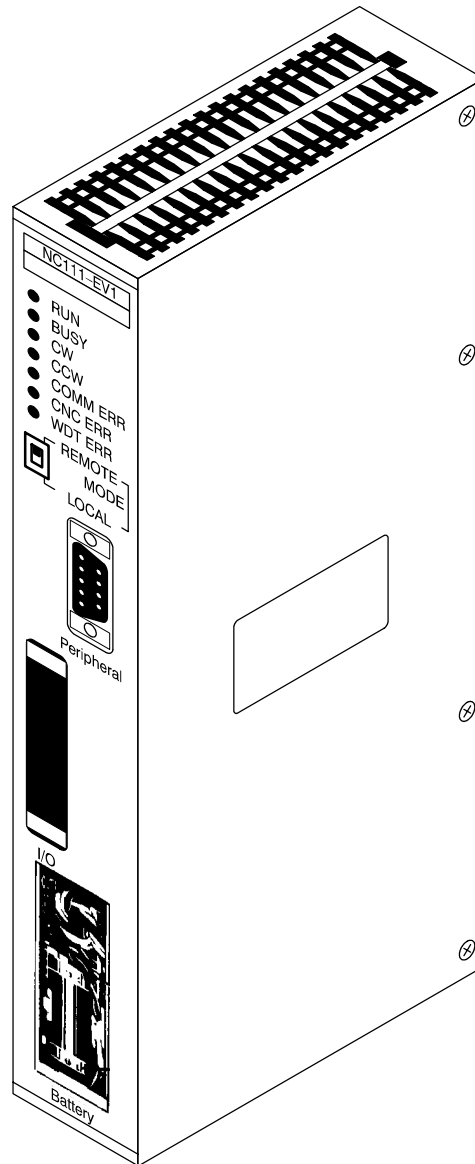


3G2A5-NC111-EV1 Position Control Unit

Operation Manual

Revision: July, 1990



Written and Produced for OMRON by:
Peter Hamann
Gold Coast Productions

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 the specifications and procedures necessary to install and operate the 3G2A5–NC111–EV1 Position Control Unit.

Section 1 describes the basic features, components, and operation of the Position Control Unit, as well as the basic configuration and principles of positioning control systems. Reading this section first will give you a familiarity with the essential terminology used in this manual and an understanding of the fundamentals necessary for successful operation.

Section 2 covers procedures such as wiring and switch setting which are necessary before operation.

Section 3 provides procedures to allow you to quickly gain “hands on” experience by setting up a trial motor operation. The steps are designed to familiarize you with the Position Control Unit, rather than to actually set up an entire control system.

Section 4 covers data allocation and other aspects of data setting necessary before executing positioning actions, as well as information concerning the Teaching Box, pulses, and the internal data the Position Control Unit uses when executing the data set by the user.

Section 5 explains data communication between the Position Control Unit and the PC. This section covers the allocation of bits in the four IR words used for communication. Included are explanations of all of the command bits (except ORIGIN SEARCH, which is covered separately in *Section 6*), all of the flags, and other aspects of communication between the Position Control Unit and the PLC. This section also describes the different types of external inputs.

Section 6 explains the methods for establishing and returning to the origin, and describes the origin input and origin proximity input which the Position Control Unit uses in carrying out these operations.

Section 7 provides programming examples for actual communication operations.

Section 8 provides application examples which illustrate the basic procedure for connecting and operating the Position Control Unit.

Section 9 outlines the procedures for handling errors and alarms that occur during Position Control Unit operation.

The appendices contain lists of error codes, specifications, and a table of standard models. A glossary of terms and an index are included at the back of the manual.

SECTION 1

Introduction

The 3G2A5-NC111-EV1 Position Control Unit is a Special I/O Unit that receives commands from a Programmable Controller (PC) and outputs pulse trains to a motor driver to control positioning along a single axis. You can use it in C500, C1000H, or C2000H PC Systems. Since this Position Control Unit outputs pulses, it is most commonly used to control stepping motor drivers in open-loop systems. If you wish to incorporate feedback, however, you can connect the Unit to a servomotor driver designed for pulse train input.

One of the features of this Position Control Unit is that it can be operated in either of two modes: LOCAL or REMOTE. You select the mode with a switch on the front panel of the Unit. With the Unit in LOCAL mode, you can use the Teaching Box for teaching positions, operating manually, and reading out error codes. Teaching is the most convenient way of entering data. While the Unit is in LOCAL mode, you can also check whether the data you enter will actually move the workpiece in the way you want. Once you have entered and confirmed all the necessary data, you can switch to REMOTE mode for continuous operation. While the Unit is in REMOTE mode, it can communicate with the PC and receive commands for execution.

This section describes the basic features, components, and operation of the Position Control Unit, as well as the basic configuration and principles of positioning control systems. Reading this section first will give you a familiarity with the essential terminology used in this manual and an understanding of the fundamentals necessary for successful operation.

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1-1 Features

| | |
|--|--|
| Applicable Motor Drivers | Pulse train permits connection to either: <ol style="list-style-type: none">1. A stepping motor driver2. A servomotor driver designed for pulse train input |
| Number of Control Axes and Controlling Capacity | The Position Control Unit is designed to control a single axis. Data configuration consisting of parameters, speeds, and positioning actions permits precise speed and position control. |
| Compensation | Backlash compensation and origin compensation functions allow highly accurate positioning. |
| Inching | The inching command can be used to manually position one pulse at a time either clockwise or counterclockwise. |
| Error Diagnostics | Troubleshooting is facilitated by error code transmission from the Position Control Unit to the PC as well as by error code display on the Teaching Box. |
| Data Backup | Data stored in the Position Control Unit (12 parameters, 10 speeds, and 200 positioning actions) is protected by battery backup in the event of power failure. |
| Teaching Box | Connecting the Teaching Box permits manual operation, teaching inputs, and error code read-out. |
| Modes | The Position Control Unit can be operated in either of two modes. In LOCAL mode you can input and check data. In REMOTE mode, the Unit can communicate with the PC and receive commands for operation. |

1-2 Basic Operating Principles

The basic operation of the 3G2A5-NC111-EV1 Position Control Unit is fairly simple. It controls either a stepping motor or a servomotor in accordance with data stored in its memory. This data includes parameters, speeds, positions, and other information necessary for effective control. Before the Position Control Unit can be operated, therefore, you must first input the essential data. This is generally done via the Teaching Box.

The way in which the Position Control Unit makes use of this data is determined by the program in the PC. The program does not control all of the Position Control Unit's operations directly, but rather, controls the Unit's commands by turning command bits ON and OFF. The commands control such functions as the starting and stopping of positioning, returning to the origin, and so on. (The origin is the point which is designated as 0 at any given time.) Thus, while the Position Control Unit functions as an integral part of your overall control system, it also exercises a good deal of autonomy. This capability is essential to the concept of distributed control, whereby control of each portion of an automated system is located near the devices actually being controlled.

The fundamental unit of positioning is the positioning action. A particular positioning action moves the workpiece along the axis in a direction, at a speed, and to a position determined by the data which has previously been set. The positioning action begins when the appropriate command bit (START) is turned ON by the program.

A single positioning action may be executed by itself, or a bank of several positioning actions may be executed in sequence. A particular bank of actions may be repeated again and again. Before beginning execution of positioning actions, it is necessary to define the origin as a reference point by, for example, executing ORIGIN SEARCH.

1-3 Operational Flow

Preparing for and executing position operations normally involves the following steps.

| Step | Item | Operations | Refer to |
|------|--|------------|--|
| 1 | Wiring | | Section 2 Before Operation |
| 2 | Mode selector setting Data word bit assignments | | Subsections: 2-1, 2-2, 7-2, 7-3 |
| 3 | Configuration of data | | Section 4 Data Configuration |
| 4 | Origin determination | | Section 6 Establishing the Origin |
| 5 | Positioning | | Section 5 Data Communication with the PC |

| Step | Item | Operations | Refer to |
|------|-----------------|--|--------------------------------|
| 6 | Troubleshooting | <p>(Continued from preceding page.)</p> <pre> graph TD Start(()) --> Error{Error?} Error -- No --> Cleared{Error cleared?} Error -- Yes --> Remote[REMOTE mode] Error -- Yes --> Local[LOCAL mode] Remote --> LEDs_PC[LEDs on Position Control Unit light/flash] LEDs_PC --> Error_Transfer[Error code transfer] Local --> LEDs_PC LEDs_PC --> Emerg[EMERG and ERROR LEDs on Teaching Box light] Emerg --> Error_Display[Error code display on Teaching Box] Error_Transfer --> Cleared Error_Display --> Cleared Cleared -- No --> Error Cleared -- Yes --> Step7[] </pre> | Section 9 Error Processing |
| 7 | Operation | <p>REMOTE mode</p> <p>Automatic operation according to PC program</p> | Section 8 Application Examples |

1-4 System Configuration

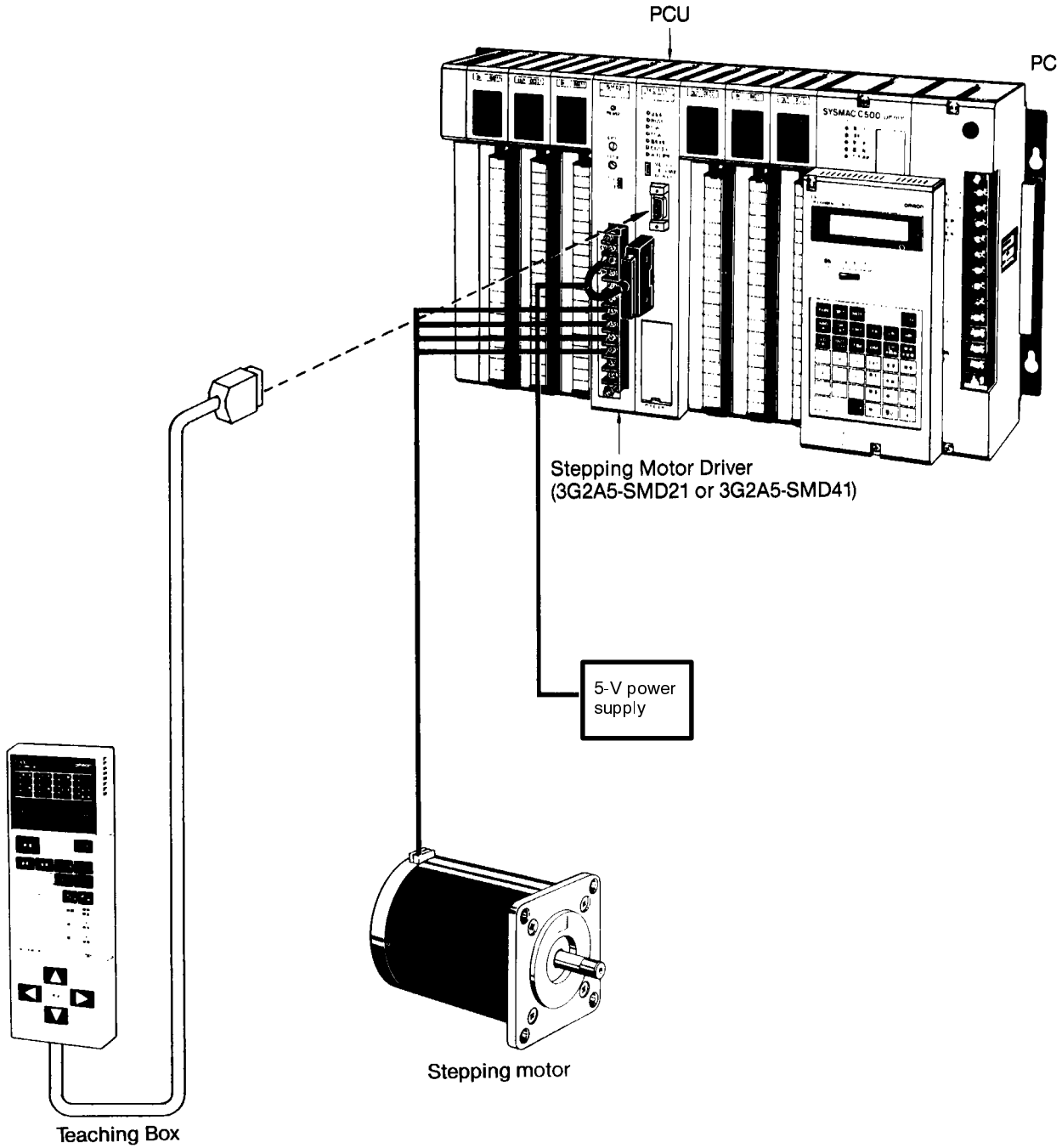
The basic system configuration is shown on the following pages. Position Control Unit (PCU) outputs are connected to a motor driver, either for a stepping motor or for a servomotor capable of receiving pulse train inputs. The Position Control Unit is controlled by inputs from the PC, external devices, and the Teaching Box. It, in turn, outputs pulse trains and direction signals to control the motor driver.

The motor driver controls either a stepping motor or a servomotor, depending on whether you choose to employ an open-loop or semiclosed-loop system. (See *Section 1-5*). The stepping motor (or servomotor) controls some type of positioning device (such as a feed screw, for example). An independent power supply must be used.

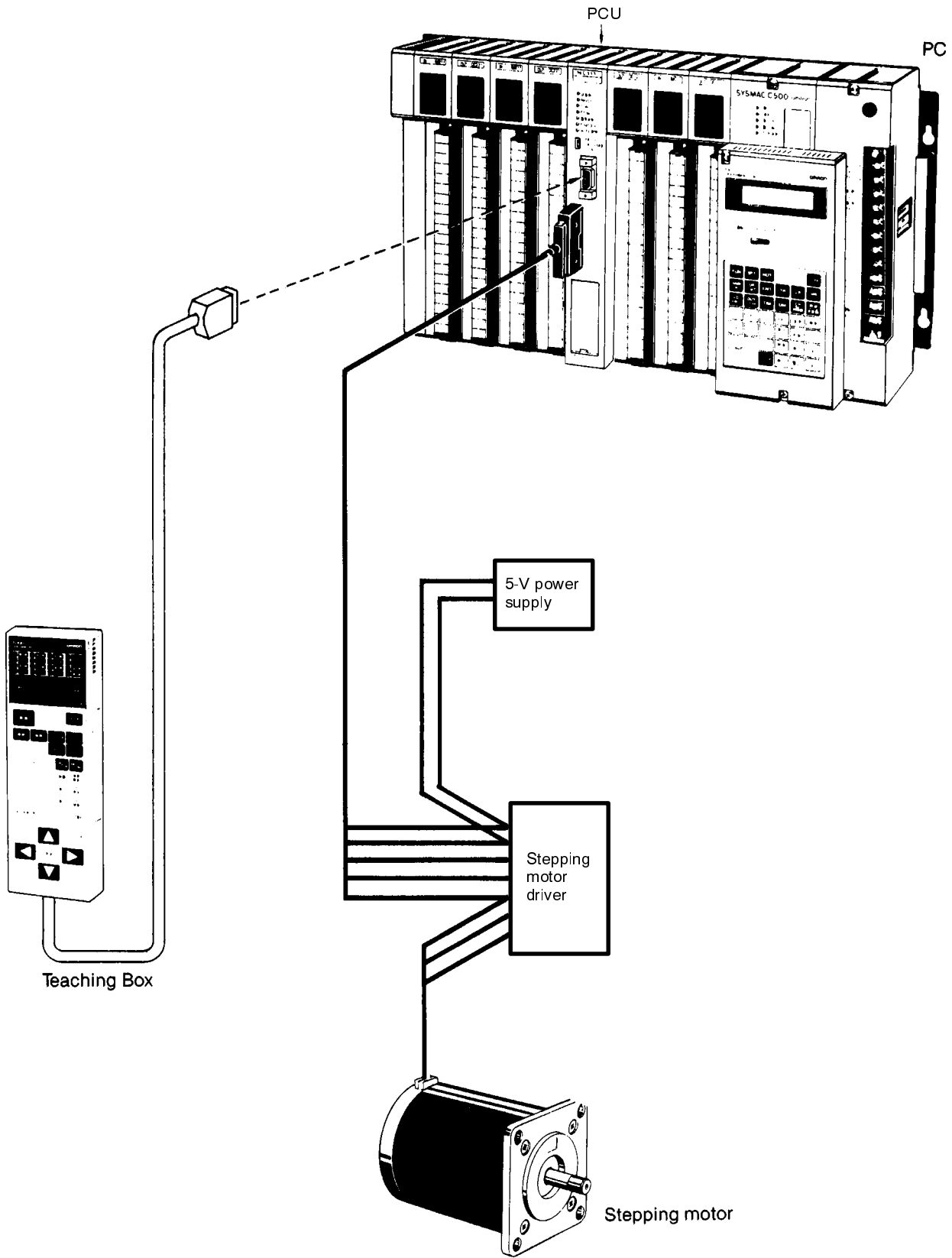
Although Unit operation can be indirectly controlled from a host computer, Remote I/O Master Unit, or other control system or peripheral device, control comes via the program of the PC or from connections to external inputs (e.g., control panel switches). The following configuration diagrams show only the

positioning system itself. Refer to the operating manuals for other OMRON control devices for details on extended control system operation.

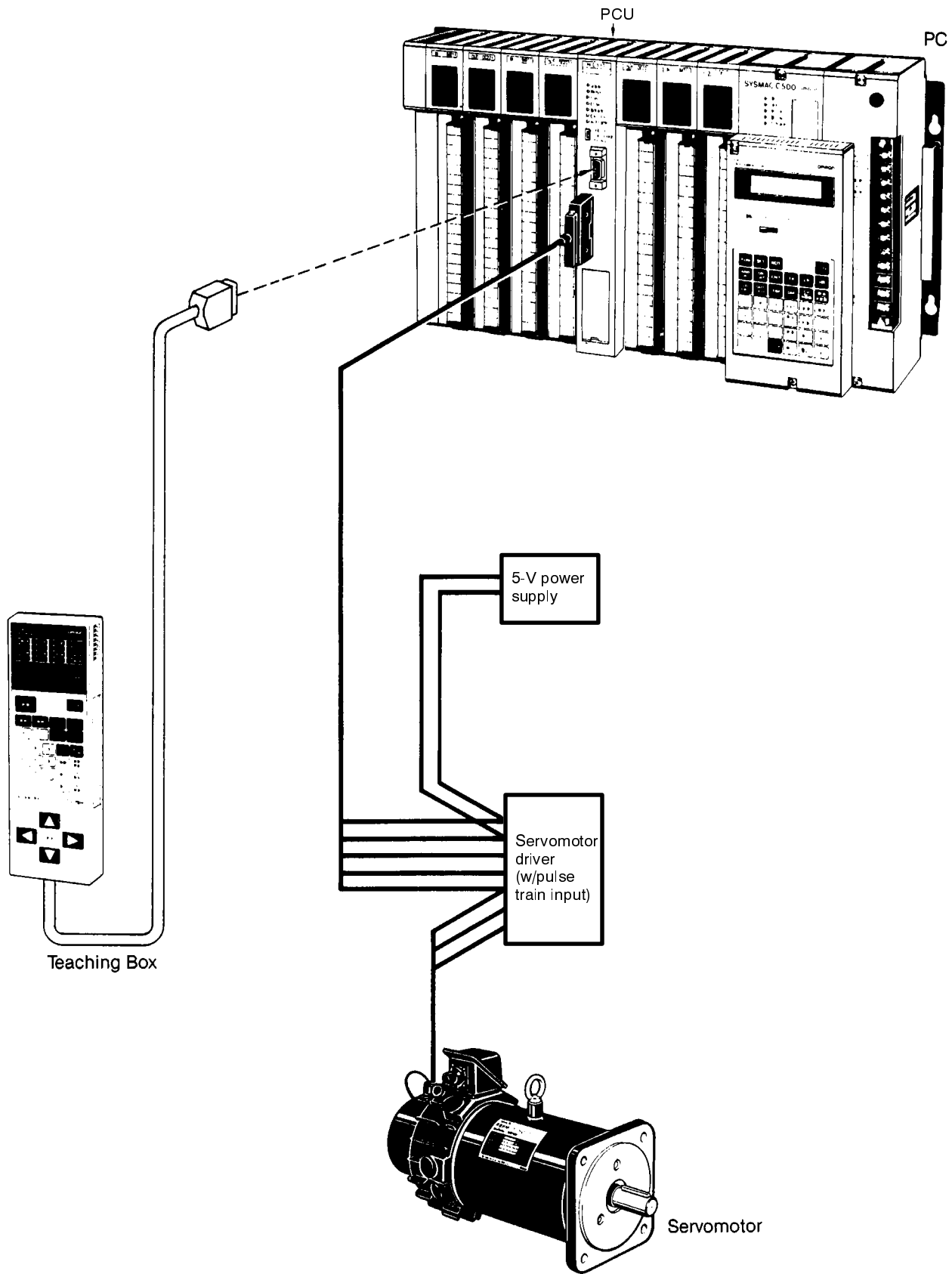
Using a C-series Stepping Motor Driver



Using Other Stepping Motor Drivers



Using Servomotor Drivers



1-5 Control System Principles

Control systems can be quite simple or relatively complex. The most basic is an open-loop system, in which a particular operation is carried out, according to programmed instructions, but in which feedback is not provided for automatic adjustments. The 3G2A5-NC111-EV1 Position Control Unit can be used in an open-loop system in conjunction with a stepping motor.

In a closed-loop system, on the other hand, the PC controls an external process without human intervention. The servomotor provides direct feedback so that actual values (of positions, speeds, and so on) are continuously adjusted to bring them more closely in line with target values.

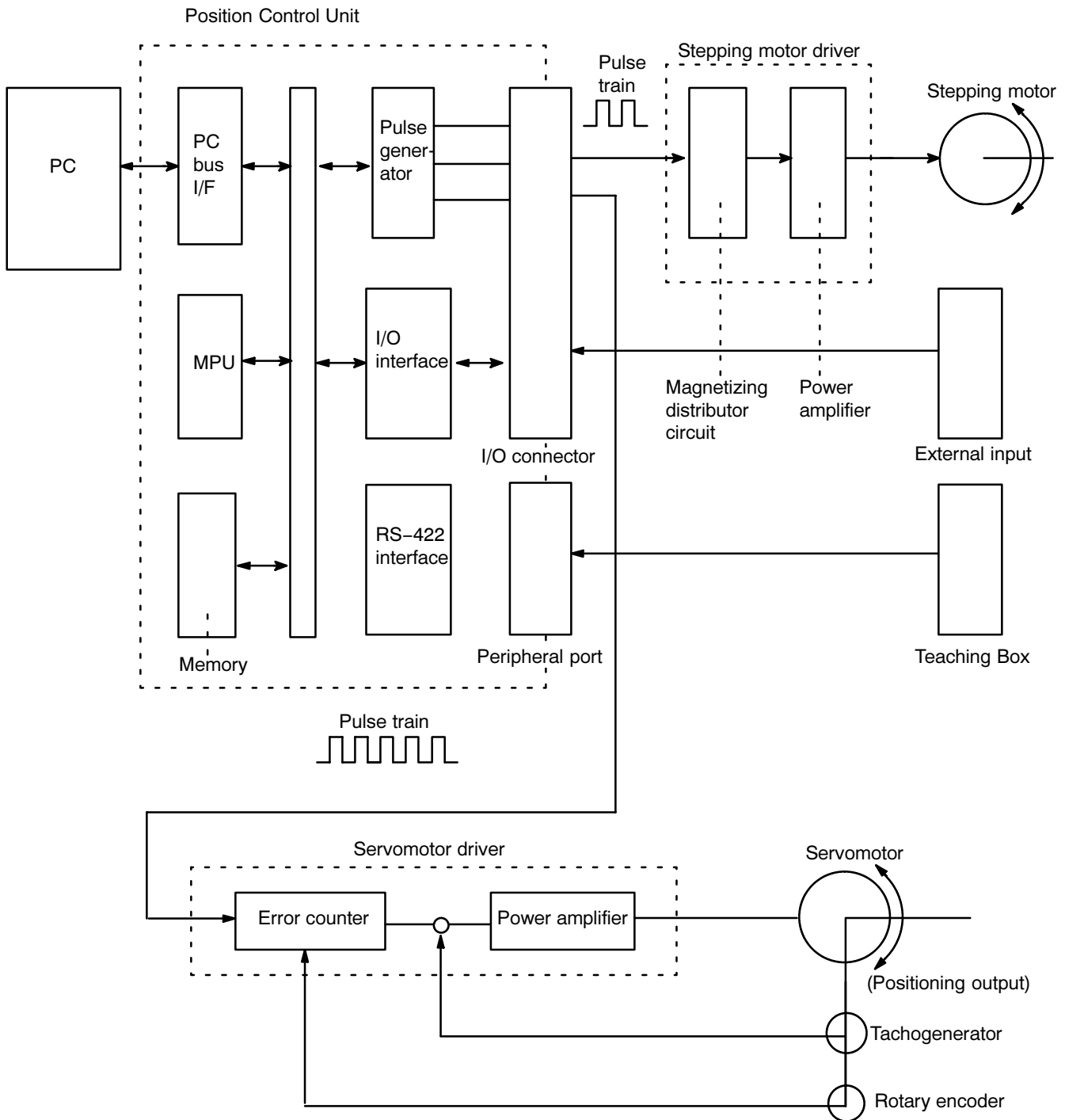
In some systems, the digital feedback signals will be transmitted to a digital-to-analog converter to complete the feedback loop, thereby permitting automated adjustment of the control process.

A semiclosed-loop system is similar to a closed-loop system, except that feedback is provided by a tachogenerator and a rotary encoder rather than directly by the servomotor. If the 3G2A5-NC111-EV1 Position Control Unit is used with a servomotor, the servomotor driver must be able to handle digital signals, and there is no need for a D/A converter. In addition, the servomotor is connected to a tachogenerator and a rotary encoder. The Unit can thus be used in either an open-loop or a semiclosed-loop system.

Both open-loop and semiclosed-loop systems are described in more detail on the following pages.

1-5-1

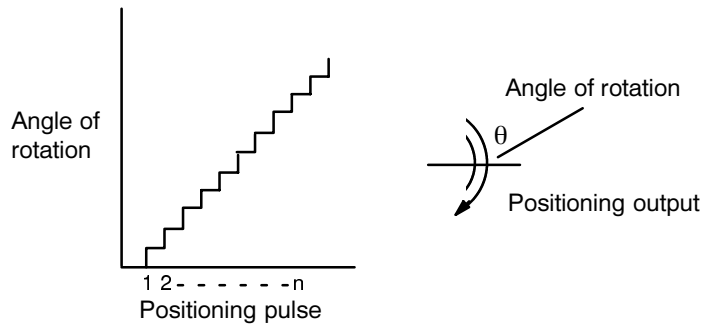
Data Flow



1-5-2 Open-loop System

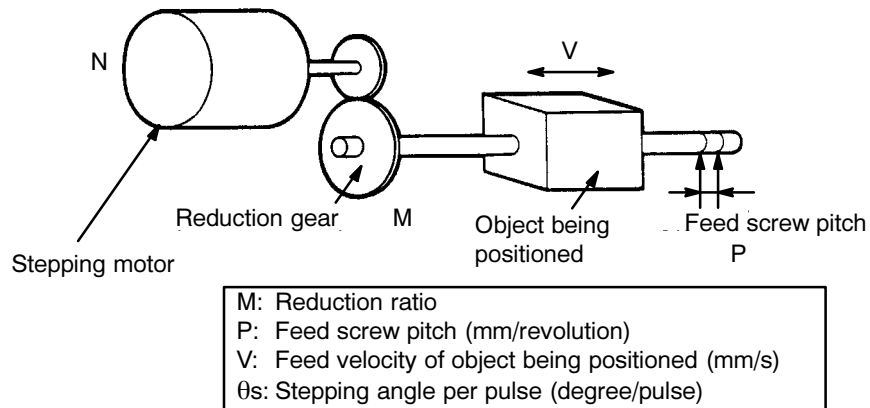
In an open-loop system, the Position Control Unit outputs pulse trains as specified by the PC program to control the angle of rotation of the motor. The angle of rotation of a stepping motor can be controlled through the number of pulse signals supplied to the motor driver. The number of rotations of the stepping motor is proportional to the number of pulses supplied by the Posi-

tion Control Unit, and the rotational speed of the stepping motor is proportional to the frequency of the pulse train.



Simplified Positioning System Design

The following diagram illustrates a simplified positioning system. As the stepping motor (or servomotor) rotates in response to signals from the Position Control Unit, it turns a feed screw to a corresponding degree in either a clockwise (CW) or counterclockwise (CCW) direction at a specified speed. This, in turn, causes the workpiece to move at that speed in a corresponding direction along the axis.



The positioning precision in mm/pulse is computed as follows:

$$\begin{aligned} \text{Positioning precision} &= P / (\text{pulses per revolution} \times M) \\ &= P / ((360 / \theta_s) \times M) \\ &= (P \times \theta_s) / (360 \times M) \end{aligned}$$

The required pulse frequency from the Position Control Unit in pulses per second is computed as follows:

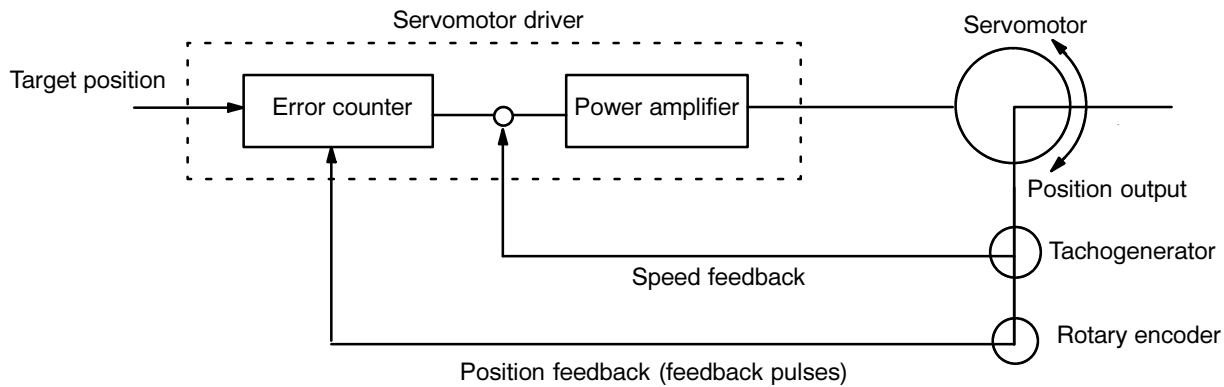
$$\begin{aligned} \text{Pulse frequency} &= V / \text{Positioning precision} \\ &= (360 \times M \times V) / (P \times \theta_s) \end{aligned}$$

And the required number of pulses to feed an object by a distance L in mm is computed as follows:

$$\begin{aligned} \text{Number of pulses} &= L / \text{Positioning precision} \\ &= (360 \times M \times L) / (P \times \theta_s) \end{aligned}$$

1-5-3 Semiclosed-loop System

When the Position Control Unit is used in a semiclosed-loop system, the system supplies feedback to compensate for any discrepancy between target values and actual values in position or speed. This system detects motor rotation amounts, for example, computes the error between the target value and actual movement value, and zeroes the error through feedback. The diagram below illustrates the basic configuration of a semiclosed-loop system.



- 1, 2, 3...**
1. First, the target position is transmitted to the error counter in units of encoder pulses. The servomotor driver must be able to handle digital input.
 2. The motor rotates at a speed corresponding to the speed voltage. The rotary encoder connected to the motor axis rotates in sync with the motor, generates feedback pulses, and subtracts error counter contents.
 3. Consequently, the encoder rotation is equivalent to the target position, and the motor stops rotating when the error counter count and the speed voltage become zero.
 4. While the motor is stopped, the rotary encoder constantly maintains the stopped position through correction. In the event that the motor axis slightly moves, the error counter receives a feedback pulse from the rotary encoder, whereby a rotation voltage is emitted in the reverse direction from which the rotary encoder moved, causing the motor to rotate toward its original position. This operation is called servolock or servoclamp.
 5. In order to execute positioning with acceleration and deceleration, target positions are set consecutively in the error counter for processing.
 6. The target position becomes the count for the error counter and controls the motor by conversion to a speed voltage for the servomotor driver. The position thus equals the total count of target positions and the speed will depend on the target position per unit time.

SECTION 2

Before Operation

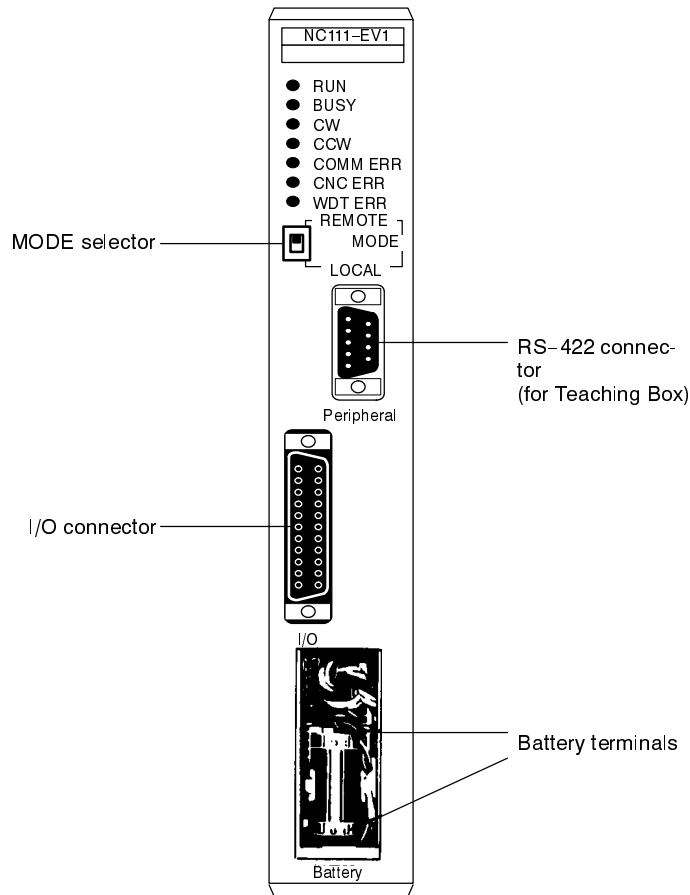
This section provides information you will need before operating your Position Control Unit. It includes nomenclature, switches, indicators, and wiring.

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| 2-3 | Wiring Precautions | 25 |

2-1 Nomenclature, Switches, and Indicators

Front Panel

The front panel of the Position Control Unit provides connectors for the Teaching Box, the motor driver, external switches, and an encoder. It provides, in addition, seven LEDs to indicate the current status of the Unit. There are also battery terminals so that you can connect to a battery for power backup. In the event of a power failure, the battery allows the Unit to retain positioning data.



Mode Selector

You use this switch to set the Position Control Unit to either REMOTE or LOCAL mode. Set the selector to LOCAL to use the Teaching Box, and to REMOTE for communication between the Position Control Unit and the PC.

RS-422 Connector

Connect the Teaching Box here.

Battery Terminals

Use a 3G2A9-BAT08 Battery. In the event of a power interruption, the battery will back up the RAM which stores positioning data. When replacing the battery, install a new one within five minutes of removing the old one.

I/O Connector

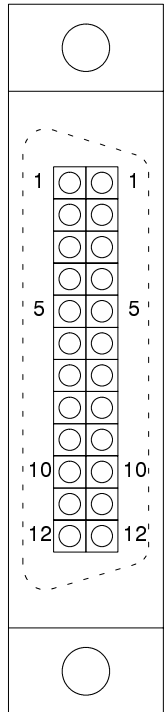
This 24-pin connector provides connections for motor driver output, external switch input, encoder input, and other peripheral devices.

Indicators

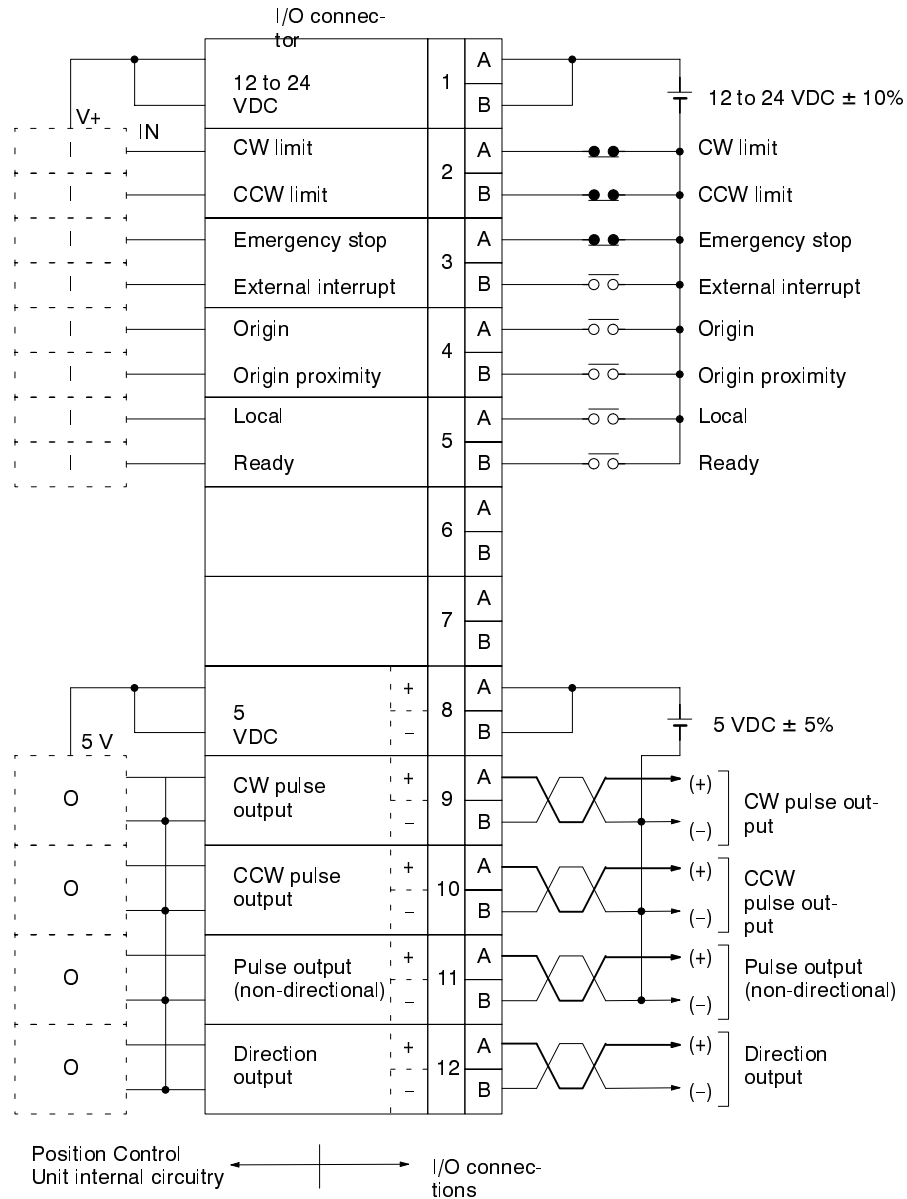
| | |
|-----------------|---|
| RUN | Lights during REMOTE mode operation. Flashes when battery voltage is low. |
| BUSY | Lights during positioning operations. Flashes during an emergency stop or sudden stop. |
| OUTPUT | Lights when a control pulse train is output. |
| CW | Lights during clockwise (CW) positioning. |
| CCW | Lights during counterclockwise (CCW) positioning |
| COMM ERR | Lights when a communications error occurs between the PCU and PC or PCU and an external device. |
| CNC ERR | Lights if an error occurs in the PCU during operation. |
| WDT ERR | Lights when there is a watchdog timer error. |

2-2 Wiring

2-2-1 I/O Connector Pin Layout

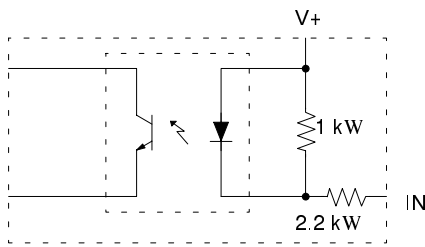


I/O Connector as viewed on front panel

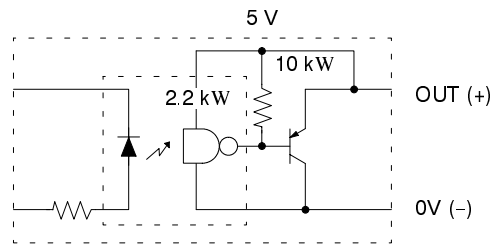


- Note:
1. The direction output is ON during CW rotations.
 2. Connect the CW limit, CCW limit, emergency stop, and ready pins to 0 volts when they are not connected to external devices.

Detail of I Sections



Detail of O Sections



| | |
|---------------------------------|-----------------|
| Rated input voltage (Vcc) | 12 to 24 VDC |
| Rated input current | 10 mA at 24 VDC |
| Allowable voltage range | +10% |
| ON delay (see Note 1) | 1 ms max. |
| OFF delay (see Note 1) | 1 ms max. |
| ON voltage | 10 V min. |
| Number of circuits | 8 |
| Response frequency (see Note 2) | 10 Hz min. |

| | |
|--------------------------------|-------------|
| Rated output voltage | 5 VDC |
| Rated output current | 20 mA |
| Allowable output voltage range | +5% |
| Residual voltage | 0.6 V max. |
| Leakage current | 100 mA max. |
| ON delay | 1 ms max. |
| OFF delay | 1 ms max. |
| Number of circuits | 4 |
| External supply voltage | 5 VDC+5% |

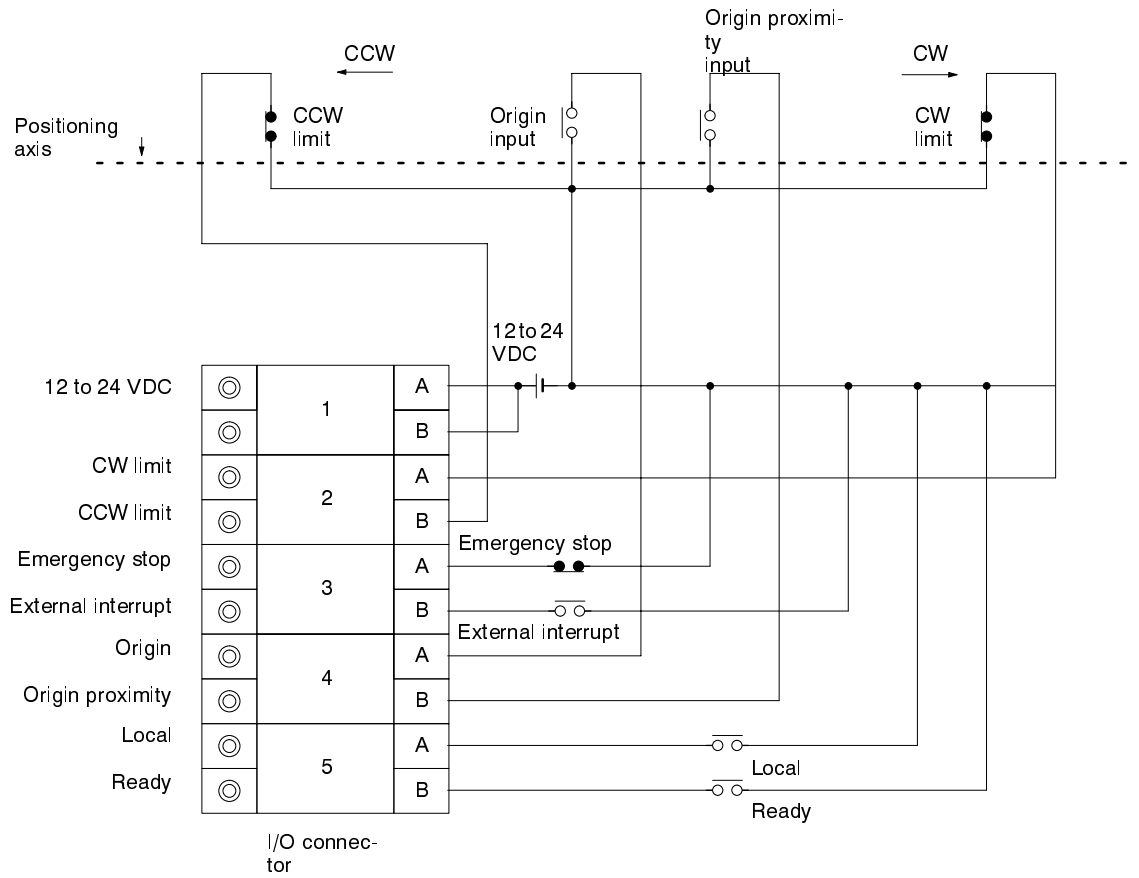
| Signal name | | |
|-------------|---|-----------------------------|
| 2 | A | CW limit (see Note 3) |
| | B | CCW limit (see Note 3) |
| 3 | A | Emergency stop (see Note 3) |
| | B | External interrupt |
| 4 | A | Origin |
| | B | Origin proximity |
| 5 | A | Local (see Note 4) |
| | B | Ready (see Note 3) |

| Signal name | | |
|-------------|---|---------------------------|
| 9 | A | Pulse output CW+ |
| | B | Pulse output CW- |
| 10 | A | Pulse output CCW+ |
| | B | Pulse output CCW- |
| 11 | A | Pulse output CW plus CCW+ |
| | B | Pulse output CW plus CCW- |
| 12 | A | Direction output CW+ |
| | B | Direction output CW- |

- Note**
1. All ON delays and OFF delays are hardware specifications and are not related to the time required by software to process the signals.
 2. This is the maximum frequency that can be processed by the system.
 3. Connect the following terminals to ground (0 V) when they are not connected to external devices: CW Limit, CCW Limit, Emergency Stop, and Ready.
 4. The Local signal is given priority over the MODE selector on the PCU.

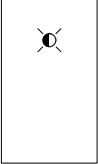
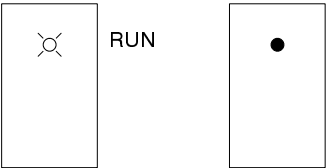
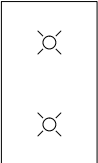
2-2-2 I/O Connector External Inputs

Most system configurations use the external connections shown below for the Position Control Unit. In order for the Position Control Unit to execute positioning, the emergency stop, CW limit switch, and CCW limit switch inputs must be NC and the ready input must be NO, and all of these inputs must be closed. In addition, the external input power, 12 to 24 VDC, should be turned on before or at the same time as the PC. Do not turn on the power before wiring is completed.



External Input Error Displays

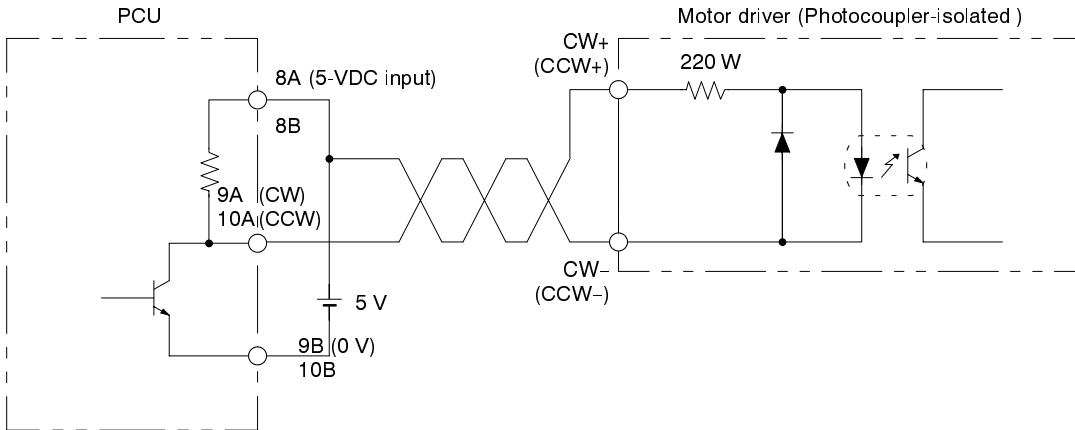
If the inputs shown in the following chart are open (OFF) instead of closed, they will generate errors. When an error occurs due to a certain input remaining open, the External Setting Check flag (IR n+3, bit 14) will turn ON. When the input closes (ON), the flag will turn OFF.

| Condition | PCU LEDs | Teaching Box LEDs |
|-------------------------------------|---|--|
| Emergency stop input open. |  <p>RUN</p> <p>RUN LED flashes in REMOTE mode.</p> | EMERG LED lights |
| Ready input open. |  <p>REMOTE mode. LOCAL mode.</p> <p>Indicators normal.</p> | Indicators normal; but, attempting to operate PCU causes ERROR LED to light. |
| CW or CCW limit switch inputs open. |  <p>RUN CNC ERR</p> <p>CNC ERR LED lights.</p> | ERROR LED lights |

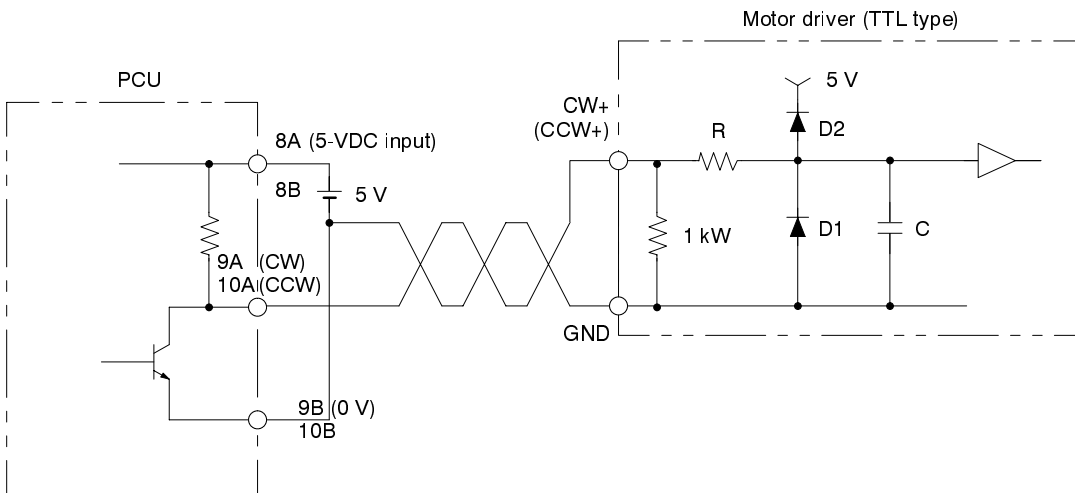
2-2-3 I/O Connector External Outputs

Pulse-input servomotor drivers and stepping motor drivers generally have a photocoupler-isolated or TTL input circuit.

Motor Driver with Photocoupler-isolated Input Circuit

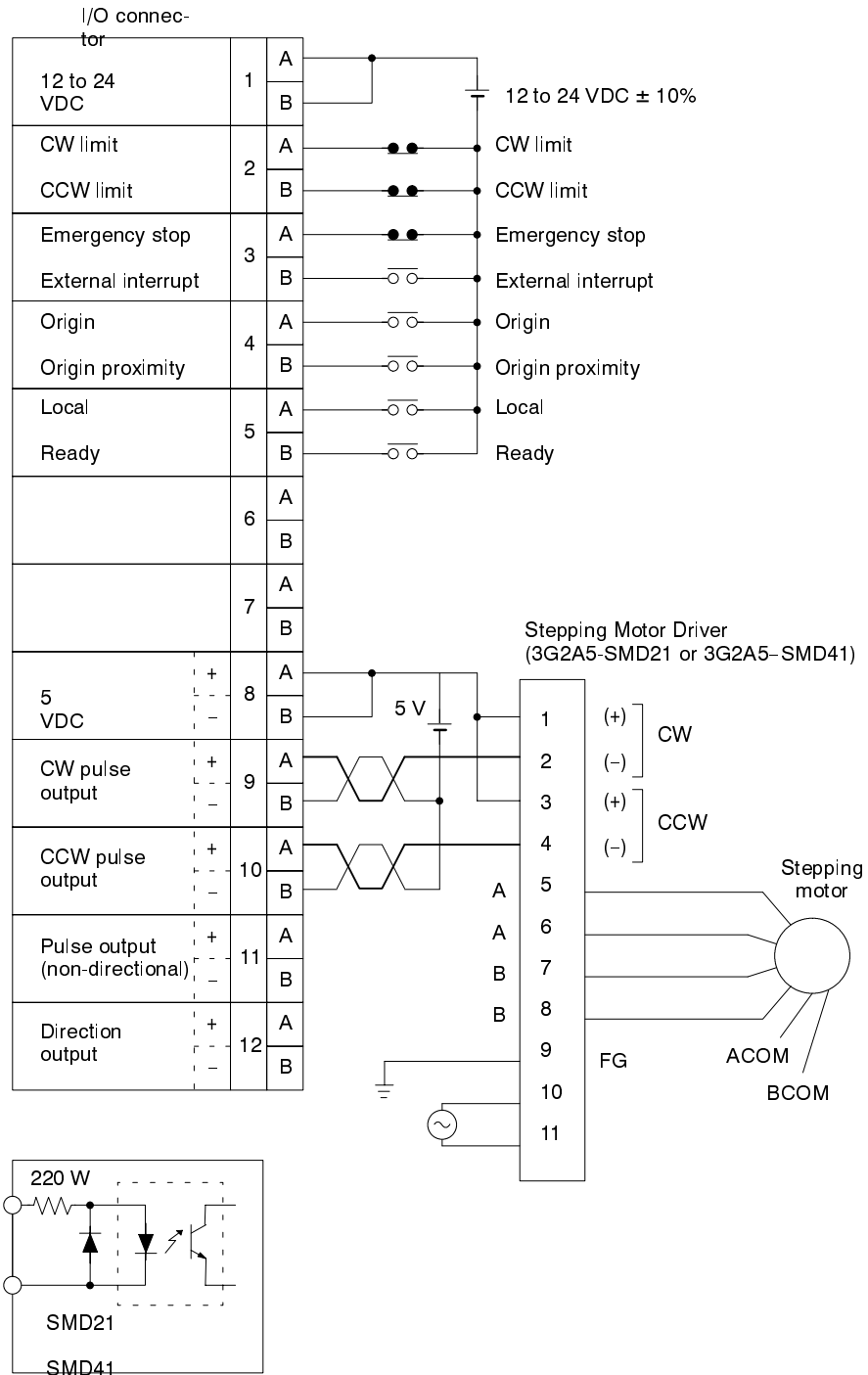


Motor Driver with TTL Input Circuit



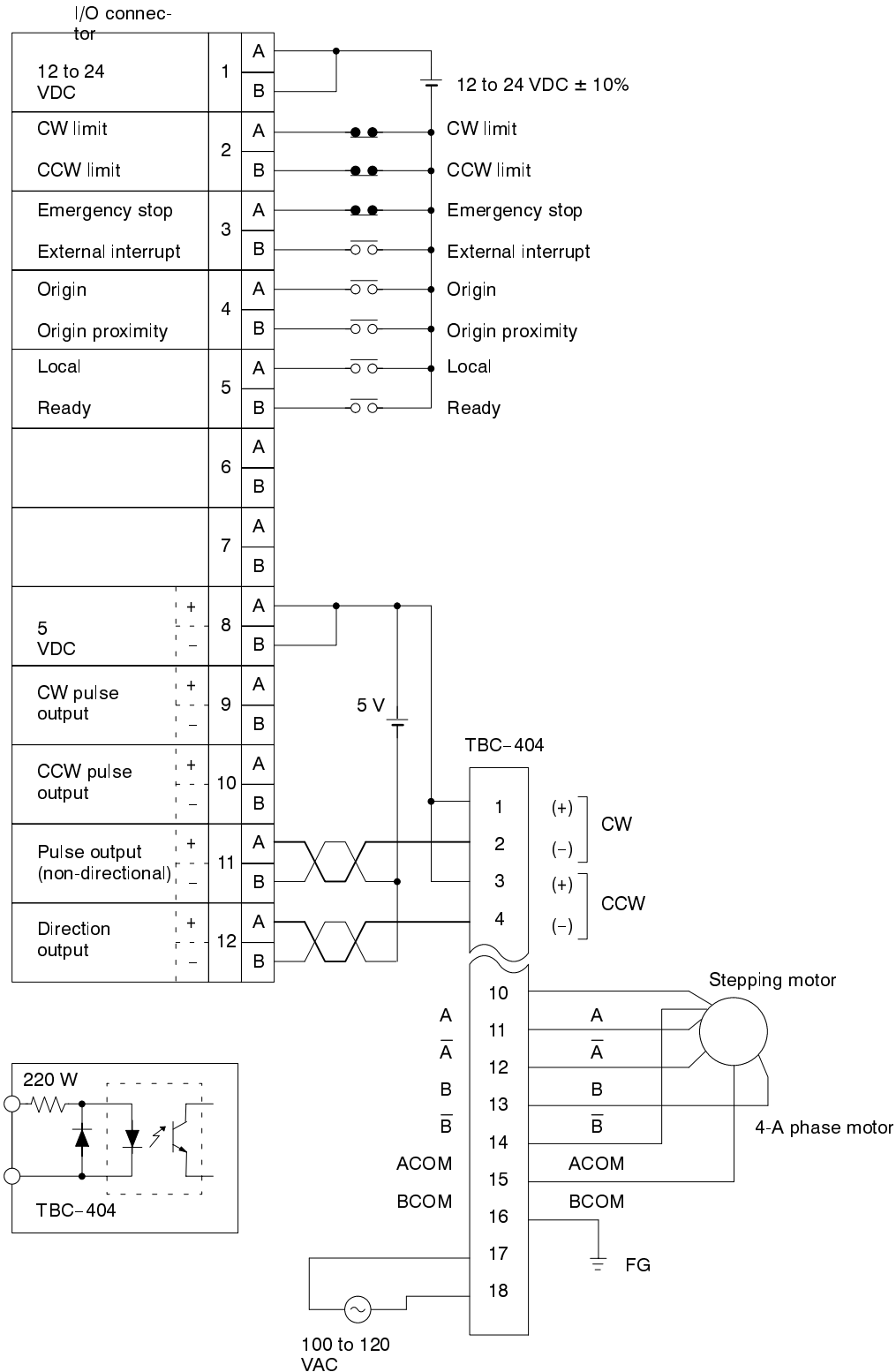
OMRON Stepping Motor Driver

The following diagram is for reference only. For actual connections, refer to the appropriate operation manuals and check the SMD21 and SMD41 specifications carefully. When turning on power to the Position Control Unit, turn ON the ready input; positioning cannot be executed as long as it is OFF.



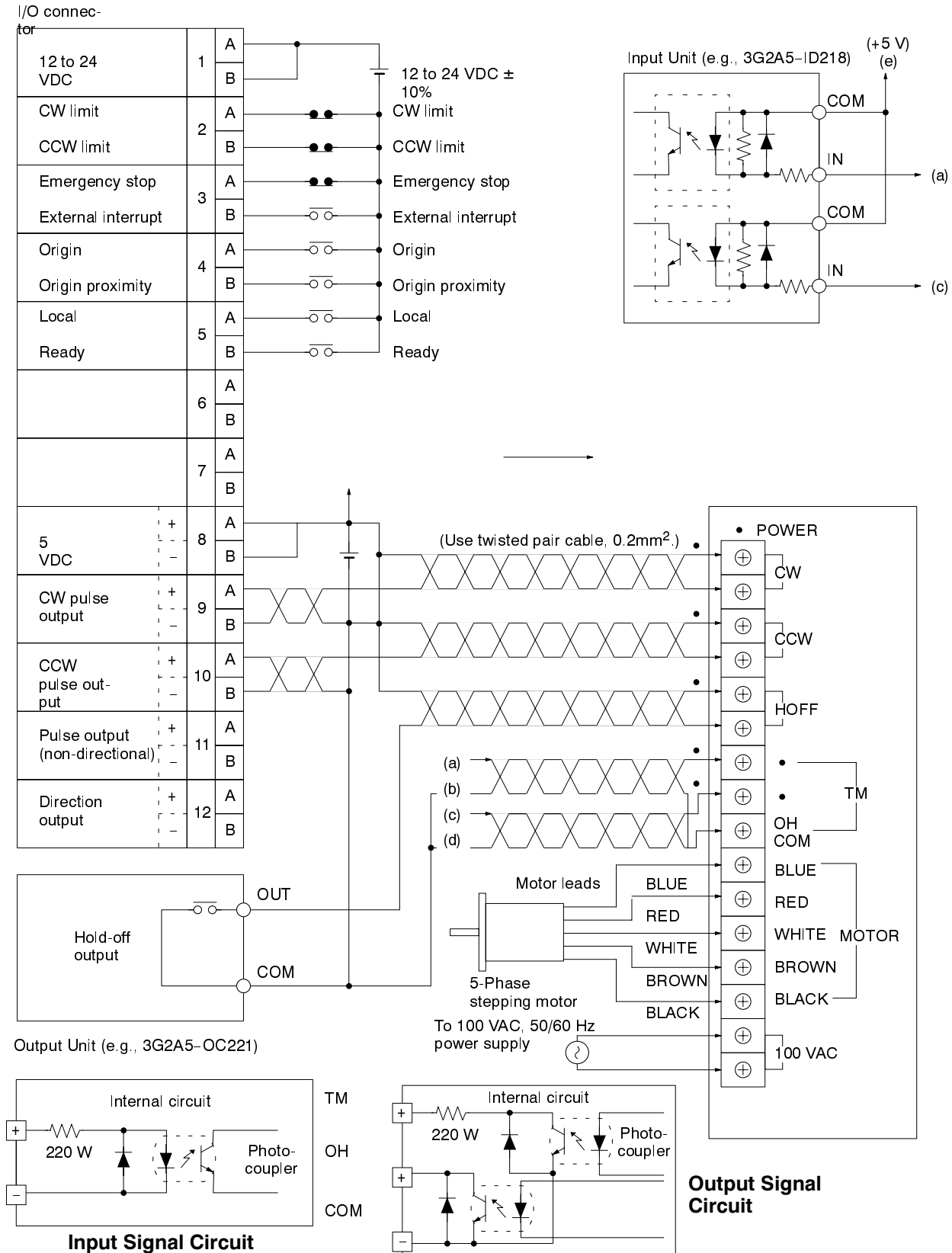
Commercial Stepping Motor Driver, Example 1

The following diagram is for reference only. For actual connections, refer to the appropriate operation manuals and check the stepping motor specifications carefully. This example uses nondirectional pulse and direction inputs. When turning on power to the Position Control Unit, turn ON the ready input; the Position Control Unit will not execute positioning when the ready input is OFF.



Commercial Stepping Motor Driver, Example 2

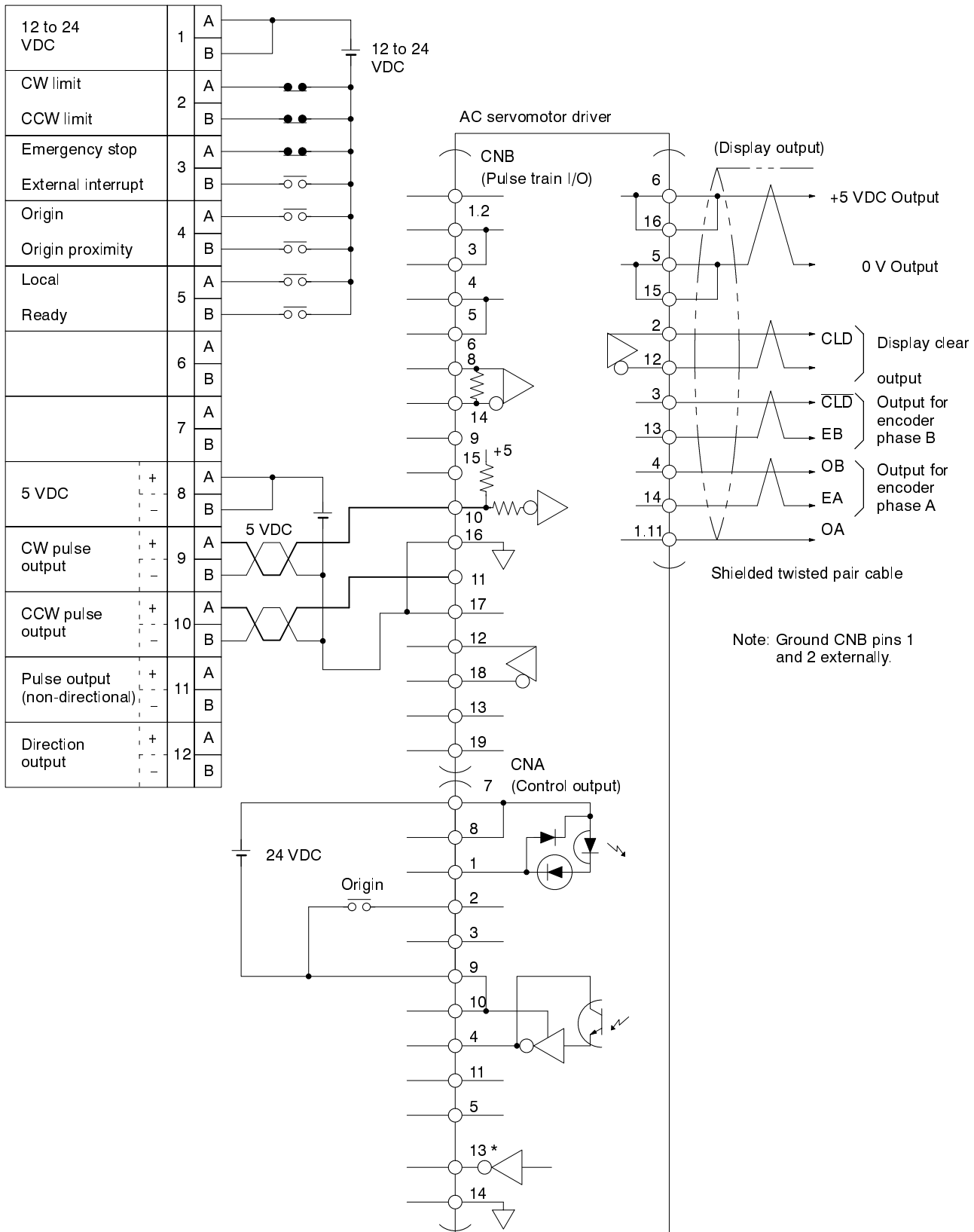
In the following example, twisted pair cable is used for signal-line connections. Their lengths should be 1 meter or less. For more extended cables, use cables with a cross-section greater than 0.5 mm² for power and greater than 0.75 mm² for ground. Use solderless terminals for driver connections (V1.25-3.7).



Commercial AC Servomotor Driver

The following diagram is for reference only. For actual connections, refer to the appropriate operation manual and check servomotor driver specifications carefully. When turning on power to the Position Control Unit, turn ON the ready input; the Unit will not execute positioning when the ready input is OFF.

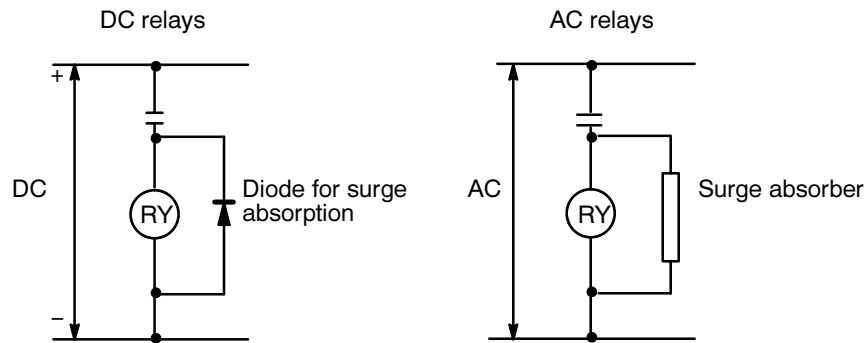
I/O connector



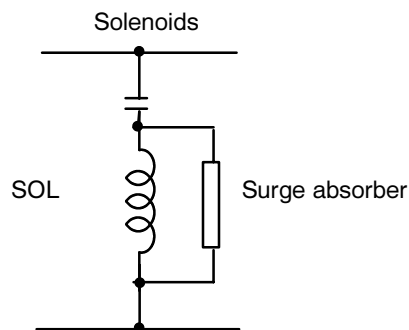
2-3 Wiring Precautions

Operational errors can occur in most electronic control devices if they are subjected to electronic noise from nearby power lines or loads. Recovery from such errors is usually very difficult and time-consuming. To avoid such noise-induced operational errors and thus improve system reliability, always abide by the following precautions in wiring the system.

- 1, 2, 3...
1. Cables must be of the required diameter.
 2. Power lines (e.g., AC power supply, motor power line) and control lines (e.g., pulse output lines, external I/O signal lines) must be wired separately. Never put these lines into the same duct or make them into a single bundle.
 3. Use shielded cable for control lines.
 4. Attach a surge absorber to all inductive loads, such as relays, solenoids, and solenoid valves.



Note Connect the diode and surge absorber as close as possible to the relay. Use a diode capable of withstanding a voltage five times higher than the circuit voltage.



5. Insert a noise filter into the power supply inlet if noise enters the power line (e.g., when it is connected to the same power supply as an electric welder or an electric spark machine or when there is any source generating high frequency noise).
6. Twisted pair cable is recommended for power lines.
7. For grounds, use thick cable with a cross-sectional area of at least 1.25 mm².

SECTION 3

Trial Motor Operation

To allow you to quickly gain “hands on” experience with the Position Control Unit, this section provides procedures to connect the Unit to a stepping motor driver (OMRON model 3G2A5–SMD21) without a workpiece. The steps are designed to familiarize you with the Position Control Unit, rather than to actually set up an entire control system. For actual system installation, this entire manual should first be read carefully.

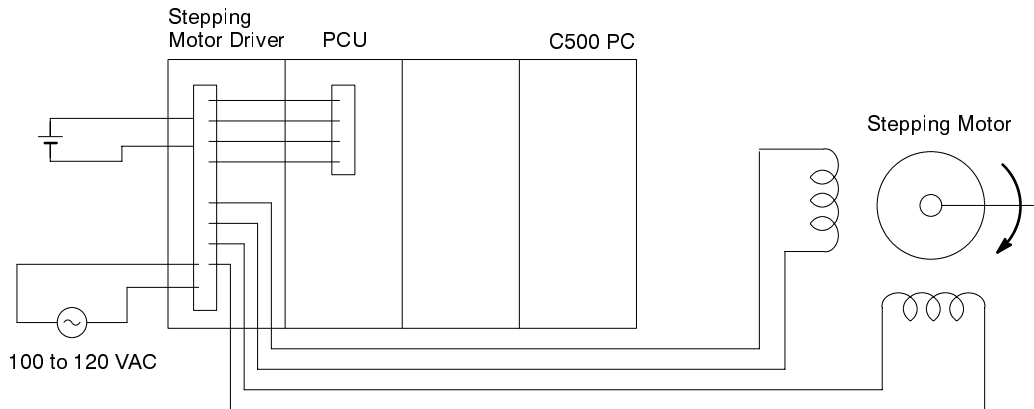
| | | |
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3-1 Wiring

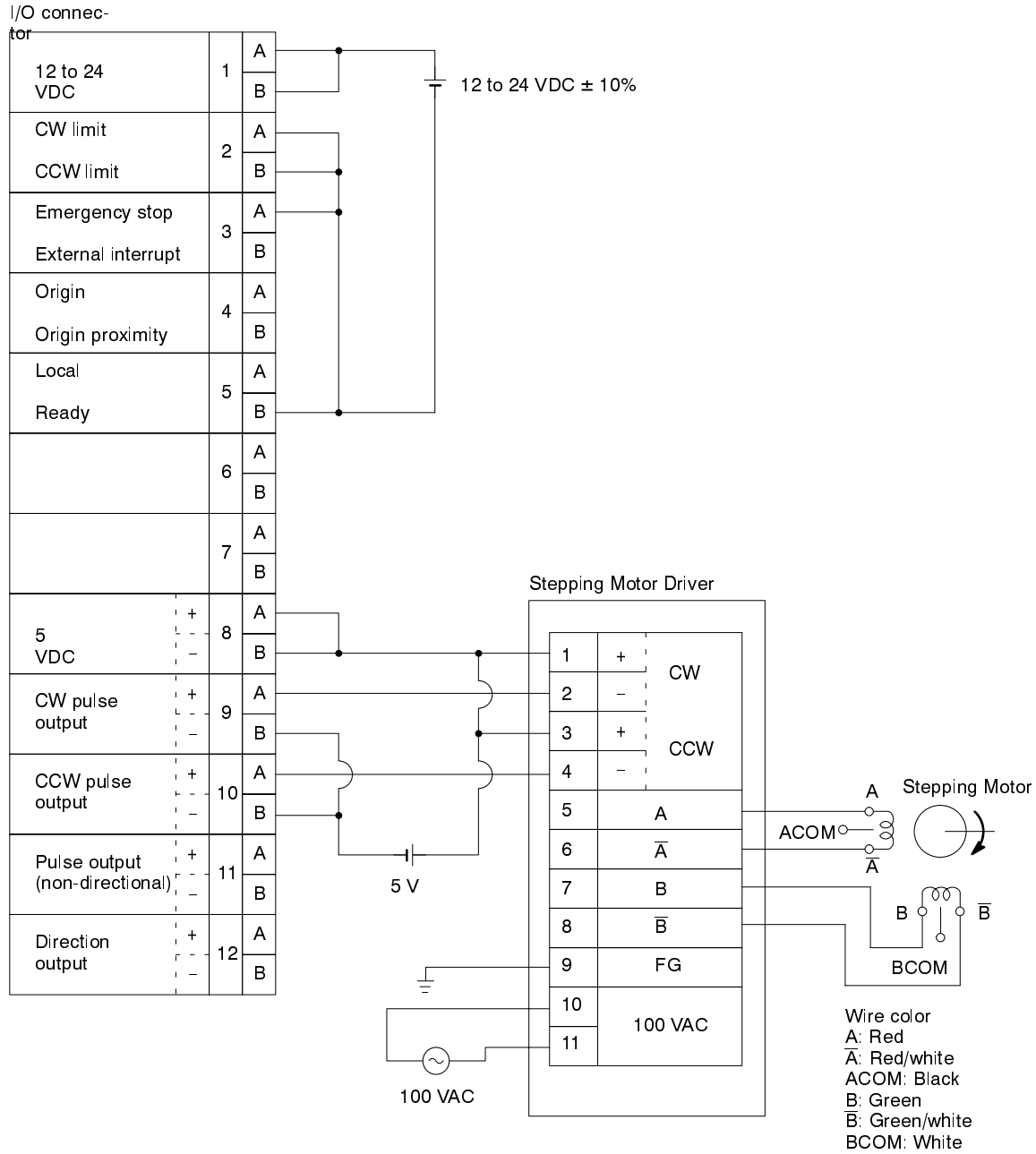
Refer to the following diagrams for connections between the Position Control Unit's I/O connector and the stepping motor driver, and those between the stepping motor driver and stepping motor. To simplify wiring, certain contacts are left open, and others are short-circuited. During actual system operation, however, be sure to use all of the required inputs.

Adjust the stepping motor driver in accordance with the current required for the motor. The motor should be a single-phase or two-phase motor. Refer to the stepping motor driver and stepping motor operation manuals.

System Configuration

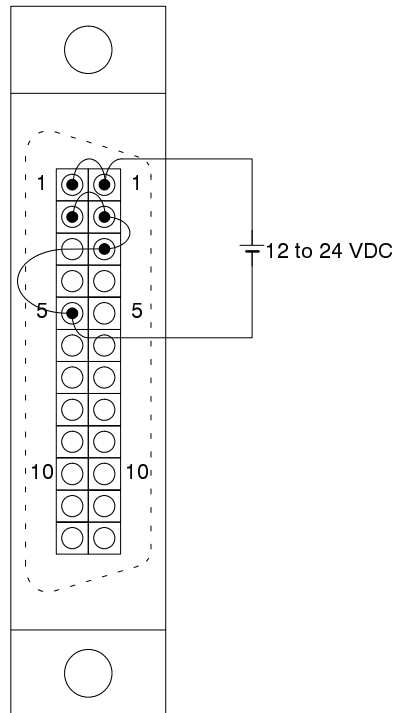


External I/O Wiring



Input Wiring (Detailed)

The external power supply of 24 VDC can be obtained from the 24-VDC output terminals of the 3G2A5-PS221-E or 3G2A5-PS222-E PC Power Supply Units.



Final Wiring Check

Before applying power to the PCU, check the following carefully.

- 1, 2, 3...**
1. Is the wiring correct?
 2. Are any clippings left from wiring causing shorts in the system?
 3. Are all terminals tight?
 4. Are all loads okay?

3-2 System Setting Procedure

- 1, 2, 3...**
1. Mount the Position Control Unit to the CPU Rack.
 2. Set the mode selector on the Position Control Unit to REMOTE.
 3. Turn on the external power input (12 to 24 VDC).
 4. Turn on the power for the PC and the motor driver (100 to 120 VAC).
 5. If necessary, clear PC CPU errors at the PC. Refer to the appropriate PC operation manual.
 6. Include the scan clock and operating mode in the PC program. (Refer to *5-2 Preliminary PC Settings*.)
 7. To reset the Position Control Unit, switch the mode selector from REMOTE to LOCAL and back to REMOTE again. If the RUN or CNC error LEDs light or flash at this point, check the external input wiring.
 8. Switch the mode selector on the PC from PROGRAM to MONITOR. The RUN LED should light on the Position Control Unit. If it does not light, check the Position Control Unit's operating mode bit (bit 07 of IR n+1). ("n" is the first word allocated to the Position Control Unit. See *Section 4 Data Configuration*.)

Caution Before starting trial operation, disconnect the motor from the device it is driving and run the trial operation controlling the motor only. If it is not possible to disconnect the motor, check the system being controlled completely to ensure that no dangerous situations could occur during trial operation.

3-3 Check Motor Lock

Make sure that torque has been generated on the motor shaft so that it cannot be easily turned by hand. If there is no torque, check the power of the stepping motor driver and check the current adjustment. Refer to the operation manual of the stepping motor driver.

3-4 Setting Data

- 1, 2, 3...
1. Set the PC to PROGRAM mode and enter the data, shown in the table below, into the DM area of the PC.
 2. Using the words allocated to the Position Control Unit, write the example transfer program from 7-1 *Transferring Data from the PC* into the memory of the PC. Note that the number of transfers has been changed from 30 to 50 for this test operation.
 3. After writing the transfer program, next write a program which enters the current address and the current positioning action into the DM area. To do this you can write the example programs from *Sections 7-4 to 7-6* entering DM 200 (current address), DM 201 (1st word of current positioning action), and DM 202 (2nd word of current positioning action).
 4. Switch the PC from PROGRAM to MONITOR mode and call the TRANSFER DATA command bit (1508) on the Programming Console.
 5. Force-set or reset the TRANSFER DATA command bit (1508) to start transfer program execution.
 6. After 4 to 5 seconds, the content of DM 000 should be 0055, confirming completion of data transfer.

DM Area Settings

| Word | Contents | Meaning | Data type |
|------|----------|------------------|--------------------------------------|
| 000 | 0000 | Counter register | Indirect address of data to be moved |
| 001 | 2000 | Address | Unit definition |
| 002 | 0000 | ----- | |
| 003 | 0004 | Unit=pulse | |
| 004 | 2001 | Address | pulse rate |
| 005 | 0100 | 1.0 | |
| 006 | 0000 | | |
| 007 | 2002 | Address | CW limit |
| 008 | 9999 | 999999 | |
| 009 | 9900 | | |
| 010 | 2003 | Address | CCW limit |
| 011 | 9999 | | |
| 012 | 9900 | 999999 | |
| 013 | 2004 | Address | Backlash compensation |
| 014 | 0000 | 0 | |
| 015 | 0000 | | |

| Word | Contents | Meaning | Data type |
|-------------|-----------------|----------------|------------------|
| 016 | 2005 | Address | Maximum speed |
| 017 | 0100 | 10 kpps | |
| 018 | 0000 | | |

| Word | Contents | Meaning | Data type |
|------|----------|-------------------------|---|
| 019 | 2008 | Address | Initial speed |
| 020 | 0001 | 100 pps | |
| 021 | 0000 | | |
| 022 | 2007 | Address | Acceleration/deceleration time |
| 023 | 0000 | 0.3 second | |
| 024 | 3000 | | |
| 025 | 2006 | Address | Constant-speed feeding at completion of positioning |
| 026 | 0001 | 100 pulses | |
| 027 | 0000 | | |
| 028 | 2009 | Address | Dwell time |
| 029 | 0001 | 1 second | |
| 030 | 0000 | | |
| 031 | 2010 | Address | Search pattern and origin search direction |
| 032 | 0000 | Pattern 0,CCW | |
| 033 | 0000 | | |
| 034 | 2011 | Address | Origin compensation |
| 035 | 0000 | 0 | |
| 036 | 0000 | | |
| 037 | 4000 | Address | Origin return speed |
| 038 | 5.0 kpps | | |
| 039 | 0000 | | |
| 040 | 4001 | Address | Origin search high speed |
| 041 | 0030 | 3.0 kpps | |
| 042 | 0000 | | |
| 043 | 4002 | Address | Manual low speed |
| 044 | 0005 | 500 pps | |
| 045 | 0000 | | |
| 046 | 1000 | Address | Positioning action |
| 047 | 0120 | Speed 1,com. code 0 to | |
| 048 | 0010 | abs.position +12000, CW | |
| 049 | 1001 | Address | Positioning action |
| 050 | 0000 | Speed 0, com.code 1 to | |
| 051 | 0007 | abs.position 0, CCW | |
| 052 | 1002 | Address | Positioning action |
| 053 | 0120 | Speed 2, com.code 0 to | |
| 054 | 002B | | |

3-5 Determining the Origin

Since the CW limit, CCW limit, origin input, and origin proximity inputs are short-circuited, you cannot use use ORIGIN SEARCH for this test operation. Establish the origin by using RESET ORIGIN from the PC. Call up the RESET ORIGIN command bit (IR n+1, bit 11) with the Programming Console,

and turn the bit ON and OFF to establish the origin. Then read DM 200 to DM 202 to access the following:

DM 200 1000 (current address)
 DM 201 0000 (1st word of current positioning action)
 DM 202 0000 (2nd word of current positioning action)

If you monitor IR n+3, the contents should appear as follows. (For details, refer to *Section 7*.)

| Bit | Name | Status |
|-----|-------------------------|-----------|
| 0 | ACK | OFF |
| 1 | Data 1 | OFF or ON |
| 2 | Data 2 | OFF or ON |
| 3 | Data Transfer | OFF |
| 4 | PCU RUN | ON |
| 5 | Handshaking Error | OFF |
| 6 | Current Position Action | OFF or ON |
| 7 | Current Address | OFF or ON |
| 8 | Busy | OFF |
| 9 | Positioning Completed | OFF |
| 10 | Origin | ON |
| 11 | Bank End | OFF |
| 12 | CNC Error | OFF |
| 13 | Interrupt | OFF |
| 14 | External Setting Check | ON |
| 15 | Hardware Error | OFF |

3-6 Positioning

- Call up START (IR n+1, bit 08) with the Programming Console and turn it ON and OFF with force-set/reset. This should rotate the shaft 60 degrees in the CCW direction and stop it at the position where the origin was set. When positioning is complete, DM 200 through DM 202 should read as follows:

DM 200 1001 (current address)
 DM 201 0120 (1st word of current positioning action)
 DM 202 0001 (2nd word of current positioning action)
- Call up START again and turn it ON and OFF. This should rotate the shaft 60 degrees at high speed in the CCW direction, slow it to low speed, rotate it an additional 60 degrees, and then stop it. When positioning, DM 200 through DM 202 should read as follows:

DM 200 1000 (current address)
 DM 201 0120 (1st word of current positioning action)
 DM 202 0001 (2nd word of current positioning action)
- Call up ORIGIN RETURN (IR n+1, bit 10) with the Programming Console and turn it ON and OFF with force-set/reset. Positioning returns, in a clockwise direction, to the origin which has been defined by RESET ORIGIN. The contents of DM 200 through DM 202, as well as the status of IR n+3 should be the same as when RESET ORIGIN is ON, except that IR n+3 (Bank End) will be ON. For more details, refer to *6-4 ORIGIN RETURN*.

SECTION 4

Data Configuration

One of the features of the 3G2A5-NC111-EV1 Position Control Unit is that it can be operated in either of two modes: LOCAL or REMOTE. You select the mode with a switch on the front panel of the Unit. With the Unit in LOCAL mode, you can use the Teaching Box for “teaching” positions, operating manually, and reading out error codes. The most convenient way to enter data is with the Teaching Box. While the Unit is still in LOCAL mode, you can also check whether the data you enter will actually move the workpiece in the way you want.

Once you have entered and confirmed all the necessary data, you can switch to REMOTE mode for continuous operation. While the Position Control Unit is in REMOTE mode, it can communicate with the PC and receive commands for execution.

This section covers data allocation and other aspects of data setting necessary before executing positioning actions, as well as information concerning the Teaching Box, pulses, and the internal data the Position Control Unit uses when executing the data set by the user.

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4-1 Pulses

The Position Control Unit outputs pulse trains to control a motor driver. The basic mechanical unit, therefore, is the pulse; pulse trains differ according to the number of pulses they contain.

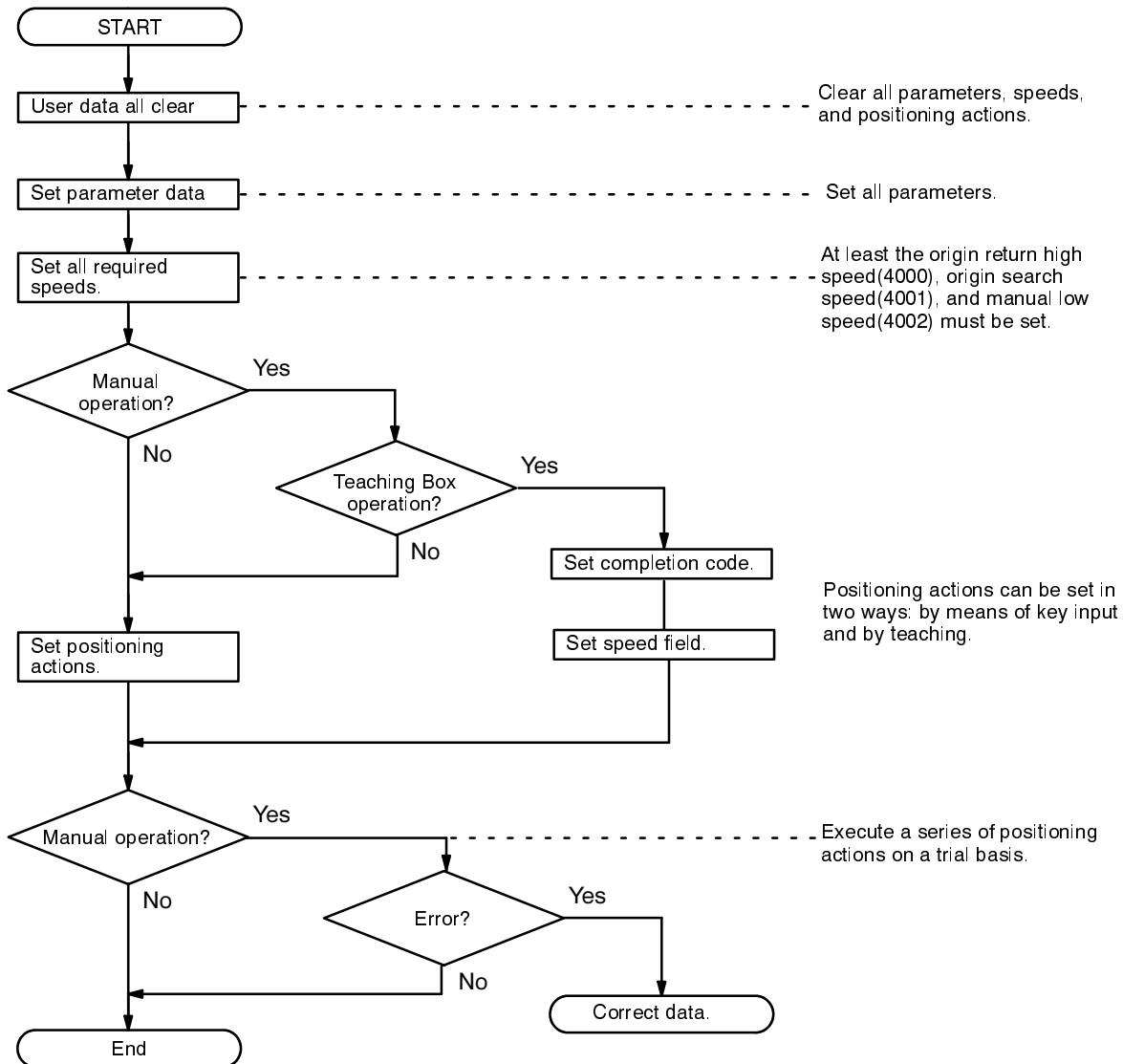
Pulses are discrete signals sent at a certain rate. Each pulse sent to the motor driver designates a certain amount of movement. In actual positioning, the pulses are converted to an equivalent control voltage. In order to facilitate programming, the Teaching Box accepts input in units of pulses, millimeters, inches, or degrees.

The pulse rate is equivalent to dividing the movement, x , of an object attached to a motor by the number of pulses, n , required for the movement. The pulse rate thus equals x/n . In actual operation, the data input in normal units of distance is translated by the Teaching Box so that the data is stored directly as pulses.

4-2 Setting Data

In most cases, you will probably want to use the Teaching Box to enter data directly into the designated memory areas in the Position Control Unit. Alternatively, you can set your PC to PROGRAM mode, enter the necessary data into the DM area of the PC, and then transfer the data to the Position Control Unit.

Before beginning actual operation, you need to set three types of data: parameters, speeds, and positioning actions. When setting data for the first time, you must set them in that order. When setting positioning actions, you will make use of data which you previously set for parameters and speeds. The following flowchart shows the proper procedure for setting, checking, and correcting data.



4-3 Using the Teaching Box

You can teach your control system an operation by leading it through the motions. You move the motor shaft sequentially to all the locations desired in the operation, and, with the Teaching Box, register each location in the memory of the Position Control Unit.

The most convenient way to enter data is to set the Position Control Unit to LOCAL mode (see *Section 4-4*) and use the Teaching Box. Before teaching, be sure to first establish the origin with either ORIGIN SEARCH or SET ORIGIN. After teaching, you can do a thorough check of workpiece movement before switching back to REMOTE mode.

The Teaching Box provides the following functions:

- Setting data is facilitated by using familiar units. The user may choose from the following: mm, pulse, inch, or degree.
- It is easy to quickly refer back to entered data for confirming or editing.
- Manual positioning is facilitated. A workpiece can be moved to any position and that point can be entered as positioning data.
- A series of positioning actions can be executed and checked.
- Troubleshooting is facilitated through Teaching Box display of error codes.

The information provided here is only a general description of Teaching Box functions. For step-by-step explanations and key sequences for all operations and commands, refer to the *Teaching Box Operation Manual*.

4-4 Initializing

Before entering data for positioning, initialize as follows.

Check the front panel of the Position Control Unit, and set the mode selector to REMOTE. Then connect the Teaching Box to the Position Control Unit. If status is normal, the POWER LED on the Teaching Box will light. You can then set the mode to LOCAL.

If the Position Control Unit is set to LOCAL mode without the Teaching Box connected, the communication error LED and the RUN LED will flash. Clear the error by connecting the Teaching Box, setting the mode to REMOTE, and then setting the mode back to LOCAL again.

The POWER, MANUAL, and READY LEDs on the Teaching Box should light. If these are all lit and the Position Control Unit still does not respond to Teaching Box commands, check to see if the ready input is OFF or the CW and CCW limit inputs are ON.

If there is any problem in the system, the ERROR LED on the Teaching Box will light. In that case, check the settings for the external inputs to the Position Control Unit.

4-5 Data Allocations

Write the data for parameters, speeds, and positioning actions into the Position Control Unit memory locations shown in the table below. You must enter the data in the following sequence: parameters (2000 to 2011), speeds (4000 to 4009), and positioning actions (1000 to 1199). Be sure to enter data for all parameters.

You do not need to enter all of the speed data, but you must at least set the manual speeds (4000 and 4002), the origin return speed (4000), and the origin search speeds (4001 and 4002). Set the manual speeds slower than the origin return speed and origin search speeds. The origin return speed (4000) is also used for the manual high speed; the manual low speed (4002) is also used for the origin search low speed.

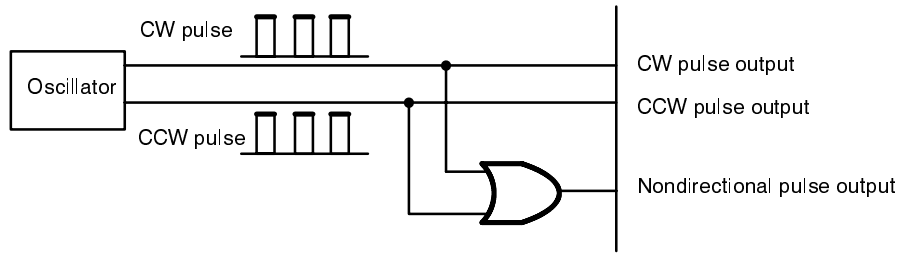
| Data | Address | Description | Permitted Settings |
|---------------------|---------------------|--|---|
| Positioning actions | 1000 to 1199 | Position | 0-999,999 (pulse) |
| | | Speed | 0-9 |
| | | Bank end | ON: 1,; OFF: 0 |
| | | Completion code | Continuous: 1; termination : 0 |
| | | Position type | ABSolute: or INCremental: 1 |
| | | Direction | CCW: 1; CW: 0 |
| Parameters | 2000 | Unit | mm: 1; inch: 2; deg: 3; pulse: 4 |
| | 2001 | Pulse rate | 0.0001-1.0000 (unit/pulse) |
| | 2002 | CW limit | 0-999,999 (pulse) |
| | 2003 | CCW limit | 0-999,999 (pulse) |
| | 2004 | Backlash correction | 0-9,999 (pulse) |
| | 2005 | Maximum speed | 32-100,000 (pulse/s) |
| | 2006 | Initial speed | 32-1,500 (pulse/S) |
| | 2007 | Acceleration/Deceleration time | 0.1-9.9 s (0.1 s increments) |
| | 2010 | Search pattern and origin search direction | Search pattern 0-5 Search direction CCW: 1; CW: 0 |
| 2011 | Origin compensation | ±(0-9,999)(pulses) | |
| Speeds* | 4000 | Speed #0: Origin return Speed and manual high speed | 1-100,000 pulse/s |
| | 4001 | Speed #1: Origin search high speed | 1-100,000 pulse/s |
| | 4002 | Speed #2: Origin search low speed and manual low speed | 1-100,000 pulse/s |
| | 4003 | Speed #3 | 1-100,000 pulse/s |
| | 4004 | Speed #4 | 1-100,000 pulse/s |
| | 4005 | Speed #5 | 1-100,000 pulse/s |
| | 4006 | Speed #6 | 1-100,000 pulse/s |
| | 4007 | Speed #7 | 1-100,000 pulse/s |
| | 4008 | Speed #8 | 1-100,000 pulse/s |
| | 4009 | Speed #9 | 1-100,000 pulse/s |

4-6 Internal Processing

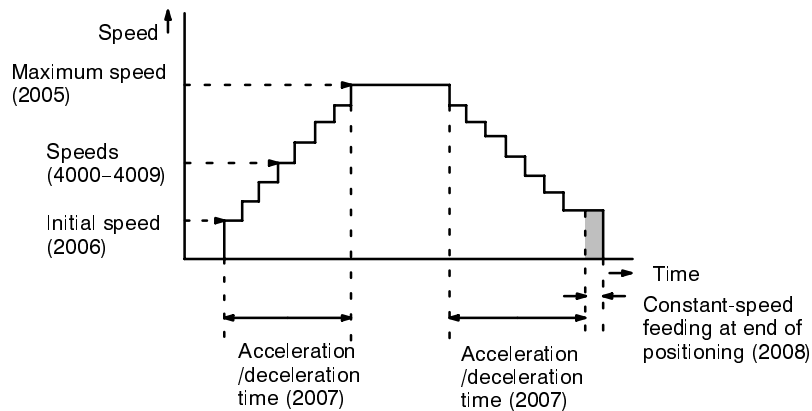
This section describes the internal processing the Position Control uses when executing position according to the data set by the user. Addresses are enclosed in parentheses following the address name.

Acceleration/Deceleration Time (2007)

Clockwise and counterclockwise pulses are output from the oscillator circuit as shown below.



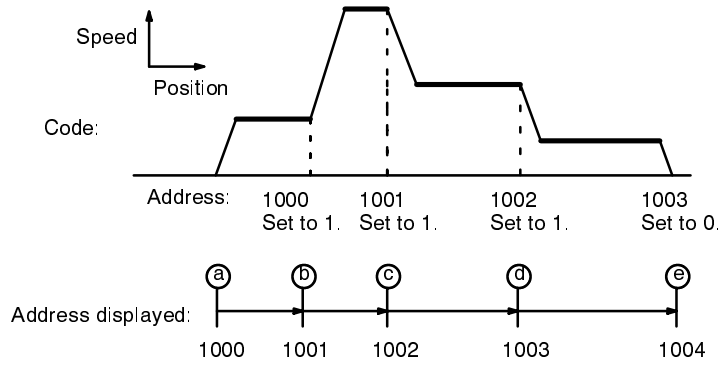
As shown in the figure below, acceleration and deceleration consist of automatic trapezoidal acceleration/deceleration curves controlled by sequentially increasing or decreasing the oscillator's frequency during the transmission of pulses.



The trapezoidal acceleration/deceleration is determined by the initial speed (2006), the maximum speed (2005), and the acceleration/deceleration time (2007). Since acceleration and deceleration times are the same, a regular trapezoid is formed. The shaded area in the figure above shows constant-speed feeding at the initial speed for a brief duration to allow for smooth stopping while the mechanical system absorbs residual momentum. You can set address 2008 to select the number of pulses for constant-speed feeding.

Automatic Address Incrementing

The Position Control Unit continuously sends to the PC both the address currently being executed and the next address to be executed. The address displayed is the next one to be executed. As shown in the figure below, address 1000 is displayed between (a) and (b), 1001 between (b) and (c), 1002 between (c) and (d), and so on. When positioning stops at point (e), the Unit automatically increments the address to 1004.



Automatic incrementing allows the next positioning action to begin immediately and consecutively from address 1004. Otherwise, the next address would have to be set and START executed again.

There are three cases when the address reverts to 1000 instead of being incremented: (1) when the final positioning action address, 1199, is completed; (2) when no positioning action exists at the next address; and (3) when a positioning action with a bank end designation is reached (see *Bank End* under Section 4-9-4).

Note that "00000" written for a positioning action does not indicate that a positioning action does not exist. Rather, no positioning action exists at an address when no data has been written there since it was last cleared by the Teaching Box.

4-7 Setting Parameters

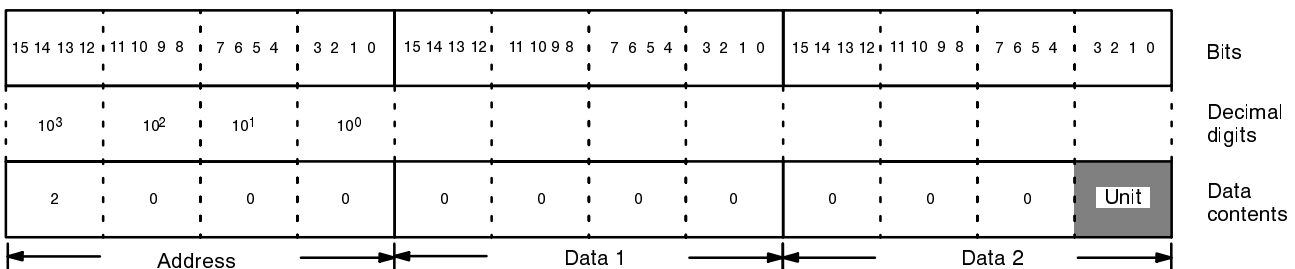
When setting data for the first time, you must set the parameters first, before speeds and positioning actions. The word "parameters," as used here, has a rather specific meaning and refers to certain data settings (described below) which delineate particular aspects of operation. There are 13 parameters to be set.

Each parameter (2000 to 2011) is allocated three 16-bit words within the Position Control Unit. Each of these words consists of four BCD or hexadecimal digits, each of which requires four bits. The bits are numbered from 00 to 15. The first 16-bit word is used to designate the address. The other two words, called "Data 1" and "Data 2," are used to store the data for that parameter. Addresses are provided for in parentheses following the Parameter name.

4-7-1 Positioning Unit (2000)

You can select inches, millimeters, degrees, or pulses as the unit to be used in inputting data. Set the unit digit (shaded in the figure below) as follows:

mm: 1 inch: 2 degree: 3 pulse: 4

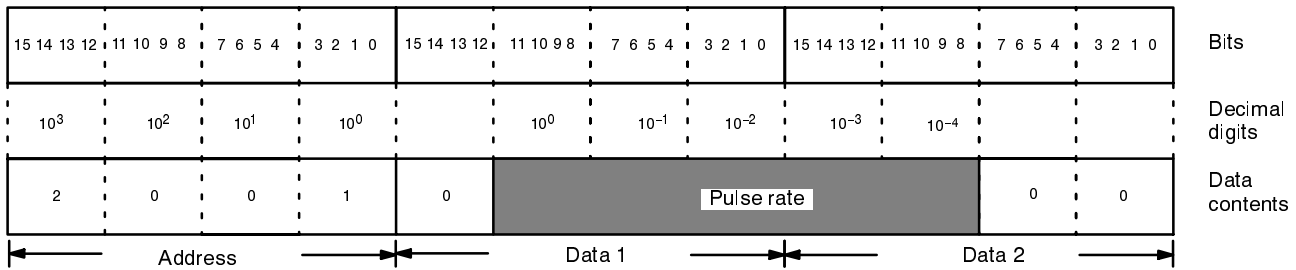


4-7-2 Pulse Rate (2001)

This setting determines the amount of workpiece movement for each pulse output by the Position Control Unit. The setting range is from 0.0001 to 1.0000. Thus, for example, if you select mm as the unit, the setting range will be from 0.0001 mm/pulse to 1.0000 mm/pulse.

You first make this setting in accordance with your application requirements. Later the Position Control Unit will use this as a basis when you input positioning data with the Teaching Box. For example, suppose that you have selected mm as the unit and set 0.5 as the pulse rate. Then, if you want to designate 1000 mm with the Teaching Box, you simply make a setting of 1000. The Position Control Unit will automatically output 2000 pulses to execute the positioning.

Set the pulse rate in the shaded area in the figure below.

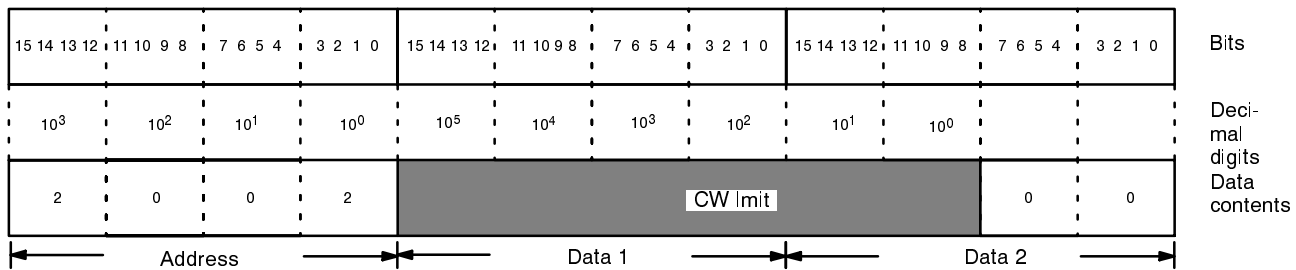


4-7-3 CW Limit (2002)

To prevent overrunning the motor, you can set CW and CCW limits, as well as a maximum speed. You set the CW limit at this address (2002). The CW limit can be set anywhere from 0 to 999,999 pulses. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

$$\text{CW limit in mm, inches, etc./pulse rate} \leq 999,999$$

Set the pulse rate in the shaded area in the figure below.



4-7-4 CCW Limit (2003)

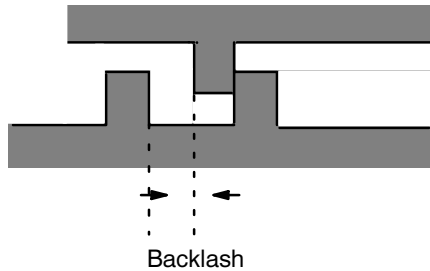
You set the CCW limit at this address (2003). Like the CW limit, the CCW limit can be set anywhere from 0 to 999,999 pulses. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

$$\text{CW limit in mm, inches, etc./pulse rate} \leq 999,999$$

The data format, except for the address, is the same as that for the CW limit (see Section 4-7-3 above).

4-7-5 Backlash Compensation (2004)

With this setting you can attain greater accuracy in positioning by compensating for mechanical imprecision. The word “backlash” refers to the mechanical play present in gears. Such play can create positioning inaccuracy when the direction of positioning changes. You can compensate for this by making a setting here from 0 to 99.99 pulses.



If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

$$\text{Backlash compensation in mm, inches, etc./pulse rate} \leq 9999$$

Set the pulse rate in the shaded area in the figure below.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------|----|----|----|--------|----|---|---|--------|---|---|---|--------|---|---|---|--------|----|----|----|--------|----|---|---|-----------------------|---|---|---|-----------|---|---|---|----------------|----|----|----|----|----|---|---|---------------|---|---|---|---|---|---|---|------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | Bits |
| 10^3 | | | | 10^2 | | | | 10^1 | | | | 10^0 | | | | 10^1 | | | | 10^0 | | | | 10^{-1} | | | | 10^{-2} | | | | Decimal digits | | | | | | | | | | | | | | | | |
| 2 | | | | 0 | | | | 0 | | | | 4 | | | | 0 | | | | 0 | | | | Backlash compensation | | | | | | | | 0 | | | | 0 | | | | Data contents | | | | | | | | |
| Address | | | | | | | | | | | | | | | | Data 1 | | | | | | | | | | | | | | | | Data 2 | | | | | | | | | | | | | | | | |

4-7-6 Maximum Speed (2005)

To prevent overrunning the motor, you can set a maximum speed of anywhere from 1 to 100,000 pulses/second. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

$$1 \leq \text{Maximum speed/pulse rate} \leq 100,000$$

The data format, except for the address, is the same as that for the CW limit (see Section 4-7-3 above).

4-7-7 Initial Speed (2006)

A servomotor starts from speed 0, but a stepping motor can start up within a certain frequency range. You can specify the initial speed with a setting at this address (2006). Be sure that the speed you specify does not cause the motor to overdrive, even within its startup frequency range.

You can set an initial speed of anywhere from 0 to 1500 pulses/per second. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

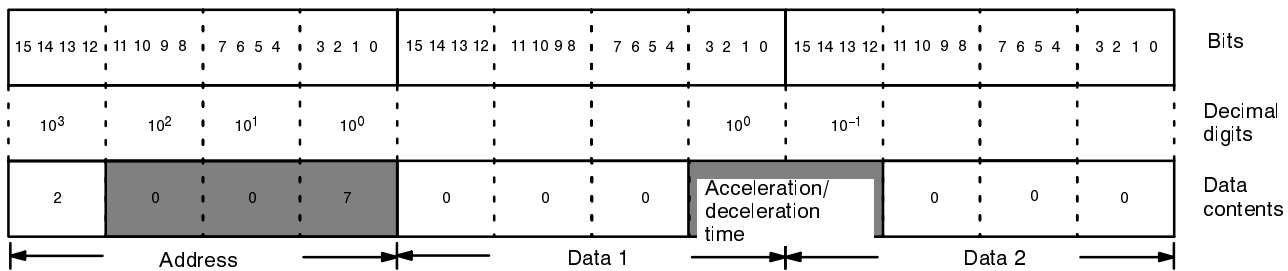
$$\text{Initial speed in mm, inches, etc./pulse rate} \leq 1500$$

The data format, except for the address, is the same as that for the CW limit (see Section 4-7-3 above).

4-7-8 Acceleration/Deceleration Time (2007)

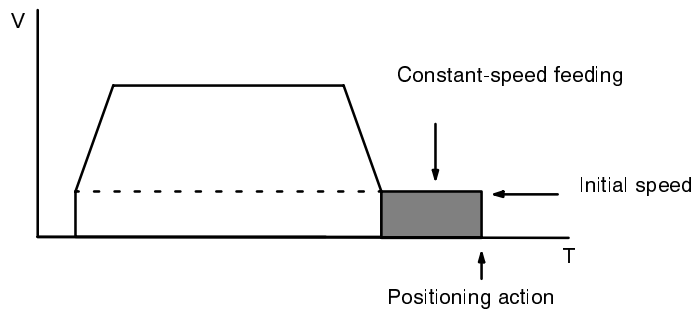
The setting you make here determines the time it takes to accelerate and decelerate between the initial speed and the maximum speed. You can set this time at anywhere from 0.1 s to 9.9 s (in units of 0.1 s).

Set the acceleration/deceleration time in the shaded area in the figure below.



4-7-9 Constant-speed Feeding (2008)

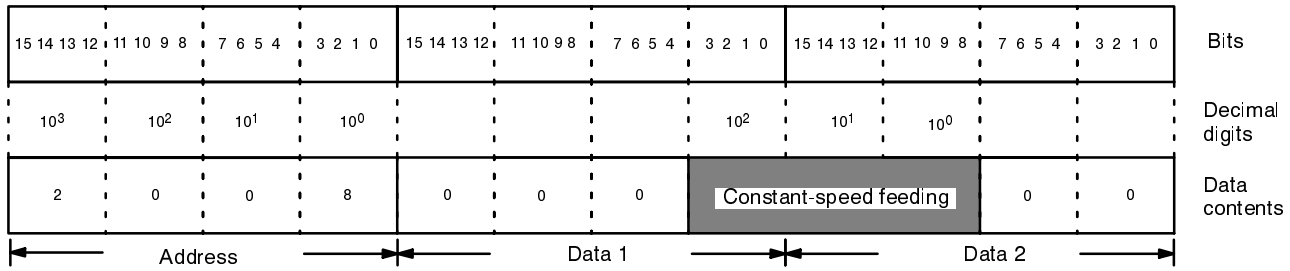
In order to allow positioning to come to a smooth stop while the mechanical system absorbs residual momentum, you can set a short period for constant-speed feeding. As illustrated in the diagram below, positioning will be executed at initial speed, at the end of a positioning action, for however long you specify.



You can set anywhere from 0 to 255 pulses for constant-speed feeding. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

$$\text{Constant-speed period in mm, inches, etc./pulse rate} \leq 255$$

Set the acceleration/deceleration time in the shaded area in the figure below.

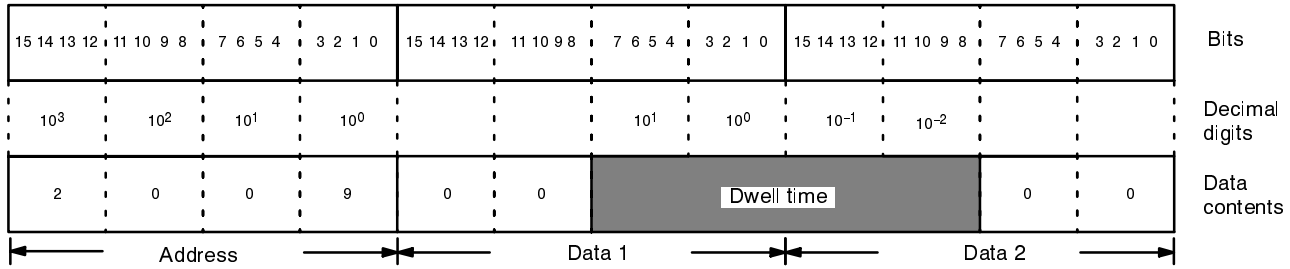


4-7-10 Dwell Time (2009)

In servo systems there is sometimes a tendency to hunt (i.e., to overcompensate when the system's momentum carries it past the target position). When this occurs there is a possibility that the subsequent positioning action may begin before positioning is completed. To allow sufficient time to ensure that a positioning action is completed before the next one begins, you can set a dwell time at this address (2009).

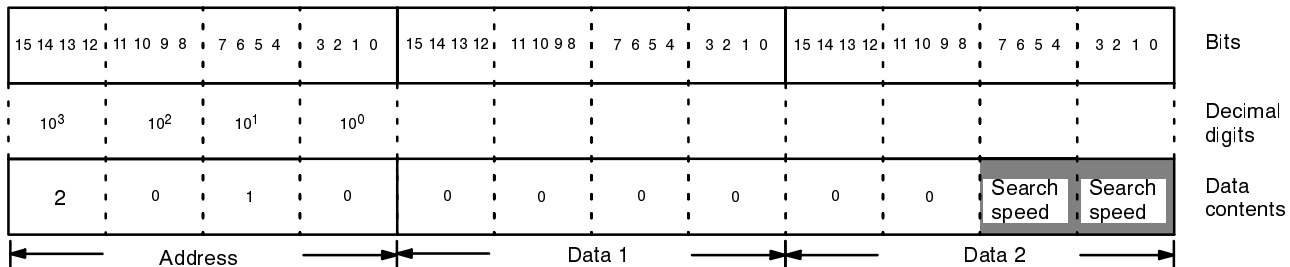
If you are using an open-loop system there will be no feedback and hunting will not occur. Dwell times, therefore, are generally not needed with stepping motors.

You can set the dwell time to anywhere from 0.00 to 99.99 seconds in 0.01 seconds increments. Set the acceleration/deceleration time in the shaded area in the figure below.



4-7-11 Search Pattern and Origin Search Direction (2010)

As shown in the figure below, the search pattern and origin search direction each occupy four bits of Data 2.



Search Pattern (Data 2, Bits 7 to 4)

You can select any of six search patterns (i.e., the pattern in which origin search is carried out). For details on each of the patterns, you can refer to *Section 6 Establishing the Origin*. To select one of the patterns, enter a digit from 0 to 5 as shown in the table below.

| Bits 7 to 4 | Digit | Pattern |
|-------------|-------|---------------|
| 0000 | 0 | Pattern no. 0 |

| | | |
|------|---|---------------|
| 0001 | 1 | Pattern no. 1 |
| 0010 | 2 | Pattern no. 2 |
| 0011 | 3 | Pattern no. 3 |
| 0100 | 4 | Pattern no. 4 |
| 0101 | 5 | Pattern no. 5 |

**Origin Search Direction
(Data 2, Bits 3 to 0)**

To select the direction in which origin search will be carried out, enter 0 for clockwise or 1 for counterclockwise.

4-7-12 Origin Compensation (2011)

Due to mechanical imprecision, the origin signal may not always locate the exact mechanical origin. In such cases, you can make an origin compensation setting to compensate for any misalignment.

You can set an origin compensation of anywhere from 0 to ± 9999 pulses. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see *Section 4-7-2* above). The following equation must be satisfied:

$$-9999 \leq \text{Origin compensation in mm, inches, etc./pulse rate} \leq +9999$$

The data format is basically the same as that for backlash compensation (see *Section 4-7-5* above), except that 1) the address is different, and 2) the lowest four bits in Data 2 are used to designate positive or negative compensation (positive: 0; negative: 1).

4-8 Setting Speeds

The data allocation for speeds is the same as that for parameters. That is, each speed is allocated three 16-bit words—one for the address and two for speed data. The data format, except for the addresses, is the same as that for the CW limit (see *Section 4-7-3* above). You can set up to ten speeds, in addresses 4000 through 4009. The first three of these speeds are designated for specific functions, as shown below. (Note that speeds #1 and #2 are each used for two different functions.) The other seven speeds have no particular designation and can be used for any purpose.

Speed #0 (4000): Origin return speed and manual high speed

Speed #1 (4001): Origin search high speed

Speed #2 (4002): Origin search low speed and manual low speed

Speed #3: (4003)

Speed #4 (4004)

Speed #5 (4005)

Speed #6 (4006)

Speed #7 (4007)

Speed #8 (4008)

Speed #9 (4009)

You can set speeds anywhere from 1 to 100,000 pulses/second. If you are using units other than pulses, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see *Section 4-7-2* above). The following equation must be satisfied:

$$\text{Speed in mm, inches, etc./pulse rate} \leq 100,000$$

Note that trapezoidal acceleration/deceleration is not possible when speeds are set from 0 pps to 31 pps.

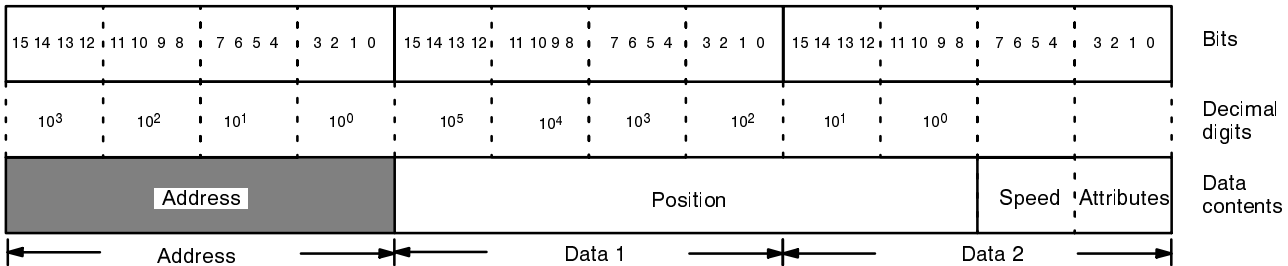
4-9 Setting Positioning Actions

After setting the data for parameters and speeds, you are ready to set the data for the positioning actions themselves. The reason for setting positioning actions last is that they make use of parameter and speed data.

The positioning action is the fundamental unit of positioning. Each positioning action is allocated three 16-bit words and is defined by four fields, or areas used to hold data settings: the address field, the position field, the speed field, and the attribute field.

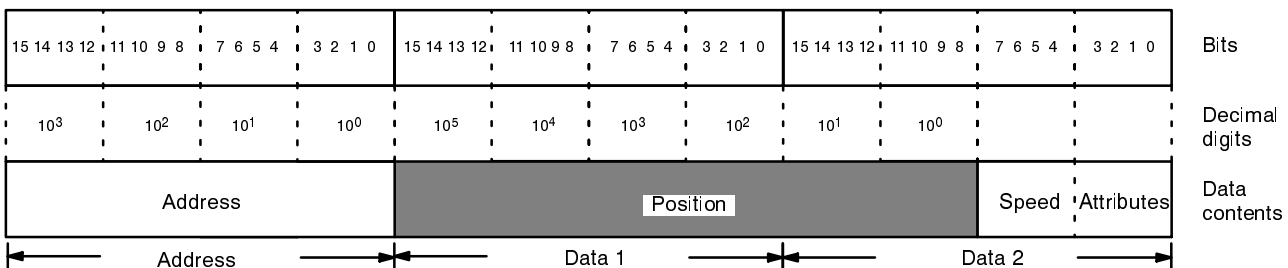
4-9-1 Address Field

This field occupies the first of the three words and contains the four decimal digits of the address. You can set addresses for up to 200 possible positioning actions (addresses 1000 through 1199). Later, during operation, the commands transferred from the PC use these addresses to access particular positioning actions.



4-9-2 Position Field

The position field occupies six digits. Each digit requires four bits in BCD, so the position field occupies one and a half words (Data 1 and half of Data 2). When START is transferred from the PC to execute the positioning action, the control system will move the workpiece to the position specified in this field.



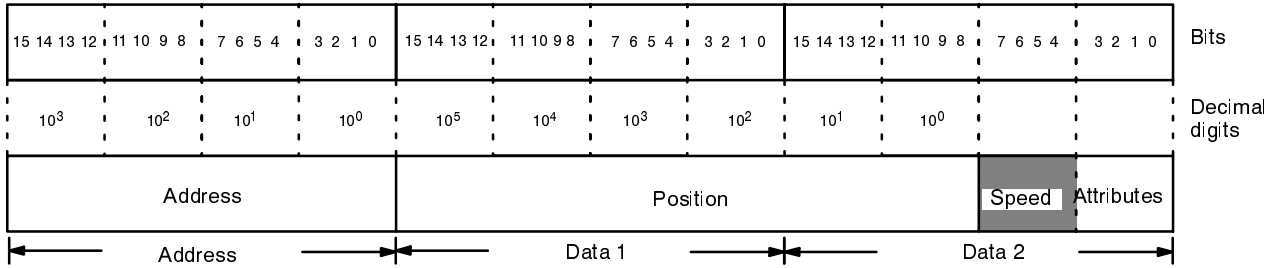
You can set a position of anywhere from 000000 to 999999 (pulses). If you are using a unit other than pulses for positioning, be sure that the range will not be exceeded when the unit is converted to pulses in accordance with the pulse rate (see Section 4-7-2 above). The following equation must be satisfied:

$$\text{Position in mm, inches, etc./pulse rate} \leq 999,999$$

4-9-3 Speed Field

The speed field designates the speed for the move to the designated position. You can designate any of the ten speeds which you previously entered

in addresses 4000 to 4009 (see Section 4-8). The speed field occupies the bits shown in the shaded area in the figure below.

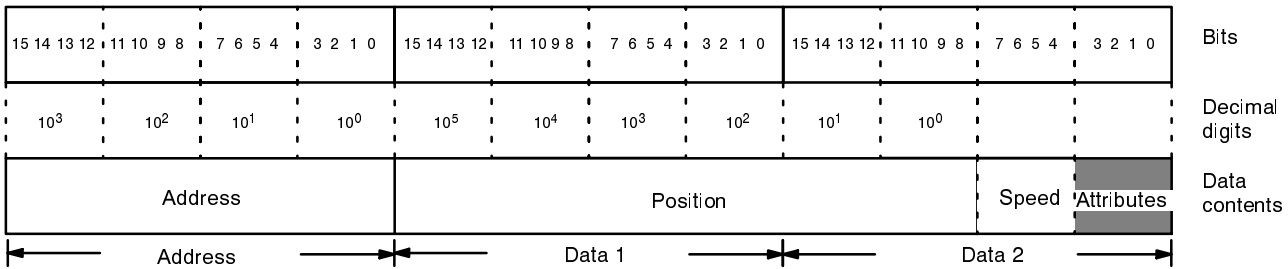


Enter a value from 0 to 9, as shown in the table below, to select one of the ten speeds.

| Bits 7 to 4 | Input | Speed |
|-------------|-------|-------------|
| 0000 | 0 | Speed no. 0 |
| 0001 | 1 | Speed no. 1 |
| 0010 | 2 | Speed no. 2 |
| 0011 | 3 | Speed no. 3 |
| 0100 | 4 | Speed no. 4 |
| 0101 | 5 | Speed no. 5 |
| 0110 | 6 | Speed no. 6 |
| 0111 | 7 | Speed no. 7 |
| 1000 | 8 | Speed no. 8 |
| 1001 | 9 | Speed no. 9 |

4-9-4 Attribute Field

The attribute field consists of four bits which designate, respectively, the bank end, completion code, type of position, and direction of motor rotation.



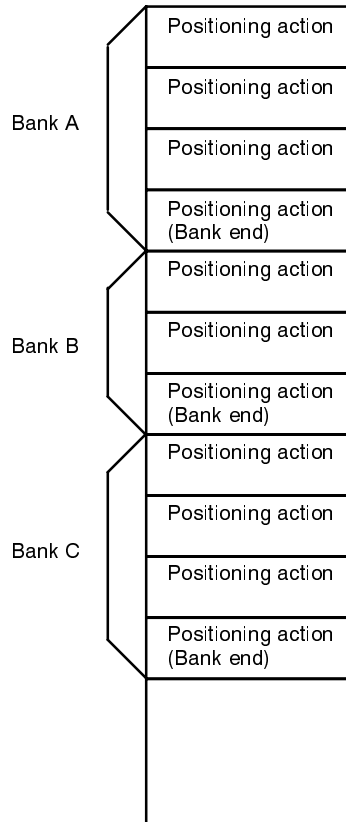
Bank End (Bit 3)

By setting the bank end bit (bit 3) to 1, you can designate a positioning action as the last one in a bank, or combined group of positioning actions. By designating certain positioning actions as bank ends, you can group positioning actions into banks. You can create several banks to be repeatedly executed in consecutive order. If you only create one bank, then the positioning action at address 1000 will be the next to be executed after the bank end.

If you create more than one bank, then after execution of a bank end positioning action, the next positioning action to be executed will be the first one in the next bank. The positioning actions in that bank will then be executed in order until the bank end is reached.

Positioning is terminated after execution of each bank end positioning action, and the Bank End flag (IR n+3, bit 11) turns ON. When START is next executed by the program, positioning begins with the first positioning action of the next bank. After the last bank end, START will begin the first positioning action of the first bank.

The diagram below illustrates a case where bank ends are used to create three banks of positioning actions.

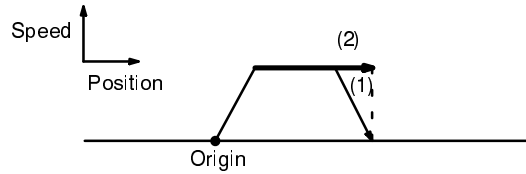


A group of positioning actions can be considered a bank even without any of them having a bank end attribute, as long as all of the other positioning action addresses have an “all clear” status at the Teaching Box. In such a case, the positioning actions will be automatically incremented in sequence and the Bank End flag will still turn ON after they have all been executed.

The situation becomes more complicated, however, if you wish to change the data for several of the positioning actions, and have them repeatedly executed in sequence, without clearing all of the other positioning actions. It would be possible to write a PC program to accomplish this, but it would be a burden on the program. You can do it much more efficiently by simply designating the final positioning action in the new group as a bank end.

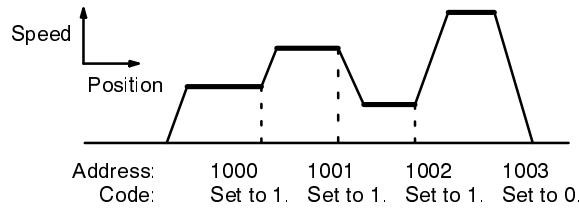
Completion Code (Bit 2)

The completion code setting determines, upon completion of a given positioning action, whether positioning stops or whether the next positioning action is executed immediately, without a break. Setting this bit to 0 designates the positioning action as “terminating” (i.e., positioning stops); setting it to 1 designates the action as “continuous” (i.e., the next positioning action is executed).



When START is executed (i.e., when IR n+1, bit 08 is turned ON by the program), positioning is carried out according to the data (speeds, parameters, etc.) which have been set for that positioning action. Depending on whether the completion code has been set to 0 (terminating) or 1 (continuous), positioning will follow either pattern (1) or pattern (2) as shown in the figure above.

Positioning will follow pattern (1) when the completion code is set to 0. When the target position is reached, the speed decelerates to 0 and positioning stops. Positioning will follow pattern (2) when the completion code is set to 1. When the target position is reached, it is treated as part of a sequence of positioning actions. In other words, the speed does not decelerate to 0, but, rather, the subsequent positioning action begins as the next part of a continuous operation.



Note that it is not possible to reverse direction during a continuous positioning sequence. Attempting to do so will result in a CNC error when START is executed.

INC/ABS (Bit 1)

This setting designates the position as absolute (ABS) or incremental (INC). An absolute position refers to the distance from the origin. An incremental position refers, rather, to the distance from the present position. (The origin is the position which is designated as 0 at any given time. The present position is the numeric value in pulses defined as being the “location” of the positioning system at any given time.) Set this bit to 1 for absolute or to 0 for incremental.

CW/CCW (Bit 0)

This setting designates either a clockwise (CW) or counterclockwise (CCW) direction for motor rotation. Set the bit to 1 for CCW rotation or to 0 for CW rotation. On the Teaching Box, - (minus) indicates CCW rotation, and + (plus) indicates CW rotation.

CW and CCW are defined for a motor shaft in reference to a viewer facing the shaft on the end of the motor from which the shaft extends from the motor for connection.

SECTION 5

Data Communication with the PC

Once you have input all the necessary data to the Position Control Unit (see *Section 4*), you are ready to switch to REMOTE mode and begin operation. Most of the commands can be executed only by setting command bits from the PC. If it is more convenient, however, you can execute ORIGIN SEARCH and ORIGIN RETURN in LOCAL mode in REMOTE mode, (with the Teaching Box).

In REMOTE mode, the Position Control Unit communicates with the PC. The Position Control Unit is allocated four I/O words (in the IR area of the PC) for communication with the PC, two for input from the PC and two for output to the PC. In general, the Position Control Unit receives commands and outputs flags. This section covers the allocation of bits in these four IR words. Included are explanations of all of the commands (except for ORIGIN SEARCH, which is covered separately in *Section 6 Establishing the Origin*), all of the flags, and other aspects of communication between the Position Control Unit and the PC. This section also describes the different types of external input.

| | | |
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5-1 IR Area Allocations

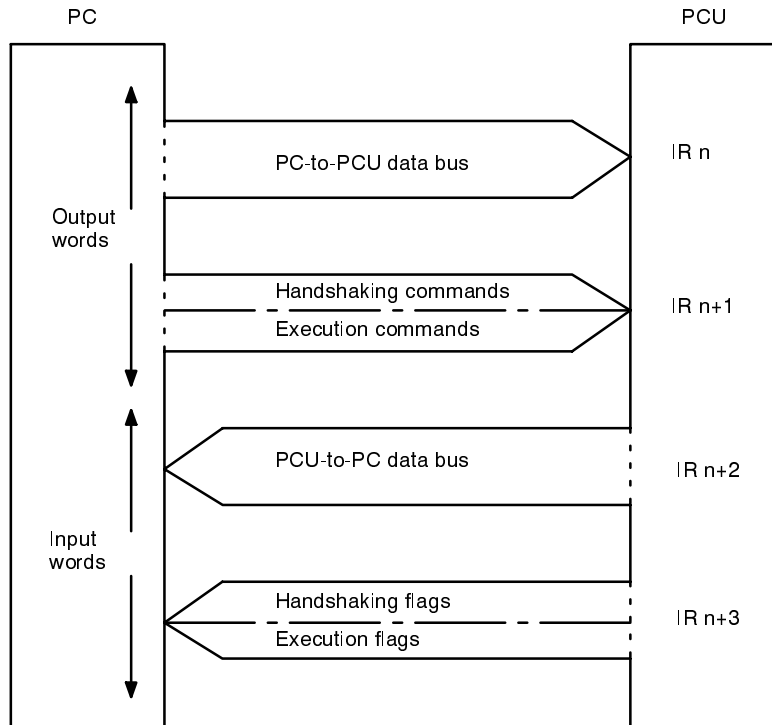
The Position Control Unit is allocated four I/O words for communication with the PC. The allocation of bits in those words is shown in the table below. Where the terms “input” and “output” are used, they are referred to from the viewpoint of the PC. (“n” indicates the first word allocated to the Position Control Unit.)

| Word | Bit | Name | Word | Bit | Name |
|------|----------|-------------------------|----------------|------------------------|----------------------------|
| n | 0 to 15 | Data bus form PC to PCU | n+2 | 0 to 15 | Data bus from PCU to PC. |
| n+1 | 0 | WRITE ADDRESS | n+3 | 0 | ACK (Handshake Busy) |
| | 1 | WRITE DATA 1 | | 1 | Data 1 |
| | 2 | WRITE DATA 2 | | 2 | Data 2 |
| | 3 | READ DATA | | 3 | Data Transfer |
| | 4 | SCAN CLOCK | | 4 | PCU RUN |
| | 5 | SET ADDRESS | | 5 | Handshaking Error |
| | 6 | CLEAR HANDSHAKING ERROR | | 6 | Current Positioning Action |
| | 7 | OPERATING MODE | 7 | Current Address | |
| | 8 | START | 8 | Busy (Positioning) | |
| | 9 | PAUSE | 9 | Positioning Completed | |
| | 10 | ORIGIN RETURN | 10 | Origin | |
| | 11 | SET ORIGIN | 11 | Bank End | |
| | 12 | INCH CW | 12 | CNC Error | |
| | 13 | PC INTERRUPT | 13 | Interrupt | |
| | 14 | ORIGIN SEARCH | 14 | External Setting Check | |
| 15 | INCH CCW | 15 | Hardware Error | | |

Output Words

Input Words

The following figure illustrates the direction of communication flow between the Position Control Unit and the PC.



Check that the ACK (Handshake Busy) flag is set for the following handshaking commands: WRITE DATA 1, WRITE DATA 2, READ DATA, and SET ADDRESS. Note that handshaking commands do not operate as differentiated instructions (i.e., they must be programmed so that they are turned OFF when they are no longer necessary.)

The following points apply to IR n+1:

- Except for bits 4 and 7, only one bit should be ON at any given time.
- Bits 0, 1, 2, 3, 8, 11, and 14 are activated at their leading edge.
- Bits 6, 9, 12, 13, and 15 are level sensitive (active high).
- Bit 4 is the clock signal.
- Bit 7 is always ON.

5-1-1 IR n

This word is used as the data bus that transfers parameters, speeds, and positioning actions from the PC to the Position Control Unit in BCD (binary-coded decimal).

5-1-2 IR n+1

As explained in *Section 4*, data for parameters, speeds, and positioning actions is stored in three consecutive 16-bit words: the address, Data 1, and Data 2. When this data is transferred from the PC to the Position Control Unit, each of the three words is sent separately. The address is sent first, followed by Data 1 and Data 2 in that order.

WRITE ADDRESS (Bit 0)

This bit is turned ON to indicate transfer of the first 16-bit word, the address, from the PC to the Position Control Unit.

WRITE DATA 1 (Bit 1)

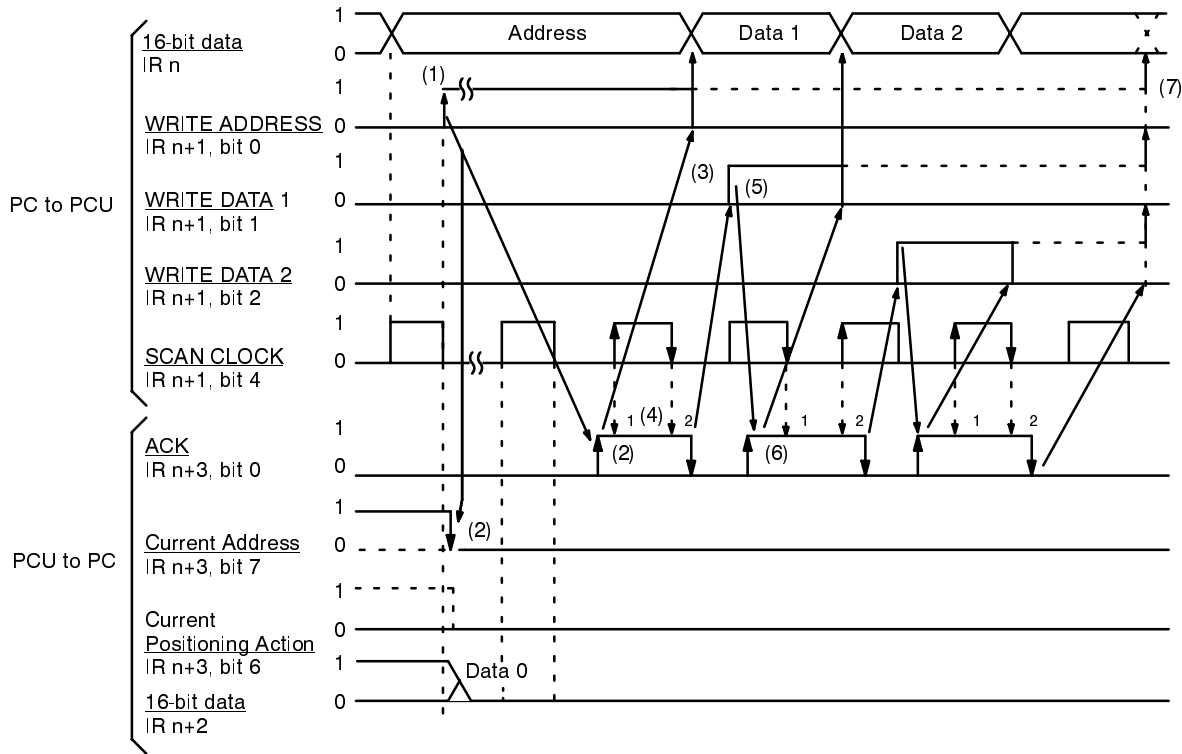
This bit is turned on to indicate transfer of the second 16-bit word, Data 1, from the PC to the Position Control Unit.

WRITE DATA 2 (Bit 2)

This bit is turned on to indicate transfer of the third 16-bit word, Data 2, from the PC to the Position Control Unit.

Timing and Protocol

Successful handshaking with the above handshaking commands and the ACK flag (IR n+3, bit 0) enables data transfer from the PC to the Position Control Unit. Data transfer timing and protocol are shown below.



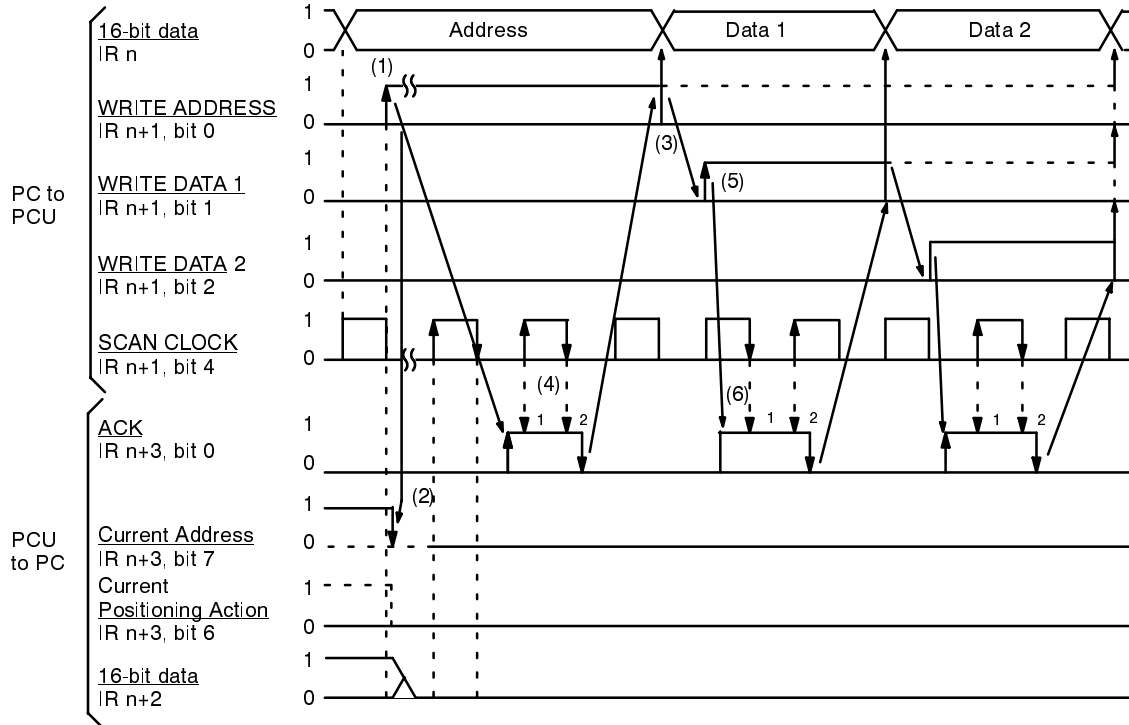
- 1, 2, 3...**
1. The PC outputs the address on the IR n data bus. WRITE ADDRESS (IR n+1, bit 0) is turned ON after one SCAN CLOCK pulse.
 2. If data transfer is attempted while the address or current positioning action is being transferred, the Position Control Unit will go to a receive ready status and the data transfer will be delayed. When data can be received, the Position Control Unit receives the data, checks the data format, and sets the ACK bit (ON). It takes approximately 10 ms for the ACK bit to be set. Incorrect data formats will cause the Handshaking Error flag (IR n+3, bit 5) to be set, indicating a communications error.
 3. When the ACK flag is set, it means that the Position Control Unit has received the data, so it makes no difference whether WRITE ADDRESS (IR n+1, bit 0) turns OFF or remains ON.
 4. The Position Control Unit will keep the ACK flag set during the leading and trailing edges of the SCAN CLOCK pulse.
 5. Next, after the ACK flag is cleared, WRITE DATA (IR n+1, bit 1) is set. The command bit must remain set for at least one SCAN CLOCK pulse after the data is output.
 6. The Position Control Unit responds by reading Data 1 and setting the ACK flag. This also takes about 10 ms.
 7. Data 2 is transferred from the PC to the Position Control Unit in the same way as Data 1. This completes the three-word data transfer. If any of the three command bits (WRITE ADDRESS, WRITE DATA 1, or WRITE DATA 2) are still ON, be sure to turn them OFF. If they are left ON, then a communications error will be generated the next time a data transfer is attempted.

Timing Summary

Data transfer timing can be summarized in three points:

- 1, 2, 3... 1. The data must be sent at least one SCAN CLOCK pulse ahead of the write command bit.
2. The subsequent data is transferred in accordance with the status of the ACK flag.
3. All write command bits must be cleared upon completion of the transfer.

Given these conditions, the following timing scheme is also possible.

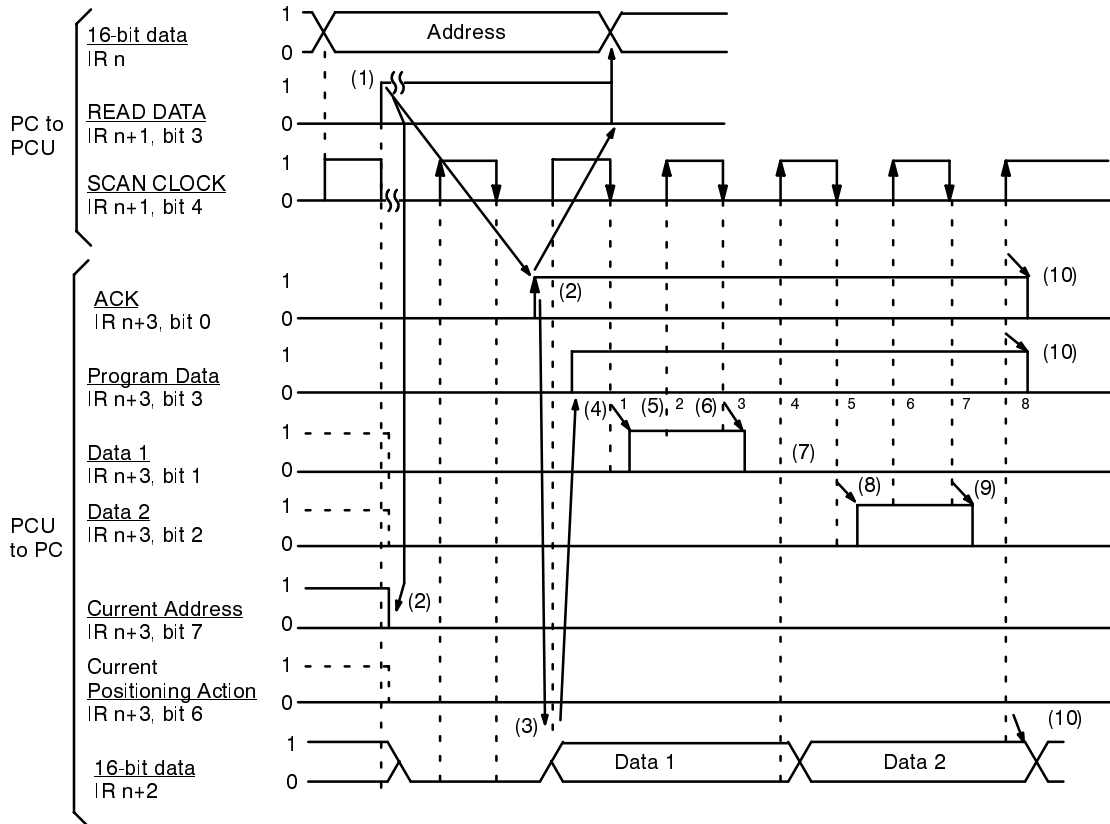


READ DATA (Bit 3)

The READ DATA command bit (IR n+1, bit 3) is turned ON to enable the PC to read data stored in the Position Control Unit. After the PC outputs the first of the three word address, this bit is turned ON to read the remaining two words (Data 1 and Data 2) into the PC.

Timing and Protocol

The timing and protocol for READ DATA are as follows:



1. The PC outputs the address on the IR n data bus. One SCAN CLOCK pulse later, the READ DATA command bit (IR n+1, bit 3) is turned ON.
2. If data transfer is attempted while the address or current positioning action is being transferred, the Position Control Unit will go to a receive ready status and the data transfer will be delayed. When data can be received, the Position Control Unit receives the data, checks the data format, and sets the ACK flag (ON). It takes approximately 10 ms for the ACK flag to be set. Incorrect data formats will cause the Handshaking Error flag (IR n+3, bit 5) to be set, indicating a communications error.
3. Approximately 10 ms after the ACK flag is set, Data 1 is output to the IR n+2 data bus.
4. After another 10 ms, the Position Control Unit will set the Data Transfer flag (IR n+3, bit 3).
5. At the next leading or trailing edge of the SCAN CLOCK, the Data 1 flag (IR n+3, bit 1) turns ON.
6. Between successful leading or trailing edges of the SCAN CLOCK, the Data 1 flag remains set.
7. At the following leading or trailing edge of the SCAN CLOCK, Data 2 is output to the IR n+2 data bus. This takes approximately 10 ms.
8. At the next leading or trailing edge of the SCAN CLOCK after the data is changed, the Data 2 flag (IR n+3, bit 2) is set.
9. The Data 2 flag also remains set between successive leading or trailing edges.
10. At the first SCAN CLOCK pulse change after the Data 2 flag is cleared, the ACK and Data Transfer flags are also cleared, and Data 2 is removed from the IR n+2 data bus.

SCAN CLOCK (Bit 4)

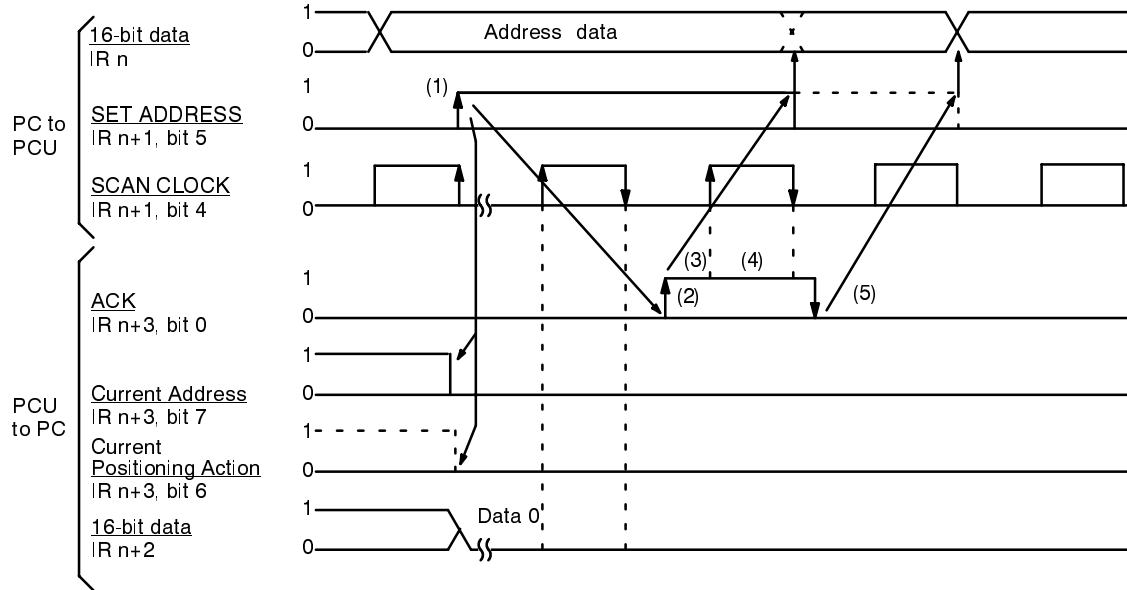
For an explanation of this bit, refer to *SCAN CLOCK* under *Section 5-2*.

SET ADDRESS (Bit 5)

The SET ADDRESS bit (IR n+1, bit 5) enables the PC to specify a particular positioning action stored in the Position Control Unit. When an address is output from the PC and this bit is turned ON, the data designated by that address is set. The positioning action data can then be used for positioning.

Timing and Protocol

The timing and protocol for SET ADDRESS are as follows:



- 1, 2, 3... 1. The PC outputs the address on the IR n data bus. One SCAN CLOCK pulse later, the SET ADDRESS command bit (IR n+1, bit 5) is turned ON.
2. If data transfer is attempted while the address or current positioning action is being transferred, the Position Control Unit will go to a receive ready status and the data transfer will be delayed. When data can be received, the Position Control Unit receives the data, checks the data format, and sets the ACK flag (ON). It takes approximately 10 ms for the ACK flag to be set. Incorrect data formats will cause the Handshaking Error flag (IR n+3, bit 5) to be set, indicating a communications error.
3. When the ACK flag turns ON, it means that the address has been set in the Position Control Unit. Therefore, as shown in the figure above, the address data bit may be cleared from the IR n data bus and the command may be reset on the leading edge of the ACK flag.
4. Between successive leading or trailing edges of the SCAN CLOCK, the ACK flag remains set.
5. After the ACK flag is cleared, make sure that the address data is cleared from the IR n data bus and the command bit is reset. Failure to do so will result in a communication error in subsequent operation.

CLEAR HANDSHAKING ERROR (Bit 6)

During data transfer from the PC to the Position Control Unit, an error is generated if data is out of range, communication protocol is wrong, or timing is off. If this happens, the Handshaking Error flag (IR n+3, bit 5) turns ON and communication stops. CLEAR HANDSHAKING ERROR clears the error from the PC. When restarting the data transfer, begin with the address.

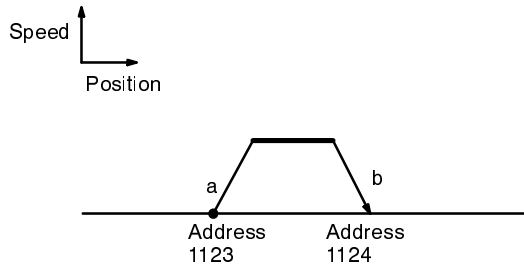
OPERATING MODE (Bit 7)

For an explanation of this bit, refer to *OPERATING MODE* under *Section 5-2*.

START (Bit 8)

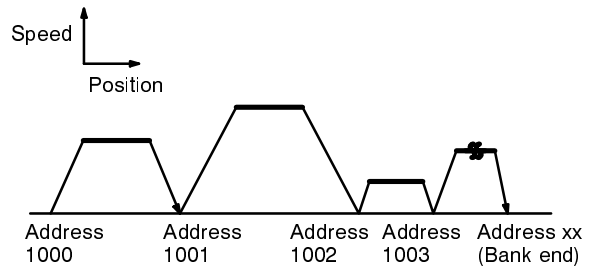
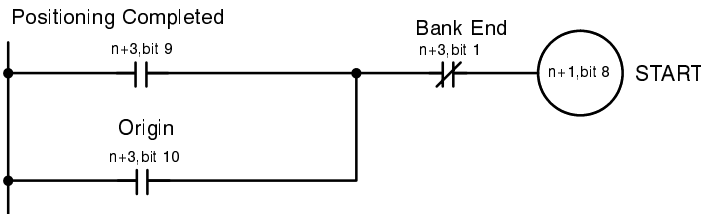
When the START command bit (IR n+1, bit 8) turns ON, positioning begins in accordance with the data at the designated address. Upon completion of positioning, the address is automatically incremented.

Caution When START is first executed following a rewriting of parameters, it will take approximately seven seconds before pulses are output. This is because the acceleration/deceleration table must be recalculated following a change in parameters.



For example, in the above diagram, when the positioning action at address 1123 has been completed, positioning stops and the the current address is automatically incremented to 1124. When START is executed at point a, positioning moves to point b in accordance with the speed data which has been set.

With the ladder diagram on the left below, you could program a sequence of positioning actions like those shown on the right. After the origin has been established (with ORIGIN SEARCH, RESET ORIGIN, or ORIGIN RETURN), all of the positioning actions can be executed once.



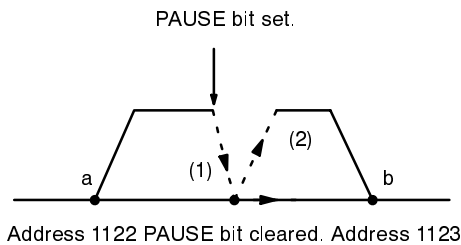
Flag Status

The table below shows the status of the flags during positioning.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|---|------------|
| n+2 | 0 to 15 | Data bus from PCU to PC | Current positioning action or current address | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | ON or OFF | OFF |
| | 2 | Data 2 | ON or OFF | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | ON or OFF | OFF |
| | 7 | Current Address | ON or OFF | OFF |
| | 8 | Busy | ON | ON |
| | 9 | Positioning Completed | OFF | OFF |
| | 10 | Origin | OFF | OFF |
| | 11 | Bank End | OFF | OFF |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF | OFF |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

PAUSE (Bit 9)

You can use the PAUSE command bit (IR n+1, bit 9) to stop positioning temporarily.



In the figure above, the PAUSE command bit is turned ON during positioning between points **a** and **b**, and positioning decelerates to a stop. After the command bit is turned OFF, positioning continues to point **b**. Since positioning is not actually terminated during PAUSE, but merely stops temporarily, the Busy flag (IR n+3, bit 8) remains set to indicate that positioning operations are continuing.

If PAUSE is executed during ORIGIN SEARCH, the origin search operation will be cancelled. Clear PAUSE and then execute ORIGIN SEARCH again. During ORIGIN RETURN, however, PAUSE is valid.

The flag status during PAUSE is the same as for START, above.

ORIGIN RETURN (Bit 10)

For an explanation of ORIGIN RETURN, refer to *Section 6-4*.

RESET ORIGIN (Bit 11)

For an explanation of RESET ORIGIN, refer to *Section 6-3*.

INCH CW (Bit 12)

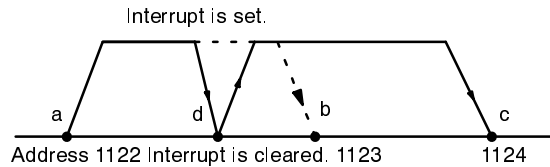
Turning the INCH CW command bit (IR n+1, bit 12) ON for 0.5 second or more causes a pulse train to be output at manual low speed (address 4002) in the CW direction. Turning it ON for less than 0.5 second causes only one CW pulse to be output at manual low speed.

PC INTERRUPT (Bit 13)

The PC INTERRUPT command bit (IR n+1, bit 13) can be turned ON to cancel positioning and pause operations whenever necessary. There are some differences, as explained below, depending on 1) whether you are cancelling positioning actions or pause operations, and 2) whether you are cancelling positioning actions with completion codes of "0" (terminating) or "1" (continuous). For an explanation of completion codes, refer to *Section 4-9-4*.

Cancelling Completion Code "0" Positioning Actions

If PC INTERRUPT is set during a positioning action with a terminating completion code, the current operation is cancelled, positioning stops, and the address is automatically incremented. When START is next executed, the Position Control Unit operates in accordance with the data set at the next address.

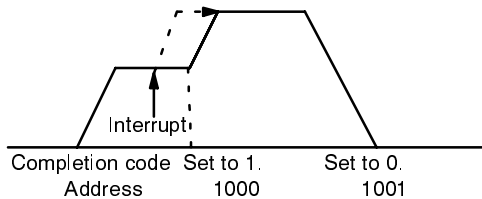


For example, in the diagram above, START is executed and positioning moves from point **a** (address 1122) toward the target position of point **b** (address 1123). The broken line shows how positioning would proceed if there were no interruption.

PC INTERRUPT is executed, however, before point **b** is reached, and positioning stops at point **d**. When PC INTERRUPT is cleared (i.e., when IR n+1, bit 13 turns OFF) and START is executed again, positioning skips point **b** and moves all the way to point **c** (address 1124).

Cancelling Completion Code "1" Positioning Actions

If PC INTERRUPT is executed during a positioning action with a continuous completion code, the positioning action currently being executed is cancelled and the following positioning action is executed immediately.



For example, in the diagram above, START is executed and positioning begins. Since the first positioning action (address 1000) has a completion code of "1" and the second has a completion code of "0," the second would normally be executed immediately upon completion of the first. The solid line shows how positioning would proceed if there were no interruption. The broken line shows how positioning would proceed if PC INTERRUPT were executed before the first positioning action were completed.

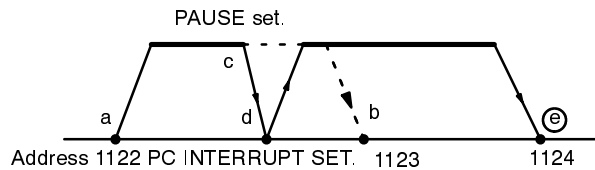
The following table shows the status of IR n+2 and IR n+3 after the interrupt.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|---|------------|
| n+2 | 0 to 15 | Data bus from PCU to PC | Current positioning action or current address | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF or ON | OFF |
| | 7 | Current Address | OFF or ON | OFF |
| | 8 | Busy | OFF | OFF |
| | 9 | Positioning Completed | * ON | * ON |
| | 10 | Origin | OFF | OFF |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | ON | ON |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

* Bit 9 is OFF until the origin is established.

Cancelling PAUSE

If PC INTERRUPT is executed during PAUSE, PAUSE is cancelled, the address is automatically incremented, and the next positioning action is executed.



For example, in the diagram above, START is executed and positioning moves from point **a** (address 1122) toward the target position of point **b** (address 1123). The broken line shows how positioning would proceed if there were no interruption. Executing PAUSE at point **c** should cause positioning to decelerate to a stop at point **d**. If, however, PC INTERRUPT is executed at least one scan after PAUSE, but between points **c** and **d**, PAUSE is cancelled.

In order to cancel PAUSE, you must execute PC INTERRUPT before positioning stops at point **d**. Once positioning stops at point **d**, then, even after PAUSE is cleared, positioning will not move to point **b** (address 1123). START must be executed in order to begin positioning again. When PC INTERRUPT is also cleared and START is executed, positioning will proceed directly to point **e** (address 1124), the target position for the next positioning action.

Caution The Position Control Unit receives both PC and external interrupts. The relationship between the two types of interrupts is a logical OR. In other words, an interrupt occurs if either is ON; to clear the interrupt, both must be OFF.

ORIGIN SEARCH (Bit 14) For an explanation of ORIGIN SEARCH, refer to *Section 6-2*.

INCH CCW (Bit 15) Turning the INCH CCW command bit (IR n+1, bit 15) ON for 0.5 second or more causes a pulse train to be output at manual low speed (address 4002) in the CCW direction. Turning it ON for less than 0.5 second causes only one CCW pulse to be output at manual low speed.

5-1-3 IR n+2

This word is used as the data bus that transfers parameters, speeds, and positioning actions from the Position Control Unit to the PC in BCD (binary-coded decimal).

5-1-4 IR n+3

This word contains flags which the Position Control Unit outputs to the PC.

ACK Flag (Bit 0) The ACK flag (IR n+3, bit 0) confirms that commands from the PC have been received by the Position Control Unit and that data from the Position Control Unit has been received by the PC. For more information, refer to the explanations of IR n+1, bits 3 and 5 under *Section 5-1-2*.

Data 1 Flag (Bit 1) The Data 1 flag (IR n+3, bit 1) turns ON, during the transfer of present position, parameters, speeds, or positioning actions, to indicate to the PC that the 16-bit Data 1 word is being transferred from the Position Control Unit to the PC.

Data 2 Flag (Bit 2) The Data 2 flag (IR n+3, bit 2) turns ON, during the transfer of present position, parameters, speeds, or positioning actions, to indicate to the PC that the 16-bit Data 2 word is being transferred from the Position Control Unit to the PC.

Data Transfer Flag (Bit 3) The Data Transfer flag (IR n+3, bit 3) turns ON when data from the Position Control Unit has been read by the PC. For more information, refer to the explanation of IR n+1, bit 3 under *Section 5-1-2*.

PCU RUN Flag (Bit 4) The PCU RUN flag (IR n+3, bit 4) turns ON when the Position Control Unit is in REMOTE mode and ready to accept commands. It turns OFF when:

1. The Position Control Unit is in LOCAL mode.
2. The Position Control Unit is computing and cannot accept PC commands.
3. An emergency stop or CNC error has occurred.
4. START is first executed following a parameter change.

Use this flag when sending commands from the PC to the Position Control Unit.

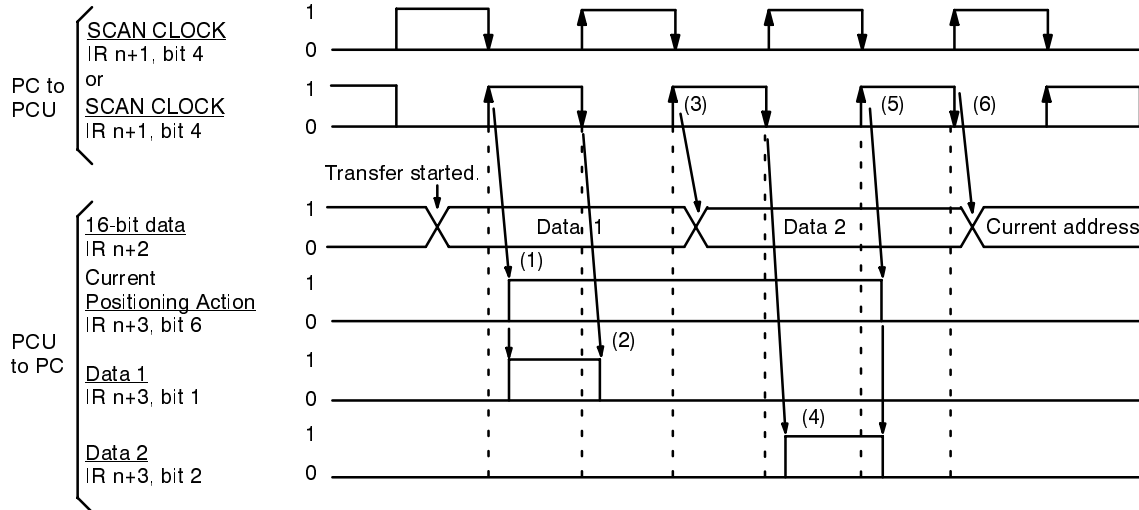
Caution There is a difference here between the 3G2A5-NC111-E and 3G2A5-NC111-EV1 Position Control Units. With the NC111-E, the PCU RUN flag would remain OFF for approximately 10 ms to 100 ms when positioning was initiated by START or restarted following PAUSE. This has been remedied with the NC111-EV1; the PCU RUN flag now remains ON in these situations.

Handshaking Error Flag (Bit 5)

The Handshaking Error flag (IR n+3, bit 5) turns ON during data communication to inform the PC that data is out of range, communication protocol is wrong, or timing is off. Data communication is halted and the error must be cleared with CLEAR HANDSHAKING ERROR (IR n+1, bit 6) in order to re-start.

Current Positioning Action Flag (Bit 6)

The Current Positioning Action flag (IR n+3, bit 6) turns ON to inform the PC that the current positioning action is being transferred. The timing for this flag in conjunction with the Data 1 and Data 2 flags is illustrated in the following diagram.

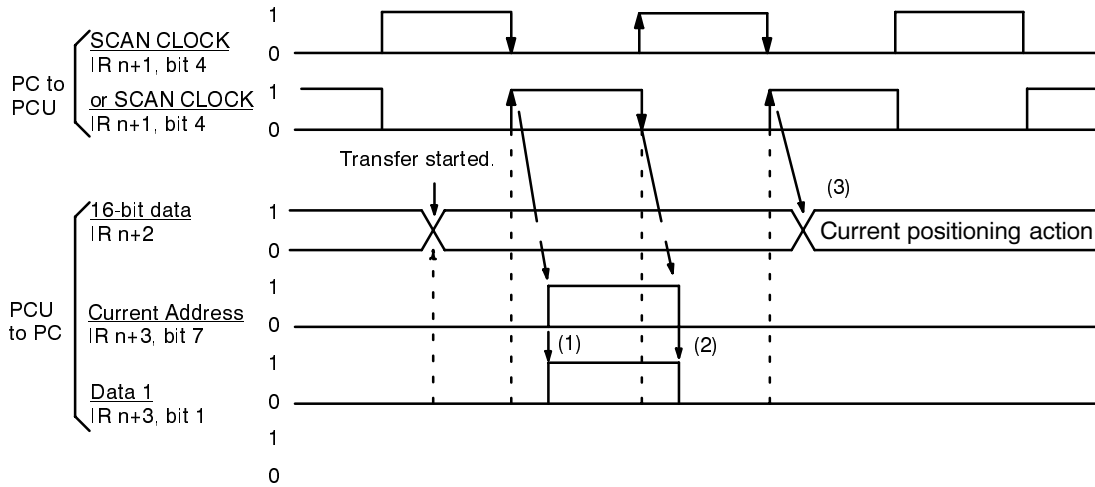


Protocol

- 1, 2, 3... 1. After outputting the Data 1 word of the current positioning action on the data bus to the PC, the Position Control Unit detects the first leading or trailing edge of the SCAN CLOCK and turns ON the Current Positioning Action flag (bit 6) and Data 1 flag (bit 1). It takes approximately 10 ms for the two flags to turn ON after the SCAN CLOCK changes.
2. After the Data 1 flag has been turned ON, the Position Control Unit detects the SCAN CLOCK's next leading or trailing edge and turns the flag OFF. It takes approximately 10 ms for the flag to turn OFF after the SCAN CLOCK changes.
3. After the Data 1 flag has been turned OFF, the Position Control Unit detects the SCAN CLOCK's next leading or trailing edge and places the Data 2 word onto the data bus to the PC. It takes approximately 10 ms for the data bus data to change after the SCAN CLOCK changes.
4. After the data changes, Data 2 is transferred in the same manner. The Data 2 flag (bit 2) is turned ON at the first leading or trailing edge of the SCAN CLOCK.
5. The Current Positioning Action flag (bit 6) and the Data 2 flag (bit 2) are turned OFF at the next leading or trailing edge of the SCAN CLOCK.
6. The data bus data switches to the current address at the next leading or trailing edge of the SCAN CLOCK.

- Note**
1. Whether incremental or absolute, the position for the current positioning action is transferred as an absolute position with direction. All other attributes and the speed are fixed to 0.
 2. The current address and current positioning action are alternately output from the Position Control Unit to the PC when the Position Control Unit is executing positioning actions or pause operations.

Current Address Flag (Bit 7) The Current Address flag (IR n+3, bit 7) turns ON when the current address is transferred from the Position Control Unit to the PC. The timing of this flag and the Data 1 flag (bit 1) are shown in the diagram below.



Protocol

- 1, 2, 3...** 1. After outputting the current address on the data bus to the PC, the Position Control Unit detects the first leading or trailing edge of the SCAN CLOCK and turns ON the Current Address flag (bit 7) and Data 1 flag (bit 1). It takes approximately 10 ms for the two flags to turn ON after the SCAN CLOCK changes.
2. The Position Control Unit detects the SCAN CLOCK's next leading or trailing edge and turns the two flags OFF. It takes approximately 10 ms for the flags to turn OFF after the SCAN CLOCK changes.
3. The Position Control Unit detects the SCAN CLOCK's next leading or trailing edge after the Current Address and Data 1 flags are cleared, and places the current positioning action onto the data bus to the PC. It takes approximately 10 ms for the data bus data to change after the SCAN CLOCK changes.

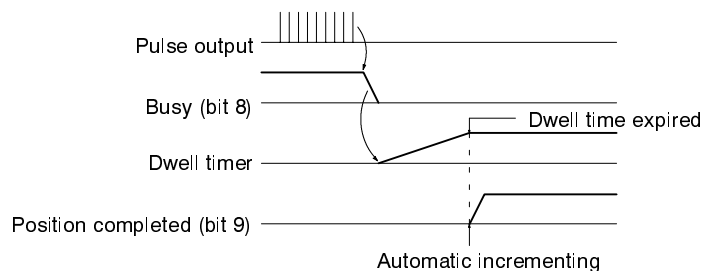
Note See program examples in *Section 7*.

Busy Flag (Bit 8)

The Busy flag (IR n+3, bit 8) remains ON during positioning operations and OFF while positioning is stopped.

Positioning Completed Flag (Bit 9)

Whereas the Busy flag indicates that positioning is in progress, the Positioning Completed flag (IR n+3, bit 9) indicates that positioning has been completed. It turns ON upon completion of not only positioning actions, but also ORIGIN SEARCH and ORIGIN RETURN. In addition, it turns ON when the RESET ORIGIN command bit is turned OFF and ON again. The relationship between the Positioning Completed flag and the Busy flag is shown in the diagram below.



- 1, 2, 3... 1. When pulse output is completed, the Busy flag turns OFF.
2. As the busy signal falls, the dwell timer is activated.
3. When the dwell time has expired, the address is automatically incremented.
4. After the address is incremented, the Positioning Completed flag turns ON.

Origin Flag (Bit 10) The Origin flag (IR n+3, bit 10) turns ON in the following cases when the motor shaft stops at the origin (but not when it merely passes the origin).

1. After execution of ORIGIN SEARCH.
2. After execution of SET ORIGIN.
3. After positioning to, and stopping at, the origin.
4. After execution of ORIGIN RETURN.

Bank End Flag (Bit 11) For an explanation of the functions of the Bank End flag (IR n+3, bit 11), refer to *Bank End* under *Section 4-9-4*.

CNC Error Flag (Bit 12) The CNC Error flag (IR n+3, bit 12) turns ON to inform the PC that a CNC error has been generated. For an explanation of CNC errors and error processing, refer to *Section 9*.

Interrupt Flag (Bit 13) The Interrupt flag (IR n+3, bit 13) turns ON to confirm reception of either an external or PC interrupt. The relationship between the external interrupt and the PC interrupt is a logical OR. In other words, the Interrupt flag turns ON while either of them is ON; it turns OFF when both of them are OFF.

External Setting Check Flag (Bit 13) The External Setting Check flag (IR n+3, bit 13) turns ON to confirm that the emergency stop, ready, CW limit, and CCW limit external inputs are all closed. The ready input is an NO (normally open) contact and must be ON to be closed. The other three are NC (normally closed) contacts and must be OFF to be closed. If any of these four external inputs is open, the External Setting Check flag remains OFF.

Hardware Error Flag (Bit 14) The Hardware Error flag (IR n+3, bit 15) turns ON when:

1. The voltage of the RAM backup battery drops.
2. An emergency stop input is detected. In this case the CNC Error flag (bit 12) also turns ON.

Note Use START, ORIGIN RETURN, RESET ORIGIN, PC Interrupt, and ORIGIN SEARCH (commands activated at their leading edge) with differentiation instructions. These commands must be processed sequentially (i.e., each command bit must be turned OFF before the next is turned ON). If two or three commands bits are ON at the same time, a communications error will be generated.

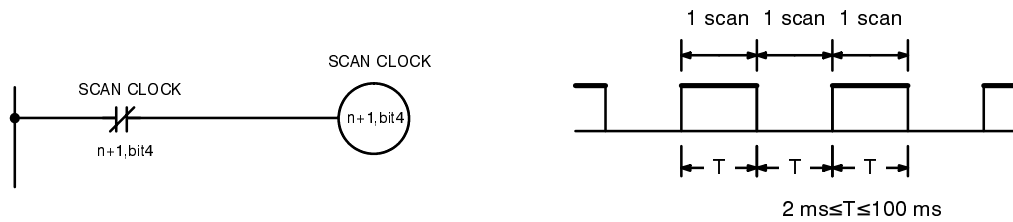
5-2 Preliminary PC Settings

In order to use the Position Control Unit, you must incorporate SCAN CLOCK (IR n+1, bit 4) and OPERATING MODE (IR n+1, bit 7) into the PC user program.

5-2-1 SCAN CLOCK

SCAN CLOCK (IR n+1, bit 4) establishes correct timing between the PC and the Position Control Unit in conjunction with the PC user program. You can use the following programming.

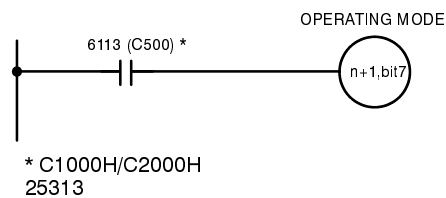
Ladder Diagram and Timing Chart



5-2-2 OPERATING MODE

The status of OPERATING MODE (IR n+1, bit 7) communicates the PC mode status (i.e., whether the PC is in RUN or MONITOR mode) to the Position Control Unit. You can use the following programming.

Ladder Diagram



Note OPERATING MODE provides an error clearing function similar to the REMOTE/LOCAL switch. The PC can clear the following inputs and errors by turning OPERATING MODE ON and then OFF again: emergency stop, CNC error, communication error, and battery voltage drop. The error clearing function, however, is only valid when the Position Control Unit is in REMOTE mode. Clearing OPERATING MODE does not automatically change REMOTE mode to LOCAL mode. It only clears the inputs or errors.

5-3 External Inputs

To facilitate operation of the Position Control Unit, there are four types of external input: external interrupt, ready, emergency stop, and externally input LOCAL. All four of them are valid regardless of whether the Position Control Unit mode is set to LOCAL or REMOTE.

The ready input is a NO (normally open) contact and must be ON to be closed. The other three are NC (normally closed) contacts and must be OFF to be closed. If any of these four external inputs is open, the External Setting Check flag (IR n+3, bit 13) remains OFF.

5-3-1 External Interrupt

External interrupts function in the same way as PC Interrupt (IR n+1, bit 13). For an explanation, refer to *PC Interrupt* under *Section 5-1-2*. Note that the Position Control Unit receives both PC Interrupt and the external interrupt. An interrupt occurs if either one turns ON; the interrupt can only be cleared when both are turned OFF.

5-3-2 Ready

The ready input interlocks motor operation. If this input is OFF (open), an attempt to operate the motor will result in a CNC error. If the ready input turns OFF during positioning, a CNC error is generated and pulse output stops.

5-3-3 Emergency Stop

You can use the external emergency stop input to stop pulse output at any time. You should do so only if there actually is an emergency, however, as it can throw the stepping motor out of step or result in damage to the system due to unabsorbed mechanical inertia.

5-3-4 Externally Input LOCAL

The externally input LOCAL provides convenient switching to LOCAL mode for Teaching Box operation or to enable error clearing .

The externally input LOCAL has a logical OR relationship with the Position Control Unit's LOCAL mode (set with the front panel switch). Therefore, in order for the Position Control Unit to operate in REMOTE mode, not only must the switch be set to REMOTE but the externally input LOCAL must be OFF as well.

The difference between the status of the flags in REMOTE and LOCAL modes, as seen from the PC, is as follows:

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|---|------------|
| n+2 | 0 to 15 | Data bus from PCU to PC | Current positioning action or current address | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF or ON | OFF |
| | 7 | Current Address | OFF or ON | OFF |
| | 8 | Busy | OFF | OFF |
| | 9 | Positioning Completed | ON | ON |
| | 10 | Origin | ON | ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF | OFF |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

SECTION 6

Establishing the Origin

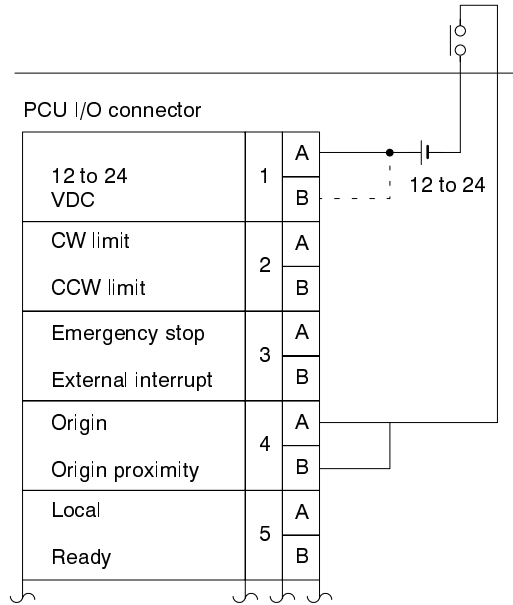
Before executing positioning actions, it is necessary to establish the origin as a reference point. You can do this with either of two commands: **ORIGIN SEARCH** or **RESET ORIGIN**. You can execute **ORIGIN SEARCH** in either mode, but you can only execute **RESET ORIGIN** in **REMOTE** mode. Once you have established the origin, you can use **ORIGIN RETURN** at any time to return to the origin from any other position. This section explains the methods for establishing and returning to the origin, and describes the origin input and origin proximity input which the Position Control Unit uses in carrying out these operations.

- 6-1 Origin and Origin Proximity Inputs 72
- 6-2 **ORIGIN SEARCH** 73
 - 6-2-1 Search Pattern 0 74
 - 6-2-2 Search Pattern 1 75
 - 6-2-3 Search Pattern 2 76
 - 6-2-4 Search Pattern 3 77
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 - 6-2-6 Search Pattern 5 79
 - 6-2-7 Flag Status after **ORIGIN SEARCH** 80
- 6-3 **RESET ORIGIN** 80
- 6-4 **ORIGIN RETURN** 80

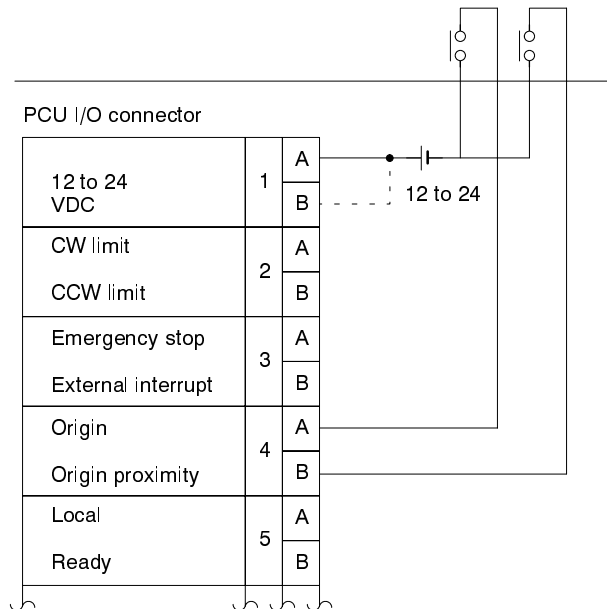
6-1 Origin and Origin Proximity Inputs

The following two diagrams show 1) the same sensor used for origin and origin proximity inputs, and 2) separate sensors used for the origin and origin proximity inputs. For these sensors, use non-chattering sensors such as proximity switches and photoelectric sensors.

One Sensor



Separate Sensors



6-2 ORIGIN SEARCH

You can use ORIGIN SEARCH to establish the absolute mechanical origin based on inputs from the origin and origin proximity signals. When ORIGIN SEARCH is executed by the program, in REMOTE mode, it starts when the program turns ON the command bit (IR n+1, bit 14). If you wish to establish the origin in LOCAL mode, you simply press the ORIGIN SEARCH key on the Teaching Box.

There are six possible search patterns, depending on your parameter setting. (For an explanation of the search pattern parameter setting, refer to *Section 4-7-11*.) As shown in the table below, the six patterns differ in terms of response to the origin and origin proximity signals. Note that when one sensor is used for both inputs, only search patterns 0 and 1 can be used.

| Pattern | Input conditions | | Search form origin | Remarks |
|---------|--------------------------------|---------------|---|---|
| | Origin proximity | Origin | | |
| 0 | Leading edge or level | Trailing edge | Origin input only. | Pattern used with 3G2A5-NC111-E |
| 1 | Leading edge or level | Trailing edge | Origin input after confirming origin proximity input. | For searches from within the proximity sensors, the search direction is reversed. |
| 2 | Leading edge or level | Leading edge | Origin input after confirming origin proximity input | _____ |
| 3 | Leading edge or level | Leading edge | Origin input after confirming origin proximity input | For searches from within the proximity sensors, the search direction is reversed. |
| 4 | Leading edge and trailing edge | Trailing edge | Origin input after confirming origin proximity input | _____ |
| 5 | Leading edge and trailing edge | Leading edge | Origin input after confirming origin proximity input | _____ |

6-2-1 Search Pattern 0

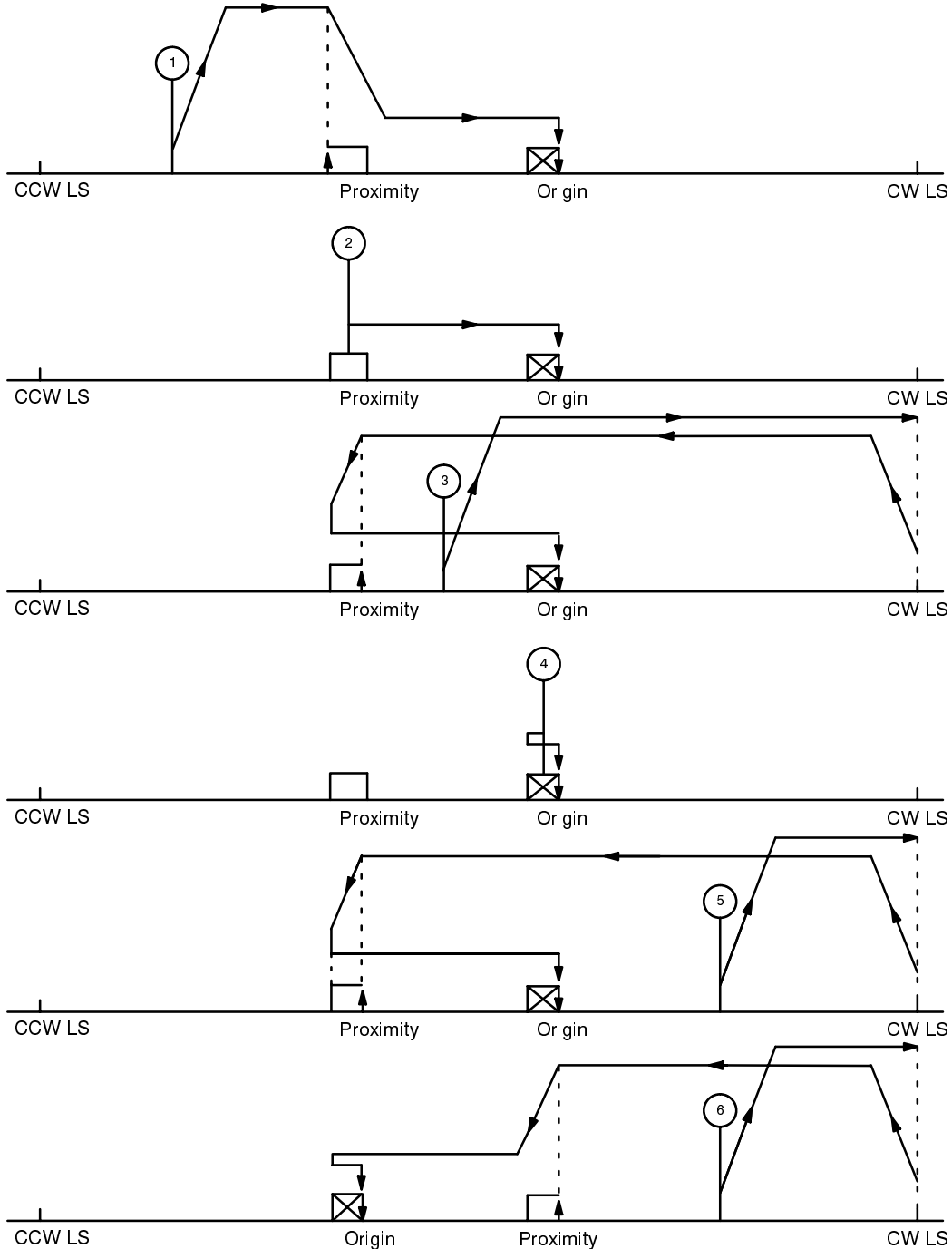
Origin proximity input: Leading edge or level

Origin input: Trailing edge

Search procedure:

The origin proximity input is not needed when searching commences at the origin.

The search patterns shown below differ according to their respective starting points.



6-2-2 Search Pattern 1

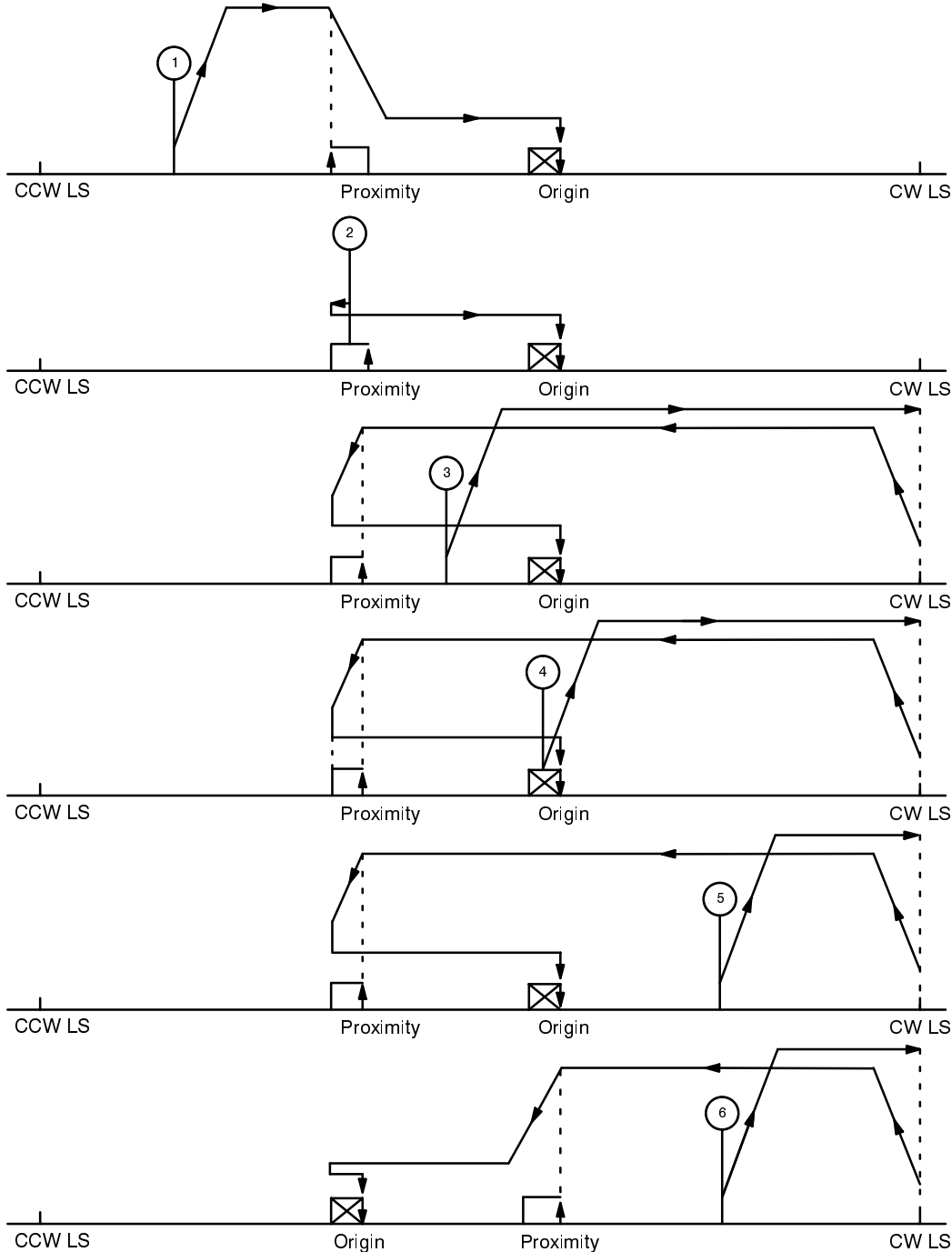
Origin proximity input: Leading edge or level

Origin input: Trailing edge

Search procedure:

After detecting the leading edge of the origin proximity input, searching ends on the trailing edge of the origin input. If the workpiece is already within the origin proximity sensor range, movement will be in the reverse direction. Note that, unlike search pattern 1, if ORIGIN SEARCH is started with the workpiece already at the origin, the search cannot be completed with the origin signal alone.

The search patterns shown below differ according to their respective starting points.



6-2-3 Search Pattern 2

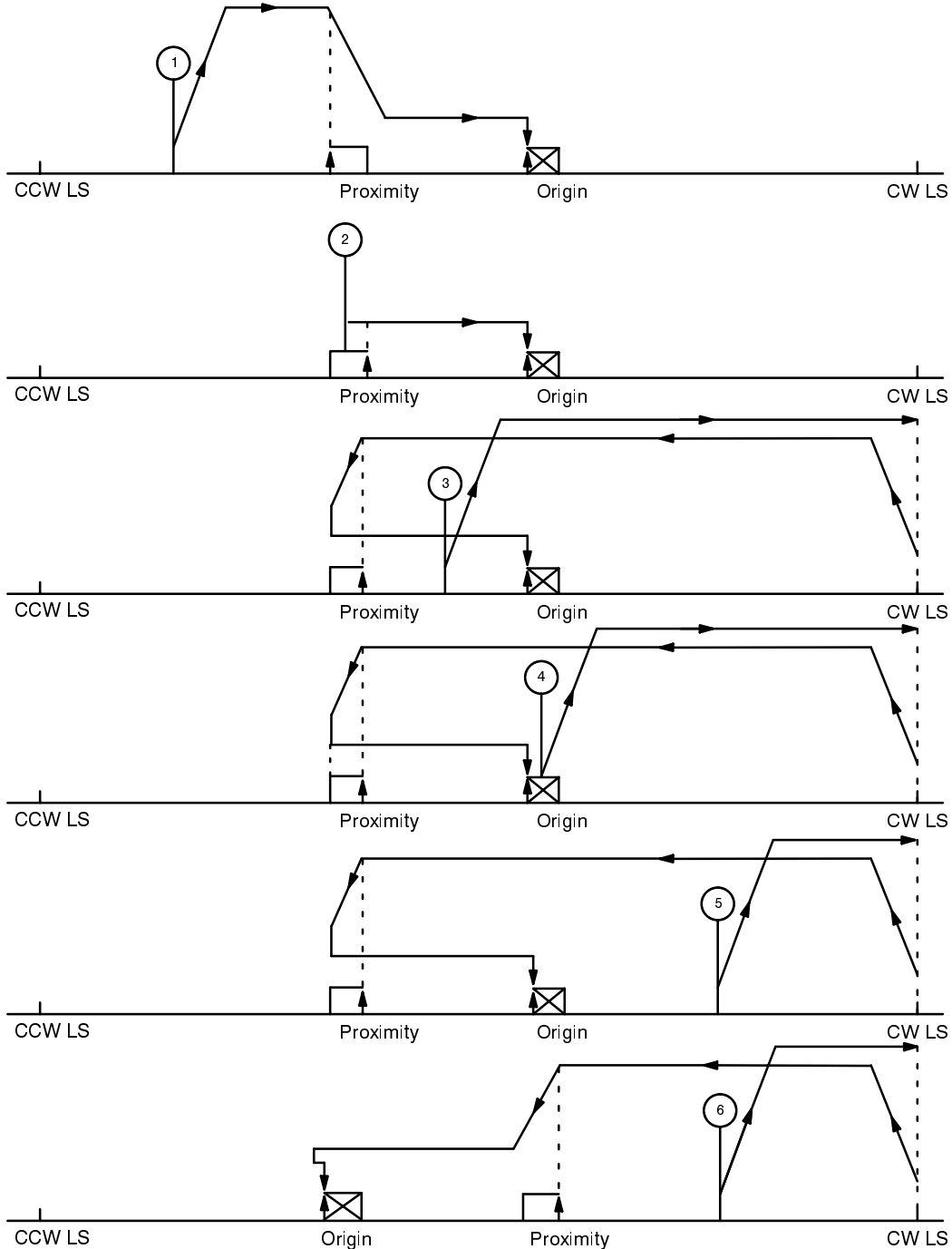
Origin proximity input: Leading edge or level

Origin input: Leading edge

Search procedure:

After detecting the leading edge of the origin proximity input, searching ends on the leading edge of the origin input.

The search patterns shown below differ according to their respective starting points.



6-2-4 Search Pattern 3

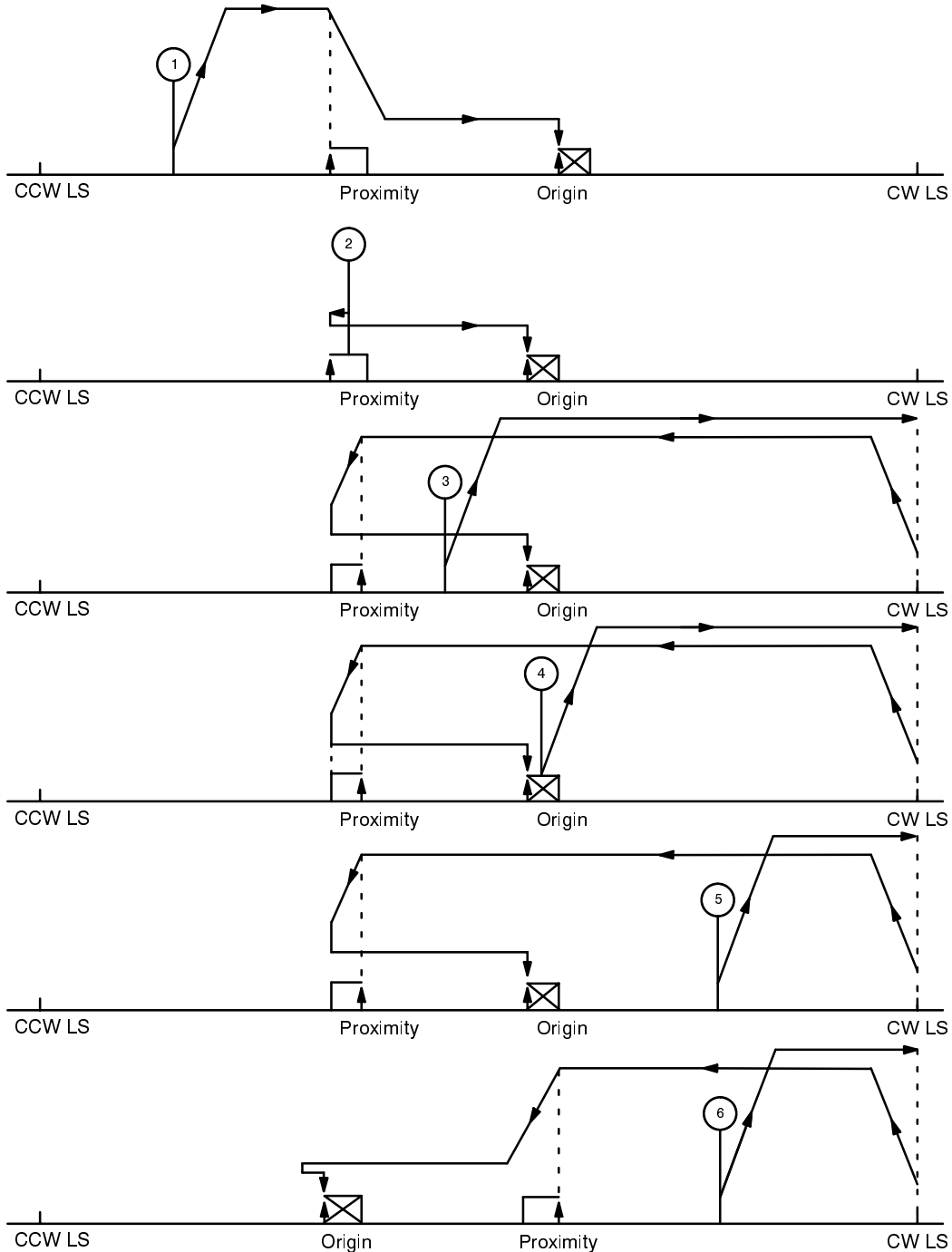
Origin proximity input: Leading edge or level

Origin input: Leading edge

Search procedure:

After detecting the leading edge of the origin proximity input, searching ends on the leading edge of the origin input. If the workpiece is already within the origin proximity sensor range, movement will be in the reverse direction.

The search patterns shown below differ according to their respective starting points.



6-2-5 Search Pattern 4

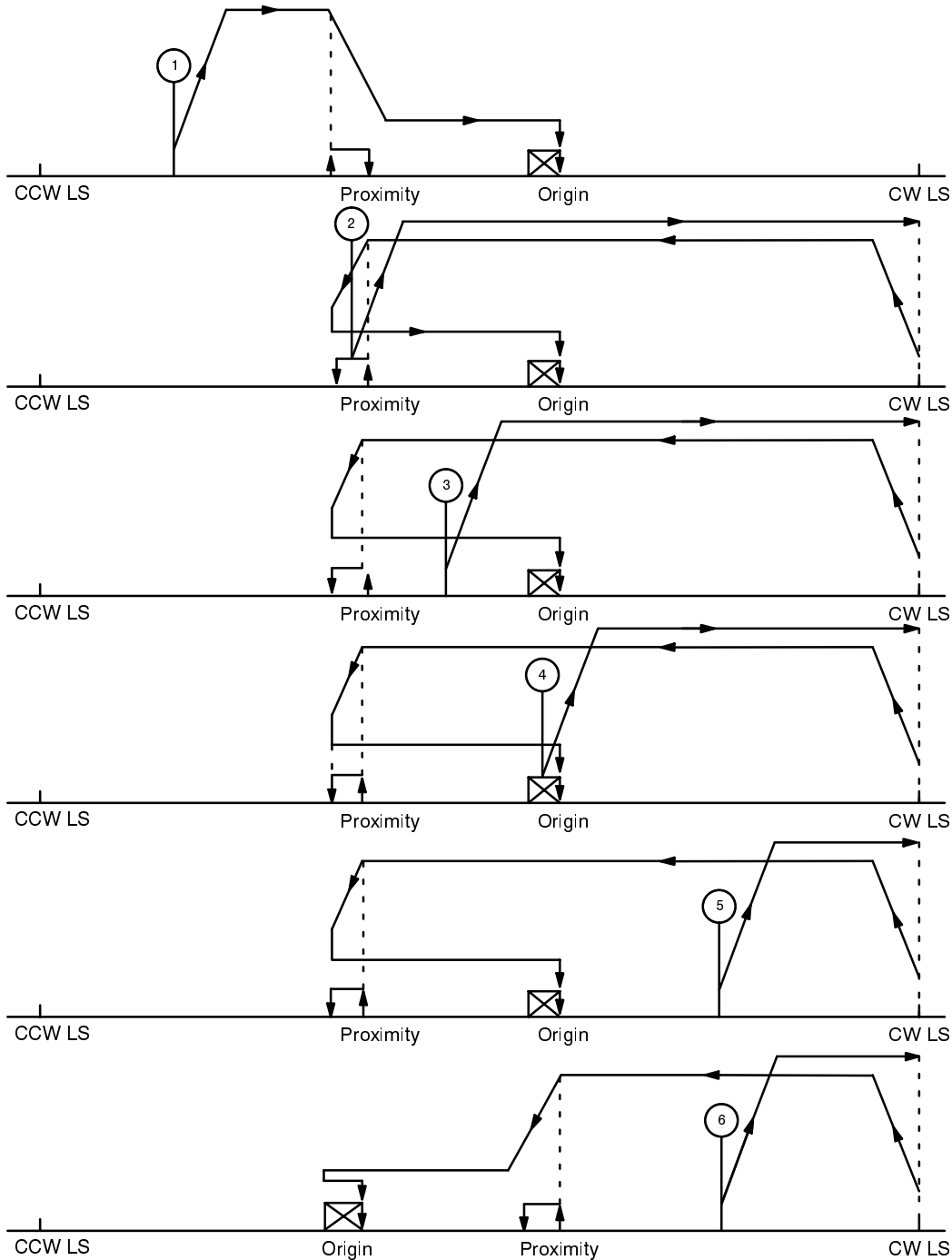
Origin proximity input: Leading edge and trailing edge

Origin input: Trailing edge

Search procedure:

Searching ends at the trailing edge of the first origin input after the proximity input is turned ON and OFF.

The search patterns shown below differ according to their respective starting points.



6-2-6 Search Pattern 5

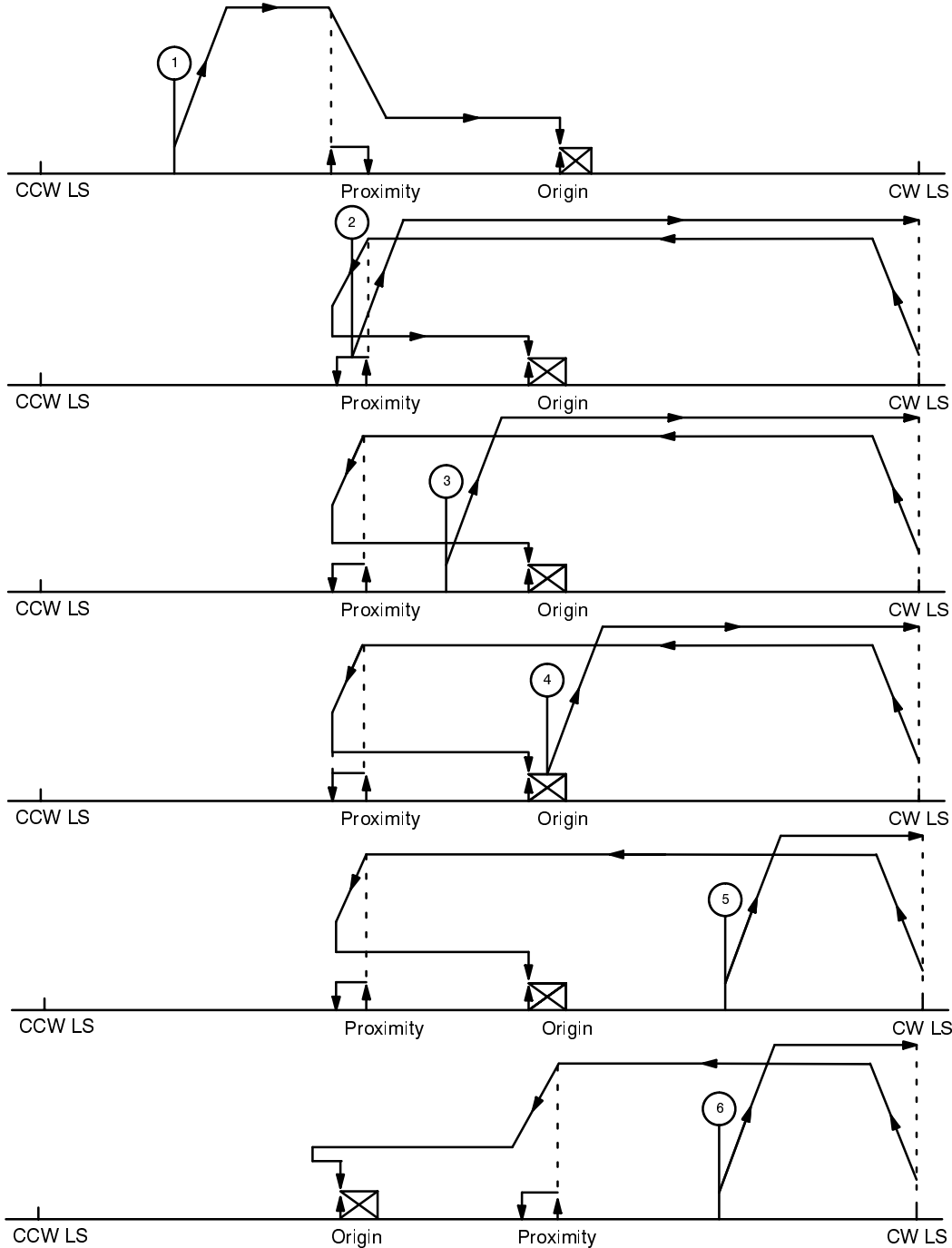
Origin proximity input: Leading edge and tailing edge

Origin input: Leading edge

Search procedure:

Searching ends at the leading edge of the first origin input after the proximity input is turned ON and OFF.

The search patterns shown below differ according to their respective starting points.



6-2-7 Flag Status after ORIGIN SEARCH

After ORIGIN SEARCH the IR area flags have the following status.
For an explanation of the Origin flag (IR n+3, bit 10), refer to *Origin Flag (Bit 10)* under *Section 5-1-4*.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|-----------------|------------|
| n+2 | 0-15 | Data bus from PCU to PC | Current address | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF or ON | OFF |
| | 7 | Current Address | OFF or ON | OFF |
| | 8 | Busy | OFF | OFF |
| | 9 | Positioning Completed | ON | ON |
| | 10 | Origin | ON | ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF | OFF |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

6-3 RESET ORIGIN

Another way to establish the origin is with RESET ORIGIN (IR n+1, bit 11). With ORIGIN SEARCH, the origin is established based on inputs from the origin proximity and origin signals. There may be times, however, when the positioning range is so small that it is physically impossible to employ origin proximity and origin inputs. In such cases you can still establish the origin by executing RESET ORIGIN.

With this command you can set the present position as the origin, and it will be stored in the Position Control Unit as the origin for subsequent positioning actions. It is also useful, therefore, when you want to move the origin for any reason.

SET ORIGIN is effective only when the motor is stopped. Note that it is activated on the leading edge of the command bit. After execution of this command, the flag status is the same as that shown in the table in *Section 6-2-7*.

6-4 ORIGIN RETURN

Once established the origin with either ORIGIN RETURN or ORIGIN SEARCH, you can use ORIGIN RETURN (IR n+1, bit 10) to return to the origin at any time. You can execute this command either by turning ON the command bit in the IR area or by pressing the ORIGIN RETURN key at the Teaching Box. The positioning system returns to position 00000 at ORIGIN RETURN speed.

Interrupts and PAUSE are valid during ORIGIN RETURN.

After execution of this command, the flag status is the same as that shown in the table in *Section 6-2-7*.

SECTION 7

Communications Programming Examples

The previous sections have explained the basic operation of the Position Control Unit, the data configuration, and communication between the Position Control Unit and the PC. This section provides programming examples for actual communication operations. Program examples in this section are written for the C500.

| | | |
|-----|---|----|
| 7-1 | Transferring Data from the PC | 82 |
| 7-2 | Using READ DATA | 84 |
| 7-3 | Transferring Data to the PC | 85 |
| 7-4 | Using SET ADDRESS | 87 |
| 7-5 | Storing the Current Address | 88 |
| 7-6 | Transferring the Current Positioning Action | 89 |

7-1 Transferring Data from the PC

You can use the example program given here to transfer data from the PC to the Position Control Unit. This program transfers data stored in DM 001 to DM 030. It uses IR 15 and IR 30 as work areas. In actual programming, however, you can use other words as work areas.

This example assumes that the Position Control Unit is allocated IR 00 to IR 03, which means that IR n is IR 00, IR n+1 is IR 01, etc.

DM Area Allocation

Parameters, speeds, and positioning actions consist of three words each, so ten of them can be stored in DM 001 to DM 030. DM 000 is a counter register used to hold an indirect address, and DM 100 is the 3-word discrimination register. From DM 001 to DM 030, data is consecutively set in 3-word blocks consisting of the address, Data 1, and Data 2. (For an explanation of data configuration, see *Section 4*.)

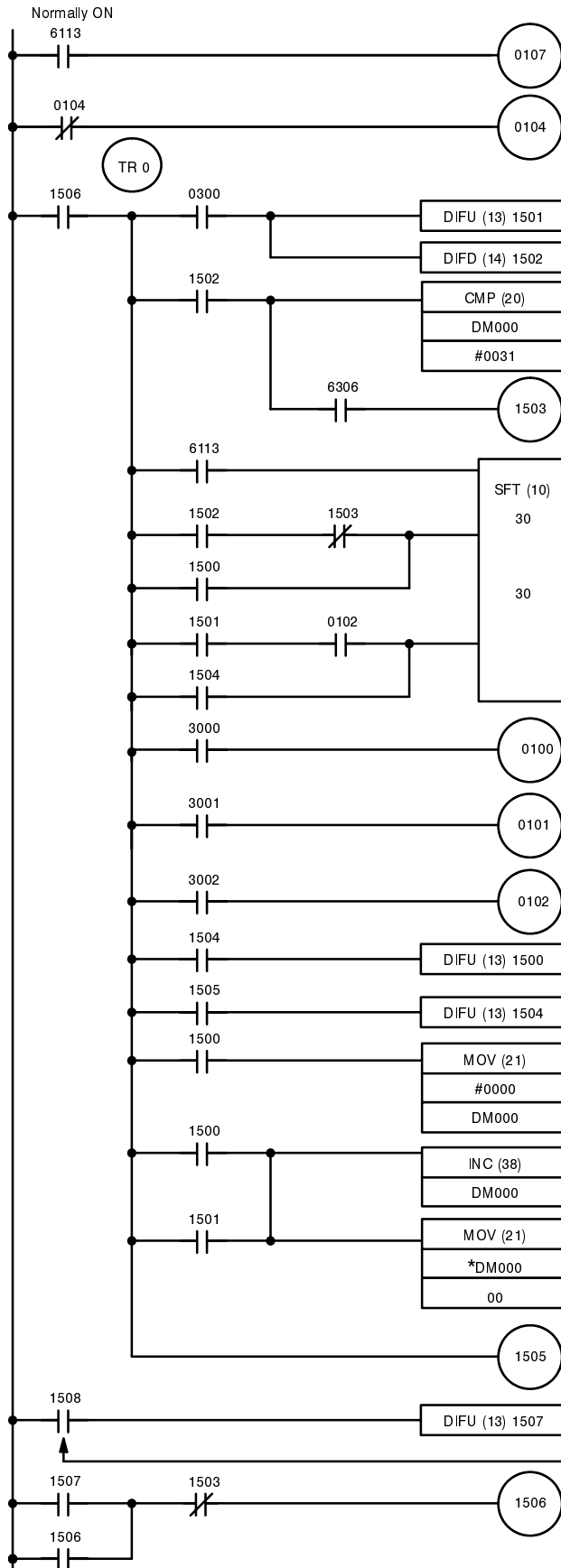
Flag Status during Transfer

The status of the IR area flags during transfer of data from the PC to the Position Control Unit is as shown in the table below.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|-------------|------------|
| n+2 | 0 to 15 | Data bus form PCU to PC | User data | "0000" |
| n+3 | 0 | ACK | OFF or ON | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF or ON | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF | OFF |
| | 7 | Current Address | OFF | OFF |
| | 8 | Busy | OFF | OFF |
| | 9 | Positioning Completed | *OFF or ON | *OFF or ON |
| | 10 | Origin | OFF or ON | OFF or ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF | OFF |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

*Bit 9 is OFF until the origin is established.

Transfer Program (for C500)



OPERATING MODE

SCAN CLOCK

Leading edge of ACK flag detected.

Trailing edge of ACK flag detected.

Counter data checked for last data.
Last operand is one greater than number of transfers.
Transfer completed signal

Used to control WRITE ADDRESS, WRITE DATA 1, and WRITE DATA 2.

WRITE ADDRESS

WRITE DATA 1

WRITE DATA 2

Internal start

Resets shift register.

Counter register initial clear

Counter register increment

Output contents of data memory sent via indirect address in counter register to data bus.

Program execution starts when this bit turns ON.

Interlock clear.

7-2 Using READ DATA

The example program given here shows how to use READ DATA. This program causes the PC to read Data 1 and Data 2 for the address in DM 050 into DM 051 and DM 052 respectively. In this example IR 25 is used as a work area, but in actual programming other words may be used.

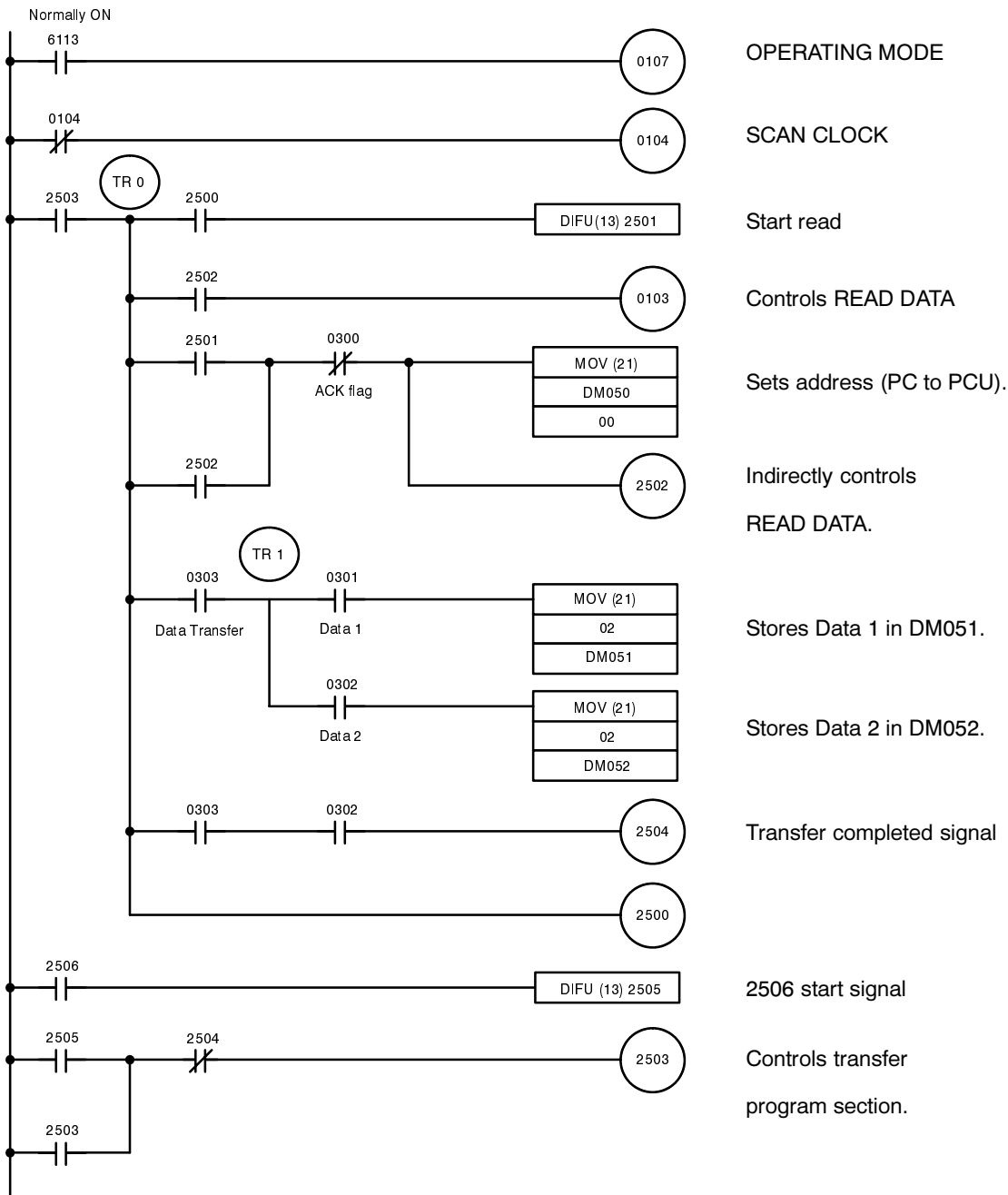
This example assumes that the Position Control Unit is allocated IR 00 to IR 03, which means that IR n is IR 00, IR n+1 is IR 01, etc.

Flag Status during Transfer The status of the IR area flags during transfer of data from the PC to the Position Control Unit is as shown in the table below.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|-------------|------------|
| n+2 | 0 to 15 | Data bus form PCU to PC | User data | "0000" |
| n+3 | 0 | ACK | OFF or ON | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF or ON | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF | OFF |
| | 7 | Current Address | OFF | OFF |
| | 8 | Busy | OFF | OFF |
| | 9 | Positioning Completed | *OFF or ON | *OFF or ON |
| | 10 | Origin | OFF or ON | OFF or ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF | OFF |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

*Bit 9 is OFF until the origin is established.

Transfer Program (for C500)



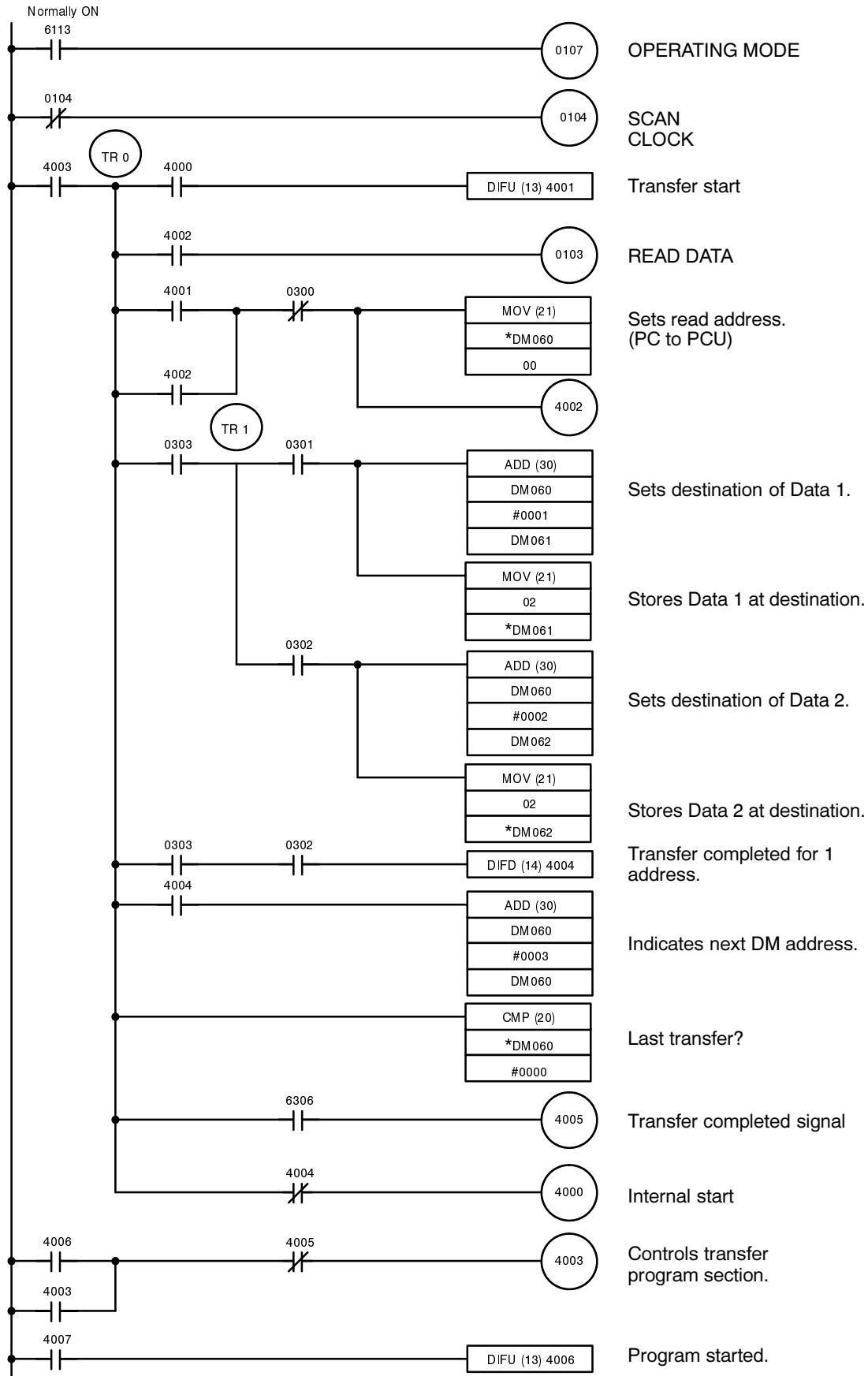
7-3 Transferring Data to the PC

By modifying the READ DATA program (see the example in *Section 7-2*), you can transfer data from the Position Control Unit to the PC. Using DM 60 to DM 62 as a work area, you can transfer data to any part of the DM area (DM m through DM m+5 in this example). In this example, IR 40 is also used as a work area.

This example assumes that the Position Control Unit is allocated IR 00 to IR 03, which means that IR n is IR 00, IR n+1 is IR 01, etc.

Flag Status during Transfer The status of the IR area flags during transfer of data from the Position Control Unit to the PC is the same as that shown in the table under *Section 7-2*.

Transfer Program (for C500)



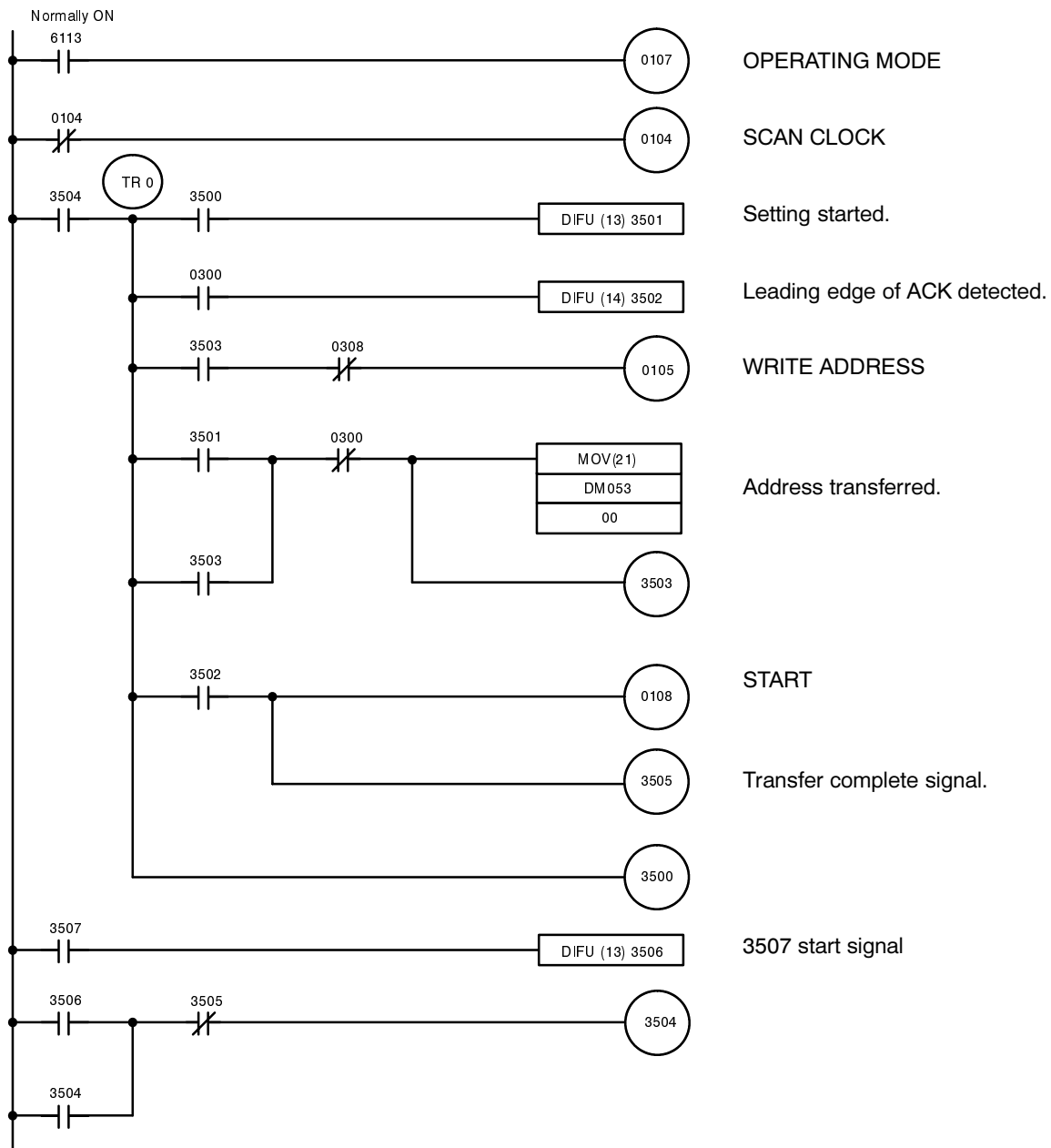
7-4 Using SET ADDRESS

The example program given here shows how to use SET ADDRESS. Using this program you can set the address for any positioning action. (The example sets the address stored in DM 53.) Then, when START is next executed, the Position Control Unit will begin positioning from this address.

In this example, IR 35 is used as a work area. The example assumes that the Position Control Unit is allocated IR 00 to IR 03, which means that IR n is IR 00, IR n+1 is IR 01, etc.

Flag Status during Transfer The status of the IR area flags during SET ADDRESS is the same as that shown in the table under Section 7-1, except that the Data Transfer flag is OFF in either REMOTE or LOCAL mode.

Transfer Program (for C500)



7-5 Storing the Current Address

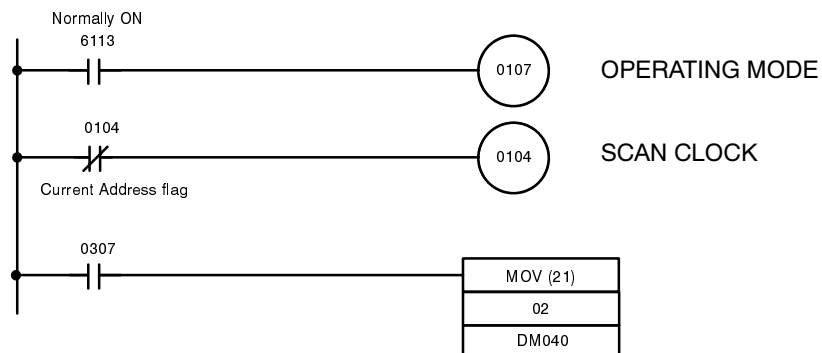
The example program given here shows how store the current address, which is constantly being output by the Position Control Unit, in the DM area. In the example, the address is stored in DM 40.

Flag Status during Transfer The status of the IR area flags during transfer of data from the PC to the Position Control Unit is as shown in the table below.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|-----------------|------------|
| n+2 | 0 to 15 | Data bus form PCU to PC | Current address | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | OFF | OFF |
| | 2 | Data 2 | OFF | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF | OFF |
| | 7 | Current Address | OFF or ON | OFF |
| | 8 | Busy | OFF or ON | OFF or ON |
| | 9 | Positioning Completed | *OFF or ON | *OFF or ON |
| | 10 | Origin | OFF or ON | OFF or ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF or ON | OFF or ON |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

*Bit 9 is OFF until the origin is established.

Transfer Program (for C500)



7-6 Transferring the Current Positioning Action

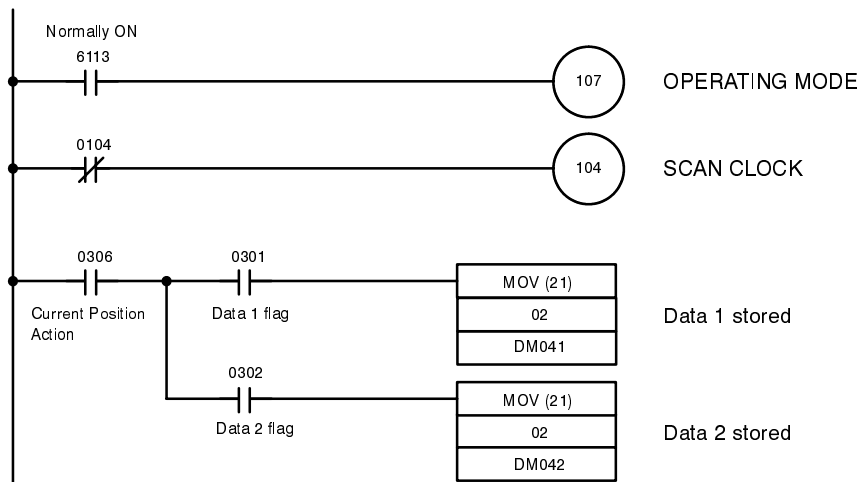
The example program given here shows how store the current positioning action, which is constantly being output by the Position Control Unit, in the DM area. In the example, Data 1 is stored in DM 041 and Data 2 is stored in DM 042.

Flag Status during Transfer The status of the IR area flags during transfer of data from the PC to the Position Control Unit is as shown in the table below.

| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|------------------|------------|
| n+2 | 0-15 | Data bus form PCU to PC | Current position | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | OFF |
| | 6 | Current Positioning Action | OFF or ON | OFF |
| | 7 | Current Address | OFF | OFF |
| | 8 | Busy | OFF | OFF |
| | 9 | Positioning Completed | *OFF or ON | *OFF or ON |
| | 10 | Origin | OFF or ON | OFF or ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF or ON | OFF |
| | 14 | External Setting Check | ON | ON |
| 15 | Hardware Error | OFF | OFF | |

*Bit 9 is OFF until the origin is established.

Transfer Program (for C500)



SECTION 8

Application Examples

The preceding section, Section 7, provided some programming examples for communicating between the Position Control Unit and the PC. Now this section provides application examples which illustrate the basic procedure for connecting and operating the Position Control Unit. The examples use a stepping motor with the following specifications: 3.6 VDC, 6.1 A/phase, 1.8 deg/step. Programming for the C500 is shown.

| | | |
|-------|--------------------------------------|-----|
| 8-1 | Operating Procedure | 92 |
| 8-2 | External Connections | 93 |
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| 8-6 | Additional PC Program Examples | 104 |
| 8-6-1 | Example 1 | 104 |
| 8-6-2 | Example 2 | 107 |

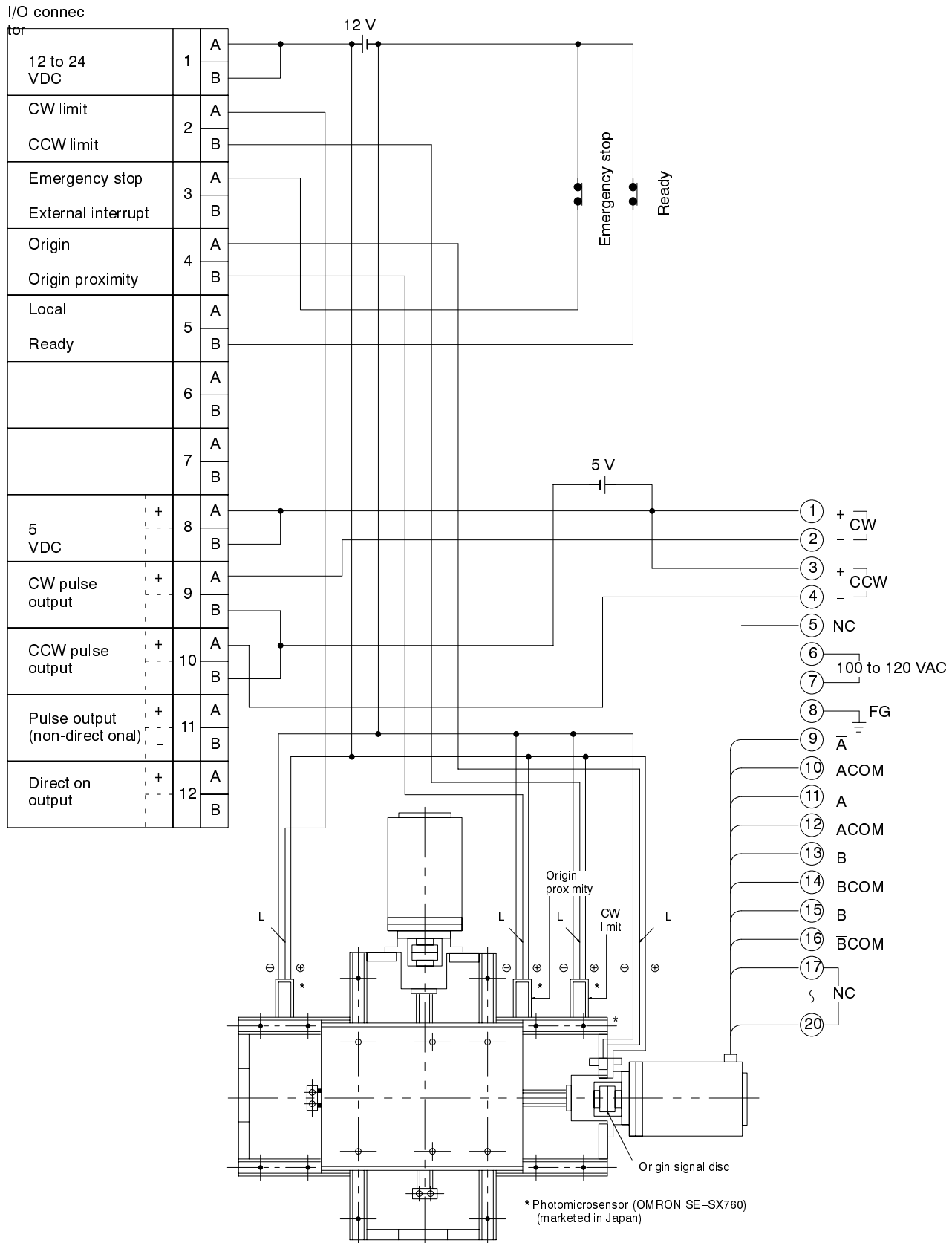
8-1 Operating Procedure

Follow the steps listed below for preparing and using the Position Control Unit:

- 1, 2, 3...** 1. Select the motor and motor driver.
2. Connect the Position Control Unit, motor, and motor driver.
3. Program the internal settings.
4. Set all required parameters and data.
5. Test the system.
6. Run the system.

8-2 External Connections

The diagram below shows the wiring between the Position Control Unit and the motor driver.

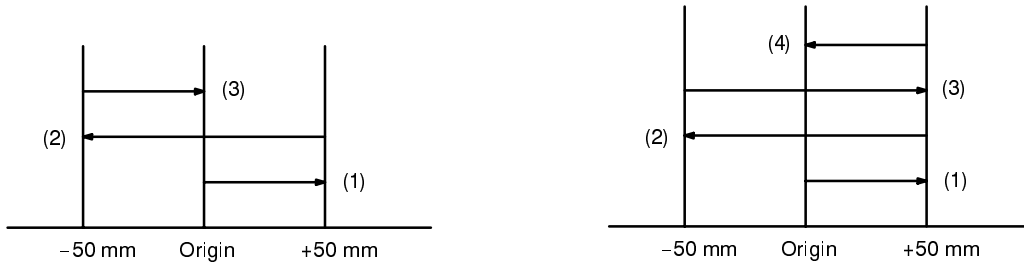


8-3 Internal Settings

The program to control the stepping motor will execute the following operations:

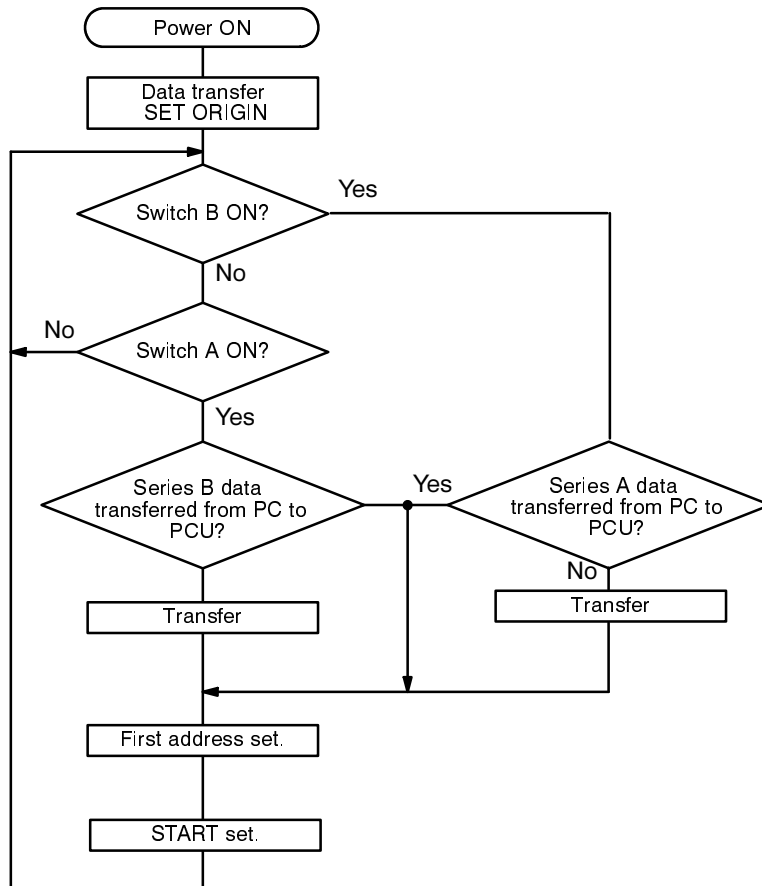
- Transfer the parameters and speeds stored in the DM area of the PC to the Position Control Unit when power turns on.
- Set as the origin the position of the motor shaft when powered up (RESET ORIGIN).
- Transfer a series of positioning actions to the Position Control Unit when either of the external switches A and B is turned ON. The Position Control Unit uses these positioning actions to control positioning until the switch is turned OFF.

The following charts illustrate the two series of positioning actions transferred to the Position Control Unit.



Flowchart

Execution of this program follows the flowchart below:



Inputting the Program

When the necessary wiring has been completed, the program must be written into PC memory via the Programming Console. First mount the Position Control Unit to the CPU Rack. This example assumes that the Position Control Unit is mounted to a slot of the CPU Rack that will be allocated IR 05 to IR 08.

Next, turn on power to the PC. The POWER LED on the PC will light and the operating mode of the PC will be displayed on the Programming Console, enclosed in <>.

```
<PROGRAM>  
PASSWORD
```

To enable operation of the Programming Console, press the **CLR**, **MONTR**, and **CLR** keys.

```
<MONITOR>  
0000
```

The messages MEMORY ERR and I/O VERIFY ERR may be displayed after the first and second times that **CLR** is pressed. If this happens, you need to identify and correct the error.

Reading the Error

To read the error, press **CLR**, **FUN**, **MONTR**, and **CLR** keys. The following displays will appear.

```
0000
```

```
FUN(??)
```

```
MEMORY ERR
```

```
I/O VER ERR
```

Clearing a Memory Error

To clear MEMORY ERR, press the following keys:

| | |
|--------------|----------------------------------|
| CLR | 0000 |
| PLAY SET | 0000 |
| NOT | 0000 |
| REC RESET | 0000 MEMORY CLR? HR CNT DM |
| MONTR | 0000 MEMORY CLR END HR CNT DM |

Clearing a No END(01) Instruction Error

To clear NO END INSTR, press the following keys:

| | |
|--------|-----------------|
| CLR | 0000 |
| FUN | 0000 FUN(??) |
| A 0 | 0000 FUN(0?) |
| B 1 | 0000 END(01) |
| WRITE | 0001 NOP(??) |

Clearing an I/O Verification Error

To clear I/O VERIFY ERR, press the following keys:

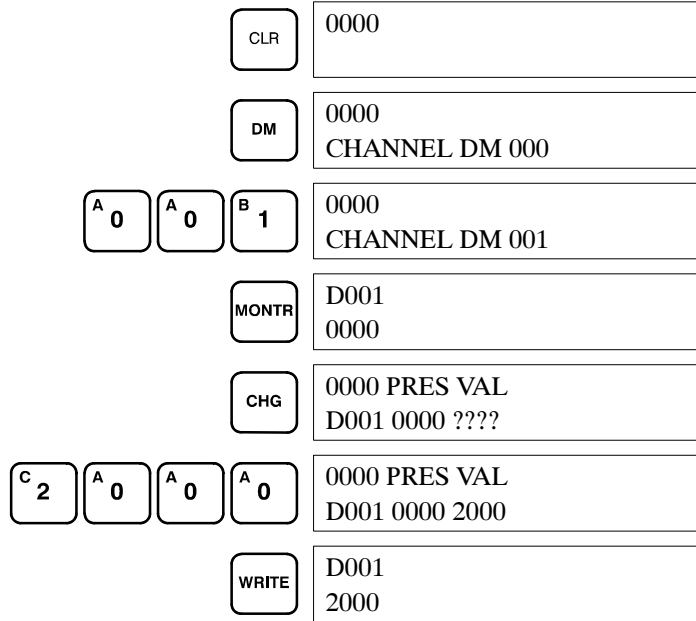
| | | | | |
|-------|-------------------------|---------------------|-----|-------------------------|
| CLR | 0000 | | | |
| FUN | 0000 FUN(??) | | | |
| SHIFT | CH * | 0000I/OTBL ?~?U= | | |
| CHG | 0000I/OTBLWRITE ???? | | | |
| 9 | 7 | B 1 | D 3 | 0000I/OTBLWRITE 9713 |
| WRITE | 0000I/OTBLWRITE OK | | | |

Writing Data

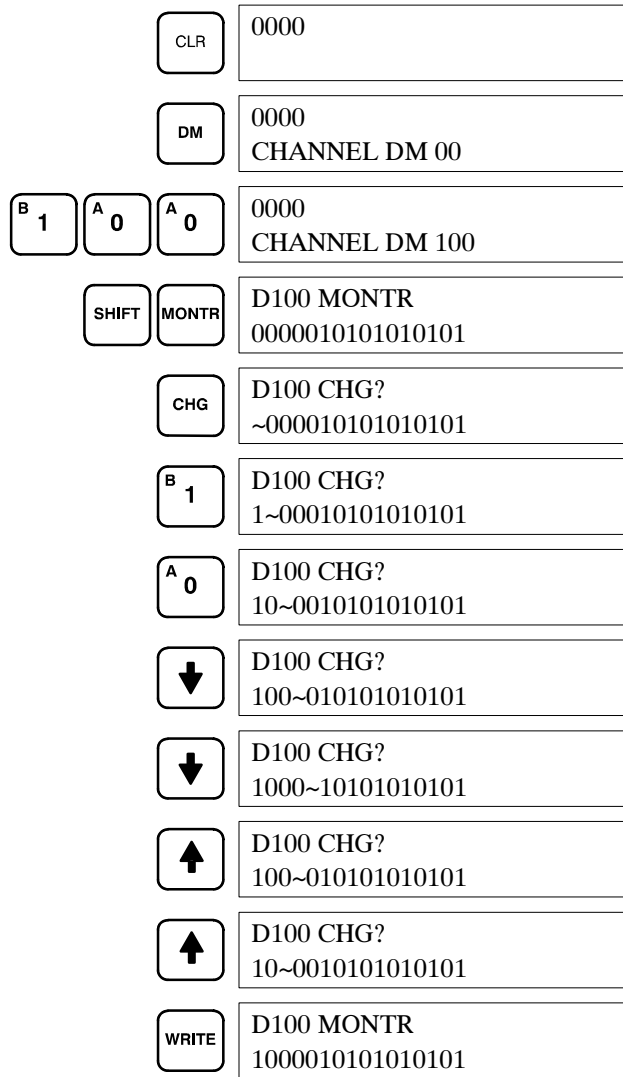
Once any errors have been cleared, the next step is to enter the parameters, speeds, and positioning actions into the DM area of the PC. (The tables on the following pages show the data to be entered for this example.) The DM area must be cleared before writing the data into it.

Decimal Input

The key sequence shown below is an example of how to write data into DM 001.



The following key sequence is an example of writing data as binary input.



DM Area Allocations

| Word | Data | Remarks |
|------|------|--|
| 000 | 0000 | Data register cleared (indirect address cleared) |
| 001 | 2000 | Unit address |
| 002 | 0000 | Unit: mm |
| 003 | 0001 | |
| 004 | 2001 | Pulse rate address |
| 005 | 0010 | 0.1 mm/pulse |
| 006 | 0000 | |
| 007 | 2002 | CW limit address |
| 008 | 9999 | 999999 pulses |
| 009 | 9900 | |
| 010 | 2003 | CCW limit address |
| 011 | 9999 | 999999 pulses |
| 012 | 9900 | |

| Word | Data | Remarks |
|------|------|--|
| 013 | 2004 | Backlash compensation address |
| 014 | 0000 | Backlash= 0 |
| 015 | 0000 | |
| 016 | 2005 | Maximum speed address |
| 017 | 0100 | Maximum speed (1,000 pulse/s) |
| 018 | 0000 | |
| 019 | 2006 | Initial speed address |
| 020 | 0000 | Initial speed (32 pulses/s) |
| 021 | 3200 | |
| 022 | 2007 | Acceleration/deceleration time address |
| 023 | 0000 | Acceleration/deceleration time (0.1 s) |
| 024 | 1000 | |
| 025 | 2008 | Address for constant-speed feeding |
| 026 | 0002 | Constant-speed feeding (255 pulses) |
| 027 | 5500 | |
| 028 | 2009 | Dwell time address |
| 029 | 0001 | Dwell time (1 s) |
| 030 | 0000 | |
| 031 | 2010 | ORIGIN SEARCH pattern and direction |
| 032 | 0000 | Search pattern (1), CCW |
| 033 | 0011 | |
| 034 | 2011 | Origin compensation address |
| 035 | 0000 | Origin compensation (0) |
| 036 | 0000 | |
| 037 | 4000 | Speed #0 address (ORIGIN RETURN speed) |
| 038 | 0050 | Speed #0 (5,000 pulses/s) |
| 039 | 0000 | |
| 040 | 4001 | Speed #1 address (ORIGIN SEARCH speed) |
| 041 | 0010 | Speed #1 (1,000 pulses/s) |
| 042 | 0000 | |
| 043 | 4002 | Speed #2 address (manual low speed) |
| 044 | 0015 | Speed #2 (1,500 pulses/s) |
| 045 | 0000 | |
| 046 | 4003 | Speed #3 address |
| 047 | 0020 | Speed #3 (2,000 pulses/s) |
| 048 | 0000 | |
| 049 | 4004 | Speed #4 address |

| Word | Data | Remarks |
|------|------|-------------------------------|
| 050 | 0025 | |
| 051 | 0000 | Speed #4 (2,500 pulses/s) |
| 052 | 4005 | Speed #5 address |
| 053 | 0000 | |
| 054 | 3200 | Speed #5 (32 pulse/s) |
| 055 | 4006 | Speed #6 address |
| 056 | 0000 | |
| 057 | 3200 | Speed #6 (32 pulses/s) |
| 058 | 4007 | Speed #7 address |
| 059 | 0000 | |
| 060 | 3200 | Speed #7 (32 pulses/s) |
| 061 | 4008 | Speed #8 address |
| 062 | 0000 | |
| 063 | 3200 | Speed #8 (32 pulses/s) |
| 064 | 4009 | Speed #9 address |
| 065 | 0000 | |
| 066 | 3200 | Speed #9 (32 pulses/s) |
| 067 | 0000 | |
| 068 | 1000 | Positioning action address |
| 069 | 0005 | |
| 070 | 0032 | Origin + 500 pulses, Speed #3 |
| 071 | 1001 | Positioning action address |
| 072 | 0010 | |
| 073 | 0033 | (1) – 1000 pulses, Speed #3 |
| 074 | 1002 | Positioning action address |
| 075 | 0005 | |
| 076 | 003A | (2) + 500 pulses, Speed #3 |
| 077 | 0000 | — |
| 078 | 0000 | — |
| 079 | 0000 | — |
| 080 | 0000 | — |
| 081 | 1000 | Positioning action address |
| 082 | 0005 | |
| 083 | 0042 | Origin + 500 pulses, Speed #4 |
| 084 | 1001 | Positioning action address |
| 085 | 0010 | |
| 086 | 0043 | (1) – 1,000 pulses, Speed #4 |
| 087 | 1002 | Positioning action address |
| 088 | 0010 | |
| 089 | 0042 | (2) + 1,000 pulses, Speed #4 |
| 090 | 1003 | Positioning action address |
| 091 | 0005 | |
| 092 | 004B | (3) – 500 pulses, Speed #4 |

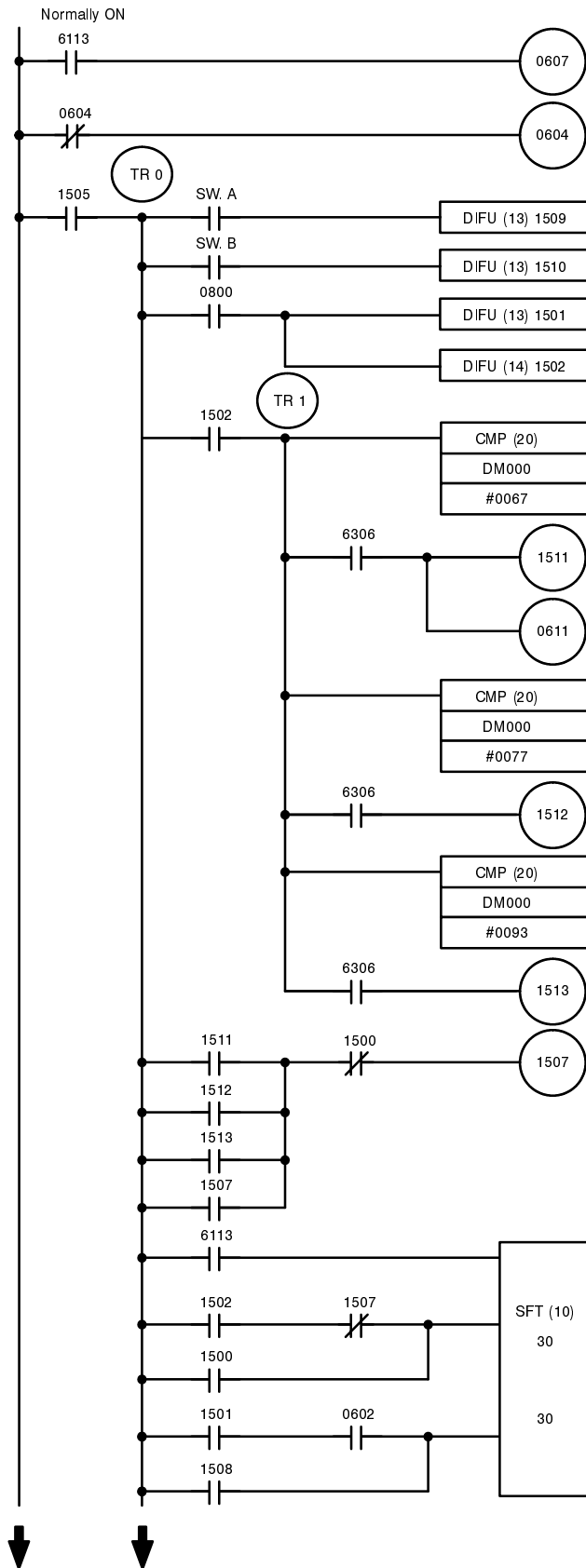
IR Area Work Bit Allocations

| Bit | IR 15 | IR 16 | IR 30 |
|-----|----------------------------------|--------------------------|------------------------|
| 0 | Transfer start (handshake) | SET ADDRESS IL | Input to WRITE ADDRESS |
| 1 | ACK rise | SET ADDRESS begin | Input to WRITE DATA 1 |
| 2 | ACK fall | SET ADDRESS differential | Input to WRITE DATA 2 |
| 3 | Program start | SET ADDRESS auxiliary | |
| 4 | Program stop | SET ADDRESS completed | |
| 5 | IL | SET ADDRESS completed | |
| 6 | Transfer start | --- | |
| 7 | Transfer end | | |
| 8 | Internal | | |
| 9 | SW A rise | | |
| 10 | SW B rise | | |
| 11 | Parameter and speed transfer end | | |
| 12 | Data transfer end when SW-A ON | | |
| 13 | Data transfer end when SW-B ON | | |

8-4 Program

Once you have completed the preparations described on the last few pages, write the following program to PC memory via the Programming Console. The PC must be in PROGRAM mode when writing a program. When this program is executed, the data stored in the DM area is sequentially transferred from the PC to the Position Control Unit.

Example for C500



OPERATING MODE

SCAN CLOCK

SW. A input to activate 1st series of positioning actions

SW. B input to activate 2nd series of positioning actions

Leading edge and trailing edge of ACK detected.

Parameters and speed transfer completed.

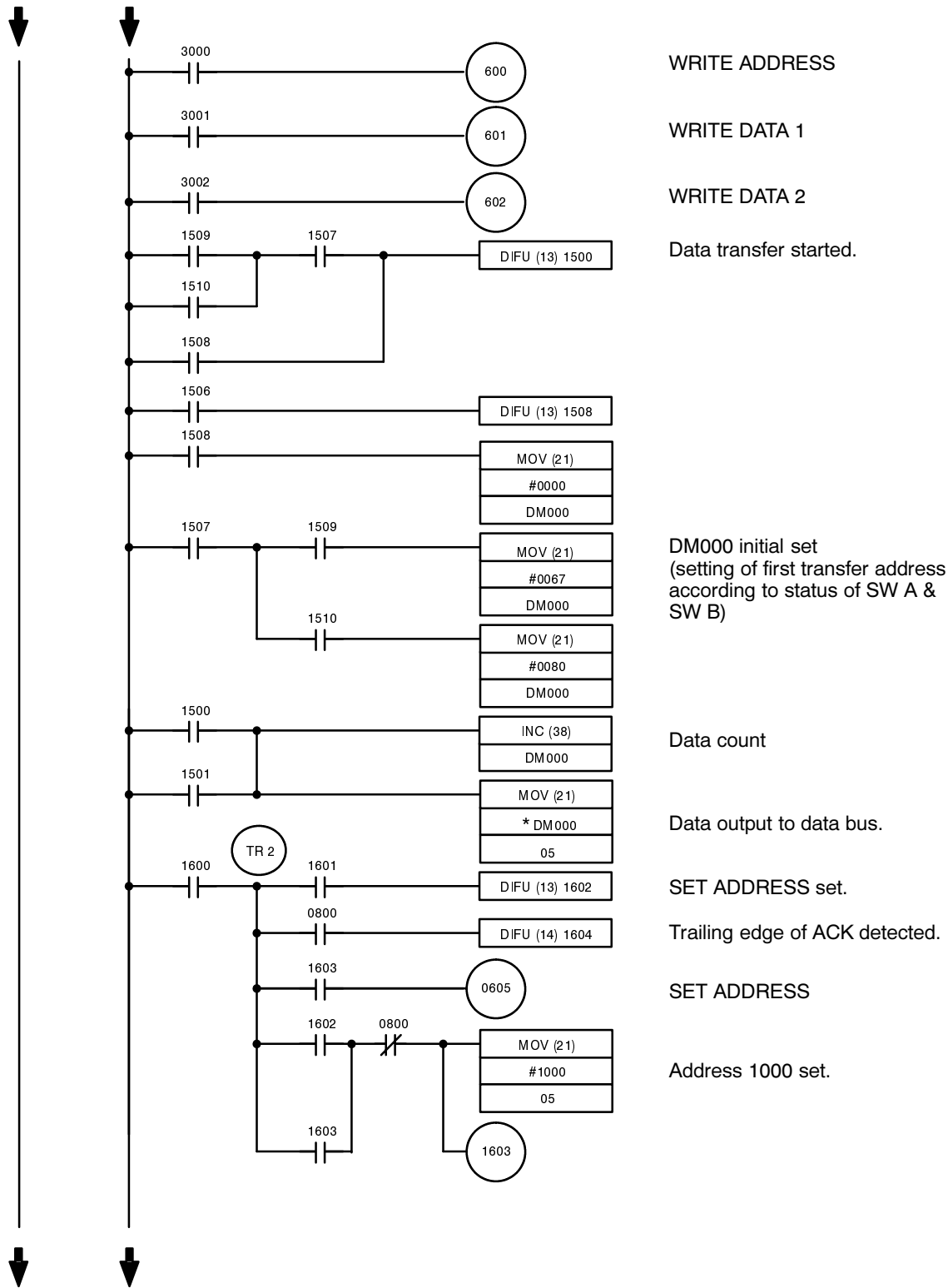
SET ORIGIN

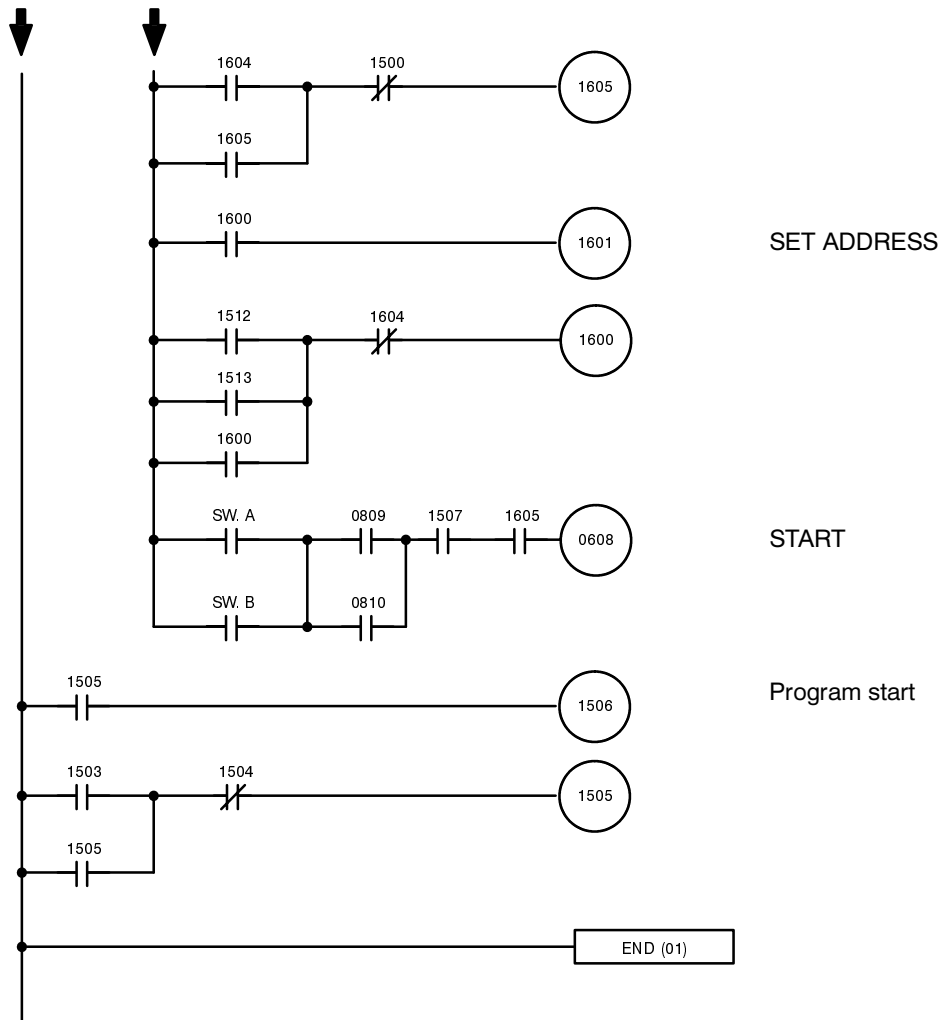
Data transfer of SW A completed.

Data transfer of SW B completed.

Data transfer completed status held.

Controls WRITE ADDRESS, WRITE DATA 1, and WRITE DATA 2.





8-5 Setting PC to RUN

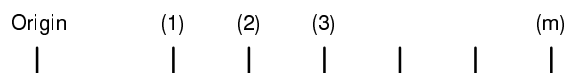
The Position Control Unit must be in REMOTE mode when it is being controlled by the PC. It is always good practice after programming to check that it is in REMOTE mode. Then set the PC to either MONITOR or RUN mode with the mode selector on the Programming Console. The RUN LED on the Position Control Unit should light. Check the operation of the A and B command inputs.

8-6 Additional PC Program Examples

This section introduces other PC programming examples for the Position Control Unit in order to describe slightly more complicated programming principles. In all of these examples, it is assumed that the Position Control Unit has been allocated IR 00 to IR 03.

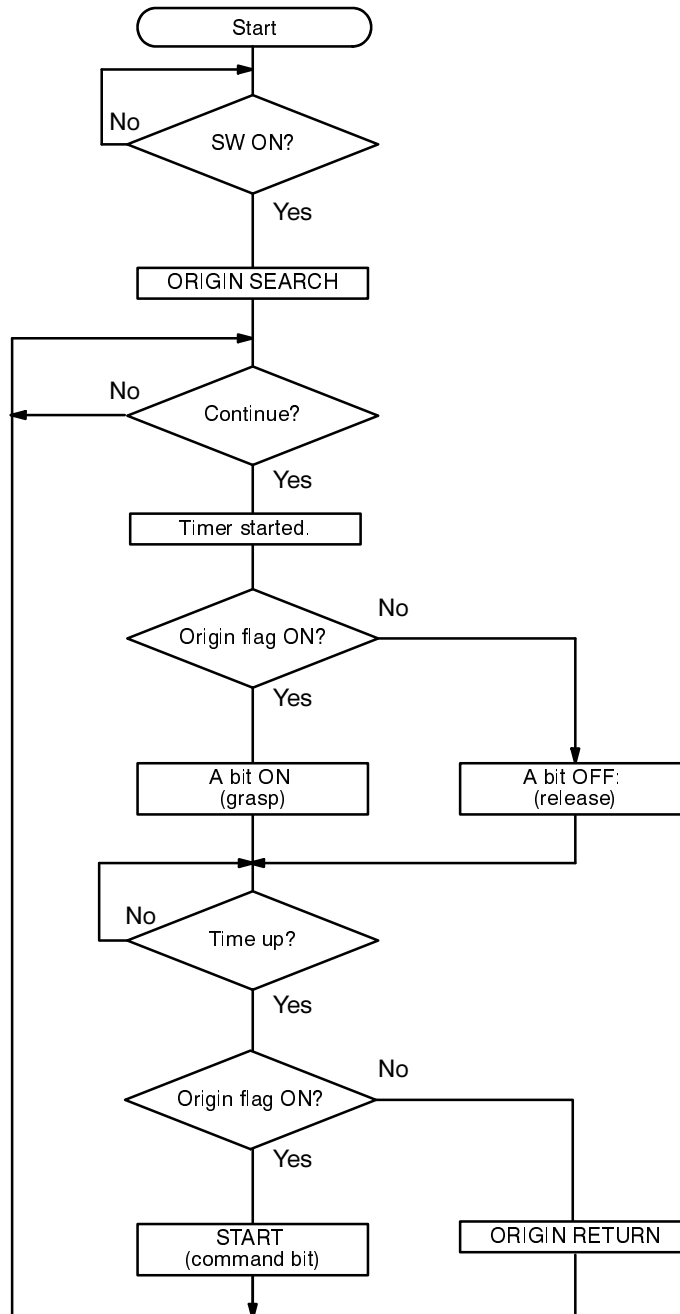
8-6-1 Example 1

This example program performs the following operation.

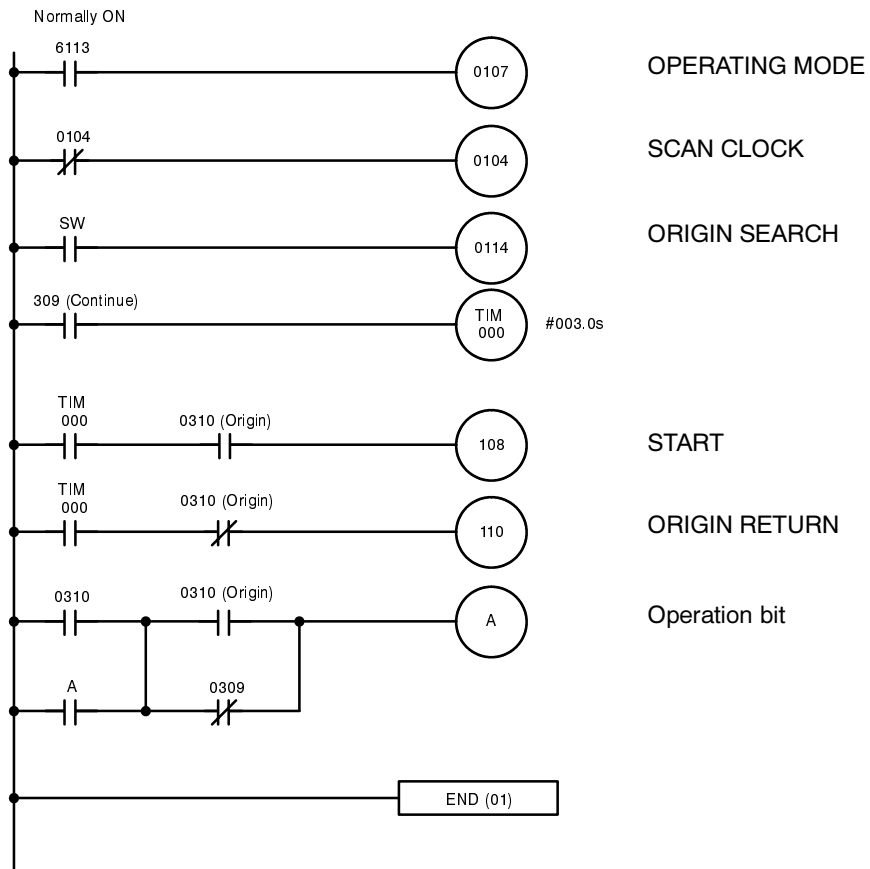


- 1, 2, 3... 1. A robot hand grasps an object located at the origin and carries it to point (1).
2. It then releases the object at point (1) and returns it to the origin.
3. The hand then grasps another object at the origin, carries it to point (2), releases it, and returns to the origin.
4. This process is repeated until all objects have been carried to points (3), (4),... (m).
5. After the object has been released at point (m), the cycle restarts from point (1).

It is assumed that all parameters, speeds, and positioning actions for points (1) through (m) are stored in memory. The following flowchart shows the execution sequence for this program.



Ladder Diagram

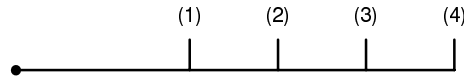


SW A:
Operation start switch

Bit which controls grasping/releasing of object (ON: grasp the object; OFF: release the object)

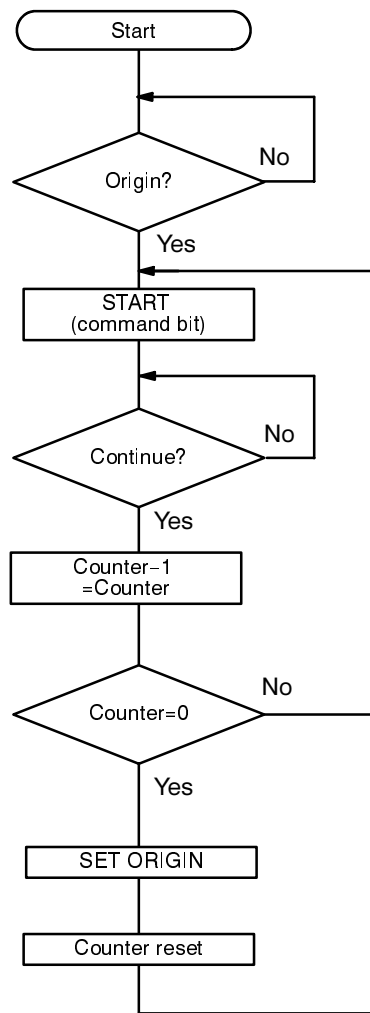
8-6-2 Example 2

This example program performs the following operation. A positioning action is stored at address 1000 as an absolute position so that its product with 99 (counter value) does not exceed limits. The origin is established prior to starting execution of the program.

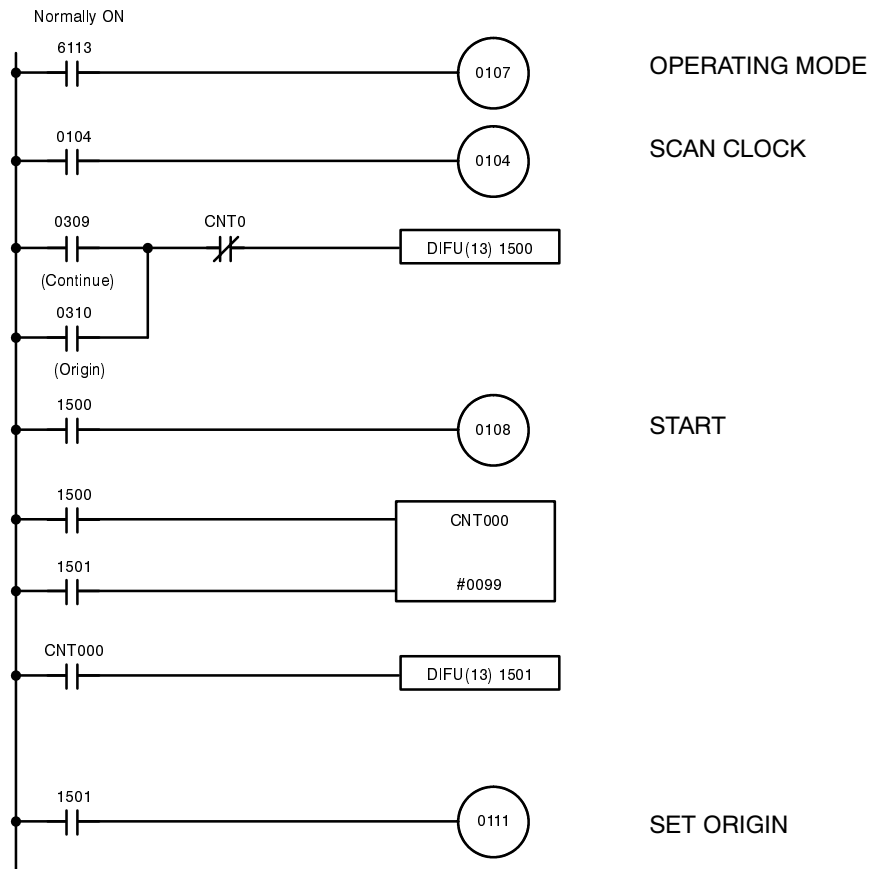


- 1, 2, 3...**
1. Positioning actions are repeated in the same direction and at equal intervals, using a specific reference point.
 2. Movement is from the origin to (1), from (1) to (2), from (2) to (3), and so on.

The following flowchart illustrates the execution sequence.



Ladder Diagram



SECTION 9

Error Processing

This section explains the types of errors which may occur, how they are identified, and how they are processed. In general, error processing is facilitated by LEDs that indicate specific errors, by error code transfers to the PC or Teaching Box, and by the subsequent error code displays on the Programming Console and on the Teaching Box.

| | | |
|-------|---|-----|
| 9-1 | Error Classification and Identification | 110 |
| 9-2 | Basic Troubleshooting | 110 |
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| 9-4 | Allocation of Error Code Data | 113 |
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9-1 Error Classification and Identification

Errors are classified into four types, as shown in the table below. The type of error can be identified by the status of the LEDs on the front panel of the Position Control Unit. A complete listing of the errors included in each of the four types, and their respective error codes, is provided in *Appendix B*. Each error can be identified by its error code.

| No. | Error type | Description | |
|-----|-----------------------|-------------|---|
| 1 | Emergency stops | LED status | RUN flashes. |
| | | Flag status | CNC Error (IR n+3, bit 12) turns ON. Hardware Error (IR n+3, bit 15) turns ON. |
| 2 | CNC errors | LED status | CNC ERR lights (in LOCAL mode, RUN turns off). |
| | | Flag status | CNC Error (IR n+3, bit 12) turns ON. LED status |
| 3 | Communication errors | LED status | COMM. ERR lights. |
| | | Flag status | Handshaking Error (IR n+3, bit 5) turns ON. |
| 4 | Battery voltage drops | LED status | RUN and COMM. ERR flash. |
| | | Flag status | Hardware Error (IR n+3, bit 15) turns ON. |

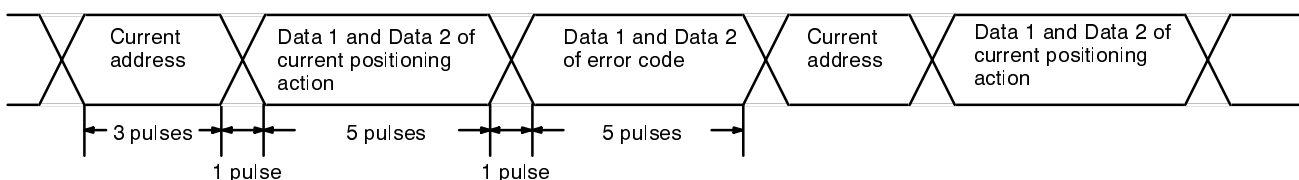
9-2 Basic Troubleshooting

Follow the general procedure below if an error should occur.

- 1, 2, 3... 1. Check the LED status on the front panel of the Position Control Unit. Check the status of the flags output to the PC.
2. If possible, determine the cause of the error. If the cause cannot be determined, access the error code.
3. Correct the cause of the error.
4. Reset operation.

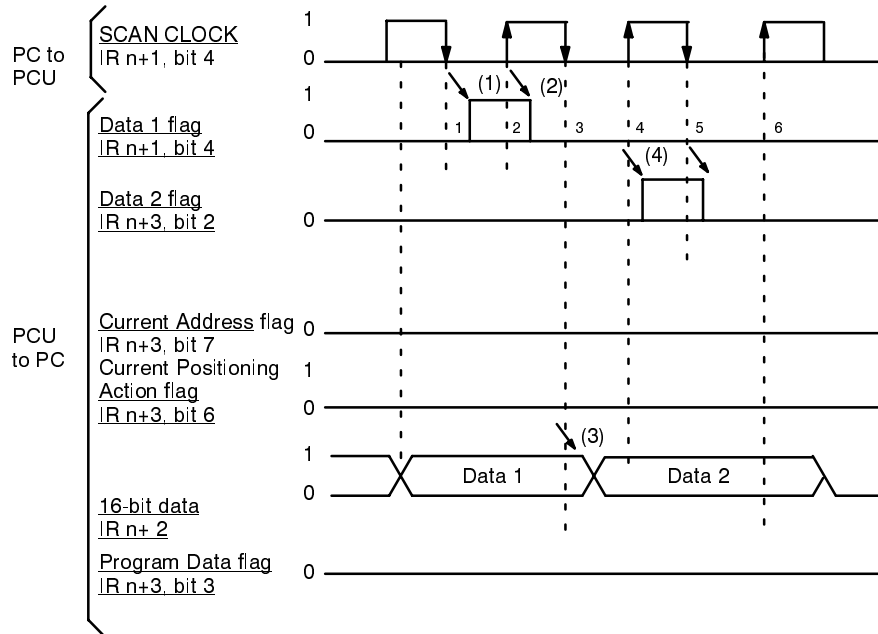
9-3 Error Code Transfer to PC

When an error occurs, the Position Control Unit transfers an error code to the PC to identify the error for the user. As shown in the figure below, the error code is sent between successive transfers of the current address and current positioning action.



Timing and Protocol

The following chart illustrates the timing and protocol for error code transfer.



- 1, 2, 3...**
1. The Position Control Unit outputs Data 1 of the error code on the IR n+2 data bus. The Data 1 flag (IR n+3, bit 1) turns ON after the leading or trailing edge of the first SCAN CLOCK. It takes approximately 10 ms for the Data 1 flag to turn ON after the SCAN CLOCK changes.
 2. The Data 1 flag turns OFF after the leading or trailing edge of the next SCAN CLOCK is detected. It takes approximately 20 ms for the Data 1 flag to turn OFF after the SCAN CLOCK changes.
 3. The data on the IR n+2 data bus switches to Data 2 of the error code after the leading or trailing edge of the the next SCAN CLOCK after the Data 1 flag turns OFF. It takes approximately 10 ms for the data to change after the SCAN CLOCK changes.
 4. The Data 2 flag (IR n+3, bit 2) turns ON after the leading or trailing edge of the first SCAN CLOCK. The protocol and timing are exactly the same as for the Data 1 flag.

Flag Status During Transfer During error code transfer, the status of the IR flags is as shown below.

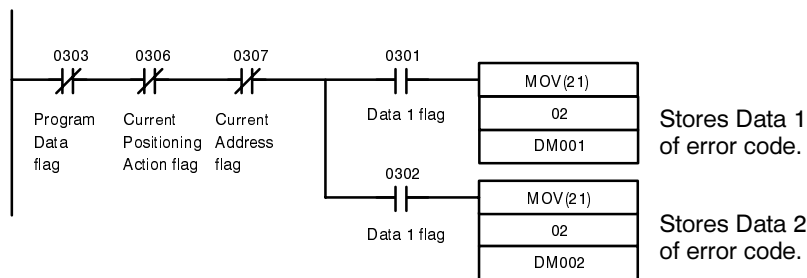
| Word | Bit | Name | REMOTE mode | LOCAL mode |
|------|----------------|----------------------------|-------------|------------|
| n+2 | 0 to 15 | Data bus form PCU to PC | User data | "0000" |
| n+3 | 0 | ACK | OFF | ON |
| | 1 | Data 1 | OFF or ON | OFF |
| | 2 | Data 2 | OFF or ON | OFF |
| | 3 | Data Transfer | OFF | OFF |
| | 4 | PCU RUN | ON | OFF |
| | 5 | Handshaking Error | OFF | ON or OFF |
| | 6 | Current Positioning Action | OFF | OFF |
| | 7 | Current Address | OFF | OFF |
| | 8 | Busy | OFF | OFF or ON |
| | 9 | Positioning Completed | *OFF or ON | *OFF or ON |
| | 10 | Origin | OFF or ON | OFF or ON |
| | 11 | Bank End | OFF or ON | OFF or ON |
| | 12 | CNC Error | OFF | OFF |
| | 13 | Interrupt | OFF or ON | OFF or ON |
| | 14 | External Setting Check | OFF or ON | OFF or ON |
| 15 | Hardware Error | OFF or ON | OFF or ON | |

*Bit 8 is OFF until the origin is established.

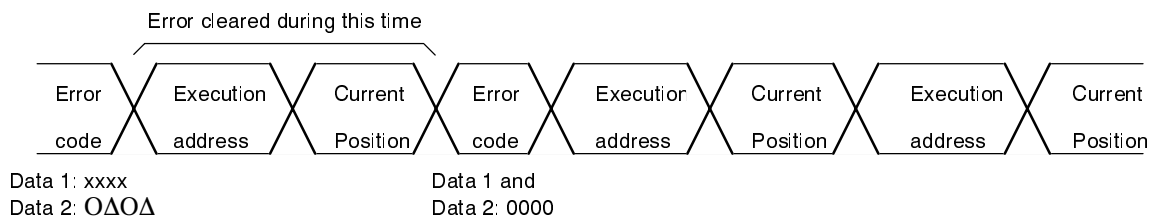
Programming Example

This example program transfers Data 1 of the error code to DM 001, and Data 2 of the error code to DM 002.

Ladder Diagram



If multiple errors are generated concurrently, errors with the lower codes are given higher priority. When an error is cleared, "0000" will be transferred to clear the error code in the PC. Therefore, the error code in the DM area is also reset to "0000."



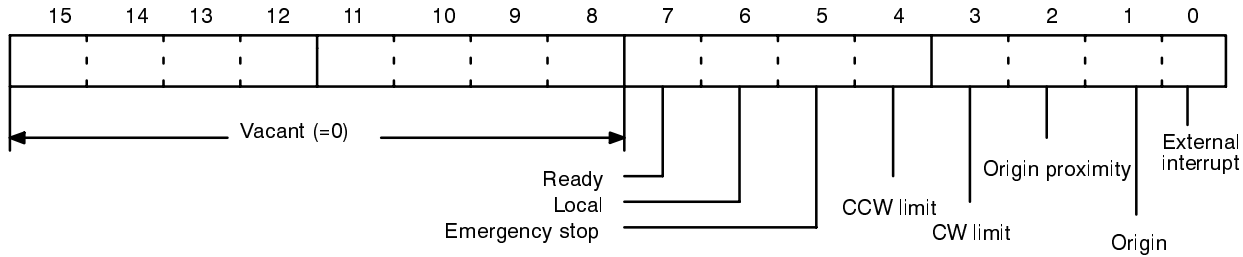
9-4 Allocation of Error Code Data

Error codes consist of two parts, Data 1 and Data 2, each of which occupies one 16-bit word. Data 1 classifies the error, and Data 2 specifies the error. Data 1 is the main error code, and Data 2 is the auxiliary error code.

9-4-1 Data 2 Allocation

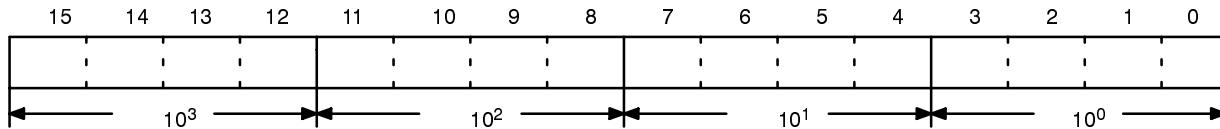
Allocation of the 16 bits in Data 2 is as follows for each of the four types of error codes.

CNC Errors (External-Input Related)

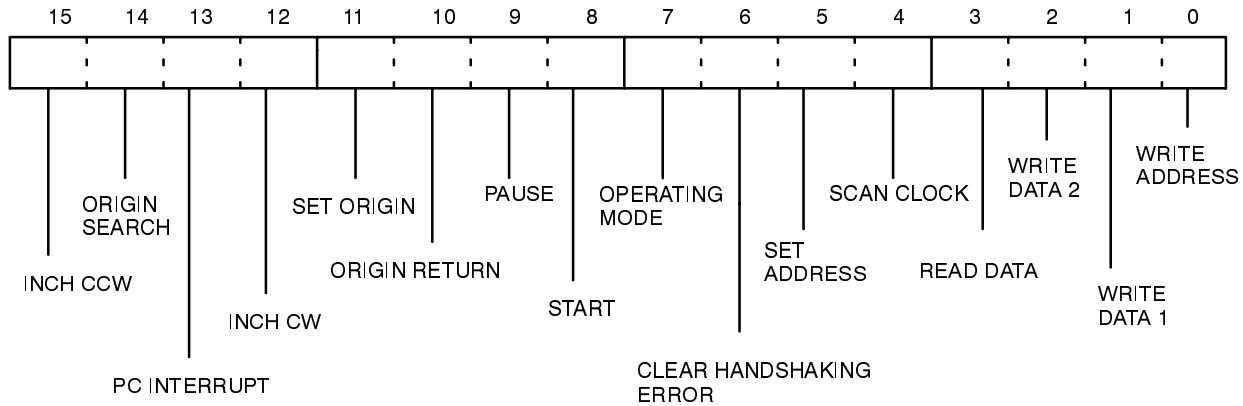


CNC and Communication Errors (Data Related)

The address and contents of the address that caused the error will be displayed in 4-digit binary-coded decimal.

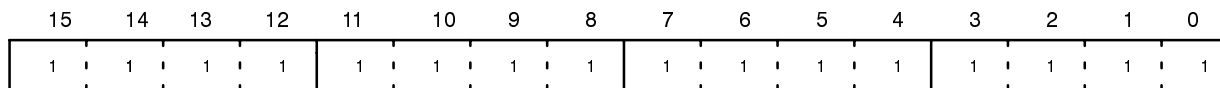


Communication Errors (Command-bit Related)



Battery Voltage Drops

If a battery voltage drop has caused the error, Data 2 of the error code (the auxiliary error code) has no meaning.



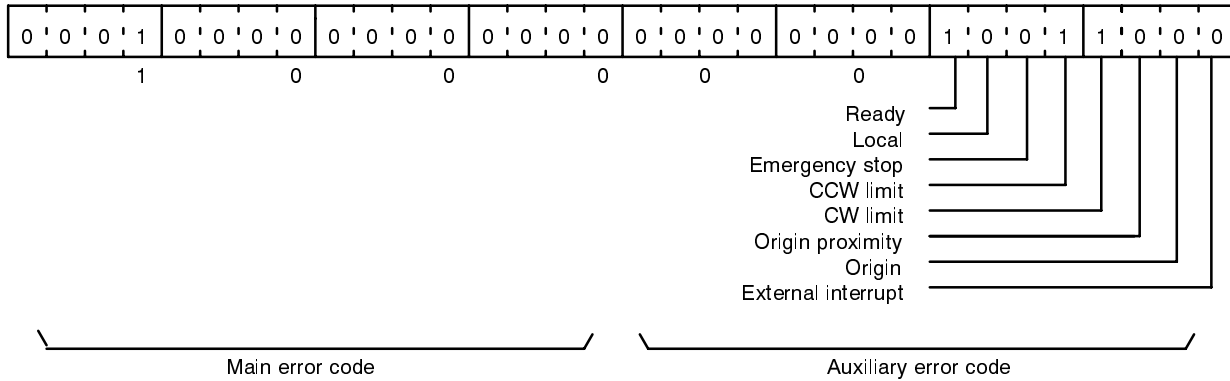
- Note**
1. For external inputs, OPEN is "0" and CLOSED is "1."
 2. For bit-related input, however, ON is "1" and OFF is "0."

9-4-2 Error Code Examples

The following three examples show the error codes which are output in various situations.

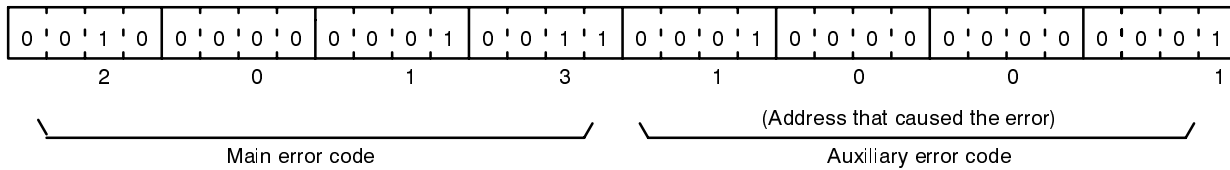
External Emergency Stop

When the external emergency stop input turns ON, Data 1 and Data 2 of the error code are output as shown below.



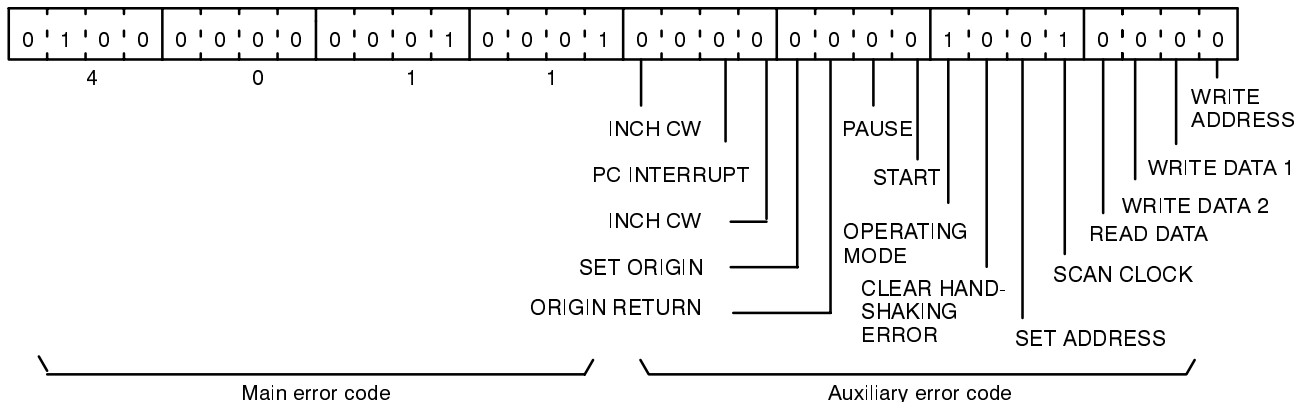
CW Limit Exceeded

If execution of a positioning action exceeding the CW limit is attempted, Data 1 and Data 2 of the error code are output as shown below. Data 2 (the auxiliary error code) displays the address of the positioning action exceeding the CW limit (in this case, address 1001).



SCAN CLOCK Error

If the SCAN CLOCK does not function during transfer of data, Data 1 and Data 2 of the error code are output as shown below. In this example the SCAN CLOCK failed to turn OFF, resulting in error code 4011.



9-5 Teaching Box Displays

In LOCAL mode, the Position Control Unit directly displays error codes on the Teaching Box. To clear the error code display on the Teaching Box, turn its power OFF and back ON, or toggle the mode selector to REMOTE and back to LOCAL. Since communication errors occur in REMOTE mode, error codes for these are not displayed on the Teaching Box.

For a detailed explanation of error code displays on the Teaching Box, refer to the *Teaching Box Operation Manual*.

9-6 Resetting

You can use any of the methods listed below to reset the Position Control Unit. For methods 1 through 3, the origin must be re-established before re-suming positioning. In addition, methods 3 and 4 are valid in REMOTE mode only.

1. Toggle the mode selector from REMOTE to LOCAL and back to REMOTE, or from LOCAL to REMOTE and back to LOCAL.
2. Toggle the external local input from ON to OFF and back to ON, or from OFF to ON and back to OFF.
3. Toggle OPERATING MODE (IR n+1, bit 7) ON and OFF.
4. Toggle CLEAR HANDSHAKING ERROR (IR n+1, bit 6) ON and OFF.

Appendix A Standard Models

| Name | Specifications | Model no. |
|----------------------------|--|------------------|
| Stepping Motor Driver Unit | 4-phase, phase voltage: 3 to 24 VDC, phase current: 0.5 to 2 A | 3G2A5-SMD21 |
| | 4-phase, phase voltage: 3 to 24 VDC, phase current: 0.6 to 4 A | 3G2A5-SMD41 |
| Teaching Box | 5 V, 7 A | 3G2A5-TU001-E |
| | | C500-TU002-E |
| CPU | Battery set included; Memory Unit not included. | C2000H-CPU01-EV1 |
| | | C1000H-CPU01-EV1 |
| | 3G2C3-CPU11-E with Intelligent I/O Read/Write and Network Read/Write instructions added. | 3G2C3-CPU11-EV1 |
| CPU Power Supply Unit | 5 V 12 A | 3G2A5-PS221-E |
| | | 3G2A5-PS222-E |
| | | 3G2A5-PS223-E |
| I/O Power Supply Unit | 5 V, 7 A | 3G2A5-PS212-E |
| | | 3G2A5-PS222-E |
| Backup Battery | ---- | 3G2A9-BAT08 |
| Connecting cable | For connection between C500-NC111-EV1 and C500-TU002-E. | C500-CN422 |

Appendix B

Specifications

General Specifications

The general specifications conform to the SYSMAC C Series specifications.

Performance Specifications

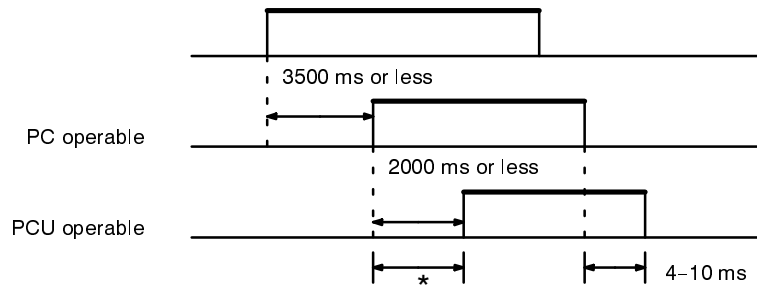
| | Item | Specifications |
|----------------------------------|---------------------------------|---|
| Control | No. of Axes | One |
| Positioning | Input unit (/pulses) | mm, inch, deg, or pulse between 0.0001 and 1. |
| | Maximum input | Selected unit x ± 999999 |
| | Data capacity | 200 positioning actions |
| Speed commands | Speeds | 7-steps speed control for ORIGIN RETURN, ORIGIN SEARCH, manual operations, and other desired speeds input by user. Unit: mm/s, inch/s, deg/s, or pulse/s. |
| | Acceleration/deceleration | Automatic trapezoidal acceleration/deceleration curve |
| | Maximum speed | 100 kpps |
| | ORIGIN RETURN and ORIGIN SEARCH | Speeds set by user. |
| Compensation | Backlash | Selected unit x 0 to selected unit x 9999 |
| | Origin | Selected unit x 9999 to selected unit x -9999 |
| Acceleration/deceleration | Time setting | 0.1 to 99.9 s (in units of 0.1 s) |
| Teaching functions | Manual operation | Single axis operation |
| | Playback | Point- to-point data teaching |
| | Stepwise execution | Individual positioning actions |

Power Ratings and Power Supply

The Position Control Unit is supplied power from the PC Power Supply Unit, either 3G2A5-PS221-E or 3G2A5-PS222-E, via the CPU Rack, Expansion I/O Rack, or Slave Rack.

| | |
|-------------------------------|------------------|
| Rated current and voltage | 5 VDC |
| Voltage fluctuation tolerance | 4.75 to 5.25 VDC |
| DC current consumption | 600 mA or less |

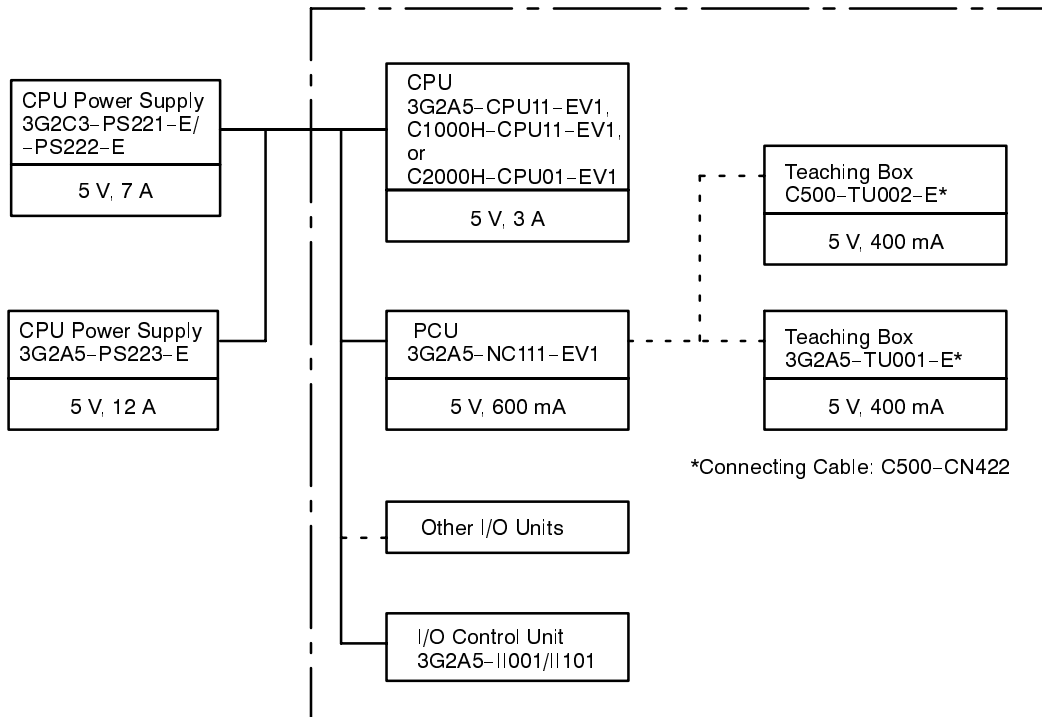
The following timing chart shows the basic timing requirements for the power supply sequence.



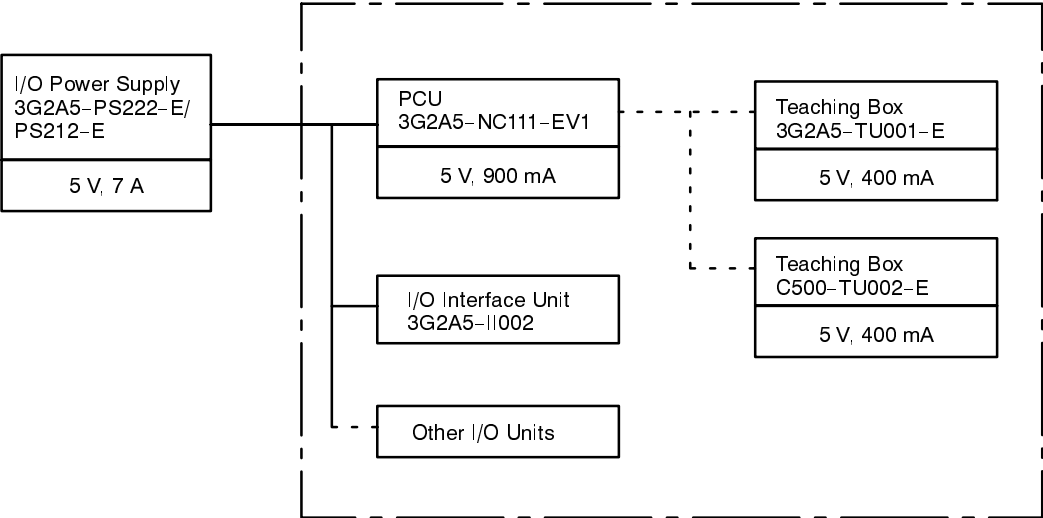
*The user should not attempt to operate the Position Control Unit during this period. Although the PC will operate, the Position Control Unit will not. Thus the AR area First Scan flag (AR 6115 for the C500 PC and AR 25315 for the C1000H or C2000H PCs) used when power turns ON will be ignored.

The figures below show the configurations of the Units along with their power requirements. The power requirements of the control system should be considered comprehensively. Connect the Power Supply Units such that their supply current output is not exceeded by the total power consumption of the Units within the broken-line boxes.

CPU



I/O



Appendix C

Error Code List

| Error type | Error (problem area) | Code | | | | Causes of abnormality and status | Correction |
|----------------|--|------|---|---|---|--|---|
| Emergency stop | (not specific) | 1 | 0 | 0 | 0 | External emergency stop input is OPEN. | Reset and resume. |
| CNC error | CW limit ON (external input) | 2 | 0 | 0 | 0 | Workpiece is at or exceeds CW limit. | LOCAL mode: set workpiece within the designated limits, reset, and resume. REMOTE mode: reset and resume. |
| | CCW limit ON (external input) | 2 | 0 | 0 | 1 | Workpiece is at or exceeds CCW limit position. | LOCAL mode: set workpiece within designated limits, reset, and resume. REMOTE mode: reset and resume. |
| | Ready input OFF (external input) | 2 | 0 | 0 | 2 | Ready input turned OFF upon execution of inching, START, ORIGIN SEARCH, or ORIGIN RETURN. | Turn ON Ready input, reset functions, and resume positioning. |
| | Mode switching (external input, front panel) | 2 | 0 | 0 | 3 | The PCU mode switched during motor operation. | Set the correct mode, and resume positioning. |
| | Direction setting error (positioning action) | 2 | 0 | 1 | 0 | Successive positioning actions attempted to change the direction of motor rotation without deceleration. | Reset and correct the positioning action attributes so that the motor shaft does not reverse direction when the positioning action completion code is set to 1. |
| | Completion code setting error (positioning action) | 2 | 0 | 1 | 1 | Positioning action with a completion code of 1 (continuous) is also designated as the bank end. | Reset, and set the completion code to 0 for any positioning actions that are designated as bank ends. |
| | Data setting error (1) (positioning action) | 2 | 0 | 1 | 2 | No positioning action existed at START (no code on Teaching Box). | Reset, and and set data for positioning action in question. |
| | Data setting error(2) (parameters) | 2 | 0 | 1 | 3 | Execution of positioning action exceeding CW limit was detected. | Reset, and correct positioning action in question so that positions lie within the limits. |
| | Data setting error (3) (parameters) | 2 | 0 | 1 | 4 | Execution of positioning action exceeding CCW limit was detected. | |
| | Data setting error (4) (positioning action) | 2 | 0 | 1 | 5 | Positioning action is input in manner that makes trapezoidal acceleration/deceleration impossible. Because the distance between points A and B is too short, deceleration between them is too sudden; therefore, trapezoidal curving is impossible. | Reset, correct positioning action in question, and avoid parameters that will cause sudden acceleration/deceleration. |
| | Data setting error (5) (parameters) | 2 | 0 | 1 | 6 | Initial speed (address 2006) is higher than maximum speed (address 2005) so the acceleration/deceleration table could not be generated. | Reset, and set initial speed slower than maximum speed. |
| | Data setting error (6) (pulse rate) | 2 | 0 | 1 | 7 | Because the pulse rate was zero, positioning action could not be converted to pulses. | Reset, and set pulse rate between 0.0001 and 1. |

| Error type | Error (problem area) | Code | | | | Causes of abnormality and status | Correction |
|---------------------|--|-------------|---|---|---|--|---|
| CNC error | Data setting error (7) (speed) | 2 | 0 | 1 | 8 | Execution of axial movement, inching, START, ORIGIN SEARCH, or ORIGIN RETURN was attempted with the speed data set to 0. | Reset and set speeds between 1 and 100,000 pps. |
| | Data setting error (8) (speed) | 2 | 0 | 1 | 9 | Execution of ORIGIN SEARCH was attempted when ORIGIN SEARCH speed was set lower the manual low speed. | Reset and set manual low speed slower than ORIGIN SEARCH speed. |
| Communication error | Address error (user data) | 4 | 0 | 0 | 0 | Transfer of address other than 1000–1199, 2000–2011, and 4000–4009 was attempted from PC to PCU. | Reset and correct data addresses In question. |
| | Data 1, Data 2, error (user data) | 4 | 0 | 0 | 1 | Contents of Data 1 or Data 2 transferred from PC to PCU had undefined values. | Reset and correct Data 1 and Data 2 in question. |
| | Address setting error (positioning action) | 4 | 0 | 0 | 2 | Address was set outside of the range 1000–1199. | Reset and correct addresses to be set. |
| | Data read error (positioning action) | 4 | 0 | 0 | 3 | Address designated for data read is other than 1000–1199, 2000–2011, and 4000–4009. | Reset and correct addresses for data read. |
| | Transmission timing error (2) (timing) | 4 | 0 | 0 | 4 | WRITE DATA 1 does not turn ON when it should. Data 2 turns ON out of sequence. This error is also generated when WRITE DATA 1 turns ON 500 ms or later after WRITE ADDRESS turns ON. | Reset and correct the transfer program timing. |
| | Transmission timing error (2) (timing) | 4 | 0 | 0 | 5 | WRITE DATA 2 does not turn ON when it should. This error is also generated when WRITE DATA 2 turns ON 500 ms or later after WRITE DATA 1 turns ON. | Reset and correct the transfer program timing. |
| | Positioning action read error (positioning action) | 4 | 0 | 0 | 6 | An address of positioning action without data is read for a positioning action (The Teaching Box shows blank data). | Reset and have data read from existing data. |
| | Leading edge active bit error (PC program) | 4 | 0 | 1 | 0 | The following leading edge active bits remain ON when the mode changes form LOCAL to REMOTE: WRITE ADDRESS; WRITE DATA 1 ; WRITE DATA 2; READ DATA; and, SET ADDRESS. | Reset, check with the PC program to see if the bits remain ON when switching from LOCAL to REMOTE, and correct the PC program is necessary. |
| | SCAN CLOCK error (PC program) | 4 | 0 | 1 | 1 | SCAN CLOCK does turn ON or OFF during data transfer form the PC to the PCU. | Reset , check to see if the SCAN CLOCK is turning ON and OFF form the PC Programming Console, and correct the PC program is necessary. |
| | Battery voltage drop | Low battery | 8 | 0 | 0 | 0 | The voltage of the RAM backup battery drops to 3 volts or less. |

Appendix D

Positioning Action Data Coding Sheets

| Address | Completion code | ABS/INC | Direction (+ / -) | Position | Speed | Address | Completion code | ABS/INC | Direction (+ / -) | Position | Speed |
|---------|-----------------|---------|-------------------|----------|-------|---------|-----------------|---------|-------------------|----------|-------|
| 1000 | | | | | | 1050 | | | | | |
| 1001 | | | | | | 1051 | | | | | |
| 1002 | | | | | | 1052 | | | | | |
| 1003 | | | | | | 1053 | | | | | |
| 1004 | | | | | | 1053 | | | | | |
| 1005 | | | | | | 1055 | | | | | |
| 1006 | | | | | | 1056 | | | | | |
| 1007 | | | | | | 1057 | | | | | |
| 1008 | | | | | | 1058 | | | | | |
| 1009 | | | | | | 1059 | | | | | |
| 1010 | | | | | | 1060 | | | | | |
| 1011 | | | | | | 1061 | | | | | |
| 1012 | | | | | | 1062 | | | | | |
| 1013 | | | | | | 1063 | | | | | |
| 1014 | | | | | | 1064 | | | | | |
| 1015 | | | | | | 1065 | | | | | |
| 1016 | | | | | | 1066 | | | | | |
| 1017 | | | | | | 1067 | | | | | |
| 1018 | | | | | | 1068 | | | | | |
| 1019 | | | | | | 1069 | | | | | |
| 1020 | | | | | | 1070 | | | | | |
| 1021 | | | | | | 1071 | | | | | |
| 1022 | | | | | | 1072 | | | | | |
| 1023 | | | | | | 1073 | | | | | |
| 1024 | | | | | | 1074 | | | | | |
| 1025 | | | | | | 1075 | | | | | |
| 1026 | | | | | | 1076 | | | | | |
| 1027 | | | | | | 1077 | | | | | |
| 1028 | | | | | | 1078 | | | | | |
| 1029 | | | | | | 1079 | | | | | |
| 1030 | | | | | | 1080 | | | | | |
| 1031 | | | | | | 1081 | | | | | |
| 1032 | | | | | | 1082 | | | | | |
| 1033 | | | | | | 1083 | | | | | |
| 1034 | | | | | | 1084 | | | | | |
| 1035 | | | | | | 1085 | | | | | |
| 1036 | | | | | | 1086 | | | | | |
| 1037 | | | | | | 1087 | | | | | |
| 1038 | | | | | | 1088 | | | | | |
| 1039 | | | | | | 1089 | | | | | |
| 1040 | | | | | | 1090 | | | | | |
| 1041 | | | | | | 1091 | | | | | |
| 1042 | | | | | | 1092 | | | | | |
| 1043 | | | | | | 1093 | | | | | |
| 1044 | | | | | | 1094 | | | | | |
| 1045 | | | | | | 1095 | | | | | |
| 1046 | | | | | | 1096 | | | | | |
| 1047 | | | | | | 1097 | | | | | |
| 1048 | | | | | | 1098 | | | | | |
| 1049 | | | | | | 1099 | | | | | |

| Address | Completion code | ABS/INC | Direction (+ / -) | Position | Speed | Address | Completion code | ABS/INC | Direction (+ / -) | Position | Speed |
|---------|-----------------|---------|-------------------|----------|-------|---------|-----------------|---------|-------------------|----------|-------|
| 1100 | | | | | | 1150 | | | | | |
| 1101 | | | | | | 1151 | | | | | |
| 1102 | | | | | | 1152 | | | | | |
| 1103 | | | | | | 1153 | | | | | |
| 1104 | | | | | | 1153 | | | | | |
| 1105 | | | | | | 1155 | | | | | |
| 1106 | | | | | | 1156 | | | | | |
| 1107 | | | | | | 1157 | | | | | |
| 1108 | | | | | | 1158 | | | | | |
| 1109 | | | | | | 1159 | | | | | |
| 1110 | | | | | | 1160 | | | | | |
| 1111 | | | | | | 1161 | | | | | |
| 1112 | | | | | | 1162 | | | | | |
| 1113 | | | | | | 1163 | | | | | |
| 1114 | | | | | | 1164 | | | | | |
| 1115 | | | | | | 1165 | | | | | |
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Glossary

| | |
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| absolute position | A position given in respect to the origin rather than in respect to the present position. |
| attribute | One of several types of data that define positioning actions. Attributes include settings such as interpolation code, interpolation point, and completion code. |
| backlash compensation | Compensation for the amount of mechanical play, or “looseness,” present in gears. Such play can create positioning inaccuracy when the direction of positioning changes. |
| bank | A combination of several positioning actions or sequences. A bank begins when START is executed for the initial positioning action and ends when a positioning action with a “bank end” attribute has been executed. |
| bank end | A positioning action attribute that designates the positioning action as the final one in a bank. |
| BCD | An acronym for binary-coded decimal. This is used to code decimal numbers in binary. |
| completion code | A positioning action attribute that determines, upon completion of a given positioning action, whether positioning stops or whether the next positioning action is executed immediately, without a break. |
| continuous (completion) | A completion code that causes the next positioning action to be executed immediately upon completion of the current one. |
| CW and CCW | Abbreviations for clockwise (CW) and counterclockwise (CCW). CW and CCW are defined for a motor shaft in reference to a viewer facing the shaft on the end of the motor from which the shaft extends from the motor for connection. |
| CW/CCW limits | Limits on the CW and CCW sides of the origin which can be internally set to restrict rotation of the shaft. |
| data area | A memory storage area in the PC. Different types of memory blocks, with differing functions, are stored in the various data areas of the PC. These blocks of memory are built up from single units, or bits, which are grouped into 16-bit words. |
| distributed control | An automation concept in which each portion of an automated system is located near the devices actually being controlled. In other words, control is decentralized and “distributed” over the system. Distributed control is a concept basic to PC systems. |
| DM area | A PC data area in which general operating parameters, speeds, and positions for positioning actions are stored. |
| dwel time | A setting that specifies the period of time during which positioning will stop before execution of the next positioning action. |
| error code | A four-digit code which is output to the PC and the Teaching Box to identify the type of error which has occurred. |
| error counter | A device used to ensure positioning accuracy when positioning via pulse trains. The error counter receives a target position as a specific number of pulses in a pulse train from the Position Control Unit and outputs analog speed voltages to drive a servomotor accordingly. The specified number of pulses in the error counter is counted down by feedback from an encoder measuring actual motor shaft movement, causing voltage output to stop when the number of pulses equals zero, i.e., when the target position has been reached. |
| external interrupt | A function whereby positioning may be stopped or speed may be changed, during operation, in response to an external signal. |
| feedback | The return of a portion of the output of a circuit or device to its input. It is used in servocontrol systems to help bring actual values closer to target values. |
| field | An area in memory used to hold various data settings which define positioning actions. Fields include address, position, speed, and attribute data. |
| flag | A bit that is turned ON and OFF automatically by the system to provide status information. |
| gain | The increase in signal power produced by an amplifier. |

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| hunting | The tendency, in servosystems, to overcompensate when the system's momentum carries it past the target position. |
| host computer | A computer that is used to transfer data to or receive data from a PC in a Host Link System. The host computer is used for data management and overall system control. Host computers are generally small personal or business computers. |
| inching | Manual feeding wherein positioning is executed one pulse at a time. |
| incremental position | A position given in respect to the present position, rather than in respect to the origin. |
| initial position mode | The present position when START is executed. |
| NC contacts | Normally-closed contacts. A pair of contacts on a relay that open when the relay is energized. |
| NO contacts | Normally-open contacts. A pair of contacts on a relay that close when the relay is energized. |
| open-loop system | A control system in which operations are carried out according to programmed instructions, but in which feedback is not provided for automatic adjustments. |
| origin | The point which is designated as 0 at any given time. |
| origin compensation | A parameter used to correct the origin from the position determined according to the origin input signal. |
| origin proximity signal | A signal input to indicate when the position is near the origin to enable shifting to a lower speed. |
| origin proximity | The region near the origin. When positioning enters this region, a proximity switch may output a signal for deceleration. |
| parameters | Data which determines limits and other conditions under which an operation will be carried out. |
| positioning action | The fundamental unit of positioning. A particular positioning action moves the workpiece along one or both axes in a direction, at a speed, and to a position determined by the data which has been set. |
| present position | The numeric value in pulses defined as being the "location" of the positioning system at any one point in time. The present position position is not absolute, but rather can be redefined as required by positioning operations. |
| pulses | Discrete signals sent at a certain rate. The Position Control Unit outputs pulses, each of which designates a certain amount of movement. Such pulses are converted to an equivalent control voltage in actual positioning. |
| pulse rate | The distance moved the motor shaft divided by the number of pulses required for that movement. |
| pulse train | A series of pulses output together. |
| search pattern | The pattern in which origin search is carried out. The particular search pattern performed depends on the position of the origin with respect to the origin input and origin proximity input. |
| semiclosed-loop system | A control system in which a PC controls an external process without human intervention. This system provides feedback (via a tachogenerator and a rotary encoder) so that actual values (of positions, speeds, and so on) are continuously adjusted to bring them more closely in line with target values. |
| servolock | An operation whereby a rotary encoder is used to maintain the position of a motor while it is stopped. Whenever the motor axis moves, the rotary encoder sends a feedback pulse to an error counter, causing a rotation voltage to be generated in the reverse direction so that the motor rotates back to its original position. |
| Special I/O Unit | A dedicated Unit, such as a Position Control Unit, High-Speed Counter Unit, or Analog Timer Unit, which is dedicated for a special purpose. |
| target position | A parameter for a positioning action that designates what position is to be reached at the completion of the action. |

Glossary

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| teaching | Writing the present position into memory, via the Teaching Box, as the target position for the designated positioning action. |
| terminating (completion) | A completion code that causes positioning to stop upon completion of the current positioning action. |
| trapezoidal acceleration/deceleration | Accelerating and decelerating in a stepwise pattern such that a trapezoidal figure is formed. |

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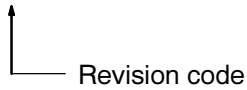
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Revision History

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

Cat No. W142-E1-3



The following table outlines the changes made to the manual during each revision.

| Revision code | Date | Revised content |
|---------------|---------------|--|
| 2 | November 1989 | <p>This manual was rewritten along with those for other Position Control Units to unify terms and manual structure.</p> <p>The Program Data flag has been renamed the Data Transfer flag and the Continue flag has been renamed the Positioning Completed flag.</p> <p>Ladder diagrams have been changed to adhere to addressing and symbol conventions in the <i>Operation Manuals</i> for the PCs. Programming Console Displays have also been corrected.</p> <p>The following mistakes have been corrected on the pages indicated</p> <p>Page 30: Contents of DM 054</p> <p>Page 39: Position of callouts</p> <p>Page 75: Wording of search procedure</p> <p>Pages 70–75: Position of Proximity and Origin on bottom diagram</p> <p>Page 94: Display content</p> <p>Page 97: Work bit allocations</p> <p>Page 99: IR 1602 leading to DIFU(13) for 1602 corrected to IR 1601</p> |
| 3 | July 1990 | Correction to <i>Appendix C</i> , error code 2018. |



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