Application Note

Anritsu envision : ensure

Wireless LAN Product Evaluation Guide

～Product Design and Development Volume～

Wireless Connectivity Test Set MT8862A

Table of Contents

1. Introduction

This Wireless LAN Product Evaluation Guide explains the key points in designing and developing wireless LAN (WLAN) products clearly to engineers designing such products for the first time. This series of guides is divided into separate volumes covering every subject from competitor surveys to development, compliance tests, and maintenance after commercial release.

Volume 1.... Wireless LAN Product Evaluation Guide

Volume 2 ... WLAN Product Design Guide

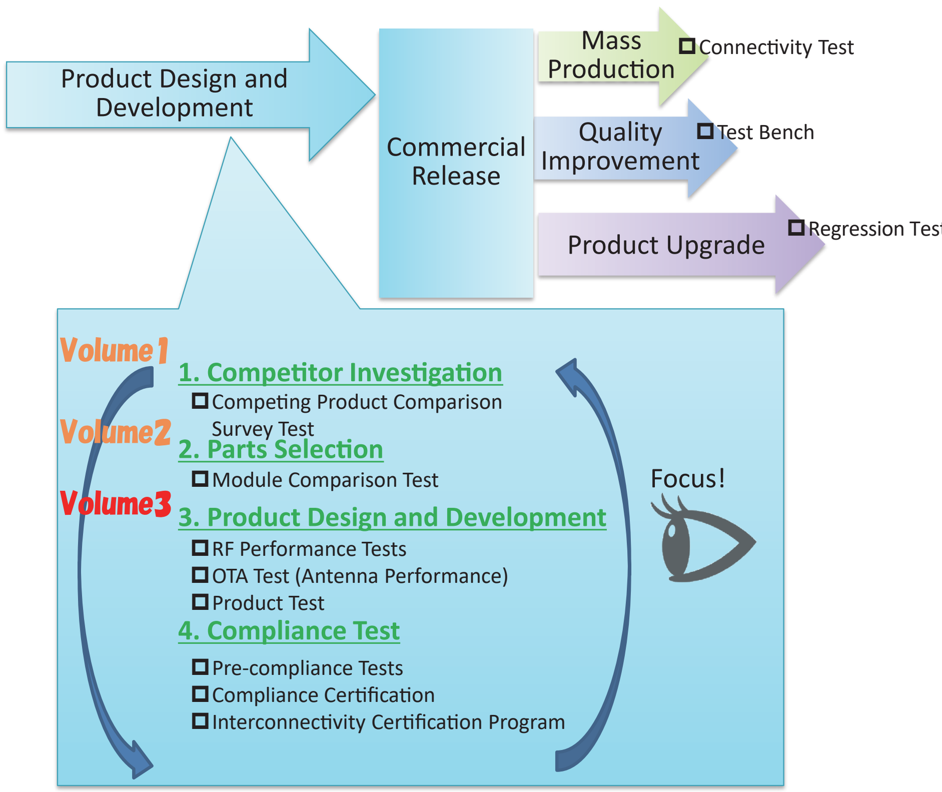


Figure 1 Product Development Process

Volume 3 (this document) is targeted at people handling the actual design and assembly, and the completed product inspection. Although product design and development require decisions about various parameters (wireless standard, frequency, bandwidth, etc.), it explains the advantages and disadvantages of the choices clearly. In addition, as described later, there are two methods for implementing WLAN communications: assembling a WLAN LSI*1 and assembling pre-designed modules. Volume 3 explains the required evaluation tests for engineers handling WLAN modules for the first time. Since WLAN products increasingly include IoT products without built-in iperf*2 functions, we recommend RF performance evaluation, but not evaluation with IP Throughput. Refer to volume 1 for more details.

*1: LSI: Large-scale integrated circuit
*2: iperf: Throughput measurement tool

2. Selecting Applicable Wireless Standard

The following table lists the main IEEE 802.11 WLAN standards, and the key features and differences. Choose the wireless standard based on the usage conditions (location, usage, purpose, etc.) for the product/equipment with the built-in WLAN module.

Table 1: Main WLAN Standard Technical Specifications

IEEE 802.11		11b	11a	11g	11n	11ac	11ax
Planning Period		1999	1999	2003	2009	2014	2020
Freq. Band	2.4 GHz	✓	n/a	✓	✓	n/a	✓
	5 GHz	n/a	✓	n/a	✓	✓	✓
	6 GHz	n/a	n/a	n/a	n/a	n/a	✓
Bandwidth [MHz]		22	20	20	20/40	20/40/80/160/ 80 + 80	20/40/80/160/ 80 + 80
Max. Communication Speed [bps]		11M	54M	54M	600M	6.9G	9.6G
Modulation		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
Multi-user Method		—	—	—	—	MU-MIMO (4 users max.)	MU-MIMO (8 users max.) OFDMA

2.1 Frequency Bands

Each frequency band used by WLAN has various advantages and disadvantages.

This section explains the following three frequency bands now being adopted by WLAN.

□ **2.4-GHz Band**

This band can be used by devices compliant with the IEEE 802.11b/g/n/ax standards.

Advantages: Since it is a low frequency, the signals propagate over longer distances and are not blocked by obstructions.

Disadvantages: The 2.4-GHz band is a commonly used license-free band in general use as an ISM*3 band. Since it is also used for Bluetooth communications, ham radio, household equipment such as microwave ovens, etc., communications are easily disrupted by interference. Moreover, it has the disadvantage of receiving interference from adjacent channels easily, because the 2.4-GHz channel gap is only 5 MHz.

*3: ISM Band: License-free band used by Industrial, Medical and Scientific equipment.

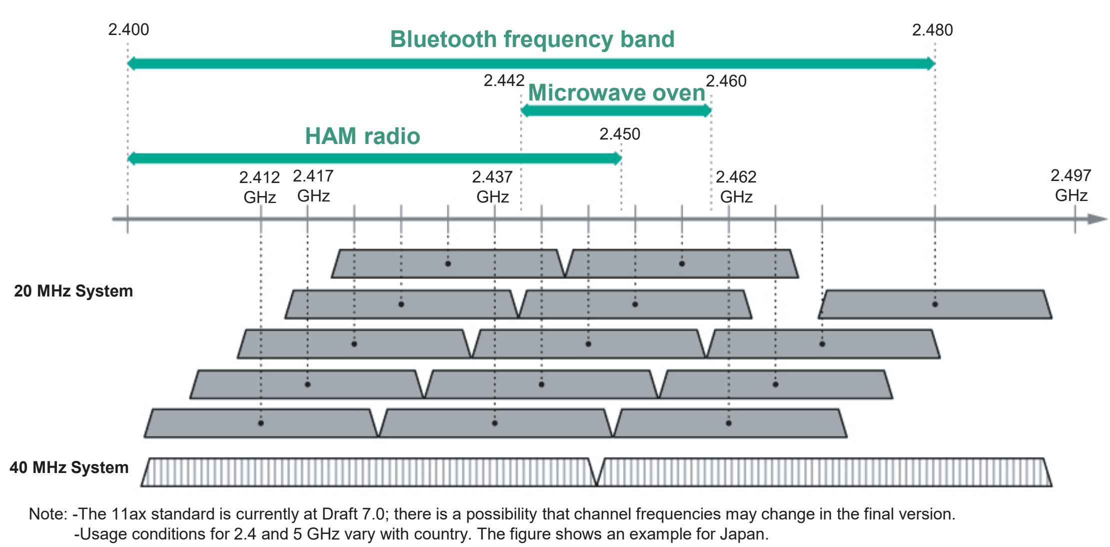


Figure 2 World 2.4-GHz RF Bands

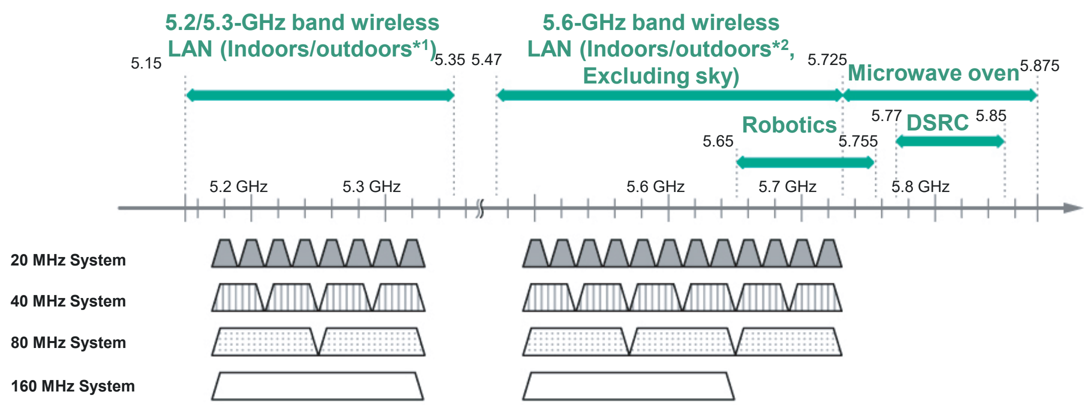
□ 5-GHz Band

This band can be used by devices compliant with the IEEE 802.11b/g/n/ax standards.

Advantages: although this band is used by some other systems (weather radar), since it is a wider band than the 2.4-GHz band the channel gap is 20 MHz and there is little interference between adjacent channels. Moreover, it supports high-speed communications using wide-bandwidth channels.

Disadvantages: 5-GHz WLAN signals are more easily obstructed than 2.4 GHz so they do not propagate over long distances. In addition, there are restrictions on frequency ranges using DFS*4, limitation on indoor use and so on.

*4: DFS (Dynamic Frequency Selection): This function restricts WLAN output to avoid interference with other signals, such as broadcast satellites.



＊1: Some restrictions on communications with 5.2-GHz band high-output data communications systems
＊2: Restricted to indoor communications in combination with 5.2/5.3-GHz band power-saving data communications systems
Note: Usage conditions for 2.4 and 5 GHz vary with country. The figure shows an example for Japan.

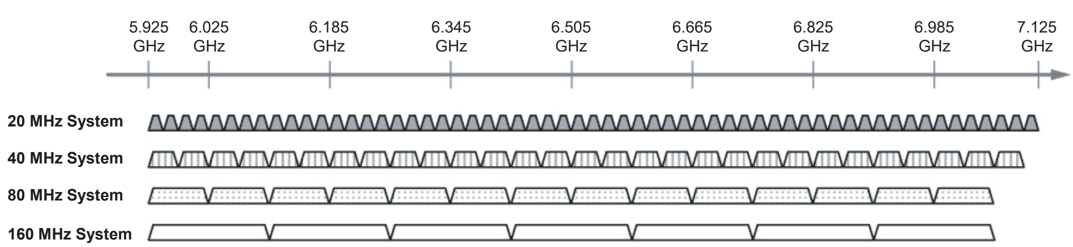
Figure 3 World 5-GHz RF Bands

□ 6-GHz Band

This is a new frequency band used by devices compliant with the IEEE 802.11ax standard.

Advantages: Since this frequency band is license-free, wide bandwidth (160-MHz bandwidth) WLAN signals can be used. In addition, a key feature is the small impact of interference from WLAN networks using legacy standards like 11a/b/g/n/ac.

Disadvantages: Countries where this band can be used are limited. Currently, only North America and the United Kingdom have decided on license-free use of this band. However, the EU and other regions are expected to open this band to use soon.



Note: -The 11ax standard is currently at Draft 7.0; there is a possibility that channel frequencies may change in the final version.

Figure 4 World 6-GHz RF Bands

When deciding which channels to use, consideration must be given to the current frequency-band usage. Figures 2.1, 2.2, and 2.3 show the frequency usages in Japan (6 GHz in N. America). They differ with each country.

Be sure to choose WLAN frequency bands by understanding the respective features of new bands such as the 6-GHz band, crowded bands such as the 2.4-GHz band, and the relatively uncrowded but narrow (output) range 5-GHz band.

2.2 Bandwidths

Generally, WLAN signals use a wide bandwidth and high data rate to achieve high-speed communications. On the other hand, if some users use wide bandwidth channels, the number of channels available to other users decreases, making it difficult to access a channel, so communications in a congested environment are difficult. Moreover, overlap with channels used by other access points causes instability due to interference.

Although the widest bandwidth in the WLAN standards (Table 1) is 160 MHz (used by 11ac/ax), this is not assured for the 2.4-GHz band. In addition, only two 160-MHz bandwidths are assured even for the 5-GHz band. As a result, there is now heavy focus on the 11ax 6-GHz band with seven 160-MHz bandwidths.

3. Key Points at Design and Implementation

(1) Selecting WLAN Device

The following two choices can be considered to implement a WLAN communications device.

- □ Purchasing WLAN module and assembling in product (WLAN Module)
- □ Obtaining WLAN chip and designing as chip-on-board (COB Design)

The features of these different approaches are listed in the following table.

Table 2: WLAN Module and COB Design Features

	WLAN Module	COB Design
PC Board Design	Not required	Required
Antenna	Unnecessary if built-in	Required
WLAN device cost	High	Low due to mass-production
Development cost	Low	High
Differentiation	Depends on module	Possible
Radio law compliance	Obtained with purchased module	Required
Performance evaluation	Required	Required

: Superior points

The major advantage of using a WLAN module is that users can incorporate WLAN communications into products without deep knowledge of RF and printed-circuit design technology. WLAN modules are becoming smaller and a variety of higher-performance modules have been released, offering more selection options. In addition, using a WLAN module offers lower initial development investment and shorter development schedule. In particular, the RF certification program for the completed product can be skipped by using a certified WLAN module. On the other hand, the disadvantages are higher price and limited design, depending on the WLAN module size.

Chip on board design makes it easy to reduce the size and weight of the products, so it makes available to users for designing differentiate products adopting WLAN communication function from other companies's products easily. Low cost is another advantage so this will be suitable for mass-production product. On the other hand, the method requires deep knowledge and high skills for RF design, evaluation and production, as well as getting RF certification program for the completed product.

As an intermediate solution between the adoption of the WLAN module and the Chip on Board design, there is also the option of ordering and adopting the WLAN module customized for the product from the manufacturer.

In this section, we will explain details of adopting the WLAN module, which is often used when incorporating the WLAN function into the product for the first time.

(2) Product Design Check Points

Using a WLAN module makes it convenient and easy to install WLAN communication functions in a product.

Since the RF performance of the module is guaranteed, evaluation of the product performance is often believed to be unnecessary, but there is a risk of deteriorating RF performance due to the following causes, which might result in product issues. Therefore, we suggest check following points in the products datasheets before choosing the WLAN module.

- □ Presence/absence of functions (antenna, amplifier, filter, etc.) comprised of module
- □ Electrical specifications, including voltage and current consumption
- □ Size
- □ Availability of modules, samples, and evaluation board

*5: This is explained in the Wireless LAN Product Evaluation Guide but sometimes specification documents do not describe the RF performance determining the WLAN signal quality. We recommend using a tester at the module purchase stage to evaluate the RF performance.

The antenna(s) are a key part of wireless communications and play a key role in input and output of the radio waves.
When using a WLAN module with built-in antenna(s), it is not necessary to confirm the antenna performance itself because it is guaranteed by the module maker.

On the other hand, when using a module without built-in antenna(s), it is necessary to select the appropriate parts after confirming antenna performance.

The four key points when using an antenna are:

- □ Frequency
- □ Gain
- □ Directivity
- □ Size

Since these points are affected greatly by the antenna installation location, the location must be adequately evaluated.

Antenna performance is affected not only by positioning, but also by the surrounding environment, so RF performance must also be confirmed at the finished product evaluation stage after assembly of the WLAN.

(3) Implementation Checkpoints

Although WLAN modules do not basically require harmonics design, the following points should be considered at a minimum so that RF performance is not degraded at product assembly.

- □ Module location
  Confirm that there is no device wiring acting as a noise source near the module location.
- □ Antenna location
  When using a WLAN module without a built-in antenna, consider the antenna location. Since the transmit and receive performance are affected by the antenna location, the location performance must be confirmed. Moreover, when using 2×2 MIMO antenna designs with two or more antennas, it is necessary to confirm the correlation.
- □ Wiring pattern
  Since wiring itself can act as an antenna collecting unwanted signals, it is necessary to confirm that there is no wiring outputting frequencies near the WLAN signals. Good grounding and shielding can prevent this type of interference. However, inadequate measures allowing interference signals to escape from wiring present a serious risk of degraded WLAN signal quality, so the countermeasures must be properly confirmed.
- □ Power Supply/Grounding performance
  If the grounding and power supply do not satisfy the WLAN module specifications, they will be a noise source, so confirm that the specifications are met.

To prevent degraded product RF performance due to these effects, it is important to evaluate and confirm from the product design and implementation stage. The following confirmation points are examples.

- □ While the product is operating, observe signals in the 2.4, 5, and 6-GHz bands used for WLAN communications to confirm noise.
- □ Evaluate the WLAN RF performance while peripheral circuits and devices are installed and operating to check WLAN RF degradation.
- □ Using a prototype product with mounted WLAN module, evaluate the RF performance with interference signals to check the WLAN RF performance degradation.

To clarify these points and further improve the communication status, the WLAN RF performance of both the WLAN module and the completed product should be evaluated quantitatively with reference to standards, such as IEEE 802.11 and the CTIA Test Plan.

4. Wireless Evaluation Methods at Development Stage

There are two methods for evaluating RF performance: using a wired RF cable connection and using an over-the-air (OTA) wireless connection in a chamber. First, the RF performance details are evaluated using a wired connection with no impact from the outside environment. Next, the product antenna performance and final completed product performance are evaluated under near-to-actual use conditions in an OTA environment.

As listed below, wired and OTA RF and antenna performance tests are regulated by IEEE 802.11 and CTIA/WFA standards.

• Wired IEEE 802.11 Based RF Performance Evaluation Test

IEEE 802.11 is a WLAN standard in widespread use. Since it describes the WLAN measurement technique itself, you can perform the most precise WLAN transmission and reception tests when you refer to this specification.

• Wireless CTIA/WFA Test Plan Based OTA Test

CTIA is a US business organization representing the wireless communications industry. WFA is the abbreviation for the Wi-Fi Alliance, which is a business organization for promoting the spread of WLAN products. Wi-Fi Alliance’s key activities are managing interactive connectivity test methods, certifying products, and promoting spread of the Wi-Fi brand.

This test plan for the product covers not only WLAN but also cellular (LTE, etc.) functions. Since this is the only standard specifying the OTA test contents, this plan is used generally when performing evaluation tests using OTA.

Many confirming the antenna performance using this test are required at the development stage. Moreover, as the final product completion stage approaches, the antenna performance changes by product covers or peripherals. Therefore, obtaining reliable antenna performance is required at the completion stage once more .

This test plan covers both WLAN and cellular (LTE, etc.) functions in one product, such as mobile phones. Since this is the only standard specifying the OTA test contents, this plan is used generally when performing evaluation tests using OTA. Because antenna performance can change as development progresses, many measurements are required during development. Moreover, as the product nears the final completion stage, the antenna performance may change again due to fitting of the product case and the presence of signals from new peripheral connections. Consequently, remeasurement is required when the product reaches the finished stage. These steps are linked to assuring reliable antenna performance.

5. Obtaining Reference Standards

5.1 IEEE 802.11

The official IEEE 802.11 documents are not free-of-charge and can be purchased from the following website.

https://www.ieee.org/

The latest version at October 1, 2020 of IEEE 802.11 for the 11a/b/g/n/ac standards is IEEE 802.11-2016. The 11ax standard is currently at Draft 7.0. IEEE members can obtain 11ax draft versions. Membership applications can be made at the above website. The IEEE 802.11 WLAN standards are very voluminous.

The latest versions of each standard can be confirmed at the following URL.

http://www.ieee802.org/11/Reports/802.11_Timelines.htm

5.2 CTIA/WFA Test Plan

https://www.ctia.org/

The CTIA Test Plan can be downloaded free-of-charge from the above site. The Regulatory Test Plan can be downloaded from the CTIA site by searching for Test Plan. However, downloading requires input of information about the downloader.

6. Evaluation Contents

This section summarizes and explains the transmit (Tx) and receive (Rx) measurement specifications described in IEEE 802.11.

6.1 IEEE 802.11

6.1.1 Tx Measurement Items

These items evaluate the quality of the RF signal sent from the WLAN device to be evaluated.

Table 3: IEEE 802.11-2016 Transmit Test Items

802.11a	802.11g	802.11n	802.11ac	Evaluation Item
17.3.9.2	18.4.7.2	19.3.18.3	N/A	Transmit power levels
17.3.9.3	18.4.7.3	19.3.18.1	21.3.17.1	Transmit spectrum mask
17.3.9.5	18.4.7.4	19.3.18.4	21.3.17.3	Transmit center frequency tolerance
17.3.9.6	18.4.7.5	19.3.18.6	21.3.17.3	Symbol clock frequency tolerance
17.3.9.7.2	17.3.9.7.2	19.3.18.7.2	21.3.17.4.2	Transmitter center frequency leakage
17.3.9.7.3	17.3.9.7.3	19.3.18.2	21.3.17.2	Transmitter spectral flatness
17.3.9.7.4	17.3.9.7.4	19.3.18.7.3	21.3.17.4.3	Transmitter constellation error
17.3.9.8	17.3.9.8	19.3.18.7.4	21.3.17.4.4	Transmitter modulation accuracy test
802.11ax				**Evaluation Item**
27.3.15.3				Pre-correction accuracy requirements
27.3.19.1				Transmit spectral mask
27.3.19.2				Spectral flatness
27.3.19.3				Transmit center frequency and symbol clock frequency tolerance
27.3.19.4.1				Introduction to modulation accuracy tests
27.3.19.4.2				Transmit center frequency leakage
27.3.19.4.3				Transmitter constellation error
27.3.19.4.4				Transmitter modulation accuracy (EVM) test

6.1.1.1 Transmit power levels

This measures the maximum power of the signal sent from the WLAN device. Since the maximum permissible power is determined by national legislation, it is necessary to reference the relevant national laws for the shipping destination country. Additionally, some WLAN devices output the maximum power when first attempting to connect with the opposing product, which requires measurement of the transmit power from the start of the connection trial.

The WLAN signal is a repetitive periodic power-on/off burst signal. Consequently, when using a power meter or a spectrum analyzer for measurement, some technologies and knowledge are required. Other hand, a WLAN tester measures the output level automatically during the power-on times. We recommend using a WLAN tester when dealing with WLAN signals for the first time.

6.1.1.2 Transmit spectrum mask

The transmit signal determines the output level at each frequency offset from the center frequency of the transmit signal channel. The permissible range is called the transmission spectrum mask and is represented by frequency on the x-axis and power on the y-axis. The evaluates whether or not the WLAN signal is within the permissible range represented by this transmission spectrum mask. The maximum power of the signal is represented as 0 dB on the spectrum mask and the relative power values are displayed based on this. In many instances, power is displayed as either dBm or dBW, but in this case the units are dBr, because measurement is based on the maximum transmit power.

This transmission spectrum mask is specified in detail for each frequency band and channel bandwidth in the IEEE 880.11a/b/g/n/ac/etc., standards. A WLAN tester (or spectrum analyzer) for WLAN transmit measurements has detailed data saved for each specified spectrum mask, making it easy to overlay and compare with an actual WLAN signal. Consequently, although pass/fail evaluations can be displayed numerically, pass/fail can also be displayed at a glance on a spectrum screen. For this reason, we strongly recommend using either a WLAN tester or appropriate spectrum analyzer for spectrum mask evaluations.

If the WLAN signal exceeds the transmission spectrum mask range, check the following items.

- Is filter limited signal bandwidth incorrect?
- Is there any signal leakage or distortion occurring in the WLAN product?

These problems can cause unexpected widening of the signal bandwidth and generation of spurious exceeding the limits.

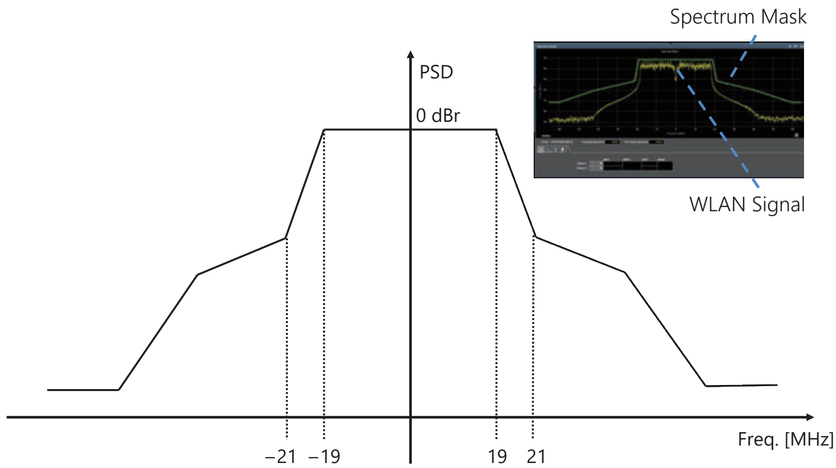


Figure 5 Spectrum Mask Example (40-MHz Bandwidth)

6.1.1.3 Transmit center frequency tolerance

This evaluates whether the transmit center frequency (carrier frequency) error exceeds the permissible (tolerance) range determined by the standard. The tolerance range for this error is determined by the standard as a different value for each frequency and bandwidth. When the center frequency exceeds the tolerance, the opposing product may be unable to receive, and there is a risk of mutual signal interference due to overlapping of adjacent channels.

6.1.1.4 Symbol clock frequency tolerance

The value representing the symbol*6 modulation period as a reciprocal is called the symbol clock frequency. This measures the error in the symbol clock frequency output from the WLAN product.

As this period error becomes larger, the timing slips between WLAN products at the send and receive sides, making reception difficult.

The frequency tolerance is expressed in PPM as units of parts per million.

*6: See the columns end of sections 6.1.1.7 and 6.1.1.8 for details about symbols.

6.1.1.5 Transmitter center frequency leakage

This measures the center frequency leakage components. Frequency leakage is observed in the original signal as frequency components that should not be included in the signal when performing signal spectrum analysis.

If the output signal includes frequency leakage that does meet the standard, the LNA (Low Noise Amplifier) or receiver components in the receiver section of the receiving device might become saturated, possibly affecting receive performance.

6.1.1.6 Transmitter spectral flatness

One WLAN signal channel is composed of smaller frequency components (called subcarriers).

This measures the average power of each subcarrier to confirm that the variation is within the specified range. IEEE specifies (see figure below) the power at two steps: at the subcarrier adjacent to the center frequency, and at non-adjacent subcarriers separated from the center frequency. If the amplitude between subcarriers does not satisfy the standard, decoding problems might sometimes occur.

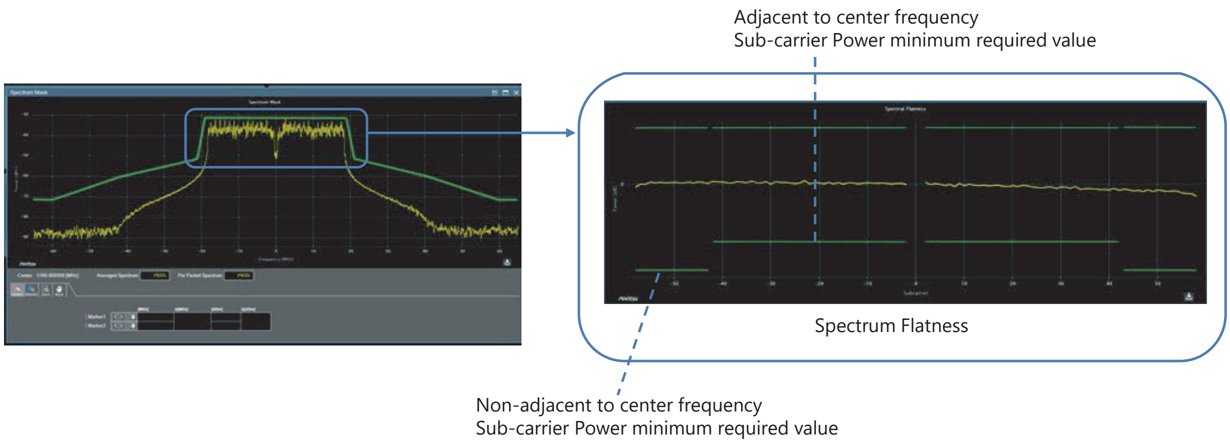


Figure 6 Spectrum Flatness Measurement Waveform

6.1.1.7 Transmitter constellation error

6.1.1.8 Transmitter modulation accuracy (EVM) test

EVM-related evaluation is described as two sections in the IEEE 802.11 standard. Section 6.1.1.7 Transmitter constellation error describes a concrete method for calculating EVM. Section 6.1.1.8 Transmitter modulation accuracy test outlines EVM and shows some required WLAN device specifications. This document explains these two items together.

These items measure the EVM*7 of the WLAN signal to check the signal quality. The EVM is an index expressing the difference ideal symbols plotted on a constellation diagram consists from amplitude and phase (see the column at the end of this section for details) and the position of actual signal modulated symbols. Since EVM is a composite value affected by the impact of the above measurements, such as power, frequency, noise, etc., although a poor EVM can be considered as being due to a variety of different causes, it can play a role in evaluating causes of a poor EVM and give some hints about countermeasures.

*7: Error Vector Magnitude; see the columns at the ends of sections 6.1.1.7 and 6.1.1.8 for details.

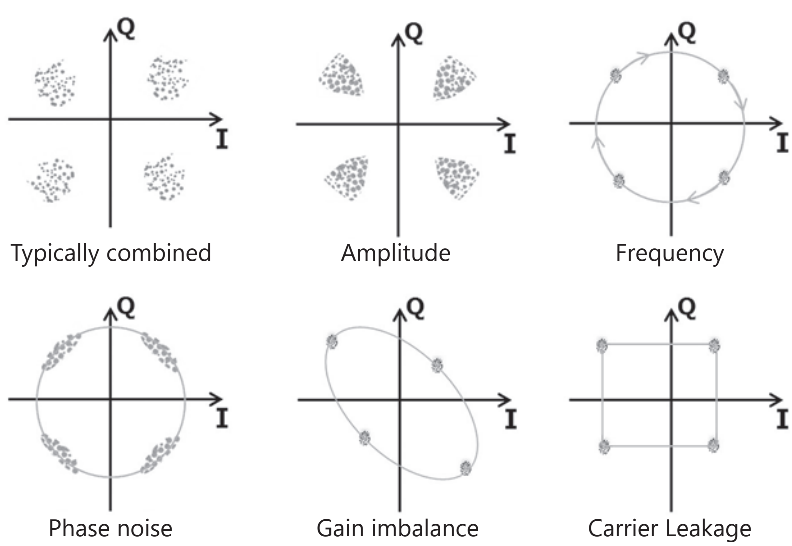


Figure 7 Parametric Error Vector Magnitude

Column: How to View the Constellation? What is EVM?

Signal modulation and demodulation are performed for reducing the noise effects of noise and transmitting signal far away.
The Constellation displays this data modulation. Digital wireless modulation is composed of a combination of the Amplitude Modulation (AM) method for recognizing data using the signal amplitude, and the Phase Modulation method for recognizing data using the phase of the signal frequency.
As an example, using the QPSK method combining AM and Phase Modulation creates the following four conditions.
The Constellation expresses this phase and amplitude combination.
In other words, it can recognize four data types (00, 01, 10, 11) using 2 bits of data. In addition, the Constellation EVM (Error Vector Magnitude) quantifies the deviation (or error) of the modulation data points from the ideal positions.

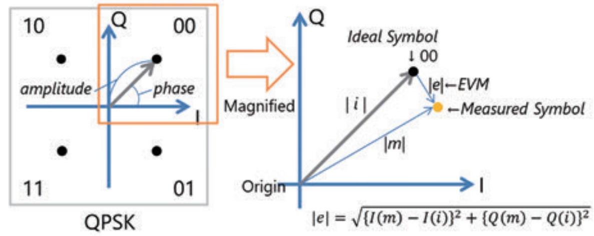


Figure 8 Constellation Diagram and EVM

6.1.2 Receive (Rx) Measurement Items

IEEE802.11 specifies the WLAN receive characteristics as follows.

Table 4: IEEE 802.11-2016 Receive Test Items

802.11a	802.11g	802.11n	802.11ac	Evaluation Item
17.3.10.2	18.4.8.2	19.3.19.1	21.3.18.1	Receiver minimum input level sensitivity
17.3.10.3	18.4.8.3	19.3.19.2	21.3.18.2	Adjacent channel rejection
17.3.10.4	17.3.10.4	19.3.19.3	21.3.18.3	Nonadjacent channel rejection
17.3.10.5	18.4.8.4	19.3.19.4	21.3.18.4	Receiver maximum input level
802.11ax				**Evaluation Item**
27.3.20.2				Receiver minimum input sensitivity
27.3.20.3				Adjacent channel rejection
27.3.20.4				Nonadjacent channel rejection
27.3.20.5				Receiver maximum input level

6.1.2.1 Receiver minimum input level sensitivity

This evaluates whether the WLAN product can receive a weak signal with errors within the tolerance range. The rate of error occurrence is represented by a numeric value called the packet error rate (PER). The PER is represented as the percentage of packets that could not be received by the DUT (error packets) relative to a fixed number of packets sent from the device to the DUT. The person performing the measurement changes the power of the input signal to the product (access point and WLAN tester transmit signal) gradually and plots the PER on a graph to find the minimum value of the power (minimum input level sensitivity) where the PER drops below some fixed value. The WLAN product satisfies the IEEE standard if this minimum input level sensitivity is below a value specified by the IEEE standard. The minimum input level sensitivity determined by various parameters, such as the modulation method, coding rate*8, channel spacing*9, etc., during communications. Plotting the relationship between power and PER for each parameter manually during this evaluation takes an extremely long time.

*8: Expresses relative packet count that can be coded/decoded by one modulation process; higher counts indicate transmission of more data
*9: Channel spacing is the difference between center frequency adjacent channels.

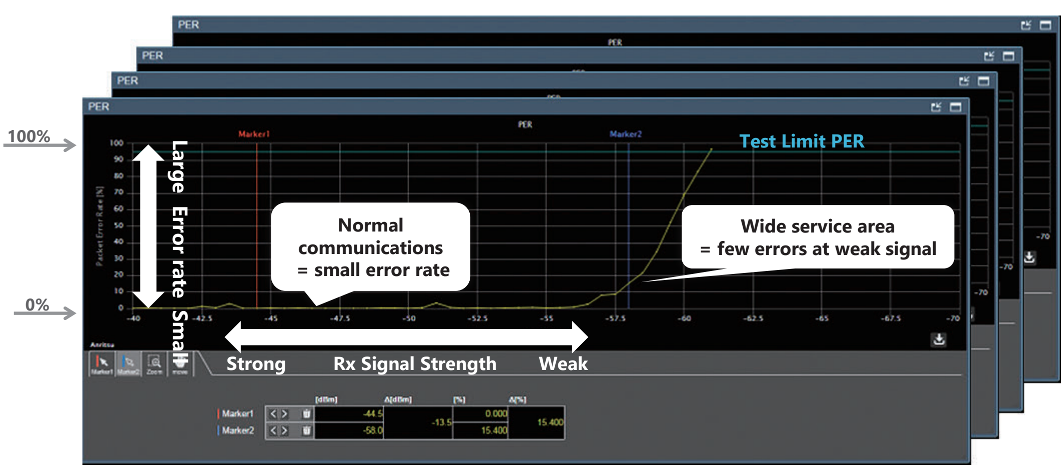


Figure 9 MT8862A Test Limit PER Measurement Screens with each parameter

Column: Easy Bathtub Curve Measurement

The MT8862A can evaluate reception sensitivity at a fixed channel (frequency), transmission rate, output level, etc.

Generally, the receive sensitivity test measures the PER repeatedly while changing the measuring instrument output level. Consequently, this evaluation takes a great deal of time when done manually. In addition, configuring an automatic measurement system is a difficult task, requiring programming to control the measuring instrument. The long time and heavy workload can be cut by using the MT8862A as follows. At the screen shown on the right, input the test limit PER ①, the start level of the MT8862A signal output ②, the stop level ③ and the step size ④.

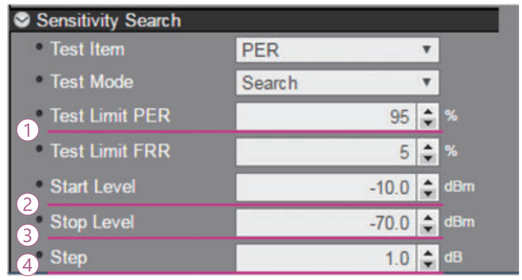


Figure 10 MT8862A Test Limit PER Measurement Menu

The MT8862A has functions for obtaining the PER results and automatically drawing the bathtub curve as a graph as shown below. Additionally, it can also save the obtained results as a file for later analysis.

6.1.2.2 Adjacent channel rejection/Receiver adjacent channel rejection

This evaluates whether or not the signal can be received with little effect from an interference signal when adjacent channels to the signal (channel) received by the WLAN product have interference. The interference signal level is increased from a slightly higher level than the minimum input level sensitivity. The difference between the receive and interference signal levels is measured when the WLAN product PER is about 8% and 10% to perform pass/fail evaluation.

6.1.2.3 Nonadjacent channel rejection

In the evaluation described in section 6.1.2.2, the interference signal is input to adjacent channels to the DUT signal, but in this evaluation, the same procedure is used to input the same standard modulation signal as interference to the non-adjacent channels (channels adjacent to adjacent channels).

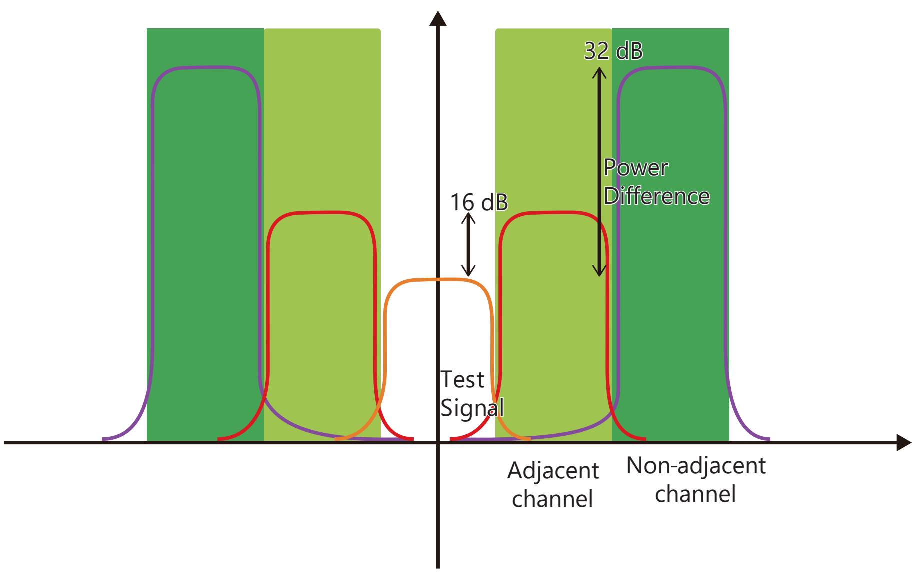


Figure 11 Adjacent Channel Interference

6.1.2.4 Receiver maximum input level

This measures and evaluates the maximum input level sensitivity. In contrast to the minimum input sensitivity level standard in section 6.1.2.1, the input power is increased gradually to evaluate whether or not the signal can be received in the standardized input power range where there are some predetermined errors. The standard requires the ability to receive the signal when the PER (index) for the receive sensitivity is 10% and 8% or less. Like the evaluation described in section 6.1.2 .1, this test plots the relationship between input power and PER. These are determined by the standard as different values for the modulation method, coding rate*8, channel spacing*9, etc.

*8, *9: See section 6.1.2.1

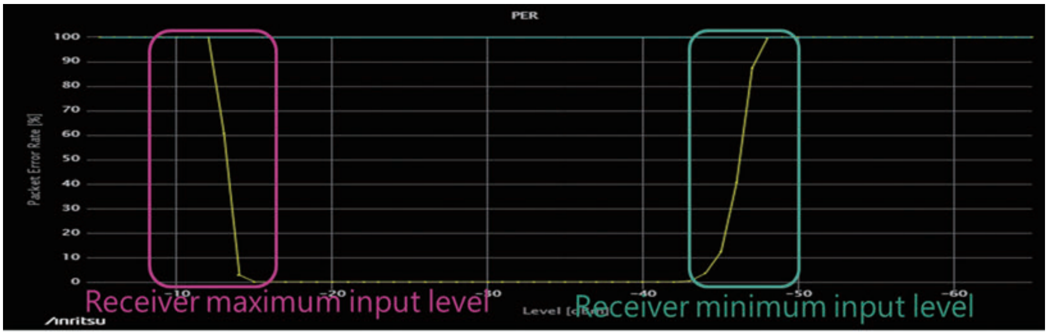


Figure 12 MT8862A Maximum Input Level Sensitivity Measurement Screen

6.2 CTIA

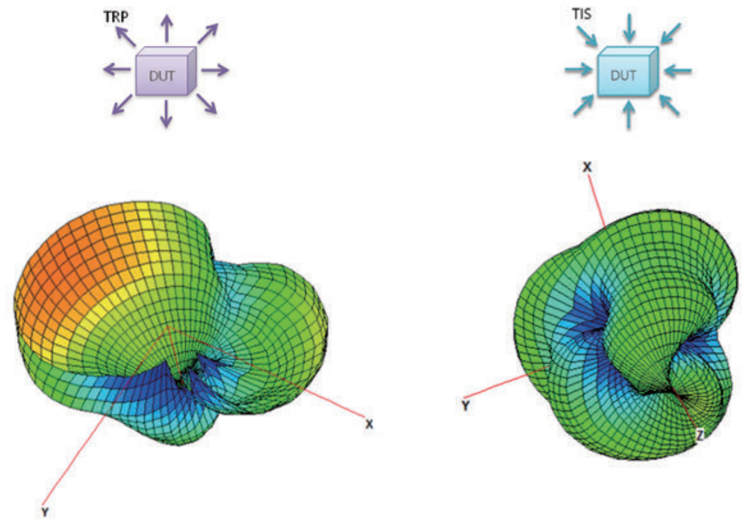
The CTIA Test Plan describes the following OTA tests. OTA measurement requires equipment for changing the orientation of the WLAN product itself or the antenna, an OTA chamber for implementing the OTA environment, and a WLAN tester with a connection to the wireless environment.
By working in partnership with OTA chamber manufacturers, Anritsu offers an integrated solution combining Anritsu measuring instruments with an OTA chamber.

Table 5: CTIA Test Items

	Test Items
4.1	Wi-Fi Total Radiated Measurements (TRP/TIS)
4.2	Wi-Fi Desense Measurements with Cellular Transmitter ON
4.3	Cellular Desense Measurements with Wi-Fi transmitter ON

6.2.1 Wi-Fi Total Radiated Measurements (TRP/TIS)

The Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) of the WLAN product are measured.



Source: http://www.tele.soumu.go.jp/resource/j/equ/mra/pdf/24/j-18.pdf

Figure 13 TRP/TIS Plotting Example

TRP measures the total power radiated in all directions from the antenna(s) of the WLAN product as an index of the transmit performance in 3D space.

In the TIS test, the PER for every reception direction is measured while the WLAN product receives and demodulates the signal from every spatial direction. The spatial average power of arriving signals with an error rate below the standard value is measured within the PER spatial distribution and plotted in 3D space as an index of receive performance.

The TPR and TIS tests are only one standard for evaluating the 3D radiowave radiation and receive characteristics including antenna directivity.

6.2.2 Wi-Fi Desense Measurements with Cellular Transmitter ON

Due to the proximity of WLAN signals to cellular uplink frequencies, sometimes sensitivity can be degraded by interference with cellular signals as well as by the effects of front-end overloading and out-of-band radiation. This test evaluates whether or not the WLAN product can maintain normal receive sensitivity in an environment affected by interference with cellular signals and radiation from an operating cellular device. In concrete terms, a WLAN tester, cellular base station simulator ,and radio-wave chamber are used to make a cellular connection with the DUT. The WLAN product Effective Isotropic Radiated Power (EIRP*10) is measured while the cellular signal is causing interference.

*10: EIRP: Unlike the test in section 6.2.1, which measures the receive sensitivity (TPR) in all directions in 3D space, this test measures the receive sensitivity in the one direction with the highest sensitivity after connecting WLAN.

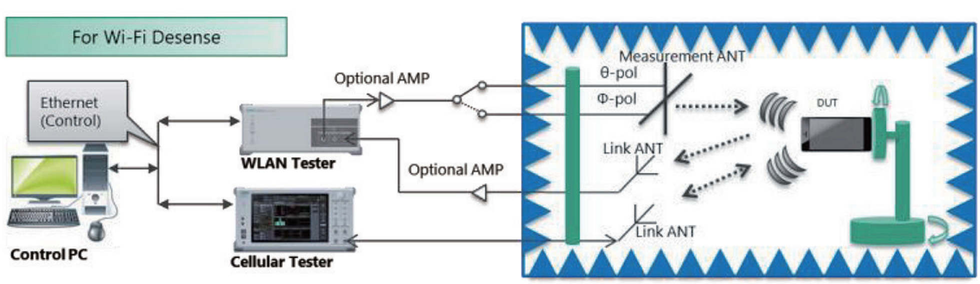


Figure 14 Measurement Setup using MT8862A and Chamber

6.2.3 Cellular Desense Measurements with Wi-Fi transmitter ON

Although similar to the test described in section 6.2.2, this test evaluates whether or not the cellular communications receive sensitivity is maintained while the WLAN is connecting. The EIRP, error rate, and throughput of the cellular communications signals are measured while the WLAN signal is causing interference. This measurement result is compared with the value when there is no interference from the WLAN signal to evaluate the impact of the WLAN product.

7. Precautions When Evaluating Measurement Results

Sometimes, completed products have different test results and measured values from those obtained during the development stage. This can be caused by final fitting of external covers to completed products, or may be due to the effect of signals generated when the WLAN product connects to a peripheral. Evaluating the module itself and the performance on the reference board early in the development stage allows comparison with completed product test results to help discover and counter any deviations.

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Specifications are subject to change without notice.

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