
LITEPOINT
Wi-Fi 6 (802.11ax) is Rolling Out.
Are You Ready?
NFC
5G
MIMO
NFC
Bluetooth
Zigbee
GPS
WAVE

Wi-Fi Gets Rebranded…

Wi-Fi 6 is coming to a router near you

The Wi-Fi alliance has changed the naming scheme for Wi-Fi standards, abandoning the 802.11 designations for simpler names like Wi-Fi 6, Wi-Fi 5, Wi-Fi 4, etc., but that may gloss over some of the finer points of the old IEEE system.

Wi-Fi 6: What Does the Naming Mean for You?

- In reality, very little – this is meant to help with consumer confusion to indicate generations of technology.
  - **6 is a bigger number than 5, it must be better!**

- **Wi-Fi 6** to identify devices that support **802.11ax** technology
- **Wi-Fi 5** to identify devices that support **802.11ac** technology
- **Wi-Fi 4** to identify devices that support **802.11n** technology

Generation of network connection	Sample user interface visual
Wi-Fi 6	6
Wi-Fi 5	5
Wi-Fi 4	4

Wi Fi ™ ALLIANCE

Note that this is Wi-Fi Alliance branding, <u>not</u> IEEE branding!

(we will still use 802.11ax in the development community)

Wi-Fi 6 AP Products Announced and Launching

AEROHIVE NETWORKS

ASUS

D-Link

TP-LINK

NETGEAR

Refresher: Key Changes in 802.11ax

	802.11n	802.11ac	802.11ax
Operating Bands	2.4 & 5GHz	5GHz	2.4 & 5GHz
Technology	OFDM	OFDM	OFDMA
MU-MIMO	No	DL MU-MIMO*	DL / UL MU-MIMO*
Subcarrier Spacing	312.5kHz	312.5kHz	78.125kHz
Modulation	64QAM	256QAM	1024QAM
User Streams	4	Up to 8 user streams*	
Bandwidth	40 MHz	20, 40, 80, 80+80 and 160MHz	

*Optional

*Optional

Key changes impacting test:

- More radios: 1 or 2 moving to 4+
- More OFDMA configurations to test
- Power & timing control

Market Update: 802.11ax Technologies Timeline

802.11ac | 802.11ax | 802.11ax (Wave 2)

Plugfest 5

Plugfest 6

2016 | 2017 | 2018 | 2019 | 2020 | 2021

802.11ax Chipset DVT

AP Chipset Customer Shipments

802.11ax products

802.11ax volume ramp

CES 2018: 1st 802.11ax AP Products Announced

Looking Ahead at New Wi-Fi Bands

FCC puts gigabit Wi-Fi on the roadmap by opening up new wireless spectrum

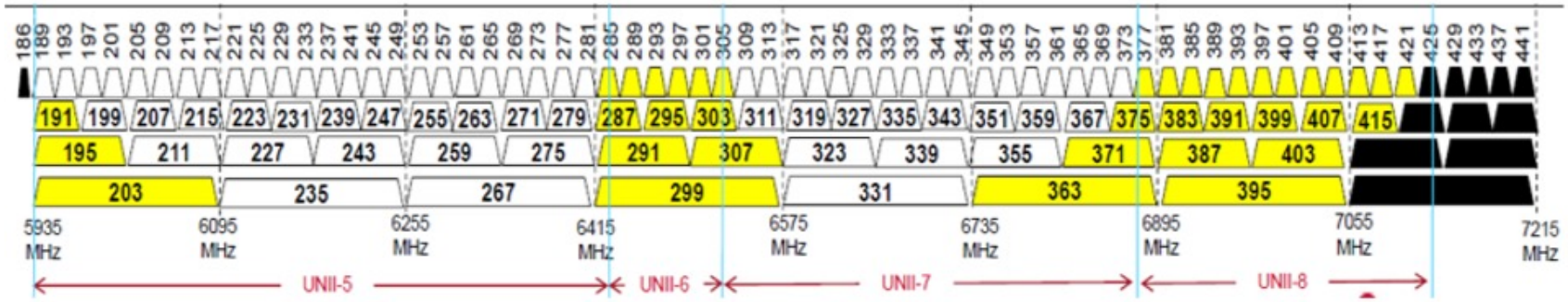
Devin Coldewey @techcrunch / 1 week ago

Comment

That's the purpose of the FCC proposing opening up what's generally called the 6 gigahertz band — 5,925 to 7,125 MHz — for similar purposes.

802.11ax “6 GHz” Band Allocations

- U-NII-5: 5925-6425 MHz
- U-NII-6: 6425-6525 MHz
- U-NII-7: 6525-6875 MHz
- U-NII-8: 6875-7125 MHz



Yellow: may require reduced power for incumbent protection
Black: not available in some locations

802.11ax Chipset Availability Roadmap

	2018	2019	2020
Smartphones / Tablets 	802.11ax 2x2 + 2x2 SDB	802.11ax 2x2 + 2x2 SDB	802.11ax 2x2 + 2x2 SDB U-NII-5/6/7/8
Laptops 	802.11ax 2x2 + 2x2 SDB	802.11ax 2x2 + 2x2 SDB	802.11ax 2x2 + 2x2 SDB U-NII-5/6/7/8
Access Point / Gateway 	802.11ax 4x4 + 4x4 8x8	802.11ax 2x2+ 2x2 4x4 + 4x4 8x8 U-NII-5/6/7/8	802.11ax 2x2+ 2x2 4x4 + 4x4 8x8 U-NII-5/6/7/8

AP STA

802.11ax chipsets debut in Access Points in 2018 and move to mobile in 2019

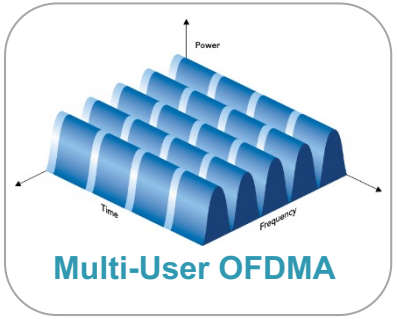
802.11ax Feature Development

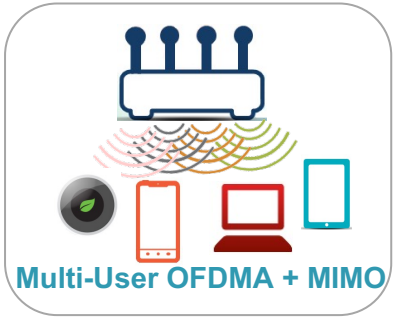
802.11ax Feature	
OFDMA	Single-User OFDMA
	Downlink Multi-User OFDMA
	Uplink Multi-User OFDMA
MIMO	Single-User MIMO
	Multi-User MIMO

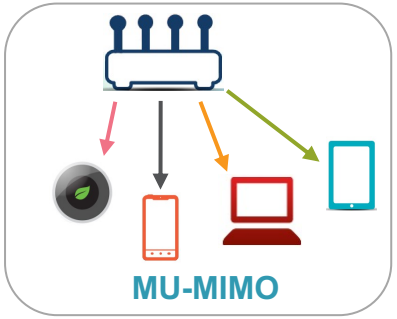
First focus for 802.11ax product development

Current focus for 802.11ax product development

Future development







Wi-Fi Alliance Plugfest 5 Update

- Wi-Fi Alliance Plugfest 5 was held October 8-19, 2018.
- Participants:
  - 3 AP developers
  - 2 STA developer
  - 5 AP chipset providers
  - 8 STA chipset providers
  - 4 Equipment Vendors
- A total of 123 people participated in the 2 week event
- Plugfest 5 goal: validate **OFDMA** test cases, particularly **UL OFDMA**
  - Previous Plugfests focused on OFDM only

- Wi-Fi Alliance goal is to establish
- certification program in **Q3 2019**

Wi-Fi Plugfest 5 Outcome and Next Steps

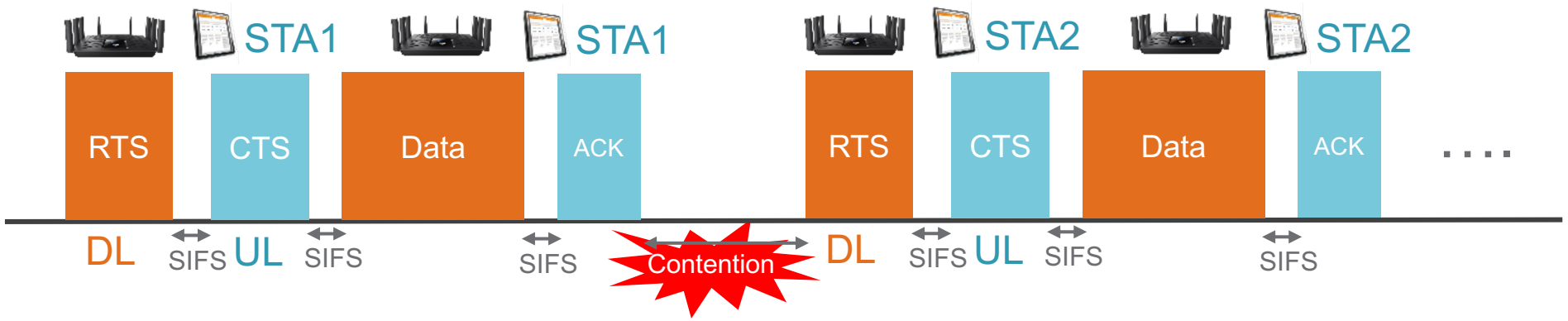
- OFDMA has proven to be **very complex** to implement!
- OFDMA Test Cases Validated:
  - AP: **~20** of **41** cases validated (vendor dependent)
  - STA: **~24** of **47** cases validated
  - PHY parameter “sniffer” validated on 2 of 4 cases
- Plugfest 6 Goal:
  - Complete remaining OFDMA test case validation
- Plugfest 6 scheduled for December 10-21, 2018

802.11ax Essential Tests for OFDMA

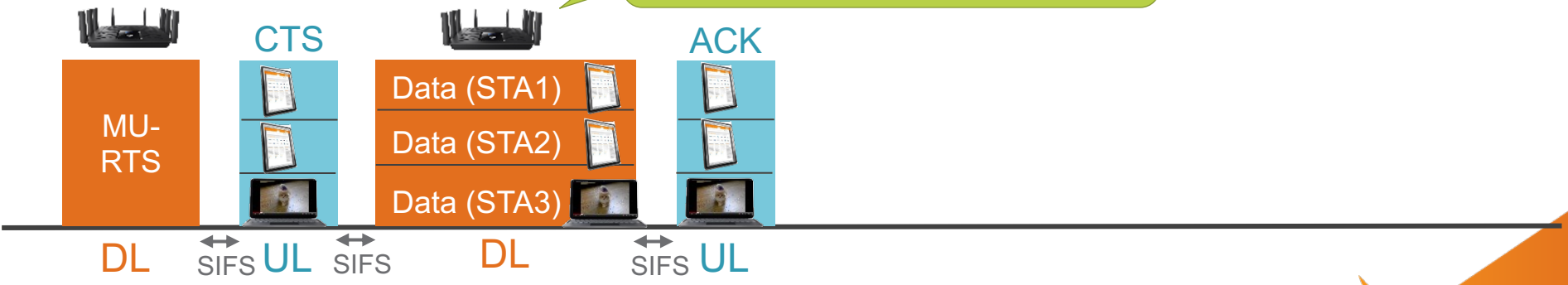
OFDM vs. OFDMA: Downlink

OFDMA improves overall network efficiency by serving multiple STAs

OFDM

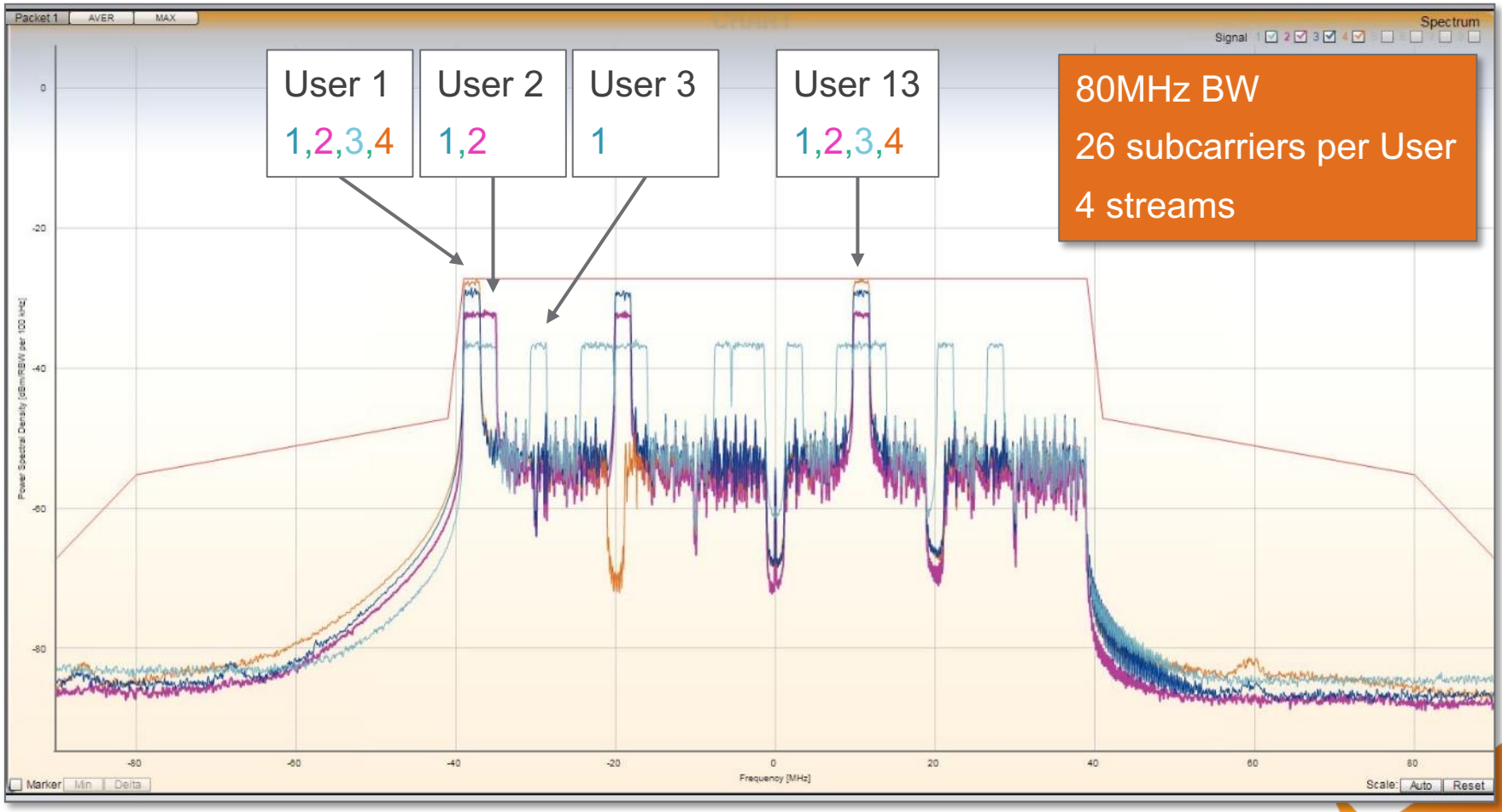


OFDMA



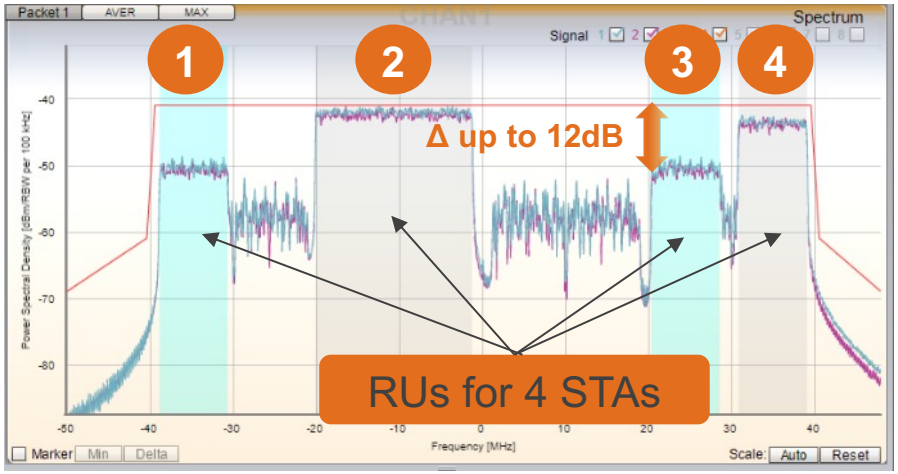
OFDMA Brings Large Number of Test Permutations

- AP simultaneously serves multiple users
  - Varying # of users, RU combinations, # of streams

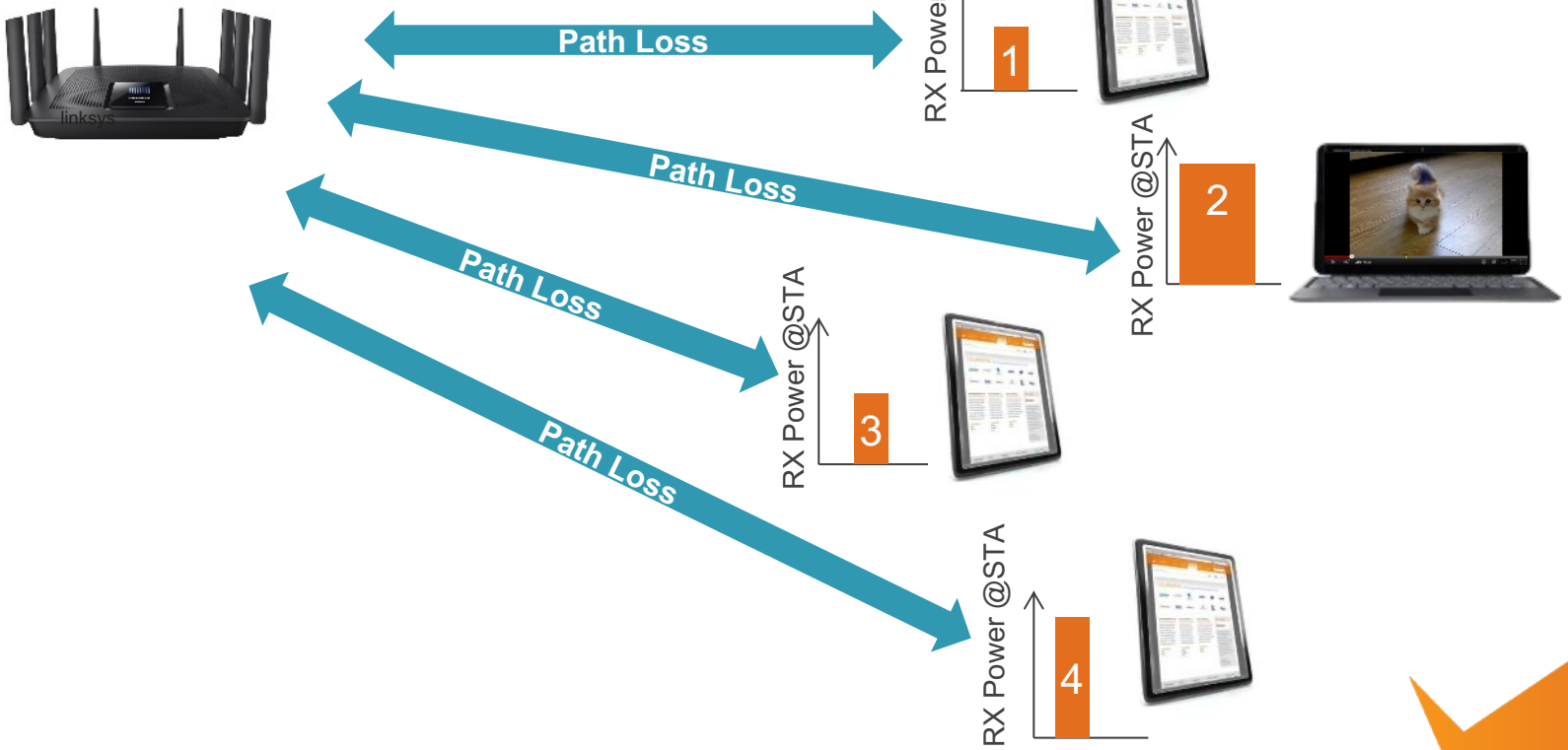


Multi-User OFDMA Power Control (“Power Boost”)

TX Power @AP

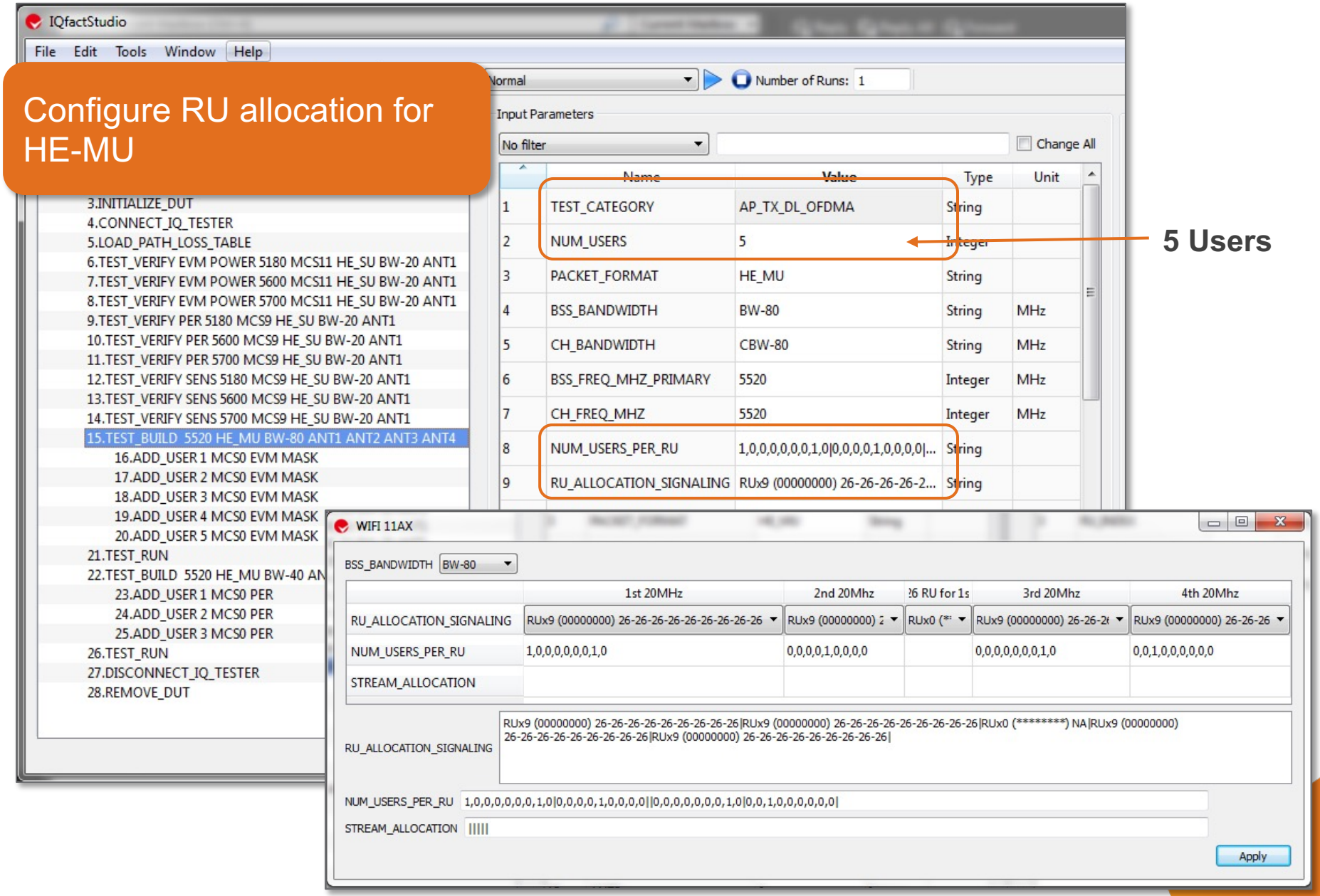


AP can adjust power level per RU so that Rx power at STAs are equal



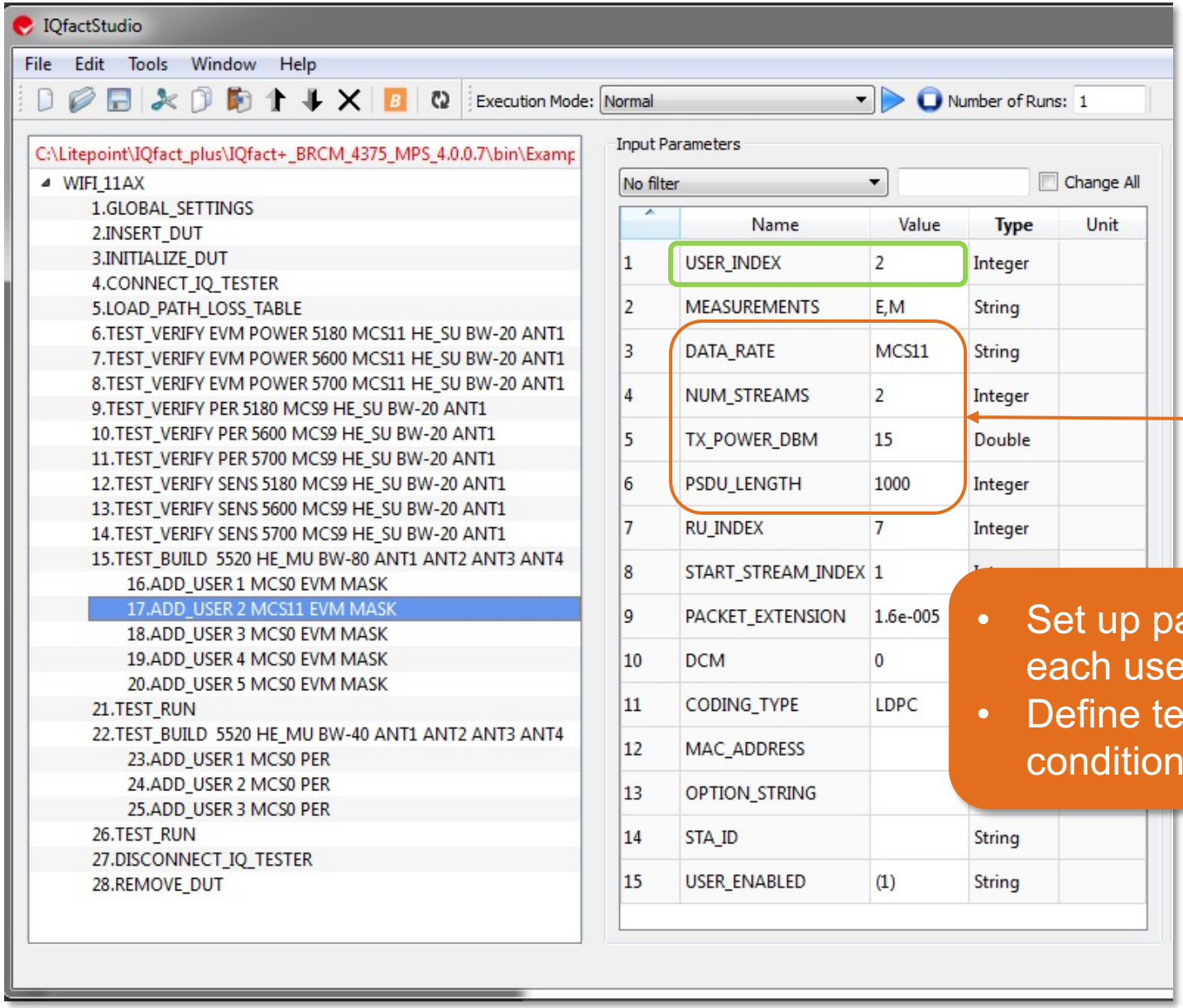
Creating 11ax Test Flow for AP with iQfact+

Configure RU allocation for HE-MU



5 Users

Creating 11ax Test Flow for AP with iQfact+



Different for each RU / user

- Set up parameters for each user
- Define test types and conditions

OFDM vs. OFDMA: Uplink

Uplink Tx requires precise frequency, timing, and power control

OFDM

STA1 STA1 STA2 STA2

RTS CTS Data ACK RTS CTS Data ACK ....

UL SIFS DL SIFS SIFS Contention UL SIFS DL SIFS SIFS

OFDMA

AP must coordinate simultaneous STA transmission

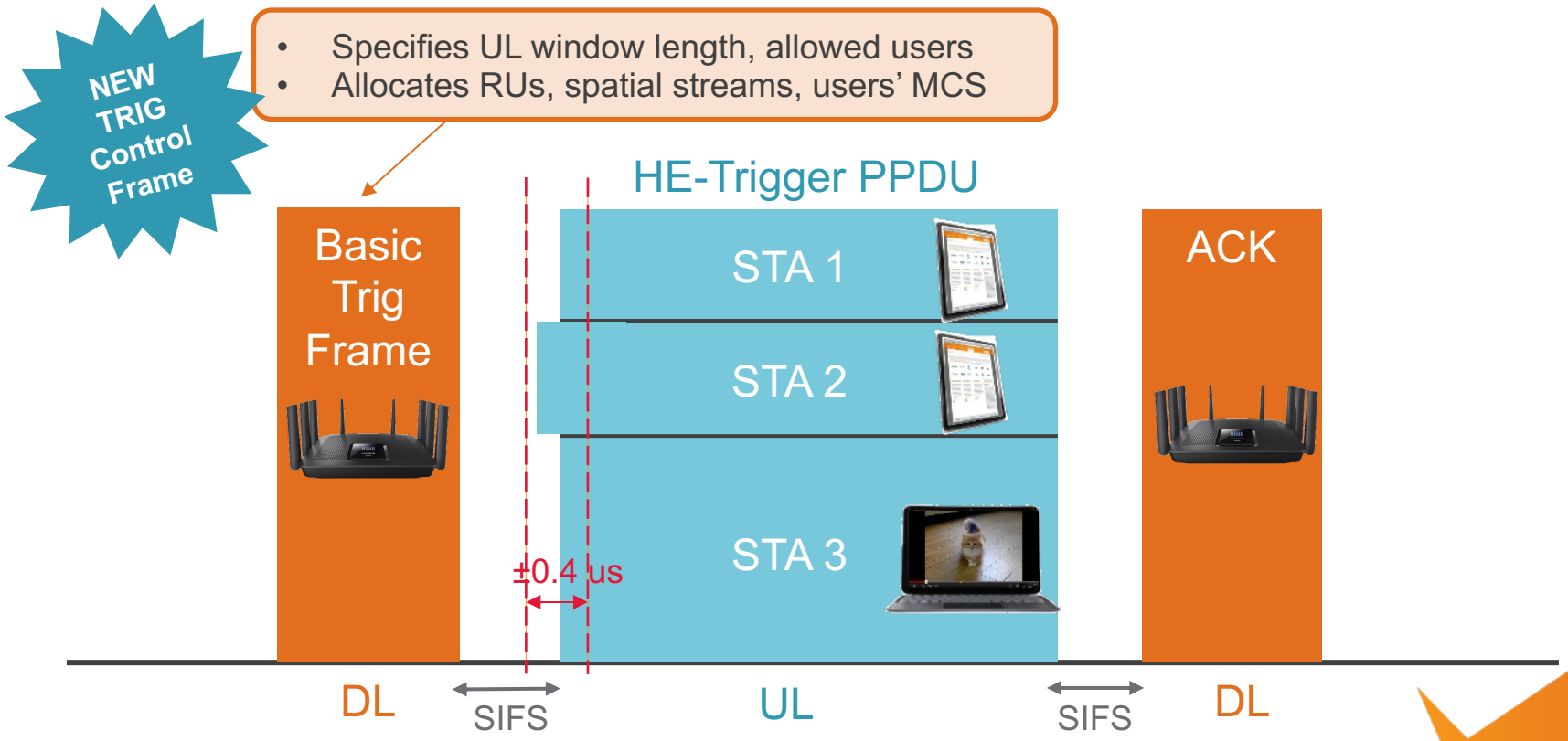
Signals from STAs can interfere each other in **Time / Frequency / Power**

MU-RTS CTS TRIG Data (STA1) Data (STA2) Data (STA3) ACK ACK ACK

DL SIFS UL SIFS SIFS SIFS

AP as Mini Base Station

- AP pre-coordinates with STAs to minimize interference
  - Power balance among STAs *Power*
  - System synchchronization among STAs
    1) Transmit at the same time (< **0.4us** difference) *Timing*
    2) Transmit at the same carrier frequency (<**350 Hz** difference) *Frequency*



How Does Power Pre-correction Work?

Maintain power balance among STAs in Uplink

Trig

1) STA calculates path loss

$$Pathloss_{DL} = Tx_{AP\ power} - DL_{RSSI}$$

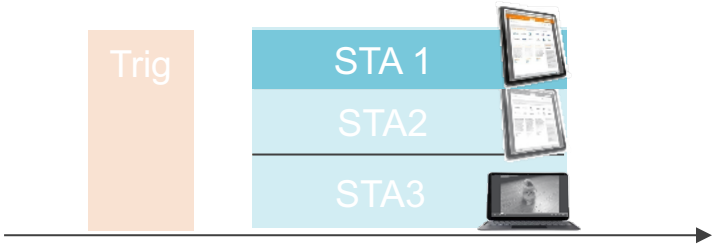
Trig Frame

MAC header

Frame Control	Duration	RA	TA	Common Info	User Info	...	User Info	Padding	FCS
Octets: 2	2	6	6	8 or more	5 or more		5 or more	variable	4

2) STA calculates UL transmit power $Tx_{STA\ power} = Pathloss_{DL} + Target_{RSSI}$

3) STA sends HE TB PPDU in response to AP Trig at Tx STA power

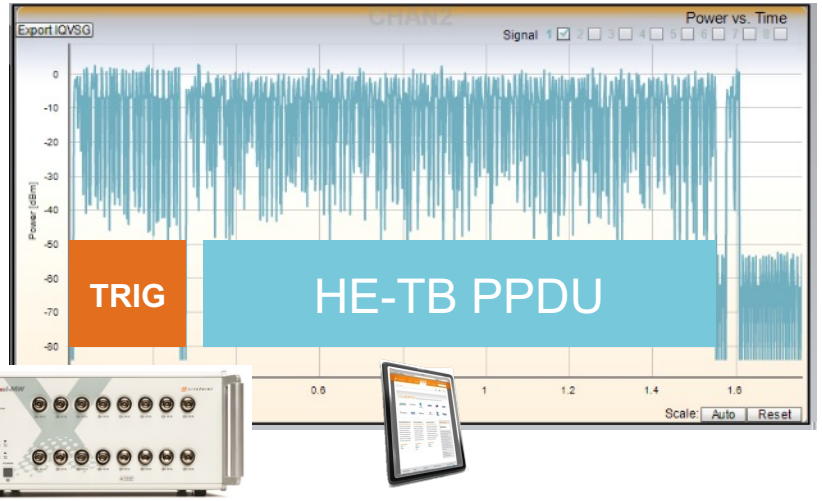


Ensures STA power does not interfere with other participating STAs

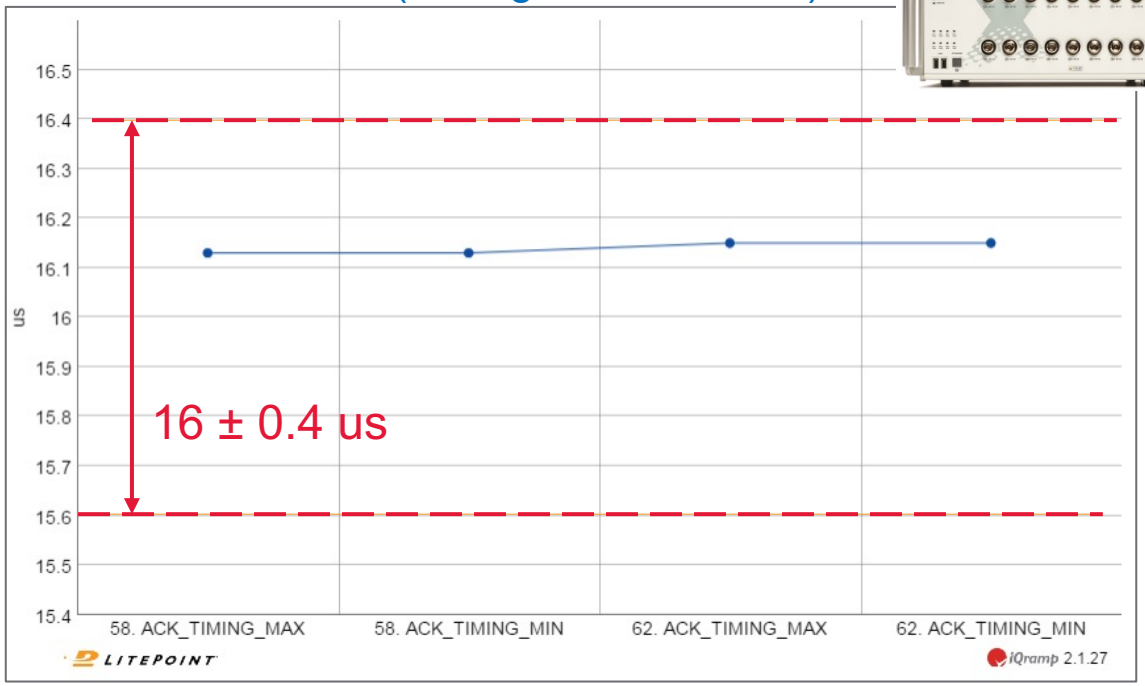
IQfact+ Data Example: Trigger Based Testing

IQfact+ automatically handles precise timing control necessary for TBT

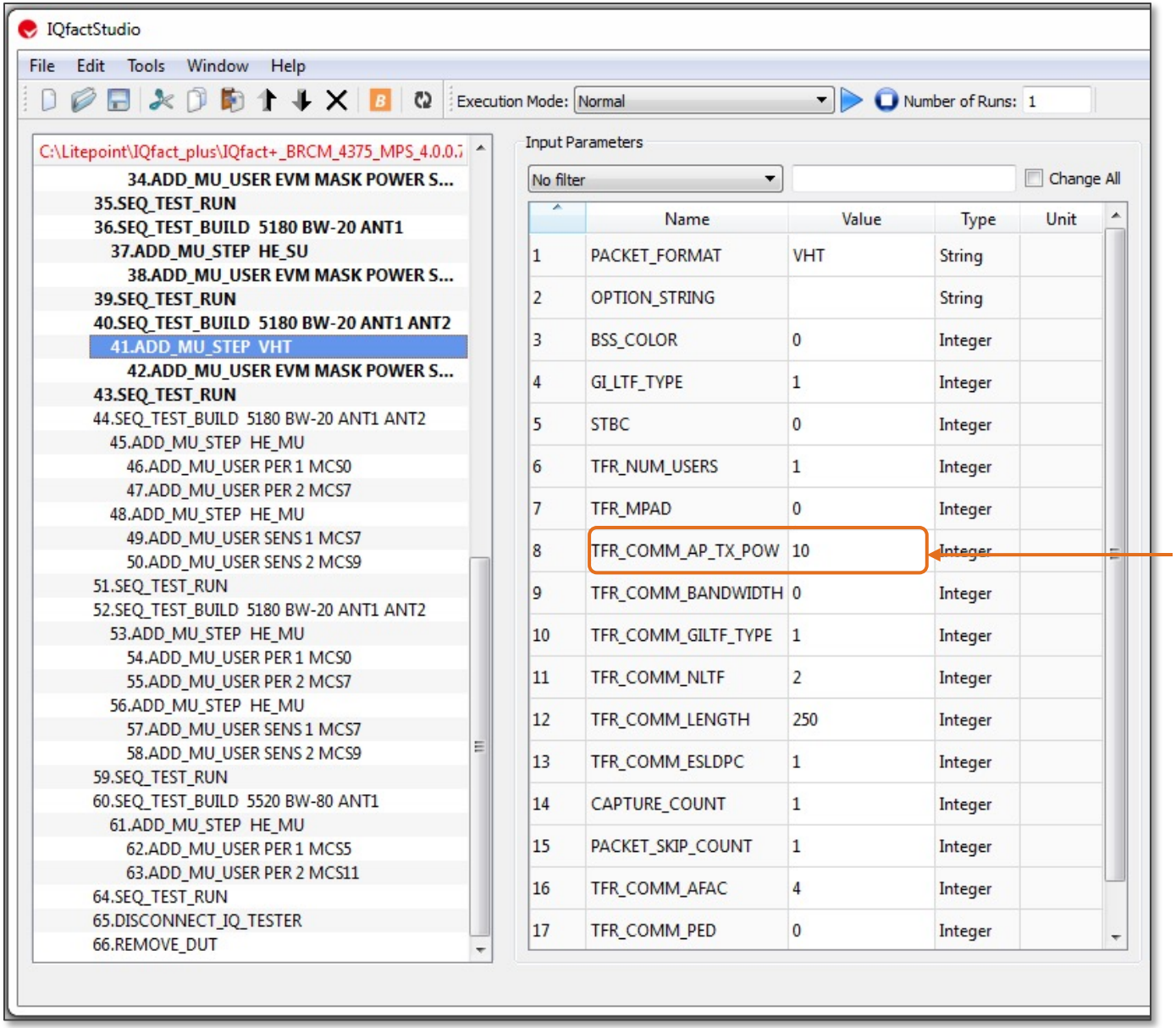
1. Tester VSG: Transmit a Trigger frame
2. Tester switches VSG to VSA
3. Tester VSA captures HE-TB from STA for analysis



TBT (Timing measurement)

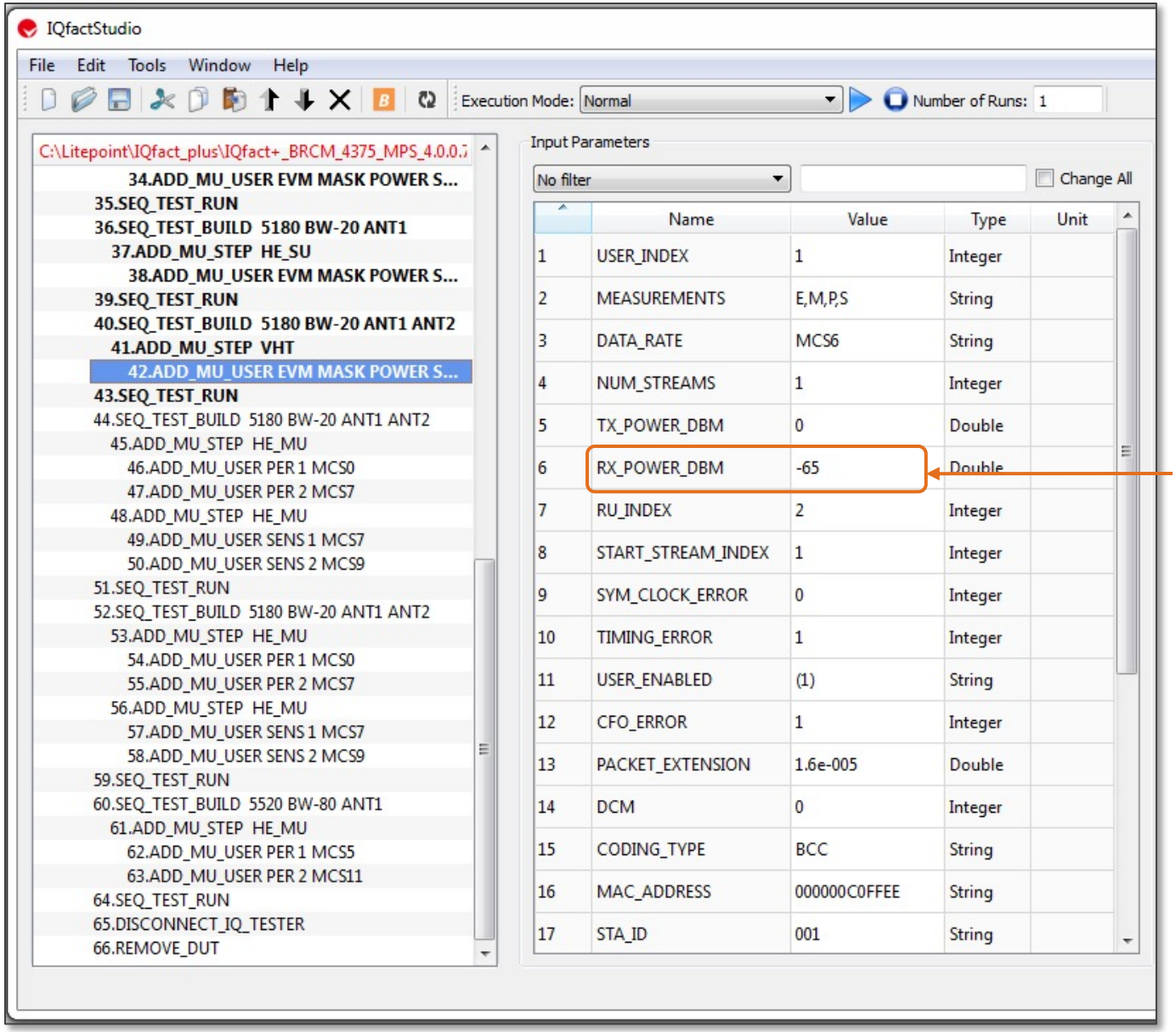


Configuring Trigger Based Test with iQfact+



Sets AP Tx power in Trigger frame (dBm)

Configuring Trigger Based Test with iQfact+



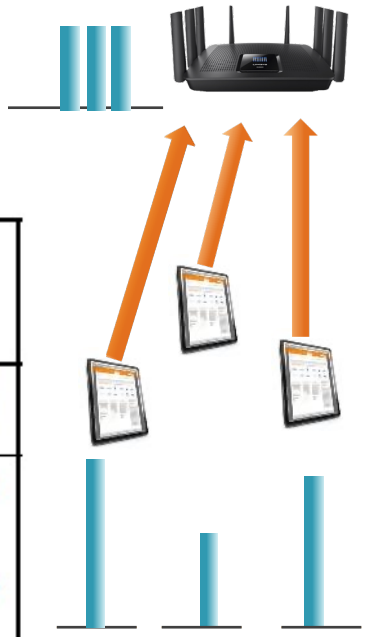
Sets target Rx signal power in Trigger frame (dBm)

STA Device Calibration

More Stringent Requirement in 11ax

- Transmit power accuracy : For uplink Tx accuracy
- RSSI measurement accuracy : To correctly calculate pathloss

Accurate power control is critical in ensuring power received from STAs at AP is equal

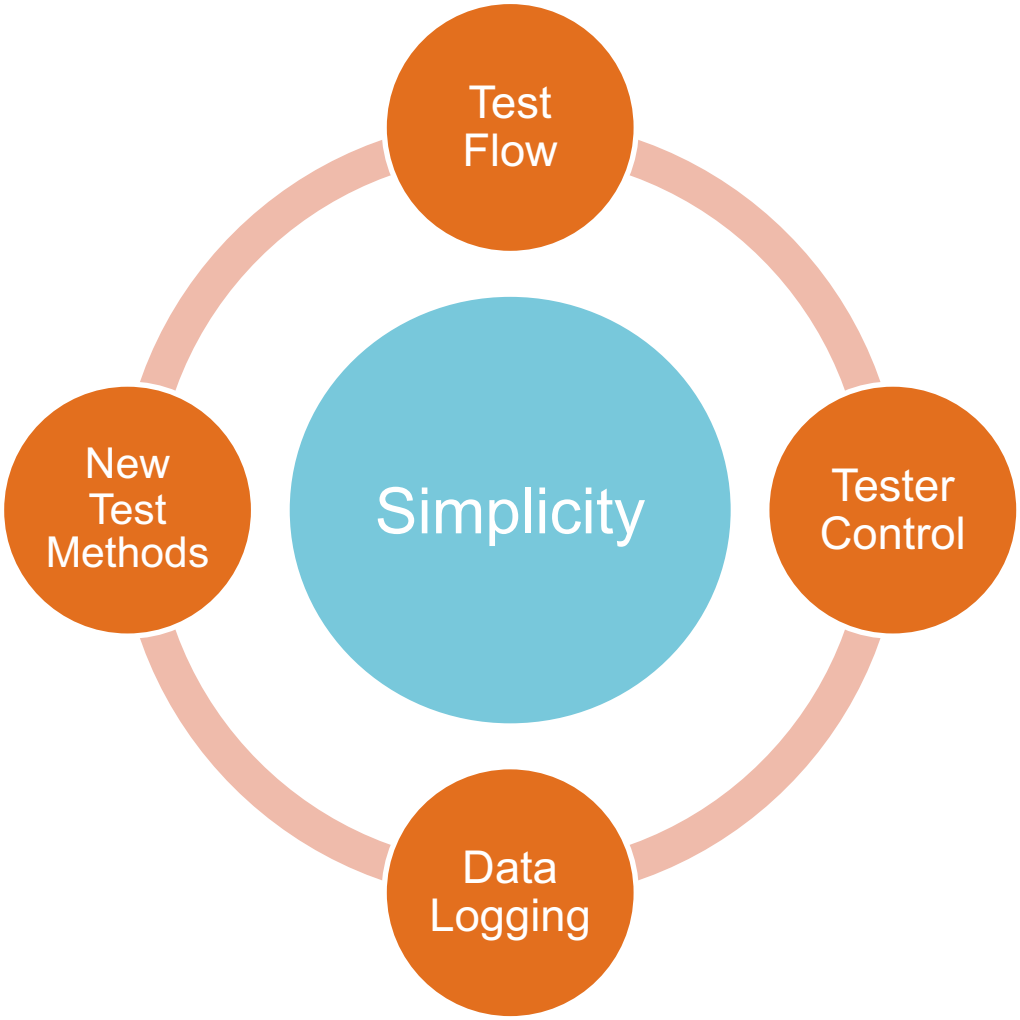


Parameter	Minimum Requirement		Comments
	Class A	Class B	
Absolute transmit power accuracy	±3 dB	±9 dB	Accuracy of achieving a specified transmit power.
RSSI measurement accuracy	±3 dB	±5 dB	The difference between the RSSI and the received power. Requirements are valid from minimum Rx to maximum Rx input power.
Relative transmit power accuracy	N/A	±3 dB	Accuracy of achieving a change in transmit power for consecutive HE TB PPDU. The relative transmit power accuracy is applicable only to Class B devices.

802.11ax Draft 2.2 Table 28-43 STA power / RSSI Accuracy Requirements

Automation Reduces 802.11ax Test Complexity

11ax has more test combinations and test requirements than previous Wi-Fi standards



IQsniffer: PHY Layer Packet Analysis

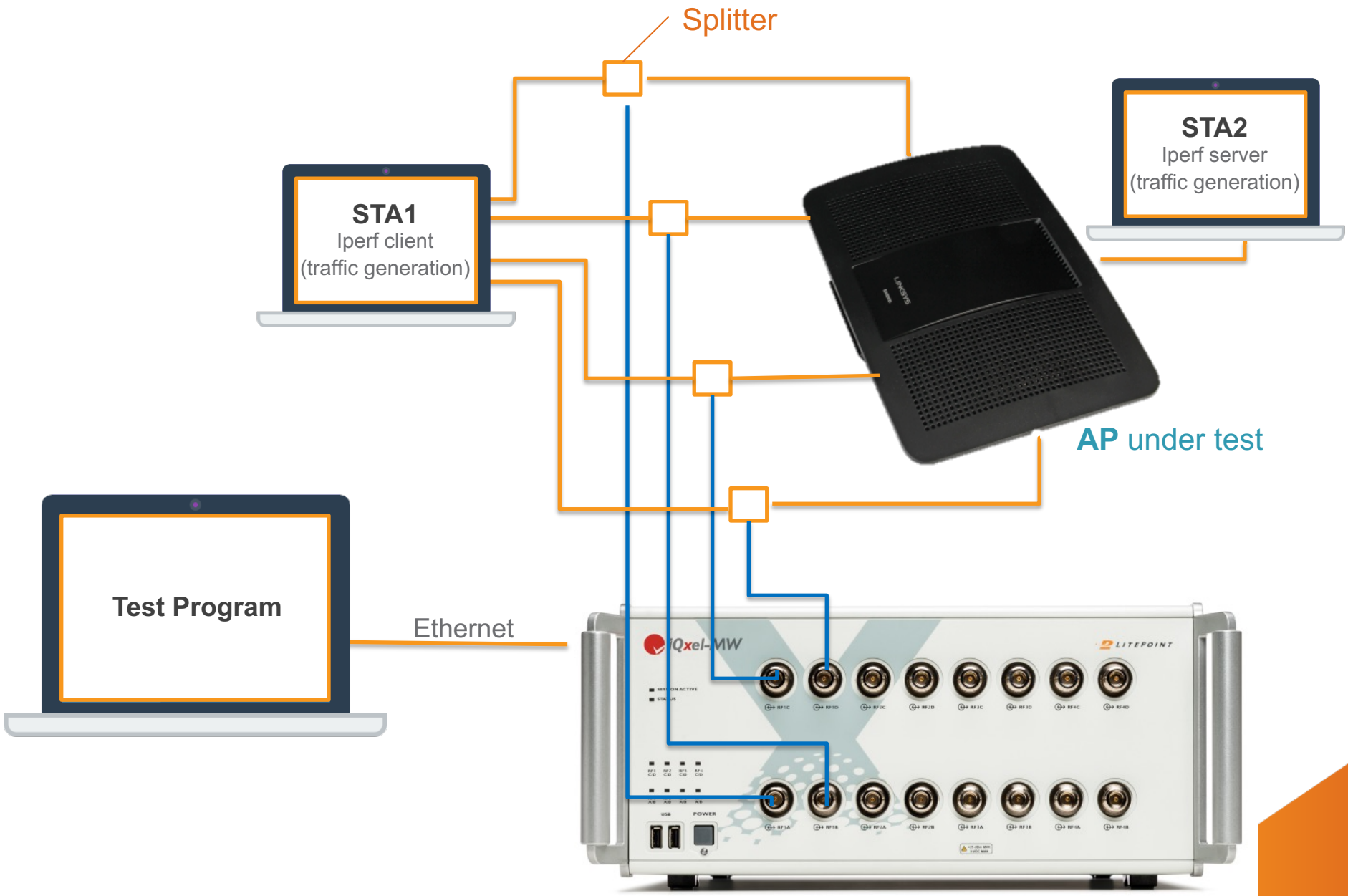
IQsniffer – WiFi PHY Traffic Analysis Simplified

- **IQsniffer is useful for product characterization and Wi-Fi Alliance certification**

- **Key Features:**
  - **PHY layer analysis:** Uncovers timing information and behavior not visible at MAC layer
    - Parametric measurements(EVM, Power, Spectrum, etc.)
    - Timing information
    - PPDU information: packet format, coding, spatial stream info
  - **MAC layer information available:**
    - Packet type, sub-type
    - MAC address(es)
    - Whole PSDU

Validated at Wi-Fi Alliance Plugfest 5

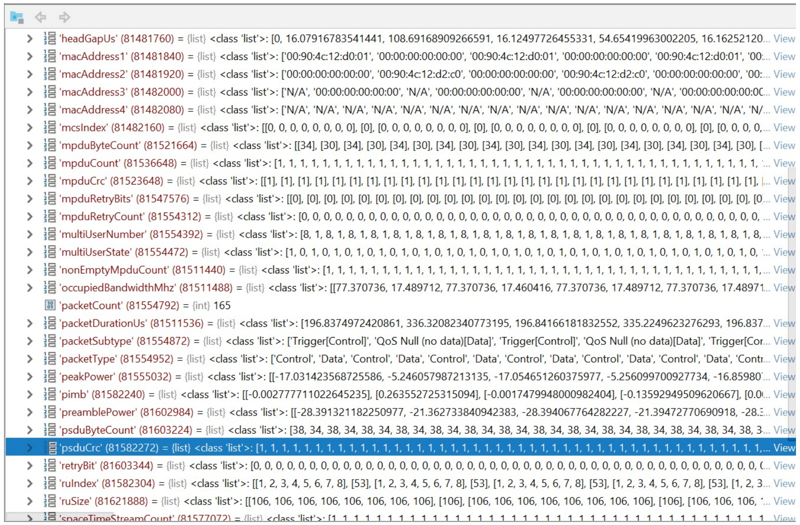
IQsniffer PHY Traffic Monitoring (4x4) on IQxel-MW



IQsniffer Return Interface – Simple to Use

- IQsniffer Interface
  - IQsniffer provides a simple SCPI interface over socket:

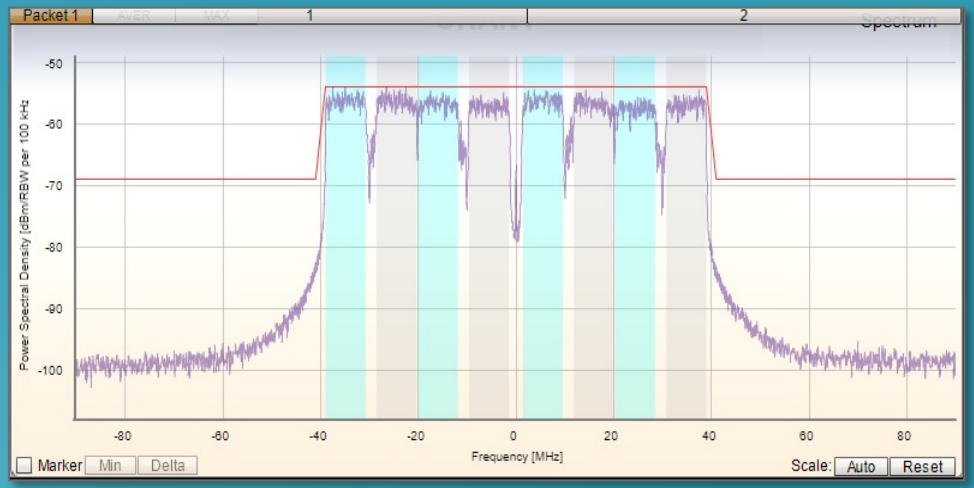
```
SNIF:CONF:OUTP ALL
SNIF:CONF:BAS 1
SNIF:CONF:PDTH 30
SNIF:CALC

SNIF:FETC:ALL:JSON ?
```

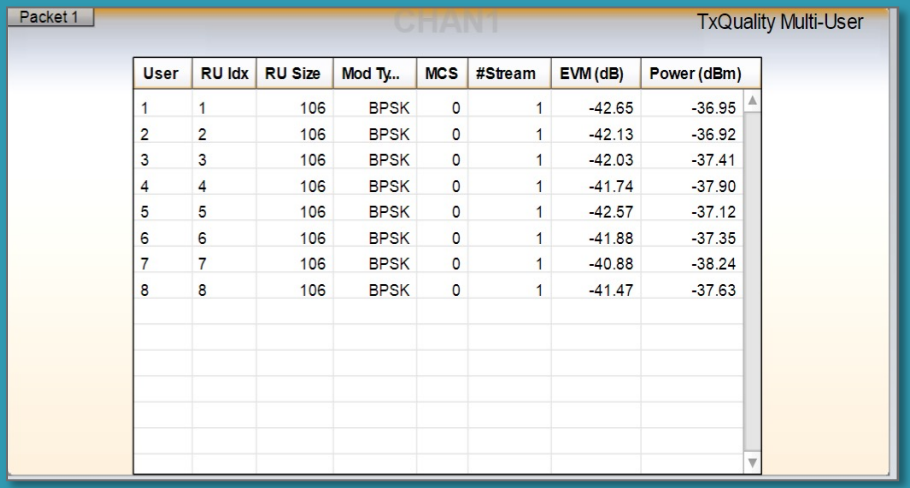


- Results all included in a JSON object:
  - Easy to load into a dictionary data type
  - Each key has a list of values
  - Each "value" could be a list of users

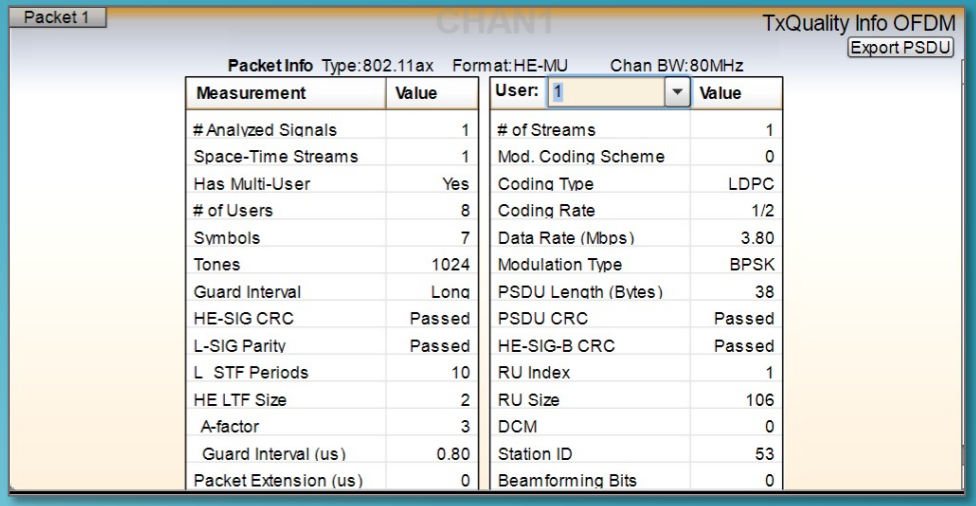
- Python example source code is proved
  - JSON returns saved into .CSV file
  - The .CSV file can be loaded in Excel or IQramp

Using IQsniffer:
PHY Parameters for 802.11ax HE-MU





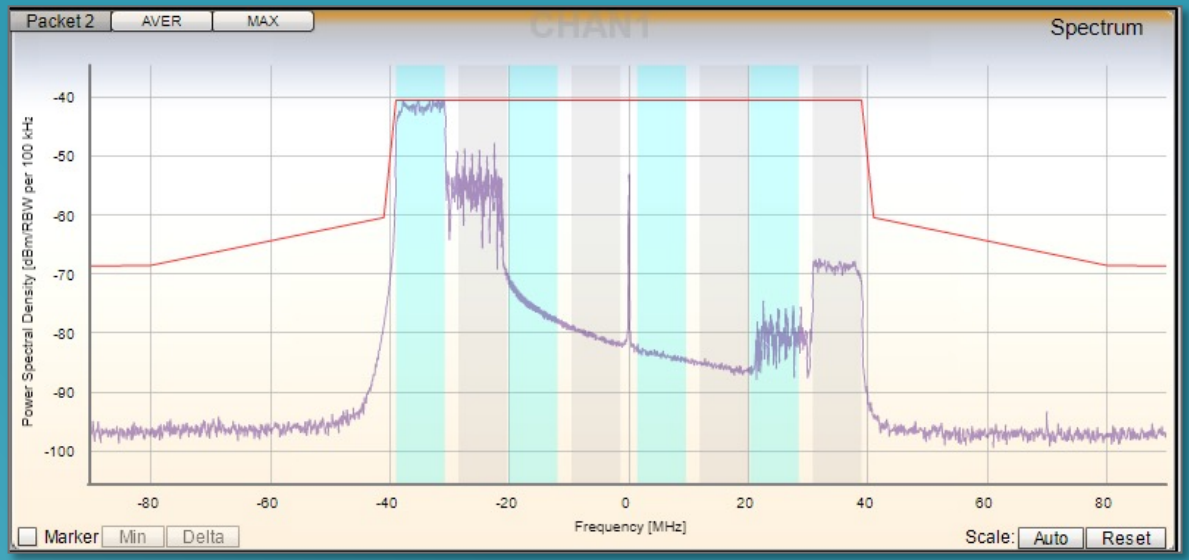
User	RU Idx	RU Size	Mod Ty..	MCS	#Stream	EVM (dB)	Power (dBm)
1	1	106	BPSK	0	1	-42.65	-36.95
2	2	106	BPSK	0	1	-42.13	-36.92
3	3	106	BPSK	0	1	-42.03	-37.41
4	4	106	BPSK	0	1	-41.74	-37.90
5	5	106	BPSK	0	1	-42.57	-37.12
6	6	106	BPSK	0	1	-41.88	-37.35
7	7	106	BPSK	0	1	-40.88	-38.24
8	8	106	BPSK	0	1	-41.47	-37.63



Measurement	Value
# Analyzed Signals	1
Space-Time Streams	1
Has Multi-User	Yes
# of Users	8
Symbols	7
Tones	1024
Guard Interval	Long
HE-SIG CRC	Passed
L-SIG Parity	Passed
L STF Periods	10
HE LTF Size	2
A-factor	3
Guard Interval (us)	0.80
Packet Extension (us)	0

User: 1	Value
# of Streams	1
Mod. Coding Scheme	0
Coding Type	LDPC
Coding Rate	1/2
Data Rate (Mbps)	3.80
Modulation Type	BPSK
PSDU Length (Bytes)	38
PSDU CRC	Passed
HE-SIG-B CRC	Passed
RU Index	1
RU Size	106
DCM	0
Station ID	53
Beamforming Bits	0

Using IQsniffer:
PHY Parameters for 802.11ax HE-TRIG



Packet 2

TxQuality Info OFDM

Export PSDU

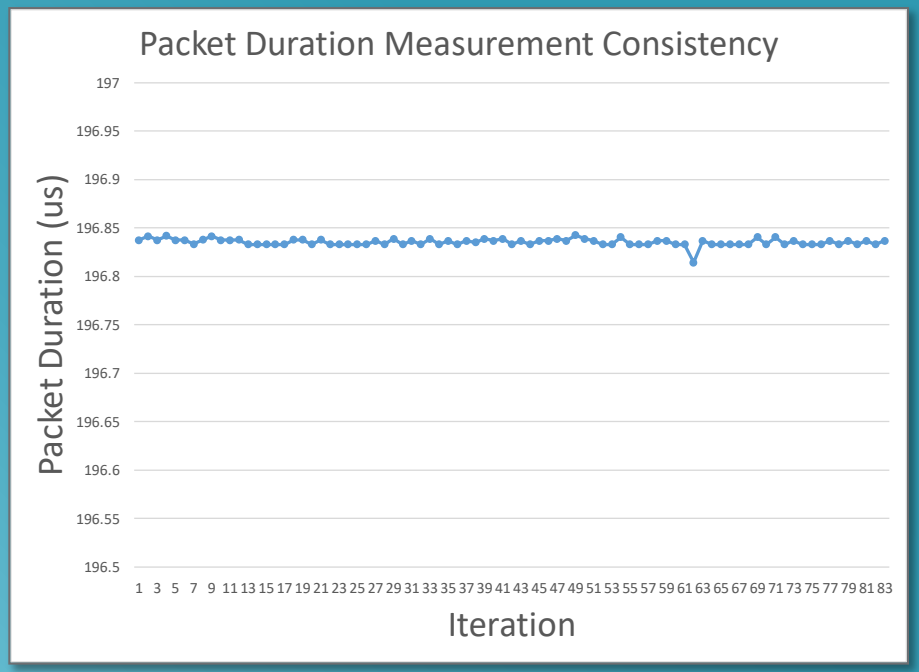
Packet Info Type:802.11ax Format:HE-TRIG Chan BW:80MHz

Measurement	Value
# Analyzed Signals	1
Space-Time Streams	1
Has Multi-User	NO
# of Users	1
Symbols	16
Tones	1024
Guard Interval	Short
HE-SIG CRC	Passed
L-SIG Parity	Passed
L STF Periods	9
HE LTF Size	2
A-factor	3
Guard Interval (us)	1.60
Packet Extension (us)	0

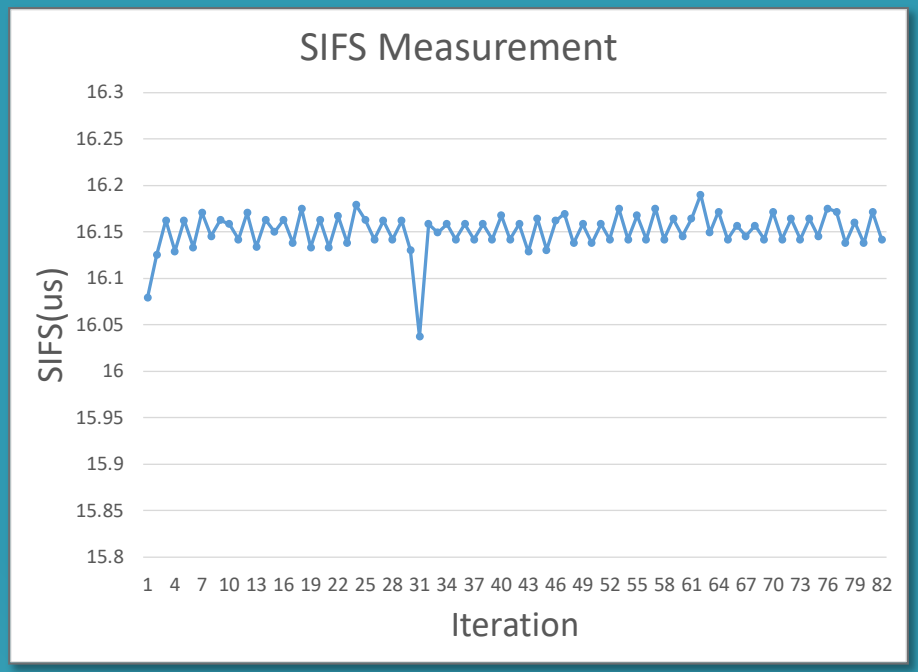
User: 1	Value
# of Streams	1
Mod. Coding Scheme	0
Coding Type	LDPC
Coding Rate	1/2
Data Rate (Mbps)	3.50
Modulation Type	BPSK
PSDU Length (Bytes)	34
PSDU CRC	Passed
HE-SIG-B CRC	--
RU Index	53
RU Size	106
DCM	0
Station ID	0
Beamforming Bits	0

Common Bits: ..

IQsniffer Packet Duration Measurement



IQsniffer SIFS Measurement



Delivering High Performance Wi-Fi 6 (802.11ax) Test

DVT

Mobile (STA) Manufacturing

Access Point Manufacturing

Performance

- Exceeds stringent 802.11ax EVM requirements
- 80+80, 160MHz and dual-band concurrent on a single port
- 11ax Trigger-based packet detection and timing

Manufacturing Quality

- Smart front-end eliminates external components
- True MIMO and Simultaneous Dual-Band
- Easy test program migration from IQxel-M8/M16

Manufacturing Throughput

- Complete turnkey solutions with IQfact+
- Sequence-based and trigger-based testing
- True MIMO reduces test time, ensures quality