



KIKUSUI

PART NO. Z1-005-202, IB023223
Sep. 2013

Operation Manual

Capacitor Tester

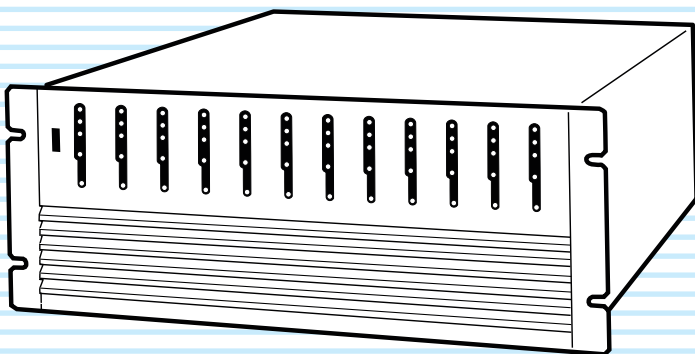
PFX2400 Series

PFX2411

PFX2421

PFX2431

PFX2441



About This Manual	2
Checking the Package Contents	3
Features	4
Safety Markings	4
Safety Precautions	5
Precautions about the Installation Location	6
Precautions for Moving the Product	6
Notations Used in This Manual	6
Front panel	7
Rear panel	10

Installation and Preparation

Connecting the Power Cord	12
Connecting the PFX2400 Series to a PC	16
Preparing to Connect the DUTs (Capacitors)	18
Connecting the DUTs (Capacitors)	25
Options	32

Operation

Turning the Power On and Off	33
Panel Indications	34
Setting the Hardware OVP and UVP	35
Test Procedure	36
External Alarm Input	37

Specifications

Functional Specifications	38
Electrical Specifications	40
General Specifications	43

App. A

Cleaning the Dust Filter	46
--------------------------	----

App. B

Troubleshooting	48
-----------------	----

Thank you for purchasing the PFX2400 Series Capacitor Tester. This series consists of a number of multi-channel charge and discharge testers. Depending on the charge and discharge power per channel, a tester has between 1 and 12 channels.

- PFX2411: 5 V, 5 A, 25 W per channel; 12 channels
- PFX2421: 5 V, 35 A, 175 W per channel; 4 channels
- PFX2431: 5 V, 70 A, 350 W per channel; 2 channels
- PFX2441: 5 V, 140 A, 700 W per channel; 1 channel

About This Manual

This manual is intended for first-time users of this product. It provides an overview of the product and notes on usage. It also explains how to configure the product, operate the product, perform maintenance on the product, and so on.

To effectively use the product features, read this manual from beginning to end. If you forget how to use the product, or if a problem occurs, we recommend that you refer to this manual again.

After you have finished reading this manual, store it so that you can use it for reference at any time.

If you find any misplaced or missing pages in this manual, it will be replaced.

If the manual gets lost or soiled, a new copy can be provided for a fee. In either case, please contact your Kikusui agent or distributor, and provide the "Kikusui Part No." given on the cover.

Every effort has been made to ensure the accuracy of this manual. However, if you have any questions or find any errors or omissions, please contact your Kikusui agent or distributor.

How to read this manual

This manual is designed to be read from beginning to end. We recommend that you read it thoroughly before using the PFX2400 Series Capacitor Tester for the first time.

Related manuals

The Capacitor Performance Checker 2400 application controls the PFX2400 Series Capacitor Tester. For details about the software and how to use it, see the software application setup guide and help.

Intended readers of this manual

This manual is intended for users of the PFX2400 Series Capacitor Tester and their instructors.

Explanations are given under the presumption that the reader has knowledge about charge and discharge tests of capacitors.

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The specifications of this product and the contents of this manual are subject to change without prior notice.

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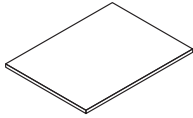
Checking the Package Contents

When you receive the product, check that all accessories are included and that the accessories have not been damaged during transportation.

If any of the accessories are damaged or missing, contact your Kikusui agent or distributor.

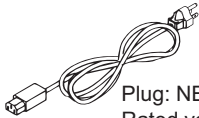
We recommend that all packing materials be saved, in case the product needs to be transported at a later date.

Common Accessories



- Operation manual (this manual; 1 pc.) [Z1-005-202]

PFX2411 Accessories

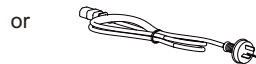


Plug: NEMA5-15
Rated voltage: 125 V
[85-10-0740]

May change depending on the shipment destination.

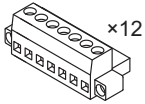


Plug: CEE7/7
Rated voltage: 250 V
[85-10-0840]



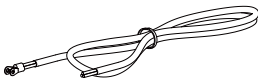
Plug: GB1002
Rated voltage: 250 V
[85-10-0790]

- Power cord (1 pc.)

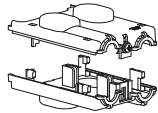


- OUTPUT connectors (12 pcs.) [84-61-5207]

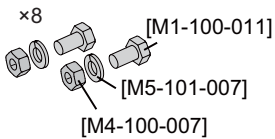
PFX2421 Accessories



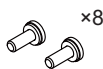
- Power cord (1 pc.) (no plug) [85-10-0630]



- OUTPUT terminal covers (4 pairs) [Q1-500-077]

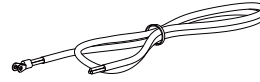


- M8 OUTPUT terminal screws (8 pairs)

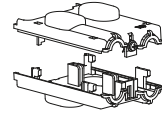


- M4 OUTPUT terminal screws (8 pcs.) [M3-112-026]

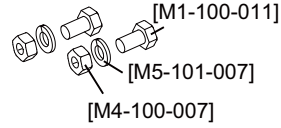
PFX2431 Accessories



- Power cord (1 pc.) (no plug) [85-10-0630]



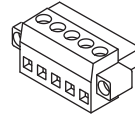
- OUTPUT terminal covers (2 pairs) [Q1-500-077]



- M8 OUTPUT terminal screws (4 pairs)

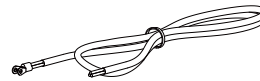


- M4 OUTPUT terminal screws (4 pcs.) [M3-112-026]

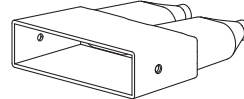


- Sensing connector (2 pcs.) [84-61-7705]

PFX2441 Accessories



- Power cord (1 pc.) (no plug) [85-10-0630]

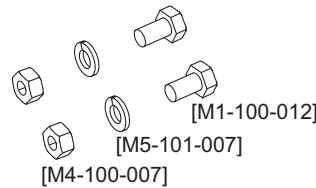


[Q1-500-085]



[P2-000-228]

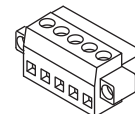
- OUTPUT terminal covers (1 pc.)
Lock plate (2 pcs.)



- M8 OUTPUT terminal screws (2 pairs)



- M4 OUTPUT terminal screws (2 pcs.) [M3-112-026]



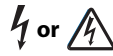
- Sensing connector (1 pc.) [84-61-7705]

Features

- **High reliability**
High reliability has been accomplished through the application of Kikusui's proven power supply circuit designs and the use of long service-life components such as semiconductor switches (in place of mechanical relays).
- **High resolution and high accuracy**
The PFX2400 Series uses 16-bit D/A converters (for setting the voltage and current used in testing) and 24-bit A/D converters (for measuring voltage and current). These ensure high resolution and high accuracy.
- **Complete software calibration**
The PFX2400 Series only uses variable resistors to adjust H OVP and H UVP. All adjustments are performed through software calibration, making adjustments during maintenance easy. This improves reliability.
- **High versatility through the use of dedicated software**
16 steps of charge and discharge patterns can be combined to create 1 cycle stage (up to 16 stages can be created). Each step consists of four parts, and each part consists of four phases. Each phase can be set to charge, discharge, or pause. The PFX2400 Series repeats up to 16 stages that you select to perform tests.
- **Independent channel operation**
All channels operate independently. This enables electric double layer capacitors with different characteristics to be mixed in a test. The PFX2400 Series also has a synchronization feature that extends rest times by taking heat chamber synchronization into account.
- **LAN ready**
Equipped with a LAN interface, the PFX2400 Series provides high-speed data transfers.
- **Energy efficient design**
The internal DC power supply switching system reduces power consumption.
- **Wide range of AC input**
The PFX2400 Series runs on AC input power in the range of 100 Vac to 240 Vac. It can be used anywhere from factories to test benches.

Safety Markings

For the safe use and safe maintenance of this product, the following symbols are used throughout this manual and on the product. Note the meaning of each of the symbols to ensure the safe use of the product. (Not all symbols may be used.)



Indicates that a high voltage (over 1000 V) is used here. Touching the part without taking proper precautions may cause a fatal or serious electric shock. If you must touch an area marked with this symbol, ensure that the area is safe before you do so.

DANGER

Indicates an imminently hazardous situation which, if ignored, will result in death or serious injury.



WARNING

Indicates a potentially hazardous situation which, if ignored, could result in death or serious injury.



CAUTION

Indicates a potentially hazardous situation which, if ignored, may result in damage to the product and other property.



Indicates a prohibited act.



Indicates a warning, caution, or danger. When this symbol appears on the product, see the relevant section in this manual.



Indicates a part that becomes hot.

Refer to the relevant sections in this manual for information about the parts of the product that are marked with this symbol.



Protective conductor terminal.



Chassis (frame) terminal.



On (supply)



Off (supply)



In position of a bi-stable push control.



Out position of a bi-stable push control.



Safety Precautions

You must observe the following safety precautions to avoid fire hazards, electric shock, accidents, and device failures. Keep them in mind and make sure to observe them.

Using the product in a manner that is not specified in this manual may impair the protective features provided by the product.



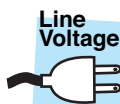
Users

- This product must be used only by qualified personnel who understand the contents of this operation manual.
- If unqualified personnel are to use the product, be sure the product is handled under the supervision of qualified personnel (those who have electrical knowledge). This is to prevent the possibility of personal injury.



Purpose of use

- Never use the product for purposes other than the product's intended use.
- This product is not designed or manufactured for general home or consumer use.



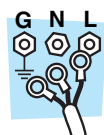
Input power

- Always use the product within the rated input line voltage range.
- Use the power cord provided to supply power. For details, see the applicable page in this manual.
- This product is a piece of equipment that conforms to IEC Overvoltage Category II (energy-consuming equipment that is supplied from a fixed installation).



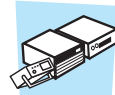
Cover

- Some parts inside the product are hazardous. Do not remove the external cover.



Grounding

- This product is a piece of equipment that conforms to IEC Safety Class I (equipment that has a protective conductor terminal). To prevent the possibility of electric shock, be sure to connect the protective conductor terminal of the product to electrical ground (safety ground).



Installation

- This product is designed for safe indoor use. Be sure to use the product indoors.
- When installing this product, be sure to observe the precautions regarding the installation location. For details, see the respective page in this manual.



Operation

- Before using this product, visually check for problems in the power cord and cables. When checking for these problems, remove the power cord plug from the outlet.
- If you notice a malfunction or abnormality in the product, stop using it immediately, and remove the power cord plug from the outlet. Make sure the product is not used until it is completely repaired.
- Do not disassemble or modify the product. If you need to modify the product, contact your Kikusui agent or distributor.



Maintenance, Inspection and Calibration

- To maintain the performance and safe operation of the product, it is recommended that periodic maintenance, inspection, and cleaning be performed.
- To prevent the possibility of electric shock, remove the power plug from the outlet or turn off the circuit breaker of distribution before carrying out maintenance or inspection.
- Check periodically that there are no tears or breaks in the power cord.
- If the panel needs cleaning, gently wipe it using a soft cloth with water-diluted neutral detergent. Do not use volatile chemicals such as benzene or thinner.
- This product is calibrated before shipment. To maintain the product's performance, we recommend periodic calibration. To have your product calibrated, contact your Kikusui agent/distributor.



Service

- Kikusui service engineers will perform internal service on the product. If the product needs adjustment or repairs, contact your Kikusui distributor/agent.

Precautions about the Installation Location

Be sure to observe the following precautions when installing the product.

- Do not use the product in a flammable atmosphere.
To prevent the possibility of explosion or fire, do not use the product near alcohol, thinner, or other combustible materials or in an atmosphere containing such vapors.
- Avoid locations where the product is exposed to high temperatures or direct sunlight.
Do not install the product near a heater or in areas subject to drastic temperature changes.
Operating temperature range: 0 °C to +40 °C
Storage temperature range: -20 °C to +60 °C
- Avoid humid environments.
Do not install the product in high-humidity locations, such as near a boiler, humidifier, or water supply.
Operating humidity range: 20 %rh to 85 %rh (no condensation)
Storage humidity range: Up to 90 %rh (no condensation)
Condensation may form even within the operating humidity range. If condensation forms, wait for the product to dry completely before you use it.
- Use Indoors
This product is designed for safe indoor use.
- Provide adequate space around the power cord plug.
Do not insert the power cord plug into an outlet that is not easily accessible. Do not place objects near the power cord plug that would make it difficult to access.
- Do not install the product in a corrosive atmosphere.
Do not install the product in a corrosive atmosphere or in environments that contain a high concentration of sulfuric acid mist. Doing so may cause corrosion of various conductors or reduce the quality of the connector contacts inside the product, and this could lead to malfunction, failure, and possibly fire.
- Do not install the product in a dusty location.
Dust accumulation can lead to electric shock or fire.
- Do not use the product in a poorly ventilated location.
Secure adequate space around the product so that air can circulate around it. Hot air is expelled from the outlet hole. Do not place objects that are affected by heat near the air outlet.
- Do not place objects on top of the product.
Placing heavy objects on top of the product may cause it to malfunction.
- Do not install the product on an inclined surface or in a location subject to vibrations.
The product may fall or tip over and cause damage and injury.
- Do not use the product in a location subject to strong magnetic or electric fields or in a location where the input power supply signal contains large amounts of distortion or noise. Doing so may cause the product to malfunction.
- Do not use the product near highly sensitive measuring instruments or receivers.
The noise generated by the product may affect these other devices.
- Use the product in an industrial environment.
This product may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

Precautions for Moving the Product

Note the following points when moving the product to the installation location or when transporting the product.

- Turn the POWER switch off.
Moving the product with the POWER switch turned on may cause electric shock or damage to the product.
- Remove all wiring.
Moving the product with the cables connected may cause wires to break or injuries due to the product falling over.
- When transporting the product, be sure to use the original packing materials.
Otherwise, damage may result from vibrations or from the product falling during transportation.
- The product weighs over 20 kg. Do not move the product alone. The weight of the product is indicated on the rear panel and also in the specifications of this manual.
- Be sure to include this manual.

Notations Used in This Manual

- In this manual, the PFX2400 Capacitor Tester may be referred to as the "PFX2400 Series," the "PFX2411," the "PFX2421," the "PFX2431," or the "PFX2441."
- In this manual, the Capacitor Performance Checker 2400 application software is sometimes referred to as "CPChecker2400."
- The term "PC" is used to refer generally to both personal computers and workstations.
- The following markings are used in the explanations in the text.

WARNING

Indicates a potentially hazardous situation which, if ignored, could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation which, if ignored, may result in damage to the product or other property.

NOTE

Indicates information that you should know.

See

Indicates a reference to detailed information.

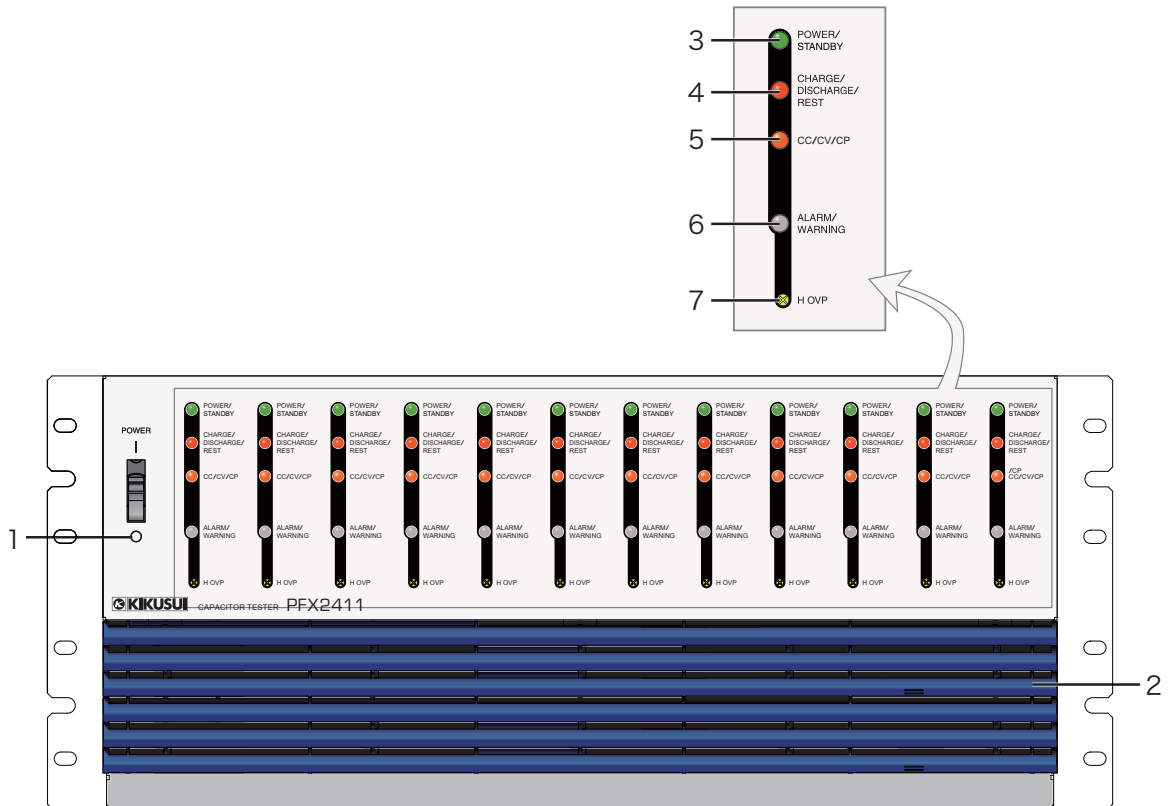
Memo

Indicates useful information.

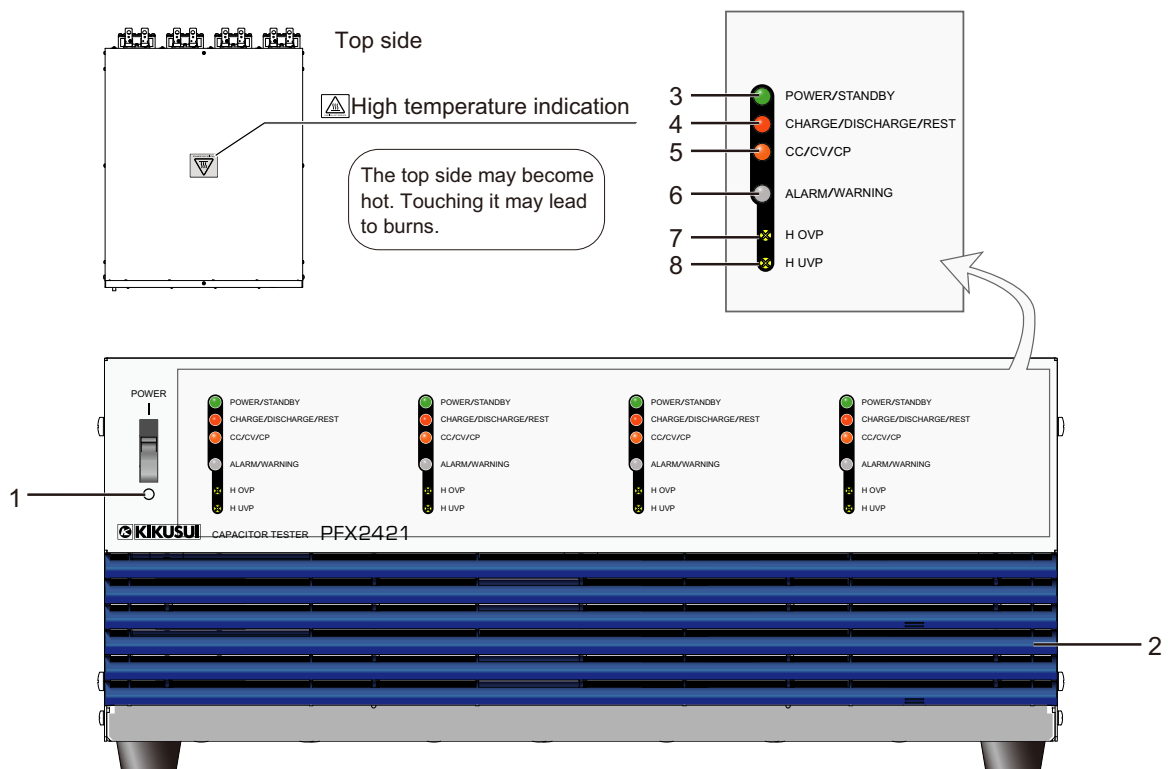
Front panel

Each channel has indicator LEDs, an H OVP variable resistor, and an H UVP variable resistor (only on the PFX2421, PFX2431 and PFX2441).

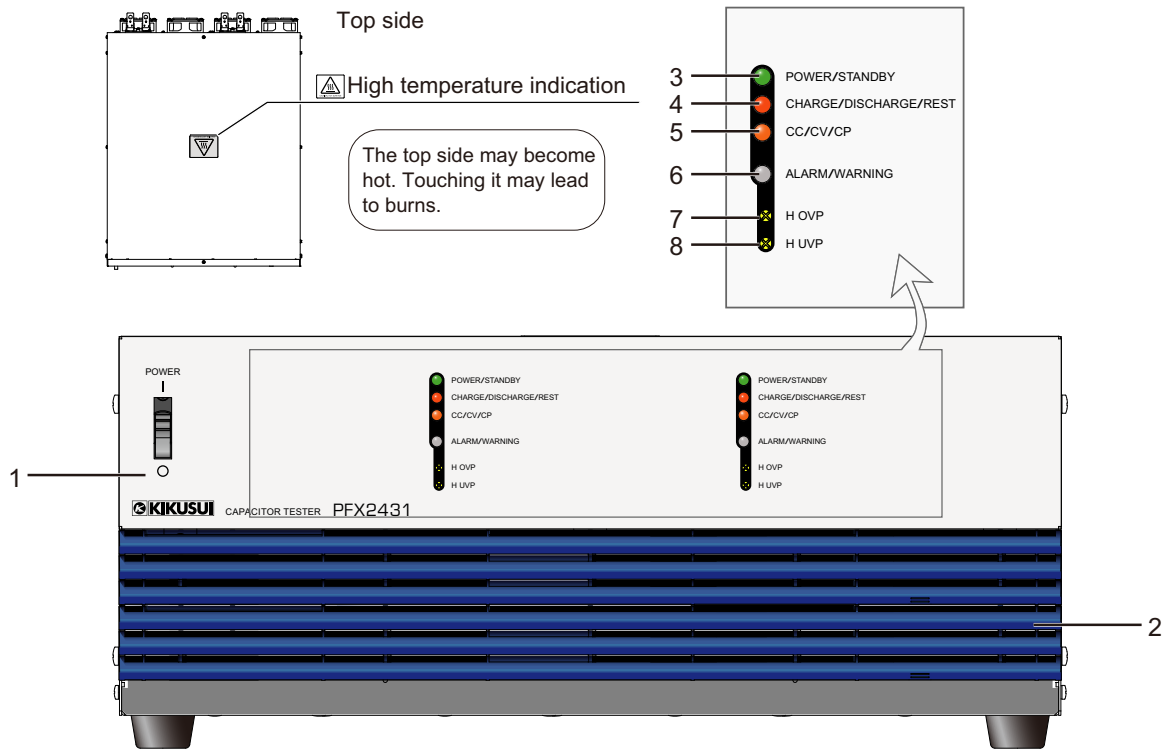
PFX2411



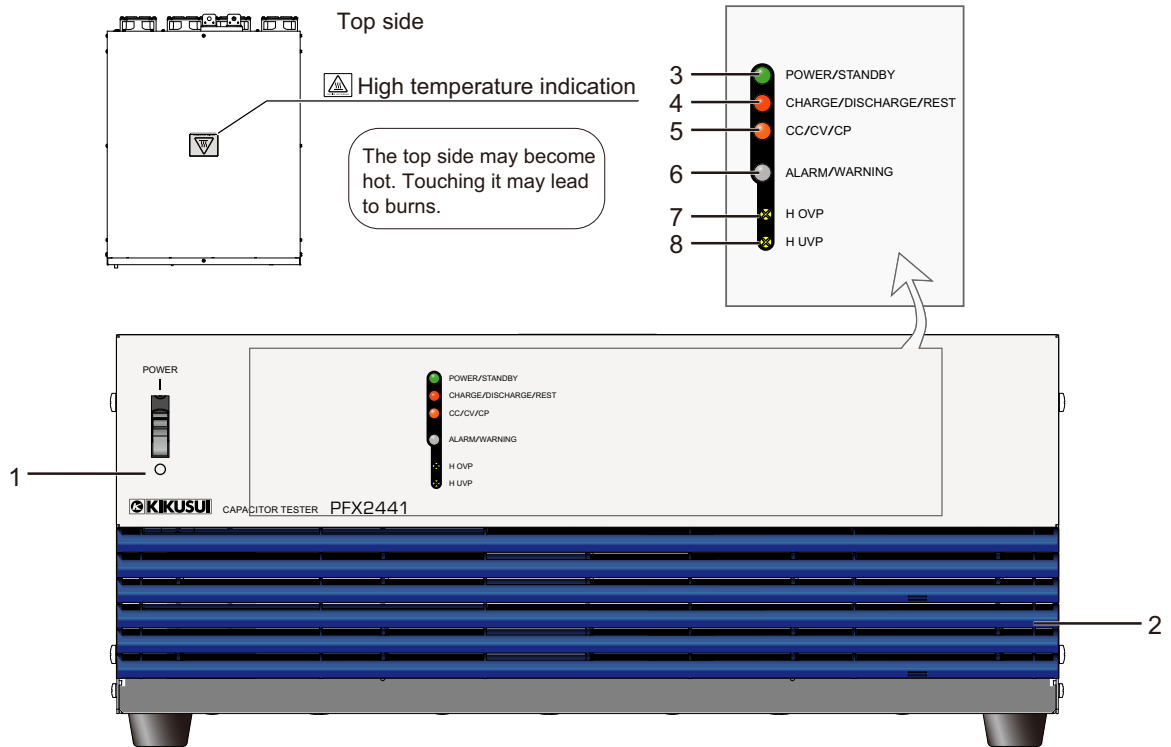
PFX2421




PFX2431



PFX2421

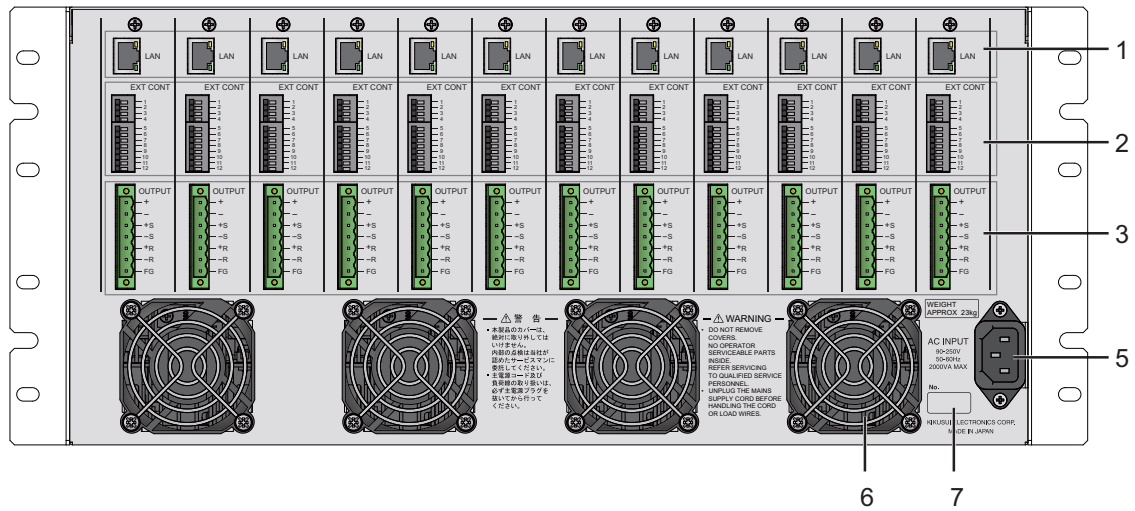


No.	Name	Function	
1	POWER switch	Turns the power on and off	<i>p.33</i>
2	Air inlet (louver)	Inlet for internal cooling	–
3	POWER/STANDBY LED	Lights in green when tests can be executed and in orange when the PFX2400 Series is in standby mode	<i>p.34</i>
4	CHARGE/DISCHARGE/REST LED	Lights in red to indicate charging, in green to indicate discharging, and in orange to indicate resting	<i>p.34</i>
5	CC/CV/CP LED	Lights in red in constant current mode, in green in constant voltage mode, and in orange in constant power mode	<i>p.34</i>
6	ALARM/WARNING LED	Lights in red to indicate alarm detection and in orange to indicate an error in the parameter settings	<i>p.34</i>
7	H OVP variable resistor	For adjusting the limit for activating the hardware overvoltage (overcharge) protection	<i>p.34</i>
8	H UVP variable resistor	For adjusting the limit for activating the hardware undervoltage (overdischarge) protection	<i>p.34</i>

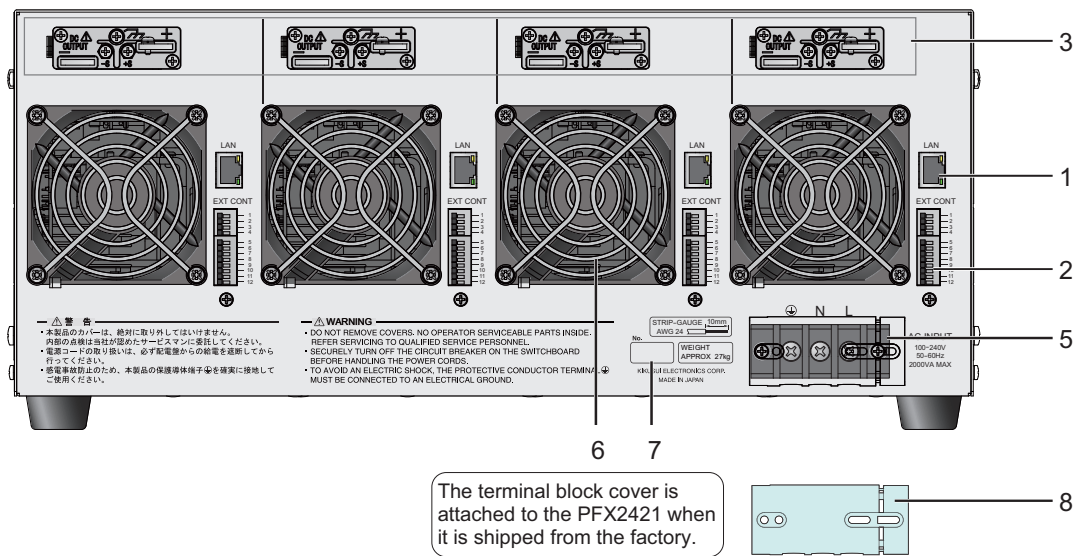
Rear panel

Each channel has a LAN connector, an EXT CONT terminal block, and an OUTPUT connector or terminal block.

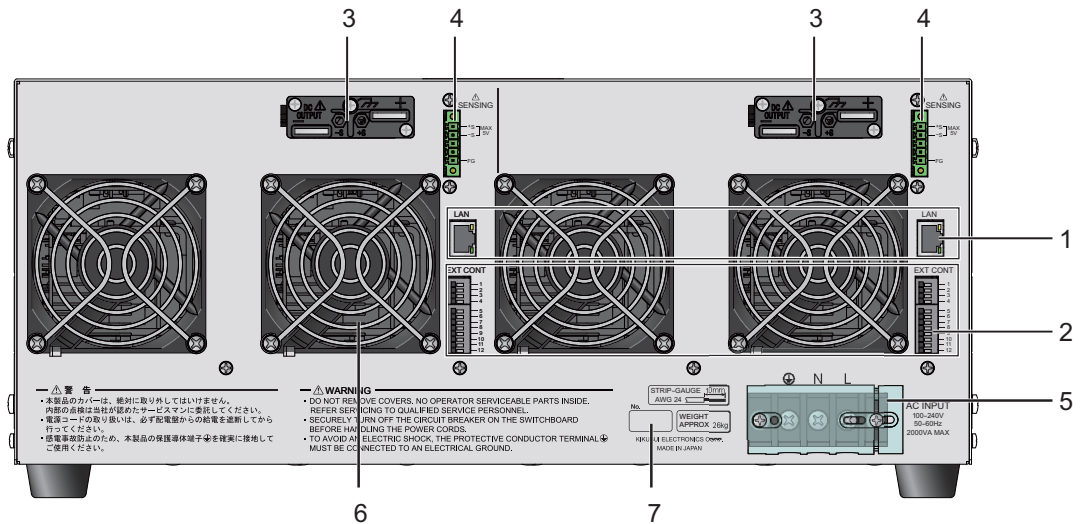
PFX2411



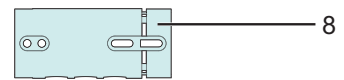
PFX2421



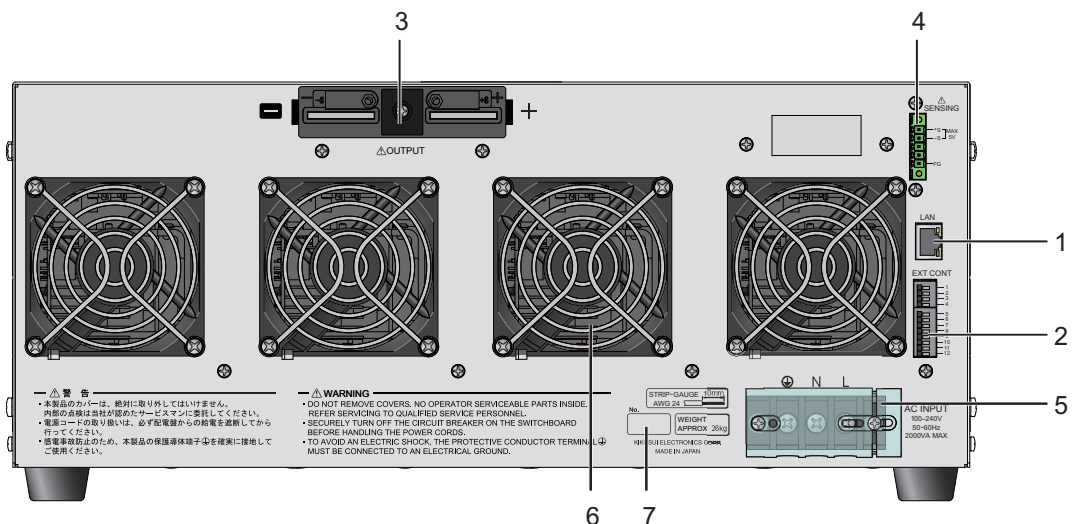
PFX2431



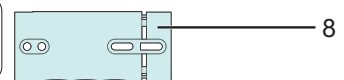
The terminal block cover is attached to the PFX2421 when it is shipped from the factory.



PFX2421



The terminal block cover is attached to the PFX2421 when it is shipped from the factory.



No.	Name	Function	See
1	LAN	For connecting the PFX2400 Series to a PC (switching hub)	p.16
2	EXT CONT	External alarm input connector	p.37
3	OUTPUT	PFX2411: Output cable connectors PFX2421: Voltage sensing wire and current wire terminal blocks PFX2431 and PFX2441: Current wire terminal blocks	p.25
4	SENSING	PFX2431 and PFX2441: Voltage sensing wire connectors	
5	AC INPUT	PFX2411: AC inlet PFX2421, PFX2431 and PFX2441: Terminal blocks	p.12
6	Air outlet	Vent for cooling the PFX2400 Series	-
7	Serial number	-	-
8	Terminal block cover	-	p.14

1 Installation and Preparation

This chapter describes how to unpack and prepare this product before you use it.

Connecting the Power Cord

The power cord provided with the PFX2400 Series varies depending on the model. This product is a piece of equipment that conforms to IEC Overvoltage Category II (energy-consuming equipment that is supplied from a fixed installation).



To avoid electric shock:

- **This product is a piece of equipment that conforms to IEC Safety Class I (equipment that has a protective conductor terminal). Be sure to earth ground the product to prevent electric shock.**
 - **The product is grounded through the power cord ground wire. Connect the protective conductor terminal to earth ground.**
-

PFX2411

NOTE

- Use the supplied power cord to connect to the AC line. If the supplied power cord cannot be used due to the rated voltage or the plug shape, have a qualified engineer replace it with an appropriate power cord that is 3 m or shorter. If obtaining a power cord is difficult, contact your Kikusui agent or distributor.
- The power cord with a plug can be used to disconnect the PFX2411 from the AC line in an emergency. Connect the plug to an easily accessible power outlet so that the plug can be removed from the outlet at any time. Be sure to allow enough space around the power outlet.
- Do not use the supplied power cord on other instruments.

1 Check that the AC power supply meets the nominal input rating of the product.

The product can receive a nominal line voltage in the range of 100 Vac to 240 Vac at 50 Hz or 60 Hz.

2 Check that the POWER switch is turned off.

3 Connect the power cord to the rear-panel AC INPUT.

4 Insert the power plug into a grounded outlet.

PFX2421, PFX2431 and PFX2441



WARNING To avoid electric shock:

- Before connecting the PFX2421, turn off the distribution board's circuit breaker (the switch that cuts off the power from the distribution board).

To prevent fire:

- Only allow a specialized technician to connect the PFX2421 to a distribution board.
- The distribution board circuit breaker must meet the following requirements.



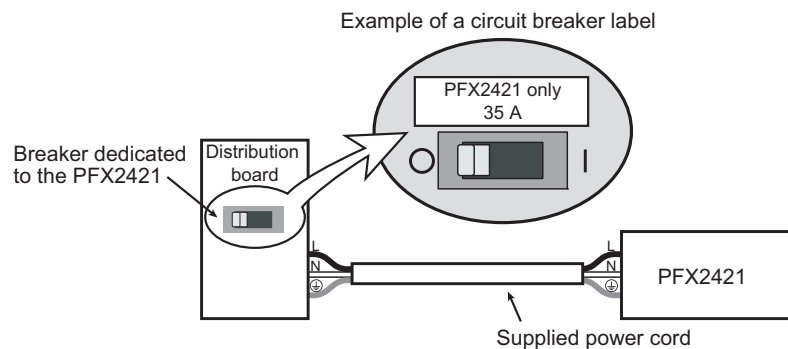
CAUTION Inside the product, the protective circuits are connected to match the polarities of the input terminals. Make sure that between the distribution board and the PFX2421, the L, N, and ⊕ (GND) wires are all connected to the correct input terminals.



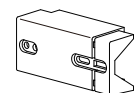
To disconnect the PFX2421 from the AC line in an emergency, turn off the distribution board's circuit breaker.

■ Requirements for the distribution board's circuit breaker

- Rated current: 35 A (for safety, circuit breakers whose rated current is more than 35 A cannot be used)
- Only use the circuit breaker for the PFX2421.
- Keep the circuit breaker easily accessible at all times.
- Label the circuit breaker to indicate that it is only for disconnecting the PFX2421 from the AC line.



The AC INPUT terminal block has a terminal block cover attached to it when the PFX2421 is shipped from the factory. The purpose of the cover is to prevent people from unintentionally touching the terminals. If it is damaged or lost, contact your Kikusui agent or distributor.



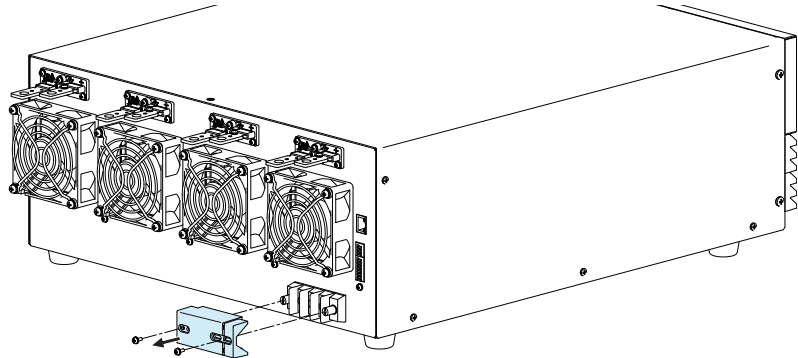
[Q5-000-159]

- The procedure for connecting the power cord is the same on the PFX2421, PFX2431, and PFX2441. The PFX2421 is shown in the following explanatory diagrams.

1 Check whether the AC power line is compatible with the input rating of the product.

The product can receive a nominal line voltage in the range of 100 Vac to 240 Vac at 50 Hz or 60 Hz.

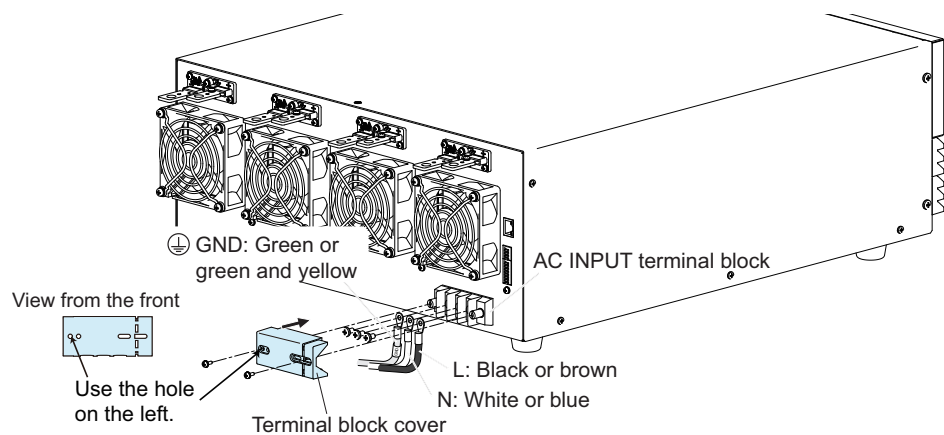
- 2 Check that the **POWER** switch is turned off.
- 3 Remove the terminal block cover of the **AC INPUT** terminal block.



- 4 Securely connect the power cable wires to match the **L**, **N**, and \oplus (**GND**) terminals in the **AC INPUT** terminal block.

- 5 Put the terminal block cover that you removed in step 3 back onto the terminal block.

Use the hole on the left side to attach the terminal block cover.



- 6 Attach appropriate crimp terminals to the distribution board end of the power cable.

The supplied power cable comes with crimp terminals on the side that connects to the PFX2421, but the cable does not come with any terminals on the side that connects to a distribution board. Attach the crimp or other terminals that are appropriate for the screws of the distribution board that you will be connecting to, and securely connect the cable. Only a specialized technician should connect the cable.

- 7 Turn off the distribution board's circuit breaker.

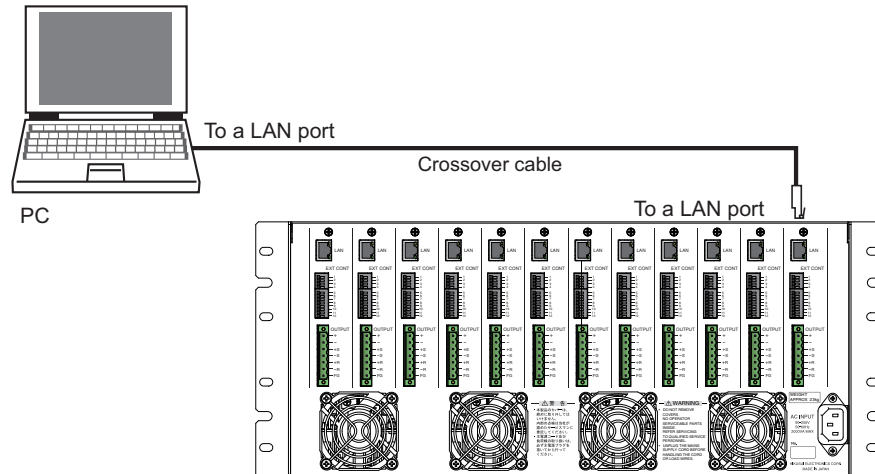
- 8 Connect the power cable wires to the appropriate **L**, **N**, and \oplus (**GND**) terminals on the distribution board.

Connecting the PFX2400 Series to a PC

Connect the PFX2400 Series to a PC, and assign IP addresses to the PFX2400 Series channels.

■ Connecting the PFX2400 Series directly to a PC (to use only one channel)

If you only need to use one channel, you can connect the PFX2400 Series directly to a PC using a crossover LAN cable.

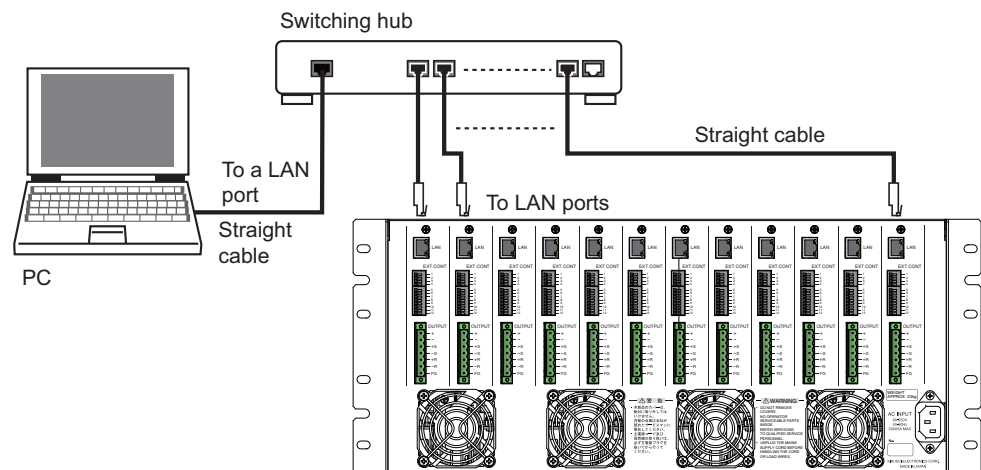


Example with the PFX2411

■ Connecting the PFX2400 Series to a PC through a switching hub (to use multiple channels)

To use multiple channels, you must connect the PFX2400 Series to a PC through a switching hub using straight LAN cables.

You can also connect another PC on the same LAN. Be sure to assign different IP addresses to the PFX2400 Series and each PC on the LAN.



Example with the PFX2411

Configuring the PFX2400 Series (IP addresses and channel numbers)

By factory default, IP addresses are assigned to the PFX2400 Series.

- PFX2411 192.168.10.1 to 192.168.10.12
- PFX2421 192.168.10.1 to 192.168.10.4
- PFX2431 192.168.10.1 to 192.168.10.2
- PFX2441 192.168.10.1

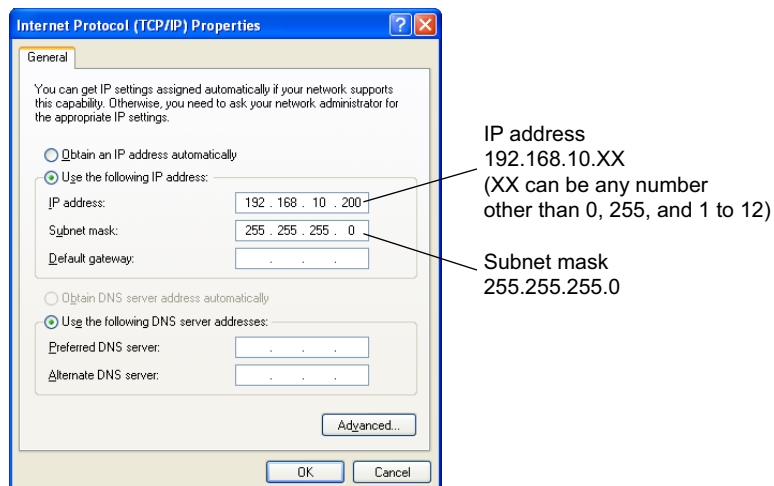
All channel numbers are 0. You can change the IP address and channel numbers by using the IP Configuration Tool application on the CD-ROM that comes with CPChecker2400. For details, see the IP Configuration Tool help.

Setting the PC's IP address

You must set the PC's IP address and subnet mask according to the PFX2400 Series's IP addresses. If the PC's IP address and subnet mask are not set correctly, you cannot connect to the PFX2400 Series.

- 1** [Windows XP] On the taskbar, click Start > Control Panel > Network Connections.
[Windows 7] On the taskbar, click Start > Control Panel > Network and Internet, View network status and tasks.
- 2** Double-click Local Area Connection, and click Properties.
- 3** [Windows XP] Select Internet Protocol (TCP/IP), and click Properties.
[Windows 7] Select Internet Protocol Version 4 (TCP/IPv4), and click Properties.
- 4** Select the Use the following IP address option.
- 5** Type the IP address and subnet mask.

To connect to a PFX2400 Series tester, set the IP address and subnet mask of the PC as indicated below.



Preparing to Connect the DUTs (Capacitors)

The PFX2400 Series does not come with output cables for connecting to the DUTs (capacitors). Prepare an output cable that matches the DUT (capacitor). Construct as many output cables as you need for the channels that you are going to use.

■ Types of DUTs (capacitors) that can be connected To

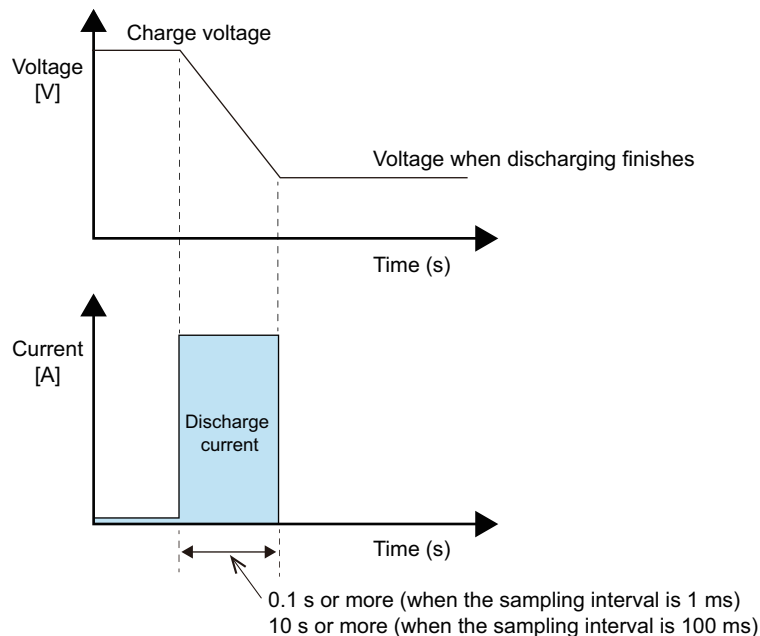
Connect to a DUT (capacitor) with the following capacitance.

	PFX2411	PFX2421	PFX2431	PFX2441
Capacitance	0.1 F or more	0.5 F or more	1 F or more	2 F or more

■ Setting the test conditions

When sampling data at 1 ms intervals, set the discharge current in accordance with the capacitance of the DUT (capacitor) so that the time between when discharging starts and when it finishes is 0.1 s or more.

When sampling data at 100 ms intervals, set the discharge current in accordance with the capacitance of the DUT (capacitor) so that the time between when discharging starts and when it finishes is 10 s or more.



Output cables



WARNING

To prevent fire:

- Use output cables whose capacity is adequate for the PFX2400 Series's rated output current.

To avoid electric shock:

- Use output cables whose rated voltage meets or exceeds the PFX2400 Series's isolation voltage. For information about the PFX2400 Series's isolation voltage, see Chapter 3, "Specifications".

■ Current capacity of output cables

If you use output cables whose capacity meets or exceeds the rated output current, even if the DUT (capacitor) is shorted, the cables will not be damaged. The cables that you use must have a current capacity that allows the PFX2400 Series's rated output current to flow.

■ **The cables' allowable current depends on the insulation's maximum allowable temperature.**

A cable's temperature is determined by the resistive loss based on the current, the ambient temperature, and the cable's external thermal resistance. The following table shows the current capacity of a single heat-resistant vinyl wire that has a maximum allowable temperature of 60 °C when the wire is stretched out horizontally in air in an ambient temperature of 30 °C. The current capacity must be reduced under certain conditions, such as when vinyl cables that have a low heat resistance are used, when the ambient temperature is 30 °C or greater, or when cables are bundled together and little heat is radiated.

■ **Nominal cross-sectional area and current capacity for wires (reference)**

Nominal cross-sectional area [mm ²]	AWG	(Reference cross-sectional area) [mm ²]	Current capacity ¹ [A] (Ta = 30 °C)	Kikusui-recommended current [A]
2	14	(2.08)	27	10
3.5	12	(3.31)	37	-
5.5	10	(5.26)	49	20
8	8	(8.37)	61	30
14	6	(13.3)	88	50
22	4	(21.15)	115	80
30	2	(33.62)	139	-
38	1	(42.41)	162	100
50	1/0	(53.49)	190	-
60	2/0	(67.43)	217	-
80	3/0	(85.01)	257	200
100	4/0	(107.2)	298	-
125	-	-	344	-
150	-	-	395	300
200	-	-	469	400

1 Taken from Japanese laws related to electrical equipment.

■ **Taking noise reduction measures into consideration**

When you use wires with the same heat resistance, you can increase current capacity by separating the wires as much as possible and allowing them to release heat. However, keeping the positive and negative load output wires next to each other or bundling them together is an effective means of reducing unwanted noise. The Kikusui-recommended current is a reduced value that assumes that you will bundle the load wires. Use it as a guide for your wiring.

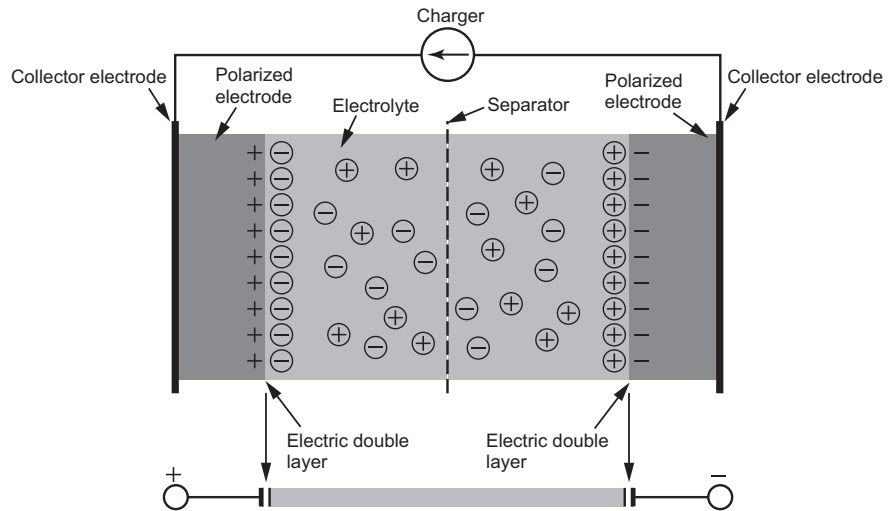
■ **Limits of the sensing feature**

Wires have resistance. A longer wire with more current flowing through it results in a greater voltage drop in the wire and a lower load-end voltage. The PFX2400 Series has a sensing feature that compensates for a one-way voltage drop of up to approximately 0.6 V. If you experience a voltage drop greater than this, use wires with larger cross-sectional areas.

■ **Measuring the reference electrode voltage of an electric double-layer capacitor (PFX2411 only)**

An electric double layer is a thin membrane that naturally forms between an electrolyte and a conductor. The membrane is one molecule thick.

Electric double layer capacitors are storage devices that are created when a pair of conductors is immersed in an electrolyte and positive and negative voltages are applied to the conductors. The structure of an electric double layer capacitor is essentially two capacitors that are connected in series across the electrolyte.



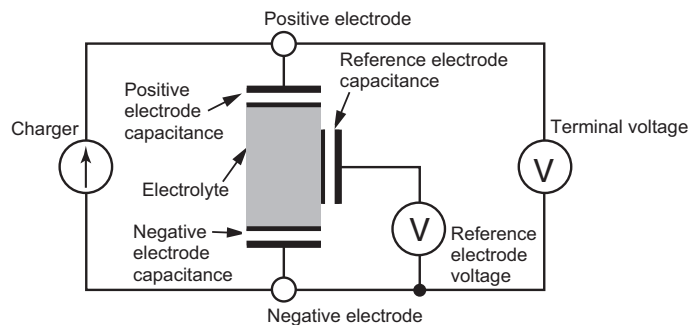
Charges are stored in the series capacitors. When the capacitors begin to store charges beyond a given voltage, the electrolyte starts to electrolyze. Therefore, electric double layer capacitors can be used as storage devices below a given voltage. The capacitance is determined by the product of the electrostatic capacitance and the square of the storage voltage.

The dielectric strength is determined by the characteristics of the polarized electrodes and the electrolyte. Even when the same polarized electrodes are used, there is a difference in the electrostatic capacitance between the positive and negative electrodes. Because of this difference, there is a difference between the charge voltage of the positive electrode and that of the negative electrode.

When there is a difference in the charge voltages, the capacitor's maximum charge voltage is the voltage at which electrolysis occurs in the electrode with the highest voltage. Even if the other electrode can still be charged, the capacitor can no longer be charged. This means that the electric double layer's electrostatic capacitance is not being used effectively.

If this happens, you need to check the electrolyte potentials of the positive and negative electrodes.

To do so, you would add another capacitor (reference electrode capacitance) to the electric double layer capacitor, and measure the potential across the reference electrode capacitance by using a high input impedance voltmeter.



If the reference electrode capacitance is not charged and the input impedance of the voltmeter that is used to measure the electrode potential is sufficiently high, the reference electrode capacitance will not be charged. Because the charge voltage of the reference electrode capacitance is 0 V, the electrode potential is equal to the electrolyte potential. This potential is the reference electrode voltage. In the above figure, the reference electrode voltage is measured with the negative electrode as the reference. You can also measure the voltage with the positive electrode as the reference.

PFX2411 output cables

See p. 32

Kikusui offers an optional output cable (TL20-PFX). The wiring necessary for connection is already assembled in the cable. This makes connecting easy and reduces the wiring time. For more details, contact your Kikusui agent or distributor.

■ Wires and tools that are necessary for connection

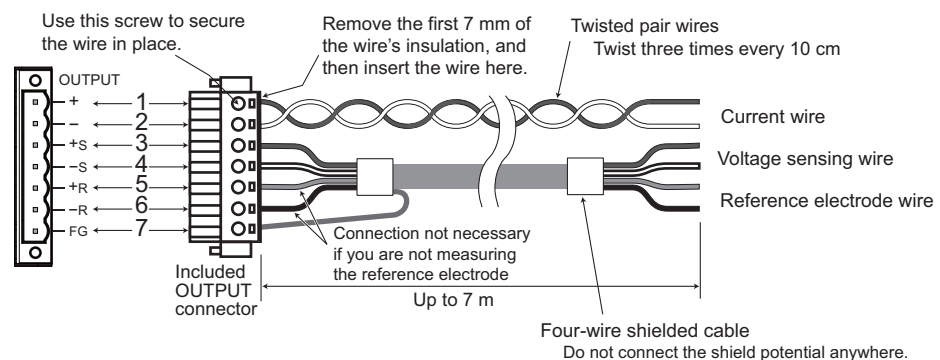
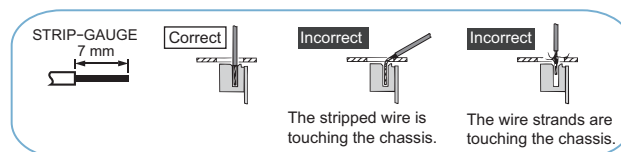
Use a four-wire shielded cable when you want to measure reference electrode voltages. Otherwise, you can use a two-wire shielded cable.

Current wires (twisted)	1.25 mm ² (AWG16), up to 7 m in length, twisted approximately three times every 10 cm
Voltage sensing wires	Two-wire shielded cable, 0.20 mm ² (AWG24), up to 7 m in length Four-wire shielded cable (when measuring reference electrode voltages), 0.20 mm ² (AWG24), up to 7 m in length
Flat-blade screwdriver	Shaft diameter: 3 mm, blade width: 2.6 mm
Wire stripper	A wire stripper that matches the wires listed above

■ Constructing output cables

Pin Number	Symbol	Description	
1	+	Current pin	Connect to the DUT's positive terminal.
2	-		Connect to the DUT's negative terminal.
3	+S	Voltage pin	Connect to the DUT's positive terminal.
4	-S		Connect to the DUT's negative terminal.
5	+R	Reference electrode pin (connect only when measuring the reference electrode voltage)	Connect to the DUT's positive reference electrode terminal.
6	-R		Connect to the DUT's negative terminal.
7	FG	Shield ground pin	This is connected to the PFX2411 chassis. Do not connect the shield potential to anywhere on the DUT.

Using the supplied output connectors and the wires that you have prepared, construct output cables. For each wire, strip 7 mm of coating, and securely screw the wire to the connector so that the wire does not come loose.



PFX2421 output cables

See p. 32

Kikusui offers an optional output cable (TL21-PFX). The wiring necessary for connection is already assembled in the cable. This makes connecting easy and reduces the wiring time. For more details, contact your Kikusui agent or distributor.

■ Wires and tools that are necessary for connection

Current wires (twisted)	22 mm ² (AWG4), up to 5 m in length
Voltage sensing wires	Two-wire shielded cable, 0.20 mm ² (AWG24), up to 5 m in length
Wire stripper	A wire stripper that matches the wires listed above

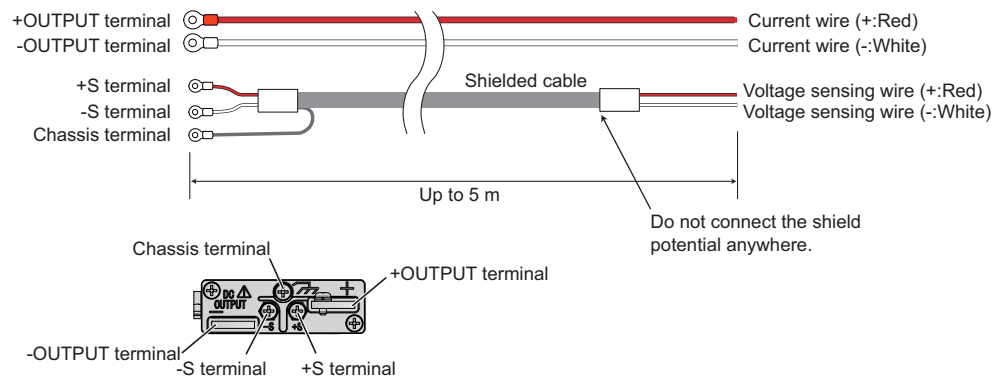
■ Constructing output cables

1 Attach crimp terminals to the current wires.

The rear panel OUTPUT terminals have M4 holes (with taps) and $\phi 8.5$ holes for connecting the current wires. Attach crimp terminals that match the bolts you are using. Use crimp terminals that are 5.5 mm² or smaller for the M4 holes.

2 Attach M3 crimp terminals to the voltage sensing wires.

The voltage sensing wires should be in a two-wire shielded cable.



PFX2431 output cables

See p. 32

Kikusui offers an optional output cable (TL22-PFX). The wiring necessary for connection is already assembled in the cable. This makes connecting easy and reduces the wiring time. For more details, contact your Kikusui agent or distributor.

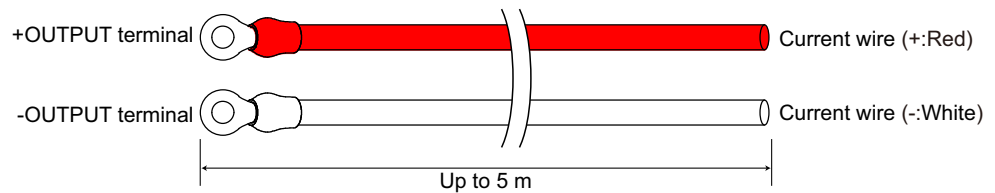
Wires and tools that are necessary for connection

Current wires (twisted)	22 mm ² (AWG4), up to 5 m in length
Voltage sensing wires	Two-wire shielded cable, 0.20 mm ² (AWG24), up to 5 m in length
Flat-blade screwdriver	Shaft diameter: 3 mm, blade width: 2.6 mm
Wire stripper	A wire stripper that matches the wires listed above

Constructing output cables

1 Attach crimp terminals to the current wires.

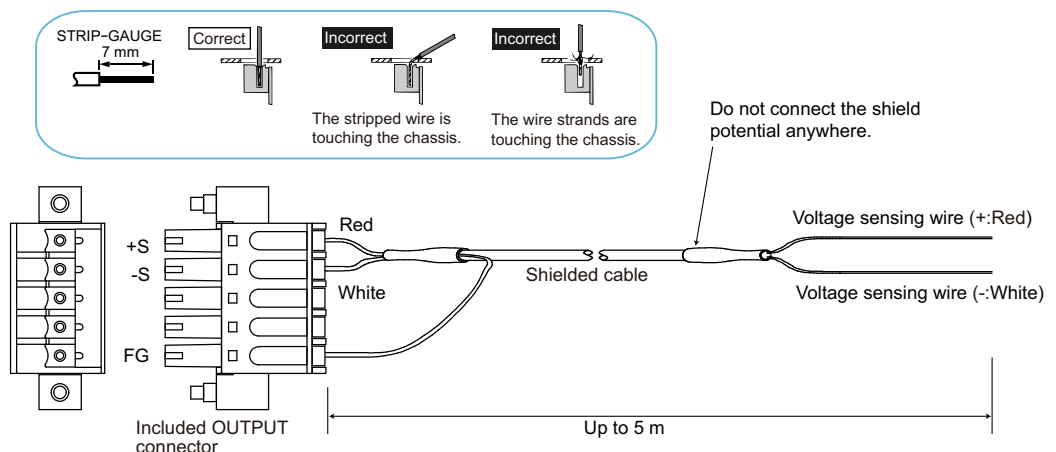
The rear panel OUTPUT terminals have M4 holes (with taps) and $\phi 8.5$ holes for connecting the current wires. Attach crimp terminals that match the bolts you are using. Use crimp terminals that are 5.5 mm² or smaller for the M4 holes.



2 Attach M3 crimp terminals to the voltage sensing wires.

The voltage sensing wires should be in a two-wire shielded cable. For each wire, strip 7 mm of coating, and securely screw the wire to the connector so that the wire does not come loose.

Pin Number	Symbol	Description	
1	+S	Voltage pin	Connect to the DUT's positive terminal.
2	-S		Connect to the DUT's negative terminal.
5	FG	Shield ground pin	This is connected to the PFX2431 chassis. Do not connect the shield potential to anywhere on the DUT.



PFX2441 output cables

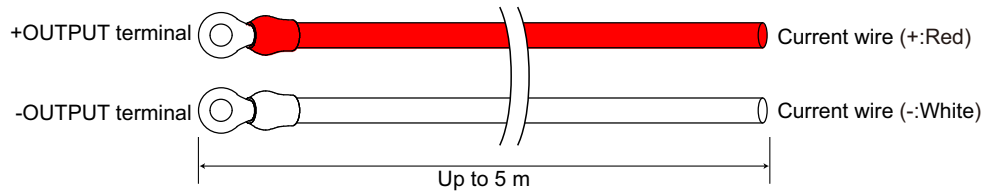
■ Wires and tools that are necessary for connection

Current wires (twisted)	38 mm ² (AWG1), up to 5 m in length
Voltage sensing wires	Two-wire shielded cable, 0.20 mm ² (AWG24), up to 5 m in length
Flat-blade screwdriver	Shaft diameter: 3 mm, blade width: 2.6 mm
Wire stripper	A wire stripper that matches the wires listed above

■ Constructing output cables

1 Attach crimp terminals to the current wires.

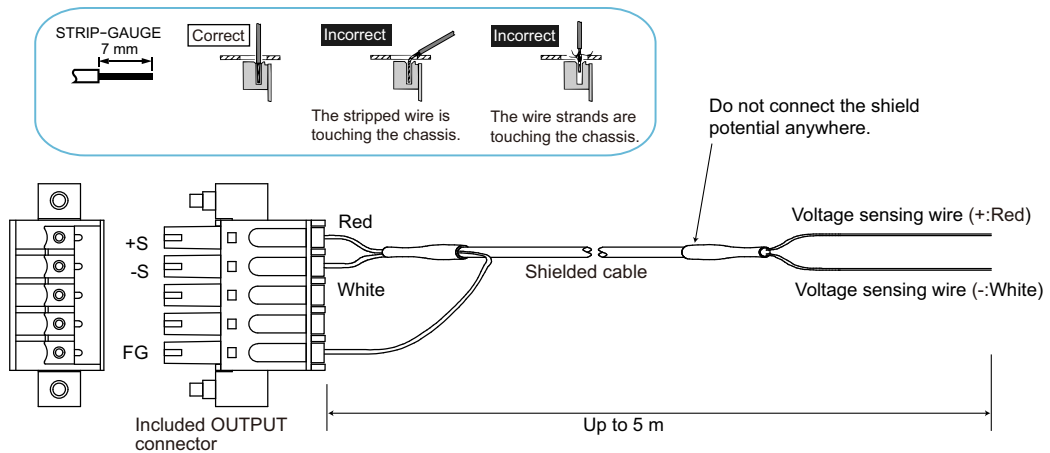
The rear panel OUTPUT terminals have M4 holes (with taps) and $\phi 8.5$ holes for connecting the current wires. Attach crimp terminals that match the bolts you are using. Use crimp terminals that are 5.5 mm² or smaller for the M4 holes.



2 Attach M3 crimp terminals to the voltage sensing wires.

The voltage sensing wires should be in a two-wire shielded cable. For each wire, strip 7 mm of coating, and securely screw the wire to the connector so that the wire does not come loose.

Pin Number	Symbol	Description	
1	+S	Voltage pin	Connect to the DUT's positive terminal.
2	-S		Connect to the DUT's negative terminal.
5	FG	Shield ground pin	This is connected to the PFX2441 chassis. Do not connect the shield potential to anywhere on the DUT.



Connecting the DUTs (Capacitors)

⚠ WARNING To avoid electric shock, connect the output cables to the PFX2400 Series first, and then connect the cables to the DUTs (capacitors).

⚠ CAUTION Be sure to connect the voltage sensing cables to the DUTs. The PFX2400 Series will not operate properly if you do not connect the voltage sensing wires. Also, be sure to connect the wires to the DUTs' (capacitors') terminals. If you perform charge and discharge testing without the voltage sensing wires connected to the DUTs, the DUTs (capacitors) may break. This is extremely dangerous.

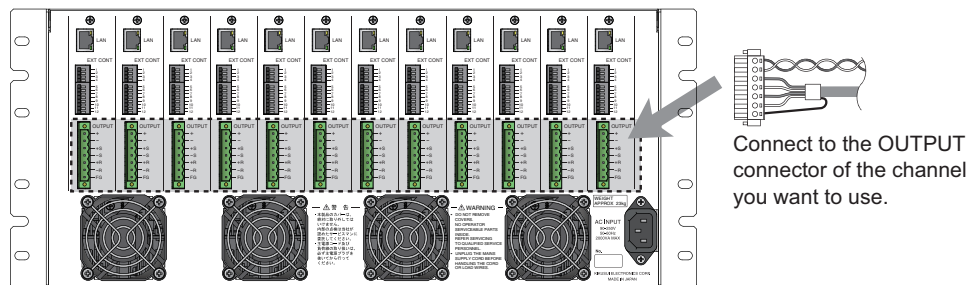
To make the connection between the PFX2400 Series and the DUTs (capacitors) safer and to prevent short circuit accidents involving current wires and shield wires, we recommend that you insert fuses or switches in the connections. Insert the fuses or circuits as close to the DUTs' (capacitors') terminals as possible.

PFX2411

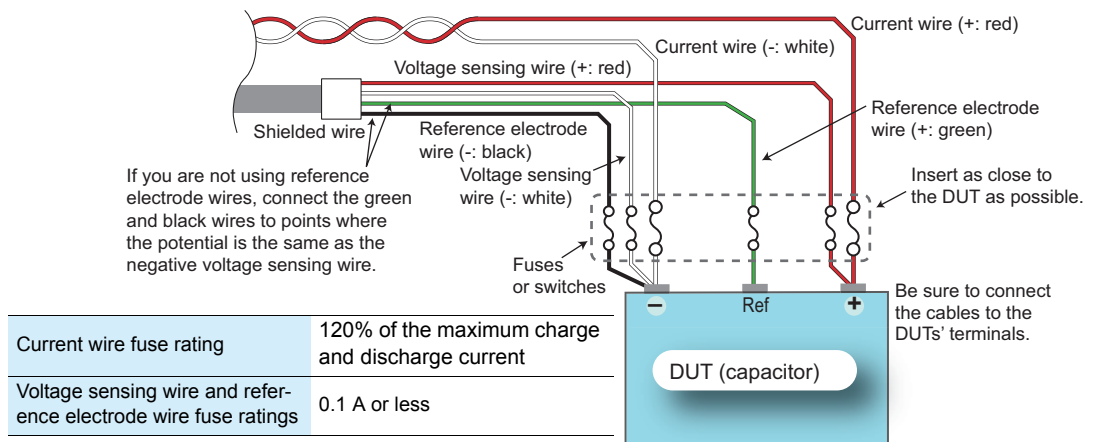
Using output cables, connect the PFX2411 OUTPUT connectors to the DUTs (capacitors).

1 Insert the output connectors into the rear-panel OUTPUT connectors of the channels that you want to use.

Tighten the output connectors' top and bottom screws to fix the connectors in place.



2 Connect or attach the output cables to the DUTs (capacitors).



⚠ CAUTION

- A fuse blowing may lead to explosions or fire. Be sure to put a cover on the fuse.
- Use DC fuses that have sufficient breaking capacity.

PFX2421

Connect a DUT (capacitor) to the PFX2421's OUTPUT terminals and sensing terminals. Use a current wire for the OUTPUT terminal and a two-wire shielded cable for the sensing terminal.



To avoid electric shock:

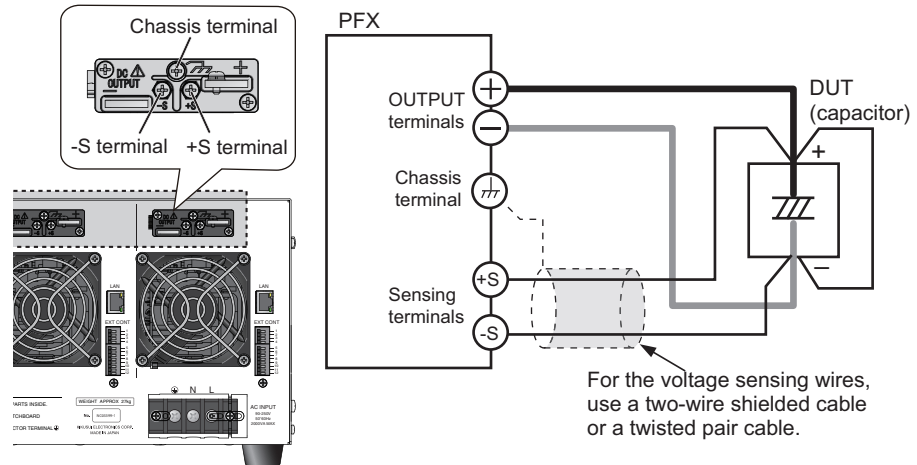
- Turn the POWER switch off before you touch the OUTPUT terminals.
- Attach the OUTPUT terminal cover after you finish wiring the DUT (capacitor).

- 1 **Connect the +S and -S terminals to the positive and negative voltage sensing wires, respectively. The voltage sensing wires should have M3 crimp terminals attached to them. Connect the shield to the chassis terminal.**

The voltage sensing wires should be in a two-wire shielded cable. If you cannot use a two-wire shielded cable, be sure to sufficiently twist the positive and negative wires.

★ Memo

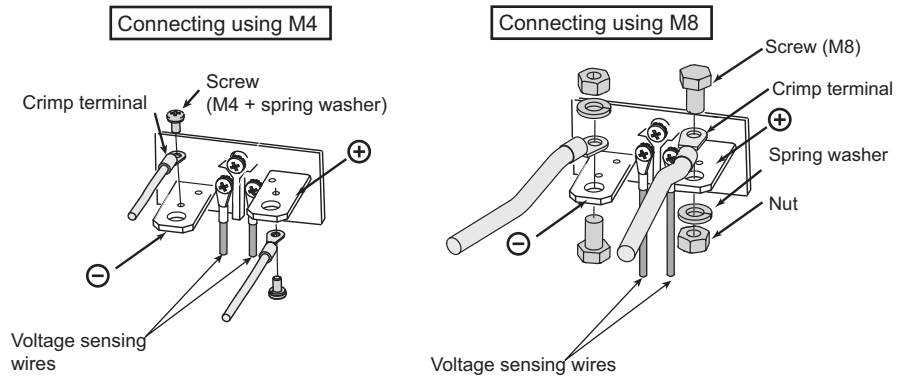
Do not connect the DUT (capacitor) side of the shield.



- 2 **Connect current wires with crimp terminals to the OUTPUT terminals of the channel you want to use.**

Connect the positive and negative terminals to the DUT's positive and negative terminals, respectively.

Use screws that are appropriate for the OUTPUT terminals to fix the wires in place. When using M8 screws to connect the wires, pay attention to the orientations of the screws.



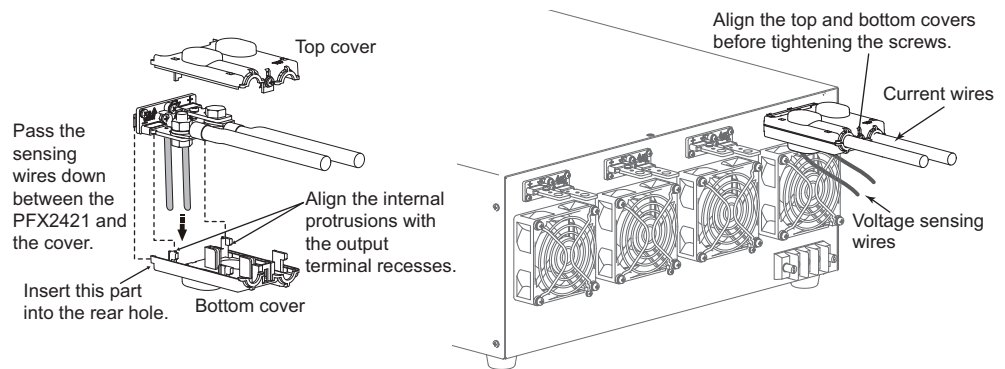
If you do not attach the wires in the manner shown in this figure, the OUTPUT terminal cover may touch the M8 screws.

3 Attach the OUTPUT terminal cover. Insert the hooks of the bottom cover into the holes on the sides of the OUTPUT terminals.

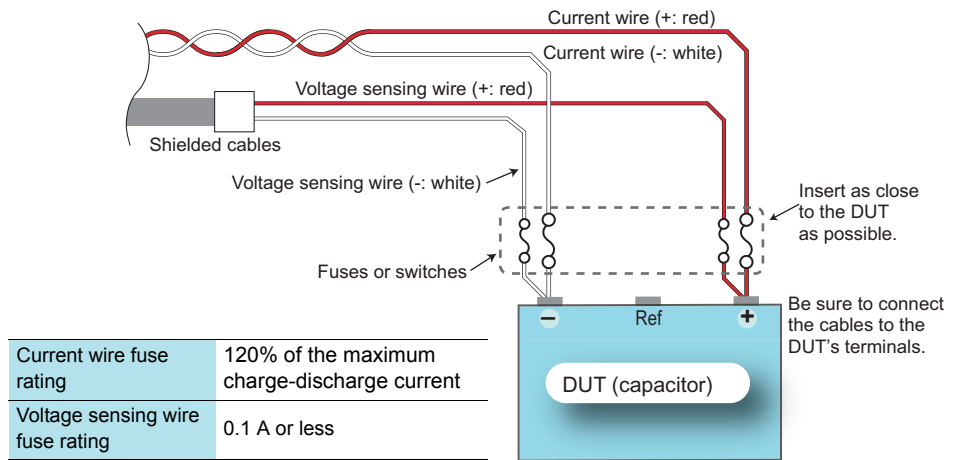
The OUTPUT terminal cover consists of a bottom cover and a top cover. The cover that does not have any screws is the bottom cover.

4 Put the bottom and top covers together, and use the screws that come with the top cover to fix the covers in place.

Attach the OUTPUT terminal cover correctly so that it does not move. Make sure that the screws are tight.



5 Attach each of the current wires and voltage sensing wires to the DUT (capacitor).



CAUTION

- A fuse blowing may lead to explosions or fire. Be sure to put a cover on the fuse.
- Use DC fuses that have sufficient breaking capacity.

PFX2431

Connect a DUT (capacitor) to the PFX2431's OUTPUT terminals and sensing connector. Use a current wire for the OUTPUT terminal and a two-wire shielded cable for the sensing connector.



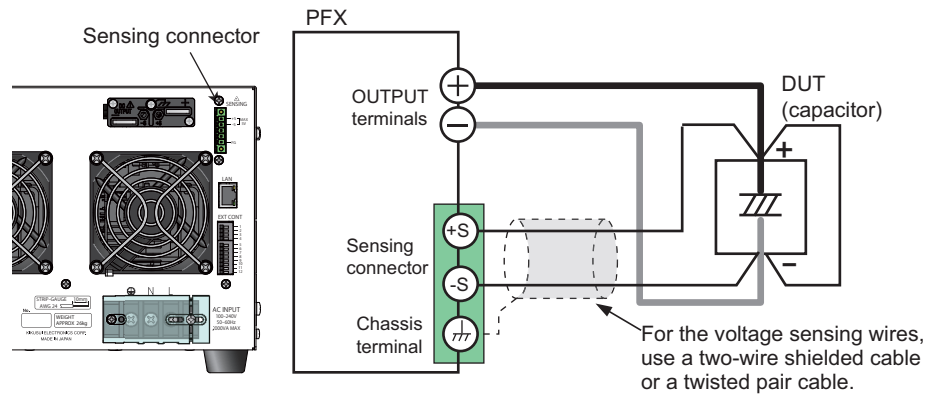
To avoid electric shock:

- Turn the **POWER** switch off before you touch the **OUTPUT** terminals.
- Attach the **OUTPUT** terminal cover after you finish wiring the **DUT (capacitor)**.

1 Connect the sensing connector plug to the sensing connector of the channel you want to use.



Do not connect the DUT (capacitor) side of the shield.

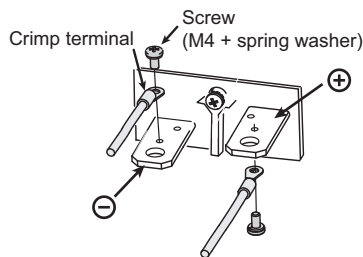


2 Connect current wires with crimp terminals to the OUTPUT terminals of the channel you want to use.

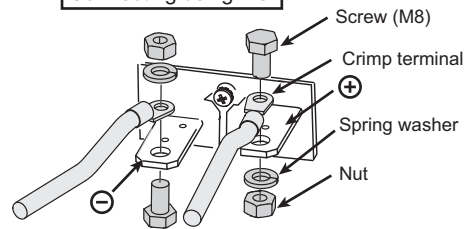
Connect the positive and negative terminals to the DUT's positive and negative terminals, respectively.

Use screws that are appropriate for the OUTPUT terminals to fix the wires in place. When using M8 screws to connect the wires, pay attention to the orientations of the screws.

Connecting using M4



Connecting using M8



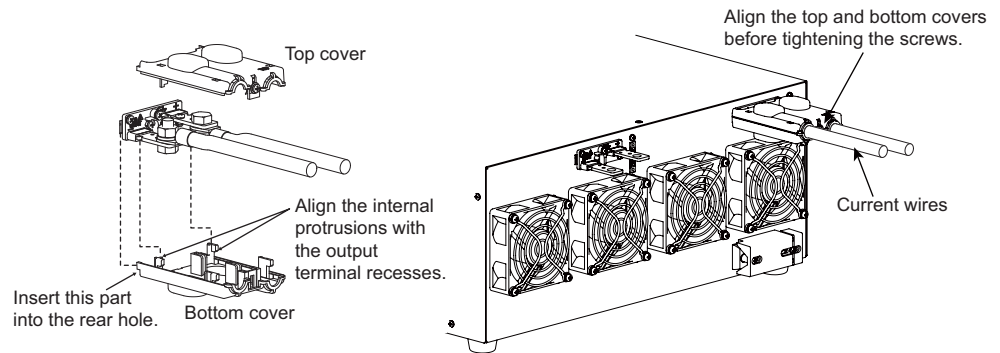
If you do not attach the wires in the manner shown in this figure, the OUTPUT terminal cover may touch the M8 screws.

3 Attach the OUTPUT terminal cover. Insert the hooks of the bottom cover into the holes on the sides of the OUTPUT terminals.

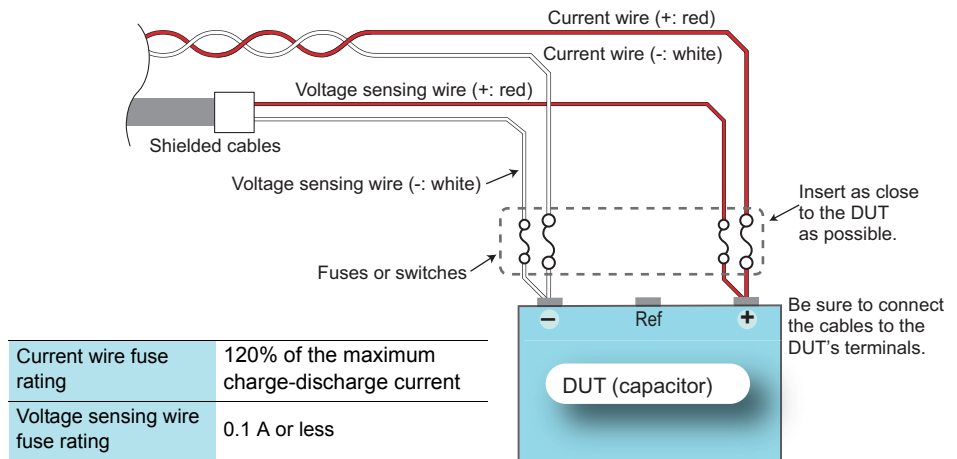
The OUTPUT terminal cover consists of a bottom cover and a top cover. The cover that does not have any screws is the bottom cover.

4 Put the bottom and top covers together, and use the screws that come with the top cover to fix the covers in place.

Attach the OUTPUT terminal cover correctly so that it does not move. Make sure that the screws are tight.



5 Attach each of the current wires and voltage sensing wires to the DUT (capacitor).



- CAUTION**
- A fuse blowing may lead to explosions or fire. Be sure to put a cover on the fuse.
 - Use DC fuses that have sufficient breaking capacity.

PFX2441

Connect a DUT (capacitor) to the PFX2441's OUTPUT terminals and sensing connector. Use a current wire for the OUTPUT terminal and a two-wire shielded cable for the sensing connector.



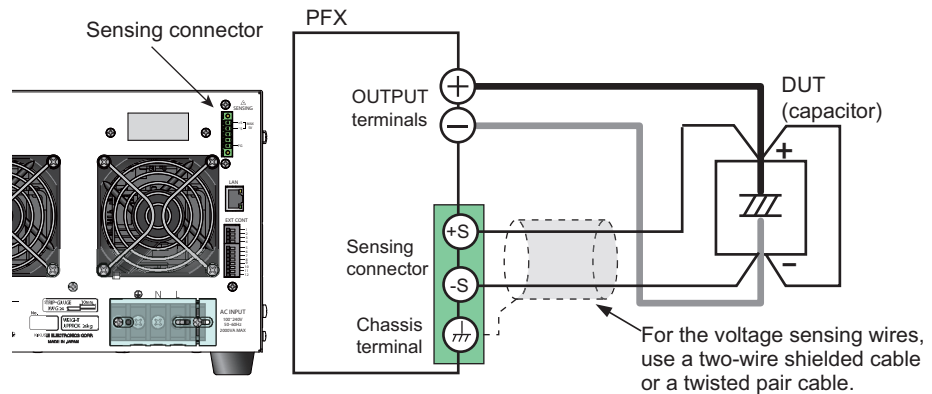
To avoid electric shock:

- Turn the **POWER** switch off before you touch the **OUTPUT** terminals.
- Attach the **OUTPUT** terminal cover after you finish wiring the **DUT (capacitor)**.

1 Connect the plug to the sensing connector.

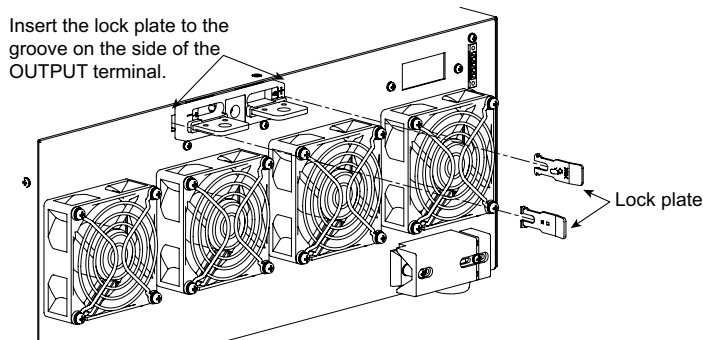


Memo
Do not connect the DUT (capacitor) side of the shield.



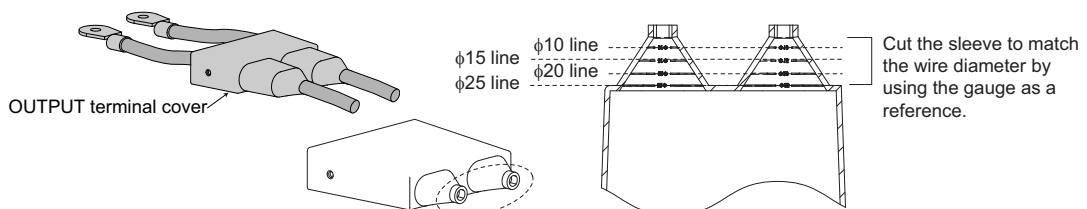
2 Attach the OUTPUT terminal cover lock plates to the OUTPUT terminal.

The lock plate is used to fix the OUTPUT terminal cover to the OUTPUT terminal. Once attached, you do not have to remove it.



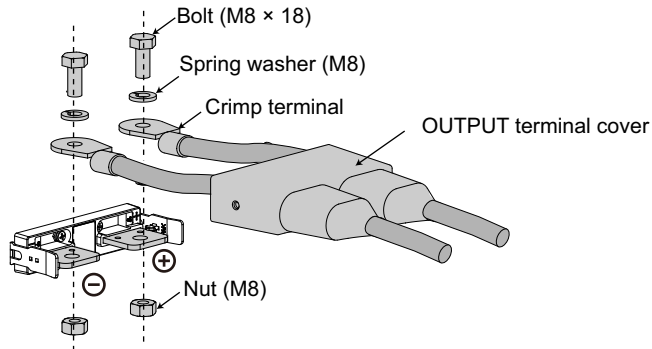
3 Pass the current wire through the cable hole in the OUTPUT terminal cover.

If the wire that you are using is thick and cannot be passed through the cover sleeve (where the wire is passed through), cut and adjust the size of the sleeve to match the thickness of the wire. Use trial and error so that you don't cut too much of the sleeve.



4 Connect current wires to the OUTPUT terminals.

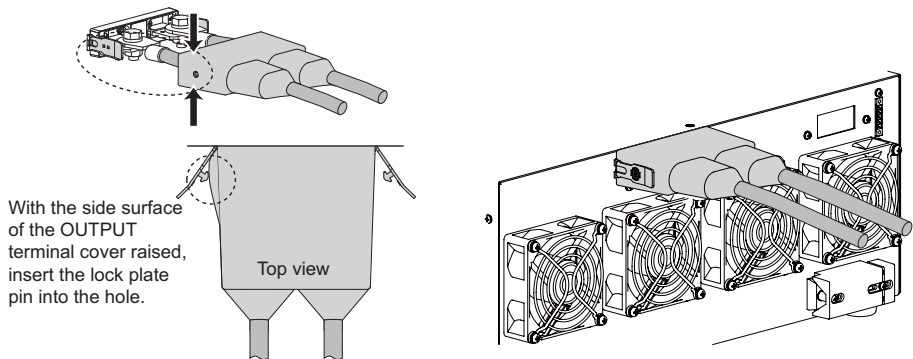
Connect the positive and negative terminals to the DUT's positive and negative terminals, respectively. Use screws to fix the wires in place.



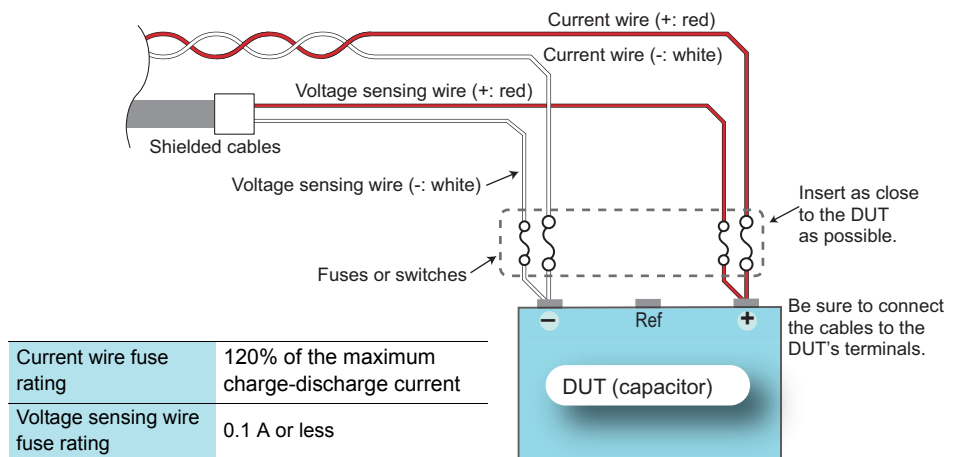
5 Move the OUTPUT terminal cover until the edge touches the rear panel.

To fix the cover in place, insert the lock plate pins into the holes on the sides of the OUTPUT terminal cover. To remove the OUTPUT terminal cover, open the lock plates on both sides to remove the pins from the holes in the cover.

Move the OUTPUT terminal cover until the edge of it touches the rear panel, and pinch the section indicated by the arrow to raise the side surface.



6 Attach each of the current wires and voltage sensing wires to the DUT (capacitor).



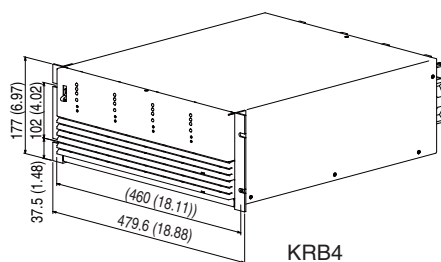
- CAUTION**
- A fuse blowing may lead to explosions or fire. Be sure to put a cover on the fuse.
 - Use DC fuses that have sufficient breaking capacity.

Options

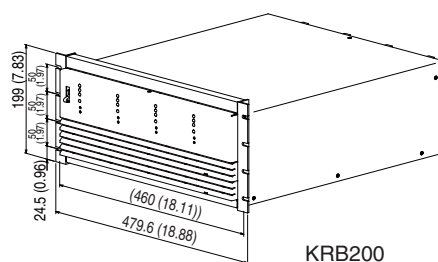
The PFX2400 series has the following options. For information about options, contact your Kikusui agent or distributor.

Rack mount options

Name	Model number	Notes
Rack mount bracket	KRB4	For an EIA inch rack
	KRB200	For a JIS millimeter rack



KRB4

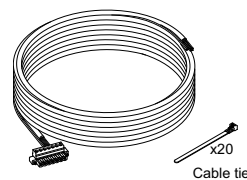
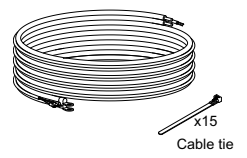
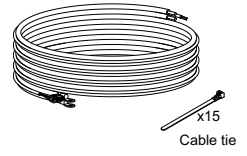


KRB200

Unit: mm (inch)

Output cables

These assembled cables, each of which consists of a current wire and a voltage sensing wire, are used to connect to the DUT (capacitor). One set is required per channel. This makes connecting easy and reduces the wiring time.

Model number	Applicable model	Remarks	
TL20-PFX	PFX2411	Current wire: AWG16 Shielded cables (core wire): AWG24 Length: Approx. 7 m	
TL21-PFX	PFX2421	Current wire: AWG4 Shielded cables (core wire): AWG24 Length: Approx. 5 m	
TL22-PFX	PFX2431	Current wire: AWG4 Shielded cables (core wire): AWG24 Length: Approx. 5 m	

2 Operation

This chapter explains how to turn the power on and describes various panel indications.

Turning the Power On and Off

Turning the POWER switch on

- 1 Check that the power cord and output cables are correctly connected.
- 2 Turn the POWER switch on (I).
If fire, smoke, an odd sound, or an odd odor occurs around or in the PFX2400 Series, remove the power plug from the outlet or turn off the switchboard.

Turning the POWER switch off



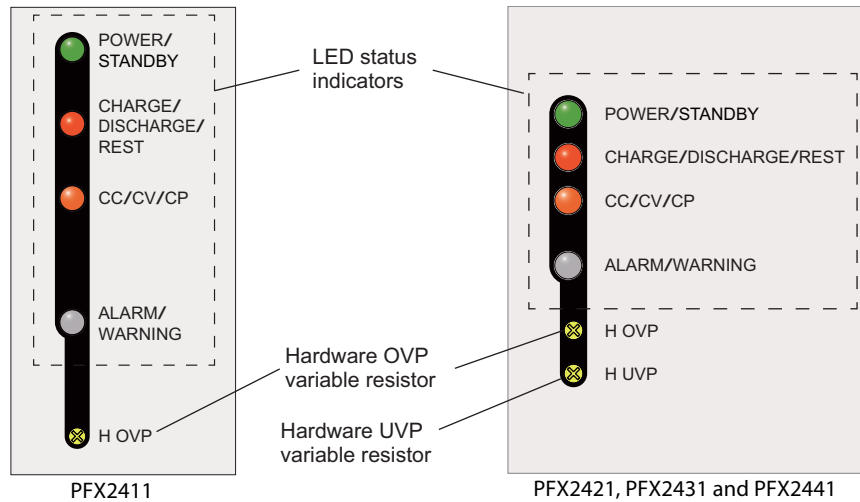
To avoid damaging the PFX2400 Series:

- After you flip the power switch, wait at least 10 seconds until you flip it again. Do not needlessly flip the switch repeatedly.
- During a charge and discharge test, don't turn the POWER switch off.
- After turning the POWER switch off, do not leave the DUT connected.

- 1 Stop the test using the CPChecker2400 application software, and check that current is not flowing through the DUT.
- 2 Turn the POWER switch off (O).

Panel Indications

When you turn the power on, the front panel LEDs light to indicate each channel's operating status. Each channel has LEDs for indicating the status, an H OVP variable resistor, and an H UVP variable resistor (only on the PFX2421, PFX2431 and PFX2441).



Panel indication	LED color	Description
POWER/ STANDBY	Green	Power is on.
	Orange	Test is paused.
CHARGE/ DISCHARGE/ REST	Red	Charging.
	Green	Discharging.
	Orange	Charging paused.
CC/ CV/ CP	Red	Constant current (CC) mode.
	Green	Constant voltage (CV) mode.
	Orange	Constant power (CP) mode.
ALARM/ WARNING	Red	Test is stopped because an alarm was detected.
	Orange	There is an error in the test settings. Executing the test will cause an alarm to occur.

Setting the Hardware OVP and UVP

Use the H OVP and H UVP variable resistors to set the hardware OVP and UVP detection values. One way is to set it directly on the PFX2400 Series. The other way is to use CPChecker2400.

Turning the H OVP variable resistor fully clockwise sets the hardware OVP to the maximum voltage (approximately 6 V).

Turning the H UVP variable resistor fully counterclockwise sets the hardware UVP to the minimum voltage (approximately -1.8 V; only on the PFX2421, PFX2431 and PFX2441).

Setting HOVP and HUVP limits using CPChecker2400

To set an HOVP or HUVP limit, while viewing the HOVP or HUVP value in the CPChecker2400 status display window, turn the H OVP or H UVP variable resistor. For details, see CPChecker2400 help.

Setting HOVP and HUVP limits directly on the PFX2400 Series

To set HOVP and HUVP limits directly on the PFX2400 Series, you need a voltage source. You have to adjust these limits for each channel separately.

■ Setting hardware OVP

- 1** Check that the PFX2400 Series POWER switch is turned off.
- 2** Turn the H OVP variable resistor of the channel that you are setting hardware OVP for fully clockwise.
- 3** Connect the +S and -S terminals of the channel that you are setting hardware OVP for to the positive and negative terminals of the voltage source, respectively, using the voltage sensing wires.
- 4** Turn the PFX2400 Series's POWER switch on.
- 5** Set the voltage source's voltage to the hardware OVP detection value.
- 6** Turn the voltage source's output on.
- 7** Slowly turn the H OVP variable resistor counterclockwise until an alarm occurs (the ALARM/ WARNING LED illuminates in red).

The hardware OVP limit has now been set.

To set the limit again, turn the PFX2400 Series off once to clear the alarm.

After you set HOVP limits, we recommend that you check them in the CPChecker2400 status display window.

■ Setting hardware UVP (only on the PFX2421, PFX2431 and PFX2441)

- 1** Check that the POWER switch is turned off.
- 2** Turn the H UVP variable resistor of the channel that you are setting hardware UVP for fully counterclockwise.

- 3** Connect the +S and -S terminals of the channel that you are setting hardware UVP to the positive and negative terminals of the voltage source, respectively, using the voltage sensing wires.
- 4** Turn the PFX2400 Series's POWER switch on.
- 5** Set the voltage source's voltage to the hardware UVP detection value.
- 6** Turn the PFX2400 Series's POWER switch on.
- 7** Slowly turn the H UVP variable resistor clockwise until an alarm occurs (the ALARM/WARNING LED lights).

This is the last step for setting hardware UVP.

To set hardware UVP again, first turn off the PFX2421 to clear the alarm.

After you set hardware UVP, we recommend that you check the H UVP value in the CPChecker2400 status display window.

Test Procedure

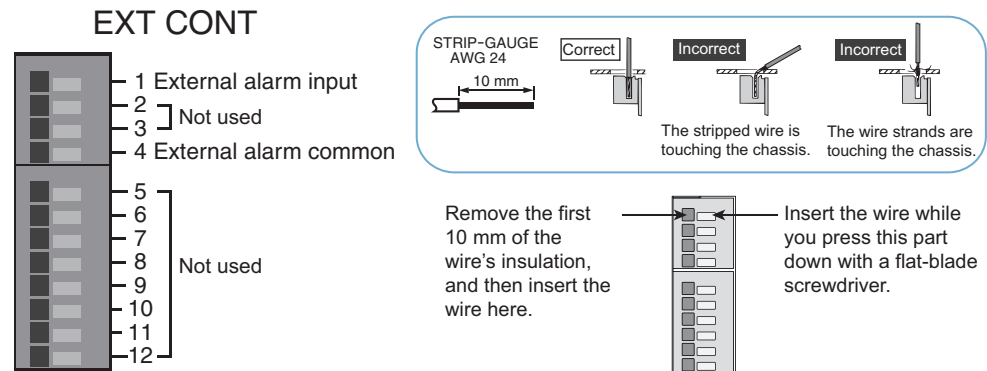
To perform charge and discharge tests, use CPChecker2400 to set test conditions and other settings. For instructions on how to set test conditions and execute tests, see the CPChecker2400 help.

If you are performing a test for the first time, follow the procedure below.

- 1** **Configure the hardware.**
Set IP addresses and channels. To do so, use IP Configuration Tool. IP Configuration Tool is included in the CD-ROM that comes with CPChecker2400.
- 2** **Create test conditions.**
Create a test conditions file.
- 3** **Execute the test.**
Assign the test conditions that you created to channels, and execute the test. Save the test results to a file.

External Alarm Input

You can stop a test by applying an external signal to the external alarm input pin on the rear panel.



Apply an alarm signal whose voltage is 2 V or more and whose pulse width is 50 ms or longer.

The external alarm input pin (pin 1) is connected to the external alarm common through a 560 Ω resistor and a photocoupler. The allowable input voltage is +12 V.

Pin No.	Signal	Description	Circuit
1	External alarm input	Stops the execution of a test when a high level signal is received.	
2	—	Do not connect anything to this pin.	
3	—	Do not connect anything to this pin.	
4	External alarm common	External alarm common.	
5 to 12	—	Do not connect anything to this pin.	

3 Specifications

This chapter contains the specifications and the external dimensions of the product.

Functional Specifications

Charge function

Common Specifications		
Charge method	CC	Constant current charge.
	CC-CV	Constant current charge until the specified voltage is reached, followed by constant voltage charge.
	CP	Constant power charge.
	Step	Charging is performed in steps that are combinations of the CC, CC-CV, and CP modes.
Charge cutoff condition	CV time	In CC-CV mode, charging stops when the CV time elapses after charging switches to CV mode.
	Voltage	In CC mode, charging stops when the specified voltage is reached.
	Current	In CC-CV mode, charging stops when the specified current is reached after charging switches to CV mode.
	Charge time	Charging stops when the specified time elapses after charging has been started.
Rest end condition	Rest time	Charging stops when the specified time elapses after charging has been paused.
	Synchronization	The pause extension feature is used to synchronize the stopping of charging.

Discharge function

Common Specifications		
Discharge methods	CC	Constant current discharge.
	CC-CV	Constant current discharge until the specified voltage is reached, followed by constant voltage discharge.
	CP	Constant power discharge.
	Step	Discharging is performed in steps that are combinations of the CC, CC-CV, and CP modes.
Discharge cutoff condition	CV time	In CC-CV mode, discharging stops when the CV time elapses after discharging switches to CV mode.
	Voltage	In CC mode, discharging stops when the specified voltage is reached.
	Current	In CC-CV mode, discharging stops when the specified current is reached after discharging switches to CV mode.
	Charge time	Discharging stops when the specified time elapses after discharging has been started.
Rest end condition	Rest time	Discharging stops when the specified time elapses after discharging has been paused.
	Sync commands during extended idling	The pause extension feature is used to synchronize the stopping of discharging.

Measurement function

Common Specifications		
Voltage	Measurement interval	1 ms or 100 ms
Current	Measurement interval	1 ms or 100 ms
Reference electrode voltage ¹	Measurement interval	1 ms or 100 ms
Time		Elapsed time from the start of test
Cycle count		Counts the total number of cycles

1 Only on the PFX2411

Protection function

Common Specifications		
Overvoltage (overcharge) protection	Software OVP	Cleared when the corresponding channel's output is turned off and when a reset command is received
	Hardware OVP	
Overcurrent protection	Software OCP	Cleared when the corresponding channel's output is turned off and when a reset command is received
Overheat protection (OHP)		Activated when the heatsink temperature is at $90\text{ °C} \pm 5\text{ °C}$. Cleared when the corresponding channel's output is turned off and when a reset command is received
Undervoltage (overdischarge) protection	Software UVP	Cleared when the corresponding channel's output is turned off and when a reset command is received
	Hardware UVP ¹	Cleared when the corresponding channel's output is turned off and when a reset command is received
External alarm input		Testing stops at the HI level (2 V to 12 V)

1 Only on the PFX2421, PFX2431 and PFX2441

Display function (status monitoring)

Common Specifications		
Power status	POWER	A test is in progress or the PFX2400 series is ready for a test to be executed. The POWER/STANDBY LED lights in green.
	STANDBY	The PFX2400 series is in standby mode or the system is ready to be stopped. The POWER/STANDBY LED lights in orange.
Charge and discharge status	CHARGE	Charging. The CHARGE/DISCHARGE/REST LED lights in red.
	DISCHARGE	Discharging. The CHARGE/DISCHARGE/REST LED lights in green.
	REST	Resting. The CHARGE/DISCHARGE/REST LED lights in orange.
Control status	CC	Constant current mode. The CC/CV/CP LED lights in red.
	CV	Constant voltage mode. The CC/CV/CP LED lights in green.
	CP	Constant power mode. The CC/CV/CP LED lights in orange.
Alarm	ALARM	Alarm detected. Protection function activated. The ALARM/WARNING LED lights in red.
	WARNING	Alarm detection warning. A warning to indicate that a protection function will be activated if a test is executed. The ALARM/WARNING LED lights in orange.

Electrical Specifications

Unless specified otherwise, the specifications are for the following settings and conditions.

- The warm-up time is 30 minutes.
- set: Indicates a setting.
- rdng: Indicates a readout value.

Rated output

	PFX2411	PFX2421	PFX2431	PFX2441
Number of outputs	12 ch	4 ch	2 ch	1 ch
Charge current range	0.0000 A to 5.0000 A	0.000 A to 35.000 A	0.00 A to 70.00 A	0.00 A to 140.00 A
Charge voltage range	0.0000 V to 5.0000 V	0.0000 V to 5.0000 V	0.0000 V to 5.0000 V	0.0000 V to 5.0000 V
Charge power range	0.01 W to 25.00 W	0.1 W to 175.0 W	1 W to 350 W	1 W to 700 W
Discharge current range	0.0000 A to 5.0000 A	0.000 A to 35.000 A	0.00 A to 70.00 A	0.00 A to 140.00 A
Discharge voltage range	-0.5000 V to 5.0000 V	-0.5000 V to 5.0000 V	0.0000 V to 5.0000 V	0.0000 V to 5.0000 V
Discharge power range	0.01 W to 25.00 W	0.1 W to 175.0 W	1 W to 350 W	1 W to 700 W
Maximum charge and discharge power	25.0 W	175.0 W	350 W	700 W

Setting accuracy

		PFX2411	PFX2421	PFX2431	PFX2441
Current setting	Range	0.0000 A to 5.0000 A	0.000 A to 35.000 A	0.00 A to 70.00 A	0.00 A to 140.00 A
	Accuracy	$\pm(0.07\% \text{ of set} + 1 \text{ mA})$	$\pm(0.15\% \text{ of set} + 15 \text{ mA})$	$\pm(0.15\% \text{ of set} + 30 \text{ mA})$	$\pm(0.15\% \text{ of set} + 60 \text{ mA})$
	Resolution	100 μA	1 mA	10 mA	10 mA
	Ripple ¹	1.5 mArms or less	20 mArms or less	40 mArms or less	60 mArms or less
Voltage setting	Range	0.0000 V to 5.0000 V			
	Accuracy ²	$\pm(0.07\% \text{ of set} + 1.5 \text{ mV})$			
	Resolution	100 μV			
	Ripple ¹	3 mVrms or less			
Power setting	Range	0.01 W to 25.00 W	0.1 W to 175.0 W	1 W to 350 W	1 W to 700 W
	Accuracy ³	$\pm(0.1\% \text{ of set} + 10 \text{ mW})$	$\pm(0.1\% \text{ of set} + 100 \text{ mW})$	$\pm(0.1\% \text{ of set} + 1 \text{ W})$	$\pm(0.1\% \text{ of set} + 1 \text{ W})$
	Resolution	10 mW	100 mW	1 W	1 W

- 1 10 Hz to 500 kHz band
- 2 During charging
- 3 At a capacitor voltage of 0.5 V or higher

Measurement accuracy

		PFX2411	PFX2421	PFX2431	PFX2441
Current measurement	Range	0.00000 A to 5.00000 A	0.000 A to 35.000 A	0.000 A to 70.000 A	0.000 A to 140.000 A
	Accuracy ^{1, 2}	$\pm(0.07\% \text{ of rdng} + 1 \text{ mA})$	$\pm(0.15\% \text{ of rdng} + 15 \text{ mA})$	$\pm(0.15\% \text{ of rdng} + 30 \text{ mA})$	$\pm(0.15\% \text{ of rdng} + 60 \text{ mA})$
	Resolution	10 μA	100 μA	1 mA	1 mA
	Sampling time	1 ms or 100 ms			
Voltage measurement	Range	-0.50000 V to 5.00000 V			
	Accuracy ^{1, 2}	$\pm(0.07\% \text{ of rdng} + 1.5 \text{ mV})$			
	Resolution	10 μV			
	Sampling time	1 ms or 100 ms			
Reference electrode voltage measurement	Range	-0.50000 V to 5.00000 V	–	–	–
	Accuracy ^{1, 2}	$\pm(0.07\% \text{ of rdng} + 1.5 \text{ mV})$	–	–	–
	Resolution	10 μV	–	–	–
	Sampling time	1 ms or 100 ms	–	–	–

1 Ambient temperature: 18 °C to 28 °C

2 Measurable range: Within the ranges indicated above

Protection function

		PFX2411	PFX2421	PFX2431	PFX2441
Overvoltage (overcharge) protection ¹					
Hardware OVP	Setting range	0.10 V to 6.00 V			
	Resolution	10 mV			
	Setting accuracy	±300 mV			
	Operation time	100 ms or less			
Software OVP	Setting range	-0.6000 V to 5.1000 V			
	Resolution	100 μV			
	Setting accuracy	±(0.07 % of rdng + 1.5 mV)			
	Operation time	100 ms or less			
Undervoltage (overdischarge) protection ¹					
Hardware UVP	Setting range	–	-1.80 V to 4.00 V		
	Resolution	–	10 mV		
	Setting accuracy	–	± 300 mV		
	Operation time	–	100 ms or less		
Software UVP	Setting range	-0.6000 V to 5.1000 V			
	Resolution	100 μV			
	Setting accuracy	±(0.07 % of rdng + 1.5 mV)			
	Operation time	100 ms or less			
Overcurrent protection					
Software OCP	Setting range	0.0000 A to 5.1000 A	0.000 A to 35.700 A	0.00 A to 71.40 A	0.00 A to 142.80 A
	Resolution	100 μA	1 mA	10 mA	10 mA
	Setting accuracy	±(0.07 % of set + 1 mV)	± (0.15 % of set + 15 mA)	±(0.15 % of set + 30 mA)	±(0.15 % of set + 60 mA)
	Operation time	100 ms or less			
Built-in fuse	7 A	40 A	40 A x 2	40 A x 4	
Overheat protection (inside the device)					
OHP	Operating temperature	Activated when the built-in heatsink temperature is at 90 °C ± 5 °C.			
AC input over current protection		Through the power switch (breaker) or the AC input fuse			
External alarm input					
Allowable input voltage		+12 V			
Input level		High level: 2 V to 12 V Low level: Open or 0 V to 1 V			
Minimum pulse width		50 ms			

1 The capacitance of the connected DUT (capacitor) must be 0.1 F or more for the PFX2411, 0.5 F or more for the PFX2421, 1 F or more for the PFX2431, or 2 F or more for the PFX2441.
When data sampling is performed at 1 ms intervals, the discharge current must be such that the time between when discharging starts and when it finishes is 0.1 s or more.
When data sampling is performed at 100 ms intervals, the discharge current must be such that the time between when discharging starts and when it finishes is 10 s or more.

Interface

		PFX2411	PFX2421	PFX2431	PFX2441
Ethernet (LAN)		Automatic 10BASE-T/100BASE-TX selection			
Connector		RJ45			

General Specifications

	PFX2411	PFX2421	PFX2431	PFX2441
Nominal input rating	100 Vac to 240 Vac, 50 Hz to 60 Hz			
Input voltage range	90 Vac to 250 Vac			
Power consumption	Per channel: Approx. 100 VA (when charged at 5 V, 5 A)	Per channel: Approx. 500 VA (when charged at 5 V, 35 A)	Per channel: Approx. 1000 VA (when charged at 5 V, 70 A)	2000 VAm _{ax} (when charged at 5 V, 140 A)
	For all 12 channels: 2000 VAm _{ax} (when all channels are charged at 5 V, 5 A)	For all 4 channels: 2000 VAm _{ax} (when all channels are charged at 5 V, 35 A)	For all 2 channels: 2000 VAm _{ax} (when all channels are charged at 5 V, 70 A)	
Operating temperature and humidity ranges	0 °C to +40 °C, 20 %rh to 85 %rh (no condensation)			
Storage temperature and humidity ranges	-20 °C to +60 °C, 90 %rh or less (no condensation)			
Operating environment	Indoors, Overvoltage Category II			
Altitude	Up to 2000 m			
Isolation voltage				
Across the I/O terminals and chassis	±50 V _{max}			
Insulation resistance				
Across the AC input and chassis	100 MΩ or more			
Across the DC output and chassis	20 MΩ or more			
Withstand voltage				
Across the AC input and chassis	No abnormality at 1500 Vac over 1 minute			
Leakage current	3.5 mA or less			
Voltage dip tolerance	Approx. 50 ms	10 ms or more (when the output current is 50 %)		
Safety ¹	Complies with the requirements of the following standards. Low Voltage Directive 2006/95/EC ² EN 61010-1 (Class I ³ , Pollution degree 2)			
Electromagnetic compatibility (EMC) ^{1, 2}	Complies with the requirements of the following standard. EMC Directive 2004/108/EC EN 61326-1 (Class A ⁴) EN 55011 (Class A ⁴ , Group 1 ⁵) EN 61000-3-2 EN 61000-3-3 Applicable condition All of the cables and wires connected to the PFX2400 series are less than 5 m in length.			
Dimensions	See the outline drawing.			
Weight	Approx. 23 kg (50.71 lbs)	Approx. 27 kg (59.53 lb.)	Approx. 26 kg (57.32 lb.)	Approx. 26 kg (57.32 lb.)
Accessories				
Power cord	1 pc.			
OUTPUT terminal cover	–	4 sets	2 sets	1 set
M8 output terminal screw	–	8 sets	4 sets	2 sets
M4 output terminal screw	–	8 pcs.	4 pcs.	2 pcs.
Sensing connector	–	–	2 pcs.	1pc.
OUTPUT connectors	12 pcs.	–	–	–
Operation manual (this manual)	1 pc.			

1 Does not apply to specially ordered or modified products.

2 Only on models that have the CE marking on the panel.

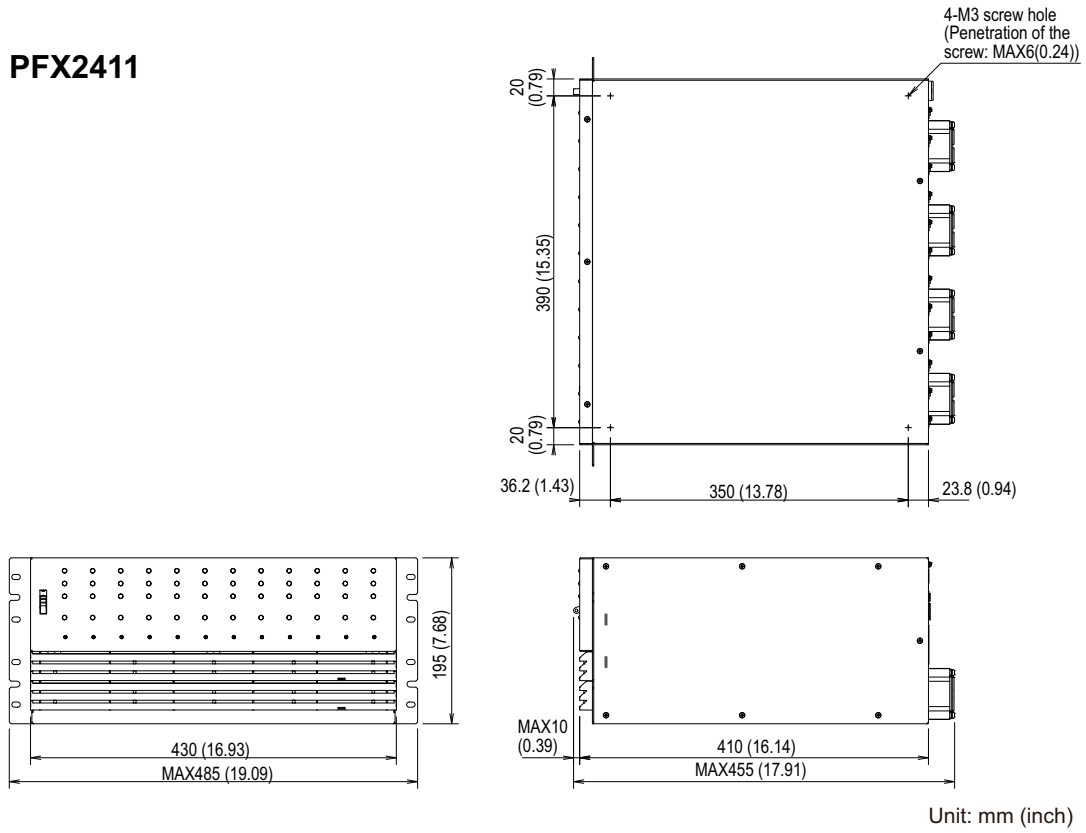
3 This is a Class I equipment. Be sure to ground this product's protective conductor terminal. The safety of this product is only guaranteed when the product is properly grounded.

4 This is a Class A equipment. This product is intended for use in an industrial environment. This product may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

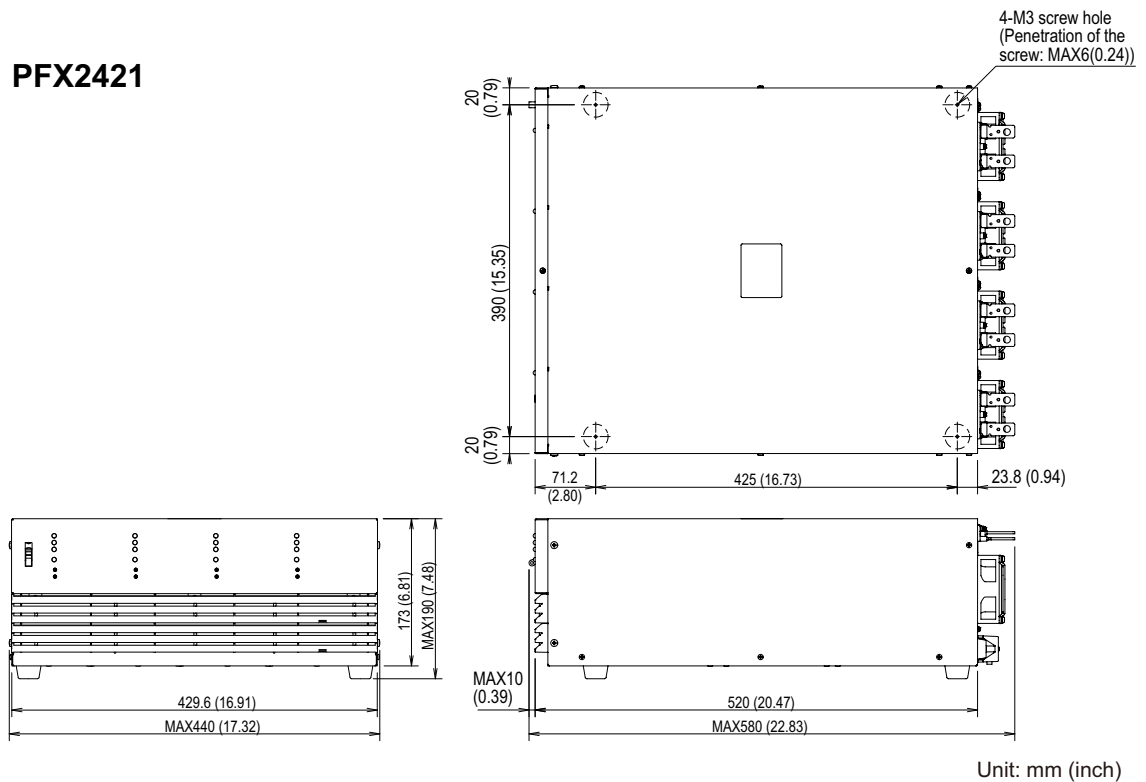
5 This is a Group I equipment. This product does not generate and/or use intentionally radio-frequency energy, in the form of electromagnetic radiation, inductive and/or capacitive coupling, for the treatment of material or inspection/analysis purpose.

Outline drawing

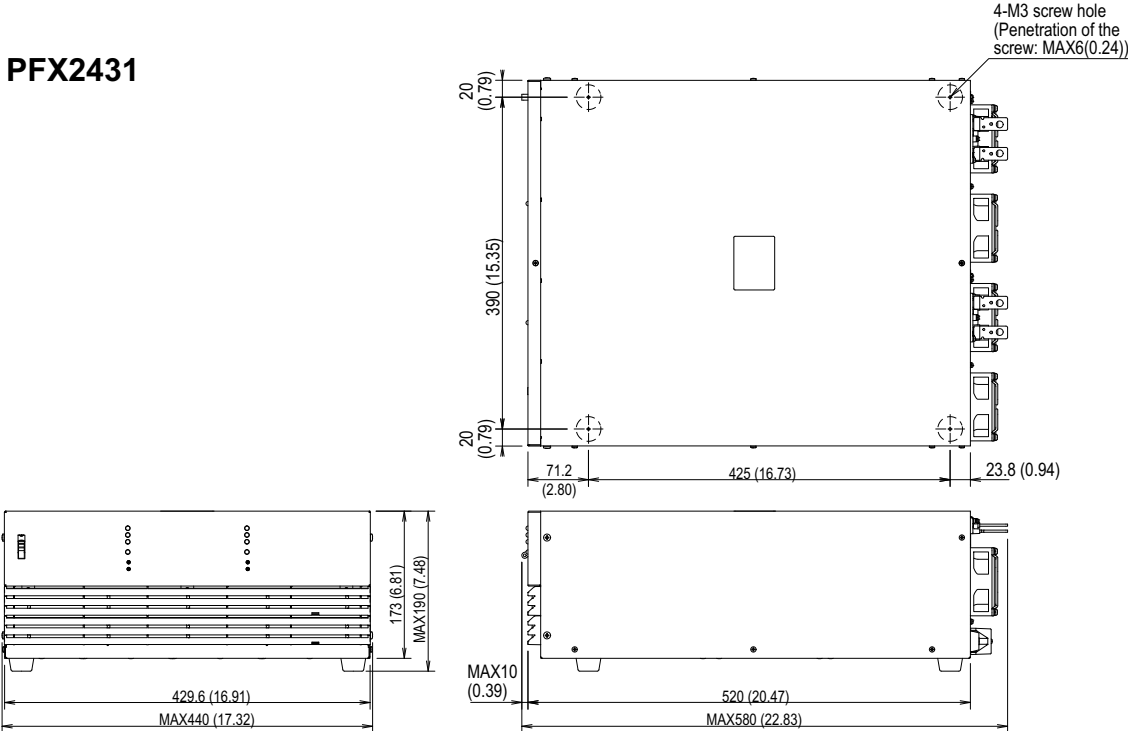
PFX2411



PFX2421

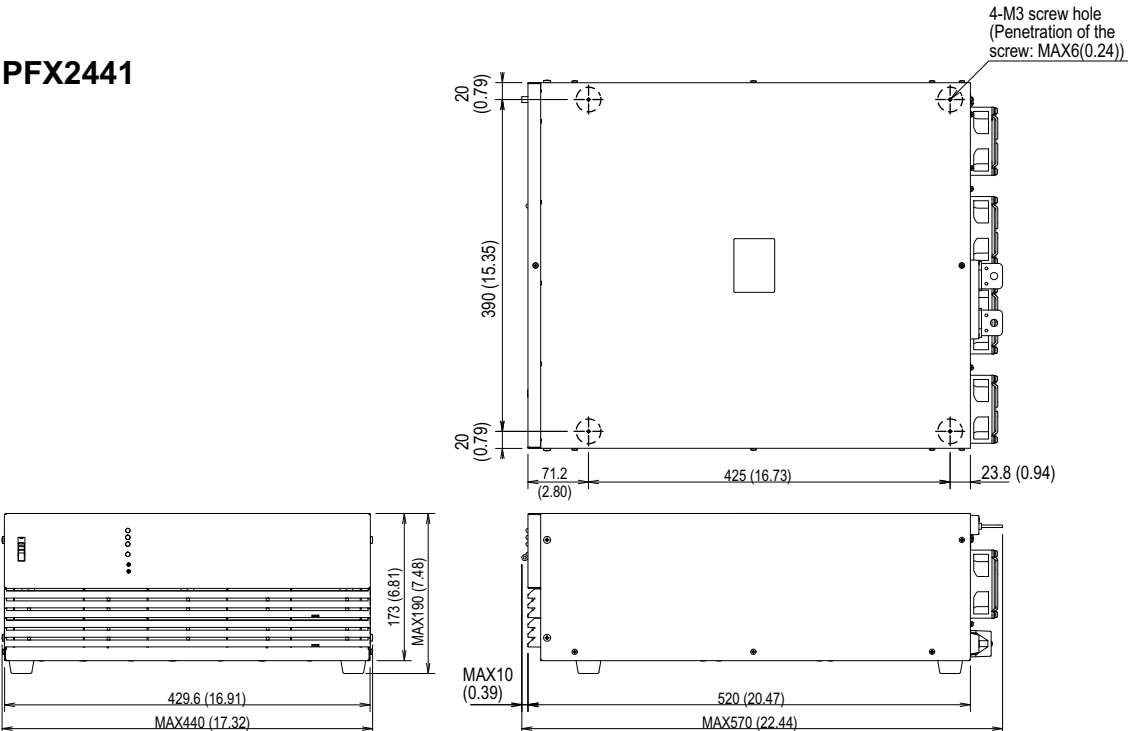


PFX2431



Unit: mm (inch)

PFX2441



Unit: mm (inch)

App. A Cleaning the Dust Filter

⚠ WARNING To avoid electric shock, be sure to turn the **POWER** switch off, and remove the power cord plug from the outlet.

⚠ CAUTION The following situations can cause a malfunction or reduce the PFX2400 Series's service life.

- A clogged filter hinders the cooling of the inside of the PFX2400 Series.
- When the PFX2400 Series is in operation, air is sucked through the dust filter to cool the inside of the device. If moisture is present in the dust filter, the temperature and humidity inside the PFX2400 Series increase.

Periodically clean the dust filter to prevent clogging.

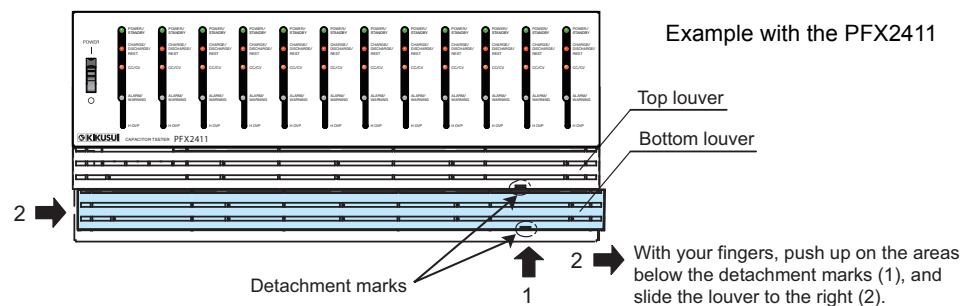
Removing the louver and cleaning the dust filter

★ Memo

The louver and dust filter specifications are the same for the PFX2400 series.

1 Remove the bottom louver from the panel.

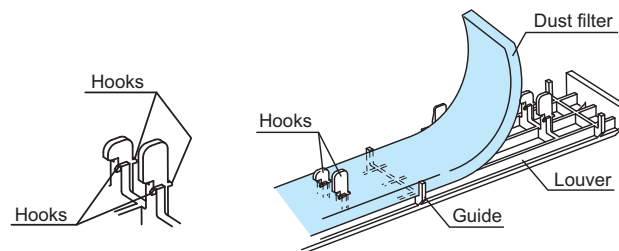
With your fingers, push up on the areas below the detachment marks, and slide the entire louver to the right. Then, pull the louver toward you to remove it.



2 Remove the top louver in the same manner as explained in Procedure 1 .

3 Remove the dust filter from the inside of each louver.

Be careful not to get the dust filter caught on the hooks when you remove it.



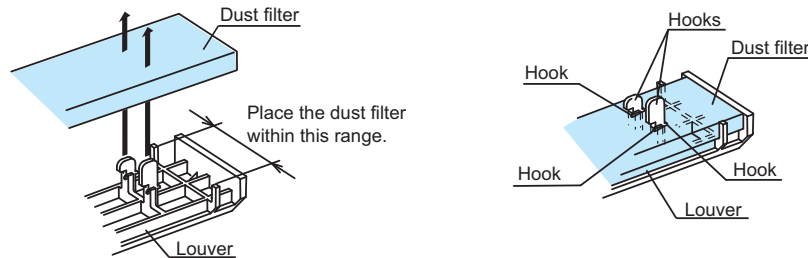
4 Clean the dust filters.

Use a vacuum cleaner to dispose of the dust and foreign particles that are attached to the dust filters. If the filters are extremely dirty, clean them using a water-diluted neutral detergent and dry them completely.

Attaching the dust filters and louvers

1 Attach the dust filter to the louver by aligning the dust filter with the guides.


Firmly attach the dust filter so that the louver's hooks protrude out of the top of the dust filter.

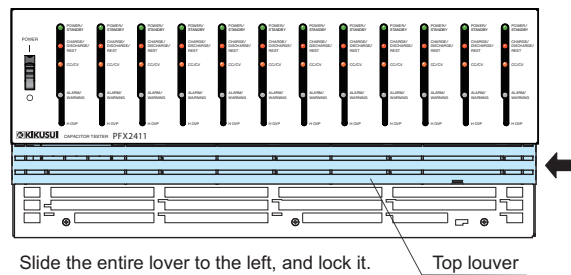


2 Attach the top louver.

Align the hooks on the inner side of the louver with the panel's grooves, and slide the louver to the left to attach it to the panel. Attaching is easy if you align the five long hooks with the grooves.



Pass the long hooks on the back side of the louver through the grooves marked with  (10 locations).



Example with the PFX2411

3 Attach the bottom louver in the same manner as explained in Procedure2

App. B Troubleshooting

This section introduces troubleshooting measures. Typical symptoms are listed. Check whether any of the items listed below apply to your case. In some cases, the problem can be solved quite easily.

If none of the items apply to your case or the remedy does not correct your problem, contact your Kikusui agent or distributor.

The power does not turn on.

Symptom	Items to check and possible remedy	See
The STANDBY LED does not light when the POWER switch is turned on.	Is the power cord connected properly? Check that the cord is connected properly.	p. 12
When the POWER switch is turned on, the ALARM/WARNING LED lights.	Is H OVP, H UVP, OHP, or UVP activated? Check that they are not activated.	p. 34

Testing cannot be performed properly.

Symptom	Items to check and possible remedy	See
The ALARM LED turned on during testing.	The overheat protection (OHP) feature may have been activated. The ambient temperature may be higher than the operating temperature, the air inlet or vent may be blocked, the dust filters may be clogged, or the fan may be broken. If there are no problems with the operating environment but the LED is lit, stop using the PFX2400 Series immediately, and contact your Kikusui agent or distributor.	p. 34
	H OVP or H UVP may have been activated. Make sure that the capacitance of the DUT (capacitor) connected to the OUTPUT terminal is appropriate.	p. 18
	H UVP may have been activated. Check that the voltage sensing wires are connected correctly.	p. 21 to p. 24
When the PFX2400 Series is idling, the ALARM/WARNING LED lights in orange.	An alarm occurs even when no charge-discharge testing is taking place (when the PFX2400 Series is idle). Eliminate all the causes of the alarm.	–
The PC suddenly shut down.	Did your PC enter standby or hibernate mode? Be sure to disable standby and hibernate modes.	–
	Even if the PC shuts down or freezes during a charge-discharge test, the charging or discharging that was taking place at the time continues.	–
CC/CV operation is abnormal.	Are voltage sensing cables connected? The PFX2400 Series will not work properly if the sensing cables are not connected. Be sure to connect the voltage sensing cables.	p. 25