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Instruction Manual

Process Loop Controller

EC321 (Software Description)

TOSHIBA CORPORATION

FCF50001B

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4. Toshiba assumes no liability for the results of operation of the system described herein.
5. Toshiba cannot guarantee if the system malfunctions due to an overvoltage or overload in the input/output unit.

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1. Before Operating the Unit

Upon acceptance of the process loop controller EC321, visually check it to see that it is not damaged. Also, check that the standard accessories are not missing.

Before operating the unit. carefully read this chapter describing the pertinent precautions.

1.1 Before Reading this Operation Manual

This manual describes the functions of the EC321. For details of mounting, wiring and maintenance operations, refer to the separate hardware manual.

General descriptions on EC300 Series (Outline and functions)
Toshiba Process loop Controller EC300 Series General Descriptions - GBK-8705

Hardware manuals for EC300 Series (Installing and maintenance)
Toshiba Process loop Controller EC311/EC321 Hardware Description - 6F8A0624

Operation manuals for configuration programs
Toshiba Process loop Controller EC311/EC321 Basic Loader - 6F8A0573

When programming the controller, be careful with the loader version.
1) Ver.3.** Can be used.
2) Ver.2.** Cannot be used about the new functions.
3) Ver.1.** Can not be used.

Toshiba Process loop Controller EC311/EC321 Graphic Loader - 6F8A0574

Operation manuals for field maintenance
Toshiba Process loop Controller EC311/EC321 Hand-held Terminal -6F8A0571

1.2 About This Manual

This manual consists of two parts for explanation on EC300 Series. Part 1 describes the basic operations and functions. Part 2 describes how to program to implement desired functions. The following outlines the contents of each chapter.

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Chapter 1 Before operation the Unit

Explains the purpose and contents of this manual. Be sure to read this chapter before use.

Part 1 Operation: Procedure from acceptance through start up operation,and basic operations

Chapter 2 General

Explains the features and standard control functions of EC300 Series.

Chapter 3 Basic Operation

Explains the front panel operation.

Chapter 4 Preparation

Explains the procedure from acceptance to start up operation.

Chapter 5 Operation and Start

Explains switch over between manual and automatic operation, checking of operation status.

Chapter 6 Status Display Operation

Explains status display of ALM, HALT, etc. and their measures.

Chapter 7 Details of Operation

Supplements the operation of front panel.

Chapter 8 Self-tuning function

Explains the AdTune operation and usage.

Part 2 Programming: Basic knowledge of control program and operation principle

Chapter 9 Software Operational Principle

Explains the controller's operational principle and programming using functional modules.

Chapter 10 Functional Module

Explains functional modules required for programming and various parameters for each module.

Chapter 11 Programming Application

Explains how to program for process control using examples.

Chapter 12 Appendix

Note : ***«NEW»***

This mark shows the new functions which are added or modified for EC311/EC321.

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PART 1 OPERATION

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2. General

2.1 Features of EC300 Series

EC300 Series provides on-panel controllers with the state-of-the-art advanced control functions. The features include:

* Two-loop independent control
* High-performance self-tuning (AdTune) function, provided as standard.
* Direct connection with thermocouples and RTD (optional module required)
* Programming function using a memory card
* Support of various communication function (option module required)
  MODBUS,ECBUS and ECBUS/H via RS485 interface port
  TOSDIC high speed communication bus (MCBUS)
* Eighteen implementation programs other than programming functions, all provided as standard

2.2 Basic Control Function

EC300 Series includes five kinds of standard built-in functions inside it (hereinafter called basic functions). The basic functions, programmed as functions which are frequently used in process implementation, can be set on the front panel of the body. Hence, it can serve as software adjuster without programming on a Loader or memory card.

The basic functions consist of five types of control, which can be switched over from each other.

PID control*
Remote-setting PID control*
MV-override PID control*
M/A station
Cascade PID control*

Note: * indicates that conventional PID control or control algorithm of 2 degrees of freedom PID control self-tuning can be selected.

Each function is explained in the following pages.

Note: Circled numbers indicate terminal block numbers.

The function in a dotted rectangle is effective only when an expansion I/O module is installed.

(##,##) indicates the number of basic function specification. Refer to 3.3.4.

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2.2.1 PID control

The PID control is suitable for one-loop basic control operations.
The PID control (AdTune) with the self-tuning function added to the PID function can also be selected.

(1) PID control 1 on FUNC1 side (01, 06)

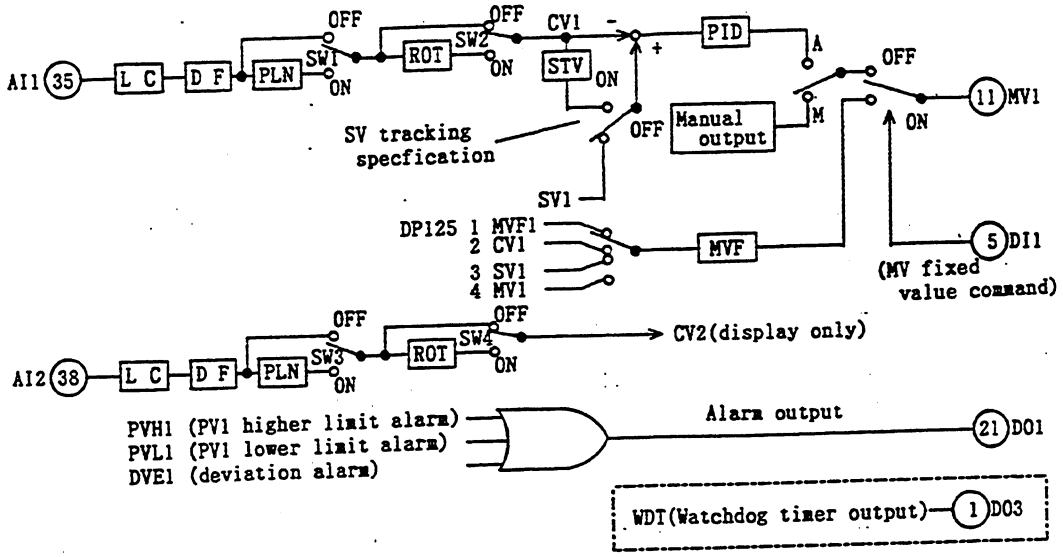


Figure 2.1 PID control 1 (FUNC1)

(2) PID control 1 on FUNC2 side (01, 06)

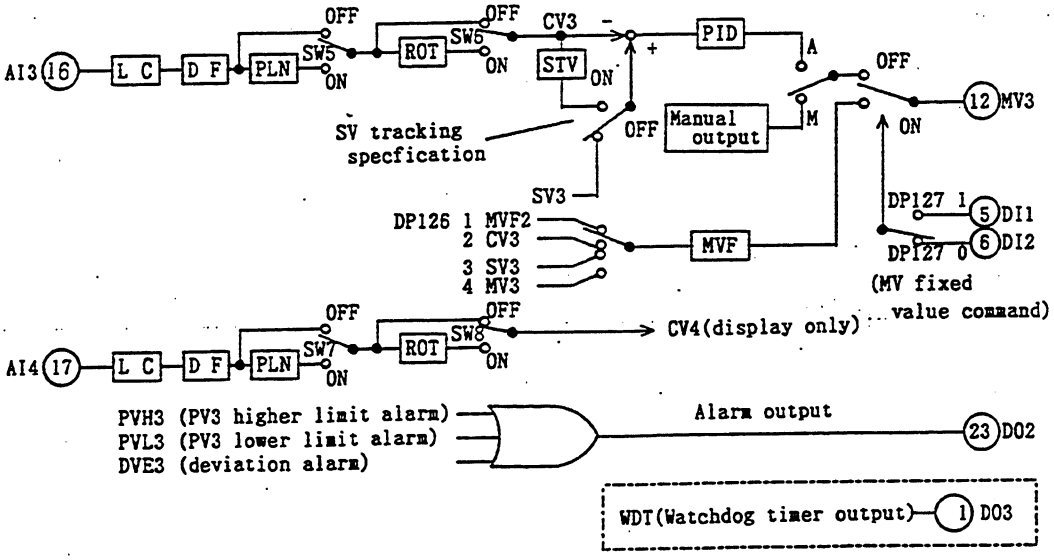


Figure 2.2 PID control 1 (FUNC2)

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(3) PID control 2 on FUNC1 side (11, 16) «NEW»

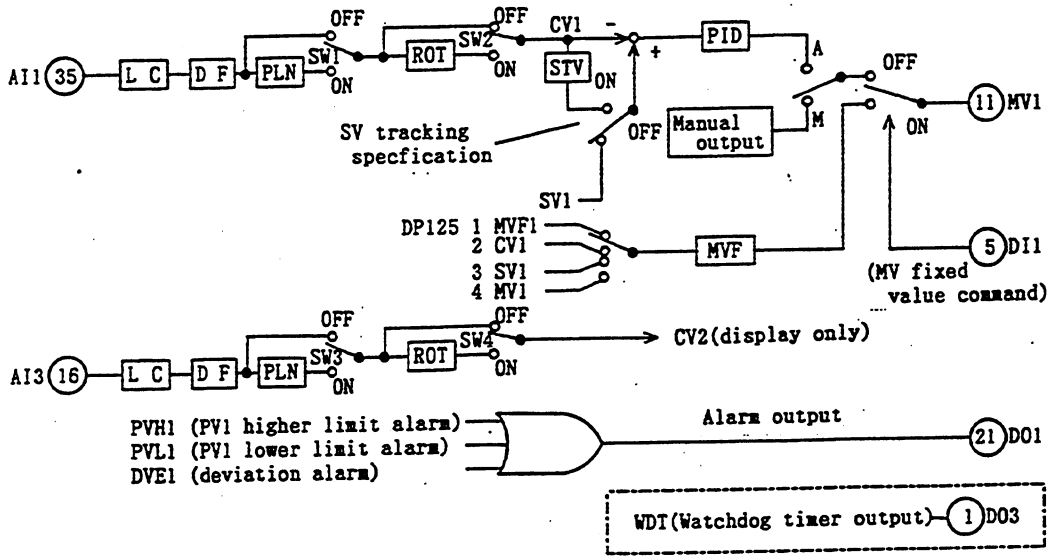


Figure 2.3 PID control 2 (FUNC1)

(4) PID control 2 on FUNC2 side (11, 16) «NEW»

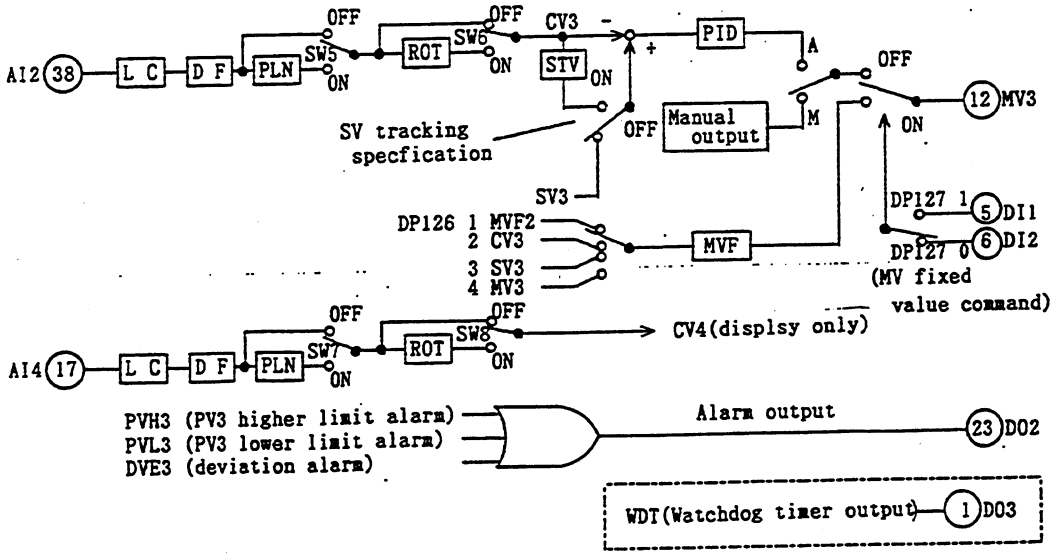


Figure 2.4 PID control 2 (FUNC2)

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2.2.2 Remote-setting PID control

The remote-setting PID control is used to set values remotely by remote input (AI2). The remote set PID (AdTune) with the self-tuning function added to the PID function can also be selected.

(1) Remote-setting PID control 1 on FUNC1 side (02, 07)

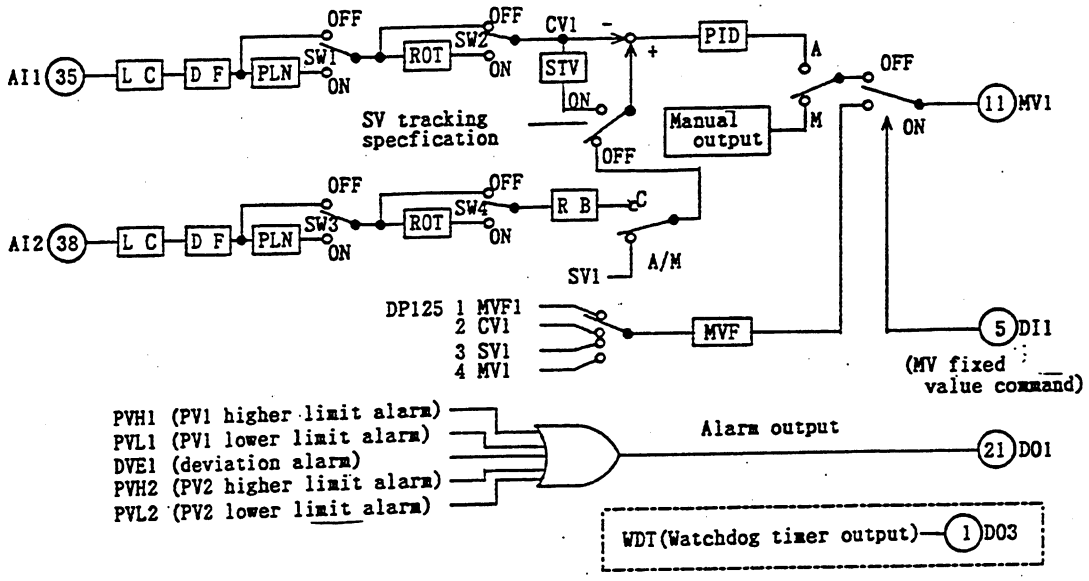


Figure 2.5 Remote-setting PID control 1 (FUNC1)

(2) Remote-setting PID control 1 on FUNC2 side (02, 07)

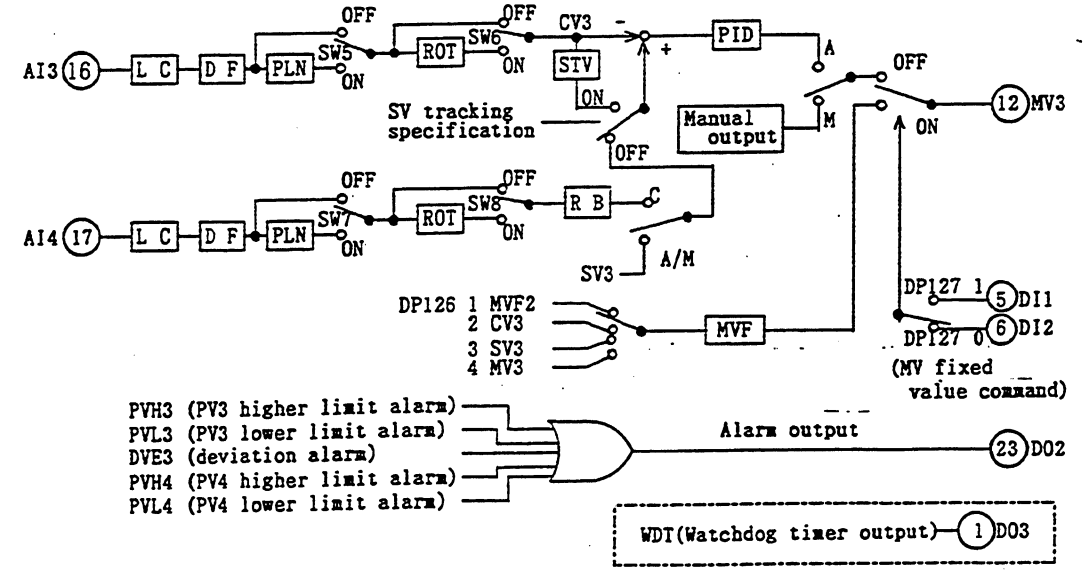


Figure 2.6 Remote-setting PID control 1 (FUNC2)

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(3) Remote-setting PID control 2 on FUNC1 side (12, 17) «NEW»

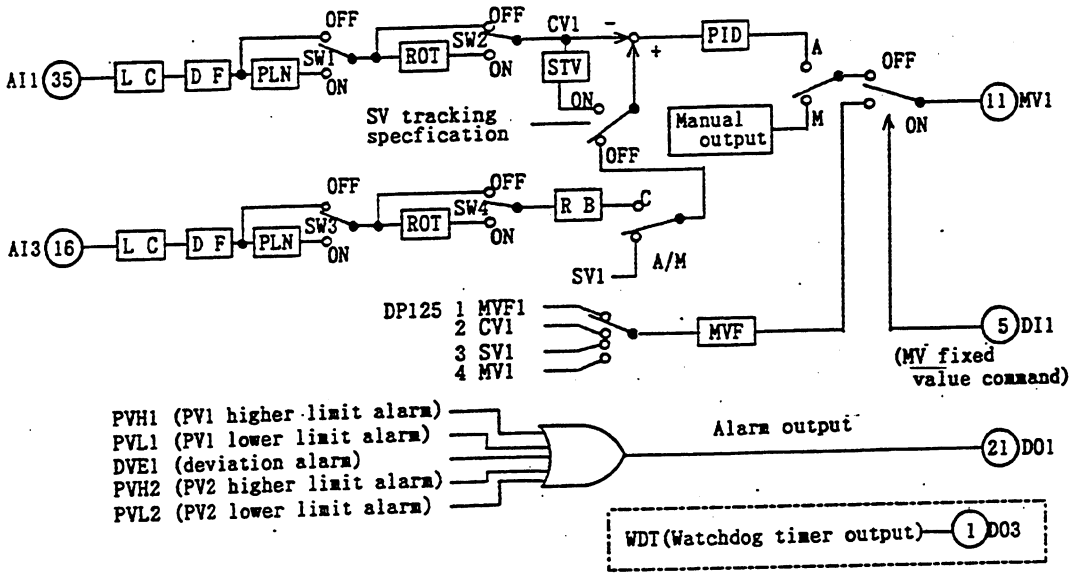


Figure 2.7 Remote-setting PID control 2 (FUNC1)

(2) Remote-setting PID control 2 on FUNC2 side (12, 17) «NEW»

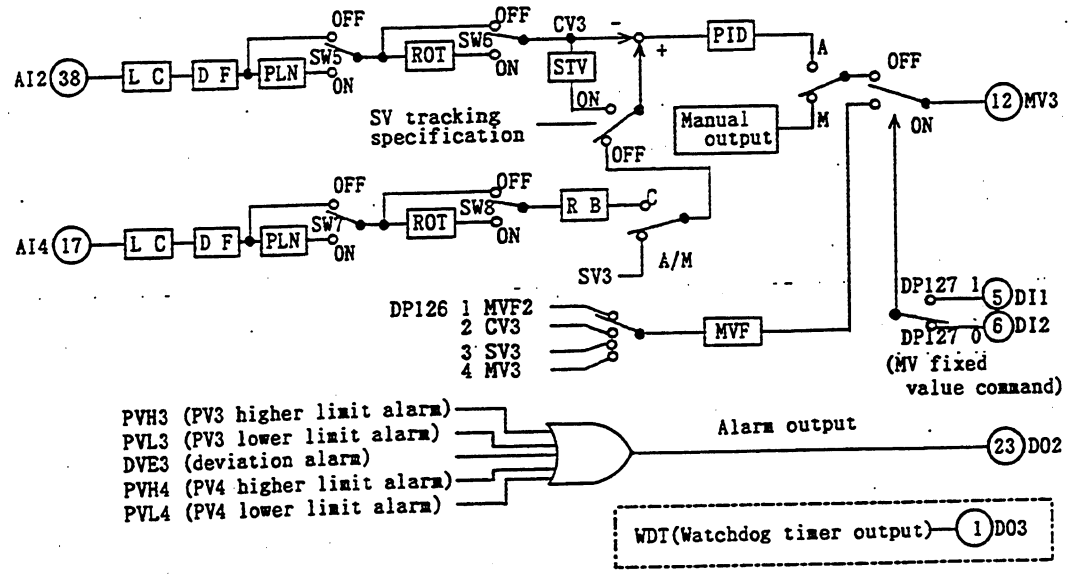


Figure 2.8 Remote-setting PID control 2 (FUNC2)

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2.2.3 MV-override PID control

The MV override PID control generates the AI2 input signal as a manipulated amount by the override command (DI1).
With the override command set to OFF, this controller operates as a PID controller.
The MV override PID control (AdTune) with the self-tuning function added to the PID function can also be selected.

(1) MV-override PID control 1 on FUNC1 side (03, 08)

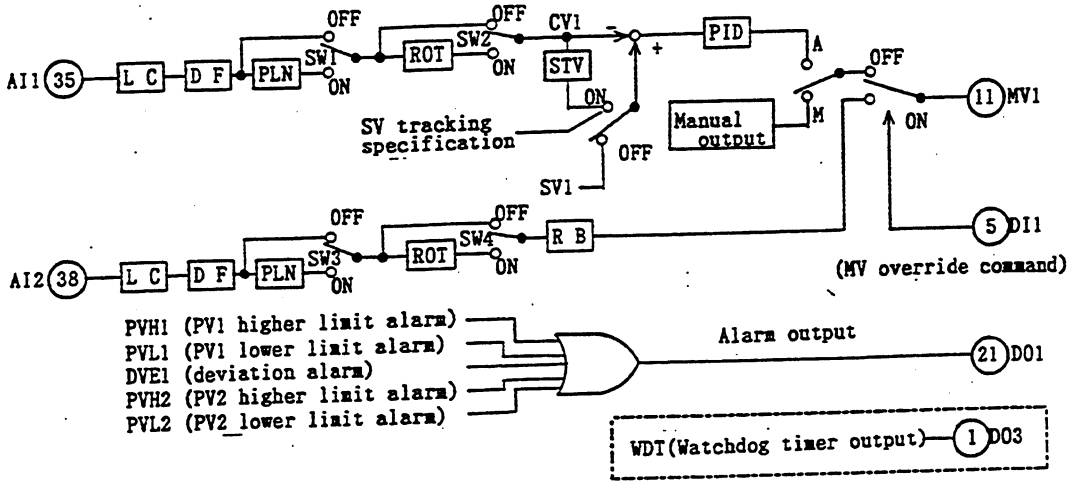


Figure 2.9 MV-override PID control 1 (FUNC1)

(2) MV-override PID control 1 on FUNC2 side (03, 08)

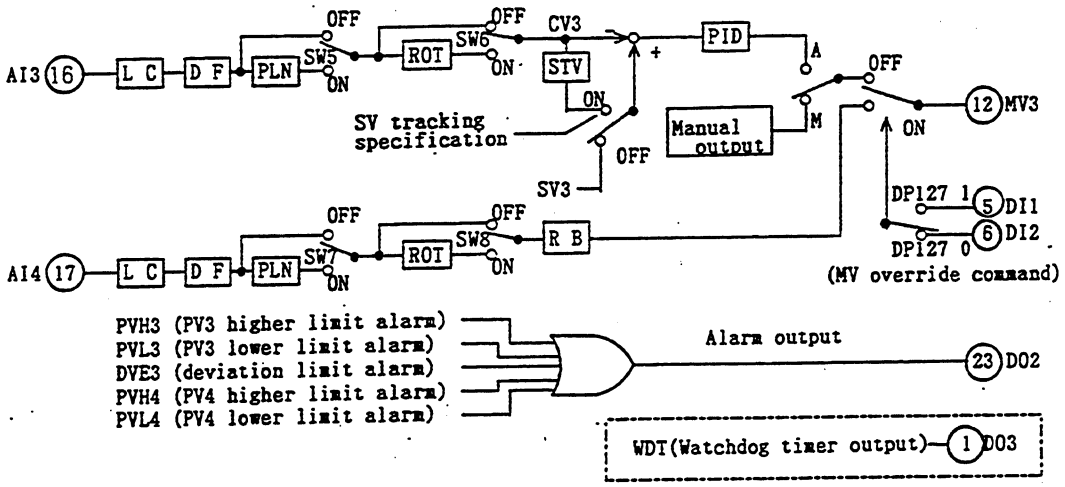


Figure 2.10 MV-override PID control 1 (FUNC2)

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(3) MV-override PID control 2 on FUNC1 side (13, 18) «NEW»

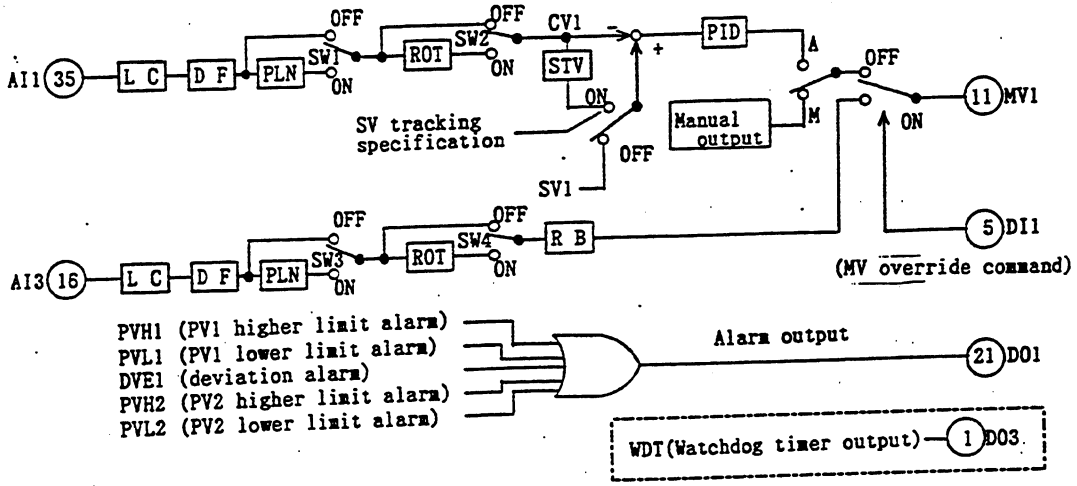


Figure 2.11 MV-override PID control 1 (FUNC1)

(4) MV-override PID control 2 on FUNC2 side (13, 18) «NEW»

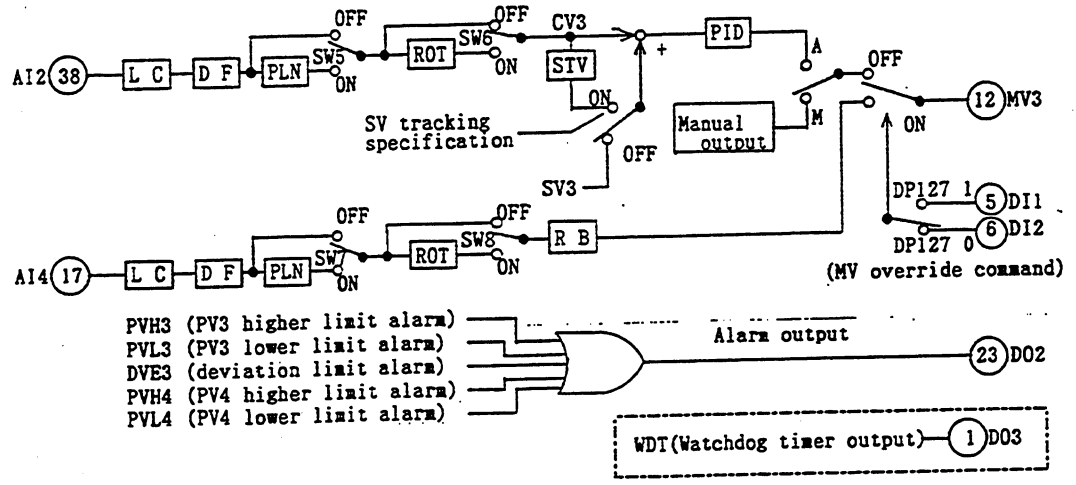


Figure 2.12 MV-override PID control 2 (FUNC2)

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2.2.4 A/M station

The A/M station is a controller to operate the control element manually.
It uses the AI1 input signal as manipulated output in the automatic mode (A mode) and changes the manipulated output with the front MV manipulation switch in the manual mode (M mode).

Note: . SV setting is not possible. SV indication matches the CV value.
. When the M mode is changed to the A mode, AI1 value tracking occurs to the manipulated output.

(1) A/M station 1 on FUNC1 side (04)

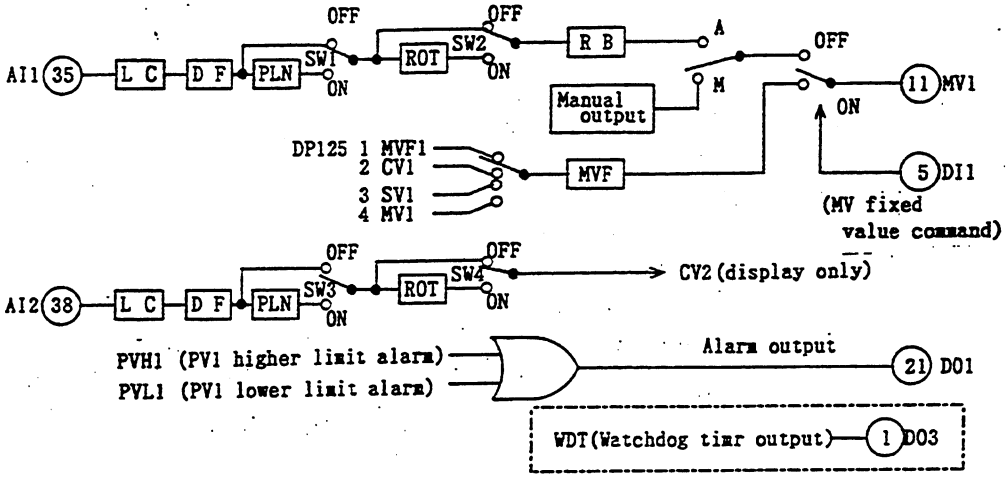


Figure 2.13 A/M station 1 (FUNC1)

(2) A/M station 1 on FUNC2 side (04)

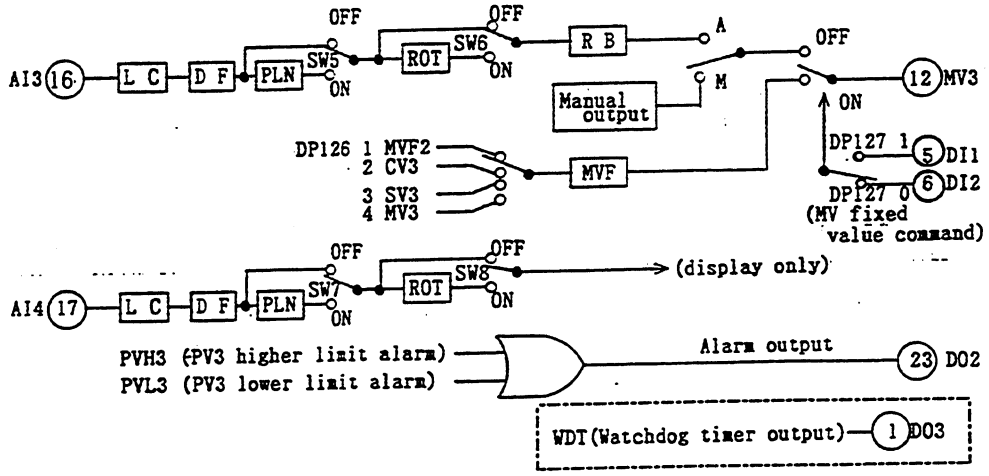


Figure 2.14 A/M station 1 (FUNC2)

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(3) A/M station 2 on FUNC1 side (14) «NEW»

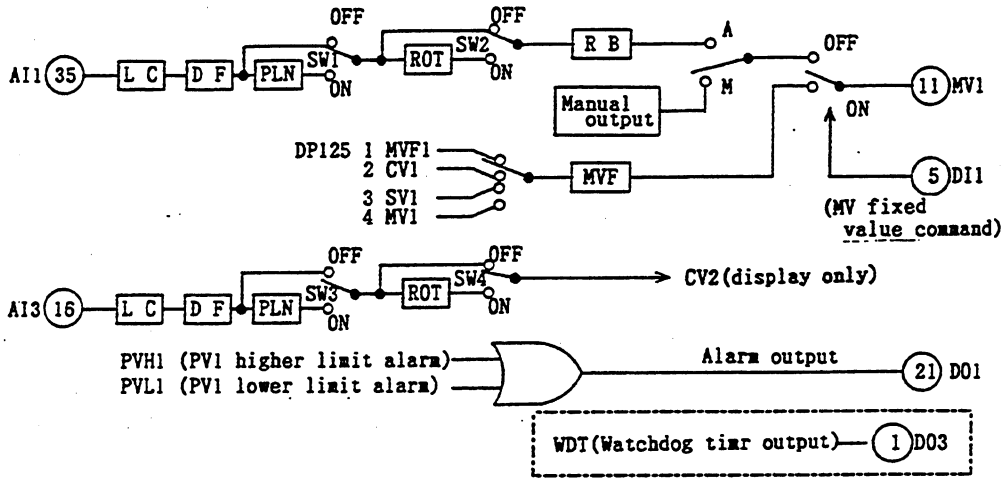


Figure 2.15 A/M station 2 (FUNC1)

(4) A/M station 2 on FUNC2 side (14) «NEW»

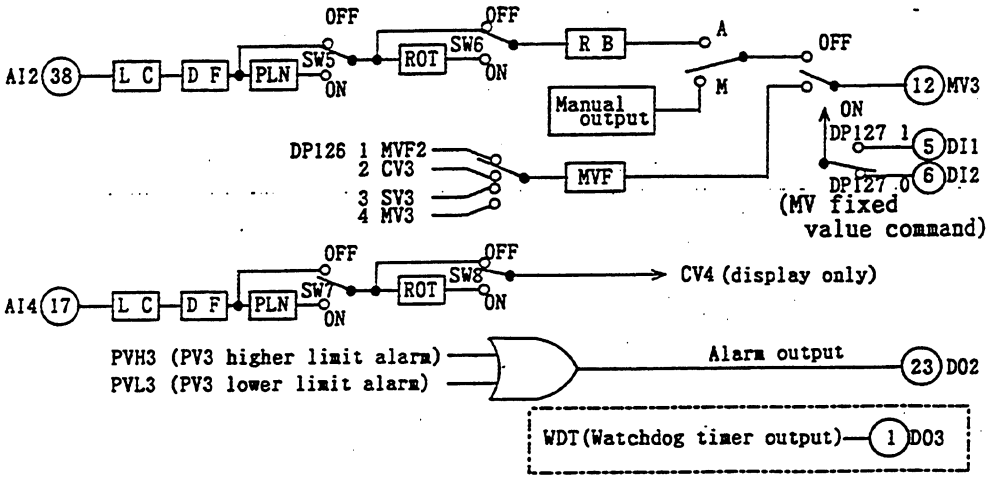


Figure 2.16 A/M station 2 (FUNC2)

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2.2.5 Cascade PID control

The cascade PID control is used for cascade control and secondary loop single control. It consists of two PID controllers.
The cascade PID control (AdTune) with the self-tuning function added to the PID function can also be selected.

(1) Cascade PID control 1 on FUNC1 side (05, 09)

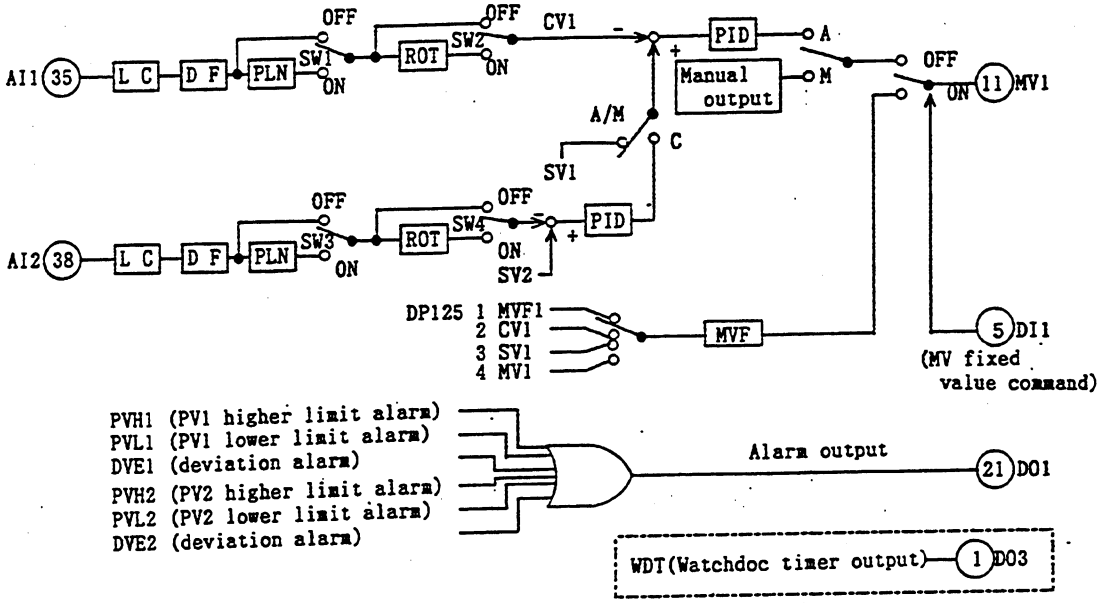


Figure 2.17 Cascade PID control 1 (FUNC1)

(2) Cascade PID control 1 on FUNC2 side (05, 09)

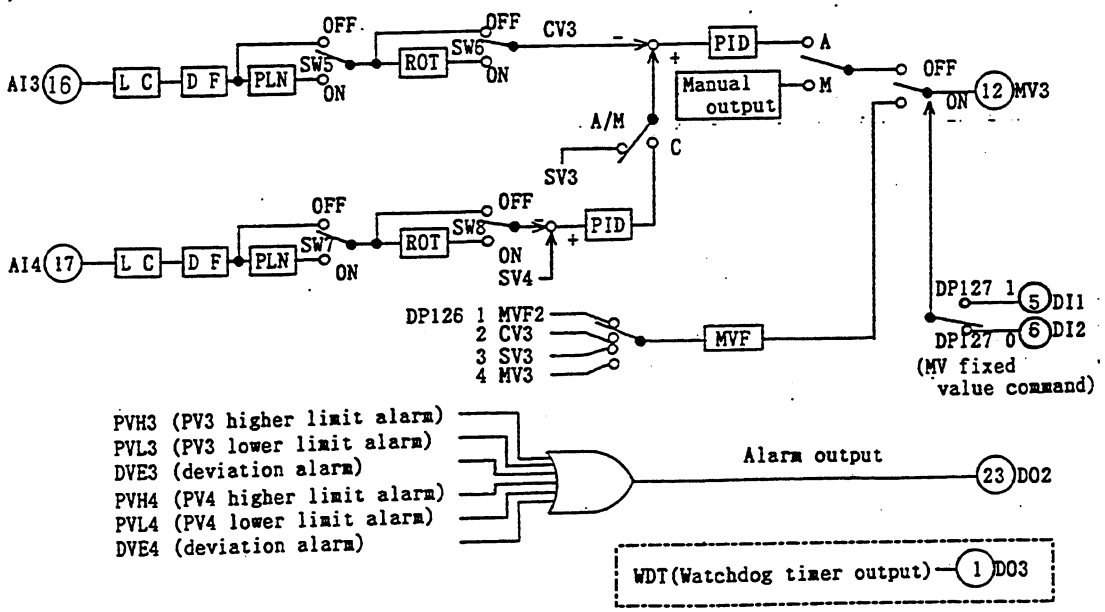


Figure 2.18 Cascade PID control 1 (FUNC2)

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(3) Cascade PID control 2 on FUNC1 side (15, 19) «NEW»

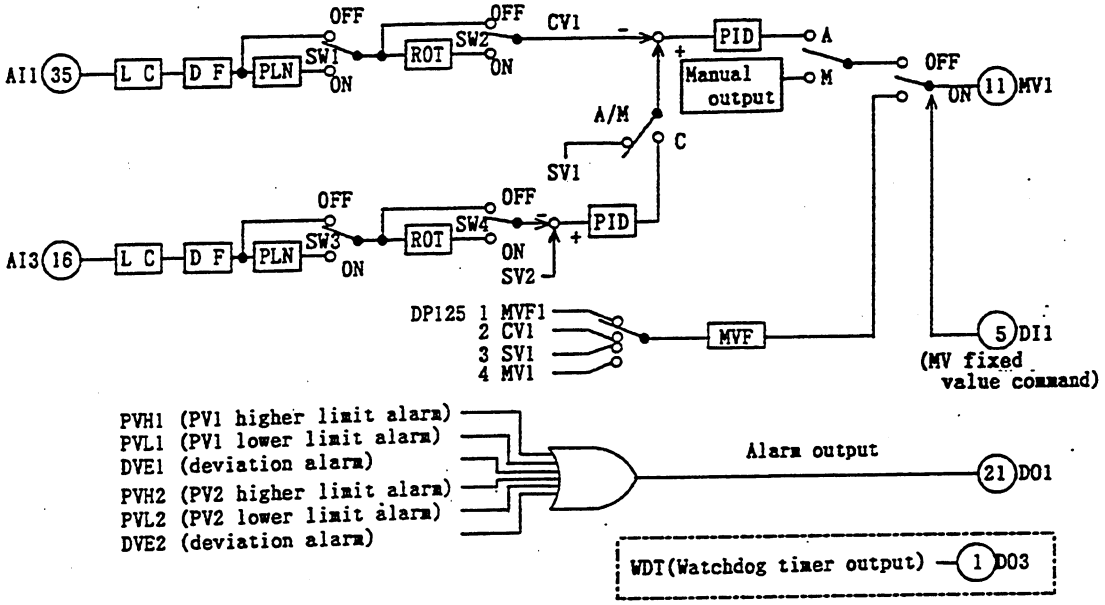


Figure 2.19 Cascade PID control 2 (FUNC1)

(4) Cascade PID control 2 on FUNC2 side (15, 19) «NEW»

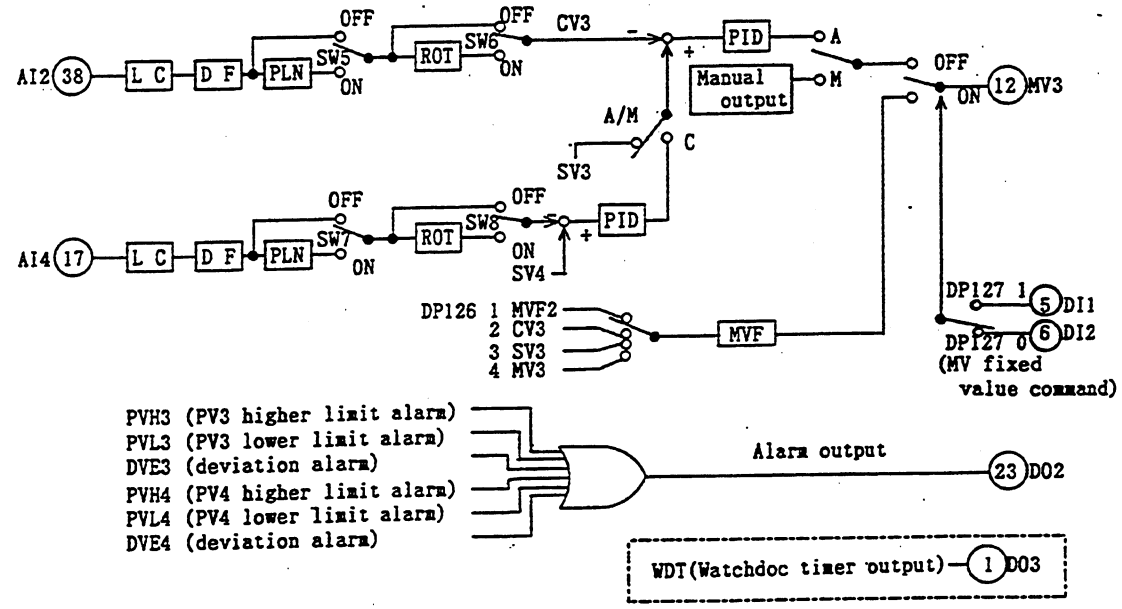


Figure 2.20 Cascade PID control 2 (FUNC2)

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2.2.6 Description of Symbols

The symbols used in the function block diagrams of the controller have the following meanings.

[LC]: Low cut
[DF]: Digital Filtering
[PLN]: Polygonal line table
[ROT]: Square root extraction
[SVT]: SV tracking
[PID]: PID operation
[Manual output]: Manual control
[MVF]: MV fixed value output
[RB]: Ratio bias
[M]: Control mode M
[A]: Control mode A
[C]: Control mode C
 SW parameter
AI : Analog input
 Logical sum (OR)
(n): External pin numbers

(35):	Analog input 1 (AI1)	(16):	Analog input 3 (AI3)
(38):	Analog input 2 (AI2)	(17):	Analog input 4 (AI4)
(11):	Manipulated output (MV1)	(12):	Manipulated output (MV3)
(5):	Contact input 1 (DI1)	(6):	Contact input 2 (DI2)
(21):	Digital output 1 (DO1)	(1):	Digital output 3 (DO3)
(23):	Digital output 2 (DO2)		

Alarm function

The controller is provided with the analog input higher and lower limit alarm and deviation alarm functions.

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3. Basic Operations

3.1 Front Panel and Functions

The figure below shows an external view of the front panel.

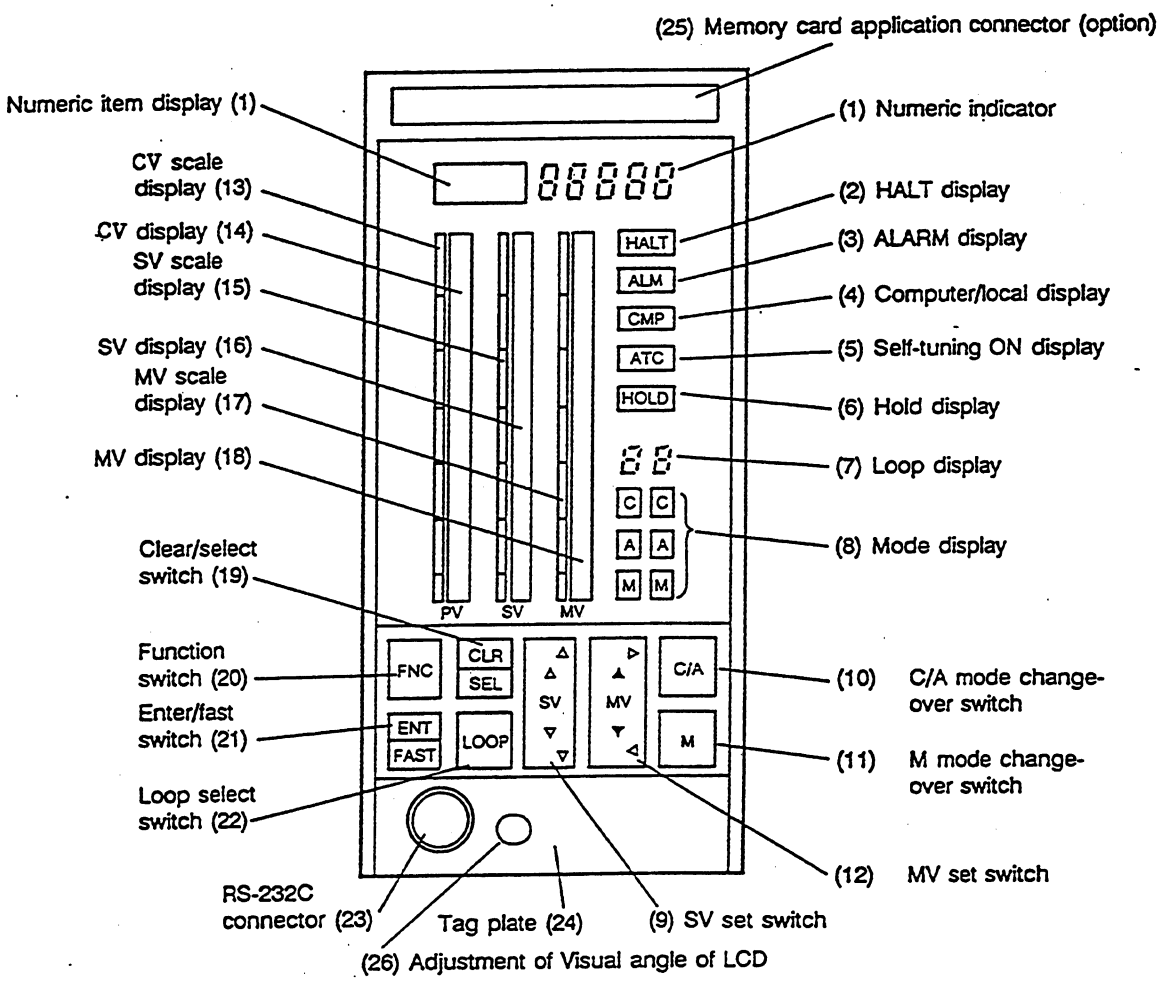


Figure 3.1 Front Panel

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(1) Numeric item display and numeric indicator

Shows a variety of parameters and data.
CV, SV and MV numeric display can be made using the [CLR/SEL] key.
CV can be displayed with User tags. «NEW»
Engineering unit can be displayed by pushing [ENT/FAST] key for more than one second.

(2) HALT display (HALT)

Indicates an error on control on the controller.
The HALT display is normally OFF. It lights up in the following cases.

HALT Display

Display Status	Cause
Continuously ON	(1) MV readback error (2) ADC fault (3) Control inactive

(3) ALM display (ALM)

Indicates an error on control.
This indicator lights up in the following cases.

ALM Display

Display Status	Cause
System alarm	(1) Communication error (2) CJC alarm (3) Battery of memory card alarm
Process alarm	(1) Sensor error (PV inactive) (2) High/Low limit error (PVH, PVL) (3) Rate of change error (PVD) (4) Deviation error (DVE)

(4) COMPUTER LOCAL display (CMP)

This indicator lights up according to computer flags (CMP flags).

(5) SELF-TUNING ON display (ATC)

This indicator blinks for self-tuning.

Display Status	Cause
Continuously ON	Tuning alarm
Fast blink	Requirement of supervisor confirmation
Slow blink	Self-tuning in process

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(6) HOLD display (HOLD)

This indicator lights up under the following conditions.

HOLD Display

Display Status	Cause
Continuously ON	(1) MV fixed value output (2) During control function registration (3) During IC memory card data read
Blinking	During simulation

(7) LOOP display

This indicator indicates the loop number of the bar graph being displayed on the panel.

(8) MODE display

This indicator indicates the control mode for the loop number.

[M]: Manual mode
[A]: Automatic mode
[C]: Set value remote

(9) SV set key (△/▽)

The set value can be changed using this key. [△] is used to increment the set value and [▽] is used to decrement the set value.
When [△] or [▽] and [ENT/FAST] are simultaneously pressed, the change speed is set to x 10.

(10) C/A mode changeover key (C/A)

This key is used to change the set value REMOTE/AUTO mode among the control modes.
Each time the key is pressed, the mode is changes. When in the manual mode, it changes to Auto mode.

(11) M mode changeover key (M)

This key is used to change to the manual control mode. Manual operation can be carried out using the manual operation key.

(12) Manual operation key (▲,▼)

Manipulated output can be changed using this key in the M mode. [▲] is for OPEN and [▼] is for CLOSE. When [▲] or [▼] and [ENT/FAST] are pressed simultaneously, the change speed is set to x 10.

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(13) CV scale display

This indicator indicates the CV scale.

(14) CV display bar graph

The bar graph indicates the CV value with 1% resolution (for one-loop display). In the event of a process higher/lower limit alarm, the normal range is indicated in blinking form on the CV scale display. Blinking can be stopped (alarm check) with the [ENT/FAST] key.
In normal operation, the higher/lower limit alarm set value can be displayed (PH/PL display) with the [ENT/FAST] key.

(15) SV scale display

This indicator indicates the SV scale.

(16) SV display

This indicator indicates the SV value with 1% resolution. One-loop display and two-loop display are available. The two-loop display based on the upper and lower division of the bar graph is made with 2% resolution.

(17) MV scale display

This indicator indicates the MV scale.

(18) MV display bar graph

This bar graph indicates 0 to 100% with 1% resolution (for one-loop display).
Two-loop display can be made by dividing the bar graph into upper and lower sections (with 2% resolution).
The type of valve in use (direct/reverse actuation valve) is selected using the front panel key. In either case, the valve opening, that is,whether the valve is opened or closed, is indicated.

(19) CLEAR/SELECT key (CLR/SEL)

This key is used to change the display data items (CV, SV and MV) on the numeric indicator and to cancel data being changed. If this key continues to be pressed for more than one second, the CV and SV values of the secondary loop are point displayed on the bar graph.

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(20) FUNCTION key (FNC)

To change between the engineering mode and the user customized mode, press the FNC key for two seconds. (To change back, again press the FNC key for two seconds.) This operation will reset the display back to the normal display, so that the next time the FNC key is pressed, the other menu mode items will be seen.

* Engineering mode
The FNC key is used to shift from the normal display mode to the function mode to access all the front panel avaliable items. After this, each time the FNC key is pressed, the selection is changed.

* User customized mode <<*NEW*>>
The FNC key is used to shift from the normal display mode to the user defined parameters. After enter the user customized mode menu, each time the FNC key is pressed, the user menu item selection is changed until all the items is seen. The item list is then restarted from the first item.

Key-in	Operation mode	Display
	Engineering mode	
	Normal operation	
FNC	Alarm operation	'ALM'
FNC	I/O operation	'I/O'
FNC	Parameter operation	'PARAM'
FNC	System operation	'SYSTM'
FNC	Self tuning operation	'ADTUN'
FNC	Back to alarm operation	'ALM'
	User customized mode	
	Normal operation	(examples)
FNC		LPAL1
FNC		Kp1
FNC		Ti1
FNC		DP100

(21) ENTER/FAST key (ENT/FAST)

When this key is pressed together with the MV open/close key [▲/▼] or SV up/down key [△/▽], the change speed is set to x 10. If this key is pressed in the event of an alarm (with the CV bar graph blinking), the alarm is confirmed and blinking stops. If the key is pressed for more than one second under normal conditions, the PH/PL range is displayed on the CV scale line. In the both cases numeric item display is changed engineering unit display.

(22) LOOP select key

This key is used to select the control loop number, input point number and polynomial line table number.

It also is used to select display loop on the front panel bar graph display. If this switch is pushed, display loop is changed from loop 1/2 to loop 3/4. If this switch continues to be pressed for more than one second, display loop is changed from loop 1/3 to loop 2/4.

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(23) RS-232C connector

This connector is used to communicate with the hand-held terminal and Loader.

(24) Tag plate

Enter the tag number on this plate.

(25) IC memory card application connector (option)

(26) Adjustment of visual angle of LCD. «NEW»

3.2 Operation

The front operation panel allows the user to set or change various control parameters as well as general mode switching and setting values.

The controller has main two modes: the engineering mode, and the user customized mode that only defined parameters are displayed or set.

(1) Engineering mode

* Normal display mode:

CV, SV and MV are displayed. The [CLR/SEL] key can change display items and the [LOOP] key changes display loops.
In addition this mode can change the mode, and set setting values and operation output.

* Parameter display mode:

Pressing the [FNC] key in normal display modes changes to the parameter display mode. Pressing the [FNC] key following that can select a parameter group (ALM,I/O, PARAM, etc.). Then, press [ENT/FAST] to display parameters of each item.
Change display items using up and down arrow keys, and display loops using [LOOP] key, in order to display parameters to work on.

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* Parameter change mode:

  Pressing the [ENT/FAST] key in parameter display mode changes to the parameters change mode.
  The digit displaying parameters to be changed blinks on the data value. If the digit does not blink, the parameter cannot be changed.

  Using up and down arrow keys, place the cursor to the column to be changed. When the cursor is positioned at the rightmost or leftmost end, moving the cursor further off the edge moves the decimal point. However, digits disappeared from upper or lower column by the decimal point movement are cleared.

  After change is made, pressing [ENT/FAST] key sets data and goes back to the parameter display mode.

* Error display mode

  If, however,the set value exceeds the input range, an error message will be displayed. Check the error and press [CLR/SEL]. The parameter mode is then restored.

(2) User customized mode ***«NEW»***

  Continuing to press the [FNC] key for more than one second in normal display mode, it changes to the user customized mode.

  Each time [FNC] key is pressed the only defined parameters are changed.

  The function of normal display mode, parameter display mode, parameter change mode and error display mode is as same as (1).

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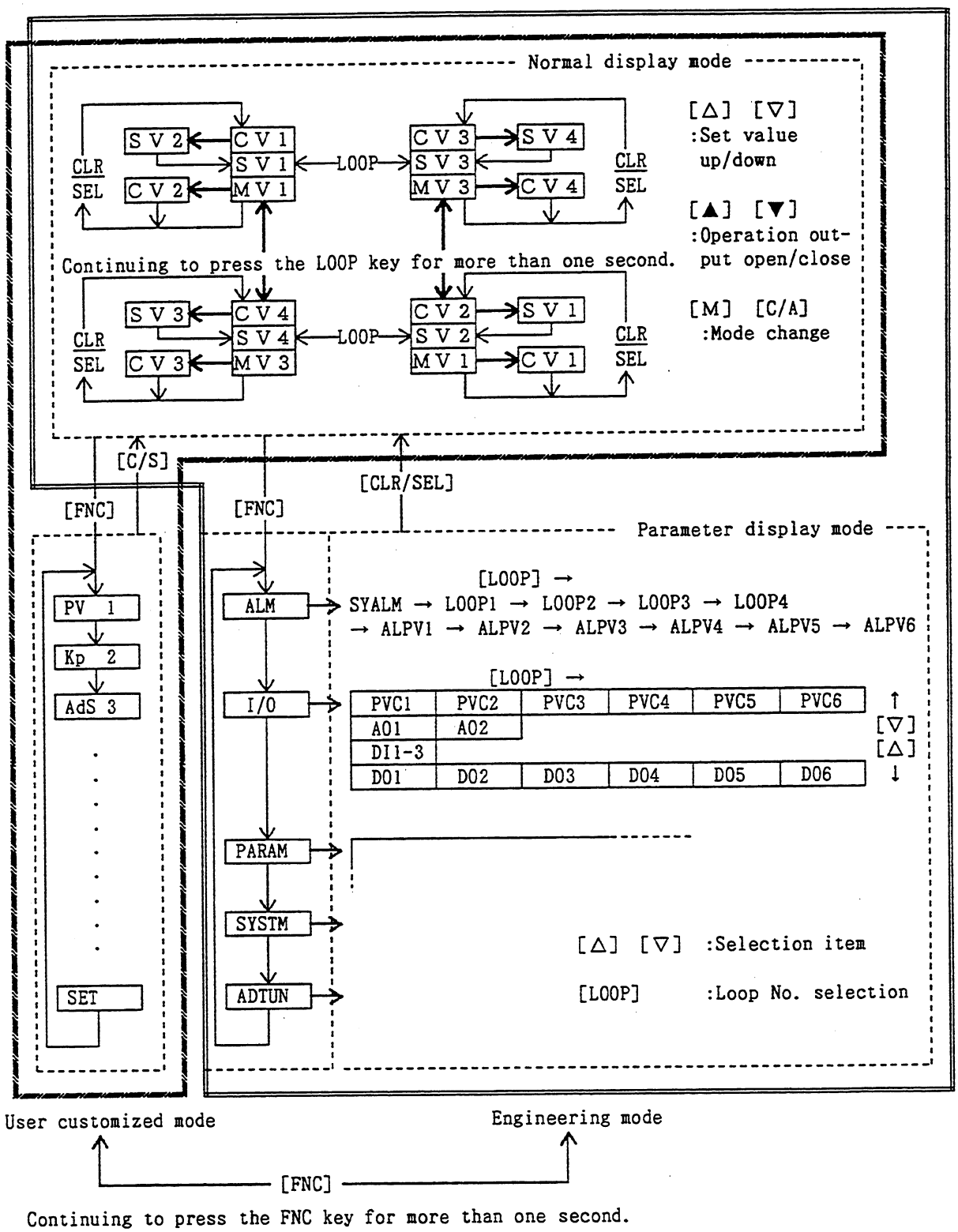


Figure 3.2 Data Display Method

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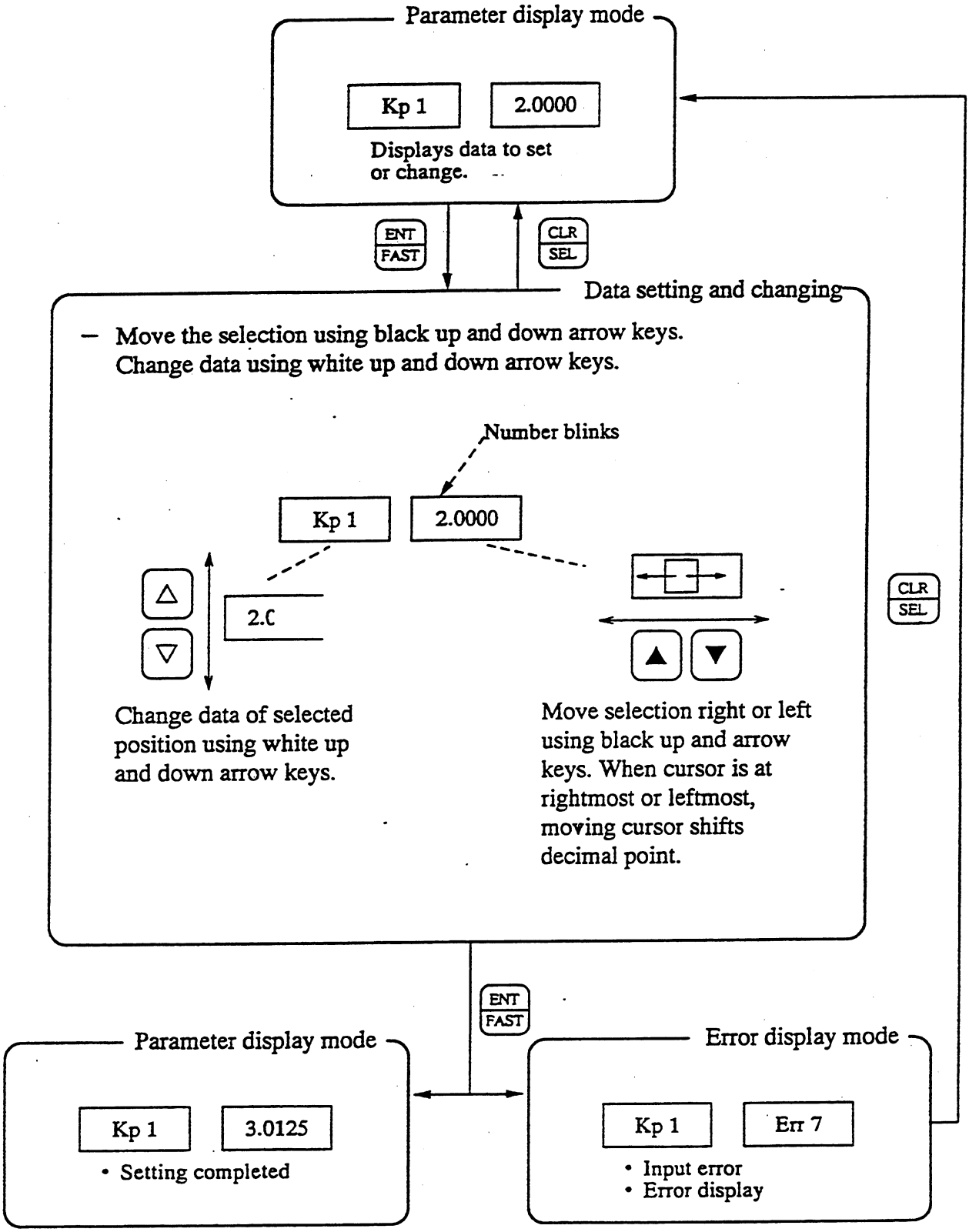


Figure 3.3 Data Input Method

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Table 3.1 Parameter Display Mode List

Functions		Items
ALM	Alarm operation	System alarm (SYALM) Loop alarm (LOOP) PV alarm (ALPV)
I/O	I/O operation	PV input (PVC) Analog output (AO) Process input/output (DI,DO,DOM)
PARAM	Parameter operation	PV alarm set values (PH, PL, ΔPV) PV input parameters (DF, LC) Engineering unit ranges (RH, RL) Post-linearize PV value (PV) Loop data (CV, SV, MV) Control mode (MODE) MV output limit values (MH, ML, ΔMV, DVL) Control parameters (Kp, Ti, Td) Control parameters (Rt, BS) Control cycle(ΔT) Direct reverse setting (D/R) Valve open/close direction specification (DV) MV fixed value (MVF)
SYSTM	System operation	Optional input specification (PVnOP, COMOP) Control type specification (FUNC1, FUNC2) Basic function change (FNCCG) Polygonal line table (PLN, PLTBL) RS232C transmission specification (RS232) Tansmission condition specification (RS485, CADDR, HSTAD, MAXST) for RS485 (CADDR, MCBUS, MCCHK) for MCBUS MC memory card specification (CARDR, CARDW, PARAR, PARAW) System code display (SYCOD) Switch parameters (SW1 to 4, SW5 to 8) Bar graph display specification (BAR, BARMD) Scale line division specification (CVSC, SVSC, MVSC) RAM data initialize function (SAVE, LOAD) Data change disable (PLOCK) SV tracking specification (SVT) Sensor check and Scan (SCAN) Alarm reset condition specification (ALMCF) AO online (AOnTP, AOnRH, AOnRL) Data logging function (LGPG) DP parameters (DPSET, DP) Control cycle alarm (CTALM) Security code (SECU) User tag, Engineering unit (TAG, UPV) User customized key specification (USR) Software version (MBVER, CBVER, LDVER)
ADTUN	Self-tuning operation	Setup signal amplitude (PA) Identification parameters (TA, SI, PF) Design parameters (DAT, MDL) Supervisors (SPS, SPC, EB, EI, EN) Tuning limit coefficients (PLMT, ILMT, DLMT) AdTune status (AdS) Tuning parameters (TKp, TTi, TTD, Tα, PTA, PSI,PPF) Tuning constant registration specification (SET) Control parameter (α)

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3.3 Operations and functions

3.3.1 Alarm operation (ALM) «NEW»

Alarm status of the controller is displayed.
When some alarms occured at the same time, display them in the order of priority according to the following.

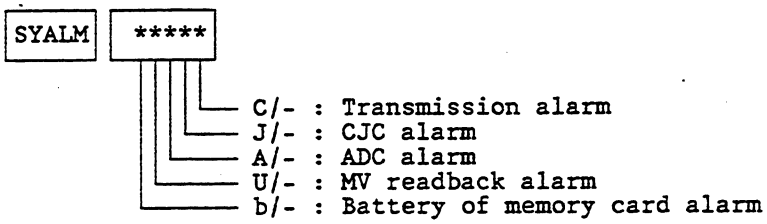
SYALM -> LOOP1 -> LOOP2 -> LOOP3 -> LOOP4 -> ALPV1
-> ALPV2 -> ALPV3 -> ALPV4 -> ALPV5 -> ALPV6

The [LOOP] key can change display alarm items.

In the case of no alarm, display as follows.

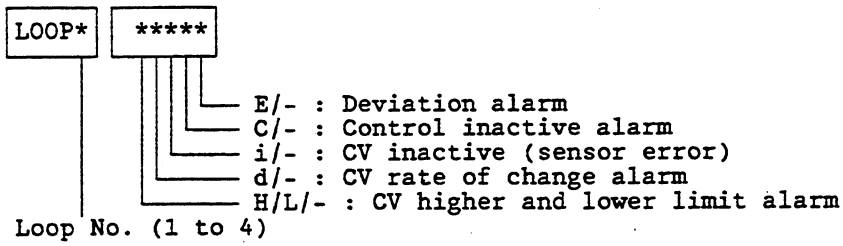


(1) System alarm



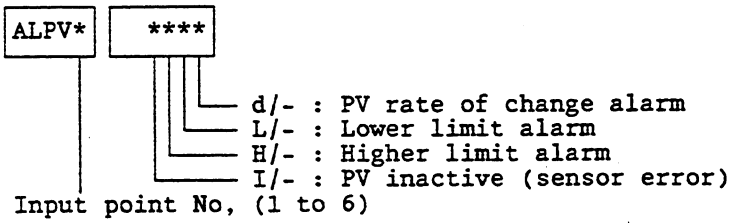
(2) Loop alarm

Display the alarms as regards control loop.



(3) PV alarm

Display the alarm status about input points that are not registered as CV.



Confirmation terminates with alarm displays. (For confirmed recovery, the alarm display and pressing [ENT/FAST] goes out upon data display.)

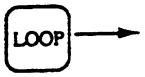
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3.3.2 I/O Operation (I/O)

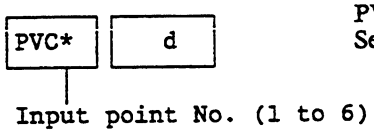
Analog outputs and digital inputs/outputs are set/changed.

1	PVC1	PVC2	PVC3	PVC4	PVC5	PVC6
2	AO1	AO2				
3	DI1-4					
4	DO1	DO2	DO3	DO4	DO5	DO6
5	DOM1	DOM2	DOM3	DOM4	DOM5	DOM6



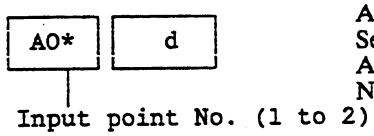


(1) PV input value



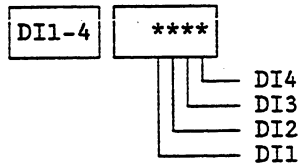
PV input value is displayed in the range of 0 to 100%.
Setting disable.

(2) Analog output value (for expanded I/O only)



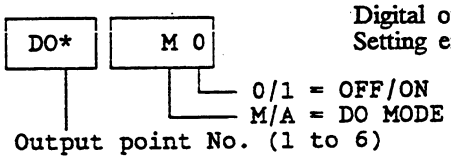
AO output value is displayed in the range of 0 to 100%.
Setting enable with AOMODE= 'M' (when function module AO is not used). (0.0<=AOn<=100.0)
Nothing displayed unless expansion I/O is installed.

(3) Digital input value *DI4 «NEW»*



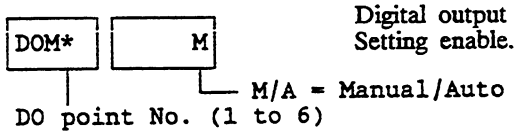
Digital input value is displayed.
1/0 = ON/OFF. Setting disable.

(4) Digital output value *DO5, DO6 «NEW»*



Digital output value is displayed.
Setting enable with DOMODE= ' M'.

(5) Digital output mode *DOM5, DOM6 «NEW»*



Digital output mode value is displayed.
Setting enable.

Note: When the expansion I/O Module is not equipped, DO3, 4, 5, 6 and DOM3, 4, 5, 6 are not displayed.

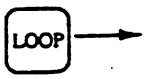
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3.3.3 Parameter operation (PARAM)

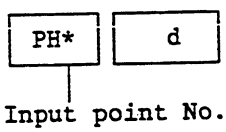
Various parameters and control constants are set/changed.
When the input flag of the input point is zero or when the FUNC of the loop is zero, no data is shown, but the items are displayed.

1	PH1	PH2	PH3	PH4	PH5	PH6
2	PL1	PL2	PL3	PL4	PL5	PL6
3	△PV.LMT1	△PV.LMT2	△PV.LMT 3	△PV.LMT4	△PV.LMT5	△PV.LMT6
4	DF1	DF2	DF3	DF4	DF5	DF6
5	LC1	LC2	LC3	LC4	LC5	LC6
6	RH1	RH2	RH3	RH4	RH5	RH6
7	RL1	RL2	RL3	RL4	RL5	RL6
8	PV1	PV2	PV3	PV4	PV5	PV6
9	CV1	CV2	CV3	CV4		
10	SV1	SV2	SV3	SV4		
11	MV1	MV2	MV3	MV4		
12	MODE1	MODE2	MODE3	MODE4		
13	MH1	MH2	MH3	MH4		
14	ML1	ML2	ML3	ML4		
15	△MV.LMT1	△MV.LMT2	△MV.LMT3	△MV.LMT4		
16	DV.LMT1	DV.LMT2	DV.LMT3	DV.LMT4		
17	Kp1	Kp2	Kp3	Kp4		
18	Ti1	Ti2	Ti3	Ti4		
19	Td1	Td2	Td3	Td4		
20	Rt1	Rt2	Rt3	Rt4		
21	Bs1	Bs2	Bs3	Bs4		
22	△T1	△T2	△T3	△T4		
23	D/R1	D/R2	D/R3	D/R4		
24	VD1	VD2	VD3	VD4		
25	MVF1	MVF2				





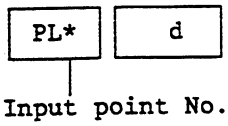
(1) PV higher limit value



PV higher limit alarm value (engineering unit)
Setting enable with 99999 >= PHn > PLn.

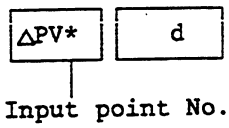
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(2) PV lower limit value



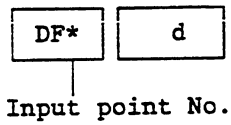
PV lower limit value (engineering unit)
Setting enable with PHn > PLn >= -9999.

(3) PV rate of change limit value



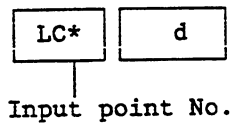
PV rate of change limit value.
Setting enable in the range of 0 <= ΔPV <= 100%.

(4) Digital filter coefficient



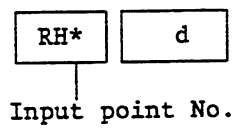
Digital filter coefficient
Setting enable with 0.0 <= DF < 1.0.

(5) Low-cut value



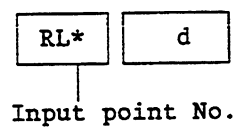
Low-cut value
Setting enable with -25.0 <= LC <= 100.0
When -25.0 low-cut ends.

(6) Engineering unit range higher limit value



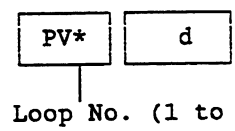
Engineering unit range higher limit value
Setting enable with 99999 >= RHn > RLn.

(7) Engineering unit range lower limit value



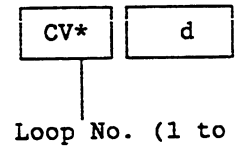
Engineering unit range lower limit value
Setting enable with RHn > RLn >= -9999.

(8) Post-linearize PV value



Post-linearize PV value (engineering unit)
Setting disable.
Setting enable with scan off. «NEW»

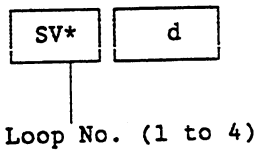
(9) CV value «NEW»



PV value for control loop (engineering unit)
Setting disable.

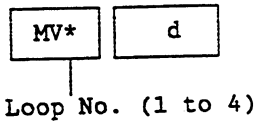
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(10) SV value



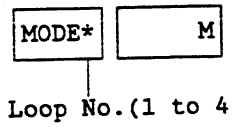
Set value (engineering unit)
M mode setting enable with RLn <= SVn <= RHn in A mode (with operation enable)

(11) MV value



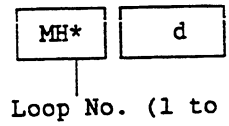
Manipulated output value (%)
Mode setting enable with -25.0 <= MVn <= 125.0

(12) Control mode



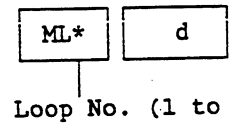
Control mode
M/A/C=Manual/Auto/Cascade

(13) Manipulated output higher limit value



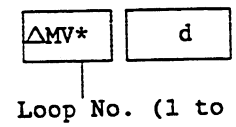
Manipulated output higher limit value (%)
Setting enable with 125.0 >= MHn > MLn

(14) Manipulated output lower limit value



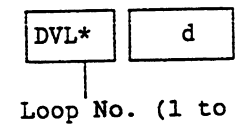
Manipulated output lower limit value (%).
Setting enable with MHn > MLn >= 25.

(15) Manipulated output deviation limit value



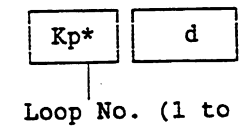
ΔMV limit value (%)
Setting enable with 0.0 <ΔMV <= 100.0

(16) Deviation limit value DV.LMT



Deviation limit value (%)
Setting enable with 0.0 < DVL <= 100.0

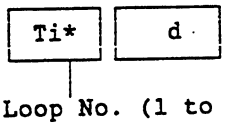
(17) Proportional gain



PID proportional gain
Setting enable.
-9999 <= Kp <= 99999

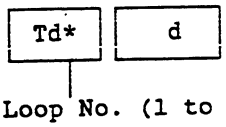
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(18) Integral time



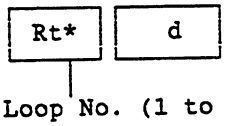
PID integral time (min).
Setting enable.
0 < = Ti < = 99999.

(19) Differential time



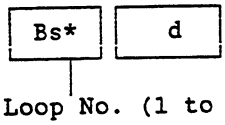
Differential time (min).
Setting enable with 0.0 < = Td < = 99999.
when 0.0 differentiation ends.

(20) Ratio



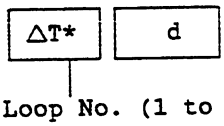
Ratio
Setting enable.
-9999 < = Rt < = 99999.

(21) Bias



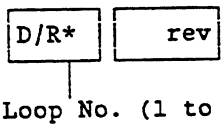
Bias
Setting enable.
-9999 < = Bs < = 99999.

(22) Control cycle



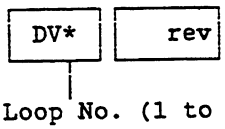
PID calculation cycle
Setting enable with 1< = ΔT < = 99.

(23) Direct reverse setting



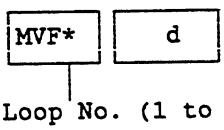
Direct/reverse setting
Setting enable with dir/rev.
(See 7.1)

(24) Valve open/close direction specification



Valve open/close direction specification.
Setting enable with dir/rev.
(See 7.1)
When valve open/close direction is changed, the control mode automatically changes to M mode.

(25) MV fixed value output (only when the basic functions are used)



MV fixed value output
Setting enable with -25.00 < = MVF < = 125.00.

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3.3.4 System Operation (SYSTM)

System functions such as transmission, basic functions, etc.

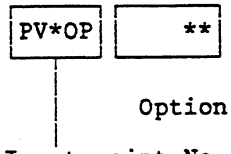
1	PV1 module	PV2 module	Option			
2	Basic function 1	Basic function 2	Function change			
3	Polynomial line 1	Polynomial line 2	Polynomial line 3	Polynomial line 4	Polynomial line 5	Polynomial line 6
4	Polynomial line TBL specificate on		Polynomial line data setting (X, Y)		Polynomial line TBL register	
5	RS232C					
6	RS485	Self st.ad	Host st.ad	Max.st.ad		
	Self st.ad	MCBUS	Otheer st.			
7	Mem. card 1 to 4	Mem. card 5 to 8	Mem. card 9 to 12	Mem. card 13 to 16		
8	Memory card RD	Memory card WR	Parameter RD	Parameter WR		
9	SYSTEM Code					
10	SW1 - 4	SW5 - 8				
11	Bar graph mode	Bar graph 1	Bar graph 2	Bar graph 3	Bar graph 4	
12	CV1 Scale-CV4 Scale / SV1 Scale-SV4 Scale / MV1 Scale-MV4 Scale					
13	SAVE	LOAD				
14	Parameter Lock					
15	SVT1	SVT2	SVT3	SVT4		
16	SCAN1	SCAN2	SCAN3	SCAN4	SCAN5	SCAN6
17	ALMCNF					
18	AO1 TP	AO1 RH	AO1 RL	AO2 TP	AO2 RH	AO2 RL
19	LGPG1	LG △T1	LG1TP	LGPG2	LG △T2	LG2TP
20	DPSET	DP000 - - - - - DP149				
21	CT alarm					
22	Security 1	Security 2				
23	TAG1	TAG2	TAG3	TAG4	TAG5	TAG6
24	PV1 Unit	PV2 Unit	PV3 Unit	PV4 Unit	PV5 Unit	PV6 Unit
25	User customized key 0 - 29					
25.	Main board Version	Comm.board Version	Loader Version			



LOOP →

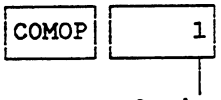
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(1) PV input option specification



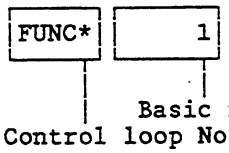
PV input option specification
0*: none (1 to 5 V input)
1*: RTD module
20: mV module
21: TC module Type K
22: TC module Type J
23: TC module Type T
24: TC module Type E
25: TC module Type B
26: TC module Type R
27: TC module Type S
30: Pulse module (without integration)
31: Pulse module (with integration)
Setting disable.

Transmission option specification



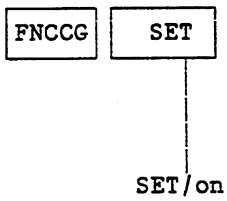
Transmission board option specification
0: none
1: MODBUS
2: BSAP
3: ECBUS
4: MCBUS «NEW»
5: ECBUS/H «NEW»
Setting disable.

(2) Basic function (control type) specification



FUNC1/2 : Control loop 1/2 side
00: Unregistered
01: Simple PID 1
02: Remote PID 1
03: MV override 1
04: M/A manipulator 1
05: Cascade PID 1
06: Simple PID (AdTune) 1
07: Remote PID (AdTune) 1
08: MV override (AdTune) 1
09: Cascade PID (AdTune) 1
11: Simple PID 2 «NEW»
12: Remote PID 2
13: MV override 2
14: M/A manipulator 2
15: Cascade PID 2
16: Simple PID (AdTune) 2
17: Remote PID (AdTune) 2
18: MV override (AdTune) 2
19: Cascade PID (AdTune) 2
-: User Function

Basic function change «NEW»

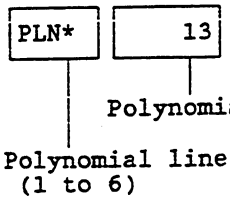


Basic function change specification

SET/on =Non-execute/Execute
On input transfers old download program from the RAM to the EEPROM.
Old download file starts again.
In the case of no download file,display error.

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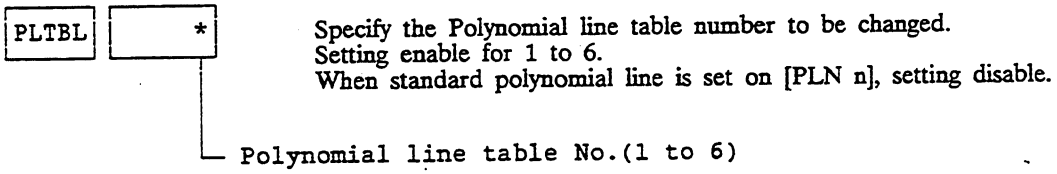
(3) Polynomial line table specification



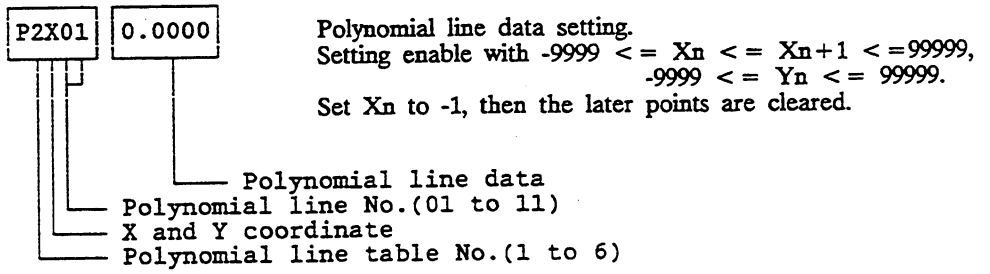
Type	deg C			deg F		
	RL	RH	No.	RL	RH	No.
JPt100	-100	100	01	-150	200	51
JPt100	0	300	02	0	600	52
JPt100	0	500	03	0	1000	53
Pt100	-100	100	04	-150	200	54
Pt100	0	300	05	0	600	55
Pt100	0	500	06	0	1000	56
TC-K	0	400	11	0	800	61
TC-K	0	800	12	0	1500	62
TC-K	0	1200	13	0	2200	63
TC-J	0	400	14	0	800	64
TC-J	0	800	15	0	1500	65
TC-T	-100	350	16	-150	700	66
TC-E	0	800	17	0	1500	67
TC-S	0	1600	18	0	3000	68
TC-R	0	1600	19	0	3000	69
TC-B	300	1800	20	600	3300	70

(4) Polynomial line table setting *«NEW»*

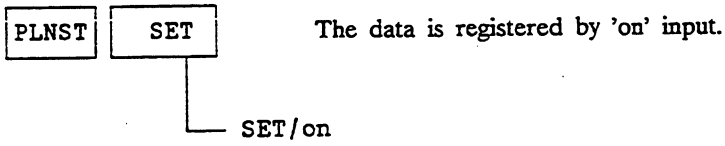
Polynomial line table specification



Polynomial line data setting



Polynomial line table register



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(5) RS-232C communication setting (hand-held terminal port setting)

RS232	96.N.8.2

RS-232C communication mode specification

```
Stop bit 1/2
Data bits 7/8
Parity: N/O/E = None/odd/even
Baud rate
  03: 300 bits/s
  06: 600
  12: 1200
  24: 2400
  48: 4800
  96: 9600
```

Device	Data
Hand-held terminal	96.N.8.2
Loader	96.N.8.2

(6) RS-485 communication setting

RS485	96.N.8.1

RS-485 communication mode specification

```
Stop bit 1/2
Data bits 7/8
Parity: N/O/E = None/odd/even
Baud rate
    03: 300 bits/s   12:1200    48:4800    19:19200
    06: 600          24:2400    96:9600    20:208000
```

208000 is only for ECBUS/H. When 208000, this item is fixed to 20.n.8.1 «NEW»

Self station ADDRESS

CADDR	**

Self station address
Setting disable.

Host station ADDRESS

HSTAD	**

Host station address is displayed when ECBUS is used.
Setting disable.

Maximum station ADDRESS

MAXST	**

The maximum address of the station which is connected to ECBUS. Setting enable. 2 <= MAXST <= 31.

MCBUS self station ADDRESS (only for MCBUS) «NEW»

CADDR	***

Self station address
Setting disable.

MCBUS specification (only for MCBUS)

MCBUS	*

MCBUS(A bus/B bus) specification during using.
A/B:Using A bus/B bus.

Other station condition (only for MCBUS)

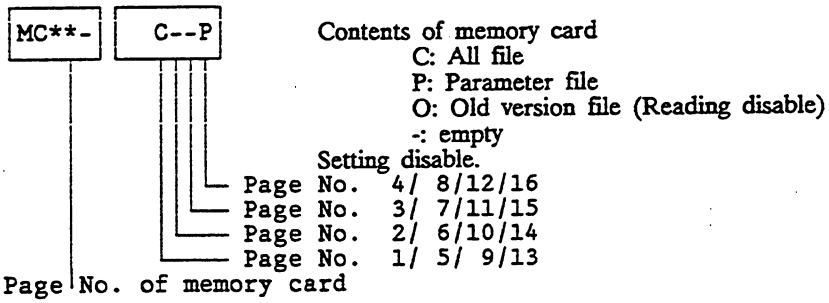
MCCHK	21.--

The condition of the other station.
Set slot No., the condition of the station is displayed.

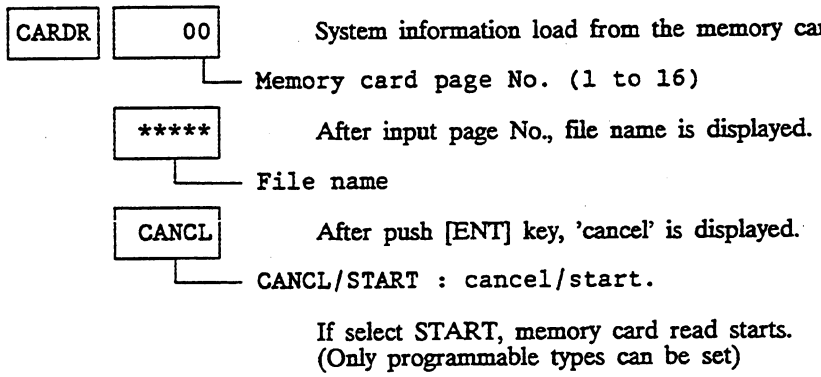
```
The condition of B bus. -/E = normal/error
The condition of A bus. -/E = normal/error
Slot No. (11 to 69)
```


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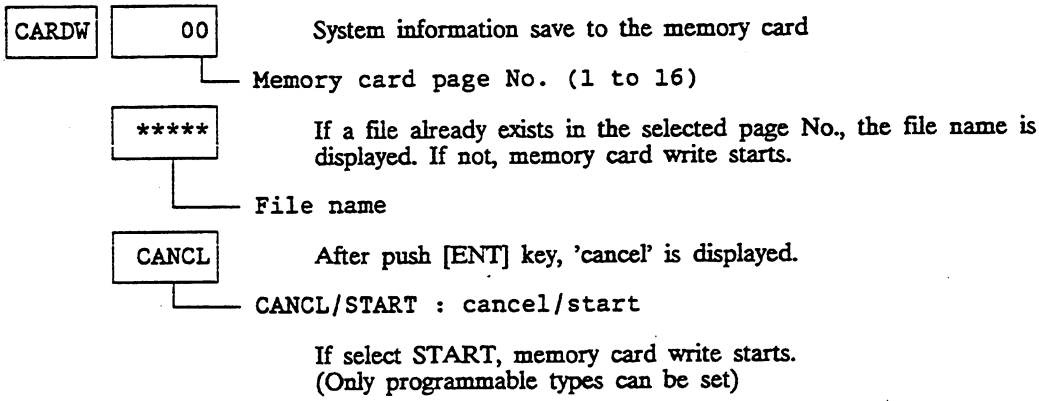
(7) Memory card contents



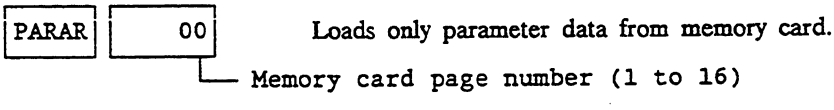
(8) Memory card read



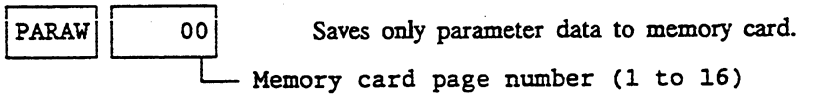
Memory card write



Memory card parameter read



Memory card parameter write



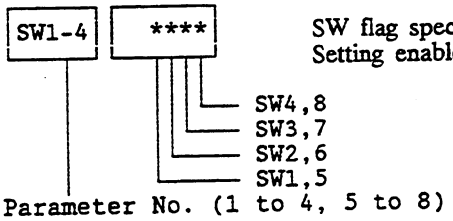
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(9) System code



System code display (to be set with loader)
Setting disable.

(10) SW flag

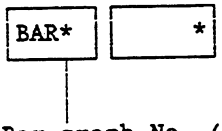


SW flag specification.
Setting enable.

(11) Bar graph display mode



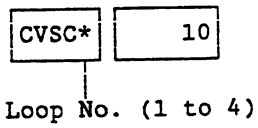
Front panel bar display mode specification
0/1: One-loop display/two-loop display
Setting enable



Front panel bar graph display changeover
1 to 4 : loop No.
Setting enable
(See 7.2)

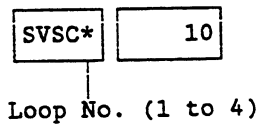
When BDP/BDM modules are used by programmable type, refer to the explanation of the modules.

(12) No. of CV scale divisions



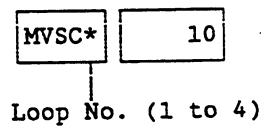
No. of CV scale divisions
Setting enable for 1 to 20 divisions.
User scale for 21 to 28 divisions.

No. of SV scale divisions



No. of SV scale divisions
Setting enable for 1 to 20 divisions.
User scale for 21 to 28 divisions.

No. of MV scale divisions



No. of MV scale divisions
Setting enable for 1 to 20 divisions.
User scale for 21 to 28 divisions.

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(13) EEPROM data registration function



EEPROM data registration function

ON input transfers data from the internal RAM to the EEPROM.
HOLD remains ON during transfer.

RAM data initialize function



RAM data initialize function

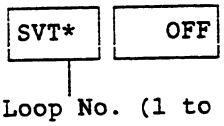
ON input transfers data from the EEPROM to the RAM.
HOLD remains ON during transfer.

(14) Parameter rewrite disable



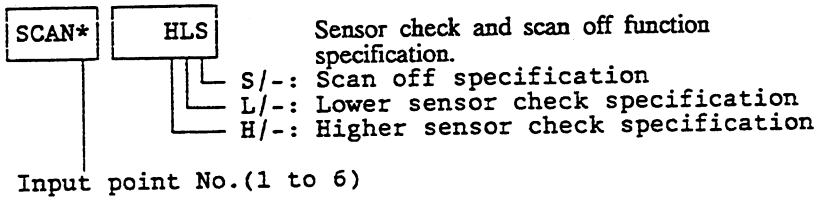
Parameter rewrite disable function
FREE/LOCK = Enable/Disable rewrite

(15) SV tracking specification



SV tracking function specification
ON/OFF = Execute/ Non-execute

(16) Sensor check and Scan *«NEW»*



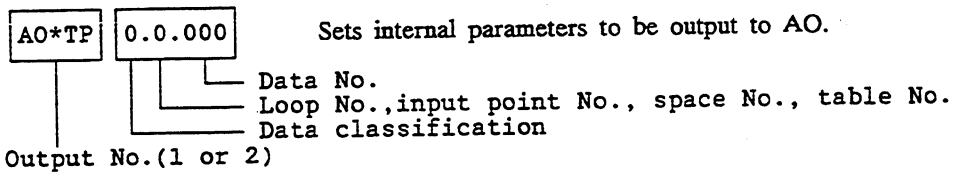
Sensor check and scan off function specification.

(17) Alarm reset condition specification



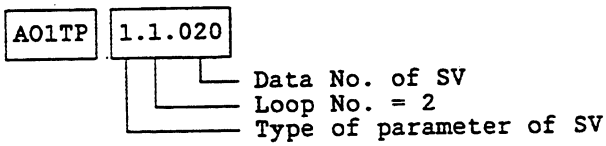
Alarm (ALM) recovery condition specification
AUTO/MAN = Automatic recovery/Confirmed recovery

(18) AO Online specification (only for expansion I/O module)



Sets internal parameters to be output to AO.

(Input example) To set SV2:



See the end of the manual for details.

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AO range upper limit specification (only for expansion I/O module)

AO*RH	d

Sets internal parameter range to be output to AO.
Setting enabled.

Output No. (1 or 2)

AO range lower limit specification (only for expansion I/O module)

AO*RL	d

Sets internal parameter range to be output to AO.
Setting enabled.

Output No. (1 or 2)

(19) Data logging function (only for optional expansion RAM) «NEW»

On line logging page No. specification

LGPG1	21

Specify expansion RAM page to be entered logging data.
Setting enable with 21 to 36.

On line logging page No.

On line logging cycle specification

LGΔT1	1

Setting logging cycle.
Setting enable with 0 <= LGΔT* <= CTS*65535.

On line logging specification

LG1TP	0.0.000

Sets internal parameter to be output expansion RAM.
On setting, starts logging.

Data No.
Loop No., input point No., space No., table No.
Data classification

(20) DP parameter set point specification «NEW»

DPSET	010

Input DP parameter point No.
Setting enable with 0 <= DPnnn <= 149.

DP parameter No.

DP parameter specification

DP010	0.0000

Setting DP parameter.
Setting enable with -9999 <= DPnnn <= 99999.

DP parameters	Basic functions / User function
DP000 - DP009	cannot be set
DP010 - DP013	cannot be set / can be set
DP014 - DP149	can be set

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(21) Control cycle alarm

CTALM	-

Control cycle alarm is displayed.
-/C = CTALM none/occurred

(22) Security code

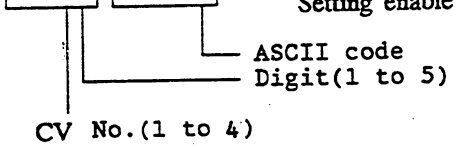
SECU*	FREE

Security status is displayed.
FREE/LOCK = security free/lock
Verification enable.

(23) User tag specification ***«NEW»***

TAG11	41

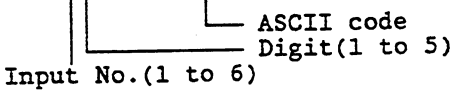
Tag name of CV setting.
Setting enable by ASCII code.



(24) Engineering unit

UPV**	20

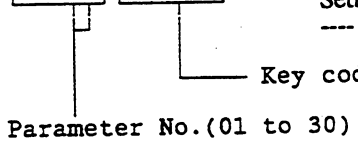
Engineering unit of CV and SV setting.
Setting enable by ASCII code.



(25) User customized key specification ***«NEW»***

USR00	0000

Setting keys for user customized mode.
Setting enable by Key code. (See the end of the manual)
---- : Unregistered



(26) Software version of controller

MBVER	d

Software version of the controller is displayed.
Setting disable.

Software version of communion board

CBVER	d

Software version of the ECBUS communication is displayed. Setting disable.

Software version of loader

LDVER	d

Software version of the loader is displayed.
Setting disable.

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3.3.5 Self-tuning (AdTune) Operation

Self-tuning parameters are set/changed.

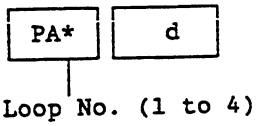
	LOOP1	LOOP2	LOOP3	LOOP4		
1	PA1	PA2	PA3	PA4		
2	TA1	TA2	TA3	TA4		
3	SI1	SI2	SI3	SI4		
4	PF1	PF2	PF3	PF4		
5	DAT1	DAT2	DAT3	DAT4		
6	MDL1	MDL2	MDL3	MDL4		
7	SPS1	SPS2	SPS3	SPS4		
8	SPC1	SPC2	SPC3	SPC4		
9	EB1	EB2	EB3	EB4		
10	EI1	EI2	EI3	EI4		
11	EN1	EN2	EN3	EN4		
12	PLMT1	PLMT2	PLMT3	PLMT4		
13	ILMT1	ILMT2	ILMT3	ILMT4		
14	DLMT1	DLMT2	DLMT3	DLMT4		
15	AdS1	AdS2	AdS3	AdS4		
16	TKp1	TKp2	TKp3	TKp4		
17	TTi1	TTi2	TTi3	TTi4		
18	TTd1	TTd2	TTd3	TTd4		
19	Tα1	Tα2	Tα3	Tα4		
20	PTA1	PTA2	PTA3	PTA4		
21	PSI1	PSI2	PSI3	PSI4		
22	PPF1	PPF2	PPF3	PPF4		
23	SET1	SET2	SET3	SET4		
24	α1	α2	α3	α4		





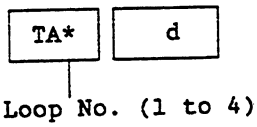
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(1) Setup tuning signal amplitude (%)



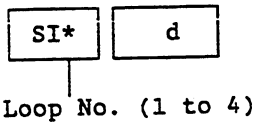
Setting enable with 0.0 < PAn <= 50.0

(2) Fixed signal amplitude (%)



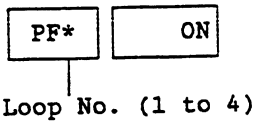
Setting enable with 0.0 < TAn <= 50.0

(3) Sampling cycle (sec)



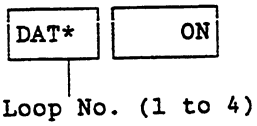
Setting enable with CTS <= SIn <= CTS*65500

(4) Identification filter execution specification



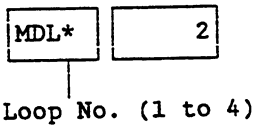
ON/OFF = Execute/Non-execute

(5) Differential term specification



ON/OFF = Execute/Non-execute

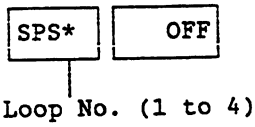
(6) Tuning reference model specification



Tuning reference model specification
1: Butterworth
2: ITAE minimum
3: Bessele
4: Binominal

* If it cannot design by specifying model, model is automatically added by 1 and redesign is executed.
* After specifying model, redesign is executed.

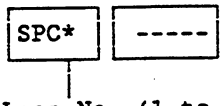
(7) Supervisor execution specification



ON/OFF = Execution/Non-execution
Setting ON enable at A or C mode.
Automatically change to OFF at M mode.

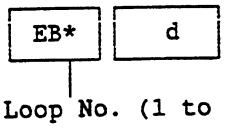
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(8) Supervisor execution status



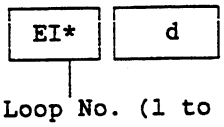
..... : Supervisor off, or MAT module not implemented.
----- : Control line normal
unSTb : Unstable status
b.rESP: Bad response
GAin.d: Request to decrease proportional gain
TunE.r: Request to execute AdTune

(9) Supervisor deviation value (%)



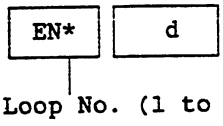
Setting enable with 0.0 < EBn < = 100.0.
Normally set automatically with Supervisor execution.

(10) Supervisor base time (sec)



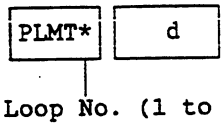
Setting enable with CTS < = EIn < = CTS*255
Normally set automatically with EB.

(11) Supervisor check time (sec)



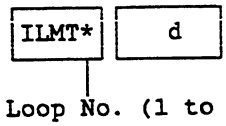
Setting enable with CTS < ENn < = EIn.

(12) Tuning KP limit coefficient



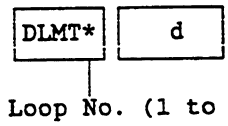
Setting enable with 0.0 < = PLMTn < = 99999.
OFF: No limit (when 0.0 is set)

(13) Tuning Ti limit coefficient



Setting enable with 0.0 < = ILMTn < = 99999.
OFF: No limit (when 0.0 is set)

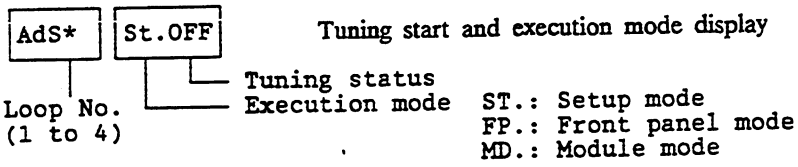
(14) Tuning Td limit coefficient



Setting enable with 0.0 < = DLMTn < = 99999.
OFF: No limit (when 0.0 is set)

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(15) Tuning status



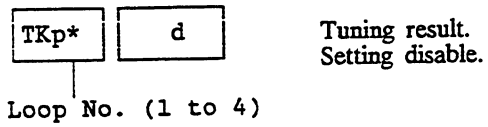
Full-tuning status
- OFF: Tuning stop
- ON : Tuning being executed & execution request
- SAM: Sampling being executed
- idn: Identification being executed
- dES: Design being executed
- Fin: Tuning completed

Full-tuning error display
- E10: Tuning abnormal
- E11: MV fixed value being output
- E12: Tuning limit alarm
- E13: Tuning error
- E14: GSD index fluctuation error
- E99: AdTune full error

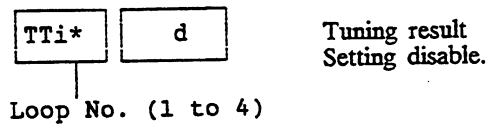
Setup tuning status
- ST1: Setup state 1
- ST2: Setup state 2
- ST3: Setup state 3
- Fin: Setup completed

Setup tuning error display
- Er1: I/O error
- Er3: S/N ratio incorrect error
- Er4: Reverse response error
- Er5: PH/PL error

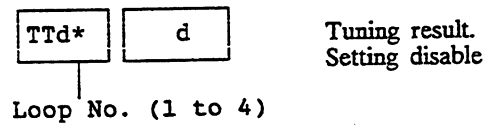
(16) Setup/full-tuning calculation result Kp



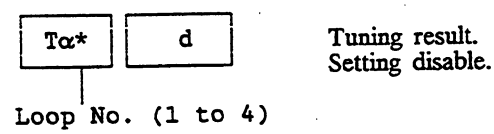
(17) Setup/full-tuning calculation result Ti



(18) Setup/full-tuning calculation result Td

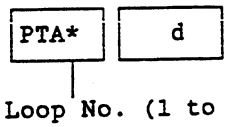


(19) Setup/full-tuning calculation result α



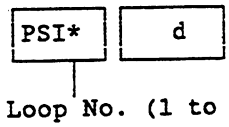
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(20) Setup calculation result TA



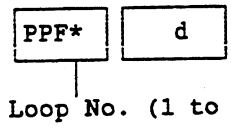
Setup result.
Setting disable.

(21) Setup calculation result SI



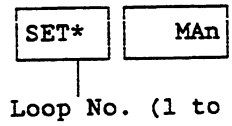
Setup result.
Setting disable.

(22) Setup calculation result PF



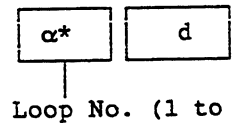
Setup result.
Setting disable.

(23) Setup/full-tuning result registration



After tuning execution, the result is registered by 'On' input.
'On' input is only valid upon completion of tuning.

(24) 2 degrees of freedom PID parameter α



2 degrees of freedom PID parameter α.
Setting enable.

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4. Preparation

Carry out preparation with the process loop controller internal unit pulled out, mounted to the instrumentation panel or placed on a working desk.

4.1 Fuse check

Withdraw the internal unit and check to see that the fuse is mounted to the specified position.

If no fuse has been mounted, refer to 6.2.3 "Fuse Replacement" of the Hardware Manual 6F8A0624.

4.2 Analog Input Option Select Pin Setting

Withdraw the internal unit and check to see that J1 to J4 shown below are set correctly (Figure 4.1).

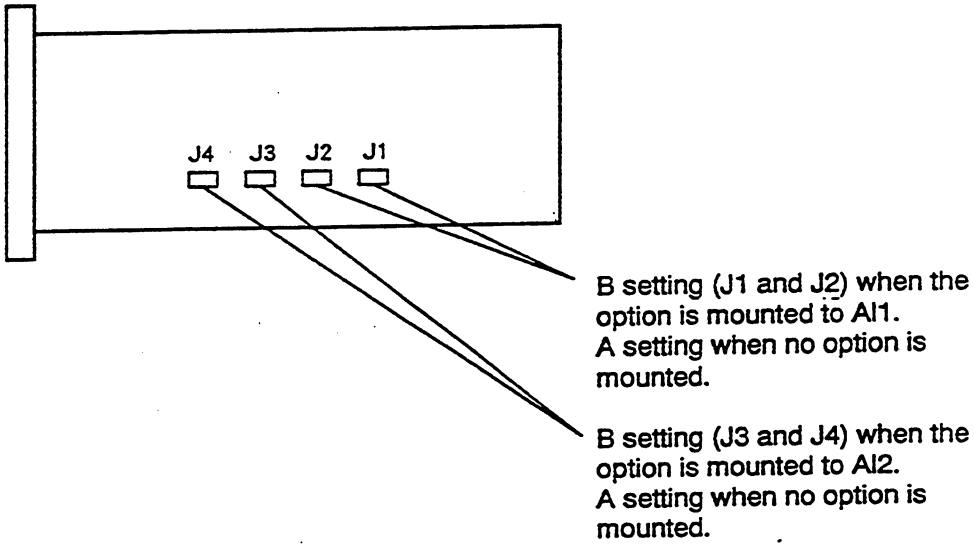


Figure 4.1 Setting with Analog input option Mounted

4.3 Preparation for Operation

4.3.1 When using the basic functions

Prior to operation, determine the control functions and set various parameters.

When the control type is set, all parameters and statuses are initialized.

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(1) Set the control type (FUNC1 or 2)

(2) Register the polynomial line and root extraction operations by the SW parameter in accordance with the control type.

(3) Set/change each control parameter.

(4) If the control parameters have been determined, write change data to the EEPROM by SAVE. (Backup with involatile memory.)

(5) Upon completion of all preparation operations, mount process loop controller to the instrumental panel, carry out signal wiring and turn ON the power supply.

NOTE: Use of the self-tuning function enables one to automatically set the optimum parameters.
For details, refer to the technical textbook GBK-8705.

4.3.2 When using a program created by Loader

(Only programmable types can be used.)

(1) Set the same transmission speed (RS232C) to the same settings as the loader and load the program. (Baud rate: 9600, Parity: none, Bit: 8, Stop bit: 2)

(2) When loading is done, install the controller in the instrumentation panel. Complete the signal wiring and turn on the power.

* Download Error Recovery Function *«NEW»*
Even if an error occurs during data transmission, the download is a failure, the data that operated up to now is recovered and continued.

4.3.3 When using a program by loading it from memory card

(Only programmable types can be used.)

(1) Load a program from memory card by the CARDR command.

(2) After loading is complete, install a controller on the meter panel and conduct wiring for signals. Tune on power.

NOTE: When using a RAM card
The data guarantee period of RAM card is two years. When the expiration date is passed, the voltage may lower and data in the RAM card may be lost. Be sure to save important data onto floppy disks, etc. using a loader and memory card reader and writer. In addition, when replacing batteries, data in RAM will be lost. Pay the same attention.

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5. Operation and Start

This chapter describes operation start and operating procedures using simple PID control as an example.

Carry out the operation described below after having a thorough understanding of control contents.

5.1 Manual Operation

Manual operation can be carried out with manual operation keys [▲ / ▼] in the M mode. If the manual operation key is used together with the [ENT/FAST] key, the change speed is changed from 40 sec/full scale (NORMAL) to 5 sec/full scale (FAST).

5.2 Set Value (SV) Setting

The SV value can be set using the SV set key [△ / ▽].

If the SV set key is used together with the [ENT/FAST] key, the change speed is changed from 100 sec/full scale to 10 sec/full scale.
Digital setting can be carried out in the parameter operation mode.

5.3 Alarm check and Changeover to Automatic Operation

The M mode can be changed to the A or C mode bumplessly by simply pressing the mode changeover switch. However, when starting automatic operation for the first time, do so using the following procedure because the optimum parameters have not been determined in most cases.

(1) Set an SV manually to as near the CV value as possible.

(2) If the PID parameter is unclear, set the proportional gain Kp to the minimum value (0.1 or less), the integral time Ti to 20 minutes or a sufficiently large value and the differential time Td to 0 minute or a sufficiently small value. (Refer to 3.3 for details of the setting procedure from the front panel.)

(3) Pressing the mode changeover key [A] or [C] lights up each mode indicator LED and starts automatic operation. If the ALM indicator LED lights up, find out the cause by checking the front panel.

If the MV readback error occurs, control is not resumed until the loop alarm is checked. (Control remains disabled in the M mode.)
If an error still occurs after the MV readback error is removed, the main unit may be defective. In that case, the main unit must be replaced.

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5.4 Steady Operation

(1) Operation mode changeover

The operation mode can be changed freely by pressing the [C], [A] and [M] pushbutton keys.
This operation can be carried out bumplessly without the need of balancing operation.

(2) Parameter setting

Use the front panel key to set/change parameters. The set value can be backed up using the SAVE function. To prevent data from being changed due to an erroneous operation, lock the parameters.

5.5 Operation after Recovery from Power Failure

Upon recovery from power failure, the process loop controller carries out the operations shown in Figure 5.1.

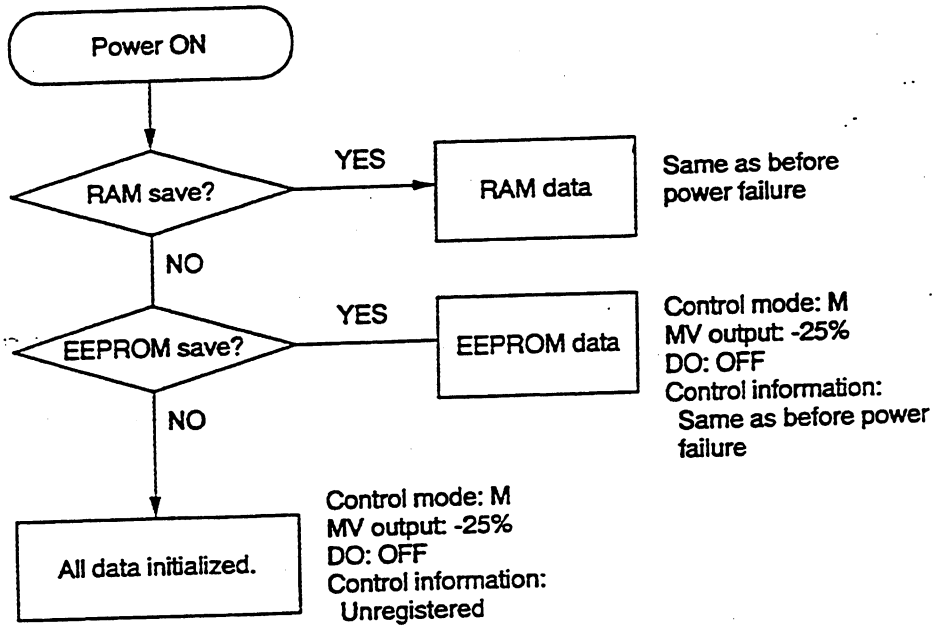


Figure 5.1 Process Flow After Power ON

If all data is initialized, carry out setting and registration again.

NOTE: When replacing the controlled, note that control information is saved in the process loop controller RAM memory and the EEPROM memory.
If the process loop controller malfunctions and a process loop controller which stores the control information different from that of the defective process loop controller in the RAM memory is used as an alternate instruments, control may start in the A or C mode and operation may be carried out in a dangerous state.
Thus, before replacing the process loop controller, check the control information carefully.

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6. Status Indicator Operation

The process loop controller displays internal faults and signal errors on the HALT and ALM indicators on the front panel. It also uses the CMP, ATC and HOLD indicators depending on operations.

6.1 Remedies when HALT and ALM Indicators Light up

(1) The HALT indicator lights up indicating that the controller errors listed in Table 6.1 have occurred.

Table 6.1 HALT Display Contents and Remedies

Error	Description	Remedy
Control inactive	AI input signal has an unspecified value. CLI=1 in the case of programmable types.	Check the input conditions, (Check for the sensor error in particular (0.7V or less input or 5.12V or more input).
MV readback error	The set MV differs from the read MV.	To continue the operation, replace the main unit.
ADC error	The reference voltage cannot be read correctly.	To continue operation, replace the main unit.

(2) The ALM indicator lights up indicating that a process alarm concerning the higher and lower limits and deviation has occurred.

ALM display recovery type, automatic recovery or confirmed recovery, can be specified (refer to 3.3.4).

When automatic recovery is selected, the alarm display is reset upon release of the alarm status, For confirmed recovery, the display continues until the contents are confirmed by alarm confirm display operation on the front panel. To confirm the alarm from the front panel, display the alarm by going to the ALM menu. With the alarm code displayed, press the [ENT/FAST] key. IF this does not clear the ALM light, switch the alarm recovery to "AUTO" and back to "MAN".

If the [ENT/FAST] key is pressed for about 1 second while and alarm continues, the blinking display on the CV scale display can be cancelled.

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Table 6.2 ALM Display Contents and Remedies

Error	Description	Remedy
Sensor error (PV inactive)	PV input signal is 0.7 V or less or 5.12 V or more.	Check the input conditions.
Higher/lower limit errors (PVH,PVL)	PV input signal is not between the higher and lower limits.	Check if the input signal or higher and lower limit values are correct.
Rate of change error (PVD)	The rate of change PV exceeded the set value.	PV Check the rate of change value.
Deviation error (DVE)	Deviation is not the set value.	Check the set value and the input signal.

6.2 CMP, ATC and HOLD Indicator Functions

(1) CMP indicator

This indicator lights up by setting CMP flags from the host unit.
(The RS-485 transmission board is optional.)

(2) ATC indicator

This indicator lights up or blinks during self-tuning.

Display	Cause
Continuous on	Tuning alarm
Fast blink	Request for supervisor confirmation
Slow blink	Self-tuning in process

(3) HOLD indicator

This indicator lights up for the process loop controller internal processing under the following conditions.

. Control type setting
. Data save to the EEPROM
. IC memory card transfer to the EEPROM
. MV fixed value output being generated
. Simulation status (blink)

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7. Operating details

7.1 Setting the Control Valve Operation Direction and Control Operation Direction

The control valve operation (positive and reverse) and control operation (positive and reverse) can be according to requirements.

Operation

(1) Select the parameter operation "PARAM".

(2) Select and set the operation direction

Control valve operation direction "VD1" "rev"

Loop No. rev: Reverse actuation valve
dir: Direct actuation valve

Control operation direction

"D/R 1" "rev"

Loop No. rev: Reverse operation
dir: Direct operation

The reverse actuation valve and reverse operation are set as initial values.

Table 7.1 Control Valve Operation Direction

"VD"	Value type	Operation Direction
rev	Reverse actuation valve (Air to open)	Increase manipulated output using the manual operation key ▲ (20 mA direction) Displays 4 to 20 mA in the range of 0 to 100% (Valve opening display)
dir	Direct actuation valve (Air to close)	Decreases manipulated output using the manual decreases key ▲ (4 mA direction) Displays 20 to 4 mA in the range of 0 to 100% (Valve opening display)
"D/R"	Type	MV display
rev	Reverse operation	As CV rises above SV, MV decreases.
dir	Direct operation	As CV rises above SV, MV increases.

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7.2 Bar Graph Display

The process loop controller has LNO module and BDP/BDM modules for the front panel bar graph display. LNO module is used for simpler display, and BDP/BDM modules are used for more flexible display. Standard control functions (FUNC=1 to 9) use LNO module.

In the both cases, the process loop controller can display not only one loop but also two loops and displays the data of the loops which are registered in BARn (n:1 to 4).

When LNO module is used, one loop or two loops display is defined by setting BARMD in the front panel of the controller or setting bar graph display mode in the program loader. And BARn is defined by setting BARn in the front panel of the controller or the program loader.

When BDP/BDM modules are used, one loop or two loops display is defined by H2 of BDM module and BARn is defined by BDP module.

(1) One loop display

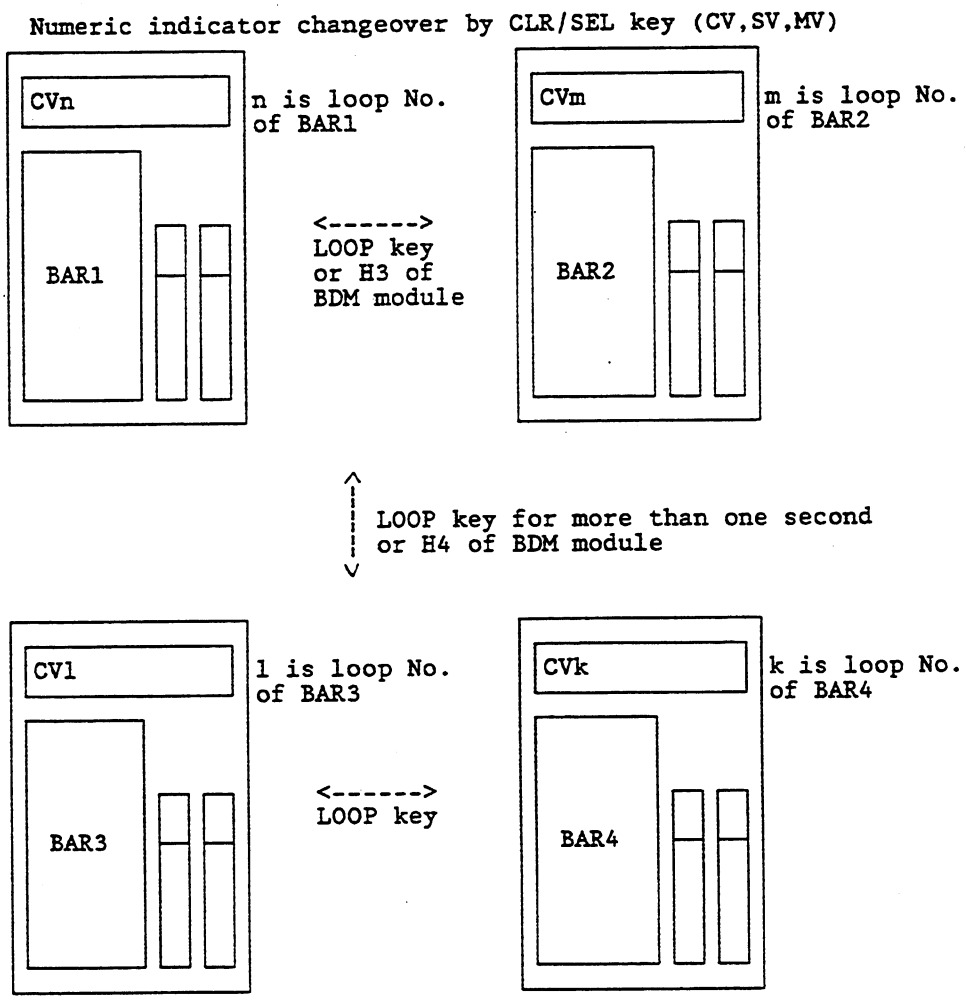


Figure 7.1 Changeover Operation Example (1-loop display)

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(2) Two loops display

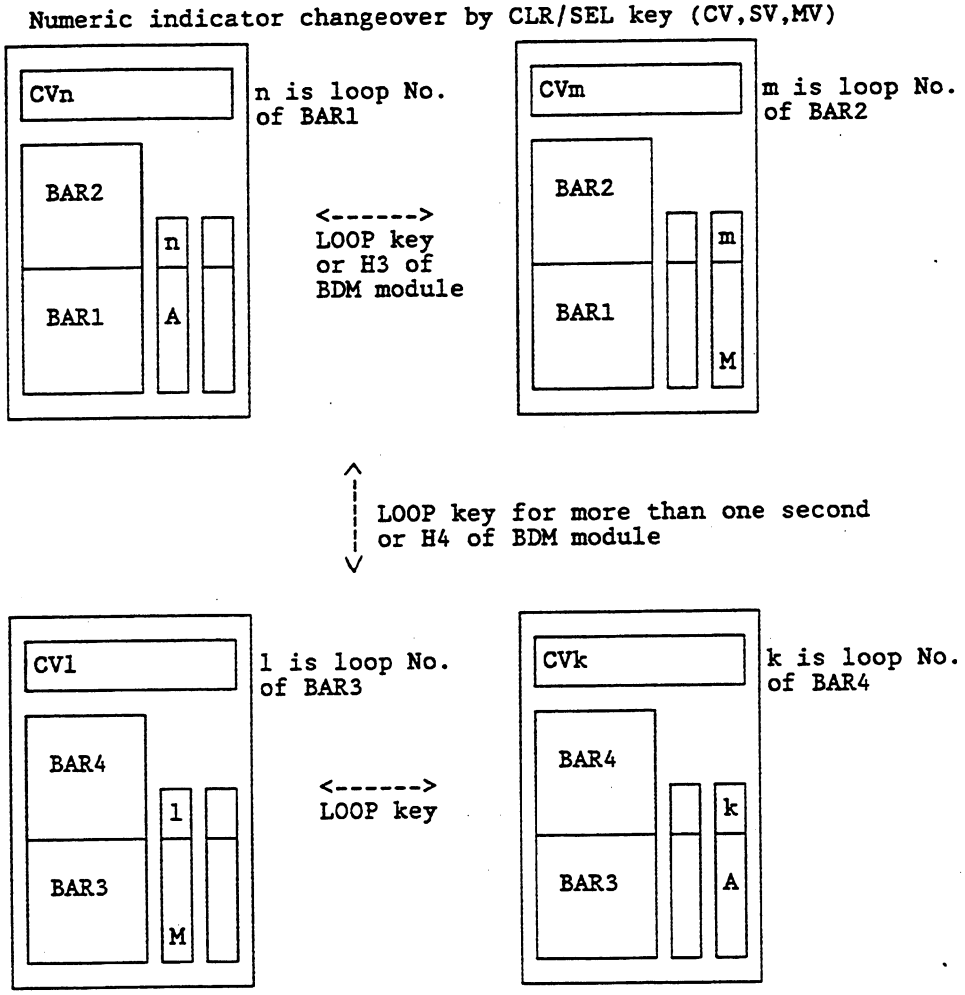


Figure 7.2 Changeover Operation Example (2-loop Display)

7.3 PH and PL Range Display Reset

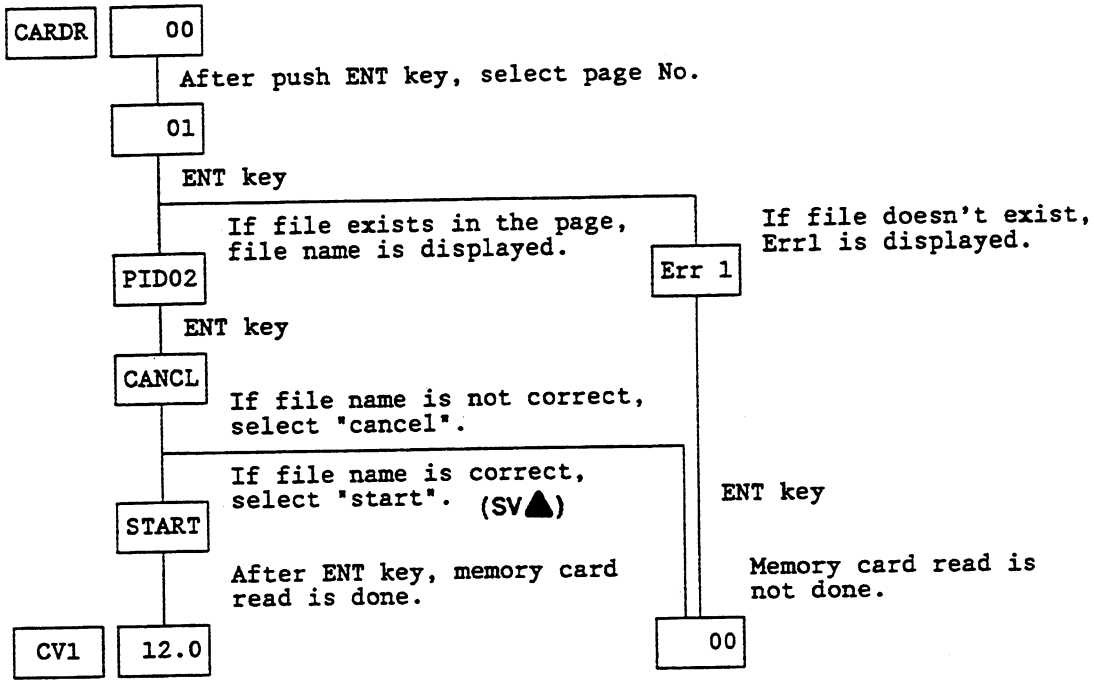
If the analog input becomes larger than the higher limit (PH) or smaller than the lower limit (PL), the higher/lower limit range is displayed on the CV scale line in blinking form.

If the analog input is reset in the range, the range continues to blink or goes out according to the alarm confirmed recovery conditions. If the blinking continues, the display can be returned to normal by pressing the [ENT/FAST] key for about 1 second.

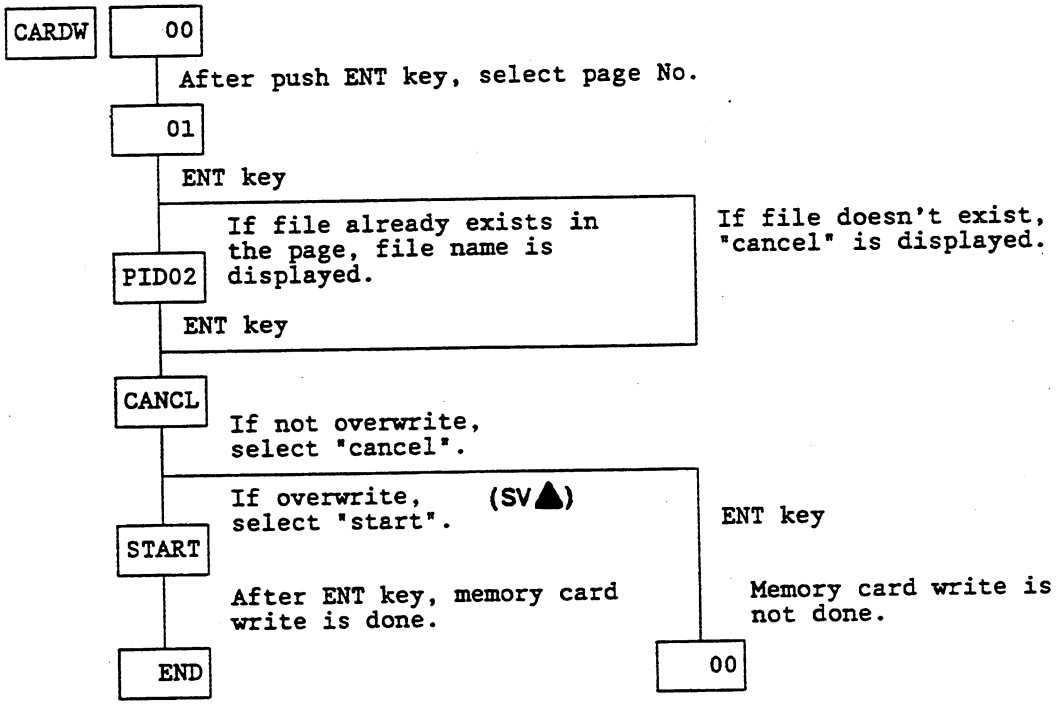
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7.4 Memory card read/write operation

(1) Memory card read operation



(2) Memory card write operation



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7.5 Bar Graph Scale Line Division

A scale line is displayed on each bar graph of CV, SV and MV. Scale line division can be set in a range of 1 to 20 using the front panel key. Each line is divided into 10 according to standard specifications as the default.

Operation

(1) Select the system operation "SYSTM".

(2) Set the number of divisions by selecting the scale line division setting.

CV scale line	"CVSC1"	"10"
SV scale line	"SVSC1"	"10"
MV scale line	"MVSC1"	"10"
	Loop No.	No. of divisions (1 to 20) User scale (21 to 28)

Note: Scale lines can be freely constructed in dot units by user scale using a program loader.

7.6 Parameter Set Inhibit Function

Data setting using the front panel switch can be inhibited. Data setting is enabled for SV, MV (in M mode) and the control mode. If the security code has been specified, data setting is inhibited even if setting is "FREE". Operate a hand-held terminal or a front panel to cancel the security code.

Operation

(1) Select the system operation "SYSTM".

(2) Select the panel key inhibit "PLOCK" and set "LOCK".

7.7 Security level

There are four security level. They are "Free", "Security level 1", "Security level 2", and "Lock". Security level is set by a program loader. The default value or security level is shown in 11.16 Security level table. In the case of standard function, The default values of security level are used.

The parameters of "Free" can always be changed by a hand-held terminal or a front panel.
The parameters of "Security level 1" can be changed only when security code 1 is free.
The parameters of "Security level 2" can be changed only when security code 1 and security code 2 are free.
The parameters of "Lock" can not be changed by a hand-held terminal or a front panel.

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7.8 Memory Initialize

The data of the RAM and EEPROM in the process loop controller is forcibly erased and the instrument is initialized (M mode, MV [-25%], SV [0%] and initial parameter value).

1 With the SV down key [▽] pressed, turn ON the power supply.

2 Press the [FNC] key and select "CLR.E".
Press the [ENT/FAST] key to check that "CLR.E END" is displayed.
Then, press [CLR/SEL] key.

3 Press the [FNC] key and select "CLR.R'.
Press the [ENT/FAST] key to check that "CLR.R End" is displayed.
Then, press [CLR/SEL] key.

4 Select "QUIT" using the [FNC] key to press the [ENT/FAST] key.

This completes memory initialization.

7.9 Manual operation from the Front Panel in an Emergency

1 When operating manually from the front panel, be sure to set the normal display mode.

2 In the normal display mode, CV, SV, or MV is displayed on the numeric item indicator.

3 If the normal display mode is not set, pressing [CLR/SEL] sets the normal display mode form any mode.

4 Loop operations displayed on the loop indicator can be carried out manually. The select loop operation can be changed by pressing [LOOP].

In the case of 2-loop display, the operation of the loop displayed on the numeric indicator can be carried out.

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7.10 Basic Function Registration

When the basic functions are set, all parameters and statuses are set to the initial values (with the MV value held).

Initialization applies to the select spaces only.

It has no effects on any other spaces.

Setting procedure

1 Set the FUNC1 and FUNC2 basic functions.

2 Set the SW parameters in accordance with the functions.

3 Set/change each control parameter.

4 If the control content is determined, transfer the data to the EEPROM using SAVE.

Data setting has now been terminated. To change to another function, carry out setting again from step 1.

If the parameter have been changed, SAVE enables a long-period backup.

7.11 Error Code During Operation

Error codes and their meanings are as follows:

Table 7.2 Error Code List

Error Code	Meaning	Description
1	Data range error	Data range is out of range.
7	Memory card protect error	Protect switch of memory card is on, or memory card is not installed.
8	Memory card data error	DL file on memory card is faulty.
9	Memory card write error	Data cannot be written onto memory card because it is ROM card, etc. or too high a #i.e. more than 4 for 32 kB RAM card 16 for 128 kB RAM card

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7.12 Diagnostic Function

The basic diagnostic function of the process loop controller are as follows:

Table 7.3 Diagnostic Function List

Check item	Check method	Check timing	Measure	Display
ROM check	Checksum	At inz	Processing stop	HALT lights
RAM check	R/W check	At inz	Processing stop	HALT lights
EEPROM check	Checksum	At inz	Processing stop	HALT lights
ADC error	Reference data check	Processing period	Processing stop	HALT lights
Sensor check	Reference data check	Processing period	PVI on	
MV read back	Reference data check	Processing period	Control stop	HALT lights

7.13 Pulse Input Option

Input pulse frequency is displayed in percentage at PVC1 where pulse input is used as analog input option.

When pulse input is used as a accumulation, use the pulse counter module (PSS).
(for only programmable type)

In the case where more than 65535 pulses are input in one process cycle, note that pulse input cannot be used.

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8. Self Tuning (AdTune: Advanced Self-Tuning)

AdTune is the self-tuning function of closed loop control. AdTune is based on the two-degree-of-freedom PID control that optimize both the set point value tracking and disturbance suppression.

8.1 Self-Tuning and its Characteristics

The configuration of AdTune are shown in figure 8.1. AdTune is a versatile self-tuning system suitable for identification of the target process and for automatic design of control parameters and constants. In addition, since AdTune employs highly advanced statistical techniques for identification of the process, it enables stable tuning even in the presence of noise and disturbances.

Using the advanced features of AdTune, the optimized controllers become much more versatile compared to the conventional self tuning controllers.

Fig. 8.2 shows the waveforms of AdTune in the presence of noise.

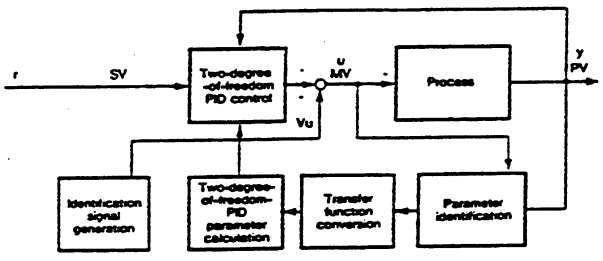


Figure 8.1 Configuration of AdTune

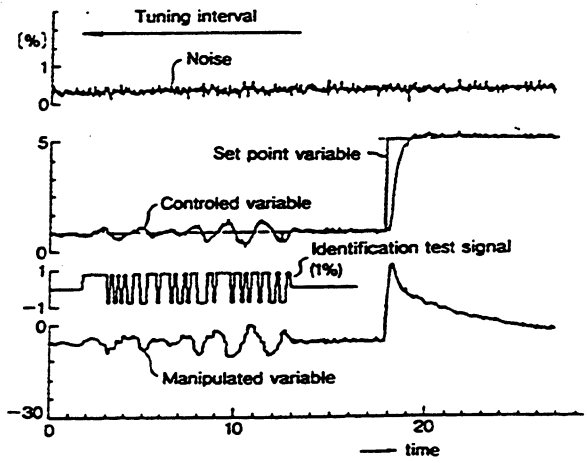


Figure 8.2 An Example of an Application of the Two-degree-of-Freedom PID Self-tuning Method

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8.2 Two Degrees of Freedom PID Control Function

In order to achieve efficient plant operation, the requirements for each PID controller of the control system have increased not only to provide disturbance suppression for a fixed value control, but also to provide set point value tracking functions. However, in the conventional PID control systems, the control constants for an optimized set point value tracking and the control constants for an optimized disturbance suppression do not necessarily coincide. Therefore, these systems can not parameter adjust control parameters to satisfy both of these requirements simultaneously. The control system which optimizes both of these characteristics independently is called a two degrees of freedom control system. Figure 8.3 shows the block diagram of the two degrees of freedom PID control method. First, the PID control parameters Kp, TI and TD are adjusted to optimize the disturbance suppression. The parameter α of the SV filter is then adjusted to optimize the set point value tracking in order to achieve the desirable characteristics for both set point value tracking and disturbance suppression.
To tune exactly, it is necessary that cycle time (CTS) is much shorter than response time of proces.

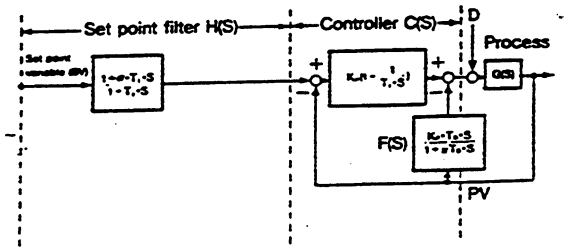


Figure 8.3 Block Diagram of Two Degrees of Freedom PID Control

8.3 AdTune Functions

AdTune has higher level tuning functions created by adding several advanced features to the basic tuning functions. These features can be used selectively when required. Therefore, when selecting the functions of the process loop controller, if the default values of the loader are not changed, these additional functions do not activate.

TA, SI, PF, and control constants can be predetermined with the setup mode function, by using AdS# in the ADTUN menu from the front panel. (See section 3)

To execute setup, set 'AdS#-ST to on' after changing the operation mode to M mode. Setting 'AdS#-ST to off' discontinues this tuning mode.

The basic and additional functions of AdTune are described below.

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8.3.1 Basic Functions of Manual Startup (Related Parameters: TA, SI, AdS)

This is the most basic function of AdTune and it provides satisfactory optimization for most processes. In order to implement this function, the two parameters described below must be set beforehand.

(1) Amplitude of the identification test signal (TA)
The self tuning function starts from the obtaining the information about the characteristics of the process (process identification). For this purpose, a weak signal is added to the manipulated variable (MV) output and the fluctuations of the measured process variable (CV) resulting from this signal are sampled.

Parameter TA specifies the amplitude of this test signal. The maximum amplitude of the test signal should be employed in order to achieve stable tuning. However, there is an allowable range of variation in the amplitude of the process variable during the process operation.

Therefore, the maximum amplitude of the test signal should be selected within the allowable range of the process variable (CV) variations. However, the amplitude of the test signal need not be increased further, if the variations of the process variable (CV) due to the test signal can be clearly observed.

(2) Sampling Period (SI)
When the self tuning function is started, the CV (process variable) input signal and the manipulated variable (MV) output signal are sampled at the specified sampling period and the characteristics of the process are determined from this data. If a sampling period which corresponds to the response speed of the process control system is selected, the process characteristics can be accurately determined.

The sampling period (SI) should be selected to satisfy the following relationship (Tc is the time constant.)

$$(1/10)\times Tc < SI < (1/2)\times Tc$$

It is clear from the above relationship that an accurate value of SI is not required.

The process time constant is determined from figure 8.4 as described below.

In case of a process including time delay and dead time-Tc is obtained from the open loop step response. In case of an static process-Tc is obtained from the closed loop step response after performing temporary tuning manually.

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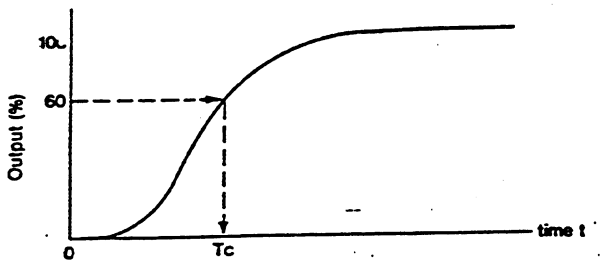


Figure 8.4 Open Loop Step Response of the Process Control System

These are obtained automatically by the setup function.

8.3.2 ON/OFF of Pre-Filtering (Related Parameter: PF)

When the CV input signals contain a lot of high frequency noise coming from the sensors, if the raw CV input signal is used as the data, the accuracy of determining the process characteristics decreases. In order to overcome this problem, a pre-filter is provided in AdTune for suppressing the high frequency noise. In case of signals as shown in figure 8.5(a), use of the pre-filter is not required. However, the pre-filter should be used in case of signals as shown in Figure 8.5(b).

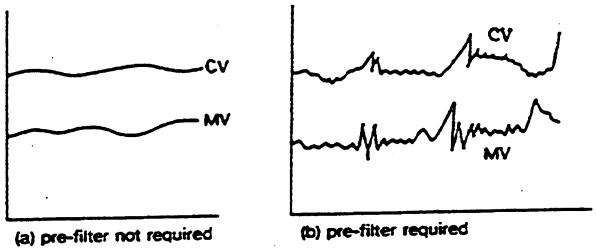


Figure 8.5 Control Systems with and without High Frequency Noise

Note that the frequency of the noise should be sufficiently higher than the response speed of the process.

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8.3.3 Selecting the PI/PID Action (Related parameter: DAT)

In many cases, the control response may be faster for PID action than for PI action (or I-P action). However, if the D (derivative) action is emphasized, the controller becomes sensitive to high frequency noise, contained in the CV input signal, coming from the sensors, and this may produce undesirable effects.

The D action should be specified for signals with low noise level like temperature control.

The D action is selected by specifying the DAT parameter.

8.3.4 Tuning Limiter (Related Parameters: RLMT, ILM, DLMT)

This function compares the proportional gain (TKP), reset time (TTI) and derivative time (TTD) obtained by auto tuning with the current values of proportional gain (KP), reset time (TI) and derivative time (TD) respectively and automatically limits these new values. This function is set by the parameters PLMT, ILMT, and DLMT. The parameters are provided as multiples of the control constants currently used and the limit check described below is performed.

```
TKP =< PLMTxKP(PLMT>1)
TTI =< ILMTxTI(ILMT<1)
TTD =< DLMTxTD(DLMT>1)
```

If the results calculated by auto tuning exceed any of these limit values, all the results of calculation are considered invalid and the error information appears on the display of the controller.

8.3.5 Specification and Modification of the Response Waveform (Related Parameter: MDL)

The AdTune employs model matching method in frequency domain for determining the control constants. This method determines the control constants in a way that the process response characteristics come as close as possible to those of a reference model. Therefore, this method enables the response parameters of the control system (for example the overshooting or the damping ratio) to be specified. AdTune uses the four standard models shown in Figure 8.6 as the reference models, and reference model can be selected by specifying the MDL parameter.

The control stability improves for models number 4, 3, 2 and 1 in that order. Therefore, it is recommended to select reference mode No. 4 first and then switch to model number 3, 2, or 1 in that order if required.
It is possible to change the model number after performing the self tuning process once. In this case, the control parameters are calculated and set again for an already identified process model and it is possible to modify the response characteristics.

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If the controller cannot design by the specifying model, it increases model by one and redesign is executed.

Note that recalculation of the control parameters is not performed if the previous auto-tuning process terminated abnormally or if the next tuning process has already been started.

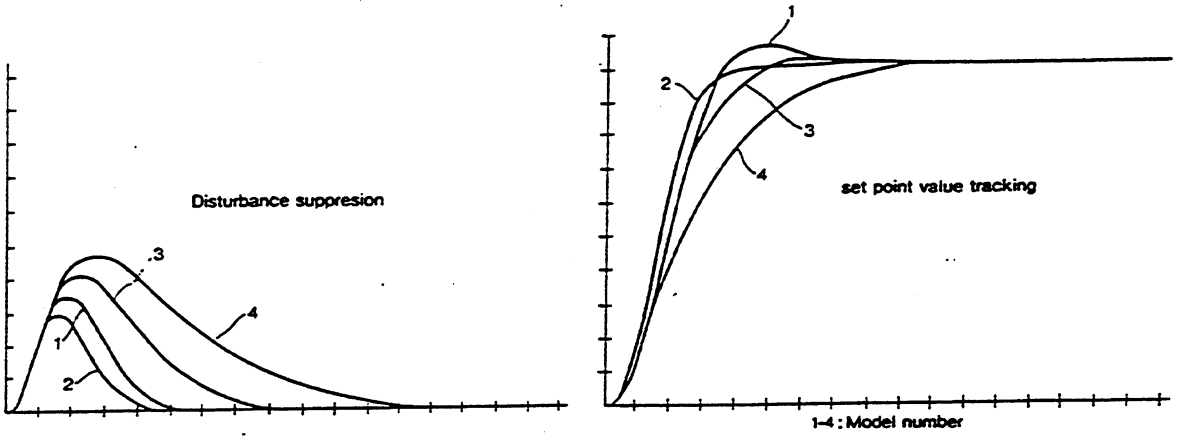


Figure 8.6 Closed Loop Step Response for Various Reference Models.

8.3.6 Supervisor function

Supervisor function watches the deviation (CV-PV). Supervisor function judges abnormal if the deviation exceeds the limits specified by the EB,EI and EN parameters. As shown in Figure 8.7, if the total time for which the value of CV is outside the limits (SV+EB) and (SV-EB) over a error limit time EN in a period of error check time EI, Supervisor function judges abnormal.

EI: Deviation base time (seconds)
EB: Deviation limit (%)
EN: Error time limit (seconds) (check time)

Note that EI and EN are multiples of the processing cycle.

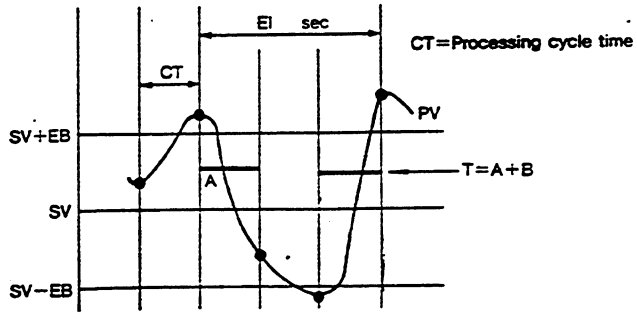


Figure 8.7 Self tuning Triggered by Deviation Limit

Turning SPS on to activates the supervisor function. If the supervisor concludes that the control system is unsteady, SPC becomes "bad response". Then if SPC is set to "gain down", control constant Kp is reduced. If the control system is judged to be in illegal response status, SPC becomes "unstable". Then if SPC is set to "tuning request", the basic tuning is activated.

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8.3.7 Gain Scheduling Function by Manual Start (Related Parameters: GX0-GX9,GT10-GT19, GTD0-GTD9, Gα0-Gα9)

The gain scheduling function is used under conditions described in the previous section. In order to use this function, a level signal (signal used for the x-axis of the gain schedule table) is required for automatic selection of a set of control parameters which has been prepared beforehand.

When the gain scheduling function is set to ON, the values already set in the gain schedule table are used to perform the actual control.

Therefore, there is no time delay with the gain scheduling function since the control constants are selected after tracking the level signal. Obviously, the selection of an appropriate signal as the level signal is very important and should be considered very carefully.

The following signals can be used as the level signal.

(1) The disturbance signal or the load signal which is detected.
(2) CV value
(3) SV value
(4) MV value
(5) The deviation or the absolute value of the deviation.

If disturbances and load signals are stable, using the level signal (item No. 1) is most suitable.

If the load variations are not very frequent or when the load variations are smooth, the MV value (item No. 4) can be used, even if the load signal cannot be detected.

The level signals in No. 2 and 3 (CV and SV values) can normally be used only when the level signal is smooth and a large deviation does not occur.

In case of large deviation, the signal in item No. 5 should be used for performing gain scheduling instead of the signals in item No. 2 or 3.

The structure of the gain scheduling function is shown in Figure 8.8. This figure gives an example of the scheduling table of the proportional gain.

The tables corresponding to reset time, derivative time, and two-degree-of-freedom parameters also have a similar structure. Note that the level signal (x-axis signal) is the same for all types of scheduling tables.

The x-axis can be divided into intervals freely. The number of divisions can also be arbitrarily selected from 1 to 10.

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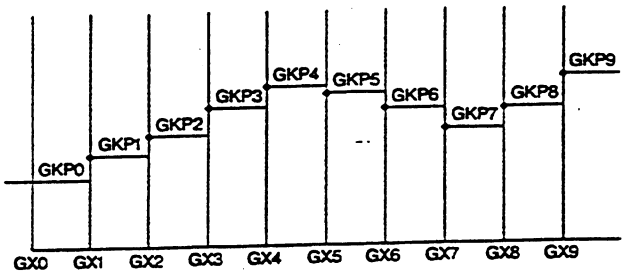


Figure 8.8 Proportional Gain Scheduling Table

The gain scheduling table can be created using the following two methods.

(1) Perform a manual tuning for each division of the level signal and set each result in the table manually.

(2) Perform an auto tuning for each division of the level signal and set up the table automatically.

If the entire table cannot be completed using the second method, it is also possible to manually input, by using the first method, an interpolated value based upon the values of the preceding and the following divisions.

Another effective use of the gain scheduling function is its application to multi-product manufacturing processes.

Up to 10 sets of control parameters are stored in a table and later selected for use. In this case, a level signal depending upon the specified type, can be entered from the controller or input externally (analog input to the controller, contact point input and transmission input). When the level signal is to be input as a code, the input code is converted internally to a continuous analog signal and used as the level signal.

The control constants of the table are set beforehand by manual tuning or auto tuning as described previously.

The gain scheduling function operates when all of the following conditions are satisfied.

(1) The MAT function block is being used.
(2) The GSD function block is registered.
(3) The U2 input value of the GSD function block is '1'.
(4) The self-tuning status (AdS) is in the module mode (Md).

When the gain scheduling function is not to be set automatically (ON or OFF), a DP parameter is assigned to the U2 input of the GSD module at the time of system configuration and its initial value is set to "0". This specifies that operation of this function is not to be automatically initiated during actual use.

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8.3.8 Automatic ON/OFF of the Full Tuning Functions

Another method of automatically starting the full tuning is to set ON the H1 input of the function module MAT.

Self tuning is repeatedly triggered while the H1 input value is a "1".

This function is used for the following applications.

(1) For periodic re-tuning using the internal timer of the controller.

(2) For performing an automatic re-tuning when a change in the operational environments is detected internally by the controller.

(3) For initiating an self-tuning operation resulting from the monitoring of the operational environments of the process by an higher level computer and checking the control results.

(4) For initiating the self-tuning by an input signal at the external contact points.

8.3.9 Automatic ON/OFF of Gain Scheduling Function

The gain scheduling function can be started or stopped by switching ON or OFF the U2 input of the function module GSD.

This function can be used for the following applications.

(1) For setting (ON or OFF) the gain scheduling function by a signal at the external contacts.

(2) For setting (On or OFF) the gain scheduling function by an higher-level computer.

8.4 Operation of AdTune

The procedure, sequence and the points to consider when using AdTune are described below.
AdTune has several supplementary functions in addition to the basic functions. It is important to initially start with the basic functions and then add the supplementary functions one by one when needed. Therefore, it is recommended that the default values of the loader should not be modified when configuring the system. (The default values of the loader are designed not to start the supplementary functions.)

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8.4.1 Using the Basic Functions in Manual Start

This function is the most basic function and should always be used in the beginning.

Before using the supplementary functions, the basic operation should be confirmed following the procedure described in this section and then adding the new functions one by one.

As a result of the sophistication of the AdTune functions, most of the processes can be satisfactorily handled by using only the basic functions. The procedure for using these functions is described below.

(1) Set the process control to the manual operation mode (M mode) and confirm normal operation.
In order to achieve normal tuning, the changes in the manipulated variable (MV) should be properly reflected in the process variable (CV) as well. Confirm the following points.

1) Confirm that a fixed value is not output to MV because of the MVF block or due to the configuration of other function blocks.

2) Confirm that even when the test signal is added to MV, the value of MV does not exceed the upper and lower limits (MH,ML).

3) Confirm that the actuator, the target process and the sensors are functioning properly and within their dynamic range (i.e. the actuator is operating between its upper and lower limits, the process is operating within its specified range, and the sensor within its measurement range.)

(2) Set the values of TA, and SI as described in section 8.3.1. Otherwise, setting is automatically done by the setup function.

(3) AdTune operates in the A mode. Therefore, if setup has already been performed, the same values of the parameters KP, TI, and TD are used. However, in order to stabilize the computations for process identification during the self-tuning operation, the proportional gain (KP) is set to 0.7 and the derivative time is set to 0.

(4) The parameter KP must be set to 0 if self tuning was started when the parameters KP, TI, and TD were still unknown. If this is not done, oscillations may occur when Mode A is set for starting the self-tuning and this may lead to a dangerous situations to develop in the plant.

When self-tuning is started after setting KP=0, the feed-back control is disabled during self-tuning, and subsequently after the completion of the self-tuning process, the feed-back control remains disabled until the SET parameter is set to ON. This situation is similar to the M mode. Therefore, it is necessary to monitor the process very carefully during self-tuning. The setup tuning function should be used.
Especially in processes such as the astatic level control systems, achieving a stable state is difficult. Therefore, in such cases, it is recommended to use the method described in step (4) after performing a rough manual tuning.

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(5) After performing the procedure described in steps (1) to (4), manually the process value (CV) to a level for which tuning is to be performed, and wait until the value of CV stabilizes sufficiently.

(6) Manipulate the set point value (SV) to match it with the value of CV.

(7) Set the control mode to A and confirm that the values of CV and MV have stabilized.

(8) The ATC lamp on the front panel of the controller slowly blinks during the execution of self-tuning.

After starting self-tuning, if the range of the variation of the process variable CV is too small compared with the allowable range for CV variations, increase the amplitude of the identification test signal even during the auto-tuning process.

Conversely, if the amplitude of the test signal is more than the range of the variation of the analog input signal CV, either immediately decrease the amplitude of the identification test signal or terminate the self-tuning process by switching to M mode.

If the amplitude of the identification test signal is too large, the MV signal may cross the upper or lower limits and may get strongly affected by the non-linear characteristics, (such as saturation), of the final control element (e.g. valves, pumps.) This may have an adverse effect on process identification.

The progress of self-tuning is displayed in the parameter AdS as described below.

SAM: sampling
idn: Identifying (Computing the process model)
dES: Calculating the P,I,D and α
Fin: Normal completion

If further execution of self-tuning becomes impossible during the execution, the ATC lamp on front panel lights and displays the error as described below.

E12: The results of the calculation of the control parameters exceeded the limit values (P.LMT, I.LMT, D.LMT).
E13: An error was detected during the execution of self-tuning.
E10: Control was disabled by self-check. (sensor error, error in ADC accuracy.)
E11: The value of MV got stuck in a fixed value during the execution of self-tuning due to MVF block.

When these error occur, during sampling, the ATC light goes ON. It turns off by confirmation of AdS.

In order to terminate the self-tuning process, either set AdS to OFF, or set the control mode to M.

(9) When self-tuning has been completed, the front ATC stops blinking.

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8.4.2 Adding of Pre-Filtering

If the tuning error ("E13") occurs during the execution of the basic self-tuning functions, set the PF to "ON". If you know with certainty that the noise does not exist, a more accurate self-tuning is possible if the pre-filtering function is not set to "ON". (See 3.3.5)

8.4.3 Selecting PI/PID Action

Select the desired operation by following the procedure in section 8.3.3.

8.4.4 Setting the Tuning Limiter

The tuning limiter is used when the control parameters cannot be accurately calculated by self-tuning due to the presence of noise or disturbances.
However, note that if this function is fully used, the basic function of self-tuning function may not be utilized. When automatic activation of self-tuning is used in order to automatically respond to the changes in the control system, or while preforming self-tuning in order to create the gain scheduling table, it is required to set values that will allow changes in the expected control parameters.

8.4.5 Specification and Modification of the Response Waveform

Specify the response waveform by following the procedure in section 8.3.5.

Select waveform No. 4 for processes in which overshooting is not allowed. For processes in which overshooting is allowed but that require an extremely fast response, select waveform No. 1.

The condition of the control environment immediately after changing the response waveform should be carefully checked.

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PART 2 PROGRAMMING

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9. Software Operation Principle

9.1 General

The process loop controller has a number of functions, as well as those performed by analog adjuster or analog modules, and can tailor a desired control system by combining them.

Figure 9.1 shows a flow of processing functions by this process loop controller.

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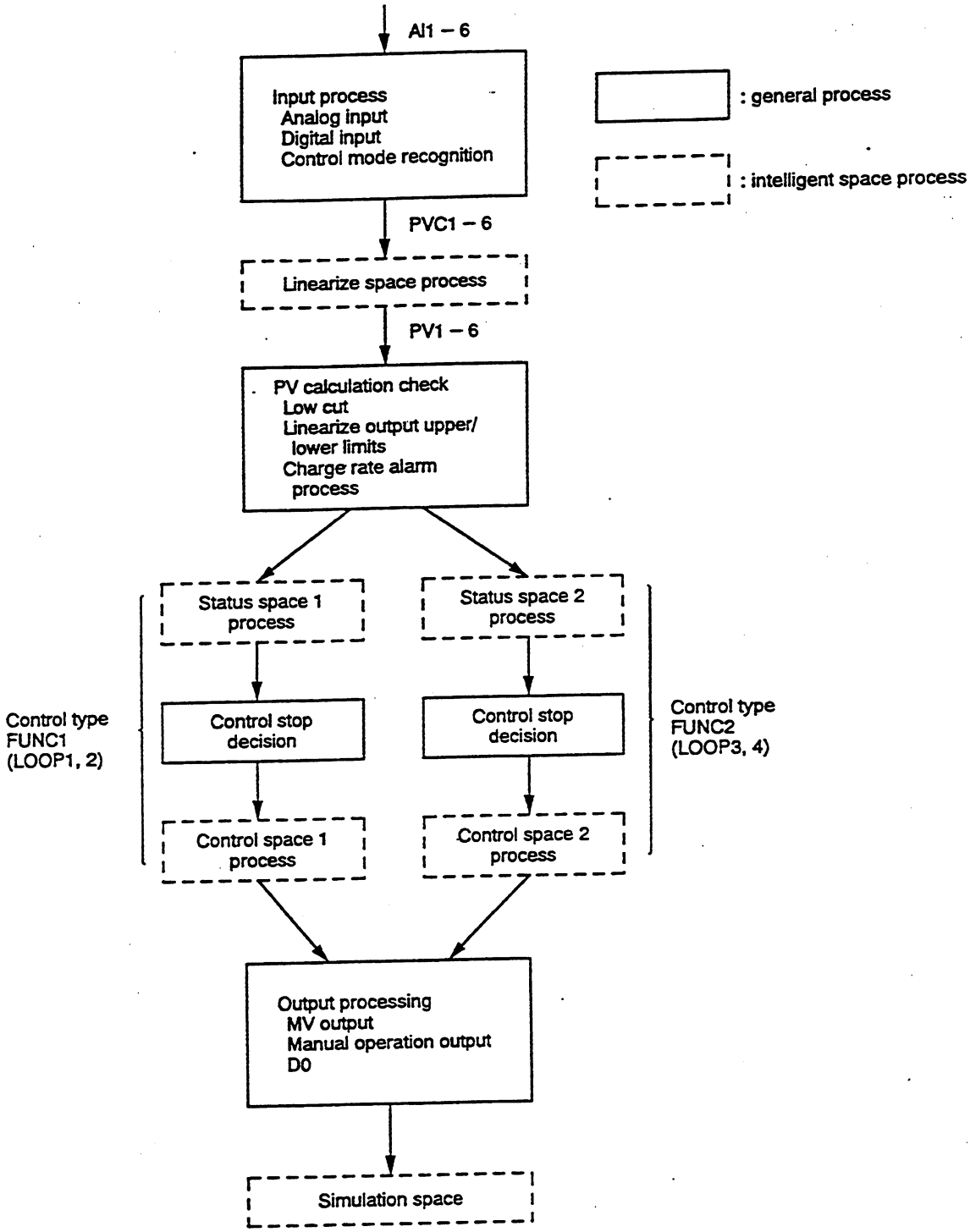


Figure 9.1 General Process Flow Chart

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It executes the enclosed parts with full lines or dotted lines from top to down at a constant period of time. The parts enclosed with full lines are executed at a certain period of time. Those with dotted lines can be added to the flow as necessary.

A part enclosed with a dotted line is called intelligence space. In this space, a total of 200 functional modules (explained later) can be contained, so that a remarkably flexible and powerful functions are realized.

The software of the process loop controller can:

Defines parameters in the system table, and
Assembles functional modules in an intelligent space.

This process loop controller is considered a two-loop controller having two points of operation output, from a viewpoint of hardware. Hence, the status space and the control space are divided in two lines.

Internal control calculation can use a maximum of 4 control loops (PID, etc.), including two independent cascade control loops.

These are called loop1, loop2, loop3, and loop4.

In the controller, operation output has four software ports. They are called MV1, MV2, MV3 and MV4. Operation output to be actually output outside uses two ports: MV1 and MV3, both fixed.

The following introduces the software of process loop controllers.

9.2 Intelligent Space

9.2.1 Concept of intelligent space

The process loop controller has 6 kinds of intelligent space, in each of which necessary functions for control are defined to configure a system at your disposal.

One intelligent space, as shown in Figure 9.2, has more than one output unique to the space. Hereafter, an intelligent space is represented by enclosing with dotted lines.

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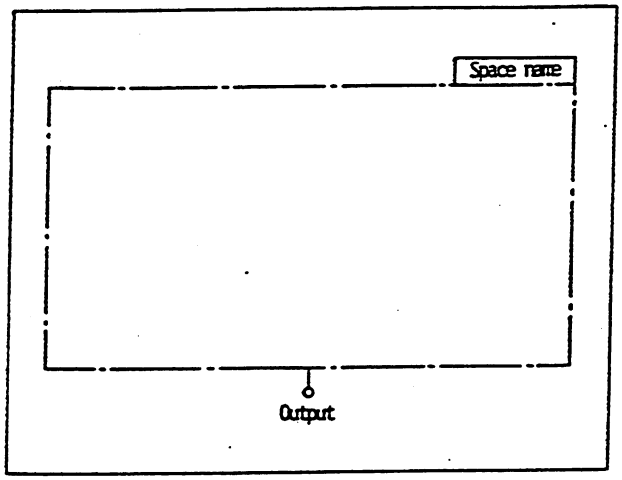


Figure 9.2 Intelligent Space

9.2.2 Function specification of intelligent space

Inside the process loop controller, function modules are provided to perform addition, decision, PID calculation, etc. (function modules are described in detail in Section 10)

In an intelligent space, calculation and control can be done by freely combining these function modules.

Function modules in the space are numbered, in the order of processing, from 1 continuously, and called block 1, block 2, and so on. Instruction to the process loop controller concerning block data input and parameters can be done by two methods: One is to write data to EEPROM through data transmission from a dedicated program loader. The other is to write data to EEPROM by reading data from a memory card.

Parameter data among those written in EEPROM is also written in RAM.

The front panel or hand-held terminal allows only change to parameters in RAM.

This data in memory contains all the necessary information required for control on each loop. The processor in the process loop controller decodes and executes the control. For this reason, changing the contents of EEPROM or RAM only can fit the controller to many kinds of control systems.

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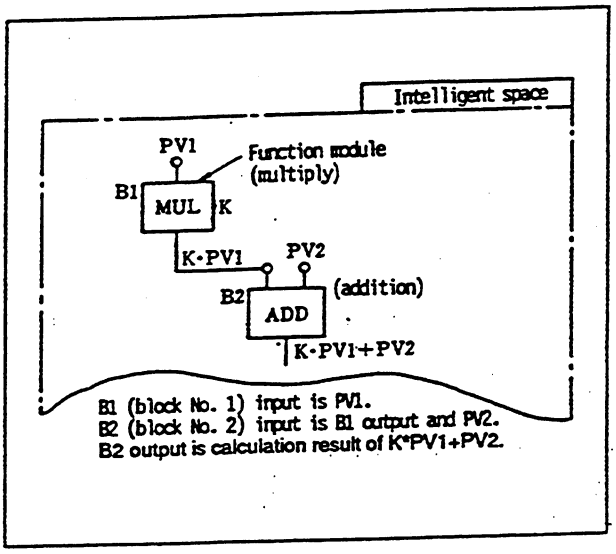
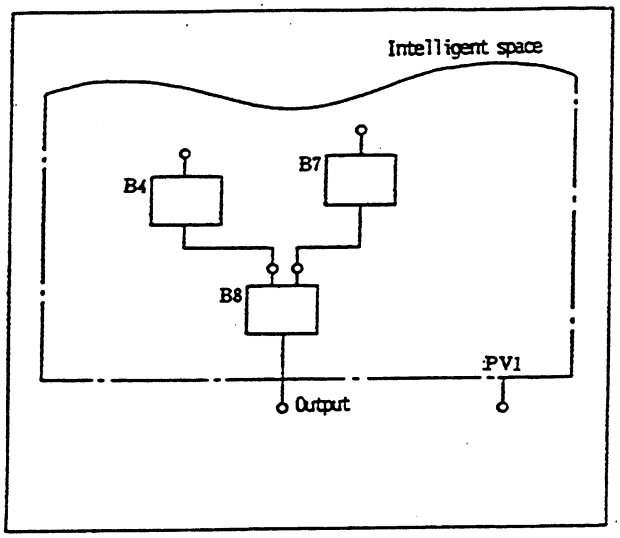


Figure 9.3 Block Display Example in Intelligent Space

9.2.3 Output of intelligent space

For an intelligent space, the space output must be specified at the end. In general space output is equivalent to block output; variables such as PV1 or PV2 can be used for definition.



The above example shows that B8 (block No. 8) output an PV1 are space output.

Figure 9.4 Output of Intelligent Space

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9.2.4 Kinds of intelligent space

There are four kinds of intelligent space, each of which has a name relevant to its output. This serves to arrange them by purpose and facilitate system grade-up. Table 9.1 shows its kinds and purposes. (Abbreviations are explained in Table 9.2)

Table 9.1 Kinds of Intelligent Space

No.	Space name	Purpose of space
1	Linearization space	Linearizes analog input (PVC1 - PVC6).
2	Status space (1,2)	Makes control, decides halt (self-diagnosis), defines status volume (Si) and data (Yi), which are 0 or 1 commonly usable among intelligent spaces.
3	Control space (1,2)	Determines algorithm taking into account control conditions, procedure, and performs feedforward and valve compensation.
4	Simulation space	Manipulates Monitors PVC activity to generate MV outputs for debugging.

The following describes an outline of intelligent space. See Section 10 for details of function modules used as examples.

(1) Linearization space

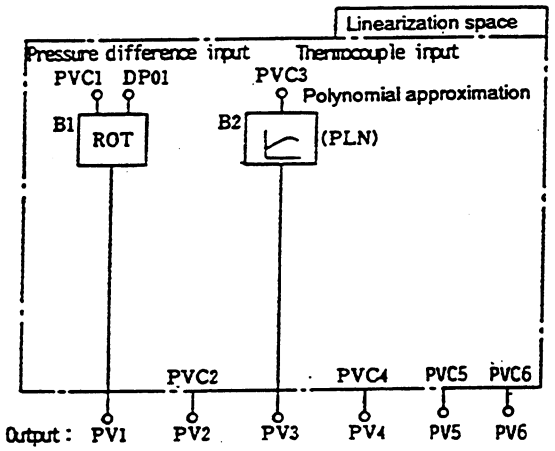


Figure 9.5 Example of Linearization Space

In this example, two analog (PVC1, PVC3) input are corrected because of their non-linear input. Other four input of (PVC2 - 6) are linear input.
Before entering linearization space, the input value is automatically converted to percentage. PVC1 - 6 are represented in 0 - 100 percent after A/D conversion.

Also shown in this example is that this % value is subject to extraction calculation or polynomial approximation, set as PV1 or PV3. PVC2 and PVC4 are set PV2 and PV4 without operation.

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(2) Status space (1,2)

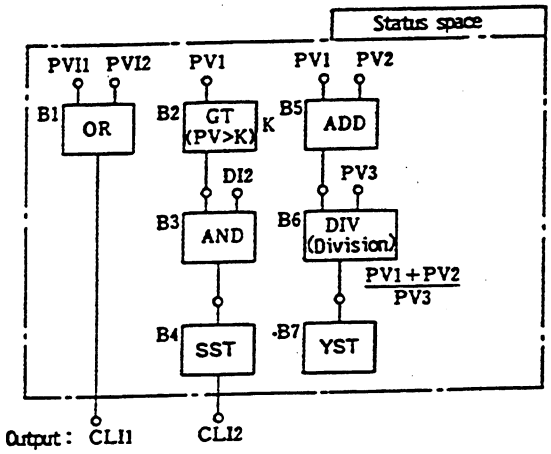


Figure 9.6 Example of Status Space

In this example if either of PV1 or PV2 input is abnormal, control is halted.

Status volume (S01) shows either 0 or 1. In this case, the PV value is defined as greater than a certain value, and the result of an AND operation with digital input (DI) is defined as S1. (For Si, a total of 16 Si can be defined and used in other spaces than this status space.)

Likewise, data volume (Y01) is defined as a result of calculation (PV1+PV2)/PV3, which can be used for other spaces. (for Yi, a total of 16 Yi can be defined and used in other spaces than this status space.)

Definition module of S01 - S16 and Y01 - Y16 are used in principle within a status space. This allows persons other than the planner of the system to understand. However, they may be used in other spaces where the necessary data is defined.

Output of status space 2 will be CLI3 and CLI4.

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(3) Control space (1,2)

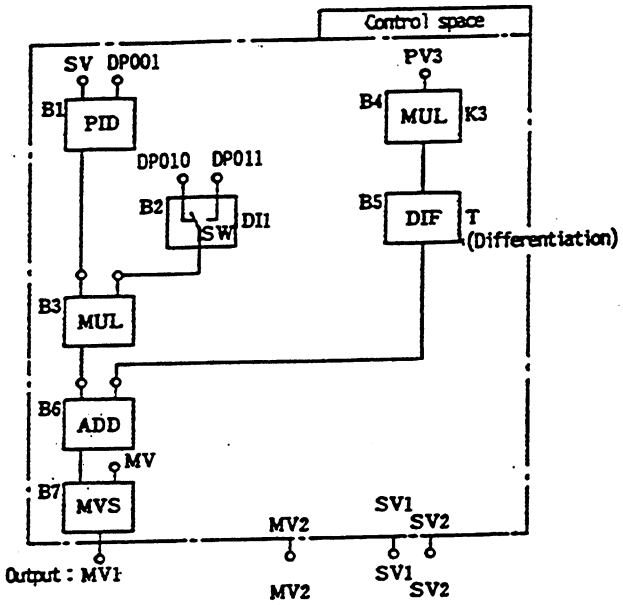


Figure 9.7 Example of Control Space

Feed forward is done in which gain of PID calculation is changed with digital input as DI1, and its output is added with auxiliary input (PV3) value.

DP010 and DP011 of B2 input are variable parameters which can be set.

MVS module calculates MVn=MVn-1 + delta MV.

Outputs from control space 2 are MV3, MV4, SV3 and SV4.

(4) Simulation space

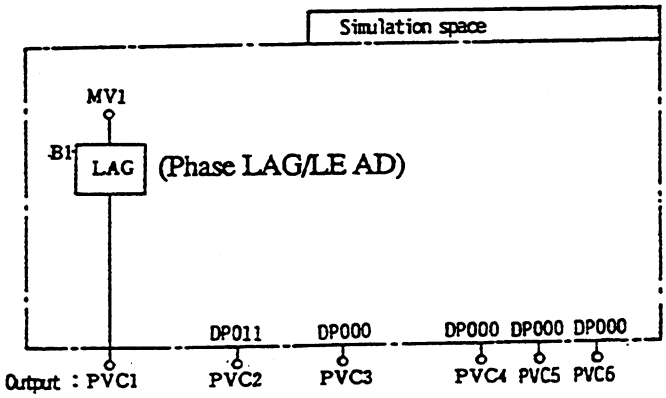


Figure 9.8 Example of Simulation Space

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When debugging, only when simulation request is made from the hand-held terminal the simulation space is executed. At this point, the MV to be output outside is kept constant and HOLD display blinks.

B1 is de primary delay element used to generate PVC1.

PVC2 is defined by variable parameter (DP011).

PVC3, 4, 5, 6, which are not connected with block output or variables, have an initial value of 0.

Even during simulation, DO and alarm display are output as requested.

The variable MV in the simulation space is different from the operation output MV which is actually output to the operation console.

9.2.5 Kinds of intelligent space output

Table 9.2 shows output in each space. The initial value of space output means the contents defined as the initial status. When output is not defined in the space, each output is made as requested.

Table 9.2 Kinds of Each Space Output

No.	Space name	Contents	Space output	Space output initial value	
1	Linearize space (LNZ space)	PV definition	PV1 to PV6	PVC1 to PVC6	Input is all linear.
2	Status space 1,2 (STA space)	Control inactive flag definition	CLI1 to CLI4	PVI1 to PVI4	Inactive flag of relevant control variable
3	Control space 1,2 (CTL space)	Control algorithm definition	SV1 to SV4 MV1 to MV4	SV1 to SV4 MV1 to MV4	Output is same as input
4	Simulation space (SIM space)	Simulation PVC definition	PVC1 to PVC6	DP000	Simulation PVC not available

SV of each control loop is set and defined in the module when control calculation module (PID, PI2,PIS,P,FPI,FP2) is used.

When the SV of an output loop is defined using a module other than control calculation modules, it is required to define it as a control space output.

When setting and defining an SV using control calculation modules, connect the control space output SV with the same name SV.

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9.3 Program Item

The system tables include the following:

- Controller Set Up Data
- Analog Input Parameter
- External Variables
- DP Parameter Table
- Polynomial Line Table
- Switches
- Loop Parameter
- Self Tune Data
- Gain Schedule
- Block Table
- Space Output
- User Scale
- User Customized Key *«NEW»*

The following shows contents of each table.

9.3.1 Controller Set Up Data

Defines data for identifying each controller.

Table 9.3 Controller Set Up Data

No.	Item	Description
01	SYSTEM NUMBER	Code to identify system
02	USER COMMENT	Name to identify system
03	ALARM CONFIRM	Alarm auto-recovery/manual confirmation
04	CYCLE TIME	Controller process period (CTS) (not control period)
05	PASSWORD	Password (integer)
06	SECURITY CODE	Security code (integer)
07	LOCK FLAG	Whether to prohibit changing parameters or not
08	BAR MODE	Bar graph display mode
09	BAR	Bar graph display loop
10	OPERATION MD	Originally mode / user customized mode «EC321»
11	RS232C	RS232C setting
12	RS485	RS485 setting
13	Option board	RTD, TC/mv, Pulse input module
14	DO	DO init status
15	Mode priority	Mode priority of M mode request from the front panel

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9.3.2 Analog input parameter

Defines presence or absence of analog input, meter range, etc.

Table 9.4 Analog Input Parameter

No.	Item	Description
01	TAG NAME	Tag name
02	ENG. UNIT	Engineering unit
03	INPUT	Input installation specification
04	H-SC	Upper limit sensor check on/off
05	L-SC	Lower limit sensor check on/off
06	PV POINT	PV decimal point specification
07	RH[EU]	Meter range upper limit (engineering unit)
08	RL[EU]	Meter range lower limit (engineering unit)
09	PH[EU]	PV upper limit (engineering unit)
10	PL[EU]	PV Lower limit (engineering unit)
11	PVBND[%]	PV non-sensitivity (%)
12	ΔPVLMT[%]	ΔPV limit (%)
13	ΔPVBND[%]	ΔPV non-sensitivity (%)
14	FT	Digital filter coefficient
15	LC[%]	Low cut (%)

9.3.3 External variables table

Parameters shown in Table 9.5 should be specified when ECBUS or ECBUS/H is used. When MCBUS is used, see MCBUS interface manual 6F8A0670. *«NEW»*

Table 9.5 External Variables Table

No.	Item	Description
01	Comm.Data Type	Text type of transmission raw data
02	Max St. Addr.	Maximum station address
03	Vnn Address	Address of the source station of external variable
04	Vnn Name	Parameter name of the source of external variable
05	Vnn Set Flag	Select flag of holding/initial value when V error
06	Vnn Init Val	Initial value of external variable

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When the other controllers use Y parameter of the controller, select "with Y parameters" to Com.Data Type. When not use, select "without Y parameters". Communication speed is higher when select "without Y parameters" than when select "with Y parameters".
To Max St. Addr. set the maximum address of the stations which are connected to ECBUS except for the host computer. When the controller is host station, communication is done among the controllers of which address is 1 to this address. Assign a consecutive address from 1 to the maximum address to each controller or communication speed is lower.
Each controller has 32 external variables from V01 to V32. Each external variables has the address and the parameter name of source station. Table 9.6 shows the parameters which can be set Vnn name.
In the case of Vnn Set Flag = 0, the last good value is selected when communication error.In the case of Vnn Set Flag = 1, the initial value is selected when communication error.
The initial value is selected, until communication starts.

Table 9.6 Parameters table of Vnn name

Kind	Parameters
Alarm variables	CLE1-4, MVE1-4, CLI1-4, DVE1-4 PVD1-6, PVL1-6, PVH1-6, PVI1-6
Mode variables	M1-4, A1-4, C1-4
Control variables	SV1-4, MV1-4, PV1-6
I/O variables	DI1-4, DO1-6, DM1-6 «NEW» DI4, DO5,6, DOM5,6
General variables	S01-16, Y01-16
The other variables	CMP1-4, CL1-4, INPT1-6, SOF1-6
Variables of EX100	Wnnmm, WDnn (00<=nn<=31, 00<=mm<=15)

Wnnmm: Bit mm of register D1406+nn of EX100 is selected.
WDnn: Register D1406+nn of EX100 is selected.

9.3.4 DP parameter table

Defines variable parameters (DP parameter) used in a function module. DP000 - DP009 are basic constants defined in system and cannot be changed. DP010 - DP149 can be set or changed as necessary.

9.3.5 Polynomial line table

When using polynomial lines in an intelligent space, relevant data of the polynomial table is defined in this table.

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Table 9.7 Content of Polynomial Table

Item	Description
Table No. 1-6	Polynomial Line No.
X01-X11	Polynomial line data X coordinate (X01, X11)
Y01-Y011	Polynomial line data Y coordinate (Y01, Y11)

9.3.6 Switches

Specified switches as on or off.

9.3.7 Loop parameter

Parameters shown in Table 9.8 should be specified for each control loop. A process loop controller can have up to 4 control loops, but only 2 operation outputs. Later-described PID module and MVS module use the control parameters from relevant loop control tables for a loop No. specified.

Table 9.8 Loop Control Table

No.	Item	Description
01	TAG NAME	Tag name
02	CTL,PT	Control variable name PV1-PV6
03	C.MODE	C mode enable/disable
04	SV(A)	SV setting enable/disable in /A mode
05	ΔT	Control period (CLT=CTSXΔT)
06	SVT	SV tracking enable/disable
07	Kp	Proportional gain
08	Ti	Integral time (m)
09	Td	Differential time (m)
10	Gp	Gap (%)
11	Gg	Gain in gap (0-1)
12	RT	Proportion
13	BS	Bias
14	DV	Deviation limit (%)
15	DV BND	Deviation non-sensitivity (band)
16	MH	MV upper limit (%)
17	ML	MV lower limit (%)
18	ΔMV	ΔMV limit (%)

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No.	Item	Description
19	ALPHA	2-degree free PID parameter α value
20	BETA	2-degree free PID parameter β value
21	GAMMA	2-degree free PID parameter value
22	D/R	Direct/reverse specification for control action
23	VD	Valve operation specification (direct/reverse)
24	CSCALE	CV bar graph scale 1-20: divided/No. 21-28: user scale
25	SSCALE	SV bar graph scale 1-20: divided/No. 21-28: user scale
26	MSCALE	MV bar graph scale 1-20: divided/No. 21-28: user scale
27	FP	(Not used)
28	HT	(Not used)
29	BL	(Not used)
30	PB	(Not used)

* Loops which have operation output MV1 and MV3 are loop No. 1 and 3 only.

9.3.8 Self tuning data

Defines each parameter for self tuning data. See 8 for details.

Table 9.9 Self tuning data

No.	Item	Description
01	PA	Setup tuning signal amplitude (%) «NEW»
02	TA	Fixed signal amplitude (%)
03	SI	Sampling cycle (sec)
04	DAT	Differential term specification
05	MDL	Tuning reference model specification
06	SPS	Supervisor execution Specification «NEW»
07	EB	Supervisor deviation value (%)
08	EI	Supervisor base time (sec)
09	EN	Supervisor check time (sec)
10	PLMT	Tuning Kp limit coefficient
11	ILMT	Tuning Ti limit coefficient
12	DLMT	Tuning Td limit coefficient

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9.3.9 Gain schedule

Defines gain scheduling data. See 8.3.7 for details.

Table 9.10 Gain schedule

No.	Item	Description
01	GSET	Gain scheduling mode
02	GEXE	Gain scheduling execution
03	LEVEL1-9	Gain scheduling table

9.3.10 Block table

Defines block of each intelligent space. See 9.2 for details.

LNZ : Linearization space
STA 1 : No.1 status space
STA 2 : No.2 status space
CTL 1 : No.1 control space
CTL 2 : No.2 control space
SIM : Simulation space

9.3.11 Space output

Defines space output of each intelligent space. See 9.2.5 for details.

9.3.12 User scale

The controller has three LED for displays on its frontside to show CV, SV, MV values. Each of this bar displays has an additional LED display to show a scale of the for display.
(CSCALE/ SSCALE/ MSCALE = 21 to 28)

9.3.13 User customized key «NEW»

When user customized mode the controller displays only the defined parameters. This table can be defined up to 30 parameters. Refer to the key code table at the end of this manual for setting enable items.

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9.4 Routine Processing and Associated Items

Routine processing and the processing of intelligent spaces are performed alternately in the process loop controller. Intelligent space processing permits specific system functions to be performed by using function blocks; while routine processing is fixed and cannot be altered.

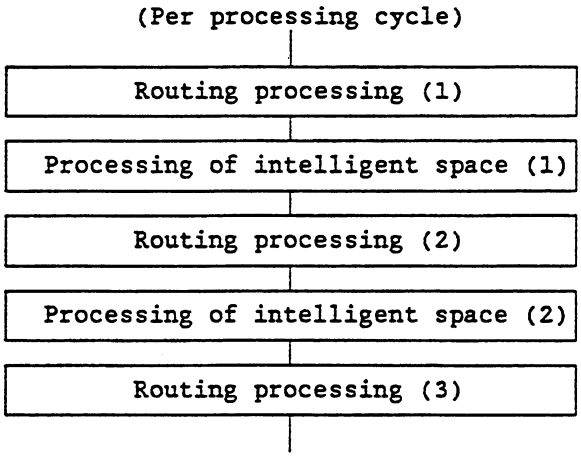


Figure 9.9 Process flow of two loop controller

The following describes the routine processing and associated items.

9.4.1 Processing cycle and control cycle

Routine processing and the processing of intelligent spaces are performed during each processing cycle specified at the time of controller configuration . The minimum processing cycle time varies with the blocks used in the space. This processing time is calculated by the loader when configuring the controller. When the set processing cycle is less than the minimum cycle time, the minimum cycle time is taken.
The processing cycle time (variable CTS) can be used as a block input. It is expressed in seconds, e.g., 0.2s.

(1) Processing in intelligent space

For each processing cycle, the function blocks in each intelligent space are processed in the order of block number. For example, if the processing cycle time is 500ms, and a totaling block is selected for use within an intelligent space, the input to the block is totaled every 500ms. In the PID and PI2 blocks, processing is carried out for each control cycle time (CLT). In the PIS block, it is carried out for each sampling cycle. (CLT = CTSXΔT.)

(2) Change detect

A change in DI, mode, or Si set by the SST block in a space causes the variable of D1CH,A1CH,S01CH, etc. to be set to 1 for one processing cycle.

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9.4.2 Processing of process input/output signal

(1) Analog input

For each of six PV inputs, the voltage of the connected and defined points is read, by the following equation:

$$C=25(V - 1)$$

These percentage values are then subjected to digital filtering, and are defined as PVC1 and PVC6.

The digital filtering equation is expressed as follows assuming that the current value is X the previous value is Xn-1, and the filtering coefficient is p:

$$Xn=(1-p)Xn + pXn-1 \quad (0 <= p < 1)$$

Where $p = 1/(1+CTS/Tf)$

CTS: processing cycle

Tf: Time constant of equivalent filter

Any input that needs conditioning should be processed in the Linearization space by using PVC1, PVC2, etc. The PV1 through PV6 defined in the linearization space output are subjected to low-cut, then defined as PV1 through PV6, and the upper/lower alarm check and rate of change alarm checks are performed on them.

The low-cut operation causes the system to ignore very low input signals, which if integrated would cause unreasonable results. Input signals below the specified value are all regarded as 0%. However, specification with a code of zero indicates no low-cut, allowing PV to be used over its entire range.

The alarm information for analog inputs, for example, can be used as PVH1, PVL1, etc. Whether the alarm function is to be confirmed or not, these flags are automatically reset when the alarm condition is corrected.

The sensor abnormality check is the function of safeguarding against the analog voltage input whose value is outside the range of 0.7 to 5.12V.
Whether the check is actually performed or not is determined during the controller configuration. The check result is indicated as PVI1, PVI2, etc. When the sensor is regarded as abnormal, PVC1, etc. are not updated, and remain at their last normal value.

(2) Digital input

Digital input is performed in very processing cycle and DI1 to DI3 will be recorded. By this, each module will use the latest information.

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(3) Digital output

The output of a DO module in an intelligent space is digitally output.
This DO output can be manually set using the front panel (See 3.3.2) on using the Hand-held Terminal.

(4) Analog output

Analog outputs are not provided unless requested by the AO block. During process loop controller operation, however, when block output from an intelligent space is temporality needed to be output to a recorder, analog output is possible by defining block output and variables to monitor from a front panel key (AO online specification). (See 3.3.4) An analog output requested through the front panel key takes priority over one requested by the AO block in the space.

If an AO block request or AO request from the front panel key is not provided AO#TP, the analog output can be adjusted by setting the digital value from the front panel key (See 3.3.2) or by using the Hand-held Terminal.

9.4.3 Set value, operation output and control mode

(1) Set value SV (%)
SV can be set as follows:
(i) Output of control space
(ii) Setting with push button on front panel
(iii) Digital value setting on front panel (engineering unit)
(iv) Through transmission line
SVs remain on a last-come-first-served basis.

In mode C, SV setting change cannot be done locally. In mode A, whether to allow SV setting of (ii) and (iii) can be defined at system configuration.

(2) Operation output MV (%)
In mode M, the MV output of a control space is neglected. The result of the manual operation is defined as MV.

A fixed value request is also output in mode M.

The conditions of console output of MV output in a control space are satisfied when the followings are met: (a) it is in control mode (C/A), (b) fixed value request is not made, (c) it is not in simulation mode, (d) there is no HALT display shown (e) MV output is made from a routine.

(3) C.A.M mode

Reading is done at every processing cycle. The latest status is set to flags named C, A, M for each Loop.

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9.4.4 Process alarm display (ALARM) and HALT display

(1) Process alarm display (ALARM display)
The alarm LED lights when any of the following alarm states occur.

(i) Sensor error of PV1 - PV6 defined as connected
(ii) Upper and lower limit error
(iii) Change rate error
(iv) Deviation error

When the ALM function block is used in an intelligent space, all these items are ignored, and the lighting of the alarm LED is dependent solely on the input state of the ALM block.

(2) HALT indication

Lighting of this lamp means that control is not being executed; that is, the operation of the MV is held. The held LED lights under one of the following conditions.

(i) MV readback error (the difference between output MV and MV readback is 5% or more)
(ii) ADC error (error in A/D conversion)
(iii) Control inactive: CLI1 - CLI4 (flags defined in a status space)

9.4.5 Operation from a host

(1) Computer/local indication

There are some cases where SV, parameters and MV are transmitted from a host to a process loop controller. In this case, when the computer flag (CMP) is set by a host, and the CMP indication LED is lighted.

All these indications are made effect by a host.

(2) CMP flag

A CMP flag is provided for each loop. This means that a host is involved in an intelligent space of the process loop controller.

Set/reset of CMP flag

Setting/resetting is done from a host. The PMS module parameter code in process loop controller also can set or reset.

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9.4.6 Data transmission

The process loop controller can communicate with a host computer and between the controllers. Figure 9.10 shows a basic configuration.

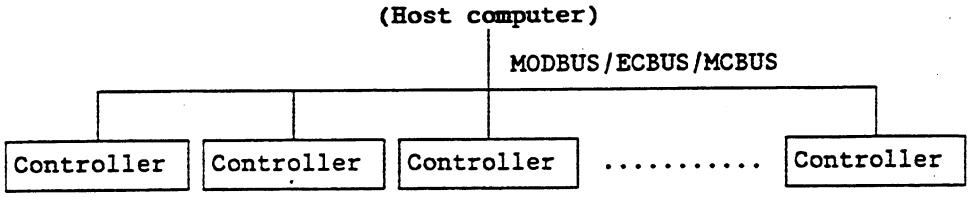


Figure 9.10 Basic transmission Configuration

Refer to each communication manual for detail

MODBUS,ECBUS	: 6F8A0663
ECBUS/H	: 6F8A0671 «NEW»
MCBUS	: 6F8A0670 «NEW»

9.4.7 Password and security code

(1) Password

The password can control reference to block configuration in intelligent space. It is defined in the down loading data. When a password is defined, to read space information is possible by matching the password by hand-held terminal operation.

(2) Security code

There are two security codes. The security code, like the set lock switch (FREE/LOCK key), can control access to setting changing various parameters from the keyboard or hand-held terminal. It is defined in the downloading data. When a security code is set, the operation is the same as the LOCK side, whether the set lock switch is set to FREE or LOCK, and setting and changing of parameters are limited. (A state in which limitation is applied is called "security mode is set".)

Each parameter has security level. Security level is defined in the downloading data. Table 9.10 shows the relation between security code and security level.

Table 9.10 Security

SECU.Code1	SECU.Code2	Security level			
		Free	1	2	Lock
Free	Free	Y	Y	Y	N
Free	Secu	Y	Y	N	Y
Secu	Secu	Y	N	N	N

Y : Setting enable
N : Setting disable (See 7.7)

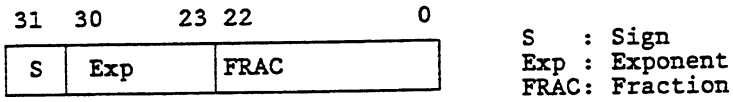
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When a security code is defined, data setting and changing is possible by matching the security code by hand-held terminal operation. (This is called to "reset the security code"). This time the set lock switch must be placed at the FREE side.

* The range of password and security code settings is Integers 0 to 9999
Note:Password and security code values must be registered via de loader program for proper operation.
If these values are registered with the Hand-held Terminal, they will only apply to the Hand-held Terminal access.

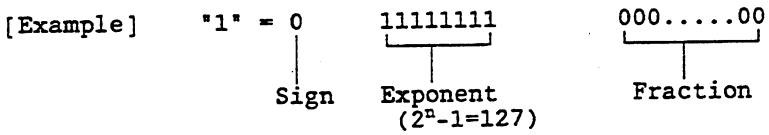
9.4.8 Data format in process loop controller

Data format in a process loop controller uses floating point number as follows



$$\text{Value} = (-1)^S \times 1.\text{FRAC} \times 2^{\text{EXP-127}}$$

Where, 1.FRAC means that the most significant bit is set to "1" in cases except when data is zero, and the fraction part has 24 bits by omitting this "1".



3F800000 (hexadecimal number)

The effective value of the fraction part is:

$2^{24} - 1 = 1677721$

Therefore, when 1.0 is integrated (the process loop controller provides 7 digits of effective value.), digit overflow occurs at 1677721. This means that if 1.0 is integrated at every processing cycle time,

when CTS=0.2 sec, 932 hours (38.8 days)
when CTS=0.3 sec, 1398 hours (58.2 days)
when CTS=0.5 sec, 2330 hours (97 days)

Note: CTS is not 0.2000000 because CT can be in the range of 0.1999999 - 0.2000001 when accuracy of CT (cycle time) is 0.2.

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9.4.9 Processing at power on

Control mode (C, A, M) at power on, SV, and MV vary depending on storing status of RAM, power-cut timer, etc. as follows.

Table 9.11 Processing Restart Conditions

Condition	Restart
EEPROM data error	M mode, SV =0&, MV = -25%
Instantaneous stop (Less than one hour power off)	Final mode, final SV, final MV,continuous control
RAM memory data loss (More than one hour power off)	M mode, SV = 0%, MV = - =25%

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9.5 System Buildup

Make a plan detailing how to use the control system. Next build up the system by defining function modules, parameters and linkage of blocks in each intelligent space using the system loading function on the program loader.

Download the completed program to the process loop controller via RS232C or a memory card.

The following shows the steps to build up the functions of the process loop controller.

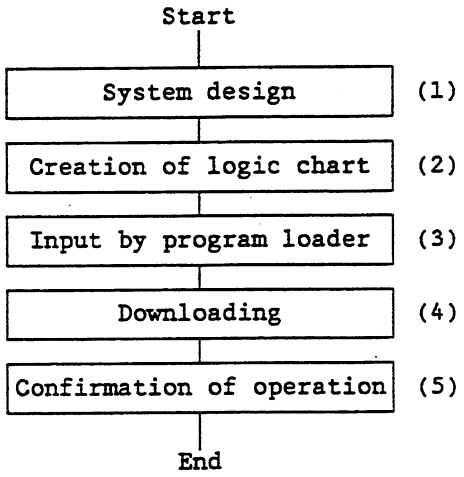


Figure 9.11 Function Buildup Steps for Process Loop Controller

The following files a detailed description of the flow.

(1) Functions to be performed on a process loop controller are determined through system analysis.

(2) A logical chart of the above functions is prepared in combination with function modules in an intelligent space.

(3) The logic chart is created according to certain rules using the program loader.
The function inputs are checked with error check functions.

(4) Downloading is done.

After download is done, check the system code on the front panel of the process loop controller in order to confirm that the correct file has been downloaded.

(5) Check the system code, functions, record of input/output, etc. Then, the functions of the process loop controller may be successfully implemented.

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The program loader allows setting of the processing period. It calculates a standard processing period from the functions configured. If the set processing period is less than the calculated one, it downloads the calculated processing period instead.
The controller has a check function for the processing period. If the controller cannot perform the configured function within the downloaded processing period, both the loop indication and mode indication LED blinks. If this is the case, set the processing period longer than the present one and download it with the program loader.
(The processing period calculated by the two-loop loader can be checked by the loader. The mode indication.
LED may blink several times just after downloading. This is because the processing volume increases at the time of initial setting. Unless the blinking continues, it will not after the routine processing.)

The program loader is used to create or change the functions performed by the process loop controller, or to write and download built-up data to the memory of the controller.

Note: In a case when a transmission error has occurred during downloading from the program loader, the controller will stop in the initial status with no function. Check the system code, etc. on the front panel; if the set value with the loader differs, perform the download again.

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9.6 How to Use Simulation Space

(1) General

When a download file is newly created or partly changed, a simulation space can be used to check the real activity of the controller.

Figure 9.12 shows a flow of signals from input to output.

The analog input connected to the PV input terminal is A/D-converted to PVC. Based on this input data, each intelligent space can perform processing and determine the output MV. However, if the simulation is requested, the analog input is determined as it is defined in a simulation space, and the MV output holds the value from just before the simulation request.

A simulation space can be said to be an approximate source space of process characteristics. In general, the way the analog inputs change the MV will be shown (operation simulation on process side).

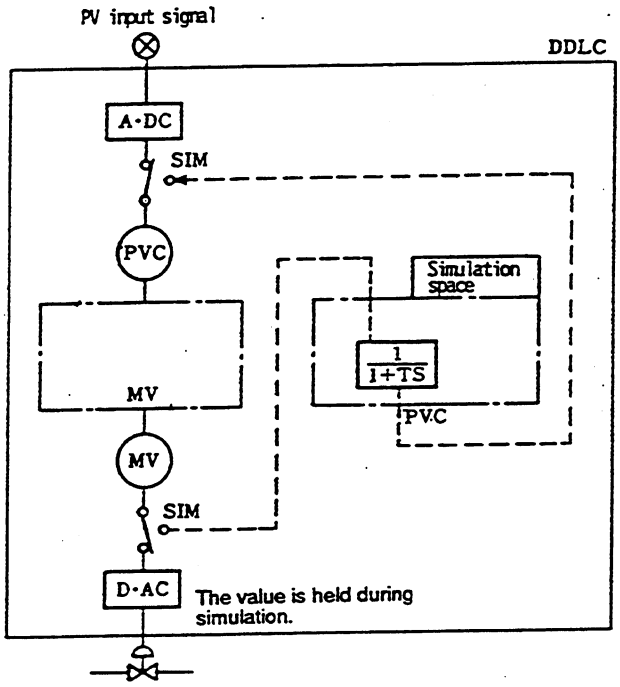


Figure 9.12 Data Flow during Simulation

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(2) Processing in a simulation space

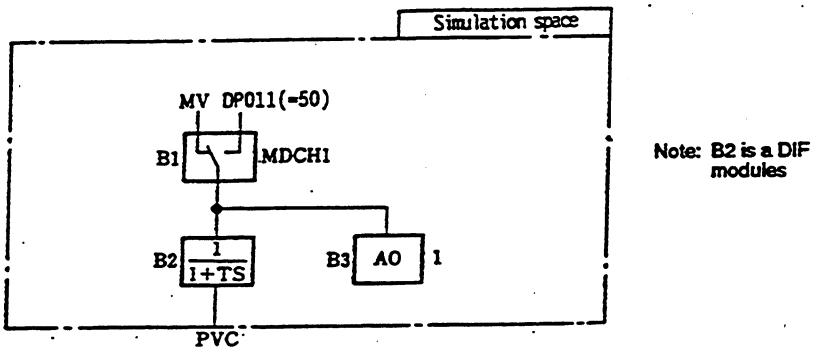


Figure 9.13 Processing in A Simulation Space

(i) When simulation execution is to be requested, the mode automatically switches to M mode.

(ii) A DP parameter determines the initial value of MV.

(iii) B3 causes processing to create an analog value of the valve position. The AO caused by the B3 output should be sent to an AI via an external terminal to provide indication of this.

Simulation is possible without processing B3 and (iii).

(iv) If simulation request is canceled, the mode come to M mode.

(v) The HOLD indicator will flash at a rate of 0.5 cycles per second to indicate that controller is in the simulation mode of operation.

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10. Function Modules

10.1 Definition

A function module, a functional unit which is executed in the process loop controller, takes the following form in general as shown in Figure 10.1. A desired function is obtained by sequentially combining inputs and outputs.

(Basic form)

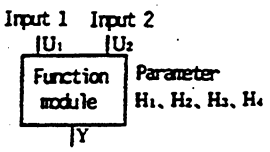


Figure 10.1 Function Module

Each module consists of up to two inputs U1 and U2, and four parameters H1 - H4. Based on these, it performs calculation and outputs Y.

Some modules require values for only some of parameters H1 - H4, or they may consider H1 - H4 to be inputs U3 - U6.

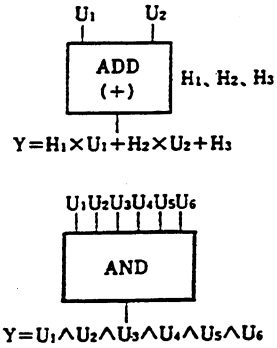


Figure 10.2 Example of Function Block Formats

10.2 How to Use Function Modules

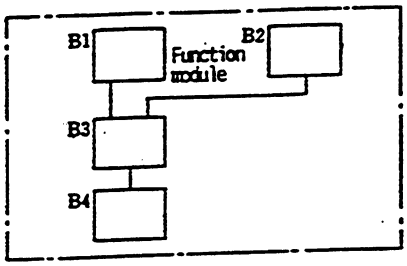
10.2.1 Function module in a space

When assembling a function module in an intelligent space to produce a desired algorithm, it is possible to reuse the same function module as many times as desired. As an exception, modules that need data storage ares, described in 10.2.3, have a limitation in the number of modules.

Function modules arranged in a space are numbered sequentially from 1; block 1, block 2, etc. If the space is changed the block number starts at 1 again.

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Processing of blocks is done beginning with block 1. It is convenient to number blocks taking into consideration the processing order. If they are numbered arbitrarily, data from a previous cycle may be used. When the relations between cyclic data are important, attention must be paid to the block numbering order.



The function module in a space is called a block, and numbered B1, B2, etc. in the order of processing.

Figure 10.3 Function Module in a Space

10.2.2 Limit on no. of blocks

The number of function modules used in each intelligent space of the process loop controller must be 200 or less. A function module used more than once is counted each time.

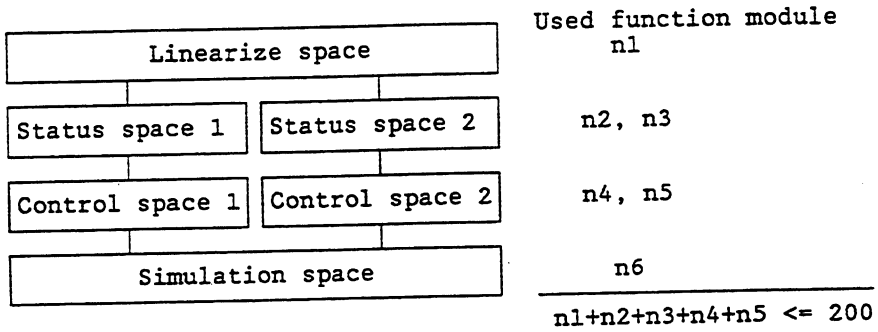


Figure 10.4 Limit on No. of Blocks

10.2.3 Function modules that require data storage area

Modules such as PID calculation (PID, PI2, PIS, FPI, FP2), lead/lag (LAG), differentiation (DIG), on/off delay timer (DEL), move average (MAV), sampling average (SAV), and dead time (DT) require specific data storage areas, because they need previous data other than the previous output data.

For this reason, this kind of block is limited to a total of 32 areas total for the intelligent. (See Table 10.1)

When specifying this kind of module, it is not necessary to specify the number of areas to use. It may cause an error if more than 32 areas are required.

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Table 10.1 shows modules which need data storage areas and the required no. of areas.

Only one MVS module can be used in each loop.

Table 10.1 Required Data Storage Areas

Module	Required areas
PID, PI2, PIS, FPI, FP2, LAG, DIF, DEL, CHD, RSM LGS, LGL, PSS	1
MAV, SAV	2
DT	4

10.2.4 Variables and parameters

Variables and parameters are used by the function blocks to represent inputs, outputs and parameters, and by the intelligent spaces to represent space outputs. The data-type of the variable or parameter must match the data-type of the function block that uses it (see figure 10.5).

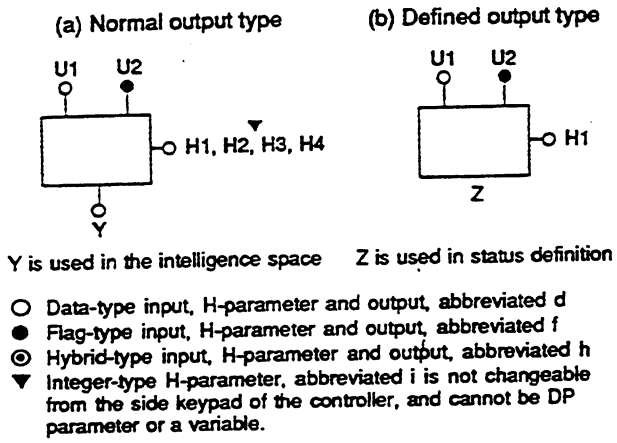


Figure 10.5 The Function Block Illustrations

Five types of data are processed by the function blocks in the controllers - data, integer, flag, hybrid and variable type. Data-type data are represented by real number; integer-type data are integers. Flag type data are used as status signals, 0 or 1. Hybrid type data can be used as either flag or data type. Variable-type data are used to represent the variable names specified by the PMS function block.

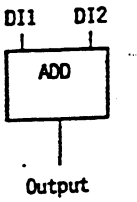
Table specifies the type of data for each of the function blocks, and abbreviates the data types as follows: d for data-type, i for integer-type, h for hybrid-type, f for flag-type, and v for variable-type data.

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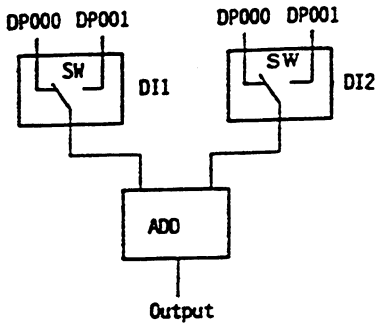
Inputs, outputs and parameters of function blocks must have a correct data type specified for them. Incorrect and correct data type usage is shown in figure. The usage in 10.6 (a) is incorrect. The addition function block cannot add flag-type inputs. The usage in 10.6 (b) is correct. The discrete signals DI1 and DI2 are converted to data-type by the use of the DP parameters. The data-type outputs can be added by the ADD block.

All flag-type variables may have inverted signals specified for them by adding a negative sign in front of the variable name. Figure 10.6 shows examples.

Hybrid and Data type data must use other methods such as a SW Block.

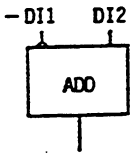


(A) Incorrect
Flag type addition
is not allowed in
addition module

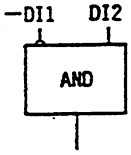


Where: DP000=0
DP001=1

(B) Correct
DI status is converted
to data type and added.



(C) Incorrect
Input invert specification
is not allowed in a data type
input function module.



(D) Correct
Input invert specification
is possible in a flag type
input function module.

Figure 10.6 Incorrect/Correct Function Block Applications

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10.2.5 Variable Types

In addition to block outputs, the following are available as inputs to function modules. See 10.2.7 for symbols used in this manual.

(1) Analog input

Analog inputs can be up to six points PV1 - PV6, and can be form external inputs. These values are used in the controller as Process Variables (PV).

(i) Percentage before linearization
The letter C is added like "PVC"
Data read from the outside is calculated in percentage.

(ii) Percentage after linearization
Like PV1 or PV2, input names are the percentage.
If the input is already linear, PV1 = PVC1.

(iii) Inactive status (sensor error)
The letter I is added like "PVI".
If the input value after A/D conversion is erroneous, it is determined inactive.

(iv) Alarm status
The input alarms are higher limit alarm, lower limit alarm and change rate alarm.
Like PVH, PLV, PVD, the letters H, L, D are added.

(2) Control

(i) Control inactive and deviation alarm
Represented by CLI and DVE.

(ii) Mode
Represents each mode by C, A and M.

(iii) Set value
Represented by SV.

(iv) Manipulated variable
Represented by MV.

(v) Loop No.
The loop no. indicates control loop no. The process loop controller actually has four loops.
Loop variables such as set value, manipulated variable and mode are specified under these loop nos.

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(3) DI, DO

Indicates status of DI and DO.

(4) Flag type variable

Represented by S01, S02, ... S16.
Used when flag type data variables are required.

(5) Data-type variable

Represented by Y01, Y02, ... Y16.
Used when data type variables are required.

(6) Variable (DP) parameter

Represented by DP000, DP001, ... DP149
Used as block input or parameters.

Constants commonly used in the system are already defined as DP000 - DP009.

Table 10.2 Predefined DP Parameters

Parameter	Data	Remarks
DP000	0	System constants
DP001	1	
DP002	2	
DP003	3	
DP004	273.15	Thermal pressure correction constants
DP005	459.4	
DP006	1.0332	
DP007	101.3	
DP008	10	System constants
DP009	100	

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(7) Change detect

The change detect becomes 1 during the cycle processing when the status change occurred. The last letters of a variable name ends with CH to denote a change detect type variable.

Change detect examples of DI, mode, S1, S2 are shown below.

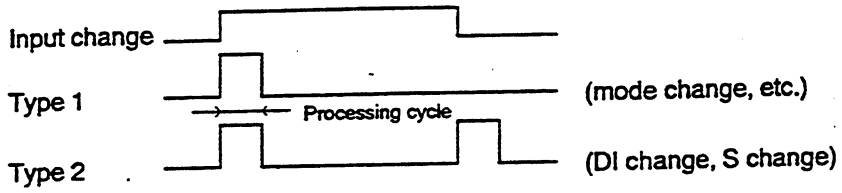


Figure 10.7 Change Detect

(8) Fixed flag variable

Represented by SW1, SW2, ... SW8

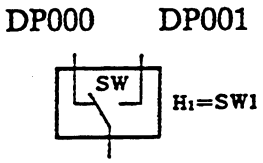


Figure 10.8 Example of SW Variable

10.2.6 Initialization of function module

The following function modules are required to be initialized. A flag, such as change detect (DnCH, SnCH, MDCHn), which hold a signal of 1 during one processing cycle is necessary for initialization.

(1) SUM: Totalizer module

Initialized when U2 is not equal to 0.
Causes the start of summing.

(2) LAG, DIF: Lead/Lag , Differential

When INZ=0 or U2 is not equal to 0, these function blocks are initialized.
Makes the previous output value equal to the current output value.
LAG output Y = U1. DIF output Y = 0.

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(3) DT, MAV, SAV: Dead time, moving average, sampling average

When INZ=0, or H1 is not equal to 0, these function blocks are initialized.
Makes all the previous output values equal to the present one.
Output Y = U1.

(4) PID, PI2, PIS, FP1, FP2: PID control calculation

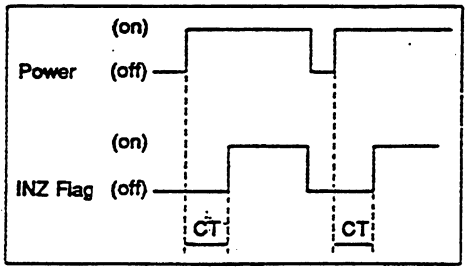
Initialized by INZ, mode change, CLE, MVF, or parameter change.
Clears previous deviation data, and starts new control calculation.

(5) MVS: MV set

Initialized by the same conditions as (4) above or H2 is not equal to 0.
Output Y = U2 (or U1+U2 if specified).

(6) RSM: Double precision totalizer

Initialized when U2 is not equal to 0.
Causes the start of summing.



During one processing cycle time after power is supplied to the controller, this flag is set to 0. Normally, this flag is on (equal to 1)

Figure 10.9 Initialization Flag/Power Supply Relationship

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10.2.7 Variable Name

The symbols in Table 10.3 are used for variable and parameter names as follows.

A * suffix such as T*, can be combined with a * prefix such as *D to form T**D which means "TD". TD, or derivative time, is a tuning parameter changeable from the front panel key.

Table 10.3 Symbols

Abbre.	Meaning
A	Automatic control
B*	Block
C	Cascade control
CL*	Control
CMP	Computer
CTS	Cycle time
CV*	Calculated variable
*C	Count
*CH	Change detection
*CK	Check
D1*	DI1
D2*	DI2
D3*	DI3
DI*	Digital input
DO*	Digital output
DV	Deviation
**D	Derivative
*E	Error
*H	High limit (Alarm)
INZ	Initialize
*I	Inactive
*L	Low limit (Alarm)
M	Manual
MD	Mode
MV	Manipulated variable
PV*	Process variable
SV	Set point variable
SW*	Function switch
*T	Time

The flag goes to 1 when the flag is on, and 0 off.

(Example)

SOF* 1 at scan off
0 at scan on

PVD* 1 at change rate alarm
0 at normal

(1) Analog input variables
Numbers mean input No.

INPT1-6	Analog input connected/not connected (flag)
SOF1-6	Scan off (flag)
PVCK1-6	Higher/lower change rate check execution (flag)
PVD1-6	Change rate alarm (flag)
PVL1-6	Lower limit alarm (flag)
PVH1-6	Higher limit alarm (flag)
PVI1-6	Sensor error (flag)
PVC1-6	PV before linearization (data)
PV1-6	PV after linearization (data)

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(2) Analog input parameters
Numbers mean input No.

RH1-6	Meter range higher limit (data)
RL1-6	Meter range lower limit (data)
PH1-6	PV upper limit (data)
PL1-6	PV lower limit (data)
DPV1-6	PV change rate limit (data)

(3) Loop variables
Numbers mean loop No.

CLE1-4	During I/O error control halt (flag)
M1-4	M mode (flag)
A1-4	A mode (flag)
C1-4	C mode (flag)
MVL1-4	MV lower limit alarm (flag)
MVH1-4	MV upper limit alarm (flag)
CMP1-4	Computer flag (flag)
CL1-4	Control calculation (flag)
MCH1-4	M mode set (only rise up one cycle)
ACH1-4	A mode set (")
CCH1-4	C mode set (")
MVE1	MV readback error (flag)
CLI1-4	Control inactive (flag)
DVE1-4	Deviation alarm (flag)
MDCH1-4	Mode change (flag)
SV1-4	Set value (data)
MV1-4	Manipulated variable (data)
CVSC1-4	CV scale division value (data)
SVSC1-4	SV scale division value (data)
MVSC1-4	MV scale division value (data)

(4) Loop parameters
Numbers mean loop No.

Kp1-4	Proportional gain (data)
Ti1-4	Integration time (data)
Td1-4	Differentiation time (data)
Gp1-4	Gap width (data)
Gg1-4	Gain inside gap (data)
RT1-4	Ratio (data)
BS1-4	Bias (data)
DV1-4	Deviation limit (data)
MH1-4	MV higher limit (data)
ML1-4	Lower limit (data)
DMV1-4	Deviation change rate alarm value (data)
ALP1-4	2 degrees of freedom PID parameter value (data)
BTA1-4	" value (data)

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CLT1-4	Control cycle time (data)

(5) External variables
Numbers mean variable No.

V00-32	External variable (data)
VE	External variables error flag (flag)
V01E-V32E	External variable individual error flag (flag)
V01S-V32S	External variable update flag (flag)

(6) Others
Numbers mean parameter No. or input/output point No.

INZ	Initialize flag (flag) (after power on and download, it is zero for one cycle.)	
INZ1	Initialize flag 1 (flag) (after download, it is zero for one cycle.)	«NEW»
INZ2	Initialize flag 2 (flag) (after power on, it is zero for one cycle.)	«NEW»
S01-16	Internal flag (flag)	
S01CH-S16CH	Internal flag change (flag) (each one cycle effective at rise-up and fall)	
Y01-16	Internal variable (data)	«NEW»
DI1-4	Digital input (flag)	DI4, D4CH, DO5, DO6
D1CH-D4CH	Digital input change (flag) (each one cycle effective at rise-up and fall)	DM5, DM6
DO1-6	Digital output (flag)	
DM1-6	Digital output mode (flag)	
AO1-2	Analog output (data)	
CME	Host transmission error (flag)	
ALM	Alarm status (flag)	
BUZ	Buzzer trigger signal (flag)	
CTS	Processing cycle (sec) (data)	
DP000-149	Variable parameter (data)	
PnXi,PnYi	n: Polygonal line table No. (data) i: Point	
SW1-SW8	Status switch (flag)	
SEL11-14,21-24	Select flag	

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(7) AdTune parameters
Numbers mean loop No.

PA1-4	Setup test signal amplitude (data)
PKP1-4	Setup Kp value (data)
PTI1-4	Setup Ti value (data)
PTA1-4	Setup TA value
PSI1-4	Setup SI value
PPF1-4	Setup PF value
TA1-4	Identified signal amplitude (data)
SI1-4	Identified sampling time (data)
PF1-4	Identification filer execution specification (flag)
DAT1-4	Differentiation term specification (flag)
EB1-4	Deviation threshold
EI1-4	Deviation check base time
EN1-4	Deviation check time limit
SPS1-4	Supervisor execution specification
PLMT1-4	Tuning Kp limit coefficient
ILMT1-4	Tuning Ti limit coefficient
DLMT1-4	Tuning Td limit coefficient
ADS1-4	Tuning status
TKP1-4	Tuning Kp Value
TTI1-4	Tuning Ti value
TTD1-4	Tuning Td value
TAL1-4	Tuning α value
GSET1-4	Gain schedule table setting
GEXE1-4	Gain scheduling execution specification
GnXm	Schedule table level (n=1-4, m=0-9)
GnKPm	Schedule table Kp (")
GnTIm	Schedule table Ti (")
GnTDn	Schedule table Td (")
GnALm	Schedule table Sa (")

10.2.8 Caution concerning function module inputs

The data-type of the variable or parameter must match the data-type of the function block that uses it.

Block output of an intelligent space can only be used as block inputs within that space, except Yn and Sn.

Variables Yn and Sn may be used in other intelligent spaces.

In order to use the block outputs of other intelligent spaces, define them as Yn or Sn, using YST and SST, and use them as variables.

A constant such as 30 cannot be directly input as a block input or parameter.

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For example, when calculating PV+10.0, the value of 10 is input as a DP parameter.

(The output of the addition module (ADD) is H1U1+H2U2+H3.)

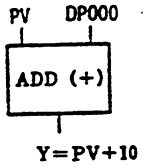


Figure 10.10 ADD Function Module

10.2.9 How to abbreviate function modules

If all the information is listed, it may not be easy-to-read figure. To avoid this, follow the abbreviation rule below.

(1) Omission of data type
It is not necessary to explicitly declare data type of flag type.

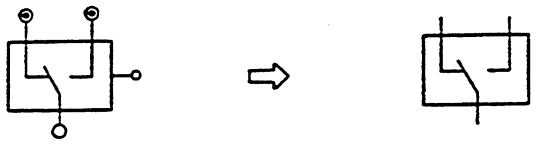


Figure 10.11 Data Type Omission

(2) Omission of parameter
Each module has initial values of parameters such as H1, H2. Parameters can be omitted if default values are used.

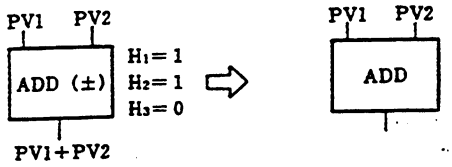


Figure 10.12 Parameter Omission

(3) Abbreviation of parameters
T1, T2 for polynomial line tables, and PV1, PV2 for input point codes.

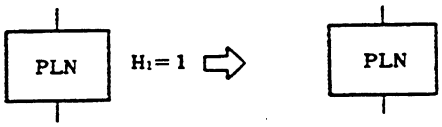


Figure 10.13 Parameter Abbreviation

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(4) Abbreviation of module symbols

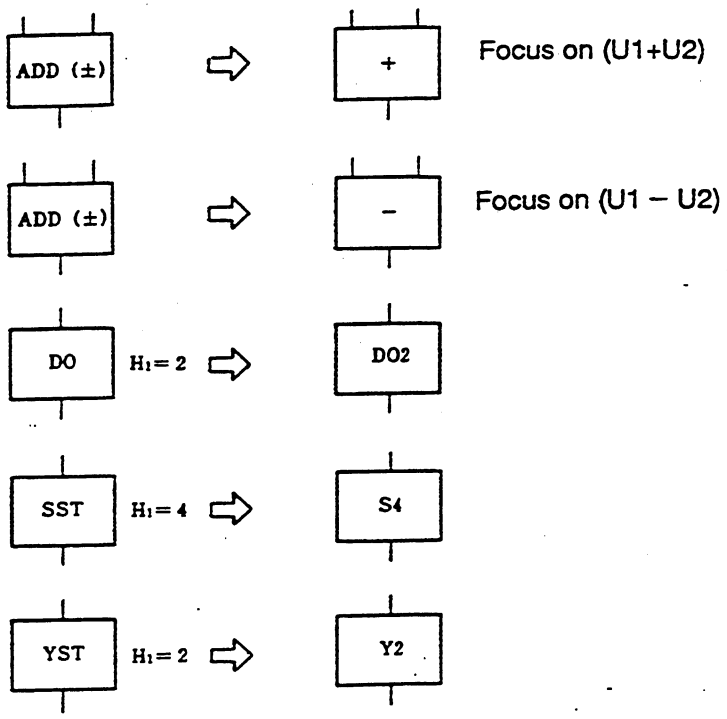


Figure 10.14 Module Symbol Abbreviation

Note: Examples in (3) and (4) show abbreviation methods for program creation. When defining for a loader, follow the official methods for representing parameters and modules.

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10.3 Function Modules

A list of function modules is shown in Table 10.11.

To effectively use function modules, application examples for some modules are given below.

* General points

Write inputs at the top of block, with U1 at left and U2 at right.
Write parameter to the right of the block.
Extend a line from the bottom of the block for the output.

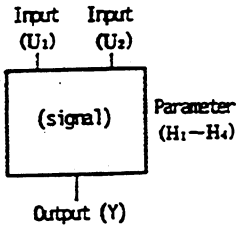


Figure 10.15 General Block Format

10.3.1 Input selection (SW)

Draw a switch with a line inclined to the left. This means that the condition to cause a switch-over to U2 is H1=1.

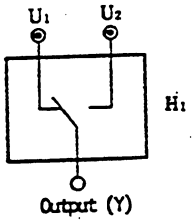


Figure 10.16 SW Module Format

[Example] The circuit below has an output of Y which is PV1 when DI1 is on (=1), or PV2 when DI1 is off (=0).

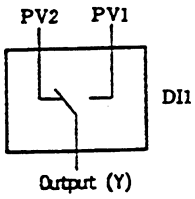


Figure 10.17 SW Block Example

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10.3.2 Polynomial input logic calculation (AND, OR)

Inputs of 2 - 6 points is possible. Only the input points which are specified will be calculated. Any of the input points can be specified as inverted (reverse).

[Example] The block below shows 5 input points and U1 and U3 are specified as inverted.

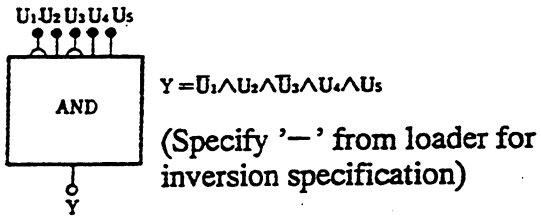


Figure 10.18 AND Block Example

10.3.3 AND/OR (A/O)

If U1 - U3 (U4 - U6) are all undefined, the result is taken as U1∧U2∧U3=0(U4∨U5∨U6=0). Otherwise, undefined inputs are considered 1.

Any input point can be specified "inverted" (reverse).

[Example] When only U1 and U2 (inverted) are defined the result is:

$Y = \overline{U1} \wedge \overline{U2}$

10.3.4 OR/AND (O/A)

If U1-U3 (U4-U5) are all undefined, the result is taken as U1∨U2∨U3=1(U4∨U5∨U6=1). Otherwise, unused inputs are considered 0.

10.3.5 Multi switch module (MSW) «NEW»

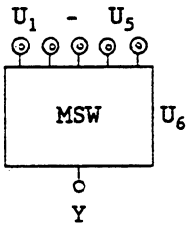


Figure 10.19 Multi switch Module

U1 - U5: Input point (data,flag,integer)
U6 : Input selection (data)

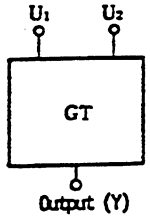
U6	1	2	3	4	5
Y	U1	U2	U3	U4	U5

Five points selection module.

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10.3.6 Comparison (GT, LT, GE, LE)

Function modules of GT, LT, GE and LE output 0 or 1 depending on the condition of the inputs. Parameter H3 is used for hysteresis band specification.



[Example] A GT module is shown which outputs the figure below depending on the PV value and the previous output (Y).

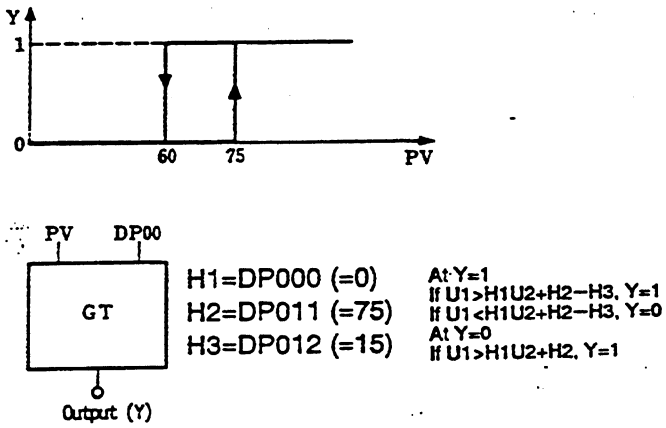


Figure 10.20 GT Block Example

10.3.7 Square root calculation (ROT)

Output is determined by $H1\sqrt{U1xU2}$

When square root extraction is done on input U1, U2 can be connected to the output of a pressure compensation module.

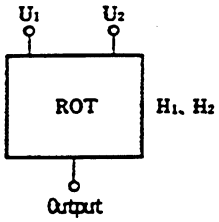


Figure 10.21 ROT Block Example

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[Example] A sample ROT application in which to temperature (TCM) or pressure (PCM) is required is shown below.

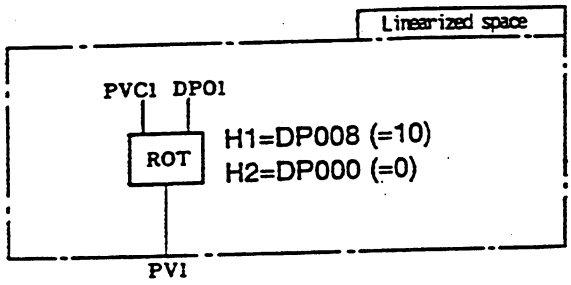


Figure 10.22 Square Root Function Block in the Linearization Space

In this example a square root function block is shown in the linearization space.
U1=PVC1, U2=DP001, H1=DP000 and H2=DP000. PVC1 is a 0-100% value before linearization, since a PV1 value of 0-100% is desired, H1 is set to 10.

In the range where the U1 value is less than the specified H2 value, the U1 value is low-cut, i.e. assumed to be equal to 0.

10.3.8 Polynomial line, reverse-polynomial line (PLN, ILN)

The polynomial module is used to approximate polynomial lines for non-linear functions by express a function with 11 pairs of coordinates (x,y), i.e., 10 lines.

The polynomial line module allows you to obtain y from x, while the reverse-polynomial line allows you to obtain x from y.
The coordinates (x, y) in a polynomial line table must be defined. There are six polynomial line tables, 1 to 6. The six tables are stored in RAM and can be changed.

One table can store up to 11 coordinates. If less than 11 coordinate points are needed, coordinate entry can be stopped by defining the last coordinate as (-0, -0).
The following figures show the results obtained for out of range values.

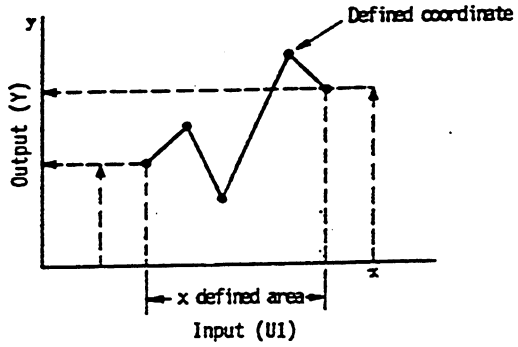


Figure 10.23 PLN Out-of-Range Example

(i) Giving x out of the defined range for a polynomial line module provides the coordinate of y at a line end point.

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(ii) Giving y out of the defined range for a reverse-polynomial line provides x coordinates of maximum and minimum values.

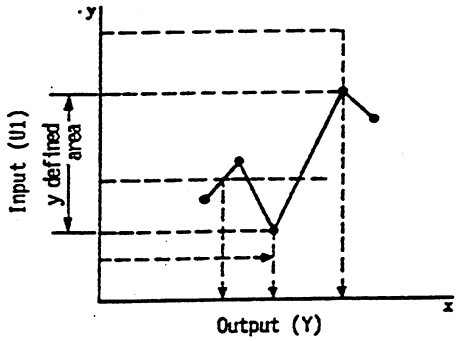


Figure 10.24 ILN Out-of-Range Example

The relationship between the polynomial modules and the polynomial line table is shown by table numbers to the right of function block.

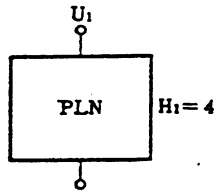


Figure 10.25 Polynomial Line Table Specification

[Example] A polynomial line is shown below for the signal characteristics for control input 1.

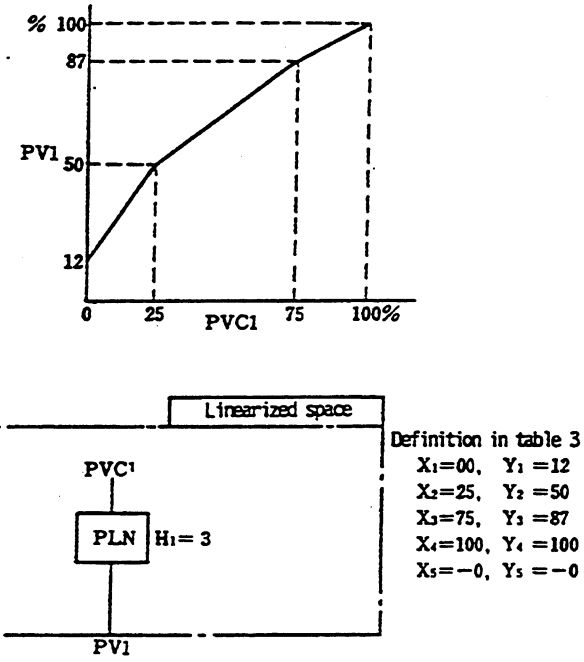


Figure 10.26 Polynomial Line Specification Example

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10.3.10 Temperature correction coefficient, pressure correction coefficient (TCM, PCM)

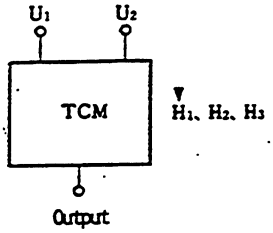


Figure 10.27 TCM Block

H1: Input point code
1-6...PV1-PV6 0....Engineering data with any U2 value
H2: Design temperature Td
H3: Constant (e.g., 273.15 when unit is deg. C, 459.4 when deg. F)

Output = U1 x (H2 + H3)/{(H1 engineering unit) + H3}

For deg C, the result, output = U1 x (Td+273.15)/(t+273.15), is obtained. When 1 - 6 are specified for H1, the specified input data is converted automatically to engineering units according to the range RH, RL specified in each input point.

The output of the TCM function block is normally input to the PCM or the ROT function blocks.

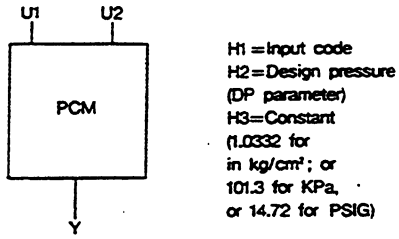


Figure 10.28 PCM Block Example

For the pressure compensation module H1 specifies the same design code as for the TCM, H2 is the design or average process pressure, and H3 is the constant for absolute pressure conversion. The output for the function block is:

Y = U1 * [(EU value of the input specified by H1)+H3]/(H2+H3)

If H1=0, the U2 input is regarded as the temperature to be compensated, and is in engineering unit data. If H1 ≠ 0, H1 is used to designate the input code, and the engineering unit data from the input is used.

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An example showing the use of the TCM and PCM blocks is shown below.

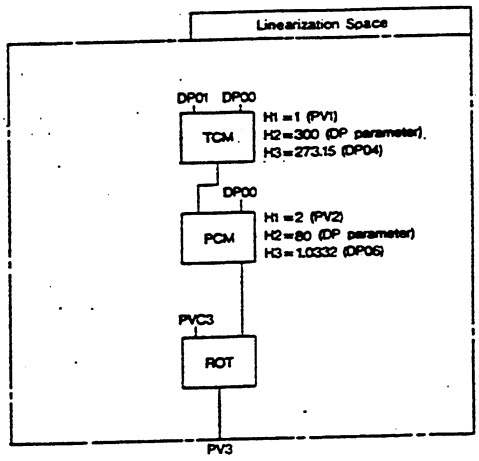
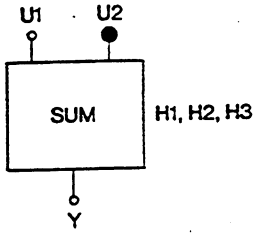


Figure 10.29 Example Using TCM, PCM and ROT Function Modules

10.3.10 Totalization (SUM)

"This module sums" the inputs (U1) every processing cycle, and uses U2 as an initialization flag. When U2=1, the initial value is set, and Y=H1+(H2*U1+H3). When U2=0, the totaling is performed:



$Y = (Y_{-1}) + (H2 * U1) + H3$

Where Y_{-1} = last calculated value for Y.

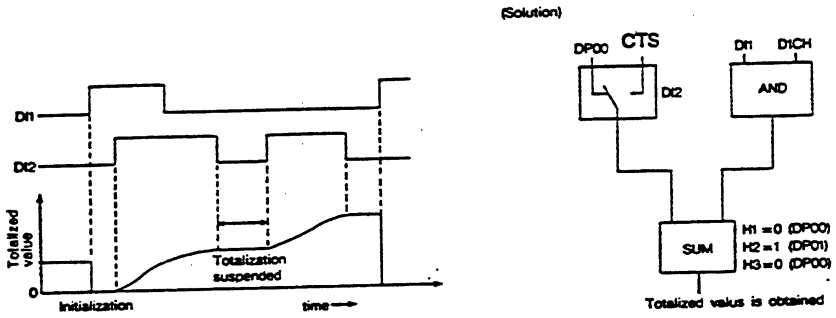


Figure 10.30 Totalizer Function Block Usage

In the example shown above, the totalizer function block is reset to 0 at the leading edge of DI1. The variable CTS is added each process cycle when DI2 is on (equal to 1).

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10.3.11 Timer 1 and Timer 2 (TM1, TM2)

Both timer 1 and timer 2 are initialized to the value of the output if U2 becomes equal to 1. When the timer counting conditions are met, the operation is made with $Y=Y_{-1}$ (the last calculated value for Y) - CTS. If the output ever has a negative value, it is set equal to zero. The output of the timer can be either zero or positive. Timer 1 is initialized with U2=1, and is retriggerable. Timer 2 is initialized when Y=0, and U2=1. Note that the timer outputs may have an error of up to one processing cycle time.

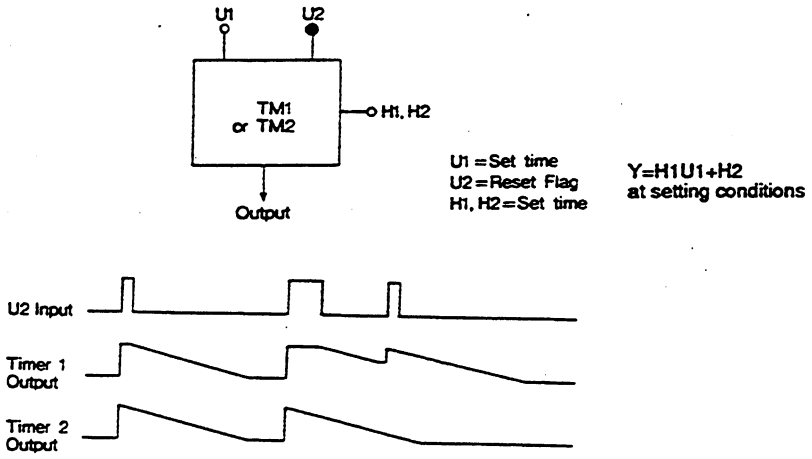


Figure 10.31 Timer 1 and Timer 2 Function Blocks

Figure 10.31 above shows the function blocks and timer outputs along with the U2 input. As the diagram in figure 10.31 shows, U2 must be kept at zero if timer 1 is to continue counting. The output is set to the initial value when U2=1; however, timer 2 function block is initialized when Y is equal to zero and U2=1 because it is non-retriggerable during timer operations.

Two examples showing the use of timer 2 are found in figure 10.31 below. The first example shows a system that outputs the value of 1 at five-second intervals. The second examples uses DI1CH to trigger the SST block output. If DI1 is changed to on, the SST block output (along with S2) will be set to 1 for ten seconds.

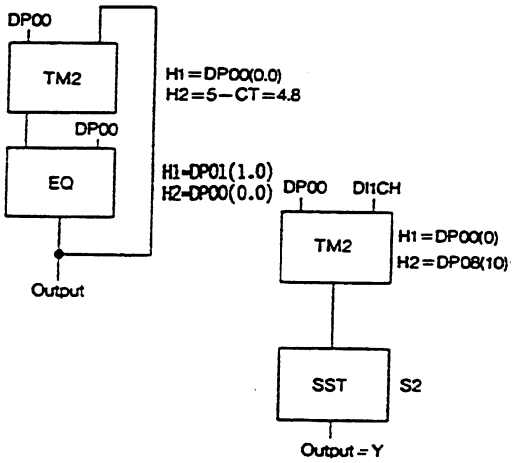


Figure 10.32 Examples of Timer 2 Function Block Usage

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10.3.12 On/Off delay timer (DEL)

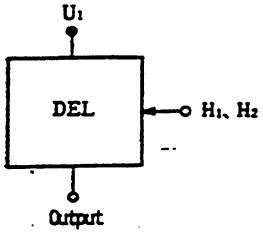


Figure 10.33 DEL Function Module

H1: On delay timer (sec)
H2: Off delay timer (sec)

The delay timer may contain a maximum error of one processing cycle time (CTS).

(i) If the input is stopped during on-delay, the on delay is continued and the off-delay is started.

(ii) If the input is started during off-delay, the off-delay is stopped, the output is set to 0 and the on-delay are started.

(iii) For pulse input at U1 the off delay cannot be zero if there is an on delay, or else no output pulse will be registered.

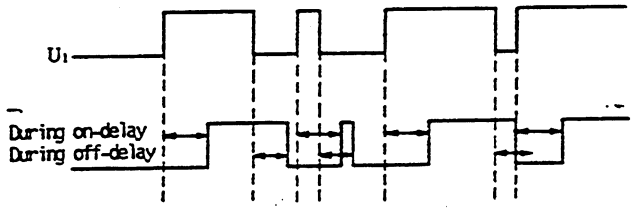


Figure 10.34 DEL Function Module Operation

10.3.13 Pulse counter module (PSS) «NEW»

This module can be used only with optional Pulse input module.

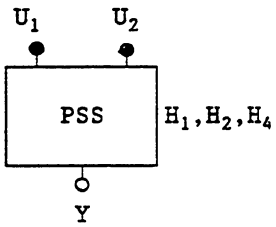


Figure 10.35 Pulse counter

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U1 : Hold flag (flag)
U2 : Reset flag (flag)
H1 : Ratio (data)
H2 : Priset value (data)
H4 : Operate mode (flag)

```
If U2 < > 0
  then (count value) = 0
  else
    if U1 < > 0
      then (count value) = (count value)-1
      else
        if H2 < (count value)-1 + (pulse input value)
          then if H4 < > 0
            then (count value) = H2
              else   (count value) = (count value)-1
                                   + (pulse input value) - H2
              else (count value) = (count value)-1
                                   + (pulse input value)

              Y = H1 * (count value)
```

10.3.14 Selector modules (MAX, MIN, AVE, MED)



Figure 10.36 Typical Format for MAX/MIN/AVE/MED Module

The selector type modules use from 2 to 6 inputs. Only defined inputs are used.

An input error status for any of the defined analog inputs (PV1 - PV6) causes that input to be executed.

10.3.15 Limiter (LMT)

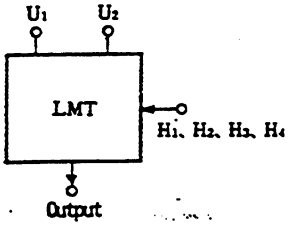


Figure 10.37 LMT Function Module

The output reflects the U1 input limited to the specified maximum and minimum values.

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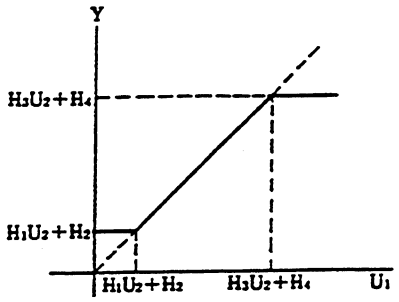


Figure 10.38 LMT Block Output

10.3.16 Change rate limit (DLM)

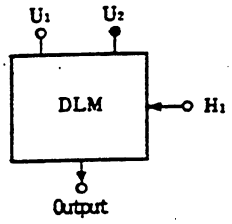


Figure 10.39 DLM Function Module

When U2 is not equal to 0, for each processing cycle, the output value is limited to the rate change specified at H1.

When U2 is 0, the output is U1.

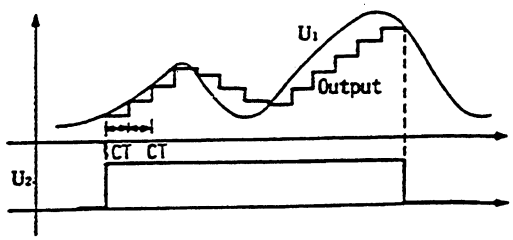
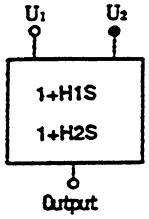


Figure 10.40 DLM Block Output

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10.3.17 Lead/lag correction (LAG)



U1 : input
U2 : initialize request (U2=0: No, U2=1: Yes)
H1 : gain parameter
H2 : lead/lag time constant (sec)

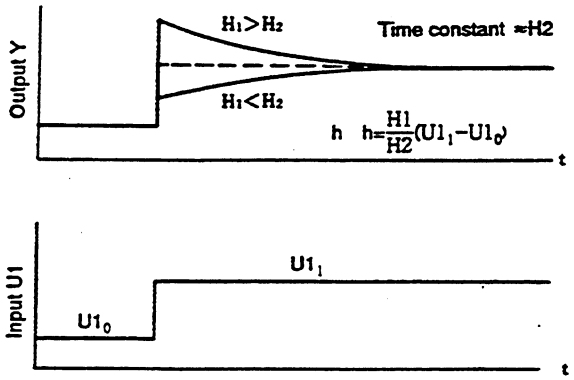


Figure 10.41 LAG Function Module

When H2=0,

$Y = U1 + (H1 - H2)/H2 \times (U1 - Y_n)$

where, $Y_0 = U1_0$

$Y_{n+1} = Y_n + CTS/H2(U1-Yn)$ ... used for next calculation

When H2=0, $Y = U1 + H1/CTS \times (U1-U1_{n-1})$

where, $U1_{n-1}$: previous U1 input

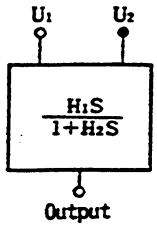
When initializing, (INZ = 0, or U2 ≠ 0),

$Y = U1$

Because the calculation is done once every processing cycle, a step-wise change may become significant unless H1 or H2 are large enough compared to CTS. The final value may be the same. Buy requesting initialization with U2≠0, the current input is considered as having continued for a sustained period of time. At power on, initialization is done automatically.

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10.3.18 Differentiation (DIF)



U1: Input
U2: Initialization flag
(0:no request, 1: request)
H1: gain parameter
H2: differential time (sec)

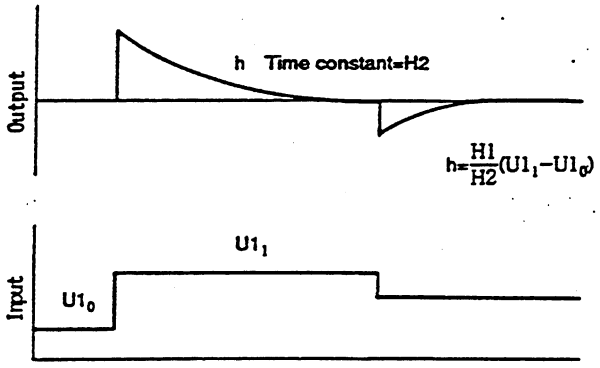


Figure 10.42 DIF Function Module

$Y = H1/H2 \times (U1 - Y_n)$
where, $Y_0 = U_0$
$Y_{n+1} = Y_n + CTS/H1 \times (U1 - Y_n)$ ... used for next calculation
when initializing (INZ = 0, or U2 ≠ 0)
$Y = 0$

Because the calculation is done once every processing cycle, a step-wise change may become significant unless H2 is large enough compared to CTS. The final value will be the same. By requesting initialization with U2 ≠ 0, the current input is considered as having continued for a sustained period of time. At power on, initialization is done automatically.

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10.3.19 Dead time (DT)

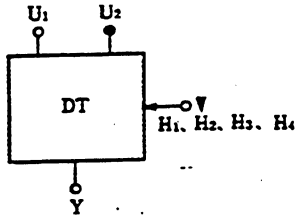


Figure 10.43 DT Function Module

H1: Initialization flag
(Clears the buffer in the DT module, used to reset data)

H1=1: Clears the buffer. Considering that the current input value has continued as is for a certain period of time, outputs U1 data to Y.

H1=0: Outputs data stored in buffer according to dead time specified.

H2: No. of samples 1 <= H2 <= 16
(total no. of data stored in DT module)

H3: Sampling period (in processing cycle CTS's)

1.0 <= H3 <= 2000.0

H4: Output sample No. 1.0 <= H4 <= H2 (rounded)

U1 input is made output (Y) with a time delay: H4 x H3 (sampling period) x CTS (processing cycle).

U2: When the sampling cycle set flag is set, the cycle is started again and the delay is continued. (sampling cycle counter only is set)

The output of the sampling cycle is corrected by linearization.

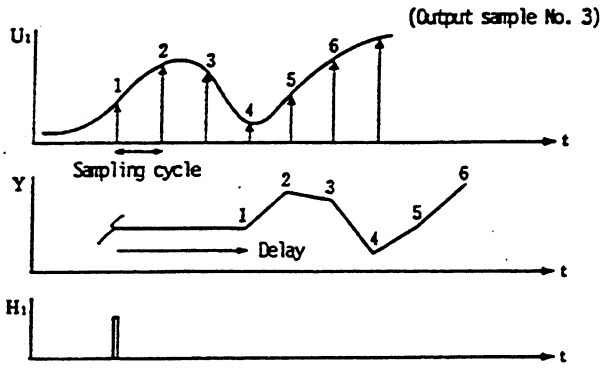


Figure 10.44 DT Function Block Output

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If the initialization flag (H1) is on, the current input value is considered to have been the value of all the previously stored values.

When H4<1.0, H4=1.0, and when H4>H2, H4=H2 are assumed for operation.

10.3.20 Move average (MAV)

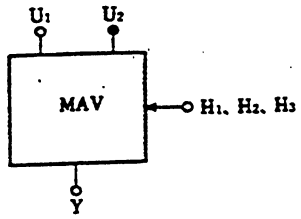


Figure 10.45 MAV Function Module

U2: Sampling cycle set flag
H1: Initialization flag
H2: No. of samples n 1 <= H2 <= 8
H3: Sampling period (in processing cycle CTS's)
1.0 <= H3 <= 2000.0

The average of the past n samples (including the current one) is output.

The output between the sampling periods is kept constant.

If initialize flag is on, the current input value is considered to have been the value of all previous values.

The sampling cycle set flag, no. of samples, sampling period, and initialization flag work the same as they do for the DT module.

10.3.21 Sampling average (SAV)

Outputs average of samples in the past n pieces (including the current one).

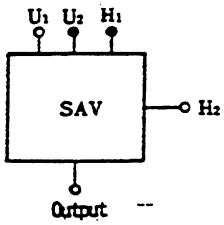


Figure 10.46 SAV Function Module

U1: Input data (sampled data)
U2: Sampling flag (timing signal)
H1: Initialization flag
H2: No. of samples n 1 <= H2 <= 8

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If H1 ≠ 0
then the output is the current value of U1.

If U2 ≠ 0
then

(i) The output is the average of n samples, the past n-1 and current one.

(ii) The sample taken n-1 times before is discarded.

(iii) The current value is used as a sample

If U2=0 the previous output value is held.

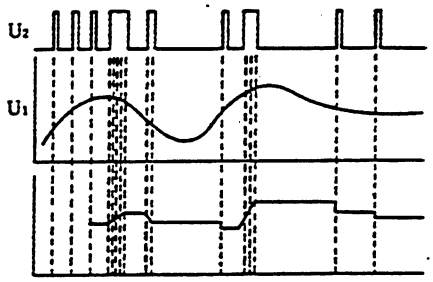


Figure 10.47 SAV Function Block Output

10.3.22 PID module (PID)

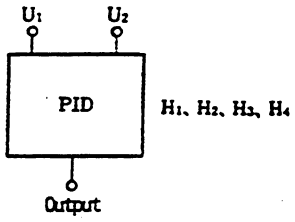


Figure 10.48 PID Function Module

The PID and MVS modules are used as a pair with the PID calculating delta MV for the MV output.

(1) Input parameters

U1: SV set point
U2: Multiplier to output (feed forward gain)
H1: Derivative constant (usually equal to 1)
H2: Bias to output (feed forward bias)
H3: Loop No. (1 - 4)
H4: PID type specification 0/1/2=PI-D/PID/I-PD

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(2) The module does its calculations using parameter and variables of the loops specified.

PV: Process variable (controlled variable)
Kp: Proportional gain (%)
Ti: Integral time (min/repeat)
Td: Differential time (sec)
Gp: Gap width (dead band on the error)
Gg: Intragap gain (gain inside dead band)
Delta T: Control cycle (integer multiple of processing cycle, CTS, to get control cycle time, CLT)
$CLT = CTS * \Delta T$

(3) PID type

For the PID module, three algorithms are available: PID, PI-D, or I-PD control. The block diagrams for the algorithms are shown in the figures below.

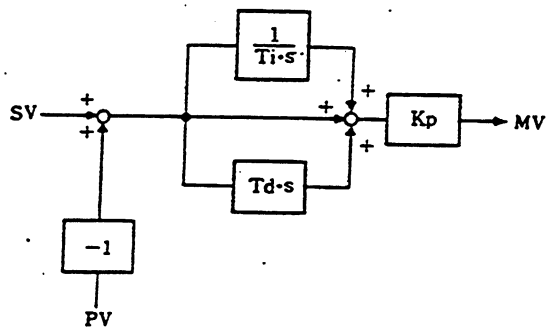


Figure 10.49 PID Control (H4 is 1) Algorithm
(Derivative on error "e" which is SV-PV)

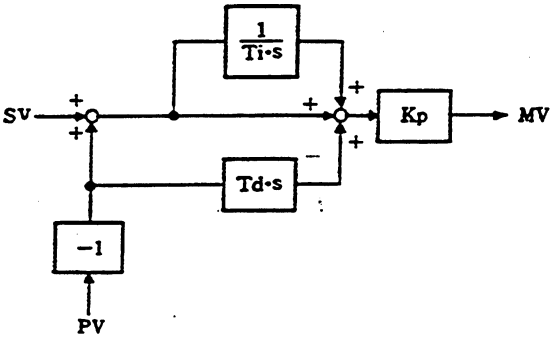


Figure 10.50 PI-D control (H4 is 0) Algorithm
(Derivative on PV)

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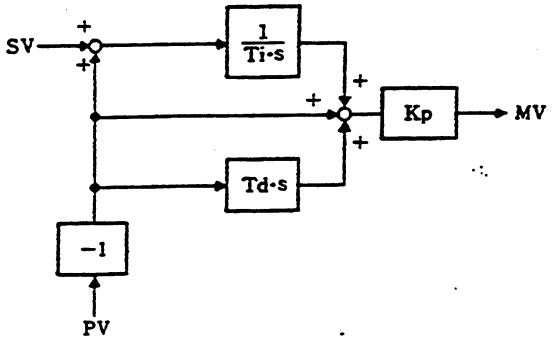


Figure 10.51 I-PD control (H4 is 2) Algorithm

(4) Control calculation

The output Y depends on the following calculations.
When in M mode and CL is 0, Y = 0.0
When in A or C mode,

delta MV = Kp (P + I + D)

$Y = U2 \times \Delta MV + H2$

where, assuming $e_n = SVn - PVn$,

$P = e_n - e_{n-1}$	(for PID, PI-D)
$P = -PV_n - (-PV_{n-1})$	(for I-PD)
$I = (\Delta T/Ti)e_n$	(if Ti ≠ 0)
$I = 0.0$	(if Ti = 0)
$D = (D_n - D_{n-1}) \times (1/H1)$	(if Td ≠ 0)
$D = 0$	(if Td = 0)
$D_n = y_n + e_n$	(for PID)
$y_{n+1} = y_n - (CLT/TdxH1)(y_n + e_n)$	D_n = present value of derivative
$D_0 = 0.0$	Y_0 = initial value of $y_n = e_0$
$y_0 = -e_n$	y_n = present value of y
$D_n = y_n - PV_n$	(for PI-D, I-PD)
$y_{n+1} = y_n - (CLT/TdH1)(y_n + PV_n)$	deviation or error (e) = SV-PV
$D_0 = 0.0$	e_n = present error
$y_0 = PV_n$	e_{n-1} = last value for error
$D = 0$	(if Td = 0)

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(5) Deviation and gap function

Deviation e=Gp [e'] is obtained for deviation data e'=SV-PV using the following gap function.

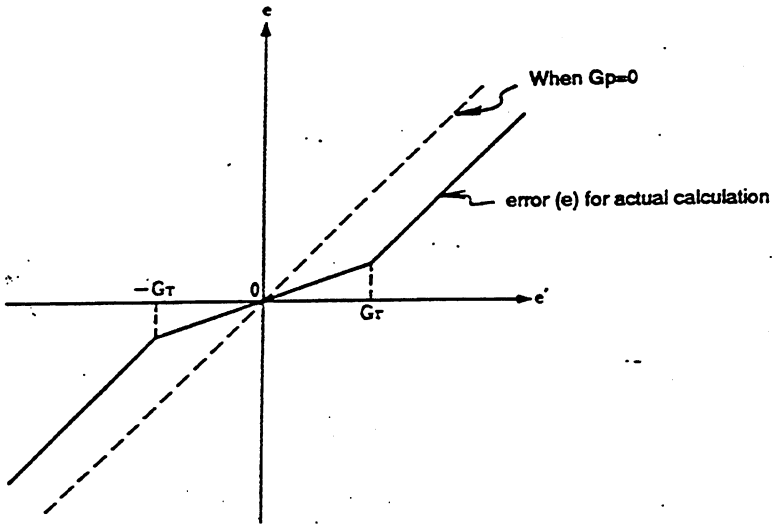


Figure 10.52 Error (e) Calculation for the PID Function Block

(6) Control cycle flag CL

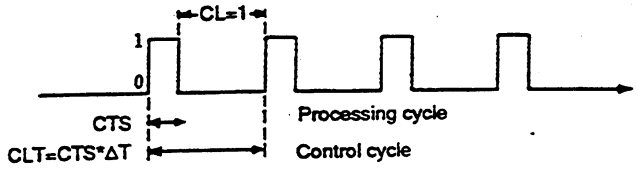


Figure 10.53 Output Timing of the PID Function Block

CL is set to 1 for one control cycle time, CLT.
When control cycle timer is reset (CINZ), CL=1 and the counter is reset.
(CINZ=INZ∨CLI∨MADCH∨CLE)

(7) Loop no.

One process controller can include PID modules for up to four loops. Only two of the manipulated variables are actually delivered externally. These outputs are fixed at MV1 and MV3.

(8) Control variable

Control variables of each control loop are defined and specified in a control table. Therefore, no definition is required in the PID module.

(9) When in direct control operation (D/R = 0) is specified, the sign of output (Y) is reversed.

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10.3.23 PID 2 module (PI2)

Same as the PID module except for the following:

(1) Deviation and gap function
Assumes that deviation error e' = |SV-PV| x (SV-PV).

10.3.24 Sample PI-module (PIS)

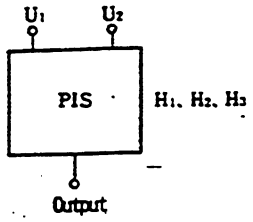


Figure 10.54 PIS Function Module

The PIS and MVS modules are used as a pair with the PIS calculating a MV for the MVS module input.

(1) Input and parameters

U1: SV set point
U2: Multiplier to output
H1: Deviative constant (usually equal to 1)
H2: Bias to output
H3: Loop No. (1-4) containing the controlled variable

(2) Performs calculation using parameters and variables of the loop specified.

PV: Controlled variable
Kp: Proportional gain (%)
Ti: Integral time (min)
T_0: Sampling cycle (sec) = Td in controller
T_1: Control operation time (sec) = Gp in the controller
CLT: Control cycle time = CTS*ΔT
One data storage area is required.

(3) There is no gap (Gp) value involved.
The deviation equation is: e = SV-PV

(4) Control operation output Y can be calculated as follows:

In the M mode, Y = 0.0
In the A or C mode, and CL is not 0;

$$\Delta MV = K_p(e_n - e_{n-1}) + I_n$$

$$Y = H1 \times \Delta MV \times U2 + H2$$

Where: In: integration term

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When Ti is not 0, $I_n=(CLT/Ti)e_n$
When Ti is 0, $I_n=0$

when CL is 0, $Y=0.0$, $e_n\text{-}1=0.0$

(5) Control period and output timing

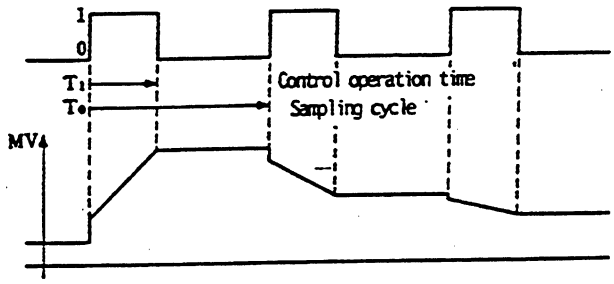


Figure 10.55 Control Period and Timing for the PIS Function Block

(6) When direct operation is concerned (D/R=0), the sign of the output (Y) is reversed.

10.3.25 Proportional control module (P)

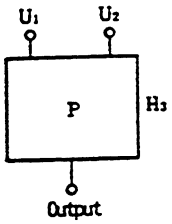


Figure 10.56 P Function Module

(1) Inputs and parameters

U1: SV set point
U2: Bias for the output equation
H3: Loop No. (1 to 4)

(2) Control operation

$$MV_n=A[(U1\text{-}PVi)+U2]+B \quad \begin{cases} A=Kp \\ B=Ti \end{cases}$$

(3) Output (y)

The input U1 is defined as the SV of the loop specified by H3.
The P function module provides high, low and rate of change limits for MVn..

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10.3.26 Ratio calculation (RB)

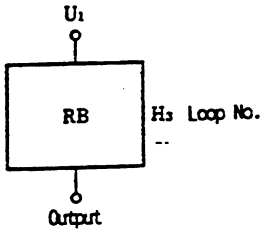


Figure 10.57 RB Function Module

Using the RATIO as BIAS of the loop specified with H3 (RT and BS), the output is defined by Y = RATIO x U1 + BIAS.

10.3.27 2 degrees of freedom PID module (FPI)

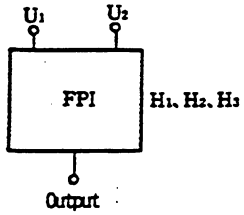


Figure 10.58 FPI Function Module

This PID control algorithm features the inclusion of a target value filter, and is designed so that response of PV to SV and PV' response to outside noise are adjusted optimally. The block diagram is as follows:

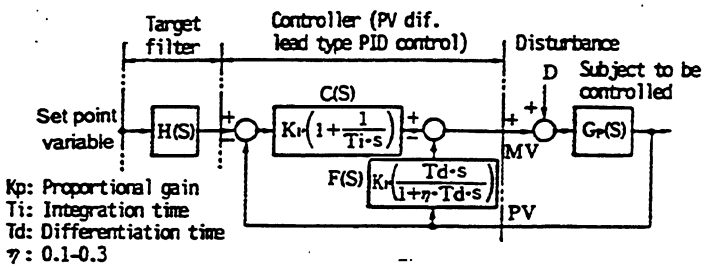


Figure 10.59 2 degrees of freedom Block Diagram

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Comparing the conventional PID response with the 2 degrees of freedom PID response to a process value change, the new method can considerably damper the overshoot.

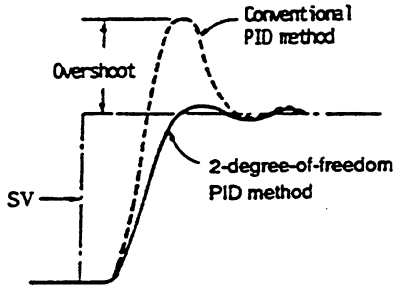


Figure 10.60 Response Comparison of Conventional/2 degrees of freedom

..Input, parameter
U1 - H3 are the same as for the PID module.

The following FPI characteristics are the same as for the PID module (see (21) above):

. Parameter of loop specified
. Deviation and gap function
. Control cycle flag CL
. When direct control operation

10.3.28 Error squared 2 degrees of freedom PID (FP2)

Same as 2 degrees of freedom PID module except for the followings:

Deviation and gap function
Deviation error e' = (SV - PV) *¦SV-PV¦

10.3.29 Panel display (LNO)

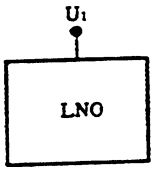


Figure 10.61 LNO Function Module

U1: display loop specification
H1: bar graph display type
H3: display loop no.
H4: loop position

Set display loops and display status on the front panel (bar graph, digital indicator) online.

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Table 10.4

		H3=0	H3≠0
U1=0	Normal	CV1, SV1, MV1	CV3, SV3, MV3
	CLR/SEL on	CV2, SV2, MV1	CV4, SV4, MV3
U1≠0	Normal	CV2, SV2, MV1	CV4, SV4, MV3
	CLR/SEL on	CV1, SV1, MV1	CV3, SV3, MV3

Table 10.5 Display mode

H1=0	Normal	Bar graph display
	CLR/SEL on	Point display
H1≠0	Normal	Point display
	CLR/SEL on	Bar graph display

Loop display position

- 0/1 = display loop 1 side (lower part)/display 2 side (upper part) See 3.2 Front Panel Operation

It is inhibited to use LNO module with BDP and BDM module.

10.3.30 Mode change prohibit module (MDI)

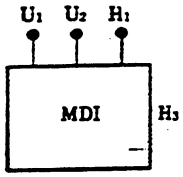


Figure 10.62 MDI Function Module

U1: When =0, prohibits change to mode M.
U2: " " A.
H1: " " C.
H3: Loop No. (1 - 4)

MDI prohibits the change of mode of the specified loop using U1, U2 and H1. Specification by MDI is priorized over the MDC module and remote operation, However, when mode priority flag is permit (set by loader), the M-mode button has a priority over MDI and M-mode change prohibition is not allowed for a displayed loop.

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10.3.31 MVS module (MVS)

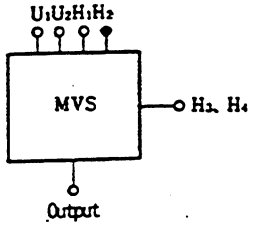


Figure 10.63 MVS Function Module

Calculates the MV in conjunction with the one of the control calculation module (PID, PI2, FP1, FP2, PIS).

(1) Inputs and parameters:

U1: delta MV, normally output of PID, PI2, FP1, FP2 or PIS control function block.
U2: Initial value of MV, used for output tracking
H1: Feed-forward input designation
H2: MV initialization/tracking request flag
H3: Loop number (1 to 4)
H4: Flag used to invalidate the delta MV addition to the output at initialization time; if H4=0, delta MV value is added to the output; if H4=1, delta MV is not added to the output.

(2) Variables for calculations:

MH : MV high limit
ML : MV low limit
DMV: MV rate of change limit value for the loop specified in H3

(3) MV calculation:

a. In the M mode: Y = MV
b. In A or C mode:

$$MV_n = \text{limit } [MV_{n-1} + \Delta MV]$$
$$Y = \text{limit } [MV_n + FF]$$

with FF being the feed-forward input specified by H1. The high, low and rate of change values for the MV output are limited by the values shown for MH, ML, and DMV specified in section 3.3.3. When the MV initialization is requested:

$$Y = \text{limit } [MV_n + FF]$$
$$MV_n = \text{limit } [U2 + \Delta MV]$$

If the invalidation of MV addition at initialization time is specified (H4=1), the value for MV is not added.

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(4) Caution about limit checks

The high (MH), low (ML) and rate of change (DMV) checks are made on the MV output only by the MVS and P control modules. When defining MV to be output without using these modules, the limiter function module (LMT) should be used.

10.3.32 MV select (MVX, MVN, MVM)

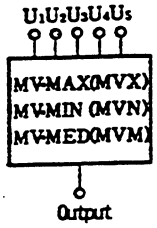


Figure 10.64 MV select Function Module

(1) Selection

The block outputs the selected input.

(2) Function of the selection blocks:

If U5=0, then an input from U1 to U4 is selected by the specified function (MAX,MIN or MED).

If U5=0, then one of the inputs (1 through 4) specified by U5 is selected regardless of the values of the U1 to U4 inputs.

(3) Select flag:

If U6=1, then SEL11 to SEL14 are set.
If U6=2, then SEL21 to SEL24 are set.
When Un (n=1 to 4) is selected, SEL(1 or 2)n=1 and the others=0.

10.3.33 Fixed MV value definition (MVF)

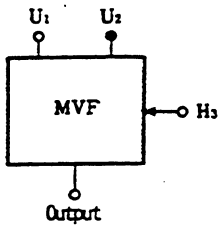


Figure 10.64 MVF Function Module

U1: MV request value
U2: MV request flag
H3: Loop No. (1 - 4)

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When a MV fixed value is requested, the value specified with U1 is output as a fixed value regardless of control mode (A/C) or control inactive setting CLI. It is possible to select by loader to enable remote operation from the panel or to output a fixed value at control mode M.

10.3.34 Digital output (DO)

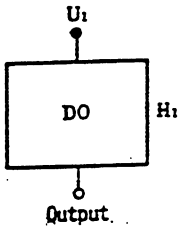


Figure 10.66 DO Function Module

U1: DO data (flag)
H1: DO No.

The DO block outputs the U1 flag status (0 or 1) to the point specified with H1 in digital form.

10.3.35 Status definition (SST)

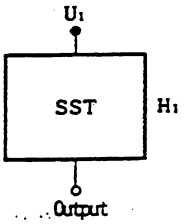


Figure 10.67 SST Function Module

The value of U1 is registered into Si, with i=1 to 16 specified by H1. Si status variables and the Y output are flag-type data and have a value of either 0 or 1. If U1=0, Si=0 and Y=0, if U1=1 and Y=1. The values of S01 to S16 can be used in any intelligent space as variables. Usually, the status registration function block creates status variables within the status space, but status variable definition is not limited to the status space.

10.3.36 Data definition (YST)

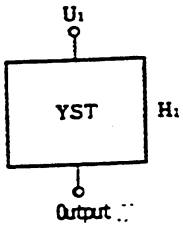


Figure 10.68 YST Function Module

H1=1 - 16 corresponds to Y01 - Y16.
U1 is the value of Y specified by H1.

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This module is required to use the block output of an intelligent space in another space.

The values of Y01 to Y16 can be used in any other intelligent space.

10.3.37 Parameter set (PMS)

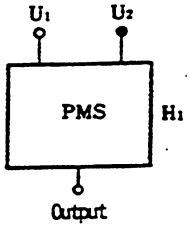


Figure 10.69 PMS Function Module

U1: data to be set
U2: request (0: not set , not 0: set)
H1: parameter specification
Y=U1

This module defines the U1 data to parameters specified with H1 when U2=0.

The example below shows how to change the Kp of loop 1 using the PV1 value.

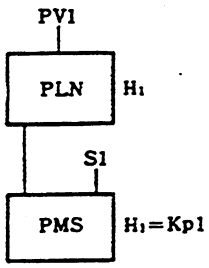


Figure 10.70 Example of PMS Function Block Usage

For this example, the value of S1 would probably be determined from a comparison module, such as GT.

Table 10.6 Parameter which can be specified with PMS module

Class	Parameter
Loop parameter	Kp, Ti, Td, Gp,Gg, RT, BS, DV, MH, ML, DMV
Analog input parameter	PH, PL, DPV
Variable parameter	DP000 - DP149
Computer flag	CMP
Scan on/off	SOF

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10.3.38 Alarm output (ALM)

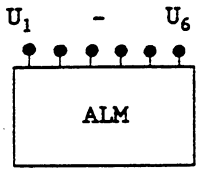


Figure 10.71 Alarm output

The alarm lamp lights when the status value of the inputs U1 to U6 parameter is 1.

When the ALM block is not configured in any space, standard conditions for the alarm is effective.

When ALM is used in configuration, routine processing is not effective, and only conditions defined by ALM take place.

$$Y = U1 \vee U2 \vee U3 \vee U4 \vee U5 \vee U6$$

10.3.39 Save/load data module (LGS, LGL) «NEW»

(for only optional expansion RAM.)

Save data module saves data to optional expansion RAM.
Load data module loads data from optional expansion RAM.
These two modules are used in a pair.

The optional expansion RAM is divided among 16 pages (#21 to #36). The size par one page is 8kB.
Page specification is H3. Write/read cycle is CTS*H4.

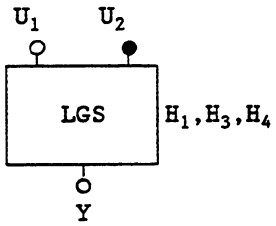


Figure 10.72 Data save

U1 : Input value
U2 : Write execution flag (When not 0, write execution.)
H1 : Initialization flag (When not 0, initialize pointer. And write from the top.)
H3 : Write page No.(#21 to 36)
H4 : Write cycle
Y : When writing, Y = 0. When stop writing, Y = 1.

Save the data of U1 on the expansion RAM.

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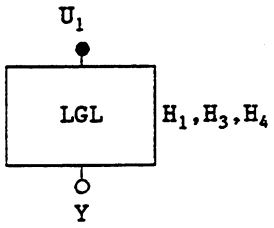


Figure 10.73 Data load

U1 : Read execution flag (When not 0, read execution.)
H1 : Initialization flag (When not 0, initialize pointer. And read feom the top.)
H3 : Read page No. (#21 to 36)
H4 : Read cycle
Y : Read data

10.3.40 Self-tuning (MAT)

The function to automatically tune a 2-freedom PID control parameter to an optimum value is called 2 degree of freedom PID self-tuning (advanced tuning - AdTune). The tuning operation consists of two processes, identification and design. 'Identification' is used to estimate dynamic characteristics, 'Design' is used to obtain an optimum control constant based on the above dynamic characteristic estimate parameter, using a method called 'practical mode matching in frequency area'.

The process loop controller provides the AdTune function with the self-tuning module MAT is configured in an intelligent space.

For AdTune tuning, PV and MV are sampled by applying a weak signal to the manipulation variable MV. Then,the tuning designs a control constant for the process dynamic characteristics estimated through the UD solving filter, using the frequency area model matching method, so that it matches a reference model.

Subsequent tuning parameter calculations using a different reference model will be done using the originally determined dynamic characteristics. See Chapter 8 Self Tuning for details about AdTune parameters.

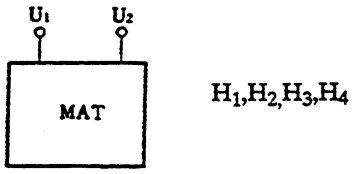


Figure 10.74 MAT Function Module

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U1: SV set point value
U2: CV process variable
H1: self tuning start request flag (flag type)
H2: MV initialization request flag (flag type)
H3: loop no. (1 - 4) (integer type)
H4: MV initial value (data type)

(1) MAT has the following three tuning functions.
-1 Setup tuning
-2 Full-tuning
-3 Re-tuning

The setup determines the values of Kp and Ti resulting from a modified version of the step Response Method by Ziegler-Nichols. These values can be set into the loop parameter table for use in control while the full-tuning is being done.

Full-tuning provides high precision tuning with the model matching method in frequency regions, and determines two degrees of freedom control constants optimum for the plant. Re-tuning re-calculates control constants by performing only "design" on the process model obtained from execution of the full-tuning. It is used for tuning with a different reference model after execution of full-tuning. Hereafter, the term "tuning" refers to these three types of tuning.

(2) Setup, tuning and control monitoring functions are preformed on loops specified using AdS and SPS.

(3) The tuning start conditions are as follows:

Table 10.7 Tuning Start Conditions

Mode	M	A/C	M	A/C	
H1	0 or 1	0 or 1	0 or 1	0	1
Setup	Y	N	N	N	N
Basic tuning	N	Y	N	N	Y
Exe. mode	Setup (ST)	Front panel (FP)	Module mode (MD)		

Setting AdS to "on" or "off" starts or stops tuning.

When AdTune is set to Module mode, the H1 parameter of the MAT module in the intelligent space determines when tuning is done.

Setup is valid while in M mode, and full-tuning is valid while in A/C mode. The start/stop request from the front panel takes the highest priority.

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(4) The tuning control constants are registered for the specific loop by changing SET to "on" from the front panel.

(5) When a GSD module is defined, the tuning control constants are entered into a schedule table under the following conditions.

When GSET (gain schedule table setting) =0, the AdTune calculated control constant are written into the scheduling table. When GSET=0, the constants must be manually set into the table.

(6) Supervisor (control monitor) function (SPS)

When SPS has been set to 1 (on) for a loop, the control monitor is in effect for that loop.

SPS judges the status of a loop control as 'stable', 'unstable' or 'faulty response'. If unstable, SPS lowers the proportional gain. If the loop response is determined to be faulty, SPC requests basic tuning (AdTune) be started for that loop (ATC LED flashes rapidly).

10.3.41 Gain Scheduling Module (GSD)

The gain scheduling function controls a control constant by switching it automatically according to scheduling level signals (level signal for short). The control constant for switching is stored according to the level signal in the scheduling table.

Table 10.8 scheduling Table

Point	U1 input	GKP	GTI	GTD	Gα
0	U1<GX1	GKP0	GTI0	GTD0	Gα0
1	GX1<=U1<GX2	GKP1	GTI1	GTD1	Gα1
~	~	~	~	~	~
8	GX8<=U1<GX9	GKP8	GTI8	GTD8	Gα8
9	GX9<=U1	GKP9	GTI9	GTD9	Gα9

A maximum of 10 pairs can be defined.

If less than 10 pairs are defined, the definition starts at GX0 and the last point of the index is set to -0.

Only one GSD module can be defined and effective in each control loop.

The conditions listed in Table 10.8 determine when scheduling is conducted.

When GSET=1 (ON), tuning control constants are written into the scheduling table. That is, the schedule table is updated.

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When GSET=0, they are not written into the scheduling table.

When more than two stages of index difference exists between the sampling start and end in AdTune, the memory table is not updated.

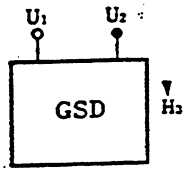


Figure 10.75 GSD Function Module

U1: Index signal
U2: Scheduling execution request (flag type)
H3: Loop No. (integer type)

The gain scheduling execution condition is shown as follows.

When Execution is YES in Table 10.9, data is transferred from the scheduling table to the control parameter.

GEXE means the gain scheduling execution specification among AdTune parameters.

Table 10.9 Gain Scheduling Execution Conditions

GEXE	0	1	2		3
U2 input	0 or 1	0 or 1	0	1	0 or 1
Execution	NO	YES	NO	YES	YES
Execution mode	Hand held terminal		Module mode		

10.3.42 Bar graph display module (BDP)

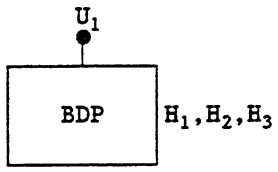


Figure 10.76 BDP Function Module

U1: execution flag (When 0, not execute. When not 0, execute.)
H1: bar graph display type (When 0, bar graph display. When not 0, point display.)
H2: display loop No. (1 to 4)
H3: bar No. (1 to 4)

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The process loop controller has four areas for bar graph display (BAR1 to 4). BDP module sets loop No. and display type to the areas. Actually, the process loop controller displays the data of the loop No. of BARn specified by BDM module.

It is inhibited to use BDP and BDM module with LNO module.

10.3.43 Bar graph display mode module (BDM)

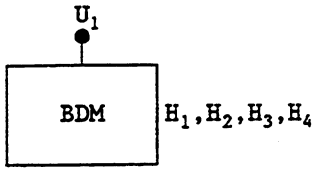


Figure 10.77 BDM Function Module

U1:execution flag (When 0, not execute. When not 0, execute.)
H1:display MV and control mode (See table 10.10)
H2:bar graph display mode (When 0, one loop display. When not 0, two loops display.)
H3:display BAR No.
- H3=0: When LOOP key is pushed, display is changed BAR1<->BAR2 or BAR3<->BAR4.
- H3=1: Display BAR1 or BAR3
- H3=2: Display BAR2 or BAR4

H4:display BAR No.
- H4=0: When LOOP key is pushed for more than one second, display is changed BAR1/BAR2<->BAR3/BAR4.
- H4=1: Display BAR1 or BAR2
- H4=2: Display BAR3 or BAR4

Table 10.10 Display data

BAR No.	Loop No.	Display loop											
		H1=0				H1=1				H1=2			
		CV	SV	MV	Mode	CV	SV	MV	Mode	CV	SV	MV	Mode
1	1	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	1	1	2	2	2	2	2	2	1	1
2	3	3	3	3	3	3	3	3	3	3	3	1	1
	4	4	4	3	3	4	4	4	4	4	4	1	1
3	1	1	1	1	1	1	1	1	1	1	1	3	3
	2	2	2	1	1	2	2	2	2	2	2	3	3
4	3	3	3	3	3	3	3	3	3	3	3	3	3
	4	4	4	3	3	4	4	4	4	4	4	3	3

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When H2=0 (one loop display), the controller displays BARn specified by H3 and H4.
When H2=0 (two loops display), the controller displays BAR2 (upper side) and BAR1 (lower side) or BAR4 (upper side) and BAR3 (lower side). It is specified by H4. BAR1/BAR3 or BAR2/BAR4 can be operated by MV arrow keys and mode key of front panel. It is specified by H3.

10.3.44 Encode (ECD) «NEW»

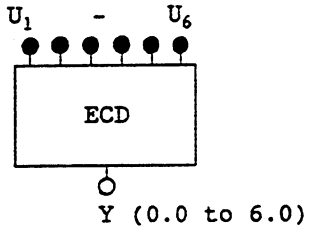


Figure 10.78 Encode

ECD module outputs the smallest number among input numbers of which input values are not 0. If all input values are 0, output is 0.

10.3.45 Binary to decimal conversion (BTD) «NEW»

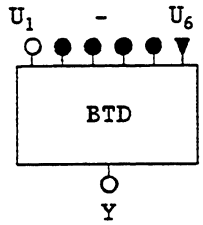


Figure 10.79 BTD function module

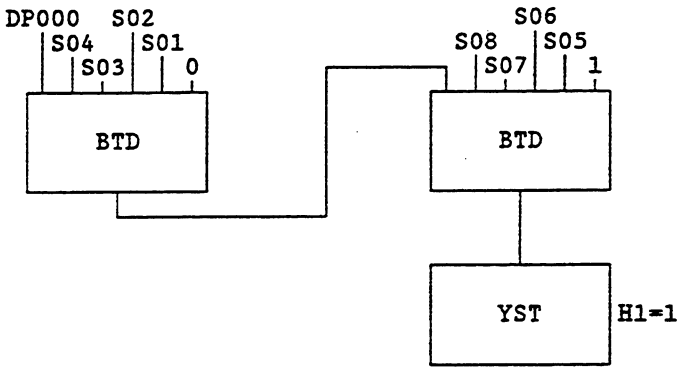
BTD module outputs the value to be converted from 4 bits binary input to decimal number.
The output is:

$$Y = U1 + (U2*2^3 + U3*2^2 + U4*2 + U5) * 2^{U6*2}$$

U1: Base input
U2 to U5: Binary inputs
U6: Packing position

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An example showing the use of the BTD module is shown below.



Y01 = decimal number of $(S08,S07,S06,S05,S04,S03,S02,S01)_2$

Figure 10.80 Example Using of BTD module

10.3.46 Decimal to binary conversion (DTB) «NEW»

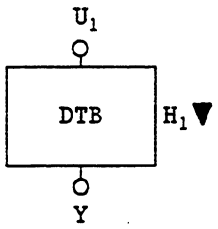


Figure 10.81 DTB Function Module

This module tests the bit to be specified by H1, after converting input to integer.
The range of input is 0 to 2^{16}-1. The fraction part is rounded down.
For example this module may be used to decode the data packed by BTD module.

U1: Decimal value
H1: Bit position (0 to 15)

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Table 10.11 Function module List of Process Loop Controller

	Function	Page	Symbol
Calculation	No operation		NOP
	Addition/subtraction		ADD
	Addition of multiple points		ADM
	Multiplication		MUL
	Division		DIV
	Absolute value		ABS
Logic arithmetic	2 input selection (switch)	119	SW
	Logical AND	120	AND
	Logical OR	120	OR
	Exclusive OR		EOR
	Signal inversion		NOT
	AND/OR	120	A/O
	OR/AND	120	O/A
	Flip-flop		FF
	Multi switch	120	MSW
Comparison	GT	121	GT
	LT	121	LT
	GE	121	GE
	LE	121	LE
	EQ		EQ
	NEQ		NEQ
	<<		GLT
	=<=<		GLE
Linearize	Square root calculation	121	ROT
	Polynomial line	122	PLN
	Inverse polynomial line	122	ILN
	Temperature correction coefficient	124	TCM
	Pressure correction coefficient	124	PCM
	Engineering unit conversion		UNT
	Engineering unit reverse conversion		Z
	Logarithm		LOG
	Exponential		EXP

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	Function	Page	Symbol
Counter timer	Totalizer	125	SUM
	Timer 1 (Retiggerable)	126	TM1
	Timer 2 (Non-retriggerable)	126	TM2
	On/off delay timer	127	DEL
	Status change detection		CHD
	Pulse counter	127	PSS
	Summing with reset (double precision)		RSM
Selector / limiter	Maximum value	128	MAX
	Minimum value	128	MIN
	Average value	128	AVE
	Median value	128	MED
	Limiter	128	LMT
	Change rate limit	129	DLM
	Encode	153	ECD
	Binary to decimal conversion	153	-BTD
	Decimal to binary conversion	154	DTB
Dynamic characteristics correction	Phase lead/delay	130	LAG
	Differential	131	DIF
	Dead time	132	DT
	Movement average	133	MAV
	Sampling average	133	SAV
	Hold		HLD
Control calculation	PID	134	PID
	Deviation squared PID	138	PI2
	Sample PI	138	PIS
	Proportional control	139	P
	Ratio control	140	RB
	2 degrees of freedom PID	140	FPI
	Error squared 2 degrees of freedom PID	141	FP2
	Panel display	141	LNO
	Mode prohibit	142	MDI

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	Function	Page	Symbol
MV processing / Alarm check	MV calculation	143	MVS
	MV max. value selection	144	MVX
	MV min. value selection	144	MVN
	MV median value selection	144	MVM
	MV fixed value output	144	MVF
	PV check specification		PCK
	Deviation check specification		DCK
Output / definition	Analog output		AO
	Digital output	145	DO
	Status definition	145	SST
	Data definition	145	YST
	Parameter definition	146	PMS
	Mode change		MDC
	Alarm output	147	ALM
	Save data	147	LGS
	Load data	147	LGL
Self-tuning	Self-tuning	148	MAT
	Gain scheduling	150	GSD
Bar graph display	Bar graph display	151	BDP
	Bar graph display mode	152	BDM
Indicator function			
Bar graph display	Bar graph display	258	BD2
	Bar graph display mode	258	BDM

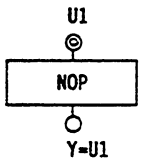
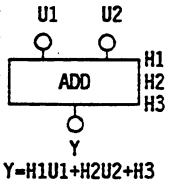
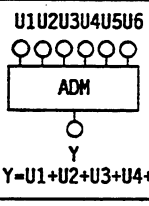
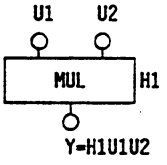
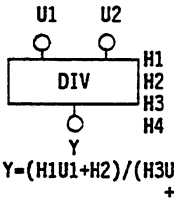
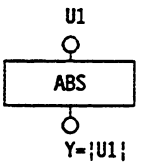
Note: Symbols such as NOP, ADM are those used when defining with the loader. They correspond to the names in up to three alphanumerics shown in the function block column on the following pages.

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(1) Arithmetic Operation

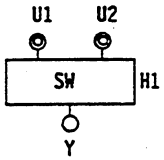
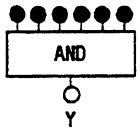
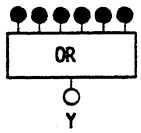
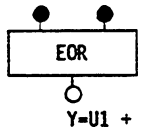
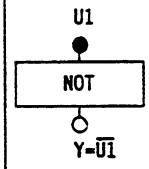
○:Data-type data
●:Flag-type data
◎:Hybrid-type data
▼:Integer-type data

Y(-1):Last calculated value for Y
. :Additional data storage areas are required, see Table 9.1

Function	Function Block	Data type	Description	Initial value
No operation		U1:hybrid	No calculation is executed	
Addition/ subtraction		U1:data U2:data H1:data H2:data H3:data	H1,H2,H3:constant	H1=DP001 H2=DP001 H3=DP000
Addition of multiple points		U1:data U2:data U3:data U4:data U5:data U6:data	Two to six inputs are acceptable. Each unassigned input is ignored at the calculation.	
Multiplica-tion		U1:data U2:data H1:data	H1:constant	H1=DP001
Division		U1:data U2:data H1:data H2:data H3:data H4:data	If H3U2+H4=0 then Y=last value calculated for Y before the denominator is 0 H1,H2,H3,H4:constant	H1=DP001 H2=DP000 H3=DP001 H4=DP000
Absolute value		U1:data	If U1 >= 0 then Y=U1 If U1 < 0 then Y=-U1	

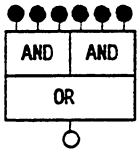
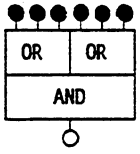
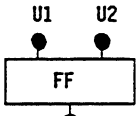
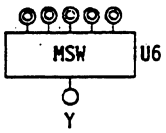
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(2) Logical Operation (1/2)

Function	Function Block	Data type	Description	Initial value
Two-input selection (SW)	 If H1=1, Y=U2 If H1=0, Y=U1	U1:hybrid U2:hybrid H1:flag	Depending upon the status (0 or 1) of the condition switch H1, data U1 or U2 is selected as block output. The flag type parameter can be specified by H1.	H1=DP000
Logical product	 Y=U1∧U2∧U3∧U4∧U5∧U6	U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	Two to six inputs are acceptable. (If all inputs=1, Y=1) Each unassigned input is ignored at the calculation.	
Logical sum	 Y=U1∨U2∨U3∨U4∨U5∨U6	U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	Two to six inputs are acceptable. (If any inputs=1, Y=1) Each unsigned input is ignored at the calculation.	
Exclusive OR	 Y=U1 + U2	U1:flag U2:flag	The exclusive logical sum of U1 and U2 is output. U1 \ U2: 0 → 0, 1; 1 → 1, 0	
Signal inversion (negation)	 Y=$\overline{U1}$	U1:flag	The flag status is changed from U1 to Y as follows: If U1=1, then Y=0 If U1=0, then Y=1	

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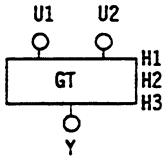
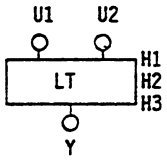
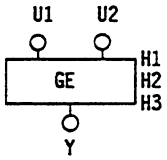
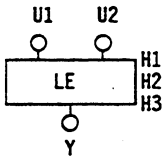
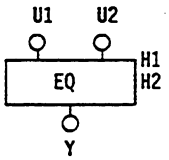
(2) Logical Operation (2/2)

Function	Function Block	Data type	Description	Initial value
AND/OR (A/O)	U1U2U3U4U5U6  Y=(U1∧U2∧U3) ∨(U4∧U5∧U6)	U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	If any input is unassigned then its input is set equal to 1. If all input is unassigned then Y=0.	
OR/AND (O/A)	U1U2U3U4U5U6  Y=(U1∨U2∨U3) ∧(U4∨U5∨U6)	U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	If all input is unassigned then Y=1. If any input is unassigned then its input is set equal to 0.	
Flip-Flop (FF)	 U1=1 ;Y=1 U1=0 U2=0;Y=Y(-1) U1=0 U2=1;Y=0	U1:flag U2:flag	U1:Set flag U2:Reset flag	
Multi switch *«NEW»*	U1U2U3U4U5  	U1:hybrid U2:hybrid U3:hybrid U4:hybrid U5:hybrid U6:data	U1 to U5 = input point U6 = input selection U6 | 1 2 3 4 5 Y | U1 U2 U3 U4 U5	U6=DP001

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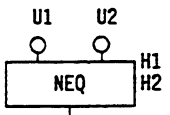
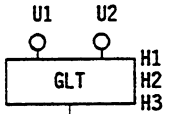
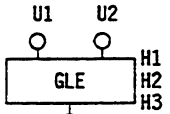
(3) Comparison (1/2)

All comparison function blocks make data comparison only.
The result of the comparison is output as flag type data (true=1, false=0)

Function	Function Block	Data type	Description	Initial value
GT (Greater than)	 If U1<H1U2+H2 then Y=1 else Y=0	U1:data U2:data H1:data H2:data H3:data	The output returns from '1' to '0' when the condition of U1<=H1U2+H2-H3 is met. H3 determines the hysteresis band.	H1=DP001 H2=DP000 H3=DP000
LT (Less than)	 If U1<H1U2+H2 then Y=1 else Y=0	U1:data U2:data H1:data H2:data H3:data	The output returns from '1' to '0' when the condition of U1>= H1U2+H2+H3 is met. H3 determines the hysteresis band.	H1=DP001 H2=DP000 H3=DP000
GE (Greater than or equal to)	 If U1>=H1U2+H2 then Y=1 else Y=0	U1:data U2:data H1:data H2:data H3:data	The output returns from '1' to '0' when the condition of U1<H1U2+H2-H3 is met. H3 determines the hysteresis band.	H1=DP001 H2=DP000 H3=DP000
LE (Less than or equal to)	 If U1<=H1U2+H2 then Y=1 else Y=0	U1:data U2:data H1:data H2:data H3:data	The output returns from '1' to '0' when the condition of U1>H1U2+H2+H3 is met. H3 determines the hysteresis band.	H1=DP001 H2=DP000 H3=DP000
EQ (Equal to)	 If U1=H1U2+H2 then Y=1 else Y=0	U1:data U2:data H1:data H2:data		H1=DP001 H2=DP000

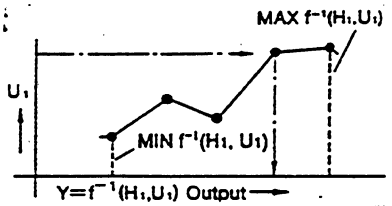
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(3) Comparison (2/2)

Function	Function Block	Data type	Description	Initial value
NEQ (Not equal)	 If U1=H1U2+H2 then Y=1 else Y=0	U1:data U2:data H1:data H2:data		H1=DP001 H2=DP000
<<	 If H1U2+H2<U1 <H3U2+H4 then Y=1 else Y=0	U1:data U2:data H1:data H2:data H3:data H4:data		H1=DP001 H2=DP000 H3=DP001 H4=DP000
<=<=	 If H1U2+H2<=U1 <=H3U2+H4 then Y=1 else Y=0	U1:data U2:data H1:data H2:data H3:data H4:data		H1=DP001 H2=DP000 H3=DP001 H4=DP000

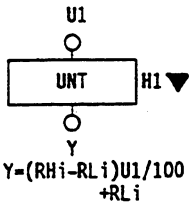
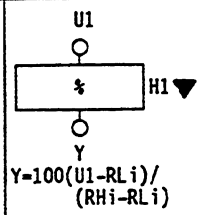
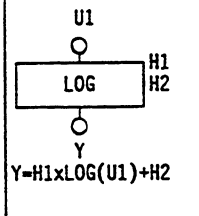
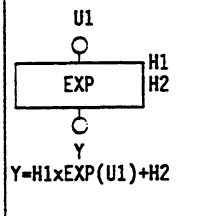
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(4) Linearize (1/2)

Function	Function Block	Data type	Description	Initial value
Square root extraction	U1 U2 ROT H1 H2 Y $Y=H1\sqrt{U1xU2}$	U1:data U2:data H1:data H2:data	Y=H1 U1xU2 (When U1xU2<=0, Y=0) H2:Setting of low cut When U1<H2, the calculation is made on the condition of U1=0. The low cut is not performed when H2=0.	H1=DP008 (10) H2=DP000
Polynomial line conversation	U1 PLN H1▼ Y=f(H1,U1) H1:Table number (1 - 6) U1:Variable	U1:data H1:int.	If U1 is outside the area defined by the polynomial line tables, the values output will be on the dashed lines indicated in the diagram below.	H1=1
Inverse polynomial line conversion	U1 U2 ILN H1▼ Y=f (H1,U1) H1:Table number (1 - 6) U1:Variable	U1:data U2:flag H1:int.	Polynomial line inverse function If U2=0 then Y=MIN[f^{-1}(H1,U1)] else Y=MAX[f^{-1}(H1,U1)] 	H1=1
Temperature compensation	U1 U2 TCM H1▼ H2 H3 Y Y=U1x(H2+H3)/ {(Eng.value of H1) +H3}	U1:data U2:data H1:int. H2:data H3:data	This is used for temperature compensation. H1:Input code H2:Design temperature(Td) H3:Constant The constant of H3 is 273.15(deg C) or 459.4(deg F). H1=0;use engineering unit U2 data H1=1 to 6;PV1 to PV6	H1=1 H2=DP009 (100) H3=DP004 (273.15)
Pressure compensation	U1 U2 PCM H1▼ H2 H3 Y Y=U1x{(Eng.value of H1)+H3}/(H2+H3)	U1:data U2:data H1:int. H2:data H3:data	This is used for pressure compensation. H1:Input code H2:Design pressure(Pd) H3:Constant The constant of H3 is 1.0332(kg/cm2), 101.3(kPa) or 14.72(PSIG). H1=0;Engineering unit data of U2 H1=1 to 6;PV1 to PV6	H1=1 H2=DP008 (10.0) H3=DP006 (1.0332)

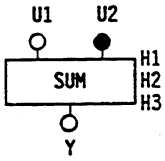
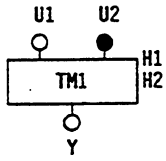
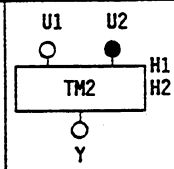
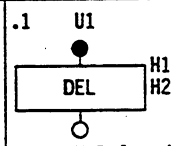
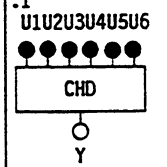
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(4) Linearize (2/2)

Function	Function Block	Data type	Description	Initial value
Engineering unit conversion		U1:data H1:int.	This is used for the engineering unit conversion. RLi:Lower limit of instrument range for H1 RHi:Higher limit of instrument range for H1 H1 :Input code 1 to 6 : PV1 to PV6	H1=1
Percent conversion		U1:data H1:int.	This is used for the percent unit conversion. RLi:Lower limit of instrument range for H1 RHi:Higher limit of instrument range for H1 H1 :Input code 1 to 6 : PV1 to PV6	H1=1
Natural Logarithm		U1:data H1:data H2:data		H1=DP001 H2=DP000
Exponential		U1:data H1:data H2:data		H1=DP001 H2=DP000

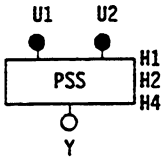
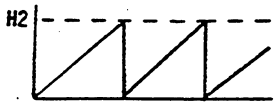
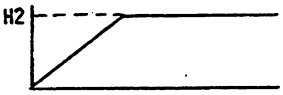
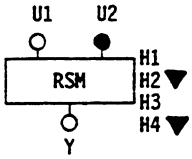
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(5) Counter Timer (1/2)

Function	Function Block	Data type	Description	Initial value
Totalizer (Summer)	 U1:Data U2:Initialization flag	U1:data U2:flag H1:data H2:data H3:data	This is used for flow totalization, program pattern timing generation, etc. If U2=1, then: Y=H1+(H2xU1+H3) [Initialized state] If U2=0, then: Y=Y(-1)+(H2xU1+H3) [Totalization] Y(-1):Last calculated value for Y	H1=DP000 H2=DP001 H3=DP000
Timer 1 (Retrigger type)	 U1:Set time (sec) U2:Reset flag H1,H2;Set time coefficient	U1:data U2:flag H1:data H2:data	If U2=1, then Y=H1U1+H2 Initialization value If U2=0, then Y=Y(-1)-CTS If Y<0, then Y=0	H1=DP001 H2=DP000
Timer 2 (Non-retrigger type)	 U1:Set time (sec) U2:Reset flag H1,H2:Set time coefficient	U1:data U2:flag H1:data H2:data	If Y(-1)>0, then Y=Y(-1)-CTS but if Y<0, Y=0 for U2=0, else if U2=1, then Y=H1U1+H2 Initialization value	H1=DP001 H2=DP000
On/off delay timer		U1:flag H1:data H2:data	H1:Delay on (sec) H2:Delay off (sec)	H1=DP000 H2=DP000
Status change detection		U1:data U2:data U3:data U4:data U5:data U6:data	At the rising point of input from U1 to U6, the output is turned ON for one processing cycle(Y). Usually only rising point is detected. When falling point should be detected, invert input.	

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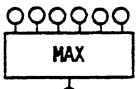
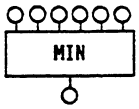
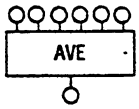
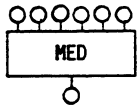
(5) Counter Timer (2/2)

Function	Function Block	Data type	Description	Initial value
Pulse counter «NEW»		U1=flag U2=flag H1=data H2=data H4=flag	For pulse input count. Can be used only with optional Pulse input module. U1:Hold flag U2:Reset flag H1:Ratio H2:Priset value H4:Operate mode Y :H1*Count value When U1 is not 0, the count will stop. When U2 is not 0, the count will be cleared 0. When H4 is 0, free run mode.  When H4 is not 0, single mode. 	H1=DP001 H4=DP000
Double precision totalizer (Summer)		U1:data U2:flag H1:data H2:int. H3:data H4:int.	If U2=1 then:Y=H1+U1(CTS/K) [Initialized state] If U2=0 and Y<H3 then:Y=Y(-1)+U1(CTS/K) [Totalization] Y(-1):Last calculated value for Y If U2=0 and Y>=H3 then:Y=Y(-1)+U1(CTS/K)-H3 H2:Time unit (0/1/2:sec/min/hour) H3:Auto reset point H4:Output precision (0/1/2/3/4:1/0.1/0.01/0.001/0.0001) K=1/60/3600, when H2=0/1/2	H1=DP000 H2=0 H3=DP000 H4=0

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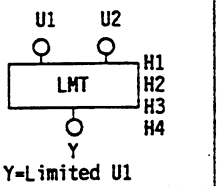
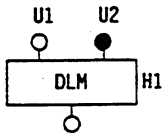
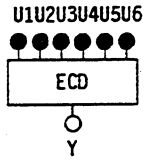
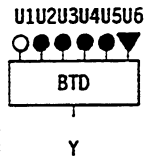
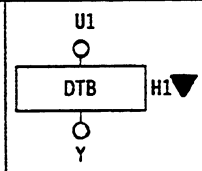
(6) Selector Limiter (1/2)

Selection is made excluding inactive signals such as sensor errors.
If all inputs are inactive, Y=Y(-1) (last calculated value for Y)

Function	Function Block	Data type	Description	Initial value
Maximum value	U1U2U3U4U5U6  Y Y=MAX(U1,U2,...,U6)	U1:data U2:data U3:data U4:data U5:data U6:data	Two to six inputs are acceptable. Maximum value of U1 - U6 is output as Y.	
Minimum value	U1U2U3U4U5U6  Y Y=MIN(U1,U2,...,U6)	U1:data U2:data U3:data U4:data U5:data U6:data	Two to six inputs are acceptable. Minimum value of U1 - U6 is output as Y.	
Mean value	U1U2U3U4U5U6  Y Y=(U1+U2+...+Ui)/i	U1:data U2:data U3:data U4:data U5:data U6:data	(U1+U2+U3+U4+U5+U6)/i where i=2 to 6 inputs	
Median value	U1U2U3U4U5U6  Y Y=Median(U1,...,U6)	U1:data U2:data U3:data U4:data U5:data U6:data	Median value of U1,U2,U3,U4,U5,U6. When the number of inputs is even, the smaller of the two medians is output as Y.	

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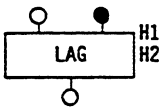
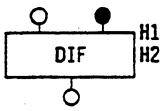
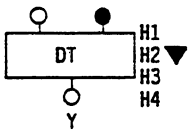
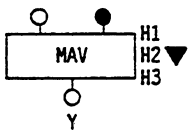
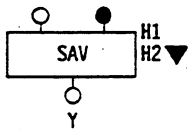
(6) Selector Limiter (2/2)

Function	Function Block	Data type	Description	Initial value
Limiter	 Y=Limited U1 (U1 limited at high and low points)	U1:data U2:data H1:data H2:data H3:data H4:data	Condition expression 1)If H1U2+H2<=U1<=H3U2+H4, then Y=U1 2)If H1U2+H2>U1 then Y=H1U2+H2 3)If H3U2+H4<U1 then Y=H3U2+H2	H1=DP001 H2=DP000 H3=DP001 H4=DP000
Changing rate limiter	 Y=Limitted U1 (U1 is limited)	U1:data U2:flag H1:data	H1:Changing rate limit value (%/CTS) U2:Inverted initialization flag When U2=1, 1)If U1-Y(-1)<=H1, then Y=U1 2)If U1-Y(-1)>H1, then Y=Y(-1)+H1 3)If Y(-1)-U1>H1, then Y=Y(-1)-H1 When U2=0, Y=U1 If INZ=0 (at initialization time), Y=U1. Y(-1):Last calculated value for Y.	H1=DP001
Encode «NEW»		U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	If U1=U2=U3=U4=U5=U6=0, then Y=0 else Y=i (i=1 to 6) i is the smallest among input No. of which values <> 0.	
Binary to decimal conversion «NEW»		U1:data U2:flag U3:flag U4:flag U5:flag U6:int.	Y=U1+(U2*2^3+U3*2^2+U4*2+U5)*2^(U6*2)	
Decimal to binary conversion «NEW»		U1:data H1:int.	If H1 bit of U1=0, then Y=0 else Y=1	

NOTE:Function blocks MAX, MIN, AVE, MED and ECD accept from 0 - 6 inputs.

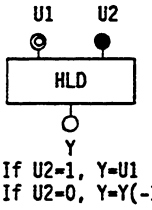
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(7) Dynamic Characteristics Compensation (1/2)

Function	Function Block	Data type	Description	Initial value
Lead/Lag (LAG)	.1 U1 U2  Y={1+(H1S)}/ {1+(H2S)}	U1:data U2:flag H1:data H2:data	H1:Gain parameter, change gain = (H1-H2)/H1 H2:Lead/lag time constant (sec) U2:Initialize flag =0 Not requesting initialization =1 Requesting initialization S :Internal LaPlace Transform If INZ=0 or U2=1, then Y=U1 else Y=calculated value.	H1=DP001 H2=DP001
Differential (DIF)	.1 U1 U2  Y=(H1S)/{1+(H2S)}	U1:data U2:flag H1:data H2:data	H1:Gain parameter, gain = H1/H2 H2:Differential time (sec) U2:Initialization flag =0 Not requesting initialization =1 Requesting initialization If INZ=0 or U2=1, then Y=0 else Y=calculated value S :Internal LaPlace Transform	H1=DP001 H2=DP001
Dead time	.4 U1 U2  Y=Previous U1	U1:data U2:flag H1:flag H2:int. H3:data H4:data	If H1=1 or INZ=0 then initialization, Y=U1 and all previous U1=present U1 else Y=Delayed and interpolated signal Delay time=H2xH3xCTS U1:Input data U2:Sampling cycle set flag H1:Initialization flag H2:No. of samples (Max. 16 samples) H3:Sampling period (in CTS's) H4:No. of output samples	H1=DP000 H2=1 H3=DP001 H4=DP001
Moving average	.2 U1 U2  Y=moving average	U1:data U2:flag H1:flag H2:int. H3:data	If H1=1 or INZ=0 then Y=U1 and all previous U1=present U1 else Y=moving average U1:Input data U2:Sampling cycle set flag H1:Initialization flag H2:No. of samples (Max. 8 samples) H3:Sampling period (In CTS's)	H1=DP000 H2=1 H3=DP001
Sampling average	.2 U1 U2  Y=averaged value of n samples	U1:data U2:flag H1:flag H2:int.	If H1=1 or INZ=0 then Y=U1 and all previous U1=present U1 else Y=averaged value of n samples U1:Input data U2:Sampling timing signal H1:Initialization flag H2:No. of samples (Max. 8 samples)	H1=DP000 H2=1

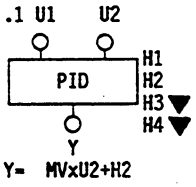
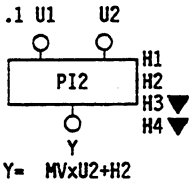
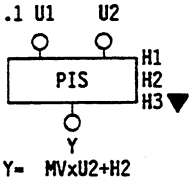
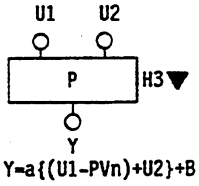
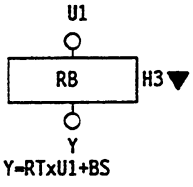
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(7) Dynamic Characteristics Compensation (2/2)

Function	Function Block	Data type	Description	Initial value
Hold	 If U2=1, Y=U1 If U2=0, Y=Y(-1)	U1:hybrid U2:flag	If U2=0 then Y=Y(-1),the last value at U1 If U2=1 then Y=present value of U1	

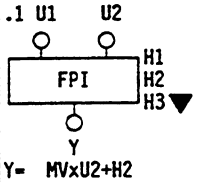
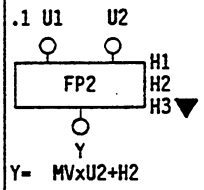
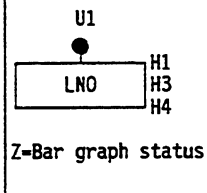
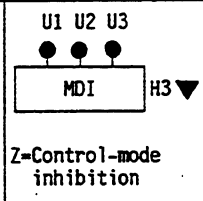
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(8) Control Operation (2/1)

Function	Function Block	Data type	Description	Initial value
PID		U1:data U2:data H1:data H2:data H3:int. H4:int.	U1:SV U2:Multiplier to output H1:Derivative constant H2:Bias to output H3:Loop number (1 - 4) H4:Differential type 0=PI-D 1=PID 2=IPD	U2=DP001 H1=Dp001 H2=DP000 H3=1 H4=0
Error squared PID		U1:data U2:data H1:data H2:data H3:int. H4:int.	Same as PID module	U2=DP001 H1=DP001 H2=DP000 H3=1 H4=0
Sample PI		U1:data U2:data H1:data H2:data H3:int.	Same as block 70 except there is no differential type option (H4)	U2=DP001 H1=DP001 H2=DP000 H3=1
Proportional control		U1:data U2:data H3:int.	U1:SV H2:Compensation input H3:Loop number (1 - 4) A=Kp B=Ti Y=MV If the P function block is used, the MVS function block is not used for the controller output.	U2=DP000 H3=1
Ratio control		U1:data H3:int.	U1:Input H3:Loop number (1 - 4) RT=Ratio BS=Bias	H3=1

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(8) Control Operation (2/2)

Function	Function Block	Data type	Description	Initial value
Two-degree-of-freedom PID		U1:data U2:data H1:data H2:data H3:int.	U1:SV U2:Multiplier to output H1:Derivative constant H2:Bias to output H3:Loop number Y= MV (compensation value)	U2=DP001 H1=DP001 H2=DP000 H3=1
Error squared two-degree-of-freedom PID		U1:data U2:data H1:data H2:data H3:int.	Same as FPI	U2=DP001 H1=DP001 H2=DP000 H3=1
Loop number designation		U1:flag H1:flag H3:flag H4:flag	This is used to make switching online of the SV and PV values on the bar graph and digital display. The switching involves different loops H1:Display mode specification H3:Display loop number H4:Loop position [Display Loop Specification] See 10.3.29	H1=DP000 H3=DP000 H4=DP000
Mode inhibit		U1:flag U2:flag U3:flag H3:int.	U1=1:M mode is inhibited for H3 loop U2=1:A mode is inhibited for H3 loop U3=1:C mode is inhibited for H3 loop H3 :Loop number (1 - 4)	H3=1

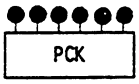
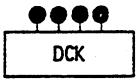
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(9) MV Processing

Function	Function Block	Data type	Description	Initial value
MV calculation	U1 U2 MVS H1 H2 H3 H4 Y Y=MV(n)+U2 MV(n)=MV(n-1)+U1	U1:data U2:data H1:data H2:flag H3:int. H4:flag	U1: MV U2:MV initialization value H1:Feed forward input H2:MV initialize flag H3:Loop number (1 - 4) H4:Specification to ignore MV at initialization If H2=1, initialization of Y If H2=0, at control time.	H1=DP000 H2=DP000 H3=1 H4=DP000
Max. MV selector	U1U2U3U4U5U6 MVX Y Y=MAX(U1,U2,U3,U4) (at U5=0) Z=SELmn (m=U6)	U1:data U2:data U3:data U4:data U5:data U6:int.	If U5=0 then Y=MAX(U1,U2,U3,U4) else Y=input specified by U5 SELmn=1 (m=U6,n=selected Un) SELmk=0 (m=U6,k=not selected Uk) (U6:1 - 2)	U5=DP000 U6=1
Min. MV selector	U1U2U3U4U5U6 MVN Y Y=MIN(U1,U2,U3,U4) (at U5=0) Z=SELmn (m=U6)	U1:data U2:data U3:data U4:data U5:data U6:int.	If U5=0 then Y=MIN(U1,U2,U3,U4) else Y=input specified by U5 SELmn=1 (m=U6,n=selected Un) SELmk=0 (m=U6,k=not selected Uk) (U6:1 - 2)	U5=DP000 U6=1
Median MV selector	U1U2U3U4U5U6 MVM Y Y=MED(U1,U2,U3,U4) (at U5=0) Z=SELmn (m=U6)	U1:data U2:data U3:data U4:data U5:data U6:int.	If U5=0 then Y=MED(U1,U2,U3,U4) else Y=input specified by U5 SELmn=1 (m=U6,n=selected Un) SELmk=0 (m=U6,k=not selected Uk)	U5=DP000 U6=1
Fixed MV output	U1 U2 MVF H3 Z={MVn=U1}	U1:data U2:flag H3:int.	U1:MV request value U2:MV request flag H3:Loop number (1 - 4)	H3=1

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(10) Alarm Check

Function	Function Block	Data type	Description	Initial value
PV check	U1U2U3U4U5U6  Zi={PViCK=Ui}	U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	If U1=1, then:the upper limit, lower limit, and rate of change alarm checks on PVi are made. (PViCK is set to 1) else:the upper limit, lower limit, and rate of change alarm checks on PVi are not made. (PViCK is set to 0)	
Deviation check	U1U2U3U4  Zi={DVi=Ui}	U1:flag U2:flag U3:flag U4:flag	If Ui=0 then:the i loop deviation alarm check is not made.(DVi=0) else:the i loop deviation alarm check is made.(DVi=1) (deviation=rate of change)	

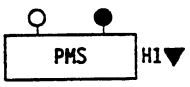
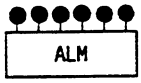
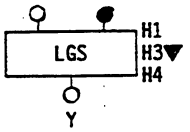
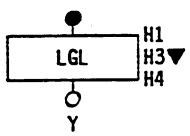
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(11) Output, Definition (1/2)

Function	Function Block	Data type	Description	Initial value
Analog output	U1 ○ AO H1▼ ○ Y=U1 Z=[AOn=U1] H1:Output point 1 for AO1 2 for AO2	U1:data H1:int.	The value of U1 ranging from 0 to 100% is converted analog output in the range of 1-5 VDC. An output value between 0V and 1V can be generated by inputting a negative value.	H1=1
Digital output	U1 ● DO H1▼ ○ Y=U1 Z=[DOn=U1] H1:Output point 1 for DO1 2 for DO2 3 for DO3 4 for DO4	U1:flag H1:int.	The status (0 or 1) of the U1 flag is digitally output to the point specified by H1.	H1=1
Status registration	U1 ● SST H1▼ ○ Y=U1 Z=[Si=U1] H1:Flag number i=1 to 16	U1:flag H1:int.	The U1 data is set into the status flag Si (i=H1:1 to 16). When U1=0, Y=0 When U1=1, Y=1	H1=1
Data registration	U1 ○ YST H1▼ ○ Y=U1 Z=[Yi=U1] H1:Data number i=1 to 16	U1:data H1:int.	U1 data is registered as variable Yi (i=H1:1 to 16). Y=U1	H1=1

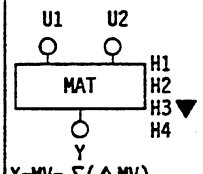
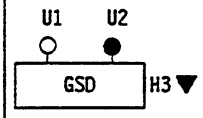
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(11) Output, Definition (2/2)

Function	Function Block	Data type	Description	Initial value
Parameter set	U1 U2  Z={Specified parameter=U1}	U1:data U2:flag H1:var.	U1:Data to be set U2:Request flag H1:Parameter specification (see Table 10.7)	H1=DP010
Mode change	U1 U2  Z=Control mode U1:Mode assign U2:Request flag H3:Loop No.(1 - 4)	U1:data U2:flag H3:int.	Control mode is switched as opacified by the U1 input. U2=0 : Not requesting mode change =1 : Requesting mode change U1 : Mode specification =1 : M =2 : A =3 : C U1 values other than 1 to 3 are ignored.	H3=1
Alarm output	U1U2U3U4U5U6  Z={Output to the alarm LED =U1 U2 U3 U4 U5 U6}	U1:flag U2:flag U3:flag U4:flag U5:flag U6:flag	If U1 to U6 is on, alarm LED on the front panel lights. When the ALM function block is used, only those variables registered for each input are targeted for ALM LED.	
Data save «NEW»	.1 U1 U2  	U1:data U2:flag H1:flag H3:int. H4:data	It saves data to optional expansion RAM. U1:Input value U2:Write execution flag (When not 0, write execution.) H1:Initialization flag (When not 0, write from the top.) H3:White page No. (#21 to #36) H4:Write cycle (CTS*H4) Y :When writing, Y is 0. When stop writing, Y is 0.	H1=DP000 H4=DP001
Data load «NEW»	.1 U1  	U1:flag H1:flag H3:int. H4:data	It loads data to optional expansion RAM. U1:Read expansion flag (When not 0, read execution.) H1:Initialization flag (When not 0, read from the top.) H3:Read page No. (#21 to #36) H4:Read cycle (CTS*H4) Y :Read data	H1=DP000 H2=DP001

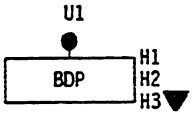
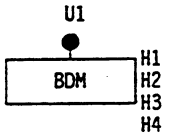
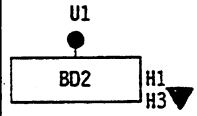
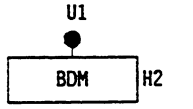
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(12) Self-tuning

Function	Function Block	Data type	Description	Initial value
Self-tuning		U1:data U2:data H1:flag H2:flag H3:int. H4:data	U1:SV U2:CV H1:ON(1)/OFF(0) self tuning H2:MV initialization flag H3:Loop number (1 - 4) H4:MV initial value Y :Manipulated volume MV (See 10.3.41)	H1=DP000 H2=DP000 H3=1
Gain scheduling		U1:data U2:flag H3:int.	U1:Scheduling input U2:ON(1)/OFF(0) scheduling H3:Loop number (1 to 4)	H3=1

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(13) Bar graph display

Function	Function Block	Data type	Description	Initial value
Bar graph display		U1:flag H1:flag H2:data H3:int.	U1:Execution flag H1:Bar graph display(0)/point display(1) H2:Loop number H3:BAR number (1 - 4) If U1=1 then BARn is registered.(n=H3)	H1=DP000 H2=DP001 H3=1
Bar graph display mode		U1:flag H1:data H2:flag H3:data H4:data	U1:Execution flag H1:Display MV and mode H2:One loop display(0)/two loop display(1) H3:Display BAR number H4:Display BAR number	H1=DP000 H2=DP000 H3=DP000 H4=DP000
Indicator mode				
Bar graph display «NEW»		U1:flag H1:flag H3:int.	U1:Execution flag H1:Bar graph display(0)/point display(1) H3:BAR number (1 - 6) If U1=1 then BARn is registered.(n=H3)	H1=DP000 H3=1
Bar graph display mode «NEW»		U1:flag H2:flag	U1:Execution flag H2:0:Three points display 1:Six points display	H2=DP000

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11. Program Application Examples

This chapter introduces how to use each intelligent space with examples of usage of a process loop controller. Although these examples seem to be typical, processing methods are only for reference, and may not be the best method for your system.

11.1 Gas Flow Control with Temperature Compensation (feedback control)

The example below shows how to calculate temperature compensation of a gas flow and to control a constant value of flow rate.

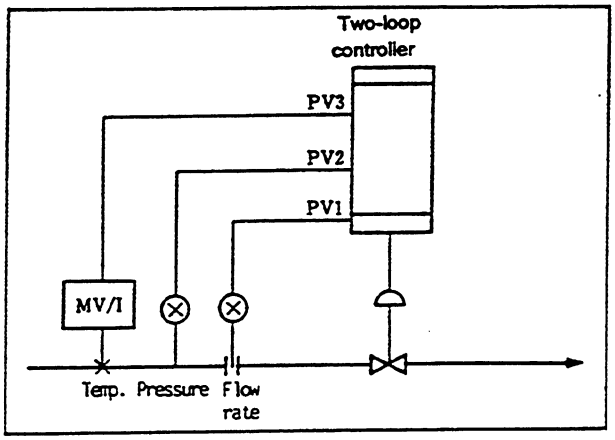


Figure 11.1 Gas Flow Rate Control

In this case, the following space processing is enough.

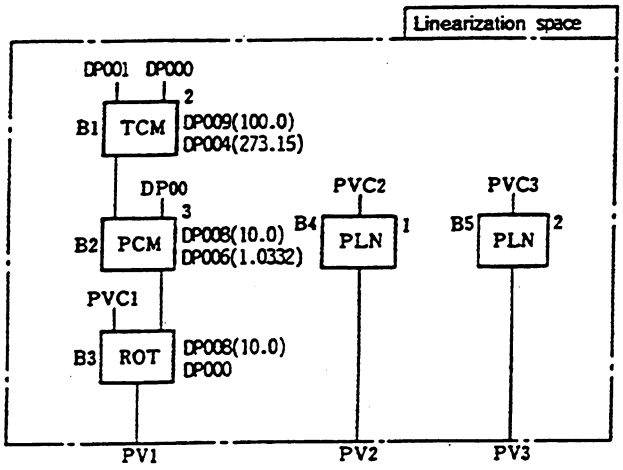
Linearization space: Linearization of thermocouple (polynomial line)
Temperature compensation of the flow rate

Control space: PID control

(1) **Linearization space**

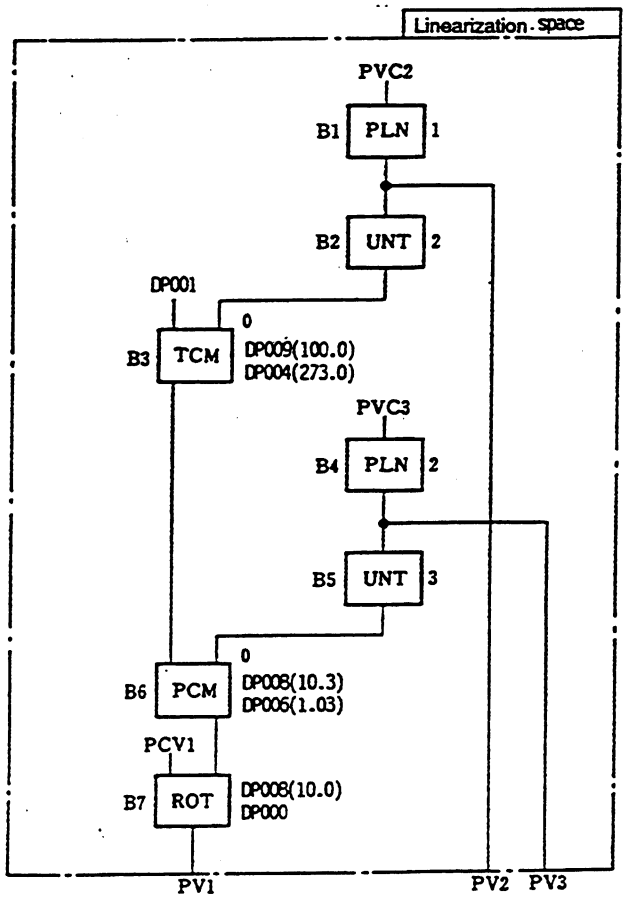
PV1: control variable (flow rate)
PV2: temperature input
PV3: pressure input

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In the linearization space diagram to the right, blocks B4 and B5 define PV2 and PV3 that are used in the TCM/PCM modules. Since PV2 and PV3 are space outputs, the values that are used for TCM/PCM are taken from the previous cycle's linearization space output.
To use the current PV2 and PV3 values for compensations, it is necessary to make changes as follows.

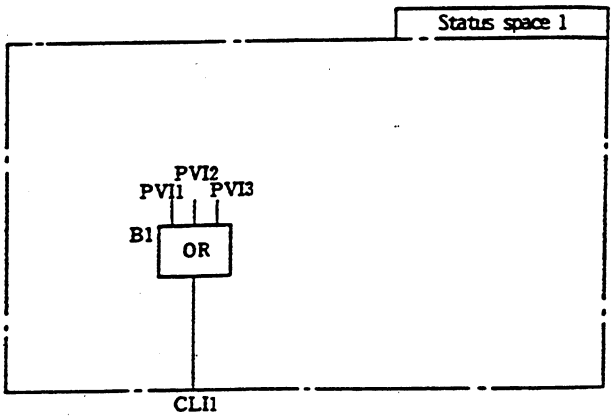
Polynomial line tables 1 and 2 are to be for linearizing PV2 and PV3. The range of Y must be 0.0 - 100.0%



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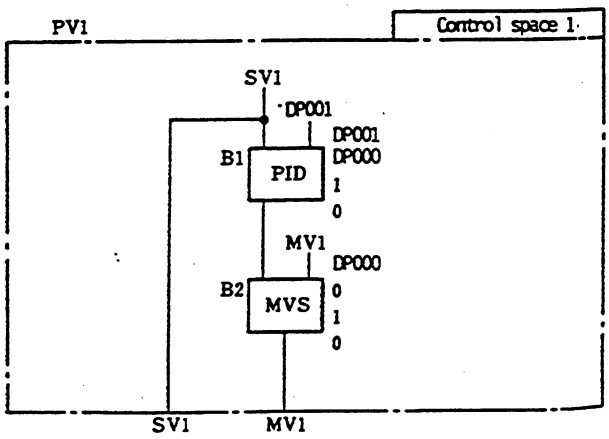
(2) Status spaces

If no processing is defined in a status space, the initial values determine the control execution conditions. A sensor error for any active input will cause a HALT of operation.



(3) Control space

PV1 is the control variable (defined in a parameter table)



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11.2 Cascade Control

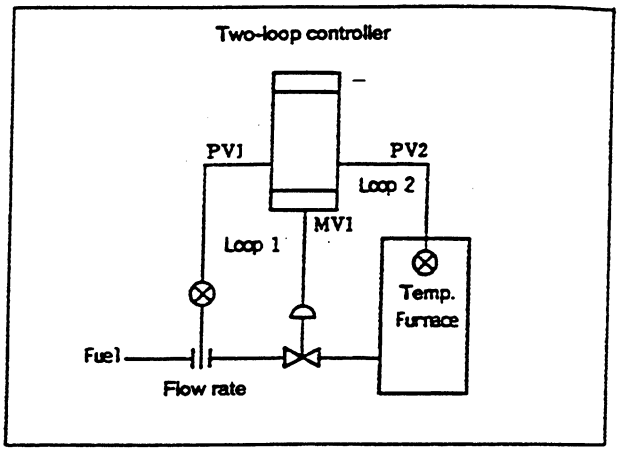


Figure 11.2 Cascade control

This subsection shows how to set up a control scheme for temperature and flow rate by using cascade of process loop controller.

Operation of process loop controller:

(i) The panel display shows fuel flow rate in mode A, and temperature in mode C. In mode M, it shows temperature (PV2).

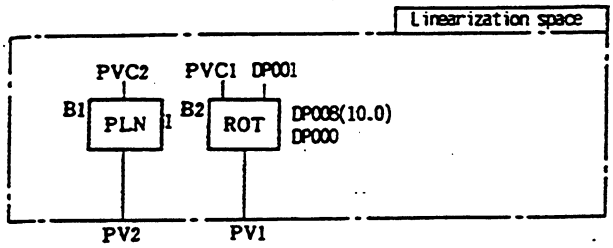
(ii) For bumpless operation, when entering mode C. the MV value of the primary loop (MV2) is forced to equal the PV value of the secondary loop (PV1).

As space processing:

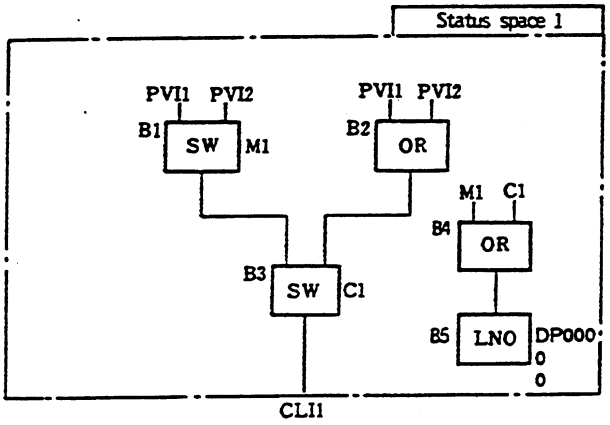
Linearization space:	Thermocouple conversation flow rate extraction
Status space:	Check required for fuel in mode A, temperature in mode M, both in mode C.
Control space:	Control including bumpless operation
Loop 1:	Secondary loop
Loop 2:	Primary loop
PV1:	Control variable of loop No. 1 (flow rate)
PV2:	Control variable of loop No. 2 (temperature)

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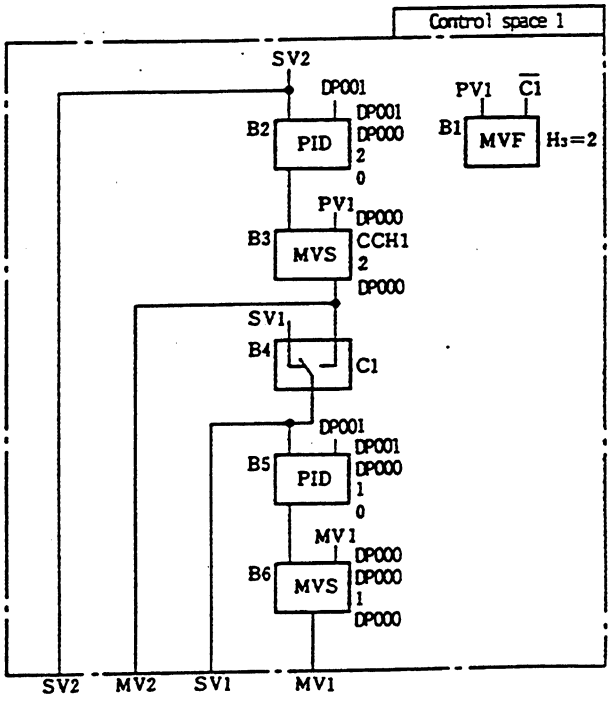
(1) **Linearization space**



(2) **Status space**



(3) **Control space**



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When the secondary loop (#1) is in C mode or M mode, PV2 and SV2 are displayed and SV2 can be set.

When the CLR/SEL switch is on, PV1 and SV1 are displayed.

When the secondary loop (#1) is in A mode, PV1 and SV1 are displayed and SV1 can be set.

When the CLR/SEL switch is on, PV2 and SV2 are displayed.

Note:Since the process loop controller can display two loops at once, the display option above (using B4 and B5 of status space) is not necessary unless additional control requirements are added.

11.3 Proportional control

The proportional control example below assumes that the combined outlet flow is open to atmosphere.

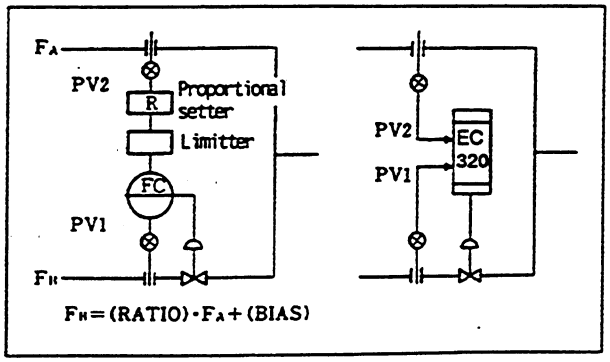
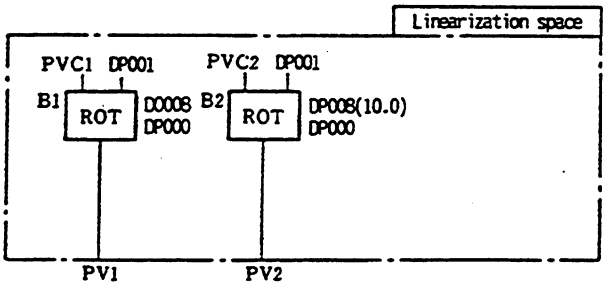


Figure 11.3 Proportional Control

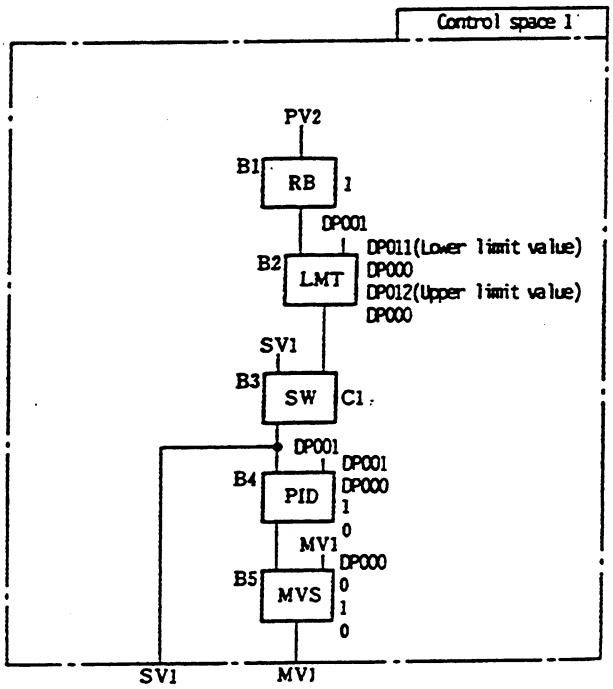
Flow rate of Fb is to be controlled so that Fb = A*Fa + B. For the A and B values, the RATIO and BIAS of the main loop are used. Fa and Fb are assumed to be input as PV2 and PV1, respectively.

(1) **Linearization space**



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(2) Control space



Proportional control occurs when loop 1 is in C mode. A limiter block limits the range allowed for SV1.

11.4 Feed Forward Control

As an example of feed forward control, a heat exchanger is taken. In analog instrumentation, two adjusters and a number of calculators are required, in this process loop controller, one unit can control the system.

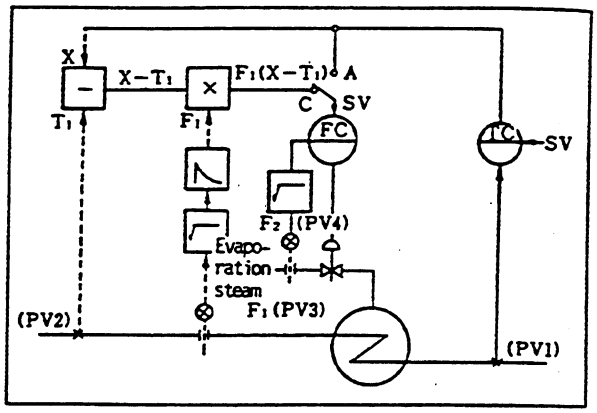


Figure 11.4 Feed Forward Control

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T1: heated flow inlet temperature . . . PV2
T2: heated flow output temperature . . . PV1
F1: heated flow rate . . . PV3
F2: steam flow rate . . . PV4

PV1 and SV1 serve as thermostatic control.

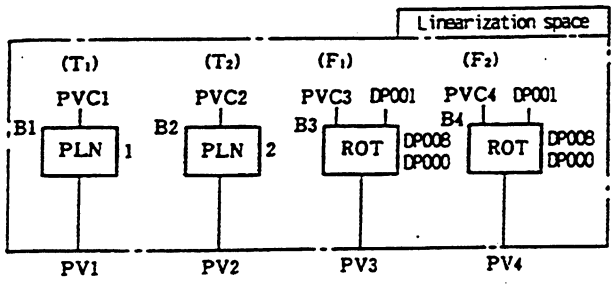
In mode A, cascade control of TC-FC is performed.

In mode C, feed forward is added.

The feed forward element is obtained by adding a phase advance element, as dynamic characteristic compensation, to the equation obtained by the heat balance.

For normal operation, if operation is done in mode C, SV of secondary loop (SV2) is calculated by SV = CF1(X - T1). (C is a coefficient)

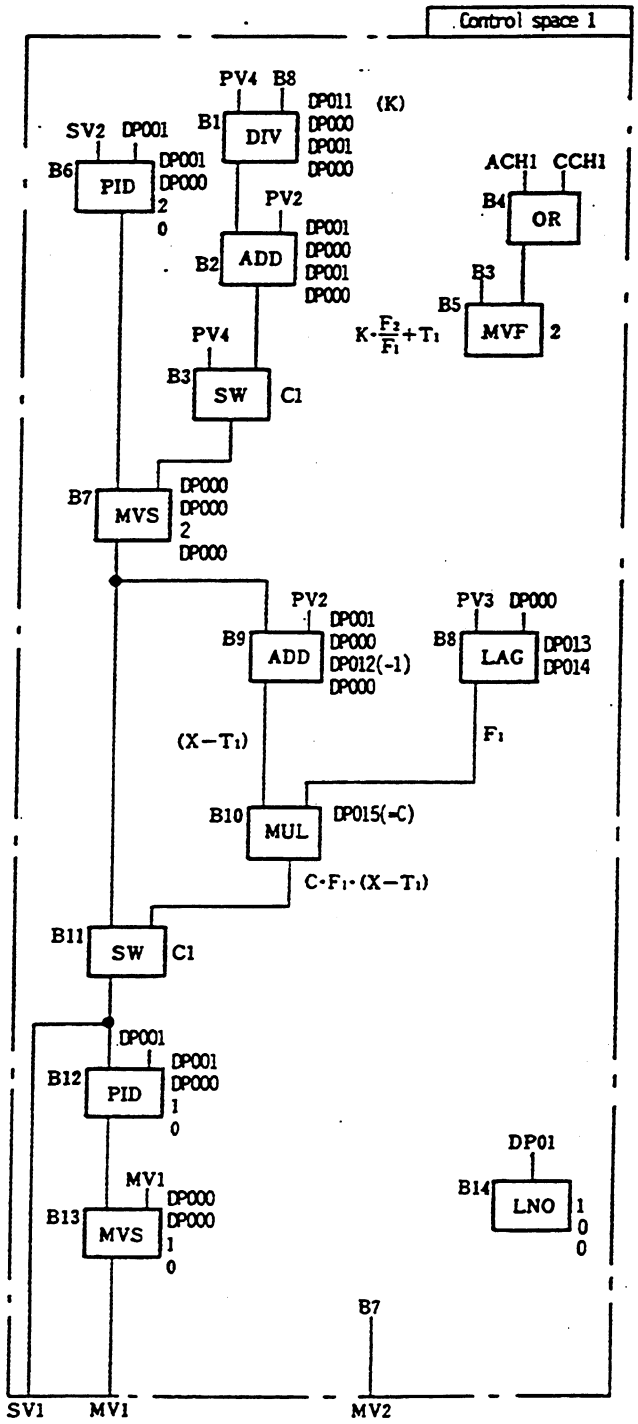
(1) Linearization space



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(2) Control space

PV1: control variable of loop no. 2
PV4: control variable of loop no. 1



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The front panel display allows CV, SV display and SV setting of the primary loop in normal status regardless of the mode of the secondary loop. When the FAST/SEL key is being pressed, PV and SV of the secondary loop are displayed.

The following explains the calculation of F1 and F2. When entering mode C, SV of steam flow loop should start at the steam flow. This can be obtained by setting SV=F2. SV becomes K*F2/F1 + T1. For F1, B8 in which dynamic characteristics are taken into account is more appropriate than PV3.

11.5 Optimum Control

The adaptive gain control system is used in the case of PH control or anything similar which has a large deviation range of process gain.

As a typical example, as shown in the figure below, the gain can be controlled by the adjuster using a function of deviation.

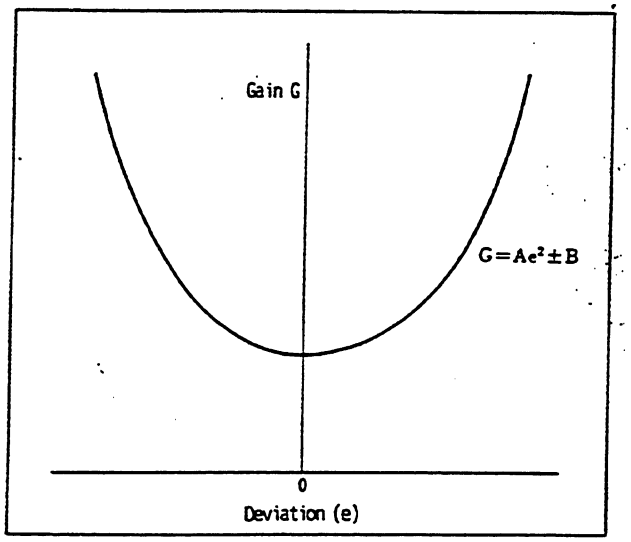
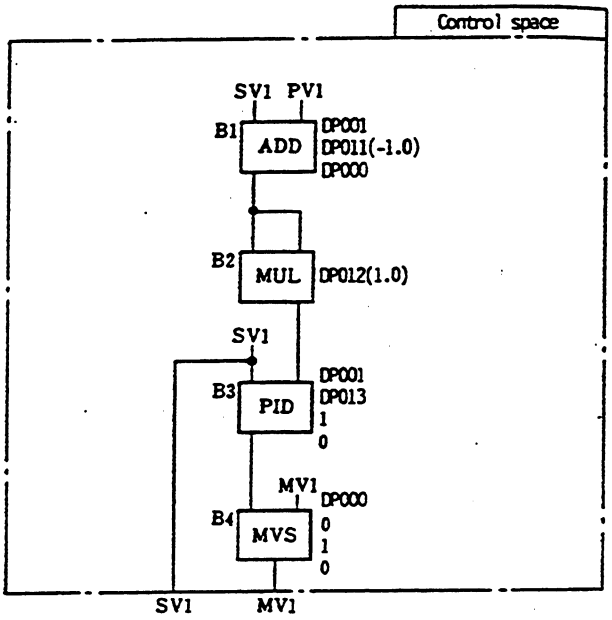


Figure 11.5 Deviation Function

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(1) Control space

PV1: control variable



Gain = DP012*(SV-PV)^2+ DP013

11.6 Autoselect Control

This is a control method of producing an operation output by selecting the smallest or largest from several manipulated variables.

The process loop controller can conduct one operation output and PID control on four loops. Hence, one process loop controller can realize autoselect control of up to four loops. The following gives an example of 2-loop low select control.

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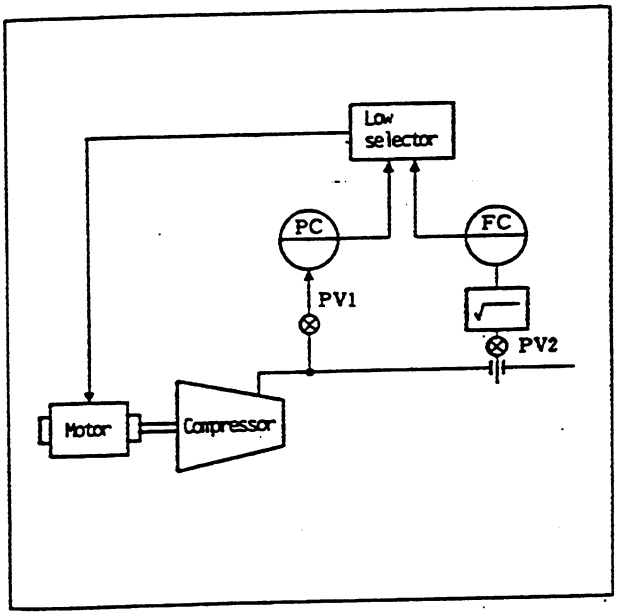


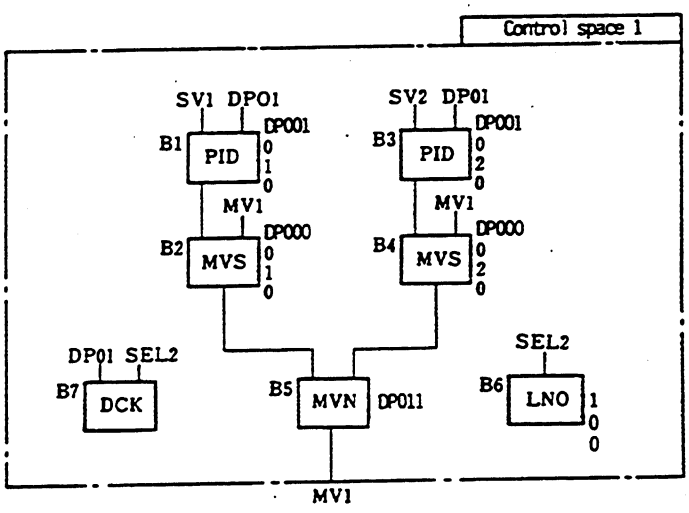
Figure 11.6 Compressor Flow Rate Pressure Selection Control

Although flow pressure/selection control of a compressor can be done by the method stated in 11.1, an example of performing autoselect with a process loop controller is shown here.

Flow input is PV2, and pressure input is PV1.

Control space

PV1: control variable of loop No. 1
PV2: control variable of loop No. 2



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During control of loop 1, SV and CV are displayed by bars on the front panel, and during control of loop 2, they are displayed by points. This is determined by B6.

DP011 allows specification of the loop output as follows:

DP011 = 0.0 auto selection
DP011 = 1.0 select loop no.1
DP011 = 2.0 select loop no.2

If the input for the loop (DV1 = U1 and DV2 = U2) to the deviation check module (DCK) is 0, the deviation check is not conducted for that loop.

11.7 Sample Value Control

Using standard function block, a sample value control can be configured.

The arbitrary transfer function of a control device is expressed as below in general.

$$D^*(Z) = M^*(Z)/E^*(Z) = (a0+a1z^{-1}+a2z^{-2}+...+alz^{-l})/(1+b1z^{-1}+b2z^{-2}+...+bkz^{-k})$$

From the above equation, assuming that sampling period is T and current time is nT, operation output (MV)is as follows by deviation of MV between the present and past:

$$MV(nT) = a0\ e(nT) + a1\ e\{(n-1)T\} + a2\ e\{(n-2)T\} + ... + aje\{(n-j)T\} - b1\ MV\{(n-1)T\} - b2\ MV\{(n-2)T\} - ... - bk\ MV\{(n-k)T\}$$

Here, an example to perform the following is shown.

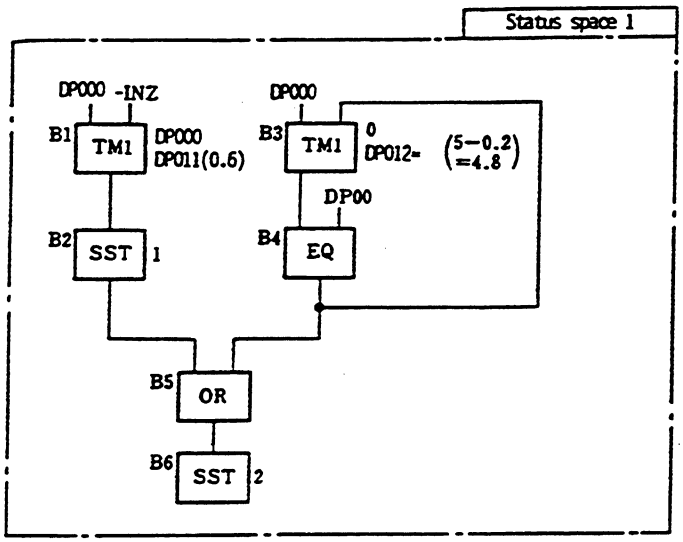
$$T = 5\ (sec)$$

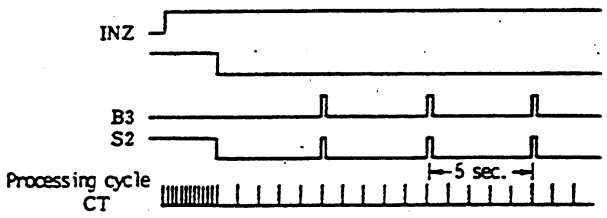
$$G(z) = (a0+a1z^{-1}+a2z^{-2}+a3z^{-3})/(1+b1z^{-1}+b2z^{-2}+b3z^{-3})$$

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(1) Status space

In a status space, timing necessary for calculation is generated.





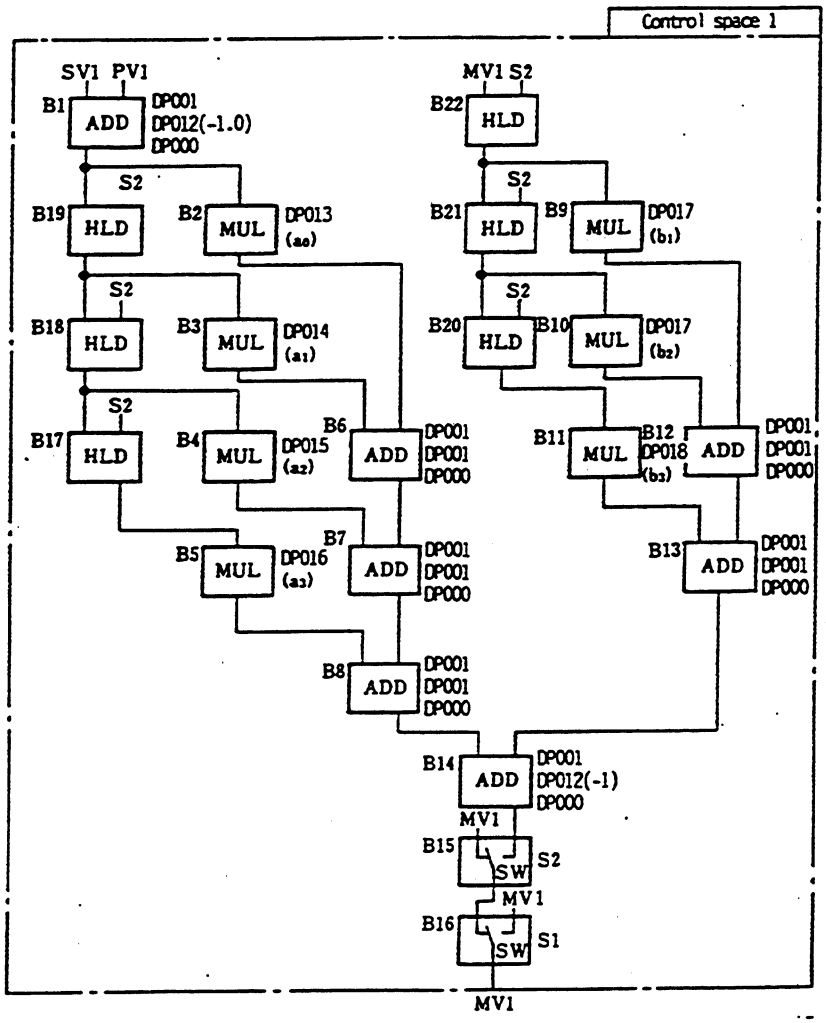
INZ is a signal which stays 0 for one processing cycle after the two-loop controller is turned on. S1 is provided to initialize the dead time module at initialization. In this example, the maximum term of z^{-m} is m^{-3} so the initial value of B1 timer is 3x 0.2=0.6 (sec). S2 shows calculation cycle. B3 timer is provided to produce a clock cycle of 5 sec.

S1 status shows a period in which correct results of calculation are not obtained.

S2 status means a timing by which data is shifted in HLD module in control space.

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(2) Control space



When using the hold module (HLD), careful attention must be paid to numbering.

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11.8 Smith Prediction Control over Dead Time Process

Otto Smith's dead time compensation method can be realized using a combination of function blocks in the process loop controller.

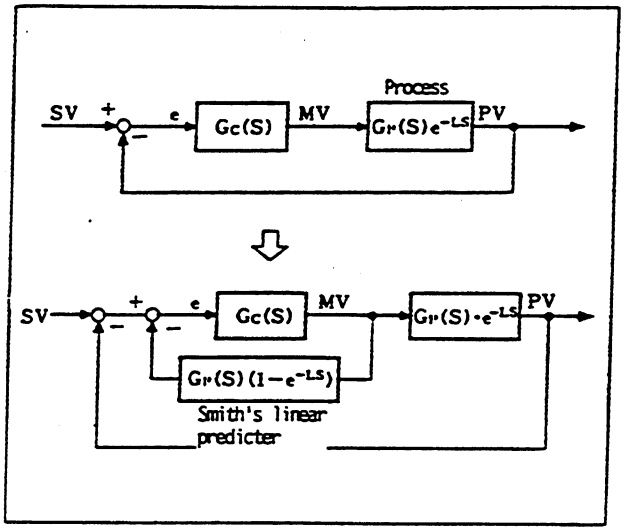


Figure 11.7 Prediction Control

The block below shows Smith's linear predictor.

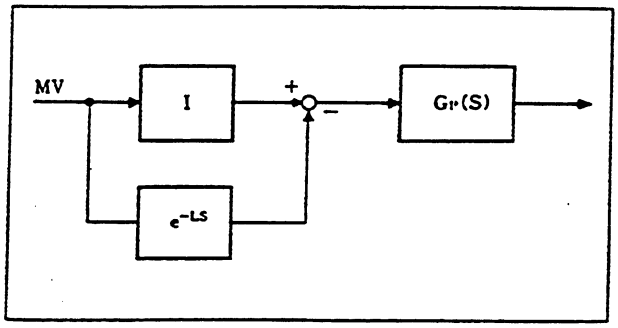


Figure 11.8 Smith's Linear Predictor

As a generating method of dead time expressed by e^{-ls}, in a simple case, the following can calculate it by using Pade approximation:

$$e\text{-}LS = \{1-(L/2)S\}/\{1+(L/2)S\}$$

However, an error may be large enough, using dead time block is useful.

In dead time module, the input U1 becomes the output Y with a time delay:

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L = no. of samples (m) x sampling period (n) x processing cycle (CTS)

No. of samples (m) is that of data to store in DT module, which data is specified with sampling cycle n how long cycle to include.

No. of sampling m and sampling cycle n are determined by approximate accuracy of L.

To improve dead time accuracy, assume sampling period n=1 (processing cycle) and specify required No. of samples. One DT module can store data of 16. Therefore, for dead time of more than 16 cycles, correction is needed by combining some DT modules. However, there are limits to no. of blocks and data storage areas. So, it is not possible to store all the data. On the other hand, considering the deviation status of data, it is not always necessary to store all the data. If this is the case, it is convenient to determine an appropriate sampling cycle and store data. If the sampling period (n) is more than 2, data between them is output after linear compensation.

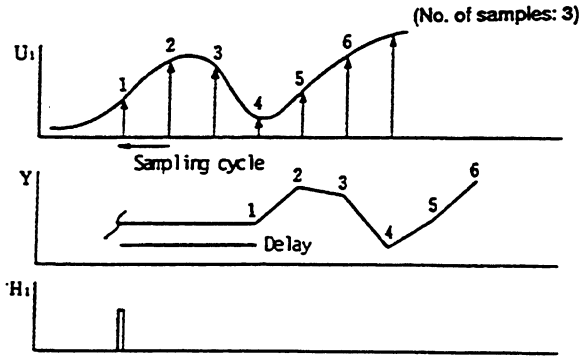
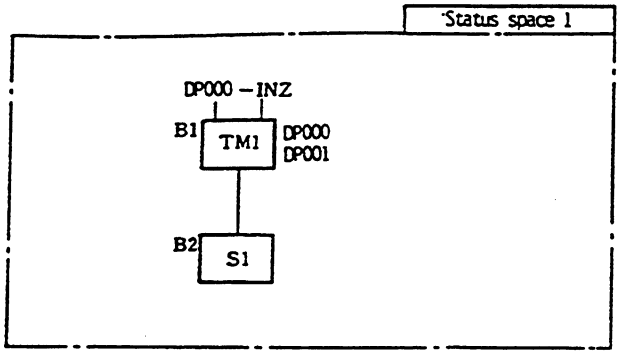


Figure 11.9 Time-Delay Operation

If the initialize flag is on, the current data is considered to have been continued.

As an example, No. of samples n is assumed 3, sampling period m, 3 (CTS unit). Dead time L becomes to L = 3 x 3 x CT sec.

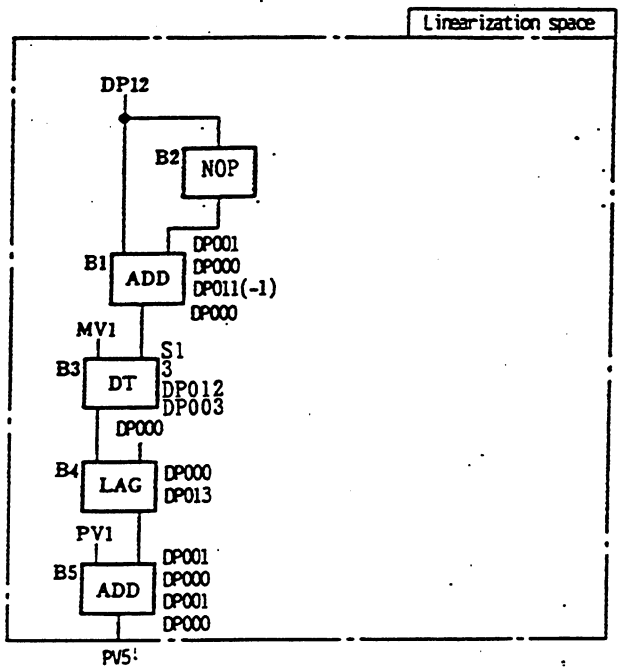
(1) **Status space**



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(2) Linearization space

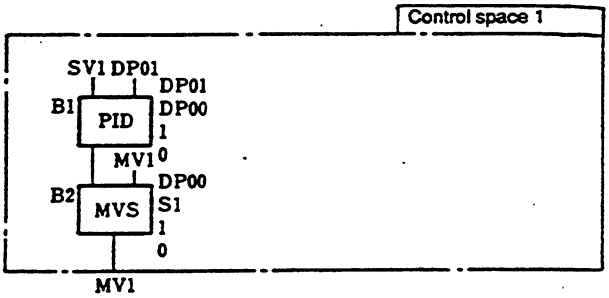
DP012: sampling cycle
DP013: primary delay time



B1 and B2 check whether the sampling period changes or not. If changed, sampling cycle set flag of the DT module is set for one processing cycle only.

(3) Control space

PV5: control variable of loop no. 1



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11.9 Program Control

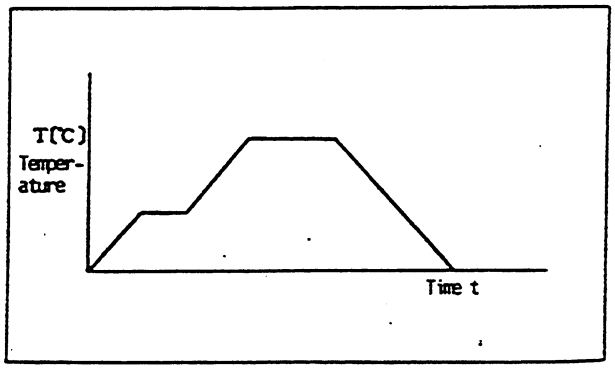


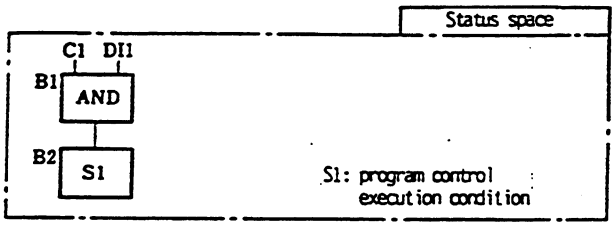
Figure 11.10 Program Pattern

The example below shows a program pattern control which changes set value SV according to the above pattern.

Program control, however, is executed only in mode C and at the time when D11 is on. When DI1 is turned on, temperature rise starts not at t=0, but at the current PV value.

To satisfy the above conditions, when the temperature starts rising, an inverse polynomial line module is used to obtain the initial value t0, the time from PV.

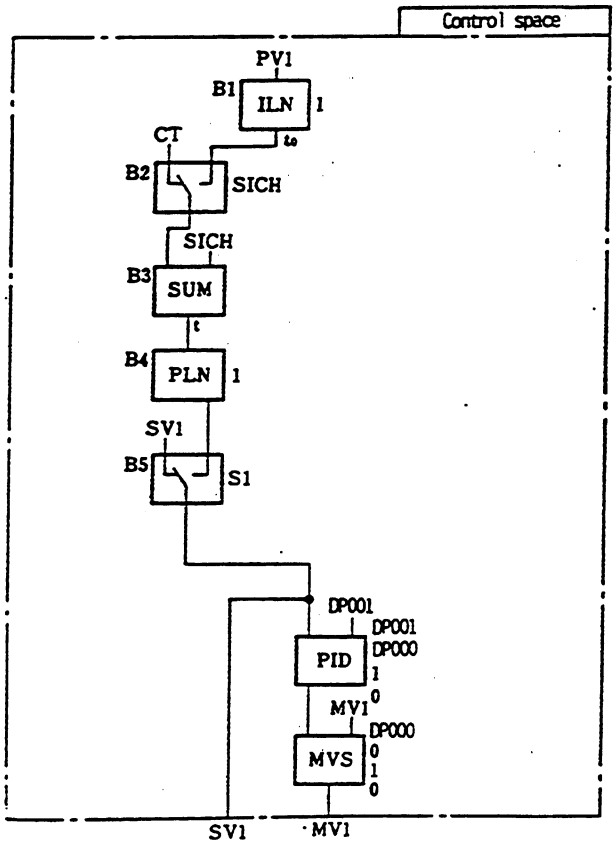
(1) Status space



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(2) **Control space**

PV1: control of loop No. 1



11.10 Signal Select

A general pattern of signal is shown below.

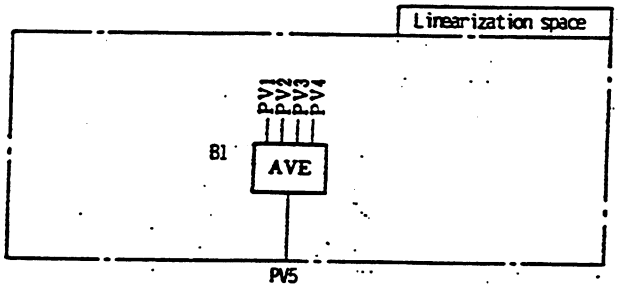
In this example, a control configuration is shown which uses the average value of PV1, PV2, PV3 and PV4.

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A function to stop control when either input signal becomes inactive is shown.

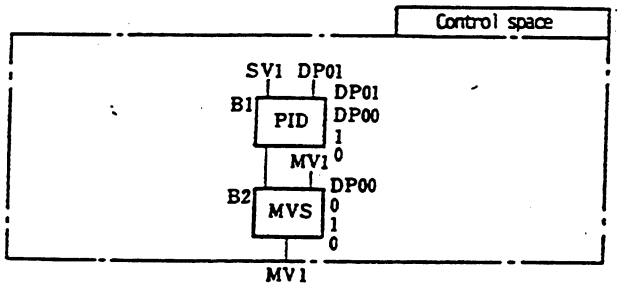
The standard function, unless it is specified otherwise in a status space, excludes inactive input signals and continues control.

(1) **Linearization space**



(2) **Control space**

PV5: control variable of loop 1



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11.11 Blower Control

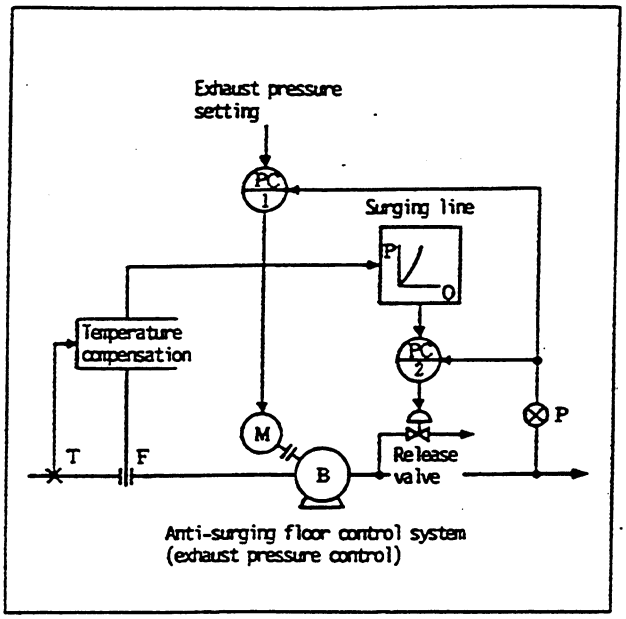


Figure 11.11 Anti-surging Floor Control System (exhaust pressure control)

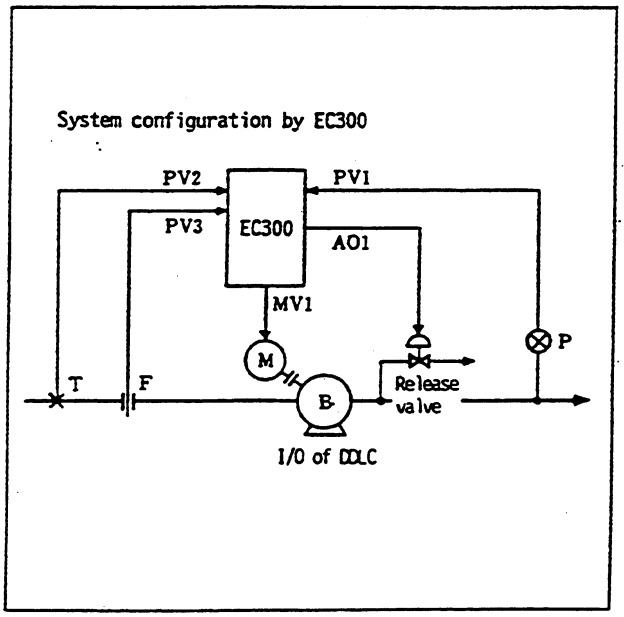
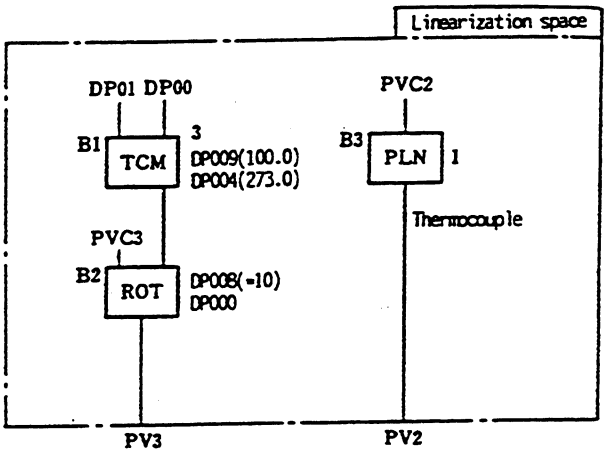


Figure 11.12 System Configuration by the process loop controller

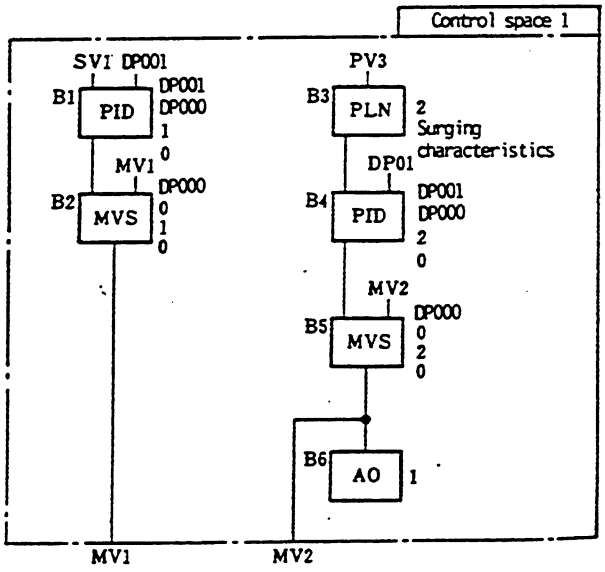
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(1) **Linearization space**



(2) **Control space**

PV3: control variable loop No. 1 and No. 2



The front panel display is as follows.

Normal: Bar graph display of loop No. 1 CV and SV

when CLR/SEL key on: Point display of loop No. 2 CV and SV

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11.12 Batch Process Control

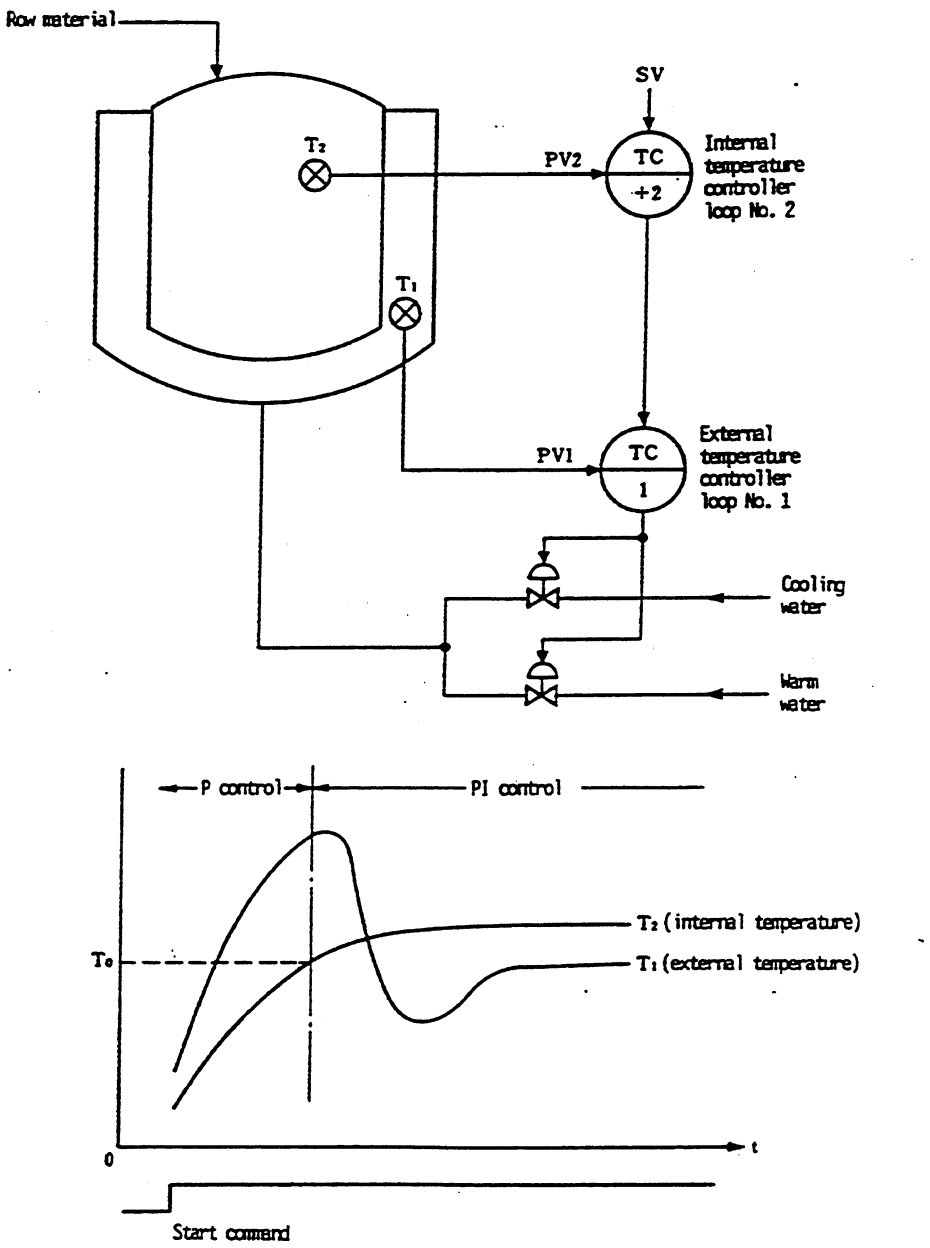


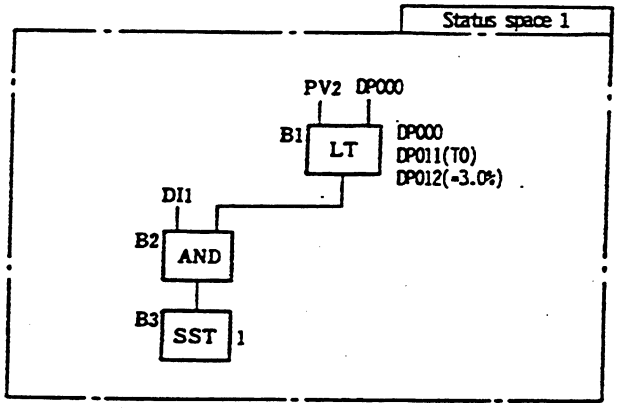
Figure 11.13 Batch Process Control

For this flow control, T1=PV1, T2=PV2 and the start command =DI1.

This configuration performs constant value control by switching the external temperature controller algorithm from P control of PI control at values where T1>T0.

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(1) Status space

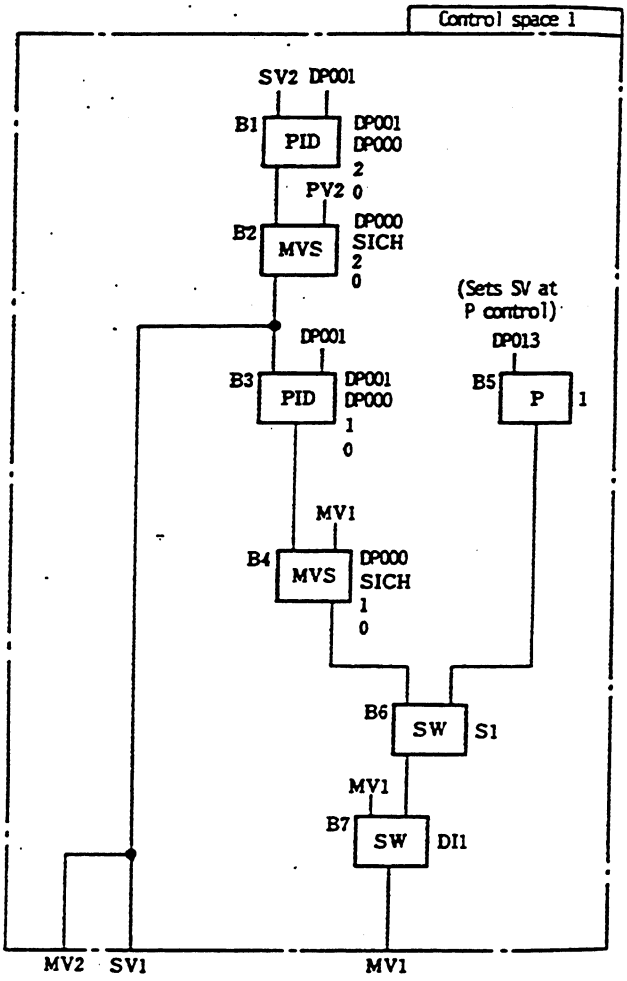


S1 shows P control execution conditions.

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(2) Control space

PV1: control variable of loop no. 1
PV2: control variable of loop no. 2



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11.13 Switching Control of Flow Meter

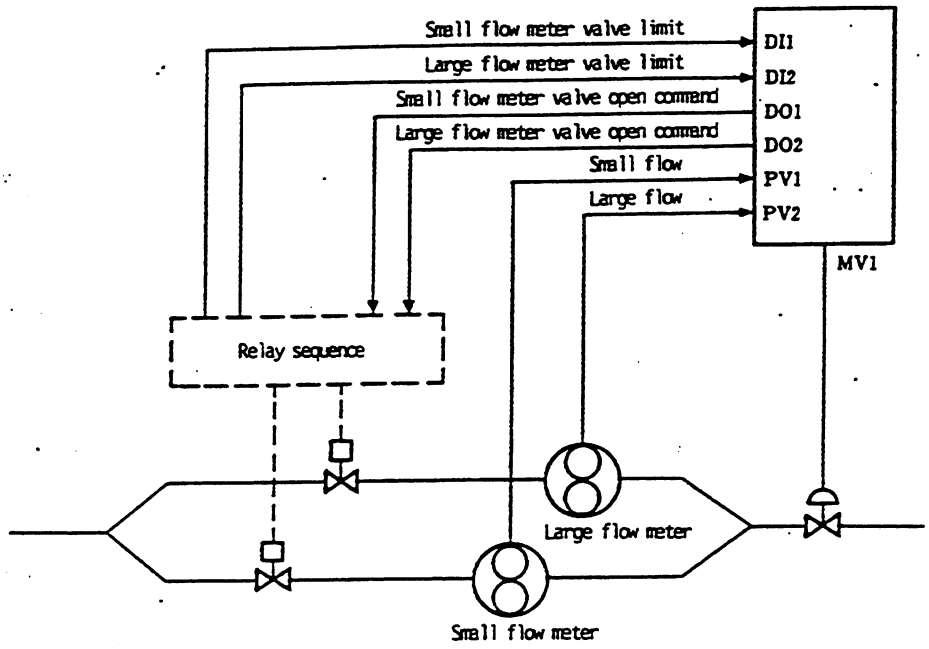


Figure 11.14 Large Small Meter Switching Control

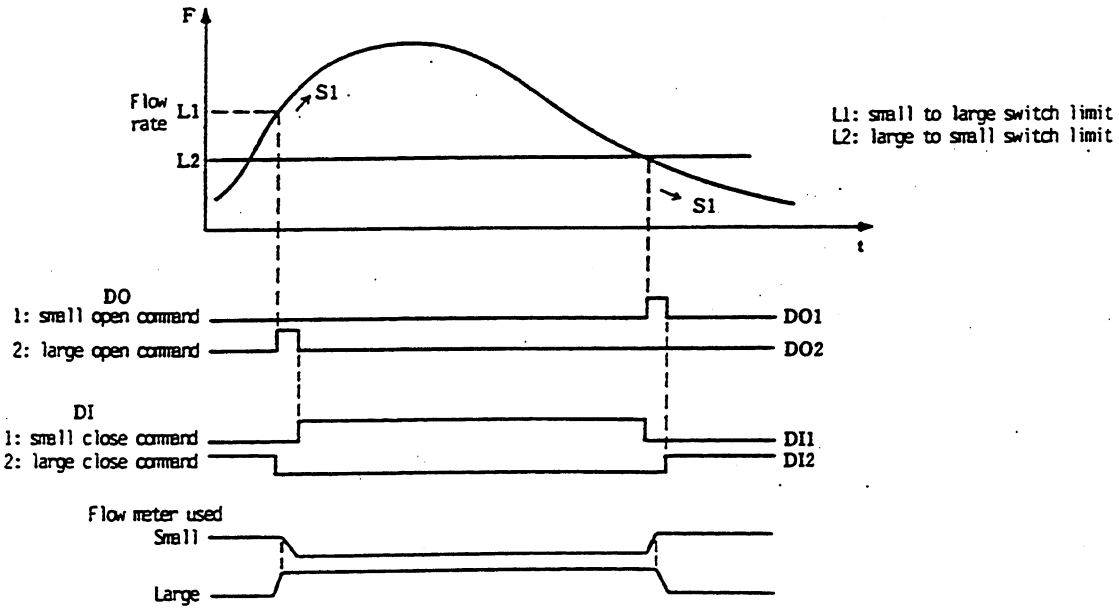


Figure 11.15 Flow Meter Switching Time Chart

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The following shows a special processing of the flow meter switching system.

(1) **Valve switching command**

When going to the small flow meter, this configuration keeps the small flow meter valve open (ON command) after the flow has exceeded limit L1, until the small valve close is confirmed. The relay sequence is assumed to be designed, so that when receiving the large valve open command, the large valve is open first, then the small valve is closed.

When using the large flow meter, if the flow rate becomes less than limit L2, the configuration keeps the small flow valve open (command ON) until the large valve close limit is confirmed.

The switching limit values L1 and L2 satisfy the condition: L1 > L2.

(2) **How to select the correct CV**

(a) The signal from the selected flow meter is used: however, the scale for the large flow meter is always used.

(b) During switching of flow meters, (i.e., DO of either small open command or large open command is ON), the flow rate before switching is kept.

(c) For a certain period of time after flow meter switching, the flow change rate is limited to prevent a flow rate change due to switching from one meter to the other.

T1 = rate change limit time period, delta F1 = limit of rate change

(d) The front panel displays CV and SV of the loop being controlled, and allows.

(3) **Control timing**

The large flow rate uses loop no.1 PID control, and the small flow rate uses loop no. 2 PID control.

During flow meter switching, MV is assumed to be held, and control is halted. Setting of variable constants are as follows.

DP021: L1
DP022: L2
DP023: T1
DP024: delta F1

The processing in each space is shown in the following diagrams.

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The relay sequence of DO conditions after valve switching follows. The timer is set to count the time after flow rate switching.

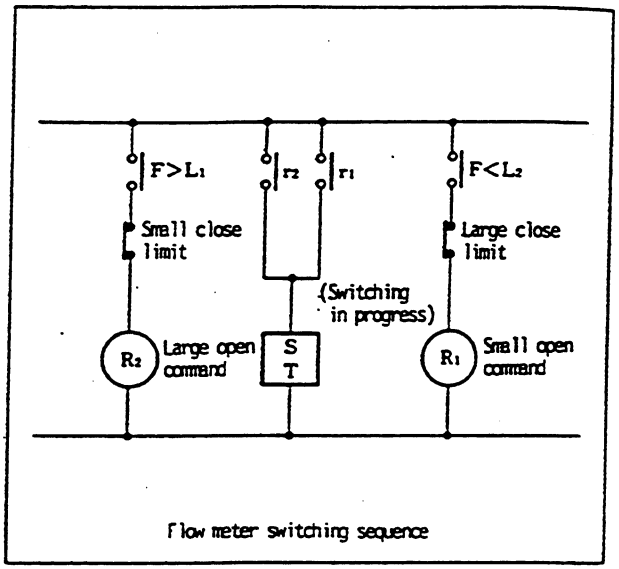


Figure 11.16 Flow Meter Switching Sequence

When the above relay sequence is processed in a status space, almost the same processing can be applied. However, in order to obtain an operation of the timer as follows, the timer should be triggered at signal rise-up during switching for execution in a function module.

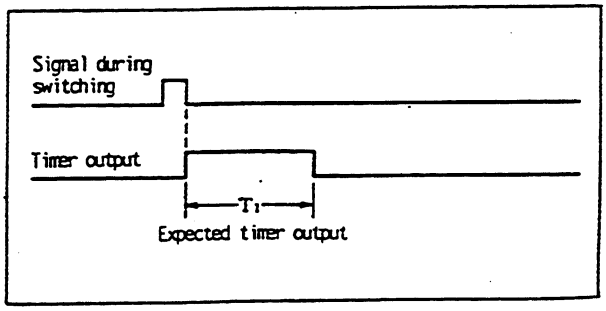


Figure 11.17 Operation of the Timer

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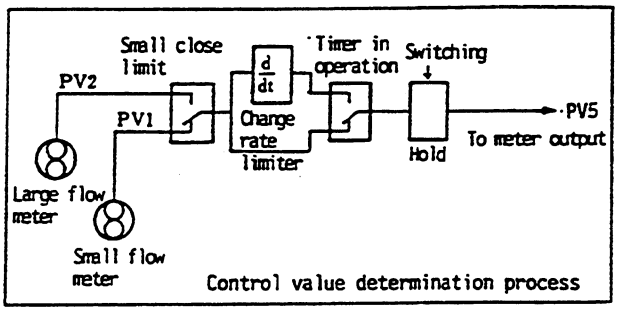
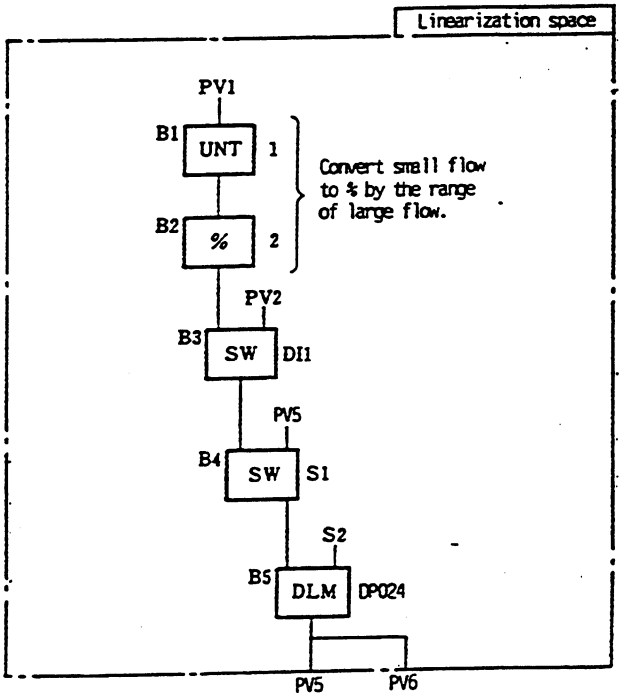


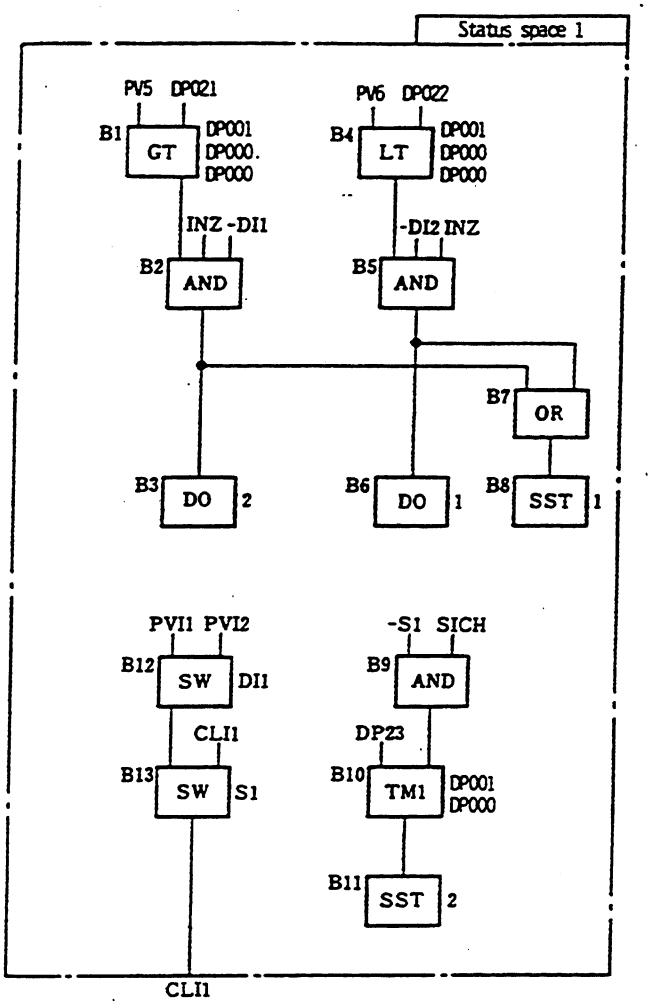
Figure 11.18 Control Value Determination Process

(4) **Linearization space**



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(5) Status space

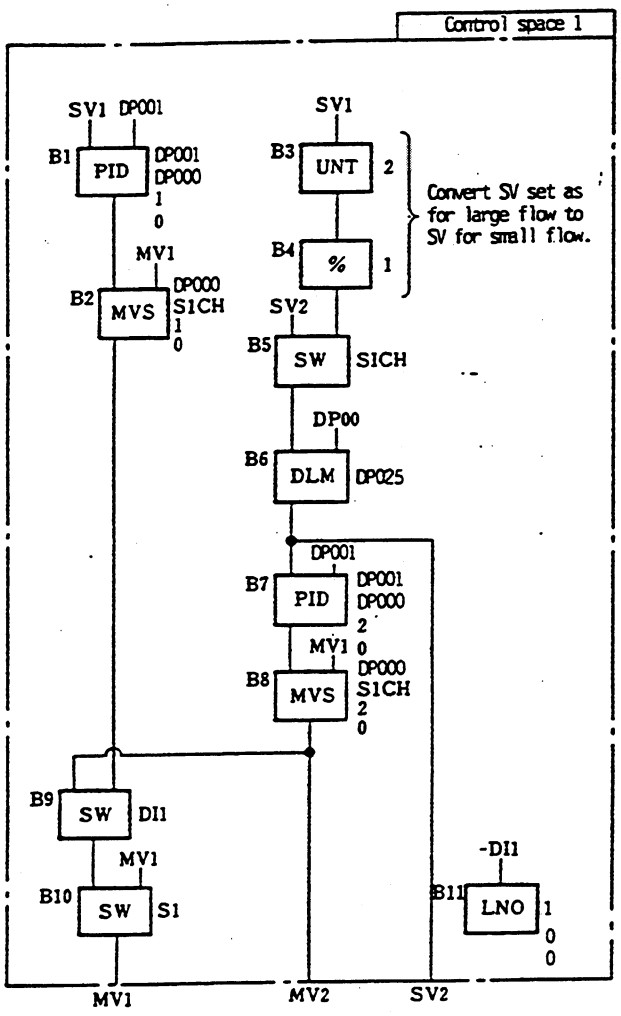


CLI1 condition is PV1 when small meter is used, PV2 when large meter is used, and unchanged during switching.

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(6) Control space

PV5: control variable of loop No. 1
PV6: control variable of loop No. 2



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11.14 Line Blend System of Heavy Oil

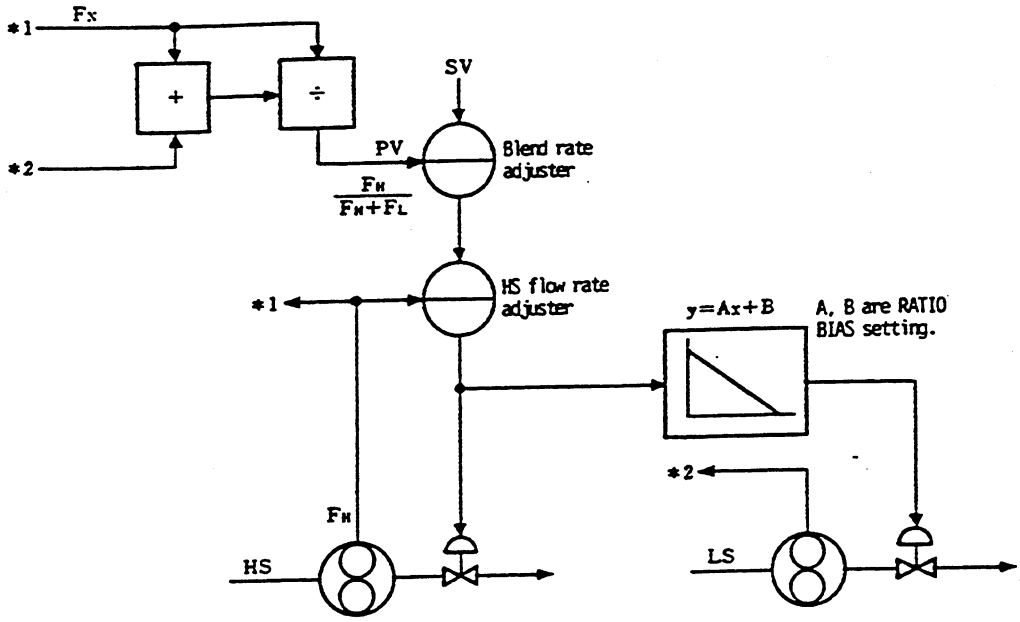


Figure 11.19 Line Blend System

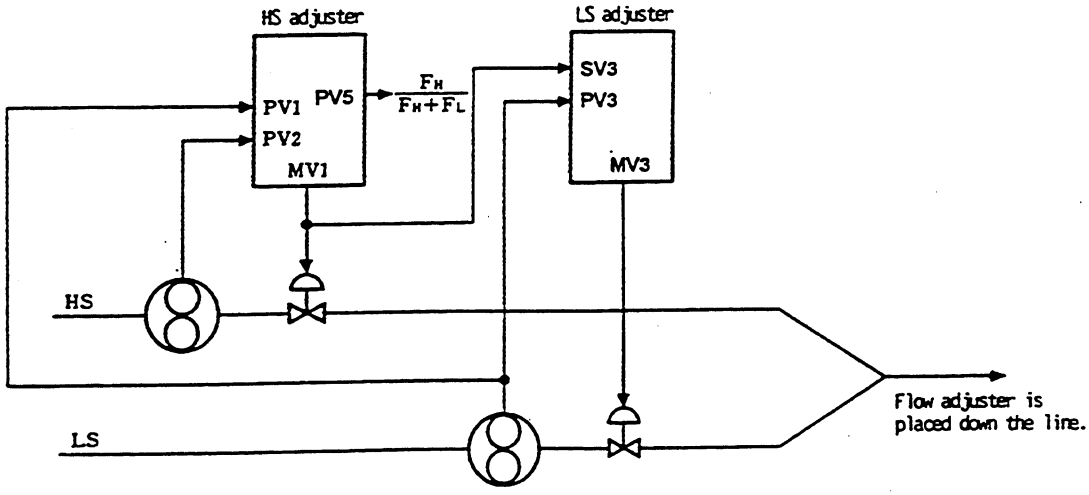


Figure 11.20 Line Blend System by the process loop controller

[Operation]

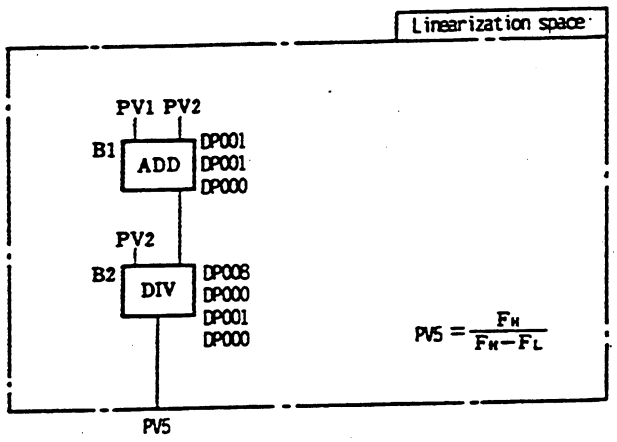
The HS adjuster serves as two adjusters in (1) above while in mode A, and controls HS flow rate directly.

The LS adjuster does not perform a PID calculation in mode A, but outputs a proportional calculation using the MV of the HS adjuster.

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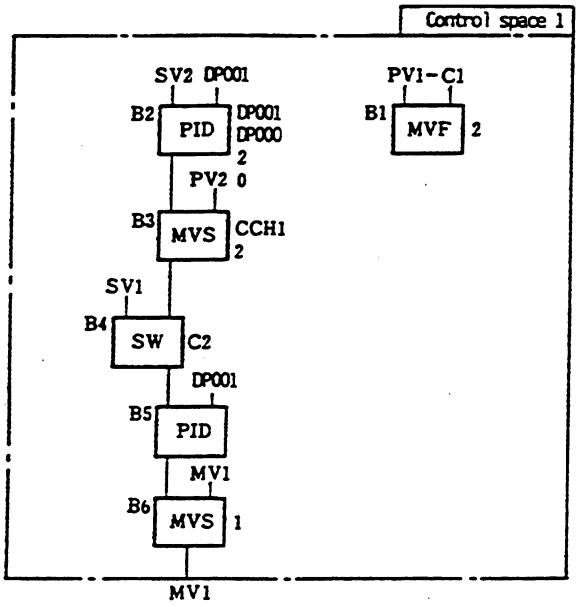
(1) **Processing of HS adjuster**

1) Linearization space



2) Control space

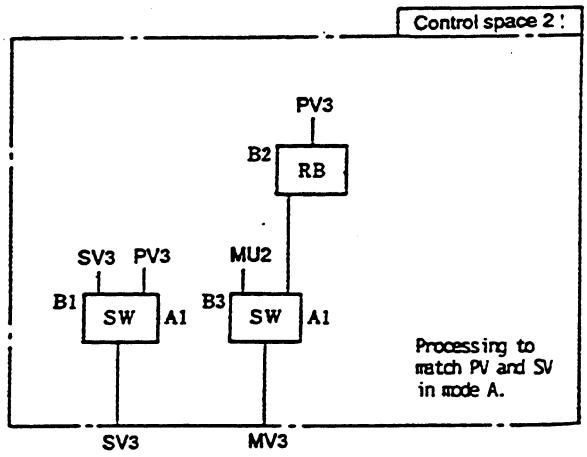
PV1: control variable of loop no. 1
PV2: control variable of loop no. 2



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(2) **Processing of LS adjuster**

1) Control space



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11.15 Combustion Control by Double Cross Limit Method

(1) System outline

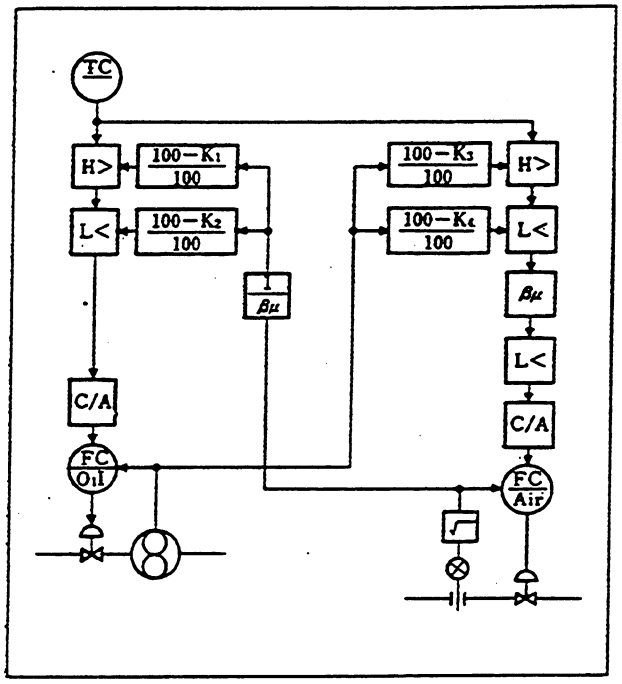


Figure 11.21 Double Cross Limit

(2) Configuration of process loop controllers

The following explains how to configure a combustion control incorporating the Double Cross Limit method, using one two-loop controller. Input information and setting information must be sent from one space to the other. This is provided using a Y parameter, so that information is defined as follows:

[loop 1]

(i) Operation: In mode A, cascade control on temperature and combustion flow is executed.

(ii) Variable constant: DP021: K1
DP022: K2

(iii) Input PV1: temperature
PV2: fuel flow

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[loop 2]

(i) Operation: In mode A, air flow control is done. In mode C, cascade is done.

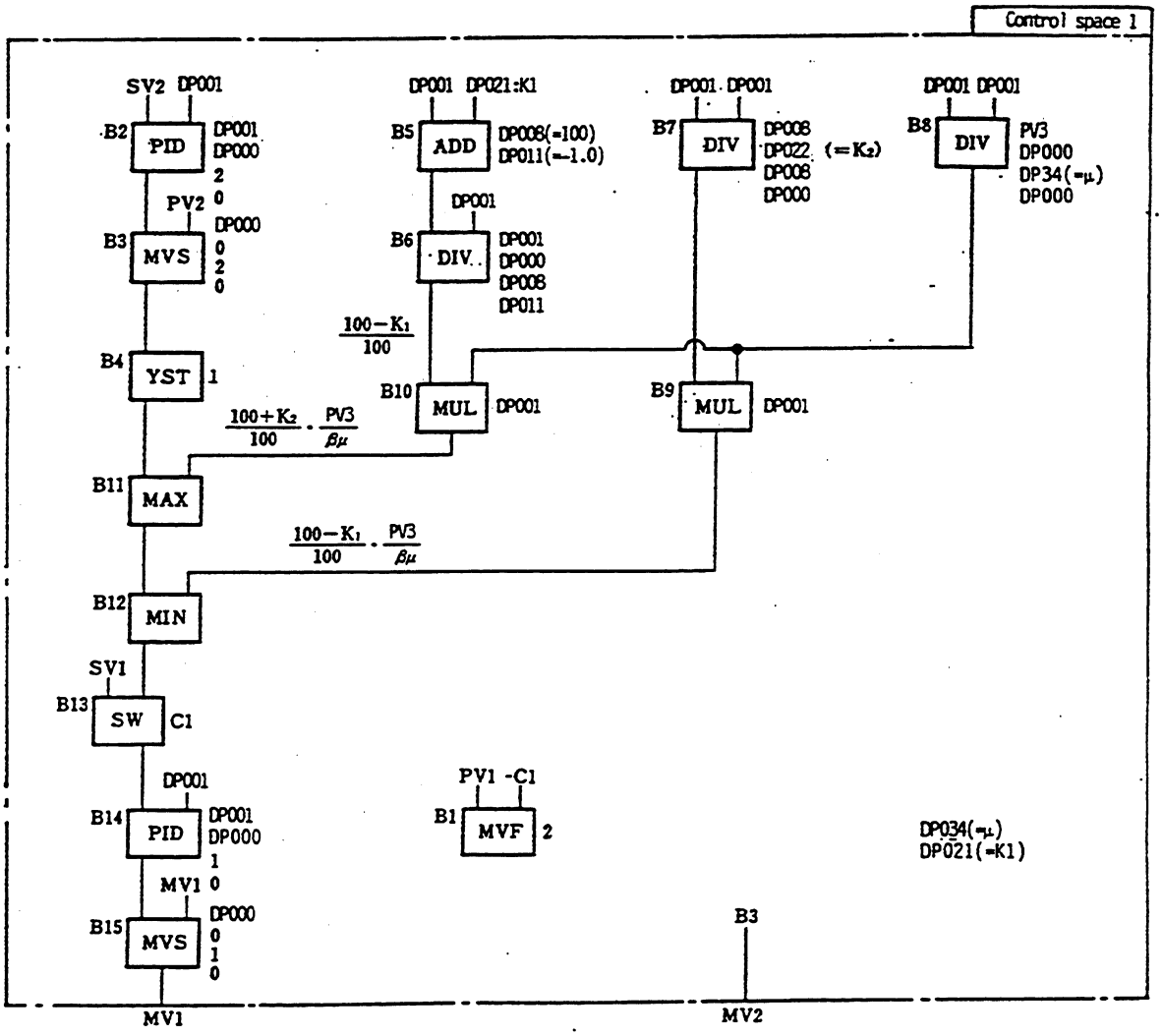
(ii) Variable constant DP031: K3
DP032: K4
DP033: β
DP034: μ

(iii) Input: PV: air flow

(3) Processing of loop 1

1) Control space

PV1: control variable of loop No.1
PV2: control variable of loop No.2



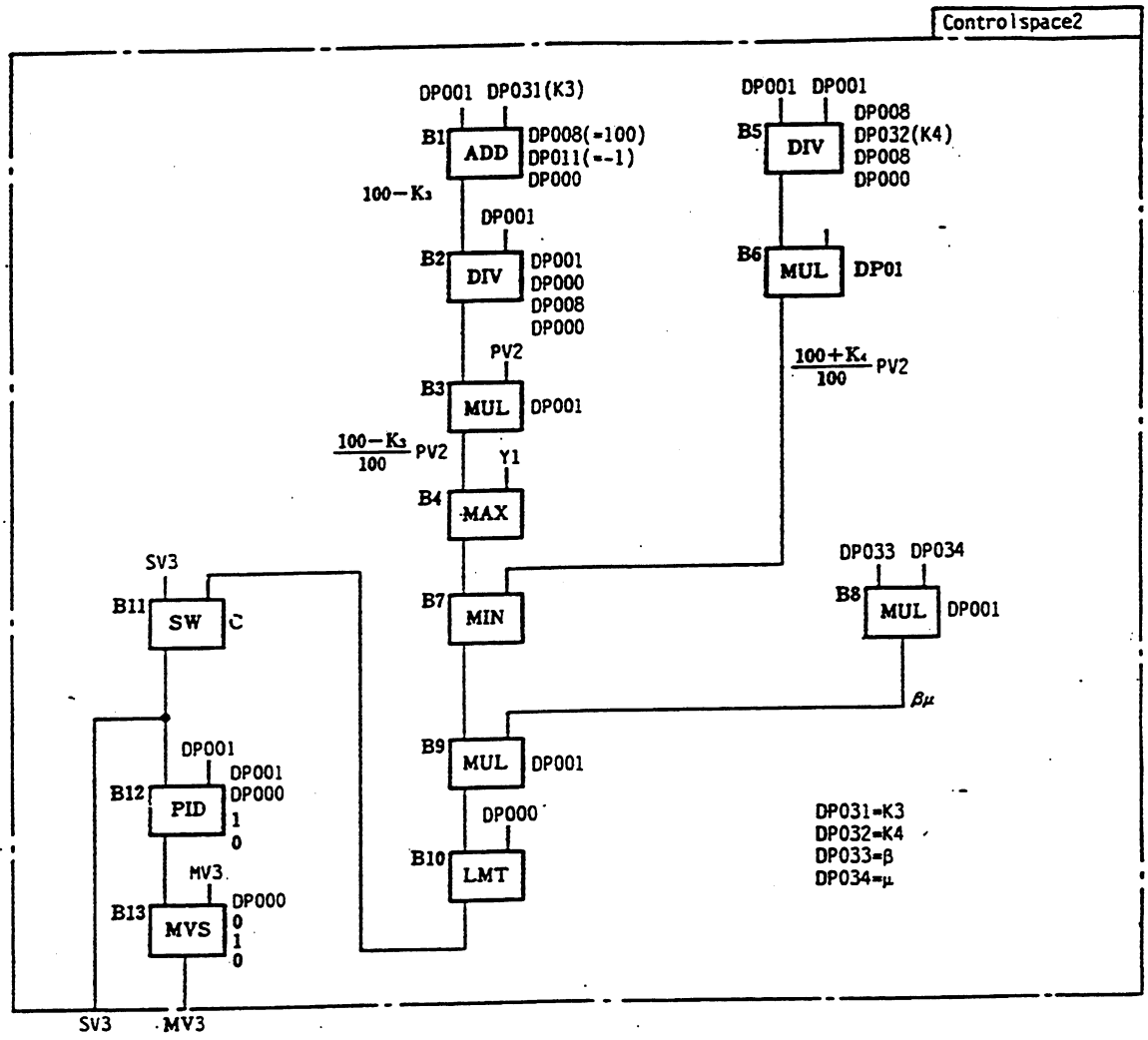
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(4) **Processing of loop 2 (air flow)**

Processing of linearization space and status space is omitted.

1) Control space

PV3: control variable of loop No. 3



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11.16 MV Special Control at Start and Stop

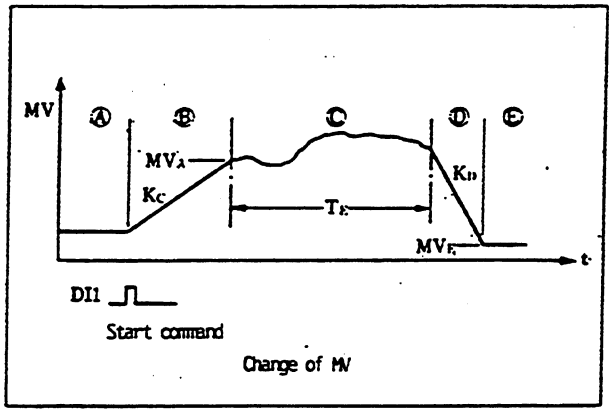


Figure 11.22 Change of MV

In mode A, the following control is done.

(i) The current MV is kept until the start command (DI1) is issued.

(ii) After the start command is issued. MV is increased at a constant rate of Kc.

(iii) When MV>MVa, PID control starts. Once PID is entered, PID is continued even when MV<MVa.

(iv) After PID is executed for the time of Te, MV is decreased at a constant rate of Kd.

(v) When MV<MVb, MV stops decreasing and waits for the next start command.

Each parameter is set in the DP parameter table as follows:

DP021 MVa (%)
DP022 MVb (%) (MVa>MVb)
DP023 Kc (%/min)
DP024 Kd (%/min) (decrease is set by minus sign)
DP025 Te (S)

Analysis of system

The status S1 and S2, and the status of the timer T are defined in accordance with process changes as shown in the following diagrams.

The relay sequence of S1 and S2 are shown in Figure 10.24

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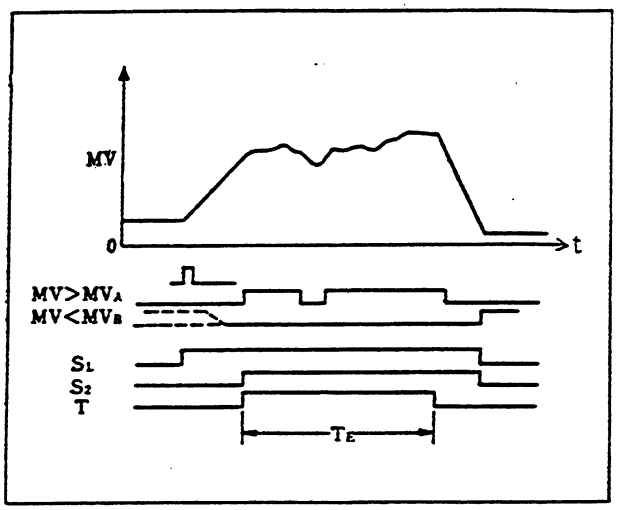


Figure 11.23 Relationship between S1, S2, Timer and Process

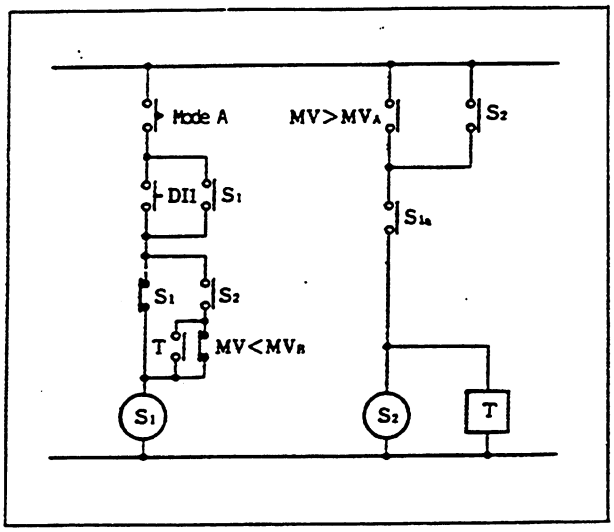
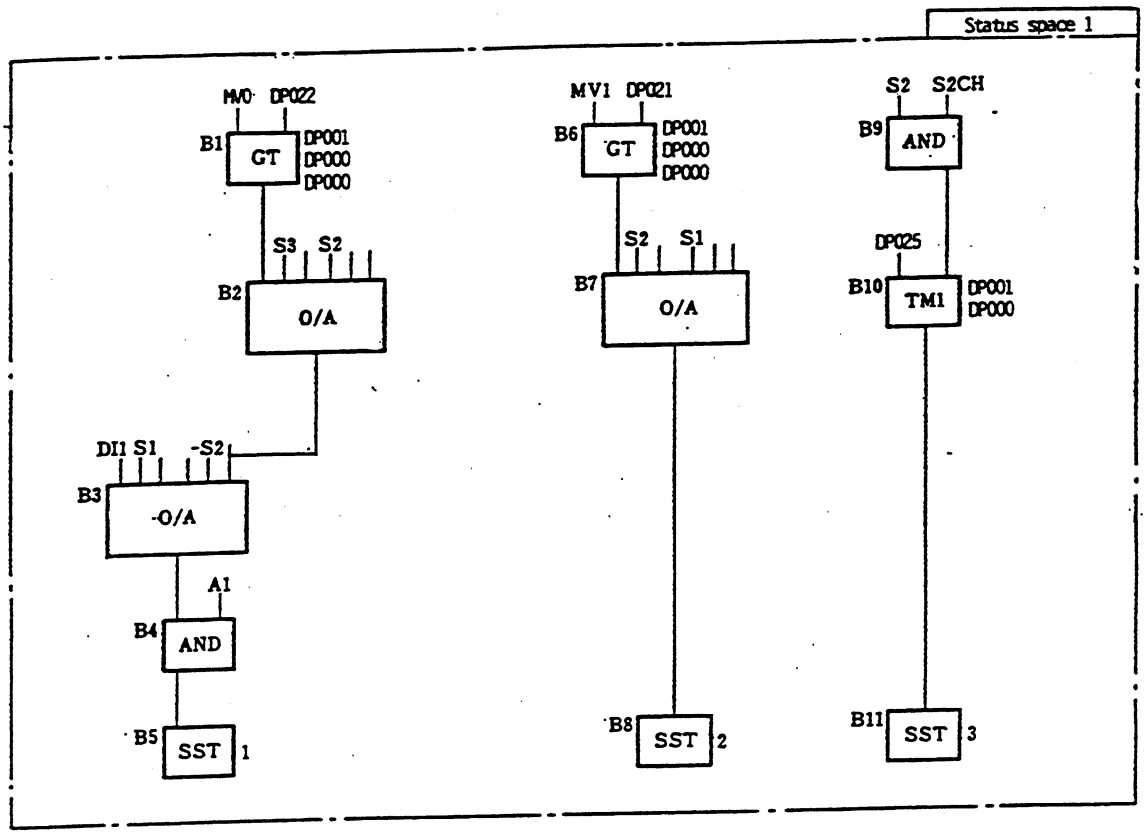


Figure 11.24 S1, S2 Operation

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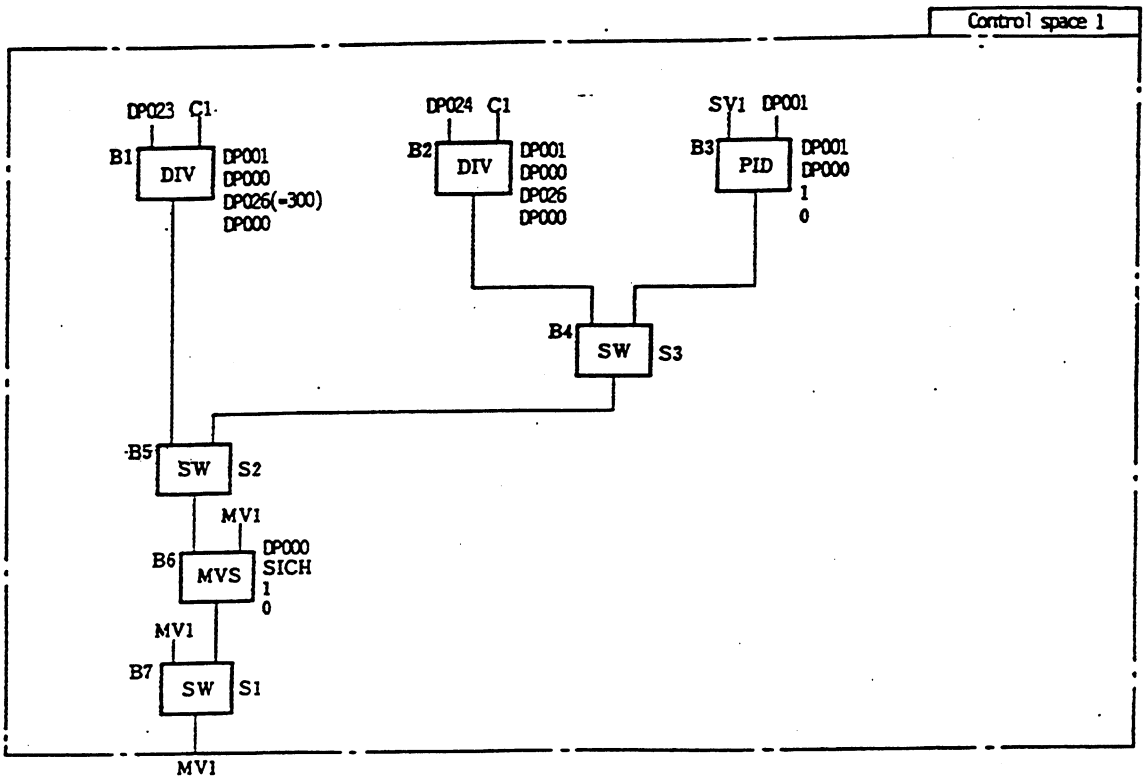
(1) Status space



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(2) Control space

PV1: control variable of loop No. 1



When S1 is off, delta MV = 0.

When S1 is on,

When S2 is off, MV increases constantly. Because Kc has the units of %/min,increment of one cycle must be divided by 60 x 1000/200 = 300.

When S1 is on,

When S2 is on: PID control is done when S3 (timer) is on.

When S1 is on,

When S2 is on: MV decrease constantly when S3 is off.

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11.17 Valve Compensation

For an output that includes valve characteristics, the MV is obtained by polynomial approximation of characteristics (1).

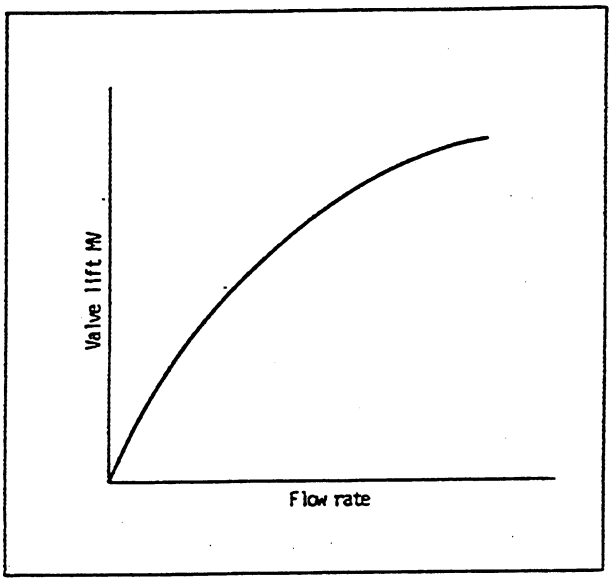
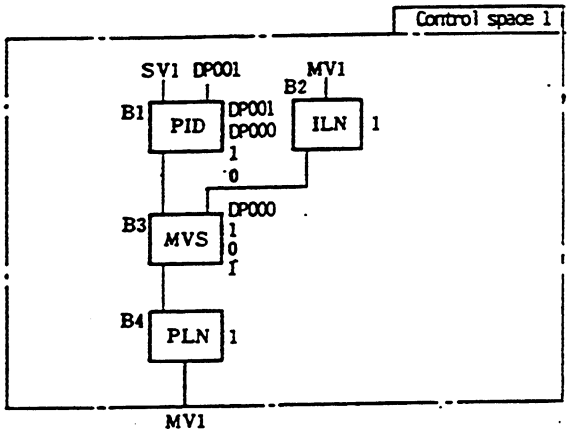


Figure 11.25 Valve Characteristics

(1) **Control space**

PV1: control variable of loop No. 1



The inverse polynomial line of B2 is used for determining the output initial value of the PID calculation when entering mode A. By this, bumpless switching is possible.

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11.18 No. of Pump Operation Control

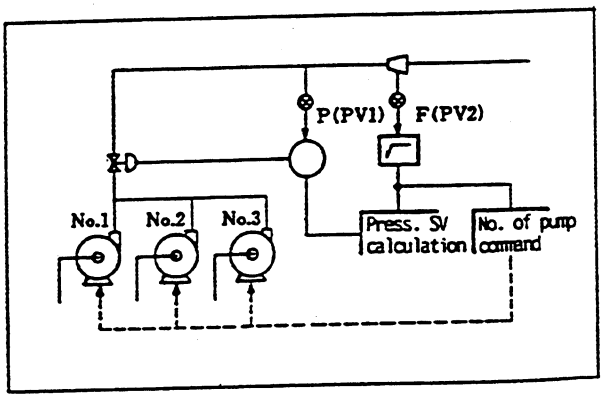


Figure 11.26 Control System for No. of Pumps

[Conditions]

(i) In mode C, use the SV which was obtained as a flow function.

(ii) The No. of pumps command is turned on sequentially using three DOs depending on flow rate. A hysterisis should be used to provide smooth start/stop operation.

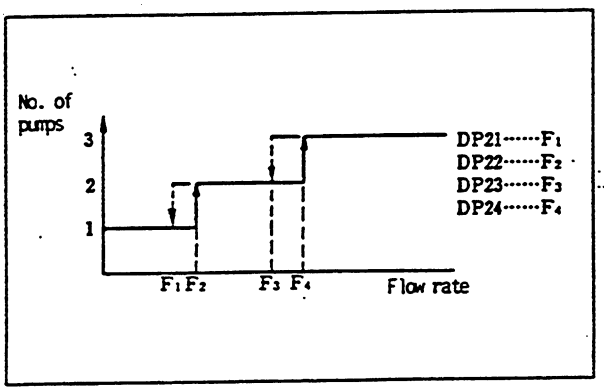


Figure 11.27 Relationship between Flow Rate and No. of Pumps

(ii) Pump No. and connection DO

DO1 ... DO1
DO2 ... DO2
DO3 ... DO3

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Relay sequence of change of Figure 11.26 is as follows.

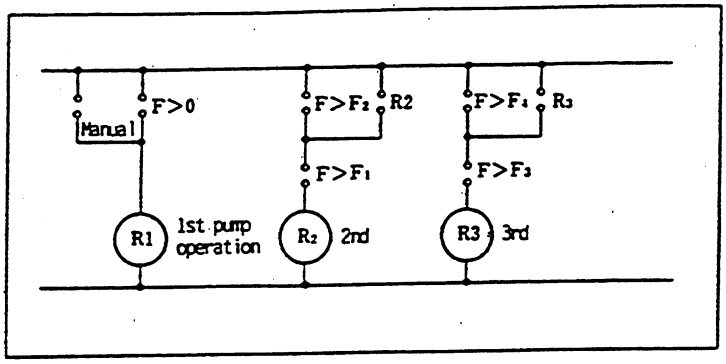
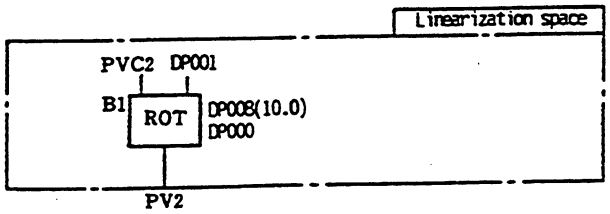


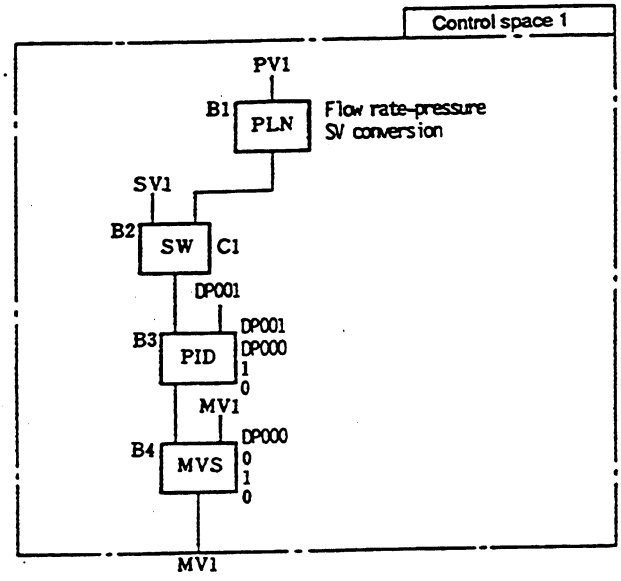
Figure 11.28 Relay Sequence of No. of pump operation command

(1) Linearization space



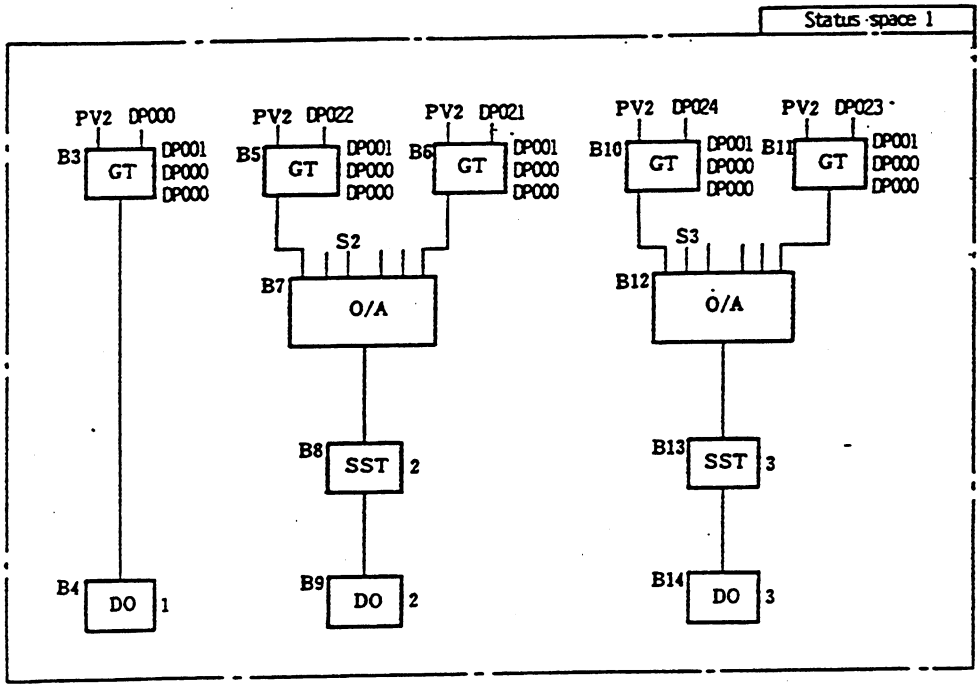
(2) Control space

PV1: control variable of loop No. 1



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(3) Status space



DO1: No. 1 pump start
DO2: No. 2 pump start
DO3: No. 3 pump start

Control on No. of pump operation

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11.19 Internal Cycle Control of Distillation Tower

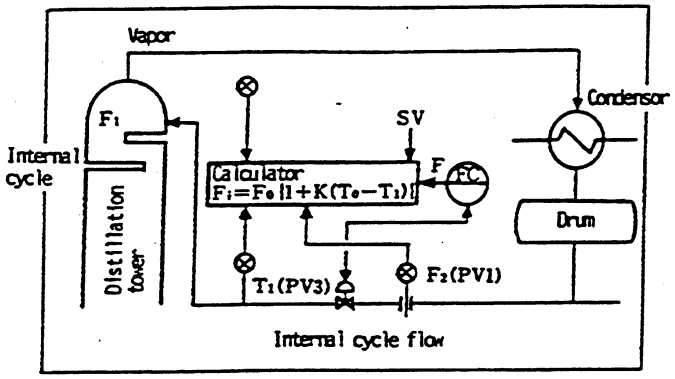


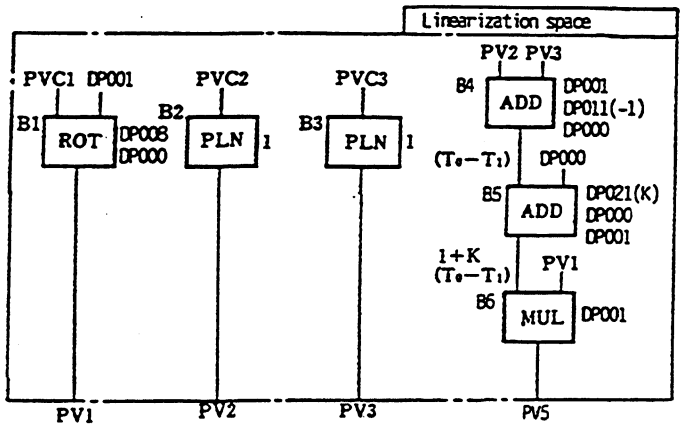
Figure 11.29 Internal Cycle Flow

The internal cycle control is used to keep the composition of the tower overhead constant. The internal cycle flow rate must be obtained by the following equation, because it cannot be calculated directly.

Fi = F0 {1 + K(T0 - T1)}

- Fi: Internal cycle flow rate
- F0: External cycle flow rate
- K: Constant (= specific heat of cycle liquid/vaporizing potential heat)
- T0: Tower top vapor temperature
- T1: Flow-in cycle temperature

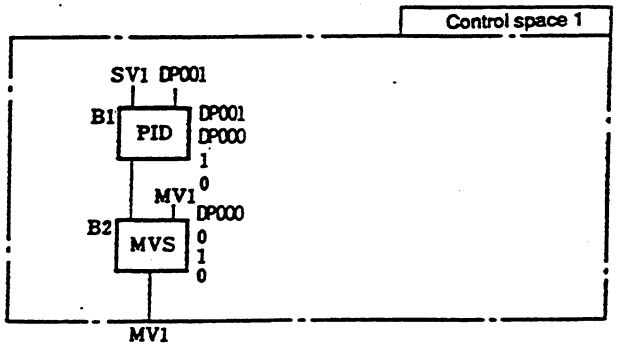
(1) Linearization space



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(2) **Control space**

SV1: control variable of loop No. 1



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12. Appendix

12.1 Data Type and Data Number

Table 12.1 Data Type and Data Number

Data Type	Space No. Loop No. PV input point No.	Data No.	Relevant table (Table 11.2)
0 Block output	*1 0 to 5	Block No. 001 to 200	
1 Loop variable	*2 0 to 3	Loop variable No. 001 to 032	Parameter table Data type 1
2 Loop parameter	*2 0 to 3	Parameter No. 000 to 030	Parameter table Data type 2
3 AI variable, etc.	0	Variable 010 to 069	Parameter table Data type 3
4 AI parameter	0	Parameter No. 010 to 064	Parameter table Data table 4
5 DP parameter	0	Parameter No. 000 to 149	Parameter table Data table 5
6 Polynomial line table	*3 0 to 5	X/Y coordinates,etc. 000 to 021	Parameter table Data table 6
7 Others	0	S,Y,DI,DO,etc. 000 to 099	Parameter table Data table 7-0
	2	External variables 001 to 032	Parameter table Data table 7-2
	3	External variables 000 to 071	Parameter table Data table 7-3
	4	External variables 001 to 032	Parameter table Data table 7-4
	5	Function switch 001 to 008	Parameter table Data type 7-5
8 Integer	0	Integer 000 to 255	
9 AdTune parameter	*2 0 to 3	Parameter No. 000 to 063	Parameter table Data type 9
A Gain scheduling parameters	*4 0 to 3	Parameter No. 000 to 059	Parameter table Data type 10

Note: *1
- 0: Linearized space
- 1: Status space 1
- 2: Status space 2
- 3: Control space 1

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	4:	Control space 2
	5:	Stimulation space
*2	0:	Loop 1
	1:	Loop 2
	2:	Loop 3
	3:	Loop 4
*3	0:	Polynomial line table 1
	1:	Polynomial line table 2
	2:	Polynomial line table 3
	3:	Polynomial line table 4
	4:	Polynomial line table 5
	5:	Polynomial line table 6
*4	0:	Gain scheduling table 1
	1:	Gain scheduling table 2
	2:	Gain scheduling table 3
	3:	Gain scheduling table 4

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12.2 Parameter Table

Table 12.2 Parameter Table Data Classification: 1

No.	Item	Type	Description
0	CLEn	f	I/O error
1	Mn	f	M mode
2	An	f	A mode
3	Cn	f	C mode
4	MVLn	f	MV lower error
5	MVHn	f	MV higher error
6			
7	CMPn	f	Computer
8			
9			
10	CLn	f	Control calculation
11	MCHn	f	M mode change
12	ACHn	f	A mode change
13	CCHn	f	C mode change
14			
15	MVEn	f	MV read back error
16	CLIn	f	Control inactive
17	DVEn	f	Deviation alarm
18			
19	MDCHn	f	Mode change
20	SVn	d	Set value
21	MVn	d	Manipulated value
22	PVSCn	d	CV scale
23	SVSCn	d	SV scale
24	MVSCn	d	MV scale
25			
26			
27			
28			
29			

No.	Item	Type	Description
30			
31	SEL1n	f	Select 1
32	SEL2n	f	Select 2
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
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Table 12.2 Parameter Table Data Classification: 2

No.	Item	Type	Description
0	KPn	d	Proportional gain
1	TIn	d	Integral time (m)
2	TDn	d	Differential time(m)
3	GPn	d	Gap
4	GGn	d	Gap gain
5	RTn	d	Ratio
6	BSn	d	Bias
7	DVn	d	Deviation limit
8	MHn	d	MV higher limit
9	MLn	d	MV lower limit
10	DMVn	d	Delta MV limit
11	ALPn	d	Alpha
12	BTAn	d	Beta
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			

No.	Item	Type	Description
30	CLTn	d	Control period (s)
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
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Table 12.2 Parameter Table Data Classification: 3

No.	Item	Type	Description
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10	INPT1	f	AI1 install
11	SOF1	f	Scan off
12			
13	PVCK1	f	PV check
14	PVD1	f	Change rate alarm
15	PVL1	f	Lower limit alarm
16	PVH1	f	Higher limit alarm
17	PVI1	f	Inactive alarm
18	PVC1	d	Before linearize
19	PV1	d	After linearize
20	INPT2	f	AI2
21	SOF2	f	
22			
23	PVCK2	f	
24	PVD2	f	
25	PVL2	f	
26	PVH2	f	
27	PVI2	f	
28	PVC2	d	
29	PV2	d	

No.	Item	Type	Description
30	INPT3	f	AI3
31	SOF3	f	
32			
33	PVCK3	f	
34	PVD3	f	
35	PVL3	f	
36	PVH3	f	
37	PVI3	f	
38	PVC3	d	
39	PV3	d	
40	INPT4	f	AI4
41	SOF4	f	
42			
43	PVCK4	f	
44	PVD4	f	
45	PVL4	f	
46	PVH4	f	
47	PVI4	f	
48	PVC4	d	
49	PV4	d	
50	INPT5	f	AI5
51	SOF5	f	
52			
53	PVCK5	f	
54	PVD5	f	
55	PVL5	f	
56	PVH5	f	
57	PVI5	f	
58	PVC5	d	
59	PV5	d	

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Table 12.2 Parameter Table Data Classification: 3

No.	Item	Type	Description
60	INPT6	f	AI6
61	SOF6	f	
62			
63	PVCK6	f	
64	PVD6	f	
65	PVL6	f	
66	PVH6	f	
67	PVI6	f	
68	PVC6	d	
69	PV6	d	
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
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88			
89			

No.	Item	Type	Description
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			
101			
102			
103			
104			
105			
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Table 12.2 Parameter Table Data Classification: 4

No.	Item	Type	Description
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10	RH1	d	PV1 range high
11	RL1	d	PV1 range low
12	PH1	d	PV1 higher limit
13	PL1	d	PV1 lower limit
14	DPV1	d	PV1 delta PV limit
15			
16			
17			
18			
19			
20	RH2	d	PV2
21	RL2	d	
22	PH2	d	
23	PL2	d	
24	DPV2	d	
25			
26			
27			
28			
29			

No.	Item	Type	Description
30	RH3	d	PV3
31	RL3	d	
32	PH3	d	
33	PL3	d	
34	DPV3	d	
35			
36			
37			
38			
39			
40	RH4	d	PV4
41	RL4	d	
42	PH4	d	
43	PL4	d	
44	DPV4	d	
45			
46			
47			
48			
49			
50	RH5	d	PV5
51	RL5	d	
52	PH5	d	
53	PL5	d	
54	DPV5	d	
55			
56			
57			
58			
59			

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Table 12.2 Parameter Table Data Classification: 4

No.	Item	Type	Description
60	RH6	d	PV6
61	RL6	d	
62	PH6	d	
63	PL6	d	
64	DPV6	d	
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			
76			
77			
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No.	Item	Type	Description
90			
91			
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105			
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Table 12.2 Parameter Table Data Classification: 5

No.	Item	Type	Description
0	DP000	d	=0.0
1	001	d	=1.0
2	002	d	=2.0
3	003	d	=3.0
4	004	d	=273.15
5	005	d	=459.4
6	006	d	=1.0332
7	007	d	=101.3
8	008	d	=10.0
9	009	d	=100.0
10	010	d	
11	011	d	
12	012	d	
13	013	d	
14	014	d	
15	015	d	
16	016	d	
17	017	d	
18	018	d	
19	019	d	
20	020	d	
21	021	d	
22	022	d	
23	023	d	
24	024	d	
25	025	d	
26	026	d	
27	027	d	
28	028	d	
29	029	d	

No.	Item	Type	Description
30	DP030	d	
31	031	d	
32	032	d	
33	033	d	
34	034	d	
35	035	d	
36	036	d	
37	037	d	
38	038	d	
39	039	d	
40	040	d	
41	041	d	
42	042	d	
43	043	d	
44	044	d	
45	045	d	
46	046	d	
47	047	d	
48	048	d	
49	049	d	
50	Up to DP149		
51			
52			
53			
54			
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Table 12.2 Parameter Table Data Classification: 6

No.	Item	Type	Description
0	PnX01	d	X coordinate
1	PnY01	d	Y coordinate
2	PnX02	d	
3	PnY02	d	
4	PnX03	d	
5	PnY03	d	
6	PnX04	d	
7	PnY04	d	
8	PnX05	d	
9	PnY05	d	
10	PnX06	d	
11	PnY06	d	
12	PnX07	d	
13	PnY07	d	
14	PnX08	d	
15	PnY08	d	
16	PnX09	d	
17	PnY09	d	
18	PnX10	d	
19	PnY10	d	
20	PnX11	d	
21	PnY11	d	
22			
23			
24			
25			
26			
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No.	Item	Type	Description
30			
31			
32			
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Table 12.2 Parameter Table Data Classification: 7-0

No.	Item	Type	Description
0	INZ	f	Initialize flag
1	S01	f	Internal flag
2	S02	f	
3	S03	f	
4	S04	f	
5	S05	f	
6	S06	f	
7	S07	f	
8	S08	f	
9			
10	INZ1	f	Initialize flag 1
11	S01CH	f	Internal flag change
12	S02CH	f	
13	S03CH	f	
14	S04CH	f	
15	S05CH	f	
16	S06CH	f	
17	S07CH	f	
18	S08CH	f	
19			
20	INZ2	f	Initialize flag 2
21	Y01	d	Internal data
22	Y02	d	
23	Y03	d	
24	Y04	d	
25	Y05	d	
26	Y06	d	
27	Y07	d	
28	Y08	d	
29			

No.	Item	Type	Description
30			
31	S09	f	Internal flag
32	S10	f	
33	S11	f	
34	S12	f	
35	S13	f	
36	S14	f	
37	S15	f	
38	S16	f	
39			
40			
41	S09CH	f	Internal flag change
42	S10CH	f	
43	S11CH	f	
44	S12CH	f	
45	S13CH	f	
46	S14CH	f	
47	S15CH	f	
48	S16CH	f	
49			
50			
51	Y09	d	Internal data
52	Y10	d	
53	Y11	d	
54	Y12	d	
55	Y13	d	
56	Y14	d	
57	Y15	d	
58	Y16	d	
59			

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Table 12.2 Parameter Table Data Classification: 7-0

No.	Item	Type	Description
60			
61	DO5	f	Digital output
62	DO6	f	Digital output
63			
64			
65	DM5	f	DO mode
66	DM6	f	DO mode
67			
68			
69			
70			
71	DI1	f	Digital input
72	DI2	f	
73	DI3	f	
74	D1CH	f	DI change flag
75	D2CH	f	
76	D3CH	f	
77	DI4	f	Digital input
78	D4DH	f	DI change flag
79			
80			
81	DO1	f	Digital output
82	DO2	f	
83	DO3	f	
84	DO4	f	
85	DM1	f	DO mode
86	DM2	f	
87	DM3	f	
88	DM4	f	
89			

No.	Item	Type	Description
90			
91	AO1	d	Analog output
92	AO2	d	
93			
94			
95			
96	WDT	f	Controller error
97	ALM	f	Alarm status
98	BUZ	f	Buzzer trigger
99	CTS	f	CT (sec)
100			
101			
102			
103			
104			
105			
106			
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Table 12 2 Paramcter Table Data Classification: 7-2

No.	Item	Type	Description
0			
1	V01	d	External variable
2	V02	d	
3	V03	d	
4	V04	d	
5	V05	d	
6	V06	d	
7	V07	d	
8	V08	d	
9	V09	d	
10	V10	d	
11	V11	d	
12	V12	d	
13	V13	d	
14	V14	d	
15	V15	d	
16	V16	d	
17	V17	d	
18	V18	d	
19	V19	d	
20	V20	d	
21	V21	d	
22	V22	d	
23	V23	d	
24	V24	d	
25	V25	d	
26	V26	d	
27	V27	d	
28	V28	d	
29	V29	d	

No.	Item	Type	Description
30	V30	d	
31	V31	d	
32	V32	d	
33			
34			
35			
36			
37			
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41			
42			
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Table 12.2 Parameter Table Data Classification: 7-3

No.	Item	Type	Description
0	VE	f	V error
1	V01E	f	V individual error
2	V02E	f	
3	V03E	f	
4	V04E	f	
5	V05E	f	
6	V06E	f	
7	V07E	f	
8	V08E	f	
9	V09E	f	
10	V10E	f	
11	V11E	f	
12	V12E	f	
13	V13E	f	
14	V14E	f	
15	V15E	f	
16	V16E	f	
17	V17E	f	
18	V18E	f	
19	V19E	f	
20	V20E	f	
21	V21E	f	
22	V22E	f	
23	V23E	f	
24	V24E	f	
25	V25E	f	
26	V26E	f	
27	V27E	f	
28	V28E	f	
29	V29E	f	

No.	Item	Type	Description
30	V30E	f	
31	V31E	f	
32	V32E	f	
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
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Table 12.2 Parameter Table Data Classification: 7-3

No.	Item	Type	Description
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71	CME	f	Communication error
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
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84			
85			
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No.	Item	Type	Description
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Table 12.2 Parameter Table Data Classification: 7-4

No.	Item	Type	Description
0			
1	V01S	f	V update
2	V02S	f	
3	V03S	f	
4	V04S	f	
5	V05S	f	
6	V06S	f	
7	V07S	f	
8	V08S	f	
9	V09S	f	
10	V10S	f	
11	V11S	f	
12	V12S	f	
13	V13S	f	
14	V14S	f	
15	V15S	f	
16	V16S	f	
17	V17S	f	
18	V18S	f	
19	V19S	f	
20	V20S	f	
21	V21S	f	
22	V22S	f	
23	V23S	f	
24	V24S	f	
25	V25S	f	
26	V26S	f	
27	V27S	f	
28	V28S	f	
29	V29S	f	

No.	Item	Type	Description
30	V30S	f	
31	V31S	f	
32	V32S	f	
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
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Table 12.2 Parameter Table Data Classification: 7-5

No.	Item	Type	Description
0			
1	SW1	f	Function switch flag
2	SW2	f	
3	SW3	f	
4	SW4	f	
5	SW5	f	
6	SW6	f	
7	SW7	f	
8	SW8	f	
9			
10			
11			
12			
13			
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28			
29			

No.	Item	Type	Description
30			
31			
32			
33			
34			
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36			
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Table 12.2 Paramcter Table Data Classification: 8

No.	Item	Type	Description
0	PAn	d	Setup signal amp.
1	PKPn	d	Setip Kp
2	PTIn	d	Setup Ti
3	PTAn	d	Setup TA
4	PSIn	d	Setup SI
5	PPFn	f	Setup PF
6			
7			
8			
9			
10	TAn	d	ID signal amp.
11	SIn	d	ID sampling time
12	PFn	f	ID filter spec.
13			
14			
15			
16			
17			
18			
19			
20	DATn	f	Differential spec.
21			
22			
23			
24			
25			
26			
27			
28			
29			

No.	Item	Type	Description
30	EBn	d	Devia. threshhold
31	EIn	d	Dev. check base time
32	ENn	d	Dev. check time lim.
33	SPSn	f	Supervisor exec.
34	SPCn	d	Supervisor status
35			
36			
37			
38			
39			
40	PLMTn	d	Kp limit coeff.
41	ILMTn	d	Ti limit coeff.
42	DLMTn	d	Td limit coeff.
43			
44			
45			
46			
47			
48			
49			
50	ADSn	d	AdTune status
51			
52			
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Table 12.2 Parameter Table Data Classification: 8

No.	Item	Type	Description
60	TKPn	d	Tuning Kp
61	TTIn	d	Tuning Ti
62	TTDn	d	Tuning Td
63	TALn	d	Tuning alpha
64			
65			
66			
67			
68			
69			
70			
71			
72			
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No.	Item	Type	Description
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Table 12.2 Parameter Table Data Classification: 9

No.	Item	Type	Description
0	GSETn	f	Gain sched. status
1	GEXEn	d	Gain sched. exec.
2			
3			
4			
5			
6			
7			
8			
9			
10	GnX0	d	Schadule table level
11	GnX1	d	
12	GnX2	d	
13	GnX3	d	
14	GnX4	d	
15	GnX5	d	
16	GnX6	d	
17	GnX7	d	
18	GnX8	d	
19	GnX9	d	
20	GnKP0	d	Scheduling table Kp
21	GnKP1	d	
22	GnKP2	d	
23	GnKP3	d	
24	GnKP4	d	
25	GnKP5	d	
26	GnKP6	d	
27	GnKP7	d	
28	GnKP8	d	
29	GnKP9	d	

No.	Item	Type	Description
30	GnTI0	d	Scheduling table Ti
31	GnTI1	d	
32	GnTI2	d	
33	GnTI3	d	
34	GnTI4	d	
35	GnTI5	d	
36	GnTI6	d	
37	GnTI7	d	
38	GnTI8	d	
39	GnTI9	d	
40	GnTD0	d	Scheduling table Td
41	GnTD1	d	
42	GnTD2	d	
43	GnTD3	d	
44	GnTD4	d	
45	GnTD5	d	
46	GnTD6	d	
47	GnTD7	d	
48	GnTD8	d	
49	GnTD9	d	
50	GnAL0	d	Scheduling table α
51	GnAL1	d	
52	GnAL2	d	
53	GnAL3	d	
54	GnAL4	d	
55	GnAL5	d	
56	GnAL6	d	
57	GnAL7	d	
58	GnAL8	d	
59	GnAL9	d	

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12.3 Security level default value

Table 12.3 Security level default value

Mode	Item	Level
ALM	SYALM	-
	LOOP*	-
	ALPV*	-
I/O	PVC*	-
	AO*	Level 1
	DI1-3	-
	DO*	Level 1
	DOM*	Level 1
PARAM	PH*	Level 1
	PL*	Level 1
	△PV*	Level 1
	DF*	Level 2
	LC*	Level 2
	RH*	Level 2
	RL*	Level 2
	PV*	-
	CV*	-
	SV*	Free
	MV*	Free
	MODE*	Free
	MH*	Level 1
	ML*	Level 1
	△MV*	Level 1
	DVL*	Level 1
	Kp*	Level 1
	Ti*	Level 1
	Td*	Level 1
	Rt*	Level 1
	Bs*	Level 1
	△T*	Level 2
	D/R*	Level 2
	VD*	Level 2
	MVF*	Level 1
SYSTM	PV*OP	-
	COMOP	-
	FUNC*	Level 2
	FNCCG	Level 2
	PLN*	Level 2
	PLTBL	Level 2
	P****	Level 2
	PLNST	Level 2
	RS232	Level 1
	RS485	Level 1
	CADDR	-
	HSTAD	-
	MAXST	Level 2
	MC**-	-
	CARDR	Level 2
	CARDW	Level 2
	PARAR	Level 2
	PARAW	Level 2
	SYCOD	-
	SW*-*	Level 1
	BARMD	Level 1
	BAR*	Level 1
	CVSC*	Level 2
	SVSC*	Level 2
	MVSC*	Level 2
	SAVE	Level 2
	Load	Level 2
	PLOCK	Free
	SVT*	Level 2
	SCAN*	Level 2
	ALMCF	Free
	AO*TP	Level 1
	AO*RH	Level 1
	AO*RL	Level 1
	LGPG*	Level 1
	LG△T*	Level 1
	LG*TP	Level 1
	DPSET	Level 1
	DP***	Level 1
	CTALM	-
	SECU1	Free
	SECU2	Level 1
	TAG*	Level 2
	UPV**	Level 2
	USR**	Level 2
	MBVER	-
	CBVER	-
	LDVER	-
ADTUN	PA*	Level 1
	TA*	Level 1
	SI*	Level 1
	PF*	Level 1
	DAT*	Level 1
	MDL*	Level 1
	SPS*	Level 1
	SPC*	Level 1
	EB*	Level 1
	EI*	Level 1
	EN*	Level 1
	PLMT*	Level 1
	ILMT*	Level 1
	DLMT*	Level 1
	AdS*	Level 1
	TKp*	-
	TTi*	-
	TTd*	-
	Tα*	-
	PTA*	-
	PSI*	-
	PPF*	-
	SET*	Level 1
	α*	Level 1

Mode	Item	Level
User customized key	UFNC 1	Free
	UFNC 2	Free
	UFNC 3	Free
	UFNC 4	Free
	UFNC 5	Free
	UFNC 6	Free
	UFNC 7	Free
	UFNC 8	Free
	UFNC 9	Free
	UFNC10	Free
	UFNC11	Free
	UFNC12	Free
	UFNC13	Free
	UFNC14	Free
	UFNC15	Free
	UFNC16	Free
	UFNC17	Free
	UFNC18	Free
	UFNC19	Free
	UFNC20	Free
	UFNC21	Free
	UFNC22	Free
	UFNC23	Free
	UFNC24	Free
	UFNC25	Free
	UFNC26	Free
	UFNC27	Free
	UFNC28	Free
	UFNC29	Free
	UFNC30	Free

When parameters are registered user functions by key code, the security level are changed the parameter's.

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12.4 Engineering unit

Engineering unit is set by following ASCII code.

Table 12.4 ASCII Code

		First digit							
		0	1	2	3	4	5	6	7
Second digit	0				0	@	P	‘	p
	1			!	1	A	Q	a	q
	2			"	2	B	R	b	r
	3			#	3	C	S	c	s
	4			$	4	D	T	d	t
	5			%	5	E	U	e	u
	6			&	6	F	V	f	v
	7			’	7	G	W	g	w
	8			(	8	H	X	h	x
	9			)	9	I	Y	i	y
	A			*	:	J	Z	j	z
	B			+	;	K	[	k	
	C			,	<	L	¥	l	
	D			-	=	M	]	m	
	E			.	>	N	^	n	
	F			/	?	O	_	o	

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12.5 Key code

User customized key is set by following key code.

Table 12.5 Key Code

Key code	Display	Key code	Display
0000	-----		
0100	SYALM	3200-3201	PV*OP
0200-0203	LOOP*	3202	COMOP
0300-0305	ALPV*	3300-3301	FUNC*
		3302	FNCCG
0A00-0A05	PVC*	3400-3405	PLN*
0B00-0B01	AO*		
0C00	DI1-4	3600	RS232
0D00-0D05	DO*	3700	RS485
0E00-0E05	DOM*	3701	CADDR
		3702	HSTAD
1400-1405	PH*	3703	MAXST
1500-1505	PL*	3800-3803	MC**~
1600-1605	ΔPV*	3900	CARDR
1700-1705	DF*	3901	CARDW
1800-1805	LC*	3902	PARAR
1900-1905	RH*	3903	PARAW
1A00-1A05	RL*	3A00	SYCOD
1B00-1B05	PV*	3B00-3B01	SW*~*
1C00-1C03	CV*	3C00	BARMD
1D00-1D03	SV*	3C01-3C04	BAR*
1E00-1E05	MV*	3D00-3D03	CVSC*
1F00-1F03	MODE*	3D04-3D07	SVSC*
		3D08-3D0B	MVSC*
2000-2003	MH*	3E00	SAVE
2100-2103	ML*	3E01	LOAD
2200-2203	ΔMV*	3F00	PLOCK
2300-2303	DVL*		
2400-2403	Kp*		
2500-2503	Ti*		
2600-2603	Td*		
2700-2703	Rt*		
2800-2803	Bs*		
2900-2903	ΔT*		
2A00-2A03	D/R*		
2B00-2B03	VD*		

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Key code	Display	Key code	Display
4000-4003	SVT*	5000-5003	PA*
4100-4105	SCAN*	5100-5103	TA*
4200	ALMCF	5200-5203	SI*
4300,4303	AO*TP	5300-5303	PF*
4301,4304	AO*RH	5400-5403	DAT*
4302,4305	AO*RL	5500-5503	MDL*
4400,4403	LGPG*	5600-5603	SPS*
4401,4404	LG△T*	5700-5703	SPC*
4402,4405	LG*TP	5800-5803	EB*
4500-4596	DP***	5900-5903	EI*
4600	CTALM	5A00-5A03	EN*
4700-4701	SECU*	5B00-5B03	PLMT*
4800-4813	TAG**	5C00-5C03	IMLT*
4900-491D	UPV**	5D00-5D03	DLMT*
4A00-4A1D	USR**	5E00-5E03	AdS*
4B00	MBVER	5F00-5F03	TKp*
4B01	CBVER	6000-6003	TTi*
4B02	LDVER	6100-6103	TTd*
		6200-6203	Tα*
4C00	DPSET	6300-6303	PTA*
		6400-6403	PSI*
		6500-6503	PPF*
		6600-6603	SET*
		6700-6703	α*
		6E00-6EC7	LNnnn
		6F00-6FC7	S1nnn
		7000-70C7	S2nnn
		7100-7107	C1nnn
		7200-7207	C2nnn
		7300-7307	SMnnn
		7400-740F	Y**
		7500	S01~
		7600	S05~
		7700	S09~
		7800	S13~
		7900-791F	V**

Note: LNnnn: Linearization space block output
S1nnn: Status space 1 block output
S2nnn: Status space 2 block output
C1nnn: Control space 1 block output
C2nnn: Control space 2 block output
SMnnn: Simulation space block output

nnn is block number.

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13. Indicator function

This controller (Ver.6****) works as an indicator, when "Indicator" is selected as controller mode of controller setup table by the loader (Ver.4.**). ***«NEW»***

13.1 Front Panel Functions

The following is the front panel functions when the controller works as an indicator.

(1) Numeric item display and numeric indicator

Shows a variety of parameters and data.
PV numeric display can be made using the [CLR/SEL] key.
PV can be displayed with User tags.
Engineering unit can be displayed by pushing [ENT/FAST] key for more than one second.

(2) HALT display (HALT)

Indicates an error on control on the controller.
The HALT display is normally OFF. It lights up in the following cases.

HALT Display

Display Status	Cause
Continuously ON	ADC fault

(3) ALM display (ALM)

Indicates an error on control.
This indicator lights up in the following cases.

ALM Display

Display Status	Cause
Process alarm	(1) Sensor error (PV inactive) (2) High/Low limit error (PVH, PVL) (3) Rate of change error (PVD)
System alarm	(1) Communication error (2) CJC alarm (3) Battery of memory card alarm

(4) COMPUTER LOCAL display (CMP)

This indicator lights up according to computer flags (CMP flags).

(5) SELF-TUNING ON display (ATC)

This indicator is OFF.

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(6) HOLD display (HOLD)

This indicator lights up under the following conditions.

HOLD Display

Display Status	Cause
Continuously ON	(1) During control function registration (2) During IC memory card data read (3) During saving to EEPROM
Blinking	(1) During simulation

(7) LOOP display

This indicator indicates the input point number of the bar graph being displayed on the panel.

(8) MODE display

This indicator is OFF.

(9) SV set key (△/▽)

When setting parameter, this key is used to select data.

(10) C/A mode changeover key (C/A)

This key is not used.

(11) M mode changeover key (M)

This key is not used.

(12) Manual operation key (▲,▼)

When setting parameter, this key is used to select the digit.

(13) CV scale display

This indicator indicates the PV1 or PV4 scale.

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(14) CV display bar graph

The bar graph indicates the PV1 or PV4 value with 1% resolution (for one-loop display). In the event of a process higher/lower limit alarm, the normal range is indicated in blinking form on the CV scale display. Blinking can be stopped (alarm check) with the [ENT/FAST] key.
In normal operation, the higher/lower limit alarm set value can be displayed (PH/PL display) with the [ENT/FAST] key.

(15) SV scale display

This indicator indicates the PV2 or PV5 scale.

(16) SV display

The bar graph indicates the PV2 or PV5 value with 1% resolution (for one-loop display). In the event of a process higher/lower limit alarm, the normal range is indicated in blinking form on the CV scale display. Blinking can be stopped (alarm check) with the [ENT/FAST] key.
In normal operation, the higher/lower limit alarm set value can be displayed (PH/PL display) with the [ENT/FAST] key.

(17) MV scale display

This indicator indicates the PV3 or PV6 scale.

(18) MV display bar graph

The bar graph indicates the PV3 or PV6 value with 1% resolution (for one-loop display). In the event of a process higher/lower limit alarm, the normal range is indicated in blinking form on the CV scale display. Blinking can be stopped (alarm check) with the [ENT/FAST] key.
In normal operation, the higher/lower limit alarm set value can be displayed (PH/PL display) with the [ENT/FAST] key.

(19) CLEAR/SELECT key (CLR/SEL)

This key is used to change the display data items (PV1 to PV6) on the numeric indicator and to cancel data being changed.

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(20) FUNCTION key (FNC)

If this key continues to be pressed for more than one second, change the engineering mode with the user customized mode.

* Enigneering mode
This key is used to shift the noraml display mode to the function mode. Each time this key is pressed the displayed selection menu is changed.

* User cutomized mode
When this key is pressed in the normal display mode, the only defined parameters are changed. Each time this key is pressed the parameter menu is changed.

Key-in	Operation mode	Display
	Engineering mode	
	Normal operation	
FNC	Alarm operation	'ALM'
FNC	I/O operation	'I/O'
FNC	Parameter operation	'PARAM'
FNC	System operation	'SYSTM'
FNC	Self tuning operation	'ADTUN'
FNC	Back to alarm operation	'ALM'
	User customized mode	
	Normal operation	example:
FNC		
FNC		DP100
FNC		DP101
FNC		DP102
		DP103

(21) ENTER/FAST key (ENT/FAST)

If this key is pressed in the event of an alarm (with the bar graph blinking), the alarm is confirmed and blinking stops. If the key is pressed for more than one second under normal conditions, the PH/PL range is displayed on the scale line. In the both cases numeric item display is changed engineering unit display.

(22) LOOP select key

This key is used to select the control loop number, input point number and polynomial line table number.

It also is used to select display input point on the front panel bar graph display.

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13.2 Operation

The following is the data display method in the case of the indicator mode.

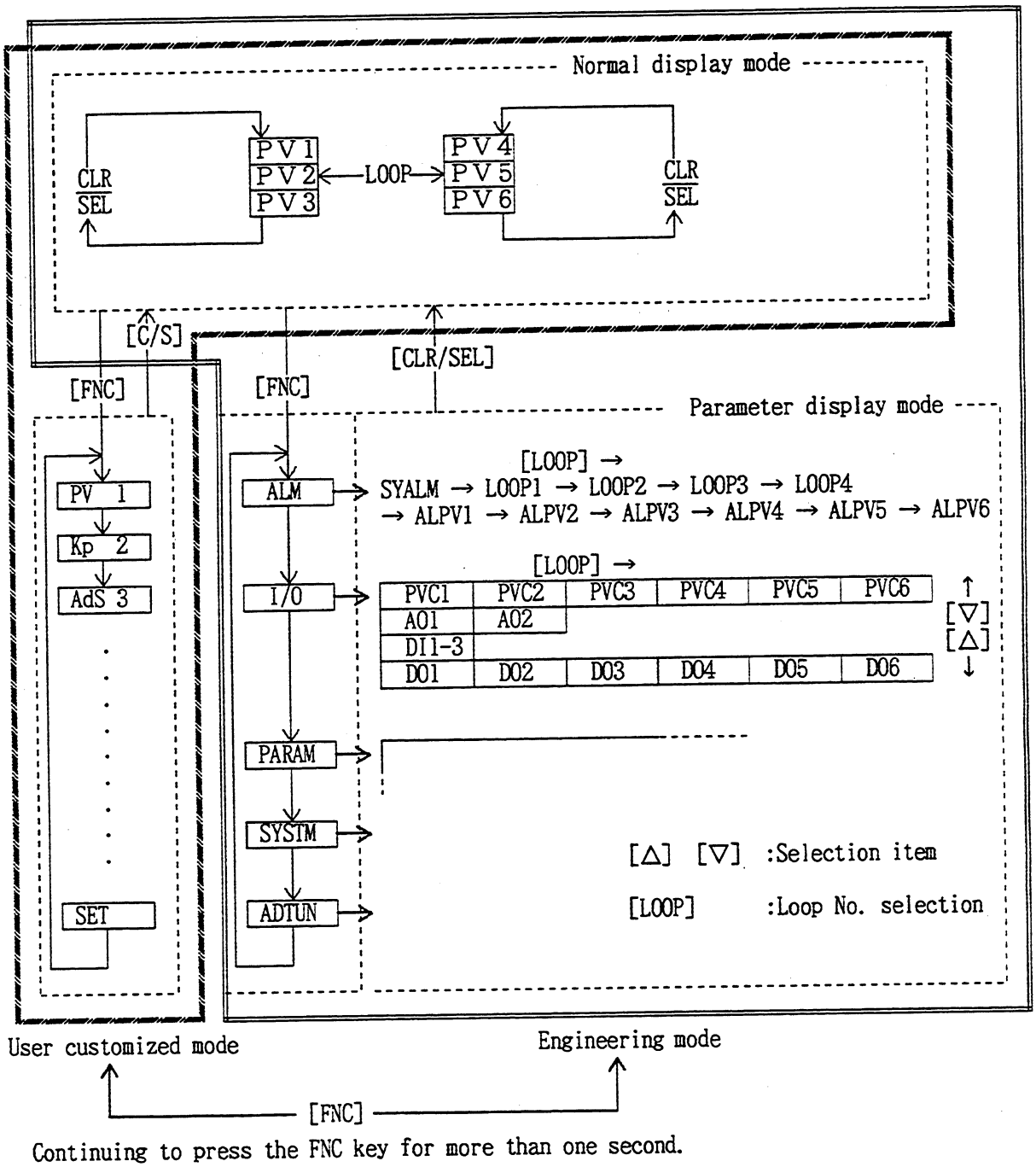


Figure 13.1 Data display method for indicator mode

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13.3 Operation of Parameters

(1) Bar graph display mode

BARMD	*	Front panel bar display mode specification 0/1: Three points display/six points display Setting enable
BAR*	*	Not used for indicator mode No.

(2) No. of CV scale divisions

CVSC*	10	No. of PV1/PV4 scale divisions Setting enable for 1 to 20 divisions. User scale for 21 to 28 divisions.
Loop No. (1 to 4)		Loop No.1/2:PV1/PV4

No. of SV scale divisions

SVSC*	10	No. of SV scale divisions Setting enable for 1 to 20 divisions. User scale for 21 to 28 divisions.
Loop No. (1 to 4)		Loop No.1/2:PV2/PV5

No. of MV scale divisions

MVSC*	10	No. of MV scale divisions Setting enable for 1 to 20 divisions. User scale for 21 to 28 divisions.
Loop No. (1 to 4)		Loop No.1/2:PV3/PV6

Loop No.	CVSC	SVSC	MVSC
1	PV1	PV2	PV3
2	PV4	PV5	PV6
3	-	-	-
4	-	-	-

(3) User tag specification

TAG11	41	Not used for indicator mode

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13.4 Bar Graph Display

The process loop controller has BD2/BDm module for the front panel bar graph display in the case of indicator mode.

Three points or six points display is defined by H2 of BDM module.

Don't use LNO and BDP module in the case of indicator mode.

(1) Three points display

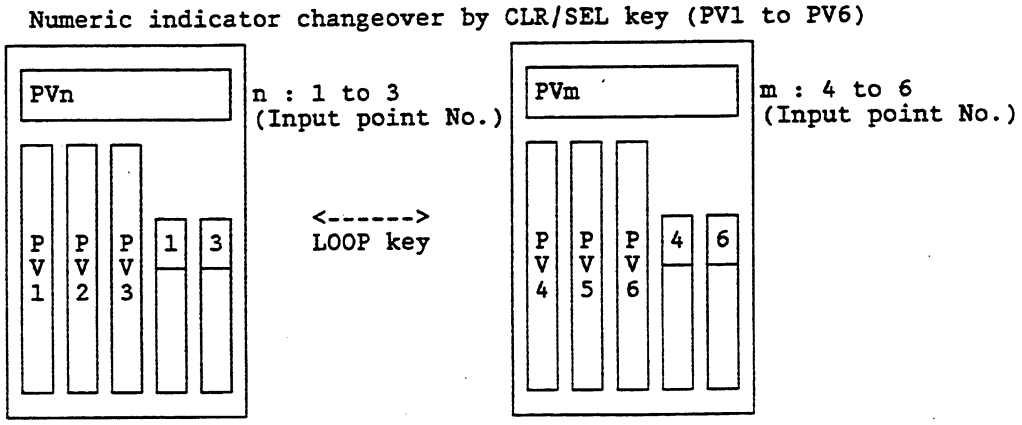


Figure 13.2 Changeover Operation (Three points display)

(2) Six points display

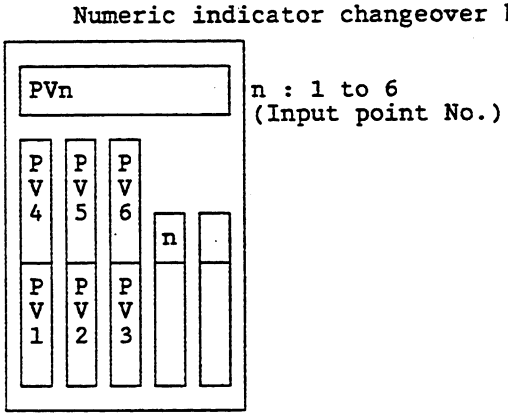


Figure 13.3 Changeover Operation (Six points Display)

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13.5 Function Modules

The following describes the difference of function modules from controller mode.

(1) Bar graph display module (BDP)

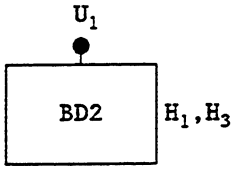


Figure 13.4 BD2 Function Module

U1: execution flag (When 0, not execute. When not 0, execute.)
H1: bar graph display type (When 0, bar graph display. When not 0, point display.)
H3: bar No. (1 to 6)

The process loop controller has six areas for bar graph display (BAR1 to 6) in the case of indicator mode. BAR No. is corresponds with input point No.
The process loop controller displays the data of the PV of BARn with display mode of H1.

It is inhibited to use BD2 module with BDP and LNO modules.

(2) Bar graph display mode module (BDM)

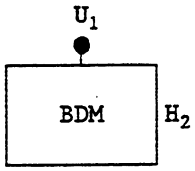


Figure 13.5 BDM Function Module

U1:execution flag (When 0, not execute. When not 0, execute.)
H2:bar graph display mode (When 0, three points display. When not 0, six points display.)

H1, H3 and H4 are ignored.

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First Edition July 1992
Second Edition July 1993



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