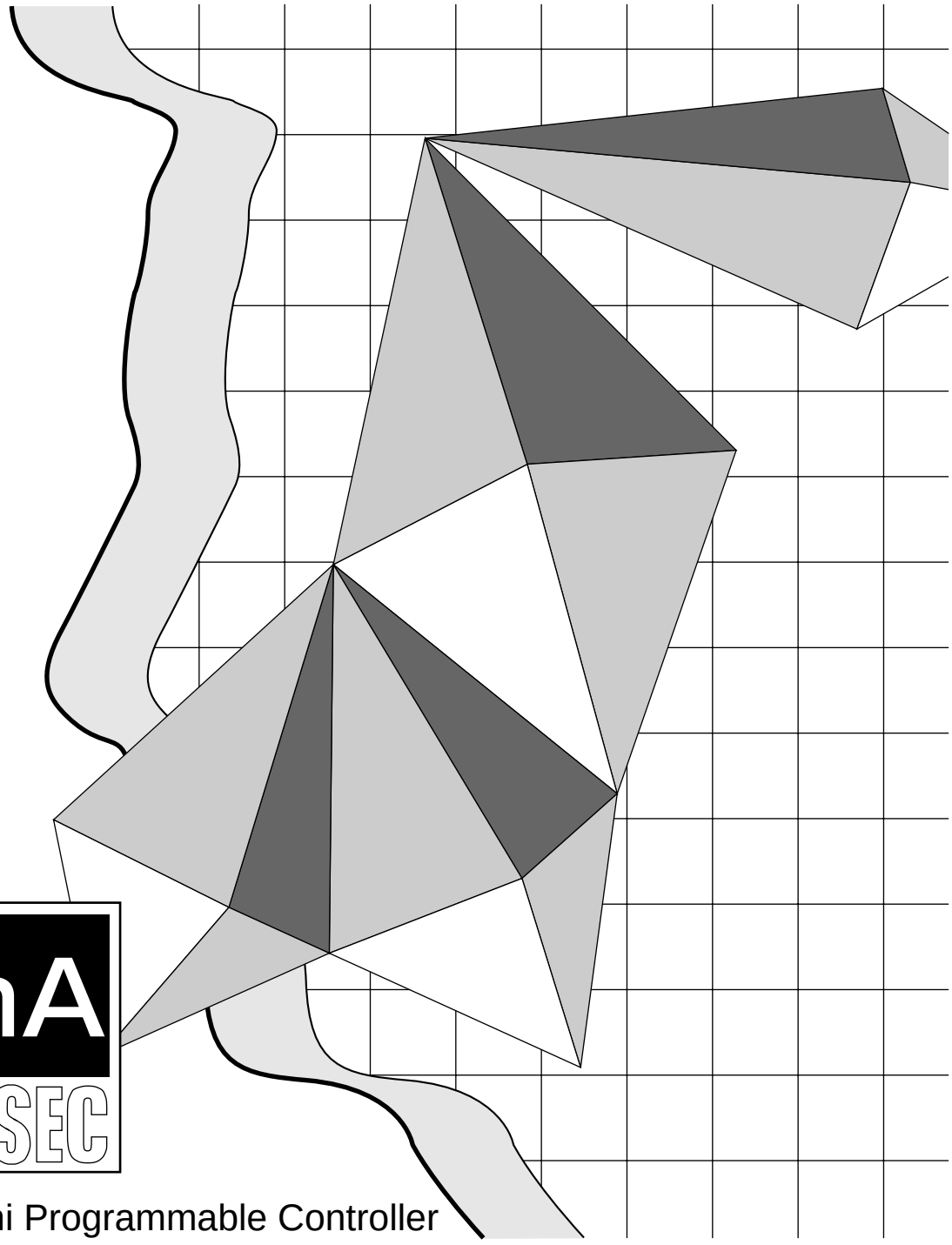
MITSUBISHI

QnA SERIES

QnACPU

PROGRAMMING MANUAL (PID Control Instructions)



QnA

MELSEC

Mitsubishi Programmable Controller

SAFETY CAUTIONS

(You must read these cautions before using the product)

In connection with the use of this product, in addition to carefully reading both this manual and the related manuals indicated in this manual, it is also essential to pay due attention to safety and handle the product correctly.
The safety cautions given here apply to this product in isolation. For information on the safety of the PC system as a whole, refer to the CPU module User's Manual.
These **SAFETY CAUTIONS** are classified into two grades: "DANGER" and "CAUTION".

DANGER Safety caution given when incorrect handling could result in hazardous situations involving the possibility of death or serious injury.

CAUTION Safety caution given when incorrect handling could result in hazardous situations involving the possibility of moderate or light injury or damage to property.

Note that, depending on the circumstances, failing to follow a  **CAUTION** may also have very serious consequences.
Both of these classes of safety caution are very important and must be observed.
Store this manual carefully in a place where it is accessible for reference whenever necessary, and forward a copy of the manual to the end user.

[System Design Precautions]

DANGER

- Safety circuits should be installed external to the programmable controller to ensure that the system as a whole will continue to operate safely in the event of an external power supply malfunction or a programmable controller failure. Erroneous outputs and operation could result in an accident.
  1) The following circuitry should be installed outside the programmable controller:
     Interlock circuitry for the emergency stop circuit protective circuit, and for reciprocal operations such as forward/reverse, etc., and interlock circuitry for upper/lower positioning limits, etc., to prevent machine damage.
  2) When the programmable controller detects an abnormal condition, processing is stopped and all outputs are switched OFF. This happens in the following cases:
     - When the power supply module's over-current or over-voltage protection device is activated.
     - When an error (watchdog timer error, etc.) is detected at the PC CPU by the self-diagnosis function.

     Some errors, such as input/output control errors, cannot be detected by the PC CPU, and there may be cases when all outputs are turned ON when such errors occur. In order to ensure that the machine operates safely in such cases, a failsafe circuit or mechanism should be provided outside the programmable controller. Refer to the CPU module user's manual for an example of such a failsafe circuit.
  3) Outputs may become stuck at ON or OFF due to an output module relay or transistor failure. An external circuit should therefore be provided to monitor output signals whose incorrect operation could cause serious accidents.

- A circuit should be installed which permits the external power supply to be switched ON only after the programmable controller power has been switched ON. Accidents caused by erroneous outputs and motion could result if the external power supply is switched ON first.

- When a data link communication error occurs, the status shown below will be established at the faulty station. In order to ensure that the system operates safely at such times, an interlock circuit should be provided in the sequence program (using the communication status information).
  Erroneous outputs and operation could result in an accident.
  1) The data link data which existed prior to the error will be held.
  2) All outputs will be switched OFF at MELSECNET (II, /B, /10) remote I/O stations.
  3) At the MELSECNET/MINI-S3 remote I/O stations, all outputs will be switched OFF or output statuses will be held, depending on the E.C. mode setting.

  For details on procedures for checking faulty stations, and for operation statuses when such errors occur, refer to the appropriate data link manual.

[System Design Precautions]

⚠ CAUTION

- Do not bundle control lines or communication wires together with main circuit or power lines, or lay them close to these lines.
  As a guide, separate the lines by a distance of at least 100 mm, otherwise malfunctions may occur due to noise.

[Cautions on Mounting]

⚠ CAUTION

- Use the PC in an environment that conforms to the general specifications in the manual.
  Using the PC in environments outside the ranges stated in the general specifications will cause electric shock, fire, malfunction, or damage to/deterioration of the product.
- Make sure that the module fixing projection on the base of the module is properly engaged in the module fixing hole in the base unit before mounting the module.
  Failure to mount the module properly will result in malfunction or failure, or in the module falling.
- Extension cables should be securely connected to base unit and module connectors. Check for loose connection after installation.
  A poor connection could result in contact problems and erroneous inputs/outputs.
- Plug the memory casette firmly into the memory casette mounting connector. Check for loose connection after installation.
  A poor connection could result in erroneous operation.
- Plug the memory firmly into the memory socket. Check for loose connection after installation.
  A poor connection could result in erroneous operation.

[Cautions on Wiring]

DANGER

- Switch off the external power supply before staring installation and wiring work.
  Failure to do so could result in electrical shocks and equipment damage.
- After installation and wiring is completed, be sure to attach the terminal cover before switching the power ON and starting operation.
  Failure to do so could result in electrical shocks.

CAUTION

- Be sure to ground the FG and LG terminals, carrying out at least class 3 grounding work with a ground exclusive to the PC.
  Otherwise there will be a danger of electric shock and malfunctions.
- Carry out wiring to the PC correctly, checking the rated voltage and terminal arrangement of the product.
  Using a power supply that does not conform to the rated voltage, or carrying out wiring incorrectly, will cause fire or failure.
- Outputs from multiple power supply modules should not be connected in parallel. Failure to do so could cause the power supply module to overheat, resulting in a fire or module failure.
- Tighten the terminal screws to the stipulated torque.
  Loose screws will cause short circuits, fire, or malfunctions.
- Make sure that no foreign matter such as chips or wiring offcuts gets inside the module.
  It will cause fire, failure or malfunction.
- Connectors for external connections should be crimped, pressure welded, or soldered in the correct manner using the correct tools.
  For details regarding crimping and pressure welding tools, refer to the input/output module user's manual.
  A poor connection could cause shorts, fire, and erroneous operation.

[Cautions on Startup and Maintenance]

DANGER

- Do not touch terminals while the power is ON.
  This will cause malfunctions.
- Make sure that the battery is connected properly. Do not attempt to charge or disassemble the battery, do not heat the battery or place it in a flame, and do not short or solder the battery.
  Incorrect handling of the battery can cause battery heat generation and ruptures which could result in fire or injury.
- Switch the power off before cleaning or re-tightening terminal screws.
  Carrying out this work while the power is ON will cause failure or malfunction of the module.

CAUTION

- In order to ensure safe operation, read the manual carefully to acquaint yourself with procedures for program changes, forced outputs, RUN, STOP, and PAUSE operations, etc., while operation is in progress.
  Incorrect operation could result in machine failure and injury.
- Do not disassemble or modify any module.
  This will cause failure, malfunction, injuries, or fire.
- Switch the power OFF before mounting or removing the module.
  Mounting or removing it with the power ON can cause failure or malfunction of the module.
- When replacing fuses, be sure to use the prescribed fuse. A fuse of the wrong capacity could cause a fire.

[Cautions on Disposal]

CAUTION

- Dispose of this product as industrial waste.

REVISIONS

*The manual number is given on the bottom left of the back cover.

Print Date	*Manual Number	Revision
Feb., 1996	IB (NA) 66618-A	First edition

INTRODUCTION

Thank you for choosing the Mitsubishi MELSEC-QnA Series of General Purpose Programmable Controllers. Please read this manual carefully so that the equipment is used to its optimum. A copy of this manual should be forwarded to the end User.

CONTENTS

About Manuals

The manuals related to the QnACPU are listed in the table below.
Please order those you require.

Related Manuals

Manual Name	Manual Number (Mode Code)
QnACPU Guidebook Aimed at people using QnACPU for the first time. Describes procedures for everything from creating programs and writing created programs to the CPU, to debugging. Also describes how to use the QnACPU most effectively.	IB-66606
QnACPU User's Manual Describes the performance, functions, and handling of the Q2ACPU(S1), Q3ACPU, and Q4ACPU, and the specifications and handling of memory cards and base units. (Purchased separately)	IB-66608
QnACPU Programming Manual (Fundamentals) Describes how to create programs, the names of devices, parameters, and types of program. (Purchased separately)	IB-66614
QnACPU Programming Manual (Common Instructions) Describes how to use sequence instructions, basic instructions, and application instructions. (Purchased separately)	IB-66615
QnACPU Programming Manual (Special Function) Describes the dedicated instructions for special function modules available when using the Q2ACPU(S1), Q3ACPU, and Q4ACPU. (Purchased separately)	IB-66616
QnACPU Programming Manual (AD57 Instructions) Describes the dedicated instructions for controlling an AD57(S1) type CRT controller module available when using the Q2ACPU(S1), Q3ACPU, or Q4ACPU. (Purchased separately)	IB-66617
Building Block Type I/O Module User's Manual Describes the specifications of building block type I/O modules. (Purchased separately)	IB-66140
MELSECNET/10 Network System (for QnA) Reference Manual Describes the general concept, specifications, and part names and settings, for MELSECNET/10. (Purchased separately)	IB-66620
MELSECNET, MELSECNET/B Data Link System Reference Manual Describes the general concept, specifications, and part names and settings, for MELSECNET(II), MELSECNET/B. (Purchased separately)	IB-66350
Type SW0IVD-GPPQ GPP Function Operating Manual (Offline) Describes the how to create programs and print out data when using SW0IVD-GPPQ, and the offline functions of SW0IVD-GPPQ such as file maintenance. (Supplied with the product)	IB-66623
Type SW0IVD-GPPQ GPP Function Operating Manual (Online) Describes the online functions of SW0IVD-GPPQ, including the methods for monitoring and debugging. (Supplied with the product)	IB-66624
Type SW0IVD-GPPQ GPP Function Operating Manual (SFC) Describes the system configuration, performance specifications, functions, system startup procedure, SFC program editing method, monitoring method, printout method, and error messages, for MELSAP-3. (Supplied with the product)	IB-66625

1. GENERAL DESCRIPTION

This manual describes the sequence program instructions used to execute PID control with the QnACPU.
The QnACPU has the capability to use instructions for PID control as a standard feature, so PID control can be executed by loading an A/D conversion module and a D/A conversion module.
In addition, the PID control status can be monitored with an AD57(S1).

1.1 PID Processing Method

This section describes the processing method for PID control using PID control instructions. (For details on PID operations, see Chapter 4.)

Execute PID control with PID control instructions by loading an A/D conversion module and a D/A conversion module, as shown in Figure 1.1.

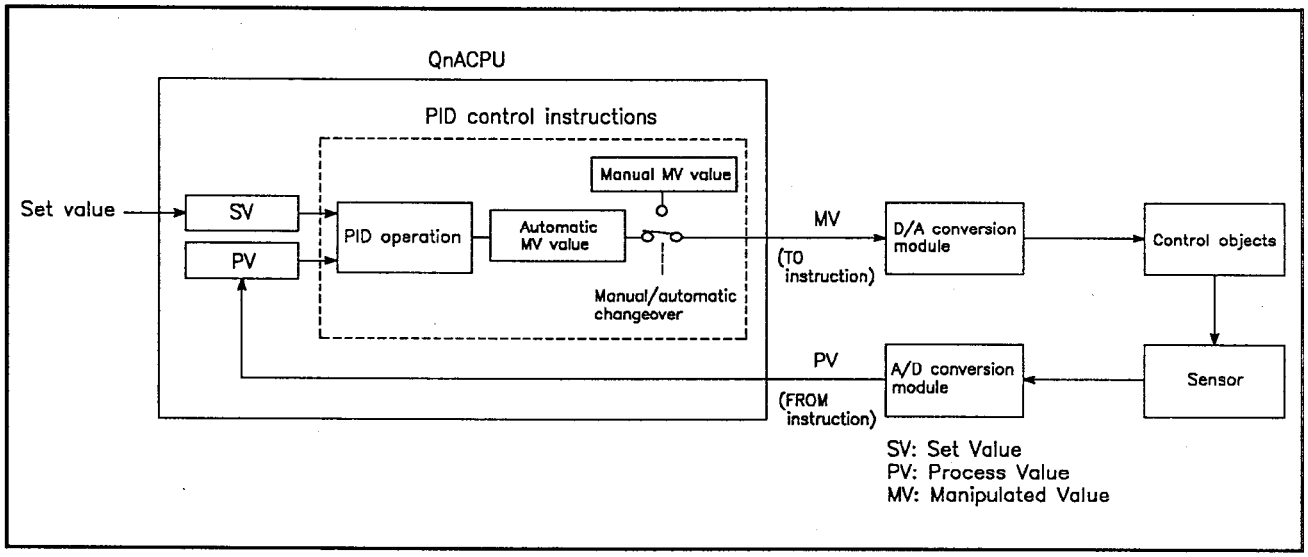


Fig 1.1 Overview of PID Control Processing

As shown in Figure 1.1, using the previously set SV (set value) and the digital PV (process value), which is read from the A/D conversion module, PID operation is executed to obtain the MV (manipulated value).
The calculated MV (manipulated value) is output to the D/A conversion module.

The sampling cycle is measured, and the PID operation is performed, when the PIDCONT instruction is executed in the sequence program, as illustrated below.
PID operation in accordance with the PIDCONT instruction is executed in preset sampling cycles.

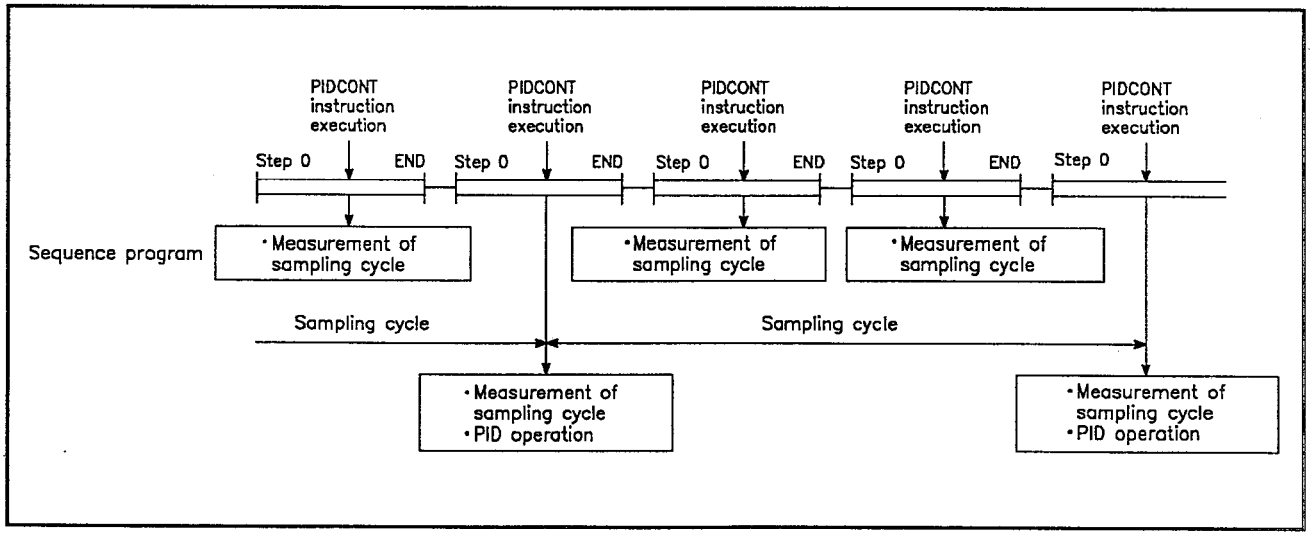


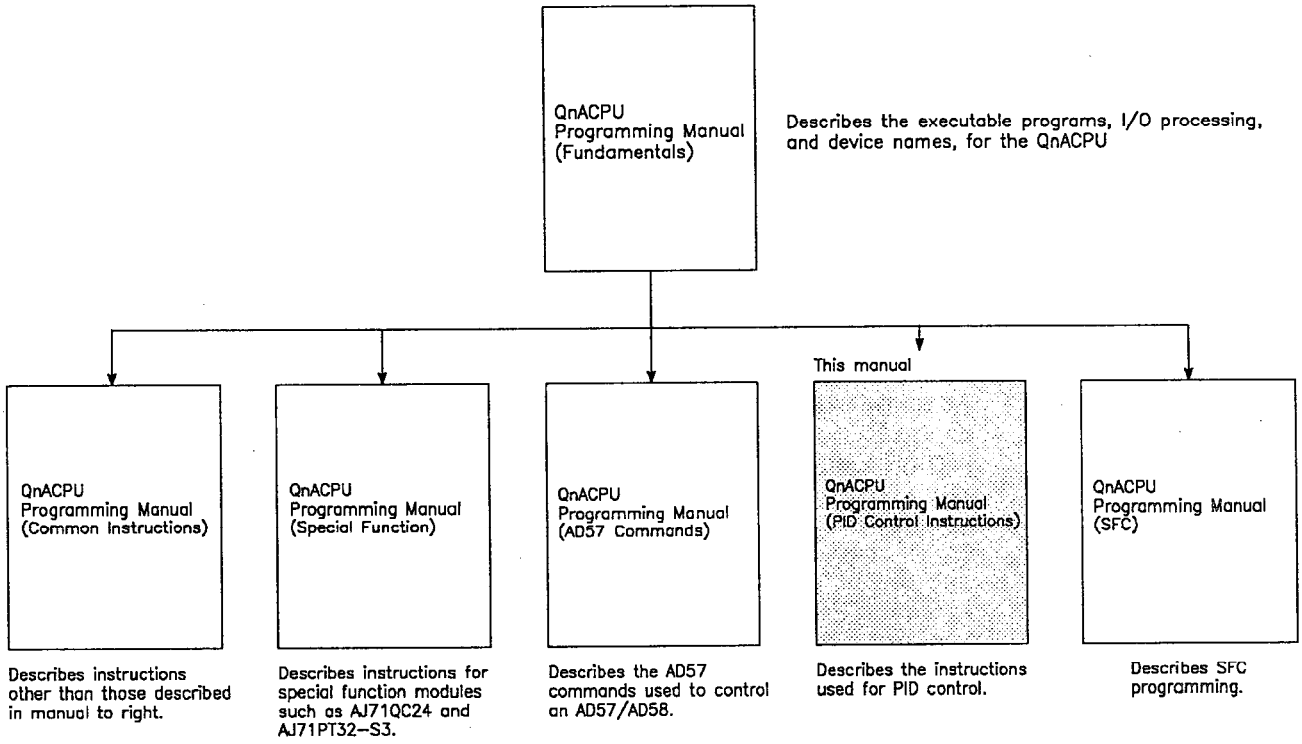
Fig. 1.2 Operation when PIDCONT Instruction Executed

1.2 Related Programming Manuals

Apart from this manual, there are the following five other programming manuals for QnACPU:

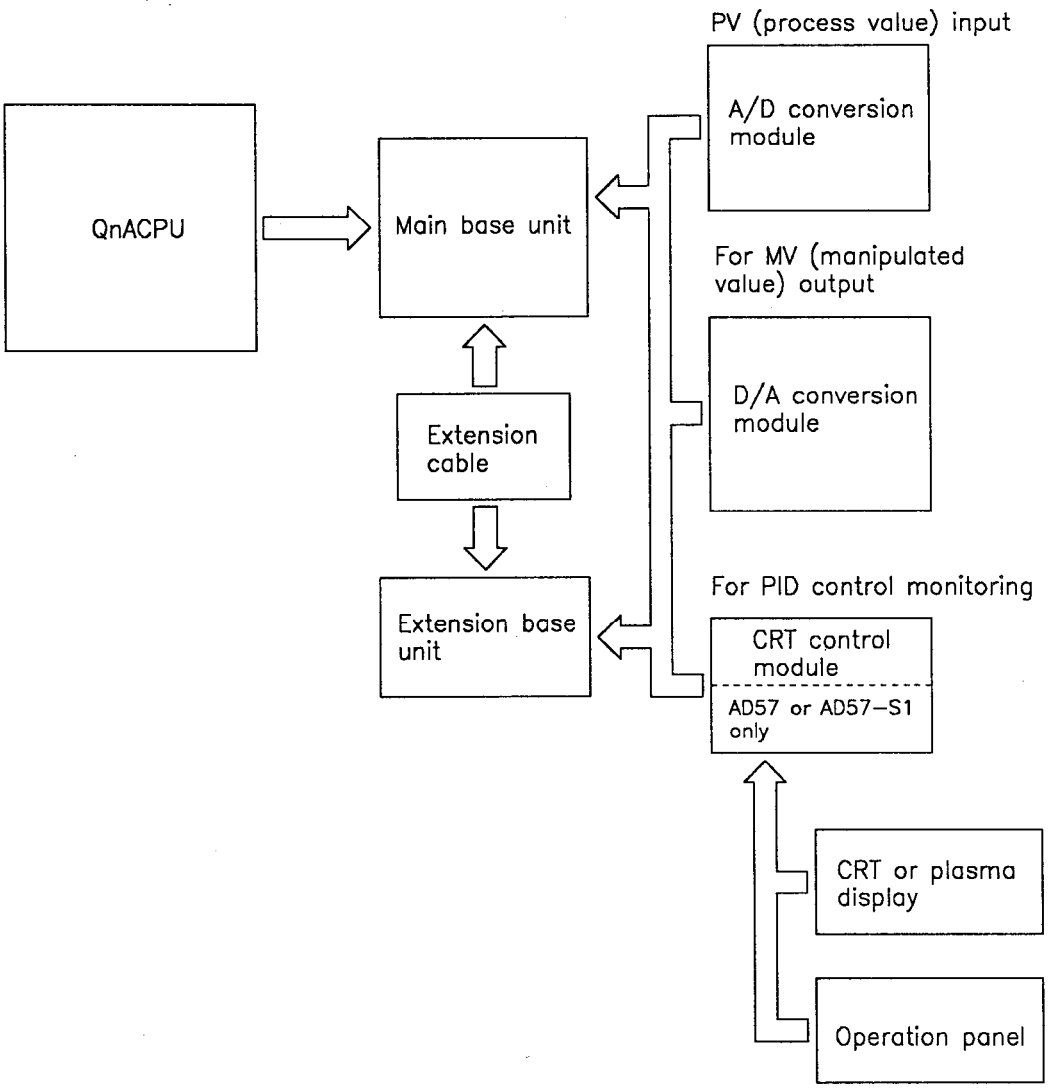
- QnACPU Programming Manual (Fundamentals)
- QnACPU Programming Manual (Special Function)
- QnACPU Programming Manual (Common Instructions)
- QnACPU Programming Manual (AD57 Commands)
- QnACPU Programming Manual (SFC)

Before reading this manual, check the programs, I/O processing, devices, etc., that can be used with QnACPU by referring to the QnACPU Programming Manual (Fundamentals).



2. SYSTEM CONFIGURATION FOR PID CONTROL

This section describes the system configuration for PID control using PID control instructions.
(For details on the units and modules that can be used when configuring the system, refer to the manual for the CPU module used.)



POINT

The reference range for SV, PV, and MV values used in PID operations is 0 to 2000.
If the resolution of the A/D conversion module or D/A conversion module used for input/output in PID control is not 0 to 2000, convert the digital values to 0 to 2000.

3. PID CONTROL SPECIFICATIONS

This section gives the specifications for PID control using PID control instructions.

3.1 Performance Specifications

The performance specifications for PID control are tabled below.

Item			Specification
Number of PID control loops		—	32 loops (maximum)
Sampling cycle		T_S	0.01 to 60.00 sec
PID operation method		—	Process value differentiation (normal operation/reverse operation)
PID constant setting range	Proportionate constant	K_P	0.01 to 100.00
	Integration constant	T_I	0.1 to 3000.0 sec
	Differential constant	T_D	0.00 to 300.00 sec
SV (set value) setting range		SV	0 to 2000
PV (process value) setting range		PV	-50 to 2050
MV (manipulated value) output range		MV	

3.2 Operation Expressions

The operation expressions for PID control using PID control instructions are indicated below.

Name		Operation Expressions	Meanings of Symbols
Process value differentiation	Normal operation	$EV_n=PV_{nf}{}^*-SV$ $\Delta MV=Kp\ \{(EV_n-EV_{n-1})+\frac{T_S}{T_I}EV_n-\frac{T_D}{T_S}(2PV_{nf-1}-PV_{nf}-PV_{nf-2})\}$ $MV_n=\Sigma\Delta MV$	EV_n : Deviation in the present sampling cycle EV_{n-1} : Deviation in the preceding sampling cycle SV : Set value PV_{nf} : Process value of the present sampling cycle (after filtering) PV_{nf-1} : Process value of the preceding sampling cycle (after filtering) PV_{nf-2} : Process value of the sampling cycle two cycles before(after filtering) ΔMV : Output change amount MV_n : Present manipulation amount K_P : Proportionate constant T_S : Sampling cycle T_I : Integration constant T_D : Differential constant
	Reverse operation	$EV_n=SV-PV_{nf}{}^*$ $\Delta MV=Kp\{(EV_n-EV_{n-1})+\frac{T_S}{T_I}EV_n-\frac{T_D}{T_S}(2PV_{nf-1}-PV_{nf}-PV_{nf-2})\}$ $MV_n=\Sigma\Delta MV$	

POINTS

(1) *:PV_{nf} is calculated using the following expression.
Therefore, it is the same as the PV (process value) of the input data as long as the filter coefficient is not set for the input data.

Process Value after Filtering $PV_{nf} = PV_n + \alpha (PV_{nf-1} - PV_n)$

PV_n : Process value of the present sampling
α : Filter coefficient
PV_{nf-1} : Process value of the preceding sampling cycle (after filtering)

(2) PVnf is stored in the I/O data area. (See Section 5.2)

3.3 PID Control Instruction List

A list of the instructions used to execute PID control is given below.

Instruction Name	Processing Details
PIDINIT	Sets the reference data for PID operation.
PIDCONT	Executes PID operation with the SV (set value) and the PV (process value).
PID57	Used to monitor the results of PID operation at an AD57(S1).
PIDSTOP PIDRUN	Stops or starts PID operation for the set loop No.
PIDPRMW	Changes the operation parameters for the designated loop number to PID control data.

3.3.1 How to read the instruction list

The instruction list in Section 3.3.2 has the format indicated below:

Table 3.1 How to Read the Instruction List

Category	Instruction Name	Ladder Format	Processing Details	Execution Condition	No. of Steps	Subset Processing	Page
Control data setting	PIDINIT	PIDINT (S)	Sets the PID control data stored in the word device (designated by (S)).		2		8-2
		PIDINTP (S)					

(1) (2) (3) (4) (5) (6) (7) (8)

Explanation

(1) Classification of instructions according to their application.

(2) Instruction names written in a sequence program

(3) Symbols used in the ladder diagram.

(4) Processing for each instruction.

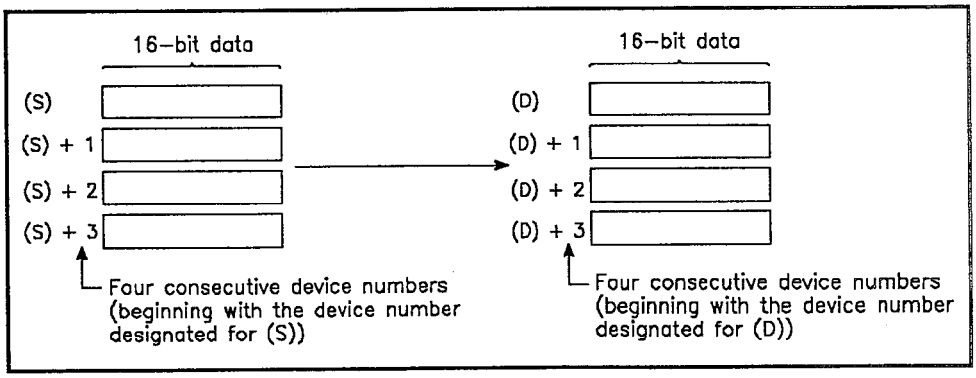


Fig. 3.1 Processing for Each Instruction

(5) The execution condition for each instruction. Details are given below.

Symbol	Execution Condition
	Indicates an instruction that is executed for the duration that the condition for its execution is ON. When the condition before the instruction is OFF, the instruction is not executed and no processing is carried out.
	Indicates an instruction that is executed once only at the leading edge (OFF → ON) of the condition for its execution; thereafter the instruction will not be executed, and no processing will be carried out, even if the condition is ON.

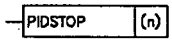
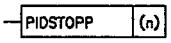
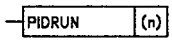
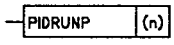
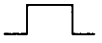
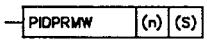
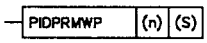
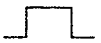
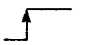
(6) Number of instruction steps
For details on the number of steps, refer to the QnACPU Programming Manual (Common Instructions).

(7) A circle indicates that subset processing is possible.
For details on subset processing, refer to the QnACPU Programming Manual (Common Instructions).

(8) Indicates the page number in this manual where a detailed description for the instruction can be found.

3.3.2 PID operation instruction list

Category	Instruction Name	Ladder Format	Processing Details	Execution Condition	No. of Steps	Subset Processing	Page
Control data setting	PIDINIT	PIDINT (S)	Sets the PID control data stored in the word device (designated by (S)). (S) to (S) + 1: Common data setting area (S) + 2 to (S) + 11: For loop 1 (S) + 12 to (S) + 21: For loop 2 to (S) + (10^n − 8) to (S) + (10^n + 1): For loop n	⌐¬	2		8-2
		PIDINTP (S)		⌐¬			
PID operation	PIDCONT	PIDCONT (S)	Executes PID operation with the SV (set value) and the PV (process value) designated by (S) and stores the PID operation results in the MV (manipulated value) area of the word device designated by (S). (S) to (S) + 9: Common data setting area (S) + 10 to (S) + 27: SV setting area, PV setting area, MV value storage area — For loop (S) + 28 to (S) + 45: SV setting area, PV setting area, MV value storage area — For loop (S) + (18^n − 8) to (S) + (18^n + 9): SV setting area, PV setting area, MV value storage area — For loop	⌐¬	2		8-3
		PIDCONTP (S)		⌐¬			
Monitoring	PID57	PID57 (n) (S1) (S2)	Monitors the PID operation results for the AD57(S1) (designated by (n)). (n): First I/O number of the AD57(S1) (S1): Monitor screen number 1: Loop 1 to loop 8 2: Loop 9 to loop16 3: Loop17 to loop24 4: Loop25 to loop32 (S2): Monitor screen display request	⌐¬	4		8-5
		PID57P (n) (S1) (S2)		⌐¬			

Category	Instruction Name	Ladder Format	Processing Details	Execution Condition	No. of Steps	Subset Processing	Page
Operation stop	PIDSTOP	 	Stops the PID operation at the loop number designated by (n).	 	2		8-8
Operation start	PIDRUN	 	Starts the operation at the loop number designated by (n).	 	2		8-8
Parameter change	PIDPRMW	 	Changes the operation parameter for the loop number designated by (n) to the PID control data stored in the word device designated by (S).	 	3		8-9

4. PID CONTROL

This section describes the method for PID control using PID control instructions.

4.1 Outline of PID Control

PID control is applicable to process control in which factors such as flowrate, velocity, air flow volume, temperature, tension, mixing ratio, etc. must be controlled. The control for maintaining the control object at the preset value is shown in the diagram below:

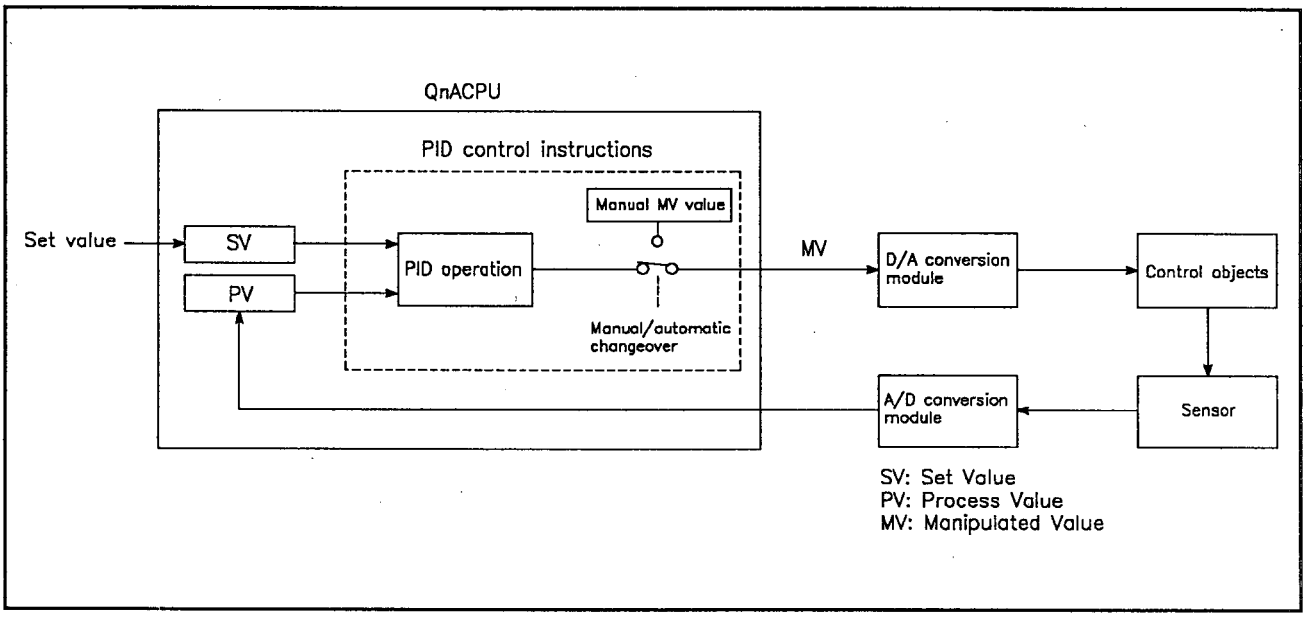


Fig. 4.1 Applicationof PID Control Process Control

During PID control, the PV (process value), detected by the detection unit, is compared to the SV (set value). The output data (MV: manipulated value) is adjusted accordingly to zero the difference between the PV and the MV.

The MV (manipulated value) is calculated by combining the proportionate operation (P), the integrating operation (I), and the differentiating operation (D) so that the PV is brought to the same value as the SV quickly and precisely.
The MV is made large when the difference between the PV and the SV is large so as to bring the PV close to the SV quickly. As the difference between the PV and the SV gets smaller, a smaller MV is used to bring the PV to the same value as the SV gradually and accurately.

4.2 PID Control

The operation methods for PID control with the PID control instructions are the speed method and process value differentiation method. The following describes the control executed for both of these methods:

4.2.1 Operation method

(1) Speed method operation
The speed method operation calculates amounts of changes in the MVs (manipulated values) during PID operation.
The actual MV is the accumulated amount of change of the MV calculated for each sampling cycle.

(2) Process value differentiation method operation
The process value differentiation method operation executes PID operations by differentiating the PV (process value).
Because the deviation is not subject to differentiation, sudden changes in the output due to differentiation of the changes in the deviation generated by changing the set value can be reduced.

Either forward operation or reverse operation can be selected to designate the direction of PID control.

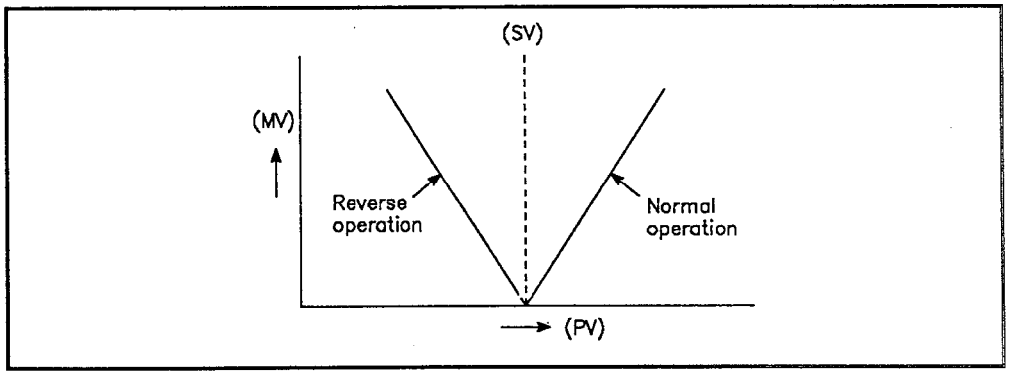
4.2.2 Normal operation and reverse operation

(1) In normal operation, the MV (manipulated value) increases as the PV (process value) increases beyond the SV (set value).

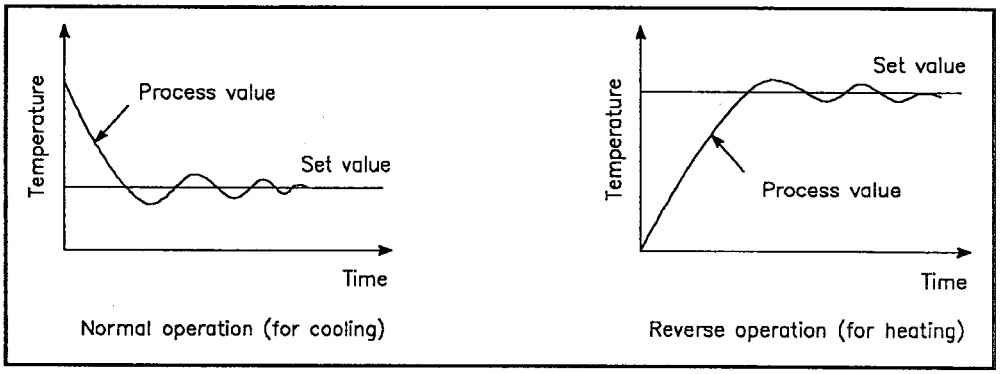
(2) In reverse operation, the MV (manipulated value) increases as the PV (process value) decreases below the SV (set value).

(3) In normal operation and reverse operation, the MV (manipulated value) becomes larger as the difference between the SV (set value) and the PV (process value) increases.

(4) The figure below shows the relationships among normal operation and reverse operation and the MV (manipulated value), the PV (process value), and the SV (set value):



(5) The figure below shows examples of process control with normal operation and reverse operation:



4.2.3 Proportionate operation (P operation)

The control method for proportionate operation is described below.

(1) In proportionate operation, an MV (manipulated value) proportional to the deviation (the difference between the set value and process value) is obtained.

(2) The relationship between E (deviation) and the MV (manipulated value) is expressed by the following formula:

$$MV=Kp \cdot E$$

Kp is a proportional constant and is called the "proportional gain".

(3) The proportionate operation in step response with a constant E (deviation) is illustrated in Fig. 4.2.

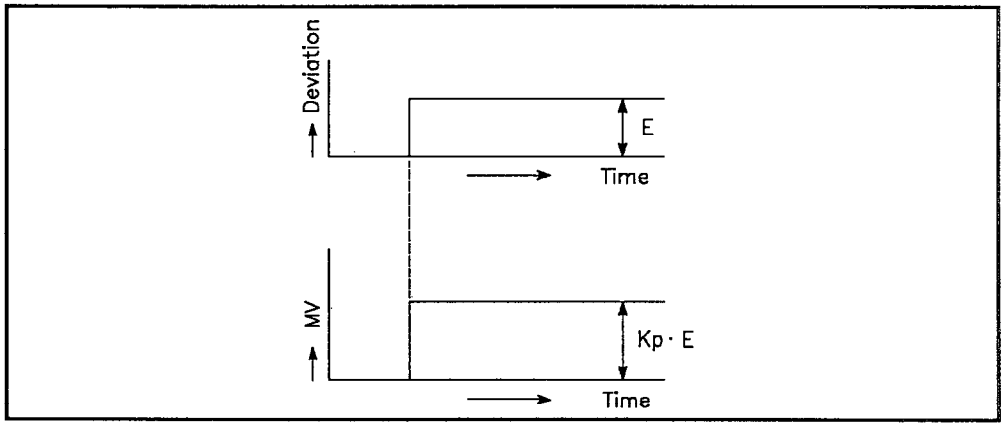


Fig. 4.2 Proportionate Operatoin with a Constant Deviation

(4) The MV (manipulated value) changes within the range –50 to 2050. The MV (manipulated value) in response to the same deviation becomes larger as Kp becomes larger, thus the compensating motion is greater.

(5) The proportionate operation is always associated with an offset (offset error).

4.2.4 Integrating operation (I operation)

The control method for integrating operation is described below.

(1) In the integrating operation, the MV (manipulated value) changes continuously to zero deviation when it occurs.
This operation can eliminate the offset that is unavoidable in proportionate operation.

(2) The time required for the MV in integrating operation to reach the MV for proportionate operation after the generation of deviation is called the integrating time. Integrating time is expressed as T_I.
The smaller the setting for T_I, the more effective the integrating operation will be.

(3) The integrating operation in step response with a constant E (deviation) is illustrated in Fig. 4.3.

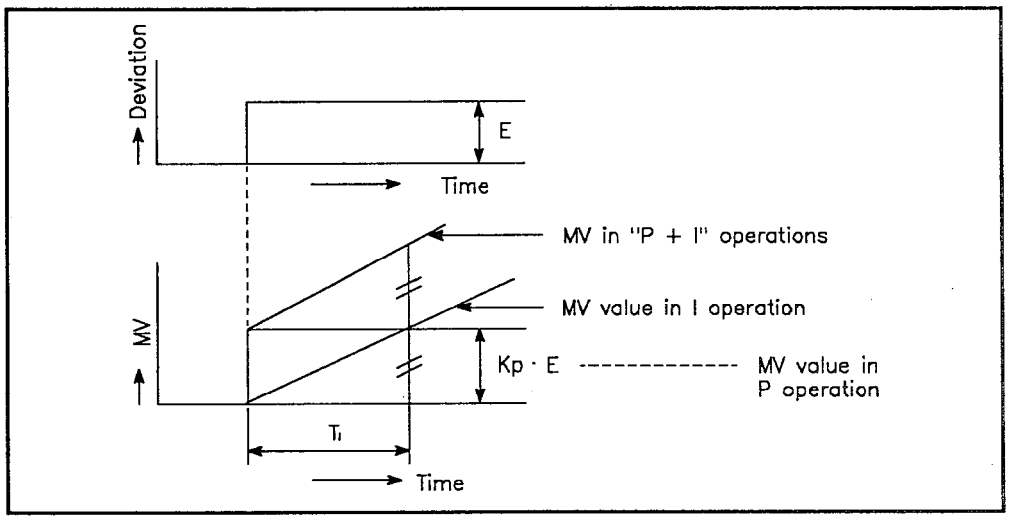


Fig. 4.3 Integrating Operation with a Constant Deviation

(4) Integrating operation is always used in combination with proportionate operation (PI operation) or with proportionate and differentiating operations (PID operation).
Integrating operation cannot be used independently.

4.2.5 Differentiating operation (D operation)

The control method for differentiating operation is described below.

(1) In differentiating operation, an MV (manipulated value) proportional to the deviation change rate is added to the system value to zero deviation when it occurs.
This operation prevents significant fluctuation at the control objective due to external disturbances.

(2) The time required for the MV in the differentiating operation to reach the MV for the proportionate operation after the generation of deviation is called the differentiating time. Differentiating time is expressed as TD.
The smaller the setting for TD, the more effective the differentiating operation will be.

(3) The differentiating operation in step response with a constant E (deviation) is illustrated in Fig. 4.4.

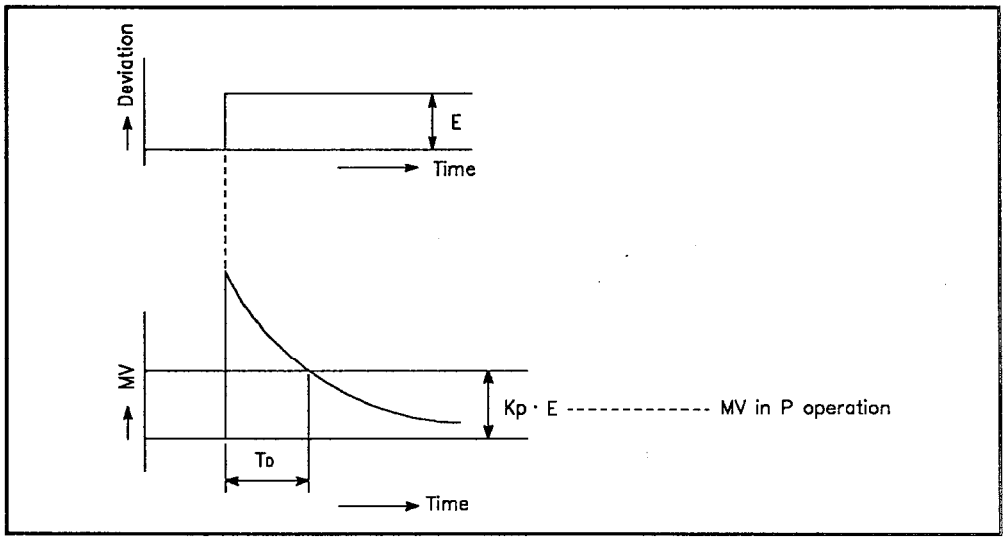


Fig. 4.4 Differentiating Operation with Constant Deviation

(4) Differentiating operation is always used in combination with proportionate operation (PD operation) or with proportionate and integrating operations (PID operation).
Differentiating operation cannot be used independently.

4.2.6 PID operation

The control method when proportionate operation (P operation), integrating operation (I operation), and differentiating operation (D operation) are used in combination is described below.

(1) During PID operation, the system is controlled by the MV (manipulated value) calculated in the (P + I + D) operation.

(2) PID operation in step response with a constant E (deviation) is illustrated in Fig. 4.5.

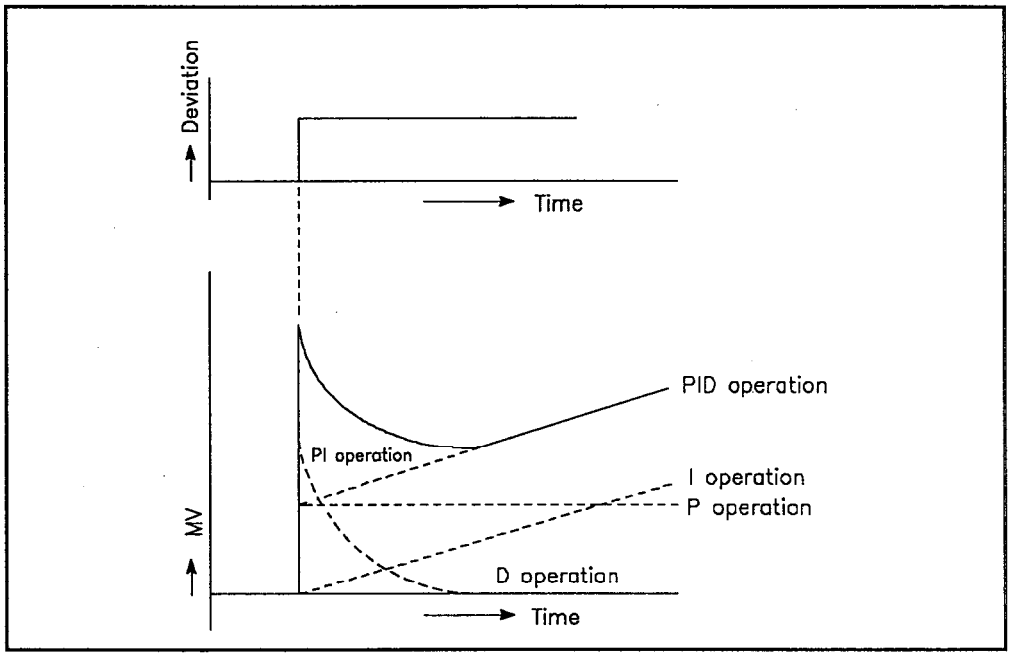


Fig. 4.5 PID Operation with Constant Deviation

4.3 PID Control Functions

During PID control using the PID control instructions, MV upper/lower limit control is automatically executed by the bumpless changeover function explained below.

4.3.1 Bumpless changeover function

This function controls the MV (manipulated value) continuously when the control mode is changed between manual and automatic.
When the control mode is changed between manual and automatic, data is transmitted between the MV area for automatic mode and the MV area for manual mode.
The control mode is changed in the input/output data area (see Section 5.2).

(1) Changing from the manual mode .... The MV in the manual mode is transmitted to the MV area for the automatic mode.

(2) Changing from automatic mode ..... The MV in the automatic mode is transmitted to the MV area for the manual mode.

POINTS

(1) Manual and automatic modes of PID control:

1) Automatic mode
PID operation is executed with a PID control instruction.
The control object is controlled according to the calculated MV.

2) Manual mode
PID operation is not executed. The MV is calculated by the user and the control object is controlled according to the user-calculated MV.

(2) The loop set in the manual mode stores the PV (process value) in the set value area every sampling cycle.

4.3.2 MV higher/lower limit control function

The MV higher/lower limit control function controls the higher or lower limit of the MV calculated in the PID operation. This function is only effective in the automatic mode. It cannot be executed in the manual mode.
By setting the MV higher limit (MVHL) and the MV lower limit (MVLL), the MV calculated in the PID operation can be controlled within the range between the limits.

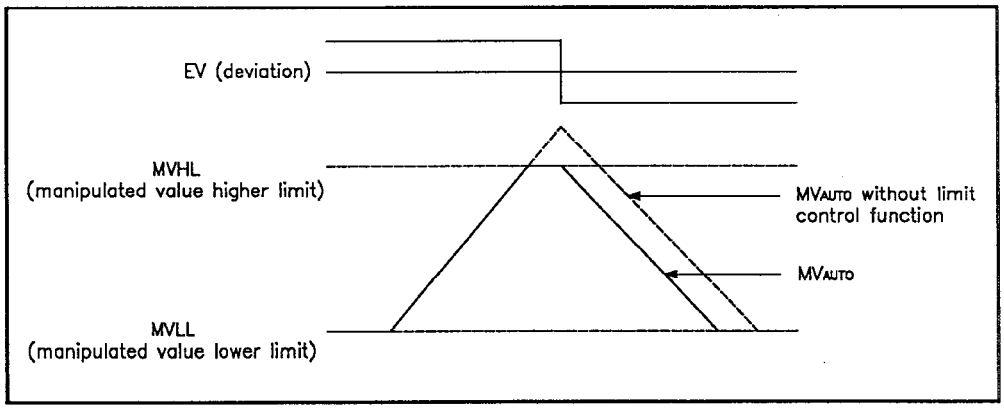


Fig. 4.6 Operation in Accordance with the MV Higher/Lower limit

When the MV higher/lower limit control function is used, the MV is controlled as illustrated above.
A value between –50 and 2050 can be set for the upper and lower limits.
The following are the default settings:

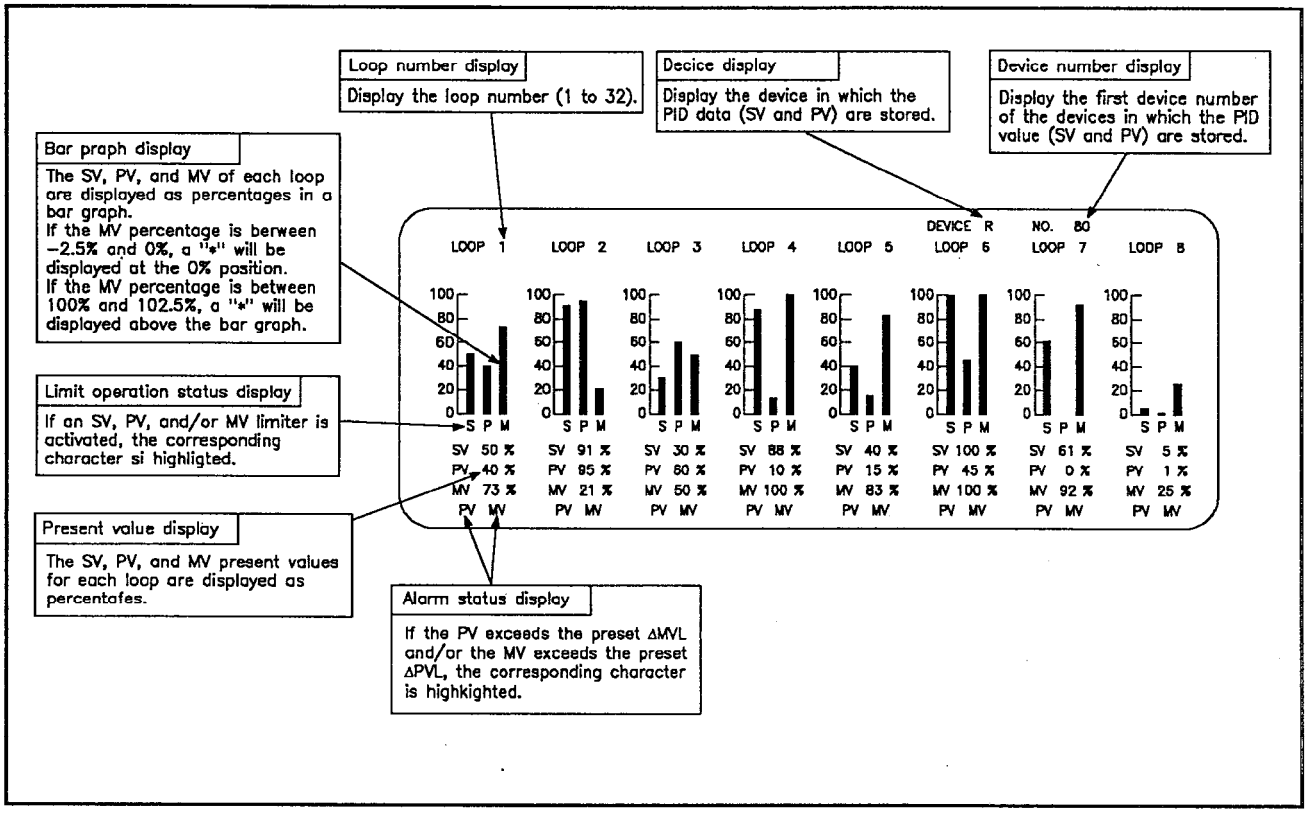
- Higher limit : 2000
- Lower limit : 0

The value set for the higher limit must not be smaller than the value set for the lower limit.
An error will occur if it is.

4.3.3 Monitoring PID control with the AD57(S1)

The PID control operation results can be monitored in a bar graph with an AD57(S1) CRT controller unit.

(1) The monitor screen displays the monitored information of eight loops beginning with the designated loop number.



POINT

The SV, PV, and MV present value are displayed as percentages of 2000.

1) SV percentage display .... $\frac{SV}{2000} \times 100\ (\%)$

2) PV percentage display .... $\frac{PV}{2000} \times 100\ (\%)$

3) MV percentage display .... $\frac{MV}{2000} \times 100\ (\%)$

(2) Use the PID57 instruction to execute monitoring with an AD57(S1). See Section 8.3 for details on the PID57 instruction.

4.3.4 Function for transfer to the SV storage device for the PV in manual mode

The PIDCONT instruction is also executed in manual mode.In the manual mode, it is possible to select whether or not the PV input from the A/D conversion module on execution of the PIDCONT instruction is transferred to the SV storage device or not in accordance with the ON/OFF status of the PID bumpless processing flag (SM774).

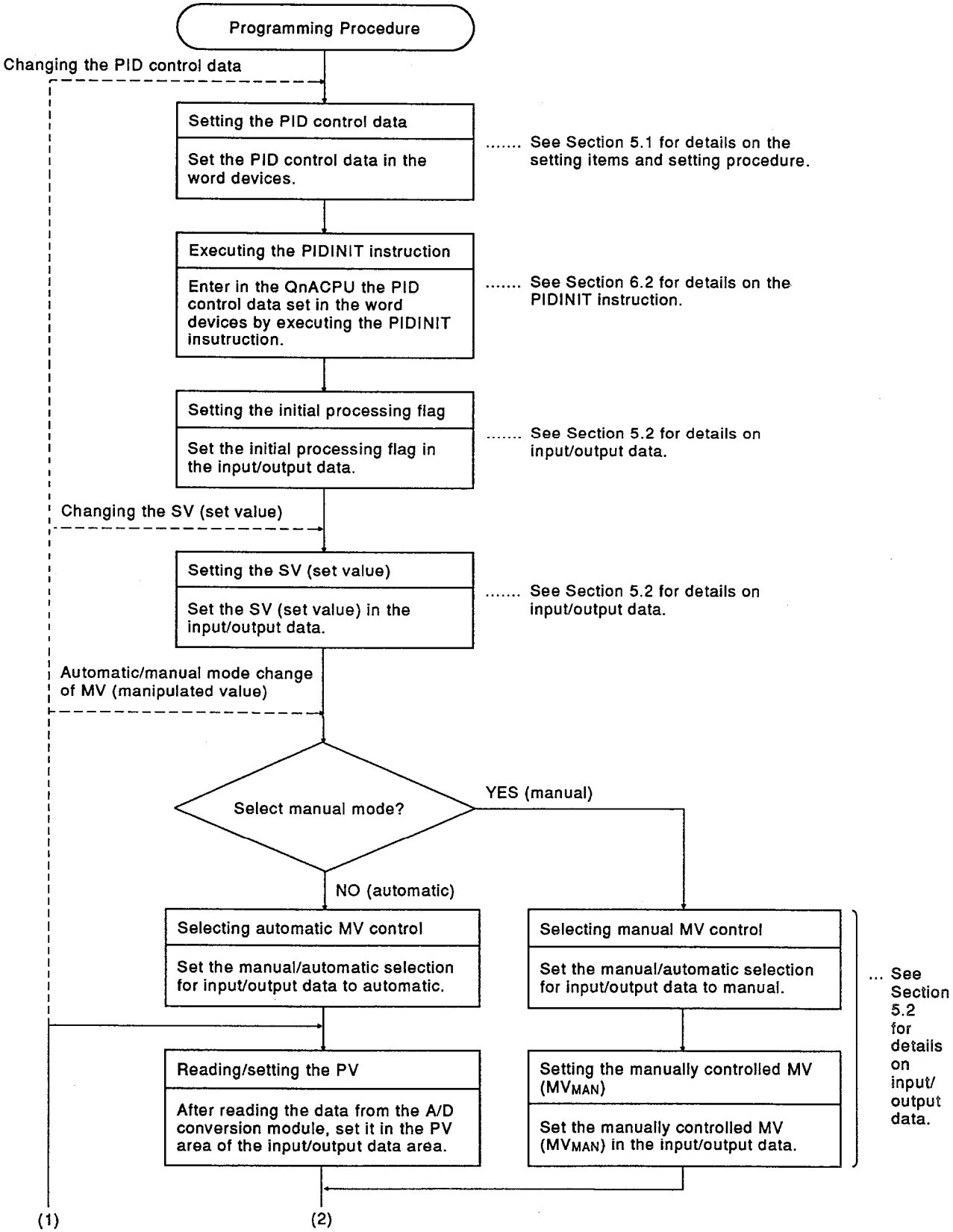
- When SM774 is OFF: When the PIDCONT instruction is executed, the PV is transferred to the SV storage device.
  On switching from the manual mode to the automatic mode, the MV output is continued from the value in the manual mode.
  After switching to the automatic mode, control can be switched from the MV that was being putput to the SV by changing the SV.
- When SM774 is ON: When the PIDCONT instruction is executed, the PV is not transferred to the SV storage device.
  On switching from the manual mode to the automatic mode, control can be switched from the MV output in the manual mode to the SV.
  Before switching to the automatic mode, store an SV in the SV storage device.

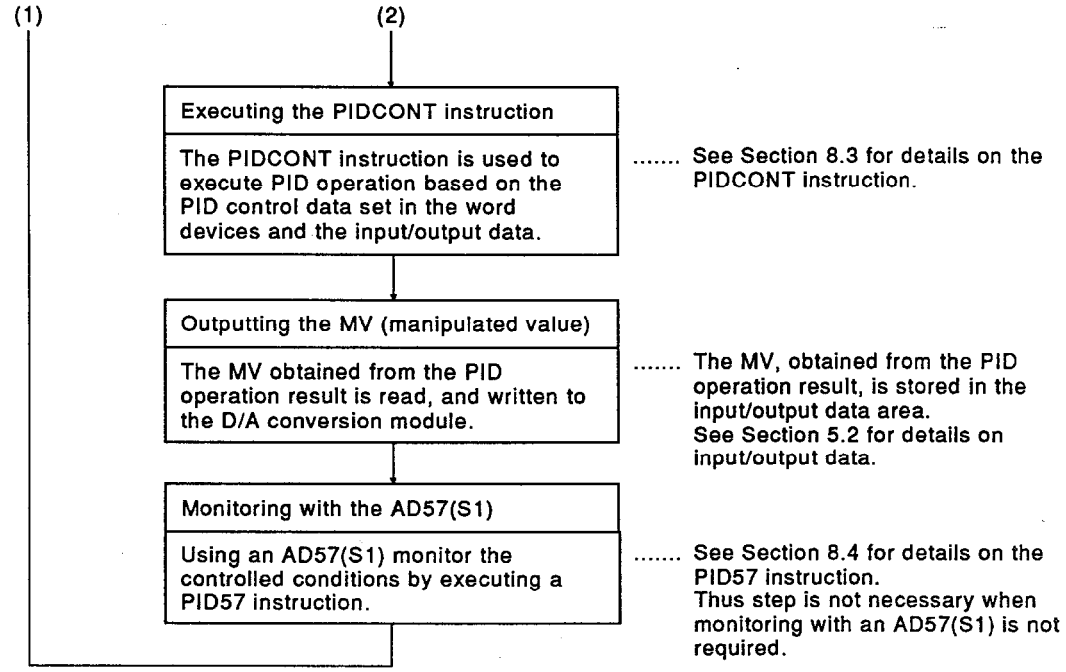
REMARK

The SV and PV are stored in the devices in the I/O data area designated by the PIDCONT instruction.

5. PID CONTROL PROCEDURE

The programming procedure required to execute PID control is shown below.





POINT

PID control data can be entered or changed in every sequence program scan.

5.1 PID Control Data

(1) PID control data sets the reference values for PID operation and is set before starting PID operation.
The PID control data must be entered in the QnACPU by executing a PIDNIT instruction before starting a PID operation with the PIDCONT instruction.
PID control data is basically classified into two groups as shown in the table below: data that is common to all loops and data for individual loops.

Table 5.1 PID Control Data List

	Data No.	Data Item	Description	Setting Range	User Designation Range	Processing if Set Data is Outside the Allowable Setting Range
Common setting data	1	Number of loops used	Sets the number of loops for which PID operation is executed.	1 to 32	1 to 32	PID operation is not executed for any of the loops
	2	Number of loops executed in each scan	Sets the number of loops that can be executed in a single PID operation if there is more than one loop for which the sampling cycle is reached.			
Data for each loop	1	Selection of operation expression	Selects one of the operation methods described in Section 3.2.	Normal operation: 0 Reverse operation: 1	0 or 1	PID operation for the corresponding loop is not executed.
	2	Sampling cycle (Ts)	Sets the cycle for PID operation execution.	0.01 to 60.00 sec	1 to 6000 (units: 10 ms)	
	3	Proportionate constant (K_P)	PID operation ratio	0.01 to 100.00	1 to 10000 (units: 0.01)	
	4	Integrating constant (T_I)	The constant that expresses the magnitude of the integrating operation (I operation) effect. The MV variation becomes smaller as the integrating constant is made larger.	0.1 to 3000.0 sec Infinite (∞) (If the setting for T_I exceeds 3000.0 sec)	1 to 32767 (units: 100 ms)	PID operation for the corresponding loop is not executed if setting value ≤ 0.
	5	Differentiating constant (T_D)	The constant that expresses the magnitude of the differentiating operation (D operation) effect. The MV variation becomes larger in a small amount of variation of the control objective as the differentiating constant becomes larger.	0.00 to 300.00 sec	0 to 30000 (units: 10 ms)	PID operation for the corresponding loop is not executed.
	6	Filter coefficient (α)	Sets degree of filtering applied to the PV (input from an A/D conversion module). The filtering effect decreases as the value gets closer to "0".	0 to 100 %	0 to 100	

Table 5.1 PID Control Data List (Continued)

	Data No.	Data Item	Description	Setting Range	User Designation Range	Processing if Set Data is Outside the Allowable Setting Range
Data for each loop	7	MV Lower limit (MVLL)	Sets the lower limit for MV (manipulated value) calculated in PID operation. Effective in the automatic mode. If the calculated MV is smaller than the MV lower limit, the MVLL is made the MV.	–50 to 2050	–50 to 2050	If the user-designated MVLL or MVHL is outside the allowable setting range, the value will be changed as described below so that PID operation can be executed: • If the value set for MVLL or MVHL is less than "–50", the value is replaced with " –50". • If the value set for Δ MVLL or Δ MVHL is greater than "2050", the value is replaced with "2050".
	8	MV Higher limit (MVHL)	Sets the upper limit for the MV (manipulated value) calculated in PID operation. Effective If the calculated MV is larger than the MV higher limit, the MVHL is made the MV.			
	9	MV change rate limit (Δ MVL)	Sets the limit for variation between the previous and present MV. If MV variation exceeds the set limit value, "1" is set for bit 1 of the device, indicating an alarm.	0 to 2000	0 to 2000	If the user-designated Δ PVL or Δ MVL is outside the allowable setting range, the value will be replaced as described below so that PID operation can be executed: • If the value set for Δ PVL or Δ MVL is less than "0", the value is replaced with "0". • If the value set for Δ PVL or Δ MVL is greater than "2000", the value is replaced with "2000".
	10	PV change rate limit (Δ PVL)	Sets the limit for variation between the previous and present PV. If PV variation value exceeds the set limit value, "1" is set for bit 0 of the device, indicating an alarm.			

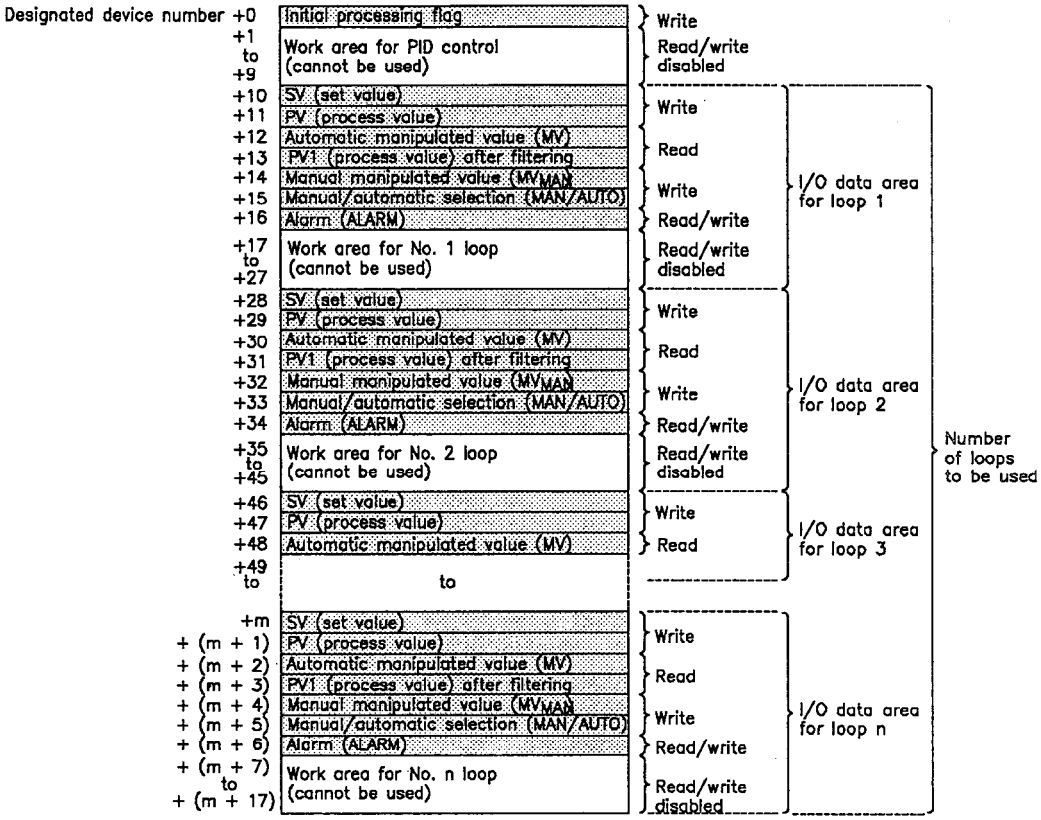
(2) PID control data can be set in any word device number.
However, all the data for all the loops used must be set in devices with consecutive numbers.

(3) The control data allocations are shown below.

Designated device number			
+0	Number of loops used	Common to all loops	For the total number of loops to be used
+1	Number of loops executed in a sigle scan		
+2	Selection of an operation expression	For loop No.1	
+3	Sampling cycle (Ts)		
+4	Proportionate constant (KP)		
+5	Integrating constant (TI)		
+6	Differentiating constant (TD)		
+7	Filter coefficient (α)		
+8	Manipulated value lower limit (MVLL)		
+9	Manipulated value higher limit (MVHL)		
+10	Manipulated value change rate limit (ΔMVL)		
+11	Process value change rate limit (ΔPVL)		
+12	Selection of operation expression	For loop No.2	
+13	Sampling cycle (Ts)		
+14	Proportionate constant (KP)		
+15	Integrating constant (TI)		
+16	Differentiating constant (D)		
+17	Filter coefficient (α)		
+18	Manipulated value lower limit (MVLL)		
+19	Manipulated value higher limit (MVHL)		
+20	Manipulated value change rate limit (ΔMVL)		
+21	Process value change rate limit (ΔPVL)		
+22	Selection of operation expression	For loop No.3	
+23	Sampling cycle (Ts)		
to	to		
+m	Selection of operation expression	For loop No.n	
+(m + 1)	Sampling cycle (Ts)		
+(m + 2)	Proportionate constant (KP)		
+(m + 3)	Integrating constant (TI)		
+(m + 4)	Differentiating constant (D)		
+(m + 5)	Filter coefficient (α)		
+(m + 6)	Manipulated value lower limit (MVLL)		
+(m + 7)	Manipulated value higher limit (MVHL)		
+(m + 8)	Manipulated value change rate limit (ΔMVL)		
+(m + 9)	Process value change rate limit (ΔPVL)		

(4) Input/output data can be set in any word device number.
However, all the data for all the loops used must be set in devices with consecutive numbers.

(5) The input/output data allocations are shown below.



(a) Use the following formula to calculate the number of device points to be used when setting the PID control data:

Number of device points = 2 + 10 × n (n: Number of loops to be used)

(b) Set the data as a binary number.

(c) An error will occur if the number of device points for the loops to be used exceeds the last device number of the designated device. In this case, no processing will occur.

5.1.1 Number of loops to be used and the number of loops to be executed in a single scan

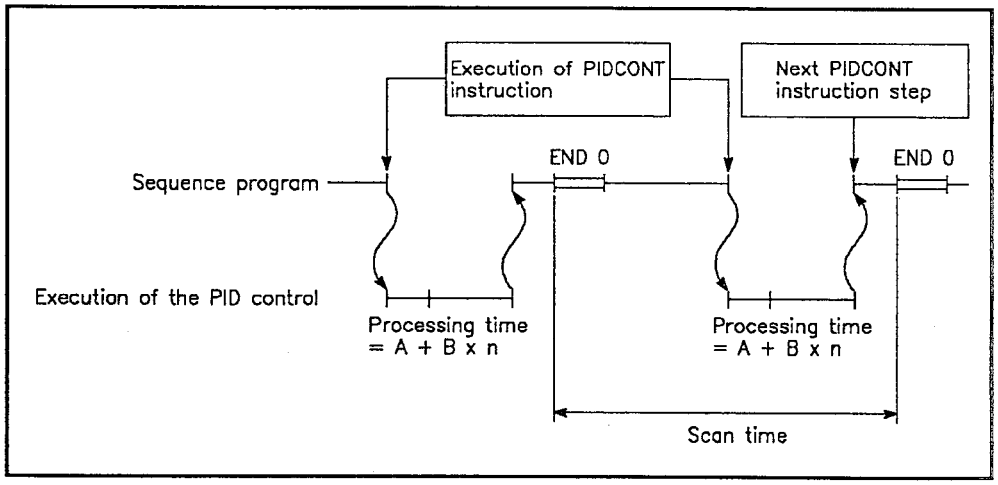
(1) The number of loops to be used means the number of loops for which PID operation is executed. The sampling time is measured for the set number of loops when the PID control instruction (PIDCONT) is executed. PID operation is executed for the loop for which the sampling cycle time reaches or exceeds the set sampling cycle.

(2) Processing time increases in proportion to the number of loops for which PID operation is executed when the PID control instruction (PIDCONT) is executed.

Processing time = A + B × n

A : Fixed time for measuring sampling time
B : Time required to execute PID operation for a loop
n = Number of loops

(3) The number of loops to be executed in a single scan means the number of loops for which PID operation is executed in one scan when there is more than one loop for which sampling cycle time reaches or exceeds the set sampling cycle when the PID control instruction (PIDCONT) is executed.
If the number of loops to be executed in a single scan is set, PID operation is only executed for the set number of loops even if there are a greater number of loops for which the sampling cycle time reaches or exceeds the set sampling cycle when the PID control instruction is executed. PID operation is executed for the rest of the loops in the next scan.



POINT

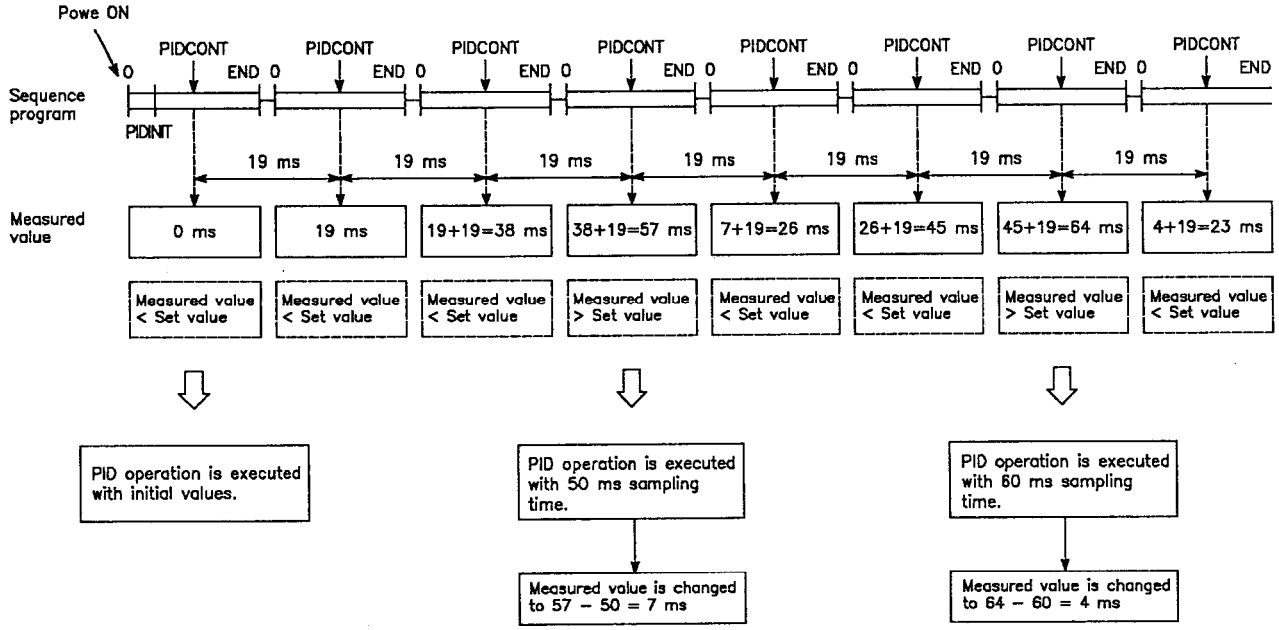
If the number of loops for which sampling cycle time reaches or exceeds the set sampling cycle is greater than the number of loops to be executed in a single scan, the PID operation execution priority is as follows:
(1)The lowest numbered loop is given the highest priority.
(2)If there are loops in the preceding scan for which PID operation has not been executed, they are given the highest priority.

5.1.2 Sampling cycle

(1) A sampling cycle is the cycle in which PID operation is executed.
The measuring time for one scan is added to the sampling time up to the preceding scan each time a PIDCONT instruction is executed.
If the accumulated sampling time reaches or exceeds the set sampling cycle, PID operation is executed for the corresponding loop.

(2) The measured value of the sampling time used for PID operation is truncated to units of 10 ms.
For example, if the sampling cycle setting is 50 ms and the measured value is 57 ms, PID operation is executed with a sampling time of 50 ms.If the measured value is 64 ms, PID operation is executed with a sampling time of 60 ms.

When sampling cycle = 50 ms



POINT

The sampling cycle is measured when the PIDCONT instruction is executed. Therefore, a value smaller than the sequence program scan time cannot be set for the sampling cycle. If a value smaller than the scan time is set, PID operation will be executed in accordance with the scan time.

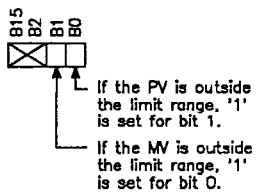
5.2 Input/Output Data

(1) The input/output data consists of input data, such as the SV (set value) and PV (process value), which are set to execute PID operation, and output data, such as operation results.

(2) The input/output data area stores the items in the table below which are allocated to each loop, and has a work area used by the system to execute PID operation.

Table 5.2 Input/Output Data List

Data Name		Description	Setting Range	Remarks
Set value	SV	PID control target value	0 to 2000	If the SV value is outside the allowable setting range, PID operation is executed after the following processing. • If SV is less than "0", SV is taken as "0". • If SV is greater than "2000", SV is taken as "2000".
Process value	PV	Feedback data from control objective to A/D conversion module	–50 to 2050	If the PV value is outside the allowable setting range, PID operation is executed after the following processing. • If PV is less than "–50", PV is taken as "–50". • If PV is greater than "2050", PV is taken as "2050".
Automatic/ manipulated value	MV	The manipulated value calculated during PID operation. Output from the D/A conversion module to the control objective.	–50 to 2050	———
Process value after filtering	PV1	Process value calculated using the operation formula in POINT (1) in Section 3.2.		
Manual manipulated value	MV_{MAN}	In the manual control mode, the data output from the D/A conversion module is stored.	–50 to 2050	If the MV_{MAN} value is outside the allowable setting range, PID operation is executed after the following processing. • If MV_{MAN} is less than "–50", MV_{MAN} is taken as "–50". • If MV_{MAN} is greater than "2050", MV_{MAN} is taken as "2050".
Manual/automatic selection	MAN /AUTO	Selects whether the output data to the D/A conversion module is a manually manipulated value or an automatically manipulated value. In manual control mode, the automatically manipulated value remains unchanged.	0: Manually manipulated value 1: Automatically manipulated value	An error occurs if the setting is neither 0 nor 1; PID operation of the corresponding loop will not be executed.

Data Name		Description	Setting Range	Remarks
Alarm	ALARM	Used to determine if the change rate of the MV (manipulated value) and the PV (process value) is outside the allowable range. Once set, the alarm data is retained until the user resets it. If the MV is outside the limit range, "1" is set for bit 0. If the PV is outside the limit range, "1" is set for bit 1.		————

(a) Use the following formula to calculate the number of device points to be used when setting the PID control data.

Number of device points = 10 + 18 × n (n: Number of loops to be used)

(b) Set the data in binary numbers.

(c) The initial processing flag sets the processing method at the start of PID operation.

1) In the initial PID operation processing cycle, operation is executed assuming that the set sampling cycle is reached or exceeded.

2) The initial processing flag is set in the following manner:

0..... PD operation is batch processed in a single scan for the number of loops to be used.

Other than 0.. PID operation is processed in several scans for the number of loops to be used.
Sampling begins sequentially from the loop for which the initial processing has been completed.
The number of processing loops per scan is the set number of loops to be executed per scan.

(d) Where "write" is designated for a data area, it indicates that the data should be written with a user sequence program.
Where "read" is designated for a data area, it indicates that the data should be read with a user sequence program. Never attempt to write data to a data area designated "read/write disabled" or "read". If this is attempted, correct PID operation will not be possible.

(e) An error will occur if the number of device points for the loops to be used exceeds the last device number of the designated device. If this happens, no processing will occur.

6. PID CONTROL INSTRUCTIONS

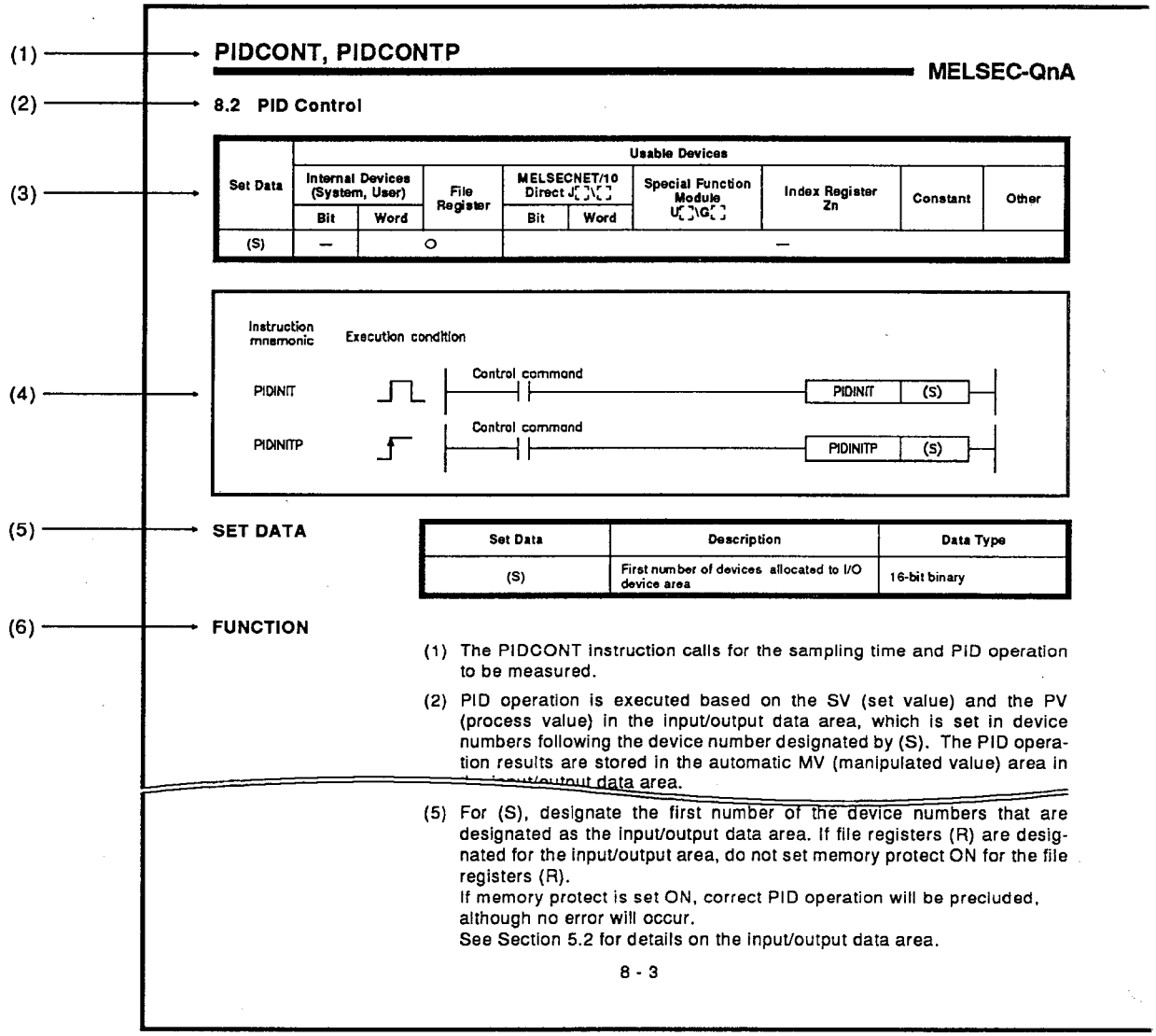
The configuration of PID control instructions is the same as that of the QnACPU common instructions.

For details on the instruction configuration, refer to the QnACPU Programming Manual (Common Instructions).

MEMO

7. HOW TO READ EXPLANATIONS FOR INSTRUCTIONS

The explanations for instructions presented in the next section take the following form.



(1) Instruction mnemonic

(2) Section number and general description of the instruction

(3) "O" is appended to those devices that can be used with the instruction. The classes of use into which the devices that can be used are divided are as follows.

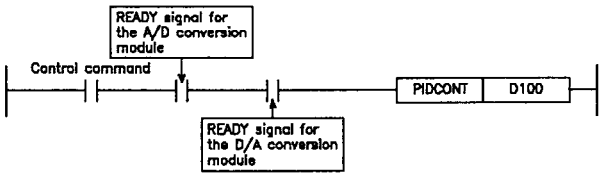
Device Classification	Internal Device (system, user)		File Register	MELSECNET/10 Direct J□\□		Special Function Module U□\G□	Index Register Zn	Constant*1	Other*1
	Bit	Word		Bit	Word				
Usable devices	X, Y, M, L, SM, F, V, B, SB, FX, FY*2	T, ST, C, D, W, SD,SW, FD	R, ZR	J□\X J□\Y J□\B J□\SB	J□\W J□\SW	U□\G□	Z	Decimal number Hexadecimal number Real number constant Character string constant	P, I, J, U,DX, DY, N, BL, TR, BLY\S

*1 : The devices that can be set are indicated in the "Constant" and "Other" columns.

*2 : FX and FY can only be used with bit data, and FD can only be used with word data.

(6) Execute the PIDCONT instruction in every scan even while the manual manipulated value (MV_{MAN}) is being output in the manual control mode. The bumpless function cannot be executed if the PIDCONT instruction has not been executed.
See Section 4.3.1 for details on the bumpless function.

(7) Use the READY signal to establish an interlock with respect to the individual modules, so that the PIDCONT instruction is executed only when both the A/D conversion module, which reads the PV (process value), and the D/A conversion module, which outputs the MV (manipulated value), are normal.*



If the PIDCONT instruction is executed while either or both of the modules are faulty, PID operation cannot be executed correctly because the PV (process value) cannot be read correctly and/or the MV (manipulated value) cannot be output correctly.

OPERATION ERRORS ← (7)

(1) An operation error will occur, the error flag (SM0) will be turned ON, and an error code will be stored in SD0, in the following cases.
- When the PIDNIT instruction is executed before executing the PIDCONT instruction. (Error code 4103)
- When the value set as the PID control data is outside the allowable range. (Error code 4100)
- When the device range allocated to the PID control data area, des-de the last device number of the correspond-

(4) Indicates the expressions and instruction execution conditions in the ladder mode.

Execution Condition	Executed while ON	Executed once at OFF → ON
Symbol used on the explanation page		

(5) Explains the set data for each instruction and indicates the data type.

Data Type	Description
16-bit binary	Indicates that binary 16-bit data or the first number of a word device can be used.

(6) Indicates the function of the instruction.

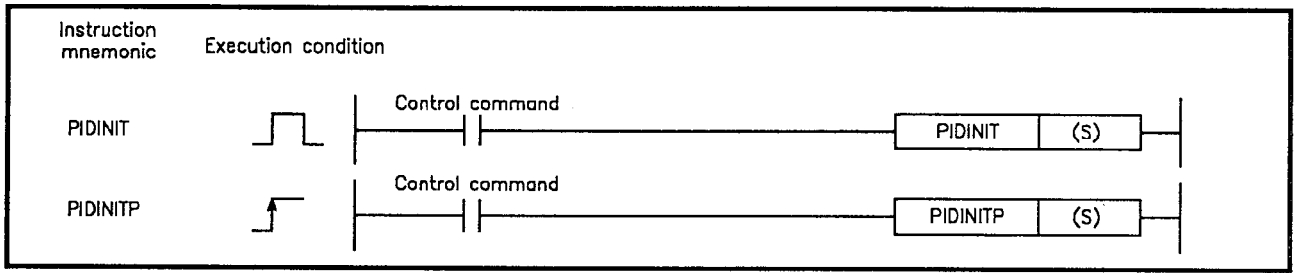
(7) Indicates the conditions that will cause errors and the error numbers.

8. PID CONTROL INSTRUCTIONS

This section explains how to use the PID control instructions for PID control.

8.1 PID Control Data Settings

Set Data	Usable Devices								
	Internal Devices (System, User)		File Register	MELSECNET/10 Direct J□\□		Special Function Module U□\G□	Index Register Zn	Constant	Other
	Bit	Word		Bit	Word				
(S)	—	o		—					



SET DATA

Set Data	Description	Data Type
(S)	First number of devices in which data for PID control is set	16-bit binary

FUNCTIONS

(1) The PID control data for the number of loops to be used, set in the device numbers following the device number designated by (S), are entered in the QnACPU in a batch, thereby making the PID control possible.
See Section 5.1 for details on PID control data.

(2) When the PIDINIT instruction is executed at more than one point within a scan, the setting value of the PIDINIT instruction closest to the PIDCONT instruction is effective.

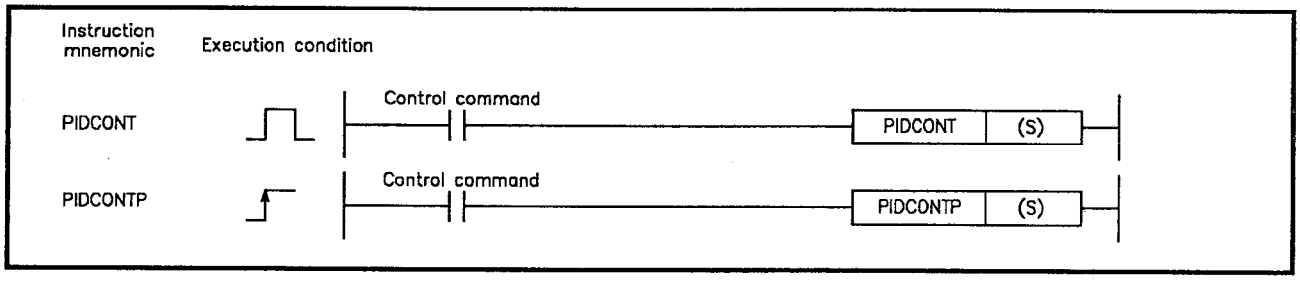
(3) The PIDINIT instruction must be executed before the PIDCONT instruction.
PID control is not possible if the PIDINIT instruction has not been executed.

OPERATION ERRORS

(1) An operation error will occur, the error flag (SM0) will be turned ON, and an error code will be stored in SD0, in the following cases.
- When the value set as the PID control data is outside the allowable range. (Error code 4100)
- When the device range allocated to the PID control data area, designated by (S), exceeds the last device number of the corresponding device. (Error code 4101)

8.2 PID Control

Set Data	Usable Devices								
	Internal Devices (System, User)		File Register	MELSECNET/10 Direct J□\□		Special Function Module U□\G□	Index Register Zn	Constant	Other
	Bit	Word		Bit	Word				
(S)	—	o		—					



SET DATA

Set Data	Description	Data Type
(S)	First number of devices allocated to I/O device area	16-bit binary

FUNCTION

(1) The PIDCONT instruction calls for the sampling time and PID operation to be measured.

(2) PID operation is executed based on the SV (set value) and the PV (process value) in the input/output data area, which is set in device numbers following the device number designated by (S). The PID operation results are stored in the automatic MV (manipulated value) area in the input/output data area.

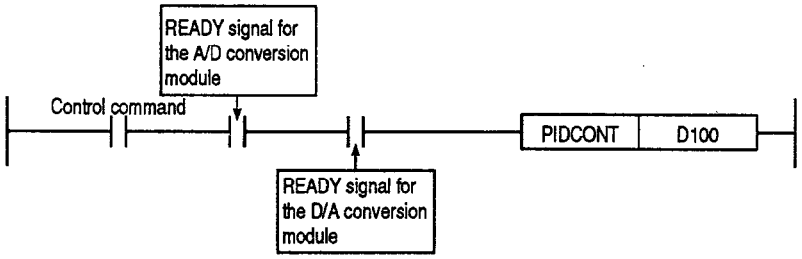
(3) PID operation is executed in response to the execution of the PIDCONT instruction appearing first after the set time for sampling cycle has elapsed (see Section 5.1.2).

(4) During PID control, turn ON the control command to execute the PIDCONT instruction in every scan.
If the instruction is not executed in every scan, it will not be possible to execute PID operation in accordance with the correct sampling time.
It is not possible to execute the PIDCONT instruction more than once in one scan.
If the PIDCONT instruction is executed more than once in one scan, it will not be possible to execute PID operation in accordance with the correct sampling time.

(5) For (S), designate the first number of the device numbers that are designated as the input/output data area. If file registers (R) are designated for the input/output area, do not set memory protect ON for the file registers (R).
If memory protect is set ON, correct PID operation will be precluded, although no error will occur.
See Section 5.2 for details on the input/output data area.

(6) Execute the PIDCONT instruction in every scan even while the manual manipulated value (MV_{MAN}) is being output in the manual control mode. The bumpless function cannot be executed if the PIDCONT instruction has not been executed.
See Section 4.3.1 for details on the bumpless function.

(7) Use the READY signal to establish an interlock with respect to the individual modules, so that the PIDCONT instruction is executed only when both the A/D conversion module, which reads the PV (process value), and the D/A conversion module, which outputs the MV (manipulated value), are normal.*



If the PIDCONT instruction is executed while either or both of the modules are faulty, PID operation cannot be executed correctly because the PV (process value) cannot be read correctly and/or the MV (manipulated value) cannot be output correctly.

OPERATION ERRORS

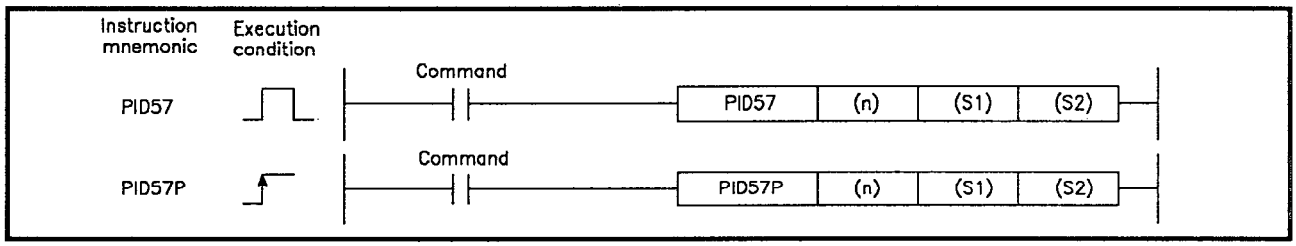
(1) An operation error will occur, the error flag (SM0) will be turned ON, and an error code will be stored in SD0, in the following cases.
- When the PIDINIT instruction is executed before executing the PIDCONT instruction. (Error code 4103)
- When the value set as the PID control data is outside the allowable range. (Error code 4100)
- When the device range allocated to the PID control data area, designated with (S), exceeds the last device number of the corresponding device. (Error code 4101)

REMARK

*: For details on the READY signals of the A/D conversion module and D/A conversion module, refer to the manual for the relevant module.

8.3 Monitoring PID Control Status

Set Data	Usable Devices								
	Internal Devices (System, User)		File Register	MELSECNET/10 Direct J□\□		Special Function Module U□\G□	Index Register Zn	Constant K, H	Other
	Bit	Word		Bit	Word				
(n)					o			o	—
(S1)					o			o	—
(S2)					o			—	—



SET DATA

Set Data	Description	Data Type
(n)	First I/O number of the AD57(S1) used to monitor the PID control status	16-bit binary
(S1)	Screen number corresponding to the loop number to be monitored	
(S2)	Initial screen display request	

FUNCTIONS

(1) The display unit of the AD57(S1) designated by (n) displays the PID control status of the loop number designated by (S1) in a bar graph.
By executing the initial screen display request, designated by (S2), the characters in the still portion of the monitor screen (with the exception of bar graphs and numerical data) are displayed in the initial state of PID control monitoring.

(2) Addresses 0 to 1599 in the VRAM area of the AD57(S1) are used for the PID control monitor.
Therefore, these addresses cannot be used by the user if PID control status monitoring is executed; if they are, the data stored in them will be lost.

(3) Execute the CMODE instruction (AD57 command) to monitor the PID control status before executing the PID57 instruction.
If the CRT standard display mode, set with the CMODE instruction, has not been set for the AD57(S1), the display unit will not be able to display anything.

(4) Execute the PID57 instruction only after the PIDINIT and PIDCONT instructions have been executed.
An error will occur if the PID57 instruction is executed before the PIDINIT and PIDCONT instructions.

(5) Designate the loop number indicated by (S1) with a screen number from "1" to "4", as shown below:

Screen Number	Loop Numbers to be Monitored
1	Loop 1 to loop 8
2	Loop 9 to loop 16
3	Loop 17 to loop 24
4	Loop 25 to loop 32

(6) The initial screen display request, designated by (S2), displays the characters in the still portion of the monitor screen.
To make the initial screen display request, set "0" for (S2).
Characters besides the bar graphs and numeric data will be not displayed unless the initial screen display request is executed.

(7) After the initial screen is displayed, the value designated by (S1) is automatically stored in (S2) and then the PID control monitor function is executed.
If the device designated by (S2) is a file register, do not set the memory protect function for the file register ON.
If the memory protect function is ON, the screen cannot display the monitor data correctly.

(8) The initial screen display request should only be executed once in response to the first PID57 instruction after the start of QnACPU operation.
If it is executed every scan, the bar graphs and numeric data will not be displayed, although the characters in the still portion are displayed.

(9) To monitor PID control status with the AD57(S1), a character generator ROM and canvas ROM must be loaded to the AD57(S1).
The characters shown in Figure 8.1, corresponding to character codes 000 to $00B_H$, must be created in the character generator ROM.
If these characters are not created, bar graphs cannot be displayed.
Refer to the following manuals for details on creating the character generator ROM and canvas ROM.
- SW1GP-AD57P Operating Manual

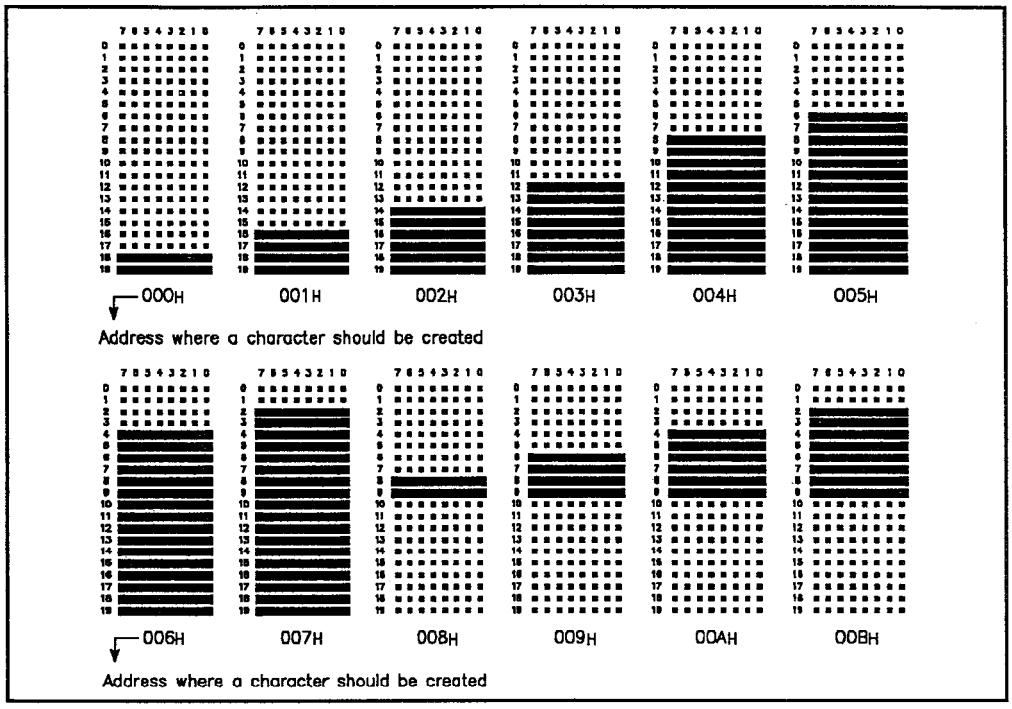


Fig. 8.1 Characters for PID Control Status Monitor

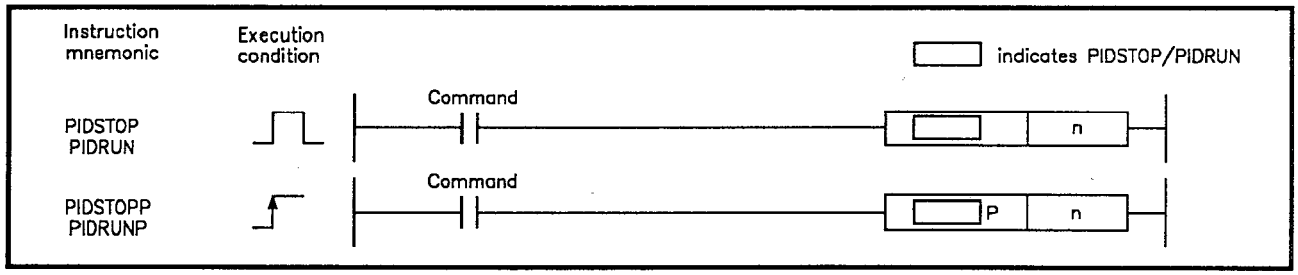
OPERATION ERRORS

(1) An operation error will occur and the error flag (SM0) will be turned ON, and an error code will be stored in SD0, in the following cases.

- When the CMODE instruction has not been executed for AD57(S1). (Error code 2110)
- When the PIDINIT instruction has not been executed before the PID57 instruction. (Error code 4103)
- When the PIDCONT instruction has not been executed before the PID57 instruction. (Error code 4103)
- When the screen number designated with (S1) is outside the range of 1 to 4. (Error code 4100)

8.4 Operation Stop/Start of Designated Loop No.

Set Data	Usable Devices								
	Internal Devices (System, User)		File Register	MELSECNET/10 Direct J□\□		Special Function Module U□\G□	Index Register Zn	Constant K, H	Other
	Bit	Word		Bit	Word				
n	o								—



SET DATA

Set Data	Description	Data Type
n	Loop number at which start/stop is to be executed	16-bit binary

FUNCTIONS

PIDSTOP

(1) Stops the PID operation for the loop number designated by (n).

(2) Retains the operation data during the stop.

PIDRUN

(1) Starts the operation for the loop number designated by (n).
This instruction serves to restart operation at a loop number whose operation was stopped by the PIDSTOP instruction.

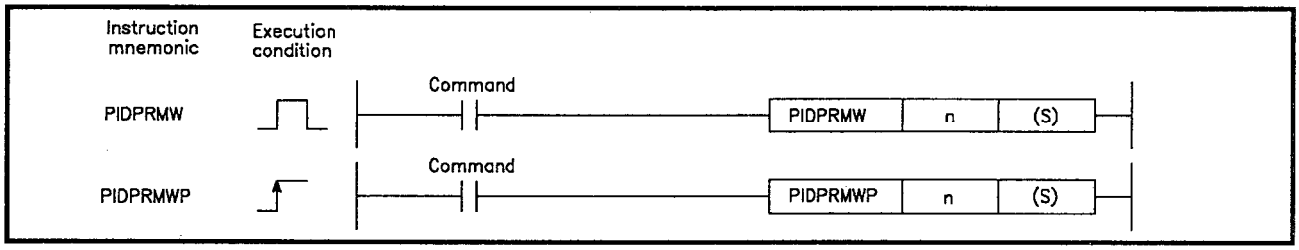
(2) If this instruction is executed with respect to a loop number whose operation is already in progress, no processing will occur.

OPERATION ERRORS

(1) An operation error will occur and the error flag (SM0) will be turned ON in the following cases.
- When the loop number designated by (n) does not exist.
(Error code 4100)
- When (n) is outside the range 1 to 32.
(Error code 4100)

8.5 Parameter Change at Designated Loop

Set Data	Usable Devices								
	Internal Devices (System, User)		File Register	MELSECNET/10 Direct J□\□		Special Function Module U□\G□	Index Register Zn	Constant K, H	Other
	Bit	Word		Bit	Word				
n	o	o		o					—
(S)	—	o		—					—



SET DATA

Set data	Description	Data Type
n	Loop number for which change is to be made	16-bit binary
(S)	First number of devices in which PID control data to be changed is stored	

FUNCTIONS

(1) Changes the operation parameter for the loop number designated by (n) to the PID control data stored in the devices starting with the device number designated by (S).

(2) The configuration of the data for PID control which starts from the device number designated by (S) is shown below.
For details on PID control data, see Section 5.1.

(S)+0	Selection of operation expression
(S)+1	Sampling cycle (T_S)
(S)+2	Proportionate constant (K_P)
(S)+3	Integrating constant (T_I)
(S)+4	Differentiating constant (T_D)
(S)+5	Filter coefficient (α)
(S)+6	Manipulated value lower limit (MVLL)
(S)+7	Manipulated value higher limit (MVHL)
(S)+8	Manipulated value change rate limit (ΔMVLL)
(S)+9	Process value change rate limit (ΔPVL)

OPERATION ERRORS

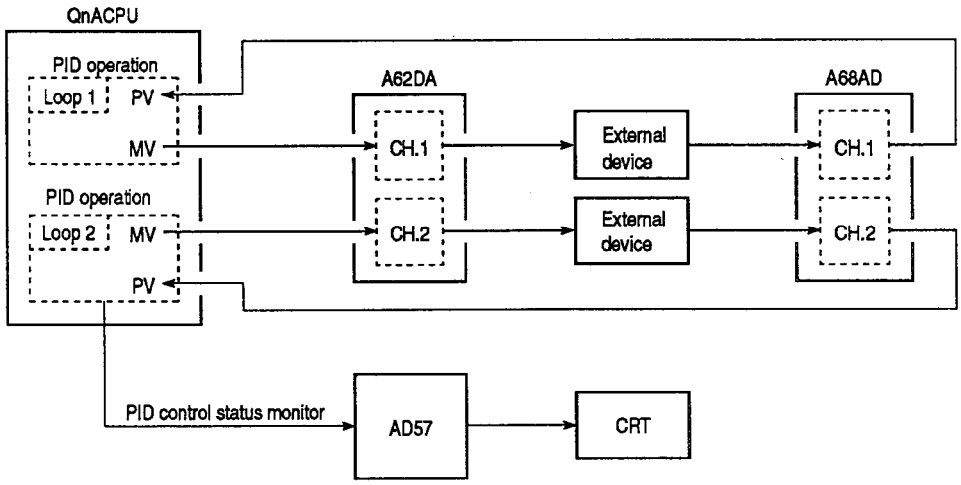
(1) An operation error will occur and the error flag (SM0) will be turned ON, and error code will be stored in SD0, in the following cases.
- When the loop number designated by (n) does not exist.
  (Error code 4100)
- When (n) is outside the range 1 to 32.
  (Error code 4100)

9. PID CONTROL PROGRAM EXAMPLES

This section describes examples of sequence programs that execute PID control.

9.1 System Configuration for Program Examples

The following illustrates the system configuration for the program examples in Sections 9.2 and 9.3.



A68AD I/O numbers ..... X/Y80 to X/Y9F

A62DA I/O numbers ..... X/YA0 to X/YBF

AD57 I/O numbers ..... X/YC0 to X/YFF

9.2 Program Example for Automatic Mode PID Control

This section describes a program example for automatic mode PID control in which PID operation is executed with the digital value read from the A68AD as the PV, and the MV obtained as the result of PID operation is output from the A62DA to control the external devices.

PROGRAMMING CONDITIONS

(1) Refer to Section 9.1 for details on the system configuration.

(2) PID operation is executed for two loops.

(3) The sampling cycle is 1 second.

(4) The PID control data is set in the following devices:*1

Common data	D500 and D501
Loop 1 data	D502 to D511
Loop 2 data	D512 to D521

(5) The I/O data is set in the following devices:*2

Common data	D600 to D609
Loop 1 data	D610 to D627
Loop 2 data	D628 to D645

(6) The following SV values are set for loop 1 and loop 2 using a sequence program:

Loop 1	600
Loop 2	1000

(7) The following devices are used for PID control start/stop commands and the monitoring command with AD57.

PID control start command	X0
PID control stop command	X1
Monitoring command with AD57	X2

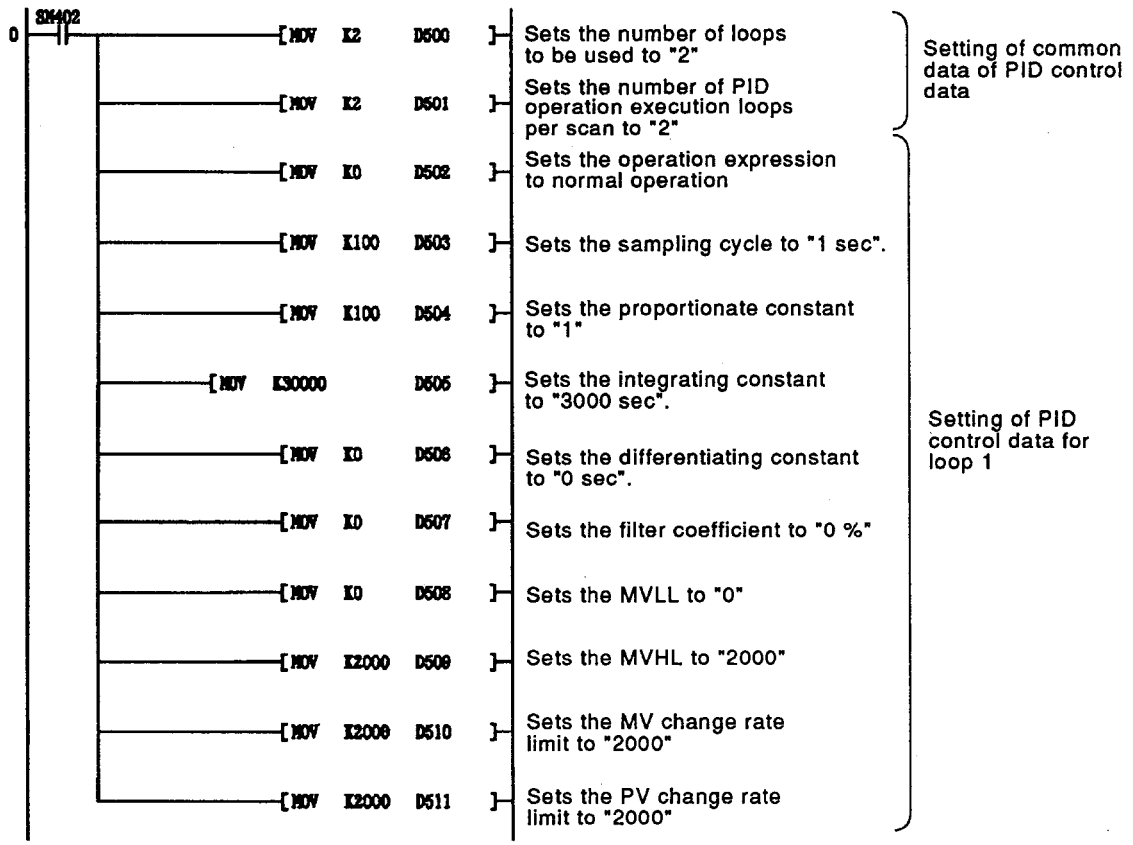
(8) The digital values of the A68AD and A62DA are set within the range 0 to 2000.

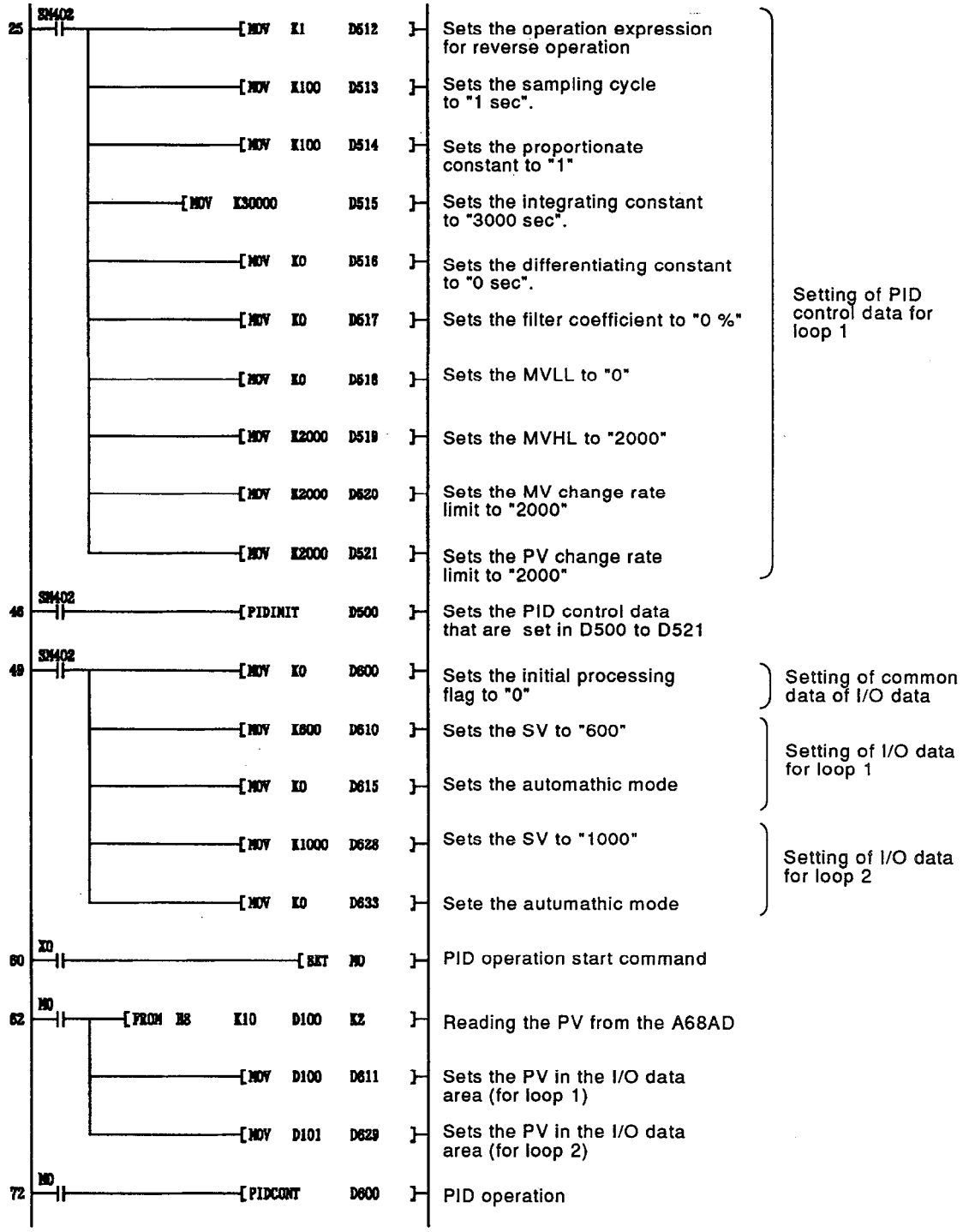
REMARKS

(1) *1: For details on PID control data, see Section 5.1.

(2) *2: For details on I/O data, see Section 5.2.

PROGRAM EXAMPLE

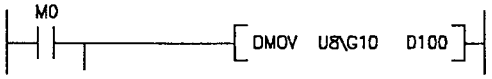


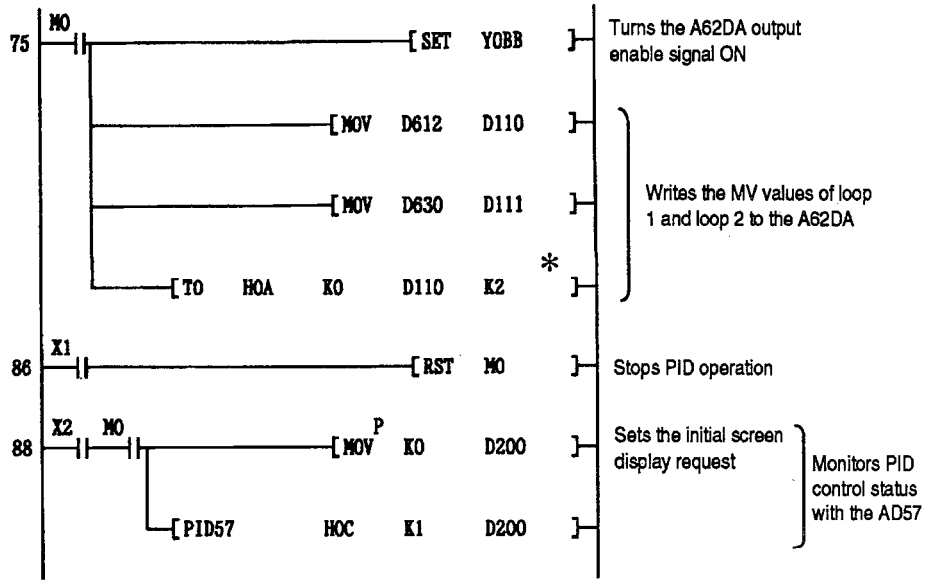


REMARK

*: It is also possible to create a program by using special function module devices.

In this case the format in the ladder is as follows:





REMARK

*: It is also possible to create a program by using special function module devices.

In this case the format in the ladder is as follows:

9.3 Program Example for Changing the PID Control Mode between Automatic and Manual

An example program for switching between automatic and manual modes while executing PID operation is described below.

PROGRAMMING CONDITIONS

(1) Refer to Section 9.1 for details on the system configuration.

(2) PID operation is executed for one loop.

(3) The sampling cycle is 1 second.

(4) The PID control data is set in the following devices:

Common data ..... D500 and D501
Loop 1 data ..... D502 to D511

(5) The I/O data is set in the following devices:

Common data ..... D600 to D609
Loop 1 data ..... D610 to D627

(6) The SV and MV in manual mode are set with external digital switches as follows:

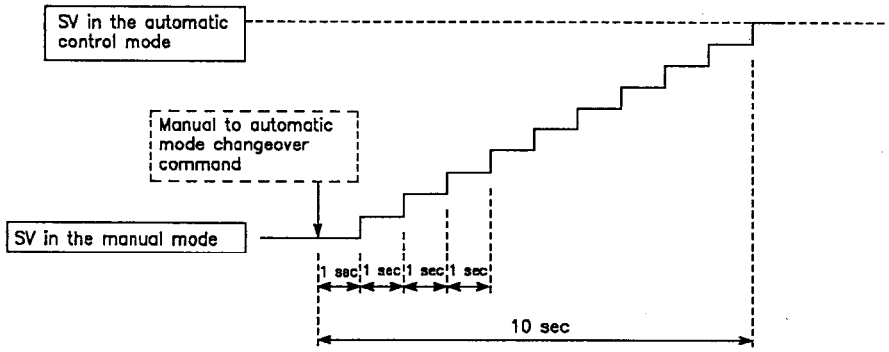
SV ..... X30 to X3F
MV (manual control mode) ..... X20 to X2F

(7) The following devices are used to start and stop PID control and the automatic/manual changeover command:

PID control start command X0
PID control stop command X1
Monitoring command with AD57 ..... X2
SV setting command X3
MV setting command in manual mode X4
Automatic/manual mode changeover command .. X6
(OFF: Automatic mode, ON: Manual mode)

(8) The digital values of the A68AD and A62DA are set within the range 0 to 2000.

(9) The SV is automatically rewritten to the PV when the control mode is changed from automatic to manual. Therefore, before returning the control mode from manual to automatic, the SV must be rewritten to the one used in the automatic mode.
The SV is rewritten step-by-step 10 times as illustrated below:

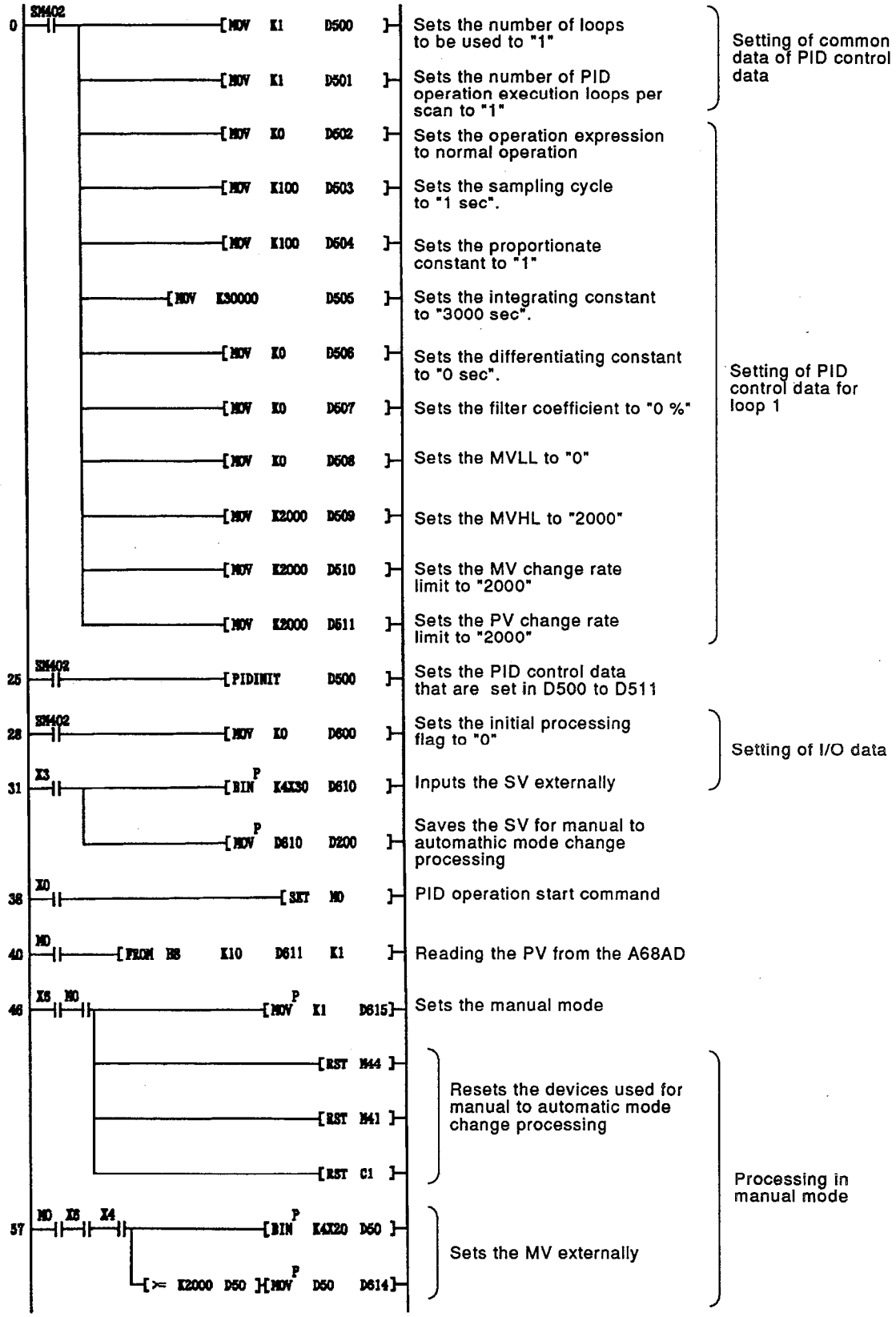


The SV is rewritten using the operation method illustrated below:

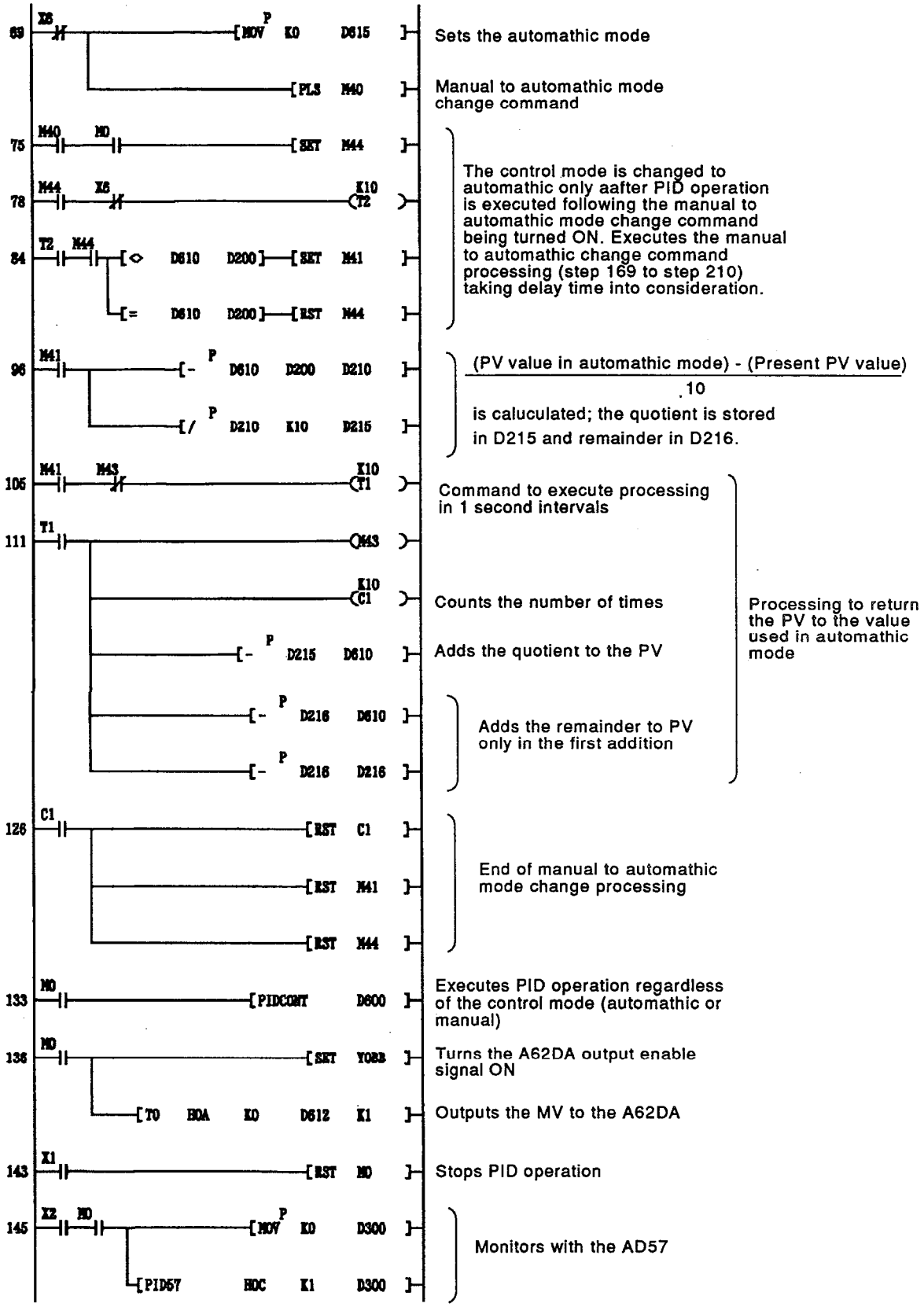
$$\frac{\left(\begin{array}{l}\text{SV to be used}\\ \text{in automatic mode}\end{array}\right) - \left(\begin{array}{l}\text{SV value to be used}\\ \text{in manual mode}\end{array}\right)}{10} = \boxed{\begin{array}{l}\text{Incremental}\\ \text{value}\end{array}} \cdots \boxed{\text{Remainder}}$$

The incremental value obtained with the formula above is added to SV every second. The remainder is added in the first addition operation.

PROGRAM EXAMPLE



PROGRAM EXAMPLE



APPENDIX

APPENDIX 1 PROCESSING TIME LIST

The processing times for PID control instructions are shown below.

Instruction Name	Conditions		Processing Time (μsec)		
			Q4ACPU	Q3ACPU	Q2ACPU(S1)
PIDINT	1 loop		23	46	61
	32 loops		153	306	407
PIDCONT	1 loop	First	80	159	211
		Others	68	136	181
	32 loops	First	1912	3824	5086
		Others	1840	3680	4894
PID57	1 loop	First	3620	7240	9629
		Others	228	456	606
	8 loops	First	3635	7270	9669
		Others	1398	2796	3719
PIDSTOP PIDRUN	1 loop		4.2	8.4	11.2
PIDPRMW			13	26	36

IMPORTANT

Design the configuration of a system to provide an external protective or safety inter locking circuit for the PCs.

Under no circumstances will Mitsubishi Electric be liable or responsible for any consequential damage that may arise as a result of the installation or use of this equipment.

All examples and diagrams shown in this manual are intended only as an aid to understanding the text, not to guarantee operation. Mitsubishi Electric will accept no responsibility for actual use of the product based on these illustrative examples.

Owing to the very great variety in possible applications of this equipment, you must satisfy yourself as to its suitability for your specific application.

QnACPU
PROGRAMMING MANUAL (PID Control Instructions)

MODEL	QNA-P(PID)-E
MODEL CODE	13JF50
IB(NA)66618-A(9602)MEE	

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE : MITSUBISHI DENKI BLDG MARUNOUCHI TOKYO 100 TELEX : J24532 CABLE MELCO TOKYO
NAGOYA WORKS : 1-14 , YADA-MINAMI 5 , HIGASHI-KU, NAGOYA , JAPAN

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