Panasonic®

PROGRAMMABLE CONTROLLER

FP0 Thermocouple Unit
Technical Manual

Safety Precautions

Observe the following notices to ensure personal safety or to prevent accidents.
To ensure that you use this product correctly, read this User's Manual thoroughly before use.
Make sure that you fully understand the product and information on safety.
This manual uses two safety flags to indicate different levels of danger.

WARNING

If critical situations that could lead to user's death or serious injury is assumed by mishandling of the product.
-Always take precautions to ensure the overall safety of your system, so that the whole system remains safe in the event of failure of this product or other external factor.
-Do not use this product in areas with inflammable gas. It could lead to an explosion.
-Exposing this product to excessive heat or open flames could cause damage to the lithium battery or other electronic parts.

CAUTION

If critical situations that could lead to user's injury or only property damage is assumed by mishandling of the product.
-To prevent excessive exothermic heat or smoke generation, use this product at the values less than the maximum of the characteristics and performance that are assured in these specifications.
-Do not dismantle or remodel the product. It could cause excessive exothermic heat or smoke generation.
-Do not touch the terminal while turning on electricity. It could lead to an electric shock.
-Use the external devices to function the emergency stop and interlock circuit.
-Connect the wires or connectors securely.
The loose connection could cause excessive exothermic heat or smoke generation.
-Do not allow foreign matters such as liquid, flammable materials, metals to go into the inside of the product. It could cause excessive exothermic heat or smoke generation.
-Do not undertake construction (such as connection and disconnection) while the power supply is on. It could lead to an electric shock.

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Precautions before Usage

- Accuracy

・Connecting/disconnecting the Thermocouple input terminal block while the Thermocouple Unit is ON will lower an accuracy temporarily. Accordingly, use the temperature data obtained 15 minutes after its action.

・When a high-accurate temperature data is required, use the temperature data obtained 15 minutes after turning ON the Thermocouple Unit. (However, the temperature data within 15 minutes is also within the Total accuracy range.)

・A rapid temperature change in the Thermocouple Unit might change the temperature data temporarily.

・The direct air (wind) from the cooling fan built in the control panel etc. to the Thermocouple Unit will lower an accuracy. Prevent a direct air.

- Programming

・From the Power-ON to the converted data Ready, the digital value will be K8001 or K16001. Create a ladder program not to use the data obtained during that period.

・When the thermocouple is broken, the digital value will change to K8000 or K16000 within 70 seconds. Practice in the ladder program a process for avoiding a risk, would be resulting from a broken thermocouple, and exchange the thermocouple.

・When the Input range setting switch is set for 4 channels or more, use a program described in "7.2 Program>, without fail.

1 Unit Outlines

1.1 Functions

1. Thermocouple input unit for FP0/FP∑ Control Unit
   The temperature data obtained using the thermocouple is converted to the digital value to be read into the FP0/ FP∑ Control Unit.

2. Thermocouple types K, J, T and R are available.

3. 3 temperature measurement ranges are available.
   -100.0 to +500.0   (Thermocouple types: K and J)
   -100.0 to +400.0   (Thermocouple type : T)
      0.0 to +1500.0   (Thermocouple type : R)

4. The data can be converted to the degree Celsius or the degree Fahrenheit.
   The temperature data measured using the sensor is converted to the degree Celsius or the degree Fahrenheit inside the Thermocouple Unit.

5. The averaging function is installed.
   The converted data (degree Celsius or Fahrenheit) is averaged, so that even unstable input signals can be properly read.

6. The broken-thermocouple detector is attached.
   A thermocouple, broken, can be detected.

1.2 Model

- Thermocouple Unit

Part number	Thermocouple input points	Product number
FP0-TC4	4 points	AFP0420
FP0-TC8	8 points	AFP0421

1.3 Unit Connection Limit

- Number limit
   Up to 3 expansion units can be connected with the Control Unit.

- Position limit
   Install the thermocouple unit on the right side of other expansion unit. If it is installed on the left side, the total
   precision will deteriorate.

Reference: "7.1 I/O No.".

2 Part Names and Functions

- Thermocouple Unit

Left side

③ Power supply connector

⑤ Expansion hook

④ DIN rail attachment lever

Front

FP0-TC4

① Input range setting switch

② Thermocouple input terminal block

FP0-TC8
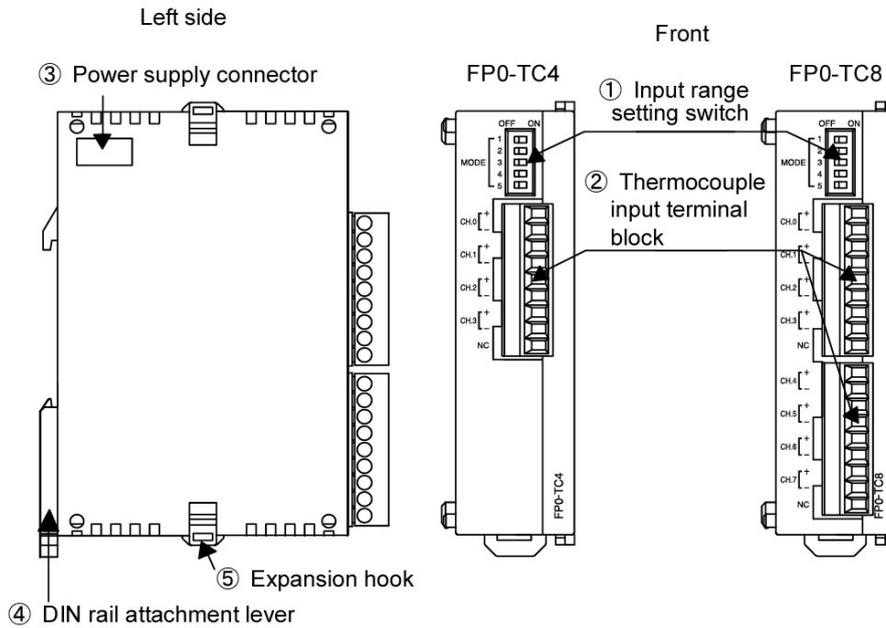
①Input range setting switch
changes between the input ranges (thermocouple types). Only the same range setting is available for all the 8 channels. (The setting can not be specified per channel.)

Reference: "4 Input Range Setting Switch".

②Thermocouple input terminal block (9-pin)
is made by Phoenix. Model No. is MC1.5/9-ST-3.5 (Part No.: 1840434)

Suitable wires

Size	Nominal cross-sectional area
AWG# 28 to 16	0.08 mm^2 to 0.25mm^2

Reference: FP0 Hardware Manual "Wiring the Terminal Type".
                 FP Σ User's Manual "Wiring of Terminal Block Type".

③Expansion connector
Connects the expansion unit to the internal circuit of the Control Unit.

Reference: FP0 Hardware Manual "Adding Expansion Units".
              FP Σ User's Manual "Expansion Method of Units for FP0 and FP Σ".

④DIN rail attachment lever (One-touch hook)
The unit can be installed to the DIN rail through one-touch operation.
This is also used for installing the unit to the FP0 Slim Type Mounting Plate (AFP0803).

⑤Expansion hook
Fixes the expansion unit with the Control Unit.

3 Input Range Setting Switch

- Input range setting switch
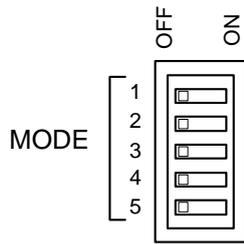
(The following switch settings are read once when the Control Unit is turned ON. Any change will not be reflected even if made while ON.)

1) Input range setting switch

	OFF ON	OFF ON	OFF ON	OFF ON
MODE SW 1				
2				
Thermocouple type	K	J	T	R

2) Temperature unit switch

	OFF ON	OFF ON
MODE SW 3		
Unit	℃	℉

3) Input channel selection switch

	OFF ON	OFF ON	OFF ON	OFF ON
MODE SW 4				
5				
Input channel	CH0, 1	CH0 to CH3	CH0 to CH5	CH0 to CH7
Number of input channels	2	4	6 *	8 *

* Do not specify it for the FP0-TC4.

4 Wiring

- Wiring method
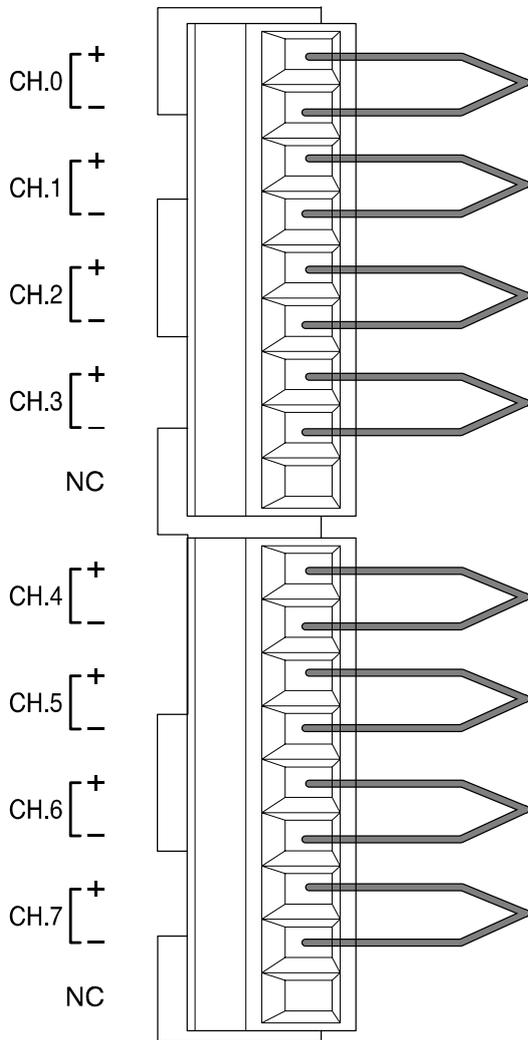
- Input line wiring
　・Keep the space more than 100mm between the input line and the power line/high-voltage line.
　・It is recommended grounding the unit using the insulated compensating wire.
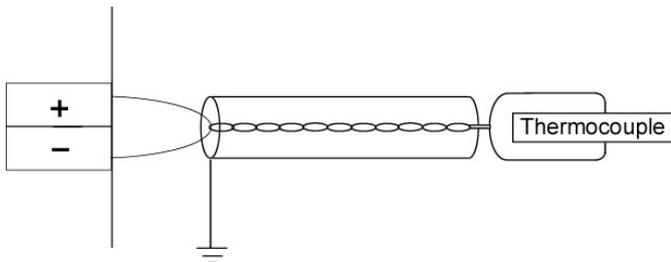
- Input terminal block

Pin No.	Name	Function
1	CH.0 +	CH0 + thermocouple input
2	CH.0 -	CH0 - thermocouple input
3	CH.1 +	CH1 + thermocouple input
4	CH.1 -	CH1 - thermocouple input
5	CH.2 +	CH2 + thermocouple input
6	CH.2 -	CH2 - thermocouple input
7	CH.3 +	CH3 + thermocouple input
8	CH.3 -	CH3 - thermocouple input
9	NC	no connection
1	CH.4 +	CH4 + thermocouple input
2	CH.4 -	CH4 - thermocouple input
3	CH.5 +	CH5 + thermocouple input
4	CH.5 -	CH5 - thermocouple input
5	CH.6 +	CH6 + thermocouple input
6	CH.6 -	CH6 - thermocouple input
7	CH.7 +	CH7 + thermocouple input
8	CH.7 -	CH7 - thermocouple input
9	NC	no connection

* Where between channels are insulated using the PhotoMos relay.

5 Conversion Characteristic

- K and J range (-100.0℃ to 500.0℃)
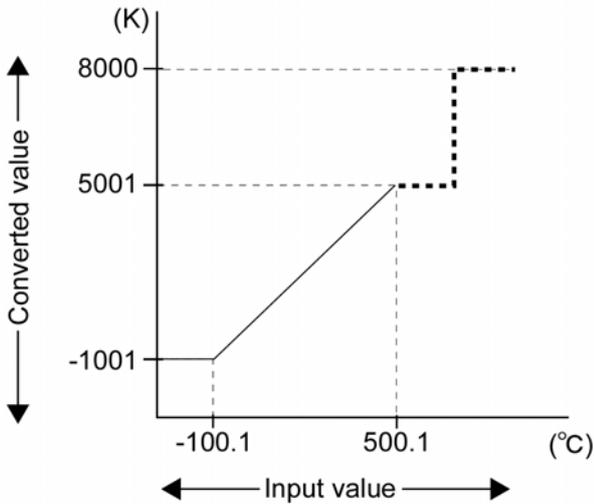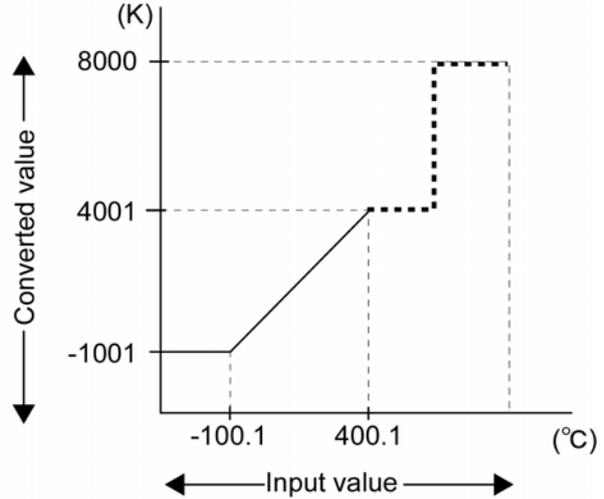
- T range (-100.0℃ to 400.0℃)

When the input out of the range is made

Input	converted to
-100.1℃ Max.	K -1001
500.1℃ Min.	K 5001 or K 8000
When the thermocouple is broken	K 8000

When the input out of the range is made

Input	converted to
- 100.1℃ Max.	K -1001
400.1℃ Min.	K 4001 or K 8000
When the thermocouple is broken	K 8000

- R range (0.0℃ to 1500.0℃)
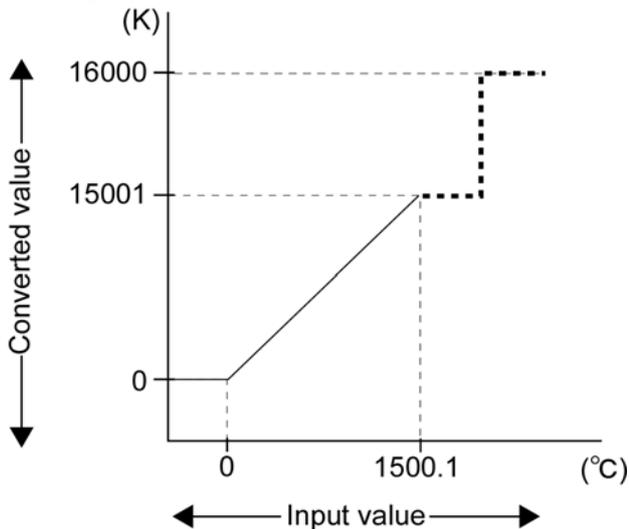
When the input out of the range is made

Input	converted to
0.0℃ Max.	K 0
1500.1℃ Min.	K 15001 or K 16000
When the thermocouple is broken	K 16000

- K and J range (-148.0℉ to 790.0℉)
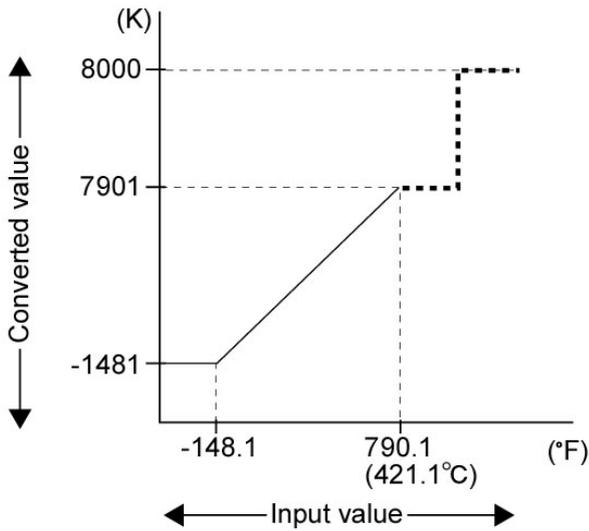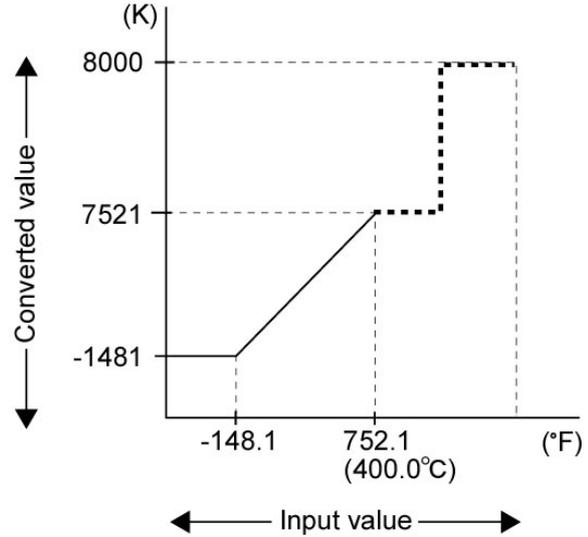
- T range   (-148.0℉ to 752.0℉)

When the input out of the range is made

Input	converted to
148.1℉ Max.	K -1481
790.1℉ Min.	K 7901 or K 8000
When the thermocouple is broken	K 8000

When the input out of the range is made

Input	converted to
-148.1℉ Max.	K -1481
752.1℉ Min.	K 7521 or K 8000
When the thermocouple is broken	K 8000

- R range(32.0℉ to 1590.0℉)
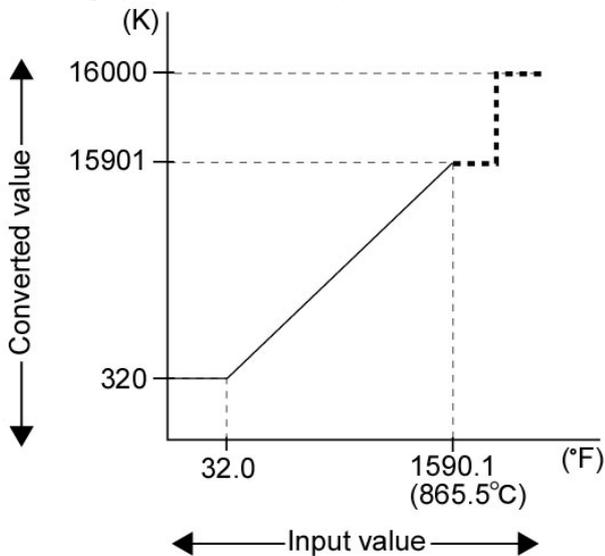
When the input out of the range is made

Input	converted to
32.0℉ Max.	K 320
1590.1℉ Min.	K 15901 or K 16000
When the thermocouple is broken	K 16000

Note: The measurement range available for degree Celsius is not available for degree Fahrenheit, of which the upper-limit measrement is set lower than degree Celsius, since the digital value (temperature value displayed) for degree Fahrenheit is bigger than that for degree Celsius.

6 What is Averaging ?

The followings are processed inside the Thermocouple Unit.
The example below is for when the number of the input channels is 2. (The input range setting switches, No.4 and No.5, are OFF.)

Operation		Timing chart
Input	CH0 input (Reading timing)	300ms 300ms 300ms ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch1 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 ch0 1800 1780 1820 1790 1800 1850 1900 1830 1870 1910 1780 1810 1950
Performance inside the unit	Internal processing by CH0	1800 1780 1820 1790 1800 1850 1900 1830 The Min. to be deleted. The Max. to be deleted. (1800+1820+1790+1800+1850+1830) /6=1815 Averages the values for the 6 measurements, from the latest 8 measurements, excluding the Min. and Max. 1780 1820 1790 1800 1850 1900 1830 1870 The Min. to be deleted. The Max. to be deleted. (1820+1790+1800+1850+1830+1870) /6=1826.7 1820 1790 1800 1850 1900 1830 1870 1910 The Min. to be deleted. The Max. to be deleted. (1820+1800+1850+1900+1830+1870) /6=1845
Output	Digital output value (CH0)	K1845 K1826 K1815

The values for the 6-time measurements, from the latest 8-time measurements, excluding the Max. and the Min., are averaged and the newest average is always output to WX2 and WX3. (The decimal fractions are rounded off.)

7 I/O Allocations and Program

7.1 I/O No.

- I/O No.

FP0/FP Σ Control Unit
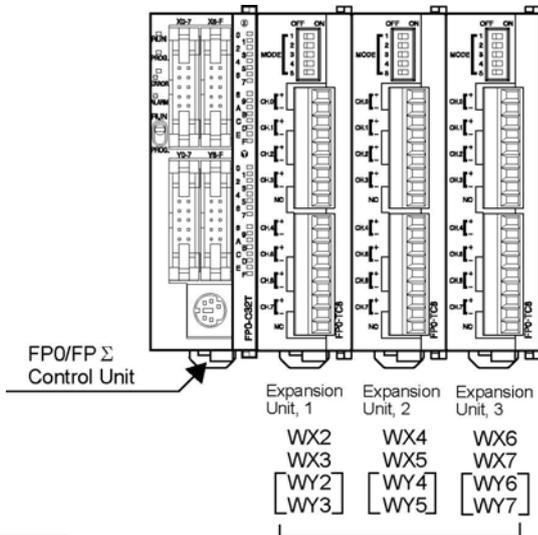
Up to 3 expansion units, including the Thermocouple Unit, can be connected with the Control Unit. (2 Words [2 x 16 bits] are assigned to WX and WY each.)

Expansion Unit, 1
WX2
WX3
[WY2
WY3]

Expansion Unit, 2
WX4
WX5
[WY4
WY5]

Expansion Unit, 3
WX6
WX7
[WY6
WY7]

Note: *Install the thermocouple unit on the right side of other expansion unit. If it is installed on the left side, the total precision will deteriorate.
*In case of 3 expansion unit (1 of which is the Thermocouple Unit): Mount the Thermocouple Unit in the place of Expansion Unit, 3.
*In case of 3 expansion unit (2 of which is the Thermocouple Unit): Mount the Thermocouple Unit in the places of Expansion Units, 2 and 3.

- The data from each channel is assigned as the I/O data to the data registers below when the A/D Converter Unit is installed in the above unit configuration;

Thermocouple Unit input channel	Expansion Unit, 1	Expansion Unit, 2	Expansion Unit, 3
CH0, 2, 4, 6	WX2	WX4	WX6
CH1, 3, 5, 7	WX3	WX5	WX7

- Example of the I/O allocations
The converted data for channels when the Thermocouple Unit is installed in the Expansion Unit, 1 and its assignment to WX2 and WX3

WX3

| X3F | X3E | X3D | X3C | X3B | X3A | X39 | X38 | X37 | X36 | X35 | X34 | X33 | X32 | X31 | X30 |

bit F   bit 0

WX2

| X2F | X2E | X2D | X2C | X2B | X2A | X29 | X28 | X27 | X26 | X25 | X24 | X23 | X22 | X21 | X20 |

bit F   bit 0

| A1 | A0 | Converted data for CH1, 3 ,5 and 7 (signed 14-bit data) |

Converted data for CH 0, 2, 4 and 6 (signed 16-bit data)

Conversion data switch flag
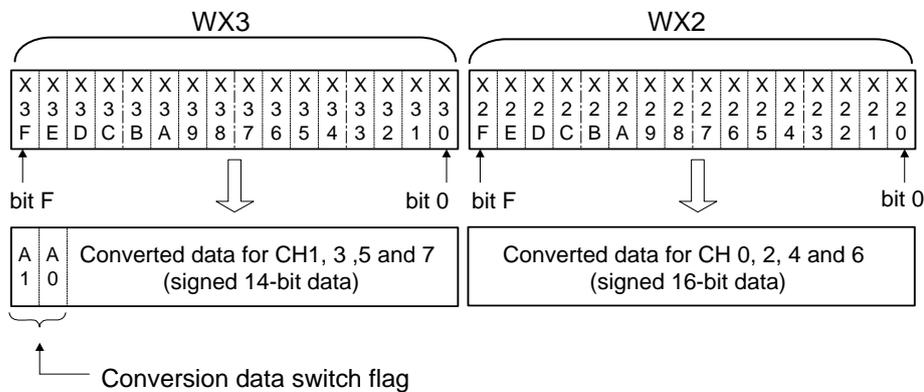
A1	A0	WX3	WX2
0	0	CH1 data	CH0 data
0	1	CH3 data	CH2 data
1	0	CH5 data	CH4 data
1	1	CH7 data	CH6 data

7.2 Program

7.2.1 Thermocouple Types K, J and T

- Ladder program to read the data from input channels

⌈ The program to store in the data registers, DT0 to DT7, the temperature
⌊ data for CH0 to CH7 of the Thermocouple Unit installed in the 1st. ⌉

	Reading flag switchig
0	When each flags R0 to R11 turns on, the data for CH0 to CH7 is read sequentially.

The data for CH0 and CH1

```
        X3F      X3E                                    R0
    0 --|/|------|/|----------------------------------( )--   CH0 data
        R0       X3D                                   R1
    3 --| |------|/|----------------------------------( )--   When CH1 data is positive.
        R0       X3D                                   R2
    6 --| |------| |----------------------------------( )--   When CH1 data is negative.
```

The data for CH2 and CH3

```
        X3F      X3E                                    R3
    9 --|/|------|/|----------------------------------( )--   CH2 data
        R3       X3D                                   R4
   12 --| |------|/|----------------------------------( )--   When CH3 data is positive.
        R3       X3D                                   R5
   15 --| |------| |----------------------------------( )--   When CH3 data is negative.
```

The data for CH4 and CH5

```
        X3F      X3E                                    R6
   18 --|/|------|/|----------------------------------( )--   CH4 data
        R6       X3D                                   R7
   21 --| |------|/|----------------------------------( )--   When CH5 data is positive.
        R6       X3D                                   R8
   24 --| |------| |----------------------------------( )--   When CH5 data is negative.
```

The data for CH6 and CH7

```
        X3F      X3E                                    R9
   27 --|/|------|/|----------------------------------( )--   CH6 data
        R9       X3D                                   R10
   30 --| |------|/|----------------------------------( )--   When CH7 data is positive.
        R9       X3D                                   R11
   33 --| |------| |----------------------------------( )--   When CH7 data is negative.
```

36	Conversion data is read. Lower word data: It read as is. Higher word data: The higher 2 digits are masked. When the value is positive, masking is carried out with "00". When the value is negative, masking is carried out with "11".

The data for CH0 and CH1 to be read

```
        R0
    ---| |------[F0  MV   , WX 2 , DT 0 ]                     CH0 data→DT0
        R1
   42 --| |-----[F65 WAN , WX 3 , H 3FFF , DT 1 ]            When CH1 data is positive.→DT1
        R2
   50 --| |-----[F66 WOR , WX 3 , H C000 , DT 1 ]            When CH1 data is negative.→DT1
```

The data for CH2 and CH3 to be read

```
        R3
   58 --| |-----[F0  MV   , WX 2 , DT 2 ]                     CH2 data→DT2
        R4
   64 --| |-----[F65 WAN , WX 3 , H 3FFF , DT 3 ]            When CH3 data is positive.→DT3
        R5
   72 --| |-----[F66 WOR , WX 3 , H C000 , DT 3 ]            When CH3 data is negative.→DT3
```

The data for CH4 and CH5 to be read

```
        R6
   80 --| |-----[F0  MV   , WX 2 , DT 4 ]                     CH4 data→DT4
        R7
   86 --| |-----[F65 WAN , WX 3 , H 3FFF , DT 5 ]            When CH5 data is positive.→DT5
        R8
   94 --| |-----[F66 WOR , WX 3 , H C000 , DT 5 ]            When CH5 data is negative.→DT5
```

The data for CH6 and CH7 to be read

```
        R9
  102 --| |-----[F0  MV   , WX 2 , DT 6 ]                     CH6 data→DT6
        R10
  108 --| |-----[F65 WAN , WX 3 , H 3FFF , DT 7 ]            When CH7 data is positive.→DT7
        R11
  116 --| |-----[F66 WOR , WX 3 , H C000 , DT 7 ]            When CH7 data is negative.→DT7

  124 --------------------------------------------------( ED )--
```

Reference: "7.1 I/O No.".

- Conversion data switch flag
When transferring the data from the Thermocouple Unit to the Control Unit, it is converted to the 32-bit data including the channel information. The data for WX2 can be used as is, but the following process is required for the WX3 data since its higher 2 bits are used as a conversion data switch flag;

- What to do
When the temperature data is negative, the data for WX2 and WX3 will be 2's complement.
That is, bit F for WX2 and bit D for WX3 will be "1".
The higher 2 bits for WX3 are used as the conversion data switch flag, so that masking using "00" is needed when the conversion data is positive, using "11" when negative.

Data for CH3	WX3	→	Data after masked
1	0100000000000001	→	0000000000000001
-1	0111111111111111	→	1111111111111111

recognizes Positive or Negative at bit D.

Conversion data switch flag

The above values to be masked.

👉 **Note:** X3D, X3E, X3F, WX2 and WX3 are changed depending on where the Thermocouple Unit is installed.

7.2.2 Thermocouple Types, R

- Ladder program to read the data from input channels

⌈ The program to store in the data registers, DT0 to DT7, the temperature
data for CH0 to CH7, of the Thermocouple Unit installed in the 1st. ⌉
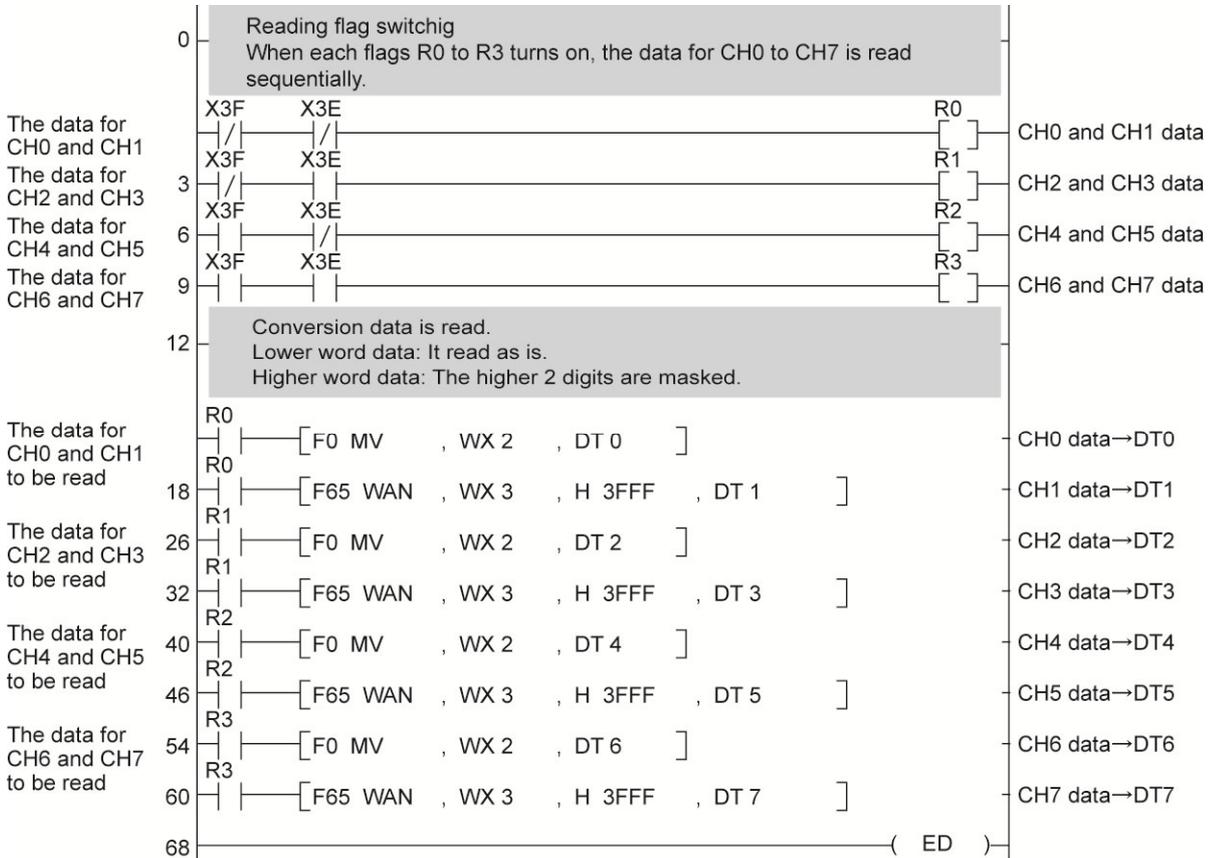
Reference: "7.1 I/O No.".

- Conversion data switch flag
When transferring the data from the Thermocouple Unit to the Control Unit, it is converted to the 32-bit data including the channel information. The data for WX2 can be used as is, but the following process is required for the WX3 data since its higher 2 bits are used as a conversion data switch flag;

- What to do
The temperature data is positive only, so that the data of bit 0 to bit F for WX2 and bit 0 to bit D for WX3 can be handled intact as a temperature.
The higher 2 bits for WX3 are used as the conversion data switch flag, so that masking using "00" is needed.

Data for CH3	WX3	→	Data after masked
1	01 00000000000001	→	00 00000000000001

The above values to be masked

Conversion data switch flag

Note: X3E, X3F, WX2 and WX3 are changed depending on where the Thermocouple Unit is installed.

8 When Error Occurred

8.1 What to Do

What to do ①
        Check whether the input signal line are properly connected.
        When the thermocouple is not connected properly or broken, K8000 is displayed for the
        Thermocouple type K, J and T and K16000 for R.

What to do ②
        Check whether the Input range setting switch (, which specifies the allowable temperature range,
        the thermocouple type and the valid channel) is properly set.

What to do ③
        Use the program described in "7.2 Program" when the number of input channels are more than 4.

Reference: "3 Input Range Setting Switch".

Reference: "7 I/O Allocations and Program".

8.2 Digital Value when Out of Range

When the input of the FP0 Thermocouple Unit is out of the range, the digital values below are displayed;

	K, J range		T range		R range	
	℃	℉	℃	℉	℃	℉
The temp-measured >the upper-limit	5001 or 8000	7901 or 8000	4001 or 8000	7521 or 8000	15001 or 16000	15901 or 16000
The temp-measured <the lower-limit	- 1001	- 1481	- 1001	- 1481	0	32
The thermocouple is connected improperly or broken	8000	8000	8000	8000	16000	16000

9 Specifications

9.1 Specifications

- General specifications

Item	Specifications
Consumption current increased for the Control Unit	25mA Max. (24V DC)
Operating ambient temperature	0℃ to +55℃
Storage ambient temperature	-20℃ to +70℃
Operating ambient humidity	30%RH to 85%RH (at25°C no condensing)
Storage ambient humidity	30%RH to 85%RH (at25°C no condensing)
Withstand voltage	between "all the thermocouple input terminals" and "all the Control unit power/functional earth terminals": 500V AC for 1min. between thermocouple input terminal channels: 200V AC for 1 min.
Insulation resistance	between "all the thermocouple input terminals" and "all the Control unit power/functional earth terminals": more than 100MΩ (Testing voltage: 500V DC)
Vibration resistance	10Hz to 55Hz 1 sweep/min. with double amplitude in 0.75mm for 10 min. on 3 axes (toward X, Y and Z directions)
Shock resistance	98m/s^2 for 4 times on 3 axes (toward X, Y and Z directions)
Noise immunity	1000V [P-P] Pulse width 50ns, 1µs (using noise simulator)
Operating condition	Must be free from corrosive gases and excessive dust.
Weight	about 85g (FP0-TC4) about 95g (FP0-TC8)

- Input specifications

Item	Specification	
Input point	Up to 8 channels per unit (The number of Input points can be changed 2, 4, 6 and 8 channels are available.)	
Input range	Thermocouple types K, J	-100.0℃ to 500.0℃ -148.0℉ to 790.0℉[*1]
	Thermocouple type T	-100.0℃ to 400.0℃ -148.0℉ to 752.0℉[*1]
	Thermocouple type R	0.0℃ to 1500.0℃ 32.0℉ to 1590.0℉[*1]
Digital output	K and J (when using ℃) : K - 1000 to K 5000 K and J (when using ℉) : K - 1480 to K 7900[*1]	
	When range over using(℃) : K -1001, K 5001 or K 8000 When range over using(℉) : K -1481, K 7901 or K 8000	
	(when the thermocouple Broken: K 8000)[*2] (Until the temperature can be measured at the initial startup: K 8001)[*3]	
	T (when using ℃) : K - 1000 to K 4000 T (when using ℉) : K - 1480 to K 7520[*1]	
	When range over using(℃) : K -1001, K 4001 or K 8000 When range over using(℉) : K -1481, K 7521 or K 8000	
	(when the thermocouple Broken: K 8000)[*2] (Until the temperature can be measured at the initial startup: K 8001)[*3]	
	R (when using ℃) : K 0 to K 15000 R (when using ℉) : K 320 to K 15900[*1]	
	When range over using(℃) : K 0, K 15001 or K 16000 When range over using(℉) : K 0, K 15901 or K 16000	
	(when the thermocouple Broken: K 16000)[*2] (Until the temperature can be measured at the initial startup: K 16001)[*3]	
Resolution	0.1℃	
Sampling cycle[*5]	300ms : when using 2 channels for an input points[*4] 500ms : when using 4 channels for an input points[*4] 700ms : when using 6 channels for an input points[*4] 900ms : when using 8 channels for an input points[*4]	

Accuracy	Range for K and J (-100℃ to 500℃) : ±0.8℃
	Range for T (-100℃ to 400℃) : ±0.8℃
	Range for R (0℃ to 99.9℃) : ±3℃
	                        (100℃ to 299.9℃) : ±2.5℃
	                        (300℃ to 1500℃) : ±2℃	

Input impedance	more than 1MΩ	

Insulation method	・between thermocouple input terminals and Control Unit internal circuits
	                 Photo-coupler insulation/DC-DC insulation
	・between thermocouple input terminal channels
	                 PhotoMos relay insulation	

Input/Output points	Input - 32 points 16 points for WX2, 4, 6: Analog input
	                                        CH0, 2, 4, 6 (WX2)[*6*7]
	                    16 points for WX3, 5, 7: Analog input
	                                        CH1, 3, 5, 7 (WX3)[*6*7]
	Output 32 points (reserved.)	

*1 The measurement range available for degree Celsius is not available for degree Fahrenheit, of which the upper-limit measurement is set lower than degree Celsius, since the digital value (temperature value displayed) for degree Fahrenheit is bigger than that for degree Celsius.
*2 When the thermocouple is broken, the digital value will become K8000 or K16000 within 70 seconds since broken. Practice in the ladder program a process for avoiding a risk, would be resulting from a broken thermocouple, and exchange the thermocouple.
*3 Until the conversion data will be ready after the initial startup was made, the digital value shows K8001 or K16001. Those are not a temperature data. Create a ladder program, so that they are not acquired as a temperature data.
*4 The settings of the Input channel selection switch.
*5 Conversion values for 6-time measurements (6 from the latest 8 measurements, excluding the Max. and Min.) are averaged, so that it takes time for the digital value to be displayed due to the rapid temperature change.
*6 The Control Unit reads the data for 2 channels per 1 scan by the Control Unit.
   Read the data using the program described in 7.2.
*7 This changes depending on where the Thermocouple Unit is installed. (This is when the Thermocouple Unit is installed in the 1st.)

- Insulation outline

9.2 Dimensions

FP0-TC4

FP0-TC8
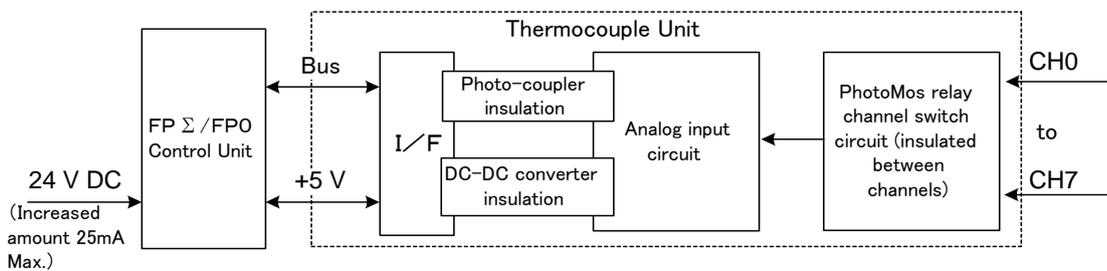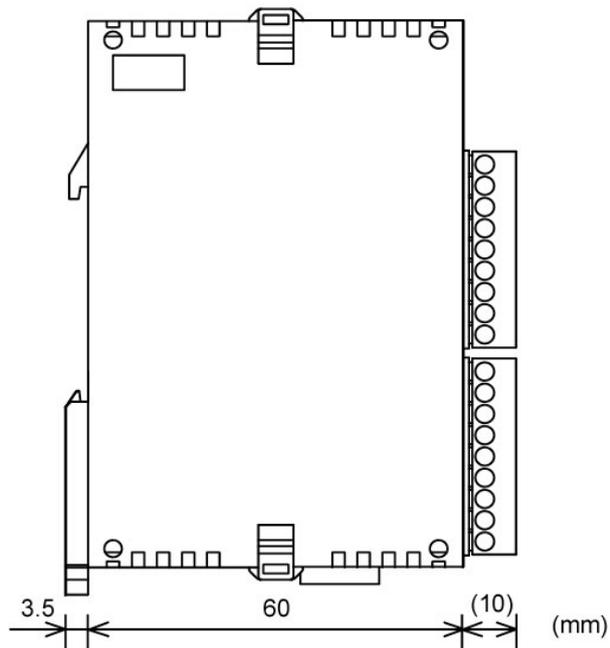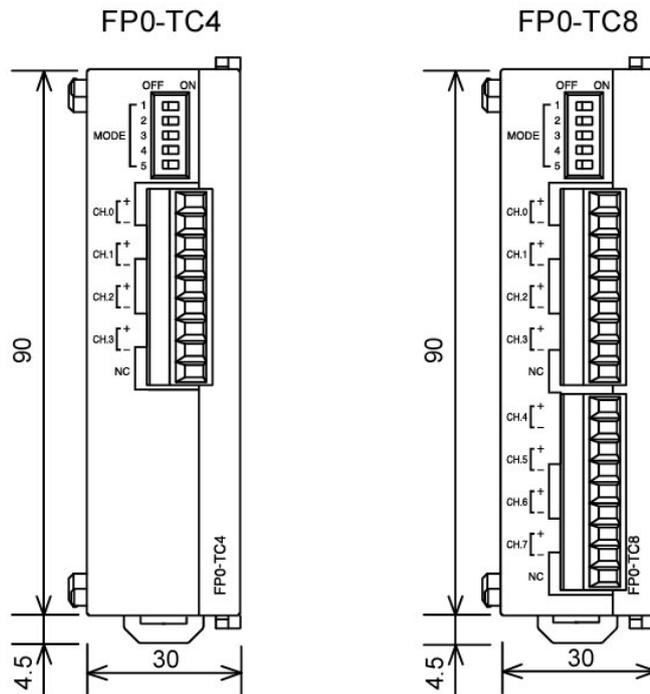
Record of changes

Manual No.	Date	Description of changes
ARCT1F366E	SEPT.2002	First edition
ARCT1F366E-1	FEB.2006	Second edition
ARCT1F366E-2	NOV.2008	Third edition - Change in Corporate name
ARCT1F366E-3	AUG.2011	Fourth edition - Change in Corporate name - Fixed Errors
ARCT1F366E-4	JUL.2013	Fifth edition - Change in Corporate name