Anritsu Advancing beyond

Evaluating WLAN Products
Transmitter Characteristics

-Introduction to WLAN Measuring Instruments-

Wireless Connectivity Test Set MT8862A

Wireless communications functions are now being built into various recent products, such as digital cameras, cleaning robots, household electrical goods, cameras, sensors, industrial equipment, and the future growth of IoT is expected to further increase wireless deployments.

Generally, a **wireless LAN (WLAN) module** is used to implement WLAN functions in these products and equipment.

Even if the WLAN module meets IEEE and radio legislation requirements, **there is a risk of problems if the WLAN has not been evaluated after implementation as the finished product.**

Wireless Connectivity Test Set MT8862A

~ Finished WLAN Product Problems ~

- ✓ **Changes to finished product firmware after evaluating WLAN product with test firmware can cause issues (drop in Tx power, poor modulation accuracy, etc.).**
- ✓ **Update of WLAN product software (OS, etc.) can cause abnormal WLAN Tx power output (risk of breaking radio legislation rules).**
- ✓ **At development of new high-end models, the Tx power may be lower than older models.**
- ✓ **Tx characteristics can be degraded by module and antenna positioning, and case characteristics.**
- ✓ **Redesigning WLAN products with new modules can result in degraded module characteristics.**

[Assumed Risks]

✓ **Weak Tx power**
→ **Reduced signal reception (service) area**

✓ **Excessive Tx power**
→ **Contravening legal max. permissible power**

✓ **Poor signal quality**
→ **Even with good Tx power, receiver may not demodulate signal correctly**

Reducing these problems and risks requires evaluation of Tx characteristics of finished products with implemented WLAN modules.

Modulation Accuracy (EVM: Error Vector Magnitude) Evaluation

What is Modulation Accuracy?

WLAN supports various transmission rates using different modulation methods, such as BPSK, QPSK, 16QAM, 64QAM, each with different transmission data rates.

Relationship Between Modulation Method and Transmission Rate: What are BPSK/QPSK/16QAM/64QAM?

For example, the 11a/g modulation method (top) and transmission rate (bottom) combinations are listed below.

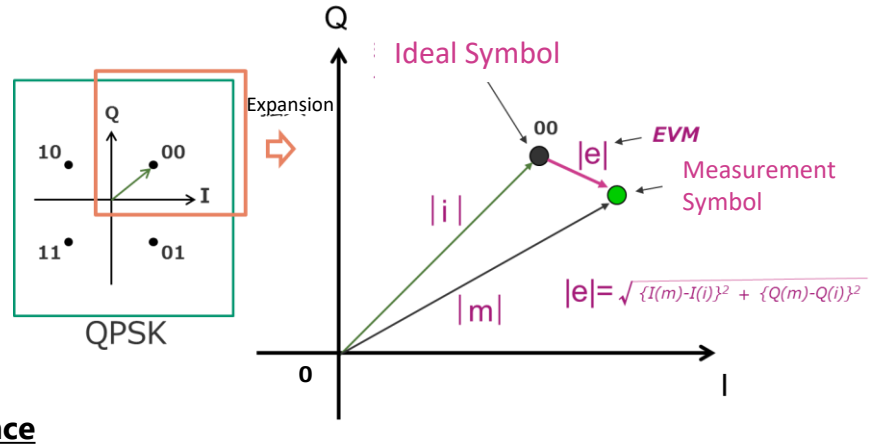
Modulation method:	**BPSK**	<	**QPSK**	<	**16QAM**	<	**64QAM**
Transmission Rate:	**~9 Mbps**		**~18 Mbps**		**~36 Mbps**		**~54 Mbps**

Symbol Point

The amount of transmitted data increases as the number of modulation symbols increases. However, since the gap between adjacent symbols becomes narrower as the number of symbols increases, the transmission is more easily affected by noise.

The figures on the right present an image of the QPSK constellation.

The modulation accuracy (EVM: Error Vector Magnitude) expresses the ratio of the error vector for the measured symbol point to the ideal symbol point.



Modulation Accuracy (EVM) Tolerance

IEEE802.11 defines the required WLAN product specifications, such as the Tx and Rx characteristics, and modulation accuracy is one of the Tx evaluation items. The IEEE standard specifies Relative Constellation Error (dB) but this can be converted to Error Vector Magnitude (EVM) (%) using the following calculation.

The modulation accuracy is better as the values becomes smaller.

However, even if the modulation accuracy is bad, the WLAN product Tx characteristics must not exceed the values (tolerances) in the following table.

Example: IEEE802.11 17.3.9.7.4

Table 17-17 Allowed relative constellation error versus data rate

[Reference] 11a/g

Modulation	Code Rate	RCE*1 [dB]	EVM*2 [%]	Transmission Speed
BPSK	1/2	-5	56.2	6 Mbps
BPSK	3/4	-8	39.8	9 Mbps
QPSK	1/2	-10	31.6	12 Mbps
QPSK	3/4	-13	22.3	18 Mbps
16QAM	1/2	-16	15.8	24 Mbps
16QAM	3/4	-19	11.2	36 Mbps
64QAM	2/3	-22	7.9	48 Mbps
64QAM	3/4	-25	5.6	54 Mbps

EVM dB and % conversion calculation

- RCE [dB] = 20 log (EVM [%] / 100)
- EVM [%] = 100 x 10 $^{\text{RCE [dB] / 20}}$

*1: Relative Constellation Error
*2: Error Vector Magnitude

Source: IEEE Std 802.11™-2020

For example, the permissible EVM is 5.6% for a transmission rate of 54 Mbps.
So, can your finished WLAN products meet these tolerances?

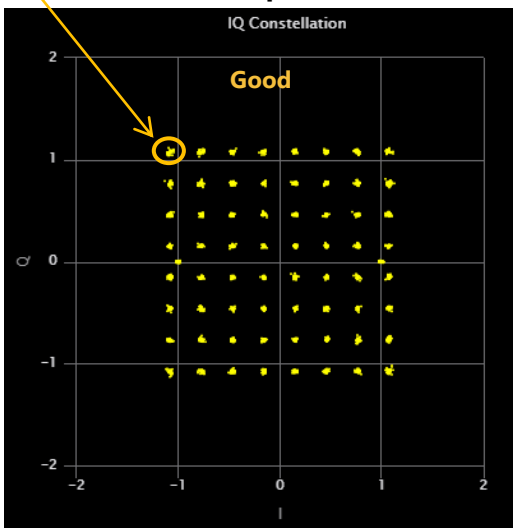
Modulation Accuracy (EVM: Error Vector Magnitude) Evaluation

Modulation Accuracy (EVM) Measurement Example using MT8862A

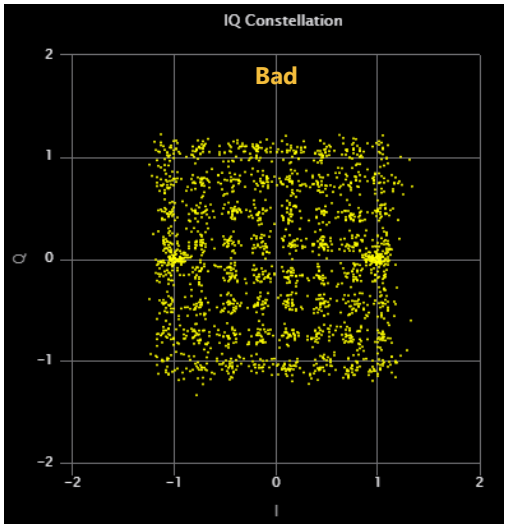
The following figures show actual constellation screens and EVM modulation accuracy measured with the MT8862A for two WLAN products using 64QAM (54 Mbps). With 64QAM, the constellation symbol point matrix is 8 x 8 vertically and horizontally. When the modulation accuracy is good, the symbol points are tightly focused, whereas they are scattered at poor modulation accuracy. With poor modulation accuracy, the receiver side does not receive this signal correctly and either automatically lowers the transmission rate or switches the modulation method, which results in delayed perceived transmission for the user and risks other problems, such as disconnections, as the modulation accuracy becomes worse.

Symbol Point

Example of Constellation Screens Measured by MT8862A



Modulation Accuracy EVMrms
1.8%



Modulation Accuracy EVMrms
9.5%

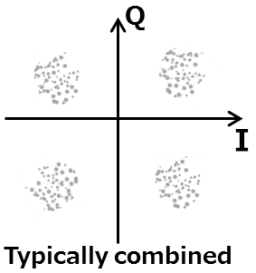
The WLAN product on the right does not meet the 5.6% tolerance for a transmission rate of 54 Mbps.
The transmitted signal is further degraded as it propagates through the air before it reaches the receiver. If the symbols cannot be identified, the receiver cannot demodulate the signal correctly.

Are Modulation Accuracy (EVM) Numeric Results Sufficient?

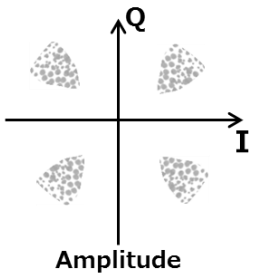
If the numeric result satisfies the IEEE-specified tolerance, it is evaluated as good.

However, **if the tolerance value is not satisfied, looking only at the numeric result only tells that something is bad overall but gives no hint about exactly which factor is bad and what countermeasures to take.**

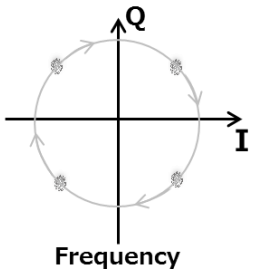
Consequently, confirmation of the constellation diagram is very important. The cause of the EVM deterioration can be evaluated from the appearance of the constellations as follows, giving a hint about which countermeasure to take.



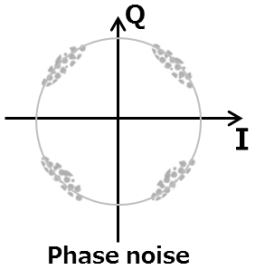
Typically combined



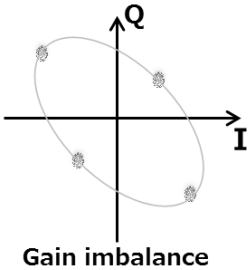
Amplitude



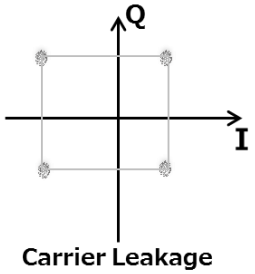
Frequency



Phase noise



Gain imbalance



Carrier Leakage

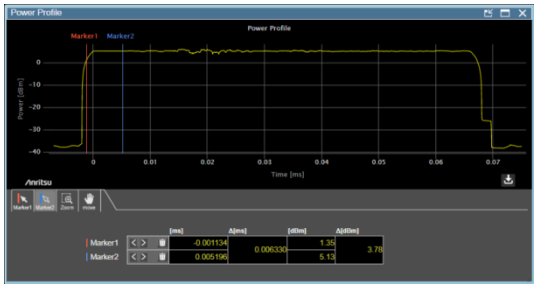
Other Tests For Evaluating Transmission Characteristics (Tx Tests)

MT8862A Transmission Evaluation Items

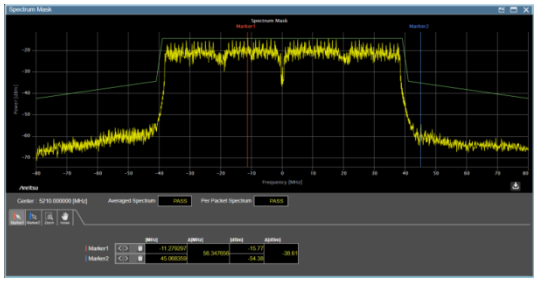
The MT8862A is for evaluating IEEE802.11 Tx characteristics. In addition to measuring the modulation accuracy and constellations, it can also be used to confirm both numeric results, such as Tx power, and graph results, such as the power profile and spectrum mask.

The Tx characteristics of finished products with implemented WLAN modules and product firmware can be evaluated to assure wireless communications quality and reduce problems and risks in actual service.

Numeric Results Screen



Power Profile



Spectrum Mask

IEEE802.11 Tx Characteristics Test Items and Section Number

The MT8862A supports the following test items.

Test Items	802.11a	802.11b	802.11g	802.11n	802.11ac*3	802.11ax*4
Transmit power levels	17.3.9.2	16.3.7.2	18.4.7.2	19.3.18.3	--	--
Transmit spectral mask	17.3.9.3	16.3.7.4	18.4.7.3	19.3.18.1	21.3.17.1	27.3.19.1
Transmit center frequency tolerance	17.3.9.5	16.3.7.5	18.4.7.4	19.3.18.4	21.3.17.3	27.3.19.3
Chip/Symbol clock frequency tolerance	17.3.9.6	16.3.7.6	18.4.7.5	19.3.18.6	21.3.17.3	27.3.19.3
Transmit power-on and power-down ramp	--	16.3.7.7	--	--	--	--
Transmitter center frequency leakage	17.3.9.7.2	--	17.3.9.7.2	19.3.18.7.2	21.3.17.4.2	27.3.19.4.2
Transmitter spectral flatness	17.3.9.7.3	--	17.3.9.7.3	19.3.18.2	21.3.17.2	27.3.19.2
Transmitter constellation error	17.3.9.7.4	--	17.3.9.7.4	19.3.18.7.3	21.3.17.4.3	27.3.19.4.3
Transmitter modulation accuracy test	17.3.9.8	16.3.7.9	17.3.9.8	19.3.18.7.4	21.3.17.4.4	27.3.19.4.4

*3: 802.11ac Tx measurements require MX886200A-001.
*4: 802.11ax Tx measurements require MX886200A-002.

"- -" indicates no defined standard.

Source: IEEE Std 802.11™-2020
IEEE Std 802.11ax™-2021

Ordering Information

We recommend the following MT8862A composition for evaluating WLAN product TRx connection characteristics.

Model	Name	Remarks
MT8862A	Wireless Connectivity Test Set	Main Unit
MT8862A-001	RF Frequency 2.4 GHz, 5 GHz*5	Required option
MX886200A	WLAN Measurement Software*6	For IEEE 802.11b/g/a/n TRx evaluations
MX886200A-001	WLAN 802.11ac Option*7	For IEEE 802.11ac TRx evaluations
MX886200A-020	WLAN Security Function*7	Supports WEP, WPA-Personal, WPA2-Personal

*5: Requires MT8862A *6: Requires MT8862A-001 *7: Requires MX886200A

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