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.

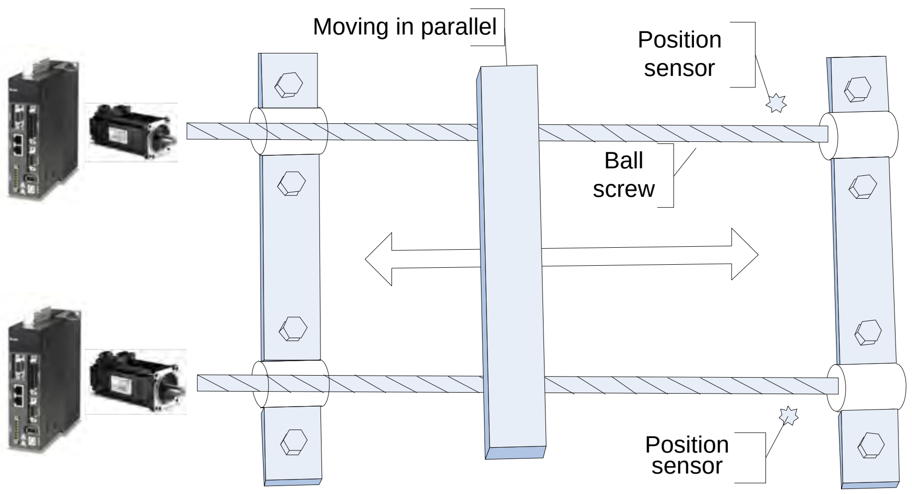


Figure 3.5.1 System Structure

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.

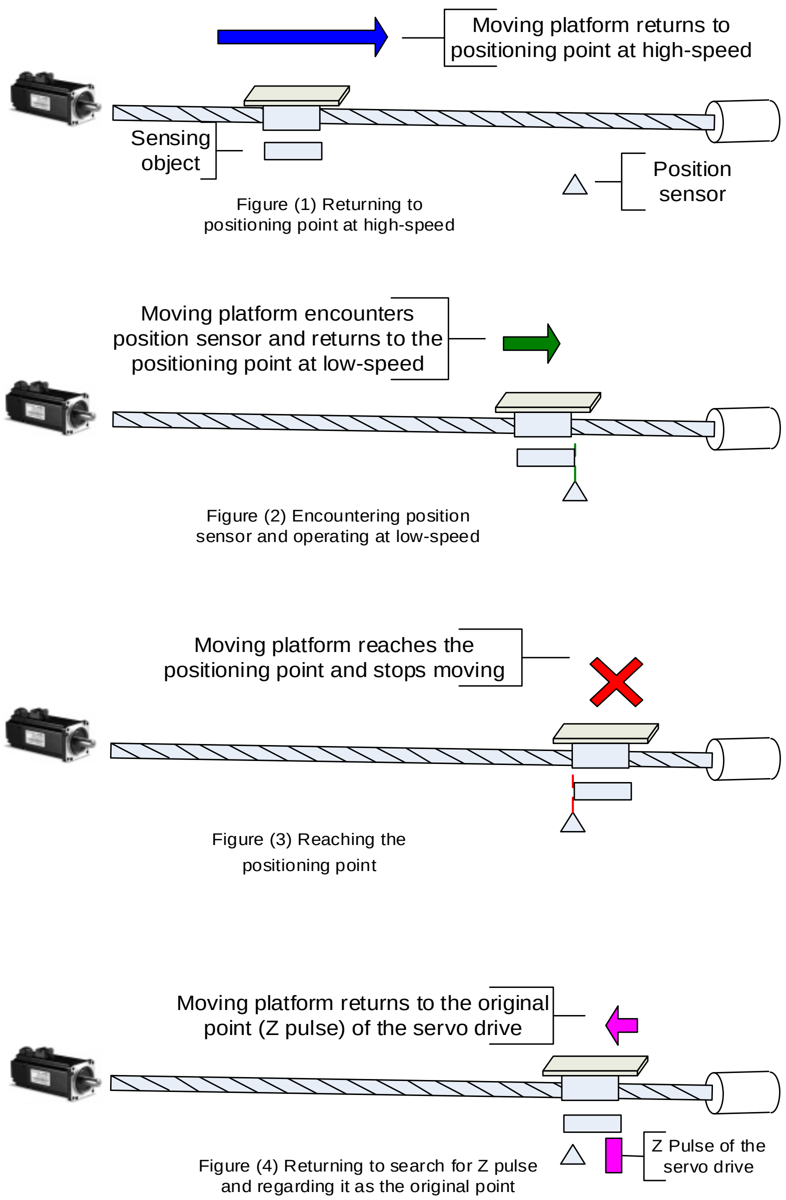


Figure 3.5.2 Returning to Positioning Point and Homing Origin

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.

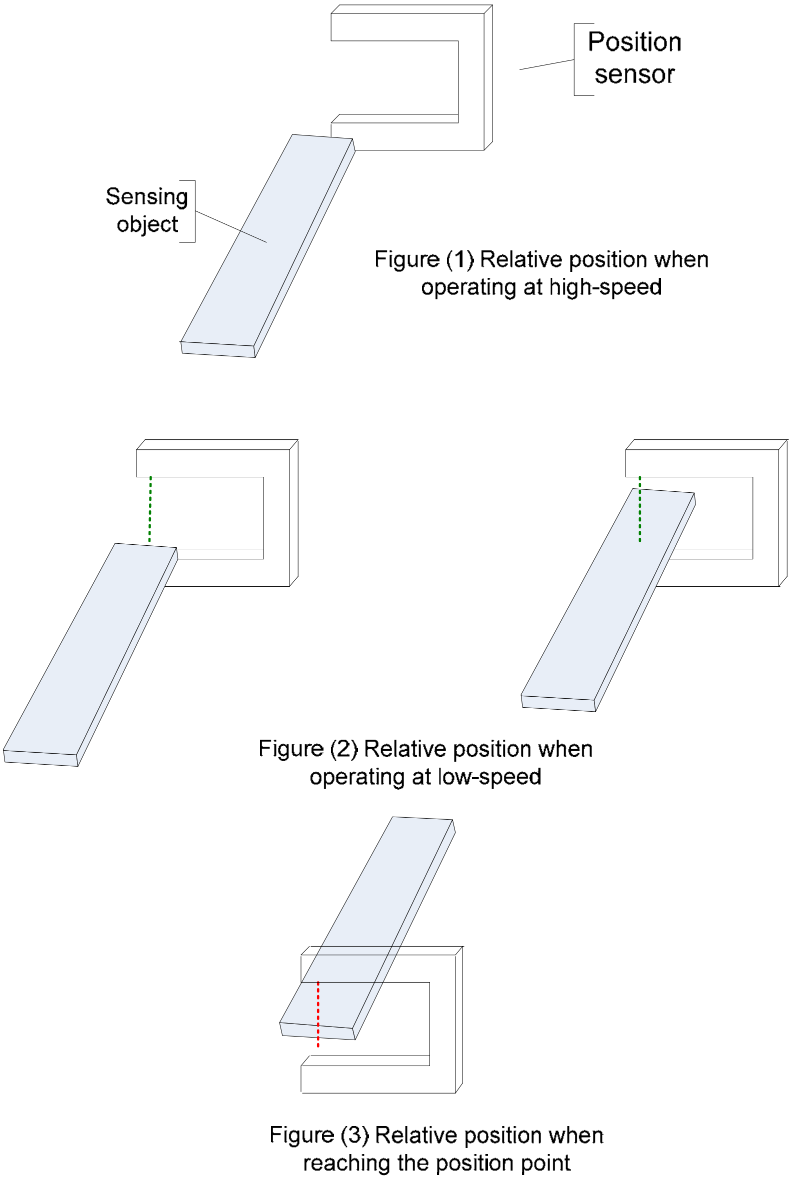


Figure 3.5.3 The Relative Position of the Position Sensor and Sensing Object

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.

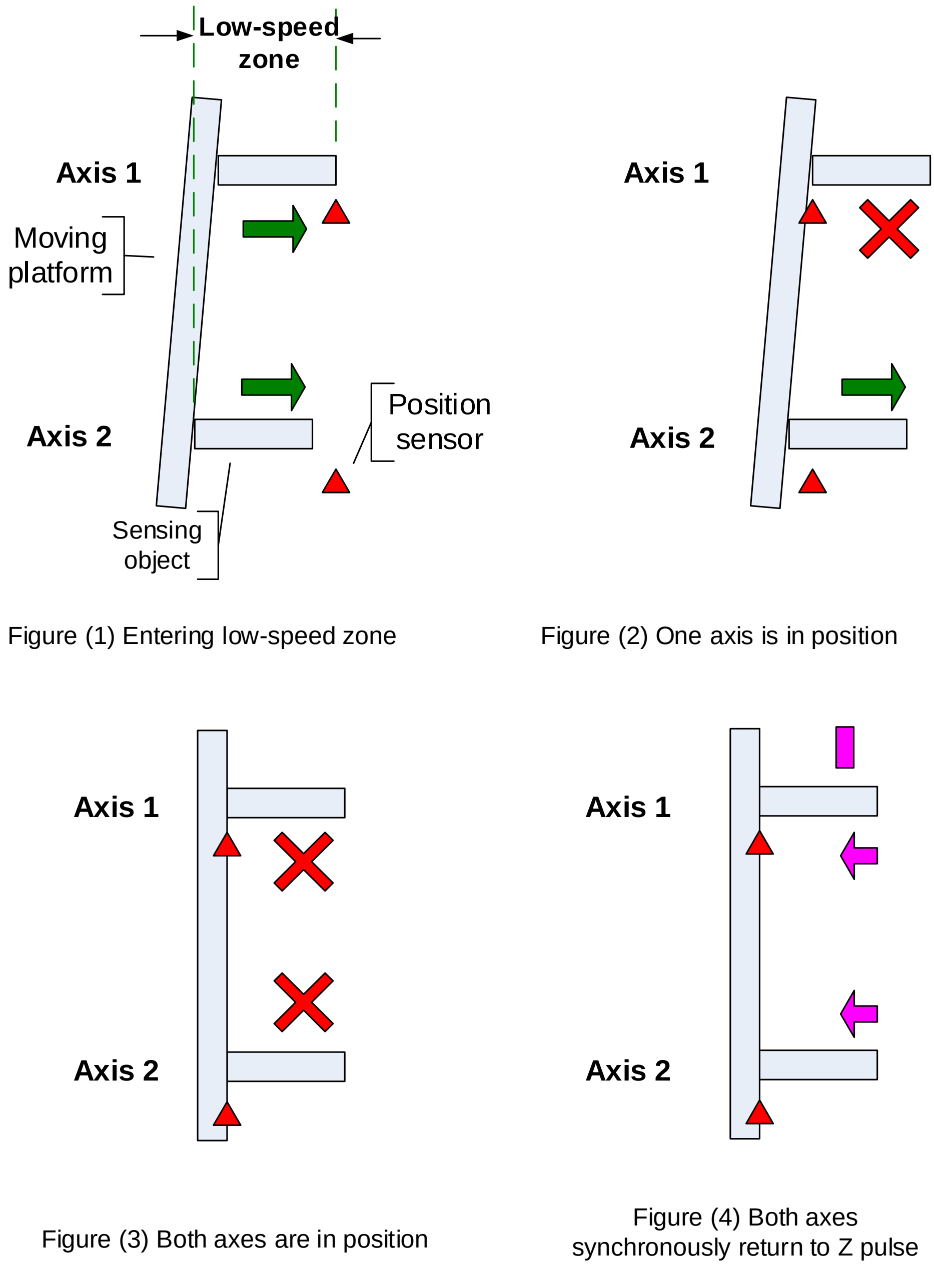


Figure 3.5.4 System Positioning and Homing

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.

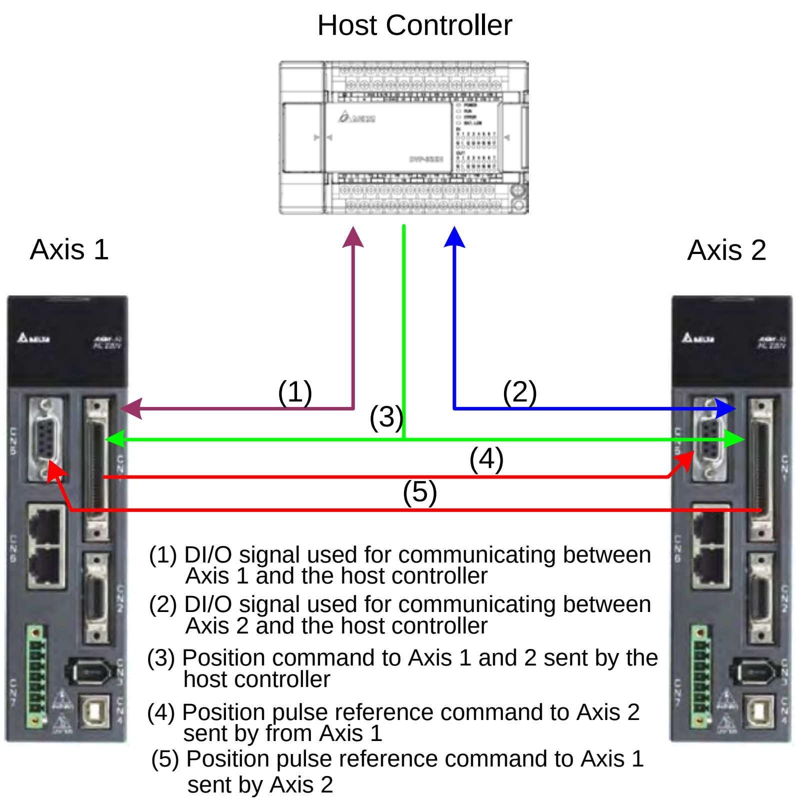


Figure 3.5.5 System Wiring Diagram

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.

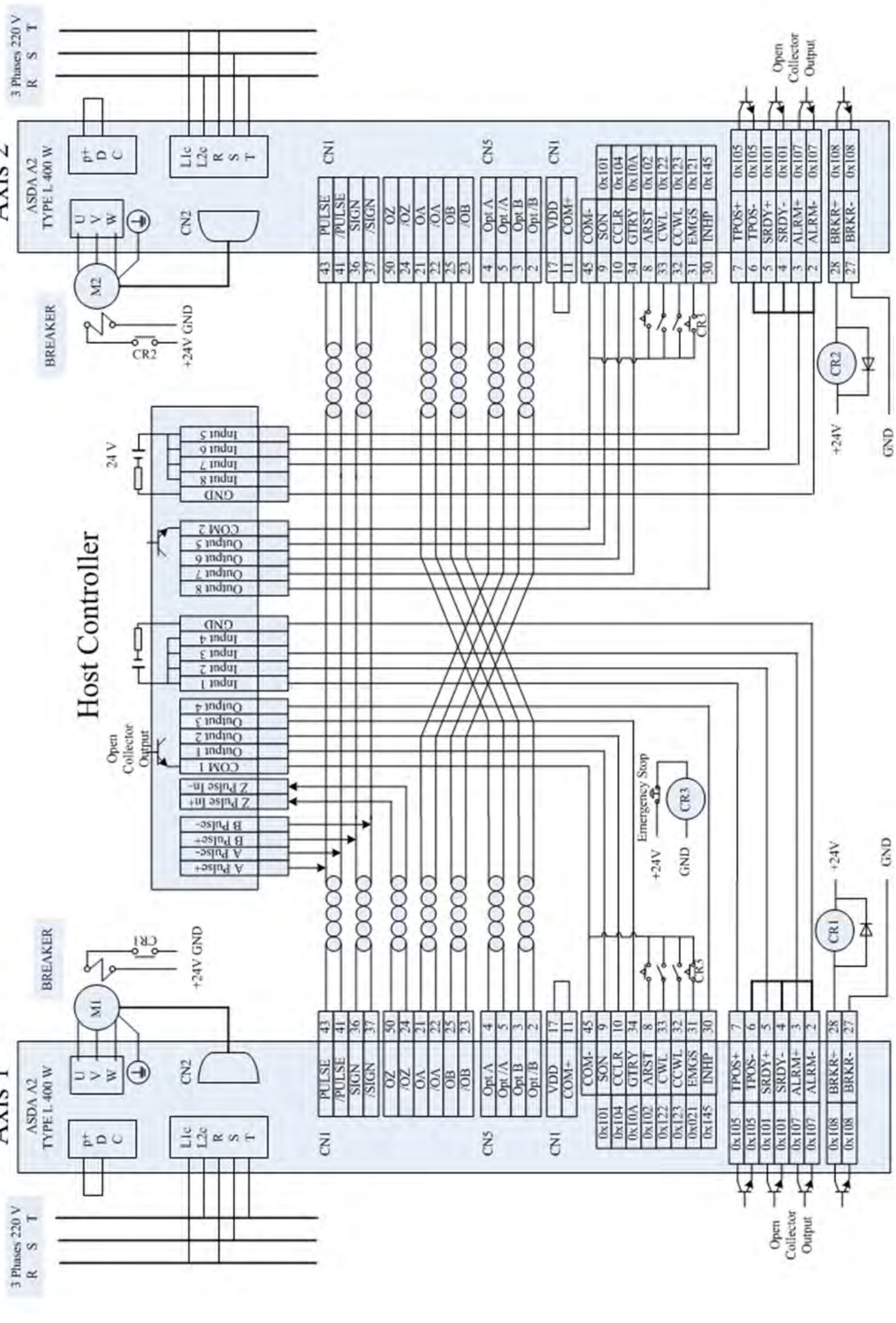


Figure 3.5.6 System Wiring Diagram (for reference)

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.

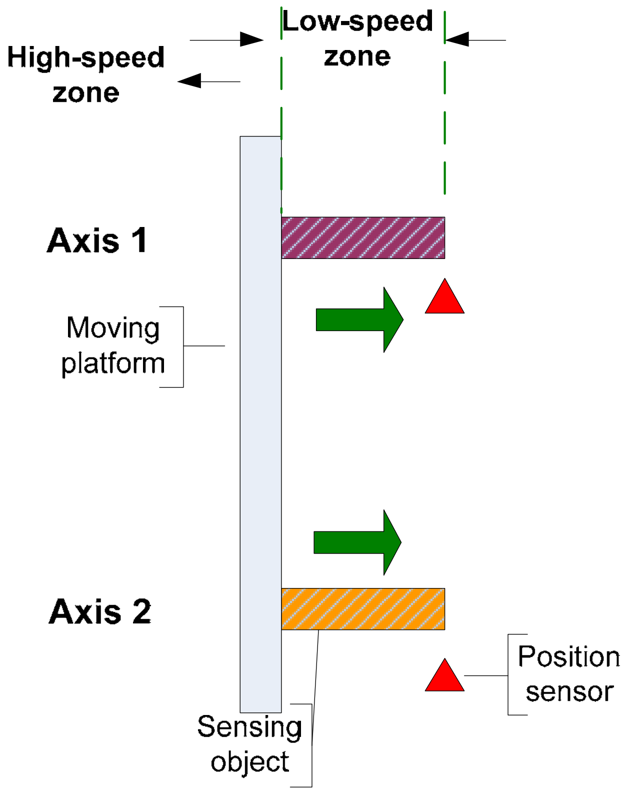


Figure 3.5.7 Two Axes Symmetrically Return to Positioning Point

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

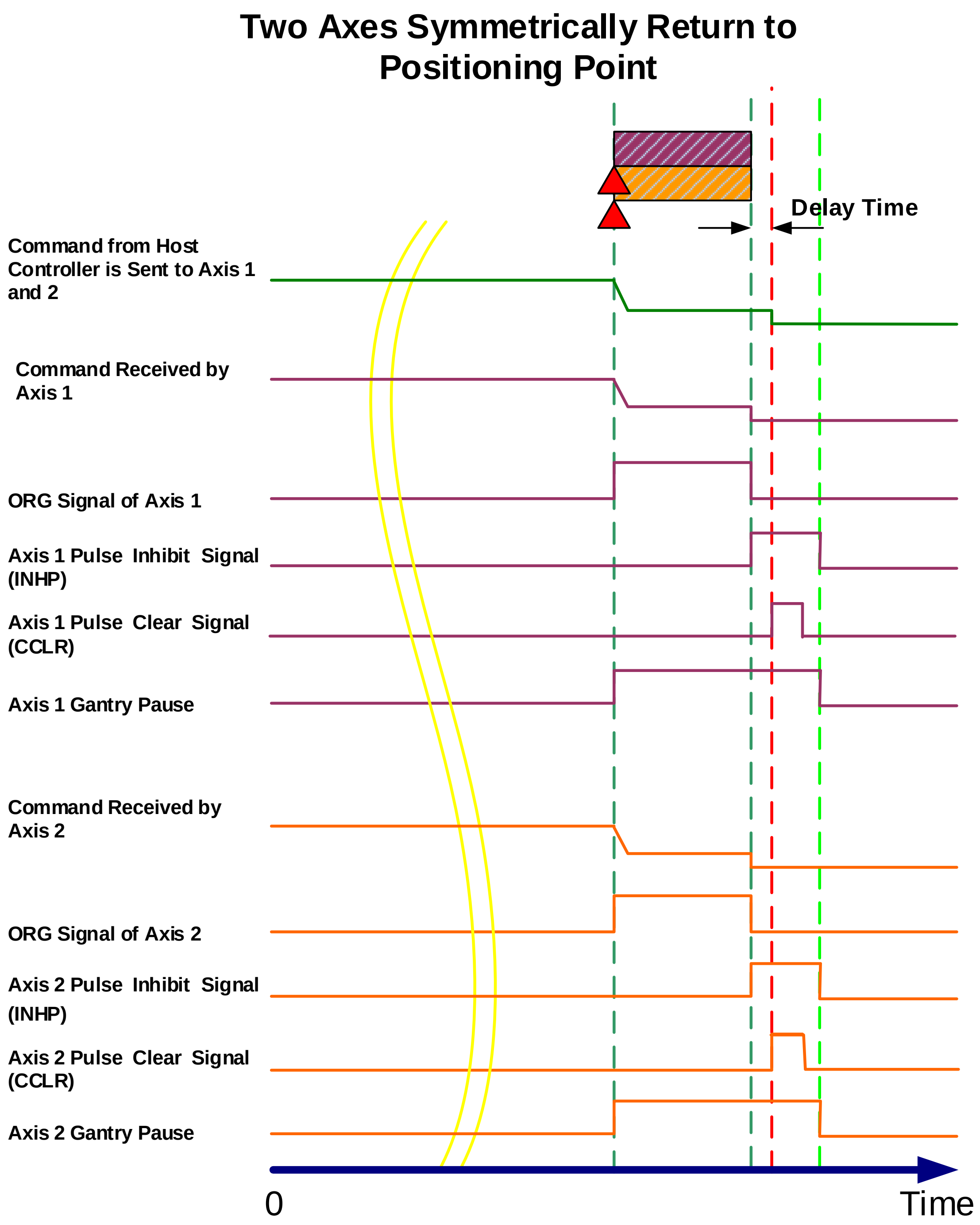


Figure 3.5.8 Timing Diagram of Two Axes Symmetrically Return to Positioning Point

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.

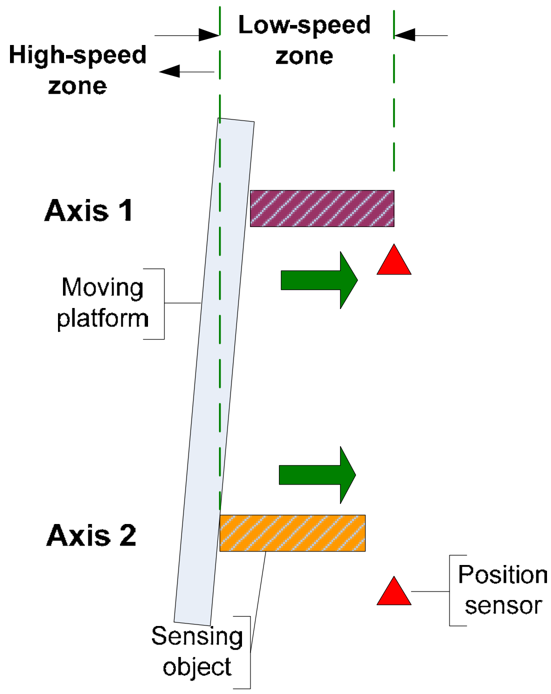


Figure 3.5.9 Two Axes Asymmetrically Return to Positioning Point

d. Timing diagram of two axes return to positioning point asymmetrically

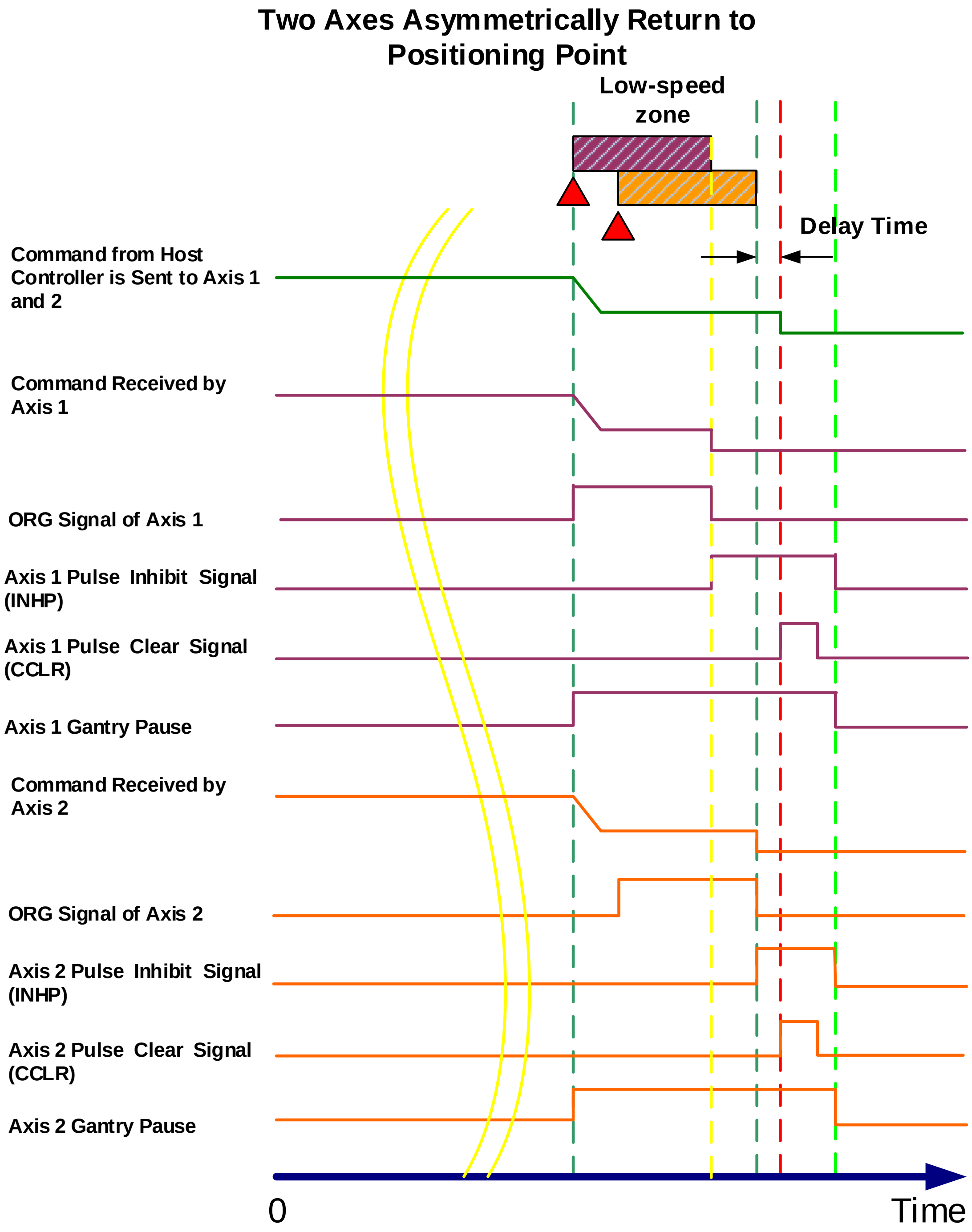


Figure 3.5.10 Timing Diagram of Two Axes Asymmetrically Return to Positioning Point.

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.

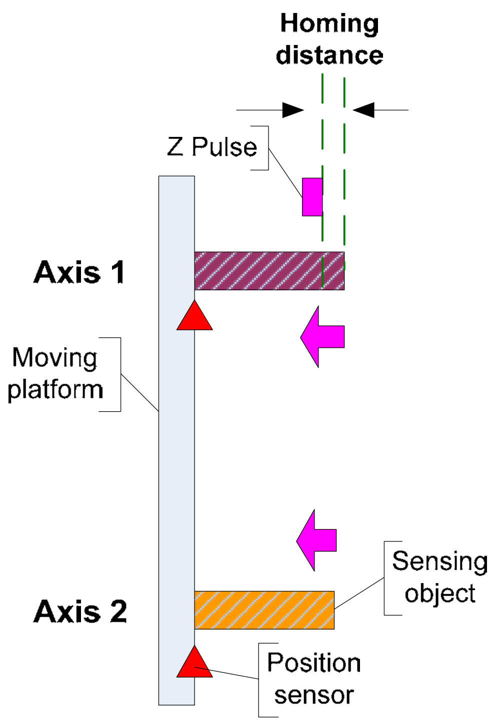


Figure 3.5.11 Homing

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.

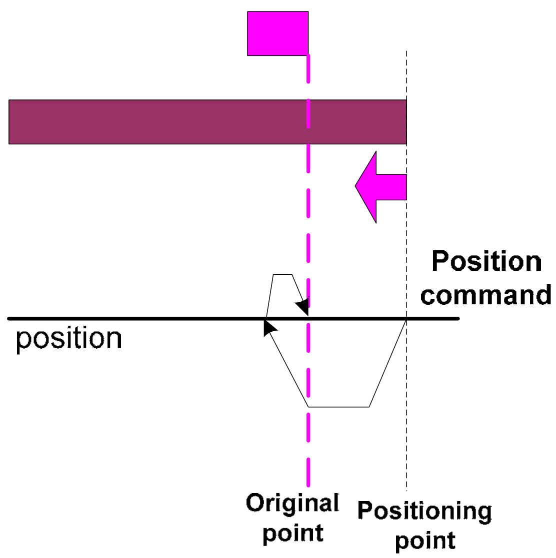


Figure 3.5.12 Homing Position and Command

f. **Signal control procedure of homing**

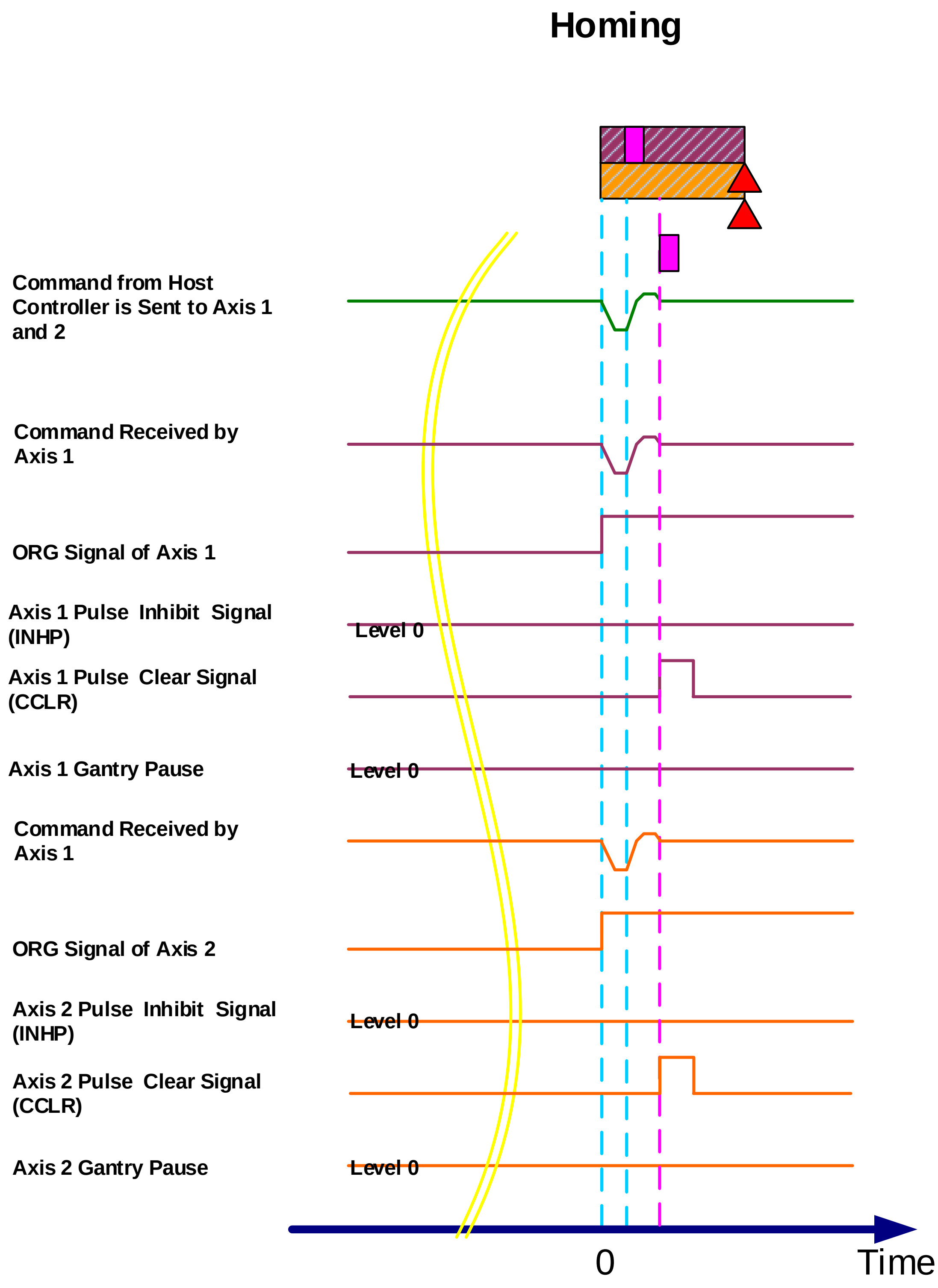


Figure 3.5.13 Timing Diagram of Homing

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.

$(46.875 * 110\%) / 60 * (P1\text{-}46) * 4 < 8 * 10^6$

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

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

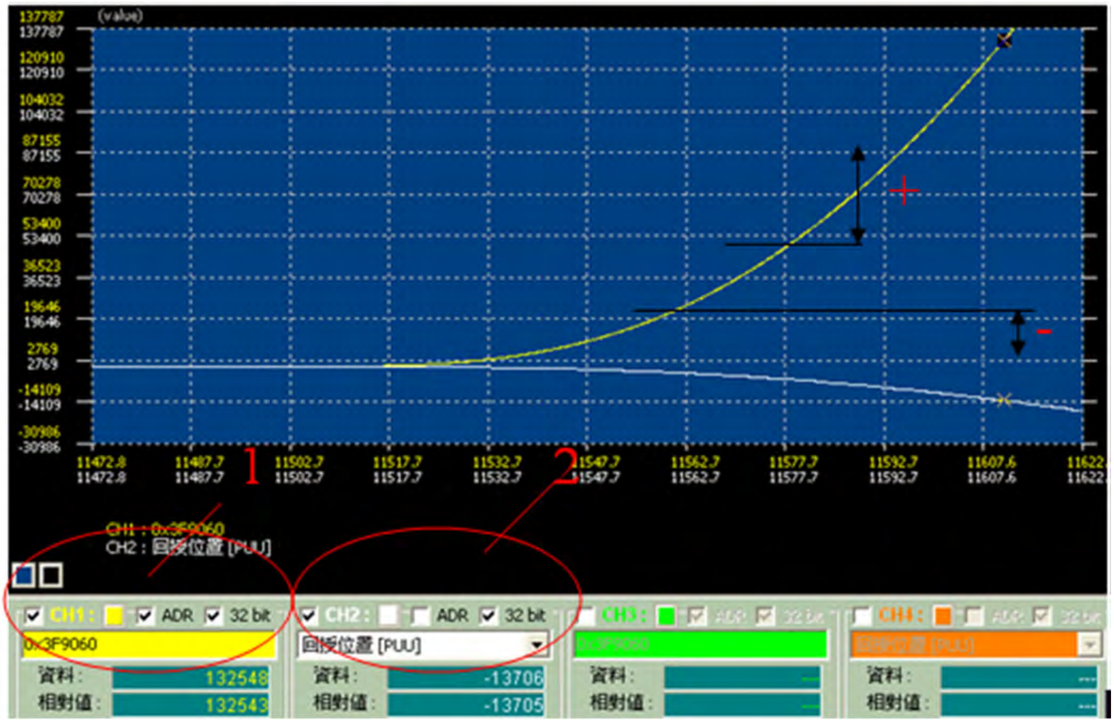


Figure 3.5.14 The Phases of Feedback Pulse in the Opposite Direction

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.)

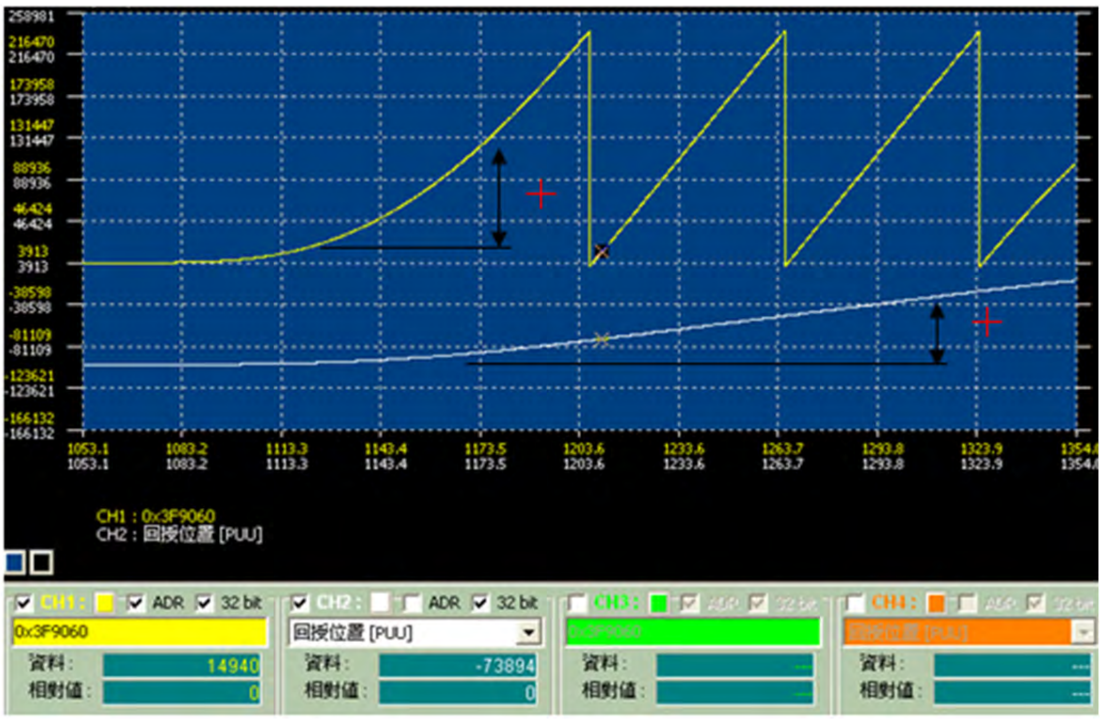


Figure 3.5.15 The Monitoring Phase of Feedback Pulse is Identical

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.

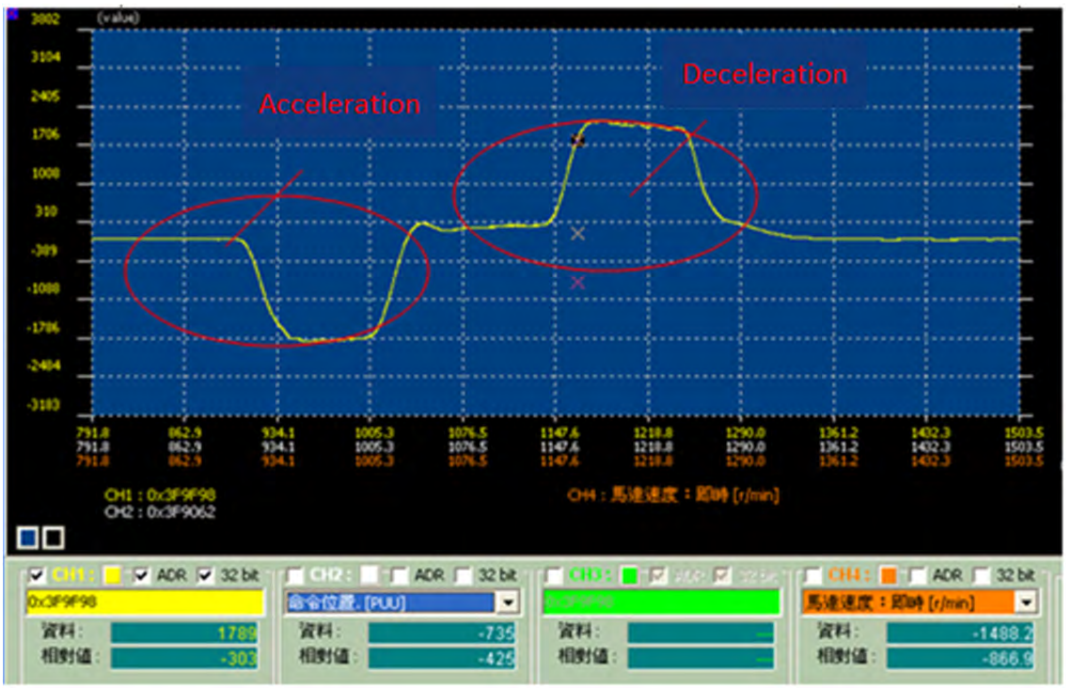
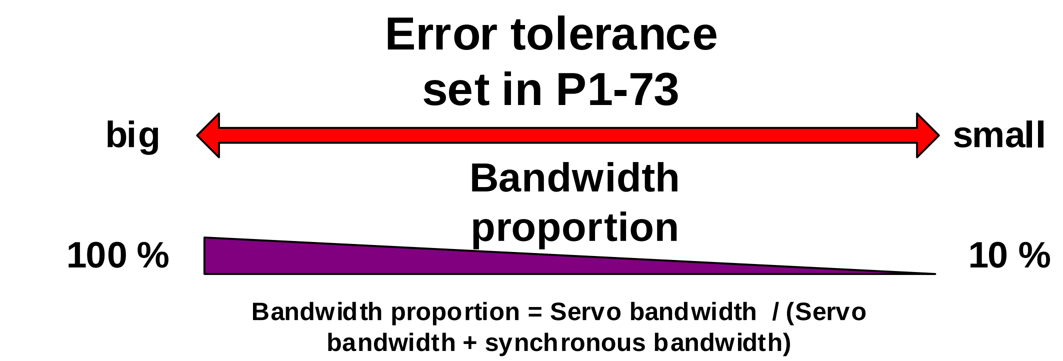


Figure 3.5.16 Monitoring Position Deviation of Gantry

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.



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.

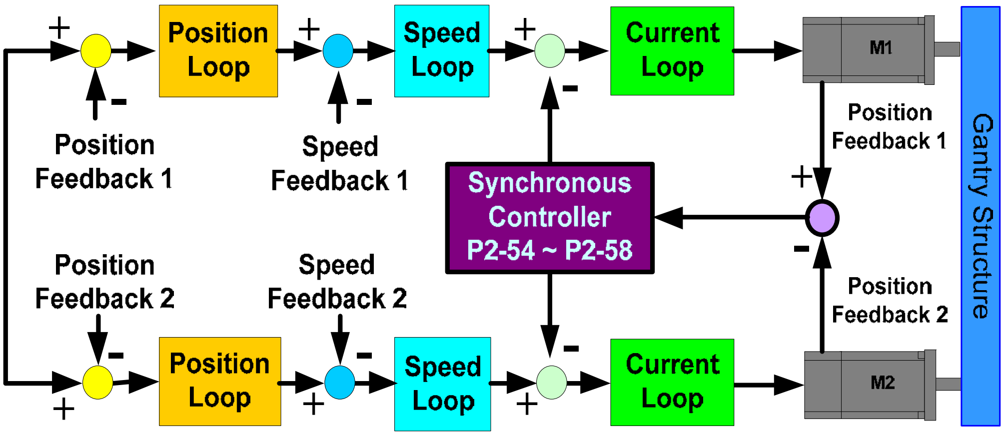


Figure 3.5.18 Gantry's Synchronous Control Structure