# Ultrasonic Cleaner

# W-357BM-1200

## — Instruction manual —

HONDA ELECTRONICS CO.,LTD.
Industrial Equipment Division

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# 1 Introduction

Thank you for purchasing this W-357BM-1200 Ultrasonic Cleaner by Honda Electronics.

This manual contains important safety information for usage and also the standard specifications and procedures for installation and operation.

Be sure to read this manual thoroughly prior to use to ensure that the product is used properly. Also, keep this manual in a safe place for future reference.

## About This Product

This product is a stand-alone batch-type ultrasonic cleaner that operates at an oscillation frequency of 1 MHz and has a maximum output of 1200 W.

This high frequency of 1 MHz is provided for enabling precision washing of delicate items such as semiconductor wafers, liquid crystal glass substrate, and magnet heads. The main functions and features of this device are described below.

| Main functions and features | Refer to |
|---|---|
| **Output adjustment function**<br>The SELECT keys on the oscillator front panel can be used to adjust the output power in the range from 200 to 1200 W. This enables you to set the optimum output for the cleaning application. | 5.2 |
| **Automatic frequency tracking function/Constant power control function**<br>The state of ultrasonic waves generated in cleaning solution varies depending on fluctuations in the supply voltage and changes in loads such as the solution depth, solution type, decompression state, and object being cleaned. In response to these fluctuations, the automatic frequency tracking function and constant power control function of the oscillator can be used to apply oscillations at the optimum frequency and at a stable output power for providing stability in the generation of ultrasonic waves. | - |
| **Error indicator function**<br>When an error occurs, a description of the detected error is shown on the display on the oscillator front panel. This function helps to identify the cause of the problem for quick resolution. | 7.1 |
| **I/O Functions** | |
| 1. Remote control input function<br>Remote control operation can be used to perform ON/OFF control of ultrasonic oscillation. | 6.1 |
| 2. Error detection output function<br>When an error occurs in this device, error notification can be sent to a remote location. This enables monitoring of the oscillator status. | 6.2 |
| 3. Oscillation detection output function<br>This sends notification of the ultrasonic oscillation state to a remote location. | 6.3 |
| 4. Power-on detection output function<br>This sends notification of the power state of the oscillator to a remote location. | 6.4 |

| | |
|---|---|
| 5. Sensor input function<br>This detects errors from external sensors (water level sensor, workpiece loaded/unloaded detection sensor, etc) for performing an abnormal stop of the oscillator. | 6.5 |
| **4 to 20 mA output function**<br>Current from 4 to 20 mA can be output based on the output power. | 6.6 |
| **Communication function (RS-485 Modbus RTU protocol)**<br>The oscillator can use the Modbus RTU protocol to perform RS-485 communication. This function can be used to change the oscillator settings and read the oscillation state. | 6.7 |

# Usage Guide

This manual provides information under the classifications "Note" and "Important" shown below.

**Note**
This contains useful information.

**Important**
This contains important information that the user should know.

If you notice any unclear points, errors, omissions, or other points in this manual, please submit them to us.

# 2 Before Use

To ensure safety, before using this product, be sure to read all provided information, and follow the instructions when operating.

## 2.1 Ensuring Safe Operation

### Classification of Safety Signal Words

In this manual, important safety information is described by classifying the information based on the expected severity of the hazard as shown below.

| | |
|---|---|
|   | **Indicates an imminently hazardous situation, which if not avoided, will result in death or serious injury.** |
|   | **Indicates a potentially hazardous situation, which if not avoided, could result in death or serious injury.** |
|   | **Indicates a hazardous situation, which if not avoided, could result in minor injury or property damage.** |

### Pictograms Used in This Manual and on This Product

The following pictograms are used for this manual and this product to indicate instructions that must be followed, prohibited actions, and other important safety information.

| | | | |
|---|---|---|---|
|  | Indicates a prohibited action. |  | Products displaying this mark indicate that the operator must refer to the corresponding section in this manual. |
|  | Indicates instructions that must be followed by the operator. |  | Do Not Disassemble |
|  | Heating without solution is prohibited |  | Danger of electrical shock |
|  | Indicates locations where a ground must be properly installed. | | |

# 2.2 Safety Information

This section contains important information for preventing dangers to people, device breakdowns, and fires and other damage.

Be sure to carefully read this information, and follow it when using this device.


| This device contains high-voltage components | |
|---|---|
|  Do Not Disassemble | Never attempt to disassemble, modify, or repair this device.<br>This could result in a fire, electrical shock, or injury. |
|  Prohibited | Never insert your finger, pins, tools or other metal objects, or other foreign objects into the fan intake holes or outtake holes. This could result in an electrical shock or injury. |

| This device does not have an explosion-proof structure | |
|---|---|
|  Prohibited | Never use in locations where flammable gases or explosive gases are generated.<br>Doing so could result in a fire or explosion. |

| This device emits strong ultrasonic waves | |
|---|---|
|  Prohibited | People who are using pacemakers must never use this device or perform work in the vicinity of this device. |

| Grounding required | |
|---|---|
|  | Be sure to properly install a ground that will not become disconnected.<br>Otherwise, a breakdown or electrical leakage could lead to an electrical shock or injury. |
|  | Never connect to the ground wires of gas pipes, water pipes, lightning rods, or telephone wires.<br>Doing so could result in a fire or explosion. |

WARNING

| | |
|---|---|
| | Use at a supply voltage that is within ±10% of the rated voltage.<br>Usage at supply voltages outside the rating could result in breakdown or a fire. |
| | Electricity at a high voltage and high current flows through the transducer cable and power cable, and so be sure that the connector connections are properly fitted without any looseness.<br>Otherwise, this could result in an electrical shock or fire. |
| Prohibited | Do not install the oscillator in a location where acidic, alkaline, or other corrosive gases are generated. Corrosion could reduce the lifespan of the oscillator, resulting in a breakdown. |
| Prohibited | Do not use combustible or flammable liquids for the cleaning solution used in this device. |
| Heating without solution is prohibited | Never operate this device without cleaning solution where the device is empty when heated.<br>Doing so could result in a breakdown.<br>※ Use with a solution depth that is at least 100 mm above the transducer radiating surface. |

CAUTION

| | |
|---|---|
| | Use the oscillator within the operating temperature range of 5°C to 40°C.<br>Also, even if the indoor temperature environment is within the rated temperature range of 5°C to 40°C, this temperature could be exceeded in the area around the oscillator due to the installation conditions, and so install a thermometer for checking the ambient temperature, and implement measures to keep within the rated temperature range.<br>Usage outside the temperature range could reduce the lifespan of the oscillator, resulting in a breakdown. |
| | The solution temperature range that can be used in the transducer unit is 5°C to 80°C.<br>Usage outside the temperature range could reduce the lifespan of the transducer, resulting in a breakdown. |
| | When connecting the power supply, supply power by passing through a circuit breaker rated at 20 A or higher for each device. Also, use 30 mA or higher per device for the sensitivity current of the ground fault circuit interrupter. |
| | Be sure to clearly indicate the specific circuit breaker where this device is connected to enable the power to be cut off quickly in the event that a problem occurs in the device. |
| | Do not cover the ventilation openings on the side and rear panels of the oscillator. Also, install by providing at least 80 mm of clearance from the side panels and at least 150 mm of clearance from the rear panel.<br>Otherwise, the oscillator internal temperature could rise, resulting in a fire or breakdown. |
| | Ensure that the cleaning object does not directly contact the ultrasonic wave vibration surface of the transducer unit.<br>Direct contact could result in reduced cleaning efficiency and also a breakdown.<br>※ Use so that the cleaning object is positioned at least 50 mm above the transducer radiating surface. |
| | The oscillator does not have a waterproof structure, and so install it in a location where it is not exposed to liquids. Otherwise, the oscillator could break down. |
| | The oscillator and transducer unit are adjusted as a set.<br>The transducer unit that is connected to the oscillator should be the transducer unit having the same machine number as the number in the equipment nameplate label on the rear panel of the oscillator.<br>If the wrong transducer is connected, a malfunction or breakdown could occur. |

| | |
|---|---|
|  Prohibited | Do not use cleaning solutions having strong acidity (pH 6 or less) or strong alkalinity (pH 10 or higher) with this device. Also, do not use organic solvents or flammable cleaning solutions.<br>To use these types of cleaning solutions, insert the acidic or alkaline solution in a separate container, and use by inserting the container into the cleaning tank filled with water. |
|  Prohibited | When draining water-soluble neutral detergents after use, be sure to comply with the standards in the Water Pollution Prevention Law and other related laws and regulations. |
|  Prohibited | Do not use by inserting the oscillator into an airtight box without ventilation openings. Otherwise, the oscillator internal temperature could rise, resulting in a fire or breakdown. |

# Other Safety Information

## Safety Information on Installation and Use of Transducer Cable and Power Cable

- Before connecting the transducer cable, power cable, and other cables, be sure that the power supply has been turned off.
- The transducer cable and power cable do not have a waterproof structure, and so install them in a location where they are not exposed to liquids.
- Do not use the transducer cable or power cable while a strong force is being applied to the cable or while the cable is twisted.
- Do not put extreme bends into the transducer cable or power cable or bind the cable in small loops. This could cause noise to radiate from the cable or cause the cable to overheat.
- Do not make incorrect connections for the transducer cable or power cable. Doing so could result in an electrical shock or fire.
- Do not use anything other than the supplied items for the power cable.
- Do not connect the power cable using a multi-plug device in the outlet or using extension cables. Doing so could result in an electrical shock or fire.

## Safety Information on Installation and Use of Oscillator

- Install the oscillator in a location that is not exposed to large amounts of dust, dirt, mist, and other contaminants. Otherwise, the ventilation openings of the oscillator could become clogged by dust, dirt, mist, or other substances, which will reduce the ventilation cooling performance and could result in a breakdown.
- Install the oscillator in a location in the humidity range from 5% to 80% and, in particular, is not damp and is not exposed to water droplets. Otherwise, the lifespan of the oscillator could be shortened, resulting in a breakdown.
- Do not install the oscillator in locations exposed to direct sunlight or near sources of heat. Otherwise, the oscillator internal temperature could rise, resulting in a breakdown.
- Periodically remove any dust adhering to the ventilation openings of the oscillator case. Dust adhering to the ventilation openings can reduce the heat dissipating performance, causing overheating inside the oscillator, and resulting in a breakdown.
- If the oscillator is installed in a location where the ambient temperature is high, put the oscillator in a box, and cool it using a cooler or other means to ensure that the temperature inside the oscillator does not rise.
- Install the oscillator in a flat location with sufficient strength and that is not exposed to vibrations. Vibrations could damage the internal parts, resulting in a breakdown.

- Do not install by stacking three or more oscillators on top of each other.
- This device has indoor specifications, and so be sure to always use it indoors.
- If not using for an extended period of time, disconnect the primary-side power supply.
- Before performing maintenance and inspection of this device, be sure to always turn off the power switch, and disconnect the primary-side power supply. This device includes high-voltage components that pose a risk of electrical shock.

## Safety Information on Installation and Use of Transducer Unit

- In the vibration plate-type transducer unit, the oscillating element and wiring do not have a waterproof structure. Install and use in a location where they will never be exposed to liquids.
- Whenever lifting and transporting heavy transducer units, either use two or more people or use safe hoisting equipment.

## Safety Information on Installation and Use of Signal Cables to I/O Terminals

- Use shielded cables when routing within 10 meters of RS-485 communication signal cables, 4 to 20 mA output signal cables, remote control input signal cables, error detection output signal cables, oscillation detection output signal cables, power-on detection output signal cables, and sensor input signal cables. Otherwise, noise could enter the oscillator and control system where the signal cable is connected, which could result in a malfunction.
- Do not route the signal cable for oscillator control or the signal cable for control of other devices in the vicinity of the oscillator power cable or transducer cable. Otherwise, noise could enter the oscillator and other control systems, resulting in a malfunction.
- When performing external control using a remote control device, connect so that one device is controlled using a single circuit. If multiple devices are used by connected in parallel or series, this could result in a malfunction or breakdown.
- Do not supply the power voltage to the signal cable. Doing so could result in a breakdown.

## General Safety Information

- Do not carelessly touch the oscillator, transducer unit, cables, or other parts when your hands are wet.
- During ultrasonic cleaning, do not insert your hands into the cleaning tank without paying careful attention.
- Do not leave the cleaning solution in a dirty state. Dirtiness could accumulate on the vibration surface, resulting in a breakdown.

- When storing this device, store it in a location that is not exposed to direct sunlight and that has a temperature range from -15°C to 60°C, humidity range from 10% to 85%, and no condensation.
- Wipe off any moisture, cleaning solution, or dirt adhering to the oscillator and transducer unit using a dry cloth.
- If the oscillator is left running, the temperature of the cleaning solution could rise, causing it to evaporate. If operating when there is no cleaning solution, heating is performed in an empty state, which could cause a breakdown.
- The oscillator case is made from electrolytic zinc-coating steel sheets (SECC). Do not wipe the oscillator using any chemicals that are corrosive to electrolytic zinc-coating steel sheets. Otherwise, the oscillator could break down.

# 3 Names of Parts and Their Functions

## 3.1 Check of Packaged Items

In this product series, an oscillator and transducer unit are combined to form a single set.
The following two types of combinations with the transducer unit are available, and the type of transducer unit set selected by the customer is provided in the package.

- Vibration plate type
- Tank type

Check that the main unit and accessories match.
If any items are missing or damaged, please contact the dealer where you made the purchase or the Honda Electronics Customer Support Center.

### Oscillator

| Packaged items | Quantity |
|---|---|
| Oscillator | 1 |
| Power cable (3 m) | 1 |
| Control cable connector (3-pin) | 1 |
| Control cable connector (6-pin) | 1 |
| Control cable connector (7-pin) | 1 |
| Output connector clamp fixture | 2 |
| Instruction manual (this document) | 1 |

### Transducer Unit

| Set name | Packaged items | Quantity |
|---|---|---|
| Vibration plate type | Vibration plate type transducer unit (standard part or special-order part)*1 | 1 |
| Tank type | Tank type transducer unit (standard part or special-order part)*1 | 1 |

* 1 Transducer cable length 5 m × 2 (standard product)

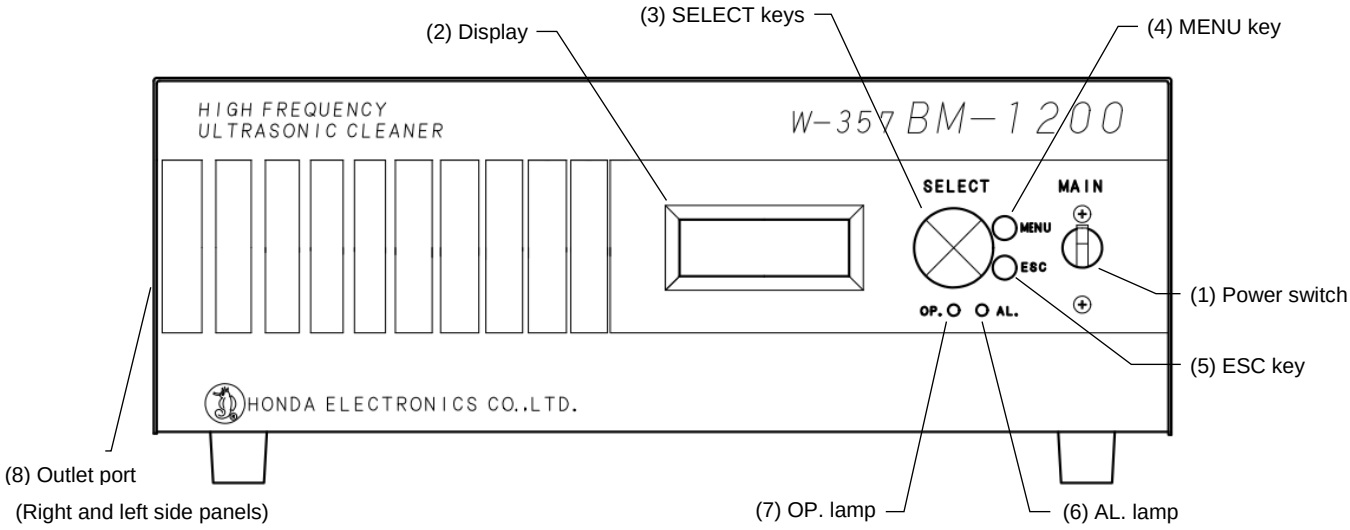
# Items Sold Separately

Depending on the customer's order, the following items that are sold separately may be included.
Check the details of your order to confirm that any items sold separately are included.

| Product name | Optional parts |
|---|---|
| Transducer unit<br>(Vibration plate type) | Vibration plate mounting packing |
| | Vibration plate mounting auxiliary frame |
| | Vibration plate mounting screws |

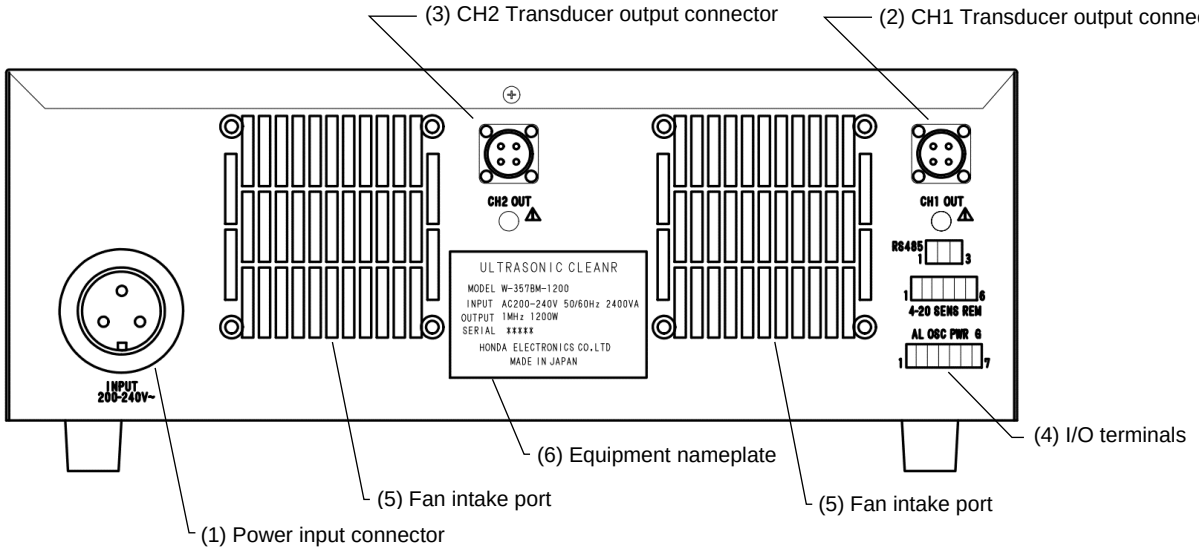
# 3.2 Names of Parts

## Front View




| No. | Name | Description |
|---|---|---|
| (1) | Power switch (MAIN) | This is the main power switch for turning on and off the power for the oscillator.<br>It also includes a function that activates a protective shutoff when an excessive power current flows. |
| (2) | Display | This shows messages. |
| (3) | SELECT keys | These are used to select setting options and change setting values. |
| (4) | MENU key | This is used to enter the MENU screen, to apply the settings that were changed in the MENU screen, and to return to the main screen. |
| (5) | ESC key | This is used to return the settings that were changed in the MENU screen back to their original values and return to the main screen. |
| (6) | AL. lamp<br>(ALARM) | This lamp is lit solid when an alarm occurs. |
| (7) | OP. lamp<br>(OPERATION) | This lamp turns on when ultrasonic oscillation is set to ON. |
| (8) | Outlet port | This is an outlet port for dissipating heat and cooling the inside of the oscillator.<br>To ensure adequate ventilation, be sure to provide at least 80 mm of clearance from the side panels. |

# Rear View




| No. | Name | Description |
|---|---|---|
| (1) | Power input connector | This connector supplies the power voltage when the supplied power cable is connected. Supply a power voltage that is within ±10% of the rated input value shown in the equipment nameplate. |
| (2) | CH1<br>Transducer output connector | This connector supplies power to the transducer when the transducer cable of the transducer unit is connected. The transducer unit that is connected to the oscillator should be the transducer unit having the same machine number as the machine number of the oscillator.<br>If the system uses multiple oscillators, the indication of CH1 / CH2 will be CH3 / CH4, CH5 / CH6, CH7 / CH8, CH9 / CH10, CH2 / CH3, CH4 / CH5, CH6 / CH7, or CH8 / CH9. |
| (3) | CH2<br>Transducer output connector | |
| (4) | I/O terminals | Various functions are used by connecting signal cables to these terminals. |
| | (1) [RS485] | This uses RS-485 communication to perform remote control of the oscillator. |
| | (2) [4-20] | This outputs a current of 4 to 20 mA based on the output power. |
| | (3) [SENS] | This detects errors from external sensors (water level sensor, workpiece loaded/unloaded detection sensor, etc) for performing an abnormal stop of the oscillator.<br>- Open between terminals: Normal<br>- Short-circuit between terminals: Abnormal stop |
| | (4) [REM] | This enables ON/OFF control of ultrasonic oscillation from a remote location.<br>- Open between terminals: Oscillation OFF<br>- Short-circuit between terminals: Oscillation ON |

| No. | Name | Description |
|---|---|---|
| | (5) [AL] | This sends notification of device alarms and errors to a remote location.<br>- Abnormal stop or power off: Open between terminals<br>- Normal: Short-circuit between terminals |
| | (6) [OSC] | This sends notification of the ultrasonic oscillation state to a remote location.<br>- Oscillation OFF: Open between terminals<br>- Oscillation ON: Short-circuit between terminals |
| | (7) [PWR] | This sends notification of the power state of the oscillator to a remote location.<br>- Power OFF: Open between terminals<br>- Power ON: Short-circuit between terminals |
| (5) | Fan intake port | This is a fan intake port for dissipating heat and cooling the inside of the oscillator.<br>To ensure adequate ventilation, be sure to provide at least 150 mm of clearance at the rear panel. |
| (6) | Equipment nameplate | This equipment nameplate shows the model, rated input, rated output, and machine number. |

# 4 Installation and Connections

This section describes the procedures for installation and connections for this device.

## 4.1 Installing the Oscillator

The oscillator is installed on a stable, flat location with sufficient strength that is not subjected to vibrations, and is not damp or exposed to water droplets.

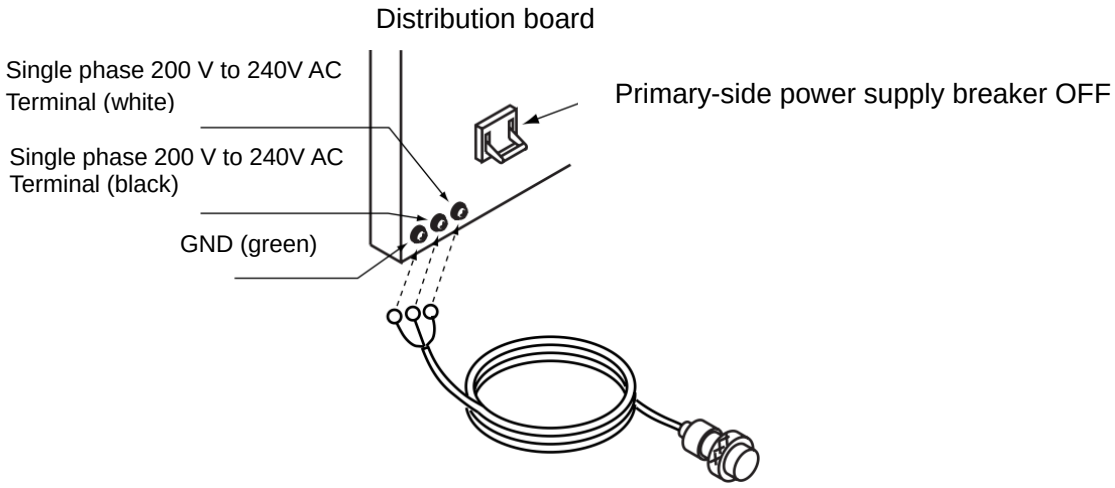
**Install in a location that meets the following environmental requirements.**

- Location with an ambient temperature from 5°C to 40°C, humidity of 80% or less, and no condensation
- Location where the ventilation openings on the side and rear panels of the oscillator will not be blocked
- Install by providing at least 80 mm of clearance from the side panels and at least 150 mm of clearance from the rear panel.

# 4.2 Connecting the Power Cable

## Preparation

Connect the power cable to the power supply prepared beforehand by the customer.
Refer to the figure below.




**Note**

The connection polarity for the supplied power cable is shown below.

Green: Connected to ground, White: Connected to single-phase AC power supply, Black: Connected to single-phase AC power supply

## Procedure

1. Connect the power cable to the circuit breaker side (single-phase 200 V to 240 V AC, 50/60 Hz).

- To prevent the risk of electric shock, before making any connections, be sure to always cut off the power supply to the circuit breaker, and check that the power switch of the oscillator is at the OFF position.
- Supply power by passing through a circuit breaker rated at 20 A or higher for each device. Also, use 30 mA or higher per device for the sensitivity current of the ground fault circuit interrupter.

2. Insert the plug of the power cable into the power supply input connector on the oscillator rear panel, and screw in firmly until the lock ring no longer moves.

Be sure to disconnect the power supply before connecting the power cable to the oscillator.
If a power cable is connected when a voltage is applied while the oscillator power switch is at the ON position, a breakdown of the oscillator could result.

# 4.3 Installing the Transducer Unit

## Mounting Procedure Example (Vibration Plate Type Transducer Unit)

1. Obtain a cleaning tank that has sufficient strength to support the weight of the vibration plate and that has a shape that matches the dimensions of the vibration plate.

**Important**
When carrying around and installing the vibration plate, handle it carefully to ensure that it does not become warped.
If the plate is warped, this will reduce the quality of the transducer attachment surface.

2. For types that have a stud bolt in the vibration plate outer circumference, place the (1) packing and (2) vibration plate, in that order, on the opening in the cleaning tank bottom surface. Check that the stud bolt passes through the bolt through hole in the packing and cleaning tank bottom surface.
3. Install the auxiliary frame from the rear side of the cleaning tank bottom surface, put a spring washer on the stud bolt that passes through the hole, and secure using a nut.

**Important**
- Ultrasonic vibrations can cause looseness to occur after tightening. This looseness can lead to leakage of solution, and so be sure to always implement measures to prevent looseness.
- When mounting to the cleaning tank, the material of the packing that makes contact with the solution varies depending on the type of cleaning solution that is used. And so, select the material that matches the type of cleaning solution. If a material is used that does not match the solution, a solution leak can occur.

4. Pull out the transducer cable to the outside of the cleaning tank, and connect it to the oscillator.

**Note**
For details on the connection procedure, see "4.4 Connecting the Transducer Cable."

# 4.4 Connecting the Transducer Cable

## Connecting the Transducer Cable to the Oscillator

Insert the plug of the transducer cable into the transducer output connector on the oscillator rear panel.

**Important**

Before connecting the transducer unit to the oscillator, be sure to check that the machine number affixed to the oscillator rear panel matches the machine number of the transducer unit.

Connecting a transducer unit with an oscillator having a different machine number could result in a malfunction or a breakdown.

# 5 Operating Procedures

This section describes the basic operating procedures for this device.

Before using this device, check that the installation and connections were completed.

## 5.1 Preparation

1. Fill the cleaning tank with cleaning solution.

- Use with a solution depth that is at least 100 mm above the transducer radiating surface.
- The solution temperature range that can be used in the transducer unit is 5°C to 80°C.

2. Put the cleaning object into the cleaning tank.

- Use so that the cleaning object is positioned at least 50 mm above the ultrasonic wave vibration surface.
- Place the cleaning object so that its exposure to the ultrasonic wave vibration surface is as uniform as possible.

3. Check that the power switch on the oscillator front panel is at the OFF position, and set the circuit breaker that is supplying power to the oscillator to the ON position.

If control is performed over an RS-485 connection or by remote control, check that operation is performed normally, and then make the settings.

This completes the preparation for operation.

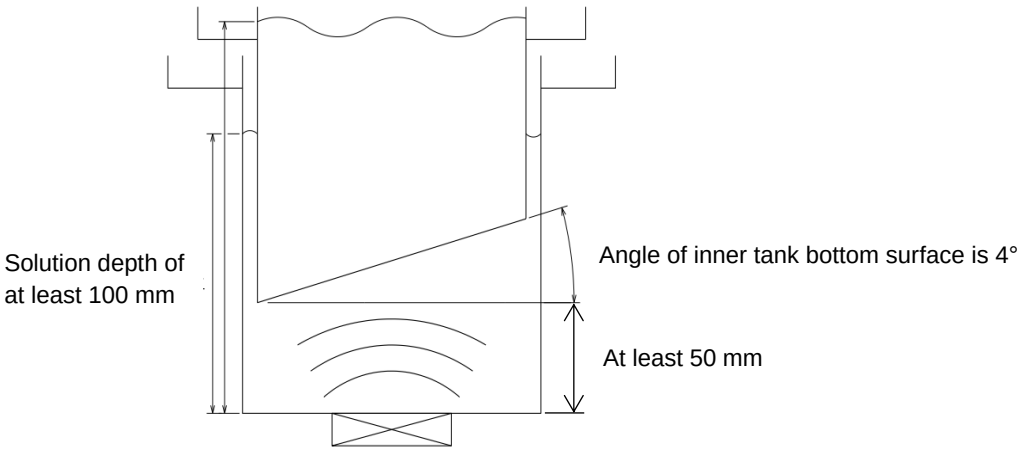
# Safety Information on Use of Inner Tank

* When adding chemicals to the cleaning solution or performing precision washing of items that are averse to metal ions such as semiconductor wafers, use an inner tank made of materials such as quartz glass to maintain the required washing quality.

When using an inner tank, taking into account the following points when manufacturing the tank will enable high-efficiency cleaning.

- To enable the ultrasonic waves to penetrate with high efficiency and low attenuation, use a plate thickness of 3 mm for the bottom of the inner tank in the case of quartz glass.
- Ensure that no air bubbles (air layer) are trapped between the vibration plate and the bottom surface of the inner tank. Air bubbles accumulating on the bottom surface of the inner tank can weaken ultrasonic penetration. Accumulated air bubbles can be removed using their buoyancy by adding an angle to the bottom of the inner tank. And the angle of the inner tank bottom surface is set to 4° for enabling high-efficiency cleaning with low attenuation of ultrasonic waves. Accumulated air bubbles can also be removed by installing a water jet toward the bottom of the inner tank.
- The distance between the bottom of the inner tank and the surface of the vibration plate is recommended wider than 50mm.
- If the bottom surface of the inner tank is flat, the ultrasonic waves that advance directly from the vibration plate are reflected on the bottom surface of the inner tank, and the reflected waves return to the vibration plate. This returning of the ultrasonic waves causes them to overlap and become stronger and weaker waves, resulting in instability. This causes abnormal vibrations to occur on the transducer, which can lead to a breakdown of the transducer and oscillator. To prevent this situation from occurring, the oscillator has a protective function for detecting errors and for automatically stopping ultrasonic oscillation. When installing inner tanks where reflected waves return to the vibration plate, take measures to prevent this from occurring, such as by increasing the distance to the vibration plate and inner tank bottom surface, lowering the output setting, or changing the angle of the inner tank bottom surface so that reflected waves are not returned.

Installation of inner tank (Example)



# Safety Information for Use of Overflow Mechanism

To ensure high-quality cleaning, the solution must be controlled to a preset temperature.

For tank type transducer units, the water supply hose is connected to the water supply/drain outlet, and the water drain hose is connected to the overflow water drain outlet so that cleaning solution is continuously circulated for using an overflow mechanism that maintains a constant solution temperature.

Take note of the following safety points when using the overflow mechanism.

- Before operating, check that incorrect hose connections have not created a situation where the water depth will not go down.
- If the overflow is not used, the cleaning solution will be over-heated by the ultrasonic waves, with the temperature rising to 50°C or higher after approximately one hour of operation. The cleaning tank will also be over-heated, and so there is a risk of burns or other injuries.
- When operating for an extended period of time, the solution temperature will increase, and the cleaning solution will become dirty. When this happens, use a cooler, filter, or other device to maintain and control the cleaning quality.

# 5.2 Basic Operations for Oscillator

### 5.2.1 Introduction

1. Check that the supply voltage is 200 to 240 V and that the power cable is firmly connected to the power input connector.
2. Check that the transducer cable is inserted into the transducer output connector on the oscillator rear panel.
3. Check that all signal cables are connected to the required I/O terminals.

### 5.2.2 Turning On the Power

1. Set the power switch (MAIN) lever on the front panel of the oscillator to the ON position.
2. The model name and program version appear on the display.
   If the system uses multiple oscillators, the "CH number" of the transducer output connector will be displayed.

| | | |
|---|---|---|
| W-357 BM-1200<br>Ver. 1.121 | BM-1200 CH1 CH2<br>Ver. 1.121 | BM-1200 CH9 CH10<br>Ver. 1.121 |

3. After two or three seconds, the main screen appears.

```
 ON[↑] / OFF[↓]
▸OFF    /    200W
```

### 5.2.3 Output Setting

1. Press the "→" key in the SELECT keys to move the ▶ to the side displaying the output setting values.
2. Press the "↑" key or "↓" in the SELECT keys to change the output setting value.
   The value can be changed in 1-W units in a range from 200 W (minimum) to 1200 W (maximum).

```
 UP[↑] / DWN[↓]
 OFF    /  ▸ 600W
```

   The default setting is 200 W.

### 5.2.4 Oscillation ON/OFF Setting

1. Press the "←" key in the SELECT keys to move the ▶ to the side displaying the oscillation ON/OFF setting.
2. Press the "↑" key in the SELECT keys to start oscillation.
   The oscillation ON/OFF setting indicator changes from OFF to ON.

```
■■■■■        50%
▸ON  9:50/    600W
```

**Important**

Do not switch oscillation ON and OFF repeatedly in a short time when the output setting is high. It may cause the oscillator to breakdown. If the oscillator breakdown, the Error message "PWR CTRL ERROR (POWER CONTROL ERROR)" will be displayed on the display screen on the oscillator front panel.

The "＊＊:＊＊" next to the ON indicator shows the remaining time for the timer.

When this timer indicator becomes 0:00, oscillation is set to OFF, and the "Time is up !!" message appears in the top section of the display.

If oscillation is set to OFF before the remaining time for the timer becomes 0:00, move ▶ to the ON indicator side. Press the "↓" key in the SELECT keys.

5.2.5 Menu Screen Settings

1. The options for settings other than the output setting and oscillation ON/OFF setting can be changed from the MENU screen.

   Press the MENU key to switch to the MENU screen.

   If oscillation is set to ON, the oscillation is automatically set to OFF.

   To return to the main screen after changing the setting options in the MENU screen:

   ・To apply the changed settings and return to the main screen, press the MENU key.

   ・To return to the main screen without applying the setting changes, press the ESC key.

2. Press the "←" key or "→" key in the SELECT keys to select the options in the MENU screen.

   The display order of the menu options is as follows.

   1. REMOTE ⇔ 2.TIMER SET⇔ … ⇔ 13.INFORMATION ⇔ 1.REMOTE ⇔ …

3. Press the "↑" key or "↓" key in the SELECT keys to change the setting values for the options in the MENU screen.

5.2.6 MENU Screen Options

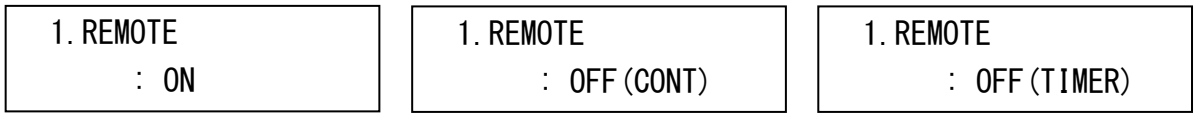
1. REMOTE

   This sets the remote control input function (appearing as "REMOTE" below) to ON, OFF (Continuous Oscillation), or OFF (Timer Oscillation).

   ON: REMOTE Enable

   OFF (CONT): REMOTE OFF (Continuous Oscillation)

   OFF (TIMER): REMOTE OFF (Timer Oscillation)

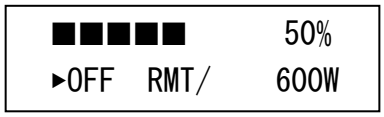



When REMOTE is set to ON, the remote control input function is enabled.

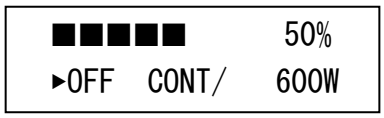
Setting of oscillation ON/OFF using the SELECT keys is disabled.

For details on the operating procedure, see "6.1 Remote Control Input Function."

"RMT" appears on the main screen.




When REMOTE is set to OFF (CONT), after oscillation is set to ON using the SELECT keys, oscillation is performed continuously.
Ultrasonic oscillation does not stop until oscillation is set to OFF.
"CONT" appears on the main screen.

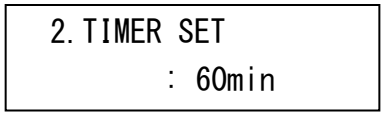



When REMOTE is set to OFF (TIMER), after oscillation is set to ON using the SELECT keys, ultrasonic oscillation is performed until the preset time for the timer has elapsed.
For details on the timer setting procedure, see "2. TIMER SET."

The default setting is OFF (TIMER).

2. TIMER SET

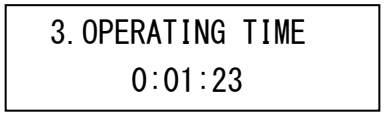
This sets a value of 1 to 60 for the time in the timer for ultrasonic oscillation when REMOTE is set to OFF (TIMER). (Units: minutes)
Once the preset time has elapsed, oscillation is stopped automatically.
The "2.TIMER SET" option does not appear when REMOTE is set to ON or OFF (CONT).




The default setting is 10 minutes.

3. OPERATING TIME

This shows the cumulative time that ultrasonic oscillation output has been performed. (Hours: Minutes: Seconds)
This displayed time cannot be reset.




4. OSC MODE

This sets the oscillation mode to AM MODE (AM modulation oscillation) or NORMAL (constant power control oscillation).

AM MODE: AM modulation oscillation

NORMAL: Constant power control oscillation

| 4.OSC MODE<br>: AM MODE | 4.OSC MODE<br>: NORMAL |
|---|---|

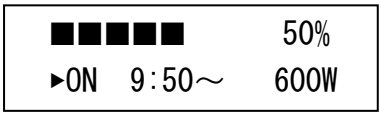
AM MODE is an AM modulation oscillation mode where the size of the CH1 and CH2 output balance changes constantly based on the relationship between the same phase and opposite phase of the sine curve.

This oscillation mode enables creation of water flows within the cleaning tank to minimize uneven cleaning.

The output value where the same phase and opposite phase channels for CH1 and CH2 are added together (cancel out) is the output setting value.

For details on how to set the sine curve cycle, see "5.AM TIME CYCLE."

When AM MODE is set, "～" appears on the main screen.



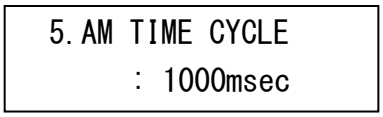

NORMAL is the constant power control oscillation mode where the total of the CH1 and CH2 outputs is the output setting value.

The default setting is NORMAL (constant power control oscillation).

5. AM TIME CYCLE

This sets a value from 10 to 10000 for the sine curve cycle that changes the CH1 and CH2 output balance when the oscillation mode is set to AM MODE. (Units: m sec)

The "5.AM TIME CYCLE" option does not appear when the oscillation mode is set to NORMAL.



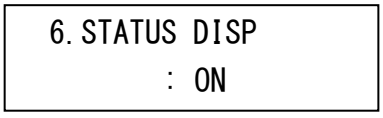

The default setting is 1000 m sec.

6. STATUS DISP

This sets the oscillator status indicator to ON or OFF.

ON: Show status indicator

OFF: Hide status indicator




When the status indicator is set to ON, status indicators other than the output bar graph can be selected for display in the top section of the main screen. This is used for confirming the operating status of the oscillator, adjusting the ultrasonic oscillation, and so on.

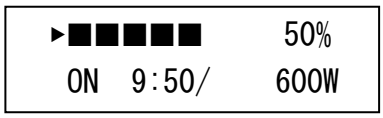
The default setting is OFF (Hide status indicator).

When returning to the main screen from the MENU screen, the ▶ can be moved to the top left section of the display.

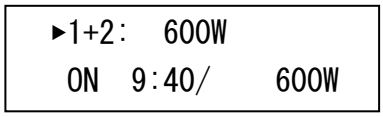
When ▶ appears in the top left section of the display, the "↑" key or "↓" key in the SELECT keys can be pressed to enable changing of the status indicator. Press the ESC key to show the Total CH1+CH2: Output bar graph.

Information displayed when STATUS DISP: ON is set

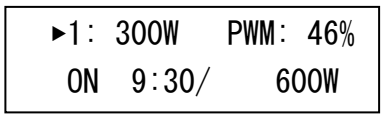
・Total CH1+CH2: Output bar graph



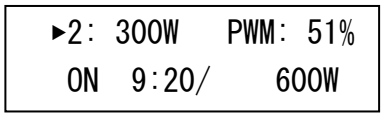

・Total CH1+CH2: Output power value



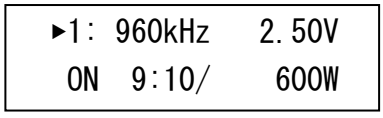

・CH1 output power: CH1 PWM opening



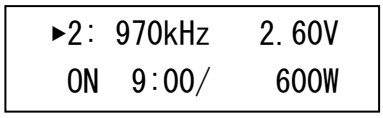

・CH2 output power: CH2 PWM opening



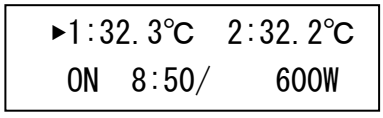

・CH1 oscillation frequency: CH1 VCO voltage



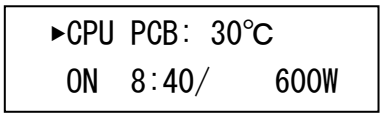

・CH2 oscillation frequency: CH2 VCO voltage




・CH1 radiator temperature: CH2 radiator temperature




・CPU board temperature



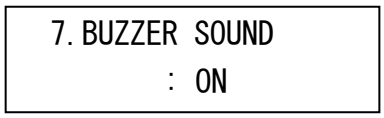
7. BUZZER SOUND

This sets the key operation sound and the buzzer sound when starting and stopping ultrasonic oscillation to ON or OFF.

ON: Buzzer sound ON

OFF: Buzzer sound OFF

The time-up sound for the timer when set to REMOTE OFF (TIMER) and the buzzer sound when an error is detected remain ON regardless of this setting.

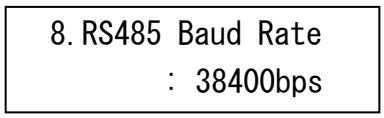



The default setting is ON (Buzzer sound ON).

8. RS485 Baud Rate

This sets the transmission speed for RS-485 communication to 38400 bps, 57600 bps, or 115200 bps.

For details on the operating procedure, see "6.7 RS-485 Communication Function."

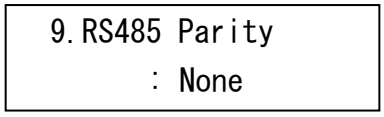



The default setting is 38400 bps.

9. RS485 Parity

This sets the parity check for RS-485 communication to None (No parity), Odd (Odd parity), or Even (Even parity).

For details on the operating procedure, see "6.7 RS-485 Communication Function."

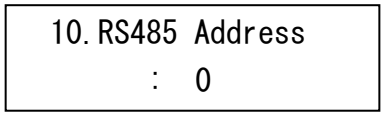



The default setting is None (No parity).

10. RS485 Address

This sets the device ID (address) for RS-485 communication in the range from 1 to 99.

For details on the operating procedure, see "6.7 RS-485 Communication Function."




The default setting is 0.

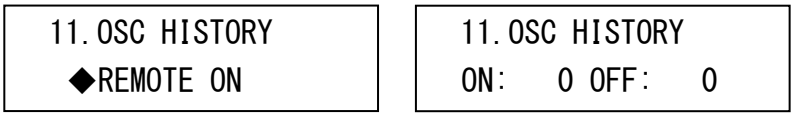
11. OSC HISTORY

This indicates the ON/OFF times of oscillation when remote control function is ON/OFF.

Automatic stop of ultrasonic oscillation due to abnormality detection is not counted.

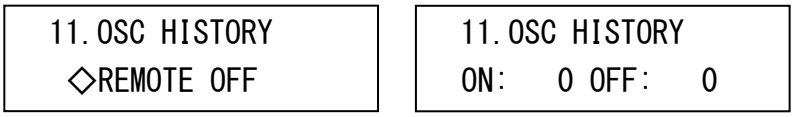
The count display cannot be reset.

・REMOTE ON :




・REMOTE OFF :

It will count when continuous oscillation (CONT) and constant oscillation (TIMER) are set.




The default setting is 0.

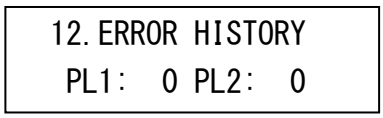
12. ERROR HISTORY

This displays the number of times of each error message when an error was detected

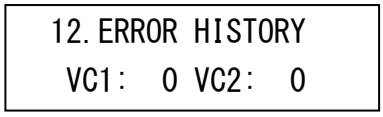
The "1" and "2" displays at the end of the error message represent the CH number.

The count display cannot be reset.

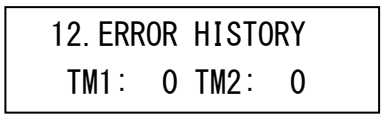
・If PLL ERROR



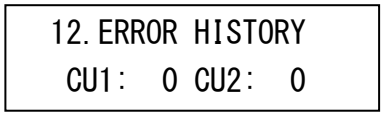

・If VCO ERROR



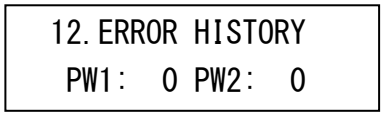

・If TEMP ERROR




・If CURRENT ERROR




・If PMW ERROR



・If SENSOR ERROR

```
12.ERROR HISTORY
 SNSR:  0
```

The default setting is 0.

13. IFORMATION

This displays the information of this equipment.

Such as the abbreviated name of the equipment and the version of the software embedded.

If the system uses multiple oscillators, the "CH number" will be displayed.

```
13.INFORMATION
BM-1200 Ver1.121
```

# 6 I/O Functions

This section describes the operating procedures for the following functions that use the I/O terminals on the oscillator rear panel.

- Remote control input function
- Error detection output function
- Oscillation detection output function
- Power-on detection output function
- Sensor input function
- 4 to 20 mA output function
- RS-485 communication function

# 6.1 Remote Control Input Function

The remote control function can be used to perform ON/OFF control of ultrasonic oscillation.

## Preparation

1. Connect the remote control input signal cable to the REM terminal (6-pin connector, numbers 5-6) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

For the 6-pin connector for the cable inside the oscillator, pin number 5 is +5V pull-up (10kΩ), and pin number 6 is GND.

2. Set the 1.REMOTE setting on the MENU screen to ON.
   i) The remote control function is enabled when the main screen is displayed.
   ii) The "RMT" indicator appears in the bottom section of the display.

## Operating Procedures

Ultrasonic oscillation can be set to ON and OFF by short-circuiting and opening the [REM] terminal (6-pin connector, numbers 5-6) using an external contact (non-voltage contact).

The relationship between the status between terminals and the ultrasonic oscillation status is shown in the table below.

| Status with [REM] terminal | Ultrasonic oscillation status | Signal cables to be connected |
|---|---|---|
| Open | Oscillation OFF | Remote control input signal cables (2 cables) *Shielded cable |
| Short-circuit | Oscillation ON | |

When the remote control setting is set to ON, oscillation ON/OFF cannot be set using the SELECT keys.

**Important**

- For the external contact signal connecting the [REM] terminal, use a non-voltage contact (switch, relay contact, etc.) with a contact rated at least 12 V DC and 0.1 A.
- Do not supply power when the REMOTE setting is set to ON and the [REM] terminal is short-circuited while there is no cleaning solution in the cleaning tank. This will heat the cleaning tank in an empty state, which could cause a breakdown of the transducer.
  Be particularly careful when setting the power switch to ON.
- To prevent malfunctions due to noise, use shielded cables within 10 meters for the signal cables.
- To reduce induced noise, route the signal cables separately from power cables, transducer cables, and other driving cables.

# 6.2 Error Detection Output Function

This function will output an error signal to a remote location whenever an error occurs in this device. This enables monitoring of the oscillator status.

## Preparation

Connect the error detection output signal cable to the [AL] terminal (7-pin connector, numbers 1-2) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

For the 7-pin connector for the cable inside the oscillator, pin numbers 2, 4, and 6 are COM terminals.

## Operating Procedures

Check the contact state (open/short-circuit) with the [AL] terminal to enable monitoring of the oscillator status.
The [AL] terminal uses photorelay contact output.
The relationship between the status between terminals and the ultrasonic oscillation status is shown in the table below.

| State with [AL] terminal | Oscillator status | Signal cables to be connected |
|---|---|---|
| Open | Abnormal stop or power off | Error detection output signal cables (2 cables) *Shielded cable |
| Short-circuit | Normal | |

**Important**

- The [AL] terminal photorelay contact rating is 30 V DC and 0.1 A. Do not use voltages and currents that exceed the rating. Doing so could result in a breakdown.
- To prevent malfunctions due to noise, use shielded cables within 10 meters for the signal cables.
- To reduce induced noise, route the signal cables separately from power cables, transducer cables, and other driving cables.

# 6.3 Oscillation Detection Output Function

This function is used to output an oscillation signal to a remote location for indicating whether the oscillator is performing ultrasonic oscillation. This enables monitoring of the ultrasonic oscillation status.

## Preparation

Connect the oscillation detection output signal cable to the [OSC] terminal (7-pin connector, numbers 3-4) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

For the 7-pin connector for the cable inside the oscillator, pin numbers 2, 4, and 6 are COM terminals.

## Operating Procedures

Check the contact state (open/short-circuit) for the [OSC] terminal to enable monitoring of the ultrasonic oscillation state.

The [OSC] terminal uses photorelay contact output.

The relationship between the status between terminals and the ultrasonic oscillation status is shown in the table below.

| State with [OSC] terminal | Ultrasonic oscillation status | Signal cables to be connected |
|---|---|---|
| Open | Oscillation OFF | Oscillation detection output signal cables (2 cables) *Shielded cable |
| Short-circuit | Oscillation ON | |

**Important**

- The [OSC] terminal photorelay contact rating is 30 V DC and 0.1 A. Do not use voltages and currents that exceed the rating. Doing so could result in a breakdown.
- To prevent malfunctions due to noise, use shielded cables within 10 meters for the signal cables.
- To reduce induced noise, route the signal cables separately from power cables, transducer cables, and other driving cables.

# 6.4 Power-on Detection Output Function

This function is used to output a power-on signal to a remote location for indicating whether the oscillator is powered on. This enables monitoring of the oscillator power status.

## Preparation

Connect the power-on detection output signal cable to the [PWR] terminal (7-pin connector, numbers 5-6) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

For the 7-pin connector for the cable inside the oscillator, pin numbers 2, 4, and 6 are COM terminals.

## Operating Procedures

Check the contact state (open/short-circuit) with the [PWR] terminal to enable monitoring of the oscillator power status.

The [PWR] terminal uses photorelay contact output.

The relationship between the status between terminals and the ultrasonic oscillation status is shown in the table below.

| State with [PWR] terminal | Oscillator status | Signal cables to be connected |
|---|---|---|
| Open | Power OFF | Power ON detection output signal cables (2 cables) *Shielded cable |
| Short-circuit | Power ON | |

**Important**

- The photorelay contact rating with the [PWR] terminal is 30 V DC and 0.1 A. Do not use voltages and currents that exceed the rating. Doing so could result in a breakdown.
- To prevent malfunctions due to noise, use shielded cables within 10 meters for the signal cables.
- To reduce induced noise, route the signal cables separately from power cables, transducer cables, and other driving cables.

# 6.5 Sensor Input Function

This function detects errors from external sensors (water level sensor, workpiece loaded/unloaded detection sensor, etc.) for performing abnormal stop of the oscillator.

## Preparation

Connect the sensor input signal cable to the [SENS] terminal (6-pin connector, numbers 3-4) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

For the 6-pin connector for the cable inside the oscillator, pin number 3 is +5V pull-up (10kΩ), and pin number 4 is GND.

## Operating Procedures

The oscillator can be set to abnormal stop/normal status by short-circuiting or opening the [SENS] terminal (6-pin connector, numbers 3-4) using an external contact (non-voltage contact).

The relationship between the status between terminals and the ultrasonic oscillation status is shown in the table below.

| Status with [SENS] terminal | Oscillator status | Signal cables to be connected |
|---|---|---|
| Open | Normal | Sensor input signal cables (2 cables) |
| Short-circuit | Abnormal stop | *Shielded cable |

An abnormal stop state is one of the following states.

- Ultrasonic oscillation OFF state
- Open state with [OSC] terminal (oscillation detection output function)
- The "SENSOR ERROR" message appears on the display of the oscillator front panel.
- The AL. lamp on the oscillator front panel is lit.
- Open state with [AL] terminal (error detection output function)

**Important**

- For the external contact signal connecting the [SENS] terminal, use a non-voltage contact (switch, relay contact, etc.) with a contact rated at least 12 V DC and 0.1 A.
- To prevent malfunctions due to noise, use shielded cables within 10 meters for the signal cables.
- To reduce induced noise, route the signal cables separately from power cables, transducer cables, and other driving cables.

# 6.6 4 to 20 mA output function

This function outputs a current of 4 to 20 mA based on the output power (W).

## Preparation

Connect the 4 to 20 mA output signal cable to the [4-20] terminal (6-pin connector, numbers 1-2) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

The 6-pin number 2 pin (negative terminal) is electrically isolated from other signals.

## Operating Procedures

This outputs a current of 4 to 20 mA based on the ultrasonic output power.

Relationship between output current and output power: 4 mA / 0 W (ultrasonic oscillation OFF) to 20 mA / 1200 W

The electrical current value for 4 to 20 mA can become unstable at the maximum output power. If this happens, lower the output power by 1 to 2 W.

| [4-20] terminal | Signal cables to be connected |
|---|---|
| Pin no. 1: Positive | 4 to 20 mA output signal cables (2 cables) |
| Pin no. 2: Negative | *Shielded cable |

**Important**

- To prevent malfunctions due to noise, use shielded cables within 10 meters for the signal cables.
- To reduce induced noise, route the signal cables separately from power cables, transducer cables, and other driving cables.

# 6.7 RS-485 Communication Function

In this function, RS-485 communication using the Modbus RTU protocol is used to change settings and read the oscillation state of the oscillator.

## RS-485 Specifications and Functions

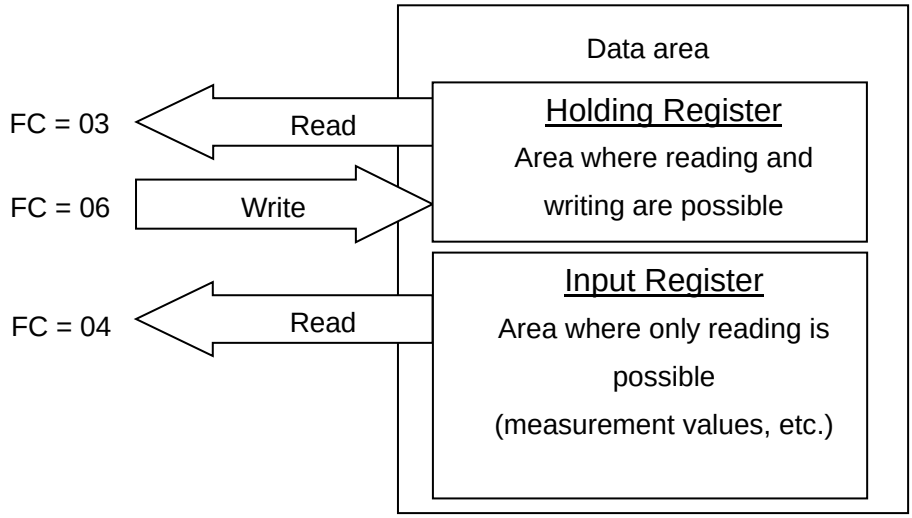
**●RS-485 Specifications**

| Item | Specifications |
|---|---|
| Communication protocol | Modbus (RTU) |
| Electrical characteristics | Compliant with EIA RS-485 |
| Communication method | Two-wire half-duplex (Polling/selecting method) |
| Synchronization method | Asynchronous |
| Baud rate | 38400, 57600, 115200 bps<br>*Set in the MENU screen |
| Start bit | 1 bit |
| Data length | 8 bits |
| Parity check | No parity (None), Odd parity (Odd), Even parity (Even)<br>*Set in the MENU screen |
| Stop bit | 1 bit |
| Delimiter | Silent interval of 3.5 characters |
| Character code | Binary code |
| Transmission control procedure | No procedure |
| Number of connections | Up to 32 devices can be connected (including host) |
| Device ID (address) | Selectable setting in range from 1 to 99<br>*Set in the MENU screen<br>*The default setting is 0. |
| Maximum cable route length | Total 1200 m |
| Error check | CRC |
| Response speed | Within time for 10 characters |

**●Functions**

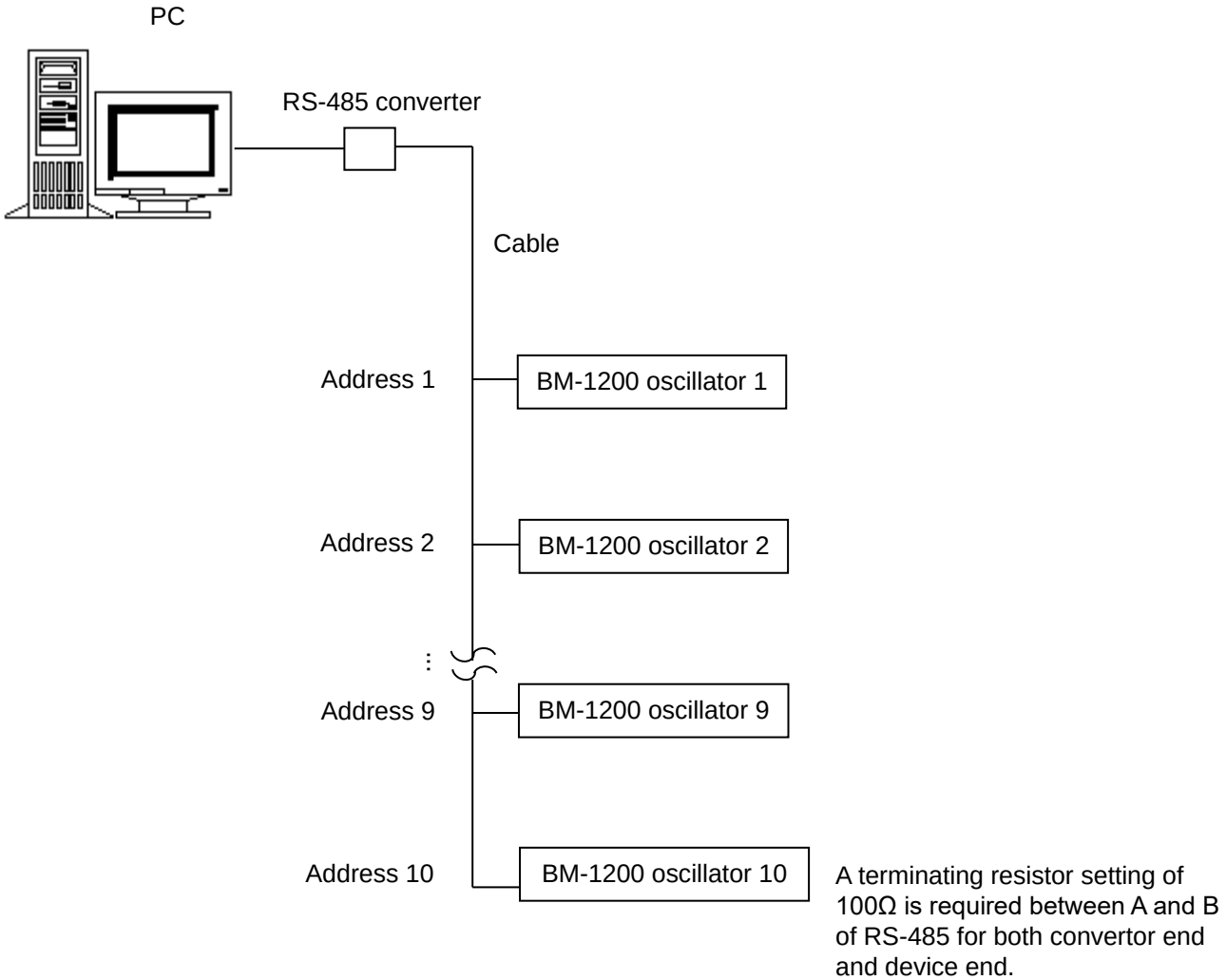
| Function code | Function name | Function |
|---|---|---|
| 03 | Read Holding Register | Reads the content of the holding register |
| 04 | Read Input Register | Reads the content of the input register |
| 06 | Preset Single Register | Changes (writes) the content of the holding register |
| 08 | Diagnostics | Loopback test |

**●Relationship between data areas and function codes (FC)**




# Preparation

**●Wiring diagram**



1. Connect the RS-485 communication signal cable to the [RS485] terminal (3-pin connector, numbers 1-3) in the I/O terminals.

**Note**

Peel off the jacket of the signal cable, and use a precision screwdriver (flat-head) to connect to the terminal.

The number 3 pin (GND) of the 3-pin connector is electrically isolated from the GND of other signals.

2. Connect the RS-485 converter A (+) terminal to all device A (+) terminals.
3. Connect the RS-485 converter B (-) terminal to all device B (-) terminals.
4. Connect the RS-485 converter GND terminal to all device GND terminals.
5. For the "8.RS485 Baud Rate" setting in the MENU screen, set to 38400 bps, 57600 bps, or 115200 bps.
6. For the "9.R485 Parity" setting in the MENU screen, set to No parity (None), Odd parity (Odd), or Even parity (Even).
7. For the "10.R485 Address" setting in the MENU screen, set to any value in the range from 1 to 99 for the device ID address.
8. A terminating resistor setting of 100Ω is required between A and B of RS-485 for convertor and (master device only when without using convertor) and device end.

| RS-485 terminal | Signal cables to be connected |
|---|---|
| Pin no. 1: A (Positive) | RS-485 communication signal cables (3 cables)<br>*2-core shielded cable |
| Pin no. 2: B (Negative) | |
| Pin no. 3: GND | |

**Important**

- Do not connect the GND terminal to metal parts or the ground on the rear panel.
- The RS-485 converter and signal cables and terminating resistor must be obtained by the customer. A 2-core shielded cable is recommended for the signal cable.

# Message Format (When Reading Data from Slave)

The function code specifies 03 or 04.

**● Process Request Message Format from Master (PC) to Slave (BM-1200)**

| Name | Description | No. of bytes |
|---|---|---|
| Address | Specifies the slave address.<br>Specify a value in the range from 1 to 99 (Set to the same value as the device ID address in "10.R485 Address" setting in the MENU screen of the BM-1200). | 1 |
| Function code | Specifies 03 or 04.<br>03: Reads from holding register<br>04: Reads from input register | 1 |
| Register address | Specifies the starting address of the register that is read.<br>Set to an address that is one less than the actual register address.<br>(To read register 4, specify 3. To read register 18, specify 17.) | 2 |
| Number of registers that are read | Specifies the number of registers that are read. | 2 |
| CRC | Error check section.<br>For details, see "CRC Calculation Method." | 2 |

An example when reading the data for address 1, function code 03, and register address 21 for one register is shown below.

Process request message (hexadecimal notation)

| Address | Function code | Register address | | Number of registers that are read | | CRC | |
|---|---|---|---|---|---|---|---|
| 01 | 03 | 00 | 14 | 00 | 01 | C4 | 0E |

**Note**

The register address is sent as a value that is one less than the target address, and so this becomes 0x0014.

**●Response Message Format for Slave (BM-1200) to Master (PC)**

A message when the slave is operating normally is shown below.

For a message when an error has occurred in the slave, see "Exception Responses."

| Name | Description | No. of bytes |
|---|---|---|
| Address | This is the same numerical value as the address contained in the message that was sent from the master. | 1 |
| Function code | This is the same numerical value as the function code contained in the message that was sent from the master. | 1 |
| Number of bytes in readout data | This is the number of bytes in the data that was read. | 1 |
| Readout data | This is the data that was read. | 2 to 254 |
| CRC | Error check section.<br>For details, see "CRC Calculation Method." | 2 |

An example when a message was sent for address 1, function code 03, register address 4, and readout register 3 is shown below.

Response message (hexadecimal notation)

| Address | Function code | Number of readout bytes | Readout data | | | | | | CRC | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data 1 | | Data 2 | | Data 3 | | | |
| 01 | 03 | 06 | 01 | F4 | 03 | E8 | 00 | 02 | 90 | C0 |

# Message Format (When Writing Data to Slave)

The function code specifies 06.

**● Process Request Message Format from Master (PC) to Slave (BM-1200)**

| Name | Description | No. of bytes |
|---|---|---|
| Address | Specifies the slave address. | 1 |
| Function code | Specifies 06.<br>06: Writes to single register | 1 |
| Register address | Specifies the register address where writing is performed.<br>Set an address that is one less than the actual register address. | 2 |
| Writing data | Specifies the data that is written to the register. | 2 |
| CRC | Error check section.<br>For details, see "CRC Calculation Method." | 2 |

**●Response Message Format for Slave (BM-1200) to Master (PC)**

If the slave is operating normally, the same message as that sent from the master is sent in response.

For a message when an error has occurred in the slave, see "Exception Responses."

An example for the address 21, register address 113, and writing data 333 is shown below.

Process request message (hexadecimal notation)

| Address | Function code | Register address | | Writing data | | CRC | |
|---|---|---|---|---|---|---|---|
| 15 | 06 | 00 | 70 | 01 | 4D | 4A | A0 |

**Note**

The register address is sent at a value that is one less than the target address, and so this becomes 0x0070.

Response message (hexadecimal notation)

| Address | Function code | Register address | | Writing data | | CRC | |
|---|---|---|---|---|---|---|---|
| 15 | 06 | 00 | 70 | 01 | 4D | 4A | A0 |

# Exception Responses

When an error has occurred in the slave, an exception response is sent in response instead of the normal response message.
An exception response includes a number (exception code) that indicates the details of the exception.

Exception codes

| Code | Name | Description |
|---|---|---|
| 01 | ILLEGAL FUNCTION | An unsupported function code was specified. |
| 02 | ILLEGAL DATA ADDRESS | The specified register address was not found. |
| 03 | ILLEGAL DATA VALUE | Data that cannot be written to the slave was specified. |

**●Response Message Format for Slave (BM-1200) to Master (PC) (When Exception Occurs)**

When it is detected that a slave (BM-1200) made an improper request, an exception response is sent in response instead of the normal response message.

| Name | Description | No. of bytes |
|---|---|---|
| Address | This is the same numerical value as the address contained in the message that was sent from the master. | 1 |
| Function code | This is a numerical value determined by adding 0x80 to the function code contained in the message that was sent from the master. | 1 |
| Exception code | This is a number indicating details about the exception.<br>For details, see "Exception codes." | 1 |
| CRC | Error check section.<br>For details, see "CRC Calculation Method." | 2 |

An example is shown below when reading the data for address 1, function code 03, and register address 1000 for one register, and then ILLEGAL DATA ADDRESS (specified register address was not found) was sent in response.

Process request message (hexadecimal notation)

| Address | Function code | Register address | | Number of registers that are read | | CRC | |
|---|---|---|---|---|---|---|---|
| 01 | 03 | 03 | E7 | 00 | 01 | 34 | 79 |

**Note**

The register address is sent at a value that is one less than the target address, and so this becomes 0x03E7.

Response message (hexadecimal notation)

| Address | Function code | Exception code | CRC | |
|---|---|---|---|---|
| 01 | 83 | 02 | C0 | F1 |

# CRC Calculation Method

The CRC is calculated using the section excluding the CRC for each message.
An example when reading the data for address 1, function code 03, and register address 21 for one register is shown below.

Section excluding CRC from process request message (hexadecimal notation)

| Address | Function code | Register address | | Number of registers that are read | | CRC | |
|---|---|---|---|---|---|---|---|
| 01 | 03 | 00 | 14 | 00 | 01 | - | - |

The CRC calculation method is shown below.
The CRC value is taken as X, and the initial value of X is 0xFFFF.

CRC Calculation Method

| Step number | Calculation details | X value | Logical AND |
|---|---|---|---|
| 1 | The exclusive OR (XOR) is taken of the value of the 1st byte (address value: 01) and X, and the calculation result is substituted in X. | 0xFFFE | - |
| 2.1 | The logical AND of X and 0x0001 is taken, and AND is saved at 0 or 1. | 0xFFFE | 0 |
| 2.2 | X is shifted by 1 bit to the right, and the calculation result is substituted in X. | 0x7FFF | 0 |
| 2.3 | Only if the result of AND in 2.1 was 1:<br>The XOR is taken of X and 0xA001, and the calculation result is substituted in X. | 0x7FFF | 0 |
| 2.4 | The process from 2.1 to 2.3 is repeated 8 times. | 0x807E | - |
| 3 | Return to step 1, and repeat the process below to perform calculation for all values.<br>Value for 2nd byte (function code value: 03) →<br>Value for 3rd byte (register position upper byte value: 00) ... | - | - |
| 4 | The value of X is found. | 0x0EC4 | |
| 5 | The lower byte (C4) of the X value is the upper byte part of the CRC, and the upper byte (0E) of the X value is the lower byte part of the CRC. | - | - |

The process request message that is actually sent is shown below.

Process request message (hexadecimal notation)

| Address | Function code | Register address | | Number of registers that are read | | CRC | |
|---|---|---|---|---|---|---|---|
| 01 | 03 | 00 | 14 | 00 | 01 | C4 | 0E |

# Note on Communication Timing

After a response message from the slave (BM-1200) is received by the master (PC), do not send a process request message to the BM-1200 from the PC until a wait time of 3.5 characters has elapsed.
The calculation method for the wait time and a calculation example are shown below.

**●1-character data structure**

| Start bit | Data bit | Parity | Stop bit |
|---|---|---|---|
| 1 bit | 8 bits | 0 or 1 bit | 1 bit |

**●Wait time for response message**

| Address | Function code | Number of readout bytes | Readout data | | CRC | |
|---|---|---|---|---|---|---|
| | | | Data 1 | | | |
| 01 | 03 | 02 | 00 | 01 | 79 | 84 |


**●Wait time calculation formula and calculation example (for 3.5 characters)**

Calculation formula

3.5-character wait time (m sec) = Number of bits for 3.5 characters ÷ Communication speed (bps) × 1000

Calculation example

●When the communication speed is 57600 bps, parity is even, and stop bit is 1 bit

3.5-character wait time (m sec) = 11 bits × 3.5 ÷ 57600 × 1000 ≈ 0.67 m sec

*Make the wait time longer than 0.67 m sec.

# Registers

This section describes the handling of register values and the functions of each register.

**●Handling of register values**

A two-byte (16 bits) value consisting of an upper byte and lower byte is assigned to a register.

The way that values are handled varies by the register, but handling is divided into two types: 2-byte integer values and bit fields.

Many registers handle values as 2-byte integer values, but some registers handle values as bit fields.

If a value is handled as a bit field, this is indicated in the description field of the register.

The 2-byte values are shown below in the format [upper byte (hexadecimal), lower byte (hexadecimal)].

**●2-byte integer value**

This expresses a value by joining the upper byte and lower byte as two bytes.

The byte order is big endian.

Example: When value is [0x04,0x06] → [0x0406] → 1030

**●Bit field**

Each bit of a 2-byte value (16 bits) is used as a flag.

A role when the value for each bit is 0 or 1 is set, and the bit value is switched between 0 and 1 based on the role.

There is no effect on operation when a bit with no role is changed.

Example: For Input Register, when the value for register 11 (STATUS_F1) is [0x0100] (bit number is 0 to 15)

| Bit no. | Value | State |
|---|---|---|
| 0 | 0 | (No used) |
| 1 | 0 | PLL error has not occurred |
| 2 | 0 | VCO error has not occurred |
| 3 | 0 | TEMP error has not occurred |
| 4 | 0 | CURRENT error has not occurred |
| 5 | 0 | PWM error has not occurred |
| 6 | 0 | SENSOR error has not occurred |
| 7 | 0 | SCI error has not occurred |
| 8 | 1 | Ultrasonic oscillation is ON state |
| 9-15 | 0 | (No used) |

**●Input register (function code 04 read-only register) functions**

| Register | Item name | Initial value | Minimum value | Maximum value | Function |
|---|---|---|---|---|---|
| 1 | Version | 1121 | - | - | Program version<br>Example: V1.121 → Readout value: 1121 |
| 2 | US_TIME_S | 0 | - | 59 | Cumulative time (seconds) of ultrasonic oscillation. |
| 3 | US_TIME_M | 0 | - | 59 | Cumulative time (minutes) of ultrasonic oscillation. |
| 4 | US_TIME_H | 0 | - | 9999 | Cumulative time (hours) of ultrasonic oscillation. |
| 9 | OSC_TIMER | 600 | 0 | 3600 | Oscillation timer counter (units: sec)<br>Time for timer when set to REMOTE OFF (TIMER).<br>Example: 3536 sec → Readout value: 3536<br>"0" is displayed when set to another option. |
| 10 | TEMP_CPU_BOARD | - | - | - | CPU board temperature (units: °C)<br>Example: 29.4°C → Readout value: 294 |
| 11 | STATUS_F1 | 0 | - | - | CH1 status<br>This is used as a bit field.<br>Bit 0: (Not used)<br>Bit 1: PLL error<br>Bit 2: VCO error<br>Bit 3: TEMP error<br>Bit 4: CURRENT error<br>Bit 5: PWM error<br>Bit 6: SENSOR error<br>Bit 7: SCI error<br>Bit 8: Ultrasonic oscillation ON/OFF status<br>Bits 9 to 15: (Not used)<br><br>The relationship between the value and status is as follows. |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Bits 1 to 7<br>0: No error occurred<br>1: Error occurred<br>Bit 8<br>0: Ultrasonic oscillation OFF state<br>1: Ultrasonic oscillation ON state |
| 12 | VALUE_POW1 | 0 | 0 | 600 | CH1 output power value (units: W)<br>Example: 600 W → Readout value: 600 |
| 16 | VALUE_VCO1 | 500 | 0 | 500 | CH1 VCO voltage (units: V)<br>Example: 1.55 V → Readout value: 155 |
| 17 | VALUE_PWMDUTY1 | 0 | 0 | 85 | CH1 PWM opening (units: %)<br>Example: 29% → Readout value: 29 |
| 18 | VAL_FREQ1 | - | - | - | CH1 oscillation frequency (units: Hz)<br>(Oscillation frequency/100 Hz)<br>Example: 970.9 kHz → Readout value: 9709 |
| 20 | TEMP_HEAT_SINK1 | - | - | 700 | CH1 radiator temperature (units: °C)<br>Example: 35.8°C → Readout value: 358 |
| 21 | STATUS_F2 | 0 | - | - | CH2 status<br>See "STATUS_F1" |
| 22 | VALUE_POW2 | 0 | 0 | 600 | CH2 output power value<br>See "VALUE_POW1" |
| 26 | VALUE_VCO2 | 500 | 0 | 500 | CH2 VCO voltage<br>See "VALUE_ VCO1" |
| 27 | VALUE_PWMDUTY2 | 0 | 0 | 85 | CH2 PWM opening<br>See "VALUE_ PWMDUTY1" |
| 28 | VAL_FREQ2 | - | - | - | CH2 oscillation frequency<br>See "VALUE_ FREQ1" |
| 30 | TEMP_HEAT_SINK2 | - | - | 700 | CH2 radiator temperature<br>See "TEMP_HEAT_SINK1" |
| 51 | PLL_ERR1_CNT | 0 | - | - | CH1 times of PLL ERROR<br>Example: 10times → Readout value: 10 |
| 52 | VCO_ERR1_CNT | 0 | - | - | CH1 times of VCO ERROR<br>Example: 10times → Readout value: 10 |

| | | | | | |
|---|---|---|---|---|---|
| 53 | TEMP_ERR1_CNT | 0 | - | - | CH1 times of TEMP ERROR<br>Example: 10times → Readout value: 10 |
| 54 | CUR_ERR1_CNT | 0 | - | - | CH1 times of CURRENT ERROR<br>Example: 10times → Readout value: 10 |
| 55 | PWM_ERR1_CNT | 0 | - | - | CH1 times of PWM ERROR<br>Example: 10times → Readout value: 10 |
| 56 | SNSR_ERR1_CNT | 0 | - | - | Times of SENSOR ERROR<br>Example: 10times → Readout value: 10 |
| 61 | PLL_ERR2_CNT | 0 | - | - | CH2 times of PLL ERROR<br>See " PLL_ERR1_CNT " |
| 62 | VCO_ERR2_CNT | 0 | - | - | CH2 times of VCO ERROR<br>See " VCO_ERR1_CNT " |
| 63 | TEMP_ERR2_CNT | 0 | - | - | CH2 times of TEMP ERROR<br>See " TEMP_ERR1_CNT " |
| 64 | CUR_ERR2_CNT | 0 | - | - | CH2 times of CURRENT ERROR<br>See " CUR_ERR1_CNT " |
| 65 | PWM_ERR2_CNT | 0 | - | - | CH2 times of PWM ERROR<br>See " PWM_ERR1_CNT " |
| 66 | SNSR_ERR2_CNT | 0 | - | - | Times of SENSOR ERROR<br>Same value as " SNSR_ERR1_CNT" |
| 71 | ON_RMTON_CNT | 0 | - | - | Times of Oscillation ON for REMOTE ON mode.<br>Example: 100 times → Readout value: 100 |
| 72 | OFF_RMTON_CNT | 0 | - | - | Times of Oscillation OFF for REMOTE ON mode.<br>Example: 100 times → Readout value: 100 |
| 73 | ON_RMTOFF_CNT | 0 | - | - | Times of Oscillation ON for REMOTE OFF mode.<br>Example: 100 times → Readout value: 100 |
| 74 | OFF_RMTOFF_CNT | 0 | - | - | Times of Oscillation OFF for REMOTE OFF mode.<br>Example: 100 times → Readout value: 100 |

※If the system uses multiple oscillators, the channel number of CH1 / CH2 will be CH3 / CH4, CH5 / CH6, CH7 / CH8, CH9 / CH10, CH2 / CH3, CH4 / CH5, CH6 / CH7, or CH8 / CH9.

**●Holding register (function code 03 (readout), 06 (write)) functions**

| Register | Item name | Initial value | Minimum value | Maximum value | Function |
|---|---|---|---|---|---|
| 1 | OSC_SEL | 0 | 0 | 1 | This is used to select the ultrasonic oscillation mode.<br>0: Constant power control oscillation (NORMAL)<br>1: AM modulation oscillation (AM MODE) |
| 2 | SET_US_ON | 0 | 0 | 1 | This is used to select ON or OFF for ultrasonic oscillation.<br>0: Oscillation OFF<br>1: Oscillation ON |
| 3 | SET_US_POWER | 200 | 200 | 1200 | This is used to set the ultrasonic output. (Units: W)<br>Setting range: 200 (Min.) to 1200 (Max.) |
| 4 | AM_TIME_CYCLE | 1000 | 10 | 10000 | This sets the AM cycle when set to AM modulation oscillation mode. (Units: m sec)<br>Setting range:10 m sec (Min.) to 10000 m sec (Max.) |

# 7 Troubleshooting

If a problem occurs during operation of this product, read this troubleshooting information to inspect the problem area and take corrective action.
If the problem is still not resolved by inspecting and taking corrective action, immediately stop usage, and contact the dealer where you made the purchase or the Honda Electronics Customer Support Center.

Please note that Honda Electronics will not be liable for any damage that occurs as a result of measures taken by the customer other than those described in this manual.
Be aware that, in these cases, a fee will be charged for repair even if the warranty period is still valid.

The warranty period is 12 months from product shipping or 2,000 hours of operation, whichever is shorter.
However, the warranty does not apply to abnormal usage, dirtiness and adhesion of foreign objects on the transducer surface, and problems due to damage arising from failure to follow the operating procedures.

In the event that a problem occurs, if after consultation and analysis, it is found that the problem is the responsibility of Honda Electronics, we will provide repairs free of charge.

# 7.1 Error Indicator Function

This product includes a function for detecting the error states that have occurred in the oscillator and for automatically stopping ultrasonic oscillation.

A description of the detected error is shown as an error message on the display screen on the oscillator front panel.

If an error was detected, check the error message, and take the proper corrective action by referring to the following table.

| Error message | Error description | Cause | Corrective action |
|---|---|---|---|
| "PLL ERROR" or "VCO ERROR" | Oscillation Control Error | When not using an inner tank: Oscillation control is no longer possible. | When this error has occurred, take the following corrective action.<br>① Set the output to 200W.<br>②-1 When REMOTE is set to ON<br>Set the connection with the REM terminal to open and then short-circuit it again, and restart ultrasonic oscillation.<br>②- 2 When REMOTE is set to OFF<br>Move the ▶ to the OFF indicator side of the display, and press the "↑" key in the SELECT keys to restart the ultrasonic oscillation.<br>③ Gradually increase the output, and visually check the ultrasonic oscillation.<br><br>If an error is detected even after restarting ultrasonic oscillation, the transducer may be deteriorated or may have failed.<br>Please contact the dealer where you made the purchase or the Honda Electronics Customer Support Center.<br>PLL ERROR and VCO ERROR are automatically cleared when stopping or starting oscillation after a short time after the error is detected.<br>However, if the error is detected for a fourth time after ultrasonic oscillation start, an error message is displayed, and an abnormal stop is applied. |

| | | | |
|---|---|---|---|
| | | When using an inner tank: Oscillation control cannot be performed due to the effect of reflected waves from the bottom surface of the inner tank. | Check the details of the detected error, and take the proper corrective measures by referring to "5.1. Preparation: Safety Information on Use of Inner tank." |
| "TEMP ERROR **°C (temperature)" | Overheat Error | The ambient temperature of the oscillator exceeds 40°C. | Use by installing in an environment where the ambient temperature does not exceed 40°C. |
| | | Ventilation is inadequate for cooling the oscillator. | Provide sufficient space for ventilation, and improve the flow of air. |
| | | Dust or other objects are blocking the cooling ventilation openings. | Periodically remove any objects adhering to the ventilation openings on the rear and side panels of the oscillator for improving the flow of air.<br>Also, avoid use in environments where large amounts of dust and other substances are produced. |
| | | If an error is detected due to a cause other than the above | Continuous operation for an extended period of time may have caused the internal temperature of the oscillator to become too high.<br>Lower the power switch lever to the OFF position, and do not operate for a short time.<br>When the display temperature shown in the error message becomes 70°C or less, the error is automatically cleared. |

| | | | |
|---|---|---|---|
| "CURRENT ERROR" | Overcurrent Error | The current flowing to the transducer side exceeded the specified value. | When this error has occurred, take the following corrective action.<br>① Set the output to 200W.<br>②-1 When REMOTE is set to ON<br>Set the connection with the REM terminal to open and then short-circuit it again, and restart ultrasonic oscillation.<br>②- 2 When REMOTE is set to OFF<br>Move the ▶ to the OFF indicator side of the display, and press the "↑" key in the SELECT keys to restart the ultrasonic oscillation.<br>③ Gradually increase the output, and visually check the ultrasonic oscillation.<br><br>If an error is detected even after restarting ultrasonic oscillation,<br>a short-circuit has occurred somewhere along the transducer cable routing path between the oscillator and transducer unit. Or the transducer may have been damaged in short-circuit mode.<br>Check that there are no short-circuits along the routing path for the transducer cable.<br>Please contact the dealer where you made the purchase or the Honda Electronics Customer Support Center. |
| "PWM ERROR" | Low Voltage Error | The voltage applied to the transducer side dropped below the specified value. | When this error has occurred, take the following corrective action.<br>① Set the output to 200 W.<br>②-1 When REMOTE is set to ON<br>Set the connection with the REM terminal to open and then short-circuit it again, and restart ultrasonic oscillation.<br>②- 2 When REMOTE is set to OFF<br>Move the ▶ to the OFF indicator side of the display, and press the "↑" key in the SELECT keys to restart the ultrasonic oscillation.<br>③ Gradually increase the output, and visually check the ultrasonic oscillation.<br>An open state has occurred somewhere along the |

| | | | |
|---|---|---|---|
| | | | transducer cable routing path between the oscillator and transducer unit. Or the spring contact terminals holding the transducer electrodes may have been disconnected.<br>Restart ultrasonic oscillation, and check if there are any transducers that are not performing ultrasonic oscillation.<br>If there are any transducers that are not performing ultrasonic oscillation, set the oscillation to OFF, and check the transducer cable routing path, and look for any unconnected locations in the area around the transducer.<br>Please contact the dealer where you made the purchase or the Honda Electronics Customer Support Center. |
| "SENSOR ERROR" | Sensor Input Error | A short-circuit was detected with the SENS terminal. | Find the cause for the short-circuit by the sensor input signal cable of the external sensor device connected to the SENS terminal.<br>The error is cleared by setting the connection with the SENS terminal to open. |
| "SCI ERROR" | RS-485 Communication Error | An RS-485 communication error was detected. | The communication error may have been detected due to external noise, and so change the RS-485 signal cable to a shielded cable.<br>The occurrence of SCI ERROR does not generate an abnormal stop due to error detection. |

Displayed error messages

The "1", "2", or "1 & 2" shown at the end of the error message indicates the CH number where the error was detected.

(Example)

"1": Error was detected for CH1 only

"2": Error was detected for CH2 only

"1& 2": Error was detected for both CH1 and CH2

# 7.2 Troubleshooting for Other Problems

| No. | Problem | Cause | Corrective action |
|---|---|---|---|
| 1 | Ultrasonic oscillation is not performed.<br>→ AL lamp is lit. | Because an error was detected, ultrasonic oscillation is not performed. | Check the error message, and take the proper corrective measures by referring to "7.1. Error Indicator Function." |
| 2 | Ultrasonic oscillation is not performed.<br>→ ON/OFF control of ultrasonic oscillation cannot be performed using the SELECT keys | The remote-control function is set to ON. | Set the REMOTE setting to OFF from the MENU screen. |
| 3 | Ultrasonic oscillation is not performed.<br>→ ON/OFF control of ultrasonic oscillation cannot be performed using the remote control function. | The remote control function is set to OFF. | Set the REMOTE setting to ON from the MENU screen. |
| | | The remote cable has a broken wire or is not connected properly. | Check that the proper connections are made for the cable for the REM terminal in the I/O terminals on the oscillator rear panel and for the cable to the customer's controller. |
| 4 | The ultrasonic oscillation operation output is weak. | The output setting is at 200 W. | Change the output setting to increase the output. |
| | | Supply voltage is incorrect. | Supply a voltage that is within the oscillator rated voltage range. |

# 8 Specifications

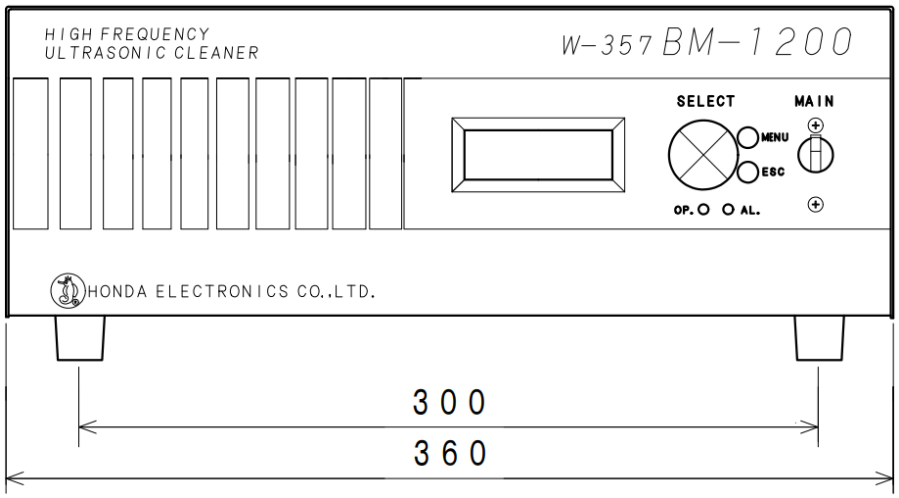
## 8.1 Oscillator

**●Specifications**

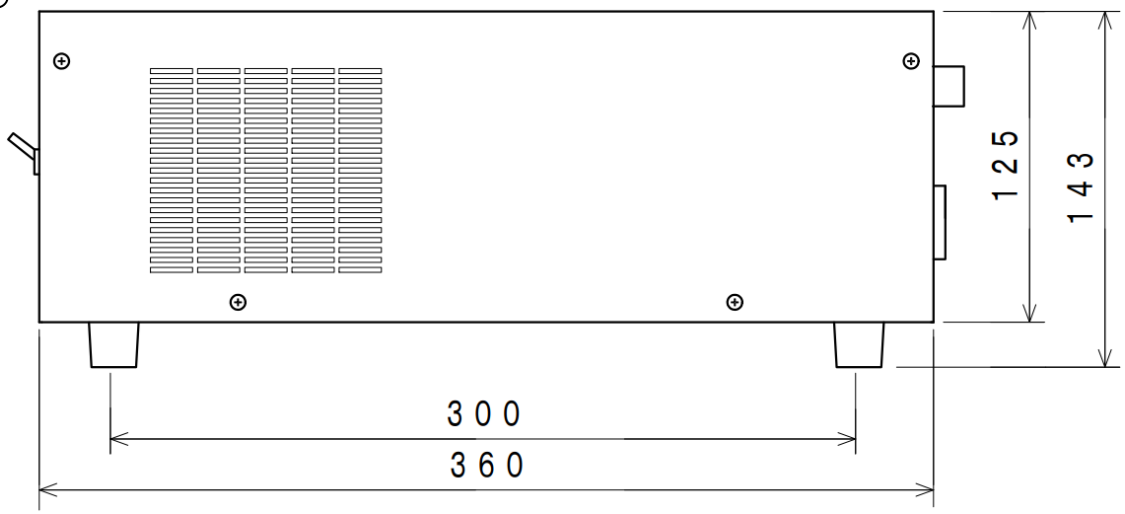
| Model | W-357BM-1200 |
|---|---|
| **Oscillation mode** | Single frequency oscillation |
| **Output setting range** | 200 to 1200 W (Adjustable in 1 W steps) |
| **Nominal oscillating frequency** | 1 MHz |
| **Power input** | Single phase 200 to 240 V AC (±10%) 50/60 Hz 2400 VA |
| **Display** | Organic light emitting diode (OLED), 16 characters × 2 lines<br>Oscillation status indicator: Oscillation ON/OFF, Setting output, Oscillation mode indicator, Description of detected error, Timer end, Timer (Timer Oscillation) / CONT (Continuous Oscillation) / RMT (REMOTE Enable)<br>MENU screen: Remote setting, Timer time setting, Cumulative oscillation time, Oscillation mode setting, AM MODE cycle setting, Status indicator setting, Buzzer sound setting, RS-485 communication setting, OSC history, ERROR history, Information<br>Status indicator screen: Output power value, PWM opening, VCO voltage, Radiator temperature, CPU board temperature<br>When error detected: Error message<br>Ultrasonic oscillation indicator lamp, Error indicator lamp (LED) |
| **Output function** | Error detection, Oscillation detection, Power-on detection (Contact output)<br>Output power (4 to 20 mA current output) |
| **Input function** | Remote terminal: Ultrasonic oscillation ON/OFF,<br>Sensor terminal: Normal/Abnormal stop (Contact input) |
| **Error detection function** | Oscillation control error, Overheat error, Overcurrent error,<br>Low voltage error, Sensor input error, RS-485 communication error |
| **Communication function** | RS-485 Modbus (RTU) protocol<br>Settings: ① Ultrasonic oscillation (ON/OFF)<br>② Output setting (200 W to 1200 W)<br>③ Oscillation mode selection (NORMAL/AM MODE)<br>④ AM MODE cycle (10 to 10000 msec)<br>Readout: ① Ultrasonic oscillation status<br>② Alarm type ③ Output power ④ Frequency ⑤ Temperature etc. |
| **Ambient operating environment** | Temperature: 5°C to 40°C<br>Relative humidity: 5% to 80% RH (no condensation)<br>Indoor use in factory environments<br>Max. altitude 2000 m |
| **Dimensions (mm)** | 360 (W) × 360 (D) × 143 (H) (excluding protrusions, including rubber feet) |
| **Weight** | 7 kg |
| **Accessories** | Power cable (3 m, 3-core), Control cable connector (3-pin, 6-pin, 7-pin),<br>Output connector clamp fixture |

●Dimensions (W-357BM-1200) (Units: mm)

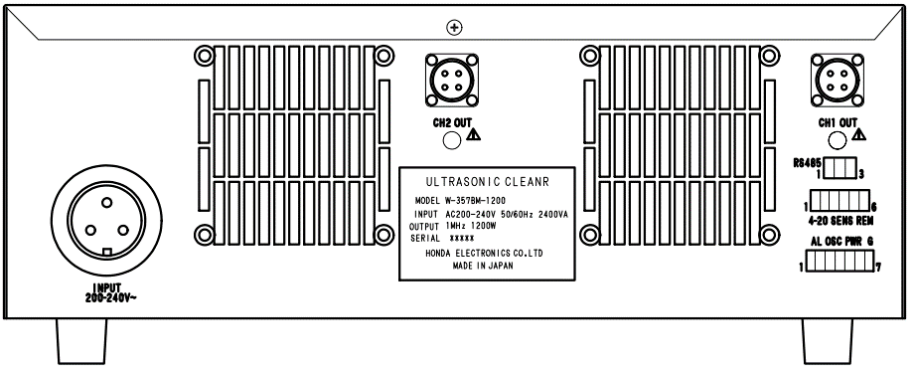
Front




Side




Rear



## ◆ After sales service

When the after service such as the repair is required, please contact the seller of product with the detailed information about the malfunction.

**W-357BM-1200**



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●This instruction manual is current as of June 2023.

●This information is subject to change without notice for the purpose of incorporating product improvements.

June 2023