Anritsu Advancing beyond

Latest Trends in IEEE 802.11ax/11be (Wi-Fi 6E/WLAN Standards)

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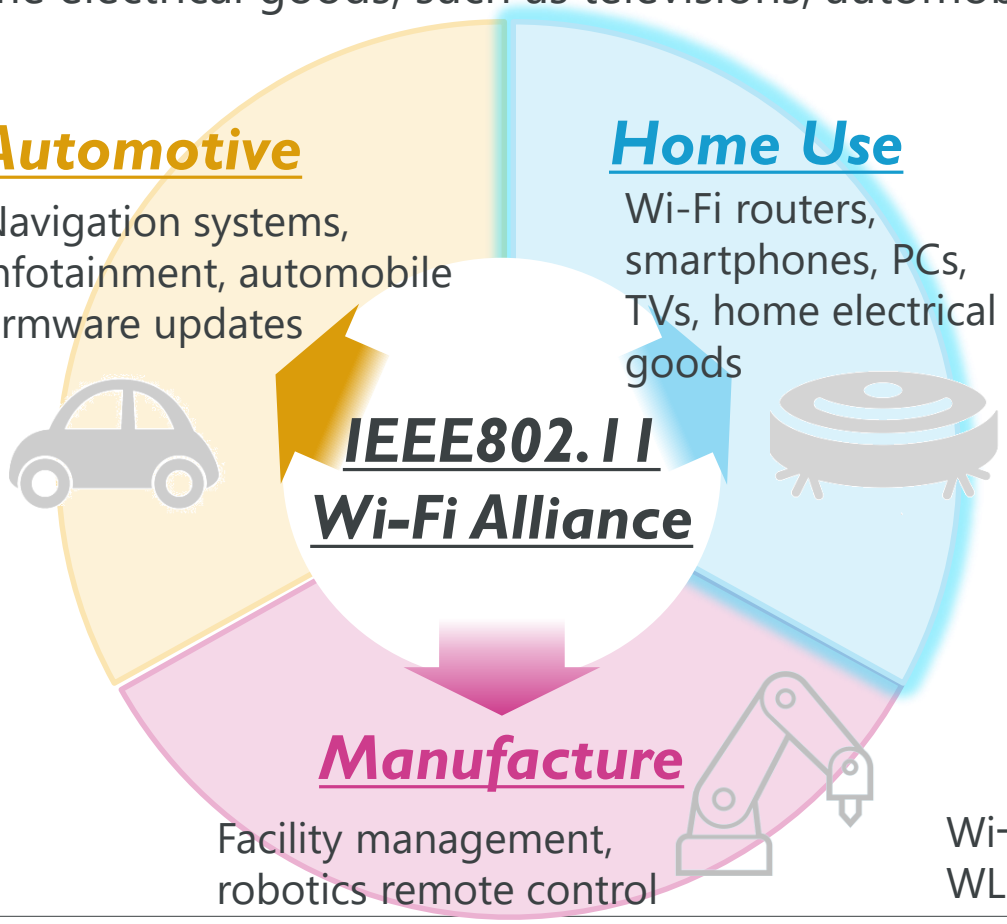
June 15, 2021

Introduction

Wi-Fi is now a commonly used connection method for indoor wireless communications, starting first with smartphones and PCs. Moreover, with the spread of IoT, wireless LAN (WLAN) technology, supporting configuration of high-speed, large-capacity, low-cost communications environments is being used increasingly by home electrical goods, such as televisions, automobiles, and industrial machinery.

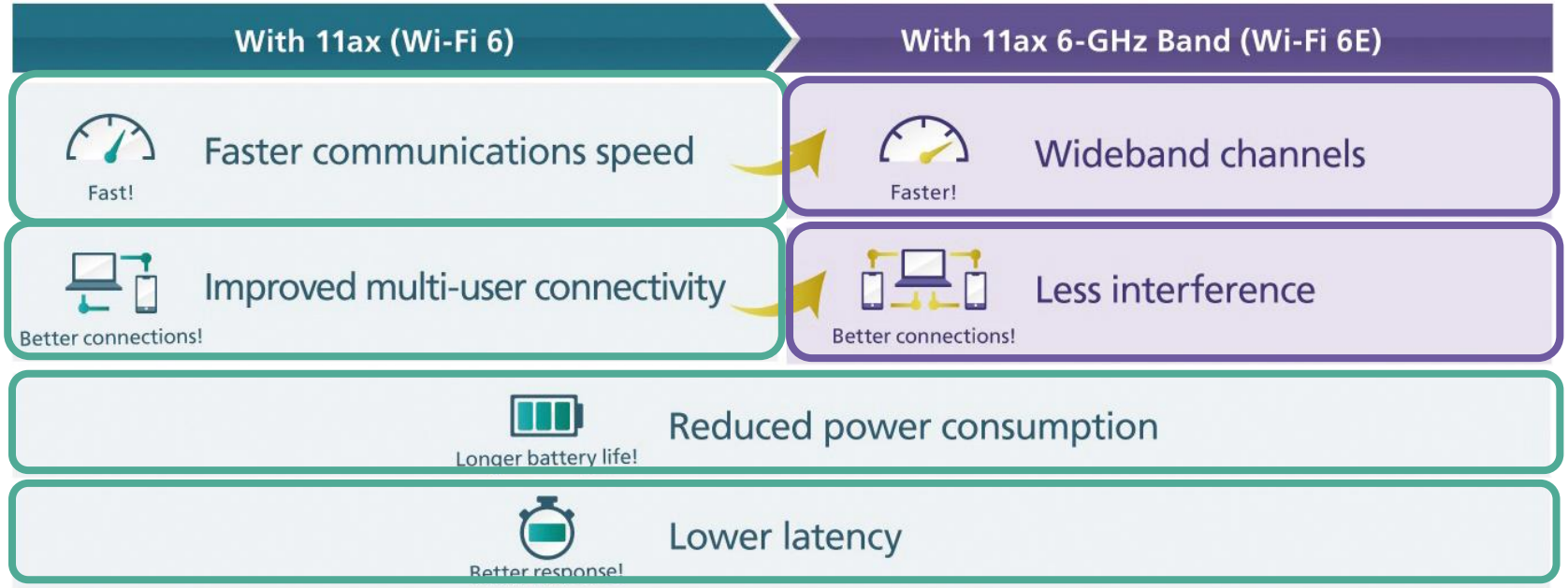


Wi-Fi: Connection assured by Wi-Fi Alliance
WLAN: General wireless LAN

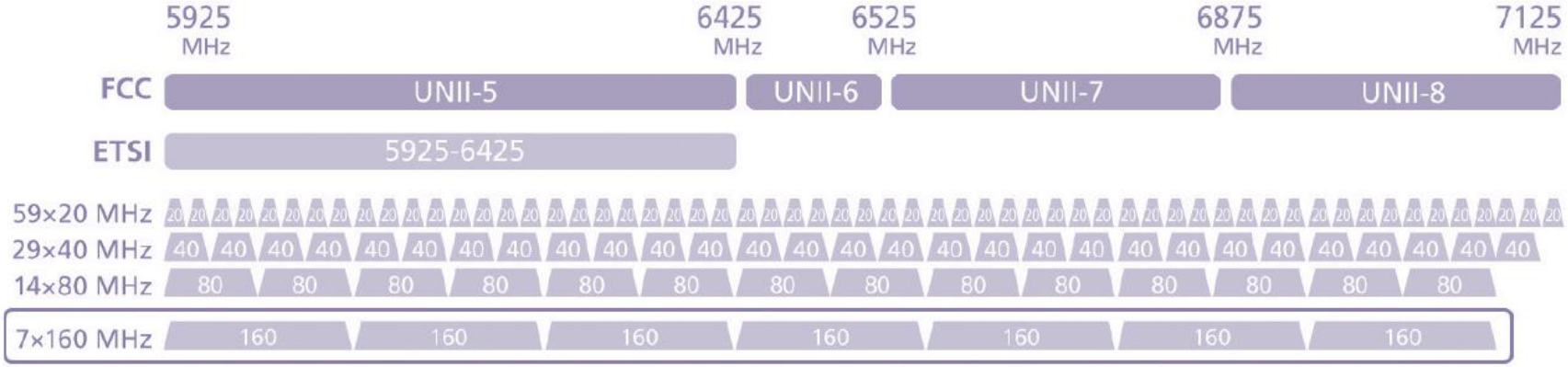
IEEE802.11 Standards

IEEE802.11		11b	11a	11g	11n	11ac (WiFi5)	11ax (WiFi6)
Transmission Vector Format		Non-HT (Non-High Throughput)	Non-HT (Non-High Throughput)	Non-HT (Non-High Throughput)	HT (High Throughput)	VHT (Very High Throughput)	HE (High Efficiency)
Definition		1999	1999	2003	2009	2014	May 2021
Freq.	2.4GHz	✓		✓	✓		✓
	5GHz		✓		✓	✓	✓
	6GHz						✓
Bandwidth [MHz]		22	20	20	20/40	20/40/80/160/80+80	20/40/80/160/80+80
Maximum throughput rate [bps]		11M	54M	54M	540M	6930M	9607.8 M
Modulation scheme		DBPSK DQPSK	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM 256QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM
Stream		-	-	-	4x4	8x8	8x8 OFDMA

IEEE802.11ax Changes

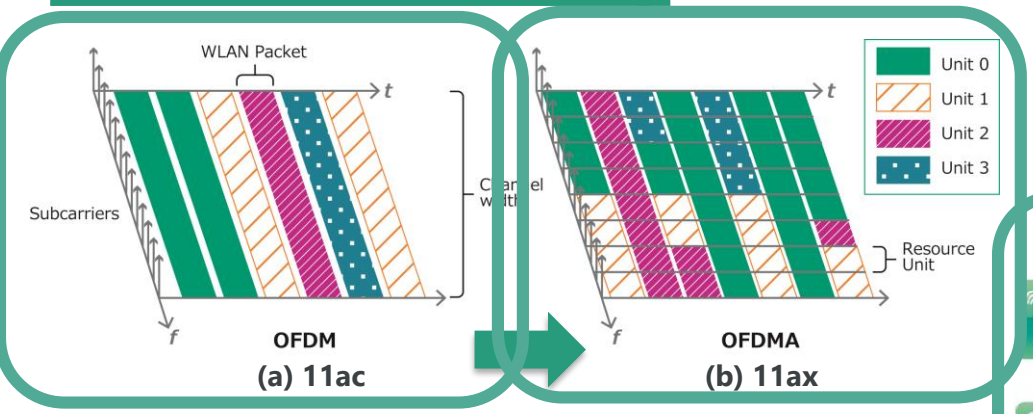


6-GHz Band Channels



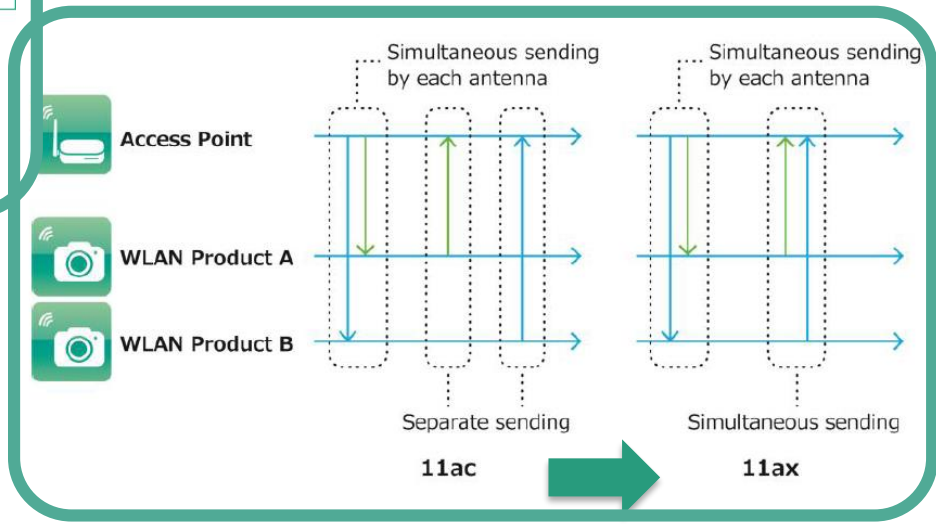
IEEE802.11ax Feature Functions

Multi User Efficiency



OFDMA

Efficient use of frequency resources



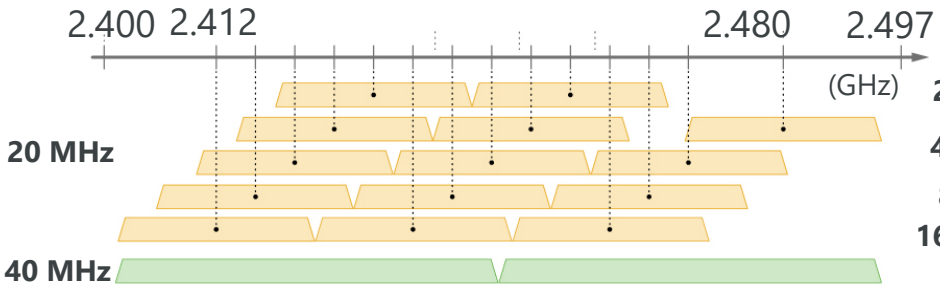
MIMO DL/UL

Efficient transmission technology

Improved Multi User Communications Environment

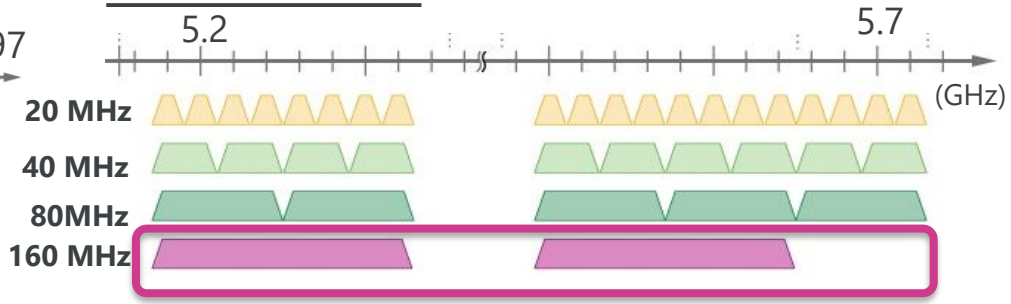
Channels in Each Frequency Band

■2.4-GHz Band



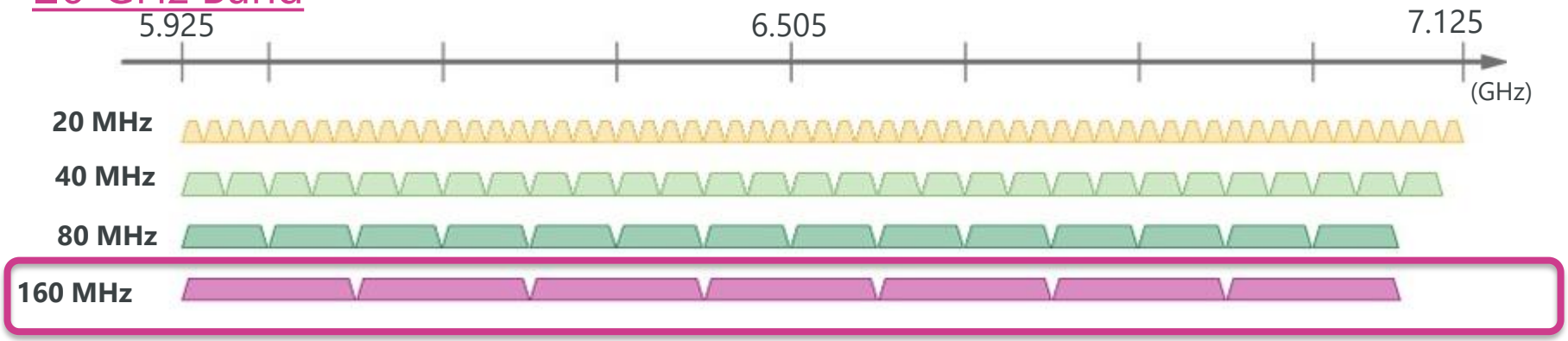
40-MHz max bandwidth channels with channel overlap causing easy susceptibility to interference. Congestion due to use of other frequencies.

■5-GHz Band



Only two 160-MHz bandwidth channels that cannot be used efficiently. Channel availability problems due to use of same band by satellites.

■6-GHz Band



Seven max. 160-MHz bandwidth channels ⇨ Faster speeds using wideband channels

National Rollouts of 6-GHz Band

Each country opens 6GHz-band spectrum to the unlicensed use of Wireless LAN.

2020

April 2020
5,925-7,125MHz
US Adopts

June 2020
5,925-6,425MHz
UK Adopts

October 2020
5,925-7,125MHz
Korea Adopts

October 2020
5,925-7,125MHz
Chile Adopts

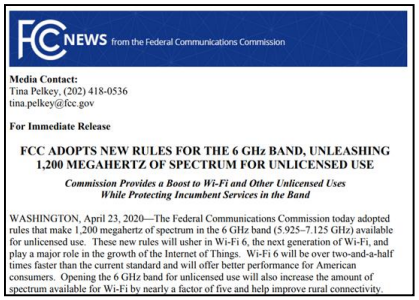
2021

Feb 2021
5,925-7,125MHz
Canada Adopts

March 2021
5,925-7,125MHz
Brazil Adopts

March 2021
5,925MHz–7,125MHz
UAE Adopt

2021 H2
5,925MHz–6,425MHz
ETSI/EU Adopt (Plan)


FCC NEWS from the Federal Communications Commission

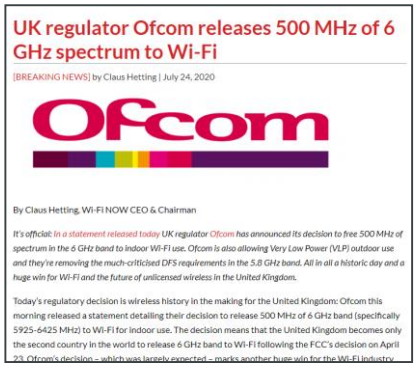
Media Contact:
Tina Pelkey, (202) 418-0536
tina.pelkey@fcc.gov

For Immediate Release

FCC ADOPTS NEW RULES FOR THE 6 GHz BAND, UNLEASHING 1,200 MEGAHERTZ OF SPECTRUM FOR UNLICENSED USE

Commission Provides a Boost to Wi-Fi and Other Unlicensed Uses While Protecting Incumbent Services in the Band

WASHINGTON, April 23, 2020—The Federal Communications Commission today adopted rules that make 1,200 megahertz of spectrum in the 6 GHz band (5.925–7.125 GHz) available for unlicensed use. These new rules will usher in Wi-Fi 6, the next generation of Wi-Fi, and play a major role in the growth of the Internet of Things. Wi-Fi 6 will be over two-and-a-half times faster than the current standard and will offer better performance for American consumers. Opening the 6 GHz band for unlicensed use will also increase the amount of spectrum available for Wi-Fi by nearly a factor of five and help improve rural connectivity.


UK regulator Ofcom releases 500 MHz of 6 GHz spectrum to Wi-Fi

[BREAKING NEWS] by Claus Hetting | July 24, 2020

Ofcom

By Claus Hetting, Wi-Fi NOW CEO & Chairman

It's official: In a statement released today UK regulator Ofcom has announced its decision to free 500 MHz of spectrum in the 6 GHz band to indoor Wi-Fi use. Ofcom is also allowing Very Low Power (VLP) outdoor use and they're removing the much-criticised DFS requirements in the 5.8 GHz band. All in all a historic day and a huge win for Wi-Fi and the future of unlicensed wireless in the United Kingdom.

Today's regulatory decision is wireless history in the making for the United Kingdom: Ofcom this morning released a statement detailing their decision to release 500 MHz of 6 GHz band (specifically 5925-6425 MHz) to Wi-Fi for indoor use. The decision means that the United Kingdom becomes only the second country in the world to release 6 GHz band to Wi-Fi following the FCC's decision on April 23. Ofcom's decision – which was largely expected – marks another huge win for the Wi-Fi industry.


South Korea makes 6GHz band available for Wi-Fi

The unlicensed 6GHz band will offer download speed of up to 2.1Gbps, the Ministry of Science and ICT said.

South Korea's Ministry of Science and ICT said on Thursday that it has approved 1.2GHz of spectrum in the 6GHz band – the 5,925MHz to 7125MHz range – for unlicensed use.

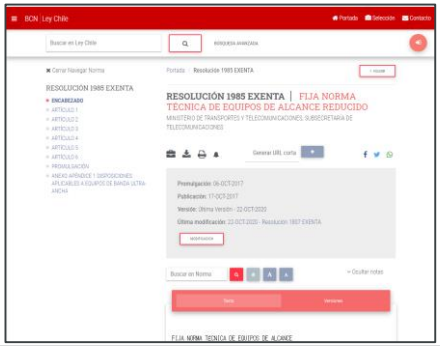
With the ministry's approval, South Korea will become the second country to make the 6GHz band available for unlicensed use after the United States gave the go-ahead in April.

The decision will make the whole 6GHz band at under 25mW available for free use at indoor settings across the country.

For device-to-device connections like tethering, spectrum sitting in the 5,925MHz-6,455MHz range will also be available for use everywhere, regardless of whether it is indoors or outdoors. According to the ministry, the decision to allow device-to-device connections in the 6GHz band is a world-first.

It will also provide more channels for Wi-Fi as well as improve data transfer speed levels to that of 5G networks, the ministry said.

In the ministry's own testing, it demonstrated that 6GHz Wi-Fi could reach speeds of 2.1Gbps.



Details of 6Ghz spectrum – Power requirements

Now there are two types of unlicensed devices to operate in 6Ghz:

Low-power Access Points (APs) and their associated client devices can occupy all 1200Mhz;

Standard-power Access Points (APs) and their associated client device, only only UNII 5 and UNI 7.

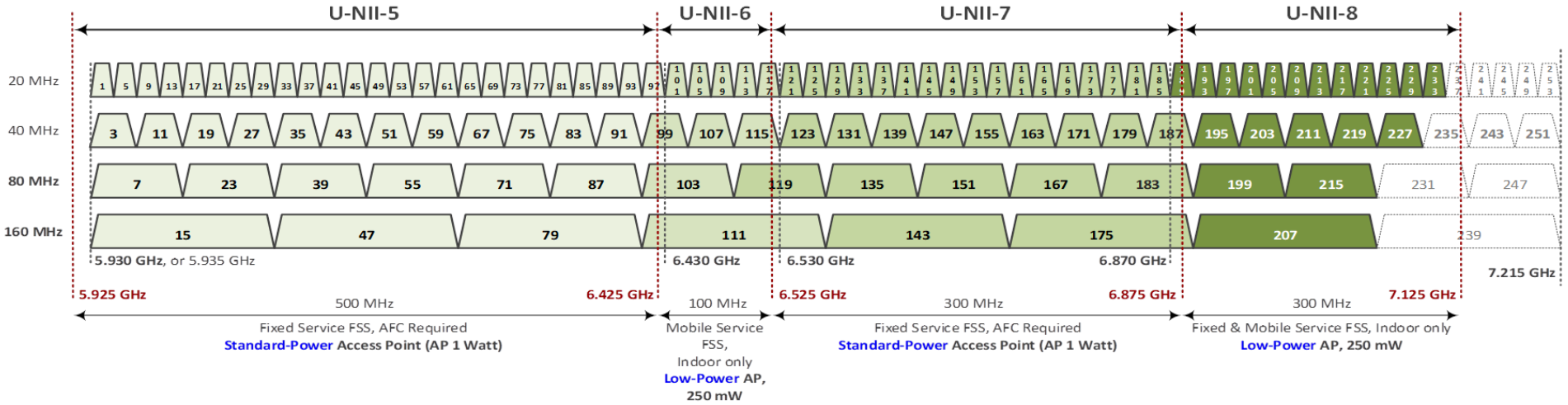


Table 3: Expanded Unlicensed Use of the 6 Gigahertz Band

Device Class	Operating Bands	Maximum EIRP	Maximum EIRP Power Spectral Density
Standard-Power Access Point (AFC Controlled)	U-NII-5 (5.925-6.425 GHz) U-NII-7 (6.525-6.875 GHz)	36 dBm	23 dBm/MHz
Client Connected to Standard-Power Access Point		30 dBm	17 dBm/MHz
Low-Power Access Point (indoor only)	U-NII-5 (5.925-6.425 GHz) U-NII-6 (6.425-6.525 GHz) U-NII-7 (6.525-6.875 GHz) U-NII-8 (6.875-7.125 GHz)	30 dBm	5 dBm/MHz
Client Connected to Low-Power Access Point		24 dBm	-1 dBm/MHz

Trends in IEEE802.11ax Standard

Main RF-related Changes in Draft 6.1

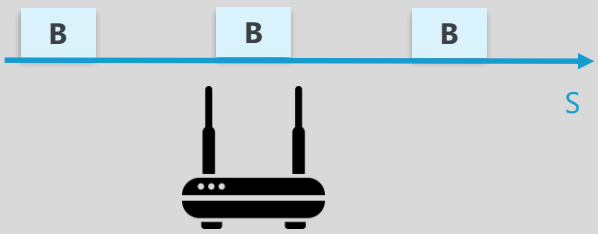
Channel Frequency Changes

Operating Class	Channel Starting Frequency	Channel Spacing
131	5.940 MHz → 5.950 MHz	20 MHz
132	5.940 MHz → 5.950 MHz	40 MHz
133	5.940 MHz → 5.950 MHz	80 MHz
134	5.940 MHz → 5.950 MHz	160 MHz
135	5.940 MHz → 5.950 MHz	80 MHz + 80 MHz
136	5.925 MHz	20 MHz

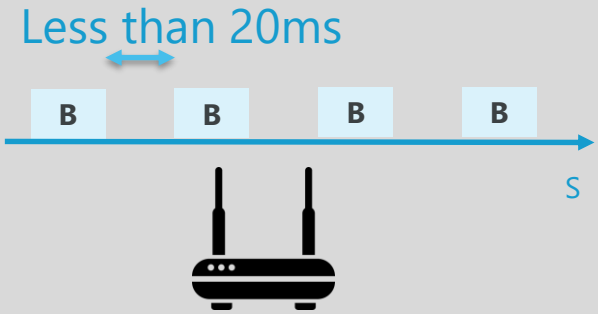
Trends in IEEE802.11ax Standard

Main RF-related Changes in Draft 7.0

For AP supporting only 6-GHz band, added function for sending notifications in about 20 ms or less



Support 3 bands



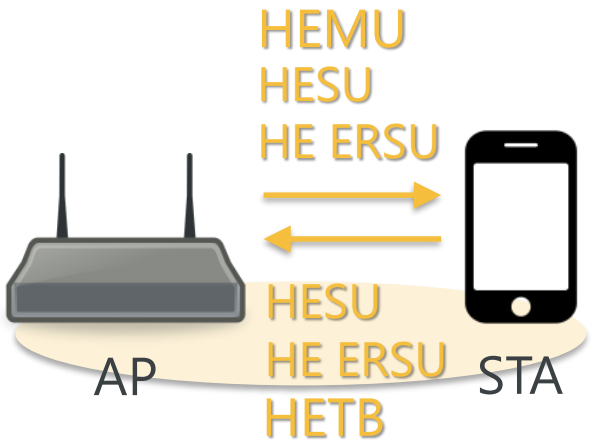
Only supports 6-GHz band

6-GHz STA can connect easily to 6-GHz band

IEEE802.11ax Evaluation Items

Evaluation Items for Each PPDU Format

IEEE802.11 evaluation items are described in each PPDU and vary according to the PPDU, so there are some undefined standard evaluation items.



Test for STA	Transmit 	Receiver 
PPDU Format		
HE SU	✓	✓
HE ERSU	✓	Non- defined
HE MU	N/A	Non-defined
HE TB	✓	N/A

Test for AP	Transmit 	Receiver 
PPDU Format		
HE SU	✓	✓
HE ERSU	✓	Non-defined
HE MU	✓	N/A
HE TB	N/A	Non-defined

PPDU: Physical layer Protocol Data Unit

IEEE802.11ax Definition RF Evaluation Items

New Evaluation Items Added by 11ax

Category	Chapter	Title	Detail	DUT	Measurement
Transmit requirements for an HE TB PPDU	27.3.15.3	Pre-correction accuracy requirements	Transmit power and RSSI measurement accuracy	STA	HETB
			carrier frequency offset error	STA	HETB
			symbol clock error	STA	HETB
			the arrival time of the HE TB PPDU at the AP	STA	HETB
Transmit specification	27.3.19.1	Transmit spectral mask		AP/STA	All PPDU Format
	27.3.19.2	Spectral flatness		AP/STA	All PPDU Format
	27.3.19.3	Transmit center frequency and symbol clock frequency tolerance		AP/STA	All PPDU Format
	27.3.19.4.2	Transmit center frequency leakage		AP/STA	All PPDU Format
	27.3.19.4.3	Transmitter constellation error		AP/STA	All PPDU Format
	27.3.19.4.4	Transmitter modulation accuracy (EVM) test		AP/STA	All PPDU Format
Receiver specification	27.3.20.2	Receiver minimum input sensitivity		AP/STA	HESU
	27.3.20.3	Adjacent channel rejection		AP/STA	HESU
	27.3.20.4	Nonadjacent channel rejection		AP/STA	HESU
	27.3.20.5	Receiver maximum input level		AP/STA	HESU

Similar Evaluation Items to Previous Standards

IEEE802.11ax Featured Evaluation Items (1/3)

27.3.15.3 Transmit power and RSSI measurement accuracy

Evaluation of DUT transmitted power accuracy and RSSI measurement accuracy

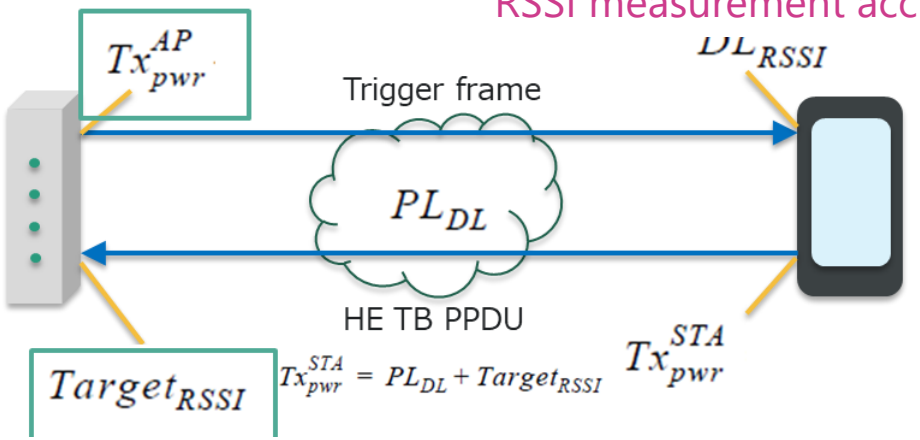
Specification: Absolute Transmit Power Accuracy — Class A: ±3 dB Class B: ±9 dB
RSSI Measurement Accuracy — Class A: ±3 dB Class B: ±5 dB
Relative Transmit Power Accuracy — Class A: N/A Class B: ±3 dB

Measurement conditions: Must satisfy above specifications in following Tx power ranges

- 2.4-GHz band : –82 to –20 dBm
- 5-/6-GHz band : –82 to –30 dBm

RSSI measured during HE PPDU pre-amble non-HE portion transmission

RSSI measurement accuracy



Tx_{pwr}^{AP}	AP Tx power
DL_{RSSI}	STA Rx power (DL power)
PL_{DL}	Path loss
Tx_{pwr}^{STA}	STA Tx power
$Target_{RSSI}$	STA Tx power assumed by AP

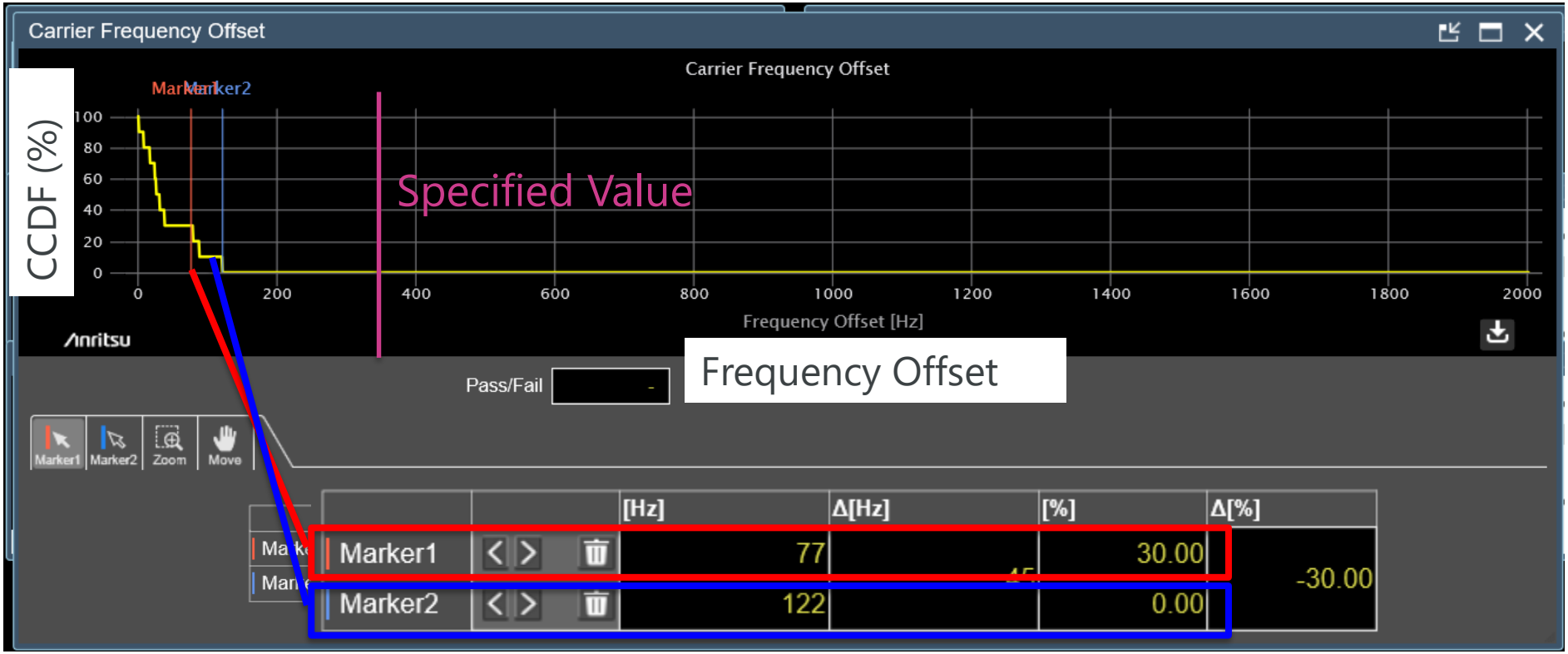
Relative transmit power accuracy = STA Tx Power Linearity (Linearity Accuracy)

IEEE802.11ax Featured Evaluation Items (2/3)

27.3.15.3 Carrier frequency offset error

Evaluates carrier frequency offset (CFO) error

Specification: CFO Error must not exceed 350 Hz where CCDF becomes 10% or less
Measurement conditions: Primary 20 MHz Ch transmission at –60 dBm



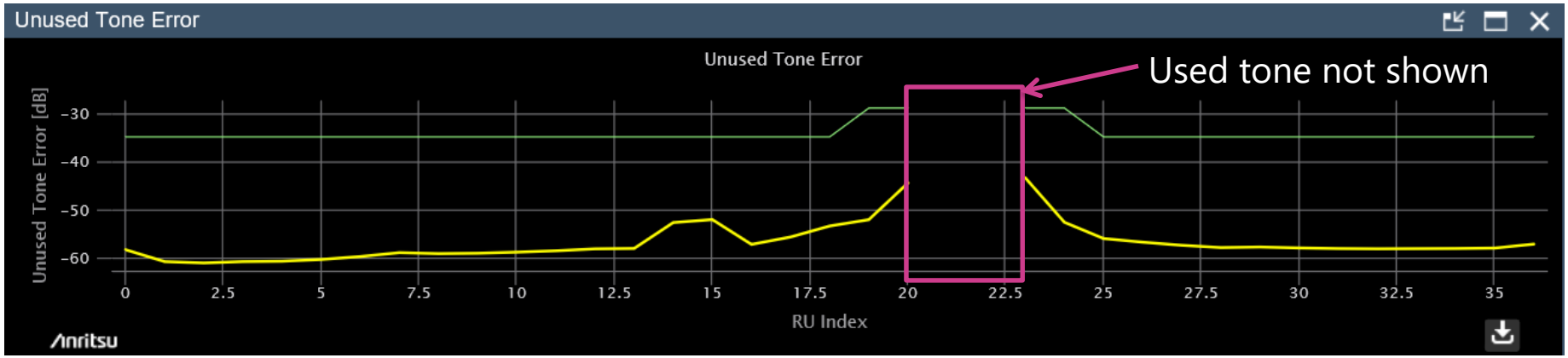
CFO: Carrier Frequency Offset CCDF: Complimentary Cumulative Distribution Function

IEEE802.11ax Featured Evaluation Items (3/3)

27.3.19.4.4 EVM Test (Unused Tone)

Measures and evaluates RU Power not used on HETB format.

Specification: Unused RU (tone) must not exceed green limit line
Measurement conditions: Measure EVM after RU specified using trigger and confirm unused tone



P802.11ax Definition :

the average unoccupied subcarrier error vector magnitude for each unoccupied 26-tone RU as calculated in step f) shall meet the staircase mask requirement in Equation (27-131).

$$UnusedToneError_{RMS}(k) = \frac{1}{N_f}\sum_{i_f=1}^{N_f}\sqrt{\frac{\sum_{i_s=1}^{N_{SYM}}\sum_{i_{sc}\in\Omega_k}(I_u(i_f,i_s,i_{sc}))^2+(Q_u(i_f,i_s,i_{RU}))^2}{N_{SYM}\cdot 26\cdot P_S}}$$

$$UnusedToneError_{RMS}(k) \le \begin{cases} max(UsedToneError_{RMS}-2,-35\ \text{dB}), \\ \quad k\in min(max(i_{RU}\pm m,0),N_{RU}-1),\ 1\le m\le r \\ max(UsedToneError_{RMS}-12,-35\ \text{dB}), \\ \quad k\in min(max(i_{RU}\pm m,0),N_{RU}-1),\ r+1\le m\le 2r \\ max(UsedToneError_{RMS}-22,-35\ \text{dB}), \\ \quad k\in min(max(i_{RU}\pm m,0),N_{RU}-1),\ 2r+1\le m\le 3r \\ -35\ \text{dB, otherwise with } k\ne i_{RU} \end{cases}$$

Trends in IEEE802.11be Standard and Contents

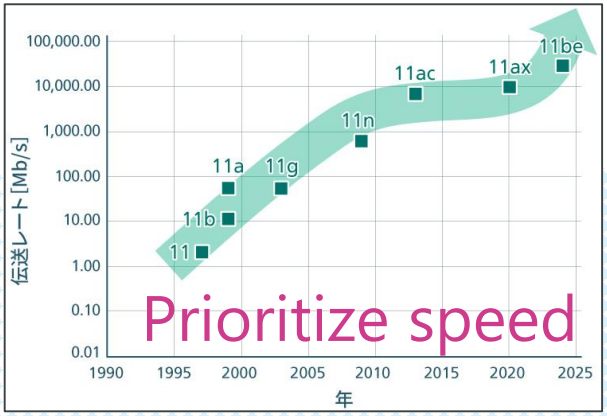
IEEE802.11 Standards

* As of June 15, 2021

IEEE802.11		11b	11a	11g	11n	11ac	11ax	11be
Transmission Vector Format		Non-HT (Non-High Throughput)	Non-HT (Non-High Throughput)	Non-HT (Non-High Throughput)	HT (High Throughput)	VHT (Very High Throughput)	HE (High Efficiency)	EHT (Extreme High Throughput)
Definition		1999	1999	2003	2009	2014	May, 2021	Planned in 2024*
Freq.	2.4GHz	✓		✓	✓		✓	✓
	5GHz		✓		✓	✓	✓	✓
	6GHz						✓	✓
Bandwidth [MHz]		22	20	20	20/40	20/40/80/ 160/80+80	20/40/80/1 60/80+80	20/40/80/16 0/320
Maximum throughput rate [bps]		11M	54M	54M	540M	6.9M	9.6G	30G～
Modulation scheme		DBPSK DQPSK	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM 256QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM 4096QAM
Stream		-	-	-	4 Stream	8 Stream	8 Steam OFDMA	16 Stream OFDMA

Prospects for IEEE802.11be

EHT Extreme High Throughput



Targets:

- True speed of ≥30 Gbps
- Improved worst-case latency and jitter
- Target bands from 1 to 7.250 GHz
- Assured backwards compatibility with 2.4-, 5-, and 6-GHz bands

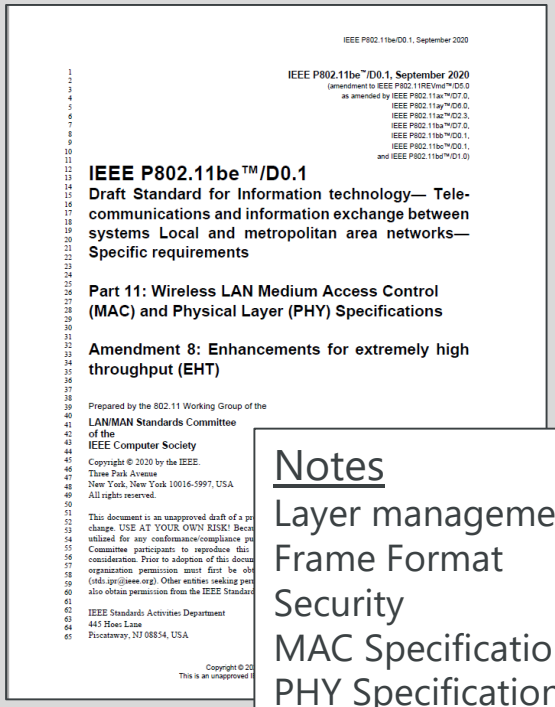
Use Cases

Industrial Wi-Fi

Home Use

Drone

Trends in IEEE802.11be Standard



IEEE P802.11be/D0.1, September 2020

IEEE P802.11be™/D0.1, September 2020
(amendment to IEEE P802.11REVmd™/D5.0
as amended by IEEE P802.11ax™/D7.0,
IEEE P802.11ay™/D6.0,
IEEE P802.11ac™/D2.3,
IEEE P802.11ba™/D7.0,
IEEE P802.11bb™/D0.1,
IEEE P802.11bc™/D0.1,
and IEEE P802.11bd™/D1.0)

IEEE P802.11be™/D0.1
Draft Standard for Information technology— Telecommunications and information exchange between systems Local and metropolitan area networks—Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

Amendment 8: Enhancements for extremely high throughput (EHT)

Prepared by the 802.11 Working Group of the
LAN/MAN Standards Committee
of the
IEEE Computer Society

IEEE Standards Activities Department
445 Hoes Lane
Piscataway, NJ 08854, USA

Release 1 (R1) Features

320 MHz, 4096QAM, Allocation of multiple RU per STA, Multi Link, Multi AP linking (simple)

Release 2 (R2) Features

16SS, HARQ, Multi AP linking (high level such as coordinated beamforming, joint transmission, etc.), Others

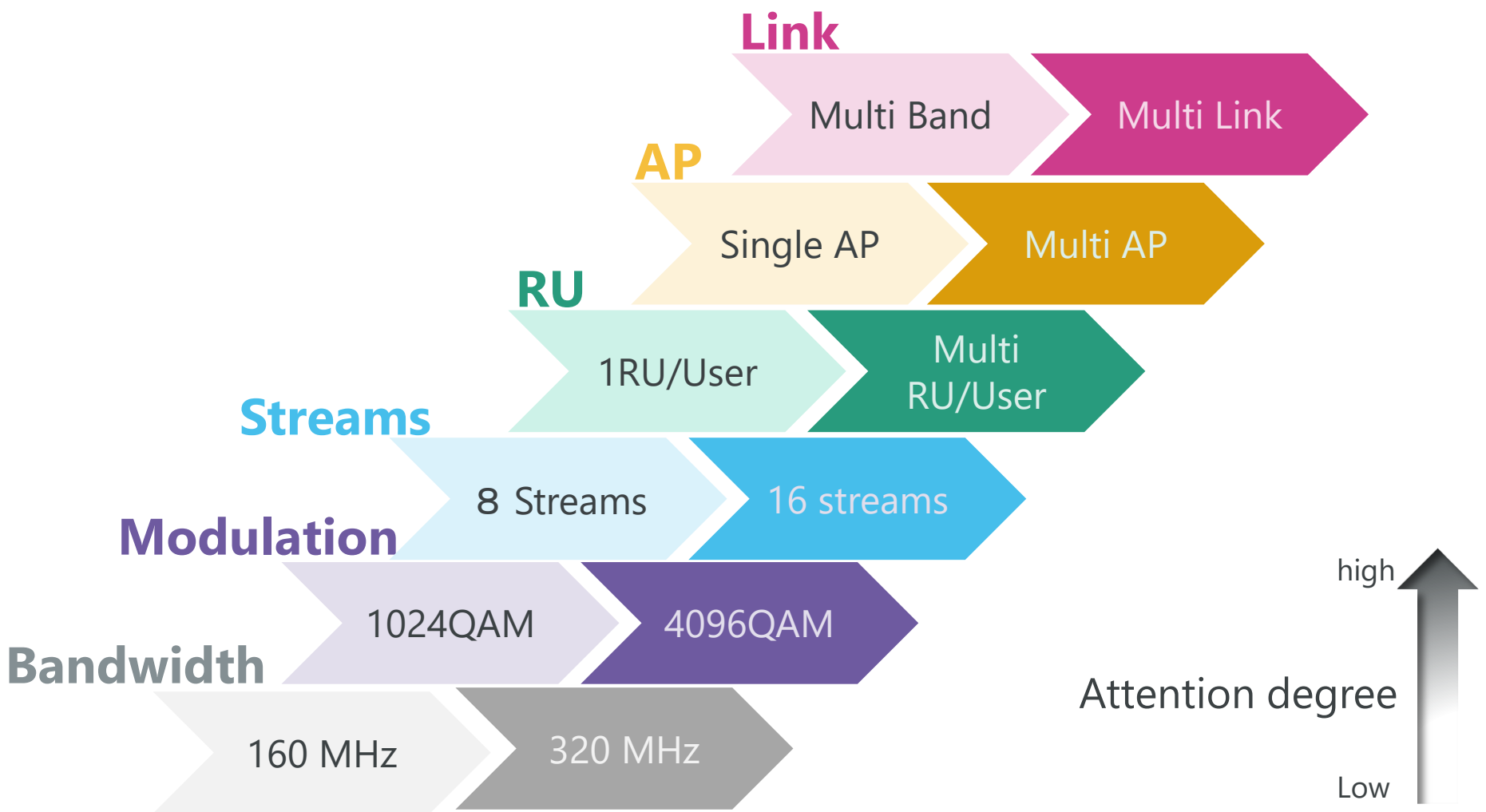
Notes

Layer management - MLME
Frame Format
Security
MAC Specification
PHY Specification

Focuses on MAC/PHY later changes because 11be action frame is Mac/PHY

New IEEE802.11be Functions

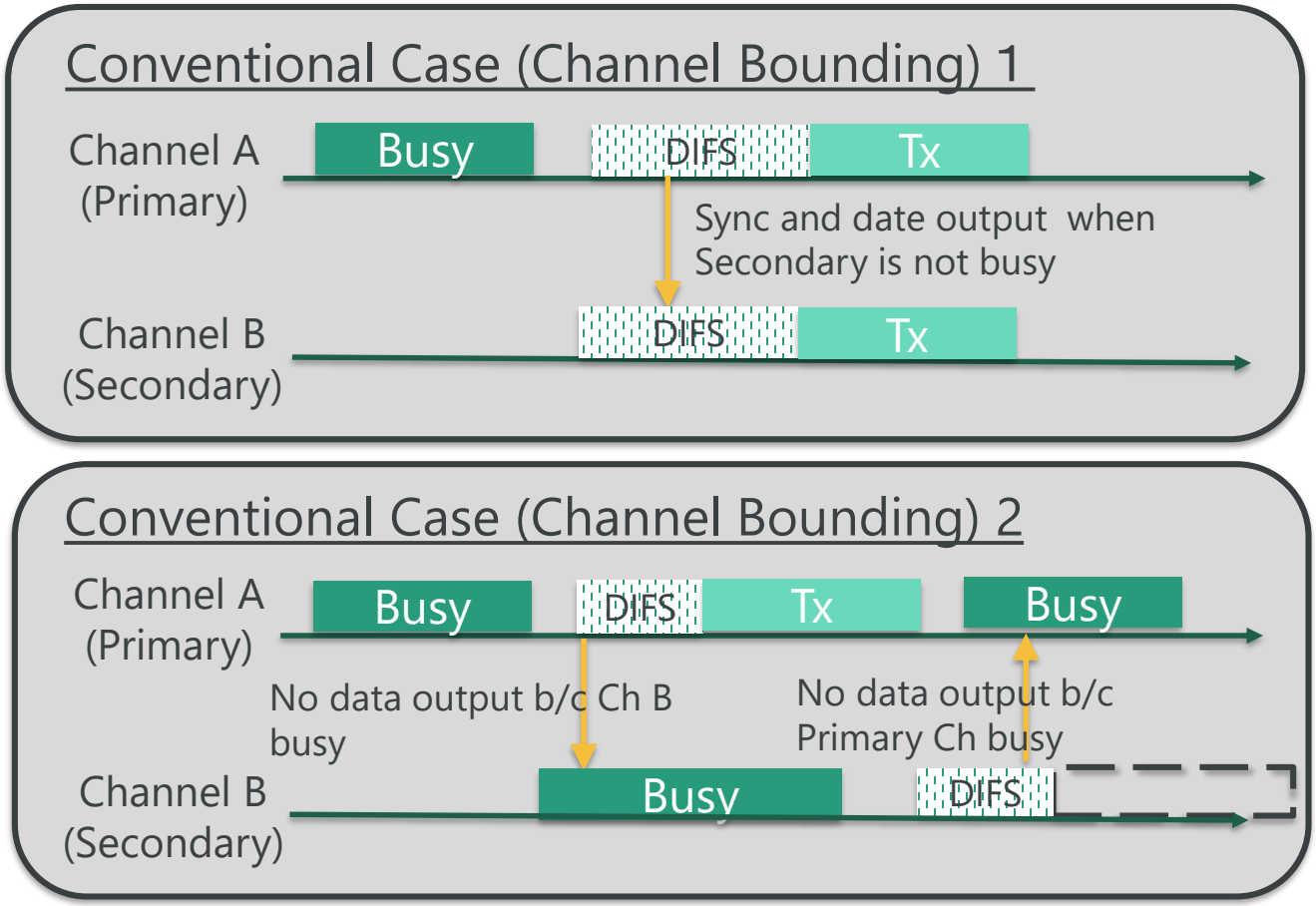
Faster speeds from expanded functions



Featured IEEE802.11be Functions (1/3)

Multi Link Transmission Technology

- **Multi Link Channel Access**
- Multi Link Transmission



Secondary cannot output data when Primary busy

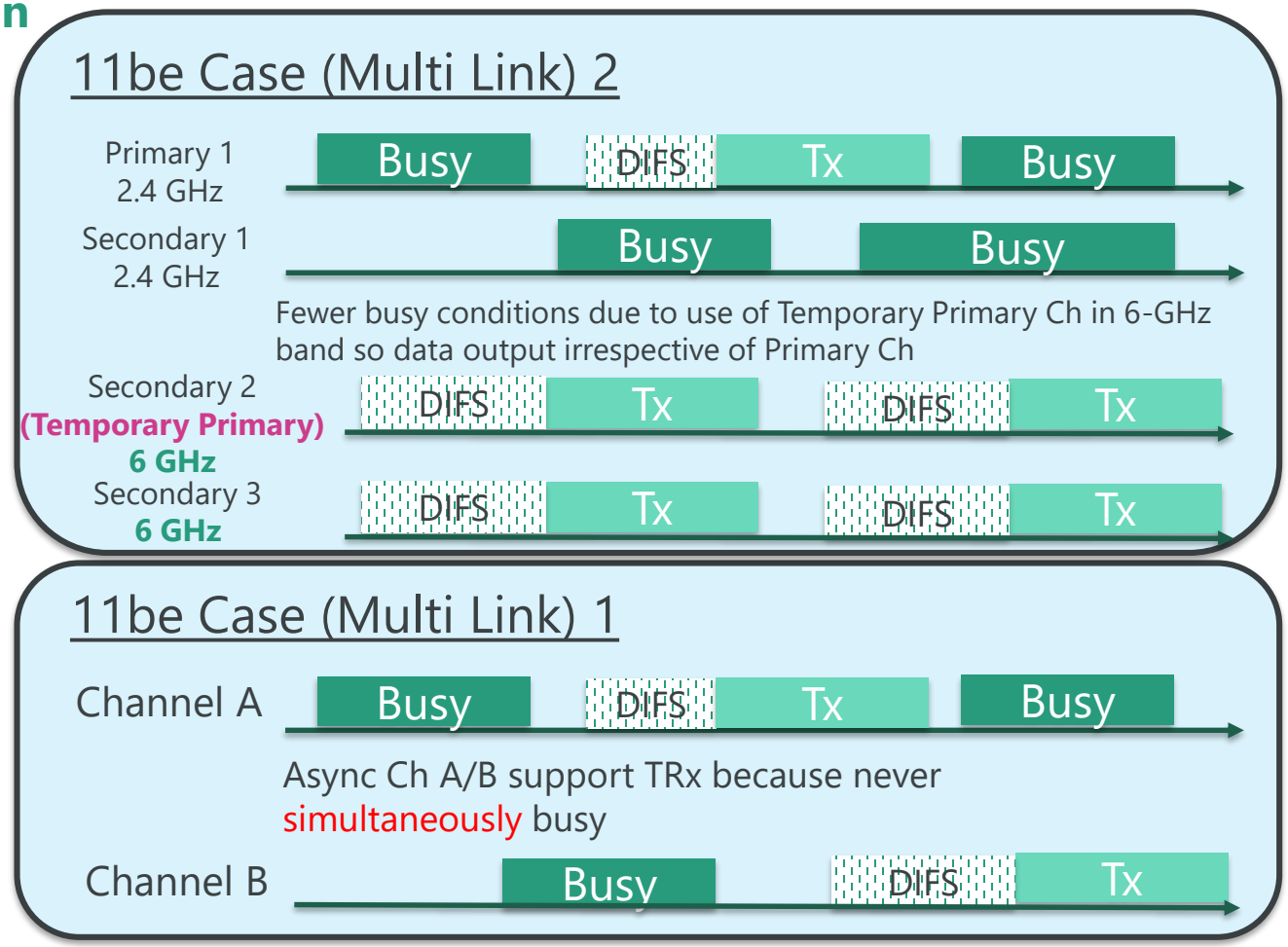
Featured IEEE802.11be Functions (2/3)

Multi Link Transmission Technology

- Multi Link Channel Access
- **Multi Link Transmission**

More efficiency from async

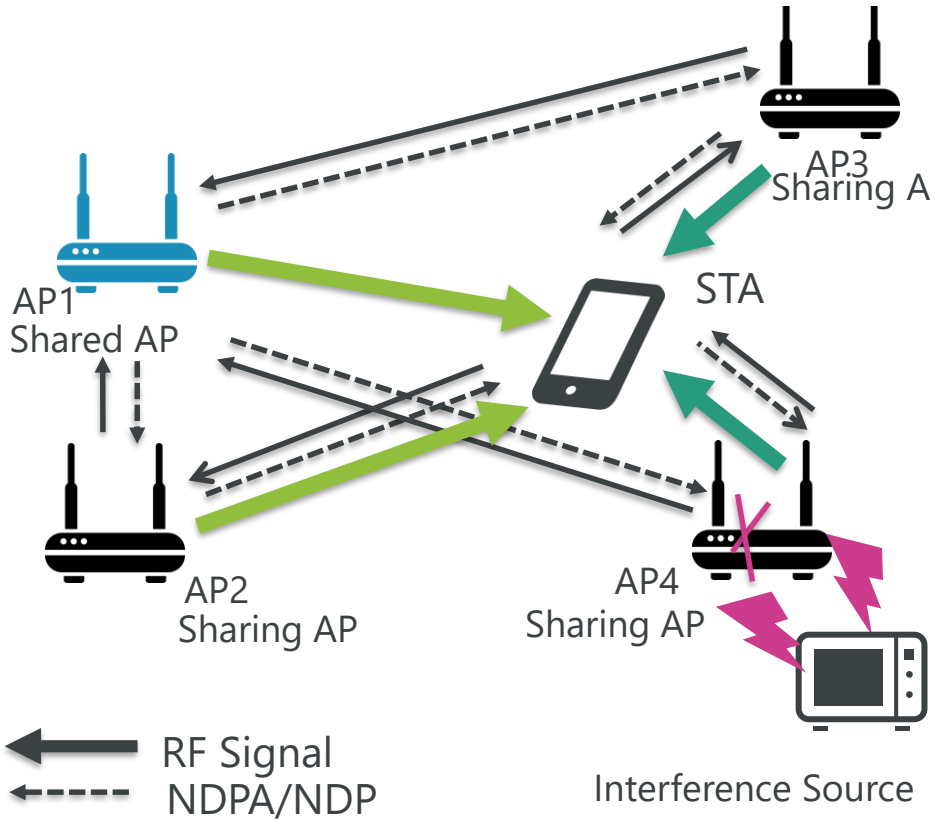
Expect higher throughput and lower latency



Featured IEEE802.11be Functions (3/3)

Multi AP (MAP) using Multiple AP Linking

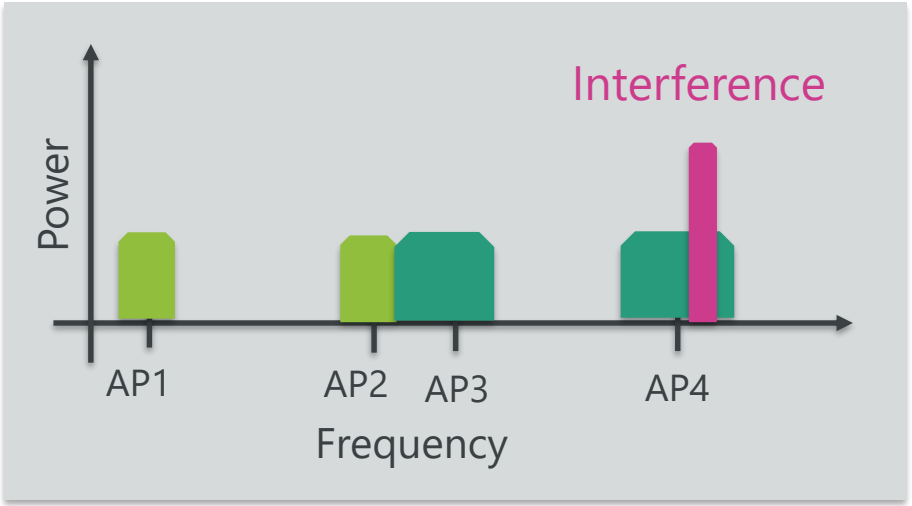
- Multi AP Channel Sounding
- **Multi AP Transmission Procedures**



NDPA: Null Data Packet Announcement

Data transmission using multiple linked AP

Optimized low-latency wireless environment



Anritsu
WLAN Measuring Instruments

MT8862A Product Summary

MT8862A is the powerful tool for RF performance tests of commercial products by simple setup with Network Mode (NW Mode) and Direct Mode on 2.4G/5G/6GHz-band up to 7.125GHz.

Connection

- Standards
  - IEEE 802.11a/b/g (20MHz BW)
  - IEEE 802.11n (20/40MHz BW)
  - IEEE 802.11ac (20/40/80/**160MHz BW**)
  - IEEE 802.11ax (20/40/80/**160MHz BW**), HESU/HETB
  - IEEE 802.11n/ac 2x2 MIMO (up to 80MHz BW)
- AP or Station mode
- Network mode/Direct mode
- WEP, WPA/WPA2-Persona/**WPA3-Personal** [AP/STA]

RF

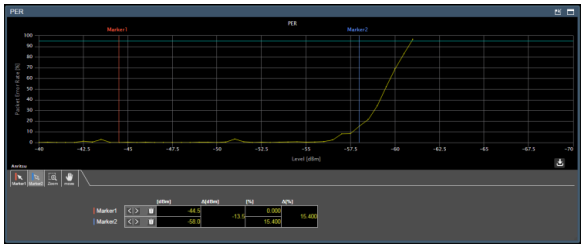
- Frequency 2.4G/5G/**6GHz-band (up to 7.125GHz)**
- Bandwidth 20MHz/40MHz/80MHz**/160MHz**
- Power Output:
  - Aux : -120 to 0dBm
  - Main 1,2 : -120 to 0dBm for 2.4/5GHz
    -120 to -5dBm for 6GHz-band
- Power Input: -65dBm to +25dBm

Tools

- Simple GUI control with web browser
- Frame capture (signaling messages logging)
- Internet connection of DUT from IP data interface

Main Window – Tx Measurement

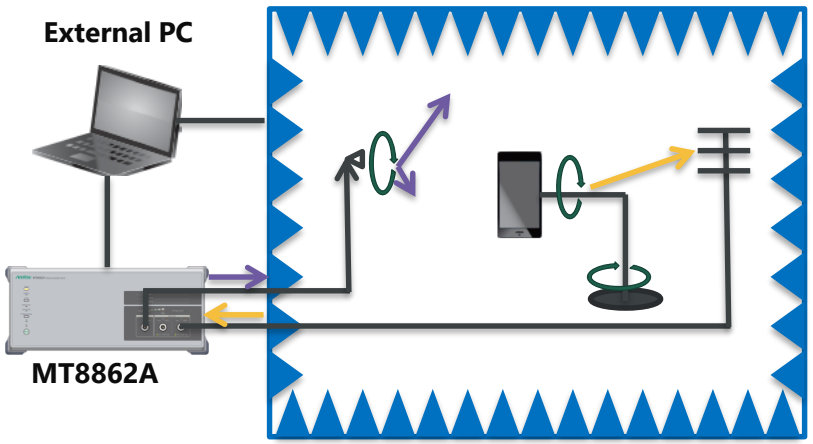
Rx Measurement



WLAN Antenna OTA Testing – TRP/TIS

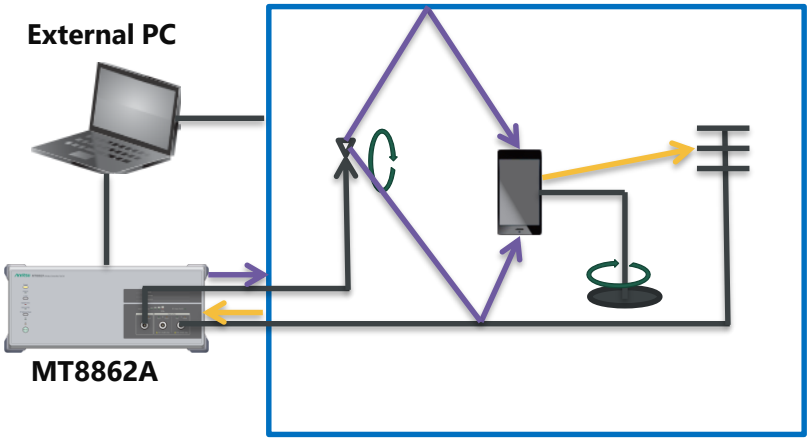
- As WLAN applications diversify, WLAN devices and their usage environment are becoming more complex, resulting in a growing need to quantify and verify that antenna characteristics by testing characteristics, such as TX power range, receiver sensitivity, etc.
- Anritsu supports an OTA measurement test environment with OTA chamber vendors for measuring the reception power range and receiver sensitivity, such as TRP/TIS, to validate RF performance in WLAN final-use environments.

Anechoic Chamber

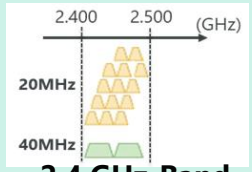


Downlink Signal Uplink Signal

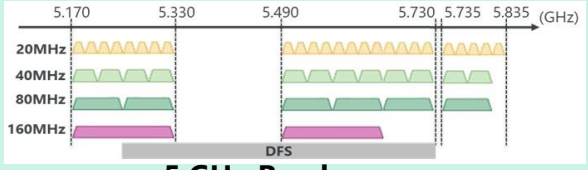
Reverberation Chamber



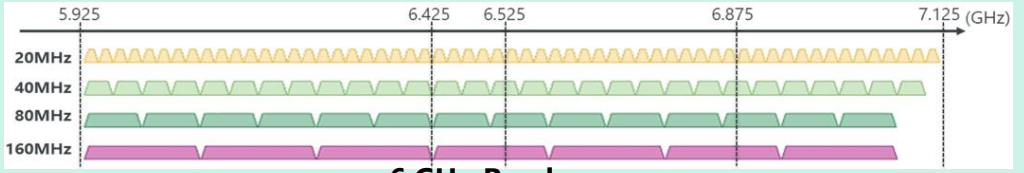
Downlink Signal Uplink Signal



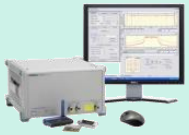
2.4 GHz-Band



5 GHz-Band



6 GHz-Band

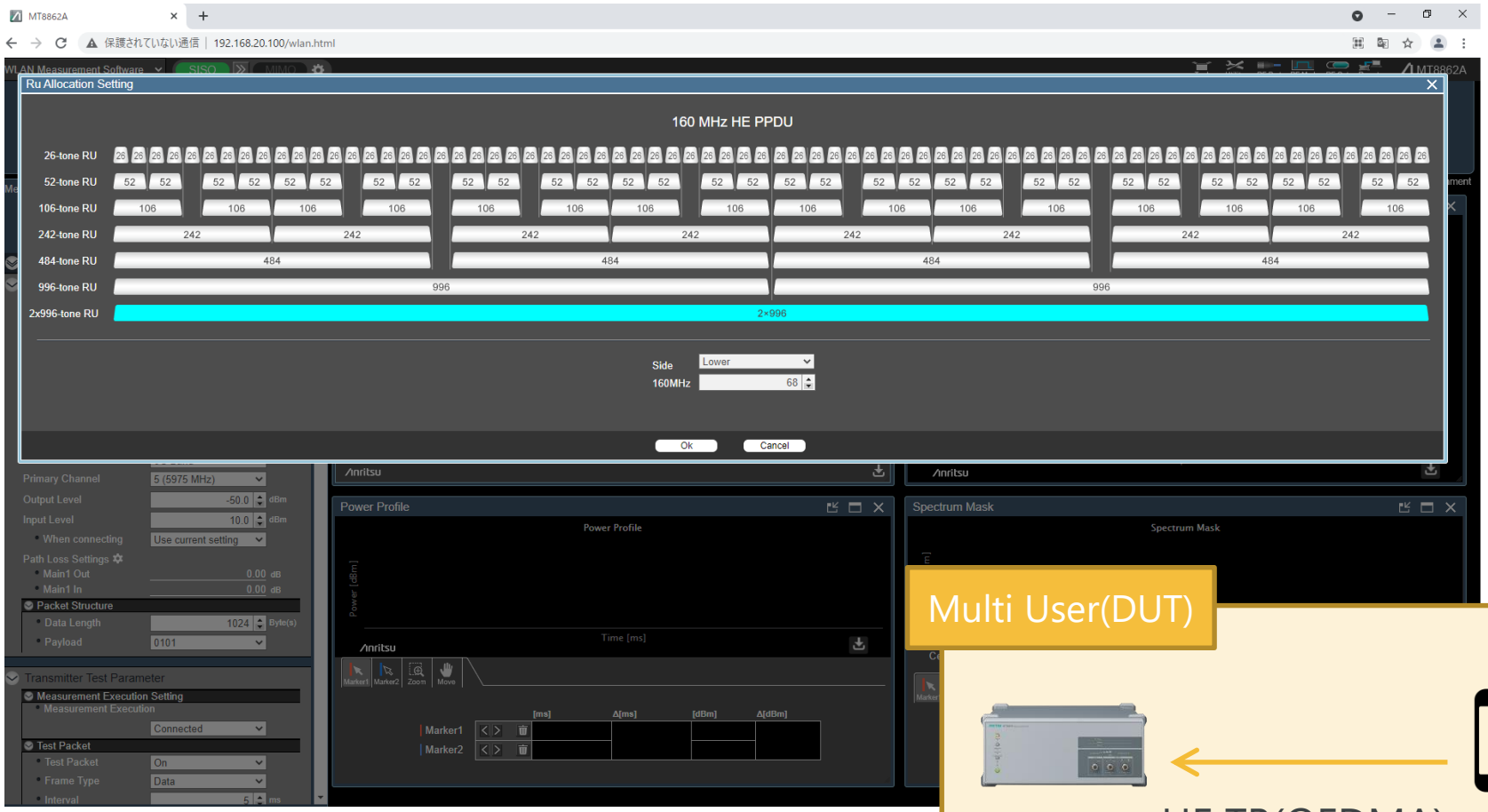


Legacy testers (MT8860C) support 2.4GHz/5GHz band.

MT8862A covers whole bands.

New Feature – HE TB RU Allocation in 160MHz BW

With OFDMA capability in 802.11ax HE TB, the MT8862A can configure the DUT to transmit specific RU allocations in the channel.



Any Questions?

Market Development Manager
brian.davis@anritsu.com

Anritsu
Advancing beyond