Application Note

Full-Closed Loop Implementation

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History

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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 Figure 1.1, 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.

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.
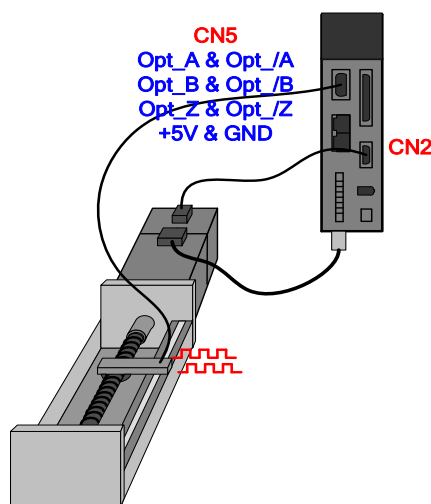
Figure 1.1   Full-closed loop system

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 2.1.1.

Table 2.1.1   Modes of the full-closed loop

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

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. Below Figure 2.1.1 and 2.1.2 is the illustration of the operating principle of each mode.

PT Full-Closed Loop

Figure 2.1.1   PT full-closed loop operating principle

PR Full-Closed Loop

Figure 2.1.2   PR full-closed loop operating principle

2.2   Related Parameter Overview
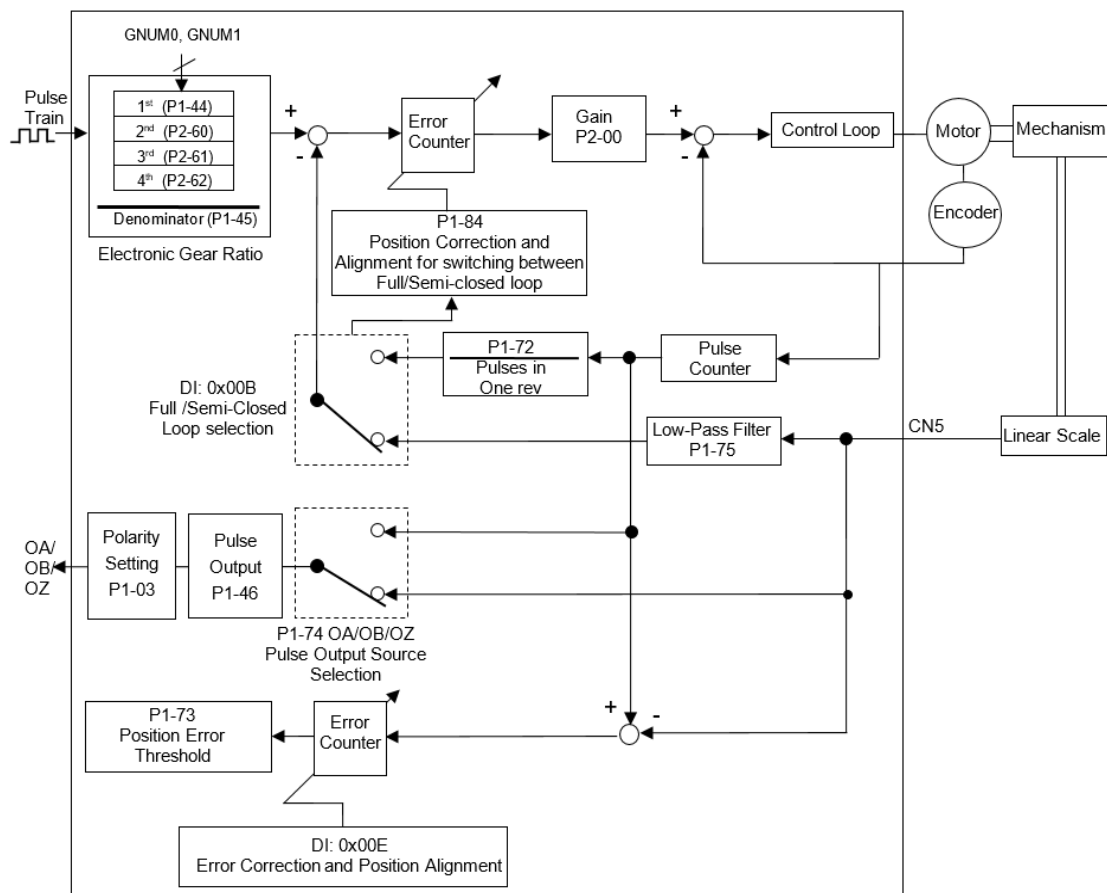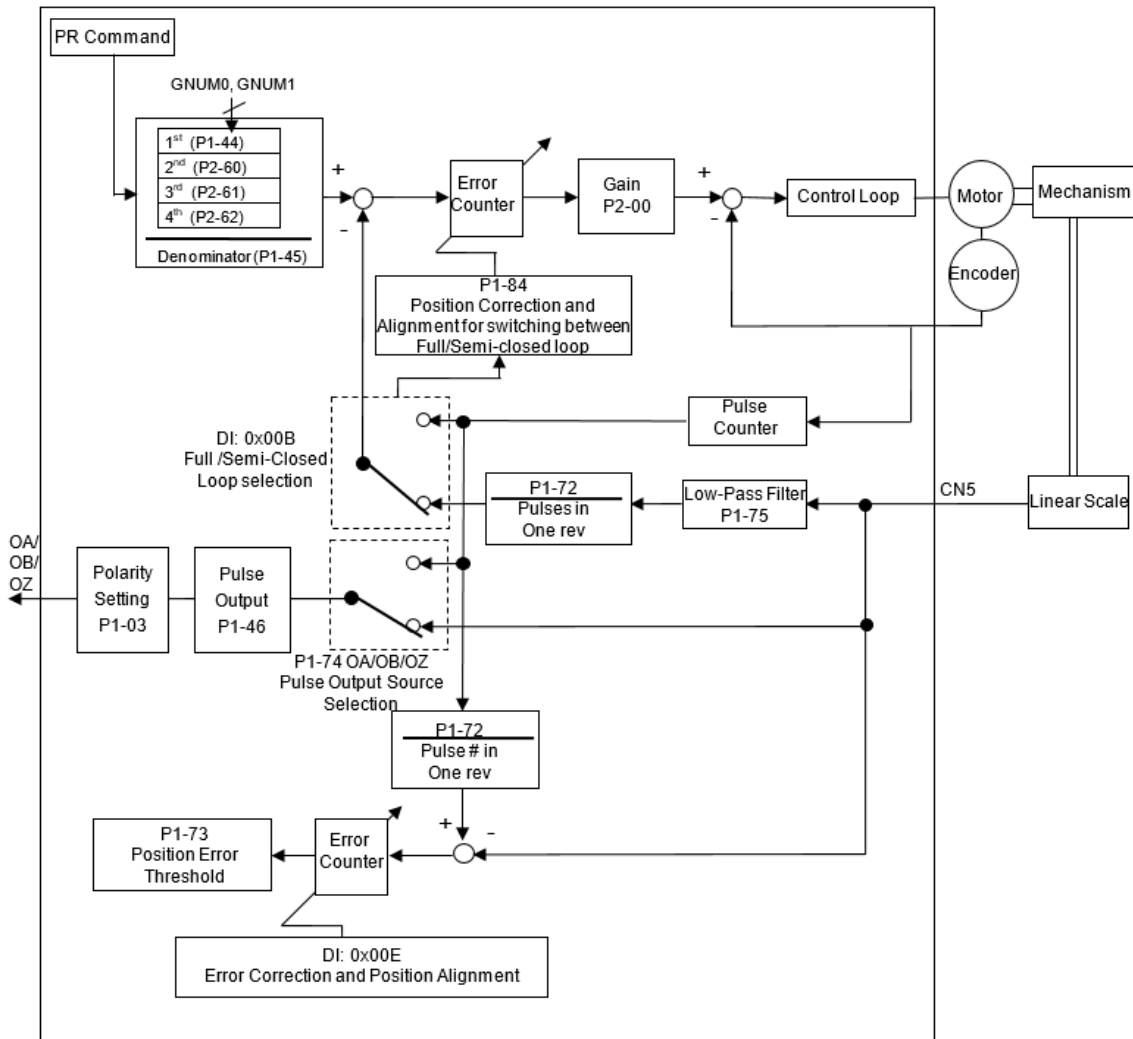
Table 2.2.1 lists the setup procedure and the relevant parameters for implementing PT & PR full-closed loop. <u>Parameters highlighted in **bold font** means *mandatory for the setup* while the rest is *optional depending on the user-requirements*</u>. Each parameter is explained individually in the following sections. To prevent damaging the mechanism, please make sure the configuration is done properly before activating the system.

Table 2.2.1   Full-closed loop setup procedure

Step	Parameters	Actions	PT	PR	Remark
1	---	Conduct the wiring	X	X	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	X	X	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	X	X	
4	**P1-44, P1-45** (Optional: P3-13)	Set the electronic gear ratio	X	X	The principle of setting up PT & PR mode is different
5	**P1-73**	Set the position error protection range	X	X	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	X	X	
7	a. DI: 0x0B b. DI: 0x0E	Assign DI (1)Full/semi-closed loop (2)Position error reset	X	X	
8	P1-84	Set the position error handling function of full/semi-closed loops	X	-	The default on PR mode is that the position error will be reset.
9	P1-85	Set the automatic position error reset function	X	X	Special firmware for PR mode is required to have this function
10	P1-86	Set the executed PR# between switching full/semi-closed loops	-	X	
11	P2-80	Set the source of Z-pulse for homing	X	-	
12	P2-66	Set the assisting register	X	X	
13	P1-46, P1-03	Set the output pulse number of the linear scale	X	X	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	X	X	

2.3 Step 1: Physical Wiring

CN5 on the servo drive as shown in Figure 2.3.1 is used for the connection between the linear scale and the servo drive. The pin description is shown in Table 2.3.1.
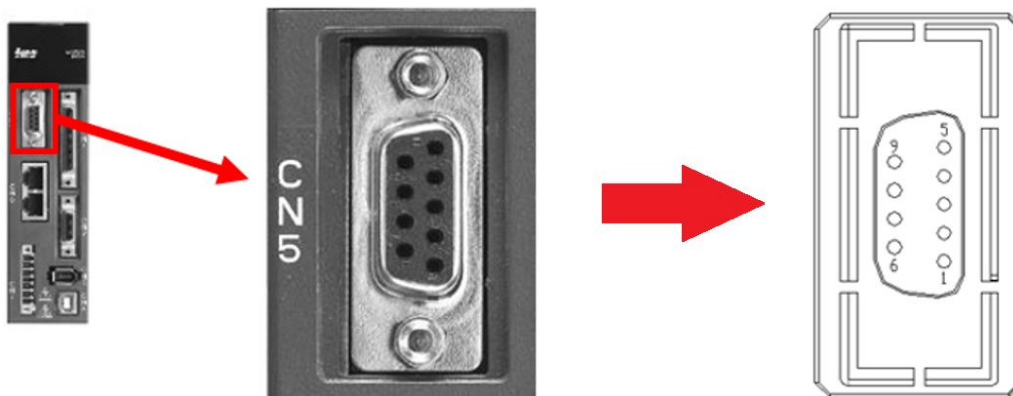

Figure 2.3.1   CN5 on ASD servo drives

Table 2.3.1   CN5 pin definition

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

Note:

1. The highest communication rate is 4 Mpps 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).

2.4   Step 2: P1-74.Z – Pulse Trend of the Linear Scale

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

Settings:

U Z Y X

X	Full-closed loop control switch	Z	Positive / negative direction selection of linear scale feedback
Y	Selection of OA / OB / OZ output source	U	Linear scale filter function

■   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

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. As shown in Figure 2.4.1, open ASDA-Soft and click the **Status Monitor** icon → Click on the **Select Monitor Items** tab → Set **Mapping Parameters Setting** as highlighted to monitor the

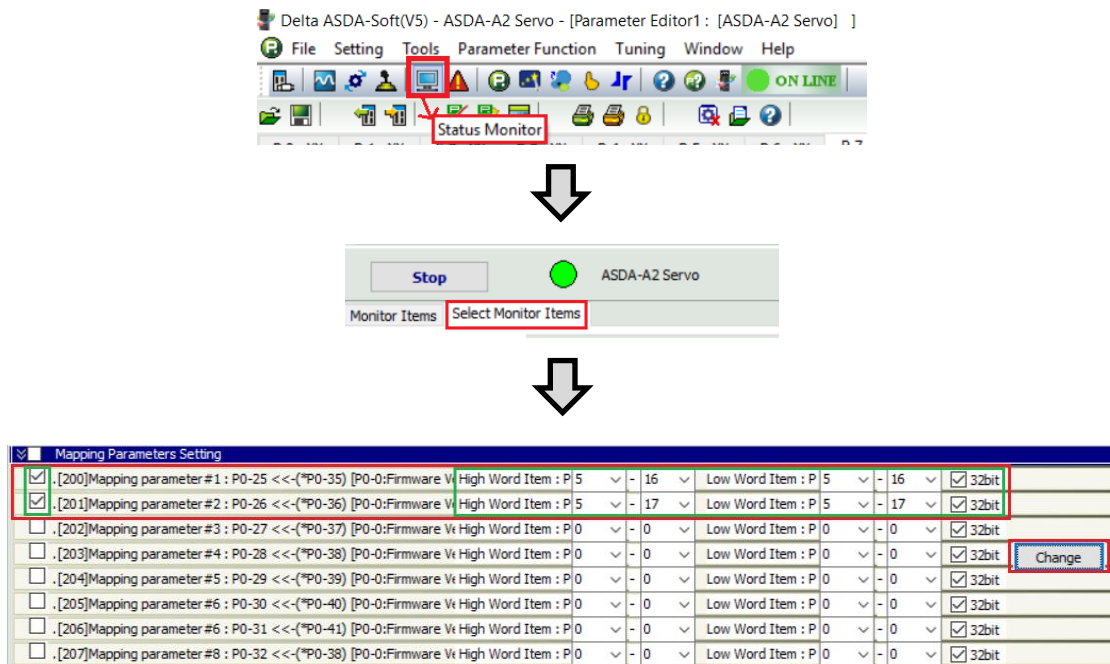feedback of the main encoder and the linear scale, then click *Change*.

Figure 2.4.1   Mapping parameters configuration

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 either one scope file in Figure 2.4.2 or Figure 2.4.3, it means the pulse trend of both encoders is the same and correct, whether being positive or negative trend, then there's no need to adjust P1-74.Z.
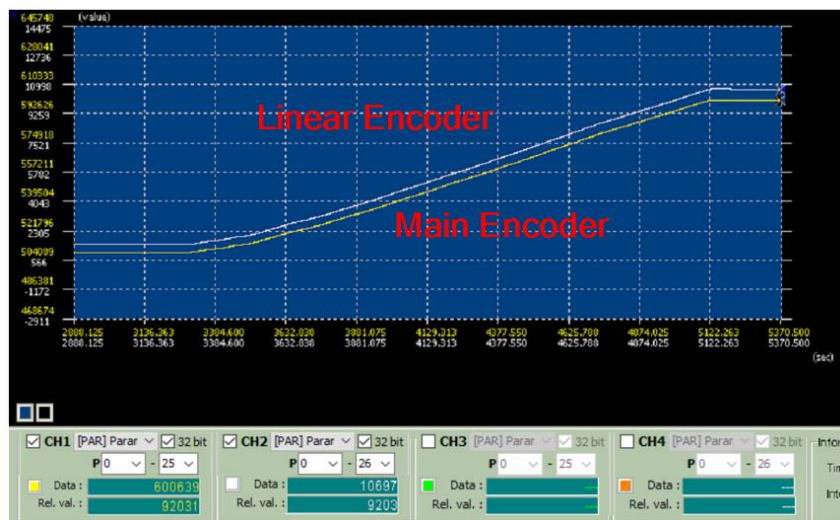
Figure 2.4.2   Same pulse trend for main and linear encoders in forward direction
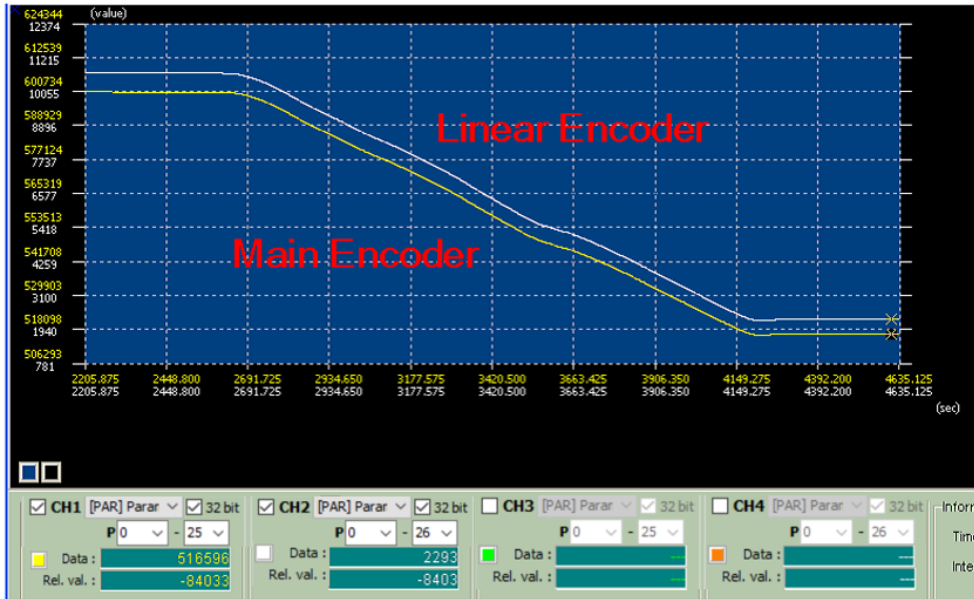
Figure 2.4.3   Same pulse trend for main and linear encoders in reverse direction

However, if the waveform is like Figure 2.4.4, it means the pulse trend is different and it should be fixed, users will have to set P1-74.Z=1 to reverse the direction of the feedback of the linear scale.
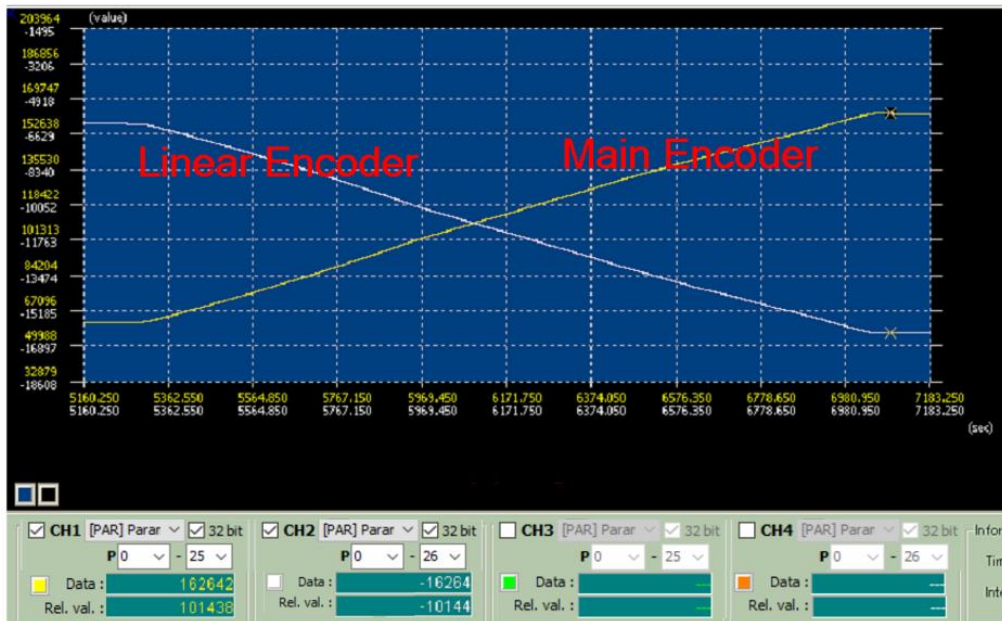

Figure 2.4.4   Different pulse trend for main and linear encoders

2.5 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)

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.

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 Figure 2.5.1. In this case, the pitch of the ball screw is 5mm, and the resolution of the linear scale is 0.5um/pulse, therefore P1-72 = 5mm / 0.5um = 10000.

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

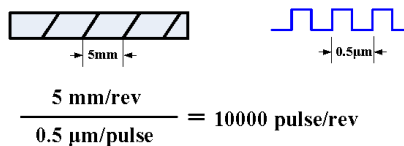Figure 2.5.1   P1-72 calculation from the specification

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** as explained below.

■ **PT mode**

Figure 2.5.2   P1-72 calculation with the scope on 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 Figure 2.5.2 shows, when the motor moves 2528000 PUU, the linear scale returns 19750 pulses. Therefore, with the formula shown in Figure.12, we can get P1-72 = 10000.
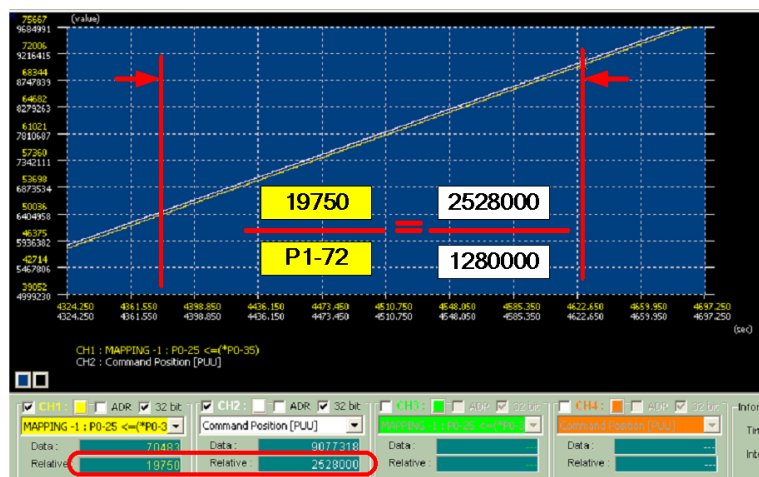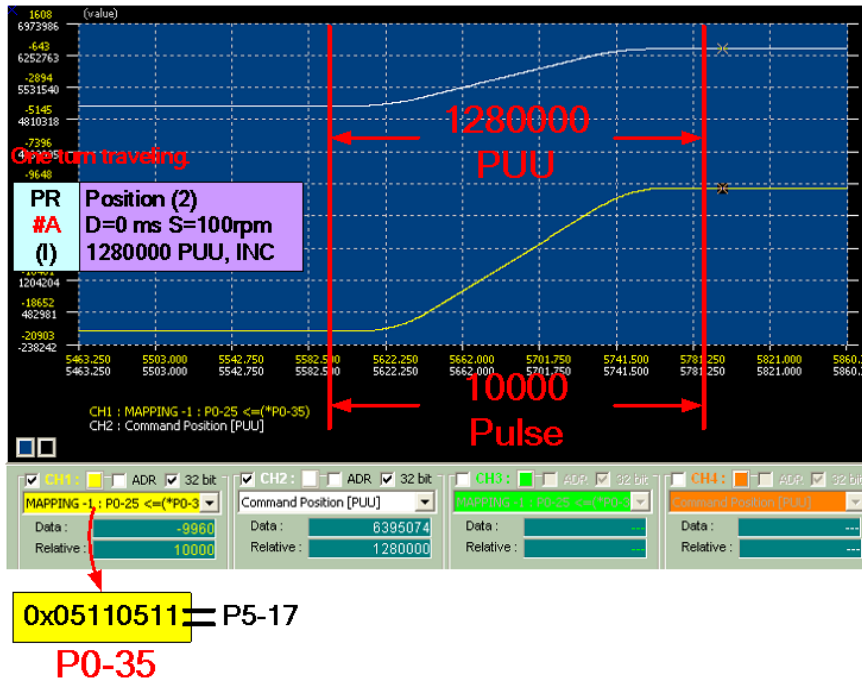
■ **PR mode**

Figure 2.5.3   P1-72 calculation with the scope on 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 Figure 2.5.3. As the scope indicates, when the motor runs a cycle (1280000 PUU), the linear scale returns 10000 pulses, so P1-72 = 10000.

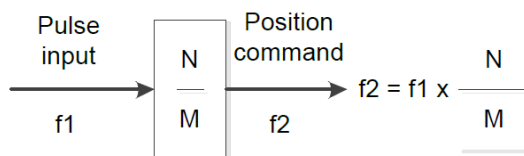## 2.6 Step 4: P1-44, P1-45 – Electronic Gear Ratio

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:

As the formula below, the recommended range of the gear ratio is **1/50 < N/M < 25600**.

f1: Pulse Command, f2: Position Command [unit: linear scale pulse (after quadruple)]

The electronic gear ratio is composed of P1-44 & P1-45. If the setting is inappropriate, there will be potential risk that the motor might have unexpected positioning. How to define an appropriate value 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.

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. 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.

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 Figure 2.6.3, 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 the required pulses for 1 motor rev = P1-72[1].
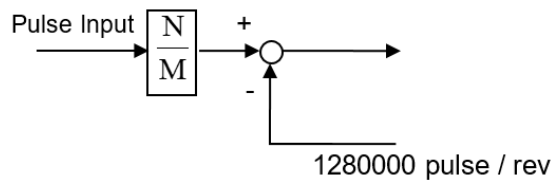
Figure 2.6.3　Command scaling mechanism of PR mode

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 x 10000 = 500).

On the other hand, if the user wants to scale up the resolution in this example 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:

1. 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. Below 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:

U Z Y X

■ X: monitoring variable [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

2.7   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

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 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.

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.

2.8   Step 6: P1-75 – Low-Pass Filter Time Constant

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

If the stiffness of the mechanical system is not enough, applying the time constant P1-75 can enhance the stability of the system by having the semi-closed loop control in the transient-state while having the full-closed loop control 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.

2.9 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.

DI: 0x0B

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

Note:

1. 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 PR mode: No need to set P1-77
A2-E	No need to set P1-77
A2-F	No need to set P1-77

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 Full-closed loop

2.10 Step 8: P1-84 - Position Error Handling Function

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

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 to define how the position error should be processed.

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.
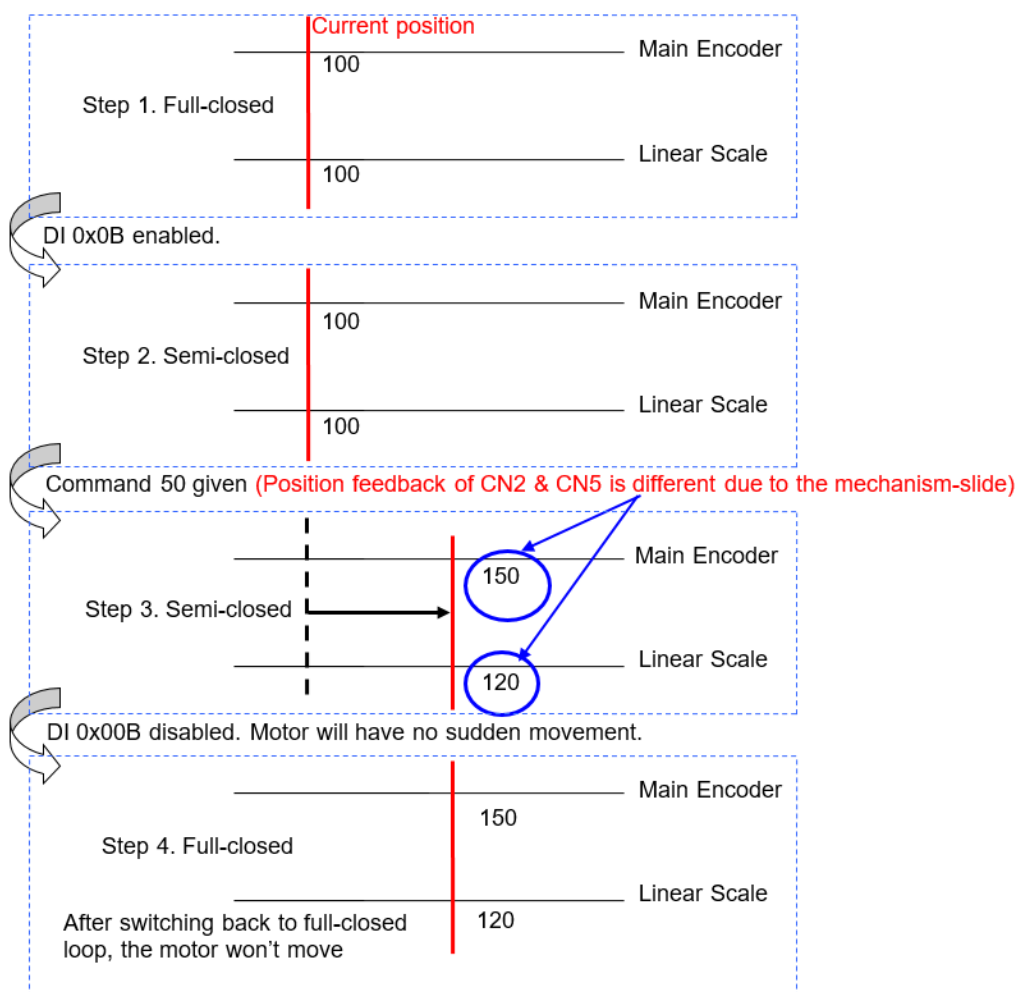
P1-84=1

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.
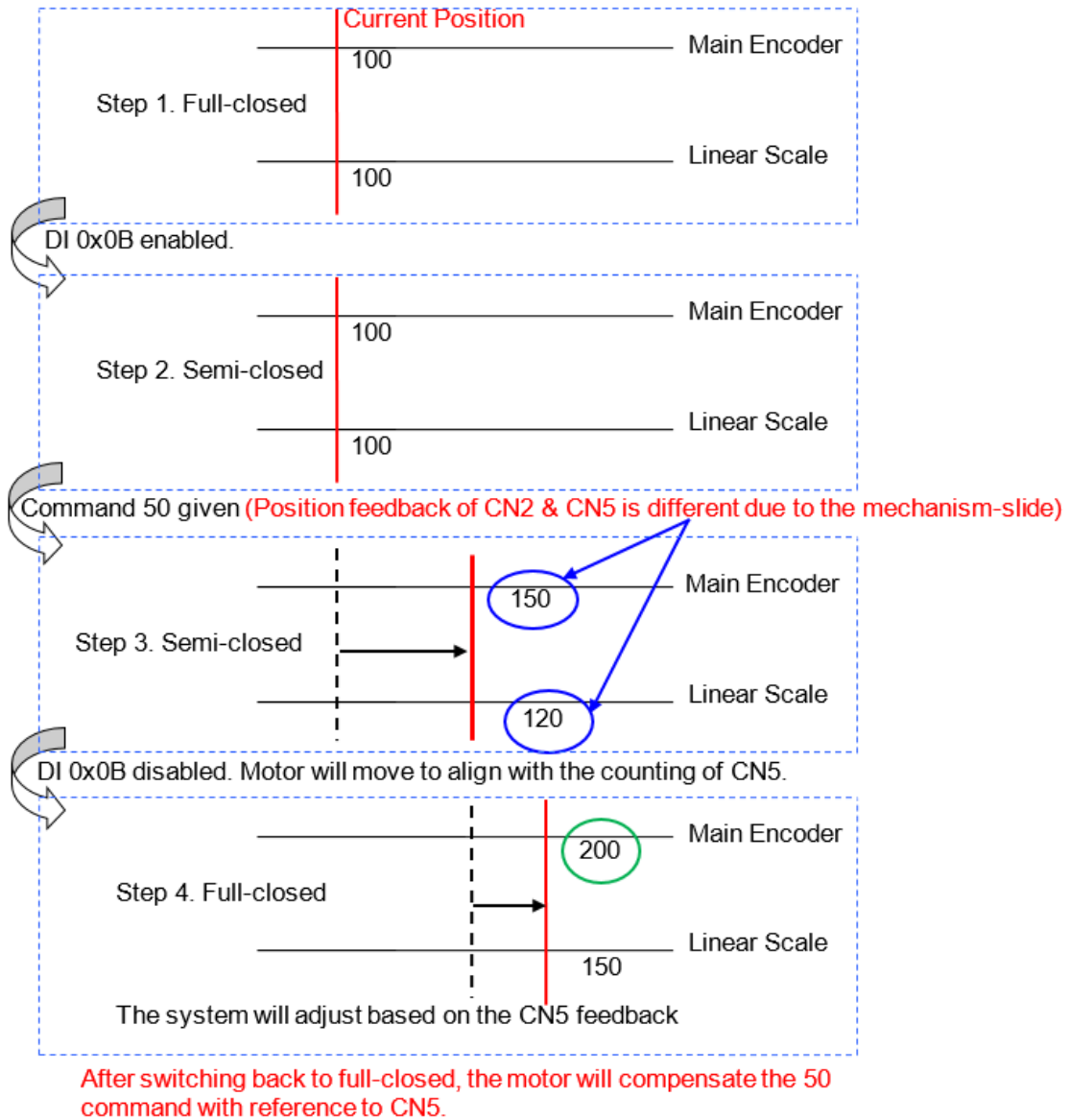
2.11 Step 9: P1-85 – Automatic Position Error Reset Function

P1-85	Automatically clear the error between the linear scale and the main encoder[1]		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
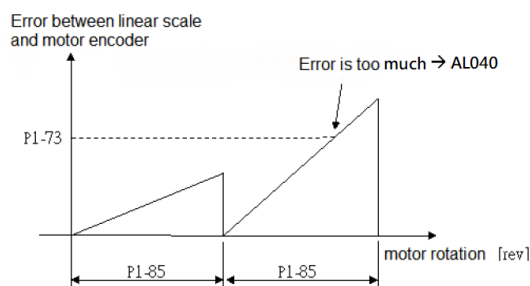
If there's mechanical-slide in the application such as the steel-plate cutting and wire feeding system which uses the friction for actuating, inevitably the position deviation between the main encoder and the linear scale will accumulate and eventually triggers AL040. In that case, users can set P1-85 to automatically clear the position deviation within the tolerance.
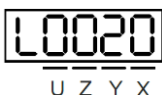
Note:

1. Resetting the position deviation will not affect the accuracy of the positioning

2.12 Step 10: P1-86 – Executed PR# for Switching between Loops

P1-86	Executed PR# between switching semi / full-closed loop[1]		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
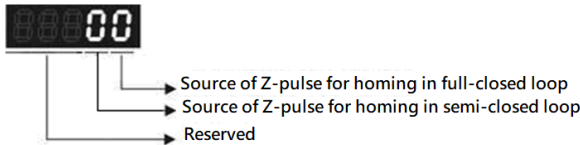
No PR# will be executed when the value is 00

Note:

1. Using PR#0 to conduct homing is not supported with this parameter

2.13 Step 11: P2-80 – Source of Z-pulse of 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

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.

2.14 Step 12: P2-66 – Assisting Register

P2-66	Assisting Register		Address: 0284H, 0285H
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 will not 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.

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 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:

1. The default value is 0 for P2-66.bit5 but it's recommended to enable this function before enabling the full-closed loop.

2.15 Step 13: P1-46, P1-03 – Output Pulse Number of the Linear Scale

P1-46

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:

1. 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 thus causes abnormal signal output.	Check the fault records (P4-00 ~ P4-05). See if the encoder error occurs (AL011, AL024, AL025, and AL026).	Conduct the corrective actions of AL011, AL024, AL025, and AL026.
The output pulse exceeds the hardware allowable range.	Check if the following conditions produce: P1-76 < Motor Speed or $\dfrac{Motor\ Speed}{60} \times P1-46 \times 4 > 19.8 \times 10^6$	Correctly set parameter P1-76 and P1-46: P1-76 > Motor Speed or $\dfrac{Motor\ Speed}{60} \times P1-46 \times 4 < 19.8 \times 10^6$

P1-03

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:

```
0 0 0 2
U Z Y X
```

X	Polarity of monitor analog output	Y	Polarity of encoder pulse output	UZ	Reserved

- ■ X: polarity of monitor analog output

    0: MON1(+), MON2(+)

    1: MON1(+), MON2(-)

    2: MON1(-), MON2(+)

    3: MON1(-), MON2(-)

- ■ Y: polarity of encoder pulse output

    0: pulse output in forward direction

    1: pulse output in reverse direction

- ■ UZ: reserved

Users can configure P1-46 & P1-03 if the application requires to have the linear scale feedback be output from the servo drive. 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.

2.16 Step 14: P1-74.X – Full-Closed Loop Activation

After finishing the configuration of the parameters in the previous sections, set P1-74.X=1 to activate the full-closed loop function. Besides P1-74.X, users can configure other bits of P1-74 stated in **2.4** depending on the requirement of the actual application.

3 Full-Closed Loop 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 Architecture

Figure 3.1.1 is the illustration of the system structure of this example. The system is composed of 1 pc ASDA-A2-M, 1 pc ECMA servo motor, 1 pc auxiliary encoder with 2500 ppr resolution to represent the linear scale and a ball-screw connecting the ECMA servo motor with 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.
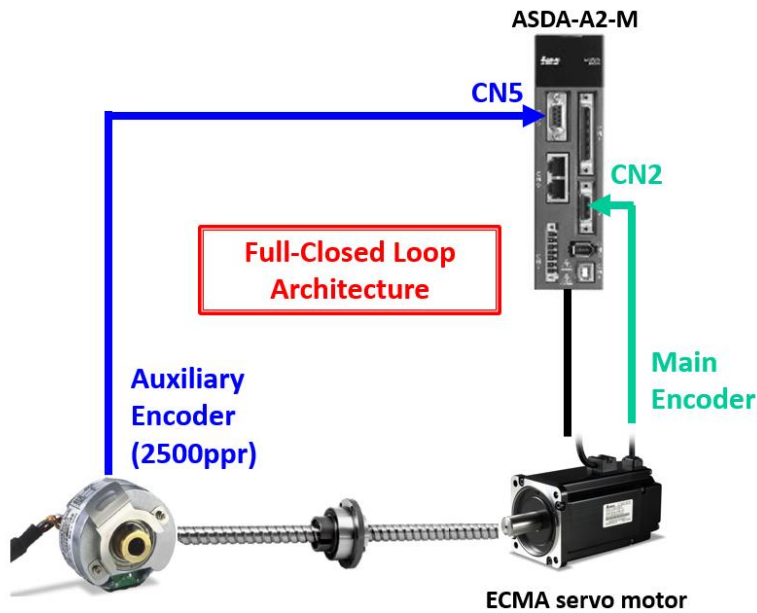

Figure 3.1.1 – Full-Closed Loop system architecture

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 • Z → Change the direction of the auxiliary encoder feedback*[1]

Note:

1. 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 3.3.1 with ASDA-Soft to verify the system.

Table 3.3.1 – Monitoring variables and parameters for the full-closed loop

Name of variables	Unit			
	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

3.4   Testing Procedure

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

■ The configuration of the full-closed loop is proper and correct

■ Making sure P1-73 can properly trigger AL040 to prevent mechanical failure

1. Three PR commands which stated in Figure 3.4.1 and explained in Table 3.4.1 are designed 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.
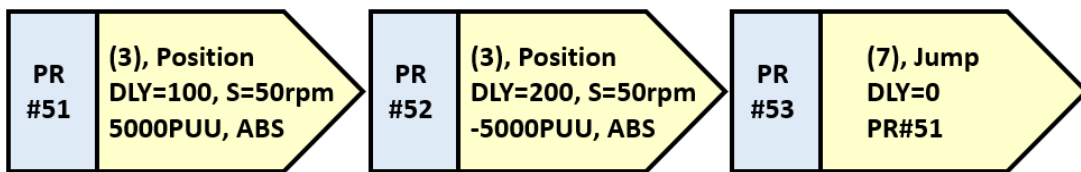
| PR #51 | (3), Position DLY=100, S=50rpm 5000PUU, ABS | PR #52 | (3), Position DLY=200, S=50rpm -5000PUU, ABS | PR #53 | (7), Jump DLY=0 PR#51 |

Figure 3.4.1   PR commands procedure

Table 3.4.1 PR commands definition

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

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 Figure 3.4.2.
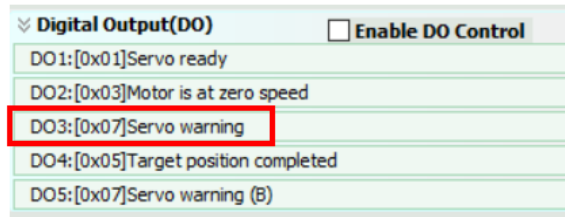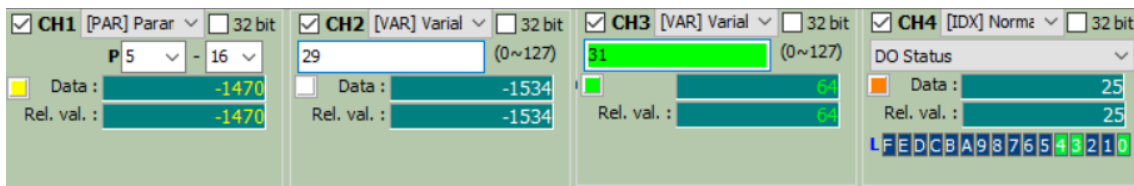

Figure 3.4.2 DO settings

3. Set each channel of the scope of ASDA-Soft as shown below.

Channel	Sampling Range	Data	Definition
CH1	16-bit*1	[PAR]Parameters: **P5-16**	Main encoder feedback position (PUU)
CH2	16-bit*1	[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

Trigger PR#51 to start the cyclic movement and record the waveform. The result is shown in Figure 3.4.3 and the result of each PR# is remarked in red and yellow.

Figure 3.4.3 Monitored scope data

Note:

1. 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 analyzing the scope data, each point could be verified as below.

■   **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 Figure 3.5.1, so it can be confirmed that the configuration is appropriate.
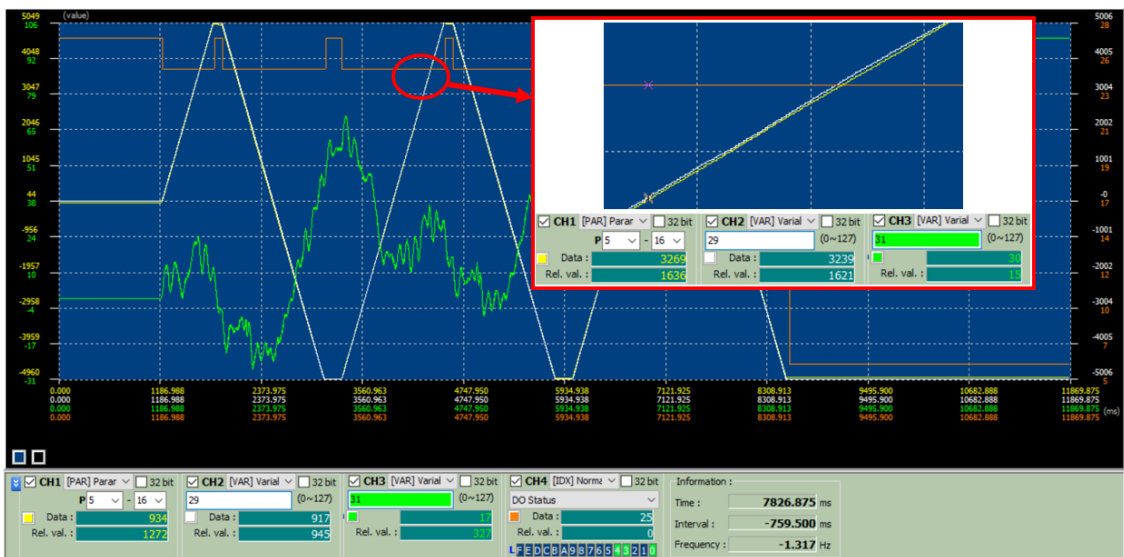

Figure 3.5.1   Zoomed-in view of the scope data

■   **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 Figure 3.5.2 and Figure 3.5.3, therefore the motor stops immediately. With this verification, it can be confirmed that P1-73 is valid and functions normally.
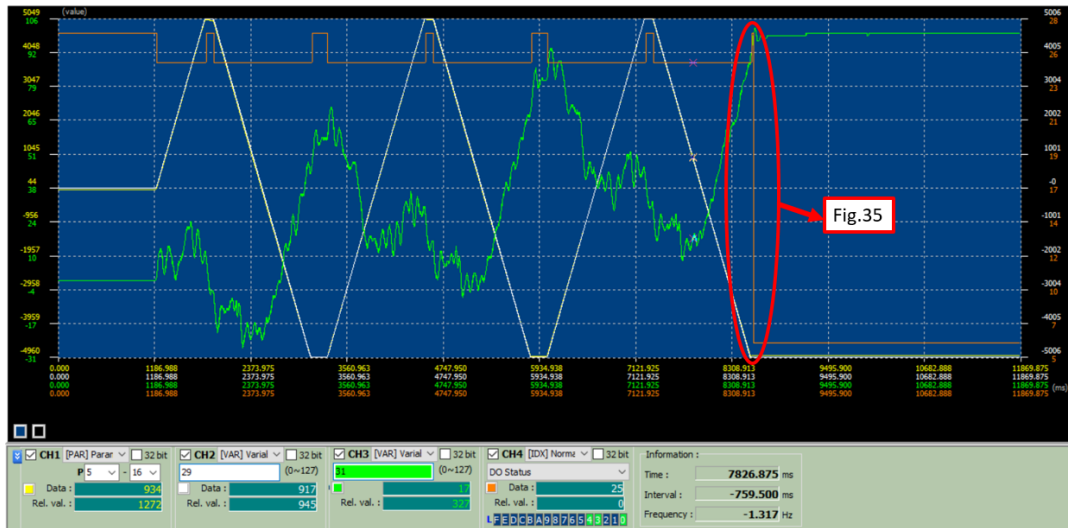
Figure 3.5.2 The timing when AL040 is triggered

Figure 3.5.3 Zoomed-in view of the timing when AL040 is triggered