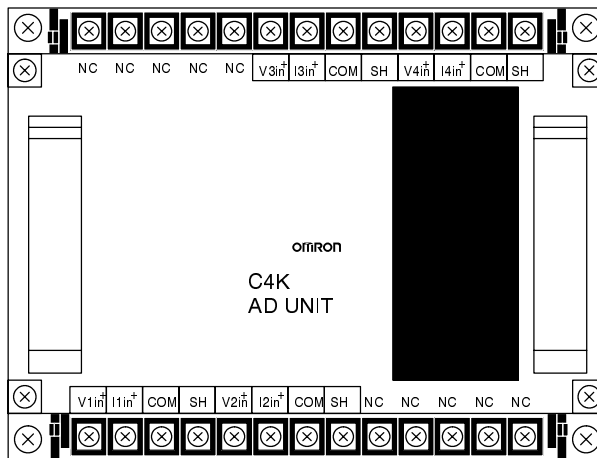
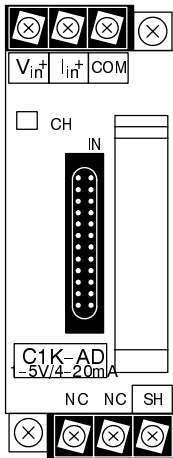


# K-type Analog I/O Units

## Operation Guide

Revision, June 1991



## **Notice:**

OMRON products are manufactured for use according to proper procedures by a qualified operator and only for the purposes described in this manual.

The following conventions are used to indicate and classify warnings in this manual. Always heed the information provided with them.

**DANGER!** Indicates information that, if not heeded, could result in loss of life or serious injury.

**Caution** Indicates information that, if not heeded, could result in minor injury or damage to the product.

## **OMRON Product References**

All OMRON products are capitalized in this manual. The word "Unit" is also capitalized when it refers to an OMRON product, regardless of whether or not it appears in the proper name of the product.

The abbreviation "Ch," which appears in some displays and on some OMRON products, means "word" and is abbreviated "Wd" in documentation.

## **Visual Aids**

The following headings appear in the left column of the manual to help you locate different types of information.

**Note** Indicates information of particular interest for efficient and convenient operation of the product.

**1, 2, 3...** Indicates lists of one sort or another, such as procedures, precautions, etc.

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## ***About this Manual:***

This manual provides hardware and software information required to design K-type Analog I/O Units into a Control System. Analog Input Units enable converting analog signals from external devices into 8-bit binary data for input into the CPU. Analog Outputs Units enable converting 8-bit binary data from the CPU into analog signals for output to external devices.

K-type Analog I/O Units can also be used with P-type PCs.

**Section 1** shows how Analog I/O Units are designed into the PC System, including the types of external I/O devices that they are used with.

**Section 2** describes the methods used to convert analog signals and binary data. It also explains other aspects of Unit operation, including bit allocations in the IR area of the PC.

**Section 3** provides the names of Unit components and accessories.

**Section 4** describes how to wire and install the Units. Unit dimensions are also included.

**Section 5** provides examples of ladder diagram programs that are applicable to Analog I/O Units.

**Appendix A** provides a list of the basic specifications and complete model numbers of K-type Analog I/O Units.

**Appendix B** provides technical specifications.

# SECTION 1

## System Design

1-1	Introduction .....	2
1-2	Basic Setup .....	2
1-3	IR Area Allocations .....	2

## 1-1 Introduction

Analog I/O Units are used to interface the digital operation of the PC with analog I/O devices. Analog Input Units convert analog signals from analog input devices to digital PC signals; the Analog Output Unit converts digital PC signals to analog signals for analog output devices.

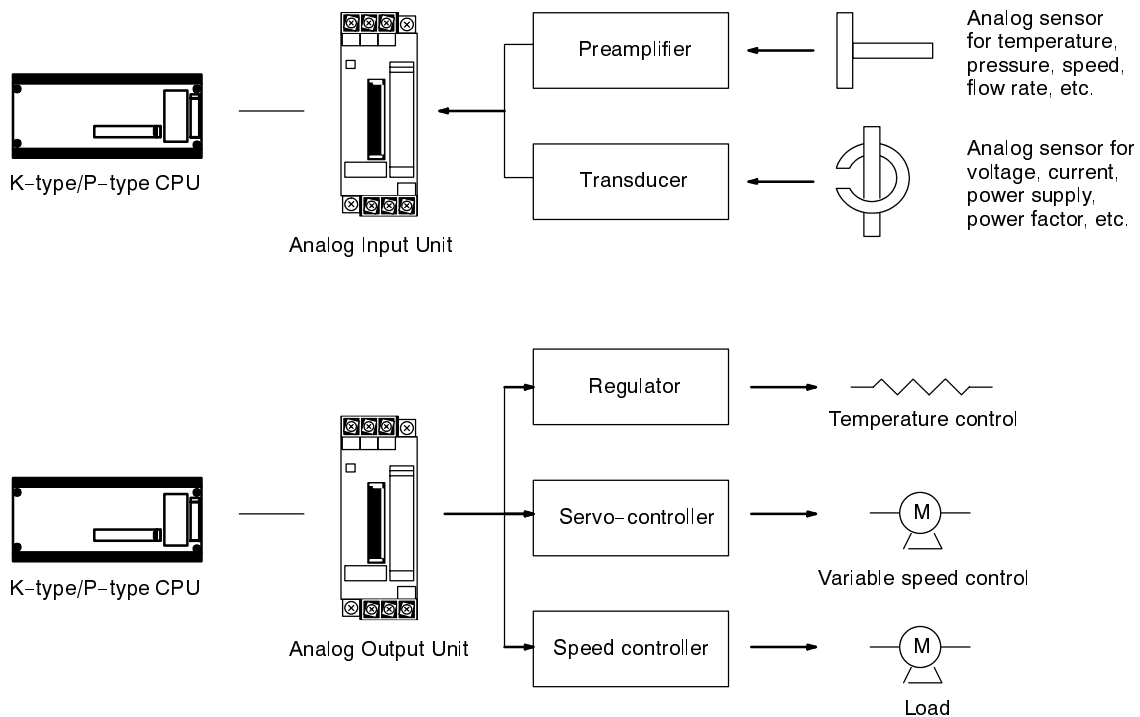
There are three K-type Analog I/O Units available. The C1K-AD Analog Input Unit, which provides one input; the C1K-DA Analog Output Unit, which provides one output; and the C4K-AD Analog Input Unit, which provides four inputs. All Units provide voltage or current I/O terminals.

## 1-2 Basic Setup

An Analog I/O Unit is connected directly to the CPU or Expansion I/O Rack using an I/O Connecting Cable. The external I/O device is then wired to the Analog I/O Unit. Any I/O device may be used as long as its voltage/current requirements fall within specified ranges (see *Appendix B*).

The I/O device connected to the Analog I/O Unit will often serve as an interface for another device, e.g., a preamplifier would interface a pressure gauge to increase the signal level to Analog Input Unit requirements; a regulator would interface a heating system to control temperature.

Some example setups are shown below. Refer to *Section 4-3* for details on wiring.



## 1-3 IR Area Allocations

The Analog I/O Units are allocated 2 words each. Refer to your CPU *Operation Manual* for details on IR area allocation. The use of these words by the Analog I/O Units is described in *Section 3-1-4* for Analog Input Units and in *Section 3-2-4* for the Analog Output Unit.

## **SECTION 2**

### **Components**

2-1	Terminals and Connectors .....	4
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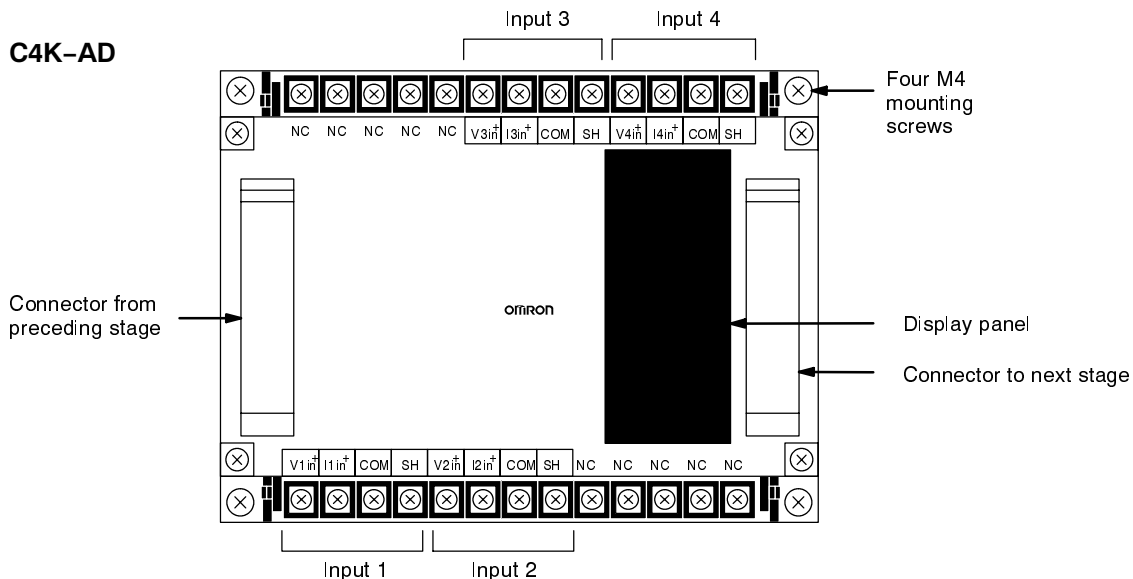
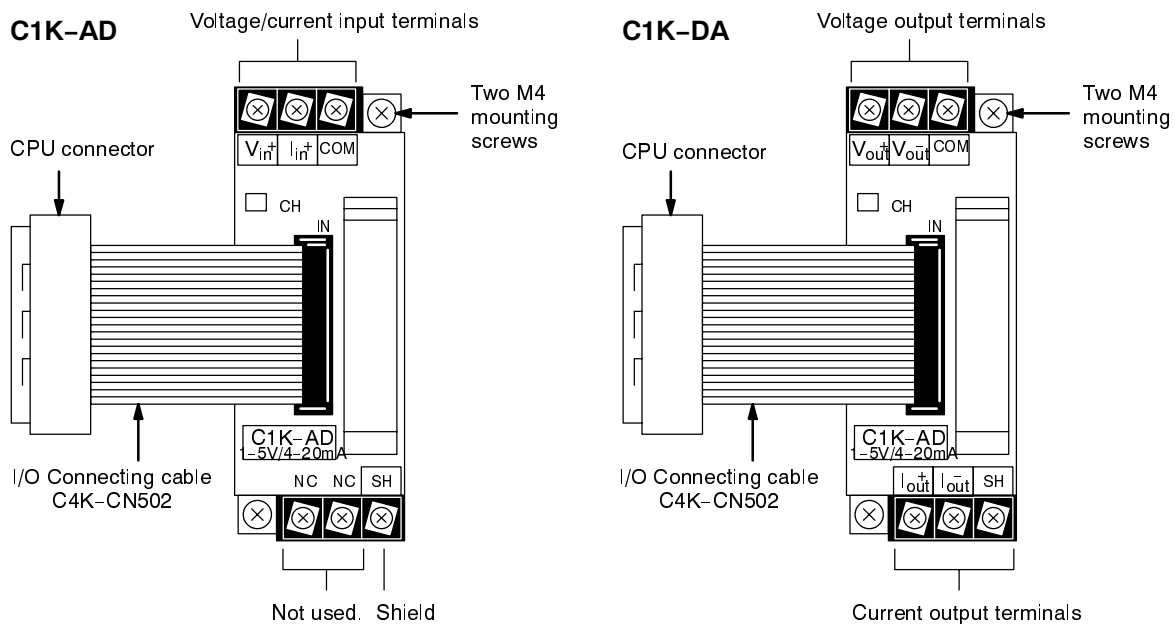
## 2-1 Terminals and Connectors

Connectors are supplied with the Units: one each with the C1K-AD and C1K-DA, and two with the C4K-AD. Mounting screws are spring-loaded and terminal pressure plates are self-rising. Terminals are as shown in the following section.

## 2-2 Component Names

Names of Analog I/O Unit components are shown below. Terminals are as follows:

<b>V<sub>IN</sub></b>	Voltage input	<b>V<sub>OUT</sub></b>	Voltage output
<b>I<sub>IN</sub></b>	Current input	<b>I<sub>OUT</sub></b>	Current output
<b>COM</b>	Common	<b>SH</b>	Shield





## SECTION 3

### Operation

3-1	Analog Input Units .....	6
3-1-1	Input Signal Ranges .....	6
3-1-2	Analog-Digital Conversion .....	6
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3-2	Analog Output Unit .....	9
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3-2-2	Digital-Analog Conversion .....	9
3-2-3	Block Diagram .....	10
3-2-4	IR Area Allocations .....	10

### 3-1 Analog Input Units

There are two Analog Input Units. The C1K-AD provides one input; the C4K-AD provides four inputs. Each of these inputs can be either current or voltage based.

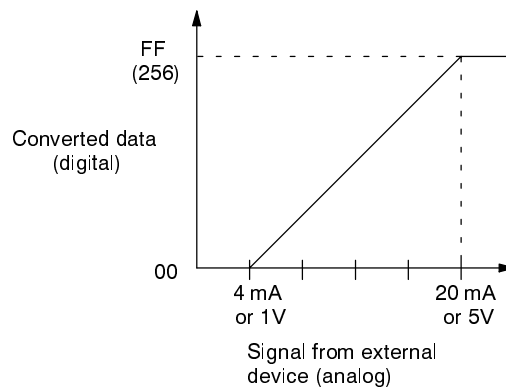
#### 3-1-1 Input Signal Ranges

Analog Input Units convert input analog signals to 8-bit binary data to enable processing by the CPU. A Unit can be connected to convert either the voltage or the current of the input signal. This current or voltage must be within the following ranges.

<b>Voltage</b>	1 to 5 V
<b>Current</b>	14 to 20 mA

#### 3-1-2 Analog-Digital Conversion

The analog input signal is converted in a straight-line relationship to binary values between 00000000 and 11111111 (00 and FF in hexadecimal). These are related to the input voltage and current ranges as shown in the following graph.

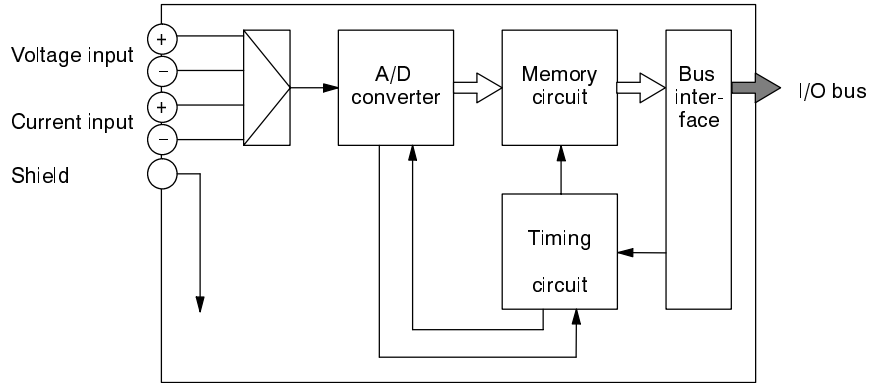


### 3-1-3 Block Diagrams

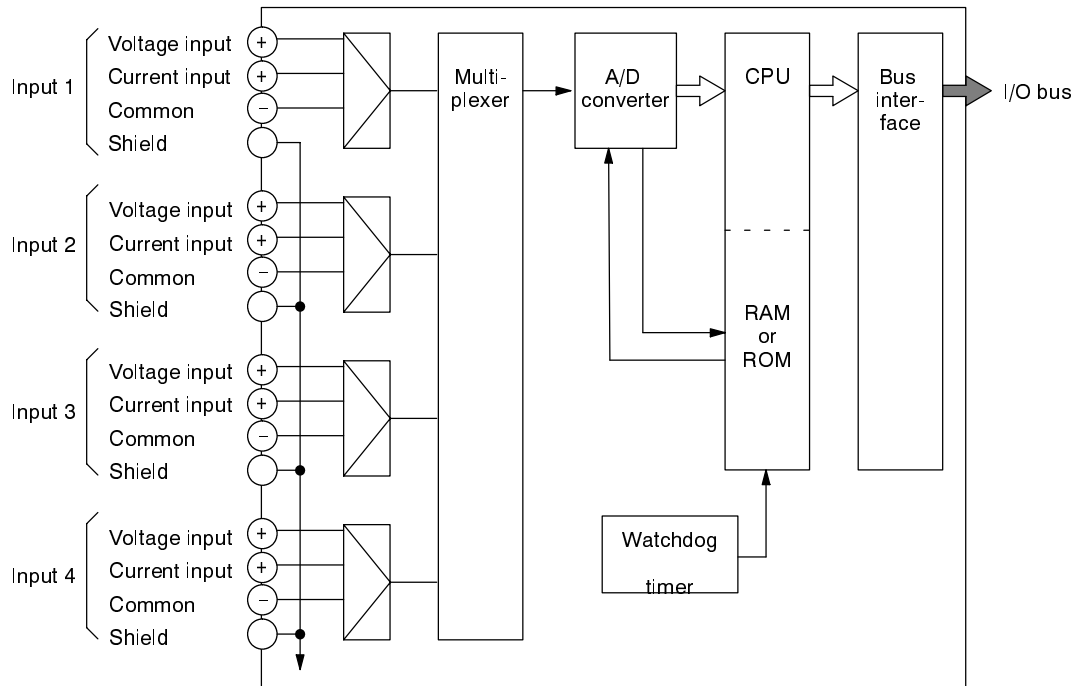
The block diagrams for the Analog Input Units are shown below. These diagram show the internal processing used to convert between analog signals and digital data.

All shield terminals are floating.

#### C1K-AD



#### C4K-AD



### 3-1-4 IR Area Allocations

Each Analog Input Unit is allocated two words in the IR area according to the system configuration of the PC. One of these words will be an input word; the other, an output word. The input word is represented by "n" in this manual; the output word, by "m." Refer to your PC's *Operation Manual* for details on IR area allocation to determine the actual input and output words that will be allocated.

#### C1K-AD

The C1K-AD uses only the first eight bits of the input word allocated to it. These eight bits are used to store the binary equivalent of the analog input signal as shown below.

The remainder of the input word is not used and cannot be accessed. The output word is also not used but can be accessed by the program for use as work bits.

Input bits: IR n		Output bits: IR m	
00	Input data 2 <sup>0</sup>	00	Available as work bits.
01	Input data 2 <sup>1</sup>	01	
02	Input data 2 <sup>2</sup>	02	
03	Input data 2 <sup>3</sup>	03	
04	Input data 2 <sup>4</sup>	04	
05	Input data 2 <sup>5</sup>	05	
06	Input data 2 <sup>6</sup>	06	
07	Input data 2 <sup>7</sup>	07	
08	Cannot be used.	08	
09		09	
10		10	
11		11	
12		12	
13		13	
14		14	
15		15	

**C4K-AD**

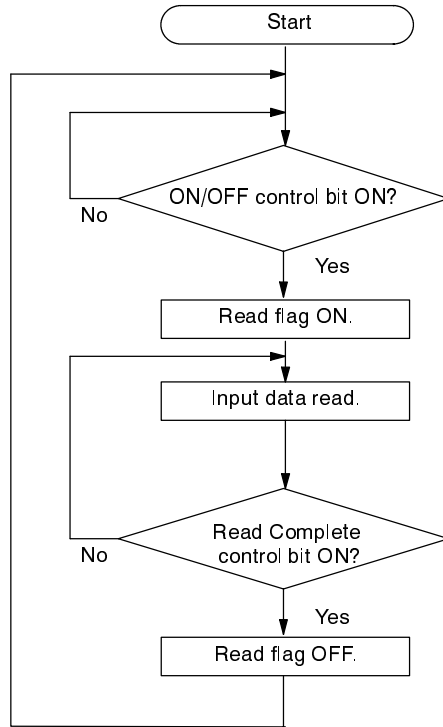
The C4K-AD uses the first eight bits of the input word allocated to it to store the binary equivalent of the analog input signal as shown below. The binary equivalent for only one of the four inputs is stored at any one time.

Most of the remaining input bits and the first eight output bits are used to indicate which analog input the binary equivalent is for and to coordinate reading in the four inputs. The operation of these is described below.

The two input bits that are not used cannot be accessed. The unused output bits can be accessed by the program for use as work bits.

Input bits: IR n		Output bits: IR m	
00	Input data 2 <sup>0</sup>	00	Input 1 ON/OFF control bit
01	Input data 2 <sup>1</sup>	01	Input 2 ON/OFF control bit
02	Input data 2 <sup>2</sup>	02	Input 3 ON/OFF control bit
03	Input data 2 <sup>3</sup>	03	Input 4 ON/OFF control bit
04	Input data 2 <sup>4</sup>	04	Input 1 Read Complete control bit
05	Input data 2 <sup>5</sup>	05	Input 2 Read Complete control bit
06	Input data 2 <sup>6</sup>	06	Input 3 Read Complete control bit
07	Input data 2 <sup>7</sup>	07	Input 4 Read Complete control bit
08	Input 1 Read flag	08	Available as work bits.
09	Input 2 Read flag	09	
10	Input 3 Read flag	10	
11	Input 4 Read flag	11	
12	Cannot be used.	12	
13	Input High flag	13	
14	Input Low flag	14	
15	Cannot be used.	15	

**Process Flow**



The flowchart at the left represents the operation of the ON/OFF control bits, the Read flags, and the Read Complete control bit in controlling data input into the IR area. This operation is repeated in sequence for each input whose ON/OFF control bit is ON, i.e., the ON/OFF control bits are set in the normal program (see example in Section 5-2-1) to control which inputs are read. Each bit requires a maximum of 20 ms to be read.

The process starts when an ON/OFF control bit is turned ON. The statuses of the input data bits for that input are read and then the Read flag is turned ON. When the Read Complete control bit has been turned ON from the program to indicate that the input data is not required any longer, the Read flag is turned OFF and the same procedure is used for the next input whose ON/OFF control bit is ON.

**Other Flags**

The Input High flag and the Input Low flag are turned ON when any input is above or below the input ranges specified in Section 3-1-1.

## 3-2 Analog Output Unit

There is one Analog Output Unit, which provides one output. This output can be either current or voltage based.

### 3-2-1 Output Signal Range

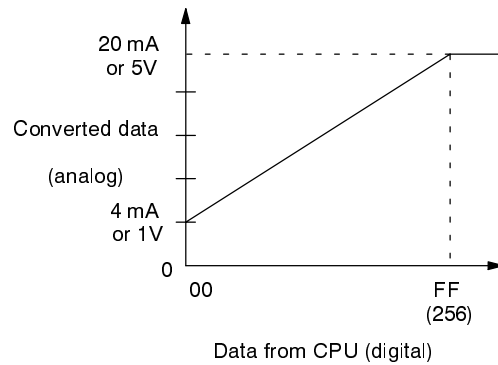
The Analog Output Unit converts 8-bit binary data from the CPU to an analog signal so that it can be output to an external device. A Unit can be connected to convert either to a voltage or to a current. This current or voltage will be within the following ranges:

<b>Voltage</b>	1 to 5 V
<b>Current</b>	14 to 20 mA

### 3-2-2 Digital-Analog Conversion

Binary values between 00000000 and 11111111 (00 and FF in hexadecimal) are converted to an analog output signal in a straight-line relationship. These

are related to the output voltage and current ranges as shown in the following graph.

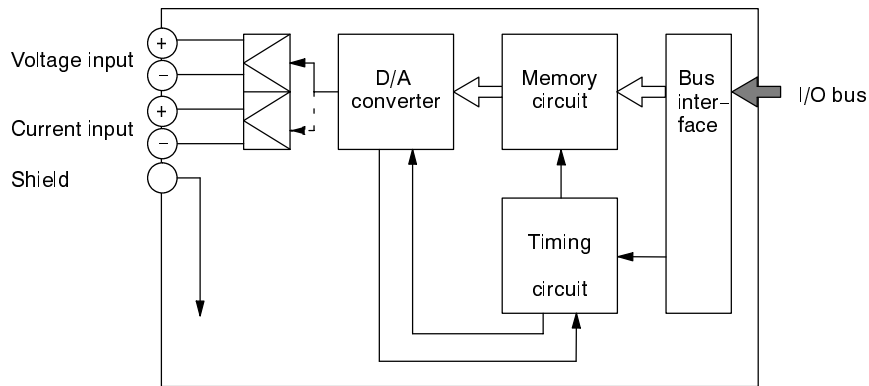


### 3-2-3 Block Diagram

The block diagram for the Analog Output Unit is shown below. This diagram shows the internal processing used to convert between digital data and analog signals.

The shield terminal is floating.

#### C1K-DA



### 3-2-4 IR Area Allocations

The Analog Output Unit is allocated two words in the IR area according to the system configuration of the PC. One of these words will be an input word; the other, an output word. The input word is represented by "n" in this manual; the output word, by "m." Refer to your PC's *Operation Manual* for details on IR area allocation to determine the actual input and output words that will be allocated.

The Analog Output Unit uses only the first eight bits of the output word allocated to it. These eight bits are used to store the binary value that is being converted for output to an external device. These bits are shown below.

The input word is not used and cannot be accessed. The last half of the output word is also not used but can be accessed by the program for use as work bits.

Input bits: IR n		Output bits: IR m		
00	Cannot be used.	00	Output data 2 <sup>0</sup>	
01		01	Output data 2 <sup>1</sup>	
02		02	Output data 2 <sup>2</sup>	
03		03	Output data 2 <sup>3</sup>	
04		04	Output data 2 <sup>4</sup>	
05		05	Output data 2 <sup>5</sup>	
06		06	Output data 2 <sup>6</sup>	
07		07	Output data 2 <sup>7</sup>	
08		Available as work bits.	08	
09			09	
10			10	
11			11	
12			12	
13			13	
14			14	
15	15			





# SECTION 4

## Installation

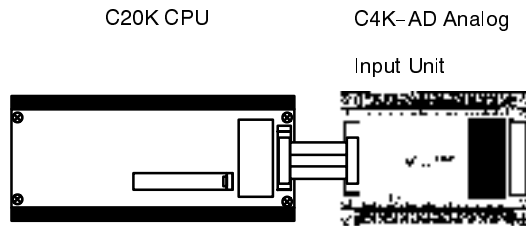
- 4-1 I/O Connecting Cables ..... 14
- 4-2 Dimensions ..... 14
- 4-3 Wiring ..... 15
  - 4-3-1 Analog Input Units ..... 15
  - 4-3-2 Analog Output Unit ..... 17

### 4-1 I/O Connecting Cables

The Analog I/O Units are connected to the CPU through the following cables.

Unit	Cable	Length
C4K (Horizontal connection)	C20P-CN501	5 cm
	C20P-CN411	40 cm
C1K (Horizontal connection)	C4K-CN502	5 cm

The I/O Connecting Cable must be connected from the right-side on the CPU or Expansion I/O Unit to the left-side (IN) connector on the Analog I/O Unit. Connect the end of the I/O Connecting Cable without a cover to the Analog I/O Unit.

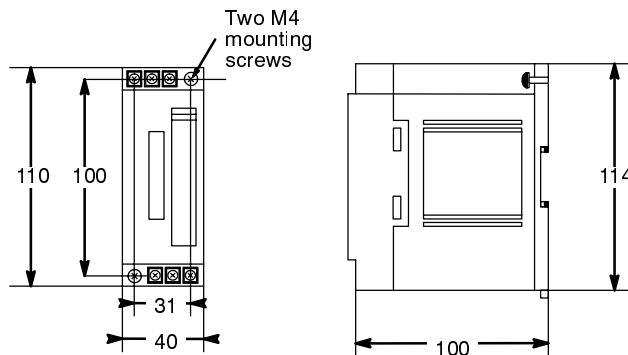


**Caution** An incorrect connection can destroy the Analog I/O Unit. Do not use any cable other than those listed above. Do not connect the CPU to the right-side (OUT) connector on the Analog I/O Unit. Do not reverse the ends of the I/O Connecting Cable.

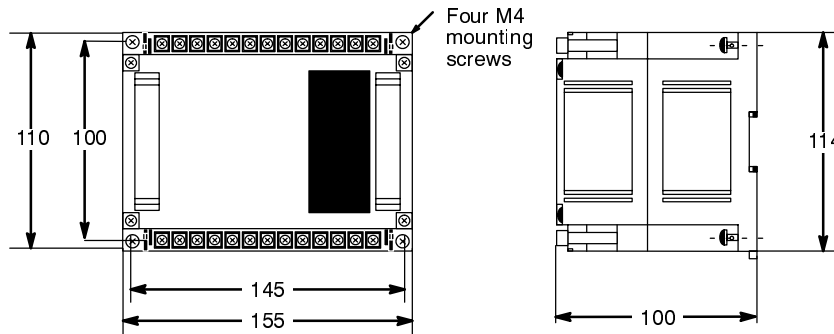
### 4-2 Dimensions

Mounting dimensions are shown below. All units are in millimeters.

C1K-AD and C1K-DA



C4K-AD



## 4-3 Wiring

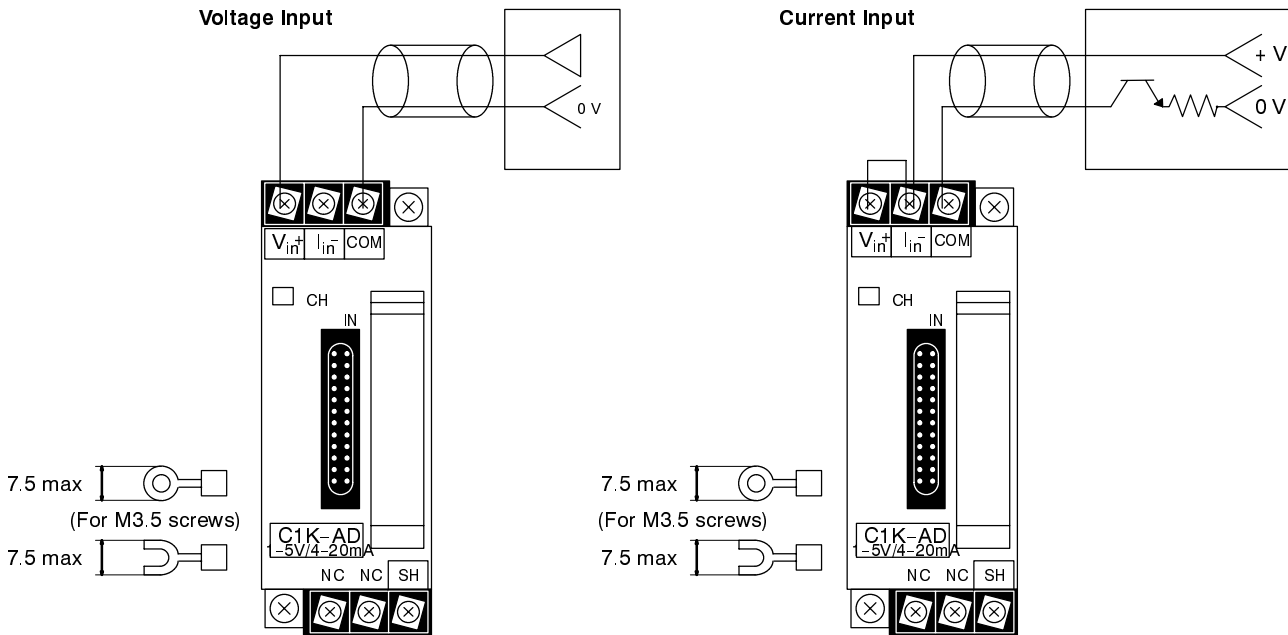
The Analog I/O Units must be wired to provide voltage or current inputs within the specified ranges. If the ultimate I/O device does not provide the correct voltage/current, an intermediate device (e.g., preamplifier) must be used. Details of wiring are provided here only for the terminals on Analog I/O Units. Refer also to the operating manual for the I/O device (or intermediate device) for wiring details.

Wiring diagrams are provided in this section for all Units. Use only shielded, twisted-pair cable to connect an Analog I/O Unit to an external I/O device. All terminals are equipped with M3.5 screws and self-rising pressure plates.

### 4-3-1 Analog Input Units

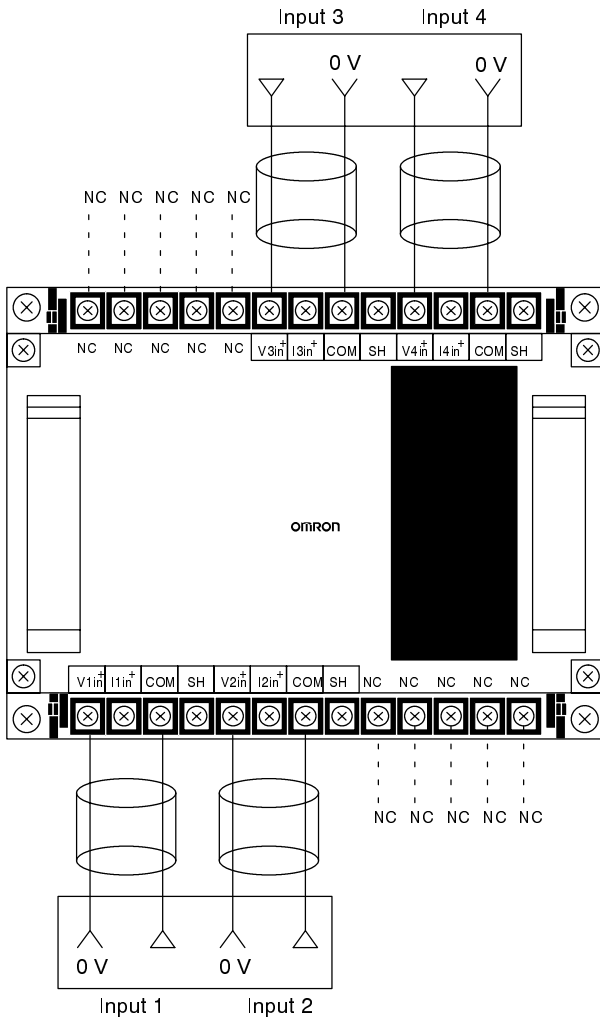
For voltage inputs, wire directly to the voltage terminals. For current inputs, wire directly to the current terminals and then short the current and voltage terminals together using the enclosed jumpers.

#### C1K-AD

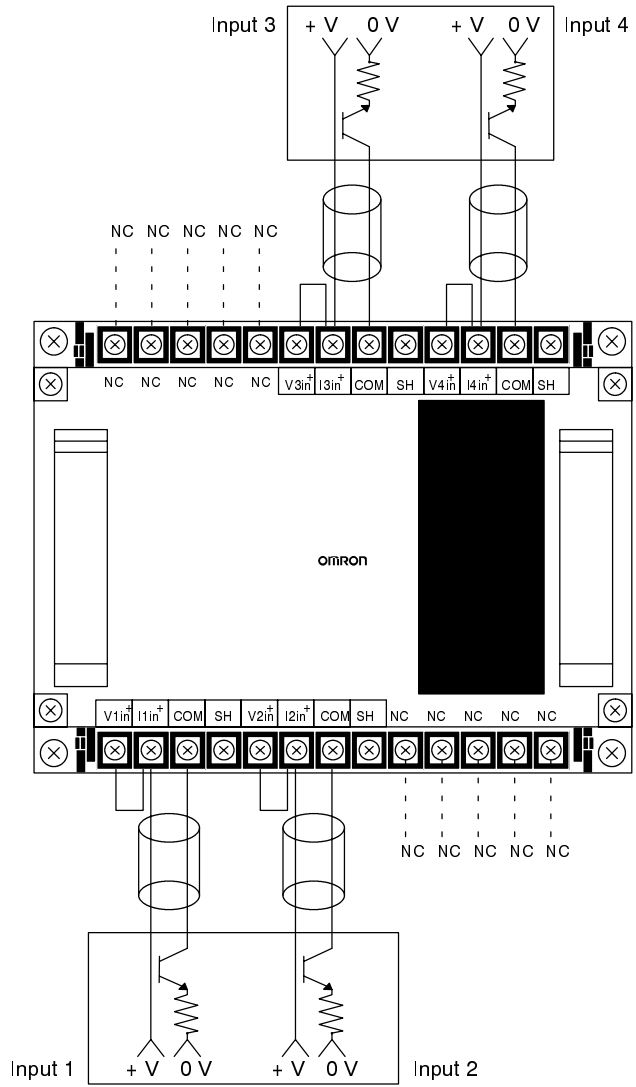


C4K-AD

Voltage Input

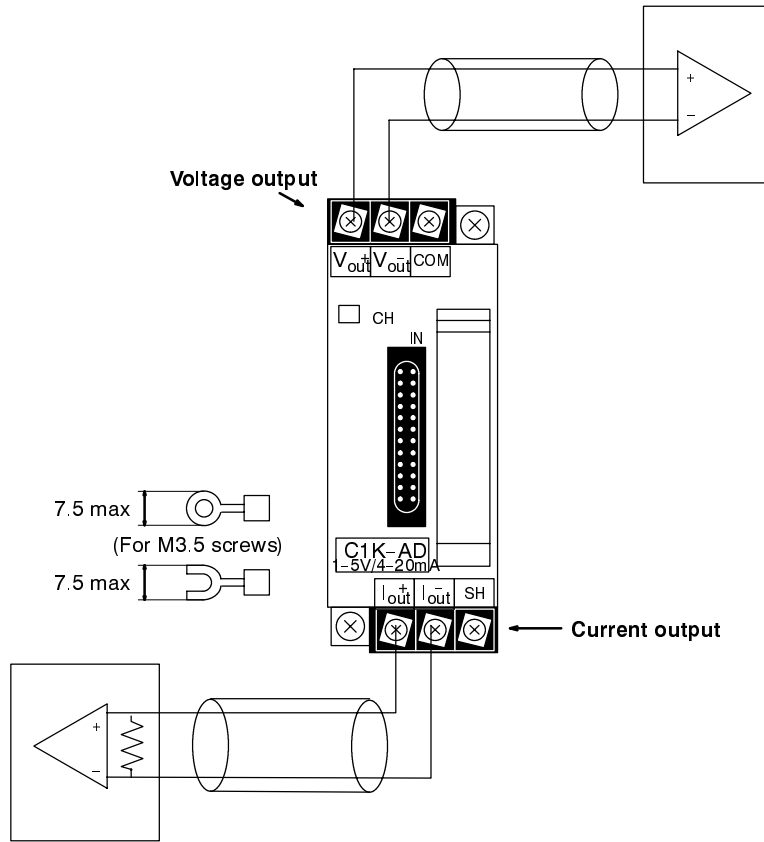


Current Input



### 4-3-2 Analog Output Unit

Voltage and current output terminals are separate on the Analog Output Unit. Never wire both at the same time; only one can be used at a time.





# SECTION 5

## Programming Considerations

5-1	Basic Considerations . . . . .	20
5-2	Programming Examples . . . . .	20
5-2-1	Analog Input Units . . . . .	20
5-2-2	Analog Output Unit . . . . .	23

### 5-1 Basic Considerations

To effectively employ the Analog I/O Units, it is important that data be moved to and from the IR words assigned to them at the proper time and stored in another location where it can be processed.

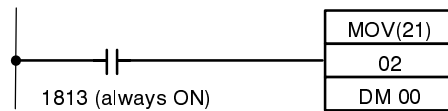
### 5-2 Programming Examples

Programming is an important consideration when using the Analog I/O Units. Programming instructions must be used to move the desired data to locations where it can be stored for later access. With the C4K-AD, the program must also be used to control which inputs are being read and the timing of these inputs.

#### 5-2-1 Analog Input Units

##### C1K-AD

With the C1K-AD Analog Input Unit, all that is necessary is that the input data be moved from the word allocated to the Unit to the data area where it is to be stored. The following example shows how to do this each scan so that DM 00 always holds the most recent input data. In this example IR 02 is the word allocated to the Unit. This word will vary with the system configuration.

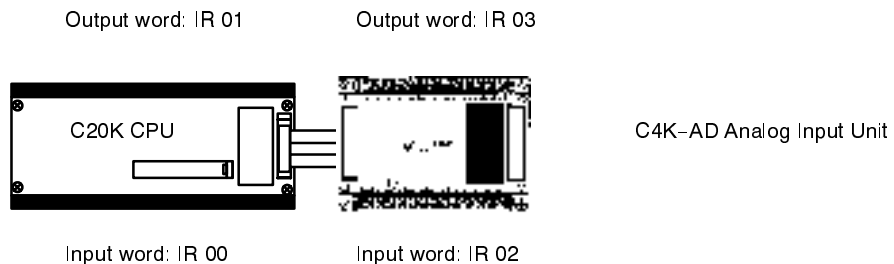


##### C4K-AD

Programming is more complex with the C4K-AD because the data for up to four inputs must be stored before it is overwritten. This requires use of the Read flags for the four inputs. The ON/OFF flags for the desired inputs must be turned ON by the program to ensure that the inputs are read and converted.

#### Example Configuration

The program given below is written for the following configuration.





**Bits and Words Used**

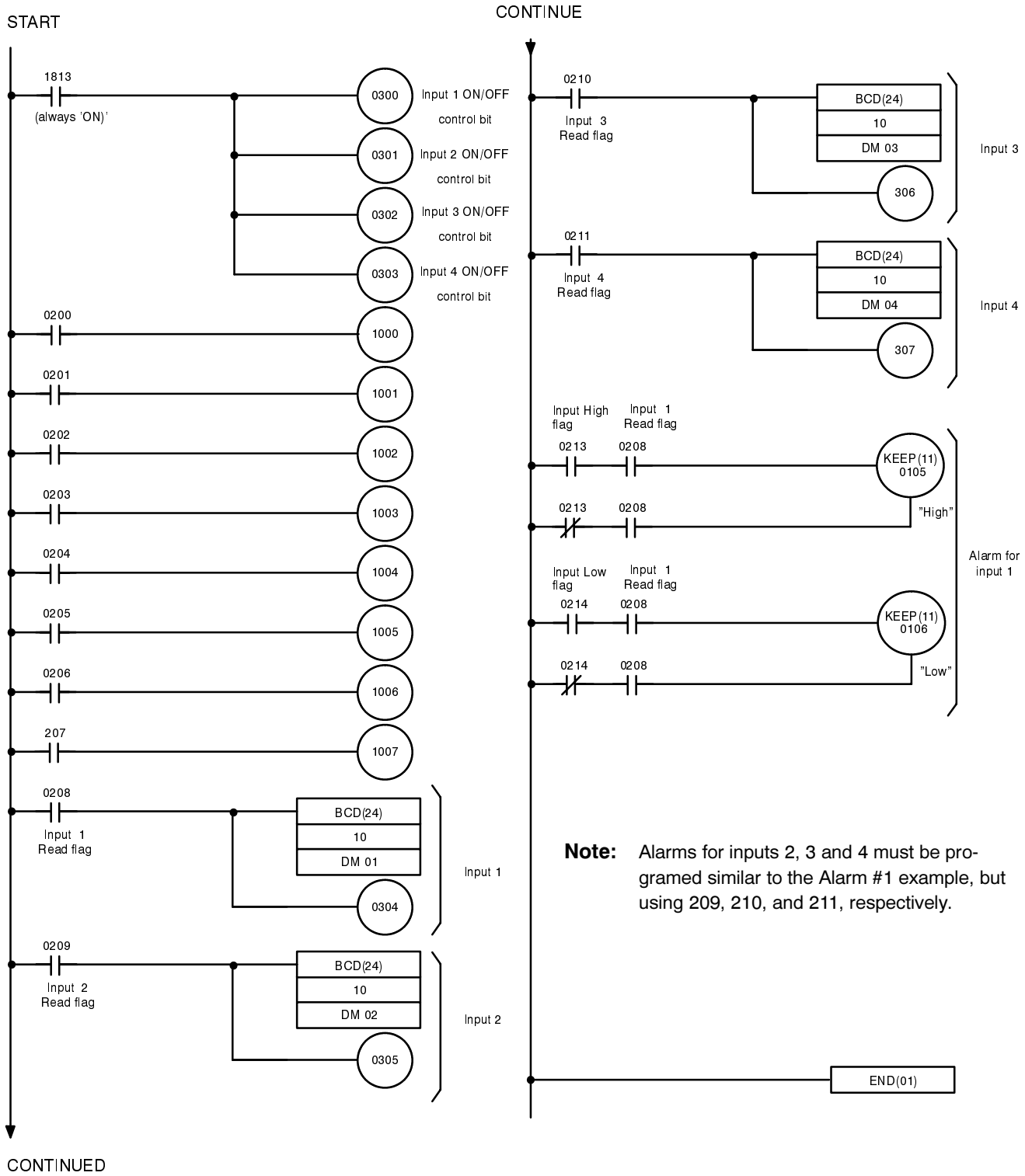
The following bits and words are used in the example program.

<b>0200 through 0207</b>	Bits in input word of the Analog Input Unit where converted input data is first placed.
<b>0208 through 0211</b>	Read flags for the four inputs
<b>0213</b>	Input High flag; used to indicate an error in input values; data not moved if ON.
<b>0214</b>	Input Low flag; used to indicate an error in input values; data not moved if ON.
<b>0300 through 0303</b>	ON/OFF control bits; turned ON each scan to ensure that all input data is read.
<b>0304 through 0307</b>	Read Complete control bits; turned ON to indicate that input data has been moved.
<b>1000 through 1007</b>	Used to store input data until it is stored in the proper location for each input.
<b>1013</b>	Work bit; used to indicate high input value.
<b>1014</b>	Work bit; used to indicate low input value.
<b>1813</b>	Always ON flag; used to ensure that ON/OFF control bits remain ON.
<b>DM 00 through DM 03</b>	Words used to store input data until a new value is input and transferred.

**Program**

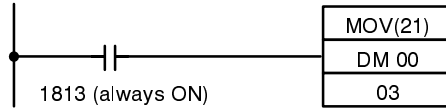
The following program is used to move the input data for each input into a separate DM word so that the most recent value for each input is always available. The Always ON flag is used to ensure that the Read flags stay ON. Input data is first temporarily stored in IR 10 for the input whose data is being read, and then the data is transferred to the proper DM word before the Read Complete control bit is turned ON and the process repeated for the next input.

Here, the Input High and Input Low flags are used both to prevent data from being moved when there is an error and to turn ON work bits that can be used to signal the errors.



### 5-2-2 Analog Output Unit

With the C1K-DA Analog Output Unit, all that is necessary is that the proper data be moved from the data area where it is stored to the word allocated to the Unit. The following example shows how to do this each scan so that the most recent contents of DM 00 is always output. In this example IR 03 is the word allocated to the Unit. This word will vary with the system configuration.



## Appendix A Standard Models

Name	Specifications	Model No.
Analog Input Unit	1 to 5 V or 4 to 20 mA, 1 input	C1K-AD
	1 to 5 V and or 4 to 20 mA, 4 inputs	C4K-AD
Analog Output Unit	1 to 5 V or 4 to 20 mA, 1 output	C1K-DA
C4K I/O Connecting Cable	5 cm (horizontal connection), included with Unit	C20P-CN501
	40 cm (horizontal connection) included with Unit	C20P-CN411
C1K I/O Connecting Cable	5 cm (horizontal connection) included with Unit	C4K-CN502

# Appendix B

## Specifications

### General

Same as other C-Series except for insulation resistance and dielectric strength, where high voltages are not withstandable.

### Analog Input Units

Item	Specifications	
Number of analog inputs	<b>C1K-AD: 1</b>	<b>C4K-AD: 4</b>
Input signal range	Voltage input: 1 to 5V Current input: 4 to 20 mA	
Resolution	Voltage input: 15.6 mV (1/256) Current input: 62.5 $\mu$ A (1/256)	
Accuracy	25°C: $\pm$ 1.0% max. of full scale 0° to 55°C: $\pm$ 2.0% max. of full scale	
Conversion time	20 ms max. (per bit)	
External input impedance	Voltage input: 1 M $\Omega$ min. Current input: 250 $\Omega$	
Code input to CPU	8-bit binary	
Number of words allocated	2	
Number of terminals on terminal block	<b>C1K-AD: 6 (fixed)</b>	<b>C4K-AD: 26 (removeable)</b>
Insulation	Non-insulated	
Internal power supply	250 mA max. at 5 V	
Weight	<b>C1K-AD: 250 g max.</b>	<b>C4K-AD: 750 g max.</b>

### Analog Output Unit

Item	Specifications
Number of analog outputs	1
Output signal range	Voltage output: 1 to 5 V Current output: 4 to 20 mA
Resolution	Voltage output: 15.6 mV (1/256) Current output: 62.5 $\mu$ A (1/256)
Accuracy	25°C: $\pm$ 1.0% max. of full scale 0° to 55°C: $\pm$ 2.0% max. of full scale
Conversion time	20 ms max. (per bit)
External output impedance	Voltage output: 0.5 $\Omega$ max.
Maximum current for external output	Voltage output: 15 mA max.
Permissible load resistance for external output	Current output: 250 $\Omega$ max.
Code required from CPU	8-bit binary
Number of words allocated	2
Number of terminals on terminal block	6 (fixed)
Insulation	Non-insulated
Internal power supply	250 mA max. at 5 V
Weight	250 g max.

## Revision History

A manual revision code appears as a suffix to the catalog number on the front cover of the manual.

Cat. No. W122-E1-3A

↑  
Revision code

The following table outlines the changes made to the manual during each revision. Page numbers refer to the previous revision.

Revision code	Date	Revised content
1	March 1988	Original production
2	October 1988	Corrections and additions to following pages: 12, 13, 14, 15, and 16
3	August 1989	Complete reorganization and rewrite
3A	June 1991	C4K-AD Analog Input Unit corrected on pages 14 and 20.