

# PCI1020

## User's Manual



Beijing ART Technology Development Co., Ltd.

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# Chapter 1 Overview

## 1.1 Introduction

PCI1020 is a 4-axis motion control card which can control 4 axes of either stepper motor or pulse type servo drivers for position, speed, and interpolation controls.

## 1.2 Features

- ✧ PCI interface, plug and play
- ✧ 4-axis servo/stepper motor control, each axis can work independently.
- ✧ Pulse Output Frequency Error: <0.1%
- ✧ Maximum Pulse Output Speed: 4 MHz
- ✧ Pulse Output Mode: CP/DIR, CW/CCW
- ✧ Non-symmetrical linear acceleration/deceleration drive, S-shaped acceleration/deceleration
- ✧ Constant Speed Driving
- ✧ Any 2/3 axes linear interpolation, any 2 axes circular interpolation, any 2/3 axes bit pattern interpolation, and continuous interpolation.
- ✧ Start/stop multi-axis simultaneously
- ✧ Control acceleration/deceleration time through programmable
- ✧ Read logic position, physic position, drive speed, acceleration, and acceleration/deceleration status in real-time
- ✧ Isolation Voltage: 2500Vrms

## 1.3 Specifications

- ✧ Control Axis 4 axes
- ✧ CPU Data Bit Width: 16 bits

### Interpolation Function

- ✧ 2-axes / 3-axes Linear Interpolation
  - ✦ Interpolation Range Each axis -8,388,607~+8,388,607
  - ✦ Interpolation Speed 1 PPS ~ 4 MPPS
  - ✦ Interpolation Accuracy  $\pm 0.5$  LSB (Within the range of whole interpolation)
- ✧ Circular Interpolation
  - ✦ Interpolation Range Each axis -8,388,607~+8,388,607
  - ✦ Interpolation Speed 1 PPS ~ 4 MPPS
  - ✦ Interpolation Accuracy  $\pm 1$  LSB (Within the range of whole interpolation)
- ✧ 2 axes / 3 axes Bit Pattern Interpolation
  - ✦ Interpolation Speed 1PPS ~ 4 MPPS (Dependent on CPU data writing time)
- ✧ Related Functions of Interpolation
  - ✦ Can select any axis
  - ✦ Constant vector speed

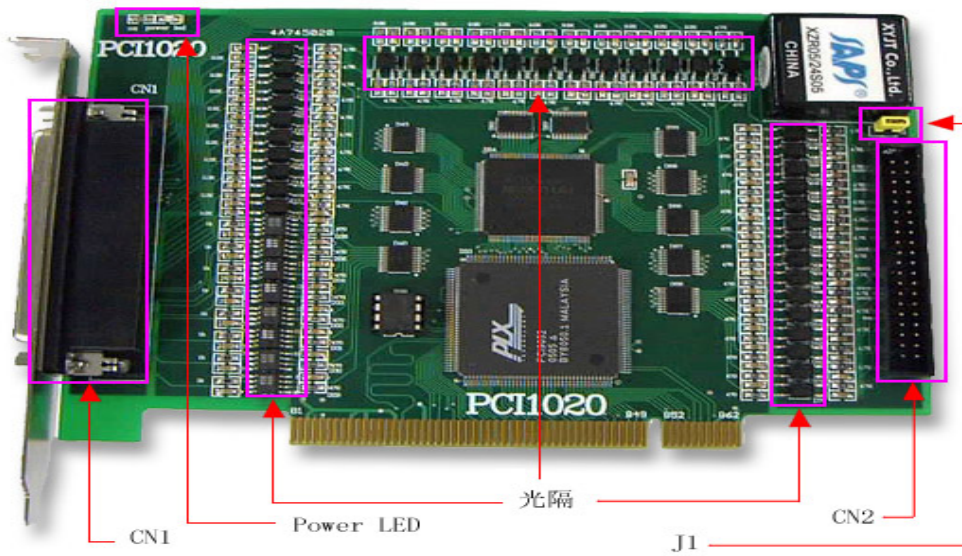
- ✚ Continuous interpolation
- ✚ Single step interpolation (Command/external signals)

### Common Specifications of Each Axis

- ✧ Drive Pulses Output (When CLK = 16 MHz)
  - ✚  Pulse Output Speed Range 1PPS ~ 4MPPS
  - ✚ Resolution of output speed within  $\pm 1$ LSB
  - ✚ Speed Multiplication: 1~500
  - ✚ S-shaped Jerk:  $954 \sim 31250 * 10^6$ PPS/ $S_2$
  - ✚ Acceleration/deceleration:  $125 \sim 500 * 10^6$ PPS/S
  - ✚ Initial Speed: 1~8000PPS (Multiple=1)  
500~4\* $10^6$ PPS (Multiple=500)
  - ✚ Drive Speed: 1~8000PPS (Multiple=1)  
500~4\* $10^6$ PPS (Multiple=500)
  - ✚ Output Pulse Number: 0~268,435,455
  - ✚ Speed Curve: constant speed, linear acceleration/deceleration, parabola s-shaped acceleration/deceleration drive
  - ✚ Fixed Drive Deceleration Mode: Auto deceleration and manual deceleration
  - ✚ Output-pulse numbers and drive speeds changeable during the driving
  - ✚ Triangle form prevention of linear acceleration fixed pulse drive and S-shaped acceleration/deceleration fixed pulse drive
  - ✚ Independent 2-pulse system or 1-pulse 1-direction system selectable
  - ✚ Logical levels of drive pulse selectable, output pin switchable
- ✧ Encoder Input
  - ✚ A/B quadrature pulse style or Up/Down pulse style selectable
- ✧ Position Counter
  - ✚ Logic Position Counter (for output pulse t) range  $-2,147,483,648 \sim +2,147,483,647$
  - ✚ Real Position Counter (for feedback pulse) range  $-2,147,483,648 \sim +2,147,483,647$   
Data read and write possible
- ✧ Comparison Register
  - ✚ COMP + Register Position comparison range  $-2,147,483,648 \sim +2,147,483,647$
  - ✚ COMP - Register Position comparison range  $-2,147,483,648 \sim +2,147,483,647$
  - ✚ Status and signal outputs for the comparisons of position counters
  - ✚ Software limit functioned
- ✧ External Signal for Driving
  - ✚ EXPP and EXPM signals for fixed pulse / continuous
  - ✚ Driving in manual pulsar mode (encoder input)
- ✧ External Deceleration / Sudden Stop Signal
  - ✚ IN0 ~ 3 4 points for each axis
  - ✚ Enable/disable and logical levels selectable
- ✧ Servo Motor Input Signal
  - ✚ ALARM (Alarm), INPOS (In Position Check)
- ✧ General Output Signal
  - ✚ OUT0 ~ 7 8 points for each axis
- ✧ Drive Status Signal Output

- ✚ DRIVE (drive pulse output), ASND (acceleration), DSND (deceleration), CMPP (position  $\geq$  COMP +), CMPM (position  $<$ COMP-)  
Drive status can also be read in the status register
- ✧ Limit Signals Input
  - ✚ 2 points, for each + and - side  
Logical levels and decelerating/sudden stop selectable
- ✧ Emergency Stop Signal Input
  - ✚ EMG, 1 point for 4 axes
- ✧ Operation Temperature: 0~+50°C
- ✧ Power Supply: 24V (external)
- ✧ Clock: 16.000MHZ
- ✧ Dimensions: 154mm (length) \* 114mm (W)

# Chapter2 Component Layout



## 2.1 Input/Output Connector

CN1: signal input/output connector  
 P1: general-purpose signal connector

## 2.2 Status Light

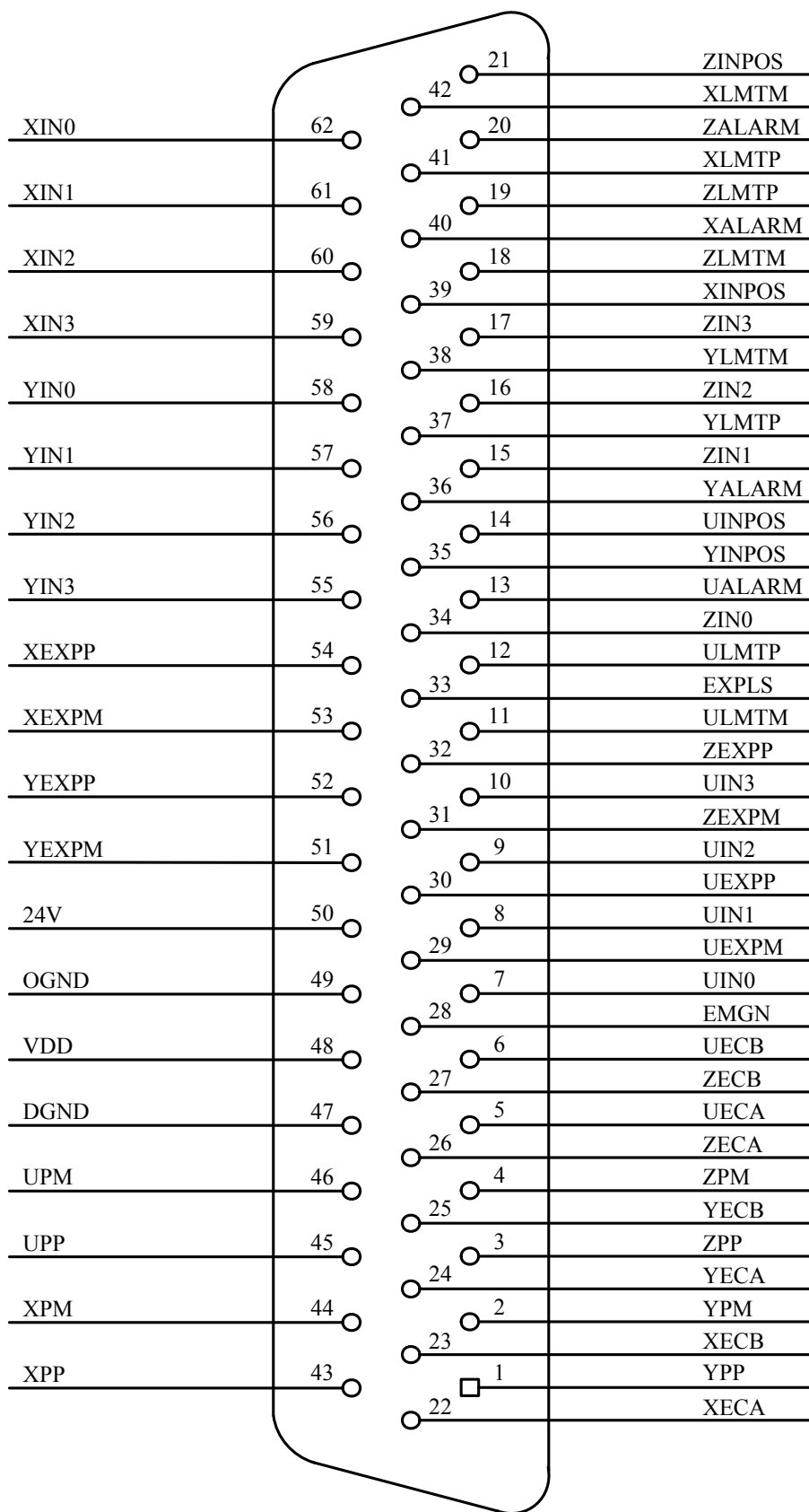
Power LED: Power indicator

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## *Chapter 3 Pin Layout*

### **3.1 Analog Signal Connector**

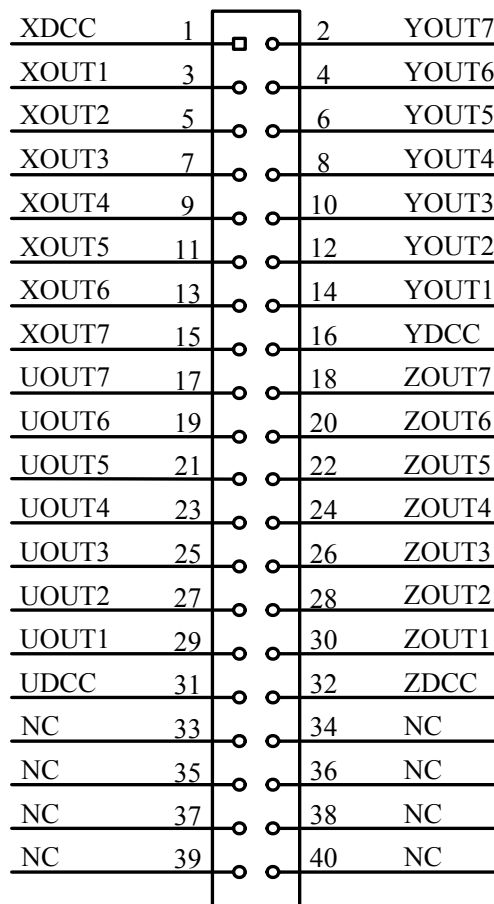




Pin No	Signal Name	Description
43 1 3 45	XPP/PLS YPP/PLS ZPP/PLS UPP/PLS	Pulse +/pulse: + direction drive pulse driving When the reset is on the low level, and while the driving is starting, DTUY 50% (at constant speed) of the pulse are outputting. +or -pulse mode is selectable. When the 1-pulse 1-direction mode is selected, this terminal is for drive output.
44 2 4 46	XPM/DIR YPM/DIR ZPM/DIR UPM/DIR	Pulse -/pulse: - direction drive pulse driving When the reset is on the low level, and while the driving is starting, DTUY 50% (at constant speed) of the pulse are outputting. +or -pulse mode is selectable. When the 1-pulse 1-direction mode is selected, this terminal is direction signal.
22 24 26 5	XECA/PPIN YECA/PPIN ZECA/PPIN UECA/PPIN	Encoder-A/Pulse +in: signal for encoder phase-A input This input signal, together with phase-B signal, will make the Up/Down pulse transformation to be the input count of real position counter. When the UP/Down pulse input mode is selected, this terminal is for UP pulses input. Once the input pulse is up, the real position counter is counting up.
23 25 27 6	XECB/PMIN YECB/PMIN ZECB/PMIN UECB/PMIN	Encoder-B/Pulse -in: signal for encoder phase-B input This input signal, together with phase-A signal, will make the Up/Down pulse transformation to be the input count of real position counter. When the UP/Down pulse input mode is selected, this terminal is for UP pulses input. Once the input pulse is up, the real position counter is counting up.
39 35 21 14	XINPOS YINPOS ZINPOS UINPOS	In-position: input signal for servo driver in-position Enable/disable and logic levels can be set as commands. When "enable" is set, and after the driving is finished, this signal is active and standby.
40 36 20 13	XALARM YALARM ZALARM UALARM	Servo Alarm: input signal for servo driver alarm Enable/disable and logical levels can be set as commands.
41 37 19 12	XLMTTP YLMTTP ZLMTTP ULMTTP	Over Limit +: signal of + direction over limit During the + direction drive pulse outputting, decelerating stop or sudden stop will be performed once this signal is active. When the filter function is disabled, the active pulse width must be 2CLK or more.
42 38 18 11	XLMTM YLMTM ZLMTM ULMTM	Over Limit -: signal of - direction over limit During the - direction drive pulse outputting, decelerating stop or sudden stop will be performed once this signal is active. The active pulse width should be more than 2CLK. Decelerating stop/sudden stop and logical levels can be set during the mode selection.
59~62 55~58 17~15 34 10~7	XIN3~0 YIN3~0 ZIN3~1 ZIN0 UIN3~0	Input 3~0: input signal to perform decelerating/sudden stop for each axis These signals can be used for HOME searching. The active pulse width should be more than 2CLK. Enable/disable and logical levels can be set for IN3~IN0. In automatic home search, IN0, IN1, and IN2 are assigned to a near home search signal, a home signal, and an encoder Z-phase signal respectively.
54 52 32 30	XEXPP YEXPP ZEXPP UEXPP	External Operation +: + direction drive starting signal from external source When the fixed pulse driving is command from an external source, +direction driving will start if this signal is down. Otherwise, when the continuous pulse driving is commanded from an external source, + driving will start if this signal is on the low level. In manual pulsar mode, the encoder A-phase signal is input to this pin.
53 51 31 29	XEXPM YEXPM ZEXPM UEXPM	External Operation -: - direction drive starting signal from external source When the fixed pulse driving is command from an external source, -direction driving will start if this signal is down. Otherwise, when the continuous pulse driving is commanded from an external source, -driving will start if this signal is on the low level. In manual pulsar mode, the encoder B-phase signal is input to this pin.
33	EXPLS	

28	EMGN	Emergency Stop: input signal to perform the emergency stop for all axes When this signal in on the low level, including the interpolation driving, every axis will stop the operation immediately. The low level pulse width should be more than 2CLK. <b>【Note】</b> For this signal, its logical levels cannot be selected.
48	VDD	+ 5V Power Terminal
50	24V	+ 24V Power Terminal
47	DGND	Ground (0V) Terminal
49	OGND	Ground (0V) Terminal of external 24V

### 3.2 General-purpose Signal Output Connector

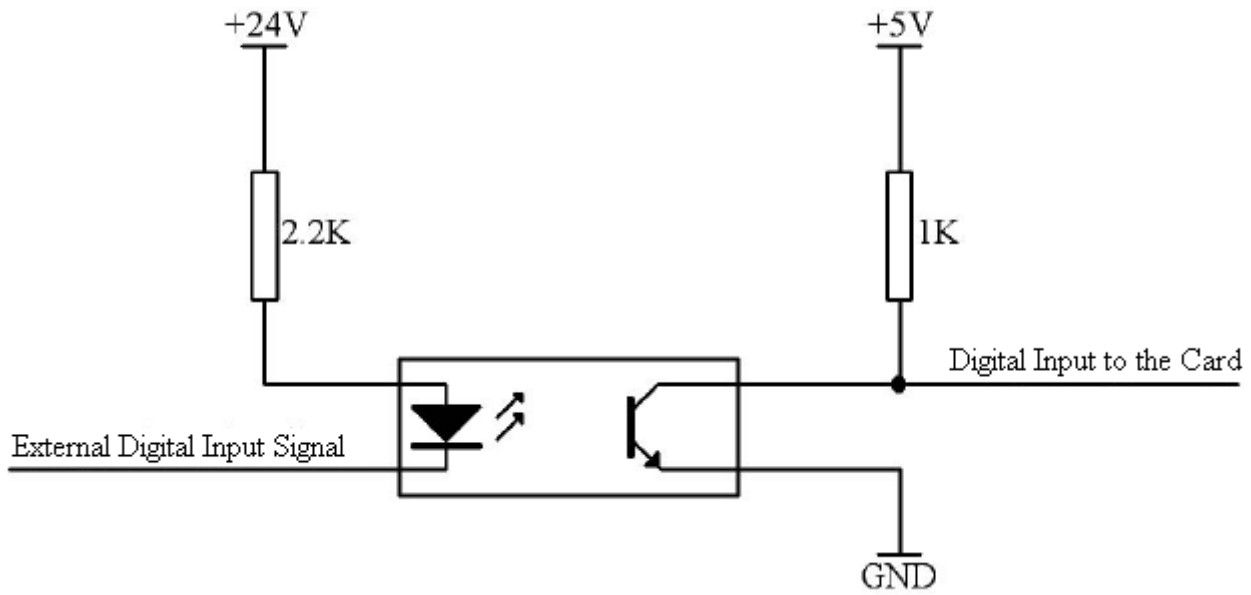


Pin No	Signal Name	Description
1 16 32 31	XDCC YDCC ZDCC UDCC	Drive/Deviation Counter Clear: Drive status output (nDRIVE) and deviation counter clear output (DCC) share the same pin. Drive status display output (nDRIVE) is set to a High level while drive pulses are output. At execution of automatic home search, this signal is set to a High level. The axis with interpolation drive specified is set to a High level while the interpolation driving is executed. The DRIVE signal is set to a High level until nINPOS becomes active, while the nINPOS signal for the serve motor is enabled by mode selection. A deviation counter clear output (DCC) signal is output for a server motor driver. The signal can be output by setting the mode in automatic home search. See Sections 2.5.2 and 2.5.3. At resetting, the drive status display output is set.

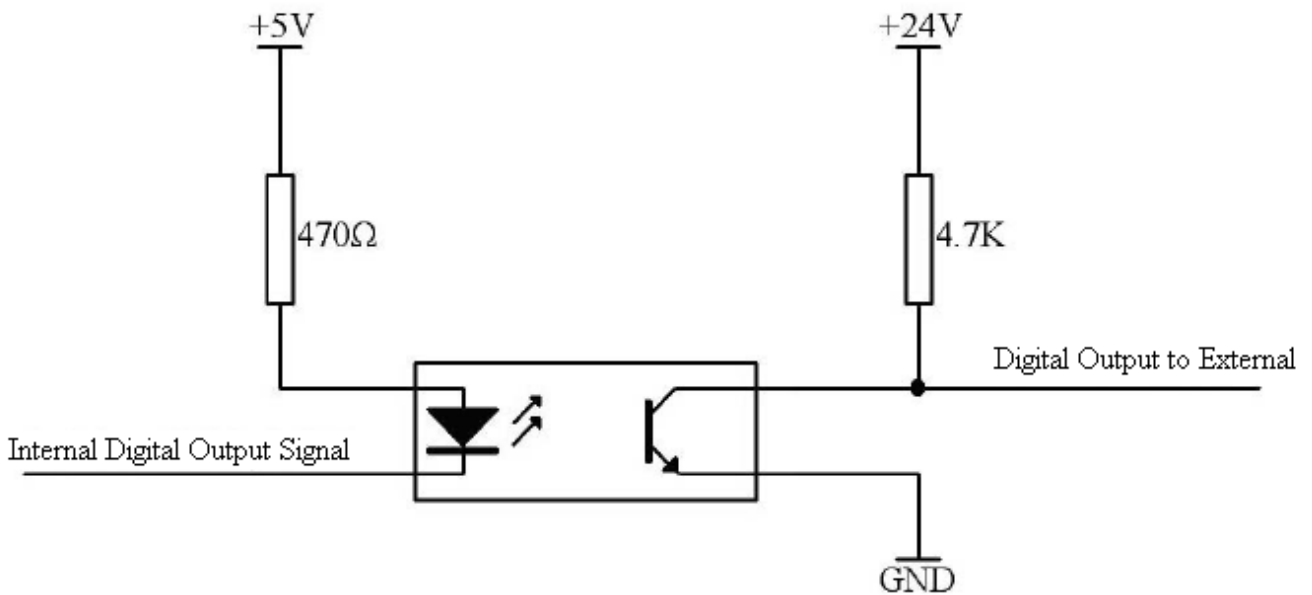
3 5 7	XOUT1 XOUT2 XOUT3	X-axis general purpose output
14 12 10	YOUT1 YOUT2 YOUT3	Y-axis general purpose output
30 28 26	ZOUT1 ZOUT2 ZOUT3	Z-axis general purpose output
29 27 25	UOUT1 UOUT2 UOUT3	U-axis general purpose output
15 2 18 17	XOUT7/DSND YOUT7/DSND ZOUT7/DSND UOUT7/DSND	General Output 7/Descend: general purpose output signals When the drive status output mode is engaged, this signal can be used for reflecting the status of deceleration. While the driving command is executed and during the deceleration, it becomes high
13 4 20 19	XOUT6/ASND YOUT6/ASND ZOUT6/ASND UOUT6/ASND	General Output 6/Ascend: general purpose output signals When the drive status output mode is engaged, this signal can be used for reflecting the status of acceleration. While the driving command is executed and during the acceleration, it becomes high
11 6 22 21	XOUT5/CMPPM YOUT5/CMPPM ZOUT5/CMPPM UOUT5/CMPPM	General Output 5/Compare-: general purpose output signals When the drive status output mode is engaged, it becomes high if the value of logical/real position counter is smaller than that of COMP-; it becomes low if the value of logical/real position counter is larger than that of COMP-.
9 8 24 23	XOUT4/CMPP YOUT4/CMPP ZOUT4/CMPP UOUT4/CMPP	General Output 4/Compare+: general purpose output signals When the drive status output mode is engaged, it becomes high if the value of logical/real position counter is larger than that of COMP+; it becomes low if the value of logical/real position counter is smaller than that of COMP+
33~40	NC	NC

### 3.3 General-purpose Signal Wiring

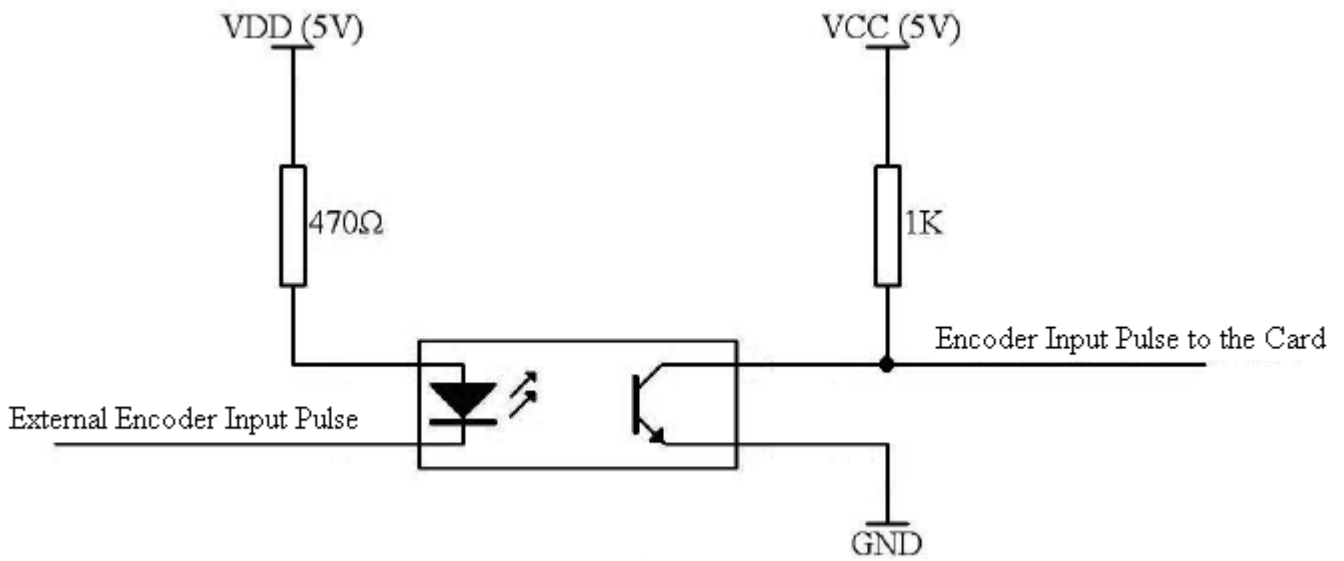
#### 3.2.1 Contact-type Digital Input



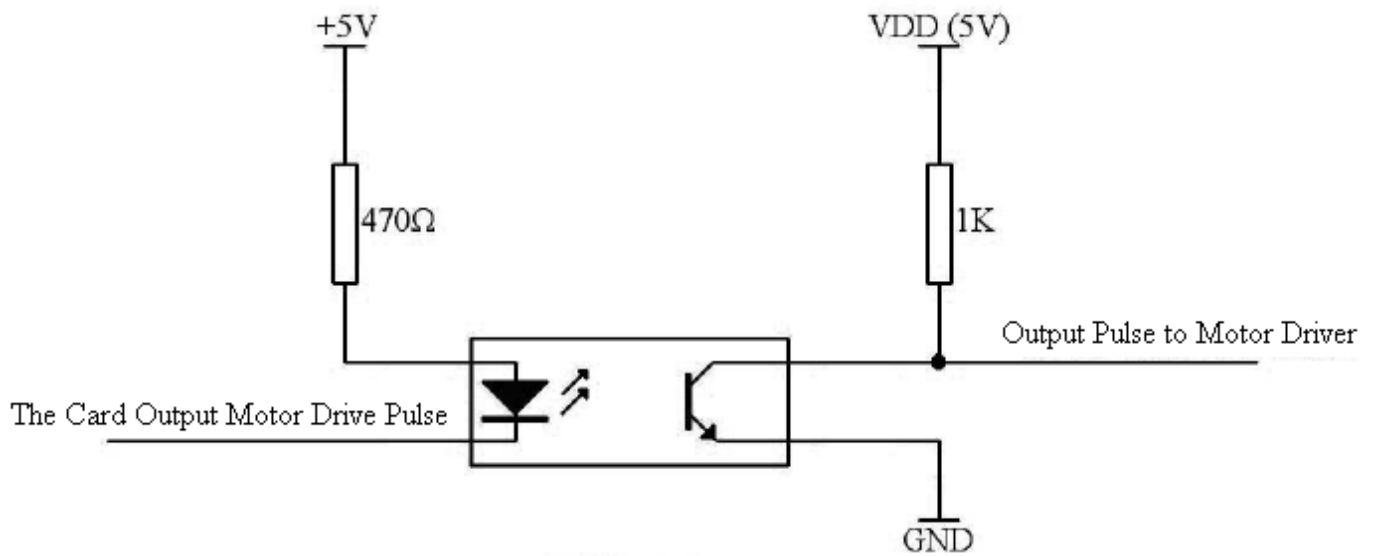
#### 3.2.2 Digital Output



### 3.4 Encoder Input Wiring



### 3.5 Motor Control Output Wiring



# Chapter 4 Brief Introduction

### ◆ 4-axis drive independently

PCI1020 can control four motors movement. Each axis can do fixed speed drive, linear acceleration/deceleration driving, and S-shaped acceleration/deceleration drive. 4-axis performance is the same.

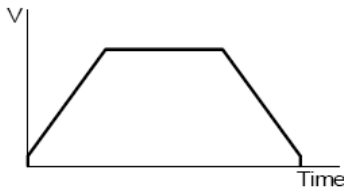
### ◆ Speed Control

The speed range of the pulse output is from 1PPS to 4MPPS for constant speed, trapezoidal or S-shaped acceleration/deceleration driving. Speed accuracy of the pulse output is less than  $\pm 0.1\%$  (at CLK=16MHZ). The speed of driving pulse output can be freely changed during the driving.

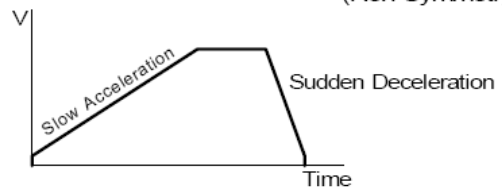
### ◆ Acceleration/deceleration driving

The PCI1020 can control each axis for acceleration/deceleration of constant speed driving, trapezoidal acceleration/deceleration driving (symmetry/non-symmetry), and S-shaped acceleration/deceleration. Automatic acceleration/deceleration of linear acceleration fixed speed pulse driving is available. Since a primary linear increase/decrease method is applied for S-shaped acceleration/deceleration, the speed curve forms a secondary parabola acceleration/deceleration curve. In S-shape acceleration and deceleration fixed pulse driving, automatic deceleration is available for symmetrical S-shaped only and triangle waveforms during S-shaped acceleration/deceleration are prevented by a special method.

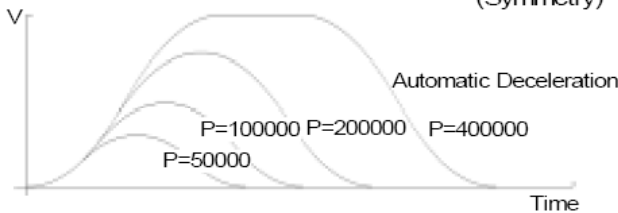
Trapezoidal Acceleration/Deceleration Driving (Symmetry)



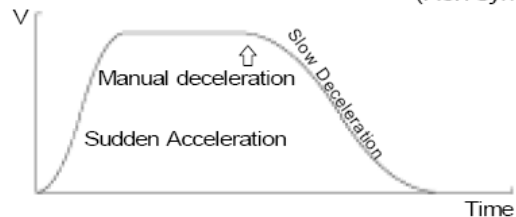
Trapezoidal Acceleration/Deceleration Driving (Non-Symmetry)



Parabola S-curve Acceleration/Deceleration Driving (Symmetry)



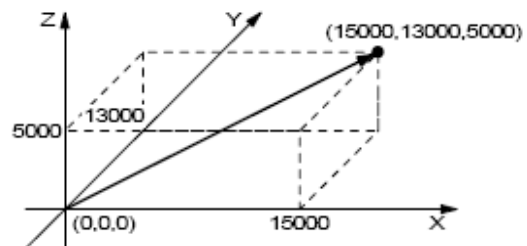
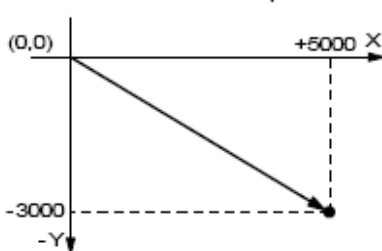
Parabola S-curve Acceleration/Deceleration Driving (Non-symmetry)



### ◆ Linear Interpolation

Any 2 or 3 axes of the 4 axes can be set for linear interpolation. Interpolation coordinates from the current location to -8,388,607 ~ +8,388,607. Resolution of interpolation is within  $\pm 0.5LSB$ .

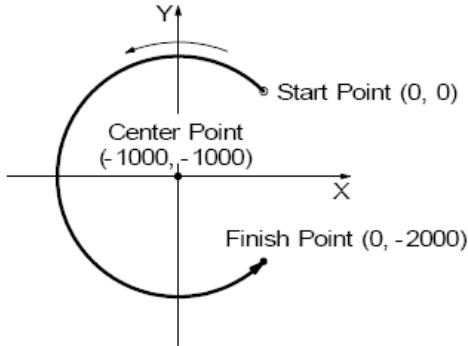
2-axis Linear Interpolation



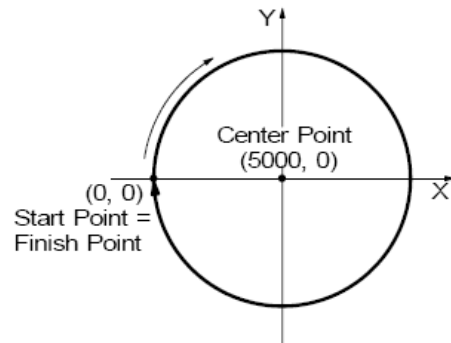
◆ Circular Interpolation

Any 2 axes can be selected to perform circular interpolation. The position boundary is between coordinates  $-2,147,483,646$  and  $+2,147,483,646$  (signed 32-bit format), and the positioning error is within  $\pm 1.0$  LSB. The interpolation speed range is from 1 PPS to 4 MPPS.

CCW Circular Interpolation (Any circle)



CW Circular Interpolation (Full circle)

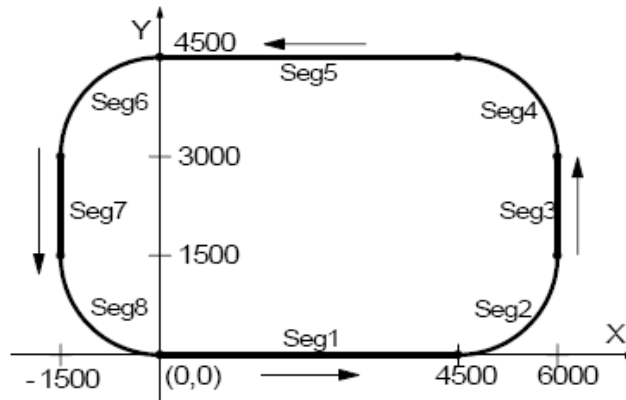


◆ The Bit Pattern Interpolation

This interpolation driving receives, for each axis in 16-bit units, interpolation data that was converted to bit patterns through the operation by the upper-level CPU and outputs interpolation pulses consecutively at the specified drive speed. This function enables drawing of various loci created by the upper-level CPU.

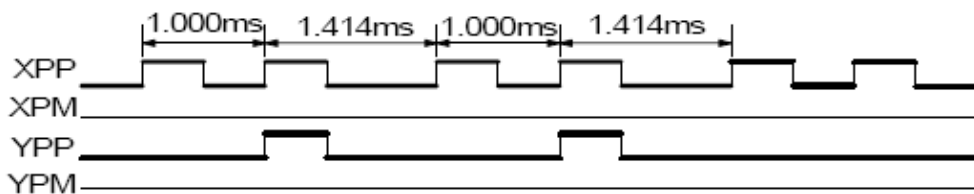
◆ Continuous Interpolation

Different interpolation methods can be used continuously, linear interpolation  $\rightarrow$  circular interpolation  $\rightarrow$  linear interpolation .... The maximum drive speed of performing continuous interpolation is 2 MHz.



◆ Constant Vector Speed Control

This function performs a constant vector speed. During the interpolation driving, PCI1020 as can set a 1.414 times pulse cycle for 2-axis simultaneous pulse output, and a 1.732-time pulse cycle for 3-axis simultaneous pulse output.



Example of Pulse Output of 2-Axis Interpolation Constant Vector Speed (Vector speed: 1000pps)



◆ Position Control

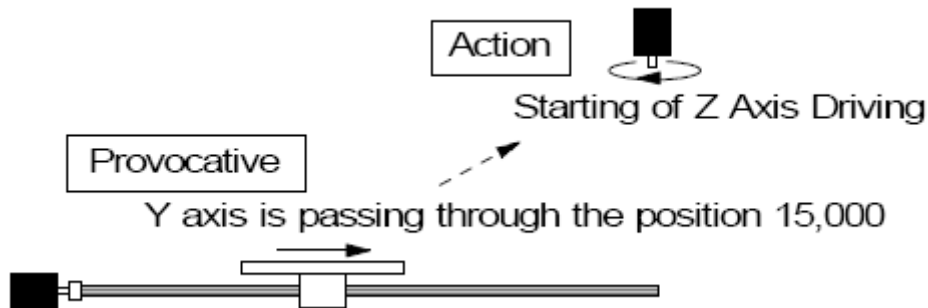
For each axis, there are two 32 bit up-and-down counters for counting present positions and two comparison registers for comparing the present positions.

◆ Compare Register and Software Limit

Each axis has two 32-bit registers which can compare the logical positions with the real positions. The main function of COMP+ Register is to check out the upper limit of logical/real position counter.

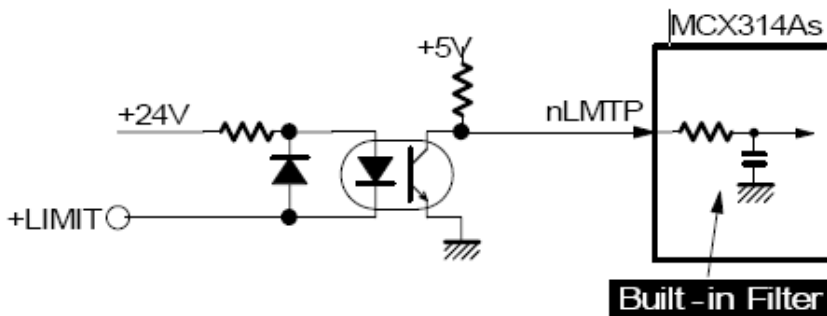
◆ Synchronous action

The synchronous action is a function that performs a specified action such as starting or stopping of driving when an activation factor (provocative) occurs within each axis, between two axes, or with a device outside of IC by linking with a provocative. Ten types of provocatives are available including the passing of the specified position, the starting/stopping of driving, and rising/falling of an input signal. Four types of actions are available, including starting/stopping of driving, saving a position counter value, writing of a drive speed, and so on.



◆ Input Signal Filter

The PCI1020 is equipped with an integral type filter in the input stage of each input signal. it is possible to set whether the filter function is enabled or the signal is passed through for a number of input signals. At reset, all the bits in the extension mode are cleared to 0 so that the filter function is disabled for all the input signals and the signals pass.



◆ Driving by External Signal

It is possible to control each axis by external signals. The +/- direction fixed pulse driving and continuous pulse driving can be also performed through the external signals. This function is used for JOG or teaching modes, and will share the CPU load.

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◆ Servo Motor Feedback Signals

Each axis includes input pins for servo feedback signals such as in-positioning. An output signal for clearing a deviation counter is also available.

◆ Interrupt Signals

Interrupt signals can be generated when: (1). the start/finish of a constant speed drive during the acceleration/deceleration driving, (2). the end of driving, and (3). the compare result once higher/lower the border-lines of the position counter range. An interrupt signal can be also generated during the interpolation driving.

◆ Real Time Monitoring

During the driving, the present status such as logical position, real position, drive speed, acceleration / deceleration, status of accelerating / decelerating and constant driving can be read.

# Chapter 5 The Description of Functions

## 5.1 Pulse Output Command

There are two kinds of pulse output commands: fixed driving output and continuous driving output.

### 5.1.1 Fixed Driving Output

When host CPU writes a pulse numbers into PCI1010 for fixed driving and configures the performance such as acceleration / deceleration and speed, PCI1010 will generate the pulses and output them automatically. Fixed driving operation is performed at acceleration/deceleration, as shown in Fig. 5.1, automatic deceleration starts when the number of pulses becomes less than the number of pulses that were utilized at acceleration, and driving terminates at completion of the output of the specified output pulses.

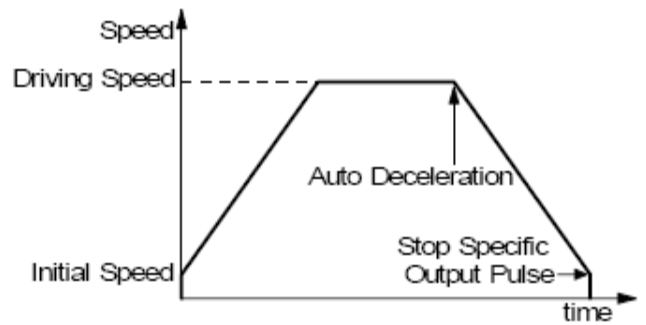


Fig. 5.1 Fixed Driving

#### ◆ Changing the Number of Output Pulse in Driving

The number of output pulse can be changed in the fixed driving. If the command is for increasing the output pulse, the pulse output profile is shown as Fig. 5.2 or 5.3. If the command is for decreasing the output pulses, the output pulse will be stopped immediately as shown in Fig. 5.4. Furthermore, when in the S-curve acceleration/deceleration driving mode, the output pulse number change will occur to an incomplete deceleration S-curve.

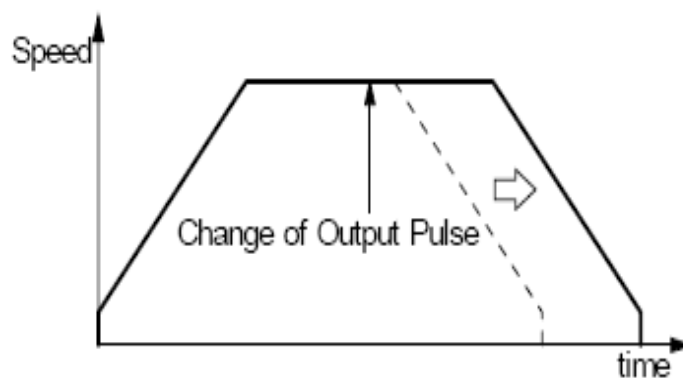


Fig. 5.2 Change of Output Pulse Number in Driving

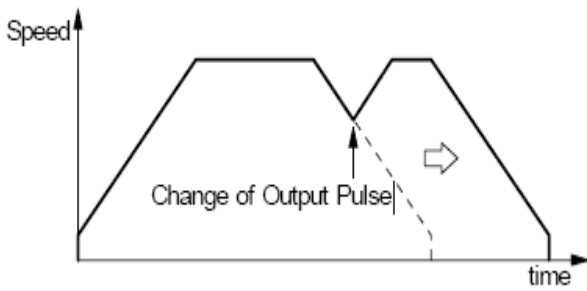


Fig. 5.3 Change the Number of Output Pulse during Deceleration

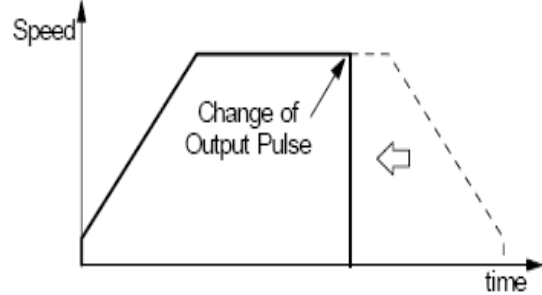


Fig. 5.4 Change the Pulse Number Less Than Output Pulse Number

◆ Manual Setting Deceleration for fixed pulse Acceleration/Deceleration Driving

As shown in Fig. 5.1, generally the deceleration of fixed pulse acceleration /deceleration driving is controlled automatically by PCI1020. However, in the following situations, it should be preset the deceleration point by the users.

- The change of speed is too often in the trapezoidal fixed pulse acceleration/deceleration driving.
- Set an acceleration, a deceleration, an jerk (acceleration increasing rate), and deceleration increasing rate individually for S-curve deceleration fixed pulse driving.
- When use circular interpolation, bit pattern interpolation and continuous interpolation for acceleration and deceleration.

◆ Changing a Drive speed During Driving

In fixed pulse driving under linear acceleration at a constant speed, a drive speed (V) can be changed during driving. However, if a speed of fixed pulse driving is changed at linear acceleration, some premature termination may occur. Therefore, caution is necessary when using the PCI1020 by setting a low initial speed. A drive speed (V) cannot be changed during fixed pulse driving in S-curve deceleration.

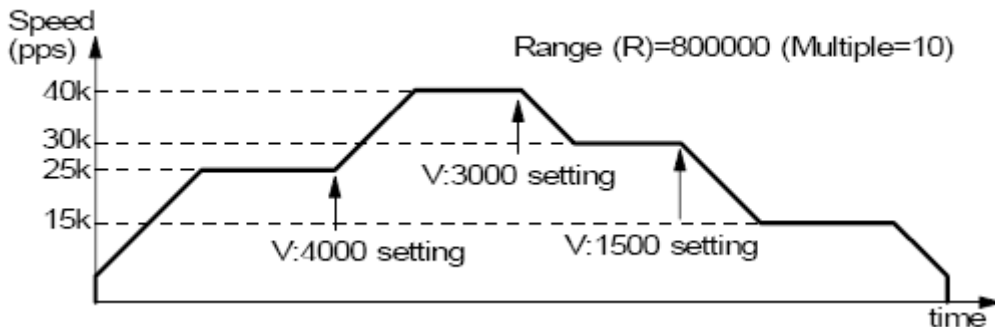


Fig. 5.5 Example of Drive Speed Change During Driving

◆ Offset Setting for Acceleration/Deceleration Driving

The offset function can be used for compensating the pulses when the decelerating speed does not reach the setting initial speed during the S-curve fixed pulse driving. MCX314As will calculate the acceleration/deceleration point automatically, and will arrange the pulse numbers in acceleration equal to that in deceleration. The method is calculating the output acceleration pulses and comparing them with the remaining pulses. When the remaining pulses are equal to or less the pulses in acceleration, it starts the deceleration.

When setting the offset for deceleration, PCI1020 will start deceleration early for the offset. The greater is the positive value set for the offset, the closer the automatic declaration point becomes, increasing the creep pulses at the initial speed

at deceleration termination. If a negative value is set for the offset value, output may stop prematurely before the speed reaches the initial speed (see Fig. 5.6).

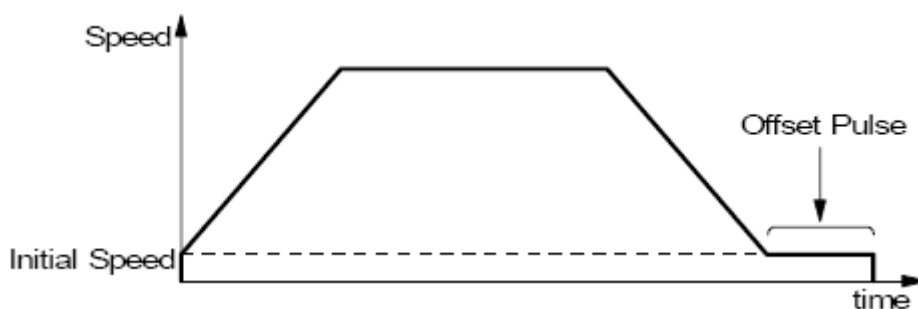


Fig. 5.6 Offset for Deceleration

### 5.1.2 Continuous Pulse Driving Output

When the Continuous Pulse Driving is performed, PCI1020 will drive pulse output in a specific speed until stop command or external stop signal is happened. The main application of continuous pulse driving is: home searching, teaching or speed control. The drive speed can be changed freely during continuous pulse driving.

Two stop commands are for stopping the continuous driving. One is “decelerating stop”, and the other is “sudden stop”. Four input pins, IN3~IN0, of each axis can be connected for external decelerating and sudden stop signals. Enable/disable, active levels and mode setting are possible.

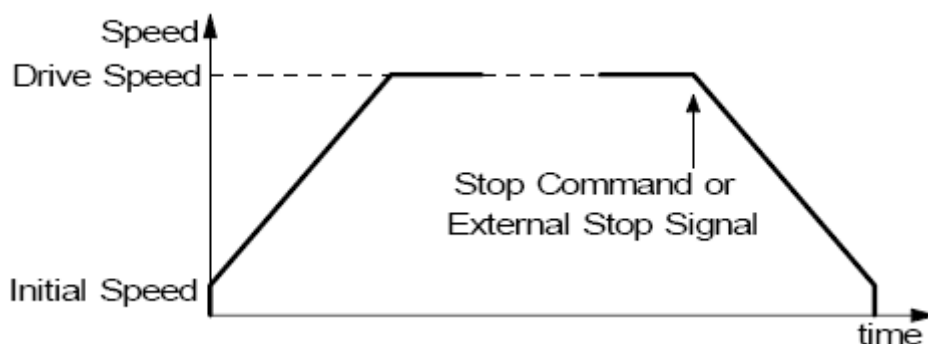


Fig. 5.7 Continuous Pulse Driving

## 5.2 Acceleration and Deceleration

Basically, driving pulses of each axis are output by a fixed pulse driving command or a continuous pulse driving command of the + direction or – direction. These types of driving can be performed with a speed curve of constant speed, linear acceleration, non-symmetrical linear acceleration, S-curve acceleration/deceleration, or non-symmetrical S-curve acceleration/deceleration according to the mode that is set or the operation parameter value.

### 5.2.1 Constant Speed Driving

When the drive speed set in PCI1020 is lower than the initial speed (or a speed higher than the drive speed is set as the initial speed), the acceleration/deceleration will not be performed, instead, a constant speed driving starts.

If the user wants to perform the sudden stop when the home sensor or encoder Z-phase signal is active, it is better not to perform the acceleration/deceleration driving, but the low-speed constant driving from the beginning.

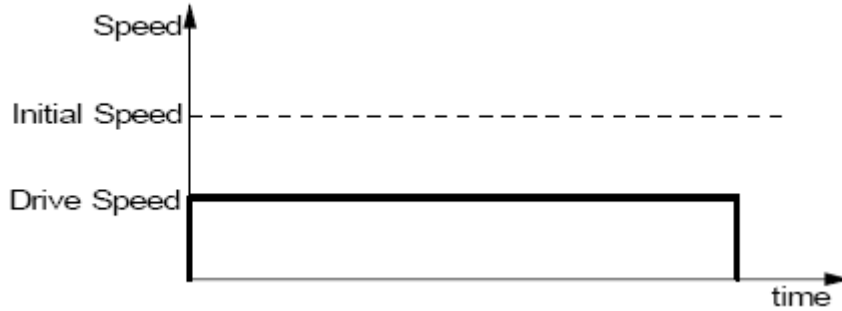


Fig. 5.8 Constant Speed Driving

### 5.2.2 Trapezoidal Driving [Symmetrical]

In linear acceleration driving, the drive speed accelerates in a primary linear form with the specified acceleration slope from the initial speed at the start of driving. When the acceleration and the deceleration are the same (symmetrical trapezoid) in fixed pulse driving, the pulses utilized at acceleration are counted. When the remaining number of output pulses becomes less than the number of acceleration pulses, deceleration starts. Deceleration continues in the primary line with the same slope as that of acceleration until the speed reaches the initial speed and driving stops, at completion of the output of all the pulses (automatic deceleration).

When the decelerating stop command is performed during the acceleration, or when the pulse numbers of the fixed pulse drive do not reach the designated drive speed, the driving will be decelerating during acceleration, as show in Fig. 5.9. By setting a triangle prevention mode, such triangle form can be transformed to a trapezoid form even if the number of output pulses low.

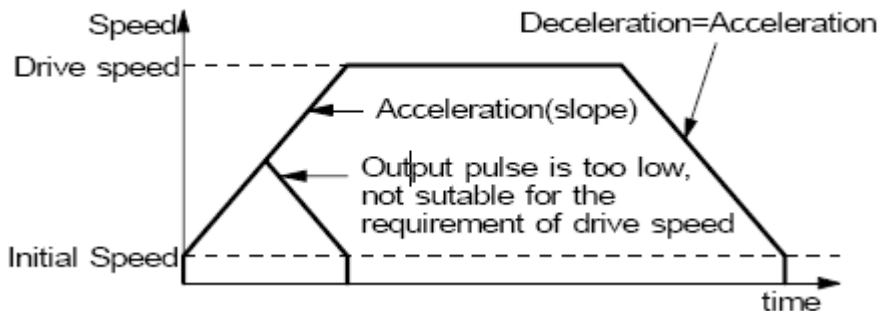


Fig. 5.9 Trapezoidal Driving (Symmetrical)

### 5.2.3 S-curve Acceleration/Deceleration Driving

This card creates an S curve by increasing/reducing acceleration/decelerations in a primary line at acceleration and deceleration of drive speed.

Figure 5.10 shows the operation of S-curve acceleration/deceleration driving where the acceleration and the deceleration are symmetrical. When driving starts, the acceleration increases on a straight line at the specified jerk (K). In this case, the speed data forms a secondary parabolic curve (section a). If the difference between the specified drive speed (V) and the current speed becomes less than the speed that was utilized at the increase of acceleration, the acceleration starts to decrease towards 0. The decrease ratio is the same as the increase ratio and the acceleration decreases in a linear form of the specified jerk (K). In this case, the rate curve forms a parabola of reverse direction (section b).

The speed reaches the specified drive speed (V) or the acceleration reaches 0, the speed is maintained (section c). In fixed pulse driving of S-curve acceleration/deceleration where acceleration and deceleration are symmetrical, deceleration starts when the number of remaining output pulses becomes less than the number of pulses that were utilized. At the deceleration also, the speed forms an S curve by increasing/decreasing the deceleration in a primary linear form (sections d and e). The same operation is performed in acceleration/deceleration where the drive speed is changed during continuous pulse driving.

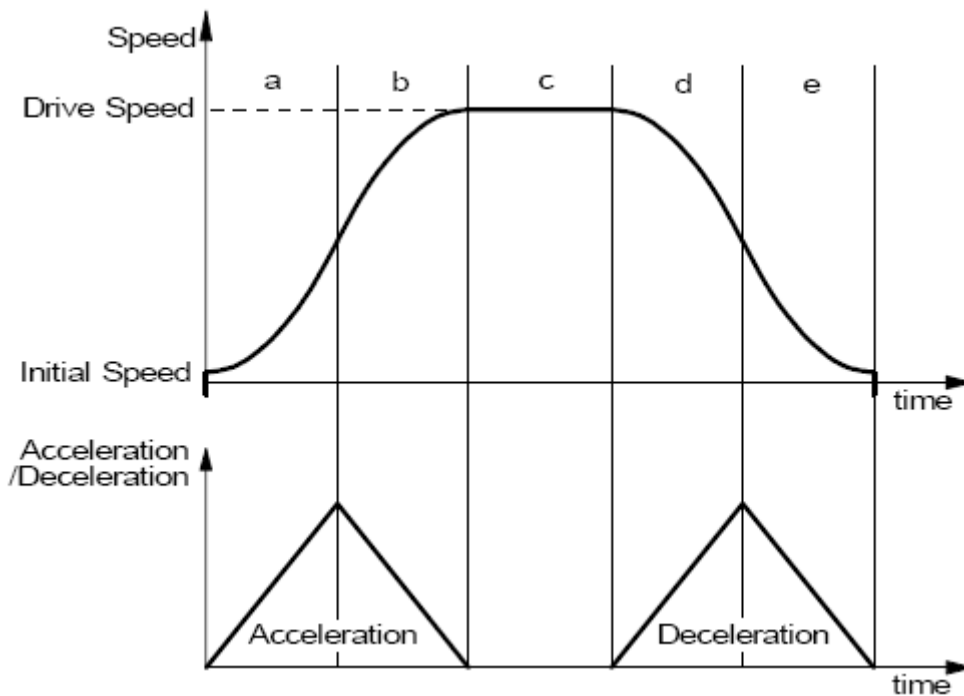


Fig. 5.10 Symmetrical S-Curve Acceleration/Deceleration Driving

### 5.3 Position Control

Fig 5.11 is 1-axis position control block diagram. For each axis, there are two 32 bit up-and-down counters for counting present positions and two comparison registers for comparing the present positions.

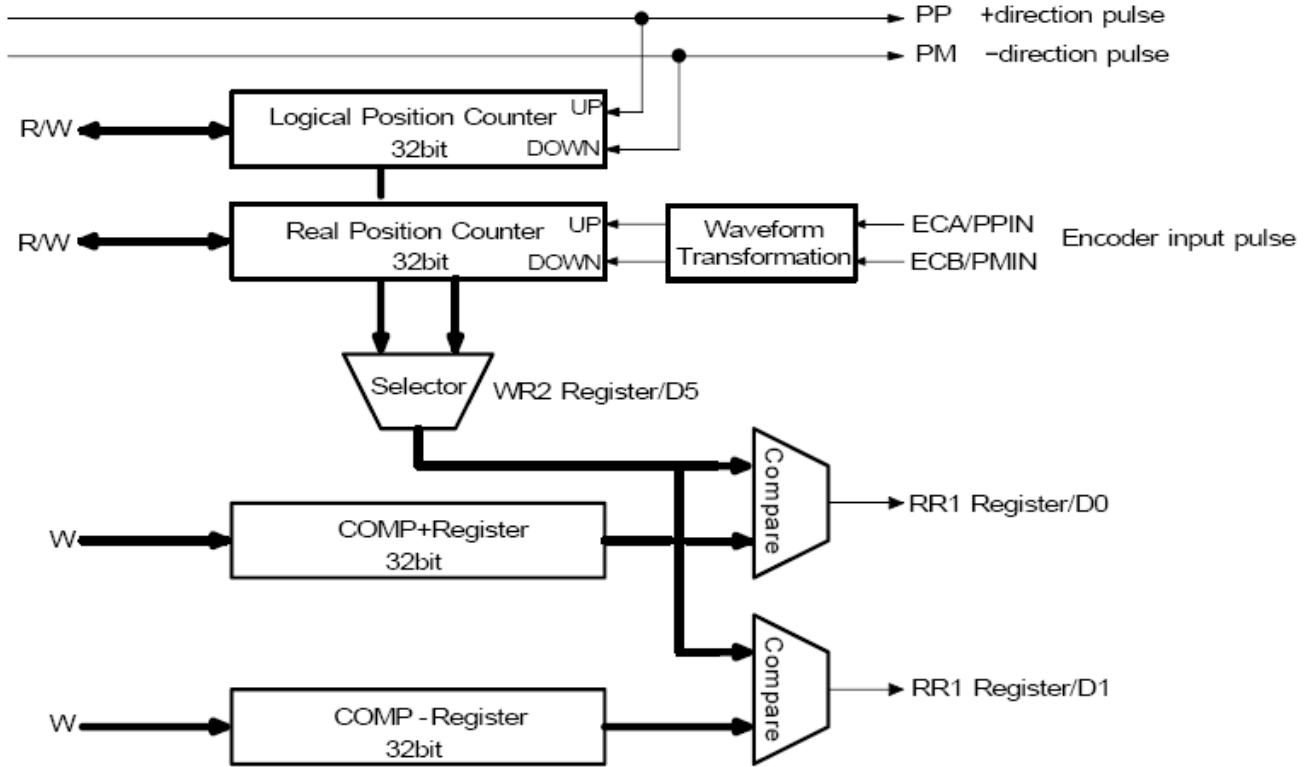


Fig. 5.11 Position Control Block Diagram

#### 5.3.1 Logic Position Counter and Real position Counter

As shown in Fig. 5.11, the logic position counter is counting the driving pulses in PCI1020. When one + direction plus is outputting, the counter will count-up 1; when one - direction pulse is outputting, the counter will count-down 1. The real position counter will count input pulse numbers from external encoder. The type of input pulse can be either A/B quadrature pulse type or Up/Down pulse (CW/CCW) type.

Host CPU can read or write these two counters any time. The counters are signed 32 bits, and the counting range is between -2,147,483,648 ~ + 2,147,483,647. The negative is in 2's complement format. The counter value is random while resetting.

#### 5.3.2 Compare Register and Software Limit

Each axis has, as shown in Fig.5.11, two 32-bit registers which can compare the logical positions with the real positions. The logical position and real position counters are selected by bit D5 (CMPSL) of register WR2. The main function of COMP+ Register is to check out the upper limit of logical/real position counter. When the value in the logical/real position counters is larger than that of COMP+ Register, bit D0 (CMP+) of register RR1 will become 1. On the other



hand, COMP- Register is used for the lower limit of logical/real position counter. When the value of logical/real position counter becomes smaller than hat of COMP+ Register, bit D1 (CMP-) of register RR1 will become 1.

### 5.4 Interpolation

This 4-axis motion control card can perform any 2/3 axes linear interpolation, any 2 axes circular interpolation and any 2/3 axes bit pattern interpolation.

The maximum drive speed is 4MPPS for linear, circular or bit pattern interpolation. For continuous interpolation, the maximum drive speed is 2MPPS.

#### In-position Signal for Servo Motor

During the interpolation driving, when the in-position signal (nINPOS) of each driving axis is active, and also when the interpolation is finished, the INPOS signal of the axis is stand-by at its active level.

#### 5.4.1 Linear Interpolation

Any 2 or 3 axes of the 4 axes can be set for linear interpolation. To execute the linear interpolation, the user can, according to the present point coordinates, set the finish point coordinates and the interpolation segment(s) for 2 or 3 axes. Fig. 5.12 shows an example of axis interpolation where linear interpolation is performed from the current coordinates to the finish point coordinates. For individual axis control, the command pulse number is unsigned, and it is controlled by + direction command or - direction command. For interpolation control, the command pulse number is signed. The resolution of linear interpolation is within ±0.5 LSB, as shown in Fig. 5.12.

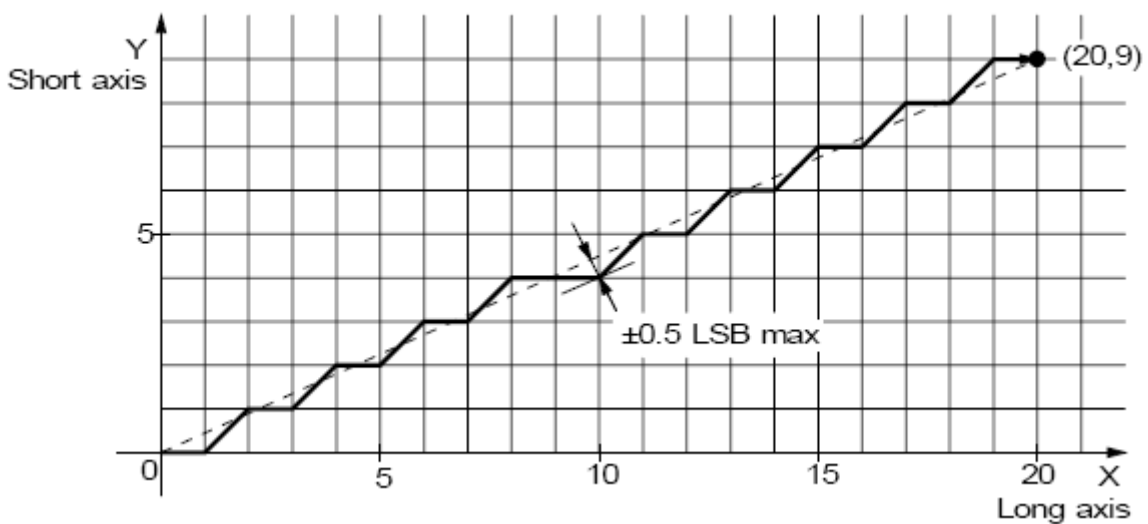


Fig. 5.12 The Position Accuracy for Linear Interpolation

As shown in Fig. 5.13, it is an example for pulse output of the linear interpolation driving. We define the longest distance movement in interpolation is the “long axis”. And the other is “short axis”. The long axis outputs an average pulse train. The driving pulse of the short axis depends on the long axis and the relationship of the two axes.

The range for each axis is a 32-bit signed counter, from -2,147,483,648 ~ + 2,147,483,647 (signed 32-bit-2LSB).

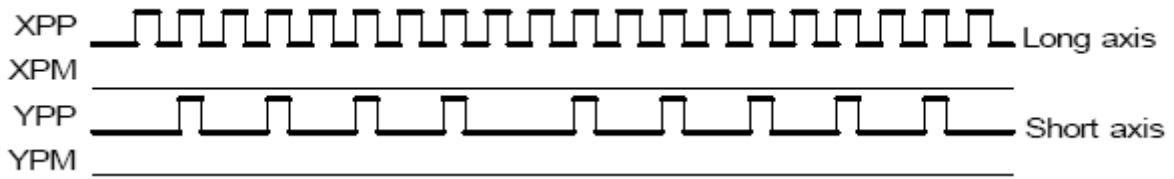
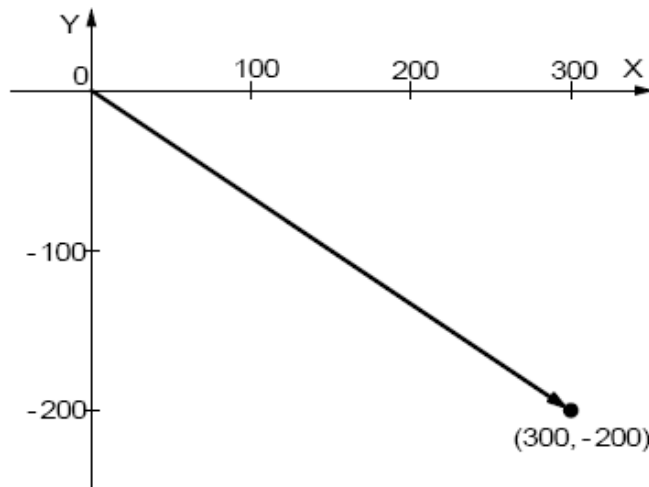


Fig. 5.13 The Example for Pulse Output at Finish Point (X=20, Y=9)

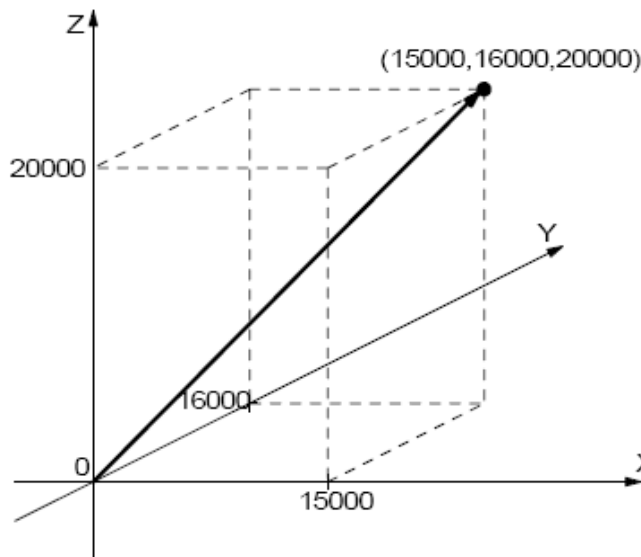
### The example of linear interpolation for 2 axes

Executing linear interpolation drives in X and Y axes from the current position to the finish position (X: +300, Y: -200). The interpolation drive speed is constant: 1000PPS.



### The example of linear interpolation for 3 axes

Executing linear interpolation drive for X, Y and Z axes from the current position to the finish position (X: 15,000, Y: 16,000, Z: 20,000). The initial speed = 500PPS, acceleration/deceleration = 40,000PPS/SEC, drive speed = 5,000PPS.



### 5.4.2 Circular Interpolation

Any 2 axes of the 4 axes can be selected for circular interpolation. The circular interpolation is starting from the current position (start point). After setting the center point of circular, the finish position and the CW or CCW direction, the user can start the circular interpolation.

Note: The coordinates setting value is the relative value of the start point coordinates.

In Fig. 5.14, it explains the definition of CW and CCW circular interpolations. The CW circular interpolation is starting from the start point to the finish position with a clockwise direction; the CCW circular interpolation is with a counter-clockwise direction. When the finish point is set to (0, 0), a circle will come out.

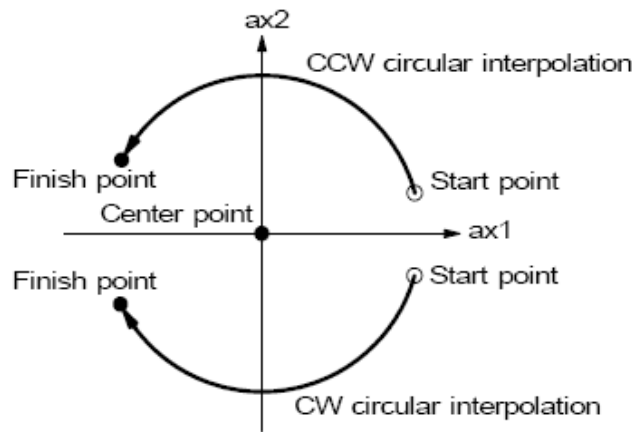


Fig. 5.14 CW/CCW Circular Interpolation

In Fig. 5.15, it explains the long axis and the short axis. First, we define 8 quadrants in the X-Y plane and put the numbers 0~7 to each quadrant. We find the absolute value of ax1 is always larger than that of ax2 in quadrants 0, 3, 4 and 7, so we call ax1 is the long axis (ax2 is the short axis) in these quadrants; in quadrants 1, 2, 5 and 6, ax2 is the long axis (ax1 is the short axis). The short axis will output pulses regularly, and the long axis will output pulses depending on the interpolation calculation.

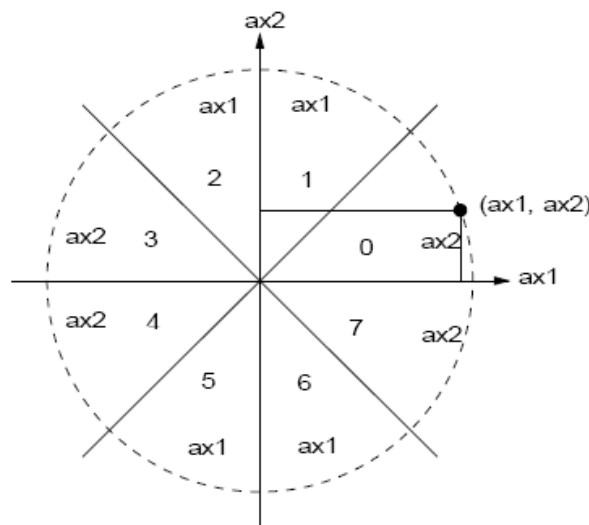


Fig. 5.15 The 0-7 Quadrants and Short

The specifiable range of coordinates of the center point and coordinates of the finish point are from  $-2,147,483,646$  to  $+2,147,483,646$  (signed 32-bit - 2LSB). The position tolerance for the specified circular curve is  $\pm 1$  within the entire interpolation range. The interpolation speed is within the range from 1PPS to 4MPPS.

**The Finish Point Checking of Circular Interpolation**

In the circular interpolation, it assumes that the current position (start point) is (0, 0). After the coordinates of the center point is set, the radius will be decided, and the circular tracking will start. The maximum error range of interpolation is within  $\pm 1$ LSB. Because of the  $\pm 1$ LSB error range, the designated finish point may not be on the circular track. When the value of finish point is same as that of short axis, this circular interpolation is finished. Fig. 5.16 shows an example of CCW interpolation with the start point (0, 0), center point (-200,500) and finish point (-702, 299). The finish point is in quadrant 4, and ax2 is the short axis in quadrant 4. So the interpolation is finished when the ax2 is 299.

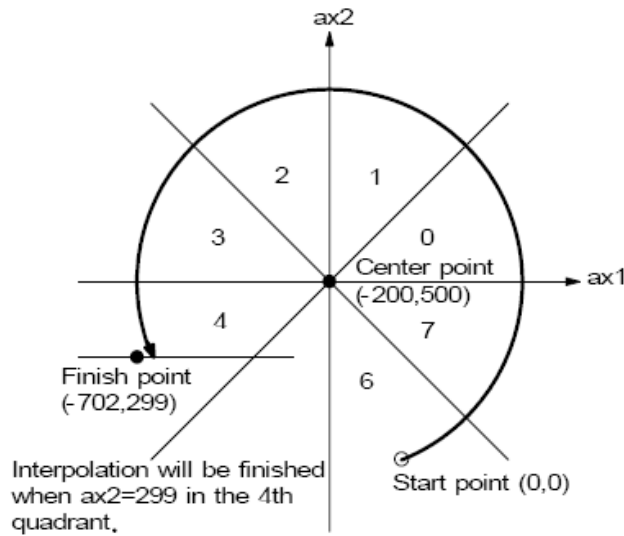
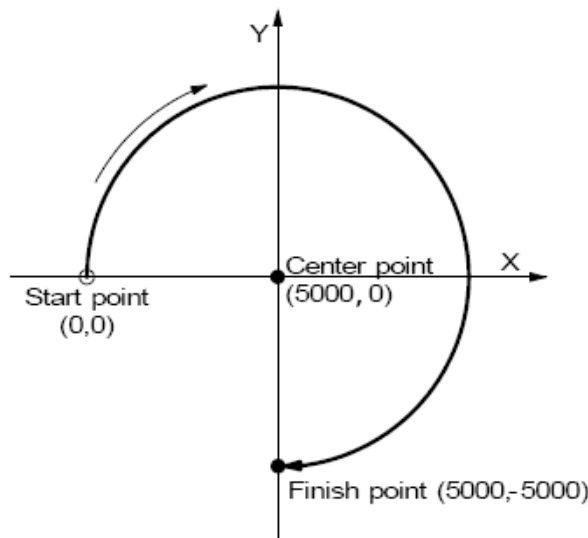


Fig. 5.16 Example of the Finish Point Checking of Circular Interpolation

**The Example for CW Circular Interpolation**

This CW circular interpolation starts from the current point (start point: 0, 0) to the finish point (X: 5000, Y: -5000); the center point is X: 5000, Y: 0. The interpolating speed is constant at 1000PPS in a constant vector speed driving.



### 5.4.3 The Bit Pattern Interpolation

This interpolation driving receives interpolation data that is created by upper-level CPU and transformed to bit patterns in a block of a predetermined size, and outputs interpolation pulses consecutively at the specified drive speed.

Every axis has 2 bit-data buffers for host CPU: one for + direction and the other for - direction. When performing the bit pattern interpolation, the host CPU will write the designated interpolation data, for 2 or 3 axes, into PCI1020.

If a bit in the bit pattern data from CPU is “1”, PCI1020 will output a pulse at the time unit; if it is “0”, PCI1020 will not output any pulse at the time unit.

For example, if the user want to generate the X-Y profile (see Fig. 5.17), the host CPU must write a set of pattern into those specific registers ---- XPP: the + direction register for X axis, XPM: the - direction register for X axis, YPP and YPM: the + and - directions registers. With in the time unit, PCI1020 will check the registers once and decide to output a pulse or not depending on the bit pattern.

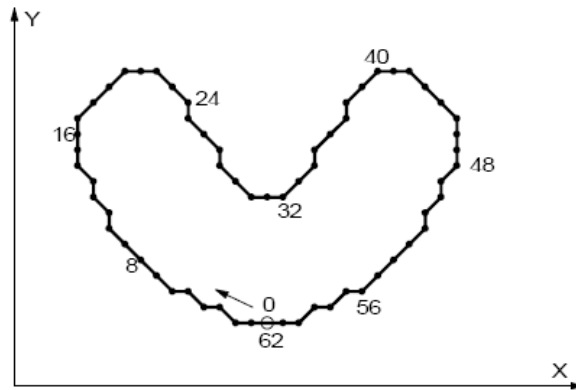


Fig. 5.17 Example for Bit Pattern Interpolation

### 5.4.4 Constant Vector Speed

PCI1020 is with the constant vector speed control function which can control the resultant speed of two axes to keep the speed in constant.

Fig. 5.18 shows the profile of 2 axes interpolation driving. The vector speed reflects 1.414 times of the individual axis drive speed. So, we have to set the speed of 1.414 times to keep the vector speed for 2-axis driving.

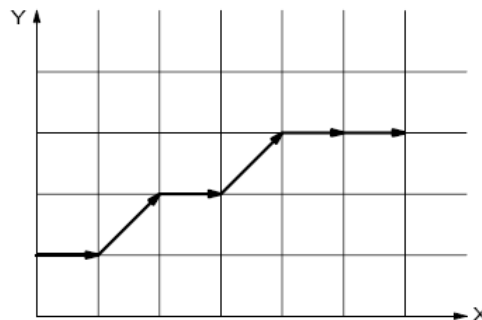


Fig. 5.18 Example of 2 -Axis Interpolation

### 5.4.5 Continuous Interpolation

The continuous interpolation is executing a series of interpolation processes such as linear interpolation → circular interpolation → linear interpolation → ...

During the continuous interpolation, the driving will not stop; contrarily, the pulses are output continuously. When executing the continuous interpolation, the host CPU has to write the next interpolation segment into PCI1020 before the previous interpolation segment is finished.

#### Attentions for Continuous Interpolation

- a. Before setting the interpolation segment, the user should first set other data such as center point, finish point... for each segment.
- b. The maximum speed for the continuous interpolation is 2MHz.
- c. The following interpolation segment must be loaded before the previous interpolation segment is finished.
- d. The segment driving time should be longer than the time for error checking and the command setting of next segment during the interpolation.
- e. It is impossible to operate 2-axis and 3-axis continuous interpolations at the same time.
- f. It is not allowed to change the axis assignment during the process of continuous interpolation.
- g. In continuous interpolation, if one of 2/3 axes is 0, interpolation is performed correctly, otherwise, 0 cannot be set to the finish point of all axes in 2/3 axes linear interpolation, or to the center point of both axes in circular interpolation, any axis cannot set the data that drive pulse is not output. If suchlike data it set, interpolation cannot be performed correctly.

#### The Example of Continuous Interpolation

Fig. 5.19 shows an example of executing continuous interpolation beginning at point (0, 0) from segment 1, 2, 3...to the segment8. In segment 1, 3, 5, and 7, the linear interpolation will be executed; in segment 2, 4, 6, and 8, the circular interpolation will be executed, and the track is a quadrant circle with radius 1500. The interpolation driving is at a constant vector speed: 1000PPS.

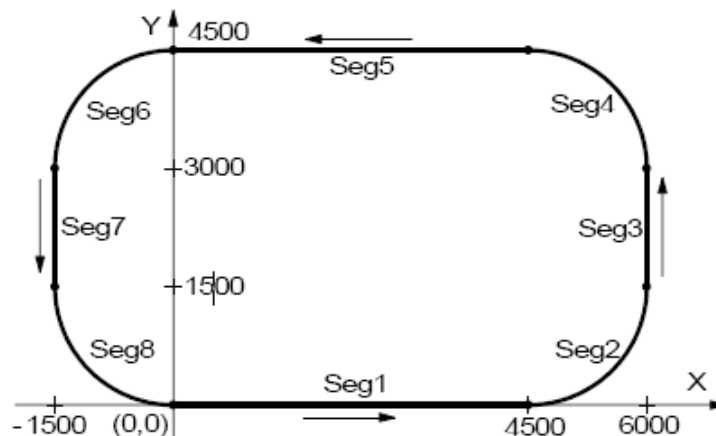


Fig. 5.19 The Example of Continuous Interpolation Axis

### 5.4.6 Single-step interpolation (from Command or External Signal)

Single-step is defined as: pulse by pulse outputting. Either command or external signal can execute the single-step interpolation. When one pulse is outputting, the master axis interpolation will be set in the constant speed driving.

## 5.5 Synchronous Action

Synchronous action of this card performs actions such as starting and stopping of driving within each axis and between axes in card and between card and an external device. For instance, the following actions can be performed.

Example 1 Starts driving of the Z axis after the Y axis passes the position 15,000.

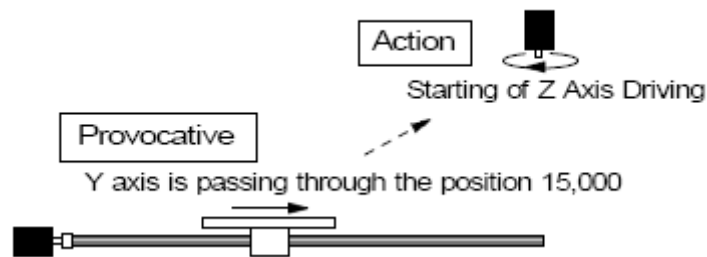


Fig. 5.20 Example of a synchronous action

Normally, such synchronous actions can be performed by coding a program on the CPU side. However, this function is useful when no delay by CPU software execution time is allowed. The synchronous action of this card is a function that executes a specified action immediately when a specified activation factor occurs. This linked action is performed without CPU intervention, achieving high-precision synchronization.

Figure 5.21 shows the flow of synchronous action of the X axis in card. If the activation factor that was set to enable becomes active among the ten types of activation factors of the X axis, the action that is set to enable starts immediately. When other axis activation is enabled, the actions of the other axis that are enabled are also executed simultaneously by the X axis activation factor.

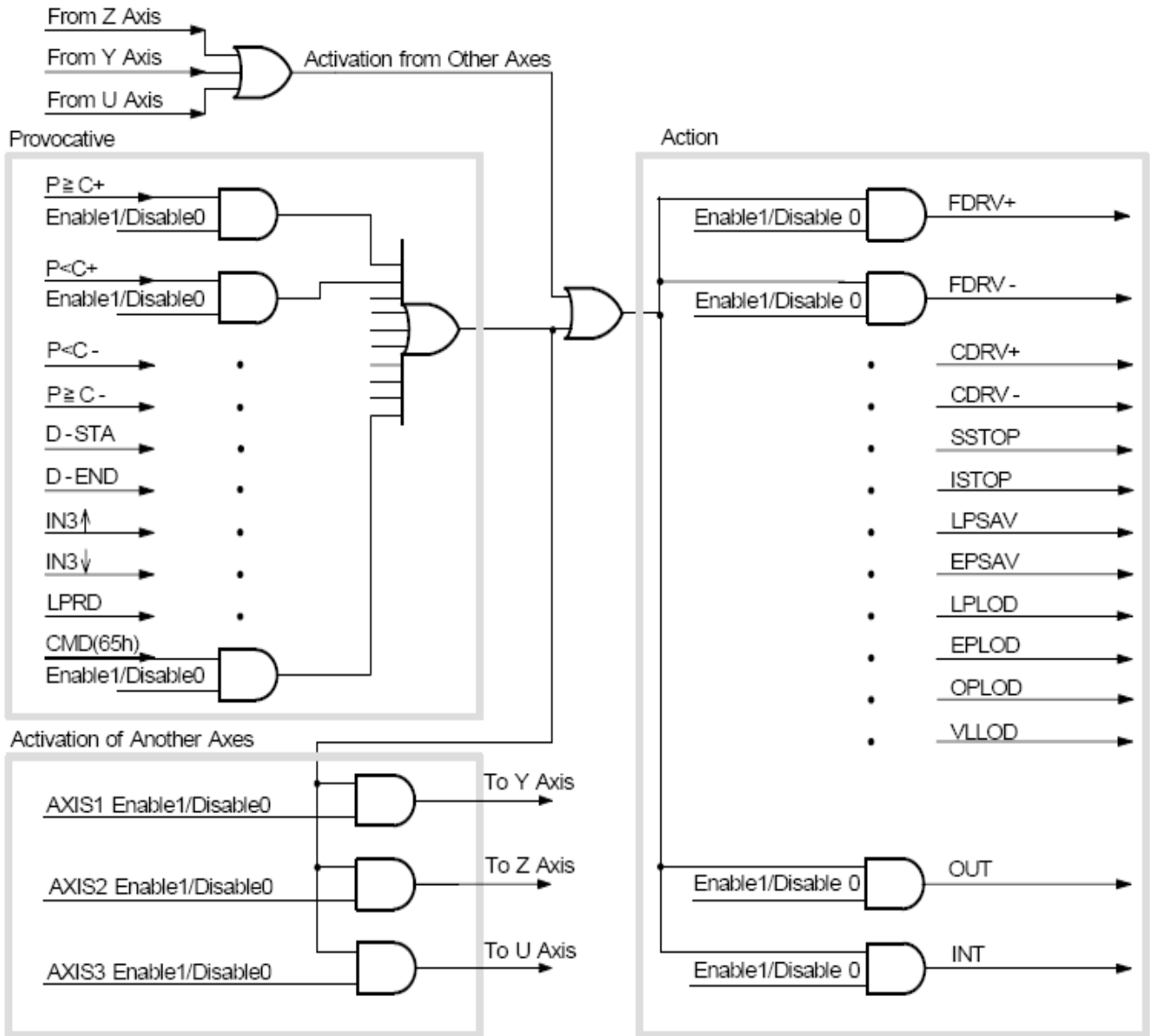


Fig. 5.21 Flow of Synchronous Action (X axis)

## 5.6 Interrupt

The interrupt is generated from X, Y, Z, or U axis, bit pattern interpolation or continuous interpolation. Every interrupt can be enabled or disabled individually. When resetting, all interrupt signals are disabled.

### Interrupt of X, Y, Z, and U Axes

The following table shows the interrupt factors generated by X, Y, Z, and U axes.

Status	The Factors of Interrupt Happening
PULSE	When one pulse outputs... (The interrupt will be generated at the rising edge of pulse output for + direction driving.)
$P \geq C-$	Once the value of logical/real position counter is larger than or equal to the value of COMP-



	register (CM)...
P<C-	Once the value of logical/real position counter is smaller than the value of COMP- register (CM)...
P<C+	Once the value of logical/real position counter is larger than the value of COMP+ register (CM)...
P≥C+	Once the value of logical/real position counter is smaller than or equal to the value of COMP+ register (CM)...
C-END	In the acceleration/deceleration driving, when the driving changes from the constant speed region into the decelerating region...
C-STA	In the acceleration/deceleration driving, when the driving changes from the accelerating region into the constant speed region...
D-END	When the driving is finished...
CNEXT	In continuous interpolation, when PCI1020 is available for the interpolation data of next node... *after next interpolation command is written, the interrupt will be cleared.
BPS1,0	In bit pattern interpolation, when the value of stack connector (SC) is changed from 2 to 1, and the stack is available for next BP command writing... *after a BP command for the stack is written, the interrupt will be cleared.

## 5.7 Input Signal Filter

This card is equipped with an integral type filter in the input stage of each input signal. Figure 5.22 shows the filter configuration of each input signal of the X axis. The same circuit is provided to the X, Z, and U axes also. The time constant of the filter is determined by the T oscillation circuit in the diagram. One time constant can be selected from eight time constants using the bits D15 to D13 (FL2 to FL0) of the WR6 register of the extension mode setting command (06h). Using the bits D12 to D8 (FE4 to 0) of the WE6 register, it is possible to set whether the filter function is enabled or the signal is passed through for a number of input signals. At reset, all the bits in the extension mode are cleared to 0 so that the filter function is disabled for all the input signals and the signals pass.

Select a filter time constant from eight stages as shown in the table below. When a time constant is increased, the removable maximum noise width increases, however, the signal delay time also increases. Therefore, set an appropriate value. Normally, set 2 or 3 for FL2 to FL0.

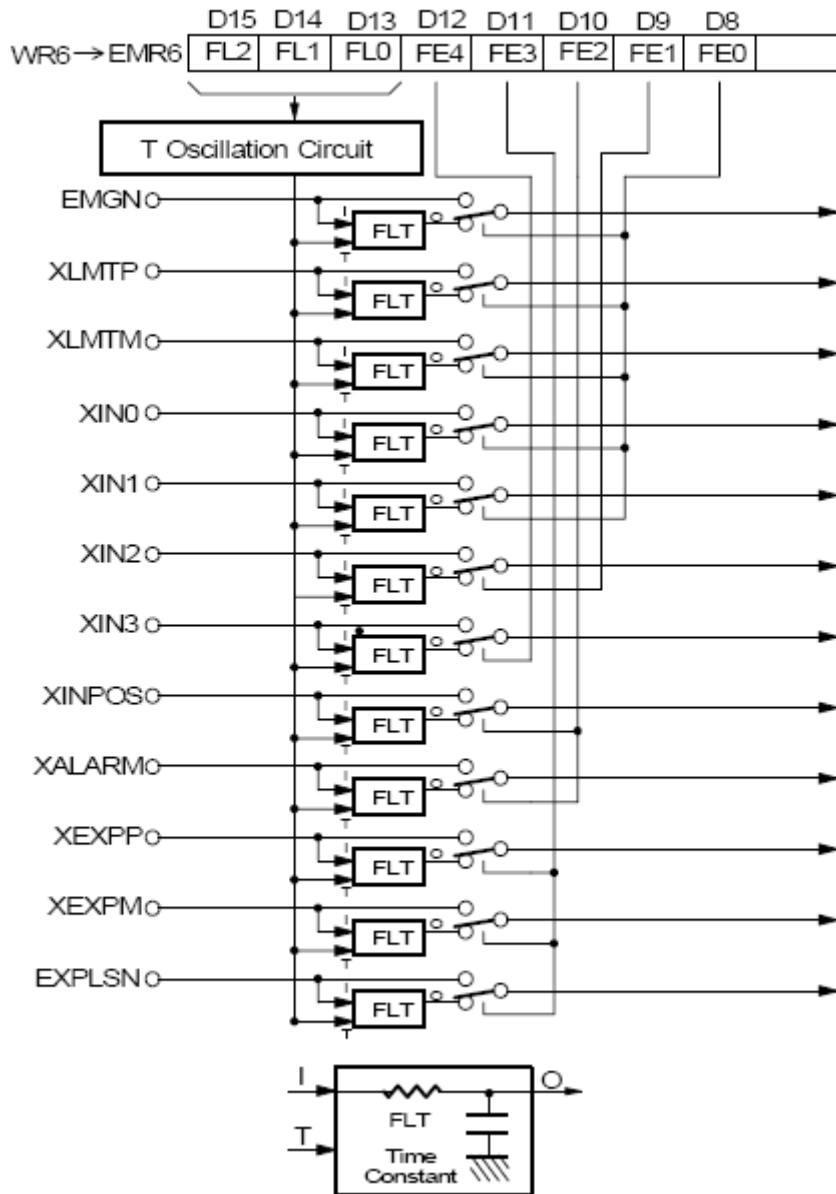


Fig. 5.22 Concept of Input Signal Filter Circuit

## 5.8 Other Functions

### 5.8.1 Driving By External Pulses

Fixed pulse driving and continuous pulse driving can be controlled by either commands or external signals, which can reduce the load of host CPU. By inputting an encoder 2-phase signal of a manual pulsar, jog feed of each axis is enabled.

Each axis has two input signals, nEXPP and nEXPM. In fixed pulse drive mode and a continuous pulse drive mode, the nEXPP signal triggers driving in the + direction and the nEXPM signal in the – direction. nEXPP controls + direction pulse output, and nEXPM controls – direction command. D3 and D4 bits of register WR3 are for the setting in driving. The user should preset the parameters and commands. The default level of nEXPP and nEXPM is normally set on Hi. In manual pulsar mode, the A-phase signal is connected to nEXPP input and the B-phase signal to nEXPM input.

### Fixed Pulse Driving Mode

Set all the parameters of fixed pulse driving. Once nEXPP is falling down to the Low level, the + direction fixed pulse driving will start; once nEXPM is raising to the Hi level, the – direction fixed pulse driving will start. The width of Low level signal must be larger than 4 CLK-cycle. Before this driving is finished, a new Hi-to-Low level falling down of the signal is invalid.

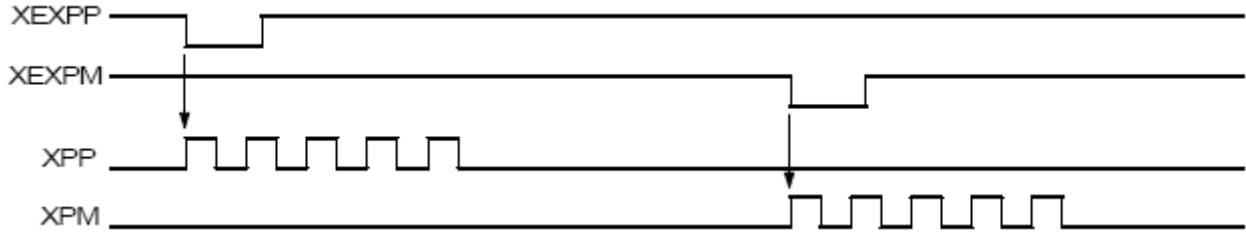


Fig. 5.23 Example of The Constant Pulse Driving by External Signal

### Continuous Pulse Driving Mode

Set all the parameters of continuous driving. Once nEXPP is falling down to the Low level (↓), the + direction continuous driving will start; once nEXPM is raising to the Low level, the – direction continuous driving will start. When nEXPP and nEXPM returns to the Hi level from the Low level, the decelerating stop will be performed in trapezoidal driving, and the sudden stop in constant speed driving.

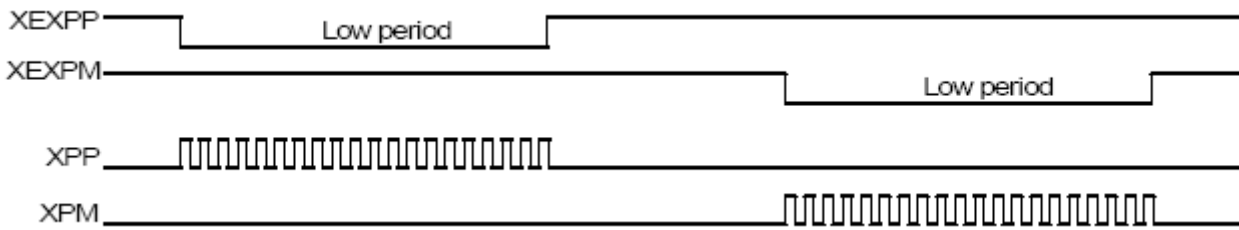


Fig. 5.24 Example of Continuous Driving by External Signal

## 5.8.2 Emergency Stop

Signal EMGN is able to perform the emergency stop function for all of the 4 axes during the driving. Normally, this signal is kept on the Hi level. When it is falling to the Low level, all axes will stop immediately. Please be noted that there is no way to select the logical level of EMGN signal.

Please check the following methods to perform the emergency stop function from the host CPU.

- a. Execute the sudden stop command for all of the 4 axes at the same time... Appoint all of the 4 axes, and then write the sudden stop command (27h) to register WR0.
- b. Reset software limit...  
Write 800h to register WR0 to reset software limit.

## 5.8.2 General Purpose Output Signal

In PCI1020, there are 8 general purpose output pins, nOUT3~0 & nOUT7~4, for each axis. However, during the outputting, nOUT7~4 cannot be used cause they share the same terminals with the position comparison output and drive status output.

NOUT3~0 can be output when the output levels of register WR4 have been set. If the user wants to use nOUT7~4 signals, D7 (OUTSL) of register WR3 should be set in the “general purpose output mode”, then the output levels of D11~8 (OUT7~4) of register WR3 can be set for outputting.

It is possible to use the general purpose output signal for motor driver current-OFF, deviation counting clear and alarm reset...

When resetting, each bit of WR4 and nWR3 registers will be cleared, then, their output levels will be kept.

## ***Chapter 6 Notes, Warranty Policy***

### **6.1 Notes**

In our products' packing, user can find a user manual, a PCI1020 module and a quality guarantee card. Users must keep quality guarantee card carefully, if the products have some problems and need repairing, please send products together with quality guarantee card to ART, we will provide good after-sale service and solve the problem as quickly as we can. When using PCI1020, in order to prevent the IC (chip) from electrostatic harm, please do not touch IC (chip) in the front panel of PCI1020 module.

### **6.2 Warranty Policy**

Thank you for choosing ART. To understand your rights and enjoy all the after-sales services we offer, please read the following carefully.

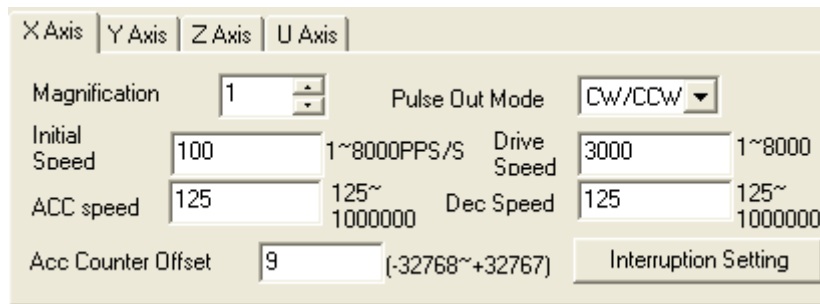
1. Before using ART's products please read the user manual and follow the instructions exactly. When sending in damaged products for repair, please attach an RMA application form which can be downloaded from: [www.art-control.com](http://www.art-control.com).
2. All ART products come with a limited two-year warranty:
  - The warranty period starts on the day the product is shipped from ART's factory
  - For products containing storage devices (hard drives, flash cards, etc.), please back up your data before sending them for repair. ART is not responsible for any loss of data.
  - Please ensure the use of properly licensed software with our systems. ART does not condone the use of pirated software and will not service systems using such software. ART will not be held legally responsible for products shipped with unlicensed software installed by the user.
3. Our repair service is not covered by ART's guarantee in the following situations:
  - Damage caused by not following instructions in the User's Manual.
  - Damage caused by carelessness on the user's part during product transportation.
  - Damage caused by unsuitable storage environments (i.e. high temperatures, high humidity, or volatile chemicals).
  - Damage from improper repair by unauthorized ART technicians.
  - Products with altered and/or damaged serial numbers are not entitled to our service.
4. Customers are responsible for shipping costs to transport damaged products to our company or sales office.
5. To ensure the speed and quality of product repair, please download an RMA application form from our company website.

# Appendix PCI1020 Test Method

Configuration of public parameters

## Linear Movement

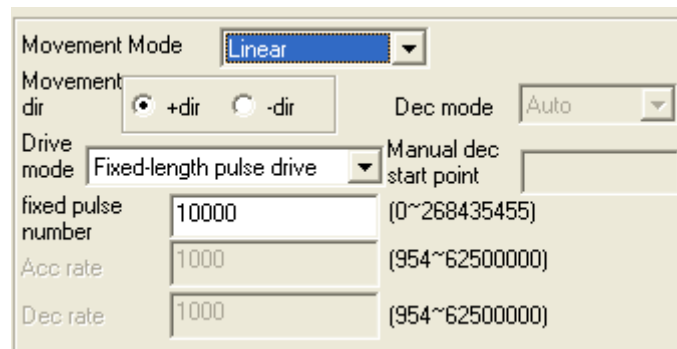
Set the public parameters of linear movement in the upper left corner of the box, we can configure multiplication, pulse output mode, initial speed, acceleration, drive speed, deceleration, acceleration counter offset and interrupt. The parameters for each axis independent, not affect each other.

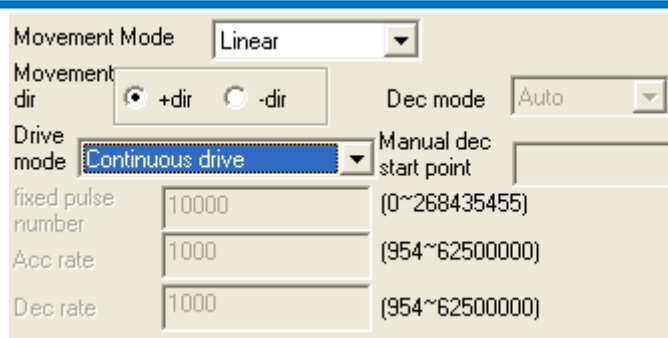


Note: The actual initial speed, drive speed, acceleration, and deceleration values are the values multiply setting values by multiplication. For example, if we want to configure the actual initial speed=1KPPS, drive speed=80KPPS, acceleration/deceleration speed=500KPPS/SEC, and magnification=10, we deed set as this, initial speed=100KPPS, drive speed=800KPPS, acceleration/deceleration=500KPPS/SEC and multiplication=10.

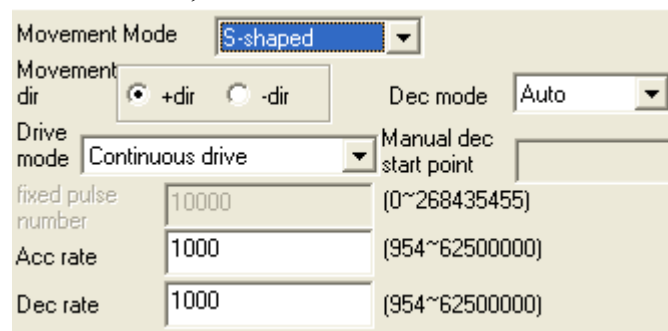
In the right box, we can set movement mode, deceleration mode, manual deceleration points, movement direction, drive mode, and so on. When select linear movement, only need to select the movement direction and drive mode (it is necessary to set fixed- pulses when fixed- pulse in the choice).

Show as the figure:





- When select S-curve movement, need to select the deceleration mode, if you want acceleration and deceleration curves are the same, select auto-deceleration. If you want acceleration and deceleration curves are different, then select Manual deceleration.



**Interpolation Movement**

Set the public parameters of interpolation movement in the upper left corner of the box.

- **Linear Interpolation**

Any 2/3 axes of the PCI1020 can be set for linear interpolation. If choose X-axis as main axis, we should set initial speed, drive speed, acceleration and deceleration for X-axis. To execute the linear interpolation, the user can, according to the present point coordinates, set the finish point coordinates. For example: set X-axis finish point coordinates: 10000, speed: 1000 Y-axis finish point coordinates: 5000. If the motor drive objects in the two-dimensional coordinates, then the object's initial coordinates is the origin of coordinates (0, 0), and makes a linear motion. Object will movement 10000 steps in X-axis, 5000 steps in Y-axis and the speed of Y-axis is 500, they are proportionable.

- **Circular Interpolation (S-shaped is invalid)**

In Fig.1, it explains the definition of CW and CCW circular interpolations. The CW circular interpolation is starting from the start point to the finish position with a clockwise direction; the CCW circular interpolation is with a counter-clockwise direction. When the finish point is set to (0, 0), a circle will come out.

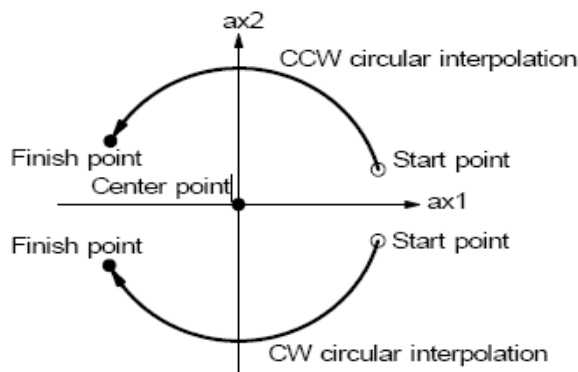


Fig.1

In Fig. 2, it explains the long axis and the short axis. First, we define 8 quadrants in the X-Y plane and put the numbers 0~7 to each quadrant. We find the absolute value of ax1 is always larger than that of ax2 in quadrants 0, 3, 4 and 7, so we call ax1 is the long axis (ax2 is the short axis) in these quadrants; in quadrants 1, 2, 5 and 6, ax2 is the long axis (ax1 is the short axis). The short axis will output pulses regularly, and the long axis will output pulses depending on the interpolation calculation.

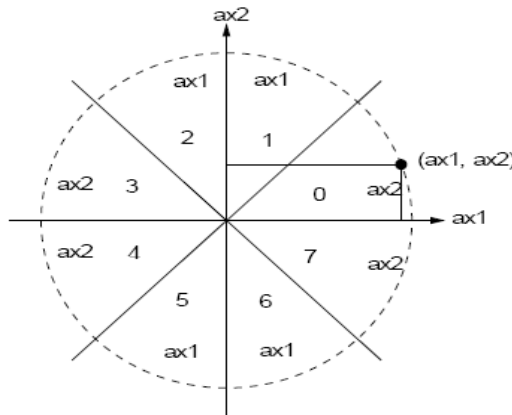
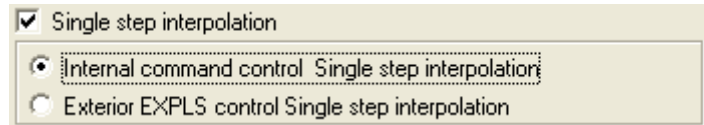
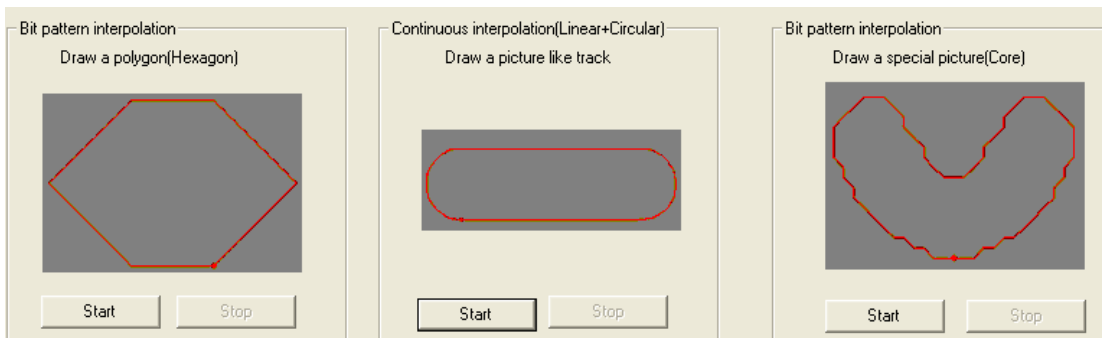


Fig. 2

➤ Single-step interpolation (from Command or External Signal)



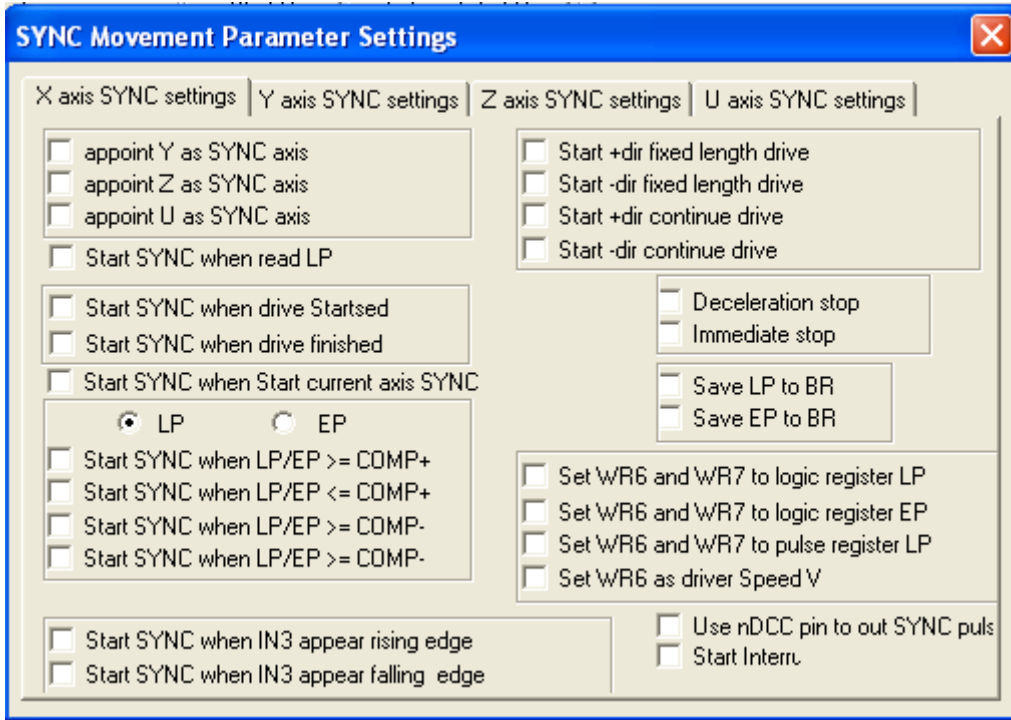
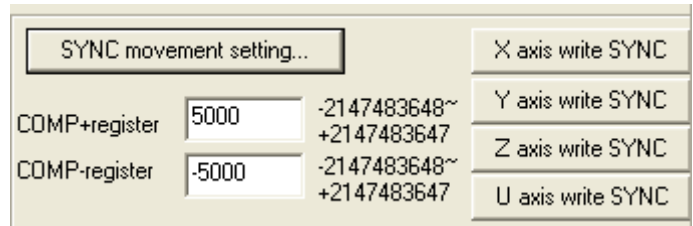
➤ Bit Pattern Interpolation



🚦 Synchronized Movement

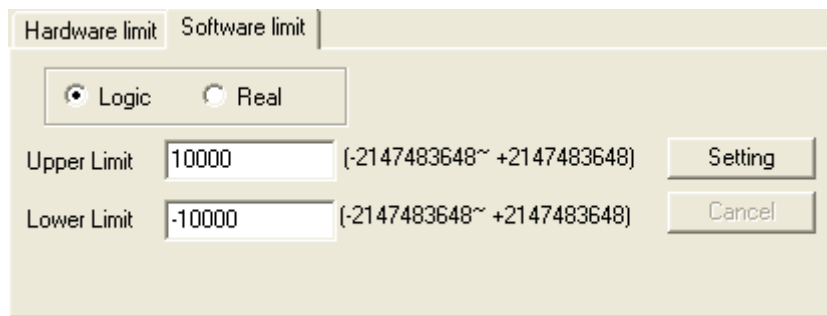


Click synchronized setting button will pop-up the box of setting synchronized parameters, each one axis is the same. On the left is the excitation conditions, the right is response.



Software limited:

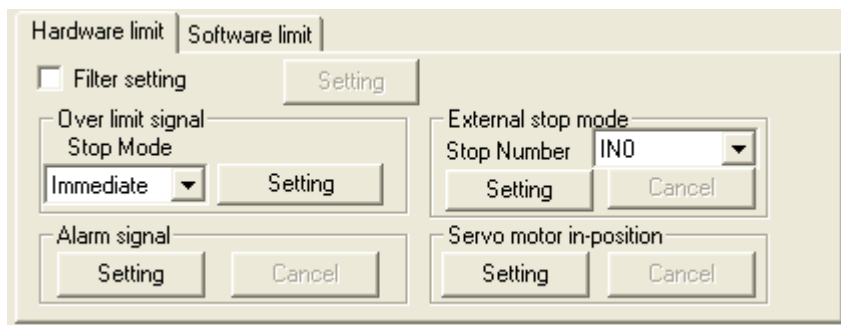
- Selection logic or real register
- Set upper limit bit and lower limit bit



Hardware limited:

- Over limited signal: Can choose immediate stop and deceleration stop. +direction: when the LMTP of specified axis appears low level (falling edge), motor stops in accordance with the setting. -direction: when the LMTM of specified axis appears low level (falling edge), motor stops in accordance with the setting.
- External stop signal: IN3~IN0, enable/disable. When it is enable, the nINN of specified axis appears low level (falling edge), motor deceleration stop immediately

- Alarm Signal: enable/disable. When it is enable, the ALARM of specified axis appears low level (falling edge), motor stops immediately
- In-position Signal for Servo Motor: enable/disable. When it is enable, the INPOS of specified axis appears low level (falling edge), and the corresponding status light turn to red.



**Status Display**

Status display																	
	Speed(Hz)	Acc(Hz)	LP	EP	BR	EXPF	EXPT	+HL	-HL	EMG ALAR	+SL	-SL	Locat signal	Stop	Acc	Const speed	Dec
X	255	0	255	255	255	■	■						■	■			
Y	255	0	255	255	255	■	■						■	■			
Z	255	0	255	255	255	■	■						■	■			
U	255	0	255	255	255	■	■						■	■			

- LP: logic counter
- EP: real counter
- BR: register BR
- EXPP: +external Operation
- EXPM: -external Operation
- +HL: + hardware limit
- HL: -hardware limit
- EMGN: emergency stop
- ALARM: alarm status
- +SL: + software limit
- SL: -software limit
- Locat signal: locating signal
- Stop: termination status
- Acc: acceleration status
- Const speed: constant speed status
- Dec: deceleration status