Motion Control 7

This chapter introduces internal motion commands of the servo drive in PR mode. In this mode, commands are generated based on the internal command of the servo drive. Various motion commands are available, including Homing, Speed, Position, Jump, Write, and high-speed position capture (Capture). This chapter contains detailed description of each command type.

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7.1 PR mode description

In PR mode, the servo drive automatically generates the motion commands and saves all parameter settings in the servo drive parameter file. Thus changing parameter values simultaneously changes the PR commands. The servo drive provides 100 path setting sets, which include the homing method, Speed command, Position command, Jump command, Write command, and Rotary Axis Position command.

The property and corresponding data for each PR path are set by parameters. You can find information of all PR parameters in the descriptions of parameter groups 6 and 7 in Chapter 8. For example, PR#1 path is defined by two parameters, P6.002 and P6.003. P6.002 is for specifying the property of PR#1, such as the PR command type, whether to interrupt, and whether to auto-execute the next PR. P6.003 is subject to change based on the property set in P6.002. If P6.002 is set to a Speed command, then P6.003 specifies the target speed. When P6.002 is set to a Jump command, then P6.003 specifies the target PR. The parameters for the PR#2 path are P6.004 and P6.005, and they work the same way as P6.002 and P6.003. The same is true for the rest of PR paths. See Figure 7.1.1.

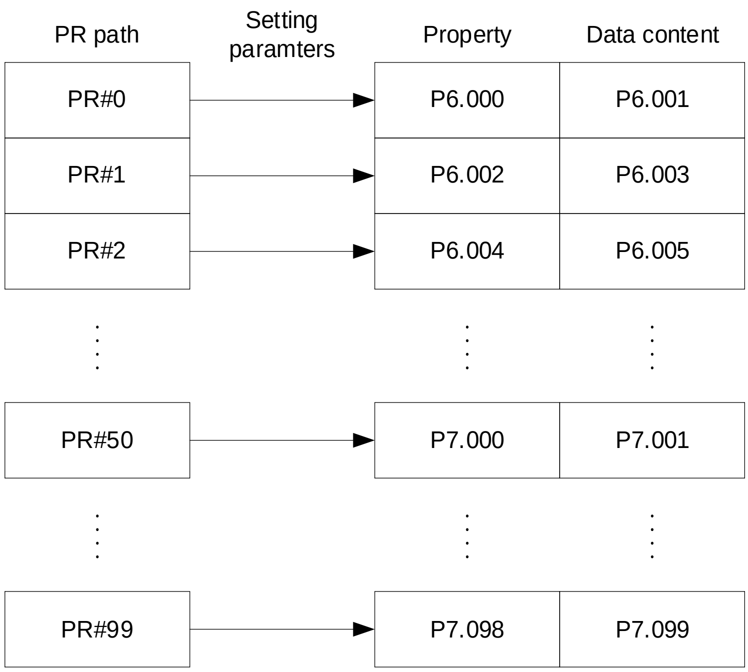

Figure 7.1.1 Setting parameters for each PR path

In the ASDA-Soft software, when you select the PR to be edited in PR mode, the corresponding parameters appear at the top of the window. See Figure 7.1.2. If you select PR#1, the settings of P6.002 and P6.003 appear at the top in the editing section. See P6.002 and P6.003 in Table 7.1.1 for example. The path property and data content differ in accordance with the motion command type. For more information about Motion Control mode, refer to Section 7.1.3.

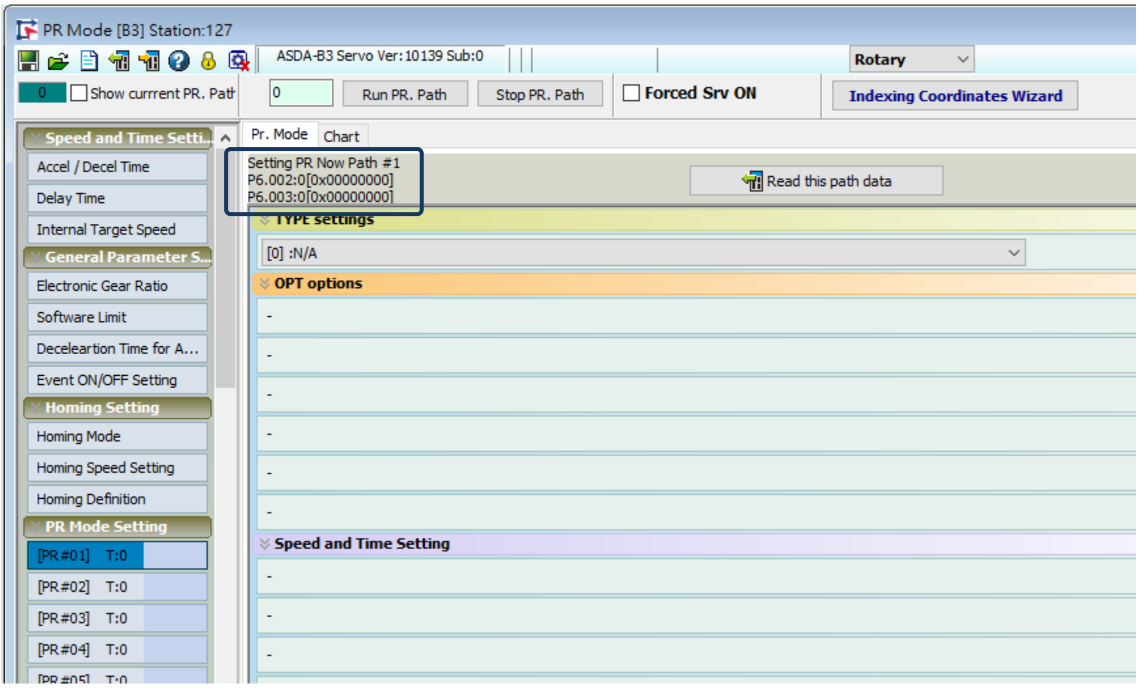

Figure 7.1.2 PR Mode interface in ASDA-Soft

Table 7.1.1 Example of PR#1 property and data content

Bit / PR#1	31 - 28	27 - 24	23 - 20	19 - 16	15 - 12	11 - 8	7 - 4	3 - 0
P6.002	-	AUTO	DLY	SPD	DEC	ACC	OPT	TYPE
P6.003	Data content (32-bit)							

Note:

TYPE: path type

Setting value of TYPE	Path type
1	SPEED, constant speed control
2	SINGLE, positioning control. The execution stops once the positioning is complete.
3	AUTO, positioning control. The next PR path is automatically loaded once the positioning is complete.
7	JUMP, jump to the specified path.
8	WRITE, write specified parameters to specified path.
A	INDEX, rotary axis position control (index position control)

ASDA-Soft version V6 provides a graphical interface for editing PR paths (see Figure 7.1.3). It is easier to set PR paths in ASDA-Soft, where you can set the options of command triggering, command types, and other properties.

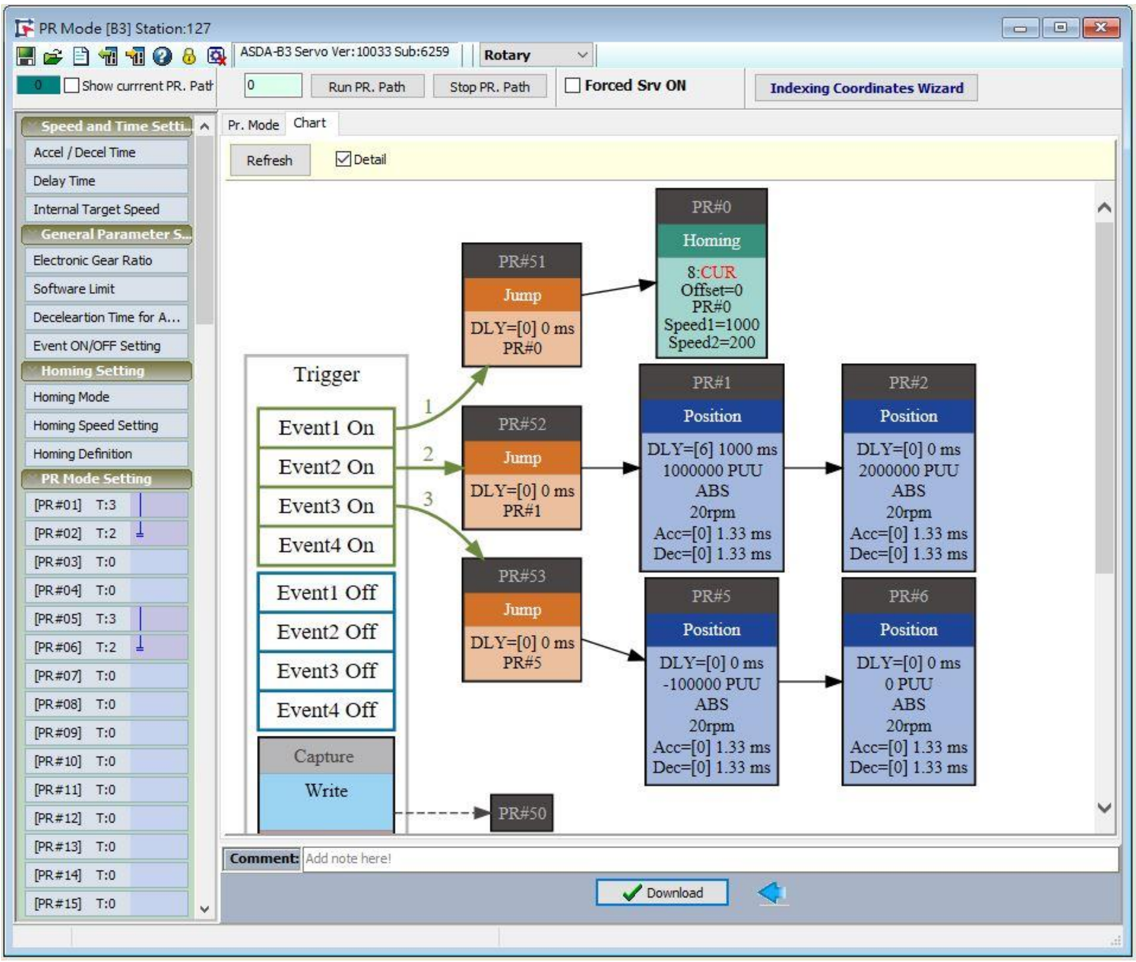

Figure 7.1.3 Graphical interface for PR paths in ASDA-Soft

7.1.1 Shared PR parameters

The servo drive provides 16 acceleration or deceleration time settings (P5.020 - P5.035), 16 delay time settings (P5.040 - P5.055), and 16 target speed settings (P5.060 - P5.075) for you to set the PR paths (as shown in Figure 7.1.1.1). If you change a parameter that is used by multiple PR paths, then all PR paths using this parameter are changed as well. For example, if multiple PR commands use the target speed setting from P5.060, when you change the value of P5.060, those PR commands' target speed settings are changed as well. Please be aware of this when setting PR paths so as to avoid any danger or damage to the machine.

ASDA-Soft also provides a user-friendly interface for setting the shared PR parameters (see Figure 7.1.1.2). Among the data, the acceleration or deceleration time is set based on the time duration required for the motor to accelerate from 0 to 3000 rpm or to decelerate from 3000 rpm to 0. For instance, if the acceleration time is set to 50 ms, when the target speed for the motion command is 3000 rpm, then the required duration is 50 ms. If the target speed for the motion command is 1500 rpm, then the acceleration time is 25 ms. Setting the acceleration or deceleration time is like setting a fixed slope for acceleration or deceleration, and the slope does not change when you change the target speed settings.

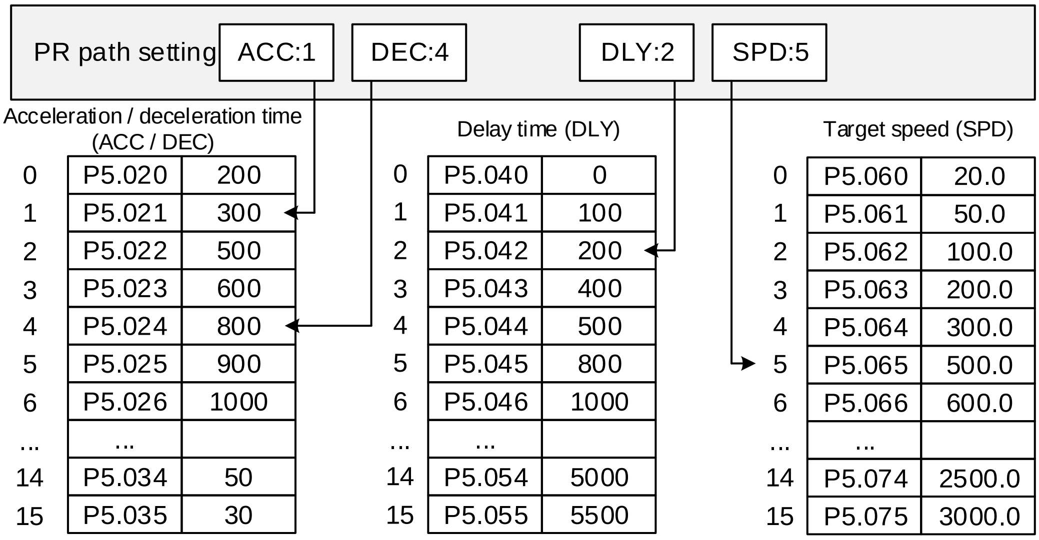

Figure 7.1.1.1 Shared parameter data for PR paths

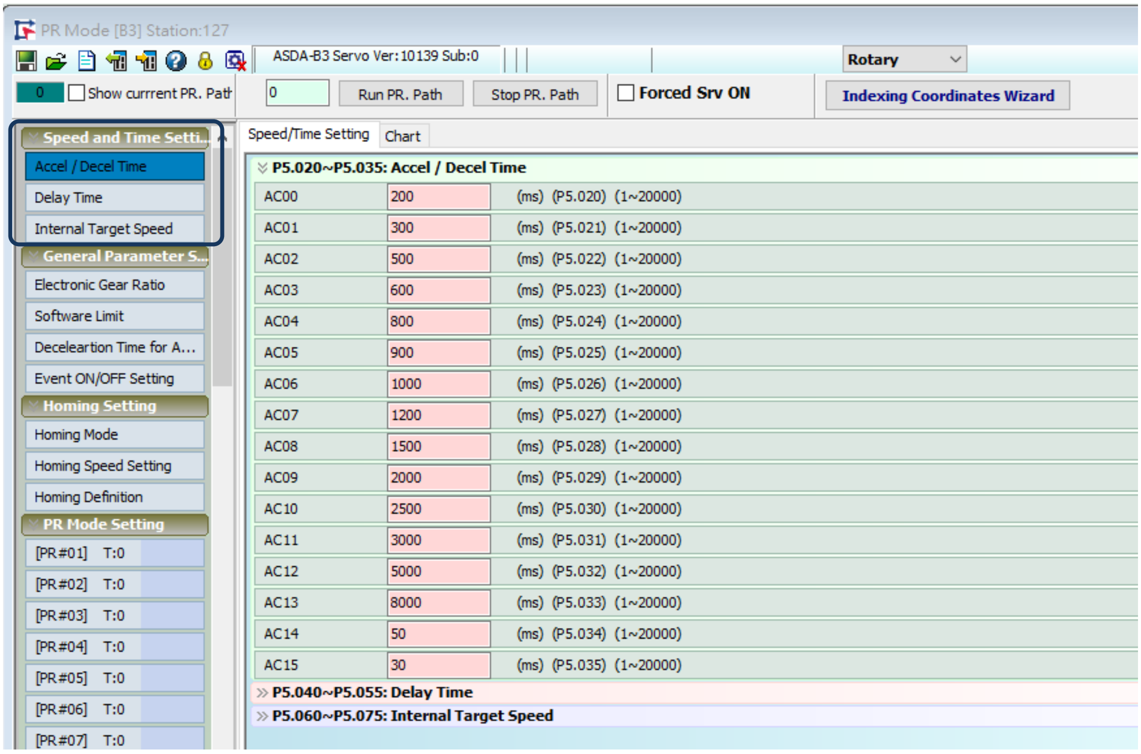

Figure 7.1.1.2 ASDA-Soft interface for shared PR parameter data

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7.1.2 Monitoring variables of PR mode

The PR mode provides four monitoring variables for the servo commands and feedback status: command position (PUU), PR command end register, feedback position (PUU), and position error (PUU). These are described as follows:

1. Command position (PUU): monitoring variable code 001, simplified as Cmd_O (Command Operation). The target position of the motion command generated per scan cycle during servo operation (updated every millisecond).
2. PR command end register: monitoring variable code 064, simplified as Cmd_E (Command End). The target position of the PR command. When a command is triggered, the servo drive calculates the target position and then updates to PR command end register.
3. Feedback position (PUU): monitoring variable code 000, simplified as Fb_PUU (Feedback PUU). The feedback position of the motor.
4. Position error (PUU): monitoring variable code 002, simplified as Err_PUU (Error PUU). The difference between the command position (PUU) and the feedback position (PUU).

How these four monitoring variables work is shown in Figure 7.1.2.1. After the servo issues a Position command, the servo sets the position of Cmd_E once the target position data is acquired. The motor operates to the target position based on the PR path setting. Cmd_O calculates the amount of command difference in each fixed cycle and sends it to the servo drive, where it is treated as a dynamic command. Fb_PUU is motor encoder feedback position and Err_PUU is the difference of subtracting Fb_PUU from Cmd_O.

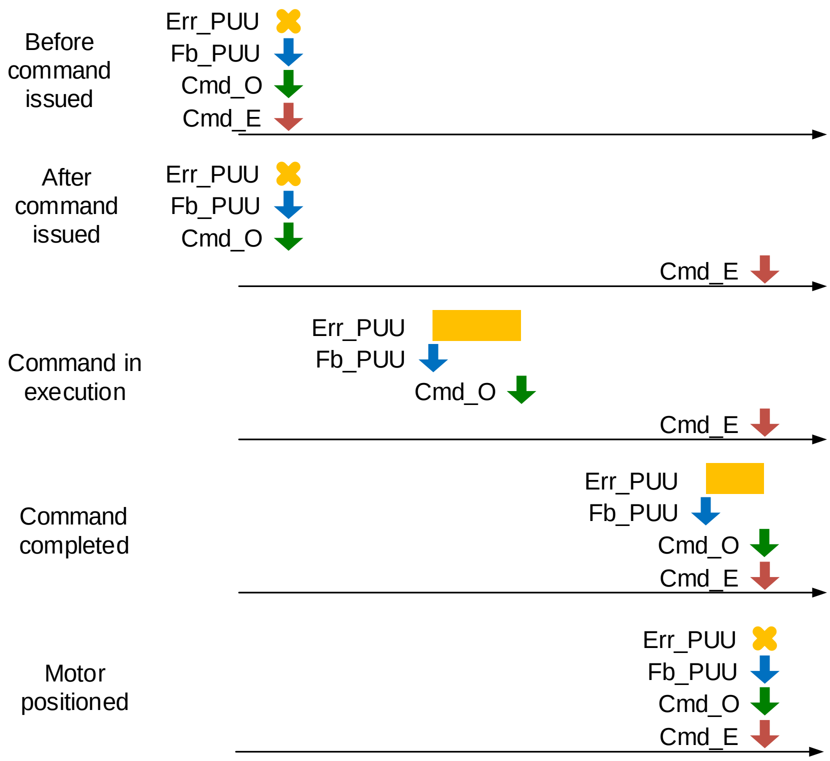

Figure 7.1.2.1 Timing diagram for PR mode monitoring variables

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The detailed command behavior of each stage is illustrated in Figure 7.1.2.2. Cmd_E is the endpoint specified by the command; it is set when the PR path is triggered. Fb_PUU is the feedback position, which is motor's actual position. Divide this motion command into slices and take one of them as example. Cmd_O is the target of this cycle command and Err_PUU is the difference between the target position of the cycle command and the feedback position.

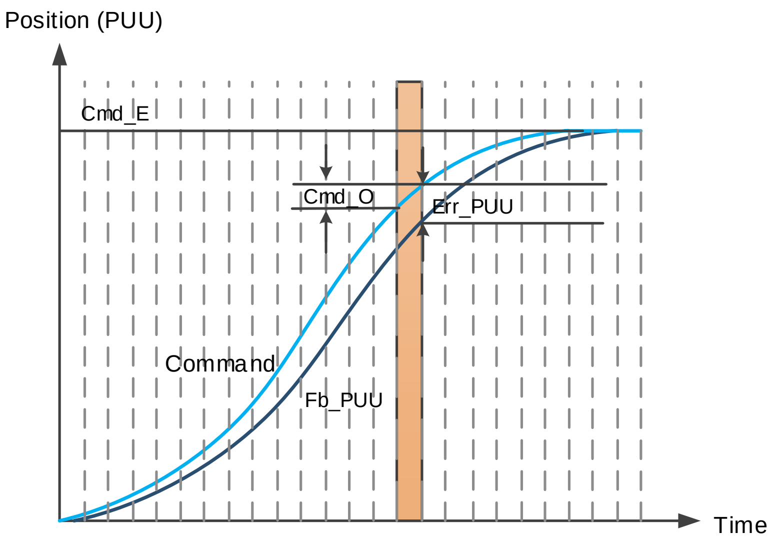

Figure 7.1.2.2 Monitoring variable status when a command is executed in PR mode

You can use digital input (DI) to call PR paths and digital output (DO) to monitor PR paths (refer to Tables 8.1 and 8.2 for the DI/O function descriptions). When you trigger the motion command with DI.CTRG (0x08), the servo drive operates based on the command from the internal registers. Once the execution is complete, DO.Cmd_OK (0x15) is set to on. When the motor reaches its target position, DO.TPOS (0x05) is set to on. Then, after the PR Position command completes and motor reaches the target position, both DO signals are on and the servo outputs the DO.MC_OK (0x17) signal to signify that it has completed this PR path. The operation is as shown in Figure 7.1.2.3.

If you have set a delay time in this PR, when the motor reaches the target position, DO.TPOS (0x05) is set to on. When the delay time is over, DO.Cmd_OK (0x15) is set to on. After these two DO signals are both on, the servo outputs the DO.MC_OK (0x17) signal to signify that it has completed this PR path, as shown in Figure 7.1.2.4.

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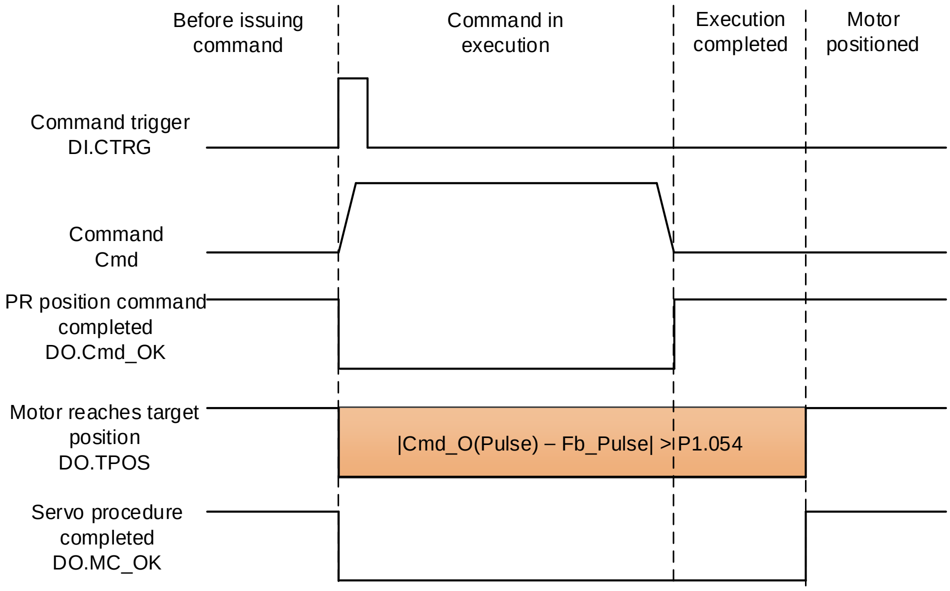


Figure 7.1.2.3 Operation of DI/DO signals in PR mode

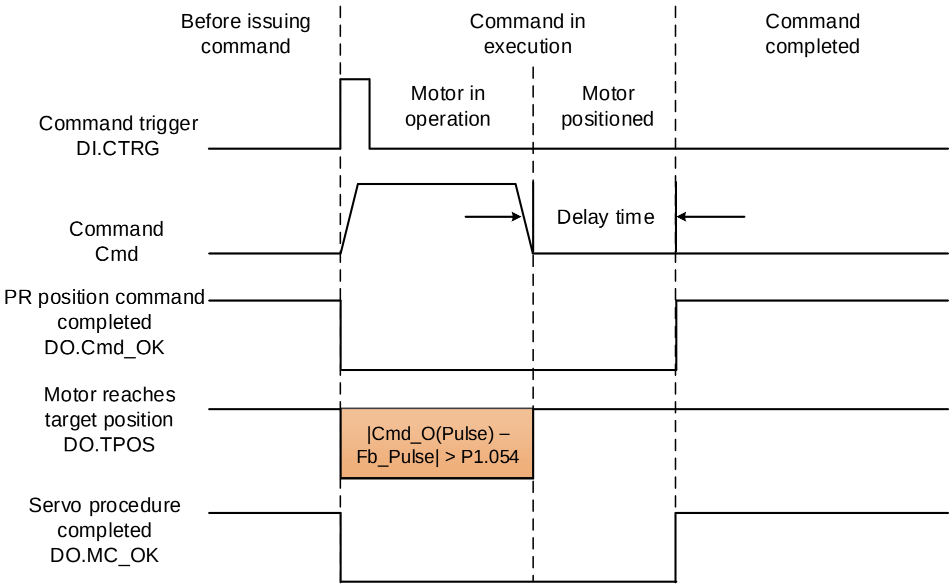


Figure 7.1.2.4 Operation of DI/DO signals in PR mode (including delay time)

7.1.3 Motion Control commands

The servo drive provides 100 path setting sets, which include the Homing methods, Speed command, Position command, Jump command, Write command, and Rotary Axis Position command (Index Position). The following sections detail each command type.

7.1.3.1 Homing methods

The servo drive provides 11 homing methods in the PR mode, including home sensor, limit, and hard stop as the reference origin. They come with sub-selections such as whether to refer to the Z pulse and the limit signal as the trigger, with more than 30 combinations available. The homing method is specified by P5.004 and the homing definition is determined by P6.000.
The following lists the function of each bit.

P5.004	Homing methods		Address: 0508H 0509H
Default:	0x0000	Control mode:	PR
Unit:	-	Setting range:	0x0000 - 0x012A
Format:	HEX	Data size:	16-bit

Settings:

0000
U Z Y X

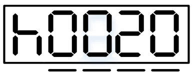
Definition of each setting value:

<table>
<tr><th>U</th><th>Z</th><th>Y</th><th>X</th></tr>
<tr><th>Reserved</th><th>Limit setting</th><th>Z pulse setting</th><th>Homing method</th></tr>
<tr><td rowspan="12">-</td><td>0 - 1</td><td>0 - 2</td><td>0 - A</td></tr>
<tr><td rowspan="2">-</td><td rowspan="4">Y = 0: reverse to Z pulse
Y = 1: go forward to Z pulse
Y = 2: do not look for Z pulse</td><td>X = 0: homing in forward direction and define the positive limit as the homing origin</td></tr>
<tr><td>X = 1: homing in reverse direction and define the negative limit as the homing origin</td></tr>
<tr><td rowspan="6">When reaching the limit:
Z = 0: show error
Z = 1: reverse direction</td><td>X = 2: homing in forward direction,
ORG: OFF→ON as the homing origin</td></tr>
<tr><td>X = 3: homing in reverse direction with ORG (when it switches from off to on state) as the homing origin</td></tr>
<tr><td rowspan="2">-</td><td>X = 4: look for Z pulse in forward direction and define it as the homing origin</td></tr>
<tr><td>X = 5: look for Z pulse in reverse direction and define it as the homing origin</td></tr>
<tr><td rowspan="2">Y = 0: reverse to Z pulse
Y = 1: go forward to Z pulse
Y = 2: do not look for Z pulse</td><td>X = 6: homing in forward direction with ORG (when it switches from on to off state) as the homing origin</td></tr>
<tr><td>X = 7: homing in reverse direction with ORG (when it switches from on to off state) as the homing origin</td></tr>
<tr><td>-</td><td>-</td><td>X = 8: define current position as the origin</td></tr>
<tr><td rowspan="2">When reaching the limit:
Z = 0: show error
Z = 1: reverse direction</td><td rowspan="2">Y = 0: reverse to Z pulse
Y = 2: do not look for Z pulse</td><td>X = 9: torque homing in forward direction</td></tr>
<tr><td>X = A: torque homing in reverse direction</td></tr>
</table>

P6.000	Homing definition		Address: 0600H 0601H
Default:	0x00000000	Control mode:	PR
Unit:	-	Setting range:	0x00000000 - 0xFFFFFF6F
Format:	HEX	Data size:	32-bit

Settings:

High word



D C B A

Low word

U Z YX

A	DEC2: deceleration time selection for second homing	YX	PATH: path type
B	DLY: select 0 - F for delay time	Z	ACC: select 0 - F for acceleration time
C	Reserved	U	DEC1: deceleration time selection for first homing
D	BOOT: whether to execute homing automatically when the drive is powered on	-	-

- YX: PATH: path type

  0x00: Stop: the servo stops after homing is complete

  0x01 - 0x63: Auto: the servo executes the specified path (PR#1 - PR#99) after homing is complete

- Z: ACC: select 0 - F for acceleration time

  0 - F: correspond to P5.020 - P5.035

- U: DEC1: deceleration time selection for first homing

  0 - F: correspond to P5.020 - P5.035

- A: DEC2: deceleration time selection for second homing

  0 - F: correspond to P5.020 - P5.035

- B: DLY: select 0 - F for delay time

  0 - F: correspond to P5.040 - P5.055

- D: BOOT: whether to execute homing automatically when the drive is powered on

  0: do not execute homing

  1: execute homing automatically (servo switches to on for the first time after power is applied)

The PR Homing mode includes the function for setting the origin offset. You can define any point in the position system as the reference origin, which does not have to be 0. Once you define the reference origin, the position system of the motion axis can be established.

See Figure 7.1.3.1.1. The position of the reference origin is 2000 (P6.001 = 2000). The motor passes by the reference origin and then stops at the position of 1477. From the position system that it established, the system automatically calculates the position of the 0 point. As soon as the PR motion command is issued, the motor moves to the specified position.

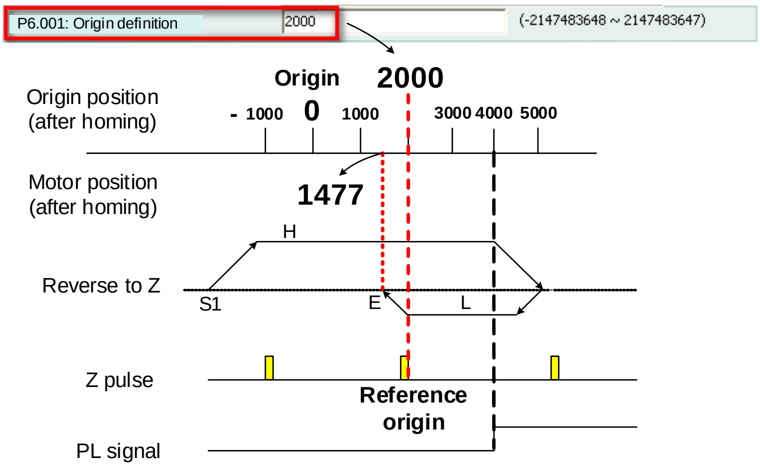


Figure 7.1.3.1.1 Origin definition

P6.001	Origin definition		Address: 0602H 0603H
Default:	0	Control mode:	PR
Unit:	-	Setting range:	-2147483648 to +2147483647
Format:	DEC	Data size:	32-bit

Settings:

Origin definition.

The homing procedure goes through two stages: high speed and low speed. The servo starts the homing procedure at high speed to seek the reference point (such as the limit switch and ORG signal), which takes shorter time. Once the servo detects the reference point, the motor runs at low speed to find the reference point accurately (such as the Z pulse). The speeds for the two stages are defined by P5.005 and P5.006.

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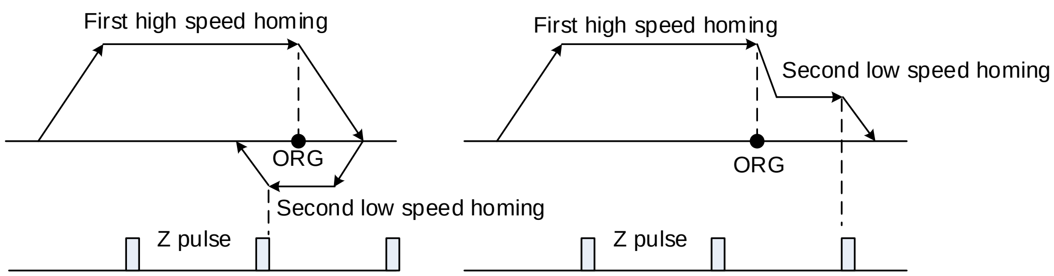
P5.005	High speed homing (first speed setting)			Address: 050AH 050BH
Operation interface:	Panel / software	Communication	Control mode:	PR (set with P5.004)
Default:	100.0	1000	Data size:	32-bit
Unit:	1 rpm	0.1 rpm	-	-
Setting range:	0.1 - 2000.0	1 - 20000	-	-
Format:	DEC	DEC	-	-
Example:	1.5 = 1.5 rpm	15 = 1.5 rpm	-	-

Settings:

The first speed setting for high speed homing.



P5.006	Low speed homing (second speed setting)			Address: 050CH 050DH
Operation interface:	Panel / software	Communication	Control mode:	PR (set with P5.004)
Default:	20.0	200	Data size:	32-bit
Unit:	1 rpm	0.1 rpm	-	-
Setting range:	0.1 - 500.0	1 - 5000	-	-
Format:	DEC	DEC	-	-
Example:	1.5 = 1.5 rpm	15 = 1.5 rpm	-	-

Settings:

The second speed setting for low speed homing.

You can set the homing parameters in the PR mode Homing Setting screen in ASDA-Soft, including the Homing Mode, Homing Speed Setting, and Homing Definition (see Figure 7.1.3.1.2).

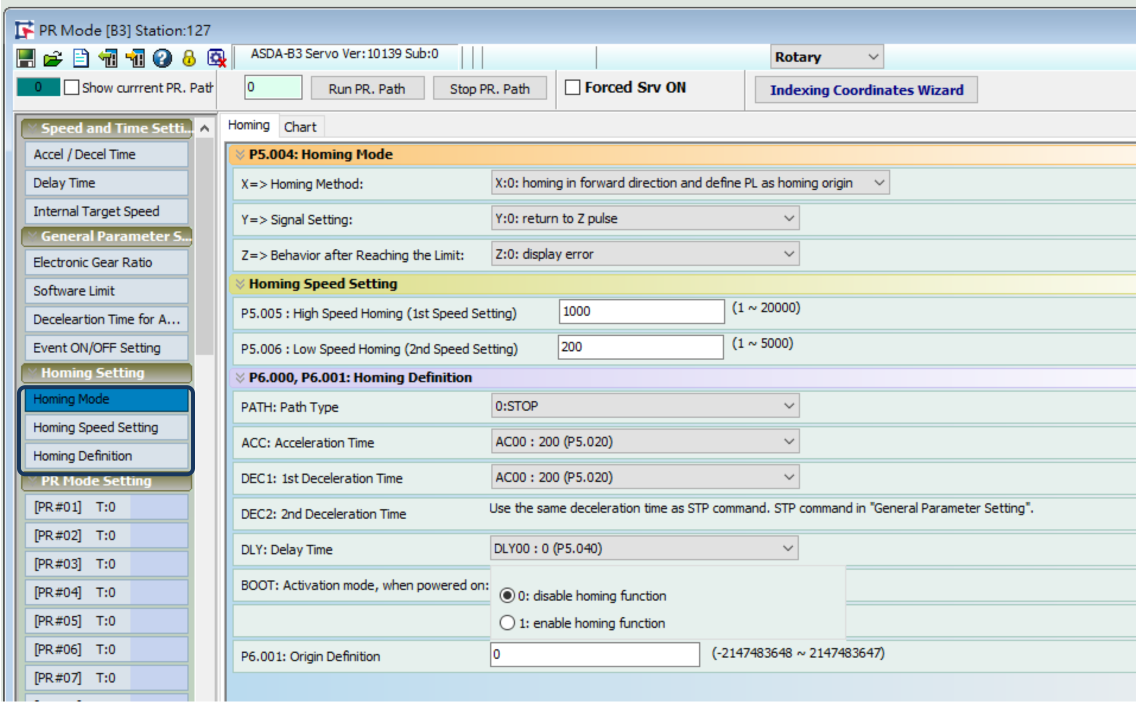
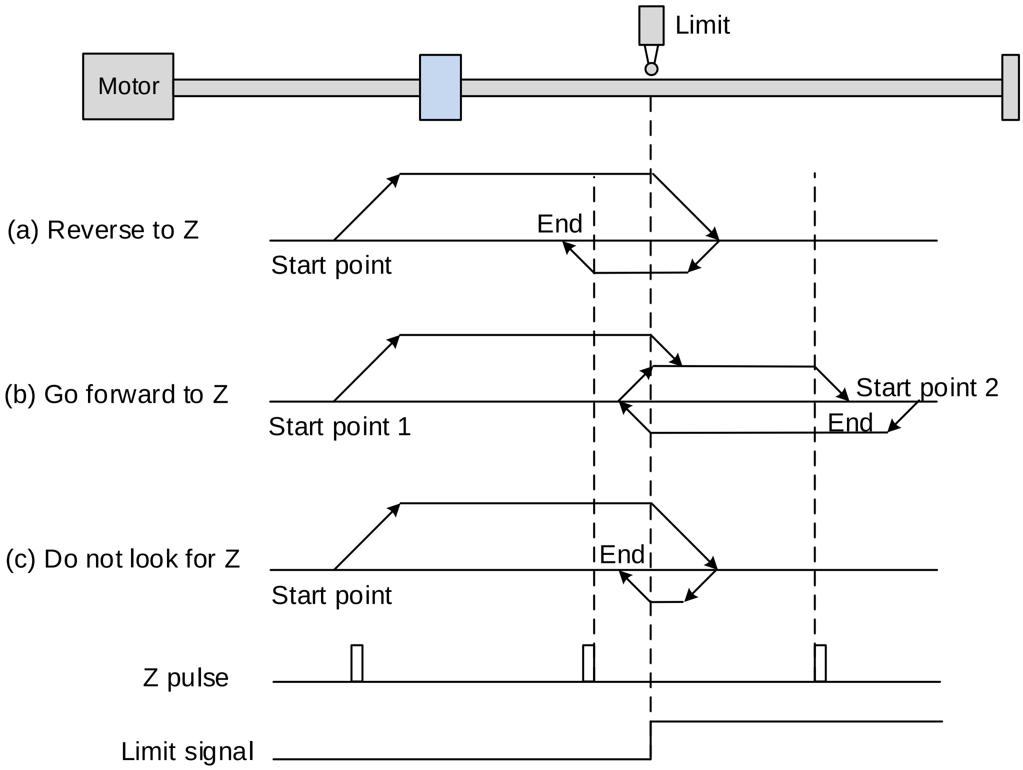


Figure 7.1.3.1.2 Homing screen in ASDA-Soft

The following describes the homing methods supported by the servo drive. They can be categorized into six types based on their reference points.

1. Referencing the limit.

   This method uses the positive or negative limit as the reference point. When the limit is detected, you can choose whether or not to look for the Z pulse and use it as the reference origin. The searching result is the same regardless of where the start point is. The servo drive always looks for the set reference point to reset the motor position.



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(a) If you set the servo to look for the Z pulse in the reverse direction, the servo operates at high speed (first speed setting) and then decelerates once it reaches the limit (rising-edge triggered). Then the servo switches to low speed (second speed setting) to look for the Z pulse in the reverse direction. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

(b) If you set the servo to look for the Z pulse in the forward direction and the limit signal at the start position is un-triggered (low, Start point 1), the servo operates at high speed (first speed setting) and then decelerates once it reaches the limit (rising-edge triggered). Then the servo switches to low speed (second speed setting) to look for the Z pulse in the forward direction. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

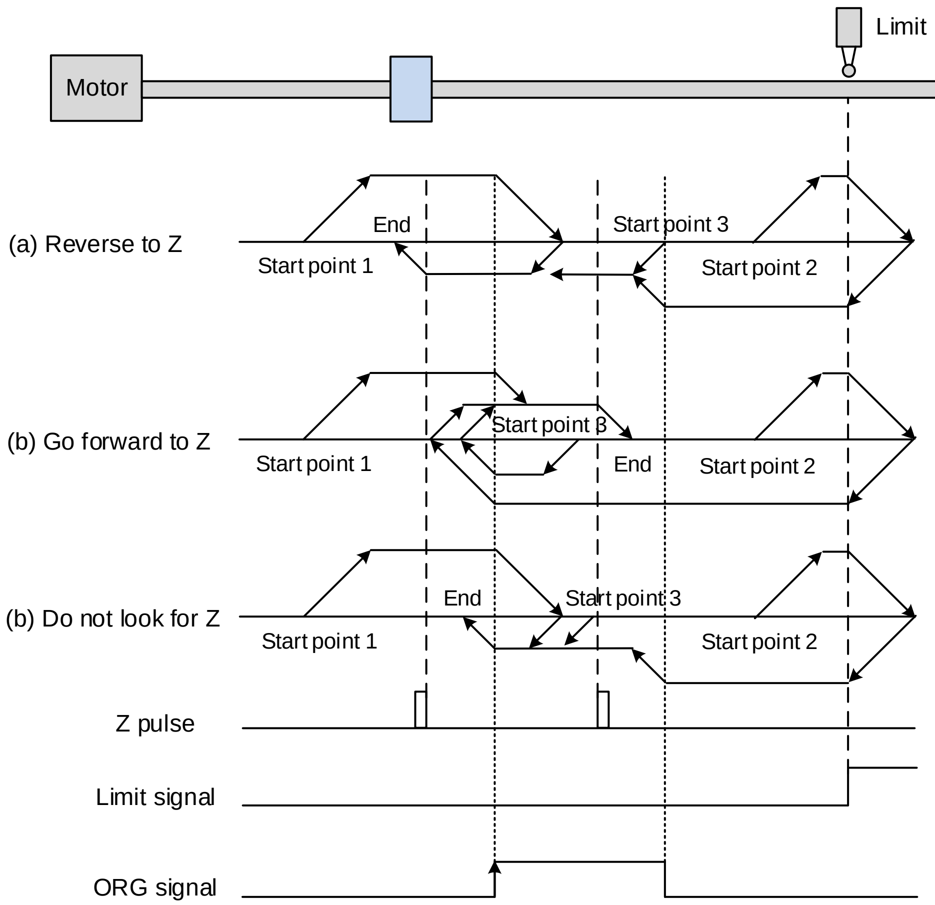
If you set the servo to look for the Z pulse in the forward direction and the limit signal at the start position is triggered (high, Start point 2), the servo operates at low speed (second speed setting) in the reverse direction to look for the rising-edge limit signal. Then the servo starts to look for the Z pulse in the forward direction once it reaches the limit (rising-edge triggered). When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

From the examples, regardless of the start positions, the origin position after homing is the same under the same setting condition.

(c) If you set the servo to not look for the Z pulse, the servo operates at high speed (first speed setting) and then decelerates once it reaches the limit (rising-edge triggered). Then the servo switches to low speed (second speed setting) in the reverse direction to look for the rising-edge limit signal. When the servo finds the rising-edge signal, it decelerates to a stop, completing the homing procedure.

2. Referencing the rising edge of the ORG signal.

   This method uses the rising edge of the home sensor signal as the reference origin. You can choose whether or not to use the Z pulse as the reference origin after the ORG signal is detected.



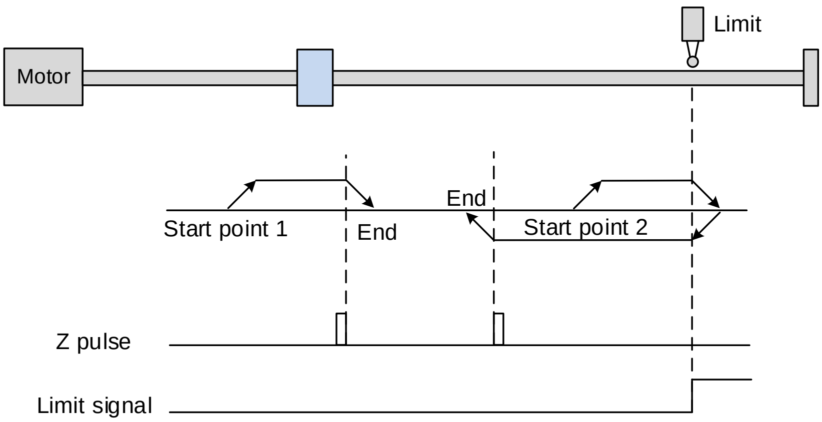
(a) If you set the servo to look for the Z pulse in the reverse direction, when the ORG signal at the start point is un-triggered (low, Start point 1), the servo operates at high speed (first speed setting) and then decelerates once it reaches the ORG signal (rising-edge triggered). Then it reverses and switches to low speed (second speed setting) until the ORG signal switches to low. Next, the servo starts to look for the Z pulse in the reverse direction. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

If the ORG signal at the start point is un-triggered and the current position is relatively closer to the limit switch (Start point 2), the servo operates at high speed (first speed setting) until reaching the limit switch. You can set whether to show an error or reverse the operating direction when the servo reaches the limit switch. If you set the servo to reverse direction, it operates in the reverse direction to reach the home sensor (ORG). Once reaching the home sensor (ORG), the servo decelerates and operates at low speed (second speed setting) until the ORG signal switches to low. Next, the servo starts to look for the Z pulse. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

If the ORG signal at the start point is triggered (high, Start point 3), the servo reverses with low speed (second speed setting) until the ORG signal switches to low. Next, the servo continues to look for the Z pulse. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

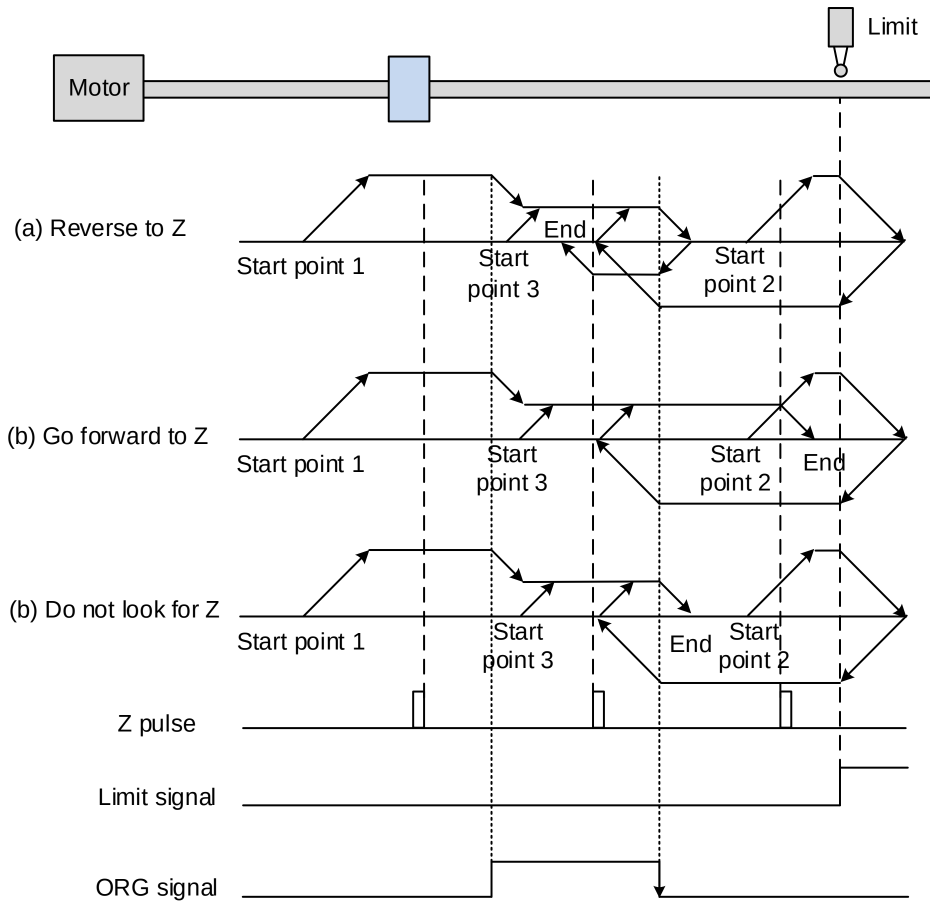
(b) If you set the servo to look for the Z pulse in the forward direction or not to look for the Z pulse (this is similar to method (a) reversing to look for the Z pulse), refer to the preceding timing diagram.

3. Referencing the Z pulse.
This method uses the Z pulse as the reference origin. One Z pulse is generated per rotation of the motor. This method is only suitable when the operation is kept within one motor rotation.



4. Referencing the falling edge of the ORG signal.

   This method uses the falling edge of the home sensor signal as the reference origin. You can choose whether or not to use the Z pulse as the reference origin after the ORG signal is detected.



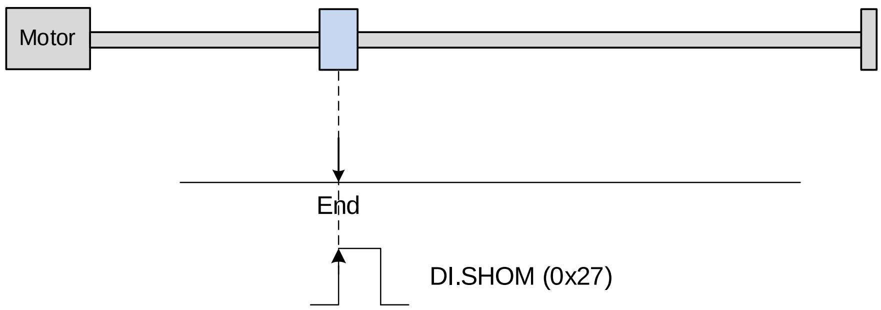
(a) If you set the servo to look for the Z pulse in the reverse direction, when the ORG signal at the start point is un-triggered (low, Start point 1), the servo operates at high speed (first speed setting) until reaching the rising edge of the ORG signal. Then it decelerates and switches to low speed (second speed setting) until the ORG signal switches to low. Next, the servo reverses to look for the Z pulse. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

If the ORG signal at the start point is un-triggered and the current position is relatively closer to the limit switch (Start point 2), the servo operates at high speed (first speed setting) until reaching the limit switch. You can set whether to show an error or reverse the operating direction when the servo reaches the limit switch. If you set the servo to reverse direction, it operates in reverse direction to reach the home sensor (ORG). Once reaching the home sensor (ORG), the servo decelerates and operates in the forward direction to reach the falling edge of the ORG signal. Next, the servo operates at low speed (second speed setting) and reverses to look for the Z pulse. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

If the ORG signal at the start point is triggered (high, Start point 3), the servo operates at low speed (second speed setting) in the forward direction until the ORG signal switches to low. Next, the servo reverses to look for the Z pulse. When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

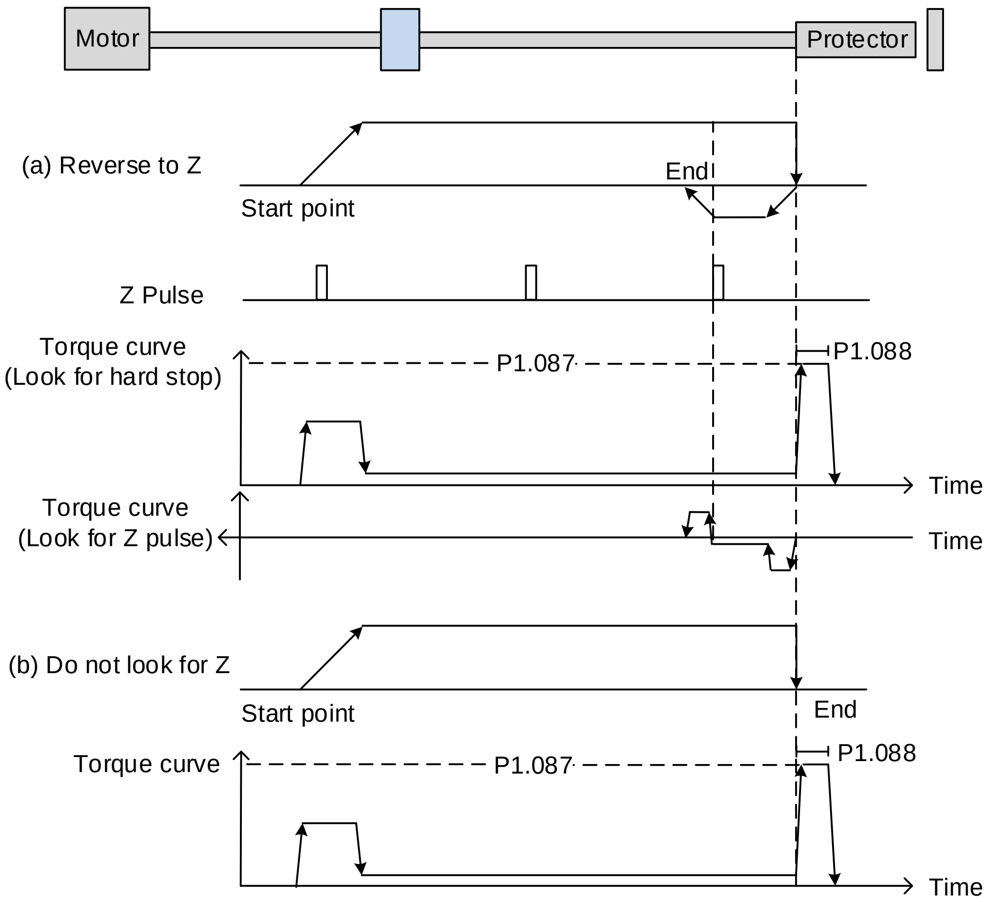
(b) If you set the servo to look for the Z pulse in the forward direction or not to look for the Z pulse (this is similar to method (a) reversing to look for the Z pulse), refer to the preceding timing diagram.

5. Referencing the current position as the origin.
This method uses the motor’s current position as the reference origin. As long as the homing procedure is triggered and the motor remains still, then motor positioning is complete.



6. Referencing the torque limit.

   This method uses the motor's stop position as the origin by referring to: the limit on the mechanical parts, the torque level detection (P1.087), and the level reached timer (P1.088). You can also choose whether to use the Z pulse as the reference origin.



(a) If you set the servo to look for the Z pulse in the reverse direction, the servo operates at high speed (first speed setting) and outputs a greater current to counter the external force once it touches the protector. When the motor torque reaches the torque level detection (P1.087) and the output duration is longer than the level reached timer setting (P1.088), the servo operates in the reverse direction to look for the Z pulse at low speed (second speed setting). When the servo finds the Z pulse, it decelerates to a stop, completing the homing procedure.

(b) If you set the servo not to look for the Z pulse, the servo operates at high speed (first speed setting) and outputs a greater current to counter the external force once it touches the protector. When the motor torque reaches the torque level detection (P1.087) and the output duration is longer than the level reached timer setting (P1.088), the servo stops, completing the homing procedure.

Pay special attention when executing the Torque homing procedure. The motor's actual maximum torque output is 10% greater than the torque level detection setting (P1.087), excessive impact may cause damage to the machine.

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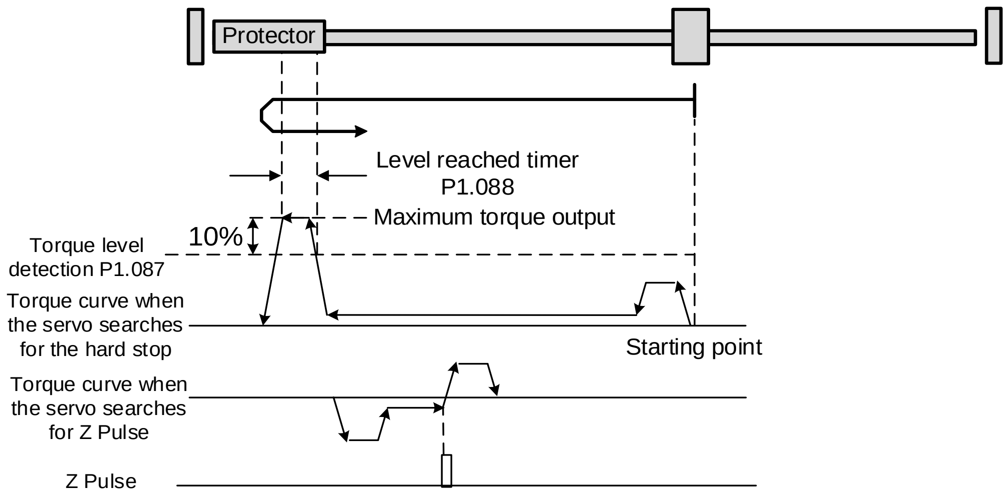
The following tables describe the settings for the torque level detection (P1.087) and the level reached timer (P1.088).

P1.087	**Torque homing - torque level detection**		**Address: 01AEH 01AFH**
Default:	1	Control mode:	PR
Unit:	%	Setting range:	1 - 300
Format:	DEC	Data size:	16-bit

Settings:

This setting is only for the torque homing mode. As shown in the following figure, after homing is triggered, the motor runs in one direction and the mechanical part reaches the protector. The servo drive then outputs a larger motor current in order to counter the external force. The servo drive uses P1.087 and P1.088 as the conditions for homing. Since the hard stops are not always the same, it is recommended that you have the servo reverse to find the Z pulse as the origin.



Note: the actual maximum torque output of the motor is 10% greater than the detected torque level (P1.087).

For example: set P1.087 to 50%, the maximum torque output of the motor is 60%.

P1.088	**Torque homing - level reached timer**		**Address: 01B0H 01B1H**
Default:	2000	Control mode:	PR
Unit:	ms	Setting range:	2 - 2000
Format:	DEC	Data size:	16-bit

Settings:

The setting of the torque level reached timer for the torque homing mode. If the motor torque output continues to exceed the level set by P1.087 and the duration exceeds this setting, the homing is complete. Refer to P1.087 for the timing diagram of torque homing mode.

As mentioned in Section 7.1.2, the PR mode provides four monitoring variables for you to monitor the servo commands and feedback status. These variables are Command position PUU (Cmd_O), PR command end register (Cmd_E), Feedback position PUU (Fb_PUU), and Position error PUU (Err_PUU). Before homing completes, Cmd_E cannot be calculated because the position system can only be established after homing is complete, and the target position remains unknown after the Homing command is issued. This is why the changes of the monitoring variables in Homing mode (Figure 7.1.3.1.3) are different from that when the servo issues the PR position command (Figure 7.1.2.1). In Homing command's default setting, the contents of Cmd_E and Cmd_O are identical. After the servo finds the reference origin and establishes the position system, it sets the content of Cmd_E to the position of the reference origin. However, once the servo finds the reference origin, it still requires some distance for the motor to decelerate to a stop. Meanwhile, Cmd_O continues to issue commands. If no other PR commands are issued after the Homing command, unlike the condition where the servo issues the PR position command, the final contents of Cmd_O and Cmd_E in Homing mode will be different. See Figure 7.1.3.1.3.

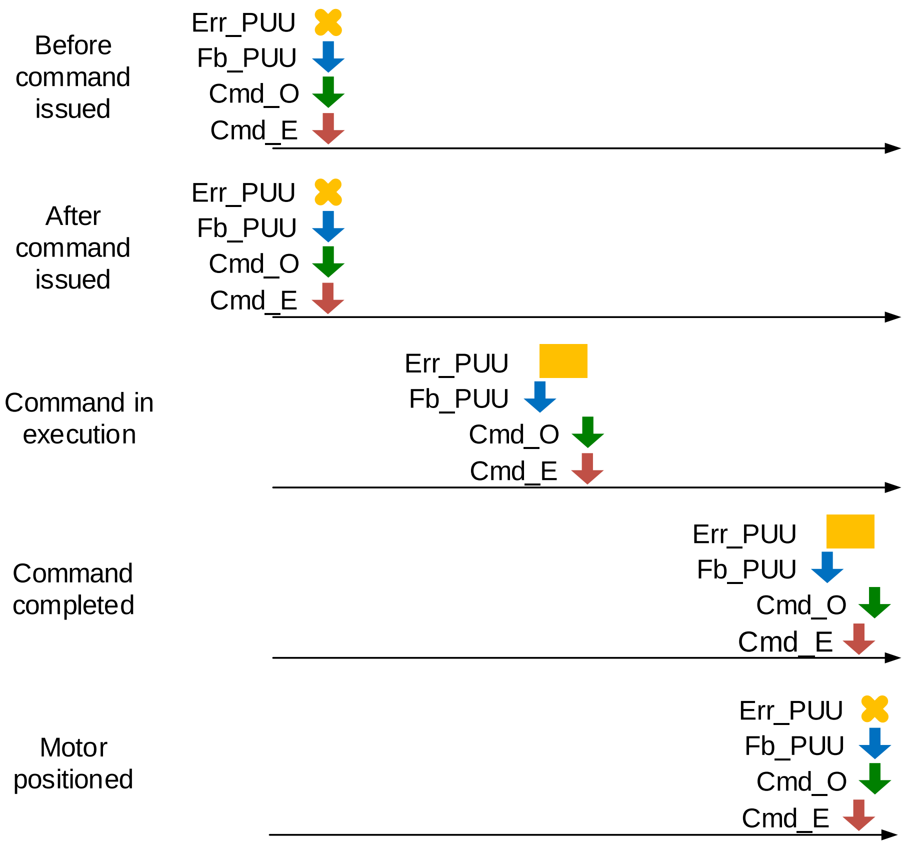


Figure 7.1.3.1.3 Timing diagram for Homing mode monitoring variables

7.1.3.2 Speed command

The PR mode includes a speed control function. The following parameters are available for PR speed setting: acceleration / deceleration time, delay time, and target speed. You can easily set the Speed command by selecting **[1]: Constant speed control** for the TYPE settings in the PR mode screen in ASDA-Soft. See Figure 7.1.3.2.1.

- INS is an interrupt command that interrupts the previous motion command. Refer to Section 7.1.6 for more details.
- AUTO is a command that automatically loads and executes the next PR path when the current PR path completes.
- UNIT is the target speed unit with two options, 0.1 rpm and 1 PPS, and the setting range is -6000 rpm to +6000 rpm.
- ACC / DEC is the acceleration / deceleration time determined by the shared PR parameters. The software calculates and displays the required duration for accelerating from 0 to the target speed or for decelerating from the target speed to 0.
- DLY is the delay time determined by the shared PR parameters. It is defined by the command from the controller; in other words, once the target speed is reached, the servo drive starts counting the delay time.

See Figure 7.1.3.2.2 for the effects of the parameters for the PR mode speed control. Table 7.1.3.2.1 shows the bit functions when speed control is in operation.

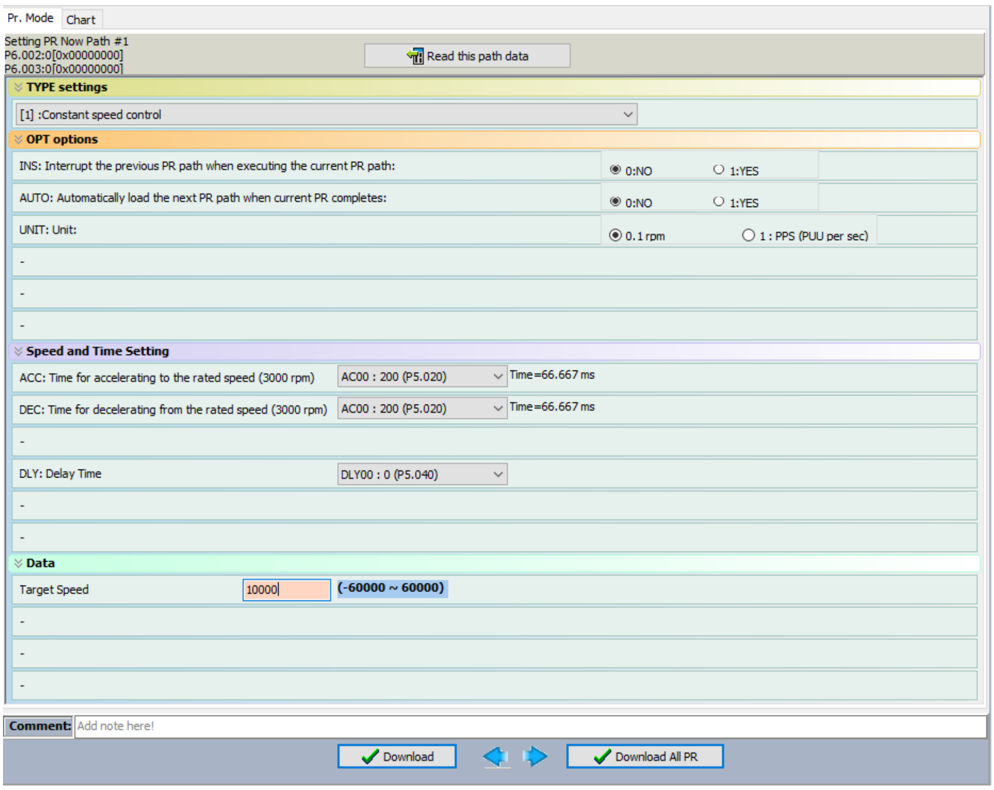


Figure 7.1.3.2.1 PR mode Speed control screen in ASDA-Soft

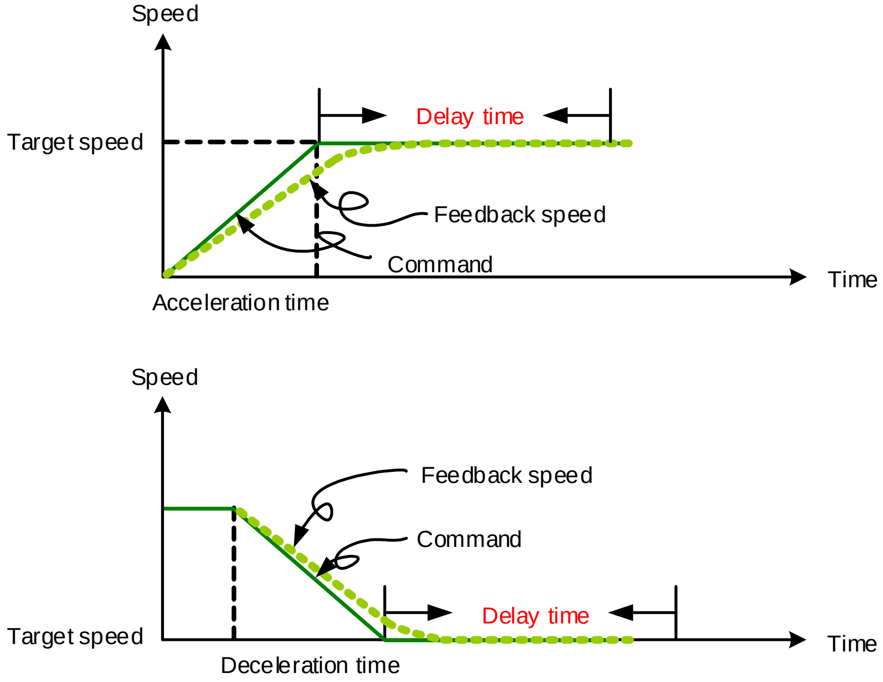


Figure 7.1.3.2.2 Parameters for PR mode speed control

Table 7.1.3.2.1 Bit functions of PR speed control

PR parameters	D	C	B	A	U	Z	Y	X
Property	-	-	DLY	-	DEC	ACC	OPT	1
Data content	Target speed [0.1 rpm / PPS]							

Note:

1. X: 1: SPEED, constant speed control
2. Y: OPT, option

Bit / Property	3	2	1	0
Property	-	UNIT	AUTO	INS

INS: interrupts the previous path when the current path is executed.

AUTO: once current PR path is finished, automatically loads the next path.

UNIT: speed unit selection; 0 = 0.1 rpm and 1 = PPS.

3. Z, U: ACC / DEC, acceleration / deceleration time, set by P5.020 - P5.035.
4. B: DLY, delay time, set by P5.040 - P5.055.

7.1.3.3 Position command

The PR mode includes a position control function. There are two types: Type 2 (The execution stops once the positioning is complete) and Type 3 (The next PR path is automatically loaded once the positioning is complete). The way to set these types of commands is the same. See Figure 7.1.3.3.1 for setting these commands in ASDA-Soft.

- INS is an interrupt command that interrupts the previous motion command. Refer to Section 7.1.6 for more details.
- OVLP is an overlap command that allows the next PR command to overlap the command currently being executed when decelerating. If you use this function, setting the delay time to 0 is suggested. Refer to Section 7.1.6 for more details.
- ACC / DEC is the acceleration / deceleration time determined by the shared PR parameters. The software calculates and displays the required duration for accelerating from 0 to the target speed or for decelerating from the target speed to 0.
- SPD is the target speed determined by the shared PR parameters. You can choose whether it is multiplied by 0.1.
- DLY is the delay time determined by the shared PR parameters. It is defined by the command from the controller; in other words, once the target position is reached, the servo drive starts counting the delay time.
- The Position command is user-defined and its unit is PUU.

See Figure 7.1.3.3.2 for the effects of the parameters for the PR mode position control. Table 7.1.3.3.1 shows the bit functions when position control is in operation.

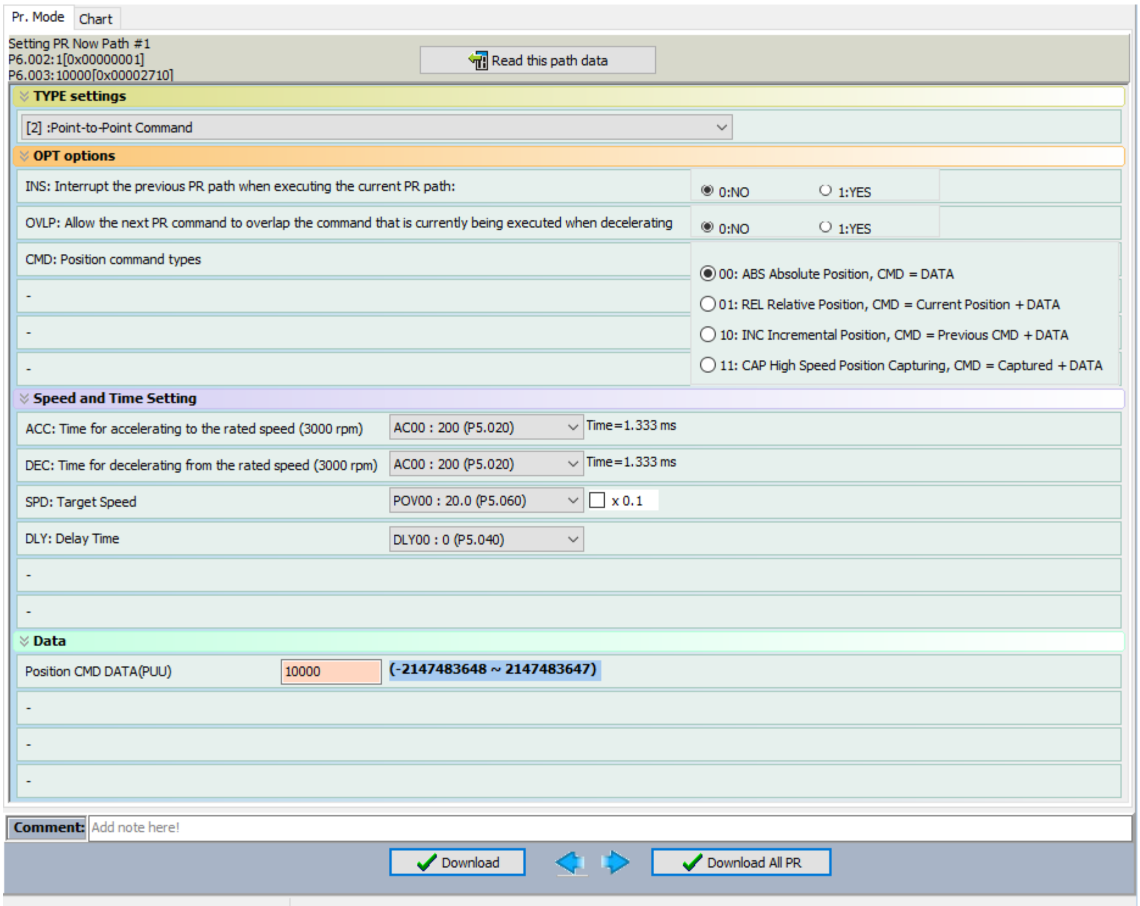


Figure 7.1.3.3.1 PR mode Position control screen in ASDA-Soft

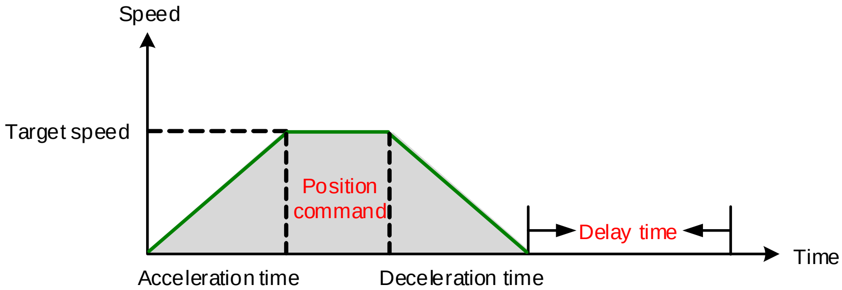


Figure 7.1.3.3.2 Parameters for PR mode position control

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There are four types of position commands for the PR mode. You can choose the position command according to the application requirements. The functions of each type are described in the following examples. Note that the condition in these examples is that a position command is still being executed and another type of command is inserted. To see the definition of each command and how the position commands are combined, please refer to Figure 7.1.3.3.3.

1. Absolute position command (ABS): when an absolute command is inserted, the target position value equals the absolute command value. In the following example, an ABS command with the value of 60000 PUU is inserted in the previous PR path, so the target position is 60000 PUU in the position system.

2. Relative position command (REL): when a relative command is inserted, the target position value is the motor’s current position value plus the position command value. In the following example, a REL command with the value of 60000 PUU is inserted in the previous PR path. The target position is the motor’s current position (20000 PUU) plus the relative position command (60000 PUU), which equals 80000 PUU in the position system. The target position specified by the original command is omitted.

3. Incremental position command (INC): when an incremental command is inserted, the target position is the previous target position value plus the current position command value. In the following example, an INC command with the value of 60000 PUU is inserted in the previous PR path. The target position is the previous target position value (30000 PUU) plus the relative position command (60000 PUU), which equals 90000 PUU in the position system. The target position specified by the previous command is combined to define the new one.

4. High-speed position capturing command (CAP): when a high-speed capturing command is inserted, the target position is the last position acquired by the Capture function plus the position command value. Refer to Section 7.2.2 for more on the high-speed position capture function. In the following example, a high-speed capturing command with the value of 60000 PUU is inserted in the previous PR path. The target position is the captured position value (10000 PUU) plus the relative position command (60000 PUU), which equals 70000 PUU in the position system. The target position specified by the original command is omitted.

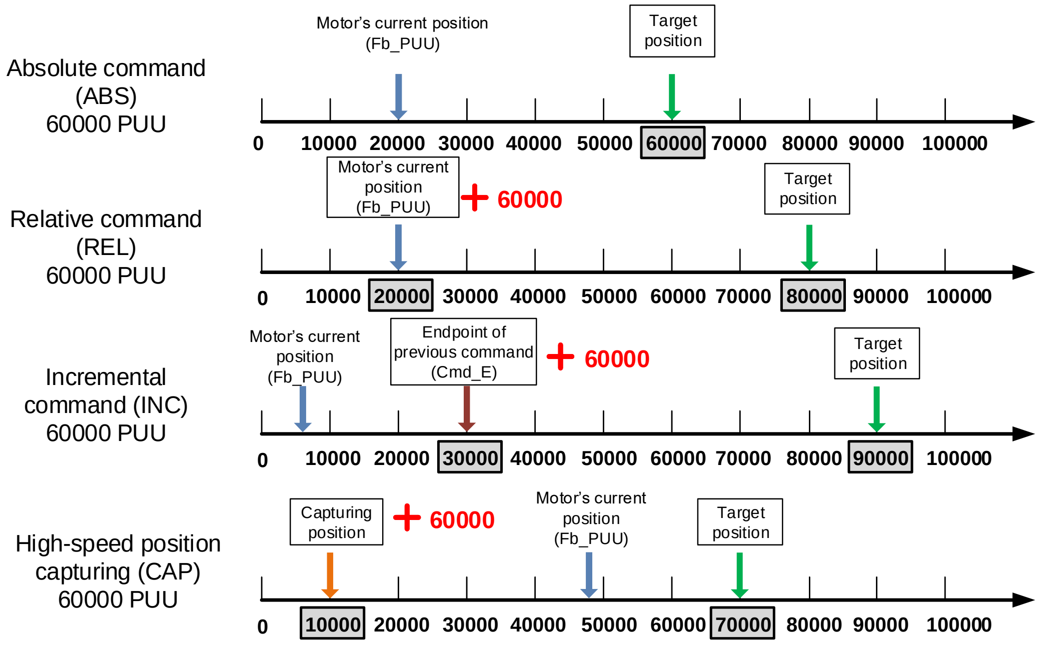

Figure 7.1.3.3.3 Four types of Position command

Table 7.1.3.3.1 Bit functions of PR position control

PR parameters	D	C	B	A	U	Z	Y	X
Property	-	-	DLY	SPD	DEC	ACC	OPT	2 or 3
Data content	Target position [PUU]							

Note:

1. X:

   2: SINGLE, positioning control. It stops once positioning is complete.

   3: AUTO, positioning control. It automatically loads the next path once positioning is complete.

2. Y: OPT, option

Bit	3	2	1	0	Description
Property	CMD		OVLP	INS	-
Data content	0	0	-	-	ABS (absolute positioning)
	0	1			REL (relative positioning)
	1	0			INC (incremental positioning)
	1	1			CAP (high-speed position capturing)

INS: interrupts the previous path when the current path is executed.

OVLP: allow overlapping of the next command.

CMD: Position command selection.

3. Z, U: ACC / DEC, acceleration / deceleration time, set by P5.020 - P5.035.

4. A: SPD, target speed, set by P5.060 - P5.075.

5. B: DLY, delay time, set by P5.040 - P5.055.

7.1.3.4 Jump command

The PR mode includes a Jump command. It can call any PR paths or form PR paths into a loop, as shown in Figure 7.1.3.4.1. You can specify the target PR number in the PR mode screen in ASDA-Soft (see Figure 7.1.3.4.2).

- INS is an interrupt command that interrupts the previous motion command. Refer to Section 7.1.6 for more details.
- DLY is the delay time determined by the shared PR parameters. Once a Jump command is issued, the servo drive starts counting the delay time.
- Available target PR numbers are PR#0 - PR#99.

Table 7.1.3.4.1 shows the bit functions when Jump command is in operation.

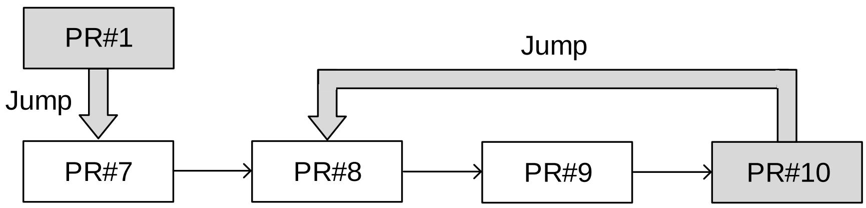

Figure 7.1.3.4.1 Jump command in PR mode

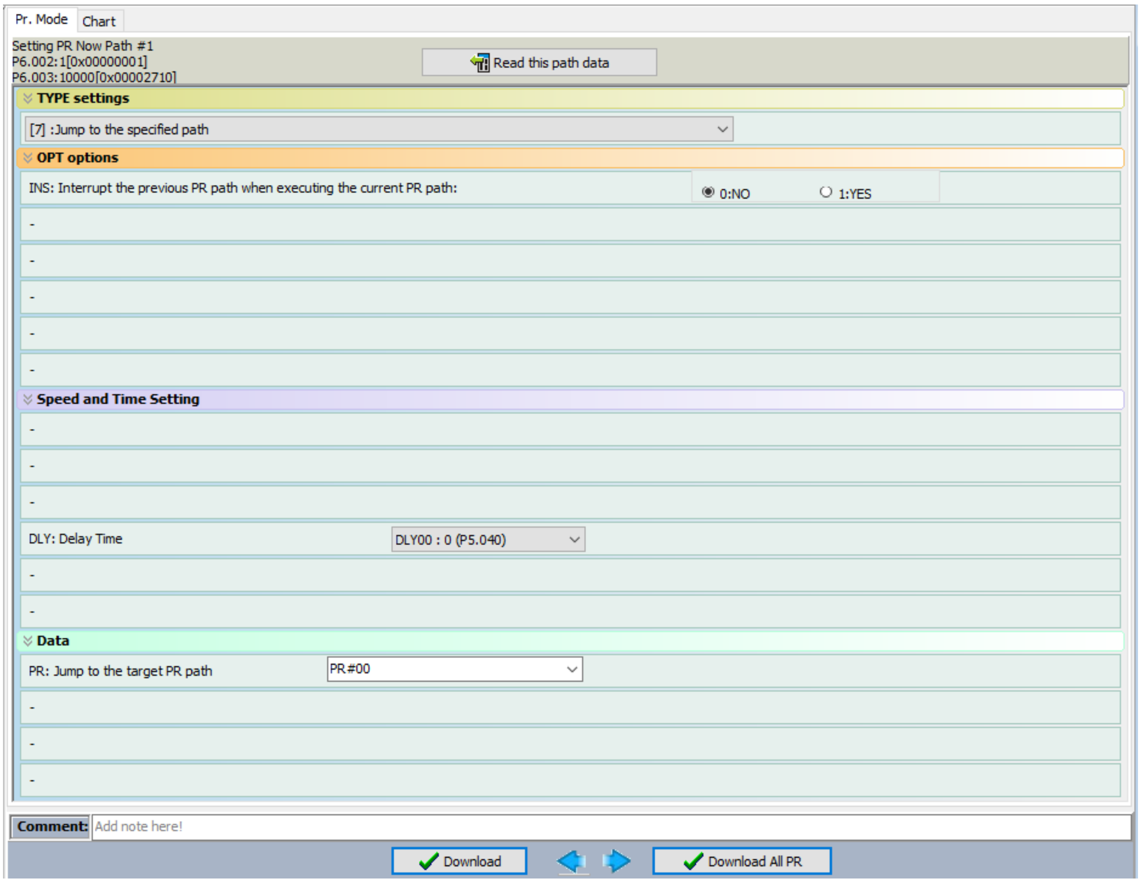

Figure 7.1.3.4.2 PR mode Jump command screen in ASDA-Soft

Table 7.1.3.4.1 Bit functions of PR Jump command

PR parameters	D	C	B	A	U	Z	Y	X
Property	-	-	DLY	-	-	-	OPT	7
Data content	Jump to target PR path (0 - 99)							

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Note:

1. X: 7: JUMP, jump to the specified path.
2. Y: OPT, option

Bit	3	2	1	0
Property	-	-	-	INS

INS: interrupts the previous path when the current path is executed.

3. B: DLY, delay time, set by P5.040 - P5.055.

7.1.3.5 Write command

The PR mode includes a Write command. It can write constants, parameters, data arrays, and monitoring variables to the specified parameters or data arrays. You can write a parameter to a specified path in the PR mode screen in ASDA-Soft (see Figure 7.1.3.5.1).

- INS is an interrupt command that interrupts the previous motion command. Refer to Section 7.1.6 for more details.
- AUTO command automatically loads and executes the next PR once the current PR completes.
- ROM command writes parameters to both RAM and EEPROM at the same time. The function of writing to non-volatile memory is also available; however, frequent usage shortens the life of the EEPROM.
- DLY is the delay time determined by the shared PR parameters. Once a Write command is issued, the servo drive starts counting the delay time.

Table 7.1.3.5.1 shows the bit functions when a Write command is in operation.

Writing Target	Data source
Parameter	Constant
Data array	Parameter
-	Data array
-	Monitoring variable

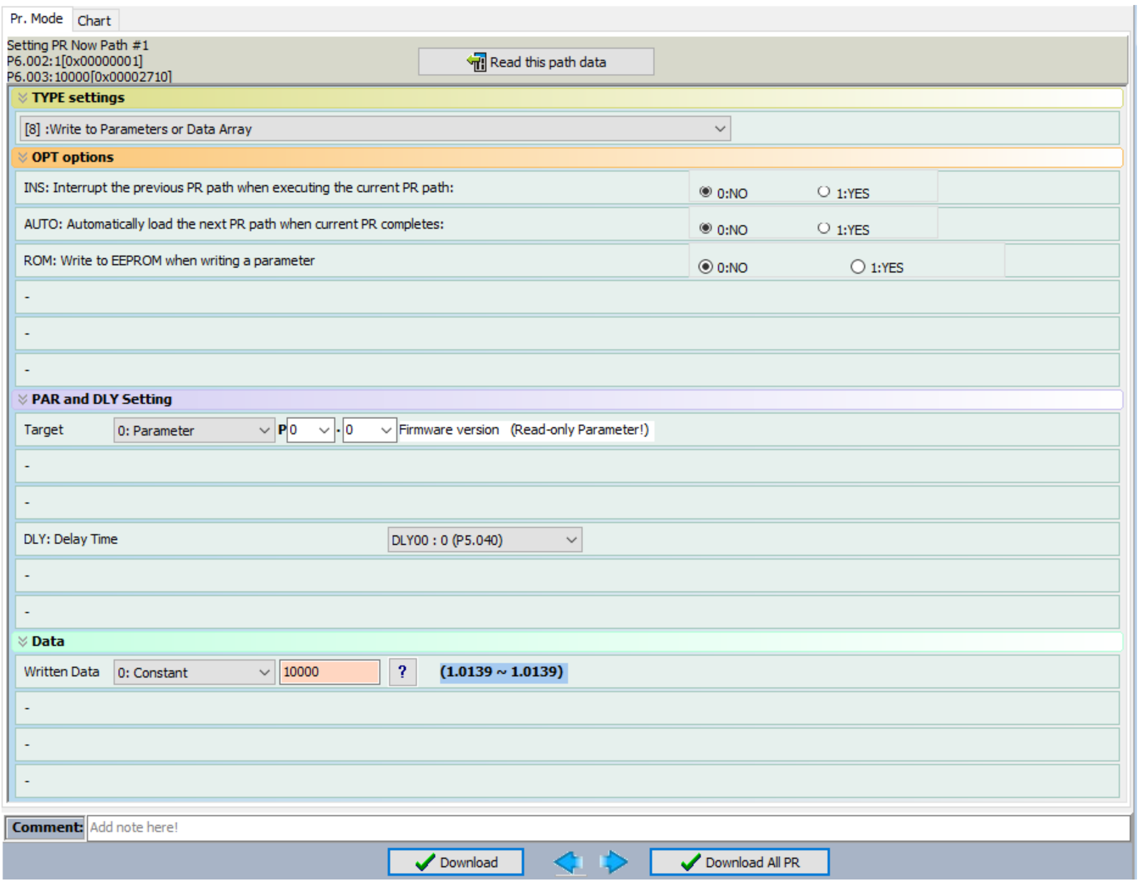

Figure 7.1.3.5.1 PR mode Write command screen in ASDA-Soft

Table 7.1.3.5.1 Bit functions of PR Write command

PR parameters	D	C	B	A	U	Z	Y	X
Property	0	SOUR_DEST	DLY	DESTINATION			OPT	8
Data content	SOURCE							

Note:

1. X: 8: WRITE, write specified parameters to the specified path.
2. Y: OPT, option

Bit	3	2	1	0
Property	-	ROM	AUTO	INS

INS: interrupts the previous path when the current path is executed.

AUTO: once current PR path is finished, automatically loads the next path.

ROM: write data to RAM and EEPROM at the same time. This function can only write parameters.

3. B: DLY, delay time, set by P5.040 - P5.055.
4. C: SOUR_DEST, data source and data format to be written.

Bit	3	2	1	0	Description	
Property	SOUR		-	DEST	Data source	Writing target
Data content	0	0	0	0	Constant	Parameter
	0	1		0	Parameter	Parameter
	1	0		0	Data array	Parameter
	1	1		0	Monitoring variable	Parameter
	0	0		1	Constant	Data array
	0	1		1	Parameter	Data array
	1	0		1	Data array	Data array
	1	1		1	Monitoring variable	Data array

5. Z, U, A: DESTINATION, destination

	A	U	Z
Writing target: parameter	Parameter group	Parameter number	
Writing target: data array	Data array number		

6. SOURCE: data source setting

	D	C	B	A	U	Z	Y	X
Data source: constant	Constant data							
Data source: parameter	-					Parameter group	Parameter number	
Data source: data array	-					Data array number		
Data source: monitoring variable	-						Monitoring variable number	

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7.1.3.6 Rotary Axis Position command (Index Position)

The PR mode includes a Rotary Axis Position command, which creates a rotary axis position system. This command positions the motor within the rotary axis position system. Unlike other feedback positions in global coordinate system, the Rotary Axis Position command is able to divide the rotary axis position scale into the number of paths required by the application (see Figure 7.1.3.6.1). When using the Rotary Axis Position command for motor operation in single direction (or mostly in the same direction), if the motor position exceeds the range, absolute position or position counter overflow occurs. Refer to the setting in Chapter 10.

You can start the rotary axis positioning in the Rotary Axis Position Setting Wizard (Index Coordinates Setting Wizard) in the PR mode screen in ASDA-Soft (see Figure 7.1.3.6.2).
As shown in the example, the starting PR path is set to 1, the number of paths (path size) is set to 8, and the total moving distance (P2.052) is 80000 PUU. When you click **OK**, the software automatically writes position command 0 PUU to PR#1, 10000 PUU to PR#2, 20000 PUU to PR#3, and so on up to PR#8. When the rotary axis position reaches 80000 PUU, it automatically returns to 0 PUU.

In addition, you can modify the rotary axis position in each PR path as needed, as shown in Figure 7.1.3.6.3.

- INS is an interrupt command that interrupts the previous motion command. Refer to Section 7.1.6 for more details.
- OVLP is an overlap command that allows the next PR command to overlap the command currently being executed when decelerating. If you use this function, setting the delay time to 0 is suggested. Refer to Section 7.1.6 for more details.
- DIR sets the rotation direction with options of forward rotation (always runs forward), reverse rotation (always runs backward), and the shortest distance. The movement is illustrated in Figure 7.1.3.6.4.
- S_LOW is the speed unit with options of 0.1 r/min or 0.01 r/min.
- AUTO is a command that automatically loads and executes the next PR path when the current PR completes.
- ACC / DEC is the acceleration / deceleration time determined by the shared PR parameters.
- SPD is the target speed determined by the shared PR parameters.
- DLY is the delay time determined by the shared PR parameters. It is defined by a command from the controller; in other words, once the target position is reached, the servo drive starts counting the delay time.
- Position command is the target position of each rotary axis traveling segment. Note that the setting range must be smaller than the rotary axis position scale (P2.052).

Table 7.1.3.6.1 shows the bit functions when a Rotary Axis Position command is in operation. If you use the rotary axis position function, execute homing first in order to create the position system so that the origin of the motor's feedback position and that of the motor's rotary axis position can be identical. If you do not execute homing, AL237 occurs.

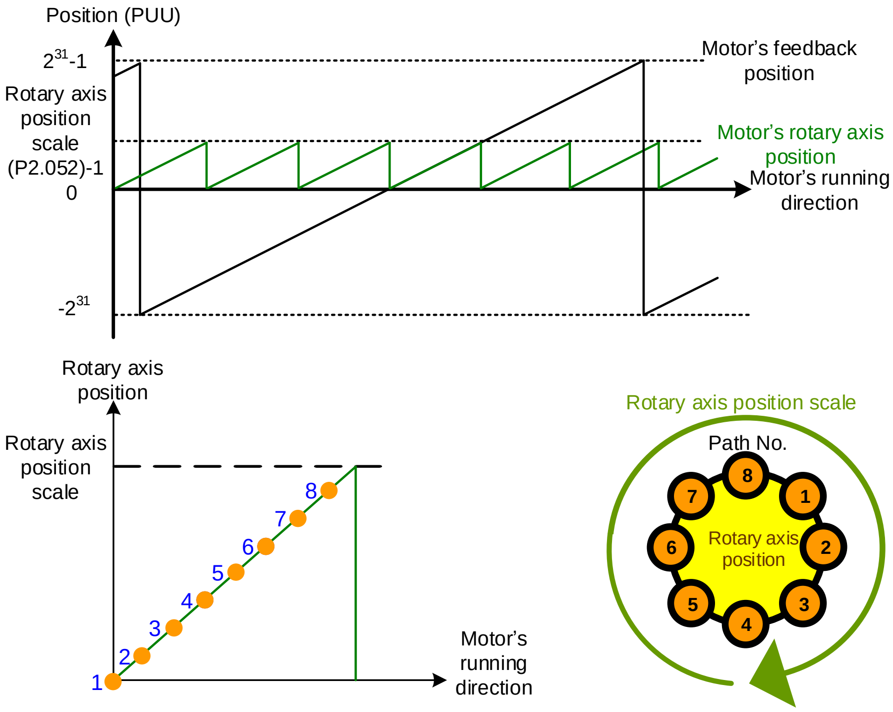

Figure 7.1.3.6.1 Rotary axis position in PR mode

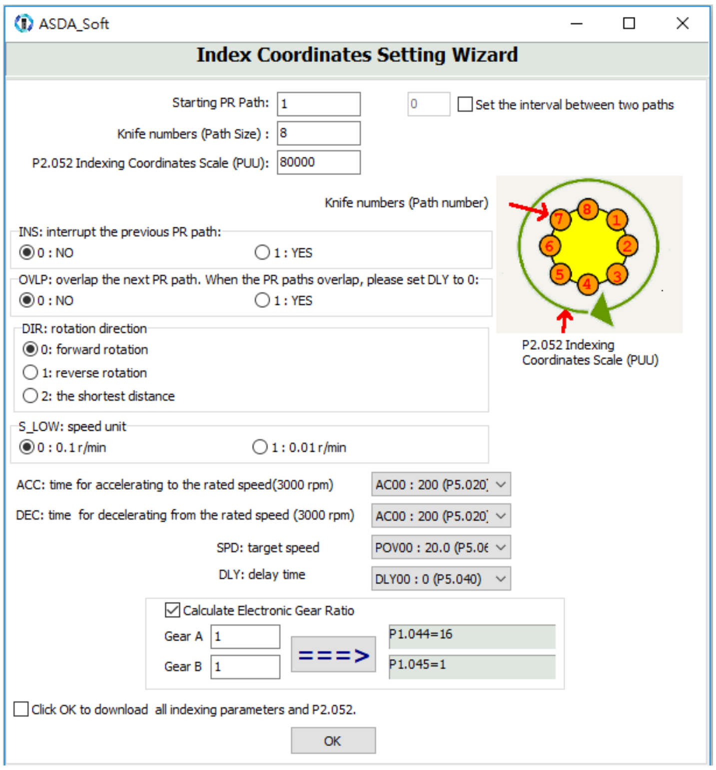

Figure 7.1.3.6.2 Rotary Axis Position Setting Wizard (Index Coordinates Setting Wizard) in PR mode

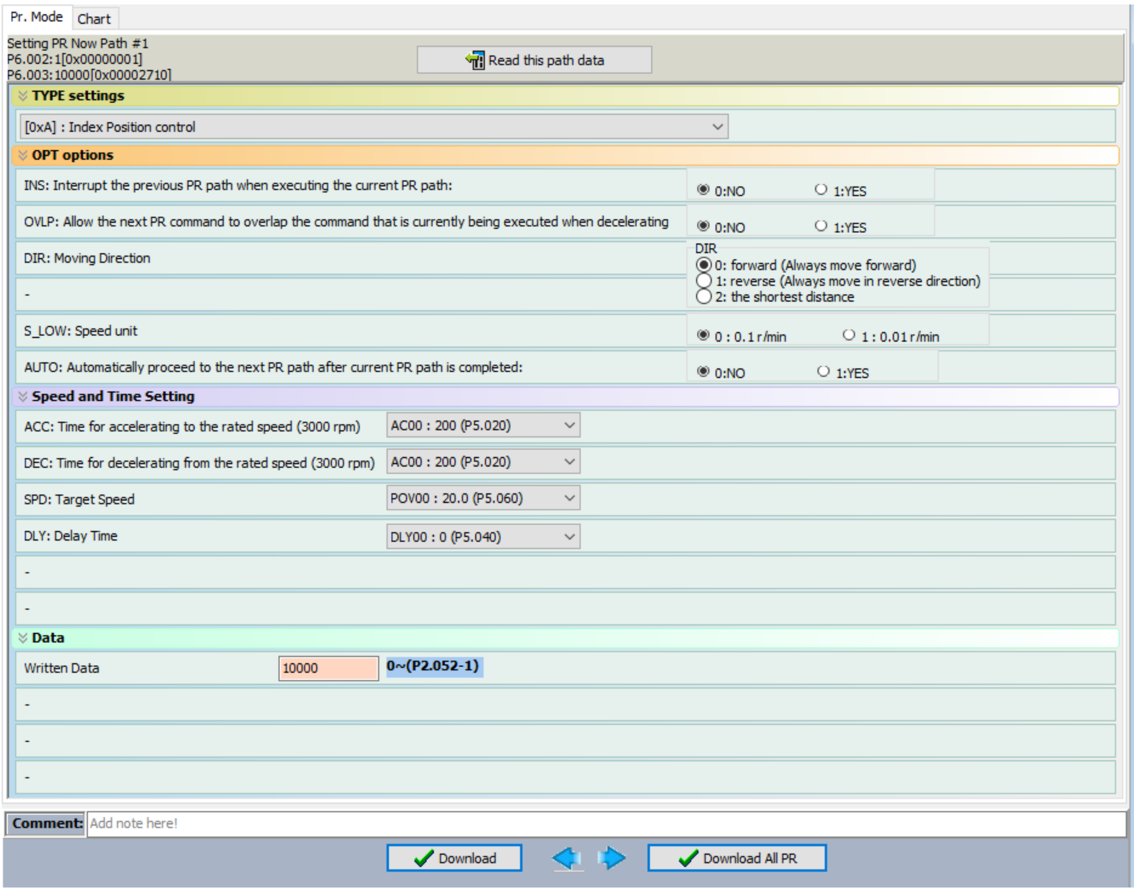

Figure 7.1.3.6.3 PR mode Rotary Axis Position control (Index Position control) screen in ASDA-Soft

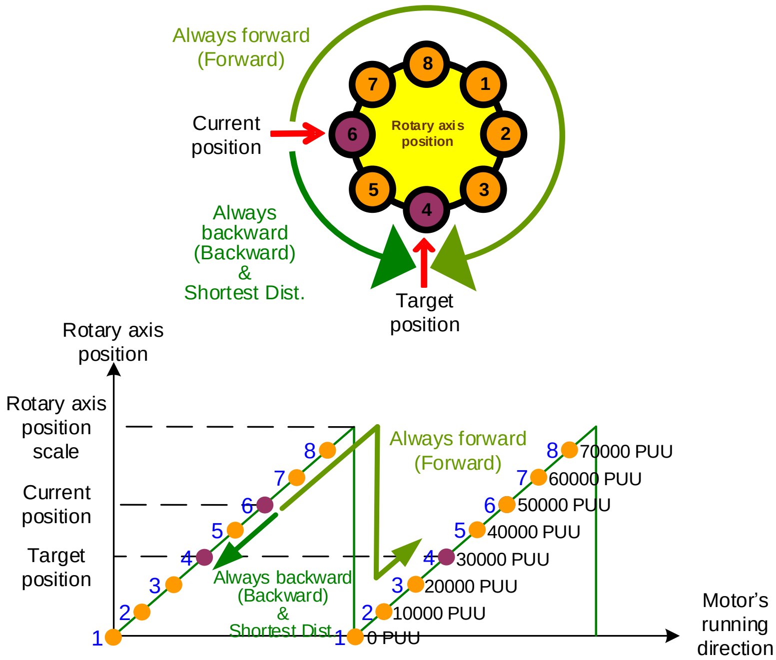

Figure 7.1.3.6.4 Motor's operation direction and rotary axis position

Table 7.1.3.6.1 Bit functions of the PR Rotary Axis Position command

PR parameters \ Bit	D	C	B	A	U	Z	Y	X
Property	-	OPT2	DLY	SPD	DEC	ACC	OPT	A
Data content	Rotary Axis Position command [PUU] (0 to P2.052 minus 1)							

Note:

1. X: A: INDEX, rotary axis position control (index position control)
2. Y: OPT, option

Bit	3	2	1	0	Description
Property	DIR		OVLP	INS	-
Data content	0	0	-	-	Always goes forward (Forward)
	0	1			Always goes backward (Backward)
	1	0			Shortest distance
	1	1			-

INS: interrupts the previous path when the current path is executed.

OVLP: allow overlapping of the next command.

DIR: rotation direction.

3. C: OPT2, option 2

Bit	3	2	1	0
Property	-	AUTO	-	S_LOW

S_LOW: speed unit options, 0 = 0.1 r/min and 1 = 0.01 r/min.

AUTO: once current PR path is finished, automatically loads the next path.

4. Z, U: ACC / DEC, acceleration / deceleration time, set by P5.020 - P5.035.
5. A: SPD, target speed, set by P5.060 - P5.075.
6. B: DLY, delay time, set by P5.040 - P5.055.

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7.1.4 Overview of the PR procedure

In the PR mode, there are six types of commands. To make users understand how the PR procedure works, ASDA-Soft presents the execution order and calling sequence of all PR procedures. The symbols and contents in the PR diagram are shown as follows. This includes five parts: number, command execution type (property), command type, next procedure command, and command information. See Figure 7.1.4.1.

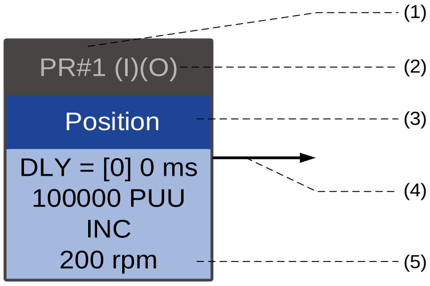

Figure 7.1.4.1 Overview of the PR procedure

(1) Number: the PR path number, ranging from PR#0 to PR#99 (100 sets of PR paths).

(2) Command execution type (property): (B) execute homing when power on; (O) command overlap; (R) write data to EEPROM; and (I) command interrupt.

(3) Command type: there are six types of PR procedure commands: Homing, Speed, Position, Jump, Write, and Rotary Axis Position (Index Position). The color displayed in this section depends on the command type.

(4) Next procedure command: if the current path is followed by a PR command, there would be an arrow pointing to the specified PR path.

(5) Command information: displays the details of this PR path. The displayed contents and color depend on the command type.

The following sections illustrate each command type and its representation.

Homing methods

In the display of homing methods, PR#0 always signifies the homing procedure, which is marked as “Homing”. See Figure 7.1.4.2.

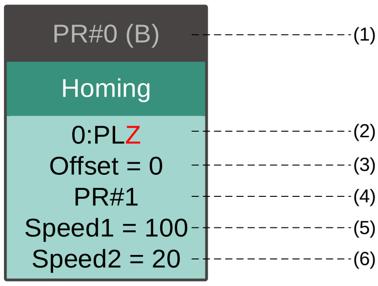

Figure 7.1.4.2 Homing methods display

(1) Activation mode (Boot): if the drive is set to execute homing in Servo On state after powered on, it displays (B); if homing is not required, no information is displayed.

(2) Method selection: including the homing methods and Z pulse setting which are shown in the following table. When the mode name ends with a “Z”, it means the servo looks for the Z pulse in the forward or reverse direction; when the mode name ends with a non-Z character, it means the servo does not look for the Z pulse. F signifies running forward; R signifies running in reverse; ORG signifies the origin; CUR signifies the current position; and BUMP signifies the hard stop.

Homing method	Y = 0: reverse to look for Z pulse Y = 1: go forward to look for Z pulse	Y = 2: do not look for Z pulse
X = 0: homing in forward direction and define the positive limit (PL) as the homing origin	0: PLZ	0: PL
X = 1: homing in reverse direction and define the negative limit (NL) as the homing origin	1: NLZ	1: NL
X = 2: homing in forward direction, ORG: OFF→ON as the homing origin	2: F_ORGZ	2: F_ORG
X = 3: homing in reverse direction, ORG: OFF→ON as the homing origin	3: R_ORGZ	3: R_ORG
X = 4: look for Z pulse in forward direction and define it as the homing origin	4: F_Z	
X = 5: look for Z pulse in reverse direction and define it as the homing origin	5: R_Z	
X = 6: homing in forward direction, ORG: ON→OFF as the homing origin	6: F_ORGZ	6: F_ORG
X = 7: homing in reverse direction, ORG: ON→OFF as the homing origin	7: R_ORGZ	7: R_ORG
X = 8: define the current position as the origin	8: CUR	
X = 9: torque homing in forward direction	9: F_BUMPZ	9: F_BUMP
X = A: torque homing in reverse direction	A: R_BUMPZ	A: R_BUMP

(3) Offset: origin offset, P6.001.

(4) Path: the next PR path to be executed after homing.

(5) Homing at high speed (Speed1): first homing speed, P5.005.

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(6) Homing at low speed (Speed2): second homing speed, P5.006.

Speed command

You can use the Speed command in any PR paths (PR#1 - PR#99). It is marked as “Speed”. See Figure 7.1.4.3.

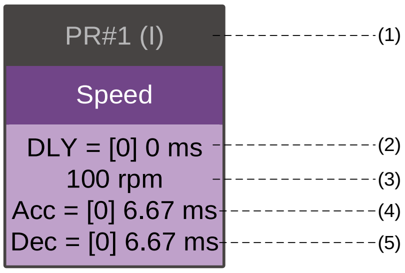


Figure 7.1.4.3 Speed command display

(1) Command execution type (property): a Speed command can interrupt (INS) the previous PR path. If the Interrupt function is enabled, it displays (I); if not, no information is displayed.

(2) Delay time (DLY): determined by the shared PR parameters. It is defined by the command from the controller; in other words, once the target speed is reached, the servo drive starts counting the delay time.

(3) Target speed: the set target speed.

(4) Acceleration time (Acc): determined by the shared PR parameters; length of time to reach the target speed from stopped.

(5) Deceleration time (Dec): determined by the shared PR parameters; length of time to decelerate from target speed to stopped.

7

Position command

You can use the Position command in any PR paths (PR#1 - PR#99). It is marked as “Position”, and includes the options to “Stop once position control completed” and “Load the next path once position control completed”. The only difference is that “Load the next path once position control completed” shows an arrow pointing to the next PR. See Figure 7.1.4.4.

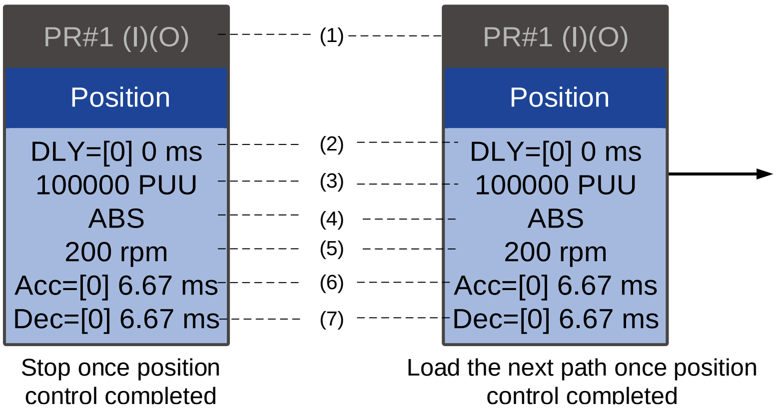


Figure 7.1.4.4 Position command display

(1) Command execution type (property): a Position command can interrupt (INS) the previous PR path. If the Interrupt function is enabled, it displays (I); if not, no information is displayed. You can also set an Overlap (OVLP) function in the Position command and set the delay time (DLY) to 0, so that the next PR path can overlap the current one. If the Overlap function is enabled, it displays (O); if not, no information is displayed.

(2) Delay time (DLY): determined by the shared PR parameters. It is defined by the command from the controller; in other words, once the target position is reached, the servo drive starts counting the delay time.

(3) Target position: the set target position.

(4) Position command type: “ABS” means absolute positioning; “REL” means relative positioning; “INC” means incremental positioning; and “CAP” means high-speed position capturing.

(5) Target speed: determined by the shared PR parameters.

(6) Acceleration time (Acc): determined by the shared PR parameters; length of time to reach the target speed from stopped.

(7) Deceleration time (Dec): determined by the shared PR parameters; length of time to decelerate from target speed to stopped.

7

Jump command

You can use the Jump command in any PR paths (PR#1 - PR#99). It is marked as “Jump” and followed by an arrow pointing to the next PR path. See Figure 7.1.4.5.

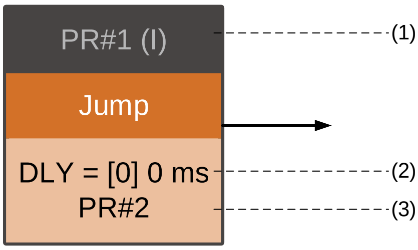


Figure 7.1.4.5 Jump command display

(1) Command execution type (property): a Jump command can interrupt (INS) the previous PR path. If the Interrupt function is enabled, it displays (I); if not, no information is displayed.

(2) Delay time (DLY): determined by the shared PR parameters.

(3) Target PR number: the set target PR number.

Write command

You can use the Write command in any PR paths (PR#1 - PR#99). It is marked as “Write”. See Figure 7.1.4.6.

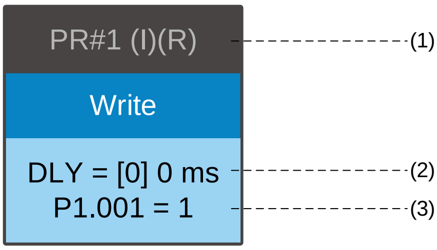


Figure 7.1.4.6 Write command display

(1) Command execution type (property): a Write command can interrupt (INS) the previous PR path. If the Interrupt function is enabled, it displays (I); if not, no information is displayed. You can determine whether to write the data to EEPROM.
If writing data to EEPROM is required, it shows (R); if not, no information is displayed.

(2) Delay time (DLY): determined by the shared PR parameters.

(3) Writing target and data source: the corresponding target and data sources are shown in the following table. Note that constants can be written in DEC or HEX format.

Writing target	Data source
Parameter (PX.XXX)	Constant
Data array (Arr[#])	Parameter (PX.XXX)
-	Data array (Arr[#])
-	Monitoring variable (Mon[#])

Rotary Axis Position command (Index Position)

You can use the Rotary Axis Position command in any PR paths (PR#1 - PR#99). The number of PR paths is determined by the number of Rotary Axis commands. It is marked as "Index Position". See Figure 7.1.4.7.

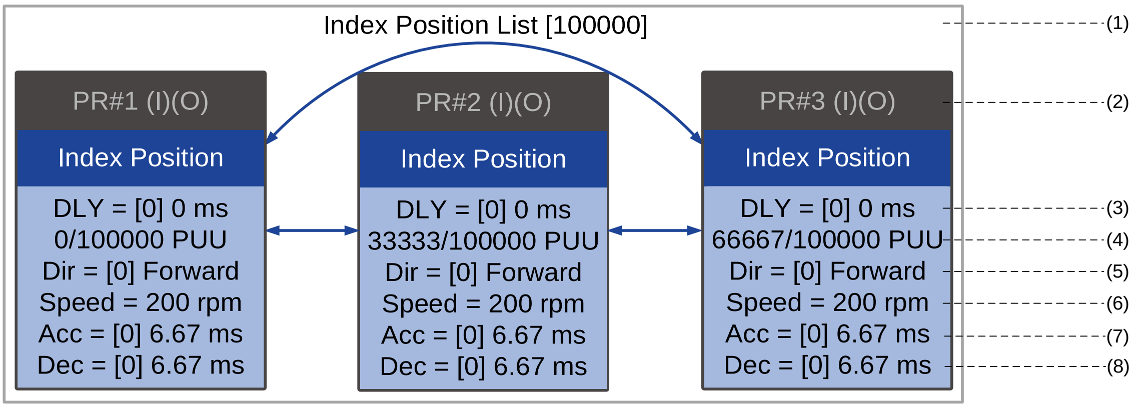


Figure 7.1.4.7 Rotary Axis Position command (Index Position) display

(1) Rotary Axis Position command section: a set of Rotary Axis Position commands. It shows the total moving distance at the top using double arrows to show that the motor can run reciprocally between each target position in each PR path.

(2) Command execution type (property): a Rotary Axis Position command can interrupt (INS) the previous PR path. If the Interrupt function is enabled, it displays (I); if not, no information is displayed. You can also set an Overlap (OVLP) function in the Rotary Axis Position command and set the delay time (DLY) to 0, so that the next PR path can overlap the current one If the Overlap function is enabled, it displays (O); if not, no information is displayed.

(3) Delay time (DLY): determined by the shared PR parameters. It is defined by the command from the controller; in other words, once the target position is reached, the servo starts counting the delay time.

(4) Position command: the numerator is the target position of this PR path; the denominator is the total moving distance of this Rotary Axis Position command, which is set by P2.052.

(5) Rotation direction (Dir): available options are "Always move forward (Forward)", "Always move in reverse direction (Reverse)", and "The shortest distance (Shortest)".

(6) Target speed: determined by the shared PR parameters.

(7) Acceleration time (Acc): determined by the shared PR parameters; length of time to reach the target speed from stopped.

(8) Deceleration time (Dec): determined by the shared PR parameters; length of time to decelerate from target speed to stopped.

7.1.5 Trigger methods for the PR command

There are four types of PR trigger methods. They are Digital input (DI) triggering, Event triggering, PR command trigger register (P5.007), and High-speed position capture (Capture) triggering. Choose the most suitable trigger method according to the applications and requirements.

Digital input (DI) triggering

You can choose the PR path to be executed by using the internal command registers (POS0 - POS6) and use the CTRG command to trigger the selected PR path. Before triggering the PR command with the digital inputs (DIs), you must define the functions of the 8 sets DIs, which are DI.POS0 (0x11), DI.POS1 (0x12), DI.POS2 (0x13), DI.POS3 (0x1A), DI.POS4 (0x1B), DI.POS5 (0x1C), DI.POS6 (0x1E), and DI.CTRG (0x08) (refer to Table 8.1). You can set these DIs in the Digital IO setting screen in ASDA-Soft, as shown in Figure 7.1.5.1.

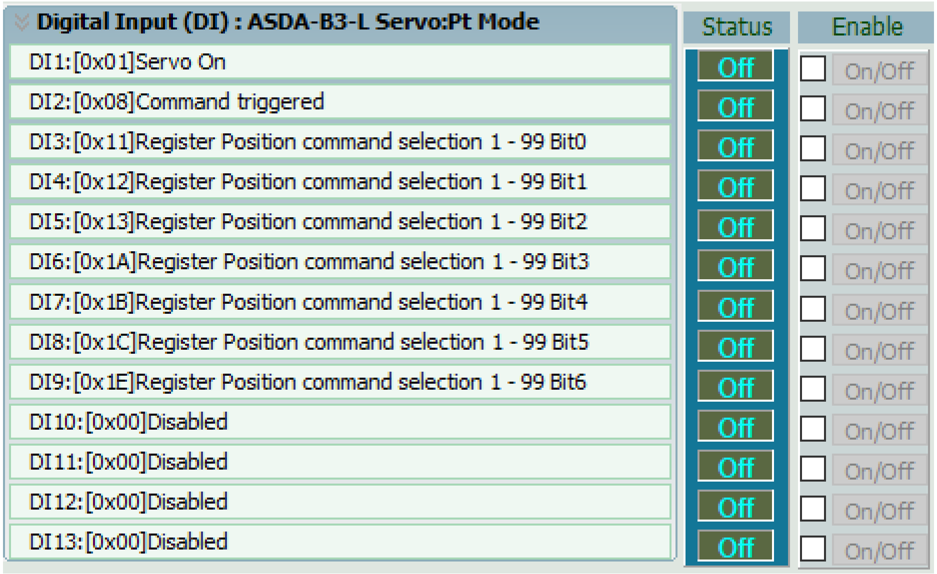


Figure 7.1.5.1 Digital IO setting screen in ASDA-Soft

Select the PR number to be executed based on the on / off status of DI.POS0 - POS6 and use DI.CTRG to trigger the specified PR path. See the following table for an example.

Position command	POS 6	POS 5	POS 4	POS 3	POS 2	POS 1	POS 0	CTRG	Correspon-ding parameter
Homing	0	0	0	0	0	0	0	↑	P6.000 P6.001
PR#1	0	0	0	0	0	0	1	↑	P6.002 P6.003
…									…
PR#50	0	1	1	0	0	1	0	↑	P6.098 P6.099
PR#51	0	1	1	0	0	1	1	↑	P7.000 P7.001
…									…
PR#99	1	1	0	0	0	1	1	↑	P7.098 P7.099

In addition, there are two sets of DIs for special functions: DI.SHOM (0x27) and DI.STP (0x46). If the former is triggered, the servo drive executes homing based on the homing setting. If the latter is triggered, the servo drive stops the motor. You can use the Digital IO setting screen in ASDA-Soft to set these functions, as shown in Figure 7.1.5.2.

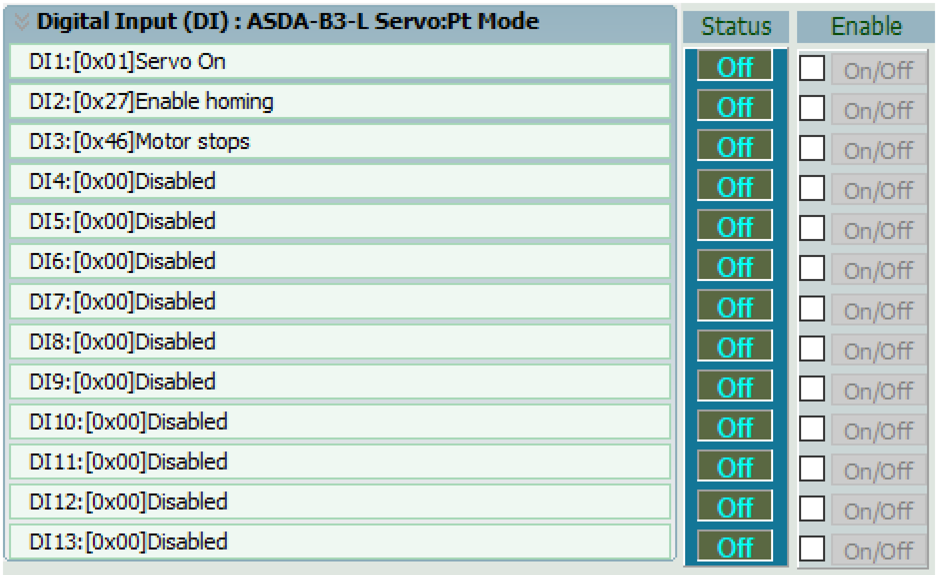


Figure 7.1.5.2 Digital IO setting screen in ASDA-Soft

Event triggering

You can use Event trigger commands 1 - 4 to execute the specified PR path. There are two types of Event triggering: rising-edge trigger and falling-edge trigger. The PR path numbers that you can specify are PR#51 - 63 (see the example in Figure 7.1.5.3). Before using the event triggering for PR commands, you must define the functions of these DIs, which are DI.EV1 (0x39), DI.EV2 (0x3A), DI.EV3 (0x3B), and DI.EV4 (0x3C) (see Table 8.1). You can use the Digital IO setting screen in ASDA-Soft to set these functions, as shown in Figure 7.1.5.4.

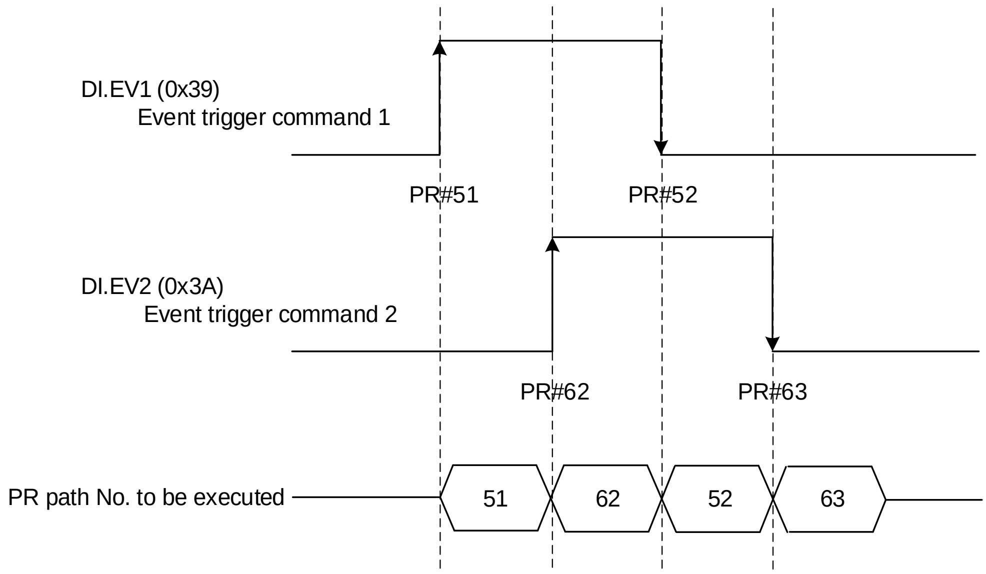


Figure 7.1.5.3 Example of event triggering timing diagram

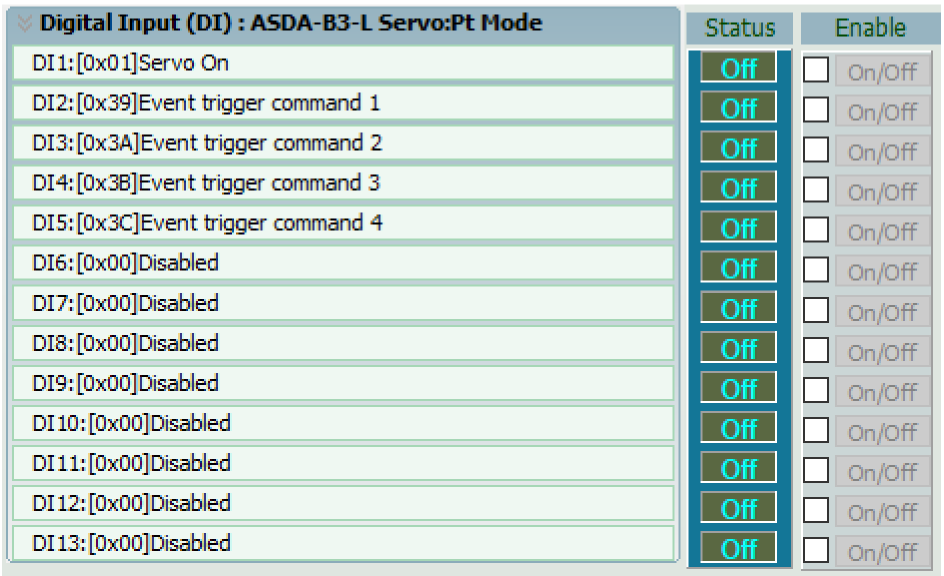


Figure 7.1.5.4 Digital IO setting screen in ASDA-Soft

You can set the rising-edge trigger of the PR path with P5.098 and set the falling-edge trigger with P5.099. Refer to Chapter 8 for more details. You can also use ASDA-Soft to set the event trigger of PR paths. See Figure 7.1.5.5.

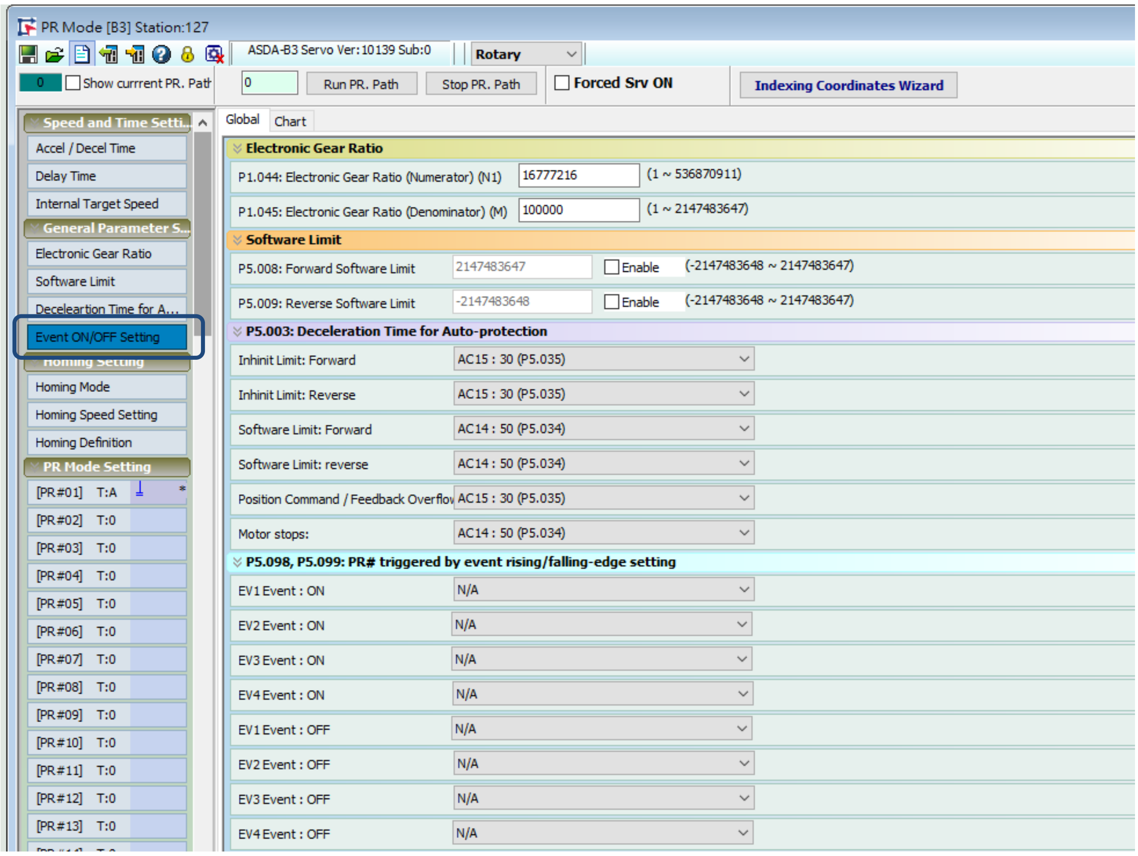


Figure 7.1.5.5 Event ON / OFF setting screen in ASDA-Soft

PR command trigger register (P5.007)

You can write the PR number to be executed in P5.007 to have the servo drive execute the specified PR path. If you set P5.007 to 0, the servo drive executes homing. If you set P5.007 to 1 - 99, the servo drive executes the specified PR path. If you set P5.007 to 1000, the servo drive stops executing PR commands. Refer to the setting descriptions of P5.007 in Chapter 8.

High-speed position capture (Capture) triggering

You can trigger the specified PR path with the high-speed position capture function. When the capturing completes, you can set whether to trigger PR#50 with P5.039.X [Bit 3]. For detailed settings, refer to Section 7.2.2.

7.1.6 PR procedure execution flow

The servo drive updates the command status every millisecond. Figure 7.1.6.1 illustrates how the servo drive deals with the PR commands. Once a PR procedure is triggered, it goes through three processing units, which are PR queue, PR executor, and motion command generator.

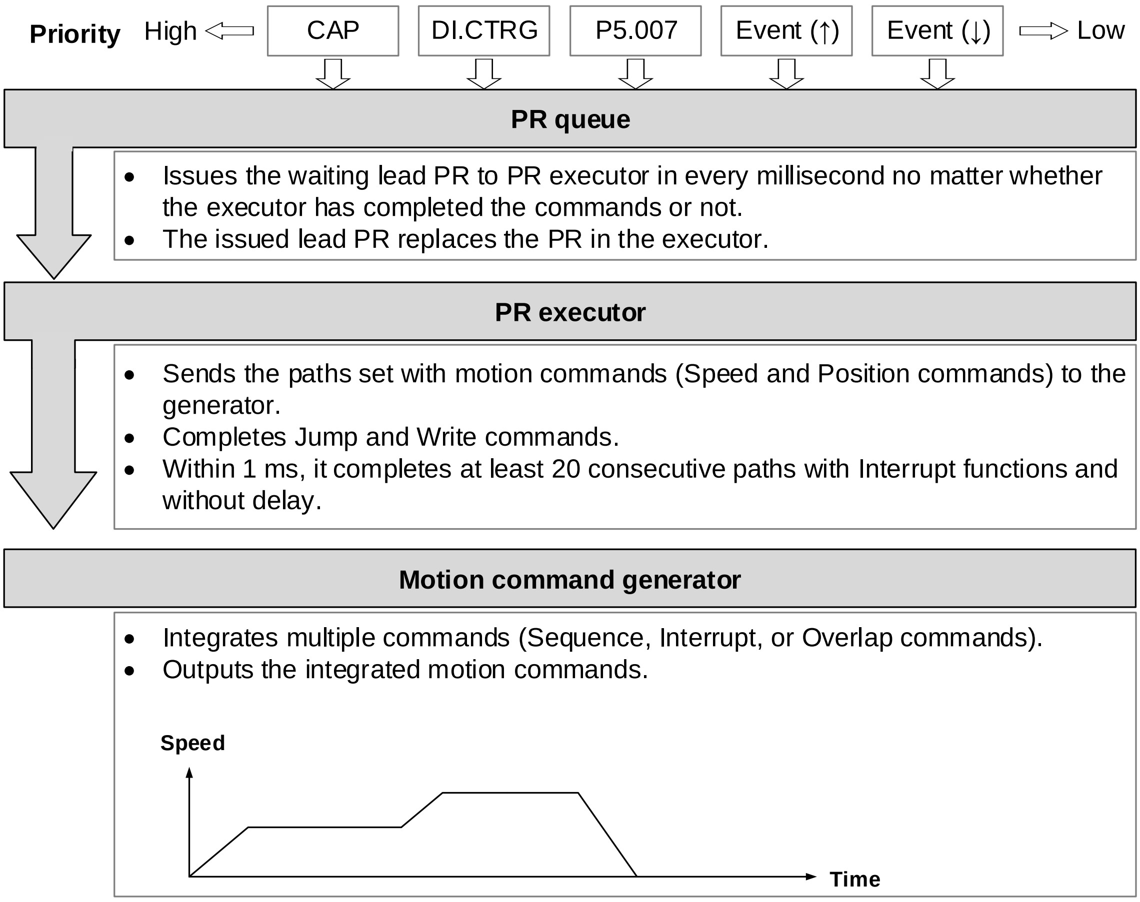


Figure 7.1.6.1 PR execution flow in the servo drive

■ **Trigger mechanism**

As mentioned in Section 7.1.5, the servo drive provides multiple trigger methods. A PR procedure is executed as long as a trigger signal is output. When two different trigger commands are generated within the same ms, the priority is as follows: High-speed position capture triggering (CAP) > DI triggering (DI.CTRG) > PR command trigger register (P5.007) > Rising-edge event triggering (Event ↑) > Falling-edge event triggering (Event ↓). Within this ms, commands with higher priority are executed first and then the lower priority commands are sent in the next ms. If three trigger commands are generated in the same ms, the third is not added to the PR queue.

■ **PR queue**

The triggered PR path is the lead PR. The PR group it leads goes into the PR queue to wait for prioritization. In each ms, the servo drive sends the lead PR and the PR group it leads to the PR executor with a first-in first-out method no matter whether a PR path is being executed. Therefore, as long as a PR path is triggered, the PR queue collects it and sends it to the executor.

■ **PR executor**

Once the PR executor receives the lead PR and its PR group, the PR group that is being executed will be replaced immediately. If the received PR group includes motion commands (Speed and Position commands), then the PR executor sends them to the motion command generator. PR paths with Write or Jump commands are complete at the moment when the PR executor reads the command, and thus they do not enter the generator. The PR executor can consecutively complete at least 20 PR paths with Interrupt functions (INS) without delay (DLY) within 1 ms. If there are PR paths that have not been completed within 1 ms, and a new PR group is sent to the executor by the PR queue, the new PR group then replaces the previous PR group. In other words, instead of executing the PR group that hasn't been completed, the executor starts executing the new PR group. If there are PR paths that have not been completed within 1 ms but no new PR group is sent to the executor, the executor continues to execute the unfinished PR paths.

■ **Motion command generator**

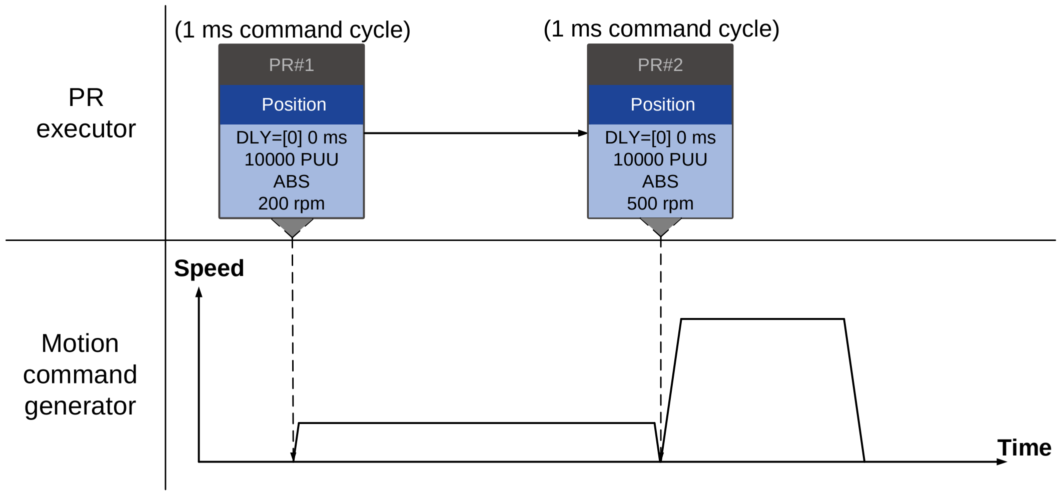
The PR executor sends the motion commands (Speed and Position commands) to the motion command generator. This generator has a buffer for temporarily storing the next motion command and all motion commands are integrated here. Motion commands can be executed as soon as they enter the generator. If another motion command with the Interrupt setting also enters the generator, it is integrated with the current command in the generator. The settings of the integrated command, including whether multiple motion commands are Sequence commands and whether they are set with the Interrupt (INS) or Overlap (OVLP) function, are determined by the setting of each PR path.

Sequence command

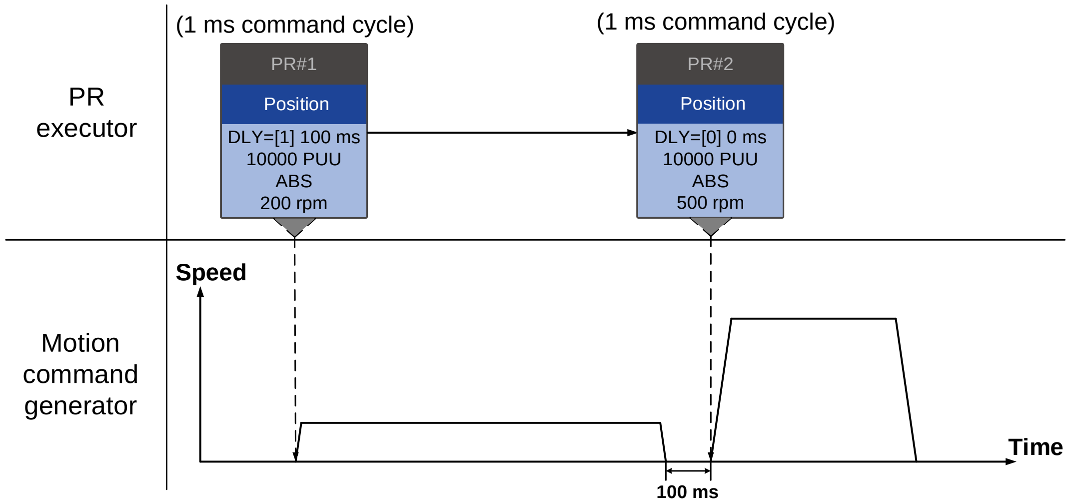
The configurable motion commands for PR paths are the Position and Speed commands. A Sequence command is a series of motion commands without the Overlap (OVLP) or Interrupt (INS) function, and the following command starts to be executed only after the delay time (DLY) set in the previous command. For Position commands, the delay time starts to count after the target position is reached. For Speed commands, the delay time starts to count after the target speed is reached.

- Position command ▶ Position command

When the PR executor receives two consecutive Position commands without the Interrupt or Overlap functions, the PR executor issues the first Position command to the motion command generator, and the generator starts the first part of position control. After the first Position command completes, if no delay time is set, the PR executor issues the second Position command for the generator to start the second part of position control (see Figure 7.1.6.2 (a)). If the first Position command includes a delay, the PR executor starts counting the delay time right after the motor reaches the target position. Then it issues the second Position command for the generator to start the second part of position control as shown in Figure 7.1.6.2 (b).



(a) Position command without delay



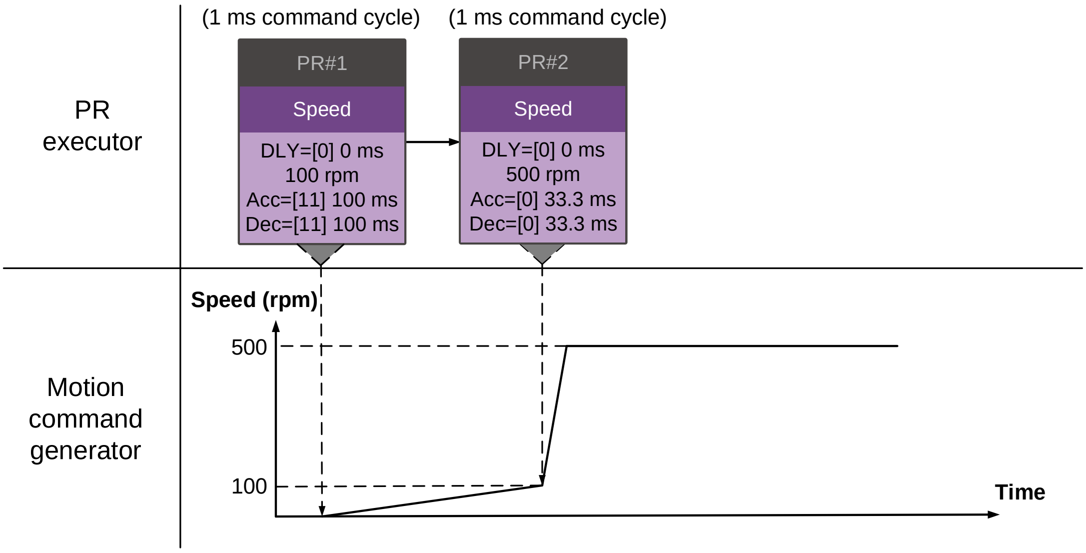
(b) Position command with delay

Figure 7.1.6.2 Position Sequence command

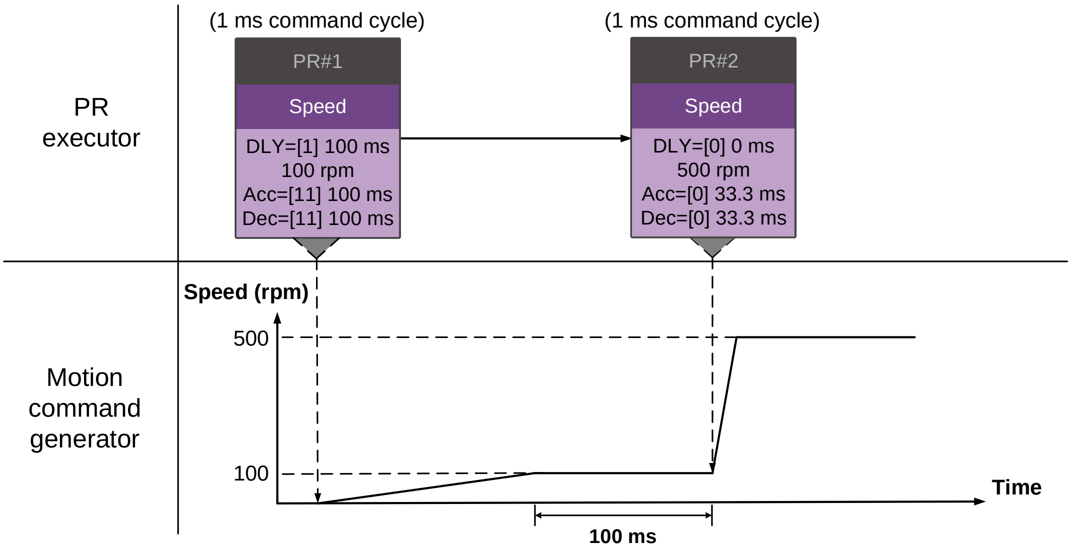
■ Speed command ▶ Speed command

When the PR executor receives two consecutive Speed commands without the Interrupt or Overlap functions, the PR executor issues the first Speed command to the motion command generator, and the generator starts the first part of speed control. After the first Speed command completes, if no delay time is set, the PR executor issues the second Speed command for the generator to start the second part of speed control (see Figure 7.1.6.3 (a)).

If the first Speed command includes a delay, the PR executor starts counting the delay time right after the motor reaches the target speed. Then it issues the second Speed command for the generator to start the second part of speed control as shown in Figure 7.1.6.3 (b).



(a) Speed command without delay



(b) Speed command with delay

Figure 7.1.6.3 Speed Sequence command

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■ Multiple commands

The PR queue updates commands every millisecond. For a motion command, the PR queue sends the next command to the generator only after the previous command completes. Jump or Write commands are executed by the PR executor immediately. As shown in Figure 7.1.6.4, in the first ms, the PR queue receives a Position command and the PR executor sends this command to the motion command generator, having the generator to execute the command. In the second ms, the PR queue receives a Write command and the PR executor executes it immediately.

In the third ms, the PR queue receives a Jump command and the PR executor executes it immediately as well. These two commands (Write and Jump commands) are not sent to the motion command generator since the PR executor and the generator execute commands independently. In the fourth ms, the PR queue receives a Position command and the PR executor sends this Position command to the generator for execution.

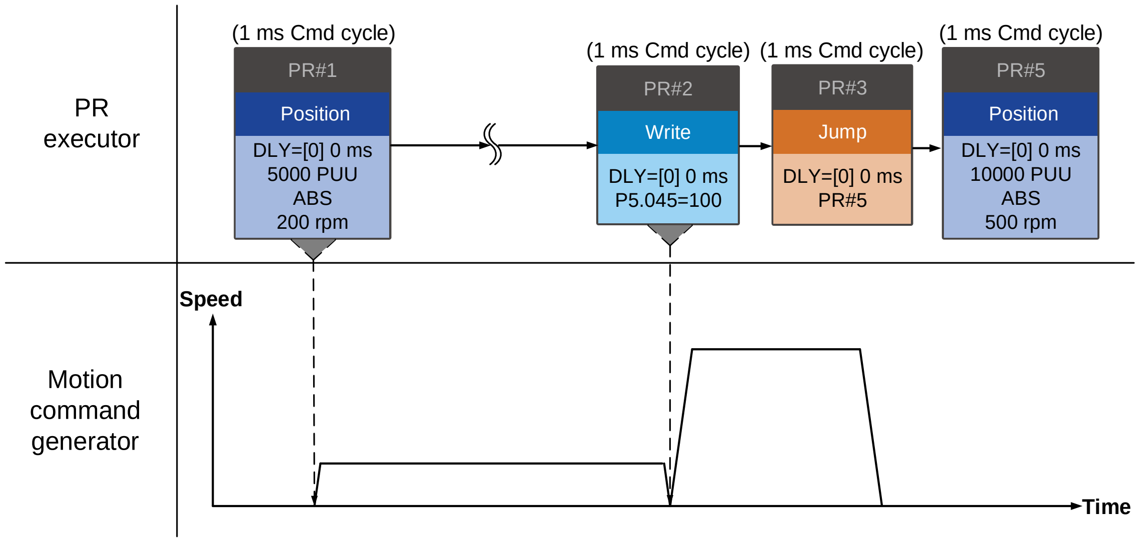


Figure 7.1.6.4 Multiple Sequence commands

Command interruption

Interruption (INS) causes a command in execution to be replaced or integrated by the next command. The results of the interruption differ based on the command types. There are two types of interruption: internal and external, as shown in Figure 7.1.6.5.

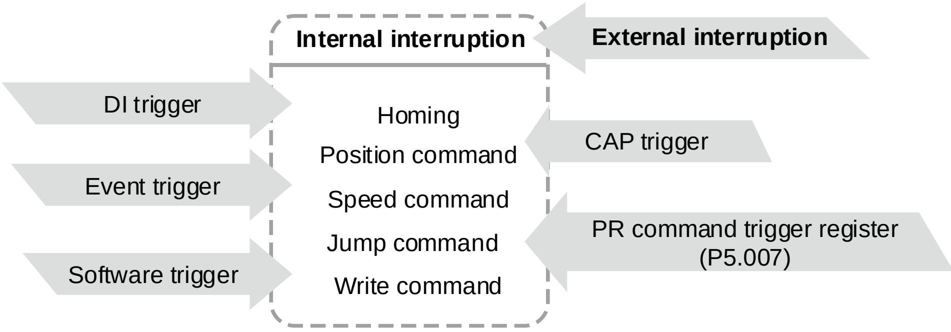


Figure 7.1.6.5 Internal and external interruption

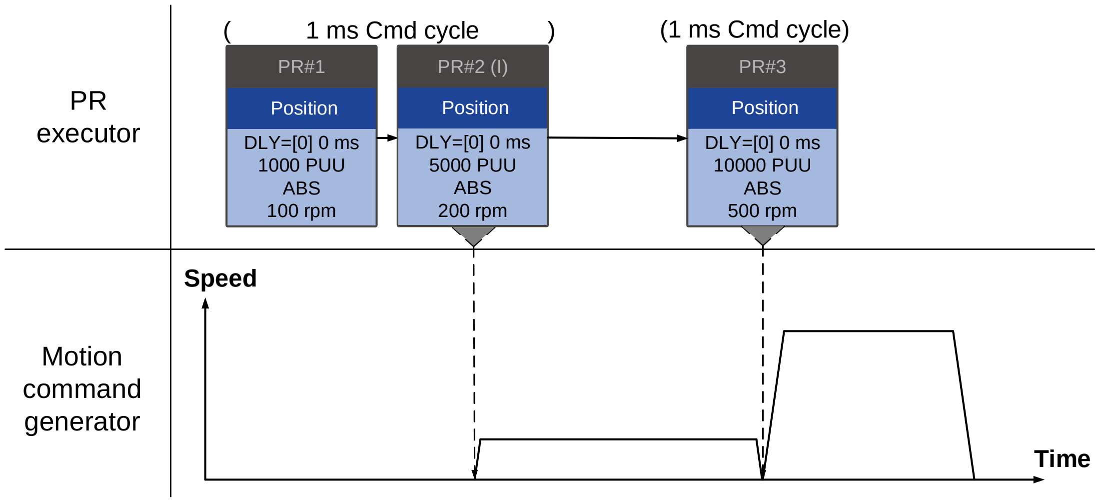
1. Internal interruption

For a series of PR paths, if one PR path includes an AUTO function (auto-execute the next path), the system continues to read the next path right after reading the current path instead of reading the next path after the current path is complete. If the current path includes a delay, the next path is read after the delay time is over. Meanwhile, if the next path includes an Interrupt function (which has a higher execution priority), the servo drive immediately executes the interrupt command by replacing the un-executed commands in the previous path with the next path or integrating the commands of the previous path which are in execution with the next path.

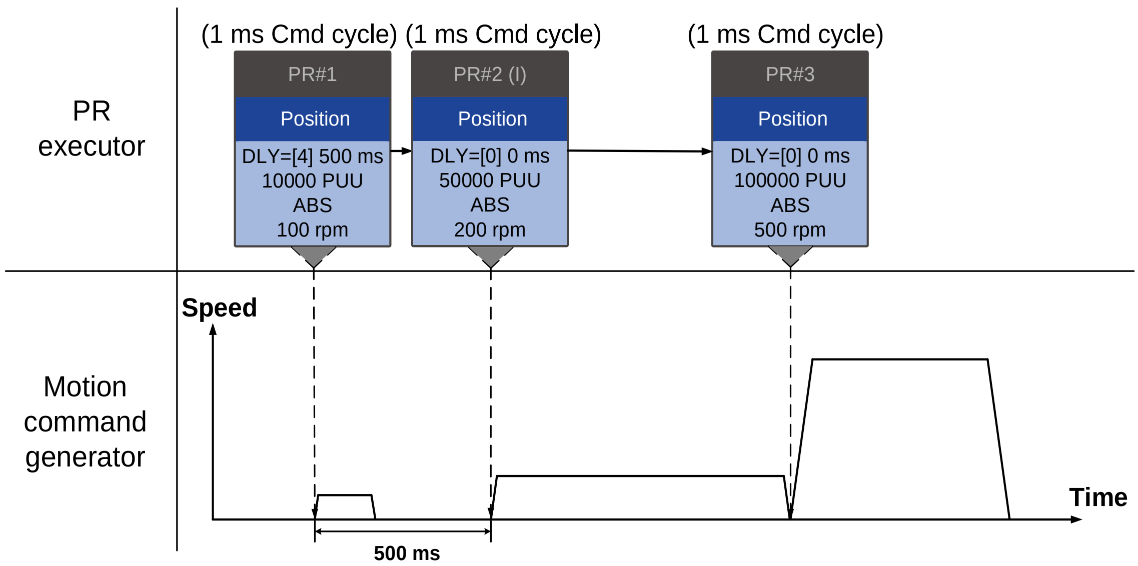
■ Position command ▶ Position command (I) ▶ Position command

When the PR executor receives three consecutive Position commands with the second command set with an Interrupt function, the executor treats the first and the second Position commands as one PR group. Since the first Position command is not executed by the executor, the executor replaces the first command with the second command and only sends the second command to the motion command generator for execution. After the second command is complete, the executor sends the third command to the generator (see Figure 7.1.6.6 (a)).

If the first command includes a delay, the PR executor sends the first command to the generator and then starts counting the delay time. After the delay is over, the executor then sends the second command and the generator starts the second part of speed control. While the first command is still being executed, it is integrated with the second command. Since this integration differs from that described in Section 7.1.3, refer to the following note for descriptions. Once the integrated command is complete, the executor sends the third command to the generator for execution (see Figure 7.1.6.6 (b)).



(a) Position command without delay



(b) Position command with delay

Figure 7.1.6.6 Internal interruption - Position command

Note: the way to integrate the position commands of internal interruption is slightly different from what is described in Section 7.1.3.3.
In general, the relative position command (REL)'s target position = motor's current position + command value. However, for internal interruption, the relative position command (REL) works the same as the incremental position command (INC), with the target position = previous target position + command value. See the following example.
The rest of the integration method is the same as that mentioned in Section 7.1.3.3.

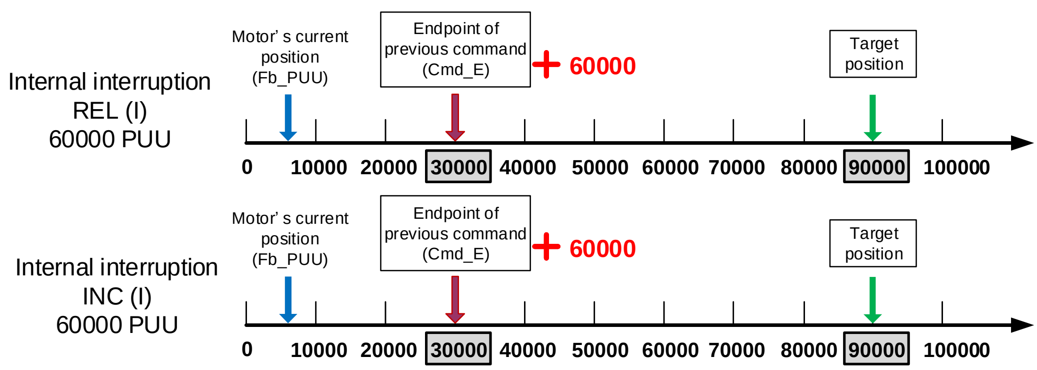
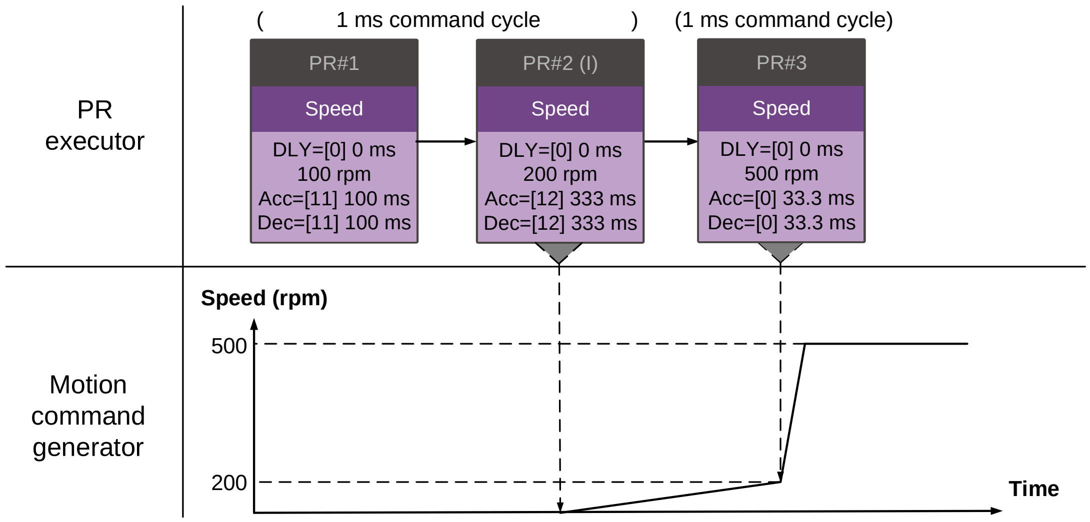


Figure 7.1.6.7 Example of relative and incremental position commands for internal interruption

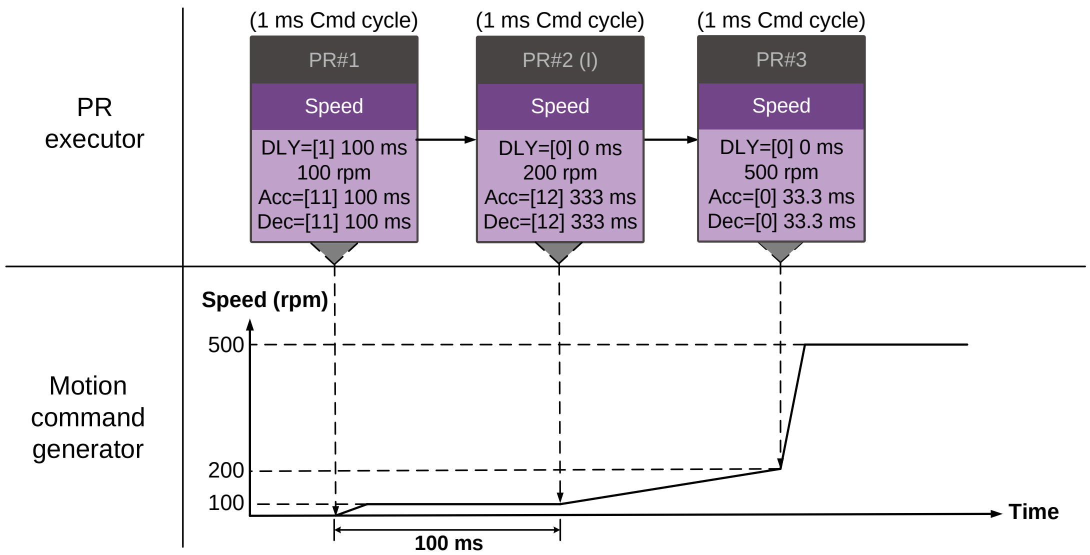
■ Speed command ▶ Speed command (I) ▶ Speed command

When the PR executor receives three consecutive Speed commands with the second command set with an Interrupt function, the executor treats the first and the second as one PR group. Since the first Speed command is not executed by the executor, the executor replaces the first command with the second command and only sends the second command to the motion command generator for execution. After the second command is complete, the executor sends the third command to the generator (see Figure 7.1.6.8 (a)).

If the first command includes a delay, the PR executor sends the first command to the generator and then starts counting the delay time. After the delay is over, the executor then sends the second command and the generator starts the second part of speed control. While the first command is still being executed, it is integrated with the second command. Once the second command is complete, the executor sends the third to the generator for execution (see Figure 7.1.6.8 (b)).



(a) Speed command without delay



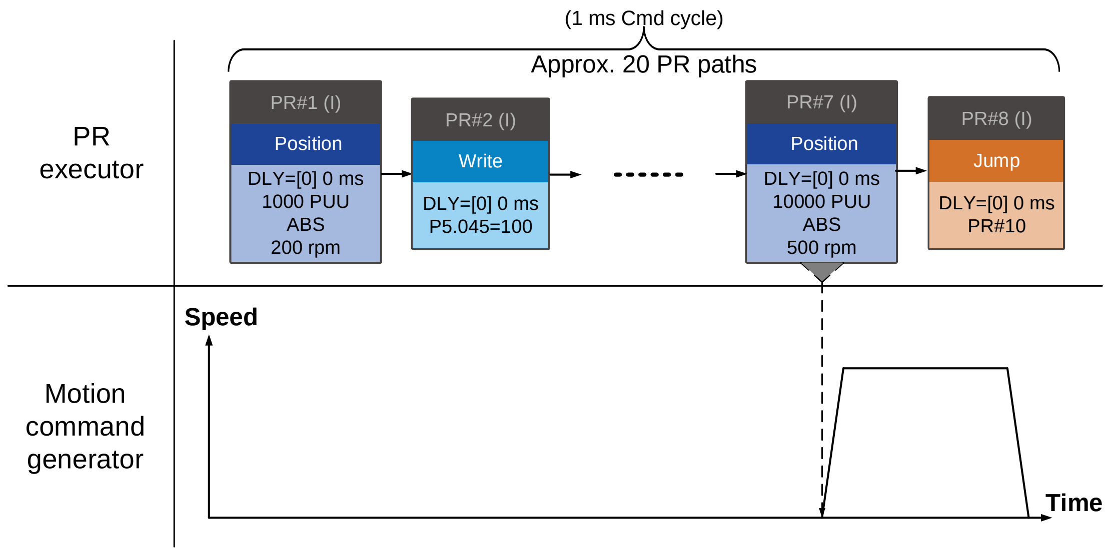
(b) Speed command with delay

Figure 7.1.6.8 Internal interruption - Speed command

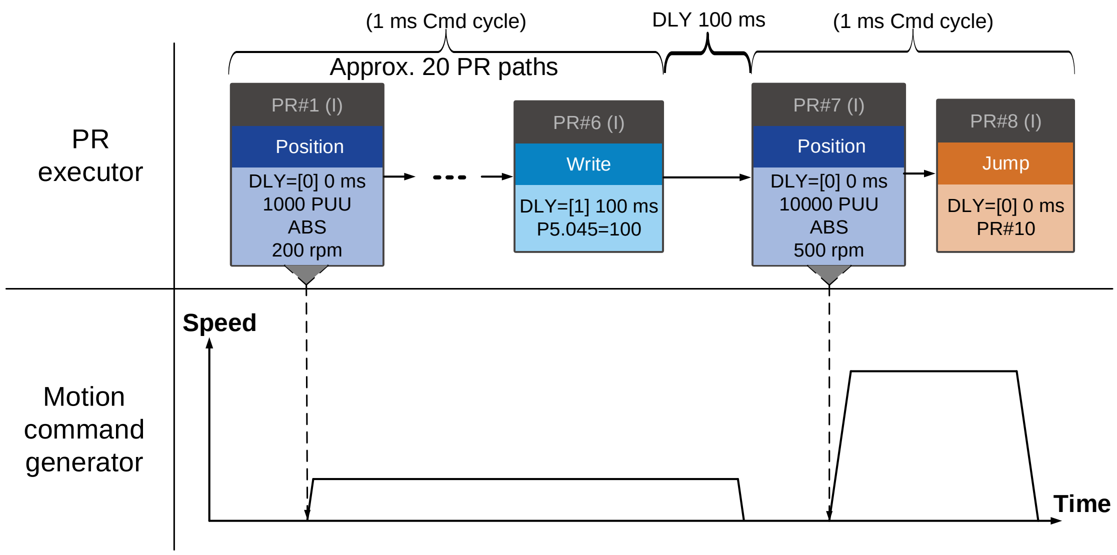
■ Multiple interrupt commands

The PR queue updates commands every millisecond. If all PR paths are consecutive with Interrupt functions and without delay, the queue can read at least 20 PR paths in 1 ms, and these paths are regarded as a PR group. If this PR group includes multiple motion commands, the PR queue only sends the last command it receives to the motion command generator for execution. Therefore, in a PR group, only one PR path with motion command is executed. The latter motion command directly replaces the former, whereas Jump and Write commands are executed by the executor as soon as they are received by the PR queue (see Figure 7.1.6.9 (a)).

If one of the PR paths includes a delay, the PR queue regards this PR path and the prior path(s) as the first PR group, and what follows is the second PR group. In this case, this PR procedure can execute up to two PR paths with motion commands, as shown in Figure 7.1.6.9 (b).



(a) Multiple commands without delay



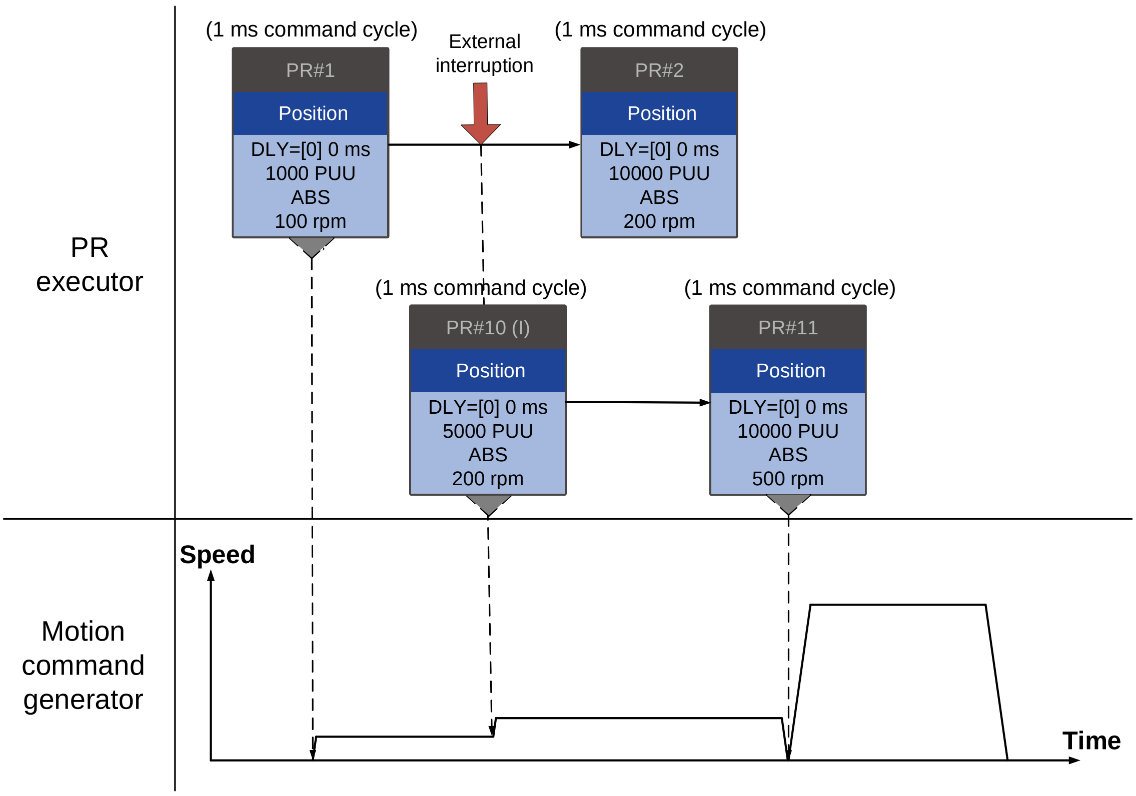
(b) Multiple commands with delay

Figure 7.1.6.9 Internal interruption - Multiple commands

2. External interruption

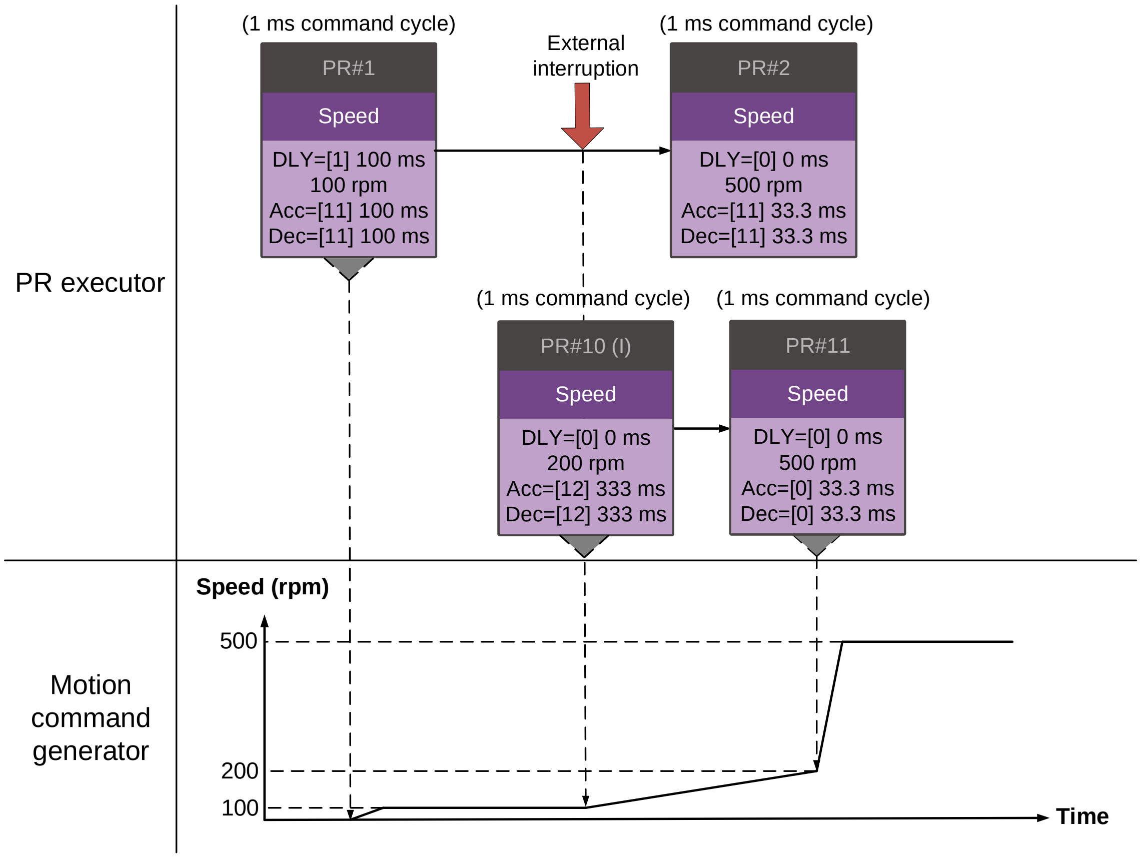
When a PR path is being executed, if another PR path is forced to execute with any of the trigger methods for the PR command (refer to Section 7.1.5 for PR trigger methods), the PR queue receives a PR path with an Interrupt function and sends this path to the motion command generator immediately, and then changes the path in execution. Note that a delay does not change the result of an external interruption. That is, once the PR queue receives an external interrupt command, the motion commands in the latter part are executed by the generator and integrated with the previous command.

The external interruption of the Position command is as shown in Figure 7.1.6.10 (a). If a PR path with an Interrupt function enters the PR executor by external interruption, the executor sends this Position command immediately to the generator so that the motor can run in accordance with the interruption. The motor uses the settings that integrate with the former motion command when running. The methods of integration are described in Section 7.1.3.3. The external interruption of the Speed commands is the same as that of the Position commands (see Figure 7.1.6.10 (b)), and the same is true for multiple commands.



(a) External interruption - Position command

7



(b) External interruption - Speed command

Figure 7.1.6.10 External interruption

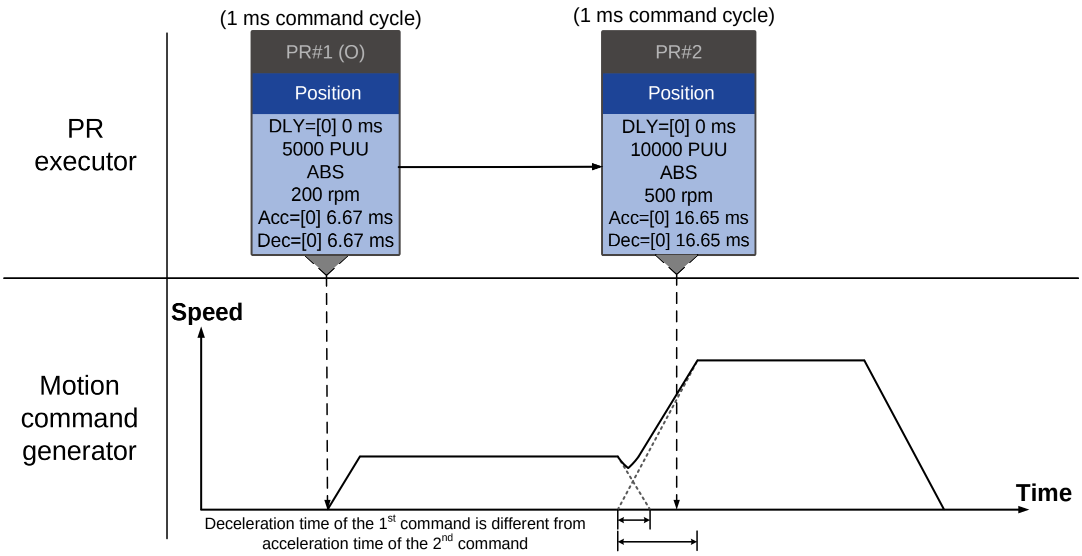
Overlap command

If the previous position command includes an Overlap (OVLP) function, it allows the next command to be executed while the previous motion is decelerating, thus achieving a continuous motion. When you use an Overlap command, the delay time is still effective. The delay time starts to count from the start point of the command with the delay time setting; however, in order to have a smooth command transition, setting the delay time to 0 is suggested. In addition, if the deceleration time of the previous command is identical to the acceleration time of the next command, the discontinuous speed during transition can be avoided, smoothing the transition between commands (see Figure 7.1.6.11).

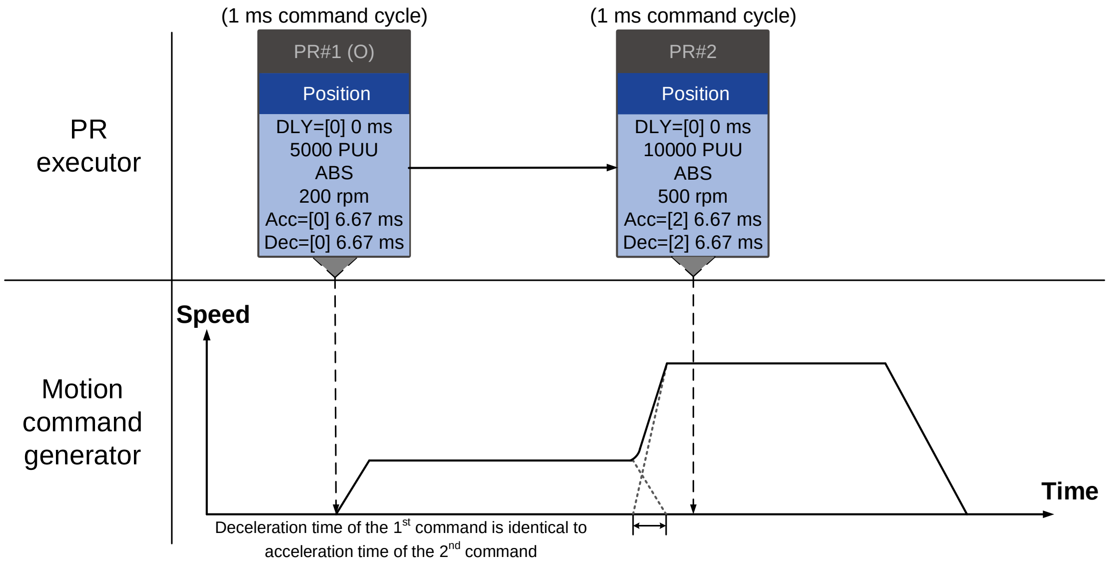
The relationship between the 1st target speed and its deceleration time and the relationship between the 2nd target speed and its acceleration time are as follows.

$$\frac{\text{1st target speed (Spd1)}}{3000} \times \text{Deceleration time (Dec)} = \frac{\text{2nd target speed (Spd2)}}{3000} \times \text{Acceleration time (Acc)}$$

An Interrupt command has a higher priority than an Overlap command. Thus, when you set an Overlap function in the current Position command, and the next motion command includes an Interrupt function, only the command with the Interrupt function is executed.



(a) Overlap command - Acceleration and deceleration times are different



(b) Overlap command - Acceleration and deceleration times are identical

Figure 7.1.6.11 Overlap command

Interpret PR path flow

The PR paths mentioned earlier include commands such as Sequence, Interrupt, and Overlap. The replacement, integration, and overlapping for commands lead to different behavior depending on the settings. The suggested steps to interpret a series of PR paths are as follows.

1. Check the command sequence. Check whether there are delay time (DLY) and interrupt (INS) settings because these two types change the command execution sequence.
2. Find the lead PR and identify the PR groups of each ms.
3. In each PR group of 1 ms, only the last motion command is executed. The Jump and Write commands are immediately executed in the PR executor.
4. Position commands are combined based on the principle described in Section 7.1.3.3.

7.2 Application of motion control

The servo drive motion control includes the high-speed position capture function (Capture). The Capture function uses the digital input DI3 (-F, -M, B3A-P models) or DI7 (-L models) to instantly capture the motor's feedback position and store this position in the data array. Refer to the following sections for more details about the setting and how it works.

Note: -E models do not support the Capture function.

7.2.1 Data array

The data array can store up to 128 sets of 32-bit data (0 - 127) captured by the high-speed capture function. Set P2.008 to 30 and then 35 or use ASDA-Soft to write the data to EEPROM; otherwise, the data in RAM is volatile. ASDA-Soft provides a user-friendly screen for reading and writing the data array.

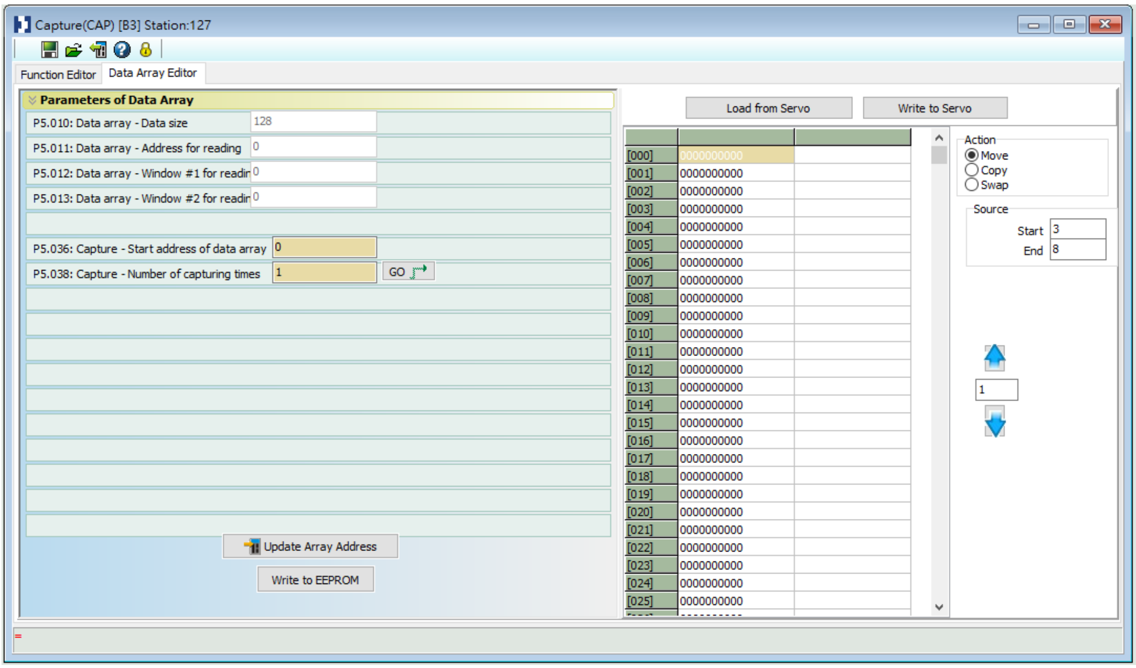


Figure 7.2.1.1 Data Array Editor screen in ASDA-Soft

You can use the panel, communication, or ASDA-Soft to read data from or write data to the data array with parameter settings. The first group of parameters for reading and writing the data array are P5.011 - P5.013. P5.011 specifies the address of data array to be read and written. P5.012 and P5.013 read data from or write data to the data array address set by P5.011. The behaviors after reading and writing with P5.012 and P5.013 differ. Refer to Table 7.2.1.1 for more information.

The second group of parameters for reading and writing the data array are P5.011 and P5.100 - P5.103. P5.011 specifies the address of data array to be read and written. P5.100 reads data from or writes data to the data array address set by P5.011. P5.101 reads data from or writes data to the data array address following the address set by P5.011. P5.102 and P5.103 work the same way. If the address value accumulates and exceeds the maximum value, the return content of the address is 0. Refer to Table 7.2.1.2 for descriptions and examples.

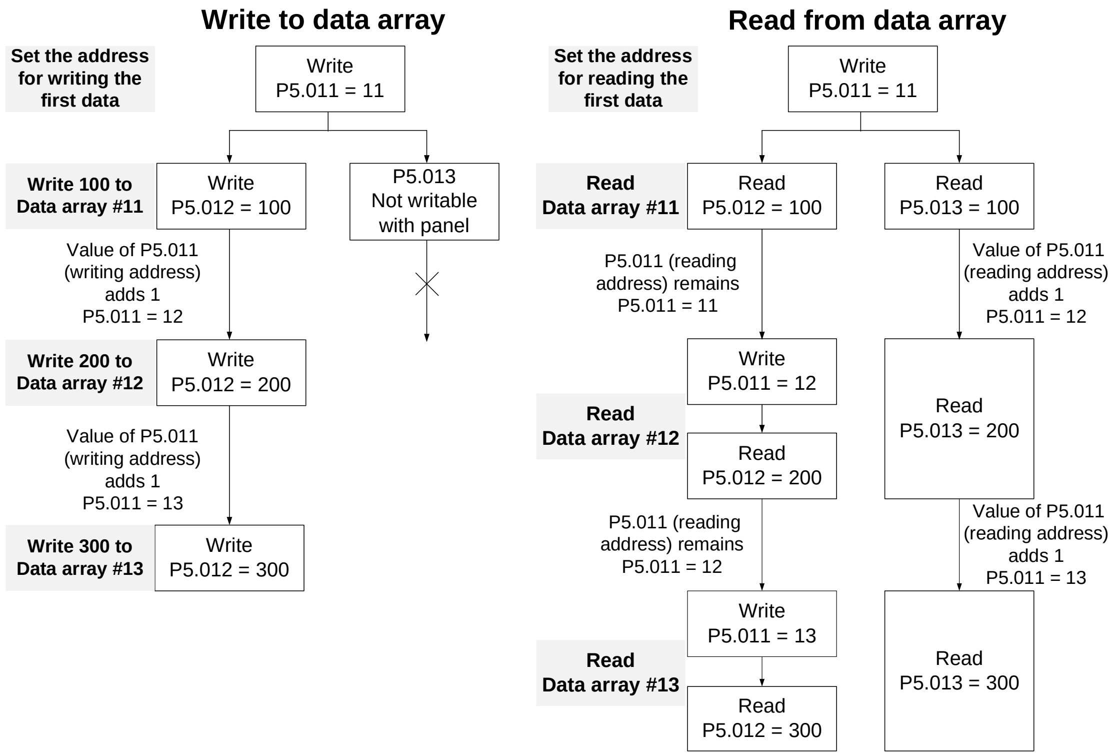
Table 7.2.1.1 Group 1 parameters for reading and writing the data array

Parameter	Description		
P5.011 Address for reading and writing	Specifies the data array address for reading and writing		
Window for reading and writing	Read / write with	Behavior after reading	Behavior after writing
P5.012 Window #1 for reading and writing	Panel	**Value of P5.011 does not add 1**	Value of P5.011 adds 1
	Communication / ASDA-Soft	Value of P5.011 adds 1	Value of P5.011 adds 1
P5.013 Window #2 for reading and writing	Panel	Value of P5.011 adds 1	**Not writable with the drive panel**
	Communication / ASDA-Soft	Value of P5.011 adds 1	Value of P5.011 adds 1

Example: reading and writing the data array through the drive panel or communication.

Write values to the data array address in the following sequence: Data array #11 = 100, Data array #12 = 200, Data array #13 = 300. Then, read the data in the same sequence.

1. Read / write with panel:



2. Read / write with communication:

To read from or write to the data array through Modbus, use the communication command 0x10 to write consecutively, 0x06 to write single data, and 0x03 to read consecutively. First, use the consecutive writing command to write 100 to Data array #11, 200 to Data array #12, and 300 to Data array #13. When reading, use the single data writing command to set the start address as Data array #11, and then use the consecutive reading command to read P5.011 - P5.013 (Data array #11 and #12). Since P5.011 has been read twice, its value is incremented by 2, you can continue to read from Data array #13.

Writing to the data array									
Packet	Communi-cation command	Start address	Data length	P5.011		P5.012		P5.013	
				Low byte	High byte	Low word	High word	Low word	High word
1	0x10	P5.011	6 words	11	0	100	0	200	0
2	0x10	P5.011	6 words	13	0	300	0	0	0

Reading from the data array									
Packet	Communi-cation command	Start address	Data length	P5.011		P5.012		P5.013	
				Low byte	High byte	Low word	High word	Low word	High word
3	0x06	P5.011	-	11	0	-	-	-	-
4	0x03	P5.011	6 words	11	0	100	0	200	0
5	0x03	P5.011	6 words	13	0	300	0	0	0

Table 7.2.1.2 Group 2 parameters for reading and writing the data array

Parameter	Description	Example 1		Example 2	
P5.011 Address for reading and writing	Specifies the data array address for reading and writing	5		125	
Window for reading and writing	Description	Example 1		Example 2	
		Address	Content	Address	Content
P5.100 Window #3 for reading and writing	Reads from or writes to the address specified by P5.011.	5	1234	125	5678
P5.101 Window #4 for reading and writing	Reads from or writes to the first address following the address specified by P5.011.	6	2345	126	6789
P5.102 Window #5 for reading and writing	Reads from or writes to the second address following the address specified by P5.011.	7	3456	127	7890
P5.103 Window #6 for reading and writing	Reads from or writes to the third address following the address specified by P5.011.	8	4567	x	0

7.2.2 High-speed position capture function (Capture)

The high-speed position capture function (Capture), abbreviated as CAP, uses the external signal to trigger the high-speed digital input DI3 (-F, -M, B3A-P models) or DI7 (-L models) (with execution time of only 5 μs) to capture the position data of the motion axis and store it in the data array for further motion control. As the Capture function is executed by the hardware, there is no lag in the software, and it is able to capture the motion axis' position accurately. While the Capture function is enabled, the servo drive defines the function of DI3 or DI7 (based on the models) as data capturing, which means the DI is not user-defined.

The flowchart for high-speed position capturing is shown in Figure 7.2.2.1. You can set the Capture function in ASDA-Soft, as shown in Figure 7.2.2.2. The relevant parameters are defined as follows.

P5.036 sets the start address of the data array for storing the captured data; if it is not set, the default start address is #0. P5.038 sets the number of capturing times, which has to be greater than 0, otherwise the Capture function is not executed. P1.019.X enables the cycle mode. When the last data is captured, the number of capturing times is reset to 0 (P5.038 = 0), and the next cycle starts automatically to capture the previously set number of capturing times. However, the start address for storing the captured position data is still determined by P5.036; that is, the captured data in the previous cycle is overwritten by the data captured in the next cycle. When the Capture function is set to capture multiple points (P5.038 > 1), use P1.020 to set the masking range for capturing. This prevents the same position data from being captured repeatedly by setting the masked area within which only one capturing is allowed. P5.039 enables or disables the Capture function and other settings. See the following table for more information.

P5.039	Bit	Function	Description
X	0	Activate Capture	1: when P5.038 > 0, the capturing starts and DO.CAP_OK (0x16) is off. Each time one data is captured, the value of P5.038 is decremented by 1.When P5.038 = 0, it means the capturing is finished, DO.CAP_OK (0x16) is on, and Bit 0 is reset to 0. If Bit 0 is already 1, the written value must not be 1; you can only write 0 to deactivate the Capture function.
	1	Reset position	1: after capturing the first data, reset the position of the first data to the value of P5.076.
	2	Reserved	-
	3	Execute PR	1: execute PR#50 automatically after all data are captured.
Y	-	Axis source of Capture	0: the Capture function is disabled 1: reserved 2: CN1 (pulse command) 3: CN2 (motor encoder)
Z	-	Trigger logic	0: NO (normally open) 1: NC (normally closed)
U	-	Minimum interval between each trigger	0 - F: 0 - 15 ms

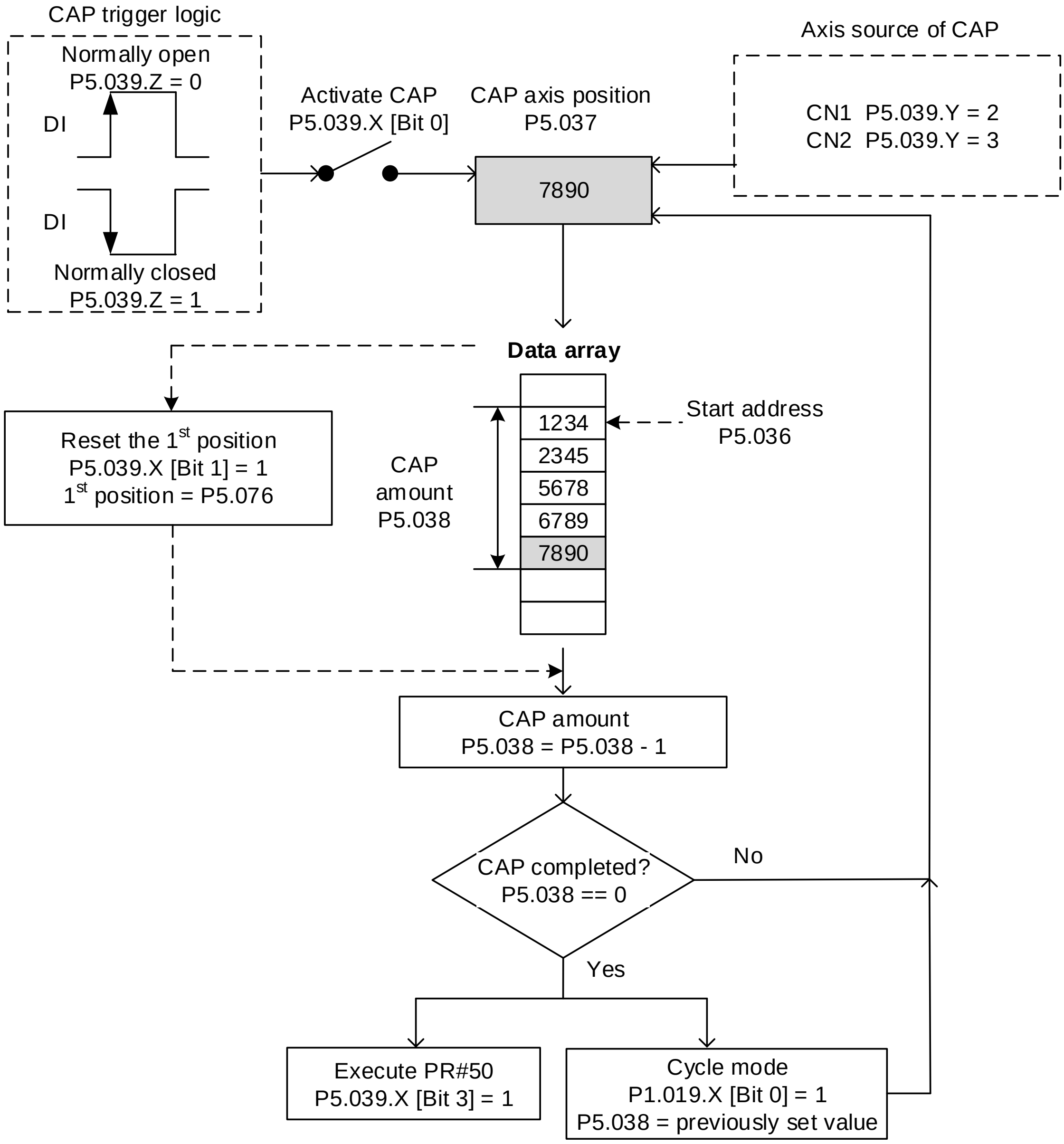


Figure 7.2.2.1 Flowchart for high-speed position capturing

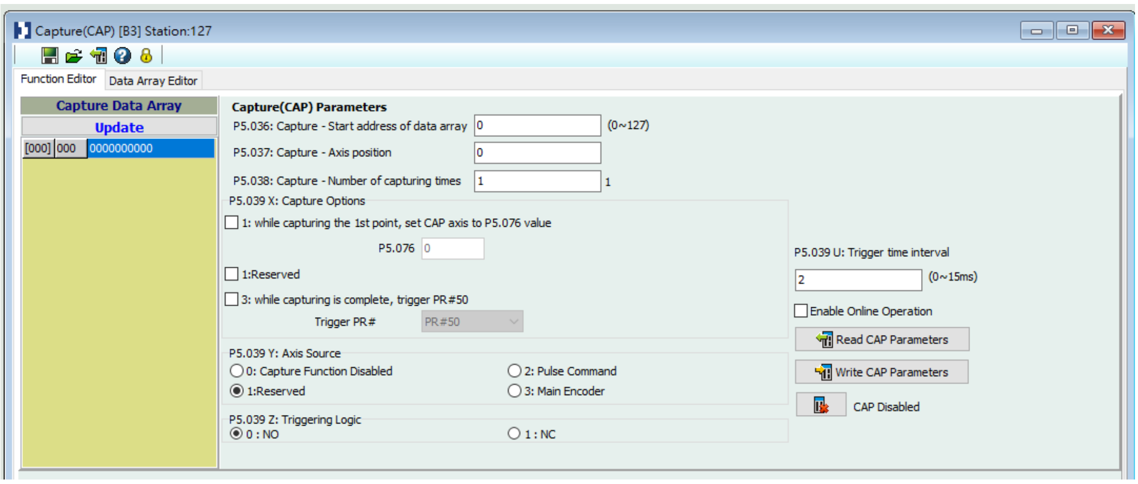


Figure 7.2.2.2 Capture function screen in ASDA-Soft

It is suggested that you program the PR paths to execute the Capture function with the motion commands. By doing so, you can use Write commands to set the high-speed position capture function, as well as to execute motion commands once capturing is complete.

See the example in Figure 7.2.2.3. PR#1 deactivates the Capture function (P5.039.X [Bit 0] = 0). PR#2 sets the start address of data array to #1. PR#3 sets the number of capturing times to 3. PR#4 sets the capturing axis' position to 0 for the first capture point. PR#5 enables the Capture cycle mode and sets a delay of 1 ms to ensure that the next PR path for activating the Capture function can be executed. PR#6 activates the Capture function, resets the position of the first point, executes PR#50 after capturing is complete, selects the motor encoder as the axis source of Capture, sets the trigger logic as "normally open", and sets the trigger interval as 2 ms. PR#7 sets the Speed command to 50 rpm. PR#50 sets the capture Position command to 50000 PUU. Once the command is complete, the servo continues to execute PR#51 with the Speed command setting remaining at 50 rpm.

In Figure 7.2.2.4, you can see that after the CAP DI is first triggered, the capturing axis's position is reset to 0 and the position data is stored in data array #1 because the Reset function for the first point is enabled and P5.076 is set to 0. At the moment the CAP DI is triggered the second and third time, the position data is written to data array #2 and #3. Once the first capture cycle is complete, DO.CAP_OK (0x16) is set to on and then PR#50 (high-speed position capture command) and PR#51 (motion with fixed speed) are executed. Then, the servo drive continues executing the next cycle; meanwhile, DO.CAP_OK (0x16) is set to off and the number of capturing times is set to 3 again. When the CAP DI is triggered for the fourth time, the capture axis' position is not reset; instead, the current position of the capturing axis is written to data array #1 again, which means the data written in the previous cycle is overwritten. At the moment the CAP DI is triggered the fifth and sixth time, the current position of the capturing axis is written to data array #2 and #3. Once the second capture cycle is complete, DO.CAP_OK (0x16) is set to on, and then PR#50 (high-speed position capture command) and PR#51 (motion with fixed speed) are executed again.

When the Capture cycle mode is enabled (P1.019.X [Bit 0] = 1), the Reset function for the first point is only valid for the first cycle. Meanwhile, the Execute PR function is valid for every cycle; in other words, PR#50 is executed every time a cycle ends. The first position data captured in every cycle is written to the data array address set by P5.036, and then other data of the same cycle is written in sequence. So, the position data written in the previous cycle is always overwritten by the position data of the next cycle.

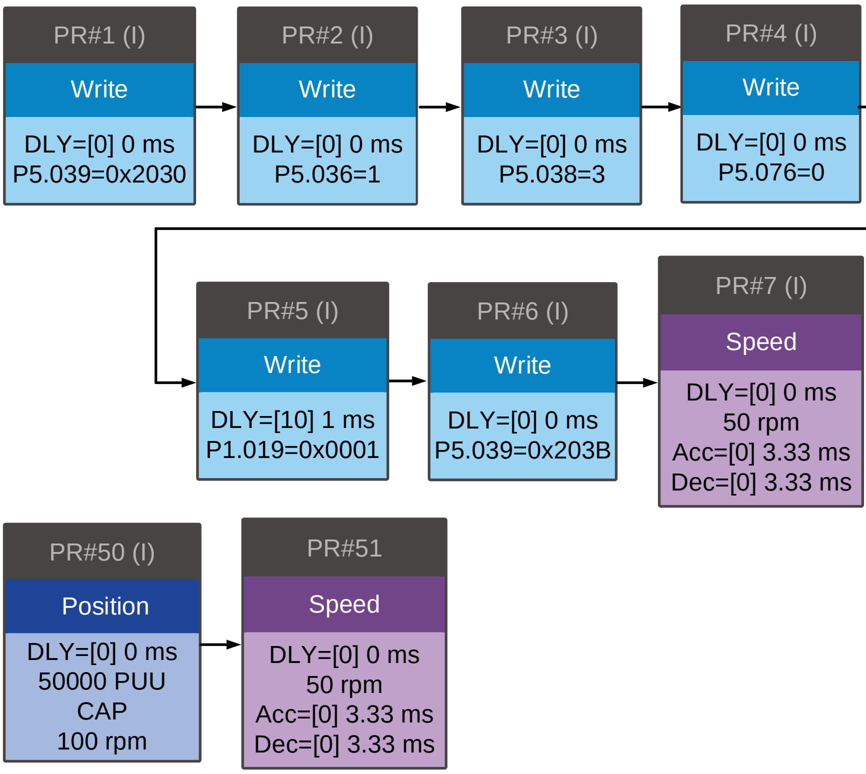


Figure 7.2.2.3 PR path with application of high-speed capture function

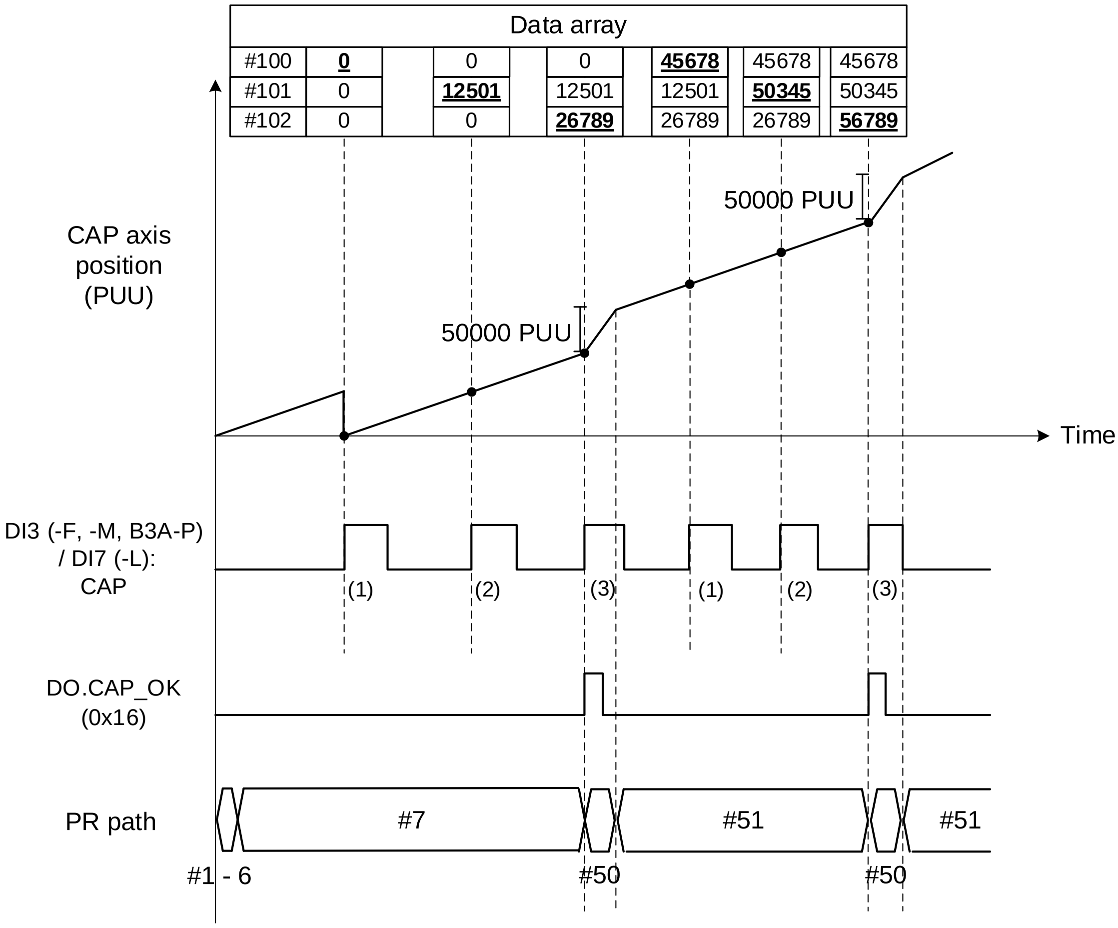


Figure 7.2.2.4 Application example for high-speed capture function