GHA-E Series Servo System

With EtherCAT

User Manual

Chapter1 Product Information

Chapter2 Wiring and system setup

Chapter3 Overview of the EtherCAT protocol

Chapter4 Object dictionary

Chapter5 Control mode

Chapter 1 Product Information

This manual is the instruction for GHA series servo EtherCAT communication function.The EtherCAT system parameters and object dictionary Settings were explained, and how to quickly use EtherCAT to run the servo test operation.Please refer to ghA-E general operating instructions for other functions.

1.1 Technical Data

Model		GHA-E3201	GHA-E3202	GHA-E3204	GHA-E3205	GHA-E3206
Rated output power (KW)		0.1	0.2	0.75	1	1.5
Rated output current (A)		0.5	1	2.8	5	6
Maximum output current (A)		1.4	2.5	4	6	7.5
Input power supply	power supply	AC220V/50Hz				
	Control power	AC220V/50Hz				
Control mode		Vector control				
Brake resistance		External (no built-in)				
Adaptive encoder		17 bit /20 bit /23 bit multi-turn absolute encoder				
Digital input		9 channels digital input (optically coupled isolation)				
Digital output		6 channels digital output (optical coupler isolation)				

1.2 EtherCAT specifications

Physical layer	100 base - TX (IEEE802.3)
Baud rate	100 MBPS/full duplex
EtherCAT port number	2(RJ45)
Maximum Length of network	The total length of 100 m

cable	
Cable specifications	Cat5e or above
Anti-interference performance	Group pulse (EFT) 4KV, 100KHz
Application layer protocol	CANopen over EtherCAT
Synchronously	DC distributed clock synchronization
Synchronization performance	Jitter < 1 us
SYN0 Synchronization period	Support us 125, 250 us and 500 us, ms, 1 2 ms
Topology	Linear
Refresh time	The synchronization accuracy of 100 servo axes is about 100us
CoE service	SDO,PDO,Emergency,SDO information.
The PDO configuration	TPDO1/RPDO1 can be configured by users. TPDO1 and RPDO1 can map a maximum of eight objects (32 bytes). Tpdo2-5 and RPdo2-5 are fixed mappings and cannot be configured by users.
Supported operating mode	1. Synchronous position mode CSP
	2. Synchronization speed mode CSV
	3. Synchronous torque mode CST
	4. Return to zero mode HM
	5. brief table position mode PP
	6. brief table speed mode PV
	7. brief table torque mode TQ
Touch Probe	Support
Instructions	Panel 5-bit 7-segment digital tube display, RUN LED,ERR LED,L/A LED (LED integrated in RJ45 port)

Chapter 2 Wiring and system setup

2.1 wiring

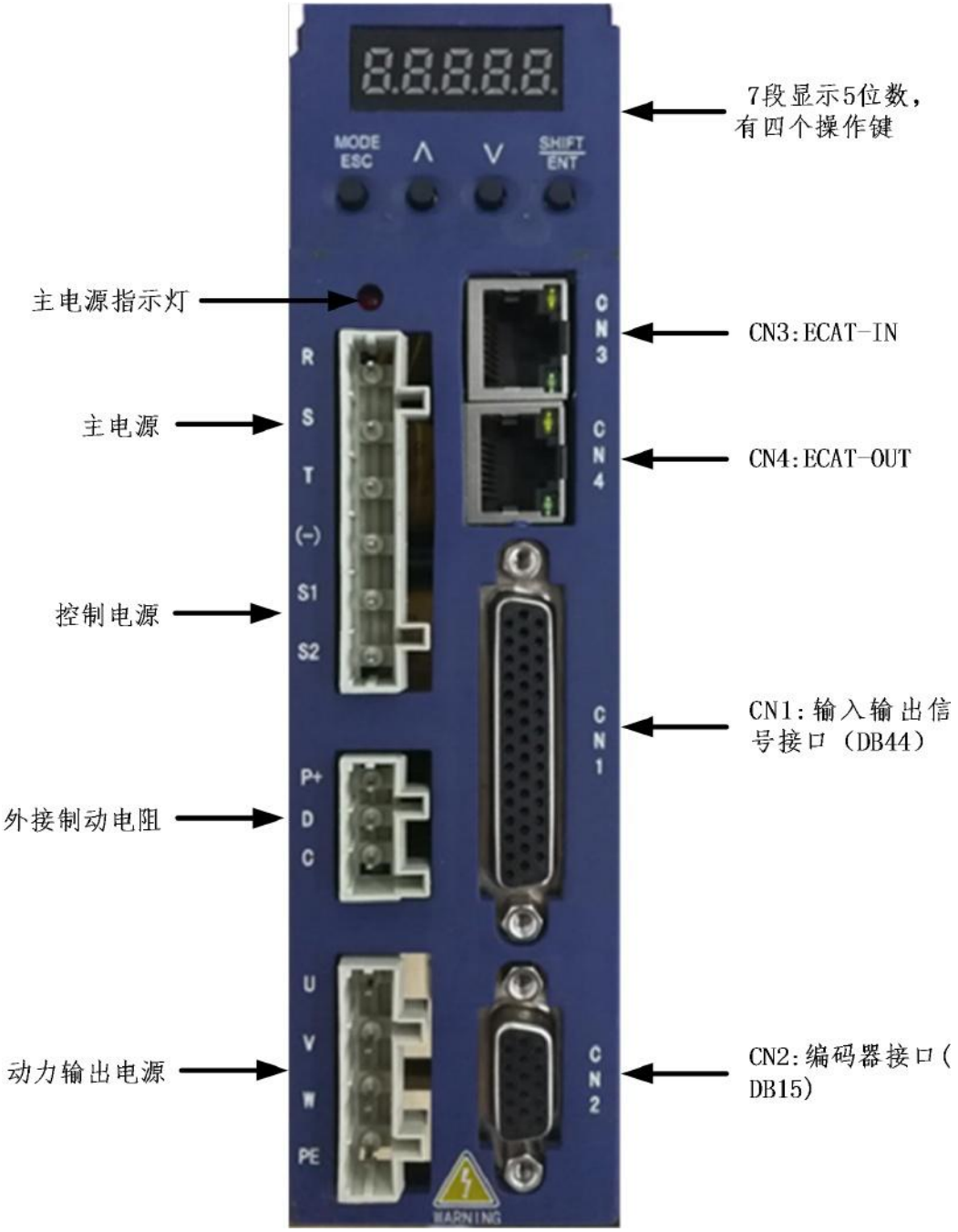


Figure 2.1 Ports on the GHA-E3204 panel

2.1.1 Description of CN3/CN4 EtherCAT Port

In networking, CN3 is the entrance and CN4 is the egress. The connection cannot be reversed. The diagram below shows the EtherCAT main station connected to several GHA-E servos:

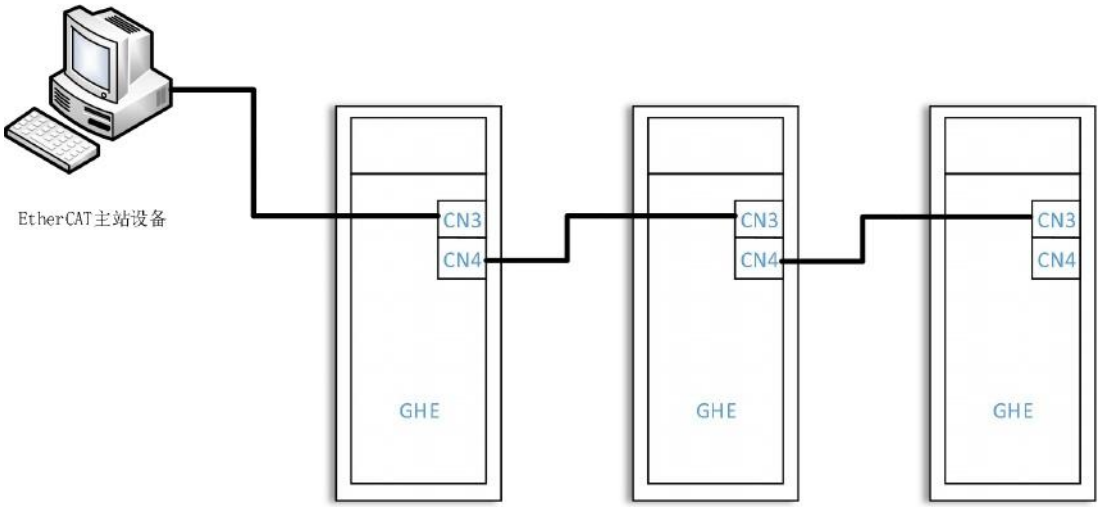
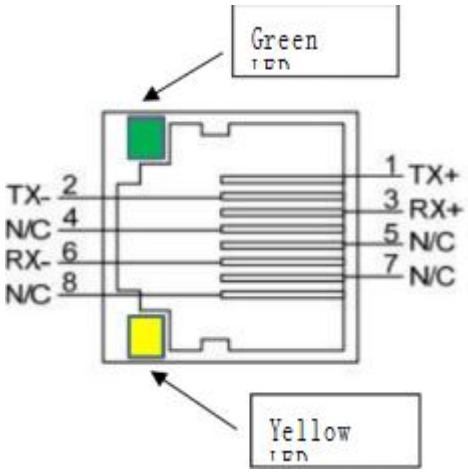


Figure 2.2 EtherCAT networking diagram of GHA-E series servo

CN3/CN4 port pins are defined as follows:

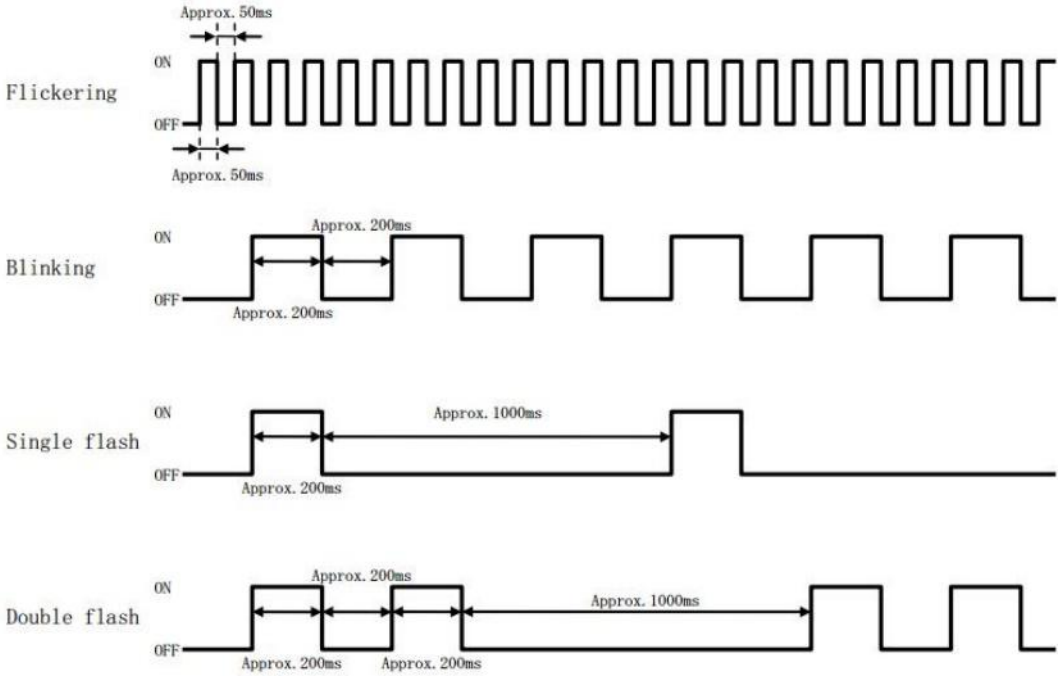


Ports on CN3 and CN4 are standard RJ45 sockets. You are advised to directly connect them using Cat5e network cables or higher shielded twisted pair cables.

About CN3/CN4 port LED：

CN3	Yellow LED	EtherCAT RUN LED
	Green LED	Port0 Link Active LED
CN4	Yellow LED	EtherCAT ERR LED
	Green LED	Port1 Link Active LED

These 4 leds have the following four on-off modes:



1) The RUN LED

The LED pattern	According to the content
OFF	ESM: Init
Blinking	ESM: Pre_Op
Single flash	ESM: Safe_Op
ON	ESM: Op

2) ERR leds

The LED pattern	According to the content
OFF	EtherCAT communication was normal
Blinking	Abnormal communication Settings
Single flash	Synchronization event exception
Double flash	The watchdog has run out of time
Flickering	Initialization exception
ON	PDI abnormal

3) L/A LED

LED pattern	According to the content
OFF	The port is not connected to the device
Flickering	Communication is established and there is data transmission
ON	Communication established, but no data transfer

2.1.2 CN1 input and output signal interface

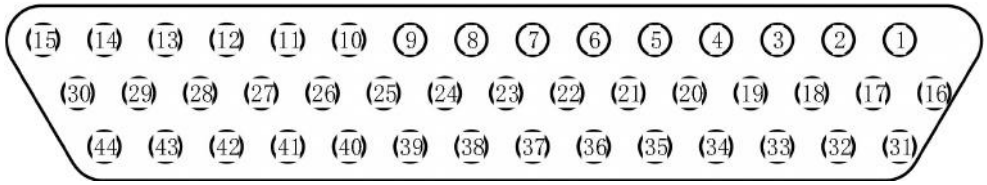
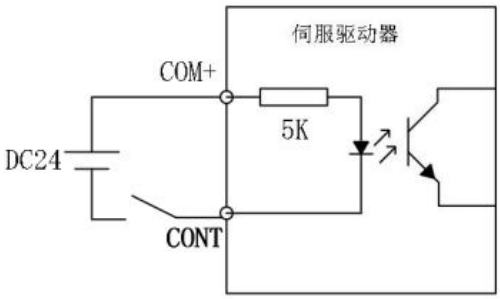
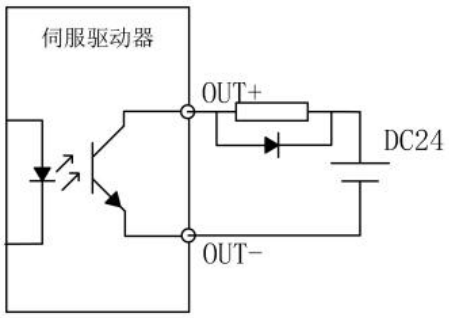


Figure 2.3 Pin diagram of DB44 terminal

Definition of stitching

Code name	CN1 Plug Number	Signal	Functions
+24V	17	output power supply 24+	Power supply for control signal input and output (DC24/0.3A)
COM-	14	output power supply 24-	
COM+	11	Input signal common anode	
CONT1	9	Input signal sequence	 Input specifications of each group: DC24/10mA
CONT2	10		
CONT3	34		
CONT4	8		
CONT5	33		
CONT6	32		
CONT7	31		
CONT8	30		
CONT9	12		
D01+	7	output signal	The maximum output current of each

D01-	6	sequence	group is 50mA, and the maximum supply voltage is 30V. 
D02+	5		
D02-	4		
D03+	3		
D03-	2		
D04+	1		
D04-	26		
D05+	28		
D05-	27		
D06+	16		
D06-	15		

2.2 System Settings

2.2.1 EtherCAT parameters

In order to enable the driver to access the EtherCAT network accurately, relevant function codes must be set before use.The following table describes related parameters.

Parameters No.	Parameter name	Optional scope	Default value	Note
Pn-000	Control mode selection	0-12	12	Note: This value must be set to 12 when using the EtherCAT feature.
Pn-410	Driver slave alias	0-65535.	0	Configured Station Alias takes effect after power-on.

Pn-409	EtherCAT communication configuration	Bit0: synchronous mode BIT1-15 :Reserve	0	Bit0:0: hardware SYNC0 output 1: software SYNC0 output
Pn-408	EtherCAT Packet loss counter	-	-	Read-only: Identifies the fault type
Pn-046	Communication Settings parameter store selection	0-1	0	0: Modify the parameters of the Pn parameter group through the EtherCAT bus SDO service and save them to the EEPROM. 1: Modify the Pn parameter group parameters through the EtherCAT bus SDO service and do not save them to EERPOM.

2.2.2 Other Key Parameters

In general, some parameters may need to be adjusted in order for the EtherCAT master control servo driver to work properly, such as electronic gear ratio, motor parameters, loop gain, etc. The parameters are listed below:

Parameters No.	Parameter name	Optional scope	Default value	Note
Pn-006	Electron gear ratio molecule 1	0-10000.	13	Molecular = Pn06 * 10000 + Pn07; The default value is 131072

Pn-007	Electron gear ratio molecule 2	0-9999.	1072	Object 01 subindex value at 6091h)
Pn-008	The electronic gear ratio is female 1	0-10000.	1	The denominator = Pn08 * 10000 + Pn09; The default value is 10000. (equivalent to the sub-index value of object 02 of 6091H)
Pn-009	Electronic gear ratio female 2	0-9999.	0	
Pn-078	Motor code	0-500.	73	It depends on the motor type
Pn-079	Encoder type	1-4	2	1: single-loop, incremental system 2: multi-circle, absolute value system 3: multi-loop, incremental system 4: Multi-circle type, absolute value system,But they ignored multiple calls Note: See section 5.7.3 for details
Pn-080	Absolute value encoder type	0-2	0	0: 17-bit absolute encoder 1: 20-bit absolute encoder 2: 23-bit absolute encoder
Pn-108	Position loop feedforward gain	0-1.2	0	
Pn-110	Feedforward filter coefficient	0-2.5	0	
Pn-111	Position loop gain	1-2000.	25	

Pn-128	Velocity loop gain	1-30000.	450	
Pn-129	Velocity loop integral time constant	1-4096.	100	
Pn-130	Velocity ring differential	0-100.	0	
Pn-200-Pn208	Enter numbers di1-DI9	1-78	0	0:None 6:HOME 7:POT 8:NOT

2.2.3 Parameter setting method

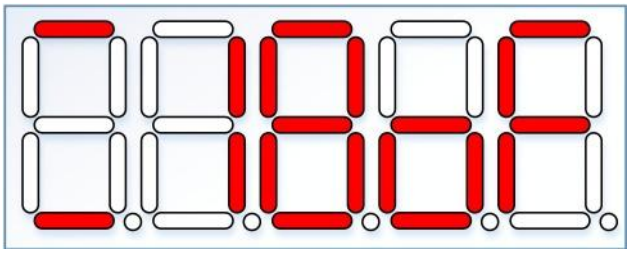
Take setting the drive slave alias Pn-410 as an example to introduce the parameter setting method: Use the MODE/ESC key to switch to the Pn group, short press the SHIFT/ENT key to enter the Pn-000 page, use ^ and v to select parameters, and short press the SHIFT/ENT key to shift ; After selecting the Pn-410 parameter, press and hold the SHIFT/ENT key for more than 1 second to enter the parameter setting interface. After setting the parameters, press and hold the SHIFT/ENT key for more than 1 second to save the parameter settings, and then power on the drive again.

Note: The way to restore the parameters to factory settings is to execute the Fn-06 operation.

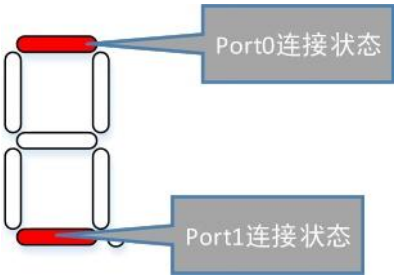
2.3 Panel status Display

When using the EtherCAT bus, the EtherCAT physical layer Port0 and Port1 connection state, ESM state, working mode and servo running state can be obtained through the panel nixie tube.

Use four buttons to switch the display page to the SN-05 status page, you will see the following screen for example:

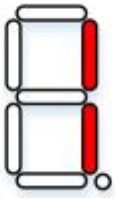
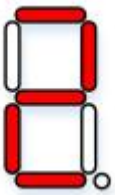
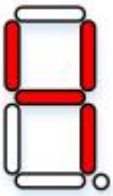
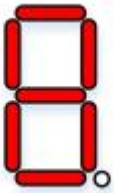


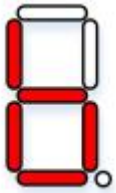
1) The first digital tube from the left represents the connection state of Port0 (CN3) and Port1 (CN4).



If the value is steady on, the Port is connected; if the value is off, the Port is not connected.

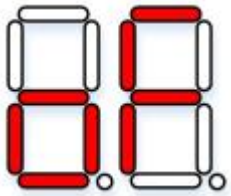
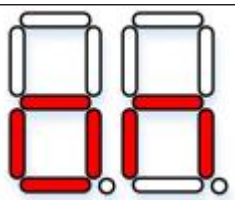
2) The second nixie tube from the left represents ESM status

Display	Description
	1: indicates that the ESM state machine is Init.
	2: indicates that the ESM state machine is in pre-op state.
	4: indicates that the ESM state machine is in safe-op state.
	8: indicates that the ESM state machine is in Op state.

	B: Indicates that an ESM status error occurs, such as a status conversion error or system disconnection.

3) The third digital tube from the left represents the current working mode of the servo, that is, the value of object dictionary 6061H.
The possible display is: the number 0 to the number 10, representing different working mode, for example, synchronous position mode (CSP), then the bit "8".0 indicates that the working mode is not set.

4)The fourth and fifth digital tubes from the left represent the current operating status of the servo.

Display	Description
	The meaning OF: Indicates that the server is disabled
	On: indicates that the server is enabled

Chapter 3 Overview of EtherCAT protocol

3.1 EtherCAT slave protocol structure

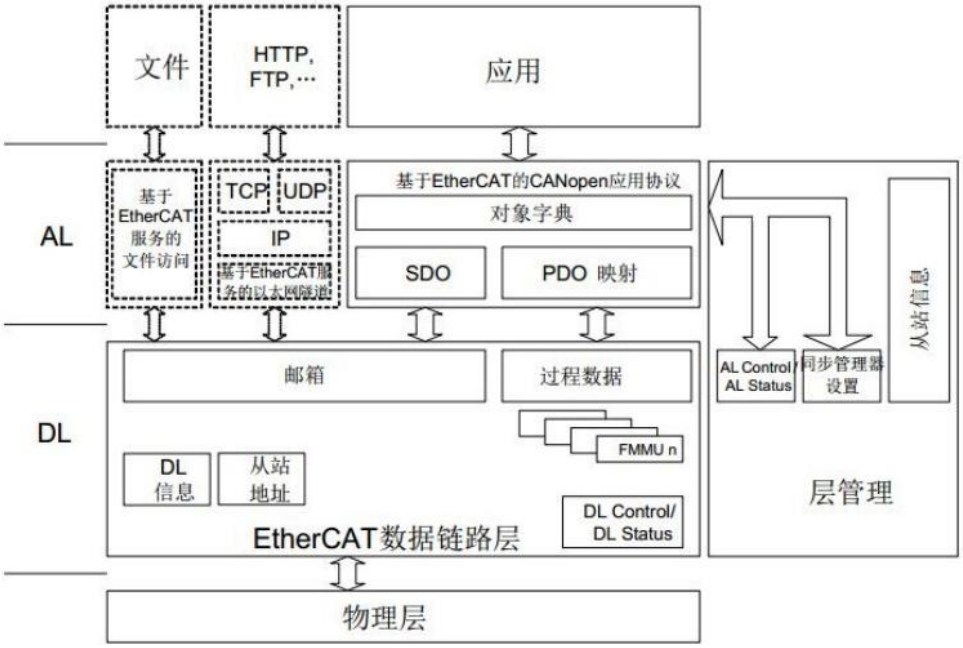


Figure 3.1 EtherCAT slave reference model

As can be seen from the figure above, EtherCAT slave nodes can be divided into three layers: application layer, data link layer and physical layer.

The physical layer uses the physical interface compatible with the standard Ethernet to ensure the convenience and generality of slave implementation.In the data link layer, the dedicated ESC slave processing chip ensures the real-time and fast data transmission from the hardware.In the application layer, MCU realizes complex data communication through EtherCAT slave protocol stack. For example, CANOpen over EtherCAT (CoE) implements SDO service and PDO service based on CANOpen protocol.

3.2 ESM State Machine

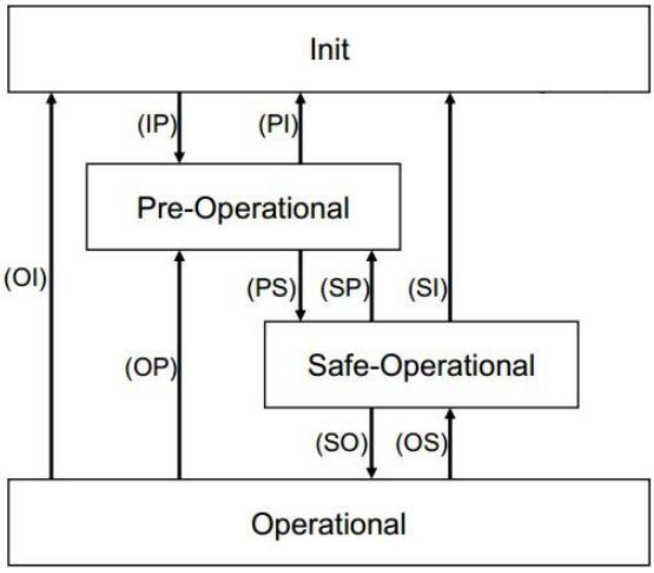


Figure3.2 EtherCAT state machine (ESM)

The ESM defines four states that should be supported:

1) Init:initialization

The master can configure the slave register when initializing the state, but neither the Service Data Object SDO (Service Data Object) nor the Process data Object PDO(Process Data Object) has been started.

2) pre-operational: pre-operational

The sending and receiving of service data is activated in the pre-run state, where the server parameters can be configured using SDO

The number.

3) Safe-operational: Safe operation

The safe operating state has process data, but only the input data is allowed to read, and no output signal is generated.For example, only TPDO is allowed to observe servo position, speed and other parameters, and RPDO is not allowed to control servo motion. 4) We are now in operation

Both service data and process data are valid in the running state, and SDO services and PDO services can be used. Typically, state changes are requested by the master, and the slave local application responds to the master request based on the current state,

If the state transition fails, the slave station sets the error flag.All supported state transitions are shown in the following table:

State transition	Operation
IP	Start service data (SDO) communication
PI	Stop service data (SDO) communication
PS	Start typing updates
SP	Stop input updates
SO	Start outputting updates
OS	Stop output updates
OP	Stop output update, stop input update
SI	Stop entering updates and stop mailbox communication
OI	Stop input updates, stop output updates, and stop service Data (SDO) communication

3.3 DC Distributed Clock

Distributed Clock (DC) allows all EtherCAT devices to use the same system time to control the synchronous execution of tasks across devices.

EtherCAT slave has three synchronization modes that can be configured as follows:

Name	Features
Free Run	Local applications are generated by local timer interrupts, independent of the EtherCAT event.
SM Event (synchronized input and output event)	Synchronized to SM events, which typically have a few microseconds of jitter due to hardware delays, etc.
DC SYNC Event(synchronized distributed clock events)	Triggered by the SYNC signal of the DC distributed clock, the jitter of the signal is less than 1us, and the general accuracy is within 100ns.

It can be seen from the above table that the clock accuracy of DC synchronous mode is much higher than the other two modes, and the servo system generally requires high periodicity and real-time performance, so this servo system only supports one synchronous mode: DC synchronous mode.

Note: The EtherCAT master connected to this server requires DC distributed clock support.

Figure 3.3 shows the relation between EtherCAT data frame arrival time and DC synchronization events. It can be seen that DC synchronization events have smaller jitter time.

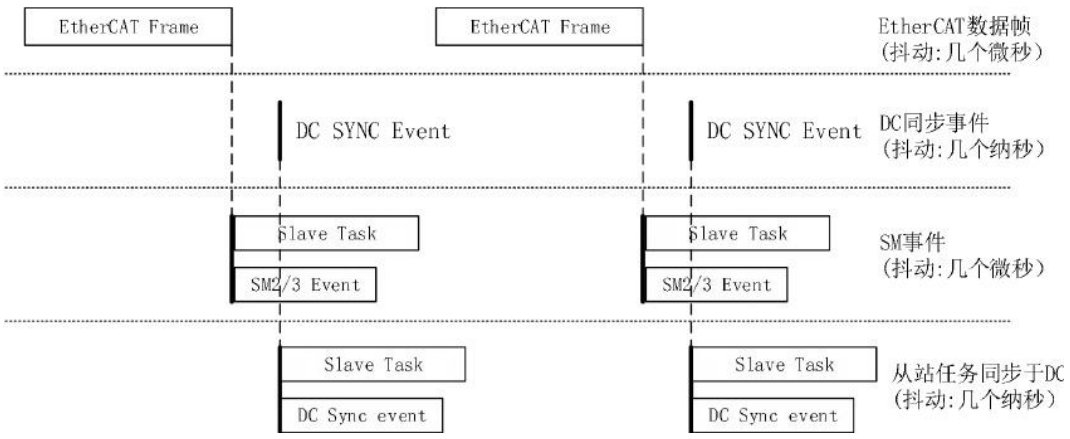


Figure 3.3 Schematic diagram of SM event and DC synchronization event

Note: This product does not support SYNC1 synchronization tasks.

Note: SYNC0 cycle should begin from the 125 us / 250 us 500 us / 1 / ms/ms in 2 options.

3.4 the SDO Abort Code

When using THE SDO service of CoE, SDO writing or reading may fail due to various reasons. When the SDO operation fails to complete successfully, the slave station will return the abort transmission fault code to the master station to facilitate the master station to locate the cause of the error. The abort transmission code list is as follows:

Code	Mean
0x05030000	The switch bit has not changed
0x05040000	SDO protocol Timeout
0x05040001	Invalid or unknown client/server command qualifier
0x05040005	Out of memory
0x06010000	Unsupported object access
0x06010001	Attempted to read a write-only object
0x06010002	An attempt was made to write a read-only object
0x06010003	Cannot write to the object dictionary because the subindex 00 is required to have a value of 0
0x06020000	The object does not exist in the object dictionary
0x06040041	The object cannot be mapped to PDO
0x06040042	The number and length of mapped objects will exceed the PDO length
0x06040043	Causes of common parameter incompatibility
0x06040047	General internal incompatibility in equipment

0x06060000	The access failed due to a hardware error
0x06070010	Data types do not match. Lengths of service parameters do not match
0x06070012	Data types do not match. Length of service parameter is too long
0x06070013	Data types do not match. Length of service parameter is too short
0x06090011	The subindex does not exist
0x06090030	The parameter value is out of range
0x06090031	The parameter value is too large. Procedure
0x06090032	The parameter value is too small
0x06090036	The maximum value is less than the minimum
0x08000000	General error
0x08000020	Data cannot be transferred or stored to the application
0x08000021	Data cannot be transferred or stored to the application due to local control
0x08000022	Data cannot be transferred or stored to the application due to the current device state
0x08000023	Object dictionary dynamic generation failed or there is no object dictionary currently

3.5 the PDO configuration

The PDO service is used to transmit data periodically, and the product supports data update frequencies up to 8KHz. PDO services are classified into RPDO and TPDO. RPDO data is sent from the primary site to the secondary site, and TPDO data is sent from the secondary site to the primary site.

3.5.1 track of PDO assignment

Rpdo-related object dictionary:

Index	Max subindex	Note
1C12h	1	Determine to use 1600H-1604H for a specific RPDO configuration.
1600h	8	Group 1 RPDO mapping information (RPDO1), which can be configured by users.
1601h	5	Group 2 RPDO mapping information (RPDO2), fixed configuration.
1602h	2	Group 3 RPDO mapping information (RPDO3), fixed configuration.
1603h	2	Group 4 RPDO mapping information (RPDO4), fixed configuration.
1604h	2	Group 5 RPDO mapping information (RPDO5), fixed configuration.

TPDO related object dictionary:

Index	Max Subindex	note
1C13h	1	Decide to use 1A00H-1A04H for specific TPDO configurations.
1A00h	8	Group 1 TPDO mapping information (TPDO1), which can be configured by users.
1A01h	5	Group 2 TPDO mapping information (TPDO2), fixed configuration.
1A02h	2	Group 3 TPDO mapping information (TPDO3), fixed configuration.
1A03h	3	Group 4 TPDO mapping information (TPDO4), fixed configuration.
1A04h	3	Group 5 TPDO mapping information (TPDO5), fixed configuration.

If you need to change the PDO configuration group, for example, from RPDO1 to RPDO2, you need to set 1C12h and 1C13h as follows:

1) Switch the ESM state machine to the pre-op state.This object can only be modified in the pre-op stateValue)

2) Write 1C12h (or 1C13h) subindex 00h is 0.

3) Write a sub-index of 1C12 (or 1C13h) whose 01h value is 1600h-1604h (1a00H-1a04h).For example, if the RPDO2 group configuration is required, the write 1C12h sub-index 01H value is 1601h.

4) Write 1C12h (or 1C13h) subindex 00h is 1.

5) Switch the ESM state to the Op state, and the PDO configuration takes effect.

3.5.2 PDO mapping

PDO mapping information is stored in objects 1600H-1604h and 1A00H-1A04h. Take 1600H as an example to illustrate the storage format. Assume that the contents of the object 1600H are as follows:

Index	Subindex	Value
1600h	00h	3h
	01h	60400010h
	02h	607A0020h
	03h	60600008h

As shown in the above table, RPDO1 group maps 3 objects, namely 6040h,607Ah and 6060h, with 7 bytes in total.

Then the steps to modify the PDO mapping are as follows (1600H as an example) :

1) Switch the ESM state machine to the pre-op state.This object can only be modified in the pre-op stateValue)

2) First write the subindex 00h value of 1600h as 0.

3) Write 1600h subindex 01 value is 60400010h, subindex 02h value is 607A0020h, subcable cite 03h value is 60600008h.

4) write subindex 00h = 3 (subindex 00h = number of subindexes).

5) Switch the ESM state to the Op state, and the PDO configuration takes effect.

Note: Only 1600H and 1A00h can be modified.

Note: The maximum number of mapped objects is 8, and the maximum number of mapped bytes is 32Bytes.

3.5.3 Default PDO Mapping

RPDO default mapping value:

The index	Subindex	Value	Mapping object name
1600h (RPDO1) (Configurable)	00h	3	
	01h	60400010h	Control word
	02h	607A0020h	The target location
	03h	60600008h	Working mode

1601h (RPDO2) (Fixed configuration)	00h	5	
	01h	60400010h	Control word
	02h	607A0020h	The target location
	03h	60FF0020h	The target speed
	04h	60710010h	The target torque
	05h	60600008h	Working mode
1602h (RPDO3) (Fixed configuration)	00h	2	
	01h	60400010h	Control word
	02h	607A0020h	The target location
1603h (RPDO4) (Fixed configuration)	00h	2	
	01h	60400010h	Control word
	02h	60FF0020h	The target speed
1604h (RPDO5) (Fixed configuration)	00h	2	
	01h	60400010h	Control word
	02h	60710010h	The target torque

TPDO default mapping value:

Index	Subindex	Value	Mapping object name
1A00h (TPDO1) (Configurable)	00h	2	
	01h	60410010h	Status word
	02h	60640020h	Position feedback
1A01h (TPDO2) (Fixed configuration)	00h	5	
	01h	60410010h	Status word
	02h	60640020h	Position feedback
	03h	606C0020h	Feedback speed
	04h	60770010h	Feedback torque
	05h	60610008h	Current Working mode
1A02h (TPDO3) (Fixed configuration)	00h	2	
	01h	60410010h	Status word
	02h	60640020h	Position feedback
1A03h (TPDO4) (Fixed configuration)	00h	3	
	01h	60410010h	Status word
	02h	60640020h	Position feedback
	03h	606C0020h	Feedback speed
1A04h	00h	3	

(TPDO5) (Fixed configuration)	01h	60410010h	Status word
	02h	60640020h	Position feedback
	03h	60770010h	Feedback torque

Chapter 4 Object Dictionary

4.1 CoE Communication Configuration Object Area (1000H-1FFFH)

Index	Subindex	Name	Scope	Data type	Access attributes	PDO mapping	Unit	Default value
1000h	00h	Device type	-	UINT32	RO	NO	-	00020192h
1001h	00h	Error register	-	UINT8	RO	NO	-	-
1008h	00h	Device name	-	STRING	RO	NO	-	Riding Servo Drives
1009h	00h	Hardware version	-	STRING	RO	NO	-	
100Ah	00h	Software version	-	STRING	RO	NO	-	
1018h	Device ID			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	4
	01h	Vendor ID	-	UINT32	RO	NO	-	000008C4h
	02h	Product code	-	UINT32	RO	NO	-	10000001h
	03h	Version number	-	UINT32	RO	NO	-	00000001h
	04h	Serial number	-	UINT32	RO	NO	-	00000000h
10F1h	Misconfiguration			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO		2
	01h	Local misconfiguration	-	UINT32	RO	NO	-	1
	02h	Synchronization error count threshold	4-65535.	UINT16	RW	NO	-	4
1600h	RPDO1 mapping object			UINT32	RW	NO		

	00h	Subindex entries	0 - 8	UINT8	RW	NO	-	3
	01h	First projection	-	UINT32	RW	NO	-	60400010h
	02h	Second projection	-	UINT32	RW	NO	-	607A0020h
	03h	Third projection	-	UINT32	RW	NO	-	60600008h
	04h	Fourth projection	-	UINT32	RW	NO	-	0
	05h	Fifth projection	-	UINT32	RW	NO	-	0
	06h	Sixth projection	-	UINT32	RW	NO	-	0
	07h	Seventh projection	-	UINT32	RW	NO	-	0
	08h	Eighth projection	-	UINT32	RW	NO	-	0
1601h	RPDO2 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	5
	01h	First projection	-	UINT32	RO	NO	-	60400010h
	02h	Second projection	-	UINT32	RO	NO	-	607A0020h
	03h	Third projection	-	UINT32	RO	NO	-	60FF0020h
	04h	Fourth projection	-	UINT32	RO	NO	-	60710010h
	05h	Fifth reflected	-	UINT32	RO	NO	-	60600008h
1602h	RPDO3 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	2
	01h	The first projection	-	UINT32	RO	NO	-	60400010h
	02h	Second projection	-	UINT32	RO	NO	-	607A0020h
1603h	RPDO4 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	2

	01h	First projection	-	UINT32	RO	NO	-	60400010h
	02h	Second projection	-	UINT32	RO	NO	-	60FF0020h
1604h	RPDO5 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	2
	01h	The first projection	-	UINT32	RO	NO	-	60400010h
	02h	Second projection	-	UINT32	RO	NO	-	60710010h
1A00h	TPDO1 mapping object			UINT32	RW	NO		
	00h	Subindex entries	0 to 8	UINT8	RW	NO	-	2
	01h	First projection	-	UINT32	RW	NO	-	60410010h
	02h	Second projection	-	UINT32	RW	NO	-	60640020h
	03h	Third projection	-	UINT32	RW	NO	-	0
	04h	Fourth projection	-	UINT32	RW	NO	-	0
	05h	Fifth projection	-	UINT32	RW	NO	-	0
	06h	Sixth projection	-	UINT32	RW	NO	-	0
	07h	Seventh projection	-	UINT32	RW	NO	-	0
	08h	Eighth projection	-	UINT32	RW	NO	-	0
1A01h	TPDO2 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	5
	01h	First projection	-	UINT32	RO	NO	-	60410010h
	02h	Second projection	-	UINT32	RO	NO	-	60640020h
	03h	Third projection	-	UINT32	RO	NO	-	606C0020h
	04h	Fourth projection	-	UINT32	RO	NO	-	60770010h

	05h	Fifth projection	-	UINT32	RO	NO	-	60610 008h
1A02h	TPDO3 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	2
	01h	The first hit,	-	UINT32	RO	NO	-	60410 010h
	02h	Second projection	-	UINT32	RO	NO	-	60640 020h
1A03h	TPDO4 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	3
	01h	First projection	-	UINT32	RO	NO	-	60410 010h
	02h	Second projection	-	UINT32	RO	NO	-	60640 020h
	03h	Third projection	-	UINT32	RO	NO	-	606C0 020h
1A04h	TPDO5 mapping object			UINT32	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	3
	01h	First projection	-	UINT32	RO	NO	-	60410 010h
	02h	Second projection	-	UINT32	RO	NO	-	60640 020h
	03h	Third projection	-	UINT32	RO	NO	-	60770 010h
1C00h	SM Channel type			UINT8	RO	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	4
	01h	SM0 type	-	UINT8	RO	NO	-	1
	02h	The SM1 type	-	UINT8	RO	NO	-	2
	03h	SM2 type	-	UINT8	RO	NO	-	3
	04h	SM3 type	-	UINT8	RO	NO	-	4
1C12h	Distribution of RPDO			UINT16	RW	NO		
	00h	Subindex entries	-	UINT8	RW	NO	-	1

1C13h	01h	RPDO group	1600h -1604 h	UINT16	RW	NO	-	1600h
	TPDO distribution			UINT16	RW	NO		
	00h	Subindex entries	-	UINT8	RW	NO	-	1
	01h	TPDO group	1A00h -1A04 h	UINT16	RW	NO	-	1A00h
1C32h	SM2 parameters			UINT16	RW	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	32
	01h	Synchronou s type	-	UINT16	RW	NO	-	2
	02h	Cycle time	-	UINT32	RO	NO	ns	0
	04h	Supported same step types	-	UINT16	RO	NO	-	0004h
	05h	Minimum cycle time	-	UINT32	RO	NO	ns	12500 0
	06h	Calculate and duplicate time	-	UINT32	RO	NO	ns	10000
	09h	Delay time	-	UINT32	RO	NO	ns	0
	0Ah	SYNC0 week time	125us /250 us/50 0us/ 1ms/2 ms	UINT32	RW	NO	ns	-
	0Bh	SM event lost counter	-	UINT16	RO	NO	-	-
	0Ch	Frame cycle time is too short	-	UINT16	RO	NO	-	-
	20h	Synchroniza tion error	-	BOOL	RO	NO	-	0
1C33h	SM3 parameters			UINT16	RW	NO		
	00h	Subindex entries	-	UINT8	RO	NO	-	32
	01h	Synchronou	-	UINT16	RW	NO	-	2

		s type						
	02h	Cycle time	-	UINT32	RO	NO	ns	0
	04h	Supported same step types	-	UINT16	RO	NO	-	0004h
	05h	Minimum cycle time	-	UINT32	RO	NO	ns	125000
	06h	Calculate and duplicate time	-	UINT32	RO	NO	ns	10000
	09h	Delay time	-	UINT32	RO	NO	ns	0
	0Ah	SYNC0 week time	125us /250 us/500us/ 1ms/2 ms	UINT32	RW	NO	ns	-
	0Bh	SM event lost counter	-	UINT16	RO	NO	-	-
	0Ch	Frame cycle time too short meter	-	UINT16	RO	NO	-	-
	20h	Synchronization error	-	BOOL	RO	NO	-	0

4.2 Servo customized parameter Area (2000H-2005h)

There are six groups of self-defined parameters in GHA-E servo, Pn0xx, Pn1xx, Pn2xx, Pn3xx, Pn4xx and Pn5xx, and each group is mapped to 2000H-2005H object respectively. The upper computer can directly write or read the servo self-defined parameters through the object dictionary.

The mapping is shown in the following table:

Index	Subindex	Name	Scope	Data type	Access attributes	PDO mapping	Unit	Default value
2000h	Pn0xx set of parameters			UINT16	RW	ALL		
	00h	Pn0xx Number group parameters	-	UINT8	RO	NO	-	98
	01h	Pn000	0-65536.	UINT16	RW	ALL	-	

	02h	Pn001	0-65536.	UINT16	RW	ALL	-	
	.	.	.	.	.	.	.	.
	62h	Pn097	0-65536.	UINT16	RW	ALL	-	
2001h	Pn1xx set of parameters			UINT16	RW	ALL		
	00h	Pn1xx Numbergroup parameters	-	UINT8	RO	NO	-	80
	01h	Pn100	0-65536.	UINT16	RW	ALL	-	
	02h	Pn101	0-65536.	UINT16	RW	ALL	-	
	.	.	.	.	.	.	.	.
	50h	Pn179	0-65536.	UINT16	RW	ALL	-	
2002h	Pn2xx set of parameters			UINT16	RW	ALL		
	00h	Pn2xx Number of group parameters	-	UINT8	RO	NO	-	81
	01h	Pn200	0-65536.	UINT16	RW	ALL	-	
	02h	Pn201	0-65536.	UINT16	RW	ALL	-	
	51h	Pn280	0-65536.	UINT16	RW	ALL	-	
2003h	Pn3xx set of parameters			UINT16	RW	ALL		
	00h	Pn3xx Number of group parameters	-	UINT8	RO	NO	-	71
	01h	Pn300	0-65536.	UINT16	RW	ALL	-	
	02h	Pn301	0-65536.	UINT16	RW	ALL	-	
	.	.	.	.	.	.	.	.

	47h	Pn370	0-65536.	UINT16	RW	ALL	-	
2004h	Pn4xx set of parameters			UINT16	RW	ALL		
	00h	Pn4xx Number of group parameters	-	UINT8	RO	NO	-	50
	01h	Pn400	0-65536.	UINT16	RW	ALL	-	
	02h	Pn401	0-65536.	UINT16	RW	ALL	-	
	.	.	.	.	.	.	.	.
	32h	Pn449	0-65536.	UINT16	RW	ALL	-	
2005h	Pn5xx set of parameters			UINT16	RW	ALL		
	00h	Pn5xx Number of group parameters	-	UINT8	RO	NO	-	100
	01h	Pn500	0-65536.	UINT16	RW	ALL	-	
	02h	Pn501	0-65536.	UINT16	RW	ALL	-	
	.	.	.	.	.	.	.	.
	64h	Pn599	0-65536.	UINT16	RW	ALL	-	

Note: 2000H-2005H objects can be read and written by SDO service and PDO service. PDO modification parameters are not saved to EEPROM.

Note: The PN-046 parameter determines whether the parameter values written to the SDO are saved to the EEPROM.(see 2.2.1 Section

4.3 CiA402 Sub-Protocol Area (6000H-6FFFH)

Index	Sub index	Name	Scope	Data type	Access attributes	PDO mapping	unit	Default value
603Fh	00h	Error code	0-65535.	UINT16	RO	TPDO	-	0
6040h	00h	Control word	0-65535.	UINT16	RW	ALL	-	0

6041h	00h	Status word	0-65535.	UINT 16	RO	TPDO	-	0
605Ah	00h	Quick stop mode selection	0-2	INT1 6	RW	NO	-	2
605Bh	00h	Shutdown shutdown mode selection	0-2	INT1 6	RW	NO	-	0
605Ch	00h	Enable shutdown mode selection	0-2	INT1 6	RW	NO	-	1
605Eh	00h	Fault shutdown mode selection	0-2	INT1 6	RW	NO	-	0
6060h	00h	Working mode	0 to 10	INT8	RW	ALL	-	0
6061h	00h	Working mode display	0 to 10	INT8	RO	TPDO	-	0
6062h	00h	Position command	-2147483 648-2147 83647	INT3 2	RO	TPDO	Instruction unit	0
6063h	00h	Internal feedback position	-2147483 648-2147 483647	INT3 2	RO	TPDO	pulse	0
6064h	00h	Position feedback	-2147483 648-2147 483647	INT3 2	RO	TPDO	Instruction unit	0
6065h	00h	Follow the error threshold	0-429496 7295	UINT 32	RW	ALL	Instruction unit	0
6067h	00h	location reaches threshold procedure	0-429496 7295	UINT 32	RW	ALL	Instruction unit	0
6068h	00h	Location to window time	0-65535.	UINT 16	RW	ALL	ms	0

606Bh	00h	Speed instruction	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit per second	0
606Ch	00h	Feedback speed	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit per second	0
606Dh	00h	The speed reaches the threshold. Procedure	0-65535.	UINT16	RW	ALL	Instruction unit per second	100
606Eh	00h	Speed to window time	0-65535.	UINT16	RW	ALL	ms	100
606Fh	00h	Zero speed threshold	0-65535.	UINT16	RW	ALL	Instruction unit per second	50
6070h	00h	Zero speed window time	0-65535.	UINT16	RW	ALL	ms	0
6071h	00h	Target torque	-65535	INT16	RW	ALL	0.10%	0
6072h	00h	The maximum torque	0-65535.	UINT16	RW	ALL	0.10%	3000
6074h	00h	Torque command	-65535	INT16	RO	TPDO	0.10%	0
6075h	00h	Motor rated current	0-4294967295	UINT32	RO	TPDO	mA	0
6076h	00h	Motor torque rating	0-4294967295	UINT32	RO	TPDO	MN m.	0
6077h	00h	Feedback torque	-32768-32767	INT16	RO	TPDO	0.10%	0
6078h	00h	Feedback current	-32768-32767	INT16	RO	TPDO	0.10%	0

607Ah	00h	The target location	-2147483648-2147483647	INT32	RW	ALL	Instruction unit	0
607Ch	00h	Origin offset	-2147483648-2147483647	INT32	RW	ALL	Instruction unit	0
607Dh	Software limit			INT32	RW	ALL	Instruction unit	
	00h	Number of subindexes	-	UINT8	RO	NO	-	2
	01h	Minimum position limit	-2147483648-2147483647	INT32	RW	ALL	Instruction unit	-2000000000
	02h	Maximum position limit	-2147483648-2147483647	INT32	RW	ALL	Instruction unit	2000000000
607Eh	00h	Instruction of polarity	0-255.	UINT8	RW	ALL	-	0
607Fh	00h	Maximum command speed	0-4294967295	UINT32	RW	ALL	Instruction unit per second	32000
6081h	00h	Table running speed	0-4294967295	UINT32	RW	ALL	Instruction unit per second	0
6083h	00h	Simplified acceleration	0-429496729-5	UINT32	RW	ALL	Instruction unit/S2	100
6084h	00h	Simple watch deceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	100
6085h	00h	Fast stop deceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	100

6087h	00h	Torque slope	0-4294967295	UINT32	RW	ALL	0.1% / s	0
6091h	Electronic gear ratio			UINT32	RW	ALL		
	00h	Number of subindexes	-	UINT8	RO	NO	-	2
	01h	Motor resolution	1-4294967295	UINT32	RW	ALL	Pul (motor)	131072
	02h	Load axis resolution	1-4294967295	UINT32	RW	ALL	Pul (shaft)	10000
6098h	00h	Origin regression method	-128-127	INT8	RW	ALL	-	35
6099h	Velocity of origin regression			UINT32	RW	ALL		
	00h	Number of subindexes	-	UINT8	RO	NO	-	2
	01h	Section 1 search deceleration point speed	0-4294967295	UINT32	RW	ALL	Instruction unit per second	0
	02h	The second paragraph searches the original point velocity	0-4294967295	UINT32	RW	ALL	Instruction unit per second	0
609Ah	00h	Return to zero deceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	100

60B0h	00h	Position command bias	-2147483648-2147483647	INT32	RW	ALL	Instruction unit	0
60B1h	00h	Speed command offset	-2147483648-2147483647	INT32	RW	ALL	Instruction unit per second	0
60B2h	00h	Torque instruction bias	-2147483648-2147483647	INT32	RW	ALL	0.10%	0
60B8h	00h	The probe model	0-65535.	UINT16	RW	ALL	-	0
60B9h	00h	State of the probe	0-65535.	UINT16	RO	TPDO	-	0
60BAh	00h	Latch position value of rising edge of probe 1	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit	0
60BBh	00h	Latch position value of falling edge of probe 1	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit	0
60BCh	00h	Latch position value of rising edge of probe 2	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit	0
60BDh	00h	Latch position value of probe 2's falling edge	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit	0
60C5h	00h	Maximum acceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	10000

60C6h	00h	Maximum deceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	10000
60E0h	00h	Forward torque limit	0-65535.	UINT16	RW	ALL	0.10%	3000
60E1h	00h	Reverse torque limit	0-65535.	UINT16	RW	ALL	0.10%	3000
60F4h	00h	Follow error	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit	0
60FCh	00h	Internal position instruction	-2147483648-2147483647	INT32	RO	TPDO	Instruction unit	0
60FDh	00h	DI digital input	-	UINT32	RO	TPDO	-	0
60FEh	DO digital output			UINT32	RW	ALL		
	00h	Number of subindexes	-	UINT8	RO	NO	-	2
	01h	Physical output	0h-FFFFFFFFh	UINT32	RW	ALL	-	0
	02h	A bitmask	0h-FFFFFFFFh	UINT32	RW	ALL	-	0
60FFh	00h	The target speed	-4294967295	INT32	RW	ALL	Instruction unit per second	0
6502h	00h	Supported working mode	-	UINT32	RO	TPDO	-	3ADh

Note: 607Dh, 607Eh and 6091H are saved into EEPROM after modification by SDO service. Others are not saved.

Note: Values modified through the PDO service are not stored in the EEPROM.

Chapter 5 Control mode

5.1 CiA402 State Machine

When using ghA-E drives, the servo drive must be guided according to the procedure specified in the standard CiA402 protocol so that the servo drive can operate in the specified state.

The state machine stipulated in CiA402 protocol is shown in Figure 5.1:

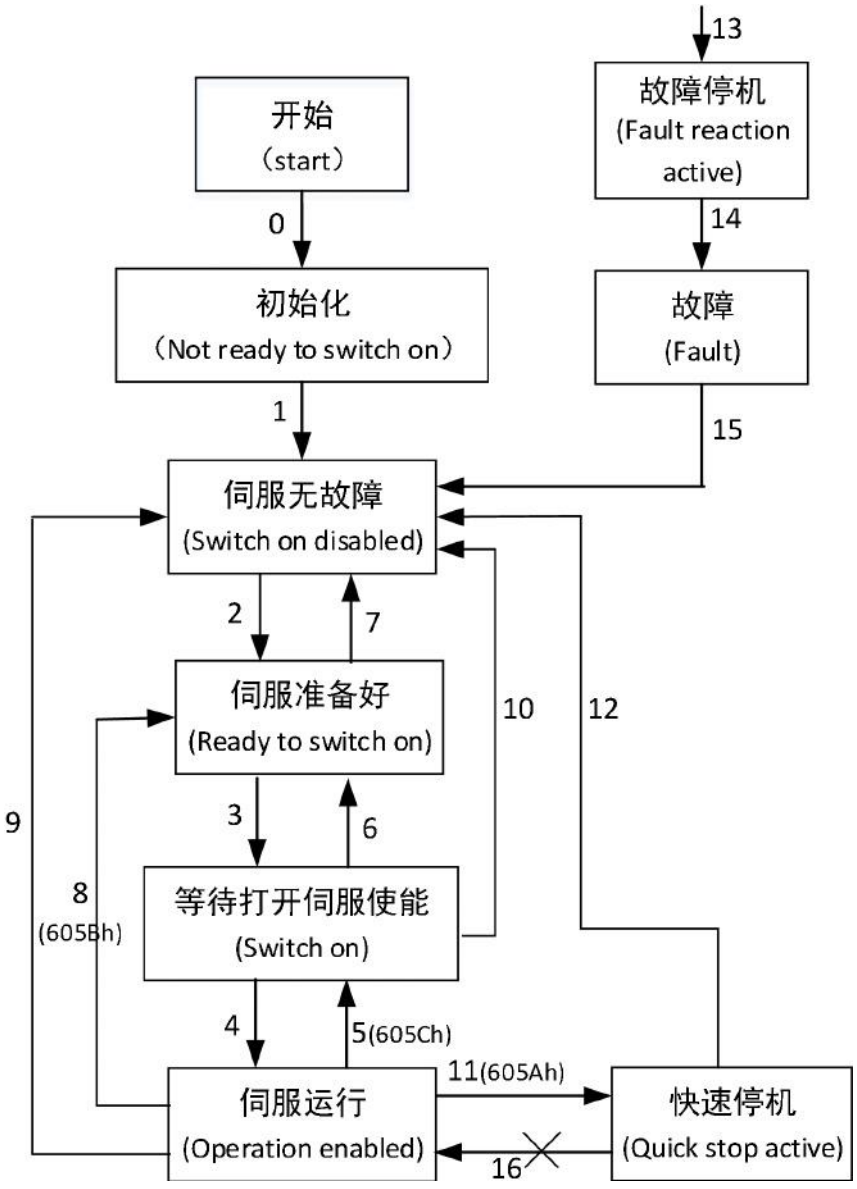


Figure 5.1 CiA402 State machine switching diagram

The following table describes each state:

state	describe
Initialize the	Drive initialization and internal self-check have been completed. Drive parameters cannot be set and driver functions cannot be performed.
Servo trouble-free	No faults or errors have been removed from the servo drive.Drive parameters can be set.
Servo ready	Servo drive is ready, drive parameters can be set.
Wait to enable the servo	Servo driver waiting to open servo enable, drive parameters can be set.
Servo operation	The driver is running normally, a servo running mode has been enabled, the motor has been powered on, the driver parameter attribute of "Operation Change" can be set, others cannot.
A quick stop	The quick stop function is activated and the drive is performing the quick stop function. Drive parameters whose property is Run Change can be set, others cannot.
downtime	The drive has failed and is in the process of performing a faulty shutdown. Drive parameters whose property is Run Change can be set, others cannot.
The fault	Failure shutdown is complete, all drive functions are disabled, and drive parameters are allowed to be changed for troubleshooting. For the resettable fault, the control word 6040h=80h can be used to reset the fault after the parameter is changed.

All switching actions of the above state machine are shown in the following table:

The status of CiA402 switched		Event	Action
0	Power on → Initialization	Natural transition, no control instructions required	Servo initialization and self - check
1	Initialization → servo without failure	Natural transition, no control instruction, if error occurs during initialization, directly enter 13	Communicatio n to activate
2	Servo trouble-free → servo ready	Receiving Shutdown command	No action
3	Servo ready → Wait to open servo enable	Receive the Switch on command	No action

4	Wait for the server to open enable → server to run	Receive the Enable operation command	Servo enable, motor power on
5	Servo operation → Waiting open server enable	Receive Disable operation command	Servo stops in 605Ch mode, and then disconnects and enables
6	Wait for the server to enable → The server is ready	Receiving Shutdown command	No action
7	Servo ready → Servo without cause	Receive the Disable VOLTAGE command	No action
8	Servo run → Servo ready	Receiving Shutdown command	The servo stops in 605Bh mode, and then stops enabling
9	Servo operation → servo trouble-free	Receive the Disable VOLTAGE command	Servo direct disenable
10	Wait to open the servo enable → the server has no fault	Receive the Disable VOLTAGE command	No action
11	Servo operation → fast stop	Receive the Quick Stop command	The servo will stop in 605Ah mode, and then stop and automatically execute 12
12	Fast stop → servo trouble-free	Natural transition, no control instructions required	No action
13	→ Malfunction stop	In any state except "fault", the servo drive will automatically switch to the fault shutdown state without control instruction once there is trouble	The servo executes the corresponding fault stop maneuver
14	Failure shutdown → failure	After the shutdown, the natural transition, no control instructions	Servo disconnection enable
15	Failure → servo without failure	Receive the Fault Reset command	Perform a reset after a fault recovery

16	Quick stop → servo operation	Quick stop mode 605A: Select 5 to 7 and return to Operation Enabled after the stop.(This servo does not support this action)	Does not support

5.2 Control Word (6040H) and Status Word (6041H)

5.2.1 Control Word (6040H)

The object 6040H (Controlword) controls the actions of the CiA402 state machine and the servo actions in different working modes.

Index	Subindex	Name	Scope	Date type	Access attribute	PDO mapping	unit	Default value
6040h	00h	Control word	0-65535	UINT16	RW	ALL	-	0

The meanings of each bit are as follows:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Mean	ms					r	oms	h	fr	oms			eo	qs	ev	so

ms: manufacturer-specific Indicates the manufacturer. Reserved. R: reserved
oms: operation mode specific H: HALT pause (not supported)
fr: Fault reset Indicates a fault reset
eo: enable operation Enable
qs: Quick Stop
ev: enable Voltage servo Ready
so: switch on Waiting to be enabled

The command combination of CiA402 state machine switching is as follows:

Instruction	Control Word (6040H)					State machine switch
	Bit7	Bit3	Bit2	Bit1	Bit0	
Shutdown	0	X	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Switch on + enable operation	0	1	1	1	1	3 + 4

Disable voltage	0	X	X	0	X	7,9,10,12
Quick stop	0	X	0	1	X	7, 11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	The 0-1	X	X	X	X	15

Note: "X" in the table means that the bit is not important at this time. Generally, write "0".

Note: For example, to execute Shutdown, write 6040h as 0x06.

Bit8 control pause function (Halt), this servo does not support this function, so this bit is invalid.

Bit4-bit6 and Bit9 have different meanings in specific working modes. Their meanings are summarized in the following table. For detailed operations, see the description of each working mode.

Working mode	Bit9	Bit6	Bit5	Bit4
pp	Change on Absolute/ set-point(not Relative)		Change set New set-point immediately	
pv	-	-	-	-
tq	-	-	-	-
hm	-	-	-	Start homing
csp	-	-	-	-
csv	-	-	-	-
cst	-	-	-	-

Note: "-" in the table indicates that it is not used. Please write "0" for this bit.

5.2.2 Status Word (6041H)

Object 6041H (Statusword) is used to indicate the current state of CiA402 state machine, indicating the working condition of the server.

Index	Subindex	Name	Scope	Data type	Access attribute	PDO mapping	unit	Default value
6041h	00h	Status word	0-65535.	UINT16	RO	TPDO	-	0

The meanings of each bit are as follows:

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Mean	ms		oms		ila	tr	rm	ms	w	sod	qs	ve	f	oe	so	rtso

ms : manufacturer-specific
oms: operation mode specific
ila: internal limit active
tr: target reached
rm: remote
w: warning
sod: switch on disabled
qs: quick stop
ve: voltage enabled
f: fault
oe: operation enabled
so: switched on
rtso: ready to switch on

The combination of bit0-bit3,Bit5 and Bit6 can determine the current state of CiA402 state machine:

Status word (6041H)	CiA402 state	
xxxx xxxx x0xx 0000b	Not ready to switch on	Initialize the
xxxx xxxx x1xx 0000b	Switch on disabled	Servo without fault, initialization complete
xxxx xxxx x01x 0001b	Ready to switch on	Servo ready
xxxx xxxx x01x 0011b	Switch on	Wait to enable the servo
xxxx xxxx x01x 0111b	Operation enabled	The servo can make
xxxx xxxx x00x 0111b	Quick stop active	A quick stop
xxxx xxxx x0xx 1111b	Fault reaction active	Fault response
xxxx xxxx x0xx 1000b	Fault	The fault

Note: "x" indicates that the bit does not affect the state it represents.

Bit4 indicates that the main power supply has been switched on. Since the servo is powered on, the main power supply has been switched on, so the bit is always kept as "1".

If Bit5 is 0, Quick Stop is valid.

If the value of Bit7 is 1, a warning is generated, which does not affect the state machine. If Bit9 is 1, the 6040H control word is processed.

Bit10,Bit12,Bit13 are related to working modes, and they have different meanings in different working modes.

The meaning of "is summarized as follows:

Working mode	Bit13	Bit12	Bit10
pp	following error	set-point acknowledge	target reached
pv	-	speed	target reached
tq	-	-	target reached
hm	homing error	homing attained	target reached
csp	following error	drive follows command value	-
csv	-	drive follows command value	-
cst	-	drive follows command value	-

5.3 Work mode

5.3.1 Supported Working Mode (6502H)

The 6502H (Supported drive modes) object represents the Supported working modes of the server.

Index	Subindex	Name	Scope	Data type	Access attribute	PDO mapping	unit	Default value
6502h	00h	Supported Working mode	-	UINT 32	RO	TPDO	-	3ADh

Each Bit indicates a working mode. When the corresponding Bit value is 1, the working mode is supported. The definitions are as follows:

Bit	Working mode	value
0	Table position mode PP	1
1	Speed control mode VL	0

2	Short table speed mode PV	1
3	Brief table torque mode TQ	1
4	keep	0
5	Return to zero mode hm	1
6	Interpolation position mode IP	0
7	Synchronous location mode CSP	1
8	Synchronization speed mode CSV	1
9	Synchronous torque mode CST	1
10-15	keep	0
16-31	Manufacturer's Custom	0

5.3.2 Setting of working mode (6060h) and Display (6061H)

The object 6060H (Modes of operation) represents the current servo working mode requested by the controller, and the object 6061H (Modes of operation display) represents the current working mode of the servo. They are described as follows:

Index	Subindex	Name	Scope	Data type	Access attribute	PDO mapping	unit	Default value
6060h	00h	Working mode	0-10	INT8	RW	ALL	-	0
6061h	00h	Working mode display	0-10	INT8	RO	TPDO	-	0

The values of 6060h and 6061H range from -128 to 127 and have the same meanings as the following table:

Value	Mean
- 128 ~ 1	Manufacturer's Custom
0	Is not specified
1	Profile position mode(pp)
2	Velocity Mode (VL)
3	Profile velocity mode(pv)
4	Torque profile mode(tq)
5	keep
6	Homing mode(hm)
7	Interpolated Position Mode (IP) (not supported)
8	Cyclic sync position mode(csp)
9	Cyclic sync velocity mode(csv)

10	Cyclic sync torque mode(cst)
11-127.	keep

Note: When setting the working mode, the controller writes the object for 6060h and reads back to the current servo working mode from 6061H for confirmation.

Note: the default value of 6060H is 0, so the corresponding working mode should be set before servo is enabled, if not
Servo alarm "Co01" (fault code: FF05).

Note: Please switch the working mode when the servo is not enabled, otherwise abnormal conditions may occur.

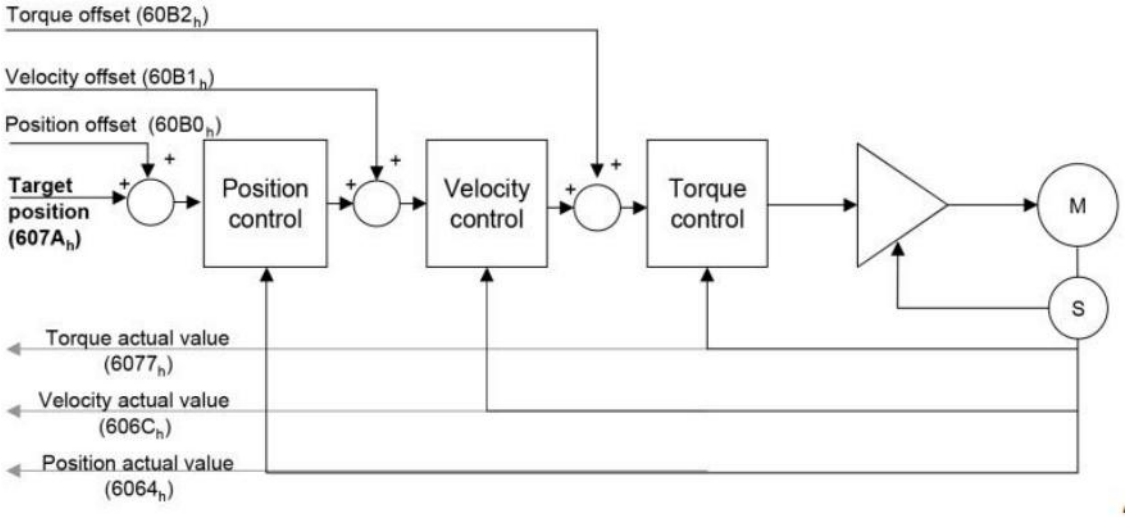
5.4 Position control Mode

5.4.1 Synchronizing location Mode CSP

Cyclic synchronous position mode is a position operation mode that sends the target position command in a periodic synchronous mode. It is characterized by the position trajectory planning in the upper computer and the server directly responds to the position command.

When using this mode, set 6060h to 8.

1) Structure diagram.



Position instruction bias 60B0h, speed instruction bias 60B1h and torque instruction bias 60B2h are all valid in this mode, and the feedback objects are actual torque 6077h, actual speed 606Ch and actual position 6064h. The result of upper computer's trajectory planning directly refreshes the target position 607Ah at a frequency of up to 8K.

2) Related objects

No special control, see section 5.2.1 for others
6041 h status word

position	Name	describe
Bit10	Reserve	
Bit12	drive follows command value	0: The slave station does not follow the target position command 1: Follow the target position command from the station
Bit13	following error	0: The following error is within the threshold 1: Following error is too large

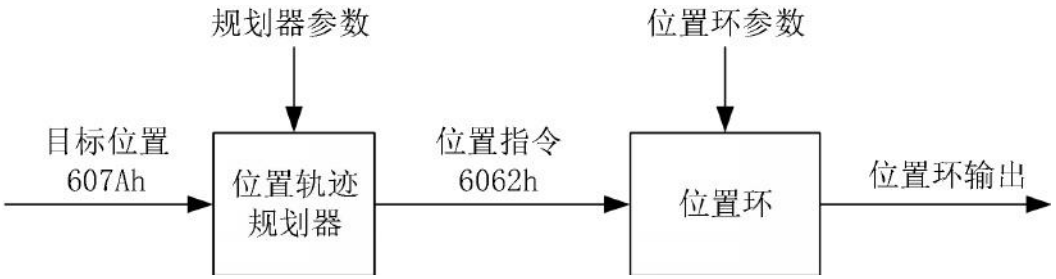
Index	Subindex	Name	Describe
6065h	0	Follow the error threshold	When the position deviation is greater than 6065h, it is considered as follow error If the difference is too large, Bit13 of 6041h is set.

5.4.2 Contour position mode PP

Profile position mode is a position control mode that generates position instructions in the servo drive after specifying target position, target speed, increase or decrease speed, etc.That is, the position planning function is accomplished by servo, mainly used in point-to-point applications.

When using this mode, set 6060h to 1.

1) Structure diagram



Compared with CSP mode, the servo has more functions of position trajectory planner.

2) Related objects

Control word 6040 h		
Position	Name	Describe

Bit4	New Set-point	Rising edge from 0 to 1 indicates triggering new target position 607Ah, speed 6081H, etc
Bit5	Change set immediately	0: not update immediately 1: update immediately
Bit6	abs/rel	0: the target position is absolute position 1: the target position is relative position instruction
Bit9	Change on set-point	Does not support
Control word 6041 h		
Position	Name	Describe
Bit10	target reached	0: the target position is not reached. 1: the target position is reached
Bit12	drive follows command value	0: the slave station does not follow the command. 1: the slave station follows the command
Bit13	following error	0: the following error is within the threshold. 1: The following error is too large

Index	Subindex	Name	Describe
6067h	0	The location reaches the threshold. Procedure	When the position deviation is within the range of ±6067h, and time
6068h	0	Location to window time	When 6068h is reached, the position is considered to have arrived, and the Bit10 position of 6041h is 1.
607Fh	0	Maximum command speed	Limit 6081H given speed, unit: instruction bit /s
6081h	0	Table running speed	Unit: command unit /s
6083h	0	Simplified acceleration	Unit: instruction unit/S2
6084h	0	Simple watch deceleration	Unit: instruction unit/S2

5.4.3 Return to zero mode HM

Homing mode: It also known as origin reset mode, is to find the mechanical origin and locate the position relationship between the mechanical origin and the

mechanical zero point.

Using this mode, set 6060h = 6.

Mechanical origin: a fixed position on a machine corresponding to the origin switch or motor Z belief number.

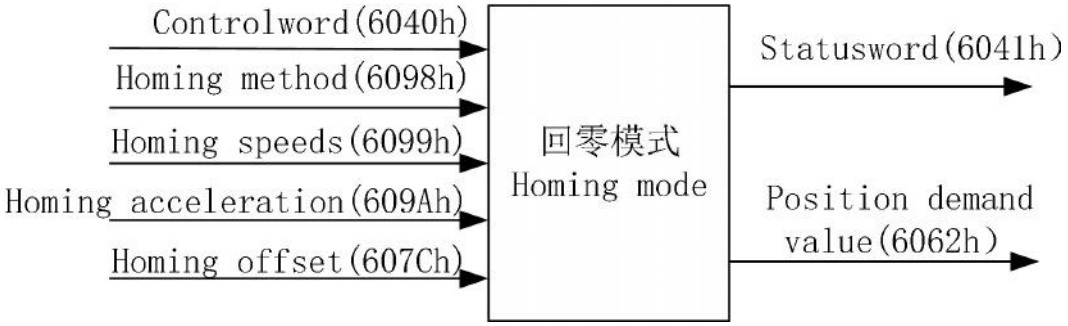
Mechanical zero: the position of absolute zero on a machine.

After the return to zero is completed, the stopping position of the motor is the mechanical origin. By setting the object 607Ch, the relationship between the Mechanical origin and the mechanical zero can be set:

Mechanical origin = mechanical zero +607Ch that is, the feedback position 6064h=607Ch

After the successful return to zero.

1) Structure diagram



2) Related objects

Control word 6040h		
position	Name	Describe
Bit4	Start homing	A rising edge from 0 to 1 indicates the start of a new zero-back action
Status word 6041h		
position	Name	Describe
Bit10	target reached	0: the target position is not reached. 1: the target position is reached
Bit12	Homing attained	0: the return to zero is not completed 1: returns to zero successfully
Bit13	Homing error	0: no error occurs 1: Zero error occurs

Index	Subindex	Name	Describe
6098h	0	Origin regression method	Method 1- method 14, method 17-method 30, method 33,34,35. Each method is described in detail in the following sections.
6099h	1	Section 1 search for deceleration point velocity	Unit: command unit /s

	2	The second paragraph searches for velocity of origin	Unit: command unit /s
609Ah	0	Return to zero deceleration	Unit: instruction unit/S2
607Ch	0	Origin offset	Unit: unit of instruction

3) Return to zero method

Method 1:

In this method, in the absence of a NOT(Negative limit), the initial action is Negative.

The detection position of the original point is the first Index pulse that is positively encountered after the NOT signal is inactive.As shown in figure 5.2:

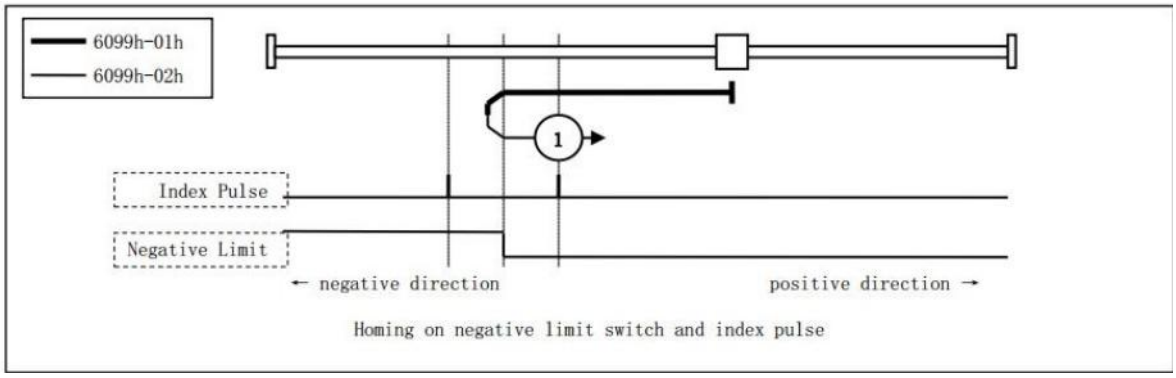


Figure 5.2 Return to zero method 1

Method 2:

In this method, when no POT(Positive limit) is encountered, the direction of initial action is Positive.

The detection position of the original point is the first Index Pulse of Z that is encountered in reverse after the POT signal is inactive.As shown in figure 5.3:

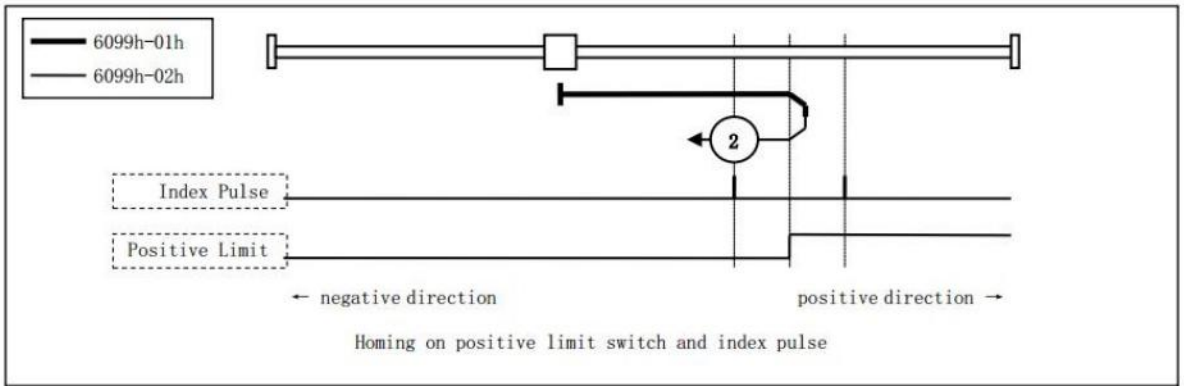


Figure 5.3 Back to zero method 2

Method 3,4

In this method, the action direction change is initialized based on the state of the Home Switch at startup.

The detection position of the original point is the first Index Pulse of the reverse side

or forward side of the Home switch after the state change.As shown in figure 5.4:

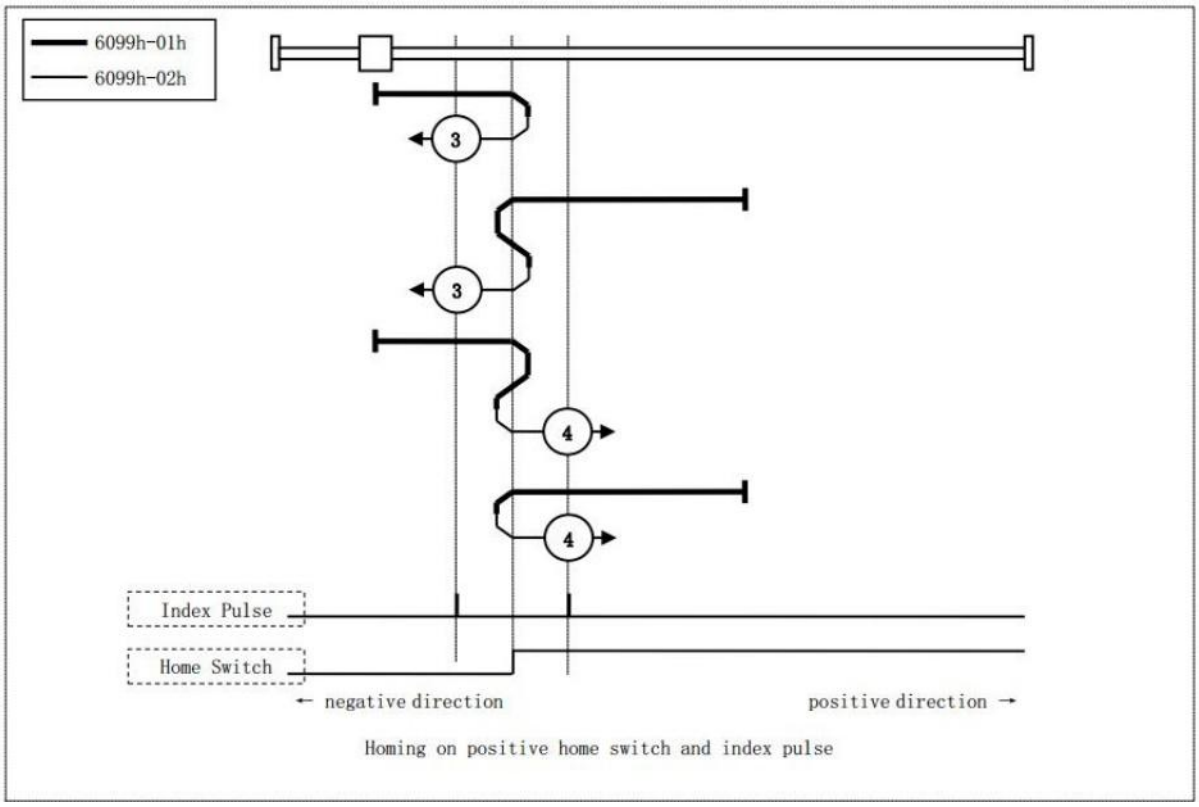


Figure 5.4 Return to zero method 3 and method 4

Method 5,6

In this method, the action direction change is initialized based on the state of the Home Switch at startup.

The detection position of the original point is the first Index Pulse of the reverse side or forward side of the Home switch after the state change.As shown in figure 5.5:

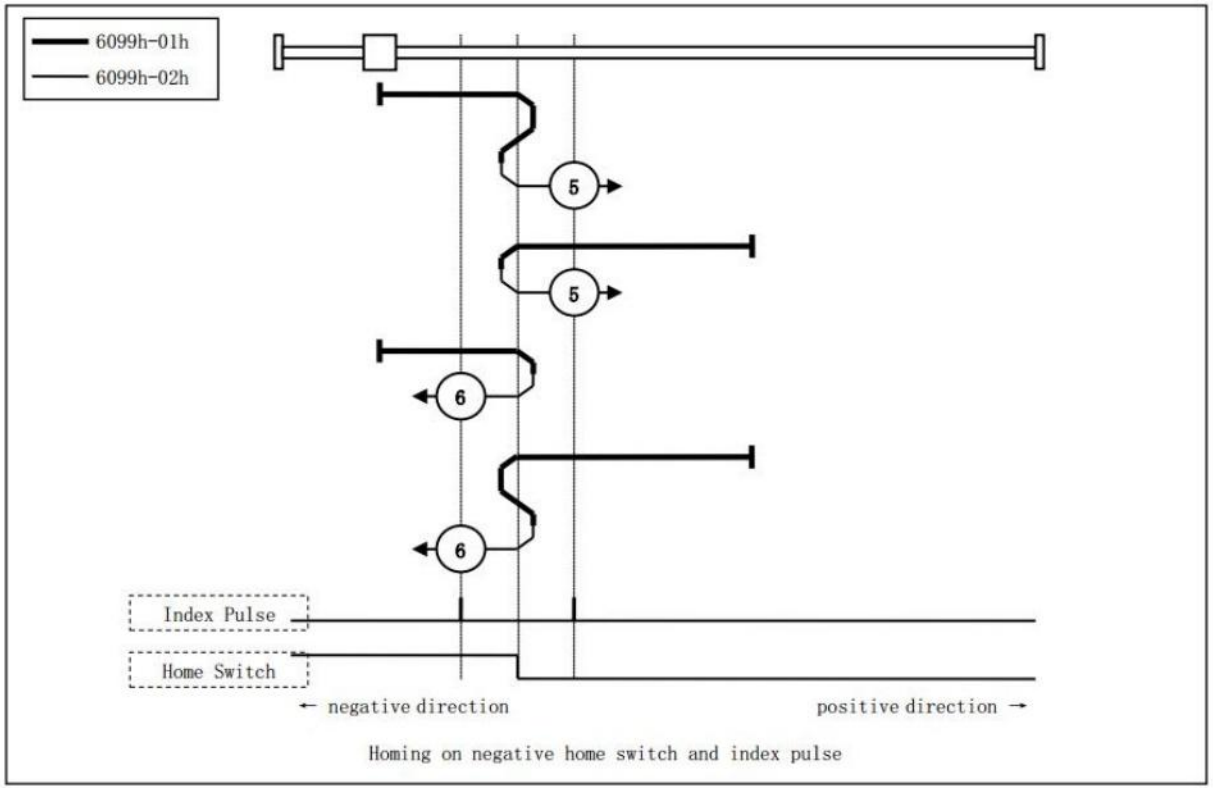


Figure 5.5 Return to zero methods 5 and 6

Methods 7,8,9,10
This method uses the Home Switch and Index Pulse.

Method 7 and 8 initialize the direction of action: if you start in the Home signal effective region, then move in the opposite direction.

Method 9 and 10 initializes the direction of action: if it starts in the Home signal effective region, it moves forward.

The original detection position is the rising edge of the home signal or the falling edge of the Index signal attached.As shown in figure 5.6:

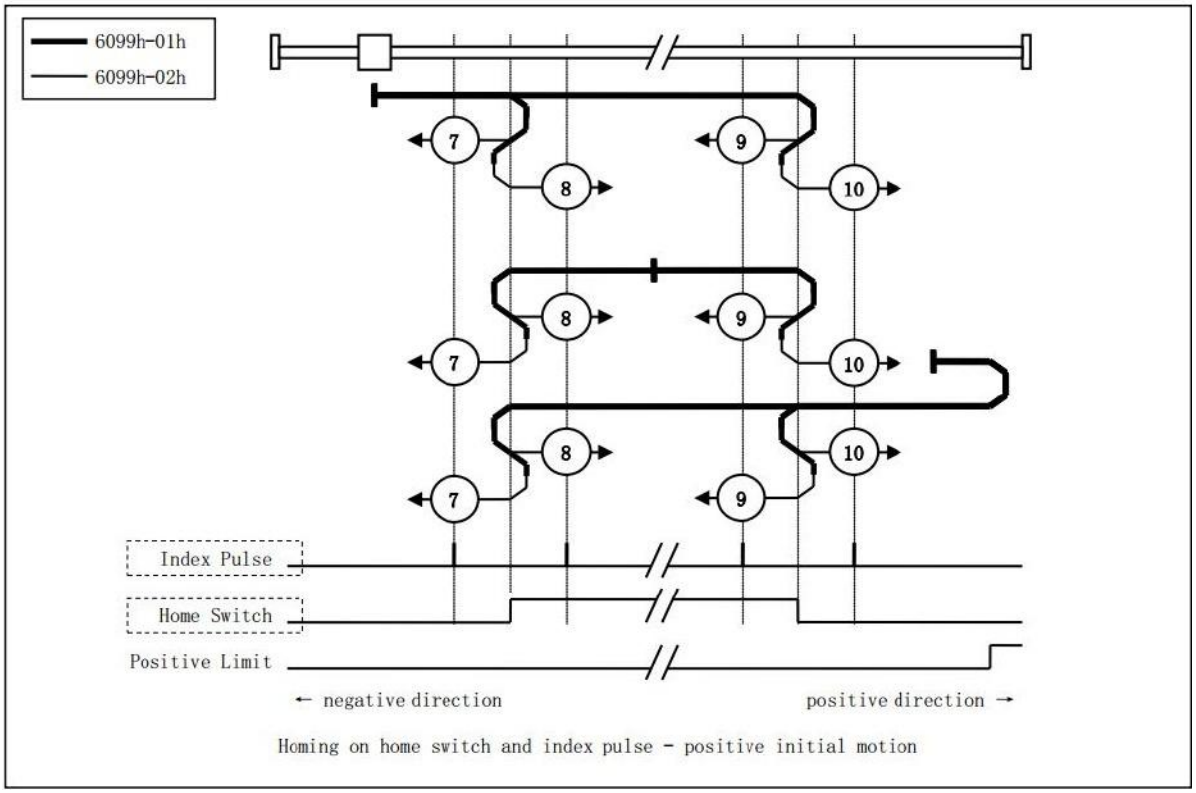


Figure 5.6 return to zero methods 7,8,9,10

Methods 11,12,13,14
This method uses the Home Switch and Index Pulse.

Method 11 and 12 initializes the action direction: if it is in the effective area of Home signal at the beginning, it moves forward.

Method 13,14 initializes the direction of action: if it starts in the Home signal area, it moves in the opposite direction.

The original detection position is the rising edge of the home signal or the falling edge of the Index signal attached.As shown in figure 5.7:

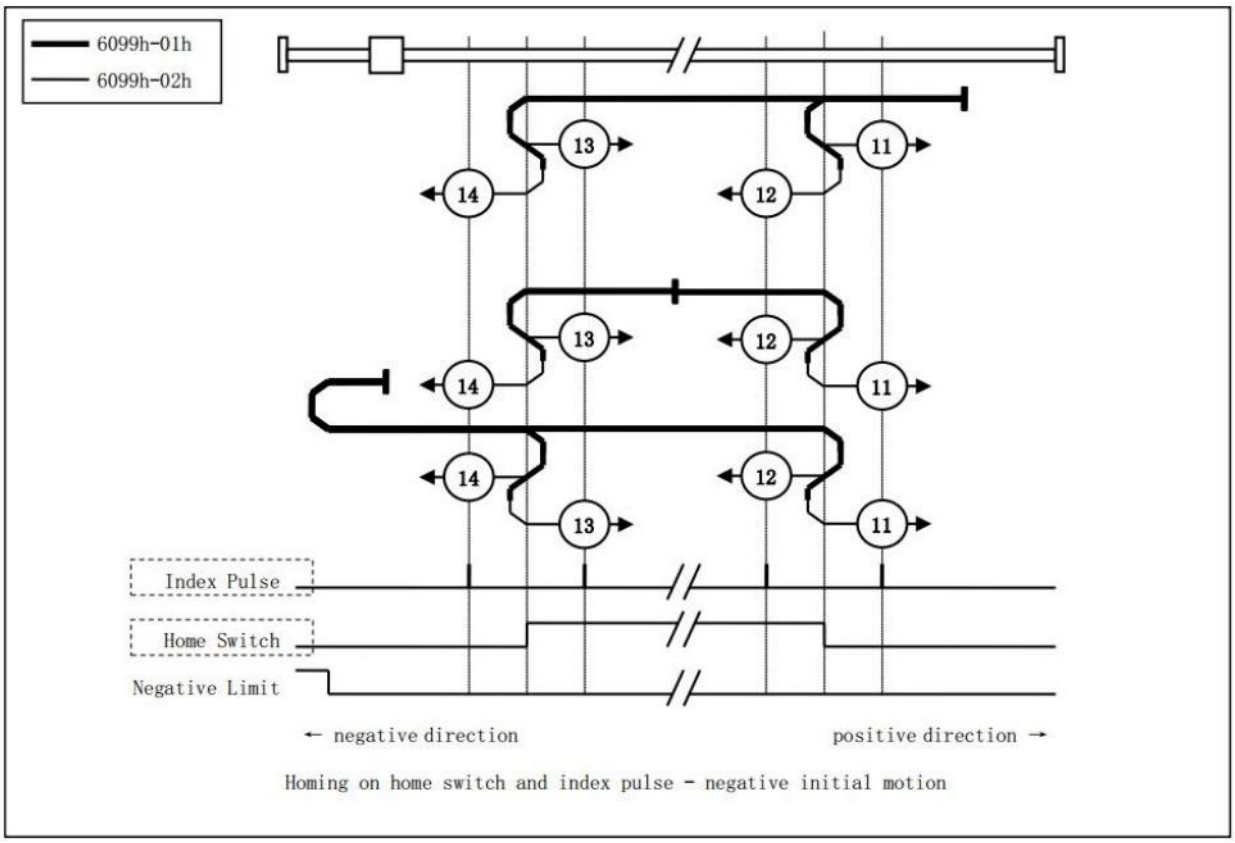


Figure 5.7 return to zero methods 11,12,13,14

Methods 17

This method is similar to method 1, but the difference is that the original detection position is NOT index pulse, but the changed position of NOT, as shown in Figure 5.8:

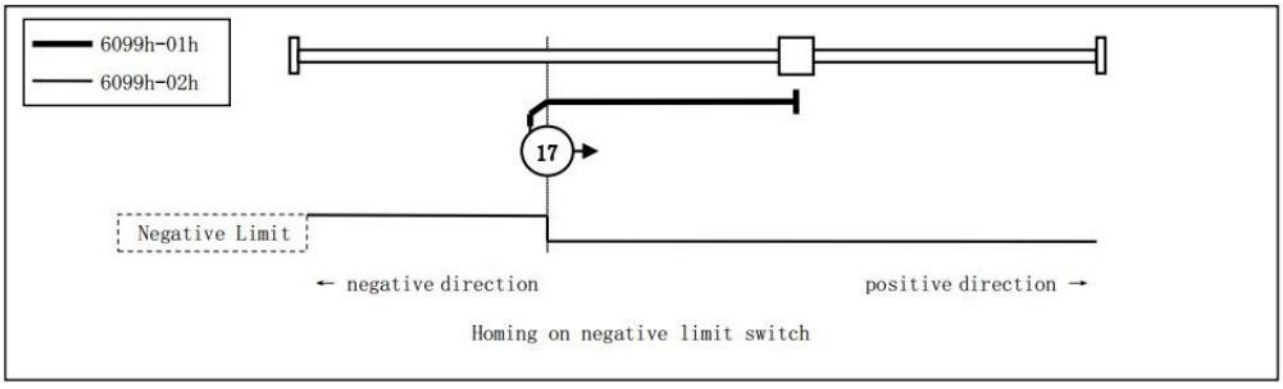


Figure 5.8 Return to zero method 17

Methods 18

This method is similar to method 2, but the difference is that the detection position of the original point is not index pulse, but POT's changed position, as shown in Figure 5.9:

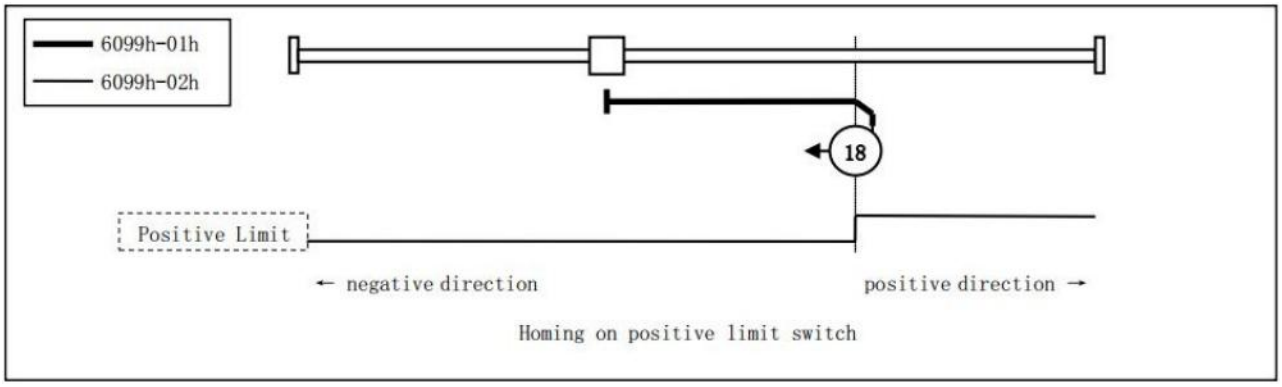


Figure 5.9 Back to zero method 18

Method 19,20

This method is similar to method 3 and 4, but the difference is that the original detection position is not index pulse, but the position where the Home signal changes, as shown in Figure 5.10:

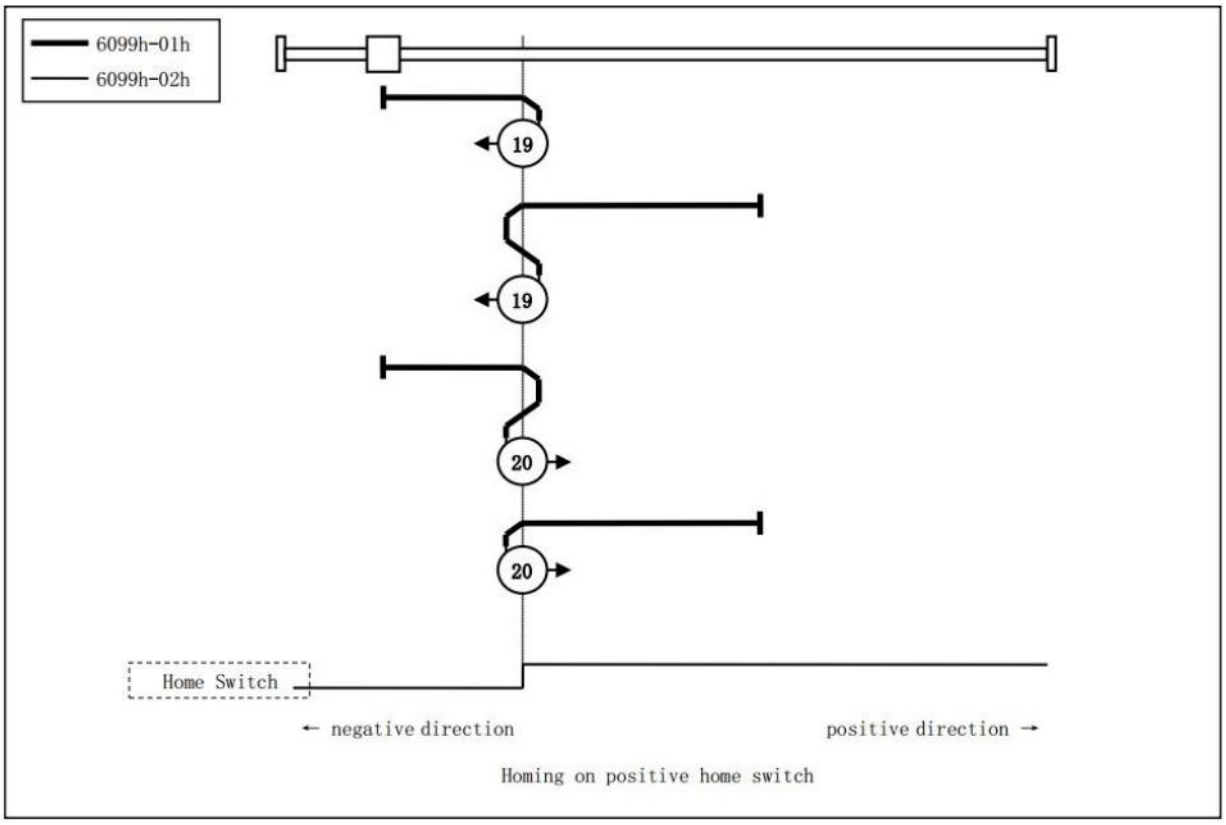


Figure 5.10 return to zero method 19,20

Method 21,22

This method is similar to method 5 and 6, but the difference is that the original detection position is not index pulse, but the position where the Home signal changes, as shown in Figure 5.11:

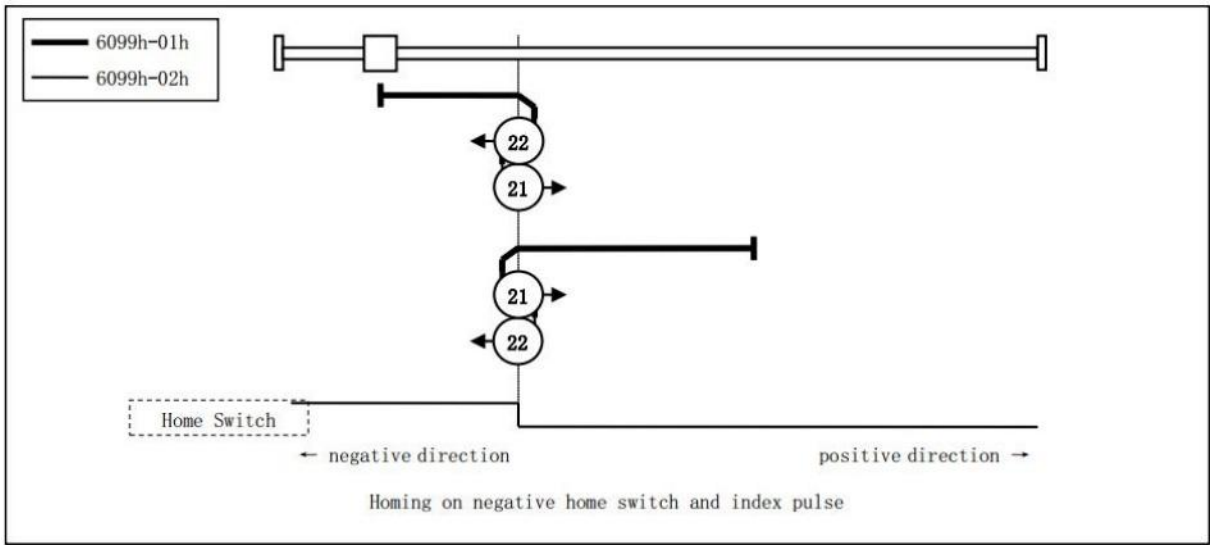


Figure 5.11 return to zero method 21,22

Methods 23,24,25,26

This method is similar to method 7,8,9,10, but the difference is that the original detection position is not index pulse, but the position where Home signal changes, as shown in figure 5.12:

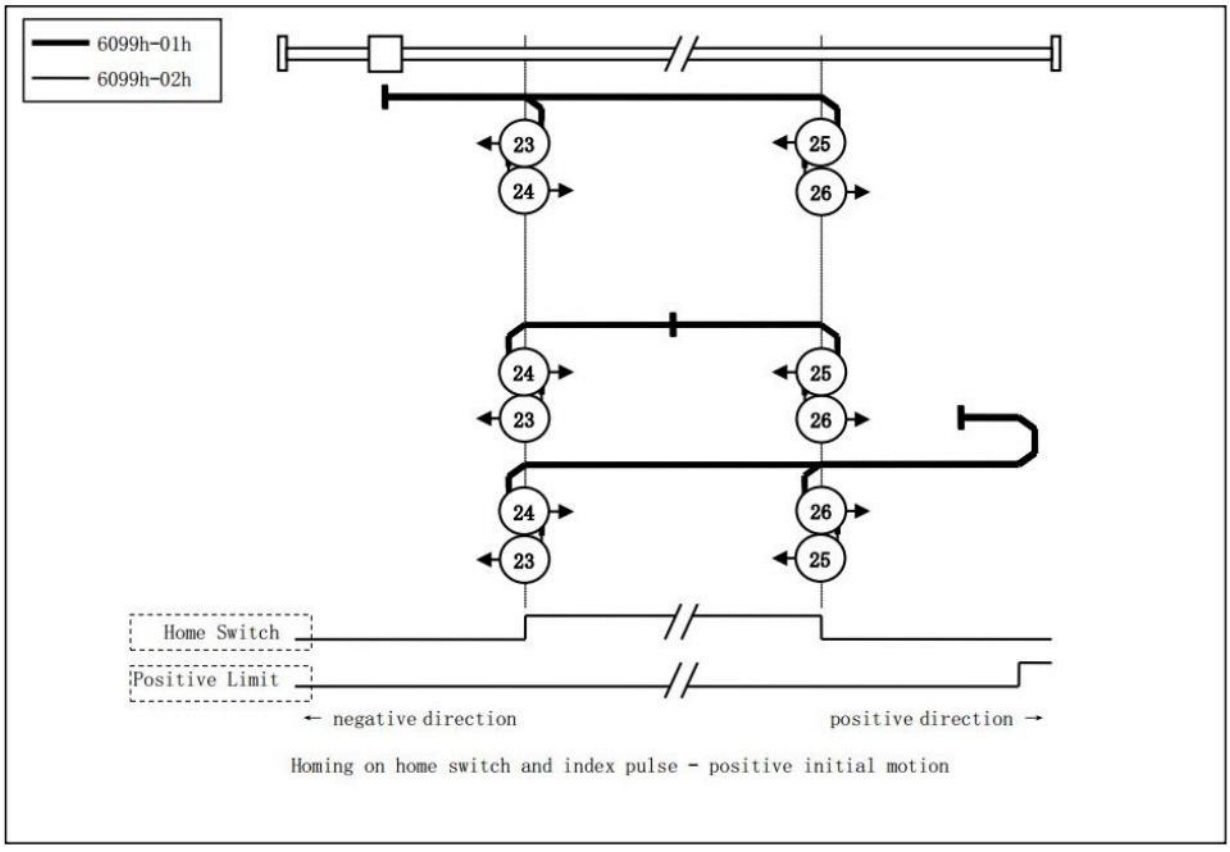


Figure 5.12 return to zero methods 23,24,25,26

Methods 27,28,29,30

This method is similar to method 11,12,13,14, but the difference is that the original

detection location is not index pulse, but the location where Home signal changes, as shown in figure 5.13:

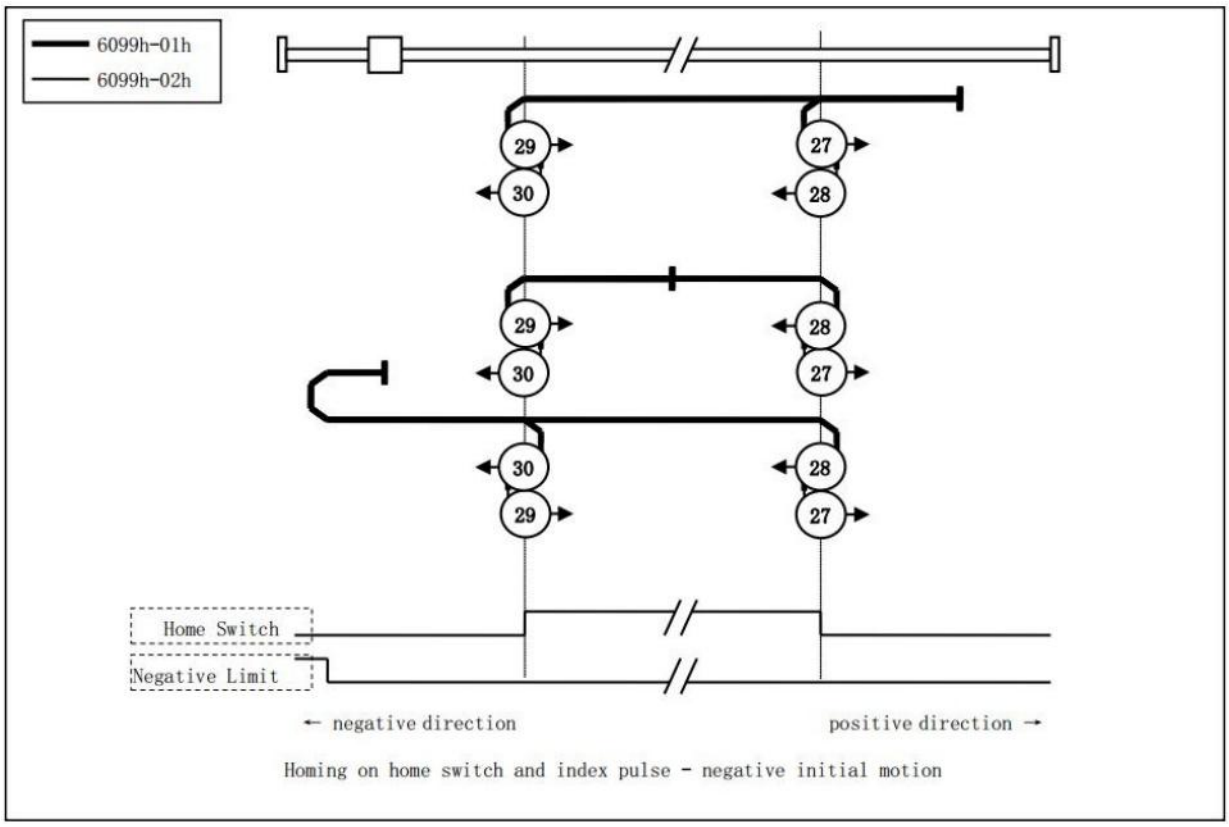


Figure 5.13 return to zero method 27,28,29,30

Method 33,34

This method uses only Index Pulse, as shown in Figure 5.14:

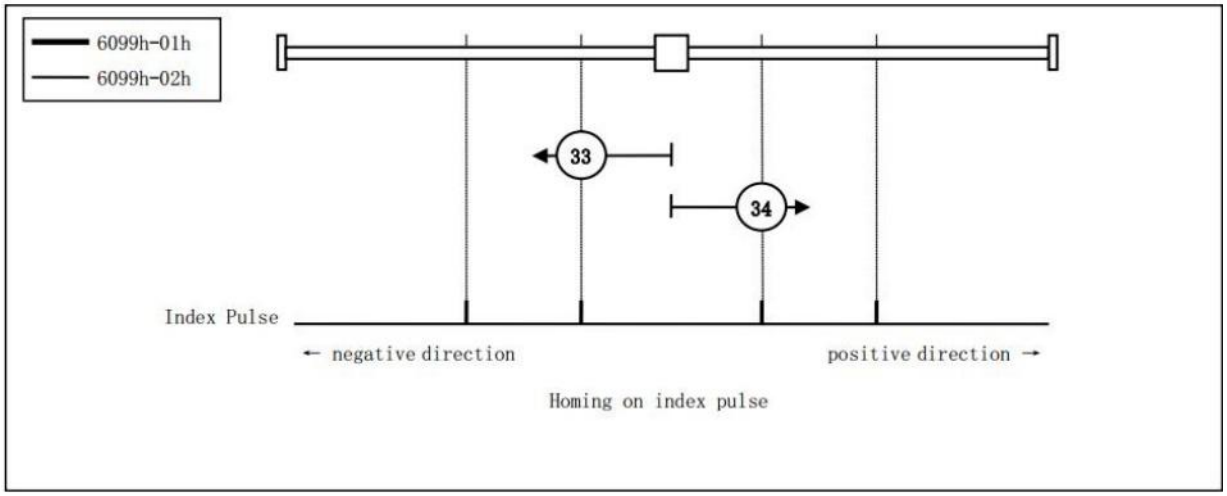


Figure 5.14 zero-back method 33,34

Methods 35

This method takes as its origin the current position when it starts back to zero.As shown in figure 5.15:

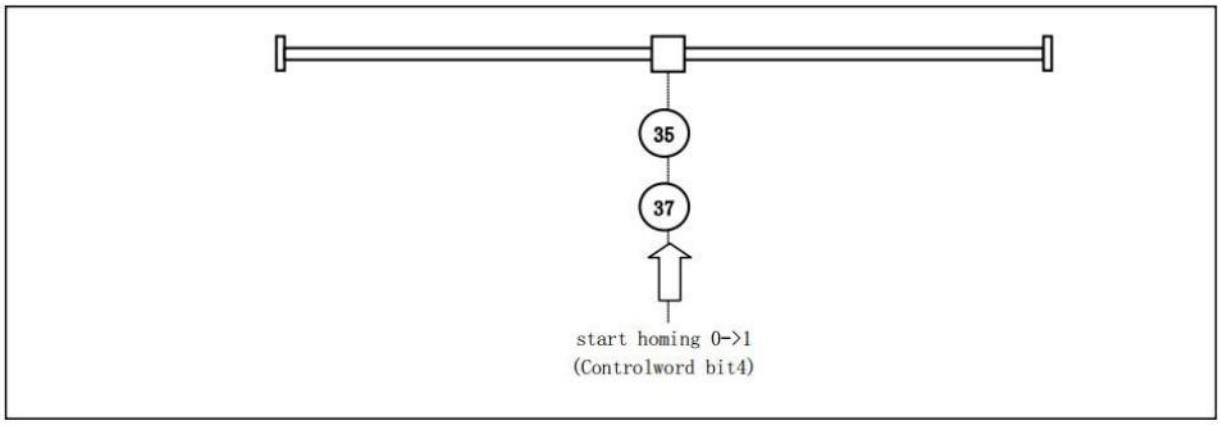


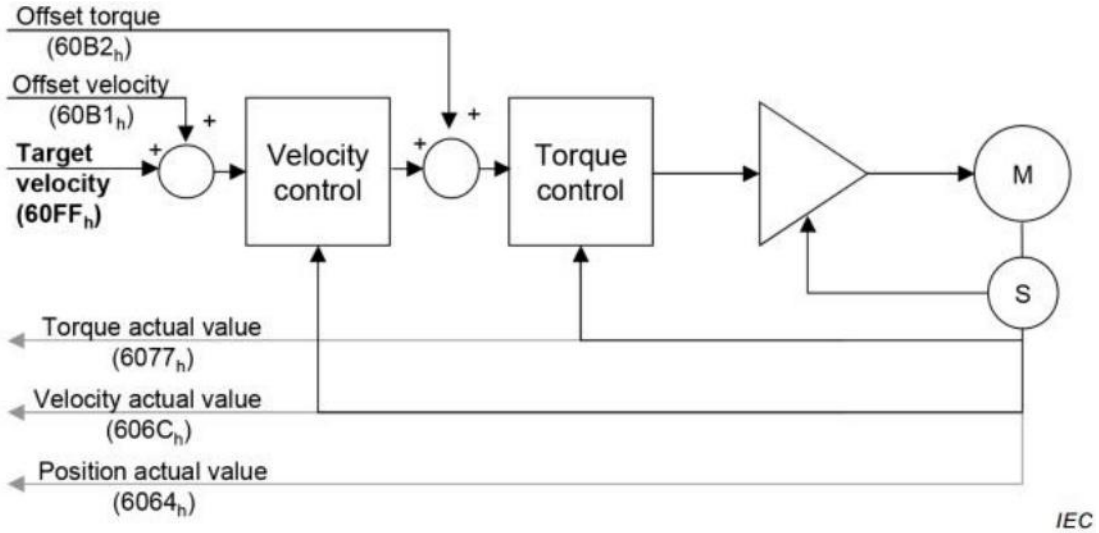
Figure 5.15 Return to zero method 35

5.5 Speed control mode

5.5.1 Synchronization Speed CSV

In Cyclic synchronous Velocity mode, similar to the synchronous position mode, the host plans the speed curve and then sends the 60FFh speed instruction to the servo at a refresh rate of up to 8K. When using this mode, set 6060h to 9.

1) Structure diagram



Compared with CSP mode, CSV has no position ring and directly receives the target speed of 60FFh and speed curve

The planning is completed in the upper computer.

2) Related objects

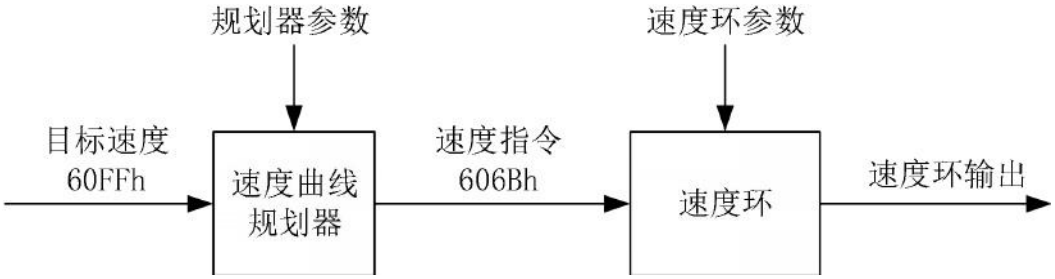
Control word 6040 h
No special control, see section 5.2.1 for others

Status word 6041h		
position	Name	describe
Bit12	drive follows command value	0: the slave station does not follow the target speed command. 1: the slave station follows the target speed command

5.5.2 Contour speed mode PV

Profile Velocity mode refers to the process in which the upper computer sends the target speed, acceleration, deceleration and other instructions to the servo, and the servo executes the speed curve planning and then executes it. When using this mode, set 6060h to 3.

1) Structure diagram



2)Associated objects

Control word 6040h		
No special control, see section 5.2.1 for others		
Status word 6041h		
position	Name	describe
Bit10	target reached	0: target speed is not reached 1: target speed is reached
Bit12	Speed	0: the motor speed is not zero. 1: the motor speed is zero

Index	Subindex	Name	Describe
606Dh	0	The speed reaches the threshold. Procedure	Target speed 60FFh and motor actual speed 606Ch When the

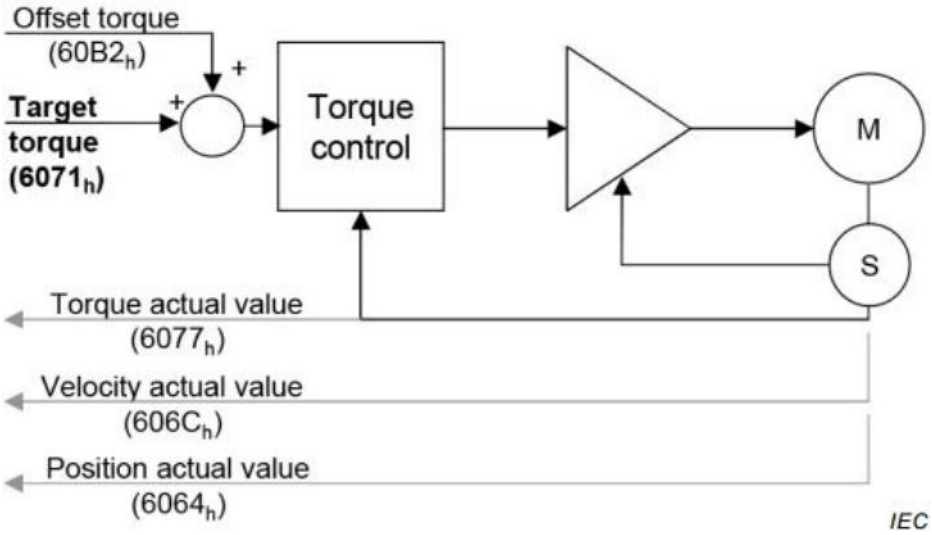
606Eh	0	Speed to window time	difference value of is within ±606Dh, and the time reaches 606Eh, the speed is considered to be reached, and Bit10 of 6041h is set to 1.
606Fh	0	Zero speed threshold	The value of actual speed 606Ch is below 606Fh and The speed is considered to be zero if the interval is kept at 6070h.
6070h	0	Zero speed window time	

5.6 Torque control mode

5.6.1 Synchronous torque mode CST

In Cyclic synchronous torque mode, the upper computer periodically sends the calculated target torque 6071H to the servo driver, which responds directly to the torque command of the controller. When using this mode, set 6060h to 10.

1) Structure diagram



2) Related objects

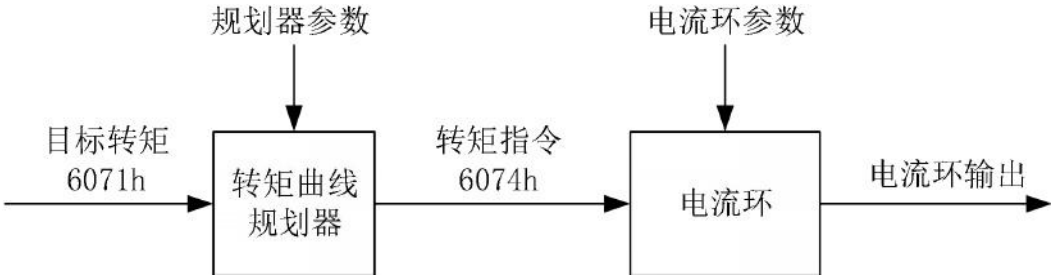
Control word 6040 h		
No special control, see section 5.2.1 for others		
Status word 6041 h		
position	Name	describe

Bit12	drive follows command value	0: slave station does not follow the target torque instruction 1: slave station follows the target torque instruction

5.6.2 Brief Table of torque modes TQ

Profile Torque Mode refers to that the upper computer directly sends the target torque 6071h and the torque slope constant 6087h to the servo driver, and the torque adjustment is performed by the servo. When using this mode, set 6060h to 4.

1) Structure diagram



2) Related objects

Control word 6040 h		
No special control, see section 5.2.1 for others		
Status word 6041 h		
position	Name	describe
Bit10	Target reached	0: target torque is not reached 1: target torque is reached

Index	Subindex	Name	Describe
60E0h	0	Forward torque limit	Limit target torque 6071H at 60E0h and 60E1h
60E1h	0	Reverse torque limit	Within the scope

5.7 Other Functions

5.7.1 Position Locking (Touch Probe)

The position latching function, also known as probe function, is a function of locking position in the edge of a signal stipulated in CiA402 sub-protocol.

This series of servos provides two sets of independent probes that can simultaneously latch position information. The trigger source can be general digital input (DI7 and DI8) and Z confidence signal (absolute encoder zero-crossing simulation).Its functional block diagram is shown below:

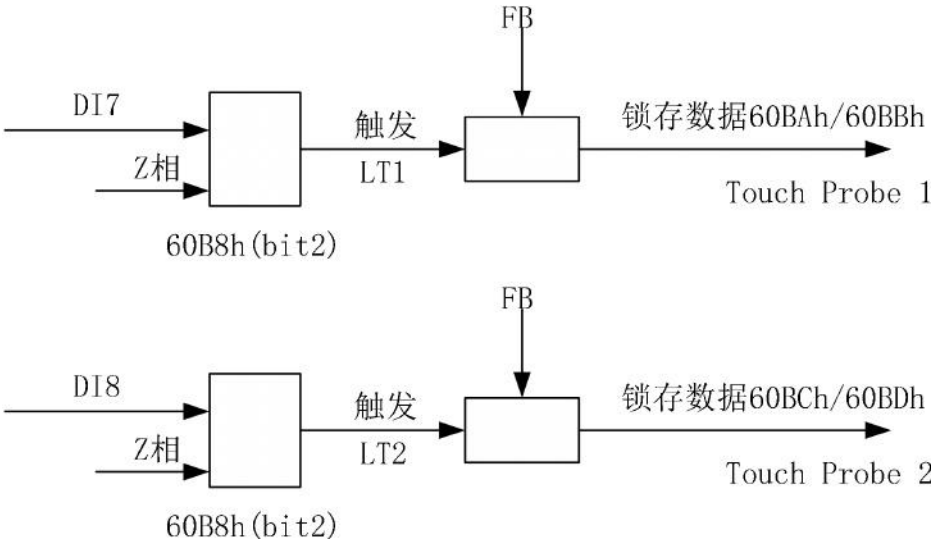


Figure 5.16 Block diagram of Touch Probe function

In order for the location latching function to work properly, the following points need to be noted:

◇ Touch Probe cannot be used when the ESM status is Init.The servo working mode cannot be HM (return to zero mode).

◇ The effective time and invalid time of trigger signal should be 2ms or above.

Touch Probe 1 is referred to as Tp1 and Touch Probe 2 is referred to as Tp2.

1) Touch Probe function (60B8h)

Index	Subindex	Name	Scope	Data type	Access attributes	PDO mapping	unit	Default value
60B8h	00h	probe model	0-65535	UINT16	RW	ALL		0

This object performs the probe function by bit. The meanings of each bit are as follows:

Position	Value	Mean	
0	0	Close the Tp1	Start and stop of Tp1 (Rising edge triggers start)
	1	Open the Tp1	
1	0	A single mode	Tp1 Trigger mode selection
	1	Continuous mode	
2	0	Trigger source select digital input DI7	Tp1 Trigger source selection
	1	Trigger source select Z believe number	
3	-	keep	Don't use
4	0	Turn off Tp1 rising edge trigger	Tp1 rising edge selection
	1	Enable Tp1 rising edge trigger	
5	0	Turn off Tp1 falling edge trigger	Tp1 descending edge selection
	1	Tp1 falling edge triggering is enabled	
6 - 7		keep	Don't use
8	0	Close the Tp2	Tp2 start and stop (Rising edge triggers start)
	1	Open the Tp2	
9	0	A single mode	Tp2 trigger mode selection
	1	Continuous mode	
10	0	Trigger source select digital input DI8	Tp2 trigger source selection
	1	Trigger source select Z believe number	
11	-	keep	Don't use

12	0	Turn off Tp2 rising edge trigger	Tp2 rising edge selection
	1	Tp2 rising edge triggering was enabled	
13	0	Turn off Tp2 falling edge trigger	Tp2 descending edge selection
	1	Tp2 falling edge triggering was enabled	
14-15		Reserve	Don't use

Note: The rising edge of trigger signal refers to the jump edge of signal from invalid state to effective state;Falling edge refers to the jump edge of the signal from the effective state to the invalid state.

2) Touch Probe Status (60B9h)

Index	Subindex	Name	Scope	Data type	access attribute	PDO mapping	unit	default value
60B9h	00h	Probe State	0-65535.	UINT16	RO	TPDO	-	0

This object indicates the state of the probe, and the meanings of the bits are as follows:

Position	Value	Mean	
0	0	Tp1 stop in	Start and stop of Tp1
	1	Tp1 in action	
1	0	Tp1 rising edge is not completed	Tp1 rising edge trigger state
	1	Continuous mode	
2	0	Tp1 rising edge has been captured	Tp1 falling edge trigger state
	1	The falling edge of Tp1 has been captured	
3-5	-	keep	Don't use
6-7		Does not support	Don't use
8	0	In the Tp2 stop	Tp2 start and stop status
	1	In the Tp2 action	
9	0	Tp2 rising edge is not complete	Tp2 rising edge trigger status
	1	Tp2 rising edge has been captured	

10	0	Tp2 falling edge is not complete	Tp2 falling edge trigger status
	1	Tp2 falling edge has been captured	
11-13	-	keep	Don't use
14-15		Does not support	Don't use

3) Touch Probe startup steps

The 60B8h object's Bit1/Bit9 selects whether the probe works in single-mode or continuous mode: when 60B8h: Bit1 =0/ Bit9 =0, the probe works in single-mode.When we hit the first trigger signal

Complete latching and end probe work.The diagram below:

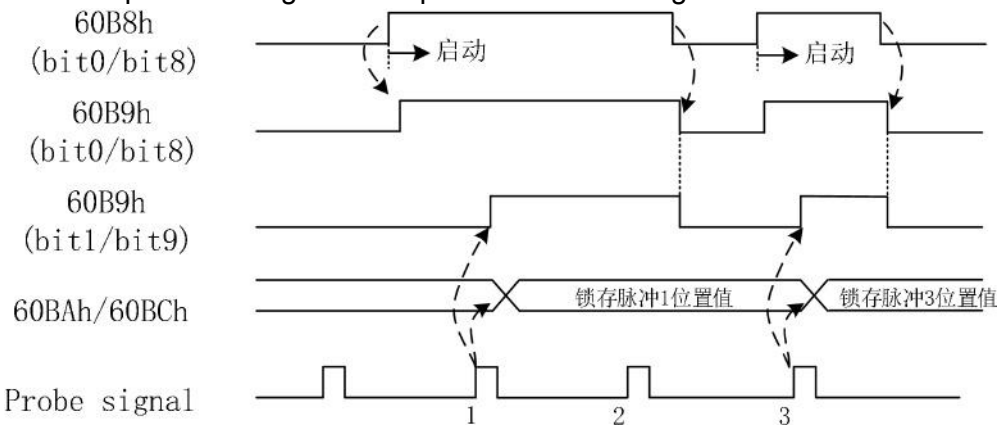


Figure. 5.17 Schematic diagram of a single rising edge trigger of the probe

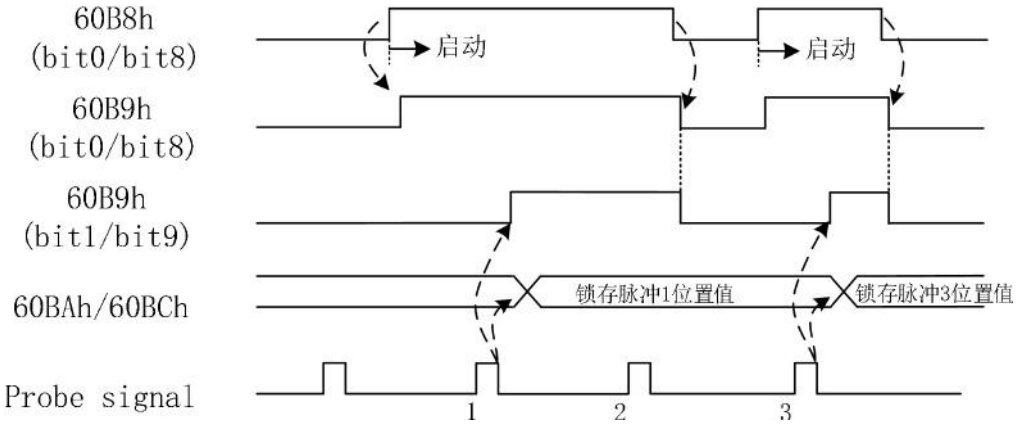


Figure. 5.18 Schematic diagram of single falling edge trigger of probe

When 60B8h: bit1=1/bit9=1, it works in continuous mode.After startup, the probe is locked every time it encounters a trigger signal and ends when the end command arrives.The diagram below:

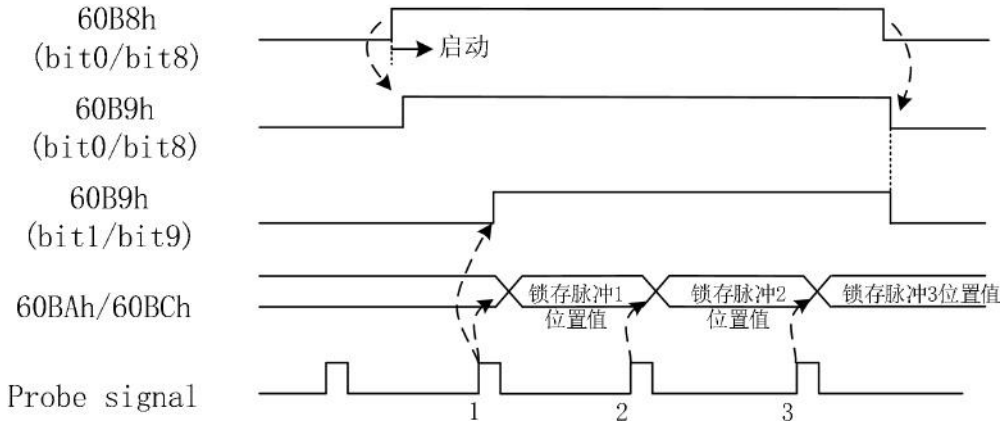


FIG. 5.19 Schematic diagram of trigger of continuous rising edge of probe

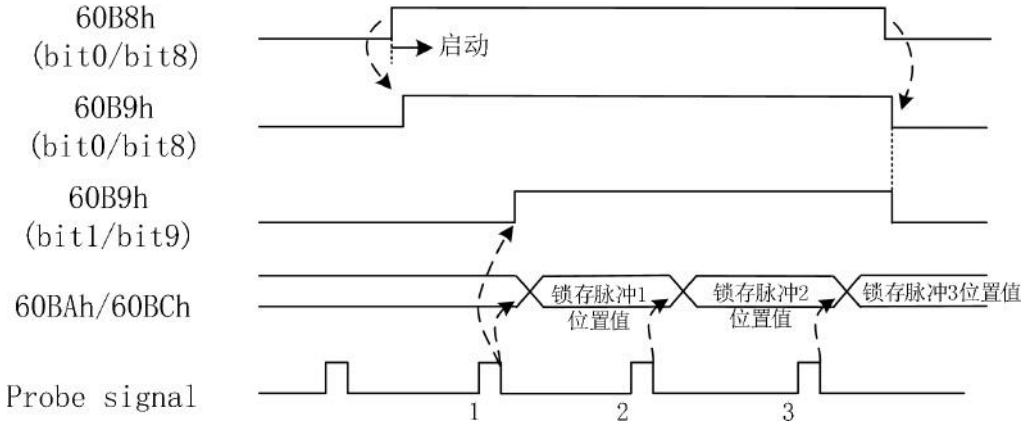


FIG. 5.20 Schematic diagram of continuous falling edge trigger of probe

5.7.2 Shutdown function

Dictionary of related objects:

Index	Subindex	Name	Scope	Data type	Access attributes	PDO mapping	Unit	Default value
605Ah	00h	Quick stop mode selection	0-2	INT16	RW	NO	-	2
605Bh	00h	Shutdown shutdown mode selection	0-2	INT16	RW	NO	-	0
605Ch	00h	Enable shutdown mode selection	0-2	INT16	RW	NO	-	1

605Eh	00h	Fault shutdown mode selection	0-2	INT16	RW	NO	-	0
6084h	00h	Simple watch deceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	100
6085h	00h	Fast stop deceleration	0-4294967295	UINT32	RW	ALL	Instruction unit/S2	100

This servo series supports Quick Stop Option code (605Ah), Shutdown Option code (Shutdown Option Code) stipulated in CiA402 sub-protocol. 605Bh), Disable Operation Option code (605Ch) and Fault Reaction Option Code (605Eh).The range of 605Ah, 605Bh, and 605Ch are 0,1, or 2.The following table:

Stop code	Operation
0	The FSM status changes to Switch on Disabled
1	After the FSM node is stopped at the specified speed of 6084h, the FSM node status changes to Switch on Disabled
2	After the FSM node is stopped at the specified speed of 6085h, the FSM node status changes to Switch on Disabled

Note: The fault shutdown mode is determined by different fault types and is not affected by the 605Eh object value.

5.7.3 Location Information

1) Electronic gear ratio 6091H

Object 6091H (Gear Ratio) can make the servo feedback position output in a certain proportion, and its definition is as follows:

Index	Subindex	Name	Scope	Data type	Access attributes	PDO mapping	unit	Default value
6091h	Electronic gear ratio			UINT32	RW	ALL		
	00h	Number of subindex	-	UINT8	RO	NO	-	2

		es						
	01h	Motor resolution	1-4294967295	UINT32	RW	ALL	Pul (motor)	131072
	02h	Load axis resolution	1-4294967295	UINT32	RW	ALL	Pul (shaft)	10000

This series of servo support 17bit,20bit,23bit absolute encoder, the internal unit is PULSE (pulse), each rotation of the motor feedback pulse number is 217,220,223 pulses respectively, The electronic gear ratio can be used to establish a proportional relationship between the load displacement (user unit) and the motor displacement (pulse).

$$\text{电子齿轮比 6091h（Gear ratio）} = \frac{\text{电机分辨率（Motor revolutions）}}{\text{负载轴分辨率（Shaft revolutions）}}$$

For example, if the 17bit absolute encoder is selected and the motor resolution is 131072 pulses, the user needs 10000 pulses servo feedback for each rotation of the motor, that is, the object 6064H increases or decreases 10000 pulses according to each rotation of the motor. In this case, 6091H is set as follows:

$$6091\text{h} = \frac{01h: 131072(pul)}{02h: 10000(pul)}$$

According to the Settings of 6091H, the relationship between feedback position 6064h and internal feedback position 6063h is as follows:

$$\text{反馈位置 6064h(指令单位)} = \frac{\text{内部反馈位置 6063h(pul)}}{\text{电子齿轮比 6091}h} + \text{原点偏移 607}Ch$$

Note: 6091H object corresponds to servo customized parameters PN006-PN009, see Section 2.2.2 for details.

Note: 6091H is saved into EEPROM after modification by SDO service, and will not be lost in power failure.

2) Polarity 607Eh

The object 607Eh (Polarity) can change location, speed, and torque instructions to determine the Polarity of the electrical device's positive rotation, as described in the following:

Index	Subin dex	Name	Scope	Data type	Access attribute	PDO mapping	unit	Default value
607Eh	00h	Instruction of polarity	0-255.	UINT8	RW	ALL	-	0

Its bitwise definition is as follows:

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
position of polarity	speed of polarity	Torque polarity	Reserve (0)				

This series of servos supports two configurations of this object:

607eh value	mean
0	The rotation direction of motor is in the positive direction of CCW
224	The rotation direction of the motor is CW positive
other	Not supported (do not set)

The CCW (counterclockwise) and CW (clockwise) directions are defined as follows:

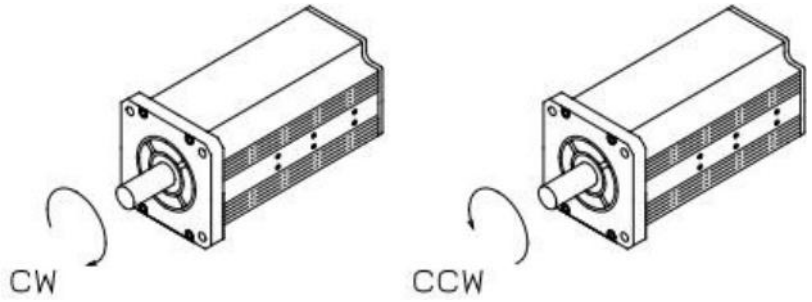


Figure 5.21 CCW and CW direction definitions

When 607Eh value is 0, CCW is the positive direction of the system, and the system reference system is shown in Figure 5.22:

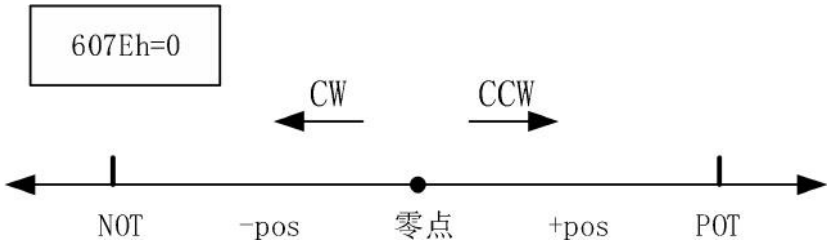


Figure 5.22

When 607Eh value is 224, the system takes CW as the positive direction, and the system reference system is shown in Figure 5.23:

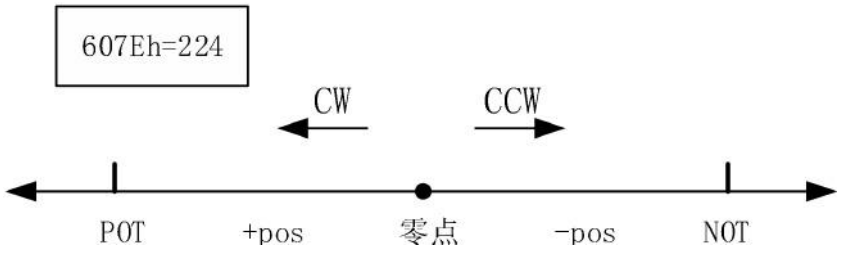


Figure 5.23

3) Absolute value is systemically correlated

Servo parameter Pn079 is used to select the encoder type and usage. This parameter is described as follows:

Parameters	parameter name	optional scope	default value	note
Pn-079	Encoder type	1-4	2	1: single-loop, incremental system 2: multi-circle, absolute value system 3: multi-loop, incremental system 4: Multi-circle type, absolute value system, But they ignored multiple calls

By default, the servo selects the multi-turn absolute encoder. Under the absolute value system, the driver saves multi-turn data through the external battery. Compared with the incremental system, there is no need to perform the origin regression action every time the system is powered on.

Absolute value system features:

External battery is required. When the battery voltage is low, an alarm will appear (BAT1/BAT2).

◇ There is no need to perform the origin regression after each power-on. After the restart, the feedback position may not be zero.

◇ Effective stroke is limited by multi-turn encoder, multi-turn data range -32768~32767, multi-turn data overflowWill alarm (LOT).

Note: When there is a multi-turn data overflow alarm (LOT), only the reset fault can clear the error, but the multi-turn data overflow still exists.At this point, the mechanical stroke should be moved to the effective range or multiple turn data should be cleared.

Note: The method of clearing multi-circle data is to perform FN-14 operation through the panel.

Incremental system features:

No external battery, battery low voltage alarm will not appear.

◇ Return to the origin after each power-on, and the feedback position is zero after restart. There is no multi-turn data overflow limitation, can always rotate in a fixed direction.

When Pn079=2 or Pn079=4, the servo driver works under the absolute value system. Their difference is that when Pn079=4, the multi-turn data overflow alarm is ignored, but the alarm is only ignored at this time, and the multi-turn data will make errors due to overflow, for example, it will become -32768 after it exceeds 32767. The feedback position changed from positive to negative.

Note: If the system does not need to use multi-turn data, or the motor keeps rotating in a fixed direction, this can be set

With Pn079=1 or Pn079=3, the servo driver works on an incremental system.

5.7.4 Digital Input and Digital Output

1) Digital input (60FDh)

Index	Subin dex	Name	Scope	Data type	Access attribute	PDO mapping	unit	Default value
60FDh	00h	DI digital input	-	UINT32	RO	TPDO	-	0

The 60FDh object is bitwise mapped. The meanings are as follows:

Bit	31	30	29	28	27	26	25	24
function	Reserved							DI9
Bit	23	22	21	20	19	18	17	16
function	DI8	DI7	DI6	DI5	DI4	DI3	DI2	DI1
Bit	15	14	13	12	11	10	9	8
function	Reserved							
Bit	7	6	5	4	3	2	1	0
function					Does not support	Origin signal (HOME)		Reverse limit (NOT)

If the value is 0, the input is invalid.If the value is 1, the input is valid.

Note: When bit0-bit2 is used, I/O function allocation parameters PN200-pN208 must be correctly configured. See 2.2.2 Section.

2) Digital output (60FEh)

Index	Sub index	Name	Scope	Data type	Access attributes	PDO mapping	unit	Default value
60FEh	DO digital output			UINT 32	RW	ALL		
	00h	Number of subindexes	-	UINT 8	RO	NO	-	2
	01h	Physical output	0h-FFFFFFFFh	UINT 32	RW	ALL	-	0
	02h	Mask bit	0h-FFFFFFFFh	UINT 32	RW	ALL	-	0

01 Subindex values are bitwise mapped to the physical output:

Bit	31	30	29	28	27	26	25	24
function	Reserved							
Bit	23	22	21	20	19	18	17	16
function	keep		DO6	DO5	DO4	DO3	DO2	DO1
Bit	15	14	13	12	11	10	9	8
function	Reserved							
Bit	7	6	5	4	3	2	1	0
function	Reserved							Does not support

Bit16-bit21 corresponds to the physical output DO1-DO6. When a bit of sub-index 01 is 1 and the bit of sub-index 02 is also 1, enable the output of the DO port. Otherwise, no effective level is output.The logical relationship is shown in the following table:

01 Sub-index Bitx value	02 sub-index Bitx value	Output state
0	0	Output invalid (switch off)
1	0	Output invalid (switch off)
0	1	Output invalid (switch off)
1	1	Output valid (switch on)

Chapter 6 Servo alarm

6.1 EtherCAT related alarm

Panel displays	The name of the	EMCY Elimination Code (603Fh)	note
Co01	402 state machine switching abnormal	FF05h	The working mode (6060H) is not set when the state machine switches to the OP state. (Enable operation is performed but working mode 6060H is not set.)
Co02	EtherCAT state machine FF06h conversion abnormal		When CiA402 is in Operation Enable state, the ESM state machine switches from the OP state to another state. (Disconnection of physical layer or misoperation of upper computer)
Co03	"EtherCAT is different with the same step		Synchronization is abnormal, the clock drift of the master station is too large, or the SYN0 period is not within the specified range.

6.2 Other alarm Information

Panel displays	Name	EMCY Message code (603Fh)	note
OC1	Over current 1	2221h	Check whether the power line is short-circuited or the output current is large
OC2	Over current 2	2222h	Internal drive failure
OS	tachycardia	8400h	Check electronic gear ratio setting or speed setting
HU	Dc bus overvoltage	3110h	Acceleration and deceleration time is too short or external discharge resistance is needed
EP	Discharge circuit failure	5420h	
DE	Storage failure	5530h	

EC	Encoder failure	7305h	Check whether the encoder cable is properly connected
EH	Current sampling error	5210h	Internal drive error
OL	overload	3230h	Drive overload
LU	Main circuit undervoltage	3120h	Check the main power supply
OF	Excessive following error	8611h	
AH	Driver overheating	4210h	
PLD	The CPLD communication is faulty. 1	7500h	Internal drive error
RH1	Regenerative resistance overheating	4210h	
NT	Using a timeout	FF00h	
POL	Main loop voltage is insufficient	3121h	Check the main power supply
CE	Motor overheat	7122h	
ND	No motor code set	FF01h	Set parameter Pn078 correctly
BAT1	The encoder battery is undervoltage	FF03h	The encoder battery voltage is lower than 3.1V
BAT2	Multiple turn position loss of encoder	FF04h	The encoder battery voltage is lower than 2.75V.The fault must be reset after the battery is replaced and powered on again (long press Enter).
LOT	Multiple turn position counter overflows	7320h	The multi-turn encoder overflows after moving more than 32767 turns in a certain direction.Move the mechanical stroke to the effective range, then reset. Note: If absolute value system is not required, refer to section 5.7.3 to set parameters.
GOH	Back to zero failure	8613h	No Home signal found in valid travel
FT	The CPLD communication	Internal drive	Internal drive error

	is faulty. 2	error	

Chapter 7 Trial operation

7.1 TwinCAT2 Connection GHA - E servo

1) Correctly install TwinCAT2 upper computer software

TwinCAT is a control software based on PC platform and Windows operating system developed by Beckhoff GMBH.The following TwinCAT version is TwinCAT2.11 (Build 2245), the operating system is Windows XP, and the network Adapter is Intel 82559 PCI Ethernet Adapter (compatible only with Intel network card, Other network cards may not be fully compatible with TwinCAT.

Select the highest level when installing, as shown in Figure 7.1.

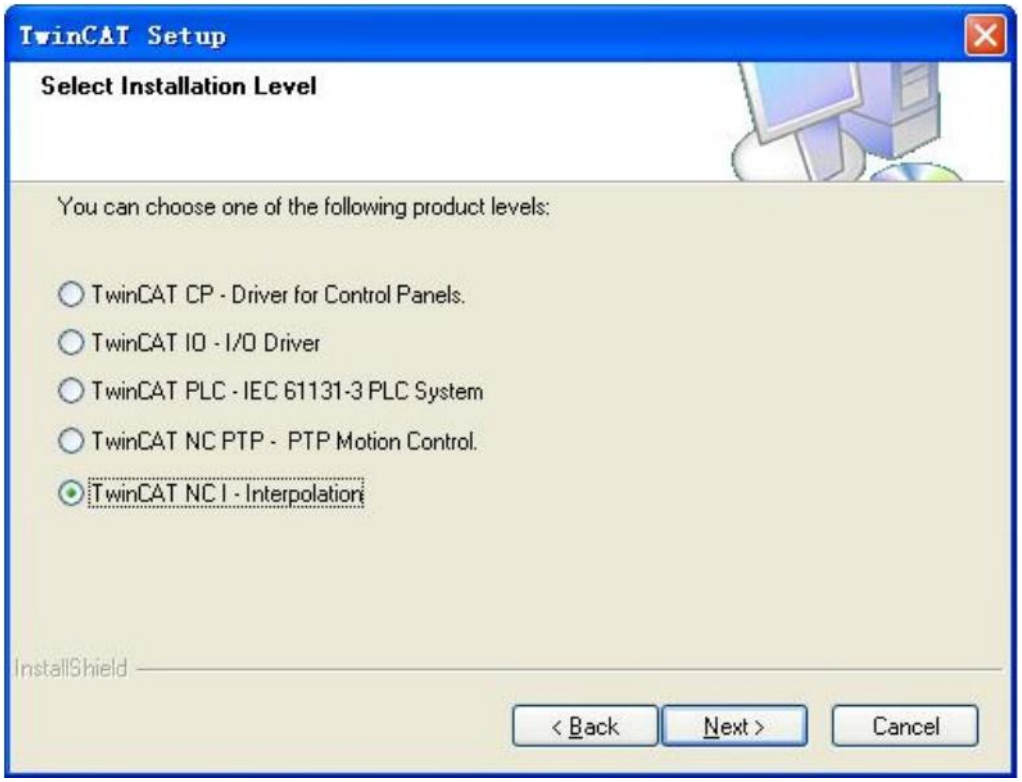


Figure 7.1 Selecting the TwinCAT installation level

If you do not have a license, choose a 30-day trial, as shown in Figure 7.2.

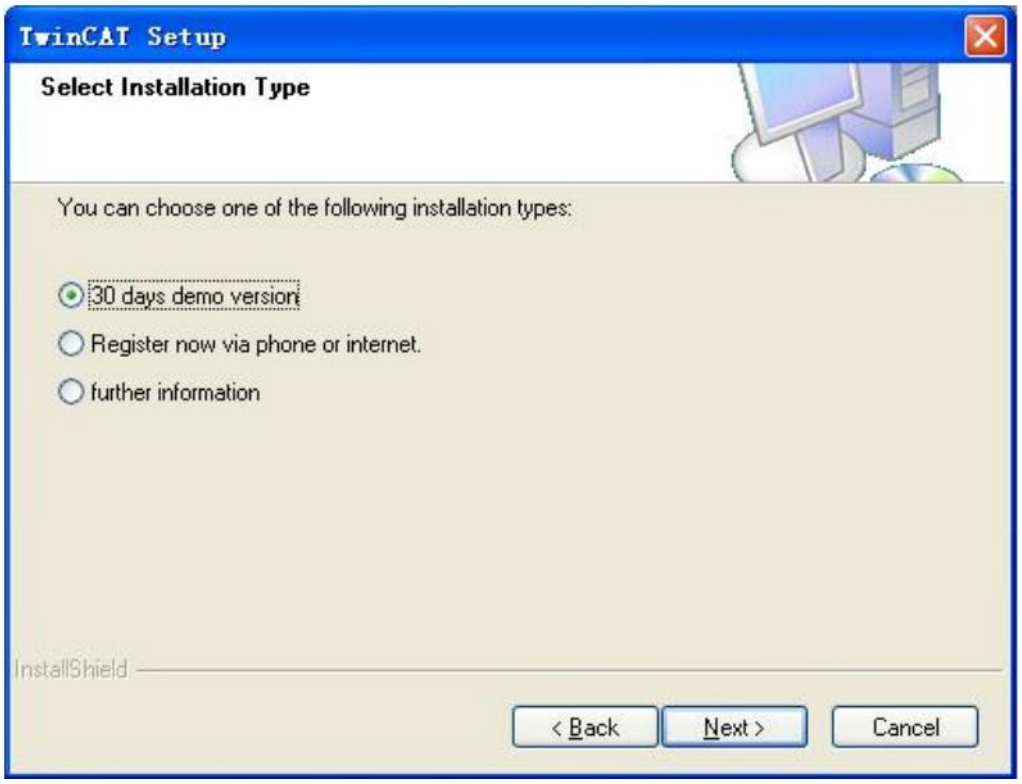


Figure 7.2 Select 30-day trial

2) XML configuration files

The EtherCAT master usually obtains the slave configuration information, which is an XML file.The ghA-E hEMS configuration file is Riding Servo driver.xml. For TwinCAT2, this file needs to be placed inC :\TwinCAT\Io\EtherCAT.

3) Correctly configure servo parameters

Refer to section 2.1 of this article to correctly connect the servo to the EtherCAT master station, and then check whether the key parameters are correctly configured according to section 2.2.

7.1.2 configuration

1) Scan for and add devices

After correctly installing the software, open TwinCAT System Manager, as shown in Figure 7.3:

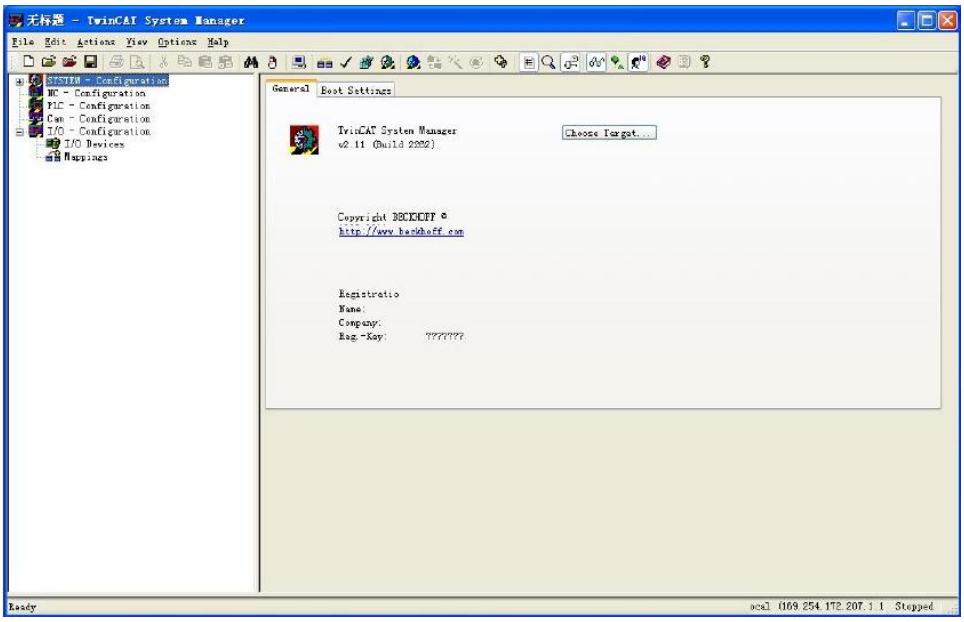


Figure 7.3

If you install TwinCAT on a PC for the first time, you may need to install a driver for the NETWORK adapter of the PC. Go to Options->Show Real Time Ethernet Compatible Devices to see if a physical nic is available. If so, click the nic name and then Install.After successful installation, see Figure 7.4:

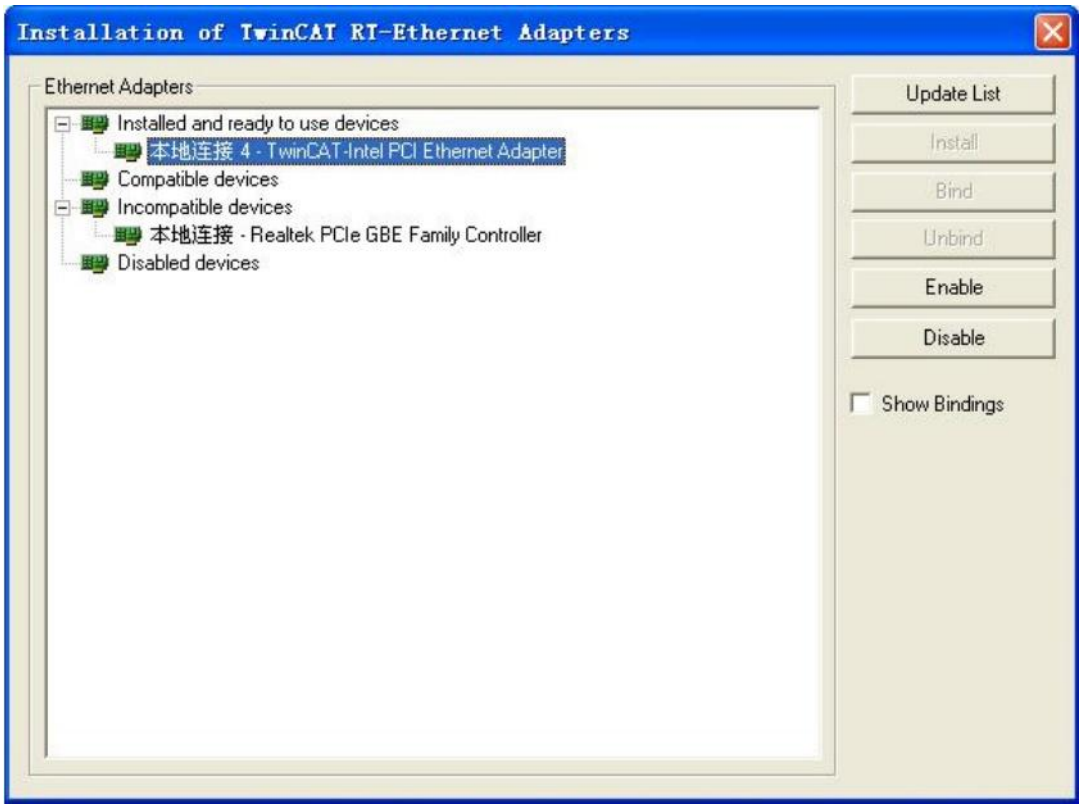


Figure 7.4 TwinCAT compatible NIC driver installation 81

After the nic driver is installed successfully, the servo device can be scanned and added, as shown in Figure 7.5:

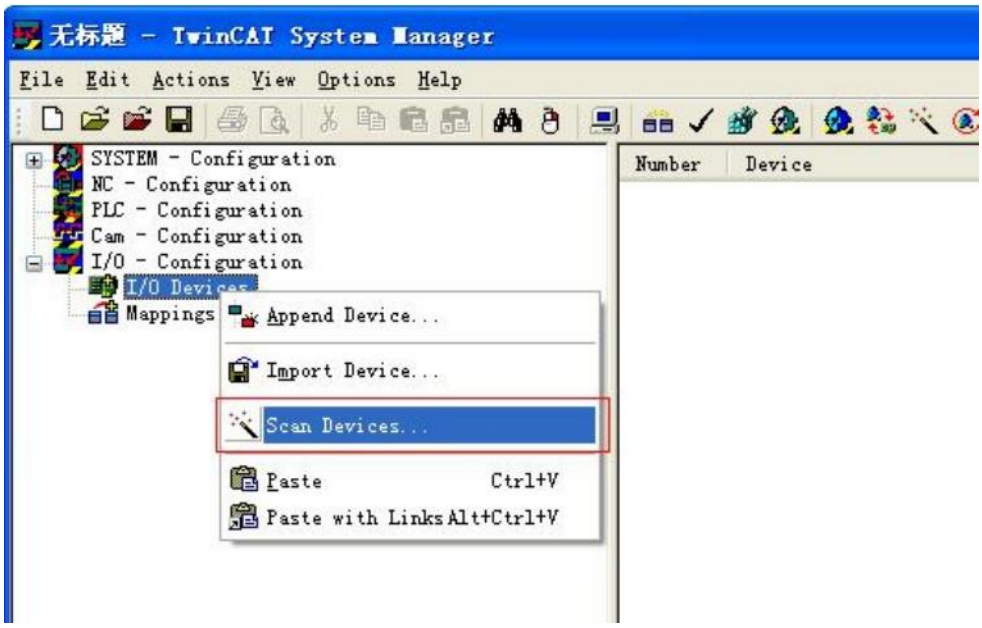


Figure 7.5 start scanning EtherCAT device

After click "ok" in the pop-up dialog, as shown in figure 7.6:

Figure 7.6

The following window will appear when the servo runs normally and the wiring is correct, as shown in Figure 7.7:

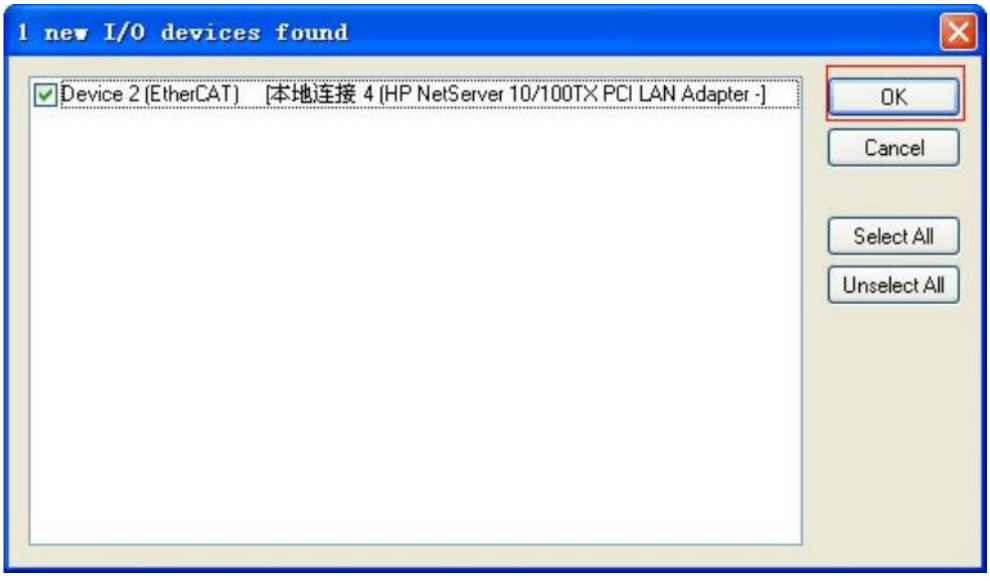


Figure 7.7

The window shown in Figure 7.7 shows that the master station has scanned the EtherCAT slave device and click "OK" to proceed to the next step.Then the window shown in Figure 7.8 appears. Click "Yes" to scan all slave devices and load.

Figure 7.8

Then the window shown in Figure 7.9 appears, asking if you want to add devices to the NC axis, click "Yes" :

Figure 7.9

The dialog box that pops up asks if you want to put the master station into "Free Run" mode, click "No".Put the master station in "Config" mode, as shown in Figure 7.10.

Figure 7.10

After the device is added successfully, the interface is shown in Figure 7.11. It can be seen that the ESM state machine is in the "PREOP" state, and NC axis parameters can be configured and servo parameters can be configured using the SDO service of CoE.

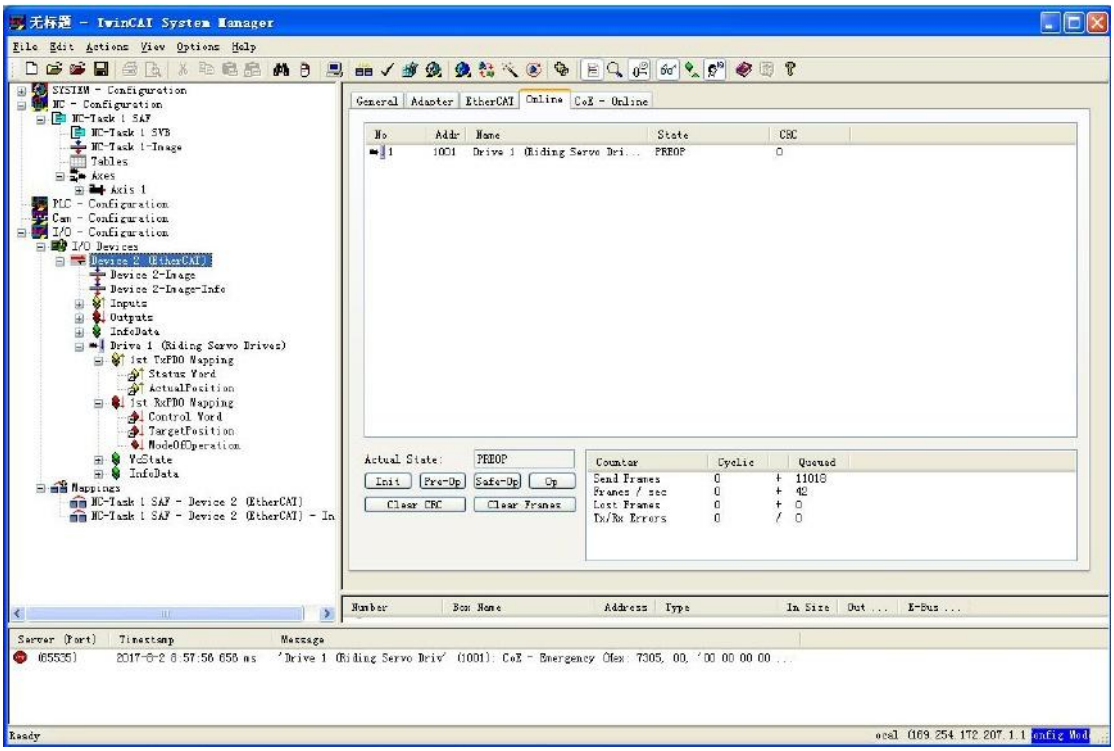


Figure 7.11

2) Configure NC parameters and servo parameters

The default system minimum time unit of TwinCAT is 1ms, but this servo supports a minimum refresh time of 125 microseconds, so the system minimum time unit is set to 125 microseconds first, as shown in Figure 7.12:

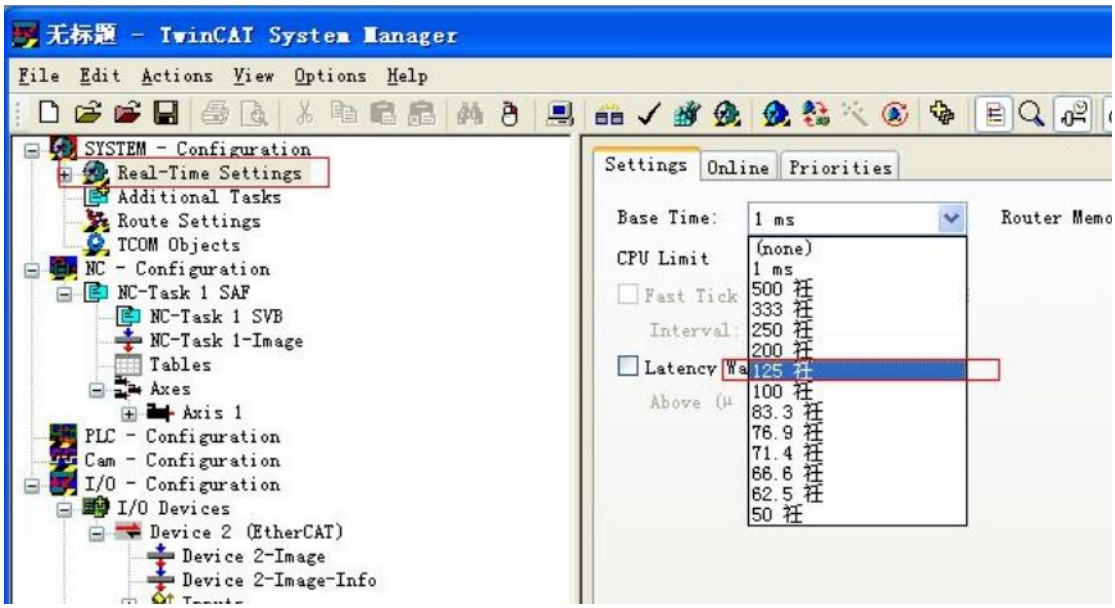


Figure 7.12

Can set SYN0 cycle time according to application demand, namely the refresh time, value range is 125 us, us 250, 500 us, ms, 1 2 ms one, set at 500 in the us in this case, as follows in figure 7.13:

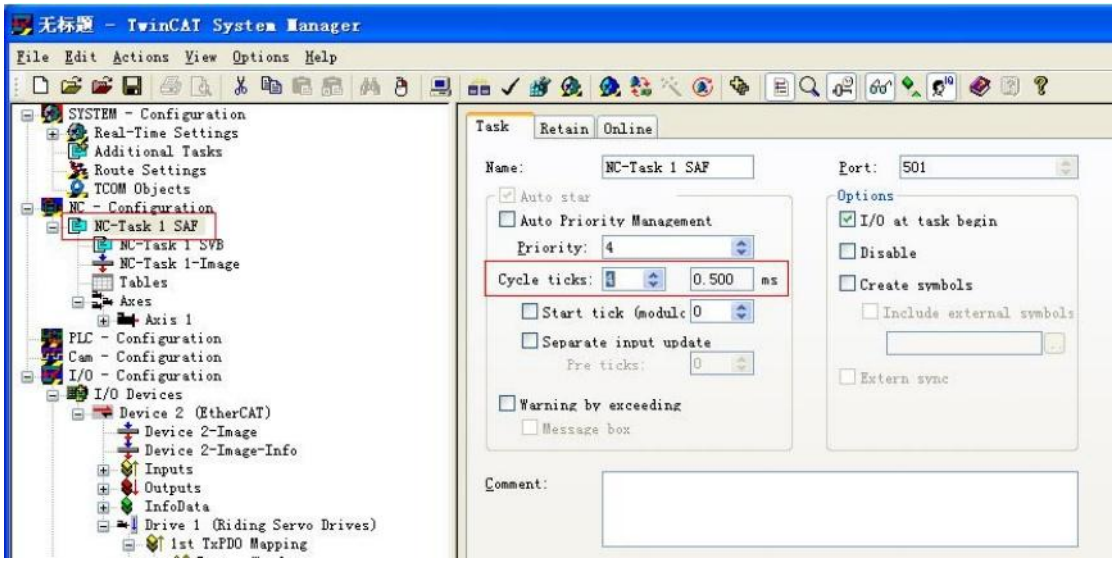


Figure 7.13

Parameters such as pulse equivalent need to be configured for NC axis. The Scaling Factor and encoder mode method are set as shown in Figure 7.14 below:

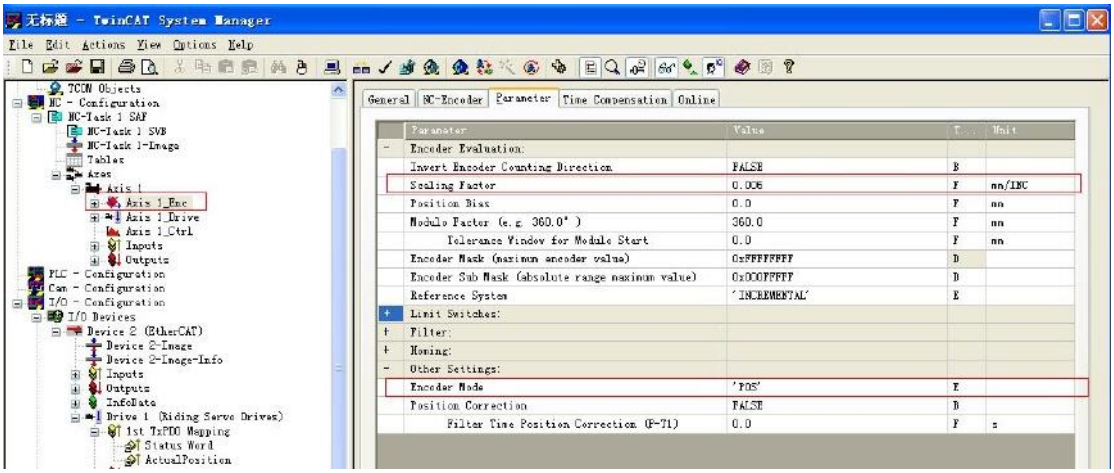


Figure 7.14

Scaling Factor: The distance corresponding to the coder pulse fed back at each position.For example, if the motor feeds 10000 pulses per rotation and one rotation of the motor corresponds to 360mm, the Scaling Factor should be 360/10000=0.036mm/INC.

For no-load debugging, it is generally assumed that each rotation of the motor corresponds to 60mm, because then the speed of 1mm/s is equivalent to 1rpm, which is very intuitive in RPM units.

As shown in FIG. 7.15, turn off the following error monitoring of NC axis:

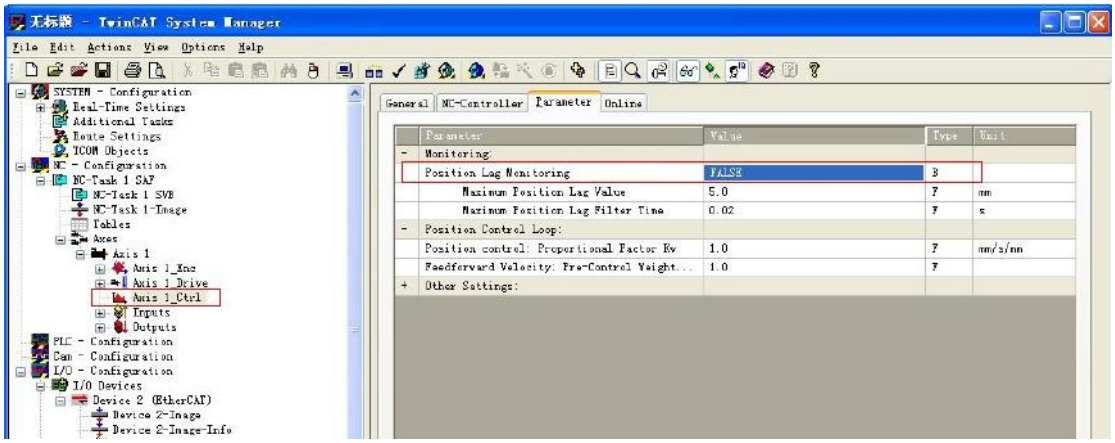


Figure 7.15 Figure 7.16

The necessary parameters for running the NC axis have been set. The following describes how to use TwinCAT System Manager to modify the object dictionary, including 6000H group objects and 2000H group factory-defined parameters.

Figure 7.16 shows modifying 6091H electronic gear ratio using SDO service:

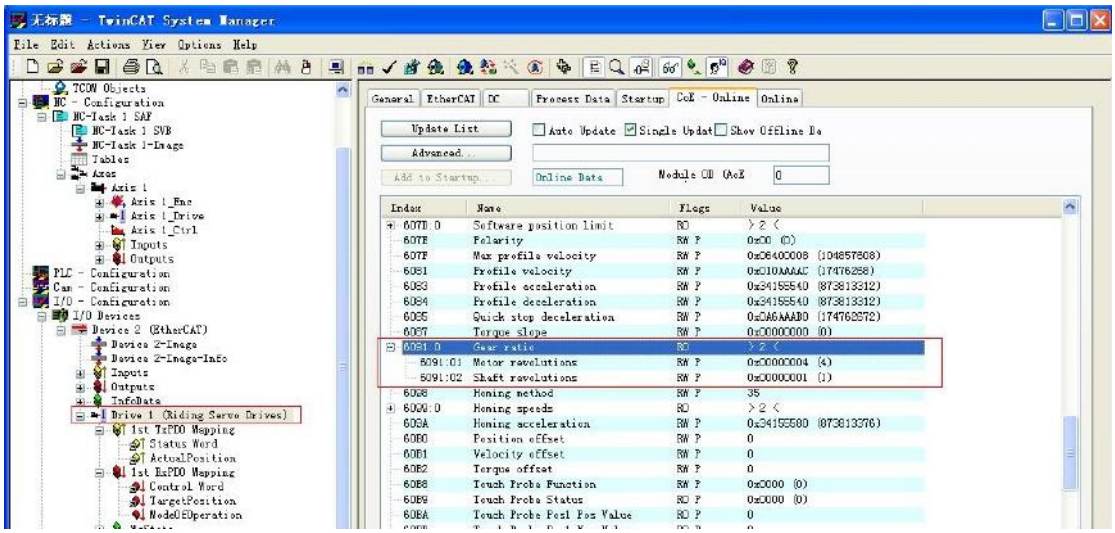


Figure 7.16

Figure 7.17 shows how to modify the Pn000 parameter using the SDO service:

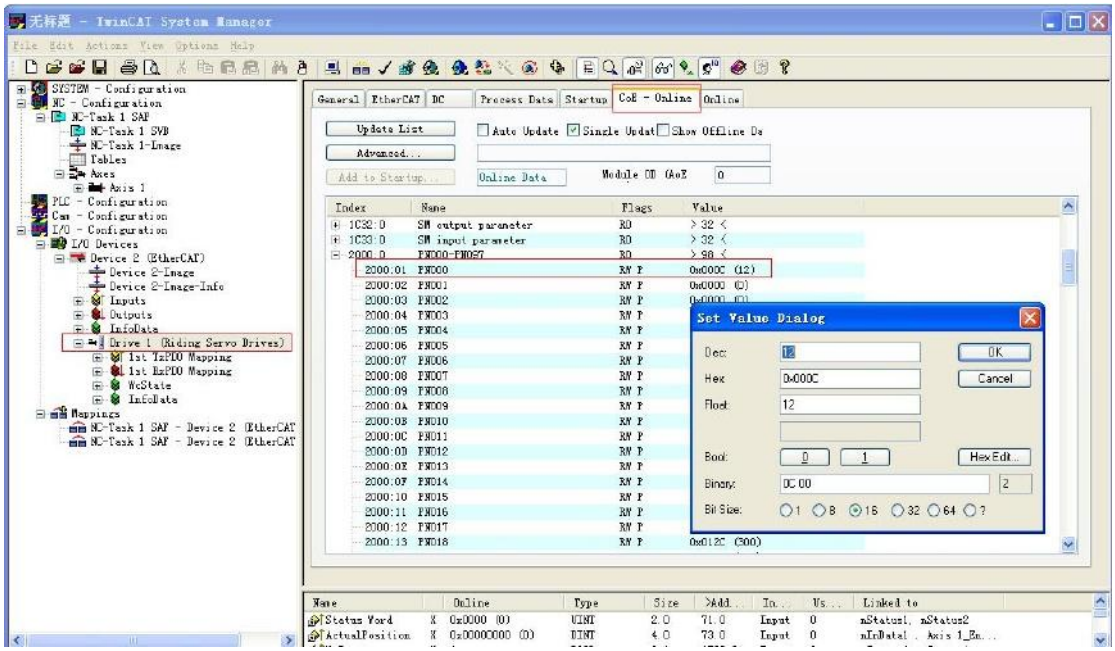


Figure 7.17

7.1.3 Run

The above demonstrates how to use TwinCAT2 to add devices and configure various parameters. After all configuration is completed, TwinCAT can be started to enter the RUN mode and control the servo movement.

Figure 7.18 shows the steps to start RUN mode:

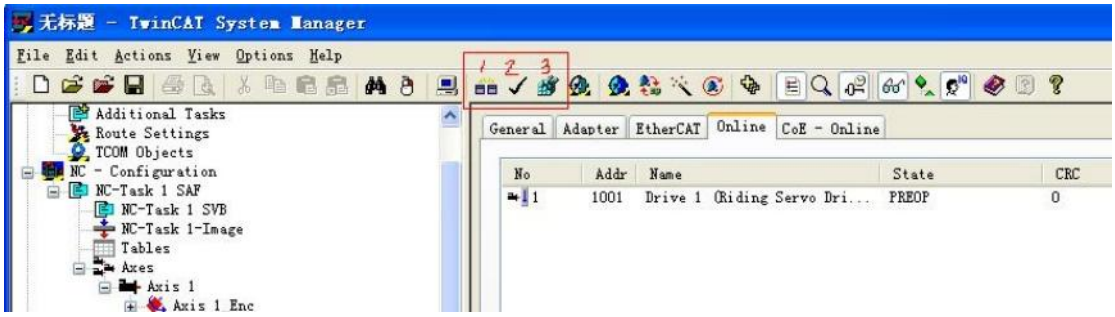


Figure 7.18

Click the first button in the red box in FIG. 7.18 successively to generate the required data mapping, press the second button to check the configuration, and the third button to activate the configuration. Then the dialog box in FIG. 7.19 appears, click "Yes" :

Figure 7.19

Then the ask dialog shown in Figure 7.20 appears, click "Yes" :

Figure 7.21

Wait 2-3 seconds for TwinCAT to enter the RUN mode, EtherCAT bus starts, ESM state is "OP", and the "Online" page of NC axis changes from invalid state to valid state, as shown in Figure 7.22:

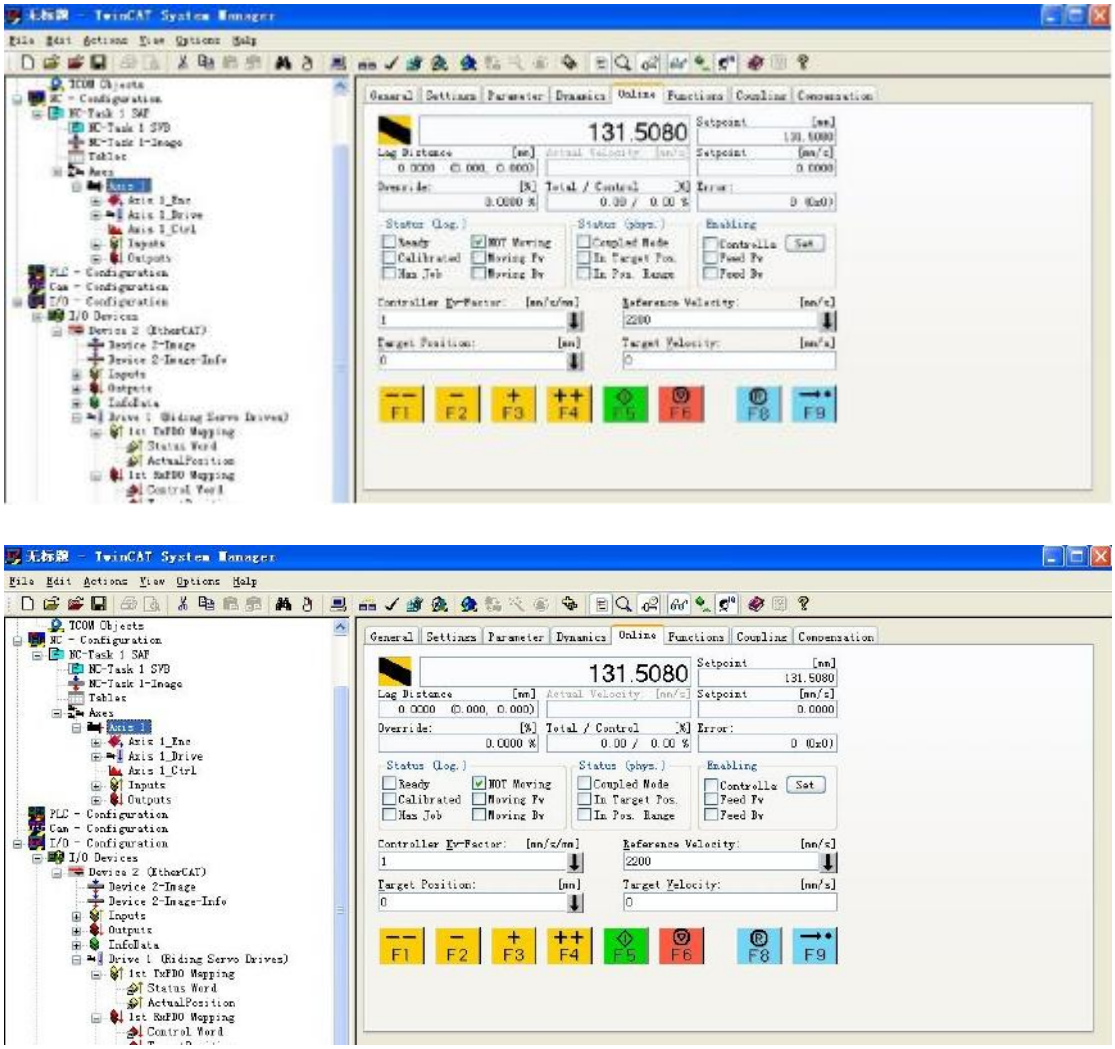


Figure 7.22

The feedback position of the motor can be seen from FIG. 7.22. The motor shaft can be manually moved and the feedback position value can also be found to change.Under this page you can control the motor to enable, point, point to point movement and other test actions.

Before motor action, the servo should also be set to work in synchronous position mode (CSP) by setting object 6060H value to 8 via PDO, as shown in Figure 7.23:

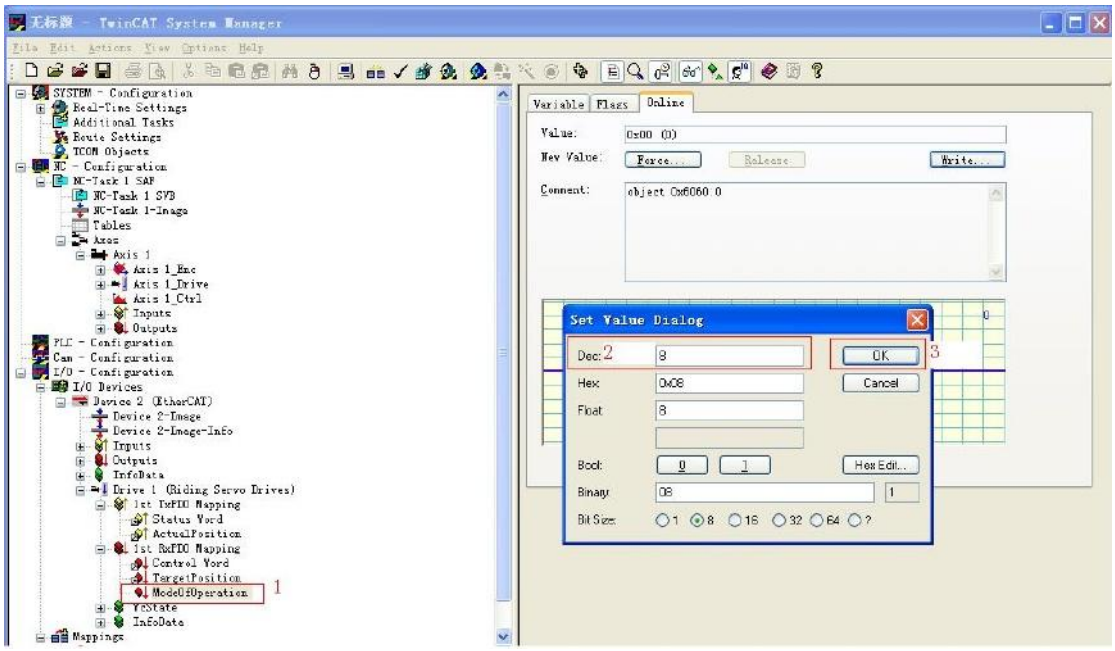


Figure 7.23

Then switch to the "Online" page of NC axis and perform the enabling action, as shown in Figure 7.24:

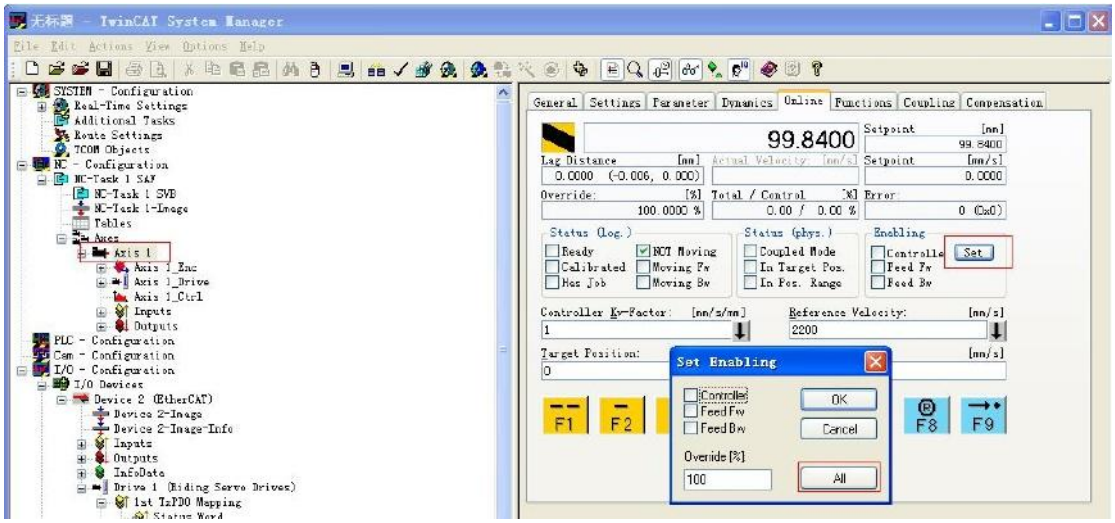


Figure 7.24

After enabling, the motor starts to output power, and the motor shaft should be locked in the current position. After enabling, the status of the "Online" page is shown in Figure 7.25:

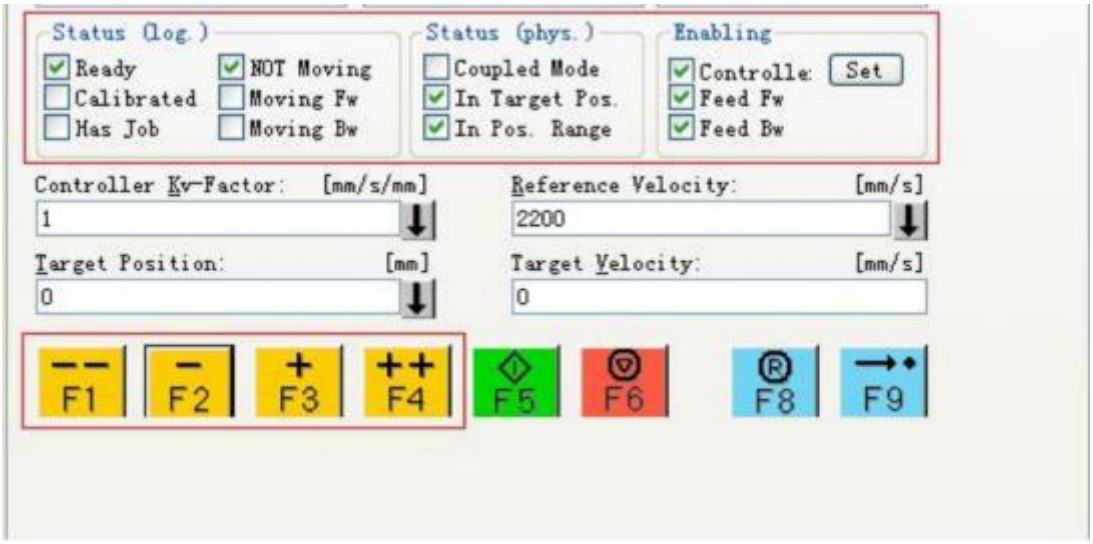


Figure 7.25

At this time, the f1-F8 function code at the bottom of the "Online" page can be used to test whether the motor moves normally. F1-f4 is the point operation, and the motor can inch by clicking the mouse or pressing the F1-F4 button on the keyboard.

In addition to point-to-point operation, point-to-point operation can also be set, as shown in FIG. 7.26. Set the speed as 100mm/s(100rpm), move to position 0, press the F5 button to start, then it should be observed that the motor starts to move in a certain direction at the speed of 100rpm, and stops when it reaches position 0.

Figure 7.26

The NC axis "Function" page can be used to perform some complex test movements, as shown in FIG. 7.27. Set the servo to reciprocate between some two points at a speed of 500mm/s, and then click "Start" button to Start operation after reaching the end point.

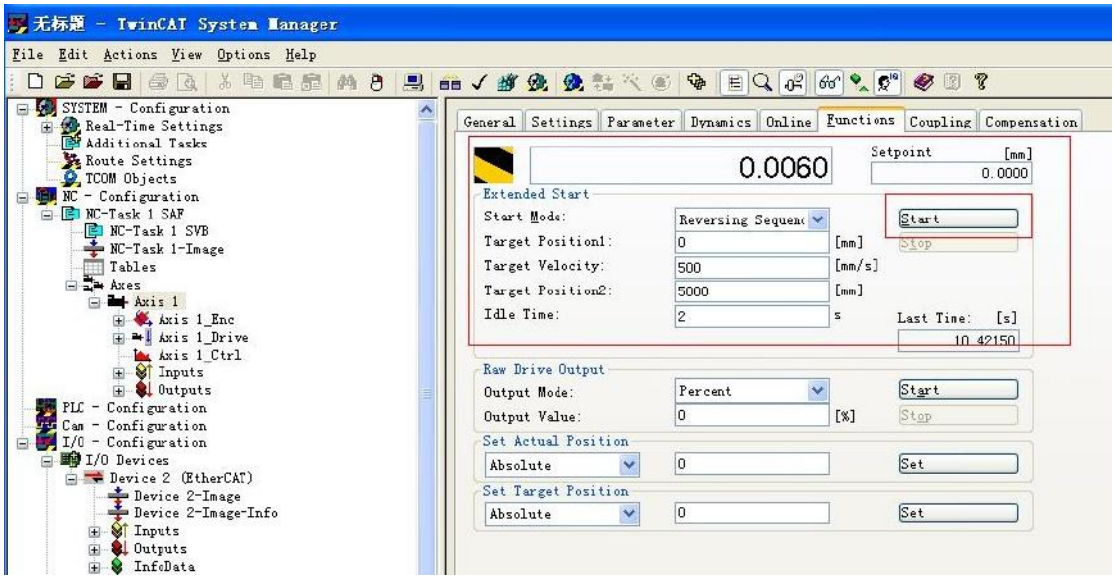


Figure 7.27

7.2 Use positive EtherCAT motion controller to connect GHA-E servo

7.2.1 Preparations

The positive EtherCAT controller model used in this case is ZMC464R, as shown in Figure 7.28.It is a bus motion controller supporting up to 64 axis motion control, with point position, straight line, arc, electron CAM, continuous trajectory movement, manipulator instructions can be directly called the movement instructions, powerful, simple development.

FIG. 7.28 Moving ZMC464R

1) Configure NIC parameters on the PC

In order to download application programs or update firmware to ZMC464, you can connect the controller to the physical network adapter of the PC using network cables and configure parameters such as THE IP address of the network adapter of

the PC, as shown in Figure 7.29:

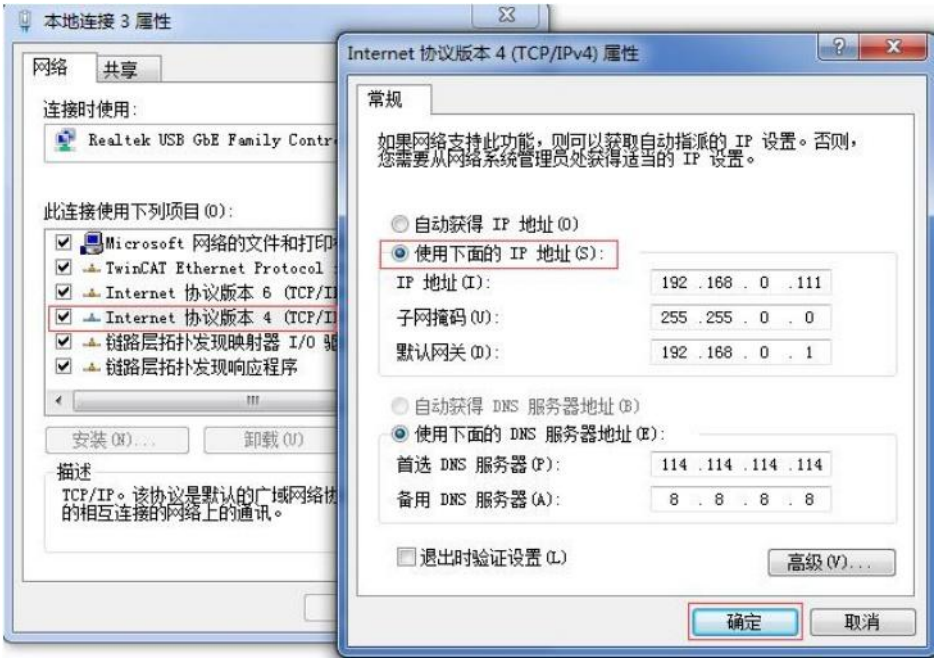


Figure 7.29

2) Obtain ZMC464 firmware suitable for servo

When using ZMC464, the first step is to obtain the corresponding firmware from the supplier, which contains the EtherCAT servo XML file, and download the firmware into the controller using the zfirmdown.exe tool.As shown in Figure 7.30, select the default IP192.168.0.11 of the controller for IP address, click "Link", and the current controller information will be displayed after success. Click "Select" corresponding firmware to download, and then click "Upgrade", and the dialog box as shown in Figure 7.31 will pop up.

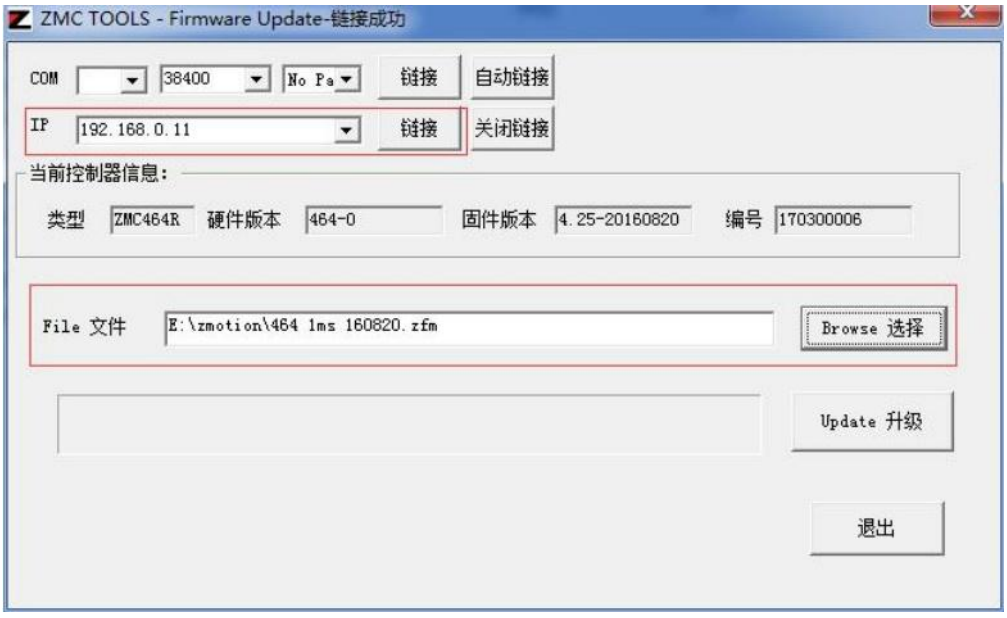


Figure 7.30

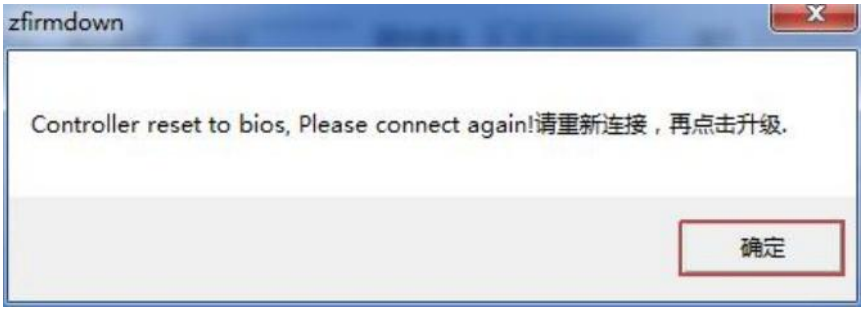


Figure 7.31

After clicking "OK", figure 7.32 appears, indicating ZBIOS link is successful.Click "Upgrade" again, as shown in Figure 7.33, and start updating firmware.

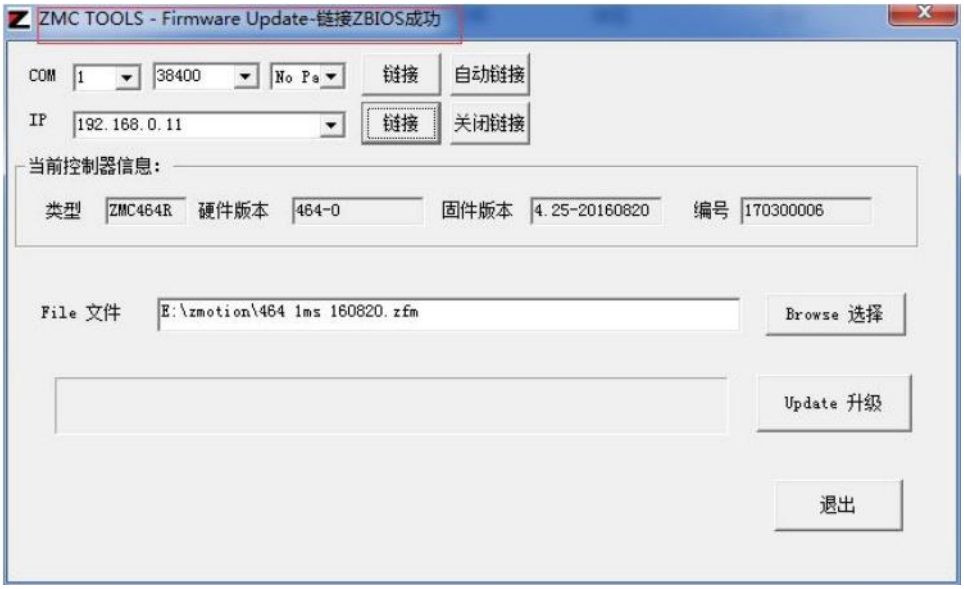


Figure 7.32

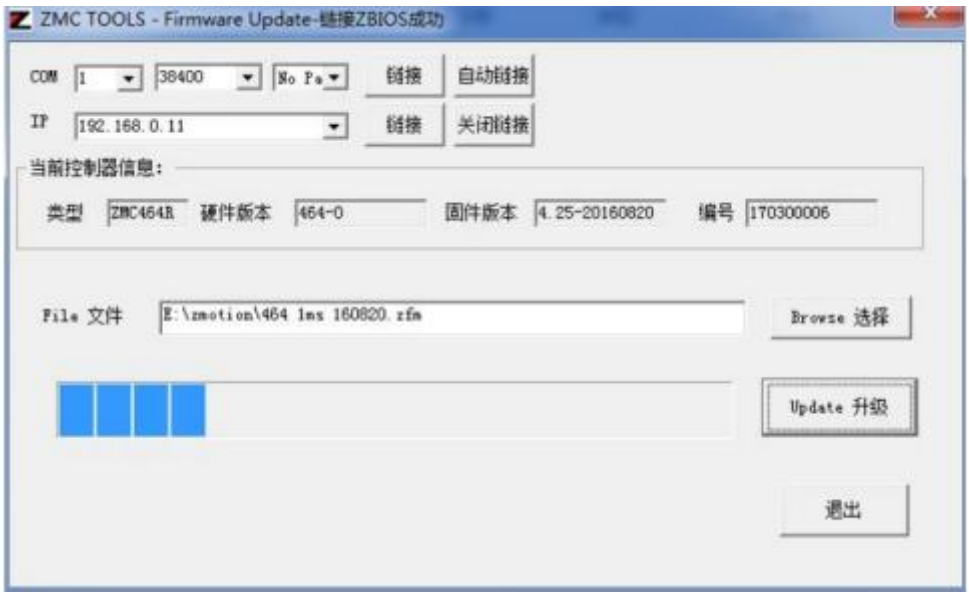


Figure 7.33

After the update, the dialog box as shown in Figure 7.34 will pop up. Click "OK" to complete the upgrade.

Figure 7.34

7.2.2 Programming

Open the Zdevelop. exe development environment, click "File", and select "New Project", as shown in Figure 7.35:

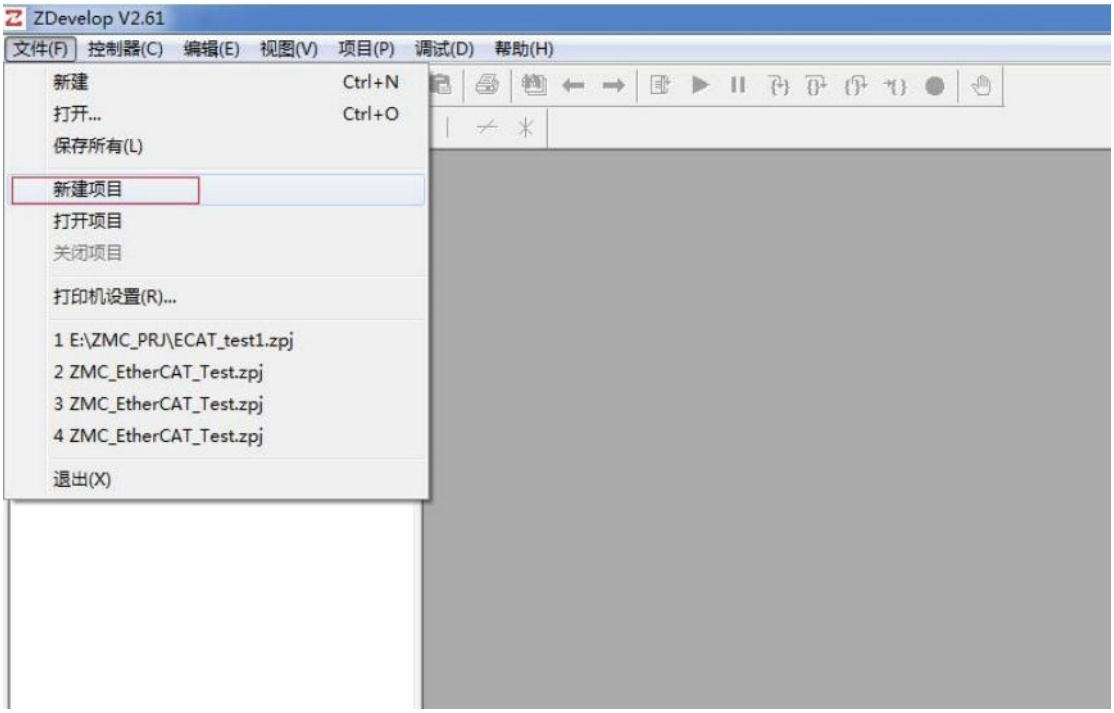


Figure 7.35

Enter the project name in the pop-up window and click "Save", as shown in Figure 7.36:

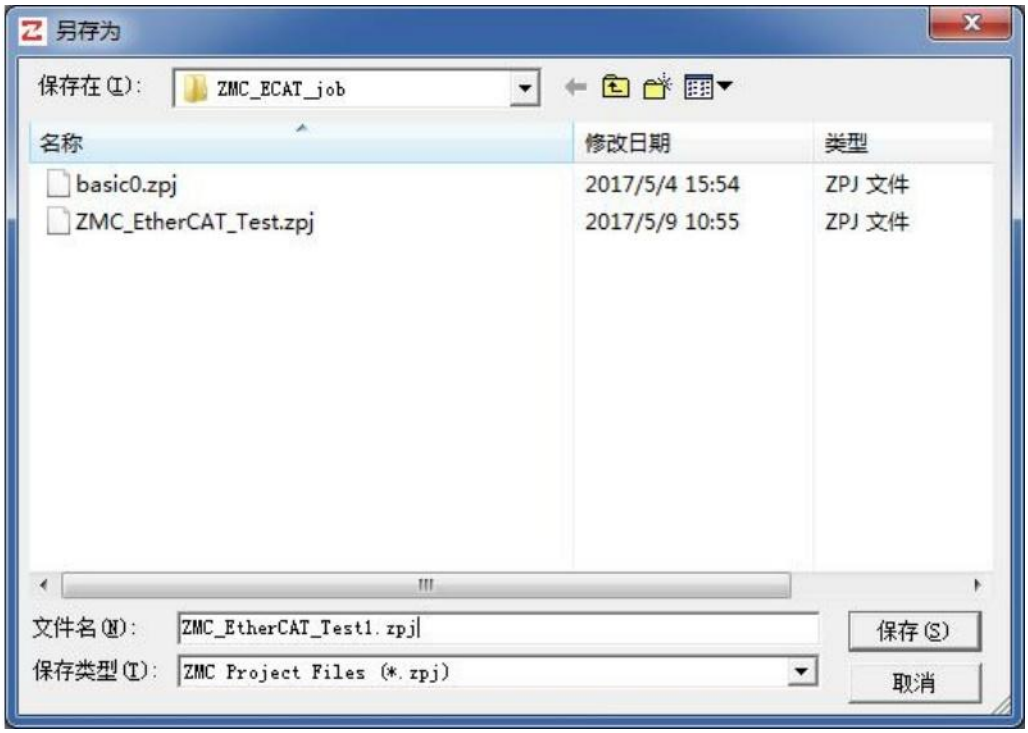


Figure 7.36

Click "File" and select "New" to create a task file, as shown in Figure 7.37:

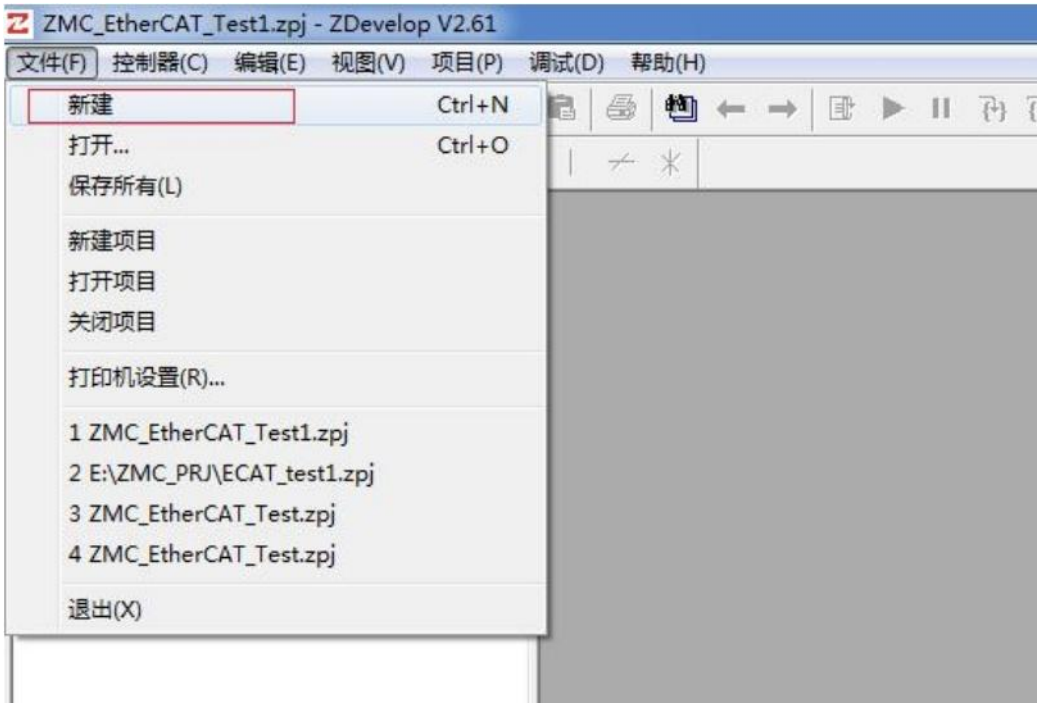


Figure 7.37

Select the "Basic" option in the pop-up dialog box and click "OK", as shown in Figure 7.38:

Figure 7.38

After creating the BASIC task file, you can write programs in the edit page on the right. For details, see the "Help" - "ZBASIC Help" page.See Appendix I for the complete ZBASIC program written in this case.The key parts are as follows:

```
base(0)                                          '停止原来可能的运动
rapidstop
units =10000/60                                  '脉冲当量
INVERT_STEP = 0                                  '方向
speed=2000
lspeed=0                                         '起始速度
creep=50                                         '回零反找速度
accel=20000
decel=20000
```

Units (pulse equivalent) : number of feedback pulses per turn of servo motor/displacement distance of load axis (mm).In this example, the servo feeds 10000 pulses per turn. Assuming that the motor shaft drives the load shaft to move 60mm per turn, set pulse equivalent units=10000/60.

Speed =2000, set the speed to 2000mm/s.

Accel =20000, set acceleration to 20000mm/s2.

Decel =20000, set deceleration to 20000 mm/s2.

The control motion part is as follows:

```
if IN_SCAN(0,3) then
    if IN_EVENT(0)>0    then
        move(60)
        delay(200)
    elseif IN_EVENT(1)>0 then
        test_start = 1
        MOVEABS(60000)
    elseif  IN_EVENT(2)>0   then
        test_start = 0
        CANCEL(0)
    elseif IN_EVENT(3)>0    then
        speed=600
        creep=200
        accel=50000
        DATUM(21)
        wait idle(0)
    endif
endif
```

In this example, the three input ports of ZMC464, IN0,IN1 and IN2, are used to control servo movement. When IN0 input is effective, move(60) instruction is executed and 60 instruction units are used to control servo movement. The motor shaft will rotate once.

When IN1 input is valid, the MOVABS(60000) instruction makes the servo move to the absolute position 60000, while the test_start variable is set, so that the servo reciprocates between the absolute position 60000 and 0;When IN2 input is valid, the DATUM(21) instruction executes, performing the return to zero motion, and the return to zero method is set through the SDO service.

After the program is written, click the "Save" button and the following picture 7.39 will appear:

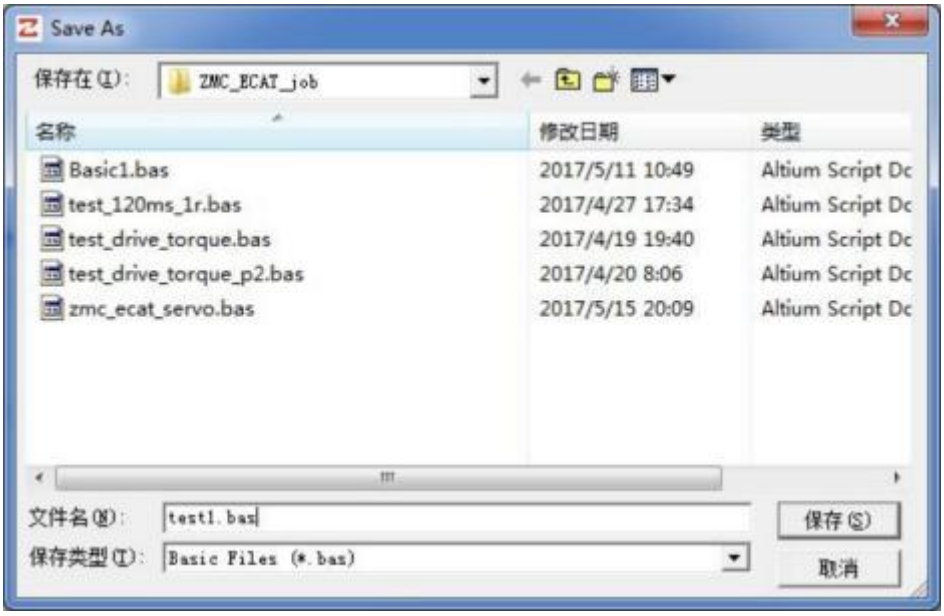


Figure 7.39

After saving, right click in the space of the file view and select "Add to Project", as shown in Figure 7.40:

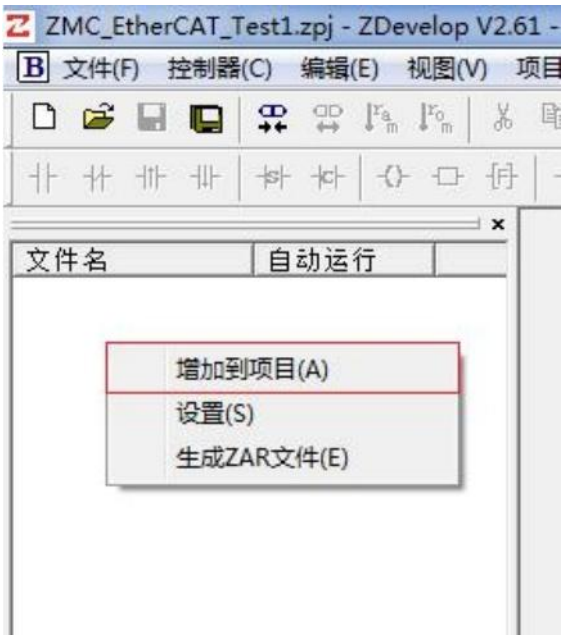


Figure 7.40

Then in the window that pops up, select the file "test.bas" that you just saved and run 98 automatically in the file view

Enter 0 in the box.As shown in figure 7.41:

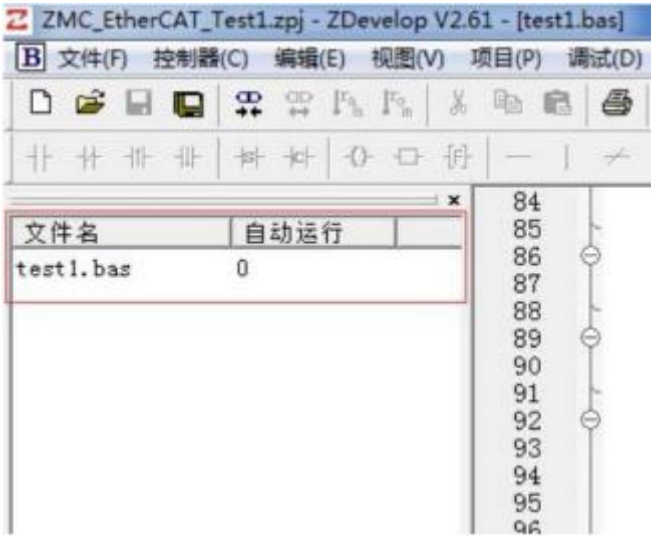


Figure 7.41

7.2.3 Debugging and Running

Click "Controller" in the menu bar and select "Connect", as shown in Figure 7.42:

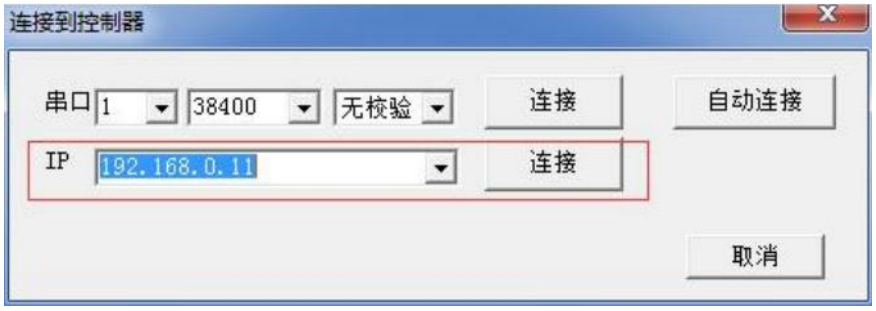


Figure 7.42

After the connection is successful, click "Debug" and select "Start/Stop Debugging", as shown in Figure 7.43:

Figure 7.43

After selecting the debugging mode, click "OK" to enter the debugging interface:

Figure 7.44

Click on the figure 7.44  After running the program, you can make the IN0 input valid and see the electricity turn the shaft shown once.

Appendix I: Forward motion ZBASIC routines

```
din num          '设备个数
num=1
din test_start
test_start = 0
din nodestatus
nodestatus = 0

reflash:

SLOT_SCAN(0)                '槽位号指的是控制器有几个EtherCAT接口，默认为0
'扫描成功将返回-1，扫描失败返回0

print return ,NODE_COUNT(0)'打印扫描返回值，0槽口连接的设备个数



if NODE_COUNT(0)<>num then goto reflash'防止设备漏接多接


axis_address(0) = 1 '第一个连接的驱动器，设置轴号为0（轴号可以随意设置）
atype(0)=65                 'CSP

DRIVE_PROFILE(0)=0      '使用ZMC第0组PDO对1600和1A00进行配置

DRIVE_MODE(0) = 8

if return then

    SLOT_START(0)       '执行后ECAT进入OP，之前全是PREOP
    ? return

    delay(1000)

    ? "clear error"
    '清除驱动器错误，驱动器不同，设置不同，根据驱动器的手册数据字典设置

    DRIVE_CONTROLWORD  =128
    wa 2
    DRIVE_CONTROLWORD  =6
    wa 2
    DRIVE_CONTROLWORD =15
    wa 2

    DELAY(500)

    '清除控制器错误
    datum(0)

    axis_enable=1   '只有总线启动了，所有轴使能wdog和单轴使能都打开了才能运动
    wdog=1      '该语句执行后电机使能

    DELAY(5)

endif

?"drive_status",DRIVE_STATUS(0)

?"node_status",NODE_STATUS(0,0)

base(0)
rapidstop                                       '停止原来可能的运动
units =10000/60                                 '脉冲当量
INVERT_STEP = 0                                 '方向
speed=2000
lspeed=0                                    '起始速度
creep=50                                    '回零反找速度
accel=20000
decel=20000
fs_Limit = 600000                           '正向软限位
```

```
rs_limit = -600000                                  '负向
fastdec=5000                                '快速减速度，CANCEL与RAPIDSTOP时用

clutch_rate =1                                      '链接速率，处理速度限制
SRAMP = 30                                          'S曲线设置
ALM_IN = -1


while 1

    if IN_SCAN(0,3) then
        if IN_EVENT(0)>0    then
            move(60)
            delay(200)
        elseif IN_EVENT(1)>0 then
            test_start = 1
            MOVEABS(60000)
        elseif  IN_EVENT(2)>0   then
            test_start = 0
            CANCEL(0)
        elseif IN_EVENT(3)>0    then
            speed=600
            creep=200
            accel=50000
            DATUM(21)
            wait idle(0)
        endif
    endif

    if IDLE(0) then
        if test_start=1 then
            delay(200)
            MOVEABS(0)
            test_start = 2
        elseif test_start=2 then
            delay(200)
            MOVEABS(60000)
            test_start = 1
        endif
    endif

    nodestatus = NODE_STATUS(0,0)

    ?"node_status",nodestatus

    if nodestatus<>1 then
        OP(0,ON)
    endif

    'SDO_WRITE(0,0,24728,0,2,1)

    'SDO_READ(0,0,24730,0,7,0)

    'dpos(0)

    '?table(0)

wend
```