

**Modbus Transparent**  
**900MHz Band Wireless Device**

**USERS MANUAL**

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## ■ TRADEMARKS

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- Modbus Protocol is a communication protocol published by Modicon for use with the programmable logic controllers.
- Windows® 11 is an operating system.
- Screen shots in this manual are used in accordance with Microsoft Corporation's guidelines.
- Other company names and product names mentioned in this manual are trademarks or registered trademarks of each company.

The symbols such like ™, ® and © are not described in this manual.

## ■ Notes

- We are not responsible for any effect caused by the results of using the products and this manual.
- We are not responsible for any effect caused by operations not described in this manual.
- The specifications of the products and the descriptions in this manual are subject to change without notice.
- A "module" or "wireless module" displayed on the maintenance console indicates a "wireless device".
- "Maintenance console" in this manual indicates "MH920 Console International" manufactured by Oki Electric Industry Co., Ltd.
- Do not disconnect the mini USB cable or turn off the power supply of a wireless device while connecting the maintenance console and the device, or the settings in writing (updating or setting firmware) may be destroyed.

# 1. INTRODUCTION

The wireless devices configure a large-scale and highly reliable wireless multihop network system, which is available in the 900 MHz frequency band and compliant with IEEE802.15.4g. The system can be used for various services such as BEMS, Smart Metering and M2M. The products include parent and child devices.

## 1.1. FEATURES

The wireless network system can realize to correct data wirelessly from data acquisition devices and remote I/Os with the Modbus protocol. A wireless device (parent) communicates with the data acquisition device using Modbus/TCP protocol, and with wireless devices (child) via Modbus-RTU protocol. The parent device converts the Modbus-RTU and Modbus/TCP protocol.

### 1.1.1. BASIC CONFIGURATION

"Figure 1.1 System configuration example" shows a system where a PC side as Modbus/Master communicates with a child device via a 900 MHz band wireless device using Modbus/TCP and RTU protocol, and also communicates with slave devices in multi drop connection (RS-485).

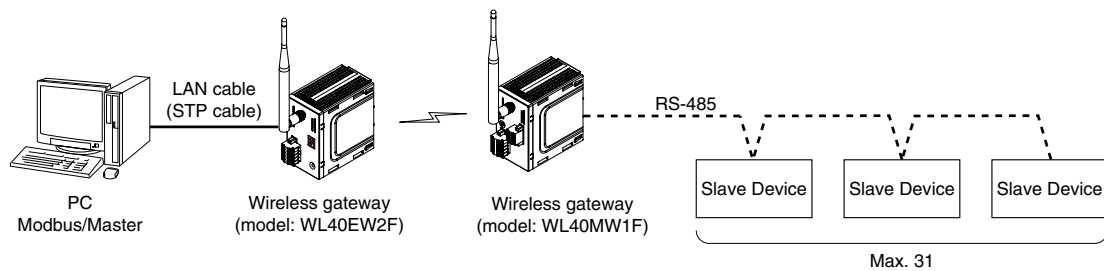


Figure 1.1 System configuration example

### 1.1.2. CONFIGURATION INCLUDING LOW-SPEED MOVING DEVICES

A data acquisition device can collect data wirelessly from remote I/Os moving in low speed (4 km/h or less). The configuration consists of a parent device, repeaters and child devices. Only the child devices move and do not have the relay function.

You can manage the devices moving in low speed within a specific range and collect data from them by radio communication.

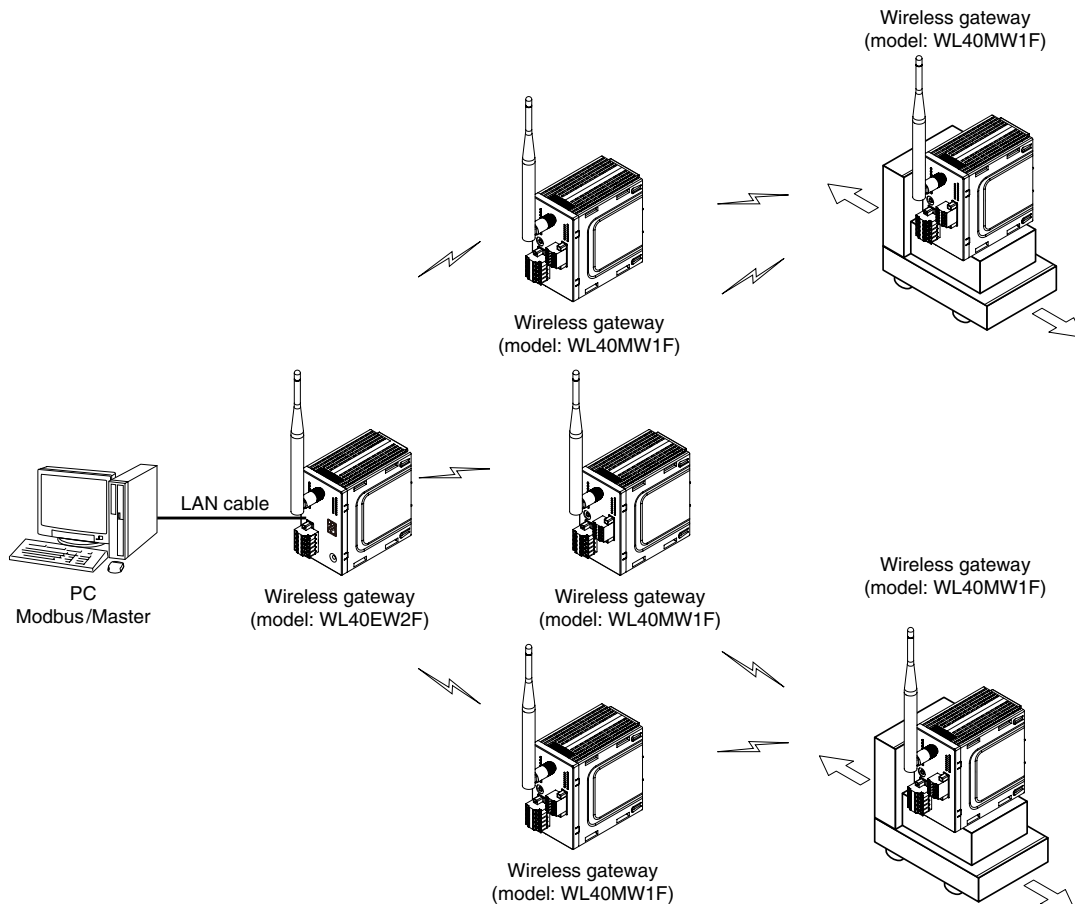


Figure 1.2 System configuration example including low-speed moving device

## 1.2. SPECIFICATIONS

The specifications of the wireless network system are as shown in the table below.

[Table 1.1] Specifications of wireless network system

ITEM		SPECIFICATIONS
Wireless system	Baud rate	Max. 100 kbps
	Effective rate	10 kbps
	Number of child devices	Max. 100 per parent device
	Number of hops	Max. 16
	Number of child nodes	25 or 15

The specifications of the wireless interface of the wireless devices are as shown in the table below.

[Table 1.2] Specifications of wireless interface

ITEM		SPECIFICATIONS
Wireless interface	Agency certification	FCC Part 15 Subpart C compliant (§ 15.247)
	Frequency	900 MHz band (902.4 – 927.6 MHz)
	Bandwidth	400 kHz
	Max. transmission power	20 mW
	Baud rate	Max. 100 kbps
	Max. packet size	2048 bytes
	Max. transmission distance	Approx. 1 km (optical linear distance) Note1: The distance depends on the installation environment. Note2: Using a coaxial cable for antenna extension decreases the transmission distance.
	Modulation	GFSK
	Receive sensitivity	-90 dBm or less (PER = 10%)

## 1.3. PRODUCT LINEUP

### ■ PARENT DEVICE

[Table 1.3] Parent device

MODEL	FEATURES
WL40EW2F	Works as a gateway, converting Modbus-RTU and Modbus/TCP (Ethernet) protocol. Sleeve and rooftop antennas selectable
IT40SW5F IT50SW5F IT60SW5F	Works as a gateway, converting Modbus-RTU and Modbus/TCP (Ethernet) protocol. Wireless parent device with integrated tower lights Complies with the protection degree IP65 Nondirectional antenna (360° horizontal)

### ■ CHILD DEVICE

[Table 1.4] Child device

MODEL	FEATURES
WL40W1F-x	Wireless I/O unit Sleeve and rooftop antennas selectable
WL40MW1F	Wireless gateway Sleeve and rooftop antennas selectable
IT40SW6F IT50SW6F IT60SW6F	Works as a gateway Wireless child device with integrated tower lights Complies with the protection degree IP65 Nondirectional antenna (360° horizontal)
R3-NMW1F	Multi-channel, wireless child device works in combination with a wide range of I/O modules (Wired Modbus-RTU, Gateway function available) Sleeve and rooftop antennas selectable

## 2. FLOW TO SYSTEM OPERATION

Confirm the following flow to the system operation. Configure the network and set wireless devices.

- EXAMINING WIRELESS NETWORK CONFIGURATION
- SELECTING DEVICES
- PREPARING MAINTENANCE CONSOLE
- PRIOR MEASUREMENT OF RADIO WAVE ENVIRONMENT
- EXAMINING PARAMETERS OF WIRELESS DEVICES
- SETTING WIRELESS DEVICES
- INSTALLING WIRELESS DEVICES
- MEASUREMENT OF RADIO WAVE ENVIRONMENT

### 3. EXAMINING WIRELESS NETWORK CONFIGURATION

#### 3.1. MULTIHOP NETWORK

##### 3.1.1. NETWORK PARTICIPATION AND ROUTE CONFIGURATION

A parent and several child devices configure a wireless multihop network.

The child devices obtain authentication from the parent device after their startup and join the wireless multihop network. Then they communicate using their IPv6 addresses. The addresses are assigned automatically using the prefix set to the parent device and short addresses set to individual parent and child devices.

##### ■ UPWARD ROUTE

- 1) A child device collects information on number of hops and the network quality (packet error rate) from adjacent parent and child devices, and decides a preferential parent as a connection destination from a list of parent candidates selected among the adjacent devices.
- 2) Based on the information, the upward network route of the child device is generated.

##### ■ DOWNWARD ROUTE

- 1) The parent device registers the route which the child device transmits in its route information table.
- 2) With this table, the downward network route (source routing) to the child device is automatically generated.

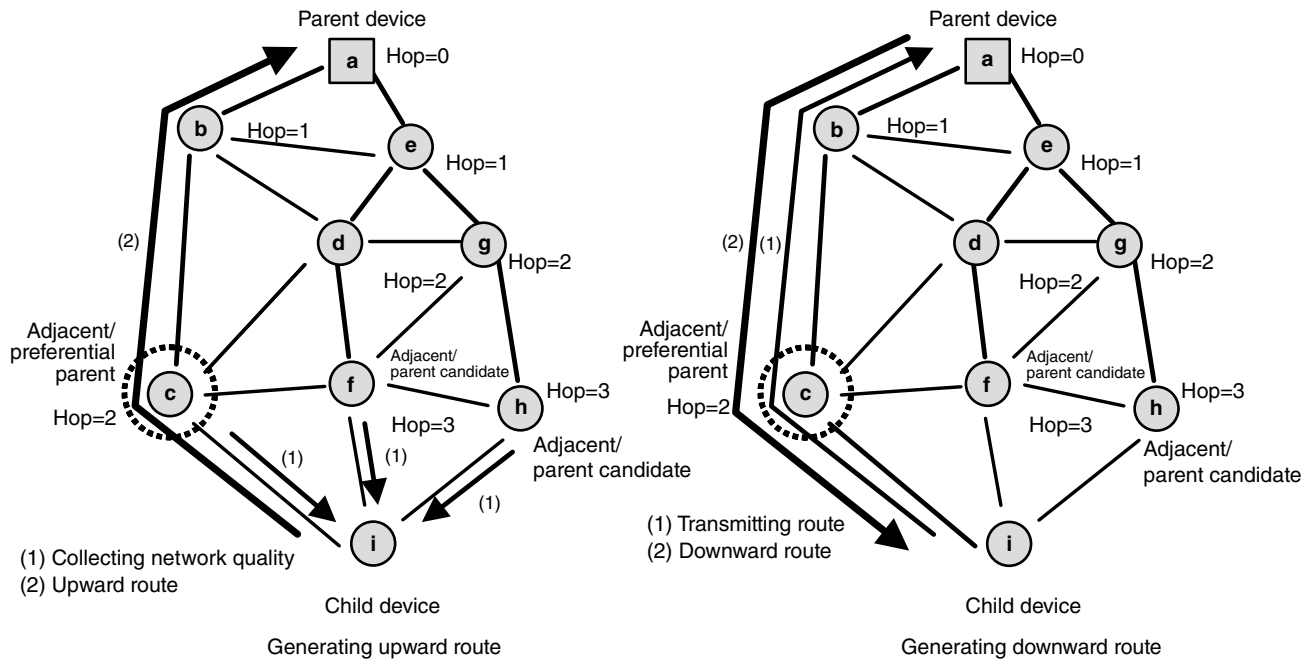


Figure 3.1 Wireless network

#### 3.2. CONFIRMING COMPONENTS IN INSTALLATION ENVIRONMENT

Confirm the installing locations and the wiring destinations of a data acquisition device and remote I/Os in the installation environment of wireless devices.

#### 3.3. CONFIRMING WIRELESS SECTIONS

Decide the wireless sections in the installation environment. Since a parent device is always connected to a data acquisition device, confirm also the connection of the parent device and remote I/O child devices.

## 4. SELECTING DEVICES

Select wireless devices and accessories necessary to configure the network based on the following criteria.

### 4.1. WIRELESS DEVICE

#### ■ PARENT DEVICE: WL40EW2F

The wireless I/O WL40F series WL40EW2F connects with an upper device (e.g. data acquisition device) via TCP/IP to collect I/O data connected to wireless child devices.

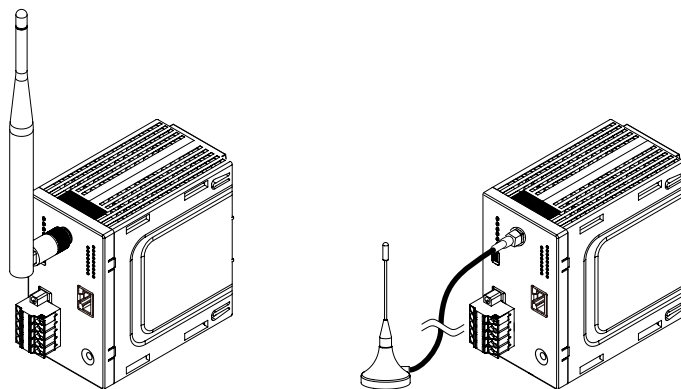


Figure 4.1 Parent device

[Table 4.1] Specifications of parent device

ITEM	SPECIFICATIONS
Power input	24V DC or 12V DC
Current consumption	24V DC: $\leq 90\text{mA}$ 12V DC: $\leq 170\text{mA}$
Operating temperature	-20 to +60°C (-4 to +140°F)
Mounting	DIN rail
Dimensions	105 mm × 60 mm × 107 mm (4.13 × 2.36 × 4.21 inch) (excluding antenna and protrusion)

■ PARENT DEVICE: IT40SW5F / IT50SW5F / IT60SW5F

ITx0SW5F connects with an upper device (e.g. data acquisition device) via TCP/IP to collect I/O data connected to wireless child devices. ITx0SW5F belongs to IT series with tower lights whose LED lights are turned on by discrete inputs.

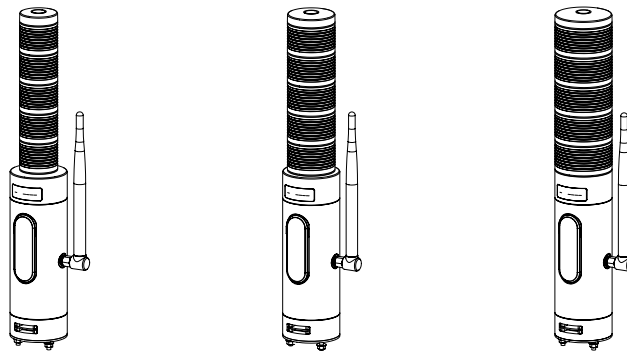


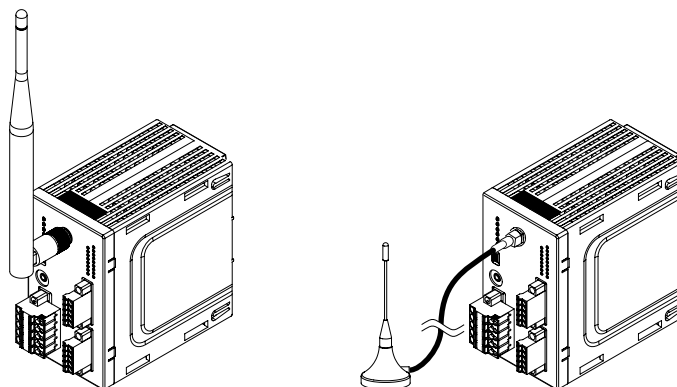
Figure 4.2 Parent device

[Table 4.2] Specifications of parent device

ITEM	SPECIFICATIONS
Power input	PoEplus (37 to 57V DC) Max. 15.4W or 24V DC
Current consumption	Approx. 7.5 W
Operating temperature	-10 to +55°C (14 to 131°F)
Degree of protection	IP65
Mounting	Direct mounting / pole mounting
Dimensions	Max. 352 mm x 60 mm dia. (excluding antenna and protrusion)

■ CHILD DEVICE: WL40W1F-X

The wireless I/O WL40F series WL40W1F-x is a wireless I/O unit.



Referential external view (WL40W1F-DAC4A)

Figure 4.3 Child device

[Table 4.3] Specifications of child device

ITEM	SPECIFICATIONS
Power input	24V DC (WL40W1F-DAC4A, WL40W1F-DS2) 12V DC (WL40W1F-DAC4A)
Current consumption	24V DC : ≤ 70mA, 12V DC : ≤ 130mA (WL40W1F-DAC4A) 24V DC : ≤ 140mA (WL40W1F-DS2)
Operating temperature	-10 to +55°C (14 to 131°F)
Mounting	DIN rail
Dimensions	105 mm × 60 mm × 107 mm (4.13 × 2.36 × 4.21 inch) (excluding antenna and protrusion)

■ CHILD DEVICE: WL40MW1F

The wireless I/O WL40F series WL40MW1F works as a gateway to output data received wirelessly to devices connected through wires.

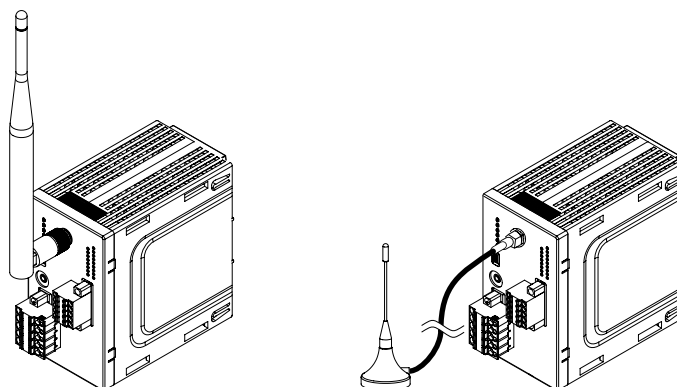


Figure 4.4 Child device

[Table 4.4] Specifications of child device

ITEM	SPECIFICATIONS
Power input	24V DC or 12V DC
Current consumption	24V DC: ≤ 70mA 12V DC: ≤ 130mA
Operating temperature	-20 to +60°C (-4 to +140°F)
Mounting	DIN rail
Dimensions	105 mm × 60 mm × 107 mm (4.13 × 2.36 × 4.21 inch) (excluding antenna and protrusion)

■ CHILD DEVICE: IT40SW6F / IT50SW6F / IT60SW6F

ITx0SW6F is a wireless I/O module with gateway function, for outputting wirelessly received data to wired network. ITx0SW6F belongs to IT series with tower lights whose LED lights are turned on by discrete inputs.

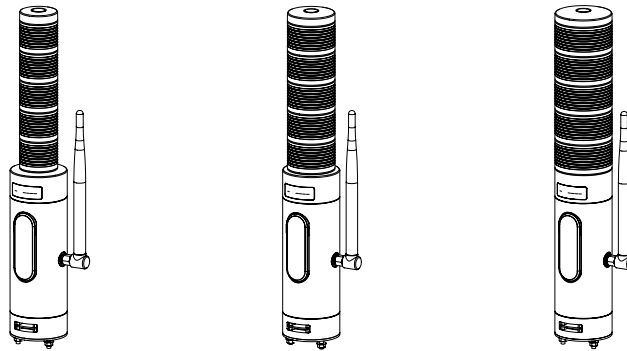


Figure 4.5 Child device

[Table 4.5] Specifications of child device

ITEM	SPECIFICATIONS
Power input	24V DC
Current consumption	Approx. 7W
Operating temperature	-10 to +55°C (14 to 131°F)
Degree of protection	IP65
Mounting	Direct mounting / pole mounting
Dimensions	Max. 352 mm × 60 mm dia. (excluding antenna and protrusion)

■ CHILD DEVICE: R3-NMW1F

R3-NMW1F belongs to multi-channel, mixed signal remote I/O R3 series.

R3-NMW1F is a wireless/Modbus interface module, which can be flexibly combined with I/O modules according to needs and used in both single and dual communication modes.

R3-NMW1F also works as a gateway for outputting wirelessly received data to wired network.

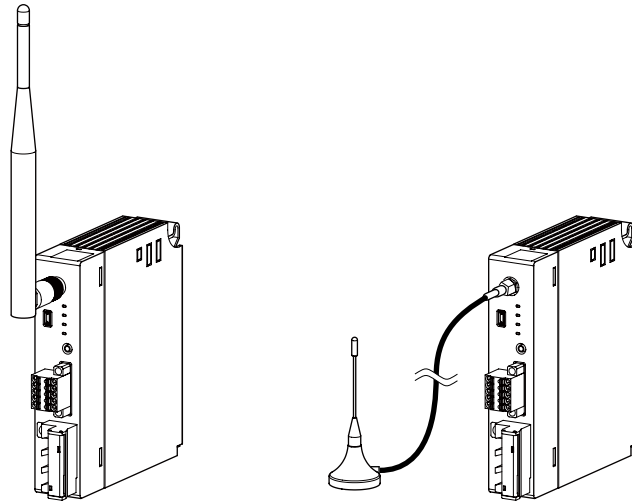


Figure 4.6 Child device

[Table 4.6] Specifications of child device

ITEM	SPECIFICATIONS
Power input	Internal power (20V DC)
Current consumption	Approx. 100mA
Operating temperature	-10 to +55°C (14 to 131°F)
Mounting	Mounted on the R3 base.
Dimensions	130 mm × 27.5 mm × 109 mm (5.12 × 1.10 × 4.29 inch) (excluding antenna and protrusion)

## 4.2. ANTENNA

### ■ ANTENNAS FOR R3 SERIES AND WL40F SERIES

Following two antennas are available for the wireless I/O R3 series and WL40F series. Select either antenna according to the usage scenes and their respective characteristics. R3 series and WL40F series do not use the diversity function.



Figure 4.7 Sleeve antenna



Figure 4.8 Rooftop antenna

#### • Sleeve antenna

An indoor-use antenna to attach to a wireless device. Tilting the antenna up to 90° deflects radio wave.

#### • Rooftop antenna

An antenna with a 2.5-m coaxial cable to install away from a wireless device. With its waterproof property, the outdoor use is available.

To fully exhibit the characteristics of the monopole rooftop antenna, a ground plane equivalent to the electric ground is needed. Attach its magnet base on a metal plate (recommended dimensions: 500 mm × 500 mm or more).

The gain of the rooftop antenna is less than that of the sleeve antenna for approximately 2.5 dB. However the rooftop antenna has the advantage that it can be installed in a high location, which is effective for the reachability of radio wave.

The specifications of the antennas are as shown in the table below.

[Table 4.7] Specifications of antennas for wireless devices (R3 series and WL40F series)

ITEM	SPECIFICATIONS	
	Sleeve antenna	Rooftop antenna
Type	Sleeve antenna	Rooftop antenna
Installation environment	Indoor	Outdoor
Cable length	–	2.5 m
Antenna type	Dipole	Monopole
Gain	3 dBi max. (*)	2 dBi max. (*)
Waterproof property	Non-waterproof	Waterproof (IPX6)
Directionality	Non-directional in horizontal plane	Non-directional in horizontal plane
Dimensions	195 mm (7.68 inch) (including connector)	80 mm (3.15 inch) (including base)

\* The performance of the antennas depends on the installation.

### ■ ANTENNA FOR WIRELESS LAN TOWER IT SERIES

The antenna for IT series cannot be replaced. Be sure to use the antenna originally attached to the unit.

The antenna characteristics can be biased by changing the angle or tilt of the antenna.

The specifications of the antennas are as shown in the table below.

[Table 4.8] Specifications of antennas for wireless devices (IT series)

ITEM	SPECIFICATIONS
Type	1/2 wavelength sleeve antenna
Gain	2 dBi max. (nominal) (*)
Operating temperature	-10 to +55°C (14 to 131°F)
Degree of protection	IP65 (waterproof when mated)
Directionality	Non-directional in horizontal plane
Dimensions	172 mm × 25.7 mm (6.77 × 1.01 inch) (including connector)

\* The performance of the antennas depends on the installation.

### 4.3. COAXIAL CABLE

A coaxial cable is for extension of the rooftop antenna.

The specifications of the coaxial cable (Oki Electric Industry Co., Ltd.) are as shown in the table below.

[Table 4.5] Specifications of coaxial cable

ITEM	SPECIFICATIONS
Type	Extension cable for rooftop antenna
Cable length	7.5 m (including connector)
Frequency	0 – 6 GHz
Impedance	50 Ω (nominal)
Cable loss	Approx. 3.1 dB in 800 MHz band Approx. 3.5 dB in 1000 MHz band
Connector	SMA, non-waterproof *
Cable	RG58

\* The connector is not waterproof. For its metal material, apply insulation treatment (e.g. taping).

## 5. PREPARING MAINTENANCE CONSOLE

### 5.1. DOWNLOADING MAINTENANCE CONSOLE

To perform maintenance of wireless devices, prepare a PC where the “MH920 Console International” (referred hereunder as ‘maintenance console’) software is installed.

The maintenance console is downloadable at our web site.

Note: Because the wireless devices incorporate the communication modules manufactured by Oki Electric Industry Co., Ltd, use Oki’s maintenance console software.

#### 5.1.1. APPLICABLE VERSION

The latest version of the maintenance console applicable to maintain the communication modules is indicated in the table below. Confirm that it is compatible with the communication module of your wireless device.

[Table 5.1] Maintenance console version

Communication module version	Maintenance console version
Ver f4.1.2	Ver 4.12 or later

### 5.2. INSTALLING & UNINSTALLING MAINTENANCE CONSOLE AND USB DRIVER

The following PC performance is required for adequate operation of the maintenance console. Check the operating environment of the PC before installation.

#### ■ HARDWARE REQUIREMENTS

[Table 5.2] Hardware requirements

ITEM	REQUIREMENTS
CPU	Core Duo 1 GHz equivalent or above
Memory	1 GB or more
HDD	100 MB minimum free space
Interface	USB *

\* USB version 1.1 or 2.0.

#### ■ SOFTWARE REQUIREMENTS

[Table 5.3] Software requirements

ITEM	REQUIREMENTS
OS	Windows 11 (64-bit)
Runtime	Microsoft .NET Framework version 4.0

### 5.2.1. INSTALLING MAINTENANCE CONSOLE

Install the maintenance console according to the following procedure.

- 1) Extract the downloaded files of the maintenance console.
- 2) Execute "mh920consoleInternational.msi" in the extracted files and start the setup wizard.  
When the "Setup Wizard" screen appears, click [Next].



Figure 5.1 Setup wizard

Note: When "Microsoft .NET Framework 4" is not installed, a message box that requires the installation appears.  
After installing "Microsoft .NET Framework 4", execute "mh920consoleInternational.msi" again.

- 3) After scrolling down and reading the entire "License Agreement," check [I accept the terms in the license agreement], then click [Next].



Figure 5.2 License agreement

- 4) When the “Destination Folder” dialog box appears, specify an installation folder and click [Next].  
The default location of the installation folder is as follows depending on the operating systems of the PC.  
C:\Program Files (x86)\OKI\MH920 Console International\

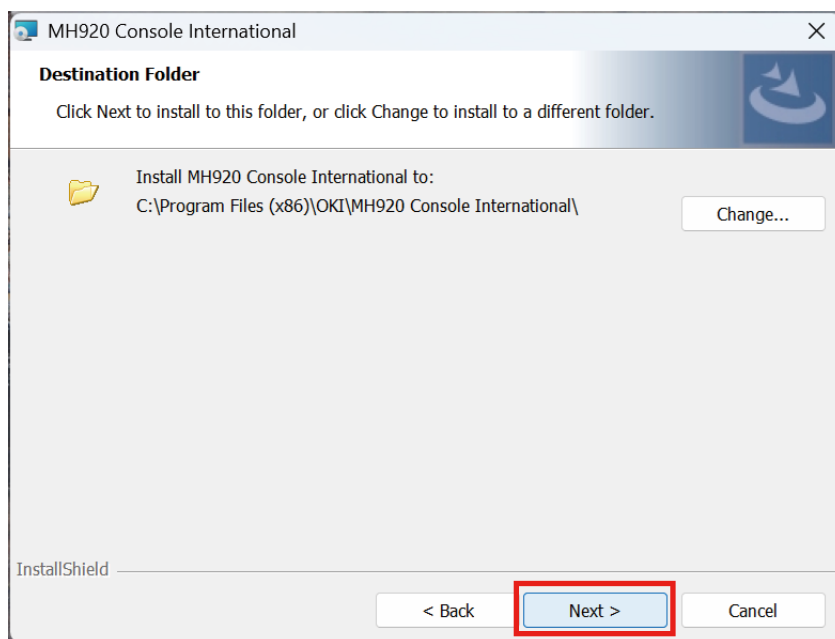


Figure 5.3 “Destination Folder” dialog box

5) When the "Set Country" dialog box appears, select "United States (US)," and click [Next].

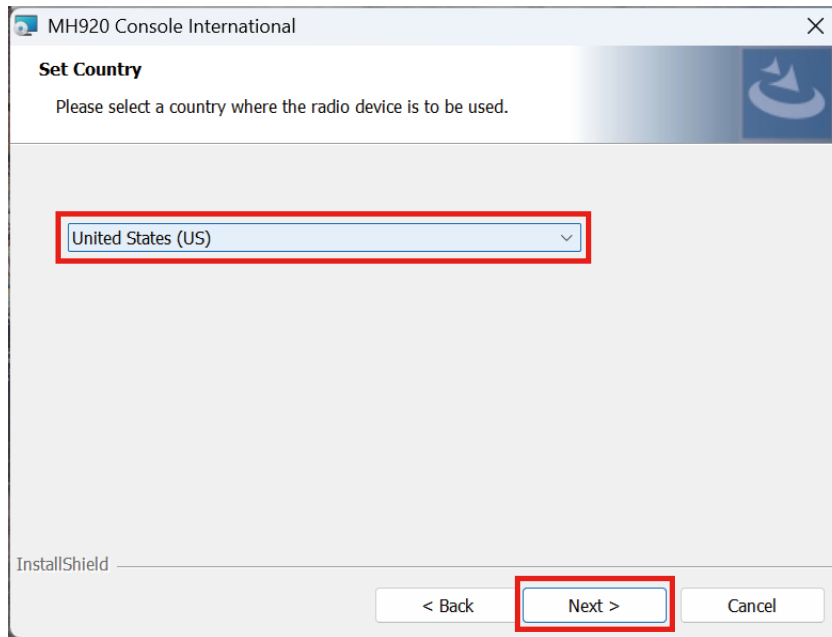


Figure 5.4 "Set Country" dialog box

6) When the "Ready to Install the Program" dialog box appears, select "Everyone," and click [Install].

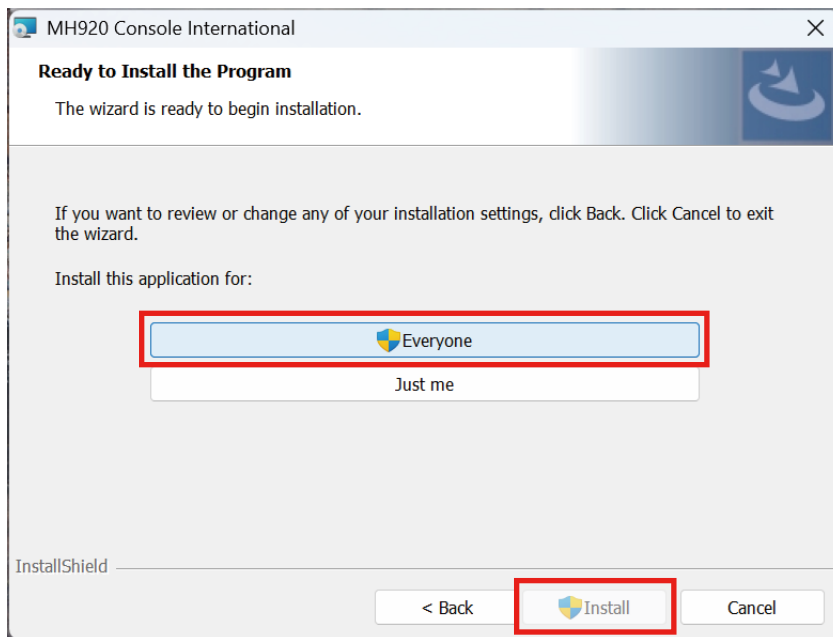


Figure 5.5 "Ready to Install the Program" dialog box

7) After the “InstallShield Wizard Completed” message box appears, click [Finish] to finish the installation.

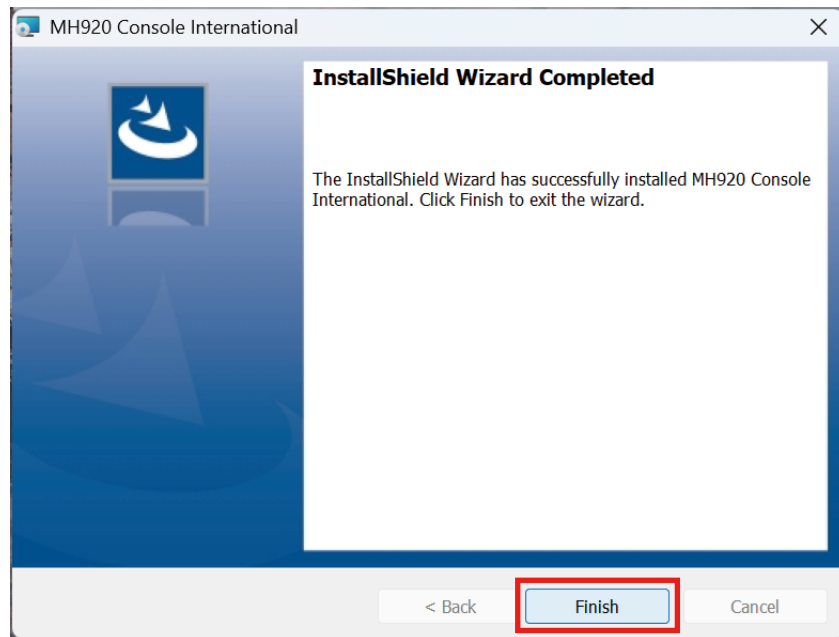


Figure 5.6 “Installation Complete” message box

## 5.2.2. INSTALLING USB DRIVER

A USB driver is required before connecting a wireless device to the PC. Install the USB driver according to the following procedure.

- 1) Connect the wireless device with the PC via a mini USB cable.
- 2) Turn on the power of the wireless device.
- 3) After a while, a message box appears on the PC stating that the driver of the wireless device cannot be found. If the driver installation dialog box appears, cancel without installing at this time.
- 4) Right-click the start button and select "Control Panel".
- 5) Select "Device Manager" from the list and expand "Ports (COM & LPT)".
- 6) Right-click "USB Serial Device (COM x)" to display a menu and select "Update Drivers".

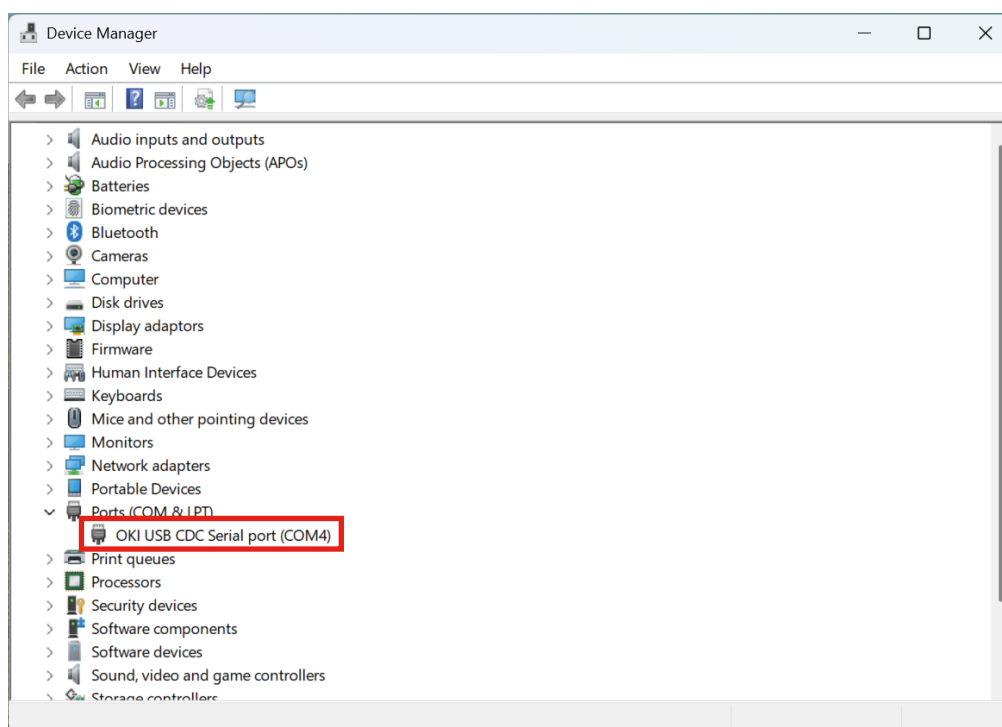


Figure 5.7 Device manager

- 7) When the “USB Serial Device (COMx) Properties” dialog box appears, click [Update Driver] button to activate the “Update Driver Software” wizard.

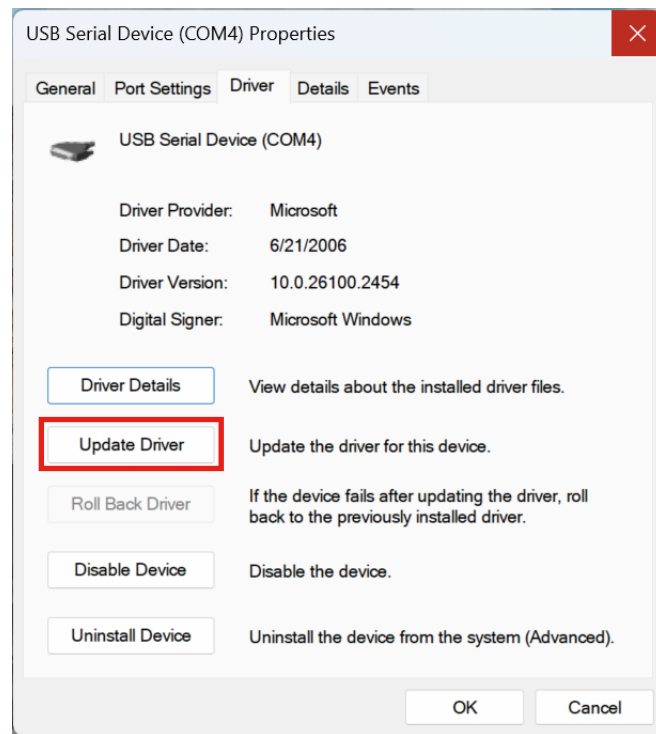


Figure 5.8 USB Serial Device (COMx) properties

- 8) On the “Update Drivers” dialog box, select “Browse my computer for driver software.”

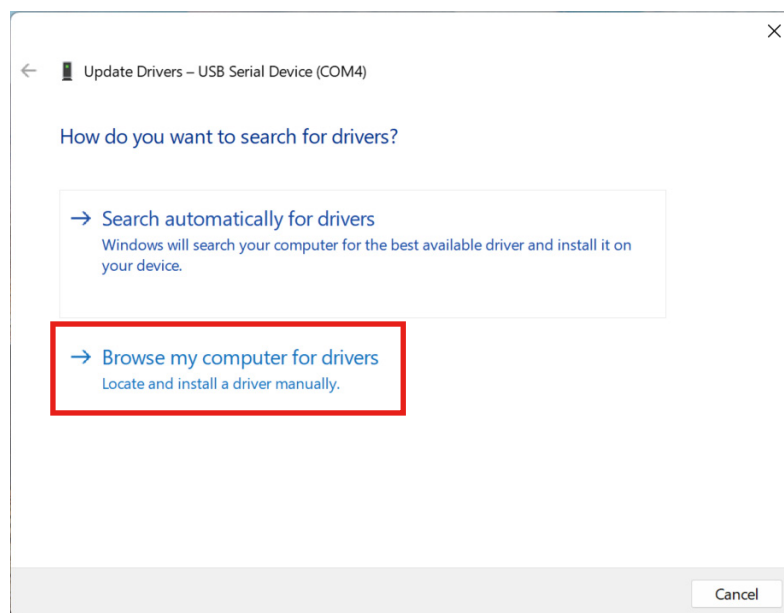


Figure 5.9 Search for driver software

- 9) On the “Update Drivers” dialog box, click [Browse] button, select an installation folder of the maintenance console, and click [Next] button.

The default location of the installation folder depends on the operating systems of the destination PC.

C:\Program Files (x86)\OKI\MH920 Console International\USB\_Driver

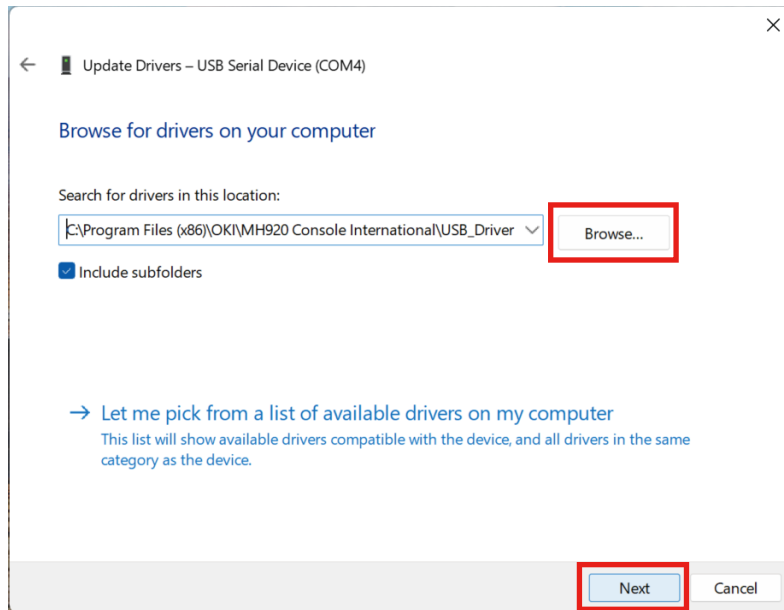


Figure 5.10 “Update Drivers” dialog

10) When a security warning appears, select “Install” and continue the installation.

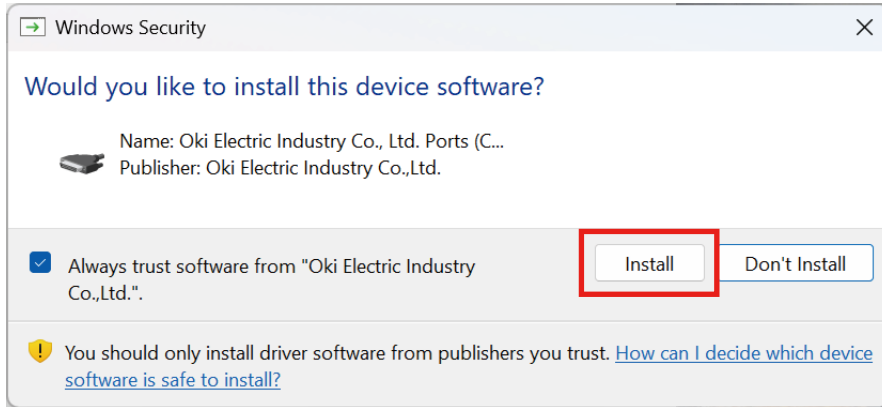


Figure 5.11 Windows security

11) The “Installing driver” and “Installation completed” messages appear in order.

12) On the “Update Drivers” dialog box, make sure that the driver has been successfully installed and click [Close] button.

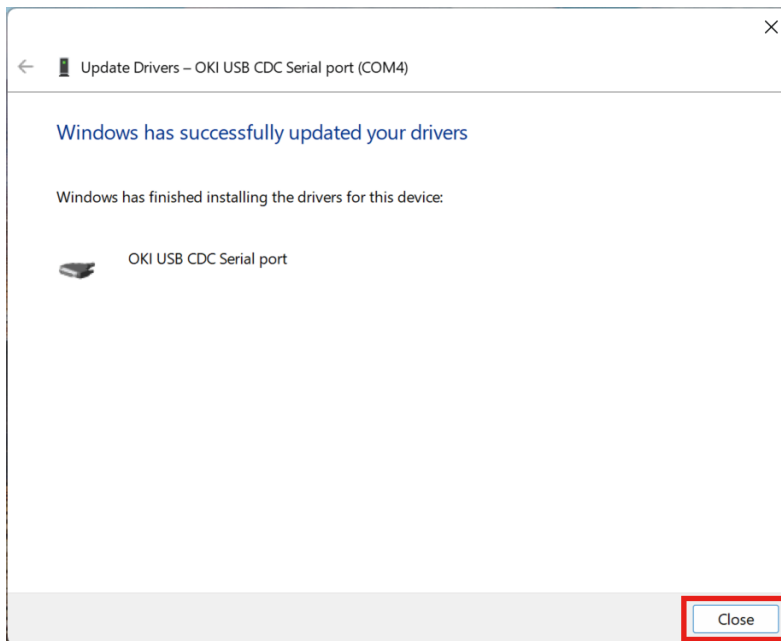


Figure 5.12 “Update Drivers” dialog

13) Make sure that the port number of “OKI USB CDC Serial port” is displayed in the “Ports (COM & LPT)” column on the Device Manager screen.

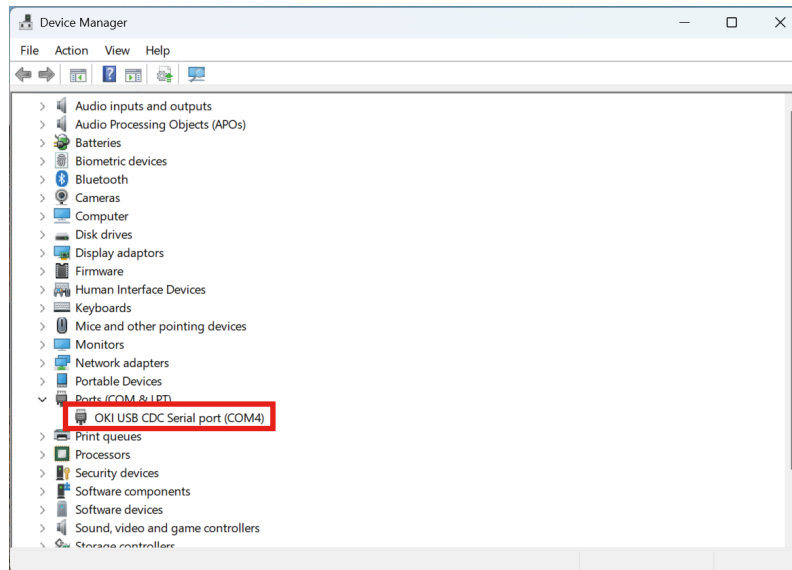


Figure 5.13 Device manager

Note: Remember this COM port number which is needed in setting in the maintenance console. Figure 5.13 shows the port number 4.

### 5.2.3. UNINSTALLING PROGRAM

Open Settings from Start menu > Apps > Installed apps.

Select the [...] of MH920 Console International from the program list and click [Uninstall] button.

Follow the instructions on the screen to uninstall the program.

### 5.3. STARTING MAINTENANCE CONSOLE

Start the maintenance console according to the following procedure.

- 1) Double-click the shortcut “MH920 Console International” on the desktop to start the maintenance console.



Figure 5.14 Shortcut of “MH920 Console International”

- 2) The following main screen appears.

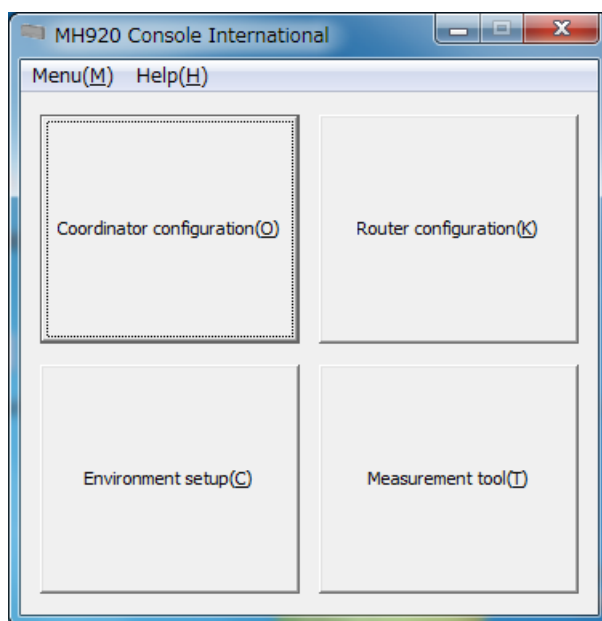


Figure 5.15 Main screen of maintenance console

### 5.3.1. ENVIRONMENT SETUP

This section explains configurable items in “Environment setup” on the main screen of the maintenance console.

Before configuring, make sure that the power of a wireless device is turned on and the device is connected with the maintenance console PC via a mini USB cable.

#### ■ COM PORT

Set a COM port for the communication between the maintenance console and the wireless device.

- 1) Click the pull-down button of the “COM port” column to show the COM port list.

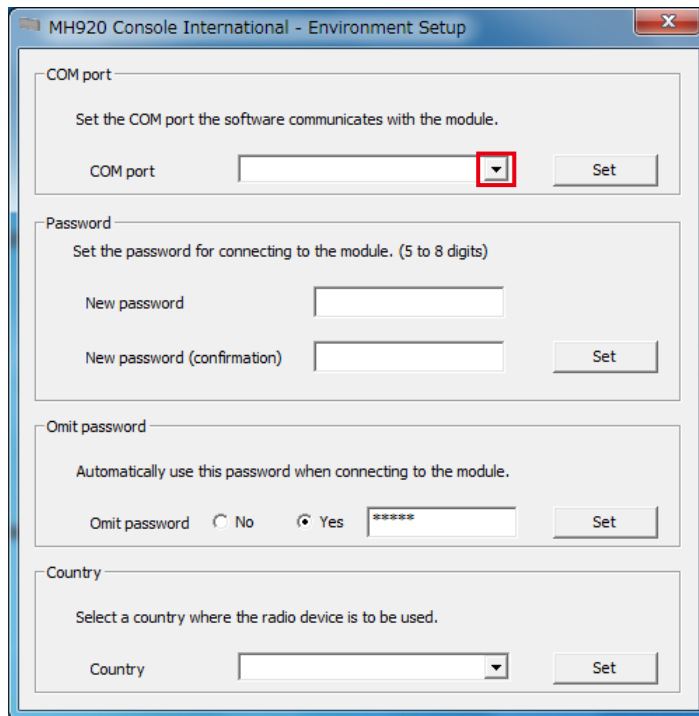


Figure 5.16 COM port setting

- 2) Select the COM port confirmed in the procedure 16 in “5.2.2 INSTALLING USB DRIVER;” and click [Set] button.

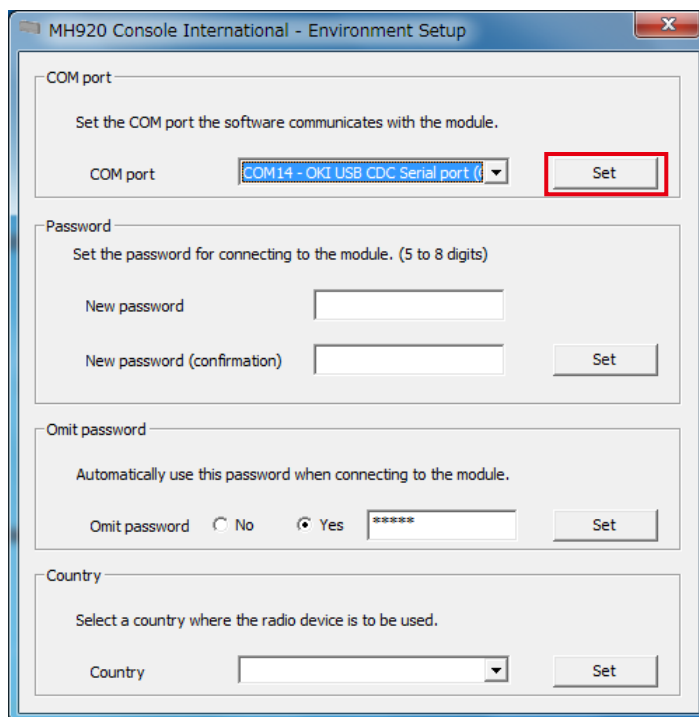


Figure 5.17 COM port setting

- 3) When the COM port is changed correctly, the successful change message appears. Click [OK] button.

## ■ PASSWORD

Set a password in connecting with the wireless device.

- 1) Enter a password in the “New password” field and enter again in the “New password (confirmation)” field.  
Refer to “7. EXAMINING PARAMETERS OF WIRELESS DEVICES” on page 56 for the details.

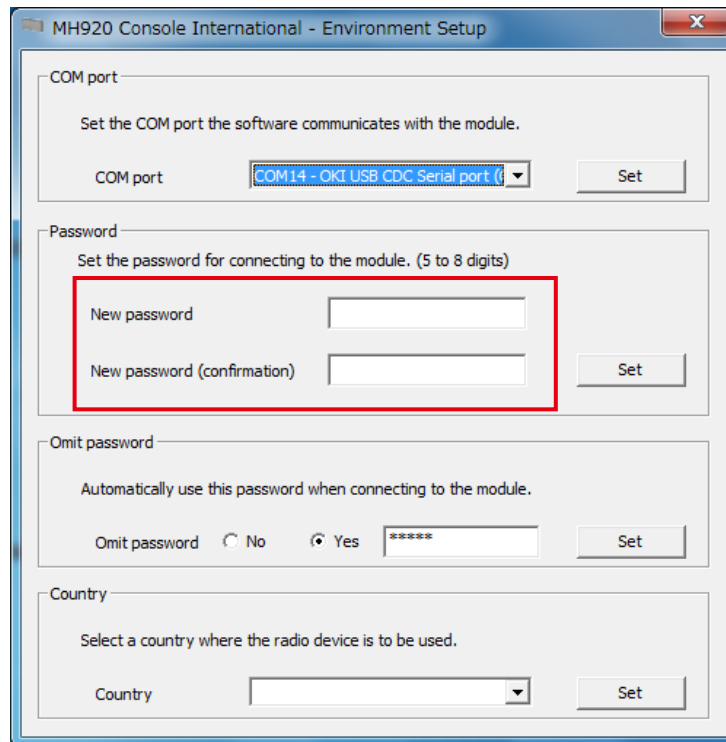


Figure 5.18 Password setting

- 2) Click [Set] button.

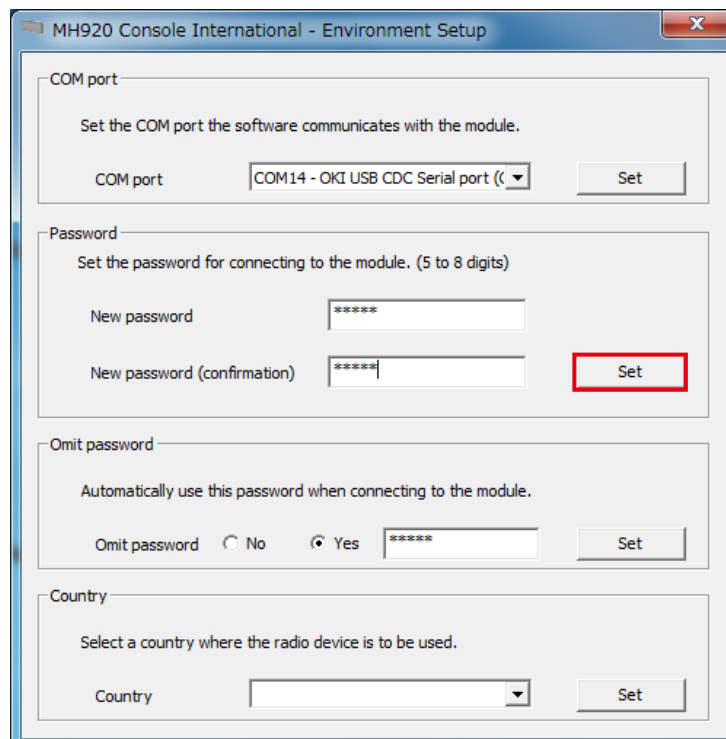


Figure 5.19 password setting

- 3) In setting "Omit password" to 'No' in "Environment setup", the password to connect the wireless device is required. Enter the password and click [Connect] button.
- 4) The following message appears. Click [OK] button.

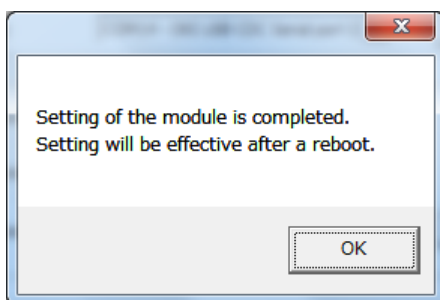


Figure 5.20 Password setting completion message

### ■ OMITTING PASSWORD

Omission of password entry in connecting to a wireless device from the maintenance console is configurable. This function presupposes a common password to connect all the wireless devices. It is recommended to set "Omit password" to 'No'.

- 1) Set "Omit password" and a common password if necessary.

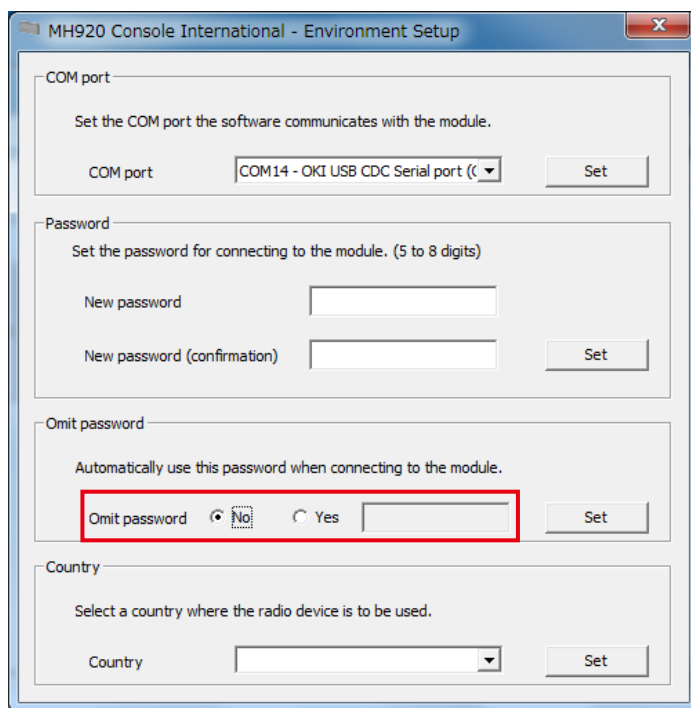


Figure 5.21 Omitting password

[Table 5.4] Password omission

ITEM	SETTING VALUE	EXPLANATIONS
Omit password	No / Yes	Check 'No' to enter a password every time connecting to a wireless device. Check 'Yes' not to enter a password every time connecting to a wireless device. The default password is 'mh920'.
Password field	English one-byte 5 – 8 characters	A common password in connecting to wireless devices The input field is enabled with 'yes' checked.

2) Click [Set] button.

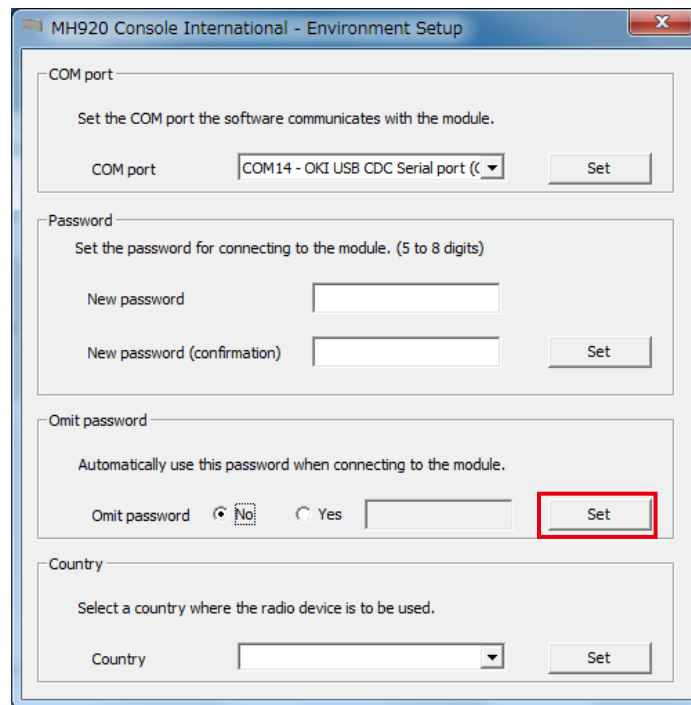


Figure 5.22 Omitting password

3) When the password omission is set correctly, the successful setting message appears. Click [OK] button.

## ■ COUNTRY SETTING

The country where the Maintenance Console is started and used is set.

- 1) Click the pull-down button in the “Country” column to show the country list.

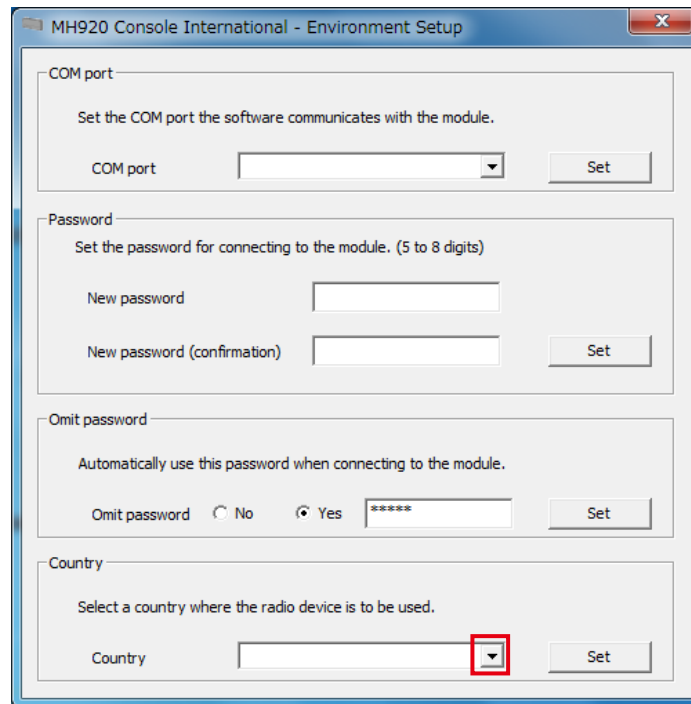


Figure 5.23 “Country” setting

- 2) Select [United States (US)] from the list, and click [Set].

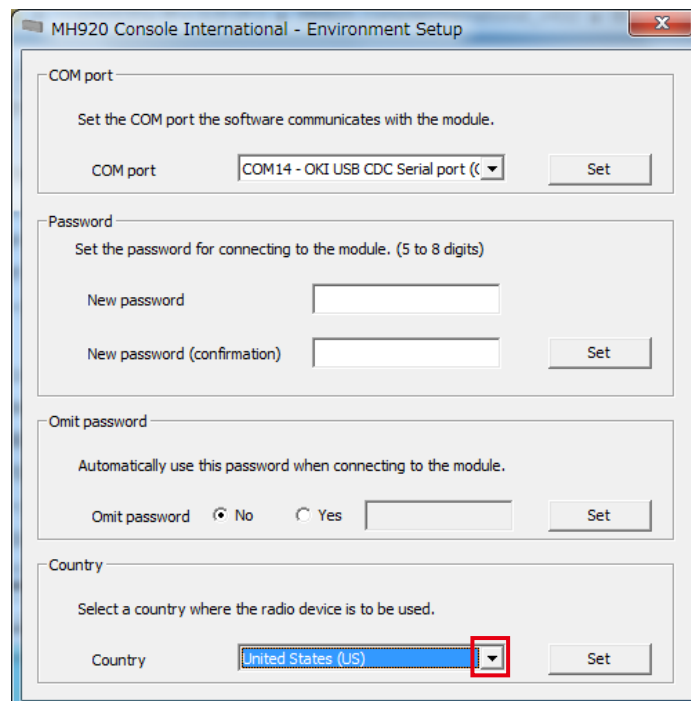


Figure 5.24 “Country” setting

3) The country setting has been applied and setting completion messages appear. Click [OK] on each message.

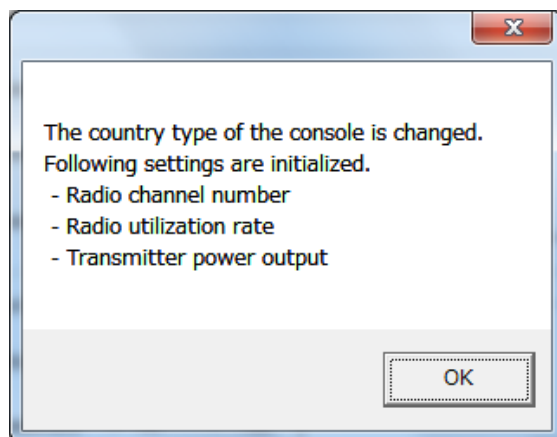


Figure 5.25 Country setting completion message

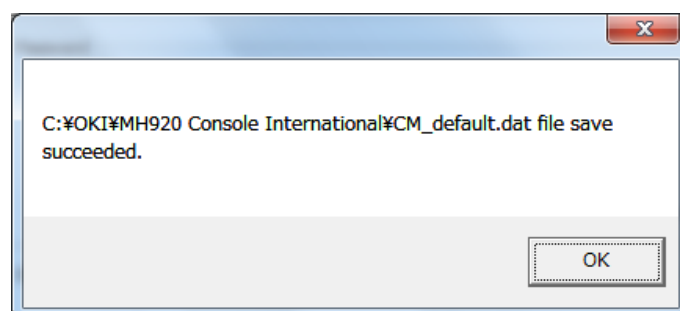


Figure 5.26 Country setting completion message

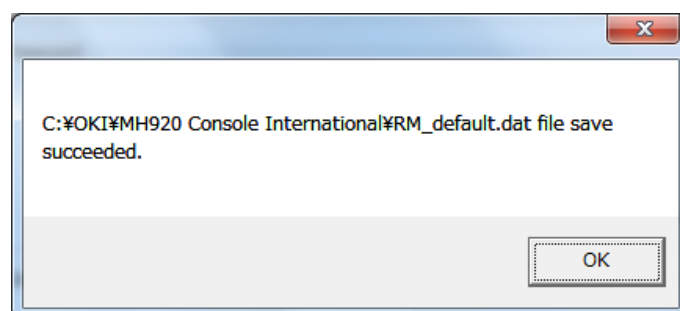


Figure 5.27 Country setting completion message

## 5.4. OTHER SETTINGS

### 5.4.1. COORDINATOR CONFIGURATION

Not used.

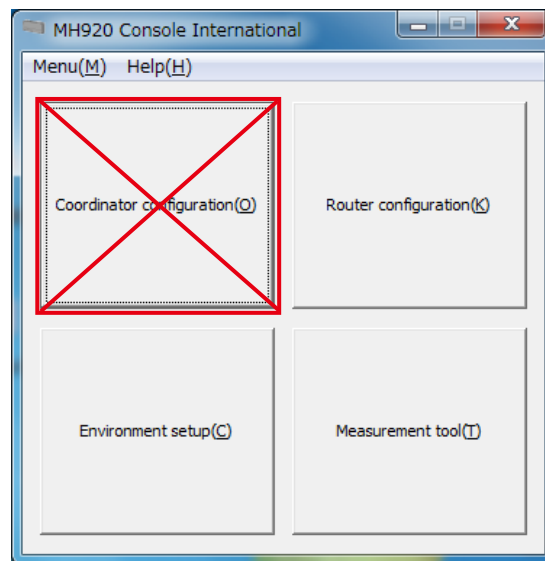


Figure 5.28 Main screen of maintenance console

### 5.4.2. ROUTER CONFIGURATION

Not used.



Figure 5.29 Main screen of maintenance console

### 5.4.3. UPDATING FIRMWARE OF COMMUNICATION MODULE

Do not update the firmware of a communication module incorporated in a wireless device, or we will not warrant the device.

## 6. PRIOR MEASUREMENT OF RADIO WAVE ENVIRONMENT

When configuring a wireless network, carry out the following measurements to decide a radio channel and installing locations of wireless devices.

- Channel noise scan
- Communication test

Execute a channel noise scan to measure RSSI values of specific channels. Check the radio channel numbers not used on the perimeter.

Execute a communication test to measure RSSI values and packet error rate (PER) of a specific channel between wireless devices.

Decide the installing locations, number of the wireless devices, and necessity to set relay nodes, based on the RSSI values and the PER of the channel to use.

Note 1: To measure the radio wave environment, switch the normal mode to the measurement mode.

To switch the measurement mode to the normal mode, refer to "6.3. TERMINATING MEASUREMENT TOOL" on page 54.

Note 2: The wireless connection is disconnected when the PAN ID of a parent device is set to '0000'. Switch to the normal mode and change the PAN ID to '0001' for example. Refer to the operating manual of the parent device in "8. SETTING WIRELESS DEVICES" on page 65 how to change the PAN ID.

Note 3: The wireless connection is disconnected when no radio channel is set, the short address is set to '0000' or no network name is set for a child device. Switch to the normal mode and change each setting. Refer to the users manual of the child devices in "8. SETTING WIRELESS DEVICES" on page 65 how to change each item.

Note 4: Switch the mode to the normal mode to change the transmitter power output. Refer to the manuals of the wireless devices in "8. SETTING WIRELESS DEVICES" on page 65 how to change it.

## 6.1. CHANNEL NOISE SCAN

The channel noise scan tool is to measure RSSI values of usable all radio channels or specific channels at regular time intervals. Start the tool on the maintenance console.

### 6.1.1. STARTING CHANNEL NOISE SCAN

- 1) Connect a wireless device with a maintenance console PC via a mini USB cable, and turn on the power of the device.
- 2) Start the maintenance console and click [Environment setup] button on the main screen.

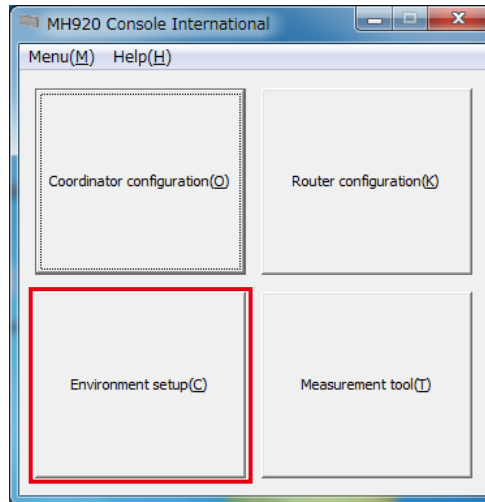


Figure 6.1 Main screen of maintenance console

- 3) Click the pull-down button of the “COM port” column, select the COM port connected to the wireless device, and click [Set] button.

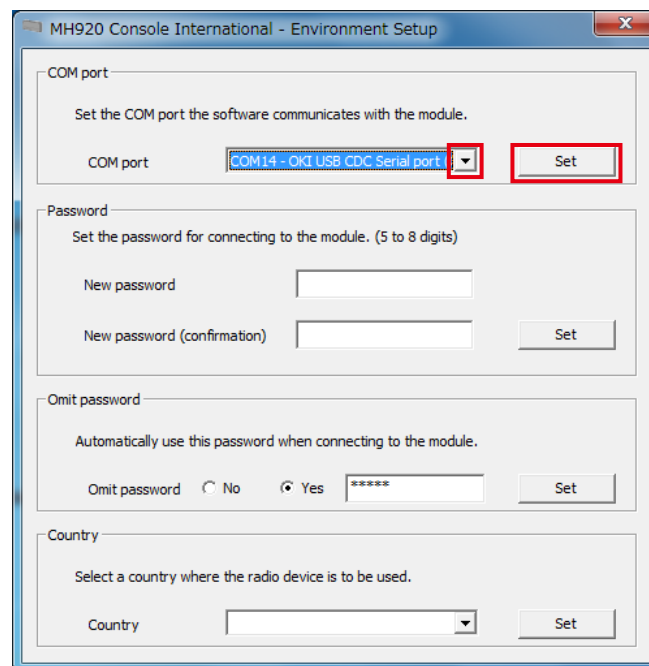


Figure 6.2 Environment setup

4) Close the “Environment setup” screen, and click [Measurement tool] button on the main screen.

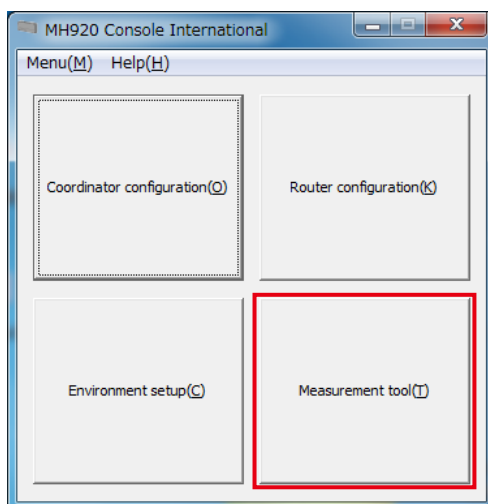


Figure 6.3 Main screen of maintenance console

5) The following screen appears. Check ‘Channel noise scan mode’ and click [Change mode] button.

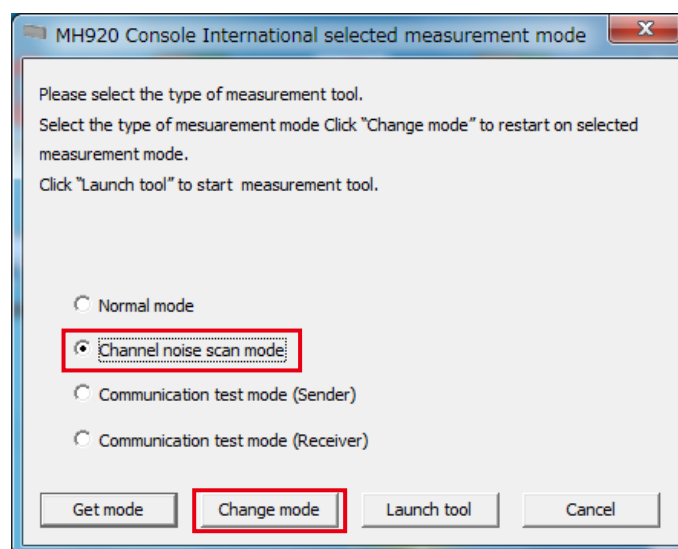


Figure 6.4 Selecting channel noise scan

- 6) In setting "Omit password" to 'No' in "Environment setup", the password to connect the wireless device is required. Enter the password and click [Connect] button.

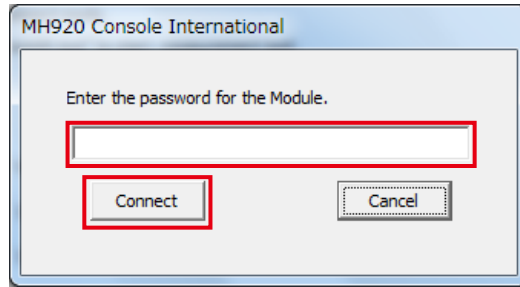


Figure 6.5 Password entry

- 7) The following message appears. Click [OK] button.

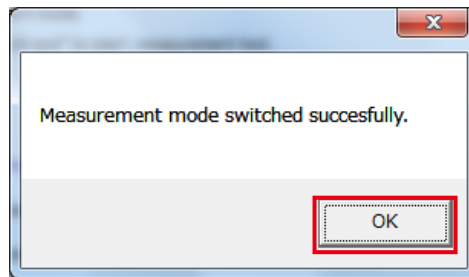


Figure 6.6 Confirming channel noise scan startup

- 8) Turn off the power of the device and reboot it.  
9) Check 'Channel noise scan mode' and click [Launch tool] button.

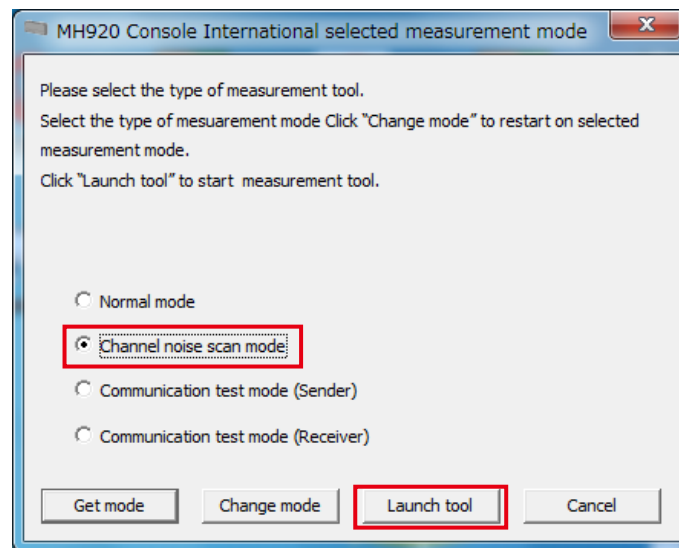


Figure 6.7 Starting channel noise scan

10) The channel noise scan screen appears.

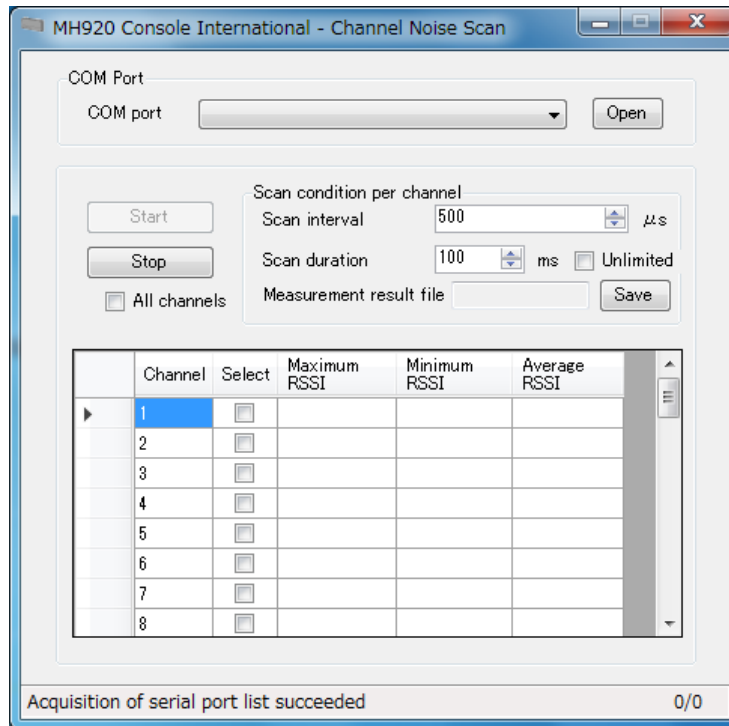


Figure 6.8 Channel noise scan

### 6.1.2. EXECUTING CHANNEL NOISE SCAN

Carry out the channel noise scan according to the following procedure.

Do not turn off the power of the wireless device or disconnect the mini USB cable during the measurement, or an error message will appear and the channel noise scan tool will be forcibly terminated.

- 1) Click the pull-down button of the “COM port” column, select the COM port connected to the wireless device, and click [Open] button.

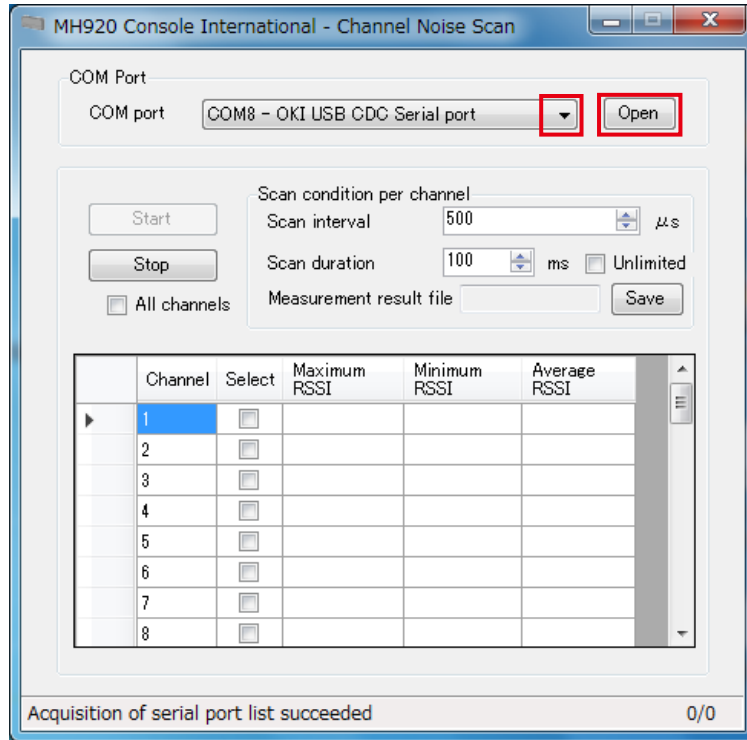


Figure 6.9 Selecting COM port

- 2) Specify “Scan interval” and “Scan duration.” In checking ‘Unlimited,’ the measurement infinitely continues.  
 For example, set “Scan interval” to 500 μs and “Scan duration” to 100 ms, and 200 measurements will be carried out for 100 ms at 500 μs interval per channel.

$$[\text{Number of channel noise scan per channel}] = (\text{scan duration [ms]} \times 1000) \div \text{scan interval [\mu s]}$$

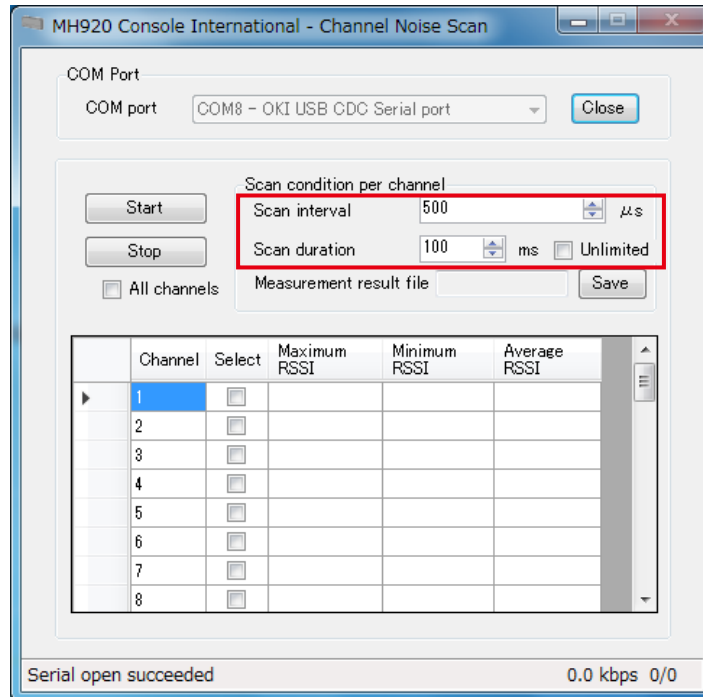


Figure 6.10 Specifying scan interval and duration

In checking ‘Unlimited,’ the measurement continues until clicking [Stop] button.  
 In unchecking ‘Unlimited,’ max. 2000 measurements are carried out.

- 3) Specify the channels to measure. Check the numbers in the “Select” column or check ‘All channels.’

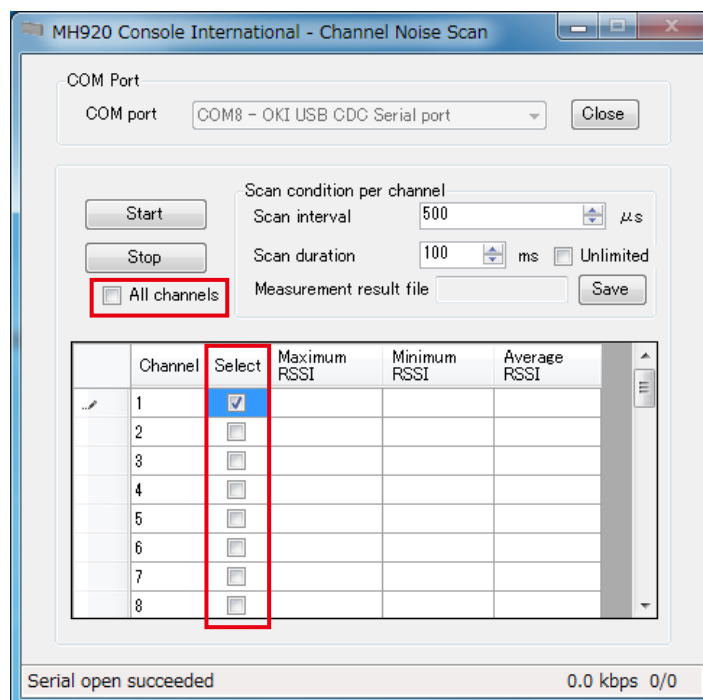


Figure 6.11 Specifying channels

- 4) To save the measurement result in a specified folder with a specified file name, click [Save] button of the “Measurement result file” column.

The file is saved under the following conditions unless the folder and the file name are not specified.

- Folder: ¥chnskan¥CH-Noise\_Log¥ under the installation folder
- File name: CHN\_ymmdd-HHMMSS.csv  
yy: year, mm: month, dd: date, HH: hour, MM: minute, SS: second

[Table 6.1] Measurement result file

ITEM	EXPLANATIONS
Time of Day	Measurement time and date
Channel	Measured channels
Interval	Measurement interval [ $\mu$ s]
Times	Number of times of channel noise scans per channel
RSSI	Measured RSSI values

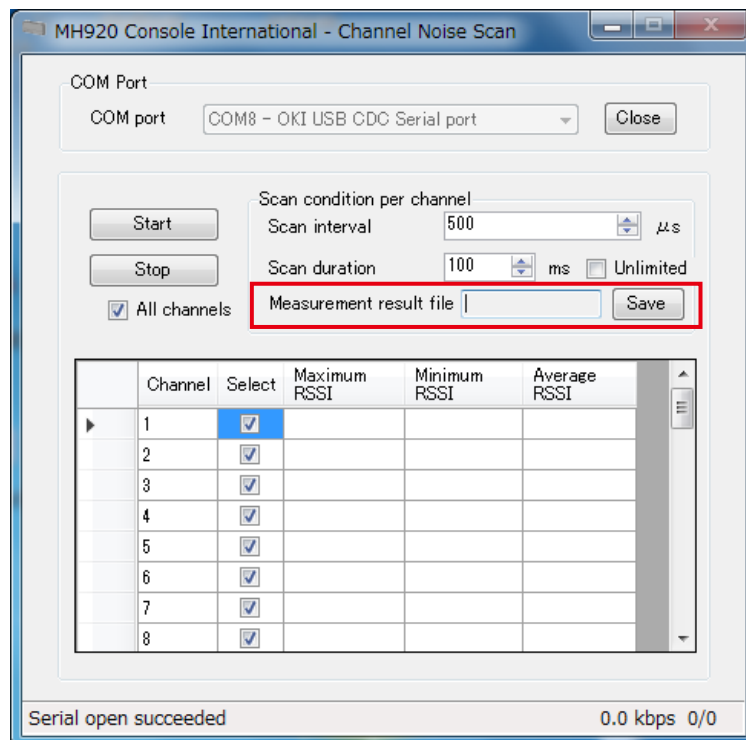


Figure 6.12 Specifying measurement result file

5) Click [Start] button to start the measurement.

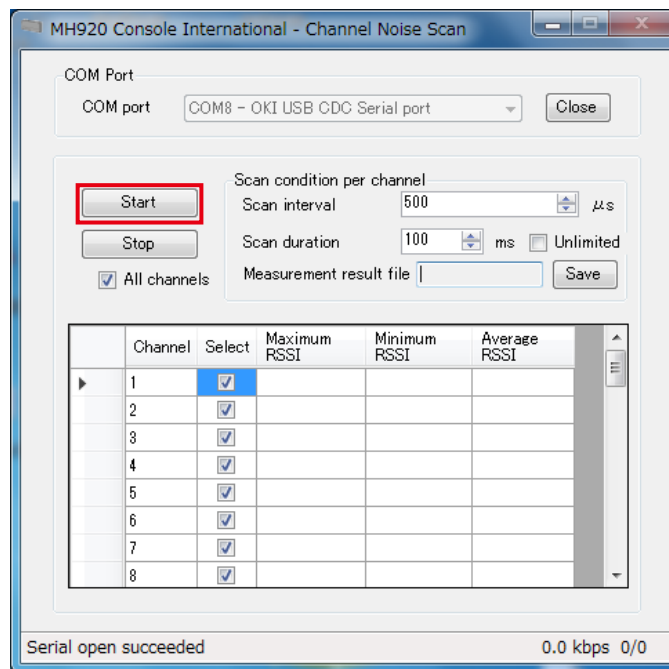


Figure 6.13 Starting measurement

6) The measurement result is displayed as shown in the screen below.

In deciding a channel to use based on the measurement result, choose one with its RSSI values as low as possible with its adjacent channels with low RSSI values. Refer to “7.1.3. RADIO CHANNEL NUMBER” on page 57 for the details.

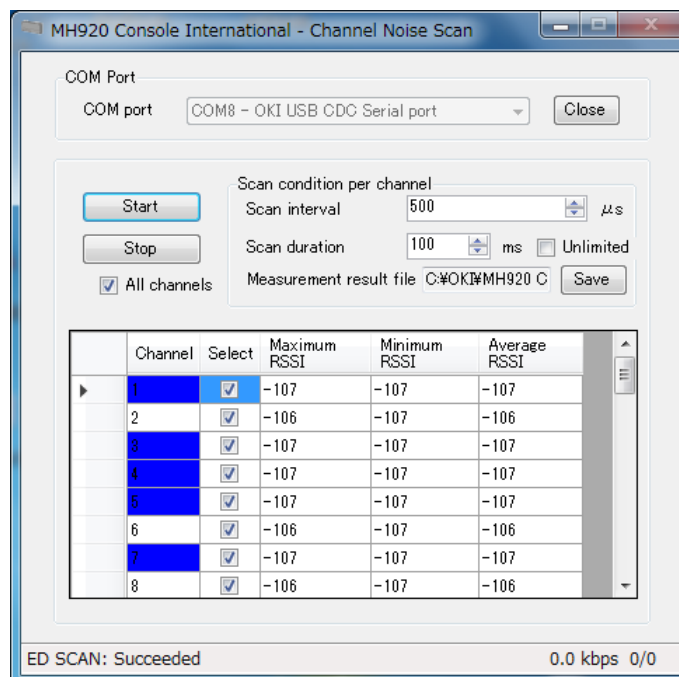


Figure 6.14 Measurement result

[Table 6.2] Measurement result

ITEM	EXPLANATIONS
Maximum RSSI	Max. RSSI value of the channel in the scan result
Minimum RSSI	Min. RSSI value of the channel in the scan result
Average RSSI	Average RSSI value of the channel in the scan result

Note: An average value may be greater than the maximum value or smaller than the minimum value because of the logarithmic and fraction calculation.

## 6.2. COMMUNICATION TEST

Carry out the communication test between two wireless devices. Set one device as a sender and another as a receiver. Use a pair of a parent device and a child, or two child devices. Both parent and child devices can be set to a sender and receiver. Set one device as a sender first and then another one as a receiver.

Following two setting steps are necessary to carry out the communication test.

RSSI value and PER (packet error rate) are measurable.

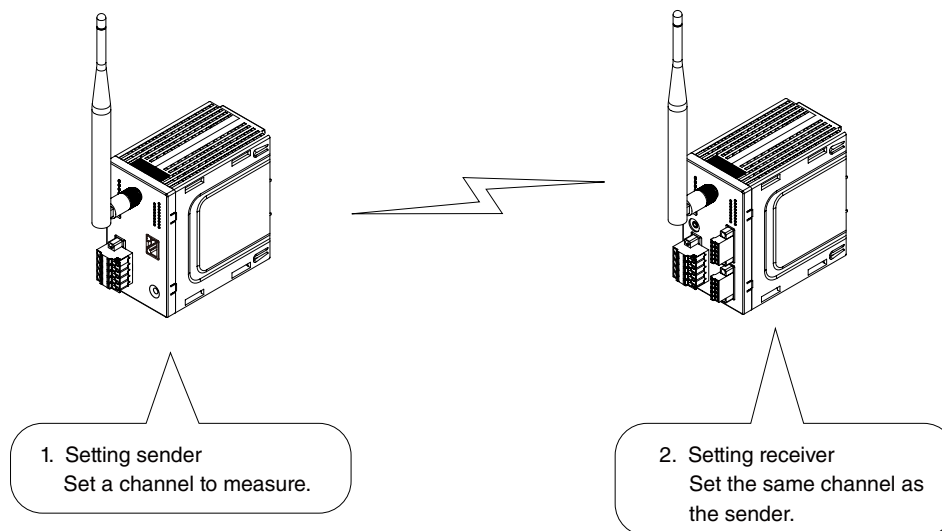


Figure 6.15 Configuration of communication test

### 6.2.1. SETTING SENDER

Set a wireless device as a sender.

- 1) Both sleeve and rooftop antennas can be used.
- 2) The transmitter power output in the communication test is the value set to the device. Refer to the manual of the device to change the output.
- 3) Connect the device with the maintenance console PC with a mini USB cable and turn on the power of the device.
- 4) Start the maintenance console and click [Environment setup] button on the main screen.

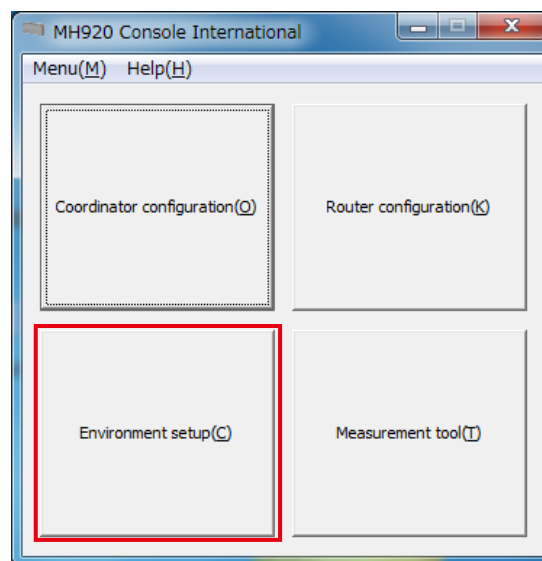


Figure 6.16 Main screen of maintenance console

- 5) Click the pull-down button of the “COM port” column, select the COM port connected to the device, and click [Set] button.

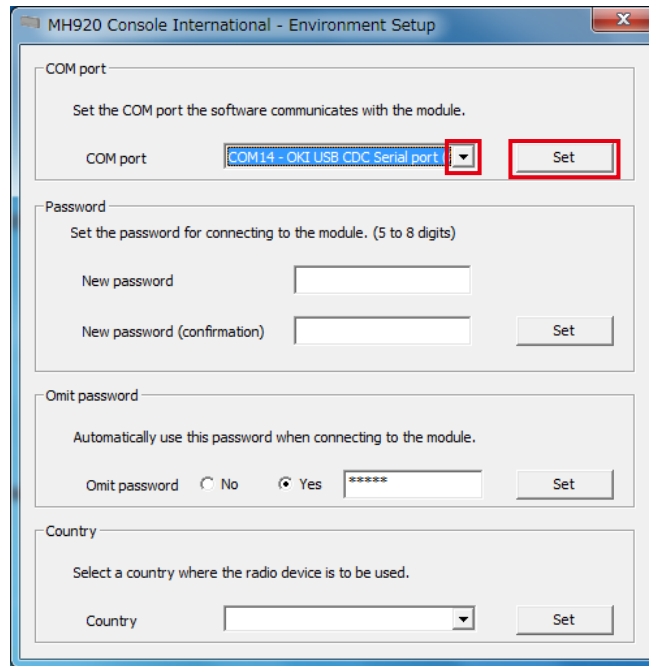


Figure 6.17 Environment setup

- 6) Close the “Environment setup” screen, and click [Measurement tool] button on the main screen.

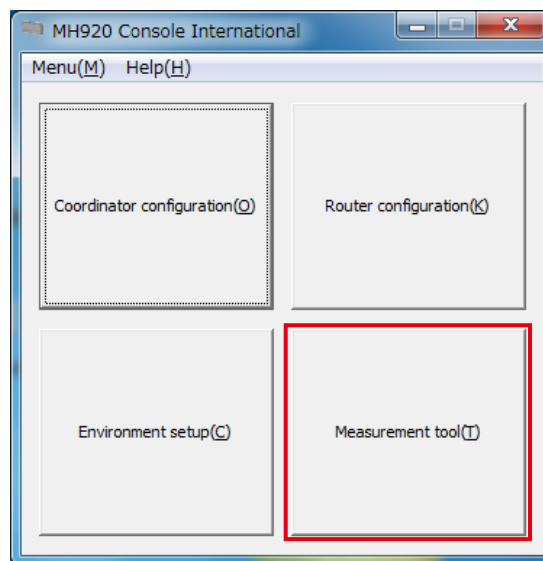


Figure 6.18 Main screen of maintenance console

7) The following screen appears. Check 'Communication test mode (Sender)' and click [Change mode] button.

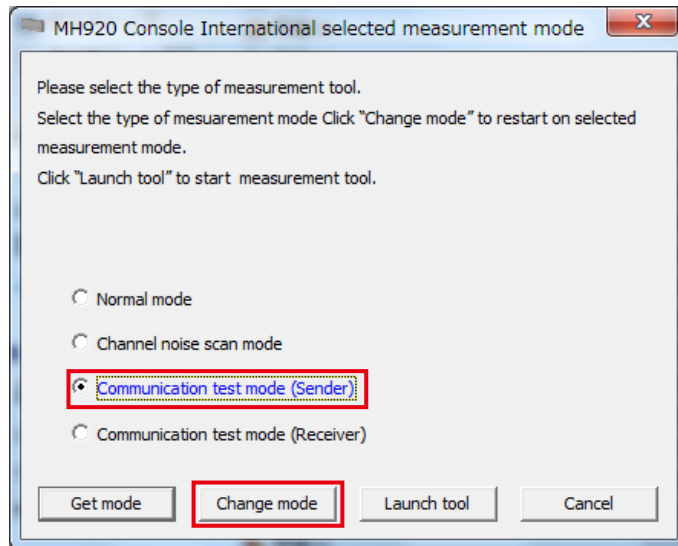


Figure 6.19 Selecting communication test (sender)

8) In setting "Omit password" to 'No' in "Environment setup", the password to connect the wireless device is required. Enter the password and click [Connect] button.

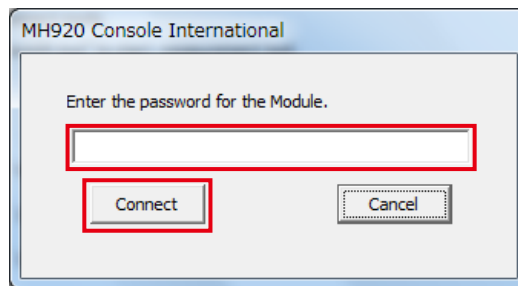


Figure 6.20 Password entry

9) The following message appears. Click [OK] button.

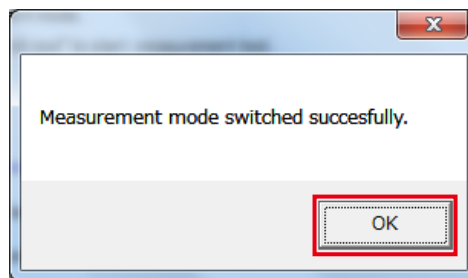


Figure 6.21 Confirming communication test (sender) startup

- 10) Turn off the power of the device and reboot it.
- 11) Check 'Communication test mode (Sender)' and click [Launch tool] button.

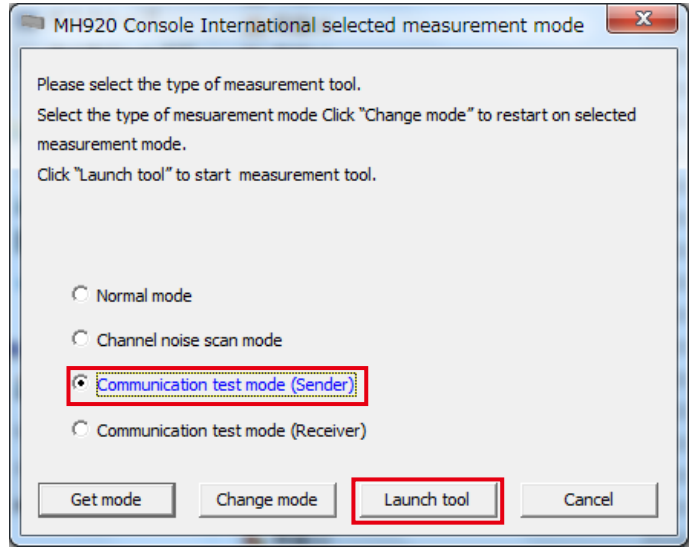


Figure 6.22 Starting communication test (sender)

- 12) The following screen appears. Click the pull-down button of the "COM port" column, select the COM port connected to the wireless device to be set as a sender, and click [Open] button.

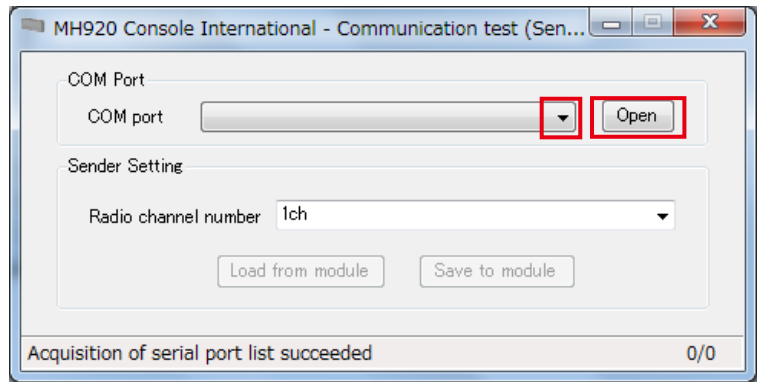


Figure 6.23 Selecting COM port

13) Specify a radio channel number. In using the channel set to the device, click [Load from module] button.

To specify a new channel, click the pull-down button of the “Radio channel number” column, select a channel and click [Save to module] button.

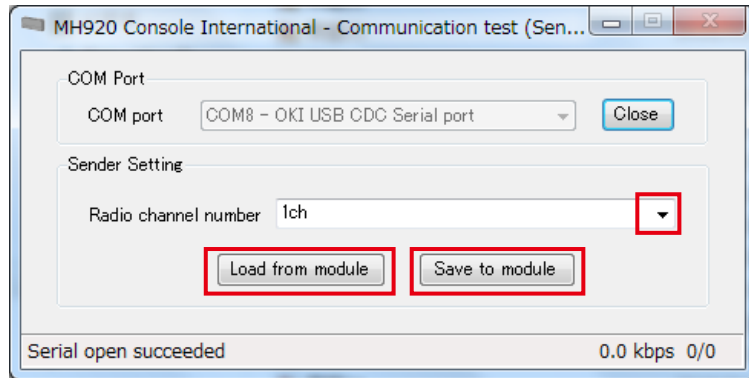


Figure 6.24 Setting sender (channel number)

14) A message “Serial open succeeded” is displayed at the lower left of the console. The sender setting is complete.

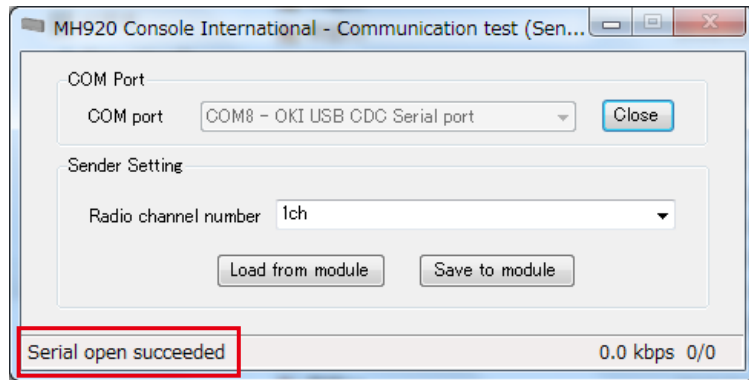


Figure 6.25 Sender setting completed

## 6.2.2. SETTING RECEIVER

Set another wireless device as a receiver.

Do not carry out other operations than measurement of RSSI and PER after setting the device as a receiver. To perform other operations, terminate the measurement tool (refer to “6.3. TERMINATING MEASUREMENT TOOL” on page 54) and return to the normal mode.

- 1) Both sleeve and rooftop antennas can be used.
- 2) Connect the device with the maintenance console PC with a mini USB cable and turn on the power of the device.
- 3) Start the maintenance console and click [Measurement tool] button on the main screen.

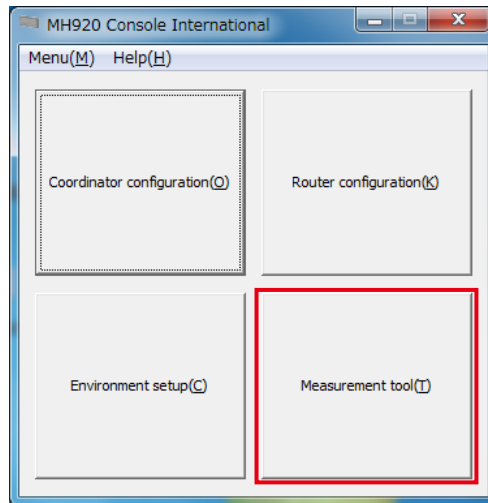


Figure 6.26 Main screen of maintenance console

- 4) The following screen appears. Check 'Communication test mode (Receiver)' and click [Change mode] button.

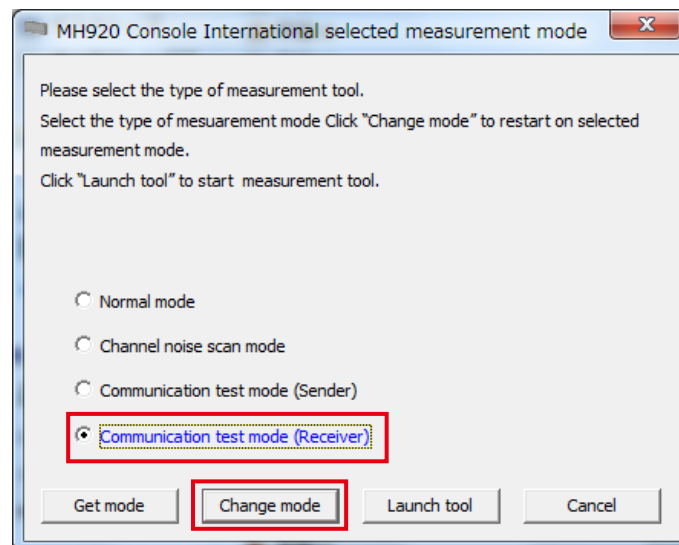


Figure 6.27 Selecting communication test (receiver)

- 5) In setting "Omit password" to 'No' in "Environment setup", the password to connect the wireless device is required. Enter the password and click [Connect] button.

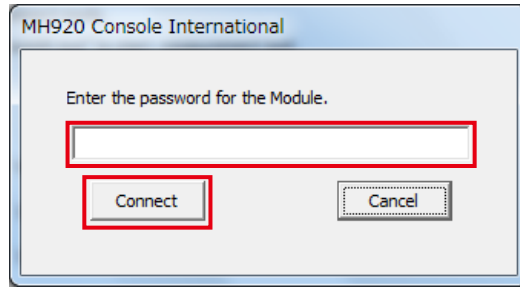


Figure 6.28 Password entry

- 6) The following message appears. Click [OK] button.

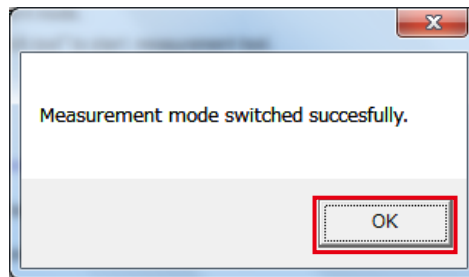


Figure 6.29 Confirming communication test (receiver) startup

- 7) Turn off the power of the device and reboot it.  
8) Check 'Communication test mode (Receiver)' and click [Launch tool] button.

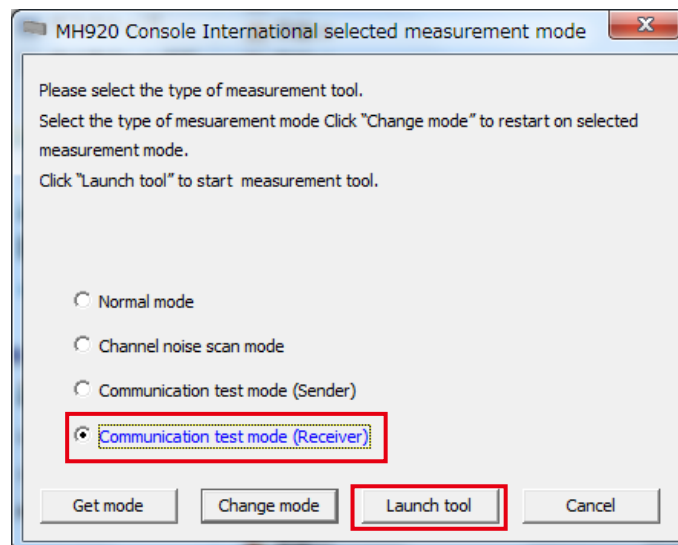


Figure 6.30 Starting communication test (receiver)

- 9) The following screen appears. Click the pull-down button of the “COM port” column, select the COM port connected to the wireless device to be set as a receiver, and click [Open] button.

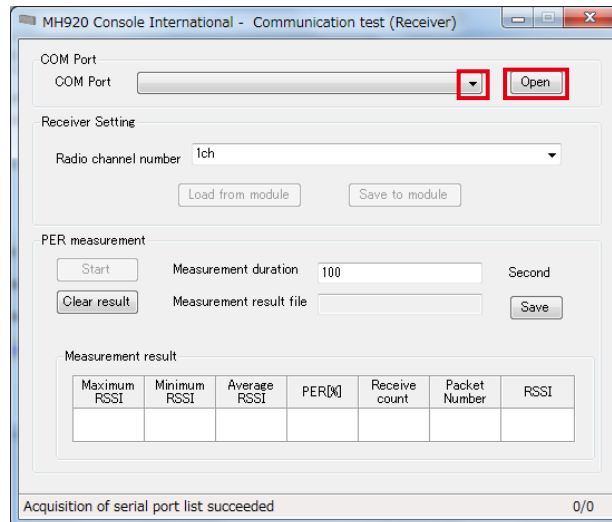


Figure 6.31 Selecting COM port

- 10) Specify a radio channel number. In using the channel set to the device, click [Load from module] button.  
 11) To specify a new channel, click the pull-down button of the “Radio channel number” column, select a channel and click [Save to module] button.

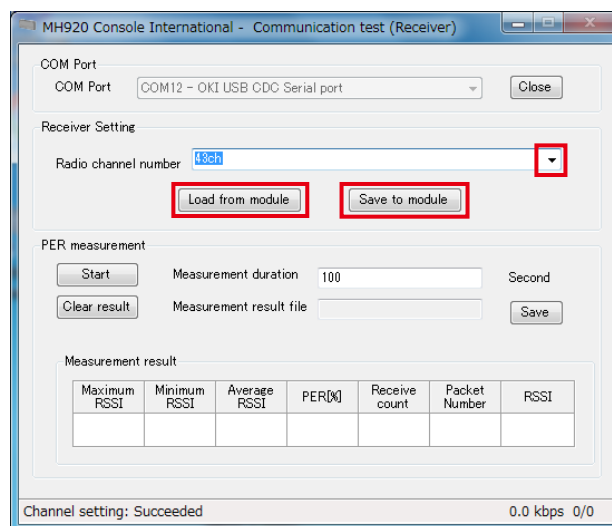


Figure 6.32 Setting receiver (channel number)

The receiver setting is complete.

### 6.2.3. MEASURING RSSI AND PER

Execute the measurement with the wireless device set as a receiver.

- 1) Specify "Measurement duration" within the range of 1 to 600000 seconds in the "Communication test (Receiver)" screen.

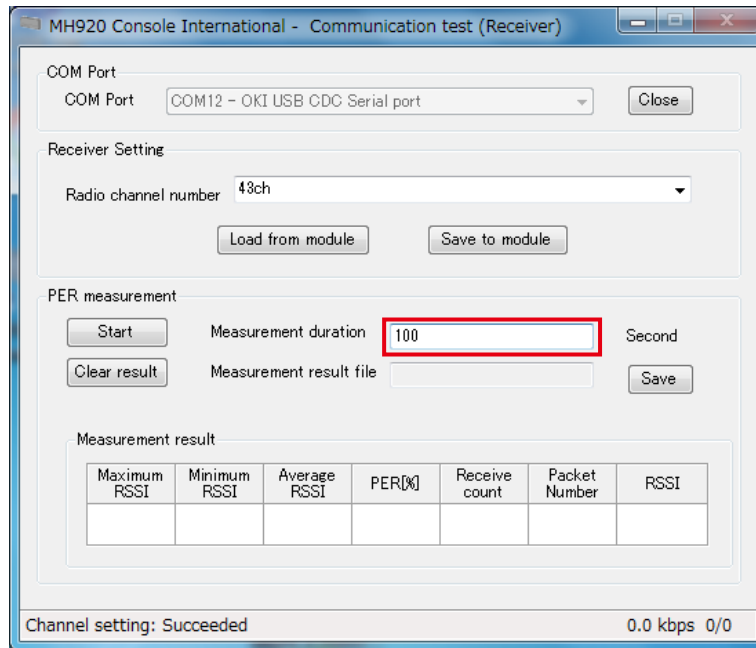


Figure 6.33 Specifying measurement duration

To save the measurement result in a specified folder with a specified file name, click [Save] button of the “Measurement result file” column.

The file is saved under the following conditions unless the folder and the file name are not specified.

- Folder: ¥PER\_Log under the installation folder
- File name: PER\_yymmdd-HHMMSS.csv  
yy: year, mm: month, dd: date, HH: hour, MM: minute, SS: second

[Table 6.3] Measurement result file

ITEM	EXPLANATIONS
Maximum RSSI [dBm]	Max. RSSI value in the measurement result
Minimum RSSI [dBm]	Min. RSSI value in the measurement result
Average RSSI [dBm]	Average RSSI value in the measurement result
PER [%]	Packet error rate in the measurement duration
Receive count	Number of packets received in the measurement duration
Packet Number	Latest received packet number (number of the packet the sender transmitted)
RSSI	RSSI value in receiving the latest packet
Ch Number	Measured radio channel

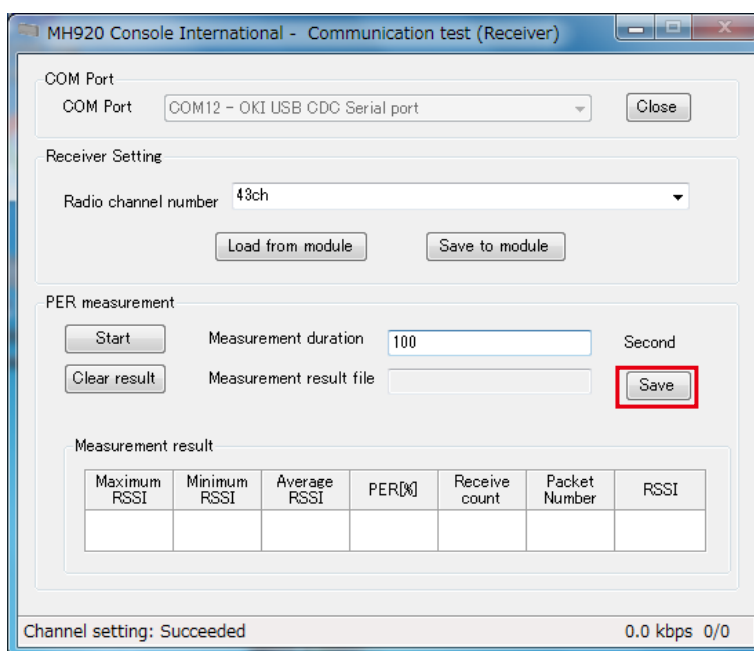


Figure 6.34 Specifying measurement result file

- 2) Click [Start] button to start the measurement. When the measurement is complete, “Measurement result” shows each value and the measurement result file is saved.

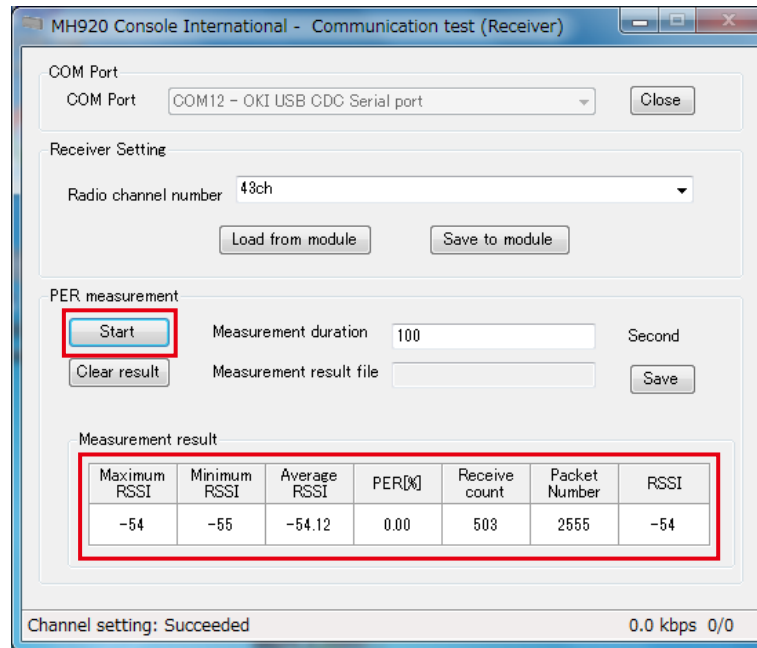


Figure 6.35 Measurement result

[Table 6.4] Measurement result

ITEM	EXPLANATIONS
Maximum RSSI [dBm]	Max. RSSI value in the measurement result
Minimum RSSI [dBm]	Min. RSSI value in the measurement result
Average RSSI [dBm]	Average RSSI value in the measurement result
PER [%]	Packet error rate in the measurement duration
Receive count	Number of packets received in the measurement duration
Packet Number	Latest received packet number (number of the packet the sender transmitted)
RSSI	RSSI value in receiving the latest packet

In using a child device at a fixed position, it is recommended to operate it with the PER less than 0.01 % and the average RSSI -85 dBm or more. In using a child device on a low-speed moving device, it is recommended to operate it with the PER less than 0.01 % and the average RSSI -75 dBm or more.

The above values are not essential. Consider a permissible error rate in the usage system and environment, set your own reference PER to decide the installation.

### 6.3. TERMINATING MEASUREMENT TOOL

Terminate the measurement tool (channel noise scan or communication test) according to the following procedure.

- 1) Clicking [Close] button of the “COM port” column in the channel noise scan or communication test (sender or receiver) screen activates [x] button in the upper right corner. Click [x] button. Then click [OK] button.

Terminate the communication test for both sender and receiver.

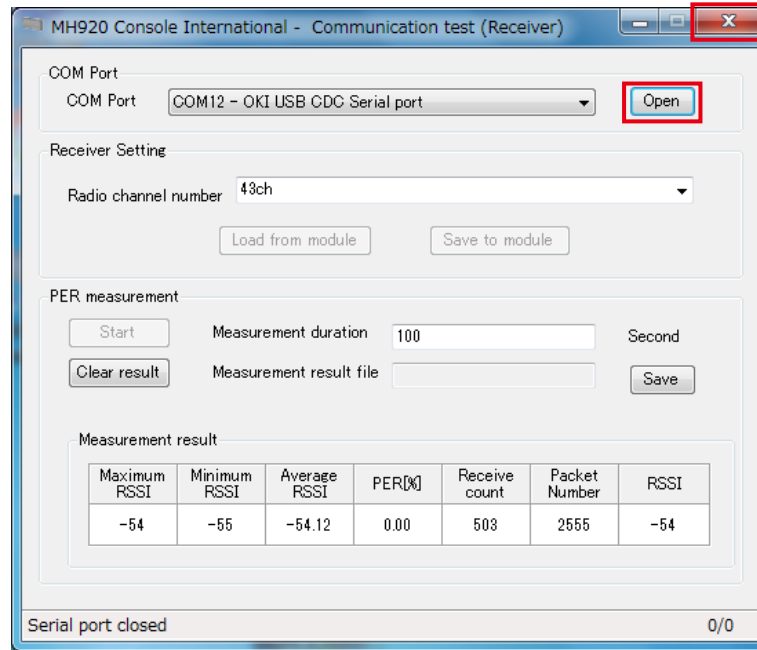


Figure 6.36 Terminating measurement tool

- 2) The mode selection screen appears. Check 'Normal mode.'

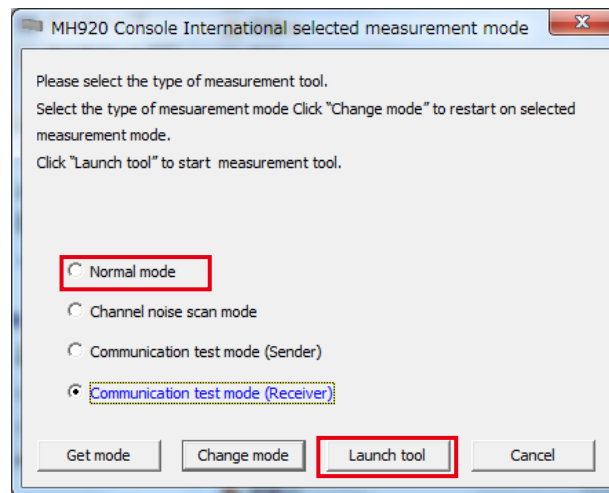


Figure 6.37 'Communication test mode (Receiver)' selected

3) Click [Change mode] button.

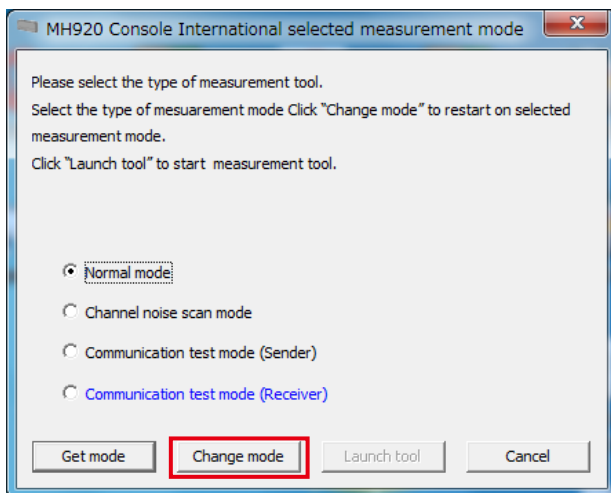


Figure 6.38 'Normal mode' selected

4) The following message appears. Click [Yes] button.

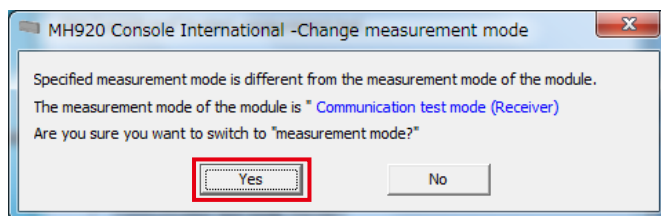


Figure 6.39 Switching measurement mode

5) The wireless device reboots in the normal mode and the following message appears. Click [OK] button.

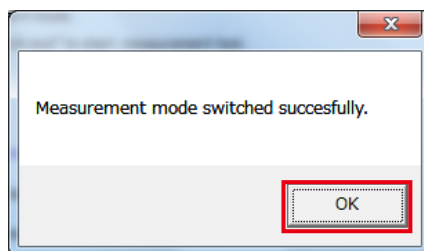


Figure 6.40 Successful mode switching message

## 7. EXAMINING PARAMETERS OF WIRELESS DEVICES

To configure a multihop network using wireless devices, decide each parameter as shown below.

[Table 7.1] Parameters

PARAMETER	PARENT	CHILD	REMARKS
Network join mode	✓	✓	Set to a parent and child devices identically.
PAN ID (group number)	✓	✓	Set to a parent and child devices identically.
Radio channel number	✓	✓	Set to a parent and child devices identically.
Network name	✓	✓	Set to a parent and child devices identically.
Transmitter power output	Δ	Δ	
Retry times before route switching	Δ	Δ	
Encryption key	✓	✓	Set to a parent and child devices identically.
MAC address authentication	Δ	×	Set to a parent device.
MAC address list	Δ	×	Set to a parent device.
Connection refusal list	Δ	×	Set to a parent device.
Low-speed moving mode	×	✓	Set to child devices.
Prefix	Δ	×	Set to a parent device.
Short address	×	✓	0000 fixed for a parent device. Set addresses for child devices individually.
Packet filtering	✓	✓	Set to a parent and child devices identically.
Setting mode of short address	✓	×	Set to a parent device.
Station number list	*1	×	*1. Set with "Setting mode of short address" set to 'list mode'
Fixed route	×	Δ	
Device type in a network, Number of devices in a network	✓	✓	Set to a parent and child devices identically.
Set network quality	Δ	Δ	Set to a parent and child devices identically.
Password for device connection	*2	*2	*2. The default value is usable, however changing to a new one is recommended.

✓: Essential

×: Not configurable

Δ: Usable with default

## 7.1. PARAMETERS

### 7.1.1. NETWORK JOIN MODE

The network join mode 'fast join mode' or 'v3-compatible mode' is selectable.

'Fast join mode' enables to obtain a faster wireless connection, in approximately 5 seconds at shortest, in starting up a device.

Select 'v3-compatible mode' when the network include low-speed moving devices. The shortest time for wireless devices to join the network is approximately 30 seconds at shortest.

It is necessary to set the same for all the wireless devices in the network.

[Table 7.2] Network join mode

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	Fast join mode / v3-compatible mode	
Child	Essential	Fast join mode / v3-compatible mode	

### 7.1.2. PAN ID (GROUP NUMBER)

Wireless devices configure a wireless multihop network (wireless PAN: Personal Area Network) under a parent device. The parent device uses the set radio channel number (frequency band) to configure the PAN and imparts a PAN ID as identifier to the PAN. Set the PAN ID not to overlap with IDs of other networks. The parent device uses this ID to configure its wireless PAN.

Set the PAN ID of the connected parent device to child devices.

When a PAN ID is not set to a child device, it obtains an ID automatically. It selects a parent device with the highest radio wave intensity among the candidate PAN IDs (parent devices) in the network search while connecting, and set the PAN ID of the parent device as its ID. When a child device does not find the PAN ID set to it, it also tries to connect to the PAN with the highest RSSI value. NOTE: It is recommended to set a PAN ID to child devices.

Set a PAN ID within the range as shown in "Table 7.3 PAN ID".

[Table 7.3] PAN ID

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	Hexadecimal, 4 digits 0x0001 – 0xFFFFE	Do not overlap with IDs of other parent devices.
Child	Essential	Hexadecimal, 4 digits 0x0001 – 0xFFFFE	Set the same ID as the connected parent device.

Note: The wireless connection is disconnected with '0x0000'.

### 7.1.3. RADIO CHANNEL NUMBER

Set a radio channel number among 43 channels as shown in the table below to a parent device to configure a wireless network (PAN). Set a different channel number from the ones of other wireless devices in the range where the radio wave reaches, or overlapping channels may cause radio wave interference and prevent normal communication.

[Table 7.4] Radio channel number

Radio channel number	Center frequency	Radio channel number	Center frequency	Radio channel number	Center frequency	Radio channel number	Center frequency
1	902.4 MHz	12	909.0 MHz	23	915.6 MHz	34	922.2 MHz
2	903.0 MHz	13	909.6 MHz	24	916.2 MHz	35	922.8 MHz
3	903.6 MHz	14	910.2 MHz	25	916.8 MHz	36	923.4 MHz
4	904.2 MHz	15	910.6 MHz	26	917.4 MHz	37	924.0 MHz
5	904.8 MHz	16	911.4 MHz	27	918.0 MHz	38	924.6 MHz
6	905.4 MHz	17	912.0 MHz	28	918.6 MHz	39	925.2 MHz
7	906.0 MHz	18	912.6 MHz	29	919.2 MHz	40	925.8 MHz
8	906.6 MHz	19	913.2 MHz	30	919.8 MHz	41	926.4 MHz
9	907.2 MHz	20	913.8 MHz	31	920.4 MHz	42	927.0 MHz
10	907.8 MHz	21	914.4 MHz	32	921.0 MHz	43	927.6 MHz
11	908.4 MHz	22	915.0 MHz	33	921.6 MHz		

Set a radio channel number not used around to a parent device.

To child devices, set the radio channel number of the parent device to connect. Up to 10 channel numbers can be specified to a child device. With multiple channel numbers, it takes time to process the channel scan in the network search to join the network.

#### 7.1.4. NETWORK NAME

In installing several parent devices adjacently, an identifier, called network name, can be given to a network so that child devices can connect with the correct parent device. English one-byte characters and some symbols (one-byte space, “-”, “\_”, “.” and “@”) within 16 characters are usable.

Register a network name to all the parent and child devices. The child devices cannot connect to the parent device with a different network name from the one set to them. Using this network name, it is available to operate a PAN configured per parent device as one network.

Set a network name as shown in the table below.

[Table 7.5] Network name

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	English one-byte characters and symbols within 16 characters*	Do not overlap with the names of other parent devices.
Child	Essential	English one-byte characters and symbols within 16 characters*	Set the same name as the parent device.

\* One-byte space, “-”, “\_”, “.” and “@” are usable.

#### 7.1.5. TRANSMITTER POWER OUTPUT

The radio wave distance depends on the transmitter power output.

20 mW, 1 mW and 0.16 mW are selectable.

[Table 7.6] Transmitter power output

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	20mW / 1mW / 0.16mW	
Child	Essential	20mW / 1mW / 0.16mW	

#### 7.1.6. RETRY TIMES BEFORE ROUTE SWITCHING

Select how many times to retry the transmission before switching the route when the communication from a parent device to repeaters or child devices (referred hereunder as 'downward route') fails.

Select among 1, 2 and 3 times. With the retry times set to 1, the switching time can be shortened and a route in better communication state is selected when a communication error occurs. However a risk that even a communication error due to temporary fluctuation of radio wave causes the route switching and normally excellent communication route is switched may arise. Based on this, setting 3 retry times is balanced well between switching frequency and communication reliability.

[Table 7.7] Retry times before route switching

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	1 / 2 / 3	
Child	Essential	1 / 2 / 3	

### 7.1.7. SECURITY DESIGN

Child devices need to be authenticated by a parent device to join a wireless multihop network. Following two authentication methods are available.

- Encryption key
- MAC address

Refusal of specific child devices to join the network is configurable with the following setting.

- Connection refusal with MAC address

The encryption key is essential to register and set wireless devices to join the network. Authentication using the MAC addresses is arbitrary. Using these two methods concurrently realizes more enhanced security.

#### ■ ENCRYPTION KEY

The wireless multihop network adopts the wireless communication coded with the AES cryptographic algorithm, similar to other wireless networks such as Wi-Fi. Each child device, in joining the network, needs to get a genuine encryption key necessary to encrypt and decrypt from a parent device. It is necessary to register the encryption key to the child devices in advance.

Set 32-digit hexadecimal encryption key.

When the participation is authenticated only by the encryption key, the key is also used in data communication on the network. Therefore the key of the child devices needs to be the same as that of the parent device.

Set the encryption key as shown in the table below.

[Table 7.8] Encryption key

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	Hexadecimal, 32 digits	
Child	Essential	Hexadecimal, 32 digits	Set the same key with that of the parent device.

#### ■ MAC ADDRESS

It is necessary to register MAC addresses of child devices to a parent device in advance for authentication of their participation in the network. Only the registered child devices are authenticated to join the network.

With the MAC address authentication, the participation in the network of a child device from a malicious third party can be refused.

When the MAC addresses are registered, different encryption keys can be set to individual child devices. Up to 200 MAC addresses can be registered.

The MAC addresses can be confirmed with the configuration tool of the wireless devices.

[Table 7.9] MAC address authentication

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	No / yes	

#### ■ CONNECTION REFUSAL

In case malicious third parties possibly attack by MAC address spoofing or abuse of stolen devices, such wireless devices can be refused by registering their MAC addresses in the connection refusal list.

### 7.1.8. LOW-SPEED MOVING MODE

Set a child device to be installed at a fixed position or in a device moving in low speed.

[Table 7.10] Low-speed moving mode

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Child	Essential	No / yes	No: fixed Yes: low-speed moving

### 7.1.9. IPV6 PREFIX

Child devices which are authenticated to join the multihop network obtain their IPv6 addresses.

Set a network prefix (leading 64 bits of IPv6 address) to a parent device to configure the addresses. The IPv6 addresses for wireless devices are automatically set combining this prefix set to the parent device and short addresses set to individual parent and child devices.

The IPv6 addresses are configured according to the following flow.

- 1) Set a prefix to the parent device.
- 2) The parent device automatically sets its IPv6 address using this prefix. (The short address of the parent device is fixed to 0.)
- 3) Then set fixed short addresses to child devices.
- 4) The child devices obtain the information on the adjacent wireless devices and the prefix.
- 5) The child devices automatically set their IPv6 addresses using the prefix and their short addresses.
- 6) The child devices notify the parent device of their IPv6 addresses.
- 7) The parent device notifies the child devices of the availability of those IPv6 addresses. It manages the addresses under its control.

Use the IPv6 global unicast address (leading 16 bits defined with 2000 to 3FFF as shown in the figure below) to set a prefix to the parent device. Do not replace consecutive groups containing zeros with single empty group using two consecutive colons (::), although it is common to represent an IPv6 address.

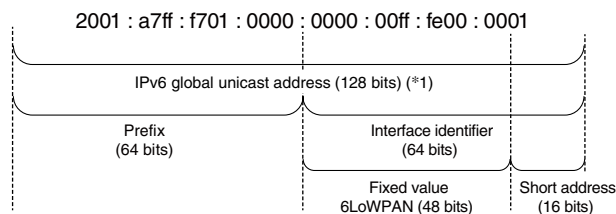


Figure 7.1 Configuration of IPv6 address

Set any prefix because of the IPv6 communication used only in the closed wireless segment. However it is recommended to set a specific prefix to each parent device for the network management.

Set a prefix as shown in the table below.

[Table 7.11] Prefix

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	Leading 64 bits of IPv6 global unicast address	Do not omit with "::"

### 7.1.10. STATION NUMBER AND SHORT ADDRESS

To collect data from remote I/Os connected to wireless devices, it is necessary for a parent device to associate short addresses set to child devices with station numbers of Modbus devices with either of following methods.

- List mode
- Range mode

Select a mode as shown in the table below.

[Table 7.12] Setting mode of short address

DEVICE	SETTING	SPECIFICATIONS / RANGE	REMARKS
Parent	Essential	List mode Range mode: 1 device (max. multi drop number) Range mode: 1 to 4 devices (max. multi drop number) Range mode: 1 to 8 devices (max. multi drop number) Range mode: 1 to 16 devices (max. multi drop number) Range mode: 1 to 31 devices (max. multi drop number)	

#### ■ LIST MODE

The list mode is a method to register the combination of the Modbus station numbers and the short addresses of the child devices on the station number list of the parent device.

- 1) Modbus station number  
Set station numbers of the Modbus devices connected to the child devices.
- 2) Short address  
Set short addresses to the parent and child devices. The address set to the parent device is fixed to 0000.  
Set short addresses to the child devices within the range of 0001 to FFFD in 4-digit hexadecimal. Do not overlap with the addresses of other child devices.
- 3) Registration of the station numbers and the short addresses of the child devices  
Register the combination of the short addresses of the child devices and the station numbers of the Modbus devices on the station number list of the parent device.

#### ■ RANGE MODE

The range mode is a method to assign the station numbers of the Modbus devices to the short addresses of the child devices within the specified range.

- 1) Max. multi drop number  
Set to the child devices corresponding to the multi drop connection.  
Decide the max. number of the multi drop devices in the network to set to the parent device.  
Select among 1, 1 to 4, 1 to 8, 1 to 16, and 1 to 31 devices so to be greater than the actual max. number.
- 2) Connection number  
The configurable station numbers depend on the max. multi drop number set to the parent device.  
A part of the range of configurable station numbers is as shown in the table below.

[Table 7.13] Connectable station number range

SHORT ADDRESS OF CHILD DEVICE	MAX. MULTI DROP NUMBER				
	CONFIGURABLE STATION NUMBER				
	1	4	8	16	31
0001	1	1 – 4	1 – 8	1 – 16	1 – 31
0002	2	5 – 8	9 – 16	17 – 32	32 – 62
0003	3	9 – 12	17 – 24	33 – 48	63 – 93
0004	4	13 – 16	25 – 32	49 – 64	94 – 124
0005	5	17 – 20	33 – 40	65 – 80	125 – 155
0006	6	21 – 24	41 – 48	81 – 96	156 – 186
0007	7	25 – 28	49 – 56	97 – 112	187 – 217
0008	8	29 – 32	57 – 64	113 – 128	218 – 247 *1
0009	9	33 – 36	65 – 72	129 – 144	
000A	10	37 – 40	73 – 80	145 – 160	

\*1. Modbus protocol allows up to 247 child devices to connect.

#### 3) SHORT ADDRESS AND STATION NUMBER

Set short addresses to the parent and child devices. The address set to the parent device is fixed to 0 (0x0000).

Set the short addresses of the child devices after deciding the station numbers of the connected Modbus devices as described in the above “2. Connection number.” For the child devices not to connect to the Modbus devices (repeaters), not required to have station numbers, set their addresses arbitrarily within the range of 4096 (0x1000) to 65533 (0xFFFC) not to overlap with those of other child devices.

### 7.1.11. EXAMINING PACKET FILTERING SETTINGS

Enabling the packet filtering to operate a system where an upper device polls transparent models, overlapped or delayed packets in the wireless network are discarded.

[Table 7.14] Packet filtering settings

ITEM	PARENT	CHILD	EXPLANATIONS
Packet filtering *1	Essential	Essential	Select 'yes' or 'no' for the packet filtering function. With "yes," delayed packets are discarded according to the filter timeout on polling.
Filter timeout on polling, parent device *2	Essential	–	Set the filter timeout on polling with the packet filtering enabled. Set a value subtracting the fixed overhead (1 sec.) from the valid polling time of an upper device (e.g. data acquisition device). Range: 10 – 600 (100 ms increments)
Filter timeout on polling, child device *2	–	Essential	Set a value greater than the polling response time. Range: 10 – 600 (100 ms increments)

\*1. Set to 'no' not to operate in a polling system.

The setting is to be identical in the same network.

\*2. Set a longer timeout of upper devices (parent device) than that of lower ones (child devices).

### 7.1.12. EXAMINING FIXED ROUTE SETTINGS

In joining a network, a wireless device attempts to connect to a device with the highest RSSI value among the devices with the same PAN ID as explained in "7.1.2. PAN ID (GROUP NUMBER)" on page 57.

The fixed route function enables a device to connect with a specified destination regardless of momentary RSSI values. With the temporary detour also set to be enabled, the device transmits data via the detour when the radio wave status to the fixed destination is poor.

When the device fails to transmit data to the fixed destination, it transmits again via a detouring route, if any. Detouring three times switches the route to this detouring one temporarily even with the fixed route enabled. The registered fixed route is adopted again when it is re-established (in several tens of seconds to several minutes).

Specify one upward precedent wireless device as a fixed destination. The downward route is calculated automatically.

Consider this function in configuring the network under the environment where the radio wave state is not stable.

[Table 7.15] Fixed route settings

ITEM	PARENT	CHILD	REMARKS
Fixed route	–	Essential	Select 'yes' (enabled) or 'no' (disabled) for the fixed route.
Destination short address	–	Essential	Short address of a fixed destination
Temporary detour	–	Δ	Select 'yes' (enabled) or 'no' (disabled) with the fixed route set to 'yes.' *1

Δ: usable with default

\*1. Unless a device receives the radio wave from the fixed destination in joining a network, the participation in the network is not available even with the temporary detour set to 'yes'.

### 7.1.13. NETWORK SCALE AND QUALITY SETTINGS

The transmission frequency of control signals to maintain a wireless network is optimized according to the number of wireless devices connected to the network.

Set the same device type and number of devices to the wireless devices with the same PAN ID (group number). The default is child (fixed), 1 to 30 devices. Select appropriate one in configuring the system. When the actual device type or number is different from the setting, a malfunction such like data omission and separation of a child device from the network may occur, and also it may take longer time to detect the separation.

When the network quality is set to 'highest frequency of route switching and delay', the packet arrival rate is improved. However the frequency of retransmission is also higher so to improve the reachability and the arrival (delay) time of data tends to be longer. Set the network quality to 'standard' to keep balance of the data arrival time and the delay time, and to 'higher' or 'highest' to emphasize the arrival time.

[Table 7.16] Network scale settings

ITEM	PARENT	CHILD	SPECIFICATIONS / RANGE	REMARKS
Device type in a network, Number of devices in a network	Essential	Essential	Child (fixed), 1 to 30 devices Child (fixed), 31 to 60 devices Child (fixed), 61 to 100 devices Child (fixed) + child (moving)	Default: child (fixed), 1 to 30 devices Note: Do not select "child (fixed) + child (moving)" in connecting with V3.1.3 devices.
Number of child devices and wireless environmental sensors	Unnecessary	Unnecessary	Fast join mode: child devices only (25 child devices, 0 sensor) V3-compatible mode: standard (15 child devices, 10 sensors)	Fixed value Note: 'Standard (15 child devices, 10 sensors)' in connecting with V3.1.3 devices.
Network quality	Essential	Essential	Standard (recommended) Frequency of route switching and delay (higher) Frequency of route switching and delay (highest)	Default: standard (recommended) Note: Select 'standard (recommended)' in connecting with V3.1.3 devices.

In using low-speed moving devices

Data collection and control of moving child devices (4 km or less per hour) is available with the settings for the low-speed moving to the parent and child devices. The configuration consists of a parent device, repeaters and the low-speed moving child devices. The moving child devices do not have a relay function. They switch the destinations with appropriate radio wave environment among the parent device and repeaters while moving. One network contains up to 50 repeaters and moving child devices.

It is premised that the parent device and repeaters are not powered off, and the radio wave from them reaches the ranges where the child devices move.

In case of the parent device powered off/on after the network configuration, it may take maximum 1 hour to restore the network.

### 7.1.14. PASSWORD TO CONNECT DEVICE

A password to login from the maintenance console for a wireless device is configurable. For security reasons, it is highly recommended to change the factory setting to new one. The specifications of the password are as shown in the table below.

[Table 7.17] Login password

ITEM	PARENT	CHILD	SPECIFICATIONS / RANGE	REMARKS
Password	Essential	Essential	English one-byte characters, 5 to 8 characters	Case-sensitive

### 7.1.15. SIMPLE CALCULATION OF SAMPLING CYCLE

This section describes how to calculate sampling cycle in using wireless devices. The values here are approximate, and may depend on the radio wave environment.

The conditions and formula to calculate the sampling cycle for a data acquisition device to collect data from sensors are shown below, taking the following model configuration as an example. Only the sensors connected to the child devices are the calculation target of the command response. Retransmissions of request to collect data due to timeouts are not considered in the calculation.

#### ■ CALCULATION CONDITIONS

[Table 7.18] Calculation conditions

ITEM	VALUE (UNIT)	REMARKS
Device type in a network,	161 (ms)	Refer to the response time in Input Register (3X)/Holding Register (4X) in "Quick charts of command response time."
Number of devices in a network		
Delay time per hop	80 (ms)	

#### ■ FORMULA

Indication of command response time of child device

$$= (\text{reference command response time} + \text{delay time per hop} \times (\text{number of hops}^* - 1)) \times \text{number of times of access}$$

\* Number of hops = number of repeaters (child devices excluding low-speed moving child devices) to pass through.

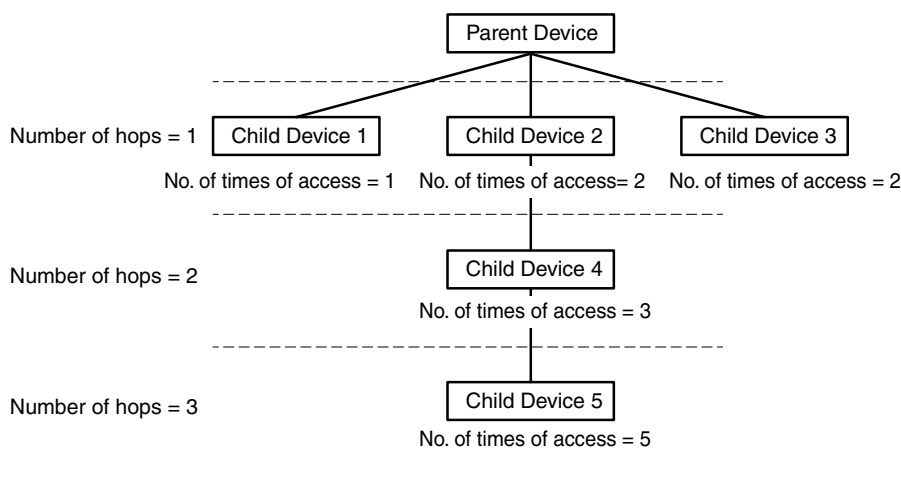


Figure 7.2 Model configuration for calculation of command response time

The command response time per child device in turning this model configuration into the above formula is as shown in the table below.

[Table 7.19] Command response time per child device in the model configuration

DEVICE	RESPONSE TIME (ms)	NO. OF HOPS	NO. OF TIMES OF ACCESS	COMMAND RESPONSE TIME PER DEVICE	COMMAND RESPONSE TIME (ms)
Child device 1	161	1	1	$(161 + 80 \times (1 - 1)) \times 1$	161
Child device 2		1	2	$(161 + 80 \times (1 - 1)) \times 2$	322
Child device 3		1	2	$(161 + 80 \times (1 - 1)) \times 2$	322
Child device 4		2	3	$(161 + 80 \times (2 - 1)) \times 3$	723
Child device 5		3	5	$(161 + 80 \times (3 - 1)) \times 5$	1605

The sampling cycle from the sensors connected to the child devices 1 to 5 is calculated as follows:

$$\text{Sampling cycle} = 161 + 322 + 322 + 723 + 1605 = 3133 \text{ (ms)}$$

Therefore it is necessary to set the cycle to 3133 (ms) or more.

The following quick charts of the command response time are convenient to calculate.

[Table 7.20] Quick charts of command response time

Coil (0X)/Input (1X) (bit unit)

Number of points	1	200	400	600	800	1000
Response time (ms)	148	182	195	224	240	257

Input Register (3X)/Holding Register (4X) (word unit)

Number of points	1	20	40	60	80	100	120
Response time (ms)	161	177	211	240	267	303	332

## 8. SETTING WIRELESS DEVICES

### 8.1. PARENT DEVICE

Refer to the manual as shown in the table below for the configuration of the parent device.

[Table 8.1] Configuration of parent device

MODEL	MANUAL
WL40EW2F	WL40EW2F Operating Manual (EM-9080-B)
IT40SW5F IT50SW5F IT60SW5F	IT40SW5 Operating Manual (EM-2431-B)

### 8.2. CHILD DEVICE

Refer to the manuals as shown in the table below for the configuration of the child devices.

[Table 8.2] Configuration of child device

MODEL	MANUAL
WL40W1F-x WL40MW1F	W920FCFG Users Manual (EM-9082)
IT40SW6F IT50SW6F IT60SW6F	ITCFG Users Manual (EM-2365)
R3-NMW1F	R3CON Users Manual (EM-9274)

## 9. INSTALLING WIRELESS DEVICES

Be careful to install wireless devices after confirming the following notes.

### 9.1. RECOMMENDED INSTALLING LOCATIONS

For data communication in satisfactory radio wave conditions, install wireless devices in the following places.

- 1) Install devices as high as possible to avoid obstacles to interrupt radio wave.
- 2) When a metal plate is mounted behind a wireless device, the backward radio wave from the device may possibly become a noise reverberatively or be emitted badly to other devices installed behind. Avoid such installation. When it is unavoidable, install an antenna as far from the metal plate as possible.
- 3) Install wireless devices in less-frequented and vantage places.

### 9.2. INSTALLING ANTENNAS

The radio wave state depends significantly on the direction and installing location of antennas. When it is poor, change their direction and location as shown below.

- 1) Match the polarization planes of a parent and child devices. Install an antenna with its direction perpendicular to the ground because its directionality is omnidirectional to the horizontal plane.

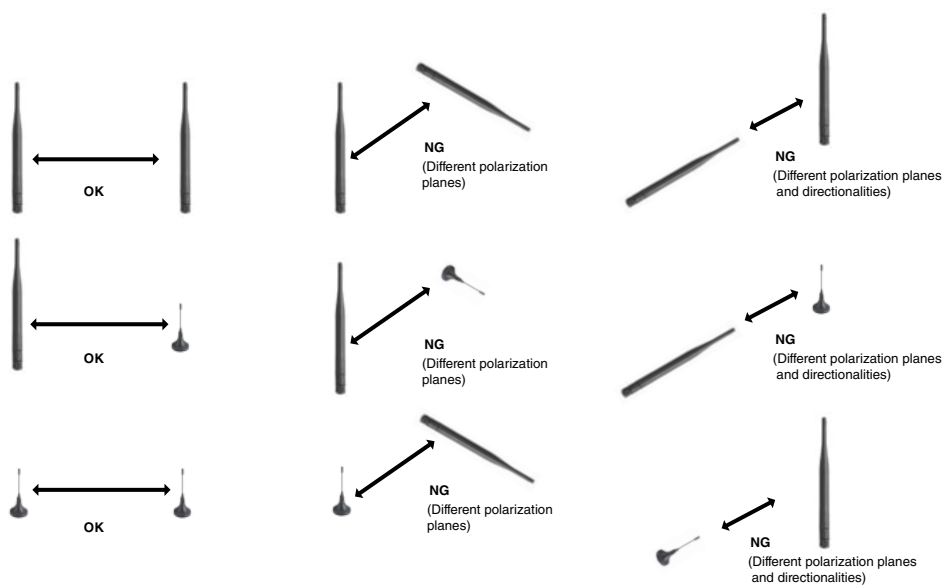


Figure 9.1 Polarization plane of antenna

- 2) Secure a Fresnel zone.
- 3) A sleeve antenna is movable in the range of 90°. Adjust the installing direction of the antenna and its angle. In changing the angle, turn the antenna clockwise not to slip off or be loosened.
- 4) Extend a cable (2.5 m) of a rooftop antenna to change the installing location of the antenna.
- 5) In using a rooftop antenna, fix the magnet base to a metal plate (recommended dimensions: 500 mm × 500 mm or more).
- 6) Make sure that there is not an antenna used in a different network in the neighborhood. If any, secure the distance at least 2 m or more far from it.

Note: In using a rooftop antenna, do not force the cable to bend less than the acceptable radius of 3 cm.

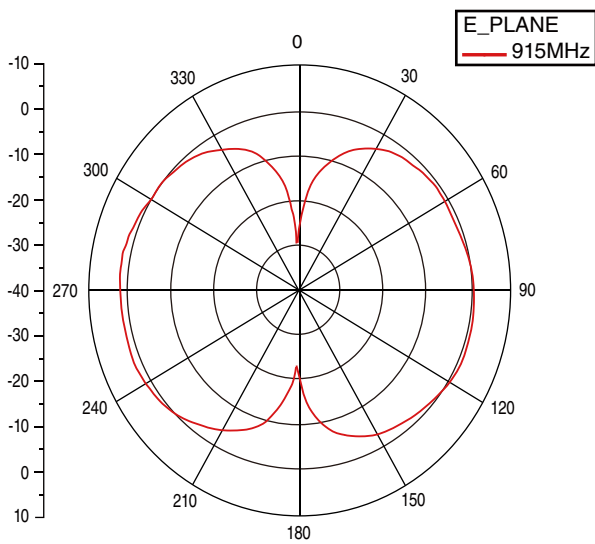
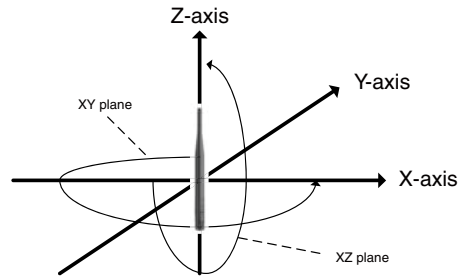
### 9.3. DIRECTIONALITY AND POLIRIZATION PLANE OF ANTENNA

An antenna has a direction where it readily transmits or receives radio wave, which is called directionality. The directionality depends on antenna types.

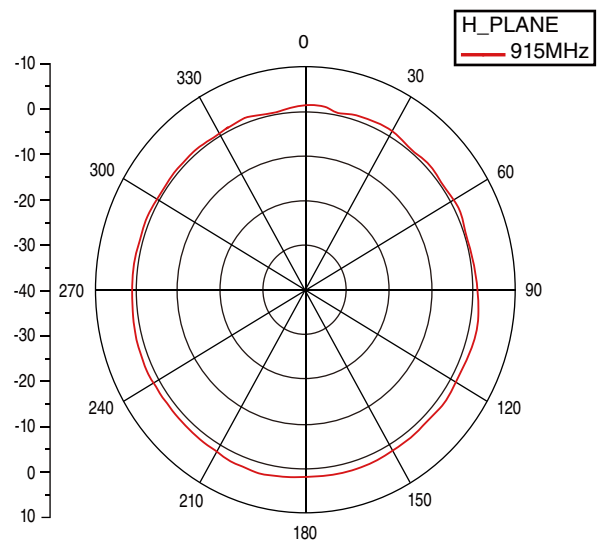
#### ■ SLEEVE ANTENNA FOR WIRELESS I/O WL40F SERIES

The following figures show the directionality of the sleeve antenna.

The sleeve antenna is omnidirectional in a horizontal plane.



**[E-Plane]**



**[H-Plane]**

Figure 9.2 Directionality of sleeve antenna for WL40F series <reference>

■ ROOFTOP ANTENNA FOR WIRELESS I/O WL40F SERIES

The following figures show directionality of the rooftop antenna.  
 The Rooftop antenna is omnidirectional in a horizontal plane.

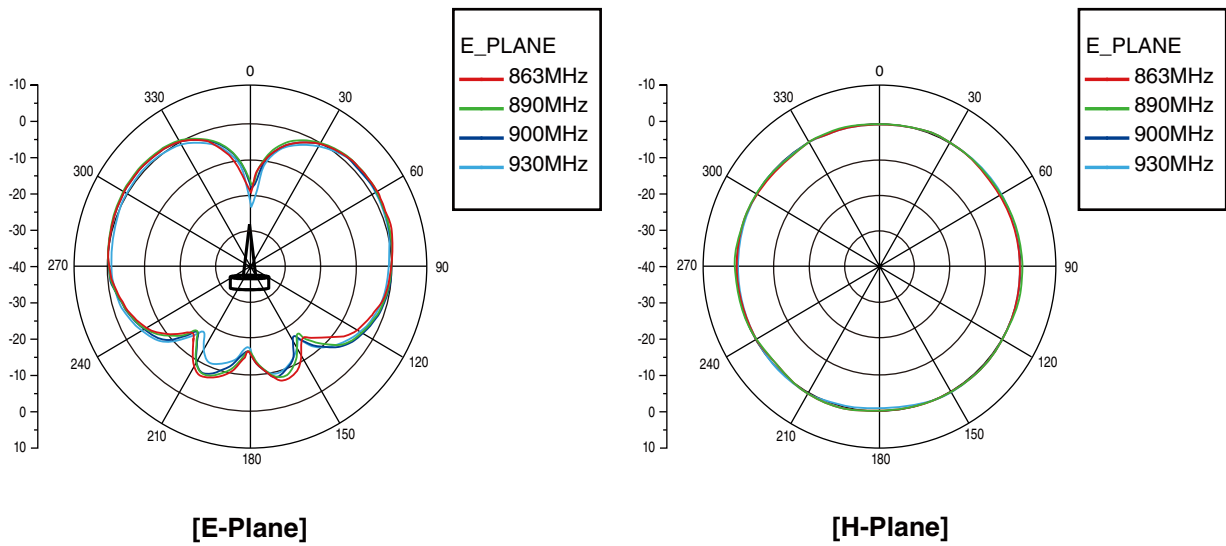
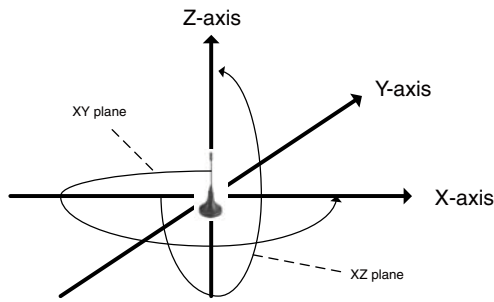


Figure 9.3 Directionality of rooftop antenna for WL40F series <reference>

## 9.4. FRESNEL ZONE

A constant space is necessary for optimum receiving sensitivity of radio wave. This space is called Fresnel zone. When the Fresnel zone is secured, the distance causes attenuation of radio wave (free space propagation loss). To secure the Fresnel zone, install antennas more highly than the Fresnel radius with clear obstruction (actually at least 60% clearance) between them as shown in "Figure 9.4 Fresnel zone".

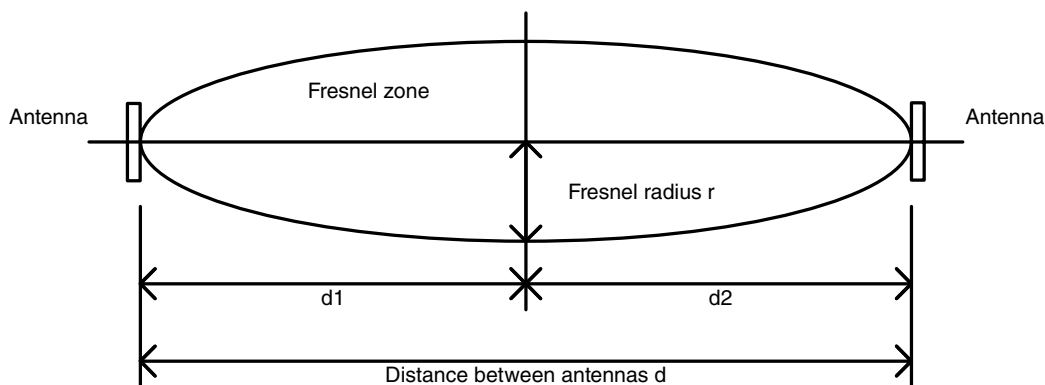


Figure 9.4 Fresnel zone

The Fresnel radius  $r$  can be obtained by the following formula:

$$r = \sqrt{\lambda \times \frac{(d1 \times d2)}{(d1 + d2)}} \quad \text{Formula 9.1}$$

where  $r$ : Fresnel radius [m]  
 $\lambda$ : wavelength [m]  
 $d, d1, d2$ : distance between antennas [m]

## 9.5. $d, d1, d2$ : distance between antennas [m]

The wavelength in 900 MHz is 0.333 m. The Fresnel radius is obtained by Formula 9.1 as shown in Table 9.1 when the antenna distance is 100 m, 200 m, 300 m, 500 m and 1000 m.

[Table 9.1] Fresnel radius

Distance between antennas	100 m	200 m	300 m	500 m	1000 m
Fresnel radius	2.89 m	4.08 m	5.00 m	6.45 m	9.13 m

The above table shows theoretical calculated values to obtain the Fresnel radius. Such a height is not always necessary for the radio wave to reach.

It is very difficult to secure the Fresnel radius for indoor use. Furthermore, indoor radio wave reaches a receiver through various routes, for example reaching directly a receiver antenna from a sender antenna, reaching reflected by walls, a floor and a ceiling, and reaching by coming around obstacles such like partitions. Therefore, simple modelization of the Fresnel zone does not show actual reception state. For indoor use, measure radio wave in each installing location in advance to check the reachability of the radio wave.

## 9.6. INTERFERENCE TO RADIO WAVES

### (1) NATURAL NOISES CAUSED BY LIGHTNING, STATIC ELECTRICITY, OR SOLAR RADIATION

- Noise caused by lightning may affect radio communications.
- Because of radio property, rain has little influence on radio communications.  
However, radio reachability can be affected when a water layer is formed by rainwater or snow accumulated on the metal plate surface to which the rooftop antenna is attached.

### (2) RADIO WAVE INTERFERENCE

- Interference from a third party:  
Reception sensitivity may be deteriorated or interference may occur due to radio waves emitted from third party wireless devices.  
For example, radio interference may occur when other wireless devices using the same radio frequencies are present in the vicinity.
- Self-interference (multipath fading):  
Radio propagation path (diffracted wave, reflected wave, transparent wave) can affect radio communication.  
Radio wave can travel directly to a receiver but often reaches the receiver after being reflected by surrounding objects.  
So-called 'multipath fading' occurs when radio waves which have arrived at the receiver through respective paths interfere with each other, resulting in affecting the reception level of the radio waves.  
'Fading' is a phenomenon in which the reception level varies due to movement of a wireless device and/or with time.

### (3) INFLUENCE OF OBSTACLES

- Radio wave status can change significantly due to the location of antenna within the installation site and objects in the vicinity which may shield radio waves.
- Radio wave transmission/reception environment may change due to new obstacles (trees, constructions, etc.) which were not present when wireless devices were initially installed.

### (4) SPURIOUS RADIATION FROM ELECTRONIC EQUIPMENT

- A source of electromagnetic waves or magnetized object in the vicinity can cause noise and may affect radio communication.

## 10. MEASUREMENT OF RADIO WAVE ENVIRONMENT

Carry out the measurements described in “6. PRIOR MEASUREMENT OF RADIO WAVE ENVIRONMENT” again with the installed wireless devices.