
| | | | | | |
|---|---|---|---|---|---|
| Product | ASD | Type/Series | ASDA servo drive | Appl. Note No. 002 | ASDA-A2, ASDA-M series |
| Issued by | DEN | Author | gFAE & modified by Jack Tsai | Released Date | January 21, 2019 |
| Title | **Full-Closed Loop Implementation** | | | | |

Devices and special tools/equipment

- ✓ Delta ASDA servo drive: ASDA-A2-F, ASDA-M-F, ASDA-A2-E, ASDA-A2-M*
- ✓ ECMA servo motor
- ✓ Host controller (Optional)

*For ASDA-A2-M, special firmware is required if the required operating mode is PR mode (P1-01=1) or Communication mode (P1-01=B, C). For updating the firmware, please contact local Delta partners or Delta offices.

Test setup

- ✓ 1pc ASD-A2-M
- ✓ 1pc ECMA servo motor
- ✓ 1pc external encoder (2500ppr)
- ✓ 1pc ball screw

# Contents

# 1. Introduction

The ideal mechanism integrated with the servo motor should be able to reflect the actual position of the machine on the motor encoder to achieve accurate positioning. However, due to the reality factors such as the backlash of the ball-screw, flexibility of the coupling or the belt, thermal expansion of the system and the slide of the machinery, the feedback position of the encoder might have apparent deviation from the exact position of the machine.

To improve such situation, the ***auxiliary encoder***, also known as the ***secondary encoder, external encoder*** or ***linear scale*** can be implemented to additionally send the actual position of the machine back to the servo drive to form a full-closed loop and ensure the accuracy of positioning.

As the full-closed loop system shown in Fig.1, besides the main encoder of the servo motor which gives feedback to the servo drive via CN2, the linear scale is connected to CN5 to send the A, B, Z signal of the auxiliary encoder back for position alignment.

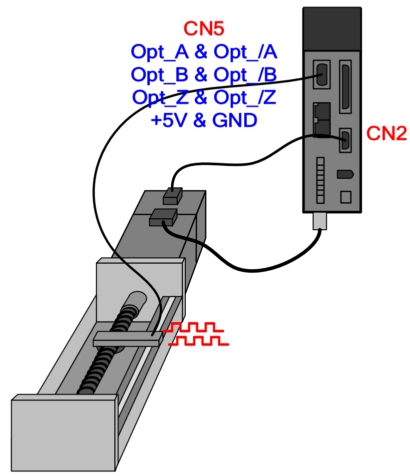



Fig.1 – Full-closed loop system

In the following chapters, the procedure of setting up the full-closed loop system will be elaborated, including the wiring, operating principle and the parameter configuration to assist users implementing the function. At last, a simple way to verify the functionality will be explained with an example as well.

# 2. Setting Up Full-Closed Loop System

## 2-1. Operating Principle

Based on the operating mode of the servo drive, the full-closed loop function can be categorized to two modes, PT mode & PR mode, as shown in Table 1.

| Full-Closed Loop mode | Operating mode |
|---|---|
| PT mode | PT mode (P1-01=0) |
| PR mode | PR mode (P1-01=1)<br>Communication mode (Ex: P1-01=C) |

Table 1 – Modes of the full-closed loop

Overall, the operating principle and the parameters involved is the same for both modes, yet there are differences when it comes to certain configuration, and this will be explained in the following sections. Fig.2 and Fig.3 is the illustration of the operating principle of each mode.

### 2-1-1. PT Full-Closed Loop

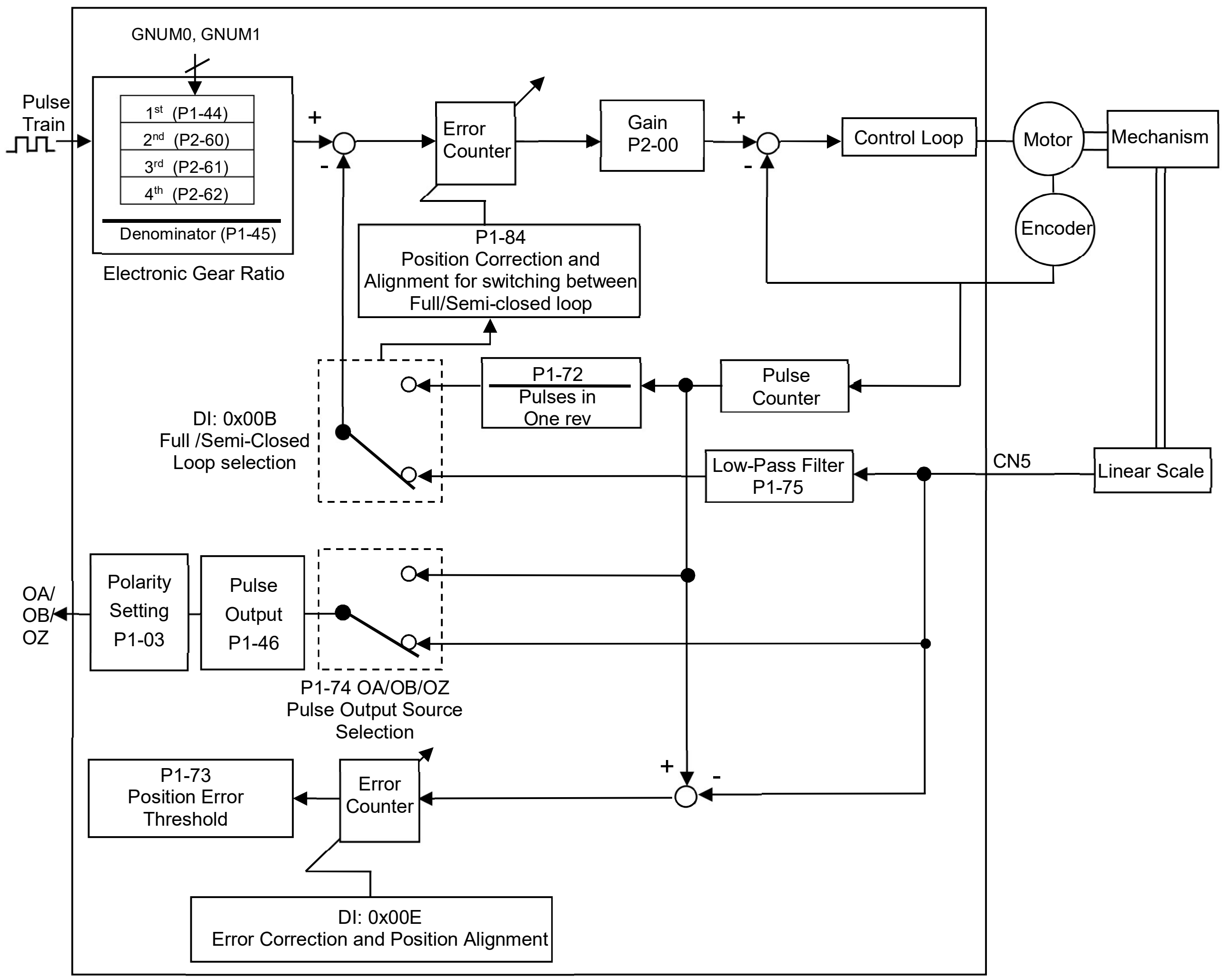



Fig.2 - PT full-closed loop operating principle

## 2-1-2. PR Full-Closed Loop

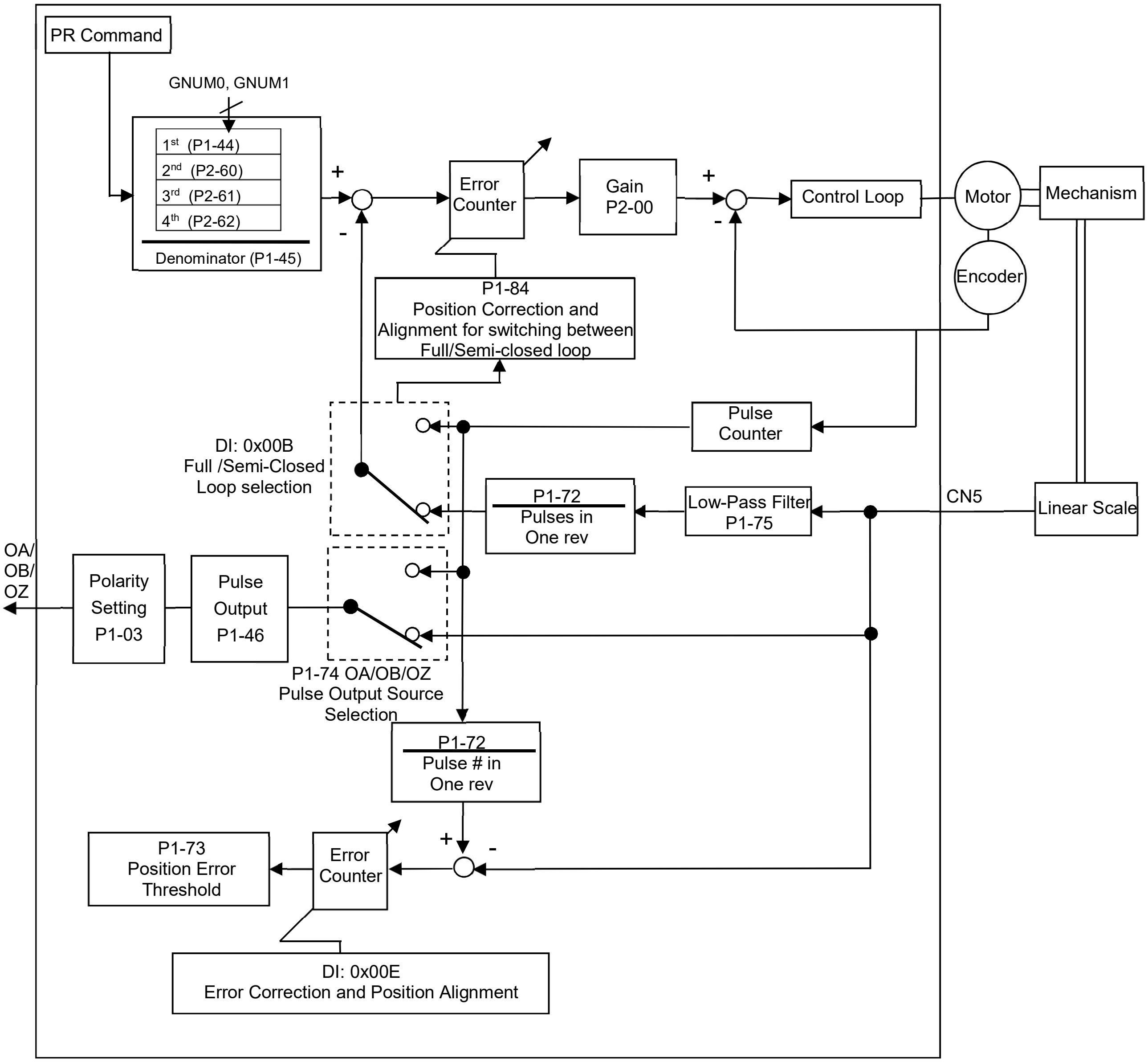



Fig.3 - PR Full-closed loop operating principle

## 2-2. Parameter Configuration

Table 2 lists the setting procedure and the relevant parameters for implementing PT & PR full-closed loop. **Parameters highlighted in BLUE means *mandatory for the setup* while GREEN means *optional depending on the user-requirements*.** Each parameter is explained individually in the following sections. To prevent damaging the mechanism, please make sure the configuration is done properly before activating the system.

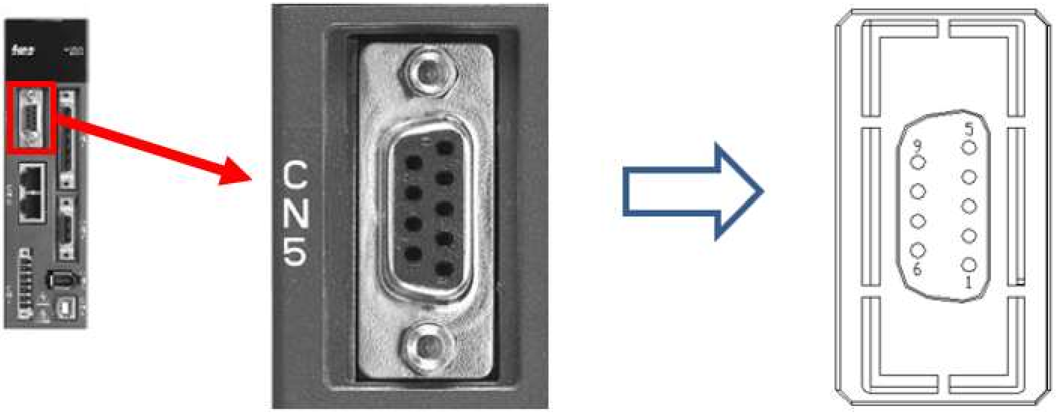
### 2-2-1. Overview

| Step | Parameters | Actions | PT | PR | Remark |
|---|---|---|---|---|---|
| 1 | --- | Conduct the wiring | ✓ | ✓ | Connect the linear scale (A, B, Z) to CN5 to form a full-closed loop. |
| 2 | **P1-74.Z** | Set the pulse trend of the linear scale | ✓ | ✓ | The pulse trend of the linear scale must be the same as that of the main encoder |
| 3 | **P1-72** | Set the resolution of the linear scale | ✓ | ✓ | |
| 4 | **P1-44, P1-45 (Optional: P3-13)** | Set the electronic gear ratio | ✓ | ✓ | **The principle of setting up PT & PR mode is different** |
| 5 | **P1-73** | Set the position error protection range | ✓ | ✓ | **Set P1-73 as a conservative value when initiating the full-closed loop for the first time to prevent damaging the machine.** |
| 6 | **P1-75** | Set the low-pass filter time constant | ✓ | ✓ | |
| 7 | **(1)DI: *0x0B* (Level triggered) (2)DI: *0x0E* (Rising-edge triggered)** | Assign DI for extra function (1)Full/semi-closed loop (2)Position error reset | ✓ | ✓ | |
| 8 | **P1-84** | Set the position error handling function of full/semi-closed loops | ✓ | ✗ | The default on PR mode is that the position error will be reset. |
| 9 | **P1-85** | Set the automatic position error reset function | ✓ | ✓ | |
| 10 | **P1-86** | Set the executed PR# between switching full/semi-closed loops | ✗ | ✓ | |
| 11 | **P2-80** | Set the source of Z-pulse for homing | ✓ | ✗ | |
| 12 | **P2-66** | Set the assisting register | ✓ | ✓ | |
| 13 | **P1-46, P1-03** | Set the output pulse number of the linear scale | ✓ | ✓ | **The setup is only necessary when the application needs to have the servo drive output the feedback from the linear scale** |
| 14 | **P1-74.X** | Activate full-closed loop function | ✓ | ✓ | |

Table 2 – Full-closed loop setup procedure

## 2-2-2. Step 1: Physical Wiring

*CN5* on the servo drive is used for the connection between the linear scale and the servo drive. The pin description is shown in Fig.4 as below.




| Pin No. | Signal Name | Terminal Symbol | Function and Description |
|---|---|---|---|
| 1 | /Z phase input | Opt_/Z | Linear scale /Z phase output |
| 2 | /B phase input | Opt_/B | Linear scale /B phase output |
| 3 | B phase input | Opt_B | Linear scale B phase output |
| 4 | A phase input | Opt_A | Linear scale A phase output |
| 5 | /A phase input | Opt_/A | Linear scale /A phase output |
| 6 | Encoder grounding | GND | Ground |
| 7 | Encoder grounding | GND | Ground |
| 8 | Encoder power | +5V | Linear scale 5V power |
| 9 | Z phase input | Opt_Z | Linear scale Z phase output |

Fig.4 – Pin description for CN5 full-closed loop wiring

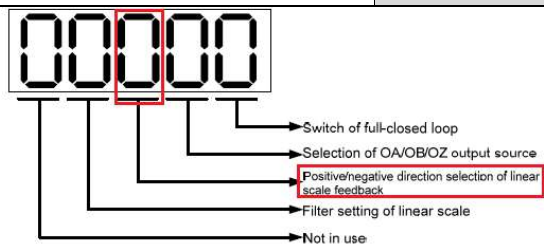
**NOTE**

1) The highest communication rate is 4Mpps and only the encoder with +5V & AB phase signal is supported.
2) Supporting encoders with resolution up to 1280000 pulse/rev (the highest quadruple frequency of the full-closed loop when the motor rotates 1 rev).

## 2-2-3. Step 2: **P1-74.Z** - Pulse Trend of the Linear Scale

| **P1-74** | **Full-Closed Loop Control of Linear Scale** | | **Address: 0194H, 0195H** |
|---|---|---|---|
| Default | 1000h | Control mode | Position |
| Unit | - | Setting range | 0x0000 – 0x4122 |
| Format | HEX | Data Size | 16-bit |

Settings :




- Z: Positive / Negative trend selection of the linear scale feedback:

  **0**: Positive trend when A-phase leads B-phase of the linear scale

  **1**: Negative trend when B-phase leads A-phase of the linear scale

Fig.5 – P1-74.bit3 definition

Fig.5 is the definition of **P1-74.Z**. The pulse trend of the main encoder and the linear scale must be the same, whether it's positive or negative trend. Users can refer to below instruction and use *ASDA-Soft* for verification.

(1) Set P1-72=80000

(2) Open ASDA-Soft and click the *Status Monitor* icon → Click the *Select Monitor Items* tab → Set the *Mapping Parameters Setting* as highlighted in Fig.6 to monitor the feedback of the main encoder and the linear scale, then click *Change*.

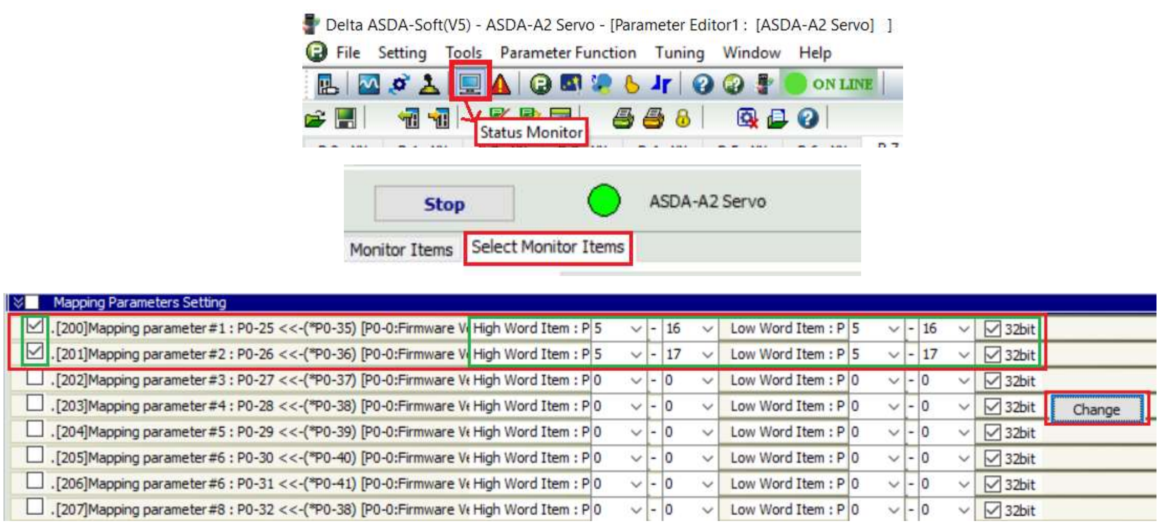



Fig.6 – Settings+ to monitor the feedback of the main encoder and the linear scale

(3) Open the scope, set CH1 and CH2 as [PAR]Parameters and tick the box in front of the *32 bit* to monitor P0-25 & P0-26.

(4) **Without activating the full-closed loop**, servo ON the drive, use JOG function to move the motor slowly towards one direction and make sure there will be no collision, then monitor the scope. If the waveform is like Fig.7 or Fig.8, it means the pulse trend of both encoders is the same and it's correct, then there's no need to adjust P1-74.Z.

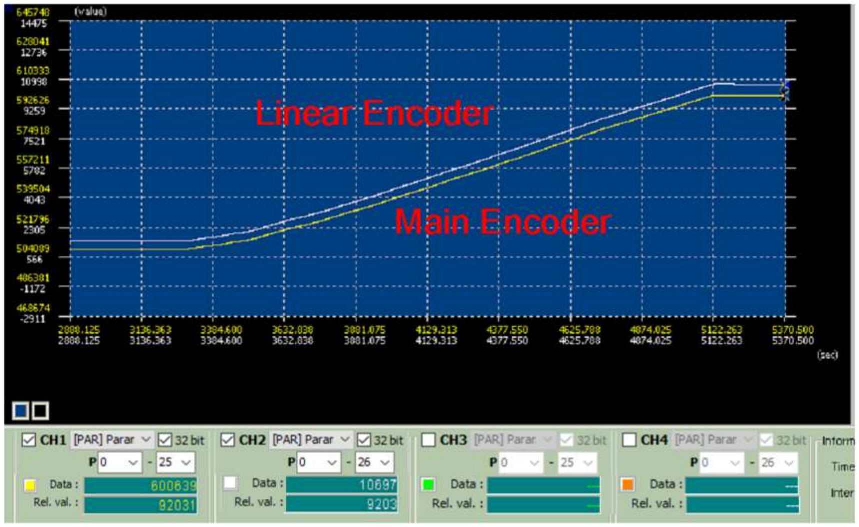



Fig.7 – Same pulse trend (positive)

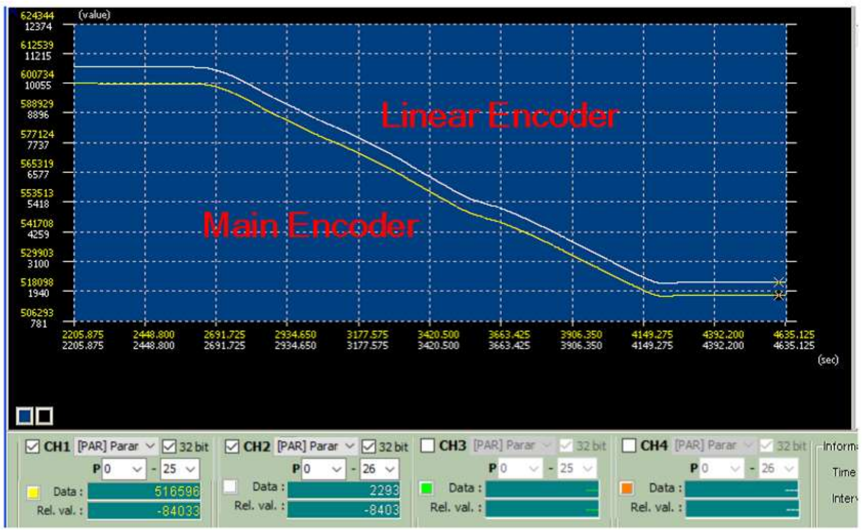



Fig.8 – Same pulse trend (negative)

However, if the waveform is like Fig.9, it means the pulse trend is different which is wrong. In that case, set P1-74.Z=1 to reverse the direction of the feedback to fix the problem.

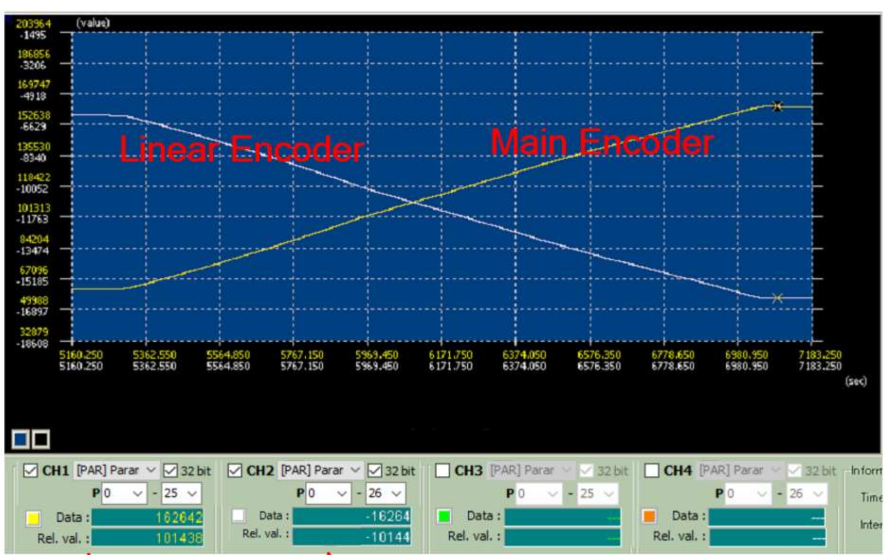



Fig.9 – Different pulse trend

## 2-2-4. Step 3: **P1-72** - Resolution of the Linear Scale

| **P1-72** | **Resolution of the Linear Scale** | | **Address: 0190H, 0191H** |
|---|---|---|---|
| Default | 1000h | Control mode | Position |
| Unit | - | Setting range | 200 – 1280000 |
| Format | DEC | Data Size | 32-bit |

Settings:
Numbers of A/B pulses of the full-closed loop when motor runs a cycle (after quadruple frequency)

Fig.10 – P1-72 definition

As defined in Fig.10, **P1-72** is the resolution of the linear scale corresponding to 1 cycle of the motor. The proper value can be calculated either *from the specification* or *from the data monitored with ASDA-Soft scope* as explained below.

**Option 1: From the specification**

If the specification of the mechanism is known or it's a ball-screw application, P1-72 can be calculated as shown in Fig.11, which is 10000 in this example.

The pitch of the ball screw is 5mm, and the resolution of the linear scale is 0.5um/pulse.


$$\frac{5\ \text{mm/rev}}{0.5\ \mu\text{m/pulse}} = 10000\ \text{pulse/rev}$$

Fig.11 – P1-72 calculation from the specification

**Option 2: From the data monitored with ASDA-Soft scope**

If the mechanism specification is unknown, complicated, or not a ball-screw, P1-72 can be defined with the help of the scope data. How to conduct the measurement differs between PT mode and PR mode, each case is explained below.

**(1) PT mode**

Set P1-44=1 and P1-45=1 to have 1280000 PUU for 1 rev of the motor. Use the host controller to send commands to move the motor slowly for a long distance without any collision, then read the data from the scope. As Fig.13 shows, when the motor moves 2528000 PUU, the linear scale returns 19750 pulses. Therefore, with the formula shown in Fig.12, we can get P1-72=10000.

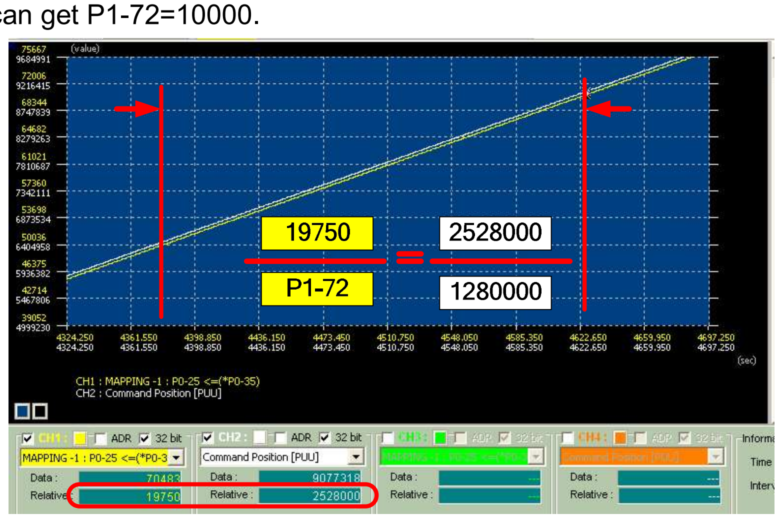



Fig.12 – P1-72 calculation with the scope on PT mode

**(2) PR mode**

Set P1-44=1 and P1-45=1 to have 1280000 PUU for 1 rev of the motor. Use this value as basis, write a simple PR command as shown in Fig.13. As the scope indicates, when the motor runs a cycle (1280000 PUU), the linear scale returns 10000 pulses, so P1-72=10000.

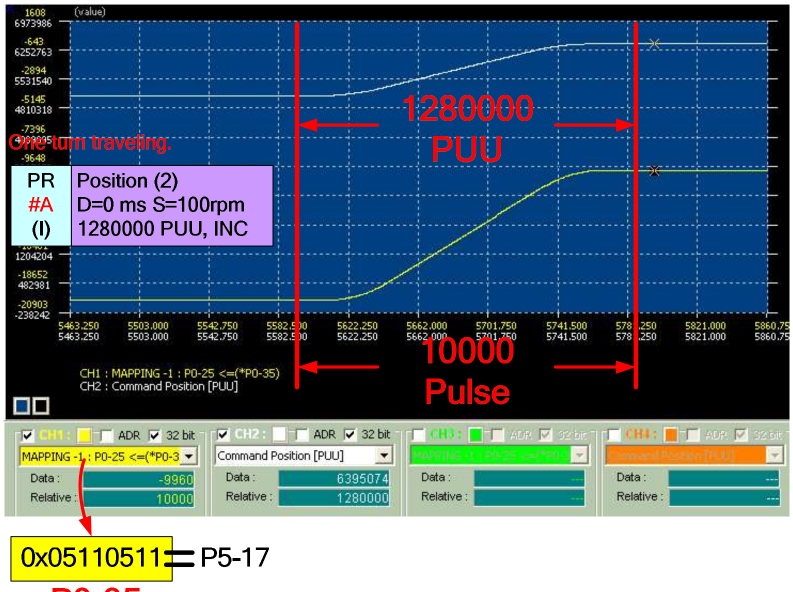



Fig.13 – P1-72 calculation with the scope on PR mode

## 2-2-5. Step 4: **P1-44, P1-45** - Electronic Gear Ratio

| **P1-44** | **Gear Ratio (Numerator) (N1)** | | **Address: 0158H, 0159H** |
|---|---|---|---|
| Default | 1 | Control mode | Position |
| Unit | Pulse | Setting range | 1 – ($2^{29}$-1) |
| Format | DEC | Data Size | 32-bit |

| **P1-45** | **Gear Ratio (Denominator) (M)** | | **Address: 015AH, 015BH** |
|---|---|---|---|
| Default | 1 | Control mode | Position |
| Unit | Pulse | Setting range | 1 – ($2^{31}$-1) |
| Format | DEC | Data Size | 32-bit |

Settings:
If the setting is inappropriate, there's potential risk that the motor might have sudden and unintended acceleration.
The setting of pulse input is as below formula, and the recommended range of command pulse input is
1/50 < N/M < 25600

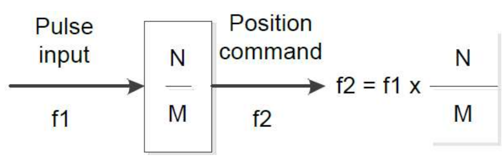



Fig.14 – P1-44 & P1-45 definition

Fig.14 is the definition of **P1-44 & P1-45** which compose the electronic gear ratio. How to define an appropriate electronic gear ratio for PT&PR mode full-closed loop is different due to the principle of scaling command/feedback is not the same, and each will be explained below.

## (1) PT mode

If it's PT full-closed loop, the electronic gear ratio will scale the system command according to P1-72 instead of its original reference from the main encoder. Fig.15 shows the formula of the E-gear ratio N/M.

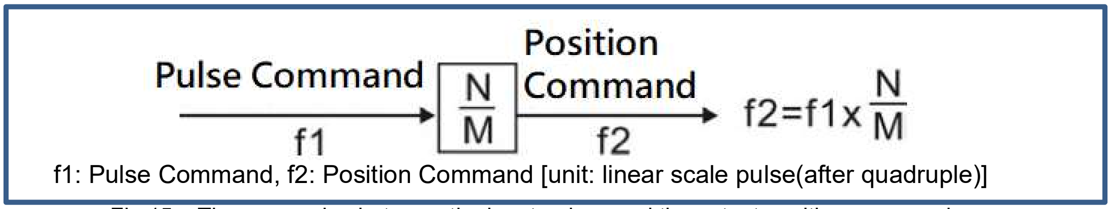



Fig.15 – The conversion between the input-pulses and the output-position-command

In most of the cases *P1-44/P1-45=1/1* but it's also plausible to set another value. For instance, if P1-44/P1-45=1/1 and P1-72=5000, the motor will rotate 1 rev when the servo drive receives 5000 pulses. But if the value is changed to P1-44/P1-45=2/1, then only 2500 pulses is required to drive the motor to rotate 1 rev.

## (2) PR mode

On PR mode, the electronic gear ratio is always referring to the main encoder, which is different from PT mode. As shown in Fig.16, the unit of the feedback resolution is 1280000 pulse/rev, so it is recommended to *set the electronic gear ratio as the value to have required pulses for 1 motor rev = P1-72*.*

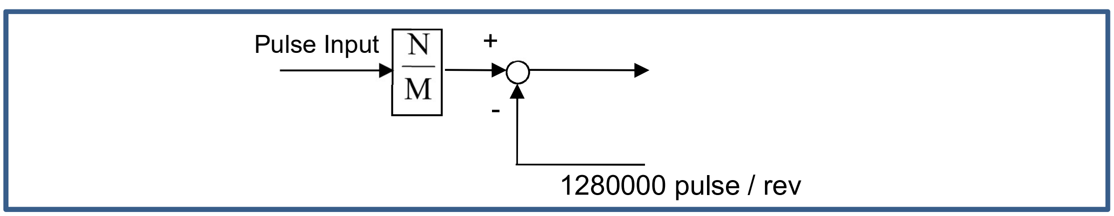



Fig.16 – Command scaling mechanism on PR mode

For example, if P1-72=10000, P1-44/P1-45=128/1 will be an appropriate setting because 10000 pulses is required for 1 motor rev, and it is the same as P1-72. With this configuration, assuming one pulse equals to 0.05mm and the user wants to have the motor move 500mm, simply sending a command of 10000 PUU will do (0.05*10000=500).

On the other hand, in this example, if the user wants to scale up the resolution to have the motor travel twice as much as the original distance of 1 pulse, just multiply P1-44 by 2 to have P1-44/P1-45=256/1, then the requirement can be met.

**NOTE** If PR full-closed loop is used but the users want to set P1-44/P1-45=1/1 to have a straightforward reference with the pulse command from the host-controller, it's necessary to adjust **P3-13.X** to change the position feedback which the servo drive is referring to. Fig.17 is the definition of P3-13, users can set it to ***1*** to fix the feedback always as the linear scale, or set it to **2** to let the servo determine the reference source automatically based on full/semi-closed loops.

| **P3-13** | **PR/DMCNET Full-Closed Loop Feedback Setting** | | **Address: 031AH, 031BH** |
|---|---|---|---|
| Default | 0x0000 | Control mode | Position |
| Unit | - | Setting range | 0x0000 – 0x0022 |
| Format | HEX | Data Size | 32-bit |

Settings: 0000

U Z Y X

**X**: monitoring variable: 00 (encoder feedback setting (user-defined unit))
0: motor feedback pulse number
1: linear scale feedback pulse number
2: motor feedback pulse number in semi-closed loop mode; linear scale feedback pulse number in full-closed loop mode

Fig.17 – P3-13.X definition

## 2-2-6. Step 5: **P1-73** - Position Error Protection Range

| **P1-73** | **Position Error Protection Range**[*1] | | **Address: 0192H, 0193H** |
|---|---|---|---|
| Default | 30000 | Control mode | Position |
| Unit | Pulse(based on the feedback of full-closed loop)[*2] | Setting range | 1 – ($2^{31}$-1) |
| Format | DEC | Data Size | 32-bit |

Fig.18 – P1-73 definition

When there's backlash or mechanical slide happening in the machinery, it will result in deviation between the position feedback of the motor and the actual position of the machine. If there's excessive position deviation, it might indicate the coupling is loose or the mechanism is not integrated properly, then the servo drive will show AL040 for warning. **P1-73** as shown in Fig.18 allows users to define the tolerance of the deviation before triggering AL040.

**NOTE 1** To prevent potential mechanism collision due to the disconnection of the linear scale or the wrong pulse trend, we highly recommend setting P1-73 as a conservative value when initiating the full-closed loop the first time. After making sure the machine works properly, users can adjust the value according to the real application.

To setup P1-73, first let the machine run for 1 complete cycle and use the scope of ASDA-Soft to monitor ***monitoring variable 31*** to check the maximum deviation, then set the value into P1-73 with a reasonable tolerance as a threshold based on the specification of the actual mechanism.

**NOTE 2** If **P1-72, P1-44** and **P1-45** are set correctly, **P1-73** could be directly referred to the PUU unit without conversion which will be very straightforward for monitoring and verification, therefore please make sure the previous three parameters are set properly.

## 2-2-7. Step 6: **P1-75** - Low-Pass Filter Time Constant

| **P1-75** | **Low-Pass Filter Time Constance of Full-Closed Loop** | | **Address: 0196H, 0197H** |
|---|---|---|---|
| Default | 100 | Control mode | Position |
| Unit | ms | Setting range | 0 – 1000 |
| Format | DEC | Data Size | 16-bit |

Fig.19 – P1-75 definition

**P1-75** as Fig.19 shows allows users to set the low-pass filter time constant. If the stiffness of the mechanical system is not enough, applying the time constant can enhance the stability of the system by having the semi-closed loop effect in the transient-state while having the full-closed loop effect in the steady-state. On the other hand, P1-75 can be set to 0 to disable the function if the mechanical system is stiff enough.

To be brief, if the stiffness of the system is high, decrease the value of P1-75 or set it to 0 to disable the function; if the stiffness of the system is low, increase the value of P1-75.

## 2-2-8. Step 7: DI Assignment for Extra Function

In case the application required switching between semi/full-closed loops, users can assign two DIs to manage it.

**(1) DI: 0x0B**

| **Definition：0x0B** | | | |
|---|---|---|---|
| Symbol | Function（DI） | Trigger | Operating Mode |
| FHS | Switching between semi/full-closed loops[*]<br>0: Full-closed loop<br>1: Semi-closed loop | Level | PT/PR<br>Full-closed loop |

**NOTE** To enable this DI, **P1-77** needs to be set depending on different models as shown below.

| **Model Name** | **Remark** |
|---|---|
| A2-M | PT mode: P1-77=1<br>PR mode: No need to set P1-77 |
| A2-E | No need to set P1-77 |
| A2-F | No need to set P1-77 |

**(2) DI: 0x0E**

| **Definition：0x0E** | | | |
|---|---|---|---|
| Symbol | Function（DI） | Trigger | Operating Mode |
| FEC | Clear the position deviation between the main encoder and the linear scale | Rising-edge | PT/PR<br>Full-closed loop |

## 2-2-9. Step 8: **P1-84** - Position Error Handling Function of Semi/Full-Closed Loops

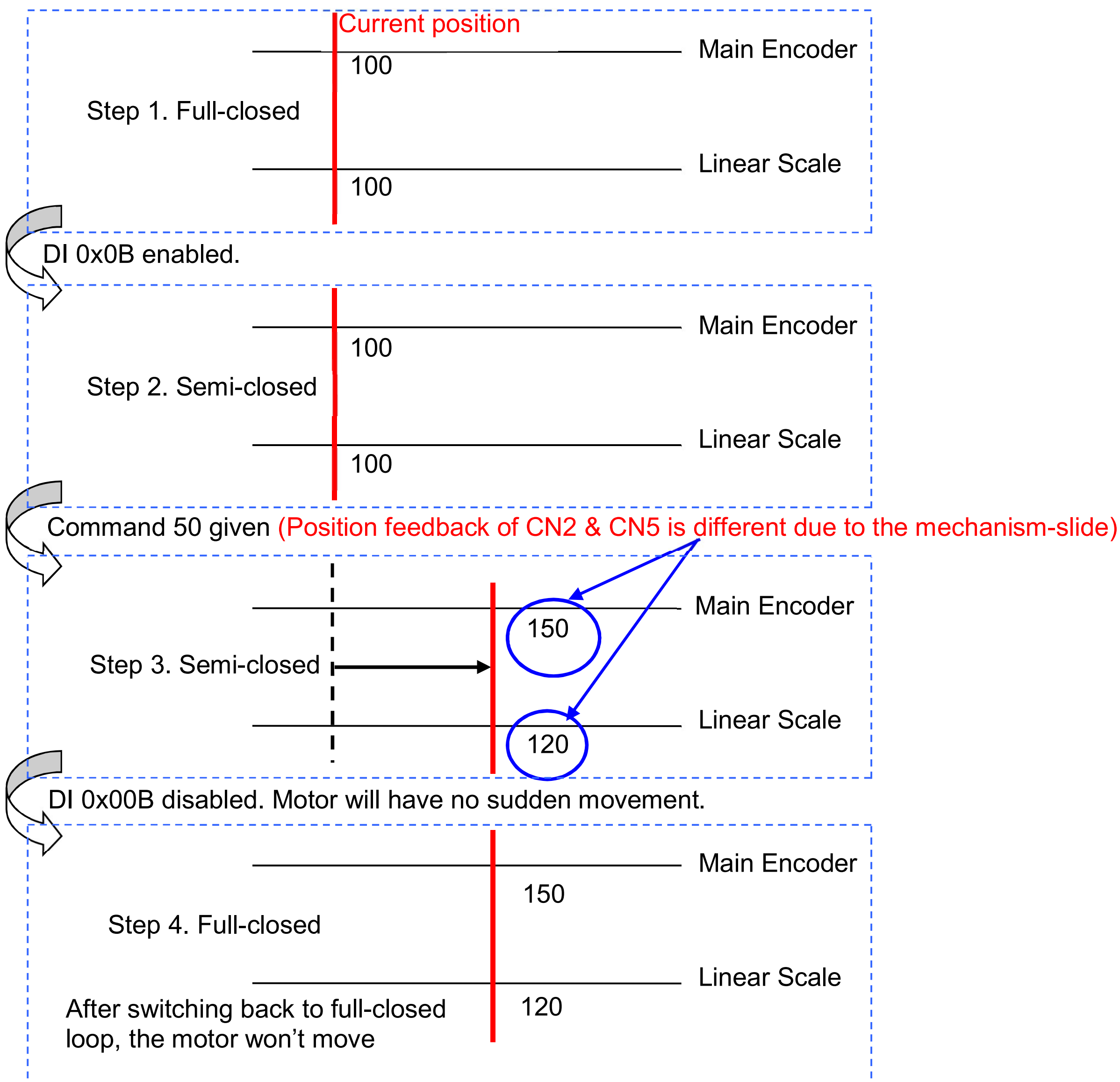
| **P1-84** | **Position error handling function of semi/full-closed loop** | | **Address: 01A8H, 01A9H** |
|---|---|---|---|
| Default | 0x0000 | Control mode | PT |
| Unit | - | Setting range | 0 – 1 |
| Format | HEX | Data Size | 16-bit |

Fig.20 – P1-84 definition

While switching from full-closed loop to semi-closed loop, the position error will accumulate fast if the motor is still rotating. After the mode is switched back, the motor will try to compensate the deviation and eventually lead to a "jump". To prevent such scenario, users can configure **P1-84** shown in Fig.20 to define how the position error should be processed.

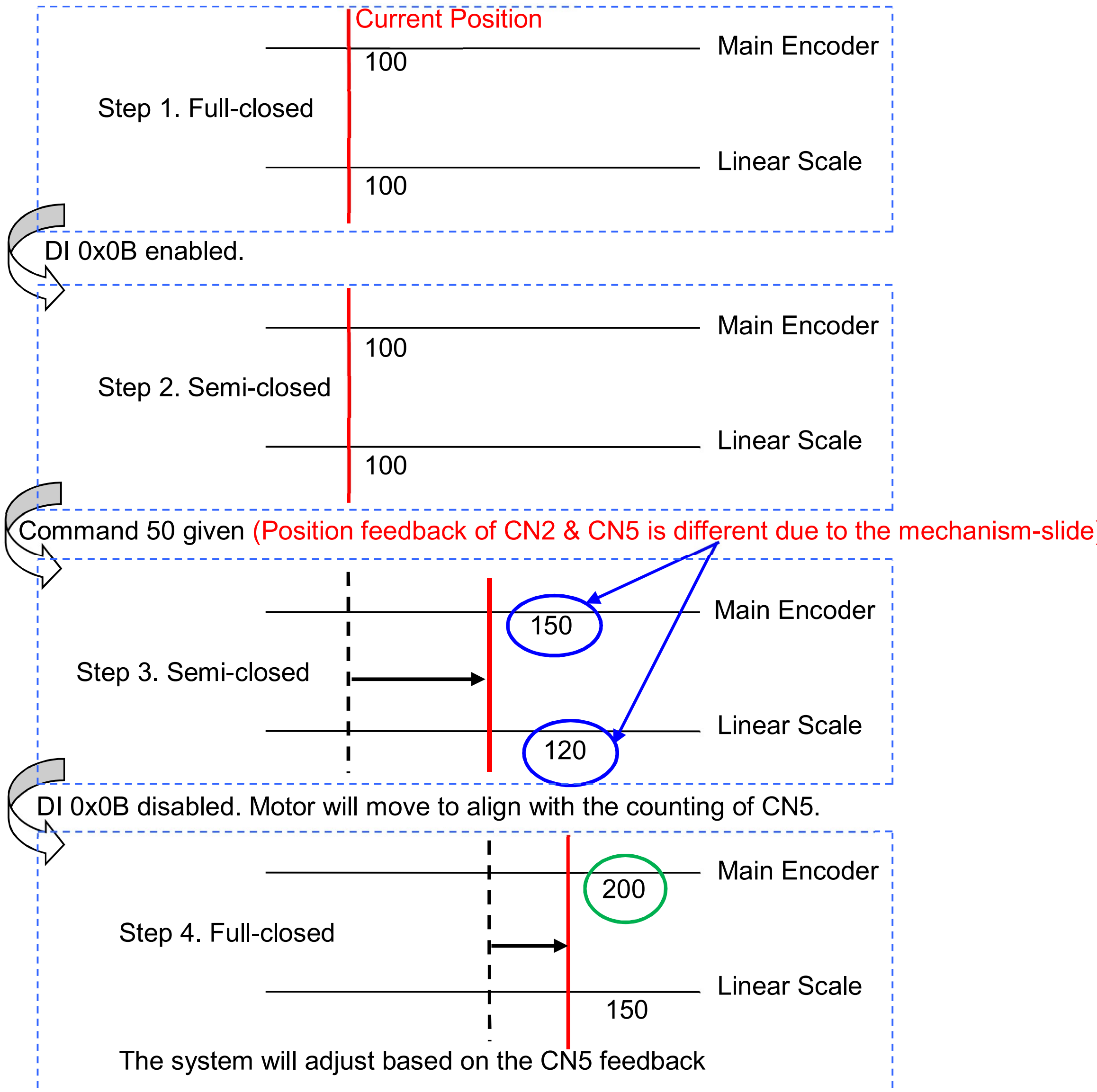
**(1) P1-84=0**

When using *DI:0x0B* to switch between semi/full-closed loops, the position error will be cleared every time it's switched. Under semi-closed loop, the command refers to the main encoder instead of the linear scale, so the motor won't have sudden movement to align with the feedback position of the linear scale.



**(2) P1-84=1**

The position error won't be cleared when using *DI:0x0B* to switch between semi/full-closed loops. Under semi-closed loop, the command refers to the main encoder and when it's switched back to full-closed loop, the command given in semi-closed loop will be converted to the full-closed loop command, so the motor will have further movement to compensate the deviation.




After switching back to full-closed, the motor will compensate the 50 command with reference to CN5.

## 2-2-10. Step 9: **P1-85** - Automatic Position Error Reset Function

| **P1-85** | **Automatically clear the error between the linear scale and the main encoder** | | **Address: 01AAH, 01ABH** |
|---|---|---|---|
| Default | 0 | Control mode | Position |
| Unit | Rev | Setting range | 0 – 32768 |
| Format | DEC | Data Size | 16-bit |

Settings:

**0**: The function is OFF

**Other value**: The position error will be reset to 0 automatically when the rotation times exceeds the set value

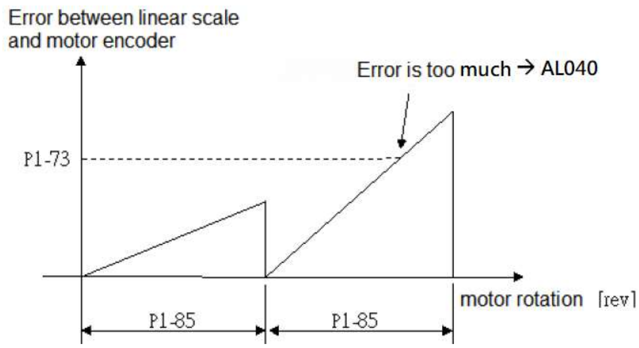



Fig.21 – P1-85 definition

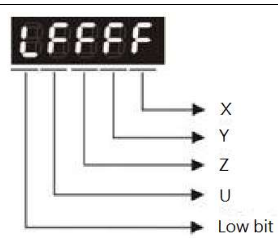
If there's mechanical-slide in the application such as the steel-plate cutting and wire feeding system which uses the friction for actuating, inevitably the position deviation between the main encoder and the linear scale will accumulate and eventually triggers AL040. In that case, users can set **P1-85** to automatically clear the position deviation within the tolerance.

**NOTE** Resetting the position deviation will not affect the accuracy of the positioning

## 2-2-11. Step 10: **P1-86** - Executed PR# between Switching Semi/Full-Closed Loops

| **P1-86** | **Executed PR# between switching semi/full-closed loop** | | **Address: 01ACH, 01ADH** |
|---|---|---|---|
| Default | 0x0000 | Control mode | PR |
| Unit | - | Setting range | 0x0000 – 0x3F3F |
| Format | HEX | Data Size | 16-bit |

Settings:




YX: The PR# being executed when switching from semi-closed loop to full-closed loop

UZ: The PR# being executed when switching from full-closed loop to semi-closed loop

No PR# will be executed when the value is 00

**NOTE** Using PR#0 to conduct homing is not supported with this parameter

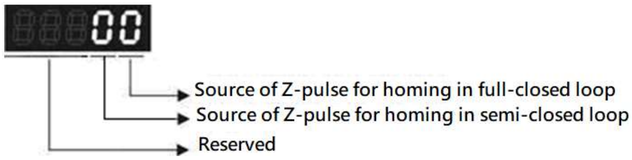
Fig.22 – P1-86 definition

If the application required to execute certain PR# while switching between full/semi-closed loop, **P1-86** shown in Fig.22 can be utilized.

## 2-2-12. Step 11: **P2-80** - Source of Z-pulse for homing

| **P2-80** | **Source of Z-pulse for Homing** | | **Address: 02A0H, 02A1H** |
|---|---|---|---|
| Default | 0x0010 | Control mode | PR |
| Unit | - | Setting range | 0x0000 – 0x0011 |
| Format | HEX | Data Size | 16-bit |

Settings:




- Source of Z-pulse for homing in full-closed loop

  0: Linear scale

  1: Main encoder

- Source of Z-pulse for homing in semi-closed loop

  0: Linear scale

  1: Main encoder

Fig.23 – P2-80 definition

Fig.23 states the definition of **P2-80**. Due to the Z-pulse alignment function shares the same control mechanism with the built-in CAPTURE function, taking the conversion of the coordinate after homing into consideration, P5-39.X.bit0 will be set to 0 automatically to disable the CAPTURE function and will remain the status after homing is completed. After that, the coordinate of the main encoder and the linear scale will be aligned. During the homing process, the software limits will be temporarily disabled.

## 2-2-13. Step 12: **P2-66** - Assisting Register

| **P2-66** | **Assisting Register** | | **Address: 02A0H, 02A1H** |
|---|---|---|---|
| Default | 0x0000 | Control mode | ALL |
| Unit | - | Setting range | 0x0000 – 0x183F |
| Format | HEX | Data Size | 16-bit |

Settings:

| B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |
|---|---|---|---|---|---|---|---|
| - | - | - | - | - | - | - | - |

- B5(bit5): Enable disconnection detection of the linear scale (Effective only when the full-closed loop control function is enabled)

  0: Detection is disabled and AL041 won't occur

  1: Detection is enabled and AL041 will occur

**AL041: Communication breakdown of the linear scale**

| Causes | Checking Method | Corrective Actions |
|---|---|---|
| Communication breakdown of the linear scale | Check the communication of linear scale. | Check the communication of linear scale again. |

Fig.24 – P2-66 definition

It's crucial to monitor the connection between the linear scale and the servo drive because if it's disconnected, the machine might collide due to the sudden acceleration of the motor. **P2-66** as shown in Fig.24 provides the function to detect whether the linear scale is connected or not. When P2-66.bit5 is enabled and the connection breaks down, AL041 will appear to indicate the problem.

**NOTE** **The default value is 0 for P2-66.bit5, so it's strongly recommended to enable this function before enabling the full-closed loop!**

## 2-2-14. Step 13: **P1-46, P1-03** - Output Pulse Number of the linear scale

| **P1-46** | **Pulse Number of Encoder Output** | | **Address: 015CH, 015DH** |
|---|---|---|---|
| Default | 2500 | Control mode | ALL |
| Unit | Pulse | Setting range | 20 – 320000 |
| Format | DEC | Data Size | 32-bit |

Settings: The number of the single-phase pulse output per revolution

**NOTE** The following circumstances may result in AL018 due to exceeding the maximum allowable output pulse frequency of the drive.

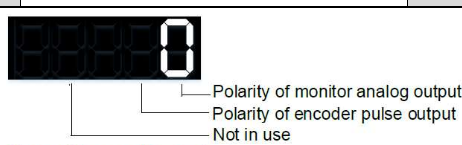
**AL018：Abnormal Signal Output**

| Causes | Checking Method | Corrective Actions |
|---|---|---|
| The encoder is in error and cause the abnormal signal output | Check the fault records (P4-00~P4-05). See if the alarm exists with the encoder error (AL011, AL024, AL025, AL026) | Conduct the corrective actions of AL.011, AL.024, AL.025, AL.026 |
| The output pulse exceeds the hardware allowable range. | Check if the following conditions produce: P1-76 < Motor Speed or $\frac{\text{Motor Speed}}{60} \times P1-46 \times 4 > 19.8 \times 10^6$ | Correctly set parameter P1-76 and P1-46: P1-76 > Motor Speed or $\frac{\text{Motor Speed}}{60} \times P1-46 \times 4 < 19.8 \times 10^6$ |

Fig.25 – P1-46 definition

| **P1-03** | **Polarity Setting of the Encoder Pulse Output** | | **Address: 0106H, 0107H** |
|---|---|---|---|
| Default | 0x0000 | Control mode | ALL |
| Unit | - | Setting range | 0x0000 – 0x0013 |
| Format | HEX | Data Size | 16-bit |

Settings:




- Polarity of monitor analog output

| | |
|---|---|
| 0: MON1(+), MON2(+) | 2: MON1(-), MON2(+) |
| 1: MON1(+), MON2(-) | 3: MON1(-), MON2(-) |

- Polarity of encoder pulse output

| | |
|---|---|
| 0: Forward output | 1: Reverse output |

Fig.26 – P1-03 definition

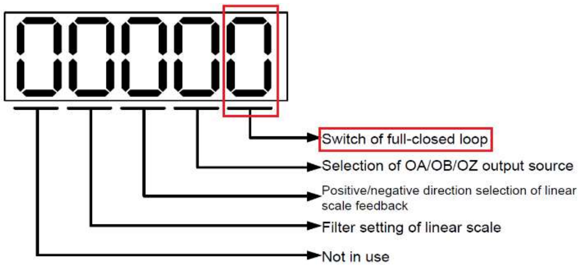
If the application requires to have the linear scale feedback be output from the servo drive, users can configure **P1-46 & P1-03** in Fig.25 & Fig.26.

P1-46 is for setting up the number of the single-phase pulse output per revolution, what worth mentioning is that inappropriate settings might results in AL018, so users need to be cautious when defining the value. As for P1-03, it can be used to determine the polarity of the encoder output pulse.

## 2-2-15. Step 14: **P1-74.X** - Full-Closed Loop Function Activation

| P1-74 | Full-Closed Loop Control of Linear Scale | | Address: 0194H, 0195H |
|---|---|---|---|
| Default | 0x0000 | Control mode | ALL |
| Unit | Pulse | Setting range | 0x0000 – 0x4122 |
| Format | HEX | Data Size | 16-bit |

Settings:




- X: Switch of the full-closed loop control
  0: Function of full-closed loop is disabled
  1: Function of full-closed loop is enabled
  2: Activate the synchronous detection
- Y: Source of OA/OB/OZ output:
  0: Main encoder
  1: Linear scale
  2: CN1 pulse command
- Z: Positive / Negative direction selection of linear scale feedback:
  0: Positive direction when A-phase leads B-phase of the linear scale
  1: Negative direction when B-phase leads A-phase of the linear scale
- U: Filter setting of the linear scale:
  0: Bypass
  1: 20 MHz
  2: 10 MHz
  3: 6.66 MHz
  4: 1.66 MHz
  5: 833 KHz
  6: 416 KHz

Fig.27 – P1-74 definition

After finishing the configuration of the parameters in the previous sections, set **P1-74.bit1=1** to activate the full-closed loop function. Besides P1-74.bit1, users can configure other bits of P1-74 shown in Fig.27 depending on the actual requirements.

# 3. Full-Closed Loop System Verification

In this section, an example with the basic full-closed loop function setup will be introduced, along with the related parameter configuration, applicable monitoring variables, parameters and the scope data analysis.

## 3-1. System Structure

Fig.28 is the illustration of the system structure of this example. The system is composed of 1pc ASDA-A2-M, 1pc ECMA servo motor, 1pc auxiliary encoder with 2500ppr resolution to represent the linear scale and a ball-screw connecting the ECMA servo motor and the auxiliary encoder. The feedback of the main encoder from the ECMA servo motor is going back to the servo drive via CN2, while the feedback of the auxiliary encoder goes back via CN5.

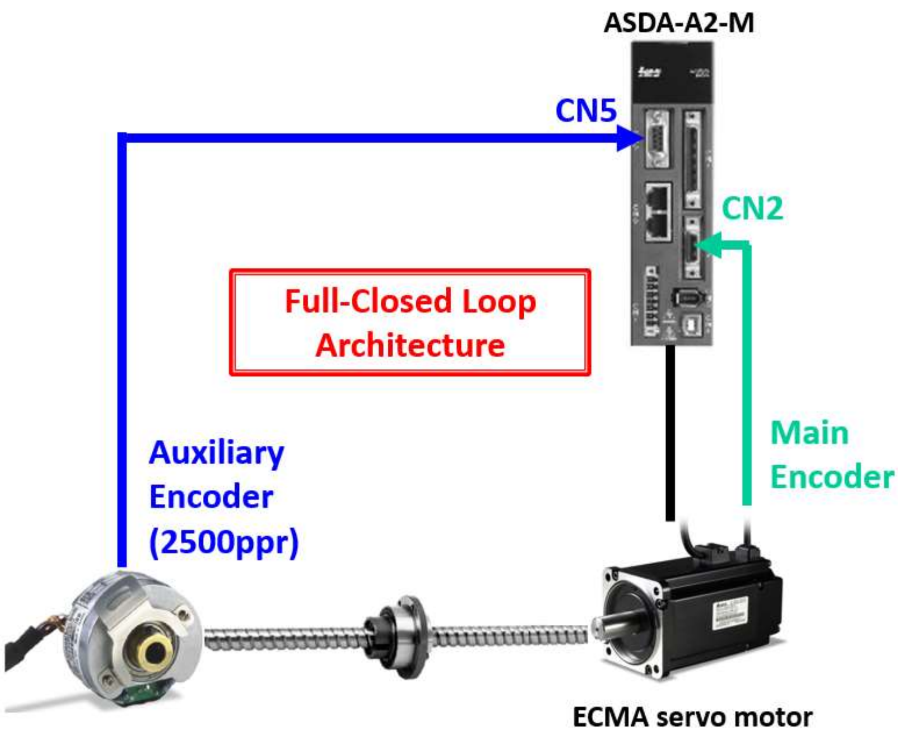



Fig.28 – Full-Closed Loop testing environment

## 3-2. Parameter Configuration

| Parameters | Value | Definition |
|---|---|---|
| P1-01 | 0x0001 | X → Set the operating mode as PR mode |
| P1-72 | 10000 | Resolution of a 2500ppr auxiliary encoder (after quadruple) |
| P1-44 | 128 | Numerator of the gear ratio (N) |
| P1-45 | 1 | Denominator of the gear ratio (M) |
| P1-73 | 100 | 100 pulses as the threshold of the position error between two encoders |
| P1-74 | 0x0101 | • X → Activate the full-closed loop function<br>• Z → Change the direction of the auxiliary encoder feedback* |

**NOTE** As stated in *2-2-3*, it's not mandatory to set P1-74.Z=1 but depending on the actual scenario.

## 3-3. Monitoring Variables & Parameters

In order to verify if the full-closed loop system is working properly, users can monitor the variables or the parameters listed below in Table 3 with ASDA-Soft to verify the system.

| Name of variables | PUU | | Pulse | |
|---|---|---|---|---|
| | Variables | Parameters | Variables | Parameters |
| Main encoder feedback position (**CN2**) | 000 (00h) | P5-16 | 003 (03h) | P5-18 |
| Auxiliary encoder feedback position (**CN5**) | 029 (1Dh) | NA | 048 (30h) | P5-17 |
| Position error between the main & auxiliary encoder (**CN2 & CN5**) | 031 (1Fh) | NA | NA | NA |
| Auxiliary encoder position error (**CN5**) | 030 (1Eh) | NA | NA | NA |
| Deviation between the Z-phase and the position of the auxiliary encoder (**CN5**) | 116 (74h) | NA | NA | NA |

Table 3 – Monitoring variables and parameters for the full-closed loop

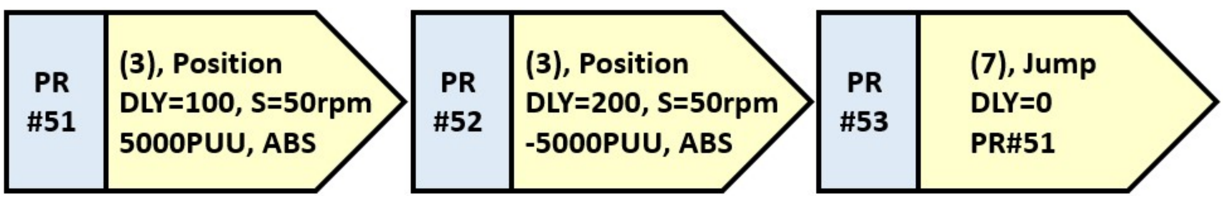
## 3-4. Testing Procedure Setup

The test is conducted step by step to verify the points below.

**(1) The configuration of the full-closed loop is proper and correct**

**(2) Making sure P1-73 can properly trigger AL040 to prevent mechanical failure**

1. Three PR commands are programmed as below in Fig.29 to move the motor back and forth repeatedly in order to check if the feedback of the auxiliary encoder is following the main encoder or not.




| PR# | Command | Delay (ms) | Speed (rpm) | Position (PUU) |
|---|---|---|---|---|
| 51 | Auto position control then goes to next PR# | 100 | 50 | 5000 |
| 52 | Auto position control then goes to next PR# | 200 | 50 | -5000 |
| 53 | Jump to assigned PR# | 0 | NA | NA |

Fig.29 – PR commands definition

2. In order to verify if AL040 will be triggered when the position error exceeds P1-73, ***DO:0x07 Servo warning*** is used to indicate the timing when it's triggered. DO settings in this example is shown in Fig.30.

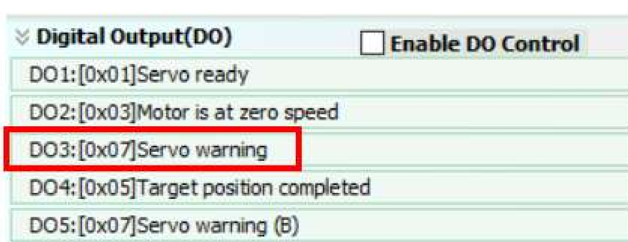
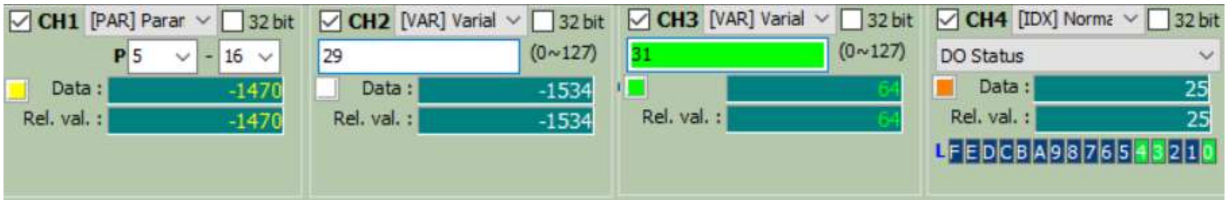



Fig.30 – DO settings

3. Set the data on each channel of the scope of ASDA-Soft as shown in Fig.31 for monitoring.




| Channel | Sampling Range | Data | Definition |
|---|---|---|---|
| CH1 | 16-bit* | [PAR]Parameters: **P5-16** | Main encoder feedback position (PUU) |
| CH2 | 16-bit* | [VAR]Variables: **29** | Auxiliary encoder feedback position (PUU) |
| CH3 | 16-bit | [VAR]Variables: **31** | Position error between the main encoder and the auxiliary encoder = CH1-CH2 (PUU) |
| CH4 | 16-bit | [IDX]Normal: **DO Status** | DO Status |

Fig.31 – Scope channel configuration

4. Trigger PR#51 to start the cyclic movement and record the waveform. The result is shown in Fig.32 while the section of each PR# is remarked in red and yellow.

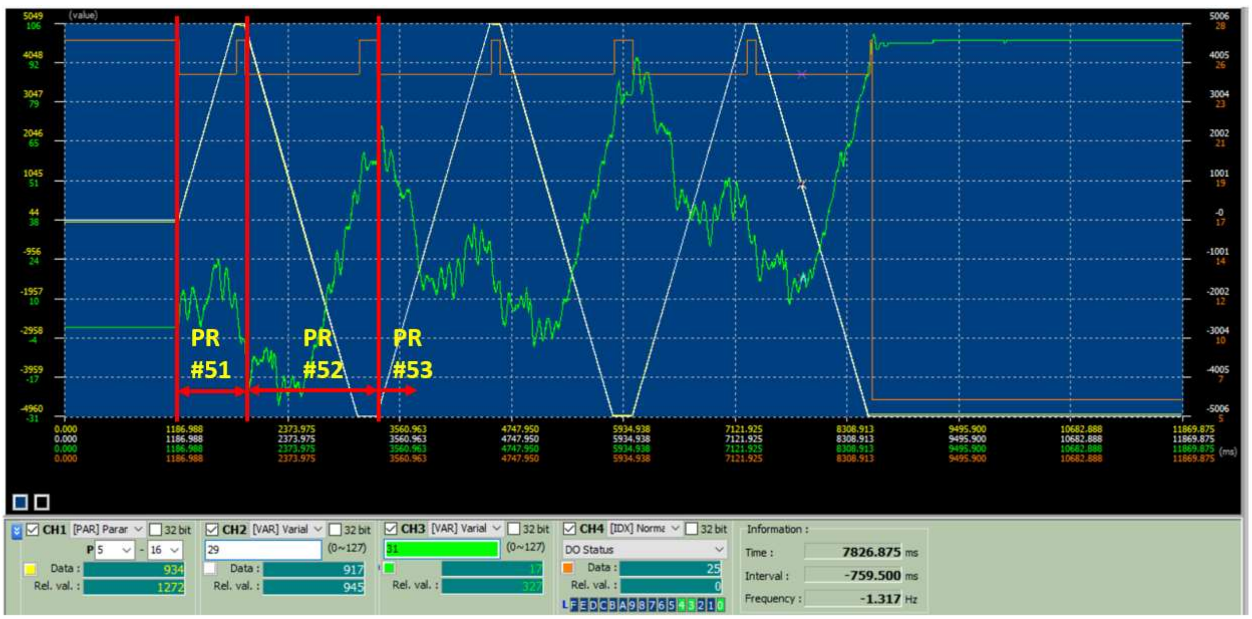



Fig.32 – Monitored scope data

**NOTE** Generally it is recommended to use 32-bit to monitor the position command, however due to the limitation of the channel numbers, the test is conducted with the command which can be fully shown in 16-bit to ensure the data correctness.

## 3-5. Scope Data Analysis

By analysing the scope data, each point could be verified as below.

**(1) The configuration of the full-closed loop is proper and correct**

If the configuration is proper, the feedback position of the auxiliary encoder will be the same as or proportional to the main encoder, depending on either the E-gear ratio or is there any gearbox. In this example, since there's no gearboxes and the E-gear ratio is set to map 1 rev of the auxiliary encoder to 1rev of the main encoder, therefore the feedback of both encoders will almost the same just with very little deviation, which is shown in Fig.33, so it can be confirmed that the configuration is appropriate.

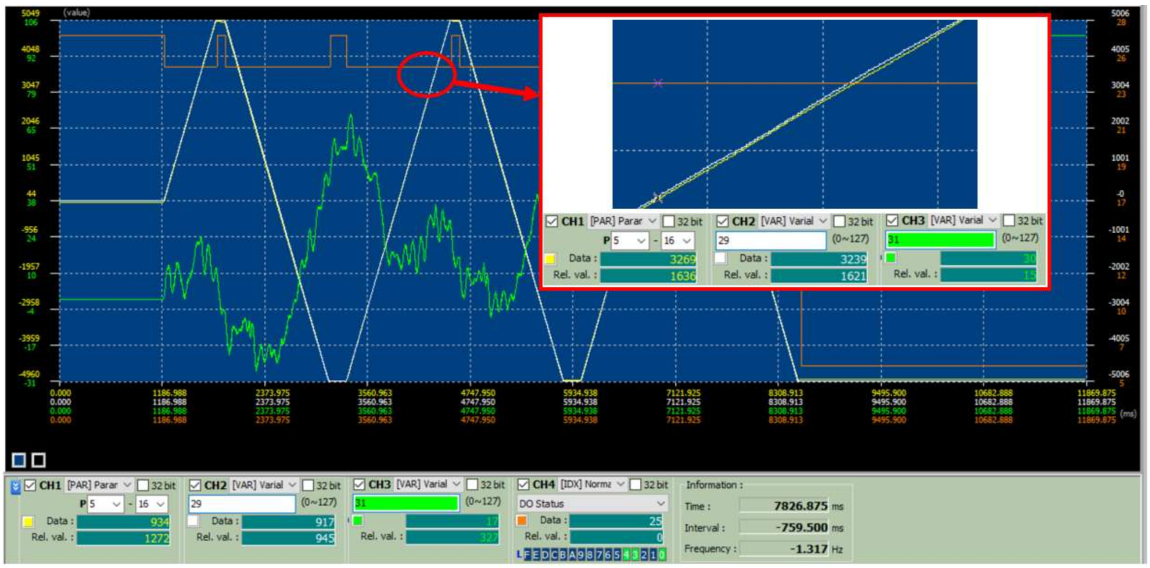


Fig.33 – Zoomed-in view of the scope data

**(2) Making sure P1-73 can properly trigger AL040 to prevent mechanical failure**

As stated in *2-2-6*, if P1-72, P1-44 and P1-45 are configured properly, the value of P1-73 could be directly referred to the PUU unit without additional conversion. In other words, AL040 will be triggered when *[VAR]Variables:31* in CH3 reaches the value of P1-73. During the test, when the position error reaches 100, which is P1-73 in this example, AL040 is triggered and DO3 outputs the signal for indication as shown in Fig.34 and Fig.35, therefore the motor stops immediately. With this verification, it can be confirmed that P1-73 is valid and functions normally.

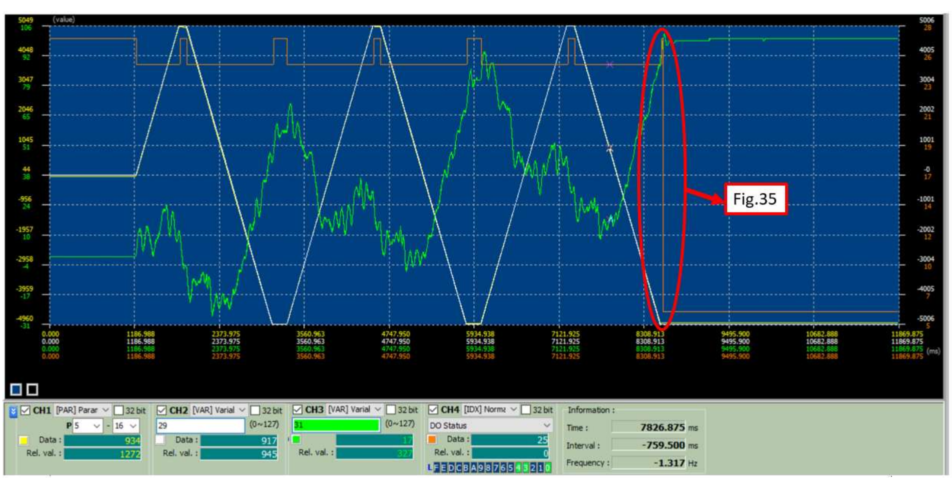



Fig.34 – The timing when AL040 is triggered

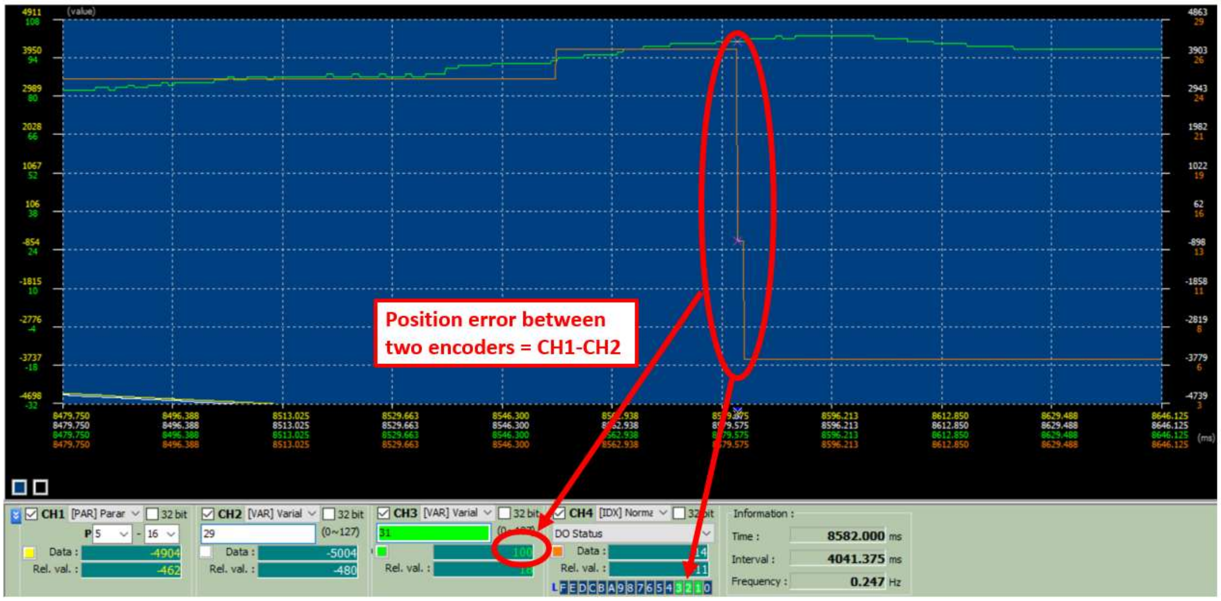



Fig.35 – Zoomed-in view of the timing when AL040 is triggered