Leadshine

EL7-EC Series AC Servo Drive

User Manual

Foreword

Thank you for purchasing Leadshine EL7-EC series AC Servo drives. This manual will provide information on the EL7-EC series servo products regarding product safety & specifications, installations & wiring, tuning & problem diagnostics.

Please contact us at tech@leadshine.com if you need further technical support.

Incorrect operation may cause unexpected accident, please read this manual carefully before using product.

- ✧ We reserve the right to modify equipment and documentation without prior notice.
- ✧ We won't undertake any responsibility with any customer's modification of product and the warranty of product will be canceled at the same time.

Safety Precautions

Please read the safety instructions carefully before using the products and pay attention to the safety signs.

	Might incur death or serious injury
	Might cause injury to operating personals or damage to equipment
	Might cause damage to equipment
	High voltage. Might cause electrocution to personals in contact
	Hot surface. Do not touch
	Protective Earth

Safety instructions

Warning

- ✓ The design of the product is not to be used in mechanical system which may incur health hazard.
- ✓ Users should be aware of the product safety precautions during design and installations of the equipment to prevent any unwanted accident.

Upon receiving

Caution

- ✓ The use of damaged or faulty product(s) is prohibited.
- ✓ Please refer to item checklist. If the labels don't match, please do not install.

Transportation

Caution

- ✓ Please provide storage and transportation under protected conditions.
- ✓ Do not stack the products too high up to prevent toppling.
- ✓ The product should be packaged properly during transportation,
- ✓ Do not hold the product by the cable, motor shaft or encoder while transporting it.
- ✓ The product should be protected from external forces and shock.

Installation

Caution

Servo drive and Motor:

- ✓ Do not install around combustibles to prevent fire hazard.
- ✓ Avoid vibration and impact.
- ✓ Do not install products that are damaged or incomplete.

Servo drive:

- ✓ Please install in electrical cabinet with sufficient protection from outside elements.
- ✓ Reserve sufficient gap as per the installation guide.
- ✓ Make sure to have good heat sinking.
- ✓ Avoid dust, corrosive gas, conductive object or fluid and combustibles.

Servo Motor:

- ✓ Make sure installation is tight to prevent it from loosening.
- ✓ Prevent fluid from leaking into motor and encoder.
- ✓ Protect motor from impact to avoid damaging encoder.
- ✓ Motor shaft should not bear the load beyond the limits as specified.

Wiring

Warning

- ✓ Participate installation personals should have sufficient training in product installation safety.
- ✓ Please power off and wait for 10 minutes to make sure a full discharge of electricity.
- ✓ Servo drive and motor must be connected to ground.
- ✓ Connect the cables only after servo drive motor installed correctly
- ✓ Make sure the wires are properly managed and insulation layer is not torn to prevent electrocution.

Caution

- ✓ Wiring must be correctly connected to prevent damage to product(s)
- ✓ Servo motor U, V, W terminal should be connected correctly and NOT connected directly to an AC power supply.
- ✓ Capacitor, inductor or filter shouldn't be installed between servo motor and servo drive.
- ✓ Connecting wires or any non-heat resistant components should be put near to heat sink of the servo drive or motor.
- ✓ The flyback diode which is connected in parallel to output signal DC relay must not be connected in reverse.

Tuning and running

⚠ Caution

- ✓ Make sure the wirings of servo drive and servo motor are installed and fixed properly before powering on.
- ✓ On the first time tuning of the product, it is recommended to run unloaded until all the parameter settings are confirmed to prevent any damage to the product or machine.

Usage

⚠ Caution

- ✓ Please install an emergency stop button on machine to stop operation immediately if there is an accident.
- ✓ Please make sure machine is stopped before clearing an alarm.
- ✓ Servo drive must be matched with specified motor.
- ✓ Frequent restart of the servo system might incur damage to the product.
- ✓ Servo drive and motor will be hot to touch shortly after power off. Please be careful.
- ✓ Modification(s) to servo system is prohibited.

Error Handling

⚠ Warning

- ✓ Please wait for 5 minutes after powering off for the electricity to be fully discharged before uninstalling the cables.
- ✓ Participate maintenance personals should have sufficient training in maintenance and operation of this product series.

⚠ Caution

- ✓ Please handle the error before clearing an alarm.
- ✓ Keep away from machine after a restart upon alarm. Mechanical axis might suddenly move. Such hazard should be prevented during the utilization of the product.

Model Selection

⚠ Caution

- ✓ Rated torque of the servo motor should be higher than continuous designated torque when fully loaded.
- ✓ Load inertia ratio of the motor should be lower or equals to recommended value for specified models
- ✓ Servo drive must be matched with specified motor.

Warranty Information

Available for

Leadshine overseas warranty only covers Leadshine AC servo products that are obtained through **Leadshine certified sales channel outside of China**.

Warranty claim

- All Leadshine AC servo products (Servo drives and motors) overseas enjoy **18-month** warranty period.
- Due to unforeseen circumstances in different sales regions around the globe, we recommend users to seek technical support from directed sales channel as any warranty claim or repair services may be required.
- Please be informed that any maintenance/repair work that is outside of the warranty claim conditions might incur some charges and to be confirmed before product(s) is being sent in.
- The duration required for maintenance work to be done is to be confirmed after initial check-up but we reserve the right to prolong the repair duration if needed.
- Discontinued products within warranty period will be replaced with a product of similar specifications.

Steps to warranty claim

1. Visit Leadshine global site www.leadshine.com to look for local certified sales channel.
2. Contact designated sales channel to check if any fee might incur. May include repair fee, spare part cost or shipping cost.

Circumstances where warranty claim is not available

- Damage/Loss due to occurrence of natural or man-made disaster such as fire, flood or earthquake.
- Installation or wiring error
- If there is any modification done to the product
- Warranty label on products is torn or not existing
- Not a product bought from Leadshine certified global network of retailers/distributors.

Before warranty claim

- Please backup device parameters before any repair work/warranty claim. Leadshine and Leadshine certified retailers/distributors will not be held responsibilities for any data loss.
- If available, please send product back in original packaging or make sure it is well packaged to prevent any damage to the product during shipping.

Leadshine Technology Co.,Ltd. and its certified sales channel reserved the final right of the interpretation of the warranty information.

Table of Contents

Chapter 1 Introduction

1.1 Product Introduction

EL7-EC Series AC servo products are high performance AC digital servo which is designed for position/velocity/torque high accurate control with power rating ranging up to 7.5kW which provides a perfect solution for different applications with easy tuning process. Based on the ETG COE + EtherCAT DSP402 protocol, it can be seamlessly connected to controllers/drives that support this standard protocol.

EL7-EC series AC servo drives are using the latest Digital Signal Processing (DSP) chip and Intelligent Power Module (IPM) with compact components integration and great reliability. Using the best PID calculation for Pulse Width Modulation (PWM) control, our EL7-EC series products are the one to beat in this product category.

In comparison to conventional pulse controlled servo drives, our EL7-EC provides advantages as listed below.

- **Lengthen communication range and lower electromagnetic interference**
  Due to the reliance of pulse command, pulse controlled servo drives could be easily disrupted by electromagnetic interferences. EtherCAT communication protocol provides fault detections limitations and error handling that makes communication more reliable over long distances.

- **Greater motion control**
  Trajectory generation can be done within the driver under non-cyclic synchronous mode. Controller only needs to deliver target position, velocity and acceleration commands to the driver. Drivers can then achieve greater control by applying feedforward to the commands.

- **Simplify complex wiring work**
  Using EtherCAT communication protocols, the connections between master device and slave stations can be realized using only LAN cables.

- **Reduce cost by lowering the requirement for more ports**
  Multiple axes control can be realized without requirement for more ports or pulse module on the master device/controller. Only a network port is needed to chain the axis controller (drivers) together in series.

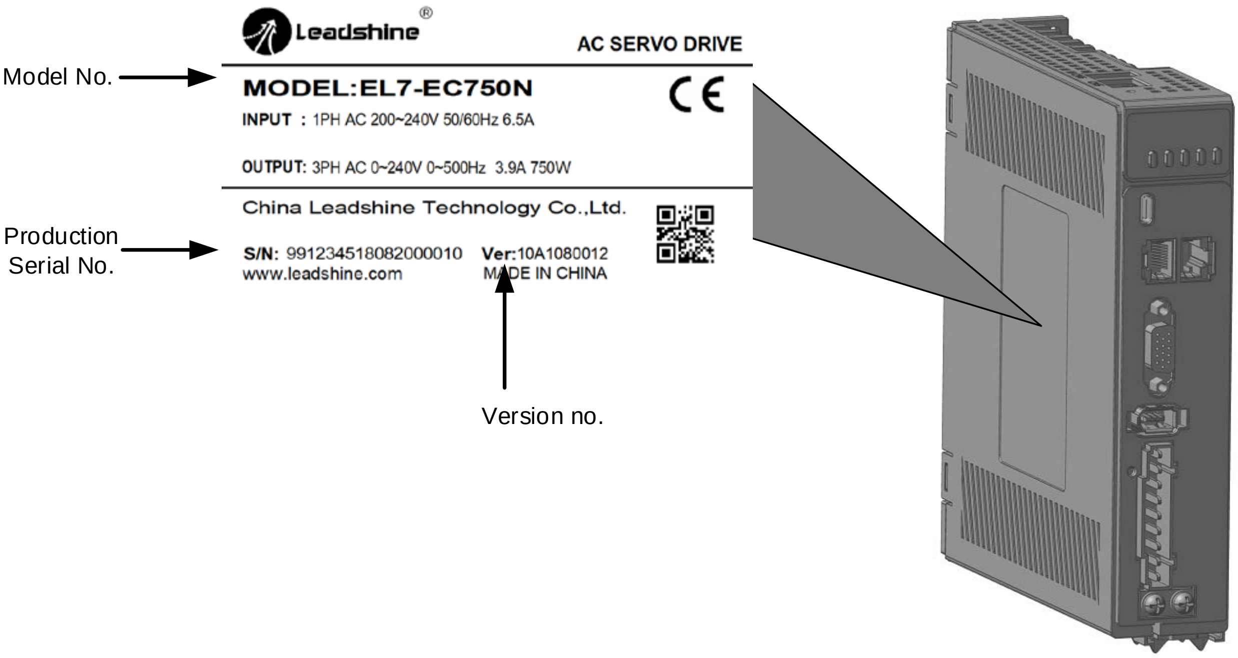
1.2 Model Number Structure

Servo Drive

EL7-EC 750 N T

① ② ③ ④ ⑤

No.	Description	
①	Series No.	EL7: Servo drive series
②	Command source	RS: Pulse + direction/Modbus RTU/Analogue EC: EtherCAT
③	Power rating	400: 400W 750: 750W 1000:1000W 1500: 1500W 2000: 2000W 3000:3000W 4400:4400W 5500:5500W 7500:7500W
④	Type	N: Drive version with STO, Certifications including CE/STO/UL
⑤	Main power input:	*Blank*: 220VAC(1 or 3-phase) T: 380VAC(3-phase)



1.3 Driver Technical Specification

EL7-EC 220V Models

EL7-ECN series	EL7-EC400N	EL7-EC750N	EL7-EC1000N	EL7-EC1500N	EL7-EC2000N
Rated power (W)	400	750	100	1500	2000
Rated Current (Arms)	3.5	5.5	7	9.5	12
Peak Current (Arms)	9.2	16.6	18.7	31.1	36
Size (mm)	40*175*156	50*175*156		80*175*179	
Main Power Supply	Single phase AC 220V, -15%~+10%, 50/60Hz				
Control Circuit Power Supply					

EL7-EC 400V Models

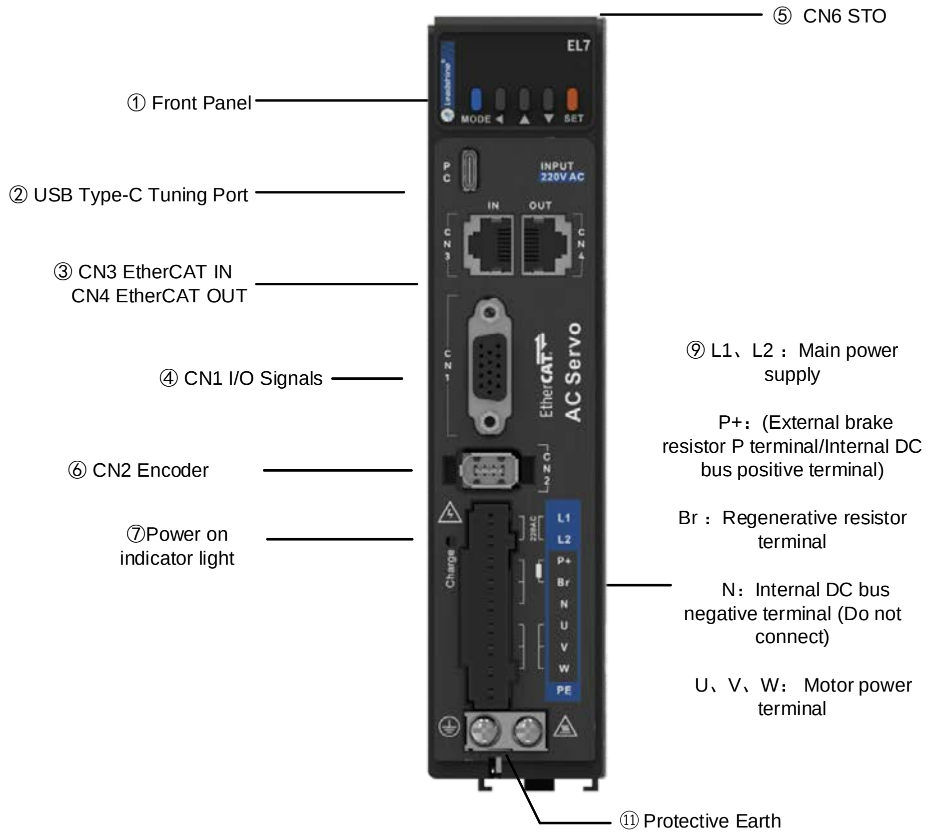
EL7-ECNT series	EL7-EC750	EL7-EC1000	EL7-EC1500	EL7-EC2000	EL7-EC3000	EL7-EC4400	EL7-EC5500	EL7-EC7500
Rated Power(W)	750	1000	1500	2000	3000	4400	5500	7500
Rated Current (Arms)	2.7	3.5	5.4	8.4	11.9	16.5	20.8	25.7
Peak Current (Arms)	8.6	10.6	14.9	24.8	33.2	38.9	51.6	33.6
Size (mm)	55*175*179			80*175*179		89*250*230		
Main Power Supply	Three phase AC 380V~440V, -15%~+10%, 50/60Hz							
Control Circuit Power Supply	Single phase AC 380V~440V, -15%~+10%, 50/60Hz							

Drive mode		IGBT PWM sinusoidal wave drive	
Control mode	Position	Profile Position Mode (PP)	
		Cyclic Synchronous Position Mode (CSP)	
		Homing Mode (HM)	
	Velocity	Profile Velocity Mode (PV)	
		Cyclic Synchronous Velocity Mode (CSV)	
	Torque	Profile Torque Mode (PT)	
		Cyclic Synchronous Torque Mode (CST)	
Encoder Feedback		RS485 protocol: 23-bit multiturn absolute magnetic/optical encoder	
I/O	Digital Input	4 Digital Inputs (Supports NPN and PNP)	
		Configurable input signals under EtherCAT mode:	1. Clear Alarm （A-CLR） 2. Positive limit switch (POT) 3. Negative limit switch (NOT) 4. Homing switch (HOME-SWITCH) 5. Emergency stop (E-Stop)
	Digital Output	3 Digital Outputs (2 single-ended, 1 differential)	
		Configurable output signals under EtherCAT mode:	1. Alarm (ALM) 2. Servo ready (SRDY) 3. External brake off (BRK-OFF) 4. Positioning completed (INP) 5. Velocity at arrival (AT-SPEED) 6. Torque limiting command (TLC) 7. Zero speed position (ZSP) 8. Velocity coincidence (V-COIN) 9. Position command (P-CMD) 10. Velocity limit (V-LIMIT) 11. Velocity command (V-CMD) 12. Servo enabled (SRV-ST) 13. Homing done (HOME-OK)
	Encoder Output	Encoder ABZ differential pulse output	

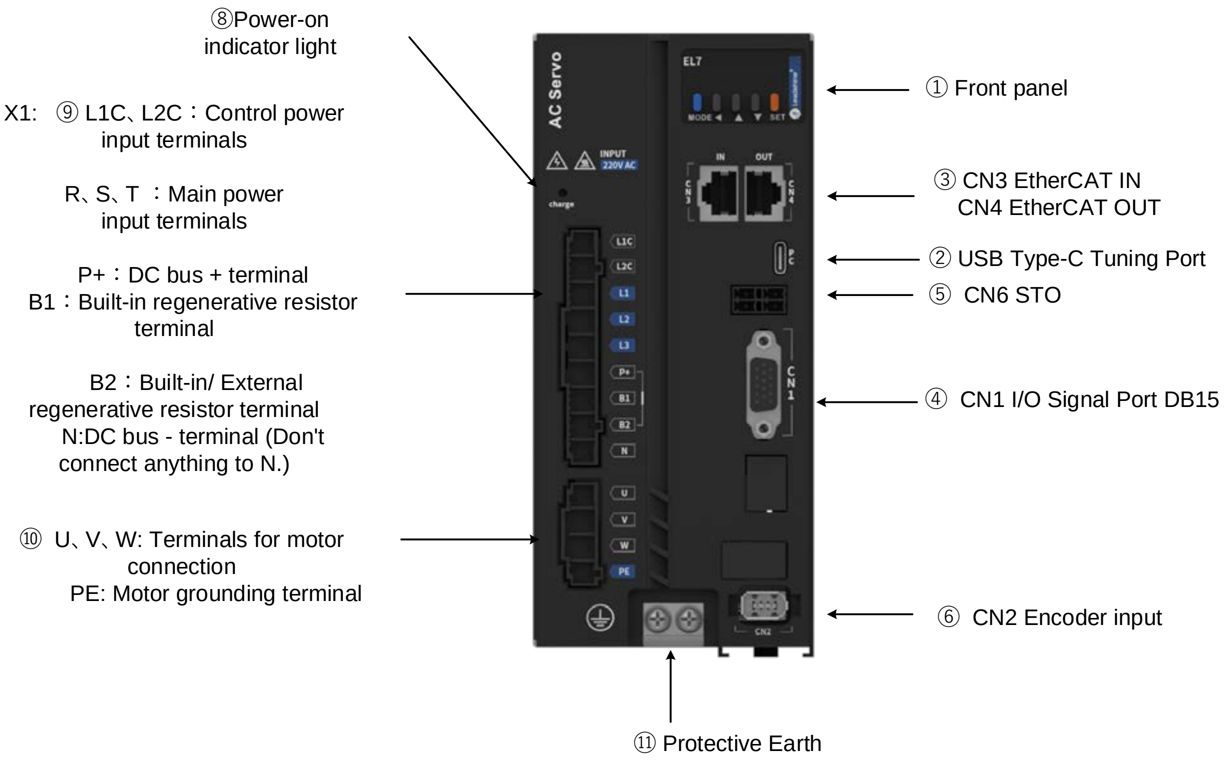
Communication Port	Probe Input	2 high speed probe inputs: EXT1+/EXT1-, EXT2+/EXT2-
	USB Type-C	Modbus USB2.0 (No need to connect driver to power supply)
	EtherCAT	EtherCAT, Communication up to 128 axes to a host
Software		Driver tuning through **Motion Studio** Ver. 2.2.x. Parameters tuning in current loop, position loop, velocity loop; Modify I/O signal and motor parameters; Variables(velocity, position deviation, etc.) monitoring using step diagrams
Driver Front Panel		5 push buttons and 8-segments display
Holding brake		Built-in (Supports external brake)
Safety Protection		Overcurrent. Overvoltage. Undervoltage. Overheat. Overload. Overtravel. Single-Phasing. Regenerative resistor error. Position deviation error. Encoder feedback error. Excessive braking rate. EEPROM error
Safe Torque Off (STO) function		Available for all EL7-EC series products
Environment	Temperature	Storage: -20-80℃ (Condensation free); Installation: 0-55℃ (Not frozen)
	Humidity	Under 90%RH (Condensation free)
	Altitude	Up to 1000m above sea level
	Vibration	Less than 0.5G (4.9m/s2) 10-60Hz (non-continuous working)
	IP ratings	IP20

1.4 Driver ports and connectors

EL7-ECN Series Servo Drive 220V Models



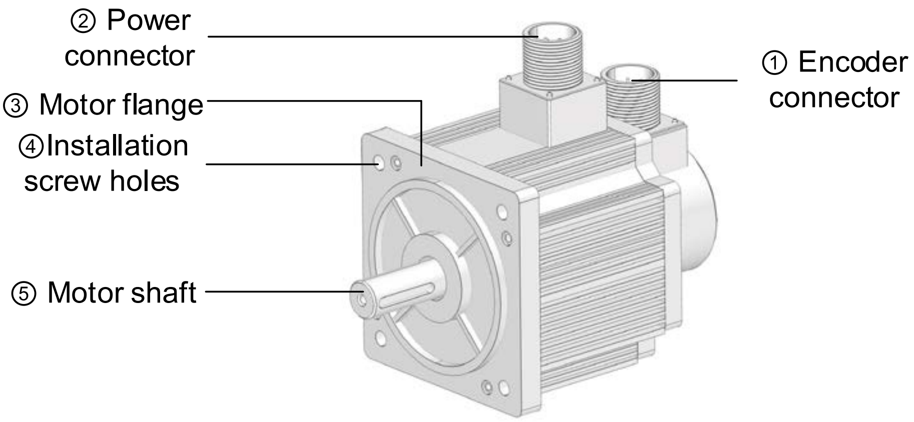
EL7-ECNT Series Servo Drive 400V Models



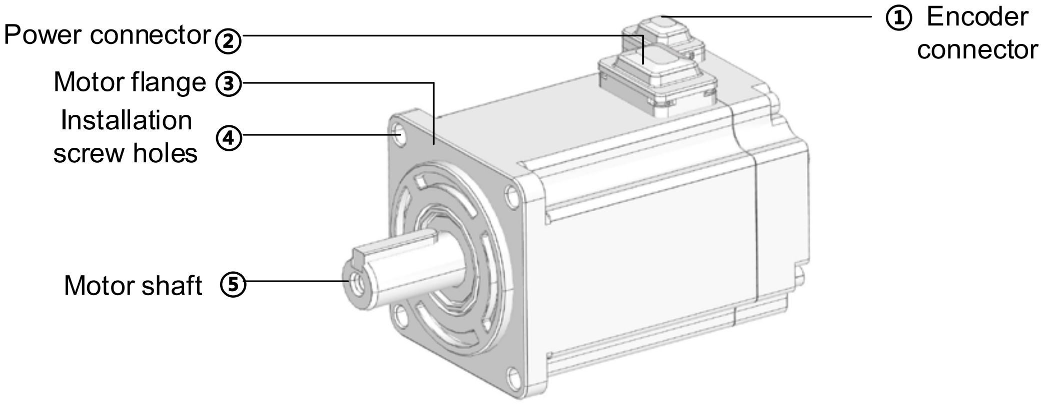
<table>
<tr><th>No.</th><th>Parts & Connectors</th><th>Description</th></tr>
<tr><td>①</td><td>Front Panel</td><td>Including a LED display and 5 buttons. LED display is used to display servo drive status and parameter settings.
5 buttons:
M : To switch between different modes and parameters
◀ : Switch between value
▲ : Switch between sub-menus/Increase
▼ : Switch between sub-menus/Decrease
S : Enter</td></tr>
<tr><td>②</td><td>USB Type-C tuning port</td><td>Connect to computer for tuning of servo drive. Parameters of the servo drive can be modified without connecting to main power supply.</td></tr>
<tr><td>③</td><td>CN1 I/O signal</td><td>Probe input signal & other I/O signals terminals</td></tr>
<tr><td>④</td><td>CN3 EtherCAT IN/
CN4 EtherCAT OUT</td><td>Connect to master device or next/previous slave station</td></tr>
<tr><td>⑤</td><td>CN6 STO</td><td>Safe Torque Off (STO) port</td></tr>
<tr><td>⑥</td><td>CN2 Encoder</td><td>Connect to motor encoder</td></tr>
<tr><td>⑦</td><td>Power-on indicator light</td><td>Lights up when servo drive is connected to main power supply. Please do not touch the power terminal immediately after power off as the capacitor might require some time to discharge.</td></tr>
<tr><td colspan="3">EL7-EC 220V models</td></tr>
<tr><td rowspan="5">⑨</td><td>L1, L2</td><td>Main power supply 220VAC</td></tr>
<tr><td>P+, Br</td><td>Connect to regenerative resistor</td></tr>
<tr><td>P+, N</td><td>Common DC bus terminals for multiple drivers</td></tr>
<tr><td>U, V, W</td><td>Motor connector: Connect to U,V,W power terminals on servo motor</td></tr>
<tr><td>PE</td><td>PE motor earth terminal: Connect to motor PE terminal</td></tr>
<tr><td colspan="3">EL7-EC 400V models</td></tr>
<tr><td rowspan="6">⑨
⑩</td><td>L1C, L2C</td><td>Control circuit power supply input – 1ph 380VAC</td></tr>
<tr><td>R, S, T</td><td>Main power supply input – 3ph 380VAC</td></tr>
<tr><td>P+</td><td>DC bus positive terminal. Connect to regenerative resistor</td></tr>
<tr><td>B1, B2</td><td>Please short connect B1 and B2 when using internal regenerative resistor. If external regenerative resistor is required, remove the short connector between B1 and B2, connect the external regenerative resistor to P+ and B2.</td></tr>
<tr><td>N</td><td>DC bus negative terminal. Do not connect.</td></tr>
<tr><td>N1, N2
(4.4/5.5/7.5kW models)</td><td>N1 and N2 are short connected. Connect N1 and N2 after removing short connector to a DC reactor to suppress electrical current high harmonics.</td></tr>
<tr><td>⑪</td><td>Protective Earth PE</td><td>Connect to PE of main power supply. For grounding</td></tr>
</table>

1.5 Motor ports and connectors

Motors with aviation connectors



Motors with direct connectors



Chapter 2 Installation & Wiring

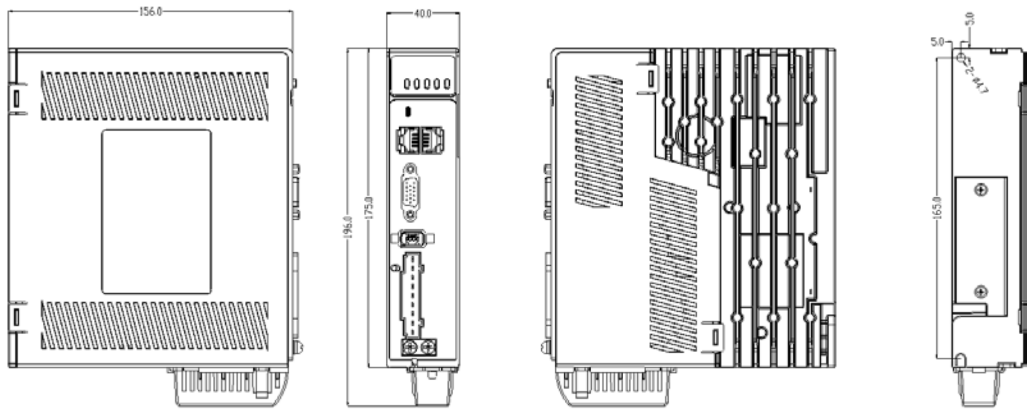
2.1 Servo Drive Installation

2.1.1 Servo drive installation environment

Temperature	Storage: -20-80℃ (Condensation free); Installation: 0-55℃ (Not frozen)
Humidity	Under 90%RH (Condensation free)
Altitude	Up to 1000m above sea level
Vibration	Less than 0.5G (4.9m/s2) 10-60Hz (non-continuous working)
Atmospheric	No corrosive gas, combustibles, dirt or dust.
IP ratings	IP20

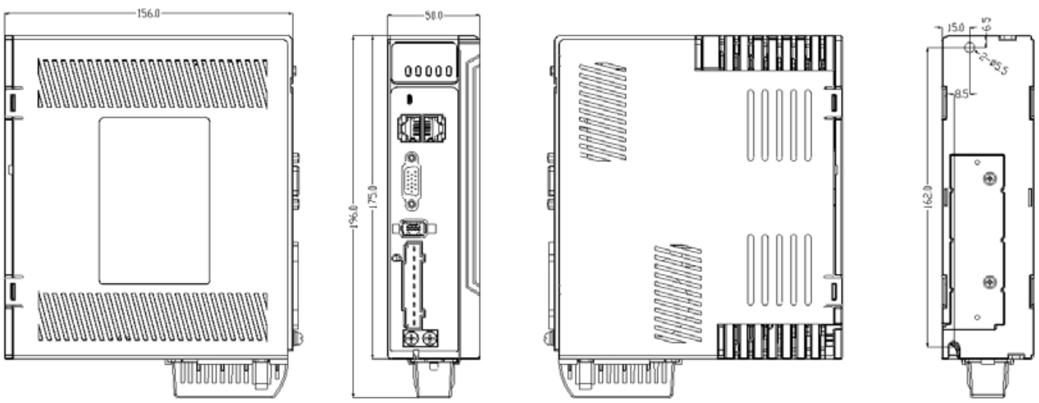
2.1.2 Servo Drive Dimension

EL7 – EC Series 400W - 220VAC Size A



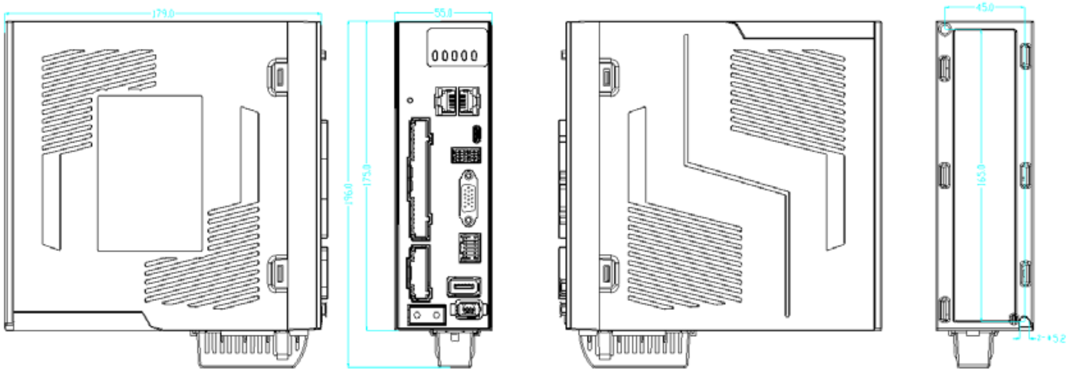
40mm x 175mm x 156mm

EL7 – EC Series 750W/1000W -220VAC Size B



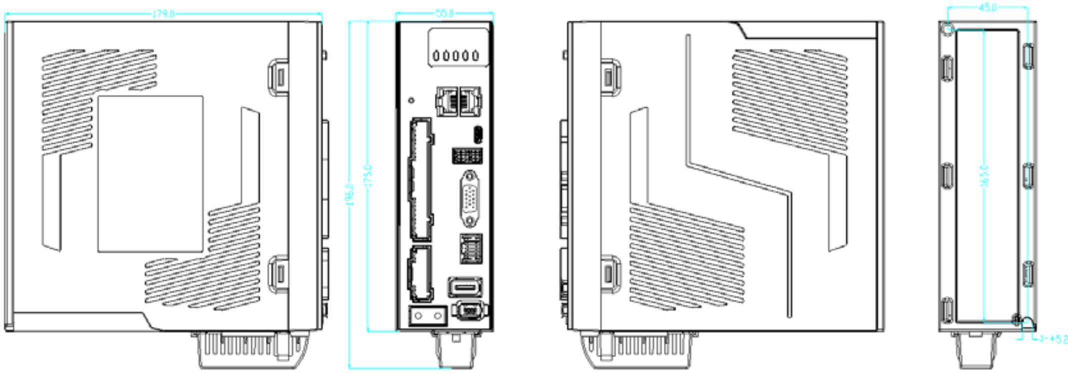
50mm x 175mm x 156mm

EL7-EC Series 750W/1000W/1500W -400VAC Size C



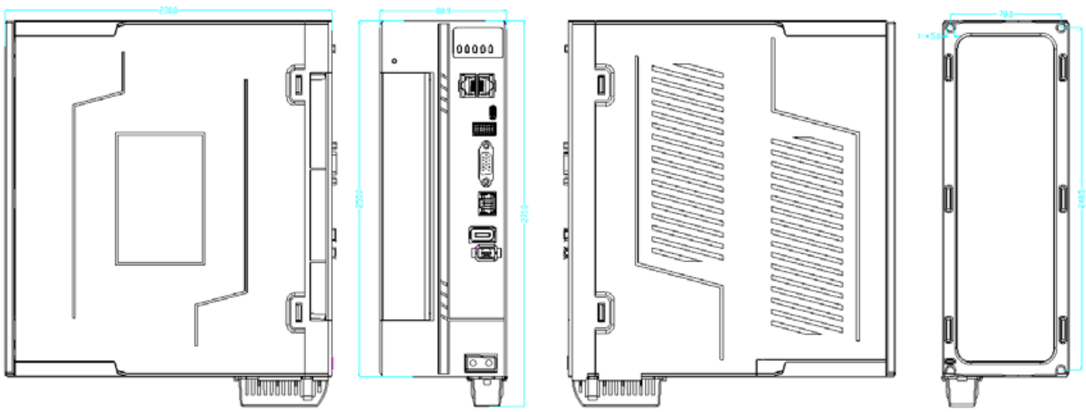
55mm×175mm×179mm

EL7-EC Series 2000W/3000W -400VAC 1500W/2000W -220VAC Size D



80mm×175mm×179mm

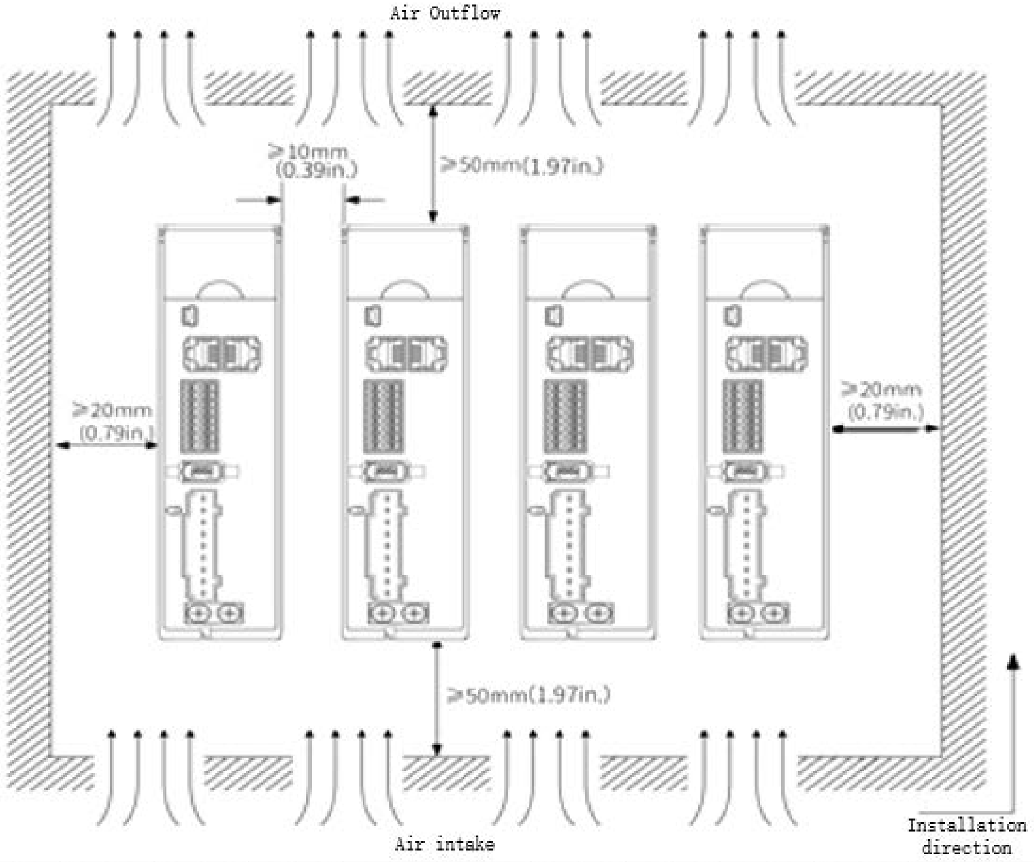
EL7-EC Series 4400W/5500W/7500W -400VAC Size E



89mm×250mm×230mm

Space requirement for installation

In order to ensure efficient heat dissipation, please leave at least 10mm installation space in between drivers. If drivers need to be mounted compactly, please leave at 1mm of installation space. Please keep in mind that under such conditions, the drivers can only run at 75% of actual load rate.



- ✓ **Installation method**
  Please install the driver vertical to ground facing forward for better heat dissipation. Always install in rows and use heat insulation board to separate between rows. Cooling fans are recommended for drivers to achieve optimal performance.
- ✓ **Grounding**
  PE terminals must be grounded to prevent electrocution hazard or electromagnetic interference.
- ✓ **Wiring**
  Please ensure there is no liquid around the wiring and connectors as liquid leakage may cause serious damage to the driver(s).

2.2 Servo Motor Installation

2.2.1 Installation conditions

Installation conditions may affect the lifespan of a motor

- Please keep away from corrosive fluid and combustibles.
- If dusty working environment is unavoidable, please use motors with oil seal.
- Please keep away from heat source.
- If motor is used in enclosed environment without heat dissipation, motor lifespan will be short.
- Please check and clean the installation spot before installation.

2.2.2 Precautions during installation

Installation method

Install horizontal to ground

Make sure power cable and encoder cable is facing downwards to make sure fluid doesn't leak into the ports.

Install vertical to ground

Please use a motor with oil seal when paired with a reducer to prevent reducer oil from leaking into the motor.

Oil- and waterproofing

- Do not submerge motor/cable under oil/water
- Please use a motor with oil seal when paired with a reducer to prevent reducer oil from leaking into the motor.
- If there is an unavoidable fluid leakage near the motor, please use motor with better IP ratings.
- Make sure power cable and encoder cable is facing downwards to make sure fluid doesn't leak into the ports.
- Avoid the usage of motor in water/oil leaking prone environment.

Cable under stress

- Do not the bend the cable especially at each ends of the connectors.
- Make sure to not let the cables be too tight and under tremendous stress especially thinner cables such as signal cables.

Connectors

- Please to remove any conductive foreign objects from the connectors before installation
- The connectors are made of resin. May not withstand impact.
- Please hold the driver during transportation, not the cables.

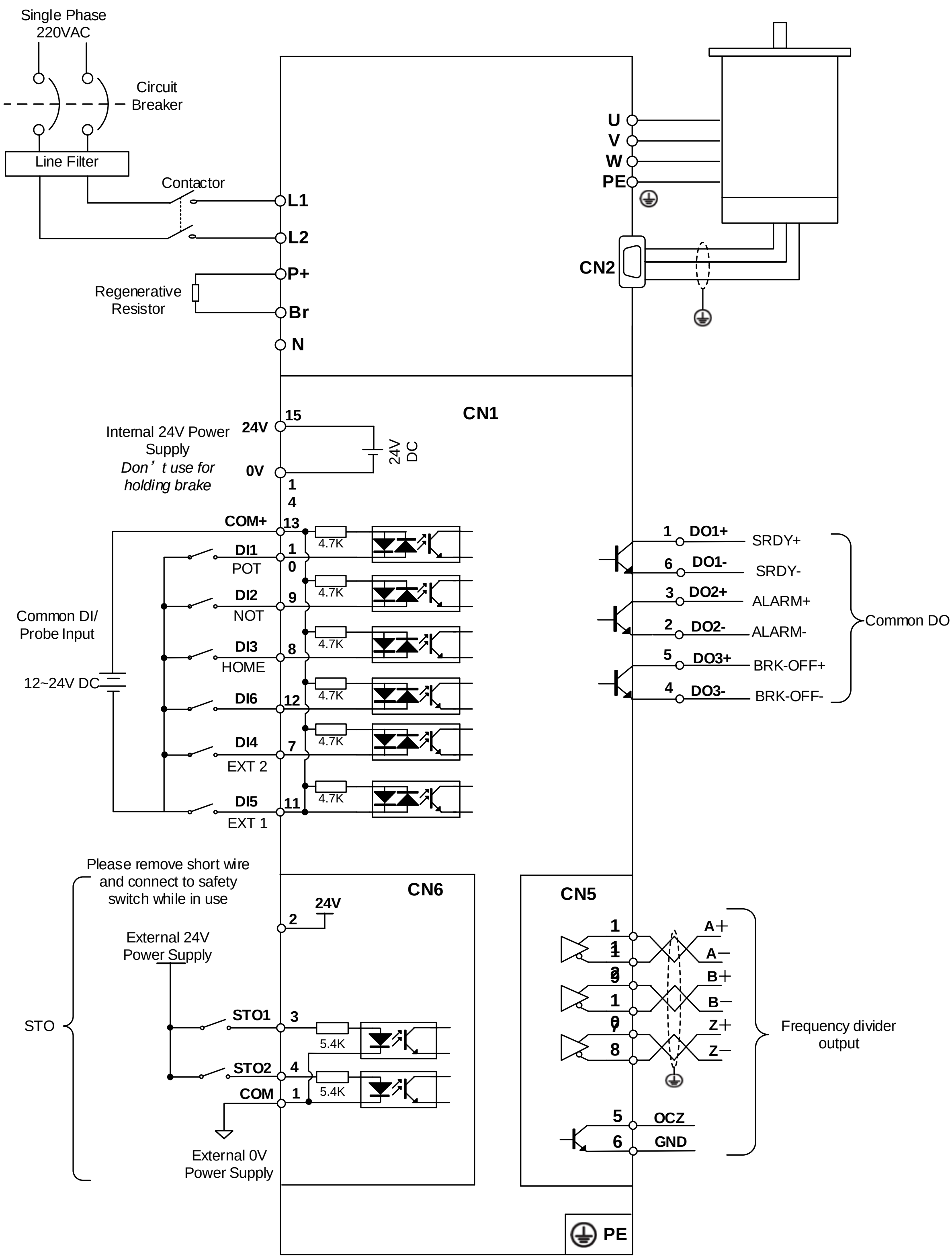
- Leave enough "bend" on the connector cables to ensure less stress upon installation.

Encoder & coupling

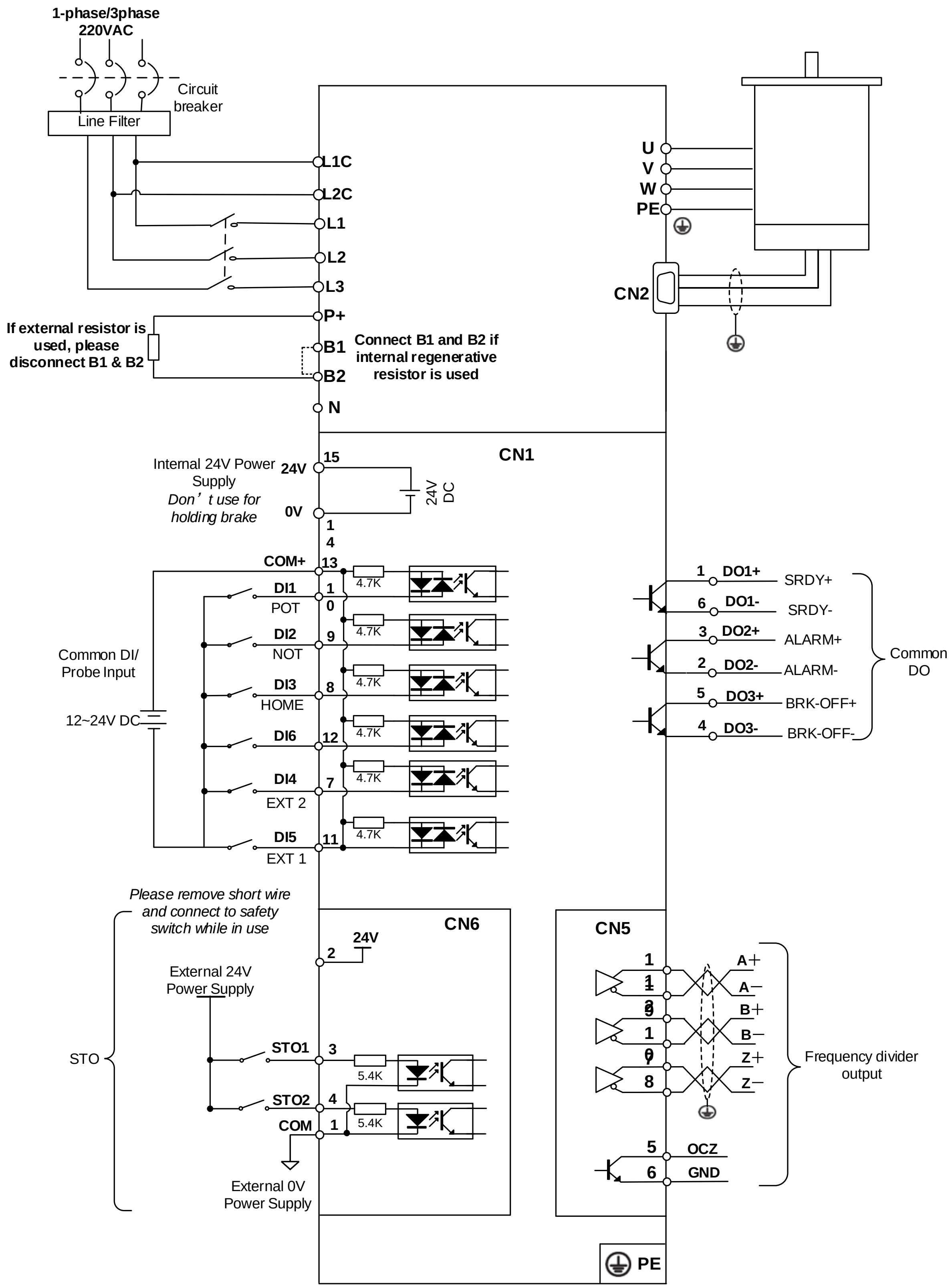
- During installation or removal of coupling, please do not hit the motor shaft with a hammer as it would cause damage to internal encoder.
- Please make sure to centralize the motor shaft and coupling, it might cause damage to motor or encoder due to vibration.
- Please make sure axial and radial load is within the limits specified as it might affect the lifespan of the motor or cause damage to it.

2.3 EL7-EC Wiring Diagram

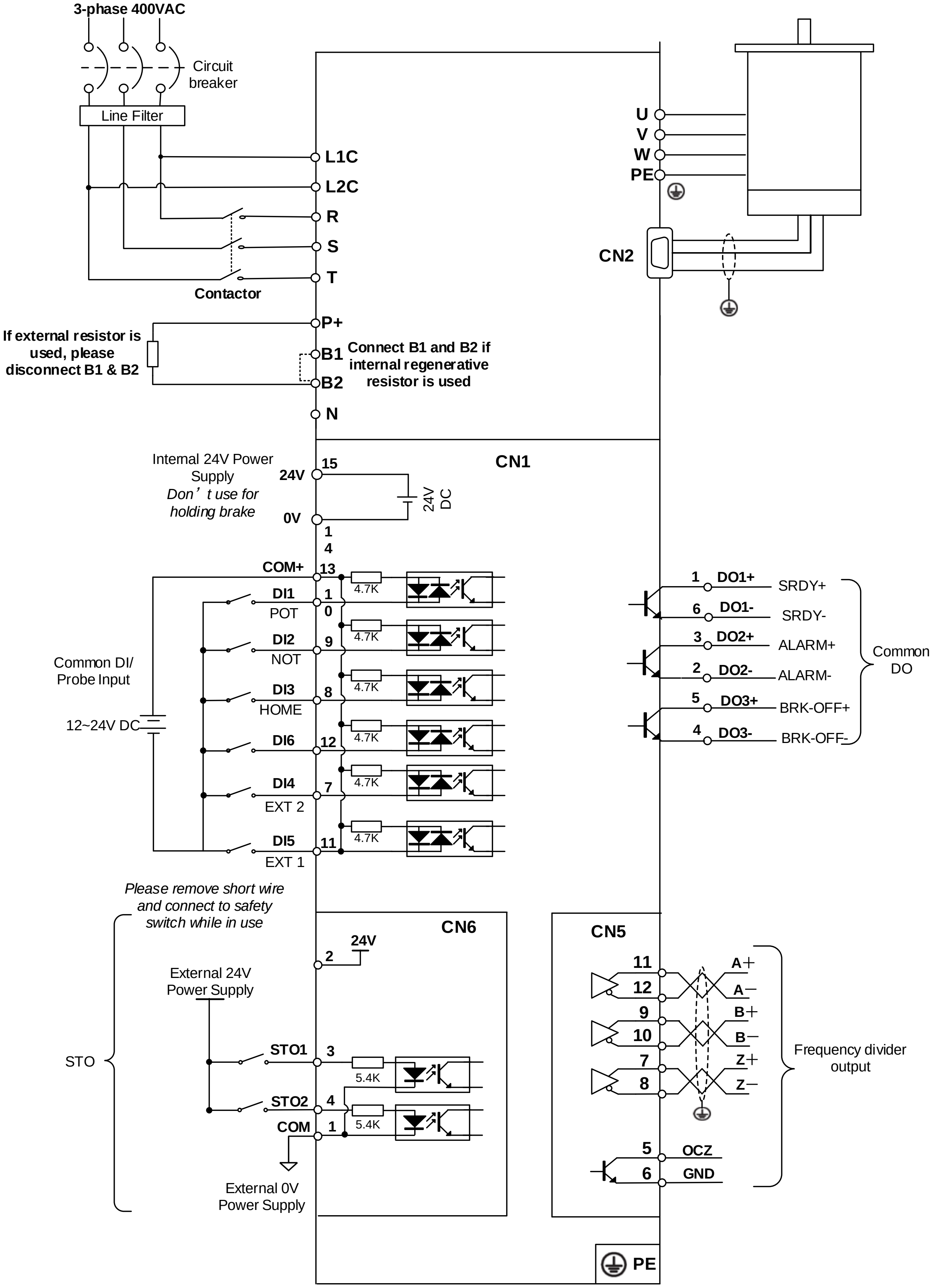
EL7-EC Series 400W/750W/1000W – 220V Models



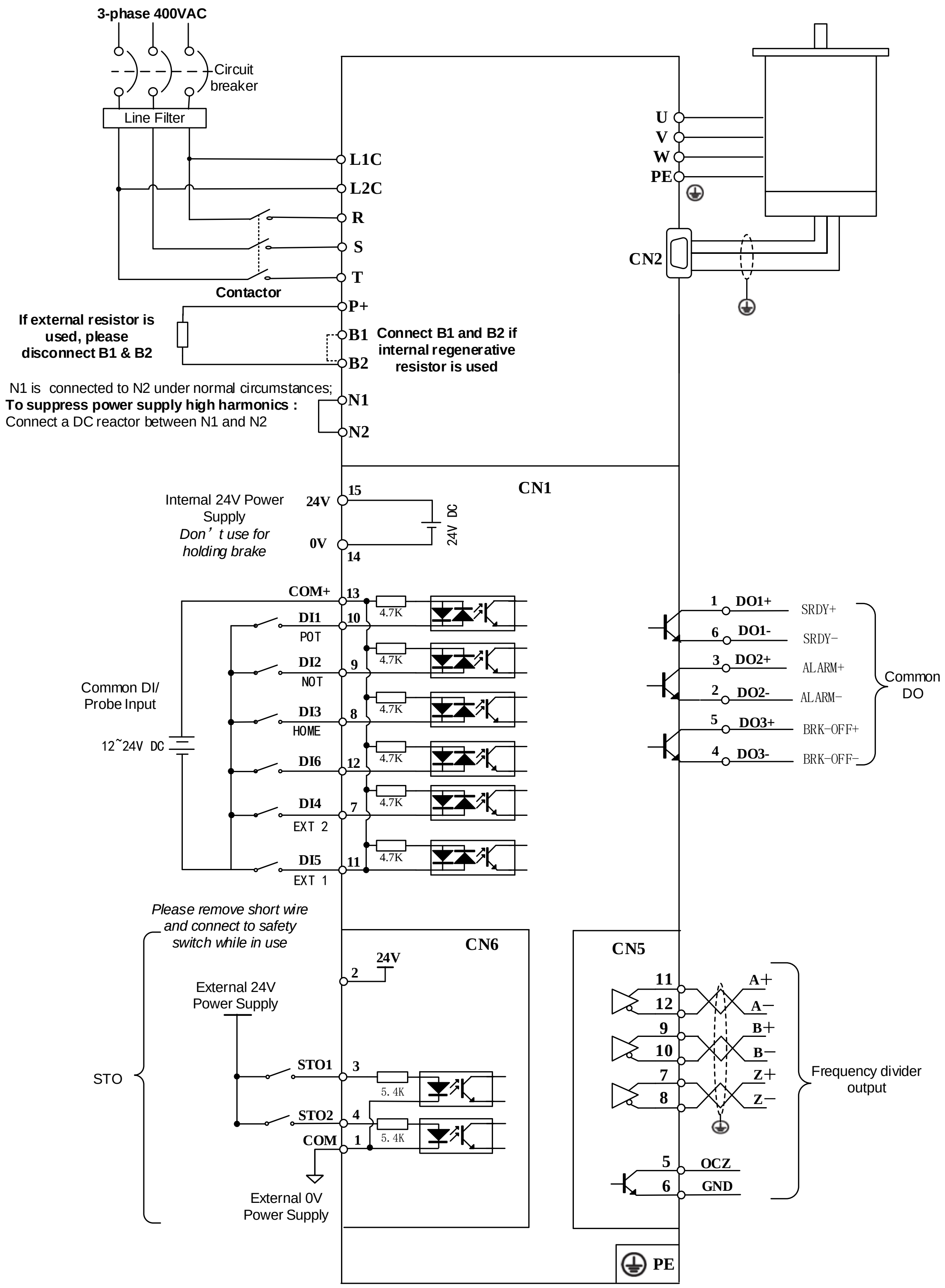
EL7-EC Series 1500W/2000W - 220V Models



EL7-EC Series 750W/1000W/1500W/2000W/3000W – 400V Models



EL7-EC Series 4400W/5500W/7500W – 400V Models



2.4 Servo Drive Ports

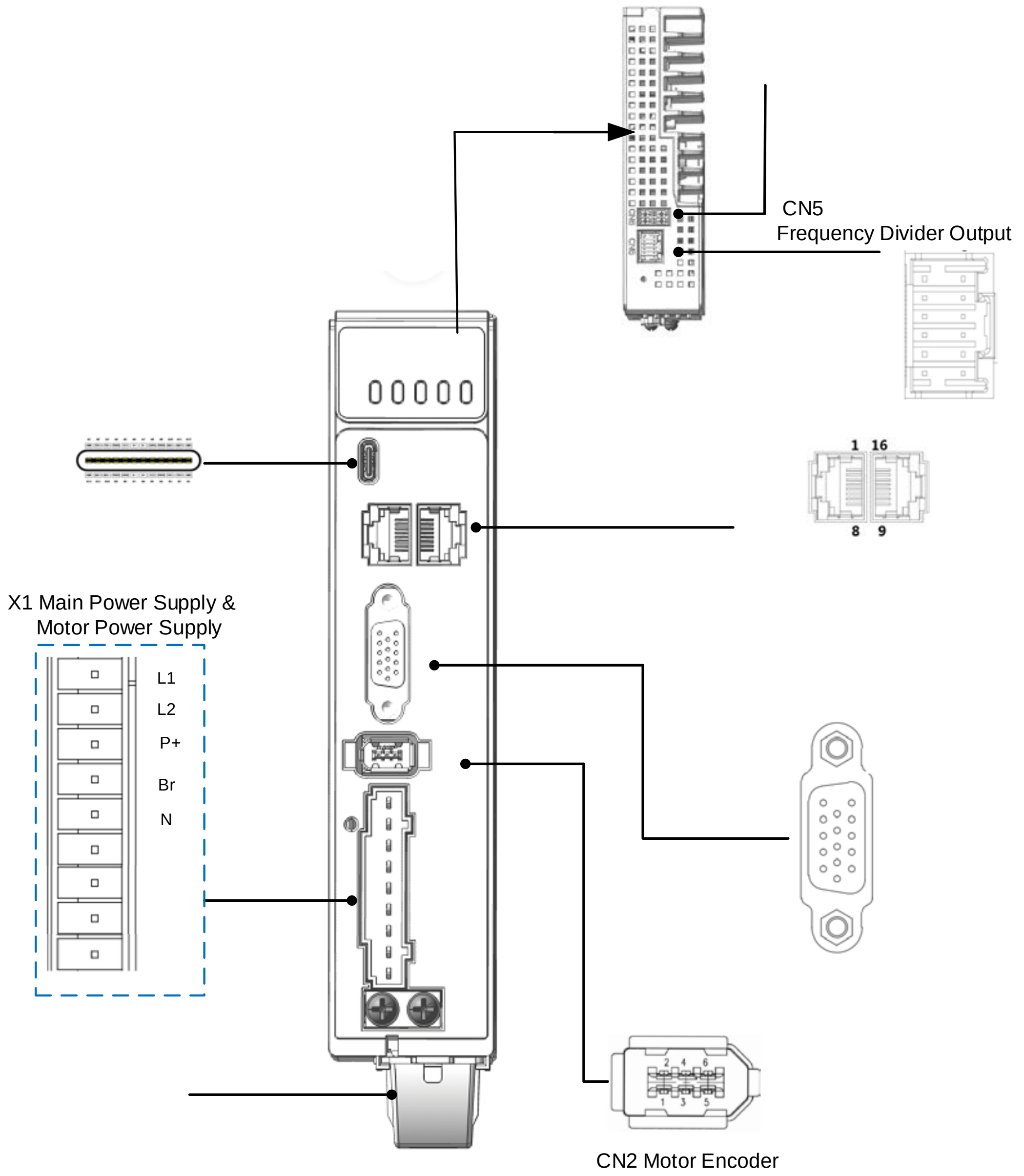


Table 2-1 Functions of driver port

Port	Function
CN1	I/O Signal Port
CN2	Encoder port
USB	USB Type-C Tuning Port
CN3	EtherCAT IN Communication Port
CN4	EtherCAT OUT Communication Port
CN6	Safe Torque Off (STO) Port
X1	Main Power Supply

2.4.1 X1 Main power supply

EL7-EC Series – 220V Models

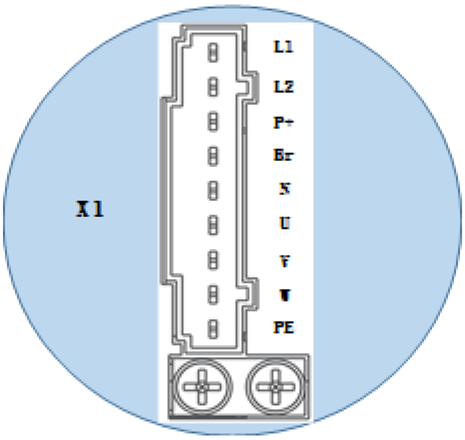
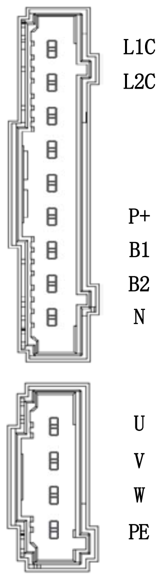
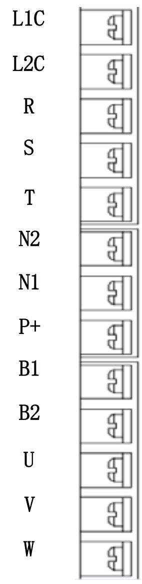


Table 2-2 X1 port descriptions

Port	Pin	Functions	Remarks
X1	L1	Single phase 220VAC, +10～-15%， 50/60Hz	① Optional isolation transformer ② Do not connect to 380VAC directly to prevent damage to driver. ③ In case of serious interference, it is recommended to connect a line filter to main power supply; *It is recommended to install a fuseless circuit breaker to cut off power supply in time when the driver fails.*
	L2		
	P +	① Internal DC bus positive terminal ② External regenerative resistor P terminal	*Please refer to 2.4.1 Regenerative resistor selection and connections*
	Br	External regenerative resistor terminal	
	N		Please do not connect
	U	Motor U terminal	Please ensure proper wire connection on motor.
	V	Motor V terminal	
	W	Motor W terminal	
	PE	Motor Protective Earth	Please ground PE of driver and motor together

EL7-EC Series – 400V Models





Port	Pin	Functions	Remarks
X1	L1C	Control circuit: Single phase 400VAC, +10～-15%, 50/60Hz	① Optional isolation transformer ② In case of serious interference, it is recommended to connect a line filter to main power supply; *It is recommended to install a fuseless circuit breaker to cut off power supply in time when the driver fails.*
	L2C		
	R	Main Power Supply: Three phase 400VAC, +10～-15%, 50/60Hz	
	S		
	T		
	P +	③ Internal DC bus positive terminal ④ External regenerative resistor P terminal	If an external regenerative resistor is required, please disconnect B1 and B2. Connect the external regenerative resistor to terminal P+ and B2.
	B1/B2	External regenerative resistor terminal	
	N	Internal DC bus negative terminal	Please do not connect
	N1		N1 and N2 are connected under normal circumstances. To suppress power supply high harmonics, please disconnected N1 and N2. Connect a DC reactor between N1 and N2.
	N2		
	U	Motor U terminal	Please ensure proper wire connection on motor.
	V	Motor V terminal	
	W	Motor W terminal	
	PE	Motor Protective Earth	Please ground PE of driver and motor together

2.4.2 Regenerative resistor selection and connections

The use of regenerative resistor

When the motor opposes the direction of rotation as in deceleration or vertical axis escalation, part of the regenerative energy will be delivered back to the driver. This energy will first be stored in internal capacitors of the driver. When the energy stored in the capacitors reach the maximum capacity, a regenerative resistor is required the excessive energy to prevent over-voltage.

Selection of regenerative resistor

Table 2-3 Recommended selection of regenerative resistor

Model no.	Internal resistance (Ω)	Internal resistor power rating (W)	Minimum resistance (Ω)	Minimum power rating (W)
EL7-EC400N	100	50	50	50
EL7-EC750N	50	75	40	50
EL7 -EC1000N	50	100	30	100
EL7-EC750NT	100	100	100	100
EL7-EC1000NT	100	100	100	100
EL7-EC1500NT	100	100	100	100
EL7-EC2000NT	50	100	40	100
EL7-EC3000NT	50	100	40	100
EL7-EC4400NT	35	100	35	100
EL7-EC5500NT	35	100	25	100
EL7-EC7500NT	35	100	25	100

Calculation of regenerative resistance under normal operation

Steps:

1. Determine if driver comes with a regenerative resistor. If not, please prepare a regenerative resistor with resistance value higher than might be required.
2. Monitor the load rate of the regenerative resistor using front panel (d14). Set the driver on high velocity back and forth motions with high acceleration/deceleration.
3.Please make sure to obtain the value under following conditions: Driver temperature < 60℃, d14<80(Won't trigger alarm), Regenerative resistor is not fuming, No overvoltage alarm(Err120).

Pb(Regenerative power rating) = Resistor power rating x Regenerative load rate (%)

Please choose a regenerative resistor with power rating Pr about **2-4 times the value of Pb** in considered of harsh working conditions and some 'headroom'.
If the calculated Pr value is less than internal resistor power rating, external resistor is not required.

$$R(\text{Max. required regenerative resistance}) = (380^2 - 370^2)/Pr$$

Problem diagnostics related to regenerative resistor:

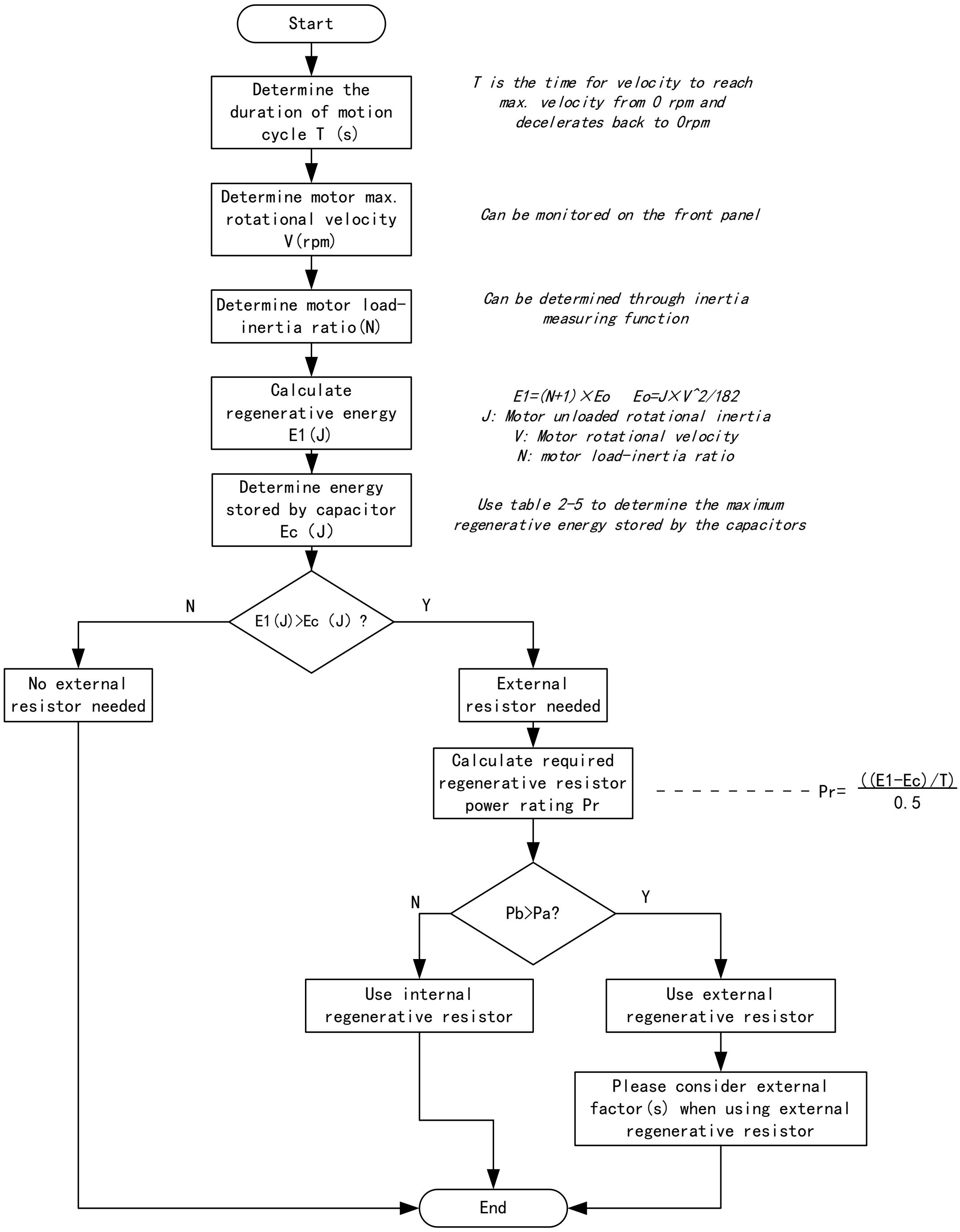
- If driver temperature is high, reduce regenerative energy power rating or use an external regenerative resistor.
- If regenerative resistor is fuming, reduce regenerative energy power rating or use an external regenerative resistor with higher power rating.
- If d14 is overly large or increasing too fast, reduce regenerative energy power rating or use an external regenerative resistor with higher power rating.
- If driver overvoltage alarm (Er120) occurs, please use an external regenerative resistor with lower resistance or connect another resistor in parallel.

Please take following precautions before installing an external regenerative resistor.

1. Please set the correct resistance value in Pr0.16 and resistor power rating Pr0.17 for the external regenerative resistor.
2. Please ensure the resistance value is higher or equals to the recommended values in table 2-3. Regenerative resistors are generally connected in series but they can also be connected in parallel to lower the total resistance.
3. Please provided enough cooling for the regenerative resistor as it can reach above 100℃ under continuous working conditions.
4. The min. resistance of the regenerative resistor is dependent on the IGBT of the holding brake. Please refer to table

Theoretical selection of regenerative resistor

Without external loading torque, the need for an external regenerative resistor can be determined as the flow chart below


Start
Determine the duration of motion cycle T (s)
T is the time for velocity to reach max. velocity from 0 rpm and decelerates back to 0rpm
Determine motor max. rotational velocity V(rpm)
Can be monitored on the front panel
Determine motor load-inertia ratio(N)
Can be determined through inertia measuring function
Calculate regenerative energy E1(J)
E1=(N+1)×Eo Eo=J×V^2/182
J: Motor unloaded rotational inertia
V: Motor rotational velocity
N: motor load-inertia ratio
Determine energy stored by capacitor Ec (J)
Use table 2-5 to determine the maximum regenerative energy stored by the capacitors
E1(J)>Ec (J) ?
N
Y
No external resistor needed
External resistor needed
Calculate required regenerative resistor power rating Pr
Pr= ((E1-Ec)/T) / 0.5
Pb>Pa?
N
Y
Use internal regenerative resistor
Use external regenerative resistor
Please consider external factor(s) when using external regenerative resistor
End

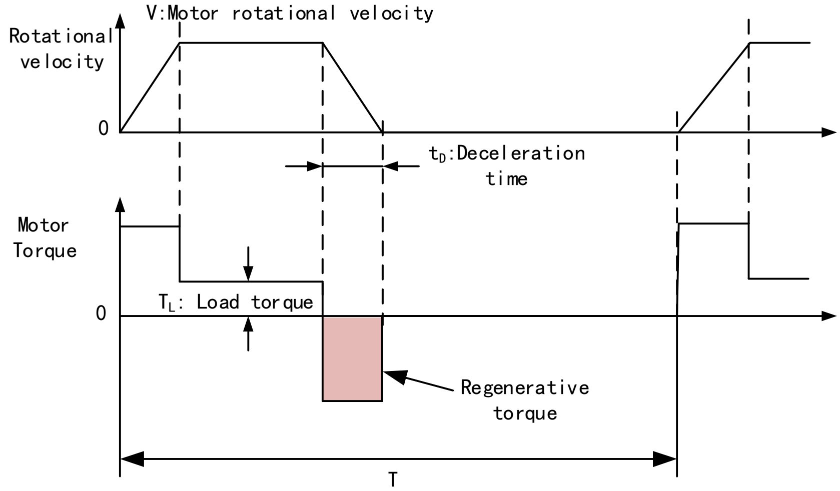


Table 2-4 Steps to calculate capacity of regenerative resistor

Steps	Calculation	Symbol	Formula
1	Servo system regenerative energy	E1	$E1=(N+1)\times J\times V^2/182$
2	Depleted energy from loss of load system during acceleration	E_L	$E_L = (\pi/60)\ V\times T_L\times tD$ *If loss is not determined, please assume $E_L = 0$.*
3	Depleted energy due to motor coil resistance.	E_M	$E_M=(U^2/R)\times tD$ R= coil resistance, U = operating voltage *If R is not determined, please assume $E_M = 0$.*
4	Energy stored by internal DC capacitors	Ec	Please refer to table 2-5
5	Depleted energy due to regenerative resistance	E_K	E_K=E1-(EL+EM+EC), If loss is ignored, EK=E1-EC
6	Required power rating of regenerative resistor	Pr	$Pr=E_K/(0.5\times T)$

Internal capacitor capacity and rotor inertia

EL7-EC Drivers	Servo motor	Rotor Inertia ($\times 10^{-4}kg.m^2$)	Max. regenerative energy stored in capacitor Ec(J)
400W	ELM2H-0400LA60	0.58	13.47
750W	ELM2H-0750LA80	1.66	22.85
1000W	ELM2M-1000LB80	1.79	27.74
	ELM2M-1000LB130	8.5	

There are motors with low, medium and high inertia. Different motor models have different rotor inertia. Please refer to servo product catalogue for more information on rotor inertia.

Calculation examples:
Servo drive: EL7-EC750N, Servo Motor: ELM2H-0750LA80. When T = 2s, rotational velocity = 3000rpm, load inertia is 5 times of motor inertia.

EL7-EC Drivers	Servo motor	Rotor Inertia （×10^{-4}kg.m^2）	Max. regenerative energy stored in capacitor Ec(J)
750W	ELM2H-0750LA80	1.66	22.85

Regenerative energy produced:

$$E1 = \frac{(N+1) \times J \times V^2}{182} = \frac{(5+1) \times 1.66 \times 3000^2}{182} = 49.3J$$

If E1<Ec, internal capacitors can't take in excessive regenerative energy, regenerative resistor is required.
Required regenerative resistor power rating Pr:

$$Pr = \frac{(E1 - Ec)}{0.5T} = \frac{49.3 - 22.85}{0.5 \times 2} = 26.45W$$

Hence, with the internal regenerative resistor Pa = 75W, Pr<Pa, no external regenerative resistor is required.

Let's assume if the load inertia is 15 times of motor inertia, Pr = 108.6W, Pr>Pa, external regenerative resistor is required. And to consider for harsh working environment,

Pr(external)=108.6/(1-40%)=181 W

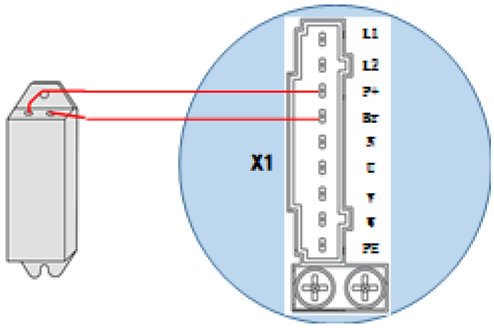
When selecting the resistance of the regenerative resistor, please be higher than the minimum value recommended in table 2-3 but lower than Rmax

Rmax =(380^2-370^2)/Pr=7500/108.6=69Ω

In conclusion, a regenerative resistor with resistance 40Ω - 70Ω and power rating 110W to 180W can be chosen.

Please take note that theoretical calculations of the regenerative resistance is not as accurate as calculations done under normal operation.

Connection of a regenerative resistor



2.4.2 Wire Gauge for Main Power Supply

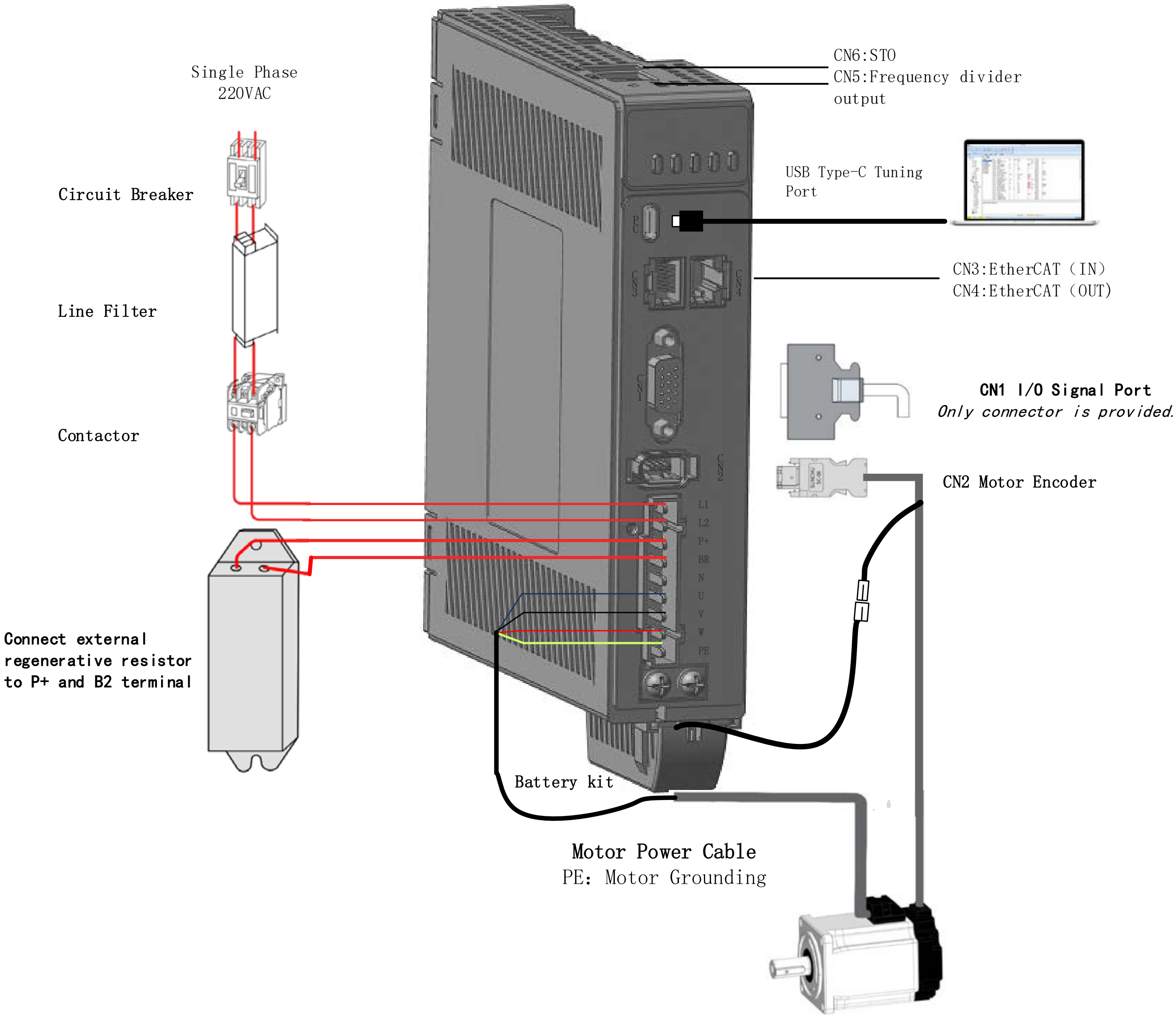
Table 2-6 Main power supply wire gauge

Driver	Wire diameter (mm^2/AWG)			
	L1 L2/R S T	P+ BR	U V W	PE
EL7-EC400N	0.81/AWG18	2.1/AWG14	1.3/AWG16	2.1/AWG14
EL7-EC750N	0.81/AWG18	2.1/AWG14	1.3/AWG16	2.1/AWG14
EL7-EC1000N	0.81/AWG18	2.1/AWG14	2.1/AWG14	2.1/AWG14
EL7-EC750NT	1.3/AWG16	2.1/AWG14	1.3/AWG16	2.1/AWG14
EL7-EC1000NT	2.1/AWG14	2.1/AWG14	2.1/AWG14	2.1/AWG14
EL7-EC1500NT	2.1/AWG14	2.1/AWG14	2.1/AWG14	2.1/AWG14
EL7-EC2000NT	2*0.75/AWG18	1.5/AWG16	3*1.5/AWG16	1.5/AWG16
EL7-EC3000NT	2*0.75/AWG16	1.5/AWG16	3*1.5/AWG16	1.5/AWG16
EL7-EC4400NT	2*0.75/AWG16	4.0/AWG12	3*4.0/AWG12	4.0/AWG12
EL7-EC5500NT	2*0.75/AWG14	4.0/AWG12	3*4.0/AWG12	4.0/AWG12
EL7-EC7500NT	2*0.75/AWG12	4.0/AWG12	3*4.0/AWG12	4.0/AWG12

- Grounding: Grounding wire should be thicker. Ground PE terminal of servo drive and servo motor together with resistance <100 Ω.
- A 3-phase isolation transformer is recommended to lessen the risk of electrocution
- Connect a line filter to power supply to reduce electromagnetic interference.
- Please install a fuseless circuit breaker to cut off power supply in time when the driver fails.

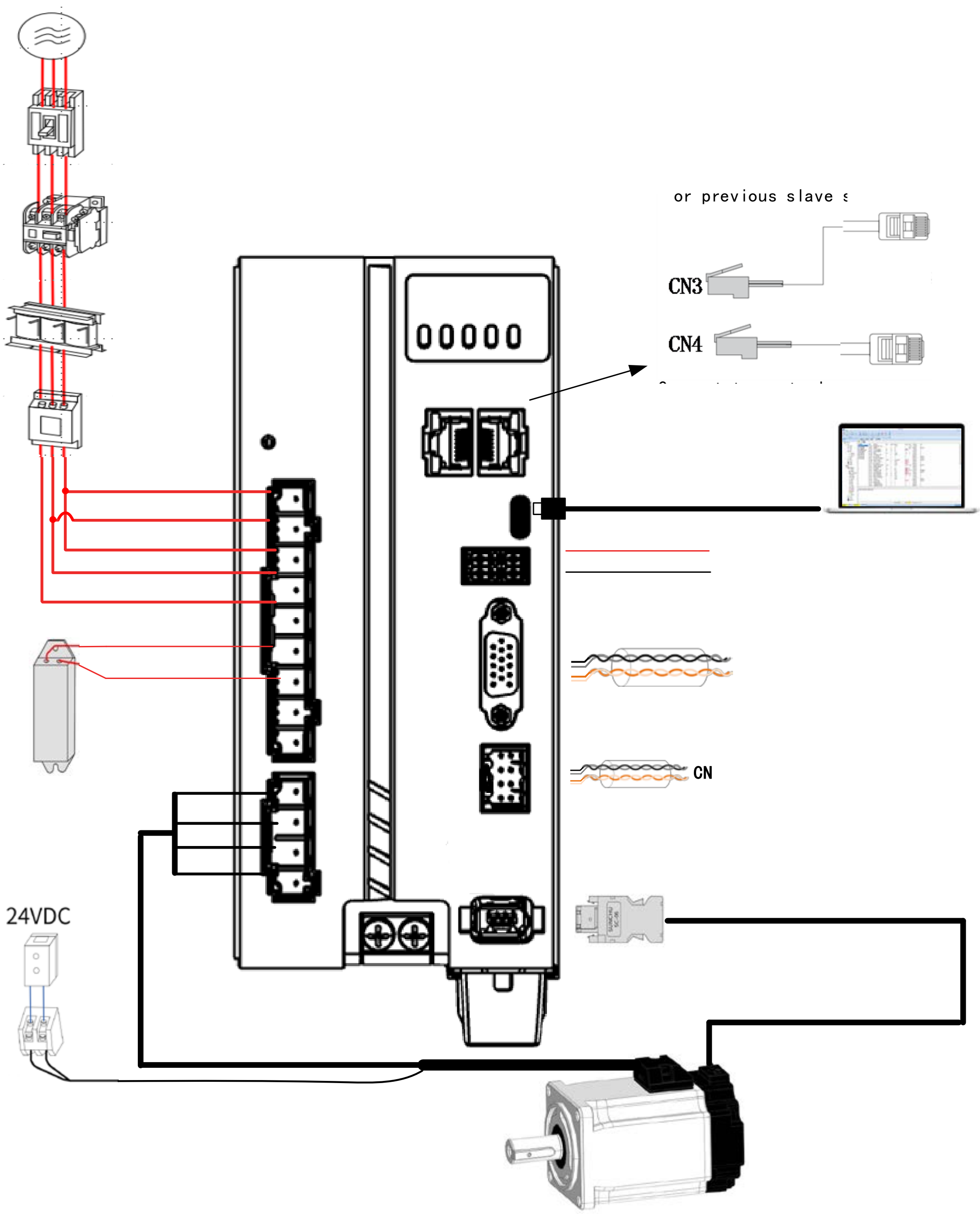
2.4.3 Wiring connections for EL7-EC series servo drives

EL7-EC Series – 220VAC



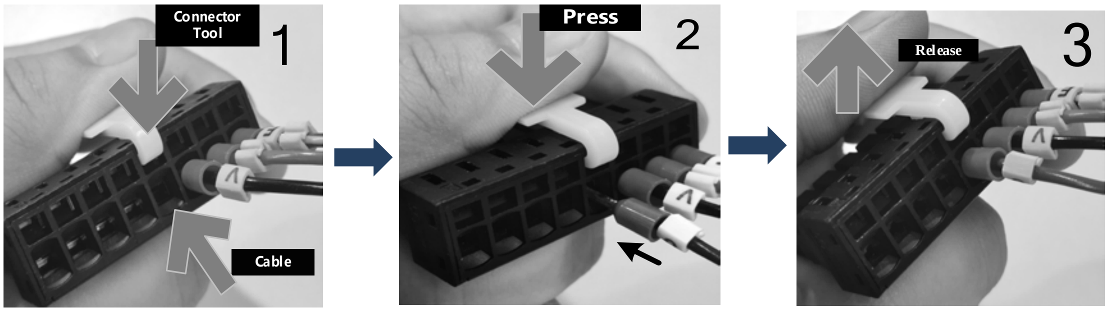
- EL7-EC series servo drive 220VAC models support single phase and three phase 220VAC. Only driver with power rating above 1500W supports three phase 220VAC.

EL7-EC Series – 400VAC

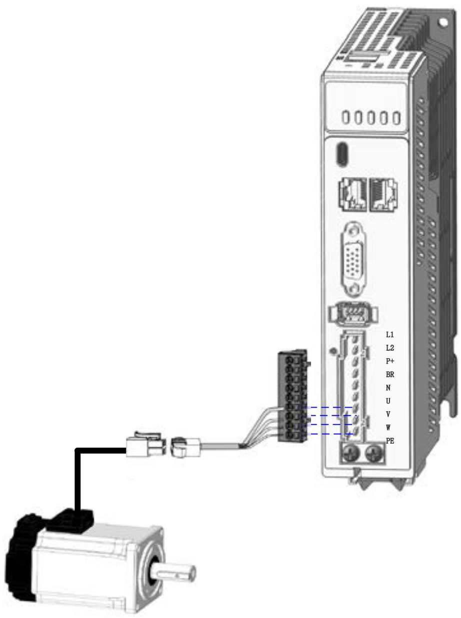


- Please use a circuit breaker for the main power supply to prevent damage to the product or machine.
- Please do not use a contactor in connection to servo motor as it may not withstand a sudden surge of operating voltage.
- Please take note of the capacity when connect to a 24VDC switching power supply, especially if power supply is shared between multiple components. Insufficient supply current will cause failure in holding brake functions.

To fix wire cables into connector



2.4.4 Connecting motor power cable to servo drive



Example: Connecting a motor with electrical connectors

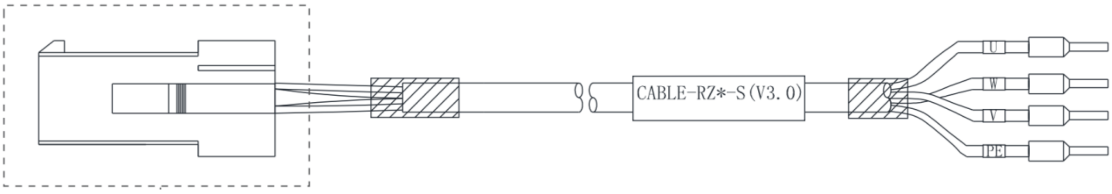
The power cable from the driver is labeled with U, V, W, PE. Please connect the wires accordingly to the power cable extending from the servo motor.

Motor power cable selection

Motor winding power cable

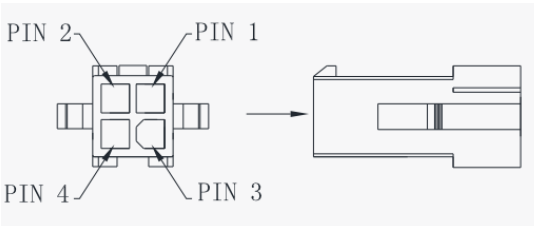
- Wire length available: 1.5m, 3m and 5m
- Connectors type available: AMP electrical connectors, aviation connectors,
  direct connectors (recommended)
- Please contact Leadshine sales team or any Leadshine certified local retailers for any customized needs.

AMP electrical connector (Frame size 80 or below） CABLE-RZ*-S(V3.0)



Motor side　　　　Driver side

Motor cable pin

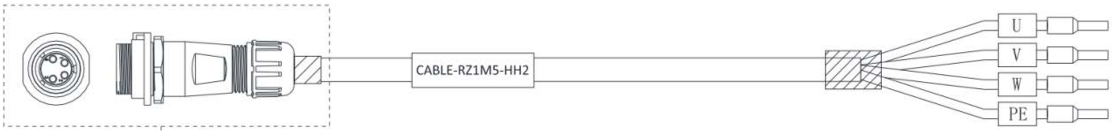


Motor side

Pins

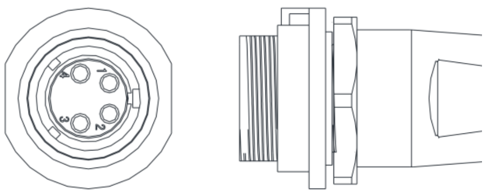
Motor	Color	Driver
1	Blue	U
3	Black	V
2	Red	W
4	Yellow-green	PE

Aviation connector（Frame size 80 or below）CABLE-RZ*-HH2(V3.0)



Motor side　　　　Driver side

Motor cable pin

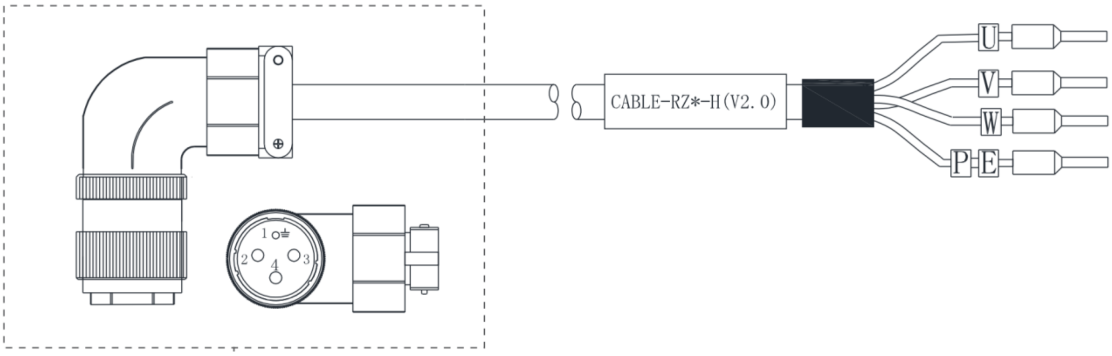


Motor side

Pins

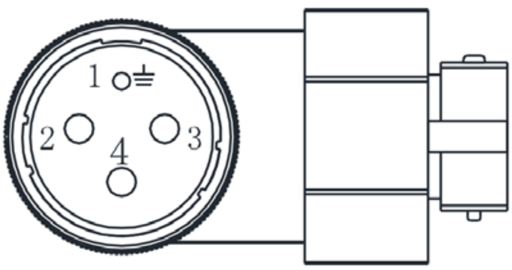
Motor	Color	Driver
1	Blue	U
3	Black	V
2	Red	W
4	Yellow-green	PE

Aviation connector（Frame size 130）CABLE-RZ*H(V1.1/V2.0)



Motor side　　　　Driver side

Motor cable pin

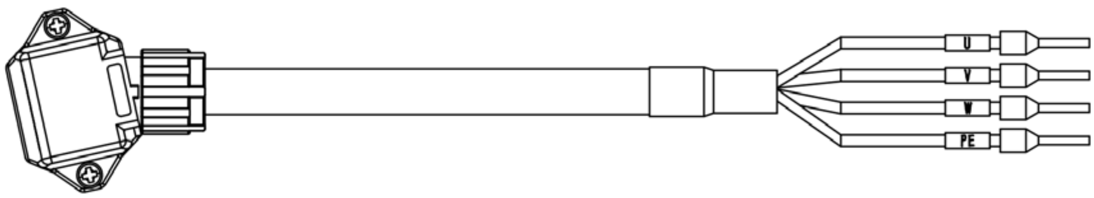


Motor side

Pins

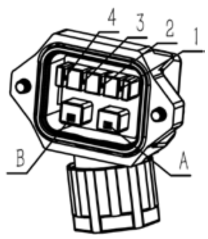
Motor	Color	Driver
1	Red	U
3	Green	V
2	Black	W
4	Yellow	PE

Direct connector(Frame size 80 or below）CABLE-RZH*M*-114-TS without holding brake



Motor side　　　　Driver side

Driver cable pin

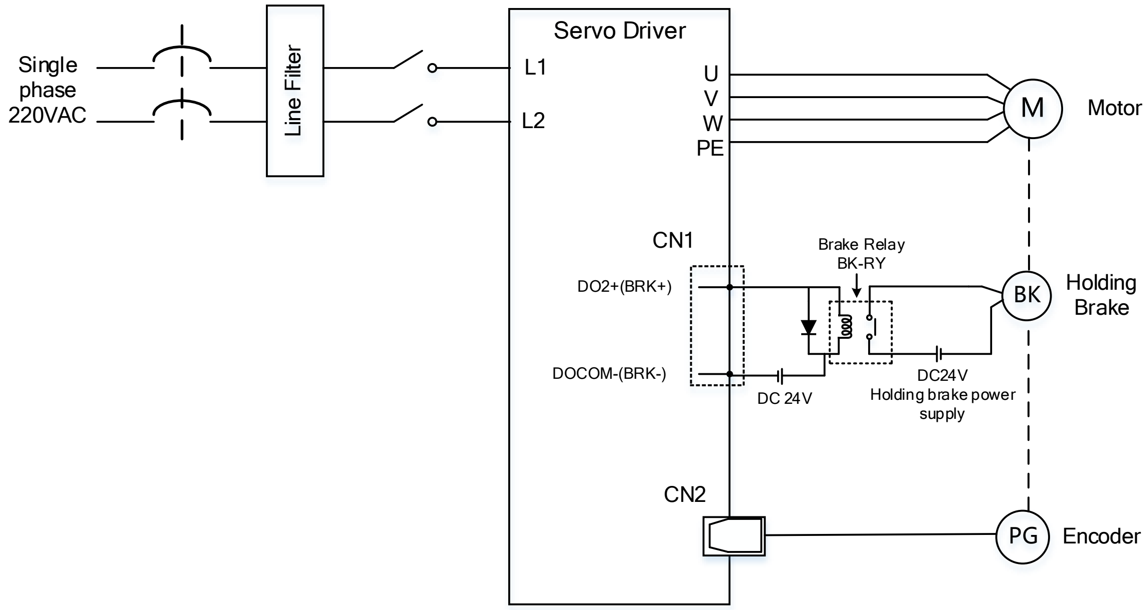


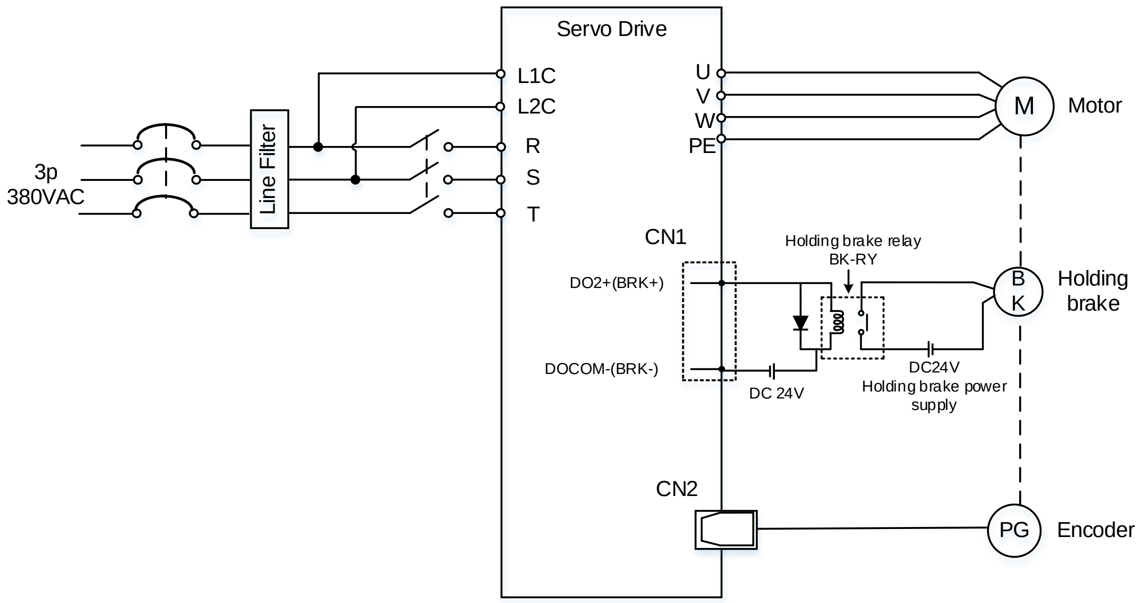
Pins

Motor	Color	Driver
1	Blue	U
2	Black	V
3	Red	W
4	Yellow-green	PE

2.5 Holding brake connection

Holding brake is activated when servo drive is not powered on to prevent axis from moving due to gravitational pull or other external forces by locking the motor in place. Usually used on axis mounted vertically to the ground so that the load would not drop under gravitational force when the driver is powered off or when alarm occurs.

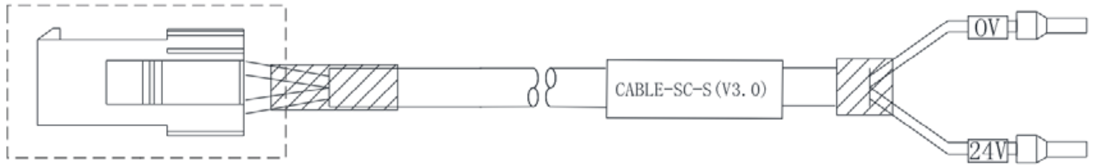




Holding brake wiring diagram

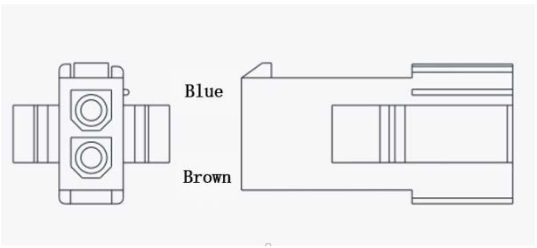
Holding Brake cable and connectors

AMP electrical connector (Frame size 80 or below） CABLE-SC*-S(V3.0)



Motor side Driver side

Motor cable pin

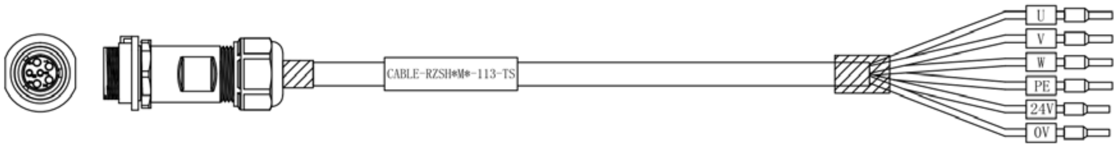


Motor side

Pins

Motor	Color	Pin
2	Blue	0V
1	Brown	24V

Aviation connector（Frame size 80 or below）CABLE-RZSH*M*-113-TS Winding cable with holding brake



Motor side Driver side

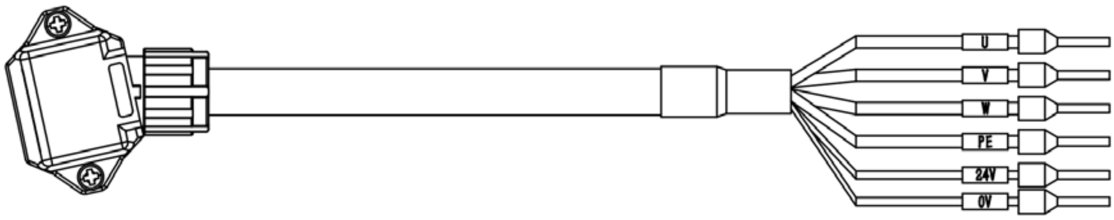
Motor cable pin

Motor side

Pins

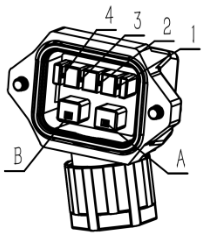
Motor	Color	Driver
1	Blue	U
2	Red	W
3	Black	V
4	Yellow-green	PE
5	Black	0V
6	Red	24V

Direct connector CABLE-RZH*M*-114-TS Winding cable with holding brake



Motor side | Driver side

Motor cable pin	Pin



Motor	Color	Driver
1	Blue	U
2	Black	V
3	Red	W
4	Yellow-green	PE
A	Black	0V
B	Red	24V

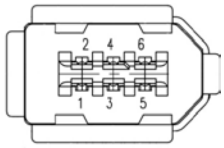
- Mechanical noise might exist when motor with holding brake is in operation but it doesn't affect the functionality of the motor.
- When the holding brake circuit is closed (holding brake deactivated), there might be magnetic flux leakage. Please be aware to not use magnetic sensor around motor with holding brake.
- 24V operating voltage for the holding brake has to be ensured to maintain the functionality of the holding brake. Please consider the voltage dropped over lengthy motor cables due to increase in cable resistance.
- It is recommended to have an isolated switching power supply for the holding brake to prevent malfunctioning of the holding brake in case of voltage drop.
- If the motor is using a magnetic encoder, holding brake wires need to be differentiated between positive and negative terminal to prevent interference to the magnetic encoder due to wrong polarity. It might cause alarm, loss in encoder accuracy or abnormal vibration, etc.

  Motor with optical encoder has no such problem, so holding brake circuit can be connected in anyway.

Table 2-7 Holding brake terminal pins in color codes

Motor flange 80 or below	Color	Brown	Blue	Red	Black
	Terminal	24V	0V	24V	0V
	Pin	1	2	6	5
Motor flange 130 or above	Color	Red		Black	
	Terminal	24V		0V	
	Pin	2		1	

2.6 CN2 Encoder

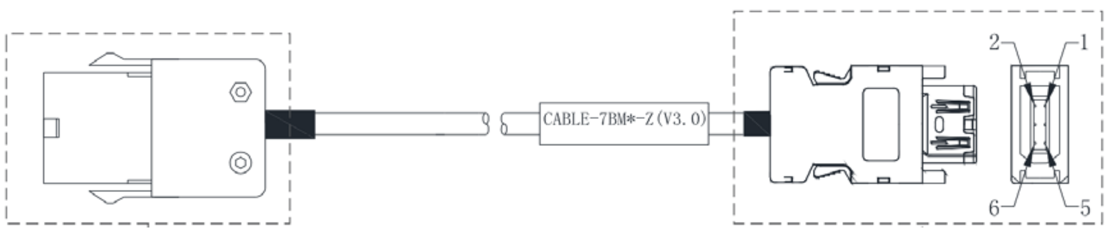


Connector	Pin	Signal	Description
CN2	1	VCC5V	Power supply 5V
	2	GND	Power supply ground
	3	BAT+	Battery positive terminal
	4	BAT-	Battery negative terminal
	5	SD+	SSI Data+
	6	SD-	SSI Data-
	Frame	PE	Shield grounding

- Please ground both driver and motor PE terminals to avoid any servo alarms.
- It is recommended to use a shielded twisted pair cable not longer than 20m.
- Please leave a space of min. 30cm between motor power cable and encoder to avoid interference.

Motor encoder cable selection

AMP electrical connector (Frame size 80 or below） CABLE-7BM*-Z(V3.0)

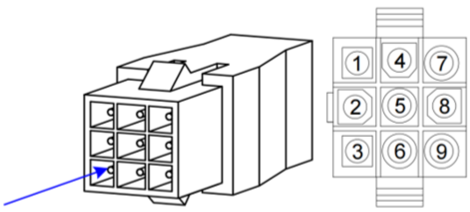


Motor side

Driver side

Motor cable pin

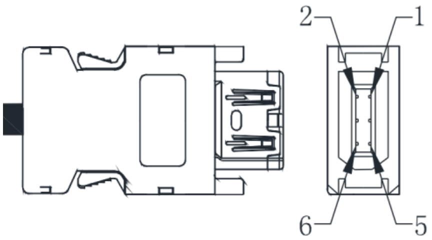
9-pin connector



Motor side

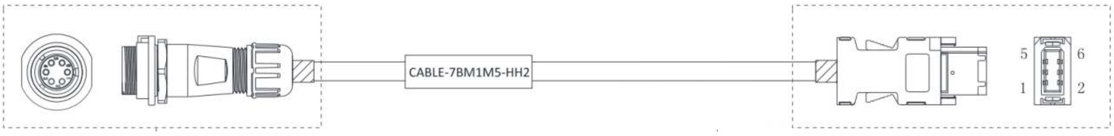
Pins

Motor	Driver	Signal
1	Frame	Shielded
2	1	+5V
3	2	0V
4	5	SD+
5	6	SD-
6	3	BAT+
7	4	BAT-



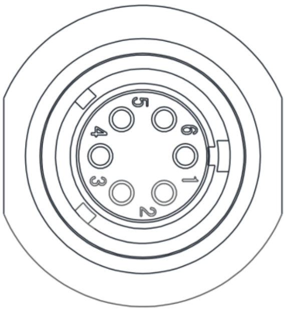
Driver side

Aviation connector（Frame size 80 or below）CABLE-7BM*-HH2



Motor side | Driver side

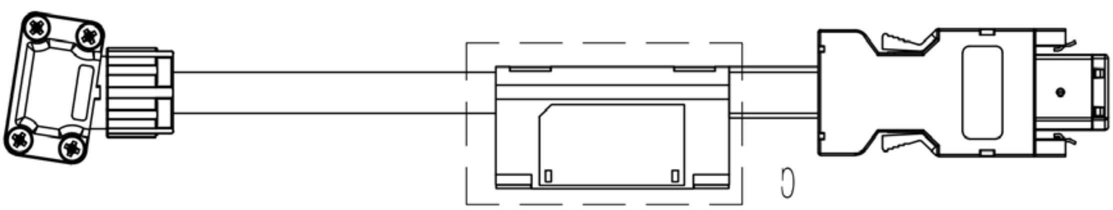
Motor cable pin	Pin



Motor side

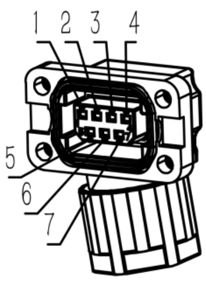
Motor	Driver	Signal
1	Frame	Shielded
2	1	+5V
3	2	0V
4	5	SD+
5	6	SD-
6	3	BAT+
7	4	BAT-

Direct connector(Frame size 80 or below）CABLE-BMAH*M*-124-TS Absolute encoder



Motor side | Driver side

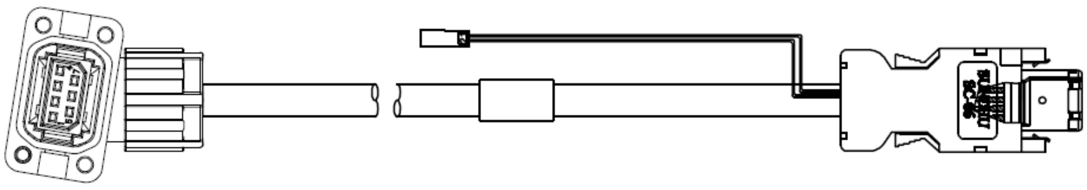
Motor cable pin	Pin



Motor side

Motor	Driver	Signal
1	Frame	Shielded
2	1	+5V
3	2	0V
4	5	SD+
5	6	SD-
6	3	BAT+
7	4	BAT-

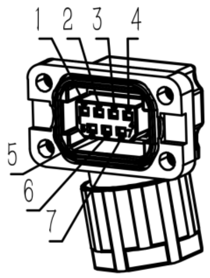
Direct connector(Frame size 80 or below）CABLE-BMH*M*-114-TS Absolute encoder



Motor side　　　　　　　　　　　　Driver side

Battery Kit *ER14505 BOX-G DCH ROHS*

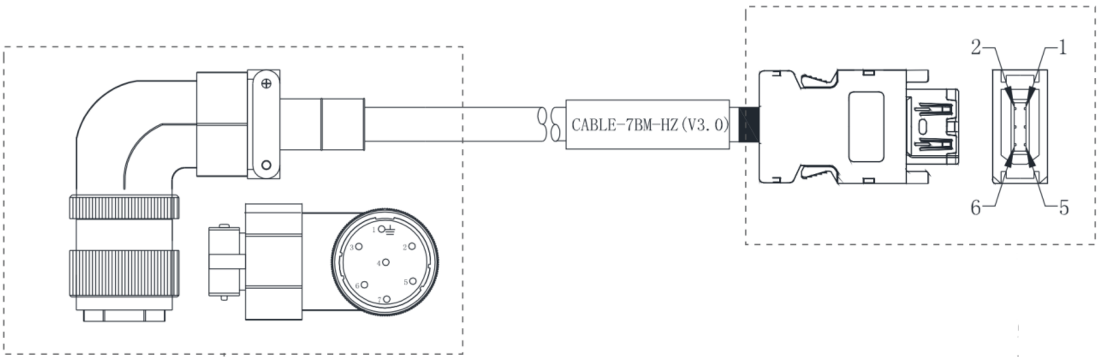
Motor cable pin	Pin



Motor side

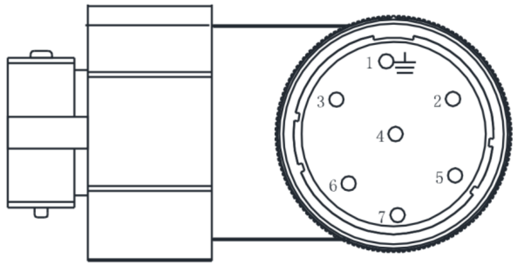
Motor	Driver	Signal
1	Frame	Shielded
2	1	+5V
3	2	0V
4	5	SD+
5	6	SD-
6	3	BAT+
7	4	BAT-

Aviation connector（Frame size 130）CABLE-7BM*HZ(V3.0)



Motor side　　　　　　　　　　　　Driver side

Motor cable pin	Pin

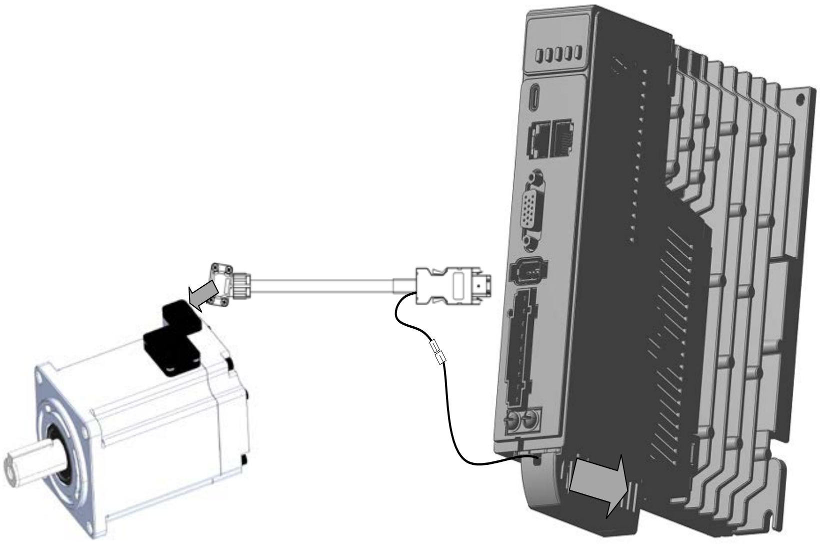


Motor side

Motor	Driver	Signal
1	Frame	Shielded
2	1	+5V
3	2	0V
4	5	SD+
5	6	SD-
6	3	BAT+
7	4	BAT-

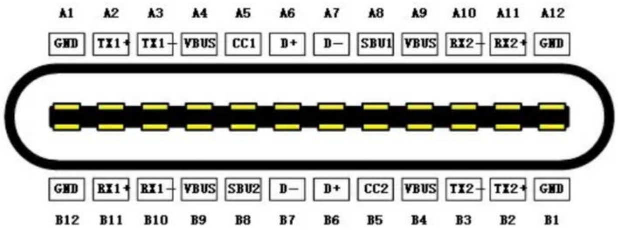
Battery box for absolute encoder

EL7-EC series servo drives come with battery kit installed on the driver or on the encoder cable.



2.7 USB Type-C Tuning Port

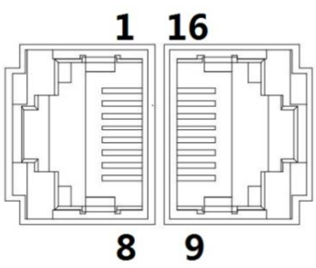
EL7-EC series servo drive can be connected to PC for performance tuning, data monitoring and parameters modifying using a **USB Type-C data cable**. Can be done without the servo drive connecting to main power supply.



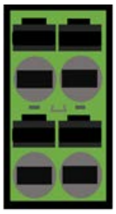
Port	Pin	Signal	Description
USB Type-C	A4, B4,A9, B9	VCC 5V	Power supply positive terminal 5V
	A12,B12,A1,B1	GND	Power supply negative terminal
	A6,B6	D+	USB data positive terminal
	A7,B7	D-	USB data negative terminal
	Frame	USB_GND	Ground through capacitor

2.8 CN3/CN4 EtherCAT Communication Port

CN3 and CN4 are communication ports for EtherCAT protocol. LAN cable from master device will be connected to CN3 (IN) and CN4 (OUT) will be connected to the next slave device.

Port	Pin	Signal	Description
	1, 9	E_TX+	EtherCAT Data sending positive terminal
	2, 10	E_TX-	EtherCAT Data sending negative terminal
	3, 11	E_RX+	EtherCAT Data receiving positive terminal
	4, 12	--	--
	5, 13	--	--
	6, 14	E_RX-	EtherCAT Data receiving negative terminal
	7, 15	--	--
	8, 16	--	--
	Frame	PE	Shielded ground

2.9 CN6 Safe Torque Off (STO) Port

Port	Pin	Signal	Description	Remarks
	1	0V	Reference ground	Connect to SF1 and SF2 when not in use. Do not use to supply power.
	2	24V	24V power supply	
	3	SF1+	Control signal 1 positive input	When SF1 = OFF or SF2 = OFF,STO is enabled.
	4	SF1-	Control signal 1 negative input	

Introduction to Safe Torque Off (STO)

Function: Cut off motor current supply physically (through mechanical means)
STO module (CN6 connector) consists of 2 input channels. It cuts off the motor current supply by blocking of PWM control signal from the power module. When the motor current is cut off, the motor will still move under inertia and stops gradually.
The STO function is set up ready to be used by factory default. Please remove STO connector if it is not needed.

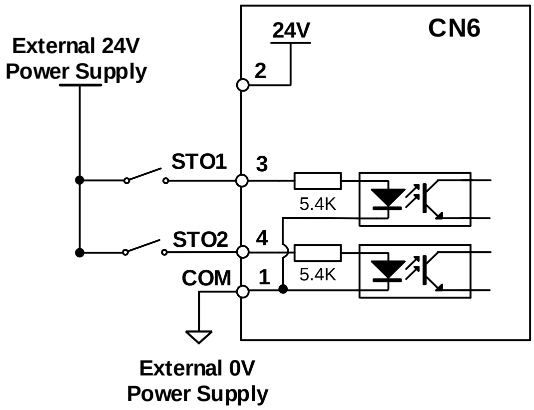
STO functional principle

STO module cuts off the motor current supply and stops motor gradually by blocking of PWM control signal from the power module through 2 isolated circuits. When a STO error occurs, the actual status of STO can be determined by the EDM status feedback.

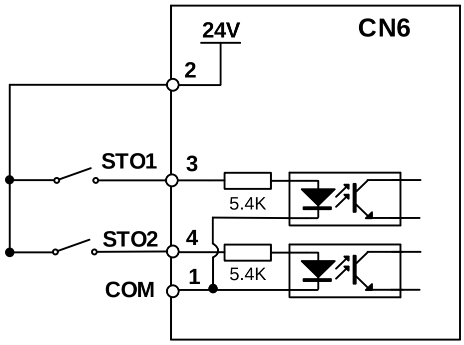
STO1 Input Status	STO2 Input Status	PWM control signal	Alarm code
ON	ON	Normal	-
ON	OFF	Blocked	Er 1c2
OFF	ON	Blocked	Er 1c1
OFF	OFF	Blocked	Er 1c0

STO wiring diagram

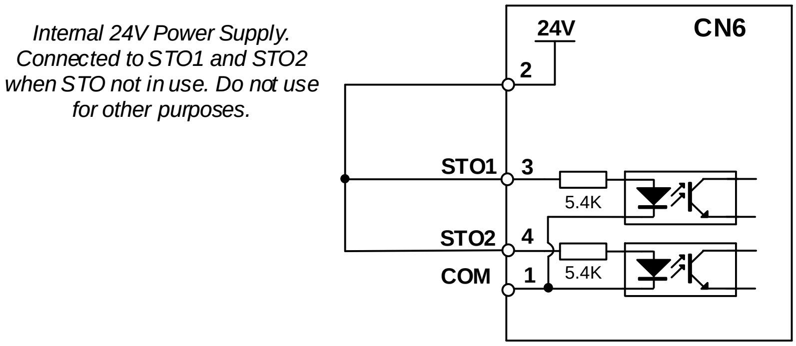
STO in use (External 24V)



STO in use (Internal 24V)



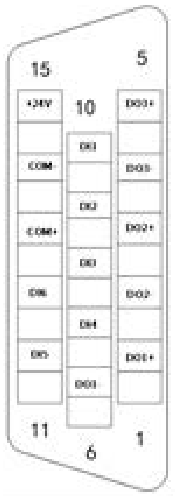
STO not in use (STO1 & STO2 shorted together)



- *Please take precautions when enabling STO functions as servo drive will lose control over the motion of the motor. Motor might dropped under gravitational pull (vertically mounted load) or moved when external forces are applied to it. Alternatively, motor with holding brake can be chosen.*
- *STO is not meant to cut off the power supply of the servo drivers and motors completely. Please power off and wait for a few minutes before starting maintenance work.*
- *It is recommended to use an isolated power supply for STO signal input as any current leakage might cause STO malfunction.*

2.10 CN1 I/O Signal Port

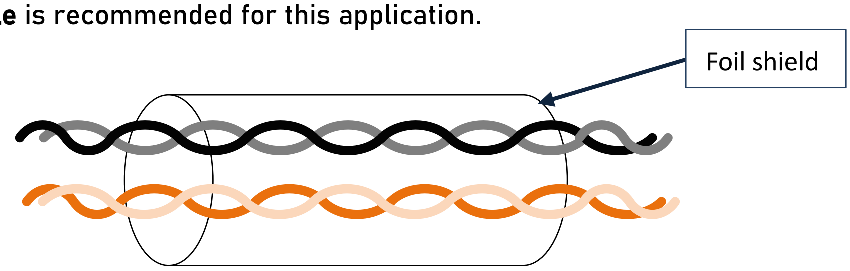
CN1 connector is a DB15 female connector.

Port	Pin	Signal	Description	Remarks
	1	DO1+	SRDY+	Servo Ready Output Signal
	6	DO1-	SRDY-	
	3	DO2+	ALM+	Alarm Output Signal
	2	DO2-	ALM-	
	5	DO3+	BRK-OFF+	Break Off Output Signal
	4	DO3-	BRK-OFF-	
	10	DI1	POT	Positive limit switch
	9	DI2	NOT	Negative limit switch
	8	DI3	HOME	Homing switch
	7	DI4	EXT 2	Touch Probe 2
	11	DI5	EXT 1	Touch Probe 1
	12	DI6	-	Up to user configuration
	13	COM+	Common DI	Common digital input terminal
	14	COM-	Internal 24V Power Supply	Output voltage: 20~28VDC, max current output: 200mA
	15	24V+		

2.10.1 Selection of I/O signal cable

I/O signal cable

To ensure I/O signal to not be affected by electromagnetic interference, a **shielded twisted pair cable** is recommended for this application.



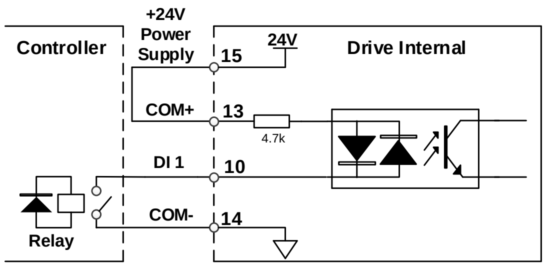
- Wire diameter ⩾ 0.14mm^2, foil shielded should be connected to PE terminal.
- Wire length should be as short as possible, not more than 3m.
- Install a surge suppressor in feedback circuit; flyback diode inversely connected in parallel in DC coil and capacitor connected in parallel in AC coil.
- Recommended wire gauge: 24 - 26AWG
- I/O signal included DI, DO and relay output signal
- Please keep 30cm away from main power supply cable or motor power cable to avoid electromagnetic interference.

2.10.2 Common input circuit

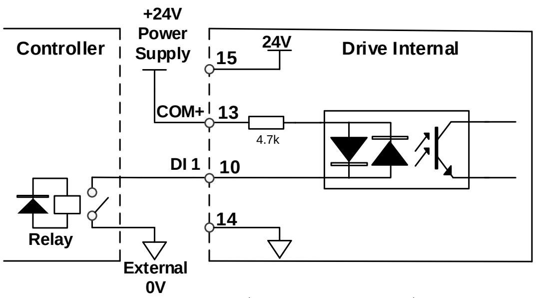
The internal circuit of common input is a bidirectional optocoupler which supports common anode and common cathode configurations. There are 2 types of outputs from master device: Relay output and Open Collector output as shown below.

① Output from master device: Relay

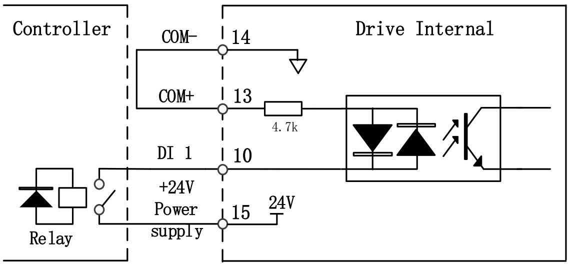
Common Anode(Internal 24V):



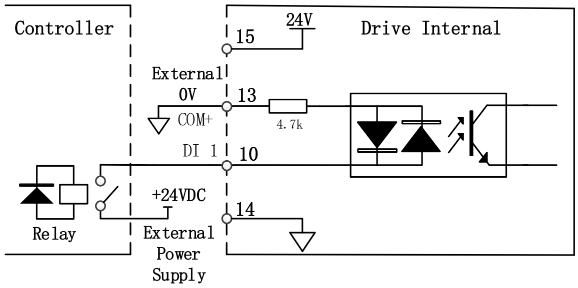
Common Cathode(Internal 24V):



Common Anode(External 24V):

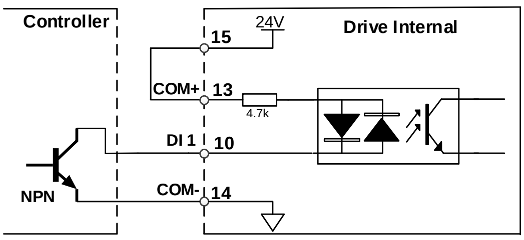


Common Cathode(External 24V):

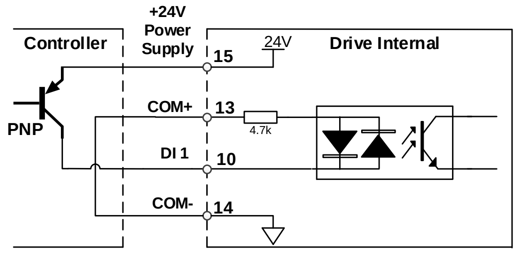


② Output from master device: Open Collector

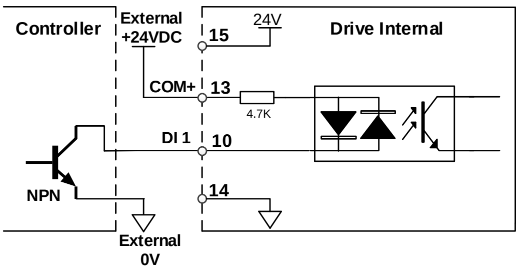
Common Anode(Internal 24V):



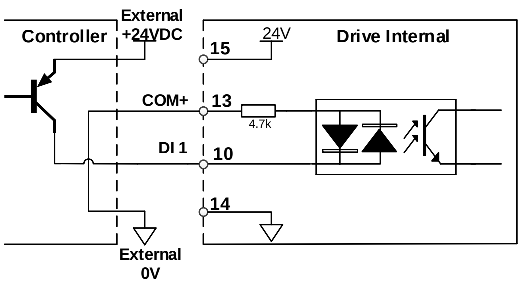
Common Cathode(Internal 24V):



Common Anode(External 24V):



Common Cathode(External 24V):

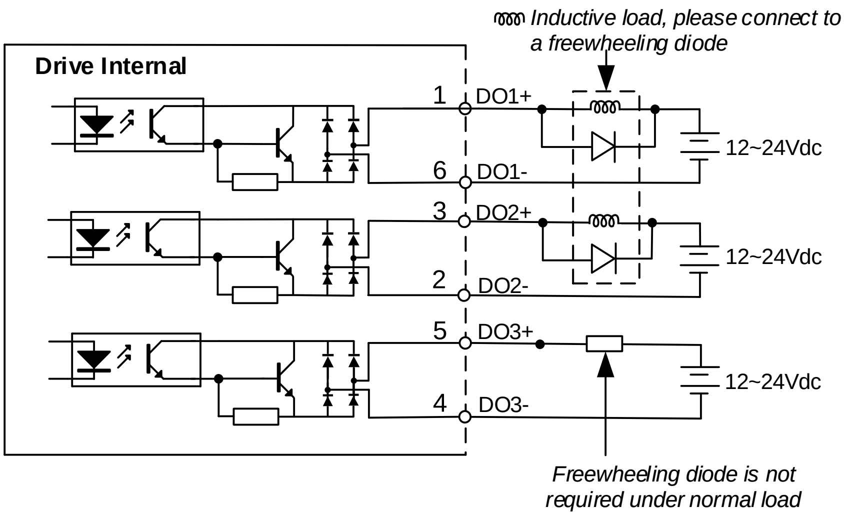


Please prepare switching power supply with output of 12-24VDC, current≥ 100mA;

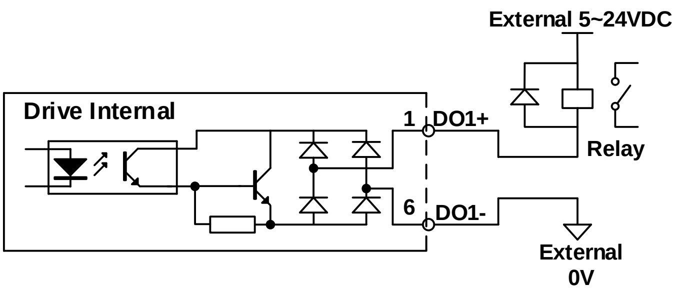
2.10.3 Common output circuit

There are 3 common outputs: DO1 ~ DO3 are double-ended, having an isolated 24v power supply.

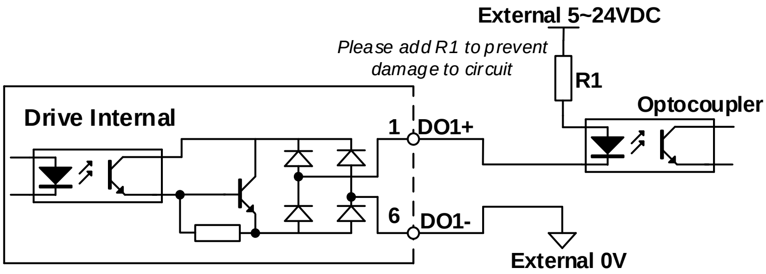
Double-ended Digital Outputs



When connected to a relay:



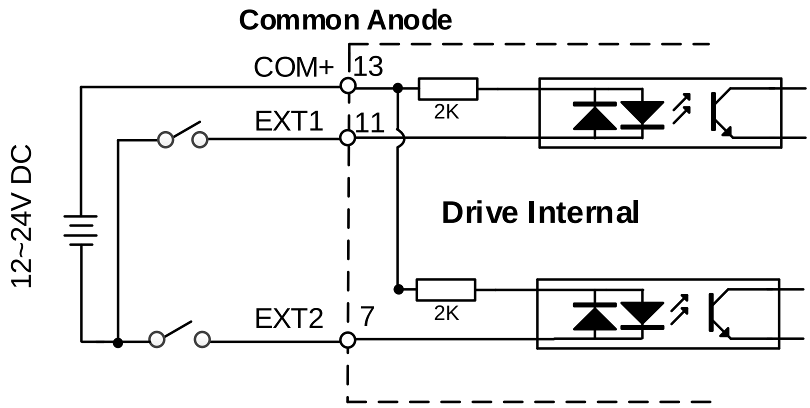
When connected to optocoupler:

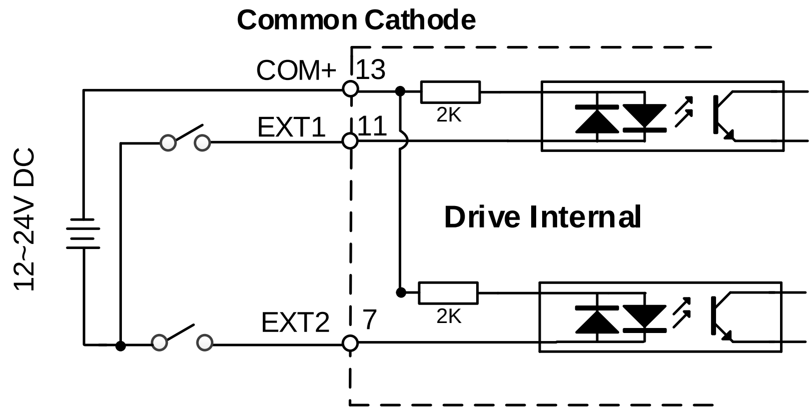


- Power supply is provided by user. Please be aware that reversed power supply polarity might cause damage to the driver.
- When it is an open collector output, max current: 50mA, max supplying voltage: 25V. Please ensure the switching power supply fulfills the conditions.
- If the load is an inductive load such as a relay, please connect a flyback diode in parallel in reverse. A wrong installation of the flyback diode might cause damage to the driver.

2.10.4 Probe input circuit

The internal circuit of probe input is a bidirectional optocoupler.





2.10.5 DI signal function configuration

Table 2-8 Default DI signal functions

CN1 Pin	Signal	Parameter	Default function	Factory default		
				Set Value	Polarity	Status
13	DI COM	-	Common Digital Input	0x0	-	-
10	DI1	PA4.00	Positive limit switch (POT)	0x1	NO	OFF
9	DI2	PA4.01	Negative limit switch (NOT)	0x2	NO	OFF
8	DI3	PA4.02	Home switch (HOME)	0x16	NO	OFF
12	DI6	PA4.05	User configurable	-	-	-

***NO: Normally Open*

➢ When limit switch or emergency stop is used, POT, NOT and E-STOP signal will be normally close (NC) by default. Please make sure there is no safety concern if these signals need to be set to normally open (NO).

Relevant parameters

PA4.00	**Label**	Input selection DI1	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2400h
PA4.01	**Label**	Input selection DI2	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2401h
PA4.02	**Label**	Input selection DI3	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2402h
PA4.03	**Label**	Input selection DI4	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2403h
PA4.04	**Label**	Input selection DI5	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2404h
PA4.05	**Label**	Input selection DI6	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2405h

Digital input DI allocation using hexadecimal system

Input	Symbol	Set value		0x60FD(bit)
		Normally open	Normally close	
Invalid	—	0h	-	×
Positive limit switch	POT	1h	81h	Bit1
Negative limit switch	NOT	2h	82h	Bit0
Clear alarm	A-CLR	4h	-	×
Forced alarm	E-STOP	14h	94h	×
Home switch	HOME-SWITCH	16h	96h	Bit2

- Please don't set anything other than listed in table above.
- Normally open: Valid when input = ON Normally close: Valid when input = OFF
- Er210 might occur if same function is allocated to different channels at the same time
- Channel that has no value doesn't affect driver motion.
- Front panel is of hexadecimal system.

PA4.00 – PA4.05corresponds to DI1 – DI6. External sensors can be connected if the parameters are all set to 0. Controller will read 60FD bit4 – 11 to get DI1 – DI6 actual status.

2.10.6 DO signal function configuration

Table 2-9 DO signal functions by default

CN1 Pin	Signal	Parameter	Default function	Factory default		
				Set Value	Polarity	Status
1	DO1+	PA4.10	Servo Ready (S-RDY)	0x01	NO	OFF
6	DO1+					
3	DO1+	PA4.11	Alarm (ALM)	0x03	NO	OFF
2	DO1+					
5	DO1+	PA4.12	External brake released (BRK-OFF)	0x04	NO	OFF
4	DO1+					

*** NO: Normally Open*

Relevant parameters

PA4.10	**Label**	Output selection DO1	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2410h
PA4.11	**Label**	Output selection DO2	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2411h
PA4.12	**Label**	Output selection DO3	**Mode**	F		
	Range	0x0~0xFF	**Default**	0x0	**Unit**	-
	Activation	Immediate			**Index**	2412h

Digital output DO allocation using hexadecimal system.

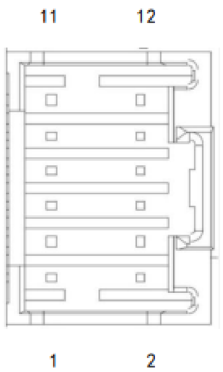
Output	Symbol	Set value	
		Normally open	Normally close
Master device control	—	00h	-
Alarm	ALM	01h	81h
Servo-Ready	S-RDY	02h	82h
External brake released	BRK-OFF	03h	83h
Positioning completed	INP	04h	84h
At-speed	AT-SPEED	05h	85h
Torque limit signal	TLC	06h	86h
Zero speed clamp detection	ZSP	07h	87h
Velocity coincidence	V-COIN	08h	88h
Position command ON/OFF	P-CMD	0Bh	8Bh
Velocity limit signal	V-LIMIT	0Dh	8Dh
Velocity command ON/OFF	V-CMD	0Fh	8Fh
Servo status	SRV-ST	12h	92h
Homing done	HOME-OK	22h	A2h
Position comparison	CMP-OUT	14h	94h

Please don't set any other than the outputs listed in the table above.

- Normally open：Active low
- Normally close：Active high
- Front panel is of hexadecimal system.

PA4.10 – PA4.12 corresponds to DO1 – DO3. If all parameters are set to 0, master device controls the outputs, object dictionary 0x60FE sub-index 01 bit16-18 corresponds to DO1-DO3.

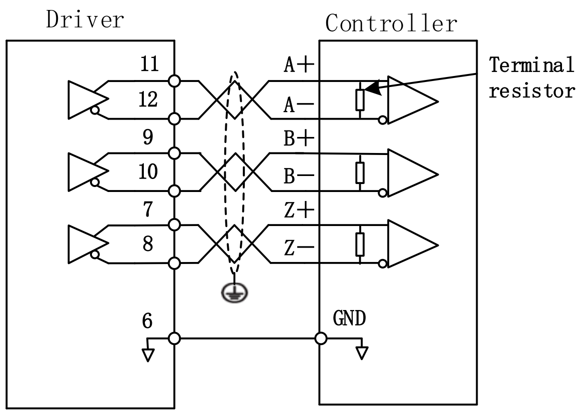
2.11 CN5 Frequency divider pulse output port

Port	Diagram	Pin	Signal	Label
CN5		11	A+	Motor encoder phase A frequency divider output
		12	A-	
		9	B+	Motor encoder phase B frequency divider output
		10	B-	
		7	Z+	Motor encoder phase Z frequency divider output
		8	Z-	
		5	OCZ	Motor encoder Z-signal OC output
		6	GND	Motor encoder Z-signal OF output reference ground
		3	/	/
		4	/	/
		1	PE	Shield grounding
		2	/	/

**Please use stranded shielded cable ≥ 0.14mm^2 with shield foil grounded to PE terminal.*
***Keep it shorter than 3 meters and away from any power cables.*

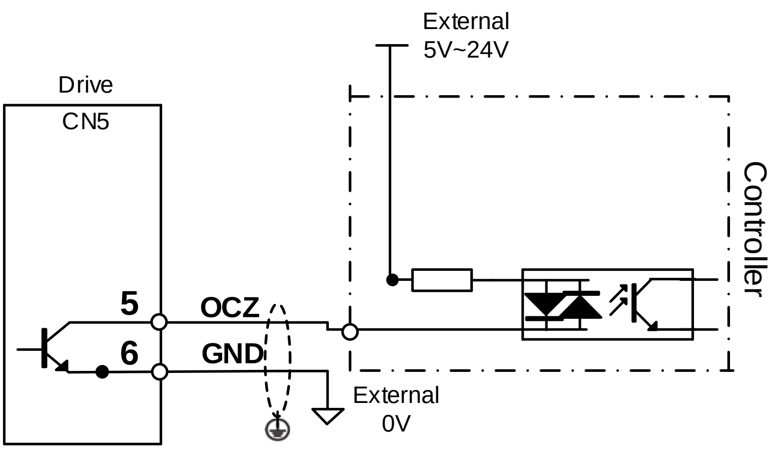
Encoder signal after frequency divider circuit is output as differential signal. It provides feedback signal for controller using position control mode. Please use differential or optocoupler receiving circuit for controller. A terminal resistor needs to be installed in the differential signal input circuit. Resistance of the terminal resistor is as accordance to actual use.

Differential Connection:



If controller input circuit is not an optocoupler input circuit but a differential receiving circuit, please connect CN5 pin 6 (OC reference ground) to GND of controller differential receiving circuit.

Encoder Z-phase frequency divider output:



2.12 Measures against electromagnetic interference

To reduce interference, please take the following measures:

- I/O signal cable > 3m; Encoder cable > 20m
- Use cable with larger diameter for grounding

  ①Grounding resistance > 100Ω

  ②When there are multiple drivers connected in parallel, PE terminal of the main power supply and ground terminal of servo drives must be connected to copper ground bar in the electrical cabinet and the copper ground bar needs to be connected to the metal frame of the cabinet.
- Please install a line filter on main power supply cable to prevent interference from radio frequency.
- In order to prevent malfunctions caused by electromagnetic interference, please take following measures:

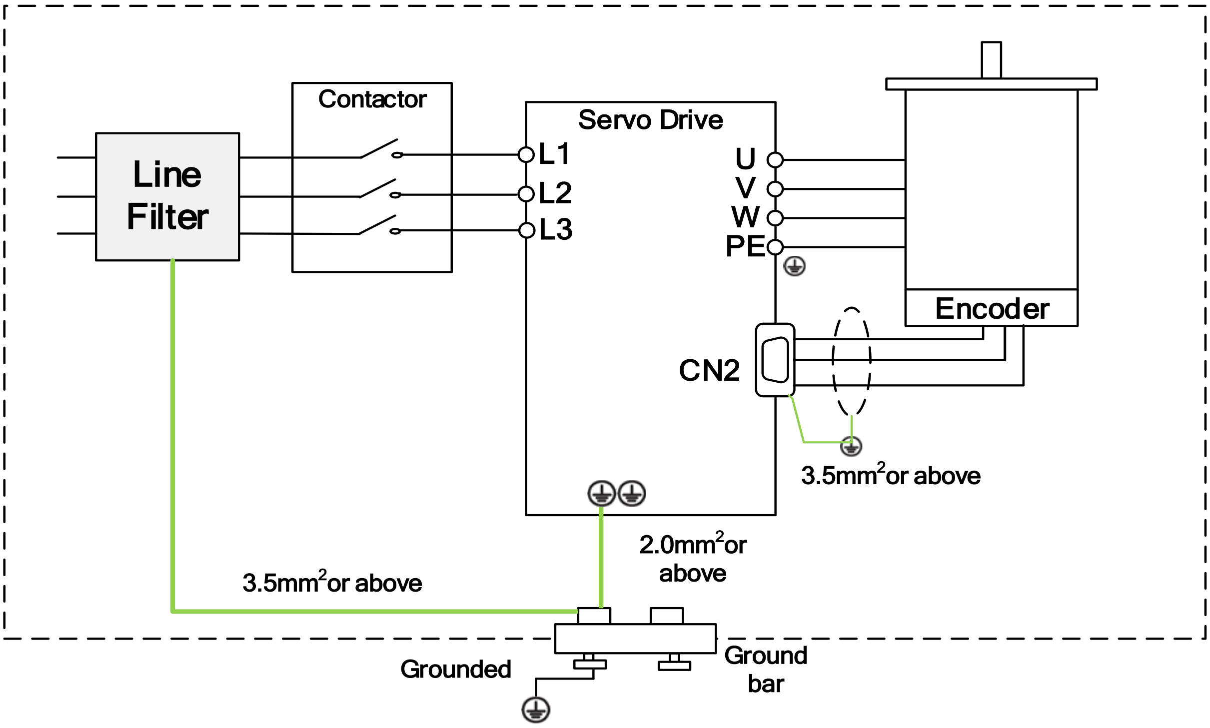
  ①Install master device and line filter close to the servo drive

  ②Install surge suppressor for relay and contactor

  ③Please separate signal/encoder cable from power cable with a space of at least 30cm

  ④Install a line filter for the main power supply if a device with high frequency generation such as a welding machine exists nearby

2.12.1 Grounding connection and other anti-interference wiring connections

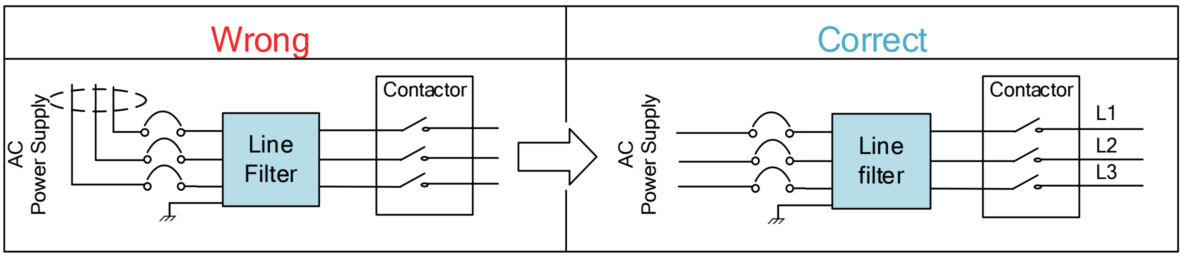


- Servo motor frame should be grounded. Please connect the PE terminal of servo motor and servo drive and ground them together to reduce interference.
- Ground both ends of the foil shield of encoder cable.

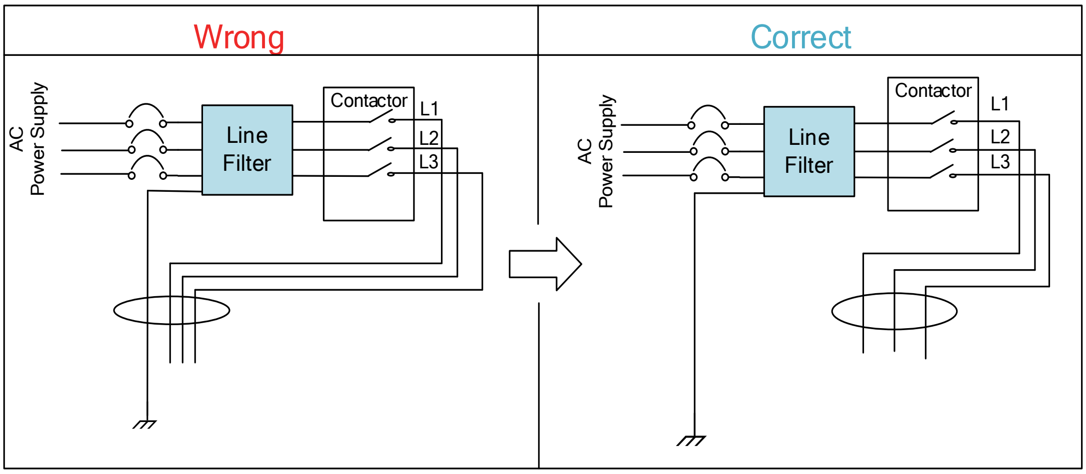
2.12.2 Using line filter

To reduce interference from main power supply cable and to prevent from affecting other sensitive components around the servo drive, please choose a line filter based on actual supply current. Please do be aware of the following mistake when installing a line filter.

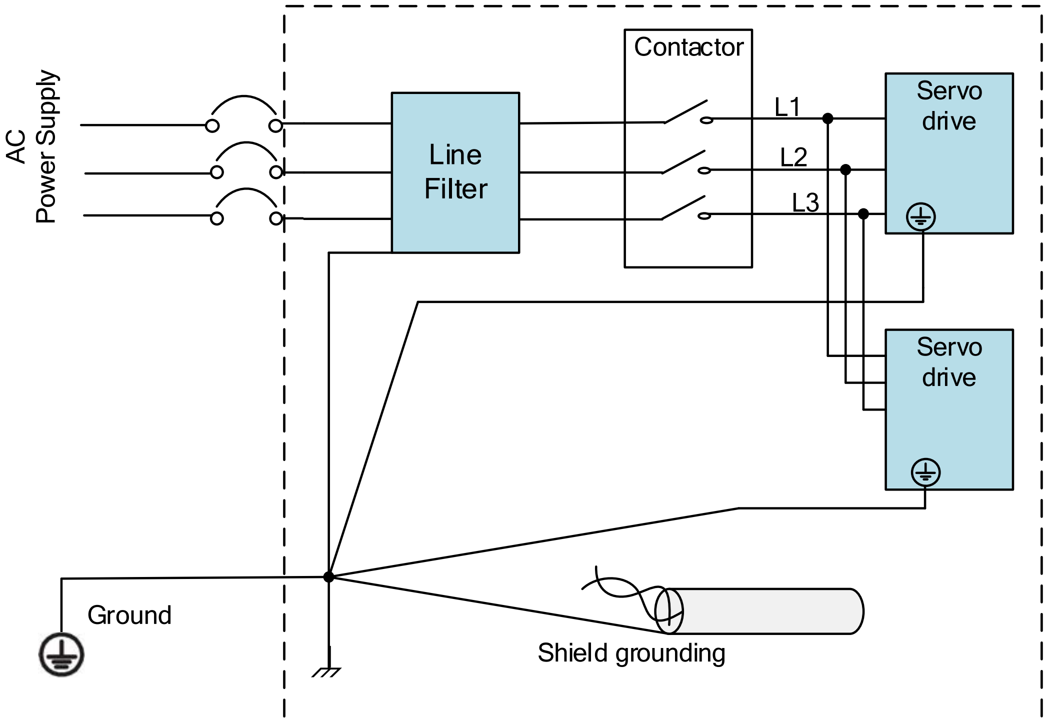
Do not band the main power supply cable together.



Separate the ground wire from the line filter and the main power supply cable.



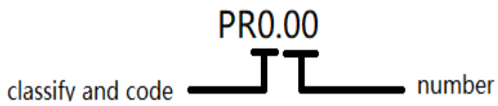
Ground wires inside an electrical cabinet



Chapter 3 Parameter

3.1 Parameter List

- Panel Display as follows:



- Parameter Valid mode Description
  CSP: Valid in cyclic synchronous position mode
  CSV: Valid in cyclic synchronous velocity mode
  CST: Valid in cyclic synchronous torque mode
  HM: Valid in homing mode
  PP: Valid in profile position mode
  PV: Valid in profile velocity mode
  PT: Valid in profile torque mode
  F: Valid in all modes

3.1.1 Servo drive parameter

Label	EtherCAT Address	Panel display	Default	Activation
Model-following bandwidth	2000h	PA 000	1	Immediate
Control Mode Settings	2001h	PA 001	9	After restart
Real time Auto Gain Adjusting	2002h	PA 002	0x001	Immediate
Real time auto stiffness adjusting	2003h	PA 003	70	Immediate
Inertia ratio	2004h	PA 004	250	Immediate
Command polarity inversion	2006h	PA 006	0	After restart
Probe signal polarity settings	2007h	PA 007	3	After restart
Command pulse counts per revolution	2008h	PA 008	0	After restart
1st command frequency divider/multiplier numerator	2009h	PA 009	1	After restart
1st command frequency divider/multiplier denominator	2010h	PA 010	1	After restart
Encoder pulse output per revolution	2011	PA 011	2500	After restart

Pulse output logic inversion	2012	PA 012	0	After restart
1st Torque Limit	2013h	PA 013	300	Immediate
Excessive Position Deviation Settings	2014h	PA 014	30	Immediate
Absolute Encoder settings	2015h	PA 015	0	After restart
Regenerative resistance	2016h	PA 016	100	Immediate
Regenerative resistor power rating	2017h	PA 017	50	Immediate
Friction compensation setting	2019h	PA 019	1000	Immediate
EtherCAT slave ID	2023h	PA 023	2	After restart
Source of slave ID	2024h	PA 024	1	After restart
Synchronous compensation time 1	2025h	PA 025	10	After restart
Synchronous compensation time 2	2026h	PA 026	50	After restart
Synchronization mode command delay cycle counts	2027h	PA 027	0	After restart
CSP mode safe self-running position setting	2028h	PA 028	10	Immediate

Label	EtherCAT Address	Panel display	Default	Activation
1st position loop gain	2100h	PA 100	320	Immediate
1st velocity loop gain	2101h	PA 101	180	Immediate
1st Integral Time Constant of Velocity Loop	2102h	PA 102	310	Immediate
1st velocity detection filter	2103h	PA 103	15	Immediate
1st Torque Filter Time Constant	2104h	PA 104	126	Immediate
2nd Position Loop Gain	2105h	PA 105	380	Immediate
2nd velocity loop gain	2106h	PA 106	180	Immediate
2nd Integral Time Constant of Velocity Loop	2107h	PA 107	10000	Immediate
2nd velocity detection filter	2108h	PA 108	15	Immediate
2nd Torque Filter Time Constant	2109h	PA 109	126	Immediate
Velocity feed forward gain	2110h	PA 110	300	Immediate
Velocity feed forward filter time constant	2111h	PA 111	50	Immediate
Torque feed forward gain	2112h	PA 112	0	Immediate
Torque feed forward filter time constant	2113h	PA 113	0	Immediate
Position control gain switching mode	2115h	PA 115	0	Immediate
Position control gain switching level	2117h	PA 117	50	Immediate

Hysteresis at position control switching	2118h	PA 118	33	Immediate
Position gain switching time	2119h	PA 119	33	Immediate
Unique registry	2137h	PA 137	0	Immediate
Unique registry 1	2138h	PA 138	0x0	Immediate
Unique registry 2	2139h	PA 139	0x0	Immediate

Label	EtherCAT Address	Panel display	Default	Activation
Adaptive filtering mode settings	2200h	PA 200	0	Immediate
1st notch frequency	2201h	PA 201	4000	Immediate
1st notch bandwidth selection	2202h	PA 202	4	Immediate
1st notch depth selection	2203h	PA 203	0	Immediate
2nd notch frequency	2204h	PA 204	4000	Immediate
2nd notch bandwidth selection	2205h	PA 205	4	Immediate
2nd notch depth selection	2206h	PA 206	0	Immediate
3rd notch frequency	2207h	PA 207	4000	Immediate
3rd notch bandwidth selection	2208h	PA 208	4	Immediate
3rd notch depth selection	2209h	PA 209	0	Immediate
1st damping frequency	2214h	PA 214	0	Immediate
2nd damping frequency	2216h	PA 216	0	Immediate
Position command smoothing filter	2222h	PA 222	300	After stopping
Position command FIR filter	2223h	PA 223	0	Disable
5th resonant frequency	2231h	PA 231	4000	Immediate
5th resonant Q value	2232h	PA 232	0	Immediate
5th anti-resonant frequency	2233h	PA 233	4000	Immediate
5th anti-resonant Q value	2234h	PA 234	0	Immediate
6th resonant frequency	2235h	PA 235	4000	Immediate
6th resonant Q value	2236h	PA 236	0	Immediate
6th anti-resonant frequency	2237h	PA 237	4000	Immediate
6th anti-resonant Q value	2238h	PA 238	0	Immediate
Adjustment mode	2248h	PA 248	0	Immediate
MFC type	2250h	PA 250	0	Immediate
Velocity feedforward compensation coefficient	2251h	PA 251	0	Immediate
Torque feedforward compensation coefficient	2252h	PA 252	0	Immediate
Dynamic friction compensation coefficient	2253h	PA 253	0	Immediate
Overtravel time coefficient	2254h	PA 254	0	Immediate
Overtravel suppression gain	2255h	PA 255	0	Immediate

Label	EtherCAT Address	Panel display	Default	Activation
Acceleration time settings	2312h	PA 312	0	Immediate
Deceleration time settings	2313h	PA 313	0	Immediate
Sigmoid acceleration/ deceleration settings	2314h	PA 314	0	Disable
Zero speed clamp function	2315h	PA 315	0	Immediate
Zero speed clamp level	2316h	PA 316	30	Immediate
Zero speed clamp static time	2323h	PA 323	0	Immediate

Label	EtherCAT Address	Panel display	Default	Activation
Input selection DI1	2400h	PA 400	0x0	Immediate
Input selection DI2	2401h	PA 401	0x0	Immediate
Input selection DI3	2402h	PA 402	0x0	Immediate
Input selection DI4	2403h	PA 403	0x0	Immediate
Input selection DI5	2404h	PA 404	0x0	Immediate
Input selection DI6	2405h	PA 405	0x0	Immediate
Output selection DO1	2410h	PA 410	0x0	Immediate
Output selection DO2	2411h	PA 411	0x0	Immediate
Output selection DO3	2412h	PA 412	0x0	Immediate
Positioning complete range	2431h	PA 431	20	Immediate
Positioning complete output setting	2432h	PA 432	1	Immediate
INP positioning delay time	2433h	PA 433	0	Immediate
Zero speed	2434h	PA 434	50	Immediate
Velocity coincidence range	2435h	PA 435	50	Immediate
Arrival velocity	2436h	PA 436	1000	Immediate
Motor power-off delay time	2437h	PA 437	100	Immediate
Delay time for holding brake release	2438h	PA 438	0	Immediate
Holding brake activation velocity	2439h	PA 439	30	Immediate
Emergency stop function	2443h	PA 443	0	Immediate
Torque compensation time upon enabling	2448h	PA448	0	Immediate

Label	EtherCAT Address	Panel display	Default	Activation
Driver prohibition input settings	2504h	PA 504	0	Immediate
Servo-off mode	2506h	PA 506	0	After restart
Main power-off detection time	2509h	PA 509	50	Immediate
Servo-off due to alarm mode	2510h	PA 510	0	After restart
Servo braking torque setting	2511h	PA 511	0	Immediate

Overload level setting	2512h	PA 512	0	Immediate
Overspeed level settings	2513h	PA 513	0	Immediate
I/O digital filter	2515h	PA 515	10	Immediate
Position unit settings	2520h	PA 520	2	After restart
Torque limit selection	2521h	PA 521	0	Immediate
2nd torque limit	2522h	PA 522	300	Immediate
LED initial status	2528h	PA 528	34	After restart
Torque limit detection time during torque initialization	2537h	PA 537	500	Immediate
3rd torque limit	2539h	PA 539	80	Immediate
D41 set value	2540h	PA 540	0x30C	Immediate
Frequency divider output – Z-signal polarity	2542h	PA 542	0	After restart
Frequency divider output – Z-signal width	2543h	PA 543	0	After restart
Frequency divider output source	2544h	PA 544	0	After restart
External encoder overspeed feedback threshold	2545h	PA 545	0	Immediate
Vent overload level	2546h	PA 546	0	Immediate

Label	EtherCAT Address	Panel display	Default	Activation
Encoder zero position compensation	2601h	PA 601	0	After restart
JOG trial run torque command	2603h	PA 603	350	Immediate
JOG trial run velocity command	2604h	PA 604	30	Immediate
Position 3rd gain valid time	2605h	PA 605	0	Immediate
Position 3rd gain scale factor	2606h	PA 606	100	Immediate
Torque command additional value	2607h	PA 607	0	Immediate
Positive direction torque compensation value	2608h	PA 608	0	Immediate
Negative direction torque compensation value	2609h	PA 609	0	Immediate
Torque compensation upon enabling	2610h	PA 610	0x0	Immediate
Current response settings	2611h	PA 611	100	Immediate
Max. time to stop after disabling	2614h	PA 614	500	Immediate
Trial run distance	2620h	PA 620	10	Immediate
Trial run waiting time	2621h	PA 621	300	Immediate
No. of trial run cycles	2622h	PA 622	5	Immediate
Trial run acceleration	2625h	PA 625	200	Immediate
Velocity observer gain	2628h	PA 628	0	Immediate

Velocity observer bandwidth	2629h	PA 629	0	Immediate
Frame error window time	2634h	PA 634	100	Immediate
Frame error window	2635h	PA 635	50	Immediate
Absolute value rotation mode denominator setting	2654h	PA 654	0	After restart
Rotor blocked torque limit threshold	2656h	PA 656	300	Immediate
Blocked rotor alarm delay time	2657h	PA 657	400	Immediate
Homing mode position deviation threshold	2659h	PA 659	8	Immediate
Z-signal sustaining time	2661h	PA 661	10	Immediate
Absolute multiturn data upper limit	2663h	PA 663	0	After restart

Label	EtherCAT Address	Panel display	Default	Activation
Motor model	-	PA 715	0x200	After restart
Encoder	-	PA 716	*Encoder*	After restart
External grating ruler precision	-	PA 754	100	After restart

3.1.2 Manufacturer parameter

Index	Sub index	Label	Unit	Default	Min	Max
5004	01	RPDO length		8	0	64
	02	TPDO length		17	0	64
	03	The number of RPDO		1	0	4
	04	The number of TPDO		1	0	2
	05	Sync0 Watchdog counter		0	0	65535
	06	Reserved			0	65535
	07	Sync0 Watchdog limit		4	0	65535
	08	Sync0 Drift watchdog counter		0	0	65535
	09	Sync0 Drift watchdog limit		4	0	65535
	0A	SM2 watchdog counter		0	0	65535
	0B	SM2 Watchdog limit		4	0	65535
	0C	Application layer SM2/Sync0 watchdog counter		0		
	0D	Application layer SM2/Sync0 watchdog limit		4		
	0E	Reserved			0	500

	0F	Time interval between SM2 and Sync0	ns	0	0	1000000000
5006	00	Synchronous alarm setting		0xFFFF	0	0xFFFF
5010	00	PDO watchdog overtime	ms	0	0	60000
5012	04	Homing setting	-	5		
5400	01	Set synchronization cycle minimum value	us	250	125	1000
5400	02	Set synchronization cycle maximum value	us	10000	4000	20000
5500	01	Absolute encoder multiturn number	r	-	-	-
	02	Encoder single turn position	Pulse	-	-	-
	03	Encoder feedback position 32 bit low	Pulse	-	-	-
	04	Encoder feedback position 32 bit high	Pulse	-	-	-
	05	The actual mechanical position 32 bit low	Unit	-	-	-
	06	The actual mechanical position 32 bit high	Unit	-	-	-
	07	Number of encoder communication exceptions		-	-	-
5501	01	Motor Speed	r/min	-	-	-
	02	Speed of position command	r/min	-	-	-
	03	Speed command	r/min	-	-	-
	04	Actual torque	0.1%	-	-	-
	05	Torque command	0.1%	-	-	-
	06	Relative position error	Pulse	-	-	-
	07	Internal position command	Pulse	-	-	-
	08	Overload ratio	0.1%	-	-	-
	09	Discharge load rate	0.1%	-	-	-
	0A	Inertia ratio	%	-	-	-
	0B	Actual positive torque limit value	0.1%	-	-	-
	0C	Actual negative torque limit value	0.1%	-	-	-
	0D	U phase current detect value	0.1%	-	-	-
	0E	W phase current detect value	0.1%	-	-	-
5502	01	DI input signal	-	-	-	-
	02	SO output signal	-	-	-	-
	03	Reserved	-	-	-	-
	04	Reserved	-	-	-	-
	05	Bus voltage	V	-	-	-
	06	Temperature	℃	-	-	-
	07	Power on time	S	-	-	-

3.1.3 Motion parameter starting with object dictionary 6000

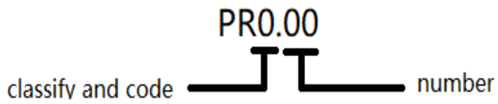
Index	Sub-index	Label	Unit	Default
603F	0	Error code	-	0x0
6040	0	Control word	-	0x0
6041	0	Status word	-	0x0
605A	0	Quick stop option code	-	2
605B	0	Shutdown Option Code	-	0
605C	0	Disable Operation Option Code	-	0
605D	0	Halt Option Code	-	1
605E	0	Fault Reaction Option Code	-	0
6060	0	Mode of Operation	-	8
6061	0	Mode of Operation display	-	0
6062	0	Position Demand Value	Command unit	0
6063	0	Position Actual Internal Value	Encoder unit	0
6064	0	Position Actual Value	Command unit	-
6065	0	Follow Error Window	Command unit	30000
6066	0	Follow Error Time Out	ms	10
6067	0	Position window	Command unit/s	0
6068	0	Position window time	ms	0
606B	0	Velocity Demand Value	Command unit/s	0
606C	0	Velocity Actual Value	Command unit/s	0
606D	0	Velocity window	Command unit /s	10
606E	0	Velocity window time	ms	0
606F	0	Velocity Threshold	Command unit/s	10
6070	0	Velocity Threshold Time	ms	100
6071	0	Target torque	0.001	0
6072	0	Maximum torque	0.001	3000
6073	0	Maximum current	0.001	3000
6074	0	Torque Demand	0.001	0
6075	0	Motor Rated Current	mA	3000
6076	0	Motor Rated Torque	mN.m	0
6077	0	Torque Actual Value	0.1%	0
6078	0	Current Actual Value	0.1%	0
6079	0	DC Link Circuit Voltage	mV	0
607A	0	Target position	Command unit	0

607C	0	Home Offset	Command unit	0
607D	1	Min Position Limit	Command unit	0
	2	Max Position Limit	Command unit	0
607E	0	Polarity	-	0x0
607F	0	Max Profile Velocity	Command unit /s	2147483647
6080	0	Max Motor Speed	r/min	6000
6081	0	Profile velocity	Command unit /s	10000
6083	0	Profile acceleration	Command unit /s²	10000
6084	0	Profile deceleration	Command unit /s²	10000
6085	0	Quick Stop Deceleration	Command unit /s²	10000000
6087	0	Torque slope	0.001/s	5000
608F	1	Encoder Increments	Encoder unit	0
6091	1	Motor Revolutions	r	1
	2	Shaft Revolutions	r	1
6092	1	Feed	Command unit/r	10000
6098	0	Homing method	-	19
6099	1	Speed During Search For Switch	Command unit /s	10000
	2	Speed During Search For Zero	Command unit /s	5000
609A	0	Homing acceleration	Command unit /s²	500000
60B0	0	Position Offset	Command unit	0
60B1	0	Velocity Offset	Command unit /s	0
60B2	0	Torque Offset	0.001	0
60B8	0	Touch Probe function	-	0x0
60B9	0	Touch Probe status	-	0x0
60BA	0	Touch Probe 1 Positive Position	Command unit	0
60BB	0	Touch Probe 1 Negative Position	Command unit	0
60BC	0	Touch Probe 2 Positive Position	Command unit	0
60BD	0	Touch Probe 2 Negative Position	Command unit	0
60C5	0	Max Acceleration	Command unit /s²	100000000
60C6	0	Max Deceleration	Command unit /s²	100000000
60D5	0	Touch Probe 1 Positive Edge Counter	-	0

60D6	0	Touch Probe 1 Negative Edge Counter	-	0
60D7	0	Touch Probe 2 Positive Edge Counter	-	0
60D8	0	Touch Probe 2 Negative Edge Counter	-	0
60E0	0	Positive Torque Limit	0.001	3000
60E1	0	Negative Torque Limit	0.001	3000
60F4	0	Following Error Actual Value	Command unit	0
60FA	0	Control Effort	Command unit /s	0
60FC	0	Position Demand Internal Value	Encoder unit	0
60FD	0	Digital Inputs	-	0x0
60FE	1	Physical Outputs	-	0x0
	2	Bit Mask	-	0x0
60FF	0	Target velocity	Command unit /s	0
6502	0	Supported Drive Modes	-	0x0

3.2 Parameter Function

- Panel Display as follows:



- Parameter valid under following modes
  CSP: Cyclic synchronous position mode
  CSV: Cyclic synchronous velocity mode
  CST: Cyclic synchronous torque mode
  HM: Homing mode
  PP: Profile position mode
  PV: Profile velocity mode
  PT: Profile torque mode
  F: All modes

3.2.1【Class 0】Basic Settings

<table>
<tr><td rowspan="3">PA0.00</td><td>Label</td><td>Model-following bandwidth</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~5000</td><td>Default</td><td>1</td><td>Unit</td><td>0.1Hz</td></tr>
<tr><td>Activation</td><td colspan="3">Immediate</td><td>Index</td><td>2000h</td></tr>
<tr><td colspan="7">Model-following bandwidth, also known as model-following control (MFC), is used to control the position loop to improve the responsiveness to commands, speed up positioning time and reduce following error. The effect is obvious especially in low and medium mechanical stiffness. Use mainly for MFC or ZTC tuning.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Disable the function.</td></tr>
<tr><td>1</td><td>Enable the function to set bandwidth automatically, recommended for most applications. PA0.00=PA1.01</td></tr>
<tr><td>2</td><td>Reserved</td></tr>
<tr><td>3-9</td><td>Invalid</td></tr>
</table>
PA0.00>9: Model-following bandwidth value set by PA0.00.
10<Pr0.00<5000: Specifies the bandwidth.
*Recommended settings for belt application: 30<PA0.00<100.</td></tr>
</table>

<table>
<tr><td rowspan="3">PA0.01</td><td>Label</td><td>Control Mode Settings</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~9</td><td>Default</td><td>9</td><td>Unit</td><td>-</td></tr>
<tr><td>Activation</td><td colspan="3">After restart</td><td>Index</td><td>2001h</td></tr>
<tr><td colspan="7">Set value to use following control modes：
<table>
<tr><th>Value</th><th>Content</th><th>Details</th></tr>
<tr><td>0-8</td><td>Reserved</td><td>Reserved</td></tr>
<tr><td>9</td><td>EtherCAT mode</td><td>PP/PV/PT/HM/CSP/CSV/CST</td></tr>
</table></td></tr>
</table>

<table>
<tr><td rowspan="3">PA0.02</td><td>Label</td><td>Real time Auto Gain Adjusting</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0x0~0xFFF</td><td>Default</td><td>0x001</td><td>Unit</td><td>—</td></tr>
<tr><td>Activation</td><td colspan="3">Immediate</td><td>Index</td><td>2002h</td></tr>
</table>

Set up the mode of the real time auto gain adjusting.

<table>
<tr><th>Data bits</th><th>Category</th><th>Settings</th><th>Application</th></tr>
<tr><td rowspan="4">0x00_</td><td rowspan="4">Motion setting mode</td><td colspan="2">Used to set motion setting mode, which can be selected according to the motion characteristics or setting requirements. Generally, it is recommended to select mode 1 with good generality when there is no special requirement, mode 2 when rapid positioning is needed If mode 1 and mode 2 cannot meet the requirements, please choose mode 0.</td></tr>
<tr><td>0:Manual</td><td>PA0.03 invalid. Gain value must be adjusted manually and accordingly.</td></tr>
<tr><td>1:Standard</td><td>PA0.03 valid. Quick gain adjusting can be achieved by changing PA0.03 stiffness value. Gain switching is not used in this mode, suitable for applications with requirements for stability.</td></tr>
<tr><td>2:Positioning</td><td>PA0.03 valid. Quick gain adjusting can be achieved by changing PA0.03 stiffness value. This mode is suitable for applications requiring quick positioning. Not recommended for load mounted vertical to ground, or please compensate for the load using PA6.07</td></tr>
<tr><td rowspan="4">0x0_0</td><td rowspan="4">Load type setting</td><td colspan="2">Used to select the load type, choose according to load-inertia ratio and mechanical structure.</td></tr>
<tr><td>0: Rigid structure</td><td>This mode prioritizes system responsiveness. Use this mode when there is a relatively rigid structure with low load inertia. Typical application including directly connected high-precision gearbox, lead screw, gears, etc.</td></tr>
<tr><td>1:High inertia</td><td>For applications with higher load inertia (10 times or above), gain settings take into account both machine stability and responsiveness. Not recommended to set stiffness above 15 for high load inertia.</td></tr>
<tr><td>2: Flexible structure</td><td>This mode prioritizes system stability. Use this mode when there is low rigidity structure with high load inertia. Typical applications included belts and chains.</td></tr>
<tr><td>0x_00</td><td colspan="3">Reserved</td></tr>
</table>

The setting type combination is a hexadecimal standard, as follows:

Setting type combination	Application type
0X000	Rigid structure + Manual
0X001	Rigid structure +Standard
0X002	Rigid structure +Positioning
0X010	High inertia + Manual
0X011	High inertia + Standard
0X012	High inertia + Positioning
0X020	Flexible structure + Manual
0X021	Flexible structure +Standard
0X022	Flexible structure +Positioning

PA0.03	**Label**	Real time auto stiffness adjusting	**Mode**	**F**		
	Range	50 ~ 81	**Default**	70	**Unit**	—
	Activation	Immediate			**Index**	2003h

Valid when PA0.03 = 1,2

Low → Mechanical stiffness ← High

Low → Servo gain ← High

81.80·······························70.69.68·····························51.50

Low → Responsiveness ← High

- Lower values ensure better system responsiveness and mechanical stiffness but machine vibration might occur, please set accordingly. Please stop the motor before doing any changes to the stiffness settings.
- When PA0.02 = 0x010, please set stiffness level to around 65.

PA0.04	**Label**	Inertia ratio	**Mode**	**F**		
	Range	0~20000	**Default**	250	**Unit**	%
	Activation	Immediate			**Index**	2004h

PA0.04=(load inertia/motor rotational inertia)×100%

Set inertia ratio according to actual load inertia. When both are uniform, actual motor velocity loop responsiveness and gain settings will be consistent. If inertia ratio is greater than actual value, velocity loop gain settings will be higher and vice versa.
For motor with high inertia, PA0.04 can be left unfilled but optimal setting of PA0.04 could improve system performance.

PA0.06	**Label**	Command polarity inversion	**Mode**	**F**		
	Range	0 ~ 1	**Default**	0	**Unit**	—
	Activation	After restart			**Index**	2006h

Used to change the rotational direction of the motor.

Set value	Details
0	Polarity of the command is not inversed. The direction of rotation is consistent with the polarity of command.
1	Polarity of command is inversed. The direction of rotation is opposite to the polarity of command.

Note: Rotational direction of the motor is recommended to be set through object dictionary 607E. However, PA0.06 has higher priority than object dictionary 607E. 607E only takes effect when PA0.06 = 0.

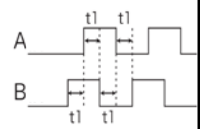
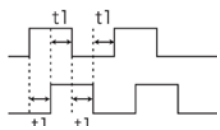
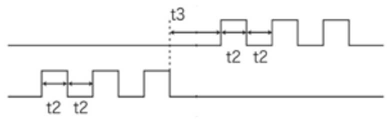
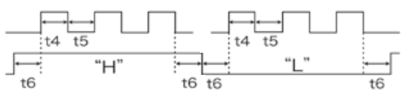
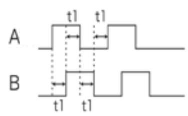
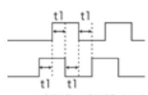
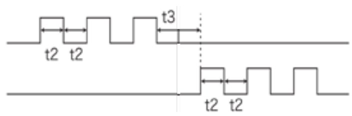
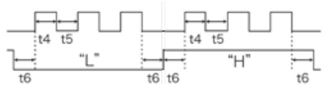
PA0.07	Label	Probe signal polarity settings	Mode	F	
	Range	0 ~ 3	Default	3	Unit	—
	Activation	After restart			Index	2007h

Probe signal polarity settings take effect when PA0.01 = 9

Set value	Details
0	Probe 1 & 2 polarity inversion
1	Probe 2 polarity inversion
2	Probe 1 polarity inversion
3	No polarity inversion for probe 1 & 2

If PA0.01 ≠ 9, PA0.07 = Command pulse input mode settings.

Command pulse input

Command Polarity inversion (PA0.06)	Command pulse input mode settings (PA0.07)	Command Pulse Mode	Positive signal	Negative signal
【0】	0 *or* 2	90°phase difference 2 phase pulse (Phase A+ Phase B)		
	1	CW pulse sequence ＋ CCW pulse sequence		
	【3】	Pulse sequence ＋ Directional symbol		
1	0 *or* 2	90°phase difference 2 phase pulse (Phase A＋Phase B)		
	1	CW pulse sequence ＋ CCW pulse sequence		
	□3	Pulse sequence ＋ Directional symbol		

Command pulse input signal max. frequency and min. duration needed

Command pulse input interface		Max. Frequency	Min. duration needed（μs）					
			t1	t2	t3	t4	t5	t6
Pulse sequence interface	Differential	500 kHz	2	1	1	1	1	1
	Open collector	200 kHz	5	2.5	2.5	2.5	2.5	2.5

Please set >0.1μs for the duration between rising and falling edge of command pulse input signal.

1 revolution with 2500 pulses 2-phase pulse input when PA0.07=0 or 2, PA0.08 = 10000;

1 revolution with 10000 pulses 1-phase pulse input when PA0.07=1 or 3, PA0.08 = 10000

PA0.08	Label	Command pulse count per revolution	Mode	F		
	Range	0~8388608	Default	0	Unit	P-
	Activation	After restart			Index	2008h
	Pulses per revolution can be set using object dictionary 608F, 6091, 6092. However, PA0.08 has higher priority.					

PA0.09	Label	1st command frequency divider/multiplier numerator	Mode	F		
	Range	1~2147483647	Default	1	Unit	P-
	Activation	After restart			Index	2009h
	This parameter correspond s to object dictionary 6091-01. Modifying this parameter is the same as changing object dictionary 6091-01 value. Valid when PA0.08 = 0.					

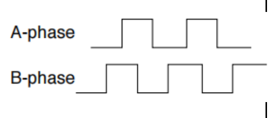
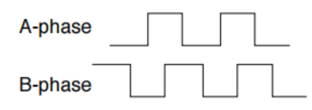
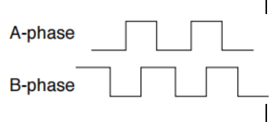
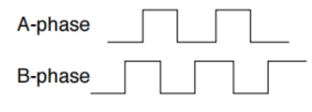
PA0.10	Label	1st command frequency divider/multiplier denominator	Mode	F		
	Range	1~2147483647	Default	1	Unit	P-
	Activation	After restart			Index	2010h
	This parameter correspond s to object dictionary 6091-02. Modifying this parameter is the same as changing object dictionary 6091-02 value. Valid when PA0.08 = 0.					

PA0.11	Label	Encoder pulse output per revolution	Mode	F		
	Range	0~65535	Default	2500	Unit	P/r
	Activation	After restart			Index	2011
	Including rising and falling edge of encoder phase A and B, encoder actual differential output pulse count = PA0.011 x 4 Please make sure: Motor rotational speed x PA0.11 x 4≤1MHz. If exceeds, alarm Er280 might occur.					

PA0.12	Label	Pulse output logic inversion	Mode	F		
	Range	0~1	Default	0	Unit	-
	Activation	After restart			Index	2012

To set phase B logic and output source from encoder pulse output. To inverse B-Phase pulse logic and change the phase relation between Phase A and Phase B

Pulse output logic inversion

PA0.12	Phase B logic	CW direction	CCW direction
[0]	Not inverted		
[1]	Inverted		

PA0.13	Label	1st Torque Limit	Mode	F		
	Range	0~500	Default	300	Unit	%
	Activation	Immediate			Index	2013h

1st torque limit is set according to ratio percentage of motor rated current. Do not exceed max driver output current.
Actual torque limit is the smaller value of PA0.13 and object dictionary 6072

PA0.14	Label	Excessive Position Deviation Settings	Mode	PP	HM	CSP
	Range	0~500	Default	30	Unit	0.1rev
	Activation	Immediate			Index	2014h

Please set threshold value for position deviation accordingly. Default factory setting = 30, Er180 will be triggered if positive deviation is in excess of 3 revolutions.

PA0.15	Label	Absolute Encoder settings	Mode	PP	HM	CSP
	Range	0~32767	Default	0	Unit	-
	Activation	Immediate			Index	2015h

0: Incremental mode:
Used as an incremental encoder. Doesn't retain position data on power off. Unlimited travel distance.
1: Multiturn linear mode:
Used as a multiturn absolute encoder. Retrain position data on power off. For applications with fixed travel distance and no multiturn data overflow.
2: Multiturn rotary mode:
Used as a multiturn absolute encoder. Retrain position data on power off. Actual data feedback in between 0-(PA6.63). Unlimited travel distance.
3: Single turn absolute mode:
Used when travel distance is within 1 revolution of the encoder. Data overflow will trigger alarm.
5: Clear multiturn alarm and activate multiturn absolute function. Will switch to multiturn mode once alarm cleared, if remains at 5 after 3s, please solve according to Er153.
9: Clear multiturn position, reset multiturn alarm and activate multiturn absolute function. Will switch to multiturn mode once alarm cleared, if remains at 9 after 3s, please solve according to Er153. ***Please disable axis before setting to 9 and home the axis before using.***

PA0.16	Label	Regenerative resistance	Mode	F

	Range	25~500	**Default**	100	**Unit**	Ohm
	Activation	Immediate			**Index**	2016h
	To set resistance value of regenerative resistor					

PA0.17	**Label**	Regenerative resistor power rating	**Mode**	**F**		
	Range	20~5000	**Default**	50	**Unit**	W
	Activation	Immediate			**Index**	2017h

To set power rating of regenerative resistor.

Drive	Resistance(Ω)	Power Rating(W)
EL8-EC400F	100	50
EL8-EC750F	50	75
EL8-EC1000F	50	75
EL8-EC1500F	50	80
EL8-EC2000F	50	80

PA0.16 and PA0.17 determines the threshold value of Er 120. Please set accordingly or it might trigger false alarm or damage to servo driver.

Note: If external regenerative resistor is used, please set according to its labeled power rating.

PA0.19	**Label**	Friction compensation setting	**Mode**	**F**		
	Range	0~1000	**Default**	0	Unit	-
	Activation	Immediate			Index	2022h

Friction compensation setting = 0, default = 1;

Friction compensation setting = x, indicating x+1/10000 of friction compensation runway;

PA0.23	**Label**	EtherCAT slave ID	**Mode**	**F**		
	Range	0~32767	**Default**	2	**Unit**	-
	Activation	After restart			**Index**	2023h

Set ID number of the slave station under EtherCAT mode

PA0.24	**Label**	Source of slave ID	**Mode**	**F**		
	Range	0~1	**Default**	1	**Unit**	-
	Activation	After restart			**Index**	2024h

0: Master device automatically assigns a slave address.

1：The slave ID = PA0.23

PA0.25	**Label**	Synchronous compensation time 1	**Mode**	**CSP**		
	Range	1~100	**Default**	10	**Unit**	0.1us
	Activation	After restart			**Index**	2025h

Synchronous dithering compensation range. Used for master device with poor synchronization.

PA0.26	**Label**	Synchronous compensation time 2	**Mode**	**CSP**		

	Range	1~2000	**Default**	50	**Unit**	0.1us
	Activation	After restart			**Index**	2026h
	Synchronous dithering compensation range. Used for master device with poor synchronization.					

PA0.27	**Label**	Synchronization mode command delay cycle counts	**Mode**	**CSP**		
	Range	1~50	**Default**	0	**Unit**	-
	Activation	After restart			**Index**	2027h
	Driver delays N position loop cycle counts to receive position command from master device. To solve motor jitter caused by master device with poor synchronization.					

PA0.28	**Label**	CSP mode safe self-running position setting	**Mode**	**CSP**		
	Range	0~10000	**Default**	10	**Unit**	-
	Activation	Immediate			**Index**	2028h
	Synchronous dithering compensation range. Used for master device with poor synchronization.					

3.2.2【Class 1】Gain Adjustments

PA1.00	**Label**	1^{st} position loop gain	**Mode**	**PP**	**HM**	**CSP**
	Range	0~30000	**Default**	320	**Unit**	0.1/s
	Activation	Immediate			**Index**	2100h
	Higher position loop gain value improves the responsiveness of the servo driver and lessens the positioning time. Position loop gain value shouldn't exceed responsiveness of the mechanical system and take in consideration velocity loop gain, if not it might cause vibration, mechanical noise and overtravel. As velocity loop gain is based on position loop gain, please set both values accordingly. Recommended range: 1.2≤PA1.00/PA1.01≤1.8					

PA1.01	**Label**	1^{st} velocity loop gain	**Mode**	**F**		
	Range	1~32767	**Default**	180	**Unit**	0.1Hz
	Activation	Immediate			**Index**	2101h
	To determine the responsiveness of the velocity loop. If inertia ratio of PA0.04 is uniform with actual inertia ratio, velocity loop responsiveness = PA1.01. To increase position loop gain and improve responsiveness of the whole system, velocity loop gain must be set at higher value. Please notice that if the velocity loop gain is too high, it might cause vibration.					

PA1.02	**Label**	1^{st} Integral Time Constant of Velocity Loop	**Mode**	**F**

	Range	1~10000	**Default**	310	**Unit**	0.1ms
	Activation	Immediate			**Index**	2102h

If auto gain adjusting function is not enabled, PA1.02 is activated.
The lower the set value, the closer the lag error at stop to 0 but might cause vibration. If the value set is overly large, overshoot, delay of positioning time duration and lowered responsiveness might occur.
Set 10000 to deactivate PA1.02.

Recommended range: 50000≤PA1.01xPA1.02≤150000

For example: Velocity loop gain PA1.01=500(0.1Hz), which is 50Hz. Integral time constant of velocity loop should be 100(0.1ms)≤PA1.02≤300(0.1ms)

PA1.03	**Label**	1st velocity detection filter	**Mode**	**F**		
	Range	1~10000	**Default**	15	**Unit**	-
	Activation	Immediate			**Index**	2103h

This filter is a low pass filter. It blocks high frequencies which cause system instability from velocity feedback data. The higher the set value, lower frequencies will be blocked and velocity responsiveness will also be lowered. PA1.03 needs to match velocity loop gain. Please refer to the following table.

Value	Velocity Detection Filter Cut-off Frequency(Hz)	Value	Velocity Detection Filter Cut-off Frequency(Hz)
0	2500	16	750
1	2250	17	700
2	2100	18	650
3	2000	19	600
4	1800	20	550
5	1600	21	500
6	1500	22	450
7	1400	23	400
8	1300	24	350
9	1200	25	300
10	1100	26	250
11	1000	27	200
12	950	28	175
13	900	29	150
14	850	30	125
【15】	800	31	100

PA1.04	**Label**	1st Torque Filter Time Constant	**Mode**	**F**		
	Range	0~2500	**Default**	126	**Unit**	0.01ms
	Activation	Immediate			**Index**	2104h

To set torque command low-pass filter, add a filter delay time constant to torque command and filter out the high frequencies in the command.
Often used to reduce or eliminate some noise or vibration during motor operation, but it will reduce the responsiveness of current loop, resulting in undermining velocity loop and position loop control. PA1.04 needs to match velocity loop gain.
Recommended range: 1,000,000/(2π×PA1.04) ≥PA1.01×4

For example: Velocity loop gain PA1.01=180(0.1Hz) which is 18Hz. Time constant of torque

	filter should be PA1.01≤221(0.01ms) If mechanical vibration is due to servo driver, adjusting PA1.04 might eliminate the vibration. The smaller the value, the better the responsiveness but also subjected to machine conditions. If the value is too large, it might lower the responsiveness of current loop. With higher PA1.01 value settings and no resonance, reduce PA1.04 value; With lower PA1.01 value settings, increase PA1.04 value to lower motor noise.

PA1.05	**Label**	2nd Position Loop Gain	**Mode**	**PP**	**HM**	**CSP**	
	Range	0~30000	**Default**	380	**Unit**	0.1/s	
	Activation	Immediate			**Index**	2105h	
PA1.06	**Label**	2nd velocity loop gain	**Mode**	**F**			
	Range	1~32767	**Default**	180	**Unit**	0.1Hz	
	Activation	Immediate			**Index**	2106h	
PA1.07	**Label**	2nd Integral Time Constant of Velocity Loop	**Mode**	**F**			
	Range	1~10000	**Default**	10000	**Unit**	0.1ms	
	Activation	Immediate			**Index**	2107h	
PA1.08	**Label**	2nd velocity detection filter	**Mode**	**F**			
	Range	1~31	**Default**	15	**Unit**	-	
	Activation	Immediate			**Index**	2108h	
PA1.09	**Label**	2nd Torque Filter Time Constant	**Mode**	**F**			
	Range	0~2500	**Default**	126	**Unit**	0.01ms	
	Activation	Immediate			**Index**	2109h	
	Position loop, velocity loop, velocity detection filter, torque command filter each have 2 pairs of gain or time constant (1st and 2nd)						

PA1.10	**Label**	Velocity feed forward gain	**Mode**	**PP**	**HM**	**CSP**
	Range	0~1000	**Default**	300	**Unit**	0.10%
	Activation	Immediate			**Index**	2110h
	Used for decreasing following error caused by low responsiveness of velocity loop. Might cause overshoot or increase in noise if set value is too high.					

PA1.11	**Label**	Velocity feed forward filter time constant	**Mode**	**PP**	**HM**	**CSP**
	Range	0~6400	**Default**	50	**Unit**	0.01ms
	Activation	Immediate			**Index**	2111h

Set velocity feed forward low pass filter to eliminate high or abnormal frequencies in velocity feed forward command. Often used when position command with low resolution or high electronic gear ration to smoothen velocity feed forward.

Position deviation under constant velocity can be lowered with higher velocity feed forward gain. Please to refer to the equation below.

Position deviation[Uint]= $\frac{Set\ velocity[\frac{Uint}{s}]}{Position\ loop\ gain[Hz]} x \frac{100 - Velocity\ feed\ foward\ gain[\%]}{100}$

PA1.12	**Label**	Torque feed forward gain	**Mode**	**PP**	**PV**	**HM**	**CSP**	**CSV**	

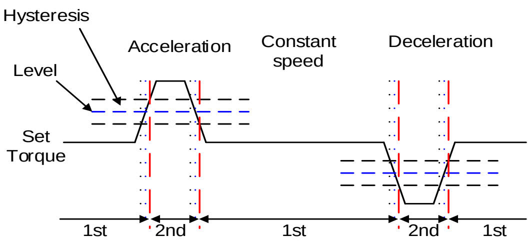
	Range	0~1000	**Default**	0	**Unit**	0.1%
	Activation	Immediate			**Index**	2112h

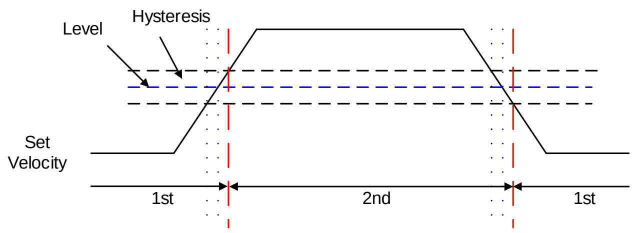
Before using torque feed forward, please set correct inertia ratio PA0.04. By increasing torque feed forward gain, position deviation on constant acceleration/deceleration can be reduced to close to 0. Under ideal condition and trapezoidal speed profile, position deviation of the whole motion can be reduced to close to 0. In reality, perturbation torque will always exist, hence position deviation can never be 0.

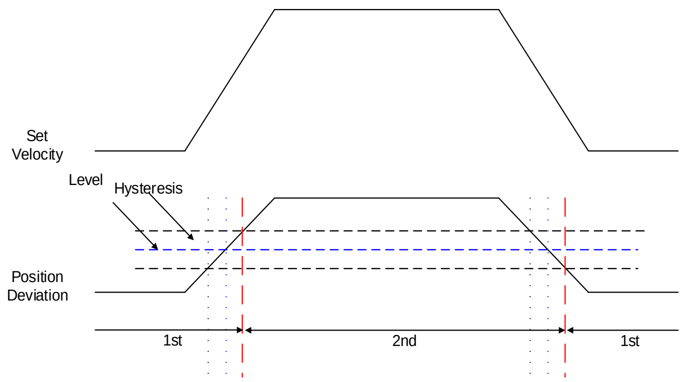
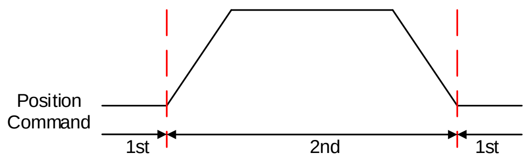
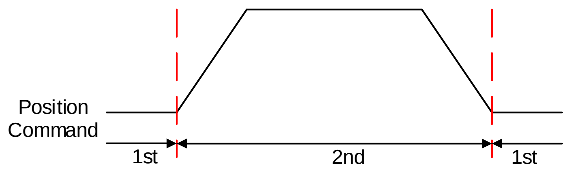
PA1.13	**Label**	Torque feed forward filter time constant	**Mode**	**PP**	**PV**	**HM**	**CSP**	**CSV**	
	Range	0~6400	**Default**	0	**Unit**	0.01ms			
	Activation	Immediate			**Index**	2113h			

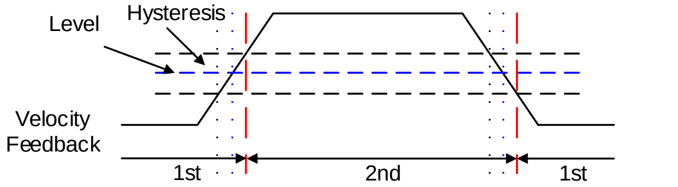
Low pass filter to eliminate abnormal or high frequencies in torque feed forward command. Usually used when encoder has lower resolution or precision.
Noise reduces if torque feed forward filter time constant is set higher but position deviation will increase at acceleration varied points.

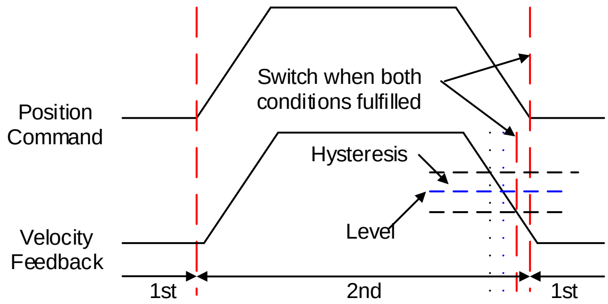
PA1.15	**Label**	Position control gain switching mode	**Mode**	**F**		
	Range	0~11	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2115h

Set Value	Condition	Gain switching condition
0	1st gain fixed	Fixed on using 1st gain(PA1.00-PA1.04)
1	2nd gain fixed	Fixed on using 2nd gain (PA1.05-PA1.09)
2	Reserved	
3	High set torque	Switch to 2nd gain when set torque command absolute value larger than (level + hysteresis)[%] Switch to 1st gain when set torque command absolute value smaller than (level + hysteresis)[%] 
4	Reserved	Reserved
5	High set velocity	Valid for position and velocity control. Switch to 2nd gain when set velocity command absolute value larger than (level + hysteresis)[r/min]

<table>
<tr><td></td><td></td><td>

Switch to 1st gain when set velocity command absolute value smaller than (level-hysteresis)[r/min]</td></tr>
<tr><td>6</td><td>Large position deviation</td><td>Valid for position control.
Switch to 2nd gain when position deviation absolute value larger than (level + hysteresis)[pulse]
Switch to 1st gain when position deviation absolute value smaller than (level-hysteresis)[pulse]

</td></tr>
<tr><td>7</td><td>Pending position command</td><td>Valid for position control.
Switch to 2nd gain if position command ≠ 0
Switch to 1st gain if position command remains = 0 throughout the duration of delay time.

</td></tr>
<tr><td>8</td><td>Not yet in position</td><td>Valid for position control.
Switch to 2nd gain if position command is not completed.
Switch to 1st gain if position command remains uncompleted throughout the duration of delay time.

</td></tr>
<tr><td>9</td><td>High actual velocity</td><td>Valid for position control.</td></tr>
</table>

<table>
<tr><td></td><td></td><td>

Switch to 2nd gain when actual velocity absolute value larger than (level + hysteresis)[r/min]
Switch to 1st gain when actual velocity absolute value remains smaller throughout the duration of delay time than (level-hysteresis)[r/min]</td></tr>
<tr><td>10</td><td>Pending position command +actual velocity</td><td>Valid for position control.
Switch to 2nd gain if position command ≠ 0
Switch to 1st gain if positional command = 0 throughout the duration of delay time and absolute value of actual velocity remains smaller than (level - hysteresis) (r/min)

</td></tr>
</table>

For position control mode, set PA1.15=3,5,6,9,10;

For velocity control mode, set PA1.15=3,5,9;

*** Above 'level' and 'hysteresis' are in correspondence to PA1.17 Position control gain switching level and PA1.18 Hysteresis at position control switching.*

PA1.17	Label	Position control gain switching level	Mode	F		
	Range	0~20000	Default	50	Unit	*As set*
	Activation	Immediate			Index	2117h

Set threshold value for gain switching to occur.
Unit is mode dependent.

Switching condition	Unit
Position	Encoder pulse count
Velocity	RPM
Torque	%

Please set level ≥ hysteresis

PA1.18	Label	Hysteresis at position control switching	Mode	F		
	Range	0~20000	Default	33	Unit	*As PA1.17*
	Activation	Immediate			Index	2118h

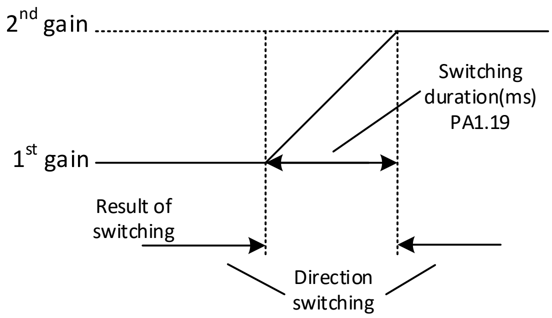
To eliminate the instability of gain switching. Used in combination with PA1.17 If level<

hysteresis, drive will set internally hysteresis = level.

PA1.19	Label	Position gain switching time	Mode	F		
	Range	0~10000	Default	33	Unit	0.1ms
	Activation	Immediate			Index	2119h

During position control, if 1st and 2nd gain difference is too large, to ease torque changes and vibration due to rapid changes in position loop gain, set suitable PA1.19 value

For example: 1st (PA1.00) <-> 2nd (PA1.05)



3.2.3【Class 2】Vibration Suppression

PA2.00	Label	Adaptive filtering mode settings	Mode	F		
	Range	0~4	Default	0	Unit	-
	Activation	Immediate			Index	2200h

Set value	Description	
0	Adaptive filter: invalid	Parameters related to 3rd and 4th notch filter remain unchanged
1	Adaptive filter: 1 filter valid for once.	1 adaptive filter becomes valid. 3rd notch filter related parameters updated accordingly. PA2.00 switches automatically to 0 once updated.
2	Adaptive filter: 1 filter remains valid	1 adaptive filter becomes valid. 3rd notch filter related parameters will keep updating accordingly.
3-4	Reserved	-

PA2.01	Label	1st notch frequency	Mode	F		
	Range	50~4000	Default	4000	Unit	Hz
	Activation	Immediate			Index	2201h

Set center frequency of 1st torque command notch filter.

Set PA2.01 to 4000 to deactivate notch filter

PA2.02	Label	1st notch bandwidth	Mode	F		
	Range	0~20	Default	4	Unit	-
	Activation	Immediate			Index	2202h

Set notch bandwidth for 1^{st} resonant notch filter. Under normal circumstances, please use factory default settings. If resonance is under control, in combination with PA2.01 and PA2.03, PA2.02 can be reduced to improve current loop responsiveness which allows higher mechanical stiffness settings.

PA2.03	**Label**	1^{st} notch depth	**Mode**	**F**		
	Range	0~99	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2203h

Set notch depth for 1^{st} resonant notch filter.
Under normal circumstances, please use factory default settings. If resonance is under control, in combination with PA2.01 and PA2.02, PA2.03 can be reduced to improve current loop responsiveness which allows higher mechanical stiffness settings

PA2.04	**Label**	2^{nd} notch frequency	**Mode**	**F**		
	Range	50~4000	**Default**	4000	**Unit**	Hz
	Activation	Immediate			**Index**	2204h

Set center frequency of 2^{nd} torque command notch filter.
Set PA2.04 to 4000 to deactivate notch filter

PA2.05	**Label**	2^{nd} notch bandwidth	**Mode**	**F**		
	Range	0~20	**Default**	4	**Unit**	-
	Activation	Immediate			**Index**	2205h

Set notch bandwidth for 2^{nd} resonant notch filter.
Under normal circumstances, please use factory default settings. If resonance is under control, in combination with PA2.04 and PA2.06, PA2.05 can be reduced to improve current loop responsiveness which allows higher mechanical stiffness settings.

PA2.06	**Label**	2^{nd} notch depth	**Mode**	**F**		
	Range	0~99	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2206h

Set notch depth for 1^{st} resonant notch filter.
When PA2.06 value is higher, notch depth becomes shallow, phase lag reduces. Under normal circumstances, please use factory default settings. If resonance is under control, in combination with PA2.04 and PA2.05, PA2.06 can be reduced to improve current loop responsiveness which allows higher mechanical stiffness settings.

PA2.07	**Label**	3^{rd} notch frequency	**Mode**	**F**		
	Range	50~4000	**Default**	4000	**Unit**	Hz
	Activation	Immediate			**Index**	2207h

Set center frequency of 3^{rd} torque command notch filter.
Set PA2.07 to 4000 to deactivate notch filter

PA2.08	**Label**	3^{rd} notch bandwidth	**Mode**	**F**		
	Range	0~20	**Default**	4	**Unit**	-
	Activation	Immediate			**Index**	2208h

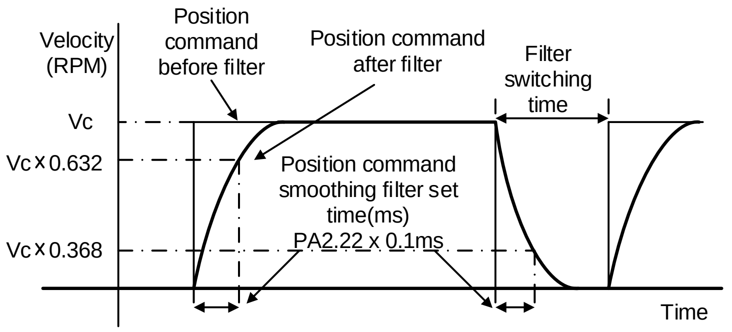
Set notch bandwidth for 3rd resonant notch filter. Under normal circumstances, please use factory default settings.

PA2.09	Label	3rd notch depth	Mode	F		
	Range	0~99	Default	0	Unit	-
	Activation	Immediate			Index	2209h
Set notch depth for 3rd resonant notch filter. When PA2.09 value is higher, notch depth becomes shallow, phase lag reduces.						

PA2.14	Label	1st damping frequency	Mode	F		
	Range	0~2000	Default	0	Unit	0.1Hz
	Activation	Immediate			Index	2214h
0: Deactivate To suppress wobble at load end. Often used when wobble of flexible structure due to high deceleration upon stopping. Especially effective for wobble with frequencies under 100Hz. Set PA2.15 to wobble frequency (wobble frequency can be determined using tracing function of Motion Studio)						

PA2.16	Label	2nd damping frequency	Mode	F		
	Range	0~2000	Default	0	Unit	0.1Hz
	Activation	Immediate			Index	2216h
0: Deactivate To suppress wobble at load end. Often used when wobble of flexible structure due to high deceleration upon stopping. Especially effective for wobble with frequencies under 100Hz. Set PA2.16 to wobble frequency (wobble frequency can be determined using tracing function of Motion Studio)						

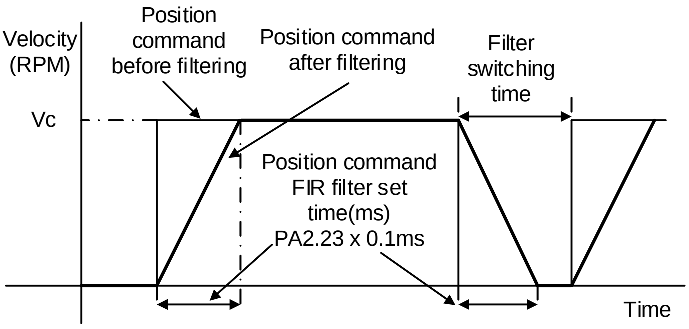
PA2.22	Label	Position command smoothing filter	Mode	PP	HM	CSP
	Range	0~32767	Default	300	Unit	0.1ms
	Activation	After stopping			Index	2222h
To set time constant of 1 time delay filter of position command. To set time constant of 1 time delay filter, according to target velocity Vc square wave command as show below.						



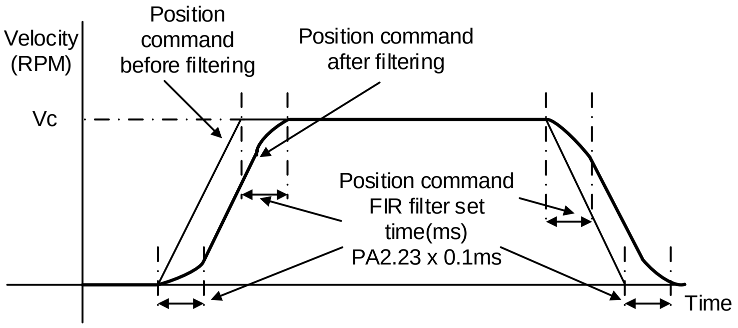
Usually applied when there is rather sharp acceleration which might cause motor overshoot or undershoot. To smoothen command signal, reduces impact to machines and eliminate vibration. If PA2.22 is set too high, overall time will be lengthened.

PA2.23	**Label**	Position command FIR filter	**Mode**	**PP**	**HM**	**CSP**	
	Range	0~10000	**Default**	0	**Unit**	0.1ms	
	Activation	After disabling			**Index**	2223h	

As shown below, when target velocity Vc square wave command reaches Vc, it becomes trapezoidal wave after filtering.



As shown below, when target velocity Vc trapezoidal command reaches Vc, it becomes S wave after filtering.



Usually applied when there is rather sharp acceleration which might cause motor overshoot or undershoot. To smoothen command signal, reduces impact to machines and eliminate vibration. If PA2.23 is set too high, overall time will be lengthened.

***Please wait for command to stop and after filter idle time to modify PA2.23.*

Filter switching time = (PA2.23 set value x 0.1ms + 0.25ms)

PA2.31	Label	5th resonant frequency	Mode	F		
	Range	50~4000	Default	4000	Unit	Hz
	Activation	Immediate			Index	2231h
	To set zero-valued eigenfrequency of 5th resonant notch filter. PA2.31 corresponds to machine specific resonant frequency. Notch filter deactivated if PA2.31 is set to any value.					

PA2.32	Label	5th resonant Q value	Mode	F		
	Range	0~10000	Default	0	Unit	Hz
	Activation	Immediate			Index	2232h
	To set notch Q value of 5th resonant notch filter					

PA2.33	Label	5th anti-resonant frequency	Mode	F		
	Range	50~4000	Default	4000	Unit	Hz
	Activation	Immediate			Index	2233h
	To set zero-valued eigenfrequency of 5th resonant notch filter. PA2.31 corresponds to machine-specific anti-resonant frequency.					

PA2.34	Label	5th anti-resonant Q value	Mode	F		
	Range	0~9900	Default	0	Unit	Hz
	Activation	Immediate			Index	2234h
	To set resonant Q value of 5th resonant notch filter					

PA2.35	Label	6th resonant frequency	Mode	F		
	Range	50~4000	Default	4000	Unit	Hz
	Activation	Immediate			Index	2235h
	To set zero-valued eigenfrequency of 6th resonant notch filter. PA2.35 corresponds to machine-specific resonant frequency. Notch filter deactivated if PA2.35 is set to any value.					

PA2.36	Label	6th resonant Q value	Mode	F		
	Range	0~10000	Default	0	Unit	Hz
	Activation	Immediate			Index	2236h
	To set notch Q value of 6th resonant notch filter					
PA2.37	Label	6th anti-resonant frequency	Mode	F		
	Range	50~4000	Default	4000	Unit	Hz
	Activation	Immediate			Index	2237h
	To set zero-valued eigenfrequency of 6th resonant notch filter. PA2.37 corresponds to machine-specific anti-resonant frequency.					

PA2.38	Label	6th anti-resonant Q value	Mode	F

	Range	0~9900	**Default**	0	**Unit**	Hz
	Activation	Immediate			**Index**	2238h

To set resonant Q value of 6th resonant notch filter

PA2.48	**Label**	Adjustment mode	**Mode**	**F**		
	Range	0~1	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2248h

To turn on/off automatic adjustments

Set value	Description
【0】	Turn off automatic adjustments
1	Activate automatic adjustments, real time inertia measuring and vibration suppression. Inertia measuring deactivated after reaching 4 times in 5 minutes, triggering conditions: changes in mechanical stiffness.

PA2.50	**Label**	MFC type	**Mode**	**PP**	**CSP**	
	Range	0~3	**Default**	0	**Unit**	Hz
	Activation	After restart			**Index**	2250h

Set value	Description
【0】	Model following control
1	Zero tracking control
2	*3 inertia (future upgrade)*
3	*Path following (future upgrade)*

PA2.51	**Label**	Velocity feedforward compensation coefficient	**Mode**	**PP**	**CSP**			
	Range	-10000~ 10000	**Default**	0	**Unit**	-		
	Activation	Immediate			**Index**	2251h		

To compensate for velocity feedforward

PA2.52	**Label**	Torque feedforward compensation coefficient	**Mode**	**PP**	**PV**	**CSP**	**CSV**	
	Range	-10000~ 10000	**Default**	0	**Unit**	-		
	Activation	Immediate			**Index**	2252h		

To compensate for velocity feedforward

PA2.53	**Label**	Dynamic friction compensation coefficient	**Mode**	**F**		
	Range	0~1000	**Default**	0	**Unit**	%
	Activation	Immediate			**Index**	2253h

To set ratio of rated torque/rated rotational speed, to compensate for dynamic friction during motion and have better control over acceleration/deceleration.

$$\text{Dynamic friction coefficient} = \left|\frac{\text{Torque(Rotational speed 1)} - \text{Torque(Rotational speed 2)}}{\text{Rotational speed 1} - \text{Rotational speed 2}} * \text{rated rotational speed}\right|$$

When there is an excess position deviation during acceleration/deceleration, please adjust PA2.53 to reduce the deviation to 0.

PA2.54	**Label**	Overtravel time coefficient	**Mode**	F		
	Range	0~10000	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2254h

To set overtravel time coefficient

PA2.55	**Label**	Overtravel suppression gain	**Mode**	F		
	Range	0~1000	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2255h

Suppression improves with larger set value but might affect the performance of MFC. Please use with caution for any value above 100.

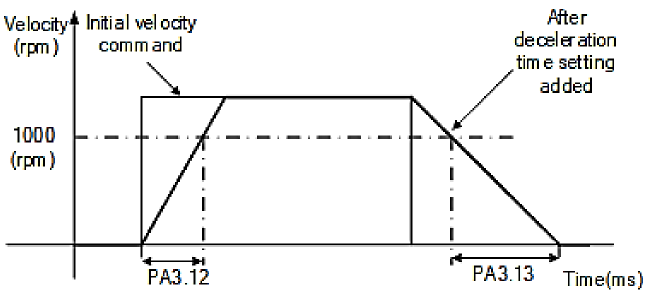
3.2.4【Class 3】Velocity Control

PA3.12	**Label**	Acceleration time		**Mode**		**PV**	**CSV**
	Range	0~10000	**Default**	0	**Unit**	ms/(1000RPM)	
	Activation	Immediate			**Index**	2312h	
PA3.13	**Label**	Deceleration time		**Mode**		**PV**	**CSV**
	Range	0~10000	**Default**	0	**Unit**	ms/(1000RPM)	
	Activation	Immediate			**Index**	2313h	

Set max acceleration/deceleration for velocity command.

If target velocity = *x* [rpm], max acceleration = *a* [unit: rpm/ms], acceleration time = *t* [ms]
PA3.12 = *1000/a*
PA3.13 = *1000/a*
a = *x/t*

For example: If motor is to achieve 1500rpm in 30s, *a=1500/30=50rpm/ms*
PA3.12 = 1000/*a*= *20.* Hence when PA3.12 = 20, motor can achieve 1500rpm in 30s.

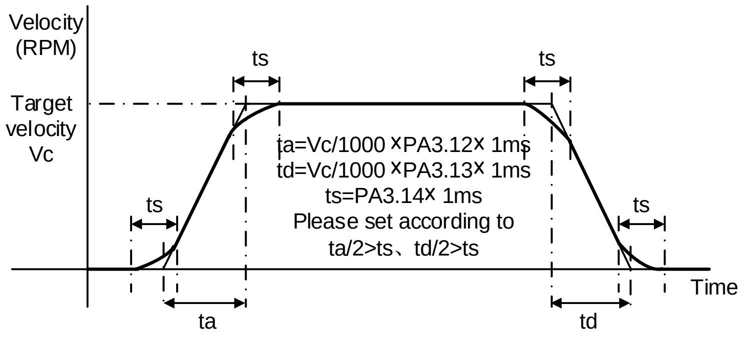


Usually used when there is rapid acceleration or trapezoidal wave velocity command due to many different internal speed segments under velocity control mode which causes instable while motor in motion.

Under velocity control mode, 6083 and 6084 is limited by PA3.12 and PA3.13 correspondingly.

PA3.14	Label	Sigmoid acceleration/deceleration settings	Mode	PV	CSV
	Range	0~1000	Default	0	Unit: ms
	Activation	After disabling			Index: 2314h

To set sigmoid acceleration and deceleration turning point in accordance to PA3.12 and PA3.13.



PA3.15	Label	Zero speed clamp function selection	Mode	F
	Range	0~3	Default	0 / Unit: -
	Activation	Immediate		Index: 2315h

Set value	Zero speed clamp function
0	Invalid: zero speed clamp deactivated
1	Velocity command is forced to 0 when the zero speed clamp (ZEROSPD) input signal is valid.
2	Velocity command is forced to 0 when actual velocity is lower than PA3.16.
3	Includes conditions from 1 and 2

PA3.16	Label	Zero speed clamp level	Mode	PV	CSV
	Range	10~2000	Default	30	Unit: rpm
	Activation	Immediate			Index: 2316h

Velocity command is forced to 0 when actual velocity is lower than PA3.16 and after static time set in PA3.23

PA3.23	Label	Zero speed clamp static time	Mode	PV	CSV
	Range	0~32767	Default	0	Unit: ms
	Activation	Immediate			Index: 2323h

To set delay time for zero speed clamp.

To prevent creeping at low speed, velocity command forced to 0 when velocity goes under PA3.16 after time set in PA3.23

3.2.5【Class 4】I/O Interface Setting

PA4.00	Label	Input selection DI1	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2400h
PA4.01	Label	Input selection DI2	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2401h
PA4.02	Label	Input selection DI3	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2402h
PA4.03	Label	Input selection DI4	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2403h
PA4.04	Label	Input selection DI5	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2404h
PA4.05	Label	Input selection DI6	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2405h

Digital input DI allocation using hexadecimal system

Input	Symbol	Set value		0x60FD(bit)
		Normally open	Normally close	
Invalid	—	0h	-	×
Positive limit switch	POT	1h	81h	Bit1
Negative limit switch	NOT	2h	82h	Bit0
Clear alarm	A-CLR	4h	-	×
Forced alarm	E-STOP	14h	94h	×
Home switch	HOME-SWITCH	16h	96h	Bit2

- Please don't set anything other than listed in table above.
- Normally open: Valid when input = ON Normally close: Valid when input = OFF
- Er210 might occur if same function is allocated to different channels at the same time
- Channel that has no value doesn't affect driver motion.
- Front panel is of hexadecimal system.

PA4.00 – PA4.05 corresponds to DI1 – DI6. External sensors can be connected if the parameters are all set to 0. Controller will read 60FD bit4 – 11 to get DI1 – DI6 actual status.

PA4.10	Label	Output selection DO1	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2410h
PA4.11	Label	Output selection DO2	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2411h

PA4.12	Label	Output selection DO3	Mode	F		
	Range	0x0~0xFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2412h

Digital output DO allocation using hexadecimal system.

Output	Symbol	Set value	
		Normally open	Normally close
Master device control	—	00h	-
Alarm	ALM	01h	81h
Servo-Ready	S-RDY	02h	82h
External brake released	BRK-OFF	03h	83h
Positioning completed	INP	04h	84h
At-speed	AT-SPEED	05h	85h
Torque limit signal	TLC	06h	86h
Zero speed clamp detection	ZSP	07h	87h
Velocity coincidence	V-COIN	08h	88h
Position command ON/OFF	P-CMD	0Bh	8Bh
Velocity limit signal	V-LIMIT	0Dh	8Dh
Velocity command ON/OFF	V-CMD	0Fh	8Fh
Servo status	SRV-ST	12h	92h
Homing done	HOME-OK	22h	A2h
Position comparison	CMP-OUT	14h	94h

Please don't set any other than the outputs listed in the table above.

- Normally open：Active low
- Normally close：Active high
- Front panel is of hexadecimal system.

PA4.10 – PA4.12 corresponds to DO1 – DO3. If all parameters are set to 0, master device controls the outputs, object dictionary 0x60FE sub-index 01 bit16-18 corresponds to DO1-DO3.

PA4.31	Label	Positioning complete range	Mode	PP	HM	CSP
	Range	0~10000	Default	20	Unit	*Command*
	Activation	Immediate			Index	2431h

To set position deviation range of INP1 positioning completed output signal.

PA4.32	Label	Positioning complete output settings	Mode	PP	HM	CSP
	Range	0~4	Default	1	Unit	-
	Activation	Immediate			Index	2432h

Output conditions of INP1 positioning completed output signal

Set value	Positioning completed signal
0	Signal valid when the position deviation is smaller than PA4.31
1	Signal valid when there is no position command and position deviation is smaller than PA4.31
2	Signal valid when there is no position command, zero-speed clamp detection (ZSP) signal is ON and the positional deviation is smaller than PA4.31
3	Signal valid when there is no position command and position deviation is smaller than PA4.31. Signal ON when within the time set in PA4.33 otherwise OFF.
4	When there is no command, position detection starts after the delay time set in PA4.33. Signal valid when there is no position command and positional deviation is smaller than PA4.31.

PA4.33	Label	INP positioning delay time	Mode	PP	HM	CSP
	Range	0~15000	Default	0	Unit	1ms
	Activation	Immediate			Index	2433h

To set delay time when PA 4.32 = 3

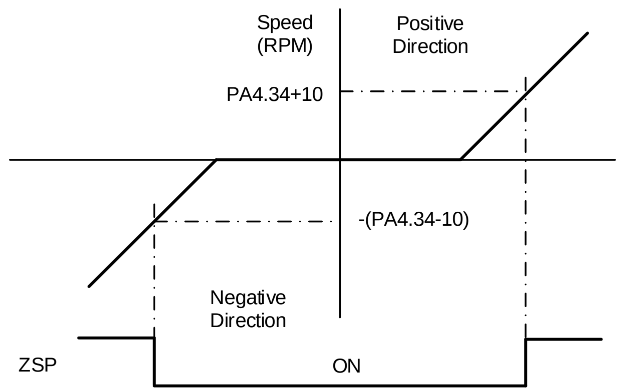
Set value	Positioning completed signal
0	Indefinite delay time, signal ON until next position command
1-15000	OFF within the time set; ON after time set. Switch OFF after receiving next position command.

PA4.34	Label	Zero speed	Mode	F		
	Range	1~2000	Default	50	Unit	RPM
	Activation	Immediate			Index	2434h

To set threshold value for zero speed clamp detection.

Zero speed clamp detection (ZSP) output signal valid when motor speed goes under the value set in PA4.34

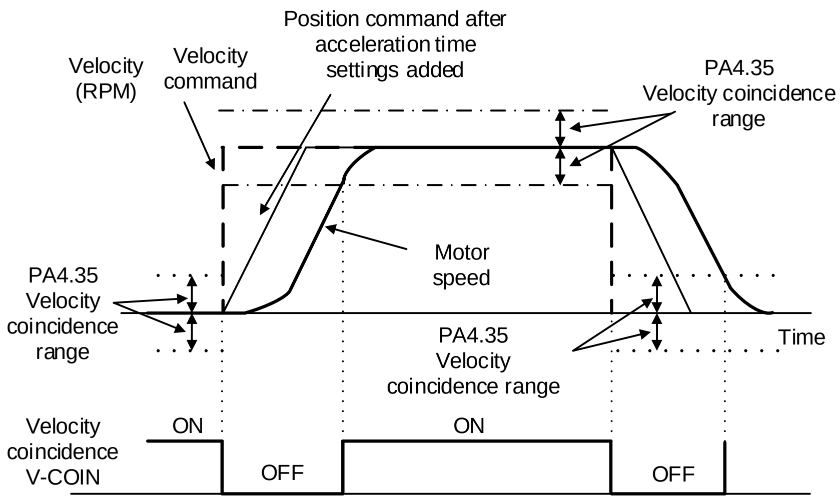
- Disregard the direction of rotation, valid for both directions.
- Hysteresis of 10RPM. Please refer to diagram on the right side.



PA4.35	**Label**	Velocity coincidence range	**Mode**	**PV**		**CSV**
	Range	10~2000	**Default**	50	**Unit**	RPM
	Activation	Immediate			**Index**	2435h

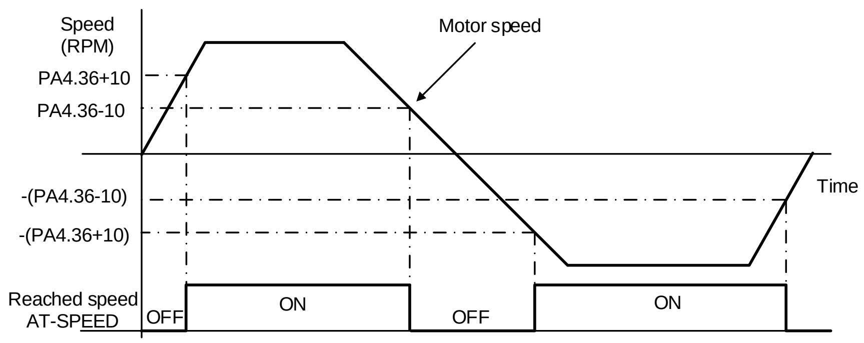
If the difference between velocity command and motor actual speed is below PA4.35, Velocity coincidence (V-COIN) output signal valid.

Due to 10RPM hysteresis:
Velocity coincidence output OFF -> ON timing (PA4.35 -10) r/min
Velocity coincidence output ON -> OFF timing (PA4.35 +10) r/min



PA4.36	**Label**	Reached speed (AT-speed)	**Mode**	**PV**		**CSV**
	Range	10~2000	**Default**	1000	**Unit**	RPM
	Activation	Immediate			**Index**	2436h

When motor velocity > PA4.36, AT-speed output signal is valid.
Detection using 10RPM hysteresis

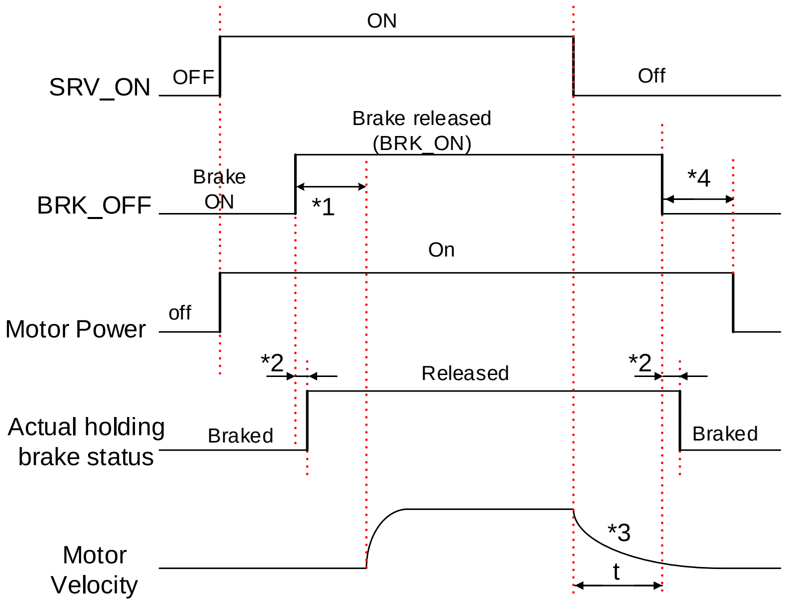


PA4.37	**Label**	Motor power-off delay time	**Mode**	**F**		
	Range	0~3000	**Default**	100	**Unit**	1ms
	Activation	Immediate			**Index**	2437h

To set delay time for holding brake to be activated after motor power off to prevent axis from sliding.

PA4.38	**Label**	Delay time for holding brake release	**Mode**	**F**		
	Range	0~3000	**Default**	0	**Unit**	1ms
	Activation	Immediate			**Index**	2438h

To set delay time for holding brake to be released after motor power on. Motor will remain at current position and input command is masked to allow holding brake to be fully released before motor is set in motion.



*1: Delay time set in PA4.38

*2: Delay time from the moment BRK_OFF signal is given until actual holding brake is released or BRK_ON signal is given until actual holding brake is activated. It is dependent on the holding brake of the motor.

*3: Deceleration time is determined by PA6.14 or if motor speed goes below PA4.39, whichever comes first. BRK_OFF given after deceleration time.

*4: PA4.37 set time value.

Delay time from the moment SRV_ON is given until BRK_OFF switch to BRK_ON, is less than 500ms.

PA4.39	**Label**	Holding brake activation speed	**Mode**	**F**		
	Range	30~3000	**Default**	30	**Unit**	RPM
	Activation	Immediate			**Index**	2439h

To set the activation speed for which holding brake will be activated.

When SRV-OFF signal is given, motor decelerates, after it reaches below PA4.39 and PA6.14 is not yet reached, BRK_OFF is given.
BRK_OFF signal is determined by PA6.14 or if motor speed goes below PA4.39, whichever comes first.

Application:
1. After disabling axis, PA6.14 has been reached but motor speed is still above PA4.39, BRK_OFF signal given.
2. After disabling axis, PA6.14 has not been reached but motor speed is below PA4.39, BRK_OFF signal given.

PA4.43	Label	Emergency stop function	Mode	F		
	Range	0~1	Default	0	Unit	-
	Activation	Immediate			Index	2443h

0：Emergency stop is valid, servo driver will be forced to STOP and alarm occurs.
1：Emergency stop is invalid, servo driver will not be forced to STOP.

PA4.48	Label	Torque compensation time upon enabling	Mode	F		
	Range	0~3000	Default	0	Unit	ms
	Activation	Immediate			Index	2448h

Torque compensation at the enabling of the servo drive can be turned on through PA6.10. Torque compensation time is set using PA4.48. Torque will increase as the motor is enabled and reduce until diminished in the time duration set in PA4.48.
When PA4.48 is set at default of 0s, continuous torque compensation duration will be 1000ms

3.2.6【Class 5】Extension settings

PA5.04	Label	Driver prohibition input settings	Mode	F		
	Range	0~2	Default	0	Unit	-
	Activation	Immediate			Index	2504h

To set driver prohibition input (POT/NOT): If set to 1, no effect on homing mode.

Set value	Description
0	POT → Positive direction drive prohibited NOT → Negative direction drive prohibited
1	POT and NOT invalid
2	Any single sided input from POT or NOT might cause Er260

In homing mode, POT/NOT invalid, please set object dictionary 5012-04 bit0=1

PA5.06	Label	Servo-off mode	Mode	F		
	Range	0~5	Default	0	Unit	-
	Activation	After restart			Index	2506h

To set servo driver disable mode and status.

Value	Description	
	Mode	Status
0	Servo braking	Dynamic braking
1	Free stopping	Dynamic braking
2	Dynamic braking	Dynamic braking
3	Servo braking	Free-run
4	Free stopping	Free-run
5	Dynamic braking	Free-run

<table>
<tr><td rowspan="3">PA5.09</td><td>Label</td><td>Main power-off detection time</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>50~2000</td><td>Default</td><td>50</td><td>Unit</td><td>ms</td></tr>
<tr><td>Activation</td><td colspan="3">Immediate</td><td>Index</td><td>2509h</td></tr>
<tr><td colspan="7">To set duration time for detection of main power-off or low voltage supply.</td></tr>
</table>

<table>
<tr><td rowspan="3">PA5.10</td><td>Label</td><td>Servo-off due to alarm mode</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~5</td><td>Default</td><td>0</td><td>Unit</td><td>-</td></tr>
<tr><td>Activation</td><td colspan="3">After restart</td><td>Index</td><td>2510h</td></tr>
</table>

To set servo driver disable mode and status if alarm is triggered.

Alarm type 2:

<table>
<tr><th rowspan="2">Value</th><th colspan="2">Description</th></tr>
<tr><th>Mode</th><th>Status</th></tr>
<tr><td>0</td><td>Servo braking</td><td>Dynamic braking</td></tr>
<tr><td>1</td><td>Free stopping</td><td>Dynamic braking</td></tr>
<tr><td>2</td><td>Dynamic braking</td><td>Dynamic braking</td></tr>
<tr><td>3</td><td>Servo braking</td><td>Free-run</td></tr>
<tr><td>4</td><td>Free stopping</td><td>Free-run</td></tr>
<tr><td>5</td><td>Dynamic braking</td><td>Free-run</td></tr>
</table>

Alarm type 1:

<table>
<tr><th rowspan="2">Value</th><th colspan="2">Description</th></tr>
<tr><th>Mode</th><th>Status</th></tr>
<tr><td>0</td><td rowspan="3">Dynamic braking</td><td rowspan="3">Dynamic braking</td></tr>
<tr><td>1</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td>Servo braking</td><td>Free-run</td></tr>
<tr><td>4</td><td>Free stopping</td><td>Free-run</td></tr>
<tr><td>5</td><td>Dynamic braking</td><td>Free-run</td></tr>
</table>

<table>
<tr><td rowspan="3">PA5.11</td><td>Label</td><td>Servo braking torque setting</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~500</td><td>Default</td><td>0</td><td>Unit</td><td>%</td></tr>
<tr><td>Activation</td><td colspan="3">Immediate</td><td>Index</td><td>2511h</td></tr>
<tr><td colspan="7">To set torque limit for servo braking mode.
If PA5.11 = 0, use torque limit as under normal situation.
Between max. torque 6072 and PA5.11, actual torque limit will take smaller value.</td></tr>
</table>

<table>
<tr><td rowspan="3">PA5.12</td><td>Label</td><td>Overload level setting</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~115</td><td>Default</td><td>0</td><td>Unit</td><td>%</td></tr>
<tr><td>Activation</td><td colspan="3">Immediate</td><td>Index</td><td>2512h</td></tr>
<tr><td colspan="7">If PA5.12 = 0, overload level = 115%
Use only when overload level degradation is needed.</td></tr>
</table>

<table>
<tr><td rowspan="2">PA5.13</td><td>Label</td><td>Overspeed level setting</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~10000</td><td>Default</td><td>0</td><td>Unit</td><td>RPM</td></tr>
</table>

	Activation	Immediate		Index	2513h

If motor speed exceeds PA5.13, Er1A0 might occur.
When PA5.13 = 0, overspeed level = max. motor speed x 1.2

PA5.15	Label	I/O digital filter	Mode	F	
	Range	0~255	Default	10	Unit: 0.1ms
	Activation	Immediate		Index	2515h

Digital filtering of I/O input. Overly large value set will cause control delay.

PA5.20	Label	Position unit setting	Mode	PP	HM	CSP
	Range	0~2	Default	2	Unit	-
	Activation	After restart			Index	2520h

Set value	Unit
0	Encoder unit
1	Command unit
2	0.0001rev

Command unit: Pulse from host (Affected by electronic gear ratio)

Encoder unit: Pulse from encoder (Related to encoder resolution)

PA5.20 can only be modified when axis is disabled as it will clear position data.

PA5.21	Label	Torque limit selection	Mode	F		
	Range	0~2	Default	0	Unit	-
	Activation	Immediate			Index	2521h

Set value	Positive limit value	Negative limit value
0	PA0.13	PA0.13
1	PA0.13	PA5.22
2	60E0	60E1

Between max. torque 6072 and PA5.21, actual torque limit will take smaller value.

PA5.22	Label	2^{nd} Torque limit	Mode	F		
	Range	0~500	Default	300	Unit	%
	Activation	Immediate			Index	2522h

Limited by motor max. torque.

Between max. torque 6072 and PA5.22, actual torque limit will take smaller value.

PA5.28	Label	LED initial status	Mode	F		
	Range	0~42	Default	34	Unit	-
	Activation	After restart			Index	2528h

To set content display on front panel of the servo driver at servo driver power on.

Set value	Content	Set value	Content	Set value	Content
0	Position command deviation	15	Overload rate	30	No. of encoder communication error

1	Motor speed	16	Inertia ratio	31	Accumulated operation time
2	Position command velocity	17	No rotation cause	32	Automatic motor identification
3	Velocity control command	18	No. of changes in I/O signals	33	Driver temperature
4	Actual feedback torque	19	Number of over current signals	34	Servo status
5	Sum of feedback pulse	20	Absolute encoder data	35	/
6	Sum of command pulse	21	Single turn position	36	Synchronous period
7	Maximum torque during motion	22	Multiturn position	37	No. of synchronous loss
8	/	23	Communication axis address	38	Synchronous type
9	Control mode	24	Encoder position deviation	39	Whether DC is running or not
10	I/O signal status	25	Motor electrical angle	40	Acceleration/ Deceleration status
11	/	26	Motor mechanical angle	41	Sub-index of OD index
12	Error cause and history record	27	Voltage across PN	42	Value of sub-index of OD index
13	Alarm code	28	Software version		
14	Regenerative load rate	29	/		

PA5.37	Label	Torque limit duration during homing	Mode	F		
	Range	0~5000	Default	500	Unit	ms
	Activation	Immediate			Index	2537h

To set time threshold for output torque to reach limit under torque initialization mode.

Only applicable for torque initialization method -6 to -1

Under torque initialization mode, motor torque reached PA5.39 and the duration reaches PA5.37 before moving into next step.

PA5.39	Label	3rd torque limit	Mode	F		
	Range	0~500	Default	80	Unit	%
	Activation	Immediate			Index	2539h

To set torque limit during torque initialization

Between max. torque 6072 and PA5.37, actual torque limit will take smaller value.

PA5.40	Label	D41 set value	Mode	F		
	Range	0x0~0xFFFFF	Default	0X30C	Unit	%
	Activation	Immediate			Index	2540h

Set object word monitored by D41, index (left 4 bits) + sub-index (right 1 bit), if monitoring 0x6092-01, set PA5.40 to 0x60921.

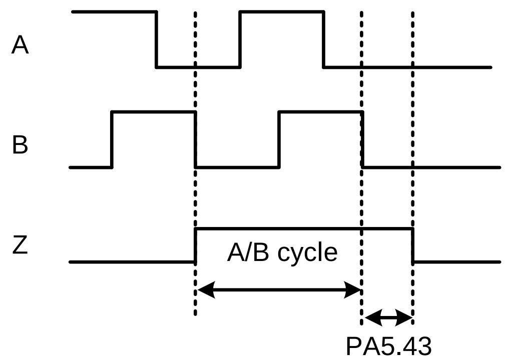
PA5.42	Label	Frequency divider output - ABZ signal polarity	Mode	F		
	Range	0~7	Default	0	Unit	-
	Activation	After restart			Index	2542h

Bit	Polarity	Description
Bit0	0 = Positive 1 = Negative	Z polarity setting of frequency divider output and position comparison
Bit1	0 = Positive 1 = Negative	Only valid in position comparison. Polarity setting when phase A frequency divider as position comparison output
Bit2	0 = Positive	Only valid in position comparison. Polarity setting when phase B frequency divider as position comparison output

PA5.43	Label	Frequency divider output – Z-signal width	Mode	F		
	Range	0~500	Default	0	Unit	μs
	Activation	After restart			Index	2543h

Set value	Description
【0】	Z bandwidth equivalent to 1 cycle of A/B
1~500	Delay setting on top of A/B cycle width

When PA5.43 = 0, width of frequency divider output Z-signal is equivalent to width of 1 cycle of A/B, value set in PA5.43 + A/B cycle width = delay setting.



PA5.44	Label	Frequency divider output source	Mode	F		
	Range	0~4	Default	0	Unit	-
	Activation	After restart			Index	2544h

Set Value	Description
【0】	Position feedback of encoder #1(motor encoder)
1	Position feedback of encoder #2(external encoder)
2	Reserved
3	Pulse input command position synchronous output; position comparison not available in this mode
4	Frequency divider output prohibited

PA5.46	Label	Vent overload level	Mode	F		
	Range	0~115	Default	0	Unit	%
	Activation	Immediate			Index	2546h

Set value	Description
【0】	Default level: 80%
1~115	Set vent overload level accordingly

3.2.7【Class 6】Other settings

PA6.01	Label	Encoder zero position compensation	Mode	F		
	Range	0~360	Default	0	Unit	°
	Activation	After restart			Index	2601h

Angle of the encoder after zero position calibration

PA6.03	Label	JOG trial run torque command	Mode	F		
	Range	0~350	Default	350	Unit	%
	Activation	Immediate			Index	2603h

To set torque for JOG trial run command.

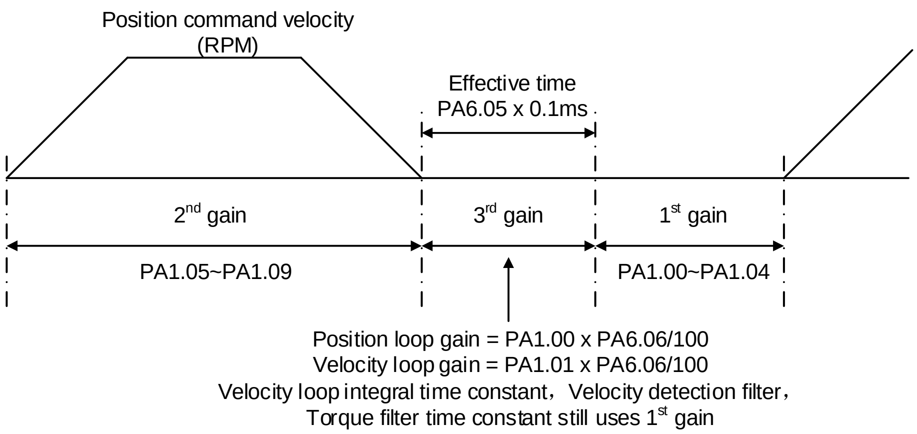
PA6.04	Label	JOG trial run velocity command	Mode	F		
	Range	0~10000	Default	30	Unit	r/min
	Activation	Immediate			Index	2604h

To set velocity for JOG trial run command.

PA6.05	**Label**	Position 3^{rd} gain valid time	**Mode**	**PP**	**HM**	**CSP**
	Range	0~10000	**Default**	0	**Unit**	0.1ms
	Activation	Immediate			**Index**	2605h
	To set time for 3^{rd} gain to be valid When not in use, set PA6.05=0, PA6.06=100					

PA6.06	**Label**	Position 3^{rd} gain scale factor	**Mode**	**PP**	**HM**	**CSP**
	Range	0~1000	**Default**	100	**Unit**	100%
	Activation	Immediate			**Index**	2606h

Set up the 3^{rd} gain by multiplying factor of the 1^{st} gain



Above diagram is illustrated using PA1.15 = 7.

3^{rd} gain= 1^{st} gain * PA6.06/100

Only effective under position control mode. 3^{rd} gain valid when PA6.05 ≠ 0. Set 3^{rd} gain value in PA6.06. When 2^{nd} gain switches to 1^{st} gain, it will go through 3^{rd}, switching time is set in PA1.19.

PA6.07	**Label**	Torque command additional value	**Mode**	**F**		
	Range	-100~100	**Default**	0	**Unit**	%
	Activation	Immediate			**Index**	2607h
	To set torque forward feed additional value of vertical axis. Applicable for loaded vertical axis, compensate constant torque. Application: When load move along vertical axis, pick any point from the whole motion and stop the load at that particular point with motor enabled but not rotating. Record output torque value from d04, use that value as torque command additional value (compensation value)					

PA6.08	**Label**	Positive direction torque compensation value	**Mode**	**F**		
	Range	-100~100	**Default**	0	**Unit**	%
	Activation	Immediate			**Index**	2608h
PA6.09	**Label**	Negative direction torque compensation value	**Mode**	**F**		
	Range	-100~100	**Default**	0	**Unit**	%
	Activation	Immediate			**Index**	2609h
	To reduce the effect of mechanical friction in the movement(s) of the axis. Compensation values can be set according to needs for both rotational directions.					

Applications: 1. When motor is at constant speed, d04 will deliver torque values. Torque value in positive direction = T1; Torque value in negative direction = T2 PA6.08/PA6.09 = $T_f = \frac{\lvert T1 - T2 \rvert}{2}$

PA6.10	Label	Torque compensation upon enabling	Mode	F		
	Range	0x0 ~ 0xFFFF	Default	0x0	Unit	-
	Activation	Immediate			Index	2610h
	In applications with vertical load axis, servo drive will automatically increase the motor torque to compensate for the gravitational force at enabling of the drive. In order to prevent the axis from having a slight drop and back to initial position behavior, PA6.10 can be set to turn on torque compensation. Set 0x0010 ： ON Set 0x0 ： OFF					

PA6.11	Label	Current response setting	Mode	F		
	Range	50~100	Default	100	Unit	%
	Activation	Immediate			Index	2611h
	To set driver current loop related effective value ratio					

PA6.14	Label	Max. time to stop after disabling	Mode	F		
	Range	0~3000	Default	500	Unit	ms
	Activation	Immediate			Index	2614h
	To set the max. time allowed for the axis to stop on emergency stop or normal axis disabling. After disabling axis, if motor speed is still higher than PA4.39 but the time set in PA6.14 is reached, BRK_ON given and holding brake activated. BRK_ON given time is determined by PA6.14 or when motor speed goes below PA4.39, whichever comes first. Applications: 1. After disabling axis, if motor speed is still higher than PA4.39 but the time set in PA6.14 is reached, BRK_ON given and holding brake activated. 2. After disabling axis, if motor speed is already lower than PA4.39 but the time set in PA6.14 is not yet reached, BRK_ON given and holding brake activated.					

PA6.20	Label	Trial run distance	Mode	F		
	Range	0~1200	Default	10	Unit	0.1rev
	Activation	Immediate			Index	2620h
	JOG (Position control) : Distance travel of each motion					

PA6.21	Label	Trial run waiting time	Mode	F	
	Range	0~30000	Default	300	Unit	ms
	Activation	Immediate			Index	2621h
JOG (Position control) : Waiting time after each motion						

PA6.22	Label	No. of trial run cycles	Mode	F		
	Range	0~32767	Default	5	Unit	-
	Activation	Immediate			Index	2622h
JOG (Position control) : No. of cycles						

PA6.25	Label	Trial run acceleration	Mode	F		
	Range	0~10000	Default	200	Unit	ms/(1000rpm)
	Activation	Immediate			Index	2625h
To set the acceleration/deceleration time for JOG command between 0 rpm to 1000 rpm						

PA6.28	Label	Velocity observer gain	Mode	F		
	Range	0~32767	Default	0	Unit	-
	Activation	Immediate			Index	2628h
0: Default stable gain; Modifications are not recommended.						

PA6.29	Label	Velocity observer bandwidth	Mode	F		
	Range	0~32767	Default	0	Unit	-
	Activation	Immediate			Index	2629h
0: Default stable bandwidth; Modifications are not recommended.						

PA6.34	Label	Frame error window time	Mode	F		
	Range	0~32767	Default	100	Unit	-
	Activation	Immediate			Index	2634h
To set EtherCAT data frame error detection window time						

PA6.35	Label	Frame error window	Mode	F		
	Range	0~32767	Default	50	Unit	-
	Activation	Immediate			Index	2635h
To set EtherCAT data frame error detection window						

PA6.54	Label	Absolute value rotation mode denominator setting	Mode	PP	HM	CSP
	Range	0~32766	Default	0	Unit	-
	Activation	After restart			Index	2654h

To set denominator of absolute encoder in rotational mode.

When PA0.15 = 2 and use in combination with PA6.54:

Feedback load position 6064= $\frac{PA6.63}{PA6.54}$ x Electronic gear ratio

PA6.56	Label	Blocked rotor alarm torque threshold	Mode	F		
	Range	0~300	Default	300	Unit	%
	Activation	Immediate			Index	2656h

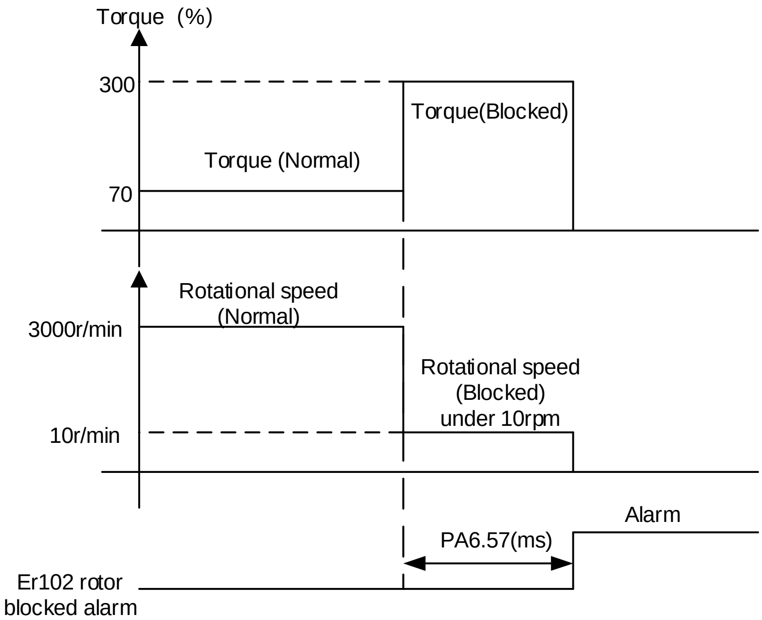
To set the torque threshold of blocked rotor to trigger alarm. (Alarm triggered if torque output% larger than threshold value & under 10rpm)

If PA6.56 = 0, blocked rotor alarm deactivated.

If motor speed is 10rpm or above, Er102 won't be triggered.

PA6.57	Label	Blocked rotor alarm delay time	Mode	F		
	Range	0~1000	Default	400	Unit	ms
	Activation	Immediate			Index	2657h

To set delay time for blocked rotor alarm to trigger, if rotor blocked duration is not longer than time set in PA6.57, Er102 won't be triggered.
Please look at the following diagram to set up Er102 alarm trigger.



**if rotational speed is more than 10rpm when motor rotor is blocked, Er100 will be triggered.*

PA6.59	Label	Homing mode position threshold	Mode	F		
	Range	0~100	Default	8	Unit	0.00001rev
	Activation	Immediate			Index	2659h

To set position threshold for homing mode.

PA6.61	Label	Z signal holding time	Mode	F		
	Range	0~100	Default	10	Unit	ms
	Activation	Immediate			Index	2661h

To set the holding time for Z signal to maintain active high

Application:

1. Z signal for 60FDH；
2. Z signal for homing process
3. Z-phase frequency output pulse width. Unit = 0.1ms;

Please set PA6.61≥0.2ms if used for 3 applications as above

PA6.63	Label	Absolute multiturn data upper limit	Mode	F		
	Range	0~32766	Default	0	Unit	rev
	Activation	Immediate			Index	2663h

To set upper limit of multiturn data with absolute encoder set as rotational mode.

When PA0.15 = 2 and use in combination with PA6.54:

Feedback load position 6064= $\frac{PA6.63}{PA6.54}$ x Electronic gear ratio

3.2.8【Class 7】Factory settings

Please take precaution when modifying Class 7 parameters. Might cause driver errors

PA7.15	Label	Motor model		Mode	F		
	Range	0x0~0x7FFF		Default	0x200	Unit	-
	Activation	After restart	Data length		16 bit	Property	R/W

Set value	Description
0x100	Read from EEPROM
[0x200]	Read from Encoder

When PA7.15 = 0x200(2xx):

Parameter	Label
PA7.00	Current loop gain
PA7.01	Current loop integral time
PA7.05	No. of motor pole pairs
PA7.06	Motor phase resistance
PA7.07	Motor D/Q induction
PA7.08	Motor back EMF coefficient
PA7.09	Motor torque coefficient
PA7.10	Motor rated rotational speed
PA7.11	Motor max. rotational speed
PA7.12	Motor rated current
PA7.13	Motor rotor inertia

PA7.14	Driver power rating
PA7.16	Encoder
PA7.17	Motor max. current
PA7.18	Encoder index angle compensation

PA7.16	Label	Encoder	Mode	F		
	Range	0x0~0x200	Default	*Encoder*	Unit	-
	Activation	After restart	Data length	16 bit	Property	R/W

Set value	Description
0x0	17-bit encoder
0x7	23-bit encoder

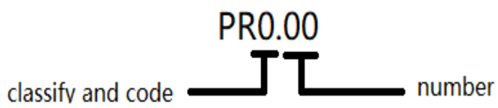
PA7.31	Label	Vent release mode	Mode	F		
	Range	0~1	Default	-	Unit	-
	Activation	After restart			Index	2731h

To set vent release mode

Power Rating(W)	Default	Description
400	1	Regenerative electricity absorbed by **internal capacitor**
750 or above	0	Regenerative electricity absorbed by **regenerative resistor**

3.3 402 Parameters Function

- Panel Display as follows:



- Parameter Valid mode Description

CSP: Valid in cyclic synchronous position mode

CSV: Valid in cyclic synchronous velocity mode

CST: Valid in cyclic synchronous torque mode

HM: Valid in homing mode

PP: Valid in profile position mode

PV: Valid in profile velocity mode

PT: Valid in profile torque mode

F: Valid in all modes

Index 603Fh	Label	Error code			Mode	F		
	Range	0x0~0xFFFF			Default	0X0	Unit	-
	Structure	VAR	Type	Uint16	Mapping	TPDO	Access	RO

Please refer to Chapter 9 for more details on error codes.

Index 6040h	Label	Control word			Mode	F		
	Range	0x0~0xFFFF			Default	0X0	Unit	-
	Structure	VAR	Type	Uint16	Mapping	RPDO	Access	RW

Bit	Label	Description
0	Start	1 - valid, 0 - invalid
1	Main circuit power on	1 - valid, 0 - invalid
2	Quick stop	0 - valid,1 - invalid
3	Servo running	1 - valid, 0 - invalid
4-6	Running mode related	Related to each servo running mode
7	Fault reset	Reset resettable fault alarm. Rising edge of Bit7 is valid, bit7 remains at 1, and all other instructions are invalid
8	Pause	For more information on how to pause in each mode, refer to Object Dictionary 605Dh
9	No definition	Undefined
10	Reserved	Undefined
11-15	Reserved	Undefined

Index 6041h	Label	Status word			Mode	F		
	Range	0x0~0xFFFF			Default	0X0	Unit	-
	Structure	VAR	Type	Uint16	Mapping	TPDO	Access	RO

Bit	Label	Description
0	Servo ready	1 - valid, 0 - invalid
1	Start	1 - valid, 0 - invalid
2	Servo running	1 - valid, 0 - invalid
3	Fault	1 - valid, 0 - invalid
4	Main circuit power on	1 - valid, 0 - invalid
5	Quick stop	0- valid, 1 - invalid
6	Servo cannot run	1 - valid, 0 - invalid
7	Warning	1 - valid, 0 - invalid
8	Reserved	Reserved
9	Remote control	1 - valid, 0 - invalid
10	Arrived at position	1 - valid, 0 - invalid
11	Internal limit valid	1 - valid, 0 - invalid
12-13	Mode related	Related to each servo operation mode
14	Reserved	Reserved
15	Origin found	1 - valid, 0 - invalid

Index 605Ah	Label	Quick stop option code			Mode	F		
	Range	0~7			Default	2	Unit	-
	Structure	VAR	Type	INT16	Mapping	-	Access	RW

Motor stops when quick stop option code is given.

PP, CSP, CSV, PV

0 ： To stop motor through PA5.06. Status: Switch on disable, axis disabled.

1 ： Motor decelerates and stops through 6084. Status: Switch on disable, axis disabled.

2 ： Motor decelerates and stops through 6085. Status: Switch on disable, axis disabled.

3 ： Motor decelerates and stops through 60C6. Status: Switch on disable, axis disabled.

5 ： Motor decelerates and stops through 6084. Status: Quick stop

6 ： Motor decelerates and stops through 6085. Status: Quick stop

7 ： Motor decelerates and stops through 60C6. Status: Quick stop

HM

0 ： To stop motor through PA5.06. Status: Switch on disable, axis disabled.

1 ： Motor decelerates and stops through 609A. Status: Switch on disable, axis disabled.

2 ： Motor decelerates and stops through 6085. Status: Switch on disable, axis disabled.

3 ： Motor decelerates and stops through 60C6. Status: Switch on disable, axis disabled.

5 ： Motor decelerates and stops through 609A. Status: Quick stop

6 ： Motor decelerates and stops through 6085. Status: Quick stop

7 ： Motor decelerates and stops through 60C6. Status: Quick stop

Index 605Bh	Label	Shutdown Option Code			Mode	F		
	Range	0~1			Default	0	Unit	-
	Structure	VAR	Type	Uint16	Mapping	-	Access	RW

PP, CSP, CSV, PV 0 ： To stop motor through PA5.06, 5.06 = 0(Emergency stop), 5.06=1(Free stop) 1 ： Motor decelerates and stops through 6084 **HM** 0 ： To stop motor through PA5.06, 5.06 = 0(Emergency stop), 5.06=1(Free stop) 1 ： Motor decelerates and stops through 609A **CST** 0 ： To stop motor through PA5.06, 5.06 = 0(Emergency stop), 5.06=1(Free stop) 1 ： Motor decelerates and stops through 6087

Index 605Ch	Label	Disable Operation Option Code			Mode	F		
	Range	0~1			Default	0	Unit	-
	Structure	VAR	Type	INT16	Mapping	-	Access	RW

To set motor stopping mode when servo drive is disabled.

PP, CSP, CSV, PV

0 ： To stop motor through PA5.06, 5.06 = 0(Emergency stop), 5.06=1(Free stop)

1 ： Motor decelerates and stops through 6084

HM

0 ： To stop motor through PA5.06, 5.06 = 0(Emergency stop), 5.06=1(Free stop)

1 ： Motor decelerates and stops through 609A

CST

0 ： To stop motor through PA5.06, 5.06 = 0(Emergency stop), 5.06=1(Free stop)

1 ： Motor decelerates and stops through 6087

Index 605Dh	Label	Halt Option Code			Mode	F		
	Range	1~3			Default	1	Unit	-
	Structure	VAR	Type	INT16	Mapping	-	Access	RW

When control word is set to halt, set deceleration and stop option. Also suitable for deceleration mode settings during mode switching

PP, CSP, CSV, PV

1 ： Motor decelerates and stops through 6084. Status: Operation enabled, axis enabled.

2 ： Motor decelerates and stops through 6085. Status: Operation enabled, axis enabled.

3 ： Motor decelerates and stops through 60C6. Status: Operation enabled, axis enabled.

HM

1 ： Motor decelerates and stops through 609A. Status: Operation enabled, axis enabled.

2 ： Motor decelerates and stops through 6085. Status: Operation enabled, axis enabled.

3 ： Motor decelerates and stops through 60C6. Status: Operation enabled, axis enabled.

CST

1, 2 ： Motor decelerates and stops through 6087. Status: Operation enabled, axis enabled.

3 ： Motor decelerates and stops through torque = 0. Status: Operation enabled, axis enabled.

Index 605Eh	Label	Fault Reaction Option Code			Mode	F		
	Range	0~2			Default	0	Unit	-
	Structure	VAR	Type	INT16	Mapping	-	Access	RW

Select stopping mode when servo alarm (Err 8xx) occurs.

PP, CSP, CSV, PV

0 ： Select motor stopping mode according to alarm properties. Status: Fault, axis disabled.

1 ： Motor decelerates and stops through 6084. Status: Fault, axis disabled.

2 ： Motor decelerates and stops through 6085. Status: Fault, axis disabled.

HM

0 ： Select motor stop by the alarm attribute for emergency stop, the fault state and disable

1 ： After the 609A motor is decelerated and stopped,, the fault state and disable

2 ： After the 6085 motor is decelerated and stopped, the fault state and disable

CST

0, 1 ： Select motor stop by the alarm attribute for emergency stop, the fault state and disable

2 ： After the 6087 motor is decelerated and stopped, the fault state and disable

When other alarms, i.e. drive-side alarms:

Select motor stop by the alarm attribute for emergency stop, the fault state and disable

Index 6060h	Label	Mode of Operation			Mode	F		
	Range	1~11			Default	8	Unit	-
	Structure	VAR	Type	INT8	Mapping	-	Access	RW

No.	Mode	Abbr.
1	Profile position mode	PP
3	Profile velocity mode	PV
4	profile Torque mode	PT
6	Homing mode	HM
8	Cyclic synchronous position mode	CSP
9	Cyclic synchronous velocity mode	CSV
10	Cyclic synchronous torque mode	CST

Index 6061h	Label	Mode of Operation display			Mode	F		
	Range	1~11			Default	8	Unit	-
	Structure	VAR	Type	INT8	Mapping	-	Access	RW

No.	Mode	Abbr.
1	Profile position mode	PP
3	Profile velocity mode	PV
4	profile Torque mode	PT
6	Homing mode	HM
8	Cyclic synchronous position mode	CSP
9	Cyclic synchronous velocity mode	CSV
10	Cyclic synchronous torque mode	CST

Index 6062h	Label	Position Demand Value			Mode	PP	CSP	HM
	Range	-2147483648~2147483647			Default	0	Unit	*Command*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO

Reflects position command when servo driver is enabled.

Index 6063h	Label	Position Actual Internal Value			Mode	F		
	Range	-2147483648~2147483647			Default	0	Unit	*Encoder*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO

Reflects motor absolute position (Encoder unit)

Index 6064h	Label	Position Actual Value			Mode	F		
	Range	-2147483648~2147483647			Default	0	Unit	*Command*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO

Reflects user's real time absolute position
6064h*Gear ratio = 6063h

Index 6065h	Label	Follow Error Window			Mode	PP	CSP	HM
	Range	0~2147483647			Default	30000	Unit	*Command*
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RO

To set an acceptable deviation for requested position.
When actual position exceed position deviation window, error might occur.

Index 6066h	Label	Follow Error Time Out			Mode	PP	CSP	HM
	Range	0~65535			Default	10	Unit	*Command*
	Structure	VAR	Type	UINT16	Mapping	RPDO	Access	RO

To set position deviation detection time

Index 6067h	Label	Position window	Mode	PP	CSP	HM
	Range	0~2147483647	Default	10	Unit	*Command*

	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RO
To set an acceptable extent of arrival position								

Index 6068h	**Label**	Position window time			**Mode**	**PP**	**CSP**	**HM**
	Range	0~65535			**Default**	300	**Unit**	*Command*
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RO
To set the time between arrival to the output of INP (In position) signal.								

Index 606Bh	**Label**	Velocity Demand Value			**Mode**	**CSV**		**PV**
	Range	-2147483648~2147483647			**Default**	0	**Unit**	*Command/s*
	Structure	VAR	**Type**	INT32	**Mapping**	TPDO	**Access**	RO
Show user set velocity demand value.								

Index 606Ch	**Label**	Velocity Actual Value			**Mode**	**F**		
	Range	-2147483648~2147483647			**Default**	0	**Unit**	*Command/s*
	Structure	VAR	**Type**	INT16	**Mapping**	TPDO	**Access**	RO
Show actual velocity value.								

Index 606Dh	**Label**	Velocity window			**Mode**	**CSV**		**PV**
	Range	0~65535			**Default**	10	**Unit**	*Command/s*
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RO
Set the range of velocity								

Index 606Eh	**Label**	Velocity window time			**Mode**	**CSV**		**PV**
	Range	0~65535			**Default**	0	**Unit**	ms
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RO
To set the time between velocity reached and status word set to TargetReached.								

Index 606Fh	**Label**	Velocity Threshold			**Mode**	**CSV**		**PV**
	Range	0~65535			**Default**	10	**Unit**	*Command/s*
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RO
To set to zero-speed range.								

Index 6070h	**Label**	Velocity Threshold Time			**Mode**	**CSV**		**PV**
	Range	0~65535			**Default**	100	**Unit**	ms
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RO

To set the time until status word – zero speed detection is canceled.

Index 6071h	Label	Target torque			Mode	CST		PT
	Range	-32768~32767			Default	100	Unit	0.1%
	Structure	VAR	Type	INT16	Mapping	RPDO	Access	RW
To set target torque for profile and cyclic torque mode.								

Index 6072h	Label	Maximum torque			Mode	F		
	Range	0~65535			Default	3000	Unit	0.1%
	Structure	VAR	Type	UINT16	Mapping	RPDO	Access	RW
To set max torque for servo drive, limited by motor's highest torque.								

Index 6073h	Label	Maximum current			Mode	F		
	Range	0~65535			Default	3000	Unit	0.1%
	Structure	VAR	Type	UINT16	Mapping	TPDO	Access	RO
To set max. current for servo driver.								

Index 6074h	Label	Torque Demand			Mode	F		
	Range	-32768~32767			Default	0	Unit	0.1%
	Structure	VAR	Type	INT16	Mapping	TPDO	Access	RO
Internal command torque								

Index 6075h	Label	Motor Rated Current			Mode	F		
	Range	0~2147483647			Default	3000	Unit	mA
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO
Shows motor rated current.								

Index 6076h	Label	Motor Rated Torque			Mode	F		
	Range	0~2147483647			Default	3000	Unit	mN.m
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO
Shows motor rated torque.								

Index 6077h	Label	Torque Actual Value			Mode	F		
	Range	-32768~32767			Default	0	Unit	0.1%
	Structure	VAR	Type	INT16	Mapping	TPDO	Access	RO

Shows servo driver actual torque feedback

Index 6078h	Label	Current Actual Value			Mode	F		
	Range	-32768~32767			Default	0	Unit	0.1%
	Structure	VAR	Type	INT16	Mapping	TPDO	Access	RO
Shows servo drive actual current value								

Index 6079h	Label	DC Link Circuit Voltage			Mode	F		
	Range	0~2147483647			Default	0	Unit	mV
	Structure	VAR	Type	UINT32	Mapping	TPDO	Access	RO
Shows DC bus voltage across P, N terminals								

Index 607Ah	Label	Target position			Mode	PP		CSP
	Range	-2147483647~2147483647			Default	0	Unit	*command*
	Structure	VAR	Type	INT32	Mapping	RPDO	Access	RW
To set the target position under profile and cyclic position mode.								

Index 607Ch	Label	Home Offset			Mode	HM		
	Range	-2147483647~2147483647			Default	0	Unit	*command*
	Structure	VAR	Type	INT32	Mapping	RPDO	Access	RW
To set position offset to compensate for the deviation of mechanical origin from motor origin under homing								

Index 607Dh-01	Label	Min Position Limit			Mode	PP		CSP
	Range	-2147483647~2147483647			Default	0	Unit	*command*
	Structure	VAR	Type	INT32	Mapping	RPDO	Access	RW
To set lower limit with calculated position and actual position using absolute position after homing.								

Index 607Dh-01	Label	Max Position Limit			Mode	PP		CSP
	Range	-2147483647~2147483647			Default	0	Unit	*command*
	Structure	VAR	Type	INT32	Mapping	RPDO	Access	RW
To set upper limit with calculated position and actual position using absolute position after homing.								

Index 607Eh	Label	Polarity			Mode	F		
	Range	0x0 – 0xFF			Default	0x0	Unit	*command*
	Structure	VAR	Type	UINT8	Mapping	RPDO	Access	RW

Set input polarity of the command.

Mode		Set Value
Position mode	PP	0：Rotate in the same direction as the position command 128：Rotate in the opposite direction to the position command
	HM	
	CSP	
Velocity mode	PV	0：Rotate in the same direction as the position command 64：Rotate in the opposite direction to the position command
	CSV	
Torque mode	PT	0：Rotate in the same direction as the position command 32：Rotate in the opposite direction to the position command
	CST	
ALL mode		0：Rotate in the same direction as the position command 224：Rotate in the opposite direction to the position command

Index 607Fh	Label	Max Profile Velocity			Mode	PP	HM	PV	CST
	Range	0~2147483647			Default	2147483647	Unit	*Command/s*	
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW	
To set max allowable velocity. Limited by 6080									

Index 6080h	Label	Max Motor Speed			Mode	F		
	Range	0~2147483647			Default	6000	Unit	r/min
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
To set the maximum allowable motor velocity.								

Index 6081h	Label	Profile velocity			Mode	PP		
	Range	0~2147483647			Default	10000	Unit	*Command/s*
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
To set target velocity. Limited by 607Fh.								

Index 6083h	Label	Profile acceleration			Mode	PP		PV
	Range	1~2147483647			Default	10000	Unit	*command/s*^{2}
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
To set motor acceleration								

Index 6084h	Label	Profile deceleration			Mode	PP		PV
	Range	1~2147483647			Default	10000	Unit	*command/s*^{2}
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
To set motor deceleration								

Index 6085h	Label	Quick Stop Deceleration			Mode	CSP	CSV	PP	PV	HM
	Range	1~2147483647			Default	10000000	Unit	*command/s²*		
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW		
	To set the deceleration during an emergency stop									

Index 6087h	Label	Torque slope			Mode	PT		
	Range	1~2147483647			Default	5000	Unit	0.1%/s
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
	To set values for tendency torque command							

Index 608Fh-01	Label	Encoder Increments			Mode	PT		
	Range	0~2147483647			Default	0	Unit	*encoder*
	Structure	VAR	Type	UINT32	Mapping	TPDO	Access	RO
	To set encoder resolution							

Index 6091h-01	Label	Motor Revolutions			Mode	F		
	Range	1~2147483647			Default	1	Unit	r
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
	To set electronic gear ratio numerator							
Index 6091h-02	Label	Shaft Revolutions			Mode	F		
	Range	1~2147483647			Default	1	Unit	r
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
	To set electronic gear ratio denominator							
Index 6092h-01	Label	Feed			Mode	F		
	Range	1~2147483647			Default	10000	Unit	*Command/*r
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
	If 6092h-01(Feed constant) is not equal to 608Fh(Position encoder resolution), then: Electronic gear ratio = Encoder increments / 6092h-01 If 6092h-01(Feed constant) is equal to 608Fh(Position encoder resolution), then: Electronic gear ratio = 6091-01 / 6092h-01							

Index 6098h	Label	Homing method		Mode	HM		
	Range	-6 ~ 37		Default	19	Unit	-
	Structure	VAR	Type UINT8	Mapping	RPDO	Access	RW

The table below describes the velocity, direction and stopping conditions of each homing methods.

Value	Description			
	Velocity	Direction	Stop	
-6	Low	Negative	When torque reached	
-5	Low	Positive	When torque reached	
-4	High	Negative	Inversed when torque reached, after torque is gone	
-3	High	Positive	Inversed when torque reached, after torque is gone	
-2	High	Negative	Inversed when torque reached, received 1st Z-signal after torque is gone	
-1	High	Positive	Inversed when torque reached, received 1st Z-signal after torque is gone	
	Direction	Deceleration point	Home	Before Z-signal
1	Negative	Negative limit switch	Motor Z-signal	Negative limit switch falling edge
2	Positive	Positive limit switch	Motor Z-signal	Positive limit switch falling edge
3	Positive	Homing switch	Motor Z-signal	Falling edge on same side of homing switch
4	Positive	Homing switch	Motor Z-signal	Rising edge on same side of homing switch
5	Negative	Homing switch	Motor Z-signal	Falling edge on same side of homing switch
6	Negative	Homing switch	Motor Z-signal	Rising edge on same side of homing switch
7	Positive	Homing switch	Motor Z-signal	Falling edge on same side of homing switch
8	Positive	Homing switch	Motor Z-signal	Rising edge on same side of homing switch
9	Positive	Homing switch	Motor Z-signal	Rising edge on same side of homing switch
10	Positive	Homing switch	Motor Z-signal	Falling edge on same side of homing switch
11	Negative	Homing switch	Motor Z-signal	Failling edge on same side of homing switch
12	Negative	Homing switch	Motor Z-signal	Rising edge on same side of homing switch
13	Negative	Homing switch	Motor Z-signal on other side of homing switch	Rising edge on other side of homing switch
14	Negative	Homing switch	Motor Z-signal on other side of homing switch	Falling edge on other side of homing switch
15				
16				
17-32	Similar with 1-14, but deceleration point = homing point			
33	Home in negative direction, Homing point = motor Z-signal			
34	Home in positive direction, Homing point = motor Z-signal			
35-37	Set current position as homing point			

Index 6099h-01	**Label**	Speed During Search For Switch			**Mode**	**HM**		
	Range	0~2147483647			**Default**	10000	**Unit**	*Command/s*
	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
To set the speed used in homing								

Index 6099h-01	**Label**	Speed During Search For Zero			**Mode**	**HM**		
	Range	0~2147483647			**Default**	5000	**Unit**	*Command/s*
	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
To set the speed used in homing								

Index 609Ah	**Label**	Homing acceleration			**Mode**	**HM**		
	Range	1~2147483647			**Default**	5000	**Unit**	*Command/s*^{2}
	Structure	VAR	**Type**	UINT32	**Mapping**	TPDO	**Access**	RO
To set acceleration and deceleration used in homing								

Index 60B0h	**Label**	Position Offset			**Mode**	**CSP**		
	Range	-2147483647~2147483647			**Default**	0	**Unit**	*Command*
	Structure	VAR	**Type**	INT32	**Mapping**	TPDO	**Access**	RO
To add offset to target position								

Index 60B1h	**Label**	Velocity Offset			**Mode**	**CSP** **CSV** **PP**	**PV**	**HM**
	Range	-2147483647~2147483647			**Default**	0	**Unit**	*Command/s*
	Structure	VAR	**Type**	INT32	**Mapping**	TPDO	**Access**	RO
To add offset to velocity demand value.								

Index 60B2h	**Label**	Torque Offset			**Mode**	**F**		
	Range	-32768~32767			**Default**	0	**Unit**	0.1%
	Structure	VAR	**Type**	INT32	**Mapping**	TPDO	**Access**	RO
To add offset to torque demand value.								

Index 60B8h	**Label**	Touch Probe function			**Mode**	**F**		
	Range	0x0-0xFFFF			**Default**	0x0	**Unit**	-
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RW

Bit	Description	Details
0	Probe 1	0--Disable 1--Enable
1	Probe 1 trigger mode	0--Single trigger, triggered only when trigger signal is valid 1—Continuous trigger
2	Probe 1 trigger signal selection	0—Probe 1 captured 1--Z signal
3	Reserved	-
4	Probe 1 rising edge enabled	0--Disable 1--Enable
5	Probe 1 falling edge enabled	0--Disable 1--Enable
6-7	Reserved	-
8	Probe 2	0--Disable 1--Enable
9	Probe 2 trigger mode	0--Single trigger, triggered only when trigger signal is valid 1—Continuous trigger
10	Probe 2 trigger signal selection	0—Probe 2 captured 1--Z signal
11	Reserved	-
12	Probe 2 rising edge enabled	0—Rising edge not latched 1—Rising edge latched
13	Probe 2 falling edge enabled	0—Falling edge not latched 1—Falling edge latched
14-15	Reserved	-

Index 60B9h	Label	Touch Probe status			Mode	F		
	Range	0x0-0xFFFF			Default	0x0	Unit	-
	Structure	VAR	Type	UINT16	Mapping	TPDO	Access	RO

Bit	Definition	Details
0	Probe 1	0--Disable 1--Enable
1	Probe 1 rising edge latching	0—Rising edge not latched 1—Rising edge latched
2	Probe 1 falling edge latching	0—Falling edge not latched 1—Falling edge latched
3-5	-	-
6-7	-	-
8	Probe 2	0--Disable 1--Enable
9	Probe 2 rising edge latching	0—Rising edge not latched 1—Rising edge latched
10	Probe 2 falling edge latching	0—Falling edge not latched 1—Falling edge latched
11-13	-	-
14-15	-	-

Index 60BAh	Label	Touch Probe 1 Positive Position			Mode	F		
	Range	-2147483647~2147483647			Default	0	Unit	*Command*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO
Shows position feedback at rising edge of probe 1 signal								

Index 60BBh	Label	Touch Probe 1 Negative Position			Mode	F		
	Range	-2147483647~2147483647			Default	0	Unit	*Command*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO
Shows position feedback at falling edge of probe 1 signal								

Index 60BCh	Label	Touch Probe 2 Positive Position			Mode	F		
	Range	-2147483647~2147483647			Default	0	Unit	*Command*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO
Shows position feedback at rising edge of probe 2 signal								

Index 60BDh	Label	Touch Probe 2 Negative Position			Mode	F		
	Range	-2147483647~2147483647			Default	0	Unit	*Command*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO
Shows position feedback at falling edge of probe 2 signal								

Index 60C5h	Label	Max Acceleration			Mode	F		
	Range	1~2147483647			Default	100000000	Unit	*Command/s*^{2}
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
To set upper limit of acceleration.								
Index 60C6h	Label	Max Deceleration			Mode	F		
	Range	1~2147483647			Default	100000000	Unit	*Command/s*^{2}
	Structure	VAR	Type	UINT32	Mapping	RPDO	Access	RW
To set upper limit of deceleration.								

Index 60D5h	Label	Touch Probe 1 Positive Edge Counter			Mode	F		
	Range	0~65535			Default	0	Unit	-
	Structure	VAR	Type	UINT16	Mapping	TPDO	Access	RO
Shows the number of times probe 1 rising edge latched.								

Index 60D6h	**Label**	Touch Probe 1 Negative Edge Counter			**Mode**	**F**		
	Range	0~65535			**Default**	0	**Unit**	-
	Structure	VAR	**Type**	UINT16	**Mapping**	TPDO	**Access**	RO

Shows the number of times probe 1 falling edge latched.

Index 60D7h	**Label**	Touch Probe 2 Positive Edge Counter			**Mode**	**F**		
	Range	0~65535			**Default**	0	**Unit**	-
	Structure	VAR	**Type**	UINT16	**Mapping**	TPDO	**Access**	RO

Shows the number of times probe 2 rising edge latched.

Index 60D7h	**Label**	Touch Probe 2 Negative Edge Counter			**Mode**	**F**		
	Range	0~65535			**Default**	0	**Unit**	-
	Structure	VAR	**Type**	UINT16	**Mapping**	TPDO	**Access**	RO

Shows the number of times probe 2 falling edge latched.

Index 60E0h	**Label**	Positive Torque Limit			**Mode**	**F**		
	Range	0~65535			**Default**	3000	**Unit**	0.1%
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RW

To set the maximum torque of servo drive in positive direction

Index 60E1h	**Label**	Negative Torque Limit			**Mode**	**F**		
	Range	0~65535			**Default**	3000	**Unit**	0.1%
	Structure	VAR	**Type**	UINT16	**Mapping**	RPDO	**Access**	RW

To set the maximum torque of servo drive in negative direction

Index 60F4h	**Label**	Following Error Actual Value			**Mode**	**CSP**	**PP**	**HM**
	Range	-2147483647~2147483647			**Default**	0	**Unit**	*Command*
	Structure	VAR	**Type**	INT32	**Mapping**	TPDO	**Access**	RO

Shows position following error

Index 60FAh	**Label**	Control Effort			**Mode**	**CSP**	**PP**	**HM**
	Range	-2147483647~2147483647			**Default**	0	**Unit**	*Command/s*
	Structure	VAR	**Type**	INT32	**Mapping**	TPDO	**Access**	RO

Shows velocity demand value(Position loop output)

Index 60FCh	Label	Position Demand Internal Value			Mode	CSP	PP	HM
	Range	-2147483647~2147483647			Default	0	Unit	*encoder*
	Structure	VAR	Type	INT32	Mapping	TPDO	Access	RO

Shows position demand value of servo drive.

Index 60FDh	Label	Digital Inputs			Mode	F		
	Range	0x0~0x7FFFFFFF			Default	0	Unit	-
	Structure	VAR	Type	UINT32	Mapping	TPDO	Access	RO

The bits of 60FDh object are functionally defined as follow:

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
Z signal	*Reserved*	*Reserved*	*Reserved*	Probe 2	Probe 1	BRAKE	INP/V-COIN /TLC
Bit23	**Bit22**	**Bit21**	**Bit20**	**Bit19**	**Bit18**	**Bit17**	**Bit16**
E-STOP	*Reserved*	*Reserved*	*Reserved*	*Reserved*	*Reserved*	DI14	DI13
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit9**	**Bit8**
DI12	DI11	DI10	DI9	DI8	DI7	DI6	DI5
Bit7	**Bit6**	**Bit5**	**Bit4**	**Bit3**	**Bit2**	**Bit1**	**Bit0**
DI4	DI3	DI2	DI1	*Reserved*	HOME	POT	NOT

Index 60FEh-01	Label	Physical Outputs			Mode	F		
	Range	0x0~0x7FFFFFFF			Default	0x0	Unit	-
	Structure	ARRAY	Type	UINT32	Mapping	RPDO	Access	RW

The bits of 60FEh object are functionally defined as follow:

Bit / Sub-index	31~21	21	20	19	18	17	16	15~0
01h	*Reserved*	DO6 valid	DO5 valid	DO4 valid	DO3 valid	DO2 valid	DO1 valid	*Reserved*

Index 60FEh-02	Label	Bit Mask			Mode	F		
	Range	0x0~0x7FFFFFFF			Default	0xFFFF0000	Unit	-
	Structure	ARRAY	Type	UINT32	Mapping	RPDO	Access	RW

The bits of a 60FEh object are functionally defined as follow:

Bit / Sub-index	31~21	21	20	19	18	17	16	15~0
02h	*Reserved*	DO6 enabled	DO5 enabled	DO4 enabled	DO3 enabled	DO2 enabled	DO1 enabled	*Reserved*

Index 60FFh	Label	Target velocity			Mode	CSV		PV
	Range	-2147483647~2147483647			Default	0	Unit	*Command/s*
	Structure	VAR	Type	INT32	Mapping	RPDO	Access	RW

Shows set target velocity. Limited by 6080h

Index 6502h	Label	Supported Drive Modes			Mode	F		
	Range	0x0~0x7FFFFFFF			Default	0x0	Unit	-
	Structure	ARRAY	Type	UINT32	Mapping	TPDO	Access	RO
Shows the control modes supported by the servo drive.								

Chapter 4 Servo Drive Operation

4.1 Get Started with Driver Operation

4.1.1 Checklist before operation

No.	Description
Power supply	
1	The voltage of main and control circuit power supply is within rated values.
2	Power supply polarity is rightly connected.
Wiring	
1	Power supply input is rightly connected.
2	Driver's power output UVW matches UVW terminals on the main circuit.
3	No short circuit of driver's input and output UVW terminals.
4	Signal cables are correctly and well connected.
5	Drivers and motors are connected to ground
6	All cables under stress within recommended range.
7	No foreign conductive objects inside/outside the driver.
Mechanical	
1	Driver and external holding brake are not place near combustibles.
2	Installations of driver, motor and axis is fastened.
3	Movement of motors and mechanical axes are not obstructed.

4.1.2 Power On

Connect 400V power supply into main power supply R, S, T terminals and 220V power supply into control circuit power supply L1C, L2C. After power on, light indicator will light up and front panel will display **rEAdy**, then LED initial status will be displayed. Driver is ready for operation if no alarm occurs.

4.1.3 Trial Run

Servo drive must be disabled before performing trial run. For safety precautions, please JOG under minimal velocity.

Related Parameters

No.	Parameters	Label	Set value	Unit
1	PA0.01	Control mode settings	9	/
2	PA6.04	JOG trial run command velocity	User defined	r/min
3	PA6.25	Trial run acc-/deceleration time	User defined	ms/1000rpm

- *Please make sure the mechanical axis is within the range of motion and travelled distance should not be too long to avoid collision.*
- *Set optimal velocity and acceleration for trial run (not too high!)*
- *Do not modify any gain related parameters during motion to avoid vibration.*

Please refer to "AF_Jog Trial Run" for detailed explanations on how to perform trial run using front panel operation

4.1.4 Motor rotational direction settings

Motor rotational direction can be changed through PA0.06 without changing the polarity of the input command.

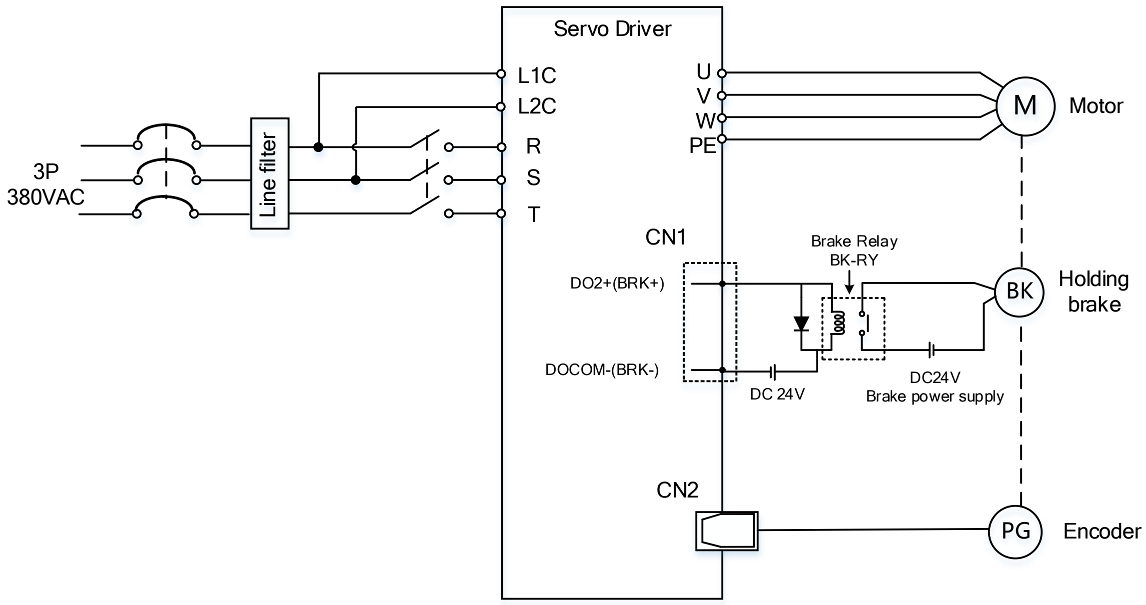
<table>
<tr><td rowspan="3">PA0.06</td><td>Label</td><td>Command polarity inversion</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0 ~ 1</td><td>Default</td><td>0</td><td>Unit</td><td>—</td></tr>
<tr><td>Activation</td><td colspan="3">After restart</td><td>Index</td><td>2006h</td></tr>
<tr><td colspan="7">Used to change the rotational direction of the motor.
<table>
<tr><th>Set value</th><th>Details</th></tr>
<tr><td>0</td><td>Polarity of the command is not inversed. The direction of rotation is consistent with the polarity of command.</td></tr>
<tr><td>1</td><td>Polarity of command is inversed. The direction of rotation is opposite to the polarity of command.</td></tr>
</table>
Note: Rotational direction of the motor is recommended to be set through object dictionary 607E. However, PA0.06 has higher priority than object dictionary 607E. 607E only takes effect when PA0.06 = 0.</td></tr>
</table>

4.1.5 Holding Brake Settings

Holding brake is designed to hold the axis in position to prevent it from sliding due to applied external forces when the driver is disabled. Holding brake is optional and depends on the model of motor chosen for the application.

- *Please only use holding brake when motor is stopped. No applicable when motor is in motion.*
- *Holding brake coil has no polarity.*
- *Motor should be disabled after stopped.*
- *There is some noise when motors with brake are in motion but that doesn't affect its functionality.*
- *Magnetic sensors might be affected when the holding brake is on. Please be aware.*

<u>Holding brake wiring</u>
Holding brake input signal is without polarity. An isolated 24V switching power supply is recommended to prevent abnormal holding brake behavior in case of sudden drop in working current or voltage.

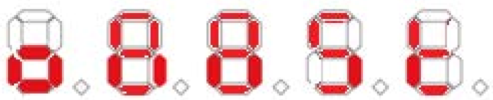


Wiring diagram of motor holding brake

4.1.6 Servo Running

1. Enable servo driver

Check if CN3/CN4 is connected properly. Servo driver is in ready mode. Motor is stopped and holding brake is activated. Front panel display shows 402 state machine = Operational, EtherCAT communication status = operational, Running mode = 8, servo is in stop mode.



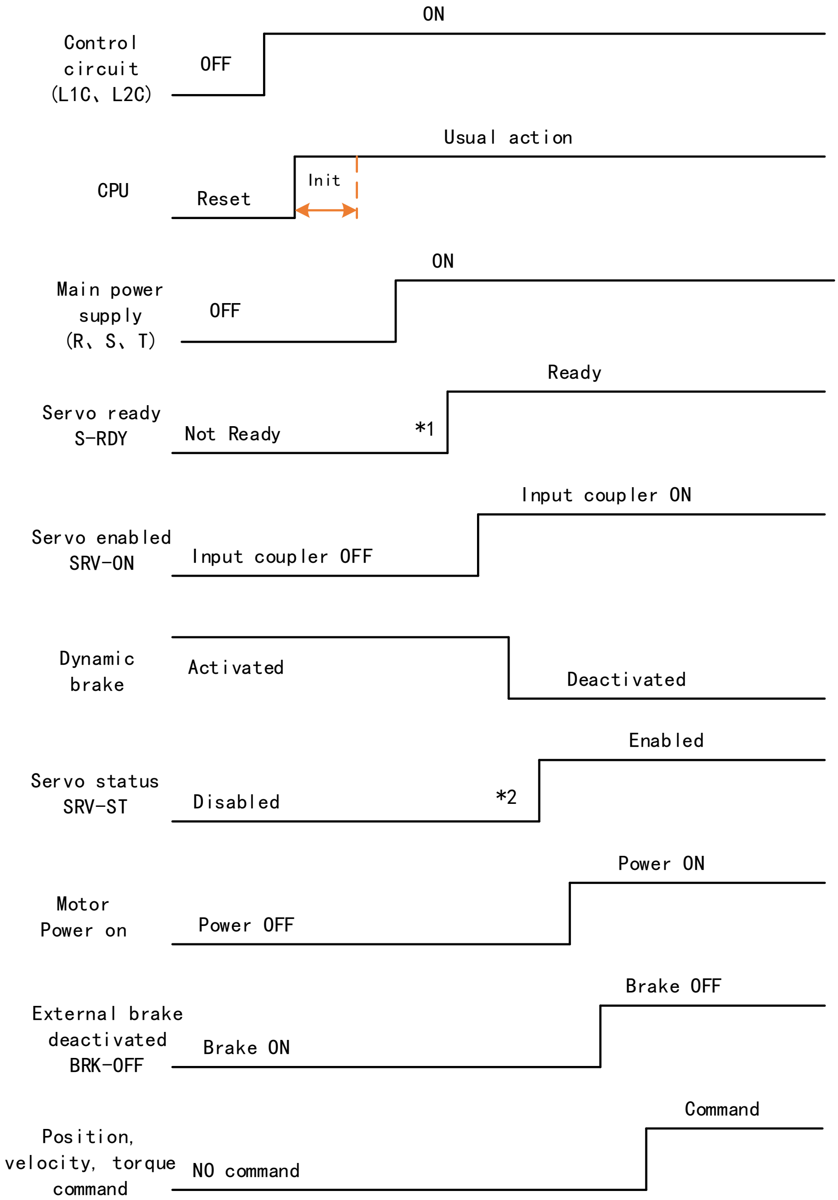
2. Motor starts to move after command input

i. On first time operation, please use suitable command at low velocity. Confirm if motor is working normally.

ii. Check if motor rotational direction is correct. If not, please check input command or parameter settings. (Pr0.06).

iii. If motor is working normally, motion data such as motor rotational velocity “d01SP” and actual torque feedback “d04tr” can be monitored on the front panel or through Motion Studio.

3. Power on sequence diagram



Please enter servo status, position, velocity, torque command as sequence diagram above.

*** 1. S-RDY signal is given after CPU initialization and main power supply powered on.*

2. SRV-ST signal is received when servo driver is enabled. Command input is not allowed yet.

4.1.7 Servo stop

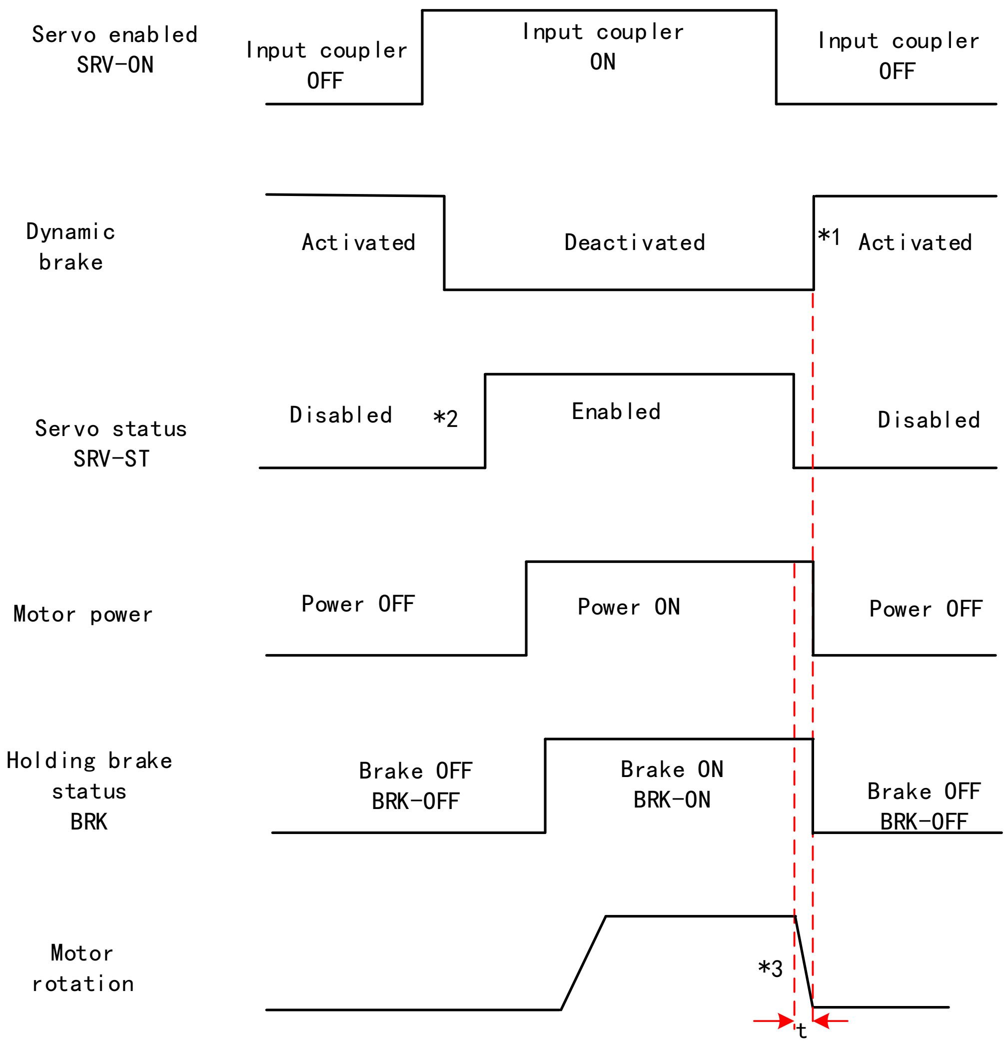
Servo stopping are of 3 different methods: Servo braking method, free stopping method, dynamic braking method.

Stopping method	Description	Details
Servo braking	Servo driver delivers braking torque in opposite direction	Quick stopping but mechanical impact might exist
Free stopping	Motor power cut off. Free to move until velocity = 0. Affected inertia, friction and other factors	Smooth deceleration, low mechanical impact but slow stopping
Dynamic braking	Brake activated when in motion	Quick stopping but mechanical impact might exist

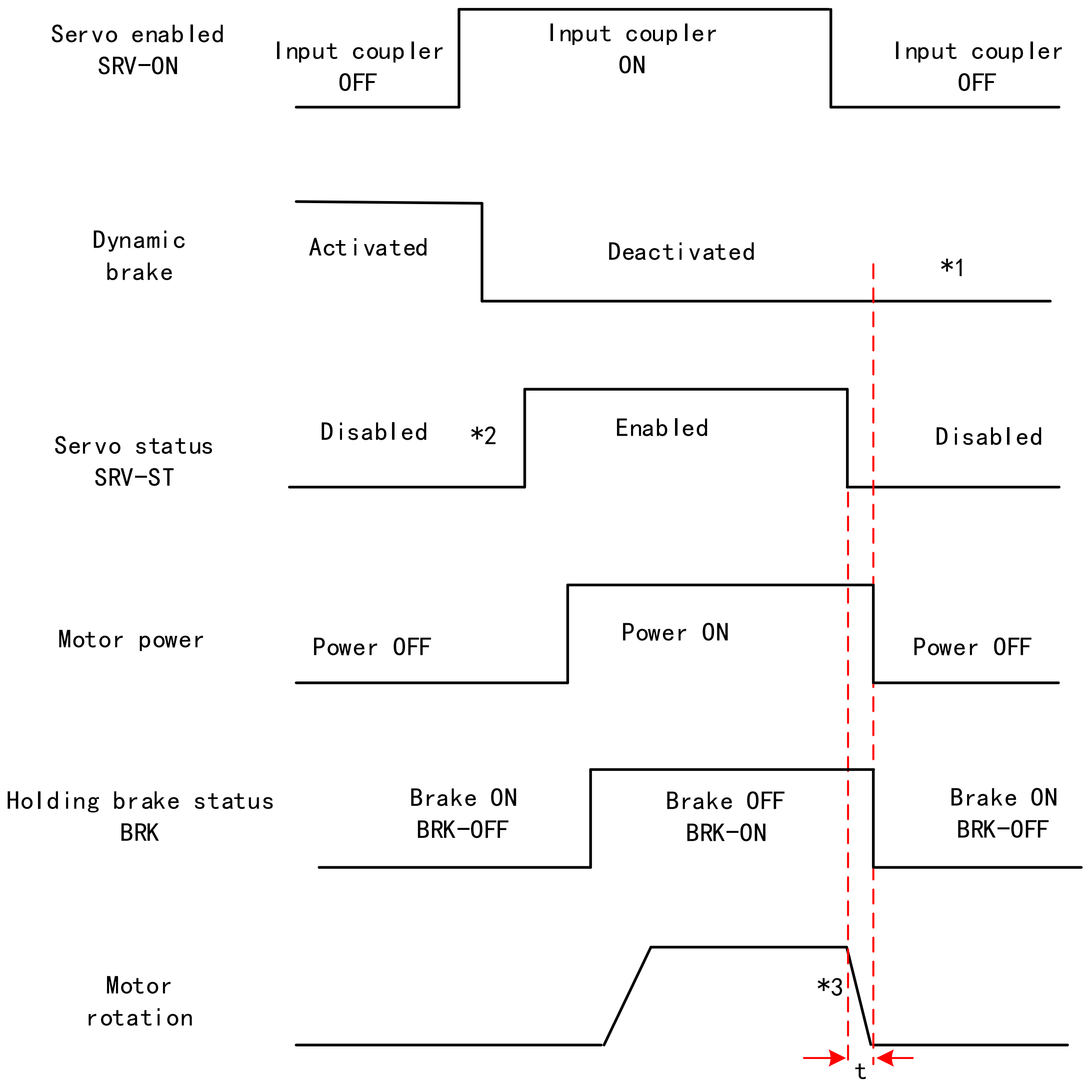
Stopping status	Status after stopped
Free moving	Motor is powered off, rotor is free to rotate
Dynamic braking	Motor is powered off, rotor is not free to rotate
Holding brake stopping	Motor axis is locked, cannot rotate freely

Motor stopping（Servo disabled） - Sequence Diagram

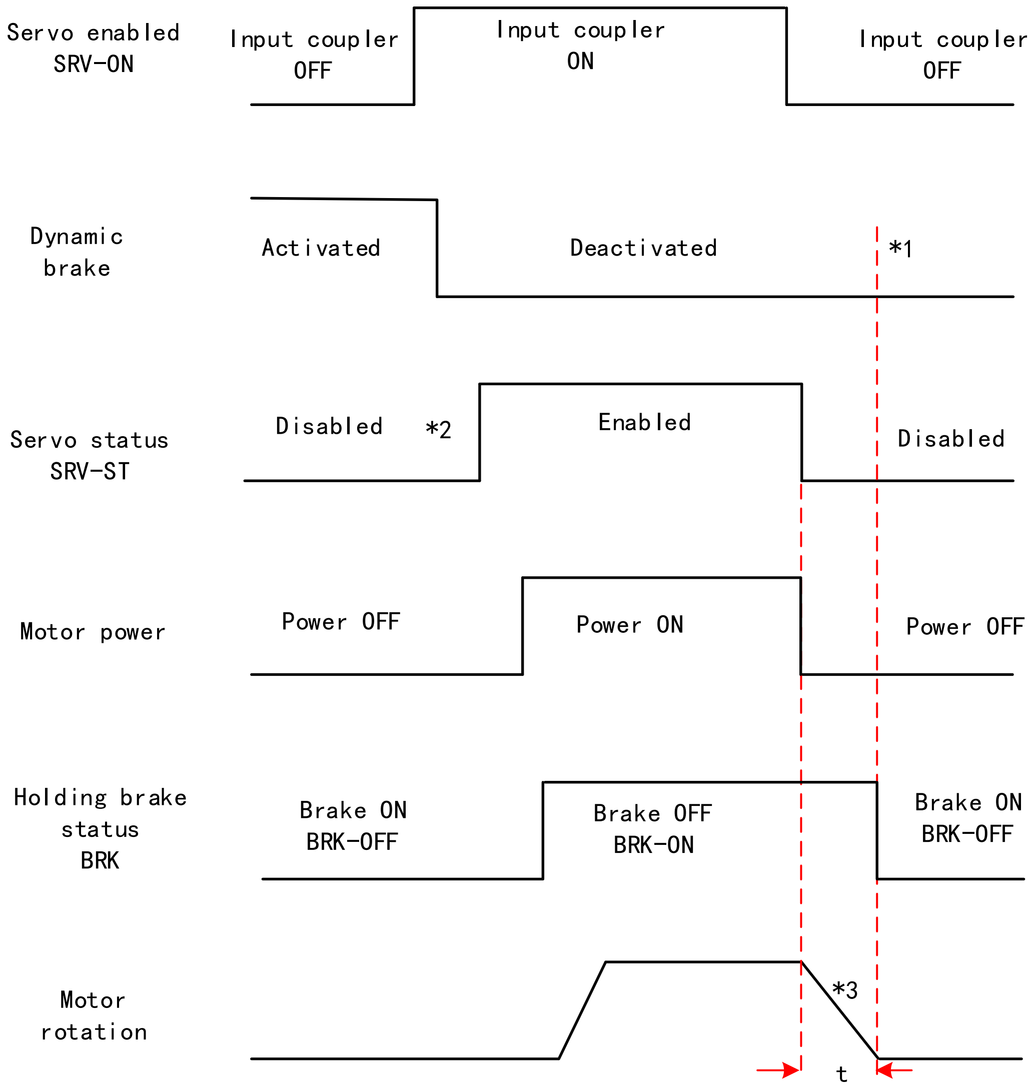
Servo braking method. Status after stopping: Dynamic braking



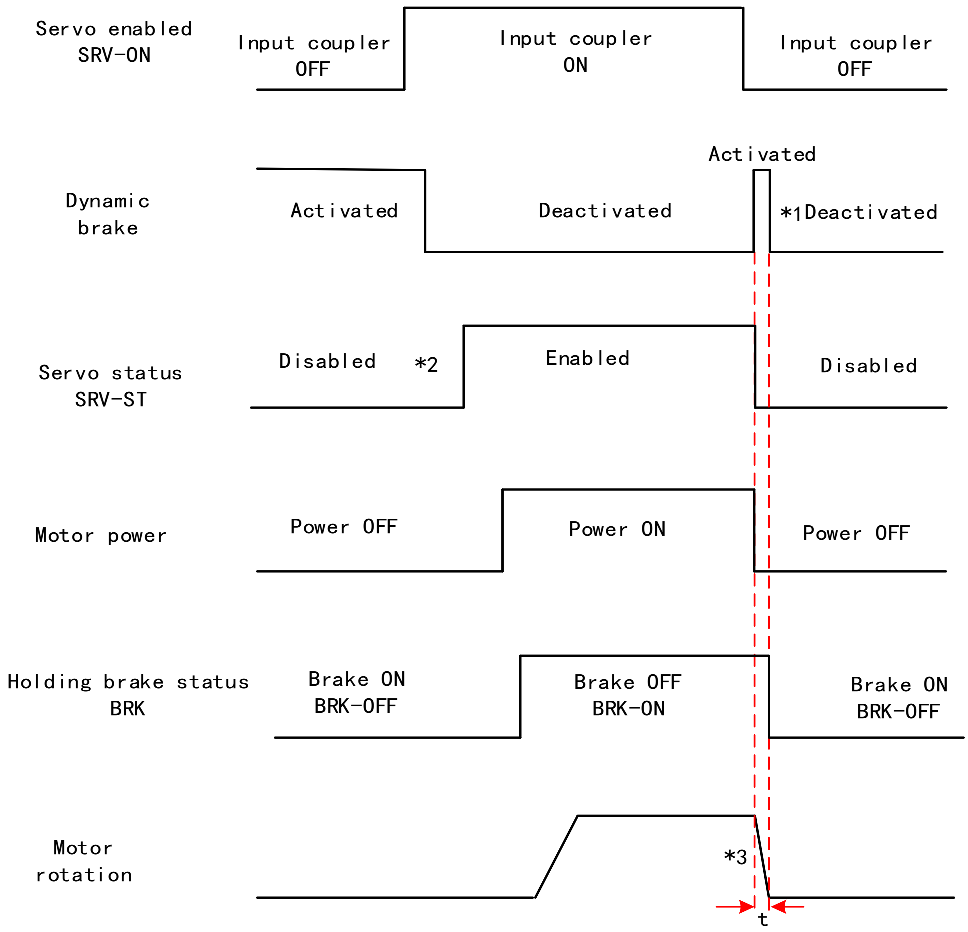
Servo stopping method. Status after stopping: free moving



Free stopping method. Status after stopping: Free moving



Dynamic braking method. Status after stopping: Free moving



*** 1. Status after stopping is as defined in PA5.06.*

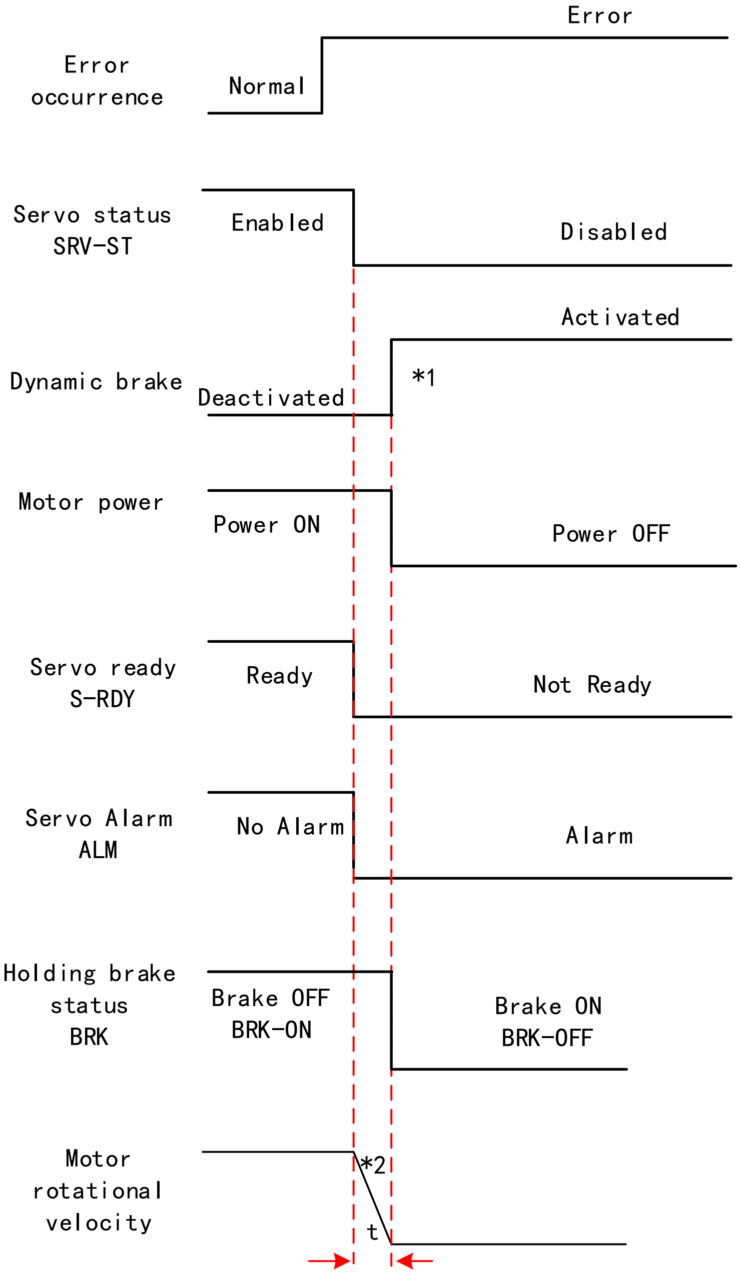
2. SRV-ST signal is received when servo driver is enabled. Command input is not allowed yet.

3. Servo stopping method is as defined in PA5.06; braking torque in opposite direction to decelerate the motor is as defined in PA5.11. Deceleration time t is determined by whichever comes first between time set in PA6.14 and time needed for motor to drop below velocity set in PA4.39. After deceleration time t, dynamic braking will be off and holding brake signal will be set to OFF (Holding brake is activated. Although BRK-OFF signal is valid, actual activation of holding brake is dependent on whether the motor comes with holding brake).

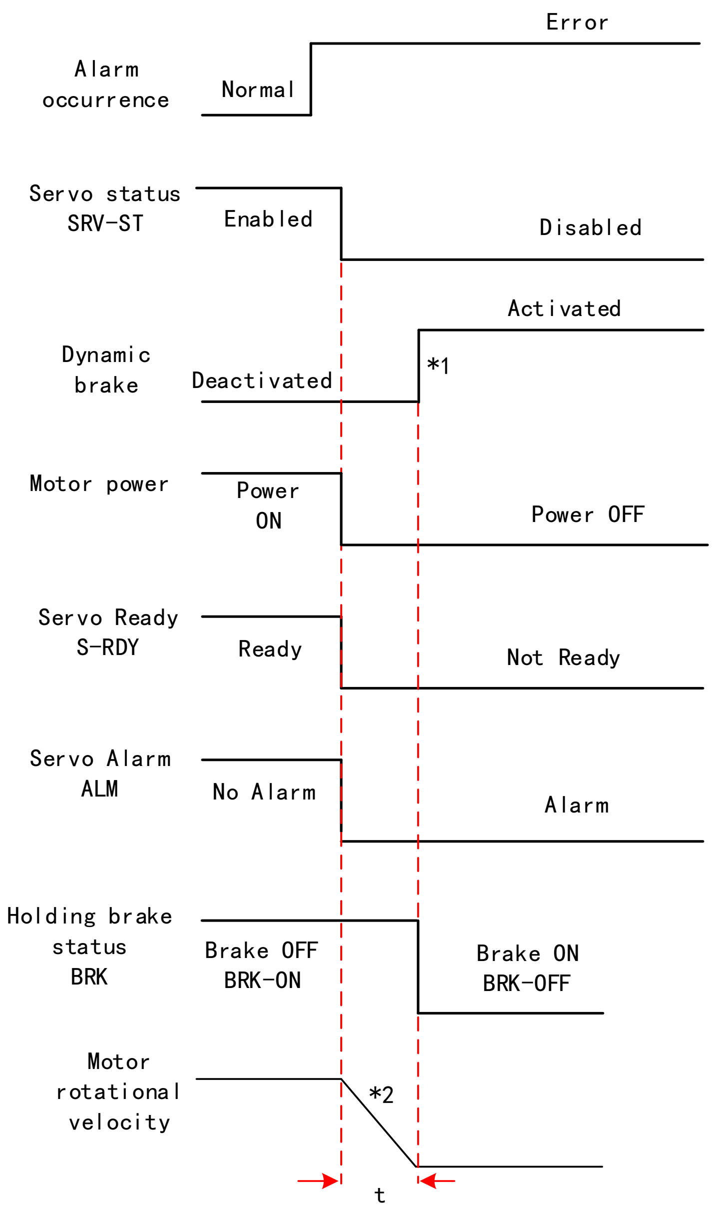
4. BRK-ON signal doesn't indicate the activation of holding brake but the validation of the signal. Holding brake is not applied when BRK-ON signal is valid. Same idea goes for BRK-OFF signal.

Stopping when alarm occurs – Sequence Diagram

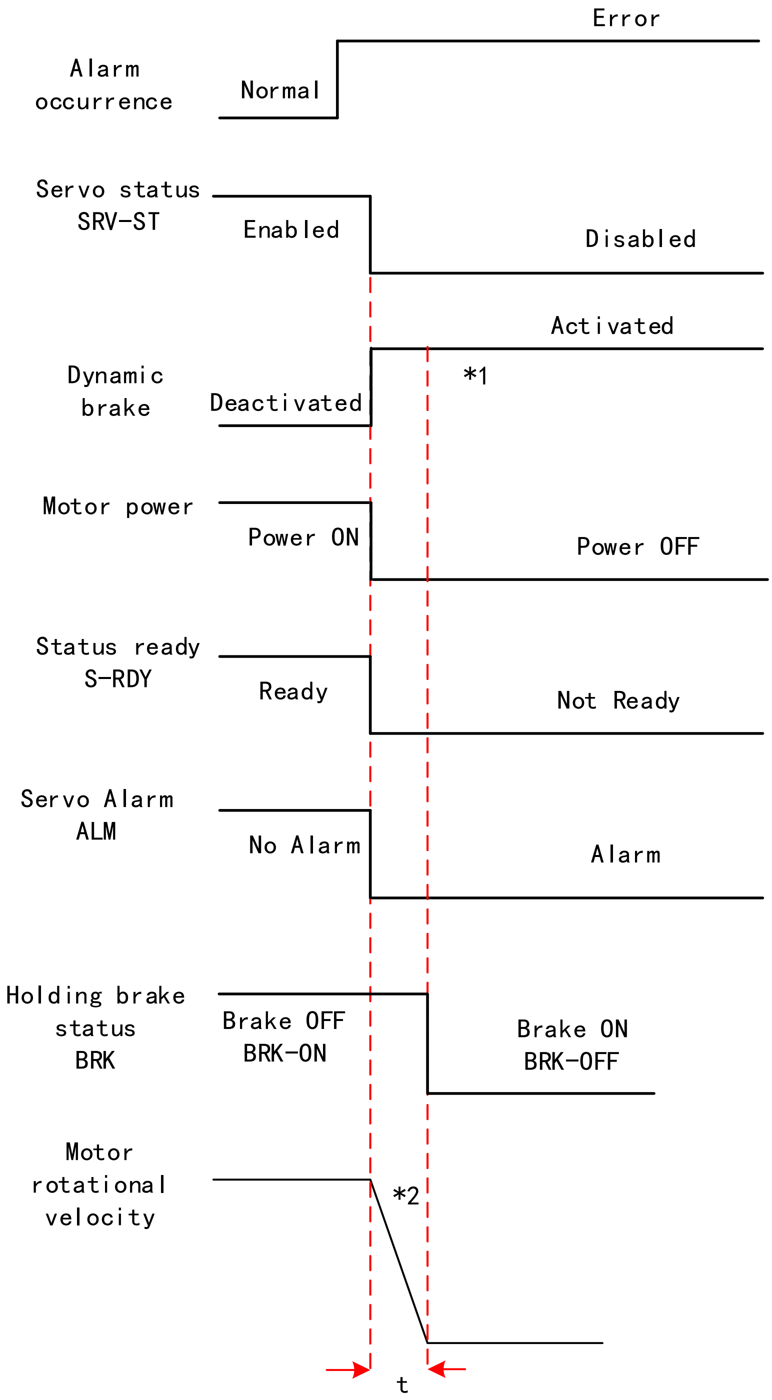
Servo braking method. Status after stopping: Dynamic braking



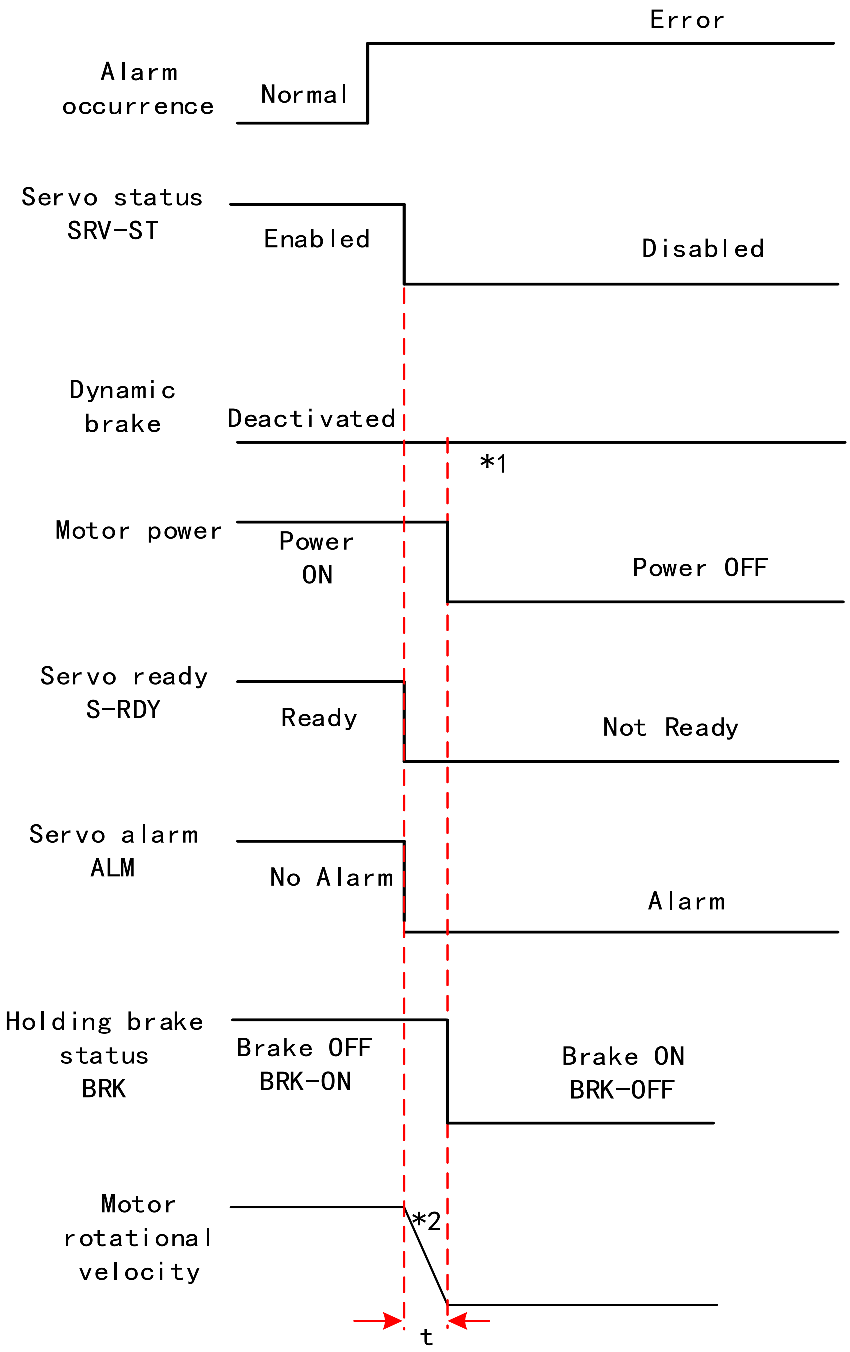
Free stopping method. Status after stopping: Dynamic braking



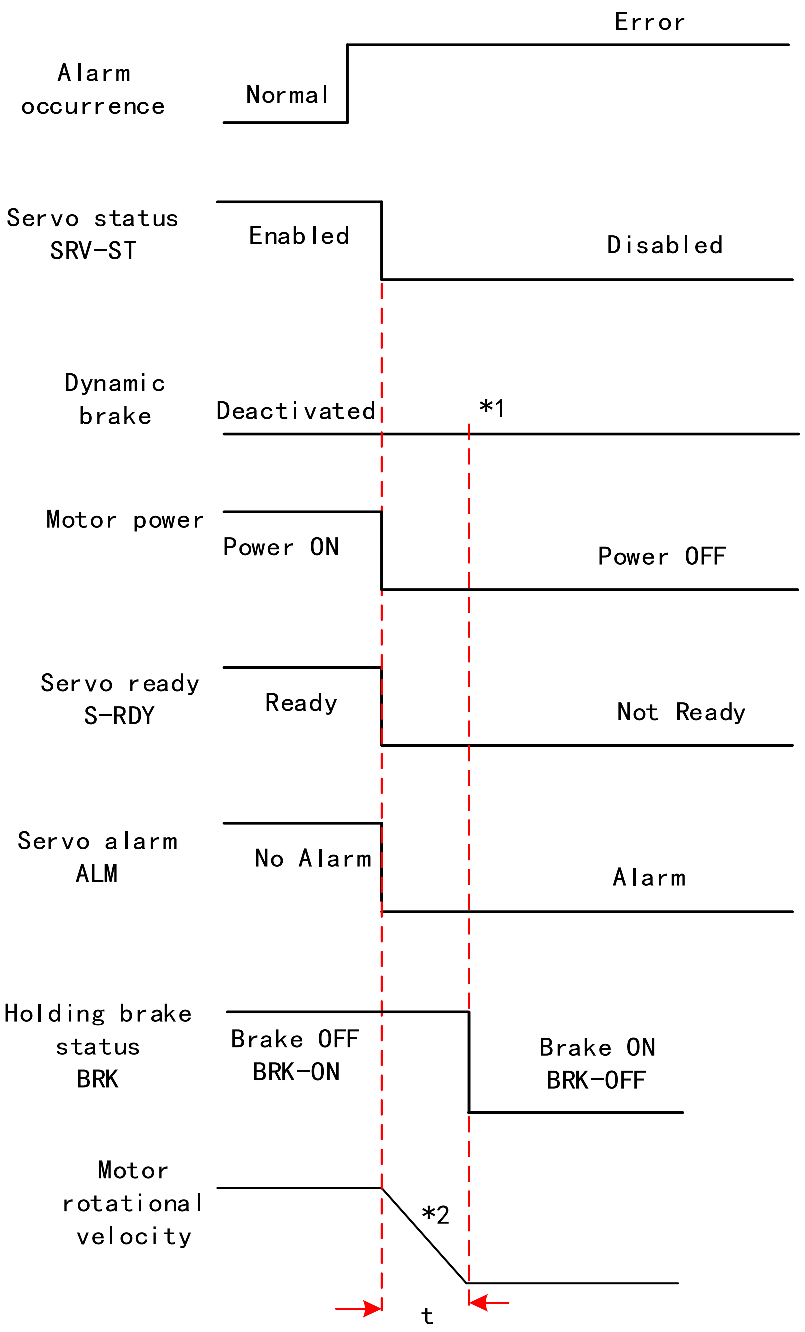
Dynamic braking method. Status after stopping: Dynamic braking



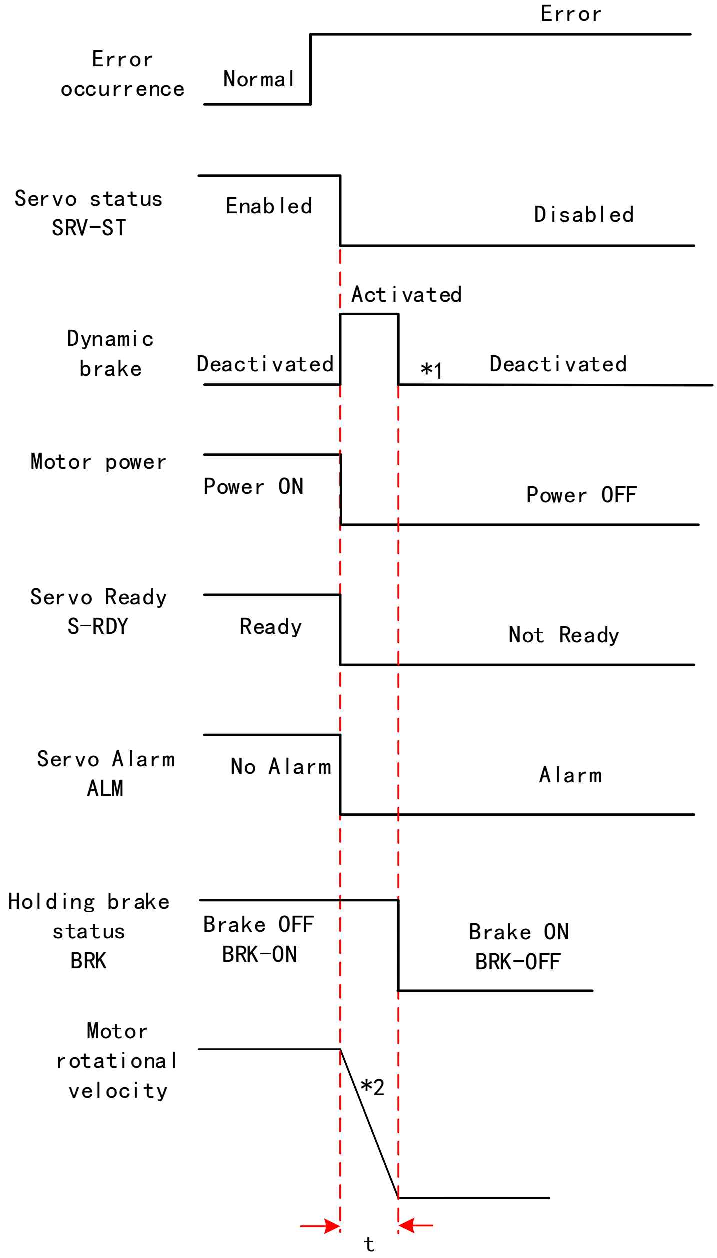
Servo braking method. Status after stopping: Free moving



Free stopping method. Status after stopping: Free moving



Dynamic braking. Status after stopping: Free moving

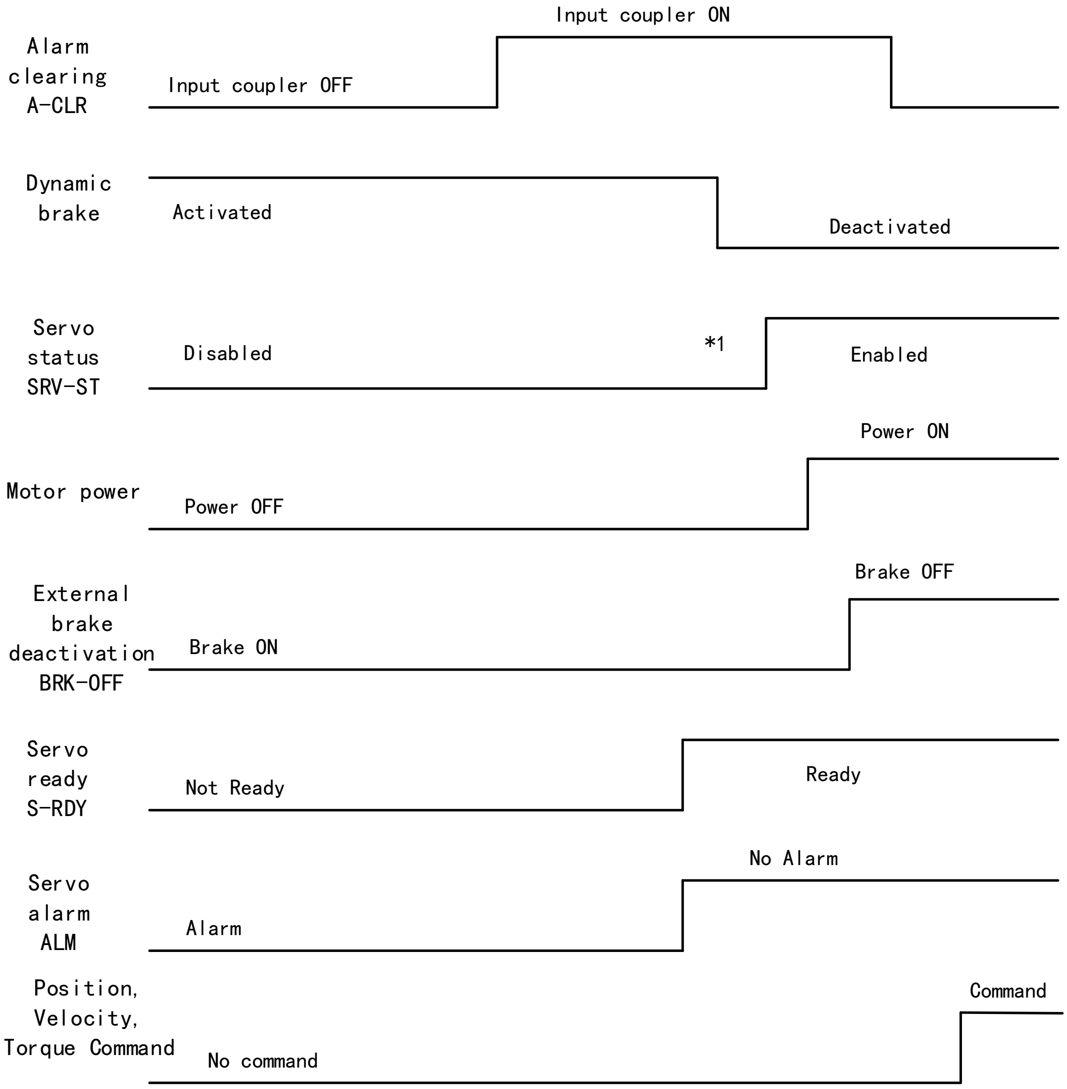


*** 1. Status after stopping is as defined in Pr5.10.*

2. Servo stopping method is as defined in Pr5.10. Deceleration time t is determined by whichever comes first between time set in Pr6.14 and time needed for motor to drop below velocity set in Pr4.39. After deceleration time t, dynamic braking will be off and holding brake signal will be set to OFF (Holding brake is activated. Although BRK-OFF signal is valid, actual activation of holding brake is dependent on whether the motor comes with holding brake).

3. BRK-ON signal doesn't indicate the activation of holding brake but the invalidation of the signal. Holding brake is not applied when BRK-ON signal is valid. Same idea goes for BRK-OFF signal.

Alarm clearing - Sequence diagram



*** 1.SRV-ST signal is received when servo driver is enabled. Command input is not allowed yet*

2. BRK-OFF signal doesn't indicate the deactivation of holding brake but the invalidation of the signal. Holding brake is applied when BRK-OFF signal is invalid.

4.2 Electronic gear ratio

When loaded axis moved for 1 command unit, it corresponds to motor encoder unit which is converted in more comprehensible physical units such as μm. The use of electronic gear ratio is to turn the movement in physical units to required pulse count equivalency.

$$\text{Electronic gear ratio} = \frac{\text{Rotor movement (Encoder unit)}}{\text{Loaded axis movement(Command unit)}}$$

Rotor might be connected to load through reducer or other mechanical structures. Hence, the gear ratio is closely related to reducer gear ratio, position encoder resolution and mechanical dimensions related parameters.

$$\text{Electronic gear ratio} = \frac{\text{Encoder resolution}}{\text{Loaded axis resolution}}$$

Electronic gear can be set through Pr0.08. If Pr0.08 ≠ 0, Pr0.08 is valid. If Pr0.08 = 0, object dictionary 6092-01 is valid.
Command pulse count per motor revolution needs to be ≥ Encoder Pulse Count per Revolution / 8000.

EL7-EC series comes with motors with 23-bit encoder. Pulse count per revolution for 23-bit encoder = 8388608. From the condition above, the command pulse count per motor revolution for 23-bit encoder ⩾ 1049.

<table>
<tr><td rowspan="3">PA0.08</td><td>Label</td><td>Command pulse count per revolution</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~8388608</td><td>Default</td><td>0</td><td>Unit</td><td>P-</td></tr>
<tr><td>Activation</td><td colspan="3">After restart</td><td>Index</td><td>2008h</td></tr>
<tr><td></td><td colspan="6">Pulses per revolution can be set using object dictionary 608F, 6091, 6092. However, PA0.08 has higher priority.</td></tr>
</table>

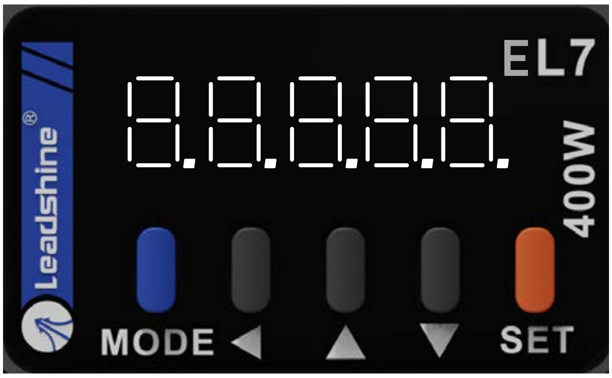
<table>
<tr><td rowspan="3">Index 608Fh-01</td><td>Label</td><td colspan="3">Encoder Increments</td><td>Mode</td><td colspan="4">PT</td></tr>
<tr><td>Range</td><td colspan="3">0~2147483647</td><td>Default</td><td>0</td><td>Unit</td><td colspan="2">encoder</td></tr>
<tr><td>Structure</td><td>VAR</td><td>Type</td><td>UINT32</td><td>Mapping</td><td>TPDO</td><td>Access</td><td colspan="2">RO</td></tr>
<tr><td></td><td colspan="9">To set encoder resolution</td></tr>
</table>

<table>
<tr><td rowspan="3">Index 6091h-01</td><td>Label</td><td colspan="3">Motor Revolutions</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td colspan="3">1~2147483647</td><td>Default</td><td>1</td><td>Unit</td><td>r</td></tr>
<tr><td>Structure</td><td>VAR</td><td>Type</td><td>UINT32</td><td>Mapping</td><td>RPDO</td><td>Access</td><td>RW</td></tr>
<tr><td></td><td colspan="8">To set electronic gear ratio numerator</td></tr>
<tr><td rowspan="2">Index 6091h-02</td><td>Label</td><td colspan="3">Shaft Revolutions</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td colspan="3">1~2147483647</td><td>Default</td><td>1</td><td>Unit</td><td>r</td></tr>
</table>

	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
	To set electronic gear ratio denominator							
Index 6092h-01	**Label**	Feed			**Mode**	**F**		
	Range	1~2147483647			**Default**	10000	**Unit**	*Command/r*
	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
	If 6092h-01(Feed constant) is not equal to 608Fh(Position encoder resolution), then: Electronic gear ratio = Encoder increments / 6092h-01 If 6092h-01(Feed constant) is equal to 608Fh(Position encoder resolution), then: Electronic gear ratio = 6091-01 / 6092h-01							

4.3 Front Panel

Servo Driver front panel consists of 5 push buttons and a 8-segments display. Can be used for displaying of status, alarms, functions, parameters setting and auxiliary functions.



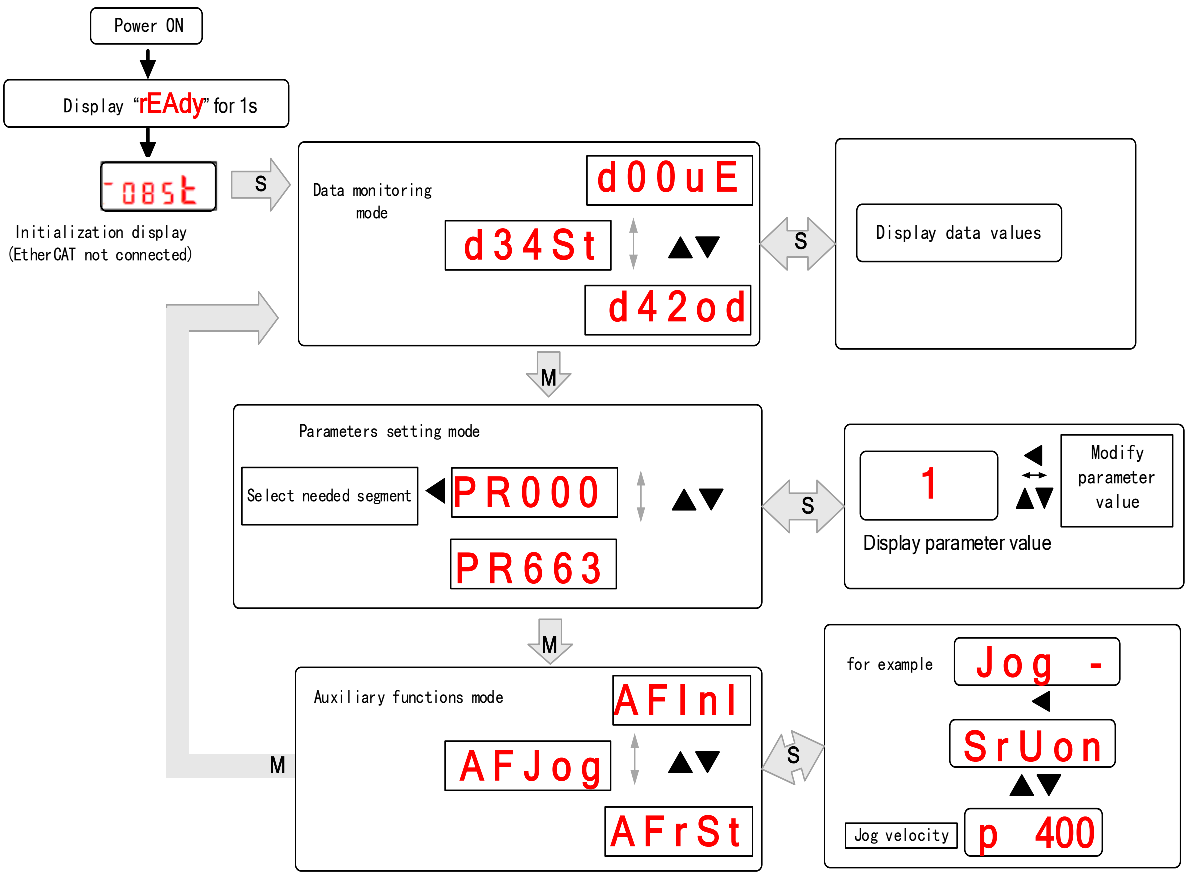
Front panel

Buttons and functions

Label	Symbol	Function
Display	/	Consists of 5 push buttons and a 8-segments display
Mode	M	To switch between 4 modes: 1. Data monitoring mode : To monitor changes of motion data values 2. Parameters setting mode : To set parameters 3. Auxiliary functions mode: To operate common functions, such as trial run, alarm clearing
Enter	S	To enter or confirm
Up	▲	To switch between sub-menus / Increase
Down	▼	To switch between sub-menus / Decrease
Left	◀	To switch between values

4.4 Panel Display and Operation

4.4.1 Panel Operation



Flow diagram of panel operation

(1) rEAdY will be displayed for about 1 second after driver is powered on. Then, automatically enters data monitoring mode and displays initial data value. Otherwise, alarm code will be displayed if error occurs.

(2) Press **M** key to switch between modes.

Data monitoring mode → Parameters setting mode → Auxiliary functions mode

Alarm code will be displayed regardless of any mode if alarm occurs. Press **M** to switch to other modes.

(3) Press ▲or▼to select the type of parameters in data monitoring mode. Press **S** to confirm.

(4) Press◀ to select current segment in parameters settings mode. Press▲or▼to

increase/decrease the value of segment. Press **S** to confirm the modified value(s) and save the parameters.

4.4.2 Data Monitoring Mode

EL7 series servo driver offers the function to monitor different types of data in data monitoring mode. After entering this mode, press **S** to monitor any data that starts with **d**. Press **S** again to get back to data monitoring mode and **M** to switch to any other modes.

Data list in data monitoring mode

No.	Label	Descriptions	Display	Unit	Data Format (x = numerical value)
0	d00uE	Position command deviation	d00uE	pulse	“xxxx”
1	d01SP	Motor velocity	d01SP	r/min	“r xxxx”
2	d02CS	Position control command velocity	d02CS	r/min	“xxxx”
3	d03Cu	Velocity control command velocity	d03Cu	r/min	“xxxx”
4	d04tr	Actual feedback torque	d04tr	%	“xxxx”
5	d05nP	Feedback pulse sum	d05nP	pulse	“xxxx”
6	d06cP	Command pulse sum	d06CP	pulse	“xxxx”
7	d07	Maximum torque during motion	d07	/	“ xxxx”
8	d08FP	Internal command position sum	d08FP	pulse	“xxxx”
9	d09cn	Control mode	d09Cn	/	EtherCAT: “CtPoS”
10	d10Io	I/O signal status	d10 Io	/	-
11	d11Ai	Internal usage	d11Ai	V	-
12	d12Er	Error cause and record	d12Er	/	“Er xxx”
13	d13rn	Warning	d13rn	/	“xxx”
14	d14r9	Regeneration load factor	d14r9	%	“xxx”
15	d15oL	Overload factor	d15oL	%	“xxx”
16	d16Jr	Inertia ratio	d16Jr	%	“xxx”
17	d17ch	Motor not running cause	d17Ch	/	“CP xxx”
18	d18ic	No. of changes in I/O signals	d18ic	/	“xxx”
19	d19	No. of times of overcurrent	d19	/	“ xxxx”
20	d20Ab	CSP position command sum	d20Ab	pulse	“ xxxx”
21	d21AE	Single turn encoder data	d21AE	pulse	“ xxxx”
22	d22rE	Multiturn encoder data	d22rE	r	“ xxxx”
23	d23 id	Communication axis address	d23id	/	“id xxx” “Fr xxx”
24	d24PE	Position deviation	d24PE	Unit	“ xxxx”

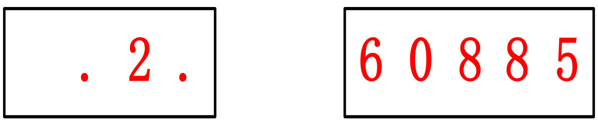
25	d25PF	Motor electrical angle	d25PF	pulse	" xxxx"
26	d26hy	Motor mechanical angle	d26hy	pulse	" xxxx"
27	d27 Pn	Voltage across PN	d27Pn	V	" xxxx"
28	d28 no	Software version	d28no	/	"d xxx Servo software" "F xxx Communication software" "p xxx Servo power rating"
29	d29AS	Internal usage	d29AS	/	"xxx"
30	d30NS	No. of times of encoder communication error	d30sE	/	"xxx"
31	d31 tE	Accumulated operation time	d31tE	/	" xxxx"
32	d32Au	Automatic motor identification	d32Au	/	"r xxx Motor no." "E xxx Servo no."
33	d33At	Driver temperature	d33At	℃	"xxx"
34	d34	Servo status	d34	/	"xxx"
35	d35 SF	Internal usage	d35SF	/	"xxxxxx"
Following are parameters related to EtherCAT bus					
36	d36	Synchronizing cycle	d36dc	ms	"xxxxxx"
37	d37	No. of times of synchronization loss	d37sc	/	"xxxxxx"
38	d38	Synchronization Type	d38st	freerun/DC	"xxxxxx"
39	d39	If DC is running	d39dr	/	"xxxxxx"
40	d40	Acceleration and deceleration status	d40sn	/	"xxxxxx"
41	d41	Object dictionary address	d41od	/	"xxxxxx" Index(4 bit)+subindex(2 bit)
42	d42	Object dictionary value	d42od	/	"xxxxxx" 1、If OD does not exist, ODNEXT is displayed. 2、If OD is out of range, ODRNG is displayed.

If EtherCAT is not connected, '  *" is displayed after power on.*

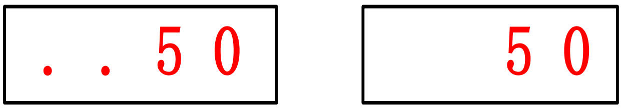
Description of data monitoring function

When using the front panel to monitor data, data is divided in low/high bit and positive/negative.

Data is differentiated as below.



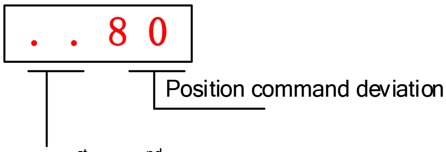
High bit: 1st and 2nd values on the right has two decimal points
Low bit: 1st and 2nd values on the right has no decimal point.



Positive: 1st and 2nd values on the left has no decimal point.
Negative: 1st and 2nd values on the left has two decimal points

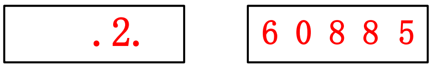
1. d00uE Position command deviation

Shows high bit and low bit of position deviation



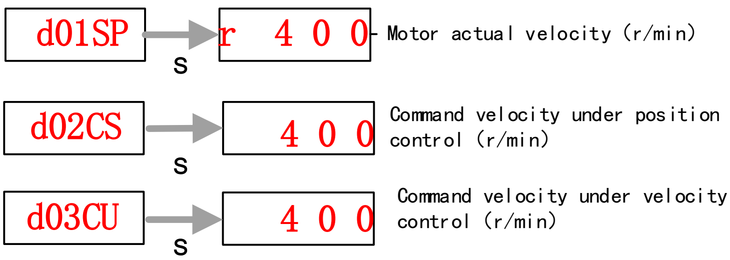
Positive: 1st and 2nd values on the left has no decimal point.
Negative: 1st and 2nd values on the left has two decimal points

Press ◀ to switch between low and high bit
Example : Position command deviation=260885



High bit: 1st and 2nd values on the right has two decimal points
Low bit: 1st and 2nd values on the right has no decimal point.

2. d01SP Motor velocity,d02CS Position control command velocity,d03CU Velocity control command velocity



3. d04tr Actual torque feedback

d04tr → S → 4

Actual torque feedback (%)

4. d05nP Feedback pulse sum d06CP Command pulse sum

Feedback pulse sum(Encoder feedback pulse)

d05nP → S → 10016

Feedback pulse sum (unit)

Press ◀ to switch between high/low bit

Example: Feedback pulse sum=210016

. 2.	10016
High bit	Low bit

Command pulse sum (Command pulse)

d06CP → S → 10016

Command pulse sum (unit)

Press ◀ to switch between high/low bit

Example: Command pulse sum=210017

. 2.	10017
High bit	Low bit

5. d07 Maximum torque during motion

d07 → S → 7

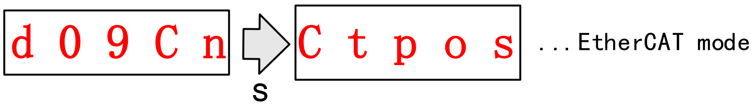
Maximum torque during motion (%)

6. d08FP Internal command pulse sum

d 0 8 F P → S → 2 0

Internal command pulse sum (pulse)

7. d09Cn Control mode

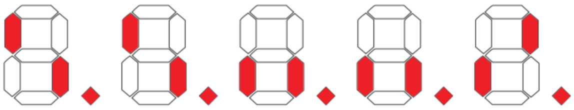


8. d10Io I/O signal status

When the top half of the digital tube is lighted, the signal is valid; when the bottom half of the digital tube is lighted, the signal is not valid. Decimal points represent I/O status, input when lighted, output when not lighted.

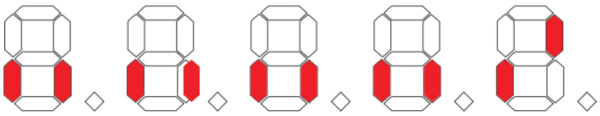
- **Input:** From low to high bit(Right to left) DI1,DI2....DI10. Decimal point is lighted to represent input signals.

  In the example below, DI1, DI8 and DI10 input signal is valid; DI2-DI7, DI9 input signal is invalid.

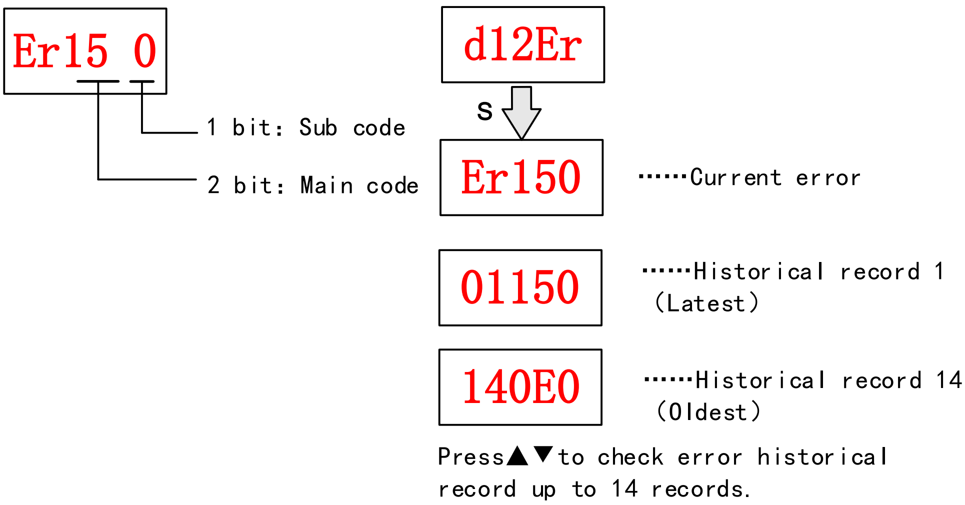


- **Output:** From low to high bit(Right to left) DO1,DO2....DO10. Decimal point is not lighted to represent output signals.

  In the example below, DO1 output signal is valid; DO2-DO10 output signal is invalid.

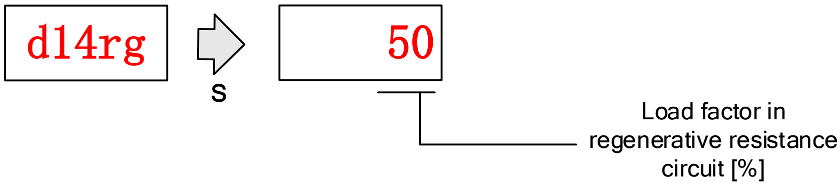


9. d12Er Alarm cause and historical record

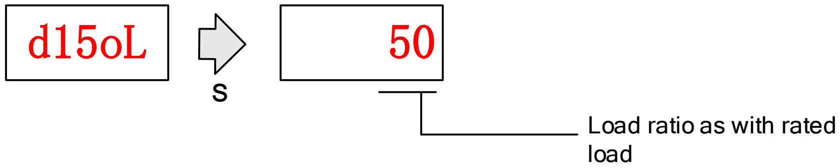


10. d14rg Regenerative load factor d15oL Overload factor

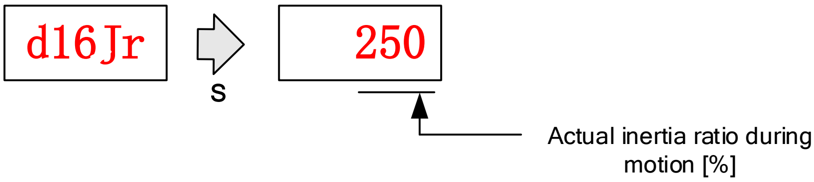
Regenerative load factor（Er120 might occur, if the value increases indefinitely）



Overload factor（Er100 might occur, if the value increases indefinitely）

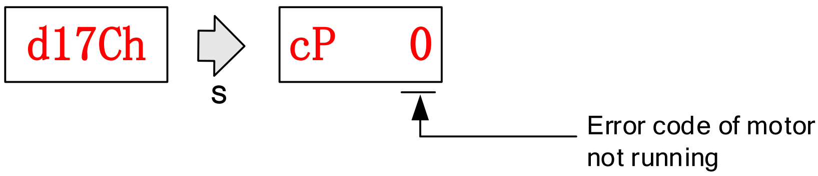


11、d16Jr Inertia ratio



Please refer to Inertia Measuring section for detailed explanations.

12、d17Ch Motor not running cause

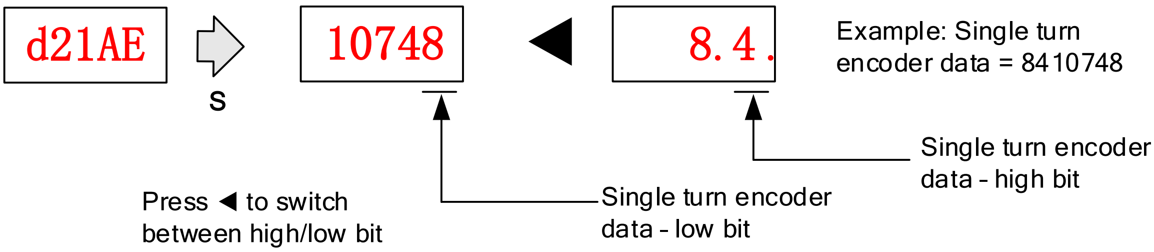


"d17Ch" Motor No Running Cause - Codes & Descriptions

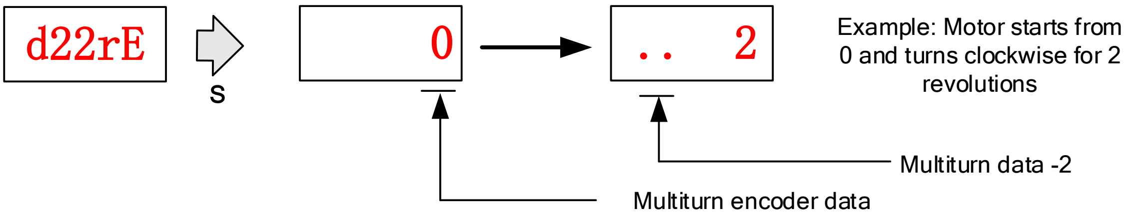
Display Code	Description	Content
cP 1	DC bus undervoltage	/
cP 2	No SRV-ON signal	Servo-ON input (SRV-ON) is not connected to COM-
cP 3	POT/NOT input valid	Pr5.04 = 0, POT is in open circuit, velocity command is in positive direction NOT is in open circuit, velocity command is in negative direction

cP 4	Driver alarm	/
cP 5	Relay not clicked	/
cP 6	Emergency stop valid	/
cP 7	Position command too low	/
cP 8	Torque limitation	/
cP 9	Zero speed clamp valid	Pr3.15 = 1, Zero speed clamp input is open
cP 10	Velocity mode command velocity too low	In velocity mode, the command velocity is too low
cP 12	Torque mode command torque too low	In torque mode, the torque limit is too low.
cP 13	Velocity limit	Emergency stop command from main bus is valid

13、d21AE Single turn encoder data d22rE Multiturn encoder data

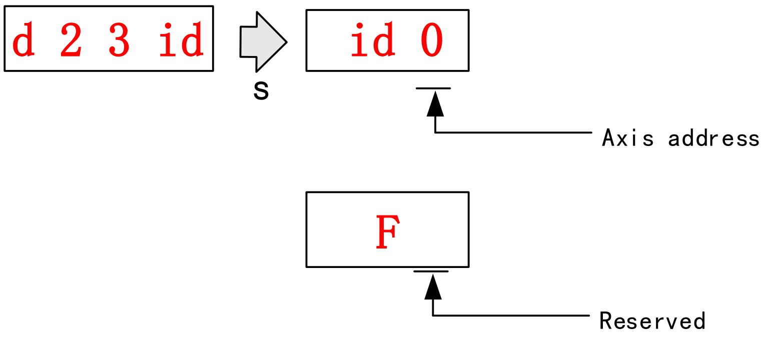


For 23-bit encoder, single turn encoder data = 0~8388607.Each value corresponds to certain position in a single revolution of the rotor, clockwise motion as negative, counter clockwise motion as positive. When counter clockwise single turn data > 8388607, multiturn data +1, clockwise single turn data < 0, multiturn data -1.

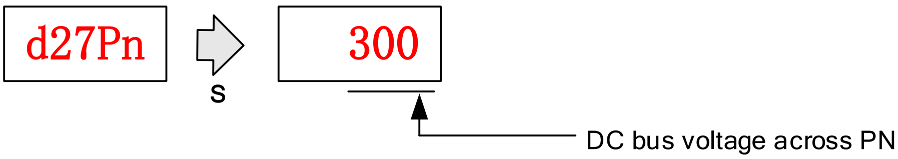


Multiturn encoder data range:-32768~+32767, As no. of revolution goes over range,32767 will jump to -32768、 -32767(counter clockwise)； -32768 will jump to 32767、 32766 (clockwise)

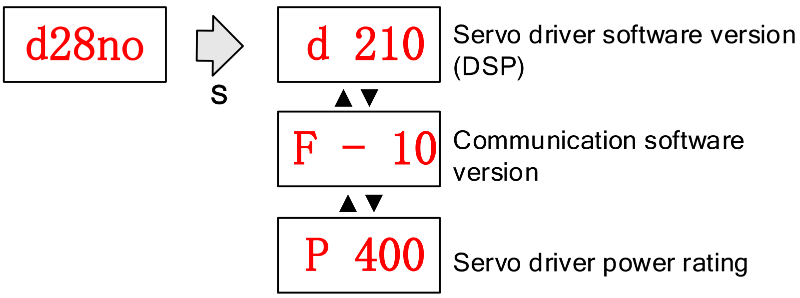
14.d23id Communication axis address



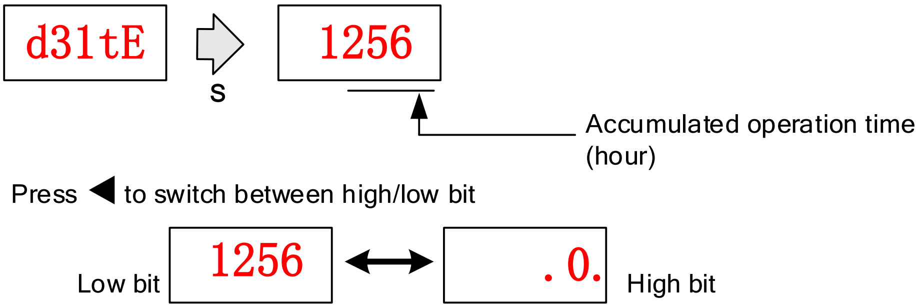
15. d27Pn DC bus voltage



16. d28no Software version

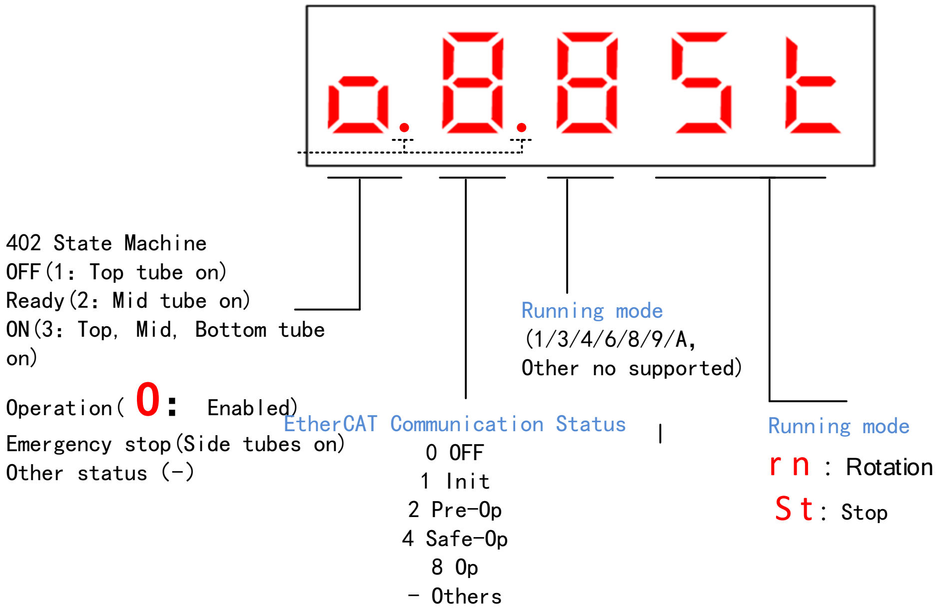


17. d31tE Accumulated operation time



18. d34 Servo driver status display

Driver status: 402 state machine, EtherCAT communication, running mode, running



Display setting at power on

- Default setting for initialization display settings at power on is **d34**,if any other display is required, please set on PA5.28.

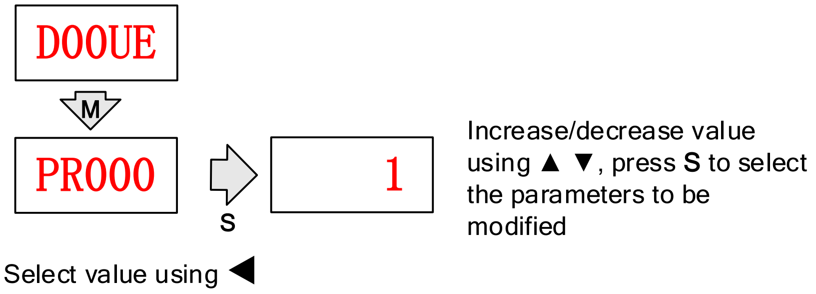
Please refer to PA5.28 for any display content required on the front panel during initialization

PA5.28	Label	LED initial status		Mode	F	
	Range	0~42	Default	34	Unit	-
	Activation	After restart			Index	2528h

To set content display on front panel of the servo driver at servo driver power on.

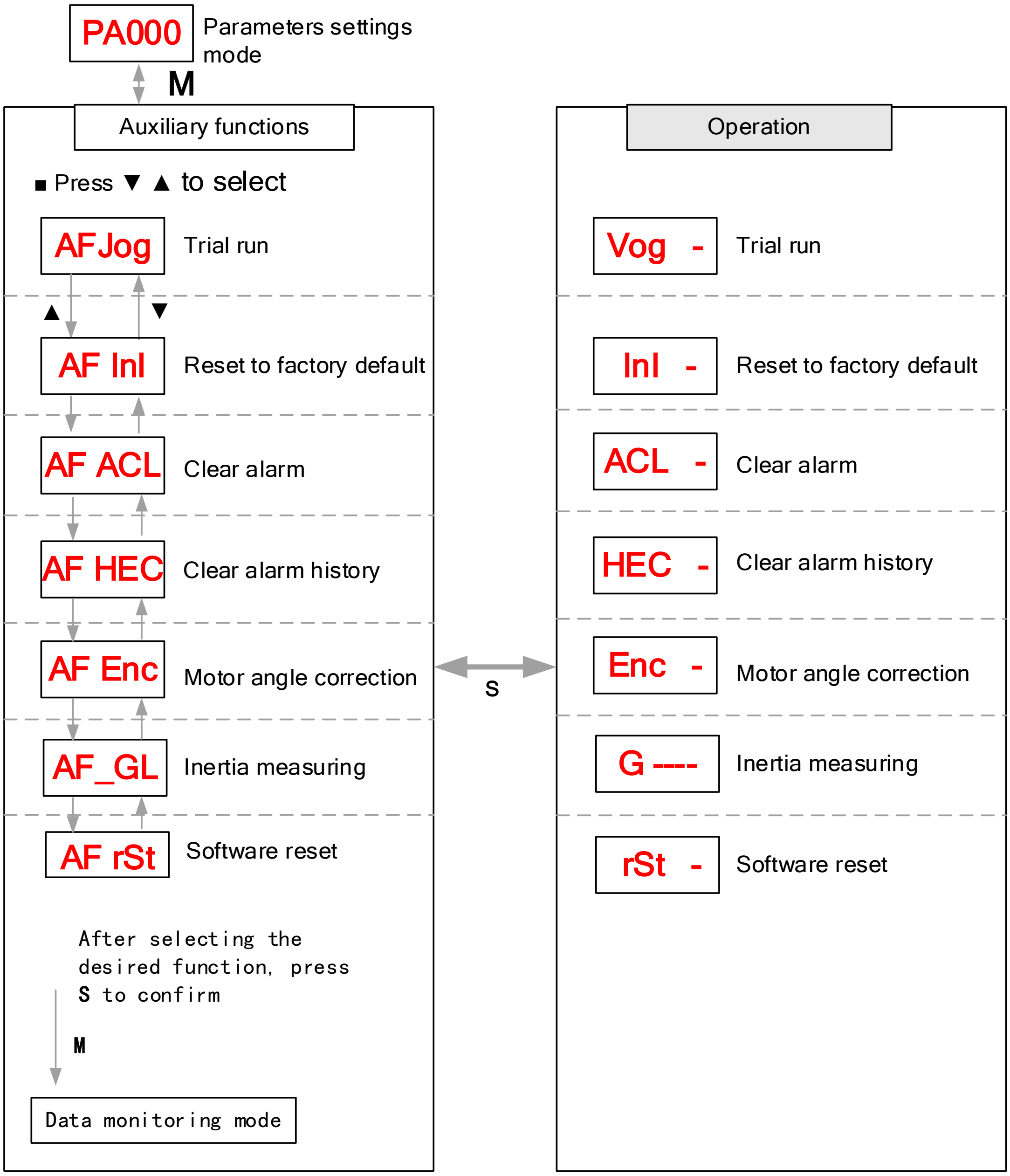
Set value	Content	Set value	Content	Set value	Content
0	Position command deviation	15	Overload rate	30	No. of encoder communication error
1	Motor speed	16	Inertia ratio	31	Accumulated operation time
2	Position command velocity	17	No rotation cause	32	Automatic motor identification
3	Velocity control command	18	No. of changes in I/O signals	33	Driver temperature
4	Actual feedback torque	19	Number of over current signals	34	Servo status
5	Sum of feedback pulse	20	Absolute encoder data	35	/
6	Sum of command pulse	21	Single turn position	36	Synchronous period
7	Maximum torque during motion	22	Multiturn position	37	No. of synchronous loss
8	/	23	Communication axis address	38	Synchronous type
9	Control mode	24	Encoder position deviation	39	Whether DC is running or not
10	I/O signal status	25	Motor electrical angle	40	Acceleration/ Deceleration status
11	/	26	Motor mechanical angle	41	Sub-index of OD index
12	Error cause and history record	27	Voltage across PN	42	Value of sub-index of OD index
13	Alarm code	28	Software version		
14	Regenerative load rate	29	/		

4.4 Parameter saving using front panel



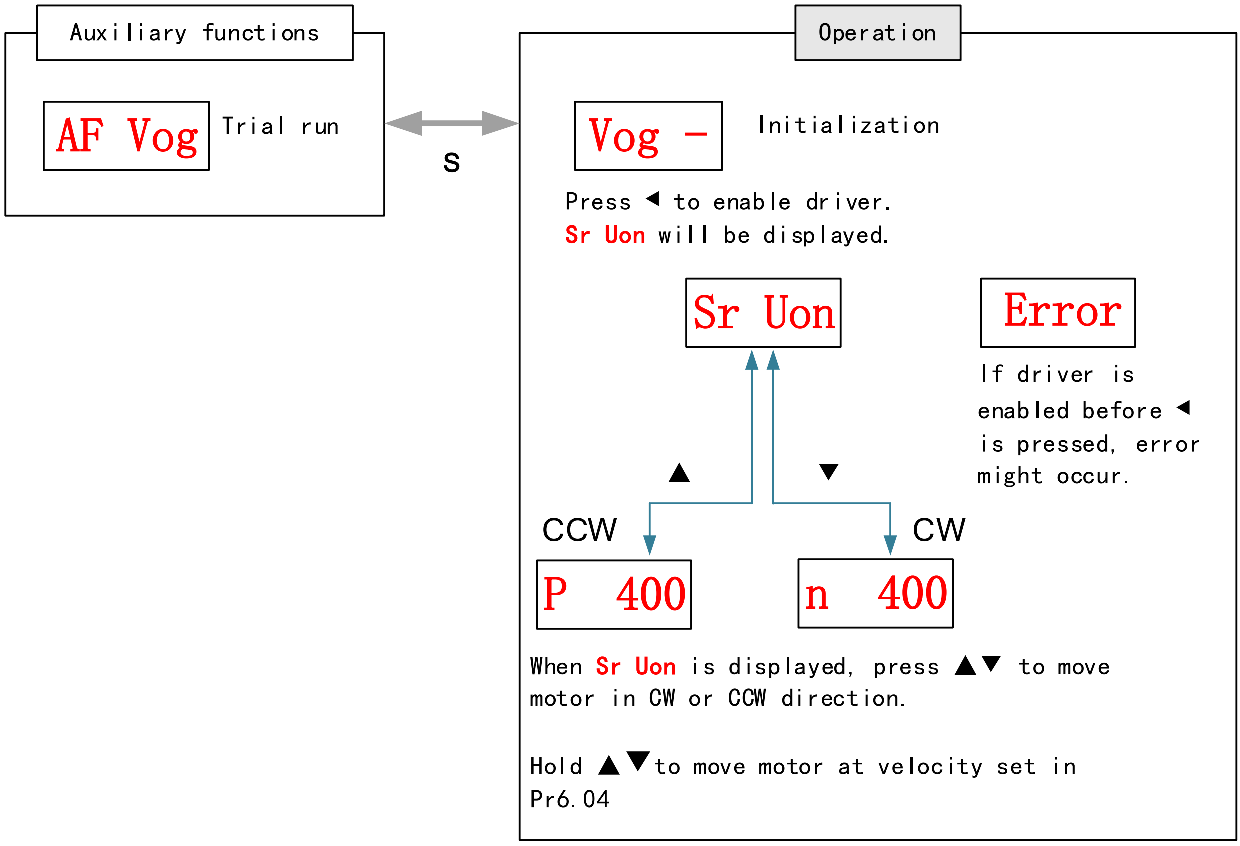
After modifying the selected parameter to desired values, press **S** to confirm and save the changes.

4.5 Auxiliary functions



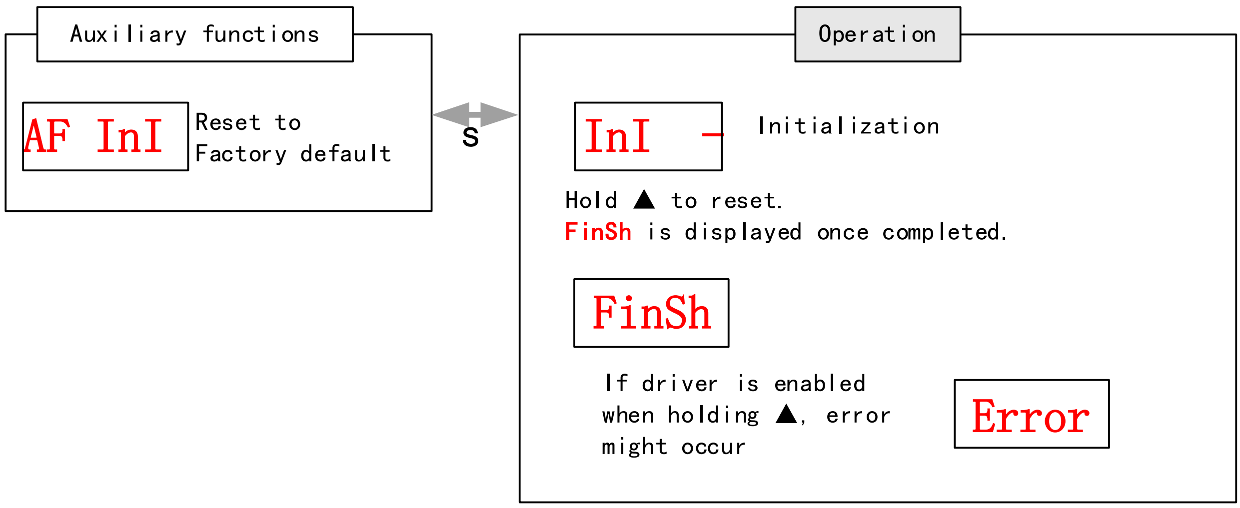
AF jog Trial run

Please disable servo driver before performing any trial run. Please don't modify gain related parameters during trial run to prevent any occurrence of mechanical vibrations. Press **S** to exit trial run.



AF Inl Reset to factory default

To reset parameters settings to factory default. Can be used to reset parameters using auxiliary function on front panel or using object dictionary.

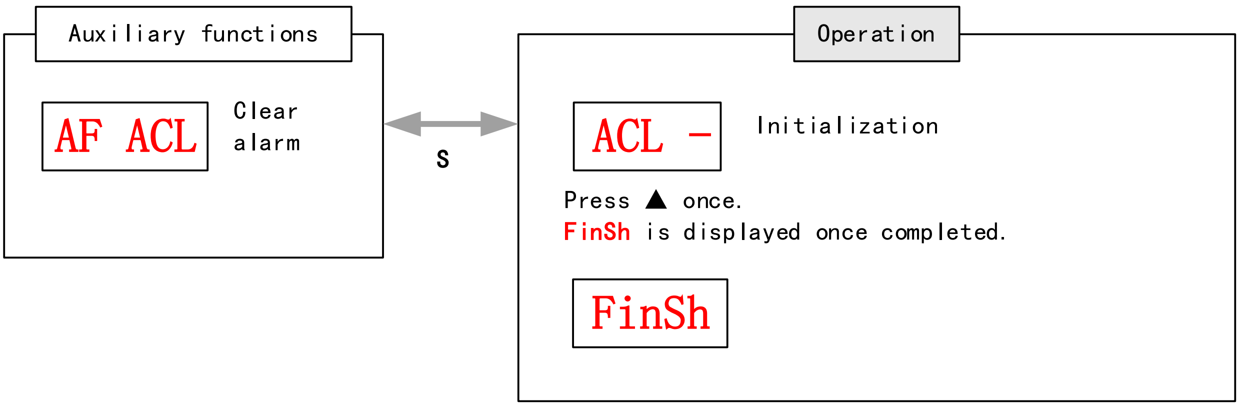


Reset to factory default using object dictionary

Object dictionary	**Parameters to reset**	**Method**
0x1011-01	All parameters	Controller can reset all parameters using 0x1011-01. If driver receives the data of 0x1011-01 as 0x64616f6c, all parameters will be reset to factory default and 1011-01=1 after saving.
0x1011-02	Communication parameters	Controller can reset communication parameters using 0x1011-02. If driver receives the data of 0x1011-02 as 0x64616f6c, communication parameters will be reset to factory default and 1011-02=1 after saving.
0x1011-03	402 parameters	Controller can reset 402 parameters using 0x1011-03. If driver receives the data of 0x1011-03 as 0x64616f6c, 402 parameters will be reset to factory default and 1011-03=1 after saving.
0x1011-04	Drivers' supplier parameters	Controller can reset drivers' supplier parameters using 0x1011-04. If driver receives the data of 0x1011-04 as 0x64616f6c, drivers' supplier parameters will be reset to factory default and 1011-04=1 after saving.

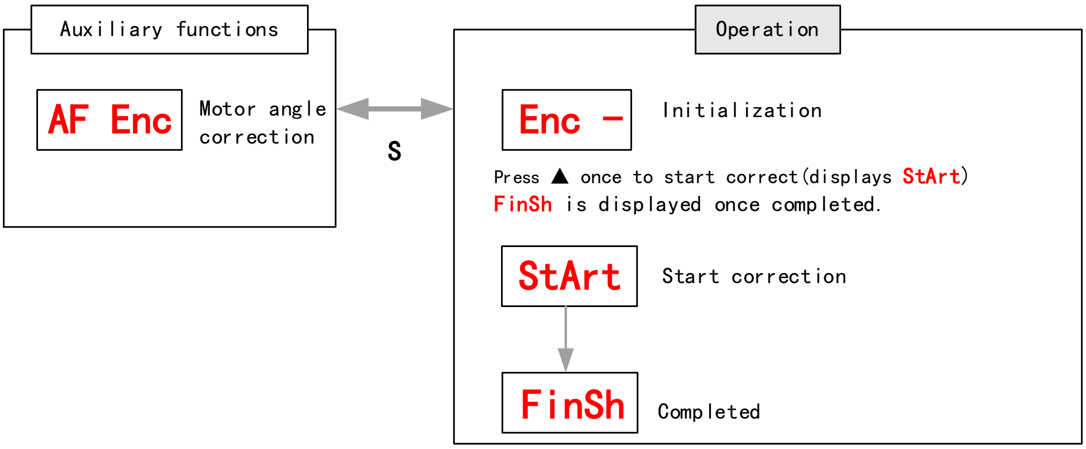
AF ACL Clear alarm

Alarm can be cleared using this auxiliary function but before that, the error needs to be solved and driver needs to be restarted.



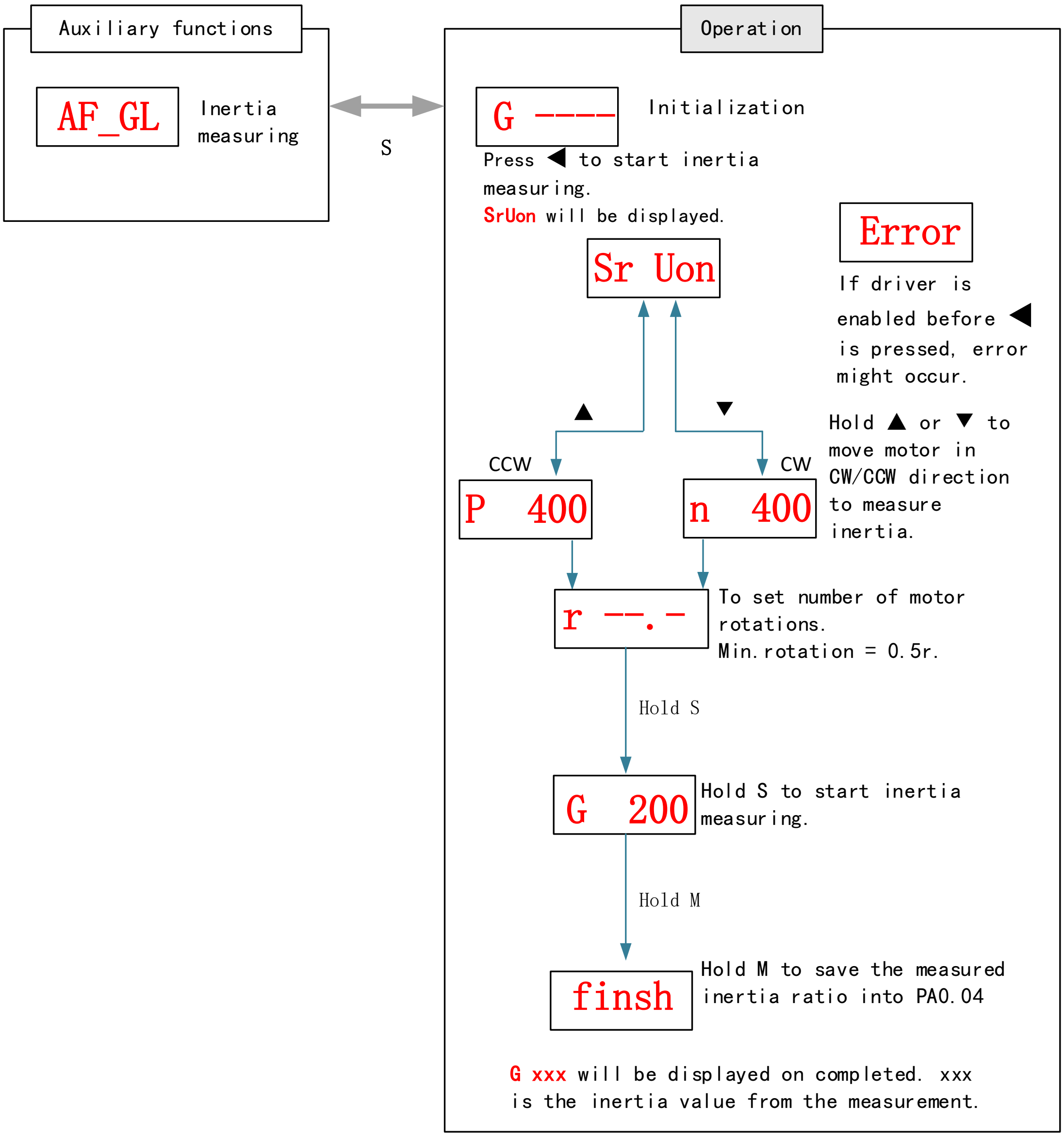
For alarms that can be cleared using this function, please refer to table in Chapter 9.

AF Enc Motor angle correction



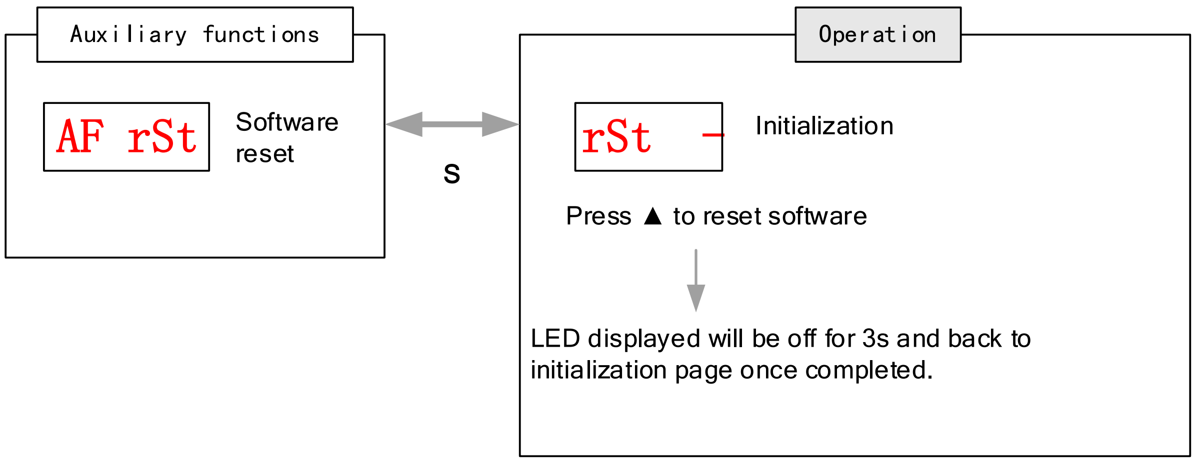
AF_GL Inertia measuring

Please make sure to use suitable velocity and acceleration for the measuring process. Press S to exit and disable the driver once completed.



AF rSt Software reset

Software reset is used mainly on parameters modification that takes effect only after driver restart.



Chapter 5 Control Mode

5.1 EL7-EC motion control step-by-step

A. EtherCAT master device sends "control word (6040h)" to initialize the drive.

B. Driver sends feedback "status word (6041h)" to the master device to indicate ready status (status word indication).

C. Master device sends enable command (control word switch).

D. The driver enables and sends feedback status to the master device.

E. The master station sends homing command to home the axis. (Homing parameter and control word switch)

F. Driver returns to home and sends feedback homed status to master device (status word indication)

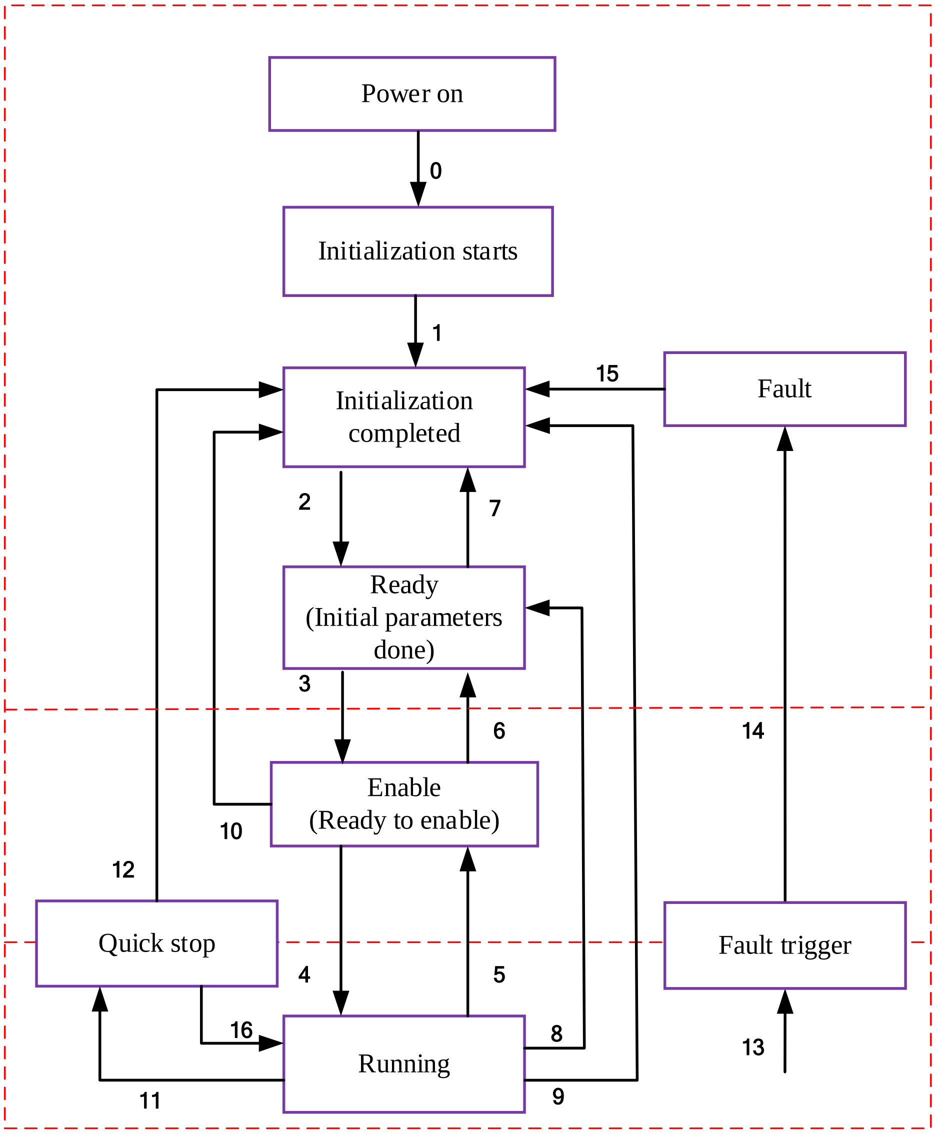
G. The master station sends the position mode command for position movement (position motion parameters and control word switch) or sends the velocity command for velocity movement (velocity motion parameters and control word switch).

H. When the drive is finished executing the command (position command), EL7-EC feedbacks the position/velocity to the master device for monitoring during the motion.

I. The master device sends commands for the next motion.

5.2 CiA 402 State Machine

State machine switchover diagram



Control Circuit	Main Power	Enable Disable
ON	OFF	Disable
ON	ON	Disable
ON	ON	Enable

Figure 5.1 EL7-EC 402 State Machine switchover diagram

Table 5.1 Status description

Status	Description
Initialization starts	Driver powered on, initialization starts; Holding brake activated; Axis disabled
Initialization done	Initialization done; Parameters initialize, faultless; Axis disabled.
Ready	Parameter initialization done; Axis disabled.
Enable	Servo driver is ready to be enabled.
Running	Driver enabled, faultless
Quick stop	Quick stop activated
Fault triggered	Alarm not solved yet; Axis disabled.
Fault	Alarm solved. Waiting to switch from 402 state machine to Initialization starts; Axis disabled.

402 state machine switching is dependent on master device controlled servo driver control word (6040h)

CiA402 status switching		Control word 6040h	Status word 6041h Bit1-Bit9
0	Power on→ Initialization	Transit automatically	0x0000
1	Initialization→ Faultless	Transit automatically, Enter 13 if fault occurs	0x0250
2	Faultless--► Ready	0x0006	0x0231
3	Servo ready→ Waiting to enable	0x0007	0x0233
4	Waiting to enable-► Running	0x000F	0x0237
5	Running→ Waiting to enable	0x0007	0x0233
6	Waiting to enable→ Ready	0x0006	0x0231
7	Ready→ Faultless	0x0000	0x0250
8	Running → Ready	0x0006	0x0231
9	Running-→ Faultless	0x0000	0x0250
10	Waiting to enable → Faultless	0x0000	0x0250
11	Running-→ Quick stop	0x0002	0x0217
12	Quick stop→ Faultless	Transit automatically	0x0250
13	Fault stop	Transit automatically	0x021F
14	Fault stop--► Fault	Transit automatically	0x0218
15	Fault → Faultless	0x80	0x0250
16	Quick stop--► Running	0x0F	0x0237

5.3 Driver Control Mode Setting

5.3.1 Supported control mode (6502h)

EL7-EC supports seven modes, as defined in 6502h.

Bit	31~10	9	8	7	6	5	4	3	2	1	0
Mode	Reserved	CST	CSV	CSP	Reserved	HM	Reserved	PT	PV	Reserved	PP
1:Supported	0	1	1	1	0	1	0	1	1	0	1

Description	Abbr.
Profile position mode	PP
Profile velocity mode	PV
Profile Torque mode	PT
Homing mode	HM
Cyclic synchronous position mode	CSP
Cyclic synchronous velocity mode	CSV
Cyclic synchronous torque mode	CST

5.3.2 Operational mode setting (6060h) and Operational mode display (6061h)

The operation mode of the servo drive is set in 6060h. The operation mode of the servo drive is viewed in 6061h.

Bit	Description	Abbr.
1	Profile position mode	PP
3	Profile velocity mode	PV
4	Profile Torque mode	PT
6	Homing mode	HM
8	Cyclic synchronous position mode	CSP
9	Cyclic synchronous velocity mode	CSV
10	Cyclic synchronous torque mode	CST

5.4 Common Functions for All Modes

5.4.1 Digital input setting and status display

Please refer to chapter 5 for more details on digital I/O input and polarity settings.60FDh object complies with IEC61800-200 standard input I/O status mapping object. 60FDh is set according to function as the table below shows.

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
Z signal	Reserved	Reserved	Reserved	Touch Probe 2	Touch Probe 1	BRAKE	INP/V-COIN /TLC
Bit23	**Bit22**	**Bit21**	**Bit20**	**Bit19**	**Bit18**	**Bit17**	**Bit16**
E-STOP	Reserved	Reserved	Reserved	Reserved	Reserved	DI14	DI13
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit9**	**Bit8**
DI12	DI11	DI10	DI9	DI8	DI7	DI6	DI5
Bit7	**Bit6**	**Bit5**	**Bit4**	**Bit3**	**Bit2**	**Bit1**	**Bit0**
DI4	DI3	DI2	DI1	Reserved	HOME	POT	NOT

5.4.2 Digital output setting and control operation method

In addition to the internal operation of the servo system, EL7-EC also provides a function for the master device to operate digital I/O output of the servo driver.

If I/O output function is set up as master device control, master device can control servo driver digital I/O output through 60FEh object

Bit / Sub-index	31~21	21	20	19	18	17	16	15~0
01h	Reserved	DO6 valid	DO5 valid	DO4 valid	DO3 valid	DO2 valid	DO1 valid	Reserved
02h		DO6 enabled	DO5 enabled	DO4 enabled	DO3 enabled	DO2 enabled	DO1 enabled	

5.4.3 Motor Rotational Direction

Rotational direction is defined in 607Eh.

Mode		Set value
Position Mode	PP HM CSP	0：Rotate in the same direction as the position command 128：Rotate in the opposite direction to the position command
Velocity Mode	PV CSV	0：Rotate in the same direction as the position command 64：Rotate in the opposite direction to the position command
Torque Mode	PT CST	0：Rotate in the same direction as the position command 32：Rotate in the opposite direction to the position command
ALL Modes		0：Rotate in the same direction as the position command 224：Rotate in the opposite direction to the position command

5.4.4 Stop Settings

EL7-EC provides quick stop function. Stopping is different under different modes. Controlled by using object dictionary 605A.

Index 605Ah	Label	Quick stop option code			Mode	F		
	Range	0~7			Default	2	Unit	-
	Structure	VAR	Type	INT16	Mapping	-	Access	RW

Motor stops when quick stop option code is given.

PP, CSP, CSV, PV

0 ： To stop motor through PA5.06. Status: Switch on disable, axis disabled.
1 ： Motor decelerates and stops through 6084. Status: Switch on disable, axis disabled.
2 ： Motor decelerates and stops through 6085. Status: Switch on disable, axis disabled.
3 ： Motor decelerates and stops through 60C6. Status: Switch on disable, axis disabled.
5 ： Motor decelerates and stops through 6084. Status: Quick stop
6 ： Motor decelerates and stops through 6085. Status: Quick stop
7 ： Motor decelerates and stops through 60C6. Status: Quick stop

HM

0 ： To stop motor through PA5.06. Status: Switch on disable, axis disabled.
1 ： Motor decelerates and stops through 609A. Status: Switch on disable, axis disabled.
2 ： Motor decelerates and stops through 6085. Status: Switch on disable, axis disabled.
3 ： Motor decelerates and stops through 60C6. Status: Switch on disable, axis disabled.
5 ： Motor decelerates and stops through 609A. Status: Quick stop
6 ： Motor decelerates and stops through 6085. Status: Quick stop
7 ： Motor decelerates and stops through 60C6. Status: Quick stop

When 402 state machine is disabled, the motor will stop freely.
When bit8(Halt) of 6040h is 1, the motor will stop with deceleration set in 6083h/6084h.

5.4.5 Position mode – Electronic Gear

EL7-EC position mode consists of cyclic synchronous position mode (CSP), protocol position mode (PP) and homing mode (HM), only in these three modes is the electronic gear valid.
Electronic gear ratio range is 0.001~8000(23-bit encoder), 0.001~to 125(17 bit encoder), otherwise ErA00 might occur if over range (the warning is not saved, after modification to a reasonable range, alarm on operational panel will automatically disappear, but the 402 state will still be in the "error" state, write 0x80 into 6040h).
Method 1:
Electronic gear ratio setting is defined by 608Fh (Position encoder resolution). 6091h (Gear ratio), 6092h (Feed constant) to change the motor position. Only valid under pre-operational mode.
608Fh (Position encoder resolution) is the resolution of the encoder, which is read

internally without additional setting. 6092h_01 represents the number of pulses that can be set for each revolution of the motor. 6091h_01/6091h_02 is real-time update effective.

Electronic gear subdivision method can be determined by modifying 6092h_01 (Feed constant)

1. If 6092h_01 (Feed constant) is not equal to 608Fh (Position Encoder resolution), then:

Electronic gear ratio = encoder resolution / 6092h_01

2. If 6092h_01(Feed constant) is equal to 608Fh(Position encoder resolution), then:

Electronic gear ratio = 6091_01/6092h_01

Electronic gear ratio range is 0.001~8000(23 bit encoder), 0.001~125(17 bit encoder)

Command pulse count per motor revolution needs to be ≥ Encoder Pulse Count per Revolution / 8000.

EL7 series comes with motors with 17-bit and 23-bit encoder. Pulse count per revolution for 17-bit encoder = 131072; for 23-bit encoder = 8388608. From the condition above, the command pulse count per motor revolution for 17-bit encoder should be ⩾ 17; for 23-bit encoder ⩾ 1049.

Method 2:

Electronic gear can be set through Pr0.08. If Pr0.08 ≠ 0, Pr0.08 is valid. If Pr0.08 = 0, object dictionary 6092-01 is valid.

Note: *when the setting value exceeds this range, the error will be reported and automatically reset to the default value. The default values of 6091_01, 6091_02 and 6092_01 are 1, 1 and 10000.*

5.4.6 Position Limits

The hardware limit is valid in all operational modes, and the software limit is valid only in the absolute operational mode of cyclic synchronous position mode (CSP) and profile position mode (PP)

The limit of the software is defined by 607Dh. The maximum position in the negative direction is defined in 607d-01h and the maximum position in the positive direction is defined in 607d-02h, the unit is consistent with the command unit.

The setting of object dictionary 0x5012-04 not only affects the homing offset of 607C, but also affects the software limit, 607D needs to be modified before the operational state

5012-04		Actual Positive Position Limit	Actual Negative Position Limit
Bit2	Bit3		
0	0	607D-02 + 607C	607D-01 + 607C

0	1	607D-02 - 607C	607D-01 - 607C
1	X	607D-02	607D-01

EL7-EC Software position limits valid conditions:

1. It can only be set in the pre-operational state of ESM. It is recommended to configure it by SDO when the system starts.
2. Only in the absolute mode of CSP and PP, in CSP mode, it is recommended to use the software limit function of the master station to achieve the fastest limit performance.
3. The incremental encoder motor is not effective until the homing process completed.
4. The setting rule is 607d-01h < 607d-02h, that is, the negative position limit value is less than the positive position limit value.

5.4.7 Control Word

Bit definition of Control Word 6040h.

Bit	15~11	10~9	8	7	6~4	3	2	1	0
Definition	-	-	Halt	Fault reset	Related to modes	Operation enable	Quick stop	Voltage output	Switch on

Command	Bit7 and Bit0 to Bit3					6040 Value	402 State machine *1)
	7: Fault reset	3: Operation enable	2: Quick stop	1: Voltage output	0: Start		
Power off	0	×	1	1	0	0006h	2;6;8
Switch on	0	0	1	1	1	0007h	3*
Switch on	0	1	1	1	1	000Fh	3**
No voltage output	0	×	×	0	×	0000h	7;9;10;12
Quick stop	0	×	0	1	×	0002h	7;10;11
Operation enable	0	0	1	1	1	0007h	5
enable	0	1	1	1	1	000Fh	4;16
Fault reset	Rising edge	×	×	×	×	0080h	15

× is not affected by this bit state

* indicates that this transition is performed in the device start state

** indicates that it has no effect on the start state and remains in the start state

*1) The state machine switch corresponds to figure 7.1

The definition of bit 8 and bit 6~4 in different operation modes are shown in the following table

Bit	Operation Mode						
	Profile Position (PP)	Profile Velocity (PV)	Profile Torque (PT)	Homing (HM)	Cyclic Sync Position (CSP)	Cyclic Sync Velocity (CSV)	Cyclic Sync Torque (CST)
8	Stop with deceleration	Stop with deceleration	Stop with deceleration	Stop with deceleration	-	-	-
6	Absolute/ Increment	-	-	-	-	-	-
5	Immediately trigger	-	-	-	-	-	-
4	New Position	-	-	Start	-	-	-

5.4.7 Status Word

Bit definition of Status Word 6041h.

Bit	Definition
15~14	Reserved
13~12	Related to modes
11	Position limit valid
10	Position arrival
9	Distance
8	Related to modes
7	Reserved
6	Not switch on
5	Quick stop
4	Voltage output
3	Fault
2	Operation enable
1	Switch on
0	Ready to switch on

Bit 11 is valid when the software or hardware limit is in effect.

The combination of bit 6 and bit 3~0 represents the device state shown in following table

Combination of bit 6 and bit 3~0	Description
××××,××××,×0××,0000	Not ready to switch on
××××,××××,×1××,0000	Switch on disabled
××××,××××,×01×,0001	Ready to switch on
××××,××××,×01×,0011	Switch on
××××,××××,×01×,0111	Operation enabled
××××,××××,×00×,0111	Quick stop active
××××,××××,×0××,1111	Fault reaction active
××××,××××,×0××,1000	Fault

× is not affected by this bit state

The definition of bit 8 and bit 13~12 in different operation modes are shown in the following table

Bit	Operation Mode						
	Profile Position (PP)	Profile Velocity (PV)	Profile Torque (PT)	Homing (HM)	Cyclic Sync Position (CSP)	Cyclic Sync Velocity (CSV)	Cyclic Sync Torque (CST)
13	Position error is too large	-	-	Homing Process error	-	-	-
12	-	Velocity is 0	-	Homing Process completed	Following valid	Following valid	Following valid
8	Abnormal stop	-	-	Abnormal stop	Abnormal stop	-	-

5.4.8 Synchronous cycle time setting

The default synchronous cycle time range of EL7-EC series is 250us – 10ms. Min value: 125us; Max value: 20ms. Please make sure the values set is the multiplier of 250us.

5.4.9 Driver Enabling

This section describes how to use control words 6040h/ status word 6041h command switching/status determination forEL7-EC controlled motor.

Steps:

1: Write 0 to the control word 6040h, and then AND 0x250 by bit, whether it is equal to 0x250

2: Write 6 to the control word 6040h, and then AND 0x231 by bit, whether it is equal to 0x231

3: Write 7 to the control word 6040h, and then AND 0x233 by bit, whether it is equal to 0x233

4: Write 15 to the control word 6040h, and then AND 0x237 by bit, whether it is equal to 0x237

5.5 Position Mode（CSP、PP、HM）

5.5.1 Common Functions of Position Mode

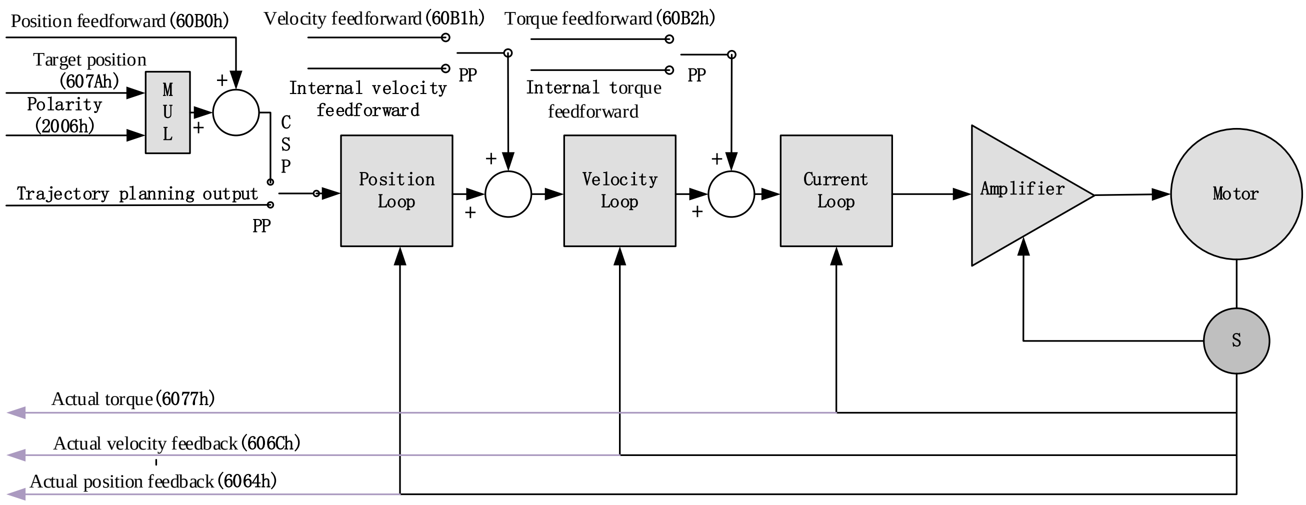
Index	Sub-Index	Label	Access	PDO	Mode		
					PP	CSP	HM
6040	0	Control word	RW	RxPDO	Yes	Yes	Yes
6072	0	Max torque	RW	RxPDO	Yes	Yes	Yes
607A	0	Target position	RW	RxPDO	Yes	Yes	/
607D	1	Min. software limit	RW	RxPDO	Yes	Yes	/
	2	Max. software limit	RW	RxPDO	Yes	Yes	/
607F	0	Maximum protocol velocity	RW	RxPDO	Yes	/	Yes
6080	0	Maximum motor velocity	RW	RxPDO	Yes	Yes	Yes
6081	0	Profile velocity	RW	RxPDO	Yes	/	/
6083	0	Profile acceleration	RW	RxPDO	Yes	/	/
6084	0	Profile deceleration	RW	RxPDO	Yes	/	/
60C5	0	Protocol maximum acceleration	RW	RxPDO	Yes	/	Yes
60C6	0	Protocol maximum deceleration	RW	RxPDO	Yes	/	Yes

Index	Sub-Index	Label	Access	PDO	Mode		
					PP	CSP	HM
6041	0	Status word	RO	TxPDO	Yes	Yes	Yes
6062	0	Position command	RO	TxPDO	Yes	Yes	Yes
6063	0	Actual internal position	RO	TxPDO	Yes	Yes	Yes
6064	0	Actual position feedback	RO	TxPDO	Yes	Yes	Yes

6065	0	Position deviation window	RW	RxPDO	Yes	Yes	/
6066	0	Position deviation detection time	RW	RxPDO	Yes	Yes	/
606C	0	Velocity feedback	RO	TxPDO	Yes	Yes	Yes
6074	0	Internal command torque	RO	TxPDO	Yes	Yes	Yes
6076	0	Rated torque	RO	TxPDO	Yes	Yes	Yes
6077	0	Actual torque	RO	TxPDO	Yes	Yes	Yes
60F4	0	Actual following error	RO	TxPDO	Yes	Yes	Yes
60FA	0	Position loop velocity output	RO	TxPDO	Yes	Yes	Yes
60FC	0	Internal command position	RO	TxPDO	Yes	Yes	Yes

5.5.2 Cyclic Synchronous Position Mode (CSP)

CSP Block Diagram



Related Objects

Basic object

PDO	Index+Sub-Index	Label	Data Type	Access	Unit	Notes
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	607A-00h	Target position	I32	RW	Uint	Required
	60B0-00h	Position feedforward	I32	RW	Uint	Optional
	60B1-00h	Velocity feedforward	I32	RW	Uint /S	Optional
	60B2-00h	Torque feedforward	I16	RW	0.1%	Optional
(TXPDO)	6041-00h	Status word	U16	RO	—	Required
	6064-00h	Actual feedback position	I32	RO	Uint	Required
	606C-00h	Actual feedback velocity	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Optional

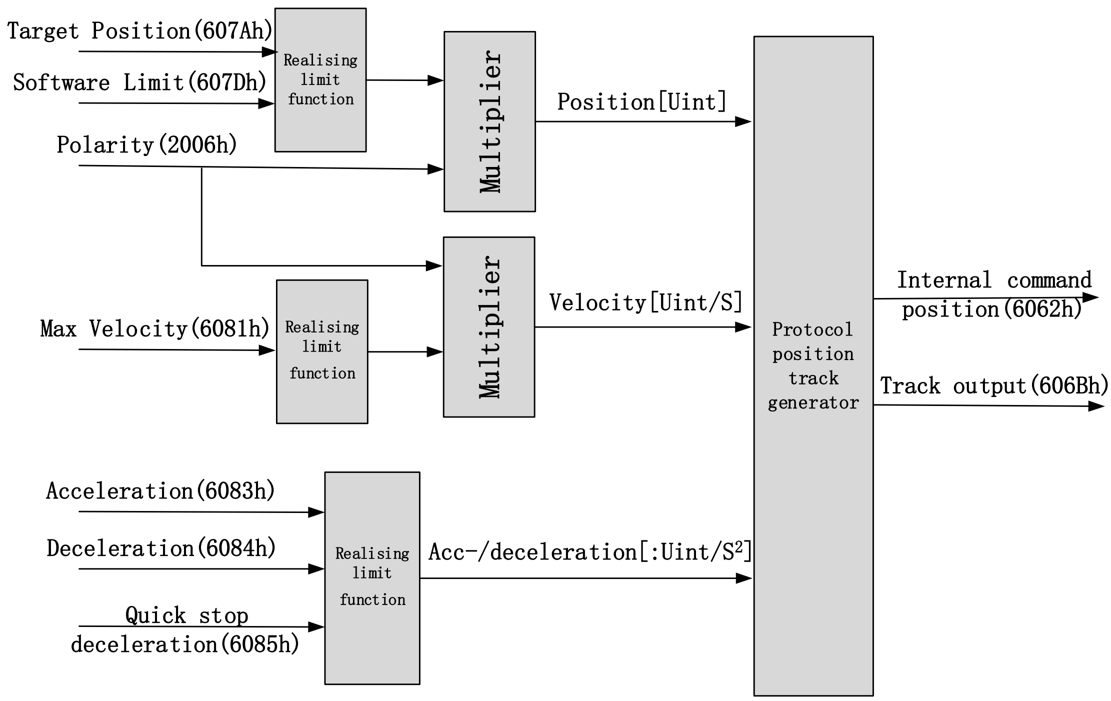
Extended object

Index+Sub-Index	Label	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
6062-00h	Position demand value	I32	RO	Uint
606B-00h	Internal command speed	I32	RO	Uint
607D-01h	Min. software limit	I32	RO	Uint
607D-02h	Max. software limit	I32	RO	Uint
605A-00h	Quick stop option code	I16	RW	—
6085-00h	Emergency stop deceleration	U32	RW	Uint /S
608F-01h	Encoder resolution	U32	RO	P
608F-02h	Motor turns	U32	RO	—
6091-01h	Electronic gear ratio numerator	U32	RW	—
6091-02h	Electronic gear ratio denominator	U32	RW	—
6092-01h	Number of pulses per rotation	U32	RW	—
6092-02h	Number of physical axis turns	U32	RO	—

5.5.3 Protocol Position Mode (PP)

Under non-synchronous mode, master device is responsible for only sending parameters and control command; After receiving enable command from master device, servo driver will plan motion route according to parameters. Under non-synchronous mode, motor motion between each axes are asynchronous.

From the perspective of servo driver functions, the difference between PP and CSP mode is that PP mode requires track generator function from L7EC



Related Parameters

Basic object

PDO	Index+Sub-Index	Label	Data Type	Access	Unit	Notes
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	607A-00h	Target position	I32	RW	Uint	Required
	6081-00h	Max. velocity	U32	RW	Uint	Required
	6083-00h	Acceleration	I32	RW	Uint /S	Optional
(TXPDO)	6041-00h	Status word	U16	RO	—	Required
	603F-00h	Error code	U16	RO		Optional
	6064-00h	Actual position feedback	I32	RO	Uint	Required
	606C-00h	Actual velocity feedback	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Optional

Extended object

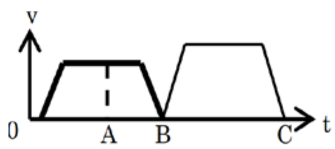
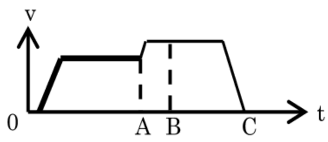
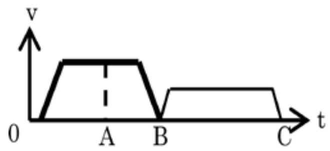
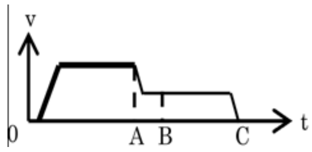
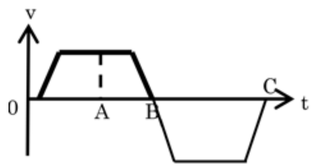
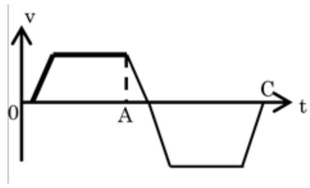
Index+Sub-Index	Label	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
6062-00h	Position demand value	I32	RO	Uint
606B-00h	Internal command speed	I32	RO	Uint
607D-01h	Min. software limit	I32	RO	Uint
607D-02h	Max. software limit	I32	RO	Uint
605A-00h	Quick stop option code	I16	RW	—
6085-00h	Emergency stop deceleration	U32	RW	Uint /S
608F-01h	Encoder resolution	U32	RO	P
608F-02h	Motor turns	U32	RO	—
6091-01h	Electronic gear ratio numerator	U32	RW	—
6091-02h	Electronic gear ratio denominator	U32	RW	—
6092-01h	Number of pulses per rotation	U32	RW	—
6092-02h	Number of physical axis turns	U32	RO	—

Control and status words under PP mode

Control word bits 4~6 definition under PP mode

Bit	Value	Definition
4 (New position)	0—>1	Latest target position(607Ah)、Profile velocity (6081h)、Acc-/deceleration(6083h/6084h) Starts
5 (Instant trigger)	0	Trigger new position command once current one is completed.
	1	Interrupted current position command and trigger new position command
6(Absolute/ relative)	0	Set target position(607Ah)as absolute position
	1	Set target position(607Ah) as relative position

5 motion structures under PP mode

<table>
<tr><th>Control words bit 5</th><th>0</th><th>1</th></tr>
<tr><td>Accelerates/ constant velocity toward target position</td><td>
</td><td>
</td></tr>
<tr><td>Decelerates towards target position</td><td>
</td><td>
</td></tr>
<tr><td>Target position in inversed direction</td><td>
</td><td>
</td></tr>
</table>

A： Command switching time from master device

B： Arrival time before target position renewal

C： Arrival time after target position renewal

Thick line: Motion before command changed

Thin line ： Motion after command changed

Status word bits 12-15, 10, 8 definition under PP mode

Bit	Value	Definition
8(Abnormal Stoppage)	0	Normal motion
	1	Abnormal stoppage triggered, motor stopped *1)
10(Arrived at position)	0	Motion not completed
	1	Target position reached
12(New position)	0	Current motion completed/interruptible, able to execute new position command *2)
	1	Current motion not completed/interruptible, unable to execute new position command
14(Motion Parameter = 0)	0	Motion parameters valid, necessary parameters all not set to 0.
	1	Parameter = 0 under current motion. One of 3 parameters, Profile velocity (6081h), acceleration (6083h) and deceleration (6084h) = 0.
15(Trigger)	0	Current motion incomplete/uninterruptable, new target position cannot be renewed. *3)
	1	Current motion completed/interruptible, new target position can be renewed.

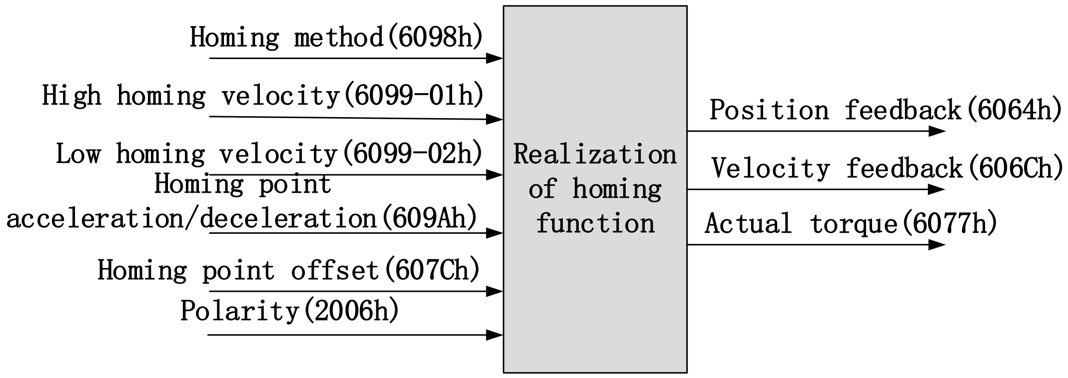
*1) Bit 8 abnormal stoppage usually valid when hardware limit, deceleration stoppage and quick stop are triggered.
*2) Bit 12 under control word(6040h)bit 5 valid and bit 4 invalid, motion interruptible.
*3) Bit 15 and bit 12 have inversed logic under PP mode.

Application: Realization of relative position motion

Step 1: 6060h = 1, determine if 6061h =1. Servo driver is now under PP mode.
Step 2: Write motion parameters: Target position 607Ah, Profile velocity 6081h, acceleration 6083h, deceleration 6084h
Step 3: Enable servo driver and switch bit 6 and 4 to realize relative position motion.

5.5.4 Homing mode (HM)

EL7-EC servo system supports every other homing method except for method 36. Output/input parameters of L7EC are as shown below.



Related Parameters

Basic object

PDO	Index+Sub-Index	Name	Data Type	Access	Unit	Notes
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	6098-00h	Homing mode	I8	RW	Uint	Optional
	6099-01h	High homing velocity	U32	RW	Uint/S	Optional
	6099-02h	Low homing velocity	U32	RW	Uint /S	Optional

	609A-00h	Homing point acceleration	U32	RW	Uint /S²	Optional
	607C-00h	Homing point offset	I32	RW	Uint	Optional
(TXPDO)	60-00h	Status word	U16	RO	—	Required
	603F-00h	Error code	U16	RO		Optional
	6064-00h	Actual position feedback	I32	RO	Uint	Optional
	606C-00h	Actual velocity feedback	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Optional

Extended object

Index+Sub-Index	Label	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
6062-00h	Position demand value	I32	RO	Uint
606B-00h	Internal command speed	I32	RO	Uint
608F-01h	Encoder resolution	I32	RO	Uint
608F-02h	Motor revolution	I32	RO	Uint
6091-01h	Electronic gear ratio numerator	U32	RW	—
6091-02h	Electronic gear ratio denominator	U32	RW	—
6092-01h	Number of pulses per rotation	U32	RW	—
6092-02h	Number of physical axis turns	U32	RO	—

Control and status words under HM mode

Control word bit 4 definition under HM mode

Bit	Value	Definition
4(Homing motion starts/stops)	0—>1	Homing motion starts
	1 —>0	Homing motion stops, motor stops

Status word bits 12-15, 10, 8 definition under PP mode

Bit	Value	Definition
8(Abnormal Stoppage)	0	Normal motion
	1	Abnormal stoppage triggered, motor stops *1)
10(Arrived at position)	0	Motion not completed
	1	Target position reached

12(Homing done)	0	Homing not done
	1	Homing done, valid after reaching position(bit 10) *2)
14(Motion Parameter = 0)	0	Motion parameters valid, necessary parameters all not set to 0.
	1	Parameter = 0 under current motion. One of 4 parameters, Homing mode (6098h), high homing velocity(6099h-01), low homing velocity (6099h-02) and homing point acc-/deceleration (609Ah) = 0.
15(Trigger)	0	Homing triggered/completed *3)
	1	Homing triggers

*1) Bit 8 abnormal stoppage usually valid when hardware limit, deceleration stoppage and quick stop are triggered.
*2) Determine if homing is done, determine if bit 10/12 is occupied.
*3) Use to indicate if homing is able to trigger or already triggered.

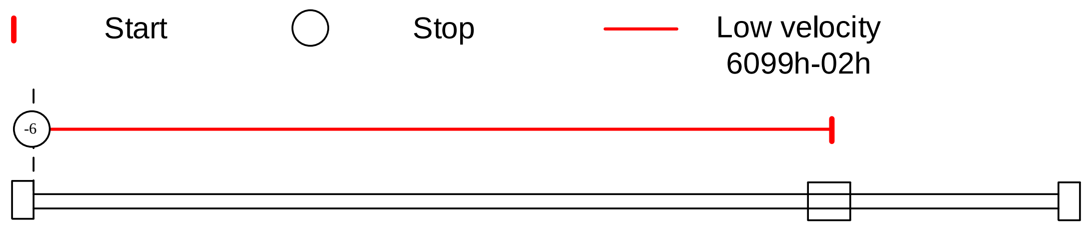
Incorrect position triggering conditions

Triggering condition	Remarks
Absolute encoder homing	Control words 6040h bit 4 from 0 to 1
2 limit switch signals detected	Positive and negative limit switches detected during homing
Negative limit valid when positive limit in used	Negative limit valid under 2,7-10,23-26 homing modes
Positive limit valid when negative limit in used	Positive limit valid under 1,11-14,27-30 homing modes
Limit switch valid when not in used	Limit switch valid under 3,4,19,20 homing modes
Limit switch/homing signal valid when only z-signal in used	Limit switch and homing sensor valid under 33,34 homing modes

Homing mode

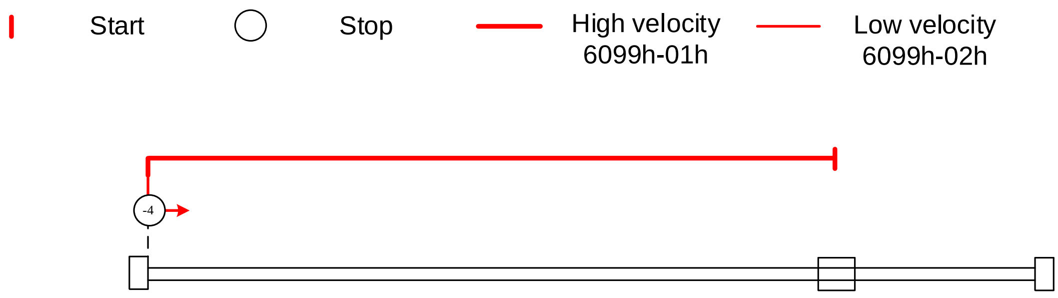
Torque limiting mode

Mode-6: Search for homing point in **negative direction** at **low velocity**. Stop after torque reaches the value set in PA5.39 and homing done signal is delivered.

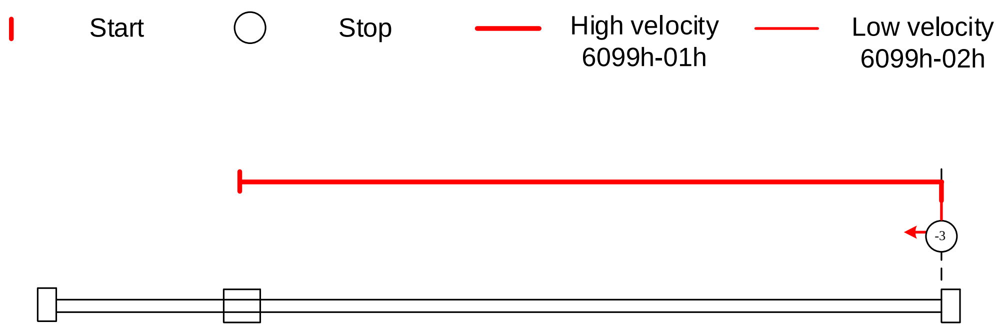


Mode -5: Search for homing point in **positive direction** at **low velocity**. Stop after torque reaches the value set in PA5.39 and homing done signal is delivered.

Mode -4: Search for homing point in **negative direction** at **high velocity**. Move in **positive direction** after torque reaches the value set in PA5.39, stops when torque is gone. Homing done signal delivers after the time value set in PA5.37

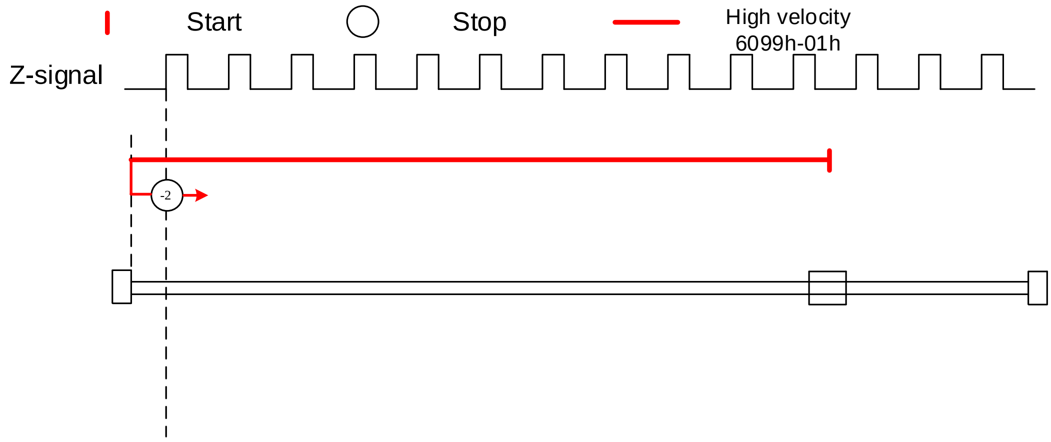


Mode -3： Search for homing point in **positive direction** at **high velocity**. Move in **negative direction** after torque reaches the value set in PA5.39, stops when torque is gone. Homing done signal delivers after the time value set in PA5.37

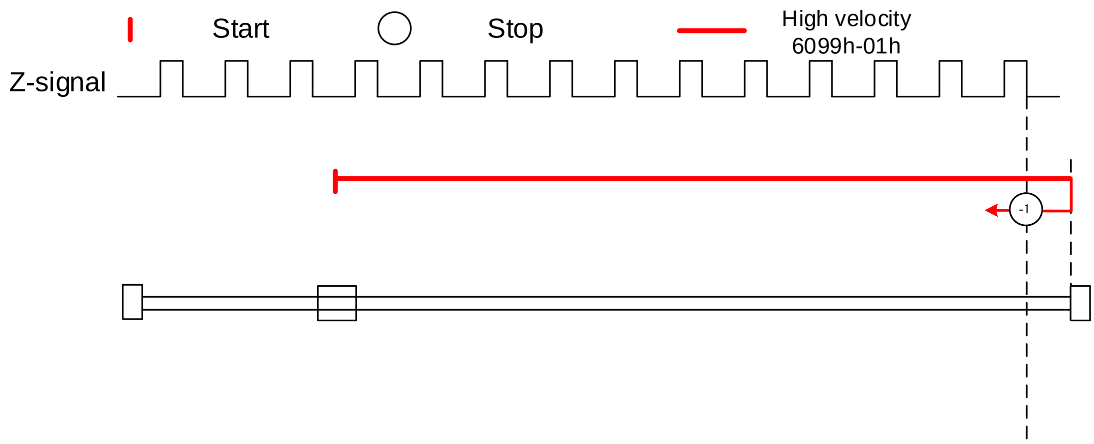


Torque limiting + Z-signal mode

Mode -2： Search for homing point in **negative direction** at **high velocity**. Move in **positive direction** after torque reaches the value set in Pr5.39, stops when torque is gone with the **first Z-signal**.



Mode -1： Search for homing point in **positive direction** at **high velocity**. Move in **negative direction** after torque reaches the value set in Pr5.39, stops when torque is gone with the **first Z-signal**.



Limit switch signal + Z-signal mode

Mode 1:

Diagram A: *Negative limit switch = OFF*

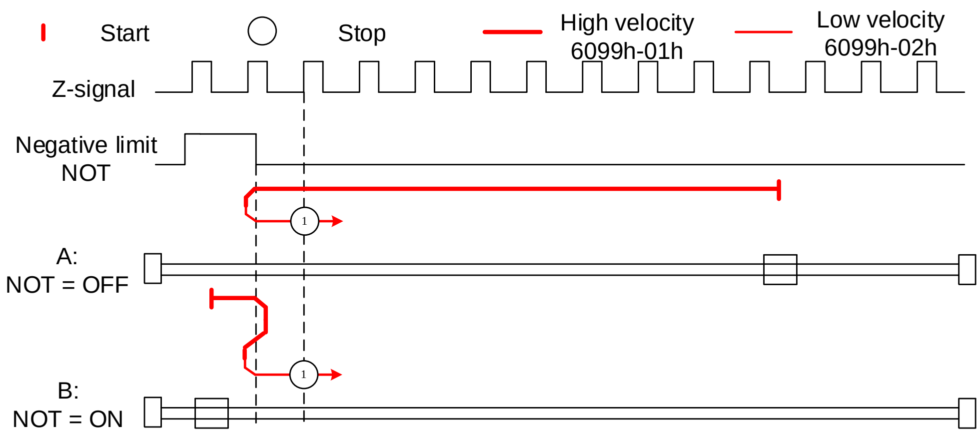
1. Move in **negative direction** at **high velocity** until **negative limit switch valid.**
2. Move in **positive direction** at **low velocity** and stops **after negative limit switch** and **first encoder Z-signal valid**

Diagram B: *Negative limit switch = ON*

1. Start to move at **negative limit switch position** in **positive direction** at **high velocity** until **negative limit switch invalid.**
2. Move in **negative direction** at **high velocity** until **negative limit switch valid.**

3. Move in **positive direction** at **low velocity** and stops **after negative limit switch** and **first encoder Z-signal valid**

If the positive limit signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 2:

Diagram A: *Positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until **positive limit switch valid.**

2. Move in **negative direction** at **low velocity** and stops **after positive limit switch** and **first encoder Z-signal valid**

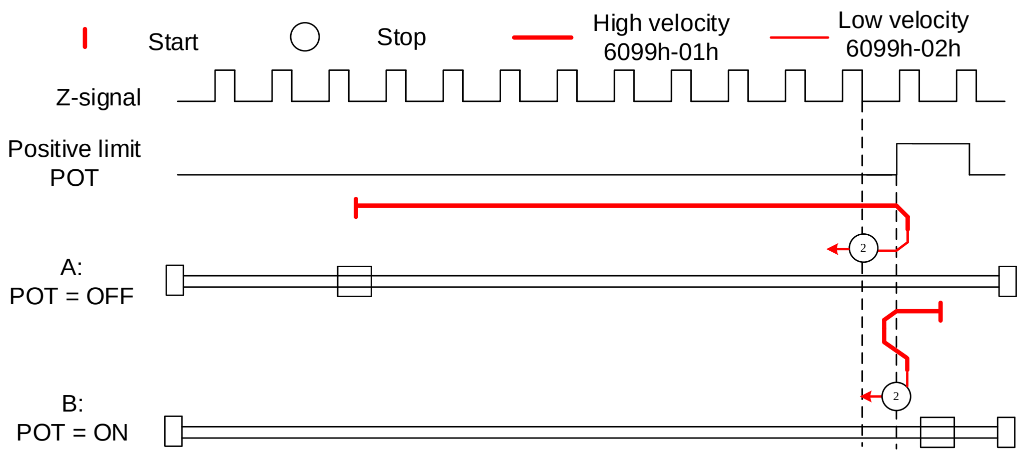
Diagram B: *Positive limit switch = ON*

1. Start to move at **positive limit switch position** in **negative direction** at **high velocity** until **positive limit switch invalid.**

2. Move in **positive direction** at **high velocity** until **positive limit switch valid.**

3. Move in **negative direction** at **low velocity** and stops **after positive limit switch** and **first encoder Z-signal valid**

If the negative limit signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Homing switch signal + Z-signal mode

Mode 3:

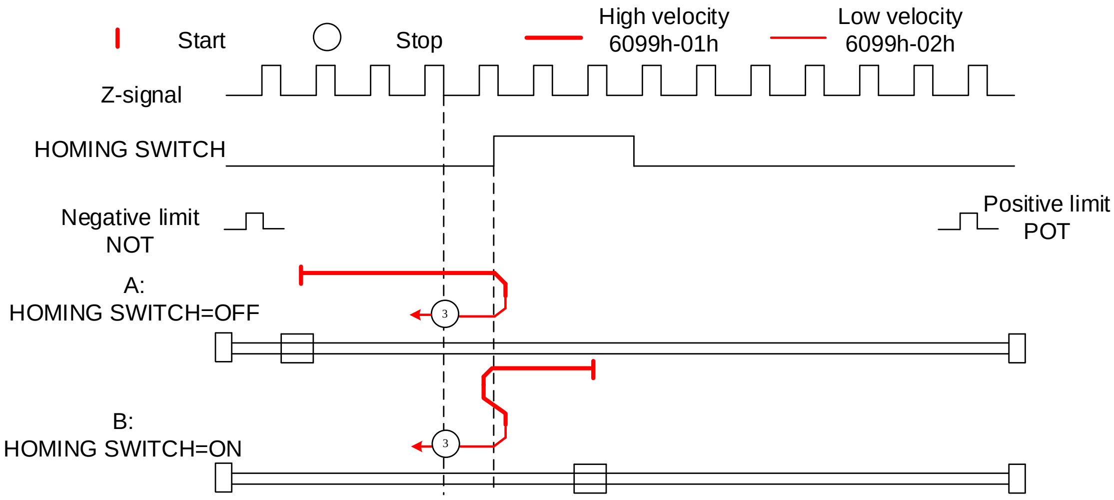
Diagram A: *Homing switch = OFF*

1. Move in **positive direction** at **high velocity** until **homing switch valid.**
2. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

Diagram B: *Homing switch = ON*

1. Start to move at **homing switch position** in **negative direction** at **high velocity** until **after homing switch.**
2. Move in **positive direction** at **high velocity** until **homing switch valid.**
3. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

If the positive/negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 4:

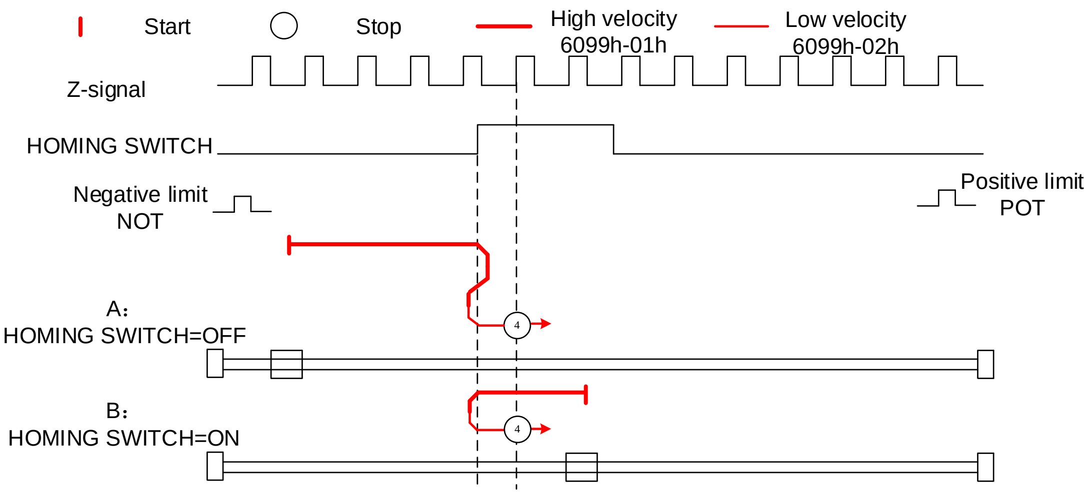
Diagram A: *Homing switch = OFF*

1. Move in **positive direction** at **high velocity** until **homing switch valid.**
2. Move in **negative direction** at **high velocity** until **homing switch invalid.**
3. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

Diagram B: *Homing switch = ON*

1. Start to move at **homing switch position** in **negative direction** at **high velocity** until **after homing switch.**
2. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

If the positive/negative limit switch signal is valid during the homing process, the status *word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.*



Mode 5:

Diagram A: *Homing switch = OFF*

1. Move in **negative direction** at **high velocity** until **homing switch valid.**

2. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

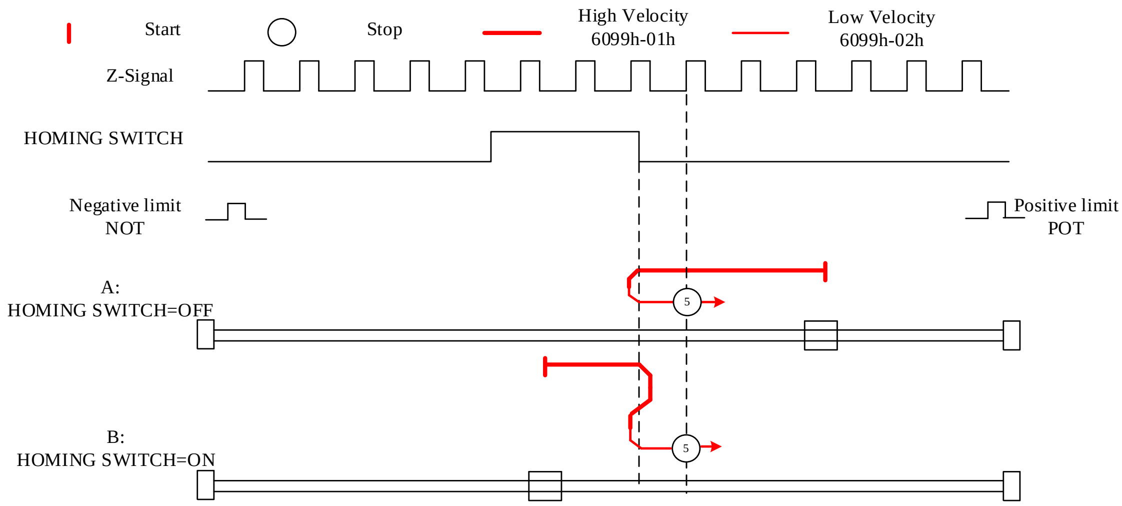
Diagram B: *Homing switch = ON*

1. Start to move at **homing switch position** in **positive direction** at **high velocity** until **after homing switch.**

2. Move in **negative direction** at **high velocity** until **homing switch valid.**

3. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

If the positive/negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 6:

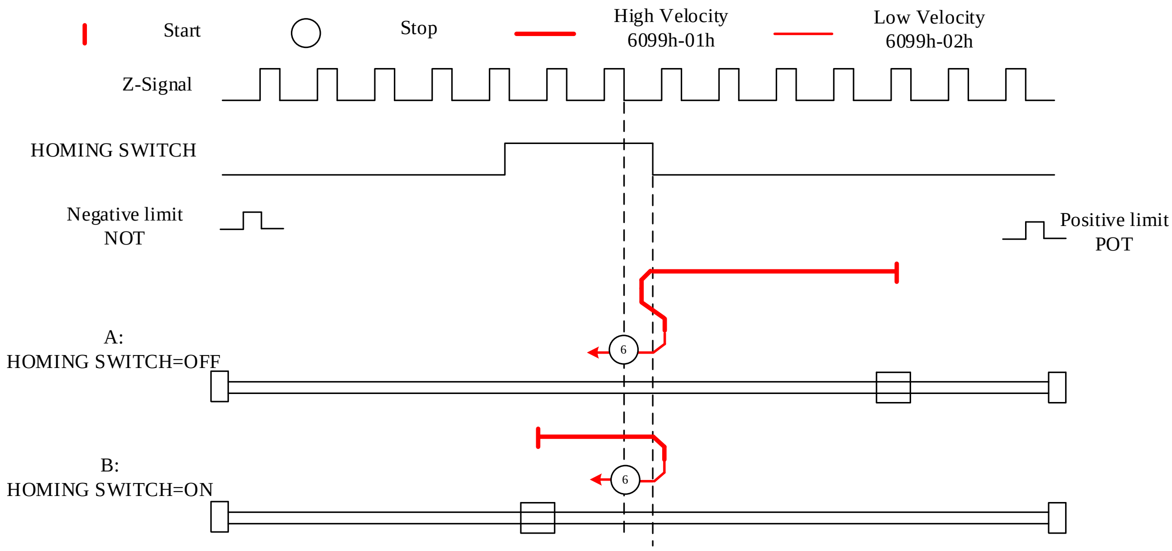
Diagram A: *Homing switch = OFF*

1. Move in **negative direction** at **high velocity** until **homing switch valid.**
2. Move in **positive direction** at **high velocity** until **homing switch invalid.**
3. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

Diagram B: *Homing switch = ON*

1. Start to move at **homing switch position** in **positive direction** at **high velocity** until **after homing switch.**
2. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

If the positive/negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Limit switch signal + homing switch signal + Z-signal mode

Mode 7

Diagram A: *Homing switch & positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until **homing switch valid.**
2. Move in **negative direction** at **low velocity** and stops after **homing switch** and **first encoder Z-signal valid.**

Diagram B: *Homing switch = ON, positive limit switch = OFF*

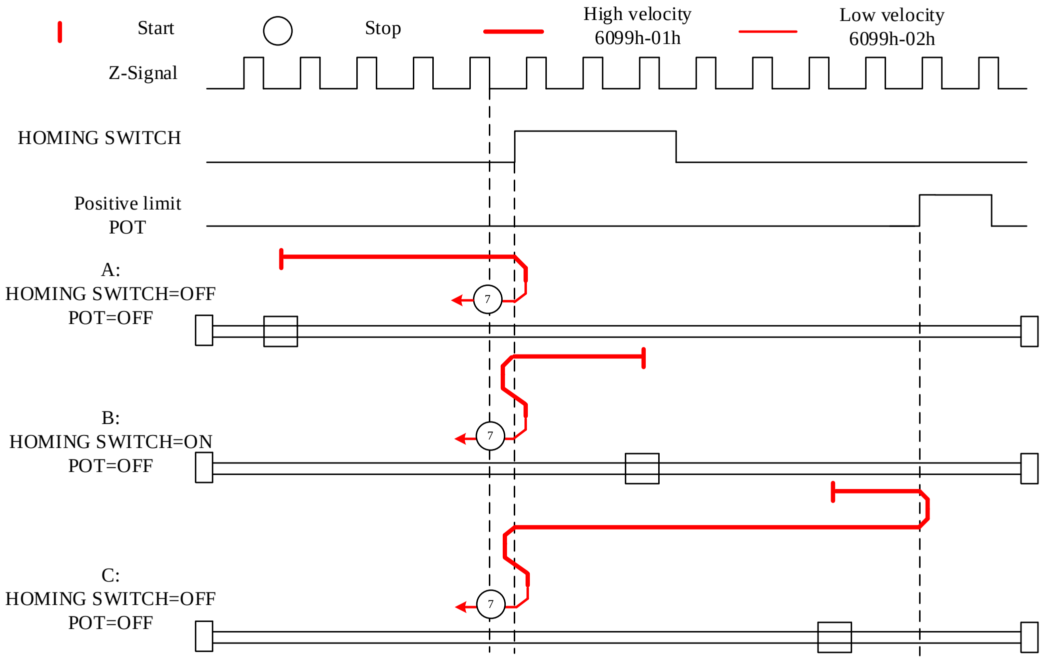
1. Start to move at **homing switch position** in **negative direction** at **high velocity** until **after homing switch.**
2. Move in **positive direction** at **high velocity** until **homing switch valid.**
3. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first**

encoder Z-signal valid

Diagram C: *Homing switch & positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until **positive limit switch valid**.
2. Move in **negative direction** at **high velocity** until **after homing switch**.
3. Move in **positive direction** at **high velocity** until **homing switch valid**.
4. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first encoder Z signal valid**

If the negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 8

Diagram A: *Homing switch & positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until **homing switch valid.**
2. Move in **negative direction** at **high velocity** until **after homing switch.**
3. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

Diagram B: *Homing switch = ON, positive limit switch = OFF*

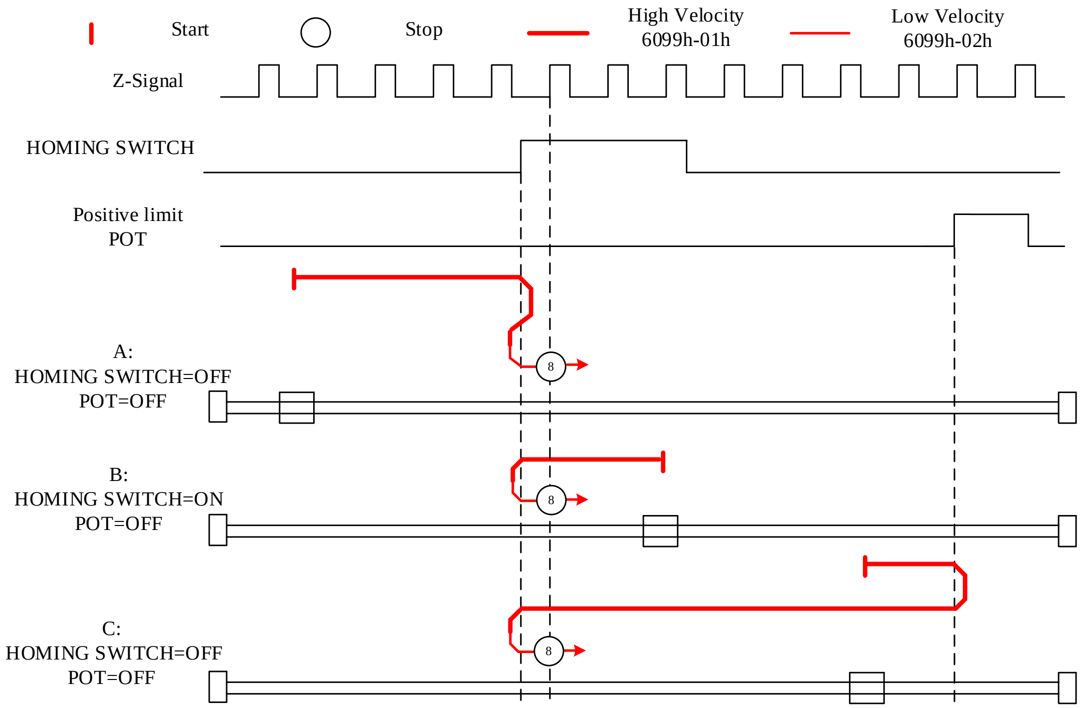
1. Start to move at **homing switch position** in **negative direction** at **high velocity** until **after homing switch.**
2. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

Diagram C: *Homing switch & positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until **positive limit switch valid**.

2. Move in **negative direction** at **high velocity** until **after homing switch**.
3. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

If the negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 9

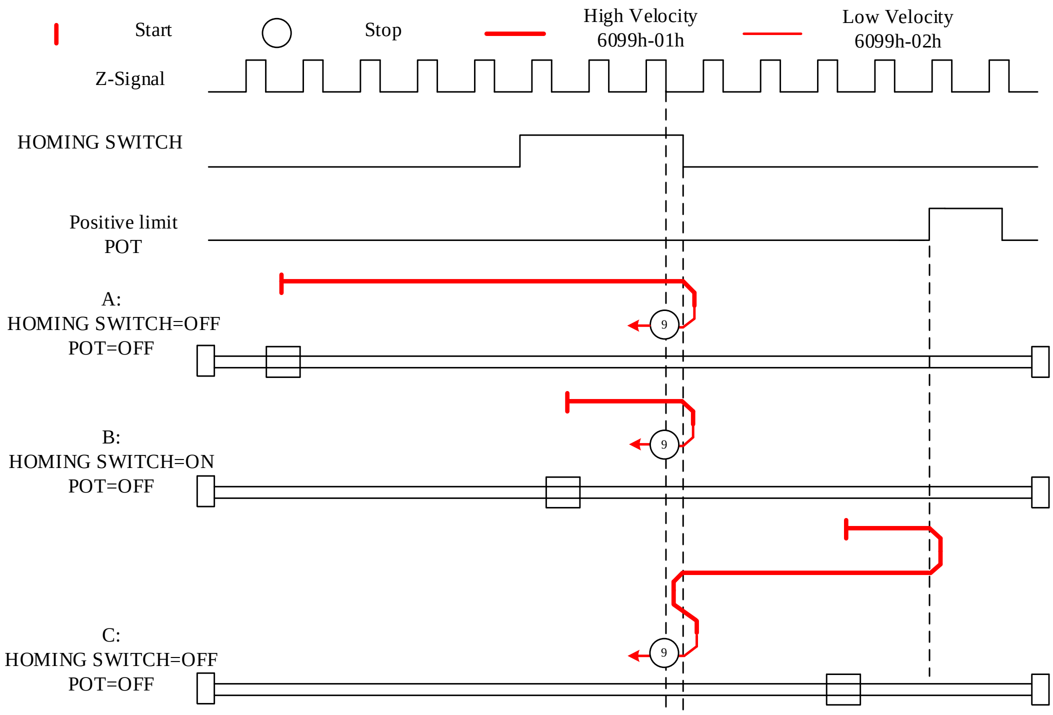
Diagram A: *Homing switch & positive limit switch = OFF*
1. Move in **positive direction** at **high velocity** until **after homing switch.**
2. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

Diagram B: *Homing switch = ON, positive limit switch = OFF*
1. Start to move at **homing switch position** in **positive direction** at **high velocity** until **homing switch invalid.**
2. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

Diagram C: *Homing switch & positive limit switch = OFF*
1. Move in **positive direction** at **high velocity** until **positive limit switch valid**.
2. Move in **negative direction** at **high velocity** until **homing switch valid**.
3. Move in **positive direction** at **high velocity** until **after homing switch**.
4. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first**

encoder Z signal valid

If the negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 10

Diagram A: *Homing switch & positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until **after homing switch.**
2. Move in **negative direction** at **high velocity** until **homing switch valid.**
3. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid.**

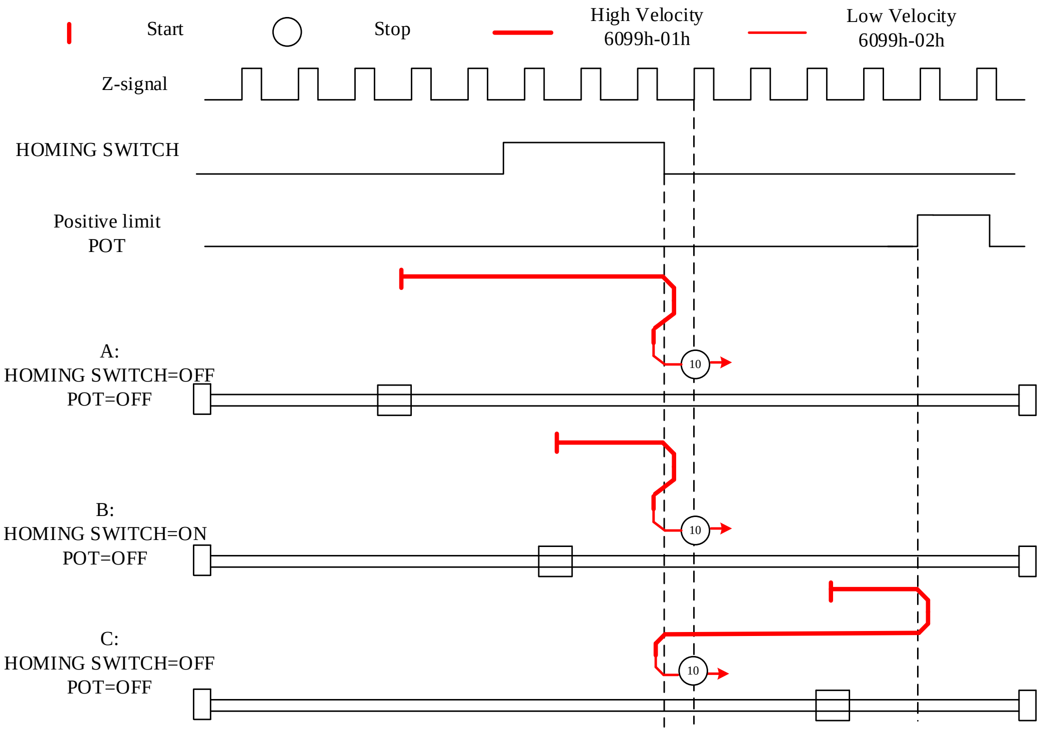
Diagram B: *Homing switch = ON, positive limit switch = OFF*

1. Start to move at **homing switch position** in **positive direction** at **high velocity** until **after homing switch.**
2. Move in **negative direction** at **high velocity** until **homing switch valid.**
3. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

Diagram C: *Homing switch & positive limit switch = OFF*

1. Move in **positive direction** at **high velocity** until positive **limit switch valid**.
2. Move in **negative direction** at **high velocity** until **homing switch valid**.
3. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z signal valid**

If the negative limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 11

Diagram A: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **homing switch valid.**

2. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

Diagram B: *Homing switch = ON, negative limit switch = OFF*

1. Start to move at **homing switch position** in **positive direction** at **high velocity** until **after homing switch.**

2. Move in **negative direction** at **high velocity** until **homing switch valid.**

3. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid**

Diagram C: *Homing switch & negative limit switch = OFF*

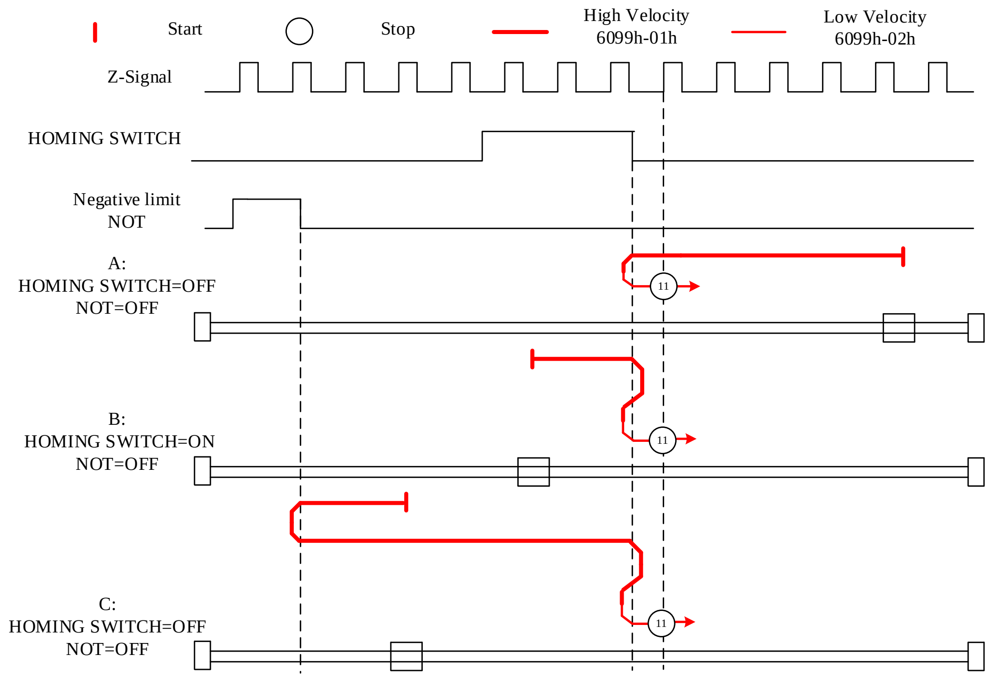
1. Move in **negative direction** at **high velocity** until the **negative limit switch valid**.

2. Move in **positive direction** at **high velocity** until **homing switch invalid**.

3. Move in **negative direction** at **high velocity** until **homing switch valid**.

4. Move in **positive direction** at **low velocity** and stops **after homing switch** and **first encoder Z signal valid**

If the positive limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 12

Diagram A: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **homing switch valid.**
2. Move in **positive direction** at **high velocity** until **after homing switch.**
3. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**

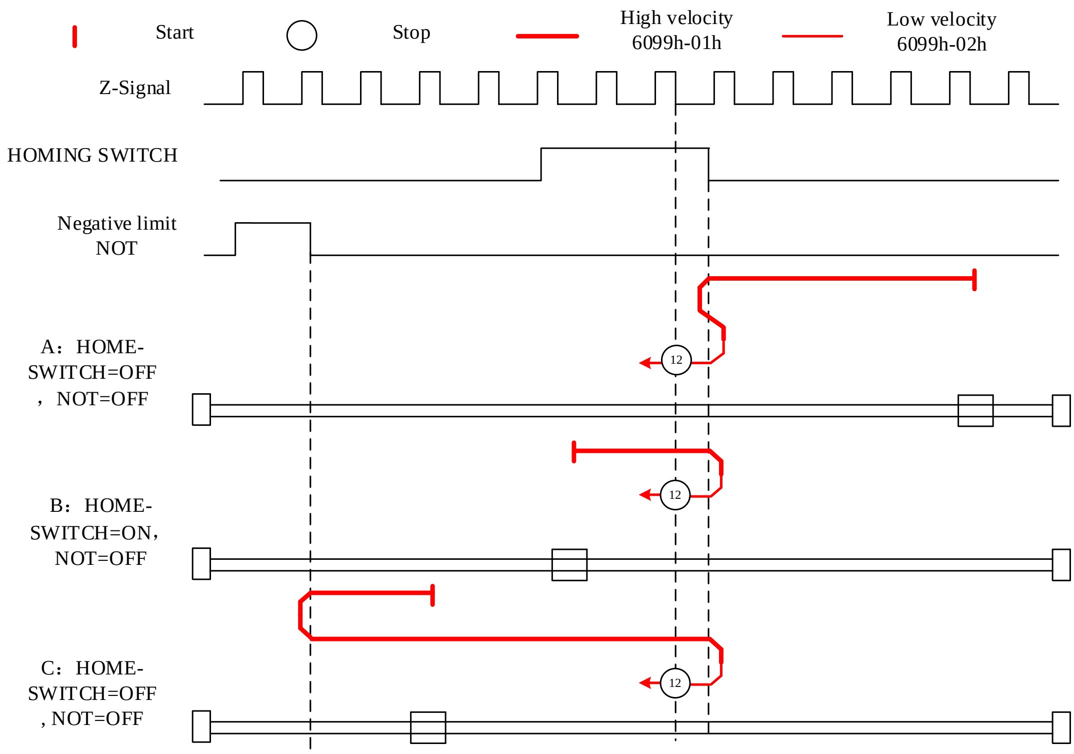
Diagram B: *Homing switch = ON, negative limit switch = OFF*

1. Move at **homing switch position** in **negative direction** at **high velocity** until **after homing switch**.
2. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

Diagram C: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **negative limit switch valid.**
2. Move in **positive direction** at **high velocity** until **after homing switch**.
3. Move in **negative direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

If the positive limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 13

Diagram A: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **after homing switch**.
2. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid**.

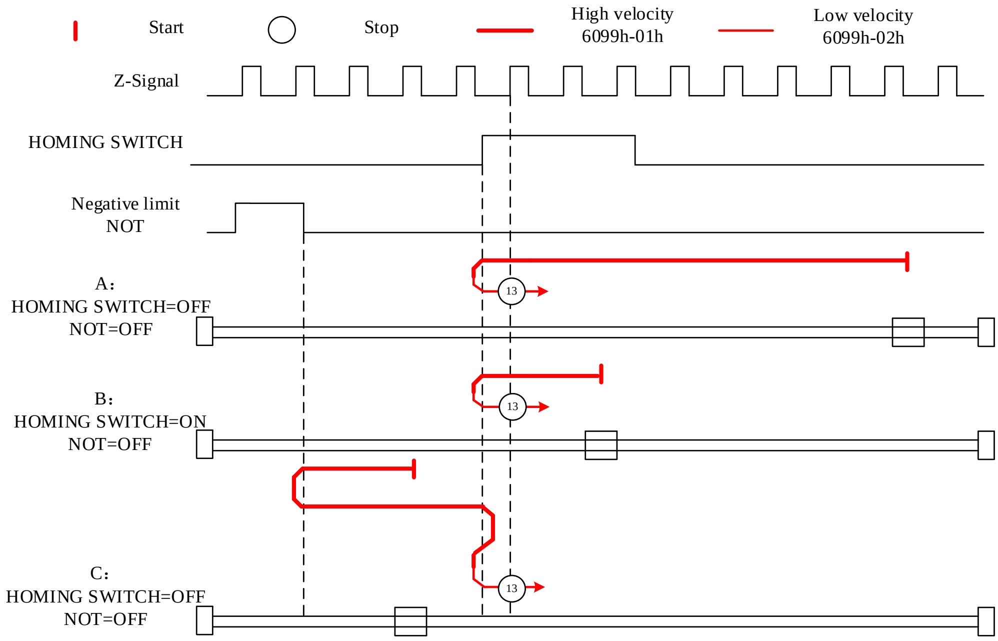
Diagram B: *Homing switch = ON, negative limit switch = OFF*

1. Start to move at **homing switch position** in **negative direction** at **high velocity** until **after homing switch.**
2. Move in positive **direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

Diagram C: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **negative limit switch valid**.
2. Move in **positive direction** at **high velocity** until **homing switch valid**.
3. Move in **negative direction** at **high velocity** until **after homing switch**.
4. Move in **positive direction** at **low velocity** and stops after **homing switch valid** and **first encoder Z-signal valid.**

If the positive limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 14

Diagram A: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **after homing switch**.
2. Move in **positive direction** at **high velocity** until **homing switch valid**.
3. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid.**

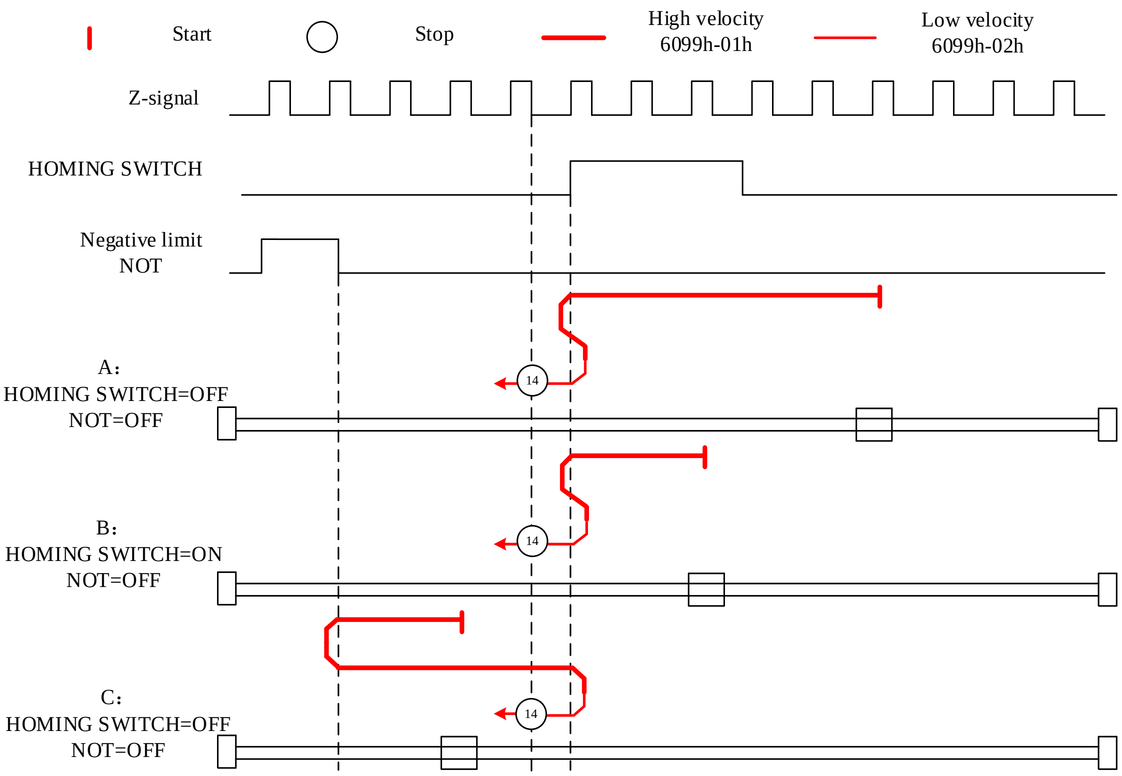
Diagram B: *Homing switch = ON, negative limit switch = OFF*

1. Start to move at **homing switch position** in **negative direction** at **high velocity** until **homing switch invalid**.
2. Move in **positive direction** until **homing switch valid**.
3. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first encoder Z signal valid.**

Diagram C: *Homing switch & negative limit switch = OFF*

1. Move in **negative direction** at **high velocity** until **negative limit switch valid**.
2. Move in **positive direction** at **high velocity** until **homing switch valid**.
3. Move in **negative direction** at **low velocity** and stops **after homing switch** and **first encoder Z-signal valid.**

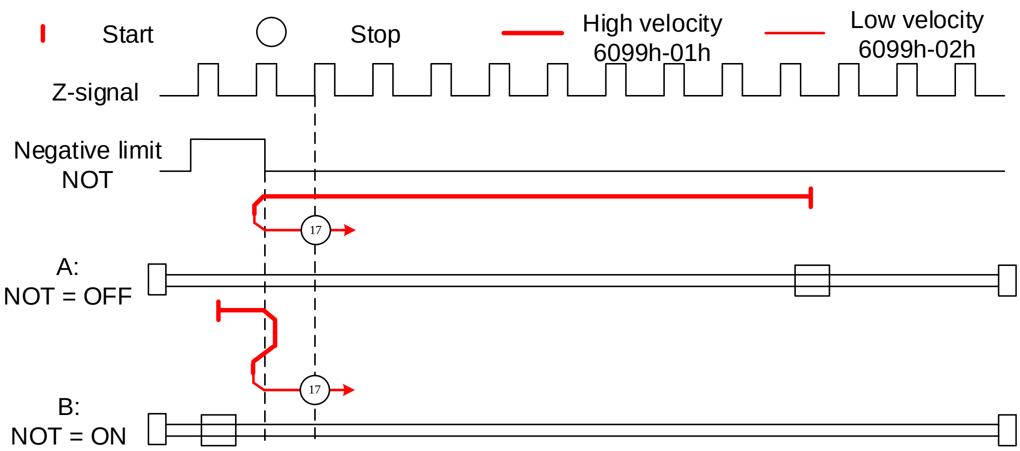
If the positive limit switch signal is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Limit switch signal triggering detection mode

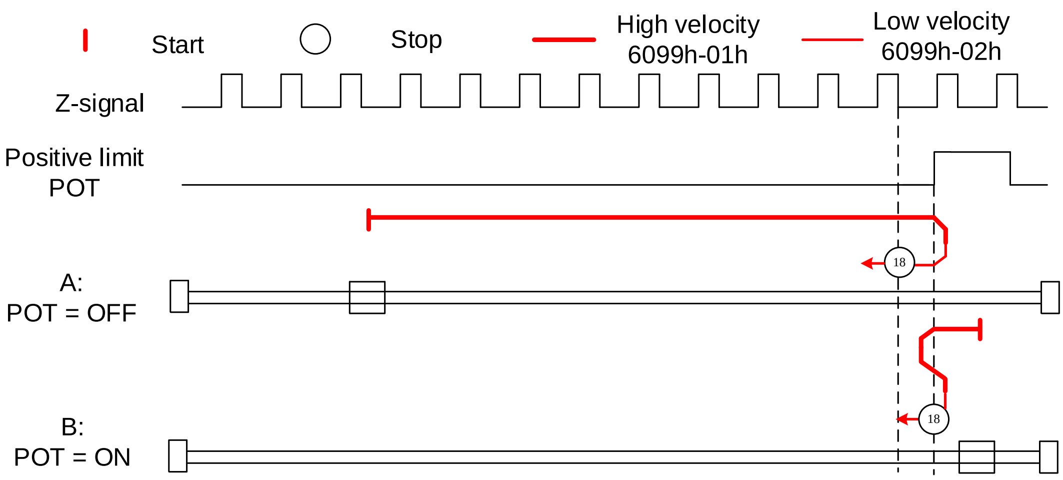
Mode 17:

This mode is similar to mode 1. Only difference is that homing point detection is not through Z-signal but through triggering of negative limit switch signal



Mode 18：

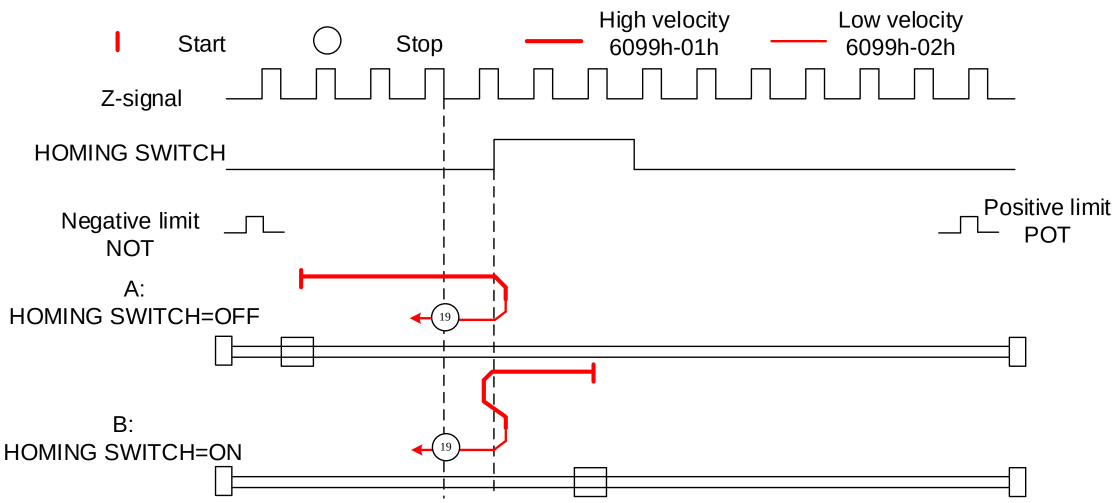
This mode is similar to mode 2. Only difference is that homing point detection is not through Z-signal but through switching of positive limit switch signal



Homing switch signal triggering detection mode

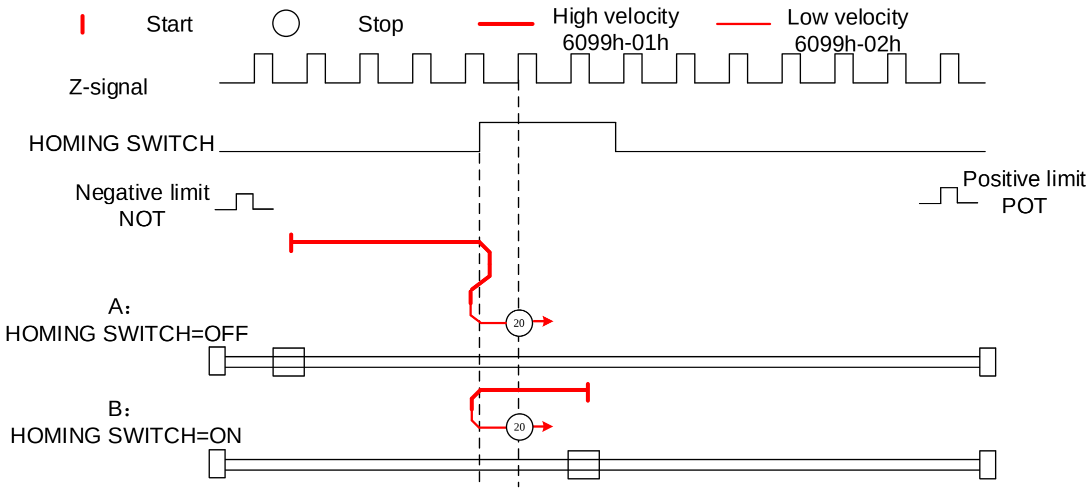
Mode 19：

This mode is similar to mode 3. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



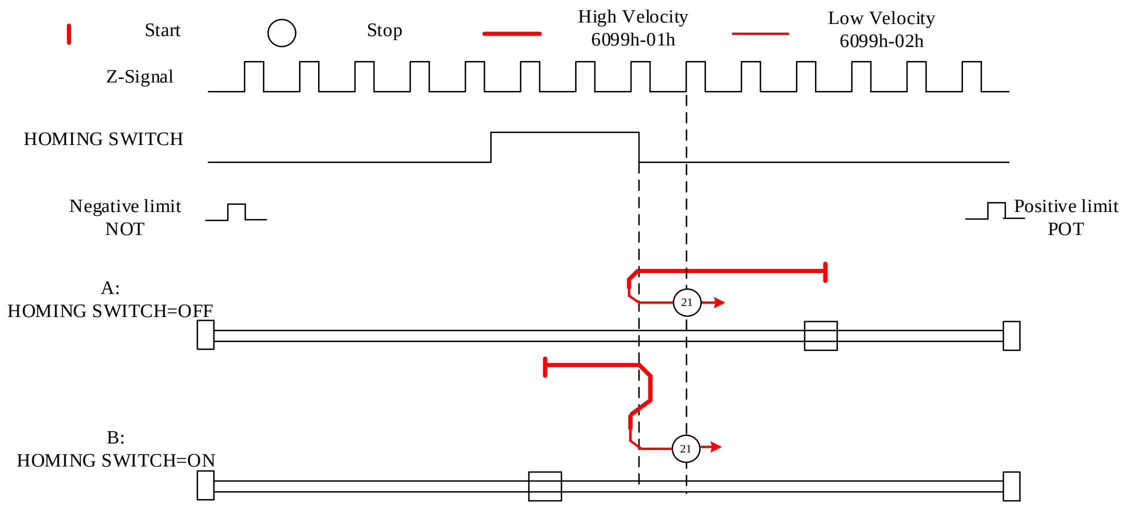
Mode 20:

This mode is similar to mode 4. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



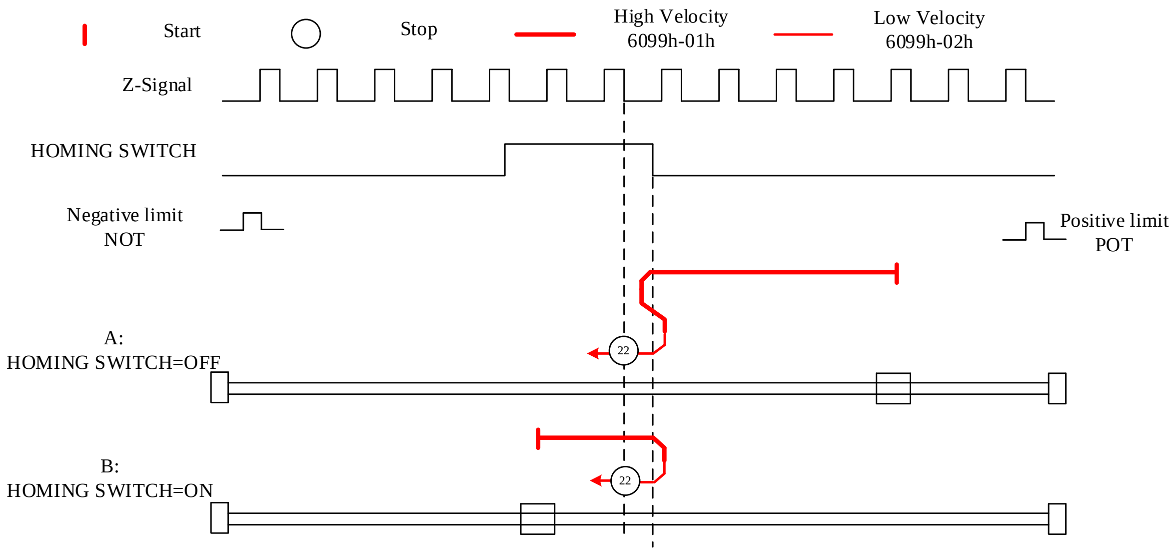
Mode 21:

This mode is similar to mode 5. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal.



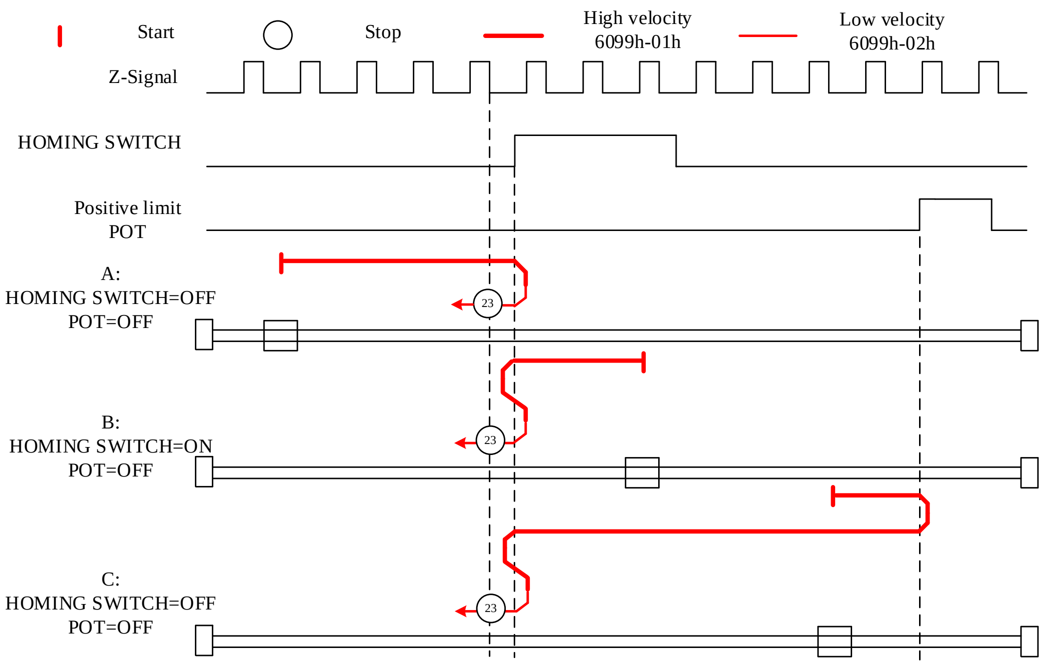
Mode 22:

This mode is similar to mode 6. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal.



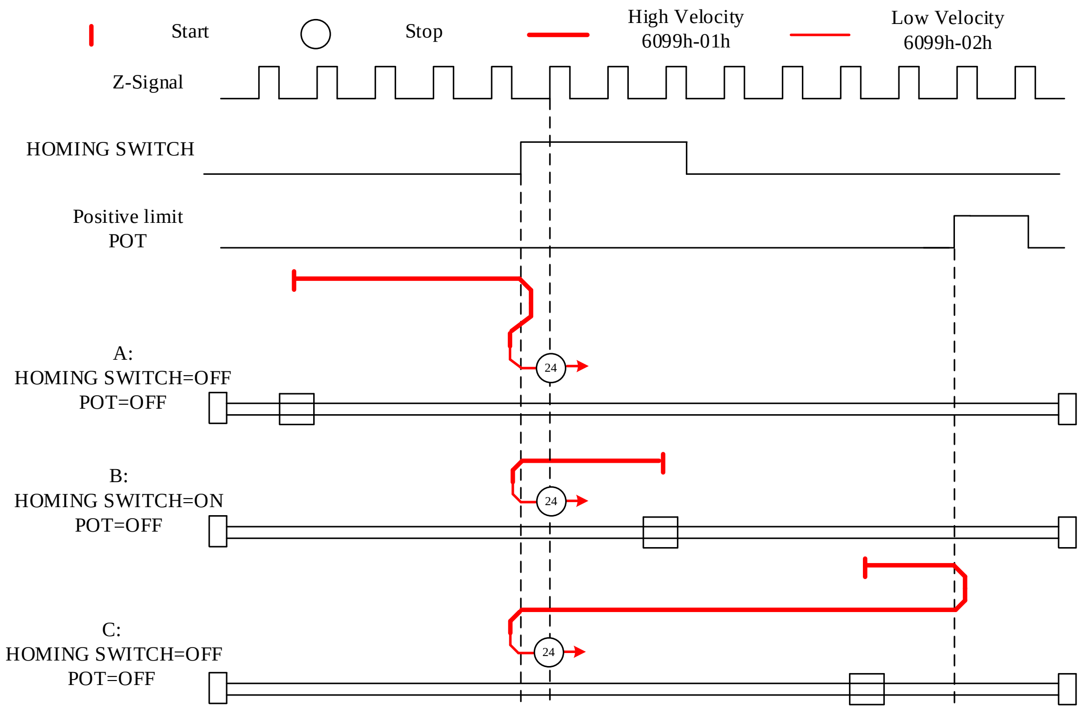
Mode 23:

This mode is similar to mode 7. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal.



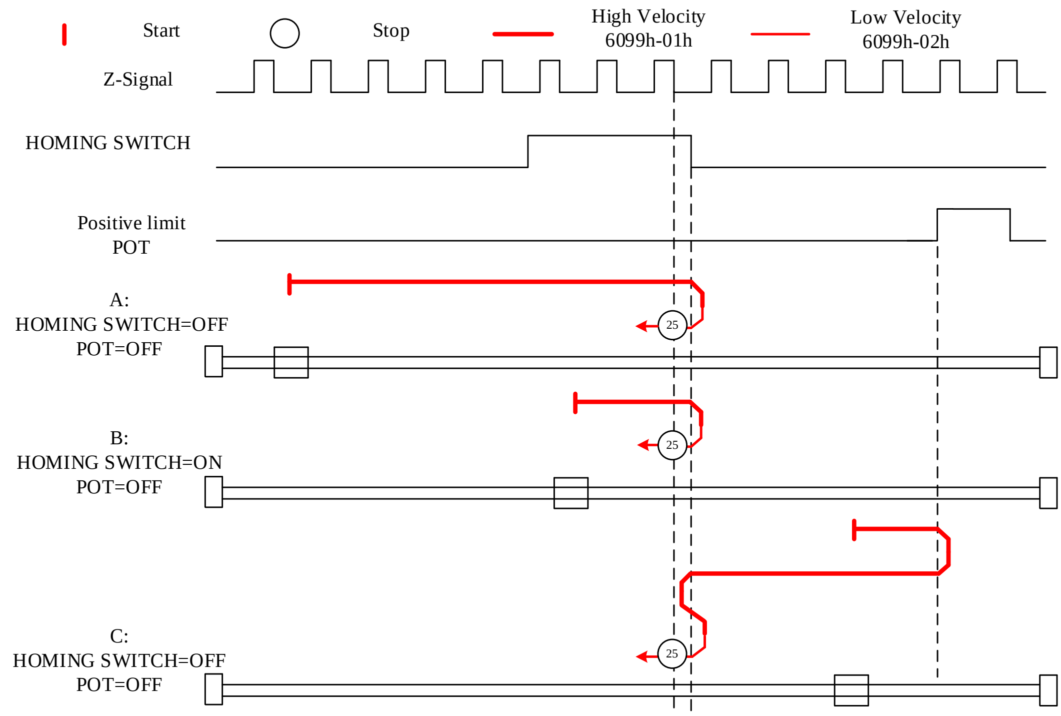
Mode 24:

This mode is similar to mode 8. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal.



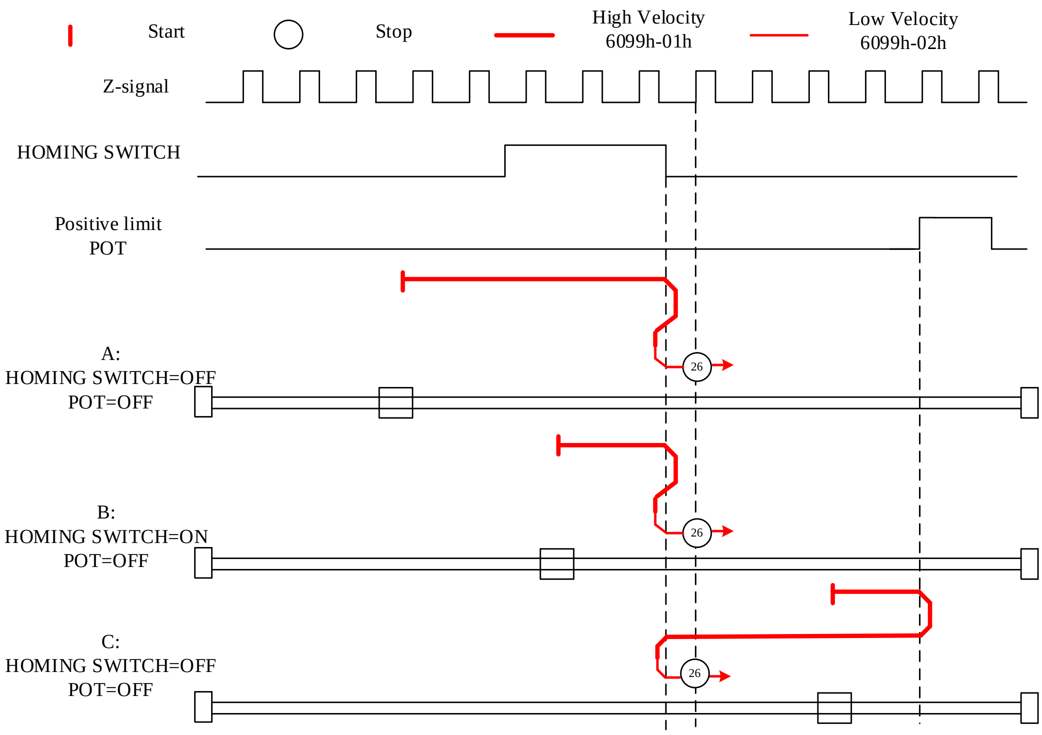
Mode 25:

This mode is similar to mode 9. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



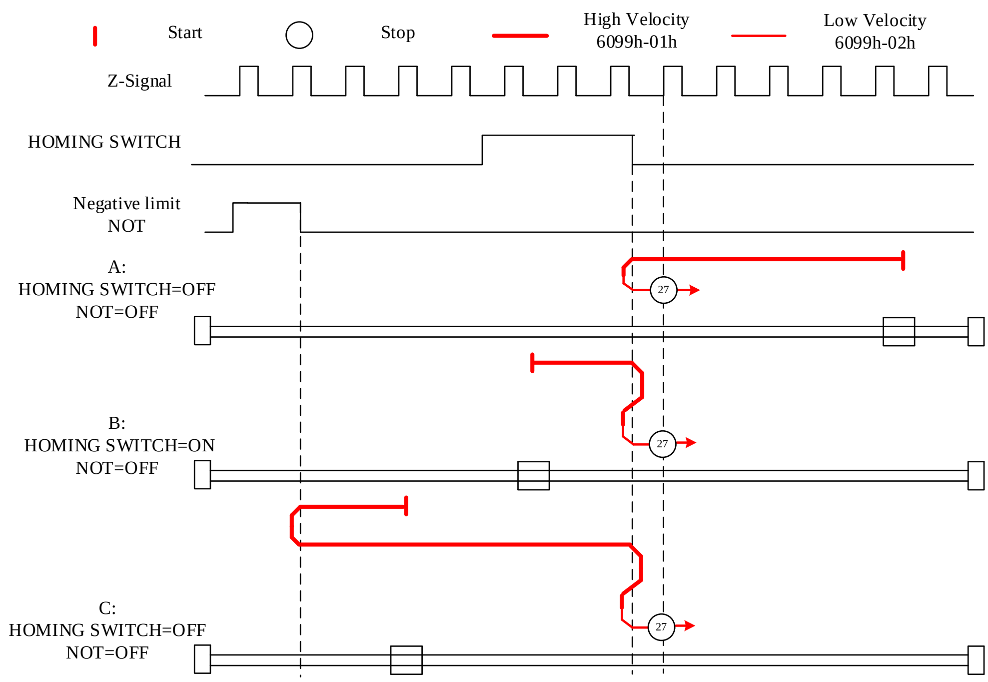
Mode 26:

This mode is similar to mode 10. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



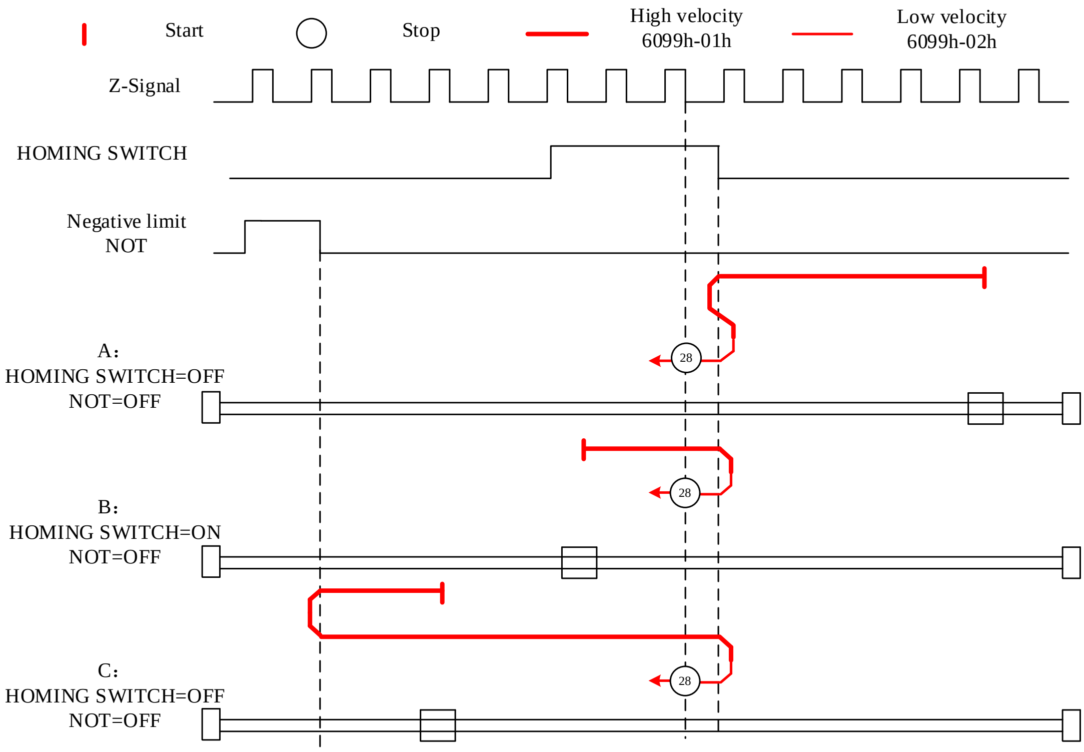
Mode 27:

This mode is similar to mode 11. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



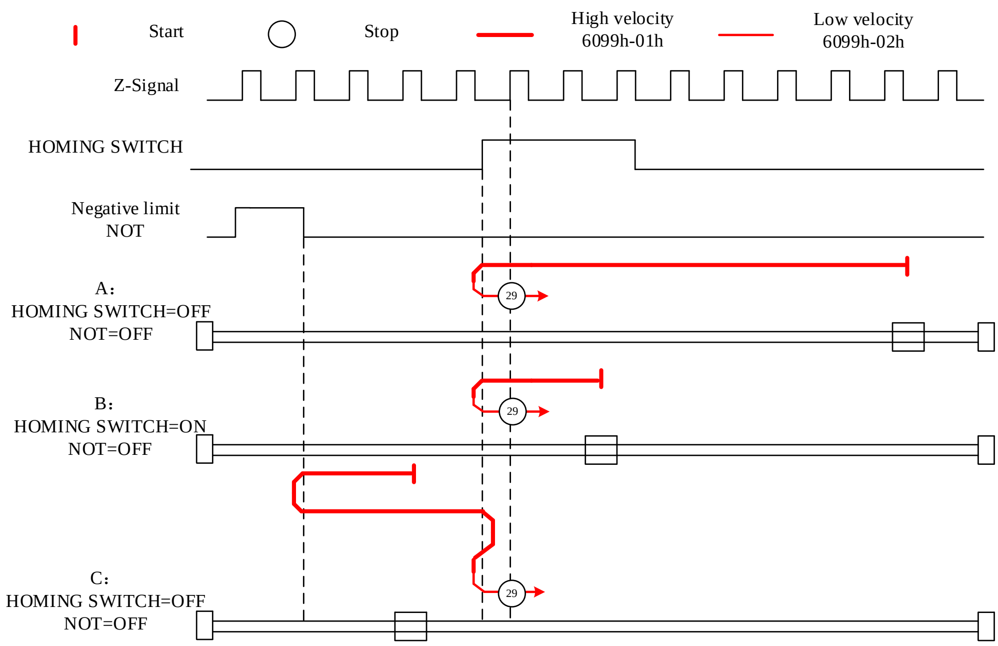
Mode 28:

This mode is similar to mode 12. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



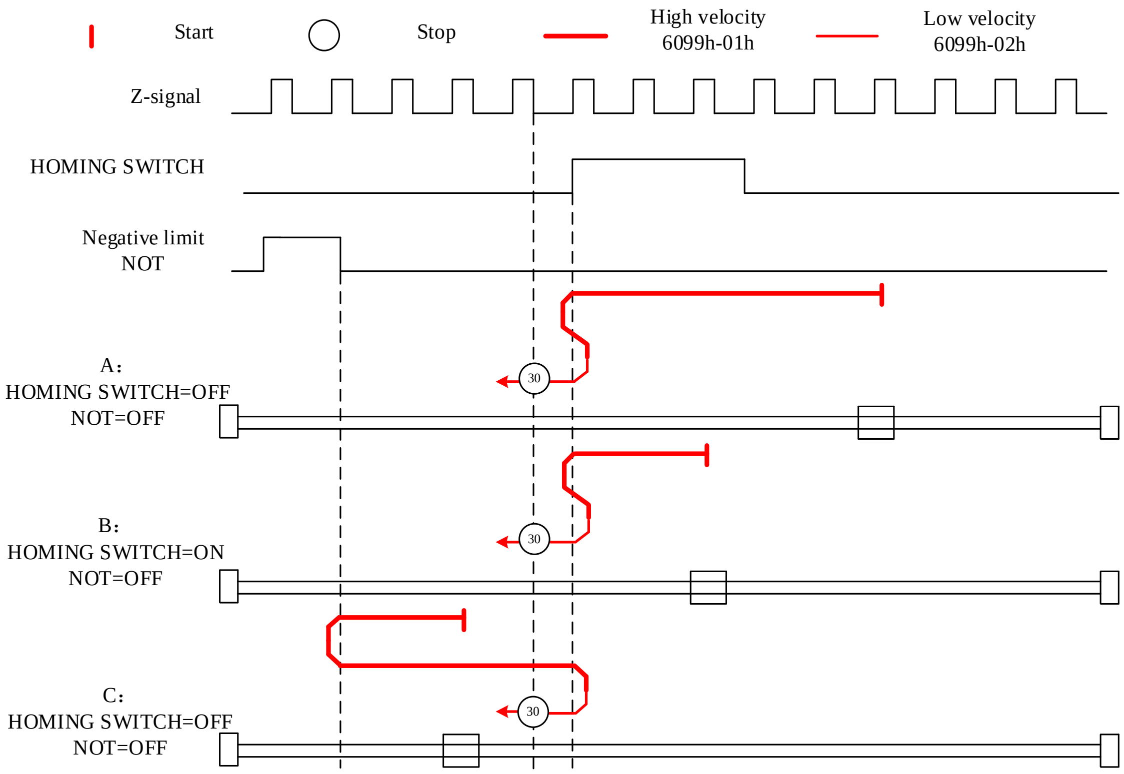
Mode 29:

This mode is similar to mode 13. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal



Mode 30:

This mode is similar to mode 14. Only difference is that homing point detection is not through Z-signal but through triggering of homing switch signal

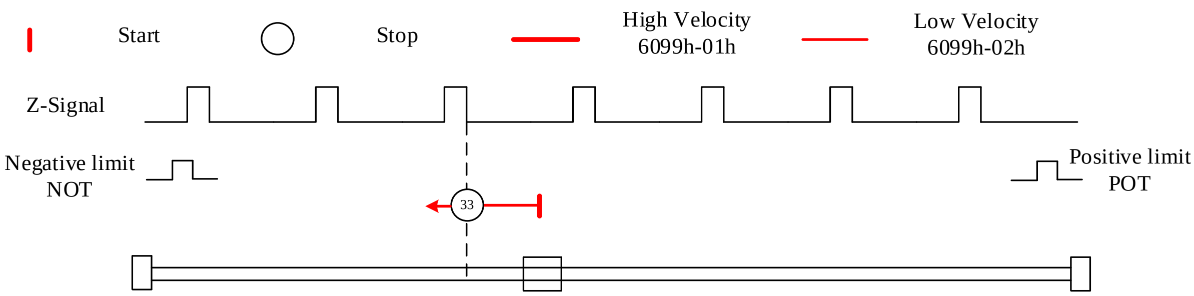


Other modes

Mode 33:

The motor starts to move in **negative direction** and stops when the **Z-signal is valid**.

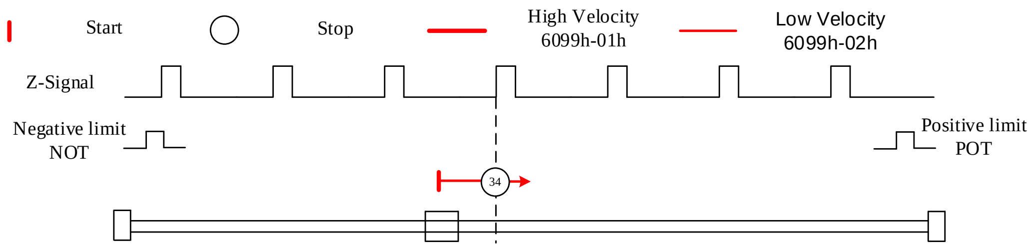
If the positive/negative limit switch signal or homing switch is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 34:

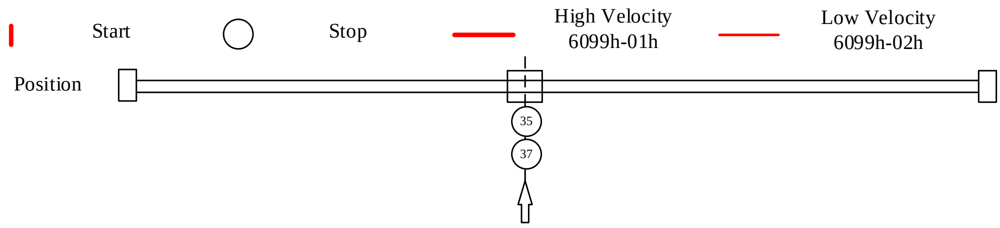
The motor starts to move in **positive direction** and stops when the **Z-signal is valid**.

If the positive/negative limit switch signal or homing switch is valid during the homing process, the status word (6041h) bit 13 will be valid, indicating homing error and the motor will stop immediately.



Mode 35/37:

Set the current position as homing point. Using this mode, motor doesn't have to be enabled. Set control word 6040h bit 4 from 0 to 1.



Application: Realization of homing motion

Step 1: 6060h = 6, determine if 6061h = 6. Servo driver is now under HM mode.

Step 2: Write motion parameters: Homing method 6098h, Homing velocity 6099h-01/6099h-02 and acceleration/deceleration 609Ah.

Step 3: Enable servo driver and switch bit 4 from 0 to 1 to start homing motion.

5.6 Velocity Control Mode（CSV、PV）

5.6.1 Common Functions of Velocity Control

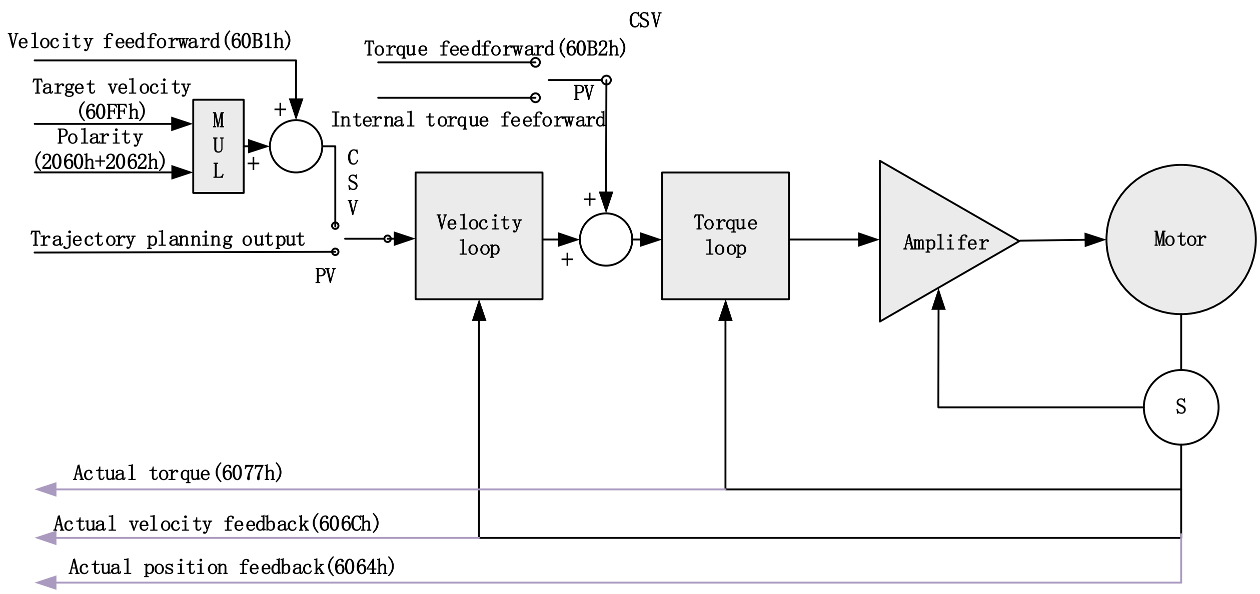
Index	Sub Index	Name	Access	PDO	Mode	
					CSV	PV
6040	0	Control word	RW	RxPDO	Yes	Yes
6072	0	Max torque	RW	RxPDO	Yes	Yes
6080	0	Maximum motor velocity	RW	RxPDO	Yes	Yes
60B1	0	Velocity feedforward (Restricted by 6080)	RW	RxPDO	Yes	Yes

60B2	0	Torque feedforward	RW	RxPDO	Yes	Yes
60FF	0	Target velocity (Restricted by 6080)	RW	RxPDO	Yes	Yes

Index	Sub Index	Name	Access	PDO	Mode	
					CSV	PV
6041	0	Status word	RO	TxPDO	Yes	Yes
6063	0	Actual internal position	RO	TxPDO	Yes	Yes
6064	0	Actual feedback position	RO	TxPDO	Yes	Yes
606B	0	Internal command velocity	RO	TxPDO	Yes	Yes
606C	0	Actual feedback velocity	RO	TxPDO	Yes	Yes
6074	0	Internal torque command	RO	TxPDO	Yes	Yes
6076	0	Rated torque	RO	TxPDO	Yes	Yes
6077	0	Actual torque	RO	TxPDO	Yes	Yes

5.6.2 Cyclic Synchronous Velocity Mode (CSV)

CSV Block Diagram



Related Objects

Basic object

PDO	Index+Sub-Index	Name	Data Type	Access	Unit	Remarks
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	60FF-00h	Target velocity	I32	RW	Uint	Required
	60B1-00h	Velocity feedforward	I32	RW	Uint /S	Optional
	60B2-00h	Torque feedforward	I16	RW	0.1%	Optional
(TXPDO)	6041-00h	Status word	U16	RO	—	Required
	6064-00h	Actual position feedback	I32	RO	Uint	Optional
	606C-00h	Actual speed feedback	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Optional

Extended object

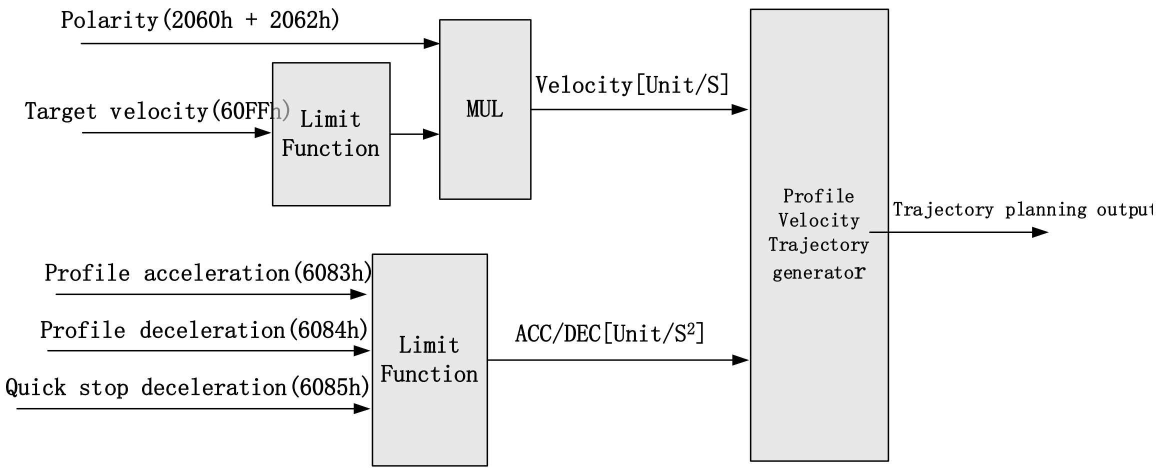
Index+Sub-Index	Name	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
606B-00h	Internal command velocity	I32	RO	Uint
605A-00h	Quick stop option	I16	RW	—
6085-00h	Quick stop deceleration	U32	RW	Uint /S

5.6.3 Profile Velocity Mode (PV)

In asynchronous motion mode, master device is only responsible for sending motion parameters and control commands.EL7-EC servo drive will conduct trajectory planning according to the motion parameters sent by master device after receiving the motion start command from the master device. In asynchronous motion mode, the motion between each axes is asynchronous.

PV Block Diagram

The difference between PV and CSV mode is that PV needs EL7-EC to have the function of trajectory generator. The input and output structure of the trajectory generator is shown in figure 7.8



Related Objects

Basic object

PDO	Index+Sub-Index	Name	Data Type	Access	Unit	Notes
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	60FF-00h	Target velocity	I32	RW	Uint	Required
	6083-00h	Acceleration	I32	RW	Uint /S	Optional
(TXPDO)	6041-00h	Status word	U16	RO	—	Required
	6064-00h	Position feedback	I32	RO	Uint	Optional
	606C-00h	Velocity feedback	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Optional

Extended object

Index+Sub-Index	Name	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
605A-00h	Quick stop option	I16	RW	—
6084-00h	Deceleration	U32	RW	Uint /S
6085-00h	Quick stop deceleration	U32	RW	Uint /S

Control Word and Status Word for Profile Velocity Mode

The bit6~4 of control words (6040h) associated with the control mode in PV mode are invalid. The motion in PV mode can be triggered as long as the motion parameters (target velocity (60FFh) ACC/DEC (6083h/6084h)) are given after the axis is enabled.

Table7. Bit15~12、10、8 of Status word (6041h) for Profile Velocity Mode

Bit (Label)	Value	Details
8 (Quick stop)	0	Quick stop invalid
	1	Quick stop valid
10 (Velocity reached)	0	Velocity not yet reached
	1	Velocity reached
12 (Zero speed)	0	It's not zero speed. It's moving.
	1	Zero speed or it's going to slow down to zero speed *1)

*1) Zero speed of bit 12 is generally effective when deceleration stop and hardware limit valid.

Application: Realization of profile velocity motion

Step 1: 6060h = 3, determine if 6061h = 3. Servo driver is now under PV mode.
Step 2: Write motion parameters: Target velocity 60FFh, acceleration 6083h and deceleration 6084h.

5.7 Torque Mode（CST、PT）

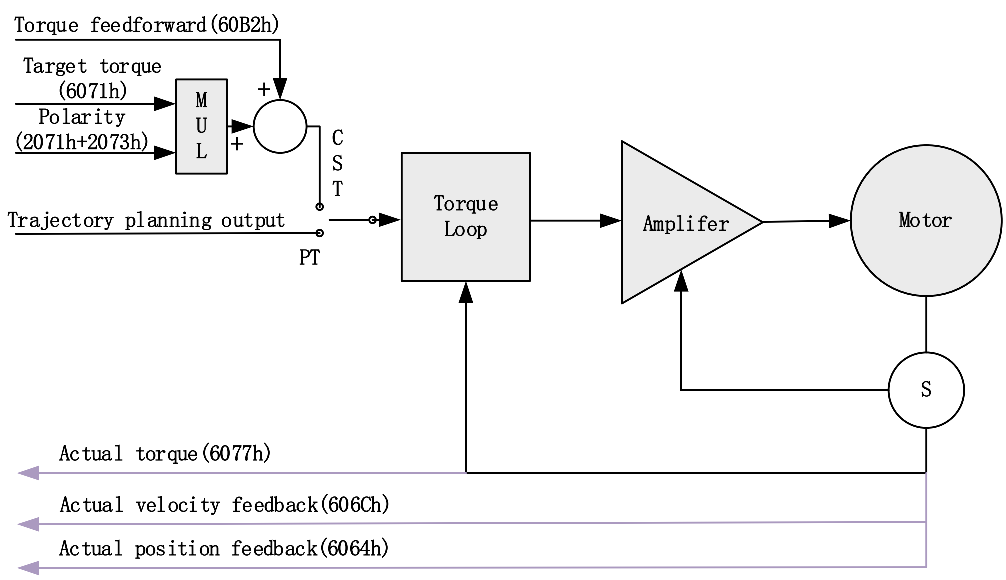
5.7.1 Common Functions of Torque Mode

Index	Sub Index	Label	Access	PDO	Mode	
					CST	PT
6040	0	Control word	RW	RxPDO	Yes	Yes
6071	0	Target torque	RW	RxPDO	Yes	Yes
6072	0	Max torque	RW	RxPDO	Yes	Yes
6080	0	Maximum motor speed	RW	RxPDO	Yes	Yes
6087	0	Torque change rate	RW	RxPDO	Yes	Yes
60B2	0	Torque feedforward	RW	RxPDO	Yes	Yes

Index	Sub Index	Label	Access	PDO	Mode	
					CST	PT
6041	0	Status word	RO	TxPDO	Yes	Yes
6063	0	Actual internal position	RO	TxPDO	Yes	Yes
6064	0	Actual feedback position	RO	TxPDO	Yes	Yes
606C	0	Actual feedback velocity	RO	TxPDO	Yes	Yes
6074	0	Internal torque command	RO	TxPDO	Yes	Yes
6075	0	Rated current	RO	No	Yes	Yes
6076	0	Rated torque	RO	No	Yes	Yes
6077	0	Actual torque	RO	TxPDO	Yes	Yes
6079	0	Bus voltage	RO	TxPDO	Yes	Yes

5.7.2 Cyclic Synchronous Torque Mode (CST)

CST Block Diagram



Related Objects

Basic object

PDO	Index+Sub-Index	Name	Data Type	Access	Unit	Remarks
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	6071-00h	Target torque	I16	RW	Uint	Required

	6087-00h	Torque feed-forward	U32	RW	0.1%/S	Optional
(TXPDO)	6041-00h	Status word	U16	RO	—	Required
	6064-00h	Actual position feedback	I32	RO	Uint	Optional
	606C-00h	Actual velocity feedback	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Required

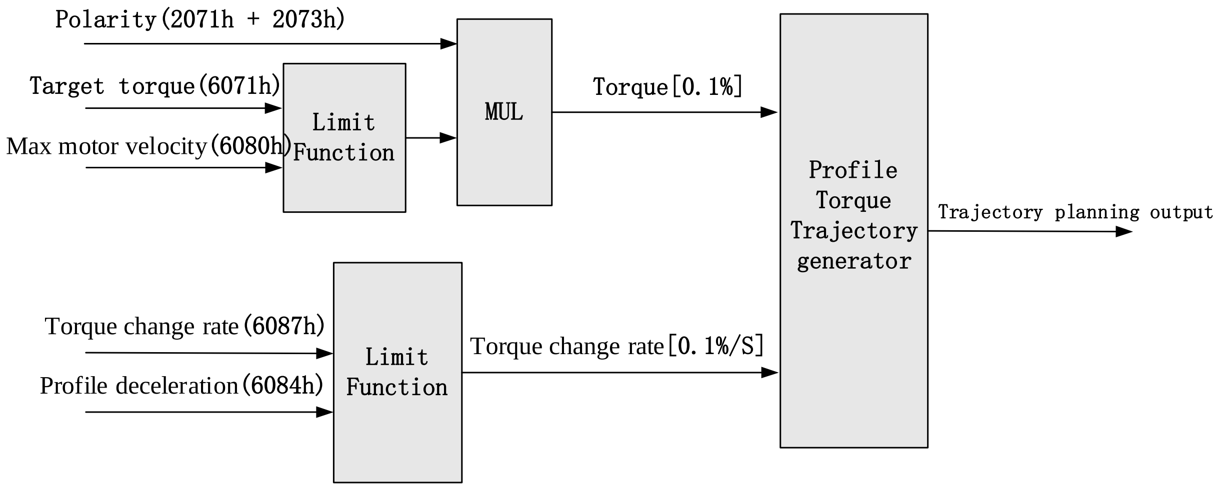
Extended object

Index+Sub-Index	Name	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
6074-00h	Internal command torque	I16	RO	0.1%
605A-00h	Quick stop option	I16	RW	—
6080-00h	Maximum motor velocity	U32	RW	Uint /S
6085-00h	Quick stop deceleration	U32	RW	Uint /S
60B1-00h	Velocity feedforward	I32	RW	Uint /S
2077-00h	Velocity limit	I16	RW	RPM

5.7.3 Profile Torque Mode (PT)

In asynchronous motion mode, master device is only responsible for sending motion parameters and control commands.EL7-EC servo drive will conduct trajectory planning according to the motion parameters sent by master device after receiving the motion start command from the master device. In asynchronous motion mode, the motion between each axes is asynchronous.

PT Block Diagram



Related Objects

Basic object

PDO	Index+Sub-Index	Label	Data Type	Access	Unit	Notes
(RXPDO)	6040-00h	Control word	U16	RW	—	Required
	6071-00h	Target torque	I16	RW	0.1%	Required
	6087-00h	Torque change rate	U32	RW	0.1%/S	Optional
(TXPDO)	6041-00h	Status word	U16	RO	—	Required
	6064-00h	Actual feedback position value	I32	RO	Uint	Optional
	606C-00h	Actual feedback speed value	I32	RO	Uint /S	Optional
	60F4-00h	Actual following error	I32	RO	Uint	Optional
	6077-00h	Actual torque	I16	RO	0.1%	Optional

Extended object

Index+Sub-Index	Label	Data Type	Access	Unit
603F-00h	Error code	U16	RO	—
6060-00h	Operation mode	I8	RW	—
6061-00h	Displayed operation mode	I8	RO	—
6074-00h	Internal command torque	I16	RO	0.1%
6080-00h	Maximum motor velocity	U32	RW	Uint /S
605A-00h	Quick stop option	I16	RW	—
6085-00h	Quick stop deceleration	U32	RW	Uint /S

2077-00h	Velocity limit	I16	RW	RPM

Application: Realization of profile torque motion

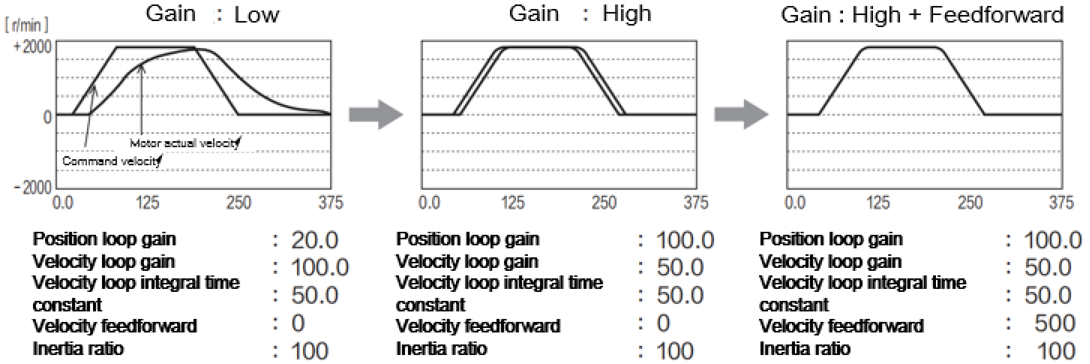
Step 1: 6060h = 4, determine if 6061h = 4. Servo driver is now under PT mode.

Step 2: Write motion parameters: Target torque 6071h, Torque change rate 6087h, and Max. velocity limit 6080h

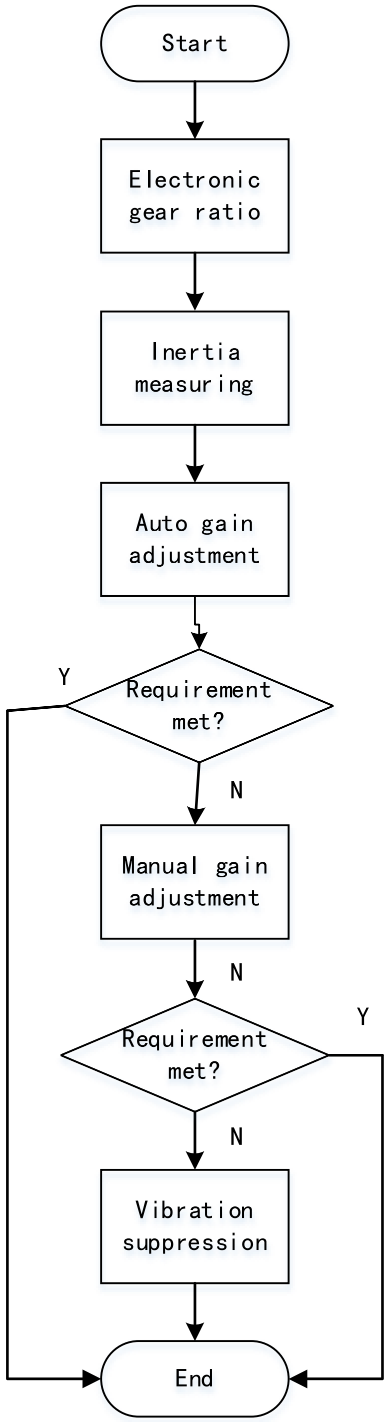
Chapter 6 Application

6.1 Gain Adjustment

In order for servo driver to execute commands from master device without delay and to optimize machine performance, gain adjustment has to be done.



Servo driver gain adjustment is done in combination with a few other parameters (Inertia ratio, Position loop gain, Velocity loop gain and Filters settings). These parameters will have an effect on each other so it always advisable to tune each parameter according in order to achieve optimal machine performance. Please refer to the steps below



Steps	Functions	Explanation
Inertia measuring	Online	Motor moves with command from controller, servo driver will automatically calculate load-inertia ratio
	Offline	Using servo driver inertia determining function, servo driver can automatically calculate load-inertia ratio
Auto gain adjustment	Auto gain adjustment	Real time determining of mechanical load, gain value is set accordingly.

Manual gain adjustment	Basic gain	On top of auto gain adjustment, manually adjust related parameters so that machine can have better responsiveness and following
	Command pulse filter	Set filter for position, velocity and torque command pulse.
	Gain feedforward	Enable feedforward function to improve following behaviour
Vibration suppression	Mechanical resonance	Using notch filtering function to suppress mechanical resonance.

6.2 Inertia measuring function

Inertia ratio = Total mechanical load rotational inertia / Electronic gear rotational inertia

Inertia ratio is an important parameter. Setting a suitable value can help with the precise tuning of the servo system. Inertia ratio can be set manually and also be determined automatically through servo driver

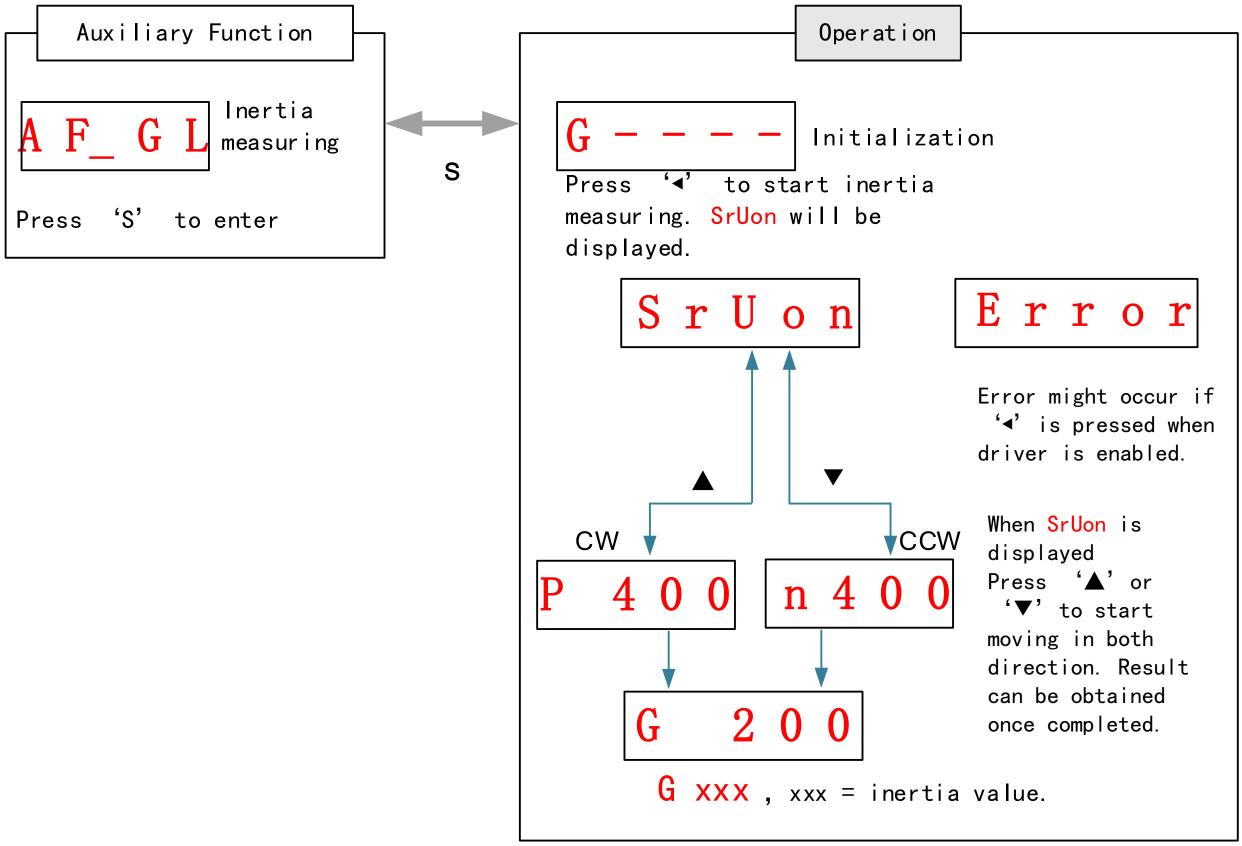
6.2.1 Online inertia determination

Enable motor using controller. Let motor run at above 400rpm, make sure there are acceleration, constant velocity and deceleration phase during the whole run. Cycle through 2-3 times to calculate load-inertia ratio. Result can be found on the front panel d16 or through Motion Studio system monitoring page. Enter the calculated value into Pr0.04 and save.

6.2.2 Offline inertia determination

Can be achieved through driver front panel or on Motion Studio.
Please make sure:
1. Servo driver is disabled.
2. Axis is within safe and allowed range and limit switch is not triggered prevent axis from over travelling.

6.2.3 Auxiliary function to determine inertia on front panel



Steps:

1、Set the trial run velocity **PA6.04**. Value set shouldn't be too large, please keep it at around **400 r/min**.

2、Enter AF_GL for auxiliary function – Inertia ratio determination into front panel

3、Press S once to enter. "G---" will be displayed on the front panel.

4、Press ◄ once to display "StUon"

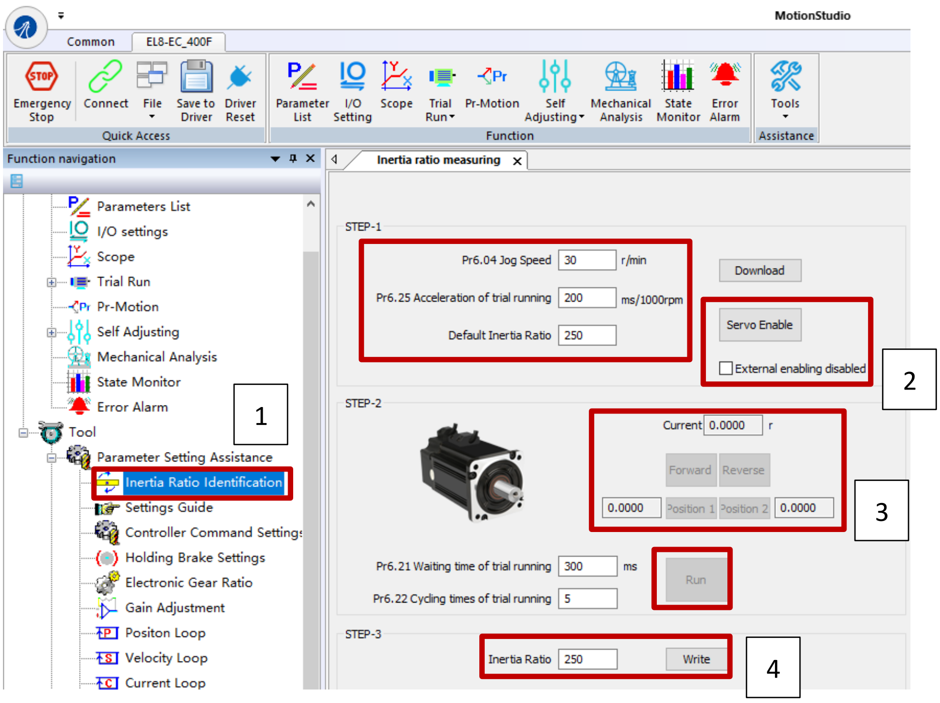
5、Press ▲ or ▼ once to start to calculate the inertia.

6、After the calculation is done, G **xxx** will be displayed and **xxx** is the value of inertia calculated.

7、Write the corresponding value into Pr0.04. Please refer to for parameter saving on servo driver.

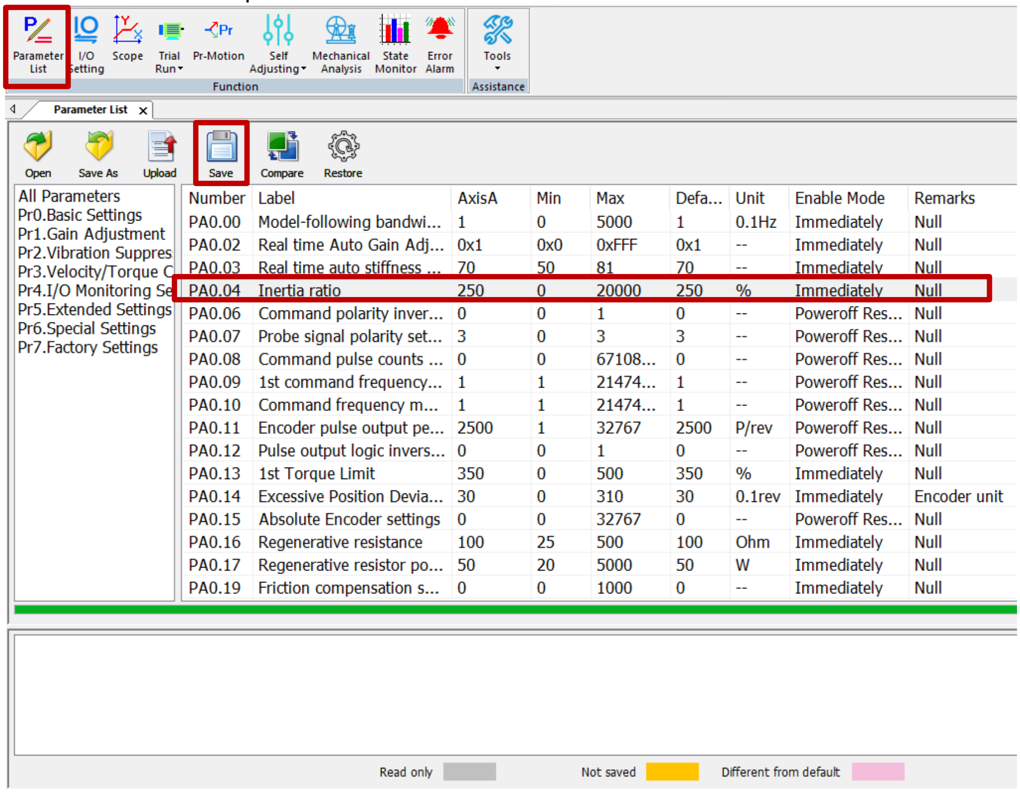
6.2.4 Inertia measuring using Motion Studio

1. Start Motion Studio and maneuver to inertia ratio identification page under performance tuning. Set trial run velocity Pr6.04 and acc-/deceleration time PA6.25, click on 'Upload' to upload parameters to servo driver.
2. Tick "Prohibit external enabling" and click on "servo on".
3. Click and hold "CCW" to start the motor. Current position will show motor cycles of revolution. Click on POS 1 to save current position as starting point. Click and hold "CW" to start the motor again. Click on POS 2 to save current position as ending point.
4. Set the waiting time between each cycle in Pr6.21 and no. of cycles in Pr6.22. Click on 'Run' and motor will run according to the parameters set.



5. After the calculation is done, inertia ratio will be calculated automatically and click on 'write' to enter the calculated value into Pr0.04.

6. Click on “Parameter List” to enter parameters management to check or modify Pr0.04. Then, click on “Save” to save parameters to driver.



Number	Label	AxisA	Min	Max	Defa...	Unit	Enable Mode	Remarks
PA0.00	Model-following bandwi...	1	0	5000	1	0.1Hz	Immediately	Null
PA0.02	Real time Auto Gain Adj...	0x1	0x0	0xFFF	0x1	--	Immediately	Null
PA0.03	Real time auto stiffness ...	70	50	81	70	--	Immediately	Null
PA0.04	Inertia ratio	250	0	20000	250	%	Immediately	Null
PA0.06	Command polarity inver...	0	0	1	0	--	Poweroff Res...	Null
PA0.07	Probe signal polarity set...	3	0	3	3	--	Poweroff Res...	Null
PA0.08	Command pulse counts ...	0	0	67108...	0	--	Poweroff Res...	Null
PA0.09	1st command frequency...	1	1	21474...	1	--	Poweroff Res...	Null
PA0.10	Command frequency m...	1	1	21474...	1	--	Poweroff Res...	Null
PA0.11	Encoder pulse output pe...	2500	1	32767	2500	P/rev	Poweroff Res...	Null
PA0.12	Pulse output logic invers...	0	0	1	0	--	Poweroff Res...	Null
PA0.13	1st Torque Limit	350	0	500	350	%	Immediately	Null
PA0.14	Excessive Position Devia...	30	0	310	30	0.1rev	Immediately	Encoder unit
PA0.15	Absolute Encoder settings	0	0	32767	0	--	Poweroff Res...	Null
PA0.16	Regenerative resistance	100	25	500	100	Ohm	Immediately	Null
PA0.17	Regenerative resistor po...	50	20	5000	50	W	Immediately	Null
PA0.19	Friction compensation s...	0	0	1000	0	--	Immediately	Null

Please take note:

1. Trial run velocity and distance should be optimal to prevent any axis from bumping into objects.

2. It is recommended to move only in 1 direction for vertically mounted axis. Take precaution before moving the axis.

3. For applications with higher frictional drag, please set a minimal travel distance.

PA0.04	**Label**	Inertia ratio	**Mode**	F		
	Range	0~20000	**Default**	250	**Unit**	%
	Activation	Immediate			**Index**	2004h

PA0.04=(load inertia/motor rotational inertia)×100%

Set inertia ratio according to actual load inertia. When both are uniform, actual motor velocity loop responsiveness and gain settings will be consistent. If inertia ratio is greater than actual value, velocity loop gain settings will be higher and vice versa.
For motor with high inertia, PA0.04 can be left unfilled but optimal setting of PA0.04 could improve system performance.

6.3 Auto gain adjustment

This function will measure real time mechanical properties and set gain values in accordance to mechanical stiffness. Can be used in any control mode

Conditions to implement	
Control mode	Please refer to PA0.02 for detailed explanations. Auto gain adjustment is different for each control mode.
Other	· Servo driver needs to be enabled · Set up input signals such as deviation counter clearing and command input; Torque limit and other motion control parameters to enable motor to move normally without obstacles.

Under certain conditions, external factors might affect automatic gain adjustment functions. If the conditions as listed exist or unfavorable, please disable the automatic gain adjustment function.

Affecting conditions	
Load inertia	· If inertia is less than 3 times or over 20 times of rotor inertia. · Changes in load inertia
Load	· Very low mechanical stiffness · If gear backlash is a non-linear property
Motion	· Velocity less than 100r/min or continuously in low velocity mode · Acc-/deceleration to 2000r/min within 1s. 。 · Acc-/deceleration torque lower than eccentric load, frictional torque. · Velocity < 100r/min, acc-/deceleration to 2000r/min within 1s but not longer than 50ms

To enable automatic gain adjustment:

1. Disable the servo driver.
2. Set PA0.02 = 0x01/0x11 or 0x02/0x12. Then, set PA0.03
3. Servo enabled. Run motion as normal to start measuring load properties.

Related parameters will be automatically set.

4. Increase motor responsiveness by increasing PA0.03. Please check if there is any vibration before setting PA0.03 to max. value.
5. Save the parameters.

Please take note:

- Please stop the motor before modifying any parameter. PA0.02 only takes effect after saving modified parameter values into EEPROM and restarting the driver.

- After enabling the servo driver for the first time or when increasing PA0.03,

mechanical noise or vibration might occur for the first run, it is normal. If it persists, please set PA0.03 to lower value.

Parameters that change in accordance to real time gain adjustment

No.	Parameters	Label	Remarks
1	PA1.00	1st position loop gain	When stiffness setting is valid, parameters will be updated to match stiffness value
2	PA1.01	1st velocity loop gain	
3	PA1.02	1st velocity integral time constant	
4	PA1.03	1st velocity detection filter	
5	PA1.04	1st torque filter	
6	PA1.05	2nd position loop gain	
7	PA1.06	2nd velocity loop gain	
8	PA1.07	2nd velocity integral time constant	
9	PA1.08	2nd velocity detection filter	
10	PA1.09	2nd torque filter	

If auto gain adjustment is valid, the parameters listed above can't be manually modified. Only when PA0.02 = 0x00 or 0x10, can the gain related parameters be modified manually.

Gain related parameters that don't change with the real time gain adjustment

No.	Parameter	Label
1	PA1.10	Velocity feedforward gain constant
2	PA1.11	Velocity feedforward filter time constant
3	PA1.12	Torque feedforward gain
4	PA1.13	Torque feedforward filter time constant
5	PA1.15	Position control gain switching mode
6	PA1.17	Position control switching level
7	PA1.18	Position control switching hysteresis
18	PA1.19	Position gain switching time

PA0.02	Label	Real time Auto Gain Adjusting	Mode	F		
	Range	0x0~0xFFF	Default	0x001	Unit	—
	Activation	Immediate			Index	2002h

Set up the mode of the real time auto gain adjusting.

Data bits	Category	Settings	Application
0x00_	Motion setting mode	Used to set motion setting mode, which can be selected according to the motion characteristics or setting requirements. Generally, it is recommended to select mode 1 with good generality when there is no special requirement, mode 2 when rapid positioning is needed If mode 1 and mode 2 cannot meet the requirements, please choose mode 0.	
		0:Manual	PA0.03 invalid. Gain value must be adjusted manually and accordingly.
		1:Standard	PA0.03 valid. Quick gain adjusting can be achieved by changing PA0.03 stiffness value. Gain switching is not used in this mode, suitable for applications with requirements for stability.
		2:Positioning	PA0.03 valid. Quick gain adjusting can be achieved by changing PA0.03 stiffness value. This mode is suitable for applications requiring quick positioning. Not recommended for load mounted vertical to ground, or please compensate for the load using PA6.07
0x0_0	Load type setting	Used to select the load type, choose according to load-inertia ratio and mechanical structure.	
		0: Rigid structure	This mode prioritizes system responsiveness. Use this mode when there is a relatively rigid structure with low load inertia. Typical application including directly connected high-precision gearbox, lead screw, gears, etc.
		1:High inertia	For applications with higher load inertia (10 times or above), gain settings take into account both machine stability and responsiveness. Not recommended to set stiffness above 15 for high load inertia.
		2: Flexible structure	This mode prioritizes system stability. Use this mode when there is low rigidity structure with high load inertia. Typical applications included belts and chains.
0x_00	*Reserved*		

The setting type combination is a hexadecimal standard, as follows:

Setting type combination	Application type
0X000	Rigid structure + Manual
0X001	Rigid structure +Standard
0X002	Rigid structure +Positioning
0X010	High inertia + Manual
0X011	High inertia + Standard
0X012	High inertia + Positioning
0X020	Flexible structure + Manual
0X021	Flexible structure +Standard
0X022	Flexible structure +Positioning

PA0.03	Label	Real time auto stiffness adjusting	Mode	F		
	Range	50 ~ 81	Default	70	Unit	—
	Activation	Immediate			Index	2003h

Valid when PA0.03 = 1,2

Low → Mechanical stiffness ← High

Low → Servo gain ← High

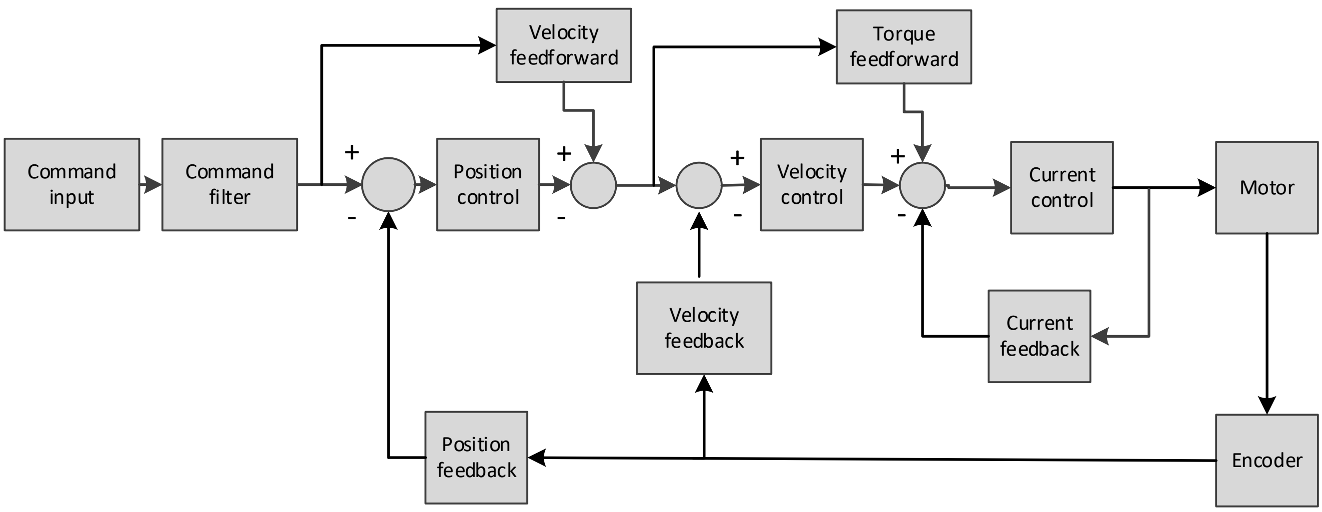
81.80······························70.69.68······························51.50

Low → Responsiveness ← High

- Lower values ensure better system responsiveness and mechanical stiffness but machine vibration might occur, please set accordingly. Please stop the motor before doing any changes to the stiffness settings.
- When PA0.02 = 0x010, please set stiffness level to around 65.

6.4 Manual gain adjustment

Due to limitation of load conditions, automatic gain adjustment might not achieve expected performance. Control can be improved through manual gain adjustment The servo system is made up of 3 control loops. From outer to inner: position loop, velocity loop, current loop as shown in the diagram below.



Inner control loop demands higher responsiveness. In order to avoid system instability, please tune in accordance to this principle. Current loop gain usually satisfies the responsiveness demand without tuning. When gain adjustment is done under position control mode, in order to keep the system stabile, position and velocity loop gain have to be increased at the same time to make sure the responsiveness of the position loop is lower than velocity loop.

Steps to tuning (Position and velocity control)

For servo gain, if any one of the parameters is changed, please modify other gain related parameters accordingly. Make sure to the change at around 5% and follow the rules as below.

1) Increase responsiveness
   a) Reduce torque command filter time
   b) Increase velocity loop gain
   c) Decrease velocity loop integral time
   d) Increase position loop gain
2) Decrease responsiveness, prevent vibration and over shoot
   a) Reduce position loop gain
   b) Increase velocity loop integral time
   c) Reduce velocity loop gain
   d) Increase torque filter time

PA1.00	**Label**	1st position loop gain	**Mode**	**PP**	**HM**	**CSP**
	Range	0~30000	**Default**	320	**Unit**	0.1/s
	Activation	Immediate			**Index**	2100h
	Higher position loop gain value improves the responsiveness of the servo driver and lessens the positioning time. Position loop gain value shouldn't exceed responsiveness of the mechanical system and take in consideration velocity loop gain, if not it might cause vibration, mechanical noise and overtravel. As velocity loop gain is based on position loop gain, please set both values accordingly. Recommended range: 1.2⩽PA1.00/PA1.01⩽1.8					
PA1.02	**Label**	1st Integral Time Constant of Velocity Loop	**Mode**	**F**		
	Range	1~10000	**Default**	310	**Unit**	0.1ms
	Activation	Immediate			**Index**	2102h
	If auto gain adjusting function is not enabled, PA1.02 is activated. The lower the set value, the closer the lag error at stop to 0 but might cause vibration. If the value set is overly large, overshoot, delay of positioning time duration and lowered responsiveness might occur. Set 10000 to deactivate PA1.02. Recommended range: 50000≤PA1.01xPA1.02≤150000 For example: Velocity loop gain PA1.01=500(0.1Hz), which is 50Hz. Integral time constant of velocity loop should be 100(0.1ms)≤PA1.02≤300(0.1ms)					
PA1.04	**Label**	1st Torque Filter Time Constant	**Mode**	**F**		
	Range	0~2500	**Default**	126	**Unit**	0.01ms
	Activation	Immediate			**Index**	2104h
	To set torque command low-pass filter, add a filter delay time constant to torque command and filter out the high frequencies in the command. Often used to reduce or eliminate some noise or vibration during motor operation, but it will reduce the responsiveness of current loop, resulting in undermining velocity loop and position loop control. PA1.04 needs to match velocity loop gain. Recommended range: 1,000,000/(2π×PA1.04) ≥PA1.01×4 For example: Velocity loop gain PA1.01=180(0.1Hz) which is 18Hz. Time constant of torque					

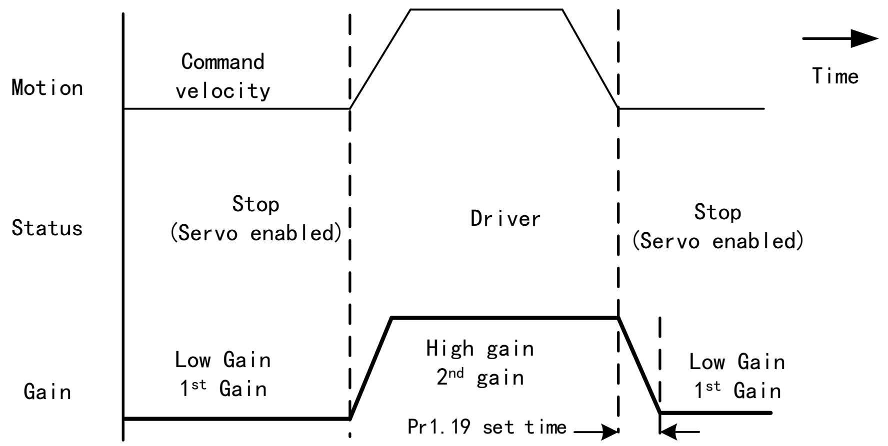
	filter should be PA1.01≤221(0.01ms) If mechanical vibration is due to servo driver, adjusting PA1.04 might eliminate the vibration. The smaller the value, the better the responsiveness but also subjected to machine conditions. If the value is too large, it might lower the responsiveness of current loop. With higher PA1.01 value settings and no resonance, reduce PA1.04 value; With lower PA1.01 value settings, increase PA1.04 value to lower motor noise.

6.5 Gain switching

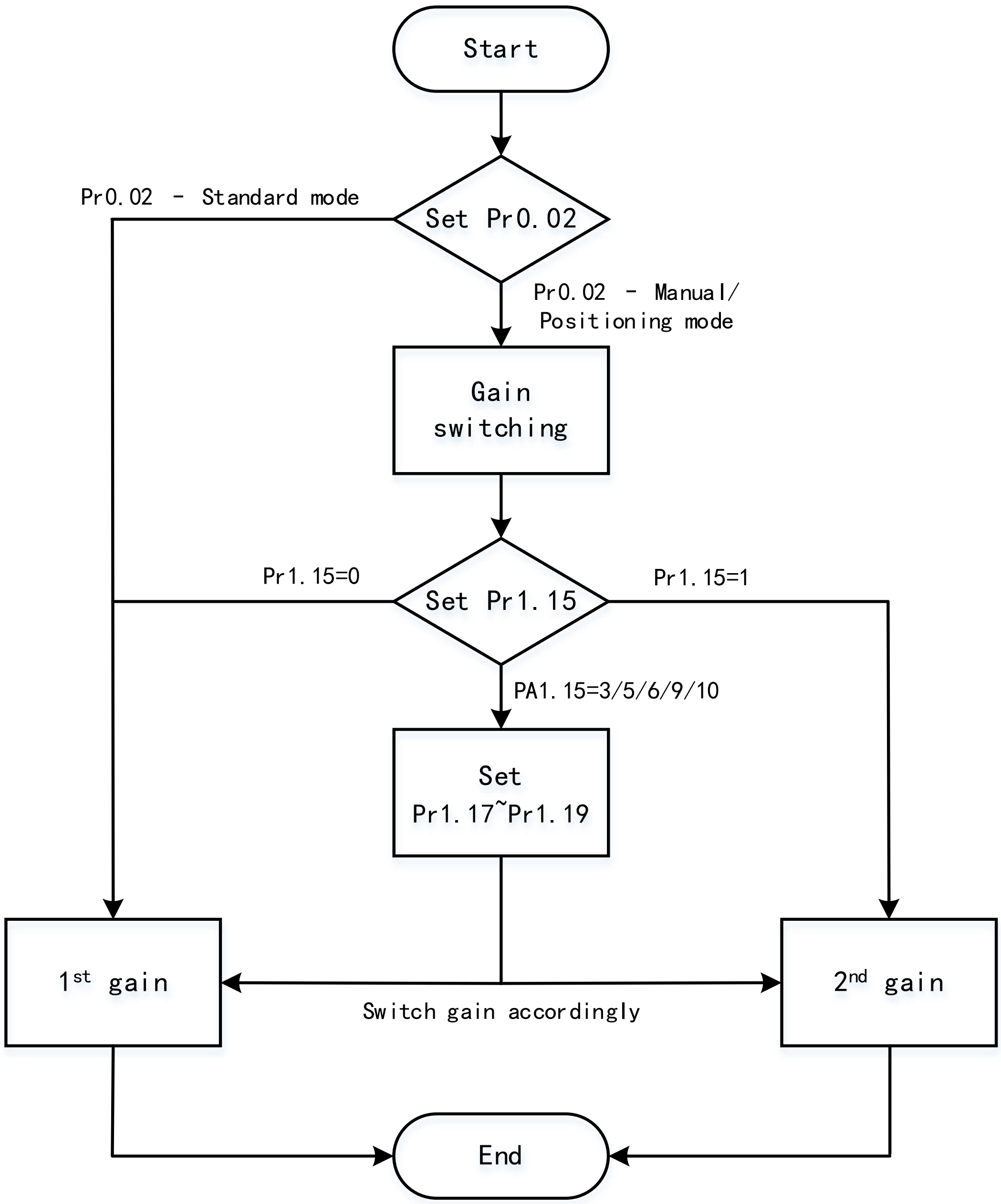
Gain switching function can be triggered internally in servo driver. Only valid under position or velocity control mode. Following effects can be realized by gain switching:

1. Switch to lower gain when motor stops to suppress vibration
2. Switch to higher gain when motor is moving at a low velocity to shorten positioning time
3. Switch to higher gain when motor is moving at a high velocity to improve command following behavior.

Diagram below shows gain switching when motor stops.



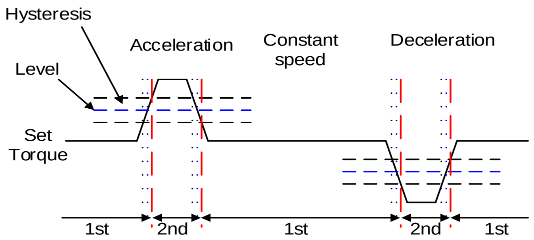
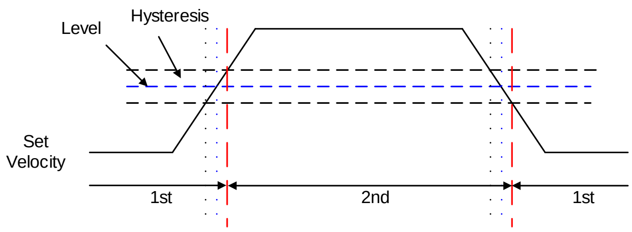
1st gain (Pr1.00-Pr1.04) and 2nd gain (Pr1.05-Pr1.09) switching can be realized through manual and positioning mode. Switching condition is set through Pr1.15. Gain switching is invalid under standard mode.

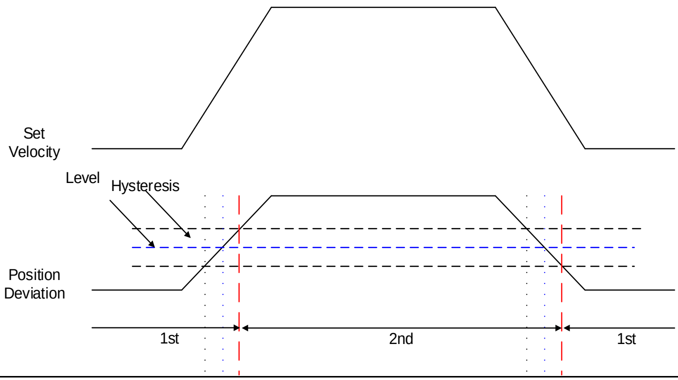
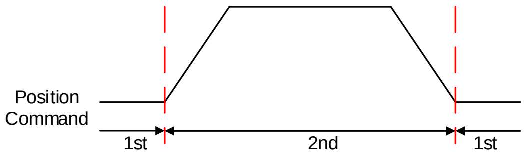
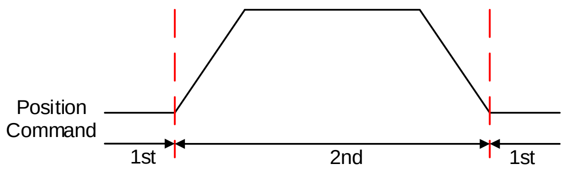
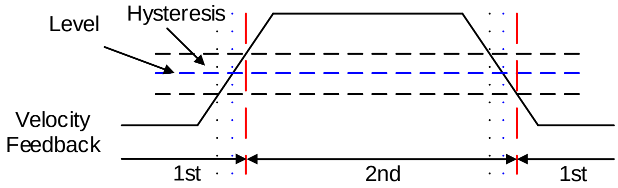


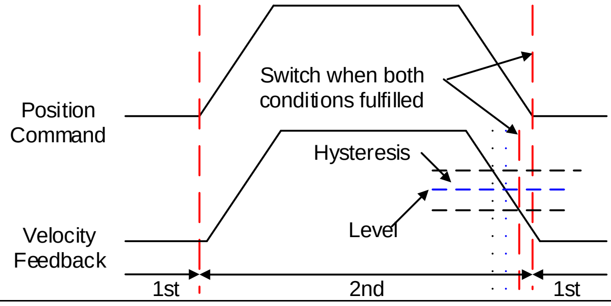
Related parameters on gain switching

No.	Parameter	Label	Remarks
1	PA1.15	Position control gain switching mode	In position control, set PA1.15=3、5、6、9、10。 In velocity control, set PA1.15=3、5、9
2	PA1.17	Position control level switching	Please set PA1.17≥PA1.18
3	PA1.18	Position control hysteresis switching	If PA1.17<PA1.18, driver will set PA1.17＝PA1.18
4	PA1.19	Position gain time switching	

PA1.15	Label	Position control gain switching mode	Mode	F		
	Range	0~11	Default	0	Unit	-
	Activation	Immediate			Index	2115h

Set Value	Condition	Gain switching condition
0	1^{st} gain fixed	Fixed on using 1^{st} gain(PA1.00-PA1.04)
1	2^{nd} gain fixed	Fixed on using 2^{nd} gain (PA1.05-PA1.09)
2	Reserved	
3	High set torque	Switch to 2^{nd} gain when set torque command absolute value larger than (level + hysteresis)[%] Switch to 1^{st} gain when set torque command absolute value smaller than (level + hysteresis)[%] 
4	Reserved	Reserved
5	High set velocity	 Valid for position and velocity control. Switch to 2^{nd} gain when set velocity command absolute value larger than (level + hysteresis)[r/min] Switch to 1^{st} gain when set velocity command absolute value smaller than (level-hysteresis)[r/min]
6	Large position deviation	Valid for position control. Switch to 2^{nd} gain when position deviation absolute value larger than (level + hysteresis)[pulse] Switch to 1^{st} gain when position deviation absolute value smaller than (level-hysteresis)[pulse]

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>7</td><td>Pending position command</td><td>Valid for position control.
Switch to 2nd gain if position command ≠ 0
Switch to 1st gain if position command remains = 0 throughout the duration of delay time.
</td></tr>
<tr><td>8</td><td>Not yet in position</td><td>Valid for position control.
Switch to 2nd gain if position command is not completed.
Switch to 1st gain if position command remains uncompleted throughout the duration of delay time.
</td></tr>
<tr><td>9</td><td>High actual velocity</td><td>
Valid for position control.
Switch to 2nd gain when actual velocity absolute value larger than (level + hysteresis)[r/min]
Switch to 1st gain when actual velocity absolute value remains smaller throughout the duration of delay time than (level-hysteresis)[r/min]</td></tr>
<tr><td>10</td><td>Pending position command +actual velocity</td><td>Valid for position control.
Switch to 2nd gain if position command ≠ 0
Switch to 1st gain if positional command = 0 throughout the duration of delay time and absolute value of actual velocity remains smaller than (level - hysteresis) (r/min)</td></tr>
</table>



For position control mode, set PA1.15=3,5,6,9,10;

For velocity control mode, set PA1.15=3,5,9;

*** Above 'level' and 'hysteresis' are in correspondence to PA1.17 Position control gain switching level and PA1.18 Hysteresis at position control switching.*

6.6 Feedforward gain

In position control, velocity feedforward is calculated by comparing the velocity control command calculated internally and velocity command calculated from position feedback. Comparing to control only using feedbacks, this will reduce position deviation and increase responsiveness. Besides, by comparing the torque needed during motion from velocity control command in comparison with velocity feedback, torque feedback can be calculated to improve system responsiveness.

6.6.1 Velocity feedforward

Velocity feedforward can be used in position control mode. When the function is enabled, it can increase velocity responsiveness, reduce position deviation during constant velocity.

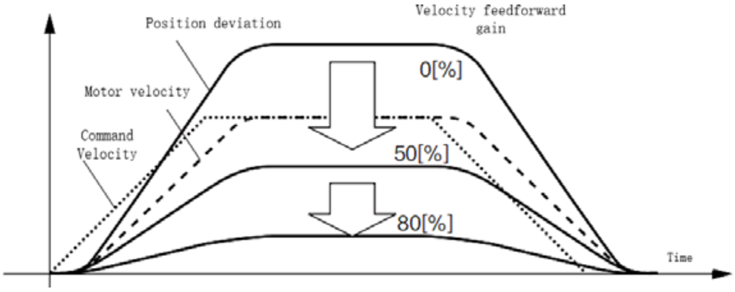
PA1.10	Label	Velocity feed forward gain	Mode	PP	HM	CSP
	Range	0~1000	Default	300	Unit	0.10%
	Activation	Immediate			Index	2110h
	Used for decreasing following error caused by low responsiveness of velocity loop. Might cause overshoot or increase in noise if set value is too high.					

PA1.11	Label	Velocity feed forward filter time constant	Mode	PP	HM	CSP
	Range	0~6400	Default	50	Unit	0.01ms

	Activation	Immediate	**Index**	2111h
	Set velocity feed forward low pass filter to eliminate high or abnormal frequencies in velocity feed forward command. Often used when position command with low resolution or high electronic gear ration to smoothen velocity feed forward. Position deviation under constant velocity can be lowered with higher velocity feed forward gain. Please to refer to the equation below. Position deviation[Uint]= $\frac{Set\ velocity[\frac{Uint}{s}]}{Position\ loop\ gain[Hz]}\ x\ \frac{100 - Velocity\ feed\ foward\ gain[\%]}{100}$			

6.6.2 Velocity feedforward application

Set Pr1.11 to around 50 (0.5ms), then tune Pr1.10 from 0 to bigger values until the velocity feedforward achieves better performance. Under constant velocity, the position deviation in a motion will decrease as the velocity feedforward gain increase.



Steps to tuning:

1. Increase Pr1.10 to increase responsiveness but velocity overshoot might occur during acc-/deceleration.
2. By reducing Pr1.11, velocity feedforward would be more effective and vice versa. Pr1.10 and Pr1.11 need to be tuned to a balance.
3. If mechanical noise exists under normal working conditions, please increase Pr1.11 or use position command filter (1 time delay/ FIR smoothing filter)

6.6.3 Torque feedforward

Position control mode:
Torque feedforward can increase the responsiveness of torque command, decrease position deviation during constant acc-/deceleration.
Velocity control mode:
Torque feedforward can increase the responsiveness of torque command, decrease velocity deviation during constant velocity.

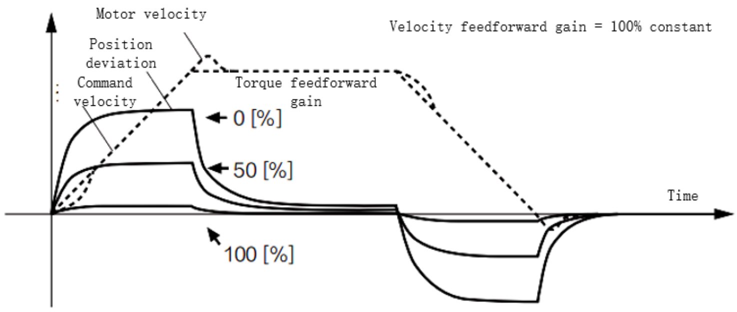
PA1.12	**Label**	Torque feed forward gain	**Mode**	**PP**	**PV**	**HM**	**CSP**	**CSV**	
	Range	0~1000	**Default**	0	**Unit**	0.1%			
	Activation	Immediate			**Index**	2112h			
	Before using torque feed forward, please set correct inertia ratio PA0.04. By increasing torque feed forward gain, position deviation on constant acceleration/deceleration can be reduced to close to 0. Under ideal condition and trapezoidal speed profile, position deviation of the whole								

	motion can be reduced to close to 0. In reality, perturbation torque will always exist, hence position deviation can never be 0.

PA1.13	**Label**	Torque feed forward filter time constant	**Mode**	**PP**	**PV**	**HM**	**CSP**	**CSV**	
	Range	0~6400	**Default**	0	**Unit**	0.01ms			
	Activation	Immediate			**Index**	2113h			
	Low pass filter to eliminate abnormal or high frequencies in torque feed forward command. Usually used when encoder has lower resolution or precision. Noise reduces if torque feed forward filter time constant is set higher but position deviation will increase at acceleration varied points.								

6.6.4 Torque feedforward application

Set Pr1.13 to around 50 (0.5ms), then tune Pr1.10 from 0 to bigger values until torque feedforward achieves better performance. Under constant acc-/deceleration, the position deviation in a motion will decrease as the velocity feedforward gain increase.



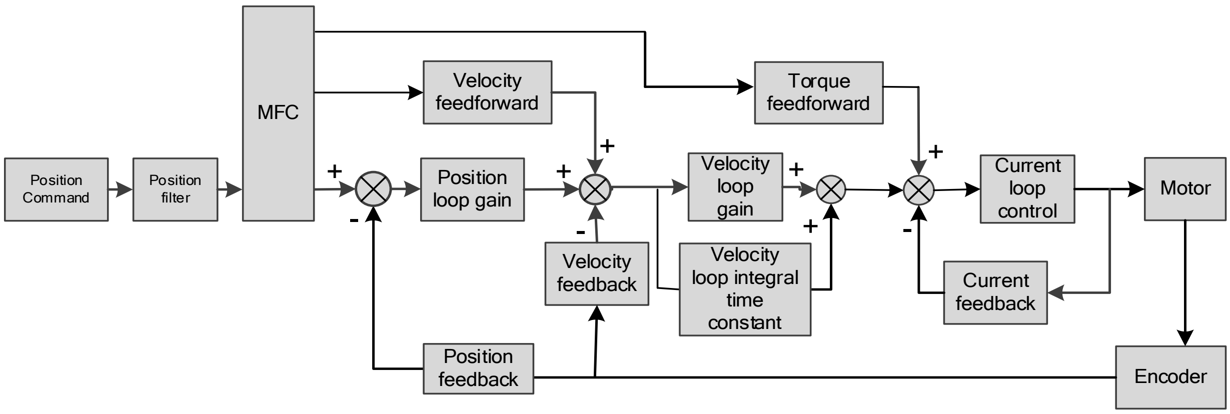
Steps to tuning:

2. Increase Pr1.12 to increase responsiveness but velocity overshoot might occur during acc-/deceleration.
3. By reducing Pr1.13, torque feedforward would be more effective and vice versa. Pr1.12 and Pr1.13 need to be tuned to a balance and reduce noise.

6.7 Model following control

Model following control is a type of closed loop control system. First, an ideal model is constructed and acts as a reference for actual model in a closed loop control. Model following control can be treated as a control mode with 2 flexibilities: Reference model can be used to improve command responsiveness and closed loop control used to increase responsiveness of the system towards interference. They don't affect each other.

Model following control can be used in position loop control to increase responsiveness to commands, reduce positioning time and following error. This function is only available in position control mode.



To adjust model following control

1. Automatic adjustment
   Set model following bandwidth PA0.00 = 1 for automatic adjustment. Now, PA0.00 = PA1.01, model following bandwidth is adjusted automatically according to different velocity loop gain.
2. Manual adjustment
   Please used manual adjustment if
   - Automatic adjustment is not satisfactory.
   - Responsiveness needs further improvement in comparison with automatic adjustment.
   - There is a need to set servo gain or model following control parameters manually.

Steps to manually adjust

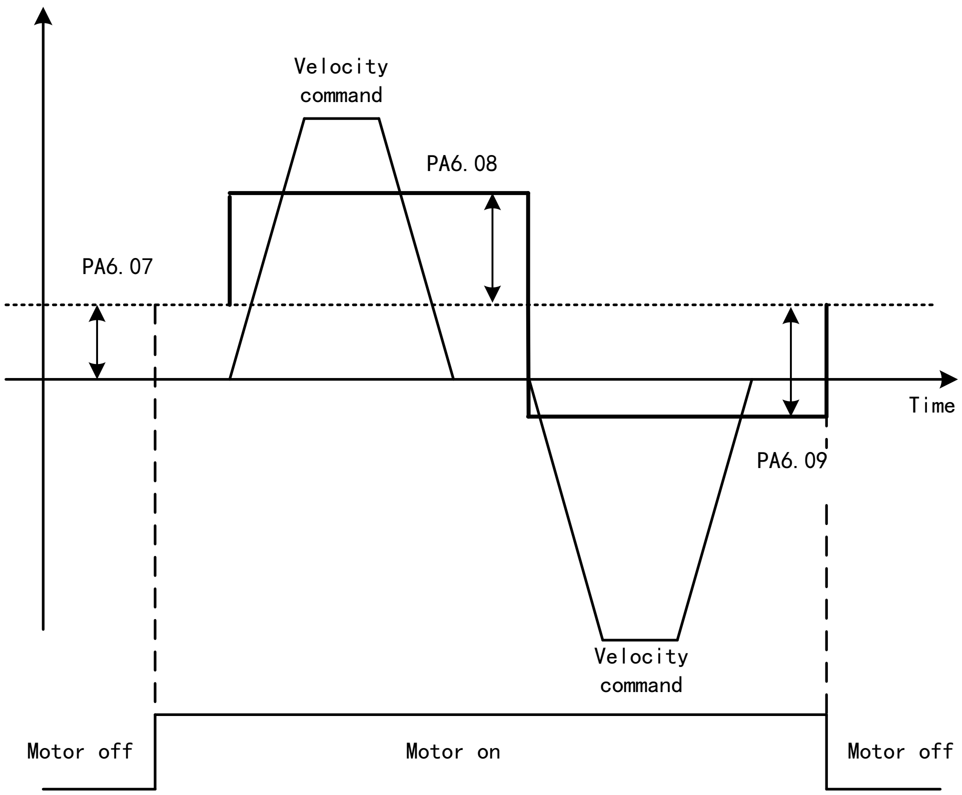
Step	Content
1	Set up vibration suppression.
2	Set up the right inertia ratio.

3	Manually adjust gain.
4	Increase PA0.00 provided that there is no overshoot and vibration. Usually PA0.00 ⩾ PA1.01 is recommended.

Model following bandwidth determines the responsiveness of the servo system. Increase the value set will increase responsiveness and reduce positioning time. Overshoot can be prevented if it is set at a lower value but responsiveness will be lowered. Model following bandwidth shouldn't be too large for mechanical structure with lower stiffness, excessive position deviation alarm might occur under high velocity.

6.8 Friction compensation function

This function is to compensation for changes in load to reduce the effect of friction in motion. The compensation value is directional.



Vertically loaded axis: A constant eccentric load torque is applied on the motor. By adjusting PA6.07, positioning deviation due to different motional direction can be reduced.
Belt-driven axis: Due to large radial load with dynamic frictional torque. Positioning time delay and deviation can be reduced by adjusting PA6.08 and PA6.09.

PA6.07	Label	Torque command additional value	Mode	F		
	Range	-100~100	Default	0	Unit	%
	Activation	Immediate			Index	2607h

To set torque forward feed additional value of vertical axis.

Applicable for loaded vertical axis, compensate constant torque.

Application: When load move along vertical axis, pick any point from the whole motion and stop the load at that particular point with motor enabled but not rotating. Record output torque value from d04, use that value as torque command additional value (compensation value)

PA6.08	Label	Positive direction torque compensation value	Mode	F		
	Range	-100~100	Default	0	Unit	%
	Activation	Immediate			Index	2608h
PA6.09	Label	Negative direction torque compensation value	Mode	F		
	Range	-100~100	Default	0	Unit	%
	Activation	Immediate			Index	2609h

To reduce the effect of mechanical friction in the movement(s) of the axis. Compensation values can be set according to needs for both rotational directions.

Applications:

1. When motor is at constant speed, d04 will deliver torque values.

Torque value in positive direction = T1;

Torque value in negative direction = T2

PA6.08/PA6.09 = $T_f = \dfrac{|T1-T2|}{2}$

6.9 Parameters adjustment under different control modes

Under different control mode, parameters adjustment has to be adjusted in this order: “Inertia measuring” -> “Auto gain adjustment”->” Manual gain adjustments”

6.9.1 Position control mode

Set load-inertia ratio PA0.04 after inertia determination.

No.	Parameter	Label
1	PA1.00	1st position loop gain
2	PA1.01	1st velocity loop gain
3	PA1.02	1st velocity integral time constant
4	PA1.03	1st velocity detection filter
5	PA1.04	1st torque filter time constant

6	PA1.05	2nd position loop gain
7	PA1.06	2nd velocity loop gain
8	PA1.07	2nd velocity integral time constant
9	PA1.08	2nd velocity detection filter
10	PA1.09	2nd torque filter time constant
11	PA1.10	Velocity feedforward gain constant
12	PA1.11	Velocity feedforward filter time constant
13	PA1.12	Torque feedforward gain
14	PA1.13	Torque feedforward filter time constant
15	PA1.15	Position control gain switching mode
16	PA1.17	Position control switching level
17	PA1.18	Position control switching hysteresis
18	PA1.19	Position gain switching time

1st and 2nd gain initial values are obtained by automatic gain adjustment

No.	Parameter	Label
1	PA1.00	1st position loop gain
2	PA1.01	1st velocity loop gain
3	PA1.02	1st velocity integral time constant
4	PA1.03	1st velocity detection filter
5	PA1.04	1st torque filter time constant
6	PA1.05	2nd position loop gain
7	PA1.06	2nd velocity loop gain
8	PA1.07	2nd velocity integral time constant
9	PA1.08	2nd velocity detection filter
10	PA1.09	2nd torque filter time constant

Manually adjusted gain parameters

No.	Parameter	Label
1	PA1.00	1st position loop gain
2	PA1.01	1st velocity loop gain
3	PA1.02	1st velocity integral time constant
4	PA1.04	1st torque filter time constant
5	PA1.10	Velocity feedforward gain constant
6	PA1.11	Velocity feedforward filter time constant

6.9.2 Velocity control mode

Velocity control mode parameters adjustment is pretty similar to position control mode. Except for position loop gain PA1.00 and PA1.05, velocity feedforward gain (Pr1.10)

6.9.3 Torque control mode

Parameters adjustment for torque control mode has to be differentiate into 2 conditions:

1. When actual velocity reaches velocity limit, adjustment will be as per velocity control mode. Motor will switch from torque control to velocity limit as velocity control.
2. When actual velocity doesn't reach velocity limit yet, Except for position loop gain, velocity loop gain and feedforward gain, parameter adjustments as per velocity control mode.

If there is no velocity limit and control is through torque command, please deactivate torque and notch filter, set velocity limit to max. value and increase velocity loop gain to as high as possible.

6.10 Safety Functions

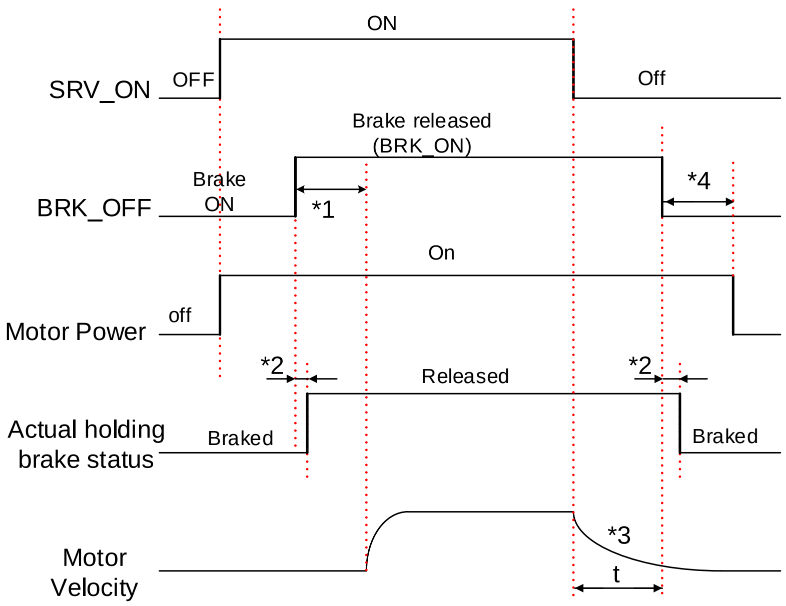
External brake deactivation output signal BRK-OFF

Please refer to PA4.11 to set up the I/O output function parameters. When enabled and timing conditions are fulfilled, the set I/O output will deliver ON signal.

<table>
<tr><td rowspan="3">PA4.37</td><td>Label</td><td>Motor power-off delay time</td><td>Mode</td><td colspan="3">F</td></tr>
<tr><td>Range</td><td>0~3000</td><td>Default</td><td>100</td><td>Unit</td><td>1ms</td></tr>
<tr><td>Activation</td><td colspan="3">Immediate</td><td>Index</td><td>2437h</td></tr>
<tr><td colspan="7">To set delay time for holding brake to be activated after motor power off to prevent axis from sliding.</td></tr>
</table>

PA4.38	**Label**	Delay time for holding brake release	**Mode**	**F**		
	Range	0~3000	**Default**	0	**Unit**	1ms
	Activation	Immediate			**Index**	2438h

To set delay time for holding brake to be released after motor power on. Motor will remain at current position and input command is masked to allow holding brake to be fully released before motor is set in motion.



*1: Delay time set in PA4.38

*2: Delay time from the moment BRK_OFF signal is given until actual holding brake is released or BRK_ON signal is given until actual holding brake is activated. It is dependent on the holding brake of the motor.

*3: Deceleration time is determined by PA6.14 or if motor speed goes below PA4.39, whichever comes first. BRK_OFF given after deceleration time.

*4: PA4.37 set time value.

Delay time from the moment SRV_ON is given until BRK_OFF switch to BRK_ON, is less than 500ms.

6.10.1 Emergency stop function

Emergency stop is used when an alarm occurs or a servo prohibition signal is received when servo driver is enabled.

Method 1: Set up PA4.43 to enable the function

PA4.43	**Label**	Emergency stop function	**Mode**	**F**		
	Range	0~1	**Default**	0	**Unit**	-
	Activation	Immediate			**Index**	2443h

0：Emergency stop is valid, servo driver will be forced to STOP and alarm occurs. 1：Emergency stop is invalid, servo driver will not be forced to STOP.

PA5.04	Label	Driver prohibition input settings	Mode	F		
	Range	0~2	Default	0	Unit	-
	Activation	Immediate			Index	2504h

To set driver prohibition input (POT/NOT): If set to 1, no effect on homing mode.

Set value	Description
0	POT → Positive direction drive prohibited NOT → Negative direction drive prohibited
1	POT and NOT invalid
2	Any single sided input from POT or NOT might cause Er260

In homing mode, POT/NOT invalid, please set object dictionary 5012-04 bit0=1

Method 2: Using 605Ah object dictionary through master device to activate this function.

PA5.11	Label	Servo braking torque setting	Mode	F		
	Range	0~500	Default	0	Unit	%
	Activation	Immediate			Index	2511h

To set torque limit for servo braking mode.
If PA5.11 = 0, use torque limit as under normal situation.
Between max. torque 6072 and PA5.11, actual torque limit will take smaller value.

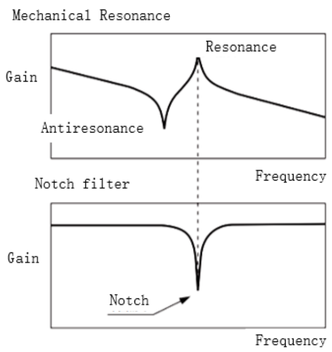
6.11 Vibration Suppression

6.11.1 Mechanical resonance suppression

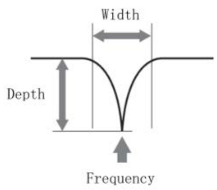
Mechanical system has certain resonance frequencies. When servo gain is increased, resonance might occur at around mechanical resonant frequencies, preventing gain value from increasing. In such situation, notch filter can be used to suppress resonance to set higher gains or lower vibration.

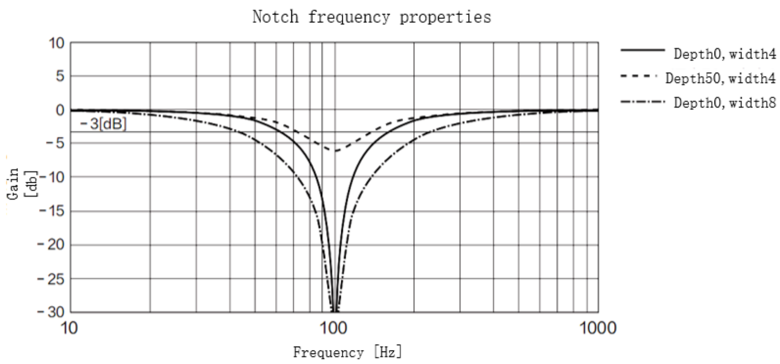
To suppress mechanical resonance:

1. Torque command filter time constant
   Set filter time constant to reduce gain at around resonant frequencies
   Torque command filter blocked frequencies（Hz） fc=1/ [2π×PA1.04(0.01ms)×0.00001）]
2. Notch filter
   Notch filter suppress mechanical resonance by reducing gain at certain frequencies. When notch filter is correctly set, resonance can be suppressed and servo gain can be increased.



- Notch filter bandwidth
  Center frequency of the notch filter, frequency bandwidth with reduction of -3dB.
- Notch filter depth
  The ratio between input and output of center frequency.
  When depth = 0, center frequency output is totally off and when depth = 100, Hence when notch filter depth is set at lower value, the depth is higher and better at suppressing mechanical resonance but it might cause system instability.





If the amplitude-frequency curve from mechanical properties analysis tool doesn't show any obvious peak but vibration did occur, it might not be due to mechanical resonance, it may be that servo gain has reached its limit. This kind of vibration can't be suppressed by using notch filter, only by reducing gain and torque command filter time.

To use notch filter

Automatic notch filter

1. Set PA2.00 = 1 for auto notch filter adjustment
2. If PA0.03 stiffness increases, 3rd group of notch filter (PA2.07/PA2.08/PA2.09) updates automatically when driver is enabled. PA2.00 = 0, auto adjustments stop.

If resonance is suppressed, it means self-adjusting notch filter is working. If resonance occurs when mechanical stiffness increases, please use manual notch filter, set filter frequency to actual resonant frequency.

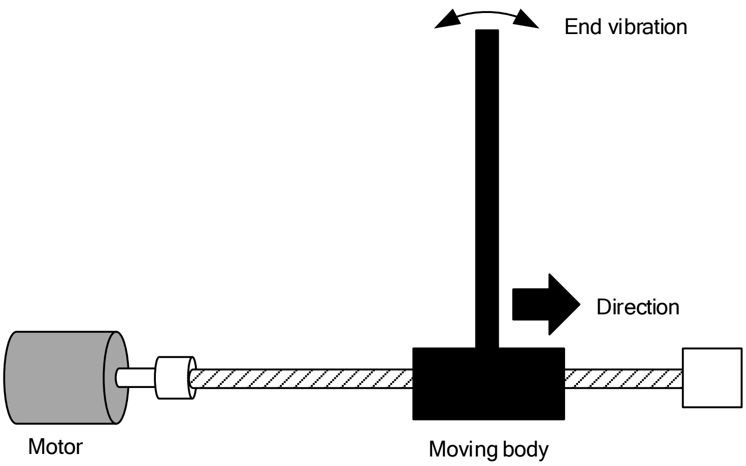
Manual notch filter

There are 2 ways to use manual notch filter.

1. After enabling self-adjusting notch filter, set the values from 3rd group of filters to 1st group of notch filter (PA2.01/PA2.02/PA2.03), see if resonance is suppressed. If there is other resonance, set PA2.00 = 1, then set the values from 3rd group of filters to 2nd group of notch filter (PA2.04/PA2.05/PA2.06)

2. Get resonant frequency, notch filter bandwidth and depth and set it into the corresponding parameters through Motion Studio.

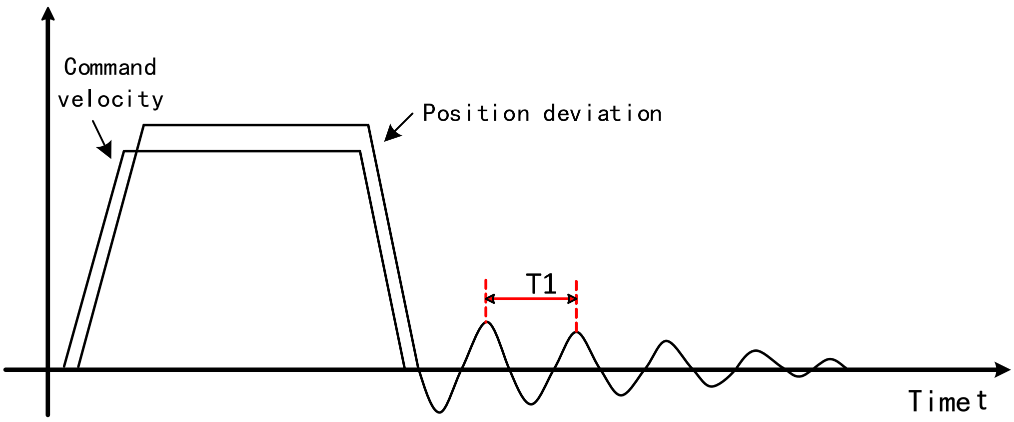
6.11.2 End vibration suppression



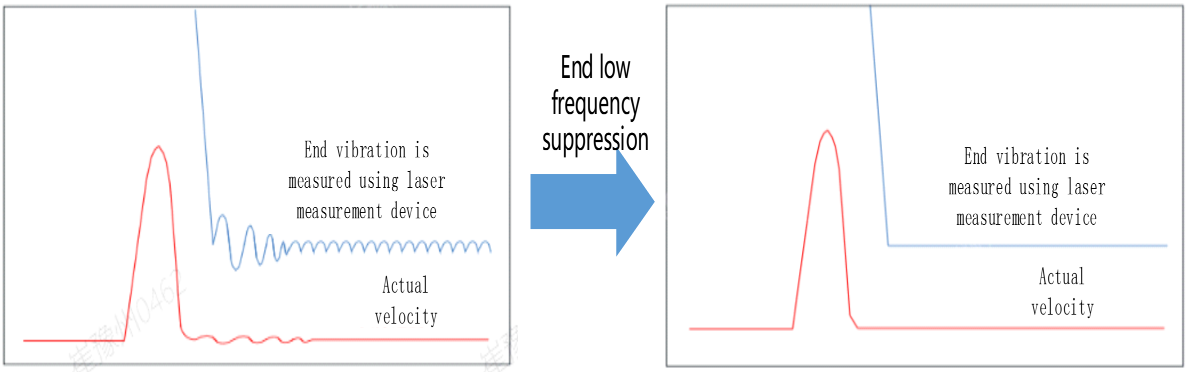
If the mechanical structure has an end that is long and heavy, it might cause end vibration at emergency stop and affect the positioning. Usually happens on long armed axis with loose end. The frequency is usually within 100Hz which is lower than mechanical resonant frequencies. It is called low-frequency resonance which can be prevented by applying low frequency suppression function.

To apply low frequency suppression

1. Trace current/ position deviation waveform when motion stops.
2. Measure the vibration cycle T1 of current waveform.
3. Convert T1 into low frequency resonance by F1 = 1/T1
4. Write F1 into PA2.14
5. If some other low frequency resonance occurs, please repeat step 1-3 and write F2 into PA2.16.

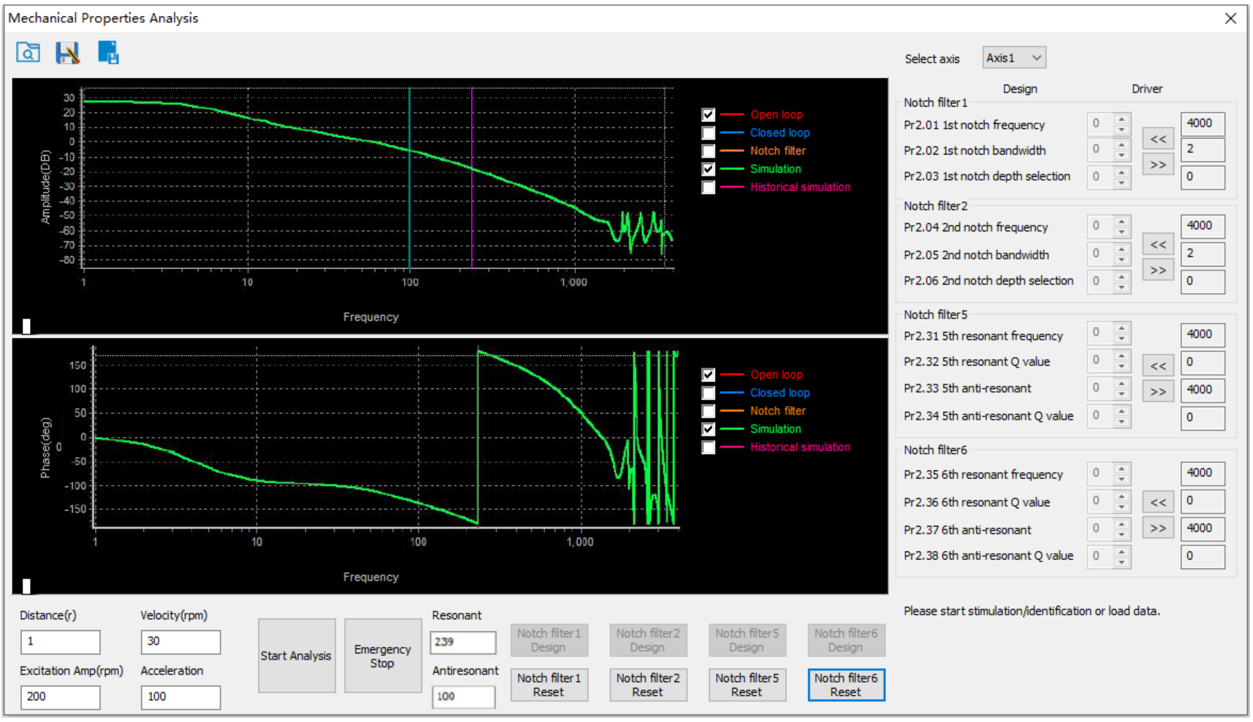


The result of suppressing low frequency resonance



6.11.3 Mechanical properties analysis

To determine mechanical and set up notch filter parameters to suppress vibration caused by resonance.



To avoid strong vibration, please first set lower excitation amplitude. However, if the set value is too low, data waveform will include some degree of distortion.

If vibration occurs during tests which can't be reduce through lowering electrical current excitation, it might be due to excessive gain. Please lower velocity gain and set notch filter as accordance from the mechanical properties analysis. Or might be due to inertia settings (Pr0.04) is too large, please use optimal inertia ratio value.

6.12 Multiturn absolute encoder

Multiturn absolute encoder records the position and the revolution counts of the motor. When driver is powered-off, multiturn absolute encoder will backed up the data using battery and after powering on, the data will be used to calculated absolute mechanical position and there is no need for a mechanical homing process. Use widely in robotic arms and CNC machines.

If it is the first time using the encoder, please home the mechanical axis and initialize the absolute position of the encoder to zero. Set up a homing point and only home when there is an alarm. Please stop the axis before reading any position data to prevent inaccuracy.

6.12.1 Parameters setting

PA0.15	Label	Absolute Encoder settings	Mode	PP	HM	CSP
	Range	0~32767	Default	0	Unit	-
	Activation	Immediate			Index	2015h

0: Incremental mode:
Used as an incremental encoder. Doesn't retain position data on power off. Unlimited travel distance.

1: Multiturn linear mode:
Used as a multiturn absolute encoder. Retrain position data on power off. For applications with fixed travel distance and no multiturn data overflow.

2: Multiturn rotary mode:
Used as a multiturn absolute encoder. Retrain position data on power off. Actual data feedback in between 0-(PA6.63). Unlimited travel distance.

3: Single turn absolute mode:
Used when travel distance is within 1 revolution of the encoder. Data overflow will trigger alarm.

5: Clear multiturn alarm and activate multiturn absolute function. Will switch to multiturn mode once alarm cleared, if remains at 5 after 3s, please solve according to Er153.

9: Clear multiturn position, reset multiturn alarm and activate multiturn absolute function. Will switch to multiturn mode once alarm cleared, if remains at 9 after 3s, please solve according to Er153. ***Please disable axis before setting to 9 and home the axis before using.***

6.12.2 Read absolute position

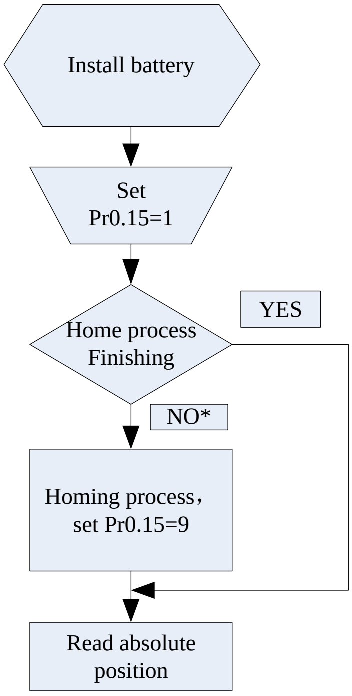
1、Steps：

1) First, select a motor with multiturn absolute encoder, install battery and confirm whether the driver version supports the specific motor;

2) Set PA0.15 = 1. If it is the first time of installation, Err153 will occur because battery is newly installed and position data is invalid. Please home the axis and initialize the absolute position of the encoder to zero.

3) When absolute homing point is set and there is no fault with the battery, the alarm will be cleared

4) Finally, the user can read the absolute position. Position won't be lost even if the driver is powered off.

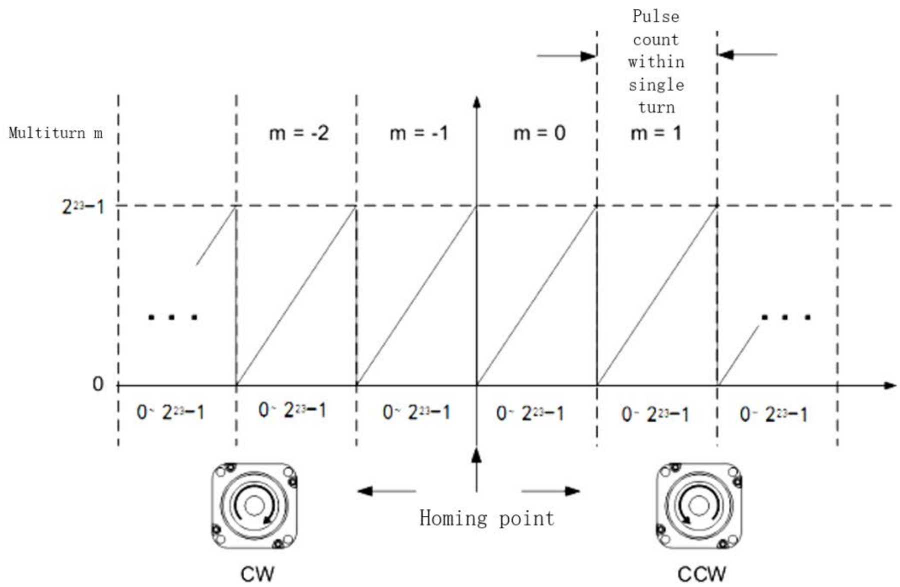


*Note：The newly installed encoder is not initialized and will alarm

2、Read absolute position

When the rotor turns in clockwise direction, the revolution count will be negative; turns in counter clockwise direction, the count will be positive. No. of revolutions will be from -32767 to +32767. If the count number reaches +32767 in counter clockwise direction, the count will revert back to -32768, -32767 and vice versa for clockwise direction.

As for position data, it depends on the precision of the encoder. For 17 bit = 0-131071, 23 bit = 0-8388607

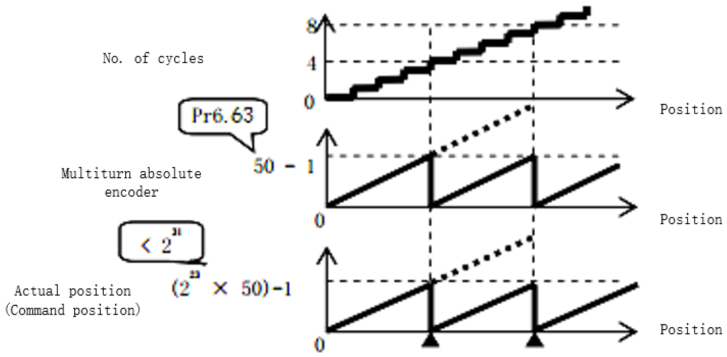


Read data from 6064h object dictionary

Please read data only when the motor is fully stopped or it might cause calculation errors. Please repeat this step for at least twice to make sure the result is uniform.

Multiturn rotational mode

For absolute encoder, multiturn rotational mode (PA0.15 = 2, PA6.63 set to multiturn upper limit) is added on top of incremental mode and multiturn linear mode. Actual feedback multiturn data is always between 0 – [PA6.63 + 1], regardless of the direction of rotation. There is no limit to no. of rotation and no data overflow.



Single turn absolute mode

Use this mode when the travel distance of the axis is within a single turn of the rotor.

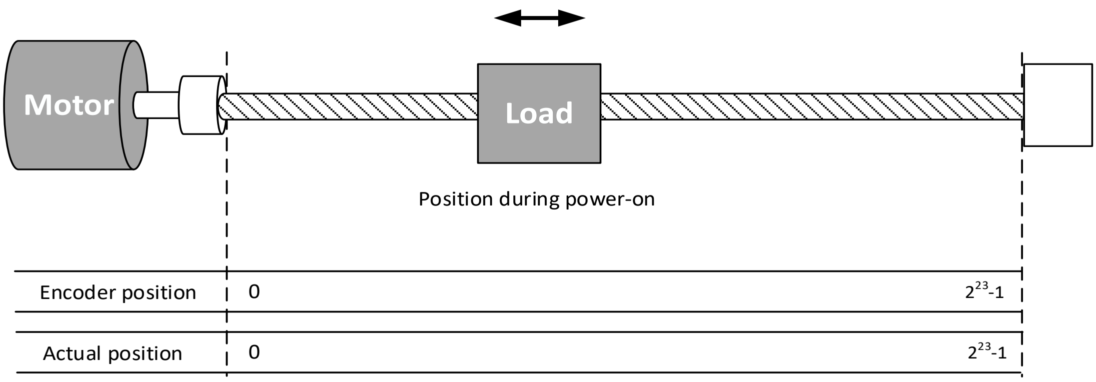
1. Target position input range – EtherCAT

When using 23-bit absolute encoder, under single turn absolute mode, electronic gear ratio =1:1

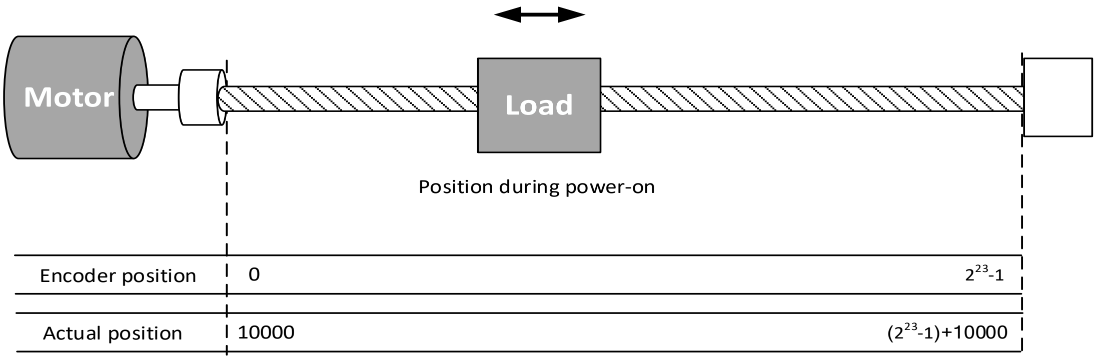
Homing point offset 607Ch = 0, target position range = 0 – [2^{23}-1]

Axis is homed, target position range = 607Ch – [2^{23}-1+607Ch]

When electronic gear ratio = 1:1, 607Ch = 0:



When electronic gear ratio = 1:1, 607Ch = 10000:



3、Clear multiturn position

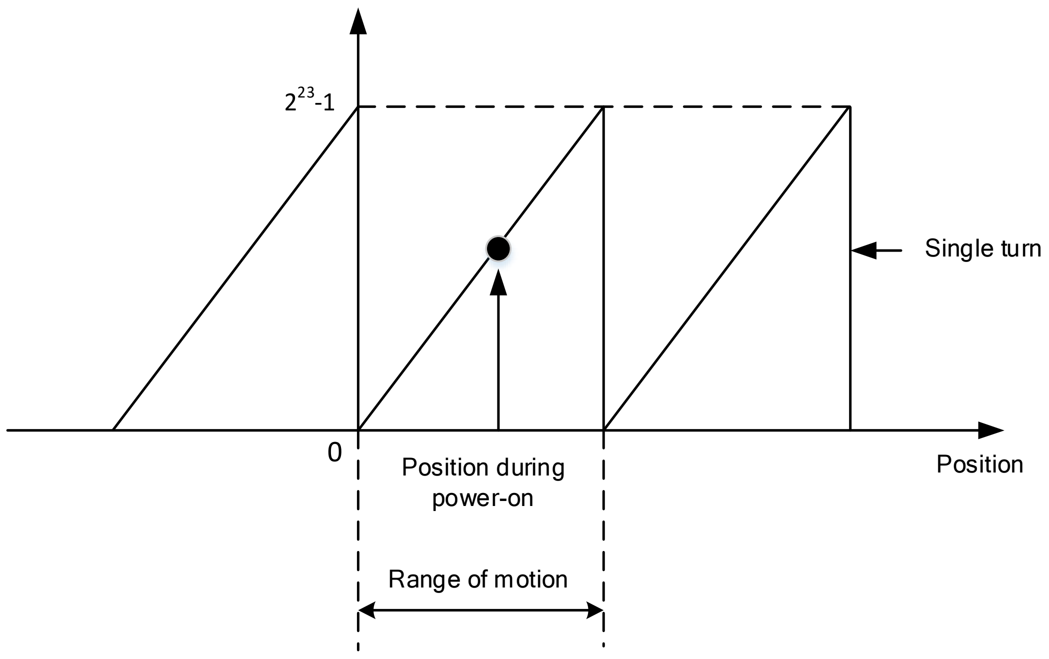
Before clearing multiturn position, axis needs to be homed. After clearing multiturn position, revolution count = 0 but absolute position remains unchanged and Err153 alarm will be cleared.

Please make sure the homing point is within the range of 1 revolution of the rotor. Installation and setup of the homing point can be set with the use of auxiliary function D21 on the front panel.

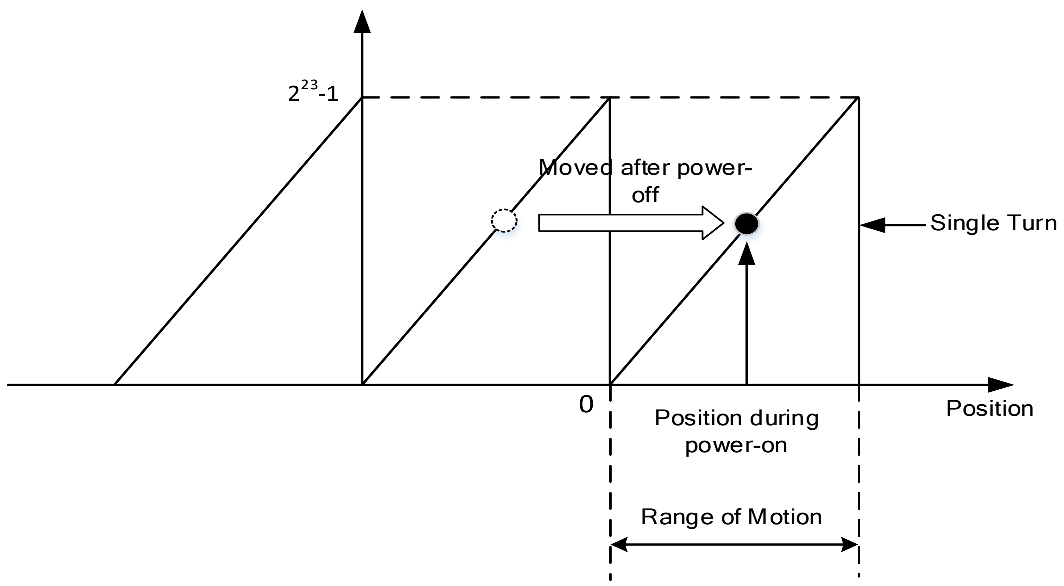
By setting PA0.15 to 9, multiturn position will be cleared.

Please take notice of motor position during power on. Range of motion of a motor depends on the position of the motor during power on (23-bit absolute encoder as example).

If the motor position is as shown below during power on. The range of motion of the motor is within the range of a single turn of the motor from motor position during power on.



If power is turned off at position as shown below and power on when motor reaches the position below. Motor range of motion changes as shown below.



6.12.3 Absolute Encoder Related Alarm

The alarm can determine if absolute value encoder is valid. If battery power is low, not a motor with absolute encoder, encoder error etc. occurs, user can find out about the error from alarm output or on the front panel. Controller will stop any operation until alarm is cleared.

Alarm output:
Err153 will be shown on front panel or by I/O ALM signal and from controller.

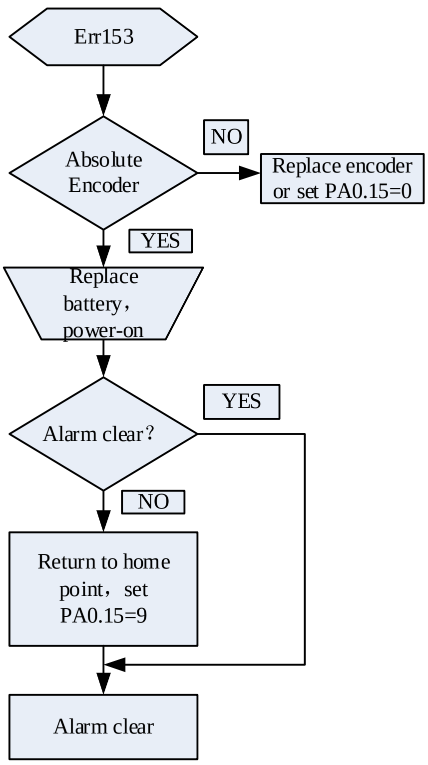
Err153 might occur,

（1）If absolute encoder is used for the first time and due to installation of new batteries Axis needs to be homed and multiturn data needs to be cleared.

（2）If battery voltage is lower than 3.2v. Replace battery and restart the motor.

（3）If battery voltage is lower than 2.5v or battery power was cut off. Replacing the battery won't clear the alarm. Axis needs to be homed and multiturn data needs to be cleared.

4、Alarm processing flow chart



6.13 Probe

Motor feedback position latching function can be realized through input signal with probe function. EL7-EC supports up to 2 inputs with probe function and can be used simultaneously, to record the position information corresponding to probe signal rising and falling edge. Probe 1 signal comes from CN1 terminal pin 1 and 5 differential signal. Probe 2 signal comes from CN1 terminal pin 2-6 differential signal.

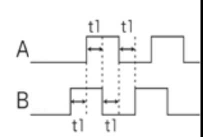
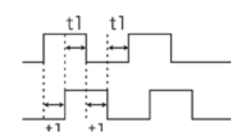
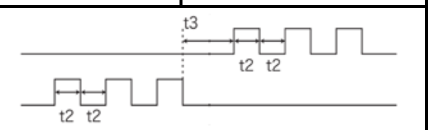
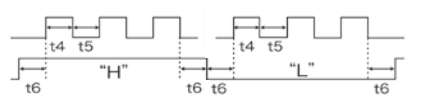
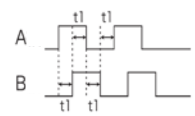
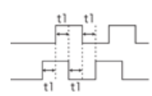
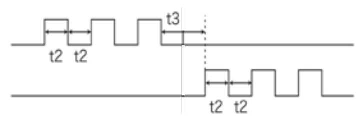
PA0.07	Label	Probe signal polarity settings	Mode	F		
	Range	0 ~ 3	Default	3	Unit	—
	Activation	After restart			Index	2007h

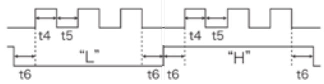
Probe signal polarity settings take effect when PA0.01 = 9

Set value	Details
0	Probe 1 & 2 polarity inversion
1	Probe 2 polarity inversion
2	Probe 1 polarity inversion
3	No polarity inversion for probe 1 & 2

If PA0.01 ≠ 9, PA0.07 = Command pulse input mode settings.

Command pulse input

Command Polarity inversion (PA0.06)	Command pulse input mode settings (PA0.07)	Command Pulse Mode	Positive signal	Negative signal
【0】	0 or 2	90°phase difference 2 phase pulse （Phase A+ Phase B）		
	1	CW pulse sequence ＋ CCW pulse sequence		
	【3】	Pulse sequence ＋ Directional symbol		
1	0 or 2	90°phase difference 2 phase pulse （Phase A＋Phase B）		
	1	CW pulse sequence ＋ CCW pulse sequence		

	□3	Pulse sequence ＋ Directional symbol	

Command pulse input signal max. frequency and min. duration needed

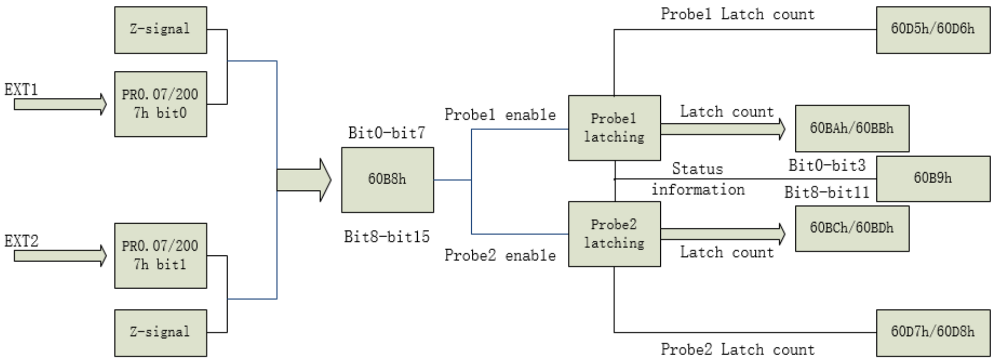
Command pulse input interface		Max. Frequency	Min. duration needed（μs）					
			t1	t2	t3	t4	t5	t6
Pulse sequence interface	Differential	500 kHz	2	1	1	1	1	1
	Open collector	200 kHz	5	2.5	2.5	2.5	2.5	2.5

Please set >0.1μs for the duration between rising and falling edge of command pulse input signal.

1 revolution with 2500 pulses 2-phase pulse input when PA0.07=0 or 2, PA0.08 = 10000;

1 revolution with 10000 pulses 1-phase pulse input when PA0.07=1 or 3, PA0.08 = 10000

6.13.1 Probe function



When using EXT1 or EXT2 as probe, please set as following:

a）Set polarity of EXT 1 or EXT 2 as probe. Set the level polarity of the probes using 0x2007 / Pr0.07. Bit 0 for EXT1 signal, bit 1 for EXT2 signal

b）Probe function is set through 0x60B8 (Bit 0-7 is for probe 1, bit8-15 is for probe 2). Functions including activation trigger signal selection, triggering mode and triggering signal edge.

Please take note:

（i）Triggering mode: Single trigger, rising signal edge = valid; triggering mode: Continuous trigger, rising and falling edge = valid

（ii）After activation, trigger signal selection, triggering signal edge settings, counter will be reset and 0x60B9 status will change as well.

（iii）Probe signal level is shown in 60FD: EXT1 -> bit 26, EXT2 -> bit 27.

Related Objects

Index	Sub Index	Label	Access	Data Type	Units	Range	Default
2007h	00h	Probe 1 polarity setting	RW	Uint16		0~0xFFFF	1

2007h	01h	Probe 2 polarity setting	RW	Uint16		0~0xFFFF	1
60B8h	00h	Probe control word	RW	Uint16		0~65535	0
60B9h	00h	Probe status word	RO	Uint16		0~65535	0
60BAh	00h	Probe 1or Z-signal rising edge latching position	RO	int32	Command unit	-2147483648~ 2147483647	0
60BBh	00h	Probe 1 or Z-signal falling edge latching position	RO	int32	Command unit	-2147483648~ 2147483647	0
60BCh	00h	Probe 2 or Z-signal rising edge latching position	RO	int32	Command unit	-2147483648~ 2147483647	0
60BDh	00h	Probe 2 or Z-signal falling edge latching position	RO	int32	Command unit	-2147483648~ 2147483647	0
60D5h	00h	Probe 1 or Z-signal rising edge counter	RO	Uint32		0~4294967296	0
60D6h	00h	Probe 1 or Z-signal falling edge counter	RO	Uint32		0~4294967296	0
60D7h	00h	Probe 2 or Z-signal rising edge counter	RO	Uint32		0~4294967296	0
60D8h	00h	Probe 2 or Z-signal falling edge counter	RO	Uint32		0~4294967296	0

6.13.2 Signal Input of EXT1 and EXT2

EXT1： Pin1 and Pin5 of CN1 terminal

EXT2： Pin2 and Pin6 of CN1 terminal

6.13.3 Probe Control Word 60B8h

Bit	Definition	Details
0	Probe 1 enable	0--Disable 1--Enable
1	Probe 1 mode	0--Single trigger mode 1--Continuous trigger mode
2	Probe 1 trigger signal selection	0—EXT1 signal 1--Z signal
3	Reserved	-
4	Probe 1 rising edge trigger	0--Disable 1--Enable
5	Probe 1 falling edge trigger	0--Disable 1--Enable
6-7	Reserved	-
8	Probe 2 enable	0--Disable 1--Enable
9	Probe 2 mode	0--Single trigger mode 1--Continuous trigger mode
10	Probe 2 trigger signal selection	0—EXT2 signal 1--Z signal
11	Reserved	-

12	Probe 2 rising edge trigger	0--Disable 1--Enable
13	Probe 2 falling edge trigger	0--Disable 1--Enable
14-15	Reserved	-

6.13.4 Probe Status Word 60B9h

Bit	Definition	Details
0	Probe 1 enable	0--Disable 1--Enable
1	Probe 1 or Z-signal rising edge trigger	0-- not executed 1-- executed
2	Probe 1 or Z-signal falling edge trigger	0-- not executed 1-- executed
3-5	Reserved	-
6-7	Reserved	-
8	Probe 2 enable	0--Disable 1--Enable
9	Probe 2 or Z-signal rising edge trigger	0-- not executed 1-- executed
10	Probe 2 or Z-signal falling edge trigger	0-- not executed 1-- executed
11-13	Reserved	-
14-15	Reserved	-

6.13.6 Latch Position Register

Index	Details
60BAh	Probe 1 or Z-signal rising edge latch position
60BBh	Probe 1 or Z-signal falling edge latch position
60BCh	Probe 2 or Z-signal rising edge latch position
60BDh	Probe 2 or Z-signal falling edge latch position

6.13.7 Latch Counter Register

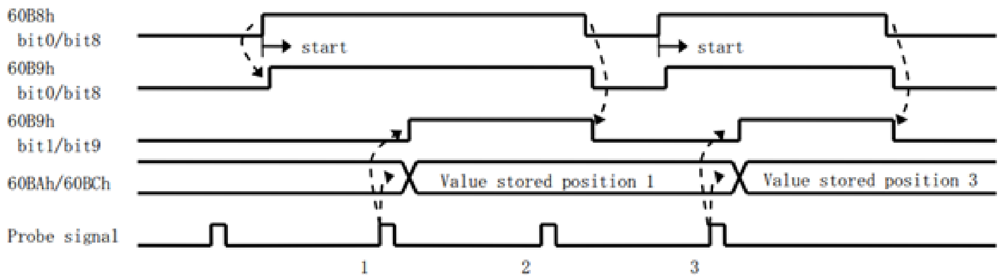
Index	Details
60D5h	Probe 1 or Z-signal rising edge counter
60D6h	Probe 1 or Z-signal falling edge counter
60D7h	Probe 2 or Z-signal rising edge counter
60D8h	Probe 2 or Z-signal falling edge counter

6.13.8 Probe mode

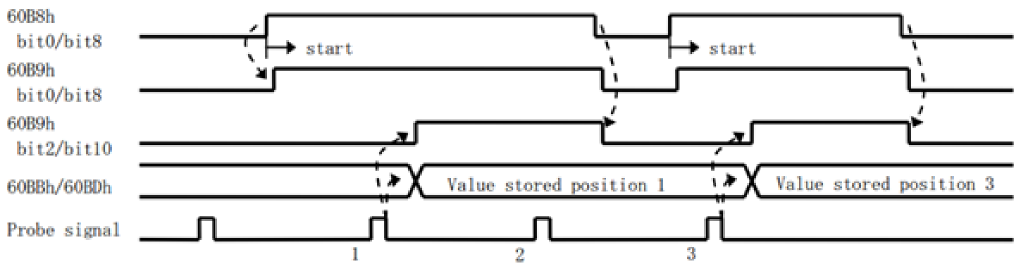
Set bit1/bit9 of 60B8h (Probe mode), 0 = Single trigger mode, 1 = Continuous trigger mode.

（1）Single trigger mode

Triggers only when the trigger signal is valid for the first time. In order to latch the position, users need to set bit0/bit8 of 60B8h to 0, then set bit0/bit8 of 60B8h to 1. The sequence diagram is as shown below:



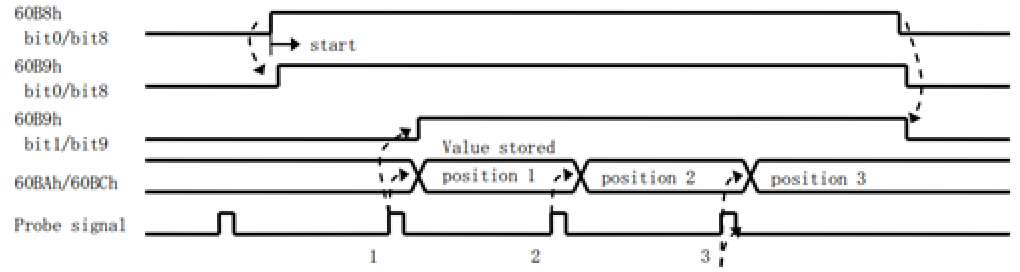
Rising edge trigger signal



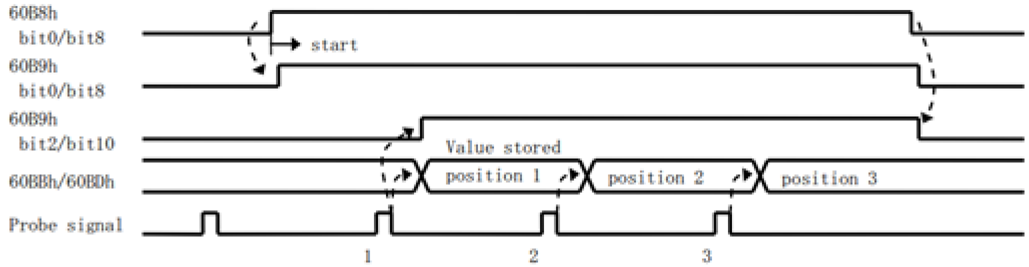
Falling edge trigger signal

（2）Continuous trigger mode

The data saved from signal triggering will be saved until the next trigger signal. Enabling the probe again is not needed. Sequence diagram as shown below:



Rising edge trigger signal



Falling edge trigger signal

6.14 Other Functions

6.14.1 Functions under Position mode

Electronic gear function

If command frequency from controller is not enough which cause the motor to not reach target rotational velocity, frequency can be increased using this function.

PA0.08	Label	Command pulse count per revolution	Mode	F			
	Range	0~8388608	Default	0	Unit	P-	
	Activation	After restart			Index	2008h	
	Pulses per revolution can be set using object dictionary 608F, 6091, 6092. However, PA0.08 has higher priority.						

Index 608Fh-01	Label	Encoder Increments			Mode	PT		
	Range	0~2147483647			Default	0	Unit	*encoder*
	Structure	VAR	Type	UINT32	Mapping	TPDO	Access	RO
	To set encoder resolution							

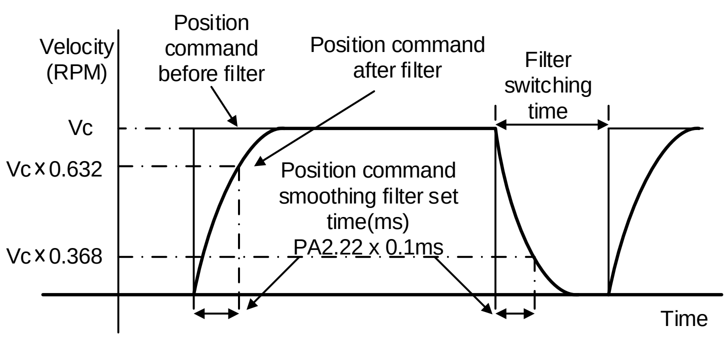
Index 6091h-01	**Label**	Motor Revolutions			**Mode**	F		
	Range	1~2147483647			**Default**	1	**Unit**	r
	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
	To set electronic gear ratio numerator							
Index 6091h-02	**Label**	Shaft Revolutions			**Mode**	F		
	Range	1~2147483647			**Default**	1	**Unit**	r
	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
	To set electronic gear ratio denominator							
Index 6092h-01	**Label**	Feed			**Mode**	F		
	Range	1~2147483647			**Default**	10000	**Unit**	*Command/r*
	Structure	VAR	**Type**	UINT32	**Mapping**	RPDO	**Access**	RW
	If 6092h-01(Feed constant) is not equal to 608Fh(Position encoder resolution), then: Electronic gear ratio = Encoder increments / 6092h-01 If 6092h-01(Feed constant) is equal to 608Fh(Position encoder resolution), then: Electronic gear ratio = 6091-01 / 6092h-01							

Position command filter function

To smoothen the position command after frequency divider/multiplier

PA2.22	**Label**	Position command smoothing filter	**Mode**	PP	HM	CSP
	Range	0~32767	**Default**	300	**Unit**	0.1ms
	Activation	After stopping			**Index**	2222h

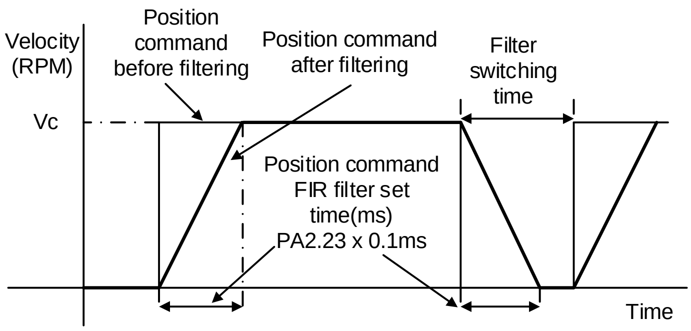
To set time constant of 1 time delay filter of position command.
To set time constant of 1 time delay filter, according to target velocity Vc square wave command as show below.



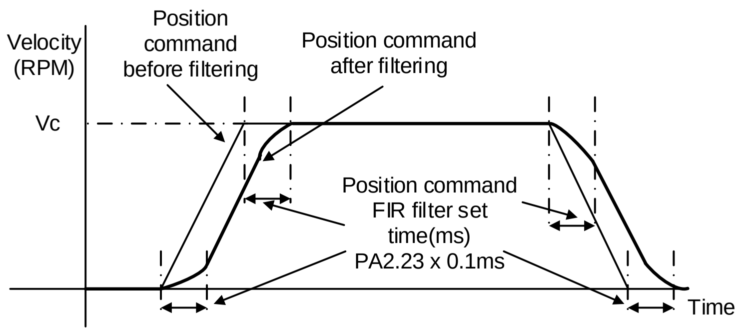
Usually applied when there is rather sharp acceleration which might cause motor overshoot or undershoot. To smoothen command signal, reduces impact to machines and eliminate vibration. If PA2.22 is set too high, overall time will be lengthened.

PA2.23	Label	Position command FIR filter	Mode	PP	HM	CSP
	Range	0~10000	Default	0	Unit	0.1ms
	Activation	After disabling			Index	2223h

As shown below, when target velocity Vc square wave command reaches Vc, it becomes trapezoidal wave after filtering.



As shown below, when target velocity Vc trapezoidal command reaches Vc, it becomes S wave after filtering.



Usually applied when there is rather sharp acceleration which might cause motor overshoot or undershoot. To smoothen command signal, reduces impact to machines and eliminate vibration. If PA2.23 is set too high, overall time will be lengthened.

***Please wait for command to stop and after filter idle time to modify PA2.23.*

Filter switching time = (PA2.23 set value x 0.1ms + 0.25ms)

In Position

Positioning completed status can be determined by output of INP signal. Under position control mode, the absolute value of position deviation counter will be ON if positioning is under the range set in PA4.31.

PA4.31	Label	Positioning complete range	Mode	PP	HM	CSP
	Range	0~10000	Default	20	Unit	*Command*
	Activation	Immediate			Index	2431h

To set position deviation range of INP1 positioning completed output signal.

PA4.32	Label	Positioning complete output settings	Mode	PP	HM	CSP
	Range	0~4	Default	1	Unit	-
	Activation	Immediate			Index	2432h

Output conditions of INP1 positioning completed output signal

Set value	Positioning completed signal
0	Signal valid when the position deviation is smaller than PA4.31
1	Signal valid when there is no position command and position deviation is smaller than PA4.31
2	Signal valid when there is no position command, zero-speed clamp detection (ZSP) signal is ON and the positional deviation is smaller than PA4.31
3	Signal valid when there is no position command and position deviation is smaller than PA4.31. Signal ON when within the time set in PA4.33 otherwise OFF.
4	When there is no command, position detection starts after the delay time set in PA4.33. Signal valid when there is no position command and positional deviation is smaller than PA4.31.

PA4.33	Label	INP positioning delay time	Mode	PP	HM	CSP
	Range	0~15000	Default	0	Unit	1ms
	Activation	Immediate			Index	2433h

To set delay time when PA 4.32 = 3

Set value	Positioning completed signal
0	Indefinite delay time, signal ON until next position command
1-15000	OFF within the time set; ON after time set. Switch OFF after receiving next position command.

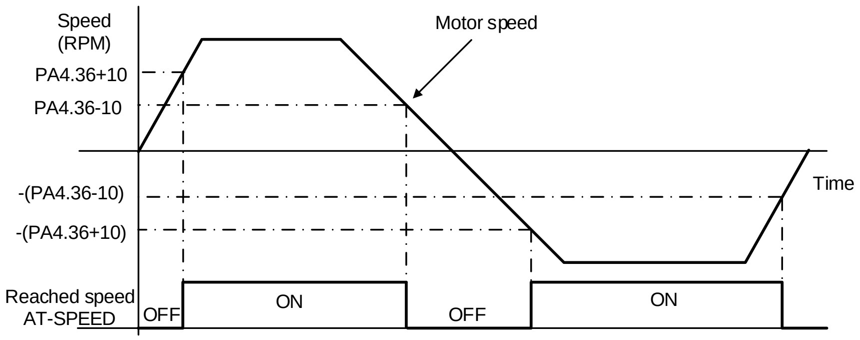
6.14.2 Functions under velocity mode

Velocity reached output signal (AT-SPEED)

AT-SPEED signal delivers after motor velocity reached target velocity.

PA4.36	Label	Reached speed (AT-speed)	Mode	PV		CSV
	Range	10~2000	Default	1000	Unit	RPM
	Activation	Immediate			Index	2436h

When motor velocity > PA4.36, AT-speed output signal is valid.
Detection using 10RPM hysteresis



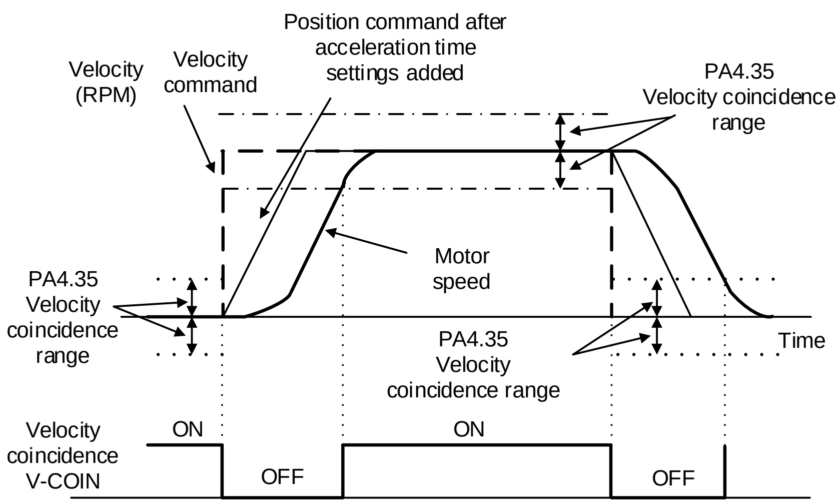
Velocity coincidence output

Velocity command (before acc-/deceleration) coincides with motor velocity. If the difference between velocity command and motor velocity is within the range set in PA4.35, it is treated as the velocity coincides.

PA4.35	**Label**	Velocity coincidence range		**Mode**	PV		CSV
	Range	10~2000		**Default**	50	**Unit**	RPM
	Activation	Immediate				**Index**	2435h

If the difference between velocity command and motor actual speed is below PA4.35, Velocity coincidence (V-COIN) output signal valid.

Due to 10RPM hysteresis:
Velocity coincidence output OFF -> ON timing (PA4.35 -10) r/min
Velocity coincidence output ON -> OFF timing (PA4.35 +10) r/min



Zero speed position output

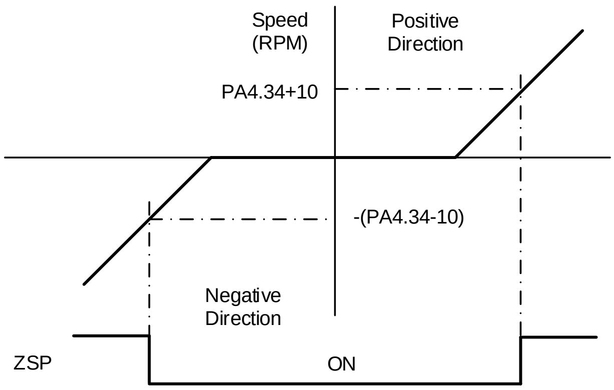
If the absolute value of the velocity feedback satisfies set conditions, corresponding output will be set to ON.

PA4.34	**Label**	Zero speed	**Mode**	**F**		
	Range	1~2000	**Default**	50	**Unit**	RPM
	Activation	Immediate			**Index**	2434h

To set threshold value for zero speed clamp detection.

Zero speed clamp detection (ZSP) output signal valid when motor speed goes under the value set in PA4.34

- Disregard the direction of rotation, valid for both directions.
- Hysteresis of 10RPM. Please refer to diagram on the right side.



6.14.3 Functions under torque mode

Velocity limit is required under torque mode to make sure motor rotational velocity stays within the limit.

Velocity limit function

During torque control, velocity control should be within the range of velocity limit. When motor reaches velocity limit, command control will switch from torque control to command control with velocity limit.

Due to gravitational or other external factors, torque command from controller might differ from the direction of rotation of the motor, velocity limit will be invalid. Please error occurs in such situation, please set PA5.13 as stopping velocity. If velocity is over the value set in PA5.13, Er1A0 might occur and motor will stop.

PA5.13	**Label**	Overspeed level setting	**Mode**	F		
	Range	0~10000	**Default**	0	**Unit**	RPM
	Activation	Immediate			**Index**	2513h
If motor speed exceeds PA5.13, Er1A0 might occur. When PA5.13 = 0, overspeed level = max. motor speed x 1.2						

Chapter 7 EtherCAT communication

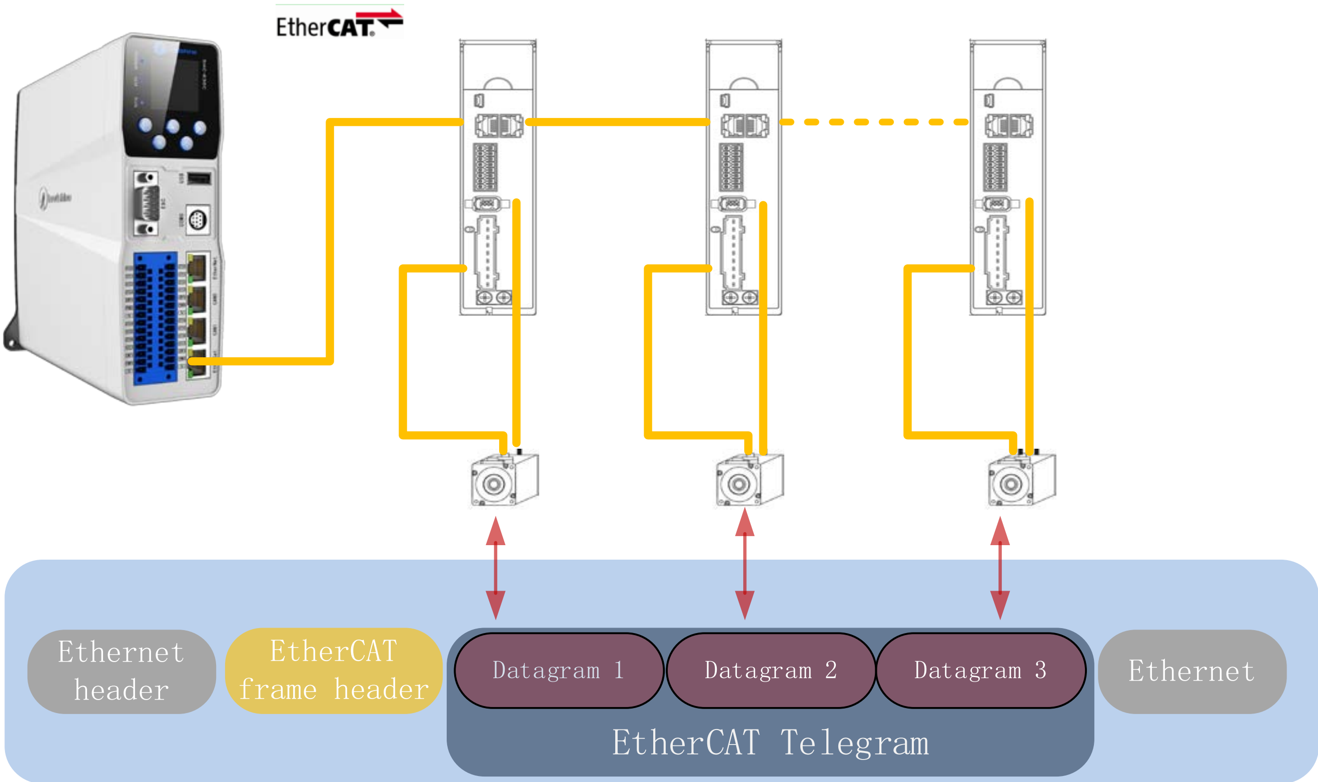
7.1 EtherCAT principle function

In comparison to Ethernet protocol which requires huge bandwidth for packets to be moved between master and clients, EtherCAT communication protocol breaks through this systemic limitation of Ethernet which requires every client to receive the whole data package from the master.

The EtherCAT master sends a telegram that passes through each node. Each EtherCAT slave device reads the data addressed to it “on the fly”, and inserts its data in the frame as the frame is moving downstream. The frame is delayed only by hardware propagation delay times. The last node in a segment (or drop line) detects an open port and sends the message back to the master using Ethernet technology’s full duplex feature.

The telegram’s maximum effective data rate increases to over 90 %, and due to the utilization of the full duplex feature, the theoretical effective data rate is even higher than 100 Mbit/s (> 90 % of two times 100 Mbit/s).

The EtherCAT master is the only node within a segment allowed to actively send an EtherCAT frame; all other nodes merely forward frames downstream. This concept prevents unpredictable delays and guarantees real-time capabilities.



EtherCAT in standard Ethernet frame

ID number setting of EtherCAT slave station

To set up EtherCAT slave station ID number, please set PA0.24 = 1 and set required ID number to PA0.23.

PA0.23	Label	EtherCAT slave ID	Mode	F		
	Range	0~32767	Default	2	Unit	-
	Activation	After restart			Index	2023h
Set ID number of the slave station under EtherCAT mode						
PA0.24	Label	Source of slave ID	Mode	F		
	Range	0~1	Default	1	Unit	-
	Activation	After restart			Index	2024h
0: Master device automatically assigns a slave address. 1：The slave ID = PA0.23						

7.2 Synchronous Mode

7.2.1 Free Running Mode

In free moving mode, EL7-EC processes the process data sent by the master asynchronously. It only applies to asynchronous motion mode such as homing mode, protocol position mode, etc

7.2.2 Distributed clock synchronization mode

EL7-EC adopts the synchronous mode of distributed clock as shown in figure 6.2. When the master station sends process data to the slave station, the slave station immediately reads the process data, and then waits for the synchronization signal to trigger the process data to act on the driver.

The process data must arrive at the EL7-EC drive before the time of Sync0 signal T1. The drive has completed the analysis of the process data and relevant control calculation before the arrival of Sync0 event. After receiving Sync0 event, EL7-EC immediately implements the control action which has a high synchronization performance.

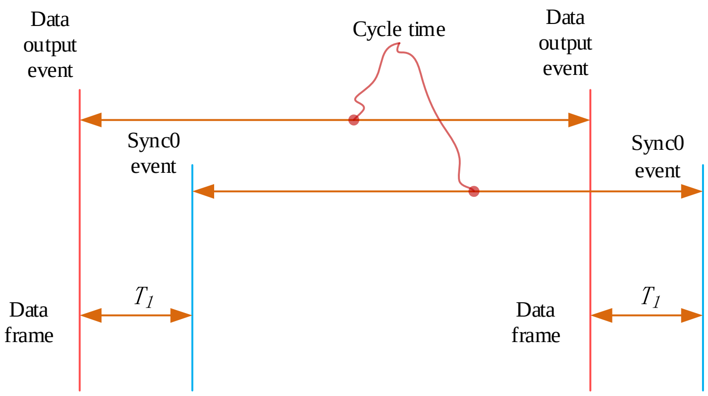


Figure 7.2 High performance synchronization mode

7.3 EtherCAT state machine

EtherCAT state machine, commonly known as "communication state machine ", is mainly used to manage communication between master and slave stations. The communication function mainly includes mailbox and process data communication. The EtherCAT state machine transition relationship is shown in figure 6.3

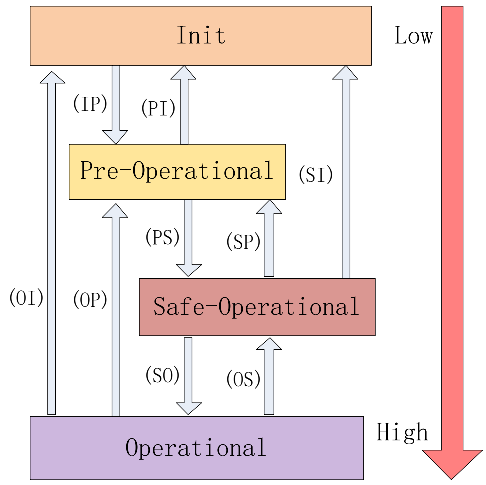


Figure 7.3 EtherCAT state machine transitions

EtherCAT state machine transitions have the following characteristics：

① From initialization to operational, the conversion must be carried out strictly in the order of initializing > pre-operational > safe operational > operational, from low to high, and no grade skipping is allowed

② When converting from high to low, grade skipping is allowed.

③ If state transition request to master station fails, slave station will send an error message to the master station.

EtherCAT 402 State Machine Communication function

State and transition	Communication function
Init	No mailbox or process data communication is possible.
Pre-Operational	Mailbox communication is effective, no process data communication, SDO function is valid
Safe-Operational	Mailbox communication and sending process data object is valid, SDO and TXPDO are valid
Operational	Mailbox communication, receive and send process data object valid, SDO、RXPDO and TXPDO valid

7.4 CANopen over EtherCAT (CoE)

7.4.1 Network structure of EL7-EC

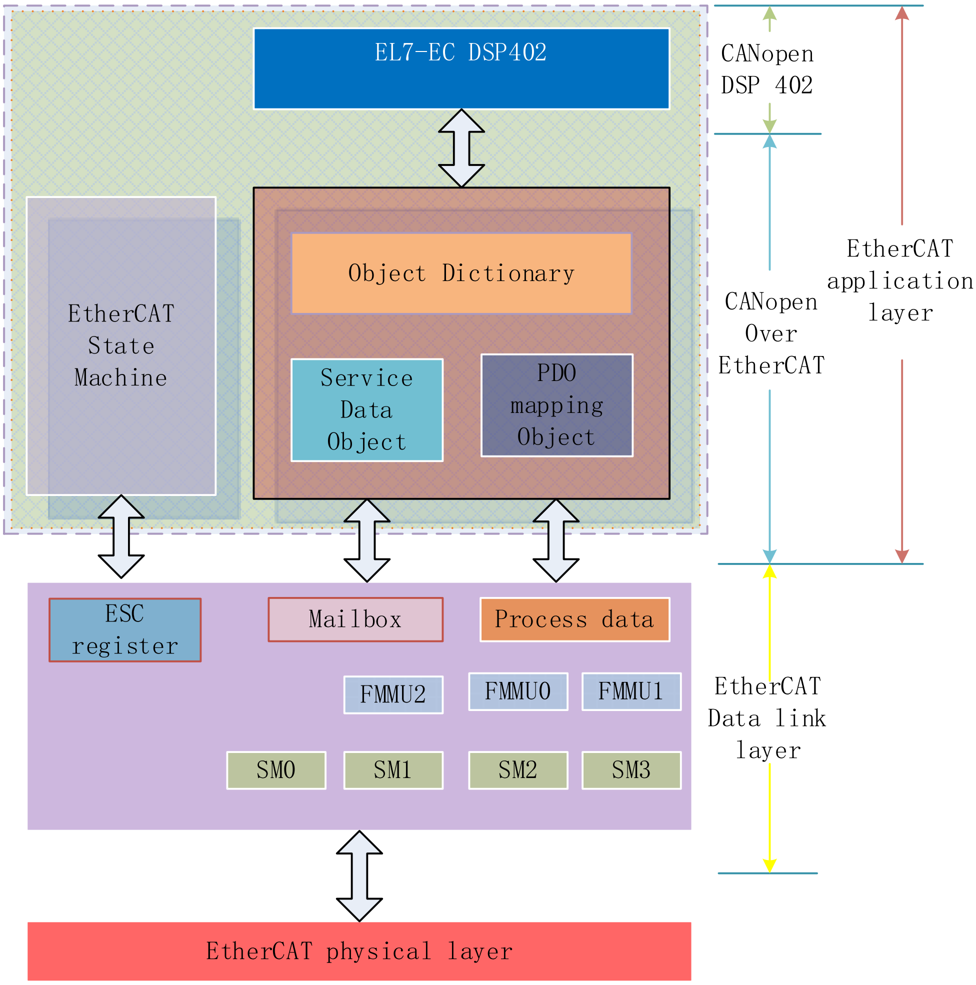


Figure 7.4 The structure of EL7-EC network module

The data link layer is mainly implemented by EtherCAT slave station controller (ESC). EL7-EC EtherCAT application layer protocol mainly includes application part (CANopen DSP402), object dictionary and communication function (red frame part), among which object dictionary and communication function can be jointly called CoE part.

Object dictionary——Bridge of communication function and application part.

Communication function——Implementation of communication rules (SDO, PDO, etc.)

Application part——Define the specific function of the device, such as the drive, IO module.

7.4.2 Object dictionary

EtherCAT master controls the EL7-EC drive by writing and reading device state /information. To do this, the drive defines read-write parameters and read-only state values. Object dictionary is the collection of these parameters and states.
The EL7-EC object dictionary contains all DSP402 and CoE related data objects in a standardized manner. It is a collection of EL7-EC parameter data structures.
The EL7-EC object dictionary is the interface with which the controller communicates. EtherCAT master implements EL7-EC motion control through the interface of object dictionary.

7.4.3 Service Data Object (SDO)

The EL7-EC series supports SDO services. EtherCAT master can configure, monitor and control EL7-EC servos by using SDO to read and write EL7-EC object dictionaries.
In conventional CANopen DS301 mode, SDO protocol CAN only transfer 8 bytes at a time to match the data length of CAN message. In COE enhancement mode, only the payload data is expanded without changing the protocol head; In this way, the SDO protocol uses mailboxes with larger data lengths, thus improving the transmission efficiency of big data.

7.4.4 Process Data Object (PDO)

PDO Introduction

PDO is generally used for real-time data updates. It is divided into receiving PDO (RXPDO) and sending PDO (TXPDO). The data stream direction of receiving PDO is from master station to slave station, while sending PDO is from slave station to master station
The PDO function of EL7-EC supports both synchronous cycle mode and non-periodic update mode. When distributed clock synchronization mode is selected on master station, PDO will update according to the synchronization cycle. If free moving mode is selected, PDO data updates aperiodic.

PDO mapping

Through PDO mapping, the real-time transmission of mapped objects can be realized. EL7-EC supports simultaneous transmission of 2 sets of RXPDO and 2 sets of TXPDO. Each PDO object can map up to 8 object dictionary (maximum length 32 bytes). The format of PDO mapping content is shown in table 6.2

Table 7.2 Format of PDO mapping

Bit	31~16	15~8	7~0
Description	Index of mapped object	Subindex of mapped object	Bit length (Hex)
Example	6040h	00h	10h(16bit)

Default PDO mapping (consistent with the XML file) is shown in table 7.3

Table 7.3 Default PDO mapping

PDO Map object index	PDO Map object Sub-index	Mapping content	Mapped Object			Description
			Index	Sub-index	Bit length	
RXPDO1 (1600h)	01h	60400010h		00h	10h(16 bit)	01h
	02h	607A0020h		00h	10h(16 bit)	02h
	03h	60B80020h		00h		03h
RXPDO2 (1601h)	01h	60400010h	6040h	00h	10h(16 bit)	Control word
	02h	60FF0020h	60FFh	00h	20h(32 bit)	Target velocity
	03h	60B20010h	60B2h	00h	10h(16 bit)	Torque feedforward
RXPDO3 (1602h)	01h	60400010h	6040h	00h	10h(16 bit)	Control word
	02h	60710010h	6071h	00h	10h(16 bit)	Target torque
	03h	60870020h	6084h	00h	20h(32 bit)	Profile deceleration
RXPDO4 (1603h)	01h	60400010h	6040h	00h	10h(16 bit)	Control word
	02h	60980008h	6098h	00h	08h(8 bit)	Homing method
	03h	60990120h	6099h	01h	20h(32 bit)	High homing velocity
	04h	60990220h	6099h	02h	20h(32 bit)	Low homing velocity
	05h	609A0020h	609Ah	00h	20h(32 bit)	Homing acceleration
	06h	607C0020h	607Ch	00h	20h(32 bit)	Homing position offset
	07h	60600008h	6060h	00h	08h(8 bit)	Operation mode
TXPDO1 (1A00h)	01h	603F0000h				
	02h	60410000h				
	03h	60610000h				
	04h	60640000h				
	05h	60B90020h				
	06h	60BA0020h				
	07h	60FD0020h				
TXPDO2 (1A01h)	No default mapping					

PDO dynamic mapping

Different from CIA DS301, CoE uses PDO specified objects (1C12h/1C13h) to configure PDO mapped objects (1600h~1603h/1A00h~1A01h) to PDO SyncManager (SyncManager 2/3). PDO specified objects are defined in table 6.4

Table 6.4 PDO specifies object definitions

Index	Sub-index	Range	Data type	Access
RXPDO (1C12h)	00h	0~4	U8*1)	RO *2)
	01h	1600h~1603h	U16	RW
	02h		U16	RW
	03h		U16	RW
	04h		U16	RW
TXPDO (1C13h)	00h	0~2	U8	RO
	01h	1A00h~1A01h	U16	RW
	02h		U16	RW

*** 1) U represents unsigned type, such as U8 for unsigned 8 bits and U16 for unsigned 16 bits*

2) Access: RO = Read Only, RW = Read and Write, WO = Write Only

PDO dynamic mapping setup procedure

A、 Switch EtherCAT state machine to pre-operational, then PDO map can be configured using SDO.

B、 Clear the PDO mapping object of the PDO specified object by setting 1C12-00h / 1C13-00h to 0.

C、 Invalidate the PDO mapping object by assigning 0 to the subindex 0 of 1600h~1603h /1A00h~1A01h.

D、 Reconfigure PDO mapping content and write the mapping object into the objects in the range of 1600-01h~1600-08h, 1601-01h~1601-08h, 1602-01h~1602-08h, 03-01h~1603-08h (RXPDO mapping content as from 1600h-01), 00-01h ~ 1A00-08h or 1A01-01h~1A01-08h (TXPDO mapping content as from 1A00h-01) according to Table 6.3

E、 Set the total number of PDO mapping objects by writing the number of mapping objects into 1600-00h, 1601-00h, 1602-00h, 1603-00h, 1A00-00h or 1A01-00h. The total number of PDO mapping objects without mapping content will be set to 0.

F、 Write valid PDO mapping object index to PDO specified object by writing valid RXPDO mapping object index 1600h~1603h into 1C12-01h ~ 1C12-04h and writing valid TXPDO mapping object index 1A00h, 1A01h into 1C13-01h, 1C13-02h.

G、 Set the total number PDO specified objects by writing the number of mapped objects to 1C12-00h and 1C13-00h.

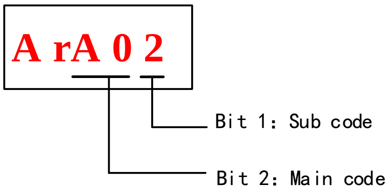
H、 Switch EtherCAT state to Safe-Operational or above, the configured PDO mapping will be valid.

Chapter 8 Warning and Alarm

8.1 Servo drive warning

When warning occurs, driver will set protective function but **motor won't stop moving**. Error code will be displayed on the front panel.

Example of warning code:



Warning Code		Content
Main	Code	
A0	1	Overload warning
	2	Regeneration energy overload warning(**85% of the regeneration threshold**)
	3	Absolute encoder **battery voltage low (<3.1V)**. Valid when Pr0.15 is set to 1.
	4	Change the parameter to a non-real time valid warning
	5	**Pr0.01 is not 9** under current control mode, please correct this parameter

8.2 Servo drive alarm

When alarm occurs, driver will set protective function and **motor stops moving**. Error code will be displayed on the front panel. Alarm history record can also be viewed in data monitoring mode, with the alarm log sub-menu displaying "d12Er".

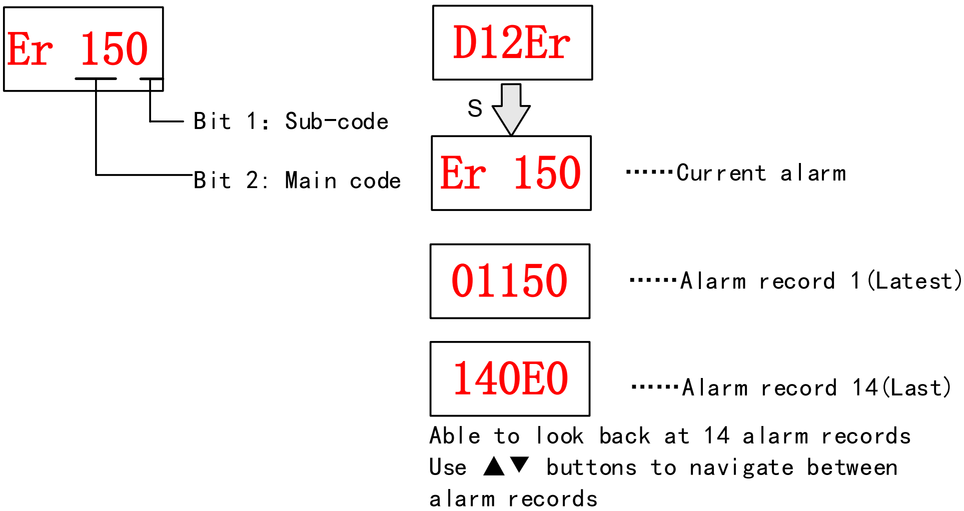


Table 9.1 Error Code List

Error code		Content	Attribute		
Main	Sub		Save	Type	Clearable
0A	0~1	Circuit current detection error	●	2	
	3	Motor power cable not connected	●	1	●
0b	0	Control circuit power supply voltage too low		2	
	1	Control circuit power supply voltage too high		2	●
0c	0	DC bus overvoltage	●	1	●
0d	0	DC bus undervoltage	●	1	●
	1	Single phasing of main power supply	●	2	
	2	No main power supply detected		2	
0E	0	Overcurrent	●	1	
	1	Intelligent Power Module (IPM) overcurrent	●	1	
	2	Power output to motor shorted to ground	●	1	
	4	Phase overcurrent	●	1	
0F	0	Driver overheated	●	2	
10	0	Motor overloaded	●	1	●
	1	Driver overloaded	●	1	●
	2	Motor rotor blocked	●	1	●
12	0	Regenerative resistor overvoltage	●	2	
	1	Holding brake error	●	1	
	2	Regenerative resistor value too low	●	2	
15	0	Encoder disconnected	●	1	
	1	Encoder communication error	●	1	
	2	Encoder initial position error	●	1	
	3	Multiturn encoder error	●	2	
	4	Encoder parameter settings error	●	2	

	5	Encoder data overflow	●	2	●
	6	Encoder overheated	●	2	●
	7	Encoder counter error	●	2	●
17	0	Encoder data error	●	1	
	1	Encoder parameter initialization error	●	1	
18	0	Excessive position deviation	●	2	●
	1	Excessive velocity deviation			
19	0	Motor vibration too strong	●	2	●
1A	0	Overspeed	●	2	●
	1	Velocity out of control	●	1	●
1b	0	Bus input signal dithering	●	2	●
	1	Incorrect electronic gear ratio		2	
1c	0	Both STO failed	●	1	●
	1	1st STO failed	●	1	
	2	2nd STO failed	●	1	
	3	STO power supply 1 anomaly	●		
	4	STO power supply 2 anomaly	●		
	5	STO input circuit 1 anomaly	●		
	6	STO input circuit 2 anomaly	●		
	7	STO circuit BUFFER 1 anomaly	●		
	8	STO circuit BUFFER 2 anomaly	●		
21	0	I/O input interface assignment error	●	2	
	1	I/O input interface function assignment error	●	2	
	2	I/O output interface function assignment error	●	2	
24	0	EEPROM parameters initialization error		2	
	1	EEPROM hardware error		2	
	2	Error saving alarm history record		2	
	3	Error occurred when saving vendor parameters		2	
	4	Error occurred when saving communication parameters		2	
	5	Error occurred when saving parameter 402		2	
	6	Data saving error during power-off			
26	0	Positive/Negative position limit triggered under non-homing mode	●	2	●
27	0	Analog 1 input overrun limit	●	2	●
	1	Analog 2 input overrun limit	●	2	●
28	0	Output pulse frequency too high	●	2	●
57	0	Forced alarm input valid	●	2	●
5F	0	Motor model no. detection error		2	
	1	Driver power module detection error		2	

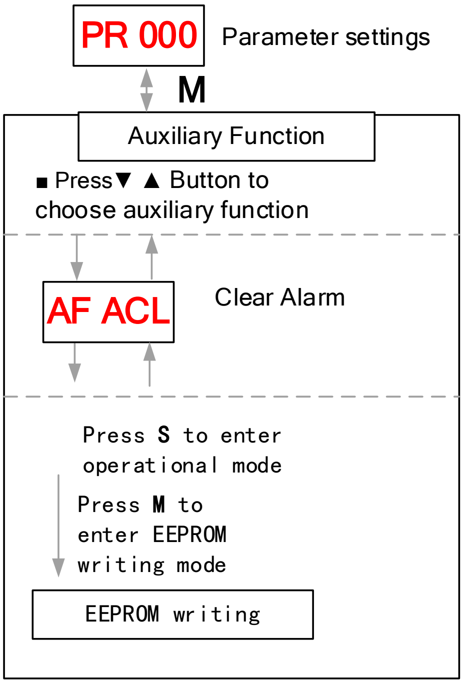
60	0	Main loop interrupted timeout		2	
	1	Velocity loop interrupted timeout		2	
70	0	Encryption error		2	

[Note:]

Save: Save error messages to alarm history.

Type: The type 1 and type 2 fault stop mode can be set via Pr5.10 [Sequence at alarm].

Clearable: Clearable alarm by operating the front panel and use auxiliary function **AFACL** as below. Besides clearable alarms, please first solve the error and restart the servo driver to clear alarm.



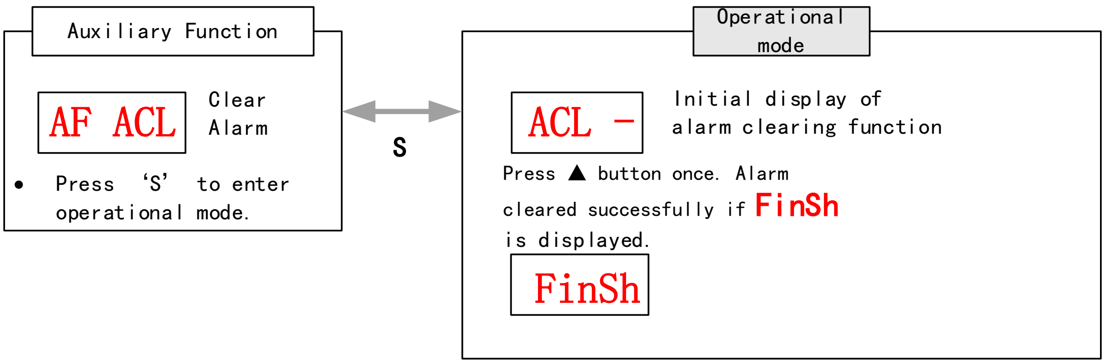


Table 8.2 Alarm and 603F correspondence

Error Code Display	1001h	603Fh	ETG Code	Alarm Description
Er 0A0	0x04	0x3150		Phase A circuit current detection error
Er 0A1	0x04	0x3151		Phase B circuit current detection error
Er 0A3	0x04	0x3153		Motor power cable not connected
Er 0b0				Control circuit power supply voltage too low
Er 0b1	0x04	0x3206		Control power supply voltage too high
Er 0C0	0x04	0x3211		DC bus overvoltage
Er 0d0	0x04	0x3221		DC bus undervoltage
Er 0d1	0x04	0x3130		Single phasing of main power supply
Er 0d2	0x04	0x3222		No main power supply detected
Er 0E0	0x02	0x2211		Overcurrent
Er 0E1	0x02	0x2212		Intelligent Power Module (IPM) overcurrent
Er 0E2	0x02	0x2218		Power output to motor shorted to ground
Er 0E4	0x02	0x2230		Phase overcurrent
Er 0f0	0x08	0x4210		Driver overheated
Er 100	0x02	0x8311		Motor overloaded
Er 101	0x02	0x8310		Driver overloaded
Er 102	0x02	0x8301		Motor rotor blocked
Er 120	0x80	0x7701		Regenerative resistor overvoltage
Er 121	0x80	0x7702		Holding brake error
Er 122	0x80	0x7703		Regenerative resistor value too low
Er 150	0x80	0x7321		Encoder disconnected
Er 151	0x80	0x7322		Encoder communication error
Er 152	0x80	0x7323		Encoder initial position error
Er 153/Er 154	0x80	0x7325		Multiturn encoder error / Encoder parameter settings error
Er 155	0x80	0x7326		Encoder data overflow
Er 156	0x80	0x7327		Encoder overheated
Er 157	0x80	0x7328		Encoder count error
Er 170	0x80	0x7324		Encoder data error
Er 171	0x80	0x7325		Encoder parameter initialization error
Er 180	0x20	0x 8611		Excessive position deviation
Er 181				Excessive velocity deviation
Er 190	0x20	0x 8401		Motor vibration too strong
Er 1A0	0x20	0x 8402		Overspeed
Er 1A1	0x20	0x 8403		Velocity out of control
Er 1b0	0x20	0x 8612		Bus input signal dithering

Er 1b1	0x20	0x 8503		Incorrect electronic gear ratio
Er 1c0	0x02	8313		Both STO failed
Er 1c1	0x02	8313		1st STO failed
Er 1c2	0x02	8313		2nd STO failed
Er 210	0x80	0x6321		I/O input interface assignment error
Er 211	0x80	0x6322		I/O input interface function assignment error
Er 212	0x80	0x6323		I/O output interface function assignment error
Er 240	0x80	0x5530		EEPROM parameters initialization error
Er 241	0x80	0x5531		EEPROM hardware error
Er 242	0x80	0x5532		Error saving alarm history record
Er 243	0x80	0x5533		Error occurred when saving vendor parameters
Er 244	0x80	0x5534		Error occurred when saving communication parameters
Er 245	0x80	0x5535		Error occurred when saving parameter 402
Er 246	0x80	0x5536		Data saving error during power-off
Er 260	0x80	0x7329		Positive/Negative position limit triggered under non-homing mode
Er 270				Analog 1 input overrun limit
Er 271				Analog 2 input overrun limit
Er 280	0x80	0x7201		Output pulse frequency too high
Er 570	0x80	0x5441		Forced alarm input valid
Er 5f0	0x80	0x7122		Motor model no. detection error
Er 5f1	0x80	0x1100		Driver power module detection error
Er 600	0x80	0x6204		Main loop interrupted timeout
Er 601	0x80	0x6204		Velocity loop interrupted timeout
Er 700	0x80	0x7001		Encryption error
Er 73A	0x10	0x873 A		SyncManager2 lost
Er 73b	0x10	0x873 B		SYNC0 lost
Er 73c	0x10	0x873 C		Excessive Distributed Clock error
Er 801	0x10	0x8201	0x0001	Unknown communication error
Er 802	0x80	0x5510	0x000 2	Memory overflow
Er 803	0x80	0x5511		RAM out of bound
Er 805	0x80	0x6202		FOE firmware upgrade failed
Er 806	0x80	0x6201		Saved ESI file does not match driver firmware

Er 811	0x10	0xA001	0x0011	Invalid EtherCAT transition request
Er 812	0x10	0xA002	0x0012	Unknown EtherCAT state machine transition request
Er 813	0x10	0x8213	0x0013	Protection request from boot state
Er 814	0x80	0x6203		Invalid firmware
Er 815	0x10	0x8215	0x0015	Invalid mailbox configuration under boot state
Er 816	0x10	0x8216	0x0016	Pre-Op status is invalid for the mailbox configuration
Er 817	0x10	0x8217		Invalid SyncManager configuration
Er 818	0x10	0x8211		No valid input data
Er 819	0x10	0x8212		No valid output data
Er 81A	0x10	0xFF02	0x871A	Synchronization error
Er 81b	0x10	0x821B	0x001B	SyncManager2 watchdog timer timeout
Er 81C	0x10	0x821C	0x001C	Invalid SyncManager type
Er 81d	0x10	0x821D	0x001D	Invalid output configuration
Er 81E	0x10	0x821E	0x001E	Invalid input configuration
Er 81f	0x10	0x821F		Watchdog configuration invalid
Er 821	0x10	0xA003	0x0021	Waiting for EtherCAT state machine Init state
Er 822	0x10	0xA004	0x0022	Waiting for the EtherCAT state machine Pre-Op state
Er 823	0x10	0xA005	0x0023	Waiting for master device for Safe-Op request
Er 824	0x10	0x8224	0x0024	Invalid process data input mapping
Er 825	0x10	0x8225	0x0025	RPDO mapping invalid (length, parameter not present, no this property)
Er 827	0x10	0x8227		Free running mode is not supported
Er 828	0x10	0x8228		Sync mode not supported
Er 82b	0x10	0x8210	0x002B	Invalid inputs and outputs
Er 82C	0x10	0x872C	0x002C	Fatal synchronization error
Er 82d	0x10	0x872D	0x002D	No synchronization error
Er 82E	0x10	0x872E	0x002E	Synchronization cycle time is too short
Er 830	0x10	0x8730	0x0030	Invalid Distributed Clock synchronization settings
Er 832	0x10	0x8732	0x0032	Distribution Clock phase-locked loop failure
Er 833	0x10	0x8733		DC sync IO error

Er 834	0x10	0x8734		DC sync timeout
Er 835	0x10	0x8735		Distribution Clock cycle time is invalid
Er 836	0x10	0x8736	0x0036	Invalid Distribution Clock synchronization cycle time
Er 850	0x80	0x5550	0x0050	EEPROM is inaccessible
Er 851	0x80	0x5551	0x0051	EEPROM error
Er 852	0x80	0x5552	0x0052	Hardware is not ready
Er 860	0x80	0xFF01		EtherCAT frame lost per unit time exceeds limit
Er 870	0x80	0x5201		Driver can't be enabled under current control mode

8.3 Alarm Handling

***When error occurs, please solve accordingly. Then, restart.*

Error code	Main	Sub	**Display:** "Er 0A0"--"Er 0A1"	
	0A	0~1	**Content:** Circuit current detection error	
Cause			Diagnosis	Solution
Motor power cable wiring error			Verify motor power cable wiring	Make sure U,V,W terminal wired properly
Main power supply undervoltage			Verify L1,L2,L3 terminal voltage	Increase main power supply voltage
Driver fault			/	Replace driver

Error code	Main	Sub	**Display:** "Er 0A3"	
	0A	3	**Content:** Motor power cable not connected	
Cause			Diagnosis	Solution
Motor power cable not connected			Verify motor power cable wiring	Measure **resistance values between U, V, W terminals**, make sure the values are almost equal. If not, might be due to damaged motor or motor winding open circuit.
Motor fault			/	Replace motor
Driver fault			/	Replace driver

Error code	Main	Sub	**Display:** "Er 0b1"	
	0b	1	**Content:** Control circuit power supply abnormal	
Cause			Diagnosis	Solution
USB power supply too low			Verify if USB cable is properly connected and not damaged.	Replace USB mini cable
Driver fault			/	Replace driver

Error code	Main	Sub	**Display:** "Er 0c0"	
	0c	0	**Content:** DC bus overvoltage	
Cause			Diagnosis	Solution
Main power supply overvoltage			Verify L1,L2,L3 terminal voltage	Decrease main power supply voltage
Inner brake circuit damaged			/	Replace driver
Driver fault			/	Replace driver

Error code	Main	Sub	Display: "Er 0d0"	
	0d	0	**Content**: DC bus undervoltage	
Cause			Diagnosis	Solution
Main power supply undervoltage			Verify L1,L2,L3 terminal voltage	Increase main power supply voltage
L1C, L2C connected when USB cable is connected			Control circuit power on before driver initialization. Alarm might occur.	Please disconnect the USB cable before powering on control circuit.
Driver fault			/	Replace driver

Error code	Main	Sub	Display: "Er 0d1"	
	0d	1	**Content**: Single phasing of main power supply	
Cause			Diagnosis	Solution
Main power supply undervoltage			Verify L1,L2,L3 terminal voltage	Increase main power supply voltage
Main power supply wiring error			Loose connection of L1, L2, L3	Secure connections
Driver fault			/	Replace driver

Error code	Main	Sub	Display: "Er 0d2"	
	0d	2	**Content**: No main power supply detected	
Cause			Diagnosis	Solution
No main power supply			Verify L1,L2,L3 terminal voltage	1. Increase main power supply voltage 2. Secure connections
Driver fault			/	Replace driver

Error code	Main	Sub	Display: "Er 0E0"	
	0E	0	Content: Overcurrent	
Cause			Diagnosis	Solution
Driver power output short circuit			Verify if there is short circuit between UVW terminals, or shorted to PG.	1. Make sure there is no circuit. 2. Make sure motor is not damaged
Motor wiring error			Verify motor wiring	Reconnect motor wiring
IGBT module short circuit			Disconnect motor output cable. Then, enable servo driver to check for overcurrent	Replace driver
Excessive motor load			Verify if motor torque output is too high	1. Reduce load 2. Add a gearbox
Excessive acceleration and deceleration			Verify if acceleration and deceleration duration time are too low	Increase acceleration and deceleration duration time
Motor wiring short circuit			Connect motor power cable to driver power output. Verify if resistance value of UVW to PE is equal and if there is short circuit	Replace motor

Error code	Main	Sub	Display: "Er 0E1"	
	0E	1	Content: Intelligent Power Module (IPM) overcurrent	
Cause			Diagnosis	Solution
Driver power output short circuit			Verify if there is short circuit between UVW terminals, or shorted to PG.	1. Make sure there is no circuit. 2. Make sure motor is not damaged
Motor wiring error			Verify motor wiring	Reconnect motor wiring
IGBT module short circuit			Disconnect motor output cable. Then, enable servo driver to check for overcurrent	Replace driver
IGBT module undervoltage			/	Replace driver
Excessive motor load			Verify if motor torque output is too high	1. Reduce load 2. Add a gearbox
Excessive acceleration and deceleration			Verify if acceleration and deceleration duration time are too low	Increase acceleration and deceleration duration time
Motor wiring short circuit			Connect motor power cable to driver power output. Verify if resistance value of UVW to PE is equal and if there is short circuit	Replace motor

Error code	Main	Sub	Display: "Er 0E2"	
	0E	2	**Content**: Power output to motor shorted to ground	
Cause			Diagnosis	Solution
Driver U, V, W terminals shorted to ground			Disconnect motor power cable and check for short circuit between driver UVW and PE	1. Reconnect wiring. 2. Change motor power cable.
Motor shorted to ground			Connect motor power cable to driver power output. Verify if resistance value of UVW to PE is in the range of MegaOhm (MΩ)	Replace motor
Driver fault			/	Replace driver

Error code	Main	Sub	Display: "Er 0E4"	
	0E	2	**Content**: Phase overcurrent	
Cause			Diagnosis	Solution
Driver U, V, W terminals shorted to ground			Disconnect motor power cable and check for short circuit between driver UVW and PE	1. Reconnect wiring. 2. Change motor power cable.
Motor shorted to ground			Connect motor power cable to driver power output. Verify if resistance value of UVW to PE is equal and if there is short circuit	Replace motor
Driver fault			/	Replace driver

Error code	Main	Sub	Display: "Er 0F0"	
	0F	0	**Content**: Driver overheated	
Cause			Diagnosis	Solution
Temperature of power module exceeded upper limit			Measure the temperature of driver radiator.	1. Improve cooling condition. Please check installation guide; 2. Replace driver and motor with higher power rating; 3. Increase duration time for acceleration and deceleration; 4. Decrease load

Error code	Main	Sub	Display: "Er 100"	
	10	0	**Content:** Motor overloaded	
Cause			Diagnosis	Solution
Load too heavy			Verify if actual load exceeds maximum value allowed	1. Decrease load 2. Adjust limit values
Strong mechanical vibration			Look for mechanical vibration from machine system	1. Adjust gain value of control loop 2. Increase duration time for acceleration and deceleration
Motor or encoder cable wiring error			Verify motor and encoder wiring	1. Reconnect wiring 2. Replace motor and encoder cable
Holding brake engaged			Verify holding brake terminal voltage	Cut off holding brake

Error code	Main	Sub	Display: "Er 102"
	10	2	Content: Motor rotor blocked

Cause	Diagnosis	Solution
Motor rotor blocked	Look for mechanical blockages	Check the machinery
Motor rotor blocking time threshold value too low	Verify value of Pr6.57	Adjust value of Pr6.57

Error code	Main	Sub	Display: "Er 120"
	12	0	Content: Regenerative resistor overvoltage

Cause	Diagnosis	Solution
Regenerative energy exceeded capacity of regenerative resistor	1. Verify if velocity is too high 2. Verify if load is too large	1. Decrease motor rotational velocity; 2. Decrease load inertia; 3. Add an external regenerative resistor;
Power supply voltage too high	1. Verify if power supply voltage is within the rated range. 2. Interval regenerative resistor value is too low	1. Decrease power supply voltage 2. Increase regeneration resistance value(add external regenerative resistor)
Unstable power supply voltage	Verify if power supply voltage is stable	Add a surge suppressor to main power supply.
Regenerative energy discharge circuit damaged	/	1. Add an external regenerative resistor; 2. Replace driver

Error code	Main	Sub	Display: "Er 121"
	12	1	Content: Holding brake error

Cause	Diagnosis	Solution
Holding brake circuit damaged	Regenerative resistor disconnected	Replace regenerative resistor
	Holding brake IGBT damaged	Replace driver

Error code	Main	Sub	Display: "Er 122"
	12	2	Content: Regenerative resistor value too low

Cause	Diagnosis	Solution
External regenerative resistor value is less than the minimum value allowed by the drive	/	Replace the regenerative resistor with the right resistance value which meets the specification of the driver

Error code	Main	Sub	Display: "Er 150"	
	15	0	Content: Encoder disconnected	
Cause			Diagnosis	Solution
Encoder cable disconnected			Verify encoder cable connection	Make sure encoder cable properly connected
Encoder cable wiring error			Verify if encoder wiring is correct	Reconnect encoder wiring
Encoder damaged			/	Replace motor
Encoder measuring circuit damaged			/	Replace driver

Error code	Main	Sub	Display: "Er 151"	
	15	1	Content: Encoder communication error	
Cause			Diagnosis	Solution
Encoder wire shielding layer is missing			Verify if encoder cable has shielding layer	Replace with standard encoder cable
Encoder cable wiring error			Verify if encoder wiring is correct	Reconnect encoder wiring
Encoder damaged			/	Replace motor

Error code	Main	Sub	Display: "Er 152"	
	15	2	Content: Encoder initial position error	
Cause			Diagnosis	Solution
Communication data abnormal			1. Verify if encoder power supply voltage is DC5V±5%; 2. Verify if encoder cable and shielded layer is not damaged; 3. Verify if encoder cable is close to high-powered power supply cable	1. Make sure encoder power supply voltage is stable 2. Make sure encoder cable is not damaged. 3. Make sure encoder cable shielded layer is grounded to frame 4. Make sure encoder cable is away from high-powered power supply cable
Encoder damaged			/	Replace motor
Encoder measuring circuit damaged			/	Replace driver

Error code	Main	Sub	Display: "Er 153"	
	15	3	Content: Multiturn encoder error	
Cause			Diagnosis	Solution
Initial use			Origin calibration not performed	Perform origin positioning and multiturn position initialization, calibrate the origin of coordinate system.
Encoder without multiturn absolute function used			Verify if encoder has multiturn absolute function	1. Replace the motor with a multiturn absolute encoder. 2. Set Pr0.15 = 0 to deactivate multiturn absolute function.
Low battery power			Replace battery and restart driver to clear alarm	Replace battery
Battery has no power or has been dismantled			Alarm not cleared after replacing battery and restart	Absolute position lost. Return to origin and perform multiturn initialization, calibrate the origin of coordinate system

Error code	Main	Sub	Display: "Er 154"	
	15	4	Content: Encoder parameter settings error	
Cause			Diagnosis	Solution
Absolute encoder mode is incorrectly set.			Verify if encoder has multi-turn absolute value function.	Modify absolute encoder mode settings

Error code	Main	Sub	Display: "Er 155"	
	15	5	Content: Encoder data overflow	
Cause			Diagnosis	Solution
Encoder data overflow			Verify if encoder is not damaged	Initialize multiturn data
Absolute value applications, motor rotates in one direction			Verify if encoder is not damaged	Adjust absolute value application mode, set to turntable mode

Error code	Main	Sub	Display: "Er 156"	
	15	6	Content: Encoder overheated	
Cause			Diagnosis	Solution
The encoder temperature is too high.			Verify if motor temperature is too high	Reduce encoder temperature.

Error code	Main	Sub	Display: "Er 157"	
	15	7	Content: Encoder counter error	
Cause			Diagnosis	Solution
Encoder data overflow			Verify if encoder is not damaged	Initialize multiturn data
Absolute value applications, motor rotates in one direction			Verify if encoder is not damaged	Adjust absolute value application mode, set to turntable mode

Error code	Main	Sub	Display: "Er 170"	
	17	0	Content: Encoder data error	
Cause			Diagnosis	Solution
Communication data abnormal			1. Verify if encoder power supply voltage is DC5V ± 5% ; 2. Verify if encoder cable and shielded layer is not damaged; 3. Verify if encoder cable is close to high-powered power supply cable	1. Make sure encoder power supply voltage is stable 2. Make sure encoder cable is not damaged. 3. Make sure encoder cable shielded layer is grounded to frame 4. Make sure encoder cable is away from high-powered power supply cable
Encoder damaged			/	Replace motor
Encoder measuring circuit damaged			/	Replace driver

Error code	Main	Sub	Display: "Er 171"	
	17	1	Content: Encoder parameter initialization error	
Cause			Diagnosis	Solution
Driver and motor not matched			Verify driver and motor models.	Replace with matching driver and motor
Error while getting parameters from encoder			1. Verify if encoder cable is standard. 2. Verify if encoder has no peeled insulator, broken connection or improper contact.	Use standard encoder cable, verify the connection of both sides of driver and motor, change encoder cable if necessary

Error code	Main	Sub	Display: "Er 180"
	18	0	Content: Excessive position deviation

Cause	Diagnosis	Solution
Improper position deviation settings	Verify if value of Pr_014 is too low	Increase value of Pr_014
Position gain setting too low	Verify if values of Pr1.00 & Pr1.05 are too low	Increase values of Pr1.00 & Pr1.05
Torque limit too low	Verify if values of Pr0.13 & Pr5.22 are too low	Increase values of Pr0.13 & Pr5.22
Excessive external load	1. Verify if acceleration and deceleration duration time is too low. 2. Verify if rotational velocity is too high 3. Verify if load is too large	1. Increase duration time for acceleration and deceleration 2. Decrease rotational velocity 3. Decrease load

Error code	Main	Sub	Display: "Er 181"
	18	1	Content: Excessive velocity deviation

Cause	Diagnosis	Solution
Deviation between set velocity and actual velocity is too great	Verify if value of Pr6.02 is too low	1. Increase value of Pr6.02; 2. Set Pr6.02 to 0, position error detection off.
Acceleration and deceleration duration time for set velocity is too low	Verify if value of Pr3.12 and Pr3.13 are too low	1. Increase value of Pr3.12, Pr3.13; 2. Adjust velocity gain to reduce velocity lag error

Error code	Main	Sub	Display: "Er 190"
	19	0	Content: Motor vibration too strong

Cause	Diagnosis	Solution
Motor velocity fluctuates too much	Verify if Pr0.03 is too large	Decrease value of Pr0.03

Error code	Main	Sub	Display: "Er 1A0"
	1A	0	Content: Overspeed

Cause	Diagnosis	Solution
Motor velocity exceeded first speed limit (Pr3.21)	1. Verify if velocity command is too high; 2. Verify if simulated velocity command voltage is too high; 3. Verify if parameter value of Pr3.21 is too low; 4. Verify if input frequency and division frequency coefficient of pulse train is proper; 5. Verify if encoder is wired correctly	1. Adjust velocity input command; 2. Increase Pr3.21 value; 3. Adjust pulse train input frequency and division frequency coefficient; 4. Verify encoder wiring;

Error code	Main	Sub	Display: "Er 1A1"	
	1A	1	Content: Velocity out of control	
Cause		Diagnosis		Solution
Motor velocity out of control, Excessive velocity error		Verify encoder phase sequence; Verify if UVW cable is connected to the right terminal		Reconnect UVW if wrongly connected. If still remains unsolved, please contact technical support.

Error code	Main	Sub	Display: "Er 1b0"	
	1b	0	Content: Bus input signal dithering	
Cause			Diagnosis	Solution
Controller synchronization dithering			Synchronization offset on the controller is set too high	Set synchronization offset to 0 and check if dithering stops
			Synchronization cycle is too short due to large number of slave stations	Set a reasonable synchronization cycle time.
			Tune synchronization dithering range	Increase PA0.25, PA0.26, PA0.28
			Command delay cycle counts in sync mode needs to be adjusted	Set PA0.27 = 2 to increase delay time

Error code	Main	Sub	Display: "Er 1b1"	
	1b	1	Content: Incorrect electronic gear ratio	
Cause			Diagnosis	Solution
Values out of range			Numerator or denominator is zero/Set values out of range	Reduce number of pulses per revolution

Error code	Main	Sub	Display: "Er 1c0"	
	1c	0	Content: Both STO failed	
Cause			Diagnosis	Solution
Both STO input signals valid			Verify if STO power supply is normal	Verify 24V STO power supply and power cable connection
			Disconnect switch connected to STO	Close switch

Error code	Main	Sub	Display: "Er 1c1"	
	1c	1	Content: 1st STO failed	
Cause			Diagnosis	Solution
1st STO input signal valid			Verify if STO power supply is normal	Verify 24V STO power supply and power cable connection
			Disconnect switch connected to STO	Close switch

Error code	Main	Sub	Display: "Er 1c2"	
	1c	2	Content: 2nd STO failed	
Cause			Diagnosis	Solution
2nd STO input signal valid			Verify if STO power supply is normal	Verify 24V STO power supply and power cable connection
			Disconnect switch connected to STO	Close switch

Error code	Main	Sub	Display: "Er 1c3"	
	1c	3	Content: STO power supply 1 anomaly	
Cause			Diagnosis	Solution
STO power supply 1 undervoltage/ overvoltage			Verify issue by restarting for a few times	Please contact manufacturer.
Drive power supply not stable			Check if there is fluctuation in the main power supply.	Add an external voltage stabiliser.

Error code	Main	Sub	Display: "Er 1c4"	
	1c	4	Content: STO power supply 2 anomaly	
Cause			Diagnosis	Solution
STO power supply 2 undervoltage/ overvoltage			Verify issue by restarting for a few times	Please contact manufacturer.
Drive power supply not stable			Check if there is fluctuation in the main power supply.	Add an external voltage stabiliser.

Error code	Main	Sub	Display: "Er 1c5"	
	1c	5	Content: STO input circuit 1 anomaly	
Cause			Diagnosis	Solution
STO input circuit 1 anomaly			Verify issue by restarting for a few times	Please contact manufacturer.

Error code	Main	Sub	Display: "Er 1c6"	
	1c	6	Content: STO input circuit 2 anomaly	
Cause			Diagnosis	Solution
STO input circuit 2 anomaly			Verify issue by restarting for a few times	Please contact manufacturer.

Error code	Main	Sub	Display: "Er 1c7"	
	1c	7	Content: STO circuit BUFFER 1 anomaly	
Cause			Diagnosis	Solution
STO circuit BUFFER 1 anomaly			Verify issue by restarting for a few times	Please contact manufacturer.

Error code	Main	Sub	Display: "Er 1c8"
	1c	8	Content: STO circuit BUFFER 2 anomaly

Cause	Diagnosis	Solution
STO circuit BUFFER 2 anomaly	Verify issue by restarting for a few times	Please contact manufacturer.

Error code	Main	Sub	Display: "Er 210"
	21	0	Content: I/O input interface assignment error

Cause	Diagnosis	Solution
Input signal assigned with two or more functions.	Verify values of Pr4.00-Pr4.09, Pr4.44-4.47	Set proper values for Pr4.00-Pr4.09, Pr4.44-4.47

Error code	Main	Sub	Display: "Er 211"
	21	1	Content: I/O input interface function assignment error

Cause	Diagnosis	Solution
Input signal assignment error	Verify values of PA4.00-PA4.09, PA4.44-4.47	Set proper values for PA4.00-PA4.09, PA4.44-4.47

Error code	Main	Sub	Display: "Er 212"
	21	2	Content: I/O output interface function assignment error

Cause	Diagnosis	Solution
Input signal assigned with two or more functions.	Verify values of PA4.10-PA4.15	Set proper values for PA4.10-PA4.15
Input signal not assigned	Verify values of PA4.10-PA4.15	Set proper values for PA4.10-PA4.15

Error code	Main	Sub	Display: "Er 240"
	24	0	Content: EEPROM parameters initialization error

Cause	Diagnosis	Solution
Error during initial reading of EEPROM parameters	Restart after changing any parameter. Verify if the parameter is saved.	If parameter not saved after several restarts, please change driver

Error code	Main	Sub	Display: "Er 241"
	24	1	Content: EEPROM hardware error

Cause	Diagnosis	Solution
EEPROM damaged	Verify if multiple storages are the same	Replace driver/Upgrade software

Error code	Main	Sub	Display: "Er 242"
	24	2	Content: Error saving alarm history record

Cause	Diagnosis	Solution
Power-off during saving	Verify alarm during power-off	Power lost after alarm appears
Several different alarms in a row	Verify alarm code	Figure out other alarm causes

EEPROM damaged	Verify if it is the same over several times	Replace driver/Upgrade software

Error code	Main	Sub	Display: "Er 243"	
	24	3	**Content:** Error occurred when saving vendor parameters	
Cause			Diagnosis	Solution
Power-off before data saved			--	Wait until data saved successfully before powering off
EEPROM damaged			Restart driver for a few times	Restart driver for a few times

Error code	Main	Sub	Display: "Er 244"	
	24	4	**Error description:** Error occurred when saving communication parameters	
Cause			Diagnosis	Solution
Power-off before data saved			--	Wait until data saved successfully before powering off
EEPROM damaged			Restart driver for a few times	Restart driver for a few times

Error code	Main	Sub	Display: "Er 245"	
	24	5	**Error description:** Error occurred when saving parameter 402	
Cause			Diagnosis	Solution
Power-off before data saved			--	Wait until data saved successfully before powering off
EEPROM damaged			Restart driver for a few times	Restart driver for a few times

Error code	Main	Sub	Display: "Er 246"	
	24	6	**Error description:** Data saving error during power-off	
Cause			Diagnosis	Solution
Power off too fast			--	Upgrade software
EEPROM damaged			Restart driver for a few times	Restart driver for a few times

Error code	Main	Sub	Display: "Er 260"	
	26	0	**Error description:** Positive/Negative position limit triggered under non-homing mode	
Cause			Diagnosis	Solution
Positive/negative position limit triggered			Verify position limit signal	/

Error code	Main	Sub	Display: "Er 280"	
	28	0	**Error description:** Output pulse frequency too high	
Cause			Diagnosis	Solution
Frequency divided pulse output exceeds 1MHz			Verify if motor rotational speed and the number of frequency divided pulse output are too high	Reduce the number of frequency divided pulse output or reduce rotational speed

Error	Mai	Sub	Display: " Er 570"

code	57	0	**Error description:** Forced alarm input valid	
Cause			Diagnosis	Solution
Forced alarm input signal occurred			Verify forced alarm input signal	Verify if the input wiring connection is correct

Error code	Main	Sub	**Display:** "Er 5F0"	
	5F	0	**Content:** Motor model no. detection error	
Cause			Diagnosis	Solution
Automatically detected motor doesn't match set motor			/	Please contact our technical support

Error code	Main	Sub	**Display:** "Er 5F1"	
	5F	1	**Error description:** Driver power module detection error	
Cause			Diagnosis	Solution
Driver power rating not within range.			Restart driver	Please contact our technical support

Error code	Main	Sub	**Display:** "Er 600"	
	60	0	**Error description:** Main loop interrupted timeout	
Cause			Diagnosis	Solution
The motor control loop calculation time overflow			Check for interference from devices releasing electromagnetic field	Ground driver and motor to reduce interference
			Restart driver	Replace driver

Error code	Main	Sub	**Display:** "Er 601"	
	60	1	**Error description:** Velocity loop interrupted timeout	
Cause			Diagnosis	Solution
Motor control loop calculation time overflow			Verify if encoder connection is and that the encoder cable is too not long (more than 20 meters)	Replace encoder cable if necessary
			Restart driver	Replace the drive with a new one

Error code	Main	Sub	Display: "Er 700"	
	70	0	**Error description:** Encryption error	
Cause			Diagnosis	Solution
Encryption error during initialization upon power-on.			Restart driver	Please contact our technical support

8.4 Alarm clearing

8.4.1 Servo Drive Alarm

For alarm can be cleared，There are 3 method.

Method 1：

1、By setting bit 7 of 6040h to 1, switches state machine from fault to initialization completion , No fault(Switch on disabled).

Method 2：

Use auxiliary function "AF_ACL"

1、Press M to select auxiliary function , Press SET to enter into "AF_ACL" , Press and hold to clear the alarm

Method 3：

Set IO input function as Alarm clear input " (A-CLR)"，refer to switch input interface connection to clear the alarm.

8.5 EtherCAT Communication Alarm

EtherCAT communication related alarms are erasable and will not be recorded in alarm history.

Clearing EtherCAT communication alarm is similar to clearing servo driver alarm. Please clear the alarm before switching to 402 machine state.

EtherCAT communication alarm however, relies on register clearance from the main station. Can be solved according to following steps:

1、Set bit 4 of ESC control register 0x120 (error responder) to 1.

2、The communication alarm can be cleared until the feedback of the ESC status code register 0x134~0x135 is 0.

3、By setting bit 7 of 6040h to 1, switches state machine from fault to initialization completion , No fault(Switch on disabled).

Error code	Main	Sub	**Display:** "Er 73A"	
	73	A	**Error description:** SyncManager2 lost	
Cause			Diagnosis	Solution
Poor master performance			--	Increase the alarm threshold
Single-unit drive has problem			Is it a single unit or multiple units together in the network	Switch drive
Interfere			Check the grounding and network wiring quality	Replace the network cable

Error code	Main	Sub	**Display:** "Er 73b"	
	73	B	**Error description:** SYNC0 lost	
Cause			Diagnosis	Solution
Poor master performance			--	Increase threshold value limit
Single-unit drive has problem			Is it a single unit or multiple units together in the network	Switch drive
interfere			Check the grounding and network wiring quality	Replace the network cable

Error code	Main	Sub	Display: "Er 73c"	
	73	C	**Error description:** Excessive Distributed Clock error	
Cause			Diagnosis	Solution
Poor master device performance			--	Increase threshold value limit
Single-unit drive has problem			Is it a single unit or multiple units together in the network	Replace driver
interfere			Check the grounding and network wiring quality	Replace network cable

Error code	Main	Sub	Display: "Er 801"
	80	1	**Error description:** Unknown communication error
Cause			EtherCAT state machine transition failed
The status of the error can be detected			All ESM status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			Verify network connection and master device EtherCAT state machine transition order

Error code	Main	Sub	Display: "Er 802"
	80	2	**Error description:** Memory overflow
Cause			CPU failed to request memory
The status of the error can be detected			All ESM status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			Verify if EL7-EC hardware is faulty

Error code	Main	Sub	Display: "Er 803"
	80	3	**Error description:** RAM out of bound
Cause			EtherCAT state machine memory address access request from master device is out of bound
The status of the error can be detected			All communication status
The result status			NO
Solution			Verify master device configuration or replace master device

Error code	Main	Sub	Display: "Er 805"
	80	5	**Error description:** FOE firmware upgrade failed
Cause			Firmware burn error
The status of the error can be detected			BOOT
The result status			Remain in the detection state
Solution			Replace firmware/driver

Error code	Main	Sub	Display: "Er 806"
	80	6	**Error description:** Saved ESI file does not match driver firmware
Cause			ESI file does not match driver firmware
The status of the error can be detected			INIT
The result status			Remain in the detection state
Solution			Burn matching firmware to driver

Error code	Main	Sub	Display: "Er 811"
	81	1	**Error description:** Invalid EtherCAT transition request
Cause			Driver received unconvertible request from EtherCAT state machine
The status of the error can be detected			All ESM Status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			Verify if the transition information from master device is correct

Error code	Main	Sub	Display: "Er 812"
	81	2	**Error description:** Unknown EtherCAT state machine transition request
Cause			Driver receives a transition request other than states of the EtherCAT state machine
The status of the error can be detected			All ESM Status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			Verify transition information from master device

Error code	Main	Sub	Display: "Er 813"
	81	3	**Error description:** Protection request from boot state
Cause			Driver receives a transition request to boot state
The status of the error can be detected			Initialize the conversion to a boot
The result status			initialization
Solution			Verify if driver software version supports this state transition

Error code	Main	Sub	Display: "Er 814"
	81	4	**Error description:** Invalid firmware
Cause			Firmware not matched with driver
The status of the error can be detected			BOOT/INIT
The result status			Keeping in the detection status
Solution			Return driver to supplier to update firmware

Error code	Main	Sub	Display: "Er 815"
	81	5	**Error description:** Invalid mailbox configuration under boot state
Cause			Boot state action not supported under current configuration
The status of the error can be detected			Initialize the conversion to a boot
The result status			Initialization
Solution			Verify if EL7-EC software version supports action under this state.

Error code	Main	Sub	Display: "Er 816"
	81	6	**Error description:** Pre-Op status is invalid for the mailbox configuration
Cause			The synchronization manager configuration under Pre-Op is invalid
The status of the error can be detected			pre-operation
The result status			initialization
Solution			1. Verify if XML file version is consistent with software version 2. EtherCAT slave controller error, please contact technical support

Error code	Main	Sub	**Display:** "Er 817"
	81	7	**Error description:** Invalid SyncManager configuration
Cause			Synchronization manager configuration is invalid
The status of the error can be detected			Pre-op above
The result status			Pre-op
Solution			Verify master device configuration/ESI file version

Error code	Main	Sub	**Display:** "Er 818"
	81	8	**Error description:** No valid input data
Cause			The input data is not updated for more than 1 second
The status of the error can be detected			All ESM status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			1. Verify if TxPDO is valid 2. Verify master device synchronization settings

Error code	Main	Sub	**Display:** "Er 819"
	81	9	**Error description:** No valid output data
Cause			Output data is not updated for more than 1 second
The status of the error can be detected			All ESM status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			1. Verify if RxPDO is valid 2. Verify master device synchronization settings

Error code	Main	Sub	**Display:** "Er 81A"
	81	A	**Error description:** Synchronization error
Cause			RxPDO and DC update order failed or one of them is not updated in sync
The status of the error can be detected			All ESM status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			1. Verify if PXPDO is valid 2. Verify master device synchronization settings

Error code	Main	Sub	**Display:** "Er 81b"
	81	b	**Error description:**SyncManager2 watchdog timer timeout
Cause			The RxPDO update timeout in operational state
The status of the error can be detected			operation
The result status			Safe operation
Solution			1. Verify if EL7EC network is connected 2. Verify RxPDO update time

Error code	Main	Sub	**Display:** "Er 81c"
	81	c	**Error description:** Invalid SyncManager type
Cause			Synchronization Manager configuration types other than the following: 1. Email output 2. Email input 3. Process data output 4. Process data input
The status of the error can be detected			Pre-operation
The result status			Initialize
Solution			Verify if XML file version is consistent with software version

Error code	Main	Sub	**Display:** "Er 81d"
	81	d	**Error description:** Invalid output configuration
Cause			Process data output synchronization manager configuration is invalid
The status of the error can be detected			Pre-operation
The result status			Initialize
Solution			1. Verify EL7EC synchronization manager configuration 2. Verify if XML file version is consistent with software version

Error code	Main	Sub	**Display:** "Er 81E"
	81	E	**Error description:** Invalid input configuration
Cause			Process data input synchronization manager configuration is invalid
The status of the error can be detected			Pre-operation
The result status			Initialize
Solution			1. Verify EL7EC synchronization manager configuration 2. Verify if XML file version is consistent with software version

Error code	Main	Sub	Display: "Er 821"
	82	1	**Error description:** Waiting for EtherCAT state machine Init state
Cause			Driver waiting for master device to send Init request
The status of the error can be detected			All ESM status
The result status			Keeping the current state
Solution			Verify transition request sent from master device

Error code	Main	Sub	Display: "Er 822"
	82	2	**Error description:** Waiting for the EtherCAT state machine Pre-Op state
Cause			Driver waiting for master device to send Pre-Op request
The status of the error can be detected			Safe operation, operation
The result status			Keeping the current state
Solution			Verify transition request sent from master device

Error code	Main	Sub	Display: "Er 823"
	82	3	**Error description:** Waiting for master device for Safe-Op request
Cause			Process data output synchronization manager configuration is invalid
The status of the error can be detected			Operation
The result status			Keeping the current state
Solution			Verify transition request sent from master device

Error code	Main	Sub	Display: "Er 824"
	82	4	**Error description:** Invalid process data input mapping
Cause			TxPDO is configured with non-mappable objects
The status of the error can be detected			Safe operation
The result status			Pre-operation
Solution			Reconfigure the TxPDO mapping object

Error code	Main	Sub	Display: "Er 825"
	82	5	**Error description:** Invalid process data output mapping
Cause			RxPDO is configured with non-mappable objects
The status of the error can be detected			Safe operation
The result status			Pre-operation
Solution			Reconfigure the RxPDO mapping object

Error code	Main	Sub	Display: "Er 828"
	82	8	**Error description:** Sync mode not supported
Cause			Sync mode is not supported in the current configuration
The status of the error can be detected			Safe operation
The result status			Pre-operation
Solution			1. Verify L7EC software version 2. Verify XML version

Error code	Main	Sub	Display: "Er 82b"
	82	b	**Error description:** Invalid inputs and outputs
Cause			No RxPDO and TxPDO updates for more than 1 second
The status of the error can be detected			All ESM status
The result status			The current state is maintained below the safe operation, and the operation state is switched to the safe operation state
Solution			1. Verify if current RxPDO and TxPDO are invalid 2. Verify master device synchronization settings

Error code	Main	Sub	Display: "Er 82c"
	82	c	**Error description:** Fatal synchronization error
Cause			DC watchdog timer timeout
The status of the error can be detected			Safe operation, operation
The result status			Safe operation
Solution			1. Verify if EL7-EC hardware is faulty 2. Verify DC setting and delay

Error code	Main	Sub	Display: "Er 82d"
	82	d	**Error description:** No synchronization error
Cause			Synchronization is invalid
The status of the error can be detected			operation
The result status			Safe operation
Solution			1. Verify if "fatal synchronization error" has occurred. 2. Verify master device synchronization settings

Error code	Main	Sub	Display: "Er 82E"
	82	E	**Error description:** Synchronization cycle time is too short
Cause			Master device synchronization cycle time is set to less than 125 microseconds
The status of the error can be detected			operation
The result status			Pre-operation
Solution			Verify master device synchronization cycle time

Error code	Main	Sub	Display: "Er 830"
	83	0	**Error description:** Invalid Distributed Clock synchronization settings
Cause			Synchronization settings in sync mode are not valid
The status of the error can be detected			Safe operation
The result status			Pre-operation
Solution			Verify master device synchronization settings

Error code	Main	Sub	Display: "Er 832"
	83	2	**Error description:** Distribution Clock phase-locked loop failure
Cause			Distribution Clock phase-locked loop setting is invalid
The status of the error can be detected			Safe operation, operation
The result status			Safe operation
Solution			Verify master device Distribution Clock settings and network transmission delay

Error code	Main	Sub	Display: "Er 835"
	83	5	**Error description:** Distribution Clock cycle time is invalid
Cause			Set synchronization cycle time is not proportional to drive position loop
The status of the error can be detected			Safe operation
The result status			Pre-operation
Solution			Refer to user manual to set a reasonable synchronization cycle time.

Error code	Main	Sub	Display: "Er 836"
	83	6	**Error description:** Invalid Distribution Clock synchronization cycle time
Cause			The synchronization cycle time setting is not as the following 1：125us 2：250us 3：500us 4：750us 5：1000us 6：2000us 7：4000us
The status of the error can be detected			Safe operation
The result status			Pre-operation
Solution			Verify master device synchronization cycle time

Error code	Main	Sub	Display: "Er 850"
	85	0	**Error description:** EEPROM is inaccessible
Cause			EtherCAT slave controller failed to access EEPROM
The status of the error can be detected			All ESM status
The result status			Keeping the current state
Solution			1. Verify if EL7EC hardware is faulty 2. Verify if master device released access

Error code	Main	Sub	Display: "Er 851"
	85	1	**Error description:** EEPROM error
Cause			EEPROM operation of EtherCAT slave controller failed
The status of the error can be detected			All ESM status
The result status			Keeping the current state
Solution			Verify if master device released access

Error code	Main	Sub	Display: "Er 852"
	85	2	**Error description:** Hardware is not ready
Cause			Data communication lost
The status of the error can be detected			All ESM status
The result status			Keeping the current state
Solution			Verify if EL7-EC hardware is faulty

Error code	Main	Sub	Display: "Er 860"
	86	0	**Error description:** EtherCAT frame lost per unit time exceeds limit
Cause			EtherCAT frame lost per unit time exceeds the setting in 2635-00h
The status of the error can be detected			All status
The result status			Keeping the detection state
Solution			Change to network cable with higher bandwidth / Replace driver

Error code	Main	Sub	Display: "Er 870"
	87	0	**Error description:** Driver can't be enabled under current control mode
Cause			Enable driver under unsupported mode
The status of the error can be detected			All status
The result status			Maintain status
Solution			Switch to the correct control mode

Error code	Main	Sub	Display: "Er 890"	
	89	0	**Error description:** Homing Error	
Cause			Diagnosis	Solution
Homing velocity too high. Passed homing sensor before signal is captured			Verify if homing velocity is too high. Or set lower homing velocity	Decrease homing velocity or increase homing acceleration
Homing mode is not coincide with input signals			Verify if input signal from sensors are corresponding to the demands of chosen homing mode	Set up the signal input in accordance to homing mode settings
Unsupported homing mode			Verify if improper homing mode is set in object dictionary 6098h	Re-select homing mode

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