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Application Notes for ASDA Series Servo Drive

Application Notes for ASDA Series Servo Drive

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Preface

About this application notes

This notes provide basic application examples and settings that apply to ASDA-A2 servo drive. The content includes:

- PR Operation

- E-Cam Operation

- Application Examples

- Application Techniques

Note: 1. Please refer to ASDA series user manual for detailed description of parameters.
2. Please refer to ASDA series user manual for detailed description of system framework and motion control mode.
3. Please refer to ASDA-Soft user manual for detailed description about using the ASDA-Soft.

Personnel

This document is for personnel who have already purchased ASDA series servo drive or engineers and technicians who use ASDA series servo drive to configure the product.

If you have any enquiry, please contact the distributors or DELTA customer service center.
Servo_Support@delta.com.tw

Important Notice

- Different device has different features and operational ways. Technical personnel who is in charge of operating the software shall implement appropriate measures and follow the instructions of the user guide.

- This manual mainly focuses on settings of ASDA-A2 servo drive when it is applied to different types of machine. Please follow the instructions and notices of the machine which is applied. Delta shall not be liable for the indirect, derivative, subsidiary, or related loss caused by inappropriate operation of machine.

- Delta will not take responsibility for the results of unauthorized modifications of this product. Delta shall not be liable for any damages or troubles resulting from unauthorized modification.

- The drawings, figures, values and content presented in this application notes are typical examples and are only used for functional description. However, there must be different demands and variations in practical operation and settings. Configurations shall be changed in accordance with the real applications. It is not suggested to use the same setting values in the example of this notes. Delta will not take responsibility for the direct or indirect loss caused by the system configuration of different applications.

- No patent liability is assumed with respect to the use of the information contained herein.

- No part of this work may be reproduced in any form (by photocopying, microfilm or any other method) without the written permission of Delta.

- Technical changes which improve the performance of the device may be made. Delta has the right to change the definition and contents of this application notes.

Safety Precautions

To your safety, please pay special attention to the following safety precautions before using this application notes.

The symbol of **danger**, **warning** and **stop** represent:

It indicates the potential hazards. It is possible to cause severe injury or fatal harm if not follow the instructions.

It indicates the potential hazards. It is possible to cause minor injury or lead to serious damage of the product or even malfunction if not follow the instructions.

It indicates the absolute prohibited activity. It is possible to damage the product or cannot be used due to malfunction if not follow the instructions.

System Operation

➢ Please follow the instruction when using servo drive and servo motor, or it is possible to cause fire or malfunction. For instructions and safety precautions of ASDA-A2 servo drive, please refer to its user manual. To use the relevant parameter settings, please refer to the important notice of ASDA-Soft User Guide.

Wiring

➢ To avoid danger, please refer to the selection of wiring rod when wiring.

Operation

➢ Before start the machine, please set the relevant parameters properly. Failing to set to correct value might cause malfunction of the mechanism.
➢ Before start the machine, please check if the emergency stop can be used anytime.

Table of Contents

4 Application Techniques

Introduction of PR Operation

<div style="text-align: right; font-size: 3em;">1</div>

This Chapter introduces the basic system and setup information about the ASDA-A2, providing the background information for using the PR function. The Delta PR function in the ASDA-A2 servo drive is defined as "Program Register" or parameterized setup of sequence and built-in motion functionality. In the last part, operation examples of PR commands will be presented to demonstrate and prove its motion command performance.

1.1   System Information

1.1.1   What is System Parameter and How is it Used?

The purpose of system parameter is allow for configuration of functions and commands of the servo drive, serving as a mode reference, data display, or operation conditions during operation. On ASDA-A2 servo system, users may have a comprehensive control over the servo by reading and writing parameters. System parameter is presented in the format of Px-xx. The first character after the start code P is the group character and the second character is the parameter character. See the parameter groups below:

Group 0: Monitoring parameters

Group 1: Basic parameters

Group 2: Extension parameters

Group 3: Communication parameters

Group 4: Diagnosis parameters

Group 5: Motion control parameters

Group 6: PR parameters

Group 7: PR parameters

16-bit and 32-bit parameters are included in ASDA-A2 system. Users may read and write parameters with the following methods.

1. Panel of the servo drive: using buttons on the panel to read or write parameters.
   Please refer to A2 user manual for setting detail.
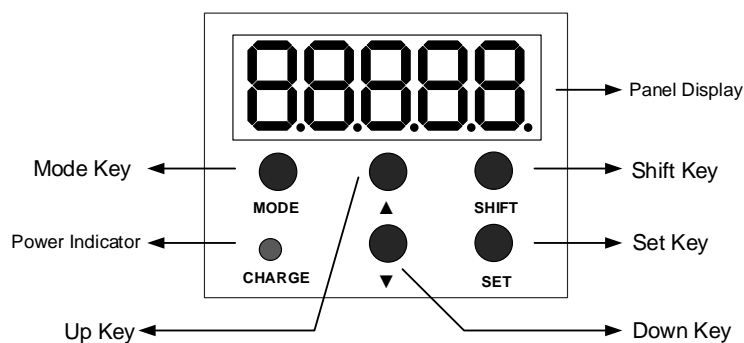

Figure 1.1 Display Panel of the Servo Drive

2. USB: Connect to a computer via USB and use ASDA-Soft (software for ASDA series
        servo drive) to read or write parameters.

ASDA-Soft provides *Parameter Editor* for users to read or write parameters. Please refer to
ASDA-Soft User Guide for operation detail.
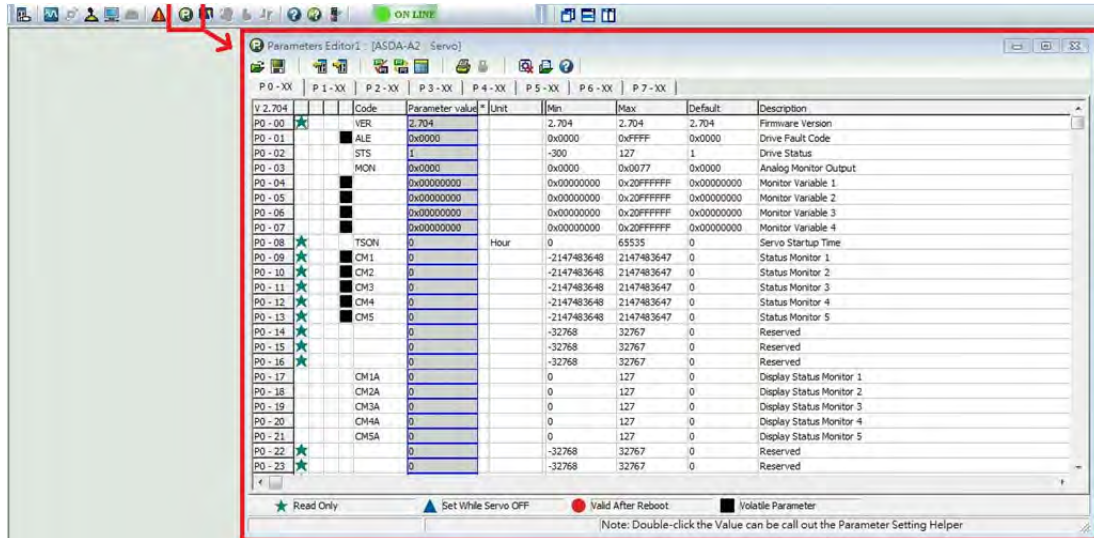
Figure 1.2 Parameter Editor

3. CANopen: Use CANopen fieldbus to connect to a host controller and
        read/write parameters with the controller.

4. RS485/RS232: Use RS485 or RS232 to connect to a host controller and
        read/write parameters with the controller.

Regarding reading and writing parameters with CANopen and RS485/RS232, it is for
editing the value for the communication address that corresponds to each parameter.
Please refer to Chapter 9 of ASDA-A2 user manual for communication protocol and
settings and Chapter 8 for communication address of each parameter which shown at the
right corner of each parameter table.

Figure 1.3 Communication Address of Parameter

5. PR: Edit parameters by triggering PR event.

Use write-in function of PR to pre-set the parameter and value that required editing. Once this PR is triggered, parameter settings can be modified. The related setting and triggering methods will be explained in Section 1.2.7.

Figure 1.4 Use PR Write-in Function to Edit Parameter Setting
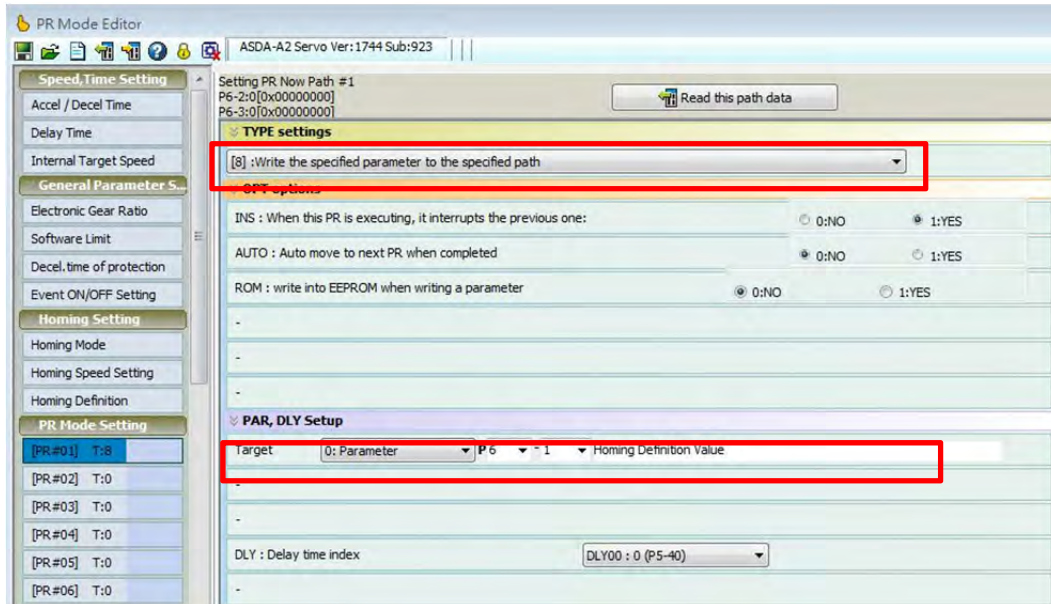
In this example, if system parameter value is shown in hexadecimal format, the bit code will be presented by 0xDCBAUZYX.

1.1.2   Mapping Parameter

Advantages about using mapping parameters are listed below:

1. Quickly read and write: It allows users to consecutively read and write communication addresses of different parameter groups that are not jointed.
2. Read any parameters from PC scope: PC scope channel can read mapping parameters; it can read any parameters via mapping parameters.
3. Enable the function of reading parameter value after password is set: users may access the parameter that is going to be monitored via mapping parameter. Then, users may still read its value via mapping parameter when a parameter is set with password.

ASDA-A2 can map any of the parameters to the specified address. In ASDA-A2 system, 8 groups of mapping parameters are available: P0-35 ~ P0-42 is the index group, the parameter value specified by the index group will be mapped to P0-25 ~ P0-32 respectively. See Figure 1.5, the input value of P0-35 ~ P0-42 is in hexadecimal format.

<div align="center">

Index   **Content**

P0-35 ⟷ P0-25

P0-36 ⟷ P0-26

P0-37 ⟷ P0-27

P0-38 ⟷ P0-28

P0-39 ⟷ P0-29

P0-40 ⟷ P0-30

P0-41 ⟷ P0-31

P0-42 ⟷ P0-32

</div>
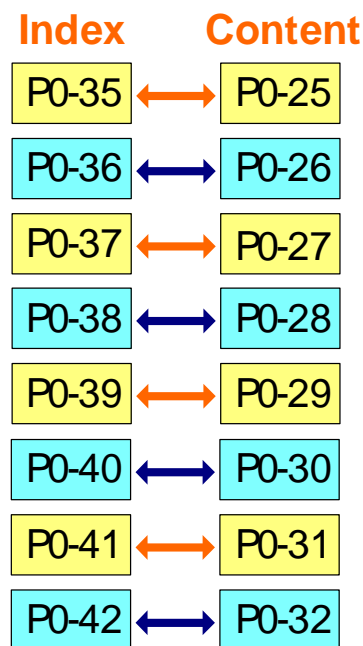
Figure 1.5 Mapping Parameters

Besides parameter setting, mapping parameter can also be set via Status Monitor in ASDA-Soft, which shown in Figure 1.6.

8 groups of mapping parameter are organized together in *Status Monitor*. Steps to setup are shown below:

1. Select the mapping parameter that is going to be used.
2. Use the drop-down list to select the parameter to be mapped.
3. If "32-bit*" is selected*, the high-word item will be blocked to insure the doubleword is mapped correctly, and all bits of the mapping parameters are used to display in the same parameter.

Click *Change* to change the setting.
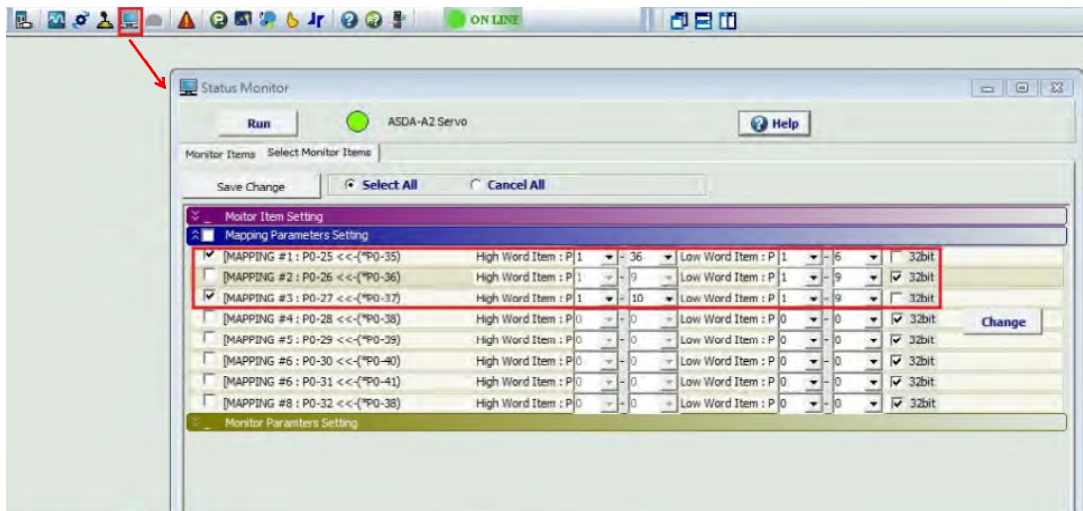
Figure 1.6 Using *Status Monitor* to Configure Mapping Parameter

The size of mapping index and mapping content is 32-bit. A mapping parameter can map to two 16-bit parameters. The parameter content specified by the low-word will be mapped to the low-word of the mapped content. The parameter content specified by the high-word will be mapped to the high-word of the mapped content. For example, P1-06 and P1-36 are both parameters of 16-bit; In P0-37, when 0x0106 is written into the low-word and 0x0124 is written into the high-word, the low-word of P0-27 will show the content of P1-06 and the high-word will show the content of P1-36. See Figure 1.7.
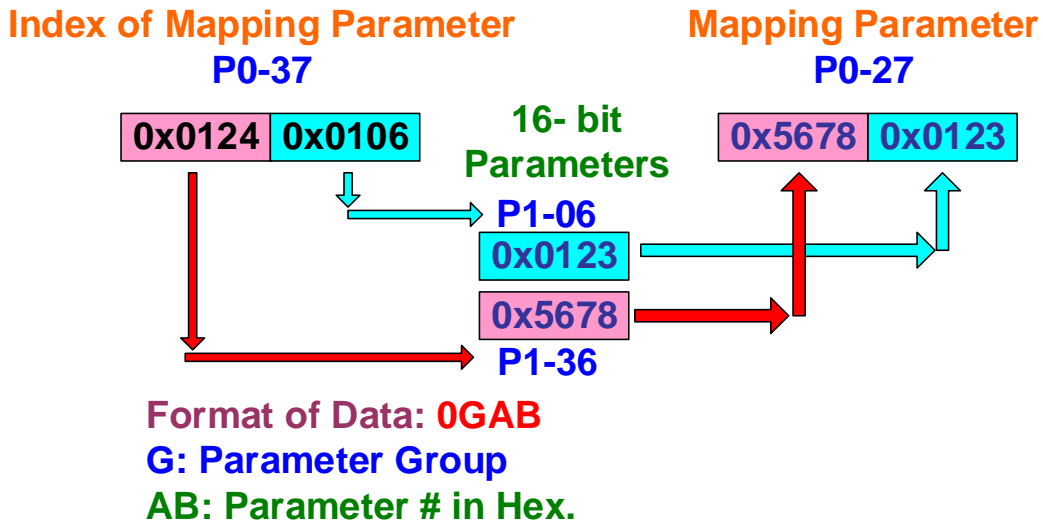
Figure 1.7 Example of Mapping a 16-bit Parameter

If the size of mapping content is 32-bit, a mapping parameter can map one parameter which has the size of 32-bit. For example, P1-09 is a 32-bit parameter. Enter 0x0109 in both high-word and low-word of P0-35, the content of P1-09 will all be mapped to P0-25.
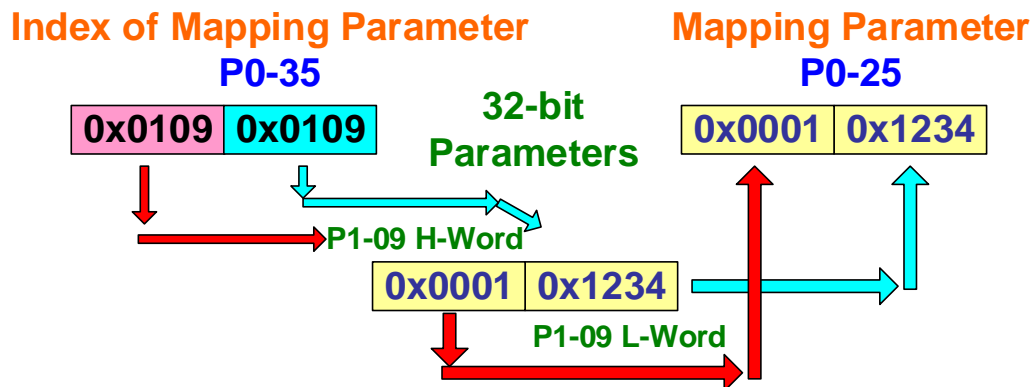
Figure 1.8 Example of Mapping a 32-bit Parameter

If respectively specifying a 32-bit parameter in low-word and high-word of the mapping index, the mapping content will only show the low-word part of each 32-bit parameter. For example, P1-09 and P1-10 are both 32-bit; writing 0x0109 into low-word of P0-38, low-word part of P1-09 will be mapped into the low-word part of P0-28. Writing 0x010A into high-word of P0-38, the low-word part of P1-10 will be mapped into the high-word part of P0-28. See Figure 1.9.
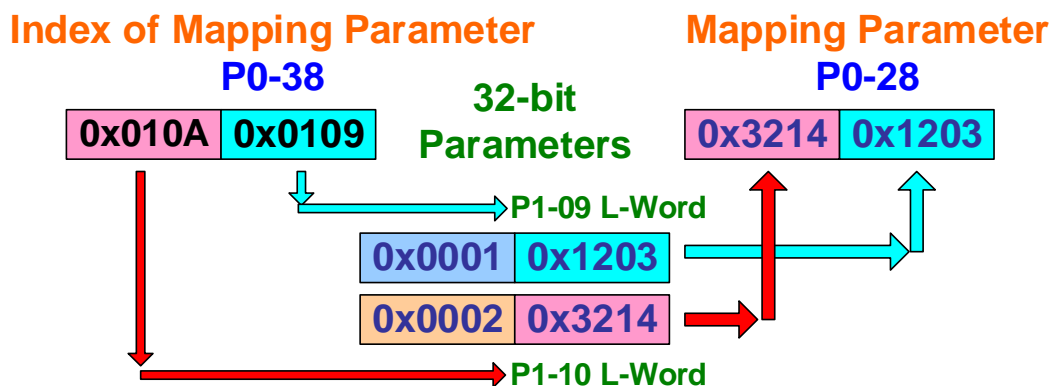
Figure 1.9 Example of Mapping Two Sets of 32-bit Parameter

Mapped parameter groups 1~4 can be observed via PC scope. This can be done by selecting the items from the drop-down list of each channel on PC scope.

Figure 1.10 Using PC Scope to monitor Mapping Parameters

1.1.3   Monitoring Parameter

Monitoring Parameter can be used to observe the prompt change inside the servo drive. Types of monitoring parameter and their codes provided by ASDA-A2 can be found in Chapter 7 of ASDA-A2 User Manual. To read monitoring variables from the drive panel, users can set the variables to be monitored in P0-02 and the panel will display the content based on the setting of P0-02. Pressing *Up* and *Down* keys can change the displayed content. To read monitoring variables via communication, users may set the codes of the variables to be monitored in P0-17~P0-21 and the set variables will be displayed in P0-09 ~ P0-13 respectively. Figure 1.11 shows the setting example; the index can specify codes of the monitoring variables and the read values that codes represent will be displayed in the content of the monitoring variables.

Figure 1.11 The Setting Example of Monitoring Variables

Monitoring variables can be set via *Status Monitor* in ASDA-Soft. The *Status Monitor* window has organized 5 groups of monitoring variables in the same section. The setting steps are shown below.

1. Select the monitoring variables to be set.

2. Use the drop-down list to select the monitoring variables user wishes to observe.

3. Click on *Change* to modify the setting.

Figure 1.12 Use *Status Monitor* to Configure Monitoring Variables

Monitoring groups from #1 to #4 can be observed via PC scope. This can be done by selecting the items from the drop-down list of each channel. See Figure 1.13.
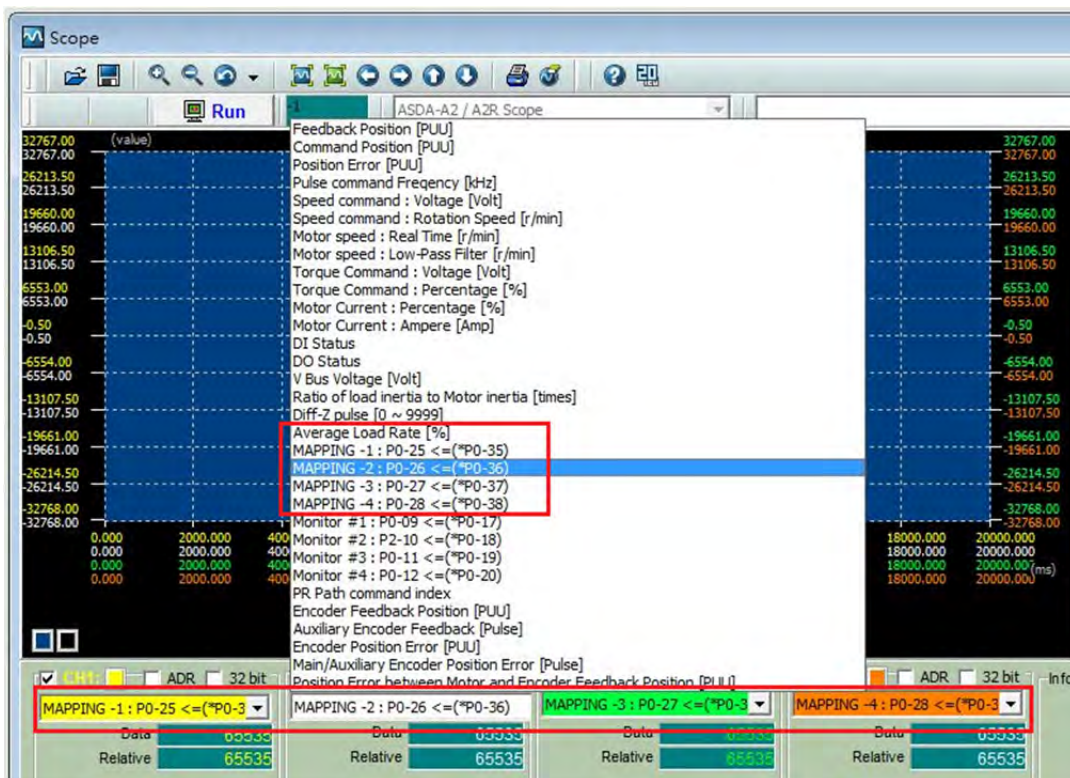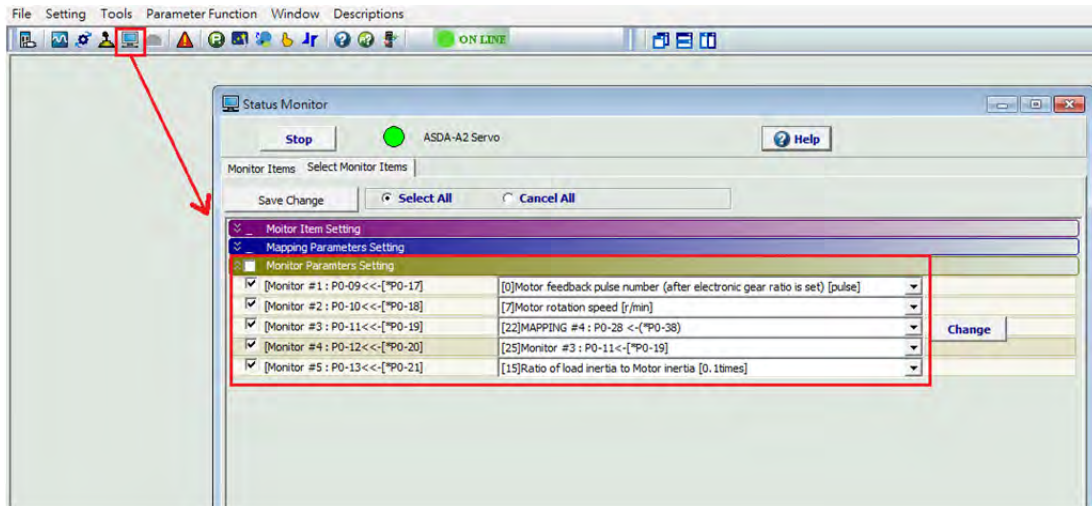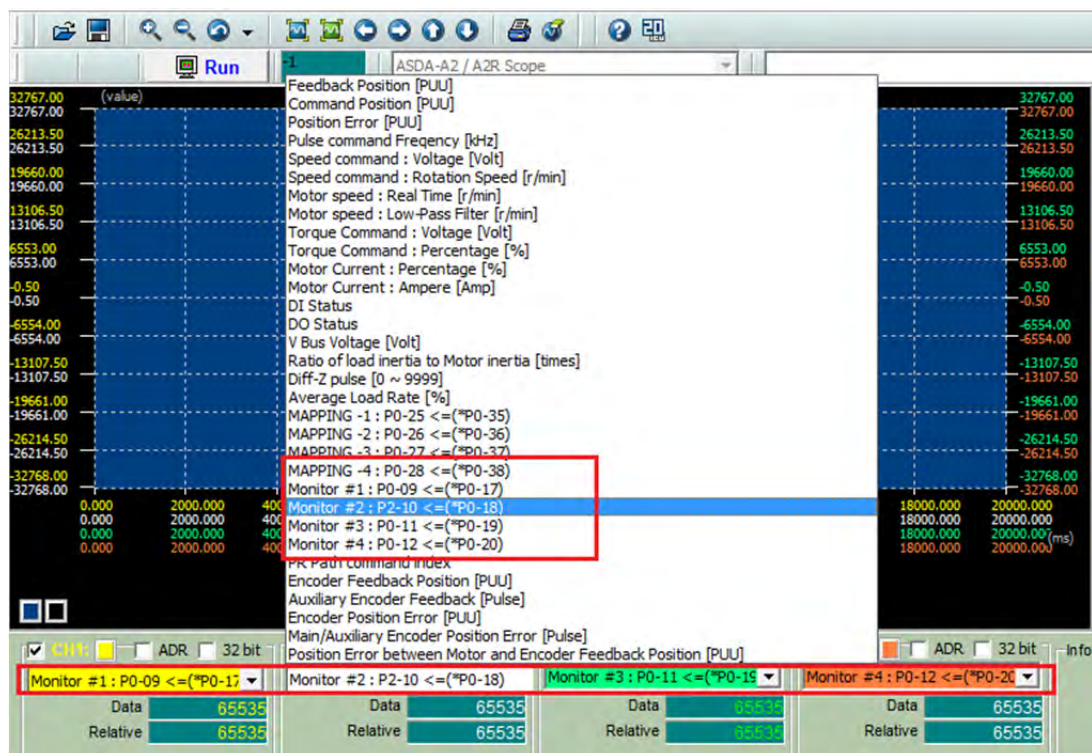

Figure 1.13 Use PC Scope to Observe Monitoring Variables

1.1.4   Data Array

Data Array in ASDA-A2 servo drive is a continuous block of memory; it is used to save the captured data, compared value and E-CAM tables. Data array is capable to save 800 data in total. As size and saving destination of these data is not specified in the system, users have to define the saving address of each datum properly so as to avoid data overlap and causing problems of overwriting. Detail about data array is explained in Chapter 2 E-CAM of this application note; details about how to read and write data array can also be found in ASDA-A2 user manual and ASDA-Soft user manual.

1.2   Introduction of ASDA-A2 PR Function

There are several ways to set the attributes and value settings for each of the PR's (such as setting P6-02 and P6-03 for PR#1). The most intuitive way is to use the PR wizard in ASDA-Soft software tool, as it uses dropdown selection boxes and pop-up wizard windows to explain each entry choice. Another way is to simply set the parameter values directly from the parameter editor in the ASDA-Soft software tool. A third way is to set the parameter values by communication port from a host controller or HMI by setting/resetting PR functions for static or dynamic use.

In PR mode, motion commands are generated in the servo drive and used to control the motor. Commands are generated based on parameters settings and are composed of one or more profiles. Thus, commands generated by PR can be changed by editing their corresponding values. Including Homing mode, ASDA-A2 provides 64 profiles.

PR#0: Homing mode

PR#1 ~ PR#63 can be set as: Position Command- Position Control

Speed Command- Speed Control

Write Command- Edit Parameter Setting or Data Array

Jump Command- Edit PR Executing Procedure

ASDA-A2 also provides various types of PR triggering methods, which allow users to select based on different applications.

Each definition and its corresponding data of PR are defined by parameter settings. Parameters related to PR mode are included in Chapter 7, mainly in Group 6 and Group 7, in ASDA-A2 user manual. If selecting a PR path to be edited in ASDA-Soft, the corresponding parameter of this PR will be shown at top of the window. See Figure 1.14 for example, when selecting PR#1 to edit, value of P6-02 and P6-03 will be displayed at top of the window. P6-02 is for defining the attribute of PR#1, which is for determine the type of PR command and to determine if this PR is going to execute interrupt command or to execute the next PR procedure automatically. On the other hand, P6-03 is the value setting for the PR#1, and definition of what the setting is for depends on the attribute setting of P6-02. For instance, if P6-02 is a speed command, P6-03 will be defining the target speed; when P6-02 is a Jump command, P6-03 determines the jumping

target of PR command. Parameters defining PR#2 are P6-04 and P6-05; the definition of P6-04 has to be identical to that of P6-02 and definition of P6-05 has to be identical to definition of P6-03, and so on. If users need to change the setting of individual PR command, directly changing the parameter that corresponds to this PR will change the definition or value of this PR command. For example, if regarding PR#1 as speed control, changing the target speed of PR#1 can be done easily by using communication, panel, or using other PR to edit the setting of P6-03. If directly changing the setting of P6-02, PR#1 will have a different command definition.
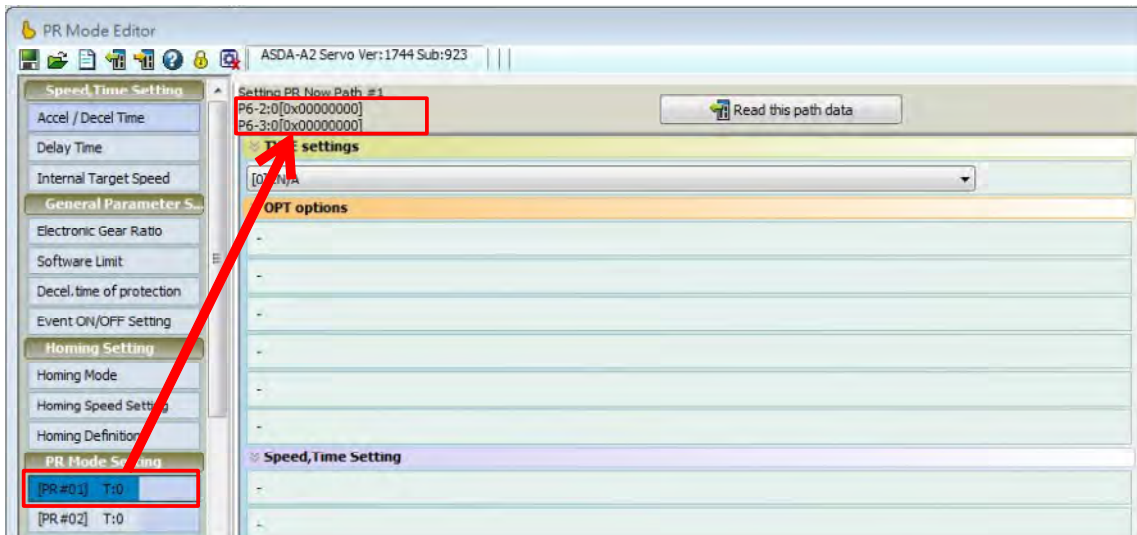
Figure 1.14 PR Parameters

Below are the parameters that correspond to PR setting. P6-02 and P6-03 are presented as examples.

P6-02	PDEF1	PATH#1 Definition	Address: 0604H 0605H
Operational Interface :	Panel / Software	Communication	Related Section: 7.10
Default :	0		
Control Mode :	PR		
Unit :	-		
Range :	0x00000000 ~ 0xFFFFFFFF		
Data Size :	32-bit		
Format :	HEX		

Settings : Properties of PATH# 1:

	.31 ~ 28	.27 ~ 24	.23 ~ 20	.19 ~ 16	.15 ~ 12	11 ~ 8	7 ~ 4	3 ~ 0
P6-02	-	-	DLY	-	-	-	OPT	TYPE
P6-03	DATA (32-bit)							

- TYPE, OPT:

OPT				TYPE
7	6	5	4 BIT	3 ~ 0 BIT
-	UNIT	22AUTO	INS	1: SPEED, Speed setting control
CMD		OVLP	2INS	2: SINGLE, Positioning control. It will load in the next path when finished.
				3: AUTO positioning control. It will load in the next path when finished.
-	-	-	INS	7: JUMP to the specified path
-	-	AUTO	INS	8: Write the specified parameter to the specified path

- TYPE: 1 ~ 3 accept DO.STP stop and software limit.
- INS: When executing this PR, it interrupts the previous one.
- OVLP: Allow the overlap of the next path. The overlap is not   allowed in speed mode. When overlap happens in position mode, DLY has no function.
- AUTO: When PR procedure completes, the next   procedure will be loaded in automatically.
- CMD: Refer to Chapter 7 for PR command description.
- DLY: 0 ~ F, delay time number (4 BIT). The delay after executing this   PR. The external INS is invalid.

  ┌──────────────┐
  │ 24DLY (4)   │   Index P5-40 ~ P5-55
  └──────────────┘

P6-03	**PDAT1**	**PATH# 1 Data**	**Address: 0606H** **0607H**
Operational Interface :	Panel / Software	Communication	Related Section: 7.10
Default :	0		
Control Mode :	PR		
Unit :	-		
Range :	-2147483648 ~ +2147483647		
Data Size :	32-bit		
Format :	DEC		

Settings : PATH# 1 Data

.31 ~ 28	.27 ~ 24	.23 ~20	.19 ~ 16	.15 ~ 12	11 ~ 8	7 ~ 4	3 ~ 0
DATA (32-bit)							

Property of P6-02; P6-03 corresponds to the target position of P6-02 or jump to PATH_NO.

Note: PATH (procedure)

The unit of position data in PR mode is PUU. PUU is the position unit that encoder's original pulse number being converted with E-gear ratio through the servo drive. For example, the resolution of ASDA-A2 is 1280000 pulse/rev, if E-gear ratio is 128:10 (P1-44=128 / P1-45=10), the PUU for an ASDA-A2 motor to make one full rotation is 1280000*(10/128) = 100000 PUU. The best thing about using this method is that the unit of commands, errors, and feedback are the same, which means no conversion is needed here and it is easy to be read and compared.
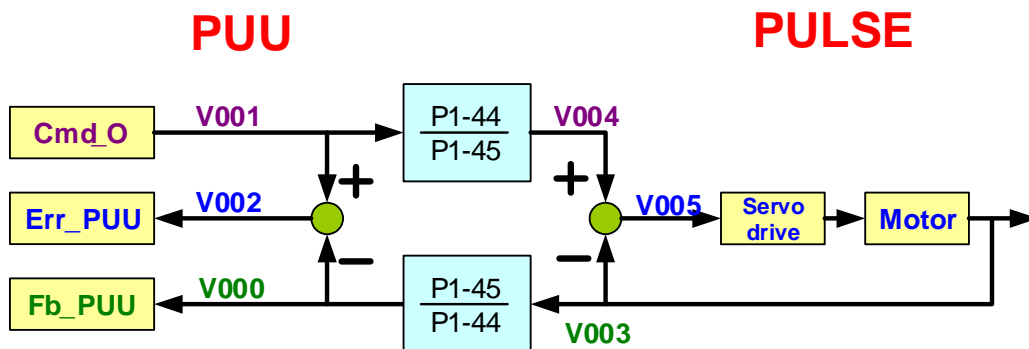
PUU   PULSE

Figure 1.15 Definition of PUU

1.2.1 Shared Setting List for PR

ASDA-A2 provides 16 sets of acceleration/deceleration time (P5-20~P5-35),16 sets of delay time (P5-40~P5-55), and 16 sets of target speed (P5-60~P5-75) in the setting list; these are available when configuring PR profiles. If multiple sets of PR use the same setting in the meantime, when value of this set is changed, all PRs that use this set will also be changed. In other words, there is no need to change each PR setting respectively and that is why it is easy and convenient to be used. For instance, if multiple PR commands all specify P5-62 as target speed, when their values are changed, the target speed of PR motion command that define P5-62 will thus be changed. Users can easily complete the setting through the built-in wizard interface of ASDA-Soft. See figure 1.16.
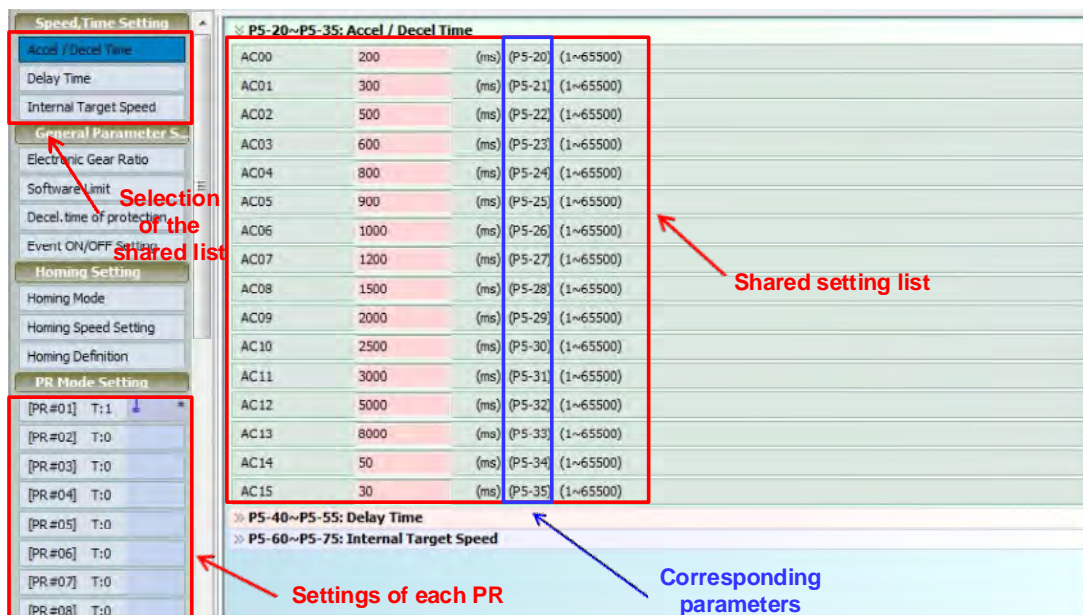

Figure 1.16 Shared Data of PR

1.2.2   Introduction of PR Homing

ASDA-A2 provides 9 homing methods in PR mode, such as using home sensor or limit as the origin. If including the sub-selection such as taking Z pulse and limit as triggering reference, over 30 choices are available. Homing method is defined by P6-00 and value of origin is specified by P6-01.

Main homing methods supported in PR mode on ASDA-A2 are listed below.

1.2.2.1   Reference to Limit (P5-04.X=0: Move forward to look for positive limit; P5-04.X=1: Move backward to look for negative limit)

This homing method is to take positive limit or negative limit as the origin. After the limit is detected, users may consider whether to regard Z pulse as the origin. See Figure 1.17.
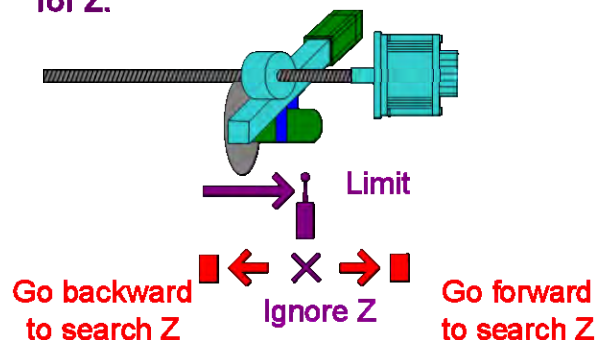

Figure 1.17 Regarding Limit Signal as Origin

If the setting of homing is identical, the origin being found will be exactly the same regardless of the starting position. See Figure 1.18 for homing path and its codes.

S1: starting position

S2: starting position is at the limit

E: end position

H: motor operating at high speed

L: motor operating at low speed
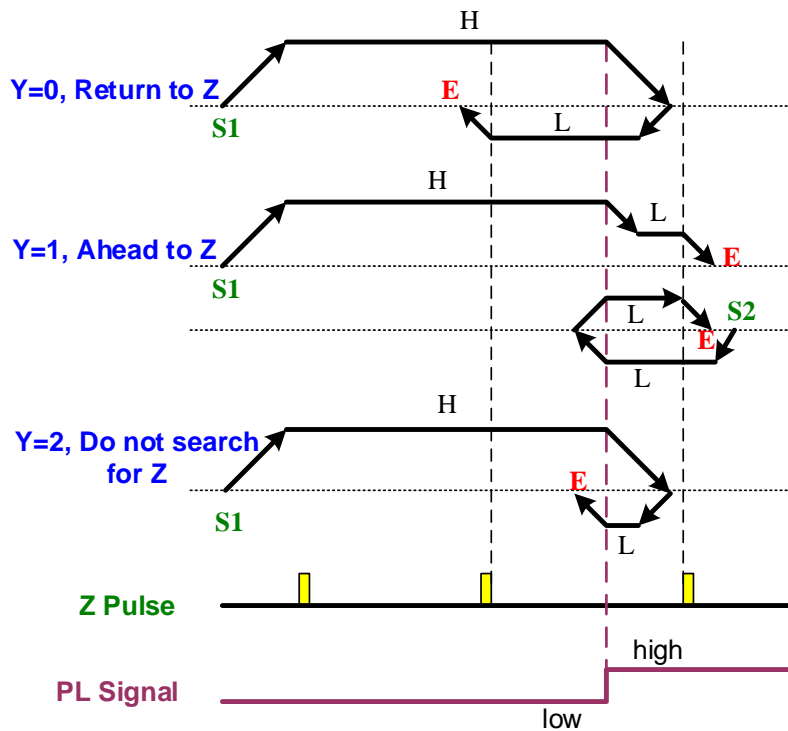
Figure 1.18 Homing Path when Reference to Limit Signal

In Figure 1.18, take Y=1 and look for Z for example, no matter the starting position is S1 or S2, it will stop at position E after homing is completed. When starting position is S1, the motor will operate at higher speed until reaching the rising signal of positive limit (PL) and then turn to lower speed to look for Z pulse. When Z pulse is found, the motor will decelerate to stop. When starting position is S2, as the PL is triggered, ASDA-A2 servo drive will have sensed that the current position has gone beyond the PL signal; motor will return and look for the rising signal of PL at low speed; upon finding, motor moves backward to look for Z pulse and then stop.

1.2.2.2 Reference to Rising-Edge Signal on Home Sensor (P5-04.X=2: move forward to look for rising signal on home sensor; P5-04.X=3: move backward to look for rising signal on home sensor)

This homing method is to take home sensor as reference, regarding rising signal on the home sensor as homing origin. When home sensor detects the signal, Z pulse can also be set as reference origin.
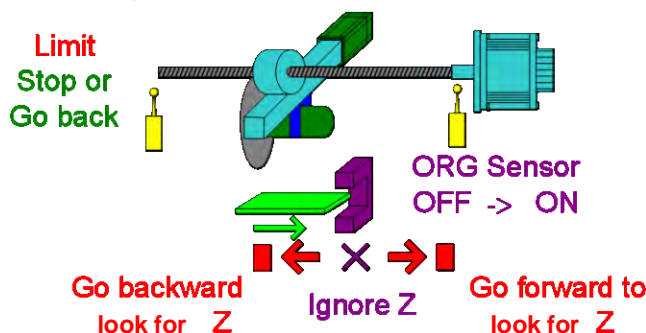

Figure 1.19 Reference to Rising-edge Signal of Home Sensor

In Figure 1.19. Y=0, the motor will return in the opposite direction to look for the Z pulse if the limit signal is encountered before the Z pulse is found. When homing command is issued, the sensor board is at S1 and has not passed through the home sensor. The motor will operate at high speed to look for the rising edge signal of ORG, which is the generated signal when the sensor board triggering home sensor. Then, the motor will return to look for Z signal at low speed. After finding Z signal, it will decelerate to stop at position E.

When staring at position S2, the motor's position has gone beyond ORG sensor; this means when homing command is issued, sensor board has also encountered the home sensor. Sensor board will firstly encounter the limit signal and meanwhile motor can be set to automatically move backward or stop and display errors; this is an example of motor moving backward automatically. After operating in reverse direction and encountering ORG triggering signal at the first time, motor will switch to low speed because it has encountered the limit signal and moved backward. As ASDA-A2 acknowledges that this ORG signal is not the origin signal, it will keep running until encountering the OFF signal of ORG and then starts to look for Z signal. Upon finding Z signal, it will decelerate to stop at position E.

When the starting position is at S3, the sensor board happens to be at the position of home sensor. Meanwhile, ASDA-A2 receives the signal of ORG ON, the motor will start looking for Z signal at the moment it returns and looks for ORG OFF signal. When finding Z signal, the motor will decelerate to stop at position E.

When executing homing, different starting positions will not influence the result of finding the

origin. No matter the starting position is S1, S2, or S3, the origin is at position E.
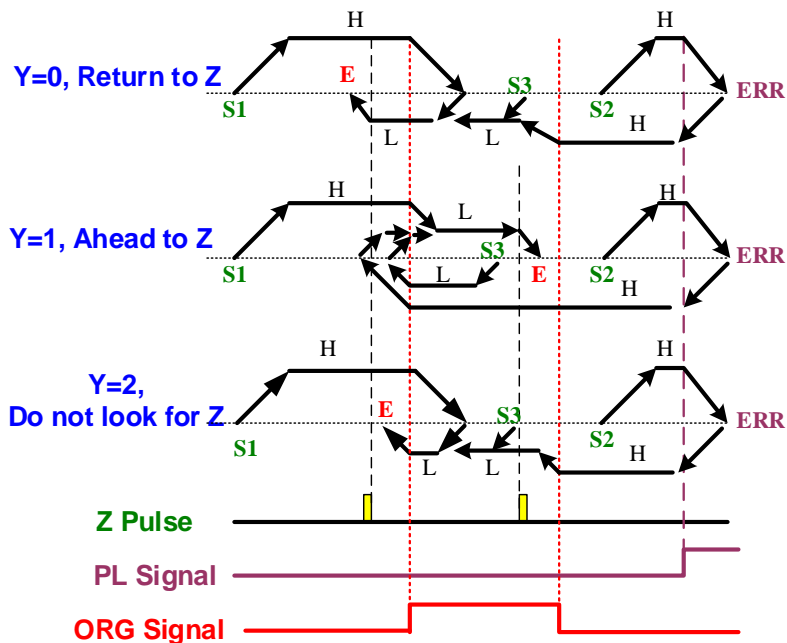
Figure 1.20 Homing Path when Taking Rising Edge Signal as Reference

1.2.2.3 **Reference to Z Pulse** (P5-04.X=4: move forward directly to look for Z pulse; P5-04.X=5: move backward directly to look for Z pulse)

Directly regard Z pulse as reference homing position. There is always a Z pulse whenever motor runs a cycle. This method is applicable when the motor operating distance is within one cycle. P5-04.Y does not need to be set here.
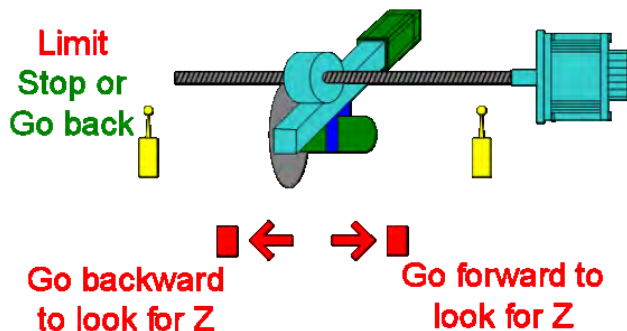
Figure 1.21 Regard Z Pulse as Original Point

When homing, users can choose whether to let motor look for Z pulse either by moving forward or backward. When encountering the limit signal, choices of making motor automatically operate in reverse direction or showing errors are available. In Figure 1.22, after homing, different starting position (S1 and S2) will lead to different stop positions. However, the origin will be at position of Z pulse. No matter starting position is S1 or S2, the generated coordinates system

after homing will be identical.
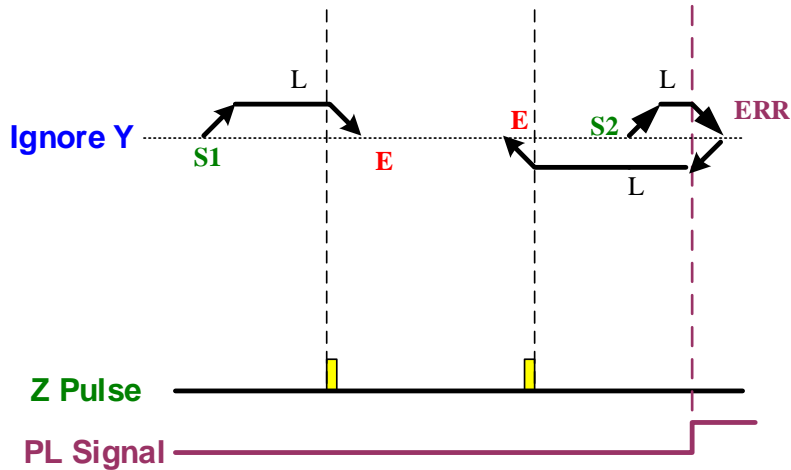
Figure 1.22 Homing Path when Taking Z Pulse as Reference

1.2.2.4 Reference to the Falling-Edge Signal on Home Sensor (P5-04.X=6: move forward to look for the falling edge signal of home sensor; P5-04.X=7: move backward to look for the falling edge signal of home sensor)

This homing method is to take the falling edge signal of home sensor as reference. After home sensor has detected the signal, Z pulse can be also regarded as homing origin.
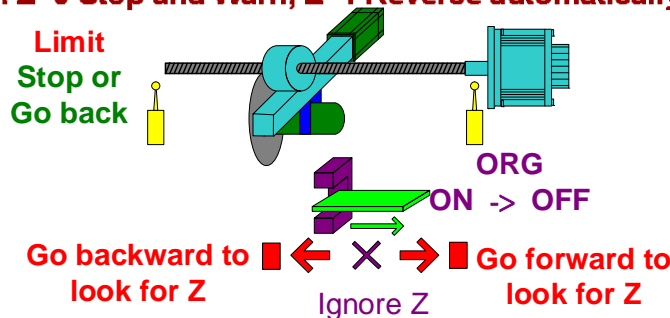
Figure 1.23 Taking the Falling-edge Signal of Home Sensor as Origin Signal

See the example in Figure 1.24. The motor returns and looks for Z. When homing command is issued, the motor's position is at S1 and the sensor board has not passed through the home sensor. At this stage, motor will operate at high speed first; as soon as it encounters the rising edge signal of ORG sensor, motor will then switch to low speed. When encountering the failing edge signal of ORG sensor, motor will keep operating at low speed to look for Z pulse; it then slows down and stops at position E upon finding Z signal.

When starting from position S2, it means when issuing the homing command, the sensor board has passed through the sensor. The sensor board will encounter limit signal first; meanwhile, motor can be selected to automatically reverse or to stop and display errors. In this example, motor encounters the limit signal and then reverse automatically. Before encountering the ON signal of ORG sensor, motor would operate at high speed. After ORG signal is triggered, motor will then switch to low speed and reverse to find the falling edge signal of ORG sensor. Next, it will return and look for Z pulse and stop at position E upon finding Z signal.

S3: While homing command is issued, the sensor board happens to be at the position of the ORG sensor. As it is a falling edge trigger, motor would operate at low speed to look for the falling edge signal of ORG. Upon finding the falling signal, motor will return to look for Z pulse and then it slows down to stop at position E after finding Z pulse.

Whether starting position is at S1, S2, or S3, the position of origin is at E.
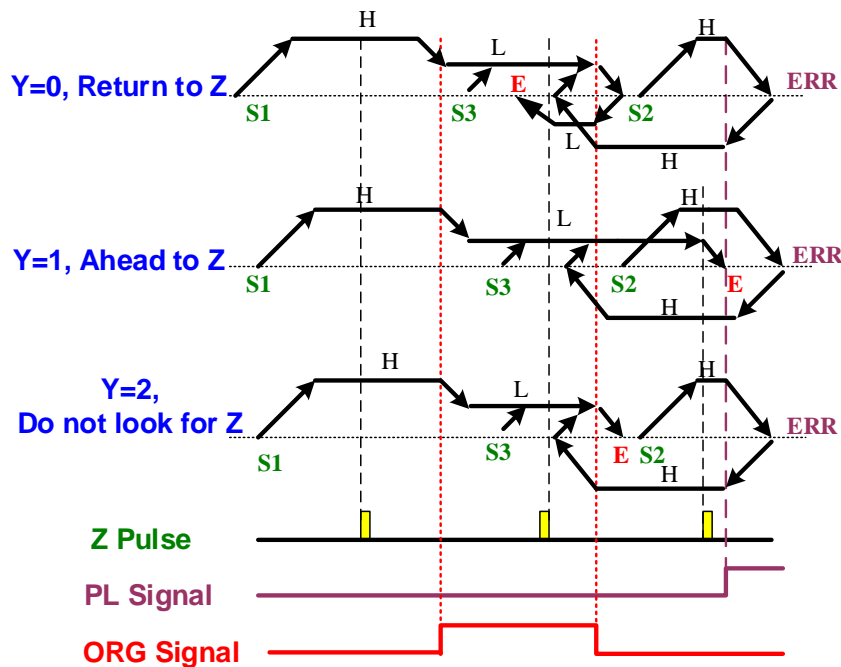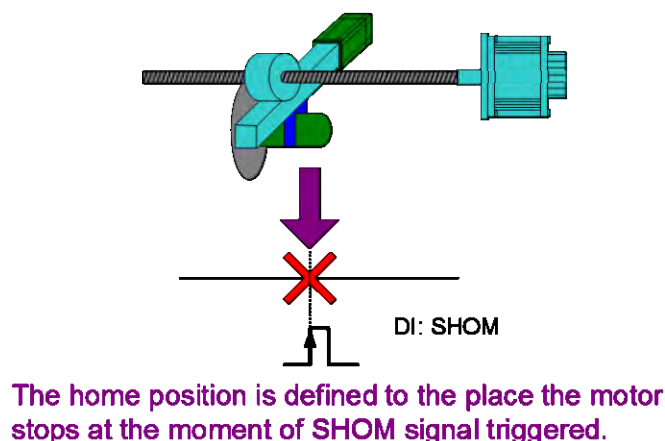

Figure 1.24 Homing Path when Taking Falling-edge Signal of Home Sensor as Reference

1.2.2.5   Reference to Current Position (P5-04.X=8)

This homing mode regards motor's current position as reference origin. Coordinates positioning can be done by triggering homing signal without operating the motor.

Figure 1.25 Regarding Current Position as Home Position

There is one thing worth noticing when homing in PR mode. When finding the reference point, motor will decelerate to stop at somewhere close to the reference point because of the inertia. ASDA-A2 will not request the motor to move to the exact reference origin automatically. Users may use another PR command to request the motor to move to the origin or to any position in the coordinate system. Now, the coordinate system has been built, no matter where the motor stops, the servo will know its stop position on the coordinates. In this case, whether motor stops at the origin or not, part of the operation such as issuing absolute commands will not be influenced. On the other hand, when it comes to relative commands or E-CAM applications, the motor has to be moved to a fixed reference position such as 0 on the coordinates because this type of command will directly regard motor's stop position as start position.

Please refer to Figure 1.26, if 0 is the homing origin, when motor finds the origin and stops, it will stop at coordinate position -523. If motor needs to move back to the absolute 0 on the coordinates, calling PR#1 after homing is required and its absolute position has to be 0.

If motor has to move to any position after homing, this method can be used. For example, motor has to move to position 44356, users may use the setting of calling one PR path after homing and regard 44356 as the target position.
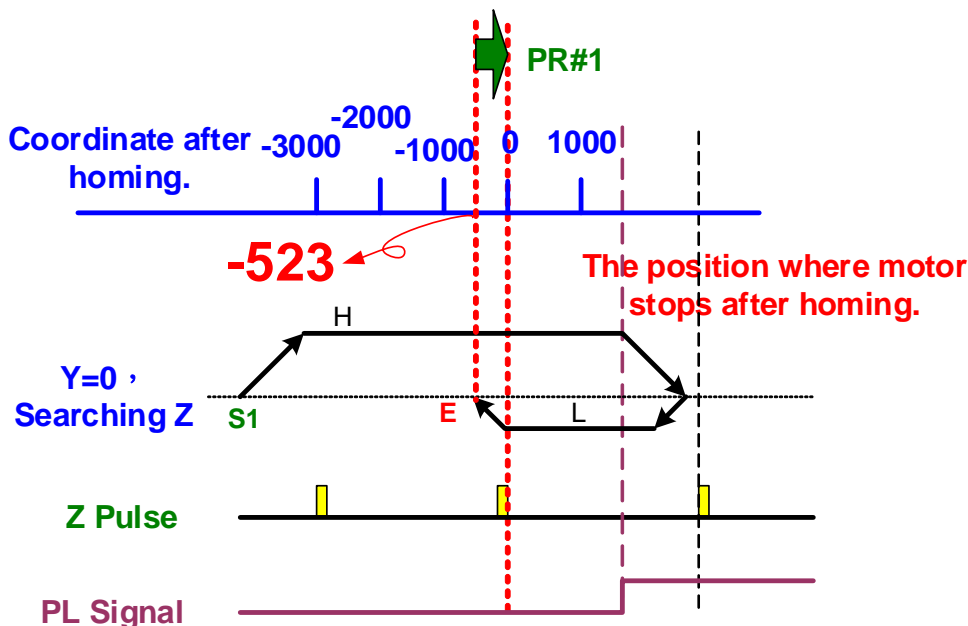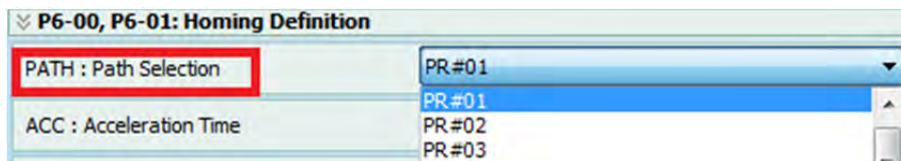
Figure 1.26 Positions of Motor and Homing Origin

PR homing mode of ASDA-A2 can regard any value in the coordinate system as homing origin; position 0 does not necessary to be the homing origin. By confirming the homing reference origin, the coordinate system can be established. Take Figure 1.27 for example, the origin reference is 2000 (P6-01=2000) and motor stops at 1477 on the coordinates. As the coordinate system has been built and acknowledge where 0 is, the next step is to issue PR motion commands. Then, ASDA-A2 is able to figure out the path of target position.
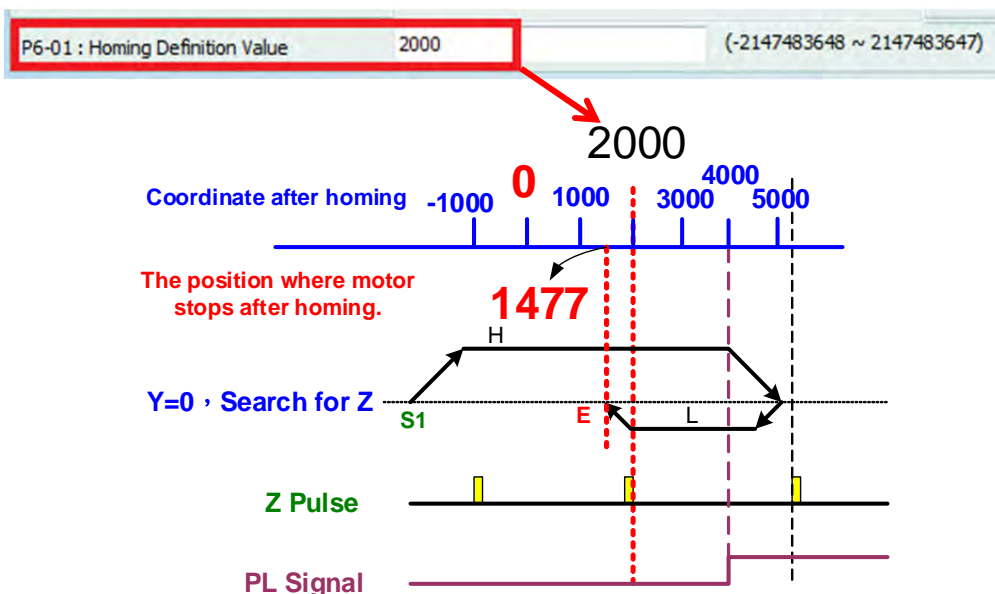
Figure 1.27 Defined Value of Homing Reference Origin

1.2.3   PR Speed Command

Users may use PR mode to configure the speed command, including acceleration/deceleration time, target speed, and delay time. The speed command here refers to the speed command in PR mode (P1-01=0), which is different from command in speed mode (P1-01=2)

Delay time refers to the interval after previous command is completed and before carrying out the next command. The setting of delay time is defined by the servo drive, which means the servo drive will not start counting the delay time until the motor has reached the target speed. Delay time is not defined by motor's feedback signal because the feedback setting time varies with different system performance.

If the trigger setting of PR is defined as a speed command, motor will operate according to the acceleration/deceleration setting until reaching the target speed. Then it keeps operating till other command interrupts this PR command.
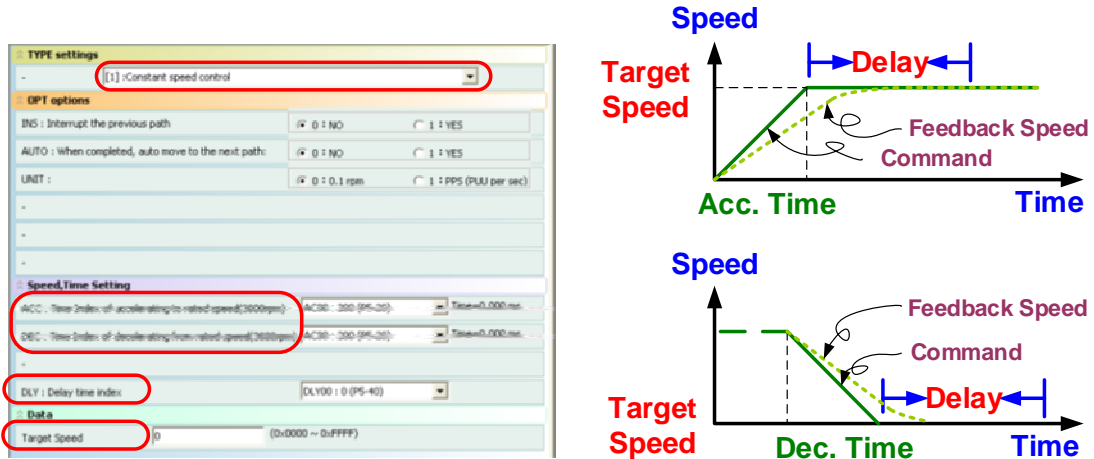
Figure 1.28 PR Speed Command

1.2.4 PR Position Command

When using PR mode to configure position commands, other than target position, users have to decide how motor reaches the target position. That is, the acceleration/ deceleration and target speed of the motor has to be specified. Besides, delay time will start to be counted after motor reaches the target position.
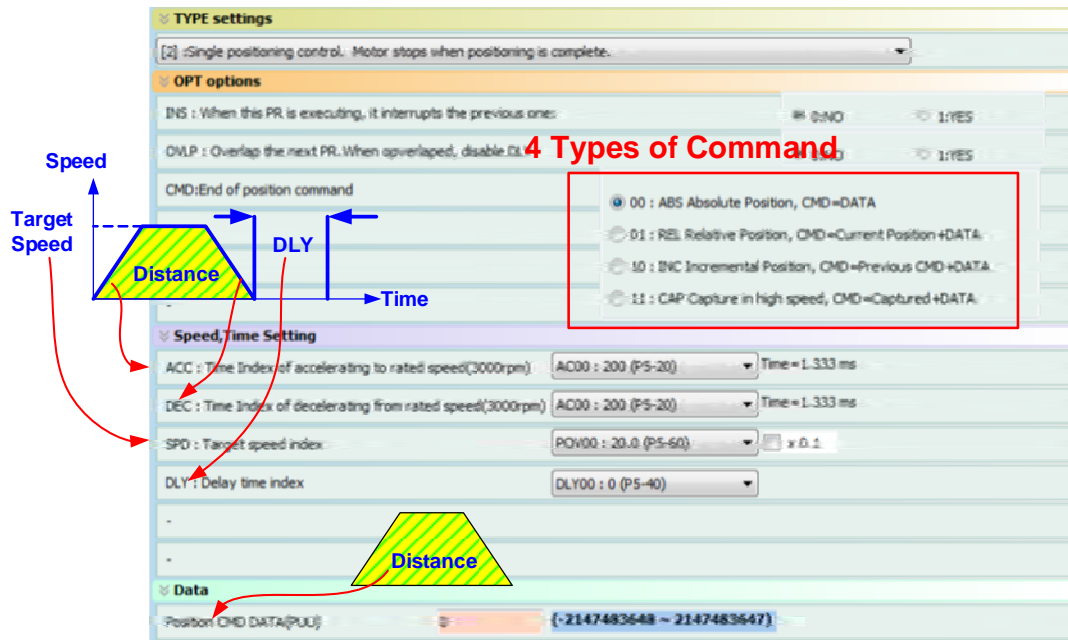
Figure 1.29 Setting of Position Command

PR position control of ASDA-A2 provides four types of position commands:

1. Absolute command:

   The value of position command is the absolute position on the coordinates, which is the target position.

2. Relative command:

   Value of motor's current position + Value of position command = Target position

3. Incremental command:

   Value of previous target position + Value of current position command = Target position

4. Capture command :

   Value captured by Capture function + Value of position command = Target position

See the example in Figure 1.30. Target position of previous command is 30000 PUU, when motor reaches position 20000 PUU, the following commands will interrupt the current motion.

1. Absolute command 60000 PUU:

   Target position is the new position command, 60000 PUU.

2. Relative command 60000 PUU:

   Target position (80000 PUU) = motor's current position (20000 PUU) + new position command (60000 PUU)

3. Incremental command 60000 PUU:

    Target position (90000 PUU) = Previous target position (30000 PUU) + New position command (60000 PUU)

4. Capture command 60000 PUU:

    If the last value captured is 10000 PUU, target position will be 10000 PUU + 60000 PUU = 70000 PUU
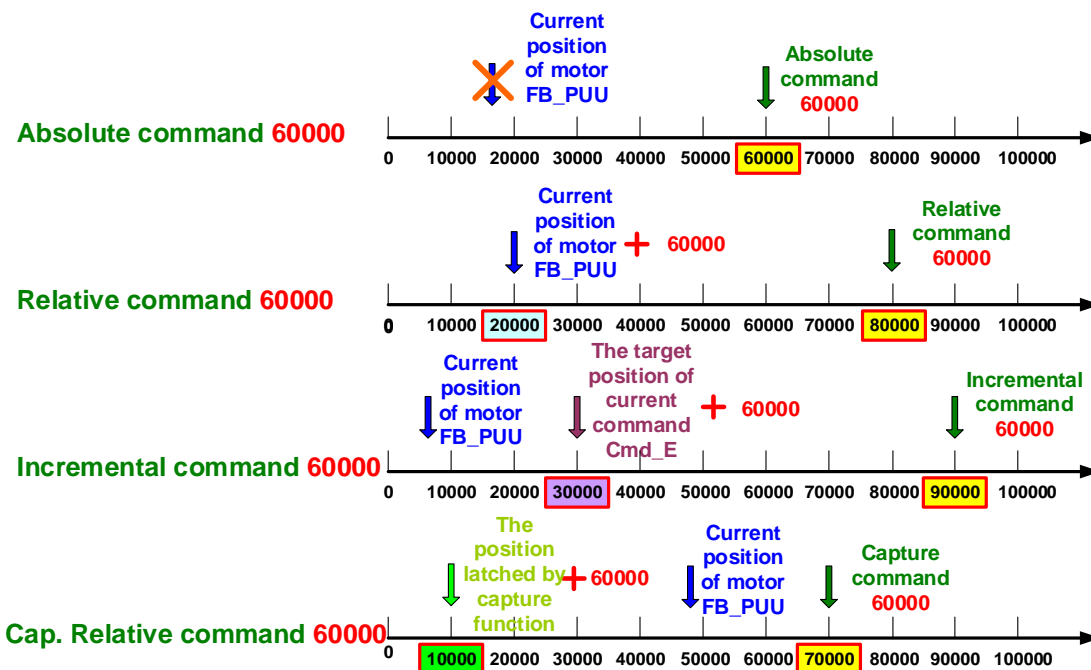
Figure 1.30 Types of Position Command

Regarding position command, two types of setting are available. Type 2 (*Single positioning control, Motor stops when positioning is complete*), the PR procedure stops when this PR command is completed. Type 3 (*Auto positioning control, Motor goes to the next path when positioning is complete*), automatically carry out the next PR command after the current one is completed. To carry on to the next path or to stop is the only difference between these two types; other settings are identical.

1.2.5   Jump Command

Users may use Jump command to call any PR. It serves as functions like subroutines and is able to turn PR paths into a loop. See Figure 1.31.
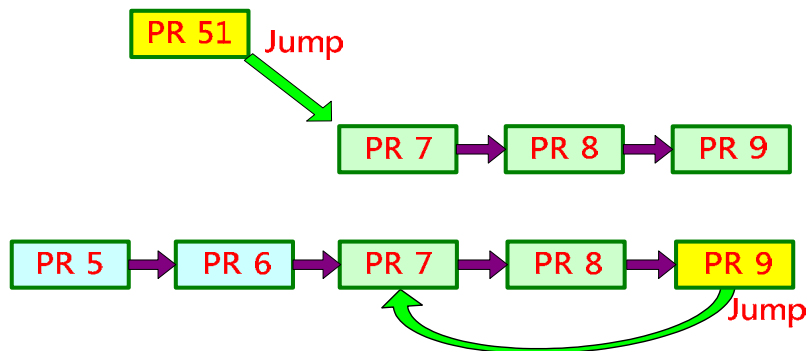
Figure 1.31 Example of PR Jump Command

1.2.6   PR Write-in Command
(Write the specified parameter to the specified path)

Write-in command can modify the writable parameter settings or values saved by data array in the servo drive. Users can edit the time of modifying parameter values by using the PR command executing time. Source of write-in data can be constants, value of system parameter, value in data array, or value presented by monitoring variables. See the following table.

Data Source	Target
Constant (Input constant) System Parameter (Specified system parameter) Data Array (Specified address of data array) Monitoring Variables (Specified monitoring variables)	System Parameter (Specified system parameter) Data Array (Specified the address of data array)
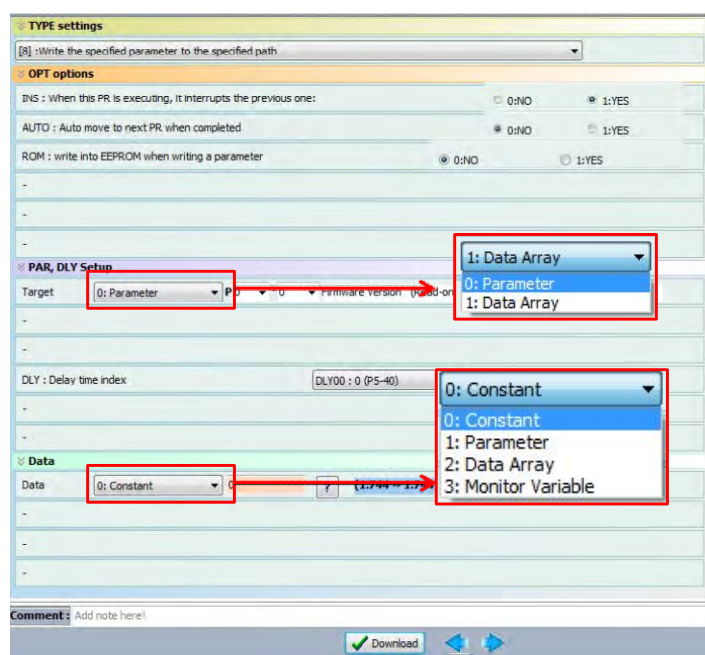
Figure 1.32 PR Write-in Function

1.2.7   PR Triggering Methods

Multiple types of PR triggering methods are available on ASDA-A2. Users may choose the most suitable method based on the application.

1.2.7.1   Trigger by DI.CTRG / POS0 ~ POS5 / STOP

To use this trigger method, users have to use DI to select the PR to be carried out. Firstly, use DI.POS0~5 (setting value: 0x11, 0x12, 0x13, 0x1A, 0x1B, 0x1C) to select PR position command. After selecting, use DI.CTRG (0x08) to carry out this PR. Users may use DI.STOP (0x46) to stop this PR. When using DI.STOP to cease the PR operation, the part that has not yet been executed in this PR command will not be eliminated. See Figure 1.33.
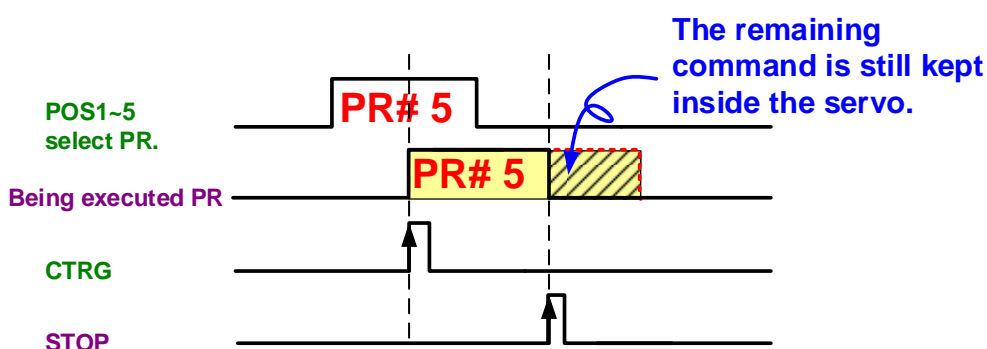
Figure 1.33 Method of Triggering PR by DI

If users would like to carry out the PR command that has not been completed after using DI.STOP and it is an absolute command (ABS), users may carry out the same PR command or call another incremental (INC) command of which position value is 0. On the other hand, if this is not an absolute command (ABS), the only way to complete it is to call another incremental command (INC) of which position value is 0. To clear the uncompleted PR command after using DI.STOP, it needs to carry out a relative command (REL) of position value is 0.

1.2.7.2   Parameter P5-07

Users may use software, HMI, host controller, or panel to write the PR to be executed in P5-07. When the read value equals the entered command value plus 10000, it means the PR command is completely issued. When the displayed value equals the entered command value plus 2000, it means PR command has been completely carried out. As shown in Figure 1.34, when the next PR path to be executed is PR#20, the displayed value of P5-07 will be 20. As PR command has been sent completely but motor is not in place, P5-07 will display 10020. After finishing carrying out the PR, P5-07 will display 20020.
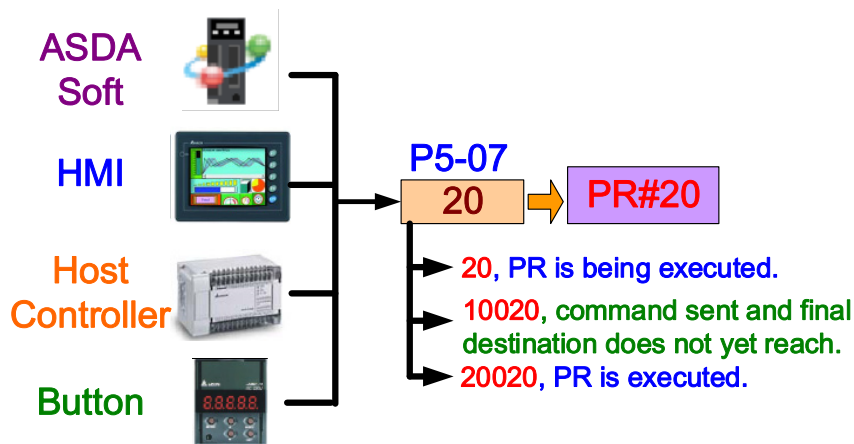
Figure 1.34 Triggering PR by Parameter

To observe the PR procedure, check the item ADR in PC scope channel and then enter 0x20002507. By doing so, users may monitor the change of P5-07. Regarding the entered value, 0X20002 is a fixed value; 5 stands for the parameter group of P5-07; 07 represents the hexadecimal value of the parameter number.
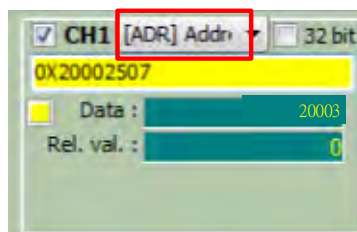
Figure 1.35 Observe PR Procedure by PC Scope

1.2.7.3 DI.SHOM

Use DI.SHOM (0x27) to trigger PR#0 (Homing mode). This DI triggers PR#0 only.

1.2.7.4 Event Trigger

Using event trigger requires settings of relevant DI and parameters. Regarding DI, four sets are available, Event 1 (EV1, 0x39), Event 2 (EV2, 0x3A), Event 3 (EV3, 0x3B), and Event 4 (EV4, 0x3C). Every DI has one rising edge and one falling edge to trigger different PRs respectively. If four sets of DI are all used, they can trigger eight PRs in total. Four sets of rising edge that can trigger PRs shall be set in P5-98; the other four sets of falling edge that can trigger PRs shall be set in P5-99. Setting values of P5-98 and P5-99 and their corresponding PRs are shown in table of Figure 1.36.
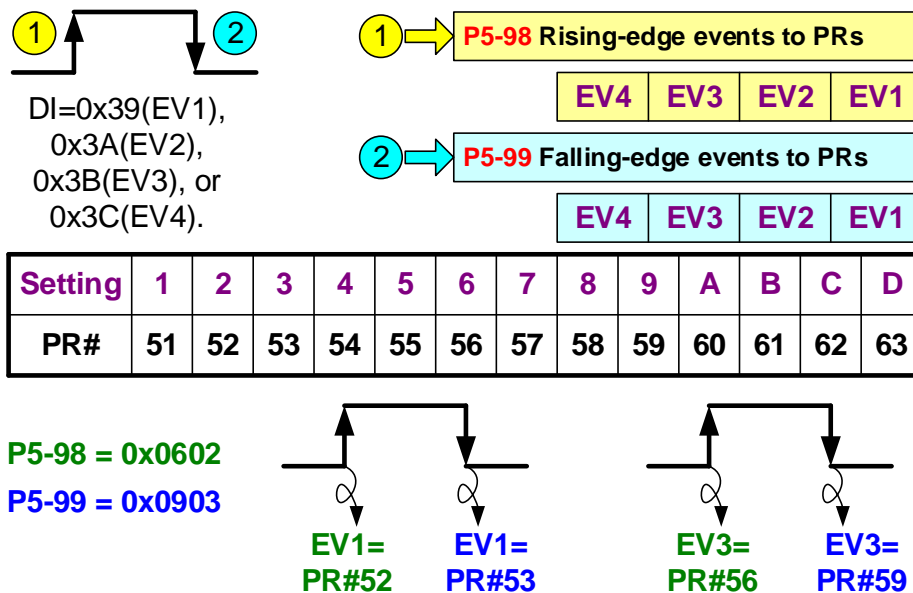
Figure 1.36 Trigger PR by Event

For example, when P5-98 = 05D2 and P5-99 = 790A: (The way that Delta usually use when describing parameters: P5-98=0xUZYX)

1. EV1: Because P5-98.X = 2, the rising edge signal of EV1 will trigger PR#52. Because P5-99.X = A, the falling edge of EV1 will trigger PR#60.

2. EV2: Because P5-98.Y = D, the rising edge signal of EV2 will trigger PR#63. Because P5-99.Y=0, the falling edge signal of EV2 will not trigger any PR command.

3. EV3: Because P5-98.Z = 5, the rising edge signal of EV3 will trigger PR#55. Because P5-99.Z=9, the falling edge signal of EV3 will trigger PR#59.

4. EV4: Because P5-98.U = 0, the rising edge signal of EV4 will not trigger any PR. Because P5-99.U = 7, the falling edge signal of EV4 will trigger PR#57.

1.2.7.5   Others CAPTURE Completed / COMPARE Completed / E-CAM Disengaged

If Bit 3 of P5-39 has been set, after Capture command (P5-38 = 0) is completed, the servo will automatically call PR#45. If P5-88.BA has been set, when E-Cam is disengaged, the system will regard the setting of P5-88.BA as PR path to be carried out and then automatically carry out this PR.
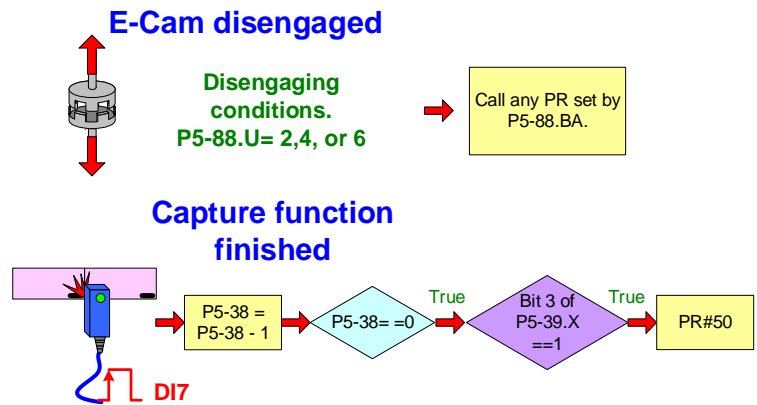
Figure 1.37 Other Methods of Triggering PR

1.3   Motion Control

1.3.1   Monitoring Variables Related to PR

Regarding the operation of PR, four parameters are available to be used to observe commands and feedback.

1. Cmd_O: Command operation, the motion command in operation which represents the absolute coordinates of the current output command. It also includes the setting of acceleration/deceleration and target speed when operating. (monitoring variable 001)

2. Cmd_E: command end, the target position; when command is issued to the servo, the servo drive will figure out the final target position and promptly update Cmd_E (variable 064).

3. Fb_PUU: feedback PUU, motor's current position (monitoring variable 000).

4. Err_PUU: error PUU, the deviation between command and the current position during motor's operation (monitoring variable 002).

Users can use PC scope of ASDA-Soft to observe PR's monitoring variables. As shown in Figure 1.38, user can select feedback position or monitoring variable 000(00h) to monitor Fb_PUU, select position command or monitoring variable 001(01h) to monitor Cmd_O, or select position deviation or monitoring variable 002(02h) to see Err_PUU, and then observe Cmd_E by setting up monitoring variable 064(40h). To observe monitoring variables in PC scope, check the item ADR and enter 0x10000064 to see the change of Cmd_E. In regards to the input value, 0x100000 is a fixed value and the value 64 represents the 64-bit monitoring variable of target position.
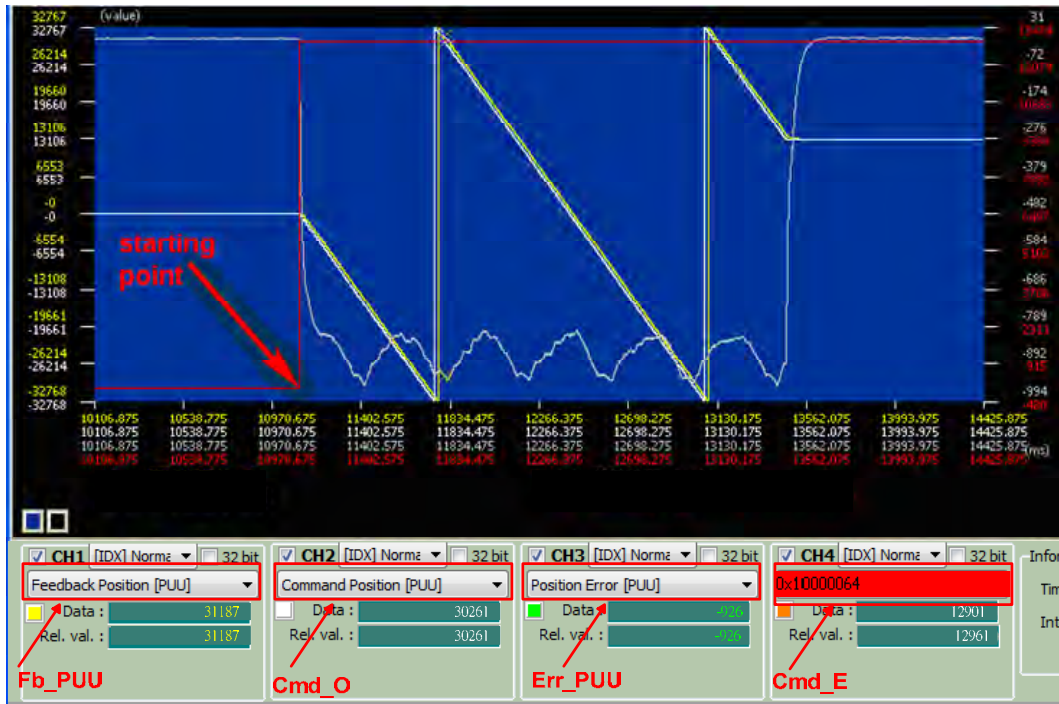
Figure 1.38 PC Scope of PR Monitoring Variables (32-bit)

Except that Err_PUU is 16-bit, other three parameters are 32-bit. To see the whole picture of Cmd_O, Cmd_E, and Fb_PUU, users have to select the item of 32-bit display; however, only two variables can be monitored at the same time in this case. See Figure 1.39.
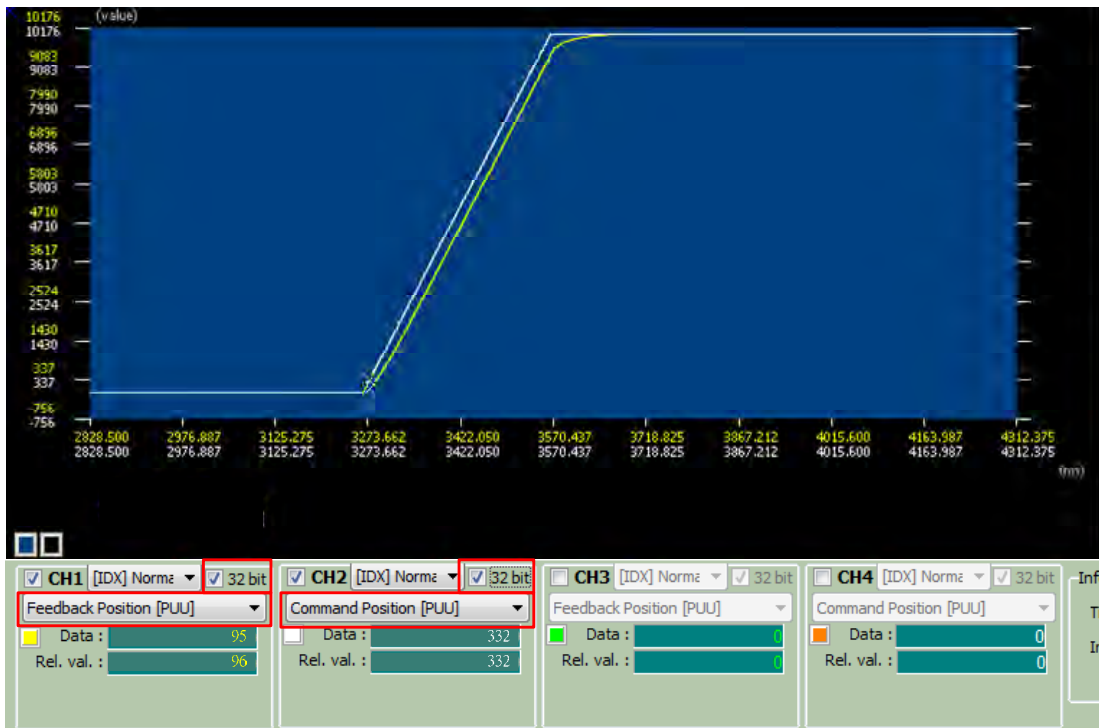
Figure 1.39 Monitoring Variables on PC Scope (32-bit)

As feedback value has to be identical to the command value, Cmd_O = Fb_PUU + Err_PUU. Shown in Figure 1.40, after the servo issues the command, which is an internal one, the servo will immediately know its target destination, which is Cmd_E in this case. However, motor has to operate according to the motion command (acceleration/deceleration and target speed) until reaching the target. Cmd_O command requests the motor to move forward step by step as specified. The current position sent by motor is Fb_PUU; Err_PUU is the actual amount that the motor falls behind Cmd_O.
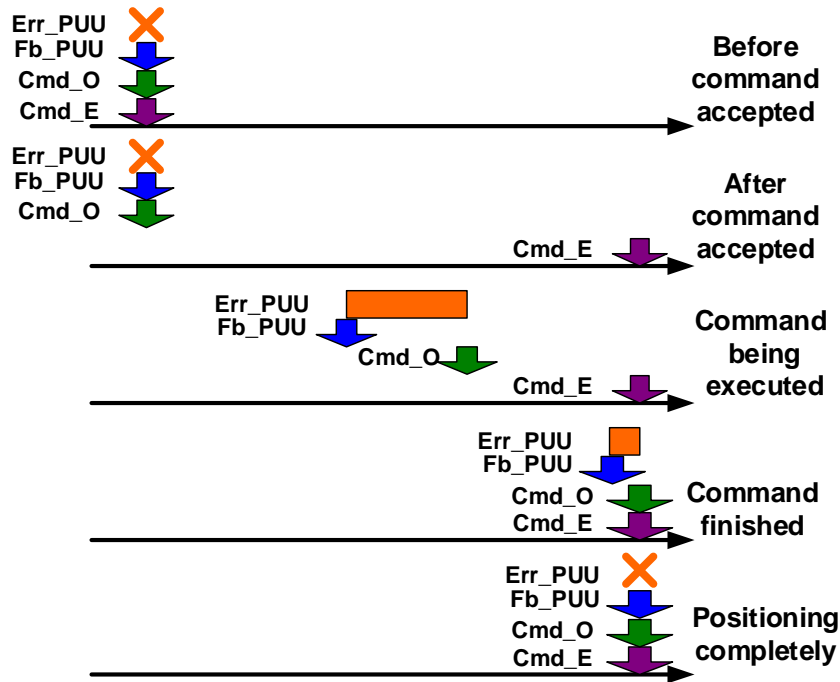
Figure 1.40 Example of Position Command

In PR mode, after command is completely issued and motor is in place, DO.MC_OK will be On. Demonstrated in Figure 1.41, DO.CMD_OK will be ON when the command is completed (including delay time) and motor is in place. If delay time is long, when motor has reached the target position but the command has not been completed, DO. MC_OK will not be On; it will wait for the conditions to be fulfilled, it will wait until DO.TPOS and DO.CMD_OK are both on.
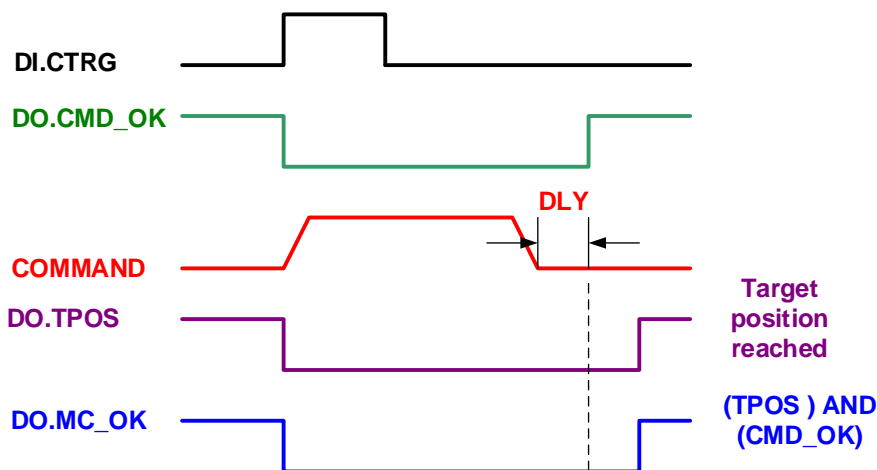
Figure 1.41 Example of Monitor Signal MC_OK

Another exception is homing command. The difference between homing and position command is that Cmd_E does not know where the target position is when homing. Only when reference origin is found and coordinate system is built can Cmd_E's position be known. That is, after homing command is issued and before origin found and coordinate system built, Cmd_E = Cmd_O. See Figure 1.42.
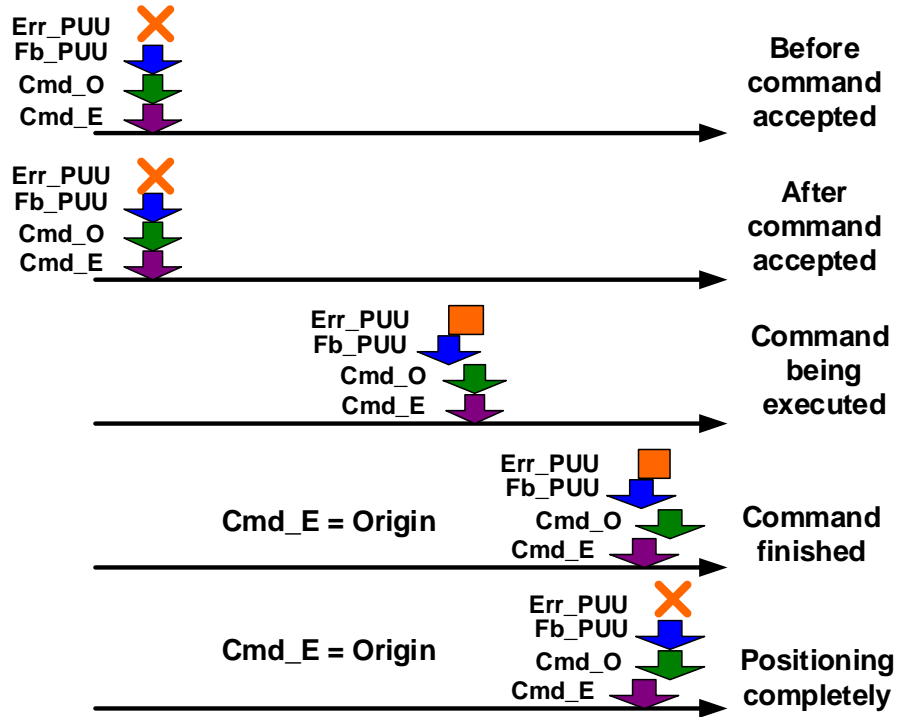
Figure 1.42 Example of Homing

1.3.2   Sequence Command

PR can also specify motion commands including position control and speed control. Sequence command is a motion command that does not have overlaps (OVLP) or interrupts (INS). It is executed in sequence. After previous command is executed and delay time is over, the next command can be carried out. In terms of command of position control, counting of delay time starts after motion command. Regarding speed command, counting of delay time will start after the command reaches the target speed. See Figure 1.43.
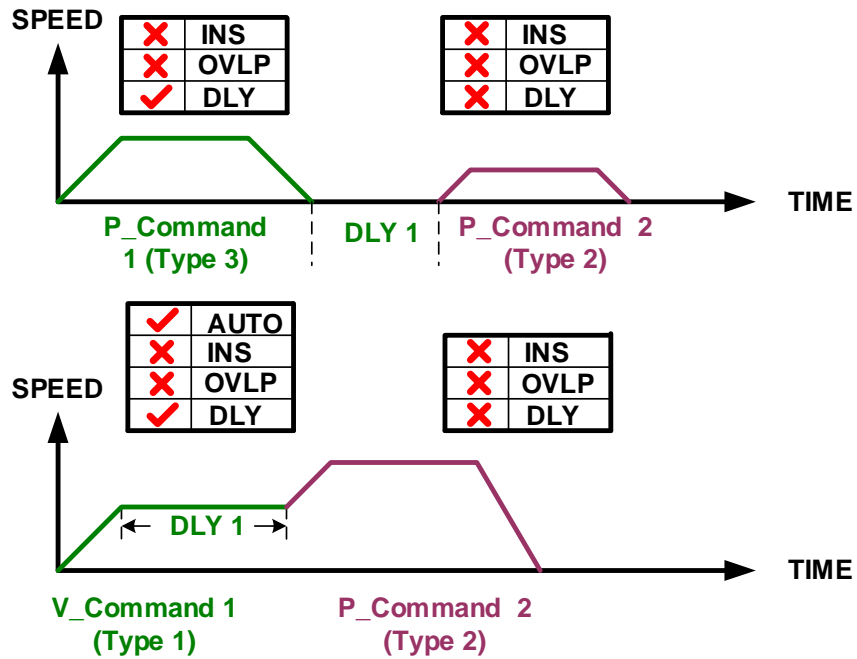
Figure 1.43 Sequence Command

1.3.3   Overlap of Commands

When using the overlap function, delay time is still effective in the system. To smoothly carry out commands one after another, please set the delay time to 0 in the previous part when using the overlap function. In this case, the next command will start operating when previous command is in deceleration zone. By doing so, two motion commands can be smoothly connected and vibration can thus be reduced. See figure 1.44. As delay time will influence the time sequence of overlap, delay time is suggested to be set 0 in this application. Please note that when overlap is enabled, previous command's delay time count will begin from the moment that command starts. Overlap is set in the previous command; that is to say, the deceleration zone of previous command overlaps the acceleration zone of the next command.
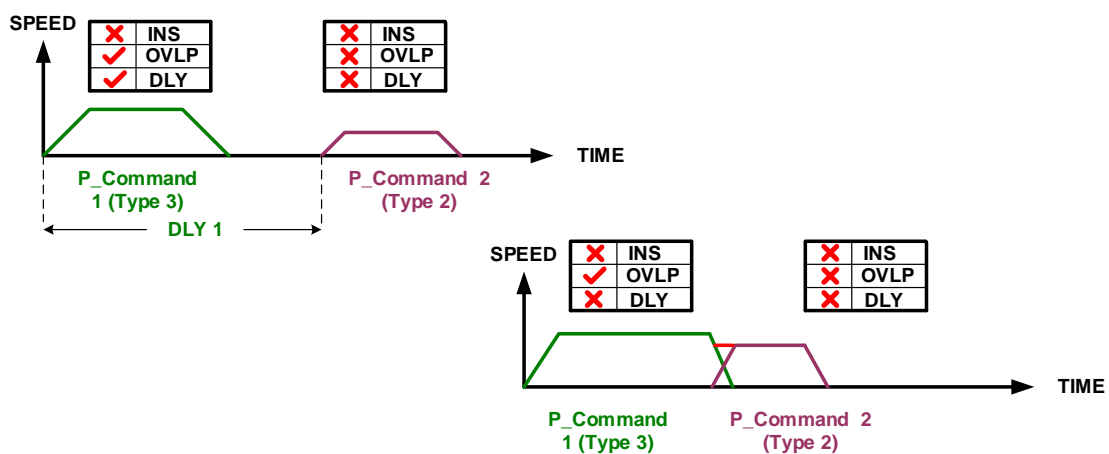
Figure 1.44 Overlap of Command

To have the overlap function perform well, users need to set up as follows:

Absolute value of deceleration curve slope from previous command = absolute value of acceleration curve slope from next command

As shown in Figure 1.45, when previous command enters the deceleration zone, it will be able to change to the speed specified by the next command smoothly, reducing the vibration caused by speed changing.

$$\frac{\text{Target Speed A}}{\text{Dec. Time A}} = \frac{\text{Target Speed B}}{\text{Acc. Time B}}$$
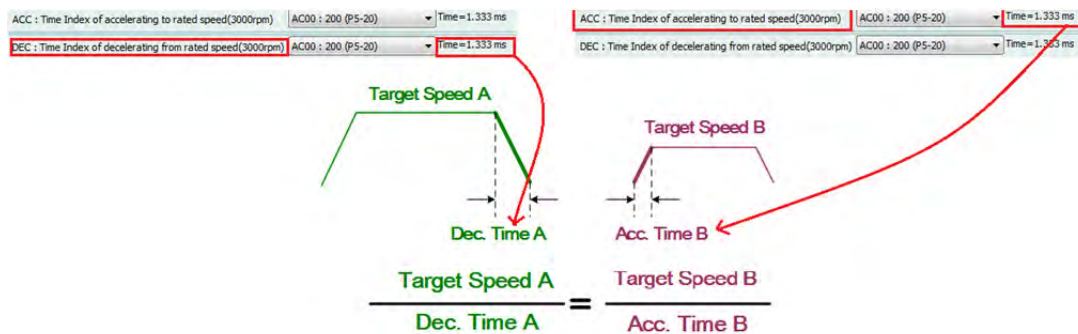
Figure 1.45 Settings of Overlap Command

See Figure 1.46 for example, the meshed part is the overlapped area. When speed of the two position commands is identical and the absolute value of deceleration curve slope of previous command equals acceleration curve slope of the next command, the measure of meshed area can compensate the area with slanting lines, allowing motor to keep the same speed when switching from the first command to the second one and keep the total operation procedure the same.
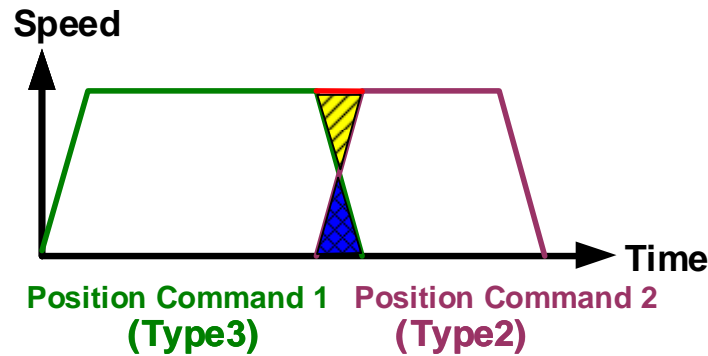
Figure 1.46 Overlap Command with Consistent Slopes

In Figure 1.47, the absolute value of deceleration curve slope does not equal to that of the acceleration curve slope. Since the overall procedure cannot be changed, which means the sum of two position command's measurement of the speed curve should be identical. When the meshed area can only compensate part of the area with slanting lines, it will cause speed changing when connecting to position commands and the two commands cannot connect smoothly during the process.
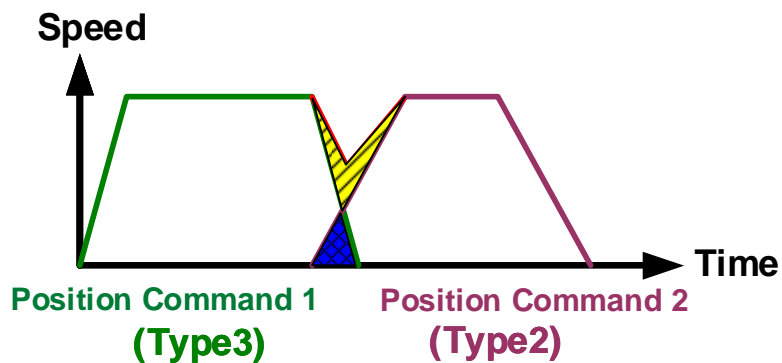
Figure 1.47 Overlap Command with Inconsistent Slope

1.3.4   Interrupt of Command

Interrupt command, a command that is being executed and being replaced or combined with the other command before it is completed. The final result of command varies with the command types. The function of interrupt is to replace the previous command with the latter command. Interrupting method can be categorized into two types: internal and external. Description is as follows.

Internal Interrupt:

In a series of PR profiles, when PR has enabled function of automatically move to the next command, the system will read the next command first after reading the current PR.(If delay time is set, the next command will be read after delay time is over.); the system reads the next command before the current one is completed. If the next command has set the interrupt function, as it has higher priority, the system will promptly deal with the interrupt command, replacing or combining previous command with the latter one. In the following example, PR#1 and PR#2 both automatically call the next command to be executed. However, interrupt is only set in PR#2. After the system finishes reading PR#1, it will read PR#2 immediately. While interrupt function is set in PR#2 and no delay time is set in PR#1, PR#1 will not be carried out and be replaced with PR#2. Next, the system will then continue to read PR#3. As PR#3 has not set interrupt, the system will start carrying out PR#2. PR#3 is the reserved command, which will be carried out after PR#2 is completed.

| PR #1 ✕ | Position(3) D=0, S =20.0 rpm 200000PUU, INC | PR #2 (I) | Position(3) D=0, S=100.0 rpm 300000PUU, INC | PR #3 ✕ | Position(2) D=0, S=200.0 rpm 100000PUU, INC |

With interrupt   Without interrupt
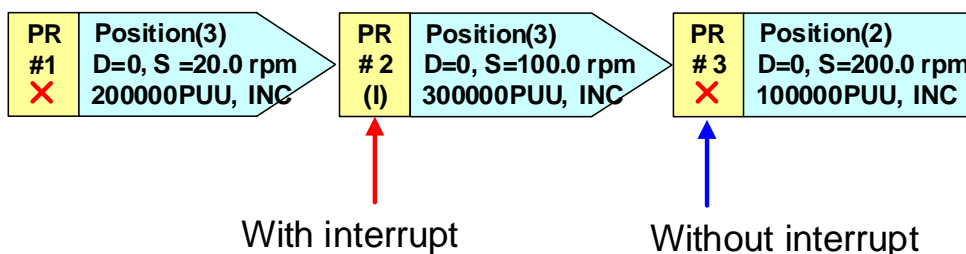
Figure 1.48 Example of Internal Interrupt in PR Profile

Delay time is effective to internal interrupt. With interrupt function, count of delay time of previous command begins when previous command starts. If the delay time of previous command is set to 0 and the next command is set with interrupt, previous command will not be executed and next command will be carried out directly. If previous command has set delay time, the next command will be executed after the delay time is over.

When next PR command is an absolute one and with interrupt, no matter what next PR is, the final destination will be the target position, CMD_E from next PR command. When next PR command is incremental or relative and with interrupt, the destination will be the previous command's CMD_E plus next PR command's CMD_E.
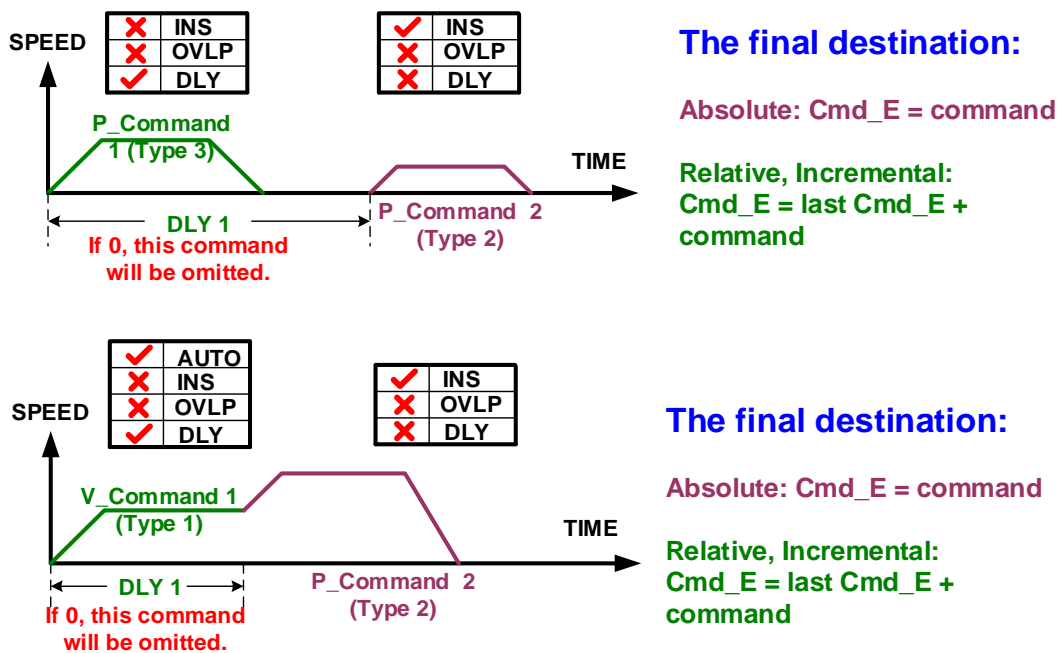
Figure 1.49 Internal Interrupt

External Interrupt:

In a PR profile, any type of trigger method is used to force carrying out the other PR command. (Please refer to Section 1.2.7 for PR trigger method.) When the next PR command with interrupt function comes in, the command that is being executed will be changed. Delay time will not be effective to the external interrupt. That is, when command with external interrupt comes in, the next command will definitely be executed no matter what type of previous command is. See Figure 1.50, PR profile A is carrying out PR#2. Meanwhile, if any type of PR trigger method is used to trigger PR profile B (Triggering PR#30, with interrupt), the motion command of PR#2 being executed will be combined with that of PR#30. Therefore, the system will not carry out the rest of the motion command of PR#2; instead, it will carry on to PR profile B.
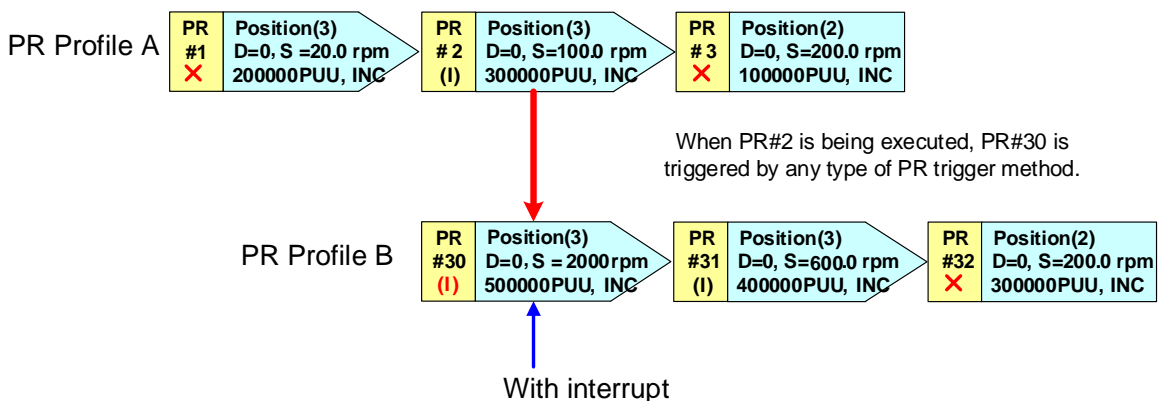
Figure 1.50 External Interrupt of PR Profile

If the next PR command is an absolute one with interrupt, no matter what previous PR command is, the final destination will be the target position CMD_E of the next PR command. If the next PR command is an incremental one and with interrupt, the final destination will be previous PR command's CMD_E plus the next command's CMD_E. If the next PR command is relative and with interrupt, when interrupt occurs, the final destination is the motor's current position Fb_PUU of previous PR plus the next PR's CMD_E.
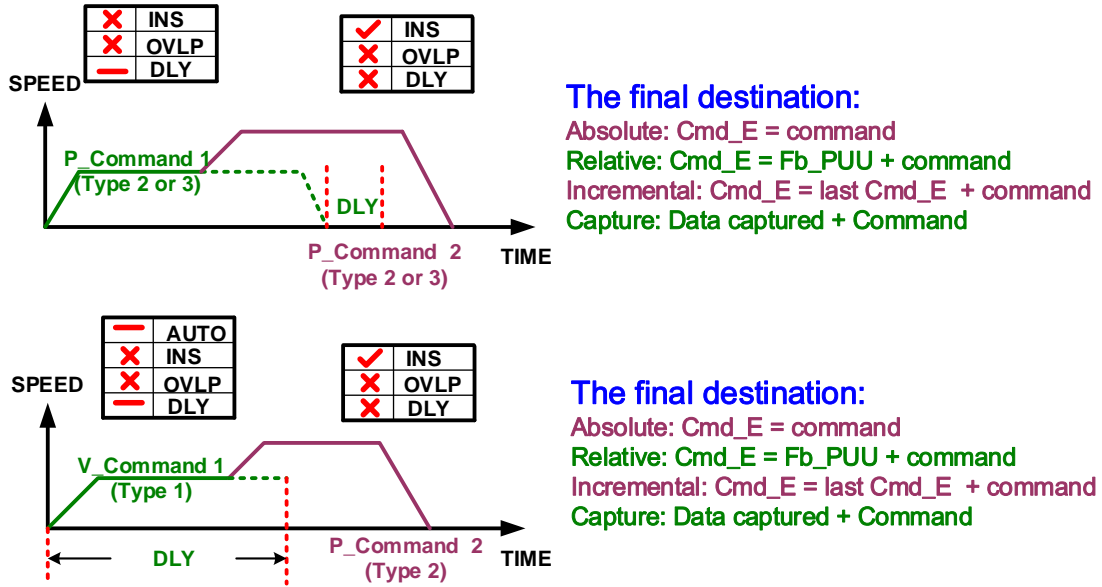
Figure 1.51 External Interrupt

1.4   Presentation of PR

This section explains how PR functions are presented. With the presentation format shown here, the whole PR procedure can be understood more easily. In this document, this format will continue be used to illustrate the PR profile. See Figure 1.52, PR profile can be presented with following ways.

1. If this PR command is completed and the PR profile is then completed without moving to the next PR (without Auto), information of this PR is presented with a rectangle frame. If the PR is with Auto function, which means it will be carrying out the next PR, this PR will be presented in an arrow-shaped frame, pointing to the next PR. This format is adapted to all presentation of PR functions. However, Jump function can only be presented in an arrow-shaped frame because the PR specified in the Jump command will definitely be executed.

2. The presentation is consisted of 5 parts. See Figure 1.52 for the description of each part.

    Part (1) The number of PR.

    Part (2) This part shows whether this PR command has interrupt function. If yes, label (I) is presented here; If not, this part will be blank.

    Part (3) This part shows functions of this PR command, which are mainly homing (Home), speed control (Speed), position control (Position), write-in (Write), and jump (Jump).

    Part (4) Information in this part varies with PR functions. Details will be explained based on each mode in the following content.

    Part (5) Information in this part varies with PR functions. Details will be explained based on each mode in the following content.
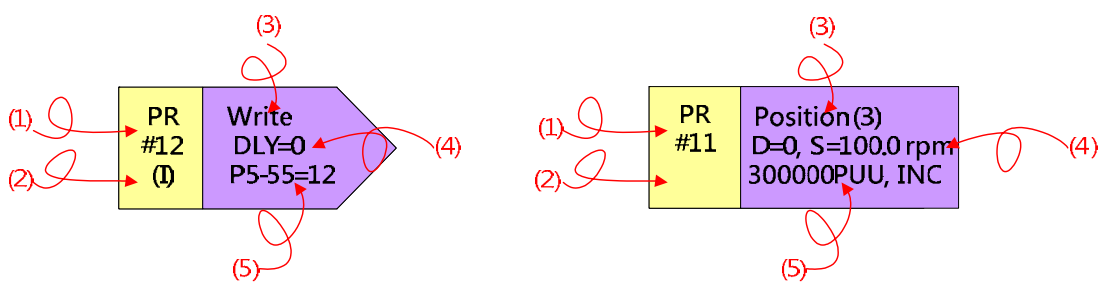
Figure 1.52 Presentation of PR

3. Homing mode: As shown in Figure 1.53, interrupt function is not available in this mode. Thus, label shown in Part (2) mentioned in Figure 1.52 is not required here. In this mode, "Home" is shown in Part (3); Part (4) is for specifying offset value on the coordinates, which is the value set by P6-01. Part (5) shows the PR command that being automatically called after homing is completed. If it stops after homing is completed and without moving to the next PR automatically, PR#0 is marked here.
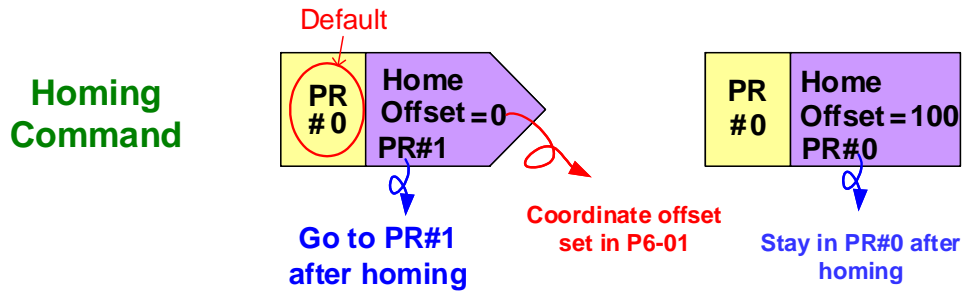
Figure 1.53 Homing Command

4. Speed command: See Figure 1.54, Part (3) mentioned in Figure 1.52 shows "Speed"; Part (4) is the delay time; Part (5) presents the target speed of this PR.
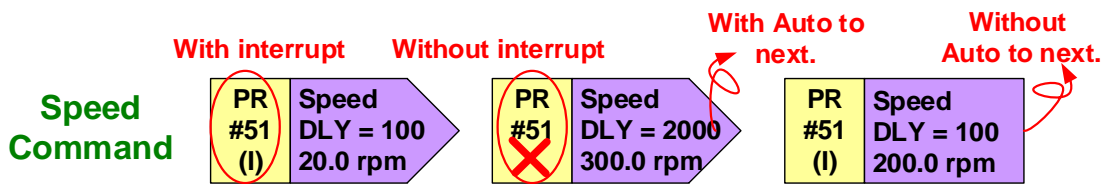
Figure 1.54 Speed Command

5. Jump Command: See Figure 1.55. Part (3) mentioned in Figure 1.52 shows "Jump" here; Part (4) shows the delay time; Part (5) presents the target PR of this Jump command.
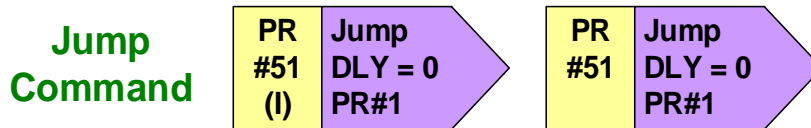
Figure 1.55 Jump Command

6. Write-in Command: See Figure 1.56. Part (3) mentioned in Figure 1.52 shows "Write" here; Part (4) shows the delay time; Part (5) is the written target and value. For example, P5-18=20 means writing 20 to P5-18 when this PR command is being executed.
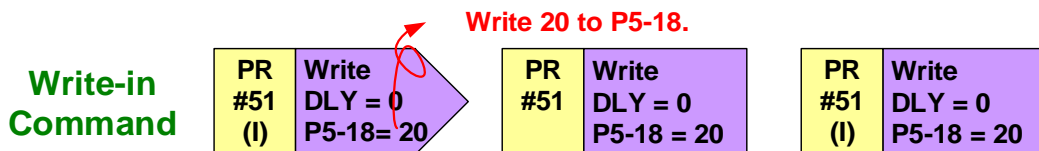
Figure 1.56 Write Command

7. Position command: See Figure 1.57. Part (3) mentioned in Figure 1.52 shows "Position (2)" here; this means to stop after the command is completed. If "Position (3)" is shown, it means to automatically carry out the next PR command after this command is completed. Part (4) here shows the delay time and target speed; Part (5) shows the type and required operating distance of the position command. Regarding the

command type, ABS stands for an absolute command, REL for relative command, INC for incremental command, and CAP for capture command.

Type 2 position command
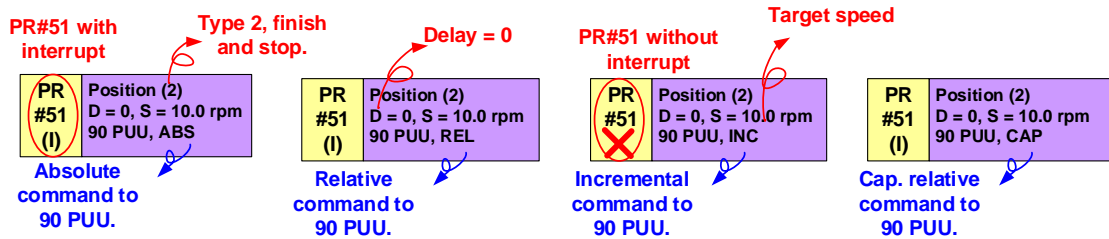
Type 3 position command
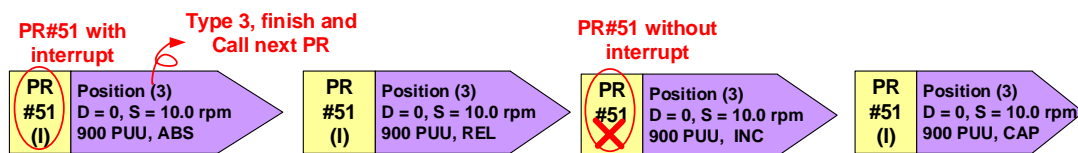
Figure 1.57 Position Command

When the system continuously carries out a series of PR paths, they are regarded as a PR group. The first PR command in the group is called the Head PR, which is externally triggered. Jump function or Auto function (automatically move to the next PR path) can be set in the Head PR to continue carrying out other PR commands. See Figure 1.58.
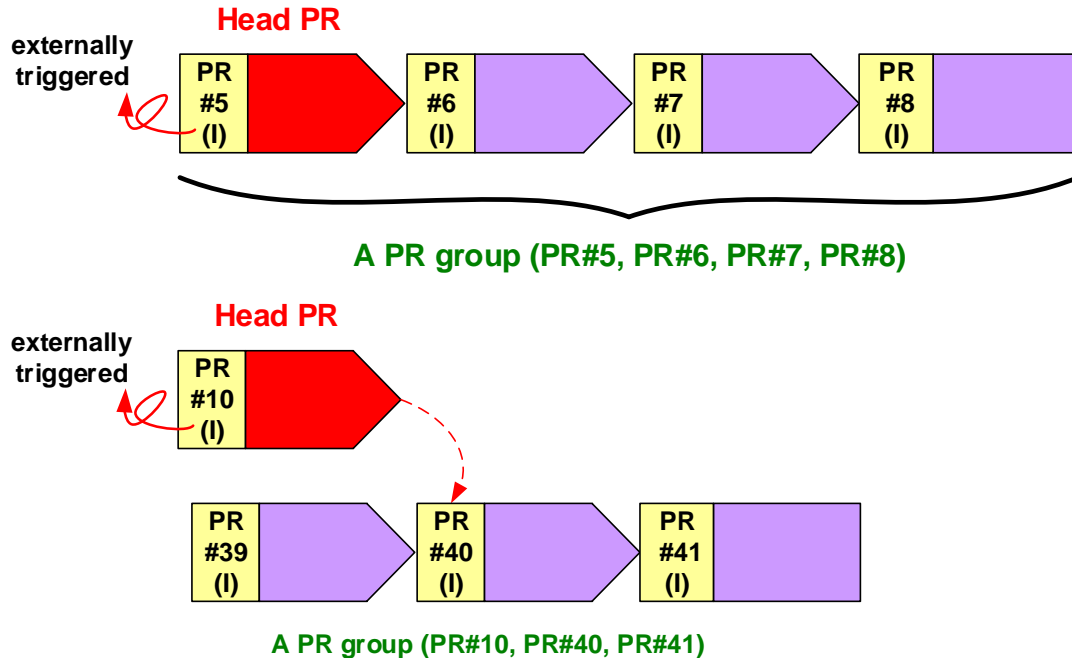
Figure 1.58 PR Group

1.5   How is PR arranged?

ASDA-A2 will update the command status every 1 ms; Figure 1.59 shows how PR profile is arranged in ASDA-A2 and illustrating how it deals with PR commands.

High ←   → Low

Priority   CTRG   STP   P5-07   SHOM   EV1~4(↓)   EV1~4(↑)

PR Queue — PR Queue (first in first out)

Every 1 ms, it will issue a Head PR command if any Head PR is waiting in the PR queue.

The new Head PR issued by PR Queue will terminate the PR group being executed in the PR Executor.

PR Executor — PR Executor
1. The PR Executor will dispatch every single PR in the PR group to the next level if it is a PR with motion function (Type 1 Constant Speed Control, Type 2 Position, and Type 3 Position to Next).
2. The Type 7 Jump and Type 8 Write-in Parameter will be finished in PR Executor.
3. Eight consecutive PRs with INS set can be guaranteed to be executed within 1 ms in PR Executor.

Sequence / Interrupt / Overlap

Motion Command Generator — Motion Command Generator
1. The motion command will be generated here.
2. It could be sequence, interrupt, or overlap.

Output Motion Profile — SPEED / TIME

Figure 1.59 Arrangement Procedure of PR

PR Trigger Mechanism

When PR command is triggered with different methods at the same time, the executing order is CTRG > STP > P5-07 > SHOM > EV1~4 (rising-edge trigger) > EV1~4 (falling-edge trigger).

PR Queue

Once all PR commands are triggered, they will enter the PR Queue and wait. Triggered PR command is the Head PR. Thus, its PR group will then enter and wait in the PR Queue. As long as there is a PR command waiting in the Queue, the system will send the Head PR every 1 ms and its PR group to the PR executor in order; the command that enters first will be sent first. Whether there is a PR command being executed, the Queue will include every triggered PR and make sure it enters the Queue.

PR Executor

The newly-received Head PR and its PR group in the PR executor will immediately replace the PR group being executed. If the PR group contains motion commands, which includes speed command and position command, no matter this PR group is completed or not, the executor will distribute those PR with motion commands to the motion command generator. In addition, PR with write-in command or Jump command will be completed at the moment PR executor is read; they will not enter the motion command generator. In PR executor, 8 commands with interrupt and without delay time, as well as being continuously carried out will be completed within 1 ms. If there is a PR command that hasn't been completed within 1 ms and a new PR command group has been sent to the PR executor by the Queue, new PR command group will then replace the previous one. In other words, instead of carrying out the group that hasn't been executed, the executor will start carrying out new ones.

Motion Command Generator

Motion command generator has a buffer zone for temporarily reserving the next command. All motion commands are integrated here. Commands that are being carried out can also be interrupted here. If a PR command contains speed or position orders, PR executor will automatically send this command to the motion generator. As long as motion commands enter the generator, they will be carried out right away. If other command (with interrupt) also enters the generator, it will be integrated with the current command in the generator and the integration is based on its setting. The setting of each PR determines whether multiple motion commands can overlap, interrupt the previous command or being executed in sequence.

1.6   PR Setting Examples

Five similar PR examples are listed here. The difference among them is whether interrupt/delay time is set in each PR. Below is the PR operating procedure.

Example 1:

Note: Each command group is read within 1 ms

Command group (A) and (B) have motion commands thus both of them need motion command generator. However, as PR#11 has no interrupt, group (B) will not be executed until PR#1 is completed.
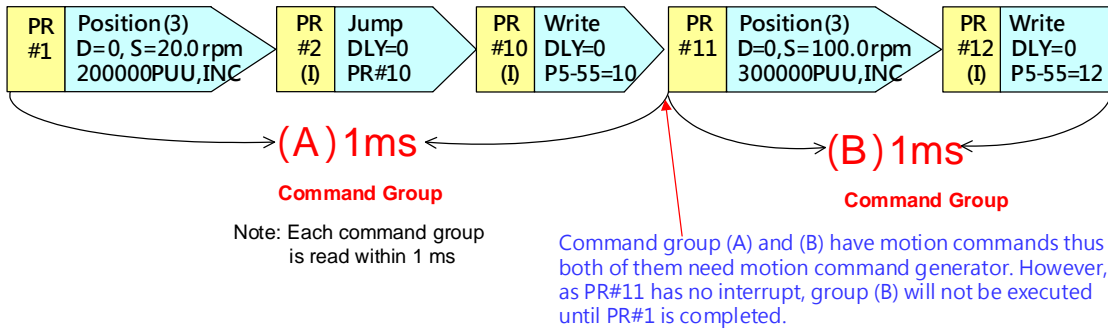
Figure 1.60 Example 1

PR Settings :

In the toolbar of ASDA-Soft, select *PR Mode Setup* to open *PR Mode Editor.*
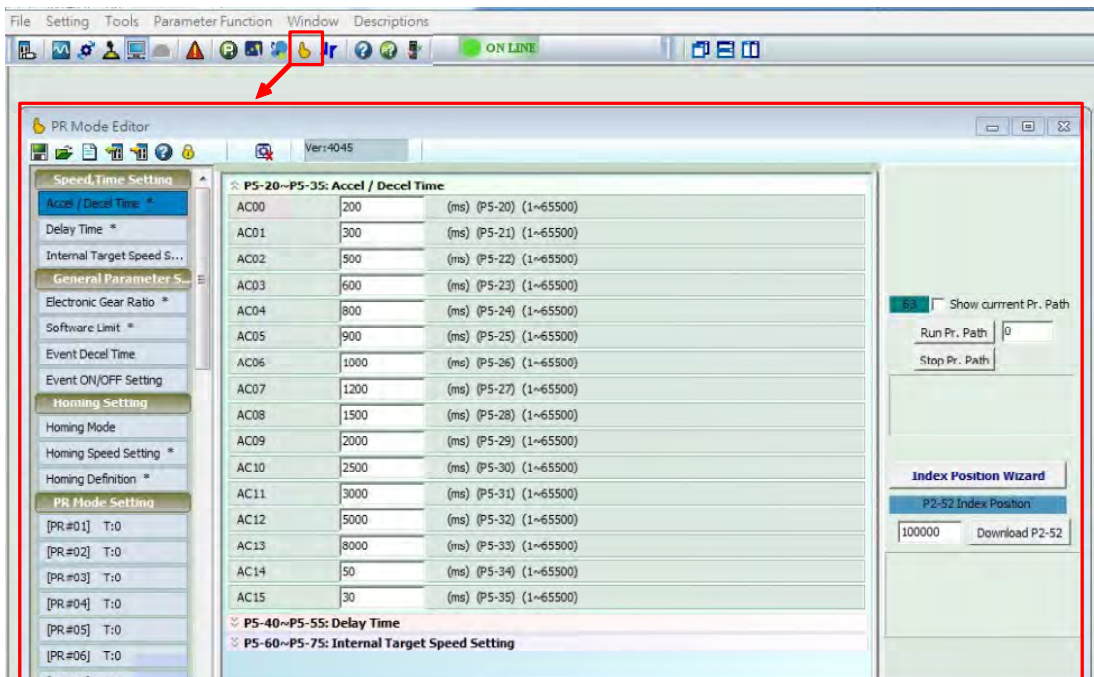
Figure 1.61 Open *PR Mode Editor*

Please follow the steps to edit the related settings in *PR Mode Editor*:

1. PR#1:

Figure 1.62 Settings of PR#1

    a.   Select path PR#01.

    b.   Select Type [3] in section *TYPE settings.*

    c.   Select item *INC Incremental Position* as the command type.

    d.   Set *Target Speed Index* to 20.0 rpm. Settings of related acceleration/deceleration shall be appropriate.

    e.   No delay time; set 0 here.

    f.   Set *Position CMD DATA* to 200000 PUU*.*

2. PR#2:
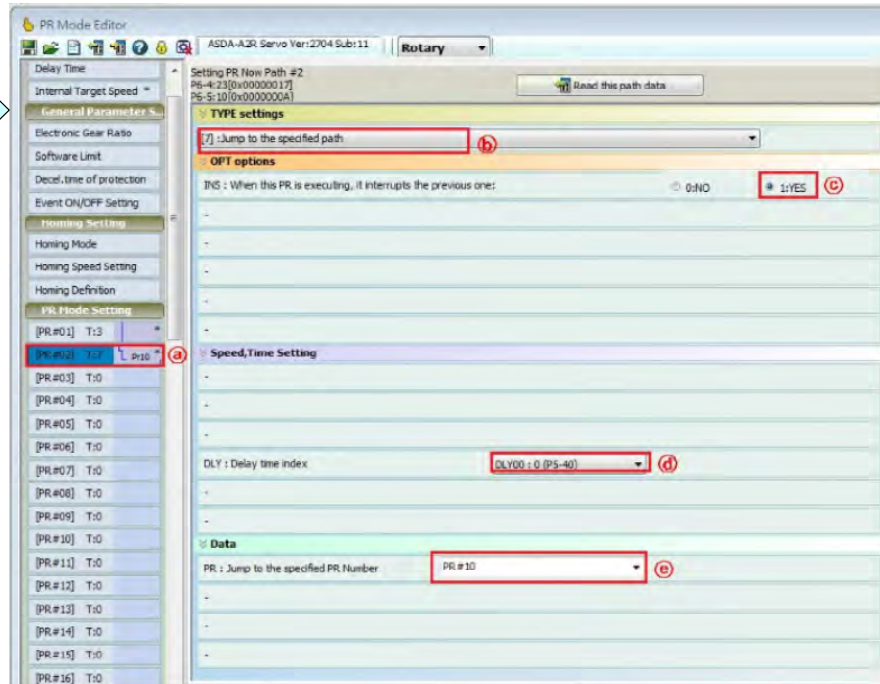
Figure 1.63 Settings of PR#2

a. Select path PR#2.

b. Select *Type [7] Jump to the specified path* in *Type Settings.*

c. Enable interrupt function; select *When this PR is executing, it interrupts the previous one (1: YES).*

d. No delay time; set 0 here.

e. Select PR#10 as the *Jump to the specified PR Number.*

3.   PR#10:

Figure 1.64 Settings of PR#10

a.   Select Path PR#10.

b.   Select *Type [8] Write the specified parameter to the specified path* in *Type Settings.*

c.   Enable interrupt function; select *When this PR is executing, it interrupts the previous one (1: YES).*

d.   As this PR is presented in an arrow-shaped frame, please select *Auto move to the next PR when completed (1: YES).*

e.   No delay time; Set 0 here.

f.   Select *0: Parameter* and P5-55 as the *target.*

g.   Select *0: Constant* and enter 10 at section *Data.*

4. PR#11:
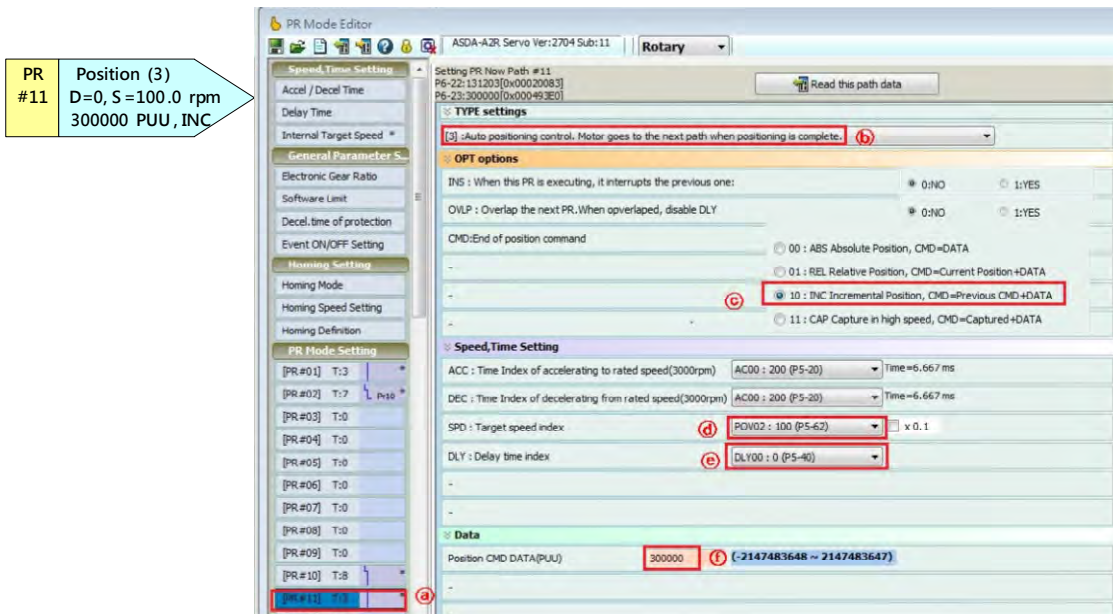
Figure 1.65 Settings of PR#11

a. Select path PR#11.

b. Select *Type [3]* in the *TYPE* settings.

c. Select *INC Incremental Position* as the command type.

d. Set *Target speed index* to 100.0 rpm. Related settings of
    acceleration/deceleration have to be appropriate.

e. No delay time; Set 0 here.

f. Set *Position CMD DATA* to 300000 PUU

5.   PR#12:

PR	Write
# 12	DLY = 0
(I)	P 5 - 55 = 12
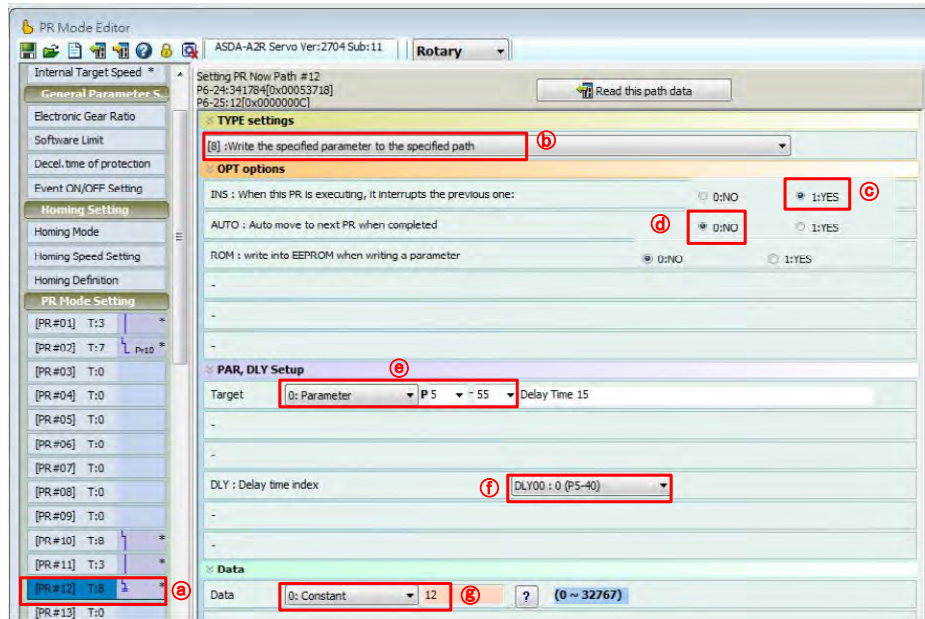
Figure 1.66 Settings of PR#12
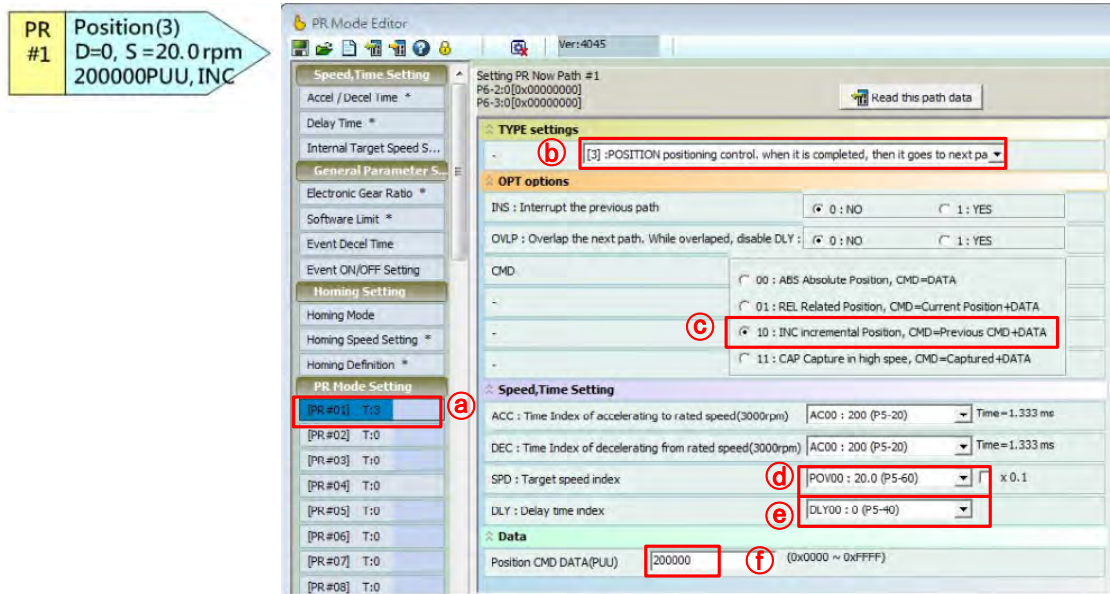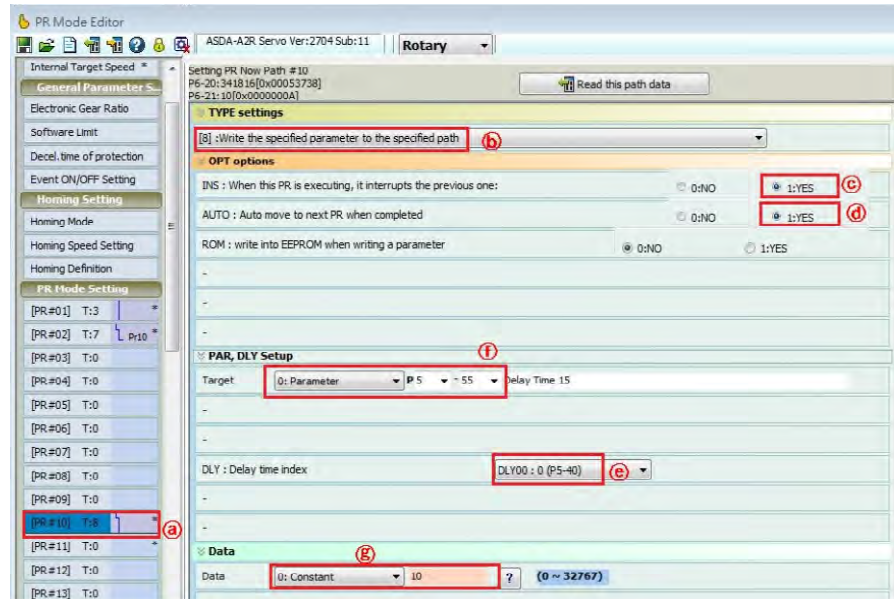
a.   Select path PR#12.

b.   Select *[8]: Write the specified parameter to the specified path* at *Type Settings.*

c.   Enable interrupt function; select *When this PR is executing, it interrupts the previous one as (1: YES).*

d.   As this PR is presented in a squared frame, please select *No* here *and* it will not automatically move to the next PR when completed.

e.   Select *0: Parameter* and *P5-55* as the *target*.

f.   No delay time; set 0 here.

g.   Select *0: Constant* and enter 12 at section *DATA*.

PR Motion Analysis:

With the feature that the servo updating commands every 1 ms, when reading a series of PR commands of different types, the first step is to arrange a series of PR commands into PR groups. The key to it is to look for the PR command without interrupt function in the group. In Figure 1.60, PR#1 and PR#11 have no interrupt, and PR#2 and PR#10 that following PR#1 have the interrupt function; the following PR#12 have interrupt function as well. In this case, PR#1, PR#2, and PR#10 in the executor will be the command group and executed in the first 1 ms; PR#11 and PR#12 will be the command group in the next 1 ms. Because PR#1 is a motion command, the second PR group (PR#11 and PR#12) will not be executed until the motion command from PR#1 is completed.

PR#1 / PR#2 / PR#10: After entering PR executor, jump command PR#2 and write-in command PR#10 will be completed here; meanwhile P5-55 is set to 10. As PR#1 is a motion command, it will be distributed to the motion command generator to generate motion commands.

PR#11 / PR#12: Because PR#11 has no interrupt, it does not exist with PR#1, PR#2, and PR#10 in the PR executor at the same time (it is not categorized into the same PR group with PR#1, PR#2 and PR#10); it will not enter the executor until the first PR group enters it after 1 ms. PR#11 will not have any influence on the motion command of PR#1; on the other hand, it waits for PR#1's motion commands to be completed and then carry on. PR#12 and PR#11 will enter the executor together and start to execute the command after PR#1 is completed. After this PR is completed, 12 will be written to P5-55.

Result:

Figure1.67 shows the final result of PR procedure in Example 1.
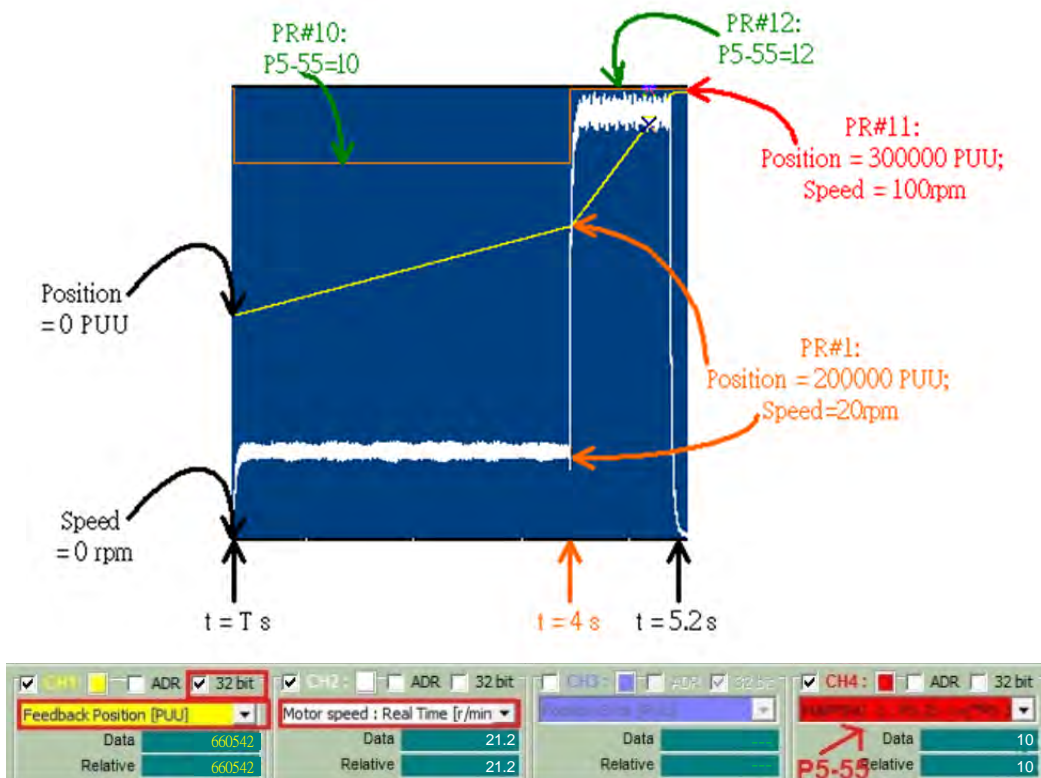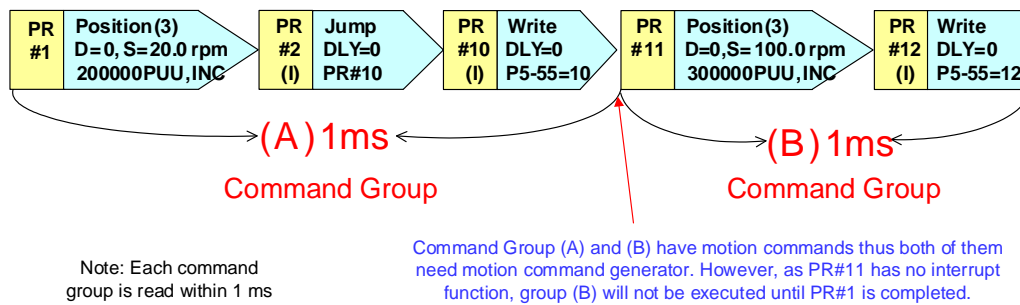
Figure 1.67 Output of PR Example 1

T: Operating start time of PR command

t = T ~ t = 4+T: Carry out PR#1, PR#2 and PR#10. Motor operates 200000 PUU at speed of 20 rpm; meanwhile, P5-55 is set to 10.

t = 4+T ~ t = 5.2+T: Carry out PR#11 and PR#12. Motor operates 300000 PUU at speed of 100 rpm; meawhile, P5-55 is set to 12.

Example 2:

1ms

Command Group
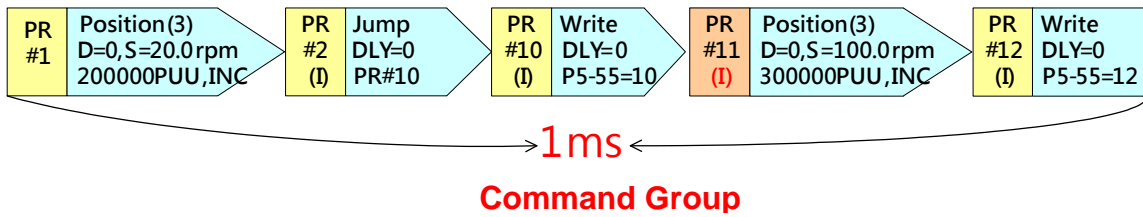
Figure 1.68 Example 2

PR Motion Analysis:

In Figure 1.68, only PR#1 has no interrupt; however, as it is the Head PR, these 5 PR commands will enter PR executor together and be completely executed within 1 ms.

After entering PR executor, motion commands generated by PR#11 will interrupt the motion commands of PR#1. Thus, only motion commands from PR#11 will enter the motion command generator. PR#2, PR#10, and PR#12 will be completed in the executor. When carrying out PR#10, P5-55 will be set to 10. After PR#12 is executed, P5-55 will be set to 12. Because they are both carried out within the same 1 ms, the result of PR#10 will be replaced by PR#12 right away. On the other hand, as there is still time difference between executing PR#10 and PR#12, the value of P5-55 will be 10 in a very short time.

Result :

Figure 1.69 shows the result after PR Group is executed in Example 2.
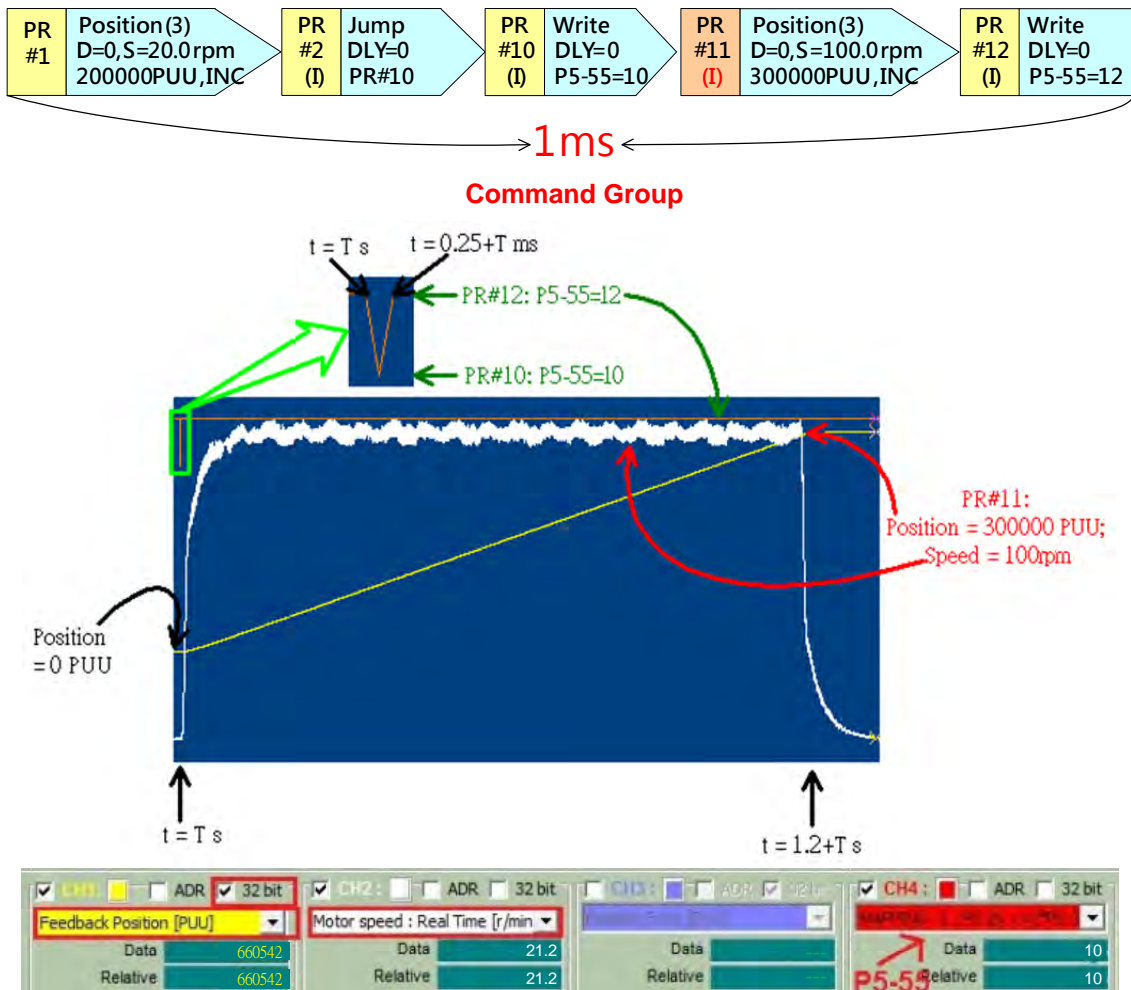
Figure 1.69 Output of PR Example 2

In this example, the first position command (PR#1) is interrupted by the second position command (PR#11). The first position command is hardly executed; therefore, only the output of the second command is read by the motion command generator. The command executing time is 1.2 sec. with the speed of 100 rpm, and moves from 0 to 300000 PUU. Regarding P5-55, when PR#10 is carried out, P5-55=10. However, it will be immediately replaced by PR#12 as P5-55 = 12. Figure 1.69 shows that from PR#10 to PR#12, it only takes 0.25 ms to carry out.

Example 3:

| PR #1 | Position(3)
D=0,S=20.0 rpm
200000PUU,INC | PR #2 | Jump
DLY=0
PR#10 | PR #10
(I) | Write
DLY=0
P5-55=10 | PR #11
(I) | Position(3)
D=0,S=100.0 rpm
300000PUU,INC | PR #12
(I) | Write
DLY=0
P5-55=12 |

(A) 1ms
Command group

(B) 1ms
Command group

When command group (A) is completed, command group (B) will be executed.
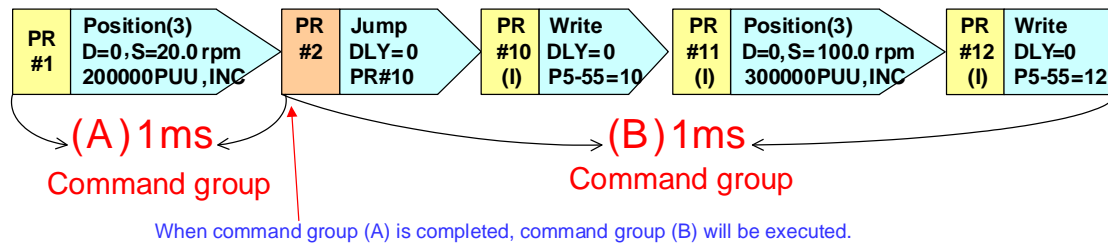
Figure 1.70 Example 3

PR Motion Analysis:

In Figure 1.70, as PR#1 and PR#2 have no interrupt; PR#1 will enter PR executor first. After 1ms, PR#1 takes other PR commands into the executor.

After PR#1 is completed in the executor, as it is a motion command, it will be distributed to motion command generator to generate motion command.

Other PR commands that enter the executor have to wait to be executed until PR#10 is completed. When PR#10 is completed and P5-55 = 10, PR#12 will interrupt immediately. Same as Example 2, result of P5-55 = 10 only lasts shortly and will be replaced by the result of P5-55 = 12. Since PR#2 has no interrupt, motion command generated by PR#11 will not interrupt motion command from PR#1. In this case, the servo system will continue to carry out the motion command of PR#11after that of PR#1.

Result：

Figure 1.71 is the result after carrying out PR groups in Example 3.

Regarding motor's operation, the result is the same in Example 1. Motion commands from PR#1 and PR#11 will both be executed. And the second position command is carried out after the first position command is over (after 4 sec.).

In terms of P5-55, as it cannot be carried out until position command of PR#1 is fulfilled, when t = T ~ 4+T, P5-55 has not been set up. In this period, P5-55 will display the previous reserved value, which is not referential. When t = 4, PR#2 ~ PR#12 start to be carried out and meanwhile the value of P5-55 will be 10 first for a very short time, then change to 12, which is identical to Example 2.

| PR #1 | Position(3)
D=0,S=20.0 rpm
200000PUU,INC | PR #2 | Jump
DLY=0
PR#10 | PR #10
(I) | Write
DLY=0
P5-55=10 | PR #11
(I) | Position(3)
D=0,S=100.0 rpm
300000PUU,INC | PR #12
(I) | Write
DLY=0
P5-55=12 |

(A) 1ms
Command Group

(B) 1ms
Command Group

When command group (A) is completed, command group (B) will be executed.
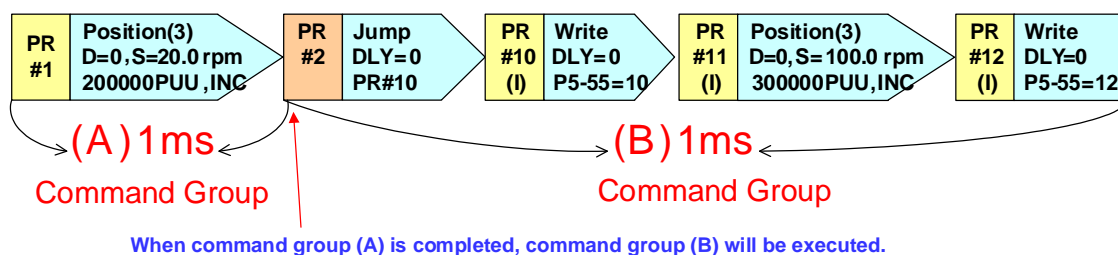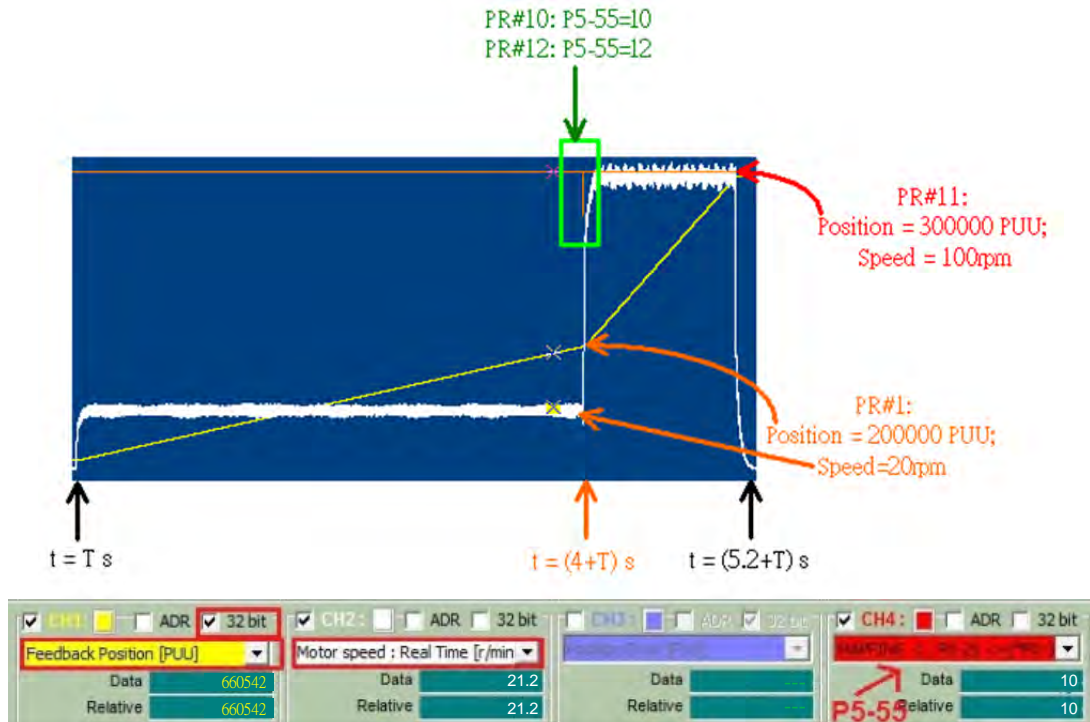
Figure 1.71 Output of PR Example 3

Example 4:
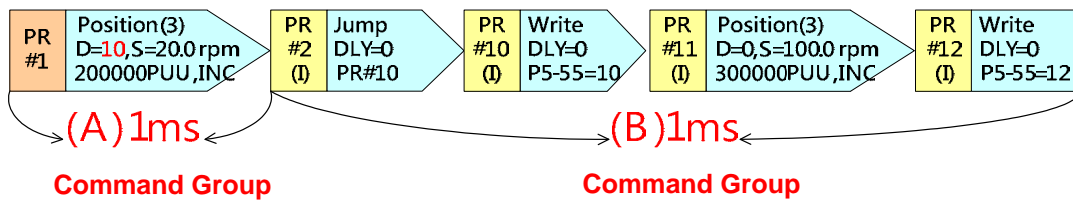
Figure 1.72 Example 4

PR Motion Analysis:

In Figure 1.72, only PR#1 has no interrupt but it has 10 ms delay time. Thus, PR#2 will enter the executor after PR#1 starts to be carried out for 10 ms.

During the 10 ms delay time, PR#1 is completed in the executor and has entered motion command generator to make the motor run. After 10 ms, other PR commands will enter the executor one after another and be completed. The motion command generated by PR#11 will enter motion command generator and replace the motion command from PR#1 because of its interrupt setting. However, as PR#11 is incremental, the motor's total traveling distance should be: distance generated by PR# + distance generated by PR#11, which is 500000PUU. After 10 ms, the motor will operate at the speed specified by PR#11.

Result:

Figure 1.73 shows the result after PR group is executed in Example 4.
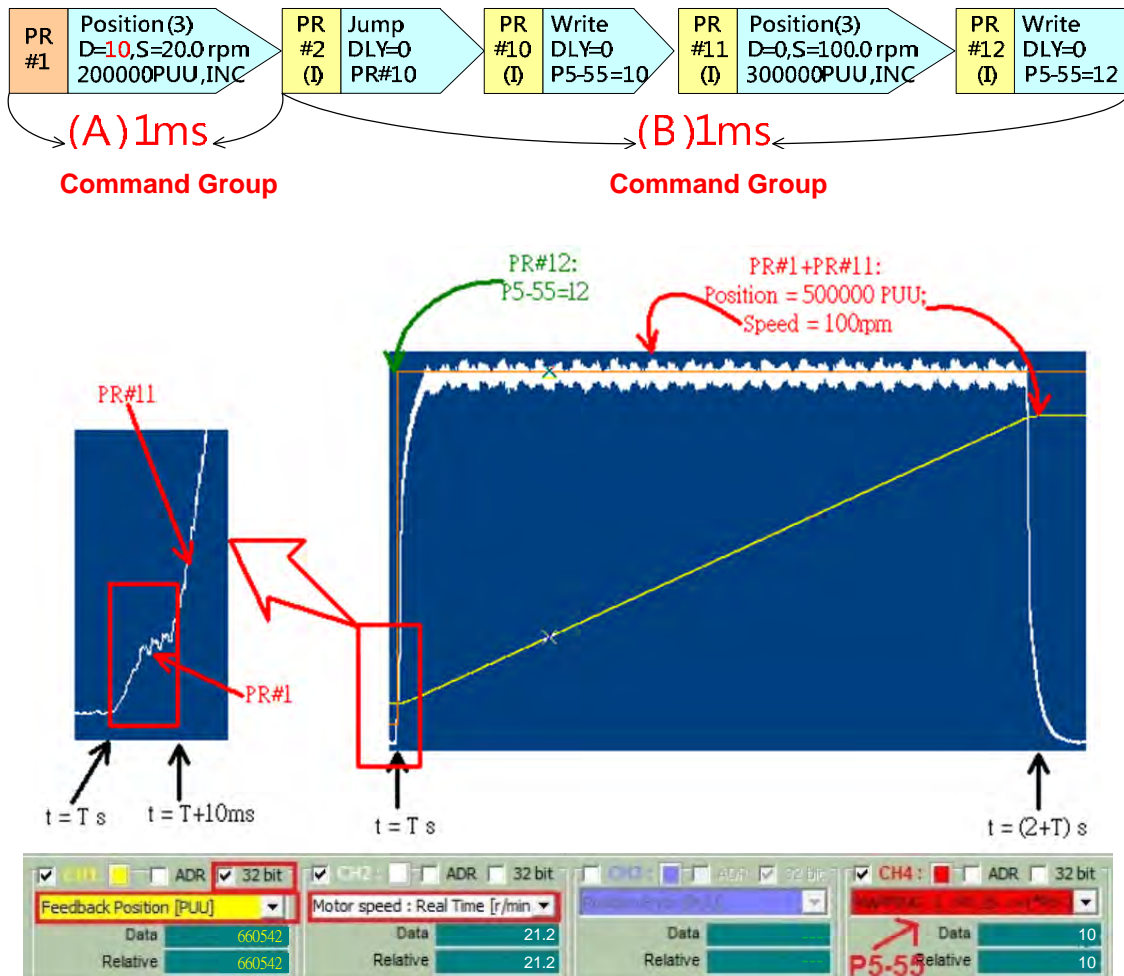
Figure 1.73 Output of PR Example 4

From t = Ts to t = T+10 ms, motor will operate based on the position command generated by PR#1. After 10 ms, the command of PR#1 will be interrupted by PR#11. Thus, motor will operate based on the motion profile generated by PR#11 after 10 ms. Regarding P5-55, it is the same as example 2 and 3. As PR#10 is interrupted by PR#12, when PR#10 is executed, P5-55 = 10. However, this will be replaced by PR#12 right away and then P5-55 = 12.

Example 5:
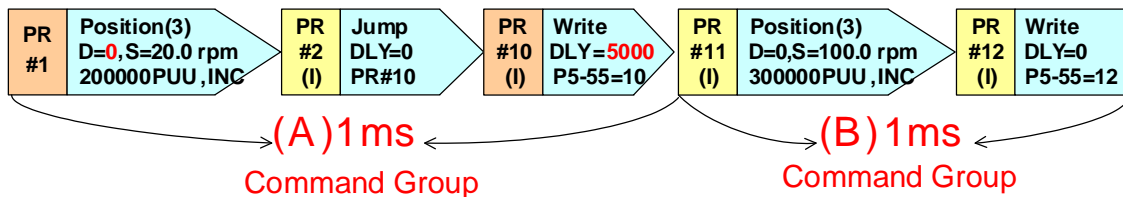
Figure 1.74 Example 5

PR Motion Analysis:

In figure 1.74, only PR#1 has no interrupt; as PR#1 is the Head PR, PR#1, PR#2, and PR#10 will enter PR executor at the same 1 ms. However, since PR#10 has set delay time of 5000 ms, PR#11 and PR#12 will enter the executor after 5000 ms.

In PR executor, PR#1, PR#2, and PR#10 are consecutively carried out. The motion command from PR#1 will enter the motion command generator to make the motor run when this PR command is completed. After PR editor has completed PR#10, it waits for 5 seconds and then carries out the next PR command. And motion command from PR#1 will be completed within 5 seconds.

After 5 seconds, PR editor will go on to carry out PR#11 and PR#12. The motion command from PR#11 will enter motion command generator to make the motor run. Therefore, motion commands from PR#1 and PR#11 will both be carried out. Besides, PR#12 will interrupt PR#11 so P5-55 = 12 after 5 seconds.

Result:

Figure 1.75 shows the result after PR group is carried out in Example 5.

| PR #1 | Position(3)
D=0,S=20.0 rpm
200000PUU ,INC | PR #2 (I) | Jump
DLY=0
PR#10 | PR #10 (I) | Write
DLY = 5000
P5- 55 = 10 | PR #11 (I) | Position(3)
D=0,S=100.0 rpm
300000 PUU,INC | PR #12 (I) | Write
DLY = 0
P5-55=12 |

(A)1ms

Command Group

(B)1ms

Command Group

Figure 1.75 Output of PR Example 5 PR

See Figure 1.75, from t = T to t = 4+T sec, motor operates according to PR#1's command. Because PR#10 has set delay time of 5 sec., PR#11's command will be executed after t = 5+T sec.. From t = T to 5+T sec., P5-55 = 10. After 5+T second, P5-55 = 12.

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Introduction of E-Cam Operation

2

2.1   Introduction of E-Cam

E-Cam, a virtual cam implemented by software that simulates a machine cam. E-Cam curve is built by software to achieve the relative motion between Master axis and Slave axis like real cams. If the output of E-cam is the same as that of the machine cams, replacing machine cams with E-Cam system becomes feasi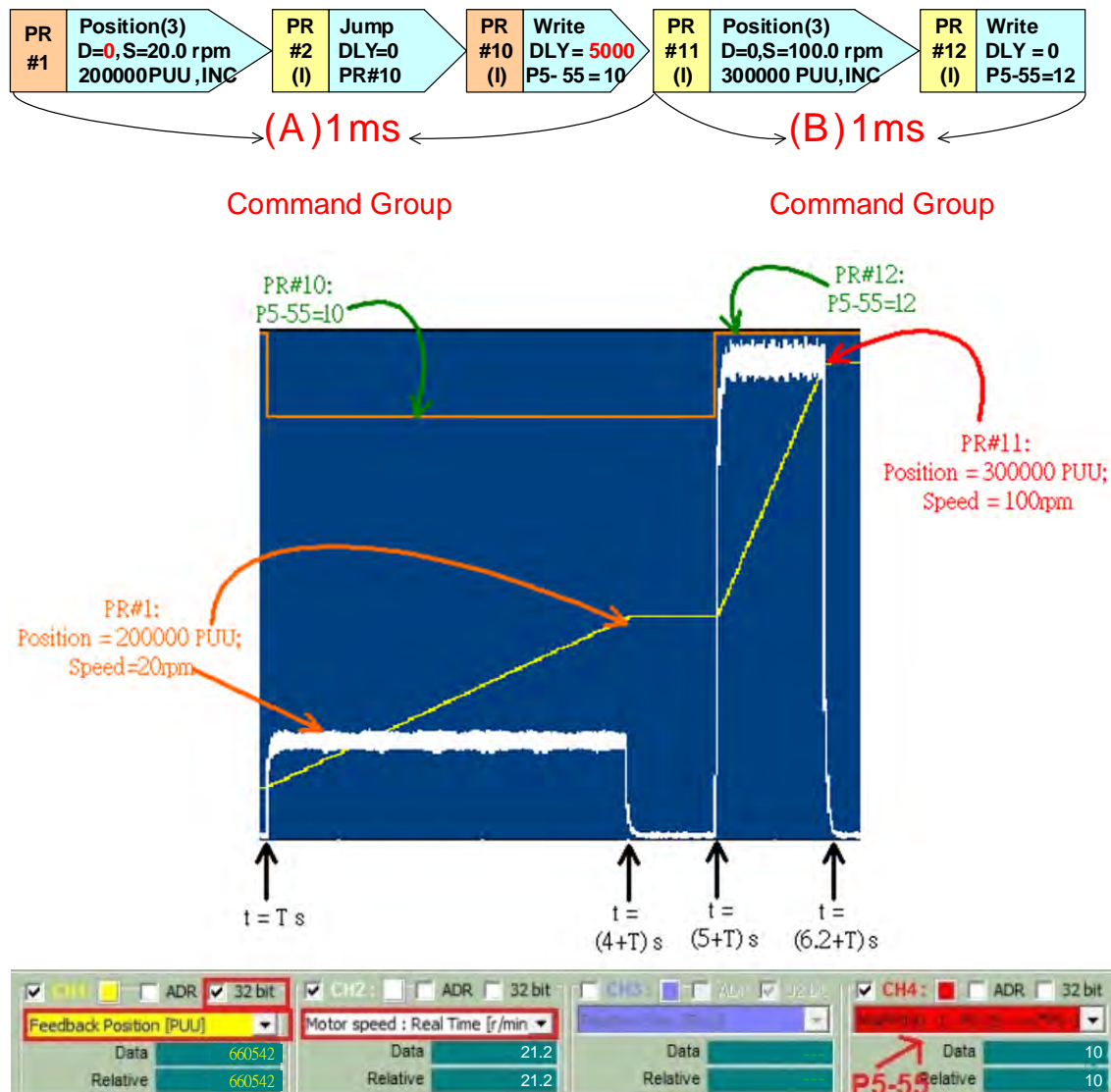ble.   Unlike the machine cam, E-Cam can be applied without the limitation on modifying cam shapes. As long as it is a Master-Slave application and the Master-Slave relation can be translated into equations, E-Cam can be applied.

What are the advantages when machine cam is replaced by E-Cams?
1.   Higher energy efficiency: Eliminating the frictions between mechanical parts such as cam discs, energy can thus be saved.
2.   Modifying cam shape becomes easy: Cam shape can be modified any time to make different motion.
3.   Low mechanical consumption: E-Cam is simulated by software, eliminating concerns on mechanical consumption.
4.   Wide range of application: E-Cam function can be applied to any applications that can be achieved by the equation; a machine cam is not necessarily required.
5.   Flexibility: One master axis can command multiple slave axes, which is rather complex in the machine cam.
6.   Positioning system for physical goods: In application of machine cam system such as packaging machine, when its cutting shear tries to aim at the target position, the system is not able to modify the error occurs during printing, thus errors are accumulated permanently.

What are the disadvantages when replacing machine cam with E-cams?
1.   Real time: Signal processing takes time; the synchronization of E-Cam is generally inferior to mechanical ones. However, this problem can be overcome by firmware.
2.   Accuracy: If signal communication is interfered and causing pulse loss, users have to use other methods to conduct positioning.

Mechanical Power   **Pulse Command**

Input of Master Axis

Cam   **Output of Cam**

If both of the axes work in the same manner, the Servo system can be used to replace the machine Cam.
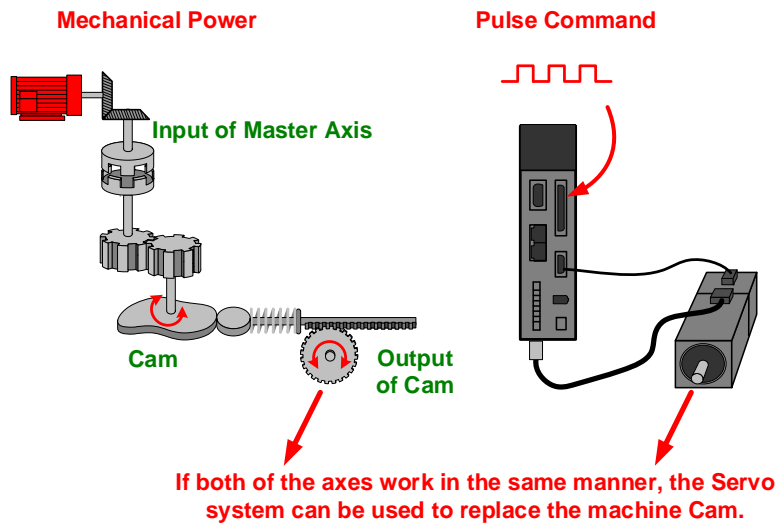
Figure 2.1 E-Cam and the Machine Cam

In E-Cam system, the cam makes the motion based on the E-Cam curve. The position of master and slave is a one-to-one function relation, which is the E-Cam curve function. The function of master axis is to send pulses to the slave axis. The slave axis will move according to the received pulses and the corresponding E-Cam curve.

PUU, Position (Slave)

The corresponding position of slave axis.

Position of the master axis corresponds to position of the slave axis.

Pulse (Master)

The pulse train from master.
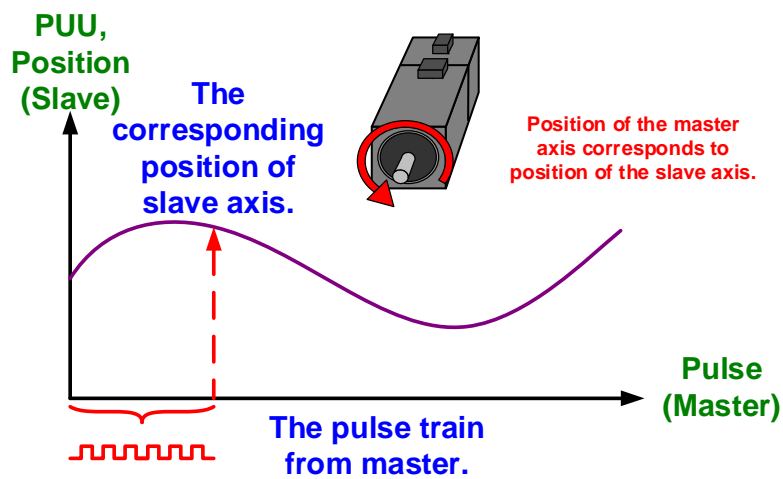
Figure 2.2 An E-Cam Curve

Figure 2.3 illustrates parameter settings of E-Cam with the concept of using machine cams. The required parameters of using E-Cam are shown below.

Master Axis:
Sources of master axis
P5-88.Y

Clutch:
Control the timing that the slave axis starts to follow the master axis.
P5-88.UZ, P5-87, P5-89

Master E-Gear:
The scaling of command pulse.
P5-83, P5-84

Slave E-Gear:
The scaling of E-Cam curve to output.
P1-44, P1-45, P5-19

E-Cam Curve:
The E-Cam function defines the relationship of master and slave.
P5-81, P5-82, P5-85

Output of E-Cam

Figure 2.3 Using Parameters to Simulate the Machine Cams

2.2 Source of the Master Axis

P5-88

Parameter settings of E-Cam

High Word			Low Word			
S	0	BA	U	Z	Y	X
0~2	-	00~3F	0~8	0~2	0~6	0~3

Figure 2.4 P5-88.Y: Settings for Source of the Master Axis

Source of the master axis can be specified by P5-88.Y. Any pulses that conform to the hardware specifications of ASDA-A2 can be the source of master axis, such as encoder, PLC, or a servo drive. 7 sources are available on ASDA-A2:

P5-88.Y = 0: CAP axis (Capture axis); use the source of capture function (P5-39.Y) as the source of master axis.

P5.88.Y = 1: AUX ENC (Auxiliary encoder); source signal of master axis is input via CN5 connected to an external encoder.

P5.88.Y = 2: Pulse Cmd (Pulse Command); pulse signal of the master axis is input from CN1.

P5.88.Y = 3: PR command; it is a virtual axis that acquires the internal signal. The PR specifies the motion command and when this PR is carried out, the signal generated will be regarded as the source of master axis.

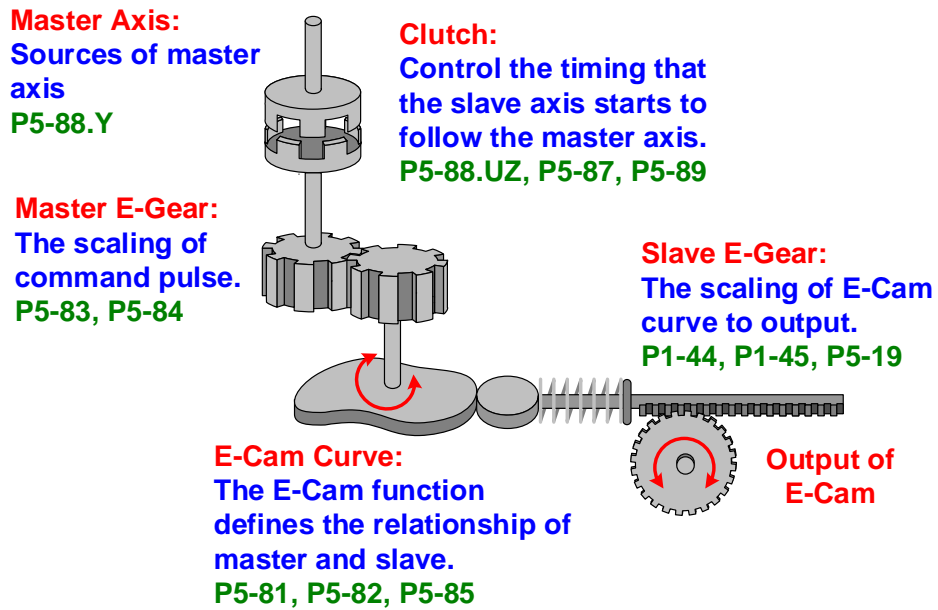P5.88.Y = 4: Time axis; the system generates signals every 1 ms and send them directly to the master axis.

P5.88.Y = 5: Synchronous capture axis; signals from this axis have been adjusted. This is mainly applied in the application of flying shears. This mechanism is to regard the captured source signal that being corrected as the source signal for slave axis. In the application of flying shears, if using mark-tracking function to correct its cutting position, synchronous capture axis shall be specified as the source for the master axis.
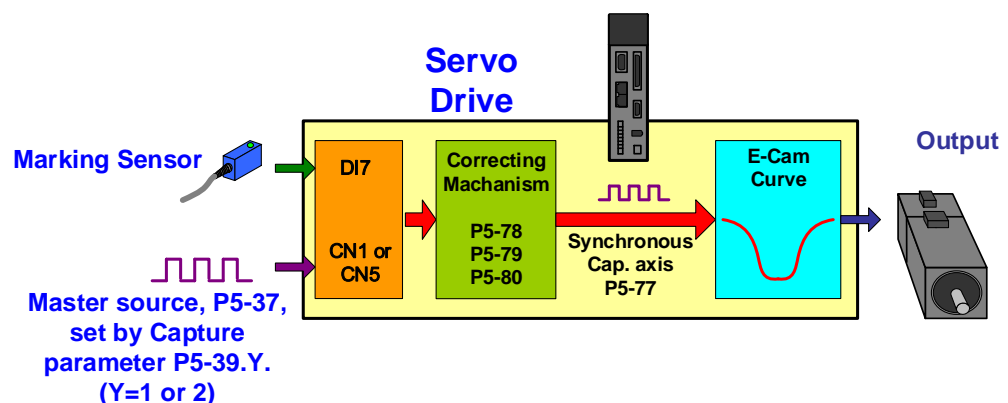

Figure 2.5 Synchronous Capture Axis

P5.88.X = 6: Analog channel 1; it is a virtual axis, which captures the analog voltage (via speed channel by analog command) and regard it as the source of master axis. The unit is the output frequency 1 M pulse/s corresponded by every 10 V.

Pulse By-pass Function

On ASDA-A2, the by-pass function allows one master axis to drive multiple slave axes. With this function, a servo can send the received signals to the next slave axis (servo). Signals passing through the servo will not be attenuated because ASDA-A2 acts like an amplifier, boosting the signal and maintain its origin intensity before output. For example, the input signal of 4.5 V will be amplified to 5 V when output. However, signal attenuation during transmission via cables shall be taken into consideration (because of the resistor in the cable). If the signal is attenuated to an extent that cannot be identified by the input terminal, strengthening or shortening the cable is required. Please be aware of this issue when wiring two servo drives; shielded twisted-pair is suggested in this case. Regardless the signal delay, the signal transmission time of every ASDA-A2 servo drive is only 50n second. That is, when 10 ASDA-A2 servos are serial connected and transmit pulses with by-pass function, the input lag between the first servo drive and the tenth is 0.5u second.

Although the only pin for pulse input on ASDA-A2 is OA, /OA, OB, /OB of CN1, pulses can also be input via CN1 or CN5. The source of input signal can be specified by P1-74.B. Thus, when using by-pass function and to use CN1 as the pulse input channel (shown in Figure 2.6), P1-74.B is set to 2 for each slave axis (servo) so the servo will output the signal received from CN1.

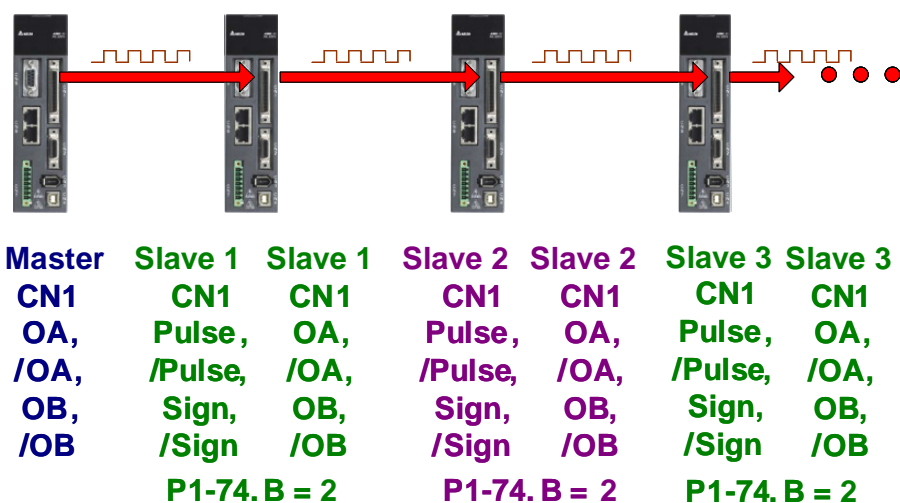| Master CN1	Slave 1 CN1	Slave 1 CN1	Slave 2 CN1	Slave 2 CN1	Slave 3 CN1	Slave 3 CN1
OA, /OA, OB, /OB	Pulse, /Pulse, Sign, /Sign	OA, /OA, OB, /OB	Pulse, /Pulse, Sign, /Sign	OA, /OA, OB, /OB	Pulse, /Pulse, Sign, /Sign	OA, /OA, OB, /OB
	P1-74.B = 2		P1-74.B = 2		P1-74.B = 2	

Figure 2.6 Pulse By-pass Function: CN1 IN / CN1 OUT

When wiring, users may use CN5 as the input channel. See Figure 2.7, P1-74.B is set to 1 on every slave axis (servo); these servos will output signals received from CN5.
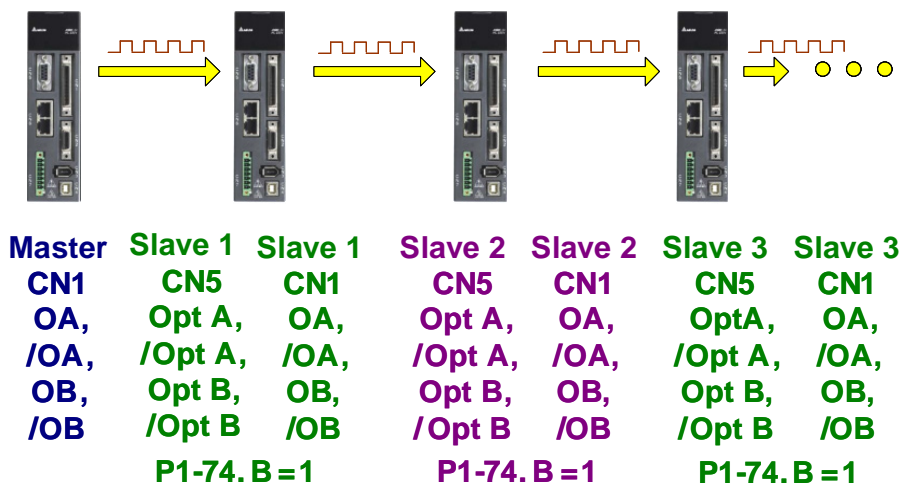
Master   Slave 1 Slave 1   Slave 2 Slave 2   Slave 3 Slave 3
CN1   CN5   CN1   CN5   CN1   CN5   CN1
OA,   Opt A,   OA,   Opt A,   OA,   OptA,   OA,
/OA,   /Opt A, /OA,   /Opt A, /OA,   /Opt A, /OA,
OB,   Opt B,   OB,   Opt B,   OB,   Opt B,   OB,
/OB   /Opt B   /OB   /Opt B   /OB   /Opt B   /OB

P1-74. B = 1   P1-74. B = 1   P1-74. B = 1

Figure 2.7 Pulse By-pass: CN5 IN / CN1 OUT

2.3   The Clutch

The function of clutch is controlling the timing for engaging and disengaging of E-Cam. When E-Cam is enabled, whether the slave axis will operate according to the master axis signal is subject to the status of clutch. Only when cams are engaged are they able to operate based on the pulses from the master axis. While cams are disengaged, slave axis is unable to operate even when pulses from the master axis are received. The conditions for engaging and disengaging are described below.

2.3.1   Settings for Engaging E-Cam

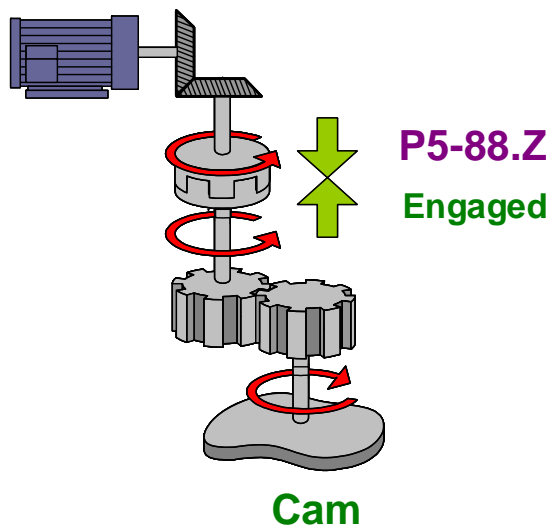

P5-88.Z
Engaged

Cam

Figure 2.8 Engaging of E-Cam

Shown in Figure 2.8, when E-Cam is engaged, the master axis will drive the slave axis via the clutch and make it operate.

P5-88 **Parameter Setting of E-Cam**	High Word			Low Word			
	S	**0**	**BA**	**U**	**Z**	**Y**	**X**
	0~2	-	00~3F	0~8	0~2	0~6	0~3

Figure 2.9 P5-88.Z: Settings for the Engaging Timing

The engaging timing is specified by P5-88.Z:

- Engage immediately: When P5-88 = 1, it means E-Cam will be engaged immediately when E-Cam function is enabled. This setting is applicable when slave axis has to keep operating unless E-Cam is disabled. P5-88.Z has to be set 0 when using this setting.

- DI enabled: E-Cam engages when DI (0x36) is ON (high level), and meanwhile P5-88.Z = 1. If DI remains ON after E-Cam is enabled, the cam will remain engaged.

- Use Capture function: When P5-88.Z = 2 and the first data is captured, E-Cam is engaged. When capture function is enabled, then the signal will be input via DI7 after the sensor is triggered. If using this function to engage E-cam, the engaging timing will be the moment that sensor is triggered and signal be input via DI7. Unlike the previous method that uses the signal of sensor to trigger DI 0x36, carrying out capture function allows the time sequence of the system become more accurate because DI7 inputs with high speed in capture function, which action time is only 5 us.

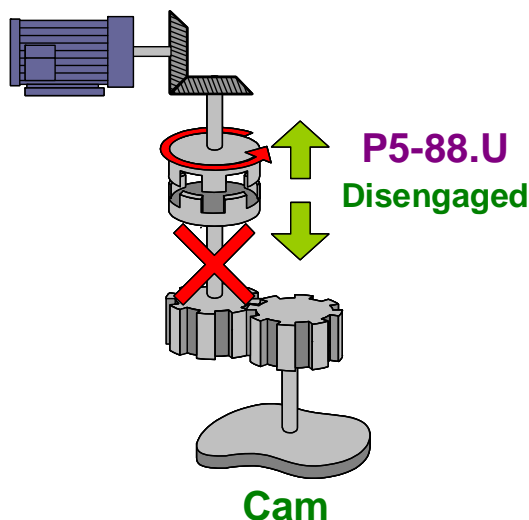## 2.3.2   Settings for Disengaging E-Cam

Figure 2.10 Disengaging of E-Cam

Compare with the engaging time of E-Cam, its disengaging time is rather complicated. After disengaging, the slave axis will remain still regardless the action of master axis. It is because the master axis is unable to use clutch to control the salve axis. See Figure 2.10.

P5-88 E-Cam Settings	High Word			Low Word			
	S	0	BA	U	Z	Y	X
	0~2	-	00~3F	0~8	0~2	0~6	0~3

Figure 2.11 P5-88.U: Settings for Disengaging Time

Disengaging timing is specified by P5-88.U:

- P5-88.U = 0: Remain engaged unless E-Cam function is disabled.

- P5-88.U = 1: DI disabled. When disabled, set DI (0x36) to OFF (low level). If this DI remains OFF, E-Cam will remain disengaged.

- P5-88.U = 2: When E-Cam reaches the moving distance specified by P5-89 after engaging, the motor will stop right away after disengaging.
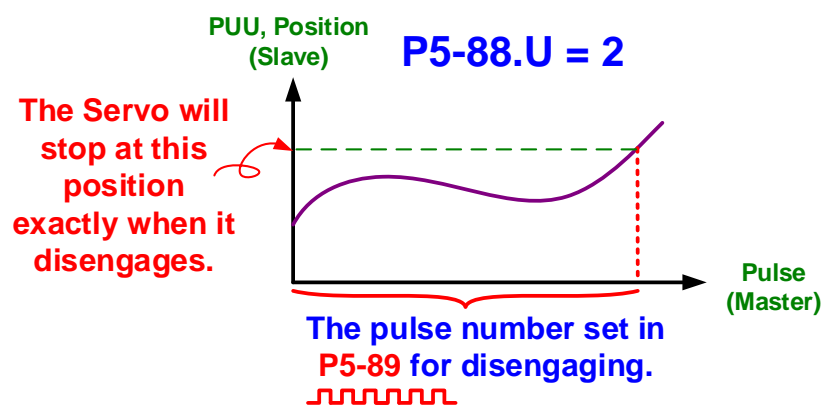

Figure 2.12 P5-88.U = 2 Disengaging Timing

- P5-88.U = 6: When E-Cam reaches the moving distance set by P5-89 after engaging, the motor will decelerate to stop with smooth speed. However, the position will go beyond the stop position commanded by the master axis.
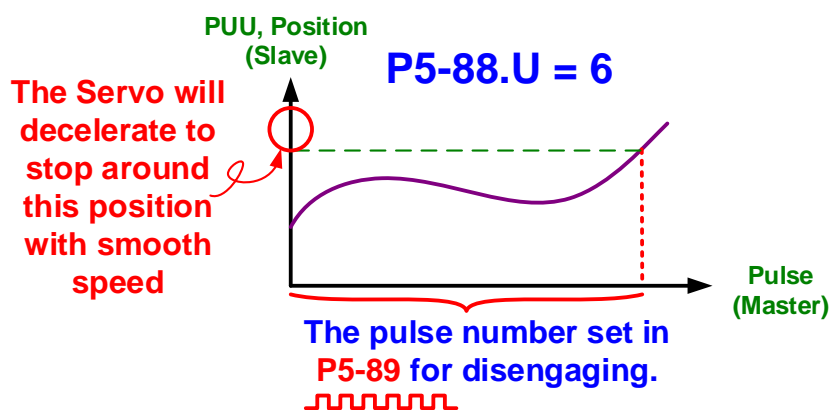

Figure 2.13 P5-88.U = 6 Disengaging Timing

- P5-88.U = 4: When E-Cam reaches the moving distance set by P5-89 after engaging, it will disengage and operate in a cyclic manner. When the lead pulse amount is reached, it automatically engages again. After starting operating in a cyclic manner, the lead pulse is specified by P5-92.
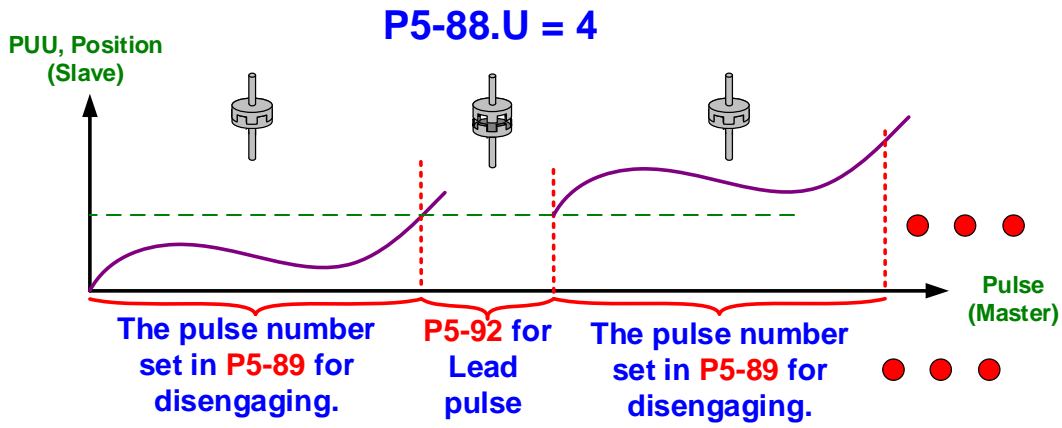
Figure 2.14 P5-88.U = 4 Operation of E-Cam

In Figure 2.14, the lead pulse number specified by P5-92 is the one before the cycle starts; this lead pulse is effective only when P5-88.U = 4 and E-Cam starts to work in a cyclic manner. No matter what engaged/disengaged condition it is, as long as E-Cam is going to engage again after disengaging, the lead pulse is still determined by P5-87. After E-Cam starts to operate in a cyclic manner, the lead pulse is determined by P5-92.
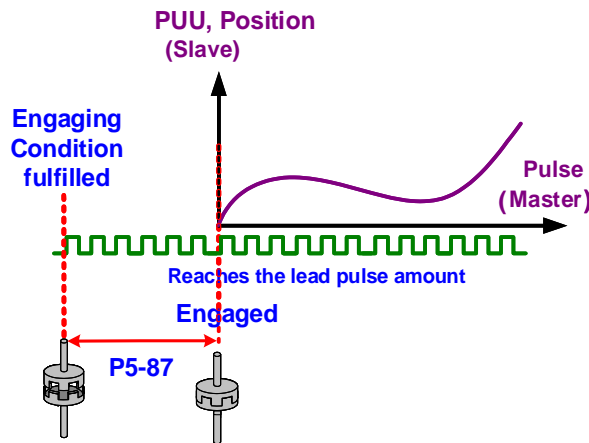

Figure 2.15 Initial Lead Pulse Amount

In addition to settings mentioned above, there are other settings available. For example, setting P5-88.U to 8 will disable E-Cam after disengaging, which is identical to the setting of P5-88.X = 0. Disengaging E-Cam is different from disabling E-Cam. When E-Cam is disabled, this function is completely unusable. On the other hand, while E-Cam is disengaged, E-Cam system remains working although motor is stopped. Meanwhile, the slave axis is still monitoring the pulses sent from the master axis. Disabling E-Cam is like switching off a car engine (P5-88.X= 0). Disengaging E-Cam is like the car is in neutral and the engine remains on (P5-88.X =1). Therefore, the function of P5-88.X is similar to the key for starting a car. Function of P5-88.UZ can be regarded as the gear for controlling a car, which determines whether to engage or disengage E-Cam. The setting of P5-88.U = 8 cannot be used individually; it has to set with the disengaging timing, which can be set by Bit-OR for multiple selection. Except P5-88.U = 2, 4, and 6 that cannot be set simultaneously, disengaging timing can also be set by Bit-OR for multiple disengaging timing. See table below.

P5-88.U	Function	Disengaged Condition	After Disengaged
0	0	Remain engaged	-
1	1	DI(0x36) OFF: CAM OFF	
2	2	After master axis receives the pulse amount which is set by P5-89, the motor stops immediately after disengaging.	Enter Stop Status
3	1+2	P5-88.U = 1 or P5-88.U = 2: E-Cam disengaged when disengaged condition fulfilled.	
4	4	After master axis receives the pulse amount which is set by P5-89, E-Cam will be disengaged and operate in a cyclic manner, waiting for the lead pulse and then engage automatically again.	Returns to Pre-engage Status, which is set by P5-92
5	1+4	E-cam keeps operating in a cyclic manner until (P5-88.U = 1) disengaged condition is fulfilled and then E-Cam disengages.	Pre-engage or stop status
6	6	After master axis receives the pulse amount which is set by P5-89, the motor will decelerate to stop with smooth speed after disengaging. However, it will go beyond the stop position commanded by the master axis.	Enter Stop Status
7	1+6	P5-88.U = 1 or P5-88.U = 6: E-Cam is disengaged after disengaged condition fulfilled.	
8	Cannot be set individually	Disable E-Cam after disengaging.	-
9	1+8	P5-88.U = 1: Disable E-Cam after disengaged condition fulfilled.	
A	2+8	P5-88.U = 2: Disable E-Cam after disengaged condition fulfilled.	E-Cam disabled (P5-88.X = 0)
B	1+2+8	P5-88.U = 1or P5-88.U = 2: Disable E-Cam after disengaged condition fulfilled.	
C	4+8	Special function, which can reduce the vibration caused by speed changing when returning to pre-engage status. It is usually applied to the condition of P5-92 = 0, P5-89 = P5-84.	Returns to Pre-engage Status
D	1+4+8	If P5-88.U = 1, E-Cam disengages when disengaged condition is fulfilled. Or it will operate according to the setting of P5-88.U = C.	Pre-engage or Stop status
E	6+8	IP5-88.U = 6: Disable E-Cam after disengaged condition fulfilled.	E-Cam disabled (P5-88.X = 0)
F	1+6+8	P5-88.U = 1 or P5-88.U = 6: Disable E-Cam after disengaged condition fulfilled.	

Monitoring E-Cam Status

P5-88,
E-Cam Settings

High Word			Low Word			
S	0	BA	U	Z	Y	X
0~2	-	00~3F	0~8	0~2	0~5	0~1

P5-88.U = 1, 2, 6
P5-88.X = 0

S1 Engaged

S0 Stop

P5-88.U = 4.
The lead pulse number is set by P5-92.

P5-88.X = 0

Initial lead pulse is set by P5-87; Pre-engaged time of each cycle is set by P5-92. (Can be read from monitoring variable 061)

The condition set by P5-88.Z satisfied. The lead pulse number is set by P5-87.
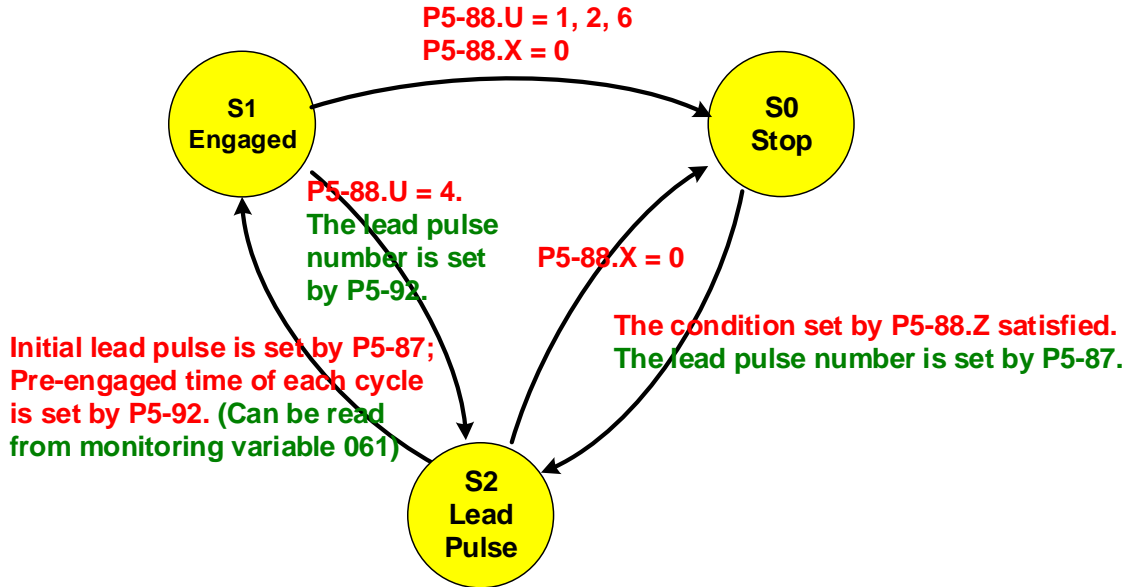
S2 Lead Pulse

Figure 2.16 E-Cam Status

The status of E-Cam can be monitored via P5-88.S. When E-Cam is enabled (P5-88.X =1), the system will update its status in P5-88.S.

P5-88.S = 0: Disengaged status. The system will check if the engaged conditions are fulfilled. When fulfilled, E-Cam will then move on to S2 Lead Pulse status.

P5-88.S = 2: E-Cam is in Lead Pulse status (S2). In this status, E-Cam will count the received pulses of the master axis. When received pulse amount reaches the setting value, E-Cam will engage again (move on to status S1). Lead pulse is the delay pulse which is counted after engaged conditions are fulfilled.

P5-87 is for specifying the initial lead pulse, which is the lead pulse amount required before the first engaging. On the other hand, P5-92 is for specifying the lead pulse number before it starts a cycle; when engaged condition is set to 4 (P5-88.U = 4) and the system is working in a cycle, the lead pulse number is determined by P5-92. However, the initial lead pulse is still specified by P5-87 in this condition. If E-Cam is disabled now (P5-88.X = 0), the E-Cam status will return to Stop status (S0).

P5-88.S = 1: Engaged Status. The system will keep checking on whether disengaged condition is fulfilled. When fulfilled, E-Cam will switch to status S0 (Stop) or S2 (Lead Pulse) based on the setting (disengaged condition is specified by P5-88.U).

2.4   The E-Gear of the Master Axis

E-gear ratio of the master axis will determine the pulse resolution, which is defined by P5-83 and P5-84. When the slave axis receives the pulse number P from the master axis specified by P5-84, E-Cam will rotate M circle specified by P5-83, which is M cycle of the E-Cam table. For example, when P5-84 = 10000 and P5-83 = 1, it means when slave axis receives 10000 pulses from the master, E-Cam travels from 0° to 360°, which is one cycle of the E-Cam table.

In Figure 2.17, If the E-gear ratio of the master is taking 10000 as a standard, when this value is higher (value of P5-84 becomes higher or value of P5-83 becomes lower), the pulse width will become narrower thus making a higher pulse resolution of the master axis. On the other hand, if the E-gear ratio value of the master is lower (value of P5-84 becomes lower or value of P5-83 becomes higher), the pulse width will become wider thus making a lower pulse resolution of the master axis.
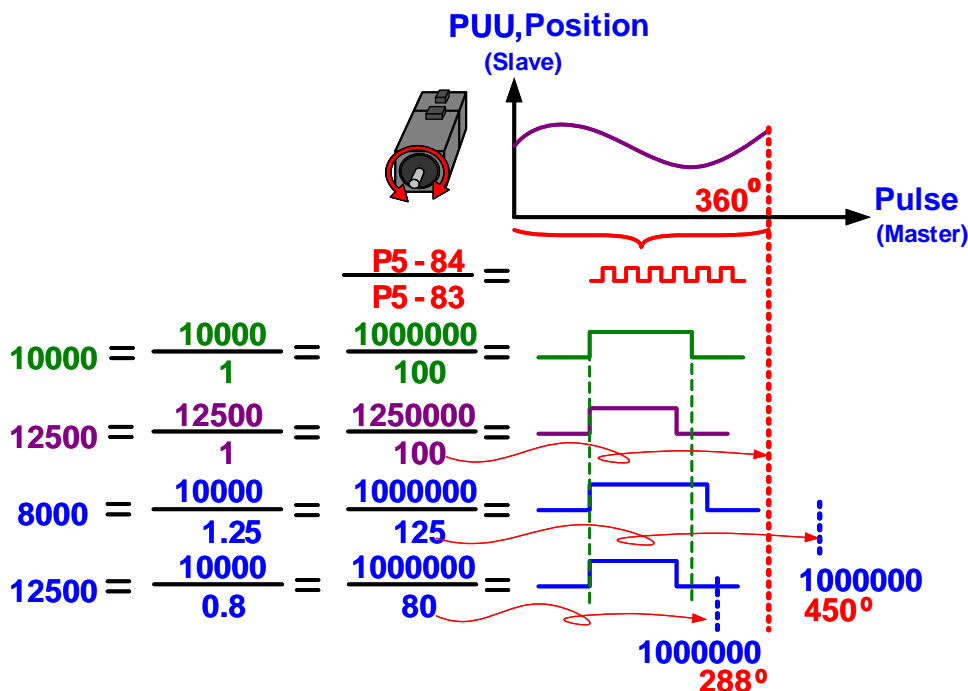

Figure 2.17 E-Gear Ratio of the Master Axis

2.5   E-Cam Curve

When E-Cam is engaged and receiving pulses from the master, the slave axis will operate according to the setting of E-Cam curve. On ASDA-A2, E-Cam can be applied as long as the pulse from the master axis and position of the slave axis is a one-to-one relation.
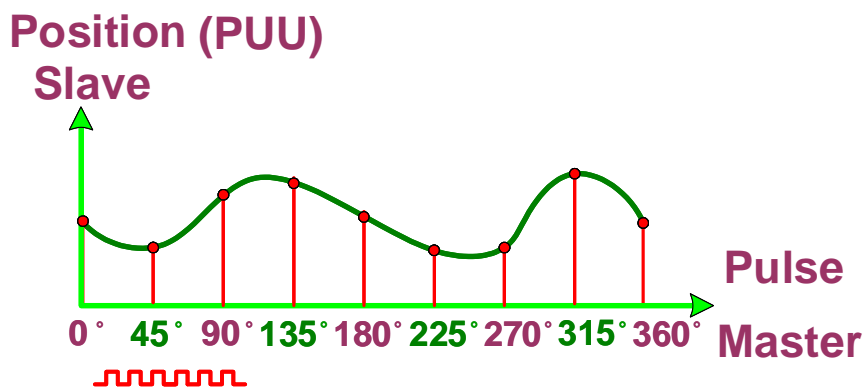
Position (PUU)
Slave

Pulse
Master

0˚   45˚ 90˚ 135˚ 180˚ 225˚ 270˚ 315˚ 360˚

Figure 2.18 E-Cam Curve

E-Cam curve can be created by ASDA-Soft or macro parameters. Although E-Cam curve can be created in several ways, the only way for ASDA-A2 is to store the angle of E-Cam and corresponding position on slave axis in data array.

ASDA-A2 can save 800 data in total; a single curve can have 721 data at maximum (720 divisions). Therefore, as long as the total data is below 800, multiple E-Cam curve data can be saved. Data amount of E-Cam is stored in P5-82. And the data of the first E-Cam curve that saved in data array is specified by P5-81. When data array has saved multiple data of E-Cam curve that can be specified by P5-81 and P5-82.

See Figure 2.19 for example. To replace a machine cam with E-Cam curve, the first step is to equally divide the cam. In this example, the real cam is divided into 8 equal parts thus the angle of each part is 360/8 =45°. The second step is to figure out distances between center of the cam and its edge. Then, put these values into data array. In this case, this data presents the position of the slave axis. The start position (0°) and destination (360°) shall be the same, and both data shall be put in data array so as to present a complete cycle of a cam. Therefore, there are 8+1 = 9 points in data array. When P5-81 = 50 and P5-82 = 8 (8 divisions), E-Cam curve (position of the slave axis) will be stored at the address from 50 to 58. When using this curve, the system will access E-Cam's position and its corresponding angle based on the setting of P5-81 and P5-82. Users may use *E-Cam editor* of ASDA-Soft to manually create a table and write the data to data array.
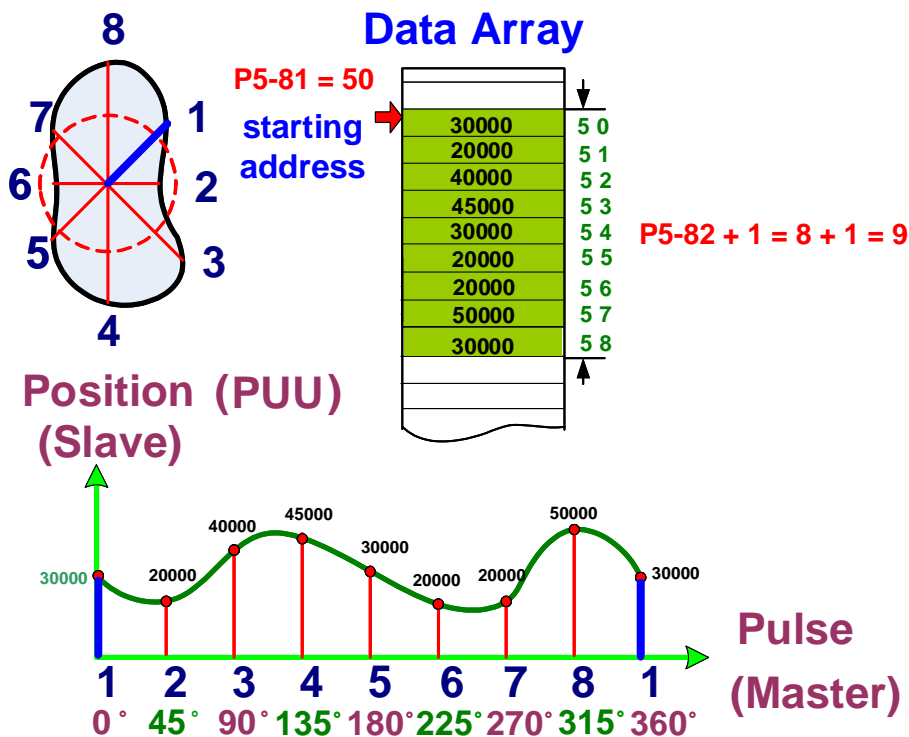
Figure 2.19 E-Cam Curve and Machine Cam

DO.0x118, DO.0x11A or monitoring variable 062(3Eh) can be used to monitor the operating speed of E-Cam.
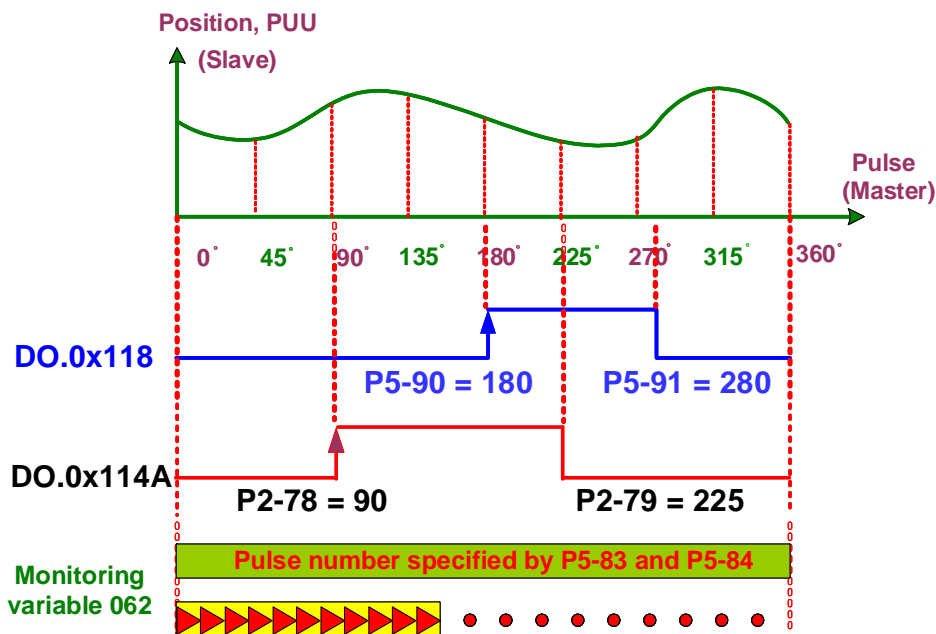

Figure 2.20 Monitoring the Operating Speed of E-Cam

As shown in Figure 2.20, if DO.0x118 is ON, it means position of E-Cam is within the setting range. P5-90 is for specifying the starting angle of DO output when DO is ON; P5-91 is for specifying the ending angle of DO output when DO is ON.

DO.0x11A and DO.0x118 have the same function. When using DO.0x11A, P2-78 is for specifying the starting angle of DO output; P5-79 is for specifying the ending angle of DO output.

Monitoring variable 062 will display the current pulse number being received so users may acquire the E-Cam's position. For example, if the master axis outputs 3600 pulses (P5-84 = 3600), E-Cam rotates one circle (P5-83 = 1), this means it moves from 0° to 360°. When E-Cam moves to 180°, and monitoring variable 062 will read 1800 pulses.

How to Create an E-Cam Curve?

2.5.1 Create an E-Cam Curve by Software

Users may use ASDA-Soft to create E-Cam curves. By clicking on *E-Cam Editor* on the tool bar, a window of *E-Cam editor* will pop up. At the starting page, users may select the way to create an E-Cam table. See Figure 2.21. There are 7 ways available:

Manually create a table, Speed Fitting Creation, Rotary Shear-W/O Sealing Zone, Rotary Shear-W/T Sealing Zone, Rotary Shear-Adjustable Sealing Zone, Cubic Curve Creation, Rotary Shear- Printer Machine, and Cubic Curve Creation.
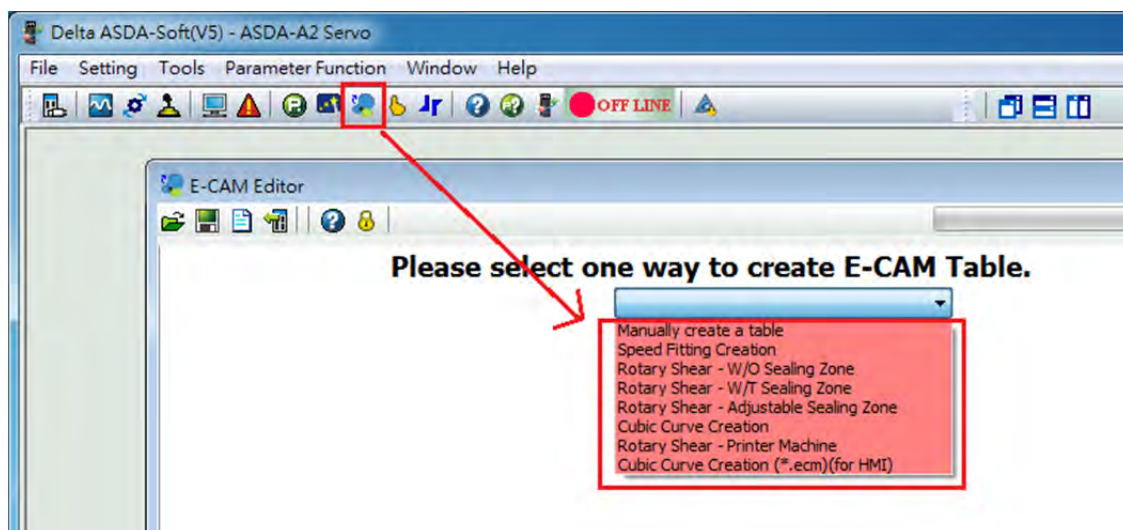

Figure 2.21 Ways to Create E-Cam Table in ASDA-Soft

● Manually Create a Table

From the perspective of using the machine cam, Figure 2.19 is an example of manually creating an E-Cam table. It is to use the distances between cam center and its edge and their corresponding angles to create an E-Cam curve, which is to present the relationship between angle and position of the slave axis. This method is applicable when each corresponding angle of the slave axis is known.

Figure 2.22 displays the screen of *Manually create a table*:

1. The first step is to setup the area number (P5-82). Despite the type of E-Cam, it can be divided into 720 equal parts (721 points) at maximum. To a cycle of 360°, it means the minimum degree of each part in one cycle is 0.5°; every 0.5° will correspond to a position of the axis. More setting points means higher curve resolution and more detail about the curve can be presented. However, it will occupy more space in data array. Users need to find a balance between resolution and resource allocation of data array and put

appropriate area number of E-Cam in data array. Data array is able to store max 800 data. Users need to pay special attention to the setting limit if desire to store multiple E-Cam curves.

2. After setting up the area number, click on *Create Table*. Then the software will equally divide 360 degree equally and put the values into the table according to the area number set by the user. When E-Cam area number is n, n+ 1 divisions will be shown in the table.

3. Every divided angle that corresponding to a position is put in the table in the unit of PUU.

4. The right down corner of the window will display a complete E-Cam curve. X-axis shows the angle of E-Cam, from 0° to 360°. Regarding Y-axis, users may select whether to show position (PUU), speed (PUU/s), or acceleration of the slave axis.

5. When manually creating an E-Cam table, change of position setting should be reasonable; otherwise, motor overload may occur due to the abrupt speed change or overcurrent.
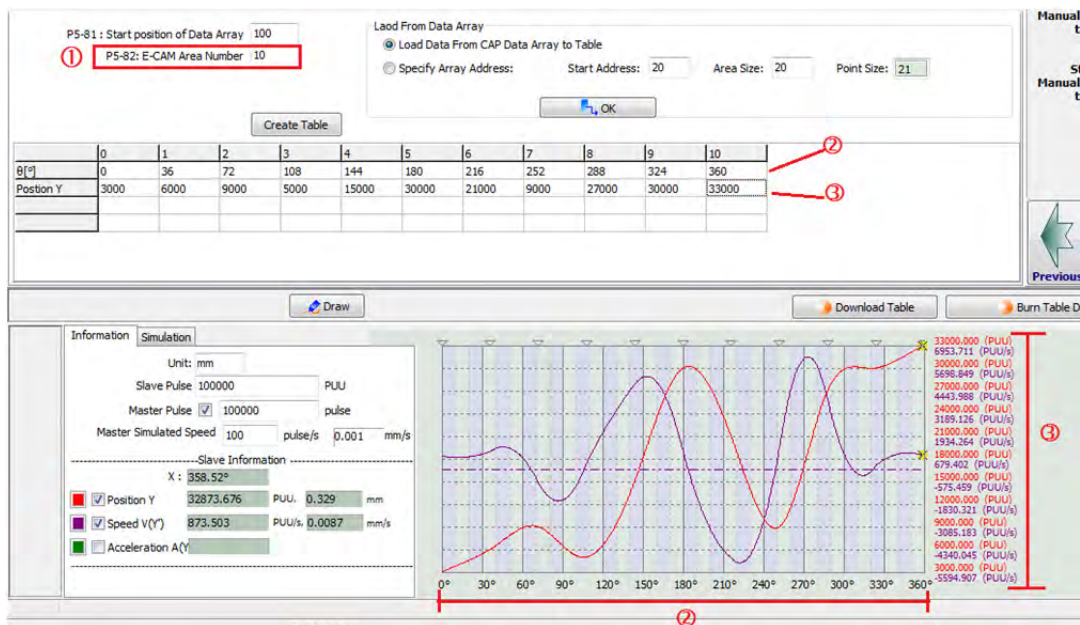

Figure 2.22 Manually Create a Table

● Speed Fitting Creation

If operating speed becomes users' first priority when using E-Cam, using *Speed Fitting Creation* to create E-Cam curve is recommended.

Figure 2.23 shows the settings of *Speed Fitting Creation* :

1. Arrange areas according to their proportion in one cycle of E-Cam curve, which includes waiting area, acceleration area, deceleration area, and stop area.

2. *Destination (L)* is the total distance the slave axis travels. Its unit is PUU.

3. *S-Curve No.* is for specifying the smooth level when the position curve transits. The higher the number the value is, the smoother of motor operation will be during acceleration and deceleration. Point number of *Stop Area* is suggested to be set to the same number as the *S-Curve No.*

4. Although this method is to use the speed relation to create an E-Cam curve, the system is actually making a curve by using cam angles and their corresponding position on the slave axis that are saved in the table.
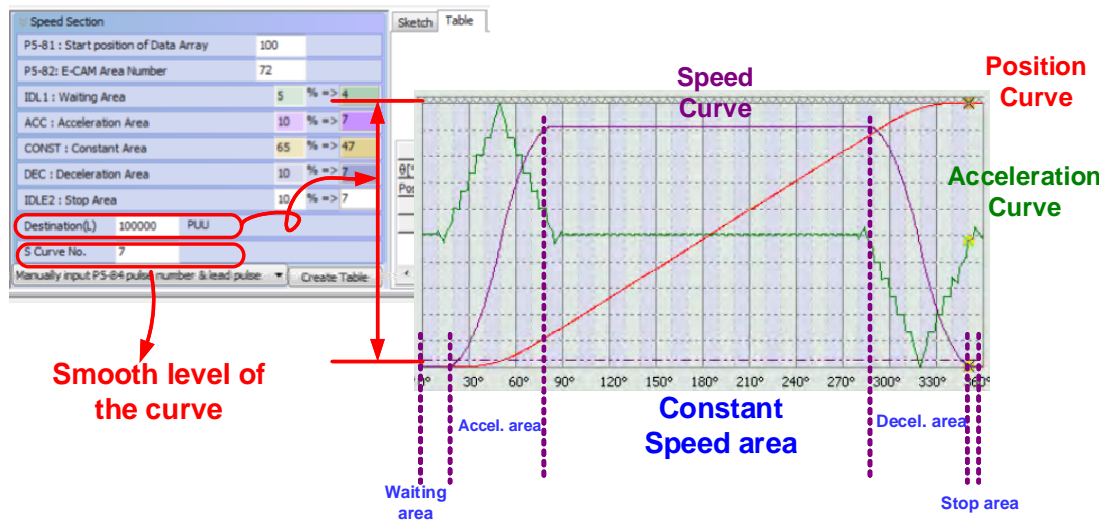

Figure 2.23 Speed Fitting Creation

● Rotary Shear- without Sealing Zone
   Rotary Shear- with Zone
   Rotary Shear- Adjustable Sealing Zone

Three types of rotary shear curve are available in ASDA-Soft, *Rotary Shear-W/O Sealing Zone*, *Rotary Shear- W/T Zone,* and *Rotary Shear- Adjustable Sealing Zone.* When using *Rotary Shear-W/O Sealing Zone*, the curve created does not have a sealing zone. While using *Rotary Shear-W/T Sealing Zone*, a rotary shear curve with fixed 51° in the sealing zone can be created. When using *Rotary Shear-Adjustable Sealing Zone*, the width of constant speed area on the rotary shear curve can be specified by software.

These three ways of creating the table is specifically designed for rotary shear application. The main difference among them is the setting of constant speed area. In general, a curve without constant speed area is applied to sharp cutter applications; a curve with constant speed area is suitable for flat cutter applications. Figure 2.24 presents the basic mechanism of rotary shear. The master axis is the material feeding axis and the slave axis is the cutter axis. The key point of rotary shear curve is that the material feeding axis (Master) and the cutter axis (Slave) must operate at the same speed during the cutting process (when cutter meets the material) so that the material will not be stocked in front of the cutter or be pulled by the cutter. See Figure 2.25.
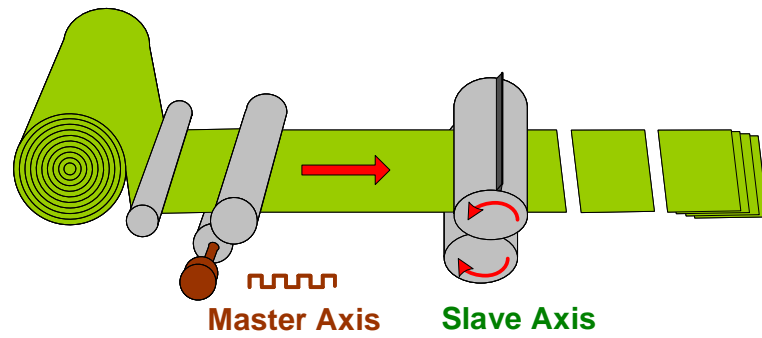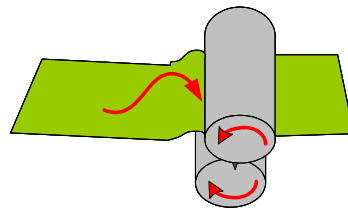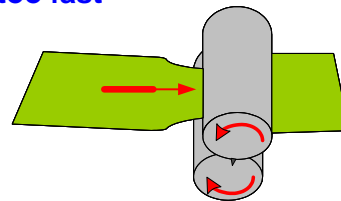
Master Axis   Slave Axis

Figure 2.24 Rotary Shear

Material being sent too fast

Material being sent too slow

Figure 2.25 Speed of Master Axis does not Synchronize with the Slave Axis

E-Cam curve with a constant speed area is mainly applied to mechanism with flat cutters, which is generally used for package with sealing zones. See Figure 2.26.
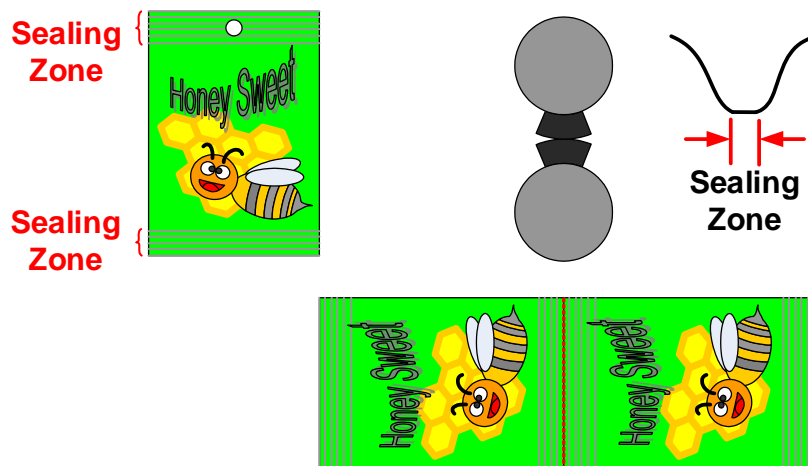

Figure 2.26 Application of Flat Cutter

An E-Cam curve with constant speed area will ensure a smooth cutting process without damaging the material. Figure 2.27 can explain why flat cutters need a constant speed area. The key is that the master axis and the cutter axis must operate at the same speed during cutting time. Therefore, as long as the cutting moment is within the constant speed area, a

curve with wider constant speed area can be applied to narrower cutters. However, when using a E-Cam curve which constant speed area is too narrow or doesn't have enough constant speed area to a flatter cutter, material might be damaged due to the inconsistent speed of the master and slave axis when cutting.
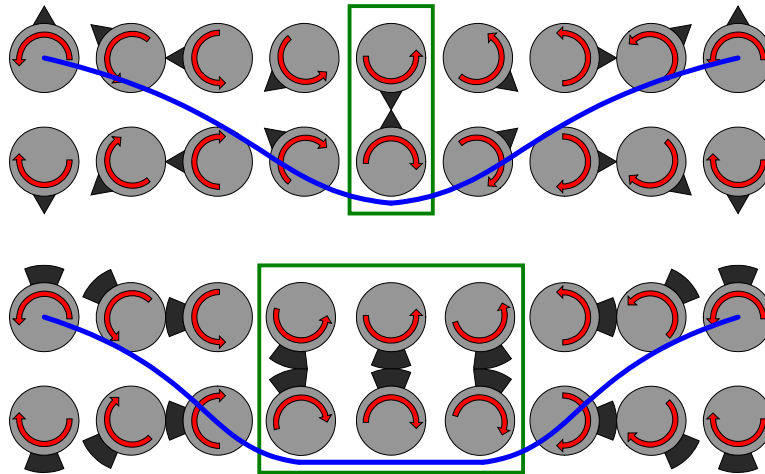

Figure 2.27 Relationship between E-Cam curve and the Rotary Shear

The table below elaborates the difference between having a constant speed area and without a constant speed area. Similarly, when cutting action takes place, speed of cutter axis and the master axis must be the same. This table may help users understand that the proportion of cutting circumferences and cutting lengths will determine how the cutter axis works.

	Curves without sealing zone: for sharp cutter applications	Curves with sealing zone: for flat cutter applications
Cutter circumference > Cutting length: U-shaped speed curve; the slave axis speed slows down for cutting action.		
Cutter circumference < Cutting length: Inverted U-shaped speed curve; the slave axis speeds up for cutting action.		

1. Cutter circumference > Cutting length: During cutting, two axes run at the same speed. Other than that, the speed of slave axis is faster than master axis. The faster the slave axis operates, the shorter the cutting length will be.

2. Cutter circumference = Cutting length: Speed of cutter axis = Speed of the master axis.

3. Cutter circumference < Cutting length: During cutting, two axes run at the same speed. Other than that, the speed of slave axis is slower than master axis.

Basically, the speed of cutter axis can be used to adjust the cutting length. However, the wider the constant speed zone, the less adjusting flexibility for cutting length. See Figure 2.28. Let's compare the curve with wider constant speed area and the curve with the

narrower constant speed area. If the required operating distance of the cutter axis is the same (integral value of the speed curve is the same), curve with wider constant speed area will accelerate/decelerate faster during the non-constant speed area thus reaching the operating limit (max. torque limit). So, compare with the curve with narrower constant speed area, when cutting length becomes shorter, curve with wider constant speed area will have less flexibility for adjusting the cutting length.
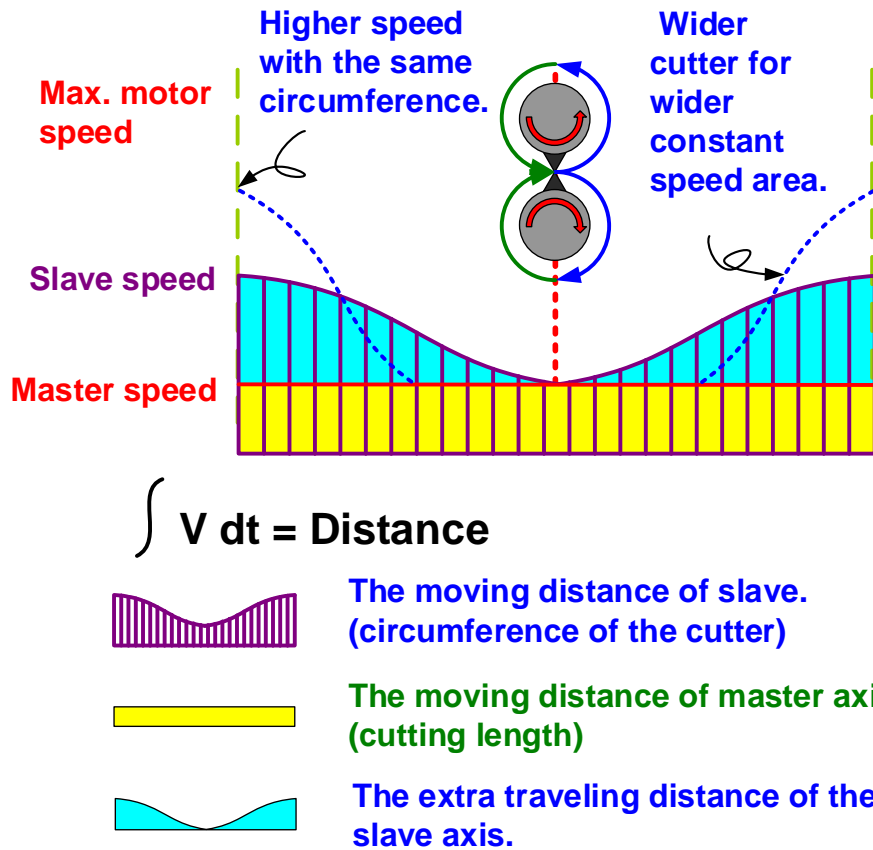

Figure 2.28 How does Width of Constant Speed Area Change Motor Speed and Current

If the cutting length cannot be shortened because of the speed or the maximum current limitation on the slave axis, without changing other conditions, adding more cutters will shorten the traveling distance of the slave axis among each cutting. In addition, this will slow down the slave axis as well as the current output; chances of motor reaching its operating limit will be less.
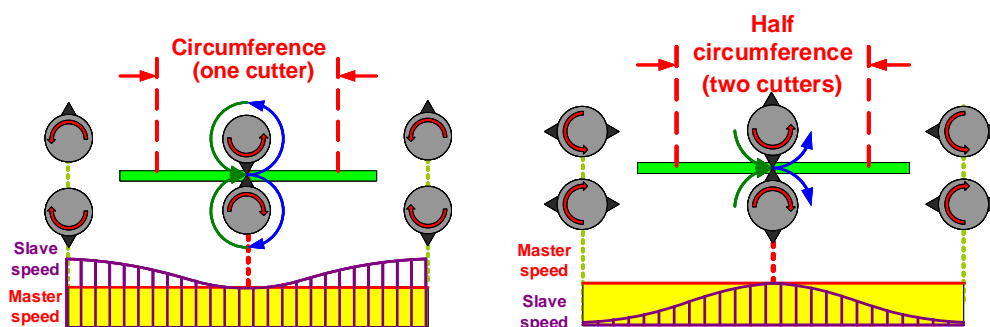

Figure 2.29 How Adding Cutters Change the Speed of the Cutter Axis

The definition of constant speed area is determined by the proportion of required constant speed during material feeding, not the constant speed area generated when cutter is operating. Different material requires different constant speed area. Thus, to generate different E-Cam curve is required. That is, the constant speed area is determined by the material.
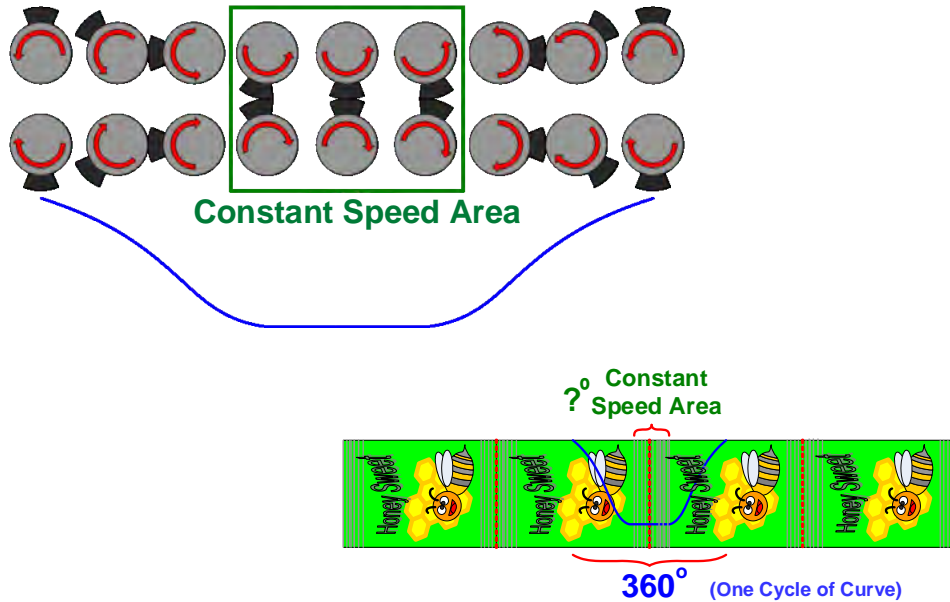

Figure 2.30 Definition of Constant Speed Area

When using software to create an E-Cam curve, the first step is to know the specifications of the mechanism. Figure 2.31 shows the specifications that users need to know before creating the curve.
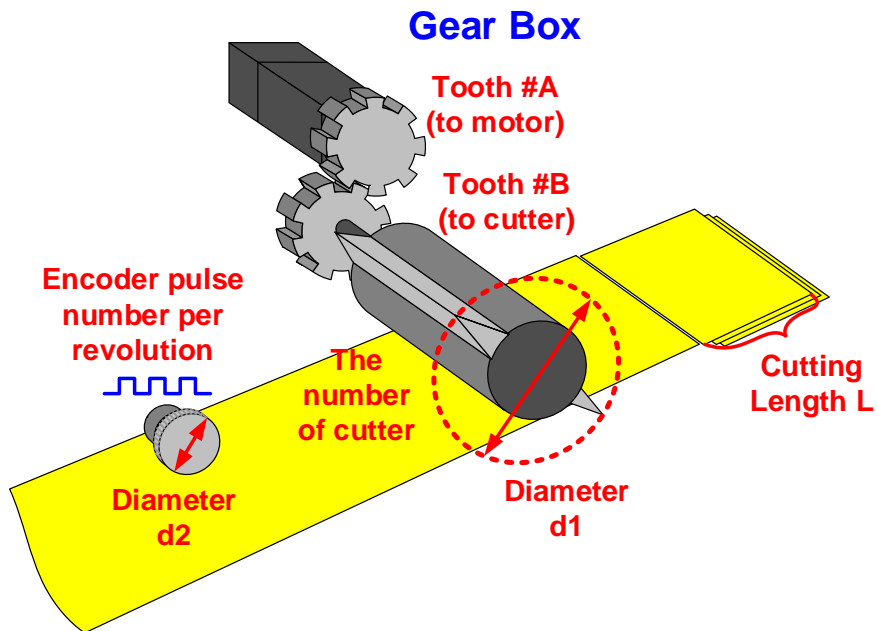

Figure 2.31 The Mechanism of a Rotary Shear

No matter it is Rotary Shear-W/O Sealing Zone, Rotary Shear- W/T Sealing Zone, or Rotary Shear- Adjustable Sealing Zone, mechanical specifications is required when creating a curve via the software. See Figure 2.32.

Figure 2.32 Enter Values of Rotary Shear Specifications

➢ Gear Ratio: Directly enter the number of gear and the system will figure out the gear ratio automatically.

➢ Cutter number (*Knife No.*) and diameter (*Knife Diameter d1*): The cutter number can be changed according to the application and should be equally allocated on the cutter axis."Cutter radius" is the distance from cam center to cutter tip, cutter radius times two is "Cutter diameter". Therefore, regardless the cutter number, cutter diameter is always the same. See Figure 2.33. ASDA-Soft will figure out the cutter circumference from the cutter diameter.
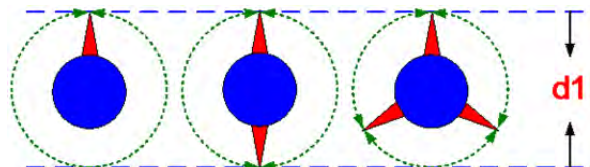

Figure 2.33 The Relationship between Cutter Number and Cutter Diameter

➢ Encoder diameter (d2) and pulse number (*Encoder Pulse*): Encoder pulse is the pulse number being sent when encoder rotates one cycle. As encoder diameter and pulse number are known, the resolution of the command of the master axis can be figured out, which is the value of P5-84 (when P5-38 = 1). In this case, if pulse number of the master axis (P5-84) is known, there is no need to enter encoder diameter and encoder pulse number. Users can directly enter the value of P5-84.

➢ Motor PUU No. per rev.: It is the required PUU when the motor operates one cycle and converted from E-gear ratio.

➢ Cut length (L): the cutting length of the material, which can be changed by users.

When using the software to create a rotary shear curve, to avoid creating an inappropriate curve, the software will automatically generate a creatable range based on the ratio of cutting range and cutter circumference. For example, if cutting length **A** is much shorter than

the moving distance **a** of slave axis when cutting, it will be unable to increase the speed of slave axis to satisfy the demand of short cutting length. If the value of **R** is too small, it might need to modify the mechanism to conquer the problem.

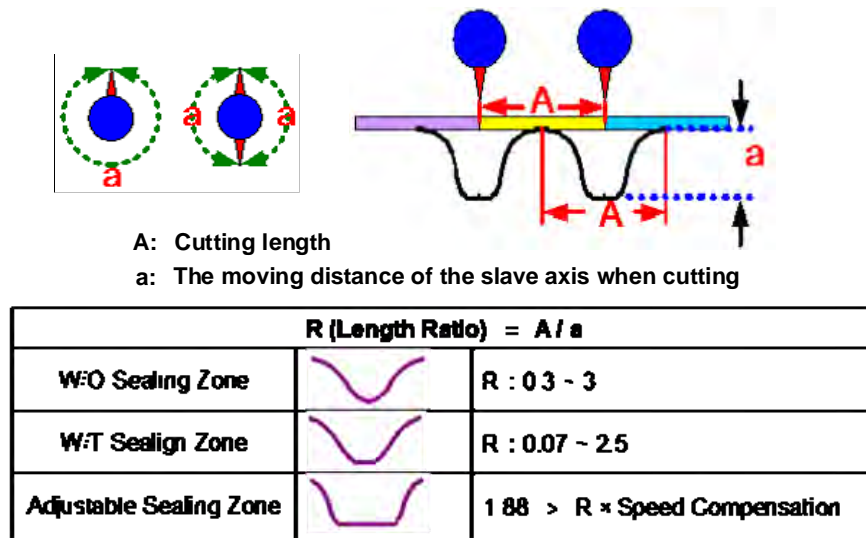Please refer to Figure 2.34 for the limit of curve creation.

A: Cutting length
a: The moving distance of the slave axis when cutting

R (Length Ratio) = A / a		
W:O Sealing Zone		R : 0.3 ~ 3
W:T Sealign Zone		R : 0.07 ~ 2.5
Adjustable Sealing Zone		1.88 > R × Speed Compensation

Figure 2.34 Range Limit for Creating the Curve by Software

➢ Speed Compensation：

In some applications, the speed of the master axis and the slave axis is not consistent when cutting. In this case, parameters of speed compensation can be used to modify the relative speed between them. When speed compensation is set to a positive value, the slave axis will operate faster than the master in constant speed area. When the speed compensation is set to a negative value, the slave axis will operate slower than the master in constant speed area.
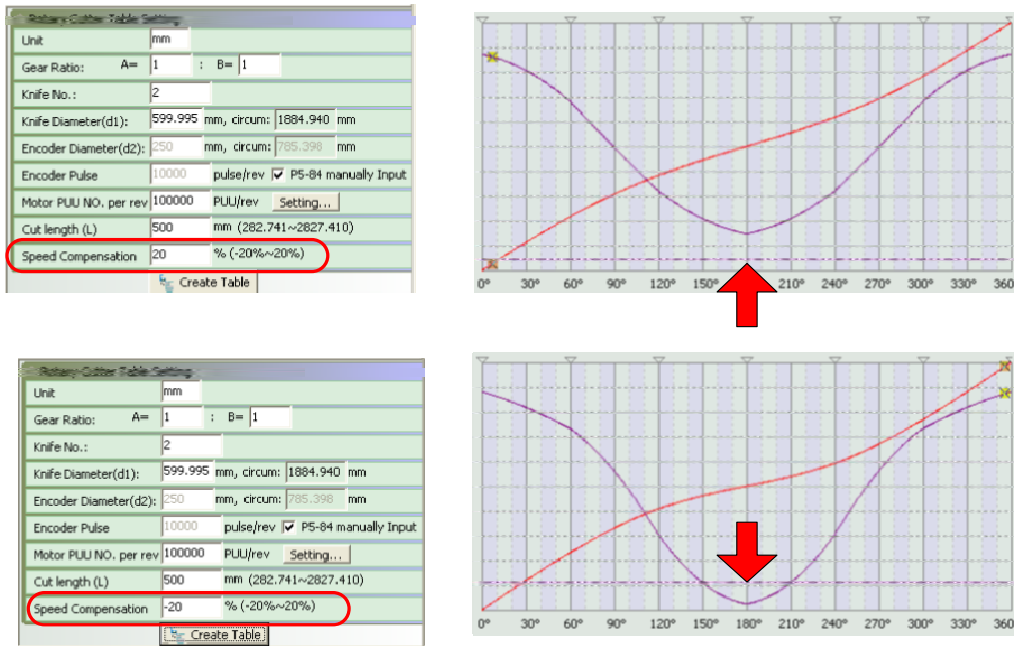
Figure 2.35 Speed Compensation

When creating a rotary shear curve by *Rotary Shear-W/T Sealing Zone*, no additional parameter is required because the constant speed area is fixed to 51°; there is no need to set up the constant speed area.

However, to use the software to adjust the constant speed area, other than entering the mechanical specifications, users have to specify the proportion among each area (constant speed area, S area, acceleration/deceleration area, and stop area) See Figure 2.36.
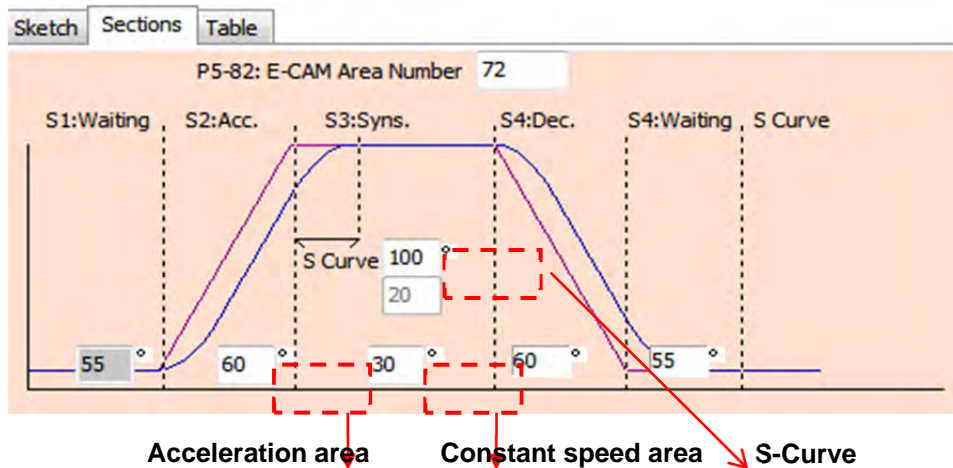

Figure 2.36 Proportion of Constant Area can be Adjusted

● Cubic Curve Creation

Knowing the position and speed, this function is rather practical. If the position and its corresponding angles are known, simply by filling in the position (0°~ 360°) of the master axis and the slave axis, this function can automatically connect and optimize the curve. In some applications, users might need a linear line or curve to complete point-to-point motion when applying the method of *Manually Create a Table*. On the other hand, modifying curves

can be easily done by *Cubic Curve Creation*.

When using this method, the connection between two points can be a straight line, a curve, or an S-curve.

1. Straight line: starting angle (the angle when departing from the start point) and ending angle (the angle when arriving the target point) cannot be adjusted.

2. Curve: A monotonically increasing or decreasing curve, which can be regarded as acceleration/deceleration curve. The starting angle is adjustable.

3. S-Curve: The starting angle and the ending angle are adjustable. The angle will determine the speed when departing the start point or reaching the target point. Inappropriate setting will result in abrupt change of speed and makes the system unstable. To have smooth operating speed, testing on the departing and arriving angle is essential when creating an E-Cam curve.
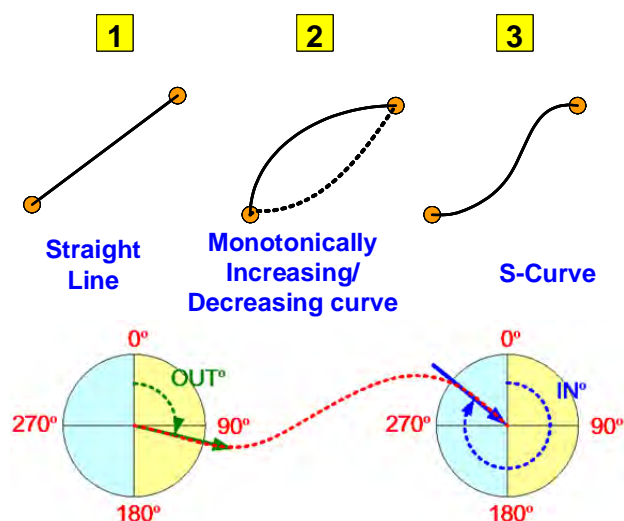

Figure 2.37 Types of Connection between Two Points

Figure 2.38 shows the screen of *Cubic Curve Creation*. Section (1) includes the angle of each point (0°~360°), *Position* (unit: PUU), *Curve Type* (constant line, constant acceleration, and cubic curve), *N1 Theta Out* (arriving angle), and *N2 Theta In* (departing angle). To modify the corresponding data of each point, users may drag the point in section (2) or by directly selecting or entering the value in section (1).

When dragging the point in section (2), the content in section (1) will be promptly changed. When directly entering or selecting the required content in section (1), the graph will be updated after clicking on *Create Cubic Table*. From section (3), the simulated E-Cam curve can be observed. Section (4) shows the current position and speed curve. Please make sure the curve size setting is appropriate.
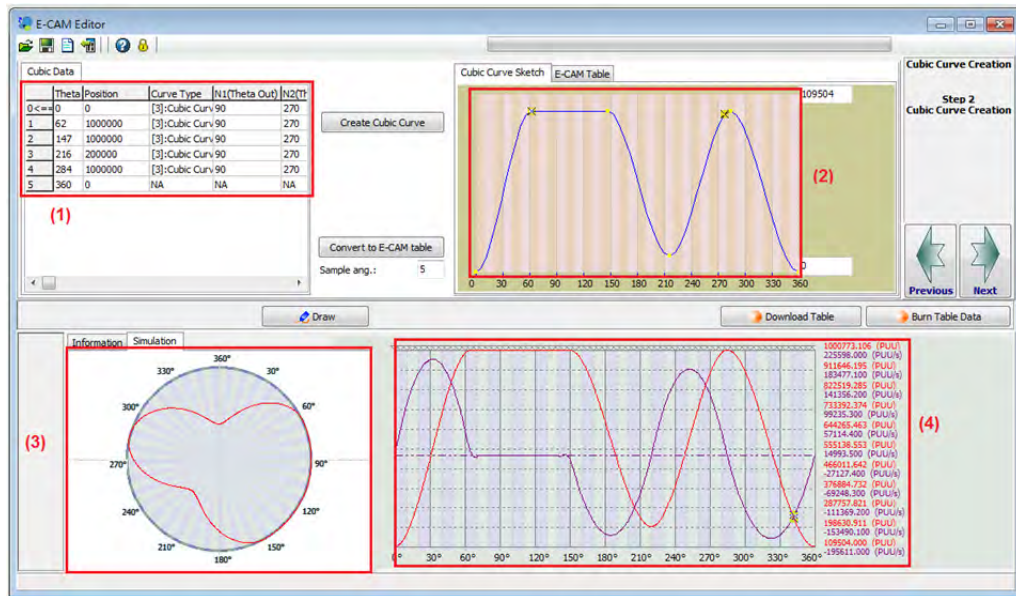
Figure 2.38 Screen of *Cubic Curve Creation*

When editing the curve by dragging points in section (2), points can be inserted or deleted by right clicking the mouse button. Users may change the point number to modify the cam shape so as to satisfy the demand of different applications.
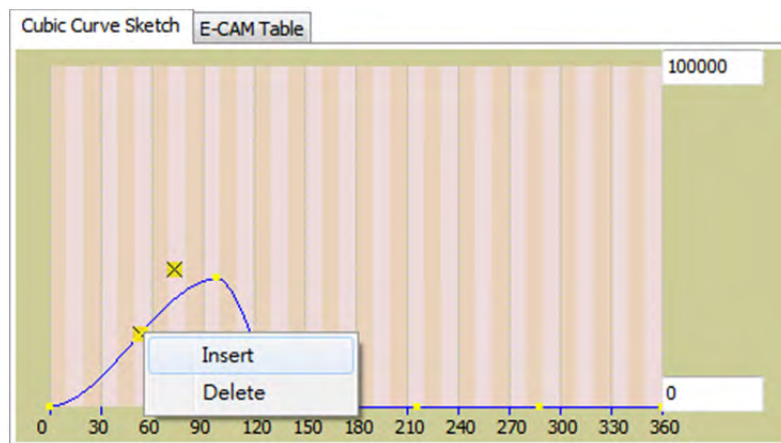

Figure 2.39 Adjusting Points

After E-Cam curve is created by using *Cubic Curve Creation*, the system will figure out E-Cam area number (P5-82) based on the sampling angle (360/sampling angle). Then, the corresponding curve position of each angle will be put in the table. The data downloaded to data array is the data of this table.
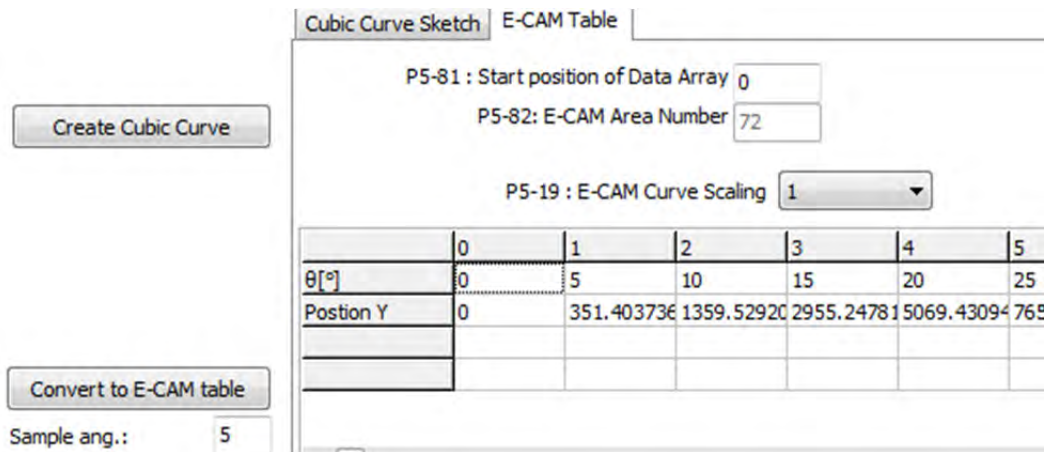
Figure 2.40 E-Cam Table of *Cubic Curve Creation*

To create a curve with higher precision, sampling angle can be set to 1 so that the E-Cam area number can be increased to 360.However, as the default setting (*P-19: E-CAM Curve Scaling = 1*) will round off the value of *Position Y* thus causing speed trembling. To solve this problem, users can select the value with more decimal digits and then use P5-19 to magnify the scaling. See Figure 2.41. When selecting a smaller scaling value, values in the table will be magnified based on the scale. For example, if value of P5-19 is changed from 1 to 0.0001, after clicking on *Convert to E-Cam Table*, the position data in the table will be magnified and become 10000 times of the original value. With this method, values with more decimals can be accessed by the system and a curve with higher precision can be made. The scale of entire curve will remain the same and the curve will become smoother.
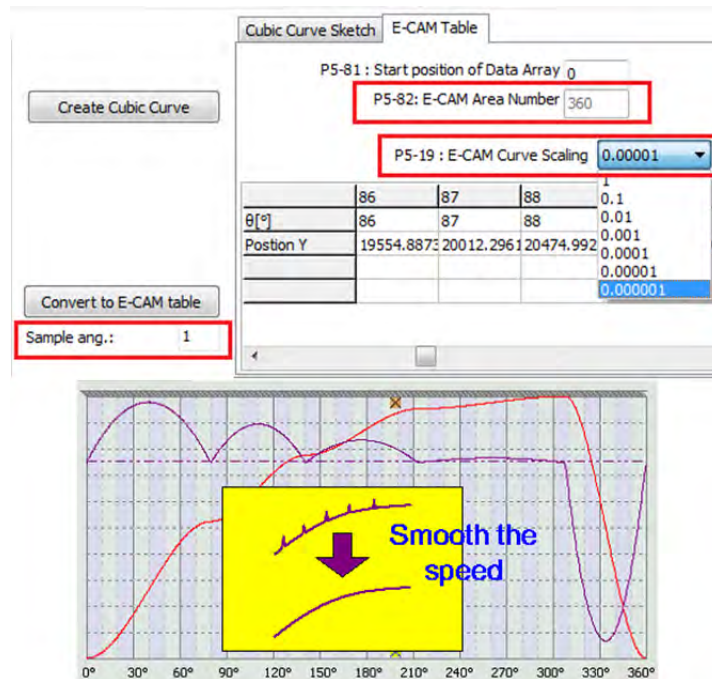

Figure 2.41 Scaling Function of *Cubic Curve Creation*

- ## Rotary Shear- Printer Machine

Here come the operational principles:

The relation between printing axis and material feeding axis is shown in Figure 2.42. Each printing axis does not connect to ball-screw but operates individually. Due to the printing length limit, it cannot do full printing. The printing axis operates at constant speed and toward the same direction. When the printing plate reaches the paper (graph A), the speed of paper and printing plate is the same and both are in the same direction (graph B). When printing is complete, paper and printing plate separate (graph C). Then, paper decelerates to stop and operate towards the opposite direction for a short distance (graph D). When it starts printing again, paper operates at the same speed and same direction as the printing cylinder. So that the printing plate always synchronizes with the paper when printing. If the printing axis and paper separate, paper is retrieved. Both axes still synchronize with one another. With this pattern, the adjacent printing pattern is closely arranged with one another and it therefore saves the use of paper. This application is very common in intermittent printing machine.
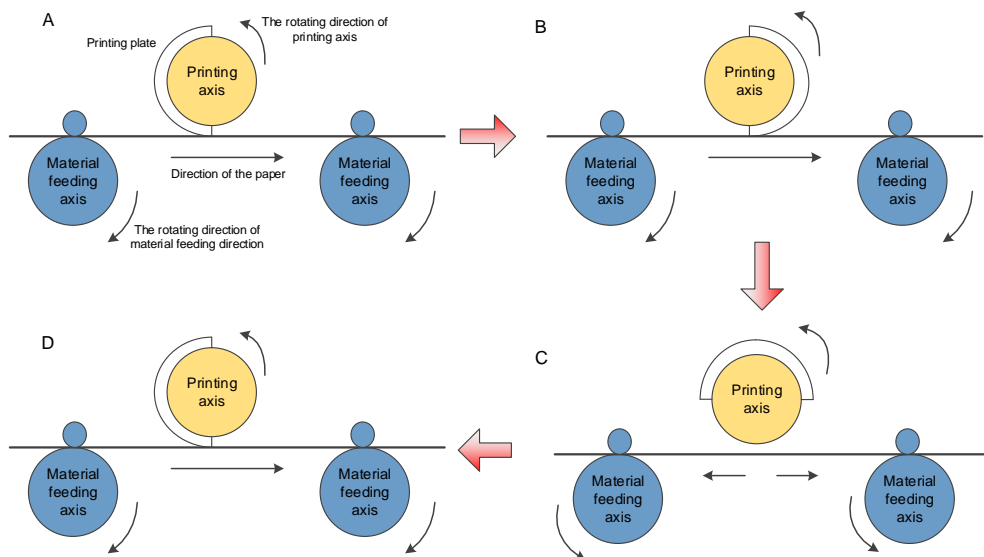

Figure 2.42 Motion Analysis on Intermittent Printing

See Figure 2.43. ASDA-Soft provides servo setting wizard for intermittent motion control. Users could plan it according to the required print area and blank area and manually adjust the angle in synchronous area and waiting area. Complete the setting of material feeding axis by following the steps below.
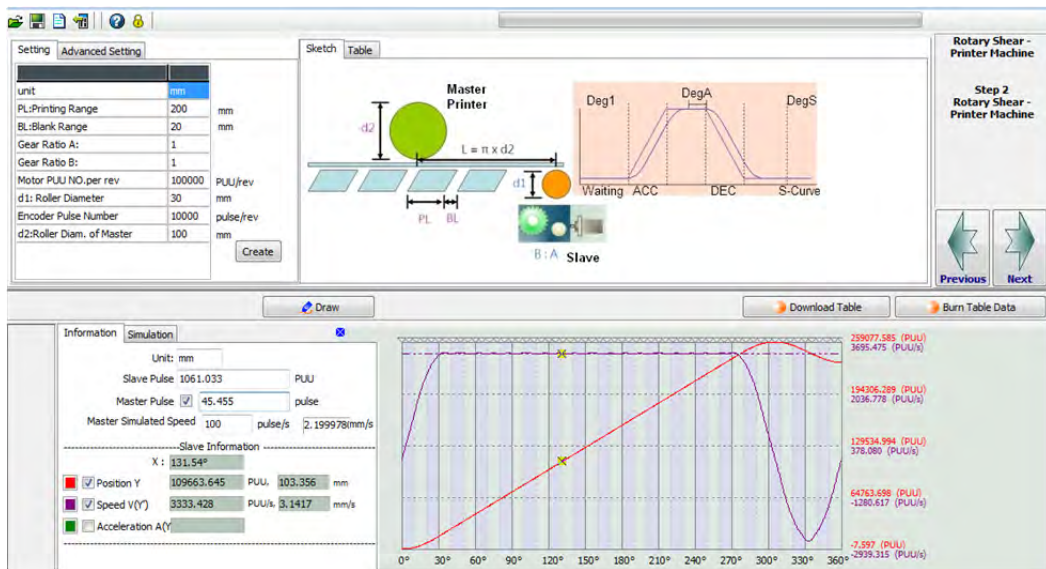
Figure 2.43 Setting Wizard for Intermittent Motion Control

When using this method to create an E-Cam curve for rotary shear printing machine, mechanical specifications have to be filled in the table. See Figure 2.44.
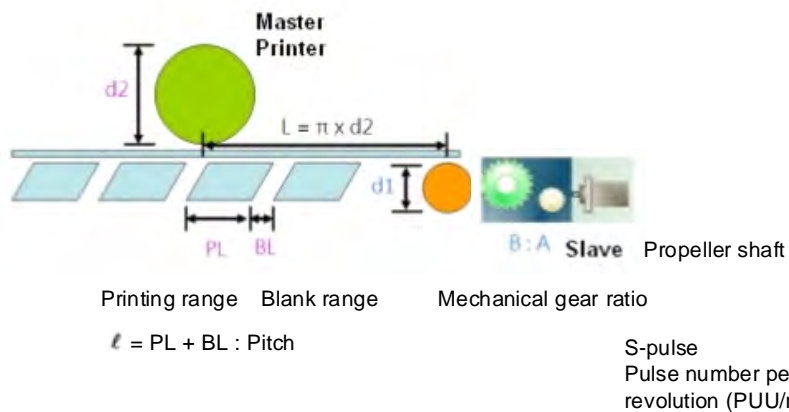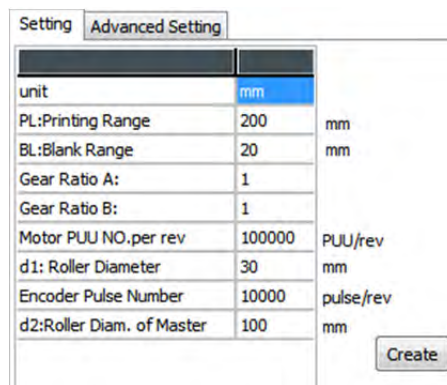

Figure 2.44 Mechanical Specification Settings for Rotary Shear-Printing Machine

Users have to learn the relation of each unit of length in advance.

L (Circumference of printing cylinder) = π x d2

ℓ (Pitch of materials) = PL + BL

R = L / ℓ (equals to the "cutting length" in Rotary shear. In printing application, most cases

are R > 1.)

Take the initial parameter in software as the example:

L (Circumference of printing cylinder) = π x 100 = 314.15 mm

ℓ (Pitch of materials) = PL + BL = 200 + 20 = 220 mm

R = L / ℓ = 314.15 / 220 = 1.428 (R > 1, reasonable range)

In addition, L (Circumference of printing cylinder) has to be larger than ℓ (Pitch of materials). The purpose of intermittent motion is to save the use of space and reduce the cost without idling and wasting the materials.

See Figure 2.44. Users only have to fill in the value according to the setting mechanical parameters. Please note that the setting of pulse number of encoder and diameter of the printing axis (d2) should be appropriate. Printing axis is the master axis of printing machine. Pulse number from the encoder represents the one sent by printing roller per cycle. If master axis connects to the printing roller, its setting value is (P1-46)*4. If the printing roller is equipped with decelerator, then the factor needs to be taken into consideration. For instance, if the decelerator is 1:5, then the setting value should be (P1-46)*4*5.

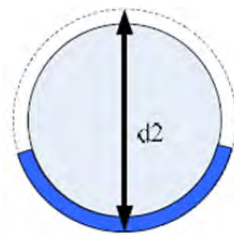d2: Diameter of printing cylinder includes the length of printing plate. See Figure 2.45.

Figure 2.45 Definition of Printing Cylinder Diameter (d2)

Next, description about how to determine the width of synchronous area is shown is as follows. See Figure 2.46.

deg_sync (Degree of synchronous area) = PL / L x 360°. This formula can help to calculate the degree of synchronous area.

Take the initial parameter in software as the example:

deg_sync (Degree of synchronous area) = PL / L x 360° = 200 / 314.15 x 360 = 229.190°

Please note that the setting of degree of waiting area and S-curve cannot exceed 360°.
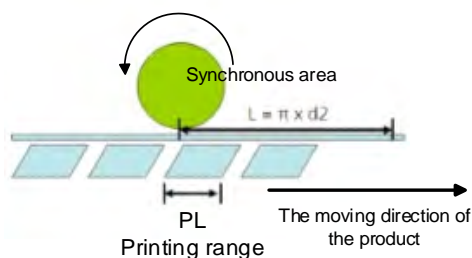
Figure 2.46 Synchronous Area Setting of E-Cam Curve for *Rotary Shear- Printer Machine*

If the curve needs to be fine adjusted, users can adjust the degree of *Waiting Angle*, *S-Curve Angle*, and *Syn. Extra Angle* in *Advanced Setting* section of the software.

Figure 2.47 Setup the Degree of E-Cam Curve for *Rotary Shear-Printer Machine*

To have a stable printing quality, users can extend the range of synchronous speed area.

deg_sync (Angle of synchronous area) = PL / L x 360° + SyncAdd (increase the angle of synchronous area)

The default setting of waiting area is 0. It is because the acceleration/deceleration curve is smoother than no one in this status. The bigger value in waiting area, the shorter distance motor can run in reverse direction and the speed change is greater. It is easier to cause current overload. When waiting area is set to 0°, if the motor is still overload due to the acceleration or deceleration, this problem can be solved by reducing the operating speed of master axis or changing to a more powerful motor.

2.5.2 Using Macro to Create an E-Cam Curve

PR mode on ASDA-A2 provides two ways to create E-Cam curve for rotary shear by macro:
Using Macro 6 to create E-Cam curve for rotary shear with a fixed 51° sealing zone; Using Macro 7 to create E-Cam curve for rotary shear with adjustable sealing zone.
The E-Cam curve created by macro command is the same as that created by ASDA-Soft. The best thing about using macro command to create E-Cam curve is that the cutting length can be easily modified by changing parameter setting with HMI or PLC. For those who need to modify the cutting length, this method can be very useful.

- Macro 6 (Rotary shear curve with a fixed 51° sealing zone): If material is changed, users only need to re-enter the cutting length and determine whether to apply speed compensation. Steps to set up are shown below:

Step 1: When using Macro 6, the first step is to store the required relevant parameters in data array, which includes P5-81 (the start address of E-Cam curve in data array) and P5-85 (engaging time). When using Macro 6, P5-82 is always set to 7, which means the E-Cam curve has 7+1 divisions only and cannot be changed.

Step 2: Specify the scaling of the E-Cam curve, which includes the E-gear ratio P1-44/P1-45 (E-Cam is part of the system, which will be influenced by E-gear ratio.) and scaling of E-Cam curve P5-19.
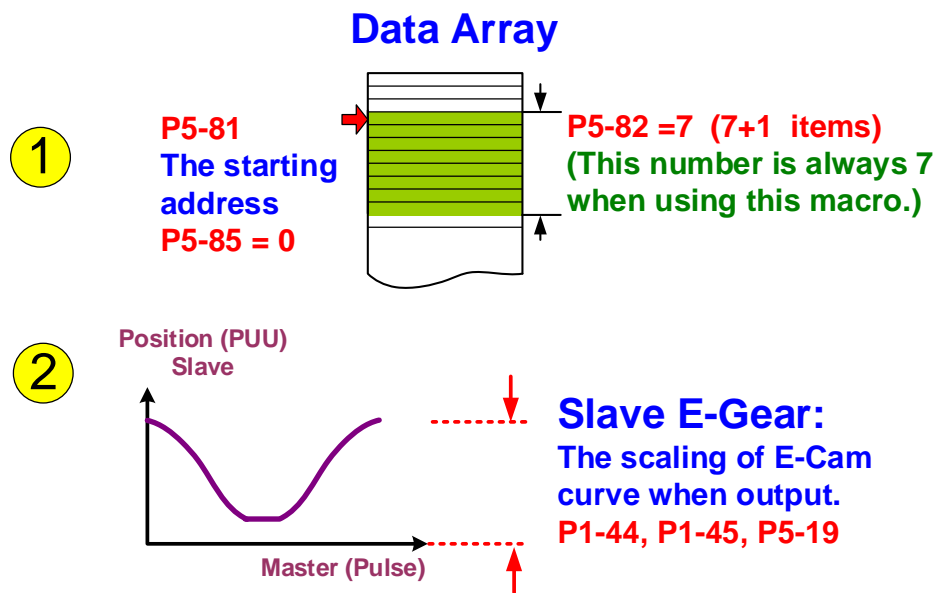

Figure 2.48 Relevant Parameter Settings of E-Cam Curve when Using Macro 6

Step 3: See Figure 2.49. Figure out the mechanical specifications and enter relevant parameters, which is the same as the data required when creating E-Cam curve for rotary shears. Users may use HMI to input the required data and use HMI or PLC to calculate relevant values and download them to the servo drive.

P5-83 = 1
P5-84 = N / (π * d2 (mm)) * L (mm) , (Pulse number required for L)
P5-94 = A * C
P5-95 = B
P5-96 = L (mm) / (π * d1 (mm)) * C * Vc * 1000000
Vc = Speed compensation   Vc = 1 Do not compensate
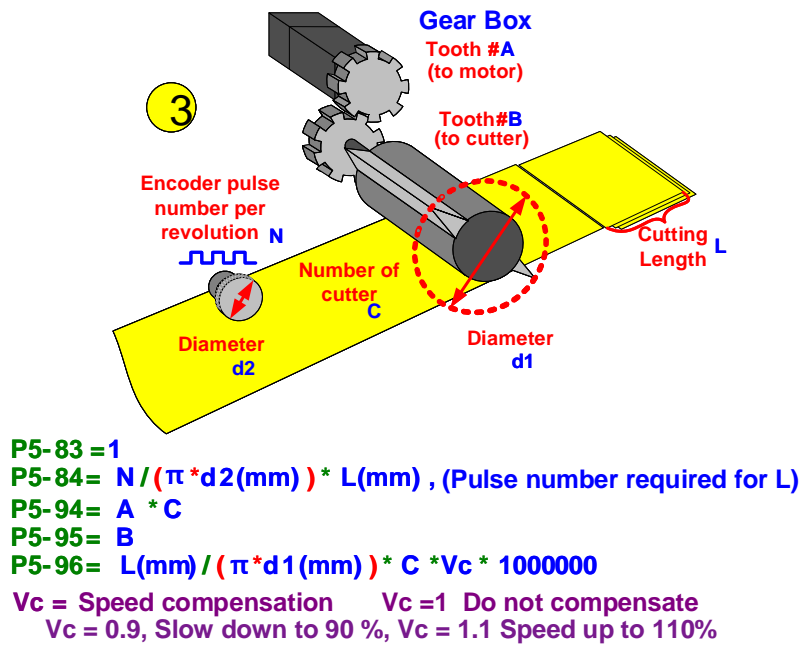**Vc = 0.9, Slow down to 90 %, Vc = 1.1 Speed up to 110%**

Figure 2.49 Mechanical Settings when Using Macro 6

Step 4: When all relevant parameters are set, write 6 to P5-97 to enable macro 6. After macro is enabled, read P5-97 again. If its value is 0x1006, it means the table is successfully created by the macro. If error codes are shown, please correct the parameter value according to the error message.

List of error codes from P5-97 for #6 macro command

F061h: E-Cam engaged. Unable to create a table.
F062h: Value of P5-94 exceeds the range of 1~65535.
F063h: Value of P5-95 exceeds the range of 1~65535.
F064h: Value of P5-96 exceeds the range of 300000~250(
F065h: Inappropriate address. Value of P5-81 exceeds the range.
F066h: Value of P5-82 must be 7.
F067h: Value of E-gear ratio is too high. Lower the value but keep the original ratio of P1-44 and P1-45. (1280:100 → 128:10)
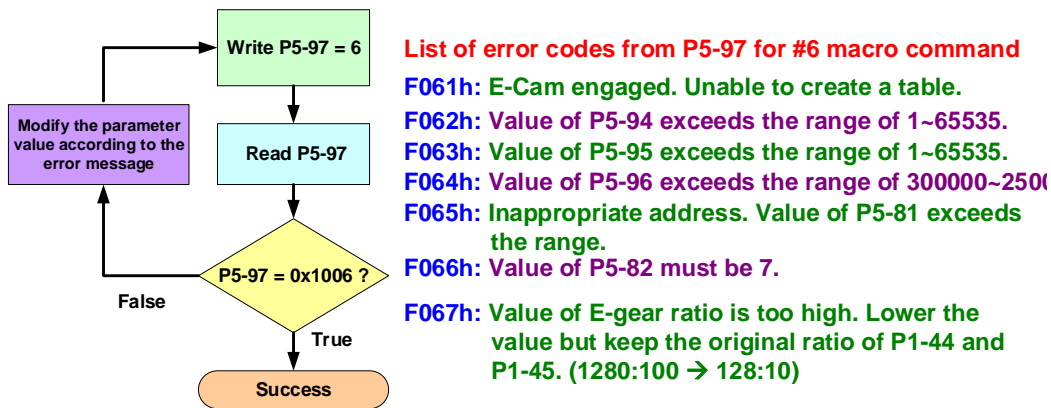
Figure 2.50 Enable Macro Command 6

After the curve is created successfully, it can be used to enable the E-Cam. When system setting is complete, most of the mechanical specification will not be changed. The parts that will be modified might be the setting of cutting length of the material and speed compensation. If the cutting length has to be changed, the setting can be done by entering the new value of cutting length and relevant parameters. After enabling the macro (P5-97 =6), a new E-Cam curve can thus be used. With this method, it is easy to modify relevant settings.

● Macro 7 (E-Cam curve for rotary shear with adjustable sealing zone.)

When using flat cutters which cutting length is changed, the width of the cutter usually remains the same. However, different material will change the cutting length and angle in synchronous zone because this area is determined by material. This is an important reason why this macro command is created. When using Macro 7 and the material has to be changed, the setting can be completed by re-specifying the cutting length and specifying whether speed compensation is needed. Steps to set up are shown below.

Step 1: The first step is to store the required relevant parameters in data array in order to create an E-cam curve. P5-81 (the start address of saving the E-Cam curve in data array) and P5-85 (engaging timing) are included. What's different from Macro 6 is that value of P5-82 is an adjustable variable, which range is from 30 to 72 when using Macro 7. That is, the E-Cam can be divided into 30 ~ 72 parts. To obtain the best resolution, set the area number to 72 is recommended.

Step 2: The second step is to specify the scaling of E-Cam curve, which includes system's E-gear ratio P1-44/P1-45 (E-Cam is part of the system thus it might be changed by the system's E-gear ratio.) and scaling of E-Cam curve (P5-19).
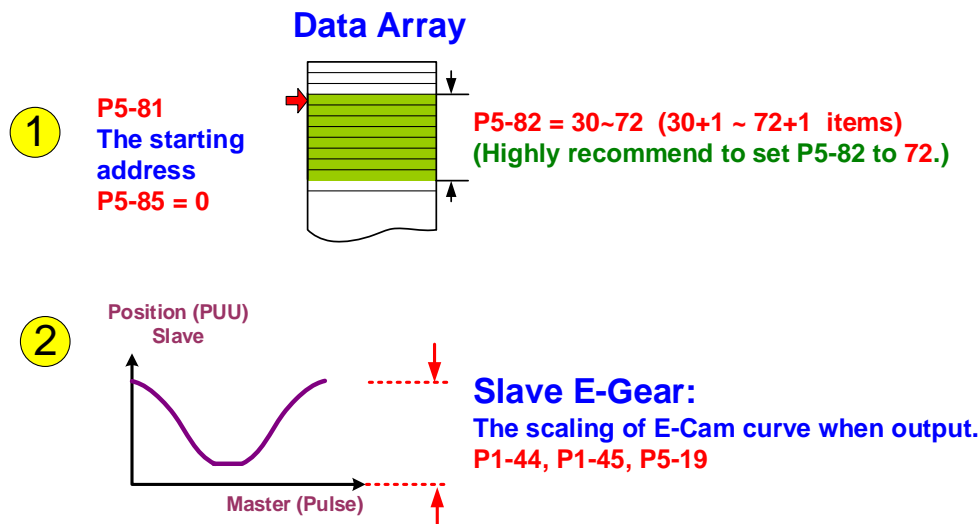

Figure 2.51 Relevant Parameter Settings for E-Cam Curve when Using Macro 7

Step 3: Specify proportion of each speed areas on E-Cam curve. As the size of constant speed area on E-Cam curve is adjustable, other areas such as acceleration/deceleration area, S-curve, and Stop area have to be set manually. The setting proportion of each area has to be appropriate in order to operate smoothly. The function of S-curve is to smooth the curve when speed changes. Its setting is level- based, which is from 1 to 4. Others are specified according to its angle.
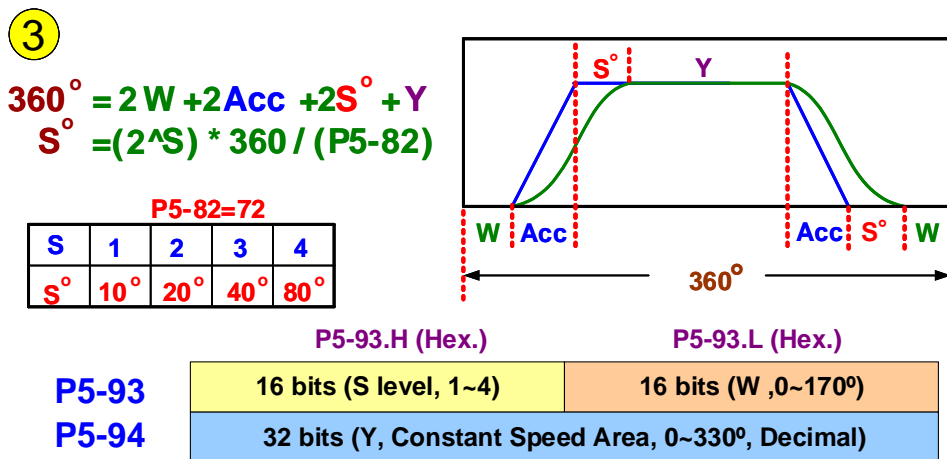
③

$$360^\circ = 2W + 2Acc + 2S^\circ + Y$$
$$S^\circ = (2\char`^S) * 360 / (P5\text{-}82)$$

P5-82=72

S	1	2	3	4
S°	10°	20°	40°	80°

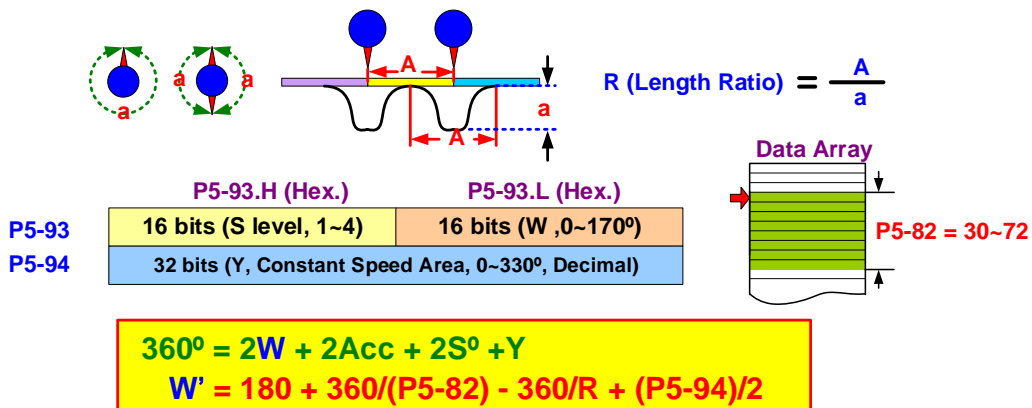|	**P5-93.H (Hex.)**	**P5-93.L (Hex.)**
P5-93	16 bits (S level, 1~4)	16 bits (W ,0~170º)
P5-94	32 bits (Y, Constant Speed Area, 0~330º, Decimal)	

Figure 2.52 Setting Proportion of Each Speed Area of Rotary Shear Curve when Using Macro 7

Since the waiting area is adjustable, there are more limitations when creating E-Cam curve by Macro 7. See Figure 2.53.

$$R \text{ (Length Ratio)} = \frac{A}{a}$$

Data Array

P5-82 = 30~72

	P5-93.H (Hex.)	**P5-93.L (Hex.)**
P5-93	16 bits (S level, 1~4)	16 bits (W ,0~170º)
P5-94	32 bits (Y, Constant Speed Area, 0~330º, Decimal)	

$$360^\circ = 2W + 2Acc + 2S^\circ + Y$$
$$W' = 180 + 360/(P5\text{-}82) - 360/R + (P5\text{-}94)/2$$

W < W', Error Code F07A, enlarge waiting zone or narrow constant speed area.

W = W', The starting speed of the curve = 0.

W > W', The starting speed of the curve > 0.

Figure 2.53 Limitations of Creating E-Cam Curve for Rotary Shear by Macro 7

Step 4: See Figure 2.54. Figure out the mechanical specifications and enter relevant parameters. The required specification data is the same as that needed when creating E-Cam curve for rotary shear. Users may use HMI to enter the data or use HMI or PLC to calculate relevant values and download them to the servo drive.
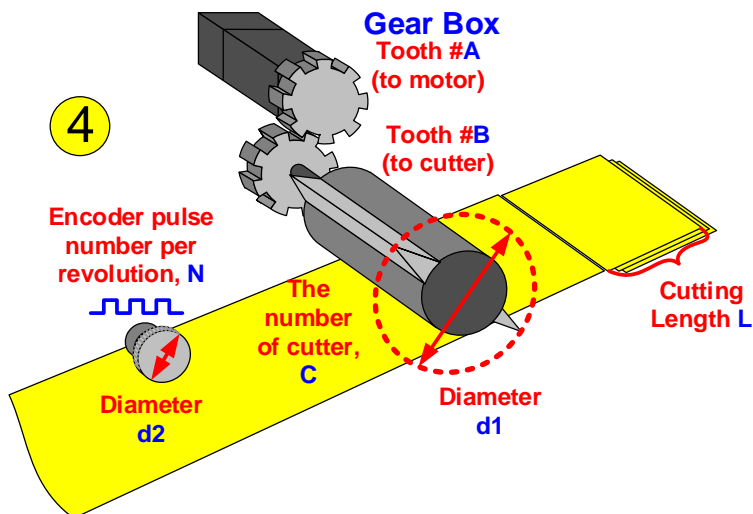
P5-83 = 1
P5-84 = N / (π * d2 (mm)) * L (mm),   (pulses required by L)
P5-95.H (in Hexadecimal) = A * C
P5-95.L (in Hexadecimal) = B
P5-96 = L (mm) / (π * d1 (mm)) * C * Vc * 1000000

P5-95.H (Hex.)	P5-95.L(Hex.)
P5-95 16 bits (A x C)	16 bits (B)

Vc = Speed compensation, Vc = 1, Do not compensate.
Vc = 0.9, Slow down to 90%, Vc = 1.1, Speed up to 110% .

Figure 2.54 Mechanical Settings when Using Macro 7

Step 5: When all relevant parameters are set, write 7 to P5-97 to enable Macro 7. After it is

enabled, read the same parameter P5-97 again, if the value is 0x1007, it means this table is

created by macro successfully. If any error code occurs, please modify the parameter
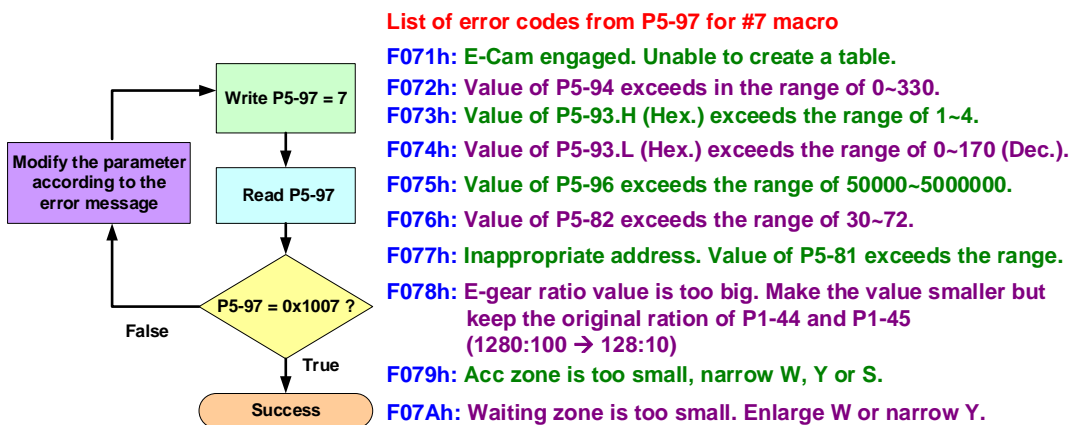
List of error codes from P5-97 for #7 macro
F071h: E-Cam engaged. Unable to create a table.
F072h: Value of P5-94 exceeds in the range of 0~330.
F073h: Value of P5-93.H (Hex.) exceeds the range of 1~4.
F074h: Value of P5-93.L (Hex.) exceeds the range of 0~170 (Dec.).
F075h: Value of P5-96 exceeds the range of 50000~5000000.
F076h: Value of P5-82 exceeds the range of 30~72.
F077h: Inappropriate address. Value of P5-81 exceeds the range.
F078h: E-gear ratio value is too big. Make the value smaller but keep the original ration of P1-44 and P1-45 (1280:100 → 128:10)
F079h: Acc zone is too small, narrow W, Y or S.
F07Ah: Waiting zone is too small. Enlarge W or narrow Y.

*Please refer to Chapter 8 of ASDA-A2 User Manual for parameter details.

according to the error message.

Figure 2.55 Enable Macro Command 7

Two examples are presented below to help users create E-Cam curves with Macro 7.

Example 1:

When using Macro 7 to create E-Cam curve and R = 1.1 ~ 5 (when R > 1.0, cutting length is longer than cutter circumference), adopting rules presented in the diagram (Figure 2.56) can avoid occurrence of error codes.

Step 1: Figure out the length ratio R first. Make sure the value is within the range of 1.1 ~ 5 or this flow chart is not applicable.

Step 2: Specify the S level. Then, figure out the proportion of constant speed area and waiting zone to meet the range condition. Enter all the values to the designated parameters.

Step 3:

1) If not applying speed compensation, the setting is done after calculating value of P5-95 and P5-96.

2) If positive speed compensation is used, which means the slave axis speed is faster than the master axis, users may consider adjusting the size of the constant speed area or speed up the slave axis.

   ➢ Taking adjusting the speed of the slave axis as priority: Select the max. possible positive speed compensation. Then calculate the variation of the constant speed area based on this compensation value. A new range of the constant speed area can thus be acquired.

   ➢ Taking adjusting the size of the constant speed area as priority: If size of the constant speed area is the priority, select a new constant speed area to re-define the range and figure out the required compensation value.

Step 4: After setting the compensation value (Vc) and new range of the constant speed area, revise the setting of constant speed area.

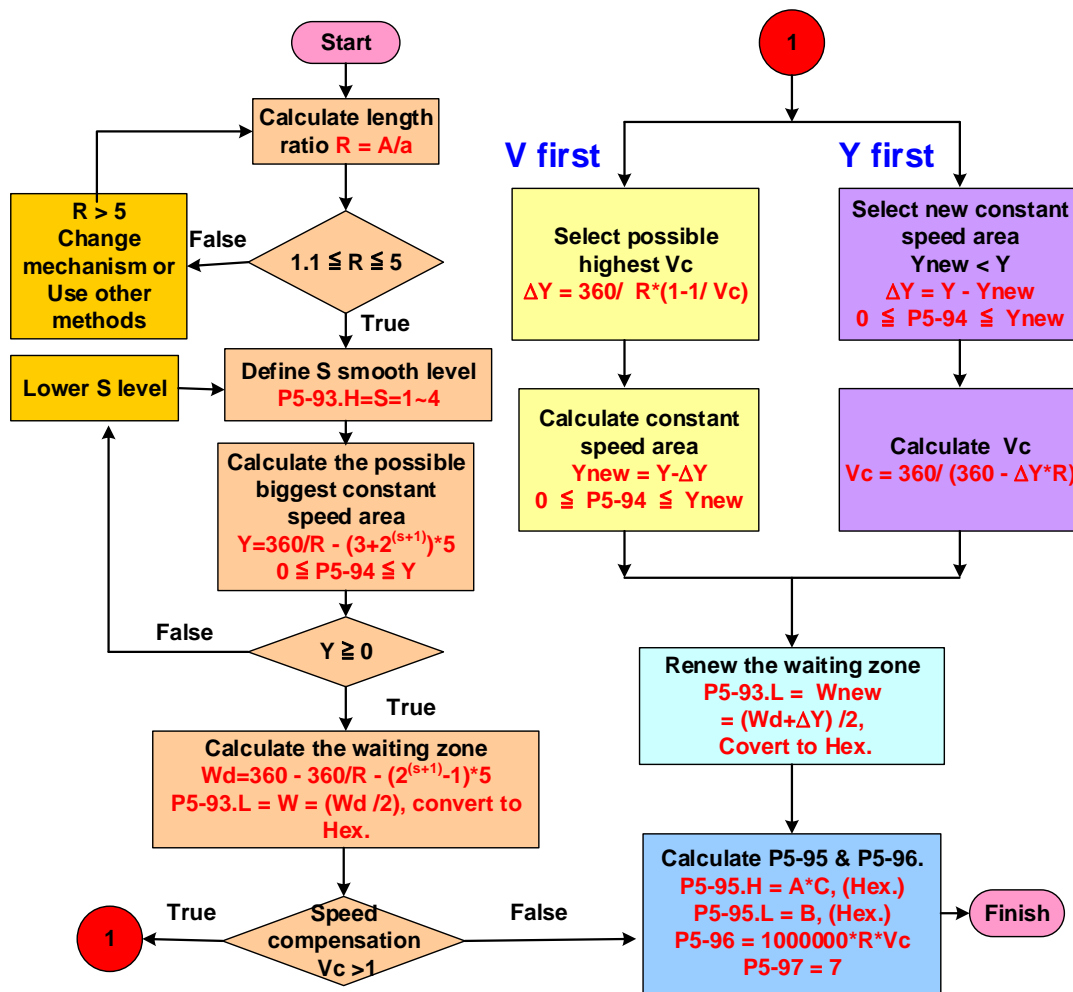Step 5: Figure out value of P5-95 and P5-96 and the setting is complete.

Start

Calculate length ratio R = A/a

$1.1 \leq R \leq 5$

R > 5 Change mechanism or Use other methods

False

True

Lower S level

Define S smooth level
P5-93.H=S=1~4

Calculate the possible biggest constant speed area
$Y = 360/R - (3+2^{(s+1)})*5$
$0 \leq P5\text{-}94 \leq Y$

$Y \geq 0$

False

True

Calculate the waiting zone
$Wd = 360 - 360/R - (2^{(s+1)}-1)*5$
P5-93.L = W = (Wd /2), convert to Hex.

Speed compensation
Vc >1

True → **1**

False

1

V first

Select possible highest Vc
$\Delta Y = 360/ R*(1-1/ Vc)$

Calculate constant speed area
$Ynew = Y-\Delta Y$
$0 \leq P5\text{-}94 \leq Ynew$

Y first

Select new constant speed area
Ynew < Y
$\Delta Y = Y - Ynew$
$0 \leq P5\text{-}94 \leq Ynew$

Calculate Vc
$Vc = 360/ (360 - \Delta Y*R)$

Renew the waiting zone
$P5\text{-}93.L = Wnew$
$= (Wd+\Delta Y) /2,$
Covert to Hex.

Calculate P5-95 & P5-96.
P5-95.H = A*C, (Hex.)
P5-95.L = B, (Hex.)
$P5\text{-}96 = 1000000*R*Vc$
P5-97 = 7

Finish

Figure 2.56 Diagram of Creating E-Cam Table with Macro 7 (R = 1.1 ~ 5)

Example 2:

When using Macro 7 to create an E-Cam curve and R = 0.5 ~ 1.09 (when R < 1.0, cutting length < cutter circumference), follow the instructions shown in Figure 2.57 to write macro commands can avoid occurrence of error codes. Table in Figure 2.57 shows the setting range of waiting area and constant speed area based on the S level.

Marco Command P5-97 = 7 (8)

The table is for the case of R = 0.05~1.09 and P5-82 = 72.

P5-93.H = S = 1 ~ 4;   P5-93.L = W = (Wd/2), (Hex.)

P5-94 = Y; P5-95.H = A*C, (Hex.); P5-95.L = B, (Hex.)

S = 1	Wd = 0°~150°	Y = 0°~150°	**S = 2**	Wd = 0°~140°	Y = 0°~150°
	Wd = 0°~(150°-$\Delta\chi$)	Y = 0°~(150°+$\Delta\chi$)		Wd = 0°~(140°-$\Delta\chi$)	Y = 0°~(150°+$\Delta\chi$)
	Wd = 0°~(150°+$\Delta\chi$)	Y = 0°~(150°-$\Delta\chi$)		Wd = 0°~(140°+$\Delta\chi$)	Y = 0°~(150°-$\Delta\chi$)
S = 3	Wd = 0°~110°	Y = 0°~110°	**S = 4**	Wd = 0°~50°	Y = 0°~30°
	Wd = 0°~(110°-$\Delta\chi$)	Y = 0°~(110°+$\Delta\chi$)		Wd = 0°~(50°-$\Delta\chi$)	Y = 0°~(30°+$\Delta\chi$)
	Wd = 0°~(110°+$\Delta\chi$)	Y = 0°~(110°-$\Delta\chi$)		Wd = 0°~(50°+$\Delta\chi$)	Y = 0°~(30°-$\Delta\chi$)

P5-96 = 1000000 * R * Vc; P5-97 = 7

Figure 2.57 Diagram for Creating E-Cam table with Macro 7 (R = 0.05 ~1.09)

2.6   E-gear Ratio and Scaling of E-Cam Curve

P5-19 and E-gear ratio of the slave axis will change the E-Cam scaling from issuing command to output. See Figure 2.58.
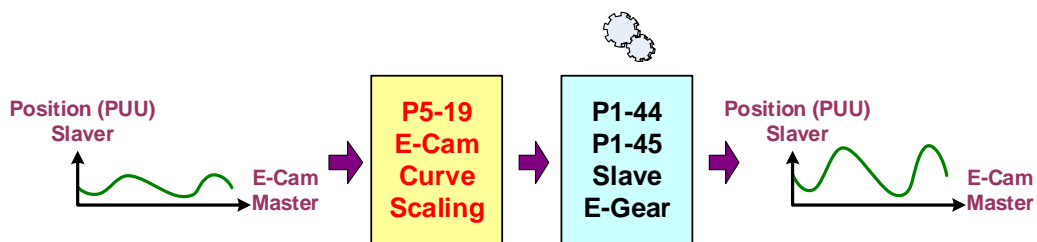
Figure 2.58 Scaling of E-Cam Curve

The E-gear ratio of E-Cam axis is identical to the system's which specified by P1-44 and P1-45. Change of slave axis' E-gear ratio will change the system's E-gear ratio; the system's E-gear ratio will not be restored even when E-Cam is disengaged. Therefore, it is not suggested to modify the scaling of E-Cam curve by P1-44 and P1-45 as this will also change the E-gear ratio of the entire system. When E-cam is disabled, PR command will also refer to this E-gear ratio. Effect brought by P5-19 is the same as the E-cam's E-gear ratio but only effective to E-Cam system instead of the system's E-gear ratio. In this case, using P5-19 to change the scaling of E-Cam curve is recommended. In terms of E-Cam's output, the effect of adjusting value of P5-19 is the same as adjusting the value of P1-44 /P1-45. When P5-19 = 0.5, the output of E-Cam axis

will only output half of the PUU number. If P5-19 is set to a negative value, the output of E-cam curve will be inverted compared with that is set to a positive value. If using firmware version earlier than v1.038 sub48, after value of P5-19 is changed, users have to re-engage E-Cam to make the modification become effective. If Bit 2 of P5-88.X is set, a new E-Cam curve scaling will be effective immediately when its value is changed.
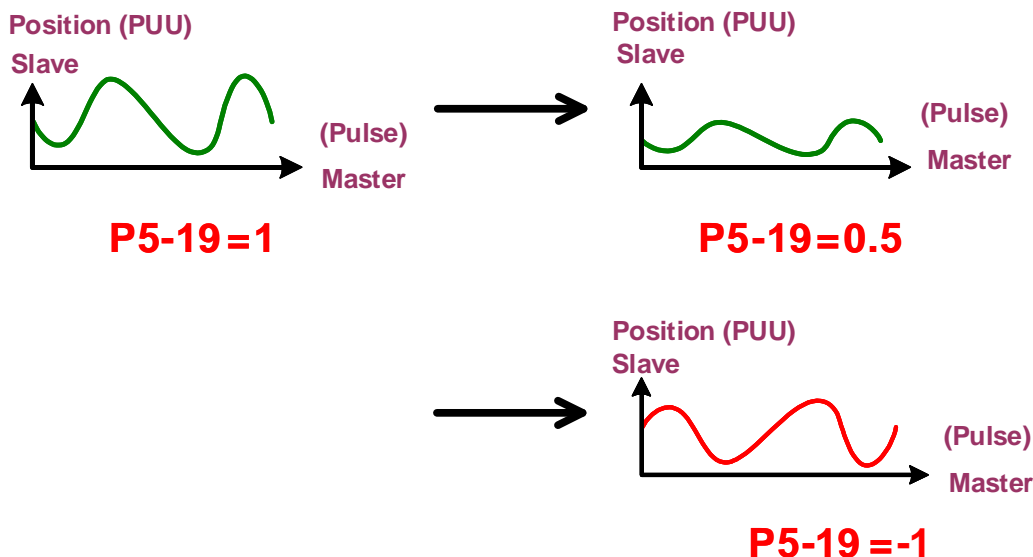

Figure 2.59 Scaling of E-Cam Curve

Changing P5-19 will only change the position of E-Cam. The pulse number from master axis required for E-Cam to rotate a cycle remains the same. That is, it only changes the value of Y-axis of the E-Cam curve; scale of X-axis remains the same. Therefore, the moving distance of the slave axis and operating speed are both changed. To allow the operating speed synchronize with the moving distance that has been changed, the pulse number of the master axis (ratio of P5-84/P5-83) shall be adjusted based on the proportional scale. See Figure 2.60.
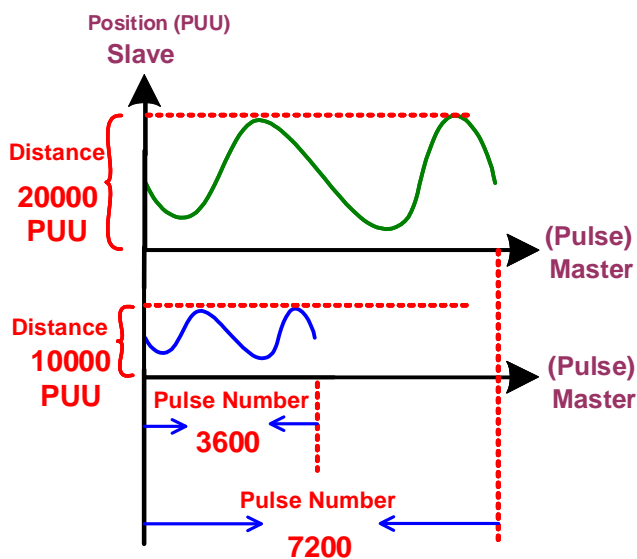
Figure 2.60 Proportional Scaling of E-Cam Curve

2.7 E-Cam Setting Example

(This example only illustrates the basic setting of E-Cam, real application example can be found in Chapter 3 of this application note.)

2.7.1 Creating an E-Cam Curve

In this example, *Speed Fitting Creation* in ASDA-Soft is used to create a simple E-Cam curve. For details about ways to create E-Cam curves, please refer to ASDA-Soft user manual.

The first step is to figure out the motion of the slave axis and mechanical specifications. Then, translate the motion into an E-Cam curve. Please note that the mechanical specifications might change the scale of the curve. The mechanical motion and specification below is also shown in Figure 2.61:

The master axis is a material feeding axis that operates with a constant speed. And there is an encoder equipped on this axis. When material feeding axis moves, it will drive the encoder to operate. The traveling distance of the material feeding axis is the total rotating distance of the encoder. Pulses sent by the encoder are directly transmitted to CN1 of the slave axis as the source of the master axis. The encoder will send 52 pulses every 1 mm and this is the specification of the encoder.

The slave axis is a ball screw which pitch is 10 mm and total length is slightly longer than 200 mm. After E-Cam is engaged, the position of the slave axis operates from 0 mm to 200 mm. After reaching the position, E-Cam will disengage. Then, a PR position command will be triggered to take the slave axis back to position 0. Then, it uses the CAP function triggered by the sensor to make E-Cam engaged. The E-gear ratio setting of the slave axis is P1-44 = 128 and P1-45 = 10, which means it takes 100000 PUU for motor of the slave axis to make one full rotation.
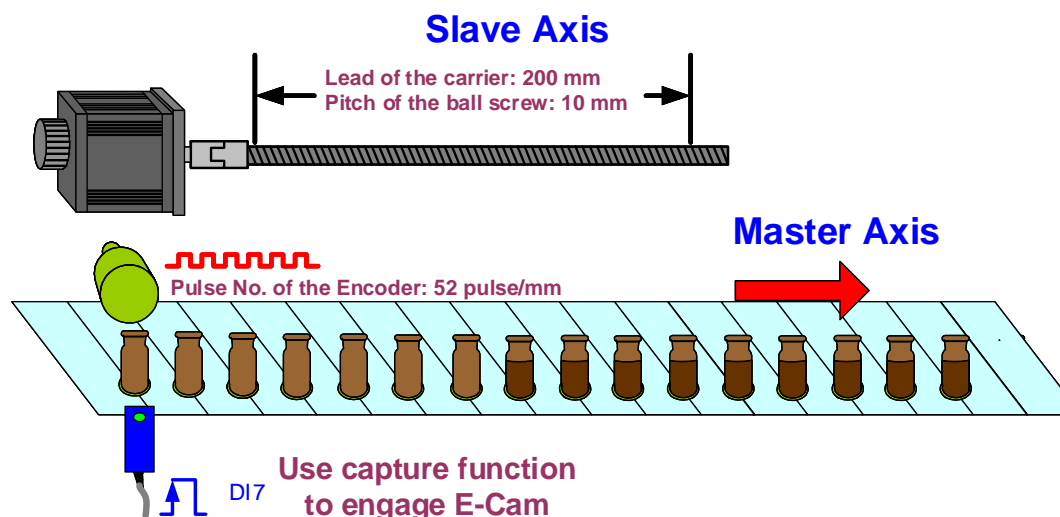
Figure 2.61 Mechanical Specification

From the information above, the required setting value for creating an E-Cam curve can be known.

1. The moving distance of the carrier is 200 mm and the pitch of the ball screw is 10 mm. →It takes 20 rotations for the moving carrier to reach the entire traveling distance.

2. It takes 100000 PUU for the motor to make one rotation. → It takes 2000000 PUU in total for the motor to make 20 rotations.

3. It takes 100000 PUU for the motor to make one rotation and its traveling distance is 10 mm per rotation. → It takes 10000 PUU to travel 1 mm.

4. The carrier's moving distance is 200 mm and the encoder which connects to the master axis sends 52 pulses every 1 mm→When the slave axis travels 200 mm, it means the encoder will send 10,400 (52 x 200) pulses to the slave axis when the slave axis operates one cycle.

See Figure 2.62 for example of creating E-Cam curve by *Speed Fitting Creation*.
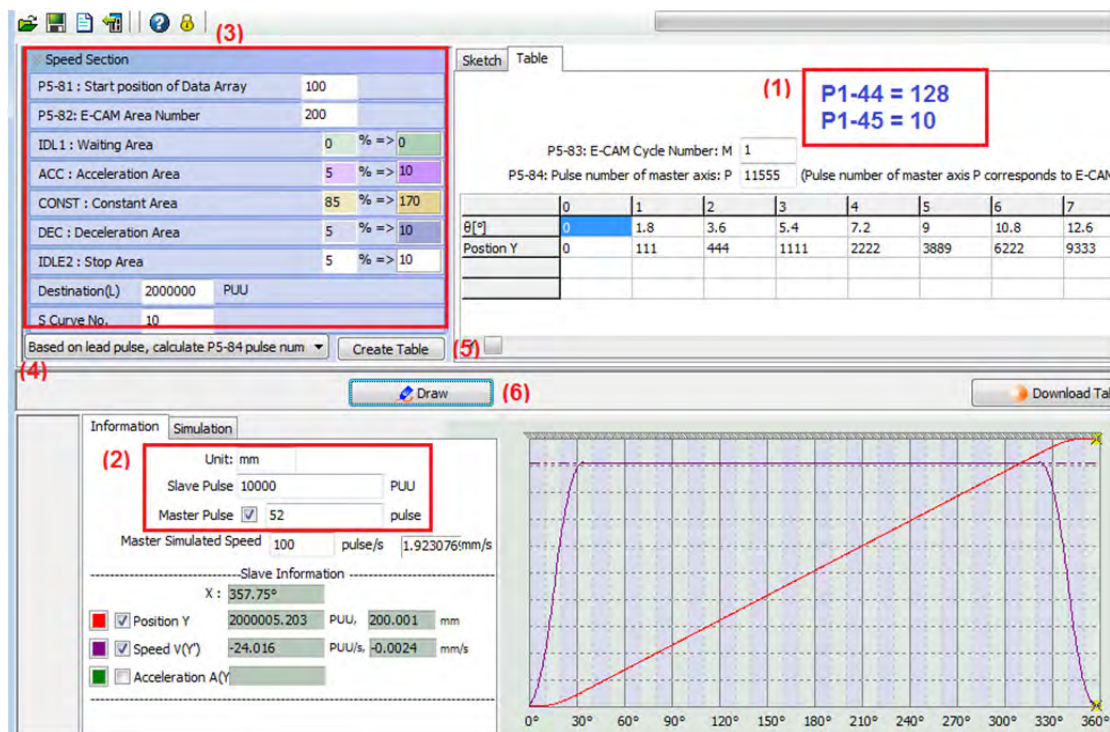
Figure 2.62 Speed Fitting Creation

1. Set up the E-gear ratio: P1-44 = 128 and P1-45 = 10。

2. Specify the required pulse number when both master and slave axis operate every 1 mm. The unit of the master axis is pulse; the unit of slave axis is PUU. From Figure 2.61, we can know that when the master axis operates for 1 mm, the encoder will send 52 pulses; from calculation above, it takes 10000 PUU for the slave axis to operate every 1 mm.

3. *Speed Section*. This section allows users to set the proportion of each area, namely *Waiting area, Acceleration Area, Constant Area, Deceleration Area,* and *Stop Area*). Area proportion will change the speed of the slave axis. The total traveling distance can be known from the calculation above, which is 2000000 PUU. Total points of this E-Cam curve can be set in P5-81; P5-82 allows users to specify the address where this E-Cam

curve is stored in data array. When only one E-Cam curve is stored, changing settings of P5-81 and P5-82 is not required.

4. Select *Based on lead pulse, calculate P5-84 pulse number.* Since the moving distance of the slave axis cannot be changed, which means the traveling distance is fixed, the system will work out the value required by P5-84 based on the lead pulse. When the setting is complete, the constant speed area of the slave axis will be consistent with the master axis.

5. When the above setting is completed, click on *Download Table* and *Burn Table Data* to data array.

2.7.2 Relevant Parameter Settings and Enabling E-Cam Function

When the creation of E-Cam curve is complete, the next step is to enable E-Cam function in order to have the system work. It is easy to use PR to setup relevant parameters to control E-Cam. Figure 2.63 is a reference setting; users may edit it to cater to the application.
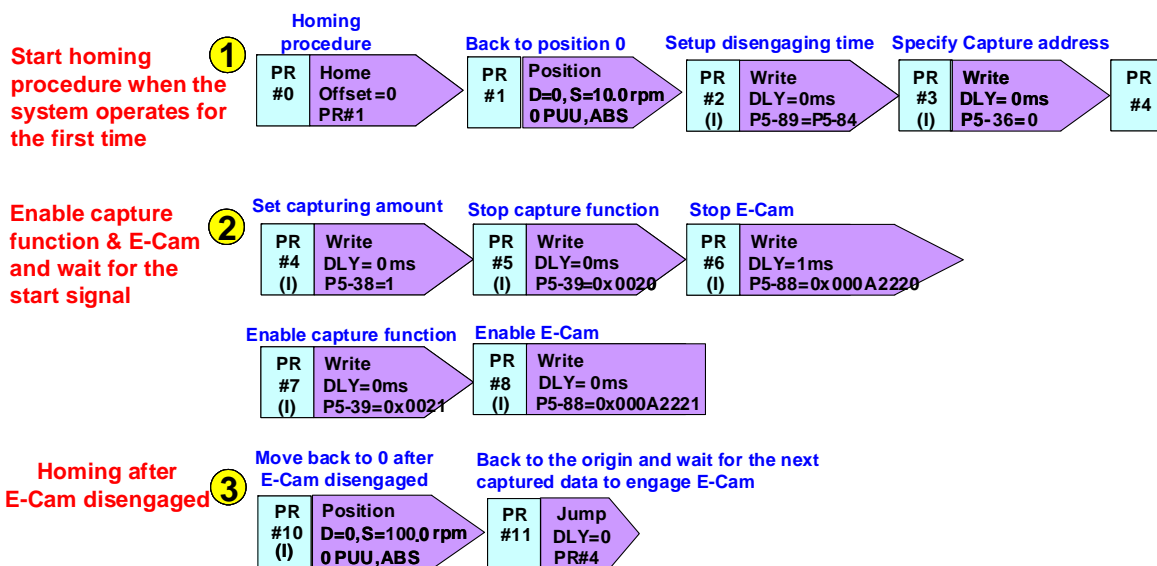
Figure 2.63 Using PR command to control E-Cam

PR#0: Homing procedure. Users can specify the homing method according to the mechanism. Take the mechanism in Figure 2.61 for example. The origin is on the far left. For this type of mechanism, it has to return to the origin first before taking the next step when system is started so as to avoid danger.

PR#1: Make sure the slave axis stops at absolute position 0.

PR#2: Specify the disengaging time. Set P5-89 to the same value of P5-84. Then, the slave axis' operating distance per cycle = the traveling distance per cycle of the E-Cam curve. In this example, P5-84 = 11555, which is figured out based on slave axis' lead pulse number by the ASDA-Soft software tool.

PR#3: Specify the place where the captured data is saved in data array. In this example, the E-Cam's engaging time is controlled by the capture signal. Therefore, parameters relevant to the capture function have to be set. The captured data can be stored anywhere in data array. However, please note that since some data of E-Cam curves have been saved in data array, it is necessary to avoid the area that is in use to ensure no safety issue arises.

PR#4: Specify the amount of the captured data. Only one datum is required. The capture function here is only for making E-Cam engaged. The captured value does not mean anything.

PR#5: Initialize the capture function. Specify CN1 pulse input (P5-39.Y = 2) as the source for the master axis of the capture function.

PR#6: Initialize E-Cam function. Specify CN1 pulse input (P5-88.Y = 2) as the master source; Set the engaging time when capture function is enabled (P5-88.Z = 2); Set the disengaging time when the moving distance has reached the setting value of P5-89 (P5-88.U = 2).When E-Cam disengaged, the system will call PR#10 (P5-88.BA = A) automatically. To ensure PR#5 and PR#6 are carried out, set delay time to 1 ms in this PR.

PR#7: Enable Capture function. Set P5-39.X to 1 in order to enable the capture function.

PR#8: Enable E-Cam function. Set P5-88.X to 1 in order to enable E-Cam function.

PR#10: After E-Cam disengaged, the system will call this PR automatically. This PR is a position command which absolute position is 0. When E-Cam is not controlling the slave axis, this PR will take the mechanism back to the origin.

PR#11: Jump to PR#4, restart the capture function and E-Cam function for the actions of the next cycle.

2.8   Simultaneously Using E-Cam Function and PR command

When servo is working at the command of E-Cam and a PR with incremental position command is triggered at the same time, E-Cam command and PR command will be overlapped. Both commands will change the output of the servo.

See Figure 2.64. When E-Cam is operating, if triggering a PR command of which target speed is higher than E-Cam speed, the motor will overlap the PR command with E-Cam command. For example, a motor operates at 1000 rpm under the control of E-Cam, when a PR which target speed is 2000 rpm is triggered, motor will not stop operating at 3000 rpm until the PR command is completed. Then it will switch back to 1000 rpm which is specified by E-Cam command.
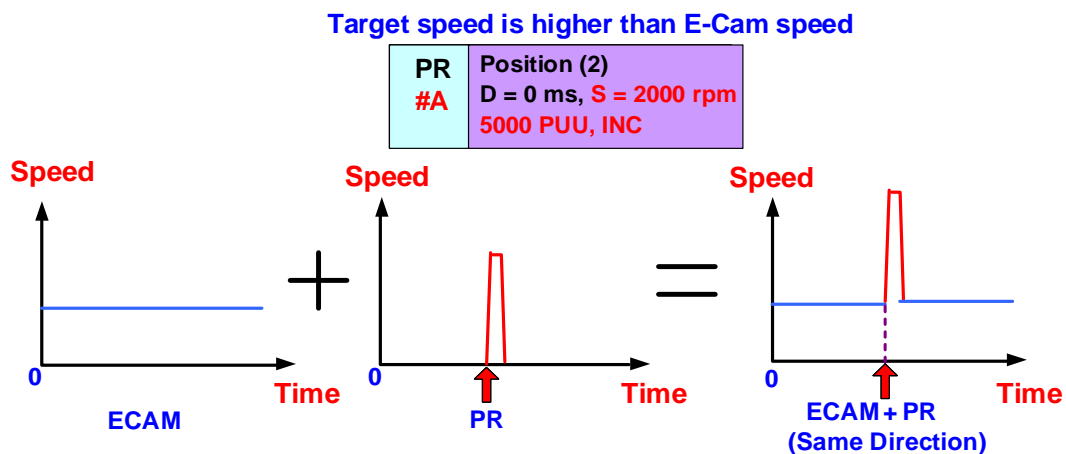
Figure 2.64 E-Cam Command plus PR command

See Figure 2.65. If triggering an incremental PR command which target speed is slower than E-Cam speed and operate in reverse direction when E-Cam is operating, the motor will counterbalance the PR and E-Cam command when PR is operating. For example, if a motor is operating at 1000 rpm under the E-Cam's command, when a PR command which target speed is 200 rpm at reverse direction is triggered, motor will keep operating at 800 rpm until this PR command is completed. Then, it will switch back to 1000 rpm under E-Cam's command.
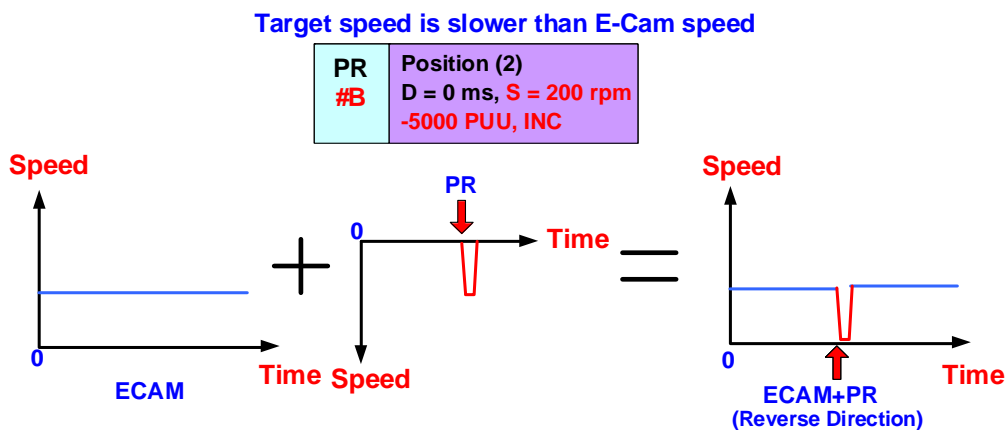
Figure 2.65 E-Cam command Counterbalances the PR Command

The method of overlapping E-Cam command and PR command is very useful. This method can be used when desire to modify the speed or phase when E-Cam is operating. In Figure 2.66,

take a three-synchronous-axis printing machine for example. Pulses from the encoder are sent to the three slave axes as the source signal to make identical curves. Phases of the three slave axes have to be identical. When phases are inconsistent, users can use PR command to overlap E-Cam command so as to have the phase shifted. To have a positive phase shift, a positive incremental position command can be used. Please make sure the speed (in forward direction) is higher than the speed specified by E-Cam command. On the other hand, to have a negative phase shift, please set a PR with negative incremental position command.
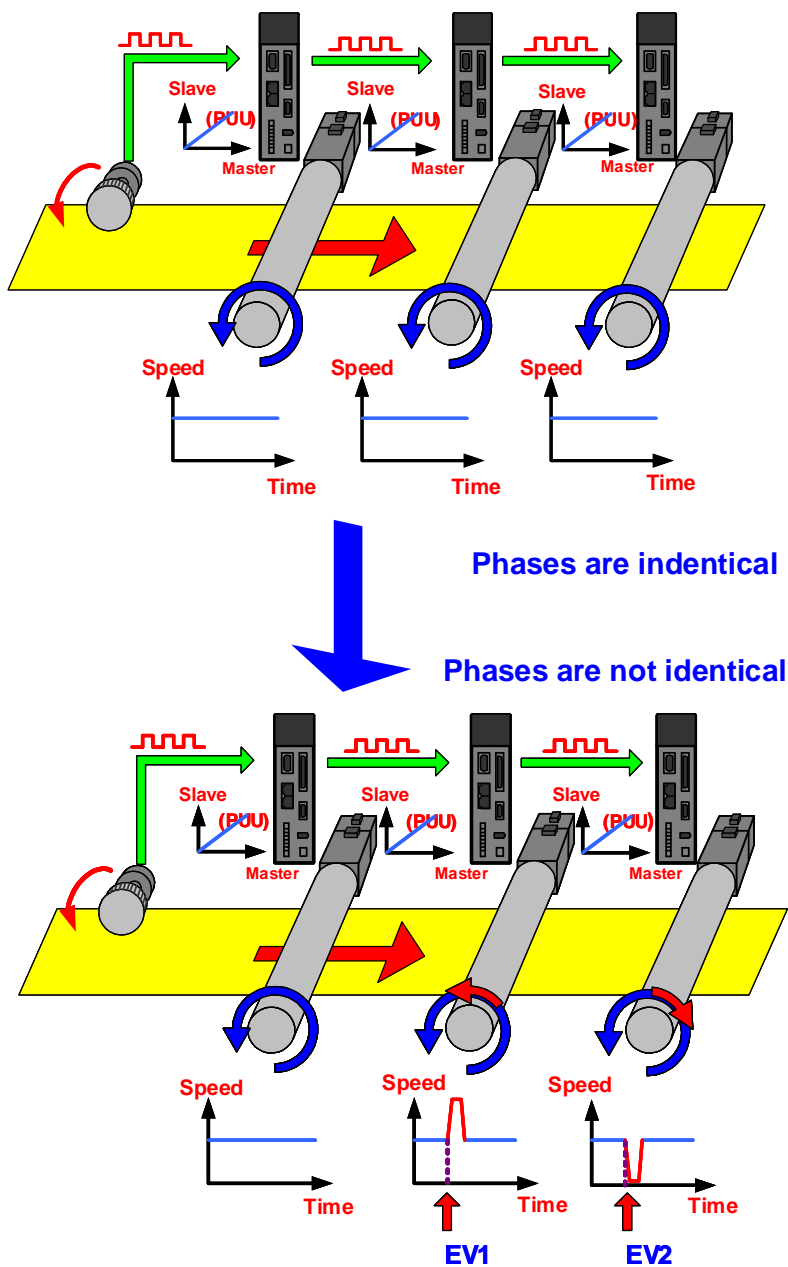
Figure 2.66 An Example of E-Cam Command Overlaps with PR Command

2.9   Troubleshooting when E-Cam is not working properly

If E-Cam is not working properly, the following methods can be used to troubleshoot.

1. Make sure source of the master axis is correct; this can be done by checking the setting of P5-88.Y that specifies the source of the master axis. When input terminal is CN1, make sure value of P5-18 is increasing; when input terminal is CN5, make sure value of P5-17 is increasing. Please note that this method is only applicable to the external input. When applying E-Cam function, it is suggested to use signal input externally as the source of the master axis; virtual signal which generates from the servo drive is for testing purpose only.

2. When E-Cam is enabled (P5-88.X = 1), count of pulse number from the master axis can be accessed by P5-86. Its value must be an increasing value, if not, please reverse the pulse direction (not the motor's operating direction). Value of P5-86 has to be an increasing value; otherwise, E-Cam axis will not be able to operate based on the E-Cam curve.

3. Check the E-Cam curve scaling. Check the setting of P5-19 to see if the scale is appropriate. If the scale is too small, the motor operation will be too subtle to be seen even when E-Cam is working. PC scope can be used to check if the motor is operating subtlety.

4. Check if data of the E-Cam curve is properly stored in data array. *Data Array Editor* can be used to check if the values are stored.

5. Make sure P5-81 specifies a correct start address in data array. If P5-81 is specifying a wrong address, a desirable E-Cam curve cannot be created. Make sure the setting of P5-82 is correct; the total number of points of E-Cam is value of P5-82+1. If incorrect, the system is unable to carry out the setting of every point on E-Cam curve.

6. Access the value of P5-88.S to acquire the clutch status. In Status 1, E-Cam is engaged and slave axis operates according to the pulses received from the master axis. In Status 0 or 2, slave axis is still.

Application Examples

<div style="text-align: right; font-size: 3em;">3</div>

3.1   How to Use Capture Function to Create E-Cam Curves?

3.1.1   Description

This application example will demonstrate how Capture function on ASDA-A2 is used to create an E-Cam curve. This chapter will focus on the procedure of creating an E-Cam curve and explain how the system work and its settings. Before getting started, basic knowledge about PR mode and E-Cam is required. To know more about these topics, please refer to chapter 1 and 2 of this application note.

3.1.2   About the System and System Configuration

This chapter will teach users to create E-Cam curves directly in the system. Capture function enables ASDA-A2 to record the current position of the system. With this feature, an E-Cam curve can be created based on the shape of the object and the required points for the curve can also be recorded.

3.1.2.1   Creating an E-Cam Curve

When creating E-Cam curves, the motions of the master axis and the slave axis have to be decomposed. The motion of master axis is making a circular motion which is 360° per circle. If it is divided into 50 equal parts, whenever the master axis travels one equal part, one point has to be created on the E-Cam curve for the slave axis. In this way, 50 points that corresponds to 50 equal parts on salve axis are recorded and thus making an E-Cam curve.

The example below will illustrate the idea. The cam is divided into 14 equal parts. How the first 5 points are created will be demonstrated with the motion analysis. Figure 3.1.1 shows the motion step by step and Figure 3.1.2 presents the relation between the motion and E-Cam curve.
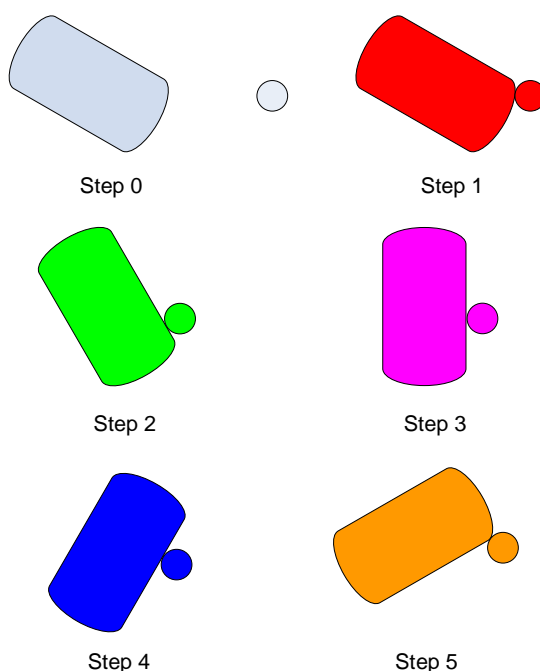

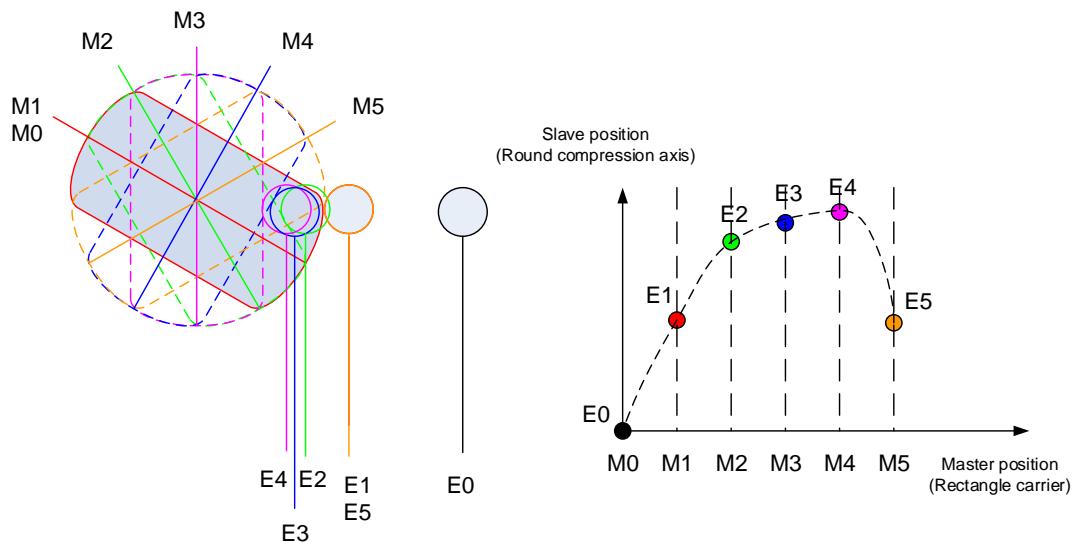Figure 3.1.1 Motion Analysis of Master Axis and Slave Axis

Figure 3.1.2 Creating an E-Cam Curve

3.1.2.2   Settings for the Route of Master Axis (Rectangle Carrier)

When creating the E-Cam curve, the moving distance of the rectangle carrier has to be divided into equal parts. In this example, the servo generates 10000 pulses per circle because E-gear ratio is set to 1 : 1. However, in the real mechanism, the master axis, ASDAS-A series servo motor, will go through a decelerator that reduce the speed to 1/5 of the original. Therefore, the rectangle carrier will make one full circle until the servo motor makes 5 rotations. To create an E-Cam curve with 50 points, the motion of the master axis has to be divided into 50 equal parts. See its calculation below.

The pulse number generated when the rectangle carrier travels one circle:
10000 x 5 = 50000 (pulses)

The required pulse number (distance) of the master axis to travel each point on the E-Cam curve corresponding to the slave axis:
50000 / 50 = 1000 (pulses)

So, the rectangle carrier will send 1000 pulses to the slave axis whenever it travels one point. Then, it has to stop and wait for the slave axis to do sampling.
The more sampling points there are, the more precise E-Cam curve it is. On the other hand, the time it takes will be longer. (ASDA-A2 series servo drive provides E-Cam curves with maximum 720 points.)

3.1.2.3   Settings for the Route of Slave Axis (Round Compression Axis)

See (1) in Figure 3.1.3. It shows the positions of the rectangle carrier and round compression axis after homing. Before creating an E-Cam curve, homing for each axis is required. That is, one point must be regarded as the reference origin for each axis.

See (2) in Figure 3.1.3. After homing, we can move the compression axis to the nearest position of rectangle carrier without obstructing its operating route. (Please be aware of the direction.) The maximum traveling distance has to be taken into consideration when setting distance B. Shorten distance B will shorten the time for creating the E-Cam curve.

When position B in (2) is selected, every time the E-Cam points are captured, the compression axis returns to this position (not the origin) and wait for the next command. In (3), C is the distance that the compression axis needs to travel to reach the rectangle carrier. If traveling distance is set to C and when there is a backlash or tolerance, the round compression axis will not be able to stay close to the carrier tightly (in this moving direction). In this case, this will cause inaccuracy or change the precision level of the curve. In (4), distance D is the proper moving distance for the compression axis. However, the round compression axis will never able to reach this distance, which will be explained later.
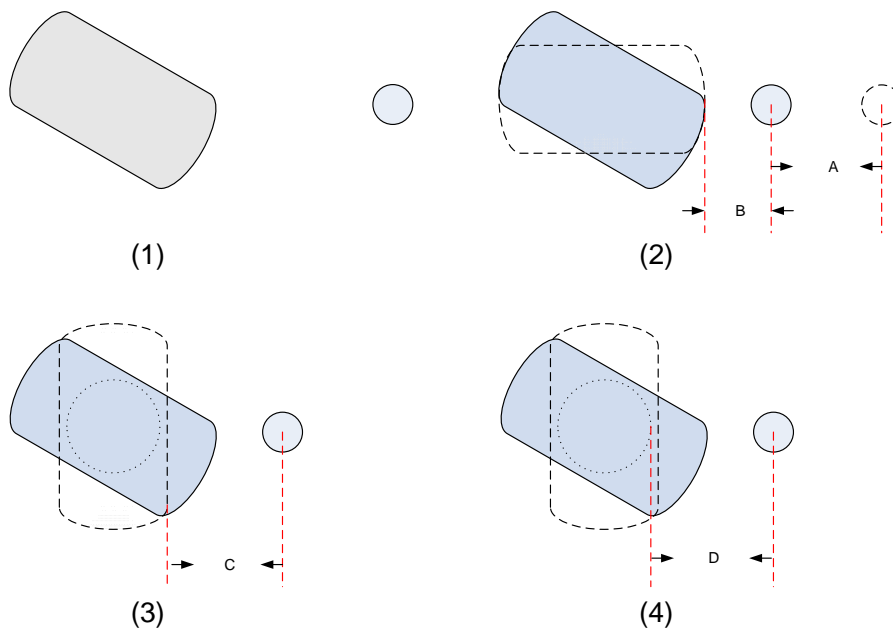

Figure 3.1.3 Motion and Traveling Route of the Slave Axis

3.1.3   Servo System Structure and Configuration

This section will explain how to manually create an E-Cam curve. A host controller can be used to automatically carry out the step and replace the manual steps. And this will be an automatic system for creating E-Cam curves. The following describes how it works.

3.1.3.1 System Structure

The master axis used here is an ASDA-A series servo drive and the slave axis used is an ASDA-A2 series servo drive. There is a decelerator which reduces the speed to 1/5 of the original speed. The slave axis drives the ball screw via the servo motor. See Figure 3.1.4 system structure. On master and slave axis, approximation sensors are equipped with the system as the reference origin for the system.
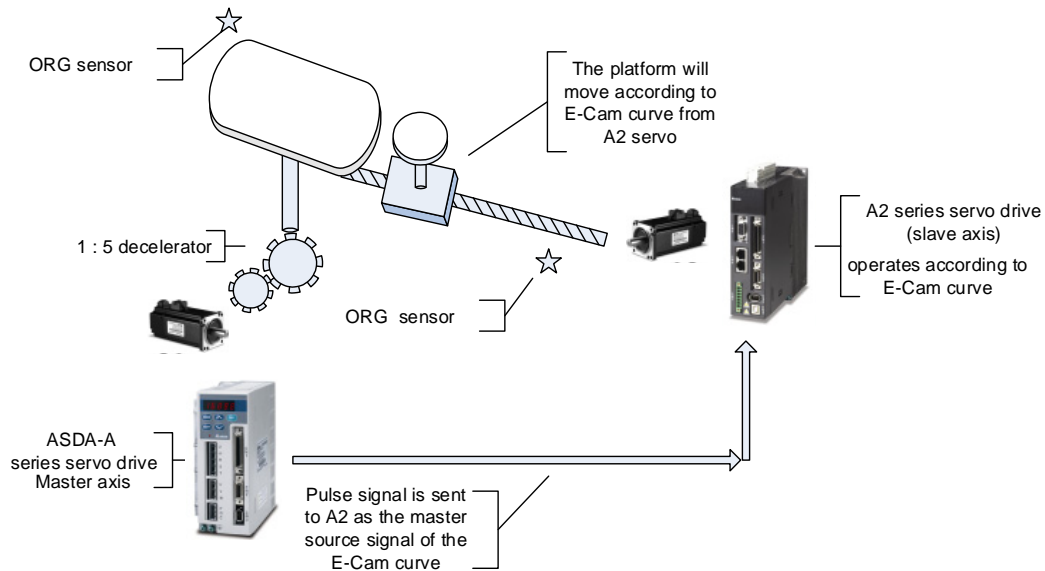

Figure 3.1.4 System Structure

3.1.3.2 Wiring

Regarding the master axis, DI signals that need to connect to the servo drive are DI.SHOM (search for the origin), DI.ORGP (origin sensor), and DI.CTRG (internal trigger). Among these DI signals, the function of DI.CTRG is to control the motion of the master axis, making it stop when it travels one sampling point of the slave axis and allowing the slave axis to complete sampling. Other signals are for internal use. Since controlling of ON/OFF is not required, actual wiring for these will be saved, making the I/O wiring easier.

For the slave axis, DI signals that need to connect to the servo drive are mainly DI.SHOM (search for the origin), DI.ORGP (origin positioning sensor), DI.EV1 (Event 1, for internal trigger), and DI.CAPTURE (DI7, the trigger point set by the system; setting for register is not required. When capture function is enabled, this DI will be enabled automatically.) Other DI signals that do not need to control ON/OFF will be replaced by internal signals without actual wiring.
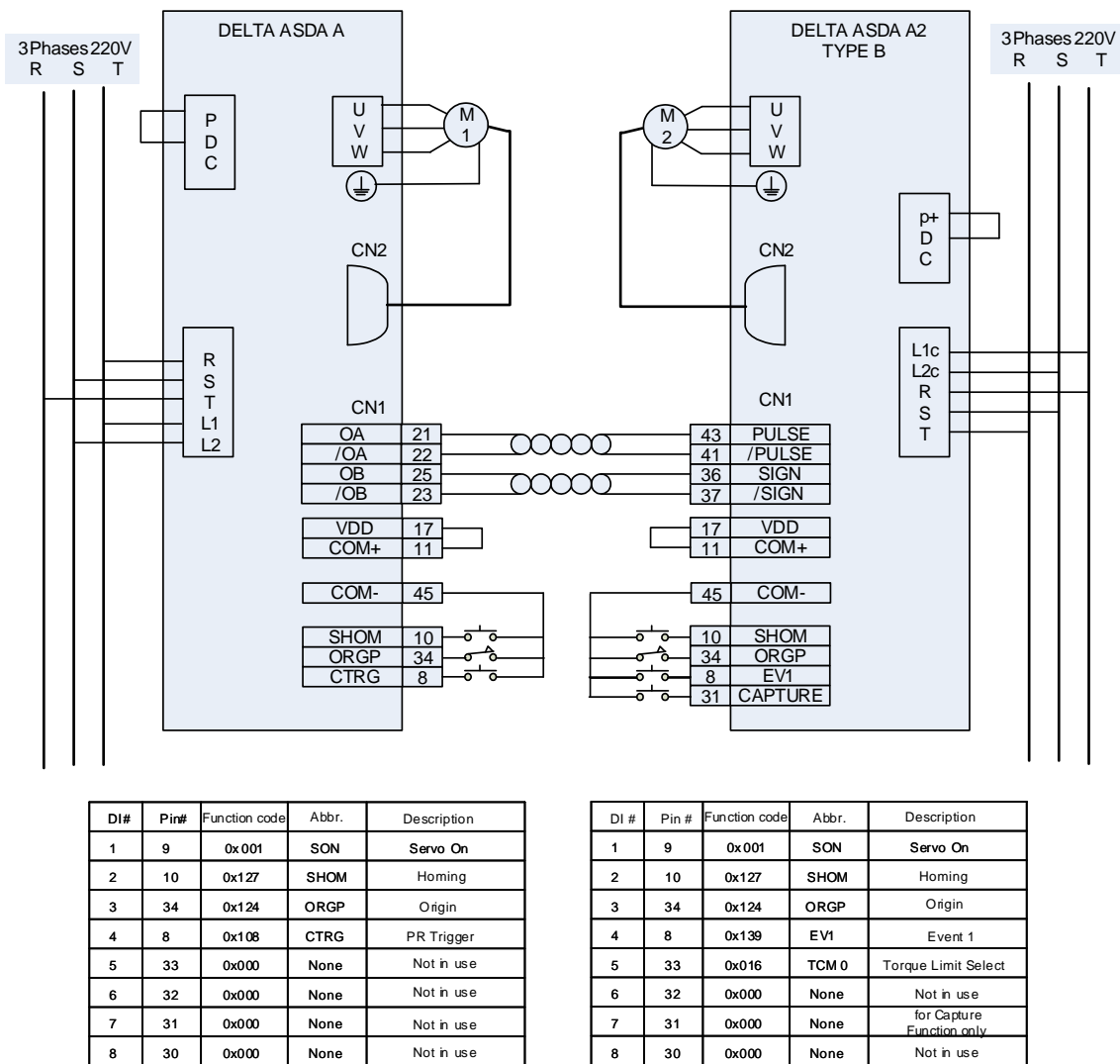
DI#	Pin#	Function code	Abbr.	Description
1	9	0x001	SON	Servo On
2	10	0x127	SHOM	Homing
3	34	0x124	ORGP	Origin
4	8	0x108	CTRG	PR Trigger
5	33	0x000	None	Not in use
6	32	0x000	None	Not in use
7	31	0x000	None	Not in use
8	30	0x000	None	Not in use

DI#	Pin#	Function code	Abbr.	Description
1	9	0x001	SON	Servo On
2	10	0x127	SHOM	Homing
3	34	0x124	ORGP	Origin
4	8	0x139	EV1	Event 1
5	33	0x016	TCM 0	Torque Limit Select
6	32	0x000	None	Not in use
7	31	0x000	None	for Capture Function only
8	30	0x000	None	Not in use

Figure 3.1.5 Wiring and I/O Configuration

3.1.3.3 Parameter Settings for Master Axis (Rectangle Carrier)

In this example, ASDA-A series servo drive is selected as the master axis. This section will mainly elaborate setting of function parameters. Settings related to performance have to be adjusted according to the mechanism on-site. When use, please adjust the gain as high as possible because the compression axis will knock against the rectangle carrier when capturing data for the E-Cam curve. If the rigidity of the carrier is not strong enough, its position will be changed (or slipped) because of the impact (or compression) and cause the inaccuracy of the curve. Please take special attention to this issue. See Figure 3.1.6.
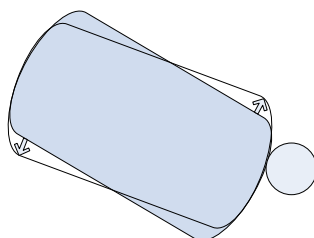

Figure 3.1.6 Change of Position of the Rectangle Carrier

Function Parameter Settings for Master Axis (Rectangle Carrier)

Please see Figure 3.1.5 the wiring diagram for I/O settings.

P1-01 Control mode: set to 0x01 in PR Mode.

P1-47 Homing mode: Set to 0x202.

> 2: Homing in forward direction; DI.ORGP is regarded as the homing origin.
>
> 0: Operate in the opposite direction to look for Z pulse of the encoder when homing.
>
> 2: Enable homing function via DI.SHOM.

This setting is for the accuracy purpose. (When the ORGP is encountered by the origin, the motor will return to look for Z pulse.) It is because the positioning precision level of external ORGP (such as limit switch and approximate sensor) is lower than the internal Z pulse. That is why Z pulse is regarded as the origin. And this might be the best choice for this type of control.

P1-44 (E-Gear Ratio (Numerator)): Set to 1.
P1-45 (E-Gear Ratio (Denominator)): Set to 1.
To have better resolution, the E-gear ratio doesn't have to be changed because of the system decelerator.
P1-16 (1st Position Command for Pulse): Set to 1000.
Please refer to section 3.1.2.2 Settings for the route of Master Axis (Rectangle Carrier) of this application note. As DI.POS0, DI.POS1, and DI.POS2 are set to 0, when DI.CTRG is triggered, the position command is set by P1-16.

P2-36 Moving Speed Setting of 1st Position: Set to 150 rpm, let the motor operate with slower speed.

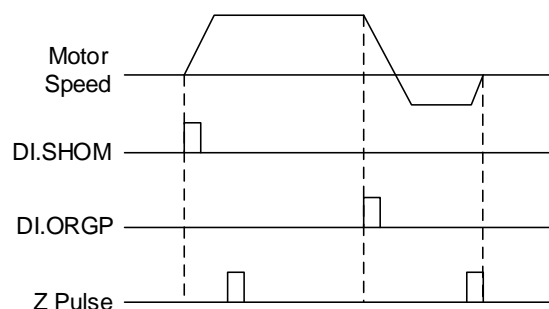### Sequence Diagram—Homing of the Master Axis

Figure 3.1.7 Homing of the Master Axis

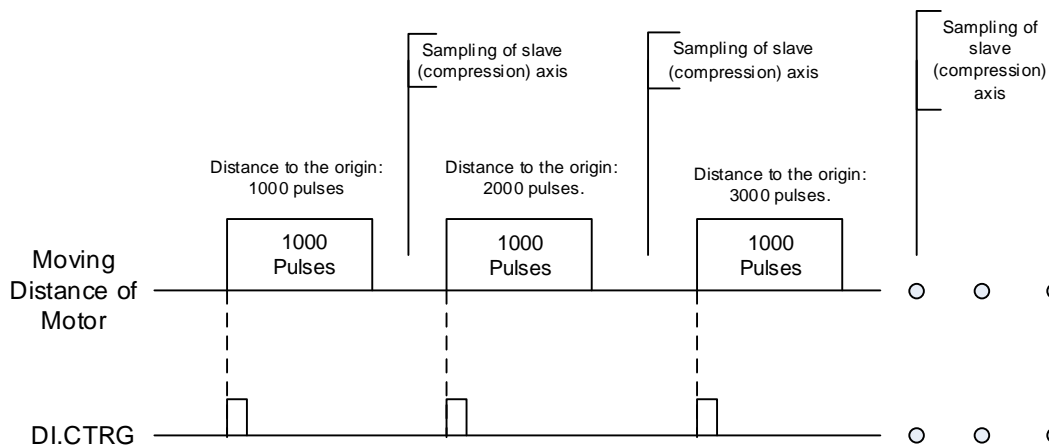**Sequence Diagram—Traveling of the Master Axis and Sampling of the Round Compression Axis**

Figure 3.1.8 Traveling of the Master Axis and Sampling of the Round Compression Axis

3.1.3.4   Parameter Settings for Slave Axis (Round Compression Axis)

An ASDA-A2 series servo drive is selected as the slave axis in this example. The following explains function of parameter settings.

For DI/O settings please refer to Figure 3.1.5 Wiring Diagram.

P1-01 (Input setting of Control mode and Control Command): Set to 0x01 in PR mode.

P1-44 (Gear Ratio (Numerator)): Default 128.

P1-45 (Gear Ratio (Denominator)): Default 10.

From this setting, we can know that 100000 PUU will be generated when this axis travels one circle.

P1-02 (Speed and Torque Limit Setting): Set to 0x10.

Function to set torque limit will be used to avoid great impact from the compression axis. Range limit will be set by P1-12 (DI setting: TCM0 = 1, TCM1 = 0)

P2-35 (Condition of Excessive Position Control Deviation Warning): The setting value here must be high enough so as to avoid excessive deviation. More details will be explained later.

P5-98 (PR# Triggered by Event Rising-Edge): Set to 0x01.

P5-99 (PR# Triggered by Event Falling-Edge): Set to 0x02.

Setting for EV1 (Event 1): when EV1 is triggered by rising edge and falling edge, PR#51 and PR#52 will be carried out respectively.

Settings and configuration for PR will be demonstrated with ASDA-Soft software screenshots in the following paragraph.

Setting Screen for PR#0— Homing

Figure 3.1.9 Setting of PR#0 for the Slave Axis

Set Homing Method to X : 2 : Homing in forward direction: ORGP : OFF-> ON, as homing origin. Then, Set Single Setting to Y : 0 : Return to Z pulse. When homing is completed, PR stops and set P6-01 which specifies the origin to 0. These settings have to be changed based on different applications.

PR#1 Setting Screen

Figure 3.1.10 Setting Screen of PR#1 for the Slave Axis

In this path, the written target is set to P1-12 and its torque setting is 50%, which can be adjusted depending on circumstances. This PR has set an interrupt command.
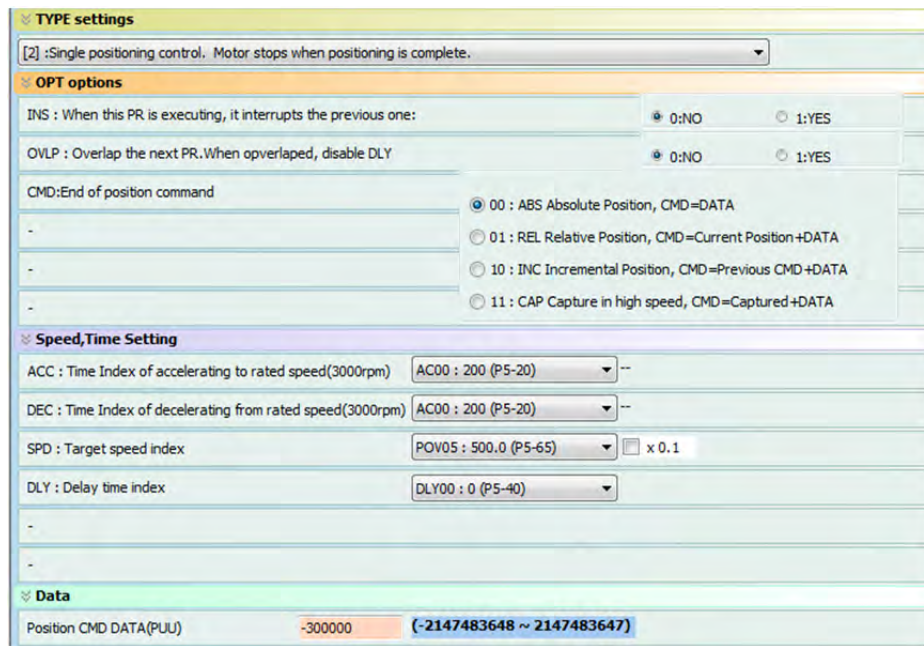
PR#2 Setting Screen

Figure 3.1.11 Setting Screen of PR#2 for the Slave Axis

PR#2 is set to control the position, which command is absolute type. See Figure 3.1.11.

PR#5 Setting Screen
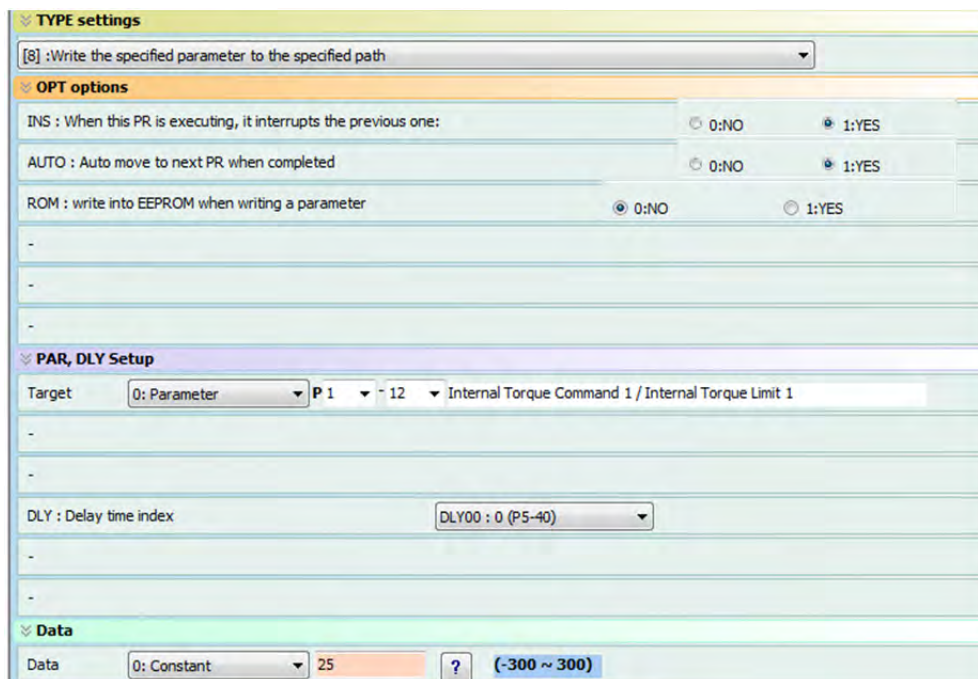

Figure 3.1.12 PR#5 Setting Screen for the Slave Axis

The program system writes value to P1-12. The toque force is set to 25%, which can be adjusted according to the situation. This PR has set an interrupt command.

PR#6 Setting Screen

Figure 3.1.13 Setting Screen of PR#6 for the Slave Axis

This PR path is set to a position command which is absolute type. See Figure 3.1.13.

PR#7 Setting Screen

Figure 3.1.14 Setting Screen of PR#7 for the Slave Axis

This path setting is for torque limit.

PR#51 Setting Screen

Figure 3.1.15 Setting Screen of PR #51 for Slave Axis

This is a jump path, which will be carried out when EV1 (Event 1) is triggered by rising-edge.

PR#52 Setting Screen

Figure 3.1.16 Setting Screen of PR#52 for Slave Axis

This is a jump path, which will be carried out when EV1 (Event 1) is triggered by falling-edge.
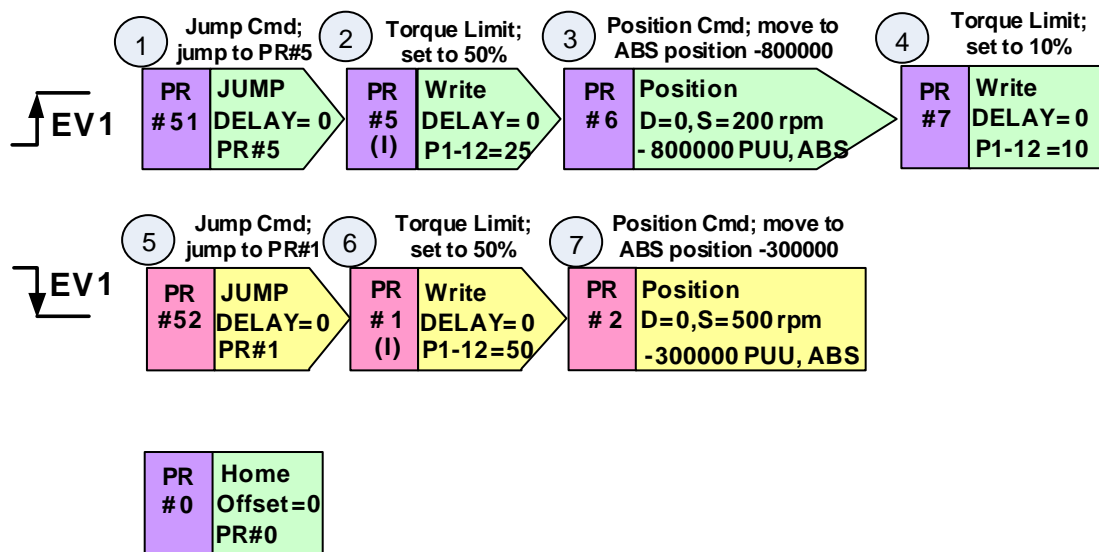
PR Program

Figure 3.1.17 PR Program of the Slave Axis

This is how ASDA-A2 deals with commands: when one command is sent, the next PR command will then be sent. It does not wait for the command to be completed and then set the next one. Below is how the mechanism works according to the PR paths above.
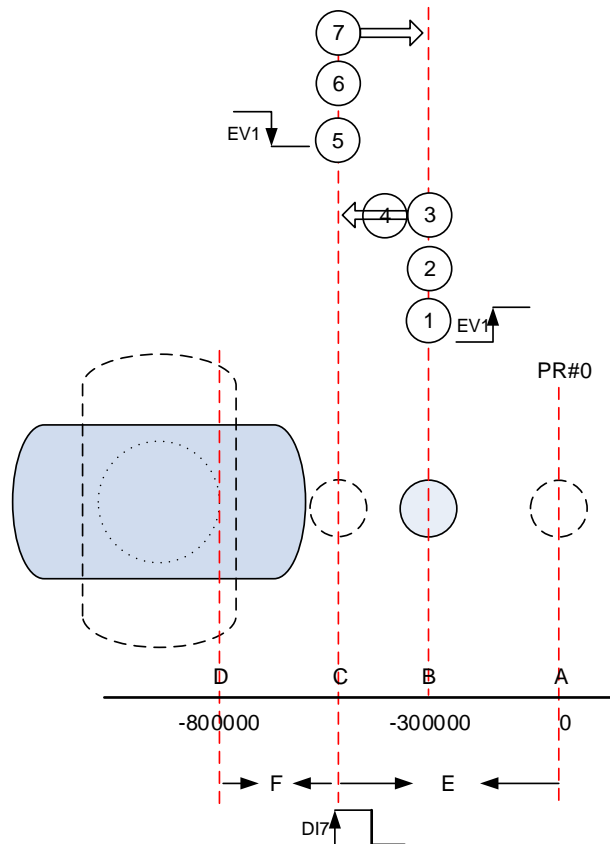

Figure 3.1.18 Slave axis works according to the PR program

Rising-edge Trigger EV1

When the system returns to the origin and after the first time EV1 is triggered by rising-edge, the starting point is A instead of B. From the second time, it will start from point B because it is set to absolute position in the PR path. First of all, set the torque force to 25% before issuing the position command. This is because there will be a bigger striction when motor is started; if torque force is set too small, the motor will not move or move only for a short while and then stop. Once the motor is started successfully, kinetic friction will be rather smaller. Then, use step 4 (PR#7) to decrease the torque force to 10%. This step is for avoiding the round compression axis knocking the rectangle carrier too hard. Then, the compression axis moves to point C but it is never able to reach the target distance D (-800000) due to the obstruction of the rectangle carrier. In this case, the setting value of P2-35 (Condition of Excessive Position Control Deviation Warning) must be bigger than distance F; Otherwise, AL009 (Excessive Deviation of Position Command) might occur. Based on the possible position of the rectangle carrier, distance F in Figure 3.1.18 is the most possible maximum distance that the compression axis can travel. When compression axis reaches position C and stops, this will be the timing for sampling. DI7 has to be switched ON to enable the Capture function and record the position. Capture function will be explained later in section 3.1.3.5.

Falling-edge Trigger EV1

After DI7 is On and sampling is complete, falling-edge trigger EV1 and raise the torque level. Let the compression axis move back to position B. Then, wait for the rectangle carrier to move to the next sampling position. Allow the system repeat the steps from 1 to 7.

3.1.3.5   Settings for Capture Function

The main purpose of using Capture function is to record the position of the round compression axis. With this function, this value can be easily written to data array on ASDA-A2. Capture function settings can be done either by directly setting parameter value or ASDA-Soft, which is rather easier.

Using Capture Function by Directly Setting Parameter Value

P5-36 (CAPTURE-Start Address of Data Array): Set to 0.

P5-38 (CAPTURE-The Number of Capturing Times): Set to 50; 50 points on E-Cam curve have
                                                                                            to be captured.

P5-39 (CAPTUR-Activate CAP Control): Set to 0xF030 (0xUZYX).

X: 0 means Capture function is not enabled.

Y: 3 means Main ECN (main encoder); Position of the compression axis is based on the main encoder.

Z: 0 stands for No. When DI7 is triggered, the system starts to sample on the rising-edge.

U: F stands for the shortest time interval. This is for preventing errors (For example, inputting multiple values into the servo drive when pressing some buttons once.

When starting Capture function, the X of P5-39 has to be written to 1.

Using Capture Function with ASDA-Soft

When using software to set the above parameters, select **Parameter Function** on the function bar and enable **Capture/Compare** function.
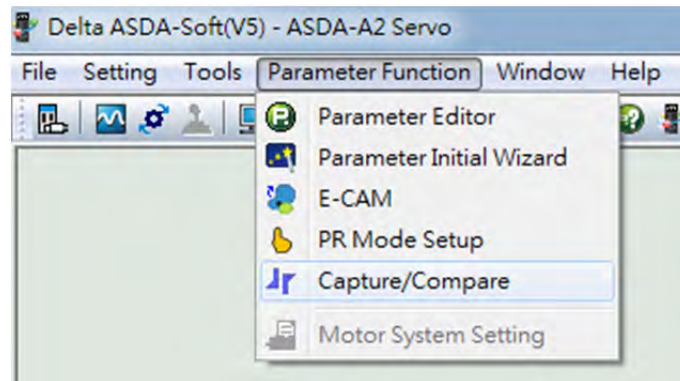
Figure 3.1.19 Using Capture Function

Figure 3.1.20 shows the screen after enabling Capture/Compare function:
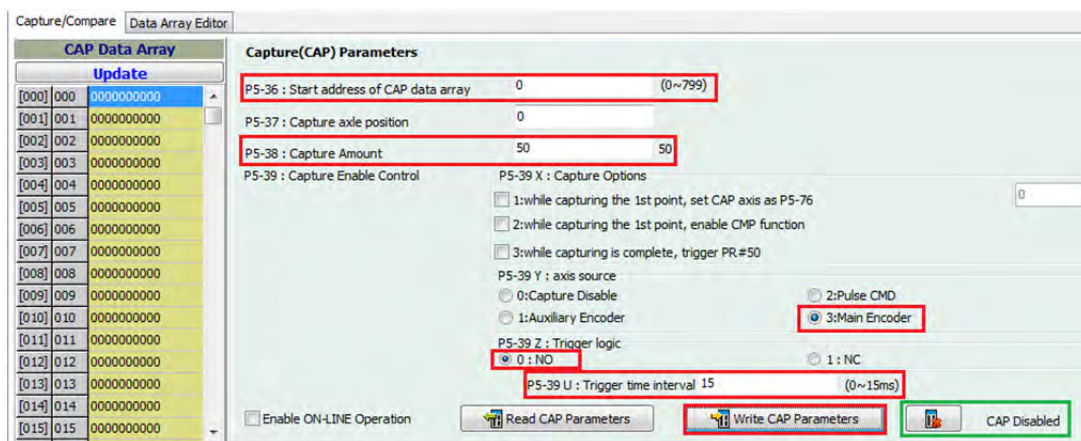
Figure 3.1.20 Capture Function Setting

First of all, write 0 to P5-36 and write 50 to P5-38. Select 3: Main Encoder for P5-39 Y. Select 0: ON for P5-39 Z. Fill in 15 for P5-39 U. Then click on Write CAP Parameters. The setting value will be the same as that in the previous method (direct setting parameter value). To start the Capture function, please click on the icon of **CAP Disabled**. When finishing capturing 50 data, the function will be disabled automatically.

3.1.3.6 E-Cam Parameter Settings

After 50 data are captured, E-Cam parameters can be set for verification. Firstly, please open E-CAM editor to set parameters.

Settings for E-Cam Table

Figure 3.1.21 Start Screen of E-Cam Editor

Open E-Cam Editor in ASDA-Soft. Select **Manually Create a Table** and then click **Next**.
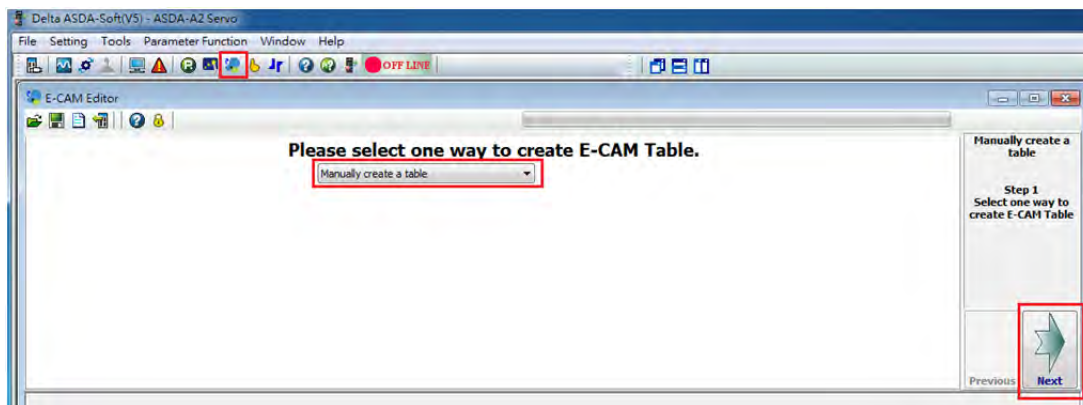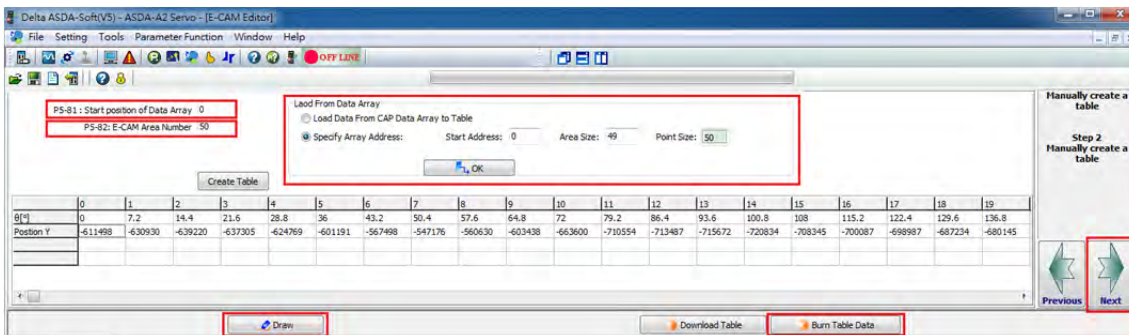

Figure 3.1.22 E-Cam Table

In the window, parameters shown below have to be set.

P5-81 (Start Address of Data Array): Set to 0. The start address of data array is 0; all captured data is stored from this address.

P5-82 (Area Number N): Set to 50; store 50 captured data.

Next, let the system read the captured value that stored in data array for the E-Cam curve. Select Specify Array Address. Then, set Start Address to 0 and Area Size to 49 because only 50 captured data can be stored. Further, Click on OK, the value in data array will be read by the PC. If clicking on Draw, the E-Cam curve will be shown (see Figure 3.1.23). If the E-Cam curve is correct, please click on Burn Table Data to write the data into the servo drive. Please note that this action can only be done when Servo Off. Otherwise, the table data will disappear when power-off. Then, click **Next** to set pulse resolution of the master axis.
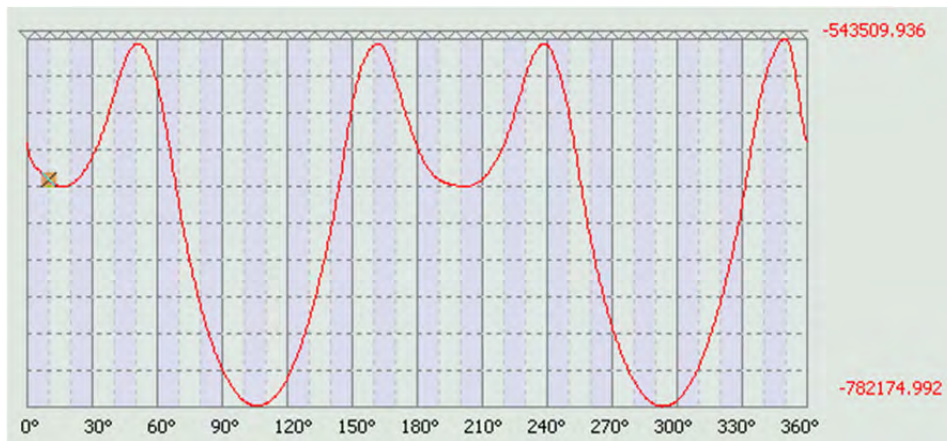
Figure 3.1.23 E-Cam Curve
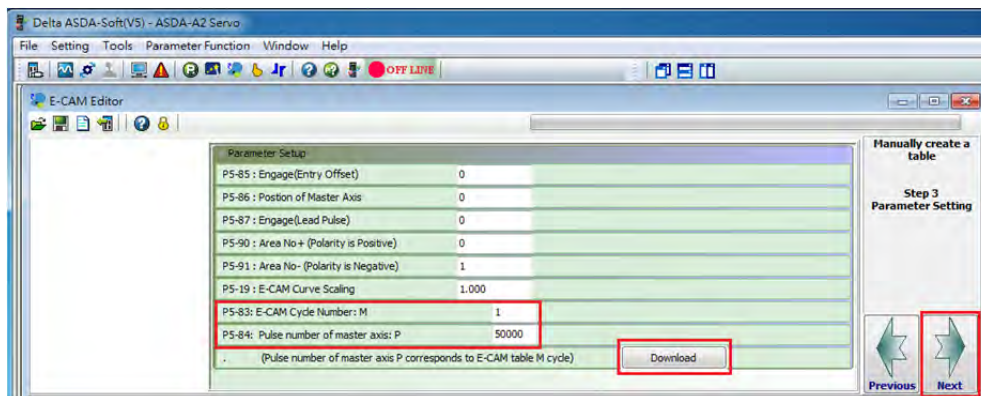
Figure 4 Setting Pulse Resolution of Master Axis

P5-83 (E-Cam Cycle Number: M): Set to 1. This value is subject to change based on the required motion.

P5-84 (Pulse number of master axis): P: Set to 50000. The master axis (rectangle carrier) sends 50000 pulses whenever it makes one rotation. This E-Cam curve will be carried out once within 50000 pulses.

When setting completed, click on **Download** to download the setting values to the servo drive. Then, click **Next**.

Parameter Settings for Slave Axis
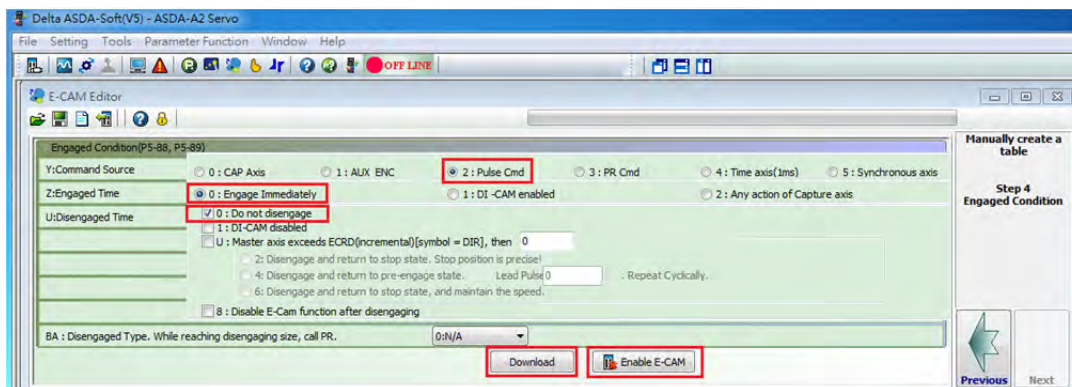
Figure 3.1.25 E-Cam Parameter Settings

Now, parameter settings for the slave axis have to be completed.

As the command source of the round compression axis is sent via Pulse, /Pulse, Sing, and /Sign, Y: Command Source has to be set to 2.Pulse Cmd. Z: Engaged time is set to 0: Engage Immediately.

As this is only for testing purpose, after the round compression axis completes homing, this setting allows E-Cam engages immediately. Set U: Disengaged Time to 0: Do not disengage. When setting is complete, click on Download. And button Enable E-Cam is used when starting testing the E-Cam curve.

3.1.3.7   Test the System

After completing the settings above, parameter values can be adjusted and enable the whole system works properly.

Adjusting the Master Axis

Regarding the master axis, parameter values listed below have to be edited so as to examine whether the E-Cam curve is suitable for the application requirements.

P1-15 (1st Position Command for Rotation): Set to 25. Let E-Cam curve conduct trial run for 5 times. As the master axis will decelerate to 1/5 of the original speed and E-gear ratio is   1 : 1, 25/5 = 5. In this setting, the rectangle carrier will make 5 circles and the E-Cam curve will also operate for 5 times.

P1-16 (1st Position Command for Pulse)：Set to 0.

P2-36 (Moving Speed Setting of 1st Position): The value can be increased according to the circumstances.

Adjusting the Slave Axis

P2-14 (DI5 Functional Planning): Set to 0x116 to cancel the torque limit.

As this is the first time testing the E-Cam curve, adjusting the position of slave axis is required to avoid system damage. Please make sure the E-Cam curve is correct. Setting for adjusting the slave axis is shown below.
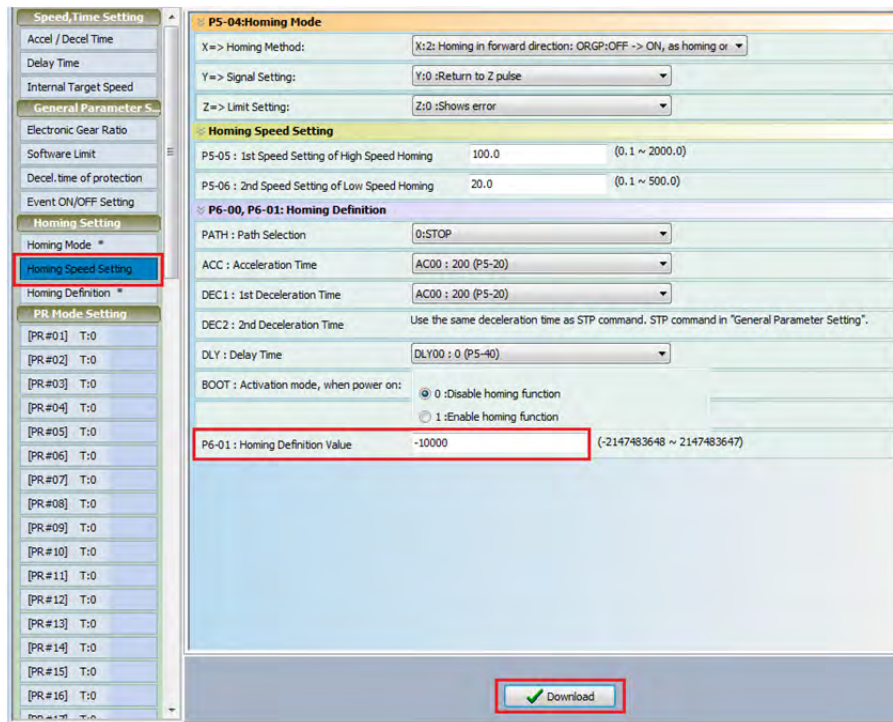
Figure 3.1.26 PR#0 Parameter Setting

In PR#0, set P6-01: Homing Definition Value to -10000. This setting will make the origin right-shifted. In this case, the compression axis will not touch the rectangle carrier. Users may check whether the system is working correctly by observing its motion. If correct, set this value to 0 (default value).
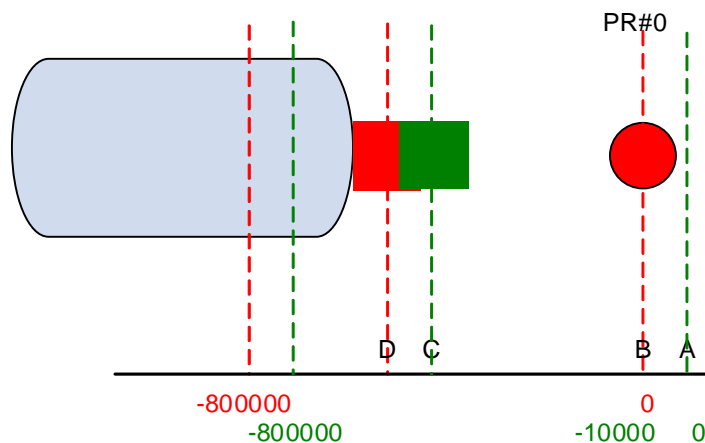
Figure 3.1.27 Shifting of the Coordinate System

The red one is the original coordinate system; the green one stands for the new coordinate system after shifting. No matter it is new or the original one, PR#0 will stop at position B after homing. The part changed is the defined coordinate value. Therefore, in the new coordinate system, round compression axis will not be in contact with the rectangle carrier. It only moves along the green outline of the carrier. See Figure 3.1.28.
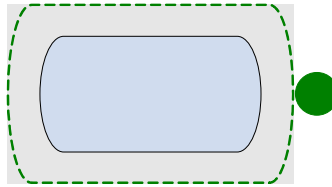
Figure 3.1.28 Traveling Route of the Compression Axis (Slave Axis)

Steps to Test the System

1. Allow the rectangle carrier (Master axis) return to the origin (DI.SHOM).

2. Allow the round compression axis (Slave axis) return to the origin (DI.SHOM).

3. Enable E-Cam. This can be done by setting P5-88 or directly click on Enable E-CAM of ASDA-Soft.
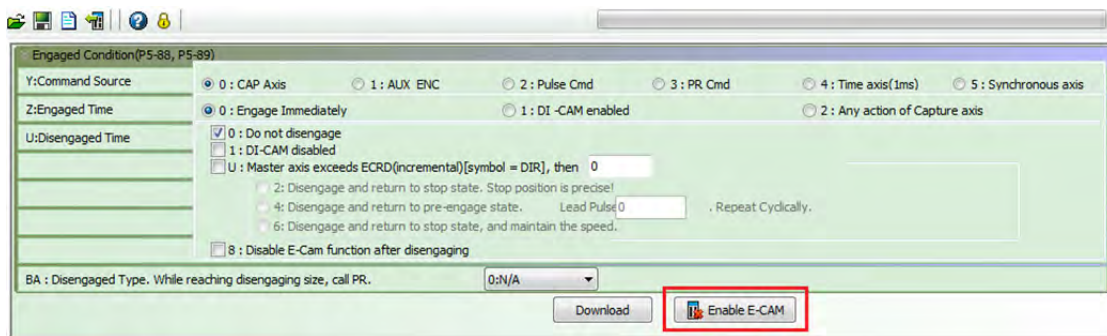
Figure 3.1.29 Enabling E-Cam

4‧ Trigger DI.CTRG signal of the master axis (rectangle carrier).

3.2   Application to Winding Machine

3.2.1   Description

This chapter aims at the application of ASDA-A2 on wrapping machine. The configuration function of tape can be done by electronic cam of ASDA-A2. The main parameters such as the width of tape, the interval of tape and the length of bobbin can be modified easily. The detailed description will be elaborated in later parts of this chapter.

3.2.2   System Theorem and Scheme

Bobbin is the master axis. When it rolls, it sends out the pulse to command the slave axis simultaneously. The slave axis operates by its internal E-cam curve and the master axis to finish the wrapping on bobbin.   ASDA-A2 servo drive is mainly in charge of the configuration of tape.
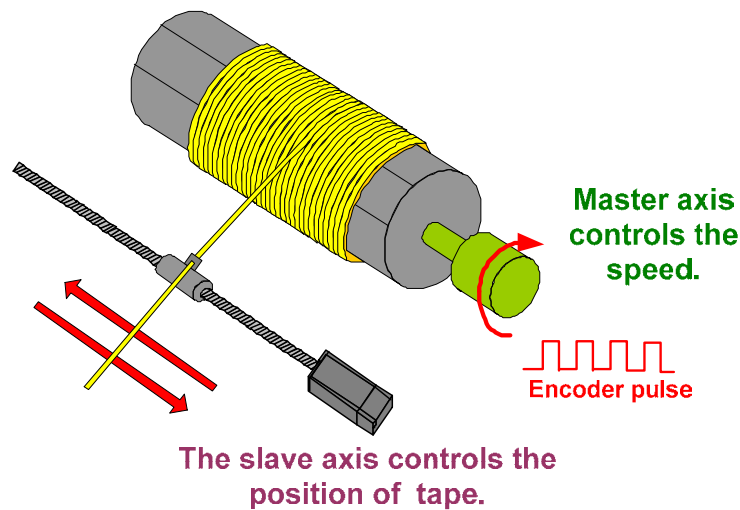
Figure 3.2.1   Wrapping machine system

3.2.2.1   Master Axis

In master axis, when using different length of bobbin, adjusting the parameters of the slave axis can complete the setting. When the master axis rolls, it sends out the pulse to command the slave axis.
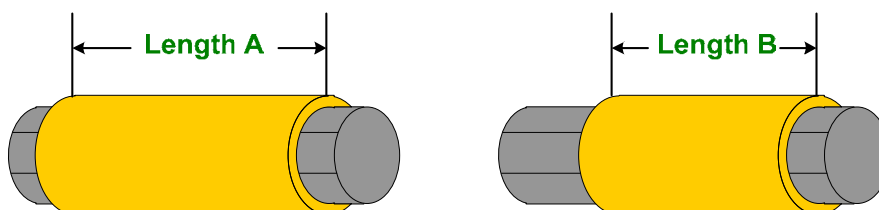
Figure 3.2.2   Different length of bobbin

3.2.2.2 Camshaft

This axis places the tape according to the pulse of master axis. The interval and width of the tape can be adjusted through the proper setting.
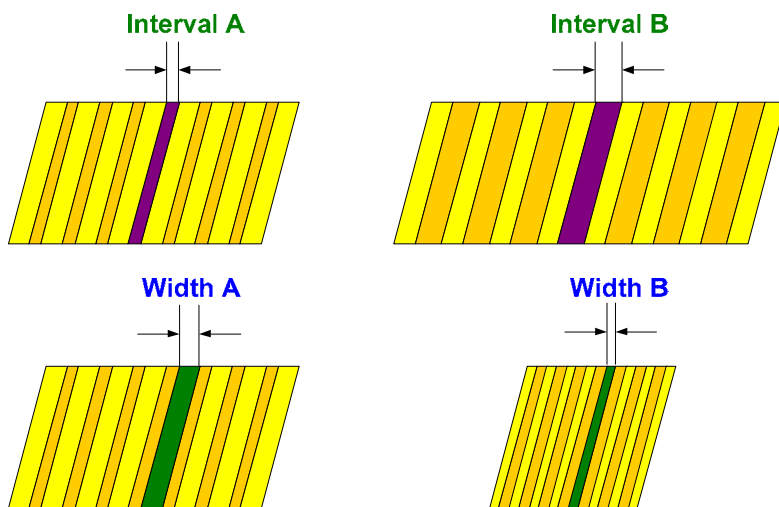
Figure 3.2.3   Different interval and different width

3.2.3 Servo System Setting

3.2.3.1. The Design of Tape

The start position of cam

There is a hole in the middle of bobbin. The tape can be directly inserted and attached on the bobbin. The advantage to start wrapping from the middle point is that the tape will not loose easily.
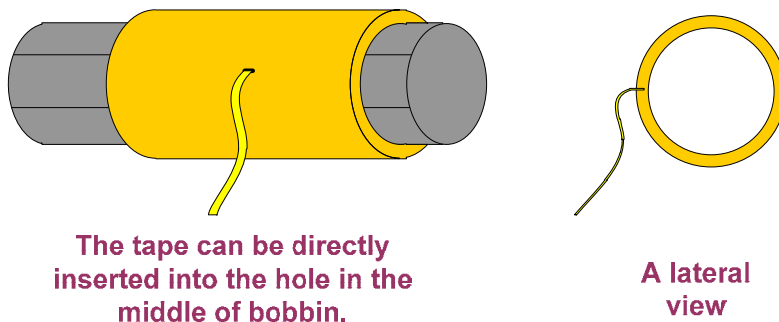
Figure 3.2.4   The start position of tape

The wrapping method of tape

The tape starts from the middle point of bobbin, goes to the end first and then goes back over and over again to complete the wrapping on the bobbin. When the tape is at the two ends, leave a specific length is a must. This is for consolidate and tighten the two sides. The following is the Figure of wrapping.
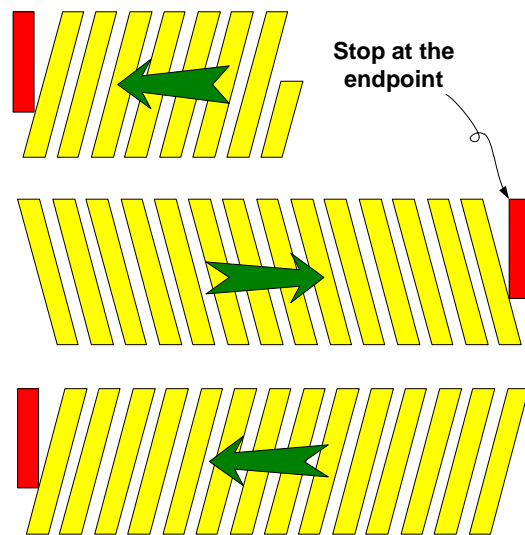
Figure 3.2.5   Configuration of tape

The purpose of stopping at the endpoint

Logically, it divides the bobbin into equal parts as the length the tape stops at the endpoint. It is for staggering the returning positions of tape, so that the tape will not overlap on bobbin and cause the bulge. Furthermore, stop at the two endpoints for a while can strengthen the two sides. Figure 3.2.6 is the example that divides the broadside into 8 equal parts. Users can plan the best equal parts by different application.
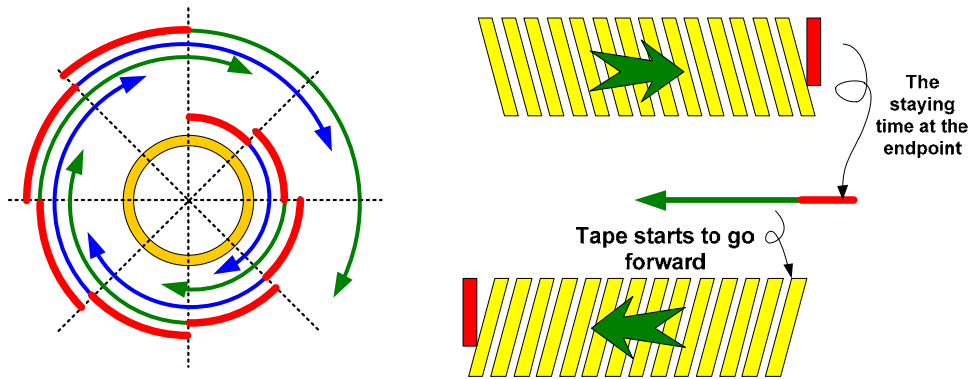
Figure 3.2.6   Stop at the endpoint

If the two endpoints are not configured properly or controls the acceleration / deceleration at the near-endpoint, it would cause the overlap and bulge at the two sides, see Figure 3.2.7 on the left. The right one is the correct example.
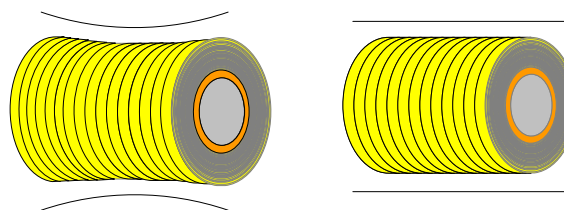
Figure 3.2.7   Incorrect and correct wrapping

3.2.3.2   The Meaning of E-cam Curve

The transverse axis of E-cam curve is the pulse number which sent out by master axis. The vertical axis is the moving distance of ball screw, which is the wrapping length on bobbin. The tape shall be placed in orderly arrangement on bobbin.
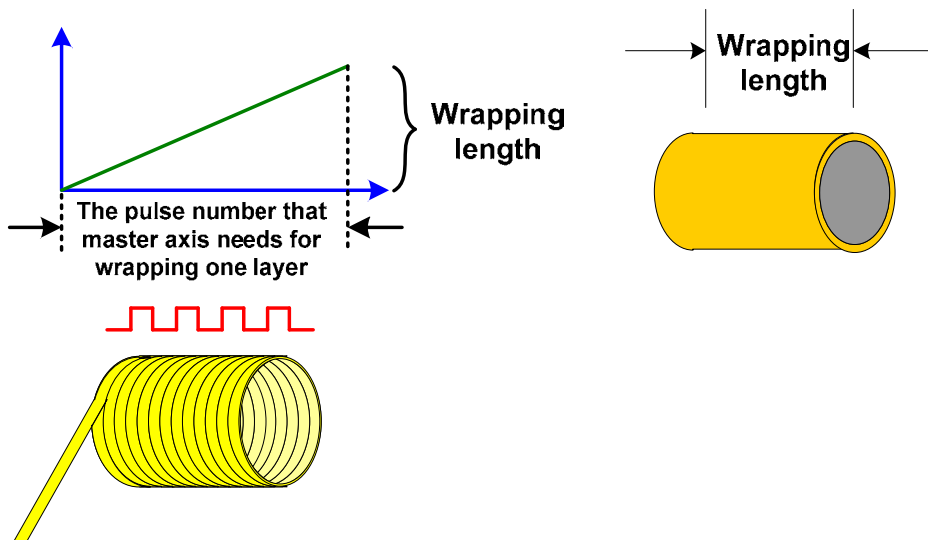
Figure 3.2.8   The meaning of E-cam curve

Use multiple E-cam curves

In this application, the system applies multiple groups of E-cam curve. The tape starts from the middle of bobbin, when it reaches the endpoint, it stops at the preserved length (The setting of preserved length is not included in E-cam curve. It is completed by lead pulse). Then, execute another curve of opposite direction to return to another endpoint. Execute the command repeatedly until it reached the setting value. The configuration of curve and motion is shown as Figure 3.2.9 and the time sequence of motion is shown as Figure 3.2.10.
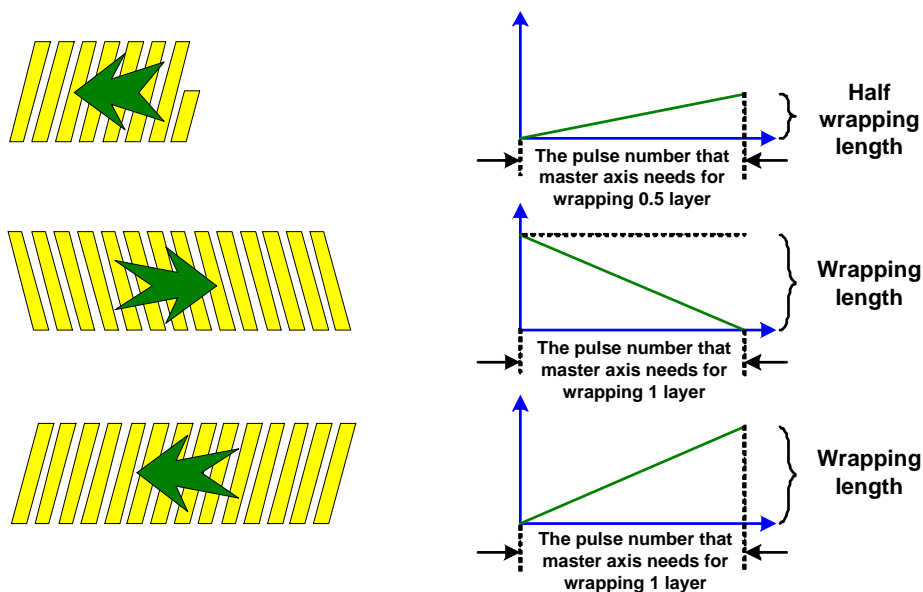
Figure 3.2.9   Multiple groups of E-cam curve
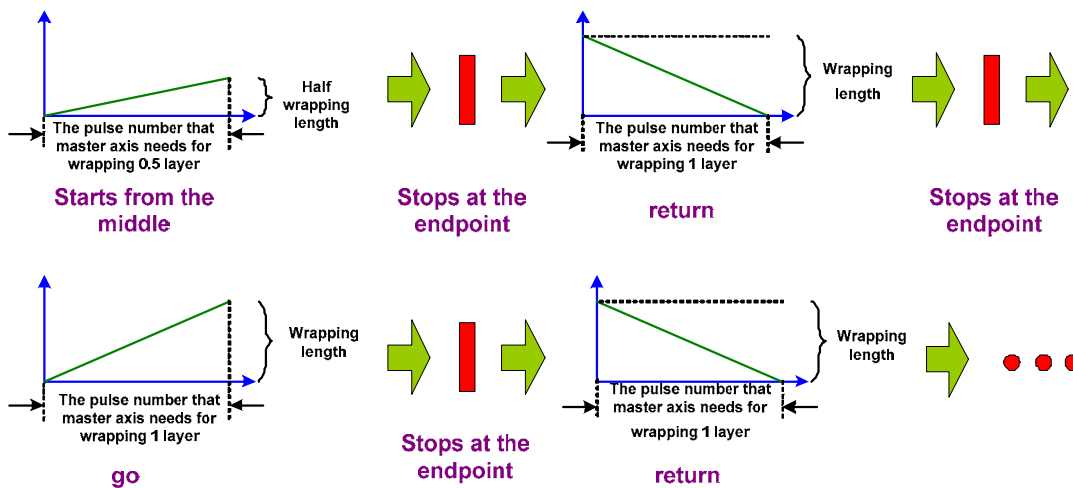
Figure 3.2.10 Time sequence of motion

3.2.3.3   Example
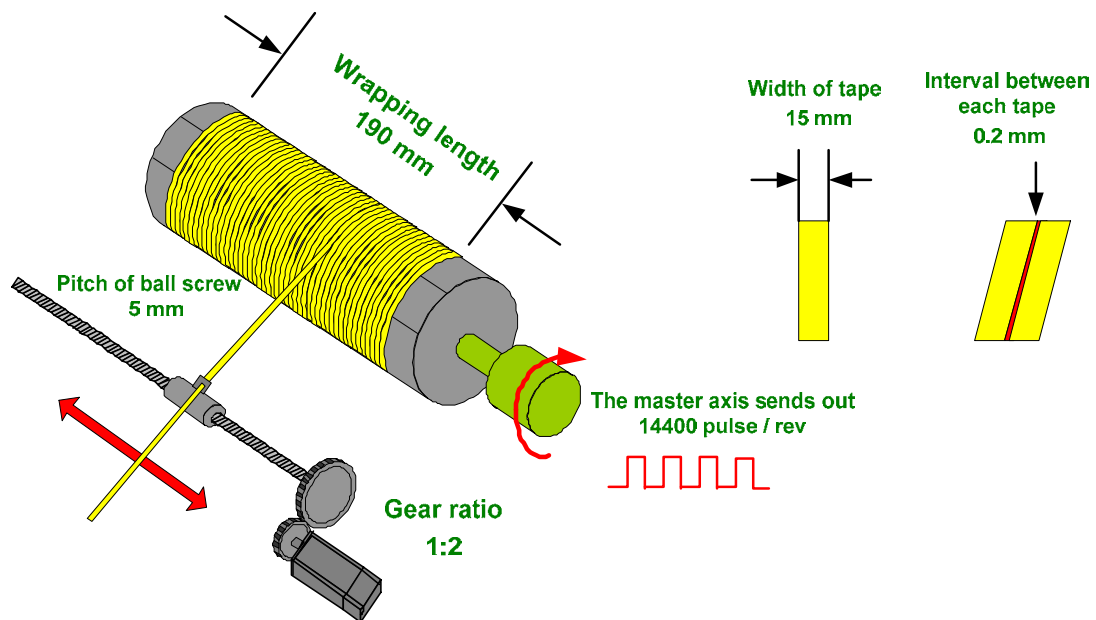
Figure 3.2.11   Application example

The master axis sends out 14400 pulses per revolution; the wrapping length is 190mm; the width of tape is 15mm; the interval between each tape is 0.2mm; the pitch of ball screw is 5mm; gear ratio of motor cam shaft and ball screw is 1:2.

The following is the calculation:

190mm/(15+0.2)mm = 12.5 cycle.

This is the amount of tape which can be placed on bobbin. However, since its first cycle is the position where the tape stops, when it is applied to slave axis, it must minus one cycle. See as Figure 3.2.12.
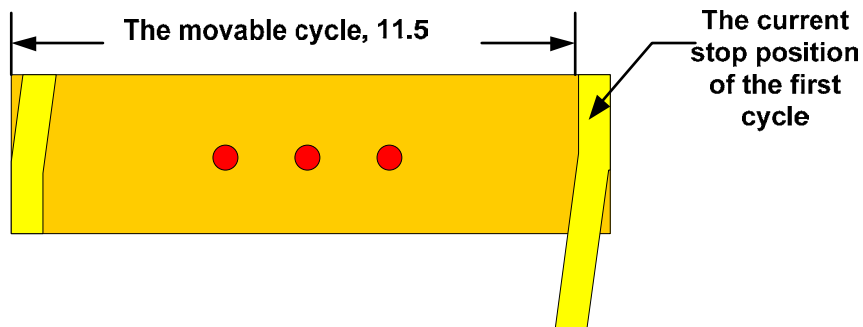
Figure 3.2.12   Configuration of tape

(12.5 -1) * 14400 = 165600 (pulses)

This is the pulse number that master axis needs for wrapping one layer, which is the pulse number for 11.5 cycles. This value is in ideal situation and not considering any error. The value should be adjusted in real situation. Normally, the actual value is smaller than the estimated one. This is because when estimating the length, the tape is in 90-degrees vertical to bobbin while in real situation the tape is inclined to bobbin.

If it desires to stop at one eighth cycle at two endpoints, then the pulse number it needs will be 14400/8=1800 pulses, see Figure 3.2.6.

The configuration of E-cam curve is shown in Figure 3.2.13.
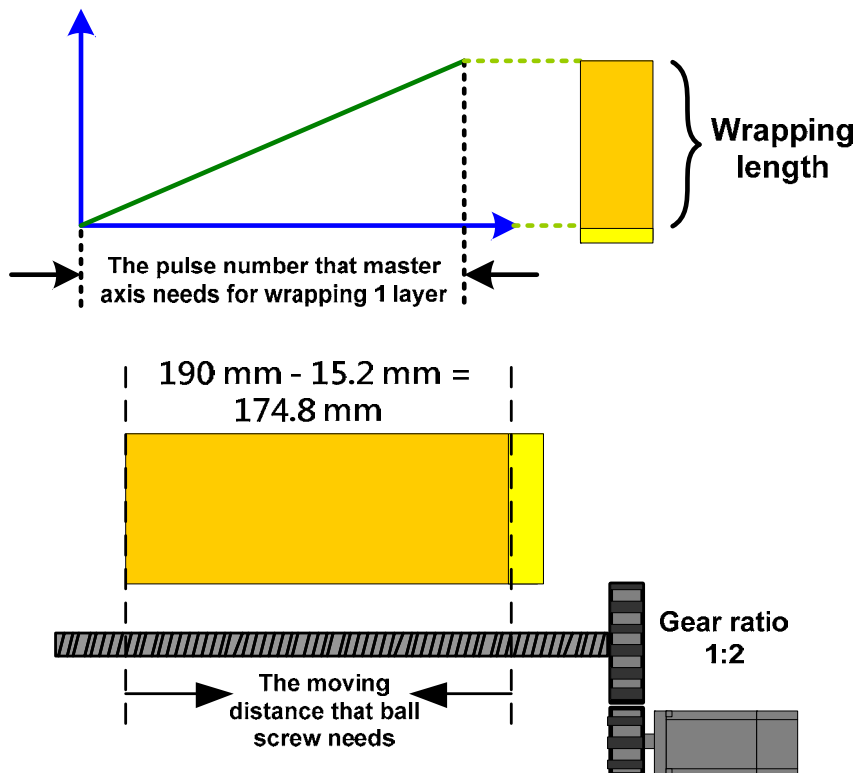
Figure 3.2.13   Configuration of E-cam curve

The pitch of ball screw is 5mm. As for the wrapping length, followings are the calculation method:

(190 mm-15.2 mm) / 5 (mm/rev) = 34.96 rev.

This is the value of the cam on ball screw. When the value corresponds to the motor, according to the calculation of gear ratio, the value should multiply double, which is 34.96*2=69.92 rev.

The PUU for one cycle of gear ratio is 100000PUU (P1-44=128, P1-45=10), thus the PUU of the cam needs to operate is 69.92 rev * 100000 PUU/rev = 6992000 PUU. This value is the ideal value which needs to be slightly adjusted when in real situation.

The corresponding relation of E-cam curve is shown as Figure 3.2.14.
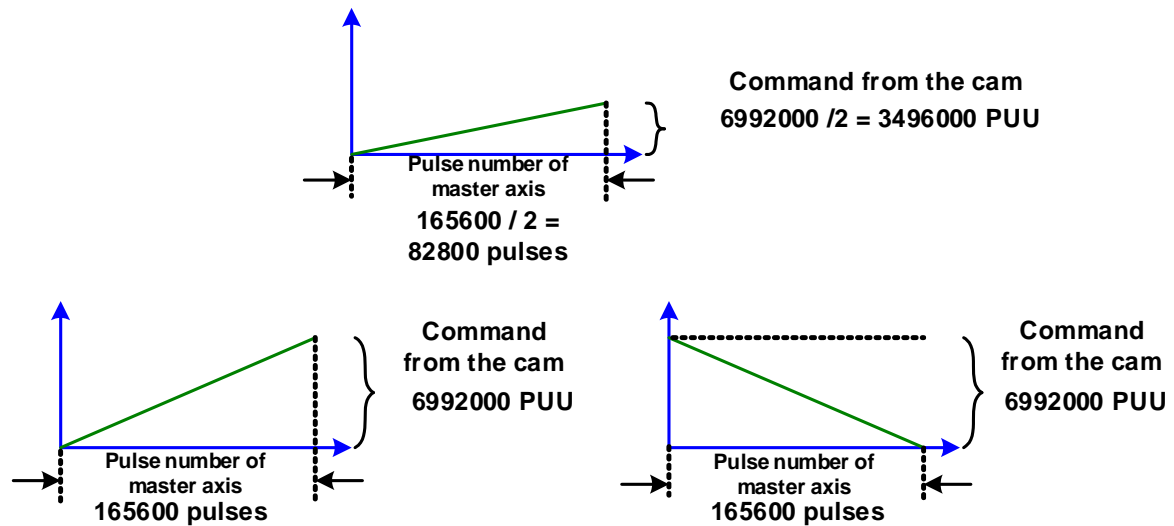
Figure 3.2.14   E-cam curve

3.2.3.4   PR Programming and Execution
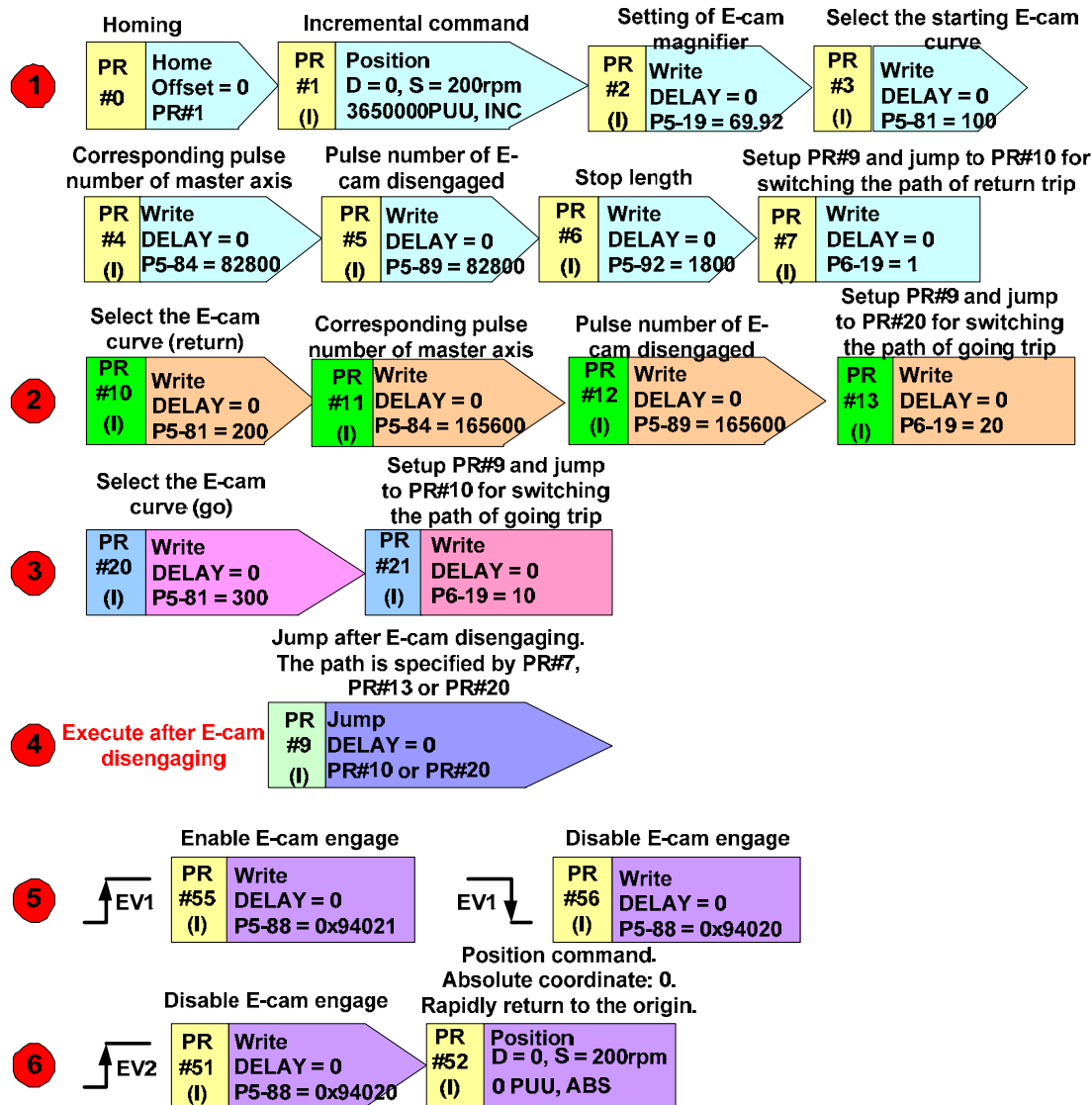
Figure 3.2.15 PR blueprint

PR#0: Homing before the system starts to operate.

PR#1: After the homing is completed, it goes to the middle point of bobbin and enables the operator to install the bobbin and the tape. The position should be adjusted according to different length of bobbin.
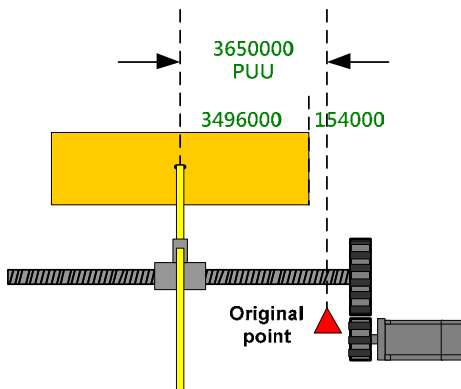
Figure 3.2.16   Original point and the middle point

PR#2: Setup the E-cam curve magnification which means to set P5-19 to 69.92. Different length of bobbin brings different magnification.

Command from the cam
100000 PUU * **69.92** =6992000
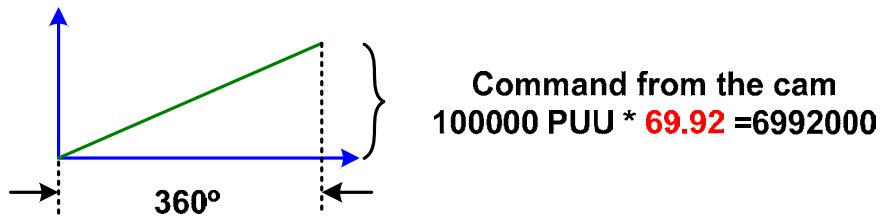
Figure 3.2.17   E-cam curve magnification

PR#3: Select the initial curve. There should be three E-cam curves in total in data array. This one is the first. P5-81=100 is the half one of going trip.
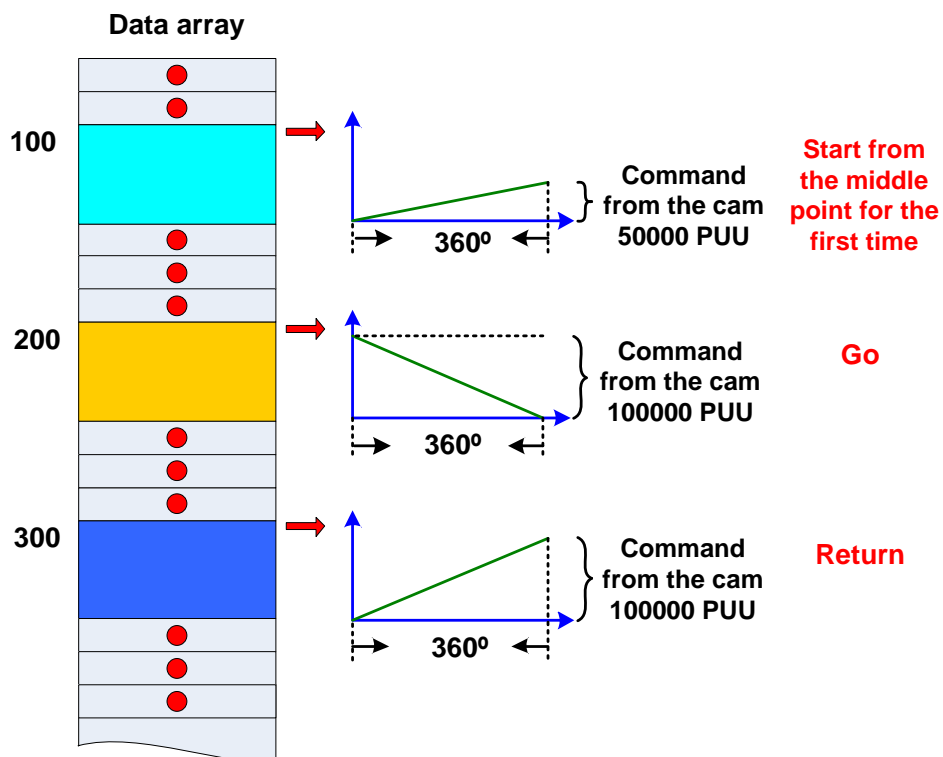
Figure 3.2.18   E-cam curve command in data array

PR#4: Setup parameter. The corresponding pulse number of master axis is P5-84=82800. Please refer to Figure 3.2.14.

PR#5: Setup parameter. The disengaged length of the cam is P5-89=82800.

PR#6: Setup parameter. P5-92=1800, the pulse number when stopping at the endpoint, which is the lead pulse of the cycle. Please refer to Figure 3.2.6.

PR#7: Setup parameter to set the return trip (PR#10), which is the execution path after E-cam disengaging. After disengaging, E-cam will call PR#9 to jump, thus, this is for setting up the target that PR#9 jumps to.

PR#10: Setup parameter to select the E-cam curve of return trip. Please refer to Figure 3.2.18.

PR#11: Setup parameter to set the pulse number that master axis needs for wrapping 1 layer. Please refer to Figure 3.2.14.

PR#12: Setup parameter to set the pulse number that slave axis receives from master axis which is the pulse number that enables E-cam to disengage.

PR#13: Setup parameter to set the path after E-cam disengaging for going trip.

PR#20: Setup parameter to select the E-cam curve of going trip. Please refer to Figure 3.2.18.

PR#21: Setup parameter to set the path after E-cam disengaging for return trip.

PR#9: Jump command. When E-cam curve operates to the position of 360 degrees, it will disengage and execute this PR. This PR is the jump command which can jump to another PR path.

PR#55: Setup parameter to enable E-cam. The setting content of E-cam is 0x94021. Among them, 1 means to enable E-cam; 2 means master axis is the pulse command; 0 means E-cam engages right after issuing the command; 4 means when E-cam operates to the position of 360 degrees, it will disengage and execute the lead pulse of P5-92. After it reaches the lead pulse, it will engage right away and execute E-cam curve again and so on and so forth. 9 means after E-cam disengaging the master axis, it will execute PR#9.

PR#56: Setup parameter to disable E-cam.

PR#51: Setup parameter to disable E-cam for executing the next PR.

PR#52: E-cam rapidly returns to the original point, not the starting point from the middle. It can be changed according to different demand.

Figure 3.2.19, the main flow chart of PR application
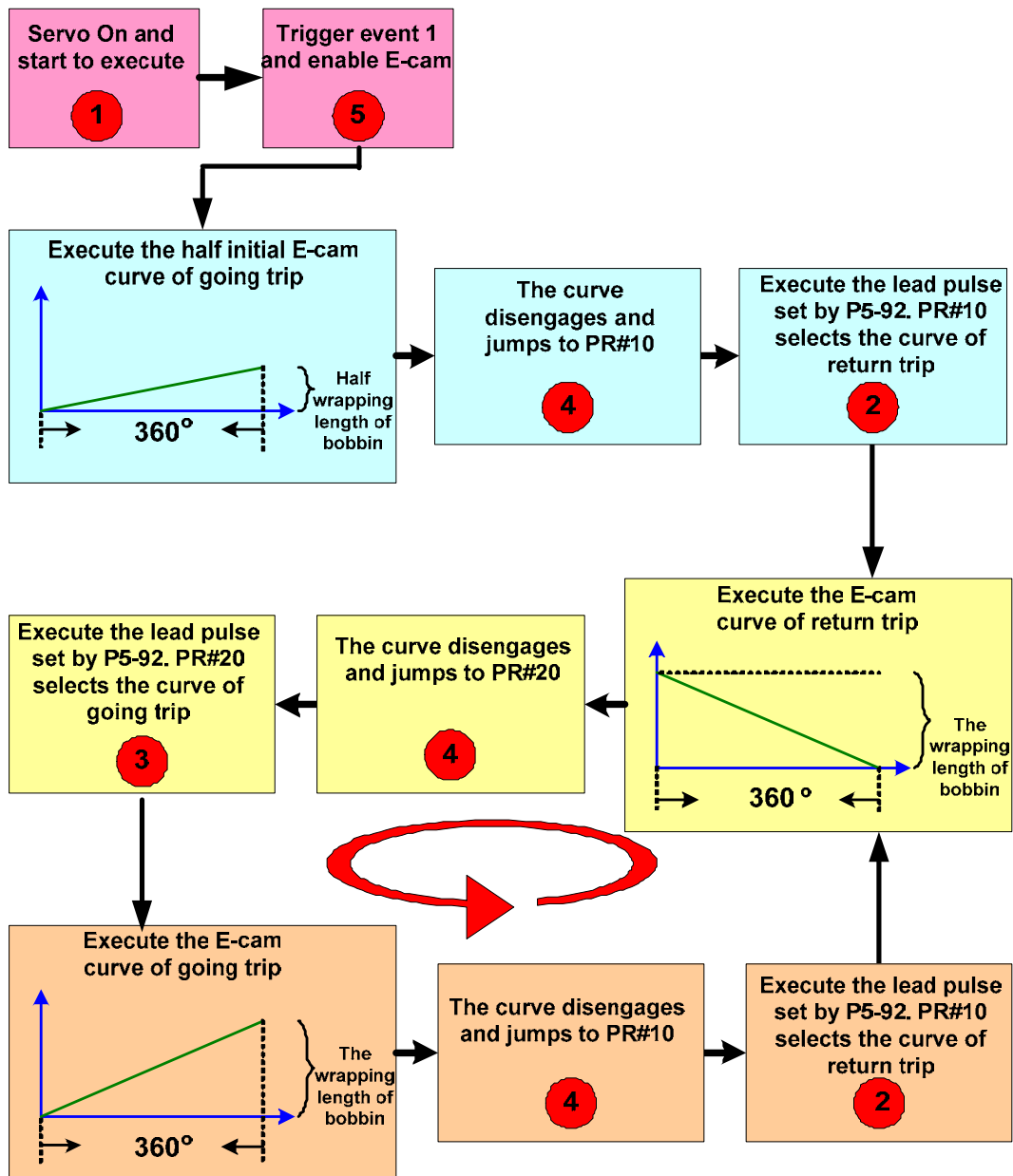
Figure 3.2.19 Time sequence of PR execution

3.2.3.5   System Adjustment

a. The length of bobbin remains and the width of tape is changed.

See Figure 3.2.20. Assume the tape is changed from 15 mm to 10 mm and the interval and the length of bobbin remain at 0.2 mm and 190 mm respectively.
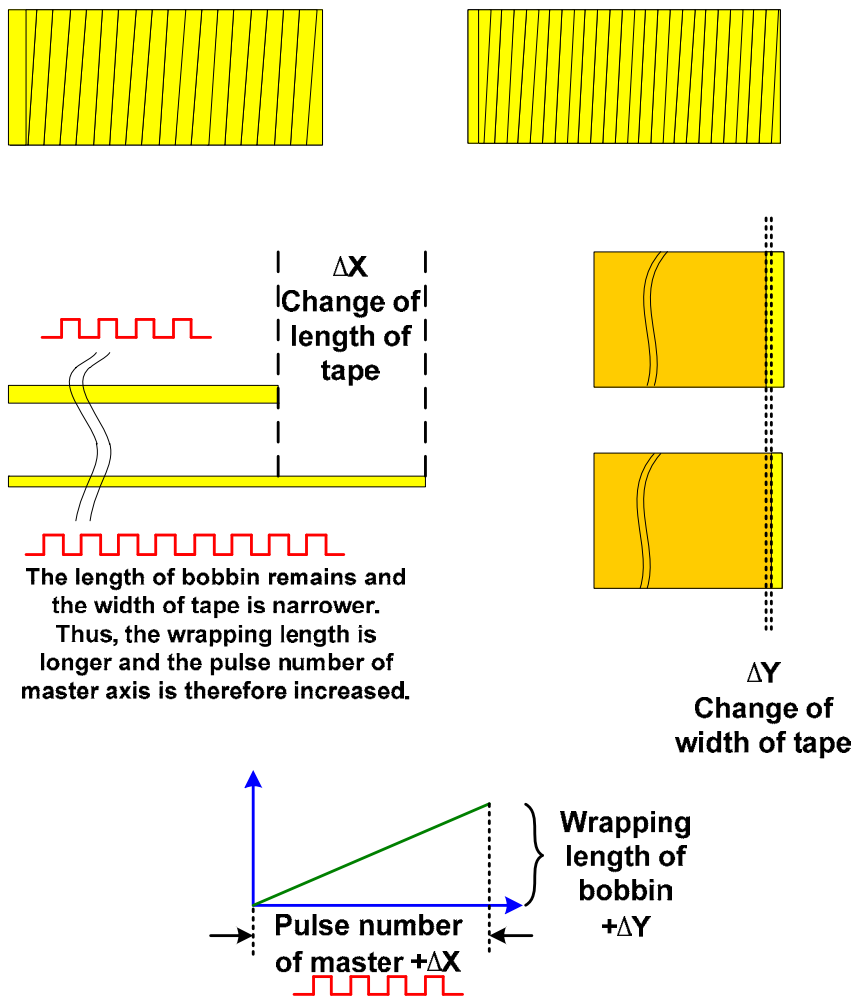
Figure 3.2.20 Change of tape width

ΔY, adjust the parameter of E-cam distance:

190mm – 10.2mm=179.8 mm;

179.8mm / 5 (mm/rev) = 35.96 rev, the cycle the ball screw travels;

35.96 * 2 =71.92 rev, converse to motor by E-cam;

PR#2: P5-19=71.92.

ΔX, adjust the pulse number sent by master axis:

190mm / (10mm + 0.2mm) =18.62745 cycles;

(18.62745-1)cycle* 14400 (pulse/cycle) =253835 pulse;

PR#4: P5-84=253835/2=126917;

PR#5: P5-89=126917;

PR#11: P5-84=253835;

PR#12: P5-89=253835.

b. The length of bobbin is changed and the width of tape remains.

See Figure 3.2.21. Assume the length of bobbin is changed from 190mm to 150mm and the width of tape and the interval remain at 15mm and 0.2mm respectively.
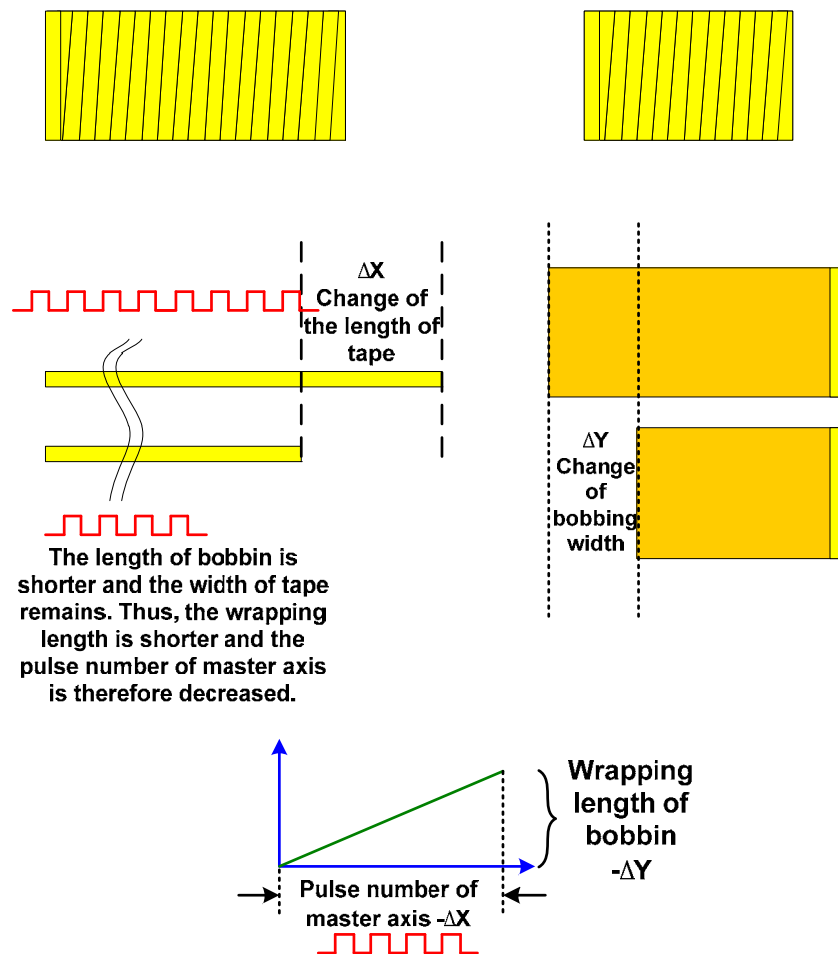
Figure 3.2.21   Change of bobbin length

ΔY, adjust the parameter of E-cam distance:

150mm – 15.2mm=134.8 mm;

134.8mm / 5 (mm/rev) = 26.96 rev, the cycle the ball screw travels;

26.96 * 2 =   53.92 rev, converse to motor by E-cam;

PR#2: P5-19=53.92.

ΔX, adjust the pulse number sent by master axis:

150mm / (15mm + 0.2mm) =9.8684 cycles;

(9.8684-1)cycle * 14400 (pulse/cycle) =127704 pulse;

PR#4: P5-84=127704/2=63852;

PR#5: P5-89=63852;

PR#11: P5-84=127704;

PR#12: P5-89=127704.

Looking for the middle point of bobbin:

PR#1: Incremental command 2850000PUU
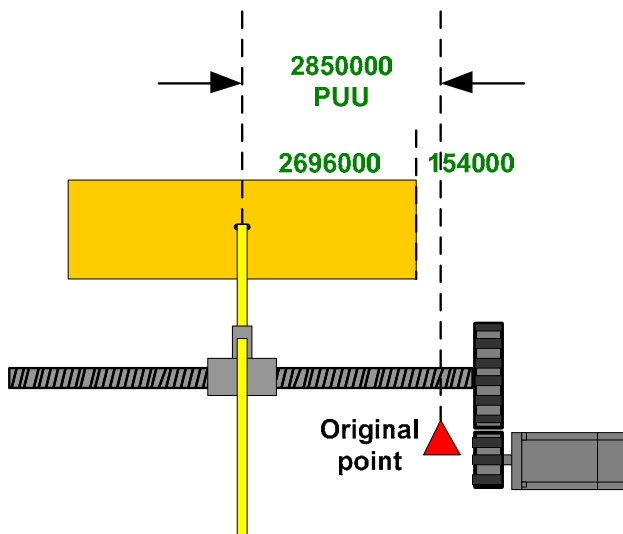
Figure 3.2.22 Looking for the middle point of bobbin

3.2.3.6   The Design of E-cam Curve

In this application, to build the E-cam curve is quite easy, only by one linear line will do. It is not suitable to plan acceleration/deceleration on two endpoints in this application. Otherwise, it might overlap at the two endpoints because of the deceleration. See Figure 3.2.7 for the result and Figure 3.2.23 for the causes. It proves that during the motor operation, either in forward or backward direction, no additional acceleration and deceleration is applied in the application. Thus, in mechanical design, low inertia and rigid mechanism should be the first priority. If the gear box is directly applied on camshaft, the effect will be better than belt.
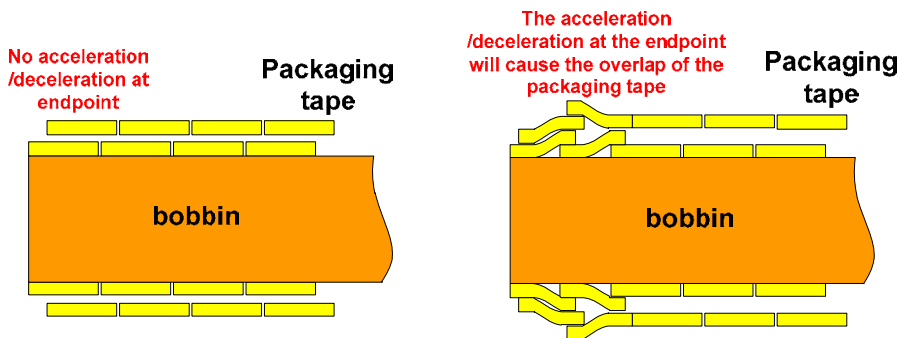
Figure 3.2.23 Tape overlap caused by acceleration/deceleration curve

Only one linear line is needed to build in E-cam curve which is shown in the following Figure.

| P5-81 : Start position of Data Array | 100 |
| P5-82: E-CAM Area Number: N(4~719) | 5 |

	0	1	2	3	4	5
θ[°]	0	72	144	216	288	360
Postion Y	1	10000	20000	30000	40000	50000
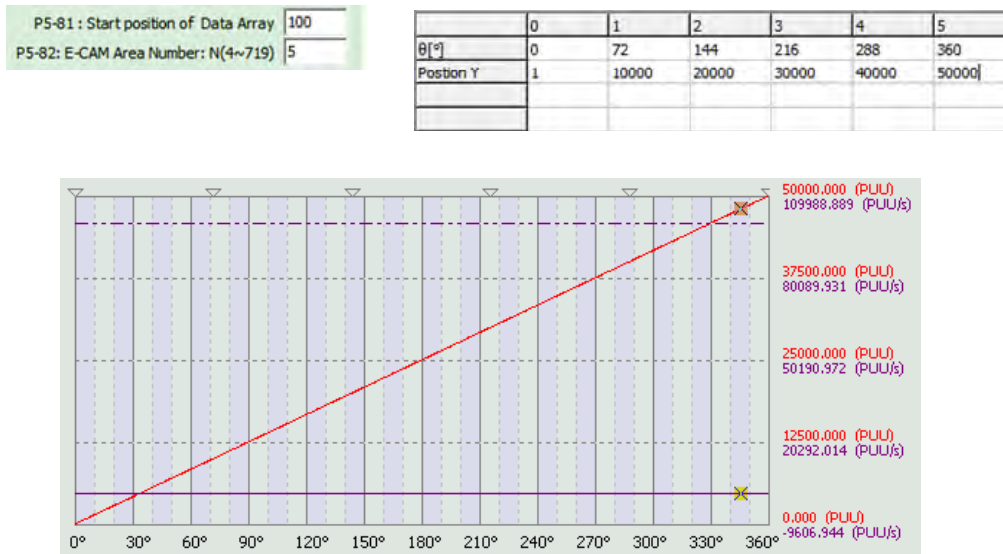
Figure 3.2.24 E-cam curve of half going trip

| P5-81 : Start position of Data Array | 200 |
| P5-82: E-CAM Area Number: N(4~719) | 5 |

	0	1	2	3	4	5
θ[°]	0	72	144	216	288	360
Postion Y	100000	80000	60000	40000	20000	0
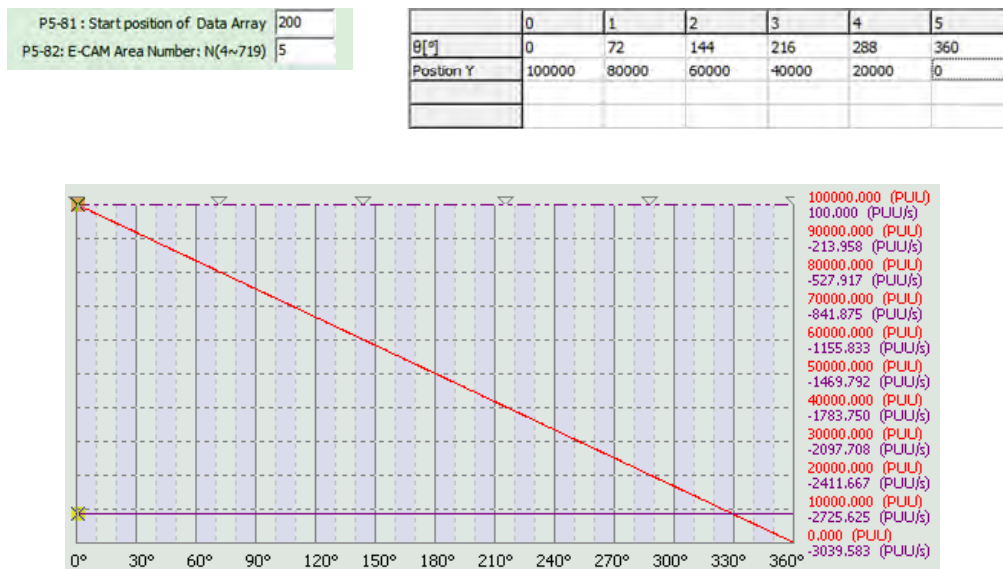
Figure 3.2.25 E-cam curve of the whole return trip

P5-81 : Start position of Data Array 300
P5-82: E-CAM Area Number: N(4~719) 5

	0	1	2	3	4	5
θ[°]	0	72	144	216	288	360
Postion Y	0	20000	40000	60000	80000	100000
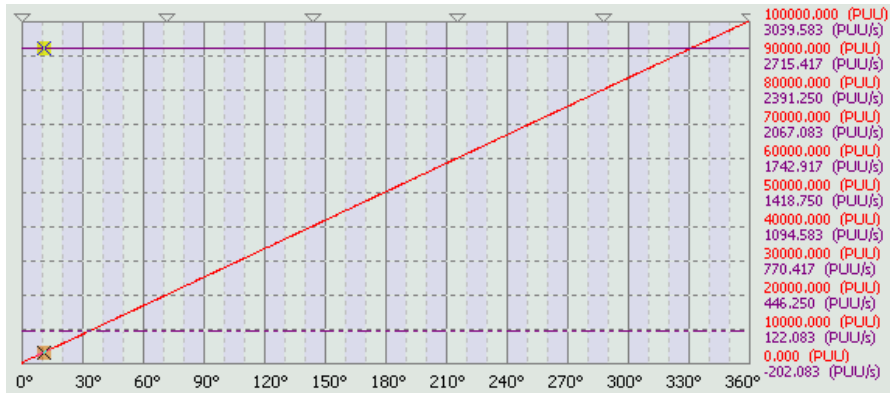
Figure 3.2.26 E-cam curve of the whole going trip

3.3   Application to Labeling Machine

3.3.1   Description

This chapter is aiming at the application of ASDA-A2 on labeling machine. Electronic cam is applied to control the speed of delivering labels and enables the packages to be delivered in the same speed so as to labeling. This application could be classified to flying shear. The length of label should be adjustable, the position should be accurate when delivering labels and the delivering speed should be the same as the main conveyor. For the convenience of operator, only photoelectric switch is adjusted in this application, such as label location position and labeling start position. (No controller and HMI is in the system since ASDA-A2 is good enough to satisfy all demands.)

Besides the detailed description of labeling motion, this chapter will introduce how E-cam curve is created in speed section by Delta's ASDA soft. This curve has a very long constant speed section, which is the table creation basis in rotary cutoff and similar applications.

Together with PR commands, E-cam can easily satisfy the controlling demand in ASDA-A2.

3.3.2   System Plan

The axis of conveyor is the master axis which is mainly for transporting objects. Camshaft axis is in charge of controlling the pace of labeling according to the pulse speed sent by master axis, see diagram 3.3.1. In this application, the label waiting position (controlled by label positioning sensor) has to be very accurate. The position error should within 1mm only each time. As for the design of E-cam curve and function, it must consider that the label length should be adjustable. Thus, the setting of E-cam should be set to the longest length for operation.
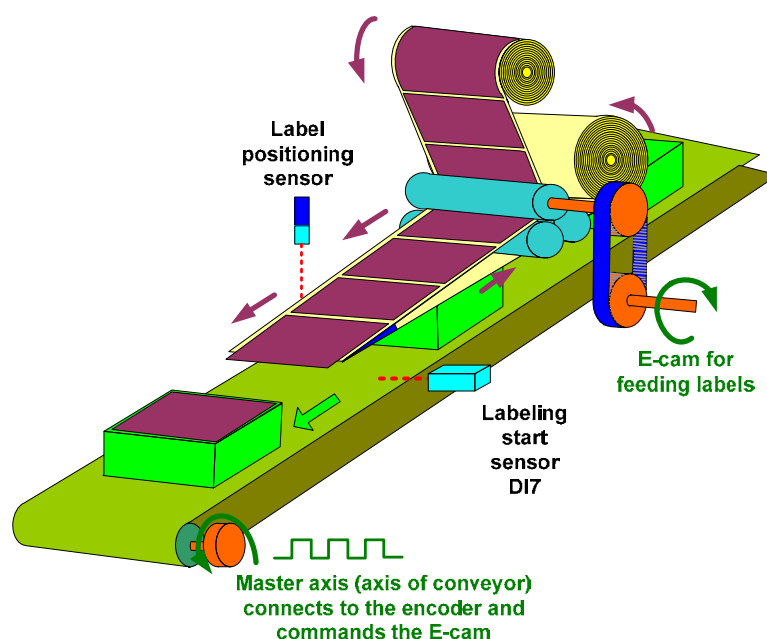
Figure 3.3.1 Labeling machine system

3.3.2.1   Master Axis – Axis of Conveyor

It transports the to-be labeled objects, such as packing box. The pulse signals are sent out to command the camshaft axis simultaneously in order to control the labeling speed.

3.3.2.2   Camshaft Axis – Label Feeding Axis

Following the command of master axis, the camshaft axis executes labeling according to the pace of master axis. When delivering the label, the pace should be accurate and stable. It should be controlled to operate the same speed with the master axis while labeling, otherwise the label will be pasted uneven.

3.3.2.3   Label Positioning Sensor

The label positioning sensor decides the outstretched length of label while the label is waiting to be pasted. It can be operated by moving the photoelectric switch (label positioning sensor).

3.3.2.4   Labeling Start Sensor

When DI7 receives the signal from labeling start sensor, it will control E-cam to engage and the camshaft axis will synchronize with the master axis. When E-cam starts to accelerate and reach the same speed as master axis, the label will just be pasted on the to-be-labeled object. It will not disengage until the labeling is completed.

3.3.3   Setting of Servo System

3.3.3.1 Camshaft is Enabled and Starts to Label

When the object on the conveyor is detected by labeling start sensor, the camshaft is enabled. The label axis follows the master axis until the labeling is completed. Then, the camshaft disengages and its operation is controlled by label positioning sensor. See Figure 3.3.2 and 3.3.3.
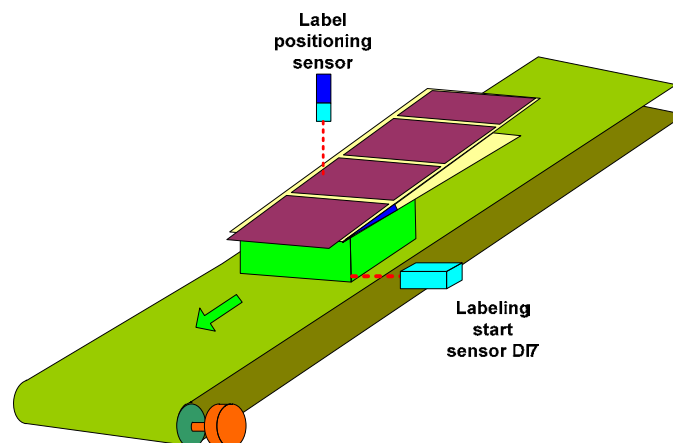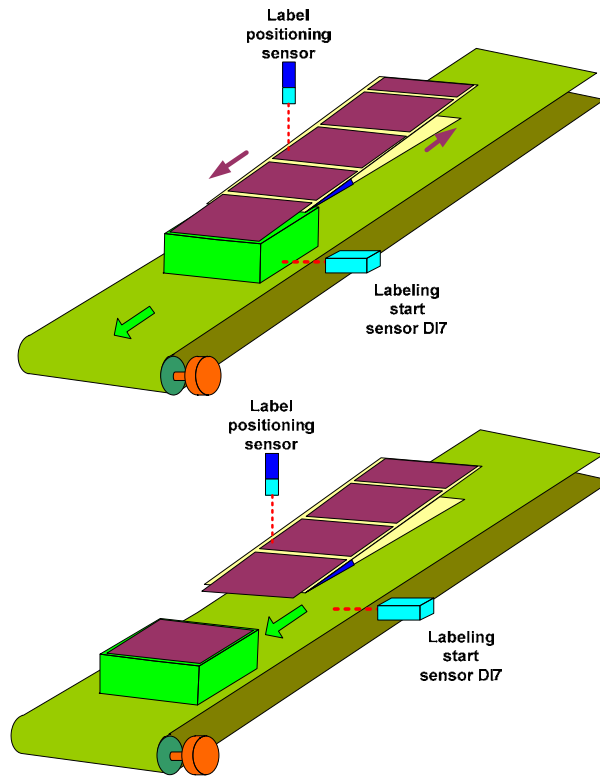
Figure 3.3.2 Labeling start
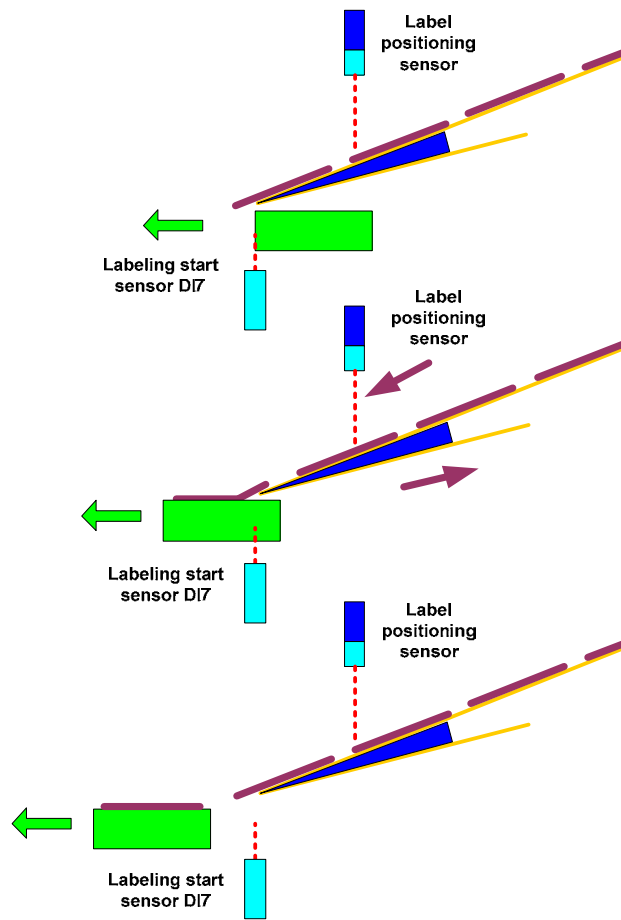
Figure 3.3.3 Side view of labeling process

3.3.3.2   Camshaft is Disabled and Label Positioning

The label positioning sensor determines the disengagement of camshaft and the outstretched part positioning. It can be adjusted by different label lengths and different demand. See Figure 3.3.4 for the adjustment of outstretched part positioning.
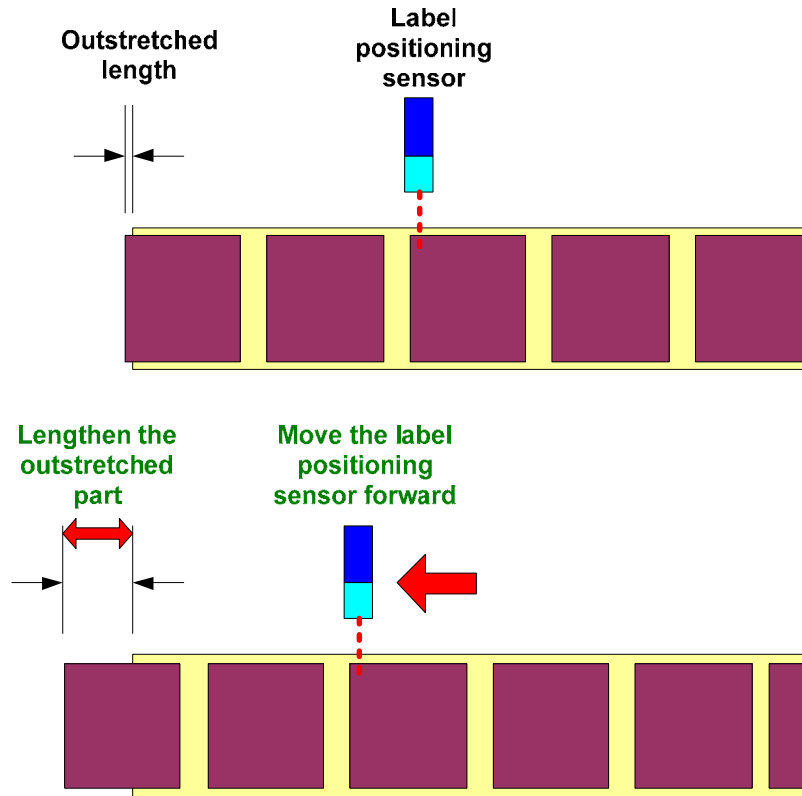
Figure 3.3.4 Adjust the outstretched part positioning

The label positioning sensor is used to control the time the camshaft disengages, prepare the label for the next cycle and control its outstretched part positioning (the stop position). This signal sets up the trigger event and calls the corresponding PR to complete the disengaged control of the camshaft and the outstretched length of the label. See Figure 3.3.5.

Label positioning sensor

When the labeling start sensor detects the object, the camshaft is enabled.

Label positioning sensor

Event trigger. (The label has left the label positioning sensor, the camshaft is disengaged and execute PR command.)

EV1

Labeling start sensor

Label positioning sensor

Event trigger. (The label positioning sensor detects the label and prepare to stop.)

EV1

Labeling start sensor

Label positioning sensor

Label is at the desired position. Stop and wait for the next trigger.

Labeling start sensor

Figure 3.3.5 Label outstretching and positioning

3.3.3.3   PR Program and Execution
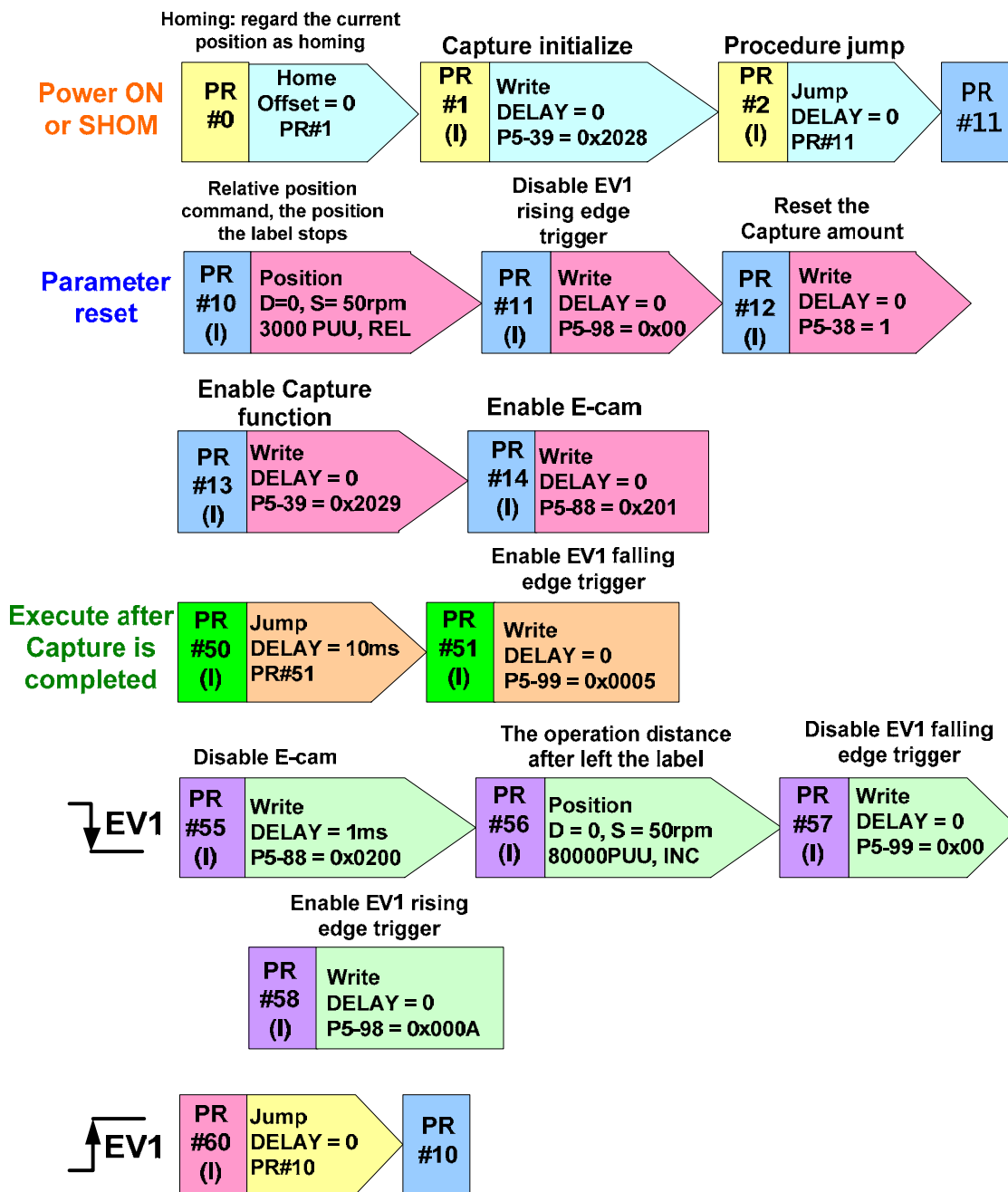
Figure 3.3.6 PR program and execution

PR#0: Homing. Due to the design of mechanical structure, when enabling the function, regard the stop position as the homing position will do.

PR#1: Initialize Capture function. After Capture function is completed, call PR#50.

PR#2: Jump to the initialized program, PR#11.

PR#10: Relative position command controls the label stop position, see Figure 3.3.7. When the camshaft returns to the original point, this program will not be executed, unless it is in normal cycle.
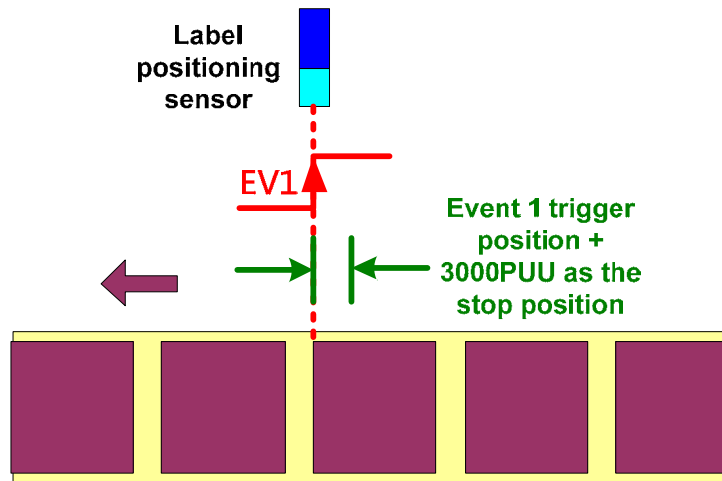
Figure 3.3.7 Label stop position

PR#11: Setup parameter to disable EV1 rising edge trigger command in order to prevent the alarm occurs.

PR#12: Setup parameter to reset the Capture amount. Only one position is needed to capture for E-cam function. Thus, set this parameter to 1.

PR#13: Setup parameter to enable Capture function.

PR#14: Setup parameter to enable E-cam function. Use Capture function to engage the camshaft.

PR#50: After the Capture is completed, this PR command will be triggered. As a jump command, this PR will jump to the next one. The auto function is not applied here. When the capture is completed, next PR (disable EV1 falling edge trigger) will be executed with a delay.

PR#51: Enable EV1 falling edge trigger. The label positioning sensor has entered into label position. Thus, enable it to detect the label disengaged position (label's end).

PR#55: When label positioning sensor leaves the label, EV1 falling edge trigger will be activated. E-cam no long controls the system at the moment. Setup E-cam command to disengage camshaft.

PR#56: Incremental command, which is the traveling distance after disengaging from label. It should consider the maximum spacing between two labels. To setup the maximum spacing the machine may operate. See Figure 3.3.8.
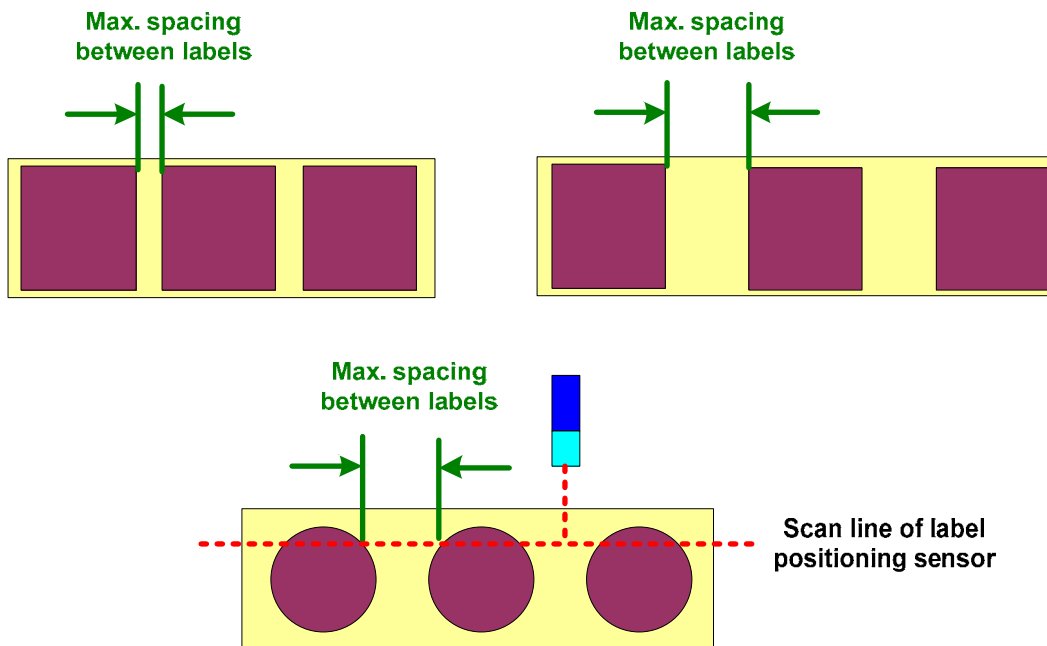
Figure 3.3.8 Spacing between labels

PR#57: When executing this PR, the label positioning sensor has left label position. EV1 falling edge trigger will not continuously be triggered twice in control procedure. In order to prevent the error occurs, disable EV1 falling edge trigger first and enable it later by PR command at an appropriate time.

PR#58: Enable the detection for rising edge trigger to prepare the next label. Thus, re-enable the detection.

PR#60: Trigger EV1 rising edge trigger and jump to PR#10.

3.3.3.4   Structure of E-cam Curve

When an object on conveyor is detected by labeling start sensor, the E-cam function is enabled. During the labeling process, the speed of master axis and camshaft axis must be the same. Otherwise, the label will be pasted uneven. See Figure 3.3.9 for cross reference of E-cam curve and the to-be-labeled object (e.g. packing box).
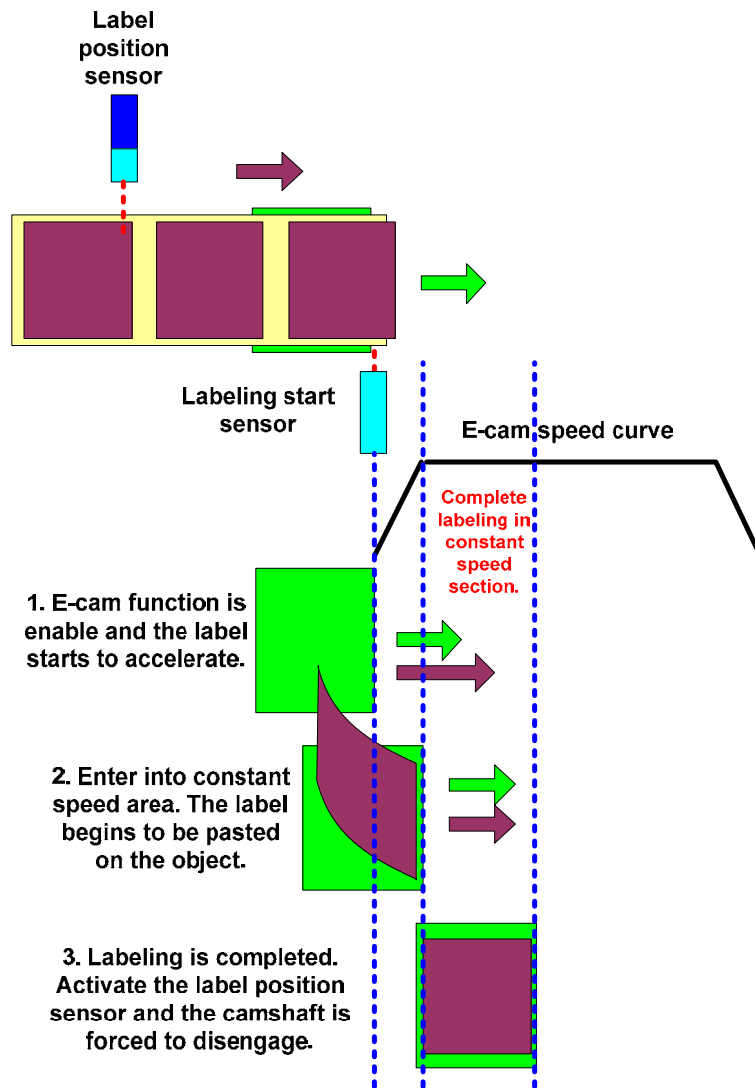
Figure 3.3.9 Labeling and E-cam curve

From Figure 3.3.9, a long constant speed section is needed in E-cam curve. Thus, the maximum label length the machine may operate should be considered. See Figure 3.3.10.
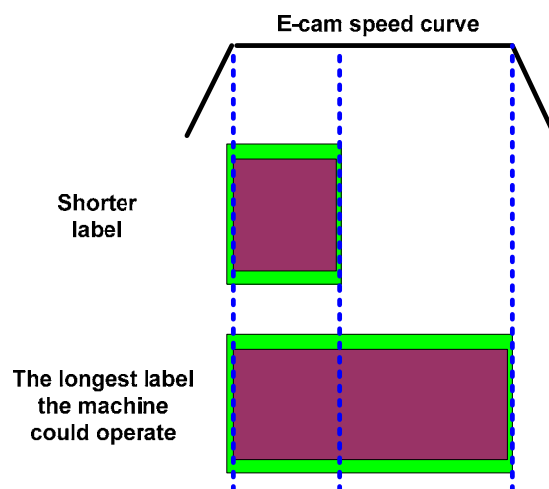
Figure 3.3.10 labeling length and E-cam curve

3.3.3.5 E-cam Curve Creation

According to the actual machine, the roller diameter of master axis is 5 cm. The encoder sends out 1600 pulses for each revolution. See Figure 3.3.11. Thus, the pulse number sent by master axis per revolution is:

1600 pulse / (π*50 mm) = 10.185916 (pulse/mm).
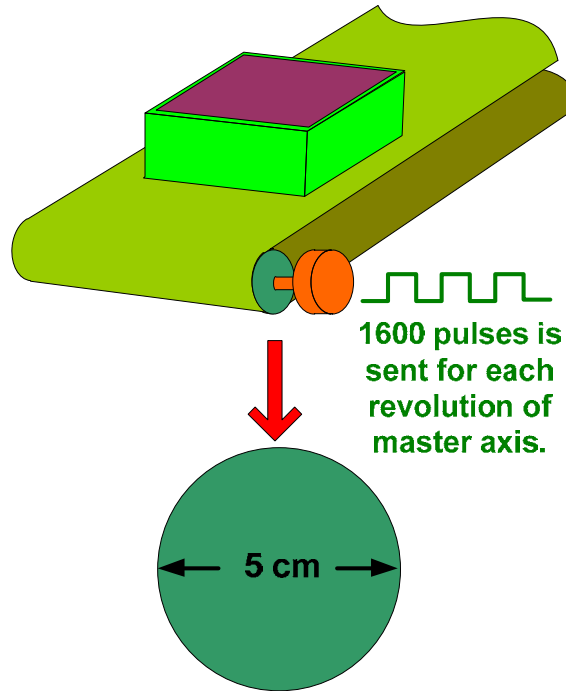
Figure 3.3.11 Roller of master axis and encoder specification

As for camshaft axis, the roller diameter is 5cm and the electronic gear ratio is 1:1, which is shown in Figure 3.3.12.
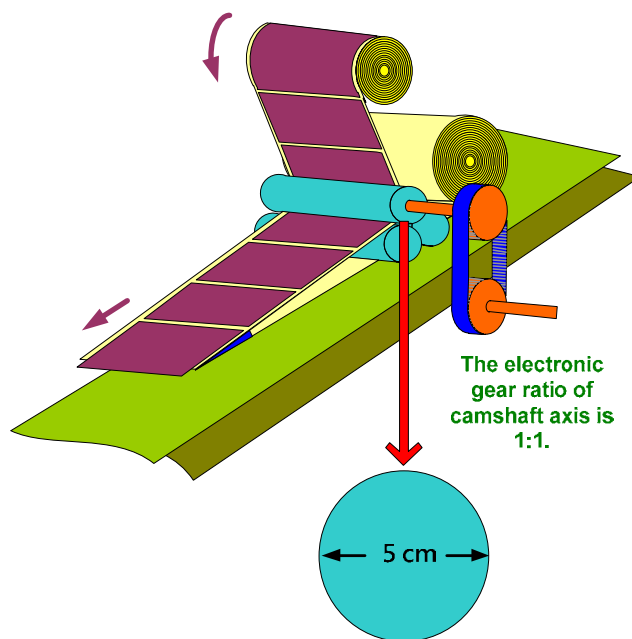
Figure 3.3.12 Dimension of camshaft axis

From the above Figure 3.3.12, the label length brought by each roller revolution is π*5 cm = 15.708 cm. To meet the requirement of maximum 23 cm, the curve must be longer than 23 cm since the acceleration / deceleration time should be left. 23 cm is the traveling distance that master axis and camshaft axis operates at the same speed. Then, to create the E-cam curve based on this value. In Figure 3.3.13, master axis is at constant speed while camshaft axis has acceleration and deceleration. Thus, within the same time, considering the acceleration and deceleration time of camshaft, master axis travels farther than camshaft axis. In actual operation, camshaft axis must be enabled in advance so as to complete labeling in constant speed section. That is to say, from Figure 3.3.13, the traveling distance is Constant Speed Area < Camshaft axis < Master axis. The creation of E-cam curve will be introduced in the following parts.
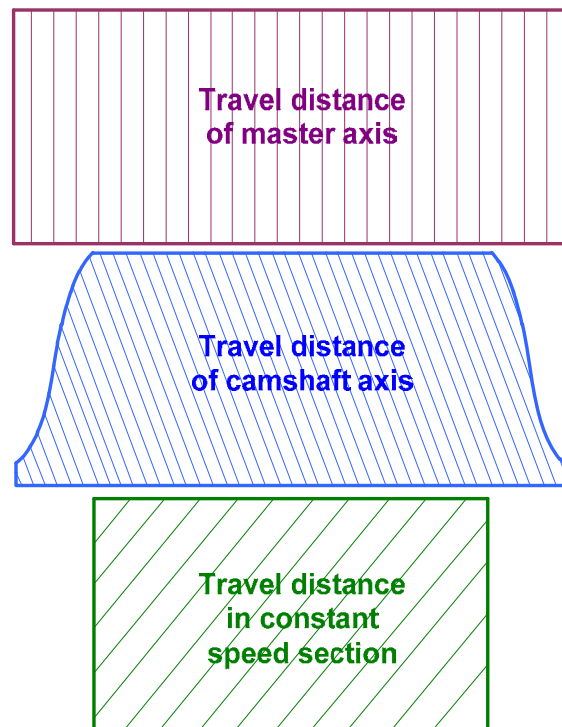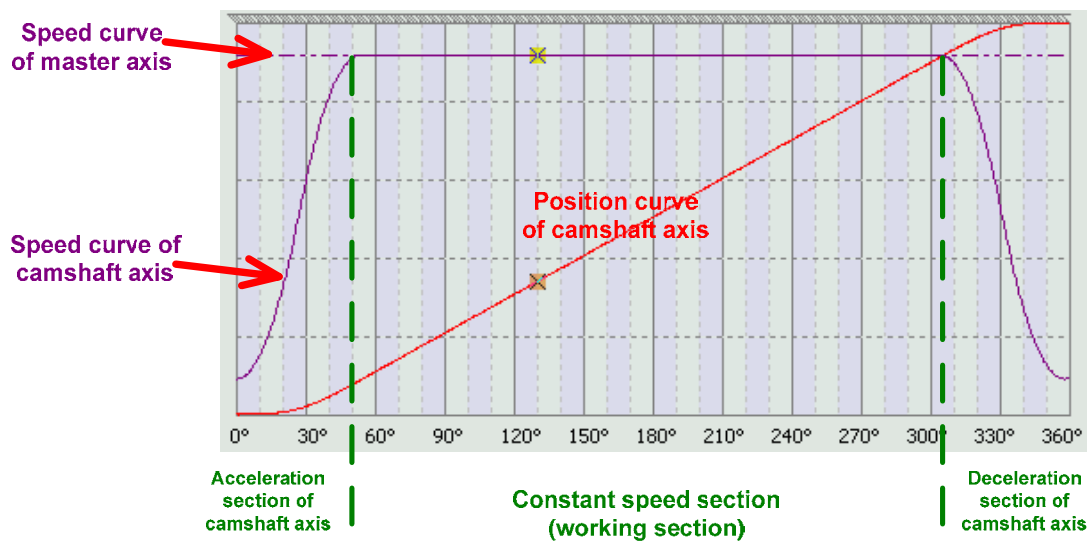
Figure 3.3.13 E-cam curve

Through the setting of electronic gear ratio, system not only can consist with the command

resolution, but increase its readability. In this example, the traveling distance for each camshaft axis resolution is π*5 cm =15.708 cm. In order to make the data more readable, users can set 157080PUU for each cycle the camshaft travels, which is 0.001 mm per PUU. Thus, set P1-44 to 128000 and P1-45 to 15708. When P5-19 is set to 1 (E-cam curve scaling), the relative pulse command is (157080PUU / 15.708 cm) = 1000 PUU/mm of each mm on camshaft axis. See Figure 3.3.14.

| P1 - 44 | | | GR1 | 128000 | * | pulse | 1 | 536870911 | 128 | Electronic Gear Ratio (1st Numerator) (N1) |
| P1 - 45 | ▲ | | GR2 | 15708 | | pulse | 1 | 2147483647 | 10 | Electronic Gear Ratio (Denominator) (M) |

Figure 3.3.14 E-gear setting

If users desire to create a curve of 31.416 cm (314.16 mm), then 314.16 (mm)* 1000(PUU/mm) = 314160 PUU.

In ASDA-A2, Speed Section is used to create E-cam table. Please refer to the following steps.

a. Select the way to create E-cam table

Select **Speed Section** to create E-cam table. See Figure 3.3.15.
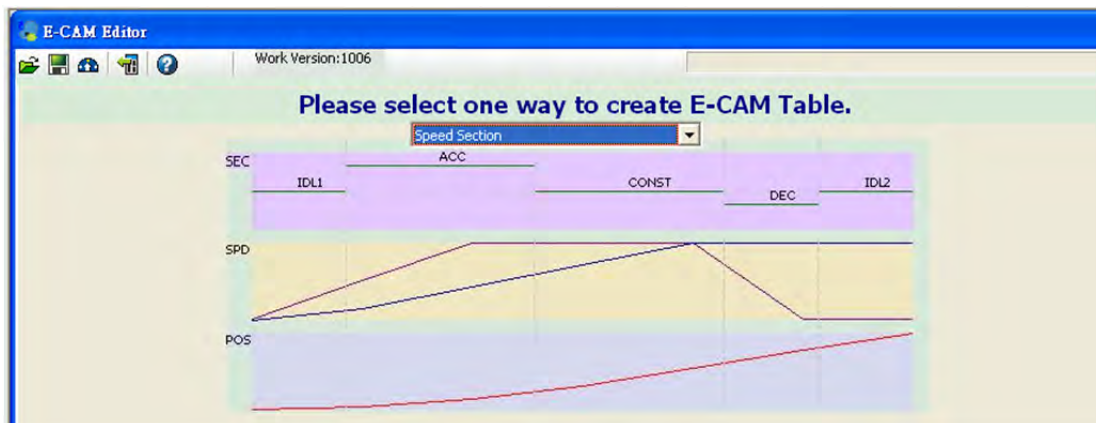
Figure 3.3.15 Select **Speed Section**

b. Setup the actual machine dimensions

Master axis is 10.185916 Pulse/mm and camshaft axis is 1000 PUU/mm. When creating E-cam curve, the system will refer to the above simulation data. Please make sure the information is correct, which is the pulse number and PUU the system needs when master axis and camshaft axis moves 1 mm. See Figure 3.3.16.
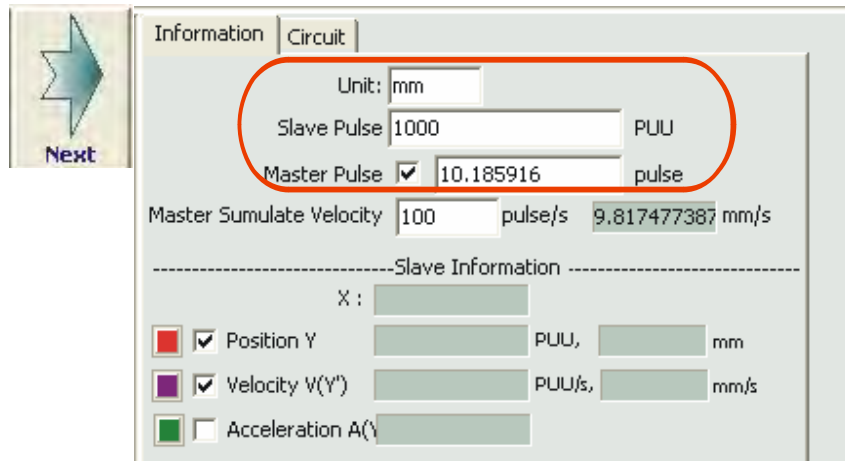
Figure 3.3.16 Simulation information

c. Set slave axis lead

Setup the longest lead of labeling, 23 cm and consider the acceleration / deceleration section, this curve must be designed longer than 23 cm. According to the previous experience, take 30 cm for a rough estimation (About 10% more, including 5% of acceleration and 5% of deceleration). Thus, the calculation is 300(mm)* 1000 (Pulse/mm) = 300000 Pulse. Fill this value into **Lead**. In addition, fill 100 into P5-81, Data Array start position, which can be set according to the actual condition.

Fill 200 into P5-82, E-CAM Areas: N(5~720). The bigger the value is, the more perfect the curve will be. It is suggested to fill in 200 at least. Users can set different values to see different results. See Figure 3.3.17.
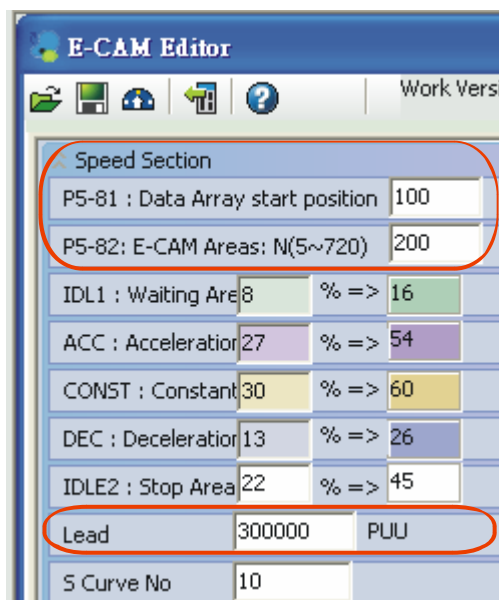
Figure 3.3.17 Setting of E-cam lead

d. Set master axis lead

It is estimated that master axis will travel 33 cm (10% more). Therefore, if P5-83 is set to 1, then P5-84 = 10.185916(pulse/mm)*330(mm) = 3361.

Parameter Setup	
P5-85 : Engage Area Number (Entry Offset)	0
P5-86 : Postion of Master Axis	0
P5-87 : Engage(Lead Command Length)	0
P5-90 : Area No+(Polarity is Positive)	0
P5-91 : Area No- (Polarity is Negative)	1
P5-19 : E-CAM Table Magnification	1.000

Figure 3.3.18 Pulse number setting of master axis

e. Create an E-cam curve

Refer to mark 1 in Figure 3.3.19, setup **Waiting Area**, **Acceleration Area**, **Constant Speed Area**, **Deceleration Area** and **Stop Area**. Among the setting, motor inertia ought to be considered in **Acceleration / Deceleration Area**. If the motor inertia is larger, the acceleration / deceleration curve will be steeper which might result in command delay, motor overload or regeneration error. Thus, if acceleration / deceleration cannot be calculated precisely, do field test first. In addition, when creating curve, a longer **Constant Speed Area** is more ideal, since it is applied in real working area. Meanwhile, it is better to leave some time for **Stop Area**; otherwise, it might be unable to complete homing. See mark 2 in Figure 3.3.19, the setting of S Curve No. is for smooth E-cam curve so that the command will not be changed dramatically. The ideal setting value is equal to the value of **Stop Area**, such as 10. Then, press **Create Table** which is marked 3, the system will create the table and the curve.

Mark 4 shows the speed of master axis is 9.817477387, which is the target speed the camshaft needs to follow (This value varies with Master Simulation Speed, but it will not influence the curve creating.). Move the cursor to **Constant Speed Area**, see mark 5. In speed field, the value is 9.867 (>9.8174477387, Master Simulation Speed). Thus, the speed of camshaft axis is slightly faster than master axis. Users can adjust **Acceleration / Deceleration Area** or master / slave axis lead to make the two values the same.
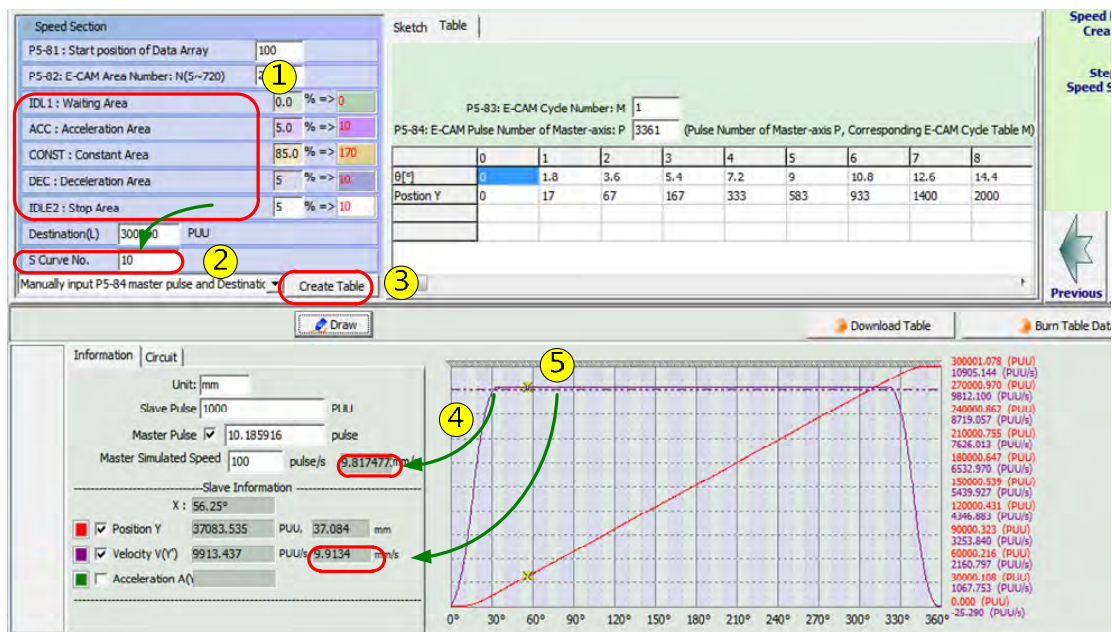
Figure 3.3.19 Create E-cam curve

f. Use camshaft axis to adjust the speed in Constant Speed Area

To adjust the curve by **Acceleration / Deceleration Area** or slave axis lead will be introduced here (Both can be adjusted simultaneously.). In Figure 3.3.20, after adjusting **Acceleration / Deceleration Area**, the **Constant Speed Area** of camshaft axis can comply with the speed of master axis (Please see the result in mark 4 and 5 in Figure 3.3.20.). During the process, several times of trying for a proper value are needed. This method is suitable for unchangeable pulse number of master axis (P5-84). Without saying, the value of P5-84 can be changed in the application of labeling machine. From Figure 3.3.21, users can acquire the desired speed curve by adjusting camshaft axis lead (mark 1). From mark 4 and 5 in 3.3.21, users could know that the speed of master axis is 9.817477387 ≒ which is the same as slave axis in **Constant Speed Area**.

In Figure 3.3.20, the length of **Constant Speed Area** is 300000 PUU * (360° - 60°) / 360° / 1000(PUU/mm) = 250 (mm), which is longer than 23 cm. 60° is the time for **Acceleration / Deceleration Area**.

In Figure 3.3.21, the length of **Constant Speed Area** is 298600 PUU * (360° - 65°) / 360° / 1000(PUU/mm) = 244.69 (mm), which is longer than 23 cm. 65° is the time for **Acceleration / Deceleration Area**.
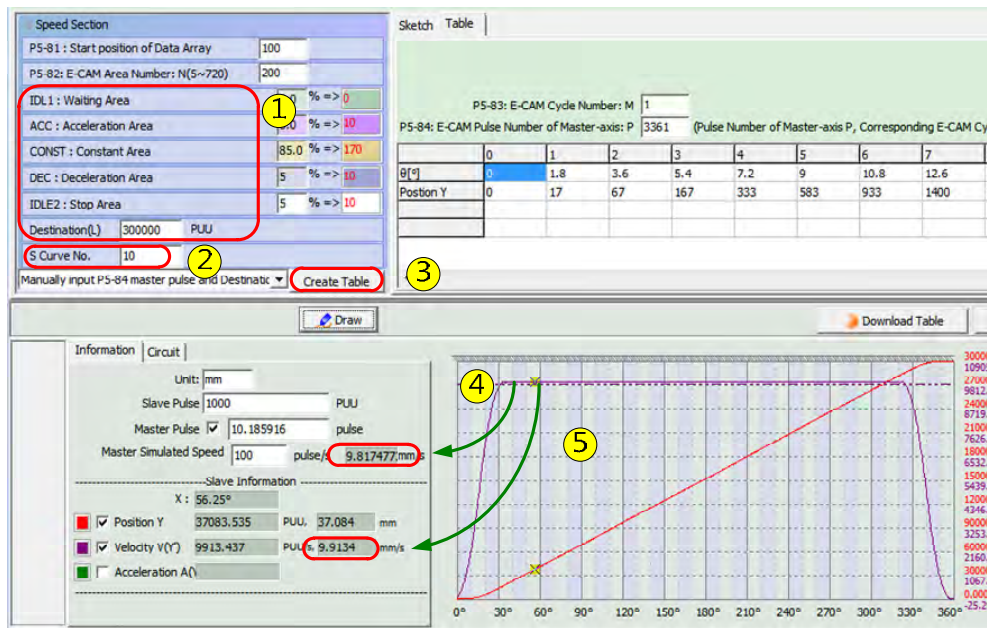
Figure 3.3.20 Adjust the E-cam curve in **Acceleration / Deceleration Area**
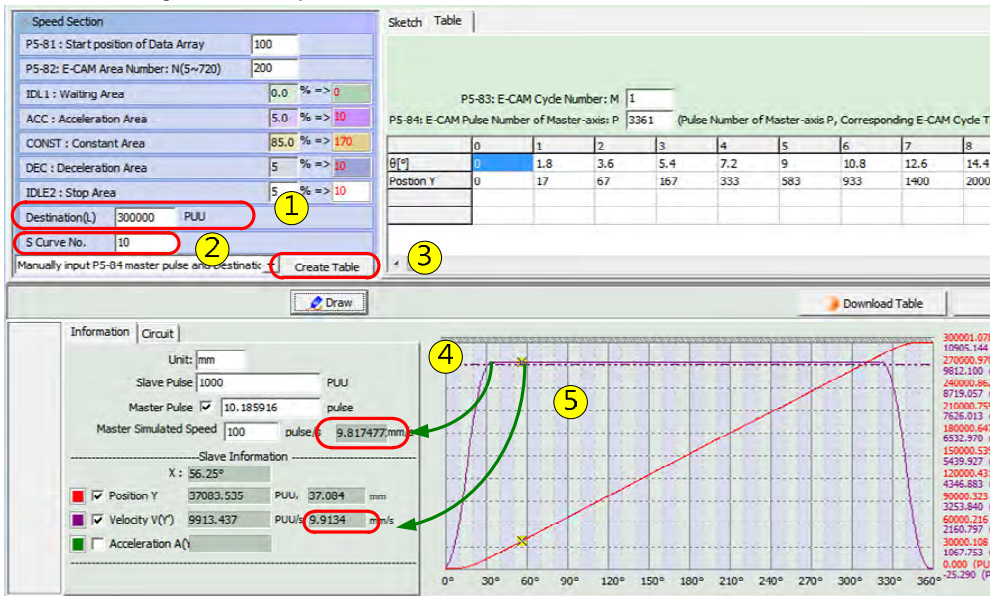
Figure 3.3.21 Adjust the E-cam curve of camshaft axis lead

g. Adjust the speed in Constant Speed Area by master axis

Data showed in Figure 3.3.22, mark 1 is the same as Figure 3.3.19. Here, adjust the pulse of master axis (P5-84) in Figure 3.3.18 from 3361 to 3376 (the result after trying several times) which is shown in Figure 3.3.22. After adjusting, the curve of constant speed can be seen in mark 4 and 5 of Figure 3.3.22. The curves consist with the design of the system. Curves in Figure 3.3.20 and Figure 3.3.22 can be used as the E-cam curve of this labeling machine but with different adjustment. One of them cannot adjust the pulse from master axis while the other one cannot adjust the pulse from slave axis.

In Figure 3.3.22, the length of **Constant Speed Area** is 300000 PUU * (360° - 65°) / 360° / 1000(PUU/mm) = 245.8 (mm), which is longer than 23 cm. 65° is the time for **Acceleration / Deceleration Area**.
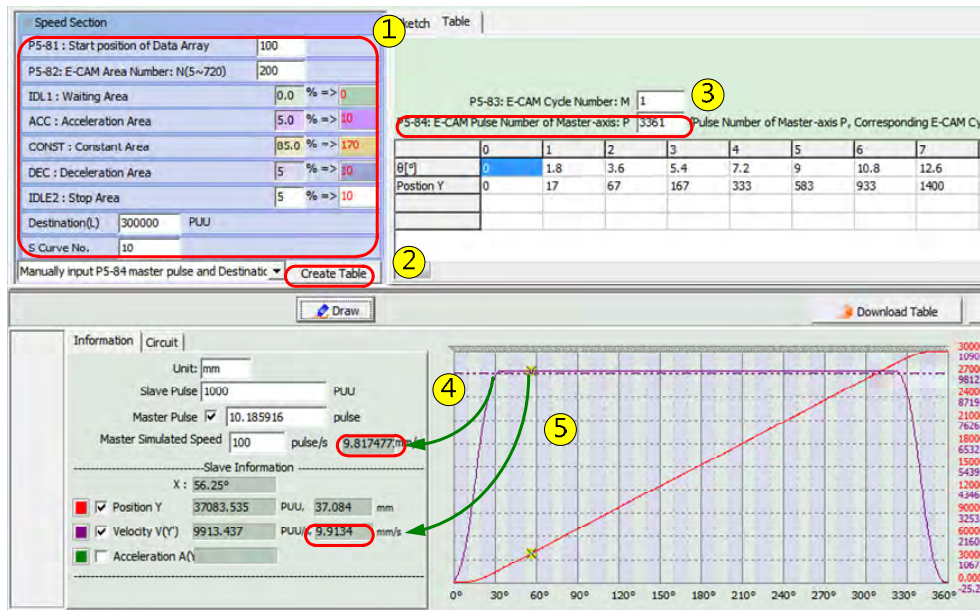
Figure 3.3.22 Adjust the E-cam curve of master axis lead

3.3.3.6 Analysis of E-cam Curve

In Figure 3.3.23, mark 5 shows the traveling distance of master axis and camshaft axis at 30° (before entering the **Constant Speed Area**).

Master axis: 3376*(30/360) = 281.333 (pulse), 281.333 / 10.185916 (Figure 3.3.23, mark 4) = 27.62 mm.

Slave axis (Move the cursor to 30° and access the position field): 15744.672 (Figure 3.3.23, mark 5) / 1000 (Figure 3.3.23, mark 4) = 15.74 mm.

From the above calculation, master axis travels 27.62 mm while slave axis only travels 15.74 mm before entering the **Constant Speed Area**. The difference between both influence the position of labeling start sensor, see Figure 3.3.24.

Before the camshaft enters the **Constant Speed Area**, it will travel 15.74 mm. If the highest speed of master axis is S (the highest speed the labeling machine could operate), then it will take T time (= 27.62/S) to travel 27.62 mm. Before entering the **Constant Speed Area**, the acceleration A of camshaft axis in **Acceleration Area** is:

A (Acceleration) = (S (target speed) – 0 (accelerate from 0) / T

α (angular acceleration)= A / r (rotary shaft radius)

T (torque) = J (inertia) *α (angular acceleration)

From the above calculation, T (the torque needed during acceleration) can see if this E-cam curve can meet the requirements or not.
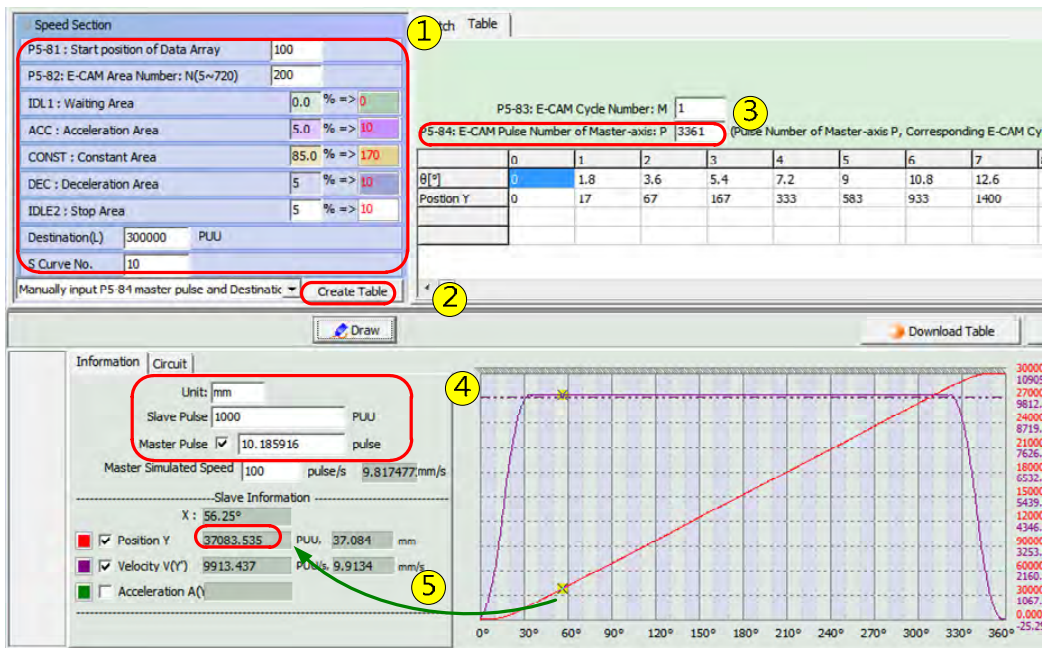
Figure 3.3.23 Analysis of E-cam curve
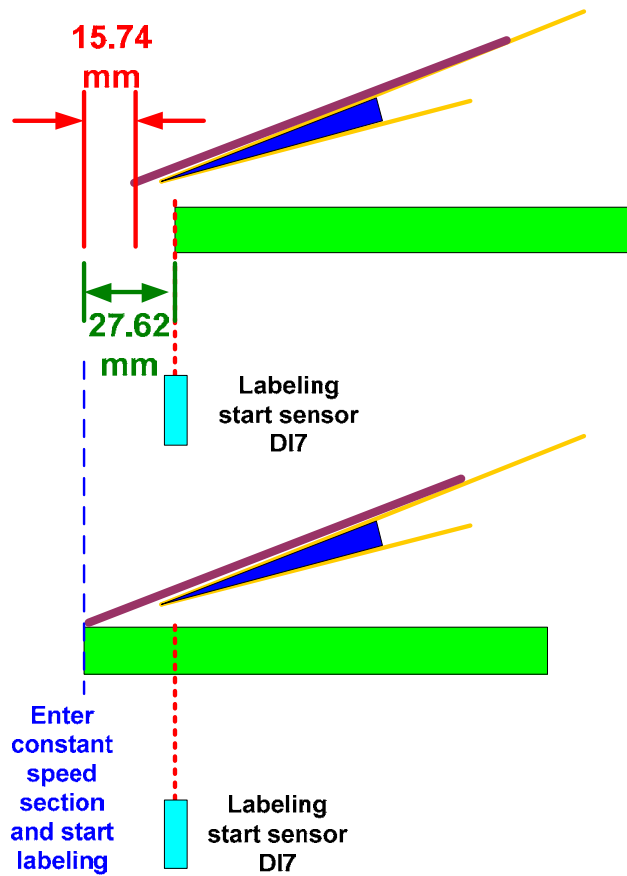
Figure 3.3.24 **Acceleration Area** and labeling start sensor

3.4   Printing Machine Application with Synchronization of Multiple Axes

3.4.1   Description

This section mainly describes the position synchronization application for shaftless color process printing. In this application, the position error is not compensated by ASDA-A2, but the host controller by sending the signal for position synchronization.

3.4.2   System Operation and Configuration

3.4.2.1   How to Configure Your System

When applying shaftless printing machine, position of all printing rollers have to be synchronized. If any of the printing rollers is deviated, position correction and compensation is needed. It can be done by E-Cam and PR overlap function provided by ASDA-A2. In this application, ASDA-A2 is unable to judge the compensation time and the amount it needs to compensate for the deviated position; however, it can control the synchronization of all printing rollers.
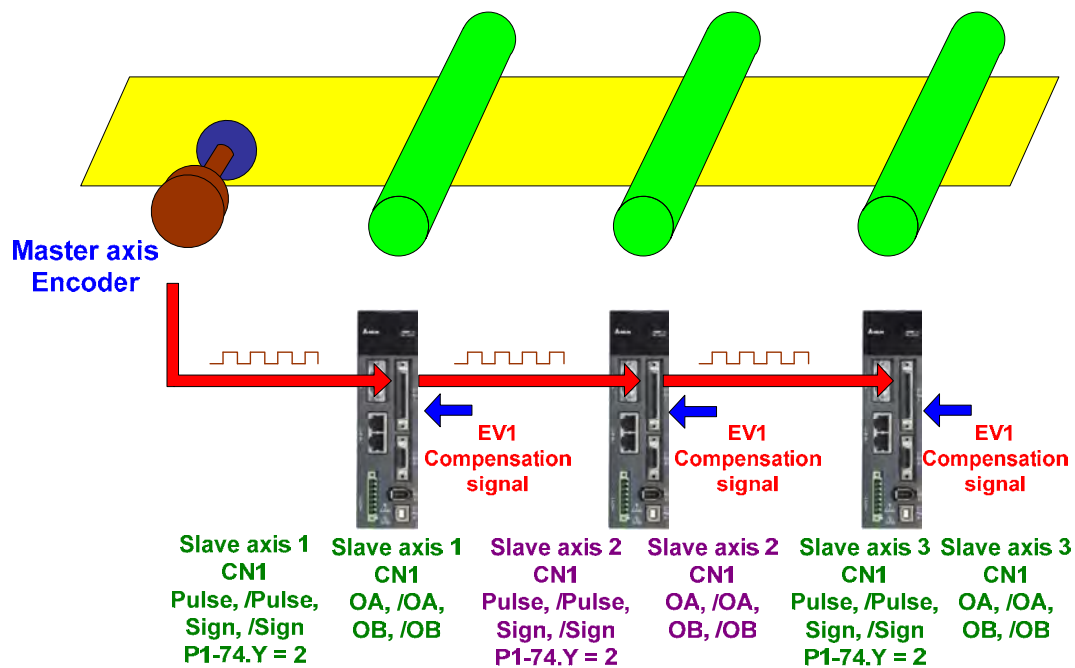
Figure 3.4.1 System Configuration

Passing on the pulse from master axis

Master axis needs to command the slave axis by passing on the pulse (for moving the material). Each axis has to be set with the function of pulse sending. The delay time set on each axis is 50 ns and will not weaken the signal strength.

EV1 position compensation

When EV1 is triggered by the controller, it will call the corresponding PR. This PR will execute one incremental command and complete the command with the speed higher than synchronous

speed. This could correct the relative position by promptly accelerating or decelerating the printing roller while it is still synchronized with the master axis.

3.4.2.2   Analysis of System Operation

When the system works normally, all slave axes follow the master with the same speed.
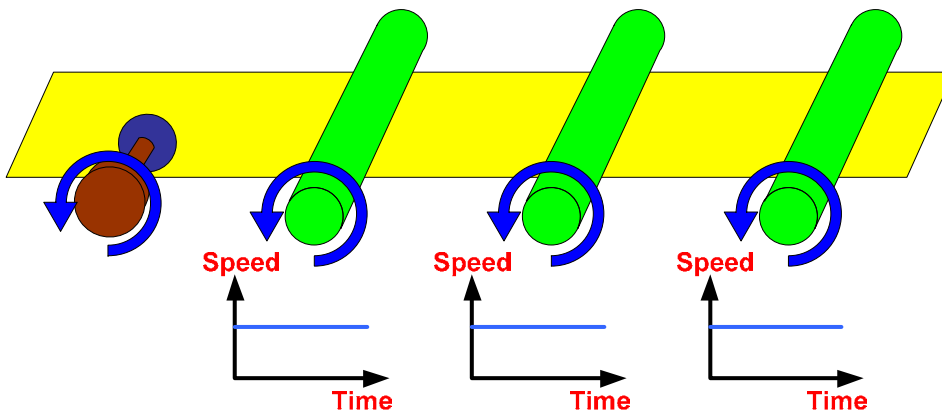
Figure 3.4.2 Normal operation of the system

When the host controller detects any of the axes is left behind, it will send EV1 signal. This is for urging the left-behind axis to move quickly and adjusting its position.
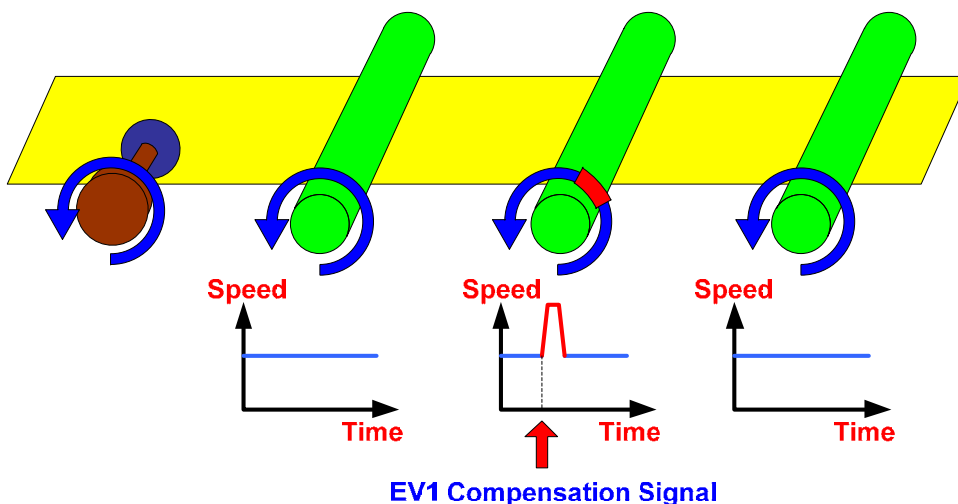
Figure 3.4.3 Host controller notifies the slave to do speed compensation

3.4.3   Servo System Setting

3.4.3.1   PR Procedure and E-Cam Curve

Master axis shall synchronize with slave axis. Both will be in linear relationship. The slave axis has to issue a PR with incremental command which connecting to this event (e.g. EV1). When the event is triggered, it will execute the corresponding PR command and start to compensate

the position.

Distance setting of PR incremental command

If EV1 is the DI signal for position compensation and P5-9 8 =0x0001, when this DI is triggered, PR#51 will be executed. See the setting of PR#51 as below:
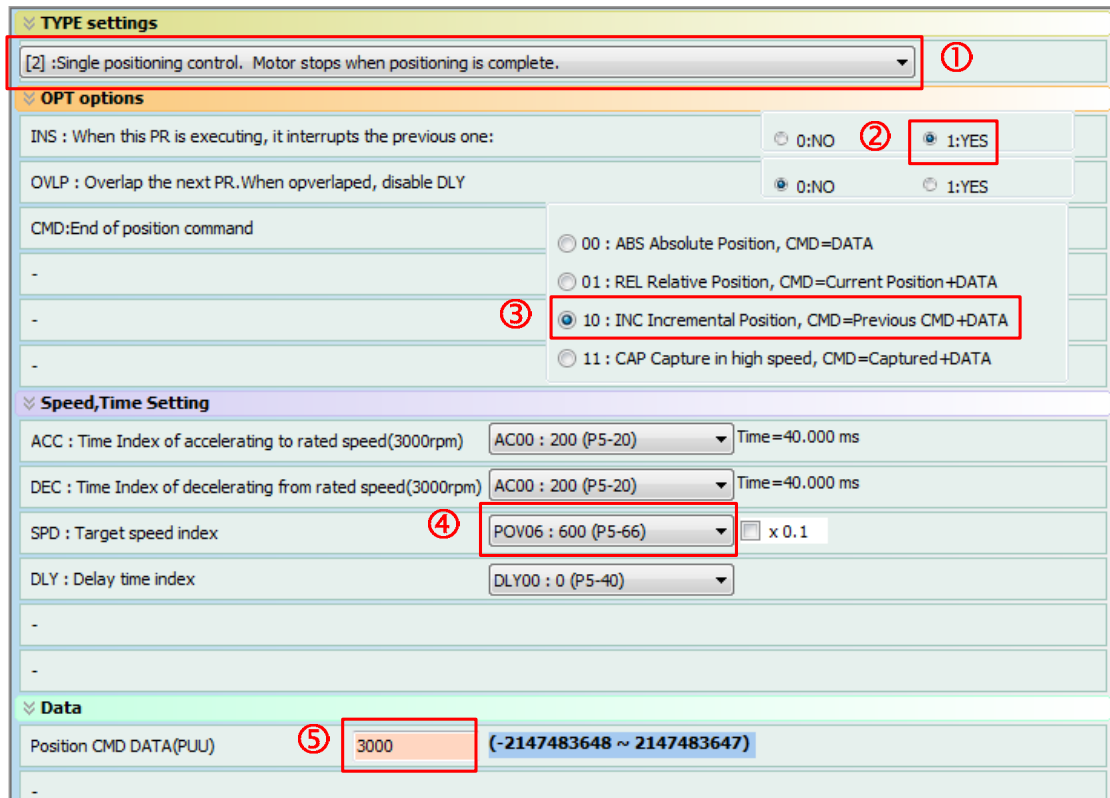
Figure 3.4.4 PR incremental command

In figure 3.4.4, mark 3, we choose 10: INC Incremental Position, CMD=Previous CMD+DATA (incremental command). SPD: Target speed index (Target speed) is selected in mark 4. The speed must be higher than synchronous speed. It can be adjusted in P5-66 by the host controller. Mark 5 indicates the position that needs to be compensated. The position value can be positive or negative. Positive value means the printing roller moves forward, while negative value means the printing roller moves backward. This value also can be changed in P7-03 (PR#51) by the host controller.

E-Cam curve setting

E-Cam curve and master axis are in linear relation. See figure 3.4.5 for the corresponding relation between master axis and E-Cam.
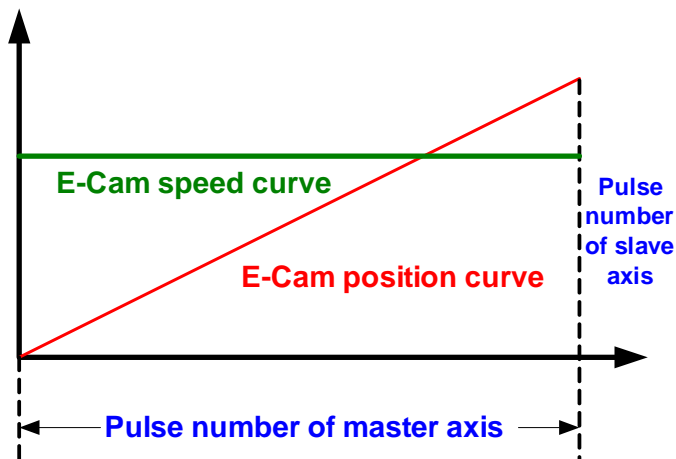
Figure 3.4.5 Traveling distance of master axis corresponds to the distance of E-cam

In figure 3.4.5, you can see the operation speed of master axis and slave axis presents a straight line, which means it is in normal operation. Slave axis and master axis run at the same speed. All printing rollers can adopt the same curve.

3.4.3.2   Simulative Operation

Following shows the result of simulative operation. We use time axis as the master axis and capture the operation curve by PC scope. See below for its setting and operation result.

	0	1	2	3	4	5
θ[°]	0	72	144	216	288	360
Postion Y	0	10000	20000	30000	40000	50000

Figure 3.4.6 Table of E-Cam curve
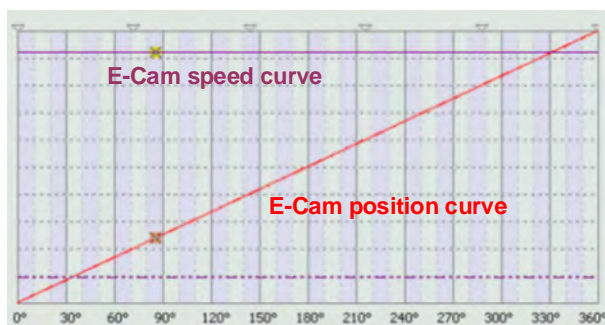
Figure 3.4.7 E-Cam curve

P5-83: E-CAM Cycle Number: M	1
P5-84: Pulse number of master axis: P	5000

Figure 3.4.8 Set up the pulse number of master axis

See figure 3.4.9 for E-Cam operation without compensation.
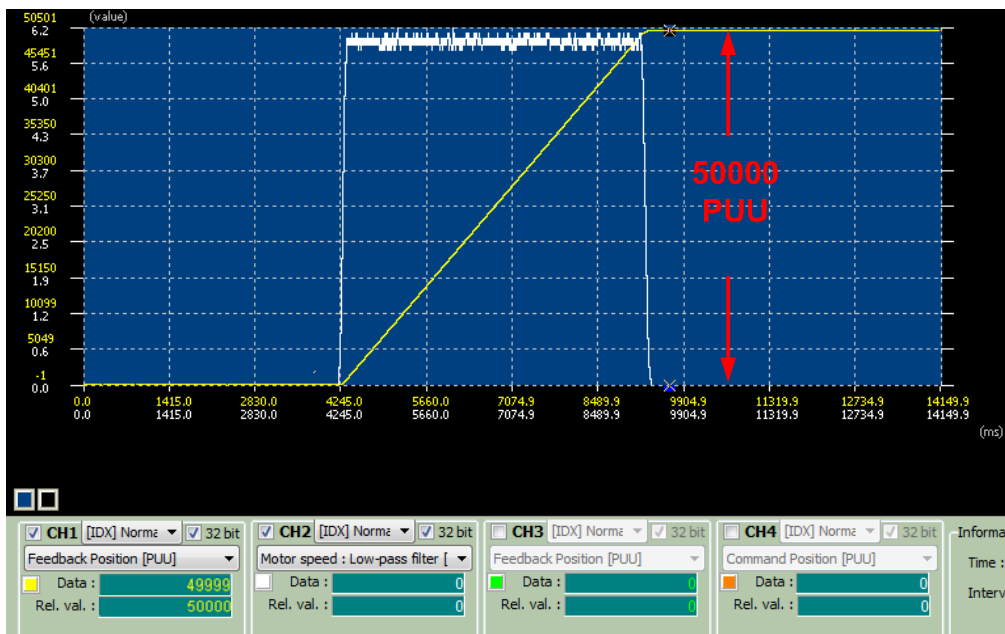
Figure 3.4.9 E-Cam operation curve without compensation

When forward shifting the phase, the printing roller moves forward for 3000 PUU. See the setting and operation curve below:
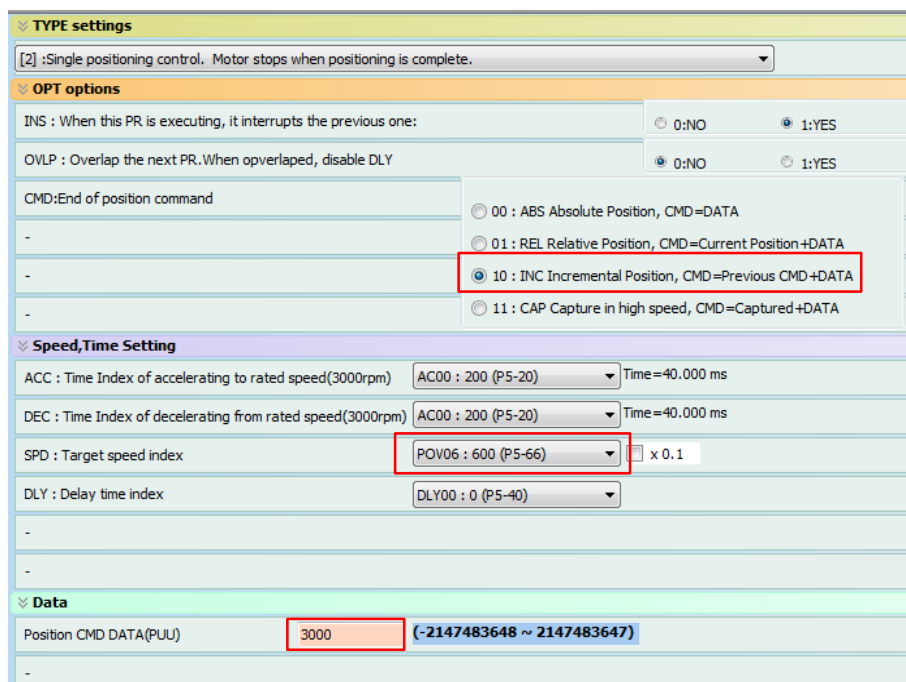
Figure 3.4.10 PR setting of forward phase shifting

E-cam command will overlap with PR. Since the operation speed of PR command is faster than E-Cam command, the phase will be moved instantaneously. See figure 3.4.11.
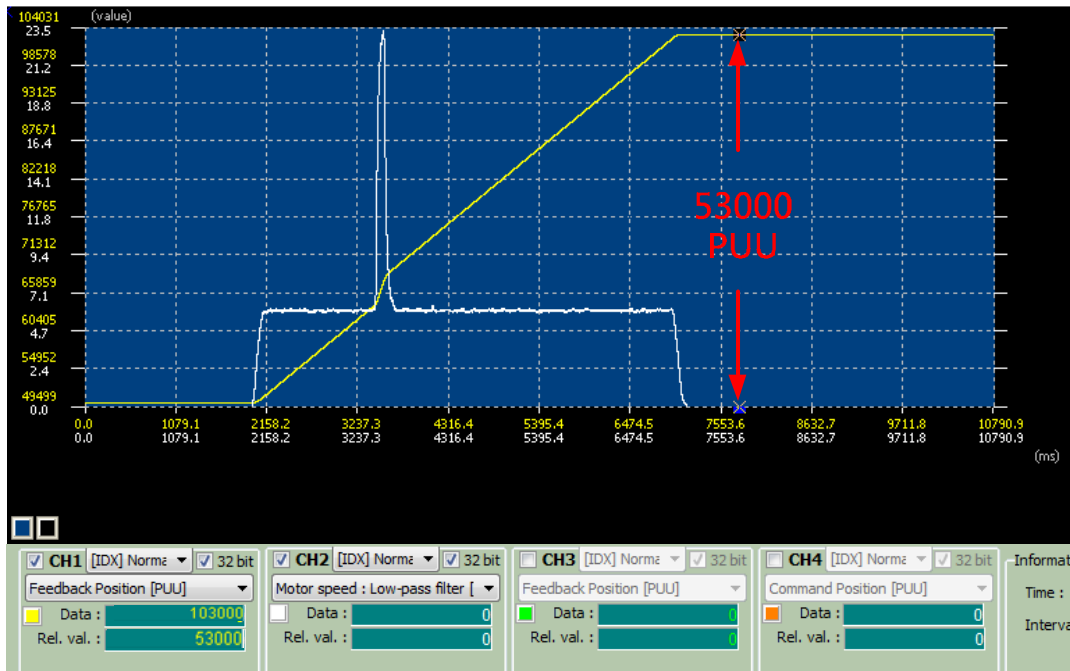
Figure 3.4.11 E-Cam operation curve of forward phase shifting

See PR setting for backward shifting the phase (= moves backward)
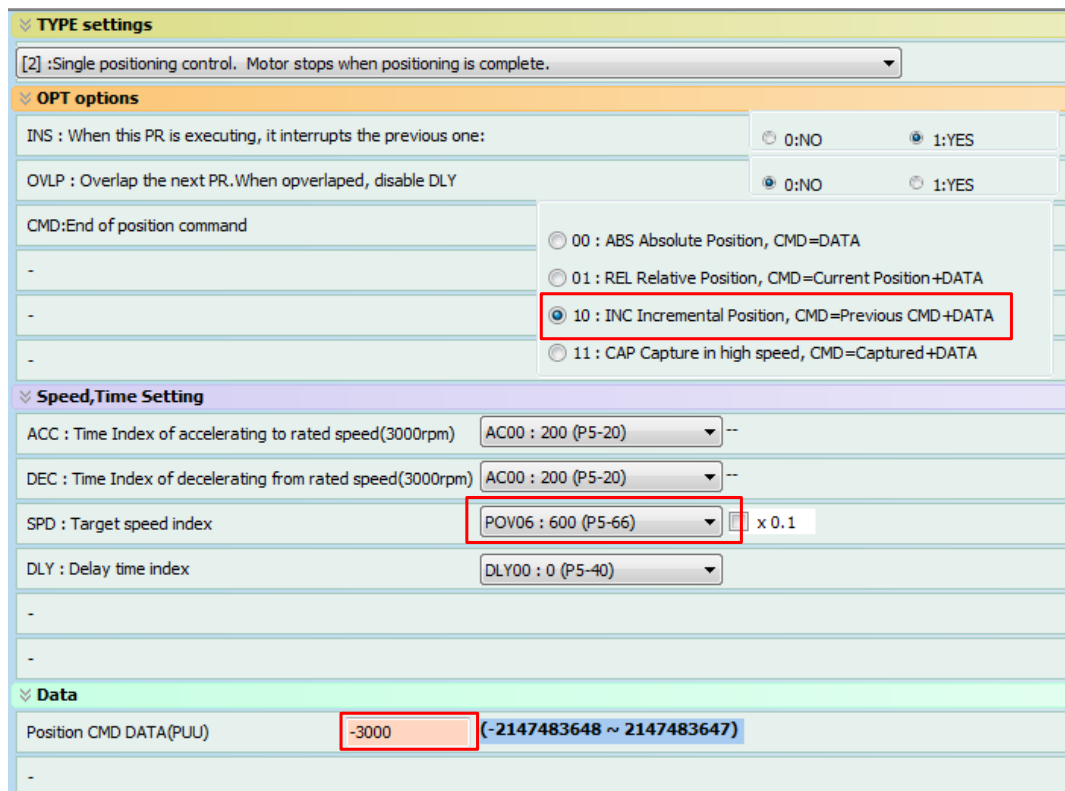
Figure 3.4.12 PR setting of backward phase shifting
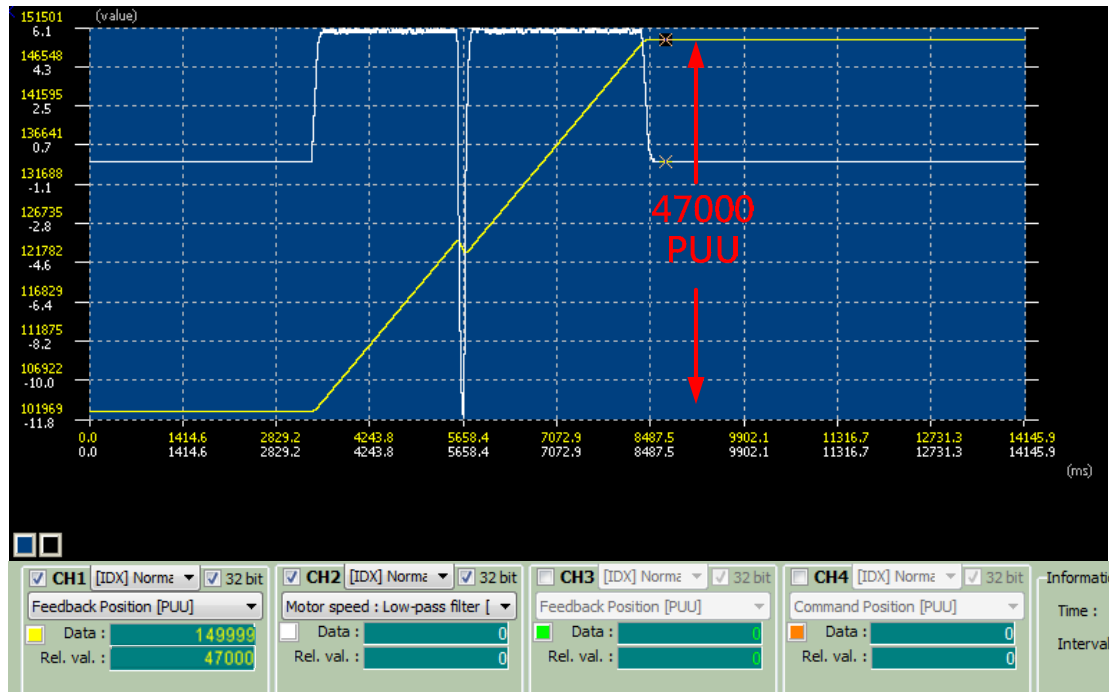
Figure 3.4.13 E-Cam operation curve of backward phase shifting

3.5   Application to Gantry

3.5.1   Introduction

This chapter explains the gantry setting and how gantry works when it is used on Delta ASDA-A2 series products. Users may increase or reduce control signals based on their needs. For other description of functions and commands, please refer to user manuals of Delta servo drive.

3.5.2   How Gantry works and the System Structure

3.5.2.1   How does gantry work?

Concerning the gantry control, two axes that control the platform must move with the same speed. A considerable deviation of moving speed between two axes might damage the mechanism. Thus, synchronizing the motion of two axes is the first priority. See the demonstration in Figure 3.5.1.
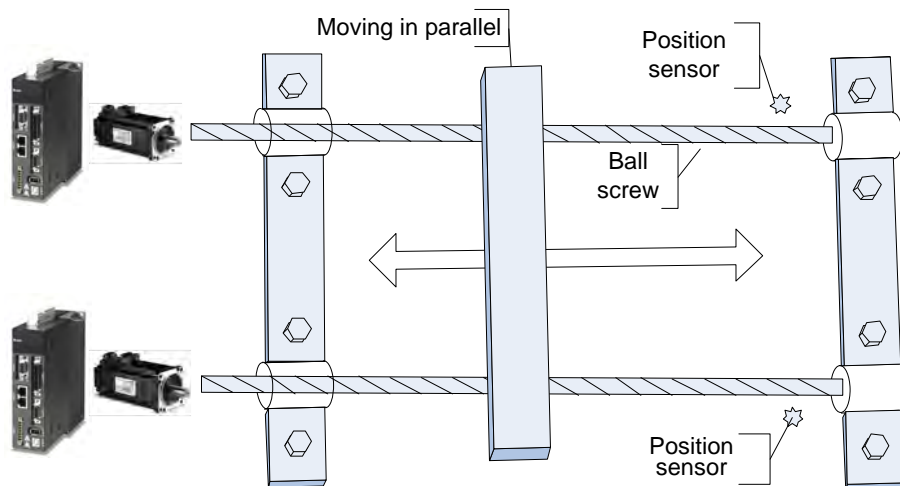
Figure 3.5.1 System Structure

The build-in gantry control function from Delta ASDA-A2 allows users to use the related applications. The controller will simultaneously follow the motion automatically. When position deviation goes beyond the permitted range, alarm will occur and system will stop working. In this application, an open-loop control is used by the host controller and ASDA-A2 servo system; the mission of the host controller is to send position commands, exercise sequential logic control, and give orders to the servo system to conduct initialization. That is, a host controller is in charge of the alignment and homing control of two axes. If regarding Z pulse as the homing origin, a host controller requires the capability to respond to the shortest Z pulse signal of 66 μs from ASDA-A2.

If misalignment of two axes does not occur on users' mechanism, positioning function is not needed. Otherwise, it requires positioning before gantry starts working because no chance will be given to adjust the two axes' relative position after it starts. The following is a reference of positioning and homing provided by Delta.

3.5.2.2 Positioning and Homing of Gantry

When gantry starts working, completed positioning and homing is required. Positioning is completed by a position sensor installed on the side of each axis. This position sensor must be correctly installed as this is the only part that enables the gantry to correct its parallel position. On gantry's moving platform, the sensing object with certain length is installed so that its length can be used to change gantry's moving speed. In this case, the positioning time can be shortened and precision level is improved. Also, please adjust the length and running speed of the sensor according to system requirements. Figure 3.5.2 shows the positioning control; after finishing positioning, positioning point can be regarded as the homing origin (shown in figure (3) of Figure 3.5.2). Or, as shown in figure (4) of Figure 3.5.2, the nearest Z pulse can also be the homing origin (either moving forward or backward to look for Z). The setting will be based on different circumstances and users' needs.

Figure (1) Returning to positioning point at high-speed

Figure (2) Encountering position sensor and operating at low-speed

Figure (3) Reaching the positioning point

Figure (4) Returning to search for Z pulse and regarding it as the original point
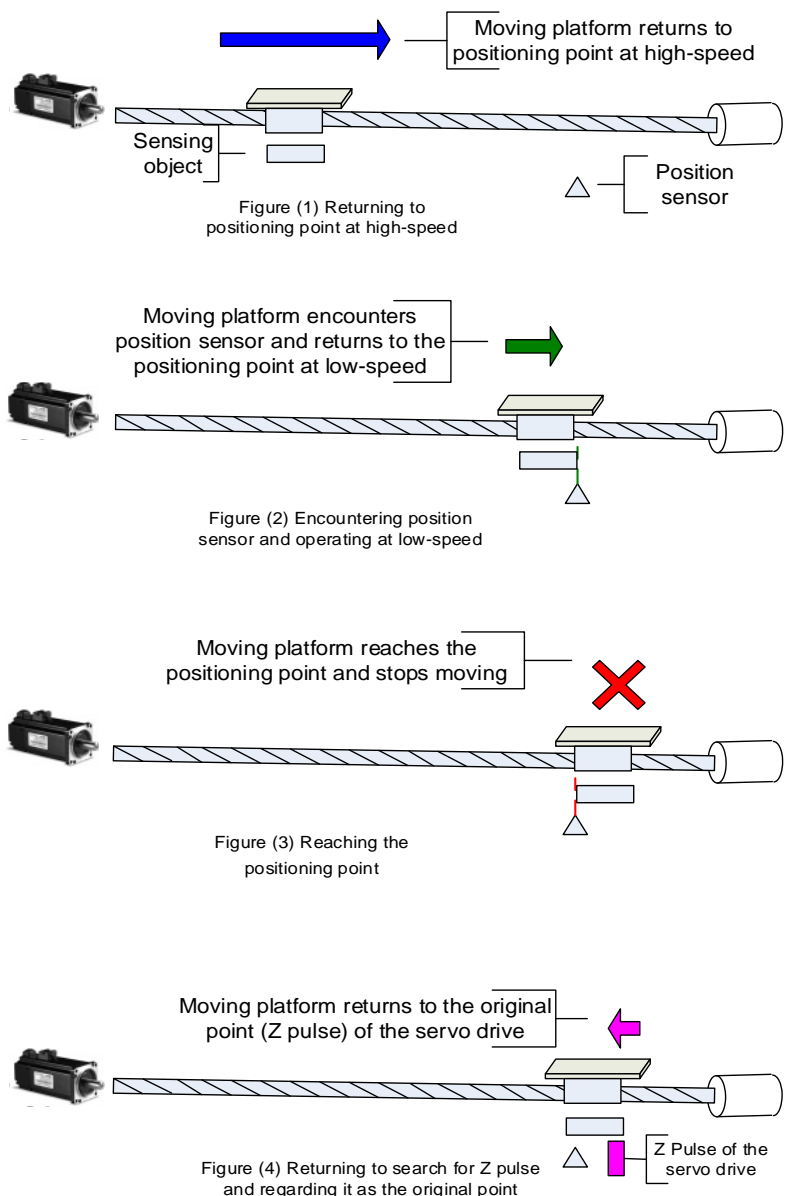
Figure 3.5.2 Returning to Positioning Point and Homing Origin

Figure 3.5.3 demonstrates the relative position between the sensing object and the position sensor. This is an example of a grooved-type photoelectric sensor.
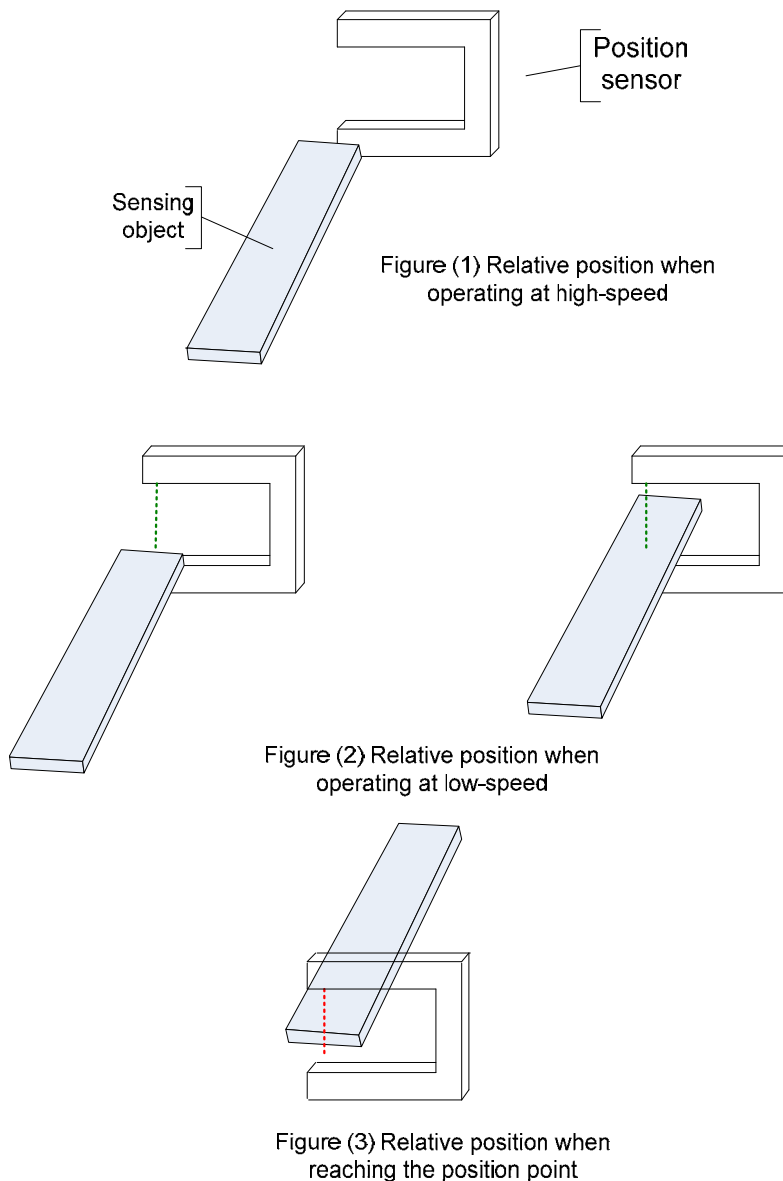
Figure 3.5.3 The Relative Position of the Position Sensor and Sensing Object

Figure 3.5.4 demonstrates the status before positioning. If position deviation between two axes has been existed, one of the axes will arrive at the low-speed zone earlier than the other. When any of the axes reaches the low-speed zone, the entire system will operate at low speed. Due to the deviation, the axis entering the low-speed zone first will reach the positioning point earlier. See the example shown in figure 3.5.4, Axis 1 that reaches the positioning point first will stop and waits for Axis 2 to arrive. After both two axes reach the positioning point, both axes can then move forward (or backward) at the same time and look for Z pulse as the homing origin. Positioning point can also be regarded as homing origin. It is determined by different applications and demands.
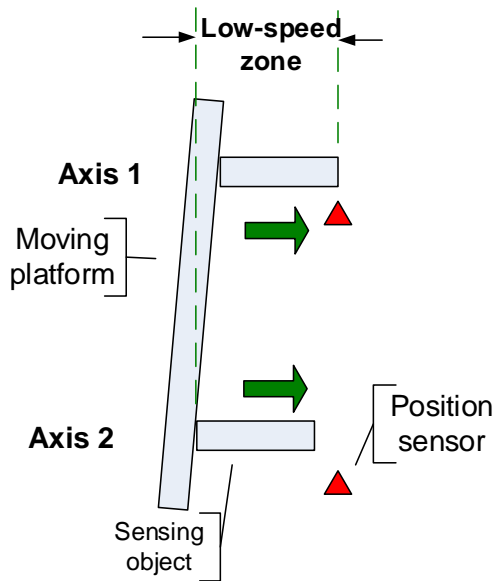
Figure (1) Entering low-speed zone
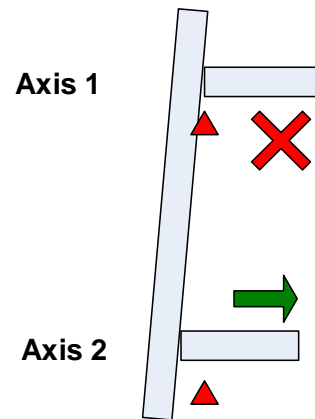
Figure (2) One axis is in position
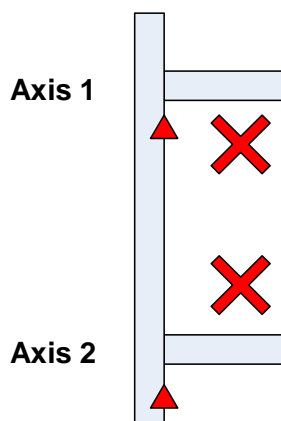
Figure (3) Both axes are in position
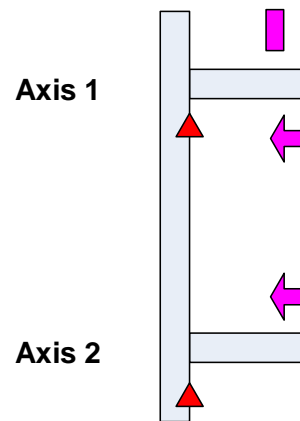
Figure (4) Both axes
synchronously return to Z pulse

Figure 3.5.4 System Positioning and Homing

3.5.2.3 Motion Following

When completing positioning and returning to the homing origin, the host controller has to issue position commands. Then, ASDA-A2 will synchronize the motion of the two axes with its remarkable performance. When reaching the position, ASDA-A2 is able to report its arrival to the host controller. In this gantry control, ASDA-A2 is operated in PT mode; it does not accept the position command from the host to speed up or slow down. Therefore, the host controller itself should plan the acceleration/deceleration time to achieve stability and efficiency.

3.5.3   Servo System Settings

3.5.3.1   Wiring

Figure 3.5.5 shows the wiring of the entire system. Users may apply different applications according to actual needs. Figure 3.5.6 shows the detailed wiring.

a.   DI signal

SON (0x01): System Start-Up; when system is activated, the start signal of each system is required.

CCLR (0x04): Pulse Clear; clear the pulse counter.

ARST (0x02): Alarm Reset; when any abnormality occurs, it is used to reset the system via the host controller or users may control it with the button. To avoid repeated starting up and shutting down the system during trial run, this signal can be used to clear the abnormality.

GTRY (0x0A): Gantry Stop (Pause); the following function of gantry does not work when this signal is on.

EMGS (0x21): Emergency Stop; external switch. Make sure that both two axes can synchronously receive this signal.

INHP (0x45): Pulse Input Inhibit; when this signal is on, any input pulse signal will not be admitted. Please note that this signal can only be set via DI8.

b.   DO signal

TPOS (0x105): Reach the Target Position, a reference for the host controller.

SRDY (0x101): System Ready, waiting for the start-up command.

SON (0x102): Servo on; servo system is able to receive commands from the host controller.

BRKR (0x108): Brake Release; for a motor system that uses brake, it has to be equipped with the function of brake release.
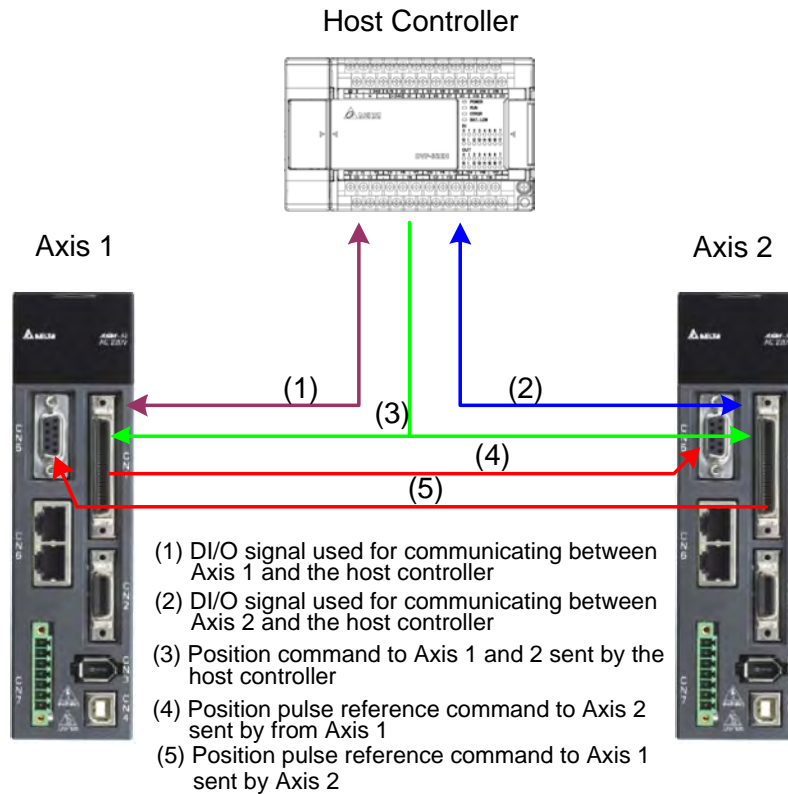
Host Controller

Figure 3.5.5 System Wiring Diagram

(1) DI/O signal used for communicating between Axis 1 and the host controller
(2) DI/O signal used for communicating between Axis 2 and the host controller
(3) Position command to Axis 1 and 2 sent by the host controller
(4) Position pulse reference command to Axis 2 sent by from Axis 1
(5) Position pulse reference command to Axis 1 sent by Axis 2

c. Pulse signal of position command

The pulse signal of host controller is directly parallel-connected and fed to both axes simultaneously. If using open collector, please carefully apply the wire and the power to avoid short circuit. ASDA-A2 supports three types of pulses; please refer to the manual for further information. If Z pulse is regarded as the homing origin, Z pulse from one of the axes should be sent back to the host controller.

d. The pulse signal communication between two axes

On Axis 1, CN1 will send pulse signals OA, /OA, OB, and /OB to OptA, /OptA, OptB, and /OptB of CN5 on Axis 2. Same as this wiring, on Axis 2, pulse signals OA, /OA, OB, and /OB from CN1 has to be sent back to CN5 of Axis 1, receiving by OptA, /OptA, OptB, and /OptB. This wiring is specially designed for the gantry, be sure to correctly connect them.

e. A detailed reference for wiring

Figure 3.5.6 is the detailed wiring reference. Users may take this reference to amplify or reduce the signal. This reference is for the wiring of servo system only. Direct signal input to the host controller such as position sensor is not included in this diagram. Be sure to reserve the DI/DO port on host controller.
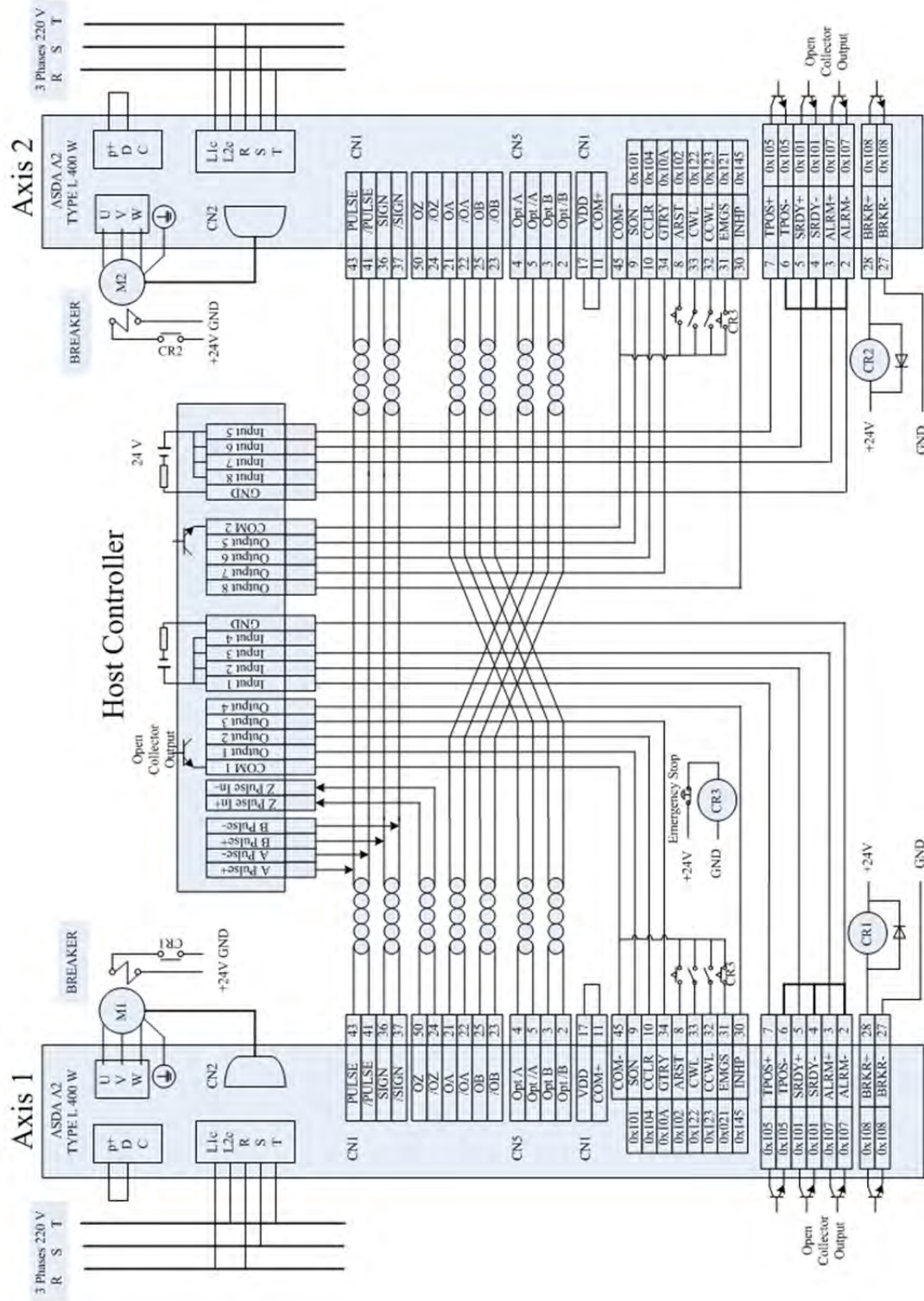
Figure 3.5.6 System Wiring Diagram (for reference)

3.5.3.2 Sequential Logic Control of Positioning and Homing

Concerning the gantry control method of ASDA-A2, the control logic of positioning and homing has to be completed by the host controller. The control sequence of a host controller and how it works is explained in previous sections. The detailed control flow chart is hereby presented. Users can decide whether to use either the positioning point or Z pulse as the homing origin.

a.   Two axes symmetrically return to positioning point

If no abnormality occurs when gantry is working, two axes will be in symmetry when performing homing as shown in Figure 3.5.7.
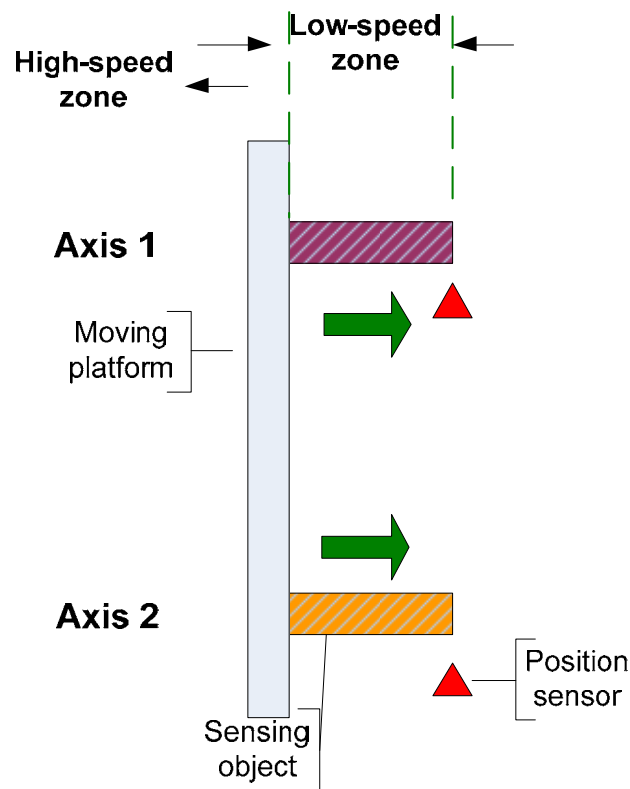
Figure 3.5.7 Two Axes Symmetrically Return to Positioning Point

b. The timing diagram of two axes symmetrically return to positioning point

Two Axes Symmetrically Return to Positioning Point
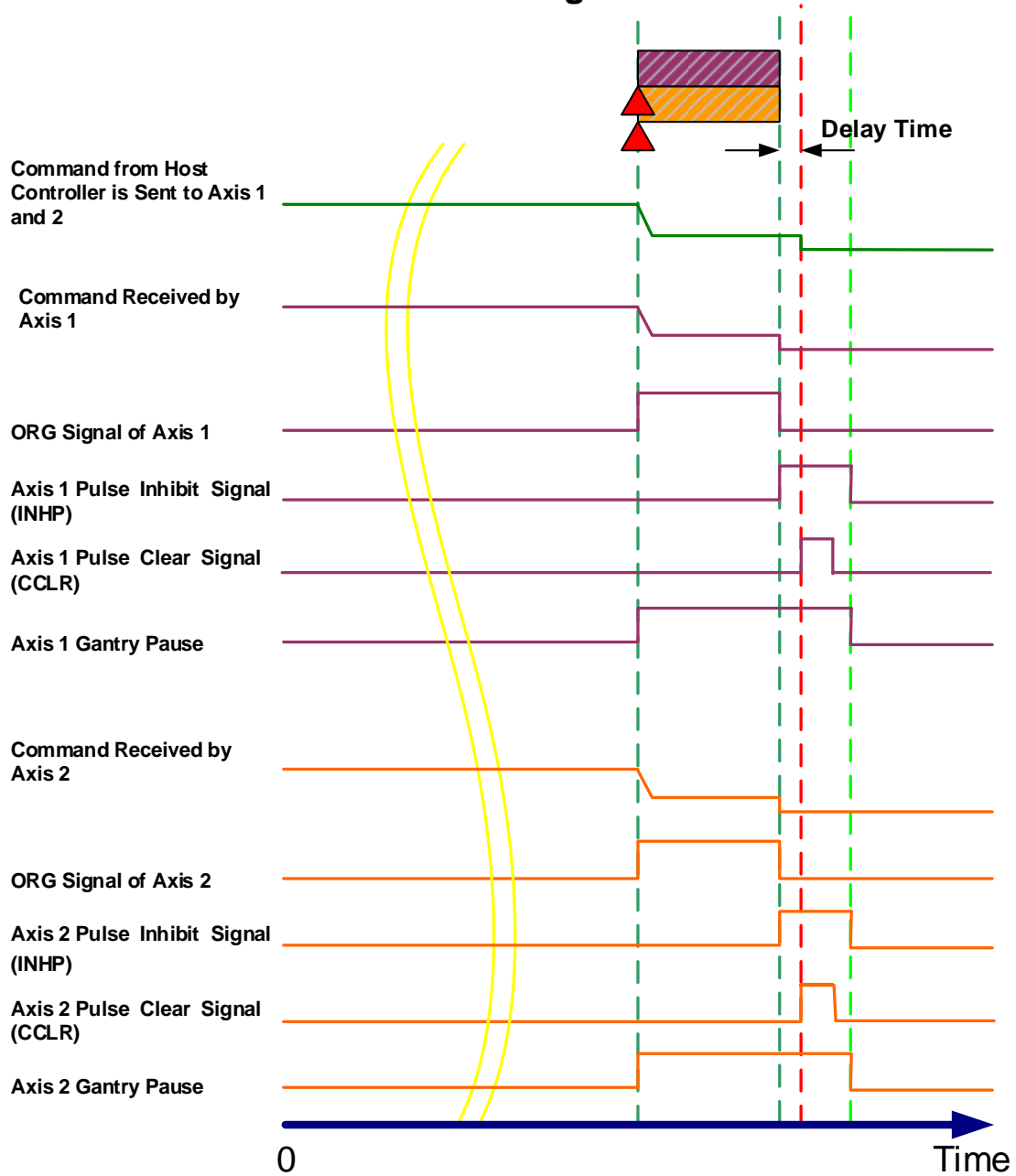
Figure 3.5.8 Timing Diagram of Two Axes Symmetrically Return to Positioning Point

c.   Two axes return to positioning point asymmetrically

Shown in Figure 3.5.9, if any unexpected problem occurs during the operation that results in asymmetry of two axes, the position of two axes can be corrected by homing.
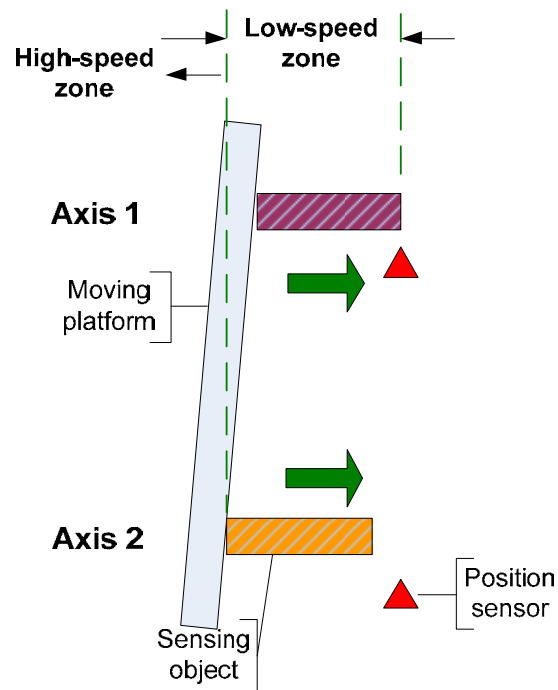
Figure 3.5.9 Two Axes Asymmetrically Return to Positioning Point

d. Timing diagram of two axes return to positioning point asymmetrically
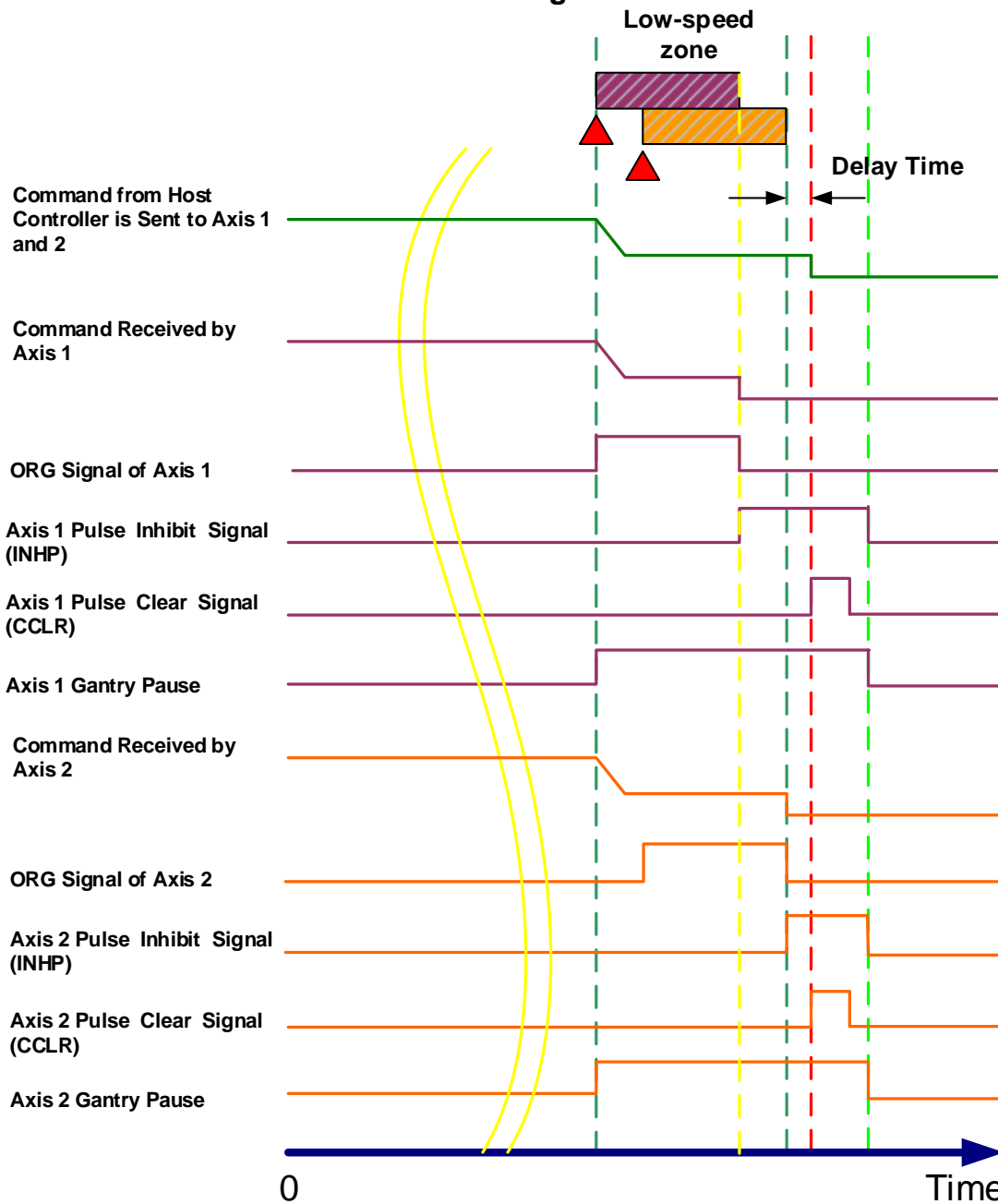
Figure 3.5.10 Timing Diagram of Two Axes Asymmetrically Return to Positioning Point.

e. Descriptions about homing

As Z pulse is set to be the homing origin, this figure below demonstrates how it searches for Z pulse of Axis 1. Please see the descriptions below.
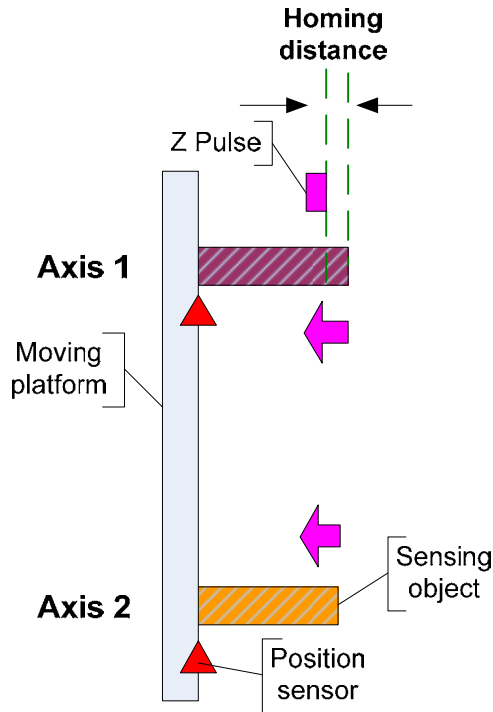
Figure 3.5.11 Homing

Figure 3.5.12 presents the position command that the host controller has to issue when homing. This figure shows the path when position command is executed.
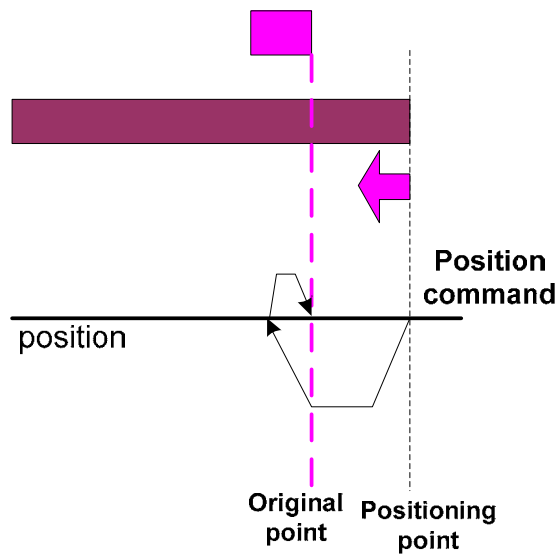
Figure 3.5.12 Homing Position and Command

f.   Signal control procedure of homing

Homing
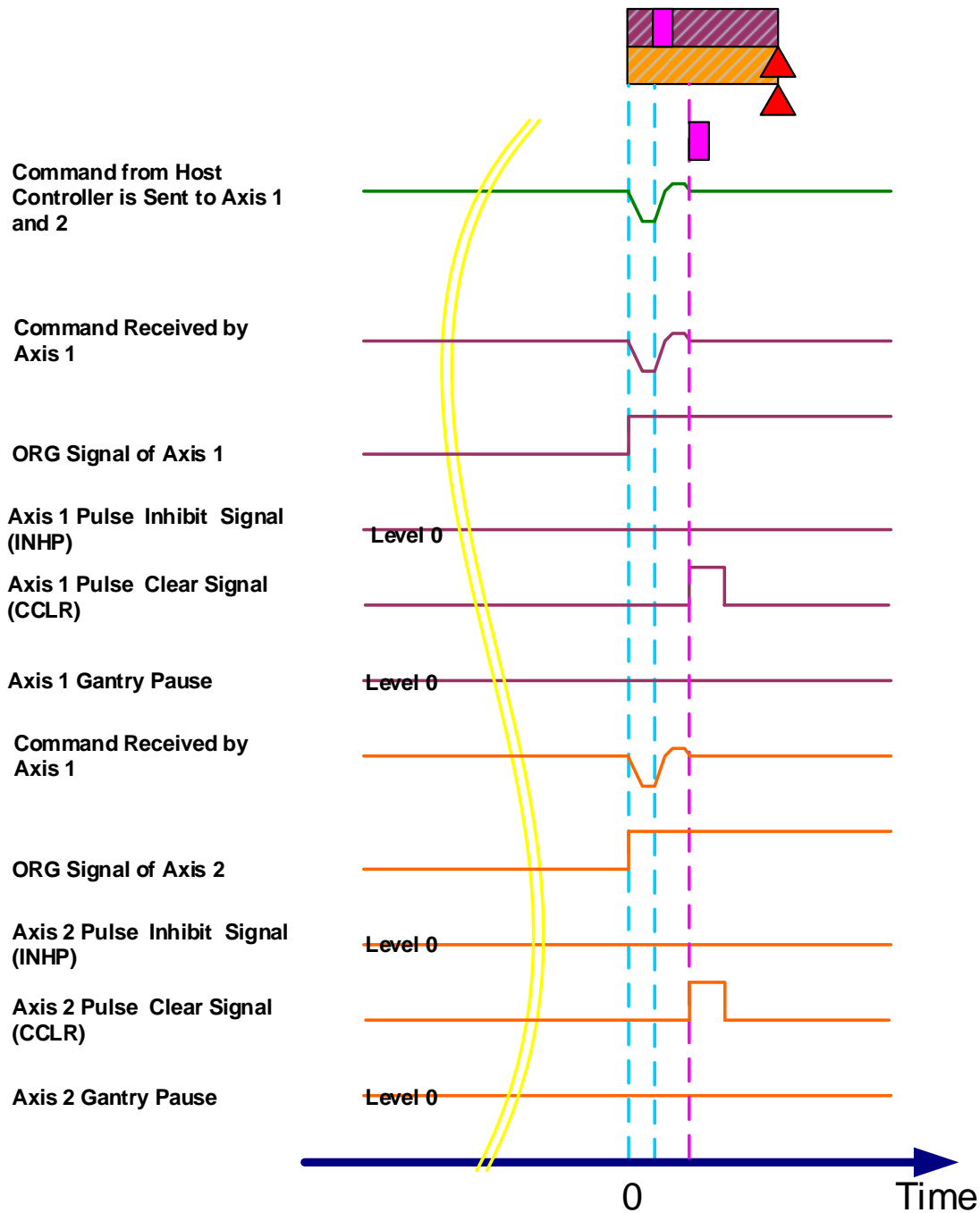
Figure 3.5.13 Timing Diagram of Homing

3.5.3.3   Steps for Adjusting the Servo when Using Gantry Control

The following steps are about the gantry setting and parameter adjusting.

Step 1: Check the wiring

Please refer to the application in section 3.5.3.1 and make sure the wiring is correct.

Step 2: Set up the inertia ratio of the system

Pause the gantry function. Check all the settings of every mechanism and servo drive such as emergency stop and positive/negative limit. Adjust the mode to J-L (for inertia monitoring) via monitoring panels of the two servo drives. Let the host controller issue a pulse command and make the gantry mechanism move back and forth with low speed so as to make sure the mechanism is working fine. Then, gradually speed up the gantry and monitor the inertia displayed on the panel. Wait until the inertia becomes stable and then write the inertia ratio into parameter P1-37 of each controller respectively (When mechanism structure is asymmetric, inertia ratio will vary with each controller). Inertia ratio is the calculation basis for servo motors' operation; this value must be correct.

Step 3: Output pulse setting for monitoring

Concerning the use of gantry synchronization, it is important to consider controller's receiving speed of monitoring pulse (which is CN5's capability of pulse receiving). The limit is calculated as below.

$$\frac{MotorSpeed}{60} * P1-46 * 4 < 8 * 10^6$$

Calculation Example:

The pulse command from one host controller at maximum speed is 50000 pulse/s. And the E-gear ratio is 20 times. When the encoder completes a full rotation, the feedback pulse is 1280000 (without going through the E-gear).

(Pulse command * E-gear ratio) / Actual pulse number * 60 sec. = Motor speed per minute (RPM),

(50000 * 20) / 1280000 * 60 = 46.875 RPM = the maximum motor speed set by the control command

Based on the above formula, the permitted maximum setting value of P1-46 (Pulse Number of Encoder Output) can be decided. Improper gain adjusting on a controller might lead to speed overshoot when the motor is operating; meanwhile, the motor speed might exceed the maximum speed set by the command; therefore, the overshoot level should be taken into consideration. For instance, if a margin of 10% is reserved, it has to be increased depending on the circumstances when using special mechanism.

(46.875 * 110%) / 60 * (P1- 46) * 4 < 8 * 10^6

Two servos' setting of P1-46 has to be the same; this is the output resolution of the motor. The higher the resolution is, the better control of the gantry will be. But, if it exceeds the controllable range, accuracy would be affected when calculating the deviation between two axes.

After setting up P1-46, please set up P1-72 (Resolution of Linear Scale for Full-Closed Loop Control): (P1-72) = (P1-46) * 4, both settings of the two servos should be the same.

Step 4: Set up the permitted deviation value of synchronization

Set up P1-73 the permitted deviation value of the two axes (for both servos). When the deviation exceeds the range, AL.040 will occur. Thus, be sure to consider the position displacement deviation of two axes that the actual mechanism can tolerate. **If the set deviation value goes beyond the actual mechanism's tolerance, the mechanical system may be damaged.**

For instance, the pitch of the ball screw is 10 mm, P1-46 = 60000 and P1-72 = 240000. If P1-73 is set to 30000 pulse, the deviation of two axes can be calculated as

$$\frac{30000}{240000} * 10 = 1.25 mm$$

, when the deviation of two axes is over 1.25 mm, the alarm will occur.

Step 5: Check if phases of monitoring pulse and feedback pulse are compatible

Prepare the scope from PC software. As demonstrated in Figure 3.5.14, enter the monitoring address and check if the system setting is correct.

1. At the bottom of the scope, select ADR and 32 bit of CH1 and enter 0x3F9060 in yellow blank, which is the feedback pulse number of linear scale port (CN5) in the servo drive. This would be a 32 bit value (monitoring the moving direction of synchronous servo drives).

2. Select 32 bit of CH2 and select Feedback Position in white blank. This is the feedback pulse number of the motor (monitoring the moving direction of the servo drive that connected to the scope).

3. Let the host controller issue position command and make two motors moving at the same time, and then monitor the variation of PC scope. See Figure 3.5.4, the increasing amount of signal of CH1 and CH2 are in reverse. If DI signal of CN5 is not moving in the same direction, as long as the gantry synchronous control is activated, the alarm will be triggered because of exceeding the permitted deviation of two axes. For the setting in this system, when the value of P1-74 is set to 100, the feedback signal of CN5 will be in reverse direction.
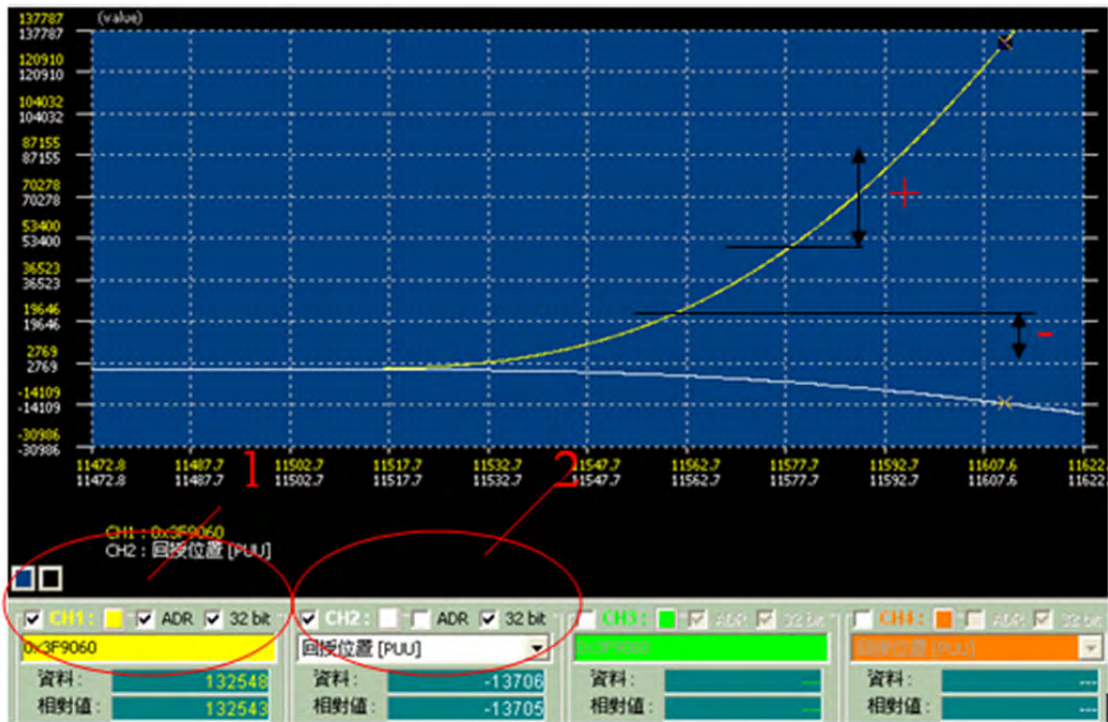
Figure 3.5.14 The Phases of Feedback Pulse in the Opposite Direction

4. If the setting is correct, the signal will be the same as shown in the figure below; the increasing amount is in the same direction. (The zigzag signal shown in yellow is normal because value resetting is done to avoid overflow.)
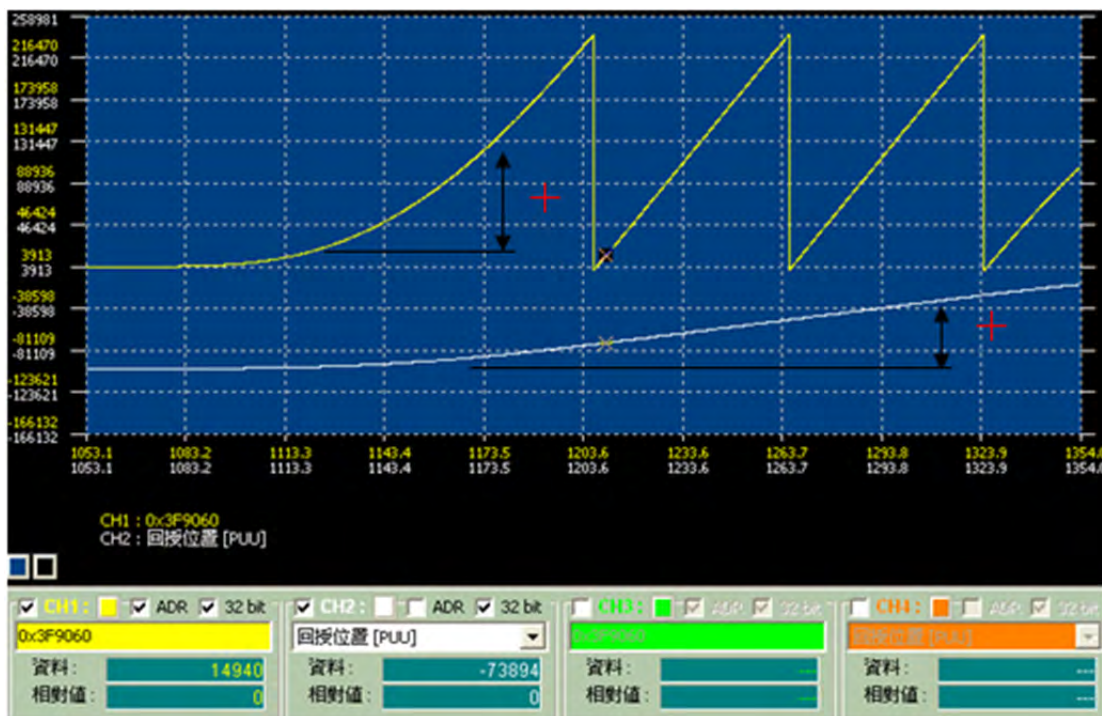
Figure 3.5.15 The Monitoring Phase of Feedback Pulse is Identical

5. Then, connect the PC scope to the other servo drive and make sure the phase of feedback pulse is correct.

Step 6: Activate the synchronous control

Activate the synchronous control via P1-74; set digit in ones to 2, the synchronous control of gantry will be activated.

Step 7: Trial runs

1. **Let gantry function remain in pause so as to assure the mechanism is safe when adjusting parameters.**

2. After setting the bandwidth to a proper value (adjust from small to large), let host controller issue position commands and observe the position deviation and synchronization of two axes via PC scope. Same as the setting in figure 3.5.16, select CH1, ADR, and 32 bit and then enter address 0x3F9F98; this would be the position deviation between both axes and the unit is pulse (using full closed-loop resolution P1-72 as a basis). If the deviation of two axes exceeds the setting value, alarm will occur. In general, there is no chance that the loading conditions of two axes are exactly identical, the acceleration/deceleration process will thus leading to a rather large position deviation.
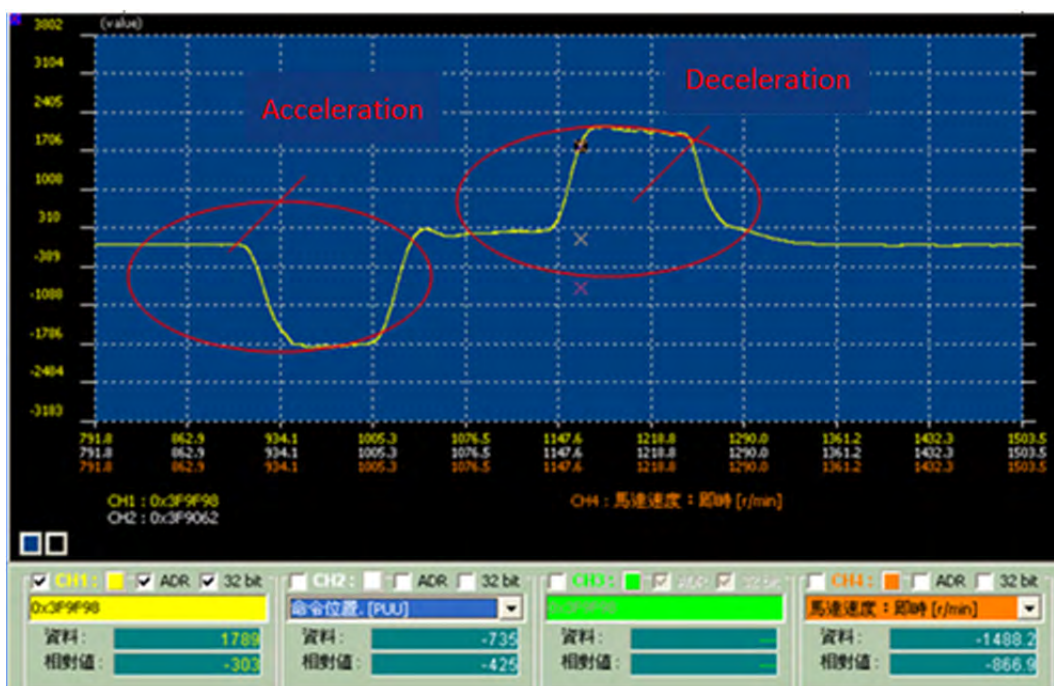
Figure 3.5.16 Monitoring Position Deviation of Gantry

3. When conducting trial runs, be sure to adjust the parameters to proper values; the bandwidth settings of the two controllers has to be identical so as to avoid alignment deviation due to their different response time. When executing the acceleration/deceleration command from the host controller, the position deviation has to be within the setting range of P1-73; otherwise, the alarm will occur.

Step 8: Synchronizing test and parameters adjustment

1. Be sure to complete the steps described above. Then, please use parallel connection to connect the gantry mechanism between two motors and then start testing the gantry.

2. Please do Step 2 mentioned above again. Re-estimate the system inertia; otherwise, the system setting will not be accurate and unable to work properly. If the mechanism is not symmetric, inertia ratio of two axes would be different.

3. The system has to be in protection of miss-synchronization and the deviation value of P1-73 must be absolutely correct.

4. Basically, the bandwidth settings of both servo drive and gantry synchronous control has to be identical. The bandwidth of the servo drive can be calculated and set in Auto Gain Tuning via ASDA Soft; Gantry bandwidth can be set via P2-57 (The Bandwidth of Synchronous Control). See Figure 3.5.17.

Error tolerance set in P1-73

big ⟵		⟶ small

Bandwidth proportion

100 %		10 %

Bandwidth proportion = Servo bandwidth / (Servo bandwidth + synchronous bandwidth)

Servo bandwidth	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%
Synchronous bandwidth	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%
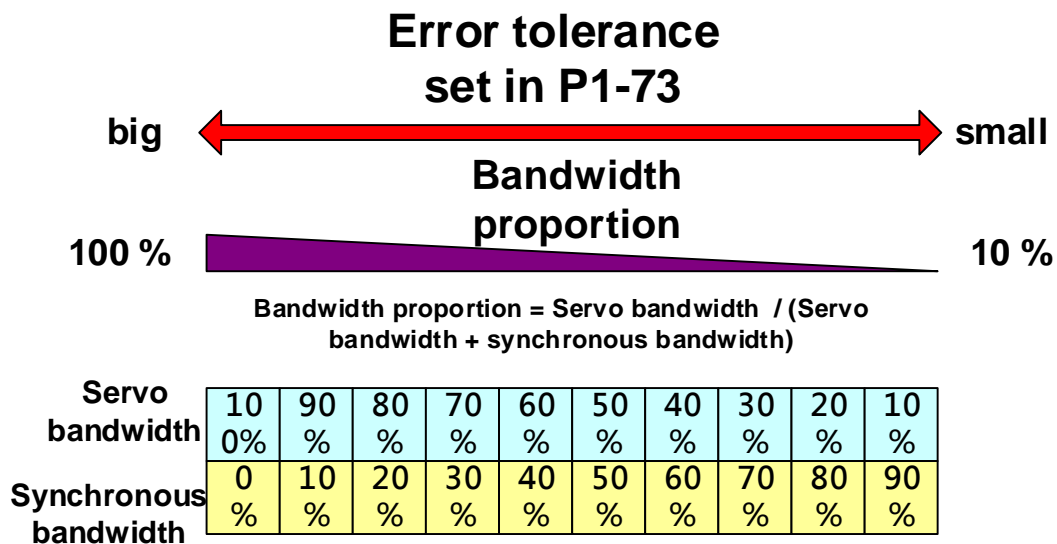
Figure 3.5.17 Setting Up Bandwidth Proportion

Regarding the synchronous bandwidth, users have to set P2-57 (The bandwidth of Synchronous Control) only. The system will automatically calculate the value of P2-54~P2-56 (the related parameters of synchronous control). When the bandwidth setting of synchronous control is wider than the bandwidth of servo drive, the following result between two motors is better. (However, the following for the host controller will be relatively worse). Please note that when "Bandwidth of synchronous control + Bandwidth of the servo drive> Permitted bandwidth of the system", it is easier to cause resonance. If bandwidth cannot be increased in order to achieve better following, please try to increase the value of P2-55 (Integral Compensation to Synchronous Position). However, if the value of P2-55 is set too high, system vibration will occur. When deciding the bandwidth, be sure that the setting value of P2-25 is much bigger than the bandwidth setting; otherwise, the result might not be satisfactory and system might become unstable if worse.

When adjusting the bandwidth of the synchronous control, start from small to large.

The synchronous control of the gantry is shown in Figure 3.5.18.
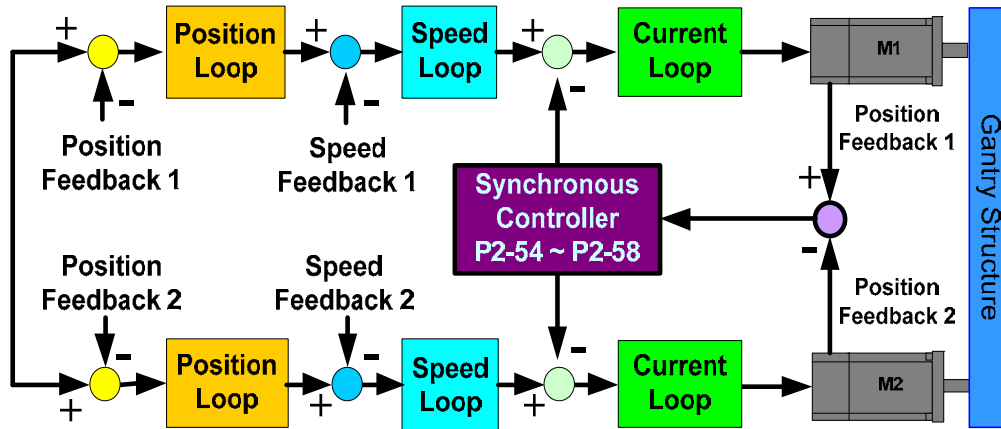
Figure 3.5.18 Gantry's Synchronous Control Structure

3.6   Application Example of Packing Machine

3.6.1   Description

This chapter aims at the application of ASDA-A2 on packing machine, which is for suing the compensation of flying shear and mark tacking. If the film has improper tension adjusting, mechanical slips or the distance between marks is different, ASDA-A2 has the automatic correction feature to correct the errors. Moreover, functions such as to avoid empty pack, to stop cutting when the package is in wrong position so as to avoid damaging the mechanism, function of initial position adjusting, to produce the adequate E-cam curve base on different width of cutter as well as the masking function between marks all provided by ASDA-A2.

It offers a novel way for servo drive users in packing industry, including the servo system with motion command and brings a faster and more smoothing operation. Dramatically increase the performance and reduce the cost of design and development. Especially the function of mark tracking, it is definitely a great tool for the application of flying shear.

3.6.2   System plan

The packing system consists of three main parts, see Figure 3.6.1. The film feeding axis is the master axis. When it is delivering the film, it issues the pulse to command the slave axes. The first slave axis is the cutting axis for sealing and cutting while the second one is the chain conveyor which is used for delivering packages. The name of the first and second slave is only for explanation in this chapter and is not named in sequence in real application. It is the typical packing system. E-cam and motion control function of ASDA-A2 can satisfy the demand of each main control in this framework.
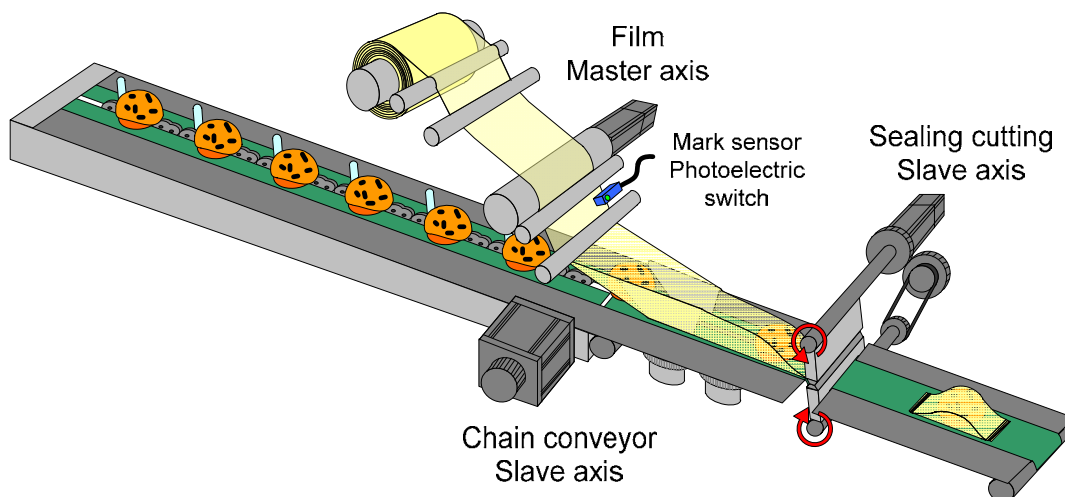
Figure 3.6.1 Packing system

3.6.2.1 Master axis (Film feeding axis)

This axis is for delivering the film for packing. The delivery should be smooth, e.g. the mechanical tension should not be too big or it might extend the length of film. However, if the tension is loose, the film feeding bobbin would slip easily. The above two situations would cause the problem that the pulse number sent by master axis does not consist with the length of film. Although the error could be corrected by ASDA-A2, a smoothing film delivery is still a vital task for packing machine.

3.6.2.2 Camshaft (Flying shear)

The design of flying shear should consider the proportion of actual cutting length and flying shear spacing. The disproportion would cause the dramatic speed change while cutting and might become the bottleneck of improving the productivity. Take Figure 3.6.2 as the example, for the same length of cutting within the same time, the distance the single cutter travels is two times of two cutters (the distance between tools). If the required cutting distance is short, single cutter is easier to reach the limit (acceleration / deceleration limit and torque limit) than two cutters. This is because the single cutter needs to travel longer distance for a cycle. With the same speed, it needs a faster acceleration and deceleration. Thus, this issue should be taken into consideration when designing the mechanical structure. Using ASDA-A2 to control flying shear, camshaft would have the mark tracking function. Please see later parts for further details.
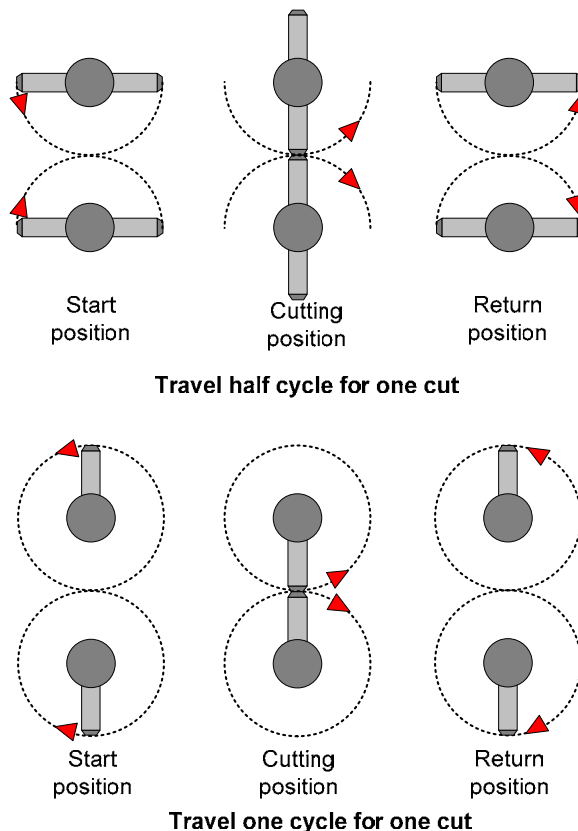
Figure 3.6.2 The comparison of cutting travel distance

3.6.2.3   Camshaft (Chain conveyor)

Chain conveyor receives the pulse sent by master axis and synchronizes with master axis. With ASDA-A2, this axis has the function of pulse tracking and mark correction which will be elaborated later.

3.6.3   Servo system setting

3.6.3.1   System configuration

While the master axis delivers the film, it sends the pulse to camshaft simultaneously. Since ASDA-A2 has built-in function of pulse by-pass, when sending pulse to slave axes, the delay time of each axis is 50 ns and the signal will not be attenuated. Repeater is included in ASDA-A2 servo drive, thus, it will not increase the cost when applying to multi-axis. Apart from pulse, mark signal also needs to be distributed to two slave axes so that the system can conduct the function of mark correction, see Figure 3.6.3.
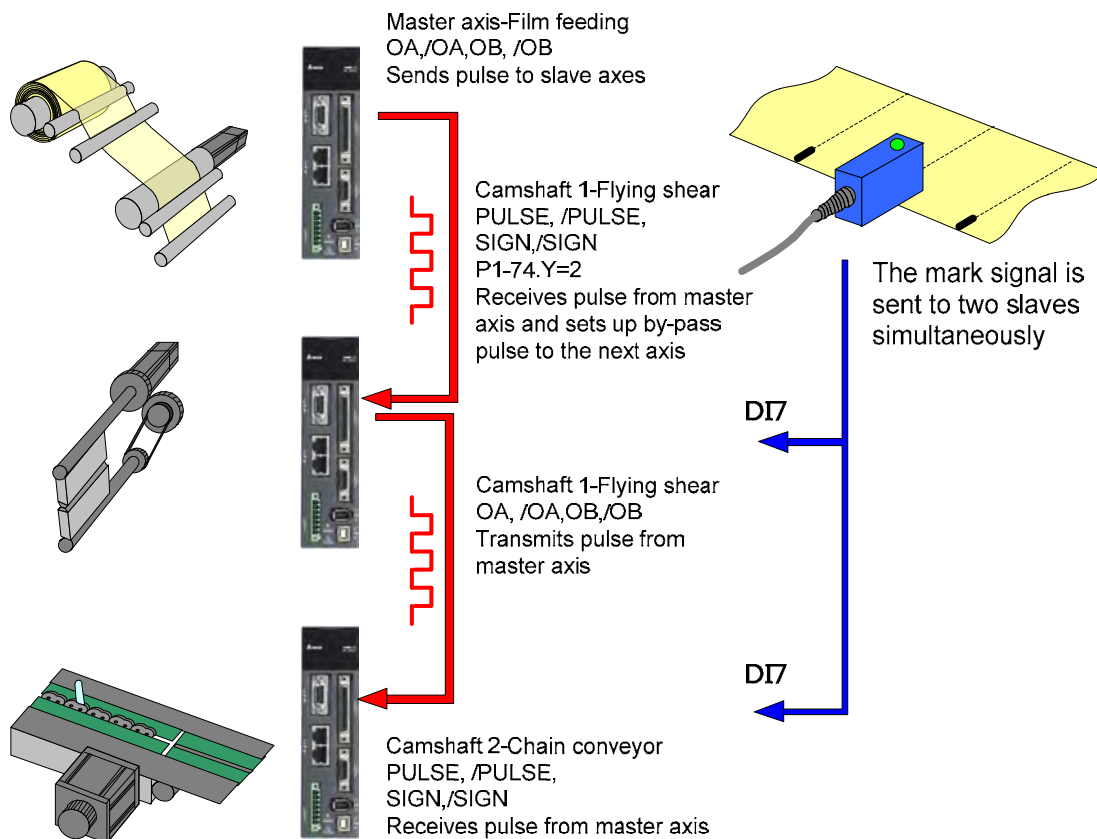
Figure 3.6.3 System configuration

For different color of mark, e.g. black mark with white background or vice versa can be done by changing the setting of ASDA-A2. No need to change the photoelectric switch to read the mark, see Figure 3.6.4.
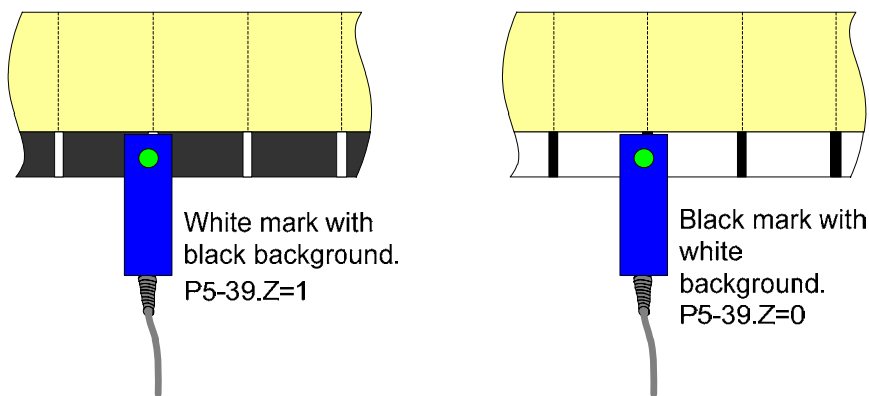
Figure 3.6.4 The setting of different color mark

3.6.3.2   Function introduction

Adjusting the cutting position

A great development of ASDA-A2 on packing machine is the function of mark correction. The packaging film has ductility, thus it is very sensitive to different tension. When the tension is too big, it would extend the length of packaging film; if the tension is loose, the packaging film slips easily. These two situations would cause the default pulse number cannot consist with the cutting length and result in incorrect cutting. Synchronous capture axis of ASDA- A2 is design for improving this situation. When the film is deformed or slips, the cutter is unable to aim at the default cutting point, the system will be compensated by this function and the cutting position will be adjusted to the right position. See Figure 3.6.5.
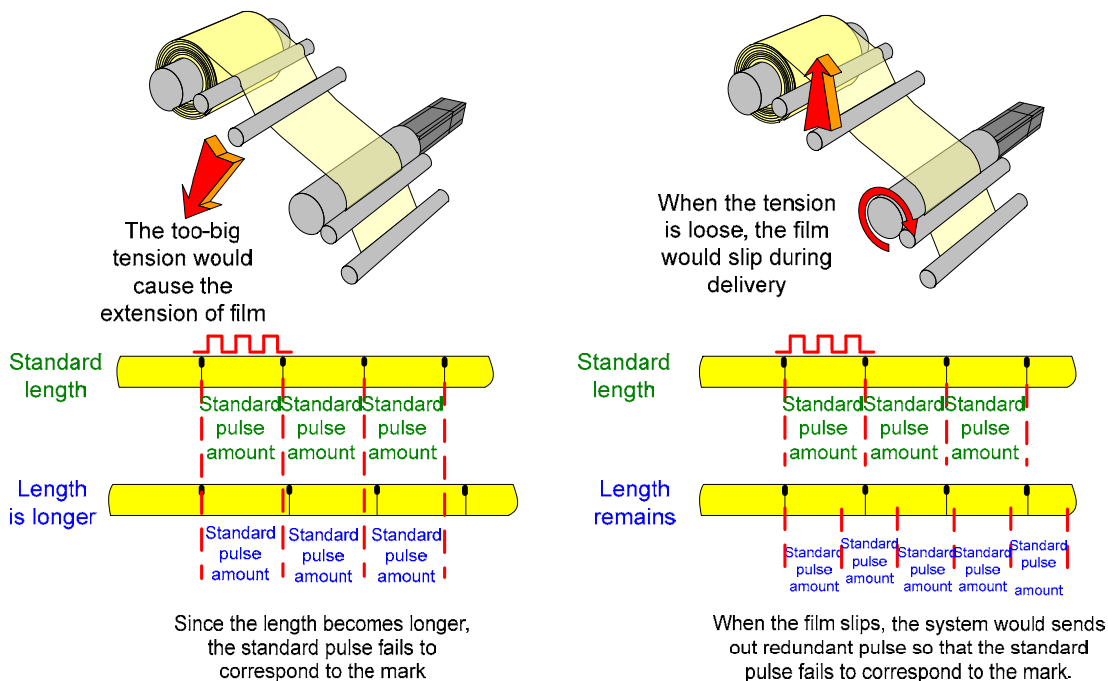
Figure 3.6.5 The cause of incorrect cutting position

Build-in function of masking and cutting with missing marks

The system inspects the actual length by marks printed on packaging material. Thus, mark plays an important role to the system. To make sure the mark can be read by the system is a vital task. In order to avoid the spot interference between marks, ASDA-A2 is embedded with masking function which can setup the start position of reading the mark. Besides, when the mark is poor printing, the system is still able to trim according to the last cutting length and makes the correction when the mark appears again.

Masking area. Signal inside this area will not be sent to the system in order to avoid the malfunciton.

When the mark sensor detects this spot, signal will not be set to the system.

This mark is poor printing and the mark sensor will not output the signal. But the system operates normally, which will cut according to the previous length.
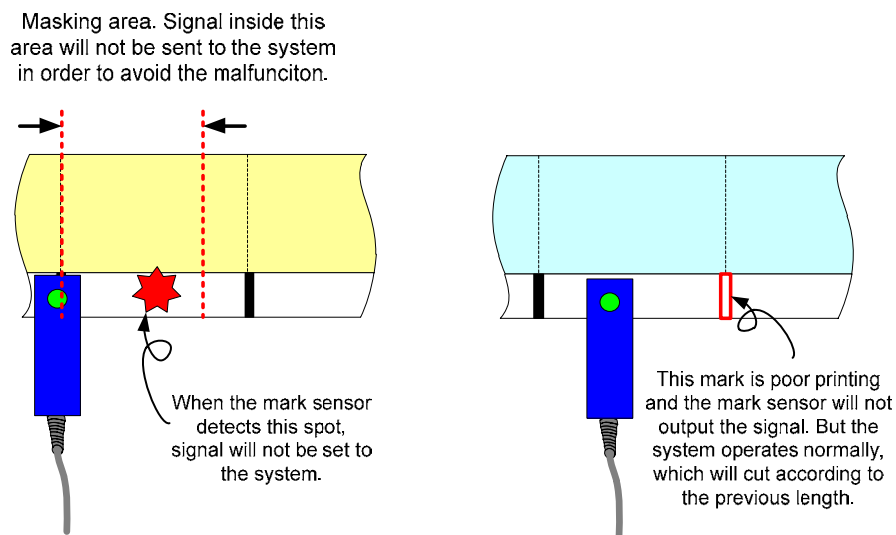
Figure 3.6.6 Masking and cutting with missing marks

Function of initial position adjusting

When changing the packaging film, the system needs to adjust the position of cutter and mark. Synchronous capture axis function of ASDA-A2 can apply the synchronous error created manually to complete the function of position adjusting. Enter the pulse number into P5-79 and memorize the total correction amount in P5-87. After re-power on, the system will trim the packaging film according to the setup offset position before the previous power-off.

Estimate the difference between the cutting position and the mark. Then, set to P5-79

①

Estimate the difference and set to P5-79

②

Cut at the correct position and no need to amend

③

P5-87 = (1)P5-79 + (2)P5-79

Note: Value of P5-79 can be negative. If the value is negative, the cutter will move backwards.
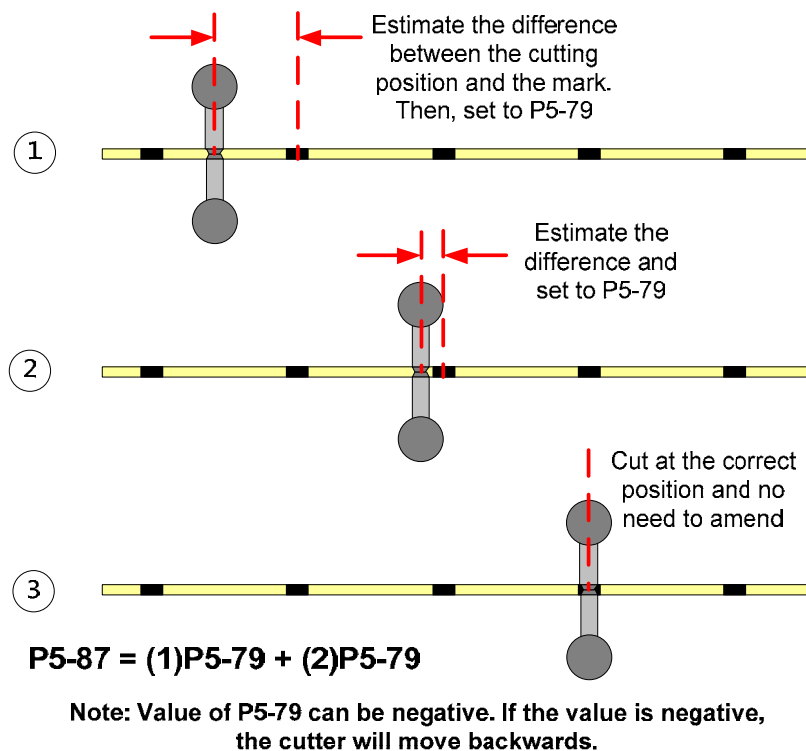
Figure 3.6.7 Function of initial position adjusting

Empty pack skip function

ASDA-A2 uses the feature of motion command overlap. With the assistance of the controller, it can skip the empty pack. The inertia produced by mechanism when stops instantaneously should be considered. Thus, when in high speed or heavy load, this function is not suitable for operation. See Figure 3.6.8. This function can deal with the problem of one empty pack or more than one empty pack. The prerequisite is to properly arrange the photoelectric switch of empty pack sensor 1 and 2. When the flying shear is at 0 degree or a proper position (the reference point for detection), empty pack sensor 1 might detect if there is any package on chain conveyor. If it is in situation 1, it means no empty pack. One empty pack is shown in situation 2. If there is more than one empty pack, then it is in situation 3. Thus, the condition of detecting empty pack should be:

No empty pack: (Signal of E-cam is at 0 degree) **AND** (Empty pack detection 1)

One empty pack: (Signal E-cam is at 0 degree)   **AND**   (NOT Empty pack detection1)

More than one empty pack: ((Situation 2) **OR** (Situation 3)) **AND** (Empty pack detection1) **AND**

(NOT Empty pack detection2)
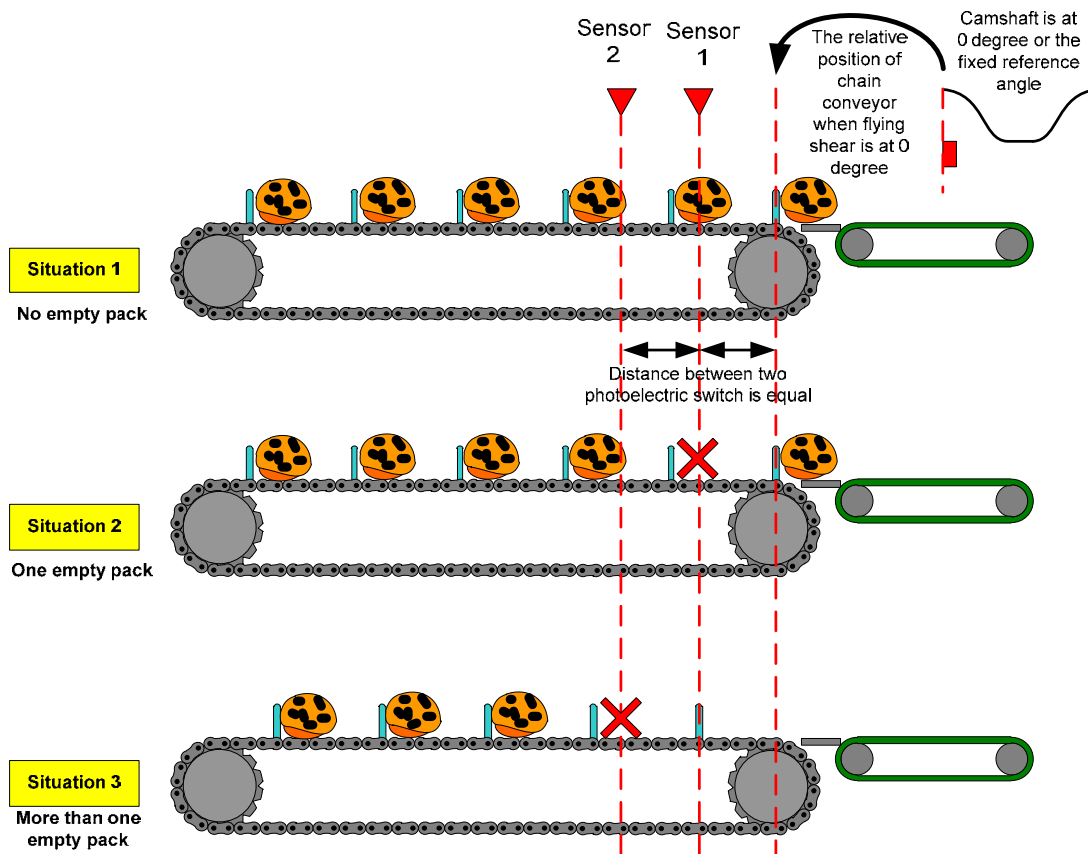
Figure 3.6.8 Photoelectric switch for detecting empty pack

When empty pack is detected, the controller will trigger EV in a proper time and conduct offset compensation. Since ASDA-A2 has the feature of command overlap, skip empty pack can be done by this function. Base on the arrangement of sensors which shown in Figure 3.6.8, when the number of empty pack is more than one, the system could detect if the next pack exists or not before the previous command execution is completed. The continuous trigger event of the controller would cause command overlap. Meanwhile, when the number of empty pack is a lot, the controller could stop the master axis (film feeding axis) and keep all camshafts in engaging status after packing. After all empty pack is gone, operate the master axis again and the system will return to the original operation status. Figure 3.6.9 shows the description of command overlap.
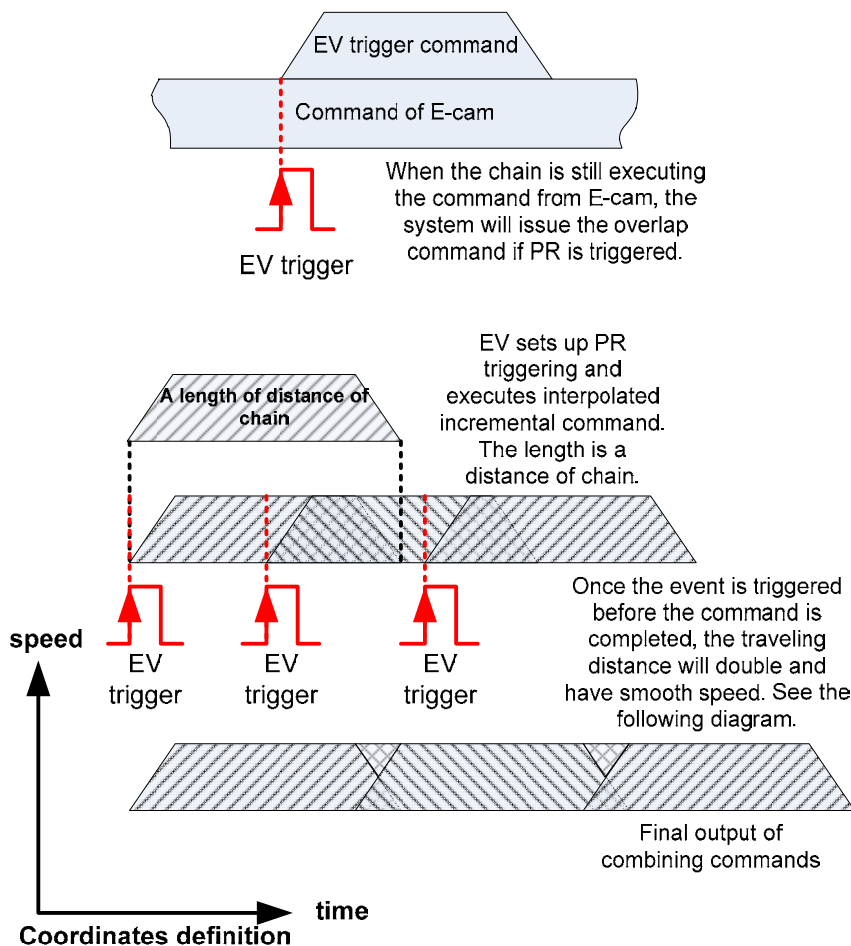
Figure 3.6.9 The combination of empty pack command

Cutting skip with incorrect object position

Before cutting, if the package is in wrong position, in order to avoid the wrong cutting and damage the mechanism, proper defense mechanism is a must. See Figure 3.6.10.

Correct position   Incorrect position
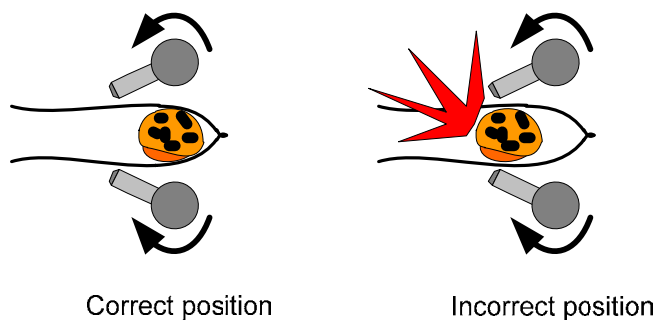
Figure 3.6.10 Shift of package

Double-layer of protection is provided by ASDA-A2. If the wrong position of package is detected before entering the cutting area, the disengaged condition could be changed to periodically disengaging. (P5-88.U=C. If P5-88.U is set to 4 as the disengaged condition, when P5-92=0 and the camshaft is in high speed operation, it will cause non-continuous speed at 360 degrees of the

curve. Set P5-88.U to C could avoid the situation and have the same function as P5-88.U=4, periodically disengage. Firmware version after V1.027 Sub.6 supports P5-88.U=C). It also can satisfy the demand of one or more cutting skips through adjusting lead pulse (P5-92). See Figure 3.6.11.
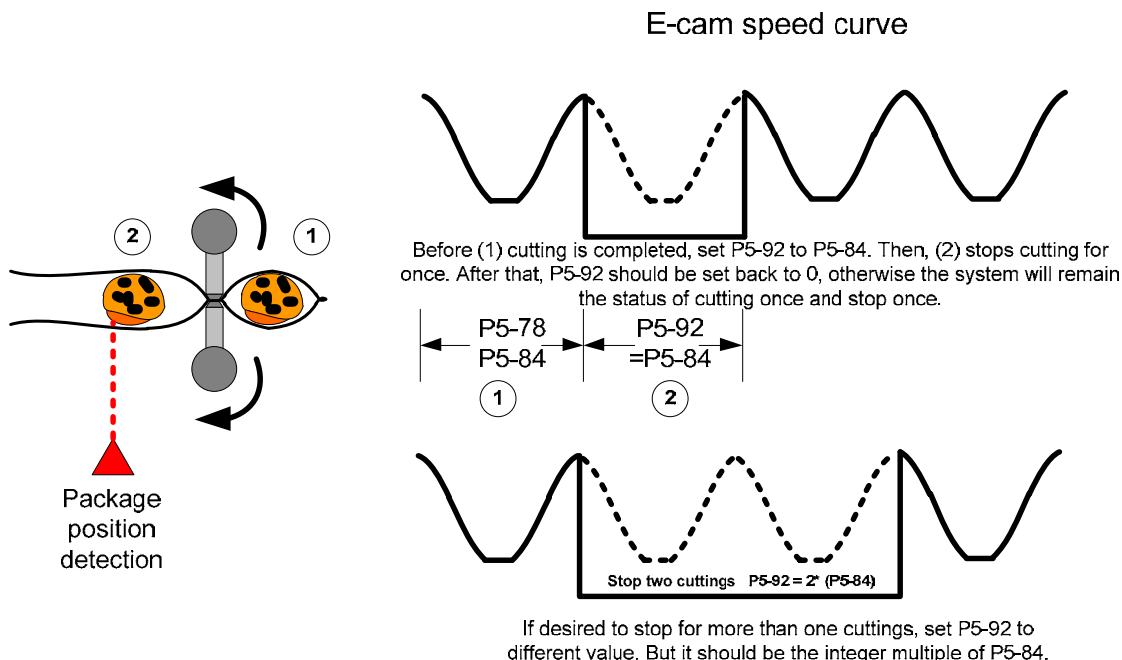
Figure 3.6.11 Controls cutting by periodical lead pulse

If the system cannot detect the wrong position of the package before entering the cutting area, then users can apply torque limit function of the servo drive. It could limit the strength of cutter. When the cutter reaches the setting value of torque limit, the DO signal will be issued to inform the controller to stop delivering the film. And the alarm will be cleared by the operator. The camshaft remains at engaging status at the moment and stops operation since the pulse stops issuing. After removing the package, the master axis will keep delivering the film and the system will continue the previous cycle. See Figure 3.6.12. Use torque limit as the mechanism protection when the package is in wrong position, the system program should be taken into consideration. If the system is in normal operation, and its toque value is close to the maximum value that servo drive can output, then this way is inappropriate.
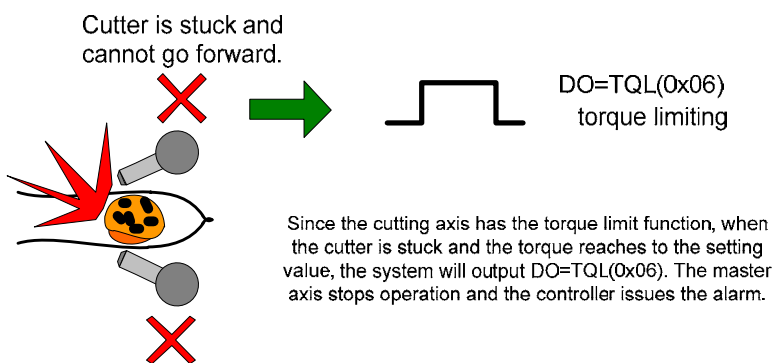
Figure 3.6.12 Use the torque limit to protect the mechanism

3.6.3.3 Design of E-cam curve

Types of flying shear curve

A variety of flying shear curves is offered by ASDA-A2. See Figure 3.6.13. There are three kinds at the moment. One is to build the curve which has no synchronous zone by PC software. The other one is to build the curve which has synchronous zone and remains at 51 degrees by PC software or macro command. The last one is to build an adjustable curve that has synchronous zone but can only be done by macro command. The advantage of building the flying shear curve in servo drive is that when the cutting length changes, users only need to setup the relevant parameter on HMI interface. After issuing the macro command, the curve is built. This is a great design for multi-process recipes machine. The definition of the calculation in synchronous zone and cutting length proportion will be elaborated later.

Speed curve

	Synchronous zone 0°	Synchronous zone remains at 51°	Adjustable synchronous zone Max. : 330°
Method of building table	PC software	PC software or servo drive	Servo drive
Cutting length proportion	0.3~3	0.05~2.5	0.05~5
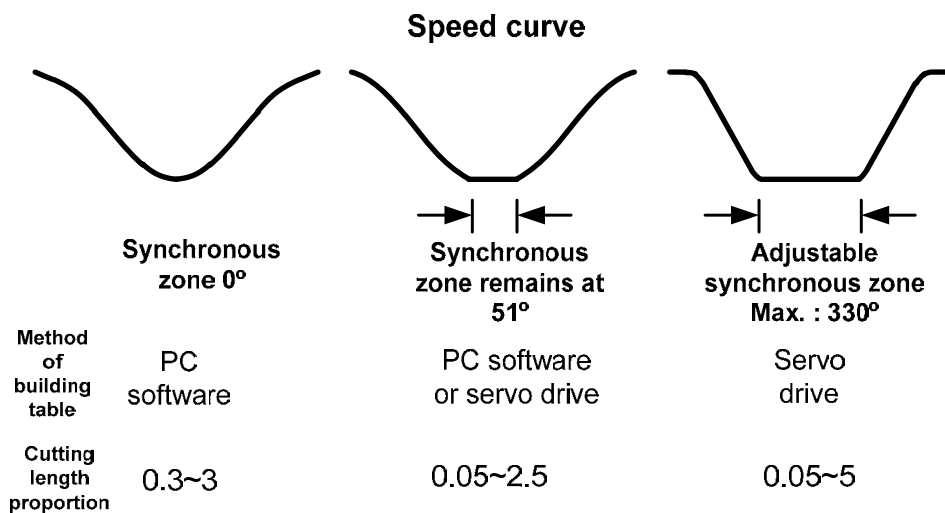
Figure 3.6.13 Camshaft curve

Meaning and calculation of synchronous zone

The synchronous zone on flying shear curve is the sealing length of wrapping paper, which is the arc length of cutting action. (If the cutter is not wide enough, the cutter width and arc length of cutting action can be regarded as the same distance) During the cutting process, when it travels to the synchronous zone which is the position the cutter starts to seal, if the cutting speed does not equal to the film feeding speed, the packing film will be lengthen or squeezed. That proves that the synchronous zone is vital to flying shear application and has to be accurate. The calculation is shown in Figure 3.6.14.
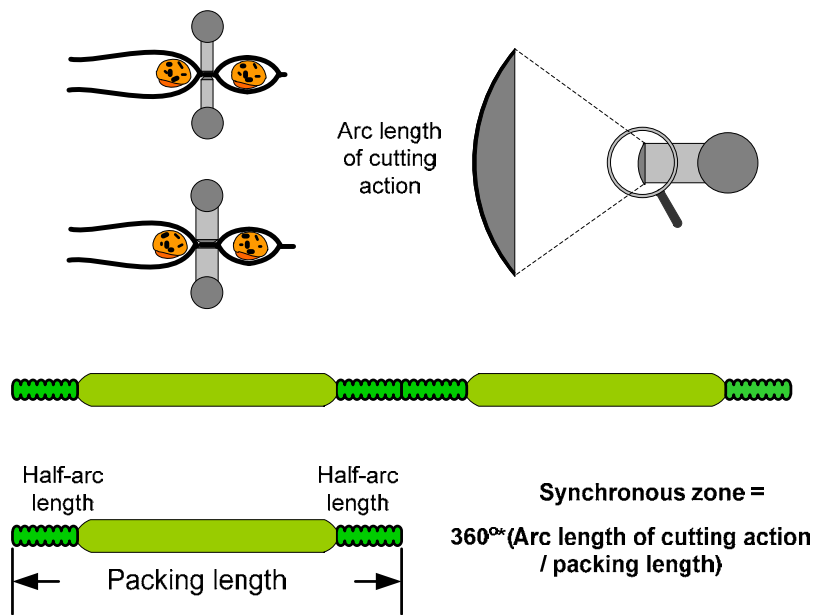
Figure 3.6.14 Calculation of synchronous zone

Limit of cutting length

Figure 3.6.13 indicates three kinds of cutting length proportion. The so called cutting length proportion represents the ratio of the wrapping length to the distance the cutter travels, see Figure 3.6.15. In Figure 3.6.13, synchronous zone remains at 51º degrees and the allowable cutting length proportion is 0.05 ~ 2.5 when using software to create the E-cam curve. When the cutting length is close to the minimum value, 0.05, the system will accelerate / decelerate dramatically during flying shear operation. As the result, it easily reaches the limit (The limit of motor operation). Thus, designing the mechanism should avoid the extreme condition during machine operation.
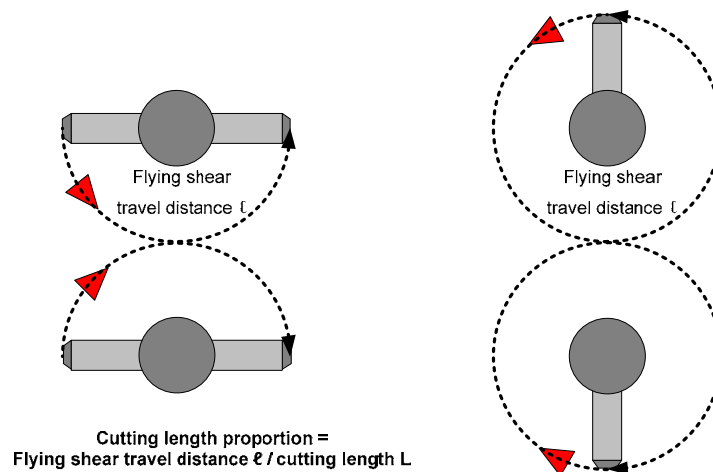
Figure 3.6.15 Cutting length proportion

If the desired cutting length is 2.5 times greater than the cutting length proportion. Use parameter P5-92 (lead pulse) could make the cutter immobile. So it can cut as long as the user desired. See Figure 3.6.16.
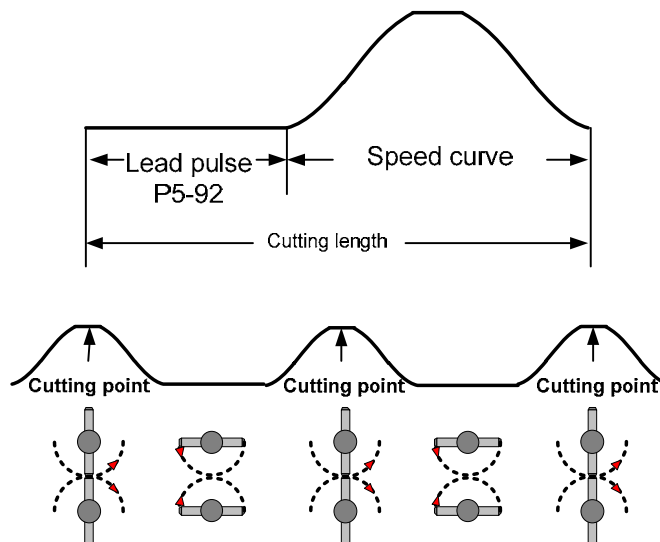
Figure 3.6.16 Use lead pulse to lengthen the cutting length

Cutting speed compensation

While cutting, the cutting speed will be faster or slower than the film feeding speed base on some specific requirement. When the cutting speed is slower than the speed of synchronous zone, the film will be squeezed. If the cutting is faster, then it will lengthen the film. It is easy to do speed compensation by ASDA-A2. See Figure 3.6.17.
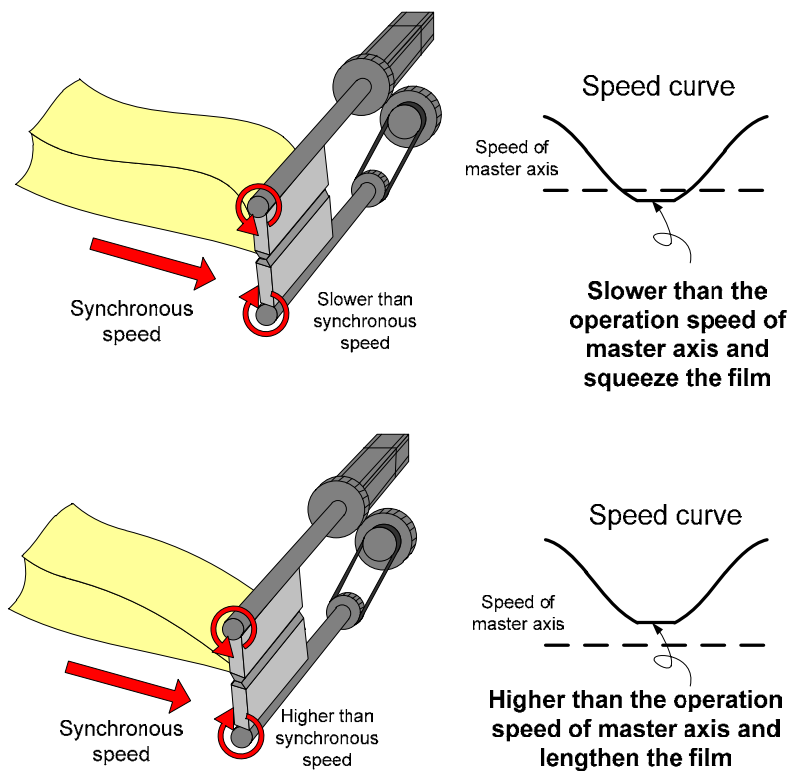
Figure 3.6.17 Compensation of synchronous speed

3.7 Application of Precision Positioning via Mark Reading

3.7.1 Description

ASDA-A2 has built-in motion control function. It can quickly complete motion control command and be applied to the application that requires quick response and precise positioning. The general controller cannot satisfy the demand of some applications, which might needs different speed control, but ASDA-A2 could show its excellent performance in this area. The example elaborated in this chapter aims at positioning control. In a length of moving distance, the system has to complete precision positioning via mark reading.

This example uses PR control, COMPARE/CAPTURE function of ASDA-A2 to complete positioning application. Unlike the traditional motion control method, ASDA-A2 provides a more flexible, better function and more instant setting. A higher cost is needed when applying to the controller, since a high-level of controller to ensure the timely communication is a must. ASDA-A2 servo system offers a smoothing motion and simple setting, which dramatically enhance the system performance and reduce the cost of design and development.

3.7.2 System theorem and setting

During operation, mark reading function has to be enabled in a section. Outside the section, the function has to be disabled for reducing the interference. If the sensor detects the mark within the mark reading section, the current command will be replaced by another one. Then, move a length of distance starting from the mark. That is the so-called positioning function. Although it is a continuous cycle, it will not produce accumulative error (because every cycle is a refresh start). If the sensor does not detect the mark result from poor printing, the system will move the default length automatically. So that it could prevent the problem of mark losing or mark undetectable and cause incorrect positioning. No matter the mark is able or unable to be read, CAPTURE and COMPARE function of ASDA-A2 can ensure the smoothing moving speed and accurate position.

3.7.3 Setting of servo system

3.7.3.1 DI setting

Users need to connect the photoelectric switch to DI7 of ASDA-A2 and setup a DI that is enabled every cycle. This DI function can be triggered by SHOM or EV or it can be replaced by parameter P5-07.

3.7.3.2 System configuration

Figure 3.7.1 is the description of system plan.
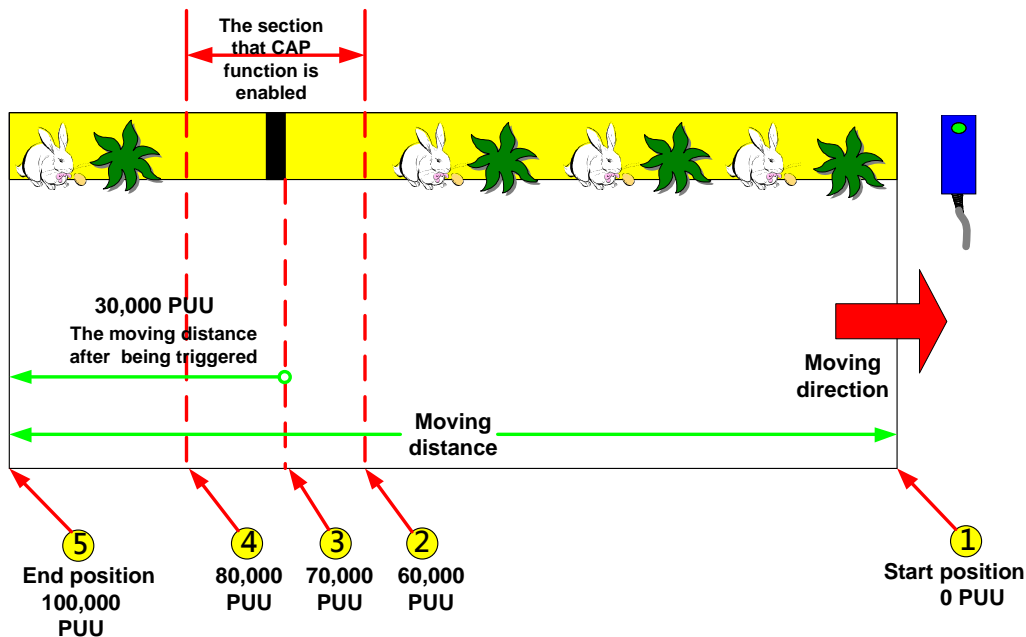
Figure 3.7.1 System plan

First, set data array address 50 to 60000, which is the start position of mark printing. Then, set data array address 51 to 80000, which is the end position. COMPARE function will use these two addresses for mark detection.

The description of mark 1 ~ 5 in Figure 3.7.1 is shown below:

1. Reset the coordinate to 0 and initialize the COMPARE function (The COMPARE point refer to data array address 50 = 50 = 60000 PUU). Then, setup the moving distance of absolute command to 100000 PUU.

2. When motor moves to 60000 PUU, the COMPARE function will be enabled (DO4 is ON). Setup and enable CAPTURE function and initialize another COMPARE function. This will refer to the content 80000 PUU of data array address 51.

3. If CAPTURE reads the mark in printing section, the system will disable COMPARE function and call PR to execute CAP so as to interrupt the original command. This will enable the motor to move another 30000 PUU starting from the mark, which is the mark reading function of each cycle. If CAPTURE is unable to read the mark, the original motion command will be executed.

4. When the position is at 80000 PUU, if the sensor does not detect the mark, CAPTURE will not be triggered. Then, the COMPARE function will be enabled and call another PR to disable CAPTURE function. It means no mark will be read after this position.

5. No matter the mark is read or not, it will go to this position as the end position for a cycle.

3.7.3.3   Motion command and PR program

Motion command and PR program are shown in Figure 3.7.2.   PR program will be elaborated in this chapter.
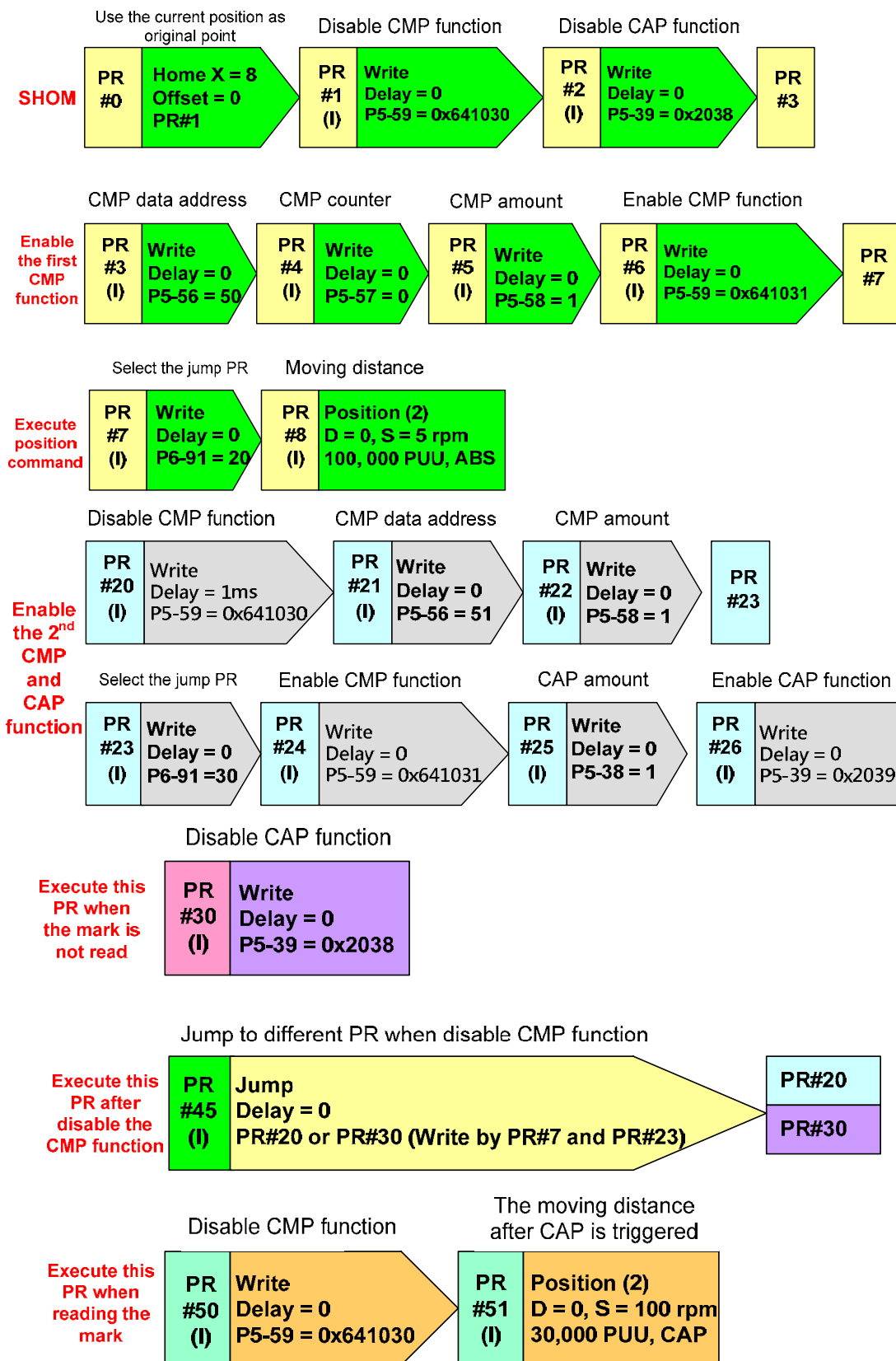
Figure 3.7.2   PR program

1.   The main PR function of each cycle:

   a   Set PR#8 to Homing mode at the start position (Use the current position as original point).

   b   Enable the first COMPARE function.

   c   Specify the JUMP path of PR#45 to PR#20.

   d   Execute position command (Absolute command: 100000 PUU): In each cycle, the system starts from the start position and operates 100000 PUU till it moves to the end position.
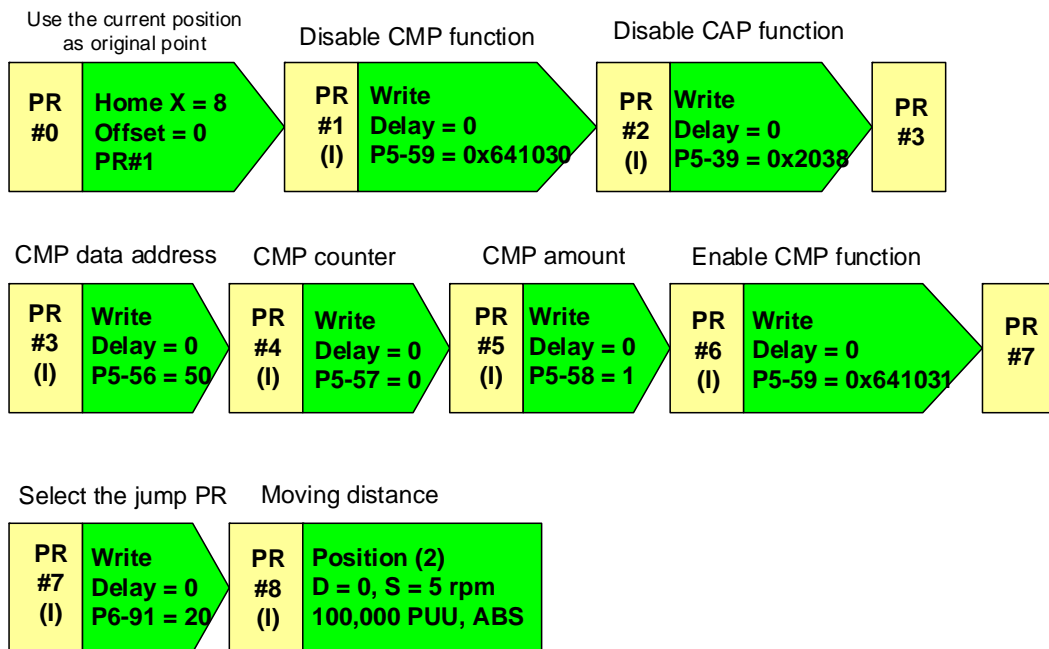
Figure 3.7.3 System initialization

2.   Before entering the mark reading area, the main PR functions are as the followings:

   a   When the position is at 60000 PUU, CMP function is triggered. Then, it will call PR#45 (This function will be provided after firmware version of v1.038 sub07).

   b   PR#45 jumps to PR#20. This jump function will jump to different PR according to different program.

   c   PR#23 changes the jump path of PR#45 to PR#30.

   d   Enable CAPTURE function and prepare to read the mark.

   e   Reinitialize COMPARE function and regard the content of data array address 51 as the output of CMP function.

Jump to different PR when CMP is completed

PR #45 (I)	Jump Delay = 0 PR#20 or PR#30 (Write by PR#7 and PR#23)	⟶	PR #20

Disable CMP function		CMP data address		CMP amount		
PR #20 (I)	Write Delay = 1ms P5-59 = 0x641030	PR #21 (I)	Write Delay = 0 P5-56 = 51	PR #22 (I)	Write Delay = 0 P5-58 = 1	PR #23

Select the jump PR		Enable CMP function		CAP amount		Enable CAP function	
PR #23 (I)	Write Delay = 0 P6-91 = 30	PR #24 (I)	Write Delay = 0 P5-59 = 0x641031	PR #25 (I)	Write Delay = 0 P5-38 = 1	PR #26 (I)	Write Delay = 0 P5-39 = 0x2039

Figure 3.7.4   The system enters the mark reading section

3. In mark reading section, when the mark is detected by the sensor, the following PR will be executed. The main functions are described below:

   a   When the mark is detected, CAPTURE function will be triggered. After CAP is completed, the system will execute PR#50.

   b   Disable COMPARE function. Since the mark is read, there is no need to use another CMP function to disable CAP function.

   c   Since the mark is detected, regard here as the reference position. Reset the motion command and setup CAP, 30000 PUU to replace the original command. The system will move 30000 PUU to the end position starting from the mark and end this cycle.

Disable CMP function		The moving distance after CAP is triggered	
PR #50 (I)	Write Delay = 0 P5-59 = 0x641030	PR #51 (I)	Position (2) D = 0, S = 100 rpm 30,000 PUU, CAP
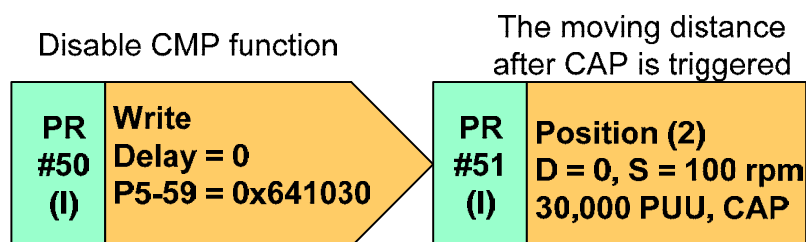
Figure 3.7.5   The system detects the mark

4. In mark printing section, the mark is not read. But it is at 80000PUU. The CMP function is triggered and calls PR#45. Main functions are shown below:

   a   When COMPARE is completed, it will call PR#45. Then, jump to PR#30 to disable CAPTURE function. This can prevent the mark is misread outside the mark printing section.

   b   The original motion command is not changed. The system keeps operating. After it is at 100000PUU, this cycle is over.

Jump to different PR when disable CMP function

PR #45 (I)	Jump Delay = 0 PR#20 or PR#30 (Write by PR#7 and PR#23)	PR #30

Disable CAP function

PR #30 (I)	Write Delay = 0 P5-39 = 0x2038
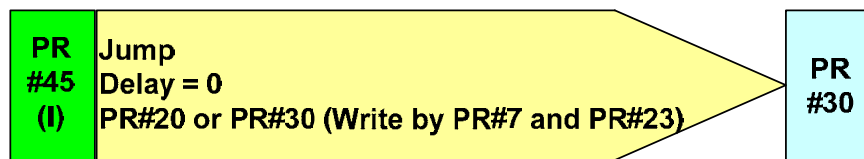
Figure 3.7.6   The system does not detect the mark

3.8   Application Example of Packing Machine with Phase Alignment Function

3.8.1   Instruction

This chapter aims at the application of horizontal packing machine which uses the material feeding axis as master axis and film feeding axis and cutter axis as slave axes. With cam positioning and synchronous capture axis, it fulfills the function of modification by mark tracking. In addition, this chapter also introduces the function of empty pack skip and cutting skip by macro. The application examples of ASDA-A2 on horizontal packing machine has already been described in Chapter 3.6. In Chapter 3.6, the film feeding axis is the master axis and the cutter axis and material feeding axis are regarded as slave axes. In production line, packing machine connects to the other devices via the material feeding axis. Therefore, when the speed changes, the packing machine can still work easily.

3.8.2   System Configuration

The packing system includes three parts, the master axis and two slave axes. See Figure 3.8.1 below, the material feeding axis is the master axis. When delivering the package, it will transmit pulse and command the slaves. Film feeding axis is one of the slaves and delivering the wrapping film is its main task. Another slave is the cutter axis, which controls the cutting time. Four sensors are used in this application. Synchronous capture axis sensor detects the chain of the master axis and the signal will be sent back to DI7 of the two slaves. The purpose is to monitor the operation of the master axis via slaves. When problems occur such as skid, pulse leaking or the different distances among chains, slaves can fix it in time. Cam positioning sensor is used for detecting the mark of the wrapping film.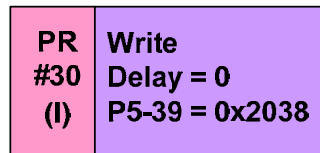 The detected signal can be sent back to any DI (except DI7) on film feeding axis. It is used for adjusting the position automatically according to the relationship between the read signal and cam curve. Cutting skip sensor is installed in front of the cutter axis. The purpose is to check the package position in order to prevent the cutting knife cutting the content in the package when operating. Empty pack skip sensor is installed in front of the packing area in order to check if there is any unpacked item. If yes, before the unpacked item reaches the packing position, the slave will stop operating for a cycle. Thus, it can reduce the waste of materials.
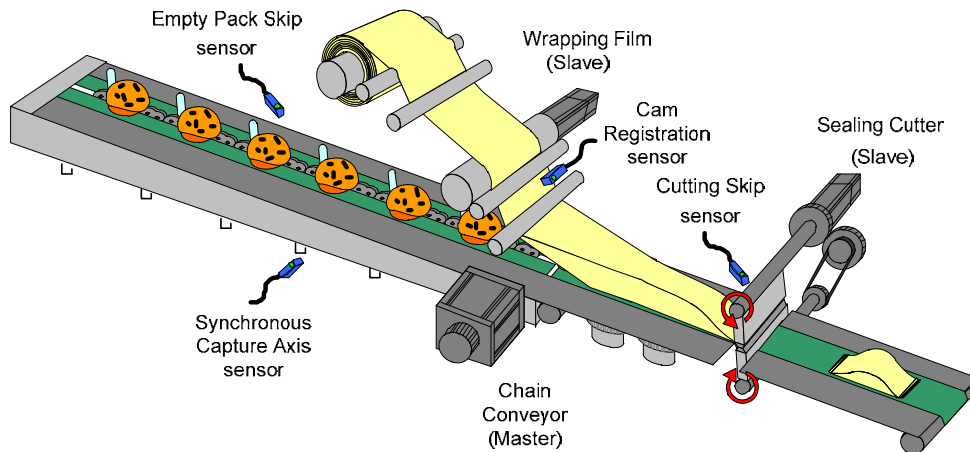
Figure 3.8.1 Systematic Diagram of Packing Machine

3.8.3   Servo System Setup

3.8.3.1   Configuration

The pulse of master axis on two camshafts is from the output pulse of material feeding axis. The film feeding axis and cutter axis can therefore operate in accordance with the speed of material feeding axis by pulse by-pass function.

In order to synchronize the phase of different axis of the whole system, there are two functions of phase adjustment.

➢ Synchronous Capture Axis: this function will be enabled on film feeding axis and cutter axis. The detected signal of positioning on master axis connects to DI7 of two axes. Since DI7 is the high-speed pin input, synchronous capture axis has to connect to high-speed pin. There is no need to set DI7 as specific DI function, (For instance, the function code can use the default 0x100.).

➢ Cam Positioning: this function is used in film feeding axis. This sensor detects the mark of the wrapping film and sends signals back to the film feeding axis as the reference for positioning. Signal can enter via any DI in one condition; DI has to be set to 0x35 (signals normally close) or 0x135 (signals normally open).
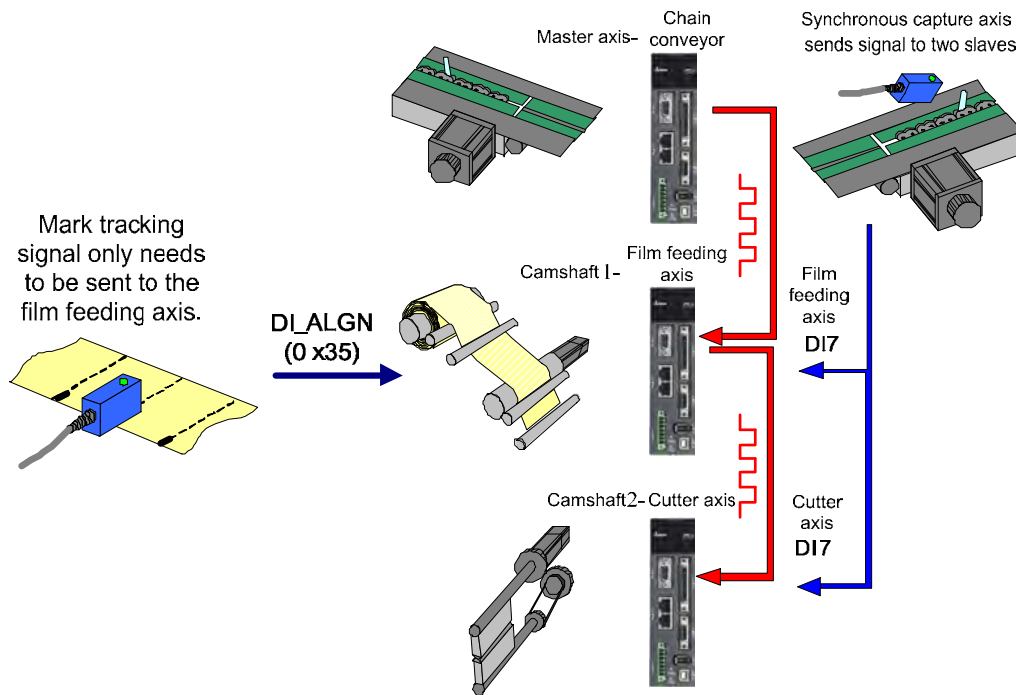
Figure 3.8.2 System Configuration – Synchronous Axis

Another two sensors are for cutting skip and empty pack skip:

➢ The signal of cutting skip sensor only needs to be sent back to cutter axis. And the signal can enter via any DI. The DI needs to be set to trigger PR and enable macro instruction via PR writing function so as to prevent the missing cutting.

➢ The signal of empty pack skip sensor needs to be sent back to the master first. Usually, the detection of preventing empty pack will be conducted in previous packs. The sensor is normally installed in some distance from the packing materials. When the sensor detects the empty pack, the master has to be in charge of calculating the package difference between sealing and cutter axis. When the empty pack is in sealing and cutter axis, the PR procedure of empty pack skip of two slaves will be triggered. Signals can enter into the drive via any DI. However, the DI has to be the one which can trigger PR. This DI needs to trigger macro to stop film feeding axis and cutter axis when the empty pack reaches the position. Until the next package enters the operation zone, two slaves start to operate. Thus, it can save the packaging materials. The empty pack skip function of Delta Servo System can apply to single or multiple packs. However, when applying this function, the capability of the machine should be taken into consideration. The operational speed for some machines does not suitable for this operation. For example, if the machine runs at the speed of 3000 rpm and the package is only 4 centimeters long. Users need to consider whether it is feasible.

Master axis – Chain conveyor

Camshaft 1– Film feeding axis

DI: EV trigger PR procedure of empty pack skip

The signal of empty pack skip is sent to PLC for calculating the appropriate time of triggering PR of empty pack skip.

Camshaft 2 – Cutter axis

DI: EV trigger PR procedure of cutting skip

DI: EV trigger PR procedure of empty pack skip

The signal of cutting skip only needs to be sent to cutter axis.

Figure 3.8.3 System Configuration – Signal of Empty Pack Skip and Cutting Skip

3.8.3.2   Features

Synchronous Capture Axis

Synchronous capture axis applying here is to ensure it can automatically adjust its motion and overcome the problem of incorrect packaging and wrong cutting position when master axis (material feeding axis) transmits the abnormal pulse to the slaves (film feeding axis and cutter axis).

In flying shear application, camshaft operates in accordance with the operational distance set by the receiving pulse of master axis. Therefore, if the master axis is unable to output the set pulse length, slaves will be unable to cut or pack in correct position. See figure 3.8.4. Assume the salve axis is set to perform the cutting operation after receiving every 10000 pulses from the master axis. If the master axis moves the same distance and pulses transmitted are fixed to 10000, then the camshaft will not go wrong on cutting. If the master axis moves the same distance, but the slave axis receives 11000 pulses instead of 10000 pulses, the slave axis will still perform the cutting operation when receiving the 10000th pulse and it will therefore have shorter cutting length. If the master axis moves the same distances, but the slave axis receives 9000 pulses instead of 10000 pulses, the slave axis will perform the cutting operation when receiving the 10000th pulse and it will therefore have longer cutting length.
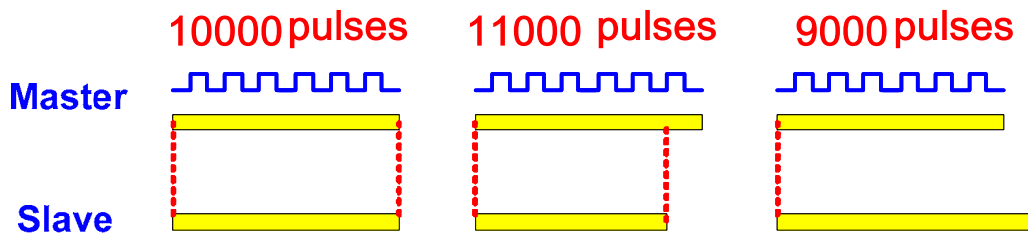
Figure 3.8.4 Relation of the Pulse from the Master Axis and the Cutting Length

In order to solve the problem of abnormal pulse sent by master axis, the pulse number between two marks can be regarded as the basis. And the difference between the actual receiving pulses of two marks can be the basis for adjusting the cutting length. See figure 3.8.5. After comparing the pulse number triggered by DI7 for two times and the pulse number set by master axis, the differences will be adjusted by correcting mechanism. The adjusted signal is the synchronous capture axis. Use the adjusted synchronous capture axis as the master axis to drive the camshaft. And the pulse of master axis corresponded by the camshaft will be adjusted by synchronous capture axis. Therefore, even when the pulse number of master axis is incorrect, the camshaft still can do the adjustment in time.
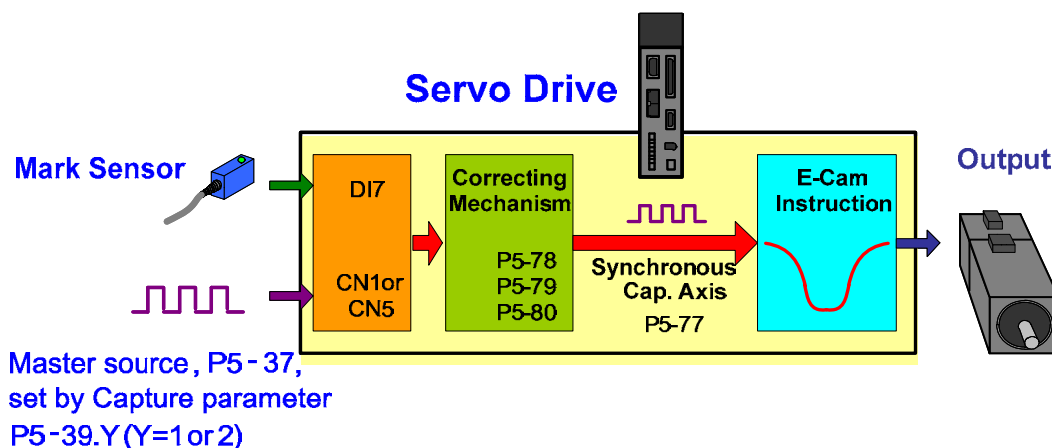
Figure 3.8.5 Synchronous Capture Axis

➢ If the user wants to use synchronous capture axis, signal of the mark sensor must be input by DI7 of CN1 of ASDA-A2 Servo;

➢ The source of master axis of E-cam must set to 5. This setting is to select synchronous capture axis as the source of master axis;

➢ The engaging condition must set to 2 and use capturing to control the engaging time;

➢ The pulse number between two marks must be set in P5-78. The setting of P5-78 must be correct, or the system has no basis for comparison. Generally, P5-78 = P5-84. If P5-83 = 1, then the distance between two marks is the distance the cam curve travels for a cycle. See figure 3.8.6. In every cycle, the actual pulse number output by master axis between two

marks will be compared with the standard pulse number set by P5-78 and be calculated the difference. The difference will be saved in P5-79 and applied by the camshaft to adjust the error.

➢ P5-80 can set the correction rate which is for correcting the value of P5-79. The bigger P5-80 is, the faster P5-79 can be to reach zero. However, the speed variation will be greater. Some mechanism does not allow such huge correction within the short time. Users need to set up the value according to the real situation.
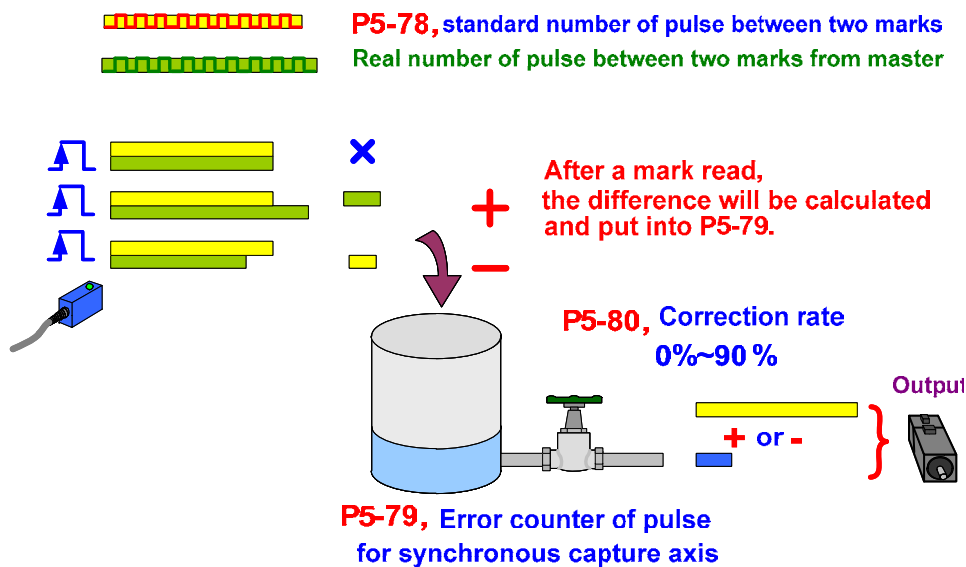
Figure 3.8.6 Operational Theorem of Synchronous Capture Axis

The main task of synchronous capture axis is to adjust the error which is long-term accumulated. Therefore, the correction rate of P5-79 should be around zero, which value is either positive or negative. When the value is increasing or continuous decreasing and cannot back to zero, it means the mechanism might need to be re-adjusted. Or improper setting or pulse loss caused by the noise might also be the reason.

Figure 3.8.7 shows the PR setting that the cam uses the synchronous axis as the source of master axis:

PR#21: Synchronous capture axis must read the mark, thus the function of reading marks must be enabled. P5-39.Y = 2, the source of master axis is pulse command (CN1). P5-39.U = 2, the minimum triggering intervening time is 2 ms.

PR#21: Set up E-Cam. The setting of P5-88.X = 2 is that after engaging, if the cam stops because of Alarm or Servo OFF, the cam will remain engaging. The cam can operate directly after Servo ON. P5-88.Y = 5, the source of master axis is synchronous capture axis. P5-88.Z = 2, the engaging time is right after reading the mark. P5-88.U = C is to set the cam to cycling mode and disable the cam after disengaging.

PR#22: P5-38 is to set up the captured quantity. The capture function captures one data every cycle. Therefore, P5-38 = 1.

PR#23: Enable Capture Function, P5-39.X = 1.

PR#24: Enable E-Cam, P5-88.X1 = 1.

Set up Capture Function

| PR #20 (I) | Write DLY = 0 ms P5-39 = 0x2020 |

Set up E-Cam

| PR #21 (I) | Write DLY= 1 ms P5-88= 0xC252 |

Set up the Captured Quantity

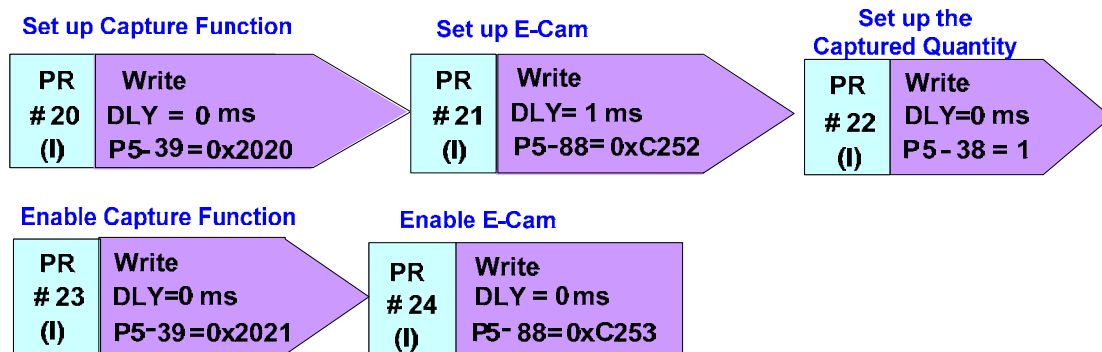| PR #22 (I) | Write DLY=0 ms P5-38 = 1 |

Enable Capture Function

| PR #23 (I) | Write DLY=0 ms P5-39 = 0x2021 |

Enable E-Cam

| PR #24 (I) | Write DLY = 0 ms P5-88 = 0xC253 |

Figure 3.8.7 PR Setting of Synchronous Capture Axis Application on Cam

Cam Positioning

The application of cam positioning is illustrated in Figure 3.8.8. Users need to set the target position first. The system will follow the setting and adjust it according to the difference between the actual position and the setting one by calculating every cycle. The target position, which is where the sensor installed, is set up by the pulse number of master axis. Take the application on wrapping film positioning as the example. When the sensor detects the mark of the wrapping film, the signal will be sent back to the drive. The system will check if the master axis is in the setting position and calculate the difference of the camshaft so as to do the adjustment. For instance, if the cam needs 36000 pulses to travel a cycle (e.g. P5-83 = 1, P5-84 = 36000), and the master axis has 19000 pulses when setting positioning. Also, from the E-cam curve, the corresponding position which is 9000 PUU can be known. When reading the mark, if the pulse number of master axis is 17000, the system knows it has 2000 pulses difference from the positioning target, the system will therefore calculate the error, 2000 pulses. With the error number calculated from the cam curve, the correction rate which is 500 PUU can be known. This is called cam positioning. Therefore, with the correction rate, positioning will be completed by overlap commands.
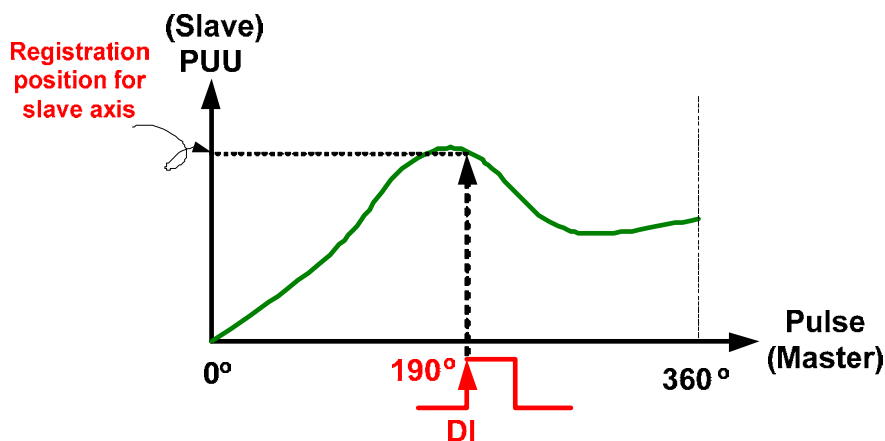
Figure 3.8.8 Theorem of Cam Positioning

Parameters from P2-73 to P2-76 have the function of cam positioning. The followings detail the description of each parameter.

Step 1: Set relevant settings of the input DI

The DI pin which connects to the sensor needs to be set to 0x35 (normally close) or 0x135 (normally open). And the DI will be therefore set to DI.ALGN which is for cam positioning only.

P2-75 is for setting the target position of cam positioning and can be observed by the pulse of master axis. Take figure 3.8.9 as the example. When P5-83 = 1/P5-84 = 10000, the pulse number of master axis the cam curve needs to travel for a cycle is 10000. If P2-75 is set to 5000, when the system receives DI signal of cam positioning, the camshaft shall operate to the corresponding position of 180°, or the system will adjust the position of camshaft automatically. The setting range of P2-75 is from 0 (P5-84/P5-83) to -1. If the setting value is out of range, entering value is not allowed and the error will be shown. If the entering value was within the range but becomes out of range because of the modification of P5-83 or P5-84, value of P2-75 will be cleared to 0 automatically.

In order to overcome the switching delay of DI input signal, users can use P2-74 to set the delay compensation. For preventing poor printing of mark and cause misreading of DI, users can use P2-73.DC to setup the masking area. If DI.ALGN is triggered in masking area, the system will not read this signal. Only if it is in the proper position (outside the masking area), is the system able to read and calculate it for adjustment. Here is the masking calculation method which bases on the percentage.

$$M >= (P5\text{-}84 / P5\text{-}83) \times P2\text{-}73.DC\%$$

This masking function only allows forward direction pulse. Reverse direction pulse will not be able to work.

The current position of cam can be read from monitoring variable v03EH. When DI is triggered, the system will compare the monitoring variable with the setting value of P2-75. If two values are different, it will conduct cam positioning.

Step 2: Filter setting

In order to have a more smooth operation of the cam and reduce the position error caused by DI noise (for example, the vibration during the delivering of the wrapping film will cause slight difference when DI is reading the mark), the filter can help for increasing the stability of positioning.

P2-73.YX sets the filter range. When DI.ALGN is triggered and enables positioning, the system will detect the current position of the cam. If the previous position error is less than the setting range (%), the filter will average the current error with the previous error. Then, adjust the position. If the previous position error rate is higher than the setting value, the filter will adjust the position directly without averaging.

P2-76.Y sets the filter's strength. The setting range is from 0 to F, which is 2^Y square average. Filter will not function if it is set to 0. The bigger the setting value is, the slower the adjustment will be. For stabilizing the movement, it can avoid the prompt adjustment and the disturbance caused by sensor's noise when positioning. If the setting value is too big, it will be unable to conduct the positioning. Therefore, it is suggested to set to 3.

Errors can be seen via monitoring variable v055h.

Step 3: Set up the adjustment direction

P2-76.UZ is the forward allowable range of the adjustment direction after positioning. The range is between 0 and 100%.

When setting to 0: Reverse direction only.

When setting to 25: 25% for forward direction; 75 % for reverse direction.

When setting to 50: it is the shortest distance of positioning. 50% for forward direction; 50% for reverse direction.

When setting to 80: 75% for forward direction; 25% for reverse direction.

When setting to 100: Forward direction only.

When P2-76.UZ = 0 or 100, the system will adjust the whole cycle of E-cam even when there is only a minor error. Thus, it might not be appropriate in some applications. If it is not for the special demand, it is suggested to set to 50%, using the shortest distance for adjustment. For some applications, if it is set to the shortest distance and the system is not allowed to do reverse adjustment, then P1-22.U can be applied. There is one condition when applying the setting of prohibiting adjusting positions in reverse direction. The system must be the one which will produce errors when operating both in forward and reverse direction. Positioning is designed for eliminating the long-term accumulated errors. For a normal system, errors will sometimes be in positive value and sometimes be negative. When the reverse adjustment is prohibited, once the forward adjustment exists, the error will be eliminated. If the system only produces errors in one direction, for example, only in forward or reverse direction, then it means the method is not working.

Step 4: Set up the maximum allowable correction rate

When a big position error exists, the movement of every adjustment might be big and thus easily causes motor vibration or overload. The setting of P2-73.UZ could separate the adjustment for positioning into several times and can moderate the adjustment. However, it takes longer time. When conducting the positioning, the limit of every maximum allowable correction rate is as follows:

$$| C | <= (P5\text{-}84 / P5\text{-}83) \times P2\text{-}73.UZ\%$$

Masking range
P2-73.DC(%)

1

P2-74
Time compensation of signal delay

slaves PUU

Pulse number of master axis
0   (P5-84) / (P5-83)

Example:
P5-84 = 10000, P5-83 = 1,
P2-75 = 5000,
5000 / 10000 * 360° = 180°

P2-75

DI:ALGN
Current position
V 03 Eh

2

Range of the filter
<= P2-73.YX

Strength of the filter
P2-76.Y

Suggestion: P2-76.Y = 3

Error 1 < P2-73.YX < Error 2

Filter works and averages the errors before doing the adjustment

Filter does not work and does the adjustment immediately

V055h
Uses % to show errors

3

Adjustment direction
<= P2-76.UZ

Current position

limit   backward   forward

P2-76.UZ = 0   100 %
P2-76.UZ = 25   75 %   25%
P2-76.UZ = 50   50 %   50 %
P2-76.UZ = 75   25%   75%
P2-76.UZ = 100   100%

4

For preventing the dramatic change, the value needs to be set in a reasonable range

Current position   **Target position**

Maximum allowable correction rate
<= P2-73.UZ

5

P2-76.X

Enable registration

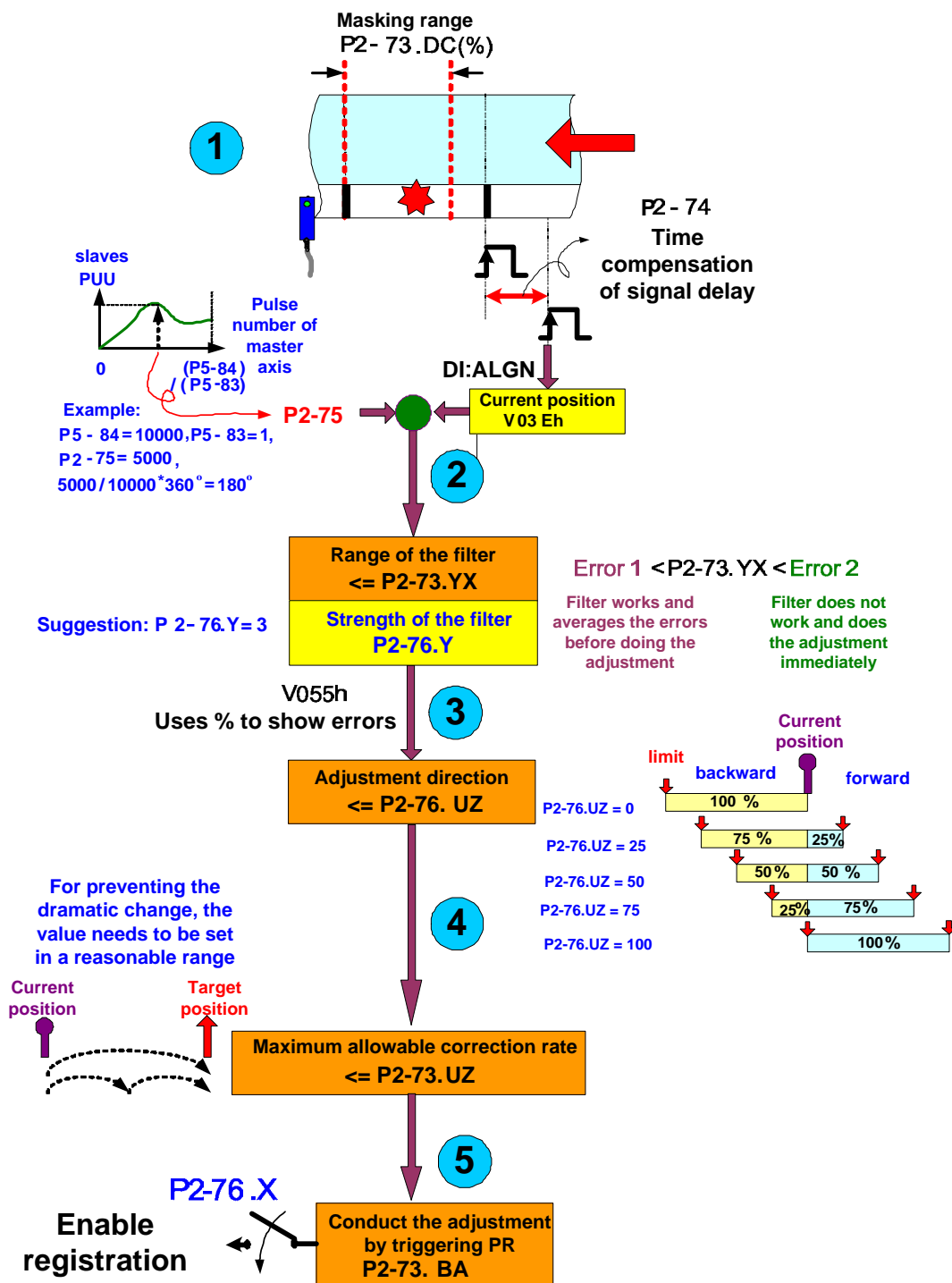**Conduct the adjustment by triggering PR**
P2-73.BA

Figure 3.8.9 Cam Positioning Setup

Step 5: Set PR and enable positioning

After positioning, the difference of the E-cam position will be saved in specified PR data of P2-73.BA. When the system needs to do the adjustment, this PR could conduct it in an appropriate time. Thus, users have to specify this PR and set it up in P2-73.BA in advance, or cam adjustment cannot be made. PR setting is shown in figure 3.8.10. It should be set as incremental position control and allows overlap and interrupt. Speed, acceleration and deceleration should be set to the reasonable value as well. There is no need to set the value of position command. It is because when cam positioning is complete, the system will write the error into the system automatically. The value will be overwritten and updated in any condition.
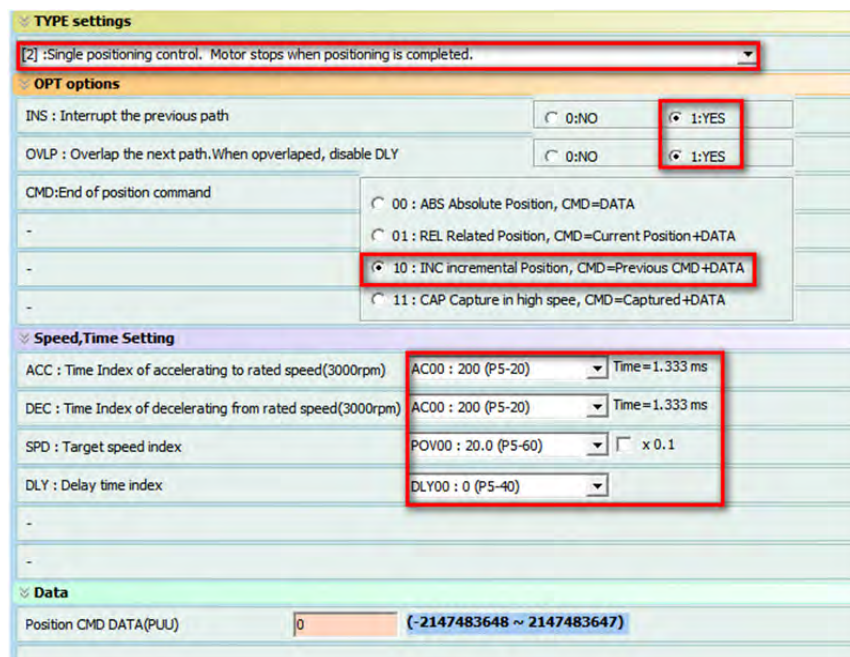

Figure 3.8.10 PR Setting

After setting up all parameters, P2-76.X can be used to enable cam positioning.

P2-76.X

Bit	2	1	0
Function	Two point phase	trigger PR immediately	Enable registration
Description	0:Single point correction 1: Adjust the phase of material feeding axis	0: Manually trigger PR set by P2-73.BA 1: When DI.ALGN signal enters, PR set by P2-73.BA will be triggered automatically	0: disable 1: enable

Figure 3.8.11 Setting to enable E-cam

In Figure 3.8.11:

➢ P2-76.X0 is the switch of positioning. When P2-76.X0 = 1, positioning function is enabled.

➢ P2-76.X1 is for setting up the triggering time of adjusting PR (PR set by P2-73.BA). Assume P2-76.X1 = 1, when the signal of DI.ALGN is triggered, if the system detects the error, the system will write the error into PR set by P2-73.BA and execute PR to correct the error automatically. If P2-76.X1 = 0, when DI.ALGN signal is triggered, the system will still write the error into PR set by P2-73.BA. However, PR will not be executed automatically. The user has to judge the execution time and manually trigger PR.

➢ P2-76.X2 is for reading the relation of marks and camshaft. Take figure 3.8.12 as the example. The cutter axis of 'mechanism **a'** is the slave axis which travels according to the E-cam curve. Film feeding axis with marks is the master axis. The sensor of cam positioning reads the marks on wrapping film which transmits by film feeding axis and transmits DI.ALGN signal to the cutter axis for adjustment. When the slave axis is doing the adjustment, it will not influence the transmission of wrapping film. When applying to this mechanism, please set P2-76.X2 = 1. For 'Mechanism **b**' in figure 3.8.12, the cutter axis is the master axis and the film feeding axis is the slave axis. Therefore, the film feeding axis travels is in accordance with the E-cam curve. DI.ALGN signal needs to be sent to the film feeding axis. When executing cam positioning, the transmission of wrapping film will be influenced by the adjustment. Thus, this application needs to set as P2-76.X2 = 1.
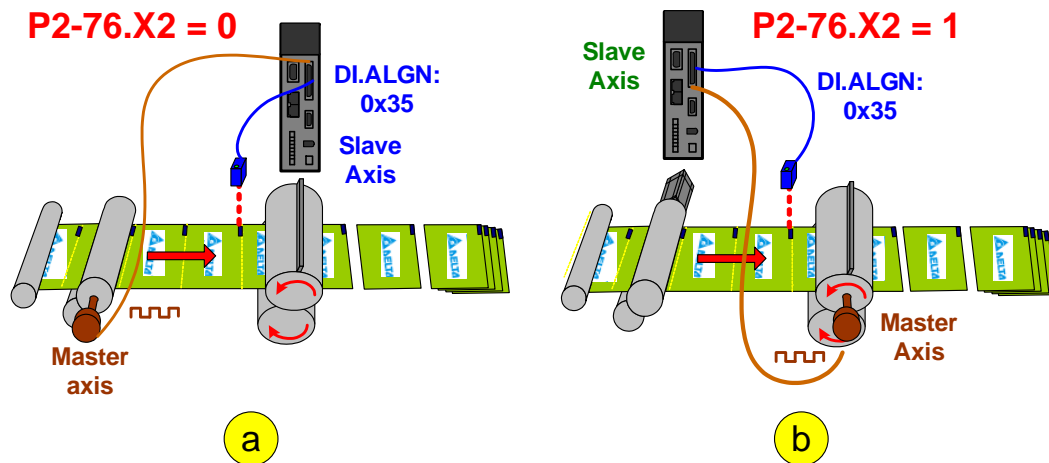
Figure 3.8.12 Mechanisms which can apply the funciton of cam positioning

In this example, the target of cam positioning is material feeding axis. The system will automatically call PR for adjustment (P2-76.X1 = 1) when DI.ALGN is triggered every time. It is also for adjusting the phase of material feed axis (P2-76.X2 = 1). Thus, P2-76.X = 7 in this application.

Empty Pack Skip

When the conveyor is in one position, the sensor needs to detect the item. If the sensor is unable to detect the item in correct position, it means the item does not exist and will regard it as empty pack. When the empty pack travels to the packing area, the slave axis has to stop packing, or it will cause empty packing.

See the practical application in figure 3.8.13. One cycle of the E-cam equals the chain travels a section. Thus, the first DO output by the cam position can detect the empty pack (in a specific position). The second output of cam position is applied by the temporal position of cutter axis and film feeding axis (The cutter has to stop at a safe position, not the cutting position). All the operational procedures are as follows:

When outputting the DO (0X11A) signal, the controller has to read the signal comes from empty pack sensor at the same time. If it detects signals, it means the item is on the conveyor and regarded as a non-empty pack. If there is no signal comes from the sensor, the item will be regarded as an empty pack. The controller has to record and count. Assuming the distance from the detection point to cutting position is two packs, after the previous two finish packing and the empty pack moves to the cutting position, the controller needs to call PR of cutter axis and film feeding axis (figure 3.8.3) if it outputs DO.0x118 signal. Two slave axes execute macro 10 (P5-97 = 0x10, Figure 3.8.17) respectively in this step. Then the two slave axes will stop for a cycle and start from the next cycle automatically. This macro allows continuous multi-triggers. It will stop for a cycle in every trigger. If there are two empty packs, then macro 10 has to be triggered for two

times continuously. Only if the master axis continues travelling, will the slave axis start to operate automatically after the stopped cycle. When setting the macro, P5-39 has to be 0. Also, the E-cam has to be engaged and operates in forward direction.

The function of DO.0x118 mentioned above is to determine the time camshaft stops. General speaking, the position camshaft stops should not obstruct the operation of master axis. It is suggested that the camshaft should stop at zero position (the starting point of cam curve). It is because that from the static status to operate, the camshaft needs to accelerate. Moreover, the acceleration curve will be planned at the beginning of E-cam curve. Then, when the camshaft starts to operate again after one cycle, it will follow the plan. If it plans like that, DO.0x118 can support another function. When the sensor of empty pack receives no signal, the controller automatically counts the required cycle the camshaft needs to operate and stops at the starting point of the next cycle.
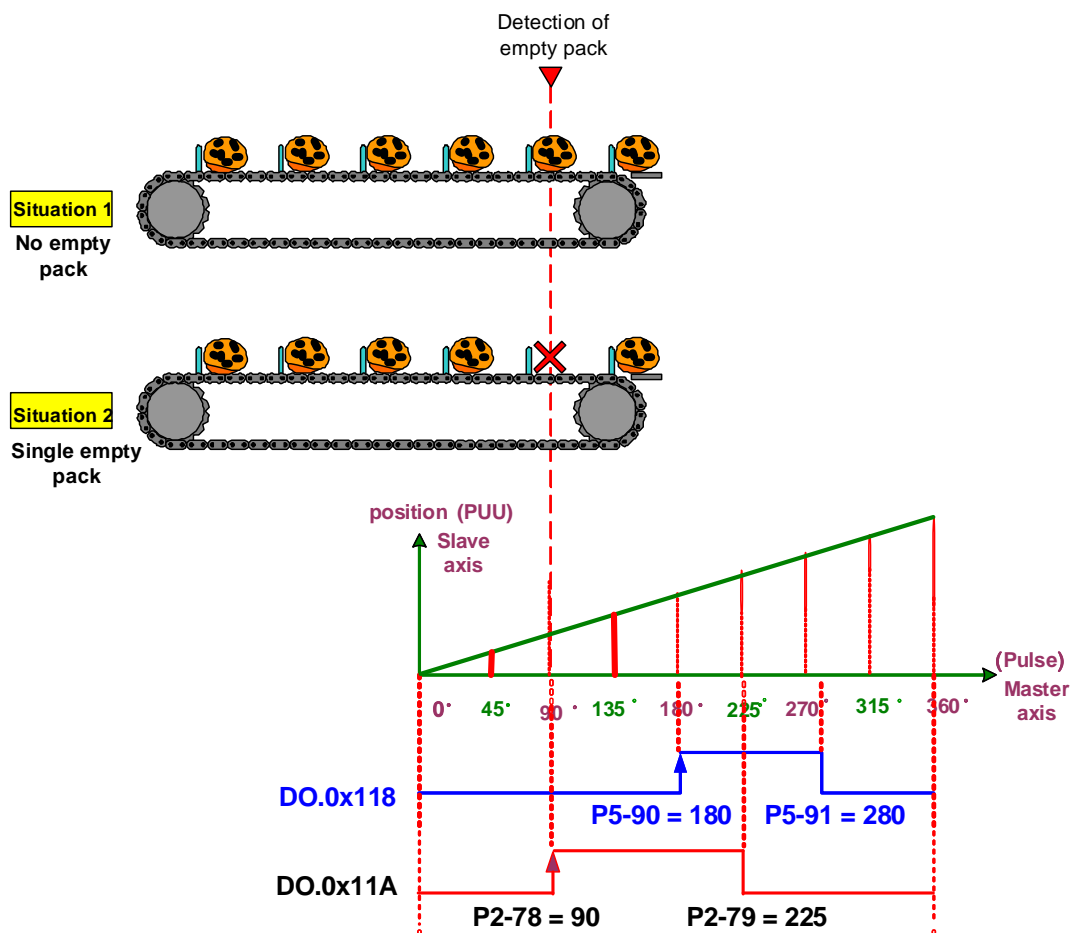
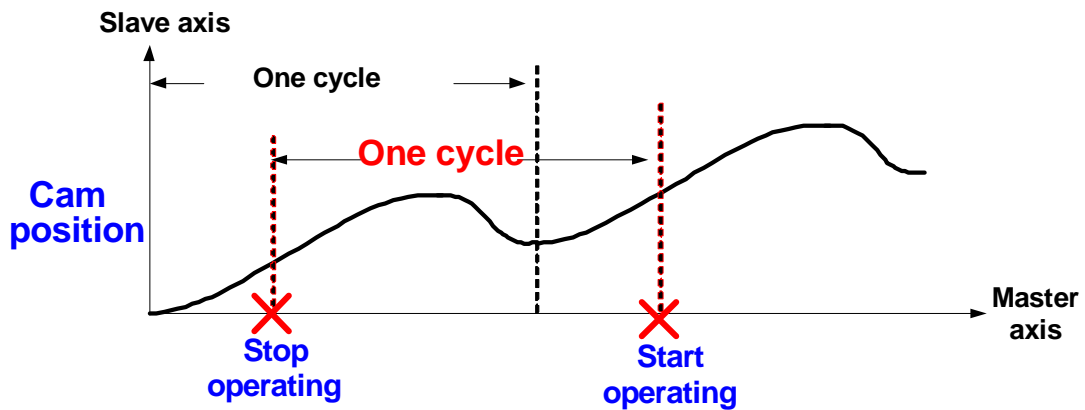
Figure 3.8.13 Detection of empty pack

Figure 3.8.14 Macro10

Macro 10 usually goes with PR special filter P1-22. It is for alleviating the disturbance caused by the dramatic change of commands. P1-22.YX sets for the limit of acceleration time. When PR (or cam) commands change too severe, this setting can smooth the mechanical operation.

Unlike the traditional filter, this special filter (figure 3.8.15) works only when the acceleration and deceleration time shorter than the setting value. If the command time is shorter than the setting value, special filter will change the setting from the original acceleration and deceleration time to the filter's time. If the time is longer than the filter's time, the filter executes its command according to the original time and will not change the command. The acceleration and deceleration time of the filter is defined between 0 and 3000 rpm. If it is set to 300 ms and the speed is at 1000 rpm, then the acceleration and deceleration time is 100 ms. When the speed is at 1500 rpm, the acceleration and deceleration time is 150 rpm and so on. The good points of using the filter is that it will gradually stops and its final position will not go wrong. The system will automatically count the spare distance. When resuming the operation, the system will deduct from it. See Figure 3.8.15.
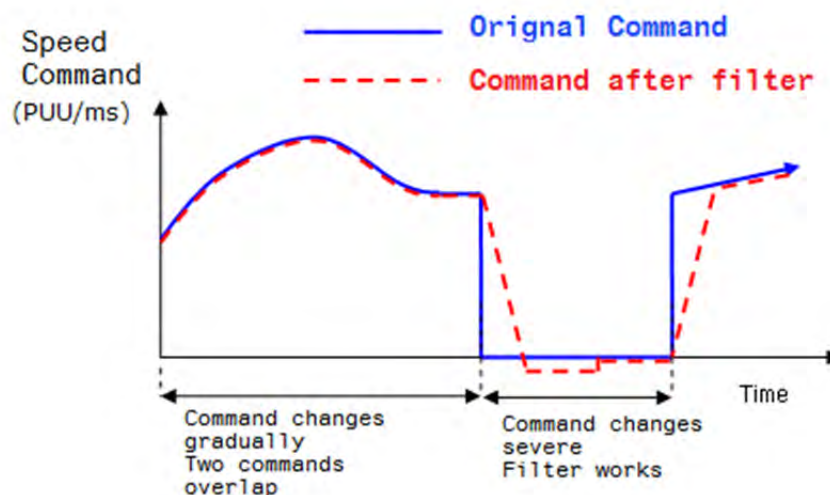

Figure 3.8.15 PR Special Filter

If the user worries that PR special filter will cause reverse operation, use the setting of P1-22.U to avoid it. When the function is working, it will prohibit reverse command. The system will save the prohibited amount. Not until the forward amount is more than the reversed one will the system output the forward command. Therefore, there is no need to concern the inaccurate final position.
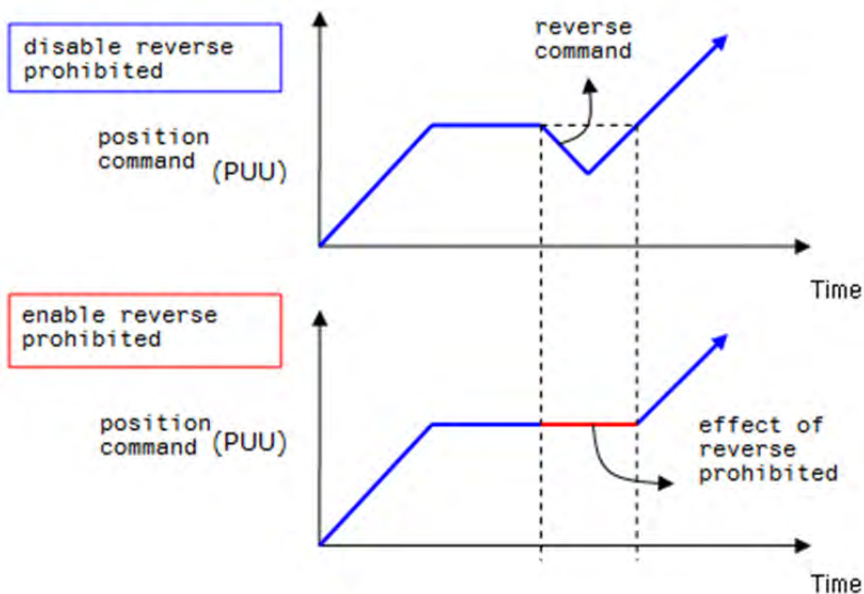

Figure 3.8.16 Reverse Prohibited
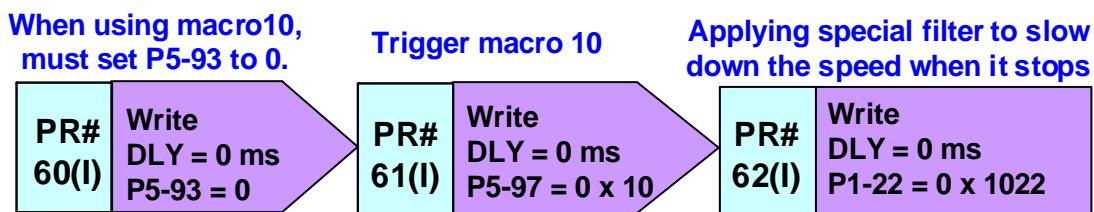
Figure 3.8.17 is the PR Setting of Triggering Empty Pack Skip Procedure

Figure 3.8.17 Empty Pack Skip PR

Avoid Wrong Cutting

When the material is misplaced before cutting, to avoid cutting the material and damage the mechanism, a proper defense mechanism is needed.

Correct packing position   Incorrect packing position
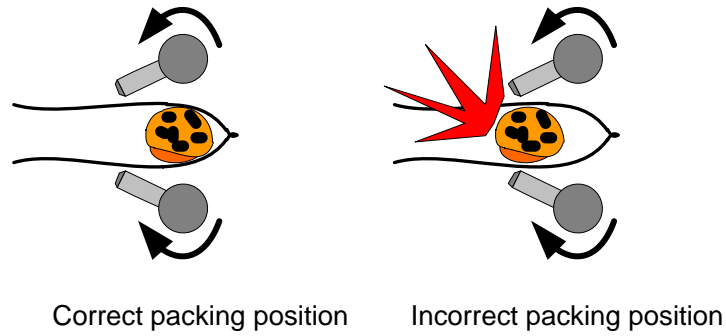
Figure 3.8.18 Material is misplaced

Using E-Cam output angle and the sensor could avoid and detect the material that is placed in a wrong position. See Figure 3.8.19, when DO.0x118 is On, if the sensor does not detect the material, it might mean the material is in a wrong position. To avoid wrong cutting, anti-cut procedure should be activated.
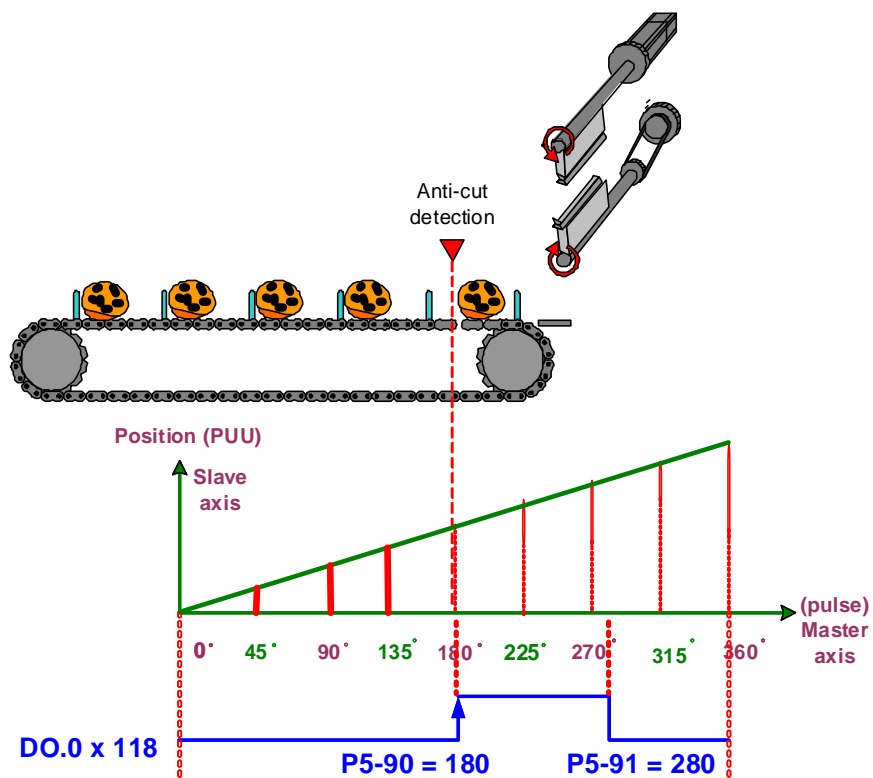

Figure 3.8.19 Anti-cut detection

When anti-cut PR is triggered, enable macro F to calculate the moving distance between current and target position (0 degree of the cutting curve) first. Then, use macro 8 to stop the slave axis for a cycle and make it return to 0 degree. See Figure 3.8.20. When E-Cam is engaged, macro F can write the correcting amount (= the position error between current and target position) into the specified PR data.
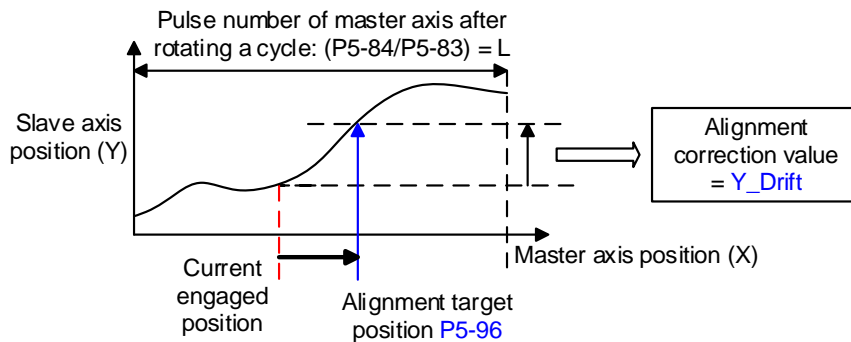
Figure 3.8.20 Macro F

When PR is triggered, the system will set P5-19 to 0 and trigger macro 8 to enable the setting of P5-19 = 0. The motor will stop since the E-Cam curve scaling is 0. After macro 8 is triggered, the setting of P5-19 can be changed back to the original one (P5-19 = 1). When the cutter stops, use macro F to calculate the error between cutter's current and original position. Then, write the error into the PR data and trigger it to return the axis to the original position. At the moment, the cutter axis is engaged, but master axis still keeps sending pulses to cutter axis. The reason the cutter does not operate is simply because P5-19 = 0. The disengaged condition is set as No. 4 cycle mode, when this cycle is completed and disengaged again, P5-19 = 1 and the cutter axis starts operating.
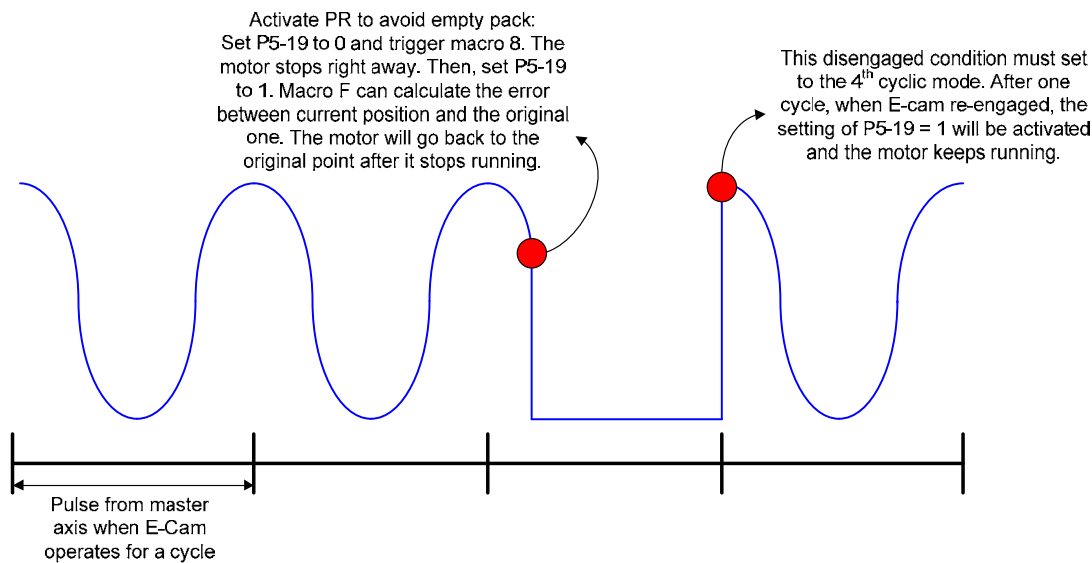

Figure 3.8.21 Avoid empty pack

Anti-cut PR procedure, see figure 3.8.22:

PR#6: Parameter setting of macro F is to set up going trip PR. This application is to move the cutter axis to 0 degree from current position. Setting up return trip PR is not needed.

PR#7: Parameter setting of macro F is to set up available forward rate. Set the going trip as the available max. proportion of forward path. The setting is based on the mechanism. If the

mechanism can only operate at forward direction, then this setting should be set as 100%.

PR#8: Parameter setting of macro F is to set up the alignment target position. Pulse from master axis is its unit. The setting range is between 0 and (P5-84 / P5-83) – 1.

PR#9: Trigger macro F. This macro will calculate the moving distance between the current position and target position which is set by P5-96. Then write the moving distance into PR that is specified by P5-93.

PR#10: Set P5-19 to 0. When the setting value of P5-19 is working, the E-Cam curve will be set to 0 and the E-Cam will stop operating.

PR#11: Trigger macro 8. It allows the setting of P5-19 (E-Cam scaling) becomes effective when E-Cam is engaged.

PR#12: Change the E-Cam scaling back to the original one.

PR#13: When triggering macro F, the calculated moving distance will be written into this PR as the target the position command needs to move. After this PR is triggered, the cutter axis will move to the position which is set by P5-96.

Set up PR of going trip

| PR#6 (1) | Write DLY = 0 ms P5-93 = 0x0D |

Available forward rate (%)

| PR#7 (1) | Write DLY = 0 ms P5-95 = 40 |

Set up the position after triggering macro F and returning to 0 degree

| PR#8 (1) | Write DLY = 0 ms P5-96 = 0 |

Enable macro F and calculate the moving distance of E-Cam

| PR#9 (1) | Write DLY = 0 ms P5-97 = 0xF |

Set up E-Cam curve and stop E-Cam

| PR#10 (1) | Write DLY = 0 ms P5-19 = 0 |

Trigger macro 8 and enable the setting of P5-19 immediately

| PR#11 (1) | Write DLY = 0 ms P5-97 = 0x8 |

Resume E-Cam scale

| PR#12 (1) | Write DLY = 0 ms P5-19 = 1 |

E-Cam moves

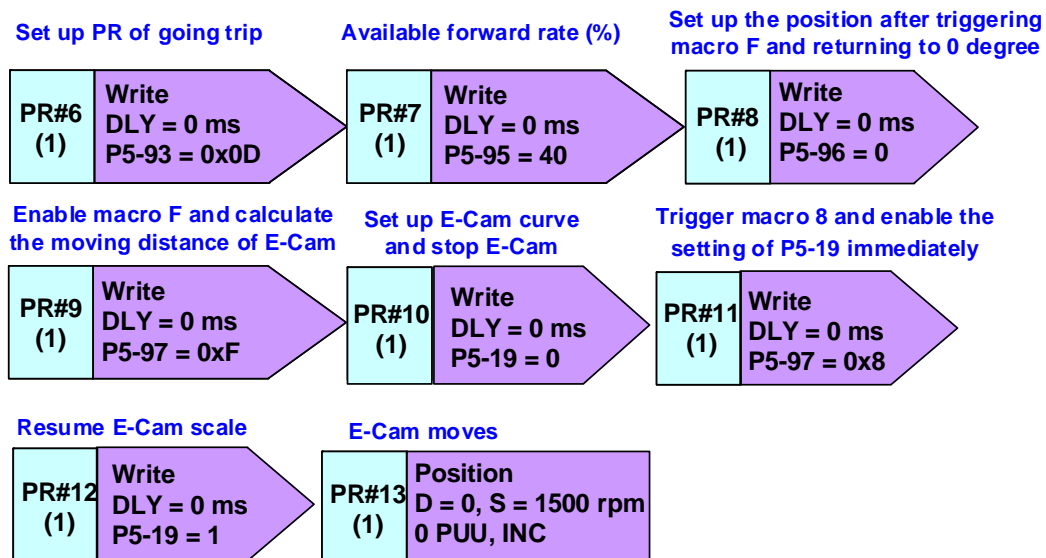| PR#13 (1) | Position D = 0, S = 1500 rpm 0 PUU, INC |

Figure 3.8.22 Anti-cut PR procedure

The time setting of E-Cam disengaged is very important when using this way to avoid mitcut. P5-88.U should be set to C (8+4), which means to set up cyclic mode and the function to disable E-Cam after disengaging. Otherwise, macro 8 cannot work. It has to set up P5-88.X1 (Set P5-88.X to 3 when E-Cam is activated) when E-Cam is engaged. If E-Cam is still engaged because of alarm or servo off, this setting is to ensure PR#13 can still work when E-Cam stops.

Troubleshooting after alarm is cleared

If mechanism stops operating because alarms occur, it might result in relative phase shift. If the system could correctly correspond the phase of master axis to the E-Cam before operation, it can save the material during the phase correction process.

For film feeding axis, the additional setting is unnecessary since it has applied the function of synchronous capture axis and E-Cam positioning. When the alarm is cleared, the system will automatically read the mark and position.

For cutter axis, macro D can be used to do cam positioning before operation. When motor is servo Off or stops because of the alarm, if the actual position is different from the E-Cam position, macro D can calculate the error amount after re-servo on. And the value will be written into the specified incremental position control PR. Then, trigger this PR and return the E-Cam to the ideal position.

The following conditions have to be established when using macro D:

1. Macro D can only be used in the cyclic E-Cam curve which starts from the same position every cycle.

2. E-Cam axis is still engaged when Servo Off or alarm is cleared (P5-88.X1 = 1).

3. E-Cam curve scaling has to be set to 1. (P5-19 = 1).

4. Value of P2-52 has to be set as the error between the slave axis position at the end of the cycle and the position at the beginning of the cycle (Last point - First point). See Figure 3.8.23.

5. Motor's start position has to be at 0 degree of E-Cam curve.
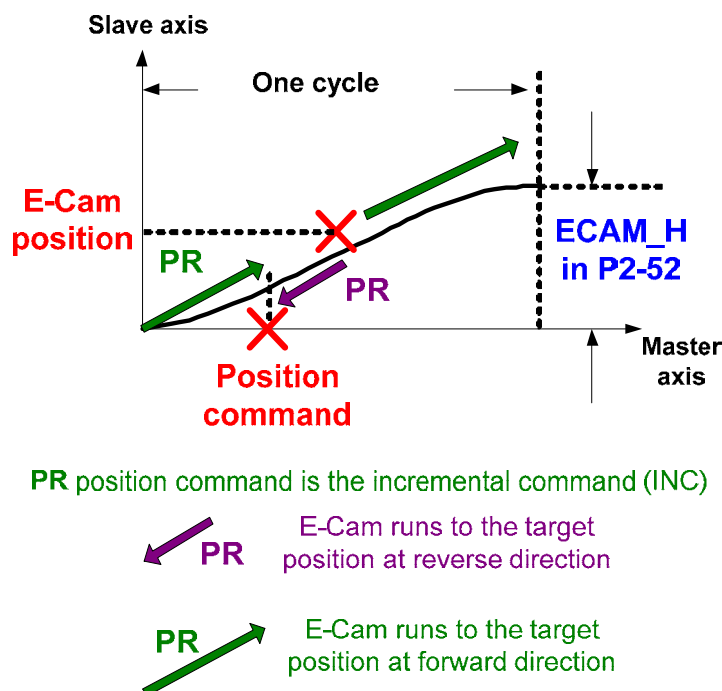
Figure 3.8.23 Marco D

When desire to move the cutter to the target position, motor can operate either at forward or reverse direction. Users can set up available forward rate or avoid point to plan the operating direction.

When setting P5-93.BA to 1, the system will determine the operating direction according to the setting of available forward rate, which is set by P5-95. See Figure 3.8.24 for the description of available forward rate. Its setting is converted by the proportion when motor runs a cycle. For example, when available forward rate is set to 25%, if motor exceeds the target position for 1/4 cycles (25/100 = 1/4) at forward direction the motor will search the target position at reverse direction. In the application, if both forward and reverse directions are allowed, it is suggested to set the rate to 50%. This setting enables the motor to complete the command with the shortest distance.
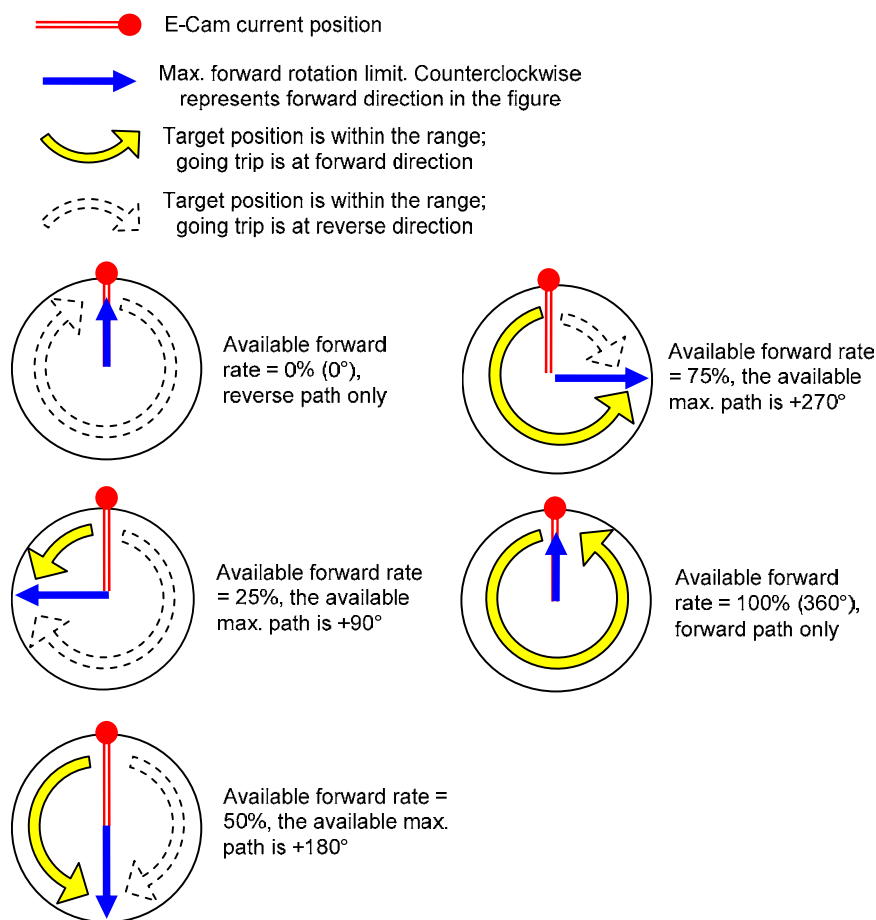
Figure 3.8.24 Setting of available forward rate

If forward and reverse directions are both allowed, but cannot pass the specified position, users can set up an avoid point. When P5-93.BA = 0, the system will determine if the motor shall run at forward or reverse direction according to the current position, target position and avoid point. The position of avoid point can be set up by P5-95. In cutting applications, if desire to move the cutter when the system stops, users can set the cutting position as the avoid point for avoiding the cutter cutting the material.
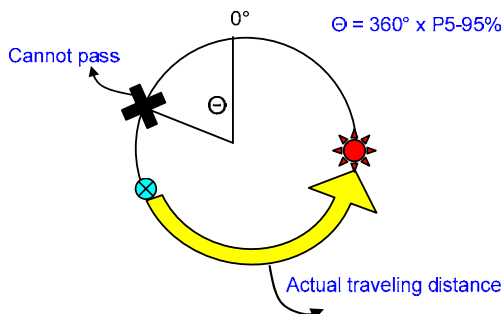
Figure 3.8.25 Setting of avoid point

If reverse direction is not allowed, users can set up reverse inhibit (P5-93.DC = 1). Then, the command of reverse direction will be neglected. That is to say, the motor will start its operation when it receives the command of forward direction. It can protect the mechanism which does not allow reverse direction.

Figure 3.8.26 shows the setting when the cutter axis re-operates after it was stopped by servo off or an alarm:

PR#43:

P5-93.YX = 2E: Set up the specified PR. Macro D will write the error between the current and target position into this PR. Triggering this PR can do positioning. 2E (hex.) means to specify PR#46 as the PR for positioning.

P5-93.UZ = 00: It has to be 0.

P5-93.BA = 01: Use available forward rate to determine the motor operation direction.

P5-93.DC = 01: Enable the function of reverse inhibition.

PR#44: Set available forward rate to 0. The motor only can operate at reverse direction. However, when setting up P5-93.DC, the function of reverse inhibition has been activated. Thus, the motor will be unable to operate to the target position. But the function of phase alignment still works. The cutter axis stands until the phase of master axis corresponds to the correct phase of cutter axis. Then, the cutter operates according to E-Cam curve.

PR#45: Enable macro D. It automatically calculates the error between the current and target position and write into the specified PR.

PR#46: When triggering macro D, the calculated moving distance will be written into this PR as

the distance the position command needs to move. After this PR is triggered, the cutter axis will move to the target position.
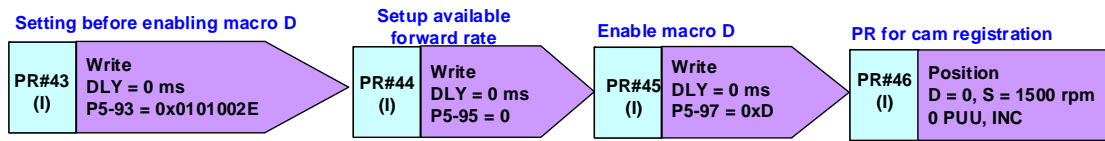

Figure 3.8.26 PR procedure when E-Cam do positioning again

3.8.3.3   Design of E-Cam Curve

In this system, E-Cam curves for operating film feeding axis and cutter axis have to be set up. Film feeding axis operates at constant speed according to master axis, thus, its E-Cam curve is the oblique straight line, which can be done by *Manually create a table* in E-CAM Editor. E-Cam curve of cutter axis is the curve of flying shear, which can be done by *Rotary Shear– W/O Sealing Zone* or macro command (if it has constant speed area).

Followings are the mechanism specification:

Gear number at motor side # (A)	5
Gear number at cutter side # (B)	5
Diameter of the encoder (d2)	20 mm
Pulse number per resolution (N)	10000
Cutter number (C)	1
Diameter of the cutter (d1)	200 mm
Cutting length (L)	500 mm
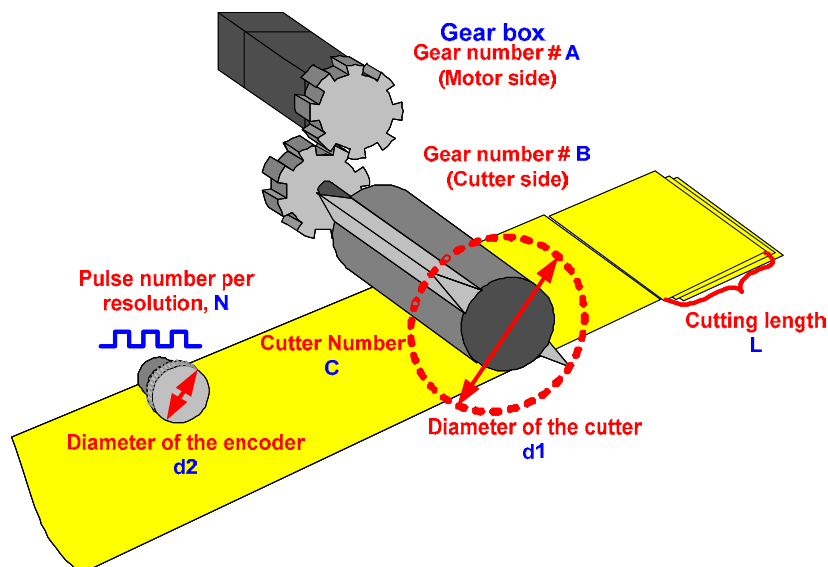
Figure 3.8.27 Mechanism specification

E-Cam curve of cutter axis

The E-Cam curve of cutter axis can be done by *E-CAM editor* of ASDA-Soft. This example uses *Rotary Shear – Adjustable Sealing Zone* to create an E-Cam curve. Users can create the curve by setting up the required mechanism specification and angle. Please refer to Chapter 2 or ASDA-Soft User Manual for detailed descriptions. The pulse number of master axis in this example is calculated by software based on mechanism specification, P5-84 = 79577 (P5-83 = 1). The setting of E-gear ratio of cutter axis is P1-44 = 128 / P1-45 = 1. After creating the curve, store it into data array to complete the setting.
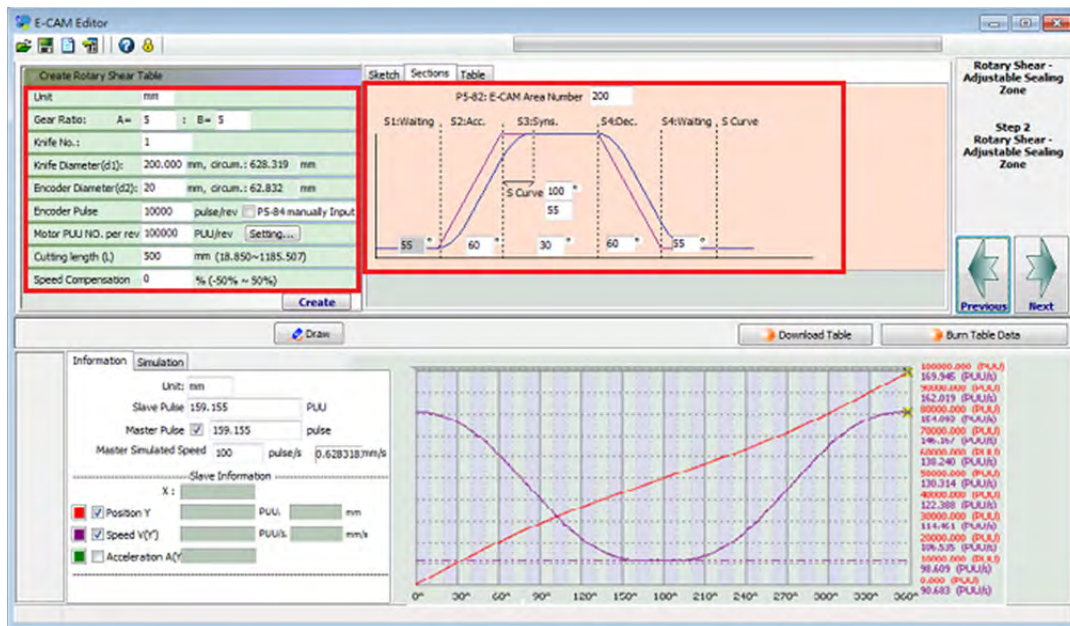
Figure 3.8.28 *Rotary Shear – Adjustable Sealing Zone*

E-Cam curve of film feeding axis

The E-Cam curve of film feeding axis can be done by *E-CAM Editor* of ASDA-Soft. Assume the gear ratio between motor and mechanism is 1:5 and the cutting length is 500 mm, 1 mm of resolution corresponds to 100 PUU and 500 mm needs 50,000 PUU. The mechanism operates 50,000 PUU, it means the motor operates 50,000 x 5 = 250,000 PUU. The gear ratio of film feeding axis can be set as P1-44 = 128 / P1-45 = 5. See Figure 3.8.29. It uses *Manually create a table* to create the curve for film feeding axis and input 250,000 as the total length to create an E-cam curve for constant speed operation. The E-gear ratio setting of film feeding axis is the same as the one of cutter axis, which is P5-83 = 1 / P5-84 = 79577.
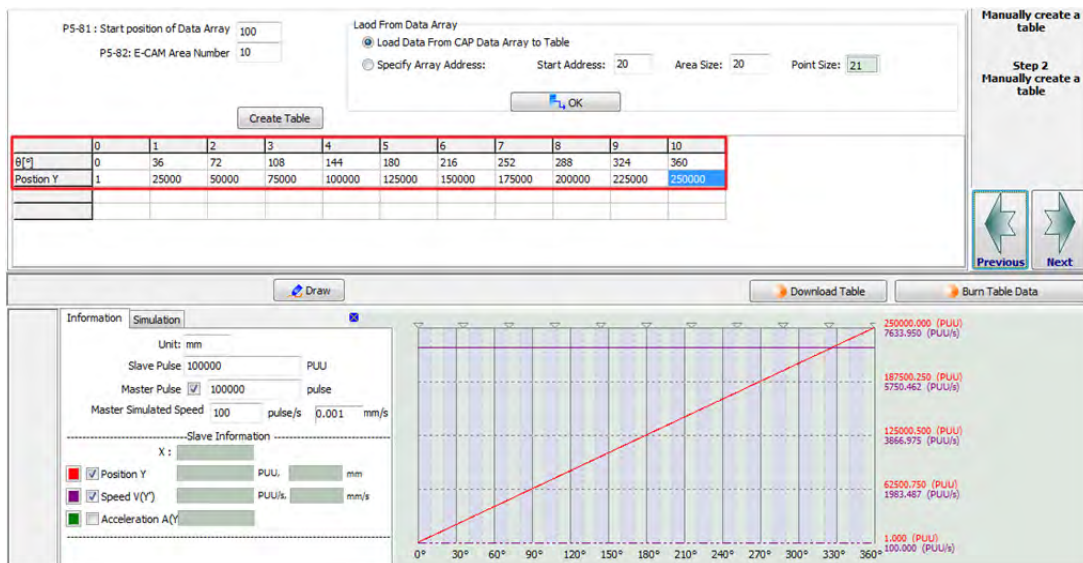
Figure 3.8.29 Manually create an E-Cam curve for film feeding axis

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Application Techniques

<div style="text-align: right; font-size: 4em;">4</div>

4.1   DO Output with Fixed Distance

4.1.1   Description

With the built-in COMPARE function of ASDA-A2, users can enable DO signal output after the motor operates for a distance. More than one DO output can be flexibly programed and its output length can also be modified. For applying this application, the related background knowledge about internal control (PR) and COMPARE function of ASDA-A2 servo drive is required. The built-in function can satisfy the demand without modifying the hardware, which not only reduces the cost of mechanism but improves the flexibility. Four digital outputs (DO1 / DO2 / DO3 / DO5) are the maximum when there is no other extension DO. Please note that, DO4 is only for COMPARE function and cannot be applied in this application.

4.1.2   System Configuration

Here are the examples of two digital outputs. The output time of one example is overlapped and the other is not.

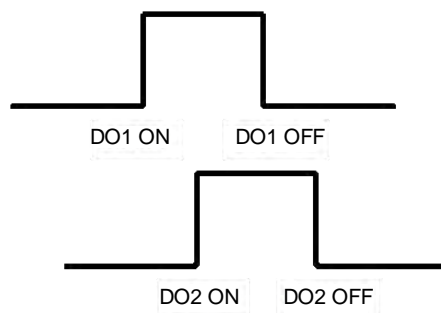Figure 4.1.1 shows the time when two DOs are overlapped.

Figure 4.1.1   The Output Time of Two DOs is Overlapped

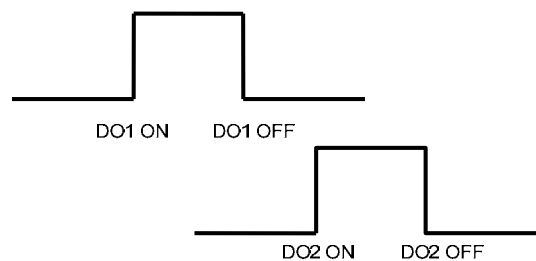Figure 4.1.2 shows the time when two DOs are not overlapped.

Figure 4.1.2 The Output Time of Two DOs is not Overlapped

See the example in figure 4.1.1. The output time of two DOs is overlapped. Followings are the system configuration:
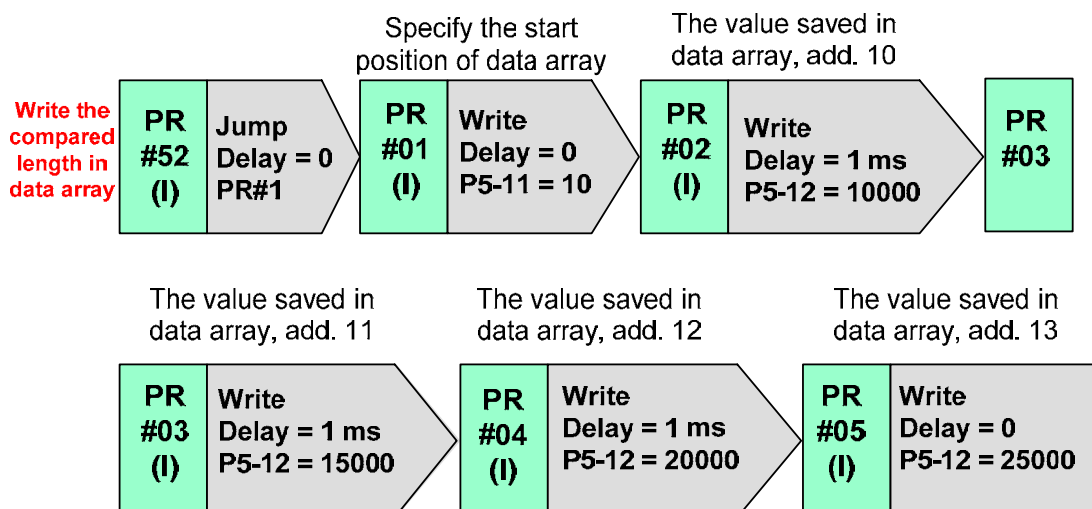
1. Use PR write-in function to write four values, input 1 to input 4 (the timing when DO1 and DO2 is on and off) into data array and regard them as the timing when Compare outputs. The first compare value (input 1) is the timing to set DO1 on; while the second value (input 2) is the timing to set DO2 on; the third compare value (input 3) is the timing to set DO1 off and the fourth one (input 4) is the timing to set DO2 off.

2. When the motor is activated, enable the 1st compare function. The compared value is the first value (input 1) entered into data array. Then, call PR#45. Use Jump function to call one PR so as to set P4-06 to 0x0001 and to set DO1 on.

3. Then, change the jump path of PR#45 as the next path that will be written into the value of P4-06.

4. Repeat step 2 ~ 3 to execute the 2nd, 3rd and 4th compare function. When the 2nd compare value (input 2) is written into data array, DO2 is on. When the 3rd compare value (input 3) is written to data array, DO1 is off. When the 4th compare value (input 4) is written to data array, DO2 will be off.
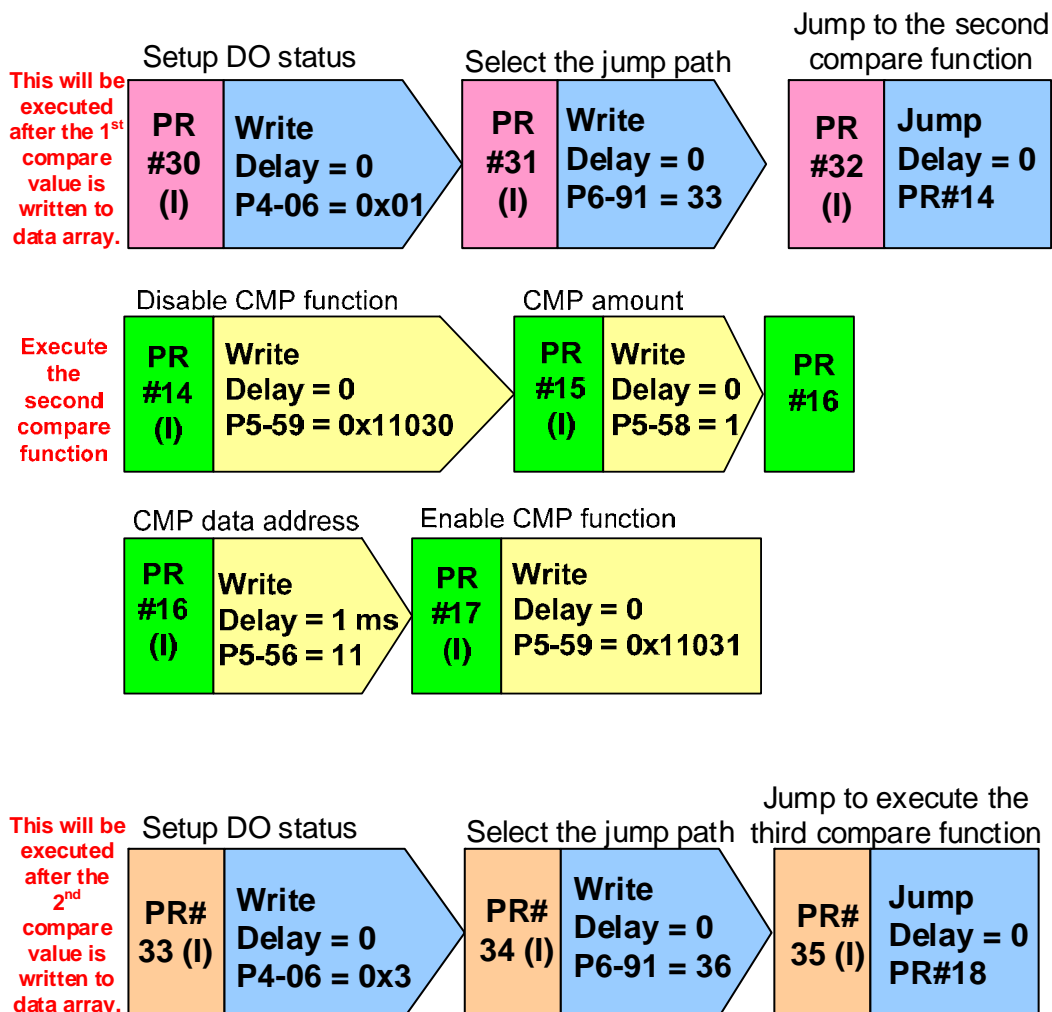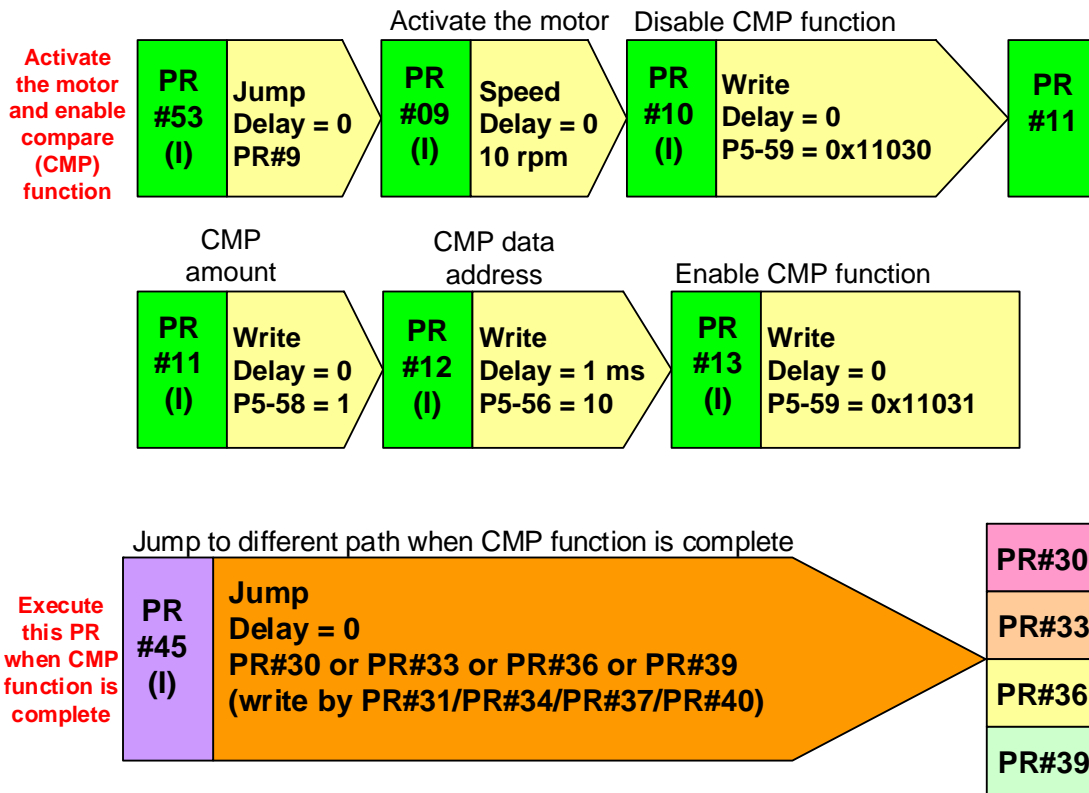
See the example in figure 4.1.2. The output time of two DOs is not overlapped. Step 4 is different in this example. In step 4, when the second compare value (input 2) is written to data array, DO1 is off. When the third compare value (input 3) is written to data array, DO2 is on. And when the fourth compare value (input 4) is written to data array, DO2 is off.

4.1.3 Servo System Setting

PR program

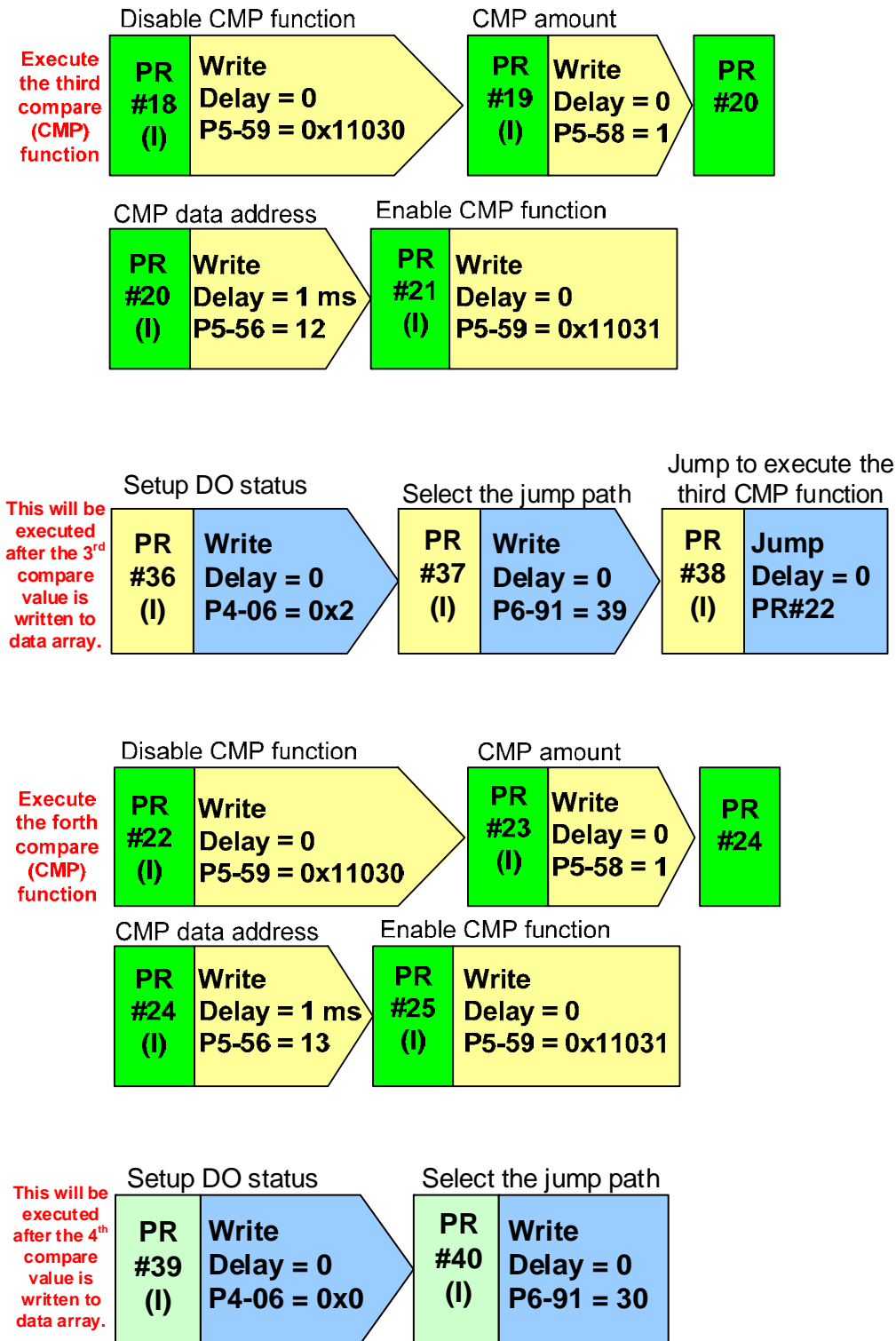Following describes the PR program when the output time of two DOs is overlapped.

Activate the motor and enable compare (CMP) function

Activate the motor   Disable CMP function

PR #53 (I) | Jump Delay = 0 PR#9 → PR #09 (I) | Speed Delay = 0 10 rpm → PR #10 (I) | Write Delay = 0 P5-59 = 0x11030 → PR #11

CMP amount   CMP data address   Enable CMP function

PR #11 (I) | Write Delay = 0 P5-58 = 1 → PR #12 (I) | Write Delay = 1 ms P5-56 = 10 → PR #13 (I) | Write Delay = 0 P5-59 = 0x11031

Execute this PR when CMP function is complete

Jump to different path when CMP function is complete

PR #45 (I) | Jump Delay = 0 PR#30 or PR#33 or PR#36 or PR#39 (write by PR#31/PR#34/PR#37/PR#40) → PR#30 / PR#33 / PR#36 / PR#39

This will be executed after the 1st compare value is written to data array.

Setup DO status   Select the jump path   Jump to the second compare function

PR #30 (I) | Write Delay = 0 P4-06 = 0x01 → PR #31 (I) | Write Delay = 0 P6-91 = 33 → PR #32 (I) | Jump Delay = 0 PR#14

Execute the second compare function

Disable CMP function   CMP amount

PR #14 (I) | Write Delay = 0 P5-59 = 0x11030 → PR #15 (I) | Write Delay = 0 P5-58 = 1 → PR #16

CMP data address   Enable CMP function

PR #16 (I) | Write Delay = 1 ms P5-56 = 11 → PR #17 (I) | Write Delay = 0 P5-59 = 0x11031

This will be executed after the 2nd compare value is written to data array.

Setup DO status   Select the jump path   Jump to execute the third compare function

PR# 33 (I) | Write Delay = 0 P4-06 = 0x3 → PR# 34 (I) | Write Delay = 0 P6-91 = 36 → PR# 35 (I) | Jump Delay = 0 PR#18

Execute the third compare (CMP) function

Disable CMP function
PR #18 (I) | Write Delay = 0 P5-59 = 0x11030

CMP amount
PR #19 (I) | Write Delay = 0 P5-58 = 1

PR #20

CMP data address
PR #20 (I) | Write Delay = 1 ms P5-56 = 12

Enable CMP function
PR #21 (I) | Write Delay = 0 P5-59 = 0x11031

This will be executed after the 3rd compare value is written to data array.

Setup DO status
PR #36 (I) | Write Delay = 0 P4-06 = 0x2

Select the jump path
PR #37 (I) | Write Delay = 0 P6-91 = 39

Jump to execute the third CMP function
PR #38 (I) | Jump Delay = 0 PR#22

Execute the forth compare (CMP) function

Disable CMP function
PR #22 (I) | Write Delay = 0 P5-59 = 0x11030

CMP amount
PR #23 (I) | Write Delay = 0 P5-58 = 1

PR #24

CMP data address
PR #24 (I) | Write Delay = 1 ms P5-56 = 13

Enable CMP function
PR #25 (I) | Write Delay = 0 P5-59 = 0x11031

This will be executed after the 4th compare value is written to data array.

Setup DO status
PR #39 (I) | Write Delay = 0 P4-06 = 0x0

Select the jump path
PR #40 (I) | Write Delay = 0 P6-91 = 30

Figure 4.1.3 System PR Configuration

1. Write the value required by compare function in data array. Here can setup the output timing and output duration of DO. See below for the main PR functions:

    a   Use P5-11 to specify the start address when writing value to data array.

    b   Use P5-12 to continuously write the value into data array.

    c   PR#2 setup the timing of DO1 on.

    d   PR#3 setup the timing of DO2 on.

    e   PR#4 setup the timing of DO1 off.

    f   PR#5 setup the timing of DO2 off.
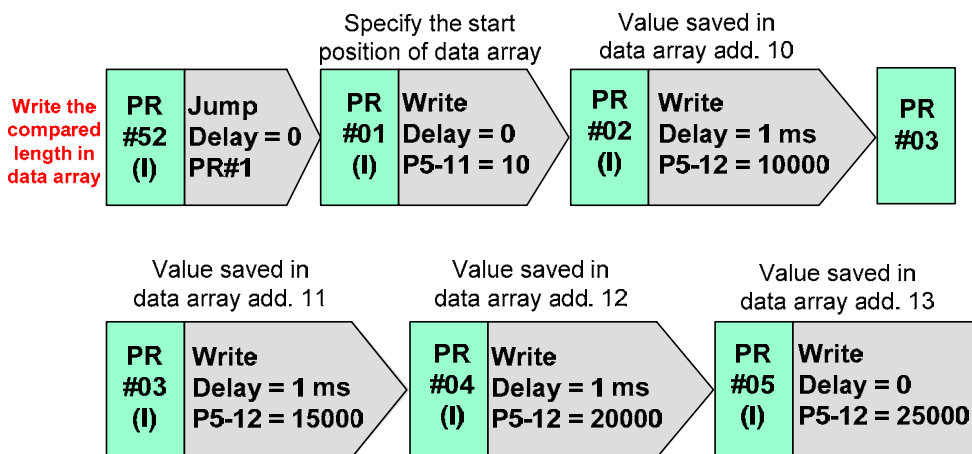
Figure 4.1.4 PR Illustration for Setting up Data Array

2. See below for the main PR functions when enabling compare function:

    a   PR#09: Activate the motor. In this example, the source axis of compare function is set to the output pulse from the encoder.

    b   PR#12: Specify the compare start address in data array. This value is the timing of DO1 on.

    c   PR#13: Enable compare function.
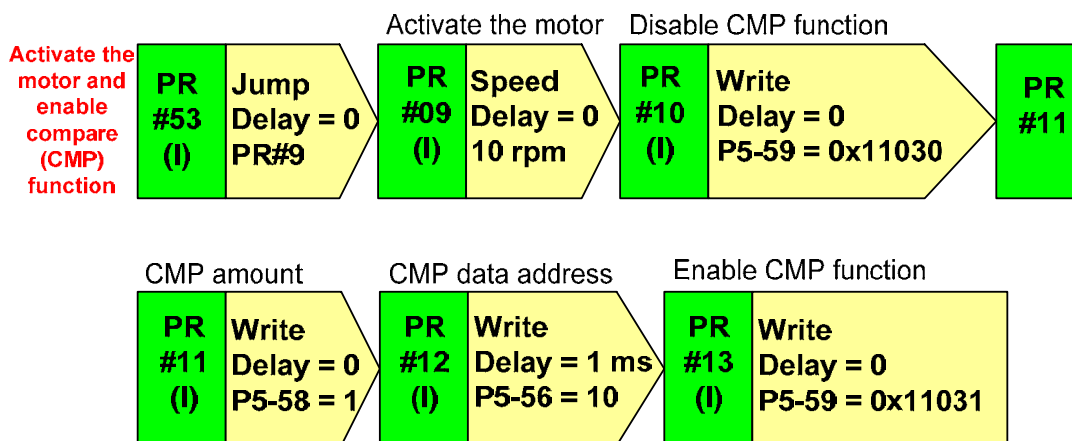
Figure 4.1.5   PR Illustration of Compare Function

3. Once the compare function is complete, a signal will be outputted and the compare function will be disabled. Then, PR#45 jumps to different PR so as to setup DO status.

   a   PR#30 / PR#33 / PR#36 / PR#39: Setup P4-06 so as to change the output status of DO1 and DO2

   b   PR#31 / PR#34 / PR#37 / PR#40: Change the jump path of PR#45 so as to fulfill the condition for the next compare

   c   PR#32 / PR#35 / PR#38: Jump to execute the next compare

   d   The second, third and fourth compare function should be identical to the first one. Specify the compare address to the correct address (PR#16 / PR#20 / PR#24).
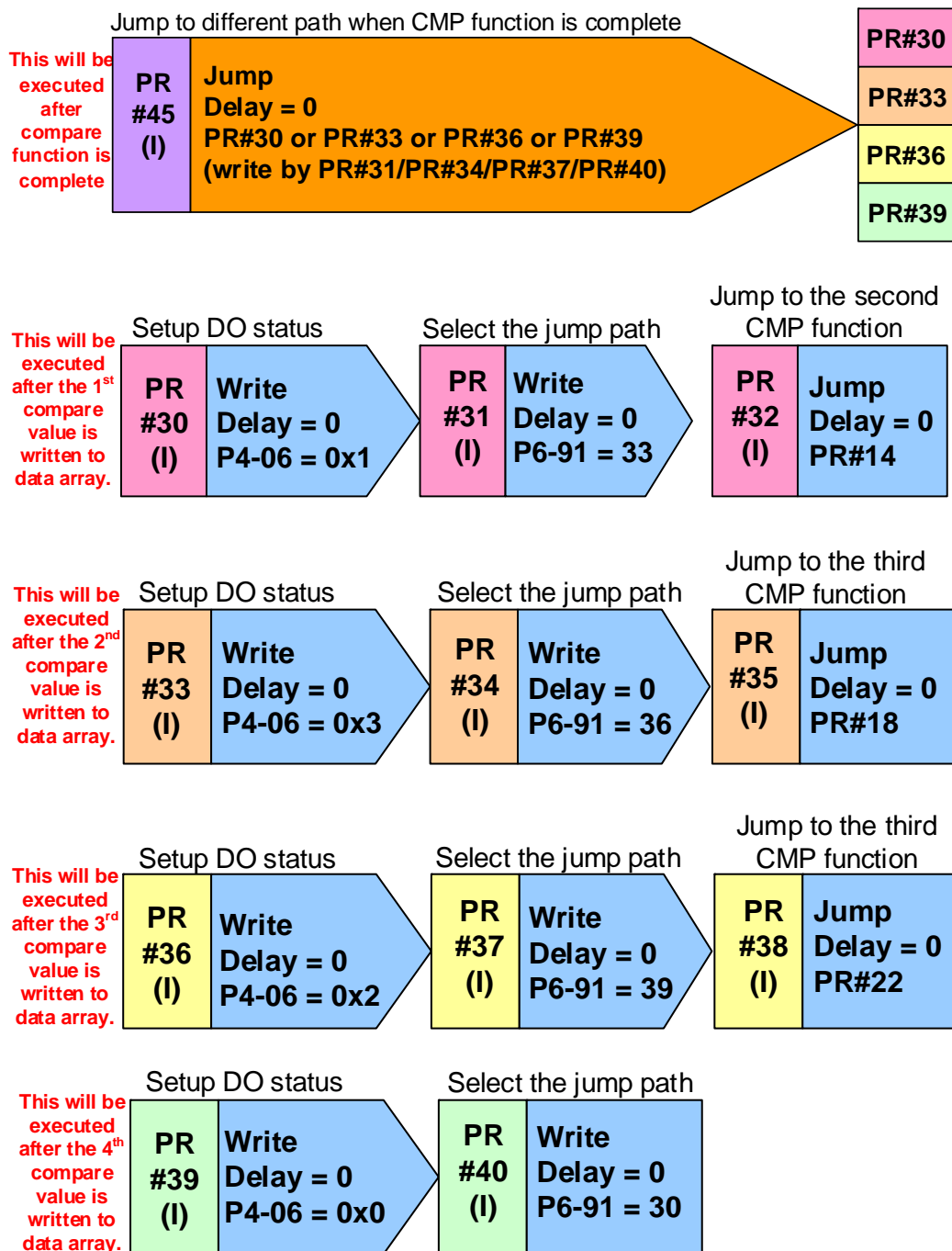
Figure 4.1.6   PR Illustration for DO Setup

4.2 How to Use E-Cam Function to Compensate Tolerances on Lead Screw

4.2.1 Description

In the application of precision machinery that adapts an open-loop system, manufacturing tolerance on pitch of lead crew will cause inconsistency between command and position of machine. System of ASDA-A2 is able to create a compensative E-Cam curve based on the measurement of the lead screw to solve this problem, keeping the resolution of command from the host controller remains the same.

4.2.2 How does the System Work?

4.2.2.1 Inconsistency between Command and Machine Position Caused by Tolerances on Lead Screw

When pitches on lead screw are identical, the correspondence between command and pitch will be consistent so no compensation is needed.
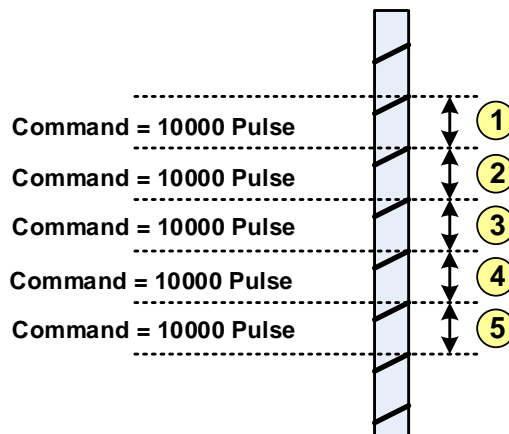
Figure 4.2.1 Command from the Host Controller and the Lead Screw without Tolerance

When pitches are not identical, the distance specified by the command and the actual moving distance of the lead screw will not be identical. That is, the actual moving distance that every pulse corresponds to is different. In this case, the resolution of command is changed.
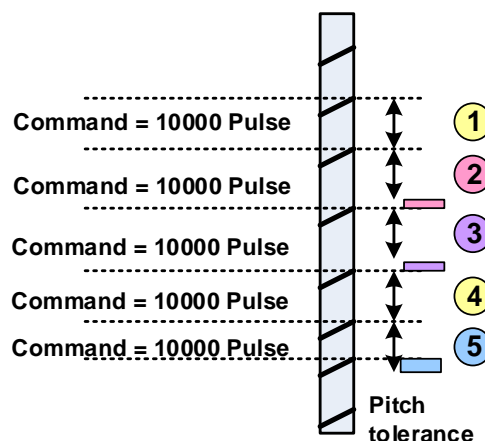
Figure 4.2.2 Command from the Host Controller and Lead Screw with Tolerance

4.2.3   Servo System Configuration

4.2.3.1   The Conversion of Command and Compensation from Servo Drive

E-Cam system of ASDA-A2 can adjust the command resolution of the host controller and keep it consistent with the moving distance of the mechanism. If tolerance of pitch exists, the system is able to adjust the E-Cam curve according to the actual moving distance of the lead screw, making every pulse correspond to the same amount of moving distance and eliminating the impact brought from different tolerances. In this setting, values from command of the host controller, E-Cam command from the servo drive have to correspond to each other, and actual moving distance of the mechanism. See Figure 4.2.3.
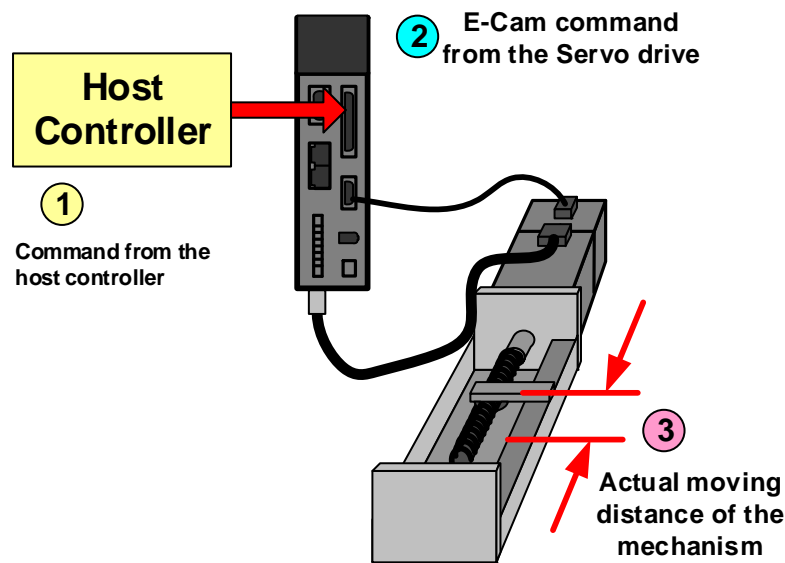
Figure 4.2.3 The Correlation of Command of Host Controller, E-Cam Curve, and Machine Moving Distance

If a host controller which pulse command resolution is 0.1 mm/pulse and the required moving distance of mechanism is 20 mm, the required pulse number will be 20 mm / 0.1 mm = 200 pulse. If there is no tolerance on lead screw and the servo does not modify the command, the correlation is 1 pulse → 1 PUU→ 0.1 mm. (See Figure 4.2.4) PUU is the unit of command from Delta's servo drive.
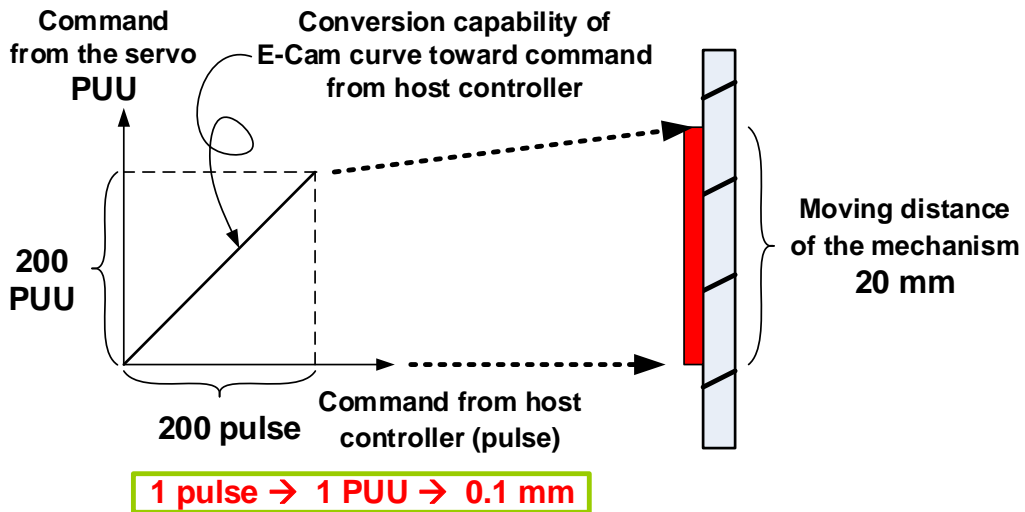
Figure 4.2.4 The Proper Correlation when No Tolerance Exists

When there is a tolerance on the lead screw, the actual moving distance is 22 mm. The correlation will be: 1 pulse→ 1 PUU → 0.11 mm. Regarding this motion, the command resolution was 0.1 mm/pulse and now becomes 0.11 mm/pulse. This is caused by the tolerance between pitches.
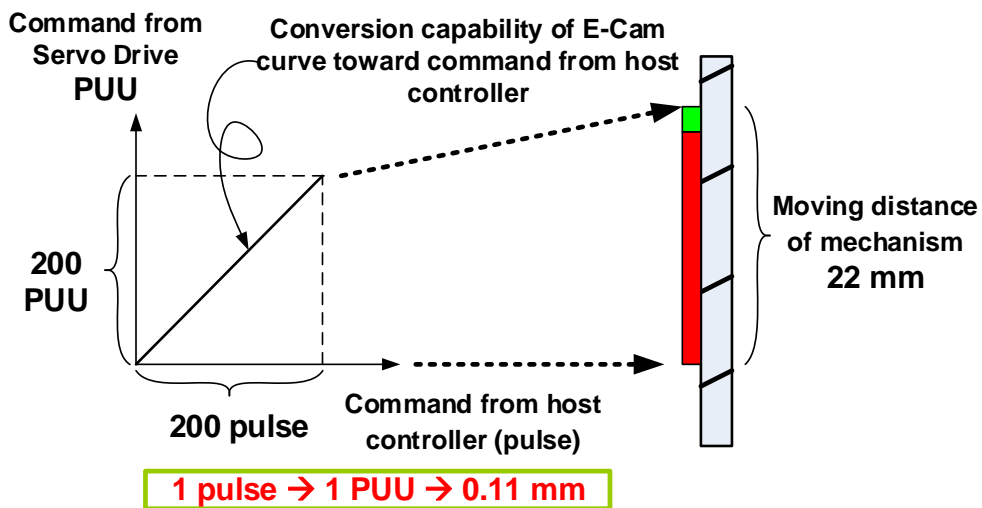
Figure 4.2.5 The Inconsistent Correlation when Tolerance Exists

In this case, an E-Cam curve can be used to modify the command resolution. If the new correlation of E-Cam curve is 1 pulse → 0.9091 PUU → 0.1 mm, the correlation between host command and the actual moving distance will be 1 pulse → 0.1 mm. By applying the E-Cam function, the command resolution of the host controller can be identical without being affected by the tolerance. There is one thing worth noticing, the feedback pulse number from motor will differ from the command value. For example, when the command is 220 pulse, the feedback pulse from motor is 200 PUU and the actual moving distance of mechanism is 22 mm.
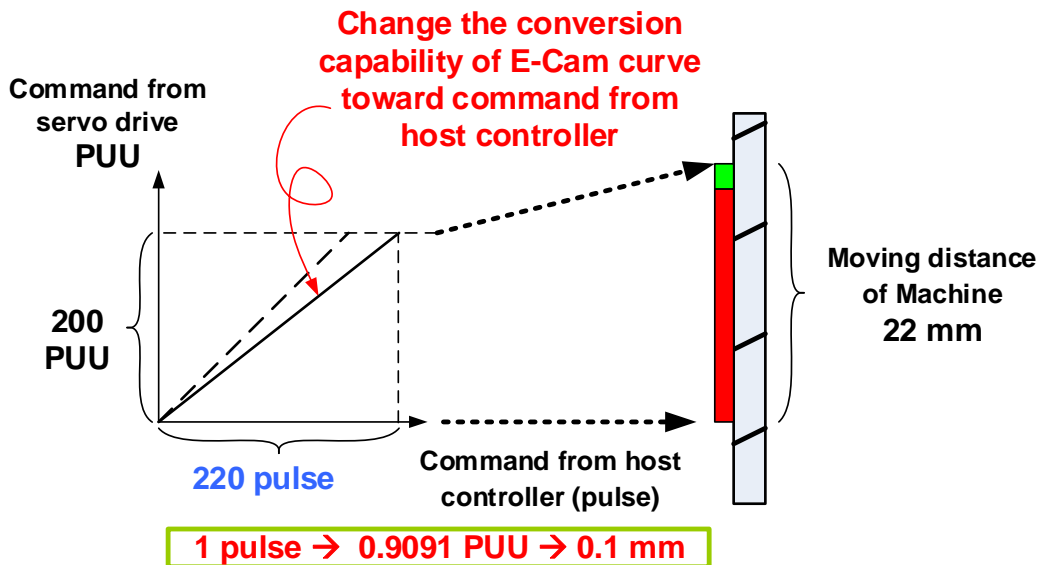
Figure 4.2.6 The Correlation after Compensation by E-Cam Curve

4.2.3.2   Measurement and Measuring Result

If equally divide the lead of the lead screw by the host controller and use laser interferometer to measure the actual moving distance and then record these data, the ideal condition is presented below in Figure 4.2.7.

Let's say command resolution is 0.1 mm / pulse.
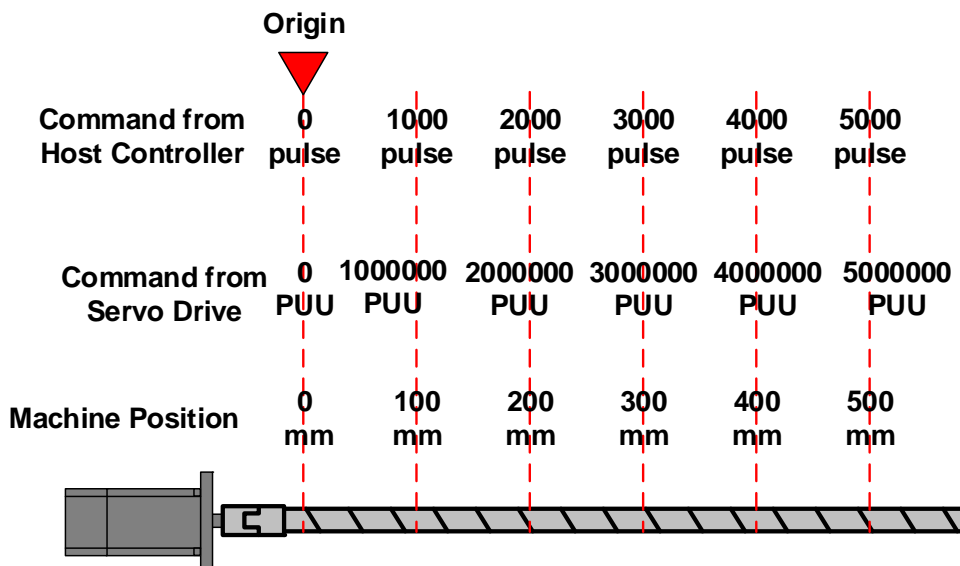
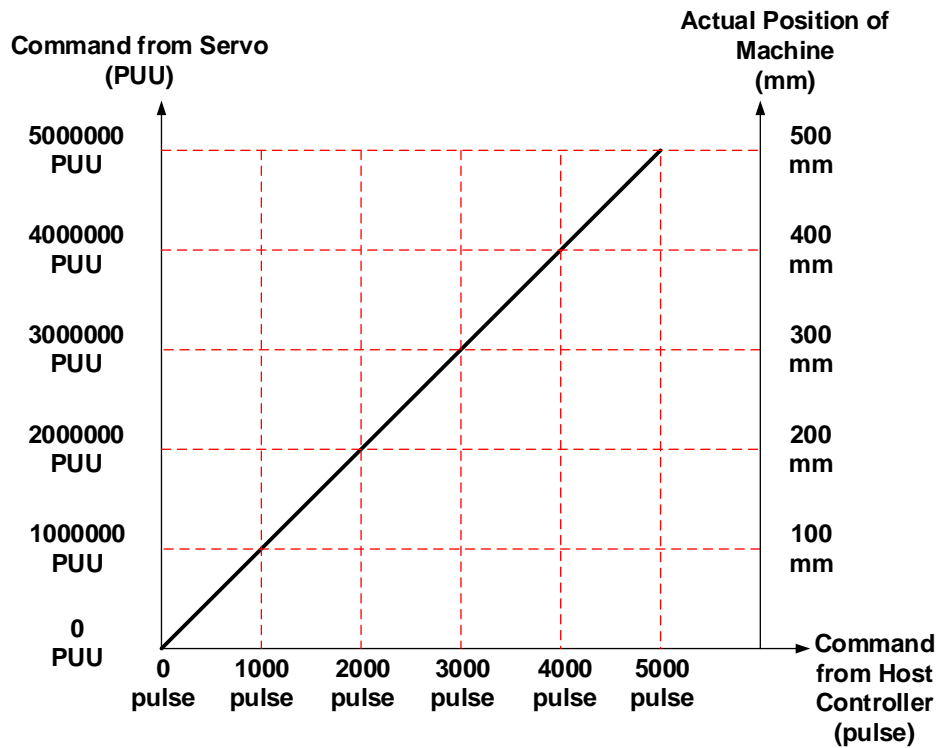Figure 4.2.7 Ideal Measurement Result when No Tolerance Exists

Figure 4.2.8 The Correlation Curve when No Tolerance Exists

In the actual measurement, there must be tolerance. See Figure 4.29. Thus, the E-Cam curve will be used to compensate and restore the resolution to 0.1 mm/pulse between every division.
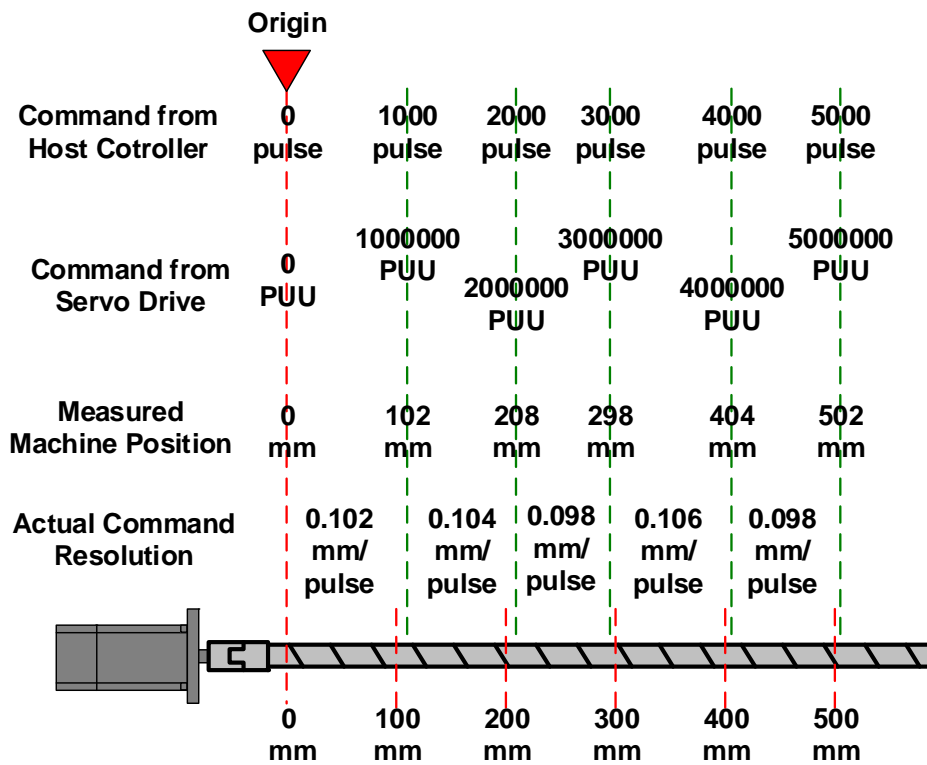
Figure 4.2.9 Measurement Result when Tolerance Exists
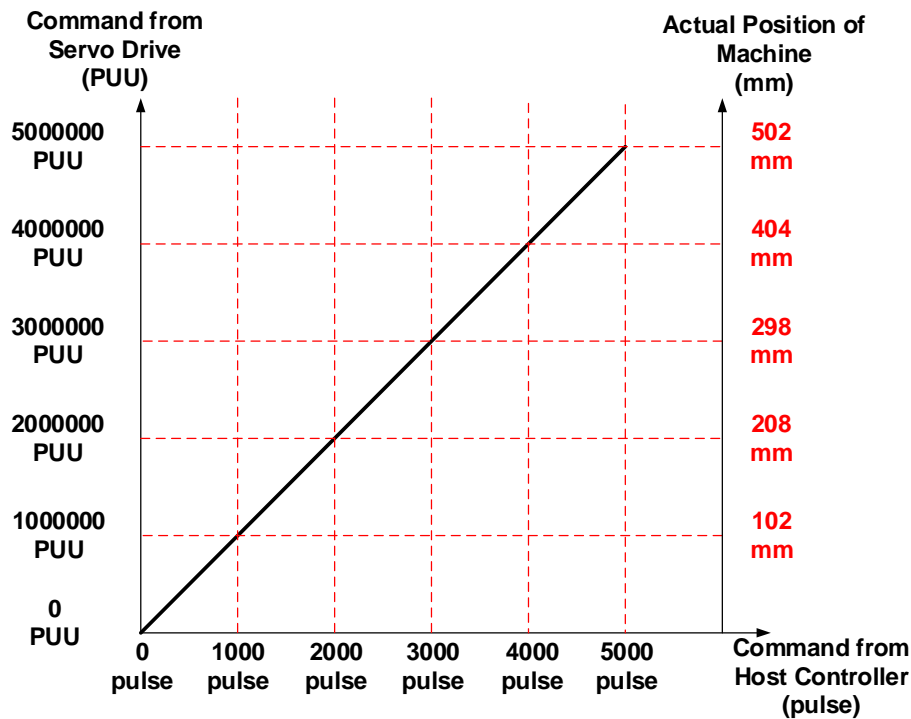
Figure 4.2.10 The Correlation when Tolerances Exist

4.2.3.3   Using E-Cam on ASDA-A2 for Compensation

Using E-Cam curve to compensate the command from the host controller is like creating a tailor-made position curve for the lead screw. By doing so, the command resolution will not be changed due to the pitch tolerances that causing the inconsistency between the host controller and machine moving distance. The result after compensation is shown in Figure 4.2.11. With the compensation, no matter it is on which division of the lead screw, the correlation between command from host controller and moving distance of mechanism will be 1 pulse → 0.1 mm.
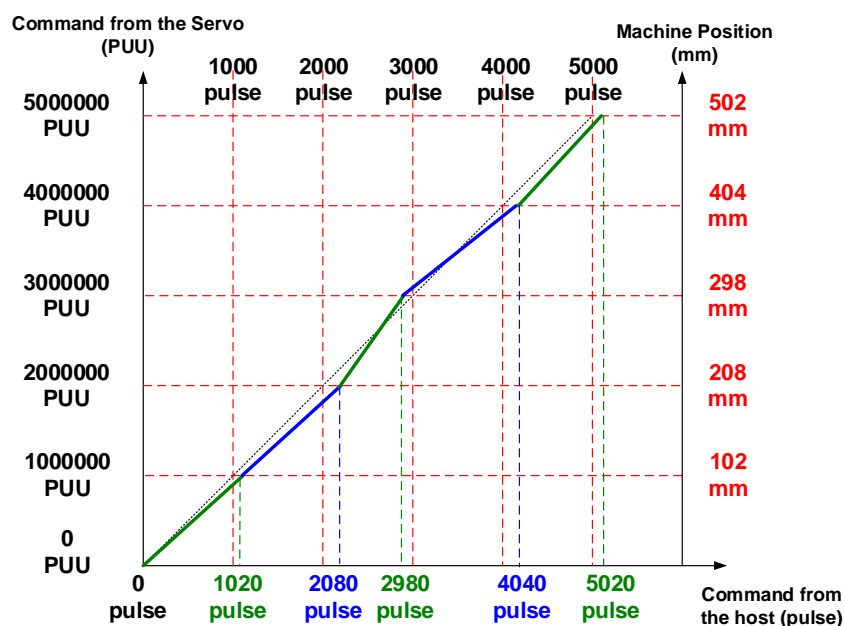
Figure 4.2.11 The Compensation Curve

Steps to create E-Cam curve are shown below:

1. E-Cam curve on ASDA-A2 is created based on corresponding positions. Pulse of the master
   axis is the command from the host controller, which corresponds to the pulse number based
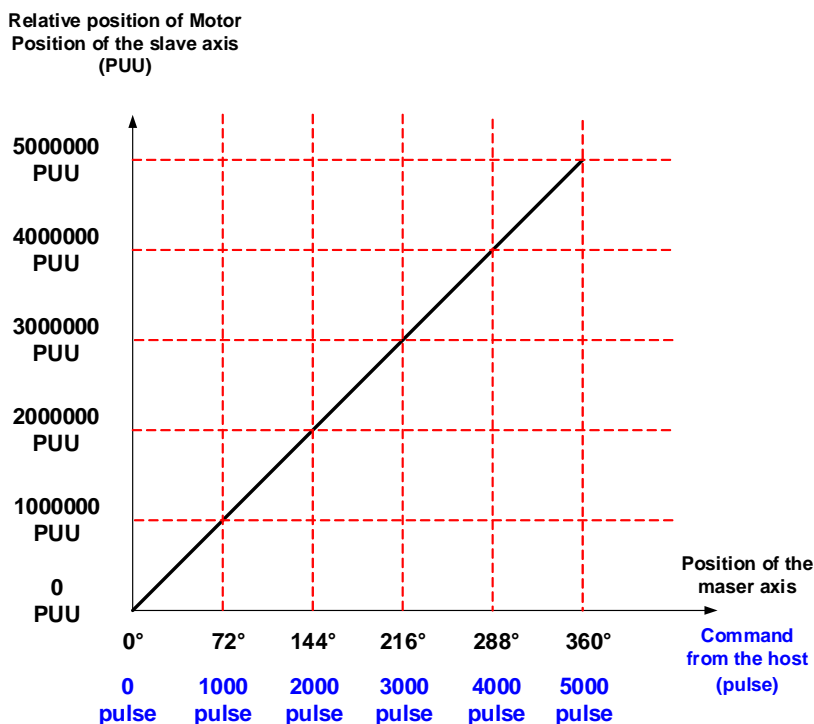   on 360°. The other axis represents motor's position, which unit is PUU.

Figure 4.2.12 E-Cam Curve and Measurement Diagram

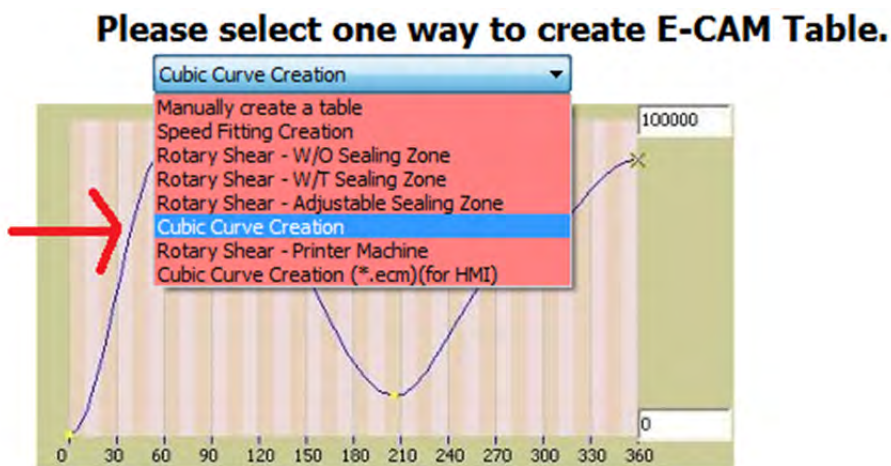2. Select *Cubic Curve Creation*. See Figure 4.2.13.

Figure 4.2.13 Select the Way to Create E-Cam Table

3. Right click the mouse button to insert points. The total points will be the measuring points plus
   the origin. See example in Figure 4.2.9, the total required points are 6 (Figure 4.2.14). Set
   Curve Type for each point to *[1]: constant line.*
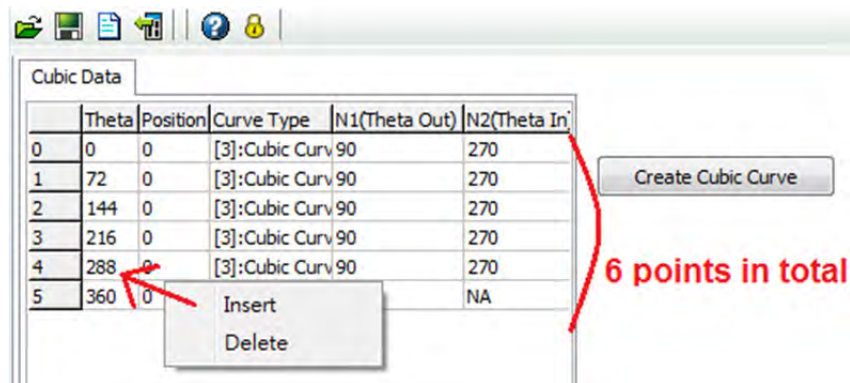
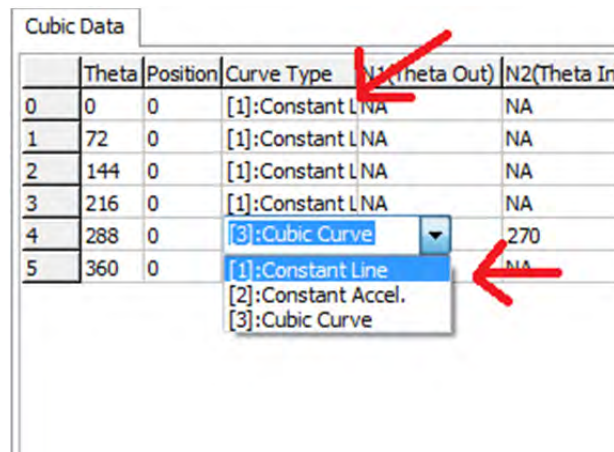Figure 4.2.14 Total points = measuring points + origin

Figure 4.2.15 Set Curve Type of Every Angle to *[1]: constant line*

4. Please refer to Figure 4.2.9 and Figure 4.2.10. Calculate the angle of the master axis and take 0.1 mm/pulse as the basis of command resolution.

    0 mm→ 0 Pulse → 0° → 0 PUU

    102 mm → 1020 pulse → 360 * 1020 / 5000=**73.44**° → **1000000** PUU

    208 mm → 2080 pulse → 360 * 2080 / 5000=**149.76**° → **2000000** PUU

    298 mm → 2980 pulse → 360 * 2980 / 5000=**214.56**° → **3000000** PUU

    404 mm → 4040 pulse → 360 * 4040 / 5000=**290.88**° → **4000000** PUU

    502 mm → 5020 pulse → 360 * 5020 / 5000=**361.44**° → **5000000** PUU

    As the last one has exceeded 360°, edit the data and keep it within the range (360°):

    500 mm → 5000 pulse → **360**° → 5000000 * 5000 / 5020 = **4980080** PUU

5. Fill in the data mentioned above. Then, set *Sample ang.* (sampling angle) to 1°. Click on *Create Cubic Curve* →*Download table*→ *Burn Table Data.* This will be the curve specially made for this lead screw.
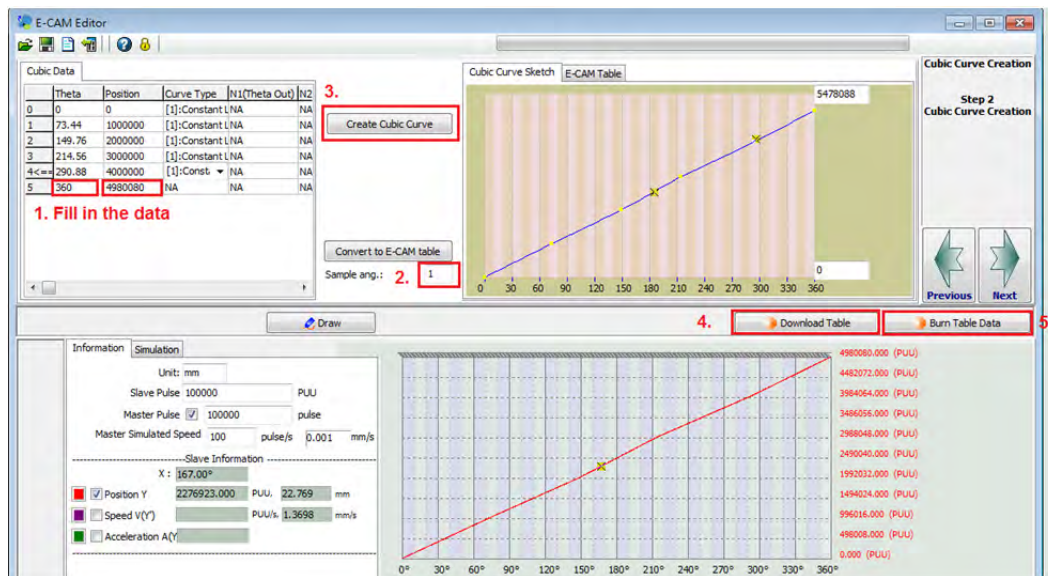
Figure 4.2.16 Creating E-Cam Curve

4.2.3.4 Notice

Please pay special attention to the following notice when using E-Cam curve to compensate the manufacturing tolerances on lead screws.

1. The origin shall not be changed. When it is changed, please re-measure and re-create an E-Cam curve to avoid wrong compensation.
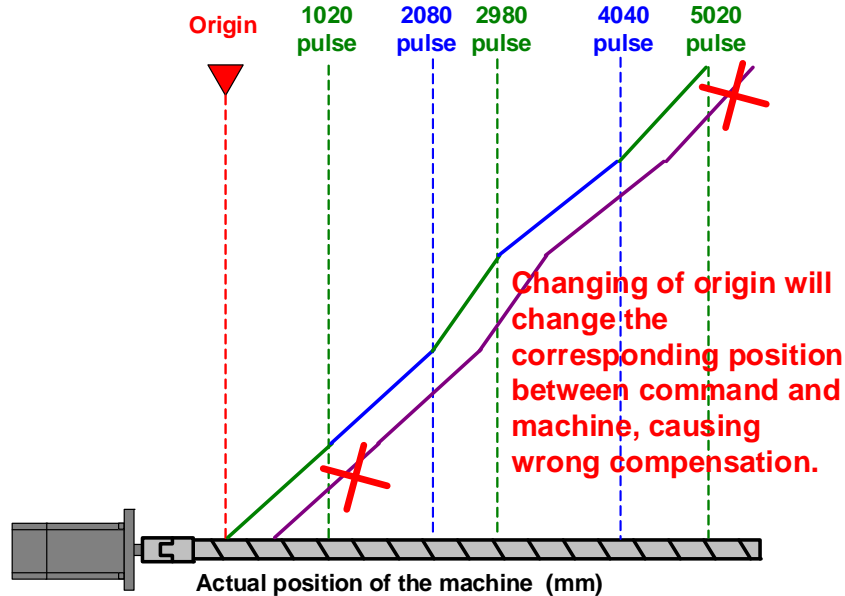

Figure 4.2.17 Wrong Compensation Caused by Change of Origin

2. Use this function in PR mode instead of the default PT mode.
3. For other operation and setting details about E-Cam, please refer to ASDA-A2 User Manual, teaching materials or contact service center of Delta Group.

4.3   PT Command Transferred from Analog Voltage

4.3.1   Description

In ASDA-A2 control mode, analog signal can directly control speed and torque. For example, if wish to use analog signal (+10V/-10V) to find motor position, the positioning function that transfers analog speed to pulse can be used. The required parameters and setting methods are described in this section.

4.3.2   System Configuration

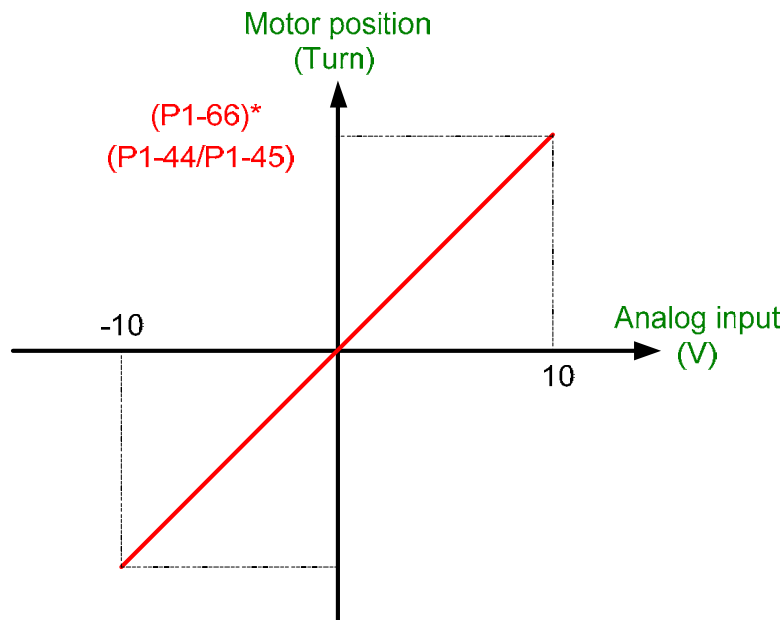The range of input voltage is from +10V to -10V. The input voltage value corresponds to the motor position.

Figure 4.3.1 Analog input corresponds to motor position

4.3.3 Servo system setting

4.3.3.1 Wiring

Analog signal is input via Pin42 (V-REF) and Pin44 (GND) of CN1. Its wiring method is identical to speed mode.
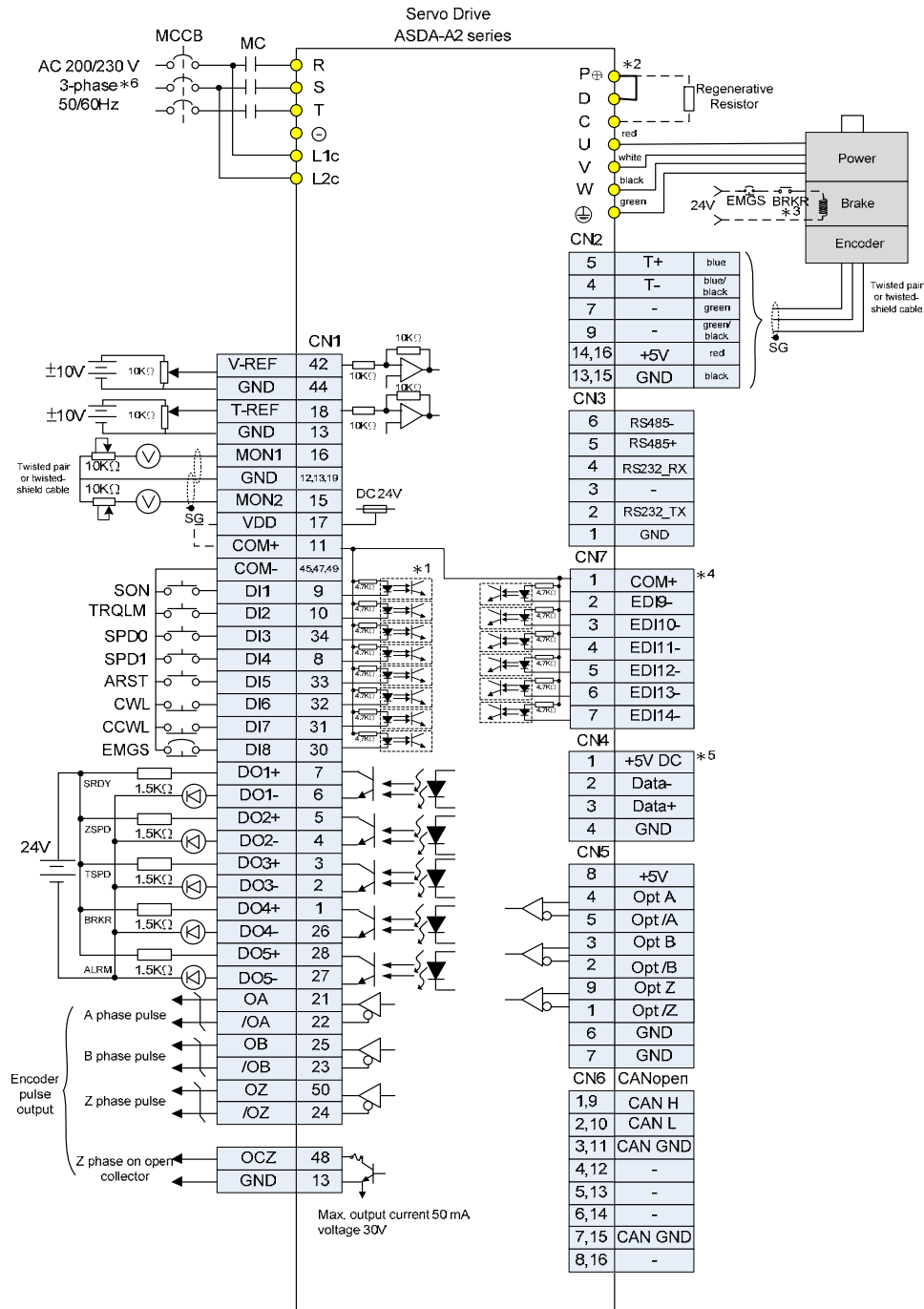

Figure 4.3.2 Wiring

Servo drive's operation mode has to be set in PT mode. To avoid danger, please correctly setup E-gear ratio. 1:1 (P1-44 = 1 / P1-45 = 1) is recommended.

4.3.3.2 Operation steps

Step 1: Setup operation mode

Set the operation mode to PT：P1-01 = 0x0000

Step 2: Setup E-gear ratio

It is strongly recommended to set E-gear ratio as 1:1 (P1-44 = 1 / P1-45 = 1). This is for avoiding the over speed of the motor.

Step 3: Setup the maximum rotating number of analog position command

Setup the maximum rotating number of motor in P1-66. The range of analog input voltage is between -10V and +10V. Thus, when setting the rotating number as voltage +10V, it represents the rotating number in forward direction. When setting voltage -10V, it represents the rotating number in reverse direction. Analog input voltage and motor rotating number are in linear relation. Users could infer the rotating direction and number from the setting of P1-66 and the value of input voltage. For example, if E-gear ratio is 1 and P1-66 is set to 100, when the input voltage is +10V, the motor will rotate 100 cycles in forward direction. When the input voltage is +3V, motor will rotate 30 cycles in forward direction. On the other hand, when the input voltage is -7V, motor will rotate 70 cycles in reverse direction. Please note that the maximum rotating number is 200.

Step 4: Select the initial position setting method

P1-64.Y can be set to judge the motor's position when servo on. When P1-64.Y = 0, motor's position when servo on will be regarded as the position of 0V. If the instant input voltage is not 0V, motor will operate to the position that corresponds to the current input voltage. That is to say, if the input voltage is not 0 when servo on, motor runs. See figure 4.3.3, the input voltage is +5V, it will servo off after motor rotates 50 cycles. Then, adjust the input voltage to +7V. Since the 50th cycle will be regarded as the position corresponded to 0V when servo on, motor will operate another 70 cycles.
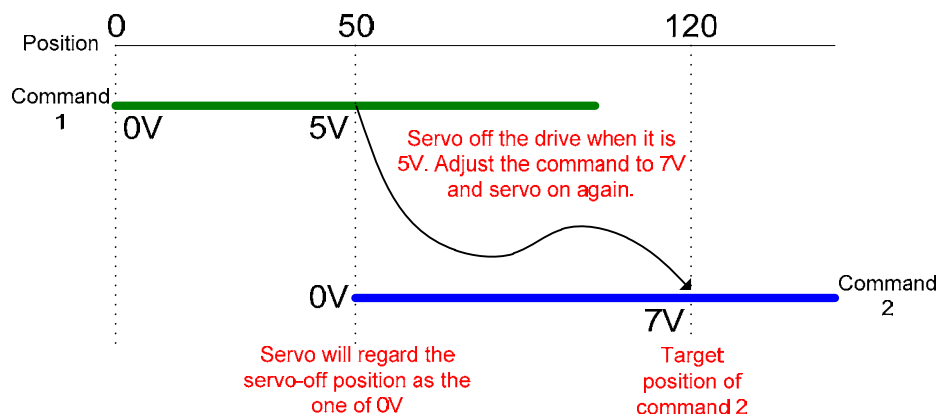

Figure 4.3.3 Regard the servo-off position as the original point

When P1-64.Y = 1, servo drive will regard the motor's current position as the position corresponded to analog command. Thus, motor will not operate when servo on. See figure 4.3.4, the input voltage is +5V, motor operates 50 cycles then servo off. Adjust the input voltage to +7V, then, the 50th cycle where motor currently stops will be regarded as the position corresponded to +7V when servo on. That is why motor does not run.
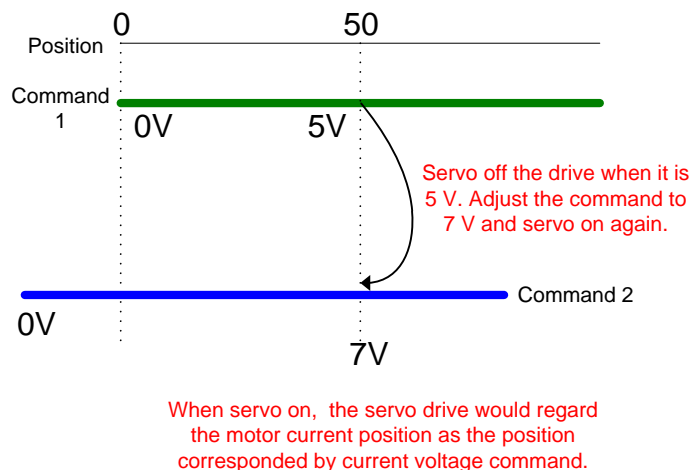

Figure 4.3.4 Voltage command corresponds to the current position when Servo ON

Step 5: Setup the operation method of analog input command

DI: 0x0C sets the latch function of analog position command. When this DI is on, motor will be held at current position. During the time when DI is on, motor will not operate even when the analog command is changed. When this DI is off, the motor will complete the command during the time the DI is triggered. See figure 4.3.5, the input voltage is +5V, motor operates 50 cycles. Then DI is on. During the time of DI on, adjust the input voltage to +7V. When DI is off, motor will operate 20 cycles to the position of 70th cycle.
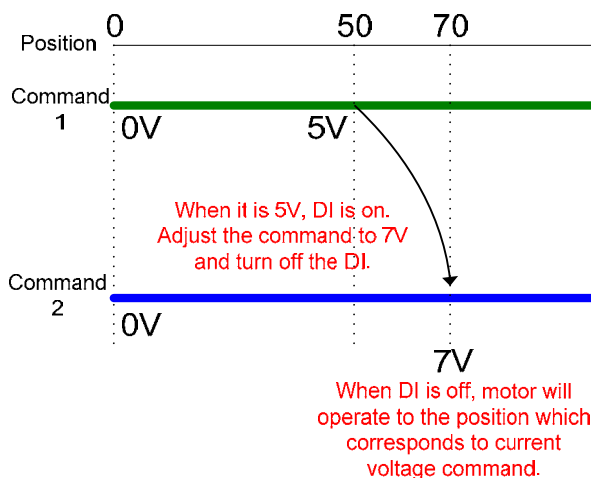

Figure 4.3.5 DI for position latch

DI: 0x0D sets the clear function of analog position command. When this DI is on, motor will be held at current position. Despite the change of analog command during the time of DI on, the motor will stay in current position even when this DI is off. However, the position where motor stays will be corresponded to the new analog command. Thus, the coordinate system of motor which corresponds to analog command will be redefined. See figure 4.3.6. When the input voltage is +5V, turn on this DI after the motor operates 50 cycles. Adjust the input voltage to +70V when DI is on. Motor will not operate when DI is off.
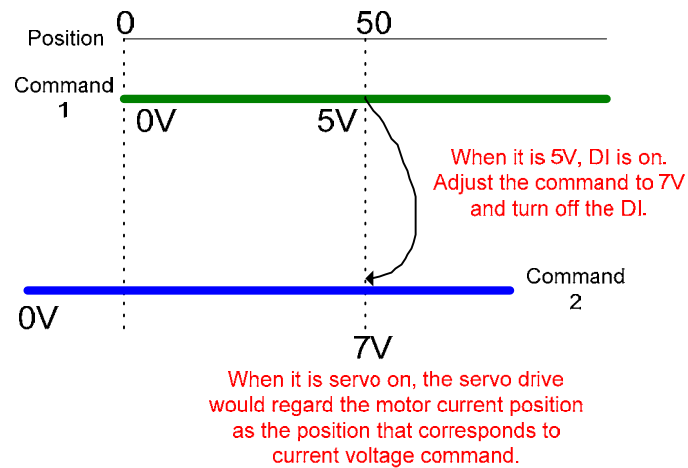

Figure 4.3.6 DI for position clear

Step 6: Enable the function of transferring analog to PT

Set P1-64.X to 1 to enable this function. Then, users can use analog voltage command to control PT position.

4.4   Speed Change during Execution of PR Position Command

4.4.1   Description

For the application of point-to-point operation, PR function in ASDA-A2 is a great tool for easy setting and wiring. Also, the host controller is not required during operation and thus can greatly enhance the efficiency and reduce the cost. Since motion is completed by triggering a series of PR during operation, PR setting has to be completed in advance. To change the speed during operation, please set up the PR for it beforehand. If not, use controller to issue the command to change the required speed.

4.4.2   How does System Work?

During the operation between two points, when issuing the command of speed change, the motor will operate with the new speed immediately. However, the next reverse command will be executed until the current position command is complete. See figure 4.4.2.
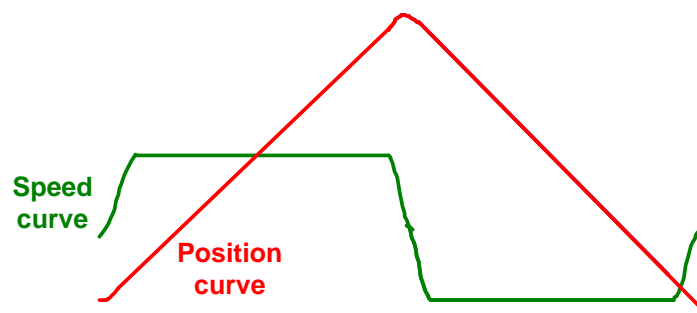

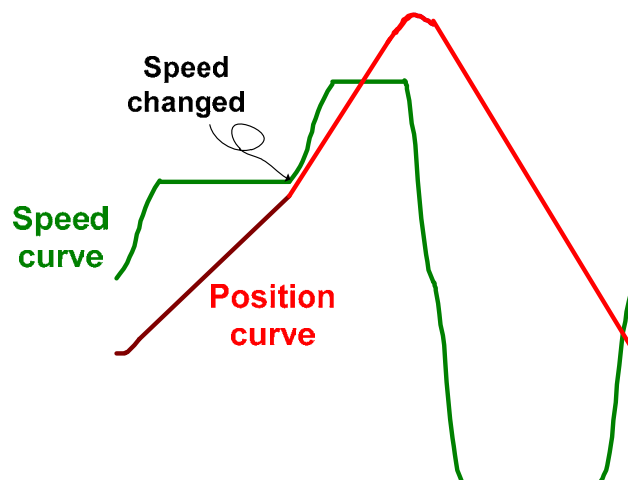Figure 4.4.1 Point-to-point operation

Figure 4.4.2 Change the speed in half way in point-to-point operation

4.4.3   Servo System Setting

4.4.3.1   Tips for Applying PR

1) Change PR definition via parameters

All PR definition and related information can refer to relative parameters. Change the setting of corresponding parameters can modify PR definition. Please refer to Chapter 7 of ASDA-A2 user manual for further information about PR.

Here, we use PR#1 and PR#3 to setup the definition of PR#13 and the target jump path defined by PR# 13 respectively.

2) Shared PR Setting

In PR mode, ASDA-A2 provides 16 sets of acceleration/deceleration, 16 sets of delay time and 16 sets of target speed for setting up PR program. If more than one PR share one target speed, when the value of this target speed is changed, all PR settings that shared this target speed will be modified. Speed setting for all position commands here is set as the third speed command (P5-63). As long as the value of the thrid speed is changed (which means to write the desired changed speed to P5-63), speed from all motion command is changed.

3) Selection of position commands

When the previous position command is interrupted by the incremental command which has zero moving distance, motor will run to the target position (0 + destination set by previous position command) set by previous command. That is how users can change motor's speed during operation. When entering the changed speed, trigger the position command to interrupt the previous command, then, new position command will be operated with the chagned speed. Thus, motor will immediately change its speed to the target position which defined by previous command.

4.4.3.2   PR Program Setting

PR#1: Write-in parameter. If the speed changed when it is executing the position command (PR#4) at reverse direction, the next position command will be executed at forward direction (PR#2).

PR#2: Position command. Execute the position command at forward direction. This PR has no interrupt. Thus, another motion command will be executed after this command is complete.

PR#3: Write-in parameter. If the speed changed when it is executing the position command (PR#2) at forward direction, the next position command will be executed at reverse direction (PR#4).

PR#4: Position command. Execute the position command at reverse direction. This PR has no interrupt. Thus, another motion command will be executed after this command is complete.

PR#5: Jump command. To keep the motor operating at forward and reverse direciton.

PR#11: Write-in command. Write the desired changed speed to this PR via the host controller (write in P6-23). This PR will enter the value to P5-63 (internal speed#3). Since all speed command is determined by P5-63, once the value is changed, all speed will be changed.

PR#12: Enter the desired changed speed. The operating speed shall be promptly changed. This PR is the position command. It interrupts currently executing motion command. The previous unfinisihed command will be compelte by the changed speed.

PR#13: Jump command. Jump to the next position command. Its target is determined by PR#1 or PR#3.

PR#51: Jump command. Trigger this PR when activating the system. Jump to PR#1 to enable position command in point-to-point operation.

PR#52: Jump command. Write the desired speed to P6-23 via the host controller. Then, trigger this PR to jump to PR#11 so as to change the motor speed.
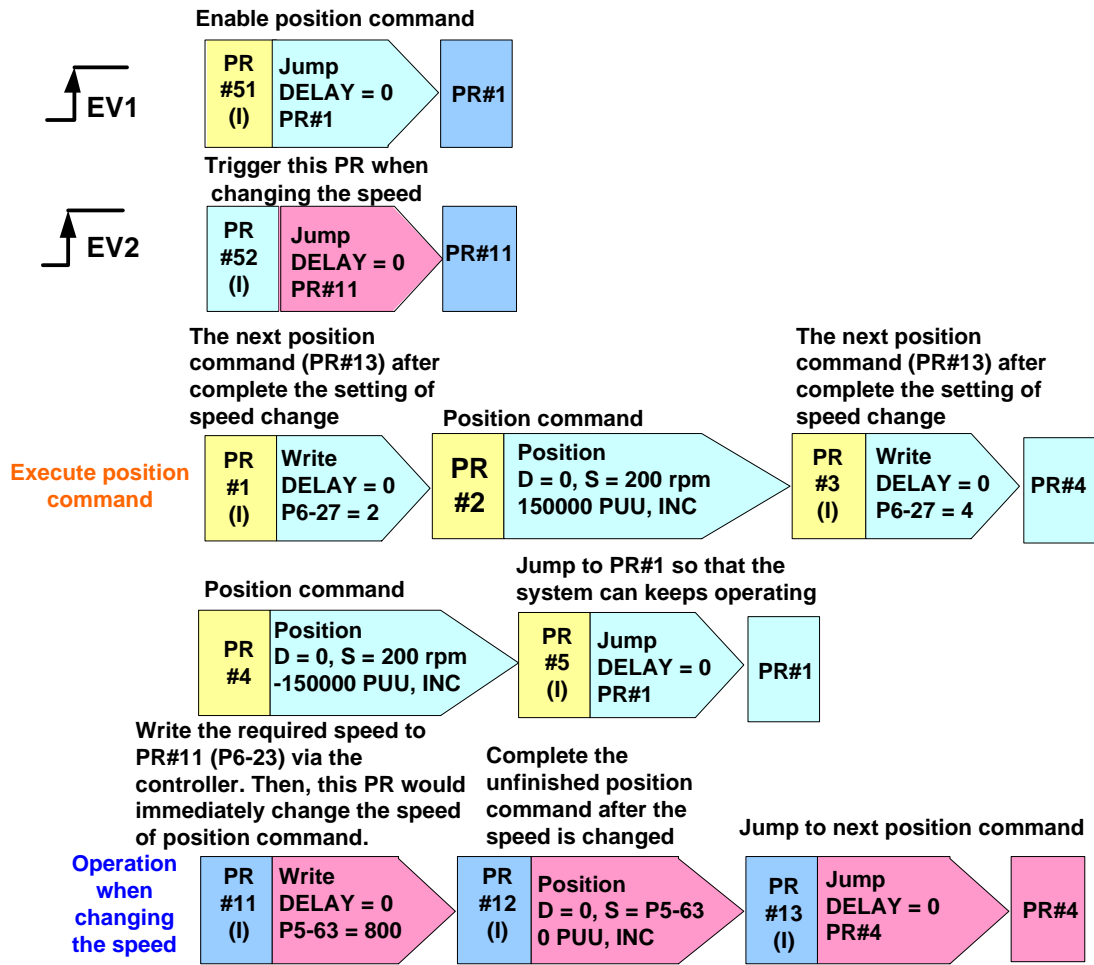
Figure 4.4.3 PR program

4.5 Macro for E-Cam Application

4.5.1 Macro C

With this macro, the current pulse number of the master axis and position of the slave axis can be redefined without changing motor's position.

Macro C allows the system to change the engaging position promptly and calculate the remaining pulses. Then, E-Cam can complete the operation according to the E-Cam curve after engaging.
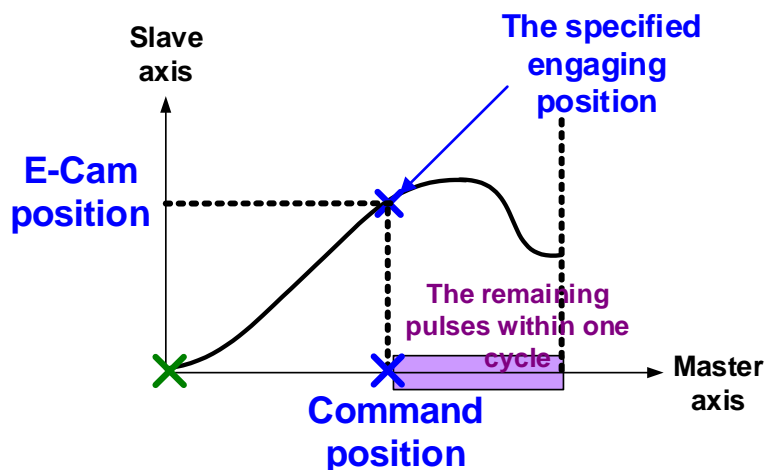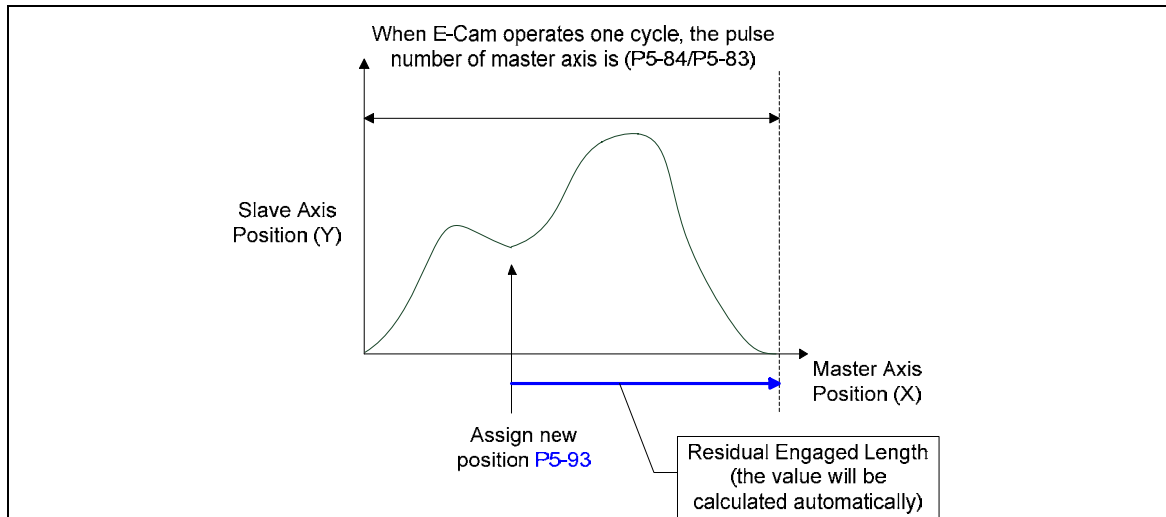

Figure 4.5.1 Macro C

The following macros are available from version V1.035 sub00 (included):

Command code 000Ch	Change position X, where E-Cam is engaged: E-Cam disengages after rotating one cycle at forward direction.
General parameters	N/A
Macro parameters	P5-93 = New engaged position X. Unit: pulse number of master axis. Monitoring variable 062(3Eh): It displays the current engaged position (X) of master axis.

This macro command can change the engaged position even when E-Cam is engaged. It will automatically calculate the residual engaged length. E-Cam will disengage after rotating one cycle at forward direction. Users have to set P5-88.U to 2, 4, 6; otherwise, the E-cam will not disengage.

E-Cam will disengage when alarm occurs or the power supply is cut off. If users desire E-Cam to re-engage at the last disengaged position and continue its operation, it is recommended to record the disengaged position (X) and resume the operation by this macro command. Please note that when E-Cam is disengaged, the servo position might slightly shift and therefore cause position error when E-Cam re-engages again.

The Engaged direction is in forward direction (Master axis operates at forward direction):

When E-Cam operates one cycle, the pulse number of master axis is (P5-84/P5-83)

Slave Axis Position (Y)

Master Axis Position (X)

Assign new position P5-93

Residual Engaged Length (the value will be calculated automatically)

Note: When using this macro command, it would be better to execute this command before operating the master axis.	
Failure code F0C1h	When executing this macro command, E-Cam is not in engaged status. The engaged position can be modified only when E-Cam is engaged.
Failure code F0C2h	The setting value of P5-93 is in error. The value cannot less than 0. It should > = 0.
Failure code F0C3h	The setting value of P5-93 is in error. The value has to less than the value of (P5-84 / P5-83)

4.5.2   Macro D

When E-Cam position and command position is not on the E-Cam curve, this macro allows the system to figure out the command position of the master axis and current correction value of motor's position. Then the correction value will be written to the PR to conduct incremental positioning. The motor can thus move back to the position corresponded by the command of the master axis. This macro command only can be applicable to periodic cycle and when every cycle starts from the same position.
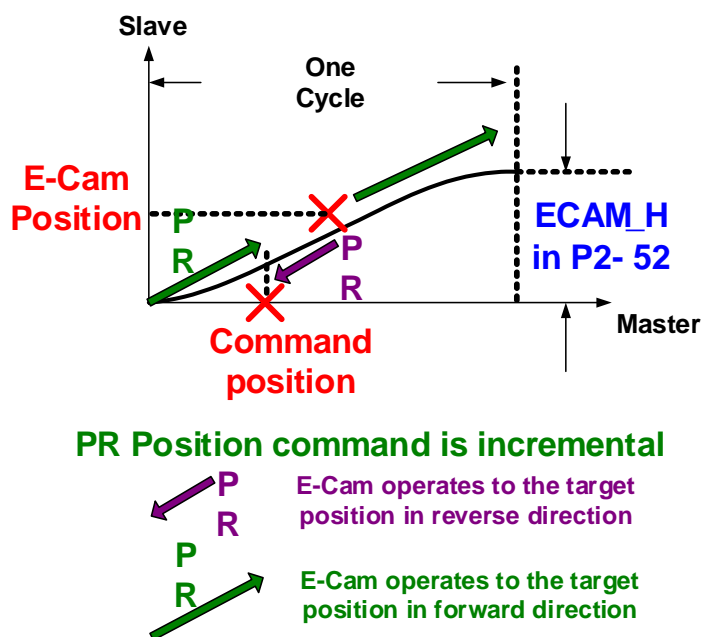
Figure 4.5.2 Macro D

The following macros are available from version V1.038 sub48 (included):

Command code 000Dh	Calculate the error between E-Cam and indexing coordinates for PR positioning.
General Parameters	N/A

Macro Parameters	P5-93.Low_Word = DCBA: UZYX (8 digits, HEX)
	YX (PR number) = 0 ~ 0x3F (it is invalid when the value is set to 0)
	UZ: The value has to be set to 0.
	BA (Function of P5-95):
	    0 (Use avoid point);
	    1 (Use available forward rate, V1.038 sub53)
	DC (Inhibit reverse rotation):
	    0 (invalid),
	    1(Inhibit reverse rotation, V1.038 sub53)
	P5-95: Avoid point (cannot pass this point) = 0 ~ 100 (%) of E-Cam cycle or available forward rate 0 ~ 100 (%)

Monitoring variable 091 (5Bh): It displays the current indexing coordinate position (PUU)	

When E-Cam is engaged, and the motor is stopped because of Servo Off or alarm occurs, it would cause position error between the actual position and E-Cam position. After re-servo On, this macro command can be used to calculate the correction value and write the value into the specified PR for incremental positioning. So that the motor can return to the ideal E-Cam position.

When using this macro command:

1. P5-88.X1 = 1 to make E-Cam keep engaging when servo Off and continue to calculate E-Cam position.

2. The height of indexing coordinate and E-Cam coordinate should be the same:

   P2-52 = ECAM_H (The moving distance when E-cam operates one cycle)

3. E-Cam table scaling (P5-19) must be 1.0 time

4. When E-Cam is engaged for the first time, 0 degree of E-cam should aim at 0 degree of indexing coordinate.
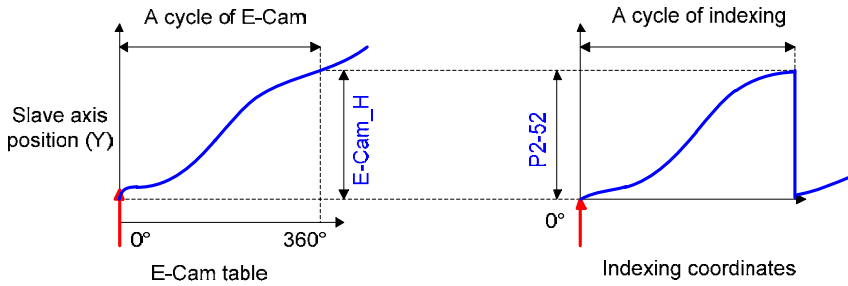
Note 1: ECAM_H (height of E-Cam table) = E-Cam table (last point - first points)

Note 2: Indexing coordinate = (absolute coordinates / P2-52) take remainder.

Note 3: Use PR command for incremental positioning control.

When motor moves from the current position to the target position, it can operate at forward or reverse direction. Due to the cyclic operation, the motor will travel to the specified position either at forward or reverse direction. However, the moving distance is different between both. Use avoid point to plan the timing of forward and reverse rotation.

* **Avoid point:** the point that cannot be passed by the planned PR.
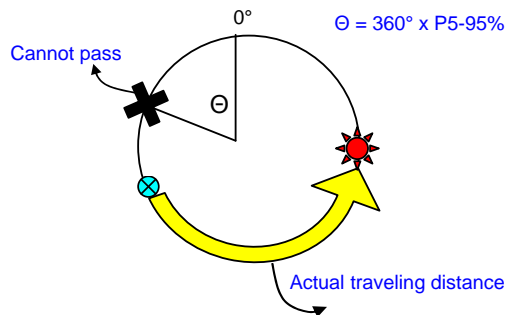
Failure code F0D1h	E-Cam is not engaged when executing this macro command. E-Cam should be engaged.
Failure code F0D2h	The value of P5-93.YX (PR number) exceeds the range: 1 ~ 0x3F
Failure code F0D3h	The value of P5-95 (available forward rate) exceeds the range: 0 ~ 100 (%)
Failure code F0D5h	The position correction value does not exist. This macro command might be triggered twice.
Failure code F0D6h	When re-servo On, E-cam is not engaged.
Failure code F0D7h	The height (Y axis) of E-Cam table is not equal to the value of P2-52.
Failure code F0D8h	P5-19 is not equal to 1
Failure code F0D9h	P5-93.BA, P5-95 exceeds the range: 0 ~ 1
Failure code F0DAh	The setting value of P5-93.DC (reverse inhibit) exceeds the range: 0 ~ 1
Failure code F0DBh	The function of reverse inhibit has failed. Do not use macro command #D, #10h consecutively.

4.5.3 Macro E

This macro performs E-Cam alignment and writes the correction value into the specified PR. Please complete relevant settings such as target position and other PRs in advance. When macro E is triggered, the system will figure out the correction value and write it to the specified PR. This PR can be triggered to make the slave axis move to the target position.
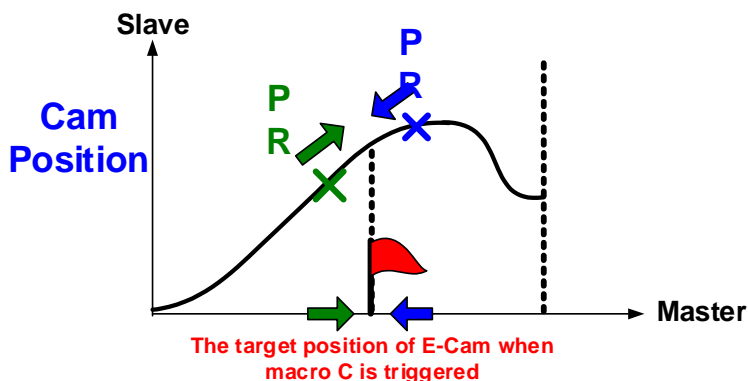

Figure 4.5.3 Macro E

The following macros are provided after version V1.038 sub26 (included):

Command code 000Eh	Perform E-Cam alignment immediately and write the correction value into the specified PR.
Macro parameters	P5-93 = DCBA：UZYX (8 digits, HEX) YX (PR number) = 0 ~ 0x3F, it is invalid when the value is set to 0. UZ (Max. alignment correction rate) = 0 ~ 0x64 (%) A (Trigger the specified PR directly) = 1: On, 0: Off DCB = has to be set to 0 P5-94 (DI delay time compensation) = -25000 ~ +25000; Unit: usec. P5-95 (available forward rate) = 0 ~ 100 (%) P5-96 (target position of alignment X); Unit: pulse number of master axis = 0 ~ (P5-84/P5-83) – 1.
Monitoring variable 062 (3Eh): It displays the current engaged position of master axis (X)	
This macro command can move the engaged position to the alignment target position (X) when E-Cam is engaged. And write the alignment correction value into the specified PR. During E-Cam operation (When E-Cam is engaged), if desire to quickly align the E-cam position to the mechanical referral point, sensor can be used to trigger DI.EVx to execute this macro command. After E-Cam alignment is completed, the engaged position will move to the new position. The excess or not enough moving distance after E-Cam operates one cycle is called alignment correction value. It will be written into PR specified by P5-93.YX. PR incremental command can be used to compensate this value so that the slave axis position will remain and offset the phase of E-Cam to align the referral position of machine. For some applications, set value of P5-93.YX to 0 will do without applying this PR. Please note that PR can be executed only when triggering the host controller.	
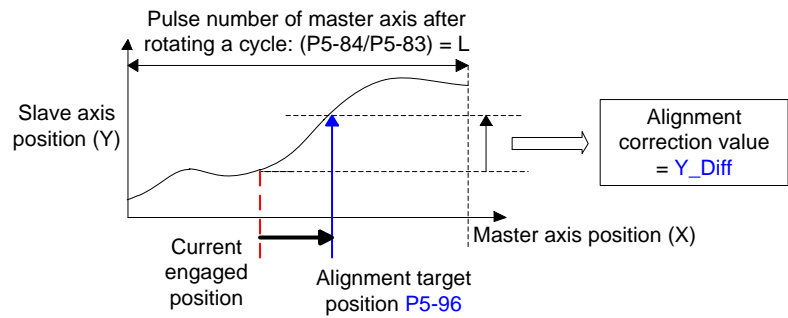
 * P5-93.UZ is able to limit the max. correction rate. The alignment target position ★ will be different from P5-96.
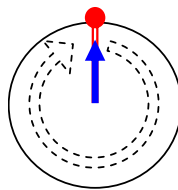
│ aignment target position★ – current engaged position │ / L <= P5-93.UZ %

 * DI time delay compensation can be set via P5-94, it can correct the error caused by different operation speed.
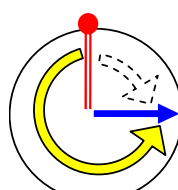
When E-Cam moves from current position to the target one, it can rotate at forward or reverse direction. Due to the cyclic operation, it can reach the target position either at forward or reverse direction. However, the moving distance between both is usually different. Use available forward rate to plan the timing of forward and reverse rotation.

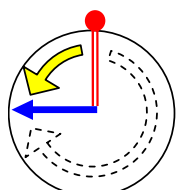 * Available forward rate: The available max. proportion of forward path

Failure code F0E1h	When executing this macro, E-Cam is not engaged. E-Cam has to engage to execute alignment correction.
Failure code F0E2h	The setting value of P5-93.YX (PR number) exceeds the range: 0 ~ 0x3F
Failure code F0E3h	The setting value of P5-93.UZ (Max. alignment correction rate) exceeds the range: 0 ~ 0x64 (%)
Failure code F0E4h	The setting value of P5-94 (DI delay time compensation) exceeds the range: -10000 ~ +10000

Failure code F0E5h	The setting value of P5-95 (Available forward rate) exceeds the range: 0 ~ 100 (%)
Failure code F0E6h	The setting value of P5-96 (alignment target position) exceeds the range: 0 ~ (P5-84/P5-83) - 1

4.5.4   Macro F

When the master axis is stopped but E-Cam is still engaged, this macro allows the slave axis to move to the given position and return. Users have to complete all relevant parameter setting beforehand. When macro F is triggered, the data for moving the slave axis will be written to the PR of going and return trip. When PR is triggered during going trip, the slave axis will move to the target position. While PR is triggered during return trip, the slave axis will return to the original position. That is, to move the slave axis while the system is stopped, this macro can be applied.
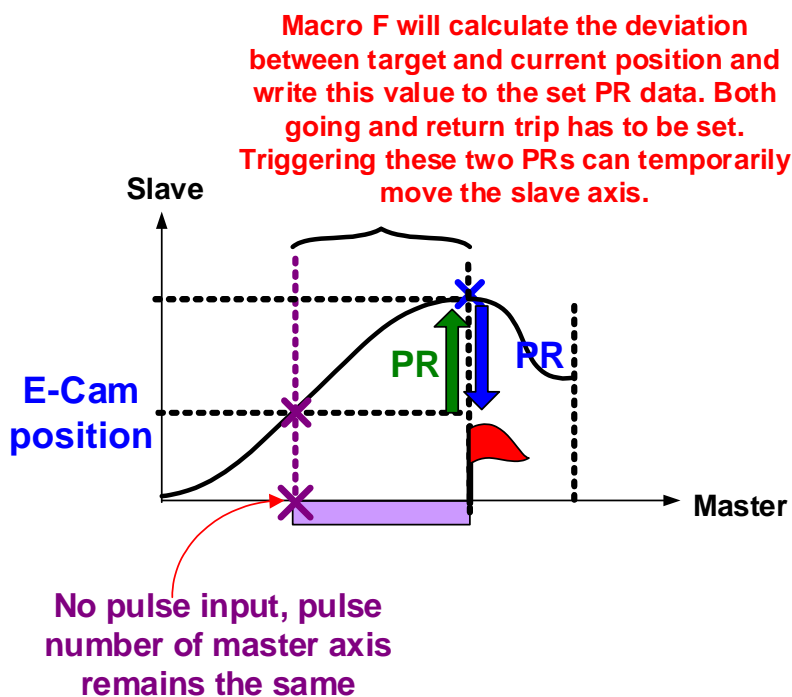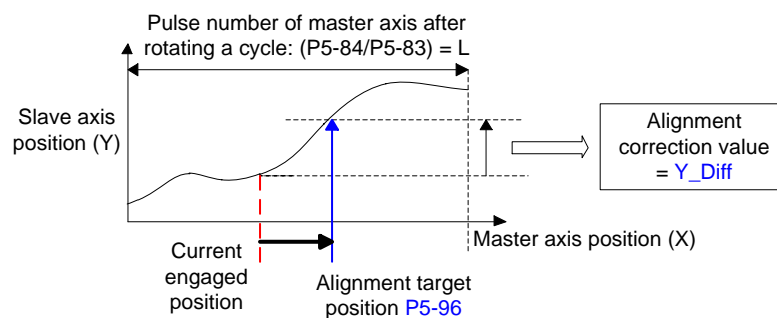

Figure 4.5.4 Macro F

The following macros are available from version V1.038 sub26 (included):

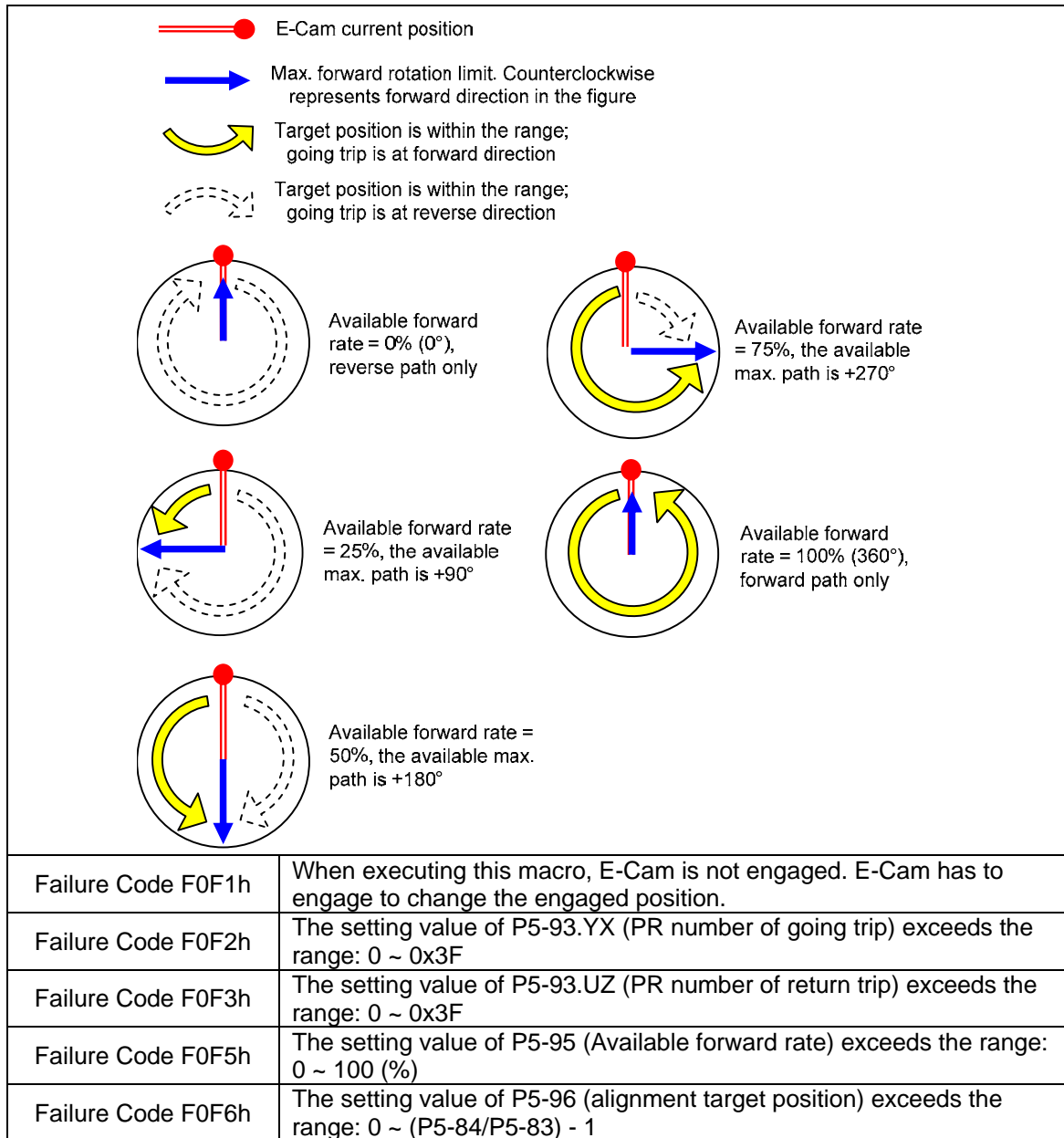| Command Core 000Fh	Calculate the moving distance between current and target position for PR positioning.
General Parameters	N/A
Macro parameters	P5-93.Low_Word = UZTX(4 digits, HEX) YX (PR number of going trip) = 0 ~ 0X3F, it is invalid if the value is set to 0. UZ (PR number of return trip) = 0 ~ 0X3F, it is invalid if the value is set to 0. P5-93.Hi_Word = it has to be set to 0. P5-95 (Available forward rate) = 0 ~ 100 (%) P5-96 (target position X); Unit: pulse number of master axis = 0 ~ (P5-84/P5-83) -1.
Monitor variable 062 (3Eh): It displays the current engaged position (X) of master axis.	
This macro command calculates the moving distance between current and target engaged position (X) and writes into the specified PR. During E-Cam operation, if users desire to move the slave axis to the specified position when master axis stops and still in engaged status, this macro command can calculate the correct moving distance (Y_Drift) of going trip for PR positioning. When master axis resumes the operation, use another PR to run the moving distance of return trip (-Y_Drift), it returns to the original position (moving distance of going trip + moving distance of return trip = 0.) E-Cam position remains the same. Note: No matter it is going trip or return trip, use incremental command when using PR. When E-Cam moves from current position to the target one, it can rotate at forward or reverse direction. Due to the cyclic operation, it can reach the target position either at forward or reverse direction. However, the moving distance between both is usually different. Use available forward rate to plan the timing of forward and reverse rotation. * Available forward rate: The available max. proportion of forward path	

Failure Code F0F1h	When executing this macro, E-Cam is not engaged. E-Cam has to engage to change the engaged position.
Failure Code F0F2h	The setting value of P5-93.YX (PR number of going trip) exceeds the range: 0 ~ 0x3F
Failure Code F0F3h	The setting value of P5-93.UZ (PR number of return trip) exceeds the range: 0 ~ 0x3F
Failure Code F0F5h	The setting value of P5-95 (Available forward rate) exceeds the range: 0 ~ 100 (%)
Failure Code F0F6h	The setting value of P5-96 (alignment target position) exceeds the range: 0 ~ (P5-84/P5-83) - 1

4.5.5   Macro 10

After Macro 10 is triggered, the slave axis will stop operating. Then, it will start operating again after stopping for one cycle. In the application of packaging machine, using this macro can skip the empty pack.
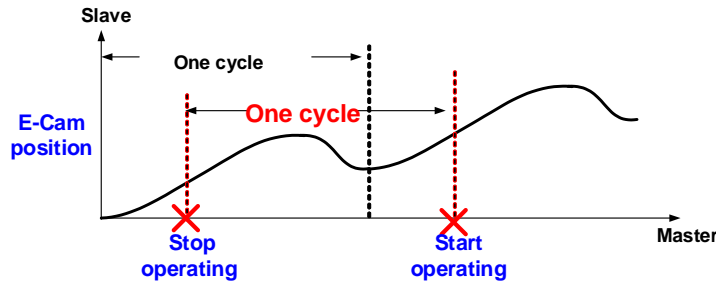

Figure 4.5.5 Macro 10

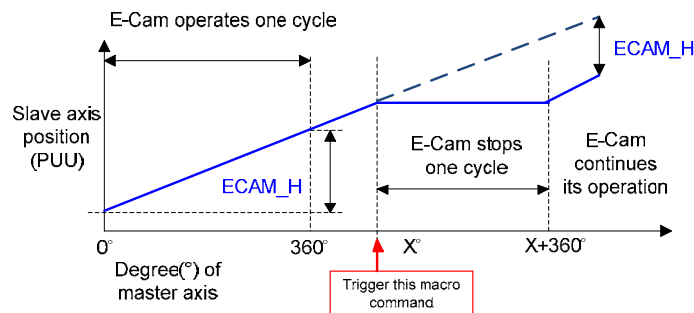The following macros are available from version V1.042 sub09 (included):

Command code 0010h	E-Cam stops for one cycle and resumes its operation at next cycle.
General parameters	N/A
Macro parameters	Value of P5-93 has to be set to 0.

After E-Cam is engaged, this macro command can stop the slave axis for a cycle of distance regardless the E-Cam degree. The following conditions have to be fulfilled when using this macro command. 1. E-Cam must be in engaged status. 2. E-Cam must be the forward operation curve (including straight line) so it can temporally stop for a cycle. Refer to the figure below, triggering this macro command, E-Cam will stop for one cycle regardless the degree (X) where E-Cam is.   Note 1: ECAM_H (E-Cam pause distance) = table (last point – first point) x P5-19 (the effective scaling) Note 2: This function can accumulate times. If the command is triggered for N times consecutively, E-Cam will stop for N cycles. The accumulated pause distance cannot exceed (>2^31), or the macro command will be disabled. Note 3: When E-Cam resumes the operation, the accumulated pause distance will be cleared to 0.

Failure code F101h	When executing this macro command, E-Cam is not engaged.
Failure code F102h	The setting value of P5-93 is incorrect: It has to be set to 0.
Failure code F103h	E-Cam has to operate at forward direction. Please check the E-Cam table and make sure P5-19 > 0.
Failure code F104h	The **accumulated pause distance** exceeds 2^31. Do not execute this macro command consecutively.

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