

Development of MT8862A IEEE 802.11be 320-MHz Bandwidth Option

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[Summary]

The number of WLAN devices is increasing yearly with demands for more stable, faster, and higher-capacity communications. To address growing data-traffic demands, the IEEE 802.11be standard added the 320-MHz bandwidth and 4096QAM modulation schemes³⁾. Anritsu's Wireless Connectivity Test Set MT8862A is a popular solution for evaluating RF performance^{4), 5)}. Consequently, we have developed new hardware and software update options for the MT8862A to support the IEEE 802.11be 320-MHz bandwidth as an industry-first^{*1} instrument for RF tests using the Network mode.

*1 Anritsu survey in August 2023

1 Introduction

Use cases for Wireless LAN-equipped (WLAN) devices continue to expand, including playback of 4K/8K videos using smartphones and tablet devices, enhancement of services using Augmented Reality (AR)/Virtual Reality (VR) technology on wearable devices, and control/remote monitoring applications in factories and medical equipment. Additionally, to meet increasing data traffic demands, the Institute of Electrical and Electronics Engineers (IEEE) is increasing the maximum communication speed of WLAN devices by widening the channel bandwidth to 320 MHz and upgrading the modulation scheme to 4096QAM in the latest IEEE 802.11be standard^{1) to 3)}. Anritsu markets its Wireless Connectivity Test Set MT8862A solution for measuring the RF transmitting and receiving (Tx/Rx) characteristics of IEEE 802.11a/b/g/n/ac/ax (2.4-GHz, 5-GHz, and 6-GHz band) WLAN devices^{4), 5)}. It supports both the Network mode, enabling Tx/RX measurements in the actual operating mode of the device under test (DUT), and the Direct mode, which uses chip vendor-specific test modes used on production lines, etc. Therefore, it is used for both Over The Air (OTA) measurements and Conducted measurements.



Figure 1 Wireless Connectivity Test Set MT8862A

We have enhanced the MT8862A functions to meet future mainstream IEEE 802.11be RF measurement needs by developing the Extended Bandwidth Hardware MT8862A-011 option, as well as the 320 MHz Bandwidth MX886200A-031 and WLAN 802.11be MX886200A-003 software options. This article describes the key IEEE 802.11be technologies, the MT8862A development policy supporting IEEE 802.11be, and the option development details and key specifications.

2 IEEE 802.11be

IEEE 802.11be adds the following functions as key technologies³⁾.

- 320-MHz bandwidth
- 4096QAM
- MRU (Multiple Resource Unit)
- MLO (Multi-Link Operation)

This section discusses the 320-MHz bandwidth, 4096QAM, and MRU technologies that were deeply involved in this development.

2.1 320-MHz Bandwidth

To increase the maximum communication speed, the maximum channel bandwidth in the 6-GHz band has been expanded from 160 to 320 MHz. The 320-MHz channel consists of two adjacent 160-MHz channels, and two types of channel configurations, 320 MHz-1 and 320 MHz-2 are defined. Figure 2 shows this channel arrangement.

2.2 4096QAM

The maximum value for the QAM modulation method has been increased from the existing 1024 to 4096, increasing the

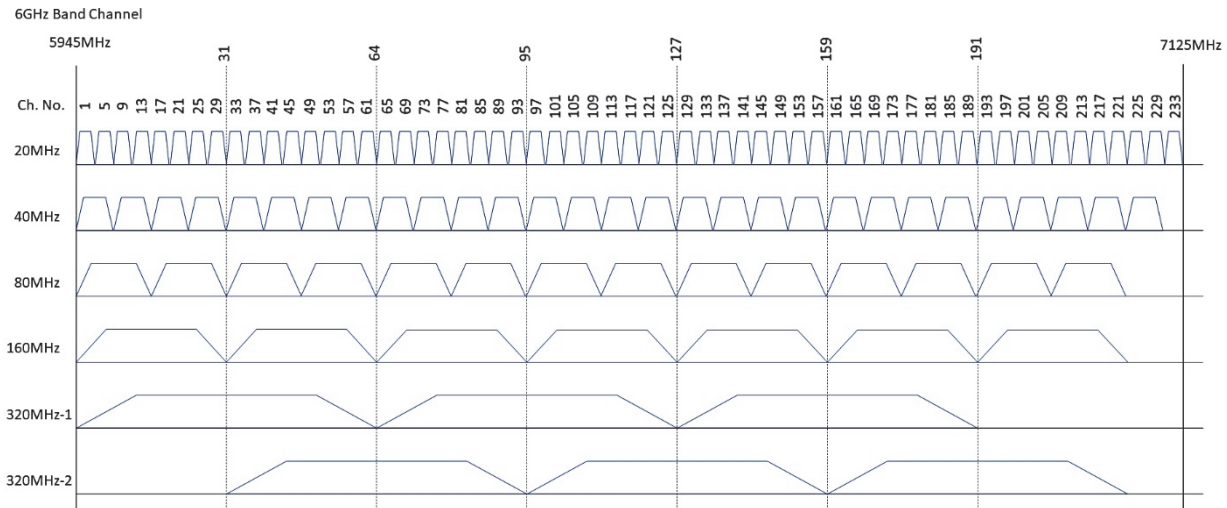


Figure 2 6-GHz band channel distribution

number of bits that can be transmitted per modulation symbol from 10 bits to 12 bits, and enabling a 20% speed improvement. The specified permissible relative constellation error for 4096QAM is -38 dB.

2.3 MRU

To use frequency resources efficiently, a Multiple Resource Unit (MRU) is defined, which allocates multiple Resource Units (RUs) to a single user. RUs are allocated in subcarrier quantities of 26, 52, 106, 242, 484, 996, 2x996, and 4x996 tones. The MRU is a group of subcarriers combining multiple RUs defined as 52+26-tone, 106+26-tone, 484+242-tone, 996+484-tone, 2x996+484-tone, 3x996-tone, and 3x996+484-tone combinations.

3 Development Concept

3.1 Developing High-Performance Hardware

Our aim was to develop hardware to measure a 320-MHz bandwidth and 4096QAM, which are the main IEEE 802.11be performance features. The design residual Error Vector Magnitude (EVM) for both the signal generator and signal analyzer was set at -43 dB based on market performance requirements, commercial release timing, and product cost.

3.2 Compatibility with Existing Hardware

To keep upgrade costs down for existing users, the design allows upgrades to 320-MHz bandwidth support by replacing the MT8862A built-in module. Additionally, by compensating for the differences from the current hardware of MT8862A by software and FPGA circuits, we provide an environment

where users can perform RF testing using exactly the same procedures and operations as the current MT8862A, without being conscious of hardware differences.

3.3 Advance Compatibility Testing with 802.11be Terminals

To cut time to market (TTM), development started early in the IEEE 802.11be formulation stage. While complementing as yet undefined parts of the standard using connection verification by chip vendors that develop standards, we also focused on enhancing the completeness of the signaling mode, which is a key MT8862A feature.

4 Hardware

There were two performance goals in meeting the technical challenges of this hardware development as follows:

- ① Expanding maximum bandwidth (160 → 320 MHz)
- ② Upgrading EVM at maximum bandwidth to reach -43 dB target

EVM (point ②) is one of the most important performance items generally required for communications measuring instruments, and this development achieved both points ① and ② for the MT8862A SG and SA functions. Additionally, repurposing in-house design assets help cut both costs and TTM, meeting instrument-market requirements.

The MT8862A hardware is divided into three units based on their roles (Figure 3). The roles of each hardware unit and the main changes from the conventional MT8862A hardware to achieve the above-mentioned performance goals ① and ② are described in following sections organized by SG/SA functions.

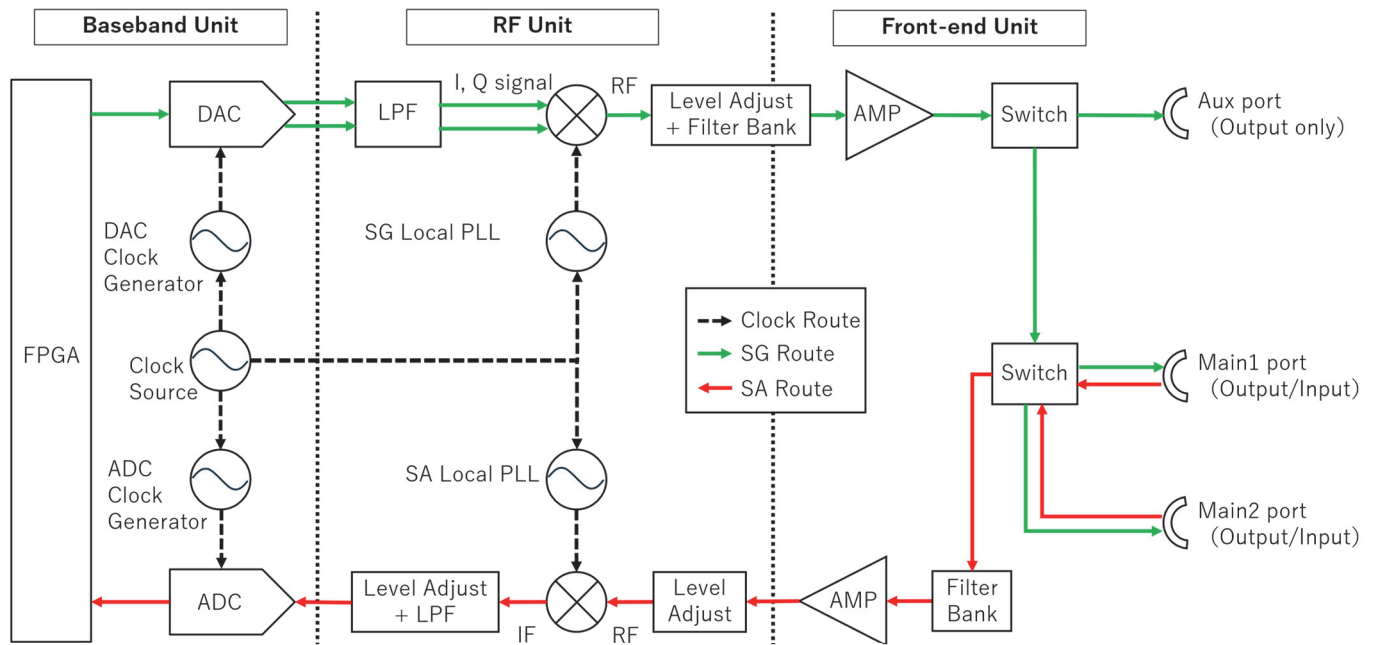


Figure 3 MT8862A Hardware block diagram supporting IEEE 802.11be 320-MHz bandwidth

4.1 MT8862A Signal Generator Functions

The green arrows in Figure 3 show the SG function signal path. Details of each unit are described below.

4.1.1 Baseband Unit

The waveform data output from the FPGA in the baseband unit is converted to IQ data by the Digital-to-Analog Converter (DAC) and output to the RF unit.

The DAC in the baseband unit is the main change to the SG function. The DAC in the conventional MT8862A cannot handle the digital-waveform data rate required for the 320-MHz bandwidth, so it was upgraded to a DAC that can accept input at a higher data rate. This required increasing the sampling clock frequency, so a new frequency multiplier was added. To ensure performance, consideration was given to preventing phase noise deterioration when selecting the frequency multiplier.

4.1.2 RF Unit

The IQ signals received by the RF unit are frequency-converted to RF signals by the quadrature modulator. The RF signal output from the quadrature modulator has unwanted waveforms removed by the filter, and is output to the Front-end unit after the signal level is adjusted by the digital attenuator.

Doubling the maximum signal bandwidth from 160 to 320 MHz could cause harmonic problems and multiple responses, resulting in an unwanted wider bandwidth at the RF unit. Consequently, the frequency plan was reviewed, and the

mixer local frequency was changed along with selection of filters with appropriate cutoff frequencies.

Additionally, in general, setting an SG to high output levels can cause distortion components to become the dominant factor in degraded EVM performance. Degraded EVM performance at high output level settings was suppressed by using an amplifier with good distortion performance at the latter level-adjustment stage. Moreover, improved EVM and lower cost increases were achieved by reviewing the level plan including digital-stage level adjustment, and optimizing the attenuator configuration of the previous MT8862A.

4.1.3 Front-end Unit

The received RF is output to the Aux, Main1, or Main2 ports specified by the user.

The Front-end unit challenge is that the distortion performance of the final amplifier contributes significantly to EVM performance at high output levels. An upgraded amplifier with better distortion performance than the one in the previous MT8862A was used to solve this issue.

4.2 MT8862A Signal Analyzer Functions

The red arrows in Figure 3 show the SA function signal path. Details of each unit are described below.

4.2.1 Front-end Unit

The RF signal input either to the MT8862A Main1 or Main2 port has unwanted waveforms removed by a filter in the Front-end unit and is amplified by the Low Noise Amplifier (LNA). The amplified RF signal then passes to the RF unit.

When the RF signal input level is low, the signal is amplified by the LNA, so the LNA characteristics affect EVM performance. Adopting an LNA with better frequency characteristics than the previous MT8862A improved the EVM performance compared to using conventional components. Cost was also considered when choosing the better LNA, resulting in a cost saving of about 40% compared to conventional components.

4.2.2 RF Unit

RF signals received from the Front-end are frequency-converted to Intermediate Frequency (IF) signals in the RF Unit. The RF signal level is adjusted at the stage prior to the mixer to achieve the appropriate mixer input level; unwanted waveforms are removed from the IF signal after the mixer and the signal level is adjusted.

Expanding the signal's maximum bandwidth required changing the frequency dial. Like the SG function, the second harmonics overlap became more stringent compared to the previous MT8862A model as the signal bandwidth doubled. Additionally, special attention was required for handling unwanted waveforms during mixing. Therefore, the local mixer frequency was changed, and filters in the path were modified to achieve appropriate pass and blocking characteristics. Additionally, Figure 4 shows the conditions for preventing overlap between the wanted wave and its second harmonic. The sum of half the bandwidth of the wanted wave (labeled "a" in figure) and half the bandwidth of the second harmonic (labeled "b" in figure) must be smaller than the IF (labeled "IF Center" in figure). The IF is adopted according to the above conditions.

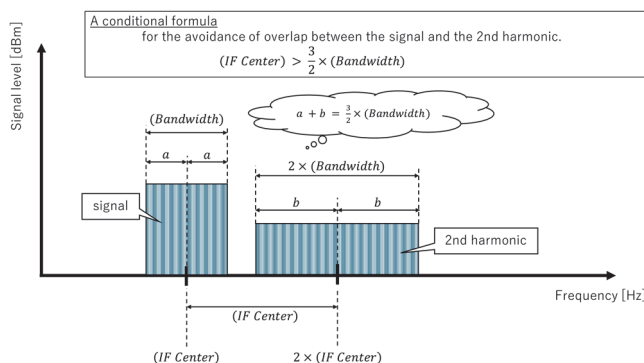


Figure 4 Conditions preventing overlap between wanted wave and second harmonic

4.2.3 Baseband Unit

The IF signal output from the RF unit is digitized by the

Analog-to-Digital Converter (ADC) in the baseband unit. The digital data output by the ADC is analyzed by FPGA and software. The main change in the SA function of the baseband unit is the ADC. The ADC in the previous MT8862A has a sampling rate of 400 MSPS, which cannot handle signals with a 320-MHz bandwidth. Therefore, it was replaced with an ADC capable of sampling at a higher rate. Although it has fewer effective bits (ENOB) than the ADC in the previous MT8862A, EVM deterioration is prevented by oversampling at a higher sampling rate.

4.2.4 ADC Clock Generation Phase-Locked Loop IC

Unlike the previous MT8862A, since oversampling is performed at a sufficiently high rate by the ADC, a faster sampling clock was necessary. Moreover, a new Phase-Locked Loop (PLL) IC with low phase noise was used to achieve the target EVM value of -43 dB at the 320-MHz maximum bandwidth, taking clock jitter requirements into account.

4.3 Changes to Shared SG/SA Functions

The PLL IC used as the local oscillator for the mixer for both SG and SA functions was changed. Phase noise, which is one component of EVM performance, is highly dependent on the phase noise performance of the local signal during the mixing stage. Therefore, changing to a PLL IC with lower phase noise contributed to improved EVM performance.

5 FPGA

The main FPGA modifications were to the interface and expansions to accommodate hardware component changes. Additionally, parallel processing was implemented in the digital signal processing block to support higher DAC and ADC sampling rates.

The signal processing block configuration was designed to handle compatibility with existing operations, such as selecting the sampling rate of received data passed to software, minimizing the impact of changes.

6 Software

This section describes the MT8862A software modifications to support 320 MHz. Figure 5 shows the software functional blocks.

6.1 Analysis Section

6.1.1 Modulation Analysis Sampling Rate

The biggest challenge in the analysis section was the

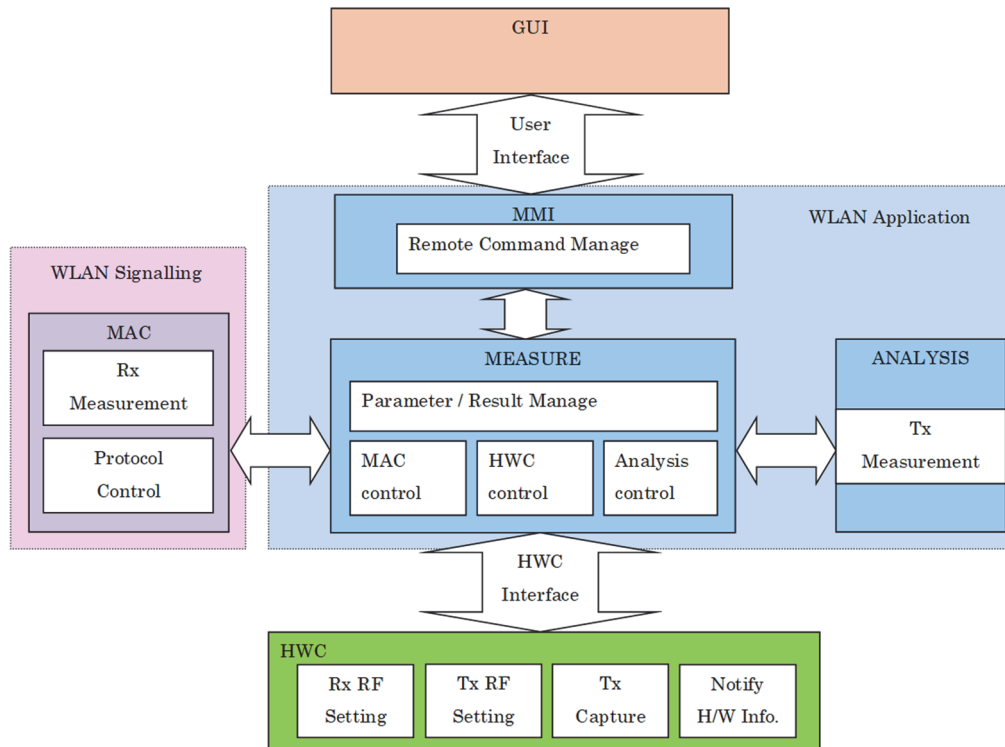


Figure 5 MT8862A Software function blocks

change in sampling rate. Since the IEEE 802.11ax standard maximum bandwidth is 160 MHz, the prior software was designed with a fixed sampling rate of 200 MHz. However, it was necessary to increase the sampling rate to 400 MHz because IEEE 802.11be extends the maximum bandwidth to 320 MHz. Also, to use the software in common with the previous MT8862A, it was necessary to ensure that IEEE 802.11be devices could be analyzed even using the 200-MHz sampling rate system.

Therefore, we designed the implementation for the newly developed IEEE 802.11be processing to use variable sampling rates, while existing IEEE 802.11ax and earlier processing is resampled to 200 MHz, allowing reuse of the existing implementation. Figure 6 shows a flowchart focusing only on the transition of sampling rates in the analysis section. This implementation style made the software compatible with both the previous and updated MT8862A.

6.1.2 IEEE 802.11be Analysis Section

The IEEE 802.11be analysis section requires a variable sampling rate. However, resampling according to bandwidth was expected to cause problems such as waveform degradation due to filtering and strain on computational and memory resources. Therefore, since the subcarrier spacing in the PPDU-format data region is fixed at 78.125 kHz, we designed

the analysis section to perform Discrete Fourier Transform (DFT) so subcarrier spacing becomes 78.125 kHz. This approach suppress waveform degradation compared to Fast Fourier Transform (FFT), enabling high-quality analysis. There were concerns about increased measurement time, but the increase in computation time was suppressed by reducing the number of resampling operations.

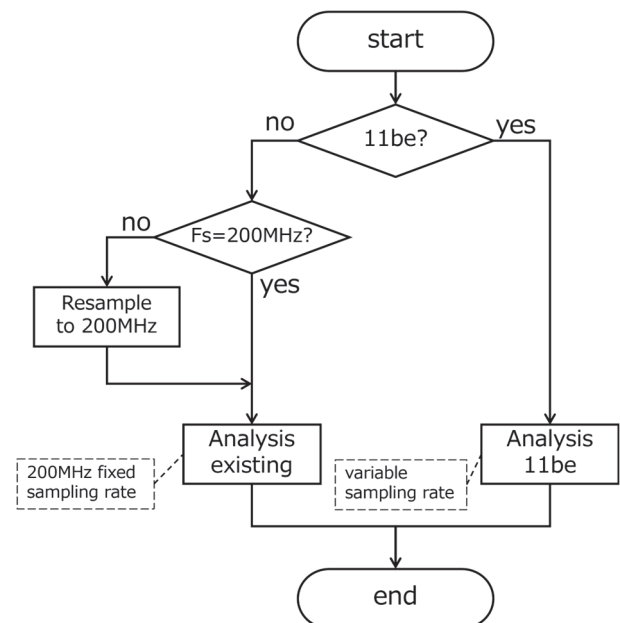


Figure 6 Flowchart of sampling rate transitions in analysis section

6.2 WLAN Signaling Section

In the WLAN signaling section, we mostly implemented support for adding IEEE 802.11be parameters, such as 4096QAM, 320-MHz bandwidth, and MRU to control packets. Software development proceeded by verifying network connections in advance with chip vendors using existing hardware. The occurrence of defects in the actual instrument was suppressed by preverifying the signaling section more than 6 months before integrated testing of the new hardware.

6.3 GUI Section

In addition to IEEE 802.11be settings and measurement results, we added a new configuration screen for the newly standardized MRU to the web GUI WLAN measurement software screen. The MRU configuration screen displays RUs up to 320 MHz as icons, helping understand the layout and

combination of RUs at a glance. Additionally, providing a function to switch between Single Resource Unit and Multiple Resource Unit facilitates switching within the same screen. Figure 7 shows the Single Resource Unit configuration screen when the bandwidth is 20 MHz, and Figure 8 shows the Multiple Resource Unit configuration screen.

Furthermore, due to GUI screen size constraints, displaying the entire view for the 320-MHz bandwidth made the 26-tone icons too small, creating an operation issue. To prevent poor usability, we added zoom and scroll functions, allowing display of the 26-tone icons at the normal size, balancing overall visibility and operability. Figure 9 shows the Single Resource Unit configuration screen in full view when the bandwidth is 320 MHz, and Figure 10 shows the configuration screen when zoomed-in.

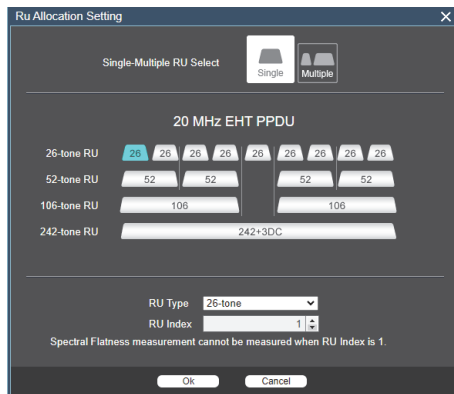


Figure 7 20-MHz Single Resource Unit Setting screen example

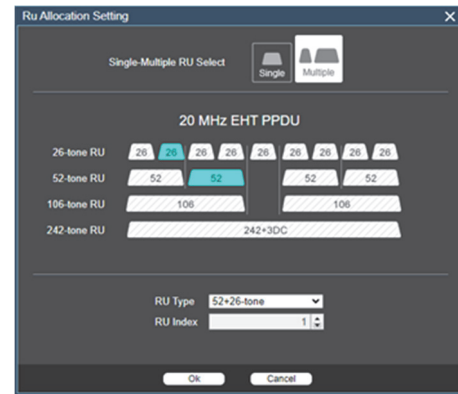


Figure 8 20-MHz Multiple Resource Unit Setting screen example

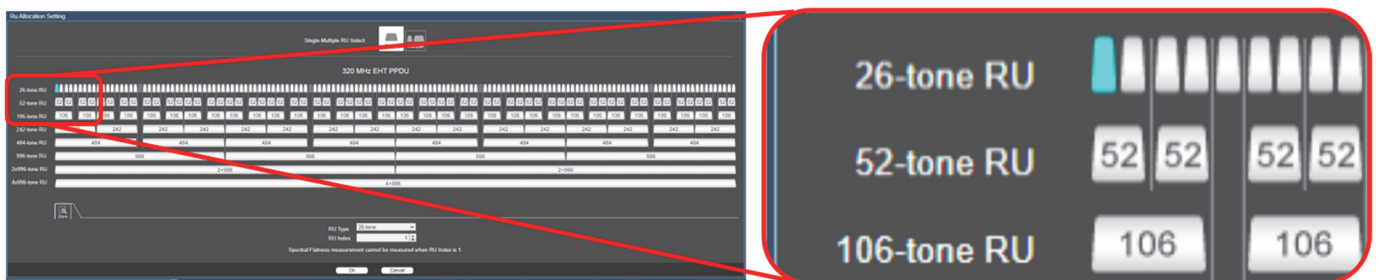


Figure 9 320-MHz Resource Unit setting screen full view example



Figure 10 320-MHz Resource Unit setting screen zoomed-in example

7 Key Specifications

Tables 1 and 2 list the main specifications of the MT8862A with 320-MHz bandwidth support.

8 Measurement Result Examples

Figure 11 shows a Constellation from EVM measurement as an example. This Constellation is the result of measuring an IEEE 802.11be MCS13 signal with 4096QAM modulation at a center frequency of 6105 MHz and an input level of -10 dBm. The EVM measurement result is -45.31 dB, meeting the development target of -43 dB. Figure 12 shows the Spectrum Mask measurement result. This Spectrum Mask is the result of measuring an IEEE 802.11be 320-MHz bandwidth signal at a center frequency of 6105 MHz and an input level of -10 dB. As shown in Figure 12, it supports measurements up to ± 480 MHz.

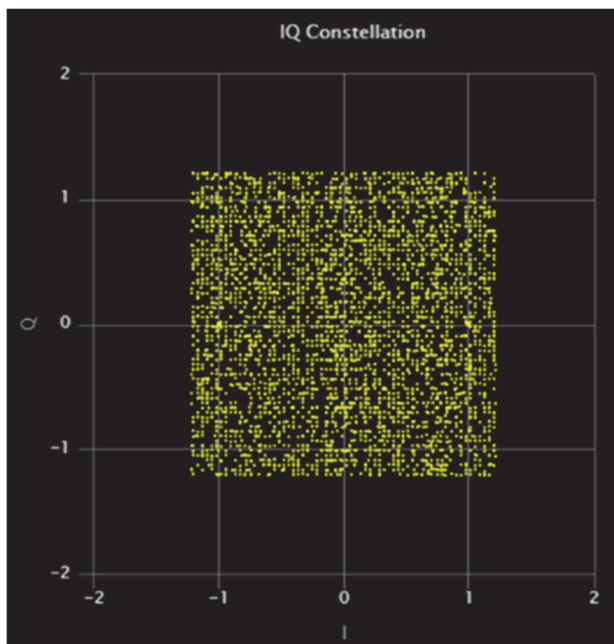


Figure 11 Example of 4096QAM Constellation for 320-MHz bandwidth signal

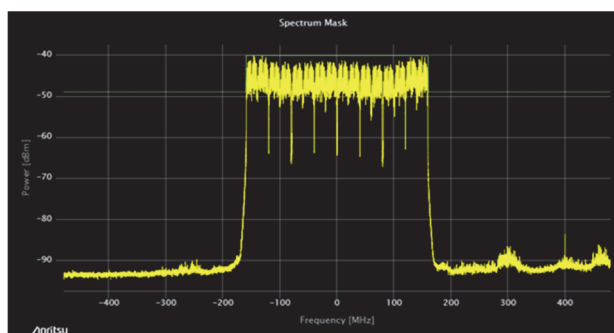


Figure 12 Example of Spectrum Measurement for 320-MHz bandwidth signal

9 Conclusions

We developed an update option for the MT8862A to support the IEEE 802.11be 320-MHz bandwidth for future mainstream RF measurement requirements. This MT8862A update is an industry-first supporting IEEE 802.11be RF measurements using the Network mode. With this update, the MT8862A provides a seamless RF measurement environment for 320-MHz bandwidth signals.

By providing measurement solutions supporting future new standards and features, Anritsu is continuing its efforts to meet the demands of users developing and manufacturing WLAN devices, helping widespread adoption and development of WLAN devices.

References

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Table 1 MT8862A Wireless Connectivity Test Set key specifications with 802.11be 320-MHz Bandwidth Option installed

Receiver	Frequency range	2.4 to 2.5 GHz, 5.0 to 6.0 GHz, 6.0 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: 320 MHz, 20° to 30°C, Input signal below setting level and excluding linearity error effects, After calibration 5.785 GHz ≤ Frequency ≤ 7.3 GHz ±0.7 dB (−30 dBm ≤ Setting level ≤ +25 dBm) ±1.0 dB (−50 dBm ≤ Setting level < −30 dBm)
Transmitter	Frequency range	2.4 to 2.5 GHz, 5.0 to 6.0 GHz, 6.0 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 calibration ±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	Harmonics: ≤−25 dBc

Table 2 MX886200A WLAN Measurement Software key specifications with 802.11be 320-MHz Bandwidth Option installed

Frequency range	Frequency range	2.4-GHz band: 2412 to 2484 MHz 5-GHz band: 5180 to 5885 MHz 6-GHz band: 5955 to 7115 MHz
Amplitude setting	Input level range	−50 to +25 dBm
	Input level accuracy	After calibration, 20° to 30°C ±0.7 dB (−30 dBm ≤ Input level ≤ +25 dBm) ±1.0 dB (−50 dBm ≤ Input level < −30 dBm)
	Bandwidth	320/160/80/40/20 MHz (802.11be)
EVM	Setting range	−20 to +25 dBm
	Residual EVM	OFDM (802.11be 320-MHz bandwidth) <−44 dB (nom.) (−10 dBm ≤ Input level, Average of 20 packets, Channel estimate: Multi packet, MCS13)
RF Signal generator	Level setting range	−120 to 0 dBm (Aux Out Connector) −120 to 0 dBm (Main 1/2 Connector, Frequency ≤6 GHz and Channel Band 2.4 GHz/5 GHz) −120 to −5 dBm (Main 1/2 connector, Frequency >6 GHz or Channel Band 6 GHz)
	EVM	802.11be ≤−40 dB rms (nom.) (5180 to 5885 MHz, 0.8 μs GI, Channel bandwidth 80 MHz, 20° to 30°C) ≤−41 dB rms (nom.) (5250 to 5815 MHz, 0.8 μs GI, MCS13, Channel bandwidth 160 MHz, 20° to 30°C)

Publicly available