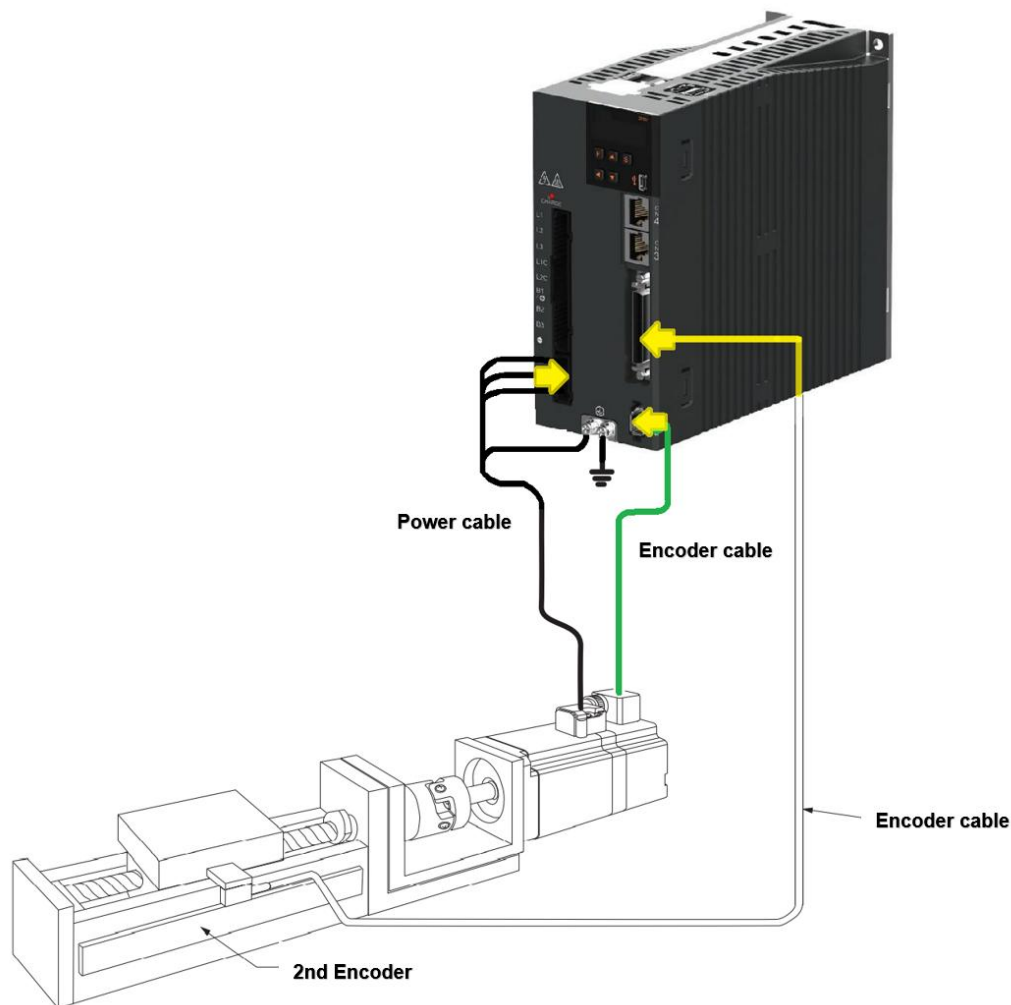


# **HSD7-ES Full Closed-Loop Control Instruction**

# What is a full closed loop system

A full closed loop system is a system that uses an encoder (2nd encoder) or grating ruler directly installed on the motion mechanism of the equipment to detect the actual position of the motion mechanism and feedback the position information to the servo unit. As the actual position of the motion mechanism is directly fed back, high-precision positioning can be achieved. However, the full closed loop system can also cause unstable positioning and vibration due to looseness or torsion of the motion mechanism.



CN1- 2nd encoder input signal pin arrangement (F1-TTL type encoder)			CN1- 2nd encoder input signal pin arrangement (F2-Biss type encoder)		
Name	Pin	Function	Name	Pin	Function
5V	43	2nd encoder 5V	5V	43	2nd encoder 5V
PA+	44	2nd encoder A+	MA+	44	Master clock output MA+ signal
PA-	45	2nd encoder A-	MA-	45	Master clock output MA- signal
PB+	46	2nd encoder B+	SL+	46	Slave data output SL+ signal
PB-	47	2nd encoder B-	SL-	47	Slave data output SL- signal
PC+	48	2nd encoder C+	—	48	—
PC-	49	2nd encoder C-	—	49	—
0V	50	2nd encoder 0V	0V	50	2nd encoder 0V

# 1. Start-up steps of the servo unit

When starting the servo unit, first confirm whether the action is normal through semi-closed loop control, and then confirm whether the action is normal through full closed loop control. The procedure for starting by full closed loop control is shown below.

Step	Content	Operation	Parameters to be set	Command
1	<p>Confirm a series of actions of semi-closed loop control in no-load state.</p> <p>&lt;Confirm items&gt;</p> <ul style="list-style-type: none"> <li>•Power supply circuit wiring</li> <li>•Servo motor wiring</li> <li>•Encoder wiring</li> <li>•Wiring with the DI/DO of the controller</li> <li>•Servo motor rotation direction, speed, position</li> <li>•Actions of protection functions such as braking and over travel</li> </ul>	<p>In the no-load state, set each parameter to ensure that the action can be normal through semi-closed loop control (Pn002=n.0□□□), and confirm the following items.</p> <ul style="list-style-type: none"> <li>•Whether the servo unit is abnormal</li> <li>•Whether the JOG operation is normal</li> <li>•Whether the ON/OFF of the DI/DO is operating normally</li> <li>•Whether the servo motor is energized after (/S-ON) signal is enabled</li> <li>•After received the position command from the controller, whether the servo motor is running normally</li> </ul>	<ul style="list-style-type: none"> <li>•Function selection basic switch 0 (Pn000)</li> <li>•Function selection application switch 1 (Pn001)</li> <li>•How to use 2nd encoder (Pn002=n.X□□□)</li> <li>•Electronic gear ratio (numerator) (Pn20E)</li> <li>•Electronic gear ratio (denominator) (Pn210)</li> <li>•Input signal selection (Pn50A、Pn50B、Pn511、Pn515、Pn516)</li> <li>•Output signal selection (Pn50E、Pn50F、Pn510、Pn514、Pn517)</li> </ul>	Servo unit or Upper controller
2	<p>With the motion mechanism and the servo motor connected, confirm the operation of the semi-closed loop control.</p> <p>&lt;Confirm item&gt;</p> <ul style="list-style-type: none"> <li>•Responsiveness with movement mechanism</li> <li>•The moving direction, moving distance, and moving speed of the motion mechanism controlled by the controller command</li> </ul>	<p>Connect the servo motor to the motion mechanism. Use the function of automatic adjustment (no controller command) to set the moment of inertia ratio to Pn103. Confirm that the movement direction, movement distance, and movement speed of the movement mechanism are correct according to the instructions of the controller.</p>	Moment of inertia ratio (Pn103)	Upper controller
3	<p>Confirm the 2nd encoder.</p> <p>&lt;Confirm item&gt;</p> <p>Whether the 2nd encoder signal has correct feedback</p>	<p>Please set the parameters related to the full-closed loop control. Instead of energizing the servo motor, move the motion mechanism manually. Use the panel operator, or iWatch+ to confirm the following status.</p> <ul style="list-style-type: none"> <li>• When moving with the forward direction of the servo motor, does the "full closed loop feedback pulse counter" count up?</li> </ul>	<ul style="list-style-type: none"> <li>•How to use 2nd encoder (Pn002=n.X□□□)</li> <li>•2nd encoder grating ruler pitch number (Pn20A)</li> <li>•Electronic gear ratio (numerator) (Pn20E)</li> <li>•Electronic gear ratio (denominator) (Pn210)</li> <li>• Encoder output resolution (Pn281)</li> </ul>	-

		<ul style="list-style-type: none"> <li>Visually check whether the movement distance of the motion mechanism is roughly the same as the number of counts of the "Full Closed Loop Feedback Pulse Counter"</li> </ul> <p>(Note) The unit of the "Full Closed Loop Feedback Pulse Counter" is 1 pulse = the sine wave frequency of the 2nd encoder.</p>	<ul style="list-style-type: none"> <li>Detection value of excessive deviation between motor and load position (Pn51B)</li> <li>Positioning completion range (Pn522)</li> <li>Product value of 1 full closed loop rotation (Pn52A)</li> </ul>	
4	<p>Perform program JOG operation. &lt;Confirm item&gt; Whether the full closed loop system of the servo motor operates normally</p>	<p>Please run the program JOG and check whether the moving distance is the same as the command value (Pn531). When performing program JOG operation, slowly increase from low speed to operating speed for confirmation.</p>	<p>Program JOG related (Pn530~Pn536)</p>	Servo unit
5	<p>Run the servo unit. &lt;Confirm item&gt; Is the full closed loop system including the upper controller operating normally?</p>	<p>Please enter the position command to confirm that the servo unit is operating normally. Please slowly increase from low speed to use speed to confirm.</p>	-	Upper controller

## 2. Parameter setting of full closed loop control

### 2.1 Full Closed-loop Control Interface Definition

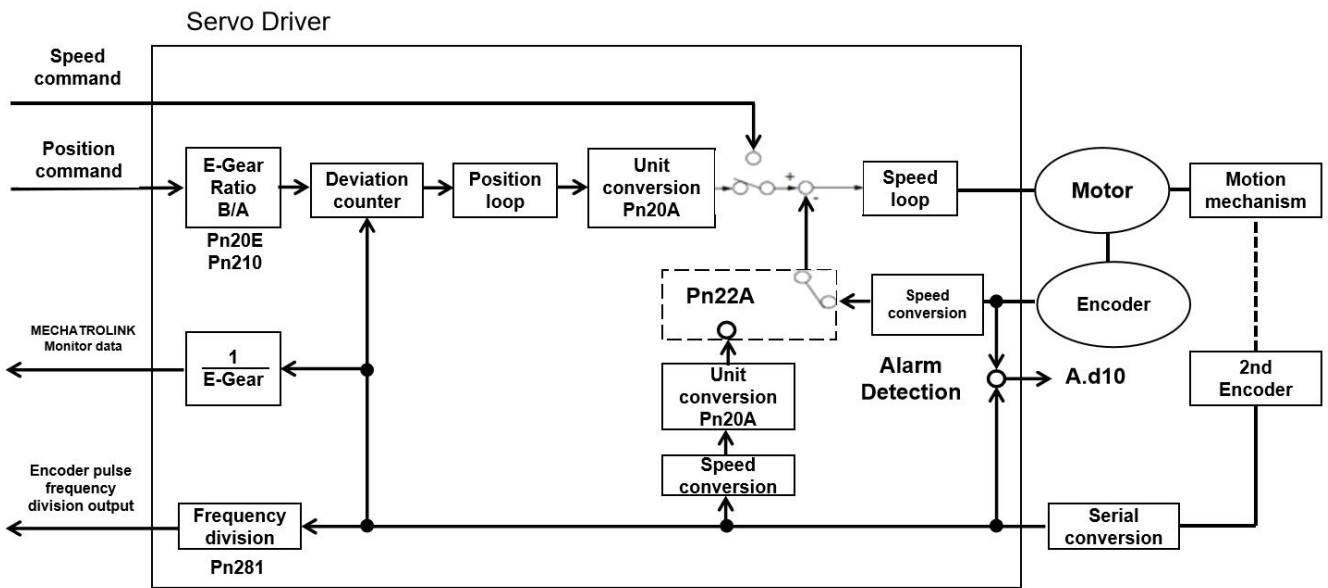
Pin No.	F1 Type Interface Definition		F2 Type Interface Definition	
	Signal Name	Function	Signal Name	Function
CN1-43	5V	2nd encoder 5V power supply	5V	2nd encoder 5V power supply
CN1-44	PA+	2nd encoder A+ phase signal	MA+	Master clock output MA+ signal
CN1-45	PA-	2nd encoder A- phase signal	MA-	Master clock output MA- signal
CN1-46	PB+	2nd encoder B+ phase signal	SL+	Slave data output SL+ signal
CN1-47	PB-	2nd encoder B- phase signal	SL-	Slave data output SL- signal
CN1-48	PC+	2nd encoder C+ phase signal	—	—
CN1-49	PC-	2nd encoder C- phase signal	—	—
CN1-50	0V	2nd encoder 0V power supply	0V	2nd encoder 0V power supply

### 2.2 Description of related parameters for full closed loop control

Parameter	Content	Position	Speed	Torque
PA002.3	Use method of 2nd encoder	○	○	○
Pn20A	2nd encoder grating ruler pitch number	○	○	○

Pn281	Servo unit encoder frequency division pulse output signal (PAO, PBO, PCO)	○	○	○
Pn20E	Electronic gear numerator	○		
Pn210	Electronic gear denominator	○		
Pn22A	BiSS encoder parameter settings	○	○	○
Pn51B	Detection value of excessive deviation between motor and load position	○		
Pn52A	Product value of 1 full closed loop rotation	○		
Un00E	Fully closed loop feedback pulse counter	○	○	○

### 2.3 Control diagram of full closed loop control



### 2.4 Setting of motor rotation direction and machine movement direction

Set the rotation direction of the motor and the motion mechanism. When performing full-closed loop control, Pn000=n.□□□X (selection of rotation direction) and Pn002= n.X□□□( Use method of 2nd encoder).

Parameter			Pn002= n.X□□□( Use method of 2nd encoder).			
			n.1□□□		n.3□□□	
Pn000= n.X□□□ (Motor rotation direction)	n.□□□0	Command direction	Forward	Reverse	Forward	Reverse
		Motor rotation direction	CCW	CW	CCW	CW
		2nd encoder direction	Forward	Reverse	Reverse	Forward
	n.□□□1	Command direction	Forward	Reverse	Forward	Reverse
		Motor rotation direction	CW	CCW	CW	CCW
		2nd encoder direction	Reverse	Forward	Forward	Reverse

- The frequency division pulse has nothing to do with the setting of Pn000= n.□□□X. For the forward rotation command, it becomes the phase B is lead.
- 2nd encoder direction is forward : Pulse count is increasing
- 2nd encoder direction is reverse : Pulse count is decreasing

## Related parameters

✧ **Pn000= n.□□□X**

.For details, refer to the table above "Setting the direction of motor rotation and motion mechanism".

✧ **Pn002= n.X□□□**

When performing full closed-loop control, set Pn002=n.1□□□ or n.3□□□

Parameter	Name	Function	Effective time
Pn002	n.0□□□ [Default]	No external encoder is used.	Restart
	n.1□□□	It is used as "the motor rotates in CCW direction and the external encoder moves forward".	
	n.2□□□	Reserved (Do Not Set)	
	n.3□□□	It is used as "the motor rotates in CCW direction and the external encoder moves in reverse".	
	n.4□□□	Reserved (Do Not Set)	

Note: Please confirm the setting value of Pn002=n.0□□□ according to below description.

- Set to Pn000=n.□□□0 (take the positive counting direction of the 2nd encoder as the positive direction), Pn002=n.1□□□ (use with "motor CCW rotation, 2nd encoder lateral movement")
- Rotate the motor shaft in the CCW direction by hand.
- When the fully closed loop feedback pulse counter is counting up, the setting of Pn002 remains unchanged (Pn002=n.1□□□).
- When the fully closed loop feedback pulse counter counts down, set Pn002=n.3□□□.

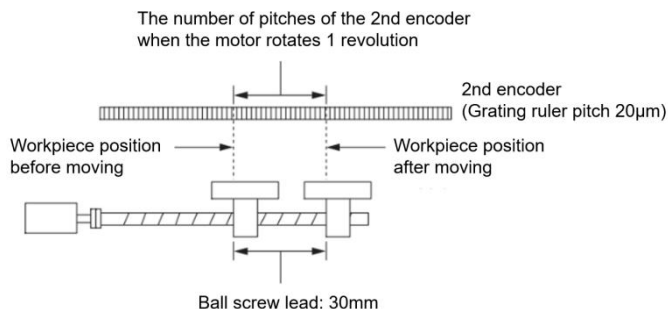
## 2.5 Setting of the number of pitches of the 2nd encoder grating ruler

Set the number of pitches of the 2nd encoder grating ruler when the motor rotates one revolution to Pn20A.

### Setting example

[Data]  
2nd encoder grating ruler pitch: 20μm  
Ball screw lead: 30mm

If directly connected to the motor  
Then  $30\text{mm}/0.02\text{mm}=1500$   
Then set Pn20A=1500



Note: 1. When a decimal point appears, please round the number after the decimal point.

2. When the pitch value of the external encoder grating ruler for one motor rotation is not an integer, the position loop gain (KP), feed-forward, and position command speed monitoring will include errors. But it has nothing to do with the position loop, so it will not affect the position accuracy.

## Related parameters

Pn20A	Number of pitches of the grating ruler <span style="border: 1px solid black; padding: 2px;">Position</span>				
	Range	Unit	Default	Effective time	--
	4~16777216	1 grating ruler pitch/Rev	32768	Restart	--

Parameter		Name	Description	Effective Time	--
Pn22A	n. □□□0[Default]	BiSS encoder single-turn data length	17 bits	Restart	--
	n. □□□1		18 bits		
	...		...		
	n. □□□F		32 bits		
* : Valid for F2 only	n. □□0□[Default]	BiSS encoder multi-turn data length	No multi-turn data	Restart	--
	n. □□1□		11 bits		
	n. □□2□		12 bits		
	...		...		
	n. □□F□		25 bits		
n. □0□□[Default]	BiSS / EnDat selection	BiSS mode	Restart	--	
		EnDat mode	Restart	--	

## 2.6 Encoder frequency division pulse output signal (PAO, PBO, PCO) setting

Set the position resolution to Pn281 (encoder output resolution).

The setting value should input the value of A and B phase edge.

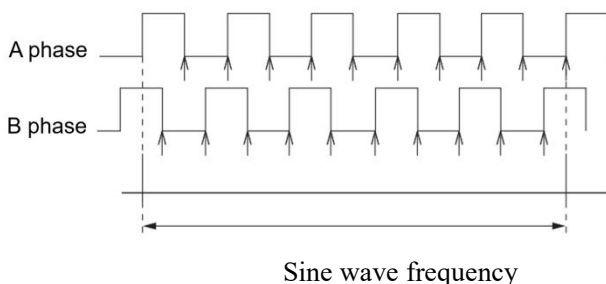
Setting example

[Parameters]  
 External grating ruler pitch: 20um  
 Ball screw lead: 30mm  
 Speed: 1600mm/s

When 1 pulse (value after 4 times) is 1um, the set value is "20".

When 1 pulse (value after 4 times) is 0.5um, the set value is "40".

The encoder frequency division pulse output waveform when the setting value is "20" is shown below.



"↑" indicates the pulse edge position. In this example, it is set to "20", so "↑" has 20 places.

(Note) The upper limit of the frequency of the encoder signal output is 6.4Mpps (the value after a 4-times), so the set value should not exceed 6.4Mpps. If it exceeds the limit, A.511 (frequency division pulse output over-speed alarm) will be output.

**Example**

When the setting value is "20", the speed is 1600mm/s,

$$\frac{1600\text{mm/s}}{0.001\text{mm}}=1600000=1.6\text{Mpps}$$

1.6Mpps < 6.4Mpps, therefore, the set value can be used.

## Parameter

Pn281	encoder output resolution				Position
	Range	Unit	Default	Effective time	--
	1~4096	1 pulse edge/pitch	20	Restart	--

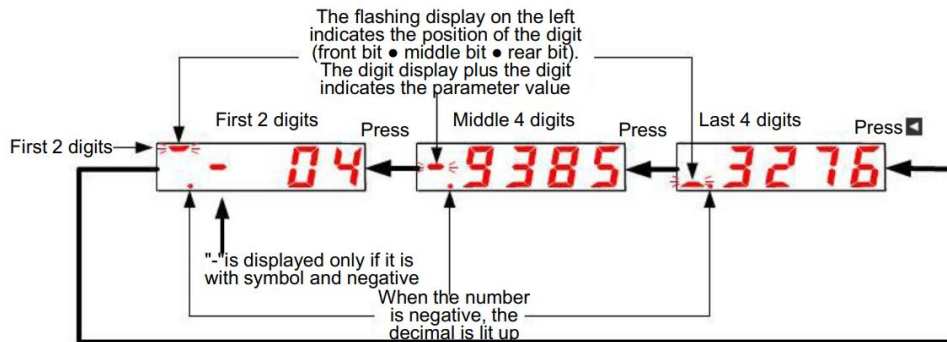
(Note) : The maximum encoder output resolution is 4096. When the resolution of the 2nd encoder exceeds 4096, pulses cannot be output linearly.

## 2.7 Un070 2nd encoder current position monitoring

The current position of the 2nd encoder can be read through Un070. It supports absolute position counting.

Since the panel operator can only display 5 digits, the setting value of 6 digits or more is as follows:

The following figure shows that the current position is: -0493853276



## 2.8 Related alarms

Alarm number alarm name	Reason	Check	Troubleshooting
A.CF1: Full closed loop feedback module communication failure (reception failure)	The cable connection between the serial conversion unit and the servo unit is incorrect or poorly connected	Confirm the wiring of the 2nd encoder.	Correctly wire the cable between the serial conversion unit and the servo unit.
	The specified cable is not used between the serial conversion unit and the servo unit	Check the cable specifications of the 2nd encoder.	Use the correct cable specified.
	The cable between serial conversion unit and servo	Check the length of the serial conversion unit	Keep the cable length between the serial conversion unit and the servo unit within

	unit is too long	connection cable.	20m.
	The cable sheath between the serial conversion unit and the servo unit is damaged	Check the connection cable of the serial conversion unit.	Replace the cable between the serial conversion unit and the servo unit.
A.CF2: Fully closed loop feedback module communication failure (timer stop)	The cable between the serial conversion unit and the servo unit is disturbed		Correctly carry out the wiring around the serial conversion unit (separate the signal cable and the power cable, grounding treatment, etc.).
	Serial conversion unit failure		Replace the serial conversion unit.
	Servo unit failure		Replace the servo unit.

## 2.9 Alarm detection setting

The settings of alarm detection (Pn51b, Pn52A) are as follows.

### Setting of detection value of excessive deviation between motor and load position (Pn51B)

It is the setting to detect the difference between the servo motor encoder feedback (motor position) and the fully closed loop 2nd encoder feedback (load position). If it exceeds the set value, A.d10 (excessive deviation alarm between motor and load position) will be output.

Pn51B	Detection value of excessive deviation between motor and load position				
	Position				
	Range	Unit	Default	Effective time	--
	0~1073741824	1 Instruction unit	1000	Immediate effect	--

Note: When set to "0", the A.d10 will be shielded, which may cause mechanical damage.

### Setting of the product value (Pn52A) of 1 full-closed loop rotation

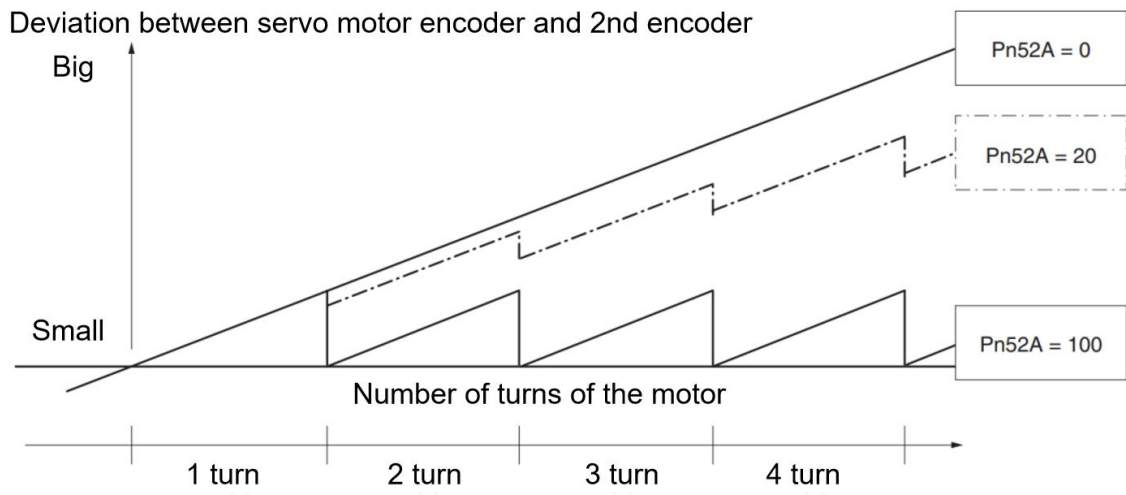
Set the "coefficient of deviation between the motor and the 2nd encoder" for one revolution of the servo motor. It can be used to prevent loss of control caused by the damage of the second encoder, or to detect "sliding" in the belt mechanism.

#### ◇ Example

When the belt slip rate is large or the twist is severe, increase the value.

If the set value is "0", the value of the external encoder is directly read.

When the set value is the factory setting value "20", the second circle starts from the "deviation after the servo motor rotates one circle multiplied by 0.8."



✧ **Parameter**

Pn52A	Product value of 1 full closed loop rotation					Position
	Range	Unit	Default	Effective time	--	
	0~1073741824	1 Instruction unit	1000	Immediate effect	--	