MITSUBISHI
PROGRAMMABLE CONTROLLER
MELSEC-K

Instruction Manual

PID Control Unit
Type KD81

MITSUBISHI
ELECTRIC

84·J·E·U/IB(NA) 66007-A

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1. GENERAL DESCRIPTION

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1.1 General Description

The PID control unit KD81 (hereinafter referred to as "KD81") is a MELSEC-K series functional unit developed to enable high-speed and high-accuracy process control with a programmable controller. The KD81 incorporates a microprocessor and processes PID operations at high speed and in high accuracy. Equipped with a variety of instruction functions required for PID control, the KD81 also permits various types of process control.

[Features]

1) The most suitable PID control can be made.
   By selection of positional, velocity or error square type PID operation, the KD81 can afford to execute PID control which is best-suited for controlled object.

2) Four loop can be controlled by one KD81 unit
   Using 4 channels of analog I/O circuits, the KD81 can simultaneously execute PID control with a maximum of 4 loops.

3) High-speed processing of PID operation can be made.
   High-speed processing can be done at a sampling period of minimum 0.01 second.

4) Various types of alarm detection functions
   The rate of PV (process variable) change check function and the rate of MV (manipulated variable) change check function are provided to allow the monitor of PV and MV.

5) A variety of instruction functions
   Higher-grade control can be made with 33 types of instructions such as PID and special instructions required for PID control and also arithmetic operation and logical instructions.

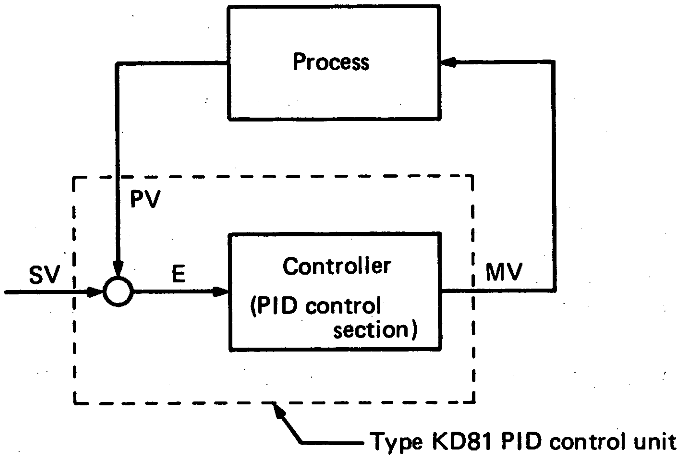
6) Easy programming
   By use of PID programmer KD81HP, direct programming can be accomplished.

For programming by use of KD81HP, see the "Instruction Manual for Type KD81HP PID Programmer".

1.2 PID Control

(1) General description of PID control

PID control is utilized for a process control system which controls flow rate, velocity, air flow, temperature, tension, etc. The basic block diagram is shown below.



SV: SET VALUE
PV: PROCESS VALUE
MV: MAINPULATED VALUE
E: ERROR

In process control, an automatically functioning mechanism is provided so that controlled variable, such as flow rate, is measured and compared with a pre-provided desirable variable, i.e. set variable, and if error exists between these variables, the controller regulates output depending on the degree of error to always equalize the controlled variable to the set variable. In PID control, the controller makes the operations of proportional variable (P), integration variable (I), and differentiation variable (D) on the basis of error (set variable minus process variable) and these variables are used as manipulated variables.

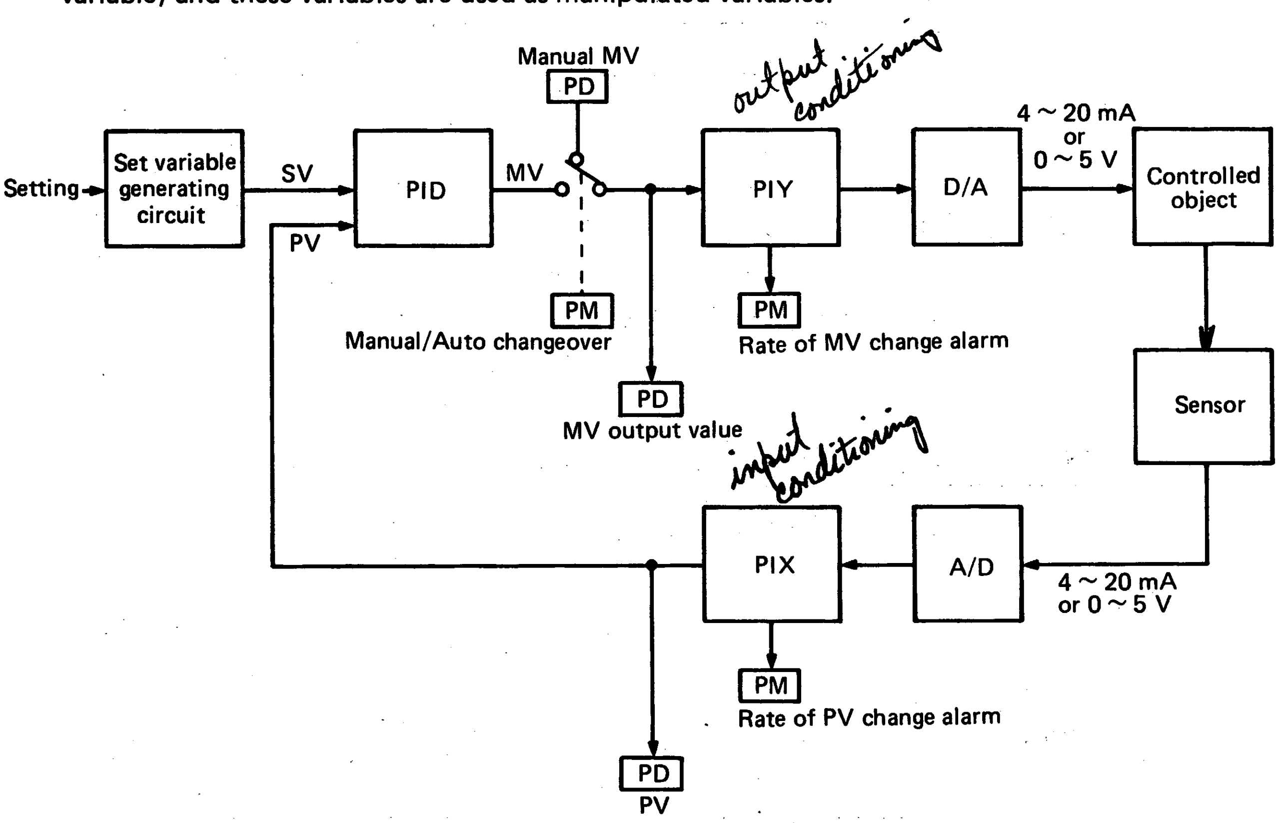


Fig. 1.1 PID Control Block Diagram

(2) P, I, and D actions

Ⓟ Proportional control action
This action causes manipulated variable, which is proportional to the error (difference between set variable and process variable), to function. However, when offset (residual error) occurs due to the variations of load variable, etc., the error cannot be corrected only by the proportional control action.

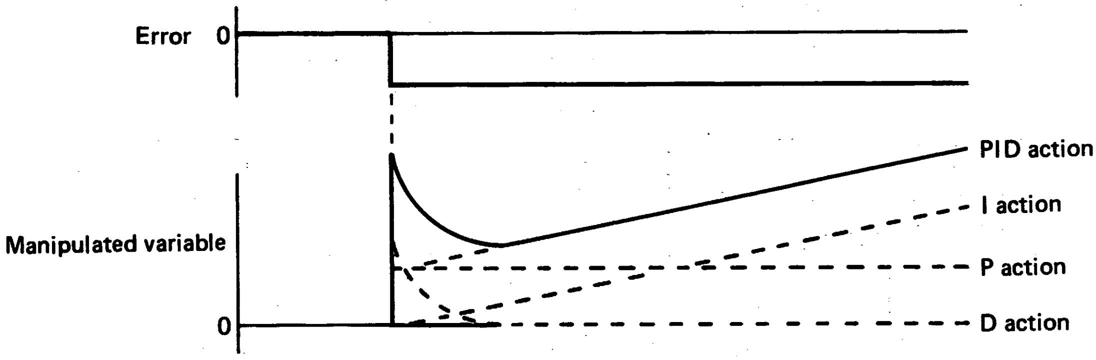
Ⓘ Integral control action
When error and offset occur, this action functions consecutively to eliminate them depending on their magnitude. (Proportional to the time integration of error)

Ⓓ Derivative control action
When error begins to occur due to disturbance, etc., this action prevents large variations of controlled unit by providing large corrective action while the error is small. Therefore, this action does not function for a uniform error, such as offset, irrespective of its magnitude.

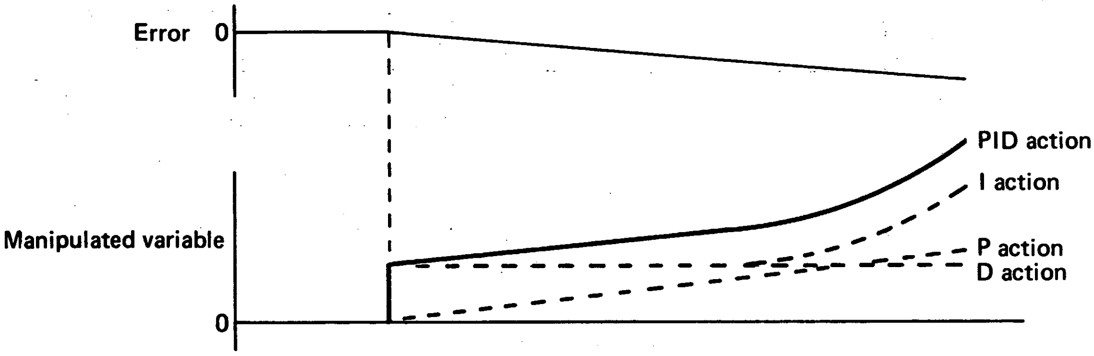
(P + I) -------This action functions to correct control, which does not have offset, and error due to disturbance.

(P + I + D) --- This action functions as described in (P + I) and also functions to immediately correct sudden changes.

Output Response of PID Action 1. (When error is uniform)



2. Output Response of PID Action 3. (When error increases gradually)



2. SYSTEM CONFIGURATION

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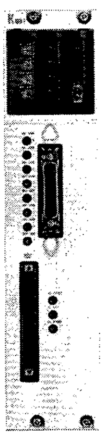
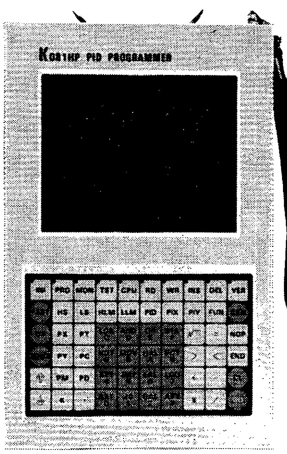
2.1 Equipment

Type	Equipment	Qty
KD81	KD81 (with 48 pin connectors for external connection)	1
KD81HP	KD81HP, K70CBL, KG73 (KD81HP containing case)	1 each

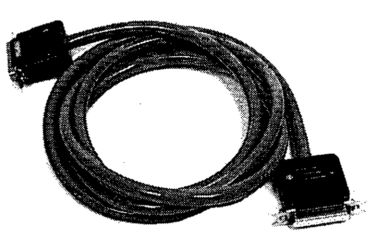
Table 2.1 Equipment



1. PID control unit KD81



2. PID programmer KD81HP

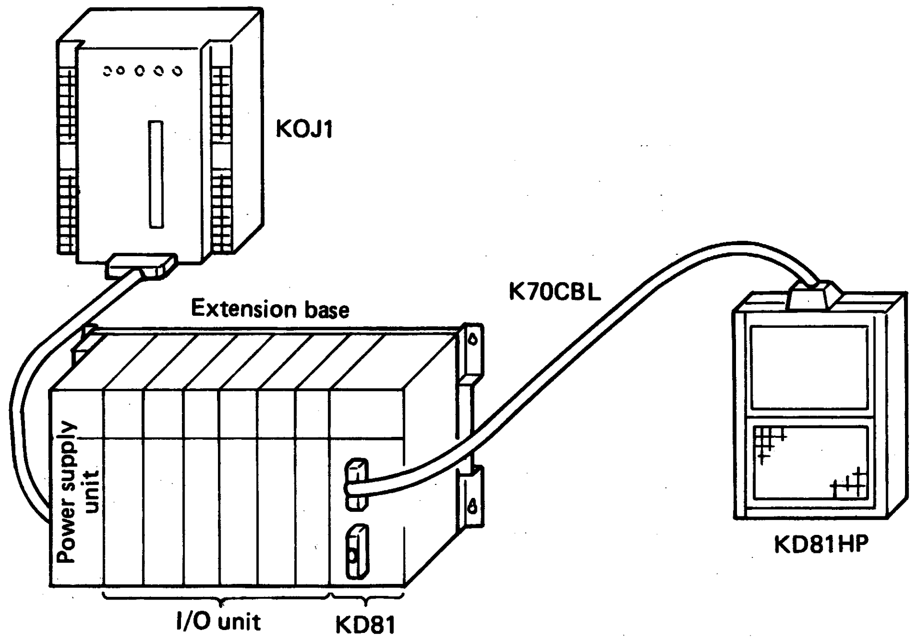


3. Connection cable K70CBL

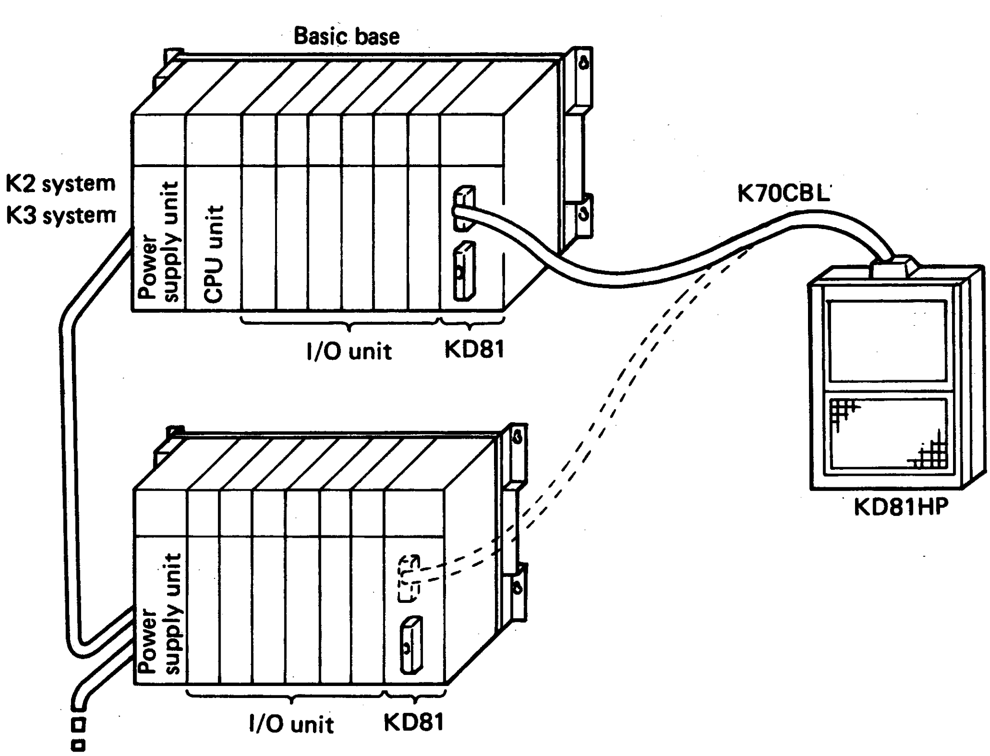
4. PID programmer containing case KG73

2.2 System Configuration

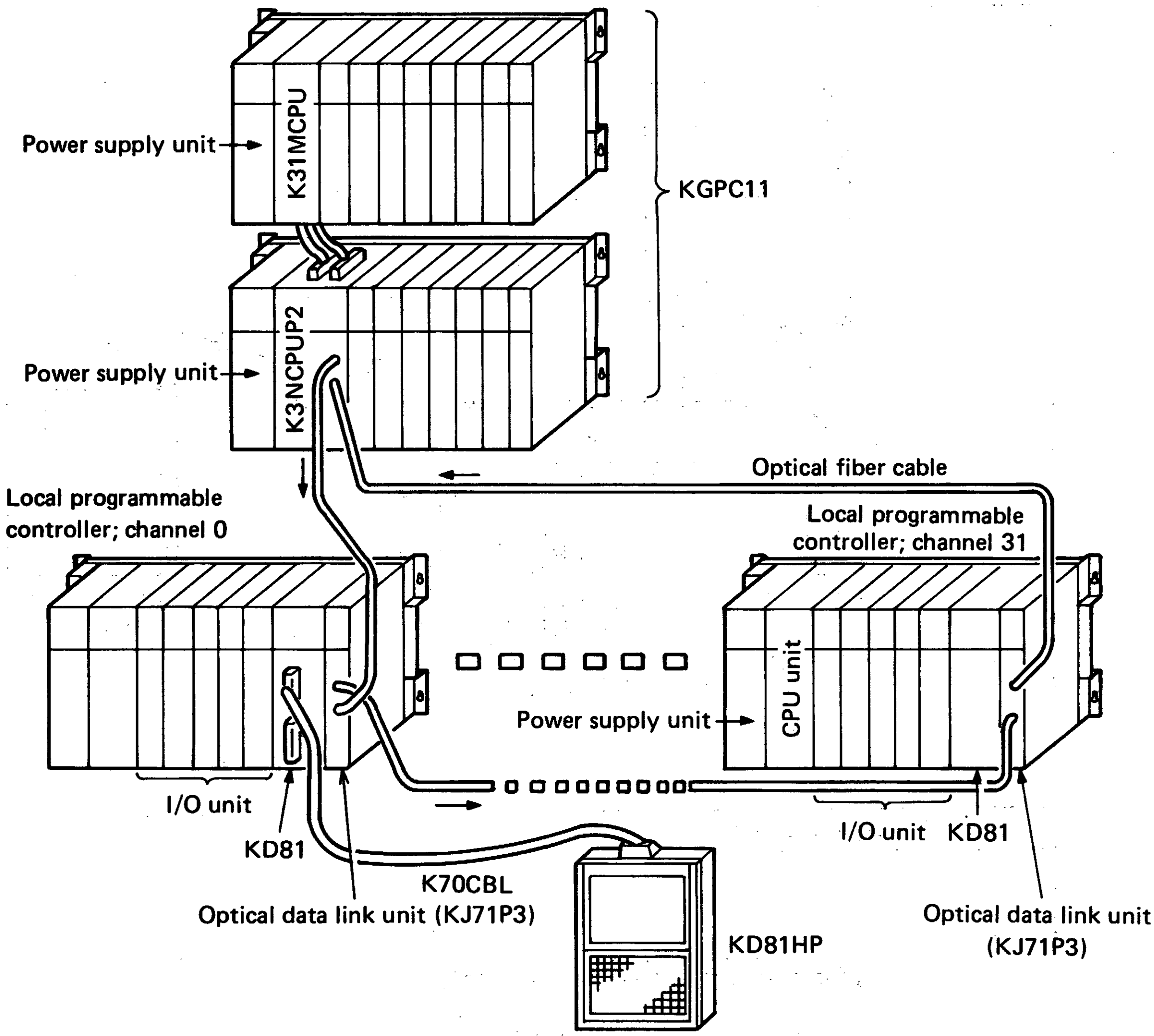
System Combined with K0J



System Combined with K2 or K3

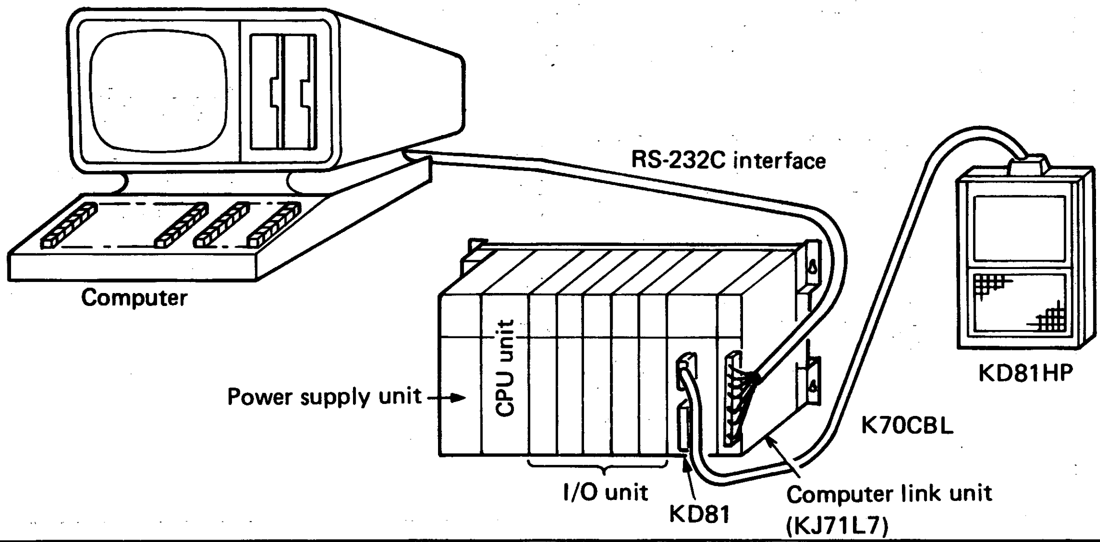


System Combined with KGPC11



*KD81 can also be used for remote I/O channel.

System Combined with Computer



2.3 Internal Configuration of KD81

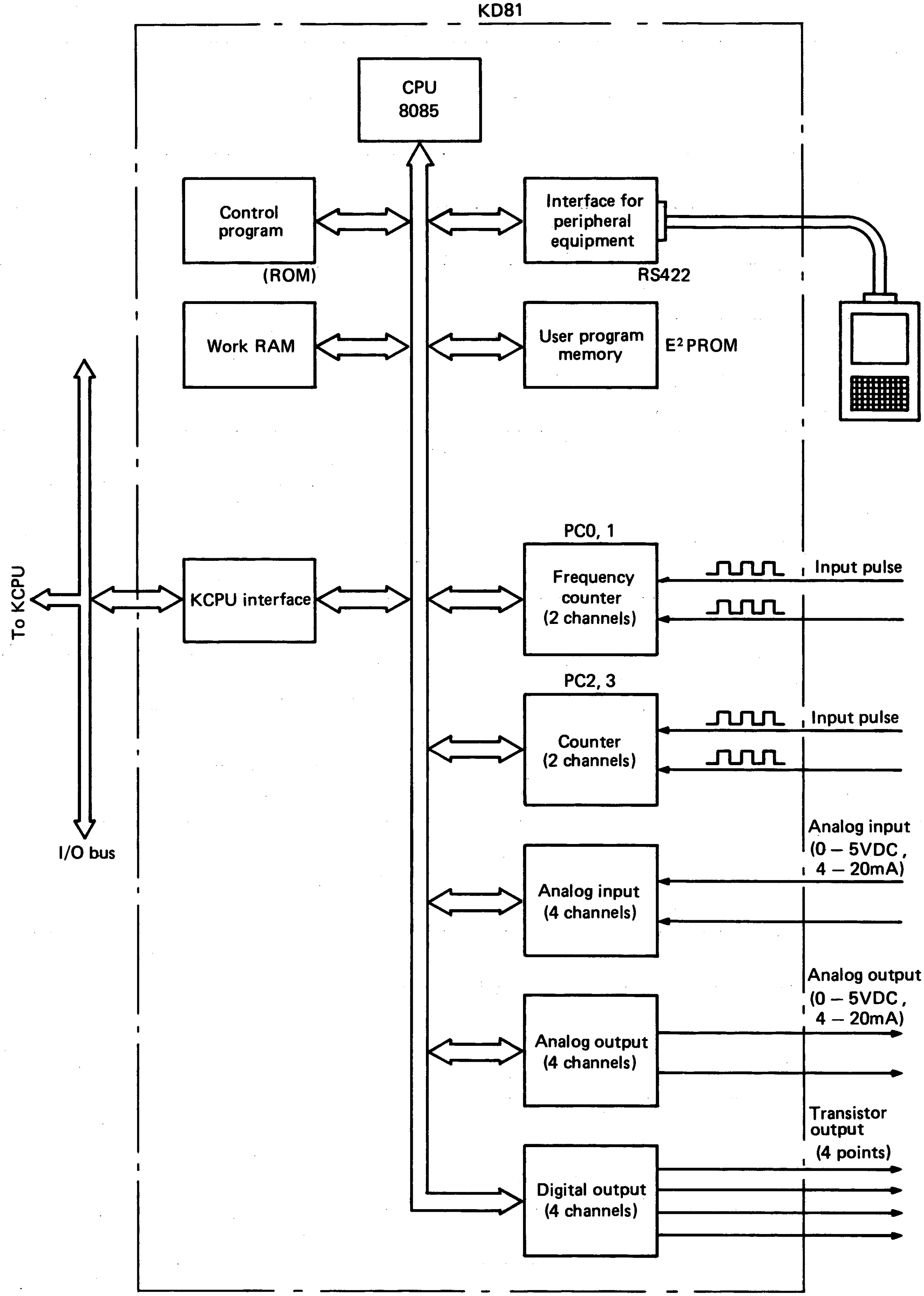


Fig. 2.2 Internal Configuration of KD81

MEMO

3. SPECIFICATIONS

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3.1 General Specifications

Item	Specifications
Operating ambient temperature	0 ~ 55°C
Storage ambient temperature	–10 ~ 75°C
Operating ambient humidity	10 ~ 85%RH (no dew condensation)
Storage ambient humidity	10 ~ 90%RH (no dew condensation)
Vibration resistance	Conforms to JIS C 0911 IIB class 3 (16.7 Hz, 3-mm double amplitude, 2 hrs.)
Shock resistance	Conforms to JIS C 0912 (10 g x 3 times in X, Y, Z directions)
Operating ambience	There should be no corrosive gas and particularly dust should be minimal.
Cooling system	Self-cooling

Table 3.1 General Specifications

3.2 Performance Specifications

3.2.1 Performance specifications

Item		Specifications
Exclusively used number of inputs/outputs		32 points
Instruction	Function instructions	33 types
	Word length	32 bits (4 bytes)/step 1 ~ 6 step instruction
Instruction execution time		Refer to Appendix (Page 87)
Program	Capacity	A total of 2000 steps in program
	Number of loops	A maximum of 4 loops
Sampling period		0.01 ~ 99.99 seconds (Setting is possible in units of 10ms.)
PID operation		8 types of operation expressions (positional, velocity type, and error square type can be selected)
PID constant setting range	Proportional constant (K_P)	0.00 ~ 100.00
	Integration constant (T_I)	0.01 ~ 32700.00 seconds
	Differentiation constant (T_D)	0.00 ~ 255.00 seconds
Set variable setting range (SV)		0.00 ~ 100.00%
Process varible range (PV)		0.00 ~ 100.00%
Dead band range (G)		0.00 ~ 100.00%
Analog input	Number of circuits	4 channels (non-insulated)
	Specifications	0 ~ 5VDC Input resistance : 0.9 MΩ or larger 4 ~ 20mADC Input resistance : 250Ω
	Resolution	1/4096 (12 bit)
Analog output	Number of circuits	4 channels (non-insulated)
	Specifications	0 ~ 5VDC External load resistance : 500Ω ~ 1MΩ 4 ~ 24mADC External load resistance : 0Ω ~ 600Ω
	Resolution	1/4096 (12 bit)
Digital output	Number of circuits	4 channel (PY12 ~ PY15)
	Specifications	Transistor output (Open collector) Rated working voltage, current : 12/24VDC, 0.1A 4 points/common
Frequency counter	Number of circuits	2 channel (PC0, PC1)
	Specifications	5VDC Input resistance : 330Ω (input current : 7 mA) 12VDC Input resistance : 1.5KΩ (Input current : 7mA) 24VDC Input resistance : 1.5KΩ (Input current : 13mA)
	Counting frequency	20 kHz (MAX.) DUTY 50%
	Counting range	0 ~ 65535 pulses/sampling period

Table 3.2 Performance Specifications

Item			Specifications	
Counter	Number of circuit		2 channel (PC2, PC3)	
	Counter mode		UP COUNTER, DOWN COUNTER, or UP/DOWN COUNTER, depending on initial setting.	
	Specifications		5VDC 12VDC 24VDC	Input resistance : 330Ω (Input current : 7mA) Input resistance : 1.5KΩ (Input current : 7mA) Input resistance : 1.5KΩ (Input current : 13 mA)
	Counting frequency		20 kHz (MAX.) DUTY 50%	
	Counting Range		–32678 ~ 32767	
Input	Number of points	8 points	PX0 ~ PX7	Write is possible from programmable controller.
Output	Number of points	12 points	PY0 ~ PY11	Read is possible from programmable controller.
Temporary memory	Number of points	16 points	PM0 ~ PM15	Read and write are possible from programmable controller.
		112 points	PM16 ~ PM127	Read and write are not possible from programmable controller.
Data register	Number of points	30 points	PD1 ~ PD31	Read and write are possible from programmable controller.
		96 points	PD32 ~ PD127	Read and write are not possible from programmable controller.
Timer	Number of points	16 points	PT0 ~ PT15	10ms timer – maximum counting time: 327 sec
		16 points	PT16 ~ PT31	100ms timer – maximum counting time: 3276sec

Table 3.2 Performance Specifications (Continued)

Note) 1. The names of devices used for KD81 are provided with "P" to differentiate them from devices for programmable controller.

Description	Device Name of KD81	Device Name of Programmable Controller	Device Name Shown on KD81HP	
			Key	Display
Input	PX	X	PX	X
Output	PY	Y	PY	Y
Temporary memory	PM	M	PM	M
Timer	PT	T	PT	T
Counter	PC	C	PC	C
Data register	PD	D	PD	D
Constant	K	K	K	K

2. Frequency counters (PC0, PC1)....................
The number of pulses input during sampling period is stored in PC0 and PC1.

3. For details of temporary memory and data register functions, see the following pages.

Temporary Memory Number	Function
PM 0 ~ 70 PM 75 ~ 80 PM 85 ~ 90 PM 95 ~ 100 PM105 ~ 110 PM113 ~ 127	Usable by user program as desired. (PM0 ~ 31 can be read and written by the programmable controller.)
PM 71	Clear of program 1 PID operation
PM 72	Clear of program 2 PID operation
PM 73	Clear of program 3 PID operation
PM 74	Clear of program 4 PID operation
PM81	Alarm for PV (process value) change rate of analog input channel 1. "1" when the change rate is large.
PM82	Alarm for PV (process value) change rate of analog input channel 2. "1" when the change rate is large.
PM83	Alarm for PV (process value) change rate of analog input channel 3. "1" when the change rate is large.
PM84	Alarm for PV (process value) change rate of analog input channel 4. "1" when the change rate is large.
PM91	Automatic-manual selection of analog output channel 1. "1" when automatic is selected.
PM92	Automatic-manual selection of analog output channel 2. "1" when automatic is selected.
PM93	Automatic-manual selection of analog output channel 3. "1" when automatic is selected.
PM94	Automatic-manual selection of analog output channel 4. "1" when automatic is selected.
PM101	Alarm for MV (manipulated value) change rate of analog output channel 1. "1" when the change rate is large.
PM102	Alarm for MV (manipulated value) change rate of analog output channel 2. "1" when the change rate is large.
PM103	Alarm for MV (manipulated value) change rate of analog output channel 3. "1" when the change rate is large.
PM104	Alarm for MV (manipulated value) change rate of analog output channel 4. "1" when the change rate is large.
PM111	"1" when preset counter PC2 overflows. CTR FLAG
PM112	"1" when preset counter PC3 overflows. CTR FLAG

Note: 1. Since 18 points of PM71 ~ 74, PM81 ~ 84, PM91 ~ 94, PM101 ~ 104, and PM111, 112 are used for fixed application, do not use these temporary memories for other purposes. (Once set, the aforementioned temporary memories do not turn off.)

2. PM71 ~ 74 are temporary memories for clearing PID operation. Only when this PM turns from off to on, the preceding result of operation is cleared to "0" and PID operation is resumed from the initial state upon the execution of PID operation of program which corresponds to the turned-on PM.

Table 3.3 Temporary Memory Functions

Data Register Number	Function
PD 1 ~ 91 PD 94 ~ 100 PD105 ~ 110 PD115 ~ 120 PD125 ~ 127	Usable by user program as desired (PD1 ~ 31 can be read and written by the programmable controller.)
PD92	Area for storing set value of UP/DOWN counter PC2.
PD93	Area for storing set value of UP/DOWN counter PC3.
PD101	Area for storing PV (process value) of analog input channel 1.
PD102	Area for storing PV (process value) of analog input channel 2.
PD103	Area for storing PV (process value) of analog input channel 3.
PD104	Area for storing PV (process value) of analog input channel 4.
PD111	Area for storing automatic MV (manipulated value) of analog output channel 1.
PD112	Area for storing automatic MV (manipulated value) of analog output channel 2.
PD113	Area for storing automatic MV (manipulated value) of analog output channel 3.
PD114	Area for storing automatic MV (manipulated value) of analog output channel 4.
PD121	Area for storing manual MV (manipulated value) of analog output channel 1.
PD122	Area for storing manual MV (manipulated value) of analog output channel 2.
PD123	Area for storing manual MV (manipulated value) of analog output channel 3.
PD124	Area for storing manual MV (manipulated value) of analog output channel 4.

Note: Since 14 points of PD92 ~ 93, PM101 ~ 104, PM111 ~ 114, and PM121 ~ 124 are used for fixed application, do not use these data registers for other purposes.

Table 3.4 Data Register Functions

3.2.2 List of instructions

	Instruction	Logical Pro-cessing	Data Pro-cessing	Function	Content of Operation	Number of steps
Logical instructions	NOT	○		Inverse	(A) ← $\overline{\text{(Device)}}$	1
	AND	○		Logical product	(A) ← (A) ∧ (Device)	1
	OR	○		Logical add	(A) ← (A) ∨ (Device)	1
	SET	○		Set	(Device) ← 1	1
	RST	○		Reset	(Device) ← 0	1
Transfer instructions	STA	○	○	Storage (WRITE)	(Device) ← (A)	1
	LDA	○	○	Read	(A) ← (Device)	1
	MOV	○	○	Transfer	S → D	1
Operation instructions	+		○	Add	(A) ← (A) + (Device)	1
	—		○	Subtract	(A) ← (A) – (Device)	1
	*		○	Multiply	(A) ← (A) x (Device)	1
	/		○	Divide	(A) ← (A) ÷ (Device)	1
	√‾		○	Square root	(A) ← $\sqrt{(A)}$	1
	PCT		○	% operation	(A) ← {(A)/(Device)} x 100	1
	LOG		○	Common logarithm	(A) ← $\log_{10}$ (A)	1
	ABS		○	Absolute value	(A) ← |(A)|	1
Comparison instructions	>		○	Comparison	When (A) ≤ (Device), "the next step + 1" is run. When (A) > (Device), the next step is run.	1
	<		○	Comparison	When (A) < (Device), the next step is run. When (A) ≥ (Device), "the next step + 1" is run.	1
	=		○	Comparison	When (A) = (Device), the next step is run. When (A) ≷ (Device), "the next step + 1" is run.	1
Branch instructions	JMP	–	–	Unconditional jump	Program jumps to specified program step.	1
	JC	○		Conditional jump	· When condition [(A) = 1] holds, program jumps to specified program step. · When condition [(A) = 1] does not hold, the next step is run.	1
Special instructions	HS (High select)		○	Magnitude comparison	When (A) ≥ (Device), (A) → (A) When (A) < (Device), (Device) → (A)	1
	LS (Low select)		○	Magnitude comparison	When (A) ≤ (Device), (A) → (A) When (A) > (Device), (Device) → (A)	1
	HLM (High limiter)		○	Clamping of higher limit value	When (A) > (Device), (Device) → (A)	1
	LLM (Low limiter)		○	Clamping of lower limit value	When (A) < (Device), (Device) → (A)	1
	NOP	–	–	No operation	No operation is executed and the next step is run.	1
	END	–	–	Program end	Declares the end of program.	1

Table 3.5 List of Instructions

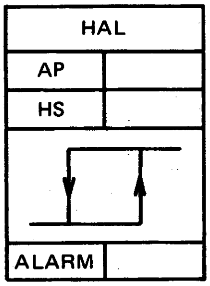
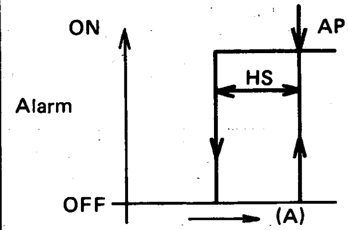
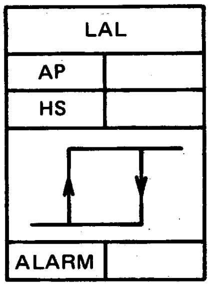
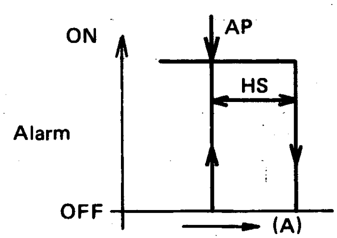
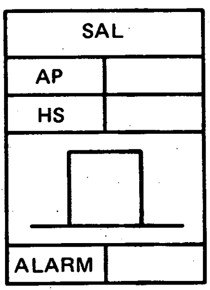
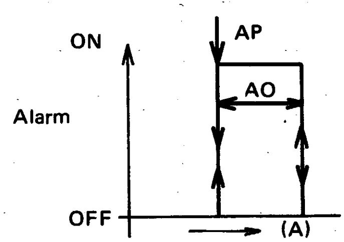
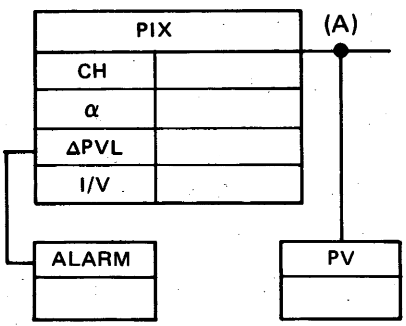
	Instruction	Symbol	Function	Contents of Operation	Number of Step
Special instructions	HAL (High alarm)		Function which provides alarm output when (A) becomes higher than set variable.	 AP : Alarm set variable HS : Hysteresis variable	3
Special instructions	LAL (Low alarm)		Function which provides alarm output when (A) becomes lower than set variable.	 AP : Alarm set variable HS : Hysteresis variable	3
Special instructions	SAL (Set alarm)		Function which provides alarm output when (A) is within set variable plus ON range.	 AP : Alarm set variable AO : Alarm output range	3

Table 3.5 List of Instructions (Continued)

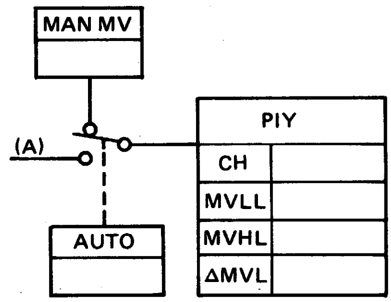
<table>
<tr><th></th><th>Instruction</th><th>Symbol</th><th>Function</th><th>Number of Step</th></tr>
<tr>
<td>PID instructions</td>
<td>PIX</td>
<td>


<table>
<tr><th colspan="2">Setting of Range</th></tr>
<tr><td>CH</td><td>K1, 2, 3, 4</td></tr>
<tr><td>α</td><td>0 – 1</td></tr>
<tr><td>ΔPVL</td><td>0 – 100 (%)</td></tr>
<tr><td>I/V</td><td>Current input : 1
Voltage input : 0</td></tr>
</table>
</td>
<td>
Analog input signal of process is converted into digital value and is stored into (A) and specified data register.
<table>
<tr><td>CH</td><td>A/D converter channel setting
Specify which of 4 channels of A/D converter is input.</td></tr>
<tr><td>α</td><td>Filter coefficient
Set the degree of filtering. As coefficient approaches zero, filter becomes inactive.</td></tr>
<tr><td>ΔPVL</td><td>Rate of PV change limit value
When the rate of change from the previous PV to present PV exceeds this set variable, specified PM is set.

CH1 PM81
CH2 PM82
CH3 PM83
CH4 PM84</td></tr>
<tr><td>I/V</td><td>Specify current or voltage mode.
When current mode is specified, 4 – 20 mA is converted into 0 – 100%.
When voltage mode is specified, 0 – 5 V is converted into 0 – 100%.
Converted analog value is stored into (A) and also into the next data register.

CH1 PD101
CH2 PD102
CH3 PD103
CH4 PD104</td></tr>
</table>
</td>
<td>4</td>
</tr>
</table>

Table 3.5 List of Instructions (Continued)

<table>
<tr><th></th><th>Instruction</th><th>Symbol</th><th>Function</th><th>Number of Step</th></tr>
<tr>
<td>PID instructions</td>
<td>PIY</td>
<td>


<table>
<tr><th colspan="2">Setting of Range</th></tr>
<tr><td>CH</td><td>K1, 2, 3, 4</td></tr>
<tr><td>MVLL</td><td>0 – 100</td></tr>
<tr><td>MVHL</td><td>0 – 100</td></tr>
<tr><td>ΔMVL</td><td>0 – 100</td></tr>
</table>
</td>
<td>
Digital value of (A) or specified data register is converted into analog value. When AUTO position of MAN/AUTO select switch is selected, the content of (A) is output. When MAN position is selected, the content of data register, which is determined by channel, is output.
<table>
<tr><th rowspan="2">Channel</th><th colspan="4"></th></tr>
<tr><th>Select Signal</th><th>Output Value</th><th>Select Signal</th><th>Output Value</th></tr>
<tr><td>CH1</td><td>PM91 OFF</td><td>PD101</td><td>PM91 ON</td><td>(A)</td></tr>
<tr><td>CH2</td><td>PM92 OFF</td><td>PD102</td><td>PM92 ON</td><td>(A)</td></tr>
<tr><td>CH3</td><td>PM93 OFF</td><td>PD103</td><td>PM93 ON</td><td>(A)</td></tr>
<tr><td>CH4</td><td>PM94 OFF</td><td>PD104</td><td>PM94 ON</td><td>(A)</td></tr>
</table>
<table>
<tr><td>CH</td><td>D/A converter channel setting
Specify to which of 4 channels of D/A converter the output is provided.</td></tr>
<tr><td>MVLL</td><td>MV lower limit value
Value higher than set variable is output.</td></tr>
<tr><td>MVHL</td><td>MV higher limit value
Value lower than set variable is output.</td></tr>
<tr><td>ΔMVL</td><td>Rate of MV change limit value
When the rate of change from previous MV exceeds set variable, specified PM is set.

CH1 PM101
CH2 PM102
CH3 PM103
CH4 PM104</td></tr>
</table>
</td>
<td>4</td>
</tr>
</table>

Table 3.5 List of Instructions (Continued)

<table>
<tr><th></th><th>Instruction</th><th>Symbol</th><th>Function</th><th>Number of Step</th></tr>
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<td>PID</td>
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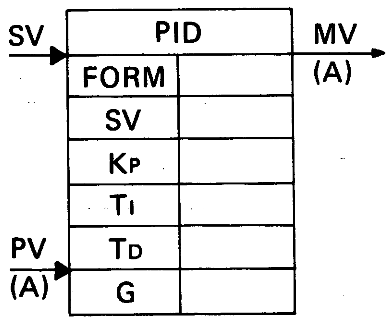


<table>
<tr><th colspan="2">Setting of Range</th></tr>
<tr><td>FORM</td><td>1, 2, 3, 4, 5, 6, 7, 8</td></tr>
<tr><td>SV</td><td>0 – 100</td></tr>
<tr><td>KP</td><td>0 – 100</td></tr>
<tr><td>Tz</td><td>0 – 32700 seconds</td></tr>
<tr><td>TD</td><td>0 – 255 seconds</td></tr>
<tr><td>G</td><td>0 – 100</td></tr>
</table>
</td>
<td>
PID operation is performed by use of SV and PV, and the result is stored into (A).

Parameter Setting
<table>
<tr><td>FORM</td><td>Operation expression selection
1. Basic velocity type normal action
2. Basic velocity type reverse action
3. Basic positional normal action
4. Basic positional reverse action
5. Error square velocity type normal action
6. Error square velocity type reverse action
7. Error square positional normal action
8. Error square positional reverse action</td></tr>
<tr><td>SV</td><td>Set variable is set.</td></tr>
<tr><td>KP</td><td>Proportional constant</td></tr>
<tr><td>TI</td><td>Integration constant</td></tr>
<tr><td>TD</td><td>Differentiation constant</td></tr>
<tr><td>G</td><td>Dead band</td></tr>
</table>
</td>
<td>6</td>
</tr>
</table>

Table 3.5 List of Instructions (Continued)

3.2.3 List of instructions and used devices

Instruction \ Device	A	K	X	Y	M	T	C	D
NOP								
NOT			○	○	○			
AND			○	○	○			
OR			○	○	○			
SET			○	○	○	○ C	○ C	
RST			○	○	○	○ C	○ C	
END								
LDA		●	○	○	○	● G	● G	●
STA			○	○	○	● G	● G	●
+		●				● G	● G	●
−		●				● G	● G	●
*		●				● G	● G	●
/		●				● G	● G	●
√	●							
÷		●				● G	● G	●
LOG	●							
ABS	●							
>		●				● G	● G	●
<		●				● G	● G	●
=		●				● G	● G	●
JC		○						
JMP		○						
HS		○				○ G	○ G	○
LS		○				○ G	○ G	○
HLM		○						○
LLM		○						○

Table 3.6 List of Instructions and Used Devices

Note 1: ○ mark and ● mark in the table indicate usable devices; ○ marks for logical processing and ● mark for data processing.

2: C next to the aforementiones marks indicate coil and G indicate temporary value.

Instruction \ Device			D						
			K	X	Y	M	T	C	D
MOV	S	K	–	–	–	–	●	●	●
		PX	–	○	○	○	–	–	–
		PY	–	○	○	○	–	–	–
		PM	–	○	○	○	–	–	–
		PT	–	–	–	–	● G	● G	●
		PC	–	–	–	–	● G	● G	●
		PD	–	–	–	–	●	●	●

Table 3.6 List of Instructions and Used Devices (Continued)

Note: ○ mark indicates logical processing and ● mark indicates data processing

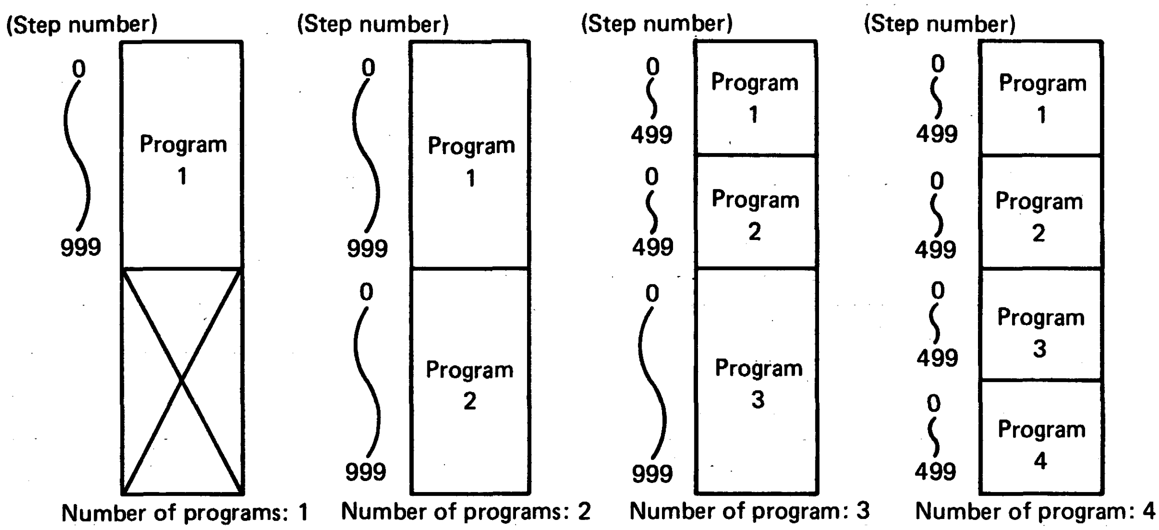
3.2.4 List of S and D of PID instructions

Instruction	Setting	Device						
		K	PX	PY	PM	PT	PC	PD
SAL	Alarm set variable	●						●
	Alarm output range	●						●
	M where alarm is set				●			
HAL	Alarm set variable	●						●
	Hysteresis variable	●						●
	M where alarm is set				●			
LAL	Alarm set variable	●						●
	Hysteresis variable	●						●
	M where alarm is set				●			
PIX	Input device setting (K1 ~ K4)	●						
	Filter coefficient α (0.00 ~ 1.00)	●						●
	Rate of PV change limit value ΔPVL(%) (0.00 ~ 100.00)	●						●
	Input mode setting (K0 (voltage) or K1 (current))	●						
PIY	Output device setting (K1 ~ K4)	●						
	MV lower limit value MVL % (0.00 ~ 100.00)	●						●
	MV higher limit value MVHL % (0.00 ~ 100.00)	●						●
	Rate of MV change limit value ΔMVL % (0.00 ~ 100.00)	●						●
PID	Operation expression (K1 ~ K8)	●						
	Set variable SV(%) (0.00 ~ 100.00)	●						●
	Proportional constant K_P (0.00 ~ 100.00)	●						●
	Integration constant T_I (second) (0.000 ~ 32700.00)	●						●
	Differentiation constant T_D (second) (0.00 ~ 255.00)	●						●
	Dead band G (%) (0.00 ~ 100.00)	●						●

Table 3.7 List of S and D of PID Instruction

3.2.5 Program memory map

The relation between the number of programs and the program capacity is as shown in the figure below. The maximum usable number of programs is 4 and the run (scan time) of each program can be set in the range of 0.01 and 99.99 seconds in units of 0.01 sec.



The allocation of program number is automatically made when the program trigger factor is set. (For the setting of program trigger factor, see Section 6 of the Instruction Manual for KD81HP.)

3.3 Specifications of Connector for External Connection of KD81

Item	Specifications			
Pin arrangement	Analog output Channel 3	1A	1B	Analog output Channel 4
		2A	2B	
	Analog output Channel 1	3A	3B	Analog output Channel 2
		4A	4B	
	(Common)	5A	5B	(Common)
	Analog input Channel 3 (Current input)	6A	6B	Analog input Channel 4 (Current input)
	(Voltage input)	7A	7B	
	(Common)	8A	8B	(Common)
	Analog input Channel 1 (Current input)	9A	9B	Analog input Channel 2 (Current input)
	(Voltage input)	10A	10B	(Voltage input)
	(SD)	11A	11B	(SD)
	(COMMON +)	12A	12B	(COMMON −)
	(COMMON −) Digital output (Transistor output)	13A	13B	Digital output (Transistor output)
		14A	14B	
		15A	15B	(Empty)
		16A	16B	
	(Empty)	17A	17B	(Empty)
	(Empty)	18A	18B	(Empty)
		19A	19B	
	Counter input	20A	20A	Counter input
	19A, 21A, 23A ----12/24VDC	21A	21B	19B, 21B, 23B -----12/24VDC
	20A, 22A, 24A ----5VDC	22A	22B	
		23A	23B	
		24A	24B	20A, 22A, 24A -----5VDC
Connection cable size	0.6 mm or less dimeter (soldering)			
Application	For external wiring			
External dimensions (m)				
Weight (Kg)				

Table 3.8 Specifications of Connector for External Connection of KD81

3.4 Type KD81HP PID Programmer

Item	Specifications
Line voltage	5VDC (powered by KD81 via K70CBL)
Transmission system	Conforms to RS422.
Transmission speed	4.8 KBPS
Current consumption	Maximum 0.7 A
Display	Full-dot matrix system by means of liquid crystal Display of 16 characters horizontally and 13 characters vertically
Effective display area	77 x 96 (dot dimensions: 0.55 x 0.55, dot distance: 0.05)
Operating section	Keyboard switches (60 keys)
Key operation check	Buzzer
Dimensions	(9.84") 250 (height) x (6.3") 160 (width) x (1.7") 43 (depth) mm
Weight	1.1 kg (2.4 lbs.)

Table 3.9 KD81HP Specifications

3.5 Type K70CBL Connection Cable (Standard for KD81HP)

Item	Specifications
Connected units	KD81 and KD81HP
Length	2 m (7 ft)
Weight	0.27 kg (6 lbs)

Table 3.10 K70CBL Specifications

4. HANDLING

4. HANDLING

4.1 Controls and Explanations

4.1.1 KD81 panel

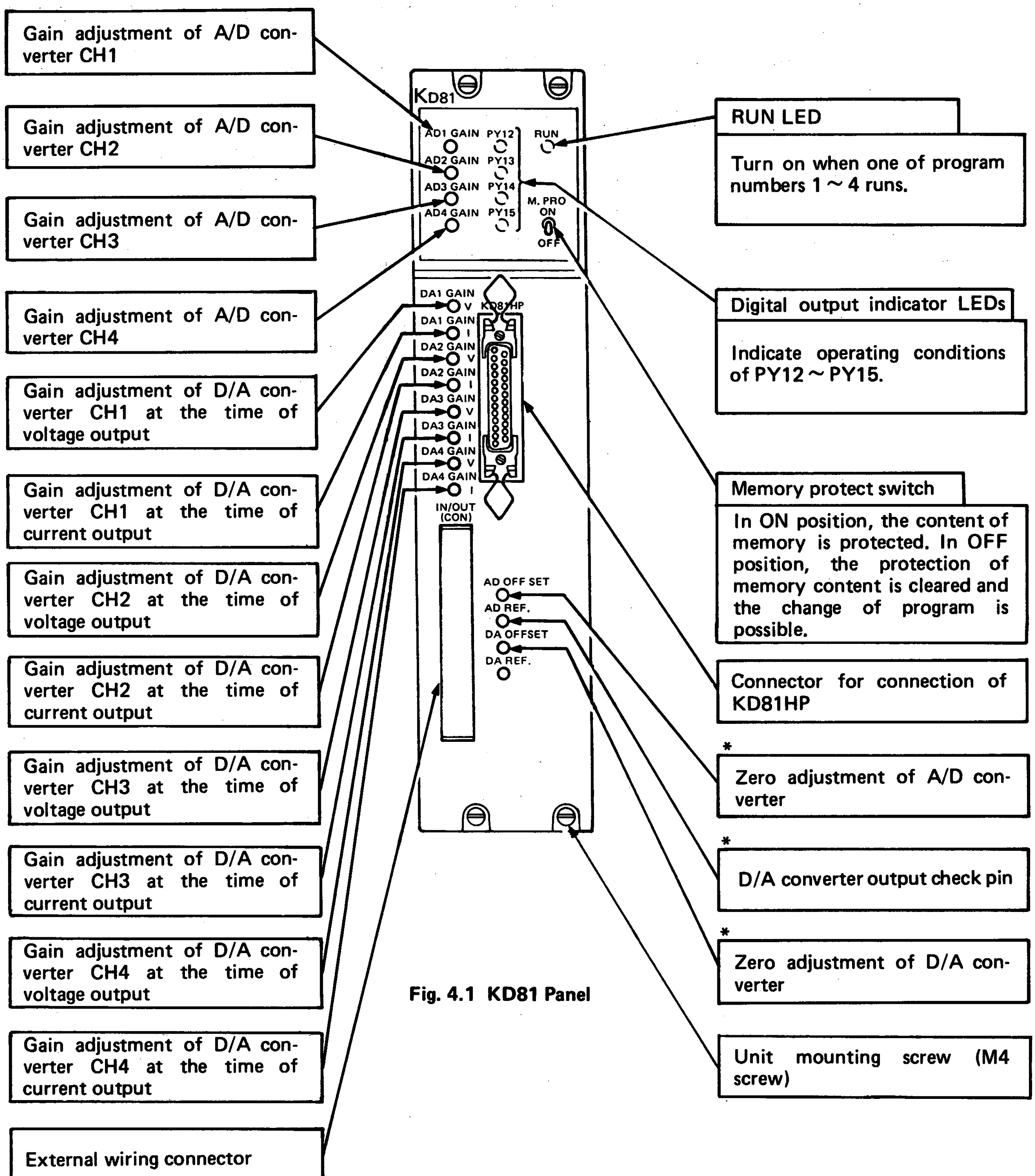


Fig. 4.1 KD81 Panel

CAUTION

Since volumes are factory-set, do not adjust them unless required. Especially, the potentiometers with * marks should never be moved.

4.1.2 Interior of KD81

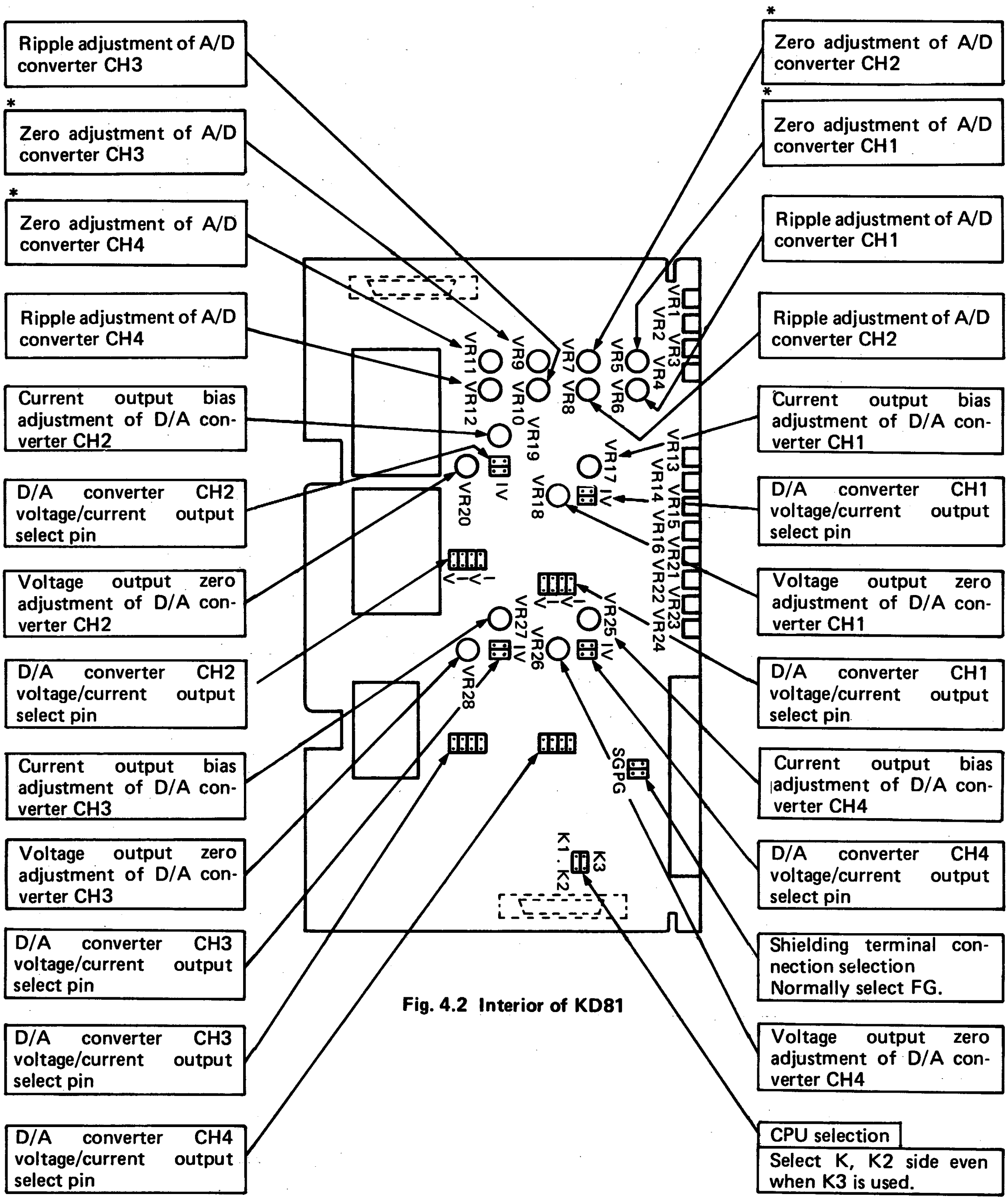


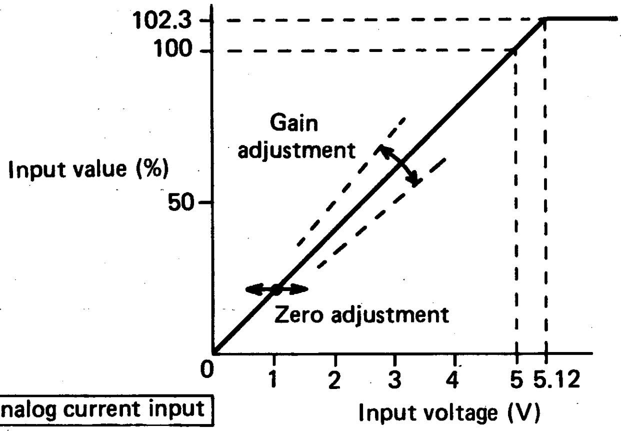
Fig. 4.2 Interior of KD81

CAUTION

Since volumes are factory-set, do not adjust them unless required. Especially, the potentiometers with * marks should never be moved.

4.1.3 Adjustments of volumes

Analog voltage input

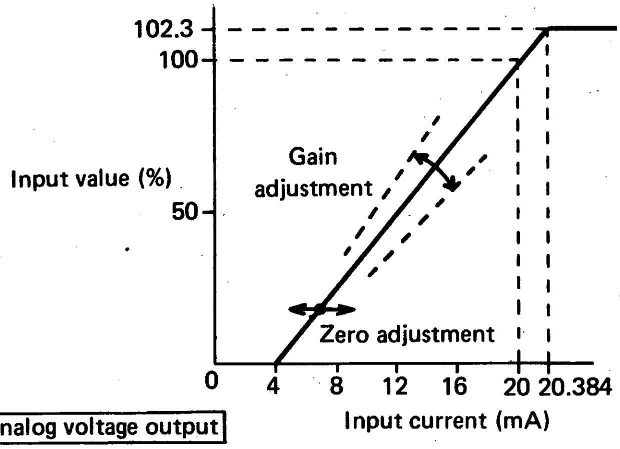


Adjustment volume

Channel	Gain adjustment
CH1	VR1 (AD1 GAIN)
CH2	VR2 (AD2 GAIN)
CH3	VR3 (AD3 GAIN)
CH4	VR4 (AD4 GAIN)

Channel	Zero adjustment
CH1	VR5
CH2	VR7
CH3	VR9
CH4	VR11

Analog current input

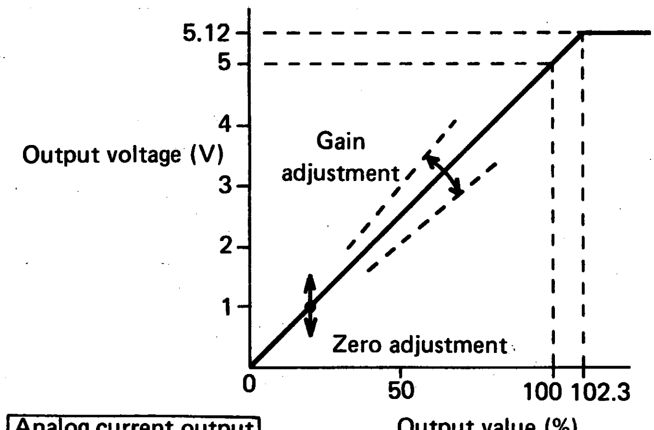


Adjustment volume

Channel	Gain adjustment
CH1	VR1 (AD2 GAIN
CH2	VR2 (AD2 GAIN)
CH3	VR3 (AD3 GAIN)
CH4	VR4 (AD4 GAIN)

Channel	Zero adjustment
CH1	VR5
CH2	VR7
CH3	VR9
CH4	VR11

Analog voltage output

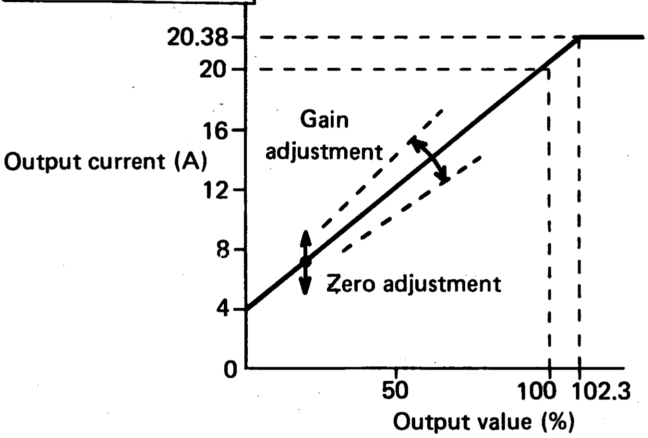


Adjustment volume

Channel	Gain adjustment
CH1	VR13 (DA1 GAIN V)
CH2	VR15 (DA2 GAIN V)
CH3	VR21 (DA3 GAIN V)
CH4	VR23 (DA4 GAIN V)

Channel	Zero adjustment
CH1	VR18
CH2	VR20
CH3	VR28
CH4	VR26

Analog current output



Adjustment volume

Channel	Gain adjustment
CH1	VR14 (DA1 GAIN I)
CH2	VR16 (DA2 GAIN I)
CH3	VR22 (DA3 GAIN I)
CH4	VR24 (DA4 GAIN I)

Channel	Zero adjustment
CH1	VR17
CH2	VR19
CH3	VR27
CH4	VR25

4.1.4 Adjusting procedures of volumes

All potentiometers have been factory-set. However, when adjustment is required, follow the procedures described below:

(1) Analog input

Voltage input

1) Load Type KD81 control unit into the rightmost slot of basic base unit and unload I/O units from other slots. (This is to provide space for adjusting the pots, which are located on the internal circuit board, with an adjusting screwdriver.)

2) Write the following program list to KD81 by KD81HP.

Step No.			
0	PIX	K 1	→ Indicates analog input channel "1". When channel 2 is selected, write "K2". When channel 3, write "K3". When channel 4, write "K4".
1		K 0	
2		K 100	
3		K 0	→ Indicates voltage input. When current input is selected, write "K1".
4	STA	D001	
5	END		

3) Run KD81 and monitor the content of (P)D001 by KD81HP.

4) Apply analog input 0 V to channel 1 of KD81.

5) Adjust the zero adjust pot VR5 until the content of (P) D001 reads "0".

6) Apply analog input 5 V.

7) Adjust the gain adjust pot VR1 until the content of (P) D001 reads "100".
(When the gain adjust pot is moved, ripple occurs at the input operating amplifier output. Therefore, adjust the ripple adjust pot until ripple reads 0 (mV or mA). Monitor the content of D001 and adjust until the variation of reading is minimized.)

8) Likewise, make adjustments for channels 2 to 4.

Current input

1) After proceeding with the aforementioned steps 1) ~ 3), apply analog input 4 mA to channel 1 of KD81.

2) Make adjustment following the aforementioned step 5.

3) Apply analog input 20 mA.

4) Make adjustment following the aforementioned steps 7 and 8.

(2) Analog output

Voltage output

1) Load Type KD81 control unit into the rightmost slot of basic base unit and unload I/O units from other slots.
(This is to provide space for adjusting the potentiometers, which are located on the internal circuit board, with an adjusting screwdriver.)

2) Write the following program list to KD81 by KD81HP.

Step No.			
0	SET	PM91	
1	LDA	K 0	→ Indicates 0%. When 100% is selected, write "K100".
2	P I Y	K 1	→ Indicates analog output channel "1". When channel 2 is selected, write "K2". When channel 3, write "K3". When channel 4, write "K4".
3		K 0	
4		K 100	
5		K 100	
6	END		

3) Connect a voltmeter to the analog output channel 1 of KD81.

4) Insert short-circuit chips into two locations "V" of channel 1 voltage/current output select pin.

5) Run KD81.

6) Adjust the zero adjust pot VR18 until voltage output of 0V is provided when LDA K 0 is written to step 1.

7) Adjust the gain adjust pot VR13 until voltage output of 5V is provided when LDA K 100 is written to step 1.

8) Likewise, make adjustments for other channels.

Current output

1) After proceeding with the aforementioned steps 1 and 2, connect an ammeter instead of the voltmeter used in the aforementioned step 3.

2) Insert short-circuit chips into two locations of "I" of channel 1 voltage/current output select pin.

3) Run KD81.

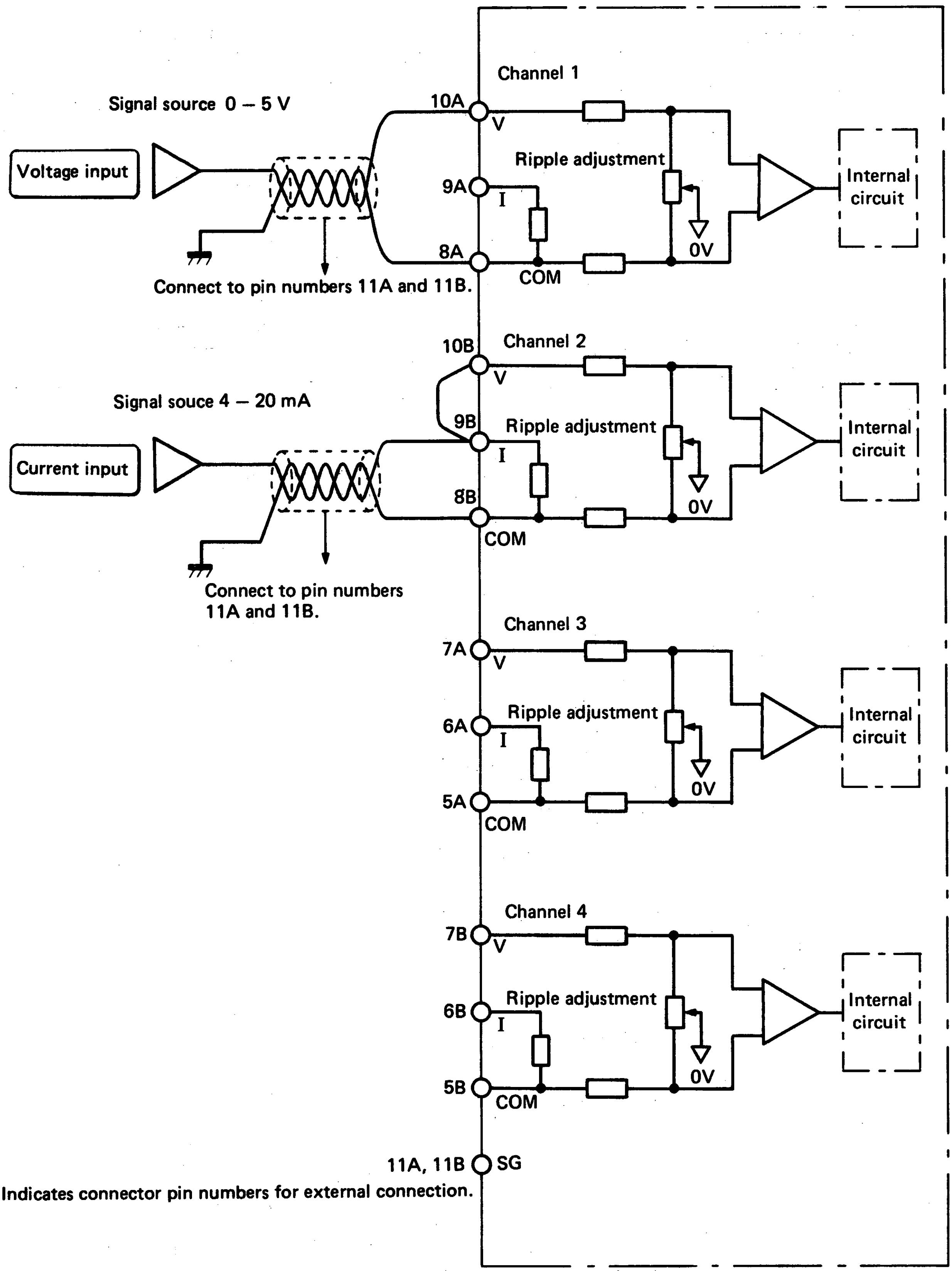
4) Adjust the bias adjust pot VR17 until current output of 4 mA is provided when LDA K 0 is written to step 1.

5) Adjust the gain adjust pot VR13 until current output of 20 mA is provided when LDA K 100 is written to step 1.

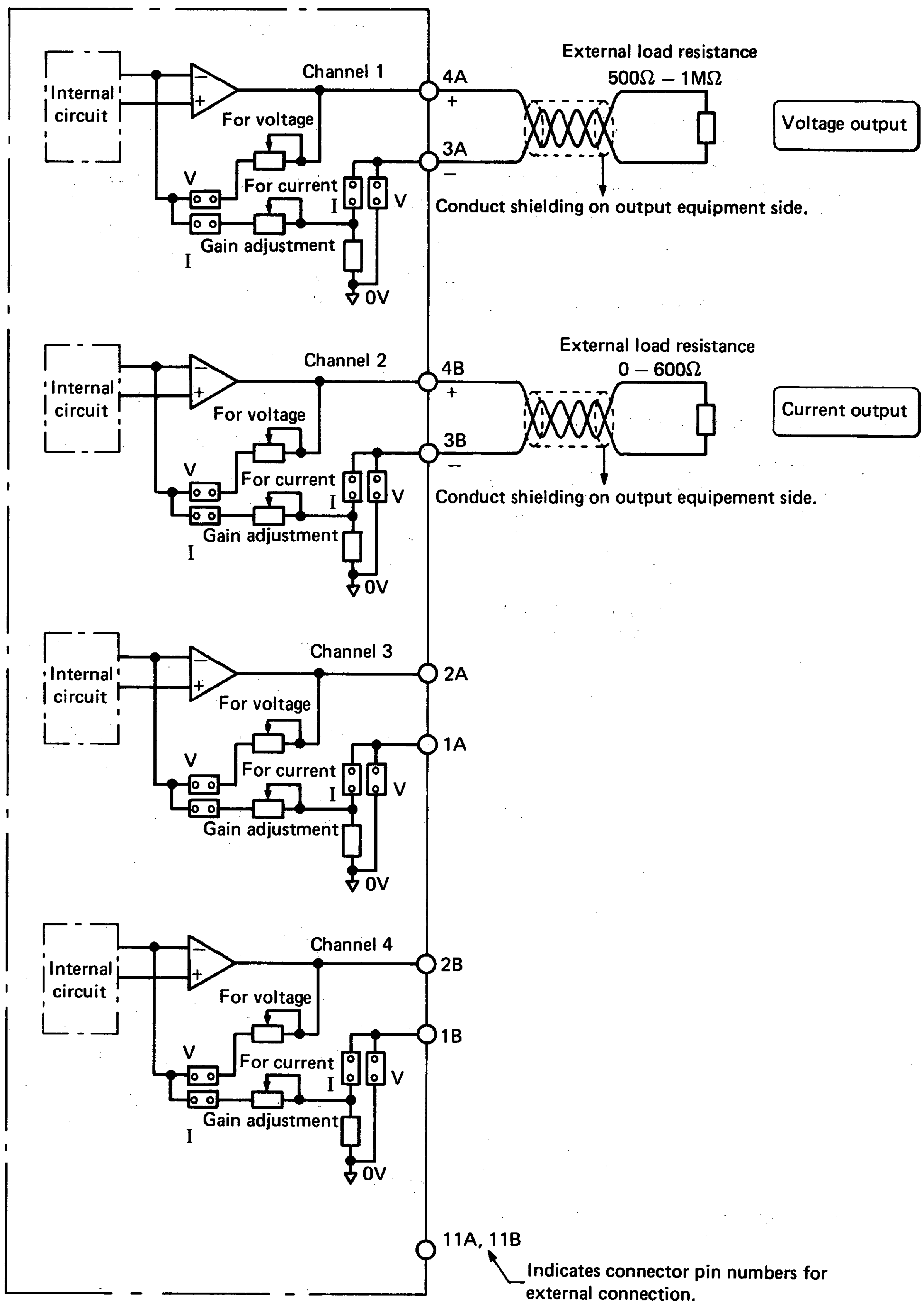
6) Likewise, make adjustments for other channels.

4.2 External Wiring

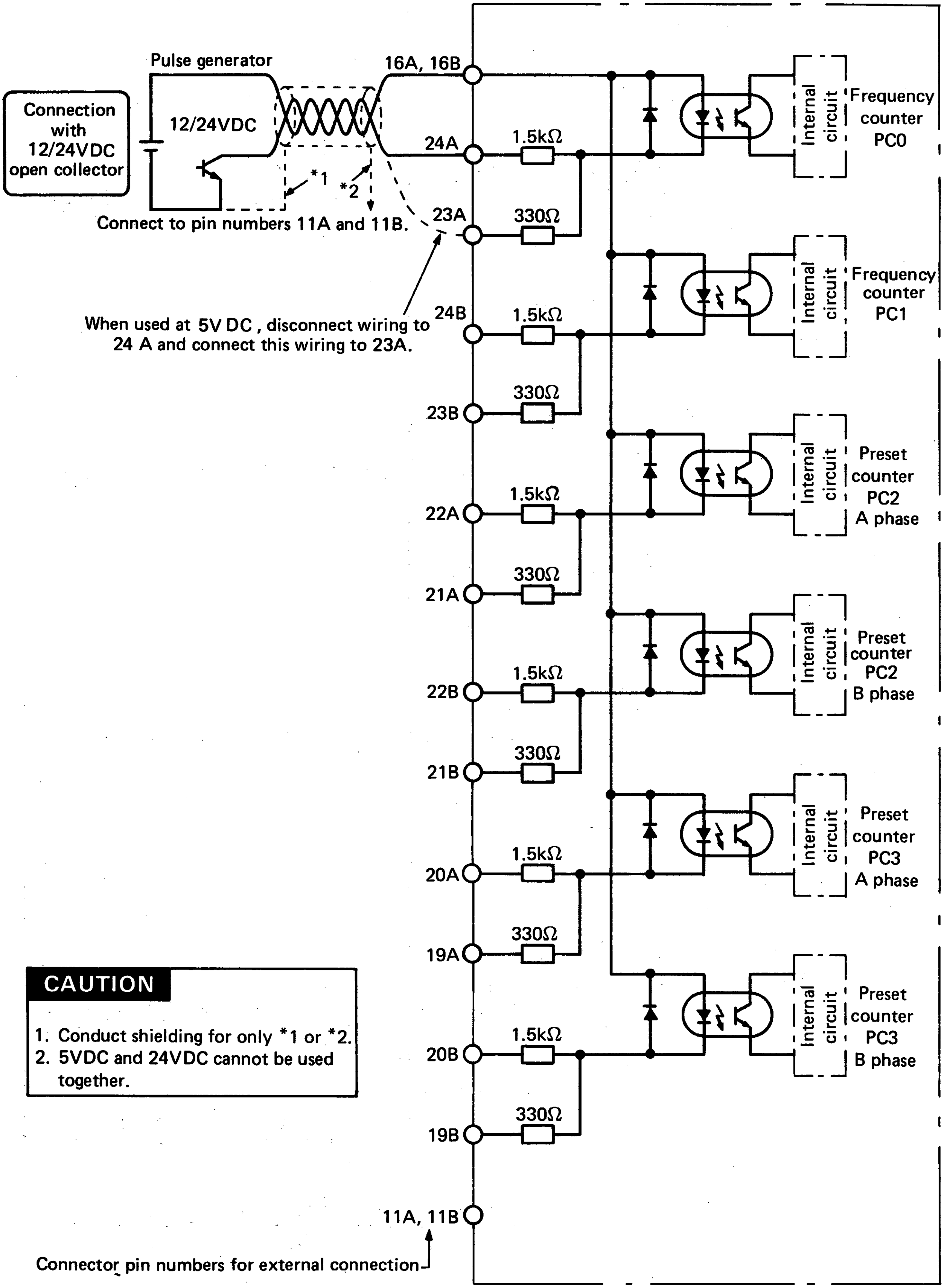
4.2.1 Analog input pin arrangement and external wiring method



4.2.2 Analog output pin arrangement and external wiring method



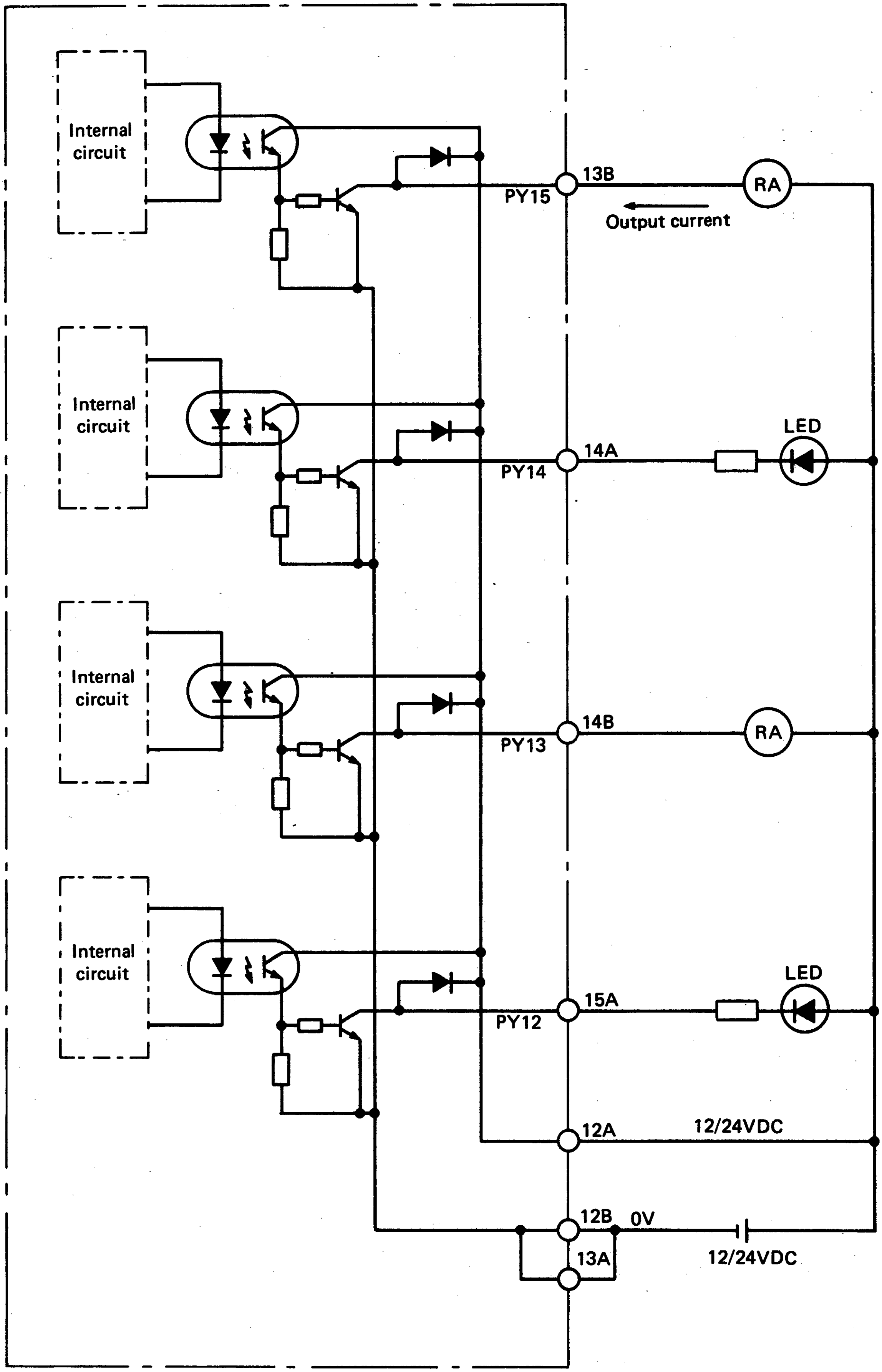
4.2.3 Counter input pin arrangement and external wiring method



CAUTION

1. Conduct shielding for only *1 or *2.
2. 5VDC and 24VDC cannot be used together.

4.2.4 Digital output pin arrangement and external wiring method



4.2.5 Wiring noise considerations

External wiring with I/O equipment should be executed so that the wiring is not adversely affected by noise. The following description explains general cautions.

(1) Cables for AC and DC I/O signal lines should be separated in order to protect them from AC side surge and induction.

(2) Do not wire I/O signal lines with the main circuit cables, high-power cables, and load cables from other than the programmable controller. Also do not wire them in proximity to the aforementioned cables.

(3) When conduits or ducts are used, securely ground them.

MEMO

5. PROGRAMMING

5. PROGRAMMING

5.1 Device Names

The names of devices used for KD81 are provided with "P" to differentiate them from devices used for programmable controller. (However, devices displayed by the KD81HP are not provided with "P" because of the number of display columns.)
For programming and other descriptions, it is recommended to describe device names with "P" provided in order to differentiate the devices.

Description	Device Name of KD81	Device Name of Programmable Controller	Device Name Displayed on KD81HP	
			Key	Display
Input	PX	X	PX	X
Output	PY	Y	PY	Y
Temporary memory	PM	M	PM	M
Timer	PT	T	PT	T
Counter	PC	C	PC	C
Data register	PD	D	PD	D
Constant	K	K	K	K

Table 5.1 Device Representations

5.2 Data Range

<table>
<tr><th></th><th>Description</th><th>Device Number</th><th>Data Range Processed by KD81</th><th colspan="2">Data Range of KD81HP and KCPU</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Timer temporary value</td><td>PT0 ~ 15</td><td>−32768 ~ +32767 (x 10ms)</td><td colspan="2">−32768 ~ +32767 (x 10ms)</td></tr>
<tr><td>PT16 ~ 31</td><td>−32768 ~ +32767 (x 100ms)</td><td colspan="2">−32768 ~ +32767 (x 100ms)</td></tr>
<tr><td>2</td><td>Counter temporary value</td><td>PC0 ~ 3</td><td>−32768 ~ +32767</td><td colspan="2">−32768 ~ +32767</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Data register</td><td rowspan="2">PD1 ~ 127</td><td rowspan="2">$\pm 2.7 \times 10^{-20} \sim \pm 9.2 \times 10^{18}$</td><td>KD81HP</td><td>Monitor range
$\pm 9.999 \times 10^{-9} \sim \pm 9.999 \times 10^{9}$</td></tr>
<tr><td>KCPU</td><td>Communication range
−32768 ~ +32767</td></tr>
</table>

Table 5.2 Data Range

(1) Timer and counter

When the temporary value of timer or counter exceeds +32767, counting is continued like −32768, −32767, ... −1, 0.

(2) Data register

The data register comprises 32 bits of floating points. When the value of data register exceeds the range of $\pm 2.7 \times 10^{-20} \sim \pm 9.2 \times 10^{18}$ by arithmetic operation, the KD81 detects an operation error (overflow or underflow) and comes to stop. At this time, the RUN indicator light flickers.

When the data processing ranges of KD81HP and KCPU are exceeded, data processing is fixed at the following values.

<table>
<tr><td rowspan="2">KD81HP</td><td>When value is less than $-9.999 \times 10^{\pm 9}$</td><td>$-9.999 \times 10^{\pm 9}$</td></tr>
<tr><td>When value exceeds $9.999 \times 10^{\pm 9}$</td><td>$9.999 \times 10^{\pm 9}$</td></tr>
<tr><td rowspan="2">KCPU</td><td>When value is −32768</td><td>−32768</td></tr>
<tr><td>When value exceeds 32767</td><td>32767</td></tr>
</table>

(3) Constant

The range of constant which can be input from the KD81HP is as follows.

−99990 ~ 999900 (Up to five digits below a decimal point is possible)

5.3 Explanation of Instructions

5.3.1 Logical instructions

(1) NOT ---------- Inverse

Functional expression: $(A) \leftarrow \overline{(Device)}$

The content of specified device is inverted and stored into accumulator (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM

Coding

Step Number	Instruction	Device Number
123	NOT	PM0

(2) AND --------- Logical product

Functional expression: $(A) \leftarrow (A) \wedge (Device)$

The AND operation of specified device content and (A) content is executed and the result is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM

Coding

Step Number	Instruction	Device Number
123	AND	PX1

(3) OR ------------ Logical add

Functional expression: $(A) \leftarrow (A) \vee (Device)$

The OR operation of specified device content and (A) content is executed and the result is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM

Coding

Step Number	Instruction	Device Number
123	OR	PY2

(4) SET ---------- Set

Functional expression: (Device) ← 1

Specified device is turned on.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM, PC, PY

PC and PT are coils.

CAUTION

SET instructions for PC0 and PC1 are inactive.

Coding

Step Number	Instruction	Device Number
123	SET	PM10

(5) RST ---------- Reset

Functional expression: (Device) ← 0

Specified device is turned off.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM, PC, PT

PC and PT are coils.

CAUTION

RST instructions for PC0 and PC1 are inactive.

Coding

Step Number	Instruction	Device Number
123	RST	PT0

5.3.2 Transfer instructions

(1) STA --------- Storage

Functional expression: (Device) ← (A)

The content of (A) is stored into specified device.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM
Data Processing	PD, PC, PT

PC and PT are temporary values.

CAUTION

1. Avoid mingling logical processing and data processing.

   Example:

   LDA PX1 --- Logical processing
   STA PD10 -- Data processing

2. STA instructions for PC0 and PC1 are inactive.

Coding

Step Number	Instruction	Device Number
123	STA	PD10

(2) LDA ---------- Read

Functional expression: (A) ← (Device)

The content of specified device is read to (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processed
Logical Processing	PX, PY, PM
Data Processing	PD, PC, PT, K

PC andPT are temoporary values.

Coding

Step Number	Instruction	Device Number
123	LDA	K10

(3) MOV ---------- Transfer

Functional expression: S → D

S: Source
S indicates the source from which data is transferred.

D: Destination
D indicates the destination where the content of S is stored.

This is a data transfer instruction between devices and transfers data from S to D. The content of S remains unchanged after the execution of the instruction.

CAUTION

MOV instructions for PC0 and PC1 are inactive (when D = PC0, PC1).

Combination of devices which can be processed

		D						
		PX	PY	PM	PD	PC	PT	K
S	PX	○	○	○				
	PY	○	○	○				
	PM	○	○	○				
	PD				●	●	●	
	PC				●	●	●	
	PT				●	●	●	
	K				●	●	●	

○ mark indicates logical processing.
● mark indicates data processing.
C and T indicate temporary value.

Coding

Step Number	Instruction	Device Number
123	MOV	K100
124		PD1

5.3.3 Arithmetic operation instructions

(1) + ------------ Add

Functional expression: (A) ← (A) + (Device)

The content of specified device and that of (A) are added and the result is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	+	PD1

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: *For details of errors, see Section 6 "ERROR MESSAGE LIST".*

(2) — ------------ Subtract

Functional expression: (A) ← (A) − (Device)

The content of specified device is subtracted from that of (A) and the result is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	—	K100

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: *For details of errors, see Section 6 "ERROR MESSAGE LIST".*

(3) * ---------------- Multiply

Functional expression: (A) ← (A) x (Device)

The content of (A) and that of specified device are multiplied and the result is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	*	K20

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(4) / ---------------- Divide

Functional expression: (A) ← (A) ÷ (Device)

The content of (A) is divided by that of specified device and the result is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	/	PD10

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow
04	Division by 0

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(5) $\sqrt{\ }$ -------- Square root

Functional expression: $(A) \leftarrow \sqrt{(A)}$

The extraction of $\sqrt{(A)}$ is executed and the result is stored into (A).

Type of Processing	Device Which Can Be Processing
Data Processing	A

Coding

Step Number	Instruction	Device Number
10	$\sqrt{\ }$	

Arithmetic Operation Error

Error Code	Content
03	Square root of negative number

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(6) PCT -----------% operation

Functional expression: $(A) \leftarrow \{(A)/(\text{Device})\} \times 100$

The percentage of (A) to specified register is obtained and the result is stored into (A). The content of specified register remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	PCT	PD10

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow
04	Division by 0

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(7) LOG ----------Common logarithm

Functional expression: $(A) \leftarrow \log_{10}(A)$

The common logarithm of (A) is obtained and the result is stored into (A).

Type of Processing	Device Which Can Be Processing
Data Processing	A

Coding

Step Number	Instruction	Device Number
123	LOG	

Arithmetic Operation Error

Error	Content
03	Logarithmic calculation of 0 or negative number

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(8) ABS ---------- Absolute value

Functional expression: $(A) \leftarrow |(A)|$

The absolute value of (A) is obtained and the result is stored into (A).

Type of Processing	Device Which Can Be Processing
Data Processing	A

Coding

Step Number	Instruction	Device Number
123	ABS	

5.3.4 Comparison instructions

(1) > -------Comparison

Functional expression:
When (A)>(Device), the next step is run.
When (A)≦(Device), "the next step + 1" is run.

The content of (A) and that of specified device are compared. When (A)>(Device), the next program step is run. When (A)≦(Device), "the next program step +1 step" is run. The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	>	K100

(2) < -------Comparison

Functional expression:
When (A)<(Device), the next step is run.
When (A)≧(Device), "the next step + 1" is run.

The content of (A) and that of specified device are compared. When (A)<(Device), the next program step is run. When (A)≧(Device), "the next program step +1 step" is run. The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	<	PD10

(3) = -------- Comparison

Function

Functional expression:

When (A) = (Device), the next step is run.
When (A) ≠ (Device), "the next step + 1" is run.

The content of (A) and that of specified device are compared. When (A) = (Device), the next program step is run. When (A) ≠ (Device), "the next program step +1 step" is run. The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	=	PT1

5.3.5 Branch instructions

(1) JMP --- Unconditional jump

This is an unconditional jump instruction and causes the program to jump to the specified program step.

Type of Processing	Device Which Cab Be Processing
	K

Coding

Step Number	Instruction	Device Number
123	JMP	K50

(2) JC ------ Conditional jump

Functional expression:
When (A) = 1, program jumps to specified step.
When (A) = 0, the next step is run.

This is a conditional jump instruction. When (A) = 1, the program jumps to the specified program step. When (A) = 0, the next program step is run.

Note: Avoid mingling logical processing and data processing.

Example:

LDA K1 ------ Logical processing
JC K15 ---- Data processing

Type of Processing	Device Which Can Be Processing
Data Processing	K

Coding

Step Number	Instruction	Device Number
123	JC	K120

5.3.6 Special instructions

(1) HS ------Magnitude comparison

Functional expression:
When (A) $\geqq$ (Device), (A) → (A).
When (A) < (Device), (Device) → (A)

The content of specified device and that of (A) are compared, and the content with higher value is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	HS	PD1

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(2) LS ------ Magnitude comparison

Functional expression:
When (A) $\leqq$ (Device), (A) → (A).
When (A) > (Device), (Device) → (A)

The content of specified device and that of (A) are compared, and the content with lower value is stored into (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, PC, PT, K

PC and PT temporary values.

Coding

Step Number	Instruction	Device Number
123	LS	K100

Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: For details of errors, see Section 6 "ERROR MESSAGE LIST".

(3) HLM -- Clamping of higher limit value

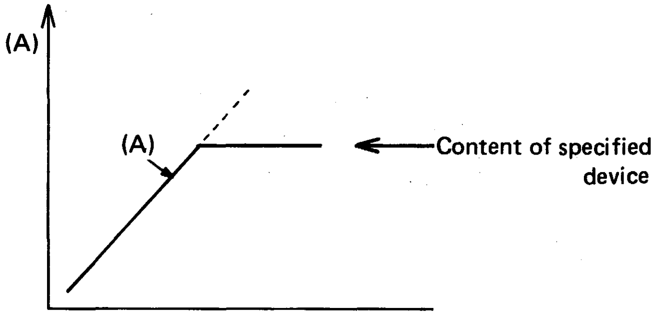
Functional expression:
When (A) > (Device), (Device) → (A).

The content of specified device and that of (A) are compared. When the content of (A) is higher than that of device, the content of device is stored into (A) and gives restriction to (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, K

Coding

Step Number	Instruction	Device Number
123	HLM	PD100



Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: *For details of errors, see Section 6 "ERROR MESSAGE LIST".*

(4) LLM ---Clamping of lower limit value

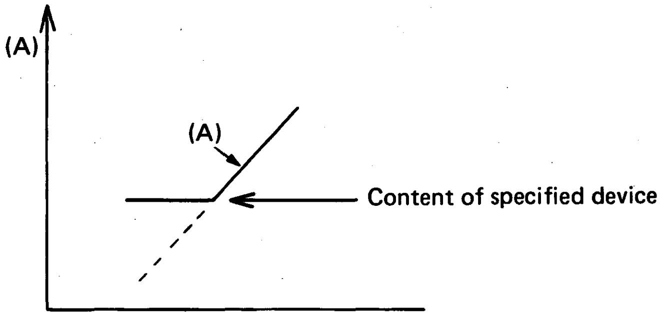
Functional expression:
When (A) < (Device), (Device) → (A).

The content of specified device and that of (A) are compared. When the content of (A) is lower than that of device, the content of device is stored into (A) and gives restriction to (A). The content of specified device remains unchanged after the execution of the instruction.

Type of Processing	Device Which Can Be Processing
Data Processing	PD, K

Coding

Step Number	Instruction	Device Number
123	LLM	K10



Arithmetic Operation Error

Error Code	Content
01	Overflow
02	Underflow

Note: *For details of errors, see Section 6 "ERROR MESSAGE LIST".*

(5) NOP --- No operation

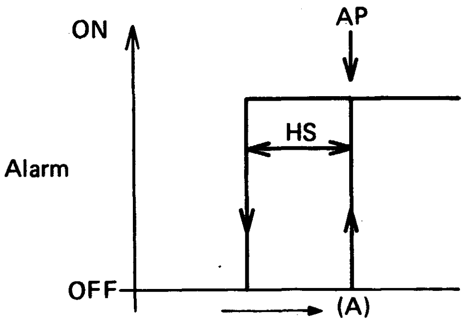
This is a no-operation instruction and has no influence on the results of preceding arithmetic operation. NOP is used when providing space for debugging of program, when it is desired to make deletion without changing the number of programs (write NOP to the corresponding step of prewritten program), or when temporarily deleting a condition.

(6) END --- End of program

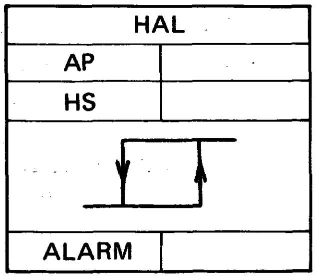
This is a program end instruction and is used to declare the end of program.

(7) HAL (High alarm)

When the content of (A) becomes higher than the alarm set variable (AP), alarm (specified PM) is turned on. The output alarm turns off at the hysteresis variable (HS).



AP: Alarm set value
HS: Hysteresis value



Symbol

Coding

Step Number	Instruction	Device Number
123	HAL	K100
124		K20
125		PM10

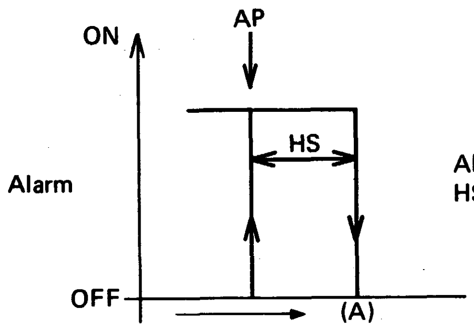
← Alarm set value (AP)
← Hysteresis value (HS)
← Alarm output (ALARM)

Details of Parameter Settings

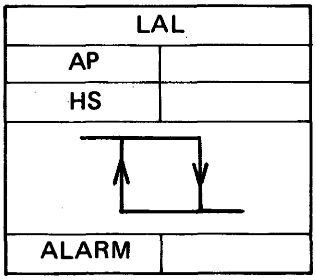
Parameter	Setting	Device Which Can Be Processed
Alarm set variable (AP)	Alarm ON point is set.	PD, K
Hysteresis variable (HS)	Hysteresis variable is set.	PD, K
Alarm output (ALARM)	PM number, which provides alarm output, is set.	PM

(8) LAL (Low alarm)

When the content of (A) becomes lower than the alarm set variable (AP), alarm (specified PM) is turned on. The output alarm turns off at the hysteresis variable (HS).



AP: Alarm set value
HS: Hysteresis value



Symbol

Coding

Step Number	Instruction	Device Number
123	LAL	PD10
124		PD11
125		PM51

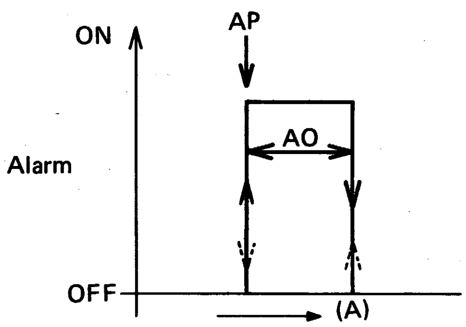
← Alarm set value (AP)
← Hysteresis value (HS)
← Alarm output (ALARM)

Details of Parameter Settings

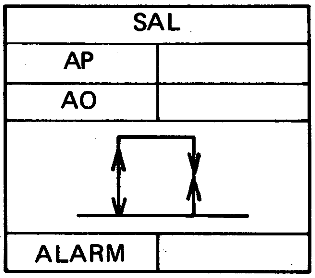
Parameter	Setting	Device Which Can Be Processed
Alarm set variable (AP)	Alarm ON point is set.	PD, K
Hysteresis variable (HS)	Hysteresis variable is set.	PD, K
Alarm output (ALARM)	PM number, which provides alarm output, is set.	PM

(9) SAL (Set alarm)

When the content of (A) is within the alarm set value (AP) plus output range (AO), alrm (specified PM) is turned on.



AP : Alarm set value
AO : Alarm output range



Symbol

Coding

Step Number	Instruction	Device Number
123	SAL	PD15
124		K50
125		PM30

← Alarm set value (AP)
← Alarm output range (AO)
← Alarm output (ALARM)

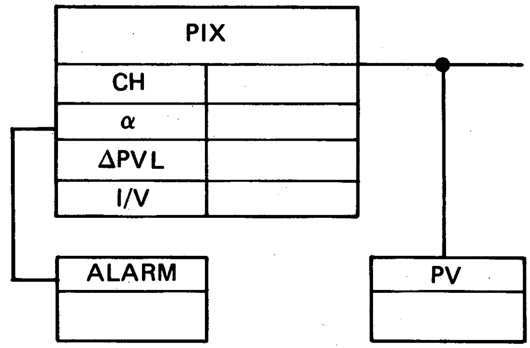
Details of Parameter Settings

Parameter	Setting	Device Which Can Be Processed
Alarm set variable (AP)	Alarm ON point is set.	PD, K
Alarm output range (AO)	Alarm output range is set.	PD, K
Alarm output (ALARM)	PM number, which provides alarm output, is set.	PM

5.3.7 PID instructions

(1) PIX

Analog input signal of process is converted into digital value and stored into specified data register.



Symbol

Coding

Step Number	Instruction	Device Number
123	PIX	K1
124		PD2
125		PD3
126		K0

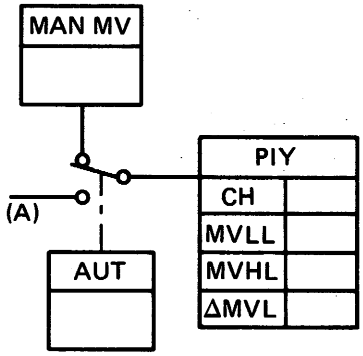
← A/D converter channel setting (CH)
← Filter coefficient (α)
← Rate of PV change limit value (ΔPVL)
← Input mode setting (I/V)

Details of Parameter Settings

Parameter	Setting	Setting Range	Device Which Can Be Processed
A/D converter channel setting (CH)	Set which of 4 channels of A/D converter is input.	1, 2, 3, 4	K
Filter coefficient (α)	The degree of filtering is set. As coefficient approaches zero, filter becomes inactive.	0 ~ 1	PD, K
Rate of PV change limit value (ΔPVL)	When the rate of change from previous PV to present PV exceeds this set variable, specified PM is set. (Once set, the PM does not turn off until reset.) CH1 PM81 CH2 PM82 CH3 PM83 CH4 PM84	0 ~ 100 (%)	PD, K
Input mode setting (I/V)	Current mode or voltage mode is set. When current mode is set, 4 ~ 20 mA is converted into 0 ~ 100%. When voltage mode is set, 0 ~ 5 V is converted into 0 ~ 100%. Converted analog value is stored into (A) and also into the next data register. CH1 PD101 CH2 PD102 CH3 PD103 CH4 PD104	Current input: 1 Voltage input: 0	K

(2) PIY

The digital value of (A) or specified register is converted into analog value. When the AUTO position of MAN/AUTO select switch is selected, the content of (A) is output. When the MAN position is selected, the content of data register, which is determined by the channel, is output.



Symbol

MAN/AUTO Position Selection

Channel	MAN Position		AUTO Position	
	Select Signal	Output Value	Select Signal	Output Value
CH1	PM91 off	PD101	PM91 on	(A)
CH2	PM92 off	PD102	PM92 on	(A)
CH3	PM93 off	PD103	PM93 on	(A)
CH4	PM94 off	PD104	PM94 on	(A)

Coding

Step Number	Instruction	Device Number	
25	PIY	K2	← D/A converter channel setting (CH)
26		PD5	← MV lower limit value (MVLL)
27		PD6	← MV higher limit value (MVHL)
28		PD7	← Rate of MV change limit value (ΔMVL)

Details of Parameter Settings

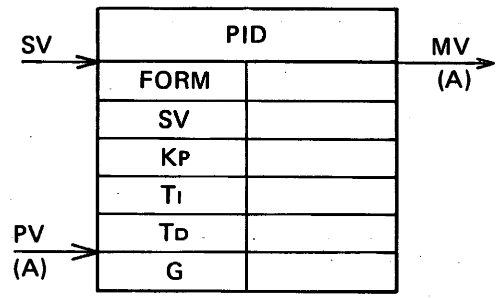
Parameter	Setting	Setting Range	Device Which Can Be Processed
D/A converter channel setting (CH)	Specify to which of 4 channels of D/A converter the output is provided.	1, 2, 3, 4	K
MV lower limit value (MVLL)	Value higher than set variable is output.	0 ~ 100 (%)	PD, K
MV higher limit value (MVHL)	Value lower than set variable is output.	0 ~ 100 (%)	PD, K
Rate of PV change limit value (ΔMVL)	When the rate of change from previous PV to present PV exceeds this set variable, specified PM is set. CH1 PM101 CH2 PM102 CH3 PM103 CH4 PM104	0 ~ 100 (%)	K

CAUTION

1. Manual selection: MV lower limit (MVLL) and MV higher limit (MVHL) become inactive. However, MV output value is output in the range of $0 \leq MV \leq 100$.
2. $MVLL \leq MVHL$ is the requirement for MV lower limit (MVLL) and MV higher limit (MVHL).

(3) PID

PID operation is executed by use of SV and PV and the result is stored into (A).



Symbol

Coding

Step Number	Instruction	Device Number	
123	PID	K1	← Operation expression selection (FROM)
124		PD51	← Set variable (SV)
125		K5	← Proportional constant (K_P)
126		PD52	← Integration constant (T_I)
127		PD53	← Differentiation constant (T_D)
128		PD54	← Dead band (G)

Details of Parameter Settings

Parameter	Setting	Setting Range	Device Which Can Be Processed
Operation expression selection (FORM)	Select from the following operation expressions. (See the following pages for the explanation of operation expressions.) 1. Basic velocity type normal action 2. Basic velocity type reverse action 3. Basic positional normal action 4. Basic positional reverse action 5. Error square velocity type normal action 6. Error square velocity type reverse action 7. Error square positional normal action 8. Error square positional reverse action	1, 2, 3, 4, 5, 6, 7, 8	K
Set variable (SV)	Set variable is set.	0 ~ 100%	PD, K
Proportional constant (K_P)	Proportional constant is set.	0 ~ 100%	PD, K
Integration constant (T_I)	Integration constant is set.	0 ~ 32700 sec	PD, K
Differentiation constant (T_D)	Differentiation constant is set.	0 ~ 255 sec	PD, K
Dead band (G)	Dead band is set.	0 ~ 100%	PD, K

PID Operation Expressions

FROM	NAME	OPERATION EXPRESSION
K1	Basic velocity type normal run Basic Flow	$EV_n = PV_n - SV_n$ $\Delta MV = K_P\left\{(EV_n - EV_{n-1}) + \frac{T_S}{T_I} EV_n - \frac{T_D}{T_S}(2PV_{n-1} - PV_n - PV_{n-2})\right\}$ $MV_n = \Sigma \Delta MV$
K2	Basic velocity type reverse run Basic flow	$EV_n = SV_n - PV_n$ $\Delta MV = K_P\left\{(EV_n - EV_{n-1}) + \frac{T_S}{T_I} EV_n + \frac{T_D}{T_S}(2PV_{n-1} - PV_n - PV_{n-2})\right\}$ $MV_n = \Sigma \Delta MV$
K3	Basic positional normal run	$EV_n = PV_n - SV_n$ $MV_n = K_P EV_n + \frac{T_S}{T_I}\Sigma EV + \frac{T_D}{T_S}(EV_n - EV_{n-1})$
K4	Basic positional reverse run	$EV_n = SV_n - PV_n$ $MV_n = K_P EV_n + \frac{T_S}{T_I}\Sigma EV + \frac{T_D}{T_S}(EV_n - EV_{n-1})$
K5	Error square velacity type normal run	$EV_n = PV_n - SV_n$ $\Delta MV = K_P\left\{EV_n \times \lvert EV_n\rvert - EV_{n-1} \times \lvert EV_{n-1}\rvert + \frac{T_S}{T_I} \times EV_n \times \lvert EV_n\rvert - \frac{T_D}{T_S}(2PV_{n-1} - PV_n - PV_{n-2})\right\}$ $MV_n = \Sigma \Delta MV$
K6	Error square velocity type reverse run	$EV_n = SV_n - PV_n$ $\Delta MV = K_P\left\{EV_n \times \lvert EV_n\rvert - EV_{n-1} \times \lvert EV_{n-1}\rvert + \frac{T_S}{T_I} \times EV_n \times \lvert EV_n\rvert + \frac{T_D}{T_S}(2PV_{n-1} - PV_n - PV_{n-2})\right\}$ $MV_n = \Sigma \Delta MV$
K7	Error wquare positional normal run	$EV_n = PV_n - SV_n$ $MV_n = K_P EV_n \times \lvert EV_n\rvert + \frac{T_S}{T_I}\Sigma EV \times \lvert EV\rvert + \frac{T_D}{T_S}(EV_n \times \lvert EV_n\rvert - EV_{n-1} \times \lvert EV_{n-1}\rvert)$
K8	Error square positional reverse run	$EV_n = SV_n - PV_n$ $MV_n = K_P EV_n \times \lvert EV_n\rvert + \frac{T_S}{T_I}\Sigma EV \times \lvert EV\rvert + \frac{T_D}{T_S}(EV_n \times \lvert EV_n\rvert - EV_{n-1} \times \lvert EV_{n-1}\rvert)$

- SV_n Set variable
- PV_n Process variable at present sampling
- PV_{n-1} Process variable 1 period prior to present sampling
- PV_{n-2} Process variable 2 periods prior to present sampling
- ΔMV Rate of output change
- MV_n Output variable
- EV_n Error at present sampling
- EV_{n-1} Error 1 period prior to present sampling
- K_P Proportional constant
- T_S Sampling period
- T_I Integration constant
- T_D Differentiation constant

5.4 Communication with Programmable Controller

5.4.1 I/O signals and allocation

I/O signals on the programmable controller side of KD81 are as follows. X and Y numbers apply when the KD81 is loaded into the slot number 1 of base unit.

Input Signal

Input Number	Content	
X0	PD data 2^{0}	PM coil (M0)
X1	〃 2^{1}	PM coil (M1)
X2	〃 2^{2}	PM coil (M2)
X3	〃 2^{3}	PM coil (M3)
X4	〃 2^{4}	PM coil (M4)
X5	〃 2^{5}	PM coil (M5)
X6	〃 2^{6}	PM coil (M6)
X7	〃 2^{7}	PM coil (M7)
X8	〃 2^{8}	PM coil (M8)
X9	〃 2^{9}	PM coil (M9)
XA	〃 2^{10}	PM coil (M10)
XB	〃 2^{11}	PM coil (M11)
XC	〃 2^{12}	PM coil (M12)
XD	〃 2^{13}	PM coil (M13)
XE	〃 2^{14}	PM coil (M14)
XF	〃 SIGN	PM coil (M15)
X10	KD81 output PY0	
X11	〃 PY1	
X12	〃 PY2	
X13	〃 PY3	
X14	〃 PY4	
X15	〃 PY5	
X16	〃 PY6	
X17	〃 PY7	
X18	〃 PY8	
X19	〃 PY9	
X1A	〃 PY10	
X1B	〃 PY11	
X1C	KD81 ready	
X1D	Not used	
X1E	Write completed	
X1F	Read completed	

Output Signal

Output Number	Content	
Y0	PD data 2^{0}	PM coil (M0)
Y1	〃 2^{1}	PM coil (M1)
Y2	〃 2^{2}	PM coil (M2)
Y3	〃 2^{3}	PM coil (M3)
Y4	〃 2^{4}	PM coil (M4)
Y5	〃 2^{5}	PM coil (M5)
Y6	〃 2^{6}	PM coil (M6)
Y7	〃 2^{7}	PM coil (M7)
Y8	〃 2^{8}	PM coil (M8)
Y9	〃 2^{9}	PM coil (M9)
YA	〃 2^{10}	PM coil (M10)
YB	〃 2^{11}	PM coil (M11)
YC	〃 2^{12}	PM coil (M12)
YD	〃 2^{13}	PM coil (M13)
YE	〃 2^{14}	PM coil (M14)
YF	〃 SIGN	PM coil (M15)
Y10	KD81 input PX0	
Y11	〃 PX1	
Y12	〃 PX2	
Y13	〃 PX3	
Y14	〃 PX4	
Y15	〃 PX5	
Y16	〃 PX6	
Y17	〃 PX7	
Y18	PD number setting 2^{0}	
Y19	PD number setting 2^{1}	
Y1A	PD number setting 2^{2}	
Y1B	PD number setting 2^{3}	
Y1C	PD number setting 2^{4}	
Y1D	Programmable controller ready	
Y1E	Write ↑	
Y1F	Read ↑	

Note: ↑ indicates that the signal is effective at its rise.

5.4.2 Communication with Programmable Controller

The programs for communication with programmable controller can be classified as shown below:

(1) Write to input (PX) of KD81
(2) Write to data register (PD) of KD81
(3) Write to temporary memory (PM) of KD81
(4) Read from output (PY) of KD81
(5) Read from data register (PD) of KD81
(6) Read from temporary memory (PM) of KD81

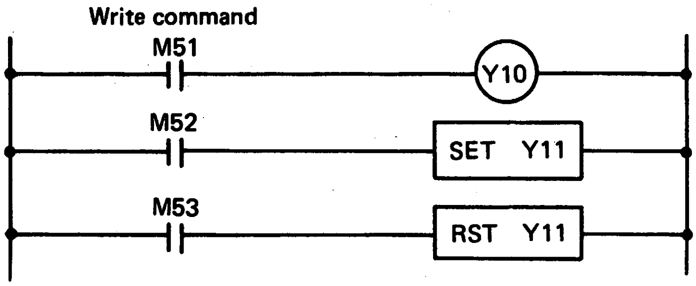
Since communication of the KD81 with the programmable controller is made by a handshaking system, the aforementioned communication programs (2), (3), (5) and (6) cannot be run at the same time. Therefore, be sure to perform programming by providing interlock so that the programs are run alternately.

5.4.3 Write from programmable controller to KD81

(1) Write to PX

1) By outputting corresponding Y numbers (Y10 ~ 17) of programmable controller to PX of KD81, PX can be turned on and off.

2) Program example of write to PX



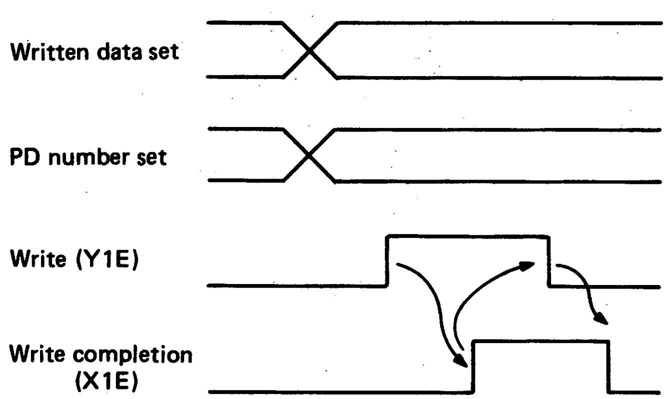
1. When M51 turns on, PX10 turns on.
2. When M52 turns on, PX11 is set.
3. When M53 turns on, PX11 is reset.

(2) Write to PD

1) Write procedure
   a. Set written data to Y0 ~ YF.
   b. Set PD numbers, which are desired to be written, to Y18 ~ Y1C.
   c. After completing a. and b. above, turn on the write command Y1E.

   Turn off Y1E by leading edge of write completion signal (X1E). (Write completion signal X1E is automatically turned off by trailing edge of Y1E.)

2) Write timing



3) Program example of write to PD

Fig. 5.1 shows a program example for writing data registers D11 ~ 25 to PD1 ~ 15.

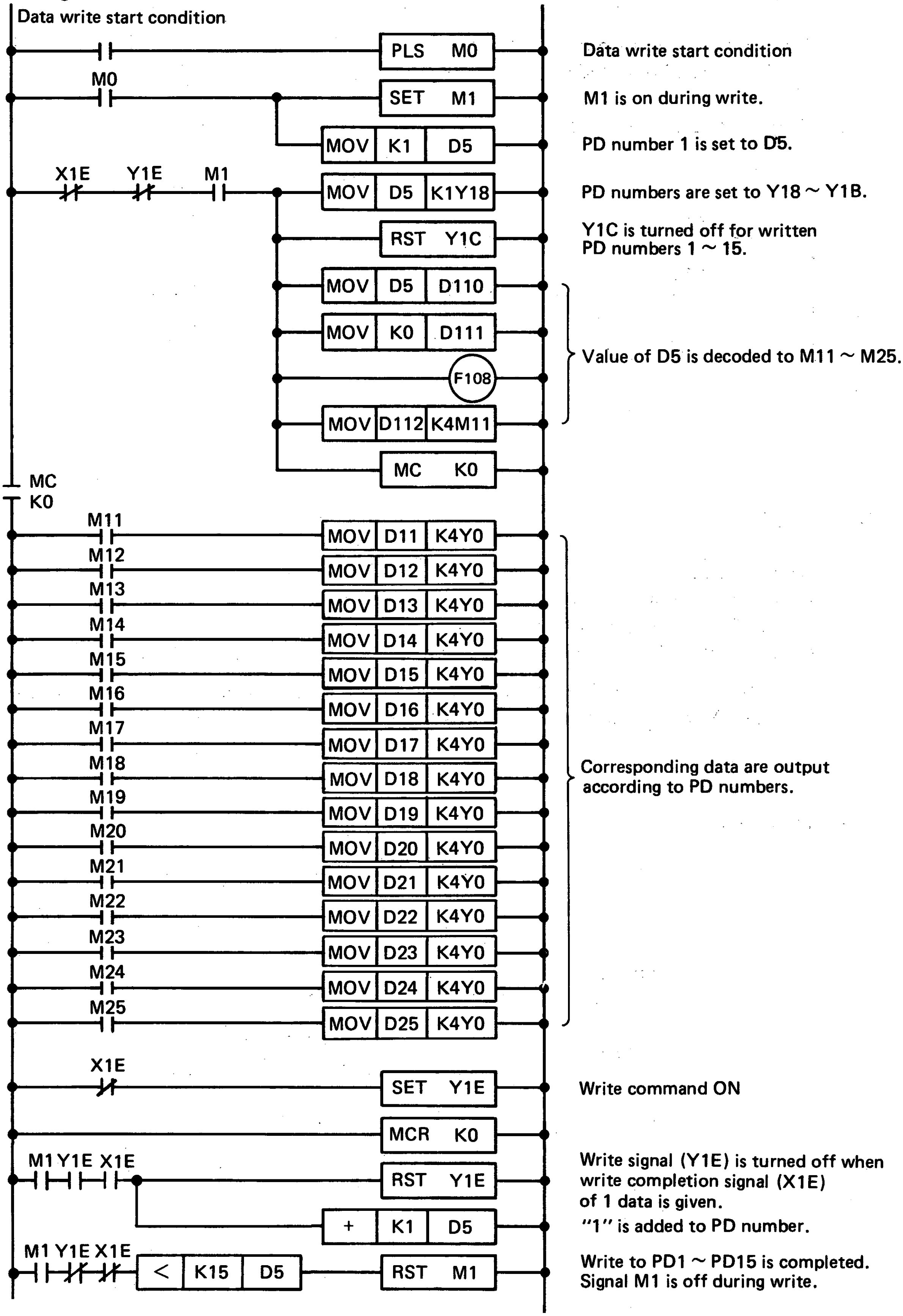


Fig. 5.1 Program Example for Write to PD

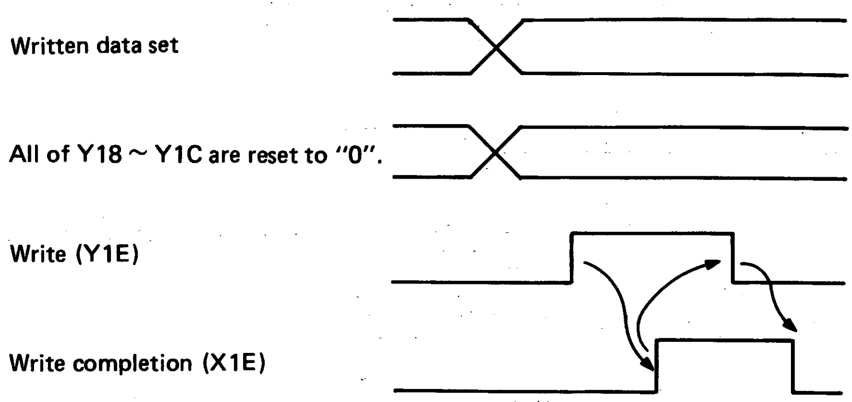
(3) Write to PM

Write to PM is a batch write of 16 points, PM0 ~ PM15. Therefore, prepare 16 Ms in serial order, which correspond to PM0 ~ PM15, on programmable controller side and write data by use of these Ms.

a. Set written data of PM0 ~ PM15 to Y0 ~ YF.
b. Set all of Y18 ~ Y1C to "0".
c. After completing the a. and b. above, turn on the write command Y1E.

Turn off Y1E by leading edge of write completion signal (X1E). (Write completion signal X1E is automatically turned off by trailing edge of Y1E.)

1) Write timing



2) Program example of write to PM

Example:
Fig. 5.2 shows a program example for batch write of temporary memories M30 ~ 45 which correspond to PM0 ~ 15.

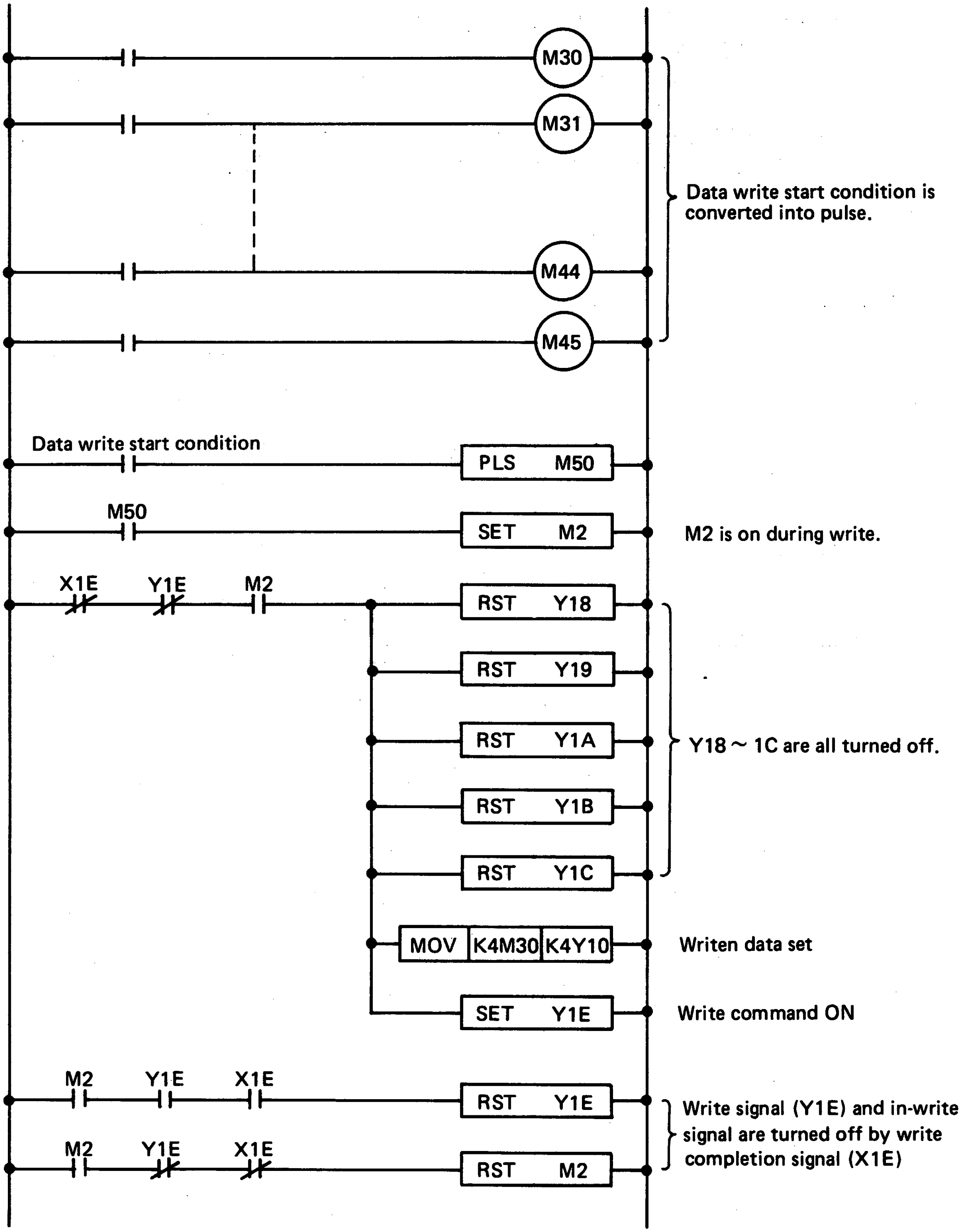


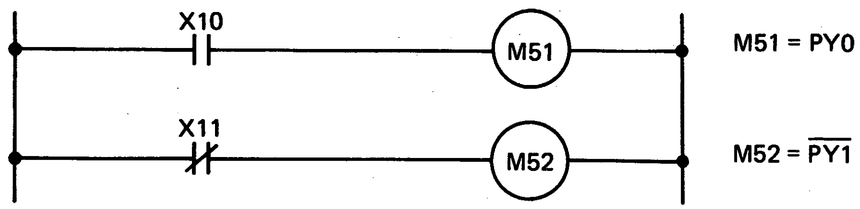
Table 5.2 Program Example for Write to PM

5.4.4 Read from KD81

(1) Read of PY

1) By inputting X numbers (X10 ~ 1B) of programmable controller which correspond to PY of KD81, the content of PY can be read.

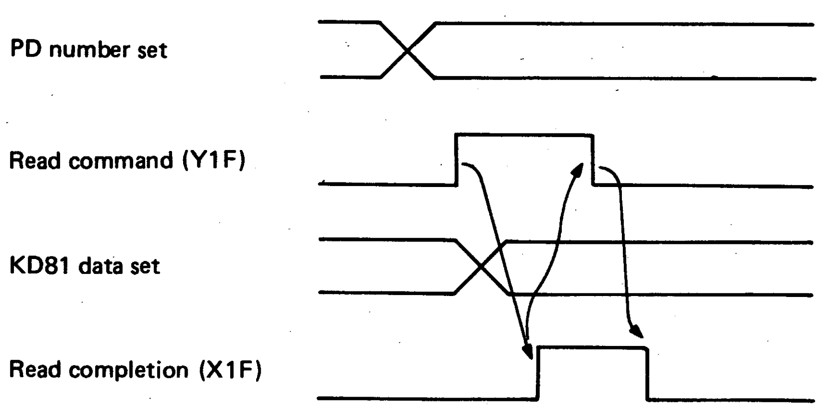
2) Program example for read of PY



(2) Read of PD

1) Read procedure
   a. After setting read PD numbers to Y18 ~ Y1C, turn on the read command (Y1F).
   b. KD81 reads the values indicated by PD numbers at the rise of read signal, and turns on the read completion signal (X1F).
   c. After making sure that the read completion signal (X1F) is on, read data and turn off the read signal (Y1F).
   d. KD81 turns off read completion signal (X1F) at the rise of read signal (Y1F).

2) Read timing



3) Protram example of read of PD

Fig. 5.3 shows a program example for read of PD1 ~ 15 to D11 ~ 25.

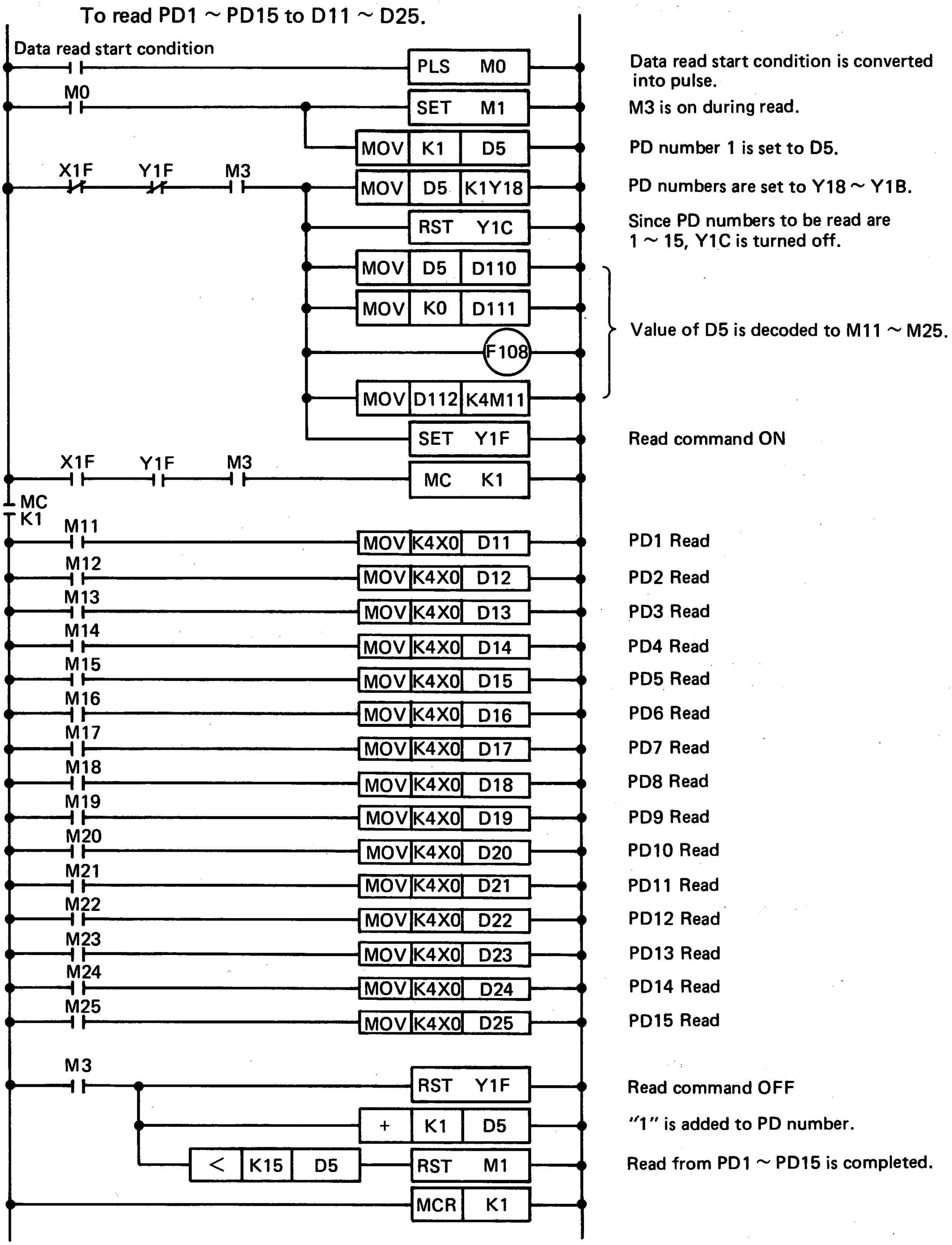


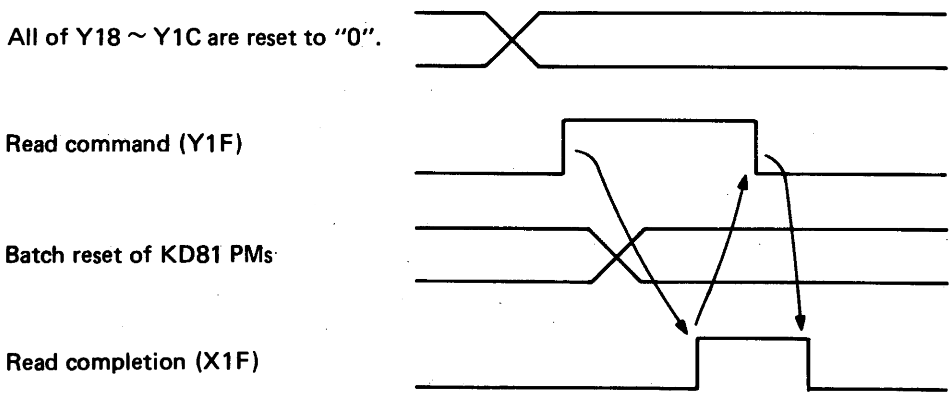
Fig. 5.3 Program Example for Read of PD

(3) Batch read of PM

Read of PM is a batch read of 16 points, PM0 ~ 15. Therefore, prepare 16 Ms in serial order, which correspond to PM0 ~ 15, on programmable controller side and read data by use of these Ms.

1) Read procedure
   a. After setting all of Y18 ~ Y1C to "0", turn on the read command (Y1F).
   b. At the rise of read signal, KD81 performs batch read of PMs and turns on the read completion signal (X1F).
   c. After making sure that the read completion signal (X1F) is on, execute batch read of data from 16 Ms and turn off the read signal (Y1F).
   d. At the rise of read signal (Y1F), KD81 turns off the read completion signal (X1F).

2) Read timing



3) Program example of read of PM

Fig. 5.4 shows a program example for batch read of PM0 ~ 15 to M10 ~ 25.

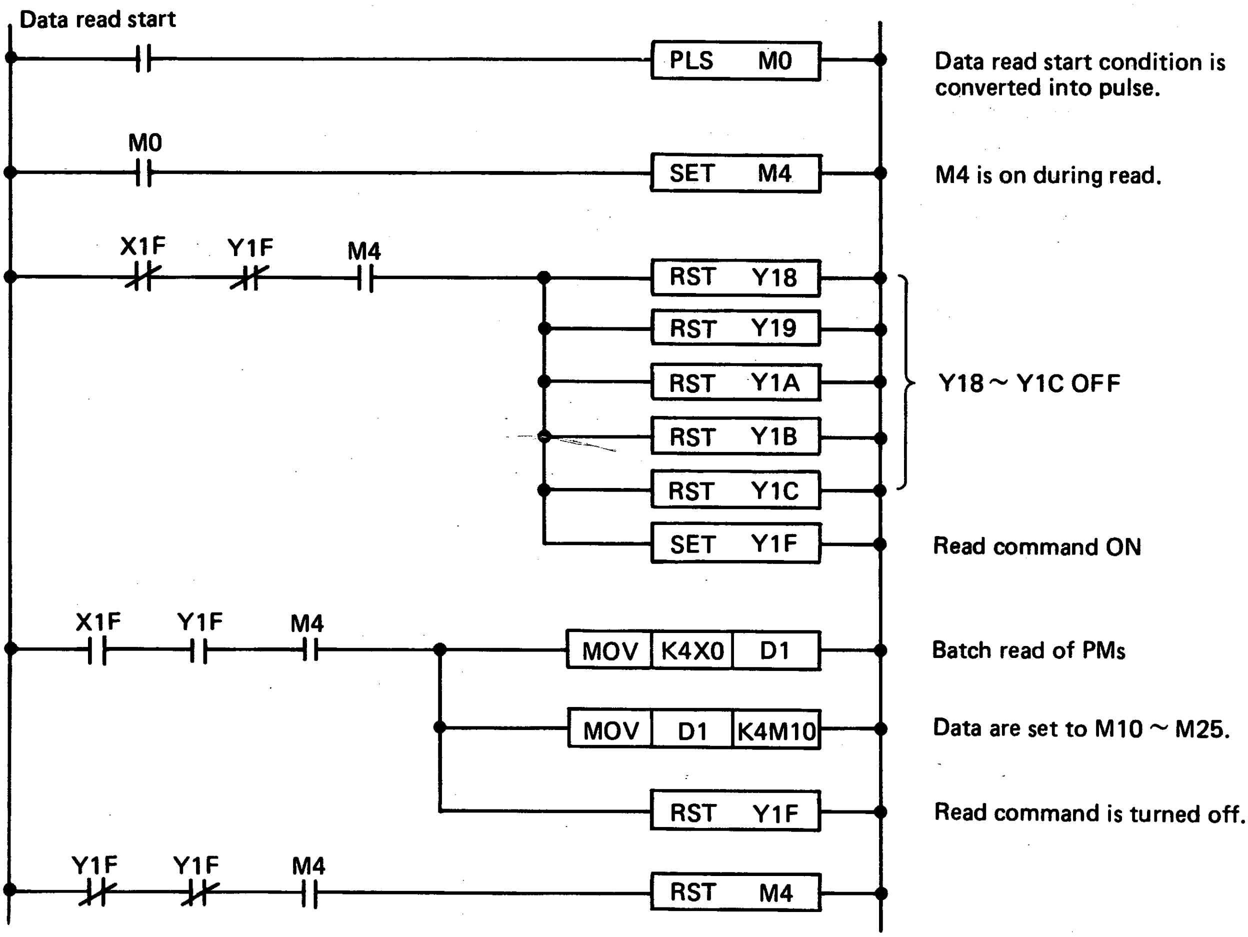


Fig. 5.4 Program Example of Read of PD

6. ERROR MESSAGE LIST

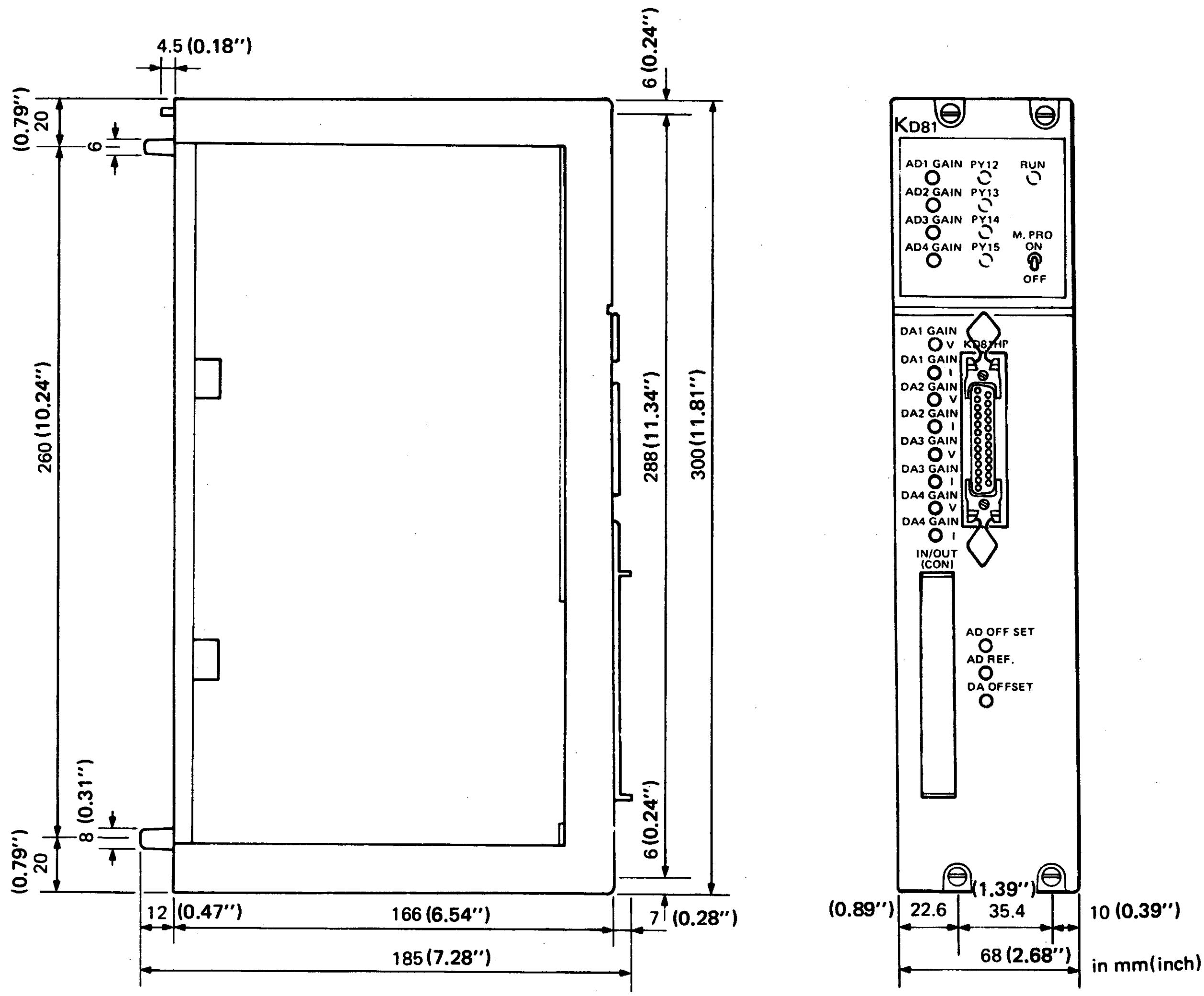
6. ERROR MESSAGE LIST

When the RUN indicator LED on the KD81 flickers, load Type KD81HP PID programmer into KD81 and press the [TST] [K] (GO) keys. Then, the screen shows the content of error as indicated in Table 6.1. Therefore, take a proper action according to the corrective action described in the table.

Error Screen Display Example	Error Content	Corrective Action
ERROR TABLE PRG. 1 STEP 123 / D007 ARITHMETIC ERR. CODE 04 [Display] Program number Step number and its instruction Arithmetic operation error code	Error Code 01: Operation result has exceeded 9.2×10^{18}.	Correct user program so that operation result does not exceed 9.2×10^{18}.
	02: Operation result has exceeded -9.2×10^{18}.	Correct user program so that operation result does not exceed -9.2×10^{18}.
	03: Square root or logarithm of zero or negative number has been calculated.	Since the error is as mentioned at left, correct the program which has the displayed step.
	04: Division has been done by zero.	Since the error is as mentioned at left, correct the program which has the displayed step.
	06: Due to hardware error, operation time has exceeded specified value.	Since the error is due to hardware failure, change the KD81.
ERROR TABLE PRG. 1 LOOP ERROR [Display] Program number	Program is repeatedly run in a certain range of user program and the END instruction is not executed, resulting in overtime.	Press [TST] [RD] [1] (GO) [SSN] [0] (GO) keys and then repeatedly press (GO) key to check the operation of program. Correct a faulty program.
ERROR TABLE PRG. 1 STEP 115 SAL M009 [Display] Program number Step number and its instruction	Instruction code of program, which be being processed, has a code which cannot be decoded by KD81.	The program with the displayed step has an error. Correct the program.
NO ERROR	When [TST] [K] GO keys are pressed while RUN indicator LED of KD81 is lit, the screen shown at left is displayed. While the LED is lit, do not perform the above operation.	

7. EXTERNAL DIMENSIONS OF KD81

7. EXTERNAL DIMENSIONS OF KD81



8. CAUTIONS FOR APPLICATION

8. CAUTIONS FOR APPLICATION

8.1 Run during Instantaneous Stop

Resumption of operation of the KD81 will be automatic in the event that power loss occurs to the base unit of the PC for 20msec or longer and is then restored. If the KD81 is in the process of being shut down by use of the KD81HP and power is restored plus field conditions activate the program, the KD81 will operate. Caution should be exercised by the user for these reasons.

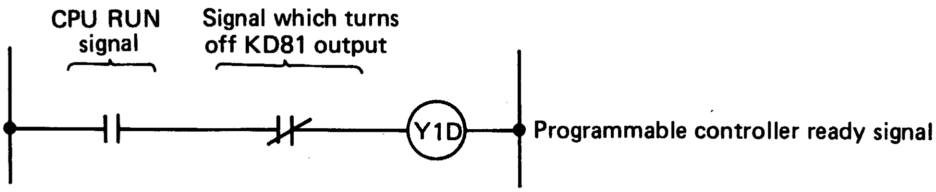
8.2 Run during Error

In the event that error occurs in any of the programs when plural programs (a maximum of four programs) are run, the other programs will stop and the "RUN" LED on KD81 will flicker.
Since the KD81 ready signal (X1C) turns off in case of error, the KCPU can detect the error of KD81 by this signal. (For the output states at error detection, see Section 8.4.)

8.3 Run during KCPU STOP

When the "RUN" switch on KCPU is moved to STOP position during operation, the program of KD81 does not stop. Since the program of KD81 continues running and provides output, prepare a user program of KCPU so that the program turns off the programmable controller ready signal (Y1D).

KCPU user program example



When the programmable controller ready signal (Y1D) turns off, the digital output of KD81 turns off and the analog output of 4 ~ 20 mA changes to 0 mA and 0 ~ 5 V changes to 0 V.

8.4 Output State of KD81

Output	Output State at Error Detection	Output State of Stop Program	Output State at Program Stop	Output State at OFF of programmable Controller Ready Signal
RY0 ~ 11	OFF	Remain the same.	Remain the same.	Operate during program run.
Digital output RY12 ~ 15	OFF	Remain the same	OFF	OFF
Analog output	0 ~ 5V changes to 0V and 4 ~ 20mA changes to 0mA.	Held at the present state. If left at this state, output reduces 5V in four hours.	0 ~ 5V changes to 0V and 4 ~ 20mA changes to 0mA.	0 ~ 5V changes to 0V and 4 ~ 20mA changes to 0mA.

CAUTION

When the analog output circuit element is damaged, analog output becomes unstable.

8.5 Caution for System Design

For safety and protection of the control system and also from a fail safe aspect, circuits which will result in machine damage or accident due to erroneous operation (such as an emergency stop circuit, a protection circuit, and an interlock circuit) should be located in the exterior of the programmable controller.

8.6 Instruction Processing

Avoid mingling a logical processing instruction and a data processing instruction. (Especially when a data processing instruction is executed after the execution of a logical processing instruction or when a logical processing instruction is executed after the execution of a data processing instruction)

1. Example of executing a data processing instruction after the execution of a logical processing instruction

   Step number

   ```
   123    LDA    PX1 ....... (Logical processing)
   124    STA    PD10 ..... (Data processing)
   ```

2. Example of executing a logical processing instruction after the execution of a data processing instruction

   Step number

   ```
   123    LDA    K1 ......... (Logical processing)
   124    JC     K150 ..... (Data processing)
   ```

8.7 Timer

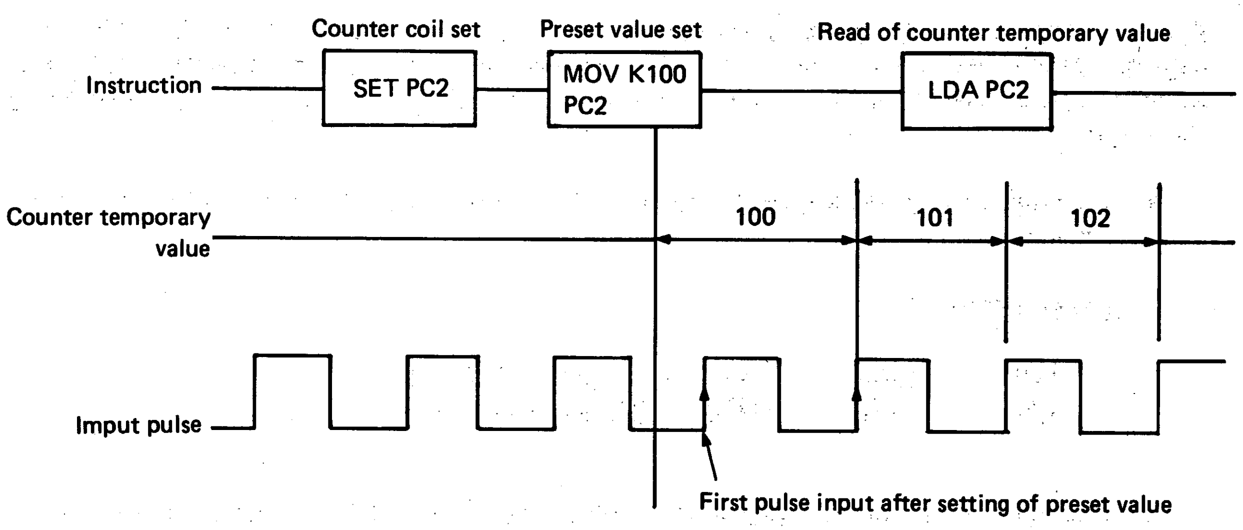
1. Even when the program is at stop, the timer continues counting while the coil is on.
2. When the coil of timer is turned off, the timer indicates a temporary value which is a count value prior to turning off the coil. When the coil is turned on again, the timer resumes counting.

8.8 Temporary Value of Counter

The following example explains the relation between the number of input pulses and the temporary value of counter. In this example, pulses are input after a preset value of 100 is set to the counter.

Number of Input Pulses	Temporary Value of Counter	
	UP Counter	DOWN Counter
0	100	100
First pulse	100	100
Second pulse	101	99
Third pulse	102	98
⋮	⋮	⋮

After the set instruction of preset value to the counter is executed, the counter is actually preset by the first pulse input. Actually, therefore, the second and succeeding pulse inputs are effective as count values.

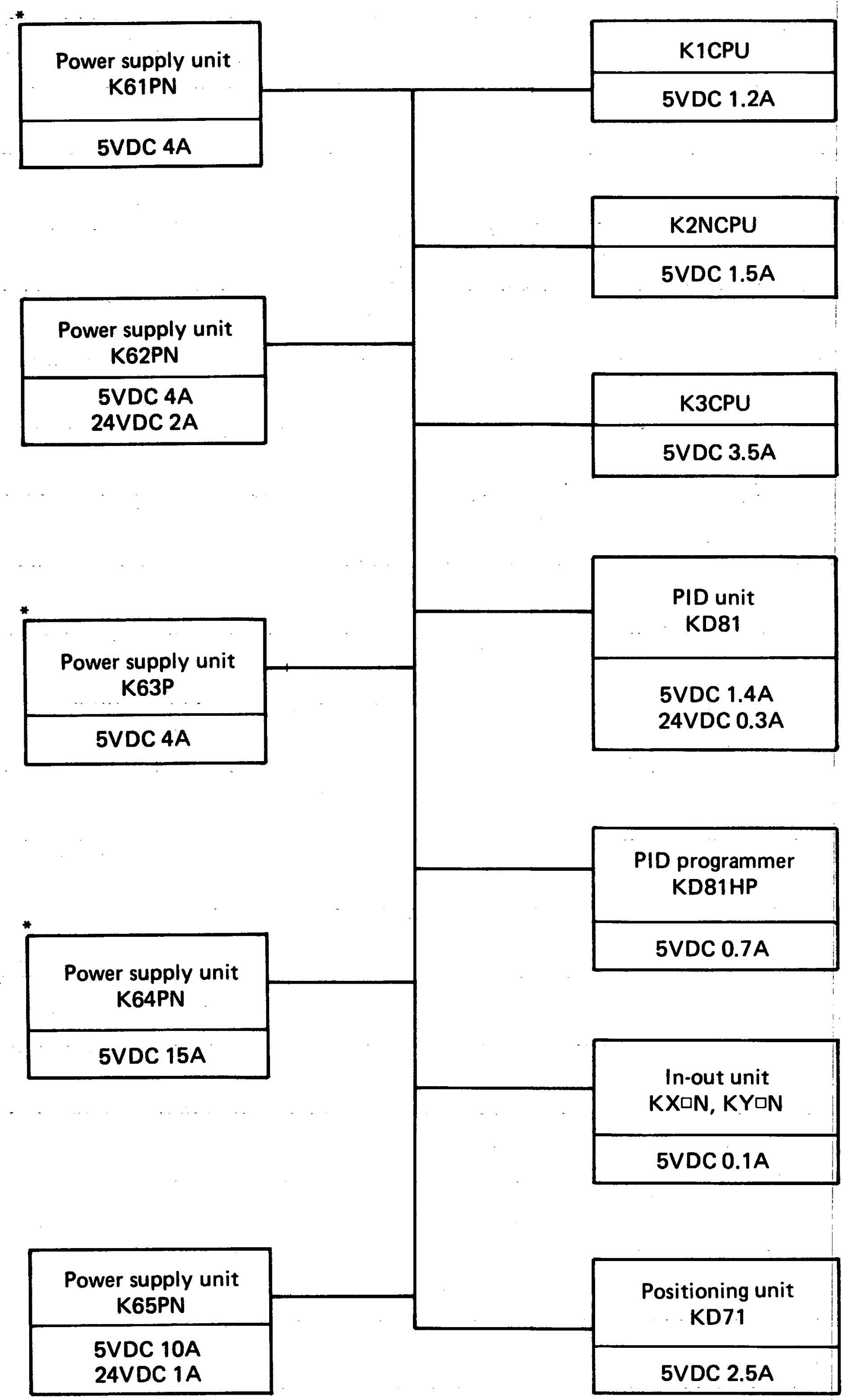


8.9 Cautions for Programming When Counter (PC2 or PC3) Is Used

When the counter PC2 or PC3 is used, insert an LDA instruction (LDA PC2 for PC2, LDA PC3 for PC3) into a program which is always run per scan time.

8.10 Selection of Power Supply Unit

The relation between the power supply capacities of power supply units and the load currents of CPU, KD81(HP), and I/O units are as shown below:



CAUTION

When power supply unit with * mark is used, supply 24VDC from exterior.

MEMO

9. MAINTENANCE

9. MAINTENANCE

9.1 Handling Instructions

(1) Since the case and connectors of this programmable controller are made of plastic, do no drop or give strong shock.

(2) Do not remove the printed circuit boards from the case. Removal may cause board failure.

(3) At the time of wiring, take care to prevent the entry of wire chips from the top into the unit. If such chips have entered, remove them.

(4) Do not overtighten the fixing screws of unit.

9.2 Storage

When the programmable controller is stored as a single unit or mounted inside control panel or machine, never keep it at the locations and environments described below:

(1) Locations where ambient temperature is outside the range of −10°C and 75°C.

(2) Locations where ambient humidity is outside the range of 10 and 90%RH.

(3) Locations where dew condensation takes place due to sudden temperature changes.

(4) Locations exposed to the weather or the direct rays of the sun.

(5) Locations where there are especially a lot of conductive powder such as dust and iron filings oil mist, and salt, and also where there exist corrosive gases.

IMPORTANT

(1) Design the system so that the protection and safety circuits, which are furnished to protect the programmable controller from troubles, are located externally of the cabinet.

(2) Since the printed circuit boards are mounted with electronic parts, which will be adversely affected by static electricity, handle them as described below when they are directly handled.

1) Ground human body and work bench.

2) Do not directly touch the conductive areas of printed circuit board and its electrical parts with a non-grounded material.

APPENDIX PROCESS TIME LIST

Since average process times are shown in the table, actual process time may vary slightly.

(Unit: μs)

Device / Function	A	PX	PY		PM	PD	PC	PT	K
			PY0 ~ 11	PY12 ~ 15					
NOP	60	–	–	–	–	–	–	–	–
NOT	–	90	90	100	90	–	–	–	–
AND	–	90	90	100	90	–	–	–	–
OR	–	90	90	100	90	–	–	–	–
SET	–	80	80	100	80	–	60	60	–
RST	–	80	80	100	80	–	60	60	–
END	180	–	–	–	–	–	–	–	–
LDA	–	80	80	100	80	90	180	190	80
STA	–	80	80	110	80	80	210	210	–
+	–	–	–	–	–	250	280	310	240
–	–	–	–	–	–	250	280	310	240
•	–	–	–	–	–	280	310	320	260
/	–	–	–	–	–	270	320	320	270
√	500	–	–	–	–	–	–	–	–
%	–	–	–	–	–	400	430	460	390
LOG	2150	–	–	–	–	–	–	–	–
ABS	180	–	–	–	–	–	–	–	–
>	–	–	–	–	–	320	370	370	350
<	–	–	–	–	–	320	370	380	350
=	–	–	–	–	–	320	380	370	340
JC	–	–	–	–	–	–	–	–	90
JMP	–	–	–	–	–	–	–	–	80
HS	–	–	–	–	–	410	420	430	360
LS	–	–	–	–	–	380	430	450	370
HLM	–	–	–	–	–	430	–	–	370
LLM	–	–	–	–	–	380	–	–	350

Function	Device Combination	Process Time (μs)
MOV	X → X	100
MOV	X → Y	100
MOV	X → M	100
MOV	Y → X	100
MOV	Y → Y	110
MOV	Y → M	100
MOV	M → X	100
MOV	M → Y	110
MOV	M → M	100
MOV	D → D	190
MOV	D → C	260
MOV	D → T	260
MOV	C → D	300
MOV	C → C	370
MOV	C → T	350
MOV	T → D	270
MOV	T → C	320
MOV	T → T	310

Function	Device Combination	Process Time (μs)
MOV	K → D	180
MOV	K → C	240
MOV	K → T	240

Function	Device PD Is Used	Process Time (μs)
SAL		580
HAL		580
LAL		580
PIX		1060
PIY		1400
PID	K1	3990
PID	K2	3960
PID	K3	4720
PID	K4	4770
PID	K5	4410
PID	K6	4310
PID	K7	5430
PID	K8	5410

MEMO

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HEAD OFFICE:MITSUBISHI DENKI BLDG.MARUNOUCHI. TOKYO 100 TELEX: J24532 CABLE MELCO TOKYO

IB(NA)66007-A(8410) REC Printed in Japan