The Pal-6 Wi-Fi 6 (11ax) smartBox subsystem

octoScope's Pal-6® is a Wi-Fi 6 (IEEE 802.11ax) test instrument. It functions as a traffic partner, sniffer, virtual station emulator and a load generator for testing throughput, capacity, roaming, band steering and more. Pal-6 comes built into an octoBox® chamber, making that chamber a *smartBox*™. It is also available as a stand-alone instrument.

Pal-6 incorporates optional Bluetooth (BT) test profiles, including A2DP, OPP, HFP, HID and BLE.

Pal-6 is based on one of the most advanced Wi-Fi 6 chipsets on the market supporting all the protocols, IEEE 802.11a/b/g/n/ac/ax. With access to the chipset's driver and firmware via the octoScope API, you can configure Pal-6 as a real device or as a test instrument. As a real device, Pal-6 acts as a traffic partner running the STA (station) and AP (access point) drivers. As an instrument, it can emulate virtual stations for testing APs under heavy traffic load from multiple stations, act as multiple APs to a station under test, perform expert monitoring and analysis, replay captured traffic or operate as a sniffer.

FEATURES

- 802.11ax up to 8x8 MIMO-OTA transmission
- 2.4 and 5 GHz 802.11a/b/g/n/ac/ax radios and two BT5/BLE/BLE 2 GHz EDR radios
- BT profiles: A2DP, OPP, HFP, HID, BLE HID
- Wireshark synchroSniffer™ with a sniffer probe on each of the 5 radios for simultaneous Wi-Fi and Bluetooth sniffing
- Up to 64 virtual Wi-Fi stations, vSTAs, per radio, up to 192 vSTAs total per Pal-6
- Complete isolation from outside interference
- REST and GraphQL API for test automation
- Test script examples in Python

BENEFITS

- Quickly and easily verify emerging 802.11ax and legacy Wi-Fi devices in the ideal 8x8 MIMO-OTA environment
- Using the octoBox personal testbed, perform key tests including throughput vs. range vs. orientation, roaming, band steering, coexistence, WFA certification and more
- Test BT/Wi-Fi coexistence
- Test BT pairing and performance of peripheral devices, including speakers, keyboards, etc.
- Perform root cause analysis of issues using built-in multi-channel sniffing
- Test capacity of APs with up to 192 concurrent virtual stations; application layer traffic

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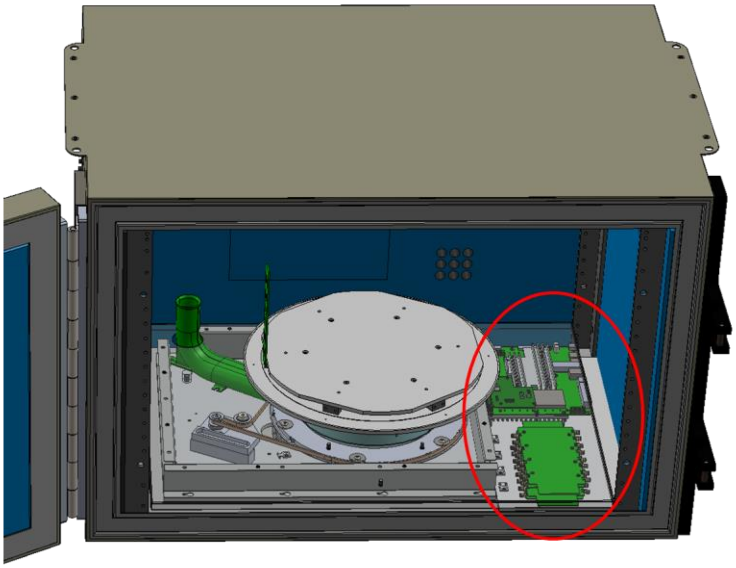
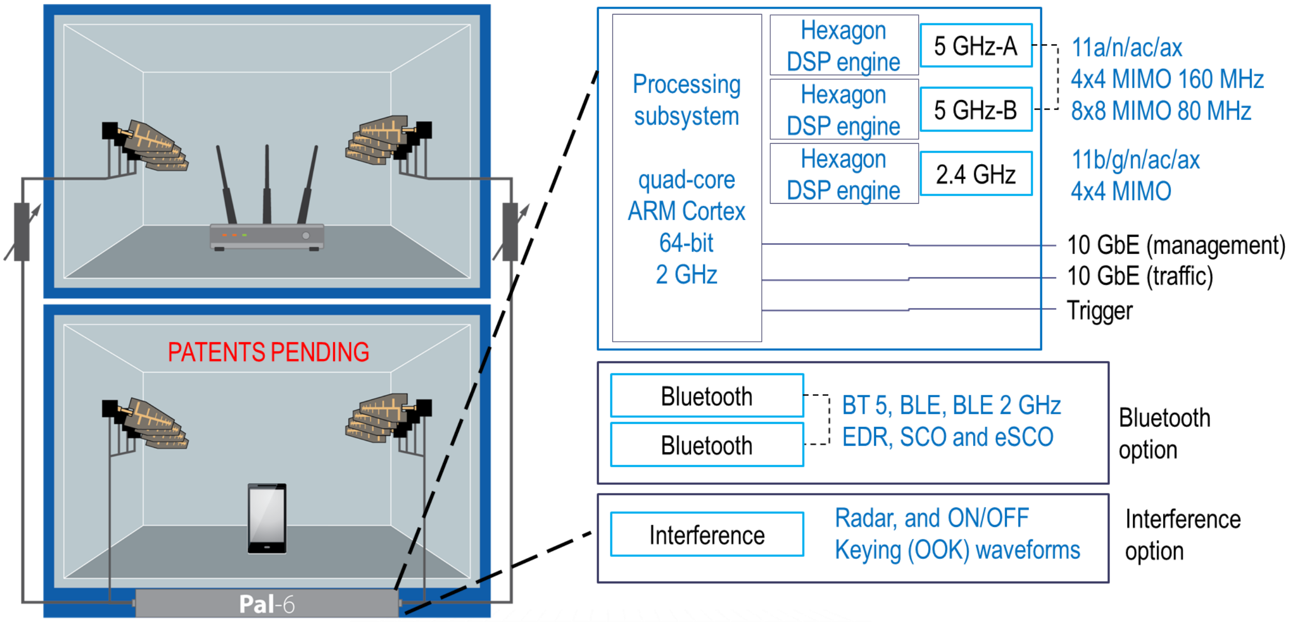
PAL-6 ARCHITECTURE

Based on the latest 802.11ax chipset and with fine controls at the firmware and driver level, Pal-6 can function as a real device or as a precision test instrument. For example, to test band steering, Pal-6 can function at a set data rate, bandwidth and number of streams. To test receiver sensitivity, Pal-6 can operate at a fixed modulation coding scheme (MCS).



Pal-6 features three 802.11ax radios. The two 5 GHz radios support up to 8x8 MIMO in channels of up to 80 MHz, or 4x4 MIMO in 80+80 or 160 MHz channels. It includes two BT5, BLE, EDR radios to test Bluetooth and to capture BT sniffer traces. Pal-6 also includes a synthesizer for generating radar and other OOK (on off keying) interference.

Pal-6 features two 10 GbE ports, one for traffic and the other for streaming plot statistics and PCAP captures.



Pal-6 built into the smartBox

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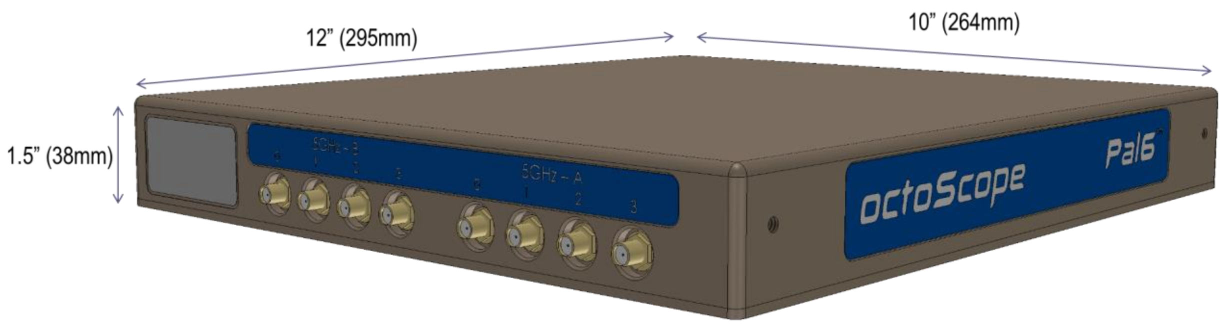
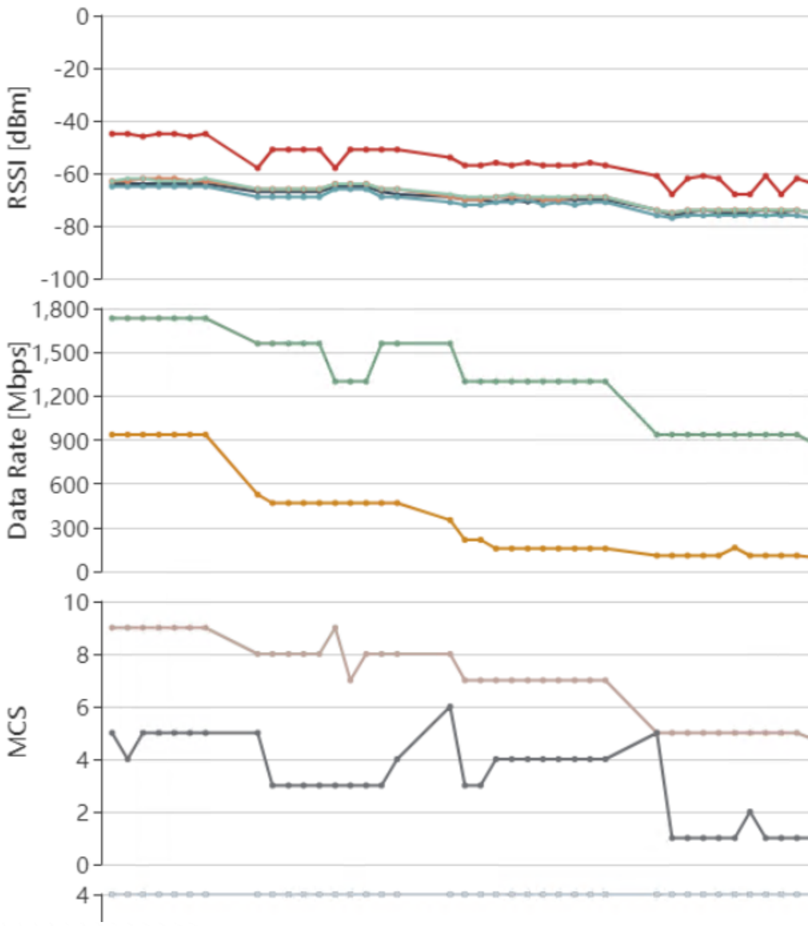


Pal-6 stand-alone module

STATISTICS AND INDICATORS

Pal-6 can function as a real-time analyzer to show adaptation behavior of modern Wi-Fi systems. It can monitor and plot RSSI, data rate, number of spatial streams, channel width and other physical layer information.



AP TESTING

To test access point (AP) performance or to emulate a realistic network with multi-station traffic, Pal-6 can emulate up to 64 vSTAs (virtual stations) per-radio, up to 192 virtual stations per Pal-6.

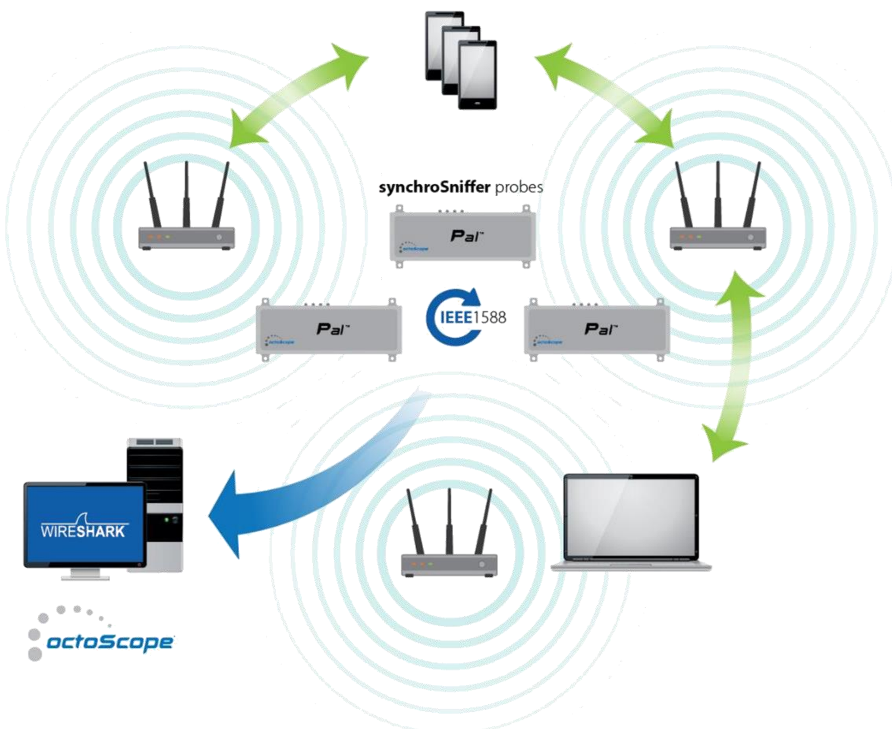
Real-life traffic can be bridged from the Ethernet interface via each vSTA to test video, voice and data performance with different priority and security settings.

STATION TESTING

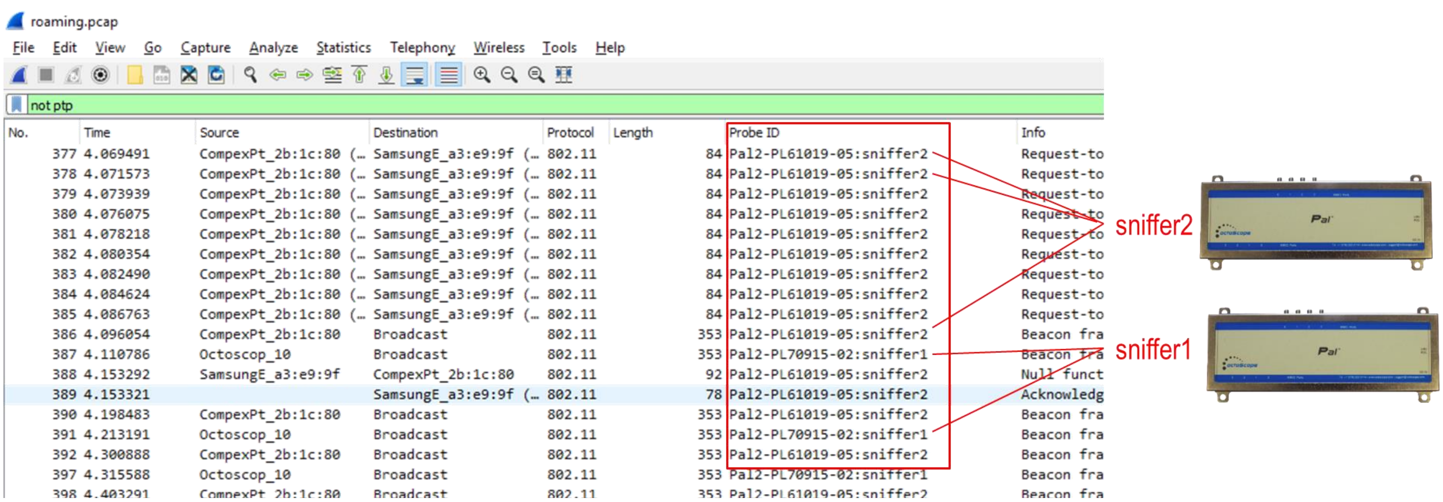
To test a station device, configure the Pal-6 radios as APs so they can be traffic partners to the station under test. The radios can also be sniffers or expert analyzers. Station tests include throught vs. range vs. orientation, RX sensitivity, data rate adaptaiton performance, roaming, band steering, and more.

SYNCHROSNIFFER™

Pal-6 can capture and stream packets in the PCAP format to the Wireshark in real-time. Each radio on the Pal-6 is synchronized with the radios on the same or other Pals via the Network Time Protocol (NTP) or Precision Time Protocol (PTP).



The captures from each radio in the octoBox testbed are combined in a common PCAP file viewable in the octoScope-customized Wireshark for easy analysis. In this custom Wireshark application, you can identify captures by probe (i.e. Pal radio). Such an aggregate multiprobe view helps analyze complex band steering, roaming and mesh behavior in the presence of motion, interference, path loss, multipath and DUT orientation.



synchroSniffer capability is particularly helpful when testing OFDMA links with multiple stations operating on different resource units (RUs) because a single sniffer can only monitor a single RU. For an OFDMA link with 4 stations, you may need 4 sniffer probes, one on each station. When placed inside a smartBox, each of the OFDMA stations can be monitored by a dedicated built-in Pal-6. The sniffer captures from each smartBox are then aggregated via the synchroSniffer software for powerful analysis of the entire complex OFDMA link. Pal-6 radios can also work as in-line sniffer probes when configured as an AP or a STA. Thus, Pall-6 radios can be synchrosniffer probes in three

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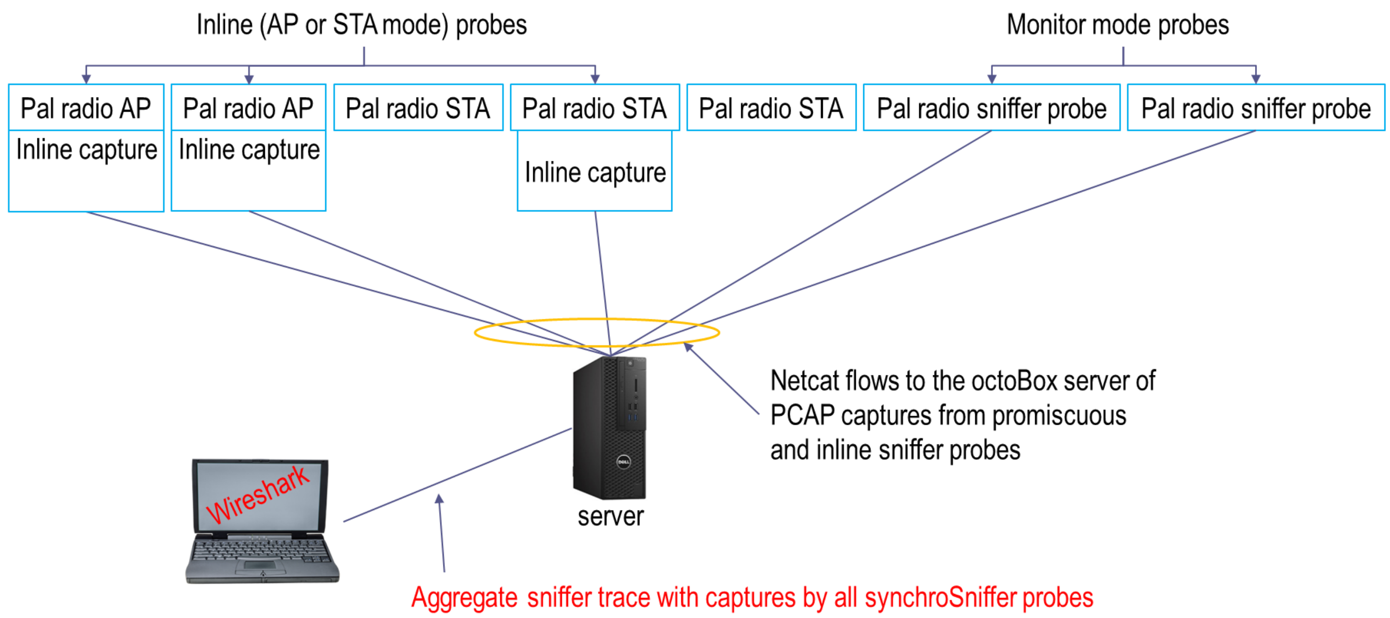
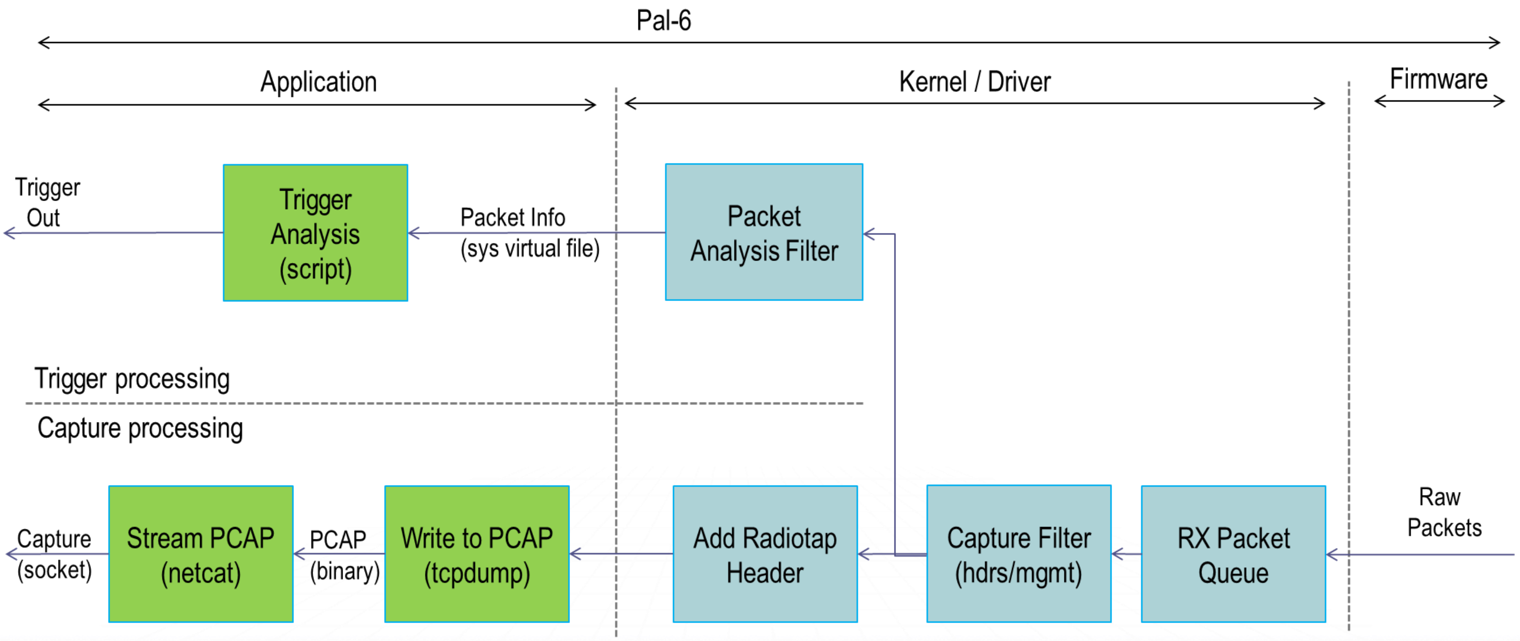
modes: monitor (capture all packets), inline AP (capture packets addressed to the AP) or inline STA (capture packets addressed to the STA).



EVENT BASED TRIGGERING

Any Pal-6 radio can generate a trigger based on conditions defined by a Javascript program running inside its OS for optimum performance. You can instantiate a filter in the driver and a trigger script.



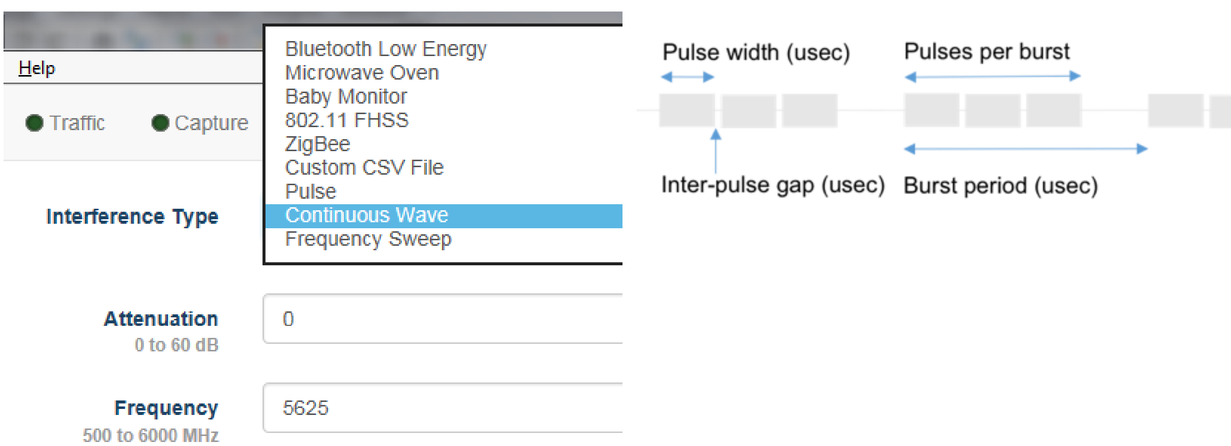
BLUETOOTH TESTING

Bluetooth testing includes:

- Pairing test of BT5, BLE, EDR and legacy BT devices
- Master and Slave modes for pairing and traffic testing
- BT sniffer on 2 BT radios simultaneously, synchronized with captures from Bluetooth or Wi-Fi radios on any octoScope Pals
- BT traffic partner to the DUT
- HID latency
- AFH map
- Configurable packet size
- Simultaneous BT and Wi-Fi traffic
- Powerful test automation API

INTERFERENCE

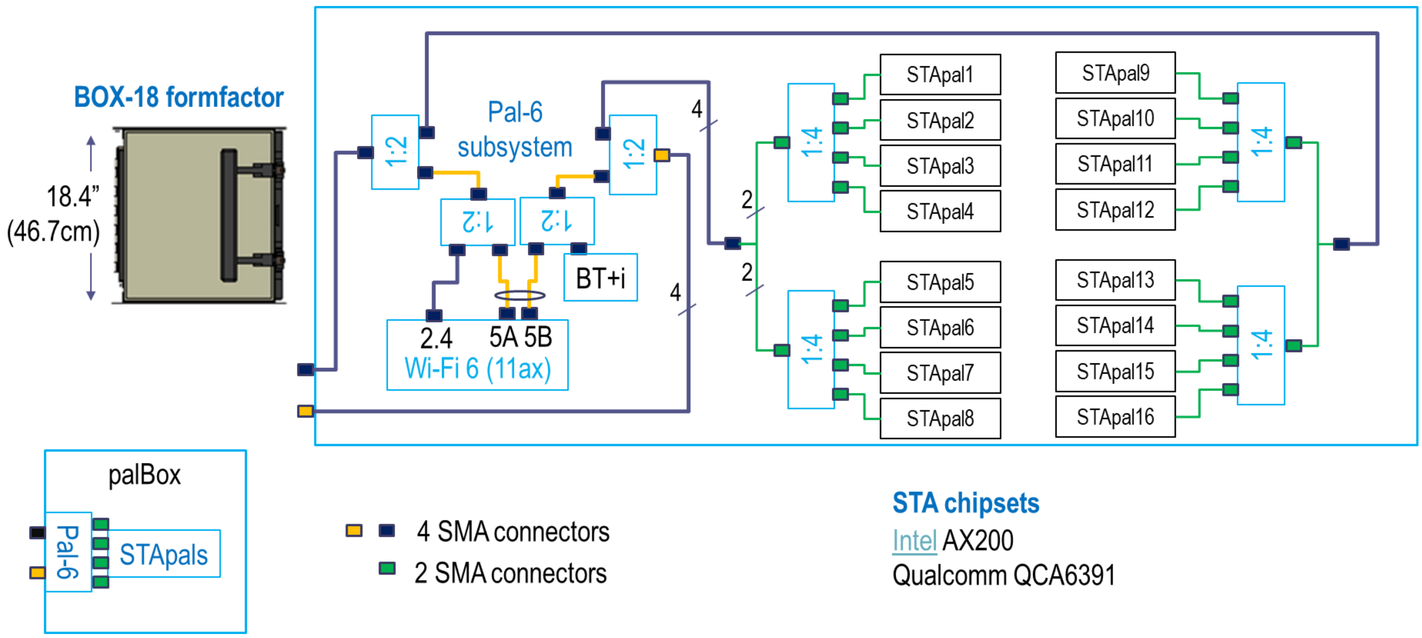
Interference is generated using a built-in frequency synthesizer and includes frequency hopping and On/Off Keying (OOK) based waveforms, including radar, Bluetooth LE, microwave oven, baby monitor, 802.11 FHSS, ZigBee and custom interference waveform.



For waveform generation, you can configure tone frequency and pulse train parameters as shown above on the right.

PALBOX

The palBox™ is a testbed building block containing 16 STApals™ and a Pal-6, all packed into a BOX-18 enclosure.

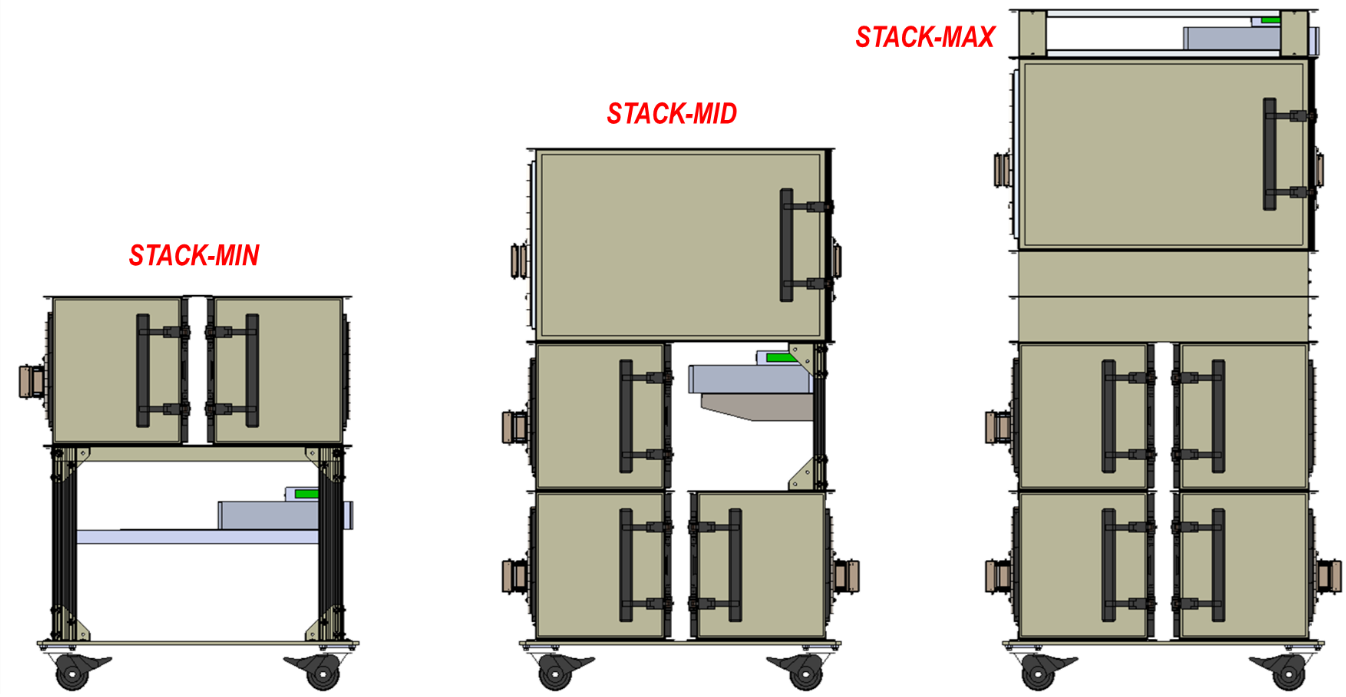


STApals are miniature Pals, each able to function as a multiPerf endpoint or a synchroSniffer probe. As a multiPerf endpoint, each STApal reports statistics similar to the Pal-6 statistics. For OFDMA sniffing, each STApal can be configured to sniff a single Resource Unit (RU) and with octoScope’s synchroSniffer capability, the captures by multiple STApals are aggregated into a single complete OFDMA trace.

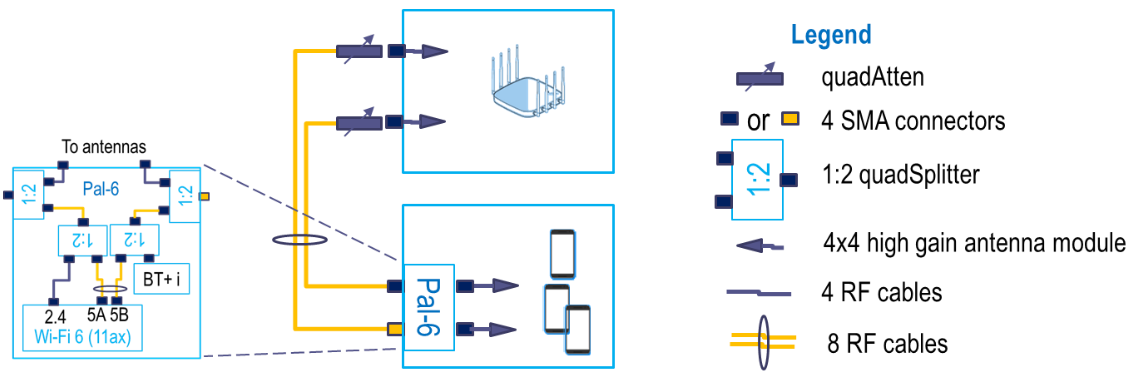
STApals can be based on either the Intel AX200 and Qualcomm QCA6391 chipsets.

PAL-6 IN AN OCTOBOX PERSONAL TESTBED

STACK-MIN, STACK-MID and STACK-MAX testbeds are recommended configurations with their test capabilities summarized in a table below.



A block diagram of the simplest Pal-6 based testbed, STACK-MIN, is shown below.



The STACK-MIN testbed is capable of the following tests:

- RvR
- RvR with rotation, RvRvO or RvOvR if a turntable is included
- Band steering
- Packet capture
- Addition of Triathlon™ to analyze the RF layer

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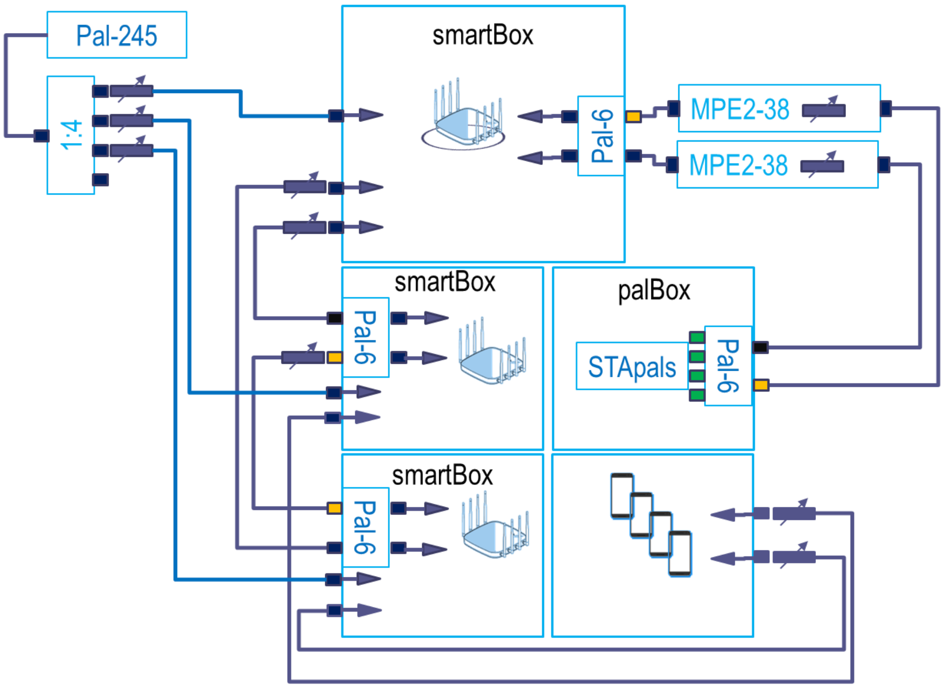
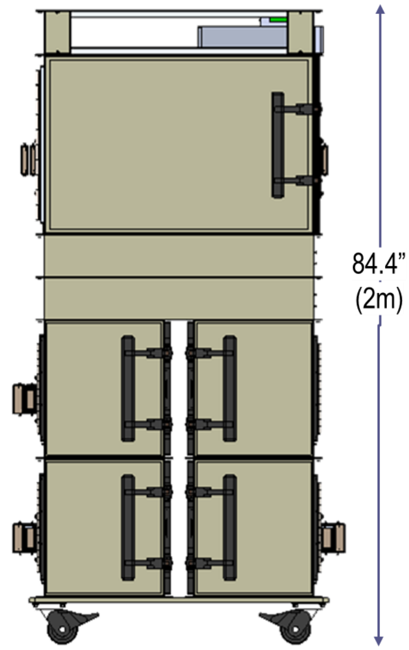
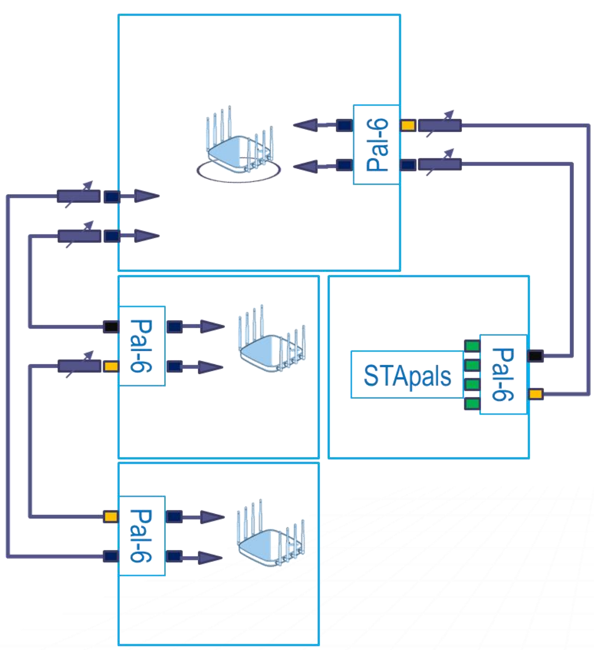
The STACK-MAX is the most comprehensive testbed.

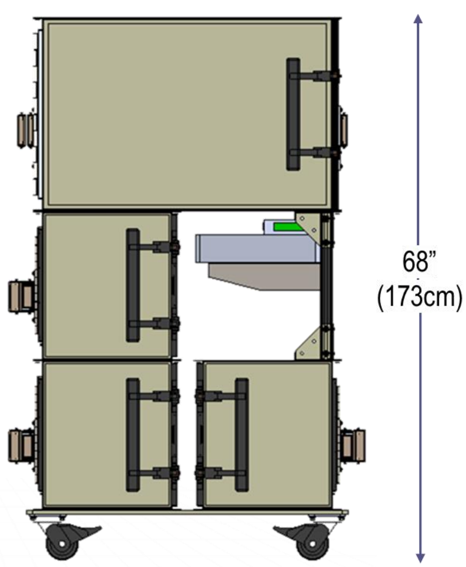




Footprint: 44” x 32”

The STACK-MID testbed supports RvR, TR-398 and other common tests.





Footprint: 44” x 32”

TESTBED CAPABILITIES

	STACK- MIN	MID	MAX	*Notes*
RvR, RvRvO, RvOvR	√	√	√	Orientation or rotation tests require a turntable
Tri-band throughput	√	√	√	Aggregate throughput on up to 3 channels
synchroSniffer probes 5 GHz 2.4 GHz	 2 1	 24 20	 24 20	palBox in STACK-MID and STACK-MAX has 16 STApals and a Pal-6 subsystem. Each STApal has a 2x2 STA radio for sniffing on either 2.4 or 5 GHz band.
OFDMA, 16 STAs		√	√	
Inline sniffing	√	√	√	synchroSniffer probe while in STA or AP mode, reporting packets targeted for the STA or AP
Band steering	√	√	√	
Roaming		√	√	
Mesh			√	
8x8 MIMO OTA	√	√	√	
8x8 with multipath			√	
160 MHz MIMO OTA	√	√	√	
MU-MIMO OTA	√	√	√	Beamforming based multi-user MIMO
DFS	√	√	√	
ACS	√	√	√	
Traffic replay	√	√	√	
vSTA 5 GHz 2.4 GHz Total	 128 64 192	 512 256 768	 512 256 768	Each vSTA can run its own traffic using octoScope's multiPerf mp2mp traffic; bridge via vSTAs to set up application layer traffic, e.g. voice/video streams
STApal OFDMA STAs		16	16	OFDM multiperf endpoints or synchroSniffer probes
TR-398		√	√	Automated certification to the Broadband Forum TR-398 performance test standard

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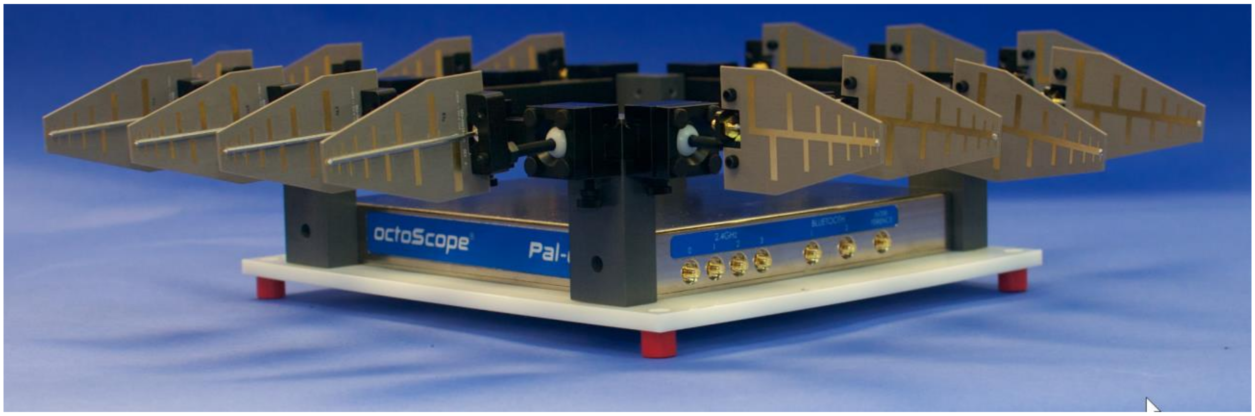
PAL-6 FOR USE IN TEST HOUSES

Use the *Pal-6* in a walk-in isolation chamber or in an open-air test environment, such as the test house.

All the RF connectors for the Wi-Fi 6 and Bluetooth radios and interference can be directly connected to the antennas or into a testbed. Antenna brackets support all octoScope's antenna carriers, including high gain antennas and dipole antennas for open air testing.

The default antenna system includes all dipole antennas for the Wi-Fi, Bluetooth and synthesizer ports.



Pal-6 antenna system can be configured with any of the octoBox antennas.

PAL-6 SPECIFICATIONS

Wi-Fi	
Channels	2.4 GHz and 5 GHz; tri-band
Bandwidth	20, 40, 80, 80+80, 160 MHz
Standards	801.11a, 802.11b, 802.11g, 802.11n, 802.11ac (wave 2), 802.11ax
Virtual stations	64 per-radio
Traffic replay	From PCAP file
Monitor	Detailed statistics from the Wi-Fi chipset
Sniffer	Wireshark captures
802.11ax PHY	Downlink OFDMA Uplink OFDMA Single user MIMO with > 1 spatial stream Downlink multiuser MIMO DL and UL single user transmit beamforming DL OFDMA + transmit beamforming
802.11ax MAC	Trigger frame support Non-trigger based and trigger-based sounding for beamforming Multi-user RTS and CTS Buffer status report UL-OFDMA Random Access Multiple BSSID Bandwidth query report
Bluetooth	
Protocols	Bluetooth 5, BLE, BLE 2 Mbps, EDR, SCO and eSCO
Test features	BT Master and Slave modes for pairing and traffic testing, HID latency, AFH map, configurable packet size, simultaneous BT and Wi-Fi traffic
Sniffer	Wireshark captures via synchroSniffer on the same time base as Wi-Fi radios in the same or disparate Pal-6s or Pals in the testbed; simultaneous capture on both BT radios
Interference	
Channels	2.4 and 5 GHz
Bandwidth	20, 40, 80, 80+80, 160 MHz
	Replay traffic captures (PCAP files) with configurable traffic load and priority
	Programmable MCS (modulation coding scheme), WMM (wireless multi media) priority and other settings

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General	
Traffic endpoints	multiPerf®, iperf3
	Trigger out connector for triggering external RF instruments
Control	Ethernet
Power	Power adapter
Dimensions	23" x 10.4" x 1.4" (58 √ 26 √ 3.5cm)
TX power	MCS, # stream, frequency and channel width dependent
Processor subsystem	quad-core, ARM Cortex 64-bit, 2 GHz

PAL-6 SOFTWARE OPTIONS

Option	Description
SW-BLUETOOTH	Bluetooth software implementing A2DP, OPP, HFP, BLE, HID, AFH
SW-IGEN	Software license for Pal-6 synthesizer for DFS testing and other OOK signal generation
SW-SNIFFER	Streaming sniffer captures
SW-VSTA	64 vSTAs (virtual stations) per radio
SW-BRIDGE	Bridging capability for each of the vSTAs to run application layer traffic
SW-TRIATHLON	Software to synchronize Pal-6 measurements with the LitePoint IQxel-MW

PAL-6 REAL-TIME RADIO STATUS

STA	AP	MON	
√	√	√	Offline
√	√	√	Monitor
√			Scanning <CH #>
√	√		PHY mode <HT20, OFDMA, HE40, etc.>
√	√	√	Channel primary and secondary channels
√			Max bandwidth
√			Associated STAs <#> hover over to show list of STAs
√			MAC address
√	√		BSSIDs <list>
	√		SSID

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TX POWER AND RX SENSITIVITY

RDP0258 (AP.HK01v2) - 5GHz (Tx)

Metric	CS	Measured	Notes
Tx Power Accuracy (dB)	+/- 1.5 dB CLPC +/- 2.5 dB OLPC	±1.5 dB CLPC +4.0 / -1.5 dB OLPC	
IEEE Mask-limited Power (VHT80 4x4)	23 dBm	23 dBm	
IEEE Mask-limited Power (VHT80 8x8)	23 dBm	23 dBm	
EVM Limited Power (MU HE80)	14.5dBm@-41dB	16dBm	
EVM Limited Power (MU VHT80)	16.5dBm@-38dB	18dBm	
EVM Limited Power (SU HE80)	18dBm@-35dB	20dBm	
EVM Limited Power (SU VHT80)	19.5dBm@-32dB	22dBm	
EVM Limited Power (MU HE160)	14.5dBm@-41dB	18dBm	
EVM Limited Power (SU VHT160)	19.5dBm@-32dB	22dBm	
Tx EVM Floor (Header-only)	-41 dB	-41.5 dB	

RDP0258 (AP.HK01v2) - 5GHz (Rx)

Metric	CS	Measured	Notes
Sensitivity (11a/6Mbps/8x8/1SS)	-98.5 dBm	-100.5 dBm	
Sensitivity (MCS0/VHT20/1x1/1SS)	-93.5 dBm	-94.0dBm	
Sensitivity (MCS0/VHT20/8x8/1SS)	-98.5 dBm	-100.5dBm	
Sensitivity (MCS9/VHT80/8x8/4SS)	-67 dBm	-67.5dBm	
Sensitivity (MCS9/VHT80/8x8/8SS)	-64 dBm	-64.5dBm	
Sensitivity (MCS9/VHT160/4x4/4SS)	-61 dBm	-61.5dBm	
Sensitivity (MCS11/HE80/8x8/4SS)	-61 dBm	-62.0dBm	
Sensitivity (MCS11/HE80/8x8/8SS)	-58 dBm	-59.0dBm	
Sensitivity (MCS11/HE160/4x4/4SS)	-55 dBm	-55.5dBm	
Max Rx Signal	-10 dBm	-10dBm	

RDP0258 (AP.HK01v2) - 2.4GHz

Metric (room temp)	CS	Measured	Notes
Tx Power Accuracy (dB)	+/- 1dB	+/- 1dB	
IEEE Mask Limited Power (CCK)	23dBm	24 dBm	
IEEE Mask Limited Power (VHT40)	23dBm	24 dBm	
EVM Limited Power (MU HE40)	16dBm@-41dB	20dBm	
EVM Limited Power (MU VHT40)	18dBm@-38dB	22dBm	
EVM Limited Power (SU HE40)	19.5dBm@-35dB	22dBm	
EVM Limited Power (SU VHT40)	21dBm@-32dB	23dBm	
Tx EVM Floor (Header-only)	-41dB	-43dB	
Sensitivity (11b/1Mbps/4x4/1SS)	-103dBm	-106.0dBm	
Sensitivity (MCS0/VHT20/1x1/1SS)	-94.5dBm	-95.0dBm	
Sensitivity (MCS0/VHT20/4x4/1SS)	-98.5 dBm	-99.5dBm	
Sensitivity (MCS9/VHT40/4x4/4SS)	-68.5dBm	-69.0dBm	
Sensitivity (MCS11/HE40/4x4/4SS)	-62.5dBm	-63.5dBm	
Max Rx Signal	-10dBm	-10dBm	

RDP0258 (AP.HK01v2) - DL-OFDMA

Metric	CS	Measured	Notes
Tx Power Accuracy (dB)	+/- 1.5 dB	+/-1.5	
IEEE Mask-limited Power (HE80 8x8)	23 dBm	23dBm	
EVM Limited Power (SU HE80 MCS11)	17.5dBm@-35dB	18dbm	
EVM Limited Power (SU HE40 MCS11)	18.0dBm@-25dB	20dBm	
EVM Limited Power (SU HE20 MCS11)	18.5dBm@-35dB	20dBm	
Tx EVM Floor (Header-only)	-41 dB	-41 dB	

RDP0258 (AP.HK01v2) - System Level Power

Metric	CS Target (W)	Measured	Notes
8x8+4x4 - Retail Thermal Max	44.5		
8x8+4x4 - Retail Typical	40.5	39.0	
8x8+4x4 - Retail Throughput Max	23.5	18.7	
4x4+4x4 - Retail Thermal Max	35.0		
4x4+4x4 - Retail Typical	32.5	30.9	
4x4+4x4 - Retail Throughput Max	20.5	15.5	

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PAL-6 RADIO STATS – AVAILABLE AS PLOTS VS. TIME

STA	AP	UI NAME	DETAILS	REPORTING
√	√	TX aggregate packets		Total since last report
√	√	TX unaggregated packets		Total since last report
√	√	RX aggregate packets		Total since last report
√	√	RX unaggregated packets		Total since last report
√	√	TX block ack window advances		Total since last report
√	√	RX overruns		Total since last report
√	√	RX decryption fails		Total since last report
√	√	RX MIC fails	Rx MIC (message integrated check) failure count	Total since last report
√	√	RX bad CRC		Total since last report
√	√	RX PHY errors		Total since last report
√	√	Bad RTS	RTS failure count	Total since last report
√	√	RTS	RTS success count	Total since last report
√	√	Missing ACKs		Total since last report
√	√	Bad FCS	FCS failure count	Total since last report
√	√	Noise floor	Channel Noise Floor; NF is re-calibrated every 15 seconds	Value
√	√	NF secondary 80+80	Noise Floor on Secondary 80 MHz channel for 80+80 mode	Value
√	√	Control RSSI per chain	RSSI on control channel; plot for each chain on the same chart, *Control RSSI*. Label each plot as chain-0, 1, 2, …, 7.	Min, Max, Linear mean in dB
√	√	Extended RSSI 80 per chain	80+80 channel RSSI on secondary 80 MHz channel; plot *Extended RSSI 80*. Label each plot as chain-0, 1, 2, …, 7.	Min, Max, Linear mean in dB
√	√	ACK RSSI per chain	Plot *ACK RSSI* per chain; label each plot as chain-0, 1, 2, …, 7.	Min, Max, Linear mean in dB
√	√	Management RSSI	Combined management RSSI for all chains	Min, Max, Linear mean in dB
√	√	Data RSSI	Combined data RSSI for all chains	Min, Max, Linear mean in dB
√	√	TX streams		Min, Max, Mode.
√	√	RX streams		Min, Max, Mode.
√	√	% load total	% utilization, including Wi-Fi traffic and non-Wi-Fi signals	Value
√	√	% load Wi-Fi	% for Wi-Fi traffic total including the reporting radio	Value

√	√	% load not my Wi-Fi	% utilization for Wi-Fi traffic by other than the reporting radio	Value
√	√	% airlink my Wi-Fi	% utilization for Wi-Fi traffic by the reporting radio	Value
√	√	TX bandwidth		Min, Max, Mode
√	√	RX bandwidth		Min, Max, Mode
√	√	TX power		Value
	√	TX beacons		Total since last report
√	√	TX bytes		Total since last report
√	√	RX bytes		Total since last report
√	√	TX packets		Total since last report
√	√	RX packets		Total since last report
√	√	TX unicast		Total since last report
√	√	TX multicast		Total since last report
√	√	RX unicast		Total since last report
√	√	RX multicast		Total since last report
√	√	TX priority	*TX packets by priority*; individual plot names: BK, BE, VI, VO	Total since last report, 4 values
√	√	RX priority	*RX packets by priority*; individual plot names: BK, BE, VI, VO	Total since last report, 4 values
√	√	TX management		Total since last report
√	√	RX management		Total since last report
√	√	TX data packets		Total since last report
√	√	RX data packets		Total since last report
√	√	TX control packets		Total since last report
√	√	RX control packets		Total since last report
√	√	TX errors		Total since last report
√	√	RX errors		Total since last report
√	√	TX dropped packets		Total since last report
√	√	RX dropped packets		Total since last report
√	√	TX rate		Min, Max, Mode
√	√	RX rate		Min, Max, Mode
√	√	TX MCS		Min, Max, Mode
√	√	RX MCS		Min, Max, Mode
√	√	Retries		Total since last report
√	√	Excessive retries		Total since last report

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Glossary

A2DP = advanced audio distribution profile
ACS = automated channel selection
AFH = adaptive frequency hopping
AP = access point
BE = best effort (priority)
BK = background (priority)
BLE = Bluetooth low energy
BT = Bluetooth
DFS = dynamic frequency selection
HE = high efficiency
HFP = hands free profile
HID = human interface device profile
MCS = modulation coding scheme
MIMO = multiple input multiple output
MP2MP = multi-point to multi-point (traffic generator)
MU = multi-user
OFDMA = orthogonal frequency domain multiple access
OPP = object push profile
OTA = over the air
RSSI = receive signal strength indicator
RU = resource unit
RvR = rate vs. range
RvRvO = rate vs. range vs. orientation
RvOvR = rate vs. orientation vs. range
RX = receive
TX = transmit
STA = station (aka client)
VI = video (priority)
VO = voice (priority)
vSTA = virtual STA

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