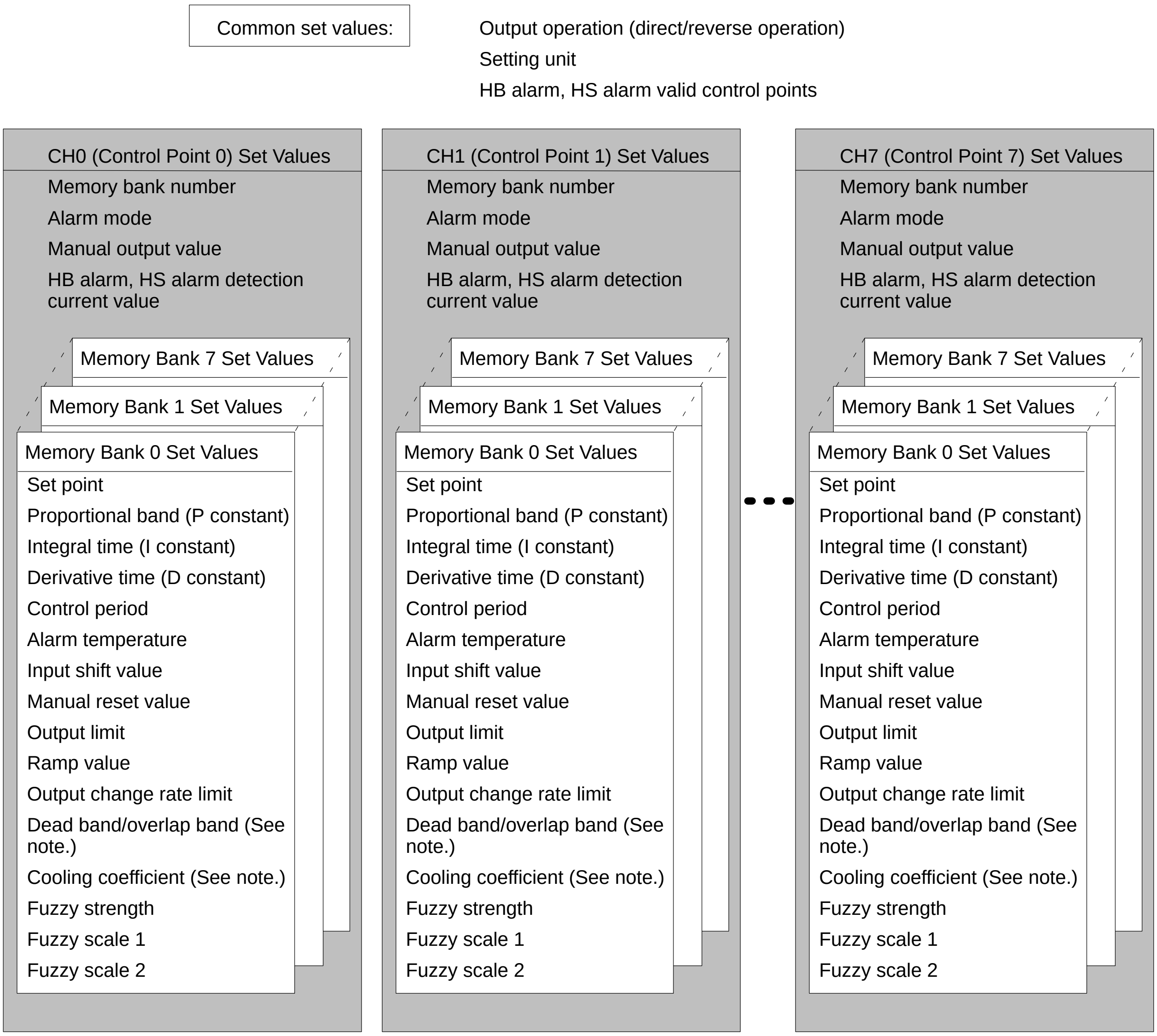
SECTION 3
Functions

This section provides details on the functions of the E5ZE and their applications. For details on the settings and measurement values for the functions, refer to the *E5ZE Multipoint Temperature Controller Communications Manual (H77)* and the *E5ZE-8 Multipoint Temperature Controller CompoBus/D Communications Manual (H104).*

3-1 Data Configuration

Set Values

The following diagram shows how data is structured in the E5ZE.



Note The cooling coefficient and dead band/overlap band are applicable only to E5ZE-8V□□□□□ Heating and Cooling Control Models.

Memory Banks

The E5ZE has 8 memory banks, 0 to 7, for each control point. The memory banks store specific groups of setting data. The E5ZE controls each control point according to the contents of the current memory bank.

- All set values are written (set) or read using communications. The control point number and memory bank number must be specified for each command. For CompoBus/D, however, the control point and memory bank numbers do not always need to be specified.
- When CompoBus/D (remote I/O) is used, set values will be read and written according to the current memory bank.

Memory Bank Designation

Memory banks are designated using contact inputs or through communications. The method of memory bank designation is set using pin 3 of the FUNCTION switch. Refer to *2-3 Setting Selectors and Switch* for details on setting methods.

- When the E5ZE is turned ON, the memory banks previously selected through communications will be in effect.

- The memory bank numbers for control points that are being auto-tuned cannot be changed.
- The following table shows the designation methods and functions of the memory banks.

Item		Operation	Function
Setting the memory bank number	Through communications	A memory bank number is designated for each control point through communications.	The different memory bank numbers can be designated for each control point.
	Using contact inputs	A memory bank number is designated by setting contacts MB0 to MB2 on the terminal block connected to the CONTROL connector.	All control points will switch to the designated memory bank number.
Confirming the selected memory bank number		A control point can be designated and read through communications to check the memory bank.	---

The following table shows the status of MB0 to MB2 and their relation to the designated memory bank.

Memory Bank	0	1	2	3	4	5	6	7
MB0	---	ON	---	ON	---	ON	---	ON
MB1	---	---	ON	ON	---	---	ON	ON
MB2	---	---	---	---	ON	ON	ON	ON

The dashed line “---” indicates that the input is OFF.

3-2 I/O Settings

3-2-1 Input Type

The E5ZE is available in models that can be used for thermocouple inputs or platinum resistance thermometer inputs.

The input type is set using the INPUT selector on the front panel of the Unit. Refer to *2-3 Setting Selectors and Switch* for details on settings.

3-2-2 Input Shift

Set the input shift parameter in each memory bank.

The input shift function adds the value set for the input shift to the process value and the E5ZE then controls using this temperature as the process value. For example, if the process value is 100°C and the input shift is –12°C, the E5ZE will use 100°C – 12°C = 88°C as the process value for control.

The input shift setting range is –99.9 to 99.9°C or –99.9 to 99.9°F (default: 0.0°C or 0.0°F.)

3-2-3 Control Period

If the Voltage Output Model is being used, set the control period in each memory bank.

Set the length of the control output period. The setting range is between 1 and 99 s (default: 2 s). For direct operation, the default can be used.

3-2-4 Direct/Reverse Operation

The direct/reverse operation parameter is the same for all control points.

Reverse operation is used for heating control and direct operation is used for cooling control.

The default is 0000, i.e., all control points will operate in reverse (heating control).

3-3 Set Point and Process Value

The setting for the set point used to control the temperature and the process value includes a temperature unit and a setting unit.

The temperature unit (°C or °F) is specified using pin 6 of the FUNCTION switch on the front panel of the Unit. Refer to *2-3 Setting Selectors and Switch* for details on settings.

The setting unit is set using the setting unit parameter as either 0 or 0.1 (default). If serial communications are used to read the set point and process value data, 4 digits will be indicated if the setting unit is “0” and 5 digits will be indicated if the setting unit is “0.1.”

The same setting unit is used for all control points.

3-3-1 Setting Set Point

Set the set point using the Set Point Write (WS) command in each memory bank of each control point.

If CompoBus/D communications are being used, the values in the memory of the host devices will be automatically reflected in the settings.

The default is 0.0°C or 0.0°F.

3-3-2 Reading Process Value

Read the process value using the Process Value Read (RX) command. The process value will be read for each control point.

If CompoBus/D is used, the values in the memory of the host device will be automatically read.

Setting Unit

The setting unit is used as the unit for the alarm temperature and current control temperature during ramp control, as well as for the set point and process value.

The settings will not be affected if the setting unit is changed. If the settings are read, however, they will be indicated as follows:

- If the setting unit is set to 0.1, and data is read after changing the setting unit to 0, any value after the decimal point will be rounded off to a whole integer. For example, 1234.5 will be read as 1235.
- If the setting unit is set to 0, and data is read after changing the setting unit to 0.1, a zero will be added after the decimal point. For example, 1234 will be read as 1234.0.

Operation Start and Stop

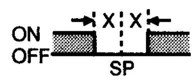
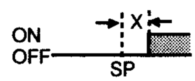
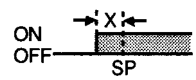
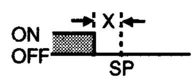
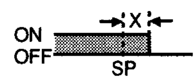
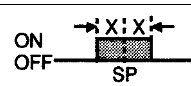
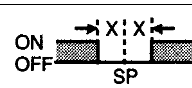
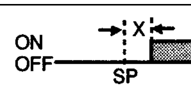
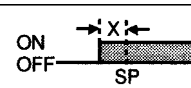
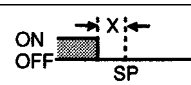
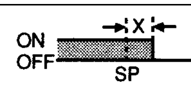
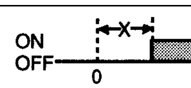
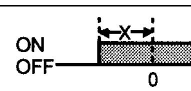
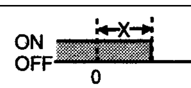
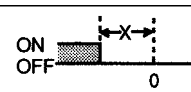
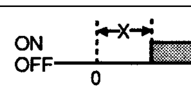
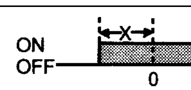
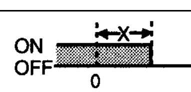
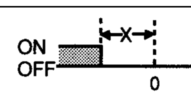
- Execute the Operation Start (OS) command for each control point to start temperature control.
- Execute the Operation Stop (OP) command to stop temperature control or manual operation.
- When CompoBus/D communications are used, specific bits are allocated in the memory of the host device for starting and stopping temperature control. Temperature control is started and stopped by turning the corresponding bit ON or OFF.

3-4 Alarm Output Settings

- The alarm outputs can be set for alarms 1 and 2 for each control point. Each alarm output will be output from the alarm 1 and alarm 2 terminals. The alarm 1 and 2 terminals are used for all control points.
- The alarm output conditions are determined by the combination of the alarm mode and alarm temperature settings.
- In addition to normal alarm outputs, alarm outputs for both HB alarms and HS alarms are also possible.
- The alarm outputs do not operate when the E5ZE is stopped.

3-4-1 Alarm Modes

- The following table shows the operations of the alarm modes of the E5ZE.

Code	Alarm mode	Alarm output function	
		Positive alarm temperature (X)	Negative alarm temperature (X)
00	No alarms	Always OFF (default setting)	
01	Upper- and Lower-limit Alarm		---
02	Upper-limit Alarm		
03	Lower-limit Alarm		
04	Upper- and Lower-limit Range Alarm		---
05	Upper- and Lower-limit Alarm with Standby Sequence		---
06	Upper-limit Alarm with Standby Sequence		
07	Lower-limit Alarm with Standby Sequence		
08	Absolute Value Upper-limit Alarm		
09	Absolute Value Lower-limit Alarm		
0A	Absolute Value Upper-limit Alarm with Standby Sequence		
0B	Absolute Value Lower-limit Alarm with Standby Sequence		
0C	HB and HS Alarm	Turns ON when the HB alarm or HS alarm is output.	

Set the alarm mode for each control point.

3-4-2 Alarm Temperatures

- The alarm temperatures are indicated by X in the above alarm mode table. The operation differs depending on whether the value is positive or negative.
- Set the alarm temperature in each memory bank. The alarm temperature setting is not required, however, if the alarm mode is set to 00 (no alarm function) or 0C (HB and HS alarm).

Standby Sequence

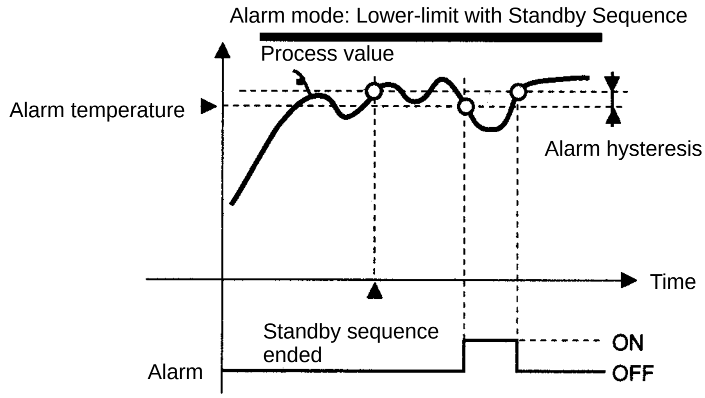
The Standby Sequence enables delaying output of an alarm until the process value enters the alarm range from outside the alarm range.

For example, if the alarm mode is set to Lower-limit Alarm without Standby Sequence, and the ambient temperature is lower than the alarm set value (i.e., within the alarm range), the alarm output will turn ON at startup. If, under the same conditions, the alarm mode is set to Lower-limit Alarm with Standby Sequence, the alarm output will only turn ON when the process value rises once above the alarm set value (i.e., outside the alarm range) and then drops back below it (i.e., within the alarm range).

- When the alarm output turns ON, the standby sequence operation will be ended. The standby sequence will restart again, however, under the following conditions.
  - If temperature control or manual operation is started.
  - If the power is turned ON.
  - If the set point is changed.
  - If the alarm temperature is changed during operation.

Alarm Operation Summary

The following time-chart shows an example of the Lower-limit Alarm with Standby Sequence Mode.



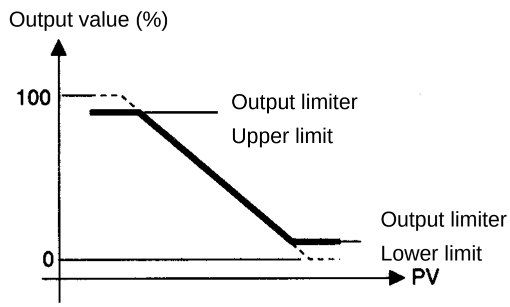
The alarm hysteresis is a fixed value: 1.0°C, 1.0°F

3-5 Output Limitations

The upper and lower limits for the output value are limited by an output limiter and the output change rate is limited by an output change rate limiter.

3-5-1 Output Limiter

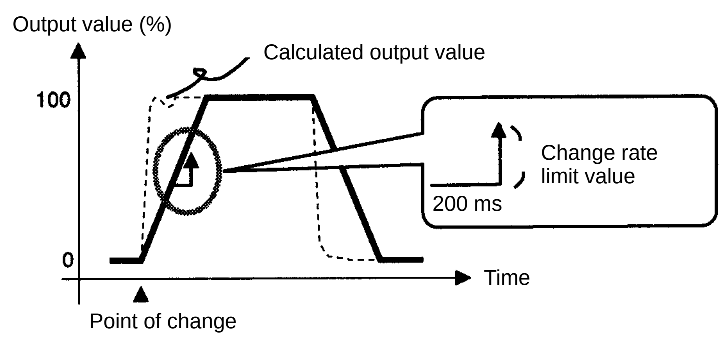
If the output value calculated by the E5ZE is outside the range of the output limiter, the actual output will be restricted to the specified upper or lower limit.



- Set the upper limit and the lower limit within the range of 0.0% to 100.0%.
- The lower limit cannot be set to a value greater than the upper limit.
- If the lower limit is 100.0, the output value will be 100.0%.
- If the upper limit is 0.0, the output value will be 0.0%.
- If the upper limit is equal to the lower limit, the output value will be equal to the output limits.

3-5-2 Output Change Rate Limiter

The change in output value during one sampling period (approx. 200 ms) is limited by the output change rate limiter. If the output value calculated by the E5ZE changes too quickly, the actual output will be that allowed by the setting of the output change rate limiter and will gradually change until it reaches the calculated output value.



- The change rate limit setting range is between 0.0% and 100.0% per 200 ms. The change rate limiter is disabled if the value is set to 0.0 (default).
- Use the following formula to calculate and set the change rate limit when the change rate is A% for 1 s of output.

  Standard Control Models: A x 0.2

  Heating and Cooling Control Models: A x 0.2 x 0.5
- The output change rate limiter will operate for both heating control and cooling control.

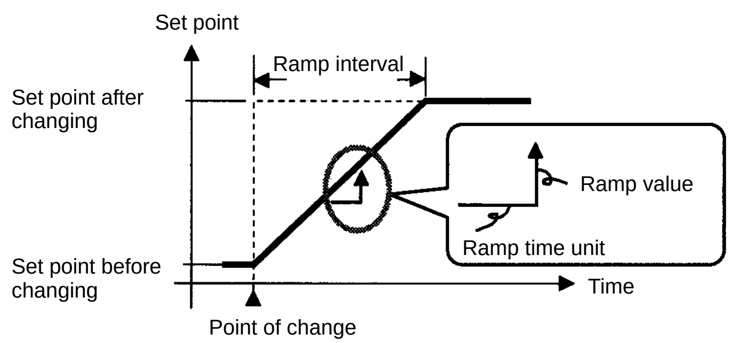
Limiter Operation Conditions

The limiter will be disabled and settings will not be required under the following conditions.

- During manual operation.
- When a temperature sensor input error or temperature controller error occurs.
- When operation is stopped.
- During ON/OFF control.
- During auto-tuning (applies to the output change rate limiter only).

3-6 Ramp

If the ramp function is enabled and the change in the set point exceeds the specified rate of change, the set point will change over an interval, as shown in the following diagram. Temperature will be controlled during the ramp interval according to the value limited by this rate of change (i.e., the current set point), and not by the new set point.



- Set the change rate of the ramp interval in each memory bank. The ramp value and the ramp time unit (hour, minute, or second) must also be set.
- The setting range is 0.1 to 99.9 (°C or °F divided by the ramp time unit).The default is 0.0, i.e., the ramp function is disabled.

Enable Conditions

The ramp function will be used at the following times.

- When temperature control is started.
- When a memory bank number is changed.
- When the set point is changed.

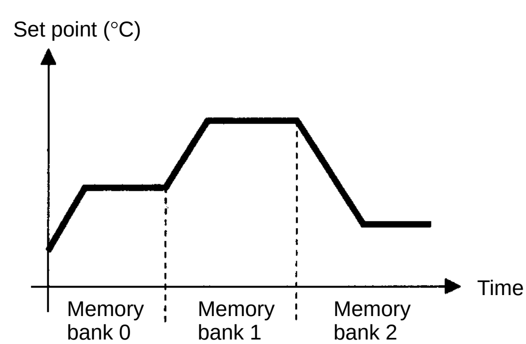
Disable Conditions

The ramp function will be ended at the following times.

- When manual operation is started.
- When auto-tuning is executed.

Application Example

If set points and ramp values are reset in memory banks in advance and the memory bank is switched from the host device over time, the following type of trapezoidal control will be achieved.



3-7 Control Adjustments

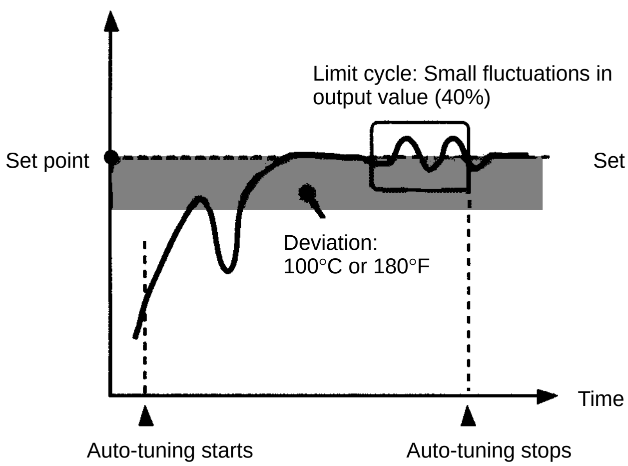
3-7-1 Auto-tuning

Auto-tuning (AT) can be executed independently for any control point, or can be executed for all control points simultaneously or in sequence. (If the CompoBus/D is being used, auto-tuning cannot be executed in sequence.)

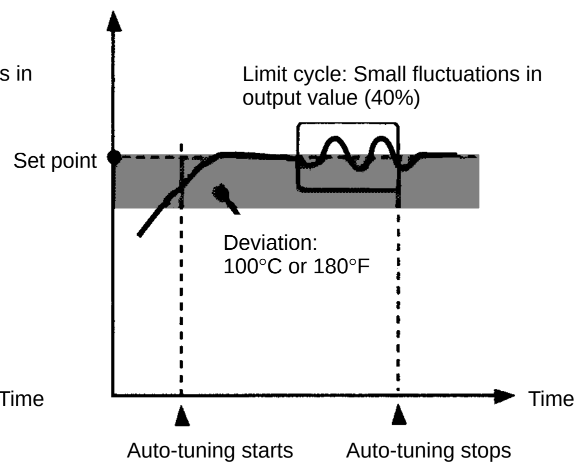
- If auto-tuning is cancelled, the auto-tuning will stop for all control points at the same time. (If the CompoBus/D is being used, auto-tuning can be stopped for each control point separately.)
- When auto-tuning is executed, the optimum PID constants and fuzzy scale for the set point will be automatically set in the current memory bank. The following set values will be changed.

  Proportional band (P constant), integral time (I constant), derivative time (D constant), fuzzy scale 1, fuzzy scale 2
- The AT indicator will be lit while auto-tuning is being executed.
- A method of obtaining the characteristics of the controlled object (the limit cycle method), by causing the output value to fluctuate is used. The application of the method, however, will vary depending on whether the deviation (the difference between the set point value and the process value) is greater or less than 100°C or 180°F when auto-tuning is started.

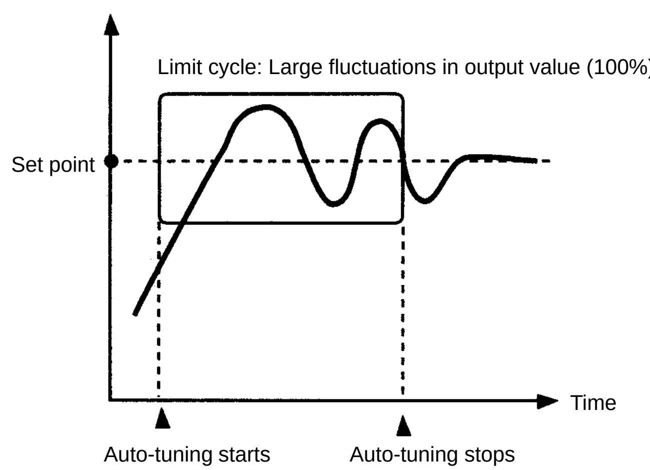
Deviation ≧ 100°C or 180°F



Deviation < 100°C or 180°F



- If auto-tuning is executed for ON/OFF control, auto-tuning will be executed with large fluctuations in the output value. After auto-tuning is completed, 2-PID control will be executed.



Operation during Auto-tuning

- Auto-tuning cannot be executed when the E5ZE operation is stopped or it is being operated manually.
- The auto-tuning execution time may be extended depending on the controlled object. In such a case, the time required for auto-tuning to be completed may be reduced if the proportional band (P constant) is set to 0.0. The E5ZE goes into ON/OFF operation with oscillations increasing.
- If the optimum PID constants have not been obtained for the controlled object, set them manually.
- Hunting will occur during auto-tuning. If hunting is undesirable, set the PID constants manually.
- The HB and HS alarms will not operate for the control point during auto-tuning.
- If the power is turned OFF during auto-tuning, the E5ZE will stop auto-tuning.
- The auto-tuning function will not operate properly if the controlled object (load) is not connected to the E5ZE.

PID Constants

- The following table shows the relationship between the PID constants and the set point responses for the temperature being controlled. Refer to this table when setting PID constants manually.

PID constant		Set point response		
		Excessive value	Oscillation	Time
Proportional band	Larger	Decreases	Decreases	Long
	Smaller	Increases	Increases	Short
Integral time	Larger	Decreases	Decreases	Long
	Smaller	Increases	Increases	Short
Derivative time	Larger	Decreases	Increases	Long
	Smaller	Increases	Decreases	Short

Excessive value: Overshooting or undershooting

Oscillation: Hunting

Fuzzy Constants

The fuzzy control function is used when there is external disturbance, to suppress overshooting or undershooting the temperature being controlled by the E5ZE and stabilize the set point within a short period.

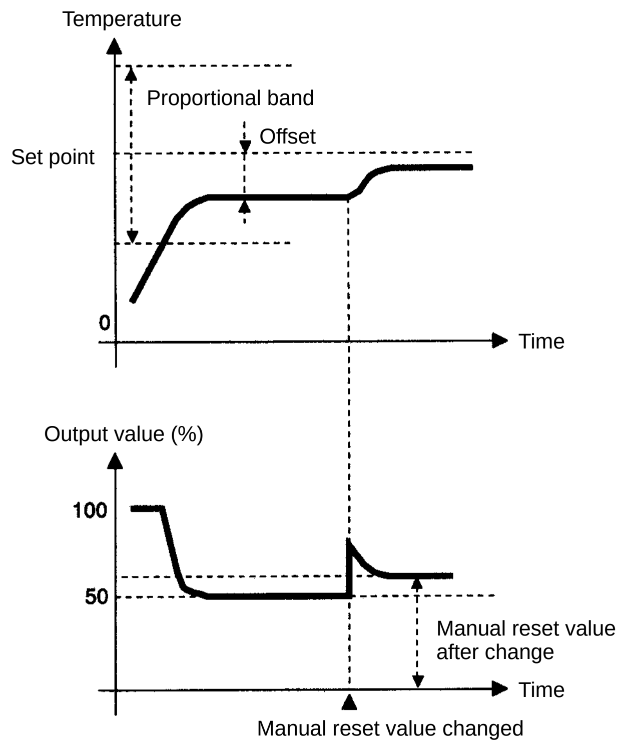
- The fuzzy constants are automatically adjusted when the PID constants are changed.
- If automatic adjustment of fuzzy constants is unsatisfactory, adjust them manually referring to the following table.

Fuzzy constant		External disturbance response		
		Excessive value	Oscillation	Time
Fuzzy strength	Large	Decreases	Increases	---
	Small	Increases	Decreases	
Fuzzy scale 1 and fuzzy scale 2	Large	Increases	Decreases	Long
	Small	Decreases	Increases	Short

3-7-2 Manual Reset

The manual reset function is used to correct a constant offset from the set point after a stable condition is obtained when using P or PD control.

- When an offset occurs, change the manual reset value as shown in the following graph.
- The setting range is between 0.0% and 100.0%. The default is 50%.
- The manual reset value can be set separately in each memory bank.



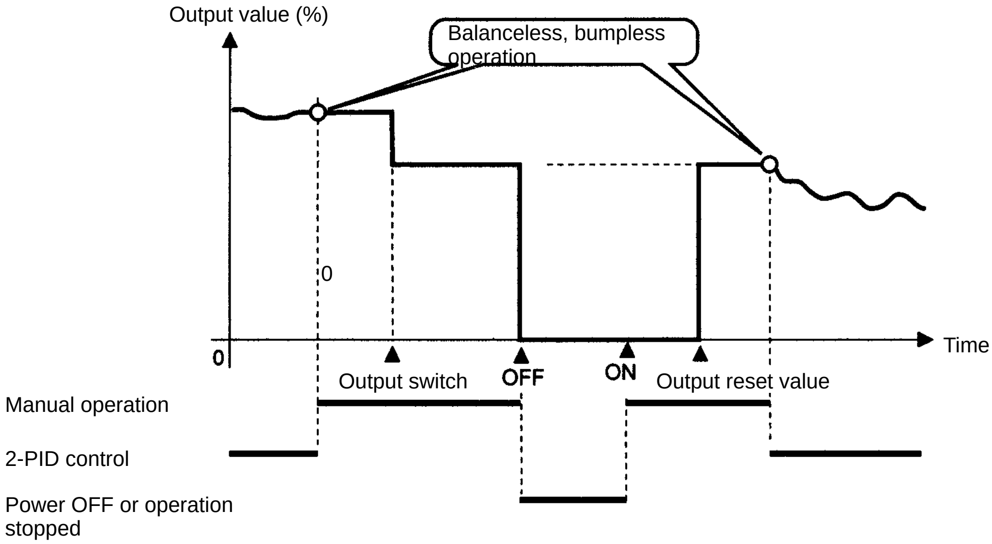
3-8 Control Method Selection

3-8-1 Manual Operation

In manual operation, the control output is operated with manually set output values.

- Each control point can be switched to manual operation independently.
- In manual operation, set the output value through communications.
- If manual operation is continued after the power has been turned OFF or if manual operation is started when the E5ZE has stopped operation, the output value will be 0.0%. In this case, reset the output value.

- When switching between manual operation and 2-PID control, the output value will enter balanceless, bumpless operation.



Operating Conditions

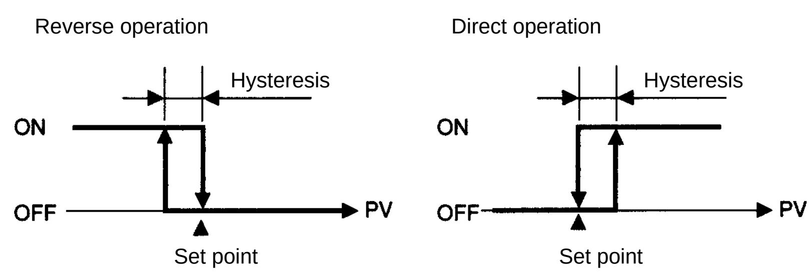
- The manual output value can be set only during manual operation. The manual output value cannot be set if there is a temperature sensor input error or a Temperature Controller error.
- Manual operation cannot be started if auto-tuning is being executed or there is a Temperature Controller error.
- The E5ZE-8□□□D1□B (CompoBus/D Model) cannot be operated manually if operation has been stopped. Temperature control must be started with remote I/O before manual operation can be started. For further details, refer to the *E5ZE-8 Multipoint Temperature Controller CompoBus/D Communications Manual (H104)*.

3-8-2 ON/OFF Control

2-PID control can be switched to ON/OFF control by setting the proportional band (P constant) to 0.0.

Hysteresis

In ON/OFF control, hysteresis is used to stabilize operation when a change is made to ON/OFF control. The following diagrams show the operation of control output during ON/OFF control.



- Set the hysteresis in each memory bank. The settings are only valid when ON/OFF control is being used.
- The setting range is between 0.0 to 99.9 (°C or °F).
- The default value is 0.8°C or 1.5°F.

3-9 Heating and Cooling Control

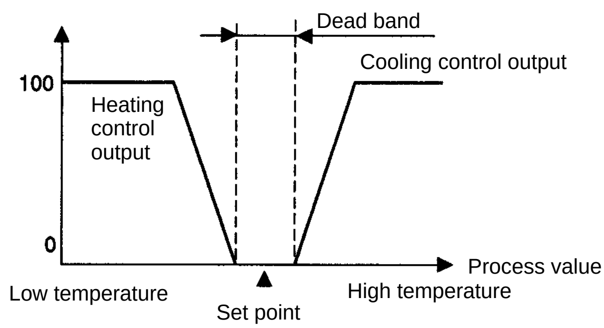
- The E5ZE-8V□□□□ Models are used for heating and cooling control.
- The heating and cooling control function is used for controlling temperatures of objects radiating heat, such as extruding molding machines. The temperature of these objects is controlled using heating control and cooling control outputs.

3-9-1 Dead Band/Overlap Band

The dead band/overlap band function adjusts the output method for the proportional output value close to the set point. The following graphs show the heating and cooling output when using proportional control.

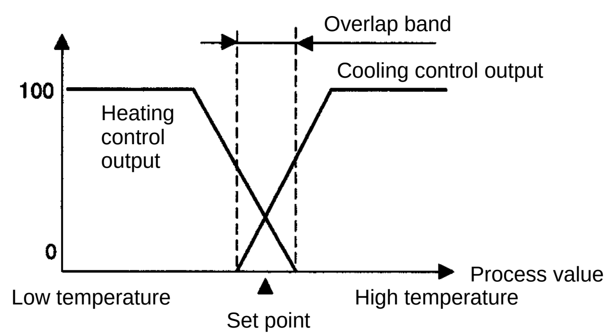
Dead Band Set Value > ×**0**

Proportional output value (%)



Dead Band Set Value < ×**0**

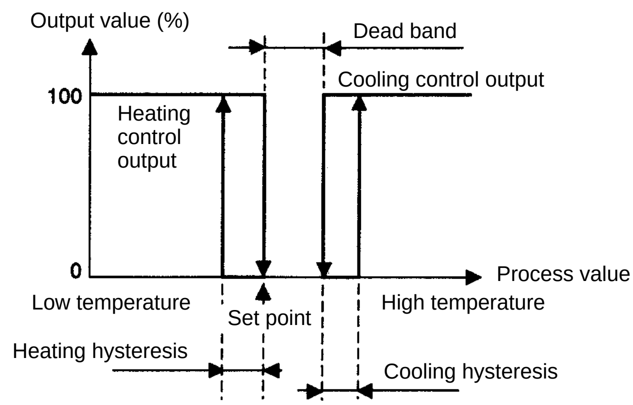
Proportional output value (%)



- If the dead band is too wide, hunting may result.
- Control output may occur within the dead band for other types of control apart from proportional control and ON/OFF control.
- Set the dead band in each memory bank.
- The setting range of the dead band is –999 to +999°C (or °F). The default is 0.

- The following graph shows the output when the E5ZE is operating using ON/OFF control.

Dead Band Set Value in ON/OFF Control $> \times 0$



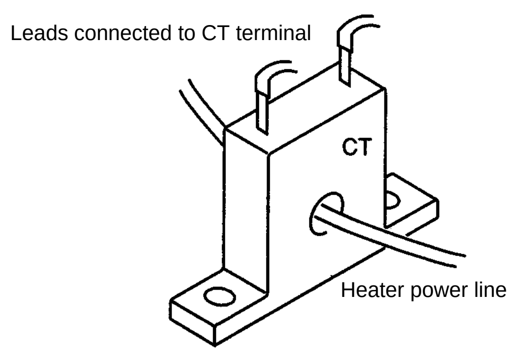
3-9-2 Cooling Coefficient

The difference between the heating characteristics and cooling characteristics of the object being controlled may cause control by PID constants to be unsatisfactory. By changing the cooling coefficient, however, the balance between heating and cooling can be readjusted.

- The cooling coefficient operates according to the following formula.

  Cooling P constant = P constant $\times$ cooling coefficient
- Set cooling coefficients in each memory bank.
- The cooling coefficient setting range is 0.0 to 10.0. The default is 1.0.
- If the cooling coefficient is set to 0.0, the cooling control output value will be 0%.

3-10 Heater Burnout Detection



Heater burnout is detected using the following method.

1, 2, 3...

1. Connect the Current Transformer (CT) for the control point to the corresponding terminal on the CT input terminal block, and pass the power cable through the hole in the CT.
2. When current flows through the heater power lines, an AC current corresponding to the amount of current flow is generated in the CT. The heater burnout detection function measures the generated AC current and obtains the amount of current flowing to the heater.
3. When the heater burns out, the current decreases, and after comparing the current with the specified heater burnout detection current value, the HB alarm output will turn ON and the HB indicator will light.

- Set the control points for which HB alarms will be enabled. The factory setting is for the HB alarm to be disabled for all control points. The HB alarm is set by executing the HB Alarm/HS Alarm Effective Control Point Setting (WU) command. If CompoBus/D communications are being used, set the HB alarm with FINS messages.
- Set the heater burnout detection current value. The setting range is between 0.0 and 50.0 A.
- If the HB alarm is set to 0.0, it will always be OFF, and if it is set to 50.0, it will always be ON. The default is 0.0 (always OFF).
- To check the CT current, read the values for the heater current and SSR leakage current.
- If the HB alarm is output, it will turn OFF again once the heater current increases to a value greater than or equal to the heater burnout detection current.
- For direct operation, set the heater current to 50 A max. for each control point. If the heater current exceeds 50 A, heater burnout cannot be detected.
- Turn ON the heater power either at the same time as or before turning ON the power to the E5ZE. The HB alarm output will turn ON if the power to the E5ZE is turned ON before turning ON the heater power.
- Temperature control will continue even when the HB alarm turns ON. (The E5ZE will attempt to control the temperature for the heater that has burnt out.)
- The heater burnout detection function operates when the control output is continuously ON for more than 100 ms.
- If the heater's rated current does not match the actual current flowing through the heater, check the actual current being applied by reading the values for the heater current and the SSR leakage current.
- If the difference between normal heater current and heater burnout current is small, the detection function will not operate properly. For reliable detection, use a heater that will give a current difference of at least 1.0 A for heaters that are less than 10.0 A, and at least 2.5 A for heaters that are 10.0 A or more.
- The heater burnout detection function cannot be used when the heater is being controlled by phase control or cycle control, or if a 3-phase heater is being used.
- The heater burnout detection delay is 10 control periods max.
- The HB alarm will not operate for a control point during auto-tuning.

Use the K2CU-F□□A-□GS Heater Burnout Alarm Unit, which has gate input terminals, to detect heater burnout when using 3-phase heaters. (Refer to the relevant datasheets for further details.)

Heater Burnout Detection Current Value Calculation

Calculate the set value for the heater burnout detection current using the following formula.

$$\text{Heater burnout detection current set value} = \frac{\text{Normal heater current} + \text{Heater burnout current}}{2}$$

- If more than two heaters are passed through the CT, set the heater burnout detection current to that for the heater with the smaller heater burnout detection current value. (If the heater burnout detection current is the same for all heaters, set the value to the heater burnout detection current for one heater.)
- Heater burnout will be detected under the following conditions.

  If heater current consumption is less than 10.0 A:

    Normal heater current – Heater burnout current ≧ 1 A

    Heater burnout may not be detected if the difference is less than 1 A.

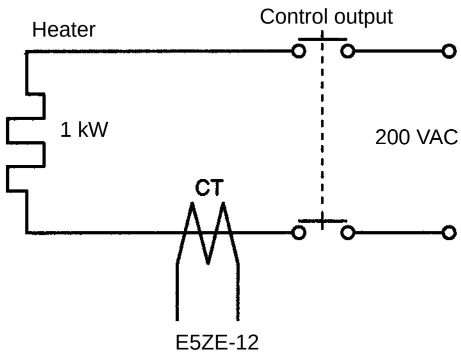
If heater current consumption is 10.0 A or more:

Normal heater current – Heater burnout current ≧ 2.5 A

Heater burnout may not be detected if the difference is less than 2.5 A.

Application Examples

Example 1: Using One 200-VAC, 1-kW Heater



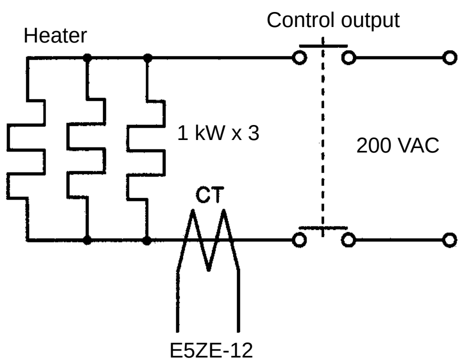
$$\text{Normal heater current} = \frac{1000}{200} = 5\text{ A } (< 10\text{ A})$$

Heater burnout current = 0 A

$$\text{Set value} = \frac{5+0}{2} = 2.5\text{ A}$$

Normal current – burnout current = 5 – 0 = 5 A (≧ 1 A)

Example 2: Using Three 200-VAC, 1-kW Heaters



$$\text{Normal heater current} = \frac{1000}{200} \times 3 = 15\text{ A } (\geqq 10\text{ A})$$

$$\text{Heater burnout current for 1 heater} = \frac{1000}{200} \times 2 = 10\text{ A}$$

$$\text{Set value} = \frac{15+10}{2} = 12.5\text{ A}$$

Normal current – Burnout current = 15 – 10 = 5 A (≧ 2.5 A)

3-11 SSR Failure Detection

The Current Transformer (CT) can be used to measure SSR leakage current and detect output short circuits. If an error is detected at any of the control points, the HS alarm output will turn ON and the HS indicator will light. The CT can also detect contact weld in relay.

Operating Conditions

- Set the control point for which the HS alarm is to be used. The factory setting is for the HS alarm to be disabled for all control points. The HS alarm is set by executing the HB Alarm/HS Alarm Effective Control Point Setting (WU) command. If CompoBus/D communications are being used, set the HS alarm with FINS messages.
- Set the SSR leakage current value. The setting range is between 0.0 and 50.0 A. The default is 0.5 A.
- To check the CT current value, read the heater current and SSR leakage current.
- The SSR failure detection function operates when the control output is continuously OFF for more than 100 ms.
- The SSR leakage current varies depending on the load voltage. Set the SSR failure detection current according to the heater power voltage that will actually be used.
- Turn ON the heater power either at the same time as or before turning ON the power to the E5ZE. The HS alarm output will turn ON if the power to the E5ZE is turned ON before turning ON the heater power.

- Temperature control will continue even when the HS alarm turns ON.
- The SSR failure detection function cannot be used when the heater is being controlled by phase control or cycle control, or if a 3-phase heater is being used.
- The SSR failure detection delay is 10 control periods max.
- For control points being auto-tuned, the HS alarm will not operate until auto-tuning is completed.

SSR Failure Detection Current Value Calculation

If the default preset SSR failure current value (0.5 A) is used, obtain the SSR failure detection current from the following formula.

SSR failure detection current = Normal SSR leakage current × 2

- For example, if the normal SSR leakage current value is 1.0 A, the SSR failure detection current is as follows:

  SSR failure detection current = 1.0 × 2 = 2.0 A