Development of MT8862A Options for IEEE 802.11ax 6-GHz Band

Taku Hasegawa, Takahiro Kasagi, Shinya Hori, Shoichi Sato

[Summary] As a solution to limited frequency resources, various countries are opening the 6-GHz band as the first new band for WLAN applications in 20 years with the expectation of facilitating faster, more stable, large-capacity communications. Anritsu has now released hardware and software upgrade options for its popular Wireless Connectivity Test Set MT8862A adding support for the 6-GHz band and 160-MHz channel bandwidth to test and evaluate the RF performance of customers' IEEE 802.11ax products.

1 Introduction

Wireless LAN (WLAN) connected devices are becoming more common after the initial development of notebook PCs, smartphones, Internet of Things (IoT) devices and, more recently, home appliances, automotive, industrial, and sensing equipment with built-in WLAN functions. Additionally, more equipment with faster speeds and wider bandwidths is appearing each year following release of the IEEE 802.11ac, ax, and later standards.

On the other hand, frequency resources are becoming tight with use of more WLAN equipment using wider bandwidths, causing new problems with unstable and slower connections. As a solution, various countries are opening the 6-GHz band as the first new band for WLAN applications in 20 years.

Anritsu developed its Wireless Connectivity Test Set MT8862A as a solution for testing WLAN RF TRx characteristics. It supports the Network Mode for measurement under actual WLAN operating conditions, as well as the Direct Mode used on mass-production lines for both Over The Air (OTA) and Conducted measurement applications.

To meet the sudden demand for 6-GHz band RF tests and expand the MT8862A functions, we developed the MT8862A-002 RF Frequency 6 GHz, and the MT8862A-010 Extended RF Hardware as well as the MX886200A-030 160 MHz Bandwidth software option supporting both the Network and Direct modes for 6-GHz band RF test functions. This article summarizes the MT8862A 6-GHz band support development concept and key specifications.

Figure 1 Wireless Connectivity Test Set MT8862A

2 WLAN Frequency Bands

WLAN equipment has been using the 2.4 and 5-GHz bands for many years but the recent popularity of mobiles supporting wideband communications is straining available frequency resources.

As shown in Figure 2, since the 2.4-GHz band has 14 channels at 5-MHz intervals, only up to three channels with a 20-MHz bandwidth can be used simultaneously. Additionally, only one 40-MHz bandwidth can be used at one time. This situation limits an efficient communications environment requiring coordination between overlapping 20-MHz bands.

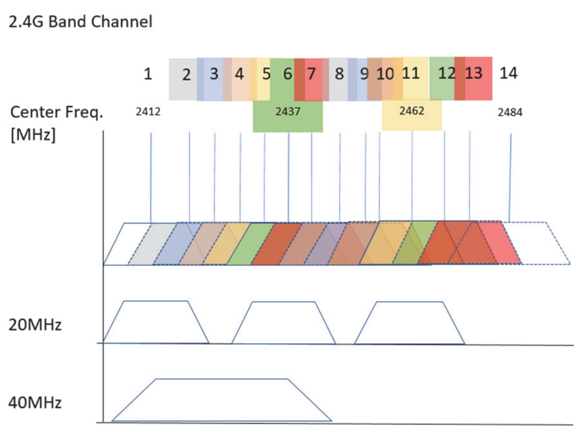

Figure 2 2.4-GHz band Channel Arrangement

For comparison, Figure 3 shows that the 5-GHz band supports seven 80-MHz channels or three 160-MHz channels, which many WLAN devices already support.

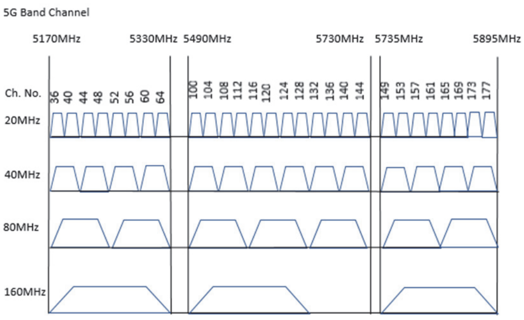

Figure 3 5-GHz band Channel Arrangement

As shown in Figure 4, the recently-added 6-GHz band supports simultaneous communications over fourteen 80-MHz channels or seven 160-MHz channels, which is about twice as many channels as the current 2.4 and 5-GHz bands.

3 Design Concept

This section describes the MT8862A design concept to support the 6-GHz band.

3.1 Expandability from Current Hardware

To facilitate upgrading of the current MT8862A to support the 6-GHz band by changing some modules, we designed the new RF and front end modules with the minimum necessary changes. Additionally, hardware differences from the current MT8862A design were ‘absorbed’ into the built-in software and FPGA circuit using a shared firmware installer. As a result, the user can update firmware using the exact same procedure as their existing MT8862A.

3.2 Upgrading Hardware Performance

The EVM performance was upgraded in anticipation of future support for 4096QAM by the IEEE 802.11be standard. The signal generator design EVM was −41 dB with a signal analysis residual EVM of −44 dB.

3.3 Support for 6-GHz band and 160-MHz bandwidth

With this upgrade, the MT8862A supports the many mobiles using the 6-GHz band and 160-MHz channel bandwidth that was difficult to support for the 5-GHz band. Since it is assumed that the opening of the 6-GHz band will lead to the release of many new mobiles using 160-MHz channels, this upgrade release also adds support for measurement of 160-MHz channels in the 5-GHz band.

4 Hardware

This section describes the MT8862A hardware changes implemented to add support for the 6-GHz band.

4.1 RF Unit

The RF unit orthogonally modulates the carrier wave with the baseband signal and is composed of a Tx section to deliver the received RF WLAN signal to the front end, and an Rx section to convert the WLAN signal received from the front end to an IF signal. Since the previous hardware only supported the 2.4 and 5-GHz bands, support for the 6-GHz band has been added.

The RF unit was designed using in-house assets for similar products to help shorten the development period and cut costs. The level diagram is optimized to match the MT8862A front-end design.

4.2 Front End Unit

The RF front end is composed of a transmitter to output the level-attenuated WLAN signal from the RF unit to a connector, and a receiver for sending the received WLAN signal to the RF unit. Like the RF unit, support for the 6-GHz band is added to the existing 2.4 and 5-GHz bands.

When the signal-generator output level is high, the Output third-order Intercept Point (OIP3) of the front-end Tx path dominates the output EVM. Therefore, the Tx path power amplifier has been upgraded with the latest high-

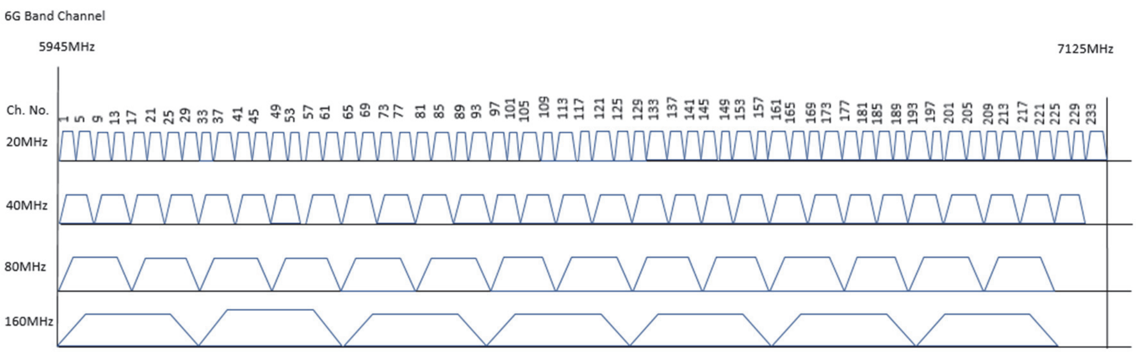

Figure 4 6-GHz band Channel Arrangement

OIP3 components manufactured using in-house assets for similar products to cut costs. As a result, the design EVM target of −41 dB is achieved.

At the signal-analysis side, when the input signal is low, the degraded Signal to Noise Ratio (SNR) caused by the Noise Figure (NF) of the front-end Rx path dominates residual EVM. Therefore, a switching Low-Noise Amplifier (LNA) has been added to the Rx path. This LNA uses parts from similar company products.

Additionally, we designed a digital step attenuator for the IF path to optimize the ADC input level at each frequency to support the RF path 160-MHz bandwidth frequency characteristics at extension of the frequency range to the 6-GHz band to suppress narrowing of the Rx dynamic range due to an increase in the modulation waveform crest factor.

These changes resulted achieving the design EVM performance of −44 dB, depending on the frequency and level, and the EVM performance of −42 dB even under the severe 6-GHz band conditions plus 160-MHz channel bandwidth.

5 Software

This section describes the MT8862A software revisions to add 6-GHz band support.

5.1 Applications

The Application section executes signal output, measurement, and analysis according to GUI and remote-command operations.

These software revisions have added support for the 6-GHz band and 160-MHz bandwidth to the WLAN Tx measurement function, Rx measurement function, and WLAN signaling system control.

160-MHz spectrum-mask measurements up to ±240 MHz are also supported.

5.2 WLAN Signalling

IEEE802.11ax defines a unique 6-GHz band protocol. Maintaining compatibility with devices in the 2.4 and 5-GHz bands not supporting IEEE 802.11ax has been difficult until now and required a major review of the protocol. On the other hand, since the 6-GHz band is used only by 11ax mobiles, the lack of restrictions facilitated addition of several unique specifications. To support these changes, we added the following functions to the MT8862A to maintain the same connectivity with earlier bands.

(1) Unsolicited Broadcast Probe Response

With earlier bands, there are challenges in compressing channel usage by the Broadcast Probe Request sent by each Station (STA) to scan for Access Points (AP), and the Probe Response sent by responding AP. As a solution, transmission of Broadcast Probe Requests is limited in the 6-GHz band. Instead, it is better to limit channel usage by implementing an STA scanning method where the AP actively and periodically transmits an Unsolicited Broadcast Probe Response.

When the MT8862A is in the AP mode and the 6-GHz band is selected, the Unsolicited Broadcast Probe Response is used automatically without conscious effort by the operator, which facilitates easy detection of the MT8862A by the STA.

(2) Channel Switching

Since the 6-GHz band has a bandwidth of several times that of the 5-GHz band, the STA requires more time to scan all channels. Consequently, the 6-GHz band defines 20 MHz as the Preferred Scanning Channel (PSC) and recommends cutting the scanning time by using the PSC only. In this case, the STA connects to the 20-MHz channel of the detected AP using PSC and uses the adjacent Non-PSC 80 and 160-MHz channels for communications.

However, an RF test instrument offering results for each frequency requires a function for measuring just the Non-PSC. Since this cannot always be achieved when connected to the PSC, the MT8862A now has a new built-in Channel Switching function in the AP mode for reconnecting a connected STA to any other Non-PSC. Using this function, an already PSC-connected STA switches to a Non-PSC by sending a Channel Switch Announcement frame.

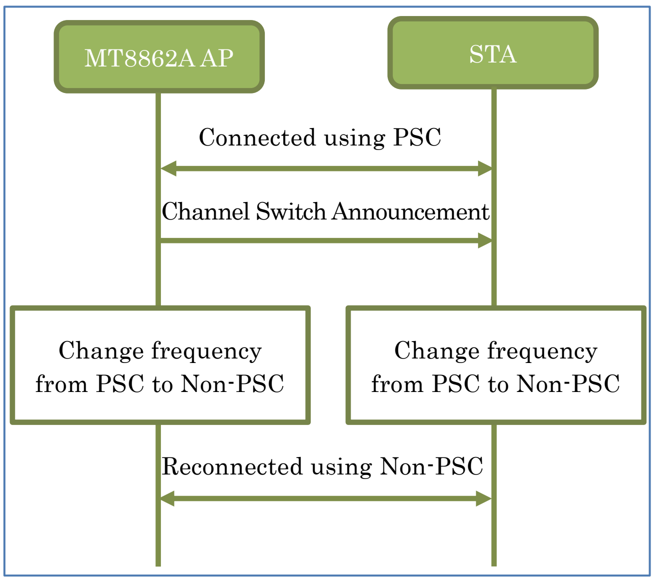

Figure 5 Non-PSC Channel Switch Sequence

(3) WPA3 Hash-to-Element

To strengthen the Wi-Fi Protected Access 3 (WPA3) security, the Wi-Fi Alliance has added Hash-to-Element as a Password Element (PWE) algorithm which upgrades the previous "hunting-and-pecking" method. Use of H2E is arbitrary for the 2.4 and 5-GHz bands but is required for the 6-GHz band. Although the MT8862A supports WPA3 H2E it also retains support for the previous "hunting-and-pecking" to test some non-H2E devices.

6 Key Specifications

Tables 1 and 2 list the key MT8862A 6-GHz band specifications.

7 Expanded Measurement Functions

To support the 6-GHz band, we have implemented the same measurement functions as for the 2.4 and 5-GHz bands. Figure 6 shows the Constellation results at EVM measurement of the 6-GHz band as an example. At a center frequency of 6455 MHz and input level of −10 dBm, the measured EVM of the IEEE 802.11ax MCS11 signal was −43.77 dB.

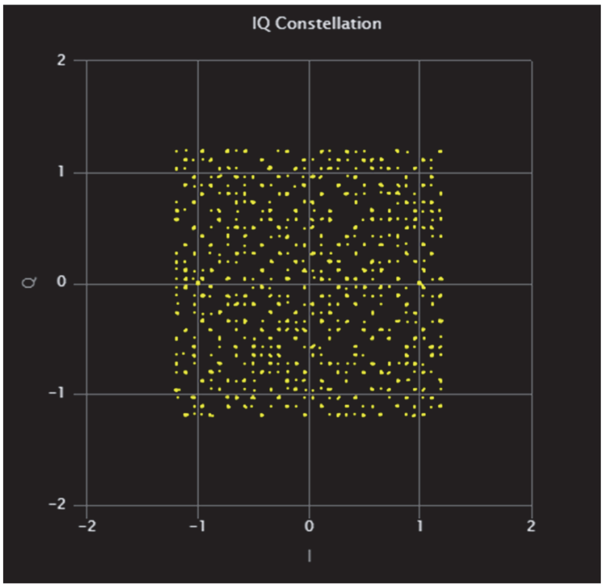

Figure 6 6-GHz band 1024QAM Constellation

To support the 160-MHz channel, we have expanded the previous 80-MHz channel measurement function to 160 MHz. As examples of the expanded functions, Figure 7 shows the IEEE 802.11ax 160-MHz spectrum mask results, and Figure 8 shows the Unused Tone Error results.

These results were obtained at a center frequency of 6505 MHz and input level of −10 dBm.

Spectrum-mask measurements support up to ±240 MHz as defined by IEEE 802.11ax.

Unused Tone Error measurement supports up to 74 Resource Units (RU) at 160 MHz.

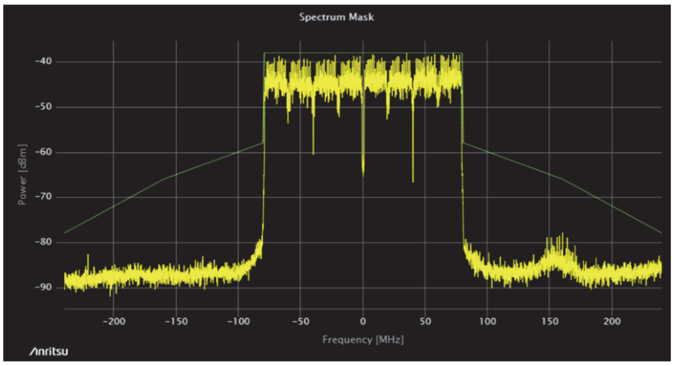

Figure 7 160-MHz Bandwidth Signal Spectrum Mask Measurement

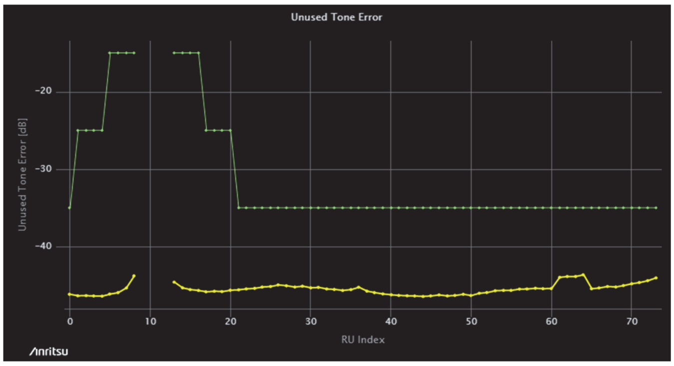

Figure 8 160-MHz Bandwidth Signal Unused Tone Error Measurement

8 Conclusion

We have implemented support for the 6-GHz band and 160-MHz channel bandwidth in the MT8862A as a test solution for future 6-GHz band WLAN equipment. This development is not targeted only at new MT8862A purchases and can be retrofitted as new hardware options adding 6-GHz band measurement functions to customers' own MT8862A units.

To help support WLAN growth and development, we plan to continue adding various other test solutions meeting customers' WLAN R&D and production requirements as well as future new test standards.

References

1) IEEE Standard 802.11-2020
"Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications"

2) IEEE Standard 802.11ax-2021
"Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 1: Enhancements for High-Efficiency WLAN"

3) Yoshitaka Kihara, Keita Masuhara, Takashi Yanagimoto, Takahiro Kasagi, Gou Inoue, Mamoru Iwamoto, Yuichi Negami: "Development of Wireless Connectivity Test Set MT8862A Supporting IEEE 802.11ac WLAN Network Mode", Anritsu Technical Review No.26 (Sep. 2018)

Authors


Taku Hasegawa
Product Development Dept.
IoT Test Solutions Division
Test & Measurement Company


Takahiro Kasagi
Product Development Dept.
IoT Test Solutions Division
Test & Measurement Company


Shinya Hori
Product Development Dept.
IoT Test Solutions Division
Test & Measurement Company


Shoichi Sato
2nd Product Development Dept.
Mobile Solutions Division
Test & Measurement Company

Table 1 Key MT8862A Specifications for 6-GHz band

Receiver	Frequency range	With MT8862A-001: 2.4 GHz to 2.5 GHz, 5.0 GHz to 6.0 GHz With MT8862A-002, 010: 6.0 GHz to 7.3 GHz
	Frequency setting resolution	1 Hz
	Level setting range	−65 to +25 dBm
	Level setting resolution	0.1 dB
	Level accuracy	Measurement conditions: CW, Measurement bandwidth: 160 MHz, 20° to 30°C, Following input signals, Excluding effect of linearity errors, After Cal 2.4 GHz ≤ Frequency ≤ 2.5 GHz ±0.7 dB (−30 dBm ≤ Setting level ≤ +25 dBm) ±1.0 dB (−50 dBm ≤ Setting level < −30 dBm) 5.0 GHz ≤ Frequency ≤ 6.0 GHz ±0.7 dB (−30 dBm ≤ Setting level ≤ +25 dBm) ±1.0 dB (−50 dBm ≤ Setting level < −30 dBm) 6.0 GHz < Frequency ≤ 7.3 GHz ±0.7 dB (−30 dBm ≤ Setting level ≤ +25 dBm) ±1.0 dB (−50 dBm ≤ Setting level < −30 dBm)
Transmitter	Setting range	With MT8862A-001: 2.4 GHz to 2.5 GHz, 5.0 GHz to 6.0 GHz With MT8862A-002, 010: 6.0 GHz to 7.3 GHz
	Frequency setting resolution	1 Hz
	Level setting range	−120 to 0 dBm
	Level setting resolution	0.1 dB
	Level accuracy	Output setting: CW 20° to 30°C, Output level: ≥−110 dBm, After Cal ±1.0 dB, ±0.7 dB (typ.) (2.4 GHz ≤ Frequency ≤ 2.5 GHz) ±1.3 dB, ±1.0 dB (typ.) (5.0 GHz ≤ Frequency ≤ 6.0 GHz) ±1.3 dB, ±1.0 dB (typ.) (6.0 GHz < Frequency ≤ 7.3 GHz)
	Signal purity	Frequency: ≤−25 dBc

Typical (typ.) values are for reference only and are not guaranteed.

Table 2 Key MX886200A Specifications for 6-GHz band

Frequency range	Frequency range	2.4-GHz band: 2412 MHz to 2484 MHz (with MT8862A-001) 5-GHz band: 5180 MHz to 5825 MHz (with MT8862A-001) 5180 MHz to 5885 MHz (with MT8862A-001, 002, 010) 6-GHz band: 5955 MHz to 7115 MHz (with MT8862A-001, 002, 010)
Amplitude setting	Input level range	−50 to +25 dBm
	Input level accuracy	After Cal, 20° to 30°C ±0.7 dB (−30 dBm ≤ Input level ≤ +25 dBm) ±1.0 dB (−50 dBm ≤ Input level < −30 dBm)
	Bandwidth	40 MHz/20 MHz (802.11n) 20 MHz (802.11a/b/g) 160/80/40/20 MHz (802.11ac, with MX886200A-001, 030) 160/80/40/20 MHz (802.11ax, with MX886200A-002, 030)
EVM	Setting range	−20 to +25 dBm
	Residual EVM	OFDM (802.11ac 160-MHz bandwidth, with MX886200A-001, 030): <−44 dB (nom.) (−10 dBm ≤ Input level, Average of 20 packets, Channel estimation: Full packet, MCS9) OFDM (802.11ax, with MX886200A-002): <−42 dB (nom.) (−10 dBm ≤ Input level, Average of 20 packets, Channel estimation: Full packet) OFDM (802.11ax 160-MHz bandwidth, with MX886200A-002, 030): <−44 dB (nom.) (−10 dBm ≤ input level, average of 20 packets, Channel estimation: Multi packet, MCS11)
RF Signal generator	Level setting range	−120 to 0 dBm (Aux Out connector) −120 to 0 dBm (Main ½ connector, Frequency ≤ 6 GHz or Channel Band 2.4 GHz/5 GHz) −120 to −5 dBm (Main ½ connector, Frequency > 6 GHz or Channel Band 6 GHz)
	EVM	802.11ac: ≤−37 dB rms (5180 MHz to 5885 MHz, Long GI, Channel bandwidth 80 MHz, 20° to 30°C) ≤−41 dB rms (nom.) (5180 MHz to 5885 MHz, Long GI, MCS9, Channel bandwidth 160 MHz, 20° to 30°C) 802.11ax: ≤−40 dB rms (nom.) (5180 MHz to 5885 MHz, 0.8 µs GI, Channel bandwidth 80 MHz, 20° to 30°C) ≤−41 dB rms (nom.) (5180 MHz to 5885 MHz, 0.8 µs GI, MCS11, Channel bandwidth 160 MHz, 20° to 30°C) ≤−41 dB rms (nom.) (5995 MHz to 7115 MHz, 0.8 µs GI, MCS11, Channel bandwidth 160 MHz, 20° to 30°C)

Nominal (nom.) values are design values and are not guaranteed.