE 802.11 Client Configuration (Not Saved) LIVE								
Mac Address	Client State	Channel Number	IEEE 802.11 Stand...	Frequency Band	Channel Width	Authentication Ty...	MIMO Mode	Noise Floor (dBm)
00:10:94:00:00:02	Associated	36	802.11(ax)	5GHz	80 MHz	Open	2x2	-101

IEEE 802.11 Client Rx Results (Not Saved) LIVE									
Mac Address	RSSI (dBm)	Rx MCS Type	Rx Phy Rate (Mbps)	Rx NSS	Rx Guard Interval	Tx MCS Type	Tx Phy Rate (Mbps)	Tx NSS	Tx Guard Interval
00:10:94:00:00:02	-47	1024-QAM 5/6	1,200.9	2	800	1024-QAM 5/6	1,200.9	2	800

802.11ax Configuration and Statistics



UDP Throughput Performance
 Example showing 2x2 MIMO, 1518-byte, Time Series from Spirent TestCenter IQ

IEEE 802.11 standard is a packet-based protocol. Each physical layer conformance procedure (PLCP) protocol data unit (PPDU) contains preamble and data fields. With OFDMA support, multiple users can simultaneously share a full channel bandwidth for channeling data sessions more effectively. The combination of the frequency section and the transmission time is a bandwidth segment called a Resource Unit (RU). These test cases need a testbed with many independent client radio interfaces to emulate realistic use cases with different types of RU assignments, managed by an AP for OFDMA operations defined in IEEE 802.11ax standard, to achieve repeatable testing results.

All 20 emulated clients within the C50 can be used for OFDMA testing with limited real-time statistics and counters reported. In this test configuration, Single User (SU) vs Multi-User (MU) is usually focused in a statistical level. Users can see real-time statistics such as PPDU type, MU counter, and

SU counter. Users can then understand the MU activities from those statistics and counters. A shadow mode is also available to set a dedicated sniffer radio behind each AID for real-time statistics and counters capturing, decoding, and reporting. This includes PPDU type, RU index, RU counters, MU counter, SU counter, and RU placement on per Association Identification (AID) basis.

For APs that use HE multicast triggering-based frames for OFDMA operation, it also provides a single sniffer mode with only one dedicated radio to obtain the statistics and counters mentioned above with the shadow mode. One radio sniffer is a unique solution to decode and report useful RU information for OFDMA testing much more economically. The results table shows an example where 19 clients are used for Downlink (DL) OFDMA testing and the results are reported accordingly.

Device Name	RX RU Type	Rx PPDU Type	Rx RU26	Rx RU52	Rx RU106	Rx RU242	Rx RU484	Rx RU996	Rx MU Packets (frames)	Rx SU Packets (frames)
STA1	52-tone	MU-OFDMA	0	77,638	302	3,183	2,965	511	2,353,741	31,596
STA2	52-tone	MU-OFDMA	0	83,686	551	1,811	2,296	696	2,369,097	19,888
STA3	52-tone	MU-OFDMA	0	83,254	547	2,006	2,289	703	2,362,791	23,943
STA4	52-tone	MU-OFDMA	0	83,317	567	2,085	2,410	680	2,369,617	22,264
STA5	52-tone	MU-OFDMA	0	75,040	189	3,763	2,826	336	2,359,878	24,358
STA6	52-tone	MU-OFDMA	0	81,597	476	2,392	2,580	661	2,363,499	25,422
STA7	52-tone	MU-OFDMA	0	81,906	514	2,343	2,506	638	2,361,726	24,467
STA8	52-tone	MU-OFDMA	0	82,375	521	2,229	2,613	662	2,361,873	25,939
STA9	52-tone	MU-OFDMA	0	83,646	615	2,179	2,520	711	2,373,098	13,980
STA10	52-tone	MU-OFDMA	0	81,416	477	2,441	2,652	590	2,371,530	15,560
STA11	52-tone	MU-OFDMA	0	81,792	506	2,371	2,518	652	2,373,638	15,212
STA12	52-tone	MU-OFDMA	0	81,837	470	2,363	2,607	605	2,368,945	19,682
STA13	52-tone	MU-OFDMA	0	82,395	545	2,293	2,624	663	2,355,922	29,939
STA14	52-tone	MU-OFDMA	0	82,451	496	2,236	2,588	739	2,374,493	14,736
STA15	52-tone	MU-OFDMA	0	83,007	554	2,091	2,576	679	2,373,659	15,925
STA16	52-tone	MU-OFDMA	0	83,313	559	2,097	2,433	717	2,372,677	17,457
STA17	52-tone	MU-OFDMA	0	83,039	565	2,132	2,526	680	2,350,862	38,920
STA18	52-tone	MU-OFDMA	0	85,781	723	1,418	1,941	771	2,367,948	23,530
STA19	52-tone	MU-OFDMA	0	85,141	658	1,526	2,068	780	2,375,175	15,108

DL and OFDMA Results Reported in Real Time

Features & Benefits

- Support 802.11 b/g/n/ax on 2.4GHz, 802.11 a/n/ac/ax on 5GHz, and 802.11ax on 6GHz frequency bands
- Support tri-band 2.4GHz, 5GHz, and 6GHz concurrently
- Support single 2.4GHz, 5GHz, or 6GHz band
- Support 1x1 SISO and 2x2 MIMO
- Support 20MHz and 40MHz channel bandwidths for clients on 2.4GHz band
- Support 20MHz, 40MHz, 80MHz, and 160MHz channel bandwidths for clients on 5GHz and 6GHz band
- Support various 802.11ac/ax client configurations for MU-MIMO grouping testing
- OFDMA RU testing with up to 20 RUs per PPDU
- Support various RU types including RU26, RU52, RU106, RU242, RU484, and RU996
- Support per AID based unicast sniffer for HE packet capture
- Support synchronized multiple AIDs based sniffer captures
- Support up to 1Gb sniffer capture buffer on per radio basis
- Report real-time PPDU type, RU type, RU counter, and RU allocations for OFDMA testing
- Support 802.11ax PHY features such as long training field; HE duration-based RTS; dual-carrier modulation
- Support various channel selection plan for different geographic regions globally
- Maximally interoperable with various chipset vendor's WLAN AP products
- Best in class realistic traffic generation and analysis over WLAN and Ethernet interfaces
- Capable of providing multiple traffic flows per client with each flow offering traffic at layers 2 through 7
- Capable of generating realistic and stateful WLAN client traffic individually on per client basis
- Support individually controlled client behavior providing accurate control of 802.11, 802.3, and IP characteristics, including medium access control, authentication and encryption, frame size, and rate
- Emulate client association mode in either a designated sequential or more realistic random fashion
- Support various RFC2544 test cases for throughput benchmark performance testing
- Each emulated client supports the full MAC per 802.11 standard independently
- Upper layer protocols (e.g., DHCP and TCP) are fully supported using independent protocol tasks
- Test AP data plane performance using flow packets of different sizes, protocol types, encryptions, and rates
- Support different 802.3 Ethernet packet length control functionalities including fixed, increment, decrement by user-defined step or automatic, list, random and shuffle
- Support user configurable iMIX traffic testing profile
- Filter options with specific types of packets (e.g. SSIDs, BSSIDs, etc.) for reducing capture file size or for a longer capture
- Extensive 802.11 statistics, counters, and statistics reporting in either real-time or periodically on per client or per port basis
- Support 802.3 and 802.11 real-time port statistics, per flow statistics, and port-level histogram
- Support per spatial stream statistics and counters
- Time series or history result report with Spirent TestCenter IQ

WLAN NIC Technical Specifications

802.11 Protocols	<ul style="list-style-type: none"> IEEE 802.11 b/g/n/ax on 2.4GHz band IEEE 802.11 a/n/ac/ax on 5GHz band IEEE 802.11 ax on 6GHz band
Number of Radio per NIC	4
Maximum Number of Clients	4 per NIC, 20 per C50
MIMO	Support MIMO configurations 1x1 and 2x2
MU-MIMO	Support DL MU-MIMO clients with 1x1 or 2x2
Frequency Band	2.4GHz (802.11 b/g/n/ac/ax), 5 GHz (802.11 a/n/ac/ax), and 6GHz, single band, dual-band, and tri-band
Selectable Channel Bandwidth	20MHz or 40MHz on 2.4GHz band, 20MHz, 40MHz, 80MHz, and 160MHz on 5GHz and 6GHz band
Guard Interval	Guard interval selection—800/400 ns for 802.11 n/ac, 800/1600/3200 ns for 802.11ax
DL OFDMA	Support DL OFDMA up to 20 RU per C50
UL OFDMA	Support UL OFDMA up to 20 RU per C50
Rate Adaptation	Support full rate adaptation by default, and selectable MCS index in TX
Coding Supported	Supports Spatial Multiplexing, Cyclic-Delay Diversity (CDD), Low-Density Parity Check (LDPC), Maximum Ratio combining (MRC), Space Time Block Code (STBC)
Coding Rates	FEC coding rates - 1/1, 2/3, 3/4, 5/6
MCS Type	Full MCS index support in 802.11 n/ac/ax <ul style="list-style-type: none"> all 0-15 MCS index for 802.11n all 0-9 MCS index for 802.11ac all 0-11 MCS index for 802.11ax

Maximum PHY Rates in 802.11ax with short GI= 800ns	MCS	Modulation	20MHz	20MHz	40MHz	40MHz	80MHz	80MHz	160MHz	160MHz
			1x SS	2x SS	1xSS	2xSS	1x SS	2x SS	1xSS	2xSS
Phy Rate (Mbps)										
	0	BPSK 1/2	8.6	17.2	17.2	34.4	36.0	72.1	72.1	144.1
	1	QPSK 1/2	17.2	34.4	34.4	68.8	72.1	144.1	144.1	288.2
	2	QPSK 3/4	25.8	51.6	51.6	103.2	108.1	216.2	216.2	432.4
	3	16QAM 1/2	34.4	68.8	68.8	137.6	144.1	288.2	288.2	576.5
	4	16QAM 3/4	51.6	103.2	103.2	206.5	216.2	432.4	432.4	864.7
	5	64QAM 1/2	68.8	137.6	137.6	275.3	288.2	576.5	576.5	1,152.9
	6	64QAM 3/4	77.4	154.9	154.9	309.7	324.3	648.5	648.5	1,297.1
	7	64QAM 5/6	86.0	172.1	172.1	344.1	360.3	720.6	720.6	1,441.2
	8	256QAM 3/4	103.2	206.5	206.5	412.9	432.4	864.7	864.7	1,729.4
	9	256QAM 5/6	114.7	229.4	229.4	458.8	480.4	960.8	960.8	1,921.6
	10	1024QAM 3/4	129.0	258.1	258.1	516.2	540.4	1,080.9	1,080.9	2,161.8
	11	1024QAM 5/6	143.4	286.8	286.8	573.5	600.5	1,201.0	1,201.0	2,402.0

WLAN NIC Technical Specifications (cont'd)

Channel and Frequency	<ul style="list-style-type: none"> • 2.412 to 2.484 GHz: 1 to 14
Operation Channels on 2.4GHz and 5GHz	<ul style="list-style-type: none"> • 5.180 to 5.320 GHz: 36, 40, 44, 48, 52, 56, 60, 64 • 5.500 to 5.700 GHz: 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 • 5.740 to 5.825 GHz: 149, 153, 157, 161, 165
Channel and Frequency	Total 59x 20MHz Channels
Operation Channels on 6GHz	UNI5: 5925–6425 (24 x 20MHz): 1,5,9,13,17,21,25,29,33,37,41,45,49,53,57,61,65,69,73,77,81,85,89,93 UNI6: 6425–6525 (5 x 20MHz): 97,101,105,109,113 UNI7: 6525–6875 (18 x 20MHz): 117,121,125,129,133,137,141,145,149,153,157,161,165,169,173,177,181,185 UNI8: 6875–7125 (12 x 20MHz): 189,193,197,201,205,209,213,217,221,225,229,233 Total 29x 40MHz Channels UNI5: 5925–6425 (12 x 40MHz): 3,11,19,27,35,43,51,59,67,75,83,91 UNI6: 6425–6525 (3 x 40MHz): 99,107,115 UNI7: 6525–6875 (9 x 40MHz): 123,131,139,147,155,163,171,179,187 UNI8: 6875–7125 (5 x 20MHz): 195,203,211,219,227 Total 14x 80MHz Channels UNI5: 5925–6425 (6 x 80MHz): 7,23,39,55,71,87 UNI6: 6425–6525 (2 x 80MHz): 103,119 UNI7: 6525–6875 (4 x 80MHz): 135,151,167,183 UNI8: 6875–7125 (2 x 80MHz): 199,215 Total 7x 160MHz Channels UNI5: 5925–6425 (3 x 160MHz): 15,47,79 UNI6: 6425–6525 (1 x 160MHz): 111 UNI7: 6525–6875 (2 x 160MHz): 143,175 UNI8: 6875–7125 (1 x 160MHz): 207
Interface Connector	Antenna interface connectors: SMA female connector, standard thread, AC coupled, 50 Ohms
Authentication Support	802.1x–PEAP/MSCHAPv2, TLS, LEAP/EAP-FAST, AKA, AKA', TTLS
Encryption Support	WEP-40 and WEP-104, TKIP (WPA), AES-CCMP (WPA2/WPA3)
Physical Specifications	3U H x 16.53" W x 19.75" D, Weight: 38 Lbs. (17 Kg)
Power Supply Safety	Input voltage range: 100V–240V 50–60Hz 750W
Compliance and Certifications	<ul style="list-style-type: none"> • FCC Part 15 Class A • CE Mark Class A EN 55032:2012; EN 55024:2010; EN 61000-3-3:2013; EN 61000-3-2:2014 • UL 60950-1:2007 R10.14 • CAN/CSA-C22.2 NO.60950-1-07+A1:2011+A2:2014 • IEC 60950-1:2005 (Second Edition) + Am 1:2009 + Am 2:2013

Description	Part Number
C50 4-Port 10G/5G/2.5G/1G/100M Ethernet Copper, 802.11AX Wi-Fi 6E Tri-Band NICs for 20 OFDMA/MU Clients, 2x2 MIMO, 2.4GHz/5GHz/6GHz, and HW Timing	C50-KIT-11AX-6E

About Spirent Communications

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks. We help bring clarity to increasingly complex technological and business challenges. Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled. For more information visit: www.spirent.com

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