# Guide for Getting Started with the A2W-series Wireless System

**Revision G**


Cat. No. A267-E1-01

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# Glossary of Terms in Wireless Technology

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## ACK

ACK stands for Acknowledgment. A signal sent from the receiving side to inform the sending side that reception is completed correctly.

## ARIB

ARIB stands for Association of Radio Industries and Businesses.
It is a public interest corporation that promotes the practical application and the spread of radio wave use system in the field of communications and broadcasting. The predecessor of ARIB is the radio system development center, called "RCR", and it is the remnant of this name change that "RCR STD" and "ARIB STD" are mixed in the standard.

## JATE

JATE stands for Japan Approvals Institute for Telecommunications Equipment.
It is a public interest corporation that conducts business such as certification conformity to technical standards related to telecommunications terminal equipment based on the Telecommunications Business Law.



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## Modbus

An open protocol for serial communications developed by Modicon (now AEG Schneider Automation International S.A.S.). Modbus is widely used in the industrial automation and process automation markets for devices such as inverters and temperature controllers. Unlike some of other open networks, Modbus has no organization for verification or certification. There are two versions of the protocol, Modbus-ASCII and Modbus-RTU.

## Error Control

A method for reducing the errors generated on a communications channel by using error-correcting codes and error-detecting codes to increase the line's reliability.

## Error Rate

The probability of an error being generated in a transmitted signal in a digital transmission. Expressed as the bit error rate (BER). Values closer to 0 indicate lower error rates and more stable communications.



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## Technical Standards Conformity Certification of Specified Radio Equipment

Certifications legally-required for wireless products in Japan. Wireless products can be get certified after passing some tests. In case operators employ only certified wireless products, there are some benefits such as: preliminary licenses are not required, inspections of facilities required on inauguration can be skipped, licenses are not required in some wireless products, etc.
As the wireless products from OMRON are already get certified, our customers can employ them without any licenses and applications.

## Antenna Power

The power supplied from a wireless transmitter to the antenna. Indicates the radio wave strength.

## Frequency Channel

A channel assigned to a frequency band.

## Reception Level

The strength of the radio waves received by a wireless receiver.



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## Serial Communications

A communications method in which data is sent one bit at a time using one signal line.

## Sourcing (NPN) and Sinking (PNP)

Open collector output types (positive common and negative common). Sinking output has a negative common and current that flows from the load to the unit when output is ON. Sourcing output is the opposite — the common is positive, and the current flows from the unit to the load when output is ON.
Which output type to use will depend on the specifications of the connected device.

## Simplex (Half-Duplex)

Simplex is a communications format that alternates between transmitting and receiving while using the same frequency. It enables bidirectional communications on the same frequency. Transceivers are a familiar example.



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## Radio Frequency Interference

A phenomenon in which two or more radio waves arrive at the same physical location and overlap, strengthening or weakening each other. The term is commonly used to refer to interference from signal infiltration in a communications system, such as interference from another radio station.

## Radio Law

The law that sets forth the basic regulations on the use of radio waves in Japan. It specifies the conditions for radio station licenses, radio equipment, and radio equipment operators (radio practitioners). It also covers areas such as permitted radio wave frequencies, strengths, and usage objectives.

## Specified Low-Power Radio

A category of radio equipment defined by Japan's Radio Law. Satisfies the following conditions:

- Has a transmitter power output of 1 W or less.
- Uses a radio wave type and frequency that has been specified by the Ministry of Internal Affairs and Communications.
- Has a function for automatically sending or receiving a call sign or call signal, and a function for preventing signal interference.
  Does not interfere with the operation of other radio stations.
- Uses only radio equipment that has been certified under the Radio Equipment Technical Standards Conformity Certification system.



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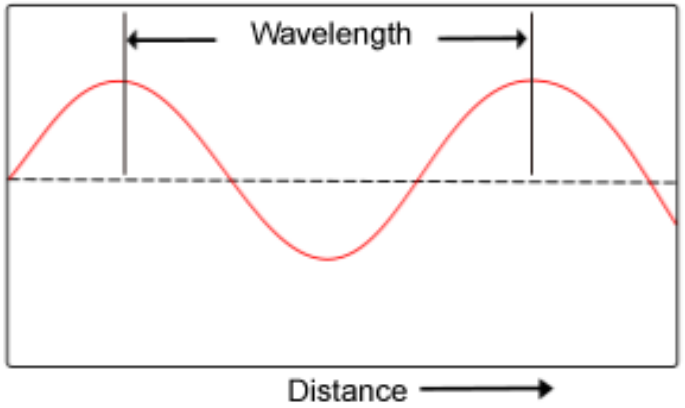
## Packet

Meaning a small bundle or parcel. As the name suggests, a packet is a single chunk of data transferred on a network. Packets usually contain information such as the protocol header that signals the start of communications, the recipient/sender address, flags indicating the nature of the data, the data body, and finally an error detection code.

## Wavelength

The distance between adjacent wave peaks in a sinusoidal wave phenomenon such as electromagnetism or sound.
As a wave's frequency increases, there is a corresponding increase in its straightness, but a corresponding decrease in its wavelength and energy.



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## Protocol

The rules governing communications. Protocols are used to enable two-way machine-to-machine communications between computers, communications terminals or communications networks. They consist of various agreements specifying areas such as methods of expressing information, information meaning/content, and communications methods.

## Multipath Phasing

When a transmitted radio wave propagates through physical space, effects such as reflection cause the wave to take several different propagation paths to the receiver. Multipath phasing refers to the interference, weakening, and distortion that occur among the signals on these different paths.



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# FAQs on Wireless Products

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## Q1. Are wireless devices vulnerable to power supply noise?

A1. The impact of noise caused by power supply will be almost the same in case of both wired devices and wireless devices.
Note: Depending on the operating environment, the degree of influence of noise etc. on the device will change. As for actual use, test it in the environment before using.

## Q2. What kind of tests are being performed on wireless devices against external noise in the factory automation environment?

A2. The A2W-series meets the European Standard (EN) for noise testing.
However, in order to avoid the influence of noise, separate the signal line and the power line from each other. Also, depending on the environment, the degree of influence such as the noise received by the device will change, so as for actual use, test it in the environment before using.



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## Q3. Are wireless devices outputting erroneous data by garbled data?

A3. In the A2W-series, incorrect data will not be output from the Master Unit.
On the receiver side, an error detection function that adds an error check code for each communications packet is pre-installed. Therefore, even if data garbled due to noise or other factors, incorrect data will not be output from the receiver as it is.

## Q4. Can data communications ever fail?

A4. In the A2W-series, communications may be disturbed due to some unavoidable reason such as large impact from environment. Even in case of the communications failure, the device is designed not to output incorrect data but to output no data. The data are always verified by the wireless device itself before output.
For factors that may cause problems, refer to "3-1 Installation and Operating Environment" in the A2W-series User's Manual (Cat. No. A265).



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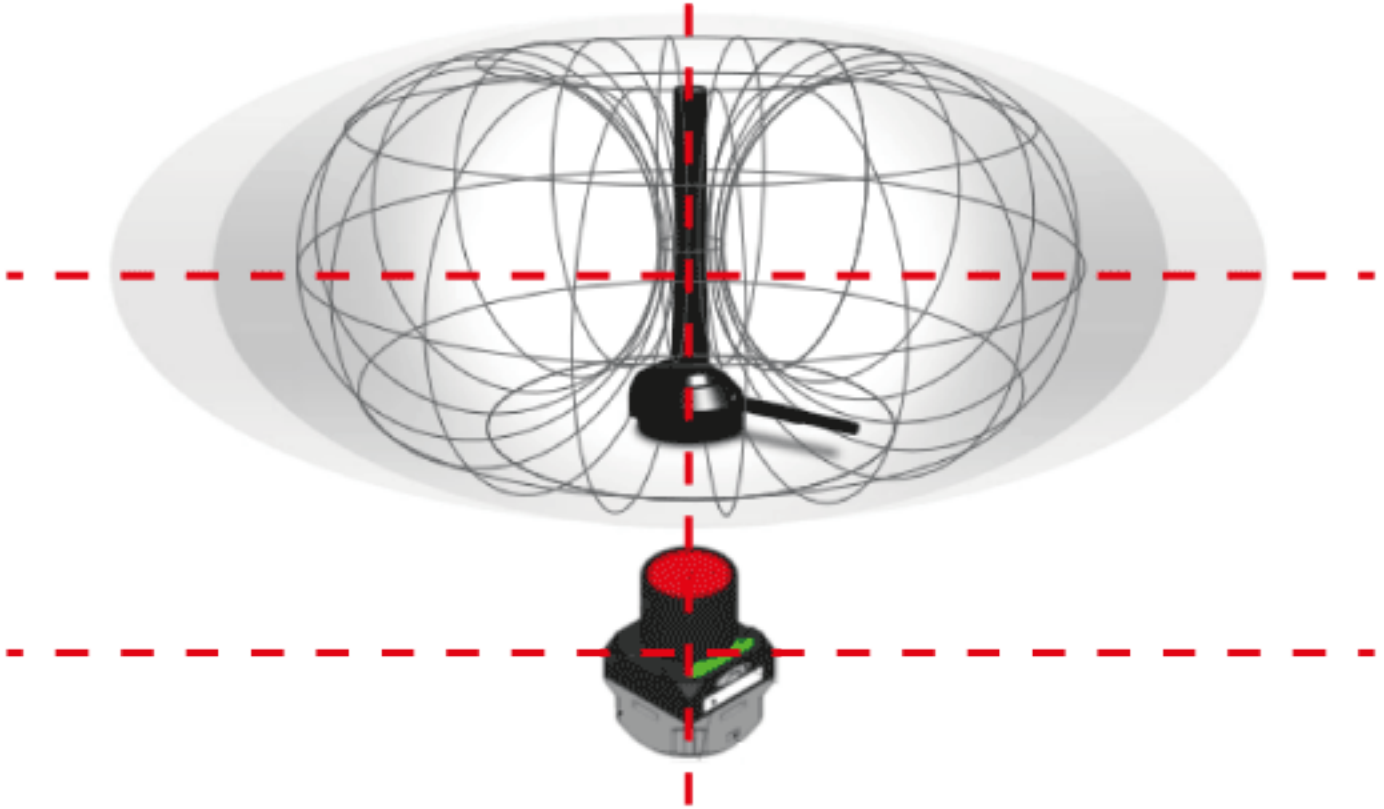
## Q5. How are the radio waves emitted from the antenna?

A5. Radio waves are generated in a circle perpendicular to the longer side direction of the antenna as shown below.







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## Q6. What is the communications distance of wireless devices?

A6. Approximate communications range of the A2W-series is about 100 m under line-of-sight environment.

- The communications distance varies depending on the installation environment (antenna installation position, height, obstacle, etc.). Be sure to perform a communications test at the site. (For testing, contact your OMRON representative.)
- The effect of an obstacle on radio waves will vary depending on what the obstacle is made of. The radio waves are affected by the material of the obstacle. Radio waves will penetrate glass, plastics etc., and will decay in concrete, walls, gypsum boards, mortars etc. Also, it reflects on metal objects.



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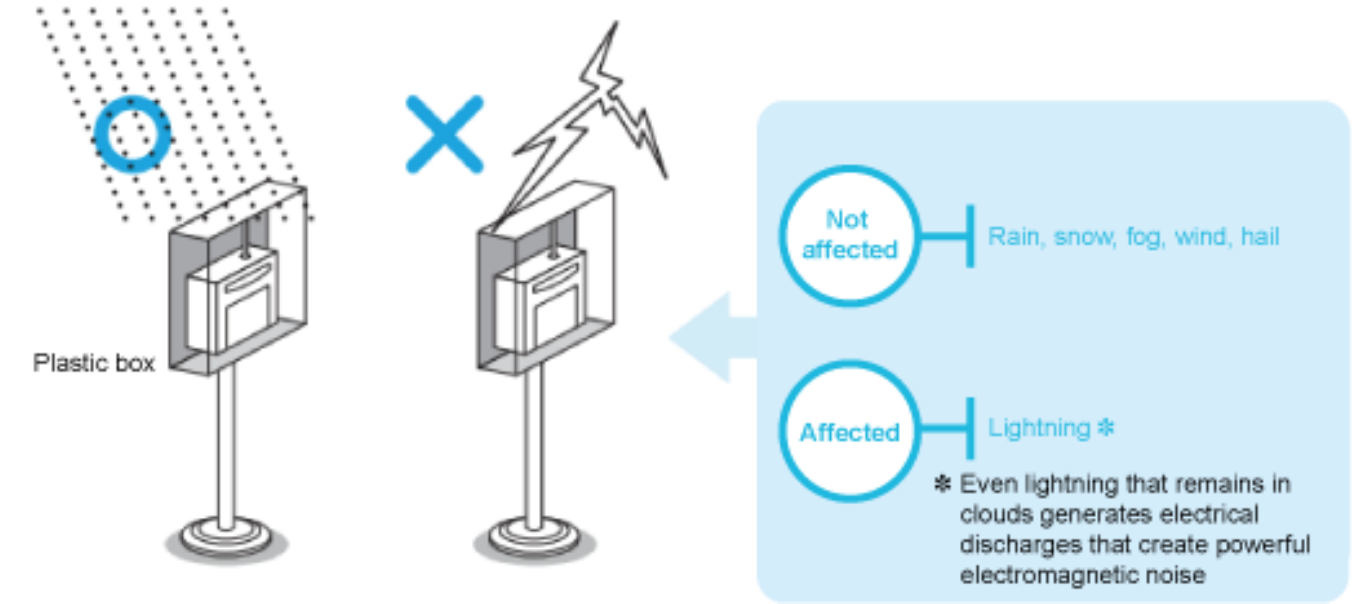
## Q7. Does the weather affect the communications of wireless devices?

A7. In general, communications are not affected by weather other than thunder.
The radio wave is affected by the weather is absorbed by oxygen ($O_2$) and water vapor ($H_2O$). Regarding rain, it is said that frequencies of several GHz or more are affected in heavy rain condition, and frequencies of 10 GHz or more (e.g., BS broadcast) are affected in normal rain condition.



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## Q8. Are there any waterproof wireless devices available?

A8. The A2W-series Slave buttons are waterproof (IP65 rating), but the Master Units are not. The optional magnetic base antenna (A2W-AT2.5-WC1) for Master Units is waterproof (IP65 rating).

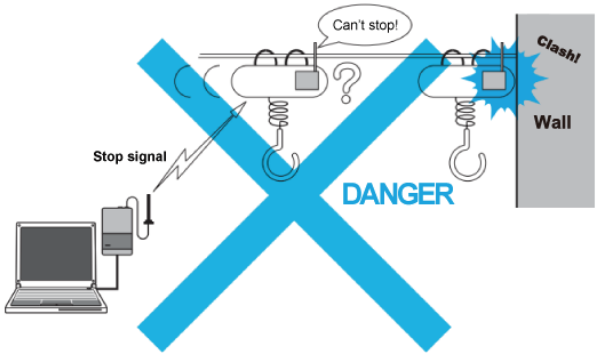
## Q9. Can the antenna be removed from the wireless device and used?

A9. No. It is prohibited by the Radio Law in Japan.

## Q10. Tell me about the applications where wireless devices can be used.

A10. In the A2W-series, a person operates a Slave button. If a person confirms a communications failure, the Slave Button needs to be operated again. You can use it in applications where the delay time of this operation can be tolerated.

- It can not be used in applications requiring high speed (real-time performance).
- It is not recommended for applications with problem for the Product Liability Law such as hoist crane application.

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## Q11. Can the wireless devices be used overseas?

A11. The A2W-series has compatible models for each area.
For the areas supported, refer to "2-3 List of Models" in the A2W-series User's Manual (Cat. No. A265).

## Q12. Does the communications distance change depending on the installation direction of the antenna?

A12. It will change.
Adjust the base antenna so that the communications can stabilize.



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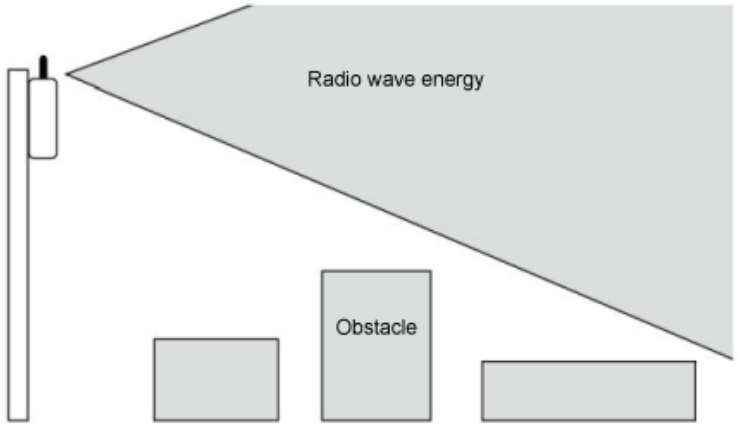
## Q13. Does the communications distance change depending on the installation height of the antenna?

A13. It will change. If the installation position is high, it will be installed in a more open space. Therefore, it is not affected by obstacles, and radio waves are easy to reach.




Mount wireless unit as high up as possible

**[IMPORTANT]**

There are three reasons why you must raise the antenna height.

1. Radio waves are transmitted over the ground.
2. Avoid obstacles (metal etc.) that radio waves are hard to transmit.
3. Ensure that radio waves are not blocked by people.
   Since the human body is composed of water, it is an obstacle to radio wave transmission.



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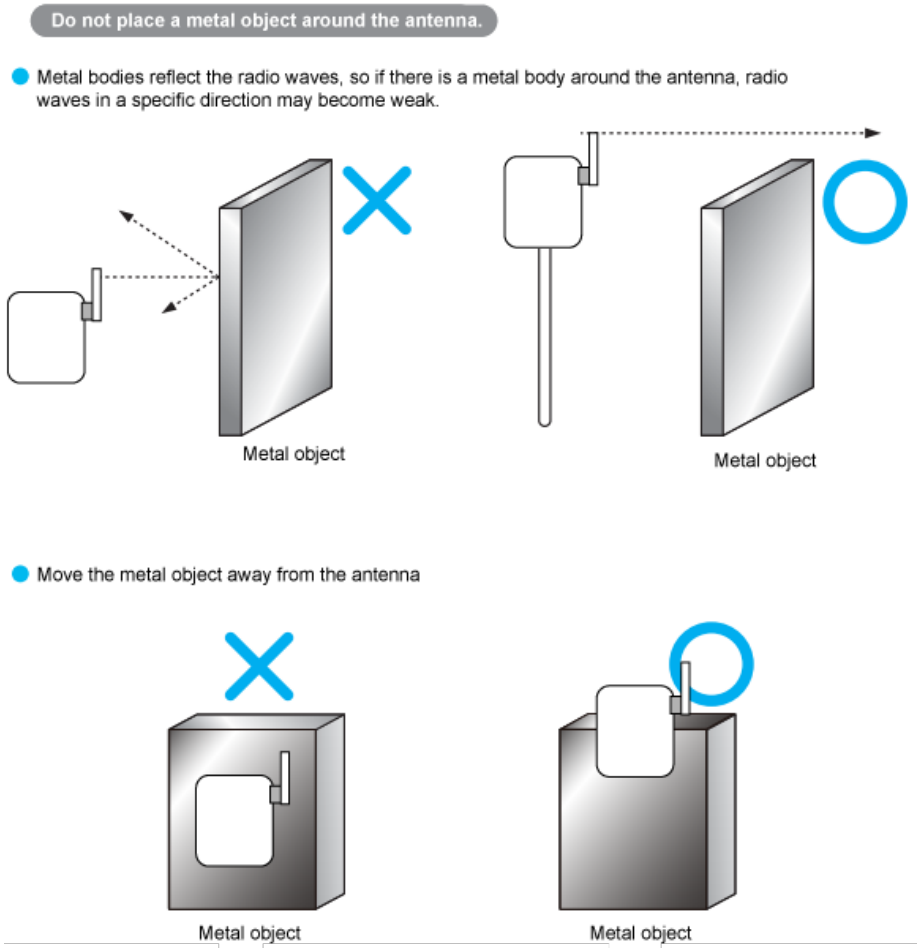
## Q14. Does metal around the antenna affect communications?

A14. Yes. Keep the antenna away from the metal object..





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## Q15. How much attenuation of radio waves by obstacles exists?

A15. It depends on material. In general, attenuation of radio waves by metals is large and radio waves are hardly transmitted. The attenuation of radio waves by concrete is also large. The attenuation of the radio waves by the glass with the wire is large, while the attenuation of the radio wave by the transparent glass is relatively small.
A calculation example showing the degree of attenuation is as follows.

| Sample No. | Construction material | Thickness (mm) | Transmission loss (dB) | Damping factor (%) |
|---|---|---|---|---|
| ① | Plywood | 12 | 1.2 | 24.1 |
| ② | Drywall | 125 | 0 | 0 |
| ③ | Glass wool | 55 | 0 | 0 |
| ④ | Glass wool | 105 | 0 | 0 |
| ⑤ | Insulation film + Glass | 5 | 0 | 0 |
| ⑥ | Drywall (water-resistant) | 125 | 0.2 | 4.5 |
| ⑦ | Drywall (reinforced) | 125 | 0 | 0 |
| ⑧ | Flooring | 12 | 0.9 | 18.7 |
| ⑨ | Slate sheet | 12 | 1.8 | 33.9 |
| ⑩ | Mortar wall (15 mm) + Lath material + Felt + Plywood (12 mm) | 32 | 15.8 | 97.4 |
| ⑪ | Reinforced glass | 6.8 | 18.3 | 98.5 |
| ⑫ | ALC concrete | 100 | 8.5 | 85.9 |
| ⑬ | Ceramic siding board (12 mm) + Plywood (12 mm) | 24 | 3.2 | 52.1 |
| ⑭ | Brick (100 mm × 210 mm × 57 mm) + Plywood (12 mm) | 72 | 5.6 | 72.5 |
| ⑮ | Steel-reinforced concrete (90 mm) + Plywood (12 mm) | 102 | 8.9 | 87.1 |
| ⑯ | Steel-reinforced concrete | 180 | 11.8 | 93.4 |
| ⑩+⑪ | Mortar wall and reinforced glass | 38.8 | 27.6 | 99.8 |
| ⑬+①+③+② | Ceramic siding board, plywood, glass wool, and drywall | 109.5 | 4.5 | 64.5 |



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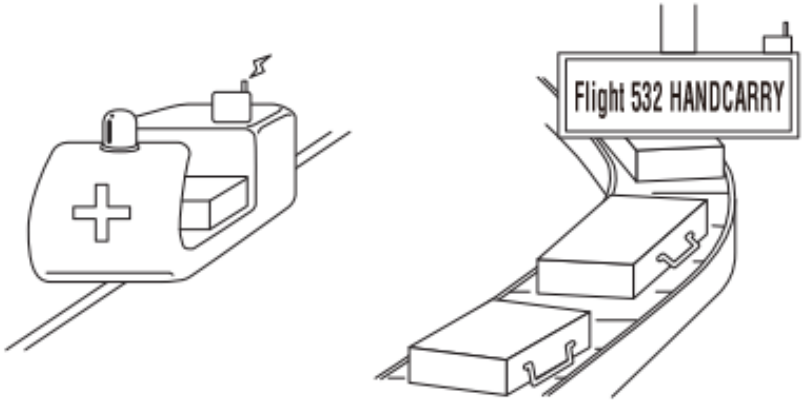
## Q16. Can the A2W-series communicate with wireless devices from other manufacturers?

A16. No. OMRON devices can't communicate with non-OMRON devices since they each adopt different protocols.
When other wireless devices are in the same area, take measures to avoid interference.

## Q17. Does the A2W-series affect other devices?

A17. The A2W-series will rarely cause other devices to malfunction, because it is a specified low-power radio device.
However, note that the A2W-series may affect devices that have not cleared the noise test according to the EN standard. Therefore, be careful if they are nearby.

- Specified Low-Power Radio Stations are used in hospitals for applications such as EKG telemetry and automated guided vehicles (AGVs) used on hospital grounds. Our Specified Low-Power Radio devices have been employed in airports (areas of high density frequency usage), but radio frequency interference among different devices has not been a problem.



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## Q18. Can communications status of wireless devices be confirmed?

A18. The A2W-series have indicators for confirmation.
The communications status can be confirmed on the LEDs on the device.

| LED color | Meaning |
|---|---|
| Green | Receiving successful (reception field strength RSSI: Low) |
| Yellow | Possibility of reception failure (Retry is recommended.) * Slave button only. |
| Red | Possibility of reception failure (Retry is recommended.) * Slave button only. |
| Not lit. | Slave button failure, deterioration, or switch signal not sent * Slave button only. |

## Q19. When multiple wireless devices transmit data at the same time, can communications be performed?

A19. Master Unit can not receive operation of multiple Slave button at the same time. The time interval from the operation of a certain Slave button to the operation of the next Slave button must be secured for 100 ms.

## Q20. Tell me the basics of radio waves.

A20. Radio waves are electromagnetic waves with a frequency of up to 3 million MHz.
Japan's Radio Law specifies the frequencies, strengths, objectives, and other properties that radio waves must have when used for various applications.
As radio waves increase in frequency, they take on properties that more closely resemble visible light.
In other words, they have greater straightness and are more affected by obstacles.

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## Q21. How is the radio waves transmitted?

A21. The radio waves are transmitted as follows.

| | |
|---|---|
| [Straight ahead] | Continue straight as long as there are no obstacles and do not change itself. |
| [Reflection] | Radio waves are reflected just as visible light is reflected by mirrors or other reflective surfaces. Radio waves pass through materials such as paper and glass, but reflect strongly off metal objects. |
| [Diffraction (wraparound)] | It travels around behind obstacles such as the shadow of the building and the back side of the mountain. Basically, the lower the frequency (the longer the wavelength), the more the degree of diffraction occurs. |

## Q22. Tell me about radio interference.

A22. The receiver receives composite waves of reflected waves and direct waves.
If the peaks of the waves are combined with each other, they strengthen each other, and if the bottoms of the waves are combined, they weaken each other (called fading).
Even if the distance from the transmitter is the same, there may be places with good reception conditions and bad ones.


Direct wave and reflected wave strengthen or weaken each other.



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## Q23. What is ARIB?

A23. ARIB stands for Association of Radio Industries and Businesses
It is a public interest corporation that promotes the practical application and the spread of radio wave use system in the field of communications and broadcasting. The predecessor of ARIB is the radio system development center, called "RCR", and it is the remnant of this name change that "RCR STD" and "ARIB STD" are mixed in the standard.

## Q24. What is technical standards conformity certification of specified radio equipment?

A24. The mark with R added indicates that it is a device that has received technical standards conformity certification or construction design certification (i.e., certification by registration certificate authority or proof of certification).
Since the A2W-series has acquired the technical certification conformity certification and the construction design certification, it can be used without license and with no application required.




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## Q25. Tell me about the differences between the 2.4 GHz band and the sub GHz band.

A25. The A2W series uses the 920 MHz band (for Japan etc.) and 860 MHz band (for Europe etc.) as the sub GHz band.
The differences between the sub GHz band and the 2.4 GHz band used in the A2W series are shown in the table below.

| | Standard | Interference | Diffraction |
|---|---|---|---|
| Sub-GHz bands<br>920 MHz band<br>860 MHz band | Specified Low-Power Radio | Low<br>● Sub-GHz wireless devices<br>● Mobile phones *1<br>● RFID *2 | Good |
| 2.4 GHz band | Wireless LAN<br>Wi-Fi<br>ZigBee<br>Bluetooth | High<br>● 2.4 GHz wireless devices<br>● LCD displays<br>● Cordless phones<br>● Microwave ovens<br>● Antenna coaxial cables (for satellite broadcasts)<br>● Power supplies | Poor |

*1: Interference may occur in areas such as China and Malaysia.
*2: Interference may occur in areas such as North America.



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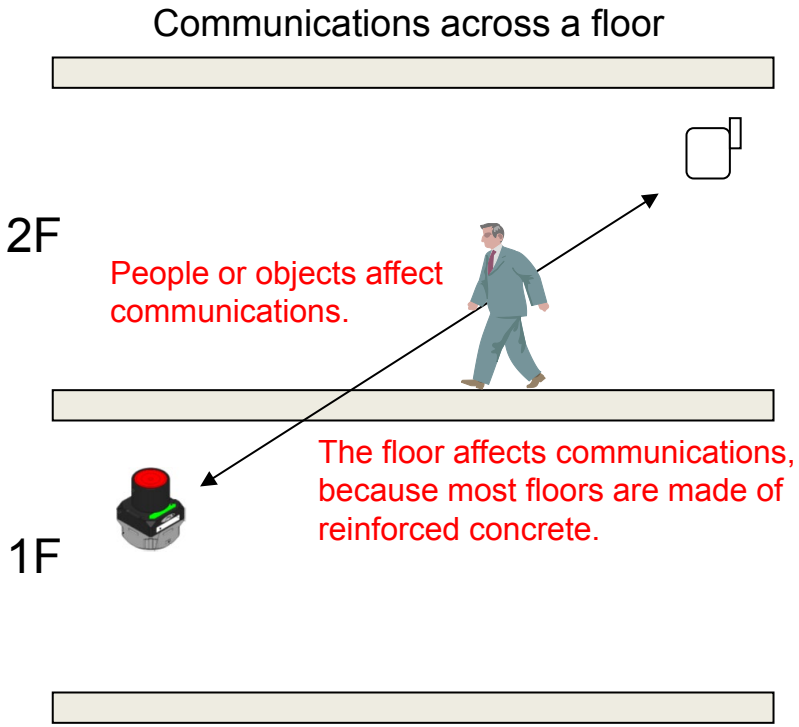
## Q26. Can the wireless communications be performed across a floor?

A26. Communications across the floor through the floor material are not recommended because it is highly likely to be affected by the floor material, people, other objects, and communications becomes unstable.



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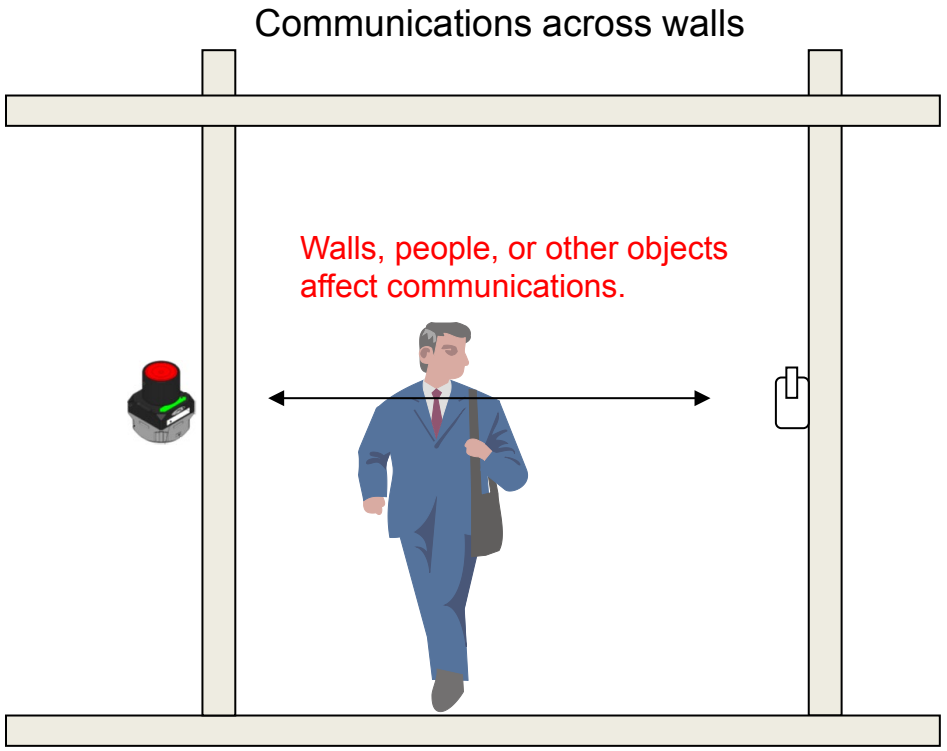
## Q27. Can wireless communications be performed across walls?

A27. The Wall itself or people or objects on the other side of the wall will become obstacles. Therefore communications becomes unstable, so it can not be recommended.



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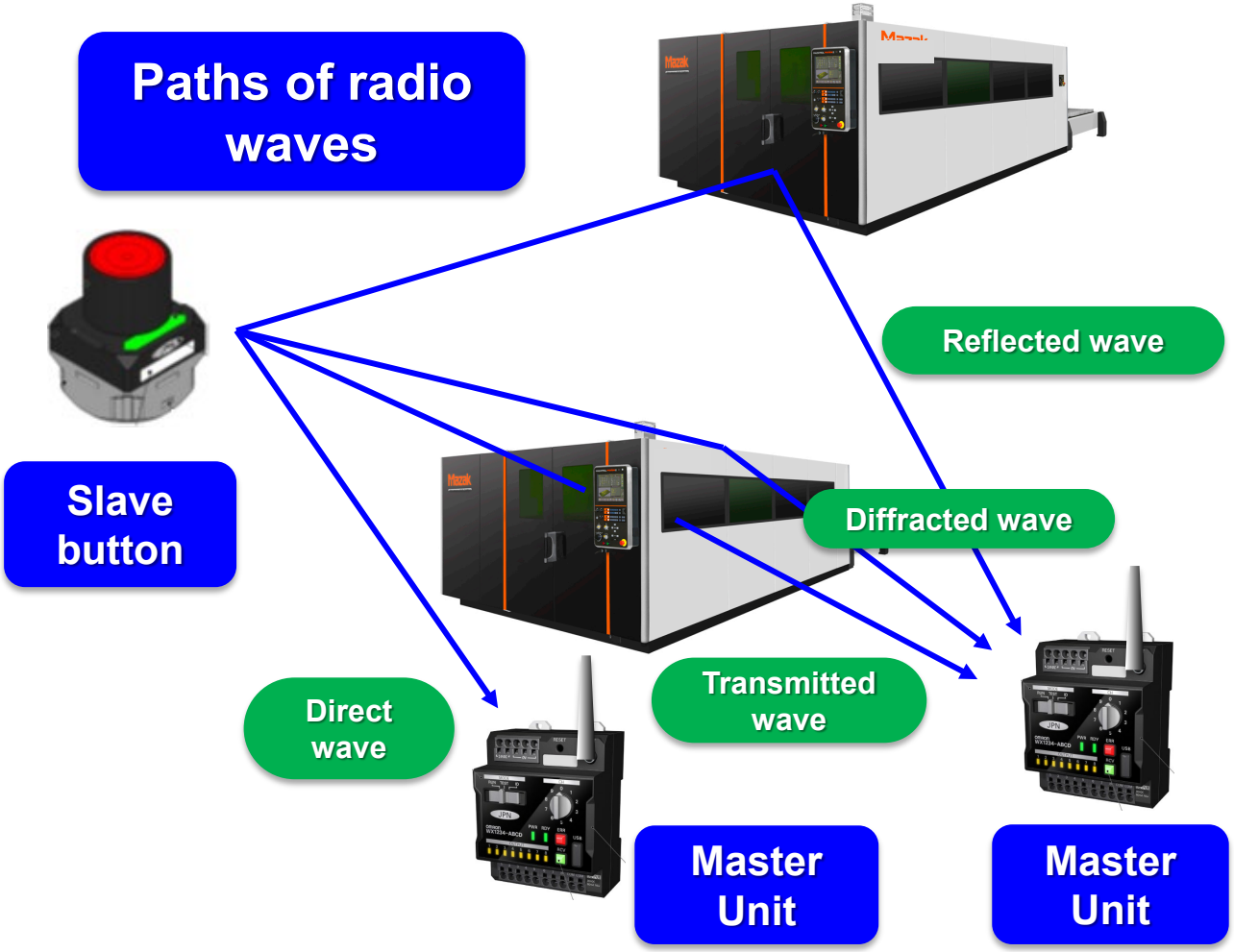
# Features and Characteristics of the Radio Waves

# How Radio Waves Are Transmitted

In the process in which radio waves are actually emitted and transmitted, the radio waves change under the influence of "reflection and transmission", "diffraction", "interference"

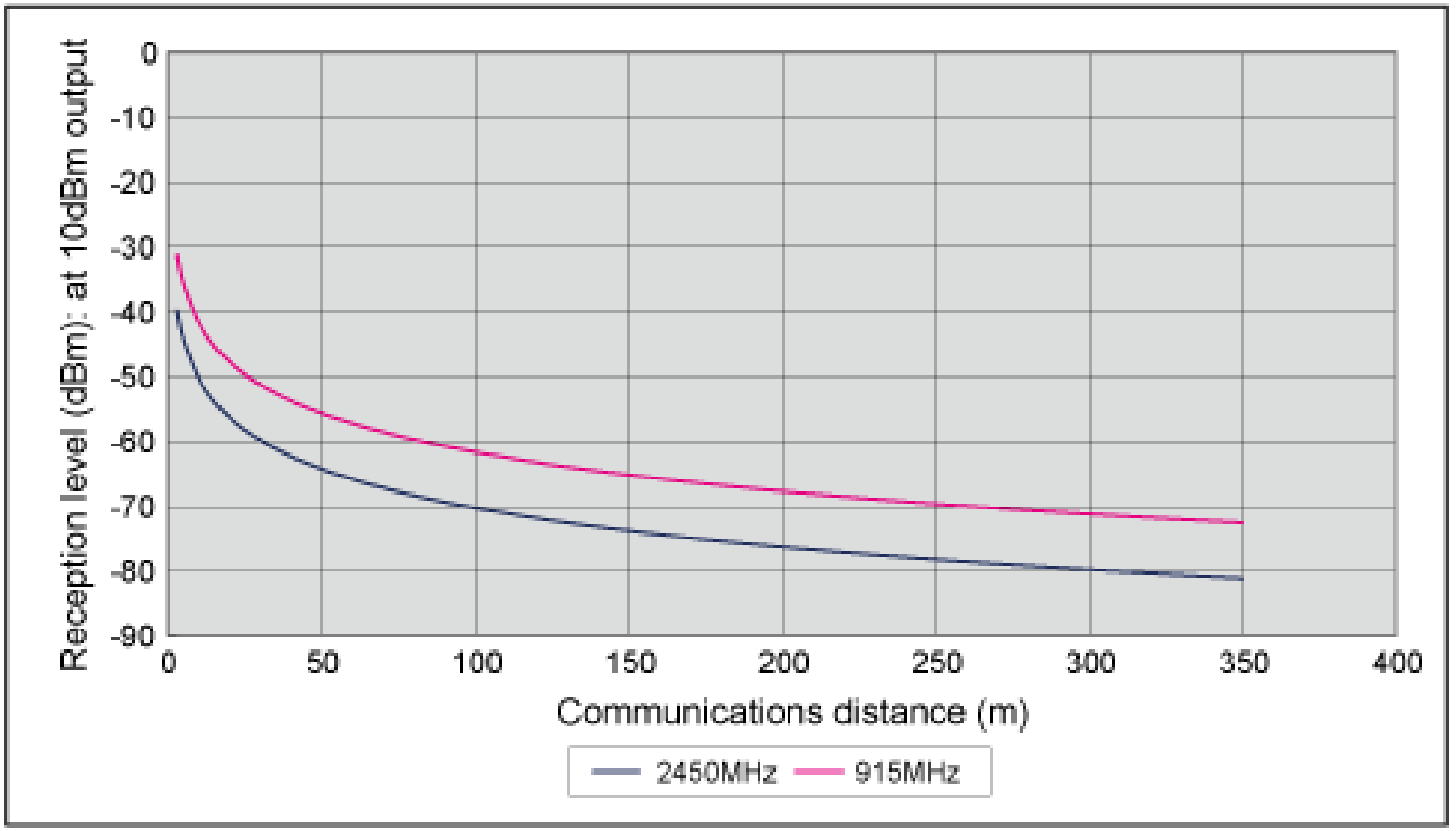


# Direct Wave: Free Space Propagation

The loss in the propagation of the free space is proportional to the square of the distance. Also, it is proportional to the minus second power of the wavelength, so the higher the frequency, the greater the attenuation.

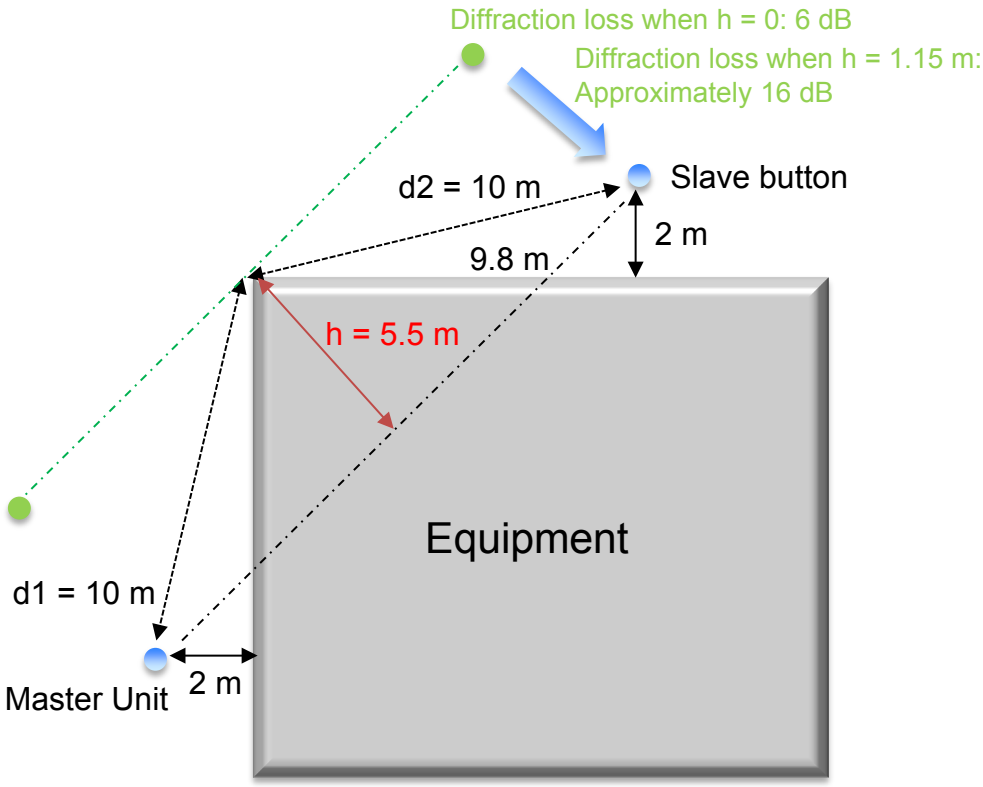
* In the case of 2450 MHz, the loss is larger by approx. 8.6 dB than in the case of 920 MHz (In the case of the same reception sensitivity with the same output power, it is approx. 2.7 times difference in distance conversion).

Free space propagation loss L (dB) = 20 Log(4πd/λ)



# Diffraction Wave: Attenuation due to Diffractions

Even if the outlook is blocked, not all the power is cut off. Diffractions will occur at the end of the blocking object, and some electric power will arrive. The higher the frequency, the more the diffraction loss will increase.




**Example: knife-edge diffraction model**

■ Diffraction parameter (ν)

$$\nu = h\sqrt{\frac{2}{\lambda}\left(\frac{1}{d_1}+\frac{1}{d_2}\right)}$$

929.2 MHz ⇒ λ = 322.6 mm  ν = 6.12
868.3 MHz ⇒ λ = 345.3 mm  ν = 5.92
2,400 MHz ⇒ λ = 124.9 mm  ν = 9.84

■ Diffraction loss approximate formula

Gd = 20 log (0.225/ν)

929.2 MHz ⇒ Gd = 28.7 dB
868.3 MHz ⇒ Gd = 28.4 dB
2,400 MHz ⇒ Gd = 32.8 dB

When ν = 0, exactly half of the path is blocked, so the loss is 6 dB.
Blocking the first Fresnel zone creates a loss of approximately 16 dB.
* 929.2 MHz  h = 1.15 m
  2,400 MHz  h = 0.72 m
The formula defining ν shows that even when h is constant, higher frequencies result in correspondingly higher values of ν, so the diffraction loss increases. The formula proves that higher frequencies result in correspondingly greater attenuating in the zone of effect.

# Transmitted Wave: Attenuation of Radio Wave by Obstacles

The attenuation of radio waves due to obstacles depends on the material. In general, attenuation of radio waves by metals is large and radio waves are hardly transmitted. The attenuation of radio waves by concrete is also large. The attenuation of the radio waves by the glass with the wire is large, while the attenuation of the radio wave by the transparent glass is relatively small.
A calculation example showing the degree of attenuation is as follows.

| Sample No. | Construction material | Thickness (mm) | Transmission loss (dB) | Damping factor (%) |
|---|---|---|---|---|
| ① | Plywood | 12 | 1.2 | 24.1 |
| ② | Drywall | 125 | 0 | 0 |
| ③ | Glass wool | 55 | 0 | 0 |
| ④ | Glass wool | 105 | 0 | 0 |
| ⑤ | Insulation film + Glass | 5 | 0 | 0 |
| ⑥ | Drywall (water-resistant) | 125 | 0.2 | 4.5 |
| ⑦ | Drywall (reinforced) | 125 | 0 | 0 |
| ⑧ | Flooring | 12 | 0.9 | 18.7 |
| ⑨ | Slate sheet | 12 | 1.8 | 33.9 |
| ⑩ | Mortar wall (15 mm) + Lath material + Felt + Plywood (12 mm) | 32 | 15.8 | 97.4 |
| ⑪ | Reinforced glass | 6.8 | 18.3 | 98.5 |
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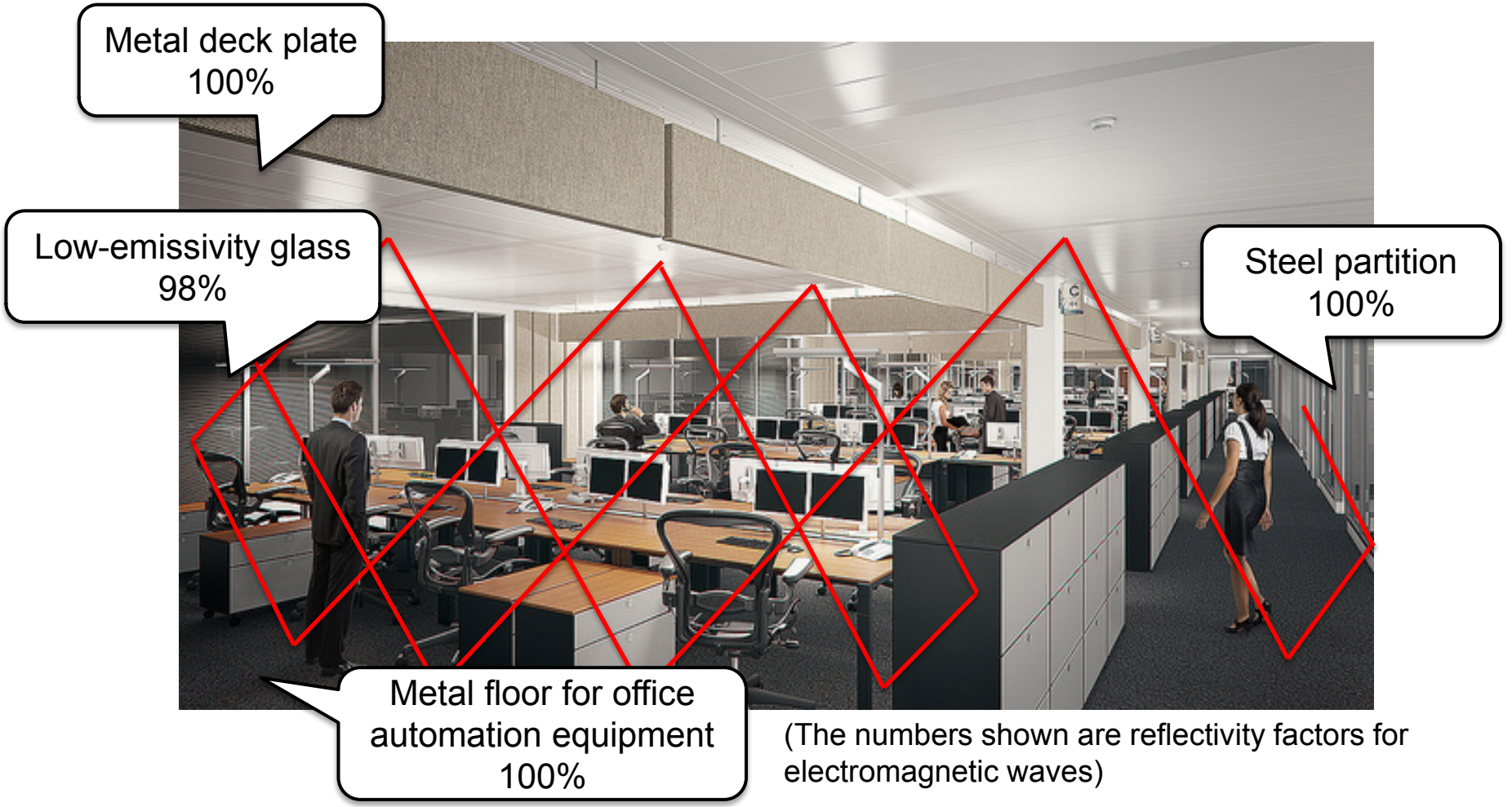
| ⑯ | Steel-reinforced concrete | 180 | 11.8 | 93.4 |
| ⑩+⑪ | Mortar wall and reinforced glass | 38.8 | 27.6 | 99.8 |
| ⑬+①+③+② | Ceramic siding board, plywood, glass wool, and drywall | 109.5 | 4.5 | 64.5 |

# Reflected Waves:

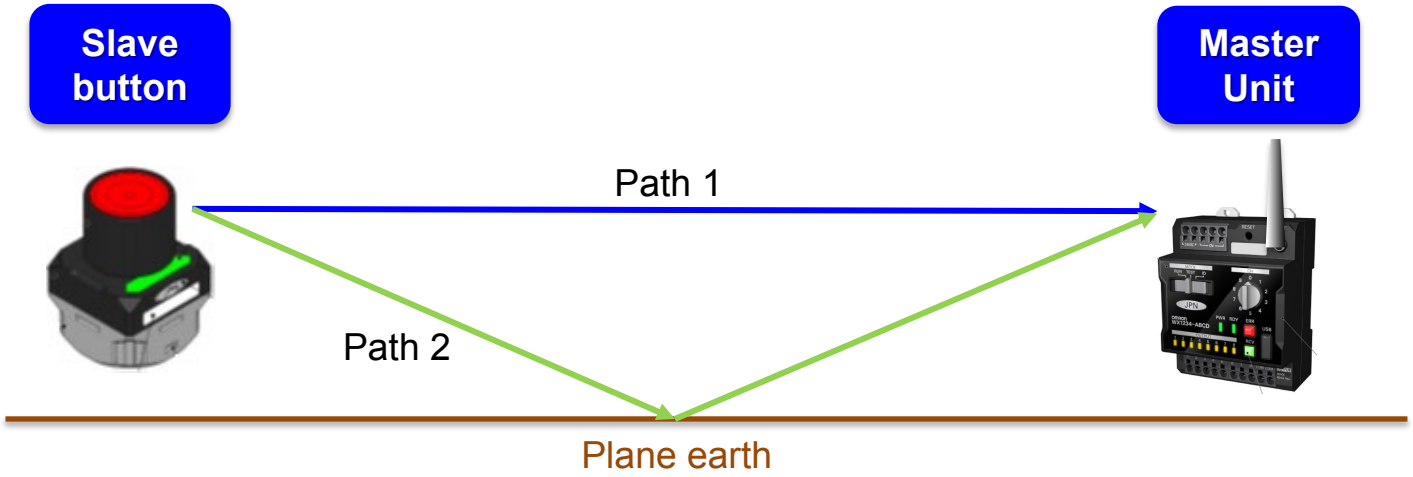
Indoor environments have many surfaces that reflect radio waves.



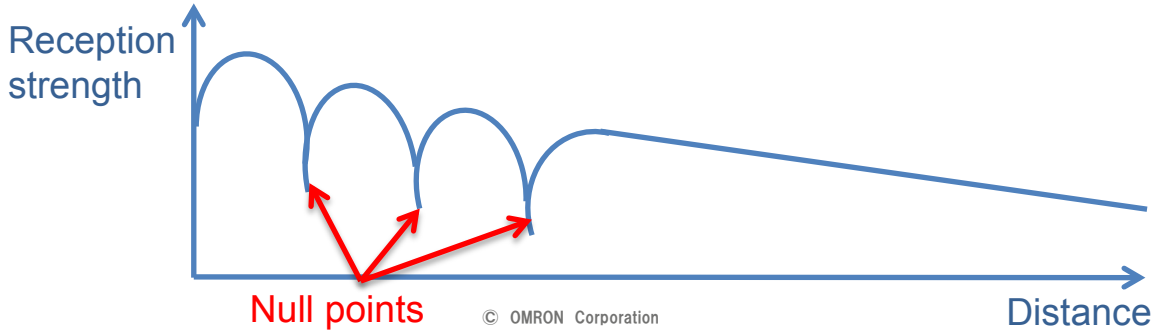

(The numbers shown are reflectivity factors for electromagnetic waves)

# Interference: Null generation

Reaching radio waves with different paths will cause a difference in reception field strength.
Compared to 920 MHz, since the wavelength is short at 2.4 GHz, the occurrence of null points due to reflection increases more.




Phase shift (i.e., arrival time differences) occurs by the difference in path length.
At the point where the phase shift is exactly opposite phase, the radio waves cancel each other and become a null point. At the position where it becomes a null point, the reception field strength is significantly lowered and it is difficult to receive.



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