WI-FI 7 MLO
(SURPRISINGLY) THE DEVIL IS IN THE DETAILS – OR HOW TO TEST MLO

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Make ideas real

Top 5 New Features in IEEE 802.11be (Wi-Fi 7)

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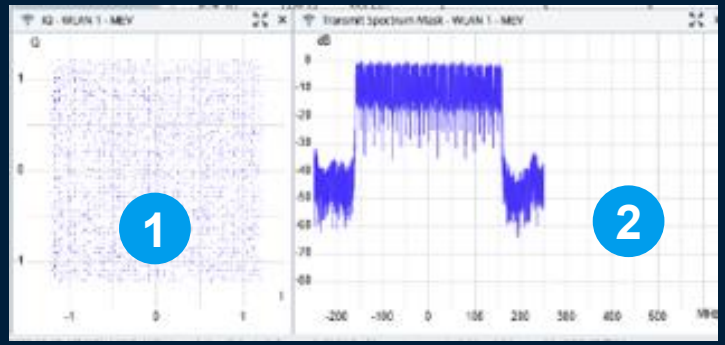
1. 4096-QAM modulation (12 bit per symbol) ✓
2. 320 MHz channel BW in 6 GHz band ✓
3. Preamble puncturing
4. Multiple resource units (MRU)
5. Multi-link operation (MLO)



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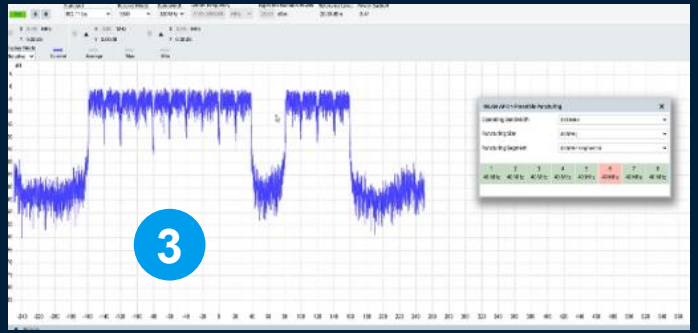

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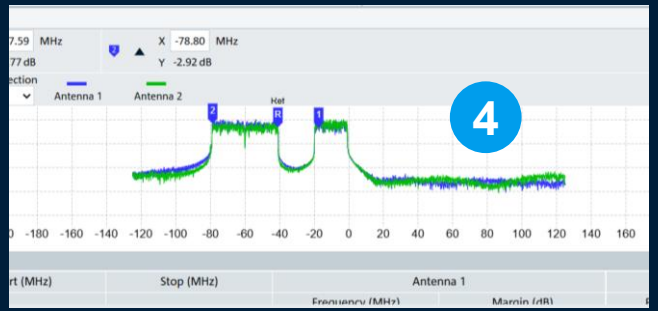

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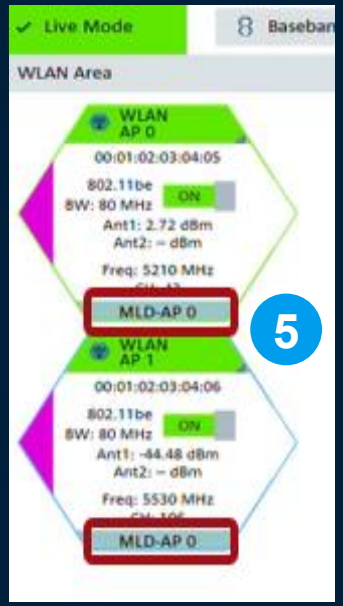
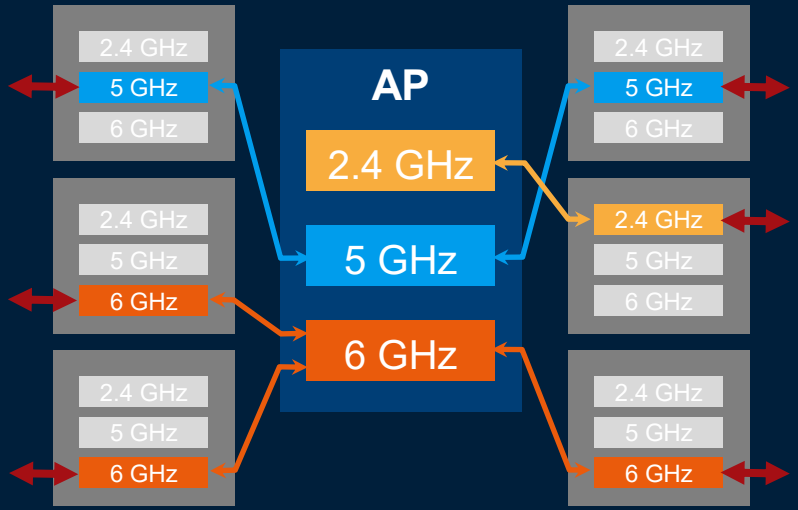
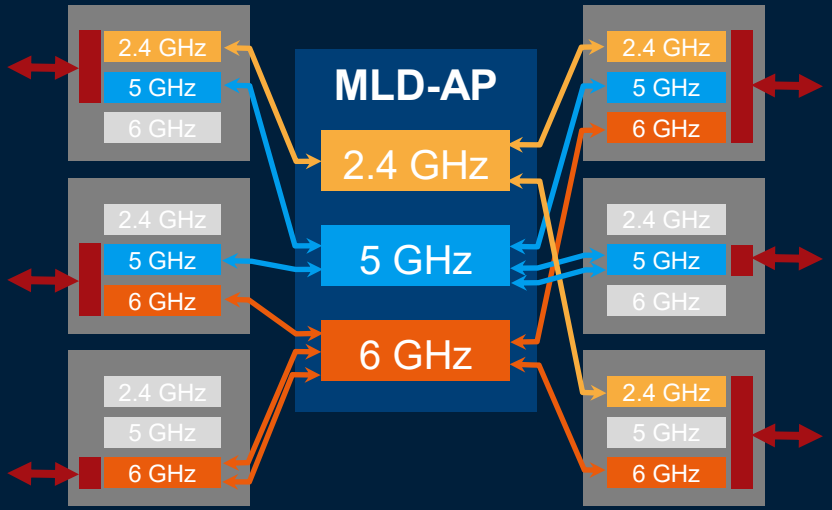


MULTI-BAND OPERATION OF ACCESS POINTS IS WELL ESTABLISHED



WI-FI 7 ALLOWS MULTI-LINK OPERATION



UTILIZING MULTIPLE CHANNELS AT THE SAME TIME
⇨THE IDEA OF MULTI-LINK OPERATION (MLO)

Link aggregation
Achieve higher throughput

Link selection
Ensure low latency

Link redundancy
Improve wireless resilience

MULTI-LINK OPERATION MODES IN A NUTSHELL

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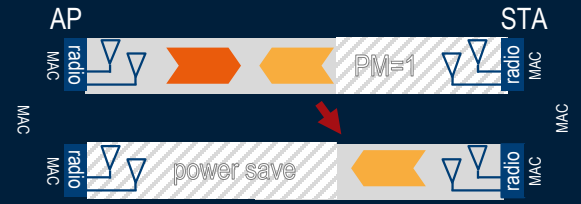
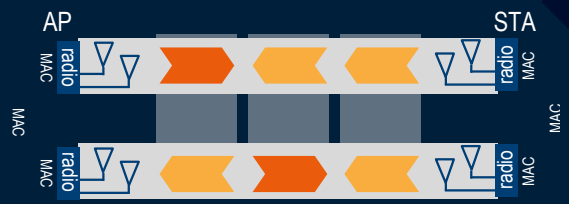
Multi-link single-radio (MLSR)
One active link at a time only



Single link operation, other(s) power save (PM=1)

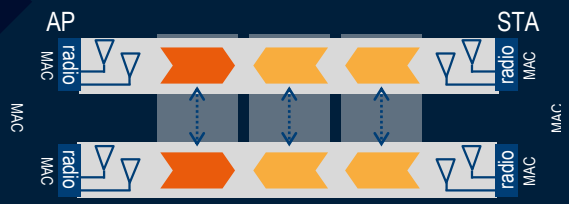
Multi-link multi-radio (MLMR)

Simultaneous Tx & Rx (STR)



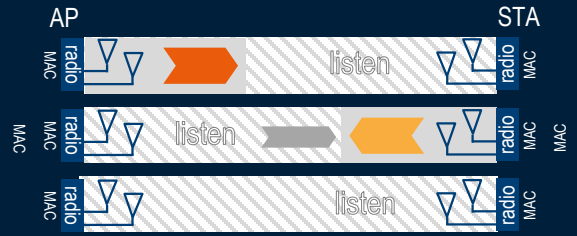
Simultaneous Tx/TX, Rx/Rx and **Tx/Rx**

Non-simultaneous Tx & Rx (NSTR)



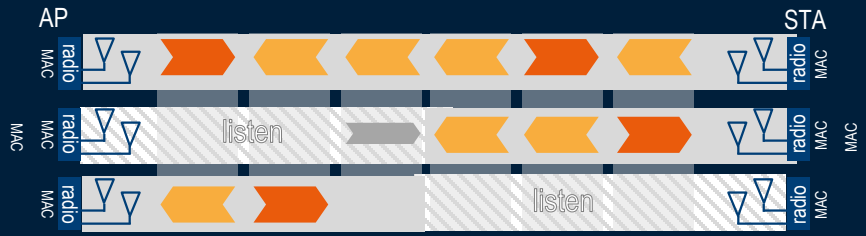
In-synch use of link pair Tx/Tx or Rx/Rx

Enhanced MLSR (EMLSR)



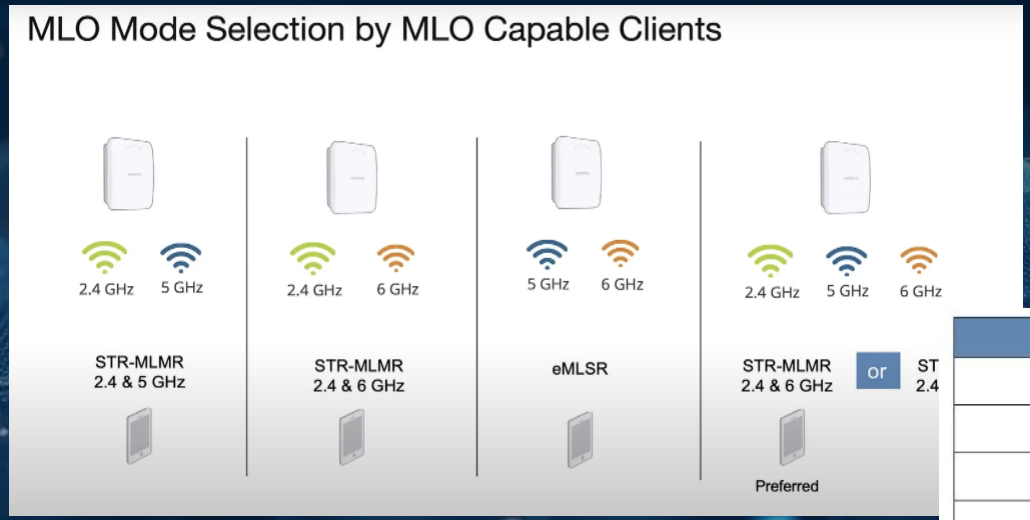
STA is able to listen on links and switch between

Enhanced MLMR (EMLMR)



Dynamically configure the EMLMR links (# spatial streams, MSC) from listen to “full power”

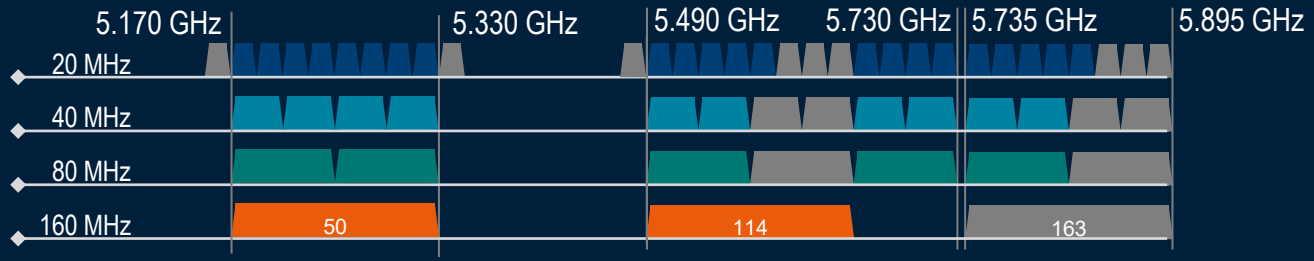
MLO Mode Depends on Device Capability and Bands



Devices	SSID w/ 2.4 + 5 + 6 GHz Enabled	SSID w/ 5 & 6 GHz Enabled
Google Pixel 8	2.4 + 5 GHz STR-MLMR 2.4 + 6 GHz STR-MLMR	5 + 6 GHz eMLSR
Samsung S24	2.4 + 5 GHz STR-MLMR 2.4 + 6 GHz STR-MLMR	SLO
One Plus 11	2.4 + 5 GHz STR-MLMR 2.4 + 6 GHz STR-MLMR	STR-MLMR (Data flow only in 6 GHz)
Intel BE200	2.4 + 5 GHz eMLSR 2.4 + 6 GHz eMLSR 5.0 + 6 GHz eMLSR	5 + 6 GHz eMLSR
Qualcomm FastConnect 7800 HBS Multi-Link Capable Adapter	2.4 + 5 GHz STR-MLMR 2.4 + 6 GHz STR-MLMR 5.0 + 6 GHz STR-MLMR	5 + 6 GHz STR-MLMR

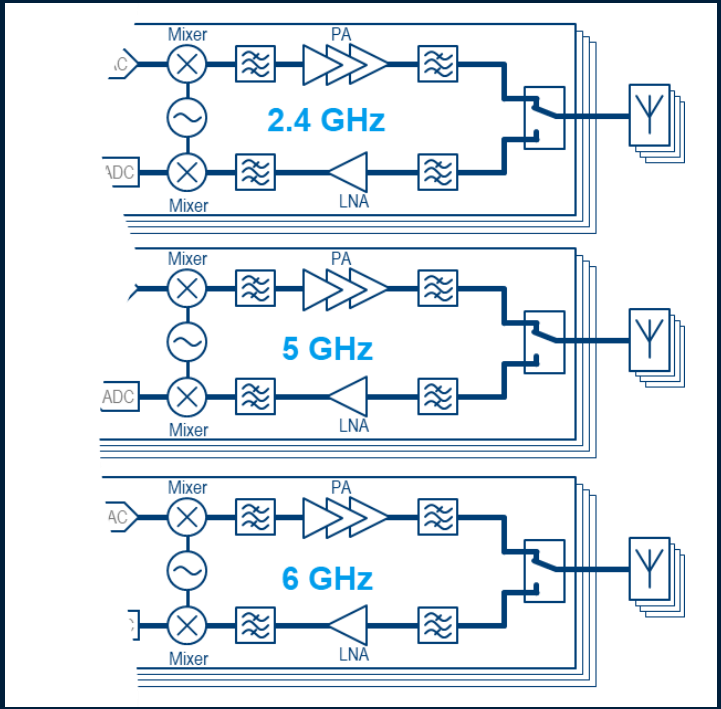
Two Link MLO: Link Combination Example

- What makes 5 GHz + 5 GHz MLO combination attractive?
  - Max. channel bandwidth in 5 GHz band is 160 MHz
  - Only two/three 160 MHz channels available



  - Combination of channel 50 with channel 114 or 163 provides 320 MHz in 5 GHz band
  - Challenge:
    - In device interference and RF filtering
    - Even more critical than for 5 GHz + 6 GHz and 6 GHz + 6 GHz band combinations

Multi-link Operation: RF Test Implications



RF challenges, if multiple radio links are active at the same time

- Self interference
- Jamming of second receiver, especially in STR mode
- Filtering
- Harmonics
- Power balance
- …

Multi-link Operation Test Needs Beyond RF

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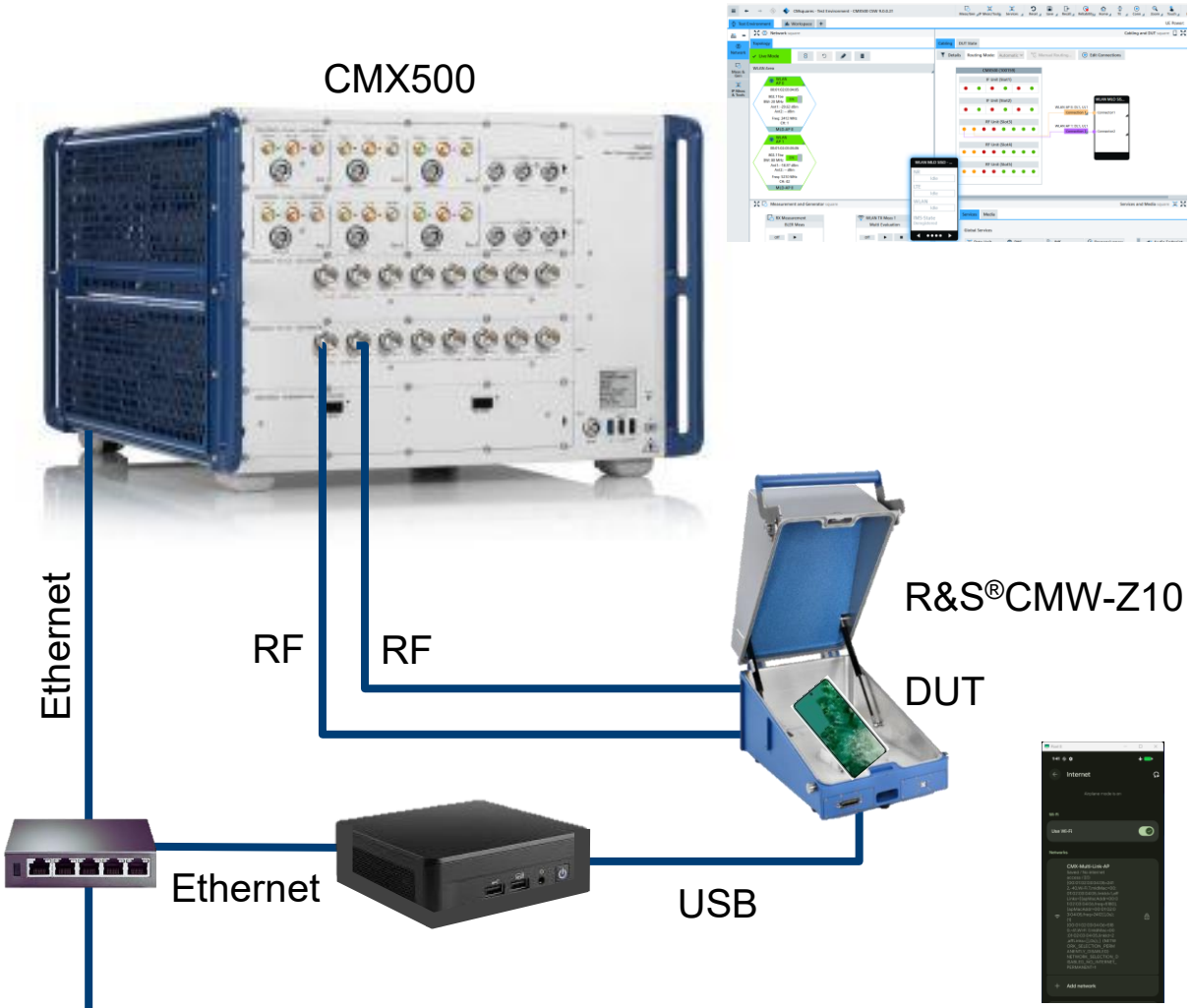
Typical MLO test items (besides RF) include

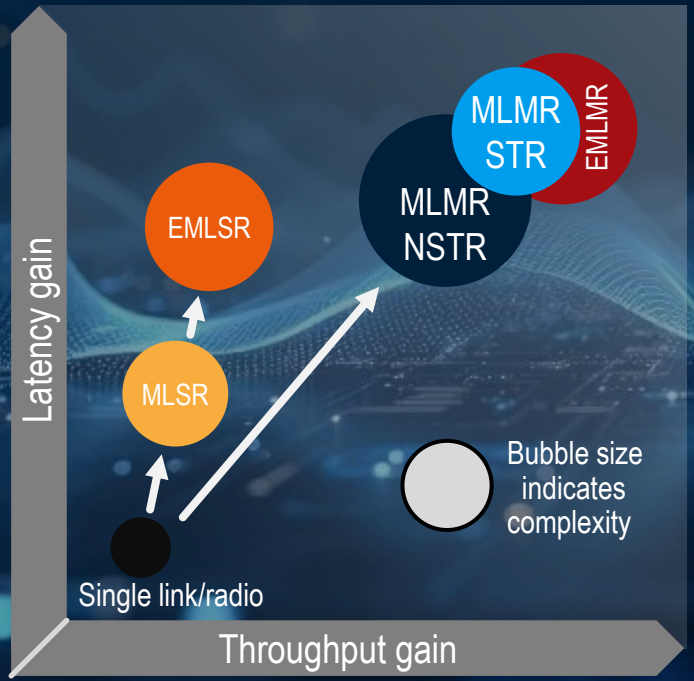
- Functional test
- Throughput
- Latency
- Battery life
- Heat dissipation
- SAR
- …

STR DEMO

- Demo setup



MLO SUMMARY



MLO

MLMR STR
- Simultaneous Rx/Tx
- ≥ 2 radios

IEEE 802.11be	Wi-Fi 7 certified
AP:M | STA:O	AP:M | STA:CM

MLMR NSTR
- Non-simultaneous Rx/Tx
- ≥ 2 radios

IEEE 802.11be	Wi-Fi 7 certified
AP:M | STA:O	AP: - | STA: -

MLSR
- Single active link
- Link switch via PM
- Single radio

IEEE 802.11be	Wi-Fi 7 certified
AP:M | STA:M	AP:M | STA:M

EMLMR
With dynamic reconf. of spatial multiplexing
≥ 2 radios

IEEE 802.11be	Wi-Fi 7 certified
AP:O | STA:O	AP:- | STA:-

EMLSR
- Single active link
- All listen on low radio
- Single radio (splittable)

IEEE 802.11be	Wi-Fi 7 certified
AP:O | STA:O	AP:M | STA:CM

M: Mandatory
O: Optional
CM: Conditional Mandatory
If a STA supports both 2 spatial streams and 160 MHz on at least one of the supported links, then at least one of EMLSR or STR shall be supported


TEST • MEASURE • INNOVATE
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THANK YOU
VERY MUCH
ROHDE&SCHWARZ
Make ideas real