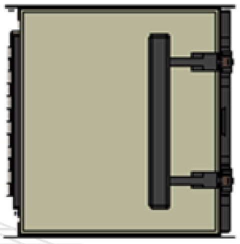
Pal-6 and STApal Wi-Fi 6 (11ax) instruments and octoBox personal testbeds

octoScope's Wi-Fi 6 testbeds incorporate RF chambers and instruments controlled by an integrated server with browser-based UI and complete API for test automation. The Pals® function as Wi-Fi 6 traffic endpoints or octoScope's synchroSniffer® probes for performance testing and expert analysis of Wi-Fi devices and systems. This document describes the *Pal-6* and *STApal* subsystems shown below and the octoBox® personal testbeds that incorporate them.

Wi-Fi 6 and legacy, Bluetooth, Interference (radar and more) Qualcomm Hawkeye QCN5054/QCN5024 and Cypress CYW20719 chipsets	***Pal-6®***	
Wi-Fi 6 and legacy Intel AX200 STA chipset Linux host per STApal for max performance	***STApal™***	
octoBox chamber with built-in instruments for ease of integration Built-in Pal-6 or 4 STApals	***smartBox™*** ***smartBox-STA***	
octoBox chamber with 16 STApals and a Pal-6 16 OFDMA endpoints; 19 sniffer probes 96 virtual stations (vSTAs)	***palBox™***	

Pal-6 and STApal can both function as traffic endpoints or synchroSniffer probes. Pal-6 also implements 32 vSTAs (virtual stations) per radio for a total of 96 vSTAs. Both Pal-6 and STApals come stand-alone or built into an octoBox chamber, making that chamber a *smartBox*. They can also be used with an antenna system for testing in open air or in a walk-in test chamber.

Both Pal-6 and STApal support all the Wi-Fi protocols: IEEE 802.11a/b/g/n/ac/ax. Pal-6 has the STA (station) and AP (access point) modes. STApal is an OFDMA capabile STA.

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

When used together, as in the palBox, Pal-6 and 16 STApals offer unmached test capabilities.

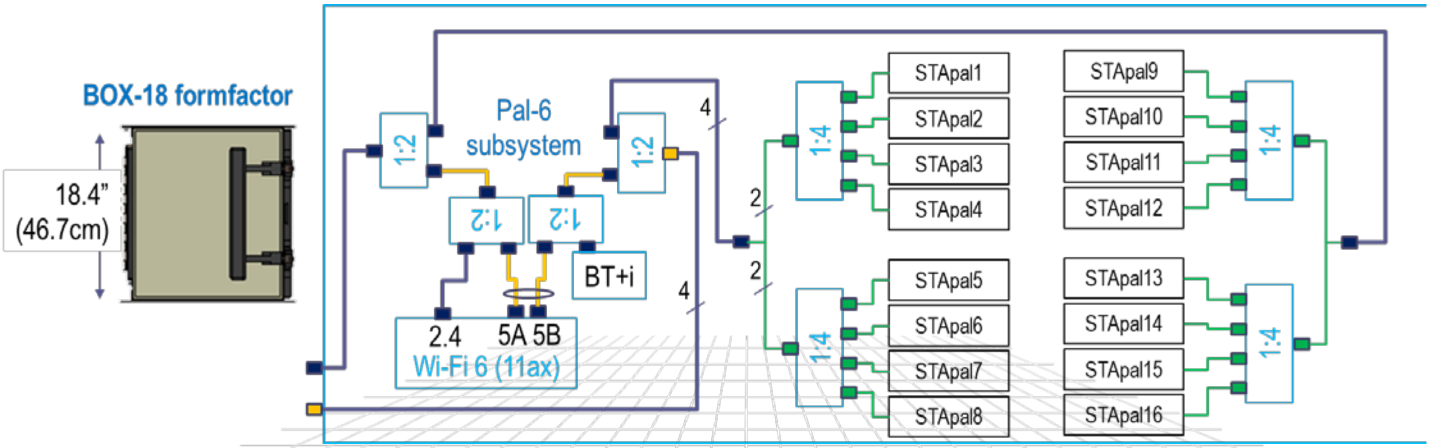
palBox, smartBox – parallel throughput and synchroSniffing

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
- palBox with up to 16 OFDMA STAs and 96 vSTAs; radios configurable for sniffing
- Wireshark synchroSniffer™ with sniffer probes on 3 Pal-6 and 16 STApal radios
- smartBox and smartBox-STA housing real devices with integrated Pal instruments
- multiperf® multi-point to multipoint traffic with managed traffic endpoints
- Complete isolation from outside interference
- REST API for test automation

BENEFITS

- Quickly and easily verify emerging 802.11ax and legacy Wi-Fi devices in the ideal MIMO-OTA environment that supports MU-MIMO
- Use multipoint-multipoint traffic while automatically recovering from dropped links during long test sequences
- Test OFDMA and MU-MIMO simultaneously using a compact octoBox personal testbed
- Use one or more palBoxes to scale to dozens of OFDMA stations in the testbed
- Use a smartBox to combine off-the-shelf devices with the built-in Pals
- Perform root cause analysis of issues using built-in multi-probe synchroSniffing



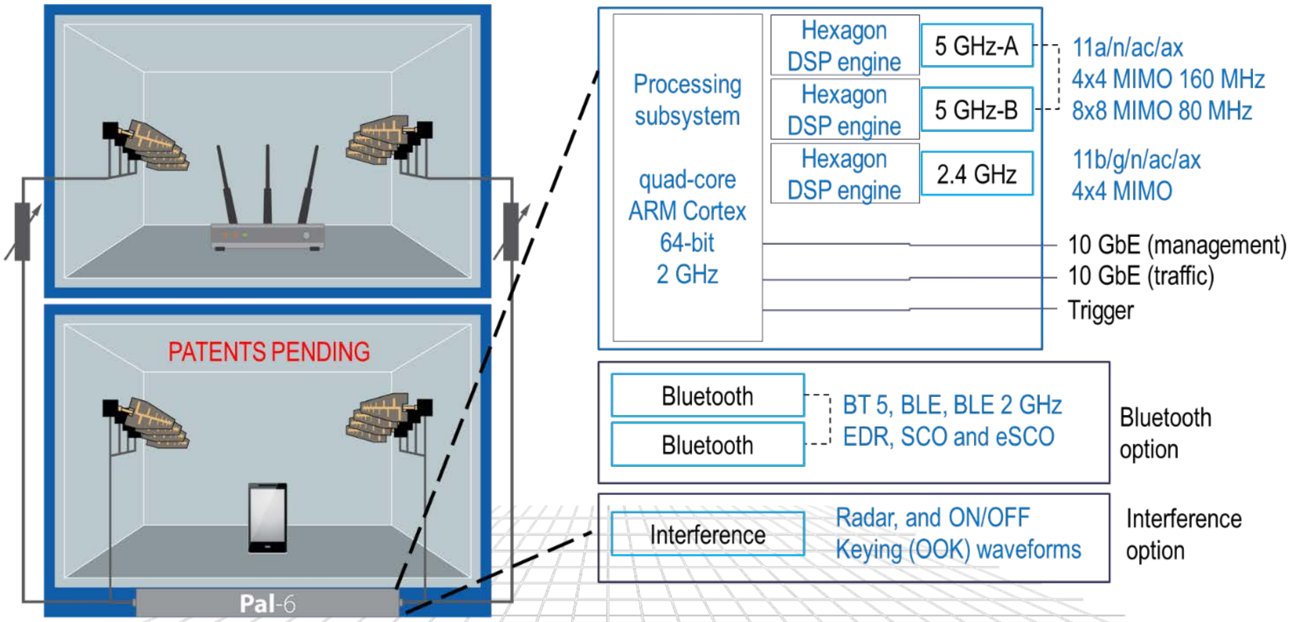
palBox block diagram

Based on the latest 802.11ax chipset and with fine controls at the firmware and driver level, Pal-6 can function as an off-the-shelf 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 (Nss). 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.

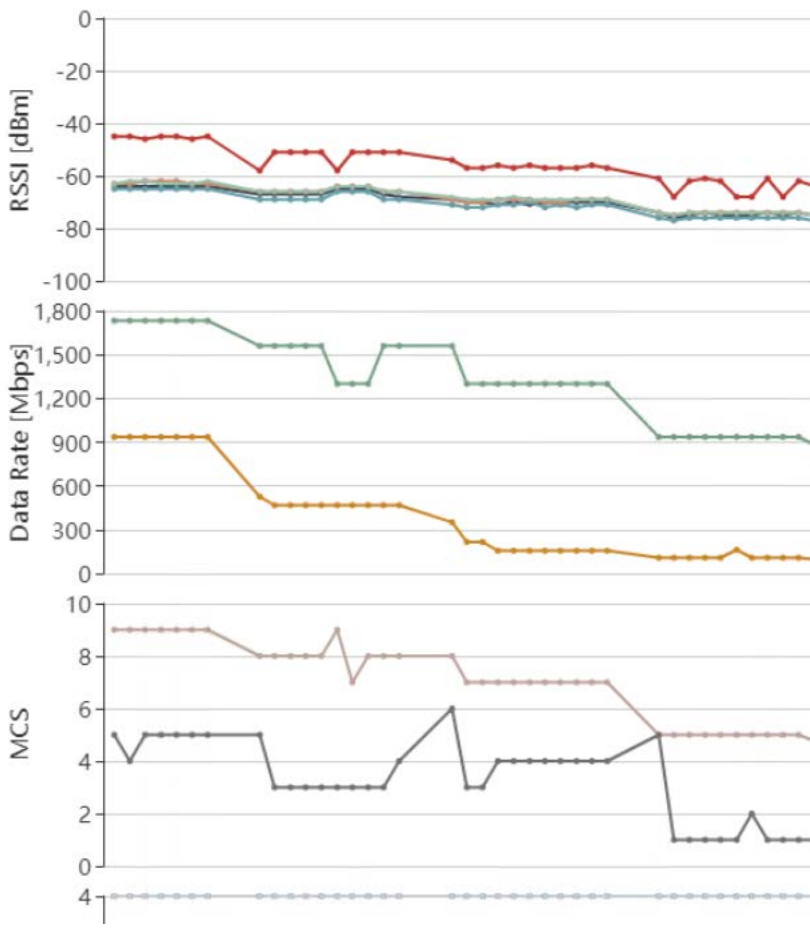
Pal-6 features two 10 GbE ports, one for traffic and the other for streaming plot statistics and PCAP captures.

Pal-6 open module



Pal-6 built into the smartBox; block diagram

Pal-6 open with the antenna subsystem



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

ACCESS POINT TESTING

To test access point (AP) performance or to emulate a realistic network with multi-station traffic, Pal-6 can emulate up to 96 vSTAs.

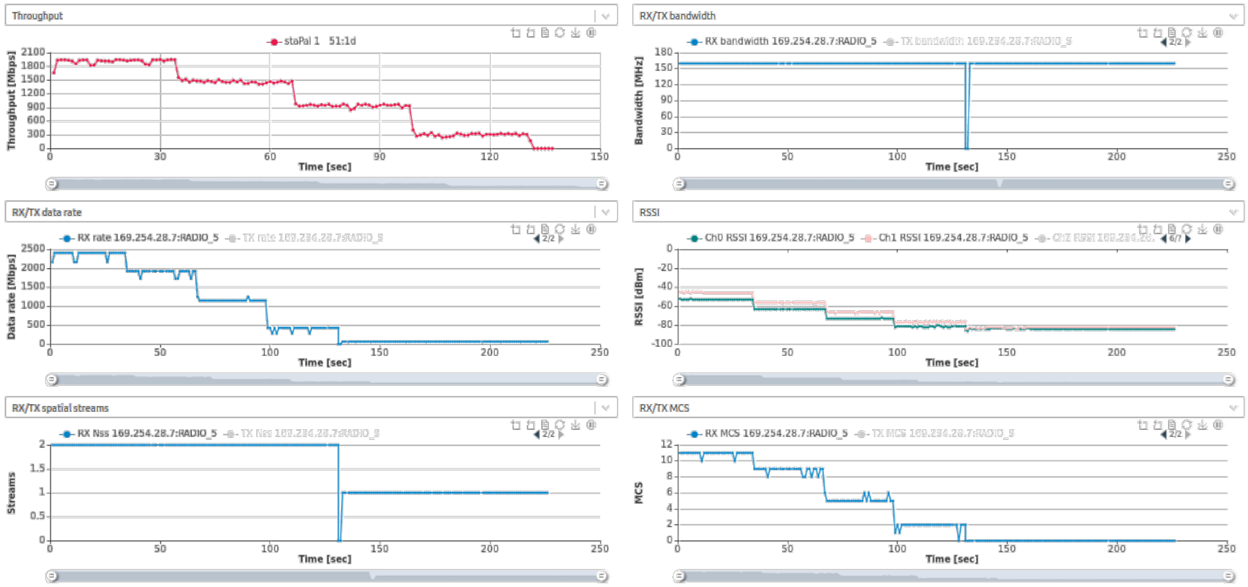
STApals, each in its own Linux host, offer maximum OFDMA performance on each radio.

Because OFDMA testing requires multiple station devices to show the expected airlink efficiency, STApal comes packaged as a set of 4 or 16. The smartBox-STA has 4 STApals while the palBox has 16 plus a Pal-6.

STApal is based on a STA chipset and supports UL and DL OFDMA. It can function as an OFDMA station or as a synchroSniffer probe and report statistics and KPIs (key performance indicators).

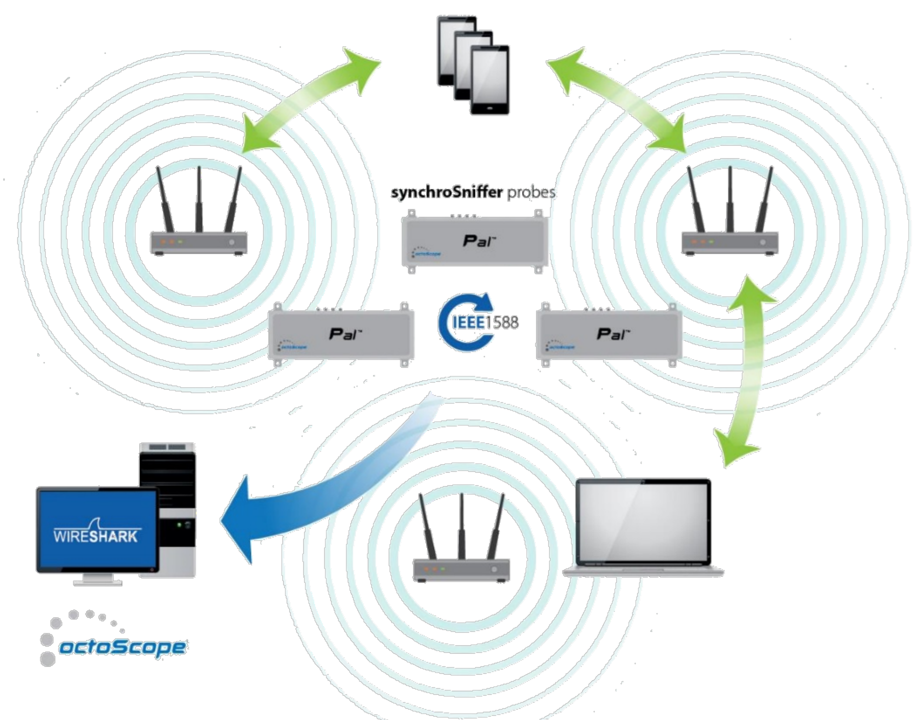
STATION TESTING

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, inline sniffers or expert analyzers. Station tests include throughput vs. range vs. orientation, RX sensitivity, data rate adaptaiton performance, roaming, band steering, and more.



octoBox software shows throughput, statistics and KPIs

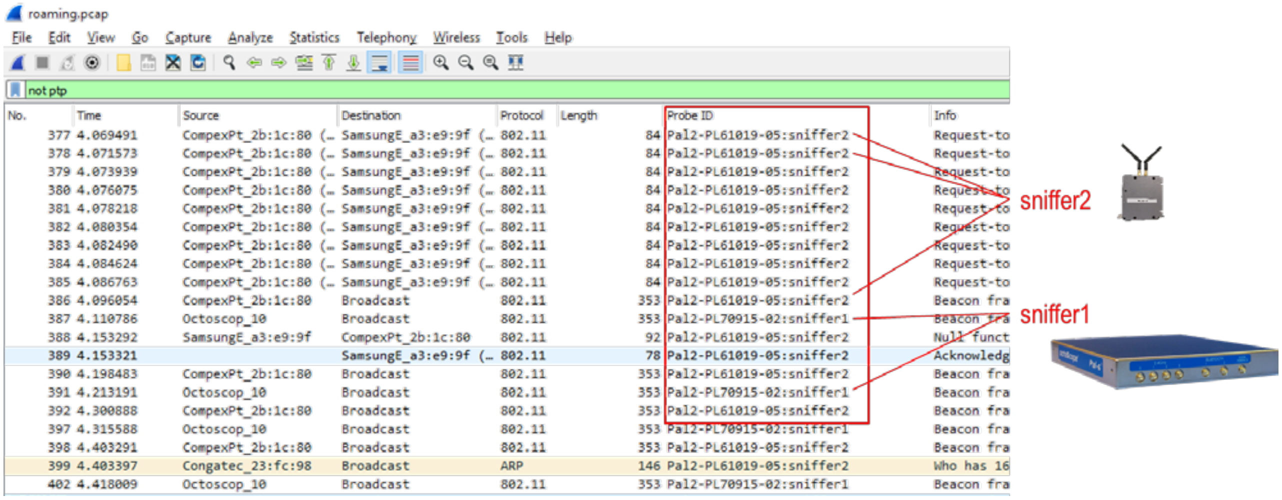
SYNCHROSNIFFER™



Pal-6 and STApal can capture and stream packets in the PCAP format to the Wireshark in real-time. All the Pal radios are synchronized via the Network Time Protocol (NTP) or Precision Time Protocol (PTP).

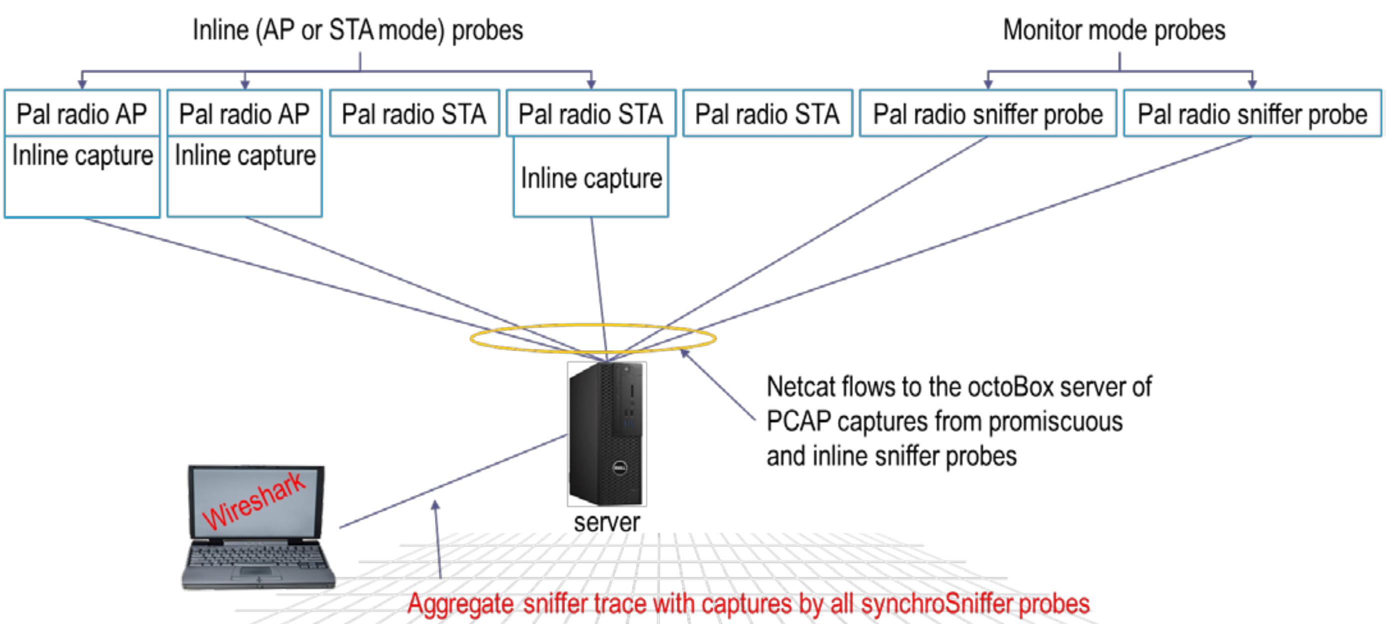
The captures from each radio in the octoBox testbed are combined by the synchroSniffer engine runnign on the server into a common PCAP stream viewable in the octoScope-customized Wireshark for easy analysis. In this custom Wireshark application, you can identify captures by probe (i.e. Pal radio).

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. synchroSniffing is required for OFDMA – to capture multiple RUs (resource units) simultaneously.



No.	Time	Source	Destination	Protocol	Length	Probe ID	Info
377	4.069491	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
378	4.071573	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
379	4.073939	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
380	4.076075	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
381	4.078218	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
382	4.080354	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
383	4.082490	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
384	4.084624	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
385	4.086763	CompexPt_2b:1c:80 (…	SamsungE_a3:e9:9f (…	802.11	84	Pal2-PL61019-05:sniffer2	Request-to
386	4.096054	CompexPt_2b:1c:80	Broadcast	802.11	353	Pal2-PL61019-05:sniffer2	Beacon fra
387	4.110786	Octoscop_10	Broadcast	802.11	353	Pal2-PL70915-02:sniffer1	Beacon fra
388	4.153292	SamsungE_a3:e9:9f	CompexPt_2b:1c:80	802.11	92	Pal2-PL61019-05:sniffer2	Null funct
389	4.153321		SamsungE_a3:e9:9f (…	802.11	78	Pal2-PL61019-05:sniffer2	Acknowledg
390	4.198483	CompexPt_2b:1c:80	Broadcast	802.11	353	Pal2-PL61019-05:sniffer2	Beacon fra
391	4.213191	Octoscop_10	Broadcast	802.11	353	Pal2-PL70915-02:sniffer1	Beacon fra
392	4.300888	CompexPt_2b:1c:80	Broadcast	802.11	353	Pal2-PL61019-05:sniffer2	Beacon fra
397	4.315588	Octoscop_10	Broadcast	802.11	353	Pal2-PL70915-02:sniffer1	Beacon fra
398	4.403291	CompexPt_2b:1c:80	Broadcast	802.11	353	Pal2-PL61019-05:sniffer2	Beacon fra
399	4.403397	Congatec_23:fc:98	Broadcast	ARP	146	Pal2-PL61019-05:sniffer2	Who has 16
402	4.418009	Octoscop_10	Broadcast	802.11	353	Pal2-PL70915-02:sniffer1	Beacon fra

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. The palBox can assign a STApal sniffer to each STApal endpoint. The sniffer captures from each Pal are aggregated via the synchroSniffer engine for powerful KPI analysis of the entire complex OFDMA link. In addition to conventional monitor mode sniffing, Pal-6 radios can also work as in-line sniffer probes when configured as an AP or a STA. Thus, Pal-6 radios can be synchroSniffer probes in three modes: monitor (capture all packets), inline AP/STA (capture packets addressed to the AP/STA).



MULTIPERF MANAGED TRAFFIC ENDPOINTS

octoScope's multiperf® traffic tool:

- Supports multipoint-to-multipoint traffic
- Automatically recovers from link drops that are common when testing the dynamic range to disconnection; restarts traffic after reconnection
- Supports iperf2, iperf3, ping, SIPP (voice) and IPv6 traffic

Each multiperf traffic endpoint is controlled and monitored via an out-of-band management link. Both traffic and management Ethernet networks in the octoBox testbeds are 10 Gbps and have enough capacity to support multipoint traffic, sniffer captures and status reporting.

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

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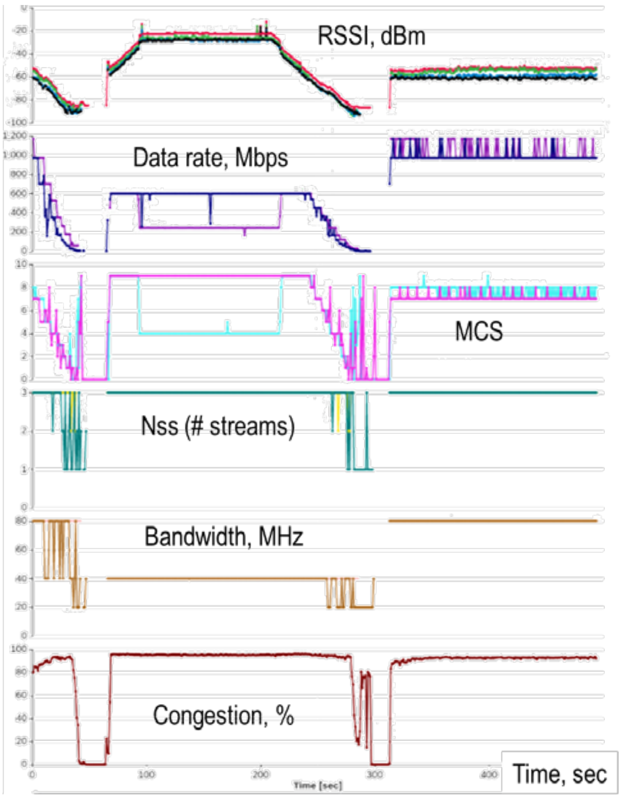
KPIs

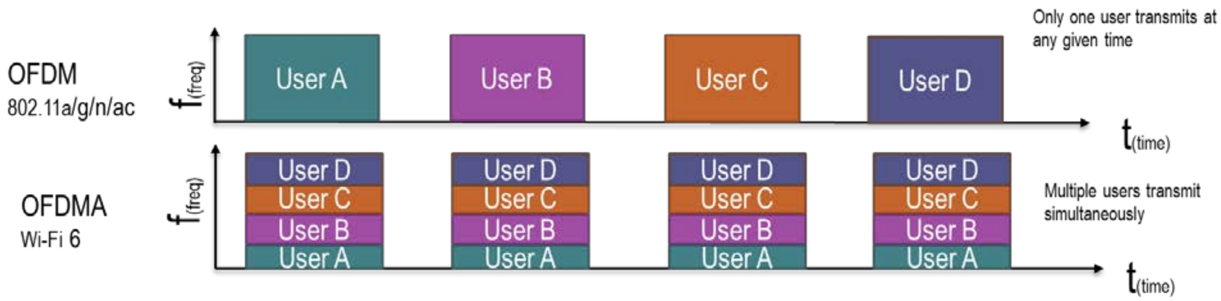
For non-OFDMA links under test, statistics are plotted as single plots for the entire channel. For example, RSSI, data rate, MCS, Nss (# of streams), bandwidth and other statistics are plotted as reported by a Pal receiver, as shown on the right. These legacy statistics are produced by each Pal receiver as follows:

1. Open each received packet
2. Extract each statistic from the packet header
3. Discard the packet
4. For each 1 second reporting interval, a point on the plot, average or find the Mode of all the packets received in that interval
5. Plot one point for each reporting interval

Mode (the most common value) is used for discrete plots, such as data rate, Bandwidth, MCS and Nss. Average is used for averageable quantities, such as throughput, RSSI and Congestion.

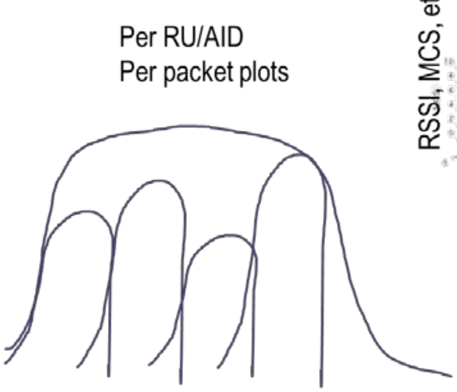


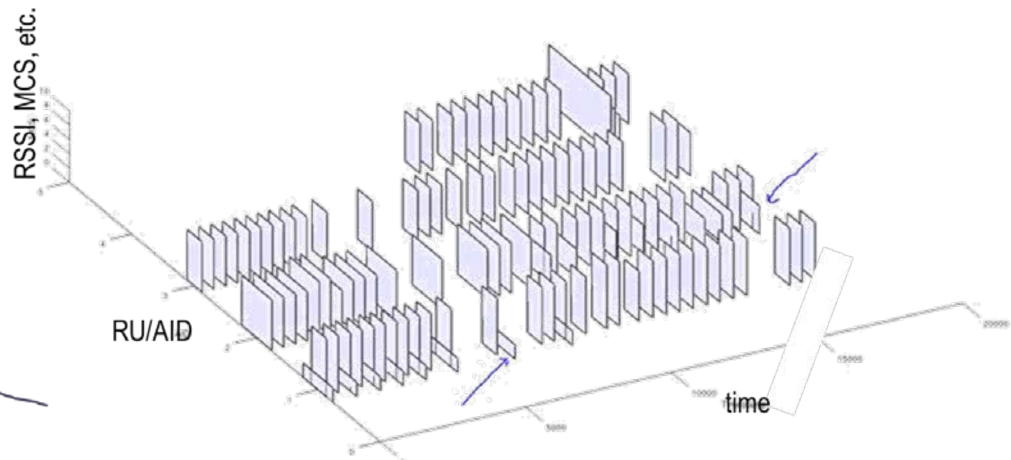
For OFDMA, multiple RUs (resource units) are assigned to each user dynamically packet by packet so that multiple users can share the frequency band, as shown below.



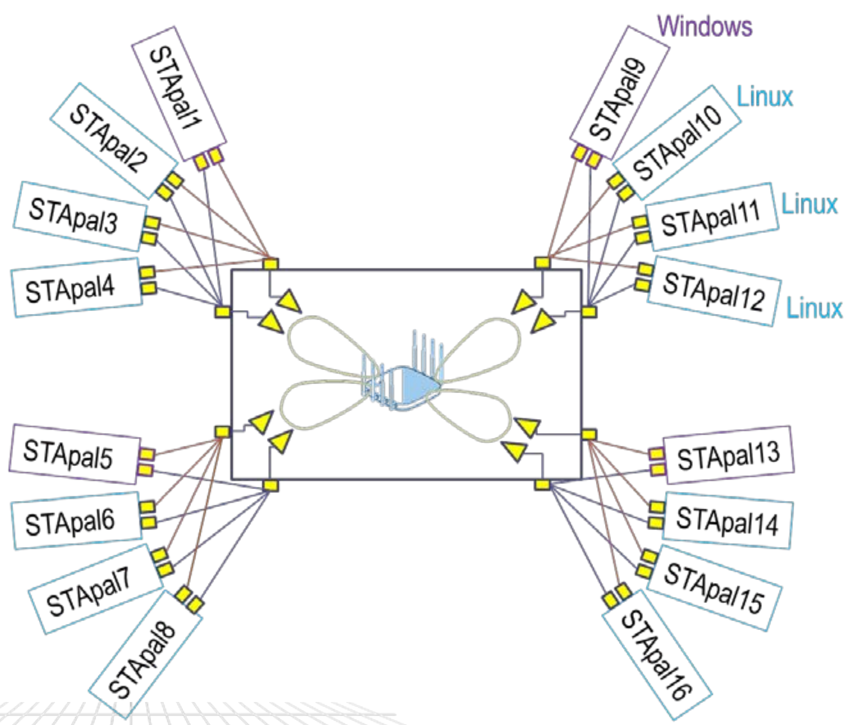
In the above example, 4 users, A, B, C and D, are shown transmitting in the same OFDMA packet (i.e. time slot) simultaneously while sharing the frequency band of the channel. The maximum number of RUs per OFDMA packet is 37.

Each user is allocated an AID (association ID) and each AID is allocated an RU (aka frequency slot). The RU allocation to AIDs (users) can change dynamically packet to packet. As the AP scheduler allocates the operating frequency channel to multiple OFDMA STAs, each STA occupies a portion of the spectrum. The figure below on the left shows 4 users' RUs within a single Wi-Fi channel . For OFDMA, with simultaneous STAs sharing the band, each plot, for example RSSI, now has a 3rd dimension – RU/AID.





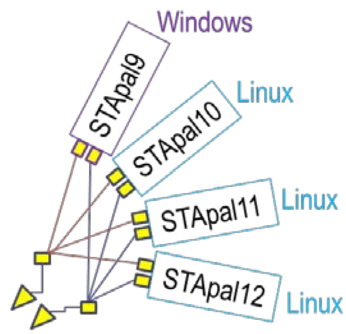
For OFDMA, since the RU/AID allocation changes from packet to packet, we need to show packet by packet plots. These packet by packet plots are called KPIs (key performance indicators) and are produced by dedicated synchroSniffer probes.



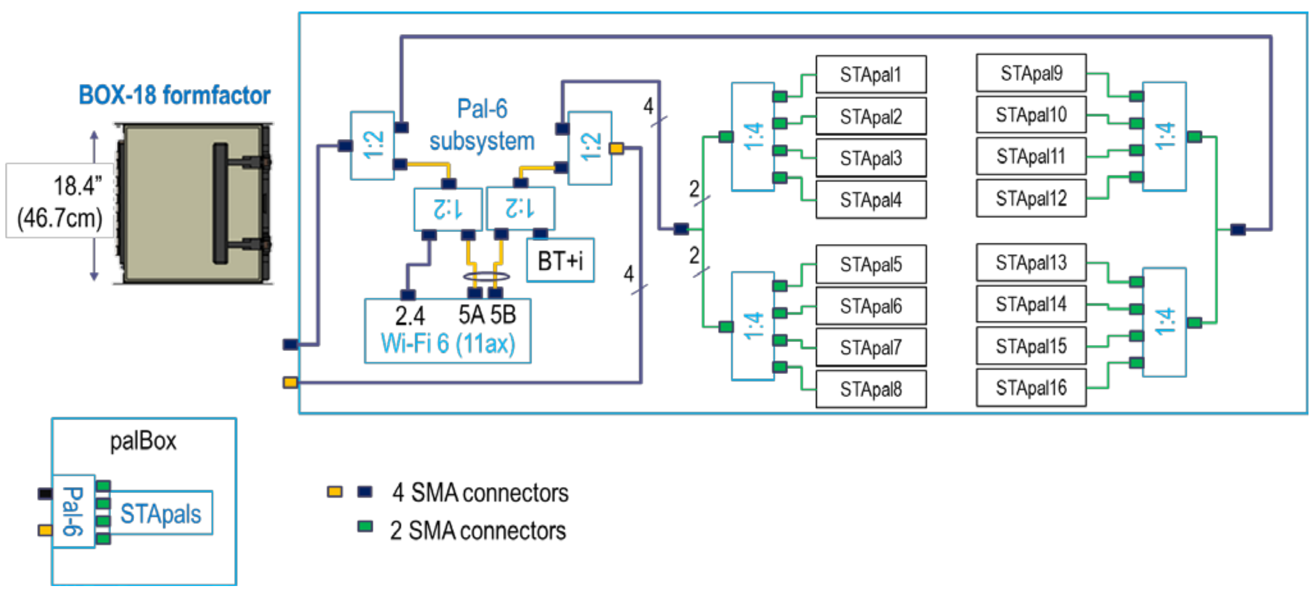
Each synchroSniffer probe can be assigned to log KPIs for a single device in the testbed. For example, if STApal2 is a sniffer, it can create KPI plots for STApal1, STApal3 or STApal4 since all four STApals are on the same pair of antennas and receive the same signal. As a sniffer probe, a STApal can capture up and downlink traffic (UL/DL) for its assigned MAC address and report its PCAP captures into the synchroSniffer trace.

In the DUT chamber, four pairs of antennas are arranged in a spatially diverse way, i.e. mounted in the corners of the chamber in order to enable MU-MIMO beamforming plus OFDMA testing.

At each pair of antennas, you have 1 Windows and 3 Linux STApals from a palBox. You have an option to configure any of the Linux STApals either as a sniffer probe or a traffic endpoint. The Windows STApals can only be traffic endpoints. Windows STApals are included in the palBox because throughput performance is driver-dependent and is different in the Windows environment vs. the Linux environment. So, testing with both drivers is desirable to determine real-world expectations.



The palBox also incorporates a Pal-6 subsystem that connects to the same 8 antennas as the STApals. The figure below shows a detailed block diagram of the palBox and its symbol as used in the octoBox testbed diagrams.



If you are testing with a reasonable number of OFDMA STAs and need dedicated synchroSniffer probes, you can use multiple palBoxes in a testbed. Here's a photo of a testbed with 2 palBoxes on the bottom. This photo shows the palBoxes with their doors open.

In addition to 16 OFDMA STApals, each palBox incorporates a Pal-6 subsystem that can be used to emulate up to 96 vSTAs for testing an access point under a heavy load. With a palBox, you can generate OFDMA and MU-MIMO traffic and also generate traffic load from up to 96 virtual stations – a lot of parallel traffic and analysis power in a small space.

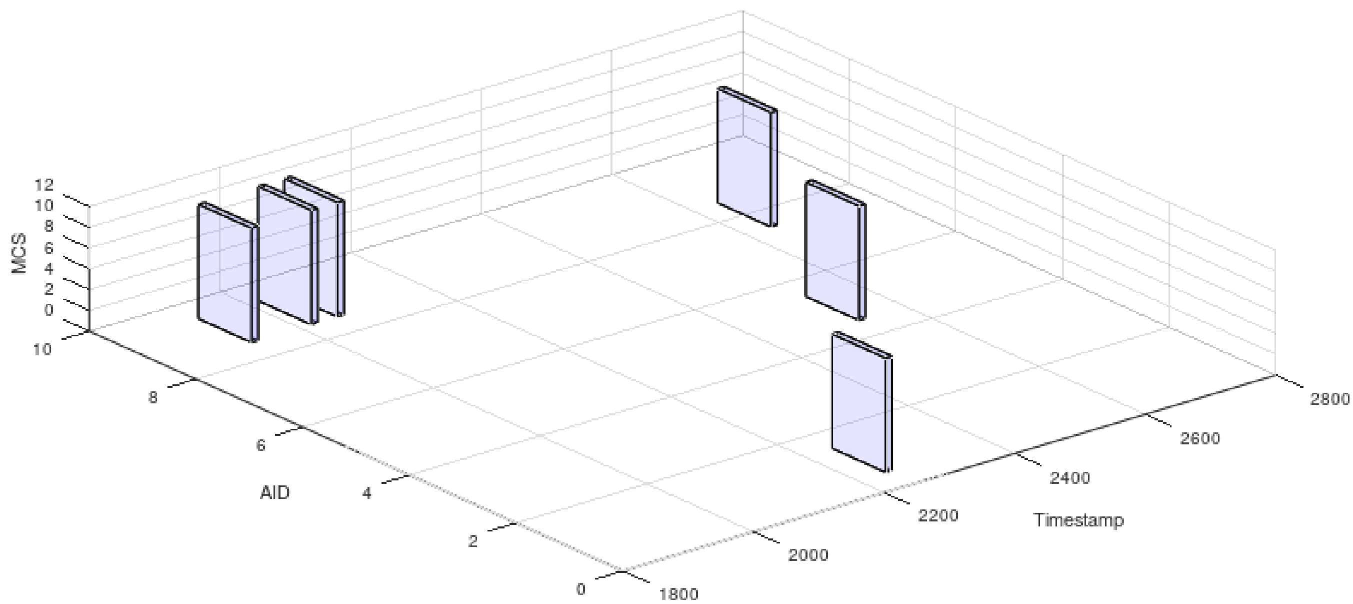
OFDMA SNIFFING AND EXPERT ANALYSIS

OFDMA sniffing requires a multi-probe mechanism such as octoScope's synchroSniffer to capture traffic on multiple RUs simultaneously. octoScope's OFDMA KPIs are produced by dedicating a STApal sniffer probe to each device in the testbed. For a STA DUT that uses the Pal-6 as a golden AP, inline sniffer traces from the Pal-6 AP are also available in the synchroSniffer trace.

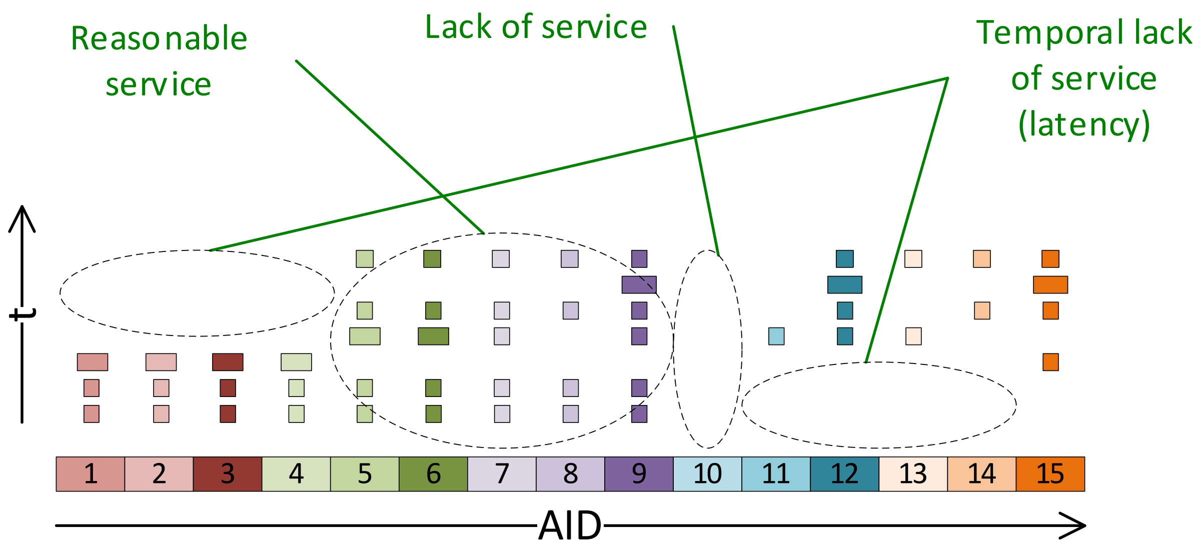
With such complete OFDMA and MU-MIMO captures gathered by multiple probes and aggregated by the synchroSniffer engine, insightful visualization of OFDMA performance can be produced.

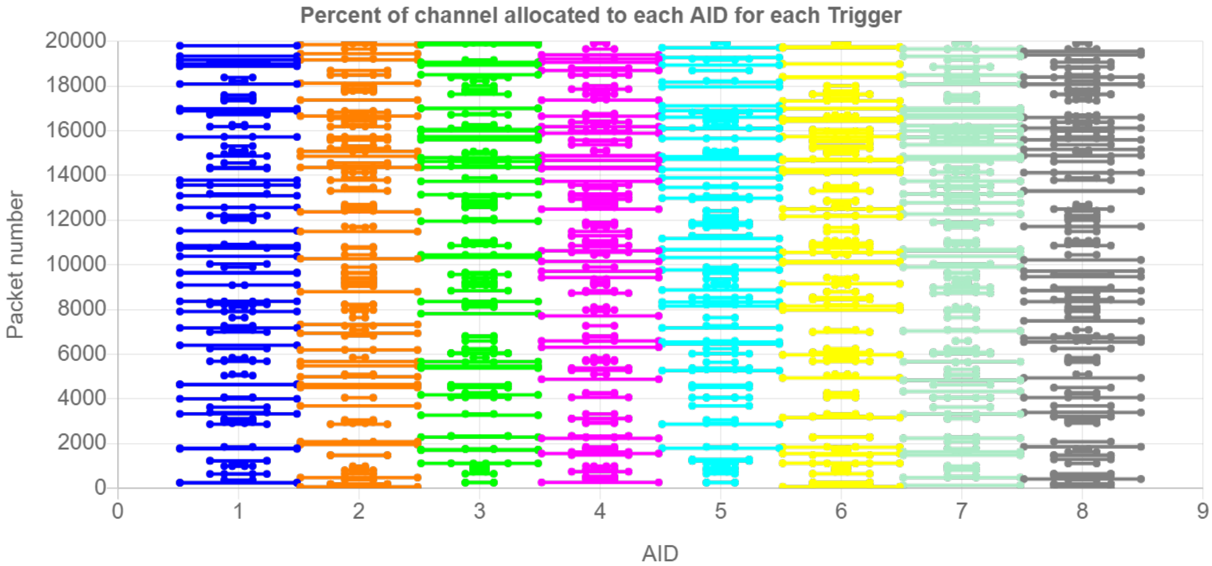
In addition to the basic per RU per packet metrics such as RSSI, Nss, bandwidth, data rate and MCS, the following plots are available.

MCS, RSSI, N per RU/AID allocation:

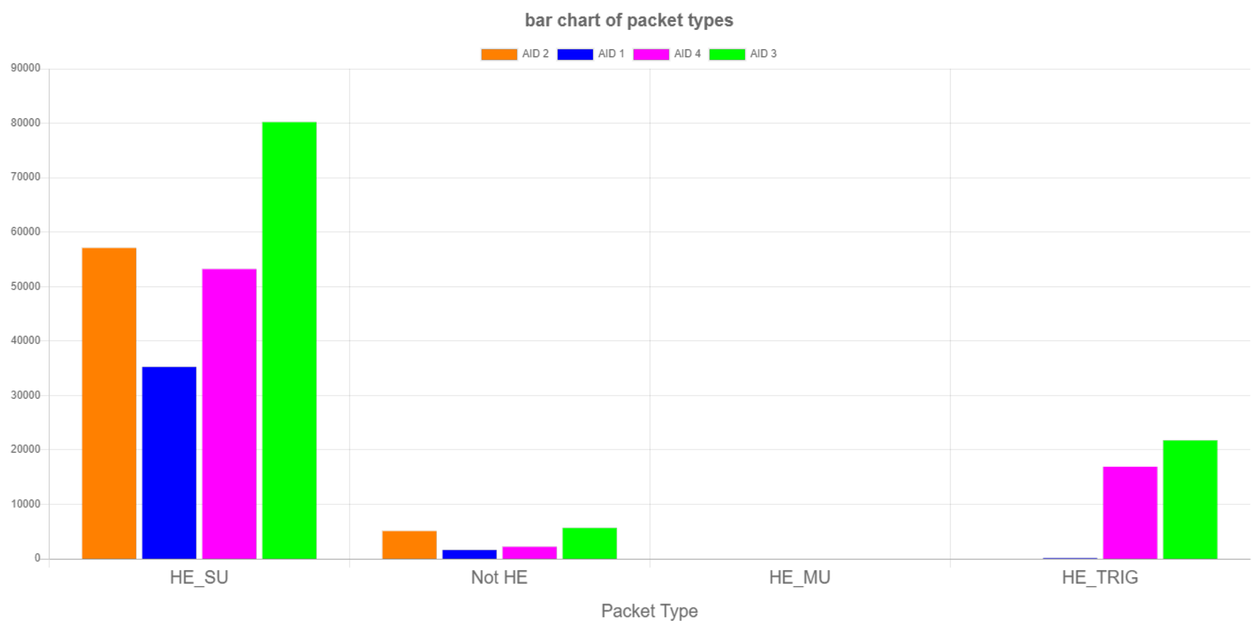


Efficiency of the scheduler:



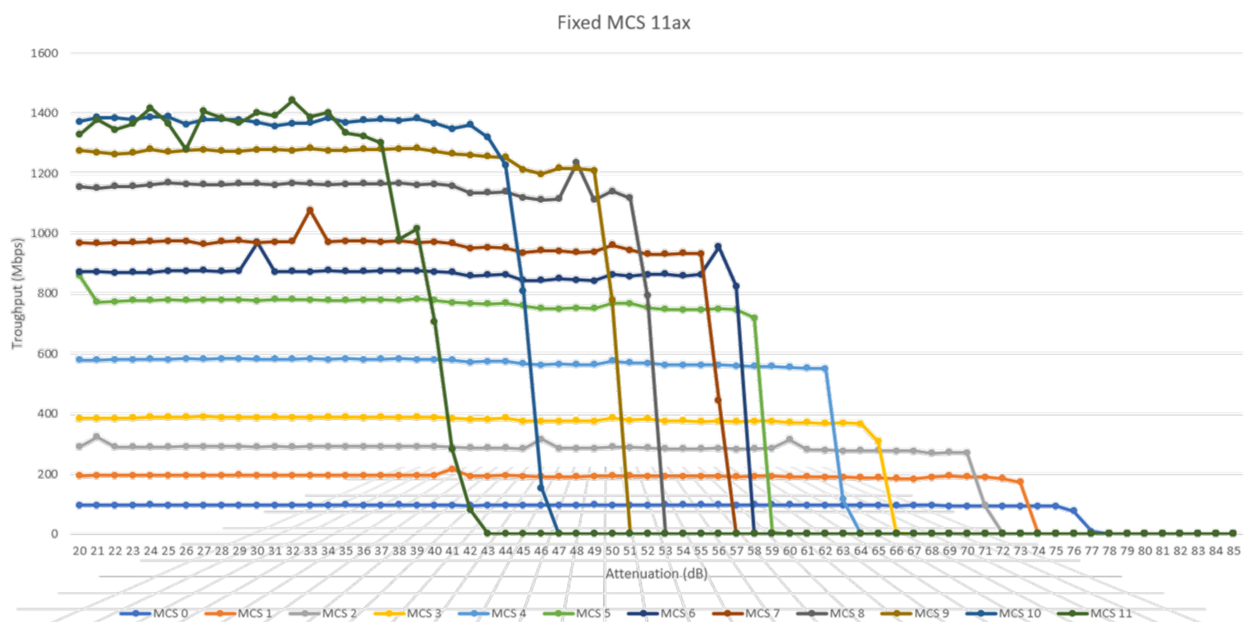


Packet type analysis



USING PAL-6 AS A TEST INSTRUMENT

When debugging early stage devices with rate adaptation issues, it is necessary to force DUT operation at some fixed parameters including fixed MCS, fixed Nss, etc. Here's an example of a test with a Pal-6 using fixed MCS one by one and observing throughput operation for each MCS setting vs. attenuation. The ideal rate adaptation would result in a throughput plot at the top perimeter of this waterfall curve.



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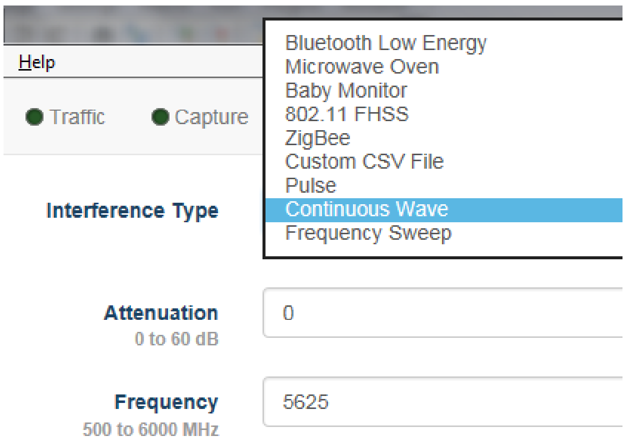
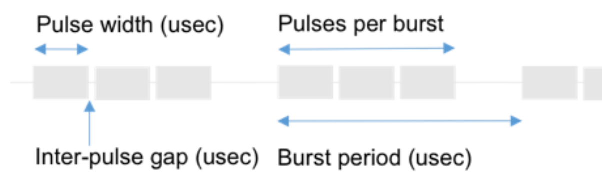
INTERFERENCE

Interference is generated using a frequency synthesizer built into the Pal-6 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.

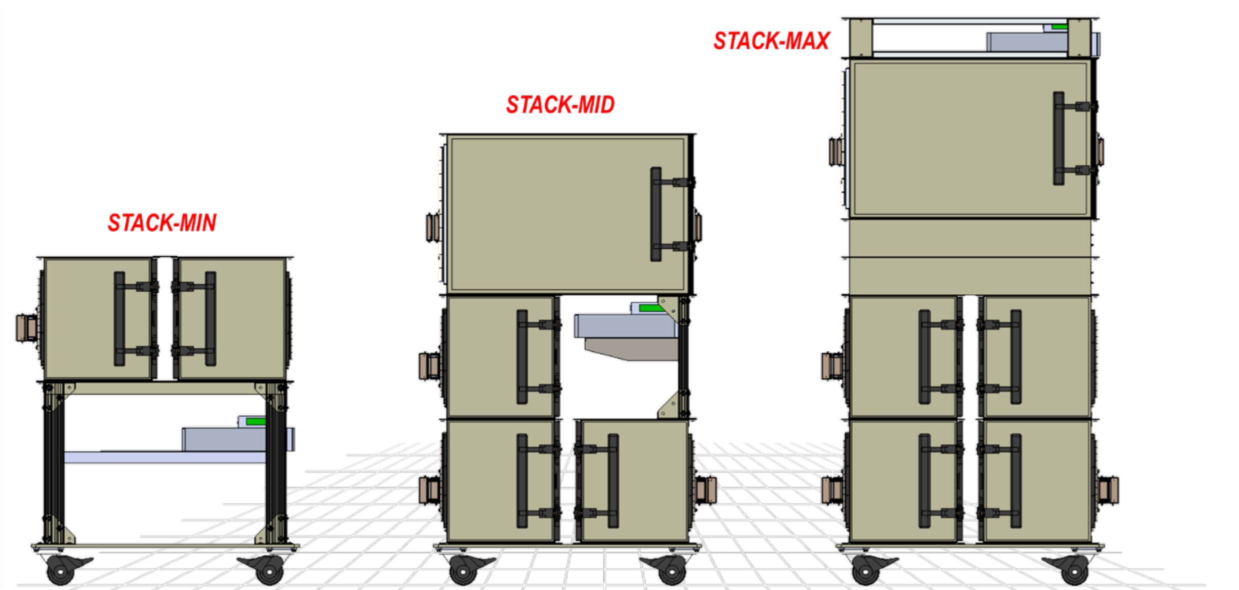




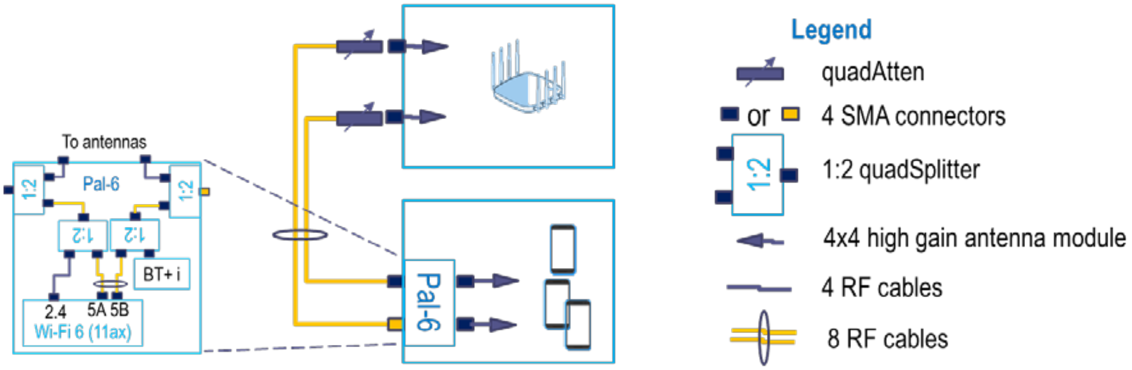
For waveform generation, you can configure tone frequency and pulse train parameters as shown above on the right.

OCTOBOX PERSONAL TESTBEDS

STACK-MIN, STACK-MID and STACK-MAX testbeds are recommended configurations.



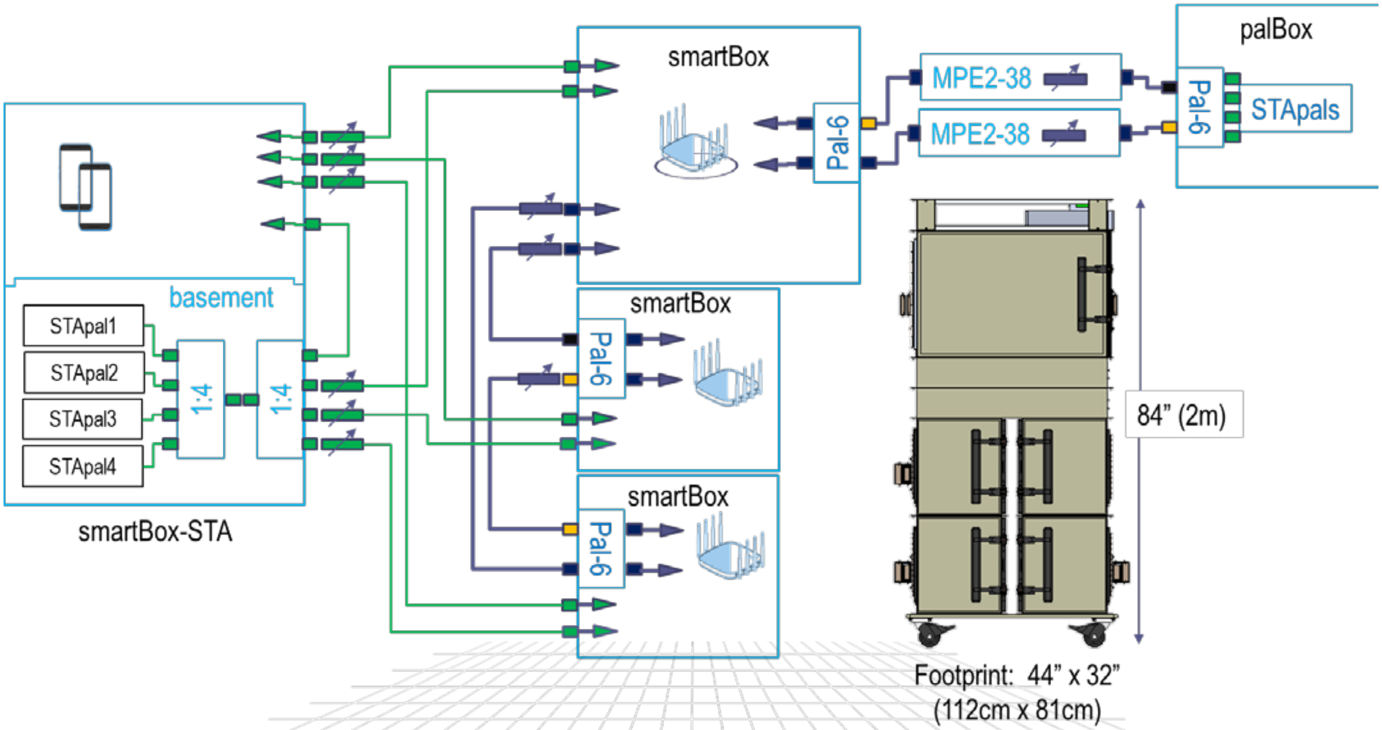
A block diagram of the simplest Pal-6 based testbed, STACK-MIN, is shown below. Replace the smartBox with a palBox for OFDMA capabilities.



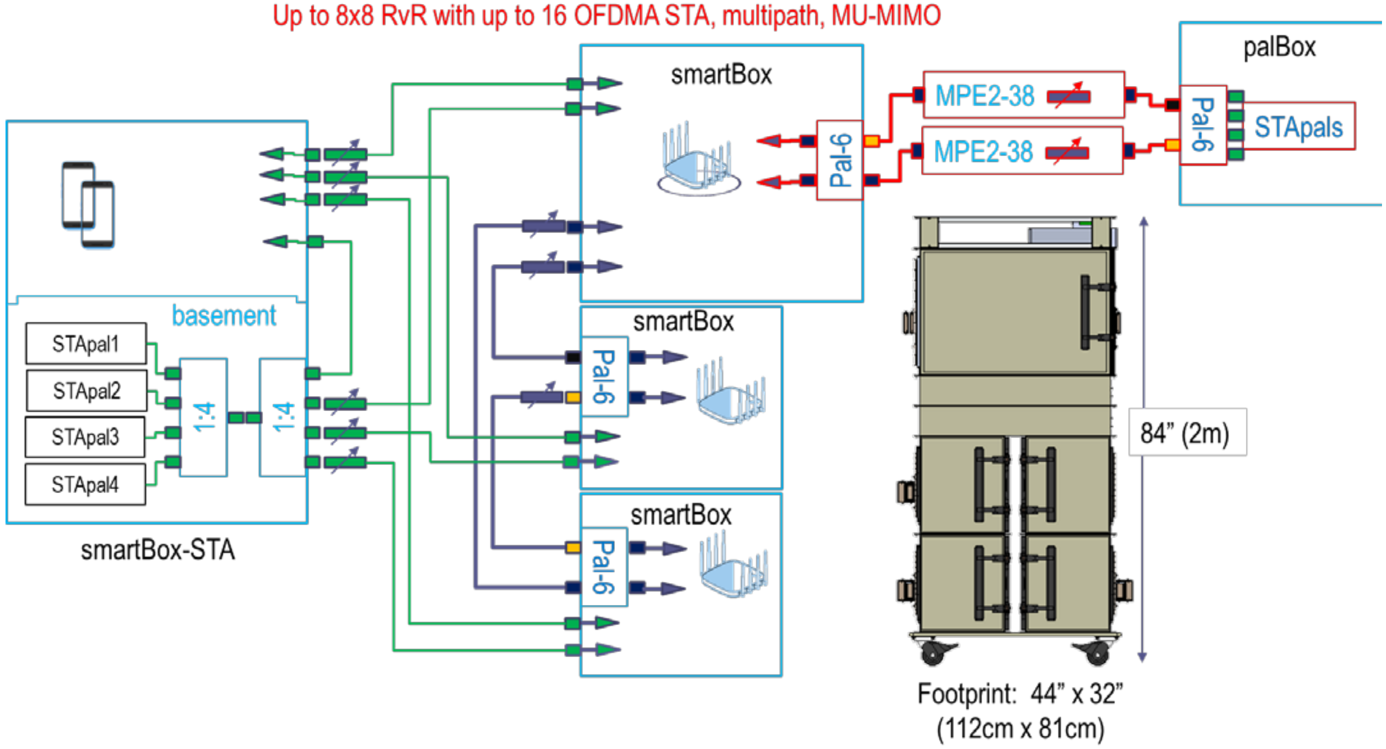
The STACK-MIN testbed is capable of the following tests:

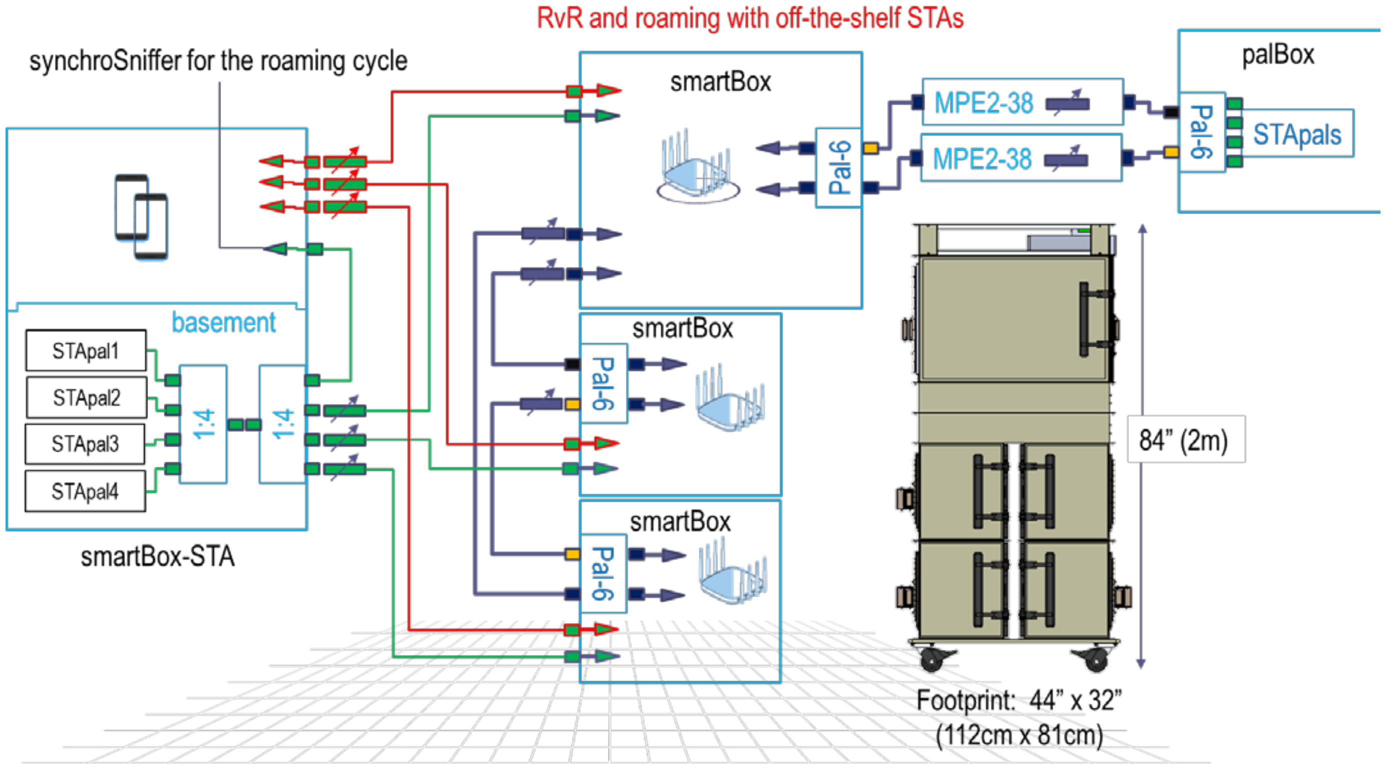
- RvR, RvR with rotation, RvRvO or RvOvR if a turntable is included
- Band steering
- Packet capture
- OFDMA testing with 16 STApals using a palBox

The STACK-MAX is the most comprehensive testbed and its block diagram is shown below.



The following 6 block diagrams show the different RF paths in the STACK-MAX and the functions they perform. The paths are highlighted in red and the functions are stated in red font.





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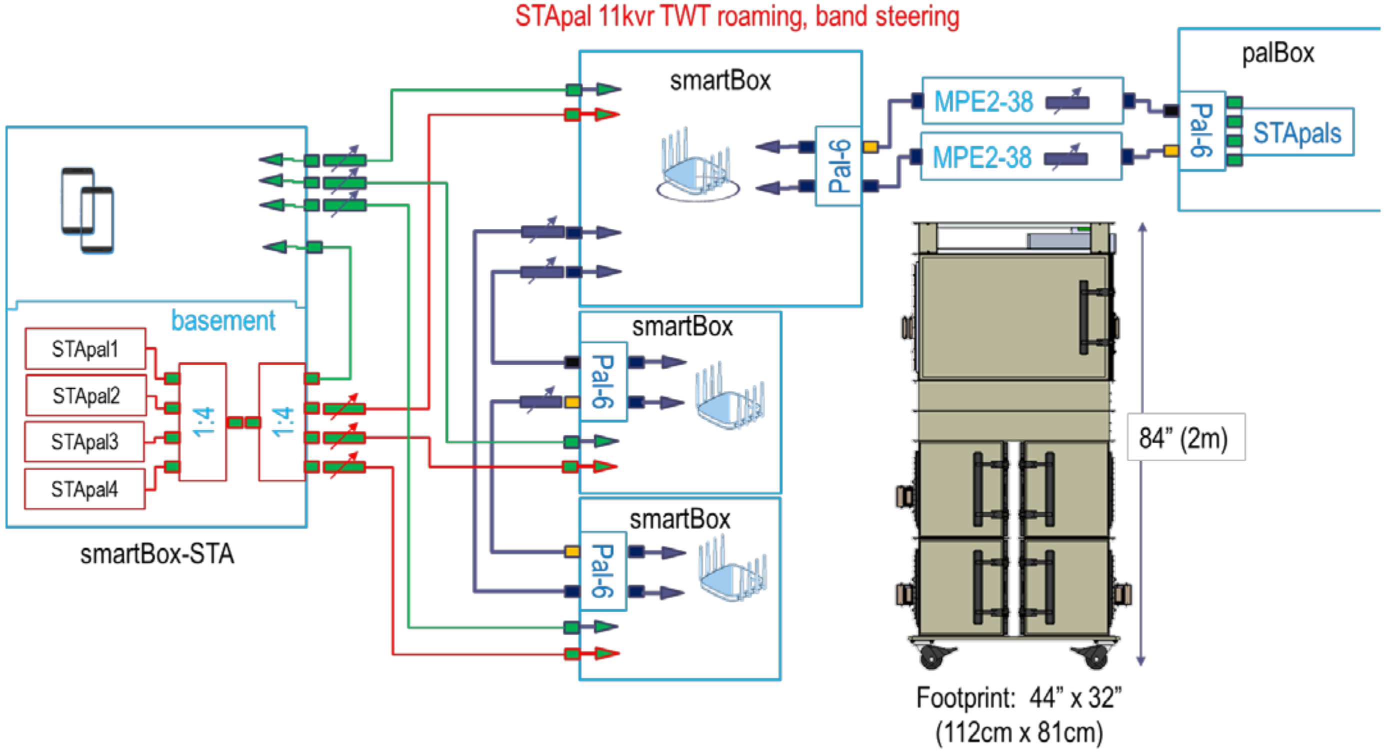
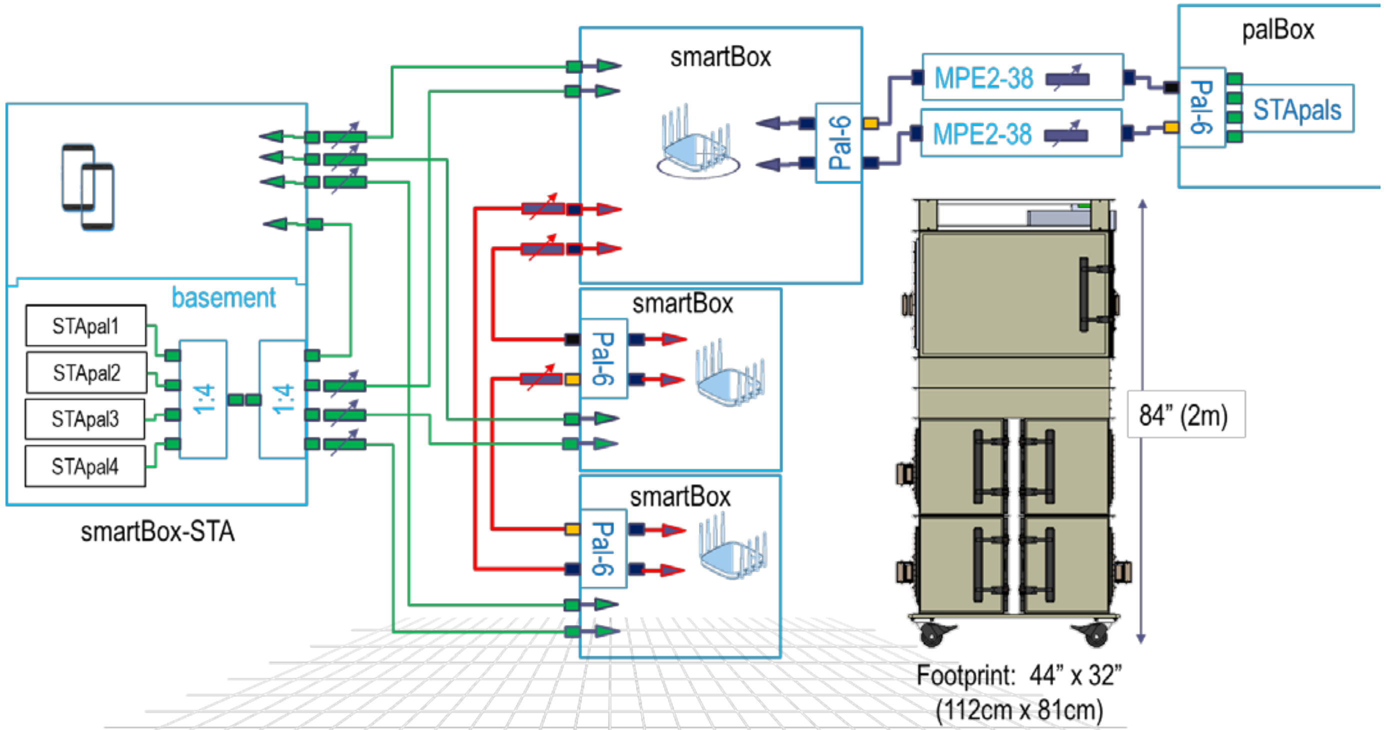
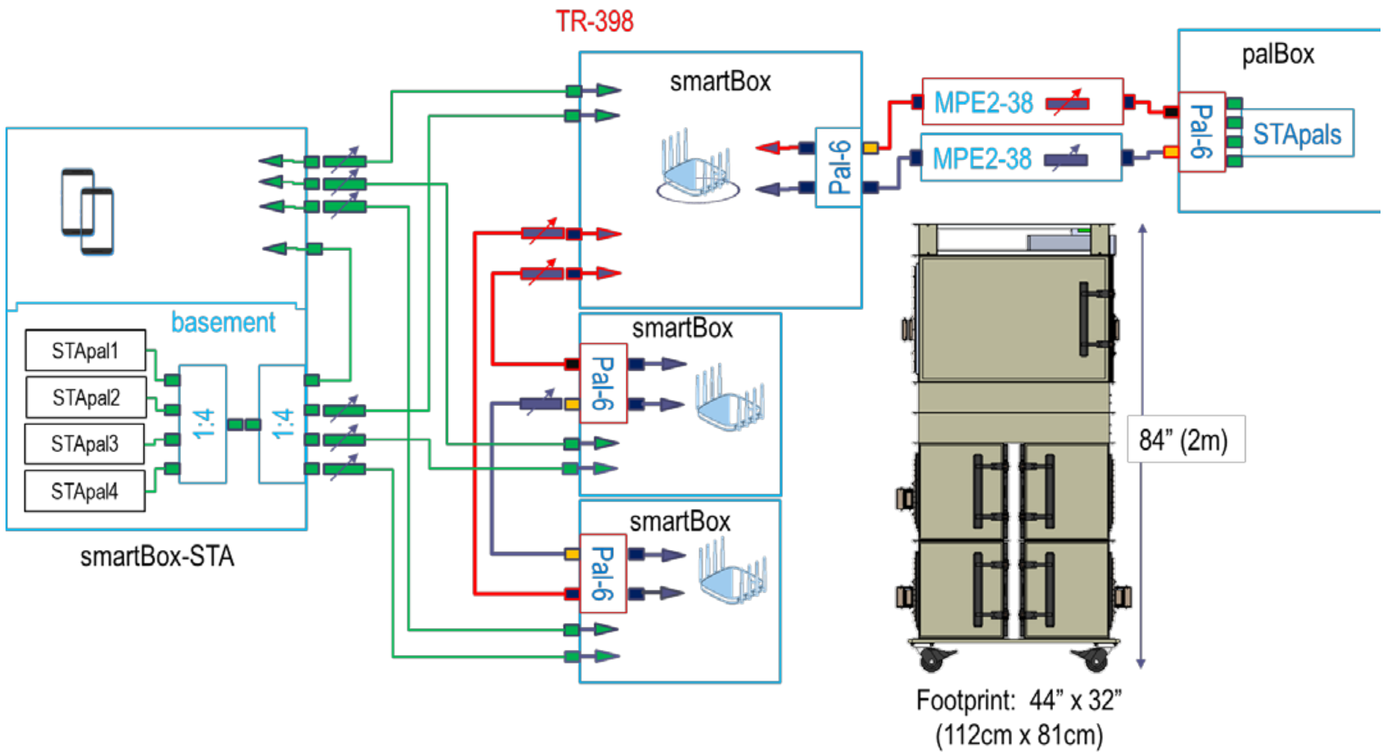
STApal 11kvr TWT roaming, band steering

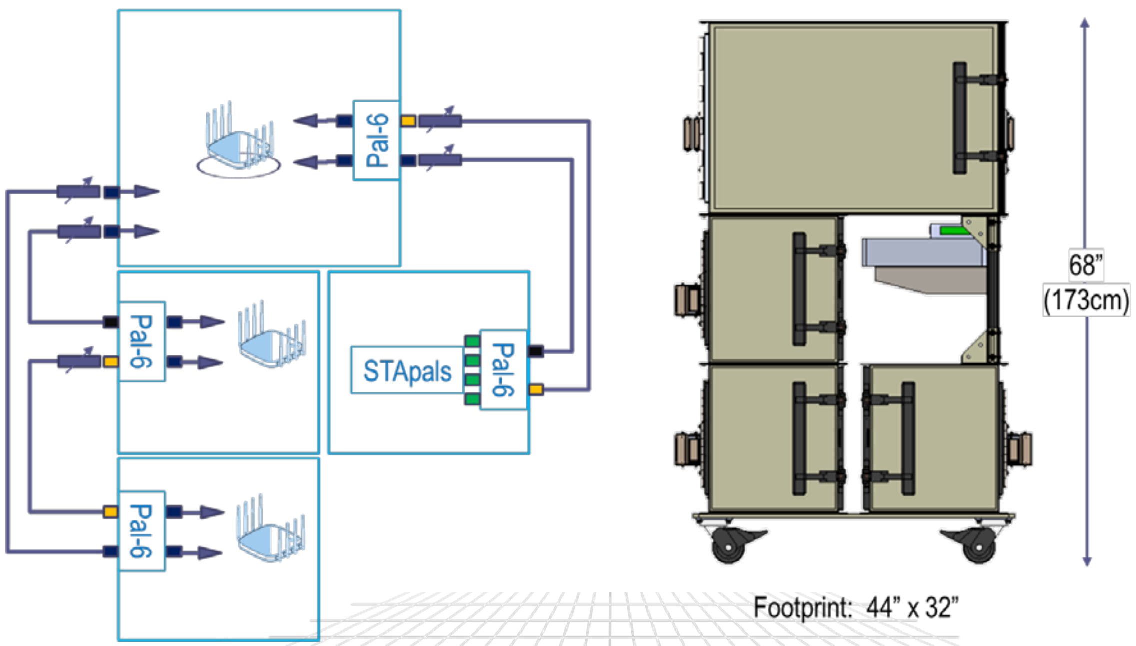


3-node full mesh





STACK-MID is a subset of STACK-MAX



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	 2/18 1/17	 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	√	√	√	OFDMA requires a palBox
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; requires a palBox
DFS	√	√	√	
ACS	√	√	√	
Traffic replay	√	√	√	
vSTA 5 GHz 2.4 GHz Total	 64 32 96	 256 128 384	 256 128 384	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
OFDMA synchroSniffing	15	16	16	OFDMA requires a palBox
TR-398	√	√	√	Automated certification to the Broadband Forum TR-398 performance test standard; STACK-MIN with a palBox

PAL-6 OPEN AND STAPAL OPEN FOR USE IN TEST HOUSES OR WALK-IN CHAMBERS

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

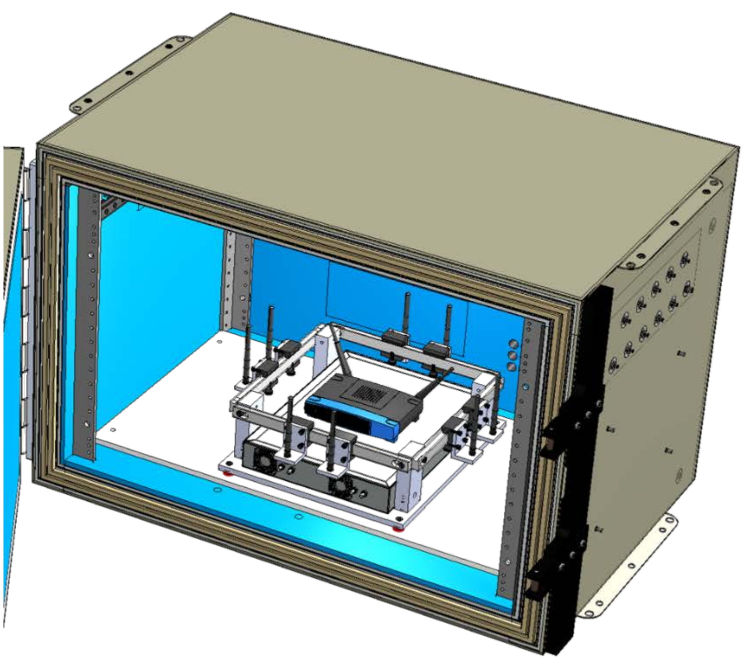
All the RF connectors for the Wi-Fi 6 and Bluetooth radios and interference can be directly connected to the antennas. The open antenna subsystem supports all octoScope's antenna carriers, including high gain antennas and dipole antennas for open air testing.

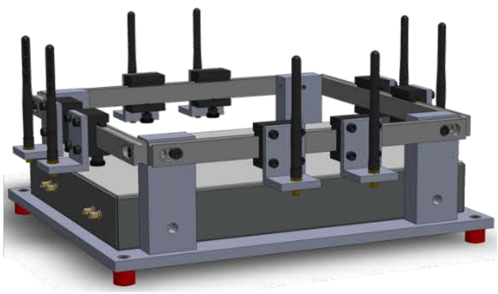
Open antenna system can be configured with any of the octoBox antennas

Both Pal-6 open and STApal open can also be placed inside an octoBox chamber as a portable synchroSniffer or traffic endpoints.

Pal-6 open photo showing all the RF ports

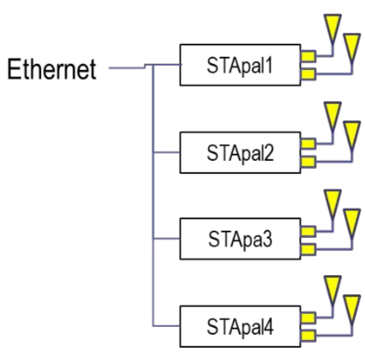
STApal open contains 4 STApals as shown.





Test cases:

- synchroSniffer on up to 4 RUs
- 4 OFDMA STAs for testing APUT



STApal open with the antenna system shown inside and outside of the octoBox chamber

PAL-6 AND STAPAL SPECIFICATIONS

Wi-Fi	Pal-6	STApal
Channels	2.4 GHz and 5 GHz; tri-band	2.4 GHz and 5 GHz dual band
Bandwidth	20, 40, 80, 80+80, 160 MHz	20, 40, 80, 160 MHz and subchannel RUs
Standards	801.11a, 802.11b, 802.11g, 802.11n, 802.11ac (wave 2), 802.11ax	801.11a, 802.11b, 802.11g, 802.11n, 802.11ac (wave 2), 802.11ax
Virtual stations	32 per-radio	
Traffic replay	From PCAP file	
Monitor	Detailed statistics from the Wi-Fi chipset	RSSI, MCS, Nss, bandwidth plus per packet KPIs from the synchroSniffer
Sniffer	synchroSniffer Wireshark captures	synchroSniffer Wireshark captures
802.11ax PHY	DL/UP OFDMA in AP mode DL MU-MIMO and beamforming	DL/UL OFDMA in STA mode DL MU-MIMO
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	Trigger frame support Non-trigger based and trigger-based sounding for beamforming UL-OFDMA Random Access
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	

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General	**Pal-6**
Traffic endpoints	multiPerf®, iperf3, iperf2, SIPP, ping
	Trigger out connector for triggering external RF instruments
Management	10 Gbps Ethernet
Power	Power adapter
Dimensions	23” x 10.4” x 1.4” (58 √ 26 √ 3.5cm)
TX power	MCS, # streams, frequency and channel width dependent (see below)
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	32 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 AND STAPAL REAL-TIME RADIO STATUS

STA	AP	MON	**Pal-6**	**STApal**
√	√	√	Offline	Offline
√	√	√	Monitor	Monitor
√			Scanning <CH #>	Scanning <CH #>
√	√		PHY mode <HT20, OFDMA, HE40, etc.>	PHY mode <HT20, OFDMA, HE40, etc.>
√	√	√	Channel primary and secondary	Channel primary and secondary channels
√			Bandwidth	Bandwidth
	√		Associated STAs <#> hover over to show list of STAs	
√			MAC address	MAC address
√	√		BSSIDs <list>	BSSIDs <list>
	√		SSID	

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TX POWER AND RX SENSITIVITY

Pal-6 5GHz (Tx)

Metric	CS	Measured
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)	23dBm	23dBm
IEEE Mask -limited Power (VHT80 8x8)	23dBm	23dBm
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 HE 160)	14.5dBm@-41dB	18dBm
EVM Limited Power (SU VHT160)	19.5dBm@-32dB	22dBm
Tx EVM Floor (Header-only)	-41 dB	-41.5 dB

Pal-6 5 GHz (RX)

Metric	CS	Measured
Sensitivity (11a/6Mbps/8x8/1SS)	-98.5 dBm	-100.5dBm
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

Pal-6 2.4 GHz

Metric (room temp)	CS	Measured
Tx Power Accuracy (dB)	+/- 1dB	+/- 1dB
IEEE Mask Limited Power (CCK)	23dBm	24dBm
IEEE Mask Limited Power (VHT40)	23dBm	24dBm
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

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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

Pal-6 DL OFDMA

Metric	CS	Measured
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

Pal-6 system level power

Metric	CS Target (W)	Measured
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 AND STAPAL RADIO STATS – AVAILABLE AS PLOTS VS. TIME

Only STA stats are available for STApals. Reporting by STApals of the KPIs from the synchroSniffer is per packet and per RU. Reporting from the Pal-6 is per interval (1 second) as indicated in the last column.

Pal-6 STA	Pal-6 AP	STApal	UI name	Details	Pal-6 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.

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√	√		% 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
AID = association ID
AP = access point
BE = best effort (priority)
BK = background (priority)
BLE = Bluetooth low energy
BT = Bluetooth
DFS = dynamic frequency selection
DL = downlink
HE = high efficiency
HFP = hands free profile
HID = human interface device profile
KPI = key performance indicator
MCS = modulation coding scheme
MIMO = multiple input multiple output
MP2MP = multi-point to multi-point (traffic generator)
MU = multi-user
Nss = number of streams
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
STA = station (aka client)
TX = transmit
UL = uplink
VI = video (priority)
VO = voice (priority)
vSTA = virtual STA

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