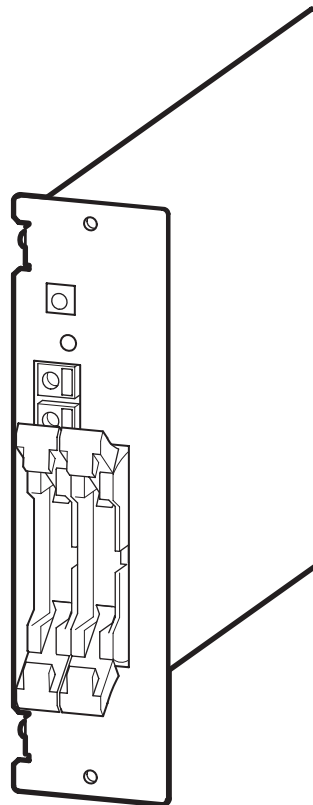


OPERATION MANUAL

PAM Series 4kW Model

Parallel Operation Option



Use of Operation Manual

Please read through and understand this Operation Manual before operating the product. After reading, always keep the manual nearby so that you may refer to it as needed. When moving the product to another location, be sure to bring the manual as well.

If you find any incorrectly arranged or missing pages in this manual, they will be replaced. If the manual gets lost or soiled, a new copy can be provided for a fee. In either case, please contact Kikusui distributor/agent, and provide the "Kikusui Part No." given on the over.

This manual has been prepared with the utmost care; however, if you have any questions, or note any errors or omissions, please contact Kikusui distributor/agent.

Reproduction and reprinting of this operation manual, whole or partially, without our permission is prohibited.

Both unit specifications and manual contents are subject to change without notice.



Safety Symbols

For the safe use and safe maintenance of this product, the following symbols are used throughout this manual and on the product. Understand the meanings of the symbols and observe the instructions they indicate (the choice of symbols used depends on the products).



Indicates that a high voltage (over 1,000 V) is used here. Touching the part causes a possibly fatal electric shock. If physical contact is required by your work, start work only after you make sure that no voltage is output here.

DANGER

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



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



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



Shows that the act indicated is prohibited.



Is placed before the sign “DANGER,” “WARNING,” or “CAUTION” to emphasize these. When this symbol is marked on the product, see the relevant sections in this manual.



Indicates a protective conductor terminal.



Indicates a chassis(frame) terminal.

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Preface

About This Manual

This is the operation manual for the parallel operation option of the PAM Series 4kW Model, in which “master-slave” parallel operation is described. To use the master-slave parallel operation function, first read the operation manual for the PAM Series (the main unit) to ensure that you fully understand the operation of, and all necessary information relating to, the unit. Then you may proceed to reading this manual.

Outline of Product

The Parallel Operation Option is a factory-installed option designed to add master-slave parallel operation functionality to the PAM Series 4kW model.

Once equipped with the parallel operation option, the model (in this manual, referred to as “the unit”) will have the following new features:

Features

- By connecting up to three units in parallel operation, you can increase the output current through master-slave parallel operation. (Rated output capacity of 12 kW)
- Using one unit as the “master” and up to two units as “slave” devices in master-slave parallel operation, you can control power supplies connected in parallel as a whole, by manipulating the master alone.



First read the operation manual for the main unit; specifically, "Chapter 2 Precautions and Preparations for Use". The following provides information you must know before starting master-slave parallel operation.

1.1 Master-slave parallel operation

Master-slave parallel operation involves the operation of power supplies “slaves” connected in parallel through another power supply “master”, also connected in parallel. These power supplies are controlled together from the master, as if they were a single power supply.

- With the unit in master-slave parallel operation, you can connect up to three power supplies in parallel, including a master.
- With master-slave parallel operation, the rated output current is calculated as the rated output current of the unit itself multiplied by the number of power supplies connected in parallel.
- Depending on the configuration of output wiring, the performance of the unit during master-slave parallel operation may not meet the specifications for the main unit. To determine a standard for constant-voltage and constant-current characteristics, multiply these values by the number of power supplies in parallel operation.



- Master-slave parallel operation is possible only between PAM Series 4kW models equipped with the parallel operation option, whose rated output voltage and current are identical.

Do not connect models with different rated outputs, as this will result in malfunction.

1.2 Applied operations during master-slave parallel operation

In master-slave parallel operation, applied operations, such as remote sensing, will be subject to the following restrictions:

- **Remote-sensing function**

Do not use this function. This function works in master-slave parallel operation, but outputs may be destabilized.

- **Analog remote control**

Analog remote control is permitted only for the master. In this case, the rated output current ‘Irtg’ (output current I_o conversion formula) shown in Figs. 4-7 to 4-10 in the operation manual for the main unit "4.3 Analog remote control" may be calculated by multiplying the number of parallel power supplies.

Applied operations during master-slave parallel operation (cont'd)

- **Remote monitoring**

For external monitoring of operation mode (status outputs), use the master. Slaves constantly output constant-current (CC) status.

External monitoring of individual output current (I MON), may be performed on the master and slaves. To monitor the total current, use the master's J3 terminal board.

External monitoring of individual output voltage (V MON) may be performed on the master and slaves. The voltage will remain at almost the same level for both master and slaves, as the units are connected in parallel.

1.3 Alarm

The protective circuits work the same way as the protective circuits described in the operation manual for the main unit "2.5 Alarm". In master-slave parallel operation, they work as follows:

- **OVP (Overvoltage protection)**

Works on the master. Be sure to set the overvoltage level (OVP trip point) on the master. The instant the OVP circuit is activated, the ALARM LED on the master lights, and outputs are turned OFF.

For slaves, set the OVP trip point to the maximum level. If the OVP trip point is set lower for slaves than for the master, the ALARM LED of a slave lights when the slave detects an overvoltage, but outputs are not turned OFF. Once the master's OVP trip point is exceeded, the master displays "ALARM" and turns all outputs OFF, as the outputs are connected in parallel.

- **OHP (Overheat protection)**

The instant the master or a slave detects internal overheating, the ALARM LED lights on the master and slaves, and outputs are turned OFF. (You will not be able to identify the malfunctioning power supply.)

To release the alarm, press the ALARM RESET switch on all power supplies connected in parallel. Be sure to release the alarm on the master, after releasing the alarm on the slaves. If the cause of the alarm is in the master, outputs are enabled when the alarm on the master is released (so long as the OUTPUT switch is ON). The slave alarms are not released automatically, even if the master alarm has been released. The ALARM LEDs of the slaves will continue to light.

- **Internal abnormality**

When the master or a slave detects an interior failure or abnormal action, the ALARM LEDs on the master and all slaves will light and outputs will be turned OFF.

This chapter explains the procedures required for master-slave parallel operations. For details concerning operation of the unit alone, see the operation manual for the main unit.



- Master-slave parallel operation is possible only between PAM Series 4kW models equipped with the parallel operation option, whose rated output voltage and current are identical.

Do not connect models with different rated outputs, as this will result in malfunction.

2.1 Preparations for parallel operation

■ Panel settings

1. From among the parallel power supplies, choose one as the master.
The other power supplies will be used as slaves.
2. Set the S2 (MASTER/SLAVE) switches on the master and the slaves respectively.
When pressed, the switches are set for the master, and when released, they are set for the slaves.
3. On the master, set the OVP trip point.
For details on the setting procedure, see the operation manual for the main unit "3.2.2 OVP (OverVoltage Protection) trip point presetting".
In master-slave parallel operation, the OVP circuit works on the master. Set the OVP trip point before connecting a load to check the operation by outputting a voltage.
4. Set the OVP trip point for the slaves to the maximum value.
Set the OVP trip point for the slaves to the maximum value. It is not necessary to check OVP performance for the slaves.
5. Set the slave outputs to the maximum value for both voltage and current.
For details on the setting procedure, see the operation manual for the main unit "3.2.1 Setting the output"
Unless each slave output is set to the maximum value, the slave outputs will fail to match the master settings.
6. Set the LOCK switch for the slaves.
In master-slave parallel operation, all manipulations are conducted on the master. To prevent unintentional changes to the settings, it is necessary to restrict the slave panels with the LOCK function.
For details, see the operation manual for the main unit "3.5 LOCK function".

Preparations for parallel operation (cont'd)

■ Connection and verification check

7. Check that all POWER switches on the parallel power supplies are OFF.
8. Connect one power supply to another using the accompanying signal connection cable for parallel operation.
See Fig. 2-1 and Fig. 2-2.
9. Connect a load cable to the output terminal of each power supply.
Be sure to connect load cables in parallel. Parallel operation does not work if the only the signal connection cable for parallel operation is connected.
If you do not want to connect a load before verifying operation, connect the load cable to the relay terminal in parallel. After verifying operation, reconnect the load to the relay terminal.
For details concerning the connection procedure for the rear output terminals, see the operation manual for the main unit "3.3.2 Connecting to the output terminal".
10. Connect the load cable from each power supply to the input terminal of the load (or to the relay terminal board connected to the load).
11. Check that the OUTPUT switch on each power supply is OFF.
12. Check that the S1 and S2 switches are set correctly.
Here, verify that all S1 switches are OFF. It is assumed that no analog remote control or remote sensing will be conducted.
13. Verify that the input power cord, load cable, and signal connection cable for parallel operation are connected correctly.
14. Turn ON all POWER switches on the power supplies.
You may turn ON switches either on the master or on a slave.
15. On the display of each power supply, the voltmeter and ammeter will show "----" respectively for a few seconds (right after the POWER switch is turned ON).
Wait for a few more seconds before establishing output settings.
16. Check that all SET ERR LEDs (red) on the power supplies are off.
If a red LED is lit, the S2 switch settings may be incorrect. Recheck the settings for all power supplies.
If a SET ERR LED is lit, this does not necessarily mean that the settings are incorrect for that particular power supply. For example, the master SET ERR LED may light when the settings are incorrect for a slave.
This LED lights, for example, when:
 - In master-slave parallel operation of two power supplies, both are designated as masters or as slaves.
 - In master-slave parallel operation of three power supplies, two or more are designated as masters, or all three are designated as slaves.

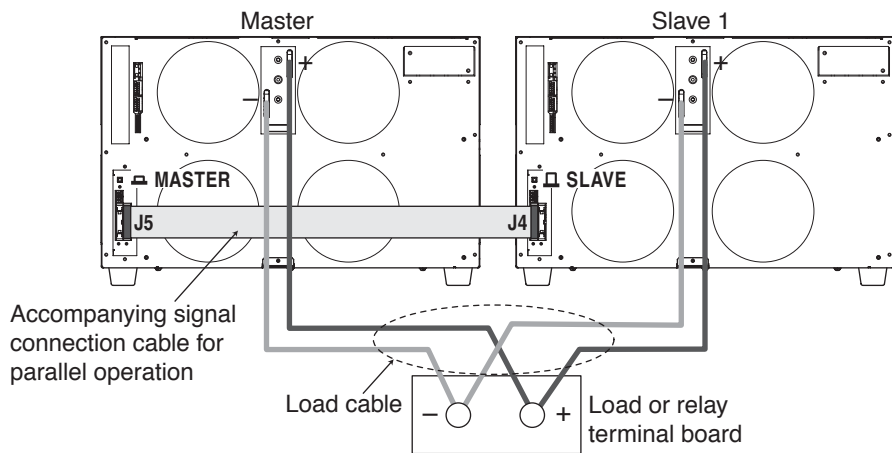


Fig.2-1 Two power supplies in parallel

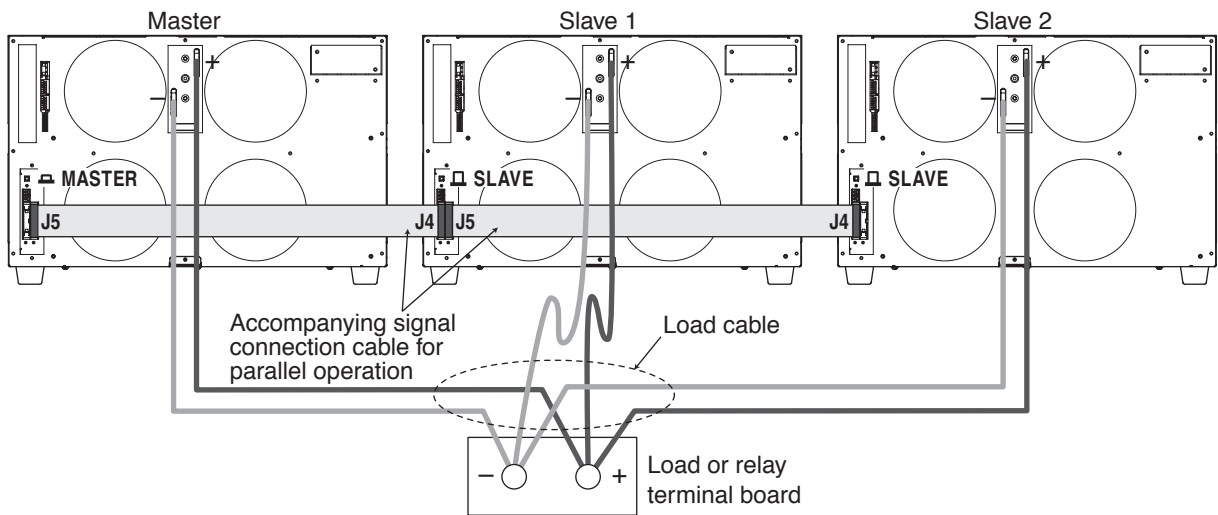


Fig. 2-2 Three power supplies in parallel

CAUTION

- When operation is effected through connection of the output terminal of the unit to the chassis terminal, be sure to connect the output terminal of the power supplies to the chassis terminal with the correct polarity (i.e., + to + and - to -).

If output terminals are connected to the chassis terminal with the incorrect polarities, outputs will be short-circuited via the GND (ground) cable of the input power cord. This will result in failure to obtain proper outputs and will burn the cables connected to the chassis.

NOTE

- For the load cables, use wires of the same diameter and length, with sufficient current capacity. The length of the cable should not exceed 3m. Twist the + cable with the - cable, or lay the wires in parallel.
- Keep the load cable as far away as possible from the signal connection cable for parallel operation.

Preparations for parallel operation (cont'd)

17. On each power supply, check the LEDs (green) below the J4 and J5 connectors.

The LED below the connector lights when the signal connection cable for parallel operation is connected correctly. When the LED is OFF with the cable connected to the connector, the cable may have been connected incorrectly. Recheck the connections.

The LED below the open connector should be OFF.

The above steps complete the necessary preparations for master-slave parallel operation.

After the completion of step 1 through step 17, each power supply reflects the conditions listed in Table 2-1.

Table2-1 Conditions of each power supply

	Master	Slave 1	Slave 2
POWER switch	ON	ON	
S1 switch	All OFF	All OFF	
S2 switch	MASTER	SLAVE	
SET ERR LED	OFF	OFF	
J4 LED	OFF	ON	
J5 LED	ON	OFF/ON (*1)	OFF
OUTPUT switch	OFF	OFF	
OVP trip point	Any value	Maximum value	
Output voltage preset value	Not set	Maximum value	
Output current preset value	Not set	Maximum value	
LOCK switch	OFF	ON	

*1. OFF when two power supplies are in parallel, ON when three are in parallel.

2.2 Master-slave parallel operation

Here we assume that the master and slaves are connected as shown in Fig. 2-1 and Fig. 2-2, according to "2.1 Preparations for parallel operation" and that settings for each power supply are as shown in Table 2-1.

■ Output settings

For master-slave parallel operation, choose either the constant-voltage (CV) mode or the constant-current (CC) mode. Depending on the operation mode chosen, set the voltage or current output for the parallel power supplies as a whole on the master unit.

Parallel operation requires the same voltage settings as for the unit alone, except that the current must be set to a value determined by multiplying the current value displayed on the master by the number of power supplies connected in parallel.

Example: In parallel operation with two power supplies, if the total current value is to be set to 100 A, set the current value on the master to 50 A.

- **Using the constant-voltage (CV) mode:**

Starting at step 6 in "3.2.3 Using as a constant voltage power supply" of the main unit's operation manual, set the current limiting value and the required voltage value.

- **Using the constant-current (CC) mode:**

Starting at step 6 in "3.2.4 Using as a constant current power supply" of the main unit's operation manual, set the voltage limiting value and the required current value.

■ Control and display in parallel operation

- **Panel control**

For panel operations, use the master.

- **OUTPUT switch**

The OUTPUT switch is functional only on the master (the OUTPUT switch on a slave may be set to either ON or OFF).

- **Ammeter**

For values other than current values, check the master.

The output currents of master and slaves are displayed independently. The total current running in the load is the sum of the current values shown on each ammeter.

When the SET switch lights, the preset output current is displayed.

2.3 J3 terminal board

This terminal board allows you to monitor the total output current of all the power supplies connected in parallel.

The signal output level is about 10V at the rated output current (the rated output current of each power supply multiplied by the number of power supplies connected) during parallel operation.



- Do not short-circuit the + terminal with the – terminal. Such short-circuiting may result in malfunction.
-

Cables and tools necessary for connection

1. Wires
 - Single wire: $\phi 0.65$ (AWG22)
 - Twisted wire: 0.32 mm^2 (AWG22); Element wire diameter: $\phi 0.18$ or more
2. Flat-head screwdriver
 - Shank diameter: $\phi 3$
 - Tip width: 2.6 mm
3. Wire stripper
 - Wire stripper which is appropriate for the cable mentioned above.

The same connection procedure as for the J1 and J2 terminal boards applies to the J3 terminal board. See the operation manual for the main unit ("J1 and J2 terminal boards connecting procedure" in "4.1.1 J1 and J2 terminal boards")

This chapter defines the names and functions of the switches, displays, and connectors used with the parallel operation option.

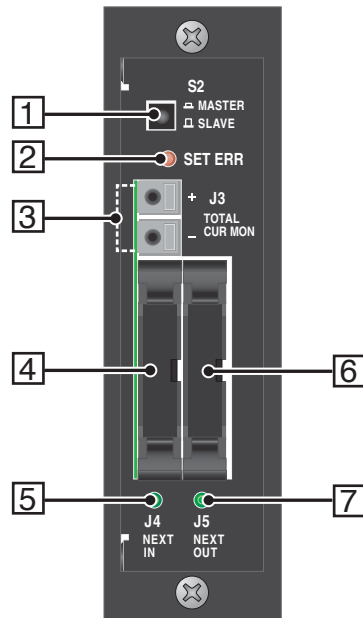


Fig.3-1 Parallel operation option

[1] S2 (MASTER/SLAVE)

Used to set a unit to master or slave mode. When pressed, the unit is set to master, and when released, it is set to slave.

[2] SET ERR

Lights when any of the master/slave settings on the parallel power supplies is incorrect.

This LED lights, for example, when:

- In master-slave parallel operation of two power supplies, both are designated as masters or as slaves.
- In master-slave parallel operation of three power supplies, two or more are designated as masters, or all three are designated as slaves.

[3] J3 (TOTAL CUR MON)

This terminal board allows you to monitor the total output current of all the power supplies connected in parallel.

The signal output level is about 10V at the rated output current (the rated output current of each power supply multiplied by the number of power supplies connected) during parallel operation.



- Do not short-circuit the + terminal with the – terminal. Such short-circuiting may result in malfunction.

[4] J4 (NEXT IN)

In master-slave parallel operation with two power supplies, J4 on the slave is used to connect the slave to the master via the signal cable.

For a slave in master-slave parallel operation with three power supplies, the first slave is connected to the signal connection cable for parallel operation from the master. The second slave is connected to the signal connection cable for parallel operation from the first slave.

[5] J4 (NEXT IN) LED

Lights when the signal connection cables for parallel operation are connected correctly. If this LED does not light after power is supplied, the cable may be connected incorrectly between J4 and J5, or the connectors may be poorly matched.

[6] J5 (NEXT OUT)

In master-slave parallel operation with two power supplies, J5 on the master is used to connect the master signal cable to the slaves.

In master-slave parallel operation with three power supplies, the master is connected to the signal connection cable for parallel operation to the first slave. The first slave is connected to the signal connection cable for parallel operation to the second slave.

[7] J5 (NEXT OUT) LED

Lights when the signal connection cables for parallel operation are connected correctly. If this LED does not light even after the power is supplied, the cable may be connected incorrectly between J4 and J5, or the connectors may be poorly matched.

This chapter explains the details of problems likely to occur in master-slave parallel operation, and provides countermeasures to correct these problems. Because some problems are limited to the unit itself, the user is asked to also read the operation manual for the main unit "6.4 Malfunctions and Causes". Problems are categorized into four groups, and check points are listed for each problem. Some problems may be easily solved. Identify your problem from those listed, and take the corrective actions shown. If your problem still remains, or if it is not found in the list, please contact Kikusui distributor/agent.

Symptom1: The ALARM LED lights when the OUTPUT switch is turned ON.

Check point	Cause and corrective action
<input type="checkbox"/> The OVP trip point for the slave is set below the output voltage (The ALARM LED of the slave lights ON).	<ul style="list-style-type: none"> The OVP protective circuit is activated on the slave. Set the OVP trip point to the maximum value. See "1.3 Alarm"

Symptom2: No output is generated even when the OUTPUT switch is turned ON.

Check point	Cause and corrective action
<input type="checkbox"/> The SET ERR LED is lit.	<ul style="list-style-type: none"> Incorrect master/slave settings. Correct the settings according to "2.1 Preparations for parallel operation"
<input type="checkbox"/> The power supply being used is set to a slave.	<ul style="list-style-type: none"> Reset to the master. Otherwise check the operation of the master.

Symptom3: Outputs are unstable.

Check point	Cause and corrective action
<input type="checkbox"/> The cable connection between the master and the slaves is not well established.	<ul style="list-style-type: none">• Reconnect the cable securely, according to "2.1 Preparations for parallel operation"
<input type="checkbox"/> The cable between the master and the slaves is too long, or too thin.	<ul style="list-style-type: none">• Shorten the cable, or replace it with a thicker one. Otherwise, ensure that the cables from the master and the slaves to the load (the relay terminal board) are the same length or thickness.
<input type="checkbox"/> There is a loop in the cable connecting the master to slaves.	<ul style="list-style-type: none">• Twist the + and - lines, or make them parallel (or bundle them).

Symptom4: The preset value does not agree with the output, or the output does not agree with the displayed value.

Check point	Cause and corrective action
<input type="checkbox"/> The voltage limiting value or current limiting value for the slaves is set too low.	<ul style="list-style-type: none">• Set the maximum voltage or current for the slaves to the limiting value.

