Technical Explanation for Power Controllers

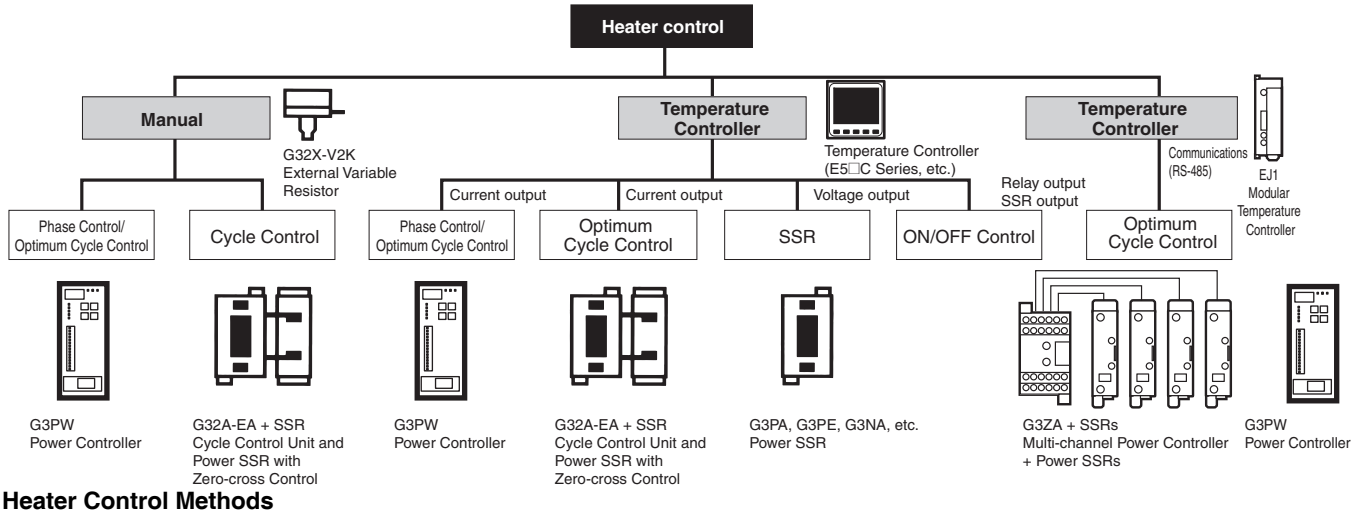
Introduction

What Is a Power Controller?

A Power Controller continuously adjusts the power consumed by a heater with phase control or optimum cycle control mainly by receiving an analog signal, such as a 4 to 20 mA signal from a temperature controller, or by receiving manual settings made with a variable resistor.

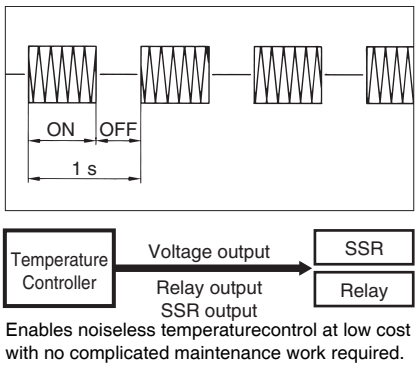
Configurations and Types of Heater Control

Power controllers are mainly used for heater control.
Each heater control method has its own features, so it is necessary to decide the method that matches your application.



Heater Control Methods

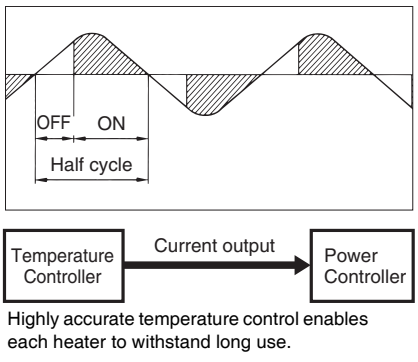
(1) ON/OFF Control



Enables noiseless temperaturecontrol at low cost with no complicated maintenance work required.

(1) ON/OFF time-sharing proportional control is the most widely used control method in combination with temperature controllers.
(2) The large difference in temperature of the heater, when turning ON and OFF will shorten the service life.
(3) This method is suitable for controlling items with a large heat capacity, which are difficult to heat and cool.

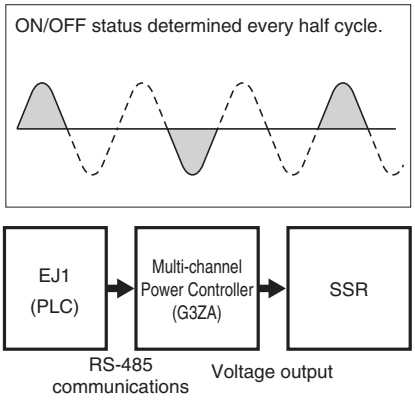
(2) Phase Control



Highly accurate temperature control enables each heater to withstand long use.

(1) The output value is changed each half cycle, enabling highaccuracy temperature control.
(2) More finely tuned control enables resistance to external disturbances and few heat shocks, thereby extending the service life of the heater.
(3) The gradient can be set as desired, and so the output value can be set when a Power Controller is used in a set with a temperature controller.
(4) Inrush current can be suppressed by using a soft start or a constant-current circuit.
(5) Noise occurs due to phase control.

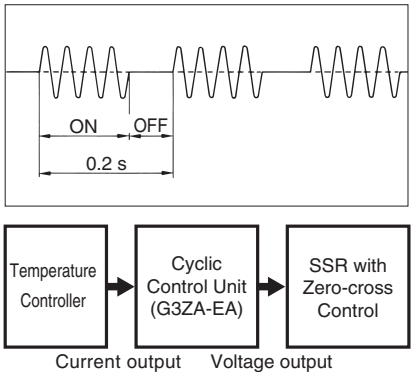
(3) Optimum Cycle Control (High-accuracy zerocross control)



Multi-channel heater control using communications.
High-speed response with no noise.
Note: Optimum cycle control can be achieved with the G3PW as well.

(1) Optimum cycle control is performed with SSR operation using load power supply detection and a trigger signal.
(2) High-speed response is provided and high-accuracy temperature control is performed by turning the output ON and OFF every half cycle while suppressing generation of noise.

(4) Cycle Control



Noiseless, high-speed response

(1) The output cycle of the voltage output enables detailed control with a short cycle, which achieves temperature control with greater precision than ON/OFF time-sharing proportional control.
(2) Manual control without the use of temperature controllers has been achieved. (An external variable resistor is used.)

For information on Multi-channel Power Controllers and Cycle Control Units, refer to the product datasheets.

G3PW Control Methods and Combination Examples

The G3PW is a thyristor-type single-phase power controller that enables precise temperature control.
It is combined with a temperature controller or other device to control a heater.

What Is G3PW Analog Control?

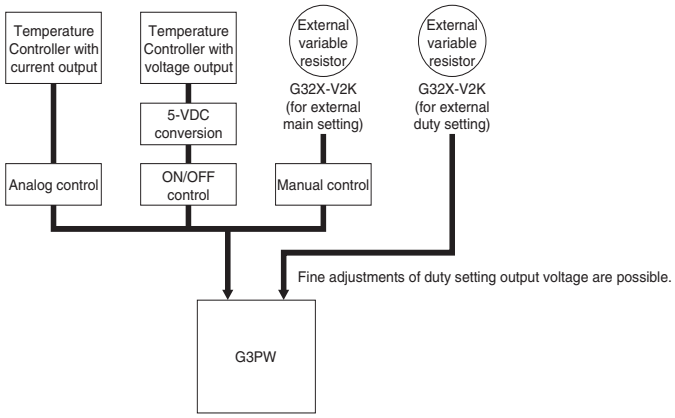
The change in current output of the temperature controllers between 4 and 20 mA is used for precise heater control by the G3PW, which outputs smoothly adjusted power. Fine adjustments of the heater temperature are possible with external or internal duty setting.

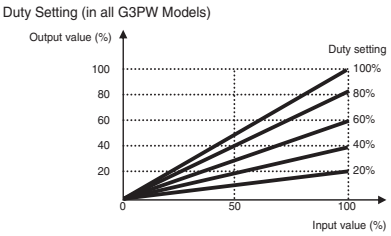
What Is G3PW ON/OFF Control?

The voltage output of the temperature controllers is used for ON/OFF heater control. Fine adjustments of the heater temperature are possible with external or internal duty setting.

What Is G3PW Manual Control?

Output adjustments are possible with an external variable resistor.

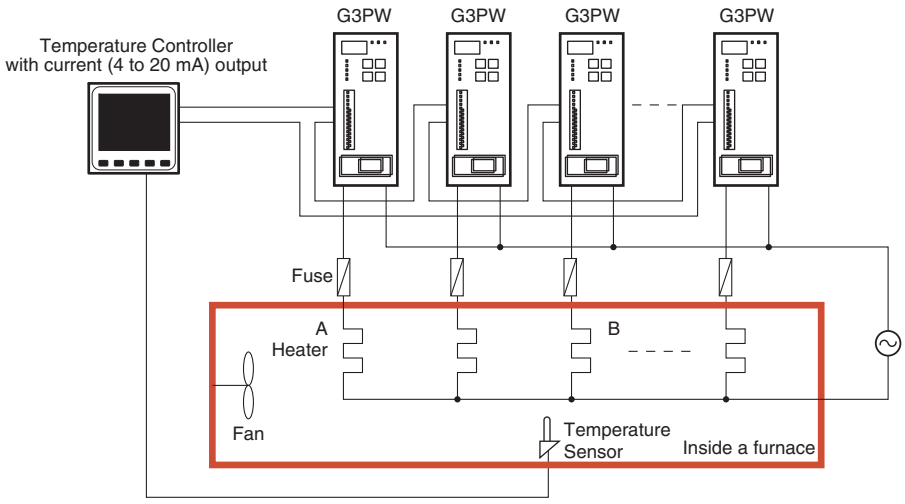




Connection Examples of G3PW and Temperature Controller

If a single temperature controllers is in control of more than one heater, by making a proper duty setting, the difference in temperature between the heaters can be improved.

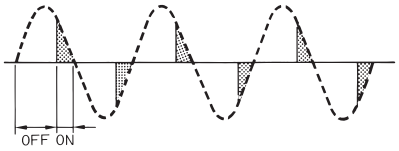
Note: The temperature at point B can be higher than that at point A due to thermal interference. In that case, make the duty set value for heater B smaller than that for heater A so that there will be no difference in temperature between points A and B.



Explanation of Terms

Phase Control

Output is varied at half-phase intervals, which enables highly accurate temperature control.

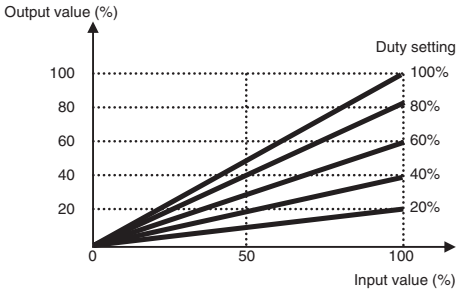


Changes in the current output from the temperature controllers between 4 and 20 mA are used for analog control of the output power.
The more-detailed control resists disturbance better and results in less heat shock, which can also length the life of heaters.
The phase zero point must be detected to perform phase control. To detect the zero point, the phases must be the same. Phase difference may result in malfunctions. (The input signal and output value will not match.)

Duty Setting

As shown in the following graph, changes in the output can be adjusted with key operations or with an external variable resistor.
In the case of an electric oven, overshooting may result by using a heater with a capacity that is excessively high for the size of the oven. By adjusting the duty-setting variable resistor, the overshooting can be suppressed.
For example, if a duty of 60% is set for a 5-kW heater, a maximum of 3 kW will be input into the heater. Thus, it operates as a 3-kW heater.

Duty Setting (in all G3PW Models)

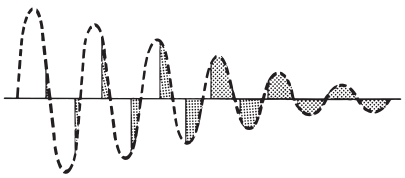


Monitoring the Total Operation Time

The time that power is supplied to the G3PW is totaled and a warning is output if the preset time is exceeded.
This is useful for the management of maintenance according to the life of the load.

Soft-start

This function suppresses the inrush current that is caused when the load is turned ON, thus ensuring smooth starting of the load. The soft-start time is adjusted between 0 and 99.9s, thus enabling the heaters to withstand long use.
This function is especially effective for loads that involve high inrush current, such as halogen lamps.



Base-up

This function briefly keeps the output of the Power Controller turned ON after heating when the input signal is OFF. This is effective for a smooth start of equipment that is slow in initial heating operation.

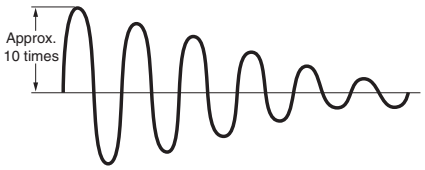
Output Limit

The output range is limited by an upper limit and a lower limit. This feature functions for the control input. It does not suppress inrush current.
Use the soft start to suppress inrush current.

Constant-current (for Constant-current Models Only)

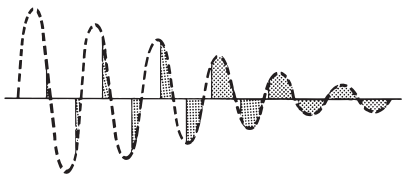
This is a function that protects the heater and the system by automatically suppressing excessively large inrush current, such as with pure metal heaters.
As shown in the following figure, ten times the rated current flows when power is applied to pure metal heaters, for which molybdenum and tungsten are typical.
(This current cannot be fully suppressed by using a long soft-start time.)

Flow without Constant-current Function



As shown in the following diagram, the constant-current circuit functions to automatically regulate to the current in response to the input signal. Inrush current is suppressed by reducing the ON phase.

Flow with Constant-current Function



Note: Protection is not provided in case of protection short circuit. Also use a quick-burning fuse.

Load Current Limit (for Constant-current Models Only)

The load current is measured by a built-in CT to adjust the output phase angle and suppress the load current.
The response time from measurement to suppression is 500 ms max. To suppress inrush current, use the soft start together with the load current limit.

Further Information

Fuse Connections (Constant-current Models)

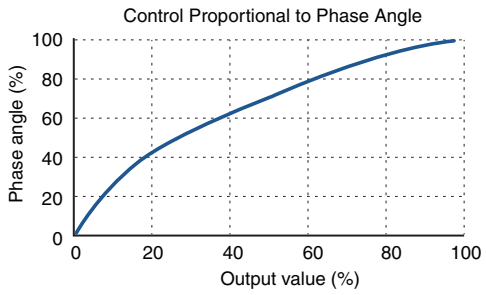
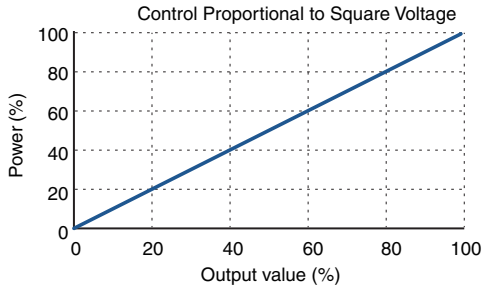
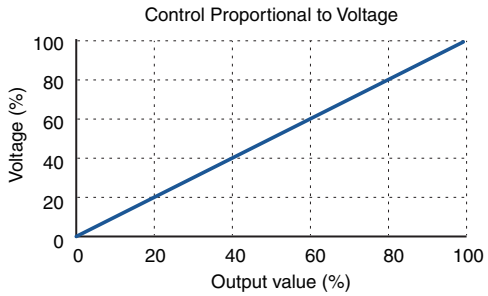
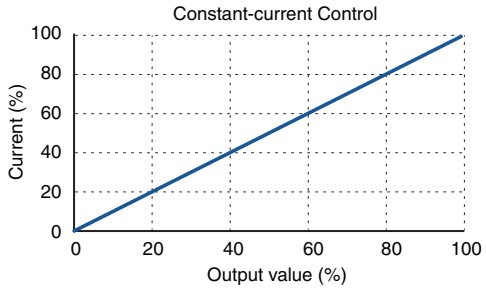
When using the Constant-current Model, the G3PW Power Controller cannot be protected against load short circuit.
If short-circuit current flows, the elements will be destroyed before the constant-current or overcurrent detection currents operate.
To protect the G3PW from short-circuit accidents, connect a quick-burning fuse.

Quick-burning Fuses

Product model	Fuse model	Fuse Holder
G3PW-A220E□-□□□	CR6L-20/UL	CMS-4
G3PW-A245E□-□□□	CR6L-50/UL	
G3PW-A260E□-□□□	CR6L-75/UL	CMS-5

Output Modes for G3PW Phase Control

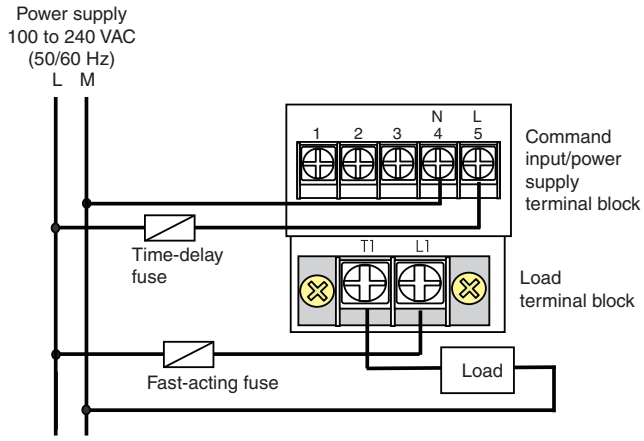
For the G3PW, when phase control is used as the control method, you can select from the following four modes for the relationship of the control value to the output value.

Control proportional to phase angle	In this mode, the phase angle is proportional to the output value.	
Control proportional to square voltage	In this mode, the square of the output voltage is proportional to the output value. When the load resistance is constant, the output power value is proportional to the output value.	
Control proportional to voltage	In this mode, the output voltage is proportional to the output value.	
Constant-current control (Constant-current Models only)	In this mode, the load current is proportional to the output value. The duty setting changes with the load resistance. To suppress the output current, use the duty setting function to suppress the duty.	

G3PW Wiring Methods

Wiring the Power Supply and Load Circuits

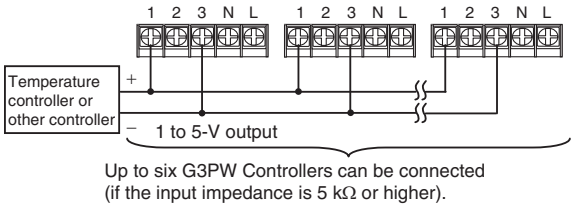
- First, connect the load to load terminal T1 and to the power supply, and then connect the power supply to load terminal L1 through a fast-acting fuse.
- Connect the AC power supply to power supply terminals 4 (N) and 5 (L).
- The AC power supply ground polarity and the G3PW terminal block polarity are not related, but connect the 4 (N) and 5 (L) terminals on the command input/power supply terminal block and the T1 and L1 terminals of the load terminal block to power supplies with the same phases.
- Always connect the load to load terminal T1.



Command Input and Power Supply Terminal Wiring

Voltage Input (1 to 5 VDC)

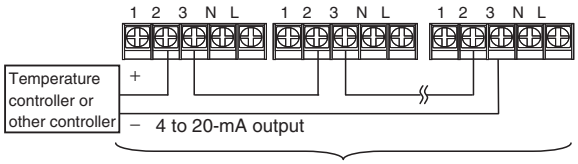
When using a voltage input, connect the positive and negative signal wires to terminals 1 and 3, respectively.
Example:
For a linear voltage output, if the input impedance is 5 kΩ or higher, up to six G3PW Controllers can be connected.



Up to six G3PW Controllers can be connected
(if the input impedance is 5 kΩ or higher).

Current Input (4 to 20 mA DC)

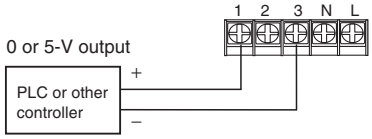
When using current input, connect the positive and negative signal wires to terminals 2 and 3, respectively.
Example:
If a temperature controller with a current output has an input impedance of 600 Ω or higher, up to six G3PW Controllers can be connected.



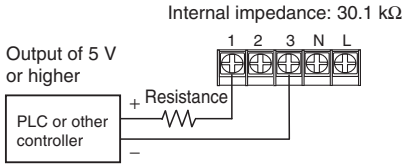
Up to six G3PW Controllers can be connected
(if temperature controller allowable load impedance is 600 Ω or higher)

ON/OFF Voltage Input (0 or 5 VDC)

When using an ON/OFF voltage input, connect the positive and negative signal wires to terminals 1 and 3, respectively. The G3PW may be damaged if a command voltage that is higher than 5 V is applied.



If it is necessary to apply more than 5 V, split the voltage as shown below by inserting resistance in the line to terminal 1 and applying the voltage across terminals 1 and 3. The internal impedance between terminals 1 and 3 is 30.1 kΩ.



Output voltage	Resistance
0 or 5 V	Not required
0 or 12 V	42 kΩ, 1/5 W min.
0 or 24 V	120 kΩ, 1/5 W min.

For details on G3PW wiring methods, refer to the user's manual.
Reference manual: *G3PW Power Controllers User's Manual* (Cat. No. Z280)

Comparison with Discontinued Products

The following table compares the G3PX (discontinued products) and G3PW (current products).

		G3PX				G3PW	
		Simple models	Advanced			Standard	Constant-current
Model		**EUN**	**EH**	**EHN**	**EC**	**EU**	**EC**
Number of heater phases		Single-phase				Single-phase	
Control object		Alloy (nichrome)			Pure metal (Kanthal Super)	Alloy (nichrome)	Pure metal (Kanthal Super)
Load voltage	**200 V**	100/110/200/220 VAC				100 to 240 VAC	
	400 V	---				---	
Load current		1 to 20, 1 to 40, or 1 to 60 A				1 to 20, 1 to 45, or 1 to 60 A	
Control method	**Phase Control**	Supported	Supported	Supported	Supported	Supported	Supported
	Optimum cycle control	---	---	---	---	Supported	Supported
Output mode	**Proportional to phase angle control**	Supported	Supported	Supported	Supported	Supported	Supported
	Proportional to voltage control	---	---	---	---	Supported	Supported
	Proportional to square voltage control	---	---	---	---	Supported	Supported
	Constant-current control (proportional to current)	---	---	---	Supported	---	Supported
Input signals from host	**Analog input (continuous proportional)**	Supported				Supported	Supported
	Voltage ON/OFF input (time-proportional)	Supported				Supported	Supported
	External main setting (using external variable resistor)	Supported				Supported	Supported
	Serial communications (RS-485)	---				---	Supported
Selecting automatic or manual for the main setting		Switched by changing connections.				Event input, key operation	Event input, key operation, communications
Duty settings	**Internal setting**	Supported	Supported	Supported	Supported	Supported (Keys)	Supported (Keys or communications)
	External setting	Supported	Supported	Supported	Supported	Supported	Supported

The following table compares the G3PX (discontinued products) and G3PW (current products).

		G3PX				G3PW	
		Simple models	Advanced			Standard	Constant-current
Model		EUN	EH	EHN	EC	EU	EC
Functions	Displayed on 7-segment display	---	---	---	---	Supported	Supported
	Level indicators (output display)	Supported	Supported	Supported	Supported	---	---
	Soft-start function	---	Supported	---	---	Supported	Supported
	Long soft-start up/down	Supported	---	Supported	Supported		
	Soft-start down function	Supported*	Supported*	Supported*	Supported*	Supported	Supported
	Base-up function	Supported	---	---	---	Supported	Supported
	Load current limit	---	---	---	Supported	---	Supported
	Output upper/lower limits	---	---	---	---	Supported	Supported
	Total run time exceeded detection	---	---	---	---	Supported	Supported
I/O functions	Event inputs	1 (alarm reset)				2 (alarm reset) (automatic/manual selection or control method selection)	
	Alarm outputs	1	1	1	1	2 (warning, caution)	
	Serial communications (RS-485)	---	---	---	---	---	Supported
Error monitoring	Overcurrent detection	---	---	---	Supported	---	Supported
	Single heater burnout detection	---	Supported	Supported	Supported	---	Supported
	Multiple heater burnout detection	---	---	Supported (1 element out of 5)	---	---	Supported (1 element out of 10)
	SSR short-circuit (element ON failure detection)	---	Supported	Supported	Supported	Supported	Supported
	SSR open failure	---	---	---	---	Supported	Supported
	CT Failure	---	---	---	---	---	Supported
	Zero cross error	---	---	---	---	Supported	Supported
	External input range error (external input disconnection detection)	---	---	---	---	Supported	Supported
	Power supply frequency error	---	---	---	---	Supported	Supported

✻ The soft-start down time is the same as the soft-start up time.