SECTION 7
Using Expansion Units and Expansion I/O Units

This section describes how to use CP-series/CPM1A-series Expansion Units and Expansion I/O Units.

7-1 Connecting Expansion Units and Expansion I/O Units 420
7-2 Analog Input Units 421
7-3 Analog Output Units 430
7-4 Analog I/O Units 438
7-4-1 CPM1A-MAD01 Analog I/O Units 438
7-4-2 CP1W-MAD11/CPM1A-MAD11 Analog I/O Units 448
7-5 Temperature Sensor Units 461
7-6 CompoBus/S I/O Link Units 476
7-7 DeviceNet I/O Link Units 482

7-1 Connecting Expansion Units and Expansion I/O Units

CP-series and CPM1A-series Expansion Units and Expansion I/O Units can be connected to the CP1L. Up to three Expansion Units or Expansion I/O Units can be connected to a CPU Unit with 30, 40 or 60 I/O points and one Expansion Unit or Expansion I/O Unit can be connected to a CPU Unit with 20 or 14 I/O points.

The functionality and performance of CP-series Expansion Units and Expansion I/O Units is the same as the functionality and performance of CP1MA-series Expansion Units and Expansion I/O Units. CP-series Units are black, and CPM1A-series Units are ivory.

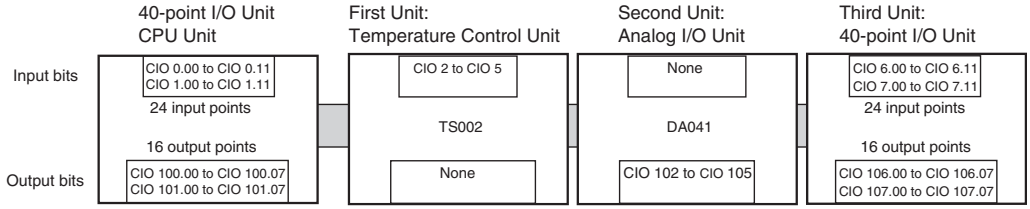
Number of I/O Words

Unit name		Model	Current consumption (mA)		I/O words	
			5 VDC	24 VDC	Input	Output
Expansion Units	Analog Input Unit	CP1W-AD041 CPM1A-AD041	100	90	4	2
	Analog Output Unit	CP1W-DA041 CPM1A-DA041	80	124	---	4
	Analog I/O Unit	CPM1A-MAD01	66	66	2	1
		CP1W-MAD11 CPM1A-MAD11	83	110		
	Temperature Control Unit	CP1W-TS001 CPM1A-TS001	40	59	2	---
		CP1W-TS101 CPM1A-TS101	54	73		
		CP1W-TS002 CPM1A-TS002	40	59	4	---
		CP1W-TS102 CPM1A-TS102	54	73		
	CompoBus/S I/O Link Unit	CP1W-SRT21 CPM1A-SRT21	29	---	1	1
	DeviceNet I/O Link Unit	CPM1A-DRT21	48	---	2	2
Expansion I/O Units	40-point I/O Unit	CP1W-40EDR CPM1A-40EDR	80	90	2	2
		CP1W-40EDT CPM1A-40EDT	160	---		
		CP1W-40EDT1 CPM1A-40EDT1	160	---		
	32-point Output Unit	CP1W-32ER	49	131	---	4
		CP1W-32ET	113	---		
		CP1W-32ET1	113	---		
	20-point I/O Unit	CP1W-20EDR1 CPM1A-20EDR1	103	44	1	1
		CP1W-20EDT CPM1A-20EDT	130	---		
		CP1W-20EDT1 CPM1A-20EDT1	130	---		
	16-point Output Unit	CP1W-16ER CPM1A-16ER	42	90	---	2
		CP1W-16ET	76	---		
		CP1W-16ET1	76	---		
	8-point Input Unit	CP1W-8ED CPM1A-8ED	18	---	1	---
	8-point Output Unit	CP1W-8ER CPM1A-8ER	26	44	---	1
		CP1W-8ET CPM1A-8ET	75	---		
		CP1W-8ET1 CPM1A-8ET1	75	---		

Note CP1W-32ER/32ET/32ET1's maximum number of simultaneously ON points is 24 (75%).

Allocation of I/O Words

Expansion Units and Expansion I/O Units are allocated I/O bits in the order the Units are connected starting from the CPU Unit. When the power to the CPU Unit is turned ON, the CPU Unit checks for any Expansion Units and Expansion I/O Units connected to it and automatically allocates I/O bits



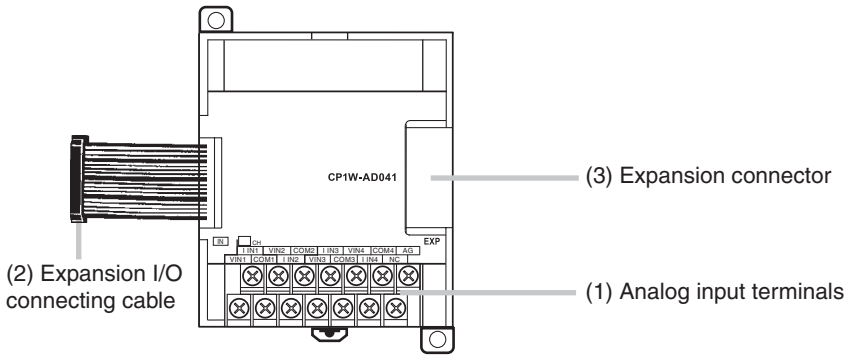
7-2 Analog Input Units

Each CP1W-AD041/CPM1A-AD041 Analog Input Unit provides four analog inputs.

- The analog input signal ranges are 0 to 5 V, 1 to 5 V, 0 to 10 V, -10 to +10 V, 0 to 20 mA, and 4 to 20 mA. The resolution is 1/6,000. The open-circuit detection function is activated in the ranges of 1 to 5 V and 4 to 20 mA.
- The Analog Input Unit uses four input words and two output words, so a maximum of three Units can be connected.

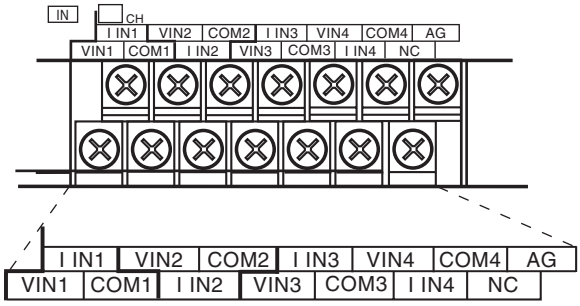
Part Names

CP1W-AD041/CPM1A-AD041



1. Analog Input Terminals
   Connected to analog output devices.

■ **Input Terminal Arrangement**



V IN1	Voltage input 1
I IN1	Current input 1
COM1	Input common 1
V IN2	Voltage input 2
I IN2	Current input 2
COM2	Input common 2
V IN3	Voltage input 3
I IN3	Current input 3
COM3	Input common 3
V IN4	Voltage input 4
I IN4	Current input 4
COM4	Input common 4

Note When using current inputs, voltage input terminals must be short-circuited with current input terminals.

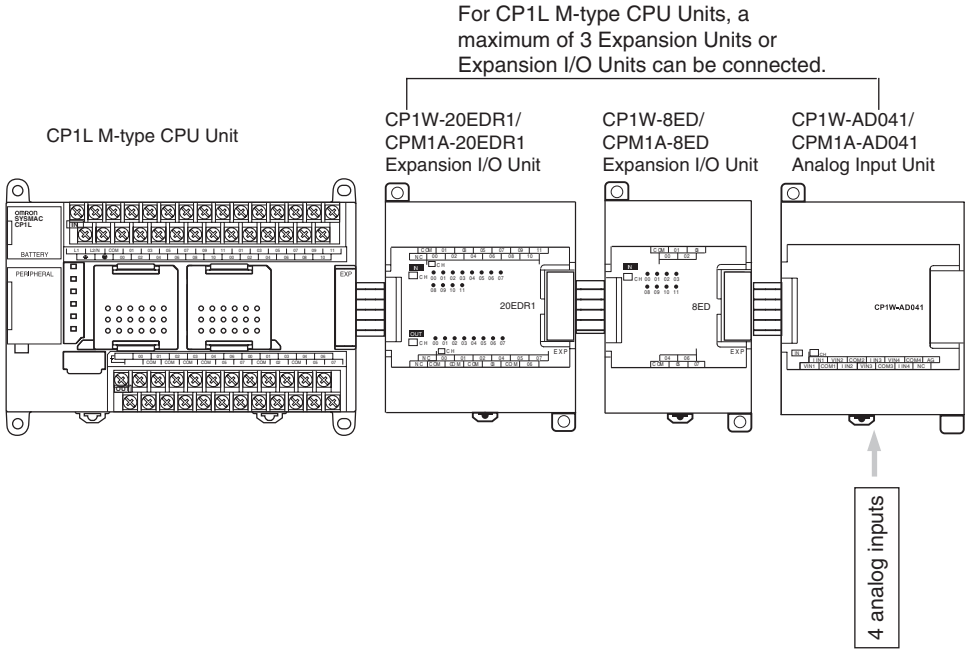
2. Expansion I/O Connecting Cable
   Connected to the CPU Unit or Expansion Unit expansion connector. The cable is attached to the Analog Input Unit and cannot be removed.

Note Do not touch the cables during operation. Static electricity may cause operating errors.

3. Expansion Connector
   Connected to the next Expansion Unit or Expansion I/O Unit to enable expansion.

Main Analog Input Unit Specifications

Analog Input Units are connected to a CP1L CPU Unit. For CP1L M-type CPU Units, a maximum of three Units can be connected, including other Expansion Units and Expansion I/O Units.



Item		Voltage Input	Current Input
Number of inputs		4 inputs (4 words allocated)	
Input signal range		0 to 5 VDC, 1 to 5 VDC, 0 to 10 VDC, or –10 to 10 VDC	0 to 20 mA or 4 to 20 mA
Max. rated input		±15 V	±30 mA
External input impedance		1 MΩ min.	Approx. 250 Ω
Resolution		1/6000 (full scale)	
Overall accuracy	25°C	0.3% full scale	0.4% full scale
	0 to 55°C	0.6% full scale	0.8% full scale
A/D conversion data		16-bit binary (4-digit hexadecimal) Full scale for –10 to 10 V: F448 to 0BB8 Hex Full scale for other ranges: 0000 to 1770 Hex	
Averaging function		Supported (Set in output words n+1 and n+2.)	
Open-circuit detection function		Supported	
Conversion time		2 ms/point (8 ms/all points)	
Isolation method		Photocoupler isolation between analog I/O terminals and internal circuits. No isolation between analog I/O signals.	
Current consumption		5 VDC: 100 mA max.; 24 VDC: 90 mA max.	

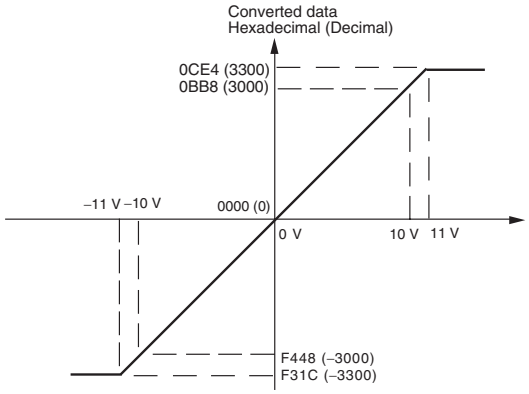
Analog Input Signal Ranges

Analog input data is digitally converted according to the input signal range as shown below.

Note When the input exceeds the specified range, the A/D conversion data will be fixed at either the lower limit or upper limit.

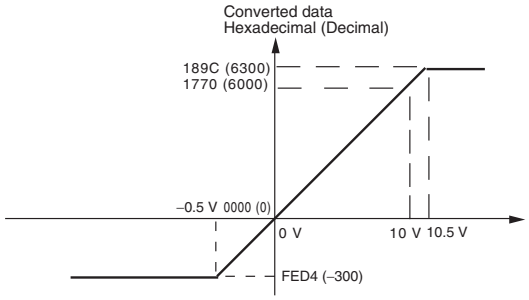
Analog Input Signal Ranges

■ –10 to 10 V Inputs



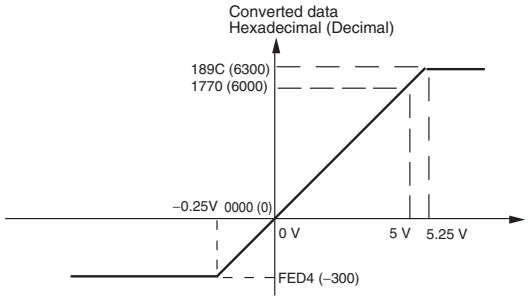
Voltage in the -10 to 10 V range corresponds to hexadecimal values F448 to 0BB8 (-3,000 to 3,000). The range of data that can be converted is F31C to 0CE4 hex (-3,300 to 3,300). A negative voltage is expressed as two's complement.

■ 0 to 10 V Inputs



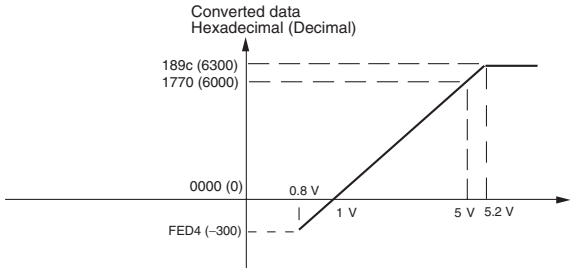
Voltage in the 0 to 10 V range corresponds to hexadecimal values 0000 to 1770 (0 to 6,000). The range of data that can be converted is FED4 to 189C hex (-300 to 6,300). A negative voltage is expressed as two's complement.

■ 0 to 5 V Inputs



Voltage in the 0 to 5 V range corresponds to hexadecimal values 0000 to 1770 (0 to 6,000). The range of data that can be converted is FED4 to 189C hex (-300 to 6,300). A negative voltage is expressed as two's complement.

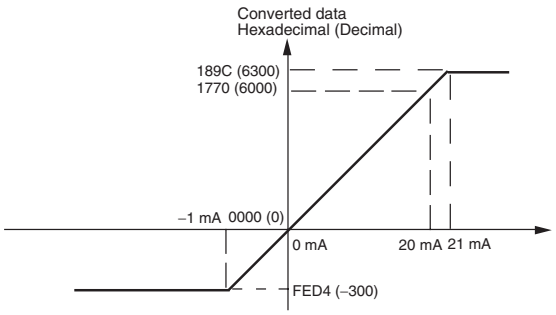
■ 1 to 5 V Inputs



Voltage in the 1 to 5 V range corresponds to hexadecimal values 0000 to 1770 (0 to 6,000). The range of data that can be converted is FED4 to 189C hex (-300 to 6,300). Voltage in the range of 0.8 to 1 V is expressed as two's complement.

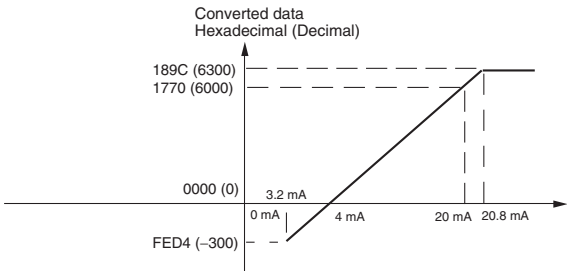
If an input is below the range (i.e., less than 0.8 V), the open-circuit detection function is activated and the data becomes 8,000.

■ 0 to 20 mA Inputs



Current in the 0 to 20 mA range corresponds to hexadecimal values 0000 to 1770 (0 to 6,000). The range of data that can be converted is FED4 to 189C hex (-300 to 6,300). A negative current is expressed as two's complement.

■ 4 to 20 mA Inputs



Current in the 4 to 20 mA range corresponds to hexadecimal values 0000 to 1770 (0 to 6,000). The range of data that can be converted is FED4 to 189C hex (-300 to 6,300). Current in the range of 3.2 to 4 mA is expressed as two's complement.

If an input is below the range (i.e., less than 3.2 mA), the open-circuit detection function is activated and the data becomes 8,000.

Averaging Function

For analog inputs, the averaging function operates when the averaging bit is set to 1. The averaging function outputs the average (a moving average) of the last eight input values as the converted value. If there is only a slight variation in inputs, it is handled by the averaging function as a smooth input.

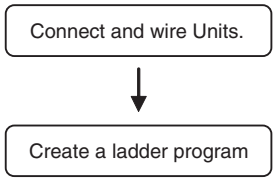
The averaging function stores the average (a moving average) of the last eight input values as the converted value. Use this function to smooth inputs that vary at a short interval.

Open-circuit Detection Function

The open-circuit detection function is activated when the input range is set to 1 to 5 V and the voltage drops below 0.8 V, or when the input range is set to 4 to 20 mA and the current drops below 3.2 mA. When the open-circuit detection function is activated, the converted data will be set to 8,000.

The time for enabling or clearing the open-circuit detection function is the same as the time for converting the data. If the input returns to the convertible range, the open-circuit detection is cleared automatically and the output returns to the normal range.

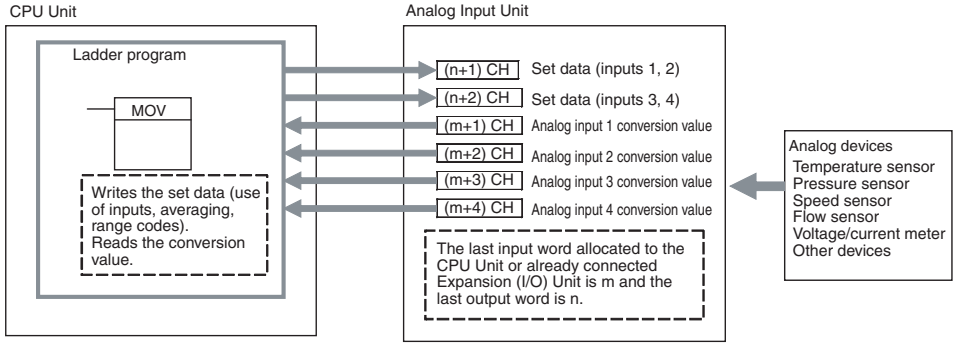
Procedure



- Connect Analog Input Units.
- Wire to analog output devices.

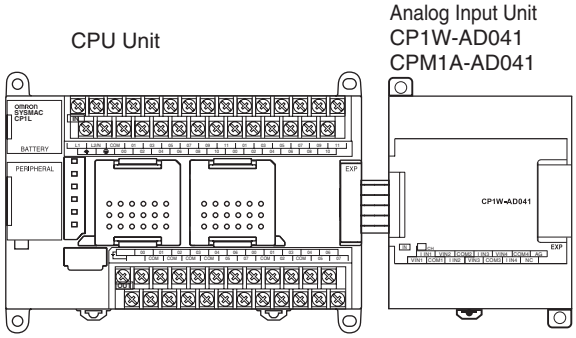
- Write set data to output words (n+1, n+2).
  - Set use of inputs.
  - Select input signals using range codes.
  - Set use of averaging.
- Read A/D conversion values from input words (m+1 to m+4).
- For current inputs, confirm that there is no open circuit.

Writing Set Data and Reading A/D Conversion Values



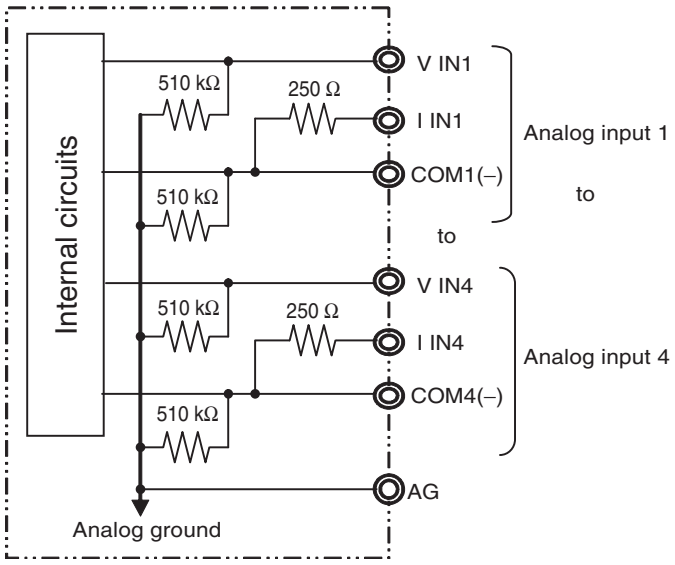
1. Connecting the Analog Input Unit

Connect the Analog Input Unit to the CPU Unit.

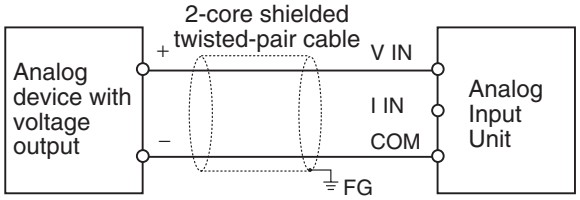


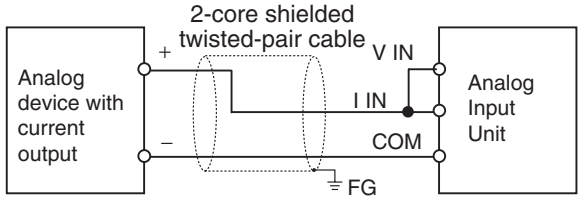
2. Wiring Analog Inputs

Internal Circuits



■ **Wiring for Analog Inputs**





Note

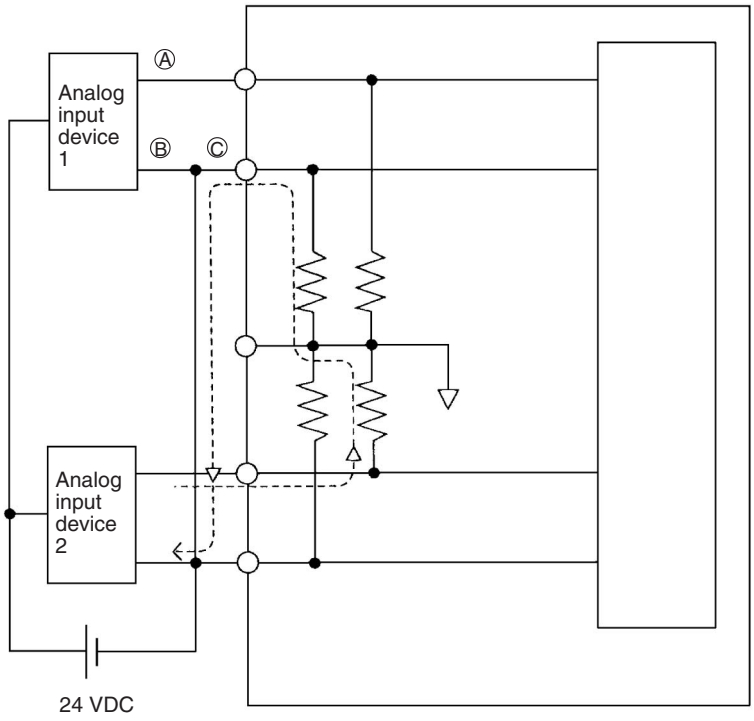
(1) Connect the shield to the FG terminal to prevent noise.

(2) When an input is not being used, short the + and – terminals.

(3) Separate wiring from power lines (AC power supply lines, high-voltage lines, etc.)

(4) When there is noise in the power supply line, install a noise filter on the input section and the power supply.

(5) Refer to the following information on open circuits when using voltage inputs.



For example, if analog input device 2 is outputting 5 V and the same power supply is being used as shown above, about 1/3, or 1.6 V, will be applied at the input for input device 1.

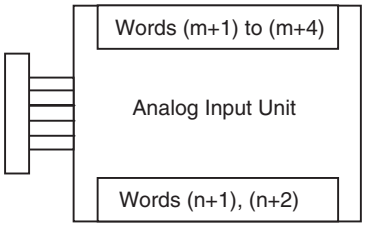
Consider the following information on open input circuits when using voltage inputs. Either use separate power supplies, or install an isolator at each input.

If the same power supply is used as shown in the following diagram and an open circuit occurs at point A or B, an unwanted current flow will occur as shown by the dotted lines in the diagram, creating a voltage at the other input of about 1/3 to 1/2. If the 1 to 5-V range is being used, the open-circuit detection function will not operate. Also, if there is an open circuit at C, the open-circuit detection function will not operate because the negative sides are the same.

3. Creating the Ladder Program

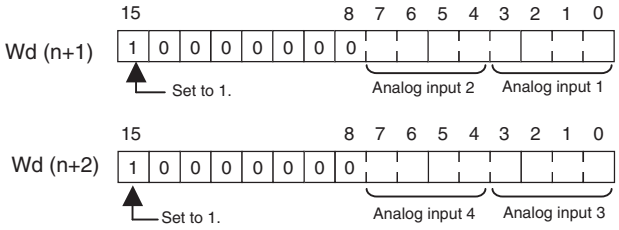
Allocating I/O Words

Four input words and two output words are allocated from the next words following the last I/O words allocated to the CPU Unit or an existing Expansion Unit or Expansion I/O Unit.

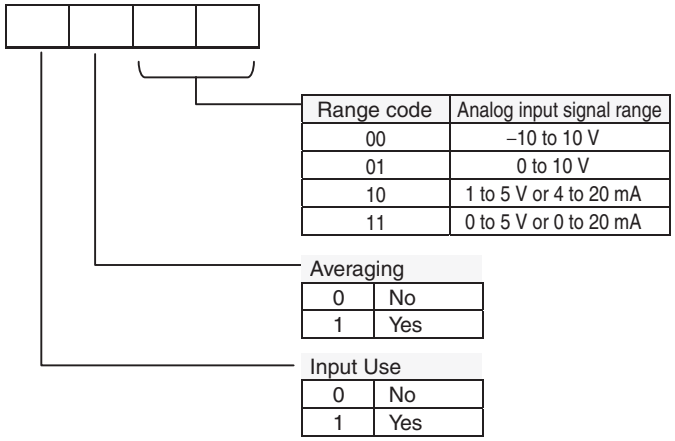


Writing Set Data

Write the settings for input use, averaging use, and range codes for words n+1 and n+2. When the set data is transferred from the CPU Unit to the Analog I/O Unit, the A/D conversion will be started.



■ **Set Data**



Range code	Analog input signal range
00	−10 to 10 V
01	0 to 10 V
10	1 to 5 V or 4 to 20 mA
11	0 to 5 V or 0 to 20 mA

Averaging

0	No
1	Yes

Input Use

0	No
1	Yes

- The Analog Input Unit will not start converting analog I/O values until the range code has been written.
- Once the range code has been set, it is not possible to change the setting while power is being supplied to the CPU Unit. To change the I/O range, turn the CPU Unit OFF then ON again.

Averaging

Set whether averaging is to be used for set data. When the averaging bit is set to 1, the average (moving average) for the past eight inputs is output as conversion data.

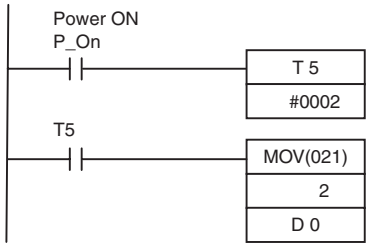
Reading Analog Input Conversion Values

Read the conversion value storage area with the ladder program. With word m as the last input word allocated to the CPU Unit or an already-connected Expansion Unit, the A/D conversion data will be output to the following words m+1 to m+4.

Startup Operation

After the power is turned ON, it will require two cycle times plus approximately 50 ms before the first conversion data is stored in the input words. Therefore, create a program as shown below, so that when operation begins simultaneously with startup it will wait for valid conversion data.

The analog input data will be 0000 until the initial processing is completed.



TIM5 is started when the power is turned ON. After 0.1 to 0.2 s (100 to 200 ms) elapses, the TIM5 contact turns ON and the analog input 1 conversion data stored in word 2 is transferred to DM0.

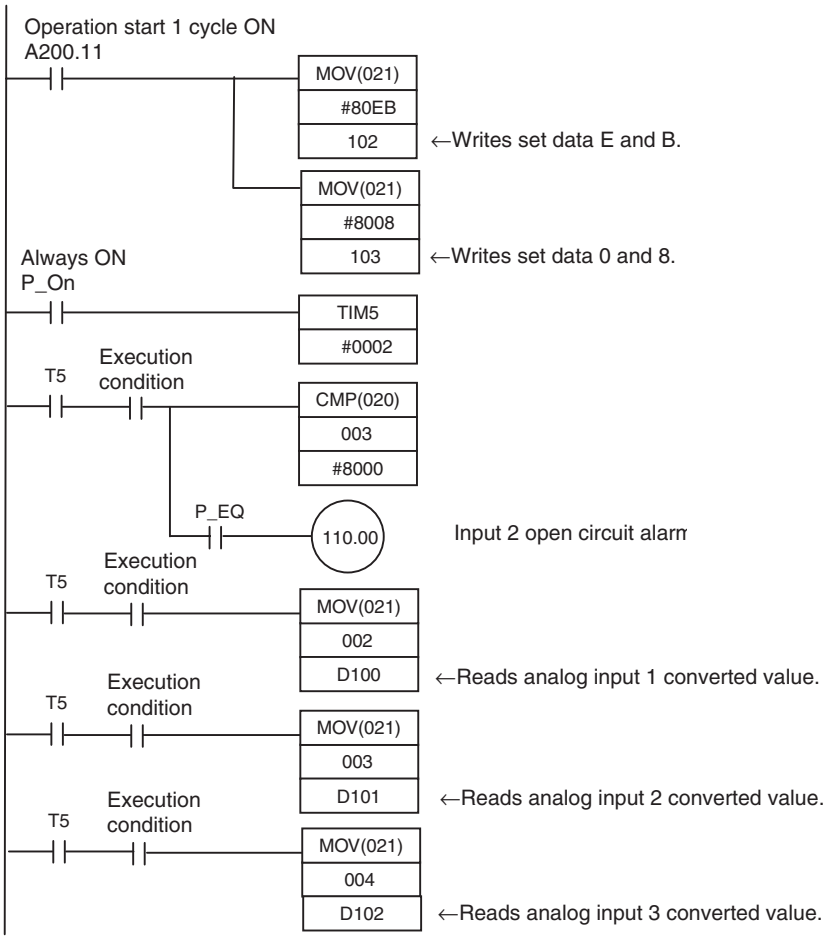
Handling Unit Errors

- When an error occurs in an Analog Input Unit, the analog input conversion data becomes 0000.

- Expansion Unit errors are output to bits 0 to 6 of word A436. The bits are allocated from A436.00 in order starting with the Unit nearest the CPU Unit. Use these flags in the program when it is necessary to detect errors.

Ladder Program Example

Analog input	Input range	Range code	Averaging	Set data	Destination word
Input 1	0 to 10 V	01	Yes	1101 (B hex)	n+1
Input 2	4 to 20 mA	10	Yes	1110 (E hex)	n+1
Input 3	-10 to +10 V	00	No	1000 (8 hex)	n+2
Input 4	Not used.	-(00)	---	0000 (0 hex)	n+2



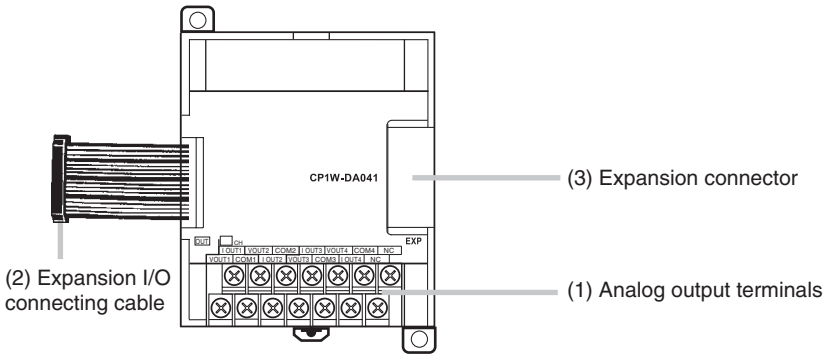
7-3 Analog Output Units

Each CP1W-DA041/CPM1A-DA041 Analog Output Unit provides four analog outputs.

- The analog output signal ranges are 1 to 5 V, 0 to 10 V, -10 to +10 V, 0 to 20 mA, and 4 to 20 mA. The resolution is 1/6,000. The open-circuit detection function is activated in the ranges of 1 to 5 V and 4 to 20 mA.
- The Analog Input Unit uses four output words, so a maximum of three Units can be connected.

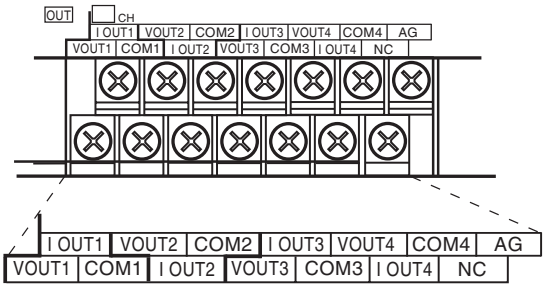
Part Names

CP1W-DA041/CPM1A-DA041



1. Analog Output Terminals
   Connected to analog input devices.

■ Output Terminal Arrangement



V OUT1	Voltage output 1
I OUT1	Current output 1
COM1	Output common 1
V OUT2	Voltage output 2
I OUT2	Current output 2
COM2	Output common 2
V OUT3	Voltage output 3
I OUT3	Current output 3
COM3	Output common 3
V OUT4	Voltage output 4
I OUT4	Current output 4
COM4	Output common 4

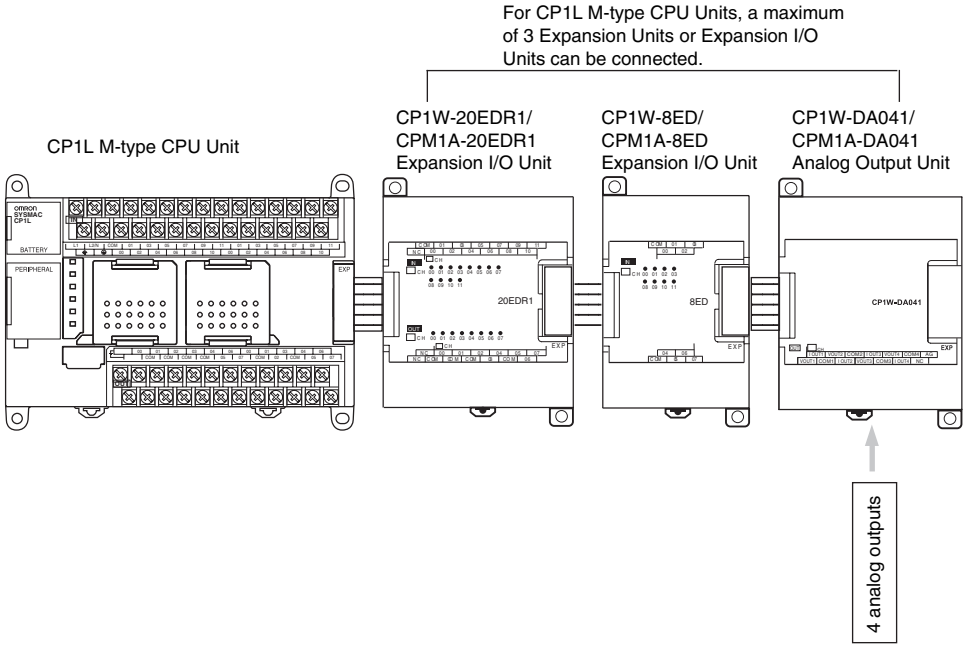
2. Expansion I/O Connecting Cable
   Connected to the CPU Unit or previous Expansion Unit. The cable is provided with the Unit and cannot be removed.

Note Do not touch the cables during operation. Static electricity may cause operating errors.

3. Expansion Connector
   Connected to the next Expansion Unit or Expansion I/O Unit.

Main Analog Output Unit Specifications

Analog Output Units are connected to a CP1L CPU Unit. For CP1L M-type CPU Units, a maximum of three Units can be connected, including other Expansion Units and Expansion I/O Units.



Item			Voltage Output	Current Output
Analog output section	Number of outputs		4 outputs (4 words allocated)	
	Output signal range		1 to 5 VDC, 0 to 10 VDC, or –10 to 10 VDC	0 to 20 mA or 4 to 20 mA
	External output allowable load resistance		2 kΩ min.	350 Ω max.
	External output impedance		0.5 Ω max.	---
	Resolution		1/6000 (full scale)	
	Overall accuracy	25°C	0.4% full scale	
		0 to 55°C	0.8% full scale	
	D/A conversion data		16-bit binary (4-digit hexadecimal) Full scale for –10 to 10 V: F448 to 0BB8 Hex Full scale for other ranges: 0000 to 1770 Hex	
Conversion time			2 ms/point (8 ms/all points)	
Isolation method			Photocoupler isolation between analog I/O terminals and internal circuits. No isolation between analog I/O signals.	
Current consumption			5 VDC: 80 mA max.; 24 VDC: 124 mA max.	

Analog Output Signal Ranges

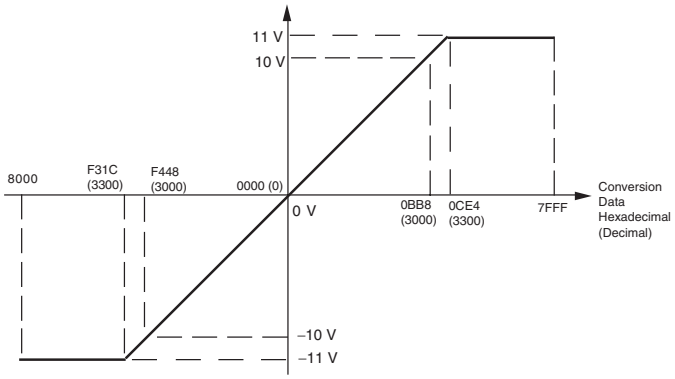
The analog values depend on the output signal ranges, as shown in the following diagrams.

Note When the output exceeds the specified range, the output signal will be fixed at either the lower limit or upper limit.

Analog Output Signal Ranges

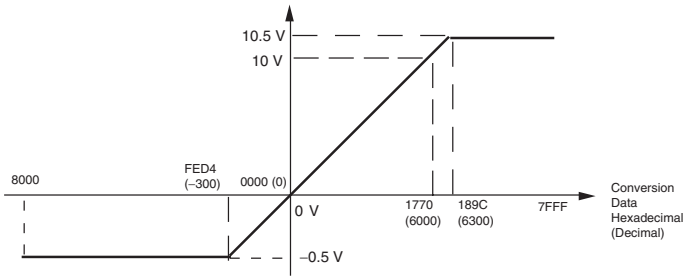
■ **–10 to 10 V**

The hexadecimal values F448 to 0BB8 (–3000 to 3000) correspond to an analog voltage range of –10 to 10 V. The entire output range is –11 to 11 V. Specify a negative voltage as a two's complement.



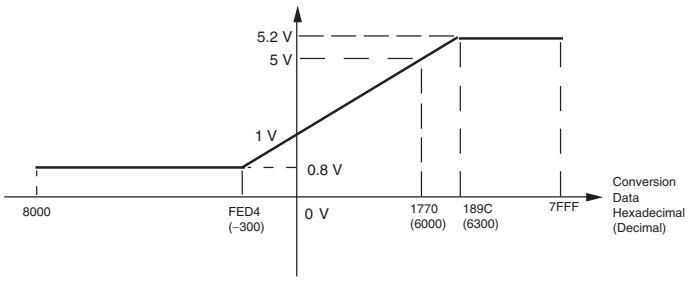
■ **0 to 10 V**

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog voltage range of 0 to 10 V. The entire output range is –0.5 to 10.5 V. Specify a negative voltage as a two's complement.



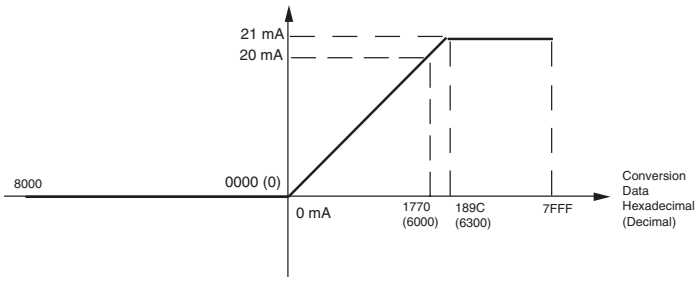
■ **1 to 5 V**

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog voltage range of 1 to 5 V. The entire output range is 0.8 to 5.2 V.



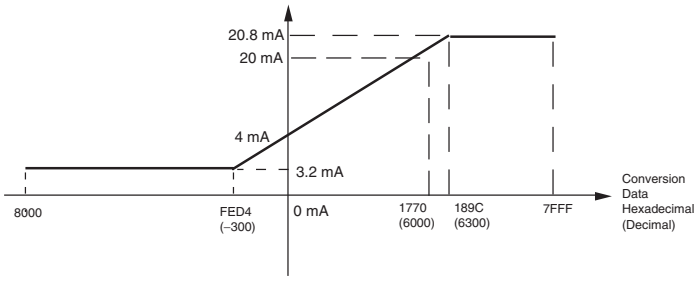
■ **0 to 20 mA**

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog current range of 0 to 20 mA. The entire output range is 0 to 21 mA.

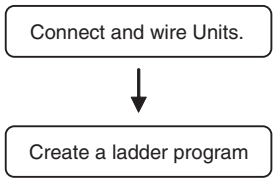


■ **4 to 20 mA**

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog current range of 4 to 20 mA. The entire output range is 3.2 to 20.8 mA.



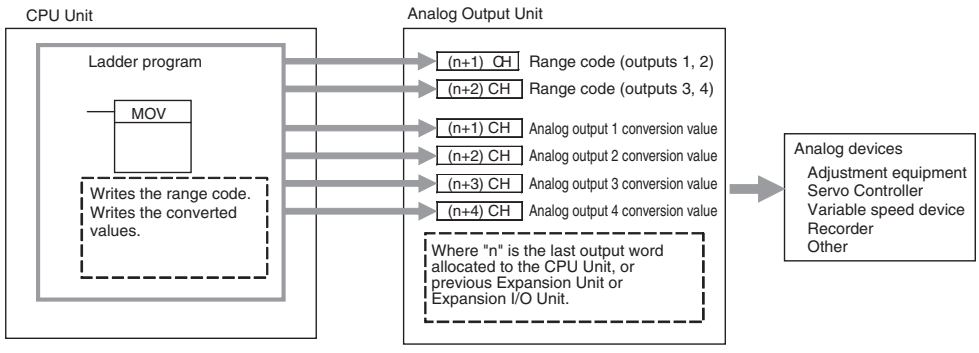
Procedure



- Connect Analog Output Units.
- Wire to analog input devices.

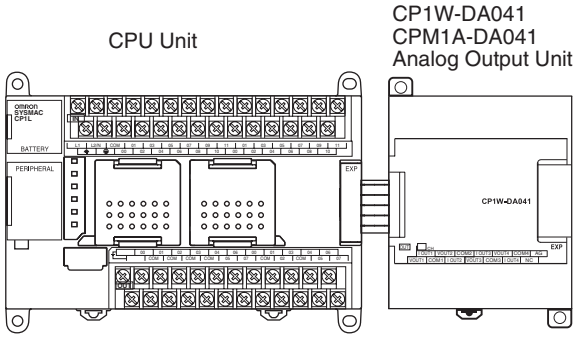
- Write range code to output words (n+1, n+2).
  - Set use of outputs.
  - Select output signals using range codes.
- Write D/A conversion values to output words (n+1 to n+4).

Writing D/A Conversion Data



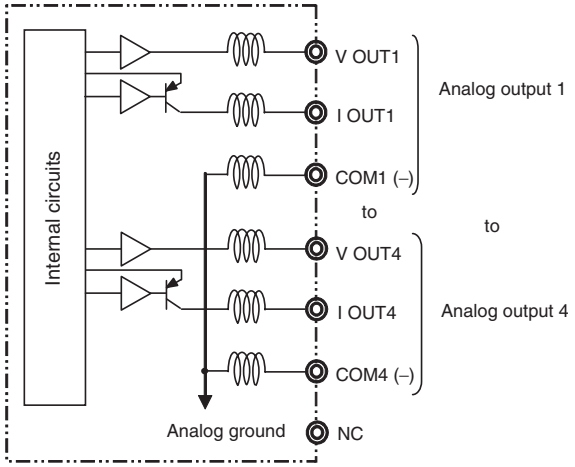
1. Connecting the Analog Output Unit

Connect the Analog Output Unit to the CPU Unit.

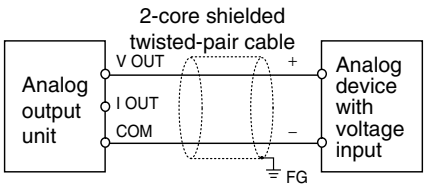


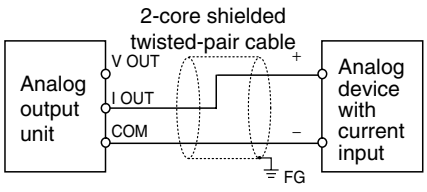
2. Wiring Analog Outputs

Internal Circuits



■ Wiring for Analog Outputs





Note

(1) Connect the shield to the FG terminal to prevent noise.

(2) Separate wiring from power lines (AC power supply lines, high-voltage lines, etc.)

(3) When there is noise in the power supply line, install a noise filter on the input section and the power supply.

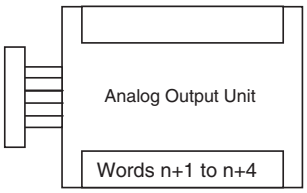
(4) When external power is supplied (when range codes are set), or when the power is interrupted, there may be a pulse status analog output of up to 1 ms. If this status is a problem, take the following measures.

- Turn ON the power to the CP1L CPU Unit, check the operation status, and then turn ON the power at the load.
- Turn OFF the power to the load and then turn OFF the power to the CP1L CPU Unit.

3. Ladder Program

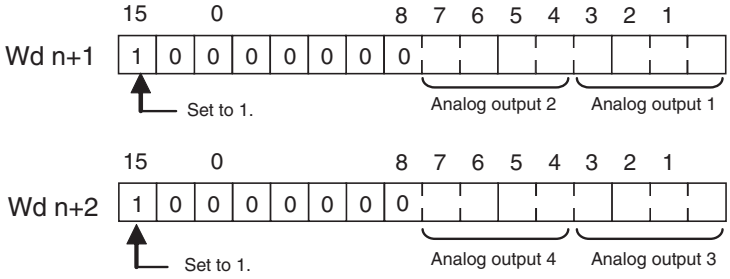
Allocation of Output Words

Four output words are allocated, beginning from the first word following the last I/O word allocated to the CPU Unit or already-connected Expansion I/O Unit or Expansion Unit.

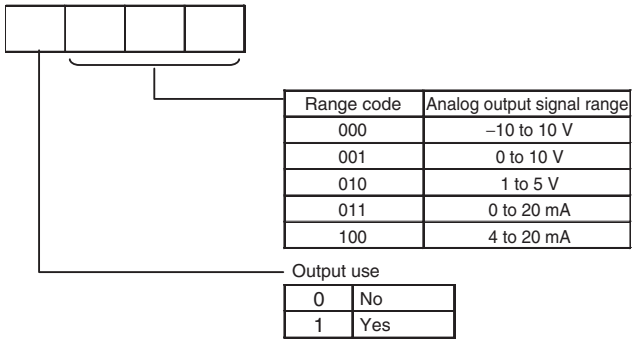


Writing the Range Code

Write the output use and the range code to words n+1 and n+2. The D/A conversion will start when the set data is transferred from the CPU Unit to the Analog Output Unit.



■ **Range Code**



- The Analog Output Unit will not start converting analog I/O values until the range code has been written. The output will be 0 V or 0 mA.
- From when the range code has been written until data in the analog output convertible range is written, 0 V or 0 mA will be output in the 0 to 10 V, -10 to +10 V, and 0 to 20 mA ranges, and 1 V or 4 mA will be output in the 1 to 5 V and 4 to 20 mA ranges.
- Once the range code has been set, it is not possible to change the setting while power is being supplied to the CPU Unit. To change the I/O range, turn the CPU Unit OFF then ON again.

Writing Analog Output Set Values

The ladder program can be used to write data to the output word where the set value is stored. The output word will be "n+1" when "n" is the last output word allocated to the CPU Unit, or previous Expansion Unit or Expansion I/O Unit.

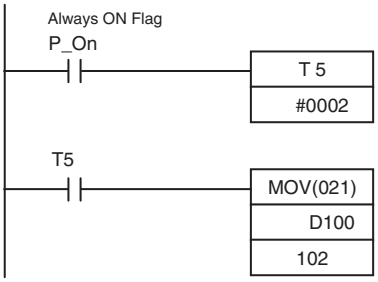
Startup Operation

After power is turned ON, it will require two cycle times plus approximately 50 ms before the first data is converted.

The following table shows the output status after the initial processing is completed.

Output type	Voltage output		Current output	
Output range	0 to 10 V, -10 to +10 V	1 to 5 V	0 to 20 mA	4 to 20 mA
Before range code is written	0 V		0 mA	
After range code is written	0 V	1 V	0 mA	4 mA

Therefore, create a program as shown below, so that when operation begins simultaneously with startup it will wait for valid set data.



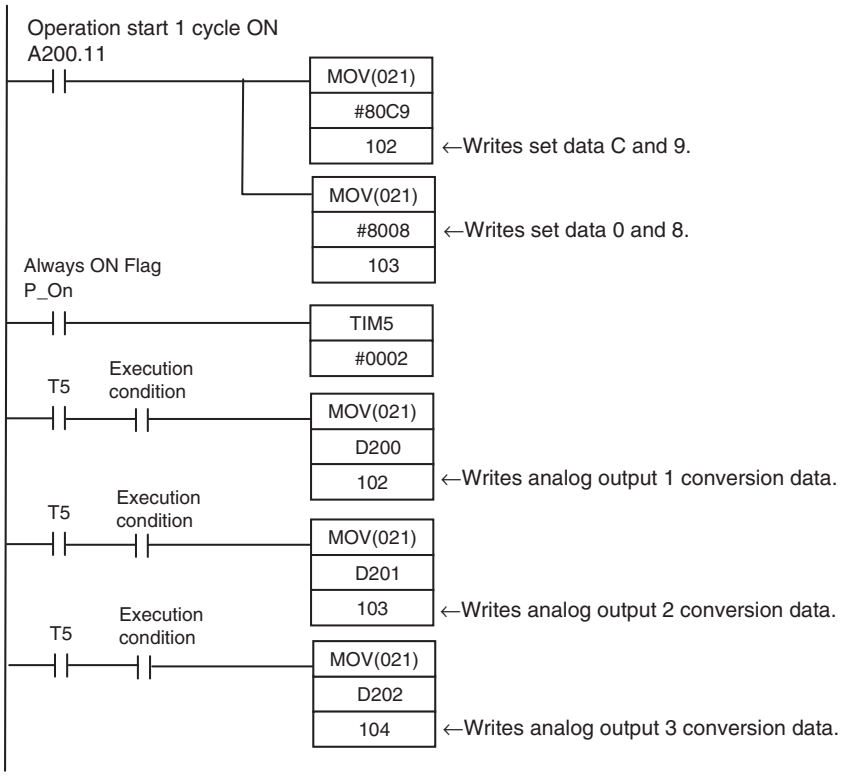
TIM 005 will start as soon as power turns ON. After 0.1 to 0.2 s (100 to 200 ms), the Completion Flag for TIM 005 will turn ON, and the data stored in DM 0100 will be moved to IR 102 as the conversion data for analog output 1.

Handling Unit Errors

- When an error occurs at the Analog Output Unit, the analog output will be 0 V or 0 mA. If a CPU Unit fatal error occurs when analog outputs are set in the 1 to 5 V or 4 to 20 mA range, 0 V or 0 mA will be output for a CPU error I/O bus error, and 1 V or 1 mA will be output for all other errors.
- Expansion Unit errors are output to bits 0 to 6 of word A436. The bits are allocated from A436.00 in order starting with the Unit nearest the CPU Unit. Use these flags in the program when it is necessary to detect errors.

Program Example

Analog output	Output range	Range code	Set data	Destination word
Output 1	0 to 10 V	001	1001 (9 hex)	Wd n+1
Output 2	4 to 20 mA	100	1100 (C hex)	Wd n+1
Output 3	-10 to 10 V	000	1000 (8 hex)	Wd n+2
Output 4	Not used.	-(000)	0000 (0 hex)	Wd n+2



7-4 Analog I/O Units

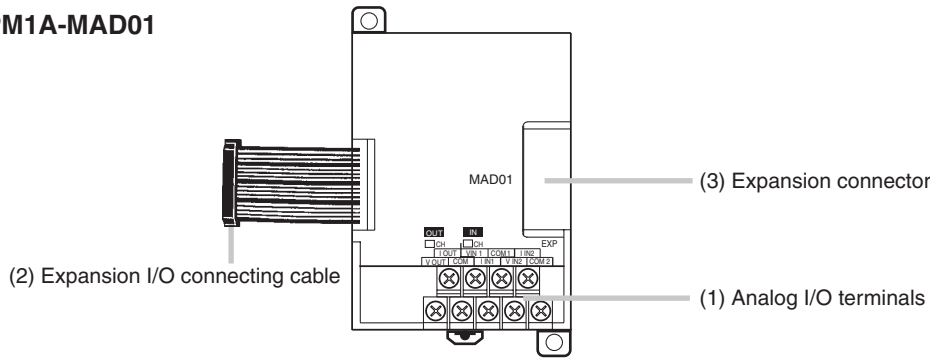
7-4-1 CPM1A-MAD01 Analog I/O Units

Each CPM1A-MAD01 Analog I/O Unit provides 2 analog inputs and 1 analog output.

- The analog input range can be set to 0 to 10 VDC, 1 to 5 VDC, or 4 to 20 mA with a resolution of 1/256.
  An open-circuit detection function can be used with the 1 to 5 VDC and 4 to 20 mA settings.
- The analog output range can be set to 0 to 10 VDC, −10 to 10 VDC, or 4 to 20 mA. The output has a resolution of 1/256 when the range is set to 0 to 10 VDC or 4 to 20 mA, or a resolution of 1/512 when set to −10 to 10 VDC.

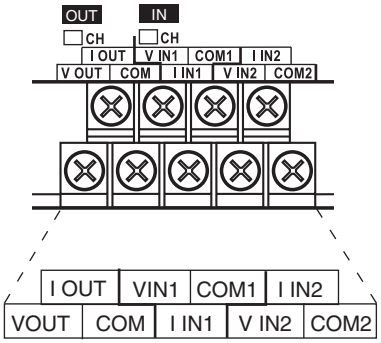
Part Names

CPM1A-MAD01



(1) Analog I/O Terminals
Connected to analog I/O devices.

I/O Terminal Arrangement



Note When using current inputs, short terminal V IN1 with I IN1 and terminal V IN2 with I IN2.

V OUT	Voltage output
I OUT	Current output
COM	Output common
V IN1	Voltage input 1
I IN1	Current input 1
COM1	Input common 1
V IN2	Voltage input 2
I IN2	Current input 2
COM2	Input common 2

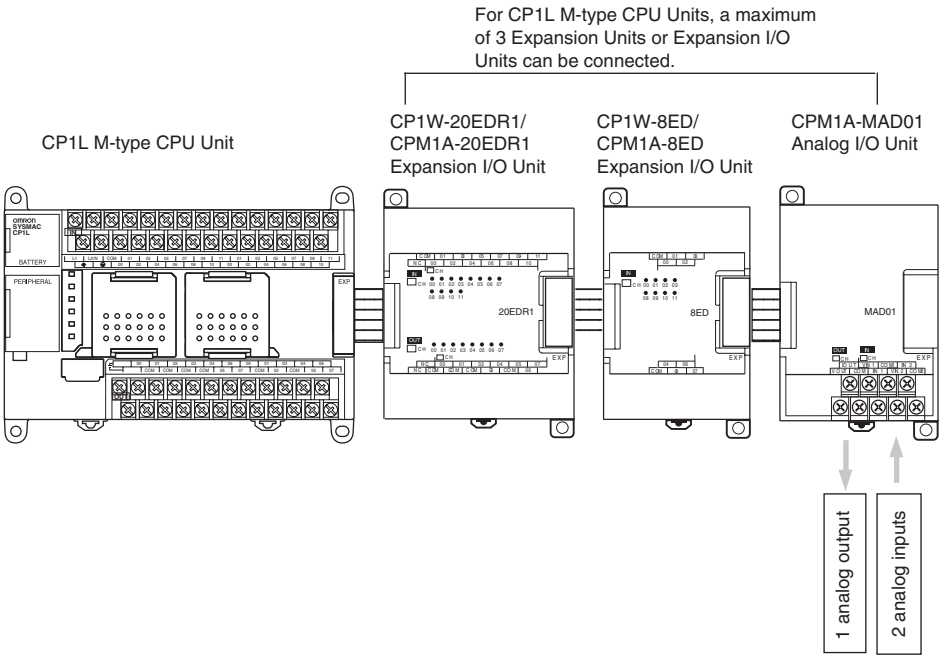
(2) Expansion I/O Connecting Cable
Connected to the expansion connector of a CP1L CPU Unit or an Expansion Unit or Expansion I/O Unit. The cable is provided with the Analog I/O Unit and cannot be removed.

⚠ **Caution** Do not touch the cables during operation. Static electricity may cause operating errors.

(3) Expansion Connector
Used for connecting Expansion Units or Expansion I/O Units.

Main Analog I/O Unit Specifications

Analog I/O Units are connected to the CP1L CPU Unit. For CP1L M-type CPU Units, up to three Units can be connected, including any other Expansion Units and Expansion I/O Units that are also connected.



Item		Voltage I/O	Current I/O
Analog Input Section	Number of inputs	2	
	Input signal range	0 to 10 V/1 to 5 V	4 to 20 mA
	Max. rated input	±15 V	±30 mA
	External input impedance	1 MΩ min.	250 Ω rated current
	Resolution	1/256	
	Accuracy	1.0% full scale	
	A/D conversion data	8-bit binary	
Analog Output Section (See note 2.)	Number of outputs	1	
	Output signal range	0 to 10 V or −10 to 10 V	4 to 20 mA
	Max. external output current	5 mA	---
	Allowable external output load resistance	---	350 Ω
	Resolution	1/256 (1/512 when the output signal range is −10 to 10 V)	
	Accuracy	1.0% of full scale	
	Set data	8-bit signed binary	
Conversion time		10 ms max. per Unit (See note 1.)	
Isolation method		Photocoupler isolation between I/O terminals and PC signals. No isolation between analog I/O signals.	
Current consumption		5 VDC: 66 mA max., 24 VDC: 66 mA max.	

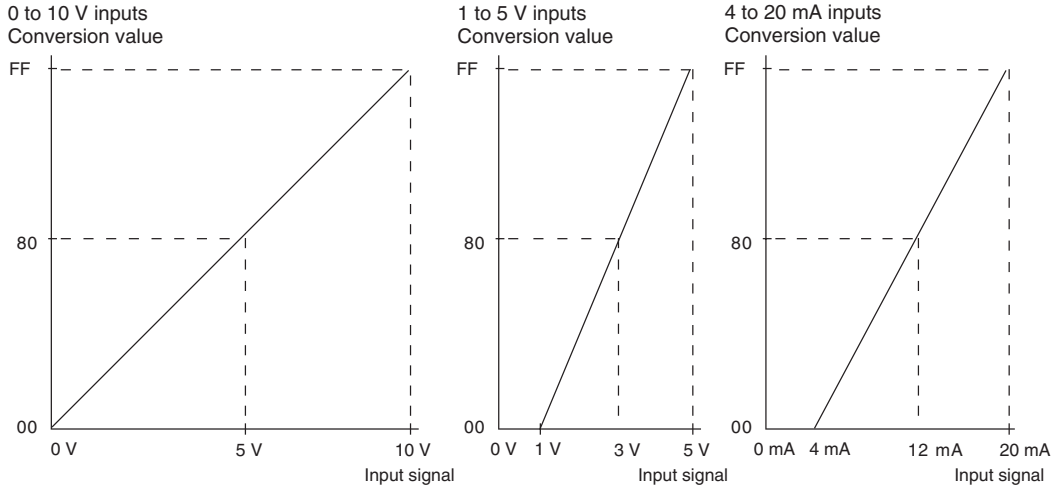
Note

(1) The conversion time is the total time for 2 analog inputs and 1 analog output.

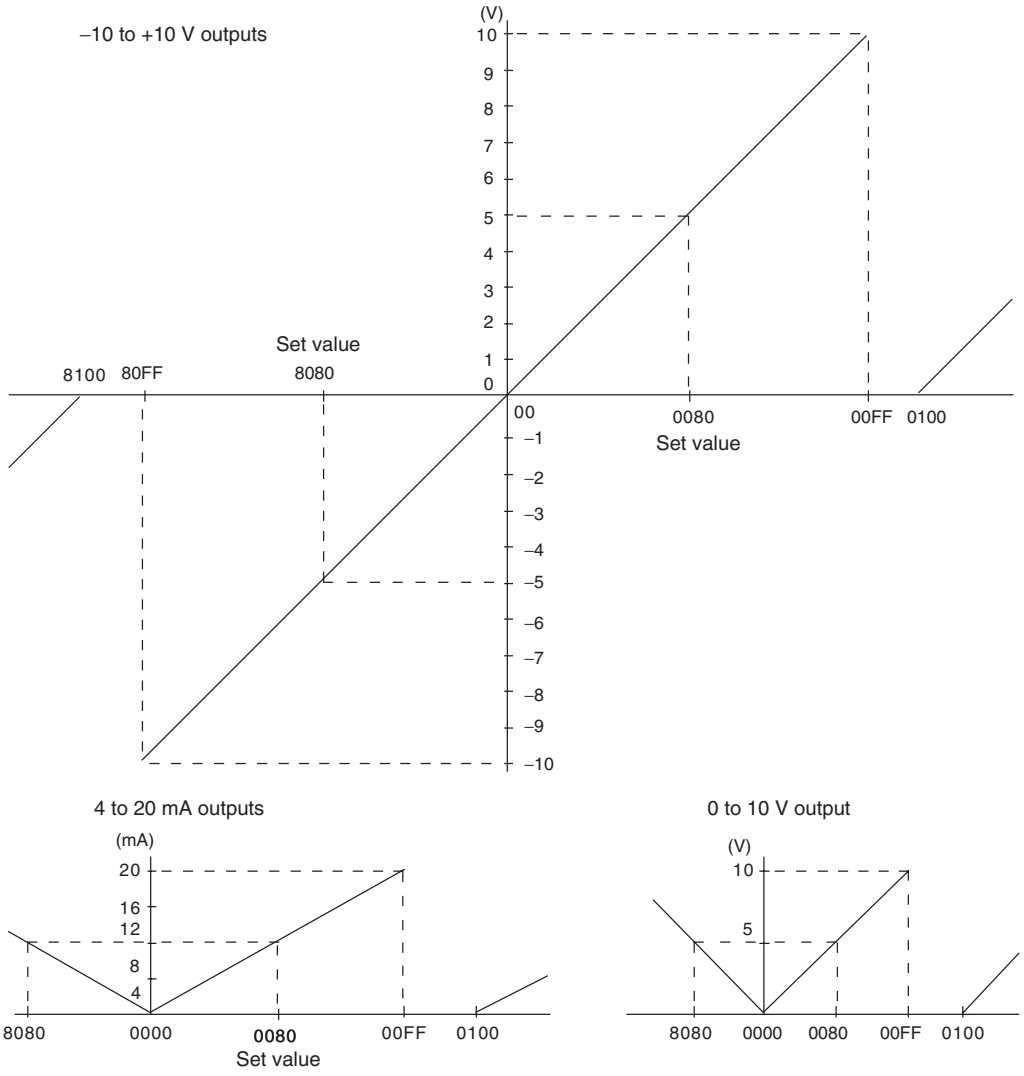
(2) With analog outputs it is possible to use both voltage outputs and current outputs at the same time. In this case however, the total output current must not exceed 21 mA.

Analog I/O Signal Ranges

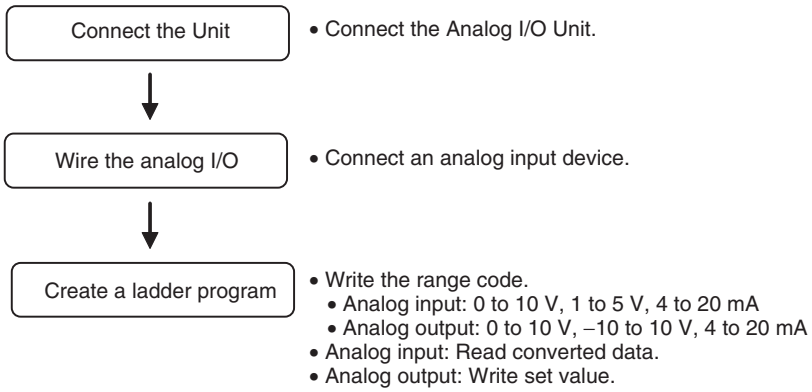
Analog Input Signal Ranges



Analog Output Signal Ranges

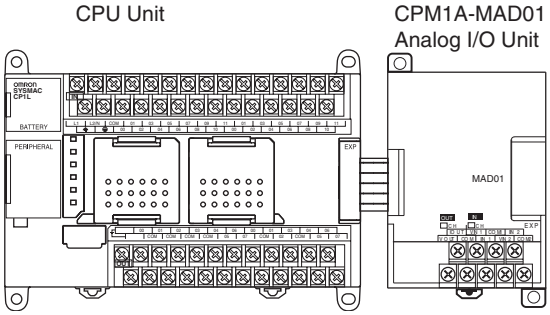


Using Analog I/O



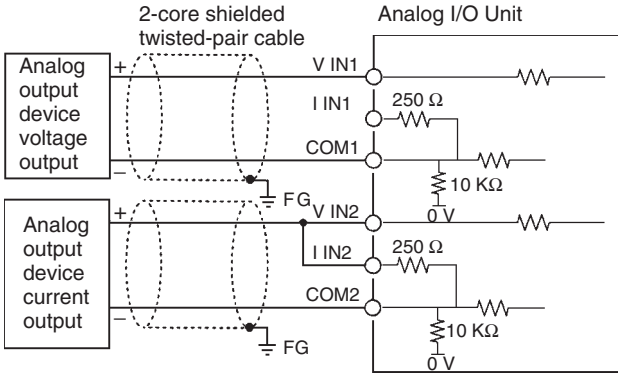
Connecting the Analog I/O Unit

Connect the Analog I/O Unit to the CPU Unit.



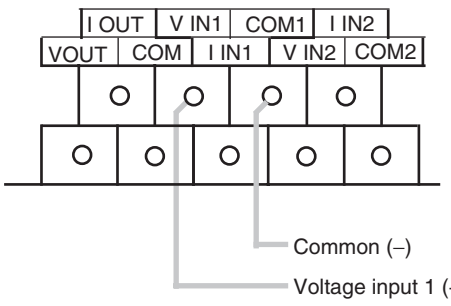
Wiring Analog I/O Devices

Analog Input Wiring

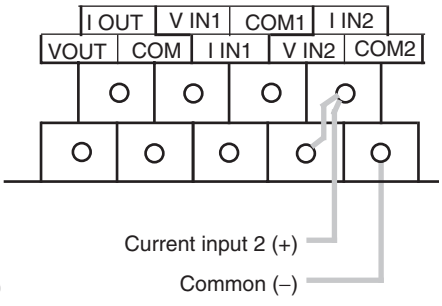


Analog I/O Wiring Example

Using analog input 1 as a voltage input

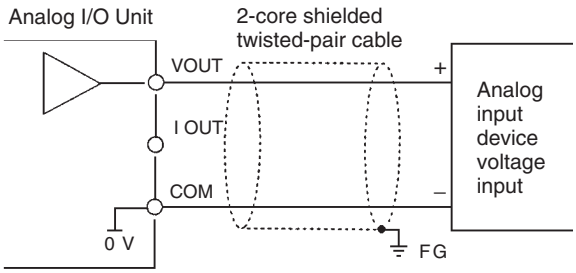


Using analog input 2 as a current input

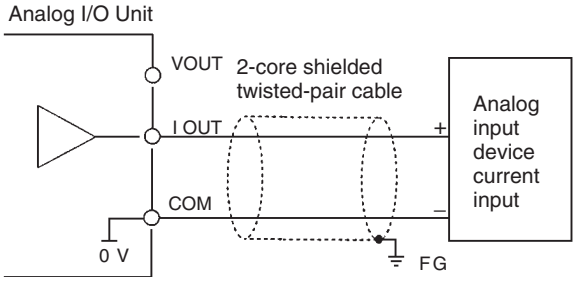


Analog Output Wiring

Voltage Outputs

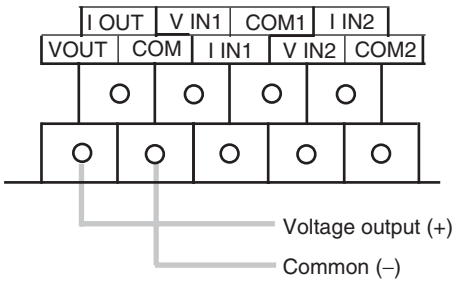


Current Outputs



Analog I/O Wiring Example

Using analog output as a voltage output



Note

(1) For analog outputs it is possible to use both voltage outputs and current outputs at the same time, but the total current output must not exceed 21 mA.

(2) Use 2-core shielded twisted-pair cables.

(3) Wire away from power lines (AC power supply wires, power lines, etc.)

(4) When an input is not being used, short V IN and I IN to the COM terminal.

(5) Use crimp terminals. (Tighten terminals to a torque of 0.5 N·m.)

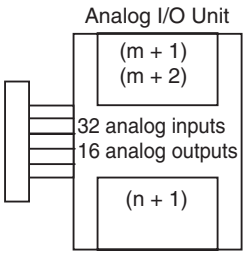
(6) When using current inputs, short V_{IN} to I_{IN}.

(7) When there is noise in the power supply line, install a noise filter on the input section and the power supply terminals.

Creating a Ladder Program

I/O Allocation

Two input words and one output word are allocated to the Analog I/O Unit, starting from the next word following the last allocated word on the CPU Unit or previous Expansion Unit or Expansion I/O Unit.



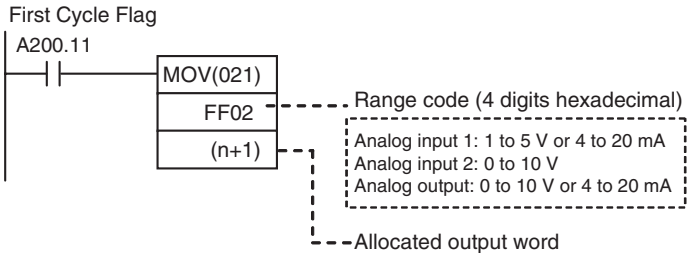
"m" is the last allocated input word and "n" the last allocated output word on the CPU Unit or previous Expansion Unit or Expansion I/O Unit.

Writing the Range Code

Write the range code to word n+1. A/D or D/A conversion begins when the range code is transferred from the CPU Unit to the Analog I/O Unit. There are eight range codes, FF00 to FF07, that combine both the analog input 1 and 2 and analog output signal ranges, as shown below.

Range code	Analog input 1 signal range	Analog input 2 signal range	Analog output signal range
FF00	0 to 10 V	0 to 10 V	0 to 10 V/4 to 20 mA
FF01	0 to 10 V	0 to 10 V	–10 to 10 V/4 to 20 mA
FF02	1 to 5 V/4 to 20 mA	0 to 10 V	0 to 10 V/4 to 20 mA
FF03	1 to 5 V/4 to 20 mA	0 to 10 V	–10 to 10 V/4 to 20 mA
FF04	0 to 10 V	1 to 5 V/4 to 20 mA	0 to 10 V/4 to 20 mA
FF05	0 to 10 V	1 to 5 V/4 to 20 mA	–10 to 10 V/4 to 20 mA
FF06	1 to 5 V/4 to 20 mA	1 to 5 V/4 to 20 mA	0 to 10 V/4 to 20 mA
FF07	1 to 5 V/4 to 20 mA	1 to 5 V/4 to 20 mA	–10 to 10 V/4 to 20 mA

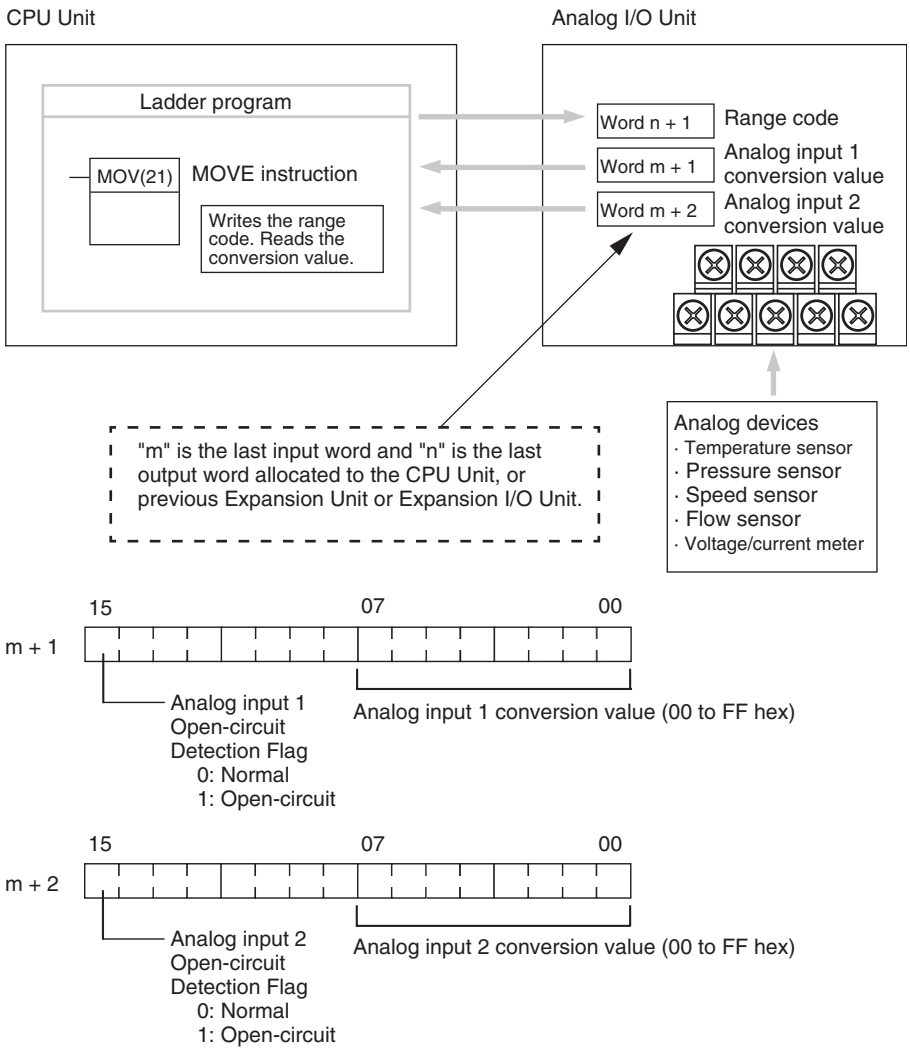
- The voltage/current selection is made by switching the wiring.
- Write the range code to the Analog I/O Unit output word (n + 1) in the first cycle of program execution.



- The Analog I/O Unit will not start converting analog I/O values until the range code has been written.
- Once the range code has been set, it is not possible to change the setting while power is being supplied to the CPU Unit. To change the I/O range, turn the CPU Unit OFF then ON again.
- If a range code other than those specified in the above table is written to n+1, the range code will not be received by the Analog I/O Unit and analog I/O conversion will not start.

Reading A/D Conversion Tables

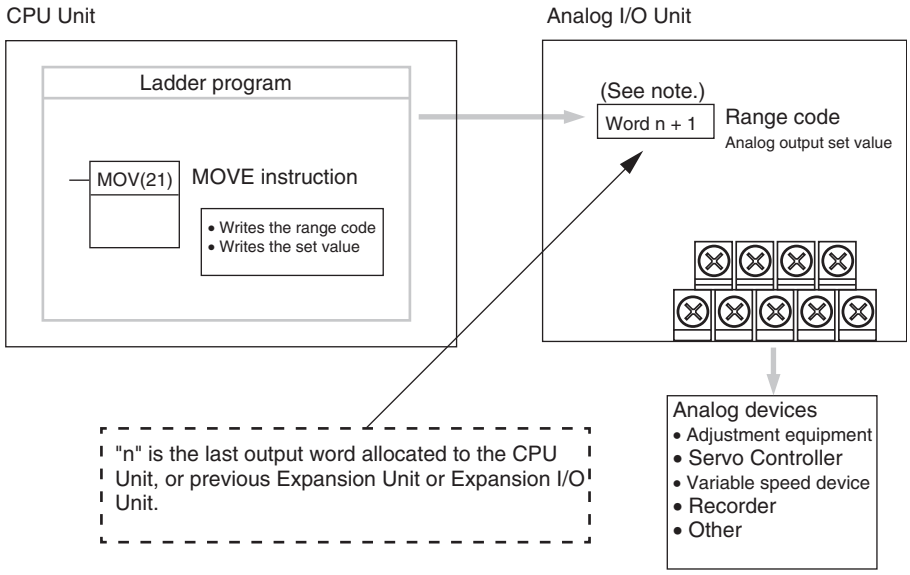
Data converted from analog to digital is output to bits 00 to 07 in words m+1 and m+2.



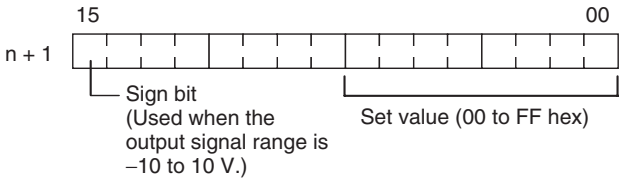
Note The Open-circuit Detection Flag is turned ON if the input signal range is set to 1 to 5 V or 4 to 20 mA and the input signal falls below 1 V or 4 mA. (Open circuits are not detected when the input signal range is set to 0 to 10 V.)

Setting D/A Conversion Data

Output data is written to the Analog I/O Unit's allocated output word, word n+1.



Note Word (n + 1) can be used for either the range code or the analog output set value.



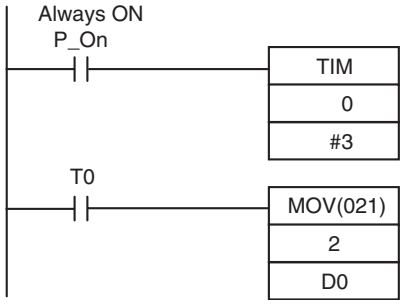
1,2,3...

1. The set value range is 0000 to 00FF hex when the output signal range is 0 to 10 V/4 to 20 mA.
2. The set value range is divided into two parts: 8000 to 80FF hex (–10 to 0 V) and 0000 to 00FF hex (0 to 10 V) when the output signal range is –10 to 10 V.
3. If FF□□ is input, 0 V/4 mA will be output.
4. If an output value is specified, the following bits will be ignored.
   - Output range of –10 to 10 V: Bits 08 to 14
   - Output range of 0 to 10 V/4 to 20 mA: Bits 08 to 15

Startup Operation

After power is turned ON, it will require two cycle times plus approx. 100 ms before the first data is converted. The following instructions can be placed at the beginning of the program to delay reading converted data from analog inputs until conversion is actually possible.

Analog input data will be 0000 until initial processing has been completed. Analog output data will be 0 V or 0 mA until the range code has been written. After the range code has been written, the analog output data will be 0 V or 4 mA if the range is 0 to 10 V, –10 to 10 V, or 4 to 20 mA.



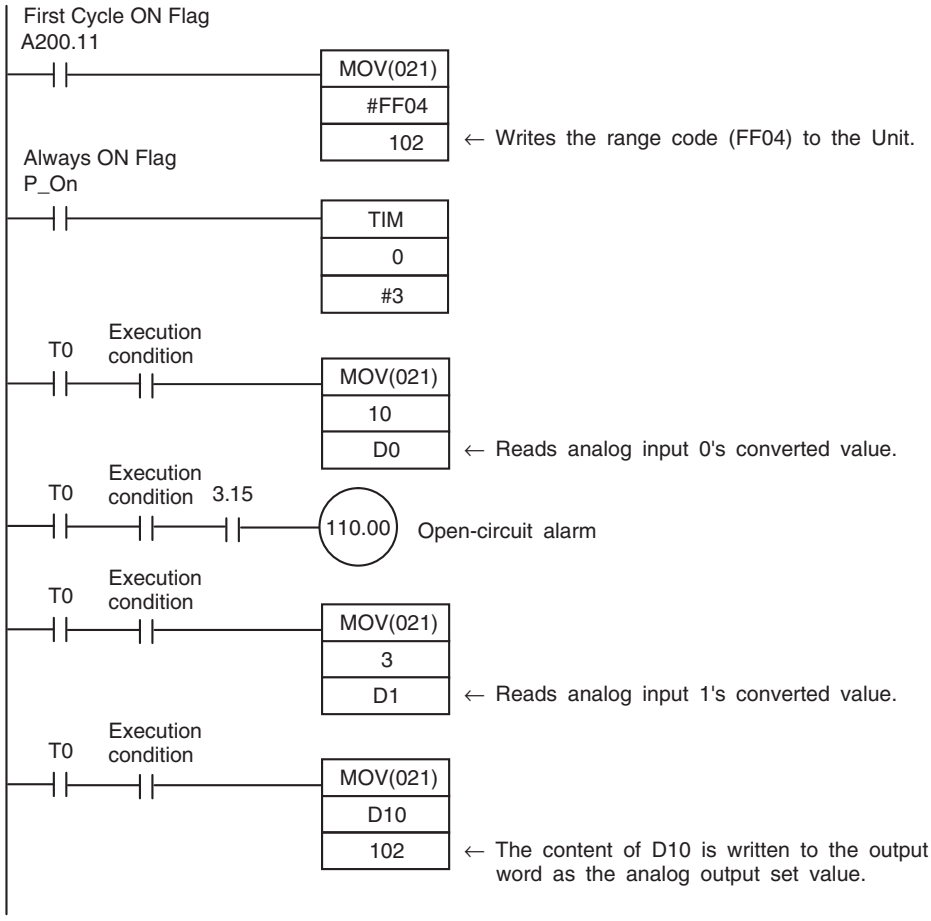
TIM 0 will start as soon as power turns ON. After 0.2 to 0.3 s (200 to 300 ms), the input for TIM 0 will turn ON, and the converted data from analog input 0 that is stored in word 2 will be transferred to D00000.

Handling Unit Errors

- When an error occurs in the Analog I/O Unit, analog input data will be 0000 and 0 V or 4 mA will be output as the analog output.
- Expansion Unit/Expansion I/O Unit errors are output to bits 0 to 6 of word A436. The bits are allocated from A436.00 in order starting with the Unit nearest the CPU Unit. Use these flags in the program when it is necessary to detect errors.

Programming Example

This programming example uses these ranges:
Analog input 0: 0 to 10 V
Analog input 1: 1 to 5 V or 4 to 20 mA
Analog output: 0 to 10 V or 4 to 20 mA



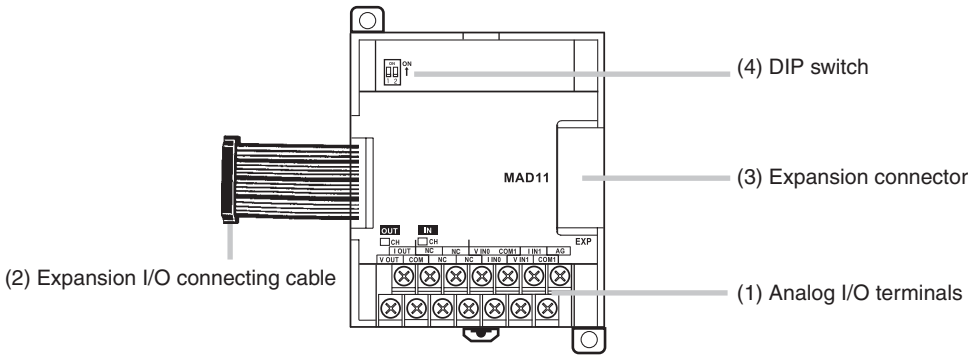
7-4-2 CP1W-MAD11/CPM1A-MAD11 Analog I/O Units

Each CP1W-MAD11/CPM1A-MAD11 Analog I/O Unit provides 2 analog inputs and 1 analog output.

- The analog input range can be set to 0 to 5 VDC, 1 to 5 VDC, 0 to 10 VDC, −10 to 10 VDC, 0 to 20 mA, or 4 to 20 mA. The inputs have a resolution of 1/6000.
  An open-circuit detection function can be used with the 1 to 5 VDC and 4 to 20 mA settings.
- The analog output range can be set to 1 to 5 VDC, 0 to 10 VDC, −10 to 10 VDC, 0 to 20 mA, or 4 to 20 mA. The outputs have a resolution of 1/6000.

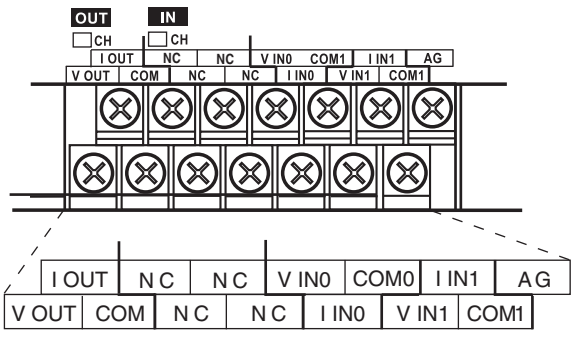
Part Names

CP1W-MAD11/CPM1A-MAD11



(1) Analog I/O Terminals
Connected to analog I/O devices.

CPM1A-MAD11 Terminal Arrangements



Note For current inputs, short V IN0 to I IN0 and V IN1 to I IN1.

V OUT	Voltage output
I OUT	Current output
COM	Output common
V IN0	Voltage input 0
I IN0	Current input 0
COM0	Input common 0
V IN1	Voltage input 1
I IN1	Current input 1
COM1	Input common 1

(2) Expansion I/O Connecting Cable
Connected to the expansion connector of a CP1L CPU Unit or a CMP1A Expansion Unit or Expansion I/O Unit. The cable is provided with the Analog I/O Unit and cannot be removed.

⚠ **Caution** Do not touch the cables during operation. Static electricity may cause operating errors.

(3) Expansion Connector
Used for connecting Expansion Units or Expansion I/O Units.

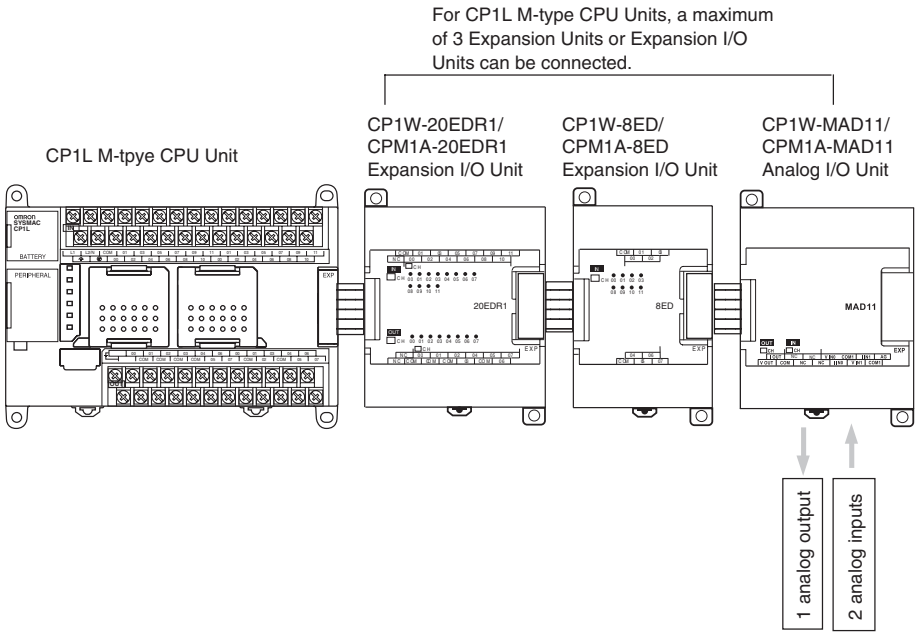
(4) DIP Switch
Used to enable or disable averaging.



Pin1: Average processing for analog input 0
(OFF: Average processing not performed; ON: Average processing performed)
Pin2: Average processing for analog input 1
(OFF: Average processing not performed; ON: Average processing performed)

Main Analog I/O Unit Specifications

Analog I/O Units are connected to the CP1L CPU Unit. For CP1L M-type CPU Units, up to three Units can be connected, including any other Expansion Units and Expansion I/O Units that are also connected.



Item			Voltage I/O	Current I/O
Analog Input Section	Number of inputs		2 inputs (2 words allocated)	
	Input signal range		0 to 5 VDC, 1 to 5 VDC, 0 to 10 VDC, or −10 to 10 VDC	0 to 20 mA or 4 to 20 mA
	Max. rated input		±15 V	±30 mA
	External input impedance		1 MΩ min.	Approx. 250 Ω
	Resolution		1/6000 (full scale)	
	Overall accuracy	25°C	0.3% full scale	0.4% full scale
		0 to 55°C	0.6% full scale	0.8% full scale
	A/D conversion data		16-bit binary (4-digit hexadecimal) Full scale for −10 to 10 V: F448 to 0BB8 hex Full scale for other ranges: 0000 to 1770 hex	
	Averaging function		Supported (Settable for individual inputs via DIP switch)	
	Open-circuit detection function		Supported	
Analog Output Section	Number of outputs		1 output (1 word allocated)	
	Output signal range		1 to 5 VDC, 0 to 10 VDC, or −10 to 10 VDC,	0 to 20 mA or 4 to 20 mA
	Allowable external output load resistance		1 kΩ min.	600 Ω max.
	External output impedance		0.5 Ω max.	
	Resolution		1/6000 (full scale)	
	Overall accuracy y	25°C	0.4% full scale	
		0 to 55°C	0.8% full scale	
	Set data (D/A conversion)		16-bit binary (4-digit hexadecimal) Full scale for −10 to 10 V: F448 to 0BB8 hex Full scale for other ranges: 0000 to 1770 hex	
Conversion time			2 ms/point (6 ms/all points)	
Isolation method			Photocoupler isolation between analog I/O terminals and internal circuits. No isolation between analog I/O signals.	
Current consumption			5 VDC: 83 mA max., 24 VDC: 110 mA max.	

Analog I/O Signal Ranges

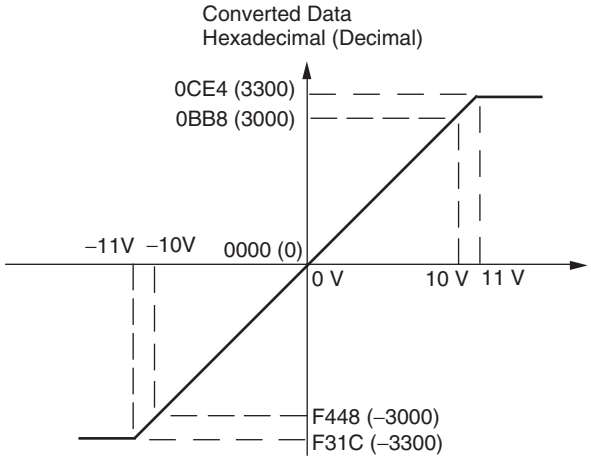
Analog I/O data is digitally converted according to the analog I/O signal range as shown below.

Note When the input exceeds the specified range, the AD converted data will be fixed at either the lower limit or upper limit.

Analog Input Signal Ranges

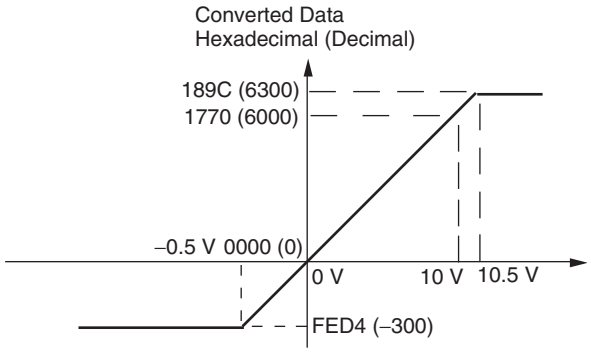
−10 to 10 V

The −10- to 10-V range corresponds to the hexadecimal values F448 to 0BB8 (−3000 to 3000). The entire data range is F31C to 0CE4 (−3300 to 3300). A negative voltage is expressed as a two's complement.



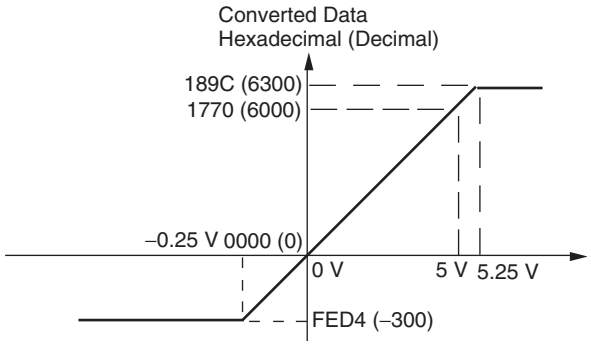
0 to 10 V

The 0- to 10-V range corresponds to the hexadecimal values 0000 to 1770 (0 to 6000). The entire data range is FED4 to 189C (−300 to 6300). A negative voltage is expressed as a two's complement.



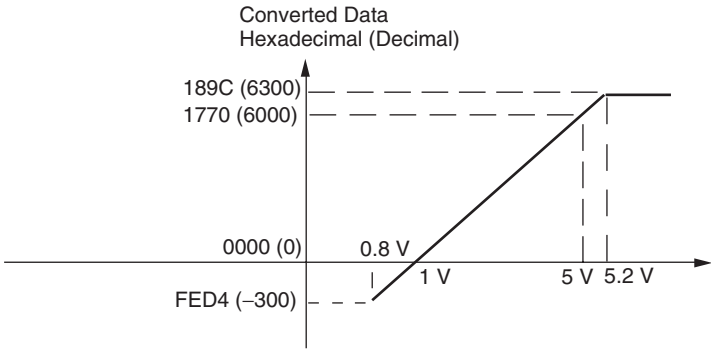
0 to 5 V

The 0- to 5-V range corresponds to the hexadecimal values 0000 to 1770 (0 to 6000). The entire data range is FED4 to 189C (−300 to 6300). A negative voltage is expressed as a two's complement.



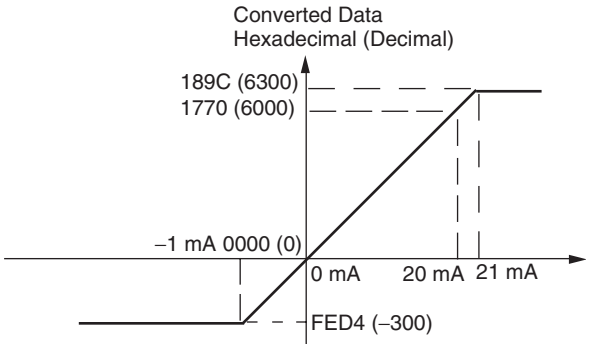
1 to 5 V

The 1- to 5-V range corresponds to the hexadecimal values 0000 to 1770 (0 to 6000). The entire data range is FED4 to 189C (–300 to 6300). Inputs between 0.8 and 1 V are expressed as two's complements. If the input falls below 0.8 V, open-circuit detection will activate and converted data will be 8000.



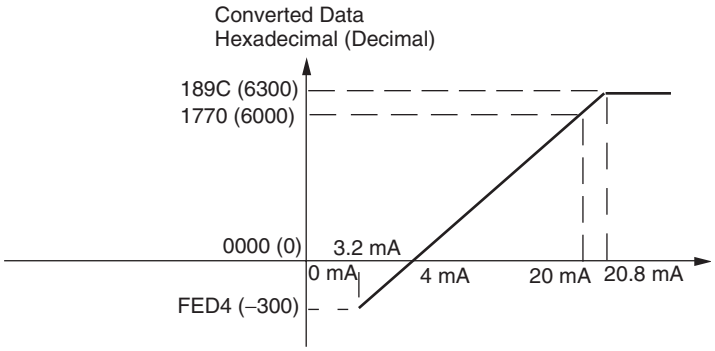
0 to 20 mA

The 0- to 20-mA range corresponds to the hexadecimal values 0000 to 1770 (0 to 6000). The entire data range is FED4 to 189C (–300 to 6300). A negative voltage is expressed as a two's complement.



4 to 20 mA

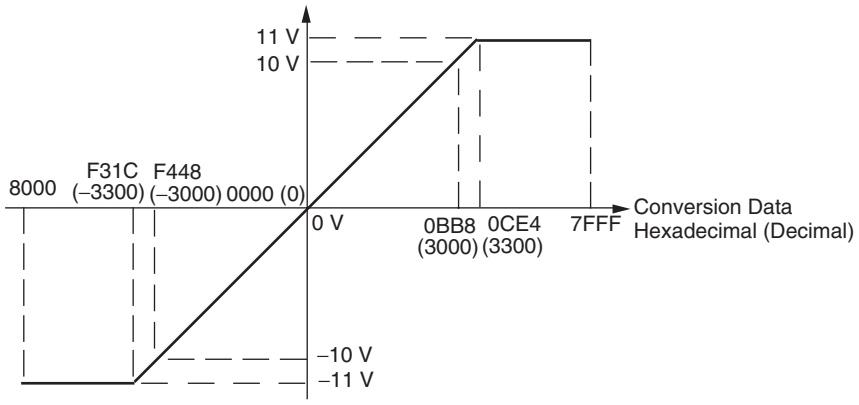
The 4- to 20-mA range corresponds to the hexadecimal values 0000 to 1770 (0 to 6000). The entire data range is FED4 to 189C (–300 to 6300). Inputs between 3.2 and 4 mA are expressed as two's complements. If the input falls below 3.2 mA, open-circuit detection will activate and converted data will be 8000.



Analog Output Signal Ranges

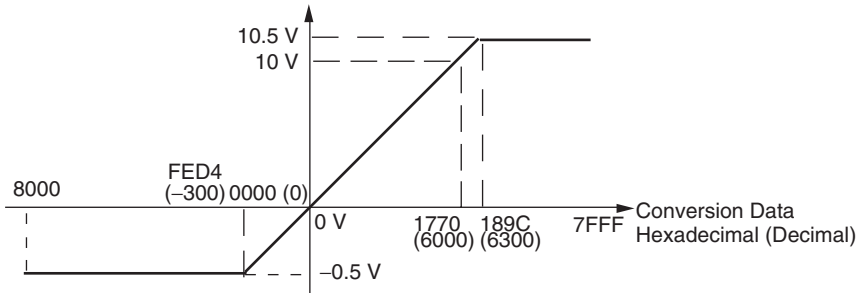
–10 to 10 V

The hexadecimal values F448 to 0BB8 (–3000 to 3000) correspond to an analog voltage range of –10 to 10 V. The entire output range is –11 to 11 V. Specify a negative voltage as a two's complement.



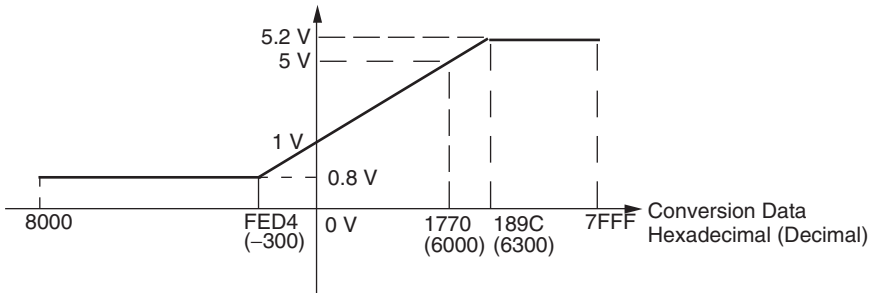
0 to 10 V

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog voltage range of 0 to 10 V. The entire output range is –0.5 to 10.5 V. Specify a negative voltage as a two's complement.



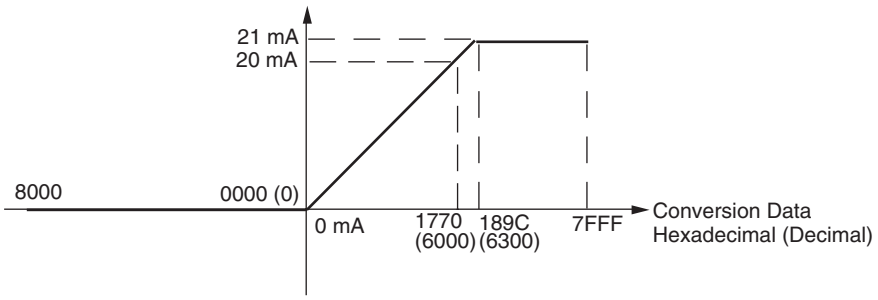
1 to 5 V

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog voltage range of 1 to 5 V. The entire output range is 0.8 to 5.2 V.



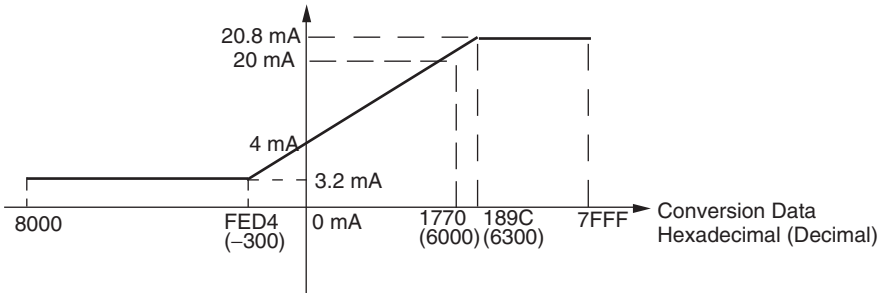
0 to 20 mA

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog current range of 0 to 20 mA. The entire output range is 0 to 21 mA.



4 to 20 mA

The hexadecimal values 0000 to 1770 (0 to 6000) correspond to an analog current range of 4 to 20 mA. The entire output range is 3.2 to 20.8 mA.



Averaging Function for Analog Inputs

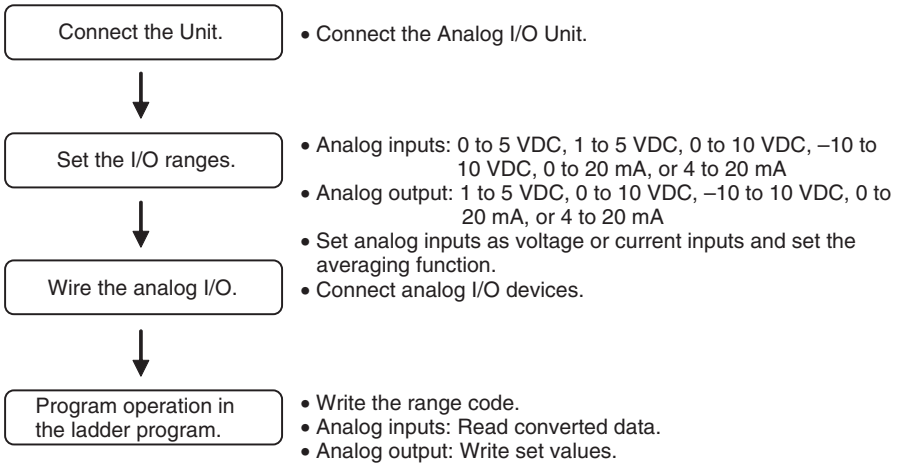
The averaging function can be enabled for inputs using the DIP switch. The averaging function stores the average (a moving average) of the last eight input values as the converted value. Use this function to smooth inputs that vary at a short interval.

Open-circuit Detection Function for Analog Inputs

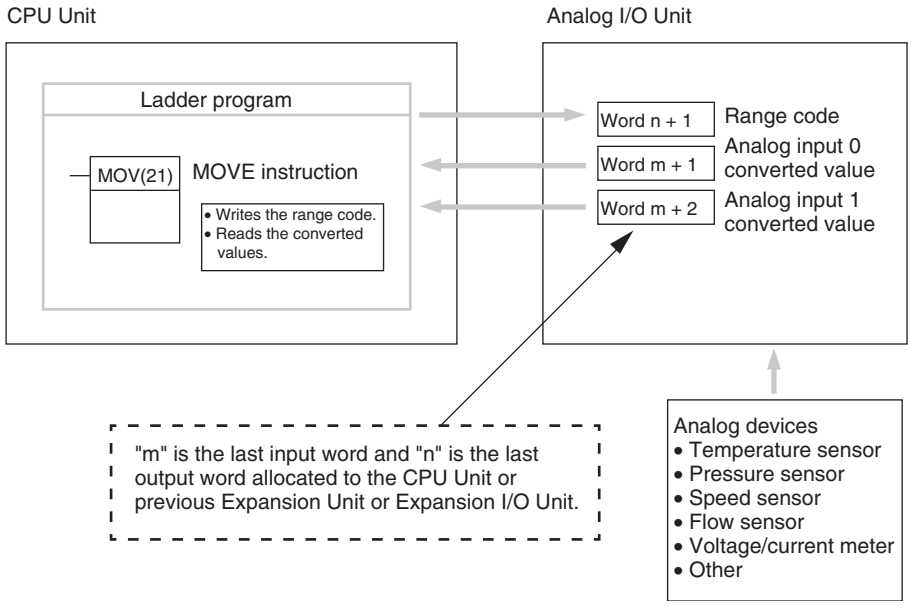
The open-circuit detection function is activated when the input range is set to 1 to 5 V and the voltage drops below 0.8 V, or when the input range is set to 4 to 20 mA and the current drops below 3.2 mA. When the open-circuit detection function is activated, the converted data will be set to 8,000.

The time for enabling or clearing the open-circuit detection function is the same as the time for converting the data. If the input returns to the convertible range, the open-circuit detection is cleared automatically and the output returns to the normal range.

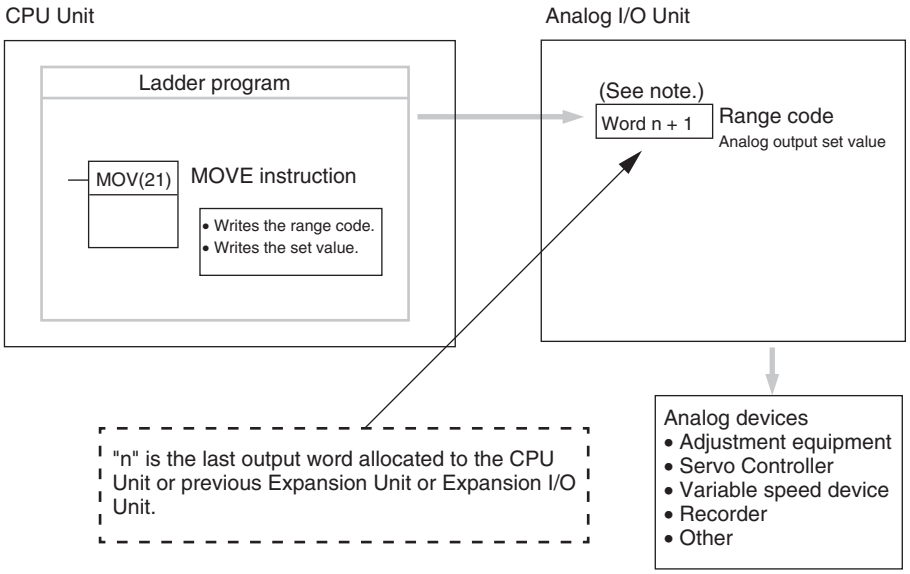
Using Analog I/O



Reading Range Code Settings and A/D Conversion Data



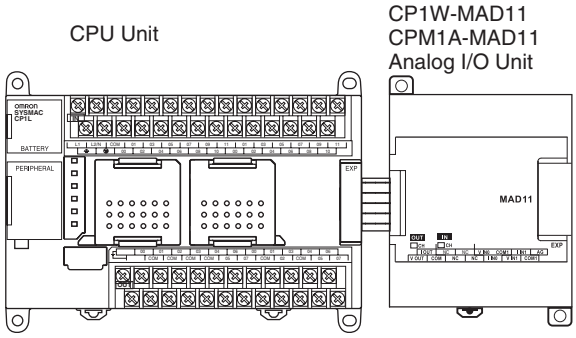
Writing D/A Conversion Data



Note Word (n + 1) can be used for either the range code or the analog output set value.

Connecting the Analog I/O Unit and Setting the DIP Switch

This section describes how to connect an Analog I/O Unit to the CPU Unit.



Setting the Averaging Function

DIP switch pins 1-1 and 1-2 are used to set the averaging function. When averaging is enabled, a moving average of the last eight input values is output as the converted value. The averaging function can be set separately for analog inputs 1 and 2.

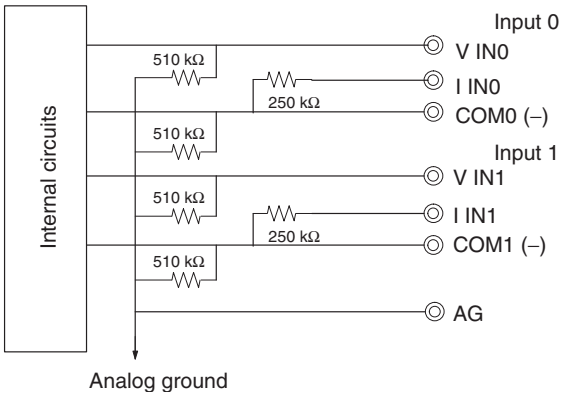


DIP switch pin	Function	Setting	Default
1-1	Averaging	Analog input 0 OFF: Disabled; ON: Enabled	OFF
1-2		Analog input 1 OFF: Disabled; ON: Enabled	OFF

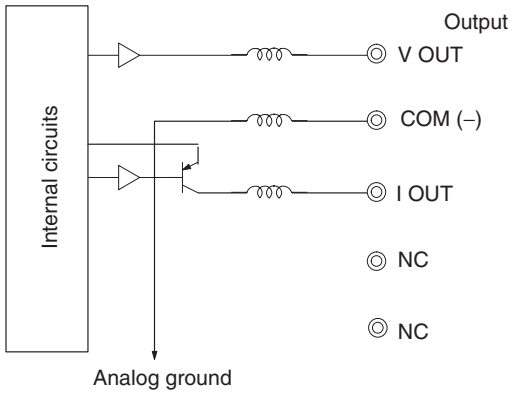
Wiring Analog I/O Devices

Internal Circuits

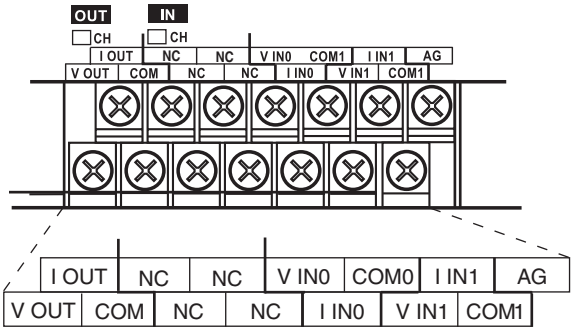
Analog Inputs



Analog Outputs



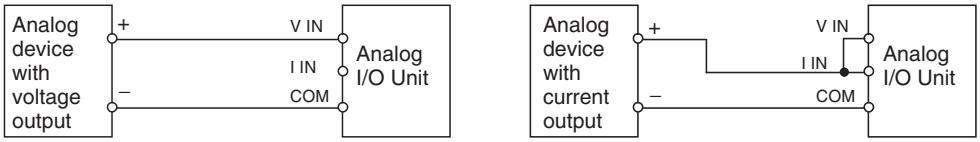
Terminal Arrangements



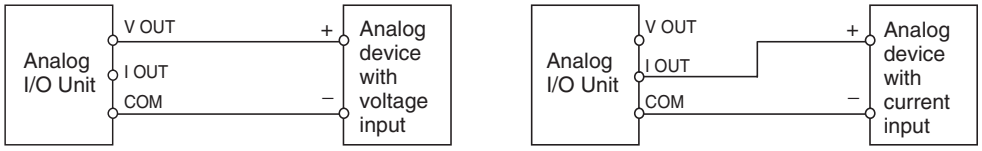
Note For current inputs, short V IN0 to I IN0 and V IN1 to I IN1.

V OUT	Voltage output
I OUT	Current output
COM	Output common
V IN0	Voltage input 0
I IN0	Current input 0
COM0	Input common 0
V IN1	Voltage input 1
I IN1	Current input 1
COM1	Input common 1

Wiring for Analog Inputs



Wiring for Analog Outputs



Note

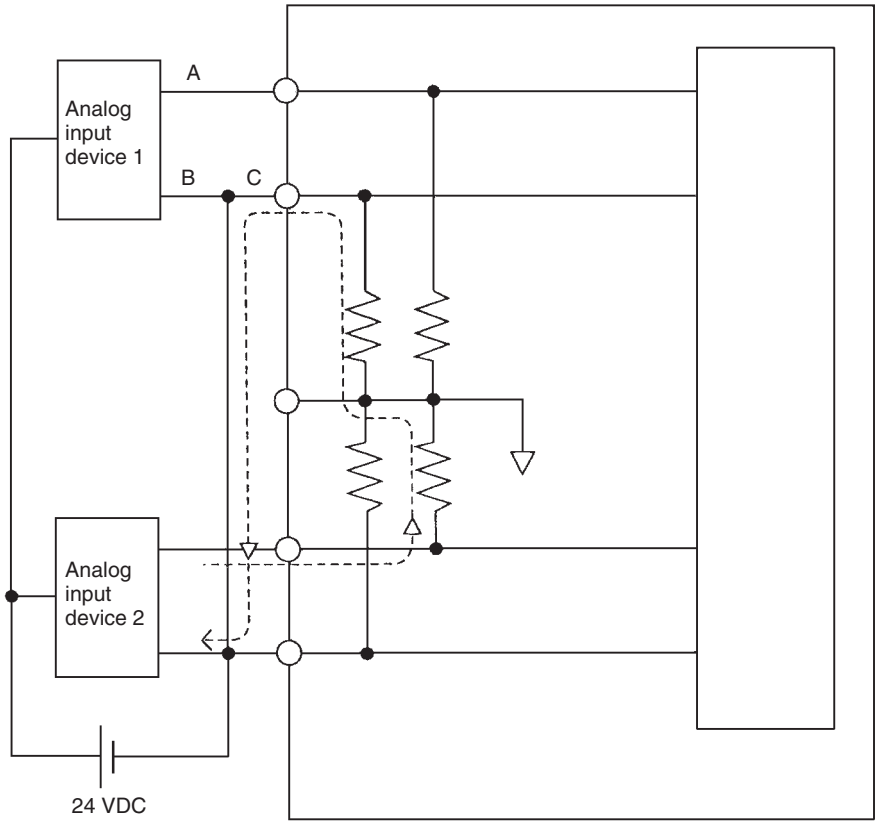
(1) Use shielded twisted-pair cables, but do not connect the shield.

(2) When an input is not being used, short the + and – terminals.

(3) Separate wiring from power lines (AC power supply lines, high-voltage lines, etc.)

(4) When there is noise in the power supply line, install a noise filter on the input section and the power supply terminals.

(5) Refer to the following diagram regarding wiring disconnections when voltage input is being used.



Example: If analog input device 2 is outputting 5 V and the same power supply is being used for both devices as shown above, approximately 1/3, or 1.6 V, will be applied to the input for input device 1.

If a wiring disconnection occurs when voltage input is being used, the situation described below will result. Either separate the power supplies for the connected devices, or use an isolator for each input.

If the same power supply is being used by the connected devices and a disconnection occurs at points A or B in the above diagram, an unwanted circuit path will occur as shown along the dotted line in the diagram. If that occurs, a voltage of approximately 1/3 to 1/2 of the output voltage of the other connected device will be generated. If that voltage is generated while the setting is for 1 to 5 V, open-circuit detection may not be possible. Also, if a disconnection occurs at point C in the diagram, the negative (-) side will be used in for both devices and open-circuit detection will not be possible.

This problem will not occur for current inputs even if the same power supply is used.

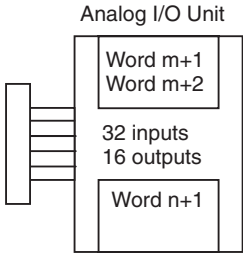
Note When external power is supplied (when setting the range code), or when there is a power interruption, pulse-form analog output of up to 1 ms may be generated. If this causes problems with operation, take countermeasures such as those suggested below.

- Turn ON the power supply for the CP1L CPU Unit first, and then turn ON the power supply for the load after confirming correct operation.
- Turn OFF the power supply for the load before turning OFF the power supply for the CP1L CPU Unit.

Creating a Ladder Program

I/O Allocation

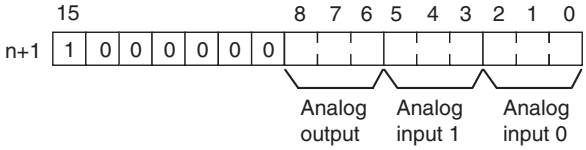
Two input words and one output word are allocated to the Analog I/O Unit starting from the next word following the last allocated word on the CPU Unit or previous Expansion Unit or Expansion I/O Unit.



Writing the Range Code

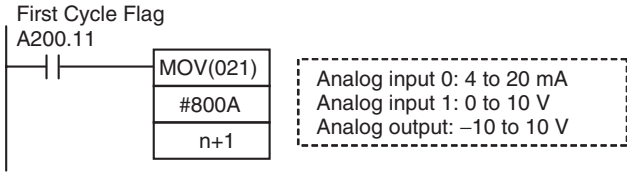
Write the range code to word n+1. A/D or D/A conversion begins when the range code is transferred from the CPU Unit to the Analog I/O Unit. There are five range codes, 000 to 100, that combine the analog input 1 and 2 and analog output signal ranges, as shown below.

Range code	Analog input 0 signal range	Analog input 1 signal range	Analog output signal range
000	–10 to 10 V	–10 to 10 V	–10 to 10 V
001	0 to 10 V	0 to 10 V	0 to 10 V
010	1 to 5 V/4 to 20 mA	1 to 5 V/4 to 20 mA	1 to 5 V
011	0 to 5 V/0 to 20 mA	0 to 5 V/0 to 20 mA	0 to 20 mA
100	---	---	4 to 20 mA



Example

The following instructions set analog input 0 to 4 to 20 mA, analog input 1 to 0 to 10 V, and the analog output to –10 to 10 V.



- The Analog I/O Unit will not start converting analog I/O values until the range code has been written. Until conversion starts, inputs will be 0000, and 0 V or 0 mA will be output.
- After the range code has been set, 0 V or 0 mA will be output for the 0 to 10-V, –10 to 10-V, or 0 to 20-mA ranges, and 1 V or 4 mA will be output for the 1 to 5-V and 4 to 20-mA ranges until a convertible value has been written to the output word.
- Once the range code has been set, it is not possible to change the setting while power is being supplied to the CPU Unit. To change the I/O range, turn the CPU Unit OFF then ON again.

Reading Converted Analog Input Values

The ladder program can be used to read the memory area words where the converted values are stored. Values are output to the next two words (m + 1, m + 2) following the last input word (m) allocated to the CPU Unit or previous Expansion Unit or Expansion I/O Unit.

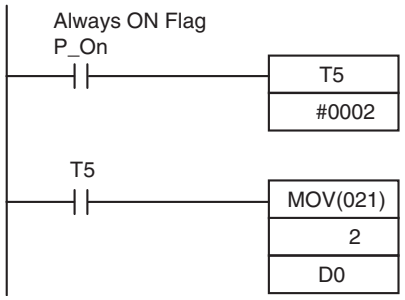
Writing Analog Output Set Values

The ladder program can be used to write data to the memory area where the set value is stored. The output word will be "n+1," where "n" is the last output word allocated to the CPU Unit or previous Expansion Unit or Expansion I/O Unit.

Startup Operation

After power is turned ON, it will require two cycle times plus approx. 50 ms before the first data is converted. The following instructions can be placed at the beginning of the program to delay reading converted data from analog inputs until conversion is actually possible.

Analog input data will be 0000 until initial processing has been completed. Analog output data will be 0 V or 0 mA until the range code has been written. After the range code has been written, the analog output data will be 0 V or 0 mA if the range is 0 to 10 V, −10 to 10 V, or 0 to 20 mA, or it will be 1 V or 4 mA if the range is 1 to 5 V or 4 to 20 mA.



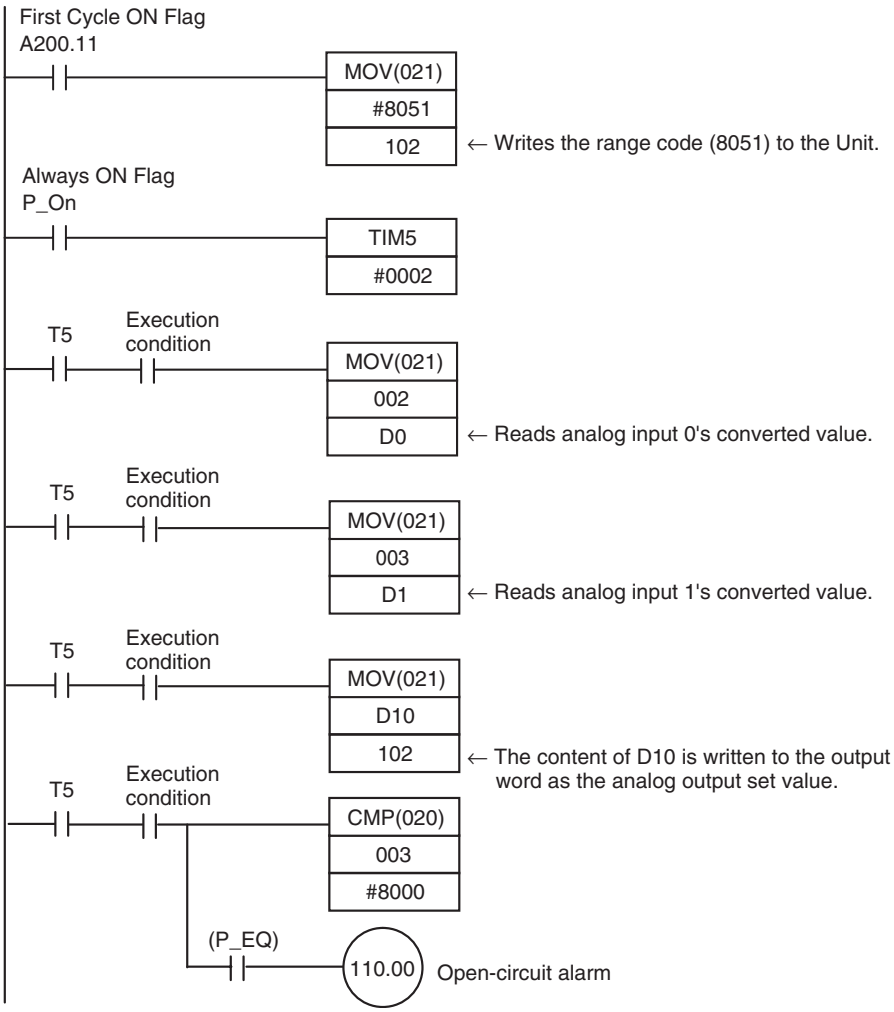
TIM 5 will start as soon as power turns ON. After 0.1 to 0.2 s (100 to 200 ms), the input for TIM 5 will turn ON, and the converted data from analog input 0 that is stored in word 2 will be transferred to D00000.

Handling Unit Errors

- When an error occurs in the Analog I/O Unit, analog input data will be 0000 and 0 V or 0 mA will be output as the analog output.
  If a CPU error or an I/O bus error (fatal errors) occurs at the CPU Unit and the analog output is set to 1 to 5 V or 4 to 20 mA, 0 V or 0 mA will be output. For any other fatal errors at the CPU Unit, 1 V or 4 mA will be output.
- Expansion Unit and Expansion I/O Unit errors are output to bits 0 to 6 of word A436. The bits are allocated from A436.00 in order starting from the Unit nearest the CPU Unit. Use these flags in the program when it is necessary to detect errors.

Programming Example

This programming example uses these ranges:
Analog input 0: 0 to 10 V
Analog input 1: 4 to 20 mA
Analog output: 0 to 10 V



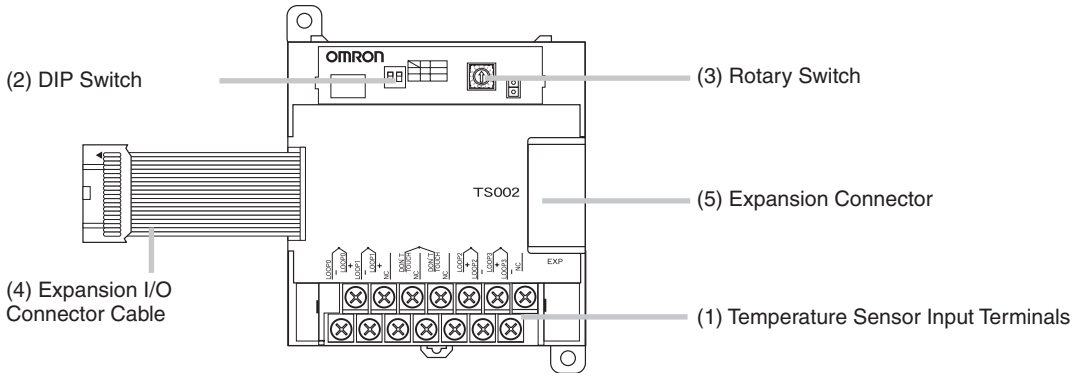
7-5 Temperature Sensor Units

CP1W-TS002/TS102 and CPM1A-TS002/TS102 Temperature Sensor Units each provide up to four input points, and CP1W-TS001/TS001 and CPM1A-TS001/TS101 Temperature Sensor Units each provide up to two input points. The inputs can be from thermocouples or platinum resistance thermometers.

CP1W-TS002/TS102 and CPM1A-TS002/TS102 Temperature Sensor Units are each allocated four input words.

Part Names

Temperature Sensor Units:
CP1W-TS□□□
and CPM1A-TS□□□



(1) Temperature Sensor Input Terminals
Used to connect temperature sensors such as thermocouples or platinum resistance thermometers.

(2) DIP Switch
Used to set the temperature unit (°C or °F) and the number of decimal places used.

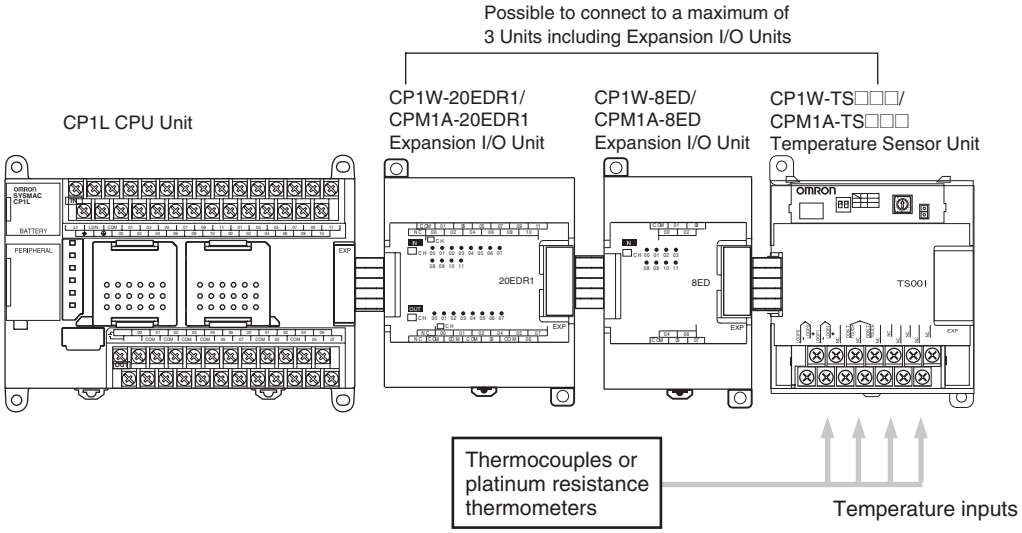
(3) Rotary Switch
Used to set the temperature input range. Make the setting according to the specifications of the temperature sensors that are connected.

(4) Expansion I/O Connecting Cable
Connected to the expansion connector of a CP1L CPU Unit or a Expansion Unit or Expansion I/O Unit. The cable is included with the Temperature Sensor Unit and cannot be removed.

Note Do not touch the cables during operation. Static electricity may cause operating errors.

(5) Expansion Connector
Used for connecting Expansion Units or Expansion I/O Units.

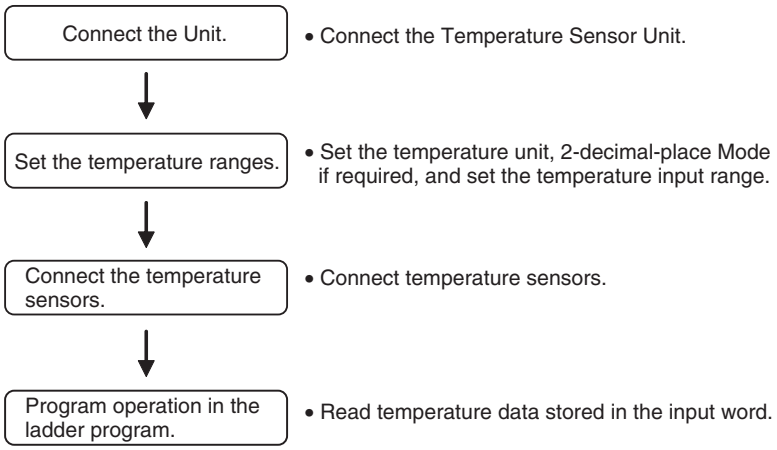
Main Specifications



Item	CP1W-TS001 CPM1A-TS001	CP1W-TS002 CPM1A-TS002	CP1W-TS101 CPM1A-TS101	CP1W-TS102 CPM1A-TS102
Temperature sensors	Thermocouples		Platinum resistance thermometer	
	Switchable between K and J, but same type must be used for all inputs.		Switchable between Pt100 and JPt100, but same type must be used for all inputs.	
Number of inputs	2	4	2	4
Allocated input words	2	4	2	4
Accuracy	(The larger of ±0.5% of converted value or ±2°C) ±1 digit max. (See note.)		(The larger of ±0.5% of converted value or ±1°C) ±1 digit max.	
Conversion time	250 ms for 2 or 4 input points			
Converted temperature data	16-bit binary data (4-digit hexadecimal)			
Isolation	Photocouplers between all temperature input signals			
Current consumption	5 VDC: 40 mA max., 24 VDC: 59 mA max.		5 VDC: 54 mA max., 24 VDC: 73 mA max.	

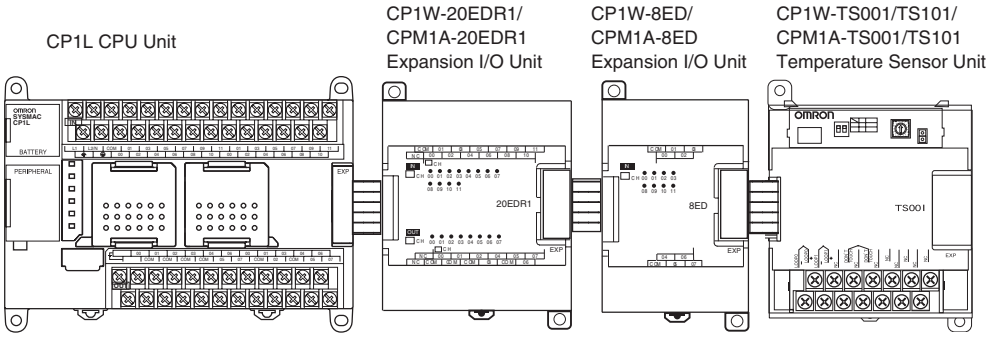
Note Accuracy for a K-type sensor at −100°C or less is ±4°C ±1 digit max.

Using Temperature Sensor Units



Connecting Temperature Sensor Units

A maximum of three CPM1A-TS002 and CPM1A-TS102 Temperature Sensor Units can be connected, because each is allocated four words.

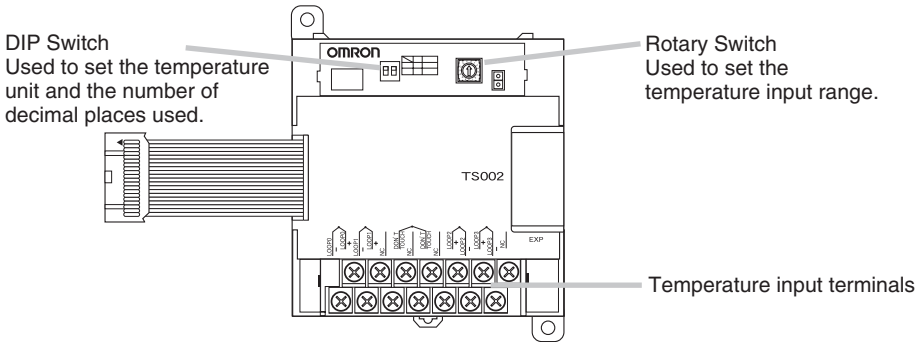


Setting Temperature Ranges

Note (1) Always turn OFF the power supply before setting the temperature range.

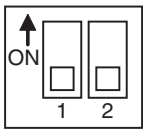
(2) Never touch the DIP switch or rotary switch during Temperature Sensor Unit operation. Static electricity may cause operating errors.

The Temperature Sensor Unit's DIP switch and rotary switch are used to set the temperature unit, to select 2-decimal-place Mode is to be used, and to set the temperature input range.



DIP Switch Settings

The DIP switch is used to set the temperature unit (°C or °F) and the number of decimal places used.



SW1	Setting		
1	Temperature unit	OFF	°C
		ON	°F
2	Number of decimal places used (See note.) (0.01 expression)	OFF	Normal (0 or 1 digit after the decimal point, depending on the input range)
		ON	2-decimal-place Mode

Note For details on 2-decimal-place Mode, refer to *Two-decimal-place Mode* on page 471.

Rotary Switch Setting

⚠**Caution** Set the temperature range according to the type of temperature sensor connected to the Unit. Temperature data will not be converted correctly if the temperature range does not match the sensor.

⚠**Caution** Do not set the temperature range to any values other than those for which temperature ranges are given in the following table. An incorrect setting may cause operating errors.

The rotary switch is used to set the temperature range.



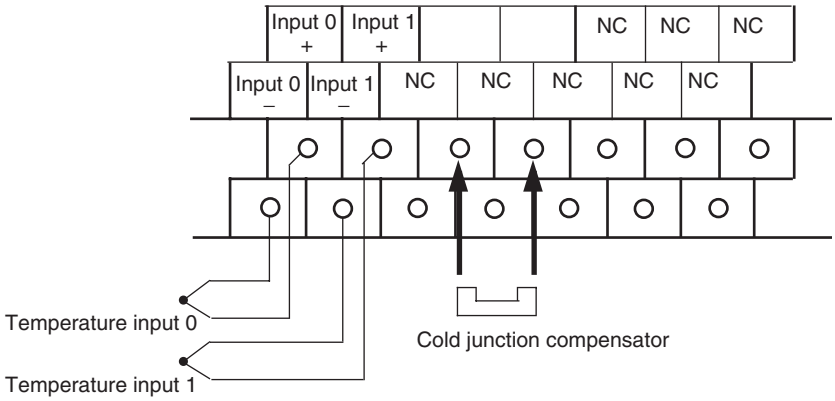
Setting	CP1W-TS001/TS002 CPM1A-TS001/002			CP1W-TS101/TS102 CPM1A-TS101/102		
	Input type	Range (°C)	Range (°F)	Input type	Range (°C)	Range (°F)
0	K	–200 to 1,300	–300 to 2,300	Pt100	–200.0 to 650.0	–300.0 to 1,200.0
1		0.0 to 500.0	0.0 to 900.0	JPt100	–200.0 to 650.0	–300.0 to 1,200.0
2	J	–100 to 850	–100 to 1,500	---	Cannot be set.	
3		0.0 to 400.0	0.0 to 750.0	---		
4 to F	---	Cannot be set.		---		

Connecting Temperature Sensors

Thermocouples

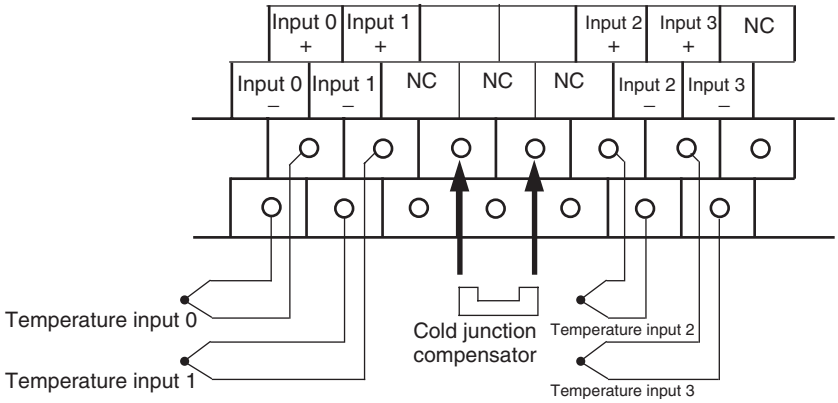
CP1W-TS001/CPM1A-TS001

Either K or J thermocouples can be connected, but both of the thermocouples must be of the same type and the same input range must be used for each.



CP1W-TS002/CPM1A-TS002

Either K or J thermocouples can be connected, but all four of the thermocouples must be of the same type and the same input range must be used for each.



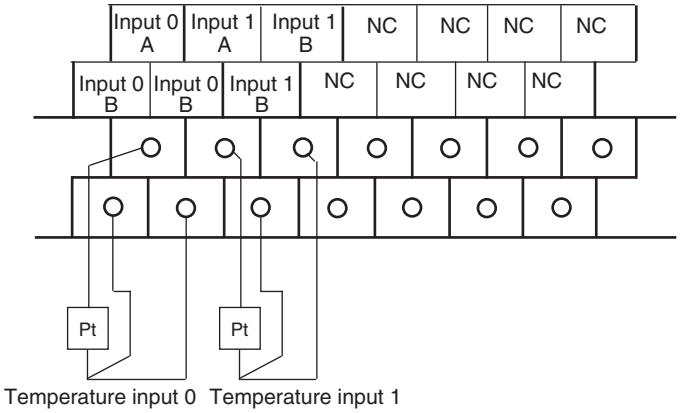
Note When using a Temperature Sensor Unit with a thermocouple input, observe the following precautions:

- Do not remove the cold junction compensator attached at the time of delivery. If the cold junction compensator is removed, the Unit will not be able to measure temperatures correctly.
- Each of the input circuits is calibrated with the cold junction compensator attached to the Unit. If the Unit is used with the cold junction compensator from other Units, the Unit will not be able to measure temperatures correctly.
- Do not touch the cold junction compensator. Doing so may result in incorrect temperature measurement.

Platinum Resistance Thermometers

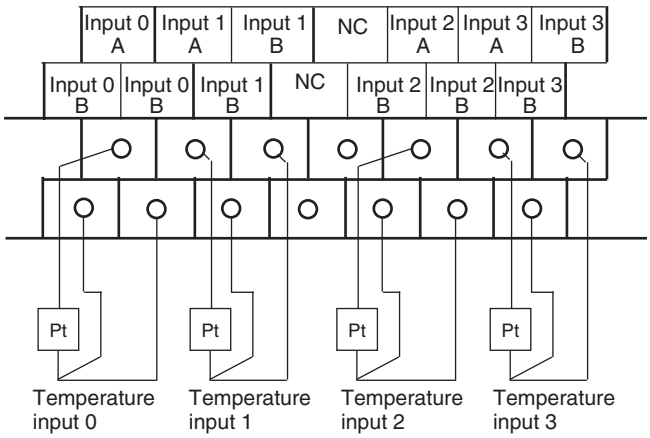
CP1W-TS101/CPM1A-TS101

One or two Pt or JPt platinum resistance thermometers can be connected, but both of the thermometers must be of the same type and the same input range must be used for each.



CP1W-TS102/CPM1A-TS102

Up to four Pt100 or JPt100 platinum resistance thermometers can be connected, but all four of the thermometers must be of the same type and the same input range must be used for each.



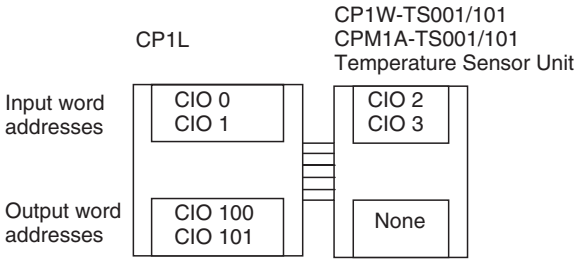
Note Do not connect anything to terminals not used for inputs.

Creating a Ladder Program

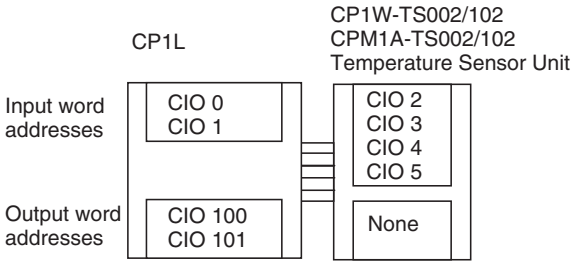
Word Allocations

Temperature Sensor Units are allocated words as Expansion Units, in order of connection. A Temperature Sensor Unit is allocated the next input words following the input words of the CPU Unit or previous Expansion Unit or Expansion I/O Unit. Four input words are allocated is to the 2-input CPM1A-TS001 or CPM1A-TS101 and four input words are allocated to the 4-input CPM1A-TS002 or CPM1A-TS102. No output words are allocated.

Example 1



Example 2



Converted Temperature Data

The temperature data will be stored in the input words allocated to the Temperature Sensor Unit in 4-digit hexadecimal.

TS002/TS102

m+1	Converted temperature data from input 0
m+2	Converted temperature data from input 1
m+3	Converted temperature data from input 2
m+4	Converted temperature data from input 3

TS001/TS101

m+1	Converted temperature data from input 0
m+2	Converted temperature data from input 1

”m” is the last input word allocated to the CPU Unit, Expansion I/O Unit, or Expansion Unit connected immediately before the Temperature Sensor Unit.

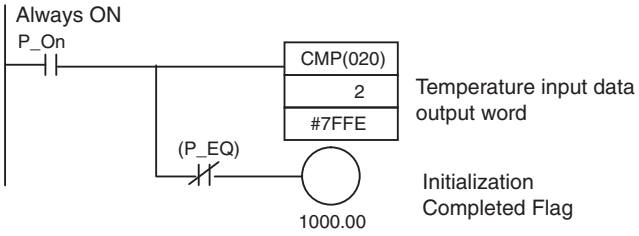
- Negative values are stored as 2’s complements.
- Data for range codes that include one digit after the decimal point are stored without the decimal point, i.e., 10 times the actual value is stored.

Input		Data conversion examples	
Unit: 1°C	K or J	850°C → 0352 hex –200°C → FF38 hex	
Unit: 0.1°C	K, J, Pt100 or JPt100	×10	500.0°C → 5000 → 1388 hex –20.0°C → –200 → FF38 hex –200.0°C → –2000 → F830 hex

- If the input temperature exceeds the range that can be converted, the converted temperature data will be held at the maximum or minimum value in the range.
- If the input temperature exceeds the range by more than a specified amount, the open-circuit detection function will detect an open-circuit and the converted temperature data will be set to 7FFF.
  The open-circuit detection function will also operate if the cold junction compensator is faulty.
- The open-circuit detection function will be automatically cleared and normal input temperature conversion will begin automatically when the input temperature returns to the convertible range.

Startup Operation

After power is turned ON, approximately 1 s is required for the first conversion data to be stored in the input word. During that period, the data will be 7FFE. Therefore, create a program as shown below, so that when operation begins simultaneously with startup it will wait for valid conversion data.

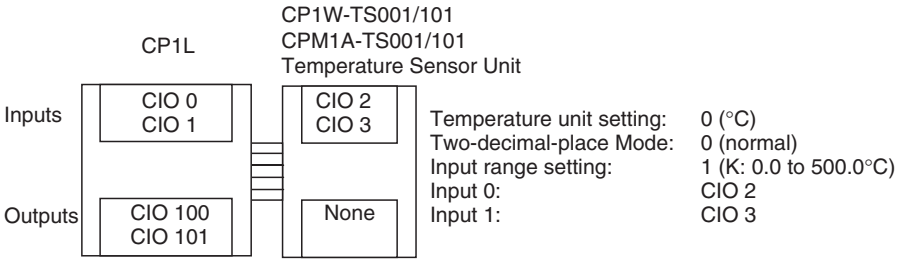


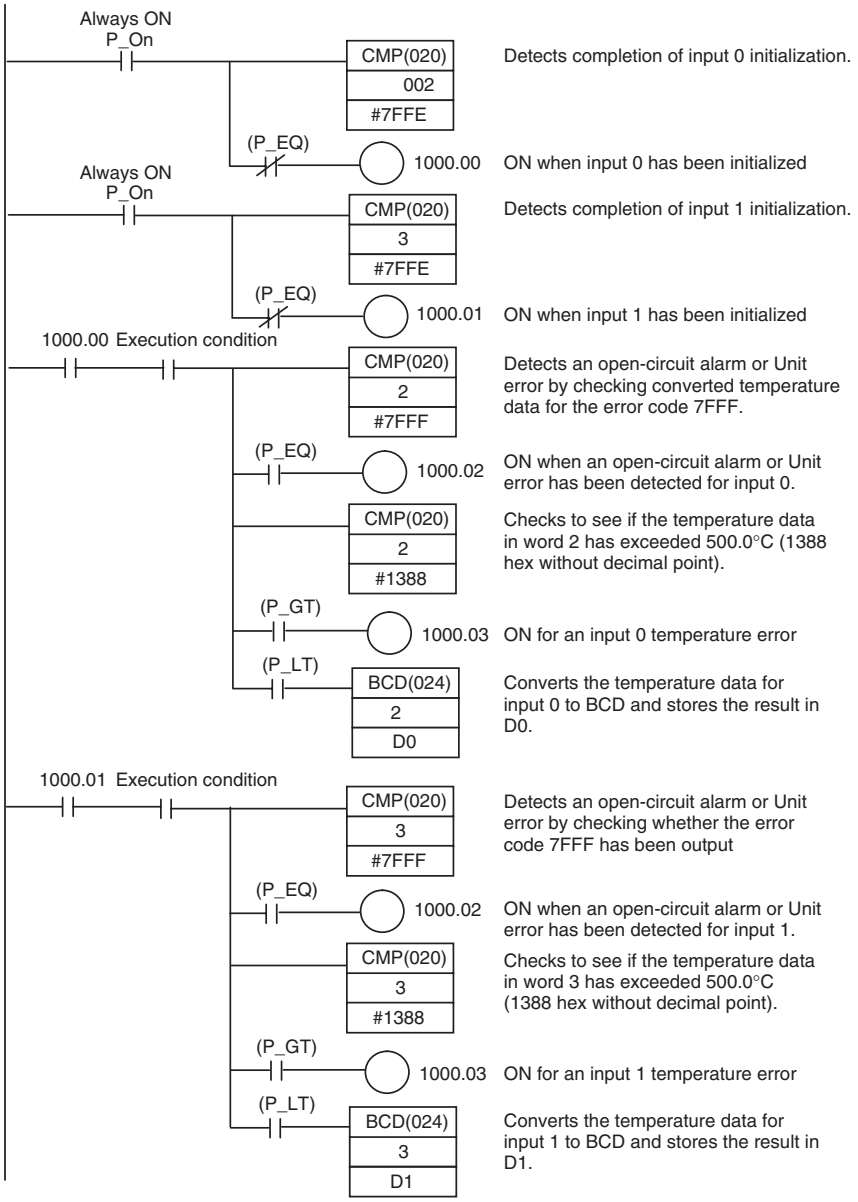
Handling Unit Errors

- Expansion Unit and Expansion I/O Unit errors are output to bits 0 to 6 of word A436. The bits are allocated from A436.00 in order starting from the Unit nearest the CPU Unit. CP1W-/CPM1A-TS002 and CP1W-/CPM1A-TS102 Temperature Sensor Units are allocated two bits each. Use these flags in the program when it is necessary to detect Expansion Unit/Expansion I/O Unit errors.
- When an error occurs, the Temperature Sensor Unit data becomes 7FFF hex (the same as for an open-circuit detection). With an open-circuit detection, it is not reflected in word A436.

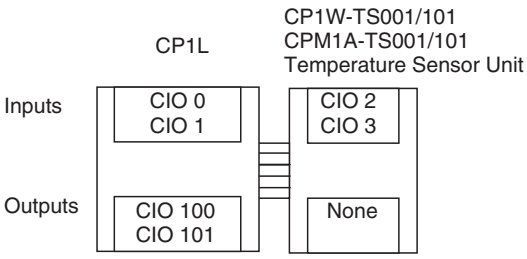
Programming Example

1,2,3... 1. The following programming example shows how to convert the input data from 2 temperature sensor inputs to BCD and store the result in D0 and D1.



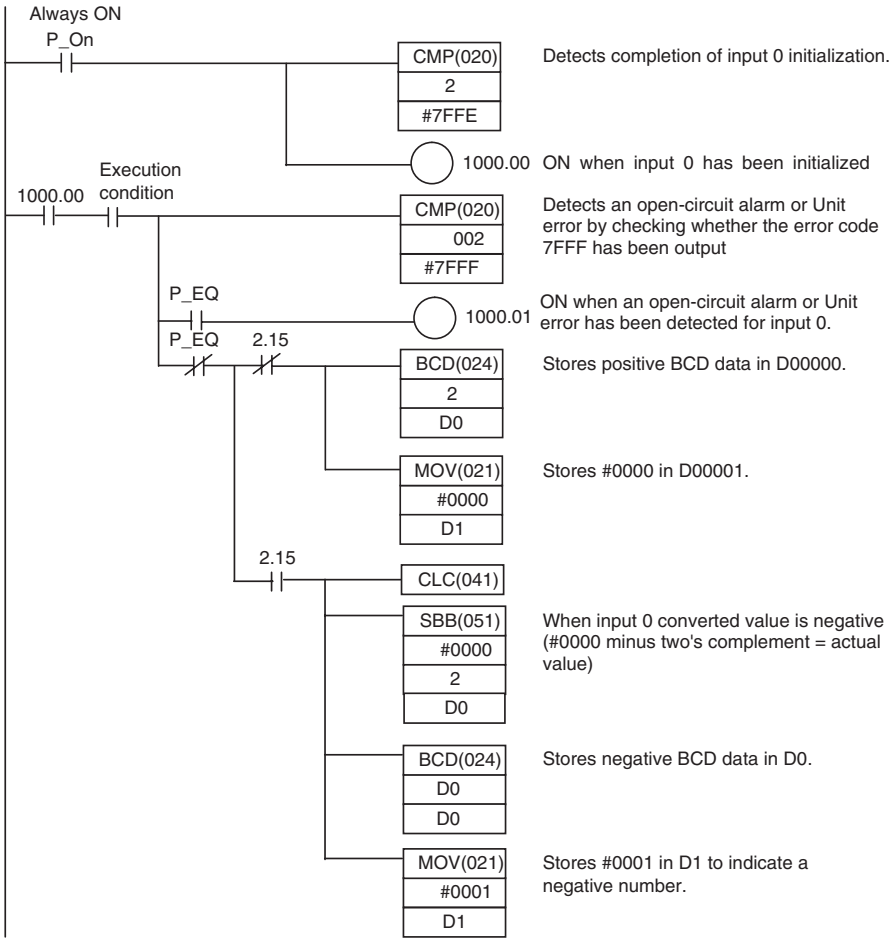


2. The following programming example shows how to convert the data for temperature input 0 to BCD and store the result in D0 and D1. “0001” is stored in D1 when the input data is a negative value. The following system configuration is used.

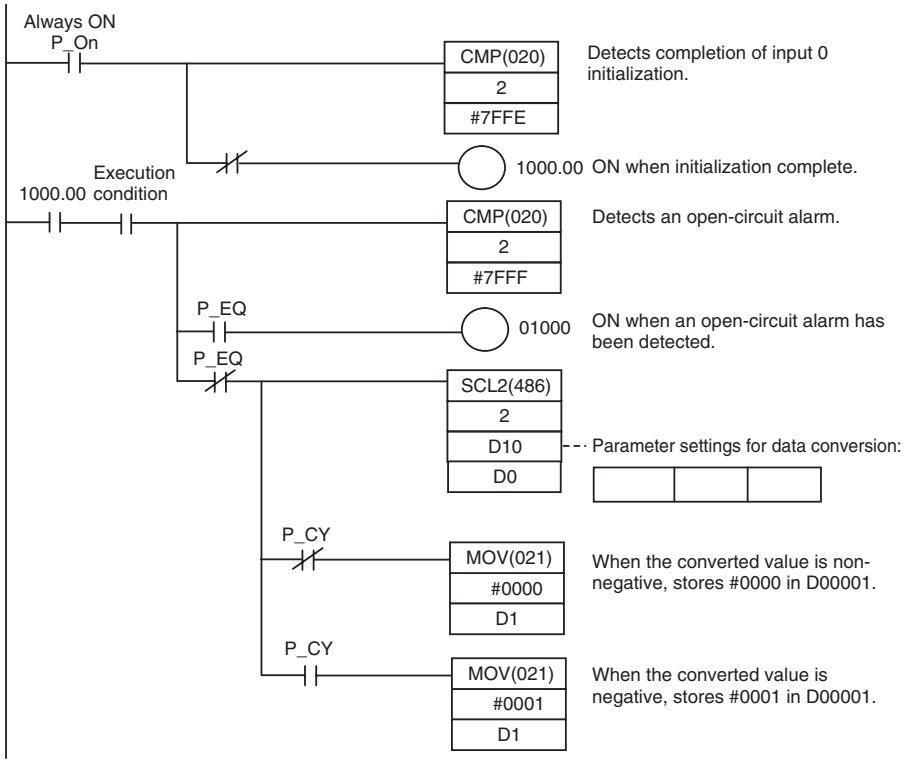


Temperature unit setting	0 (°C)
Two-decimal-place Mode	0 (normal)
Input range setting	1 (Pt100: –200.0 to 650.0°C)
Input 0	CIO 2

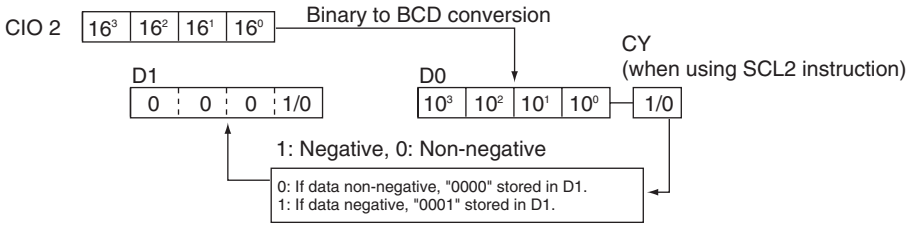
Programming with BCD(24) Instruction



Programming with SCL2(–) Instruction



Operation



Two-decimal-place Mode

If pin 2 on the DIP switch is turned ON, values are stored to two decimal places. In this case, temperature data is stored as 6-digit signed hexadecimal (binary) data with 4 digits in the integer portion and 2 digits after the decimal point. The actual data stored in memory is 100 times the actual value, i.e., the decimal point is not indicated. Methods for handling this data are described in this section.

Note When set to store values to two decimal places, temperature data as far as two digits after the decimal point is converted to 6-digit binary data, but the actual resolution is not 0.01°C (°F). For this reason, there may be skipping and inaccuracies in the first digit after the decimal point (0.1). Treat any resolution above that specified for the normal data format as reference data.

Temperature Data Partitioning and Structure

Temperature Data (Actual Temperature x 100 Binary)

□□□□□□

Leftmost 3 Digits and Flags

15	14	13	12	11 to 8	7 to 4	3 to 0
Leftmost/ Rightmost Flag	Temperature Unit Flag	Open-circuit Flag	Not used.	Temperature data		
0: Leftmost 1: Rightmost	0: °C 1: °F	0: Normal 1: Error	Always 0	$\times 16^5$	$\times 16^4$	$\times 16^3$

Rightmost 3 Digits and Flags

15	14	13	12	11 to 8	7 to 4	3 to 0
Leftmost/ Rightmost Flag	Temperature Unit Flag	Open-circuit Flag	Not used.	Temperature data		
0: Leftmost 1: Rightmost	0: °C 1: °F	0: Normal 1: Error	Always 0	$\times 16^2$	$\times 16^1$	$\times 16^0$

Leftmost/Rightmost Flag: Indicates whether the leftmost or rightmost 3 digits are provided.
Temperature Unit Flag: Indicates whether the temperature is in °C or °F.
Open-circuit Flag: Turns ON (1) when an open-circuit is detected. The temperature data will be 7FF FFF if this flag is ON.

Data Conversion Examples

Example 1

Temperature: 1,130.25°C
×100: 113025
Temperature Data: 01B981 (hexadecimal for 113025)

Leftmost 3 Digits and Flags

	Flags				$\times 16^5$	$\times 16^4$	$\times 16^3$
Bits	15	14	13	12	11 to 08	07 to 04	03 to 00
Data	0	0	0	0	0	1	B

Normal
°C
Leftmost

→ 0 0 1 B

Flags: 0 0 | Temperature data: 1 B

Rightmost 3 Digits and Flags

	Flags				$\times 16^2$	$\times 16^1$	$\times 16^0$
Bits	15	14	13	12	11 to 08	07 to 04	0
Data	1	0	0	0	9	8	1

Normal
°C
Rightmost

→ 8 9 8 1

Flags: 8 | Temperature data: 9 8 1

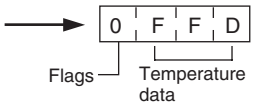
Example 2

Temperature: –100.12°C
×100: –10012
Temperature Data: FFD8E4 (hexadecimal for –10012)

Leftmost 3 Digits and Flags

	Flags				$\times16^5$	$\times16^4$	$\times16^3$
Bits	15	14	13	12	11 to 08	07 to 04	03 to 00
Data	0	0	0	0	F	F	D

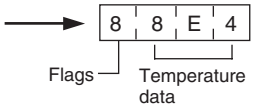
Normal
°C
Leftmost



Rightmost 3 Digits and Flags

	Flags				$\times16^2$	$\times16^1$	$\times16^0$
Bits	15	14	13	12	11 to 08	07 to 04	03 to 00
Data	1	0	0	0	8	E	4

Normal
°C
Rightmost



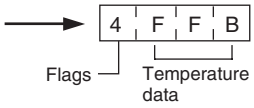
Example 3

Temperature: –200.12°F
×100: –20012
Temperature Data: FFB1D4 (hexadecimal for –20012)

Leftmost 3 Digits and Flags

	Flags				$\times16^5$	$\times16^4$	$\times16^3$
Bits	15	14	13	12	11 to 08	107 to 04	03 to 00
Data	0	1	0	0	F	F	B

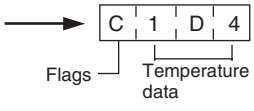
Normal
°F
Leftmost



Rightmost 3 Digits and Flags

	Flags				$\times16^2$	$\times16^1$	$\times16^0$
Bits	15	14	13	12	11 to 08	07 to 04	03 to 00
Data	1	1	0	0	1	D	4

Normal
°F
Rightmost



Example 4

Temperature: Open circuit (°F)
Temperature Data: 7FFF FFFF

Leftmost 3 Digits and Flags

	Flags				$\times 16^5$	$\times 16^4$	$\times 16^3$
Bits	15	14	13	12	11 to 08	07 to 04	03 to 00
Data	0	1	1	0	7	F	F

Error
°F
Leftmost

6	7	F	F

Flags — Temperature data

Rightmost 3 Digits and Flags

	Flags				$\times 16^2$	$\times 16^1$	$\times 16^0$
Bits	15	14	13	12	11 to 08	07 to 04	03 to 00
Data	1	1	1	0	F	F	F

Error
°F
Rightmost

E	F	F	F

Flags — Temperature data

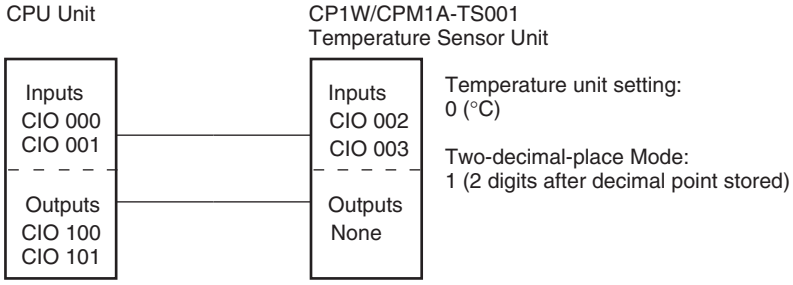
Note

(1) Leftmost digits are stored in the lower memory addresses. Treat the data in the lower memory address as the leftmost digits when programming.

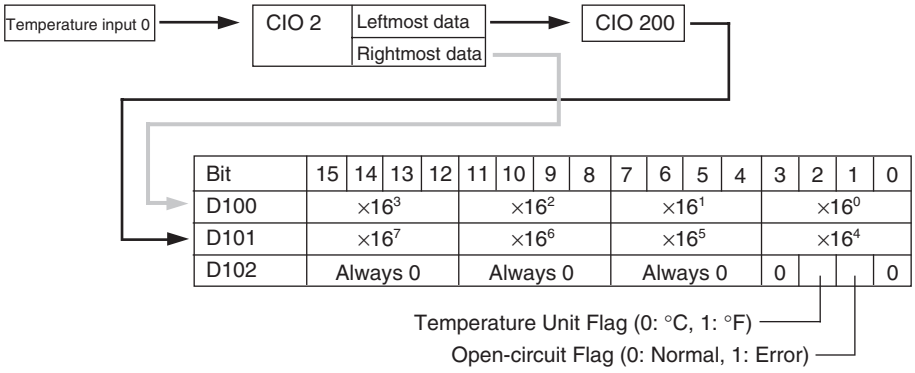
(2) Be sure that the data is read at least once every 125 ms to allow for the CPU Unit's cycle time and communications time. Correct data may not be obtained if the read cycle is greater than 125 ms.

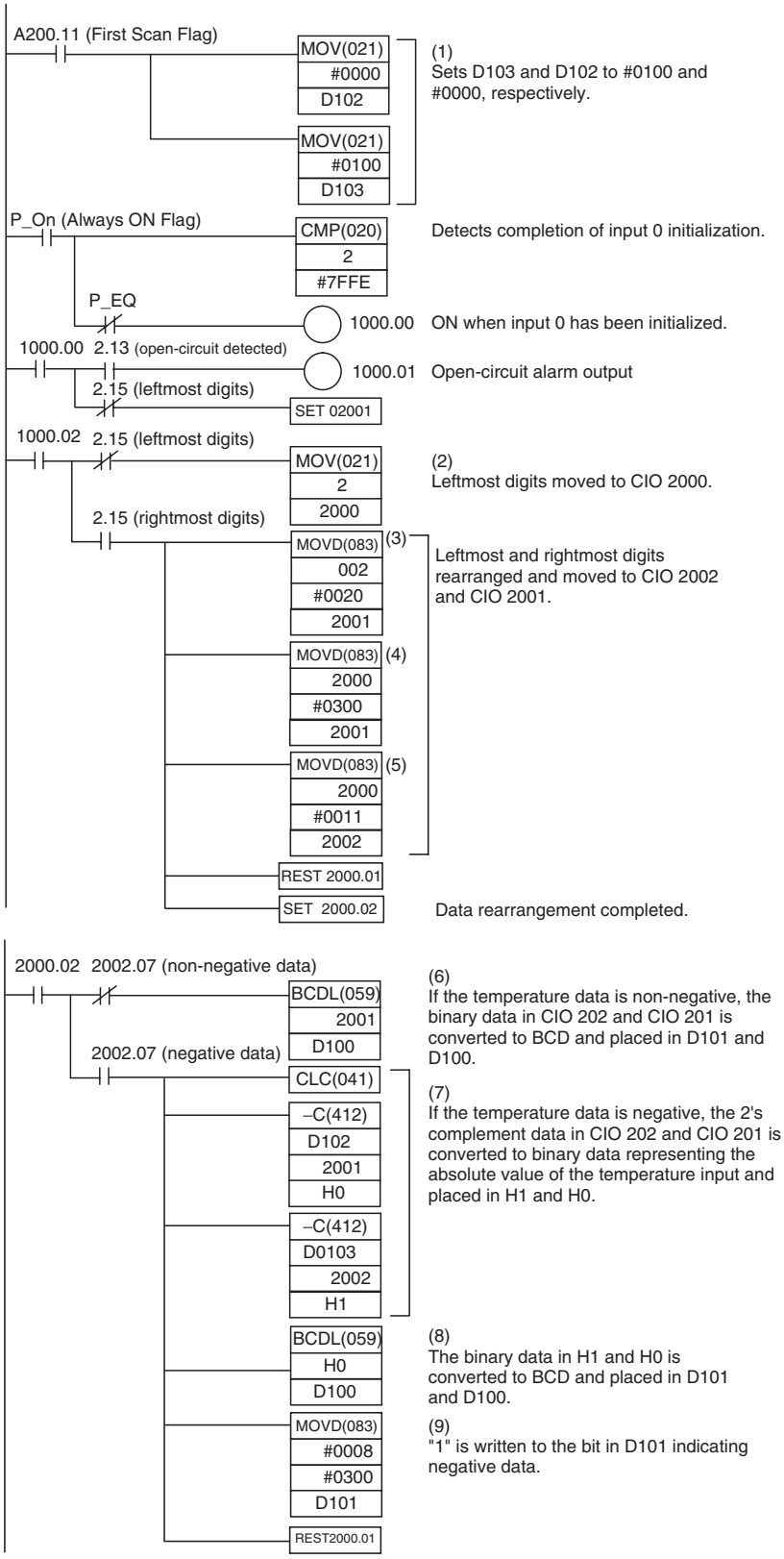
Programming Example

The following programming example shows how to use 2-decimal-place Mode for the following PC configuration.

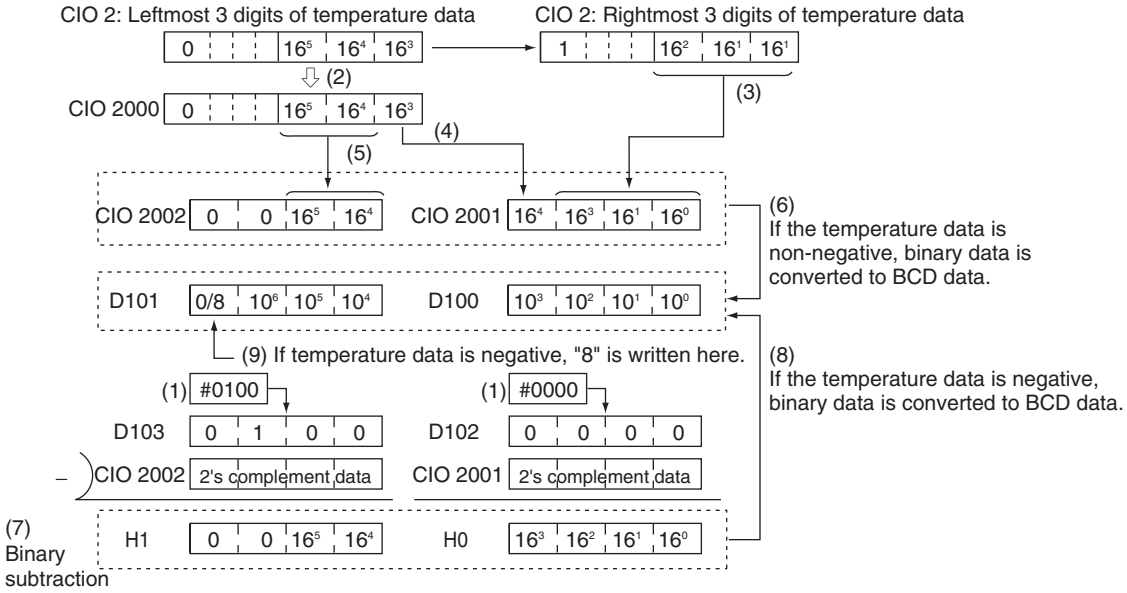


In this example, 100 times the temperature data for temperature input 0 is stored in binary form in D100 to D102.



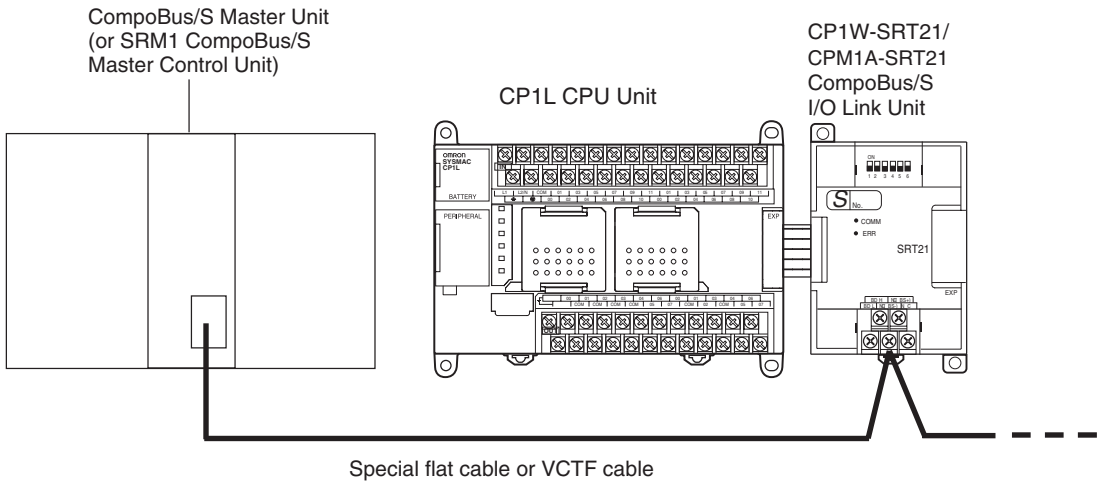

A200.11 (First Scan Flag)
MOV(021)
#0000
D102
MOV(021)
#0100
D103
(1)
Sets D103 and D102 to #0100 and #0000, respectively.
P_On (Always ON Flag)
CMP(020)
2
#7FFE
Detects completion of input 0 initialization.
P_EQ
1000.00
ON when input 0 has been initialized.
1000.00 2.13 (open-circuit detected)
1000.01
Open-circuit alarm output
2.15 (leftmost digits)
SET 02001
1000.02 2.15 (leftmost digits)
MOV(021)
2
2000
(2)
Leftmost digits moved to CIO 2000.
2.15 (rightmost digits)
MOVD(083)
(3)
002
#0020
2001
Leftmost and rightmost digits rearranged and moved to CIO 2002 and CIO 2001.
MOVD(083)
(4)
2000
#0300
2001
MOVD(083)
(5)
2000
#0011
2002
REST 2000.01
SET 2000.02
Data rearrangement completed.
2000.02 2002.07 (non-negative data)
BCDL(059)
2001
D100
(6)
If the temperature data is non-negative, the binary data in CIO 202 and CIO 201 is converted to BCD and placed in D101 and D100.
2002.07 (negative data)
CLC(041)
–C(412)
D102
2001
H0
–C(412)
D0103
2002
H1
(7)
If the temperature data is negative, the 2's complement data in CIO 202 and CIO 201 is converted to binary data representing the absolute value of the temperature input and placed in H1 and H0.
BCDL(059)
H0
D100
(8)
The binary data in H1 and H0 is converted to BCD and placed in D101 and D100.
MOVD(083)
#0008
#0300
D101
(9)
"1" is written to the bit in D101 indicating negative data.
REST2000.01

Description of Operation

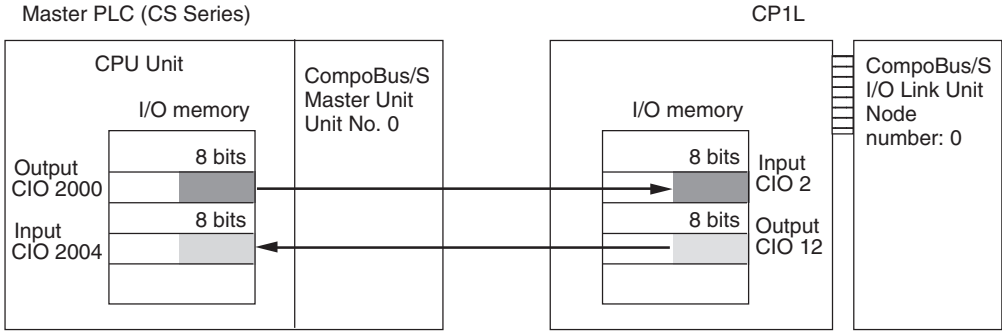


7-6 CompoBus/S I/O Link Units

The CP1L can function as a slave to a CompoBus/S Master Unit (or SRM1 CompoBus/S Master Control Unit) when a CP1W-SRT21/CPM1A-SRT21 CompoBus/S I/O Link Unit is connected. The CompoBus/S I/O Link Unit establishes an I/O link of 8 inputs and 8 outputs between the Master Unit and the PLC. Up to three CompoBus/S I/O Link Units, including other Expansion I/O Units, can be connected to a CP1L CPU Unit.



From the standpoint of the CP1L CPU Unit, the 8 input bits and 8 output bits allocated to the CompoBus/S I/O Link Unit are identical to input and output bits allocated to Expansion I/O Units even though the CompoBus/S I/O Link Unit does not control actual inputs and outputs. The input and output bits allocated to the CompoBus/S I/O Link Unit are one side of an I/O link between the slave CPU Unit and the CPU Unit to which the Master Unit is connected.



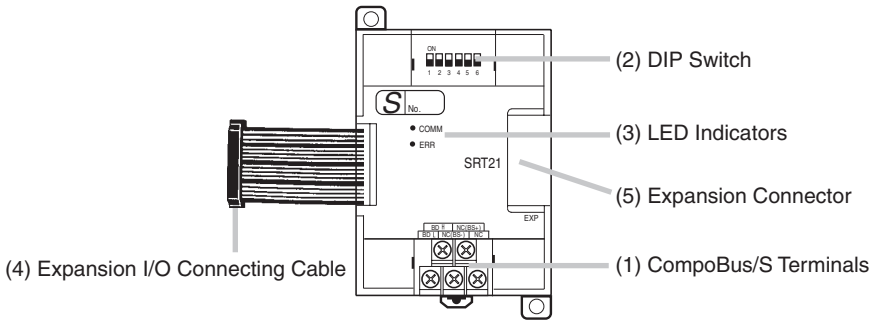
Specifications

Model number	CP1W-SRT21/CPM1A-SRT21
Master/slave	CompoBus/S Slave
Number of I/O points	8 input points, 8 output points
Number of words allocated in CPU Unit I/O memory	1 input word, 1 output word (Allocated in the same way as Expansion Units and Expansion I/O Units.)
Node number setting	Set using the DIP switch (Set before turning on the CPU Unit's power supply.)

LED Indicators

Indicator	Name	Color	Meaning
COMM	Communications Indicator	Yellow	ON: Communications in progress. OFF: Communications stopped or error has occurred.
ERR	Error indicator	Red	ON: A communications error has occurred. OFF: Indicates normal communications or stand-by.

CP1W-SRT21/CPM1A-SRT21 CompoBus/S I/O Link Unit

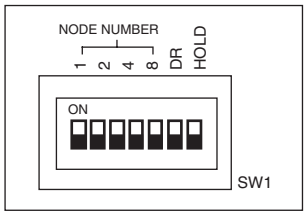


(1) CompoBus/S Terminals

The following CompoBus/S terminals are provided: CompoBus/S communications data high/low terminals, NC terminals for communications power supply plus (+) and minus (–), and an NC terminal. (Power is supplied internally for this Unit, so the NC terminals for communications power supply can be used as relay terminals.)

(2) DIP Switch

Used to specify the node number for the CompoBus/S I/O Link Unit. (Refer to the following table.)



Pin labels	Contents		
1 2 4 8	Node Number Setting / SW1 (8 4 2 1): 0: 0 0 0 0 1: 0 0 0 1 2: 0 0 1 0 3: 0 0 1 1 4: 0 1 0 0 5: 0 1 0 1 6: 0 1 1 0 7: 0 1 1 1 8: 1 0 0 0 9: 1 0 0 1 10: 1 0 1 0 11: 1 0 1 1 12: 1 1 0 0 13: 1 1 0 1 14: 1 1 1 0 15: 1 1 1 1 1 = ON, 0 = OFF		
DR	ON	Long-distance communications mode (See note.)	
	OFF	High-speed communications mode	
HOLD	ON	Retain inputs after a communications error.	
	OFF	Clear inputs after a communications error.	

Note: The long-distance communications mode can be used only when one of the following Master Units is connected: C200HW-SRM21-V1, CQM1-SRM21-V1, or SRM1-C0□-V2.

(3) LED Indicators

Used to show the CompoBus/S communications status.

Indicator	Name	Color	Meaning
COMM	Communications indicator	Yellow	ON: Communications in progress. OFF: Communications stopped or error has occurred.
ERR	Error indicator	Red	ON: A communications error has occurred. OFF: Indicates normal communications or stand-by.

(4) Expansion I/O Connecting Cable

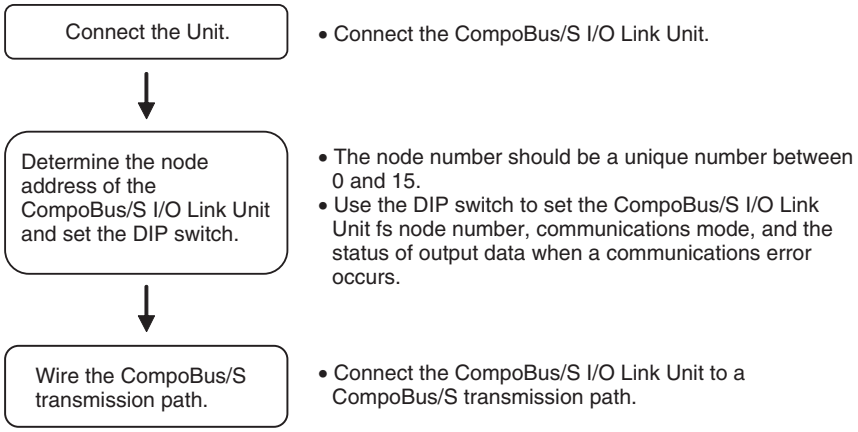
Connected to the expansion connector of a CP1L CPU Unit or a Expansion Unit or Expansion I/O Unit. The cable is provided with the CompoBus/S I/O Link Unit and cannot be removed.

Note Do not touch the cables during operation. Static electricity may cause operating errors.

(5) Expansion Connector

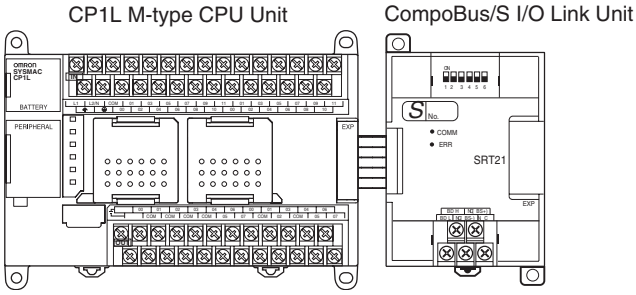
Used to connect Expansion Units or Expansion I/O Units.

Operating Procedure



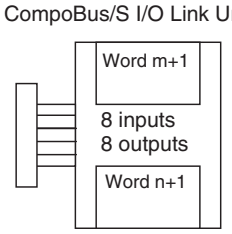
Connecting the CompoBus/S I/O Link Unit

CompoBus/S I/O Link Units are connected to the CP1L CPU Unit. For CP1L M-type CPU Units, up to three Units can be connected, including any other Expansion Units and Expansion I/O Units that are also connected. The Units can be connected in any order from the CPU Unit.

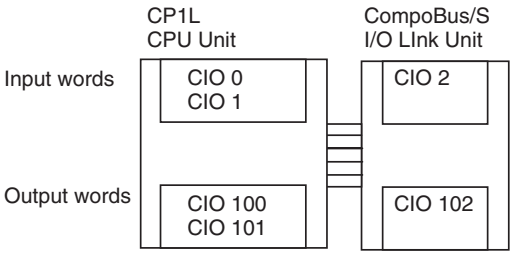


I/O Allocation

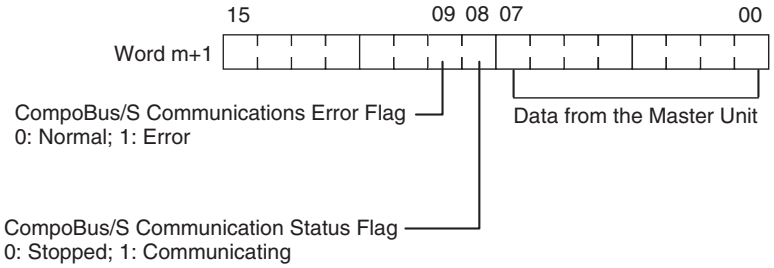
I/O words are allocated to the CompoBus/S I/O Link Unit in the same way as to other Expansion Units and Expansion I/O Units, i.e., the next available input and output words are allocated. As shown below, when “m” is the last allocated input word and “n” is the last allocated output word, the CompoBus/S I/O Link Unit is allocated “m+1” as its input word and “n+1” as its output word.



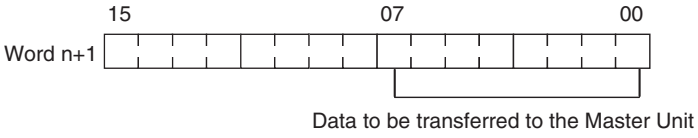
In the following example, a CompoBus/S I/O Link Unit is connected as the first Unit after the CP1L CPU Unit.



The input word (m+1) contains the 8 bits of data from the Master Unit and two CompoBus/S communications flags.



Write the data to be transmitted to the Master Unit in the output word (n+1).



Note

(1) The 8 bits of I/O data are not always transmitted simultaneously. In other words, 8 bits of data transmitted from the Master CPU Unit at the same time will not always reach the Slave CPU Unit simultaneously, and 8 bits of data transmitted from the Slave CPU Unit at the same time will not always reach the Master CPU Unit simultaneously.
When the 8 bits of input data must be read together, modify the ladder program in the CPU Unit receiving the data. For example, read the input data twice in succession and accept the data only when the two values match.

(2) Unused bits in the CompoBus/S I/O Link Unit's output word can be used as work bits, but unused bits in the output slaves cannot be used as work bits.

(3) Unused bits in input word cannot be used as work bits.

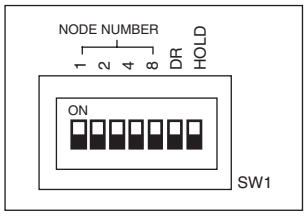
Determining the Node Number and Making DIP Switch Settings

Node Number

- The CompoBus/S I/O Link Unit is a Slave Unit with 8 input bits and 8 output bits. The node number setting is made using the DIP switch; the inputs and outputs share the same node number.
- The range of possible node number settings is determined by the type of PLC the Master Unit is mounted to and the settings on the Master Unit. For details refer to the *CompoBus/S Operation Manual*.

DIP Switch Settings

Use the DIP switch to set the CompoBus/S I/O Link Unit's node number, communications mode, and the status of output data when a communications error occurs.



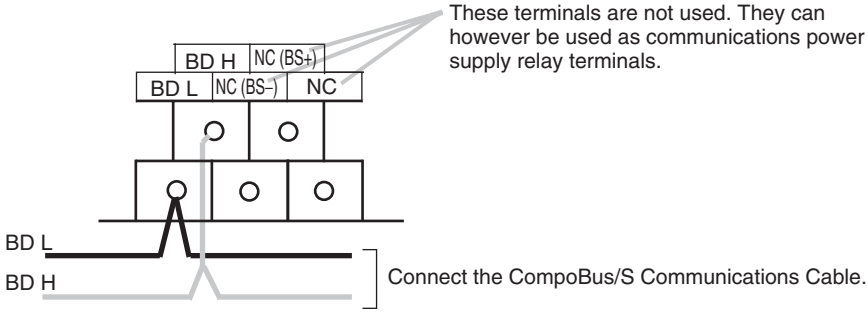
Pin labels	Contents		
1 2 4 8	Node Number Setting	SW1 8	4	2	1
	0	0	0	0	0
	1	0	0	0	1
	2	0	0	1	0
	3	0	0	1	1
	4	0	1	0	0
	5	0	1	0	1
	6	0	1	1	0
	7	0	1	1	1
	8	1	0	0	0
	9	1	0	0	1
	10	1	0	1	0
	11	1	0	1	1
	12	1	1	0	0
	13	1	1	0	1
	14	1	1	1	0
	15	1	1	1	1
	1 = ON, 0 = OFF				
DR	ON	Long-distance communications mode (See note.)			
	OFF	High-speed communications mode			
HOLD	ON	Retain inputs after a communications error.			
	OFF	Clear inputs after a communications error.			

Note: The long-distance communications mode can be used only when one of the following Master Units is connected: C200HW-SRM21-V1, CQM1-SRM21-V1, or SRM1-C0□-V2.

Note Always turn OFF the power supply before changing the DIP switch settings.

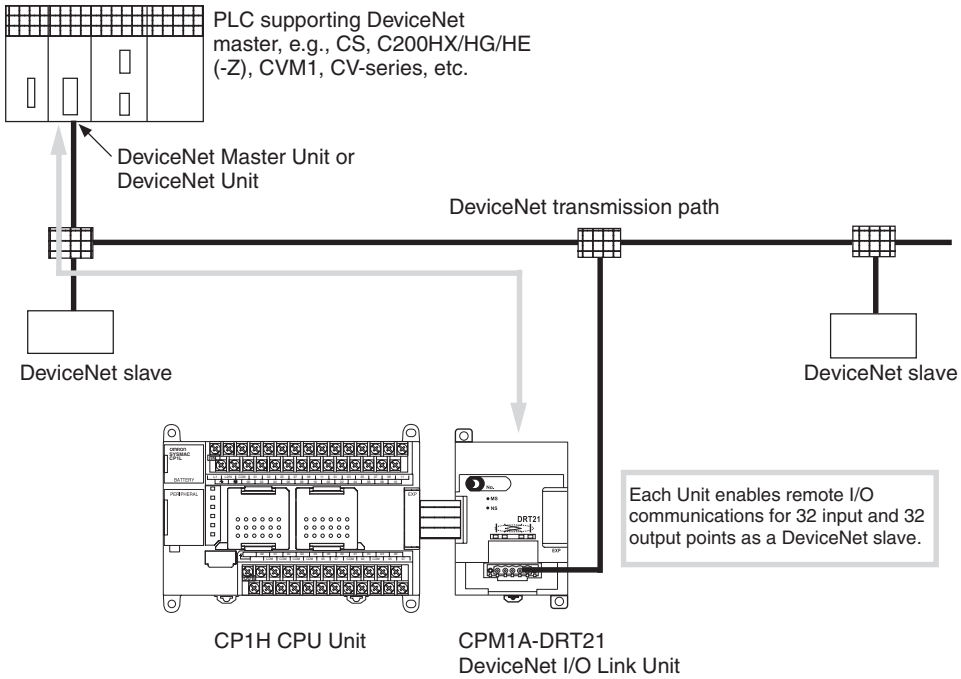
Wiring the CompoBus/S Communications Path

Wire the CompoBus/S communications path as shown in the following diagrams.

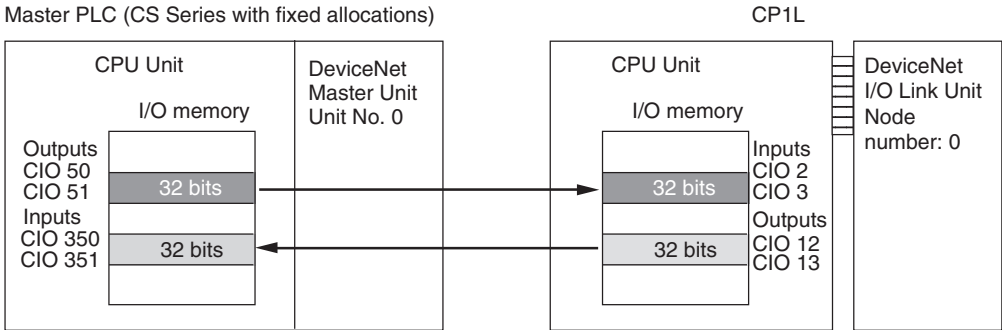


7-7 DeviceNet I/O Link Units

Connecting a CPM1A-DRT21 DeviceNet I/O Link Unit (with 32 inputs and 32 outputs as built-in I/O) to function as a slave allows the CP1L to be used as a DeviceNet slave. A maximum of three DeviceNet I/O Link Units can be connected to the CP1L to create I/O Links for up to 192 points (96 inputs and 96 outputs) between the CP1L and the DeviceNet master.



From the standpoint of the CP1L CPU Unit, the 32 input bits and 32 output bits allocated to the DeviceNet I/O Link Unit are identical to input and output bits allocated to Expansion I/O Units even though the DeviceNet I/O Link Unit does not control external inputs and outputs. The input and output bits allocated to the DeviceNet I/O Link Unit are one side of an I/O link between the slave CPU Unit and the CP1L CPU Unit to which the Master Unit is connected.



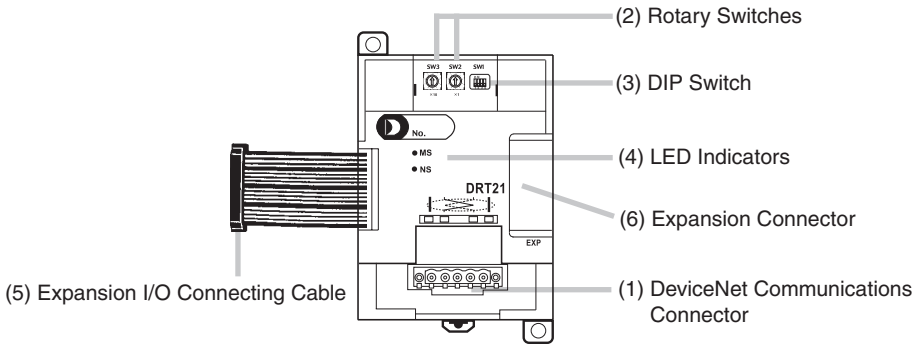
Note Refer to the *DeviceNet Slaves Operation Manual* (W347) for details on DeviceNet networks.

Specifications

Model number	CPM1A-DRT21
Master/slave	DeviceNet Slave

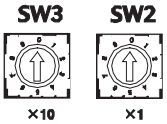
Number of I/O points	32 input points, 32 output points
Number of words allocated in CPU Unit I/O memory	2 input words, 2 output words (Allocated in the same way as other Expansion Units and Expansion I/O Units.)
Node number setting	Set using the rotary switches (Set before turning ON the CPU Unit's power supply.)
Communications current consumption	48 mA

CPM1A-DRT21 DeviceNet I/O Link Unit



(1) DeviceNet Communications Connector
Used to connect DeviceNet communications. For the wiring, use the connector provided with the CPM1A-DRT21 or use a connector purchased separately.

(2) Rotary Switches (SW2, SW3)
Used to set DeviceNet node numbers.



Setting range: 0 to 63 (Do not set 64 to 99.)

(3) DIP Switch (SW1)
Used to set the DeviceNet baud rate and the output hold function.



Baud rate setting (See note.)			
Pin 1	**Pin 2**	**Baud rate**	**Max. transmission path length**
OFF	OFF	125 kbps	500 m
ON	OFF	250 kbps	250 m
OFF	ON	500 kbps	100 m
ON	ON	Not allowed.	---

Output hold function setting	
Pin 4	DeviceNet baud rate
OFF	Clears remote outputs when communications error occurs. (Outputs turned OFF for each logic value.)
ON	Holds remote outputs when communications error occurs.

Note When using Expansion Unit/Expansion I/O Unit Error Flags (A436) in the program, set pin 4 on the DIP switch to ON. If communications are set to be cleared, the timing for clearing outputs and setting the Error Flags may not agree.

(4) LED Indicators
Used to indicate CPM1A-DRT21 status, as shown in the following table.

Indicator	Color	Status	Condition	Meaning
MS	Green	Lit	Normal status	• Normal status
		Flashing	Not set	• Switch settings being read
	Red	Lit	Fatal error	• Fatal hardware error (watchdog timer)
		Flashing	Nonfatal error	• Incorrect switch settings.
	---	OFF	Power not supplied.	• Power not supplied. • Waiting for initialization to start. • Reset in progress.
NS	Green	Lit	Online and communications established.	• Network normal and communications established.
		Flashing	Online and communications not established.	• Network normal and communications not established.
	Red	Lit	Fatal communications error	Unit has detected network status preventing normal communications. • Node number duplications • Bus OFF detected.
		Flashing	Nonfatal communications error	• Communications timeout or communications error for one or more slaves.
	---	OFF	Online and power OFF.	Waiting for node number check by master. • Switch setting error. • Power not supplied.

(5) Expansion I/O Connecting Cable
Connected to the expansion connector of a CP1L CPU Unit or an Expansion Unit or Expansion I/O Unit. The cable is included with the DeviceNet Unit and cannot be removed.

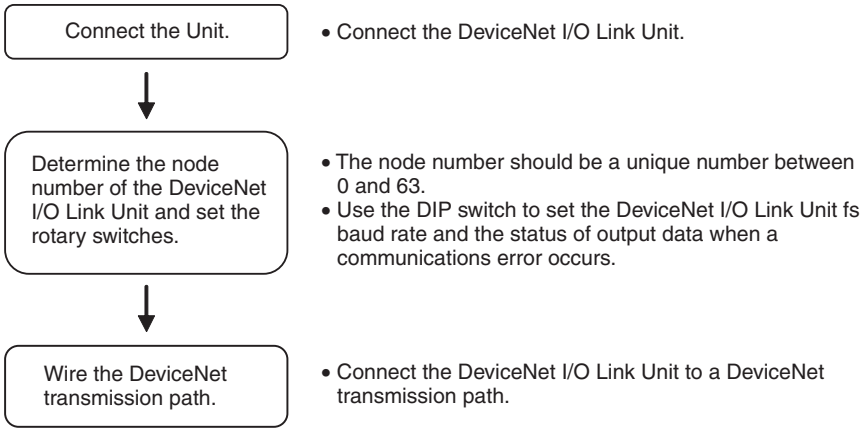
Note Do not touch the cables during operation. Static electricity may cause operating errors.

(6) Expansion Connector
Used for connecting Expansion Units or Expansion I/O Units.

Handling Unit Errors

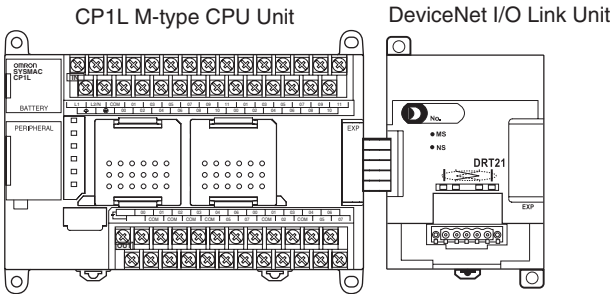
If a communications error occurs while the slave is on standby, the appropriate bit in word A436 will turn ON. The appropriate bit is determined by the order in which the Expansion Units and Expansion I/O Units are connected. The Unit nearest to the CPU Unit uses A436.00. Use these flags in the program when it is necessary to detect errors.

Operating Procedure



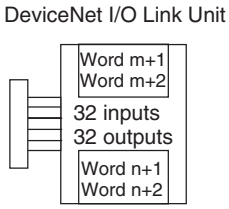
Connecting the DeviceNet I/O Link Unit

DeviceNet I/O Link Units are connected to the CP1L CPU Unit. For CP1L M-type CPU Units, up to three Units can be connected, including any other Expansion Units and Expansion I/O Units that are also connected. The Units can be connected in any order from the CPU Unit.

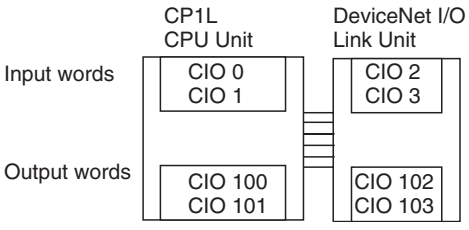


I/O Allocation

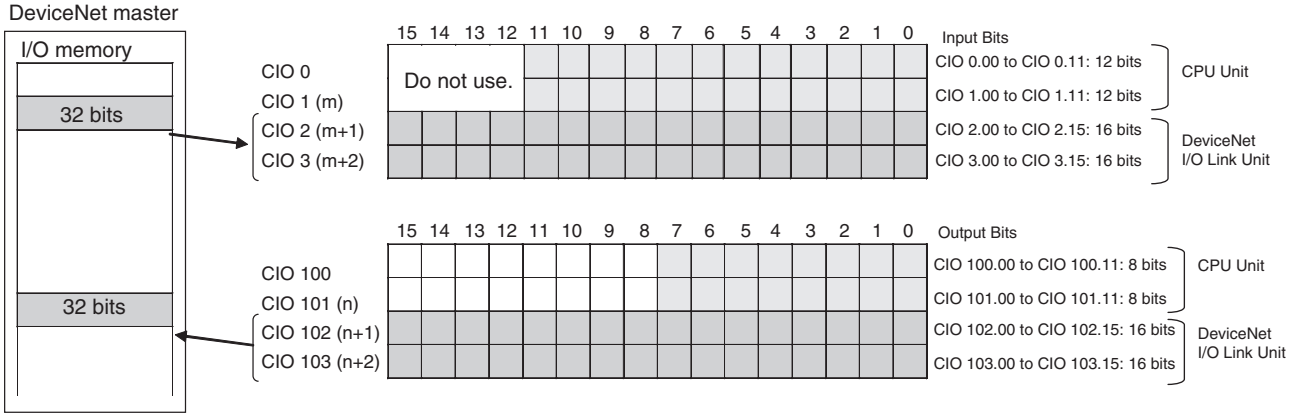
I/O words are allocated to the DeviceNet I/O Link Unit in the same way as to Expansion I/O Units or other Expansion Units, i.e., the next available input and output words are allocated. As shown below, when “m” is the last allocated input word and “n” is the last allocated output word, the DeviceNet I/O Link Unit is allocated “m+1” as its input word and “n+1” as its output word.



In the following example, a CompoBus/S I/O Link Unit is connected as the first Unit after the CP1L CPU Unit.



All of the words allocated to the DeviceNet I/O Link Unit are used to read and write data between the CPU Unit of the DeviceNet I/O Link Unit and the CPU Unit of the DeviceNet master, as shown in the following illustration.



Note

(1) The 32 bits each of I/O data are not always transmitted simultaneously. In other words, 32 bits of data transmitted from the Master CPU Unit at the same time will not always reach the CP1L CPU Unit simultaneously, and 32 bits of data transmitted from the CP1L CPU Unit at the same time will not always reach the Master CPU Unit simultaneously.
When the 32 bits of input data must be read together, modify the ladder program in the CPU Unit receiving the data. For example, read the input data twice in succession and accept the data only when the two values match.

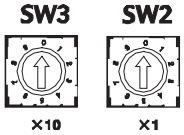
(2) Unused bits in the DeviceNet I/O Link Unit's output words can be used as work bits if they are not used for output from the slave.

(3) Unused bits in input words cannot be used as work bits.

Determining the Node Number and Making DIP Switch Settings

Setting Node Numbers

Use rotary switches SW2 and SW3 to set DeviceNet node number. The setting range is from 00 to 63, and 64 to 99 cannot be set. Rotary switch settings go into effect when the power is turned ON.



Setting range: 0 to 63 (Do not set 64 to 99.)

Note The actual range of node numbers that can be set depends on the type of PLC to which the Master Unit is mounted, and on the Master Unit setting. For details, refer to the *DeviceNet DRT1-series Slaves Operation Manual*.

Setting the DIP Switch (SW1)

Used to set the DeviceNet baud rate and the output hold function.



Baud Rate

Pin 1	Pin 2	Baud rate	Max. transmission path length
OFF	OFF	125 kbps	500 m
ON	OFF	250 kbps	250 m
OFF	ON	500 kbps	100 m
ON	ON	Not allowed.	---

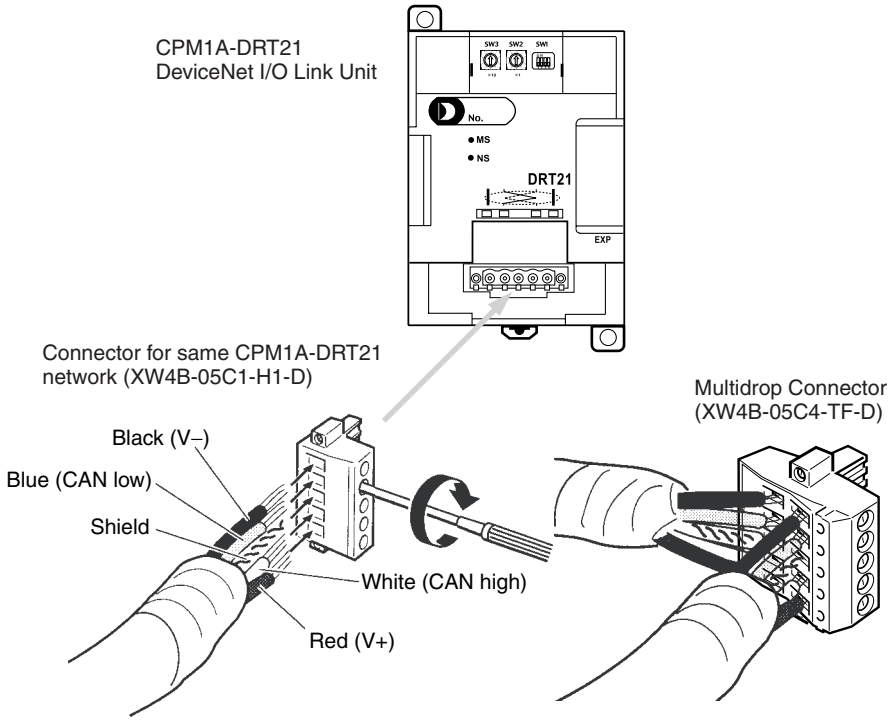
Output Hold Function

Pin 4	DeviceNet baud rate
OFF	Clears remote outputs when communications error occurs. (Outputs turned OFF for each logic value.)
ON	Holds remote outputs when communications error occurs.

Note When using Expansion Unit/Expansion I/O Unit Error Flags (A436) in the program, turn ON pin 4 on the DIP switch. If communications are set to be cleared, the timing for clearing outputs and setting the Error Flags may not agree.

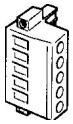
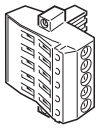
Wiring the DeviceNet Communications Path

When using a CPM1A-DRT21 DeviceNet I/O Link Unit, wire the DeviceNet communications cable as shown in the following diagram.



DeviceNet Connectors

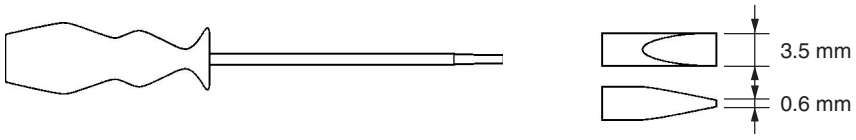
Use the following connectors.

Model	XW4B-05C1-H1-D	XW4B-05C4-TF-D
Form and specifications	OMRON connector with screws (provided with CPM1A-DRT21) 	OMRON connector for multidrop connections (See note.) 

Note Use the XW4B-05C4-TF-D when wiring multidrop connections using Thick Cables.

Use the following screwdriver for the above connector.

XW4Z-00C



I/O Response Time

Refer to the *DeviceNet Slaves Operation Manual* (W347) for details on the response time. The data read/write time for one cycle for the CPM1A-DRT21 is approximately 0.5 ms. Add a maximum of 1 ms to the I/O response time.