PROGRAMMABLE AC POWER SOURCE

# ES-E series

## ES020ES
## ES040ES
## ES060ES

# INSTRUCTION MANUAL

**NF Corporation**

DA00070409-001

PROGRAMMABLE AC POWER SOURCE

# ES-E series

## ES020ES
## ES040ES
## ES060ES

INSTRUCTION MANUAL

# Preface

Thank you for purchasing our Programmable AC Power Source ES-E series.
For safe and correct use of the electrical product, please first read "Safety Precautions" on the next page.

- Alert symbols in this manual

  This manual uses the following alert symbols. The instructions by these alert symbols shall be carefully obeyed to ensure equipment operator's safety and prevent damage to equipment.

**⚠ WARNING**

Equipment handling could result in death or serious injury. This symbol contains information to avoid such risk.

**⚠ CAUTION**

Equipment handling could result in minor or moderate injury, or property damage. This symbol contains information to avoid such risk.

- The chapters of this manual are organized as follows.

  If you are reading this manual for the first time, please begin with Chapter 1, “Overview”.

1. Overview

   This chapter explains the items that must be checked before you use this product.
2. Part Names

   This chapter explains the names of each part of the two component units that constitute this product.
3. Preparation for Use

   This chapter explains points that require caution concerning the installation of this product in the process from connecting the power source up to the state in which this product is ready for use.
4. Operation

   This chapter explains how to use this product, from the basic operations to advanced functions.
5. Specifications

   The specifications (functions and performance) of this product are described in this chapter.
6. Maintenance

   The basic operation testing and daily maintenance for this product are explained in this chapter.
7. Troubleshooting

   This chapter explains error messages and events that may indicate equipment failure and what to do when they occur.
8. Supplementary Information

   This chapter contains supplementary information to provide a better understanding of the device.

# ——— Safety Precautions ———

For safe use, ensure to obey the following warnings and considerations.
We are not responsible for damage resulting from failure to obey these warnings and considerations.
This product is an insulation Class I device (with a protective conductor terminal) complying with the JIS and IEC standards.

- Ensure you obey the instructions in this instruction manual.
  This instruction manual contains instructions for safe operation and use of this product.
  Before using this product, please read this manual first.
  All the warning items contained in this instruction manual are intended for preventing risks that may lead to serious accidents. Ensure to obey them.

- Ensure to ground.
  Ensure to connect the protective conductor terminal of the power input terminal of this product to an earth ground so that ground resistance is 100 Ω or less. If the product is not certainly grounded, an electric shock might occur.
  To prevent electric shock, ensure that the protective grounding conductor is connected before you connect a cable to the power input terminals L and N.
  For grounding, use the supplied power cable or an equivalent cable whose diameter is same or greater.

- Check the power supply voltage
  This product operates at the power supply voltage specified in the “Grounding and power connection” section of the manual. Before connecting this product to the power supply, confirm that the power supply voltage conforms to the rated power supply voltage of this product.

- Give attention to heat exhaust.
  The air exhaust vent on the rear side of this product becomes hot when this product is operated under load for a long time. Take care to prevent contact with the exhaust vent by the human body.

- Do not use the handles of this product for hoisting.
  To prevent danger from dropping, etc. do not use the handles of this product for hoisting.

- Do not use the accessories provided with this product with other products.
  All of the accessories provided with this product are for exclusive use with this product. Do not use the accessories for any purpose other than the installation and use of this product.

- Take care when wiring the remote sensing terminals.
  To prevent electrical shock or equipment malfunction, disconnect the power when attaching wires to the remote sensing terminals or removing wires from the terminals. When attaching wires to the terminals, make sure that no metal parts of the cable are left exposed.

- If you notice anything strange

  If this product produces smoke, unusual odor, or strange sound, immediately cut the power to the product and stop using it.

  Should you encounter any anomaly like above, immediately contact us or our agent. Never use it until the repair is completed.

- Do not operate in an explosive atmosphere.

  An explosion or other such hazard may result.

- Do not remove the cover.

  This product has high-voltage portions inside. Never remove the cover.

  When inspection into the inside of the product is needed, never allow anybody to touch the innards except our certified service engineers.

- Do not modify the product.

  Never modify the product. Modification to the product may pose a new risk. We may refuse the repair of a modified product at fault.

- Prevention of electric shock by output voltage

  The maximum output of this product is ± 424 V. Be careful to avoid electric shock. Directly touching the output or changing the cable connection while the output is on may cause electric shock.

- This product weights approx. 48 kg.

  Do not carry it alone, or you may suffer physical injury.

- Do not expose this product to water.

  When this product is used in wet condition, it may cause an electric shock and a fire. If this product is exposed to water, cut the power at the distribution board immediately, and contact NF Corporation or one of our representatives.

- If lightning occurs, power off this product and cut the power at the distribution board.

  A lightning may cause an electric shock, a fire and a failure.

- Safety symbols

  The following shows the general definitions of the safety symbols used on the product main unit and in the instruction manual.

  Refer to the instruction manual

  This notifies the user of potential hazards and indicates that he/she must refer to the instruction manual.

  Electric shock hazard

  This indicates that an electric shock may occur under specific conditions.

  Protection conductor terminal

  This indicates that the terminal needs to be grounded in order to prevent electric shock accidents.
  Before operating the equipment, ensure to connect this terminal to an earth ground so that ground resistance is 100 Ω or less.

**⚠ WARNING** Warning

Equipment handling could result in death or serious injury. This symbol contains information to avoid such risk.

**⚠ CAUTION** Caution

Equipment handling could result in minor or moderate injury, or property damage. This symbol contains information to avoid such risk.

- Other symbol

  This indicates the “on” position of the power switch.

  This indicates the “off” position of the power switch.

  This indicates that the terminal or the outer conductor of the connector is connected to the enclosure.

  This indicates that the terminal or the outer conductor of the connector is connected to the signal ground.

- Request about disposal

  For environmental preservation, pay attention to the followings when you dispose of this product.

  a) Do not discard this product in domestic household waste. This product shall be disposed of through an appropriate industrial waste disposer.
  b) This product is equipped with one coin-type rechargeable lithium battery.
  c) This product does not contain mercury.

# Contents

# Figures



# Tables

# 1. Overview

# 1.1 Features

The ES-E series Programmable AC Power Source is capable of simulating power supply environments with the objectives of achieving performance, functionality, and ease of use.

Because the ES-E series provides an output voltage with stable voltage level and frequency and little waveform distortion, it is a suitable power supply for testing the performance of electronic equipment and measuring EMC.

The three package models of the ES-E series are listed below.

| Rated output power | Single-phase output package model |
|---|---|
| 2 kVA | ES020ES |
| 4 kVA | ES040ES |
| 6 kVA | ES060ES |

The options and peripheral devices listed below are also available.

| | |
|---|---|
| ES4474A | Remote Terminal |
| 4481 | Power Inlet Unit |
| 4482 | Outlet Unit |
| ES0406D | Immunity Test Software |
| ES0406D-U | Immunity Test Software (upgrade) |

# 1.2 Manual organization

This manual covers the ES-E series.

For more information on each option and peripheral device, refer to the respective instruction manual.

ES-E series Programmable AC Power Source Instruction Manuals

| | |
|---|---|
| **ES-E series Instruction Manual**<br>Single-phase output package models<br>ES020ES, ES040ES, and ES060ES | **Power Inlet Unit and Outlet Unit Instruction Manual**<br>4481 Power Inlet Unit<br>4482 Outlet Unit |
| **P-STATION/ES series and ES-E series Instruction Manual (interface)**<br>P-STATION/ES series<br>ES-E series (same for all models) | **Remote Terminal Instruction Manual**<br>ES4474A Remote Terminal |
| **Immunity Test Software Instruction Manual**<br>ES0406D Immunity Test Software | |

# 1.3 Checking the accessories

Before using this product, check for damage that may have occurred during transport and confirm that all the constituent units and accessories are included. If anything is missing, please contact the agent from which you purchased this product.

Table 1-1 Single-phase output package model components

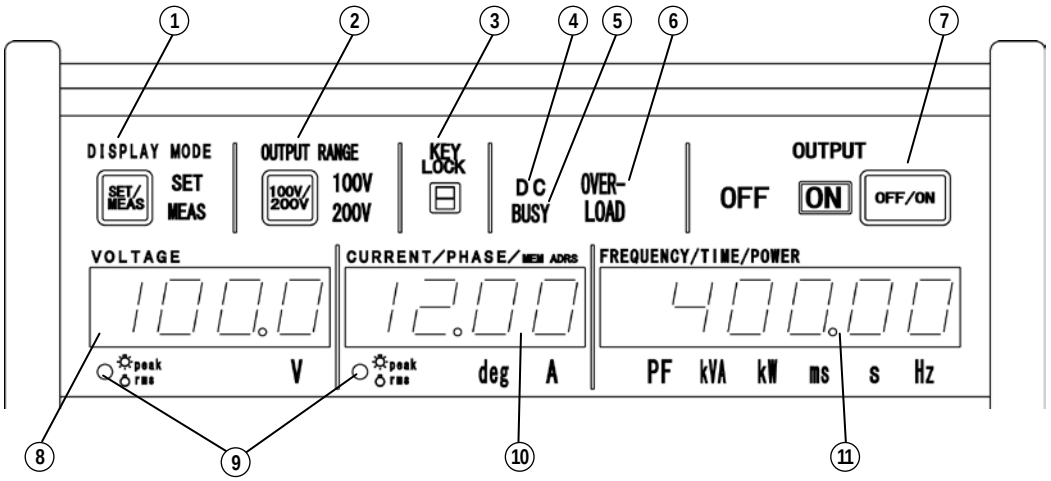
| Product Name | | Quantity |
|---|---|---|
| ●ES020ES | | |
| Constituent unit | ES2000ES (single-phase master) | 1 |
| Accessories | Instruction Manual (this document) | 1 |
| | Instruction Manual (interface) | 1 |
| | Power cable (3.5 $mm^2$ × 3 cores × 3 m, VCT cable) | 1 |
| | Screwdriver for output wiring (–) | 1 |
| | D-sub 37-pin connector and connector hood (for external control input and output) | 1 |
| ●ES040ES | | |
| Constituent unit | ES2000ES (single-phase master) | 1 |
| | ES2000EB (booster) | 1 |
| Accessories | Instruction Manual (this document) | 1 |
| | Instruction Manual (interface) | 1 |
| | Booster cable A (16-pin connector, approx. 400 mm) | 1 |
| | Booster cable B (6-pin connector, approx. 400 mm) | 1 |
| | Power cable (3.5 $mm^2$ × 3 cores × 3 m, VCT cable) | 2 |
| | Screwdriver for output wiring (–) | 1 |
| | D-sub 37-pin connector and connector hood (for external control input and output) | 1 |
| ●ES060ES | | |
| Constituent unit | ES2000ES (single-phase master) | 1 |
| | ES2000EB (booster) | 2 |
| Accessories | Instruction Manual (this document) | 1 |
| | Instruction Manual (interface) | 1 |
| | Booster cable A (16-pin connector, approx. 400 mm) | 2 |
| | Booster cable B (6-pin connector, approx. 400 mm) | 2 |
| | Power cable (3.5 $mm^2$ × 3 cores × 3 m, VCT cable) | 3 |
| | Screwdriver for output wiring (–) | 1 |
| | D-sub 37-pin connector and connector hood (for external control input and output) | 1 |

When repacking this product for transportation, etc., make sure that the equipment is fully protected by a box that is of appropriate size and strength and is filled with a packing material that is suitable for the weight of the equipment.

# 2. Part Names

# 2.1 ES2000ES (single-phase master)

## 2.1.1 Controller (upper)




① DISPLAY MODE

Set the display mode to either “Setting value” or “Measured value”.

☞ Refer to 4.2.7 Measurement function.

② OUTPUT RANGE

Set the output voltage range. ☞ Refer to 4.2.3 Setting the output voltage and range.

③ KEY LOCK

Switches the key lock on and off. The key lock is on when the switch is in the up position.

☞ Refer to 4.2.6 Key lock.

④ DC

The light is lit in the DC output mode.

☞ Refer to 4.2.2 Switching between DC and AC output modes.

⑤ BUSY

The light is lit when the voltage range is being changed.

☞ Refer to 4.2.3 Setting the output voltage and range.

⑥ OVERLOAD

The light is lit during an overload. ☞ Refer to 4.2.8 Protection function.

⑦ OUTPUT OFF/ON

Switches the output on or off. ☞ Refer to 4.2.5 Switching output on and off.

⑧ VOLTAGE

Display for the output voltage setting value or measured value.

☞ Refer to 4.2.7 Measurement function.

⑨ peak/rms

Lights that indicate whether the measured value display is the peak value or the RMS value.

☞ Refer to 4.2.7 Measurement function.

⑩ CURRENT/PHASE/MEM ADRS

Display for the measured output current value, QC phase, or memory address.

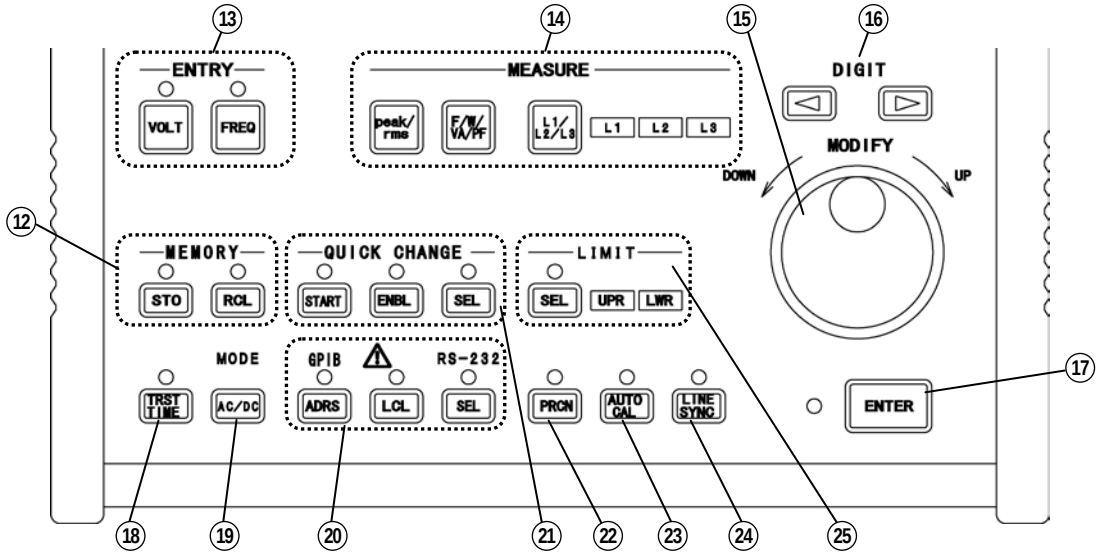
☞ Refer to 4.2.7 Measurement function, 4.4.1 Voltage quick-change (frequency unchanged), and 4.3.3 Memory.

⑪ FREQUENCY/TIME/POWER

Displays the output frequency, active/apparent power, power factor, QC time, or transition time.

☞ Refer to 4.2.4 Setting the output frequency, 4.2.7 Measurement function, 4.4.1 Voltage quick-change (frequency unchanged), and 4.4.2 Voltage sweep 1 (frequency variation).

## 2.1.2 Controller (lower)




⑫ MEMORY

Save data to memory or retrieve data from memory. ☞ Refer to 4.3.3 Memory.

⑬ ENTRY

Set the output voltage or output frequency.

☞ Refer to 4.2.3 Setting the output voltage and range and 4.2.4 Setting the output frequency.

⑭ MEASURE

Select the data to be measured. ☞ Refer to 4.2.7 Measurement function.

⑮ MODIFY

This is the modify dial. Use it to increase or decrease the setting value.

⑯ DIGIT

When setting values, use the arrow keys to move the digit being increased or decreased to the left or right.

⑰ ENTER

Finish the input of a setting value.

⑱ TRST TIME

Set the transition time. ☞ Refer to 4.4.2 Voltage sweep 1 (frequency variation).

⑲ AC/DC

Switch between the AC output mode and the DC output mode.

☞ Refer to 4.2.2 Switching between DC and AC output modes.

⑳ GPIB/RS-232

Set values that are related to the interface. ☞ Refer to Instruction Manual (interface).

㉑ QUICK CHANGE

Set values for the output voltage QC test. ☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).

㉒ PRCN

Switch between the compensation modes.

☞ Refer to 4.5.1 Precision and high stability (setting the compensation mode).

㉓ AUTO CAL

Perform auto-calibration.

☞ Refer to 4.5.3 Auto-calibration (output voltage adjustment function).

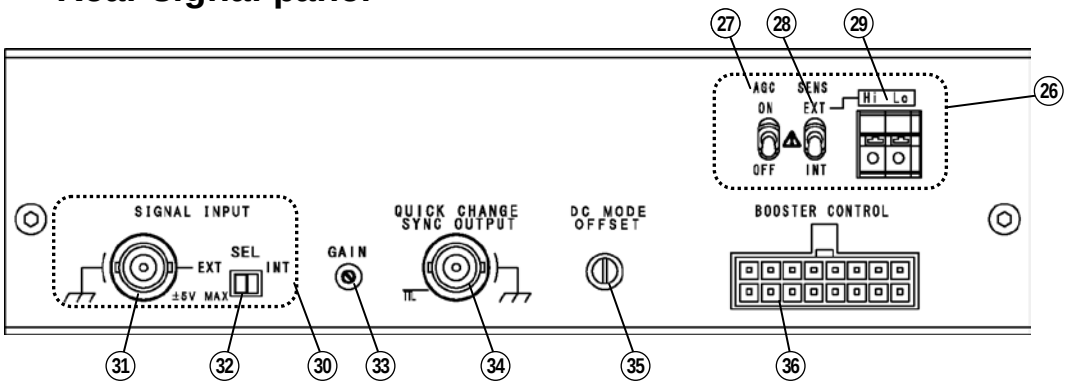
㉔ LINE SYNC

Set the line synchronization mode. ☞ Refer to 4.3.2 Line synchronization.

㉕ LIMIT

Set limit values. ☞ Refer to 4.3.1 Setting limit values.

## 2.1.3 Rear signal panel




㉖ Switches and connectors related to remote-sensing AGC.

☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).

㉗ AGC

Set the AGC operation. ☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).

㉘ SENS

Select the output voltage sensing point.

☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).

㉙ Hi Lo

These are connection terminals for external sensing of the output voltage.

☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).

㉚ SIGNAL INPUT

For input of an external signal. ☞ Refer to 4.6.1 External input.

㉛ EXT

This connector is used for inputting an external signal.

☞ Refer to 4.6.1 External input.

㉜ SEL

This switch is for selecting the input signal.

☞ Refer to 4.6.1 External input.

㉝ GAIN

For adjusting the gain of the internal amplifier. ☞ Refer to 6.3 Gain adjustment.

㉞ QUICK CHANGE SYNC OUTPUT

This connector is for outputting a synchronization signal for QC operation.

☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).

㉟ DC MODE OFFSET

For adjusting the offset voltage for operation in DC output mode.

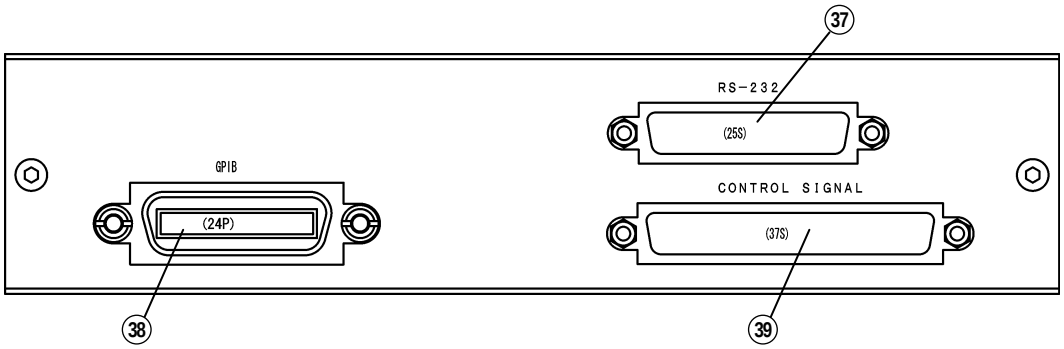
☞ Refer to 4.2.2 Switching between DC and AC output modes.

㊱ BOOSTER CONTROL

For parallel connection to the ES2000EB.

☞ Refer to 3.5.1 ES040ES and ES060ES connections.

## 2.1.4 Interface panel




㊲ RS-232

This connector is used for connecting an RS-232 cable or an ES4474A Remote Terminal unit.

㊳ GPIB

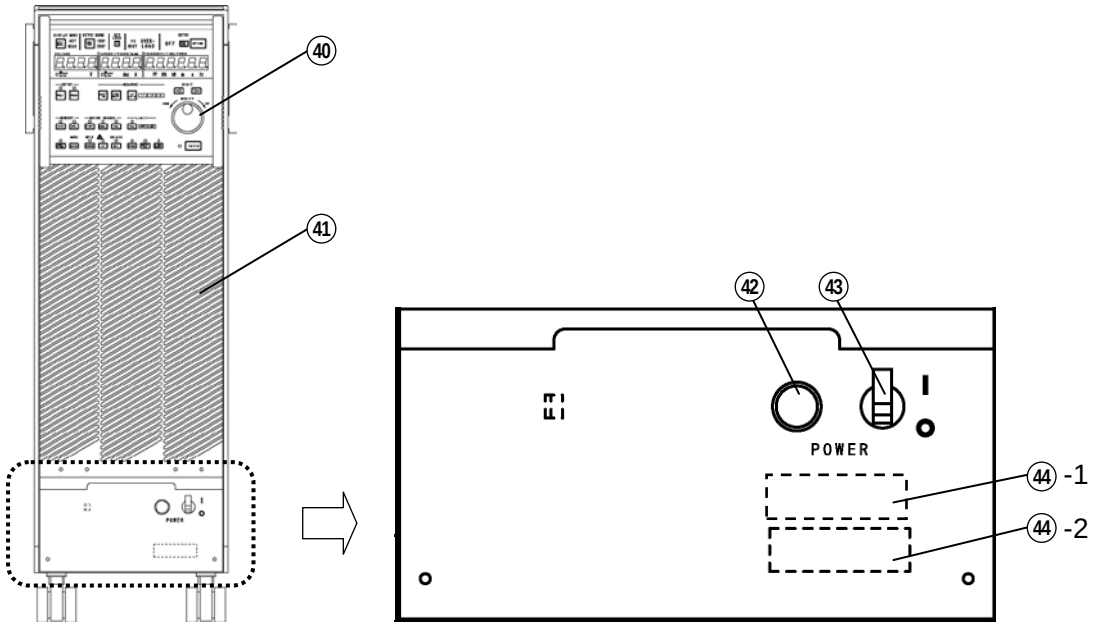
This connector is for connecting a GPIB cable.

㊴ CONTROL SIGNAL

This connector is for output of the internal status signal and input of the addition and amplitude modulation signals.

Concerning the RS-232, GPIB, and CONTROL SIGNAL connectors, refer to “Instruction Manual (interface)”.

## 2.1.5 Front




㊵ Controller

㊶ Intake vent

The intake for cooling air.

㊷ POWER light

This is the pilot light for the power supply. It is lit when the power is on.

㊸ POWER switch

This is the power switch for turning the power to this product on or off.

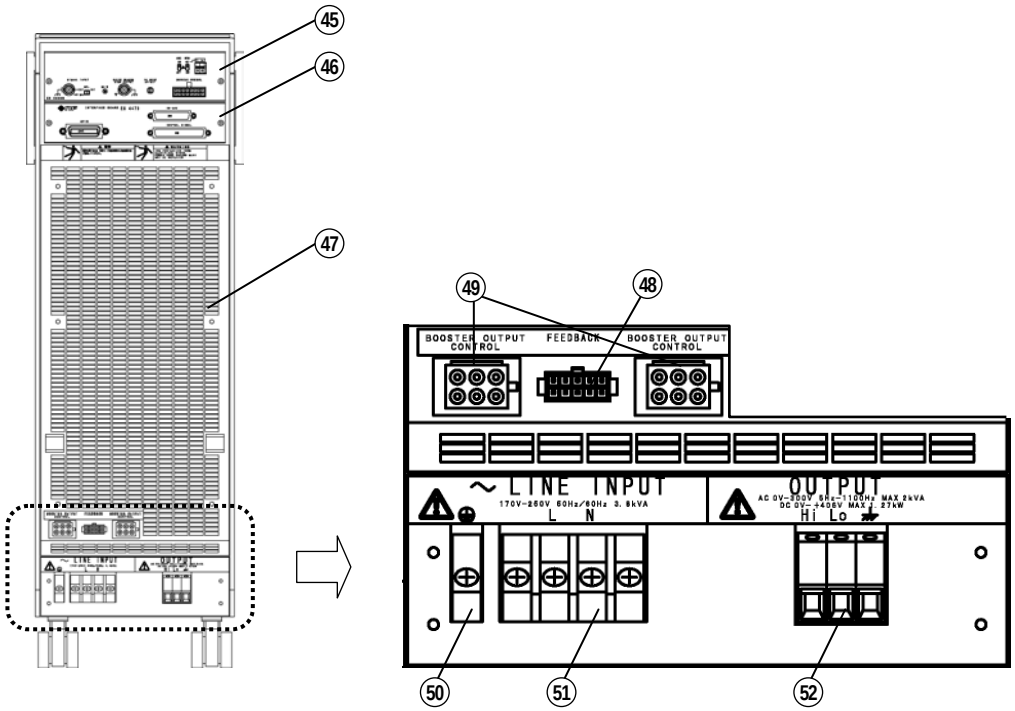
㊹ -1 Serial number label (package)

The serial number for this product is displayed here.

㊹ -2 Serial number label (constituent unit)

The serial number for this product is displayed here.

## 2.1.6 Rear




㊺ Rear signal panel

㊻ Interface panel

㊼ Exhaust vent

This is the outlet for cooling air.

㊽ FEEDBACK

This connector is for future extension. Do not connect anything to this connector.

㊾ BOOSTER OUTPUT CONTROL

This connector is for booster output control. For parallel connection, connect to the ES2000EB unit.

☞ Refer to 3.5.1 ES040ES and ES060ES connections.

㊿ ⏚

This is the protective conductor terminal. It must be connected to ground.

☞ Refer to 3.3.1 Connection to power input terminal.

(51) LINE INPUT

These are the power supply input terminals. Give attention to the rated input range.

☞ Refer to 3.3.1 Connection to power input terminal.

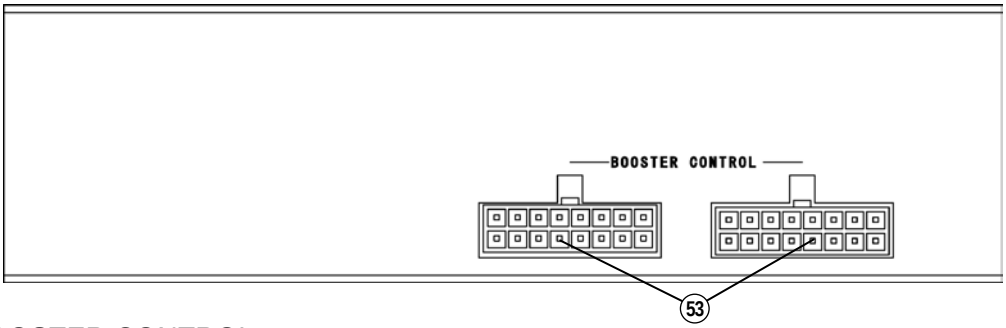
(52) OUTPUT

These are the output terminals. Use the screwdriver provided with this equipment when connecting wires to these terminals.

☞ Refer to 3.3.2 Connection to output terminals.

# 2.2 ES2000EB (booster)

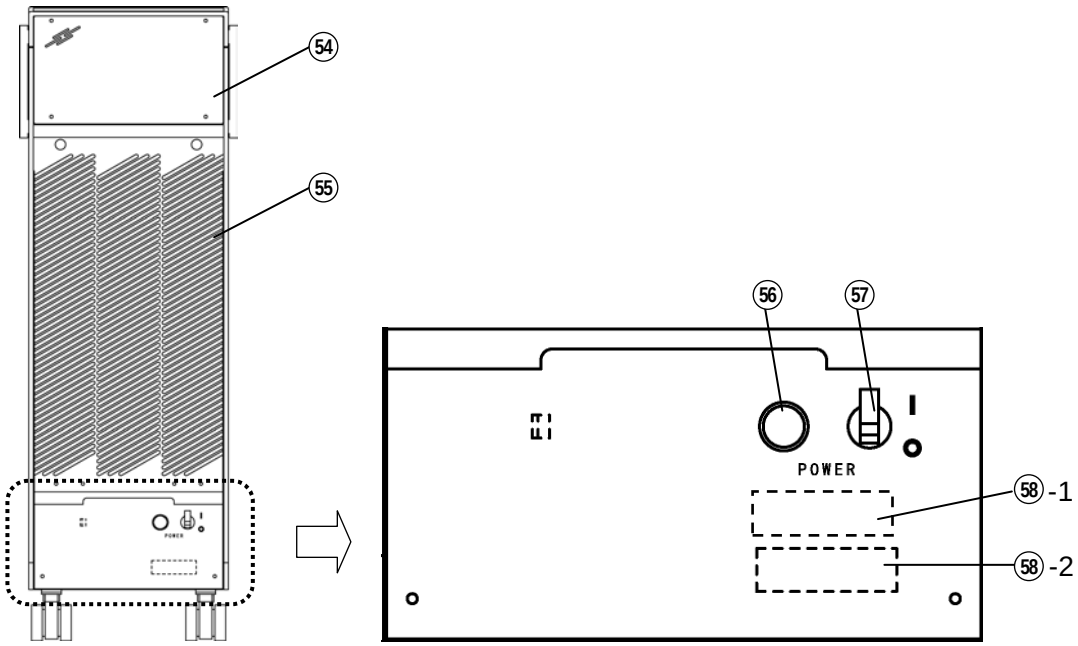
## 2.2.1 Rear signal panel




㊸ BOOSTER CONTROL

For ES040ES or ES060ES, use either connector block for connection to the master device.
For the ES060ES, it is possible to set the phase to 6 kVA by connecting the other connector block to the booster. ☞ Refer to 3.5.1 ES040ES and ES060ES connections.

## 2.2.2 Front




㊹ Blank panel

㊺ Intake vent

A vent for drawing cooling air into the equipment.

㊻ POWER light

This is the pilot light for the power supply. It is lit when the power is on.

㊼ POWER switch

This is the power switch for turning the power to this product on or off.

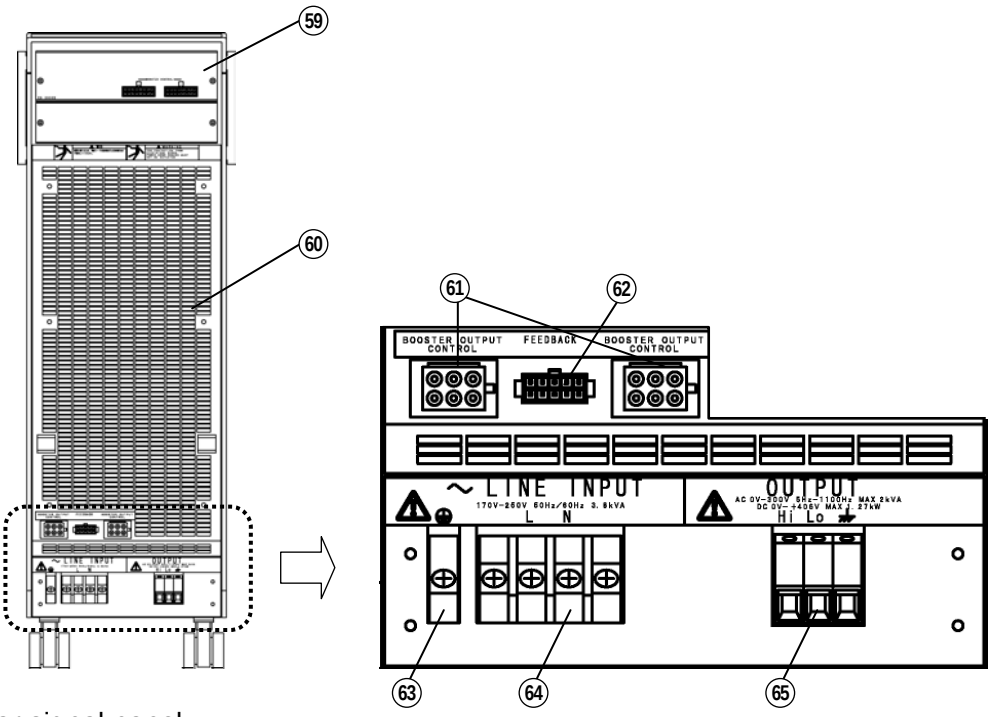
㊽ -1 Serial number label (package)

The serial number for this product is displayed here.

⑱ -2 Serial number label (constituent unit)

The serial number for this product is displayed here.

## 2.2.3 Rear




⑲ Rear signal panel

⑳ Exhaust vent

This is the outlet for cooling air.

㉑ BOOSTER OUTPUT CONTROL

For ES040ES or ES060ES, use either connector for connection to the master device.
For the ES060ES, it is possible to set the phase to 6 kVA by connecting the other connector to the booster. ☞ Refer to 3.5.1 ES040ES and ES060ES connections.

㉒ FEEDBACK

This connector is for future extension. Do not connect anything to this connector.

㉓

This is the protective conductor terminal. It must be connected to ground.

☞ Refer to 3.3.1 Connection to power input terminal.

㉔ LINE INPUT

These are the power supply input terminals. Give attention to the rated input range.

☞ Refer to 3.3.1 Connection to power input terminal.

㉕ OUTPUT

These are the output terminals. Use the screwdriver provided with this equipment when connecting wires to these terminals.

☞ Refer to 3.3.2 Connection to output terminals.

# 3. Preparation for Use

# 3.1 Installation environment

For safe and reliable use of this product, give consideration to the items described below.

- To prevent toppling, install this product on a floor that is level, free of vibration, and can withstand the weight of the product (48 kg per unit).
- Use the product within the temperature and humidity ranges specified in the following table.

| | | |
|---|---|---|
| To ensure performance | +5°C to +35°C | 5% to 80%RH<br>Absolute humidity of from 1 to 25 g/m$^3$, with no condensation. |
| To ensure operation | 0°C to +40°C | 5% to 80%RH<br>Absolute humidity of from 1 to 25 g/m$^3$, with no condensation. |
| For storage | -10°C to +50°C | 5% to 95%RH<br>Absolute humidity of from 1 to 29 g/m$^3$, with no condensation. |

High temperature and humidity will reduce the reliability of this product. It is recommended to use this product in environments of close to 25°C and 50%RH.

- Position this product so that the air vents (intake on the front side and exhaust on the rear side) are at least 50 cm away from walls or other obstructions to maintain an adequate airflow for forced-air cooling.
- Place this product in a location that satisfies the conditions listed below.
  Indoors, with no exposure to direct sunlight
  Ambient temperature and humidity within the rated ranges (no condensation in any case)
  Little dust (no conductive dust)
  No corrosive, explosive, or inflammable gases
  No flame or dampness
  Little vibration
  No exposure to salty air

# 3.2 Grounding and power connection

## 3.2.1 Grounding

This product uses a line filter. Electrical shock may result if this product is not properly grounded.

**⚠ WARNING**

The protective conductor terminal (⏚) of the power input terminals of this product must be connected securely to an earth ground so that ground resistance is 100 Ω or less. Failure to do so may result in electrical shock.

To prevent electrical shock when connecting the cable to the power input terminals, be sure to connect the protective ground line before making connections to the L terminal or N-terminal.

For grounding, use the power cable that is provided with this product or an equivalent cable (nominal cross-section area of 3.5 mm² or more).

## 3.2.2 Power supply

**⚠ WARNING**

Be sure to supply power to this product from the power distribution board.

Before connecting this product to the power distribution board, be sure to turn off the power to the power distribution board. There is a possibility of electrical shock.

**⚠ CAUTION**

Before connecting the power supply, check to make sure that the voltage of the power supply conforms to the rated power supply voltage of this product.

If this product is subjected to sudden changes in ambient temperature or humidity, such as during transport in the winter, condensation may occur inside the equipment. In such cases, wait until the condensation is gone before connecting the power supply.

- The power specifications for this product are listed below.

  Voltage: 170 V AC to 250 V AC

  Frequency: 48 Hz to 62 Hz

  Maximum power consumption: about 3,800 VA per unit

  (for power supply voltage of 170 V, the input current is about 23 A)

- Take sufficient care when tightening screws and routing cables to prevent unintended cable detachment or loosening at the terminals.

# 3.3 Connection to I/O terminals

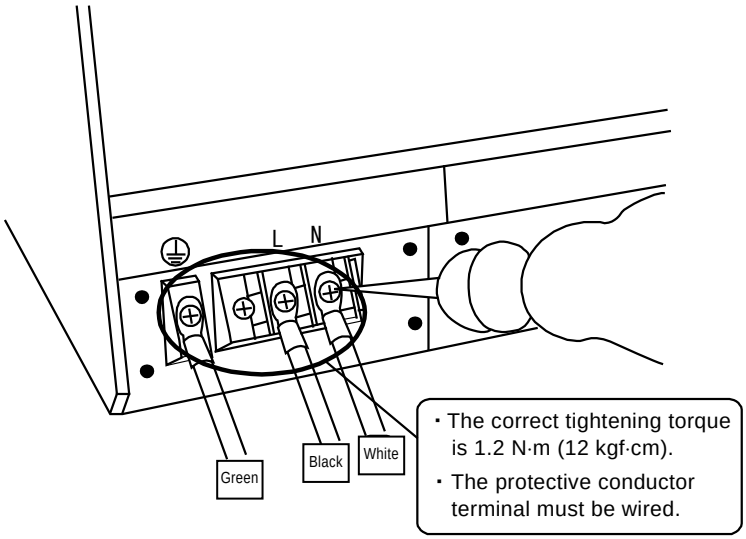
To prevent electrical shock, be sure to turn off the power to the power distribution board before making the connections.

## 3.3.1 Connection to power input terminal

Use the power cable provided with this product for the 200 V power connection from the power distribution board to the terminals (⏜ LINE INPUT) on the rear side of this product.
For safety, be sure to turn off the power to the power distribution board before making the connection.

In the input terminal section of this product, there is a terminal labeled (⏚ L N). Connect the protective ground to the terminal indicated by the symbol ⏚. If one side of the power supply is grounded in the connection to the power distribution board, connect "N" to the ground side polarity and connect "L" to the ungrounded side polarity. Otherwise, it is not necessary to consider polarity.
When connecting to a power distribution board that has a single-phase three-wire configuration in particular, the neutral phase (ground polarity) is not used and the connection is made to phase 1 and phase 2.

A Phillips screwdriver (+) is required for turning the M4 screws when wiring the terminal block.
Remove the safety cover from the terminal block and remove the screws. Insert the screws through the terminals of the power cable that is provided and use the screwdriver to tighten the screws into the terminal block.
The correct tightening torque is 1.2 N·m (about 12 kgf·cm).
(from IEC Standard IEC60947-7-1)
The protective conductor terminal must be wired. When the wiring is completed, be sure to attach the protective cover.




**⚠ WARNING**

For safety, be sure to turn off the power to the power distribution board before making the connection.

## 3.3.2 Connection to output terminals

The output is isolated from the power supply input.

The “Hi” and “Lo” output terminals are both isolated from the enclosure. The “Lo” terminal can be used when connected to the enclosure.

The output terminals on the rear panel can be used with wires that have a cross-section of up to 8 mm² or with single wires that have a diameter of up to 4 mm.

For stranded wire, end treatment is not necessary, but take care not to fray the ends.

Strip the insulation to a distance of 11 mm from the end, insert the wire into the terminal, and use the provided the screwdriver to tighten the M4 screw.

The correct tightening torque is 1.5 to 1.8 N·m (about 15 to 18 kgf·cm).

**⚠ CAUTION**

- To tighten the screws properly without damaging the groove, use the screwdriver that is provided for wiring work.
- The “Lo” terminal can be used when connected to the enclosure, but the specified performance will not be obtained if the “Hi” terminal is connected to the enclosure.

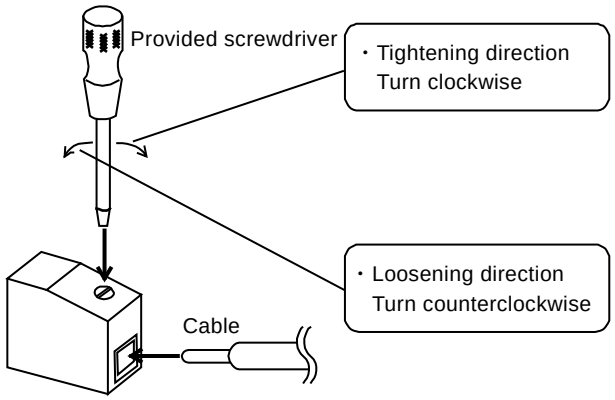
■ The procedure for connecting a cable to the screw-type (clamp) terminal block is described below.

(1) Strip the insulation from the wire to expose the core to a distance of 11 mm from the end.

(2) Loosen the screw in the terminal block until the cable insertion port is open to the maximum extent.

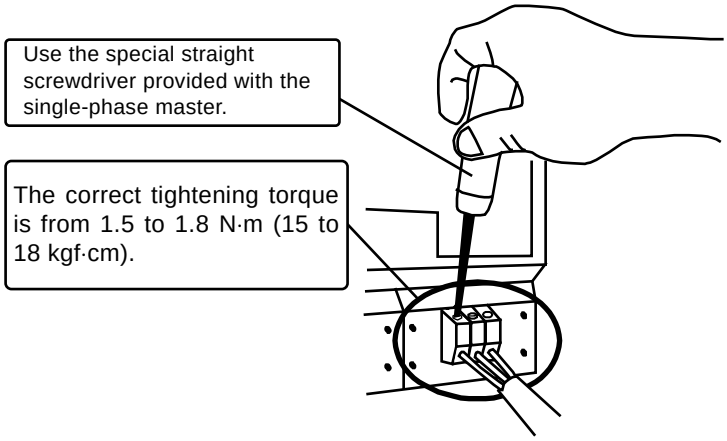
(3) Insert the cable core into the insertion port.

(4) Tighten the screw to the specified torque.




When connecting the cable to a screw-type (clamp) terminal block, loosen the screw of the terminal block fully and then insert the cable.

When using stranded wire, take care not to fray the tip of the wire core. The screws are loosened by turning counterclockwise and tightened by turning clockwise




**⚠ WARNING**

For safety, be sure to turn the power off before making the connection.

**⚠ CAUTION**

- Do not solder the wire core. Soldering creates high contact resistance that may result in high temperatures in the contact area and heat damage to the terminal block.
- Insert only one cable into the terminal block. If two or more cables are inserted, the cables may tend to pull out.

## 3.4 ES020ES connections

This section explains the connections for when the ES020ES (ES2000ES×1) is used.

(1) Connect the power supply
Read “Connection to power input terminal” for how to make secure connections.
☞ Refer to 3.3.1 Connection to power input terminal.

(2) Connect the output to the load
Read “Connection to output terminals” for how to make secure connections.
☞ Refer to 3.3.2 Connection to output terminals.

**⚠ CAUTION**

The internal circuits of this product are controlled so that the voltage at the output terminal on the rear side of this product is sensed and kept constant relative to the set voltage.
Thus, if the peak value of the output current is high or the output frequency is high, etc., the impedance is affected by the cable and the wiring from the terminal to the load, and load regulation deteriorates. For that reason, make sure that the wiring between the output terminal and the load is no longer than necessary and use an output cable that has a nominal cross-section area of at least 3.5 mm² or so.

**⚠ WARNING**

For safety, be sure to turn the power supply off before connecting the output.

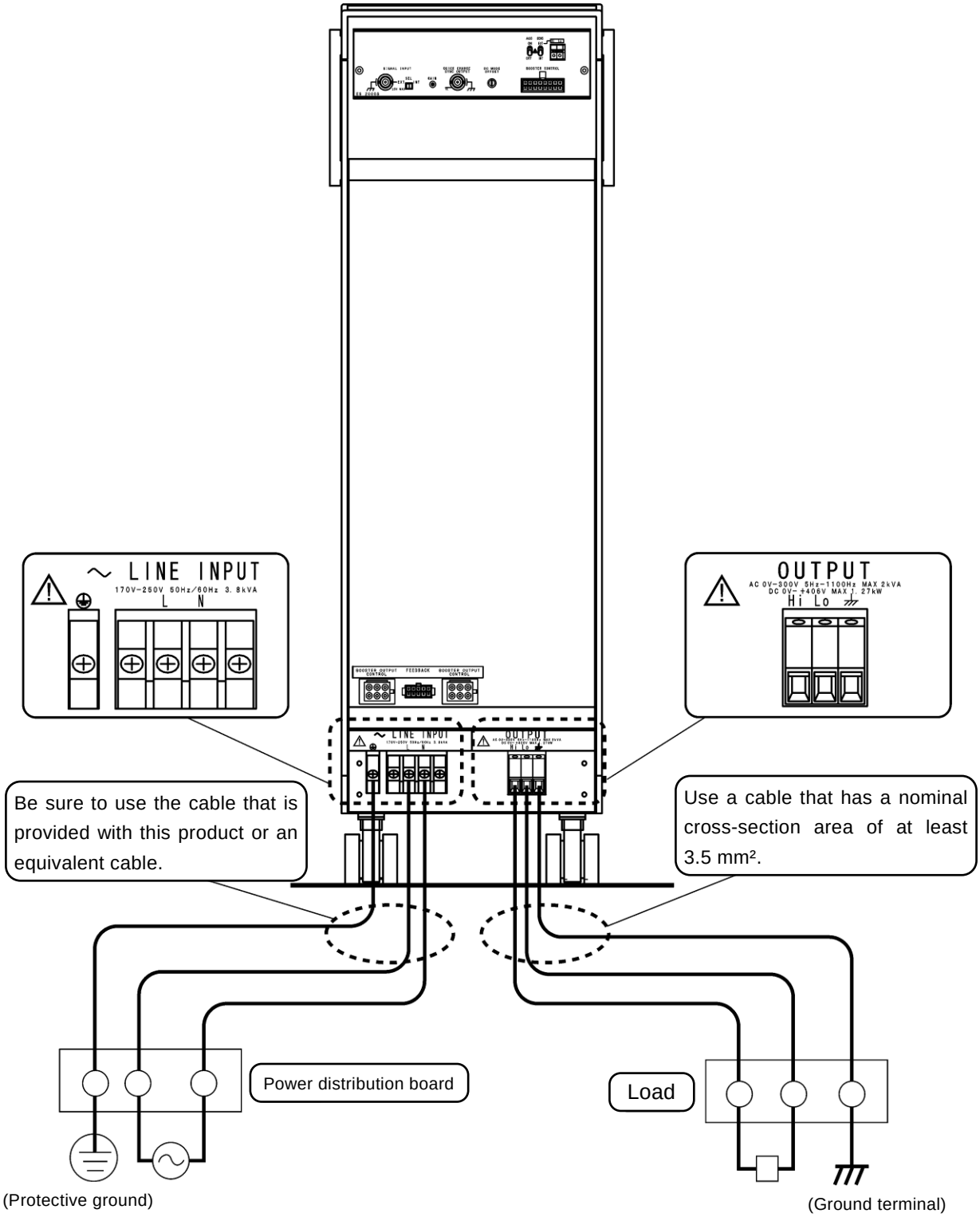



Figure 3-1 ES020ES connections

# 3.5 Connecting the booster and control cable

## 3.5.1 ES040ES and ES060ES connections

This section explains the connections for when the ES040ES (ES2000ES×1 + ES2000EB×1) or ES060ES (ES2000ES×1 + ES2000EB×2) configuration is used.

**⚠ CAUTION**

Before wiring the power supply, check the power capacity of the distribution board.
The maximum input power of the single-phase master and booster is about 3800 VA per unit, so when the input voltage is 170 V, the input current is about 23 A per unit.

**⚠ WARNING**

For safety, be sure to turn the power supply off before making the connection.

(1) Connect the power supply.

Read “Connection to I/O terminals” for how to make secure connections. Also, be sure to wire to the respective power supply input terminals individually when connecting the power supply cable.

☞ Refer to 3.3 Connection to I/O terminals

(2) Connect booster cables A and B.

Connect the single-phase master and each booster with booster cables A and B, which are included with the boosters. The cables are connected in a daisy chain configuration.

(3) Connect the output to the load.

Read “Connection to I/O terminals” for how to make secure connections.

☞ Refer to 3.3 Connection to I/O terminals

■ Connections using the Power Inlet Unit and Outlet Unit

When the 4481 Power Inlet Unit (optional) is used, it is possible to supply power to the respective power inputs of the ES040ES and ES060ES units together.

Also, by using the 4482 Outlet Unit (optional), parallel output connections from ES040ES and ES060ES units is possible, enabling output from a single terminal block.

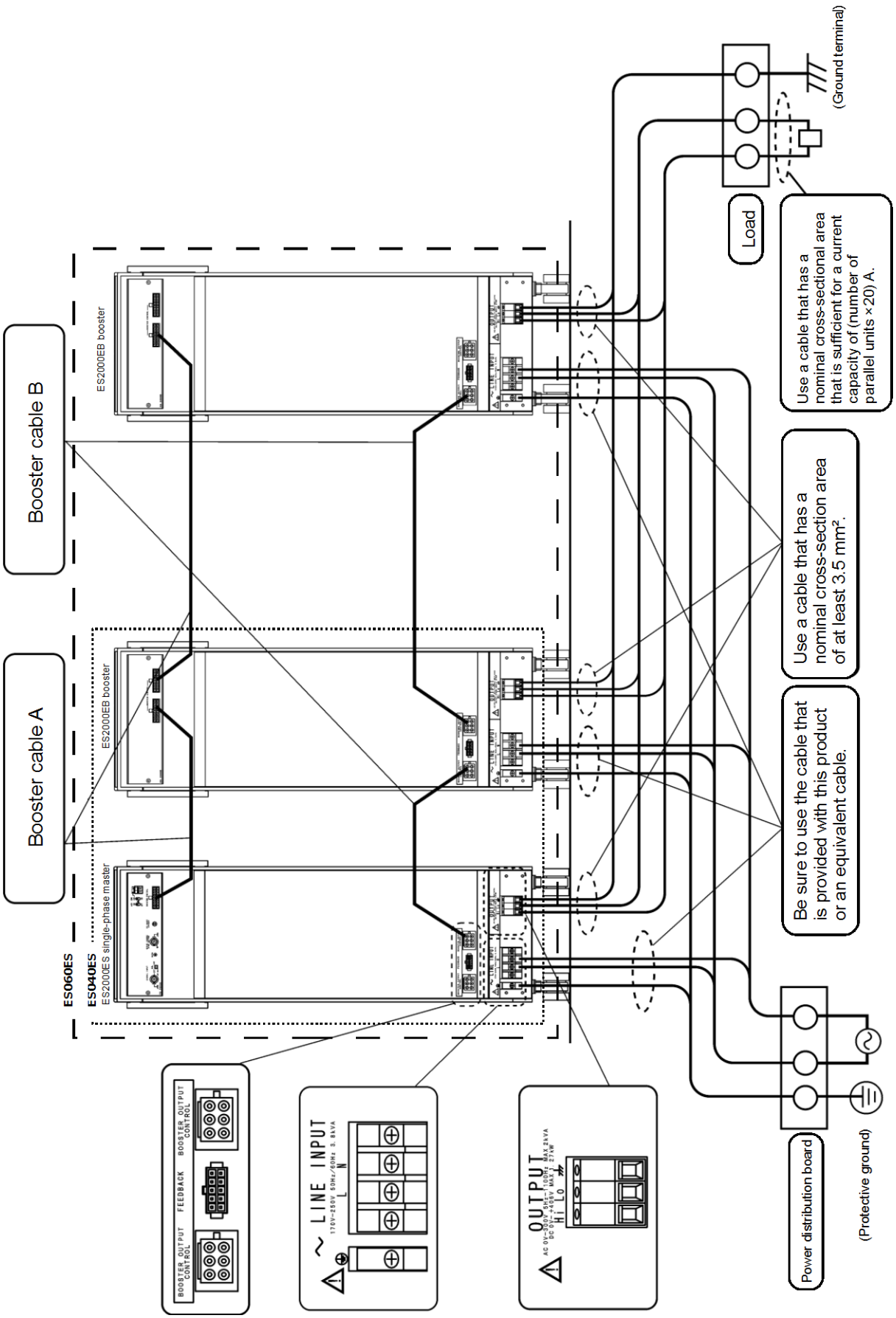



Figure 3-2 ES040ES and ES060ES connections

## ⚠ CAUTION

Consider the information on the relationship between the cable and the permissible current when selecting the cable to use.

■ Permissible current of two-core vinyl cab tire cable (JIS C 3312 VCT cable)

For ambient temperature of 30 °C or less

| Cores | Nominal cross-section area ($mm^2$) | Permissible current (A) |
|---|---|---|
| 2 | 2 | 22 |
| | 3.5 | 32 |
| | 5.5 | 41 |
| | 8 | 51 |
| | 14 | 72 |
| | 22 | 97 |
| | 38 | 130 |
| | 60 | 175 |
| 1 | 60 | 225 |
| | 100 | 315 |

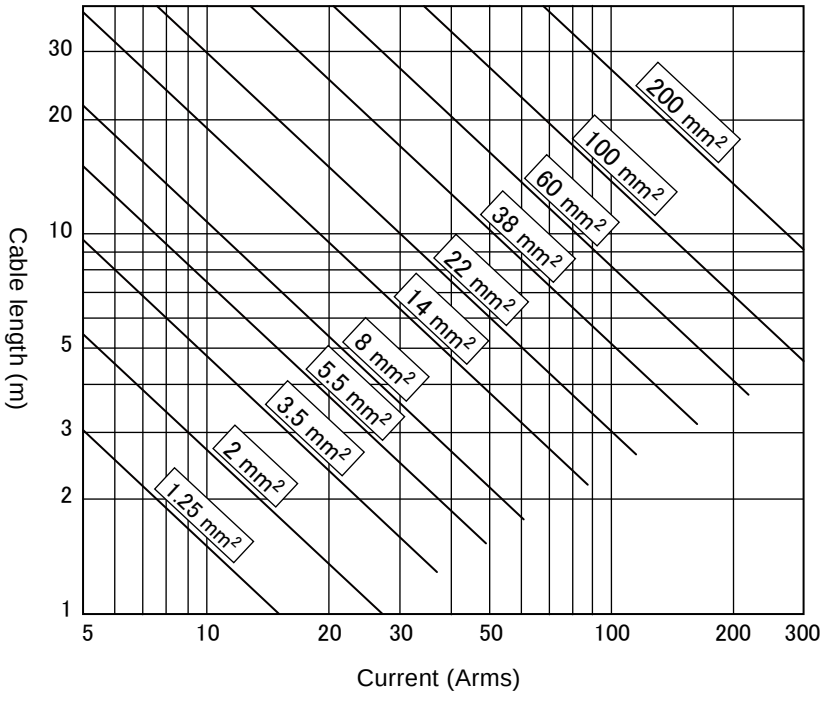
For ambient temperatures above 30 °C

| Ambient temperature (°C) | Permissible current reduction factor |
|---|---|
| 30 | 1.00 |
| 35 | 0.91 |
| 40 | 0.82 |
| 45 | 0.71 |
| 50 | 0.58 |

(from JEAC 8001-2011)

*Multiply the permissible current from the table on the left by the relevant reduction factor from the table above.

■ Relation between cable length and voltage drop (JIS C 3307 IV cable)




* The cable length for which the voltage drop due to wire resistance is 0.5 V

* The values enclosed in boxes in the figure represent cross-sectional area.

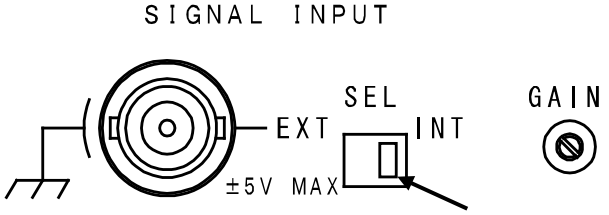
# 3.6 Power on/off and operation check

After completing the connection, check operation.

Follow the procedure described below to turn on the power.

For the meaning of each display, refer to Chapter 4. ☞ Refer to 4.1 Notation.

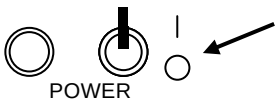
(1) Confirm that the SIGNAL INPUT switch in the rear signal panel of the single-phase master is set to INT.




(2) Confirm that the wiring is done correctly according to the instructions up to this point.

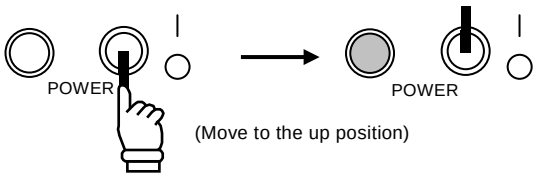
(3) Turn the booster power switch on. (Leave the single-phase master power off.) Up to this time, the power is not on.

<< all boosters >>




(4) Turn on the single-phase master power switch. When the power is turned on, operation begins.
Each booster is powered up automatically in sequence and the state is displayed in the single-phase master control section.

<< single-phase master >>

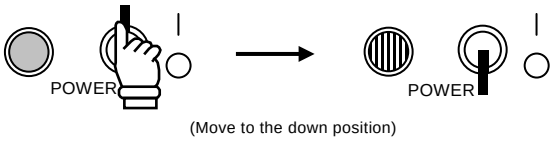



(5) The various setting values for the time immediately after power is turned are set to the content of memory address 1.
The first time the product is turned on after purchase, the settings are set to the default values that are stored internally.
☞ Refer to 4.3.3 Memory.

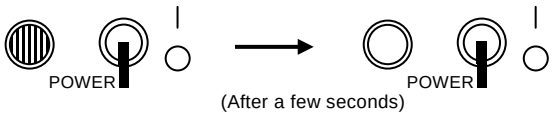
(6) Check that the output voltage setting value and the measured value are about the same.
If the values are different, auto-calibration may have been enabled. Set auto-calibration to disabled and check the values again.
☞ Refer to 4.5.3 Auto-calibration (output voltage adjustment function).

(7) To turn the power supply off, set the power switch of the single-phase master to the off position. The power supply is interrupted and goes into the off state.
The power switch of each booster remains in the on position, but the power is turned off.

<< single-phase master >>




(8) After the power is turned off, the pilot lights of the single-phase master and boosters blink on and off for a few seconds.
To turn the power on again, wait for at least 10 seconds after the lights have stopped blinking and are no longer lit.




**⚠ CAUTION**

- Connect cables securely. Incorrect cable connections can cause equipment failure.
- Immediately after the power is turned on, OVER-LOAD may light up until the internal circuits have stabilized.

# 3.7 Calibration

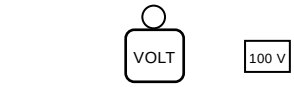
If this product requires calibration, contact the NF Corporation or an authorized agent.

# 4. Operation

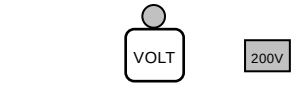
# 4.1 Notation

This section explains the notation that is used in explaining the operation of equipment.

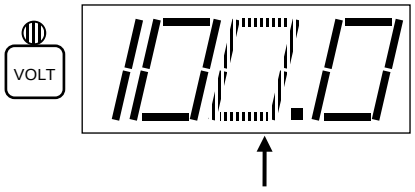
(1) Concerning displays




This represents a light that is not lit.




This represents a light that is lit

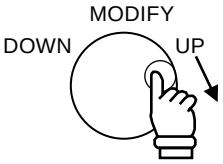



This represents that a light or display device is blinking on and off. For display devices in particular, the digit indicated by the arrow is blinking on and off.

(2) Concerning operations


This indicates that a key is being pressed.

It is not necessary to press and hold the key down.




This indicates that a dial is turned.

In this case, the dial is being turned in the clockwise direction.

Notes

It will be easier to learn how to use the functions if you perform the operations on this product as you read the instructions.

# 4.2 Basic operations

## 4.2.1 Attaching and removing the controller

The operating unit of the single-phase master can also be used after detaching it from the constituent unit.

You can choose how to use the operating unit according to your purpose.

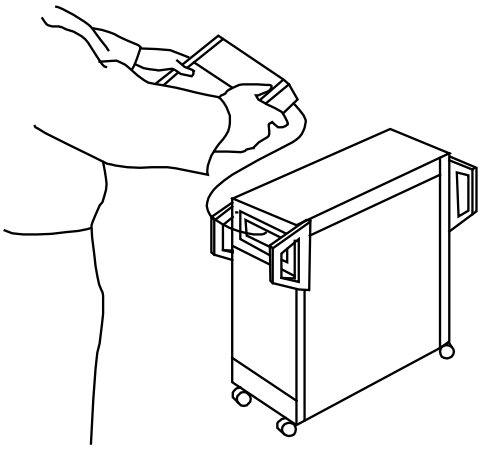


Figure 4-1 Controller attachment and detachment

When removing the controller unit, gently pull the bottom of the unit toward you.

When the unit detaches from the magnet that holds it in place, lift the bottom of the unit upwards and remove the unit from the socket. The socket has two positions and can hold the control unit in a slightly raised position.

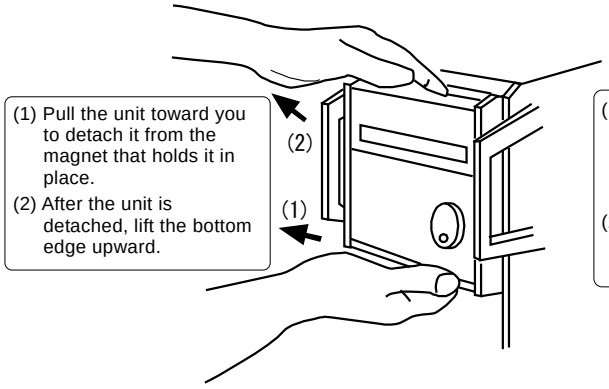



Figure 4-2 Detaching the controller

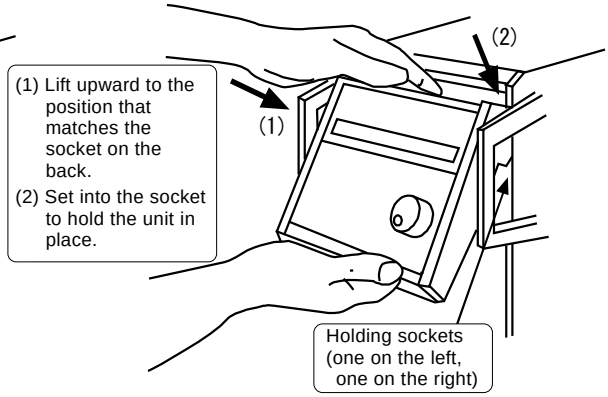



Figure 4-3 Placing the controller in a slightly raised position

**⚠ CAUTION**

- Take care not to drop the controller when removing or replacing it.
  Replace the unit securely and take care not to drop it when moving it.
- To prevent disconnection, do not pull forcefully on the cable where it is attached.

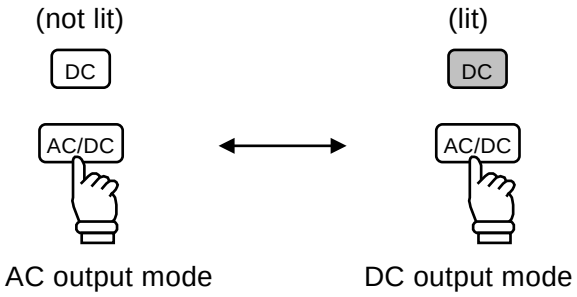
## 4.2.2 Switching between DC and AC output modes

You can switch between DC and AC output modes by pressing the AC/DC key on the control panel.

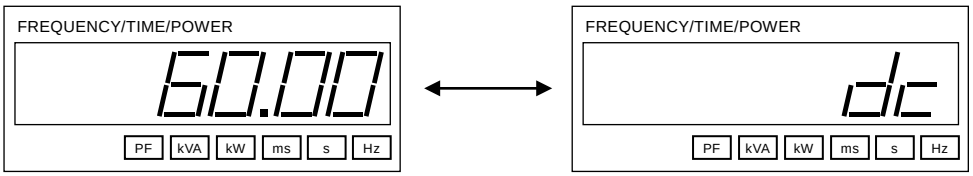
When the AC output mode is set, the DC is not lit.

■ Operating procedure

Each time the AC/DC key is pressed, the output mode toggles between DC output and AC output. When the light is lit, the DC output mode is in effect; when the light is not lit, the AC output mode is in effect.




In the DC output mode, “dc” is displayed in the frequency display; in the AC output mode, the set frequency is displayed.




Use OFFSET on the rear signal panel to adjust the offset voltage for when the output voltage is set to 0 V in the DC output mode. ☞ Refer to 2.1.3 Rear signal panel.

### ⚠ CAUTION

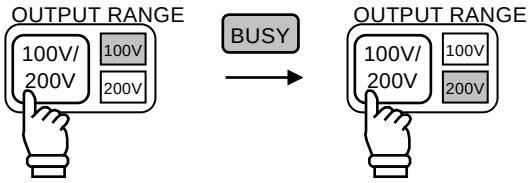
- It is not possible to output direct current in the AC output mode or to output alternating current in the DC output mode.
- The output mode cannot be switched from DC to AC unless the voltage is 150 V or less when the 100 V range is set or unless the voltage is 300 V or less when the 200 V range is set.
- When line synchronization is set in the AC output mode, the mode cannot be switched to DC output. In the DC output mode, line synchronization cannot be set.
- Switching between the DC and AC output modes is not possible under the conditions listed below.
  - CF ON (The unit is being controlled from an external computer or from the ES4474A Remote Terminal.)
  - QC ENABLE
  - Output is on
  - Sweep operation is in progress
  - QC operation is in progress
  - Range switching is in progress

## 4.2.3 Setting the output voltage and range

- After setting the output voltage range according to the desired output voltage, set the voltage setting mode and use the modify dial to adjust the voltage.
- The voltage value that is set applies to both AC and DC modes. If 100 Vrms is set in the AC output mode, the value becomes 100 Vdc in the DC output mode. The reverse is also true.
- In DC output mode, the output voltage range setting of 100 V represents a range from 0 to +203.0 V and the setting of 200 V represents a range from 0 to +406.0 V. A negative voltage cannot be output for the Lo terminal reference.
- The upper limit of the output voltage is determined by the output voltage range setting and the limit setting.
- The voltage setting step size of the modifier dial is different for the setting mode and the measurement mode. In the setting mode, the step size can be changed by using the arrow keys ( ◀ ▶ ). In the measurement mode, the step size is fixed at 0.1 V.

■ Operating procedure

Press the 100V/200V key to set the output voltage range to the specified range. The setting value is toggled between the two choices each time the key is pressed. While the switching operation is in progress, the BUSY light is lit.

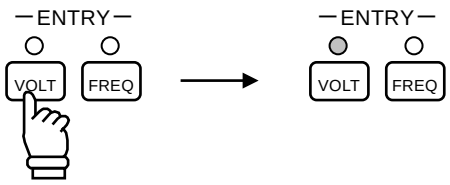



| Output mode | Voltage range | |
|---|---|---|
| | 100 V | 200 V |
| AC | 0 to 150.0 V | 0 to 300.0 V |
| DC | 0 to 203.0 V | 0 to 406.0 V |

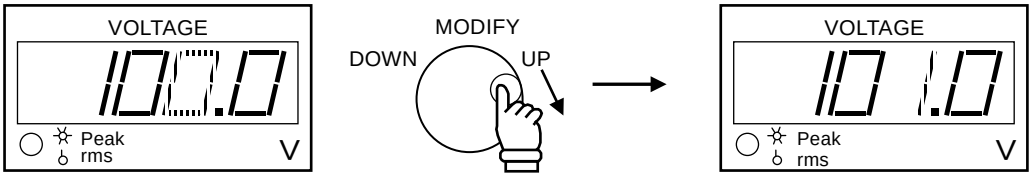
**⚠ CAUTION**

If the output voltage or the QC voltage setting exceeds 150.0 V in the AC output mode or 300.0 V in the DC output mode, the voltage range cannot be switched from 200 V to 100 V.

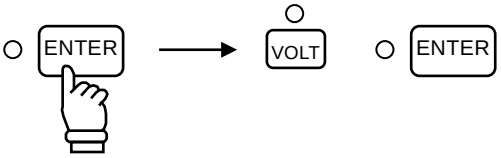
Press the VOLT key to enter the voltage setting mode. In the voltage setting mode, the light is lit.



Turn the modify dial to adjust the voltage. The display and the output voltage both change. In the setting mode, the value of the digit that is blinking on and off will change. In the measurement mode, the 0.1 V digit will change.




After setting the value, press the ENTER key. The light will turn off and the voltage setting mode will exit.




**⚠ CAUTION**

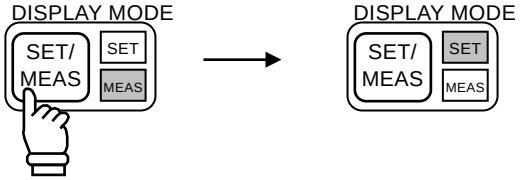
The maximum output current depends on the output voltage range. Select the range that is appropriate for the load current.

## 4.2.4 Setting the output frequency

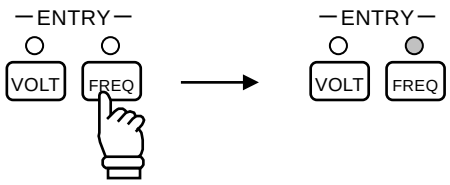
- Set the frequency setting mode and then use the modify dial to adjust the frequency value.
- The maximum frequency range is from 5 to 1100 Hz, but if limits have been set, those settings determine the upper and lower range of values.
  (☞ Refer to 4.3.1 Setting limit values.)

■ Operating procedure

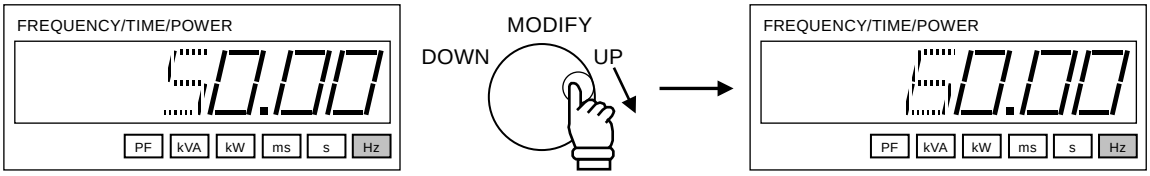
Press the SET/ MEAS key to set the display to the setting mode. In the setting mode, the SET light is lit.



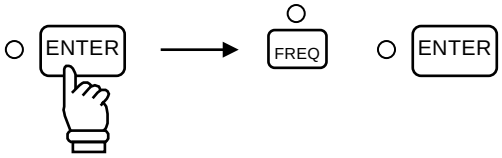

Press the FREQ key to set the frequency setting mode. In the frequency setting mode, the corresponding light is lit.



If you turn the modifier dial, the value of the digit that is blinking on and off will change. You can use the arrow keys ( ◀ ▶ ) to move the digit that is blinking. The display and the output frequency value will both change.




After completing the setting, press the ENTER key. The light will turn off and the frequency setting mode will end.




**⚠ CAUTION**

- When setting the frequency, give attention to the permissible frequency range for the load that is connected.
- The frequency setting cannot be performed while line synchronization is enabled.
  ☞ Refer to 4.3.2 Line synchronization.

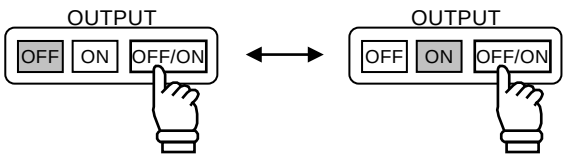
If the frequency display is “dc", the DC output mode has been set. Switch to the AC output mode.
☞ Refer to 4.2.2 Switching between DC and AC output modes.

## 4.2.5 Switching output on and off

The procedure for switching the output on and off is described here.

■ Operating procedure

Press the OFF/ON key. Each time you press the key, the state toggles between on and off.



## 4.2.6 Key lock

Pushing the keylock switch to the up position enables the key lock and the key lock knob light turns on. In that state, all of the keys on the front panel are disabled.


Key lock off
(operation enabled)

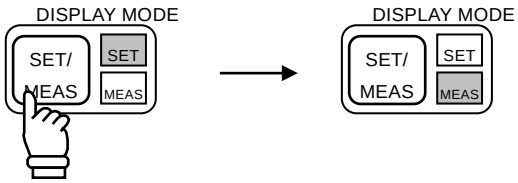

Key lock on
(operation disabled)

## 4.2.7 Measurement functions

- The measured values of the effective voltage and current, active power, apparent power, and power factor are displayed.
- The output voltage can be changed without affecting the measurement display.
  ☞ Refer to 4.2.3 Setting the output voltage and range.
- In the DC output mode, the value calculated from the effective measured values of the voltage and current are displayed in VA. The active power (W) is not measured.

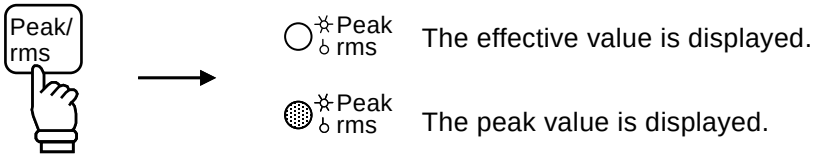
■ Operating procedure

Press the [SET/ MEAS] key to set the display mode to measurement. In the measurement display mode, [MEAS] lights up.




<<Display of effective/peak values of voltage and current>>

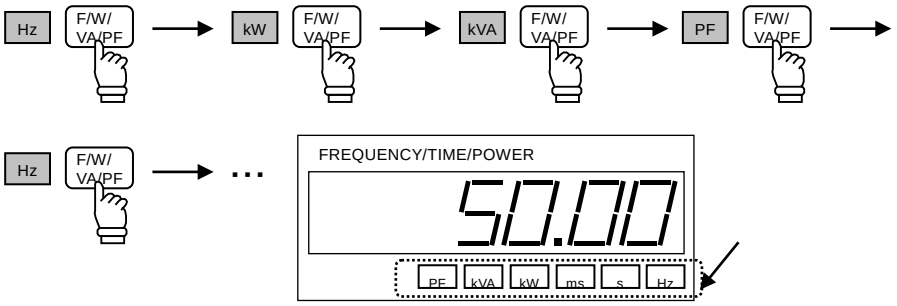
Press the [Peak/ rms] key. When the light is lit, the peak value is displayed; when the light is not lit, the effective value is displayed.



<<Display of active power, apparent power, and power factor>>

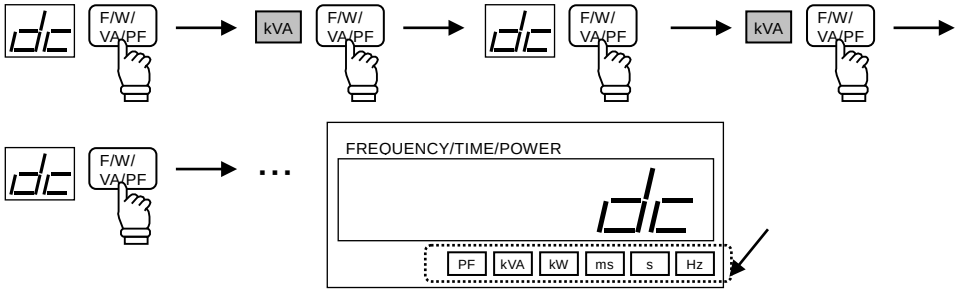
● For the AC output mode

Press the F/W/ VA/PF key. Each time the key is pressed, the measured value that is displayed progresses in the order of "frequency (Hz) → active power (kW) → apparent power (kVA) → power factor → frequency (Hz) →…".




● For the DC output mode

Press the F/W/ VA/PF key. Each time the key is pressed, the calculated value for the power that is displayed toggles between "dc" and "power" (kVA).




**⚠ CAUTION**

- The measured value of frequency is not displayed. (Only the setting value is displayed.)
- The Peak/ rms key and the F/W/ VA/P are disabled when the display mode is setting (SET is lit). It may take a few seconds for the display to stabilize after these keys are pressed.

## 4.2.8 Protection function

- The protection function of this product is described below.
- If an overload occurs when output limits are in effect, OVER-LOAD lights up.

| Protection trigger | Protection | | Operation |
|---|---|---|---|
| | Output limit | Power interrupt | |
| Output overcurrent | Yes | Yes | Detect and limit the peak current. Detect the average value and reduce the input voltage to limit it. |
| Output device loss | Yes | Yes | If the loss of the output stage semiconductor exceeds the specified value, lower the input voltage to limit it. |
| Output device safe operation range | Yes | Yes | When the safe operation range of the output stage semiconductor exceeds the specified value, limit the output voltage and current. |
| Internal device overheating | No | Yes | Detect degradation of the cooling capability due to environmental factors or fan failure, etc. |

**⚠ CAUTION**

When the protection function operates to limit output, this product is in the overload protection mode and the OVER-LOAD is lit. When the cause for the limit (overload, short-circuit, etc.) is eliminated, recovery to the normal state is automatic, but the power may be turned off, depending on the degree and duration of the protection state.

Also, if remote-sensing AGC is in use and the external sensing terminal is open when output on is enabled or the output is greatly outside the voltage compensation range, compensation will be set to off and OVER-LOAD will light up. That state continues until output is set to off.

☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).

The light may also be on for a short time during voltage range switching.

# 4.3 Advanced operations

## 4.3.1 Setting limit values

- Limit values can be set to restrict the setting range for output voltage and output frequency. Setting limits in advance according to the permissible input range of the connected load can prevent failure of the load equipment due to overvoltage, etc.
- It is possible to set three limits: an upper limit for voltage and upper and lower limits for frequency.
- The limit values that are set apply even when QC voltage is set.

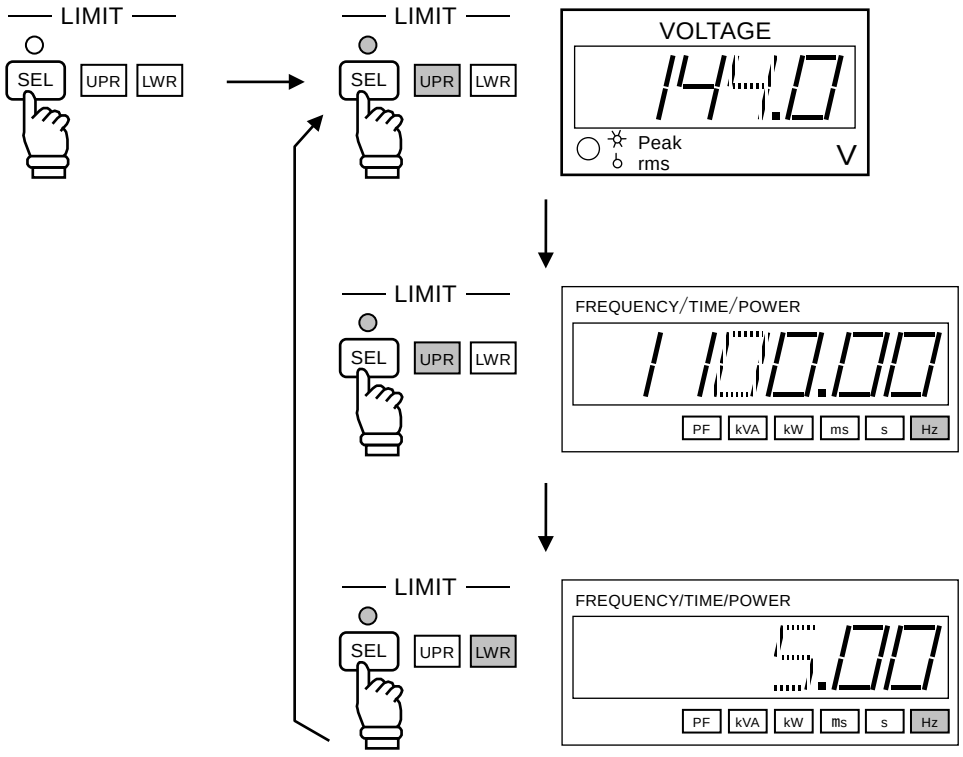
☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).

■ Operating procedure

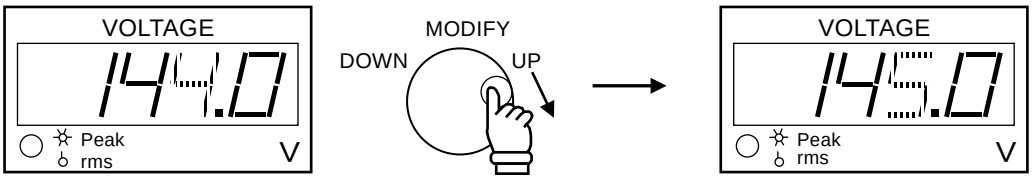
Press the SET/MEAS key to set the display mode to the setting mode.

☞ Refer to 4.2.7 Measurement function.

If you press the SEL key, the three limit values that are currently set are displayed.
A cursor is displayed for one of the values. By pressing the SEL key, the cursor can be moved from one value to the next in the order of "Upper voltage limit (V) → Upper frequency limit (Hz) → Lower frequency limit (Hz) → Upper voltage limit (V) → …" so that the respective limit value can be set.



Adjust the limit value by turning the modifier dial. The cursor can be moved from digit to digit with the arrow keys ( ◀ ▶ ).




After adjusting the settings, press the ENTER key. The display returns to the basic state prior to the time the SEL key was pressed, completing the setting procedure.
To check the setting values, press the SEL key again to enter the setting state.
To change the other limit values, repeat the procedure from the beginning.

**⚠ CAUTION**

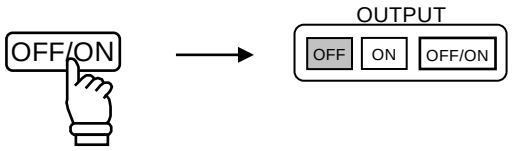
When setting the voltage limit value, it is not possible to set a value that is lower than the output voltage or QC voltage value that has already been set.
When setting the upper or lower frequency limit value, it is not possible to set a value that is outside the frequency range that has already been set.

## 4.3.2 Line synchronization

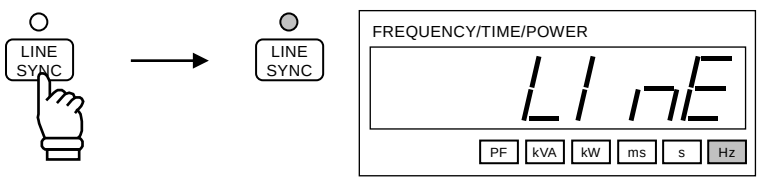
This function synchronizes the output frequency with the frequency of the AC power line. It is possible to synchronize to a power line frequency of from 48 to 62 Hz.

■ Operating procedure

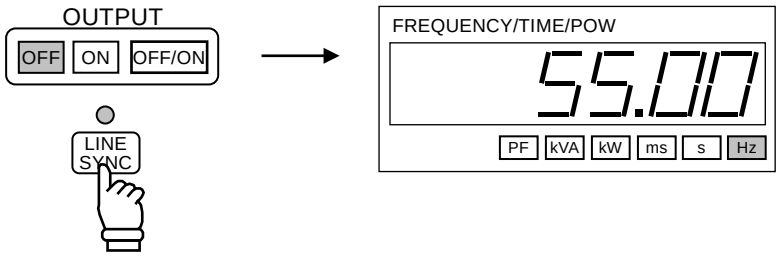
Turn the output off. In the output on state, it is not possible to turn the line synchronization on or off.




Press the LINE SYNC key. After the system stabilizes (about 100 ms), the frequency display will change to “LInE” to indicate that line synchronization is enabled.



To turn line synchronization off, set the output to off and then press the LINE SYNC key.
The output frequency is always set to 55 Hz after line synchronization is switched off.




**⚠ CAUTION**

The frequency range for which line synchronization is possible is from 48 Hz to 62 Hz. You should use that range.
Line synchronization cannot be switched on or off in the output on state. Turn output off before making this setting.
When line synchronization is switched off, the output frequency is always set to 55 Hz.
If 55 Hz is not included in the permissible range of the frequency setting because of the frequency limit values that have been set, it is not possible to turn line synchronization on.
☞ Refer to 4.3.1 Setting limit values.

## 4.3.3 Memory

- Setting values and states can be saved to internal memory that has battery backup and values can be retrieved from the memory.
- 121 memory addresses are available (numbered from 0 to 120). Address 0 contains the default values and is read-only. The other 120 addresses can be used to store arbitrary values.
- When the power is turned on, the values that are stored in memory address 1 are set. If states and values that are usually used are stored in memory address 1, it is not necessary to set those values each time the power is turned on.
- It is possible to use the state settings saved to memory to perform an “Output QC operation” with the states before and after retrieval from memory. It is also possible to perform a “sweep” operation in which the output voltage and frequency are varied for the states before and after retrieval from memory over the time specified by the transition time that was saved to memory. (☞ Refer to 4.4.2 Voltage sweep 1 (frequency variation).) For more information, refer to Power fluctuation tests. ☞ Refer to 4.4 Power fluctuation tests.

## ⚠ CAUTION

1) To prevent incorrect supply of output to the load when data is retrieved from memory in the output on state, perform the operation as described below.

   - If the state is set to “output off” after memory recall.
     The state is always set to “output off” after retrieving data from memory.
   - If the state is set to “output on” after memory recall
     If any of the states listed below are different before and after data is retrieved from memory, “output off” is set for safety, but if they are the same, the output on state can be left unchanged.
     - Line synchronization on/off
     - QC enable mode
     - Output voltage range 100 V/200 V
     - Precision/high-stability
     - Output mode AC/DC
     - Crest factor function enabled/disabled (If enabled, the criterion is whether the CF values are the same.)

2) The values stored in memory address 1 are retrieved when the power is turned on, but to prevent incorrect supply of output to the load, always set the output to off, regardless of the values that are stored in memory address 1.

3) If “sweep” is not used, check to make sure the transition time is set to 0 when data is saved to memory to prevent an incorrect sweep operation.
   ☞ Refer to 4.4.2 Voltage sweep 1 (frequency variation).

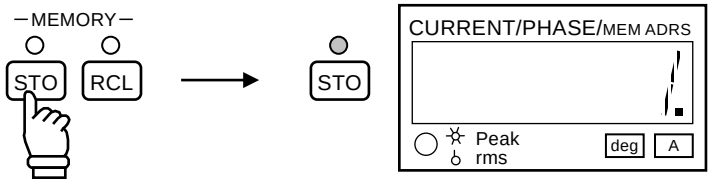
4) Settings related to the interface are not saved to or retrieved from memory. For more information, refer to Instruction Manual (interface).

5) When using the optional ES4474A Remote Terminal, the state in which store/recall is enabled is added. For more information, refer to “ES4474A Remote Terminal Instruction Manual”.

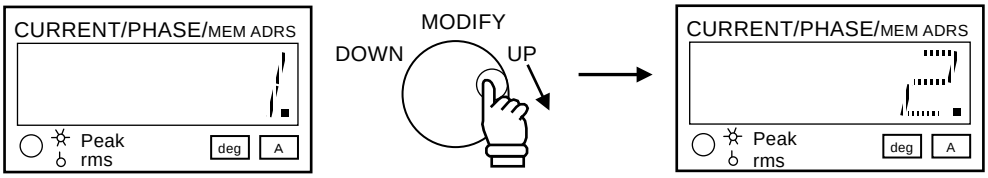
6) When the “output sweep operation” is not used, set the transition time to 0.
   ☞ Refer to 4.4.2 Voltage sweep 1 (frequency variation).

### ■ Operating procedure: save to memory

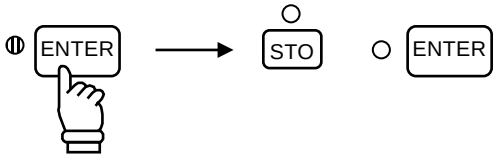
Press the STO key. The light links on and off, a memory address is displayed, and the setting state is enabled.



Use the modify dial to select a memory address. Address 0 is read-only; values cannot be saved to that address.

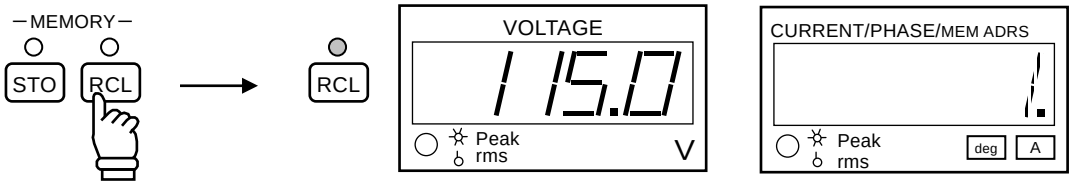



After setting the address, press the ENTER key.
After pressing the key, the state values are saved to the specified memory address, the light is turned off, and the setting state is disabled.

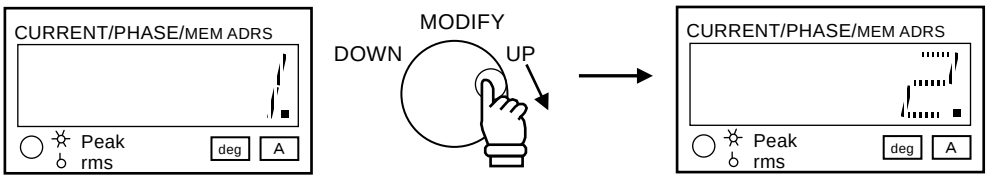



■ Operating procedure: Retrieve data from memory

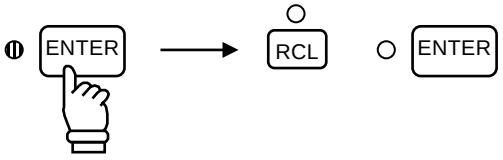
Press the RCL key. The light turns on, the memory address is displayed, and the setting state is enabled. At that time, the output voltage and frequency settings that are stored at that memory address are displayed and can be used as a reference for selecting the memory address.




Use the modify dial to select the memory address.




After setting the memory address, press the ENTER key. The light turns off, the values stored in that memory address are retrieved, and the setting state is disabled.



## 4.3.4 Memory store and default settings

Table 4-1 Memory store and default settings

| Setting description | | Can be saved to memory | Default setting (When retrieved from address 0) |
|---|---|---|---|
| Output mode (ES020ES, ES040ES and ES060ES) | | Yes | AC |
| Output voltage | | Yes | 0.0 V |
| Output voltage range | | Yes | 100 V range |
| Output frequency | | Yes | 50.00 Hz |
| Output on/off | | *1 | Off |
| Key lock | | No*2 | |
| Measuring functions | | | |
| Limit | Voltage upper limit | Yes | 300.0 V |
| | Frequency upper limit | | 1100.00 Hz |
| | Frequency lower limit | | 5.00 Hz |
| Line synchronization | | Yes | Off |
| Voltage QC (frequency unchanged) | QC enable mode | Yes | Disabled |
| | QC level A | | 0.0 V |
| | QC start phase | | 0 deg |
| | QC time | | 0.1 ms |
| Voltage sweep 1 (frequency variation) transition time | | Yes | 0.0 s |
| Precision/high-stability mode | | Yes | Precision mode |
| Remote-sensing AGC | | No*2 | |
| Auto-calibration (start) | | | |
| External input | | | |

*1 Even if the output on state is stored in memory address 1, the output is always set to off. when turning the power on. Also, if memory recall is performed for a Voltage sweep 1 (frequency variation) operation when any of the states listed below are different before and after data is retrieved from memory, “output off” is set, even if the output on state is stored in memory.

- The following settings are the same before and after memory recall.
  - ・ Output mode AC/DC
    ☞ Refer to 4.2.2 Switching between DC and AC output modes.
  - ・ Crest factor function enabled/disabled (if enabled, the criterion is whether the CF values are the same)
  - ・ Line synchronization on/off
    ☞ Refer to 4.3.2 Line synchronization.
  - ・ Output voltage range 100 V/200 V
    ☞ Refer to 4.2.3 Setting the output voltage and range.
  - ・ Precision/high-stability
    ☞ Refer to 4.5.1 Precision and high stability (setting the compensation mode).
- The QC enable mode is disabled before and after memory recall.
  ☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).

*2 The settings are not subject to memory store/recall. Use the switch operation for setting these states.

**⚠ CAUTION**

- When the setting for the function that is available from the optional ES4474A Remote Terminal has been saved to memory, the stored setting is not changed, even when used later after the remote terminal has been removed. For that reason, unexpected operation may result when the settings are retrieved from memory or a QC function is executed, etc. If the remote terminal is removed after use and then used again, you should restore the default states by “Address 0 recall”.

- When the settings have been restored to the default values by “Address 0 recall”, the settings will include the function that is available from the optional ES4474A Remote Terminal and operation from the interface only in addition to what is described in Table 4-1.
  However, settings that are related to communication with an external control device such as a GPIB address are not retrieved with the default settings.
  When using the functions described above, be sure to carefully read the ES4474A Remote Terminal Instruction Manual and Instruction Manual (interface).

# 4.4 Power fluctuation tests

When using the controller of this product for operation, it is possible to simulate power supply faults such as described below. When performing standard tests as specified by IEC, etc., use the corresponding peripheral devices and options.

| Subject | Description |
|---|---|
| Voltage QC (frequency unchanged) | The power supply voltage is instantaneously interrupted, decreased, or increased and then returned to the original voltage after a certain period of time. The frequency does not change. |
| Voltage sweep 1 (frequency variation) | The power supply voltage and frequency are changed instantaneously or over a certain period of time.<br>(Either the voltage and frequency change simultaneously or only one or the other changes.) |
| Voltage sweep 2 (frequency unchanged) | The power supply voltage changes instantaneously or over a certain period of time. The frequency does not change.<br>Alternatively, the above operations are repeated an arbitrary number of times |

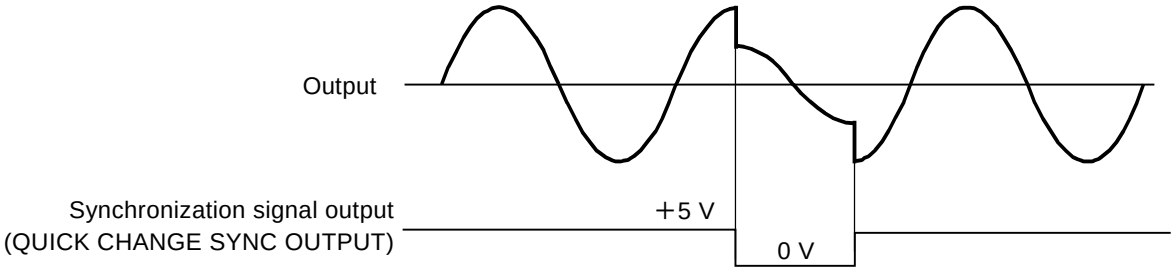
**⚠ CAUTION**

- An instantaneous change in power supply state is referred to as a quick-change (QC), and the terms “voltage QC” and “frequency QC” are used. A change that occurs over a certain period of time, on the other hand, is referred to as a “sweep”, and the terms “voltage sweep” and “frequency sweep” are used. This product uses a “linear sweep”, in which the change is linear with respect to time.
- For this product, the ES4474A Remote Terminal and the ES0406D Immunity Test Software are available as options for performing various types of power supply fault simulations other than those described above.

☞ Refer to 4.7.4 ES0406D Immunity Test Software.

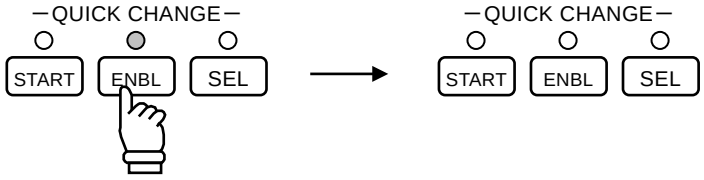
### 4.4.1 Voltage quick-change (frequency unchanged)

- The output voltage QC function instantaneously interrupts, decreases, or increases the voltage and then, after a certain period of time, returns the voltage to the value prior to the quick change. The phase at which the quick change begins can be set arbitrarily.
- To perform the test, set three values in advance: the QC voltage, the QC phase, and the QC time. After setting the values, switch to the QC enable mode and press the QC start key to execute the test. The output for when the test is executed is as shown below.



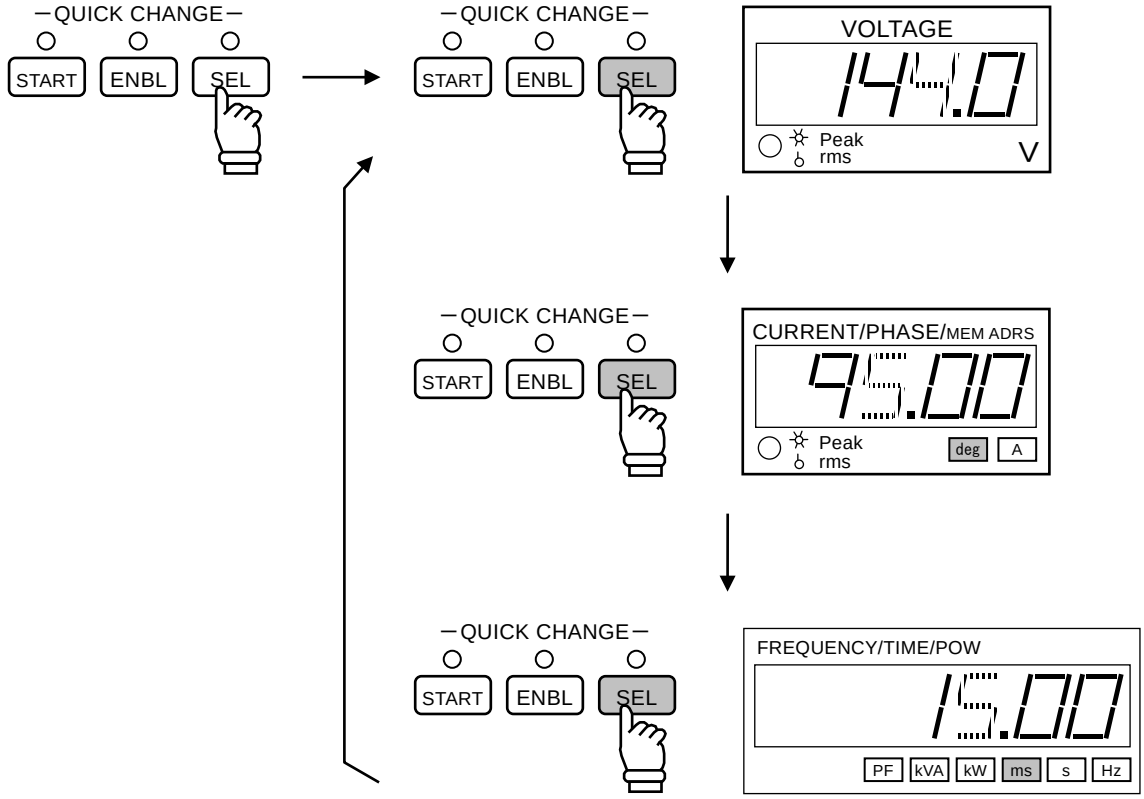

■ Operating procedure: parameter settings and preparation

Press the ENBL key. The light will turn off, the QC enable mode will be disabled, and the state in which the QC parameter values can be set will be enabled. Each time the ENBL key is pressed, the mode switches between enabled and disabled.

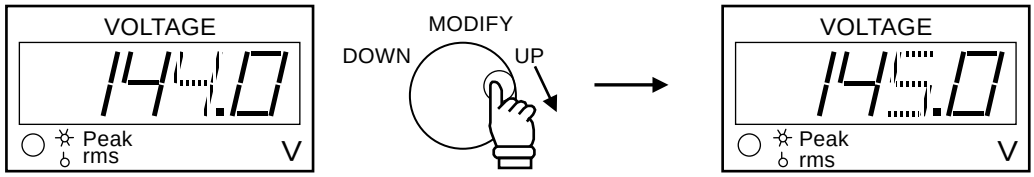



If you press the SEL key, the currently set values for the QC voltage, QC time, and QC phase will be displayed.

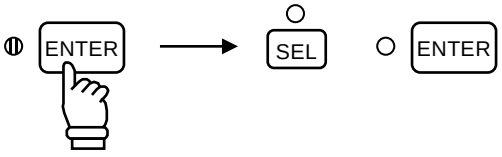
The cursor will appear in one of the values that is displayed. You can move the cursor by pressing the SEL key. Each time you press the key, the cursor will move from one value to the next in the order of "QC voltage (V) → QC phase (deg) → QC time (ms) → QC voltage → ..." so that the parameter setting values can be changed.




Change the parameter values by turning the modify dial. The cursor can be moved between digits by using the arrow keys ( ◀ ▶ ).

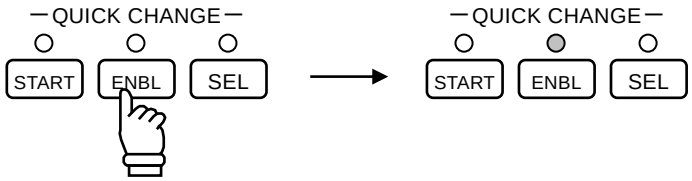



After changing the settings, press the ENTER key. The display returns to the base state before the SEL key was pressed and the setting operation is finished.
To check the values that have been set or to change other parameter values, press the SEL key again to enter the setting state.

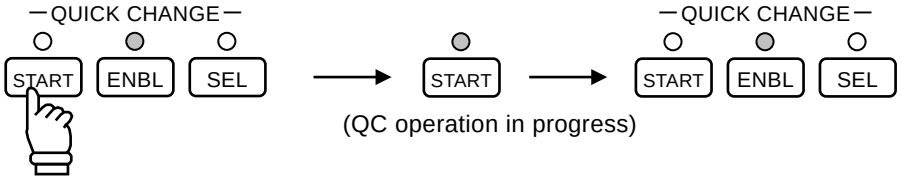


■ Operating procedure: performing the test

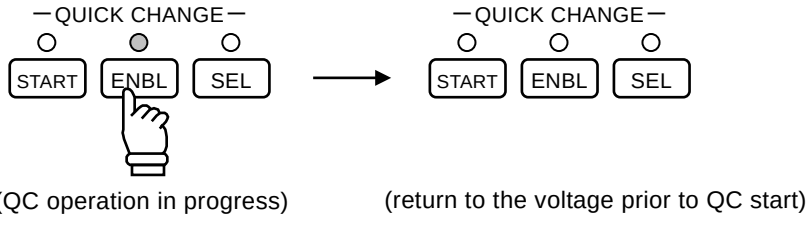
After setting the parameter values, press the ENBL to set the QC enable mode. The light is lit and the QC operation enable mode is set.




Press the START key. The QC operation begins according to the parameter values that have be set. During operation, the light is lit. When the operation is finished, the light turns off.
Also, a synchronization signal is output from the QUICK CHANGE OUTPUT terminal on the rear side. The signal can be used as a trigger signal for an oscilloscope, etc.

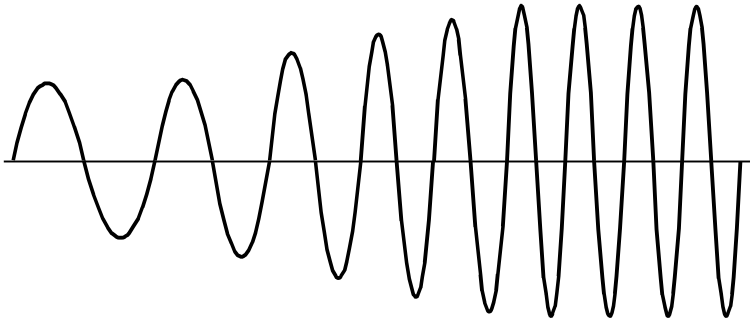



To forcibly stop a QC operation in progress and restore, press the ENBL key. The output is restored to the original voltage and the QC enable mode is forcefully disabled.
It is also possible to set the output to off by pressing the OFF/ON key, even when the operation is in progress.



## 4.4.2 Voltage sweep 1 (frequency variation)

- This function uses the memory function in the transition time setting to perform a "sweep" in which the output voltage and frequency are varied linearly over the time that has been set. If the transition time has been set to 0, the QC operation can also be performed.
  ☞ Refer to 4.3.3 Memory.
- The voltage and frequency can be varied independently or both can be varied simultaneously. An example of the output for when this function is executed is illustrated in the figure below.



**⚠ CAUTION**

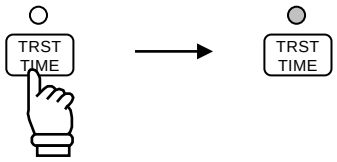
Differently from “voltage QC (frequency unchanged)”, it is also possible to vary the frequency, but the restoration operation (returning to the value before QC) is not available.

■ Operating procedure: parameter setting in preparation

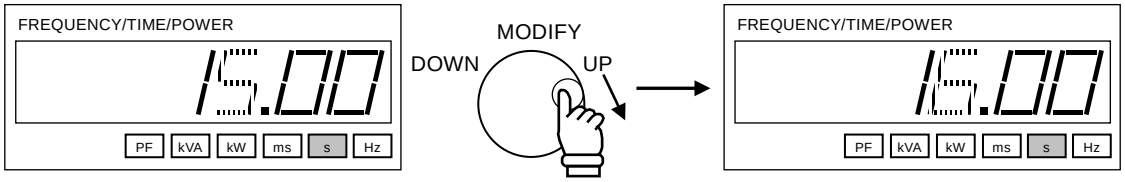
Set the output voltage and frequency to the “after change” state and save that state to any address in memory.

Refer to the section on setting the memory store. ☞ Refer to 4.3.3 Memory.

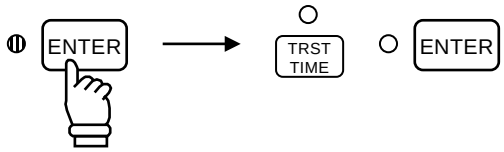
Press the TRST TIME key. The light is lit and the setting mode is enabled, and the transition time value is displayed.




Use the modify dial to change the transition time. To perform a QC operation, set the transition time to 0. To perform a sweep operation, set the transition time to the duration for the sweep.

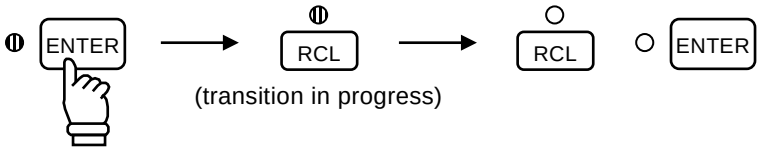


After setting the transition time, press the ENTER key. The light will turn off and the setting state will be disabled.




■ Operating procedure: performing the test

After setting the output voltage and frequency to the state before the change, recall the values from the memory address of the previous memory store operation.
The output change begins at the same time as the recall. Refer to the section on performing a memory recall. ☞ Refer to 4.3.3 Memory.




**⚠ CAUTION**

At the time of memory recall, the states before and after the recall are compared, and if the conditions are not satisfied, a QC operation is performed instead of the sweep operation. To perform a sweep operation, make the settings so that the conditions listed below are satisfied.

Sweep operation conditions

- The settings listed below are the same before and after memory recall.
  - ・Line synchronization on/off ☞ Refer to 4.3.2 Line synchronization.
  - ・Output voltage range 100 V/200 V
    ☞ Refer to 4.2.3 Setting the output voltage and range.
  - ・Output mode AC/DC
  - ・Crest factor function enabled/disabled
    (If enabled, the criterion is that the CF values are the same.)
  - ・Precision/high-stability
    ☞ Refer to 4.5.1 Precision and high stability (setting the compensation mode).
- The QC enable mode is disabled both before and after memory recall.
  ☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).

### 4.4.3 Voltage sweep 2 (frequency unchanged)

In addition to the voltage QC operation, in which the change is instantaneous, and the voltage sweep operation, in which the value is varied over time, it is also possible to perform QC and sweep operations that are repeated any number of times, etc. by adding parameters to the output voltage QC function and using the interface and the optional ES4474A Remote Terminal for operation. This function cannot be used by operation from the main unit alone. For more information on this function, refer to Instruction Manual (interface) and ES4474A Remote Terminal Instruction Manual.

## 4.5 Obtaining high-precision output

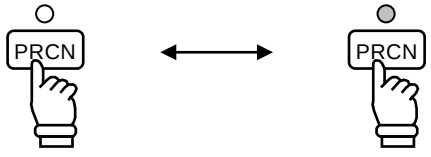
### 4.5.1 Precision and high stability (setting the compensation mode)

- This function switches between high and low sensitivity settings for maintaining the output voltage constant with respect to the load current and its fluctuation.
- When the sensitivity is set to high (precision mode), operation is in a high-precision mode where the output voltage changes by a small degree relative to a change in the load current, and although a peak current that is 3.5 times the rated current can be output, the output tends to become unstable for high capacitive loads.

  When the sensitivity is set to low (high-stability mode), on the other hand, the change in output voltage is somewhat higher, but there is an overwhelming increase in stability with respect to capacitive loads.

■ Operating procedure

Press the PRCN key to toggle between modes. In the precision mode, the light is lit; in the high-stability mode, the light is not lit.




High-stability mode　　Precision mode

**⚠ CAUTION**

- Concerning stability for capacitive loads:
  The upper limit of capacitive load for stable operation in the precision mode is about 20 μF, but operation is stable up to about 1000 μF in the high-stability mode. However, overcurrent or overload may occur, depending on the output voltage and frequency settings.
- In the DC output mode, the setting is fixed in the high-stability mode, which is stable for capacitive loads.

## 4.5.2 Remote-sensing AGC (AC output mode)

- The “Remote-sensing AGC” function senses the output voltage at an arbitrary location away from the main unit (remote-sensing) and performs a control to keep that voltage constant (AGC).

  It is thus possible to eliminate the voltage drop that occurs in the output cable, etc. and stabilize the voltage at both ends of the load.
- There are terminals for connection and a switch located in the rear signal panel for wiring to the sensing point and switching the function states. The connections and switching are done with the power turned off.
- The AGC is effective for when the output voltage of the output terminals of this product is in the range from 50 V to 300 V.
- For output voltage QC, the waveform is clipped.
- For the resistance component R and the capacitance component C of the load, including the output cable, RC ≦ 1500 (μF·Ω) (C≦1000 μF, high-stability mode) .

**⚠ WARNING**

The voltage at the connection terminals is the same as the output.
For safety, make the connections when the power is turned off.

**⚠ CAUTION**

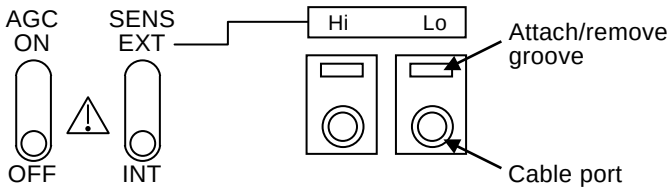
- Use stranded wire with a cross-section of from 0.3 to 1.25 mm² to make a secure connection between the connection terminals and the output sensing point. If a disconnection or interruption occurs in the remote sensing AGC mode, there may be an overvoltage in the output that can damage the load.

  In that case, an overload state occurs and the overvoltage is returned to a level near the normal voltage. However, the overload state remains until the cause of the abnormality is eliminated in the output is turned off. ☞ Refer to 4.2.8 Protection function.
- When making the connection, make sure the polarity between the connection terminals and the output sensing point is correct.

■ Operating procedure: Performing the test

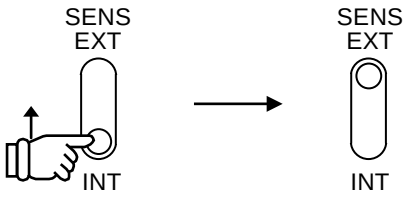
Connect the sensing cable to the SENS terminals. Make the connections so that the Hi/Lo display of the SENS terminals is the same as the display of the output terminals.

For safety be sure to make the connections when the power is turned off.

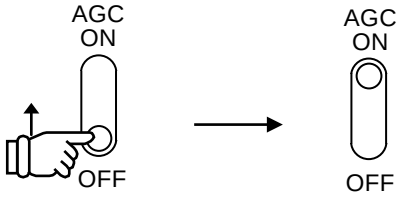



Strip the insulation from the sensing cable, use a straight screwdriver to press in the attach/detach groove, and insert the cable into the cable port.

Set the SENS INT/EXT switch to EXT.
When not using the remote sensing AGC function, keep the switch set to INT.
For safety, be sure to set the switch when the power is turned off.




Set the AGC ON/OFF switch. When not using the remote sensing AGC function, keep the switch set to OFF. For safety, be sure to set the switch when the power is turned off.




Turn the power on and check that the output is being correctly controlled.

## ■ Set the AGC switch and the SENS (sensing) switch

The AGC function maintains high voltage stability by sensing the average of the absolute value of the output voltage and controlling it to compensate fluctuations in the load, etc.
Generally, this function is used to compensate the voltage drop in the output cable by sensing the voltage on the load side. (The function implemented by this product is referred to as “remote-sensing AGC”.)

The sensing switch is used to switch the voltage sensing point for the AGC function in the measurement functions described above from internal to external. When the switch is set to external and the sensing cable is connected to an external sensing point, the remote sensing function is enabled. This function can thus be used only for the measurement point, without using AGC.
These two functions can be combined to select operation as shown in the table below.

| Sensing | Measurement display | AGC | |
|---|---|---|---|
| | | Off | On |
| Internal | Display the voltage at the internal sensing point | AGC does not operate (factory setting) | AGC operation with internal sensing |
| External (remote-sensing) | Display the voltage at the external sensing point | AGC does not operate | AGC operation with external sensing |

*Refer to the the explanation of terms while reading this.

☞ Refer to 8.1 Explanation of terms.

## 4.5.3 Auto-calibration (output voltage adjustment function)

This function adjusts the difference between the set value for the output voltage and the measured value to match the measured value. Adjustment by the amount of decrease in load regulation due to the voltage drop in the output cable and the load connection is possible.

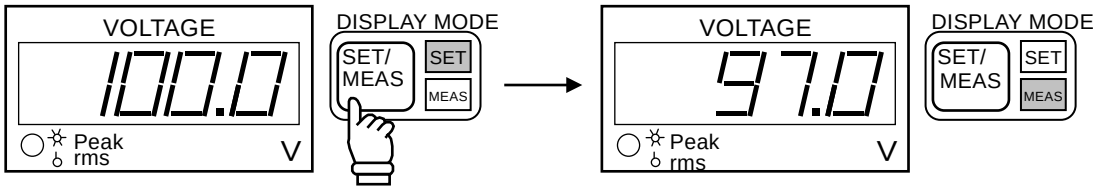
■ Operating procedure

Set the output voltage to the specified value.

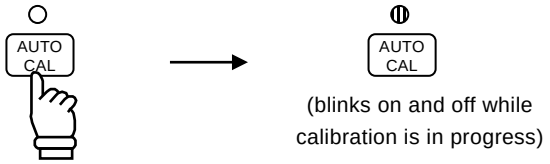
☞ Refer to 4.2.3 Setting the output voltage and range.

Assume that the displayed measurement value is a few percent less than the set value when the output is connected to the load and turned on.

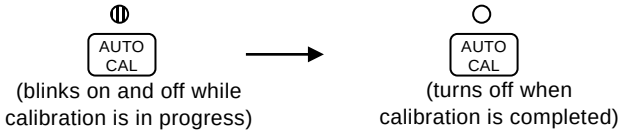
☞ Refer to 4.2.5 Switching output on and off and 4.2.7 Measurement function.




Press the AUTO CAL key. The light turns on and the adjustment operation begins.
The set voltage value and the measured value are compared, and a calibration coefficient that makes the measured value the same as the set value is obtained.




The calibration coefficient is determined, the operation to make the setting value and the measured value consistent is completed, and the light is turned off. The coefficient value is stored internally in memory that has battery backup. That value is not changed until the key is pressed again.




* To disable auto-calibration (adjustment is not performed), set the output voltage to 0 V and in the output off state, press the AUTO CAL key. The buzzer sounds and the calibration function is disabled.

### ⚠ CAUTION

- The adjustment range at the time the AUTO CAL key is pressed is ±10 % or less of the set value. If the difference between the set value and the measured value is excessive or if the calibration operation cannot be completed within a certain period of time, the operation ends with the calibration coefficient set to the default value (no calibration). (A buzzer sounds one time when the operation ends.) That tends to occur when the output voltage is relatively low (20 V or less).
- This function cannot be performed in the QC enable mode. Disable the QC enable mode and try again. ☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).

# 4.6 Using external signals

Concerning the added input, amplitude modulation input, or status output signal, refer to Instruction Manual (interface).

## 4.6.1 External input

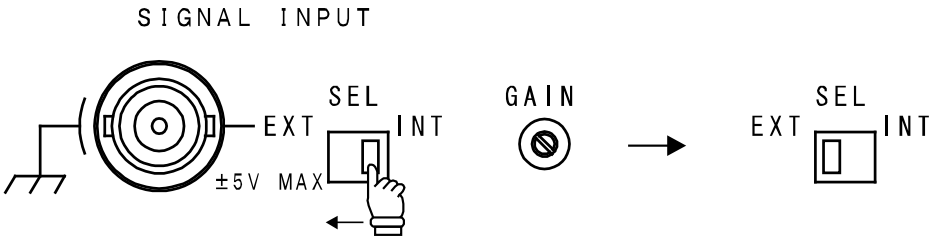
- An external signal can be input via the terminals in the rear signal panel and used as an amplifier (gain = × 100).
  The input impedance is 100 kΩ (unbalanced) and the input frequency range is from 5 Hz to 1000 Hz.
- Set the maximum voltage for output before using this function.
- Some functions cannot be used in the external signal input mode. Also, all values that are saved to memory before setting this mode are reset.

**⚠ CAUTION**

To prevent malfunction of this product or the load by incorrect operation, read this section carefully before setting this mode.

■ Operating procedure: Rear signal panel switch settings

With the power turned off, first set the SIGNAL INPUT SEL switch in the rear signal panel to EXT. When the power is turned on, the state of the switch is detected and this product operates in the external input mode. All values that are stored in memory are reset. The voltage and frequency are not displayed on the control unit.

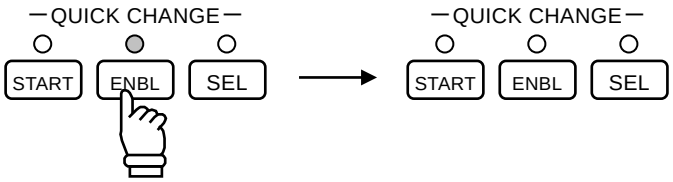


■ Operating procedure: Maximum output voltage setting

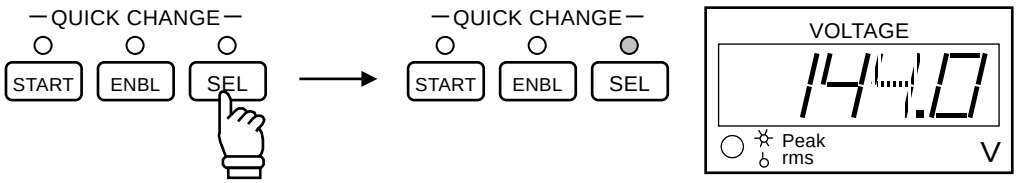
Before inputting a signal, set the maximum voltage that can be output. Set the value for each output voltage range. ☞ Refer to 4.2.3 Setting the output voltage and range.

Limit values cannot be set in the external input mode. Be sure to make this setting.
☞ Refer to 4.3.1 Setting limit values.

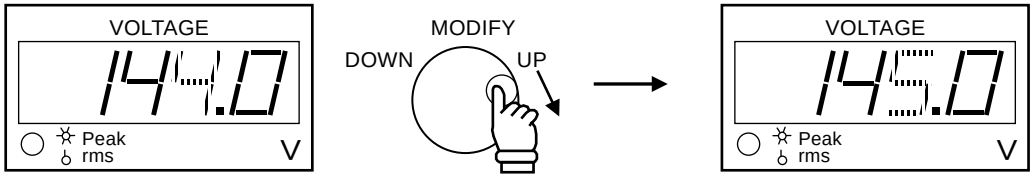
Press the ENBL so that the light turns off. Each time the ENBL key is pressed, the light toggles on or off.



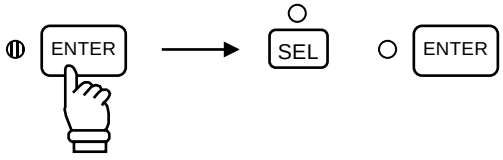

If you press the SEL, the current setting value for the maximum voltage that can be output is displayed. The voltage is displayed as the effective value of the sine wave, so the peak value is the displayed value multiplied by $\sqrt{2}$.



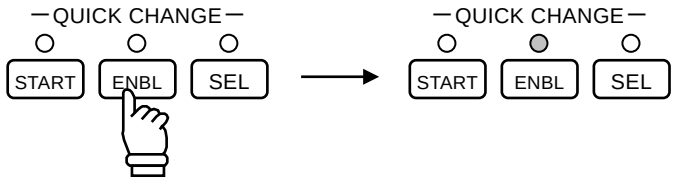

Turn the modify dial to change the parameter value. Use the arrow keys ( ◀ ▶ ) to move the cursor.




After changing the parameter, press the ENTER key. The display returns to the state before the SEL key was pressed and the setting operation is completed.
To check the set values, press the SEL key again to return to the setting mode.



After completing the parameter setting, press the ENBL key. The light turns on and the previously set voltage is the voltage that can be output.




■ Operating procedure: signal input

The operations and settings done up to now complete the preparation for external input. Connect the signal source and input the signal.

The amplifier gain factor is 100. The gain can be varied by about ±3 % by turning the GAIN adjuster, but the adjustment affects the internal signal as well as the external signal, so adjust the gain for the internal signal after returning to the normal mode.

☞ Refer to 6.3 Gain adjustment.

Please note that if a signal causing the output to exceed the maximum output voltage is input, the voltage is clipped at the set voltage multiplied by $\sqrt{2}$ , resulting in waveform distortion.

To disable the external output mode, turn the power off and then set the SIGNAL INPUT SEL switch to INT. When the power is turned on again, the switch status is detected and the equipment operates in normal mode. All values that were saved to memory in the external signal input mode are reset.

## ⚠ CAUTION

- To prevent clipping of the output voltage, use input voltages of ±4.24 V or less. To avoid internal malfunction this product, do not use an input voltage that exceeds ±5 V.
- Please note that when operation is switched between external input mode and normal mode, memory content will be the default settings and all saved data will be reset.
  ☞ Refer to 4.3.3 Memory and 4.3.4 Memory store and default settings.
- The functions and operations listed below can be used in normal mode but cannot be used in external input mode.
  - Output voltage setting (However, the output voltage range can be set.)
    ☞ Refer to 4.2.3 Setting the output voltage and range.
  - Output frequency setting ☞ Refer to 4.2.4 Setting the output frequency.
  - Limit setting ☞ Refer to 4.3.1 Setting limit values.
  - Power fluctuation tests ☞ Refer to 4.4 Power fluctuation tests.
  - Auto-calibration (output voltage adjustment function)
    ☞ Refer to 4.5.3 Auto-calibration (output voltage adjustment function).
  - Line synchronization ☞ Refer to 4.3.2 Line synchronization.
  - Memory ☞ Refer to 4.3.3 Memory.
- In normal mode (when external input is not being used), make sure that the switch is set to INT.
  When the power is on, the operation mode is not changed, even if the switch position is changed. To switch modes, the power must be turned off before changing the switch setting.
  The external conductor of the input signal connector is connected to the enclosure of this product, but it is isolated from the output.
  The output of this product operates so as to suppress the DC component. When a DC signal is input, operation is not normal. Do not input a signal that has a DC component.
  The GAIN setting affects the internal signal as well as the external input signal. After returning operation to the normal mode, adjust the gain for the internal signal before use.
  ☞ Refer to 6.3 Gain adjustment.

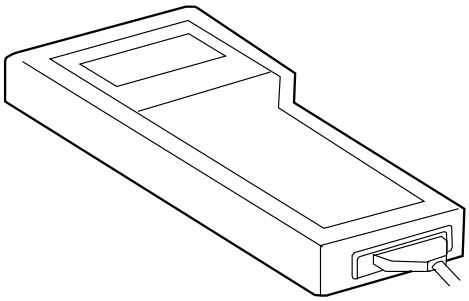
# 4.7 Peripheral devices and options

The peripheral devices and products described below are provided as options. Use them as is appropriate for your purpose.

## 4.7.1 ES4474A Remote Terminal

The remote controller is a handheld device that can be detached from the main unit to perform operations. It can be used to perform extended power fluctuation test functions as well as the functions provided by the main unit. ☞ Refer to 4.4 Power fluctuation tests.

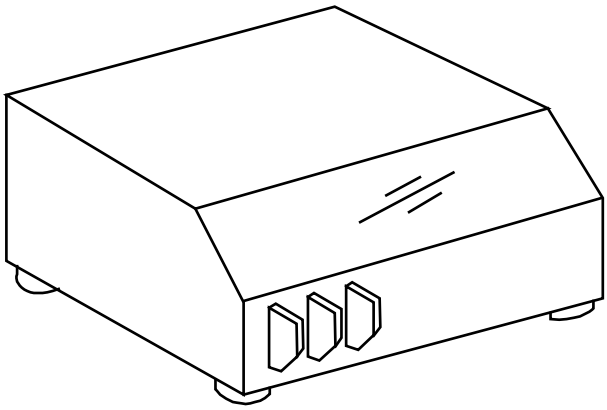
This device is connected via the RS-232 connector on the interface panel, so it cannot be used at the same time as external control via the RS-232 interface.



## 4.7.2 4481 Power Inlet Unit

This unit makes it possible for multiple constituent units to receive input power together. Up to three units can be connected.

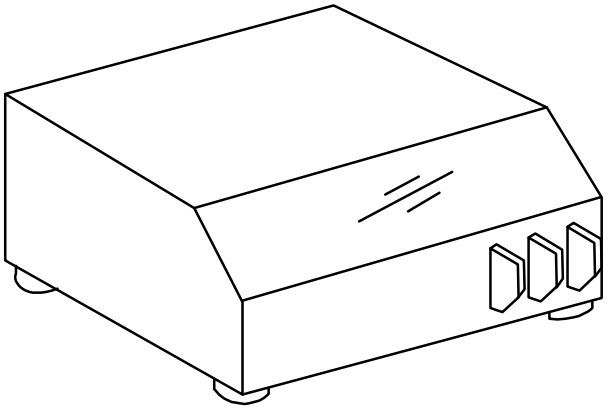
It can be used with the ES040ES and ES060ES.



## 4.7.3 4482 Outlet Unit

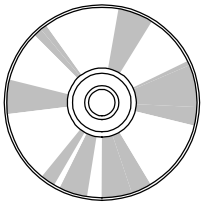
This unit makes it possible to connect the outputs from multiple constituent units in parallel and supply power from a single terminal block. Up to three units can be connected.

It can be used with the ES040ES and ES060ES.



## 4.7.4 ES0406D Immunity Test Software

This software can be used to perform various types of low-frequency immunity testing (power environment simulation) in addition to the power fluctuation test function that is provided by this equipment.



(ES0406D Immunity Test Software)

Table 4-2 Standard tests that can be performed

| Standard | Test |
|---|---|
| IEC 61000-4-11 (2004) | Voltage dip, short power outage, and voltage fluctuation tests *1 |
| IEC 61000-4-13 (2002) +A1 (2009) +A2 (2015) | Combined harmonic tests (flat curve) |
| | Combined harmonic tests (over swing) |
| | Frequency sweep tests*2 |
| | Individual harmonic tests*2 |
| | Inter-harmonic tests*2 |
| | Meister curve tests*2 |
| IEC 61000-4-14 (1999) +A1 (2001) +A2 (2009) | Voltage fluctuation immunity tests |
| IEC 61000-4-27 (2000) +A1 (2009) | Unbalanced immunity tests*3 |
| IEC 61000-4-28 (1999) +A1 (2001) +A2 (2009) | Power frequency fluctuation immunity tests |
| IEC 61000-4-29 (2000) | DC voltage dip, short power outage, and voltage fluctuation tests*4 |
| IEC 61000-4-34 (2005) +A1 (2009) | Voltage dip, short power outage, and voltage fluctuation tests for power equipment in which the input current exceeds 16 A per phase*5 |
| Nonstandard | Voltage QC (phase variable) tests |
| | Single-phase 3-wire and three-phase phase imbalance tests |
| | Arbitrary wave testing |

*1: If a test is conducted only with ES-E, it is conducted as a preliminary test because the rise time of the voltage does not satisfy the requirements of the specified test power supply (1 µs to 5 µs). To satisfy the requirements, NF's As-537 or As-517A Voltage Dip Simulator is necessary in addition to ES-E.

*2: In addition to ES-E, NF's Multifunction Generator WF 1948 / WF 1974 or Multifunction Synthesizer WF1946A or WF1946B (hereinafter referred to WF1946A/B) is required as an external signal source.

*3: If a test is conducted only with ES-E, it is conducted as a preliminary test because the rise time of the voltage does not satisfy the requirements of the specified test power supply (1 µs to 5 µs).

*4: This test can be done only if the system configuration of ES-E is single-phase two-wire. If the configuration is single-phase three-wire or three-phase, this test cannot be executed. In voltage dip and short interruption, the voltage rise time does not satisfy the requirement of the standards (1 µs to 50 µs). For short interruption, only low impedance can be tested. Use it as a preliminary test.

*5: If a test is conducted only with ES-E, it is conducted as a preliminary test because the rise time of the voltage does not satisfy the requirements of the specified test power supply (1 µs to 5 µs). To satisfy the requirements, NF's Voltage Dip Simulator (custom-made) is necessary in addition to ES-E.

# 5. Specifications

Unless stated otherwise, these specifications apply under the conditions listed below.

Power supply voltage: 200 V, 48 Hz to 62 Hz
Load: rated load (pure resistive load for obtaining the rated power at the rated output voltage)
Output voltage: voltage at the single-phase master output terminals
Output frequency: 48 Hz to 62 Hz
AGC: off
Remote-sensing: internal
Warm-up time: 1 hour

In the specifications, [set] indicates the setting value, [rdg] indicates a reading value, and [FS] indicates a full-scale value.

Numerical values that have accuracy indicated are guaranteed values in the specifications. However, accuracies marked as reference values indicate supplementary data for reference when using this product and are not guaranteed values. Values that do not have accuracy indicated are nominal values or typical values (marked as “typ.”).

# 5.1 AC output

Single-phase output package models

Use for configurations of 1 ES2000ES unit and from 0 to 2 ES2000EB units.

| Package model | | ES020ES | ES040ES | ES060ES |
|---|---|---|---|---|
| Constituent unit | ES2000ES single-phase master | 1 | 1 | 1 |
| | ES2000EB booster | 0 | 1 | 2 |
| Form | | Single-phase two-wire, floating output, the Lo terminal can be grounded | | |
| Rated output power *1, *2, *4 | | 2 kVA | 2 kVA×2 (4 kVA) | 2 kVA×3 (6 kVA) |
| Maximum output current *1, *2, *4 | 100 V range | 20 Arms | 20 Arms×2 (40 Arms) | 20 Arms×3 (60 Arms) |
| | 200 V range | 10 Arms | 10 Arms×2 (20 Arms) | 10 Arms×3 (30 Arms) |

| Constituent unit | | ES2000ES | ES2000EB |
|---|---|---|---|
| Rated output power*1, *2, *4 | | 2 kVA | |
| Terminals | | Screw-type (clamp) terminal block | |
| Output waveform | | Sine wave | |
| Rated output voltage | 100 V range | 100 Vrms | |
| | 200 V range | 200 Vrms | |
| Output voltage setting range | 100 V range | 0 to 150 Vrms | — |
| | 200 V range | 0 to 300 Vrms | — |
| Output voltage setting resolution | | 0.1 Vrms | — |
| Output voltage setting accuracy (reference value) *3 | | ± (0.3 % set + 0.6 V) | |
| Maximum output current *1, *2, *4 | 100 V range | 20 Arms | |
| | 200 V range | 10 Arms | |
| Maximum output current *5 (peak value, reference value) | Precision mode | Effective value × 3.5 | |
| | High-stability mode | Effective value × 2.7 | |
| Reverse flow (reference value) *10 | | 30 % of the maximum output current (effective) | |
| Output frequency | Setting range | 5 Hz to 1100 Hz | |
| | Setting resolution | 0.01 Hz | |
| | Setting accuracy | $\pm 1 \times 10^{-4}$ or less | |
| | Stability | $\pm 5 \times 10^{-5}$ or less | |
| | Power supply frequency synchronization | Possible (in the range from 48 Hz to 62 Hz) | |
| Load regulation *6 | Precision mode | ±0.5 % or less | |
| | High-stability mode | ±1.0 % or less | |
| Line regulation *7 | | ±0.2 % or less | |
| Output voltage stability *8 | | ±100 ppm/°C (typ.), ±100 ppm/8 h (typ.) | |
| Load power factor range *4 | | 0 to 1 (lead and lag) | |
| Frequency characteristic | | ±1 dB or less (40 Hz to 1 kHz, rated output voltage) | |
| Output voltage distortion | | 0.5 % or less (rated output voltage)<br>0.3 % or less (40 Hz to 100 Hz, rated output voltage, typ.) | |
| Output noise level *9 | | 300 mVrms or less | |
| Output DC offset voltage | | ±15 mV or less | |

*1: The output current decreases above the rated output voltage (Figure 5-1).

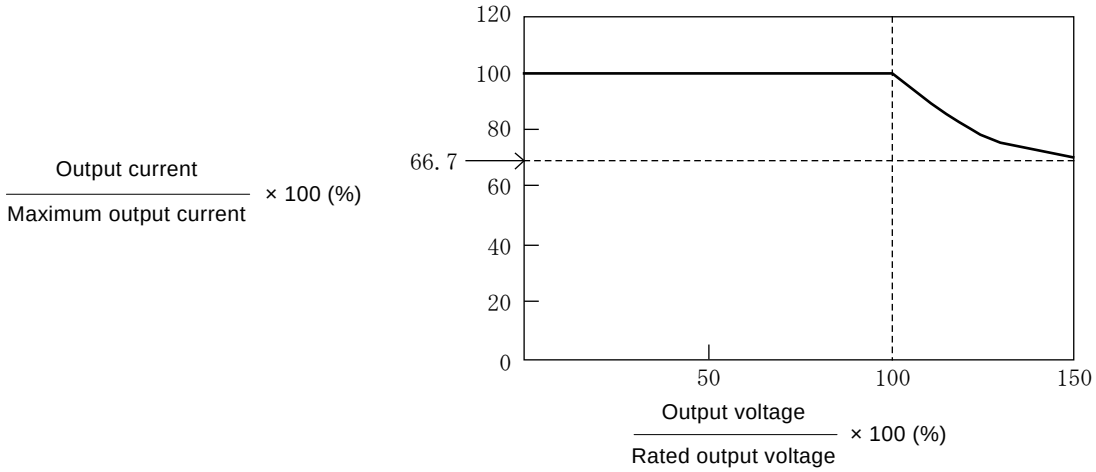



Figure 5-1 Output voltage vs. output current characteristic

*2: The output current decreases with the output frequency (Figure 5-2).

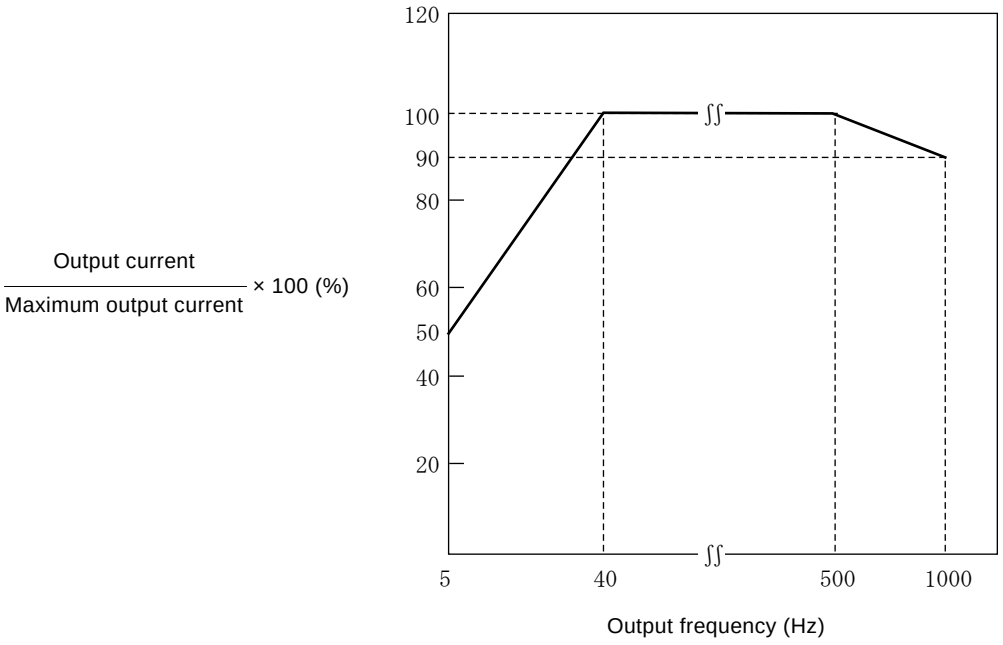



Figure 5-2 Output frequency vs. output current characteristic

*3: Output frequency of 50 Hz/60 Hz, no load, as shipped from factory, high-stability mode, gain adjustment function available

*4: Load power factor

The minimum load power factor (PFr) for which the maximum output current can be supplied is obtained from the output voltage Vo and the output frequency fo by using the following equation.

$$PFr = 7Vo\ (fo-5) \times 10^{-7} + 0.75$$

The relationship between PFr and the output frequency for when the output voltage is Vo = 300 Vrms and 200 Vrms (200 V range) and Vo = 150 Vrms and 100 Vrms (100 V range) is shown in Figure 5-3.

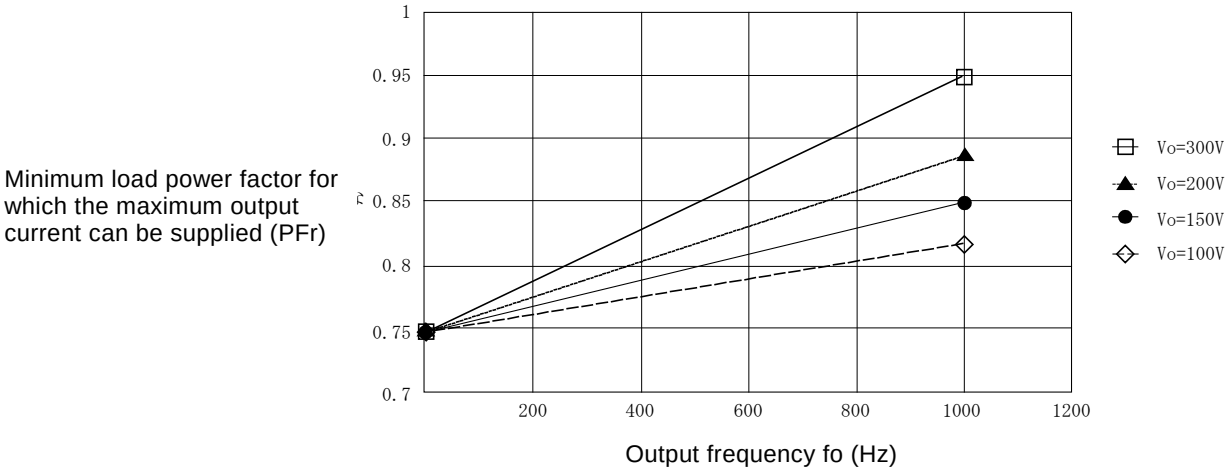



Figure 5-3 Frequency vs. minimum load power factor for which the maximum output current can be provided

If the load power factor (PF) is smaller than PFr, the output current that can be supplied decreases with respect to the maximum output current as described below.

Output current / maximum output current = 93.3 (PF – PFr) +100 (%)
when output current ≦ rated value

The decrease in output current that can be supplied with respect to the maximum output current for when the values of PFr are 0.95, 0.85, and 0.75 is shown in Figure 5-4.

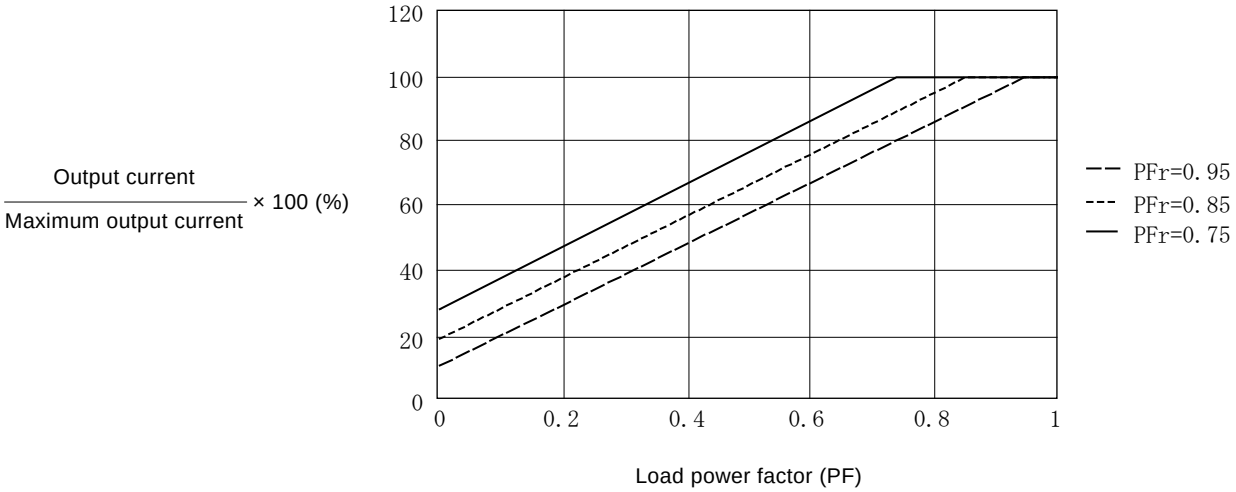



Figure 5-4 Load power factor vs. output current

The capacitance that can be connected is limited to 1000 μF or less in the high-stability mode and to 20 μF or less in the precision mode.

The output current value is obtained by multiplying by the decrease due to the output voltage, frequency, and load power factor.

*5: 45 Hz to 70 Hz; the ratio to the effective value at the peak value of the current applied to a capacitance input type rectifier load

*6: With respect to a change in load from 0 % to 100 % at the rated output voltage; for the range from 45 Hz to 100 Hz; at the voltage of the main output terminals

*7: At the rated output voltage, for a change in power supply voltage from 170 V to 250 V

*8: Rated output voltage, no load

*9: Output voltage set to 0 V, frequency band of from 20 Hz to 100 kHz

*10: 100 V range, at the rated output voltage

# 5.2 DC output

Switching between the AC output mode and DC output mode is possible when the output is off.

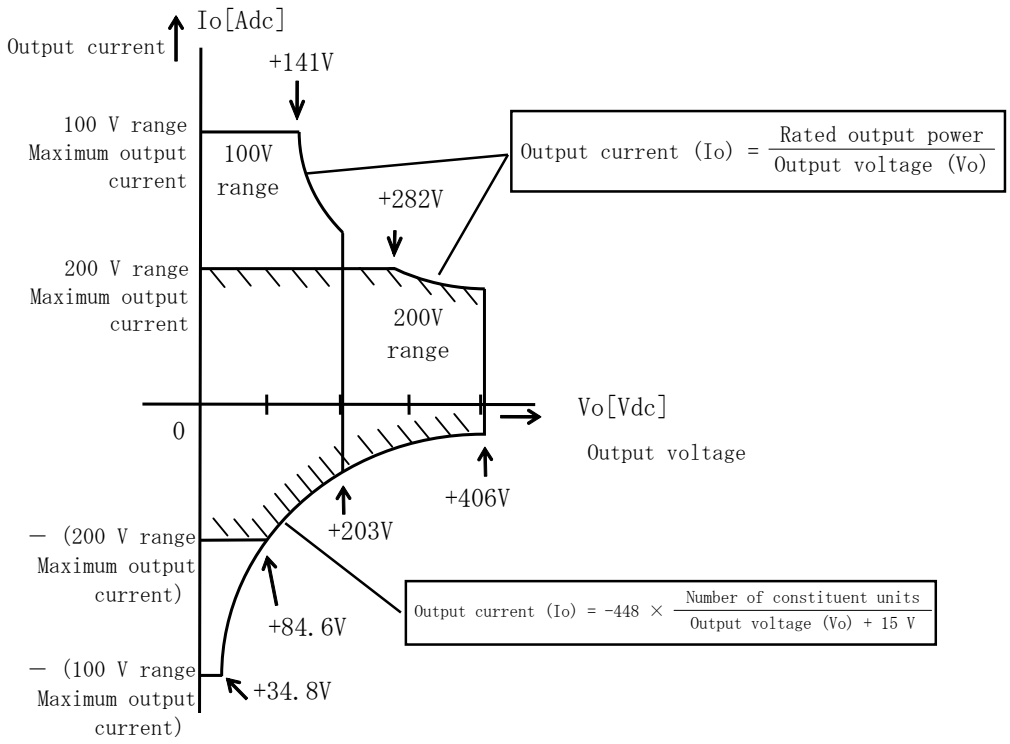
Use for configurations of 1 ES2000ES unit and from 0 to 2 ES2000EB units.

| Package model | | ES020ES | ES040ES | ES060ES |
|---|---|---|---|---|
| Constituent unit | ES2000ES single-phase master | 1 | 1 | 1 |
| | ES2000EB booster | 0 | 1 | 2 |
| Form | | Voltage unipolar output, Hi (+) Lo (–), floating output, the Lo terminal can be grounded | | |
| Rated output power | | 1.27 kW | 1.27 kW×2 (2.54 kW) | 1.27 kW×3 (3.81 kW) |
| Maximum output current (DC) *12 | 100 V range | +9 A | +9 A×2 (+18 A) | +9 A×3 (+27 A) |
| | 200 V range | +4.5 A | +4.5 A×2 (+9 A) | +4.5 A×3 (+13.5 A) |

| Constituent unit | | ES2000ES, ES2000EB |
|---|---|---|
| Rated output power | | 1.27 kW |
| Rated output voltage | 100 V range | +141 V |
| | 200 V range | +282 V |
| Output voltage setting range | 100 V range | 0 V to +203.0 V |
| | 200 V range | 0 V to +406.0 V |
| Voltage setting resolution | | 0.1 V |
| The voltage setting accuracy (reference value) *11 | | ± (0.5 % set +0.6 V) |
| Maximum output current (DC) *12 | 100 V range | +9 A |
| | 200 V range | +4.5 A |
| Output voltage stability *8 | | ±500 ppm/°C (typ.), ±500 ppm/8h (typ.) |
| Output offset voltage | | ±500 mV or less (adjustable) |

*11: No load, as shipped from factory, high-stability mode, gain adjustment function available

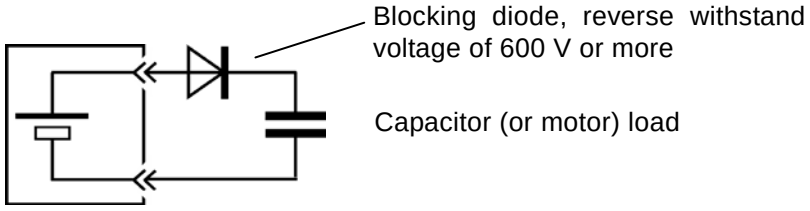
*12: The maximum output current is reduced by the output voltage as shown below.




Output voltage in DC output mode vs. output current characteristic

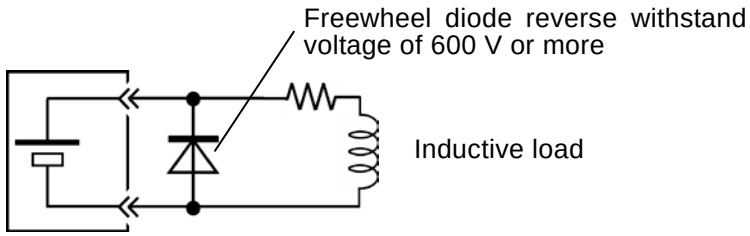
**Cautions concerning DC output**

- Negative-side voltage cannot be output.
- The only operating mode is the high-stability mode, which is stable for capacitive loads.
- Protected operation in the DC output mode
  If there is a voltage drop with the output connected to a capacitor, an injected current will be applied in this product, so protection is provided against a current smaller than the maximum output current described above. In that case, the action of the protection circuit may turn the output off.
  Also, when the output is turned on or off, the output voltage is temporarily switched to 0 V to protect the contacts of the output relay. For that reason, if the output is turned on with a capacitor connected to the output, current to the capacitor may trigger the protective circuit and the output may be turned off.
- Connecting a capacitive load
  When the load is a capacitor (150 μF or more) or a motor, connect a blocking diode to prevent reverse injection of current.




(ES-E main unit)

- Connecting an inductive load
  When the load is an inductor, connect a freewheel diode to absorb the kickback voltage that occurs when the output is turned off.




(ES-E main unit)

# 5.3 Measurement functions

| | Measurement range (FS) | Resolution | AC mode accuracy | DC mode accuracy | Conditions |
|---|---|---|---|---|---|
| Voltmeter (effective value) | 480 V | 0.1 V | ±1 % FS or less | ±3 % FS or less | DC, 40 Hz to 1 kHz<br>10 % FS to 100 % FS<br>Including non-sine waves |
| Ammeter (effective value) | 80 A | 0.01 A | | | |
| | 800 A | 0.1 A | | | |
| Voltmeter (peak) | 480 V | 0.1 V | ±3 % FS or less | ±3 % FS or less | DC, 40 Hz to 1 kHz<br>10 % FS to 100 % FS<br>Sine wave |
| Ammeter (peak) | 80 A | 0.01 A | | | |
| | 800 A | 0.1 A | | | |
| Active power meter | 2 kW | 0.1 W | ± (1.5 % rdg + 0.2 % FS) or less (for power factor of 1) | (No measurement) | 45 Hz to 65 Hz sine wave<br>Voltage of 50 Vrms or higher<br>10 % or more of rated current |
| | 20 kW | 1 W | | | |
| | 200 kW | 10 W | | | |
| Apparent power and power factor | Calculated from the measured voltage, current, and active power values and displayed | | | | |

- The measurement ranges for ammeter (effective value) and ammeter (peak value) are switched automatically according to the peak value.
- For the peak values, the waveforms are detected on the negative side in the AC output mode and on the positive side for the DC output mode for both voltage and current. (The reference is the output Lo terminal.)
- The active power can only be measured in the AC output mode.
- The active power measurement range switches automatically according to the peak current value.

| Power measurement range | 2 kW | | 20 kW | | 200 kW | | |
|---|---|---|---|---|---|---|---|
| Peak current value | 0 A | to | 7.3 A | to | 77 A | to | 800 A |

- For the power value in the DC output mode, the value calculated from the voltage and current effective values is displayed in the apparent power VA display.

# 5.4 AGC and remote-sensing (AC output mode)

The operations described in the table shown below are possible with the AGC function and sensing switching function.

In the DC output mode, the AGC function is not available, regardless of the switch setting.

■ AGC function

This function is for improving the output voltage fluctuation. The voltage fluctuation is improved at the sensing point.

■ Remote-sensing AGC [Settings AGC: on, Sensing: external]

The voltage drop in the output cable can be compensated by switching the AGC sensing point to external and detecting the voltage at the load terminals.

■ Switching the sensing point

The AGC sensing point is also the voltage measurement point for the measurement function. It can be switched as described in the following table.

| Sensing | Measurement display | AGC | |
|---|---|---|---|
| | | Off | On |
| Internal | The voltage at the internal detection point is displayed. | AGC does not operate (factory setting) | AGC operation with internal sensing |
| External (remote-sensing) | The voltage at the external detection point is displayed. | AGC does not operate | AGC operation with external sensing (remote sensing AGC) |

■ Output rating for when remote-sensing AGC is used

| | Rating | Conditions | |
|---|---|---|---|
| Load regulation | ±0.2 % or less | 5 Hz to 400 Hz | At the sensing input terminals |
| | ±0.3 % or less | 400 Hz to 1 kHz | |
| Frequency characteristic | ±0.05 dB or less | 40 Hz to 1 kHz | At the sensing input terminals, with no load |
| Voltage distortion | 0.5 % or less | 40 Hz to 1 kHz | For the rated voltage at the output terminals |
| | 1 % or less | 5 Hz to 40 Hz | |
| Response time | 50 ms or less | Output voltage is 100 V | |
| | 25 ms or less | Output voltage is 200 V | |
| Output cable voltage drop compensation range | Less than 5 % of the voltage or 10 V, whichever is less | | |

- The output cable resistance R and the load capacitance C are such that RC $\leqq$ 1500 μF·Ω.
  (Where C $\leqq$ 1000 μF in the high-stability mode)
- The output voltage is in the range from 50 V to 300 V. The load is a pure resistance.
- When output is changed quickly, the waveform is clipped.

## 5.5 Auto calibration (AC output voltage adjustment function)

This function adjusts the AC output voltage so that the output voltage measured by the measuring function (sensing point voltage) is equal to the setting value for the AC output voltage.

| | |
|---|---|
| Range | ±10 % or less (error between the measured value and the setting value) |
| Accuracy | ±1 % FS or less (40 Hz to 1 kHz at 50 V or higher) |

## 5.6 Memory function

It is possible to save up to 120 sets of control section settings other than for the measurement function in memory (memory addresses 1 to 120). The settings stored in memory address 1 are retrieved and set when the power is turned on.
However, the GPIB and RS-232 parameters are not stored in that memory; they are saved separately.

## 5.7 Setting limit values

It is possible to set upper and lower limits for the output frequency and to set an upper limit for the output voltage. The setting ranges and resolutions are the same as for the ordinary frequency and voltage settings.

## 5.8 Key lock

Setting the key lock switch makes it possible to disable all operations from the control panel.

## 5.9 Power fluctuation tests

Power fluctuation tests can be performed using the voltage quick change (frequency unchanged), voltage sweep 1 (frequency variation), and voltage sweep 2 (frequency unchanged) functions. The voltage sweep 2 function can be used only via the interface. Quick Change is abbreviated as QC in this document.

☞ Refer to 5.12 Interface.

■ Voltage Quick Change (frequency unchanged) function

Parameters that can be set or controlled

$V_{STR}$: start level　　$T_{Q1}$: QC time

$V_A$: QC level A　　$\theta$: QC start phase

$T_{Q2}$: interval time (only when using the interface)

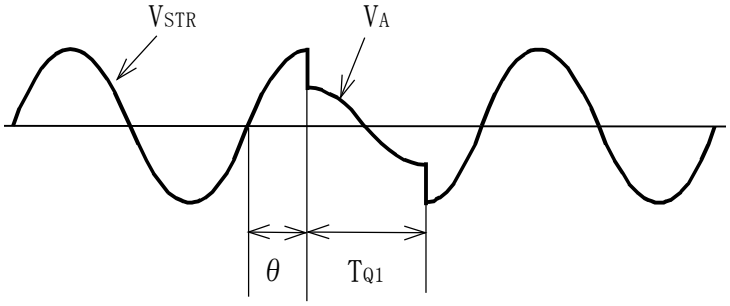
n: number of repetitions (only when using the interface)

Main unit only (panel operation)

| Function | Setting range | Setting resolution | Accuracy |
|---|---|---|---|
| QC time ($T_{Q1}$) *13 | 0.1 ms to 6 s | 0.1 ms | ± (0.2 ms + Setting value ×$10^{-4}$) or less |
| | 6 s to 60 s | 1 ms | |
| | 60 s to 600 s | 10 ms | |
| QC start phase ($\theta$) | 0° to 360° | 1° | |

The setting ranges for the start level ($V_{STR}$) and the QC level ($V_A$) are as specified by the Output voltage setting range.

The number of repetitions (n) is fixed at 1.

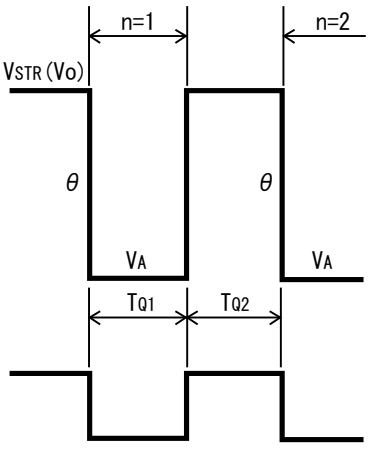



Can be used only via the interface

| Function | Setting range | Setting resolution | Accuracy |
|---|---|---|---|
| QC time ($T_{Q1}$) *13 | 0.1 ms to 600 s and ∞ | 0.1 ms | ± (0.2 ms + Setting value ×$10^{-4}$) or less |
| QC start phase ($\theta$) | 0° to 360° | 1° | |
| Interval time ($T_{Q2}$) | 1 ms to 999.999 s | 1 ms | ± (2 ms + Setting value ×$10^{-4}$) or less |
| Number of repetitions (n) | 1 to 99 and ∞ | | |

The setting ranges for the start level ($V_{STR}$) and the QC level ($V_A$) are as specified by the Output voltage setting range.

For sweep time A ($T_A$) and sweep time B ($T_B$), set to 0.




Synchronization signal output
(QUICK CHANGE SYNC OUTPUT (TTL))

■ Voltage sweep 1 (frequency variation) function

Parameters that can be set and controlled

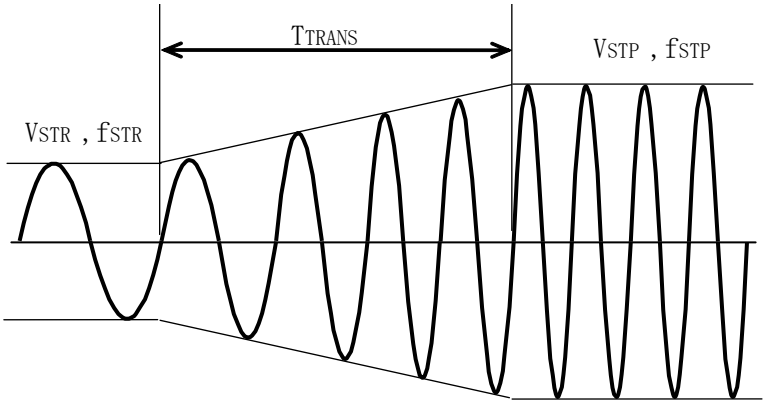
When executing voltage sweep 1 (frequency variation)

$V_{STR}$: start level $T_{TRANS}$: transition time $f_{STR}$: start frequency

$V_{STP}$: stop level $f_{STP}$: stop frequency

| Function | Setting range | Setting resolution | Accuracy |
|---|---|---|---|
| Transition time ($T_{TRANS}$) | 0 to 99.9 s | 0.1 s | ±0.1 s or less |

The setting ranges for the start level ($V_{STR}$) and the stop level ($V_{STP}$) are as specified by the Output voltage setting range. The setting ranges for the start frequency ($f_{STR}$) and the stop frequency ($f_{STP}$) are as specified by the Output frequency setting range.




■ Voltage sweep 2 (frequency unchanged) function

This function can be set with the interface.

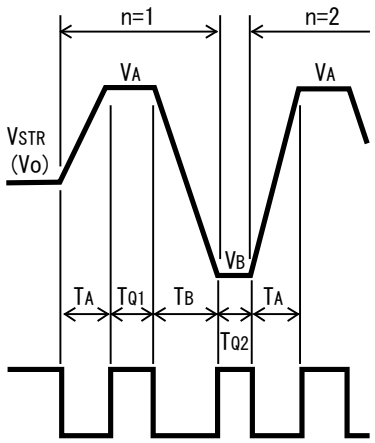
Parameters that can be set and controlled

$T_{Q1}$: QC time $T_{Q2}$: interval time $\theta$: QC start phase

$T_A$: sweep time A $T_B$: sweep time B

$V_A$: QC level A $V_B$: QC level B n: number of repetitions

| Function | | Setting range | Setting resolution | Accuracy |
|---|---|---|---|---|
| QC start phase ($\theta$) | | 0° to 360° | 1° | ± 1° |
| QC time ($T_{Q1}$) | Conditions: $T_A = T_B = 0$ *13 | 0.1 ms to 600 s and ∞ | 0.1 ms | ± (0.2 ms + setting value ×$10^{-4}$) |
| | Conditions: $T_A > 0$ or $T_B > 0$ | 0.1 ms to 600 s and ∞ | 0.1 ms | ± (2 ms + setting value ×$10^{-4}$) |
| Sweep time A ($T_A$) Sweep time B ($T_B$) *14 | | 0.000 s to 999.999 s | 1 ms | |
| Interval time ($T_{Q2}$) *15 | | 0.001 s to 999.999 s | 1 ms | |
| QC level A ($V_A$) | | Same as the output setting for the AC power source main unit | | |
| QC level B ($V_B$) | | | | |
| Number of repetitions (n) | | 1 to 99 and ∞ | | |




Synchronization signal output
(QUICK CHANGE SYNC OUTPUT (TTL))

*13: If the value set for the QC time is 2 ms or less:

If the QC level is not $V_A = V_B$, then $T_{Q1}$ = 2 ms, even if the QC time $T_{Q1}$ is set to 2 ms or less. For repeated operation, $T_{Q1}$ is 2 ms only for the first operation; for the second and subsequent operations, the value is the set value.

*14: Because the resolution setting is 1 ms, the voltage is changed at 1 ms intervals in the sweep waveform.

*15: If the value set for the sweep time A is 0 s:

When $T_A$ is 0, QC start phase control is performed, so one cycle of the output voltage waveform is added to the setting accuracy of the QC interval time $T_{Q2}$.

## 5.10 External signal input

In the AC output mode, it is possible to input external signal such as below.

| | |
|---|---|
| Input impedance | 100 kΩ (unbalanced) |
| Input frequency range | 5 Hz to 1 kHz |
| Maximum input voltage | ±5 V or less |
| Gain | × 100 |
| Terminals | Rear signal panel BNC connector, chassis potential (ES2000ES) |
| Switching method | After the rear signal panel switch has been set (EXT setting), the switch setting becomes effective when the power is turned on. |

# 5.11 External control input and output

This function makes it possible to add an analog signal (ADD) to the output voltage and control amplitude of the output voltage with a voltage control signal (VCA) input. Also, the status of the main unit is output.

■ Addition input (ADD)

| | |
|---|---|
| Input impedance | 20 kΩ unbalanced |
| Input frequency range | 10 Hz to 1 kHz |
| Addition sensitivity | 10 %/V |
| Polarity | Input output same phase |
| Terminals *16 | Interface panel CONTROL SIGNAL connector (D-sub) |

■ Amplitude modulation input (VCA)

| | |
|---|---|
| Input impedance | 20 kΩ unbalanced |
| Input frequency range | DC to 100 Hz |
| Modulation sensitivity | 10 %/V |
| Polarity | The output voltage is large when the input is positive and small when the input is negative. |
| Terminals *16 | Interface panel CONTROL SIGNAL connector (D-sub) |

■ Status output

| | |
|---|---|
| Output impedance | 470 Ω |
| Output level | 0 V/+5 V (open) |
| Update interval | 20 ms |
| Terminals *16 | Interface panel CONTROL SIGNAL connector (D-sub) |

*16: Connector forms

Main unit terminals (ES2000ES, chassis potential):

D-sub 37-pin connector (socket)

(JAE DCLC-J37S equivalent, set screws are M2.6)

Cable-side connector:

D-sub 37-pin connector (pin contacts)

(JAE DC-37P-N equivalent)

# 5.12 Interface

This product is equipped with two interfaces: a GPIB interface that is mainly used for connection to measurement instruments and an RS-232 interface for data communication. The interfaces can be used together with the ES0406D Immunity Test Software to easily perform low-frequency EMC testing. Select either the GPIB interface (IEEE-STD-488.1-1987) or the RS-232 interface.

GPIB interface

■ Interface functions

| Function | Description |
|---|---|
| SH1 | All send handshake functions |
| AH1 | All receive handshake functions |
| T6 | Basic talker functions, serial polling, and MLA talker functions |
| L4 | Basic listener functions and MTA listener release |
| SR1 | All service request functions |
| RL1 | All remote/local functions |
| PP0 | Parallel polling disabled |
| DC1 | All device clear functions |
| DT0 | Device trigger functions disabled |
| C0 | Controller functions disabled |

■ Bus drivers

| | |
|---|---|
| DIO 1 to 8<br>NDAC<br>NRFD<br>SRQ | Open collector |
| DAV<br>EOI | 3-state |

■ Character codes

For listeners, the code is ISO 7-bit code (ASCII) and MSB is ignored, even if there is a parity. Letter case is not distinguished and interpretation is performed for both uppercase and lowercase characters. Spaces (20H), tabs (09H), and semicolons (3BH) between program codes are disregarded.

For talkers, the send code is ISO 7-bit code (ASCII) with no parity. Alphabetic characters are all sent in uppercase.

■ Addresses

Addresses are set with the control panel of the main unit. The setting values are automatically saved to memory with a battery backup when the power is turned off.

The default setting (factory settings) is “2”.

■ Delimiters

The delimiters that can be used for the received code strings for listeners are < CR >, < LF >, and < EOI >. They can also be used in any combination.

For talkers, the send code string delimiters are set with the controller panel. They are backed up automatically. You can select < CR > or < CR > < LF >. An EOI signal is also output.

■ Responses to interface messages

| | |
|---|---|
| IFC | Initialize the GPIB interface.<br>Cancel listeners and talkers. |
| DCL, SDC | Clear GPIB input output buffer.<br>Clear the error status.<br>Cancel SRQ.<br>Set the output to off and clear the status byte. |
| LLO | Disable the controller panel LOCAL key. |
| GTO | Set the local state. |

■ Program code format

The program code format is as shown below.

Header part + parameter part

The header part consists of three alphabetic characters that indicate the code function.

When a setting code is received, functions or numerical values are set. When a query code is received, the response data for the query is output when the next talker designation is received.

The parameter types for setting inquiry codes are real number, integer, boolean, and parameterless.

■ Output data format

When a query command has been received, the response data is output when the next talker designation is received. The output format for that response data is as shown below.

Header part + 1 space character + parameter part

The header consists of 3 alphabetic characters and is the same as the query code header.
The parameter part contains numerical values that represent the data content. If “header off” has been set, the header and the space that follows it are omitted.

■ Input buffer

The input buffer holds 255 characters (255 bytes), which do not include delimiters, spaces, tabs, or semicolons.

■ Service requests

When an SRQ cause that is specified for the service request (SRQ) occurs, the bus SRQ signal line is set to Low by a function that sends an interrupt to the controller.
In the cases listed below, the SRQ is canceled and the SRQ signal line returns to High.

- When serial polling is performed from the controller and the status byte is sent
- When a device clear (DCL or SDC) is received
- When the SRQ cause is masked

Any of the SRQ causes can be masked. After masking, an SRQ is not issued, even if the masked cause occurs, but the status byte still indicates that the cause actually occurred.

The SRQ causes for this product are listed in the following table.

| SRQ cause | Description |
|---|---|
| Busy states ends | The busy state indicates the three states listed below.<br>● An output voltage range switching operation<br>● A quick change operation (QC)<br>● An auto-calibration operation |
| Data output preparation completed | Data output preparation complete indicates the following state.<br>● Preparation for data output in response to a query command (?MVL, etc.) has been completed |
| Error | When various types of errors occur |
| Overload | When an overload has occurred |

■ Error codes

When an error occurs, a description of the internal error status is output and sent as a response to a query made with the “?ERS” command.

RS-232 interface

■ Signal specifications

| Item | Rating |
|---|---|
| Communication mode | Asynchronous |
| Baud rate | 300/600/1200/2400/4800/9600 bps |
| Data bits | 7/8 bit |
| Stop bits | 1/2 bit |
| Parity | None/odd/even |
| Output signal | ±12 V |
| Input signal | ±30 V |
| Connector | D-sub 25-pin connector (socket)<br>(JAE DBLC-J25S equivalent, set screws are M2.6) |

■ Connector pin numbering

| Pin number | Name | Abbre-viation | Explanation | Direction |
|---|---|---|---|---|
| 1 | Frame Ground | FG | Connected to the SG of pin 7 | - |
| 2 | Transmitted Data | TxD | Data output signal line | Output |
| 3 | Received Data | RxD | Data input signal line | Input |
| 4 | Request to Send | RTS | “H” when data output begins; returns to “L” when output ends. | Output |
| 5 | Clear to Send | CTS | When “H”, data output is enabled. The original procedure is for the modem, etc. to return “H” to CTS as a response to RTS. However, when it is not necessary to wait for a response on the receiving side, connect CTS directly to RTS. It is also possible to set BUSY on the receiving side. | Input |
| 7 | Signal Ground | SG | Connected to FG of pin 1. | - |
| 9 | +5V DC Power | +5V | Dedicated power supply for the remote terminal (ES4474A). Do not use for other purposes. | Output |
| 10 | Power Ground | PG | Power ground for pin 9. Do not use for other purposes | - |
| 20 | Data Terminal Ready | DTR | “H” in RS-232 mode and “L” in GPIB mode. | Output |

## 5.13 Power supply input

| Package model | ES020ES | ES040ES | ES060ES |
|---|---|---|---|
| Constituent unit | ES2000ES 1 | ES2000ES 1<br>ES2000EB 1 | ES2000ES 1<br>ES2000EB 2 |
| Power consumption<br>(at rated output) | Approx. 3800 VA | Approx. 3800 VA ×2<br>(7600 VA) | Approx. 3800 VA ×3<br>(11400 VA) |

| Constituent unit | ES2000ES, ES2000EB |
|---|---|
| Voltage range | 170 Vrms to 250 Vrms overvoltage category II |
| Frequency range | 48 Hz to 62 Hz |
| Power consumption<br>(at rated output) | Approx. 3800 VA<br>This is the per-unit power consumption for the ES2000ES single-phase master or ES2000EB booster. |
| Power factor | 0.9 or more (0.97 typ.) (at rated output) |
| Terminals | 2-pin terminal block (M4 screws) *Equipped with a protective conductor terminal |

## 5.14 Operating environment

| Operating environment | Use indoors, pollution degree 2 |
|---|---|
| Altitude | 2000 m or less |
| Performance guarantee | +5 °C to +35 °C,<br>5 to 80 %RH (Absolute humidity of from 1 to 25 g/$m^3$, with no condensation) |
| Operation guarantee | 0 °C to +40 °C,<br>5 to 80 %RH (Absolute humidity of from 1 to 25 g/$m^3$, with no condensation) |
| Storage conditions | –10 °C to +50 °C,<br>5 to 95 %RH (Absolute humidity of from 1 to 29 g/$m^3$, with no condensation) |

■ Installation location

Install this product in a location that satisfies the conditions listed below.

- No direct sunlight
- Ambient temperature and humidity within the rated ranges
  *with no condensation in any case
- Low levels of dust and dirt; no conductive dust or particles
- No corrosive, explosive, or inflammable gases
- No fire or moisture
- Little vibration
- No exposure to salty air
- There is at least 50 cm between the front and rear sides of this product and any obstruction to the flow of cooling air. (This product uses a fan for forced air cooling, so obstruction to cooling air flow may make it impossible to use this equipment within the temperature range for which operation is guaranteed.)

## 5.15 Insulation resistance and withstand voltage

■ Insulation resistance

10 MΩ or more (500 VDC)

This value is for the chassis and the collective power supply input with respect to output and for the chassis and the collective output with respect to the power supply input.

The value is per constituent unit.

For ES040ES and ES060ES, it is the value divided by the number of constituent units.

■ Withstand voltage

AC 1500 Vrms, 1 minute (50 Hz / 60 Hz)

This value is for the chassis and the collective power supply input with respect to output and for the chassis and the collective output with respect to the power supply input.

The value is per constituent unit.

## 5.16 Dimensions and weight

■ Dimensions

(width) 240 mm × (height) 705 mm × (depth) 800 mm (including constituent units and protrusions)

■ Weight

Approx. 48 kg: per constituent unit

# 5.17 Dimensional diagram

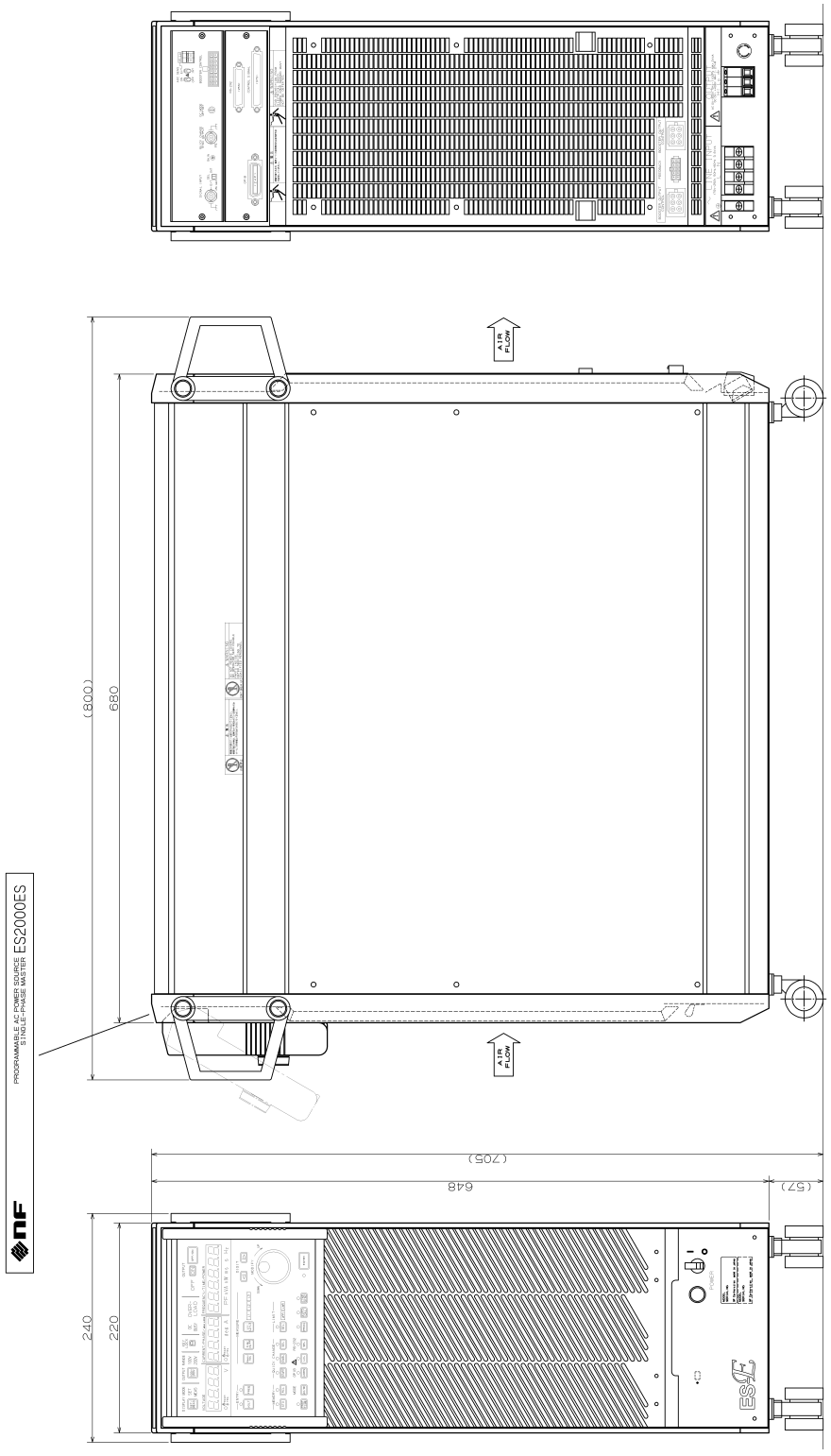



Figure 5-5 ES2000ES single-phase master

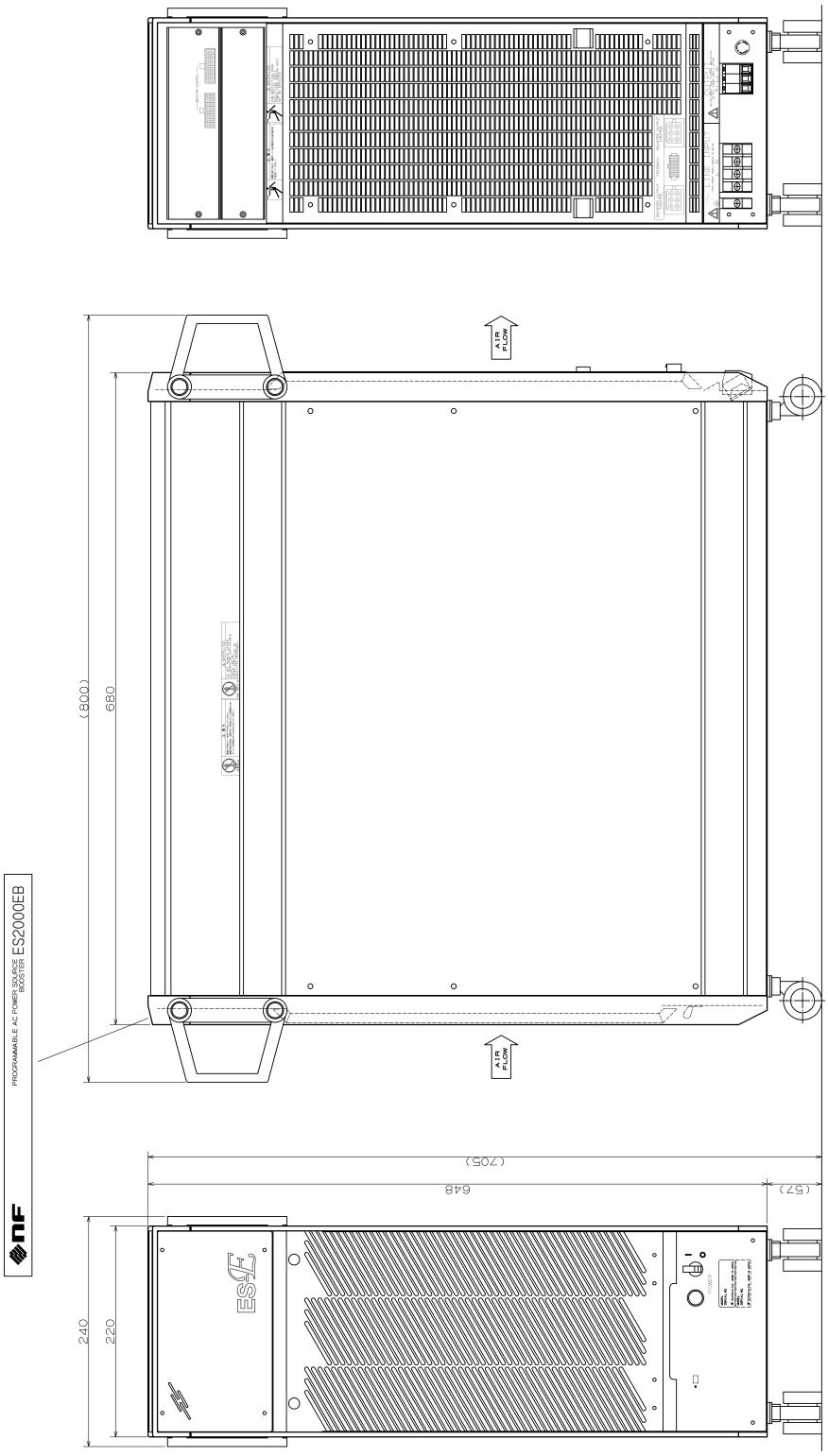
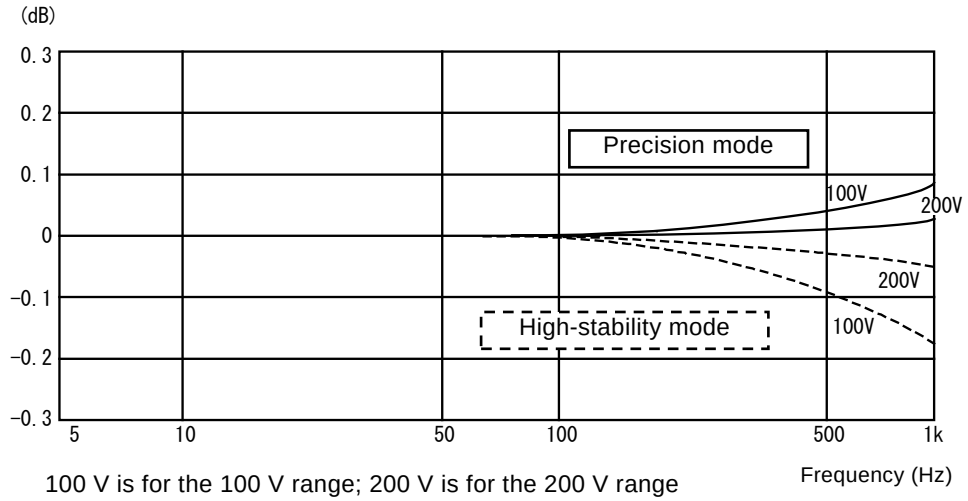



Figure 5-6 ES2000EB booster

# 5.18 Standard data

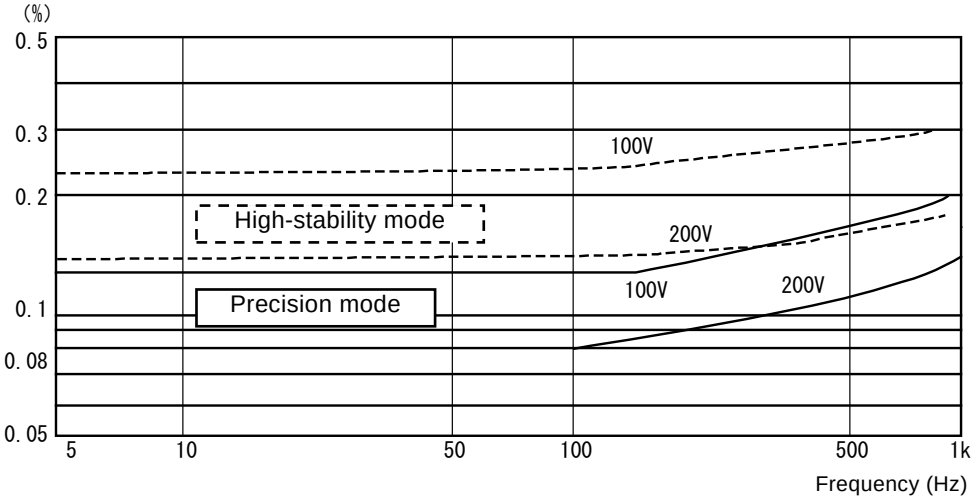
Output voltage (50 Hz, 0 dB)




100 V is for the 100 V range; 200 V is for the 200 V range
SIG SELECT is INT, rated load

Figure 5-7 Output voltage vs. frequency characteristic

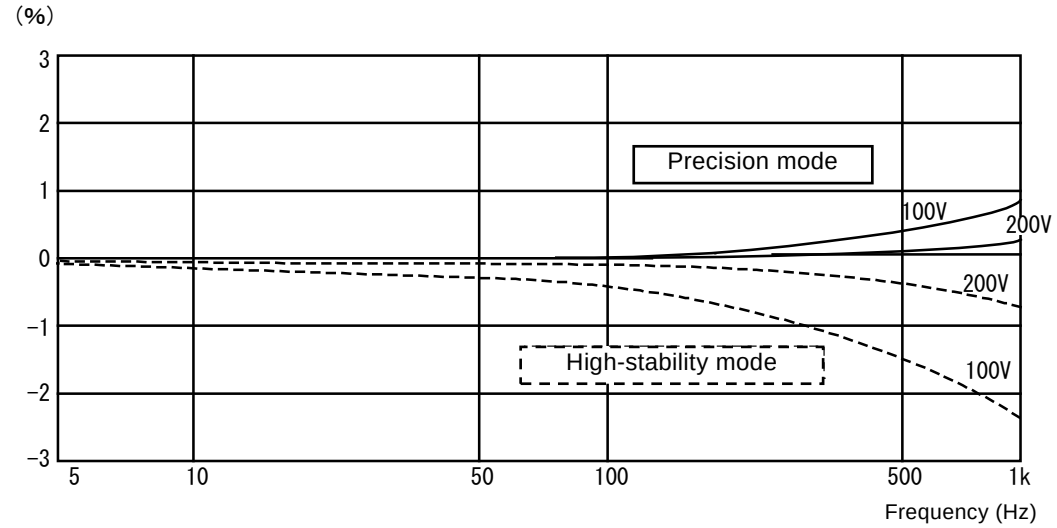
Distortion




100 V is for the 100 V range; 200 V is for the 200 V range
SIG SELECT is INT, rated load

Figure 5-8 Total harmonic distortion vs. frequency characteristics

Load regulation




100 V is for the 100 V range; 200 V is for the 200 V range
SIG SELECT is INT, rated load

Figure 5-9 Load regulation vs. frequency characteristics

# 6. Maintenance

# 6.1 Cleaning the air filter

Dust that enters the equipment and adheres to internal surfaces can absorb moisture from the air and cause corrosion of metal parts. It can thus result in degradation of insulation performance in high-voltage components and lead to malfunction.
To prevent such problems, this product is equipped with an air filter at the front air intake vent for removing dust and other airborne materials.
Dust accumulating on the air filter reduces air flow and may result in higher internal temperatures and lower product reliability.
Remove accumulated dust from the filter by washing the filter well with water, etc. For safety, make sure the filter is completely dry before reinstalling it.

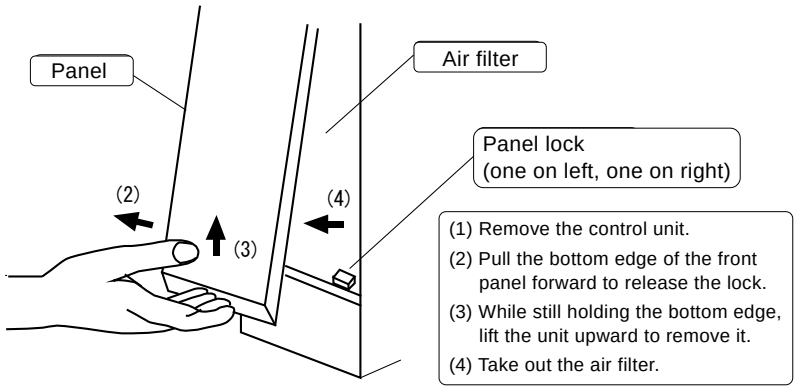



Figure 6-1 Removing the air filter

However, the filter is not perfectly effective against very fine dust or powder, and clogging may result in decreased reliability. Accordingly, make the best effort to avoid installing this equipment and locations where there is a lot of dust or fine powders, where humidity is high and condensation is likely, or where corrosive, explosive, or inflammable gases are present.

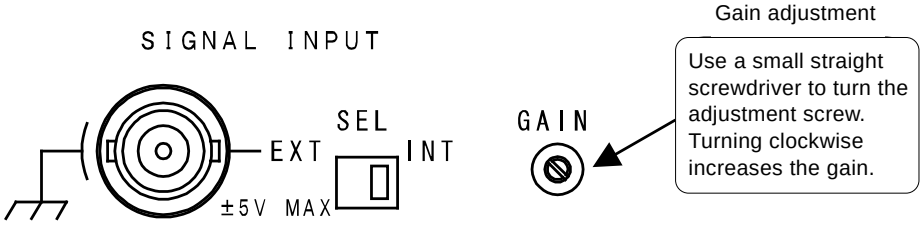
# 6.2 Back-up battery

The ES2000ES is equipped with an internal coin-type rechargeable lithium battery for backing up the contents of the memory (☞ Refer to 4.3.3 Memory.) and other required parameters and data.
The battery is in a fully-discharged state when shipped from the factory. It is in a fully-charged state after the power has been on for 50 hours. After that, it remains fully charged if the power is on for at least 20 hours per week.
In a fully-charged state, the battery can usually backup the internal memory device for 60 days, but the time may vary due to individual differences and changes in ambient temperature.
If the battery deteriorates, the backup time period may decrease. If the battery becomes practically unusable, we will replace it. Please contact the NF Corporation or an authorized agent.
Storing this product for six months or more without the power turned on will shorten the battery lifetime, so we recommend that this equipment be powered up occasionally.

The backed-up data is checked each time the power is turned on and an error message is displayed if any of the data has been corrupted. (☞ Refer to 7.1 Error messages.) In that case, all values are reset to the default values. (☞ Refer to 4.3.4 Memory store and default settings.)

# 6.3 Gain adjustment

On the rear signal panel of the ES2000ES, there is there is a trimmer potentiometer for adjusting the voltage gain of the internal power amplifier. ☞ Refer to 2.1.3 Rear signal panel.




The procedure for adjusting the internal amplifier gain using the measuring function of this product is described below.

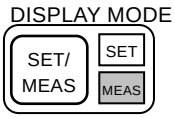
(1) Disable the external input function by setting the SEL switch to INT.


(2) Turn the power on. Set the output voltage range to 200 V and set the output voltage to 0 V. Do not turn the output on.

(3) Press the [AUTO CAL] key to execute the auto-calibration function. A buzzer will sound when the process is complete.
(This operation resets the calibration constant that is stored internally.)

(4) Set the output voltage to 300.0 V. Do not turn the output on.

(5) Press the [SET/ MEAS] key to set the display mode to measurement display.




(6) Adjust the gain so that the voltage reading on the measurement display is 300.0 V.

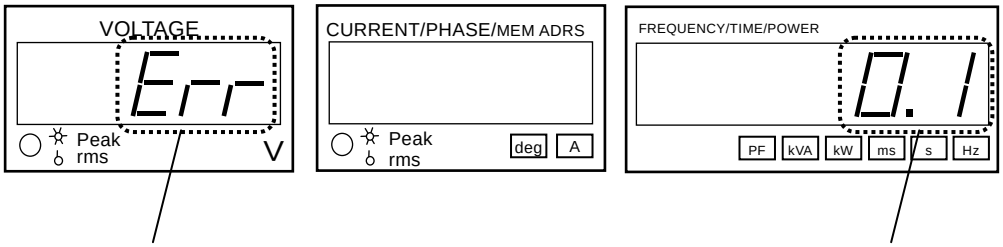
If the auto-calibration function is used, the output voltage is automatically adjusted for each phase by the measurement function of this product. It is therefore not necessary to perform the adjustment explained here normally. ☞ Refer to 4.5.3 Auto-calibration (output voltage adjustment function).
However, the adjustment affects both the signal from the internal signal generator and the external input signal, so it is necessary to readjust the gain when returning to the normal internal signal mode when the gain was adjusted in the external input mode.
☞ Refer to 4.6.1 External input.

# 7. Troubleshooting

# 7.1 Error messages

This product checks each constituent unit when the power is turned on and displays an error description on the controller when an abnormality is found. The error is described by the value that follows the “Err” display.
The error descriptions for each error display as well as the operation of this product and measures to be taken by the user are described below.
None of the situations that exist when an error is displayed will develop into a serious malfunction if nothing is done. Nevertheless, when an error display appears, turn the power off and check each component.

Example error display




The display indicates that an error has occurred (Err).

Description of the error that has occurred. (See below)

| Error Display | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| r0 | Data stored in the ROM memory device is corrupted. | A component may have failed.<br>Check the contents of the display and contact the NF Corporation or an authorized agent.<br>Operation stops at this point and the display remains as it is until the power is turned off. |
| r1<br>r2<br>r4 | There is an error in the result of checking the internal RAM memory operation. | |
| r3 | Some or all of the data stored in the internal battery back-up memory device is corrupted. | When this error occurs, the display continues for two seconds and then all of the values stored in memory are set to the default values and normal operation begins.<br>☞ Refer to 4.3.4 Memory store and default settings.<br>This may happen when this product is stored for a long period of time without the power being turned on, but frequent occurrence may indicate that the back-up battery has deteriorated.<br>☞ Refer to 6.2 Back-up battery. |
| 0. 1 | A failure has occurred in the internal signal transmission path. | A component may have failed.<br>Check the contents of the display and contact the NF Corporation or an authorized agent.<br>Operation stops at this point and the display remains as it is until the power is turned off. |

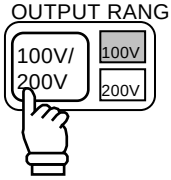
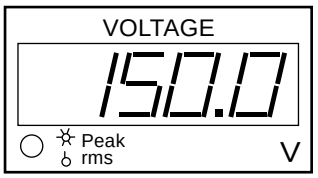
# 7.2 When an error seems to have occured

If you think that a malfunction has occurred while using this product, refer to the troubleshooting information provided below to determine whether the problem is an actual malfunction or the result of error in operation or use or an incorrect connection.
If none of those cases apply, product malfunction is a possibility. Continuing to use this product may result in secondary problems, so do not turn on the power and contact the NF Corporation or an authorized agent.

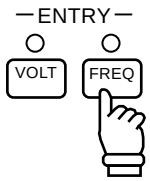
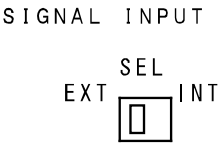
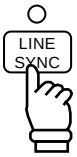
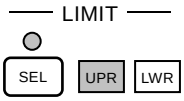
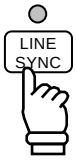
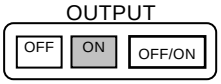
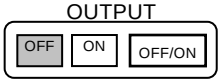
■ Turning power on or off

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| When the power switch is turned into the off position during operation, the pilot light blinks on and off and operation does not stop immediately.<br>After five seconds or so, the light turns off and operation stops. | A high-capacitance capacitor is discharging in an internal circuit. The blinking light indicates the discharging. | This is not abnormal.<br>If you want to switch the power on again, wait until the indicator light stops blinking and then set the switch to the on position. |
| When the power switch is turned to the on position, the pilot light blinks on and off, but operation does not begin.<br>Operation does not begin, even though the pilot light is blinking. | A high-capacitance capacitor is discharging in an internal circuit. The blinking light indicates the discharging. | Turn the switch to the off position and wait until the indicator light stops blinking. Then return the switch to the on position. |
| Operation does not begin, even though the power switch is in the on position. | Is power being supplied to the unit? | Make sure that power is being supplied to the unit. |
| | Is the power cable connecting the master in the booster securely connected? | Make sure that the cable connection is secure. |

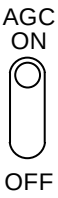
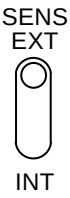
■ Setting the output voltage or voltage range

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| The voltage range cannot be switched from 200 V to 100 V.<br>  | The setting for the output voltage or QC voltage exceeds 150 V. | Set the value to 150 V or less.<br>  |
| It is not possible to set the output voltage. | External input is enabled. | Set the normal mode, in which external input is disabled.<br>☞ Refer to 4.6.1 External input. |

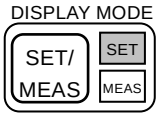
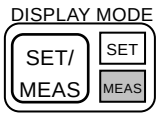
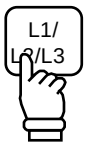
■ Frequency setting

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| It is not possible to set the output frequency.<br>  | Line synchronization is enabled.<br>  | Disable line synchronization.<br>☞ Refer to 4.3.2 Line synchronization.<br>  |
| | External input is enabled.<br>  | Set the normal mode, in which external input is disabled.<br>☞ Refer to 4.6.1 External input.<br>  |
| Line synchronization cannot be set.<br>  | The frequency upper limit is set to a value lower than 55 Hz or the lower limit is set to a value higher than 55 Hz.<br>  | Set the frequency limits to values such that the range between the upper limit and the lower limit includes the value of 55 Hz. (i.e., the upper limit is 55 Hz or higher in the lower limit is 55 Hz or lower)<br>☞ Refer to 4.3.1 Setting limit values. |
| | External input is enabled. | Set the normal mode, in which external input is disabled.<br>☞ Refer to 4.6.1 External input. |
| Line synchronization cannot be enabled or disabled.<br>  | The output on state is in effect.<br>  | Line synchronization cannot be enabled or disabled unless the output is set to off.<br>☞ Refer to 4.2.5 Switching output on and off.<br>  |

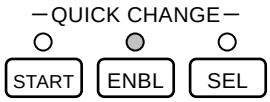
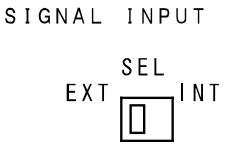
■ Overload (☞ Refer to 4.2.8 Protection function.)

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| The overload light is lit.<br>OVER-LOAD | An overload has occurred. | Check the load to make sure that it is within the rated range. |
| | The power has turned off. | There is no abnormality. |
| | The power has turned on. | If the indicator light is lit for a short time, there is no abnormality. |
| | The output voltage has increased suddenly. | |
| | The output has turned on. | |
| | It is the QC operation start time or end time. | |
| | The voltage range is being switched. | |
| | External input is on. | Check the input signal for normal values or output voltage clipping due to excessively high input.<br>Check for values of 3.00 Vrms and 4.24 Vpk or less. |
| | The AGC switch is in the on position.<br>  | Check for values that are outside the compensation range (the voltage that is less than 5 % of the output voltage or 10 V, whichever is smaller). |
| | The SENS switch is set to the EXT position.<br>  | Make sure that the sensing cable is correctly and securely connected. |

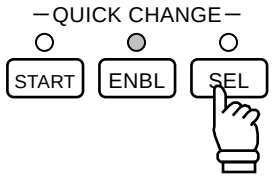
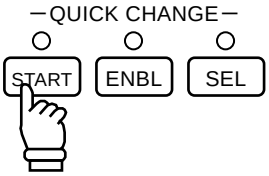
■ Measurement function

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| It is not possible to switch between the effective value and the peak value.<br>  | The DISPLAY MODE is SET.<br>  | Set the display mode to MEAS.<br>☞ Refer to 4.2.7 Measurement function.<br>  |
| It is not possible to switch the measurement phase for MEASURE.<br>  | Not used.<br>The ES2000ES controller display is also disabled. | |

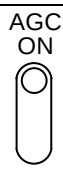
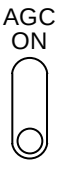
■ Auto-calibration

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| Auto-calibration is not possible.<br>  | The frequency is set to less than 40 Hz. | Set the frequency to 40 Hz or higher. |
| | The quick change mode is enabled.<br>  | Disable the quick change mode before executing auto-calibration.<br>☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged). |
| | The signal input is set to external.<br>  | Set the normal mode, in which external input is disabled.<br>☞ Refer to 4.6.1 External input.<br>  |

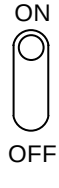
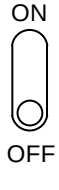
■ Quick Change (QC) [1]

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| The QC parameter setting key is ineffective.<br>  | The QC enable mode is in effect.<br>  | Disable the QC enable mode before using the QC parameter setting key.<br>☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).<br>  |
| The QC operation cannot be started.<br>  | The QC enable mode has not been enabled.<br>  | The operation cannot be started unless the QC enable mode is enabled.<br>☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged).<br>  |
| When the QC operation start key has been pressed, the QC operation is executed more than one time. | A voltage sweep 2 operation has been performed from the ES4474A Remote Terminal or interface. When that operation is used, it is possible to set this kind of multiple-execution operating mode, and it is possible that the settings from the previous operation remain. | To stop the execution of the operation, cancel the enable mode while the operation is in progress.<br>Also, check the settings for the remote terminal and interface or perform a recall on memory address 0 to reset all of the settings to the default values<br>☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged), 4.7.1 ES4474A Remote Terminal.<br>☞ Refer to 4.3.3 Memory. |

■ Quick Change (QC)[2]

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| When a QC is performed such that the voltage increases, there is distortion in the output voltage waveform for a short time immediately after the operation begins. | The operation was started immediately after the QC enable mode was enabled. | After setting the QC enable mode to enabled, wait for one or two seconds before starting the operation.<br>☞ Refer to 4.4.1 Voltage quick-change (frequency unchanged). |
| | The AGC switch is in the on position.<br>  | When performing a voltage QC operation, set the AGC switch to the off position to disable the AGC function.<br>☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).<br>  |

■ Other phenomena

| Problem | Cause or Condition | Explanation or Measures to Take |
|---|---|---|
| When an external input is being used and the signal suddenly increases from 0 V, the output voltage waveform is distorted for a short time. | A value has not been set for the maximun output voltage. | Set a value for the maximun output voltage.<br>☞ Refer to 4.6.1 External input. |
| | The AGC switch is in the on position.<br>  | Set the AGC switch to the off position to disable the AGC function.<br>☞ Refer to 4.5.2 Remote-sensing AGC (AC output mode).<br>  |

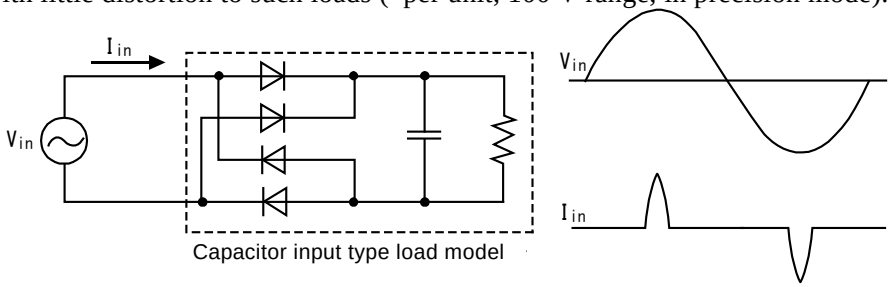
# 8. Supplementary information

# 8.1 Explanation of terms

| Term | Explanation |
|---|---|
| AC power supply<br>Stabilized AC power supply | Although a commercial AC power supply is widely used as a power source for various types of electrical equipment, the path of power distribution from the power generation plants of various power companies involves power substations, power distribution boards, and wall-mounted outlets. The effects of the impedance of the power line and the load create disturbances in the voltage value and voltage waveform.<br>However, various types of electronic equipment for which quantization and precision are increasing are raising the demand for higher reliability of the commercial power supply.<br>One solution to that problem is stabilization of power on the receiving side. Conventional approaches include using a saturable reactor and a slide regulator controlled by a servomechanism, but the slow response time and lack of waveform improvement are serious drawbacks. That approach has become impractical in recent years, and methods that employ electronic circuits have come into use.<br>Because this product adopts a power amplifier method for power stabilization, it can supply AC voltage that has low distortion and high stability from an internal signal generator and also perform power fluctuation tests such as simulating the effects of various types of abnormal phenomena that occur in commercial power lines on loads. |
| Low-frequency immunity | Various abnormal phenomena that occur in commercial power lines are quantitatively generated and the ability of the device under test to withstand such phenomena (immunity) is tested.<br>These tests are for determining immunity against external abnormalities and noise for the purposes of improving device reliability and safety rather than measuring the generation of noise such as the conductive radiation noise regulated by CISPR, FCC, VDE, and VCCI or harmonics regulated by IEC61000-3-2 from the device as is done conventionally.<br>In the IEC international standards, this is referred to as the “Immunity test for low-frequency conducted disturbances”, and there are various provisions in the IEC 61000 series of standards related to electromagnetic compatibility (EMC).<br>Since 1996, the test has been mandatory for equipment exported to the EU region and the CE label for safety testing has been obligatory (low-voltage and EMC Directives). Products which do not bear the CE marking that certifies product satisfaction of the standard cannot be sold. |

| Term | Explanation |
|---|---|
| Harmonic regulation | If a large harmonic component in the input current to a device flows into the power line, it may result in problems such as voltage distortion leading to malfunction of other devices and failures caused by overheating of transformers.<br>That problem created a movement to quantitatively measure the harmonic component of the device input current and regulate its level to a certain maximum value. The resulting international standard is IEC61000-3-2.<br>In the same way as for low-frequency immunity, it has been incorporated in the EMC Directive of the CE marking since 1996.<br>In Japan, JIS C 61000-3-2 has been issued and there has been self-regulation in various industries. |
| QC (Quick Change) | The state of the power supply is changed instantaneously. |
| QC<br>Voltage QC<br>Frequency QC | A sudden change in voltage is referred to as “voltage QC” and a sudden change in frequency is referred to as “frequency QC”. This product can produce both types of change. |
| Phase QC | Similarly, a sudden change in phase is referred to as “phase QC”. Phase QC may happen when switching occurs in the commercial power grid, etc. Phase QC can be generated when this product is used together with the optional ES0406D Immunity Test Software. |
| Sweep<br>Voltage sweep<br>Frequency sweep | This is an operation in which the voltage changes over a period of time rather than instantaneously.<br>When the change is linear with respect to time, is referred to as a linear sweep. If the change is logarithmic with respect to time, it is referred to as a log sweep.<br>This product can perform a linear sweep for both voltage and frequency. |
| Load regulation | This refers to a change in the output voltage due to a change in the load state. It generally represents the amount of voltage fluctuation at the time the load is connected relative to the voltage for when there is no load (no load is connected) expressed as a percentage. |
| Line regulation | This refers to a change in output voltage due to a change in power supply input voltage. For this product, it is specified as a rating for the amount of change in output voltage (at the rated output) relative to the change in input voltage (170 V to 250 V) expressed as a percentage. |
| Apparent power | In the case that power is supplied to the load from an AC power supply and the load current and voltage are denoted as $I_L$ and $V_L$ (both effective values), the apparent power [VA] is expressed as the product of the absolute values of the load current and voltage ($\|I_L\| \cdot \|V_L\|$). |

| Term | Explanation |
|---|---|
| Active power | The part of the power that is supplied by the power supply in the following way is referred to as the active power and is expressed as [W].<br>$\frac{1}{T}\int_0^T i_L \cdot v_L \, dt$ ($i_L$ and $v_L$ are instantaneous value) |
| Power factor | The ratio of those two values is the power factor ([W] / [VA]).<br>We can thus consider the apparent power to be the power that is expected to be supplied by the AC power supply, the active power to be the power that is used as energy by the load, and the power factor to be the use ratio of the supplied power.<br>In this product, these values are obtained by performing the same calculations described above for the detected values of $i_L$, $v_L$, $I_L$, and $V_L$. |
| Stability for a capacitive load | For AC power supplies that consist of power amplifiers, such as this product, feedback from an electronic circuit is used to compensate fluctuations in output voltage due to changes in the load, etc. However, when a load that has excessively high capacitance is connected, the feedback circuit loses stability and oscillation or other such abnormal phenomena is likely to occur.<br>Therefore, this product provides a function for selecting a feedback circuit compensation mode for cases in which it is necessary to connect a load of high capacitance.<br>In the precision mode, which emphasizes high accuracy, a capacitive load of about 20 μF can be accommodated, but in the high-stability mode, which emphasizes stability, a capacitive load of up to 1000 μF can be connected. |
| Remote sensing | When long cables are used for the connection between the output terminals of AC power supply and the load, the impedance of the cable will be large enough to cause a voltage drop.<br>In that case, a separate cable for sensing the voltage at the load end is connected. That method is generally referred to as “remote sensing”.<br>This product provides a function for selecting an “external” setting and an “internal” setting for the voltage sensing point. When external is selected, the remote sensing function is enabled and the voltage detection input for the measurement function operation and the AGC function operation that is described later is set to the load end. |
| AGC | This function detects the envelope of the absolute value of the AC output voltage, takes the average of the values (converts to DC), and then uses the value to control the output voltage.<br>Using the value converted to DC for control makes it possible to maintain high voltage stability with high accuracy, and there is less susceptibility to the effects of the AC elements of the sensing cable when performing remote sensing described above (impedance, etc.). |

| Term | Explanation |
|---|---|
| Capacitor input type load | The switching power supply that is used in various consumer and industrial devices usually adopts a capacitor input rectifier circuit in the power input module because it is simple and inexpensive.<br>For the power input current of devices that have such circuits, the waveform is such that current flows only near the peaks of a given sinusoidal voltage and many harmonic components are included (refer to "Regulation of Harmonics"). Furthermore, the ratio of the peak value to the effective value (crest factor, CF) is larger than for resistance loads or other linear loads (CF = 1.41) by a factor of from 1.5 to 2.<br>Therefore, it is considered possible to supply a current of up to CF = 3.5 (equivalent to 70 Apk) with this product so as to be able to supply a voltage with little distortion to such loads (*per unit, 100 V range, in precision mode).<br>  <br><br>Capacitor input type load model |
| GPIB and RS-232 | The GPIB (General Purpose Interface Bus) is a hardware and protocol specification for a communication interface that is widely used for measurement instrument control.<br>The specification enables instruments that are equipped with this interface to be connected in a daisy chain with GPIB cables, so a controller (often a personal computer) can be connected to multiple instruments with a cable attached to a single connector on the controller. It is thus easy to construct an automated measurement system.<br><br>RS-232 is a hardware interface for serial data transfer specified by the Electronic Industries Alliance (EIA) of America.<br>The currently most recent specification is EIA-232-F, but the basic specifications are the same and the generic name RS-232 is used for this product. The cable can be several tens of meters long. The disadvantages are that data transfer is slow and a connector is needed for each instrument, so this interface is not suitable for constructing complex systems.<br><br>This product is equipped with both interfaces so that they can be used according to the respective advantages and disadvantages. |

# WARRANTY

NF Corporation certifies that this product was thoroughly tested and inspected and found to meet its published specifications when it was shipped from our factory. In the unlikely event that you experience an issue during use, please contact our company or agency of our company from which you purchased the product.
All NF products are warranted against defects in materials and workmanship for a period of one year from the date of shipment. During the warranty period, NF will repair the defective product without any charge for the parts and labor.
For repair service under warranty, the product must be returned to either NF or an agent designated by NF. The Purchaser shall prepay all shipping cost, duties and taxes for the product to NF from another country, and NF shall pay shipping charges to return the product to the purchaser.

This warranty shall not apply when corresponding to following particulars.

A) Failure caused by improper handling or use of the product in a manner that does not conform with the provisions of the Instruction Manual.
B) Failure or damage caused by transport, dropping, or other handling of the product after purchase.
C) Failure caused by repair, adjustment, or modification of the product by a company, organization, or individual not approved by NF.
D) Failure caused by abnormal voltage or the influence of equipment connected to this product.
E) Failure caused by the influence of supply parts from the customer.
F) Failure caused by such as corrosion that originate in the use of causticity gas, organic solvent, and chemical.
G) Failure caused by the insect or small animal that invaded from the outside.
H) Failure or damage caused by fire, earthquakes, flood damage, lightning, war, or other uncontrollable accident.
I) Failure caused by the reason that was not able to be foreseen by the science and technology level when shipped from our company.
J) Replacement and replenishment of consumables such as batteries.

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If there are any misplaced or missing pages, we will replace the manual.  Contact the sales representative.

NOTES

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