DORNA DS1E EtherCAT Handbook

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1. System Overview

1.1 Overview of EtherCAT

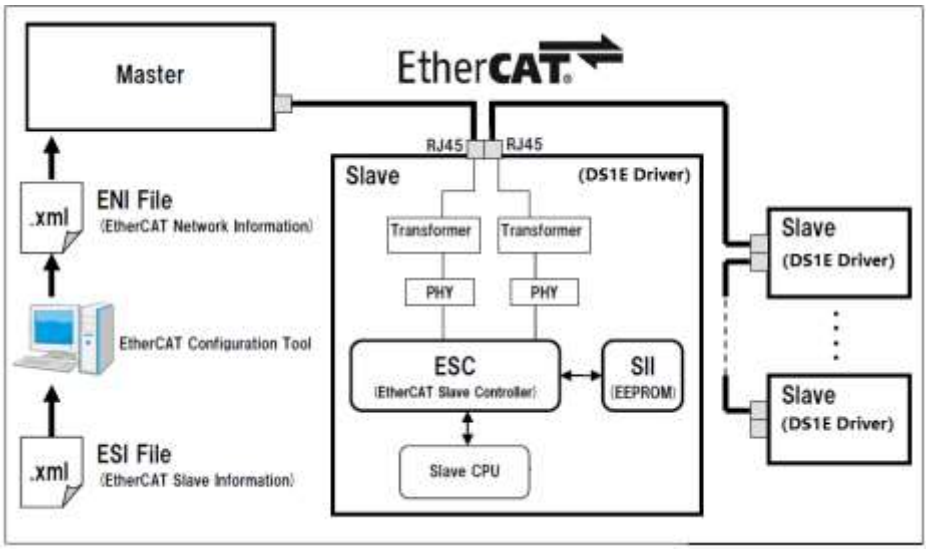
EtherCAT is short for Ethernet for Control Automation Technology. It is open network communication between master and slave for real-time Ethernet developed by Beckhoff Automation GmbH , and managed by ETG (EtherCAT Technology Group).

1.2 Product Overview

DS1E series servo drives achieve the EtherCAT communication (real-time Ethernet communication News), and realize in its application layer CANopen Drive Profile (CiA402).
This driver supports HM, CSP , CSV , CST and other control modes.
This document describes the specifications of the network interface EtherCAT that connects the servo driver DS1E series (slave) and the host device (master).

1.3 System configuration

EtherCAT connection form is , the linear connecting the main station (FA controller) and a plurality of slave stations of the network system. The number of nodes that can be connected to a slave station depends on the processing or communication cycle of the master station, the number of bytes transmitted, and so on. Check the specifications of the matching master station.
Master station is based on EtherCAT Network Information (ENI) through EtherCAT Slave Information (ESI) provided by our company (using Configuration tool) and uses ENI to form an EtherCAT network.



1.4 Technical terms

The following table lists the terms used in EtherCAT and CANopen .

Short name	Description
APRD	Automatically increase physical read mode: Select the storage space of the slave station according to its position within the network segment
APWR	Automatically increase physical write mode: Select the storage space of the slave according to the position of the slave in the network segment
APRW	Automatically add physical read and write to a single slave
ARMW	Automatically add physical read and write multiple slaves
BRD	Broadcast read, read physical storage area of all networked slaves
BRW	Broadcast write, write to the physical storage area of all networked slaves
CiA	CAN in Automation
CoE	CANopen over EtherCAT
DC	Distribute Clock, so all slaves get the same time
ECAT	EtherCAT
EEPROM	Electrically erasable read-only memory
SII	Slave Information Interface The ESC is connected to an EEPROM that holds SII data. In this EEPROM (SII), information such as the initialization information of the ESC, the specification value (mailbox data size value) of the application communication settings of the slave station , and the mapping of process data are set.
ENI	EtherCAT Network Information File generated on the master side ENI contains information identifying the slave stations (supplier information, etc.) and information for initializing each slave station. The master station initializes and builds the network based on the information recorded in the ENI .
ESC	EtherCAT Slave Controller
ESI	EtherCAT Slave Information Our company provides XML format files Records the definitions of slave-specific information (vendor information, product information, profile, object, process data, presence or absence of synchronization, SyncManager settings, etc.)
ESM	EtherCAT network state machine
ETG	EtherCAT protocol organization
EtherCAT	Real-time industrial Ethernet standard
FMMU	Fieldbus storage management unit
INIT	EtherCAT state machine: initialization state
LRD	Read the memory space of one or more slaves selected according to the logical address
LWR	Write data to the slave space selected according to the logical address
LRW	Read or write data to the storage space of the slave selected according to the logical address

OP	EtherCAT state machine: operating state
OD	Object dictionary
PDO	Process data
PREOP	EtherCAT state machine: pre-operational state
RXPDO	Accept PDO
SAFEOP	EtherCAT State Machine: Safe Operating State
SDO	Service data object
SyncManager	Sync manager to control access to application storage
TXPDO	Send PDO
P UU	Pulse User Unit

1.5 Data Type

The following table lists the types of data and their ranges involved in this material

Code		**type of data**	**range**
UINT8	U 8	Unsigned 8 digits	0 ~ 255
INT8	I 8	Signed 8 digits	--128 ~ +127
UINT16	U 16	Unsigned 16-bit parameter	0 ~ 65535
INT16	I 16	Signed 16-bit parameter	--32768 ~ +32767
UINT32	U 32	Unsigned 32-bit parameter	0 ~ 4294967295
INT32	I 32	Signed 32-bit parameter	--2147483648 ~ +2147483627
STR	S TR	String	-

1.6 Communication specifications list

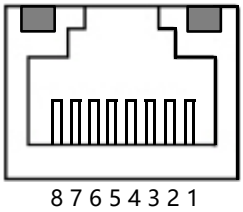
project	**specification**
Physical Layer	100BASE-TX (IEEE802.3)
Baud rate	100 [Mbps] (Full duplex)
Topology	Linear
connecting cables	Shielded twisted pair CAT5e
cable length	Between nodes: up to 100 [m]
Number of connected slaves (axis)	Max 65535
Communication port	2ports (RJ45 connector) CN1 (RJ45): EtherCAT Signal OUT CN2 (RJ45): EtherCAT Signal IN
EtherCAT Indicators (LED)	[RUN] RUN Indicator (Yellow) [L/A IN] Port0 Link / Activity Indicator (Green)
Device Profile	CoE (CANopen over EtherCAT)

<table>
<tr><td>SyncManager</td><td>4</td></tr>
<tr><td>FMMU</td><td>3</td></tr>
<tr><td>Modes of Operation
(Control mode)
Abbreviation: Op-mode</td><td>
<table>
<tr><td></td><td colspan="2">Modes of operation</td></tr>
<tr><td>Cycle synchronous position control</td><td>csp</td><td>Cyclic synchronous position mode
(Cyclic position control mode)</td></tr>
<tr><td>Return to zero</td><td>hm</td><td>Homing mode
(Origin return position control mode)</td></tr>
<tr><td>Cycle synchronous speed control</td><td>csv</td><td>Cyclic synchronous velocity mode
(Cyclic speed control mode)</td></tr>
<tr><td>Cycle synchronous torque control</td><td>cst</td><td>Cyclic synchronous torque mode
(Cyclic torque control mode)</td></tr>
</table>
</td></tr>
<tr><td>Synchronous mode</td><td>DC (SYNC0 event synchronization)
SM2 (SM2 event synchronization)
FreeRUN (asynchronous)</td></tr>
<tr><td>Cycle time (DC communication cycle)</td><td>125 [μs] ╳ n (n = 1 , 2, … 128)</td></tr>
<tr><td>Communication object</td><td>SDO (Service Data Object), PDO (Process Data Object)</td></tr>
<tr><td>SDO information</td><td>Correspondence: SDO Request, SDO Response, SDO information, Emergency message
Not corresponding: Complete Access</td></tr>
<tr><td>Free PDO Mapping</td><td>correspond</td></tr>
<tr><td>Maximum number of PDO allocations</td><td>RxPDO : 4 [Table]
TxPDO : 4 [Table]</td></tr>
<tr><td>Maximum PDO data length</td><td>RxPDO : 16 [byte]
TxPDO : 16 [byte]</td></tr>
</table>

2. Hardware configurations

2.1 Terminal descriptions

The schematic diagram of DS1E servo driver is as follows. The terminals of CN1 and CN2 are EtherCAT terminals. CN2 is EtherCAT IN and CN1 is EtherCAT OUT.

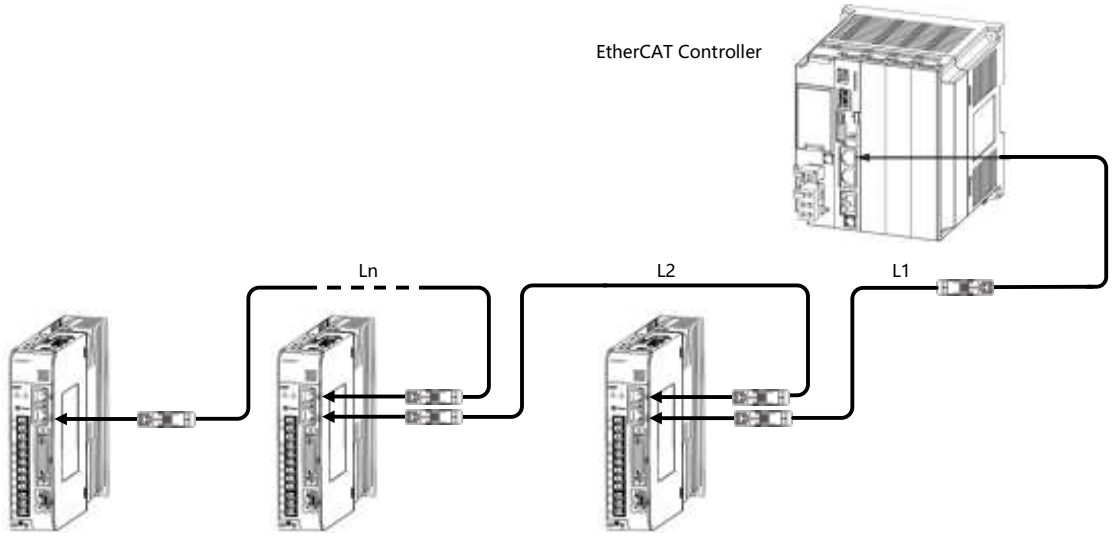


EtherCAT connector is a connector for connecting Ethernet twisted pair cable
Electrical characteristics: according to IEEE802.3 standard
Connector mechanism: 8-pin modular connector for RJ45 (according to ISO 8877)

DS1E: EtherCAT type		
Pin	**Name**	**Function**
1	TX+	Data transmission +
2	TX-	Data transmission -
3	RX+	Data reception +
4		Leave open
5		Leave open
6	RX-	Data reception -
7		Leave open
8		Leave open
Housing	FG	Shielded cable

2.2 System wirings

The EtherCAT network is generally composed of a master station (such as IPC) and a series of slave stations (such as DS1E servo controller). Each EtherCAT slave (such as DS1E servo controller, etc.) has two standard Ethernet interfaces. The wiring diagram is shown below.

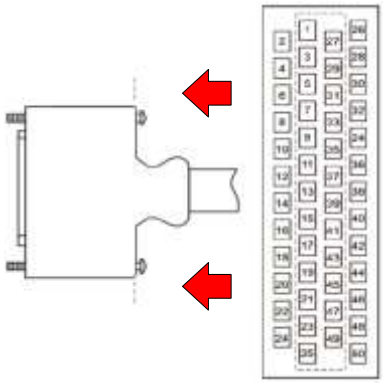


2.3 Cable specifications

Corresponds to category 5 or higher shielding.
Note: When selecting a connector, make sure that the cable used is suitable for the connector. Items to be confirmed are conductor specifications, single / twisted wires, 2/4 pairs, outer diameter, etc.

2.4 CN3 terminal definition

The IO of DS1E driver is different from DS1P driver.

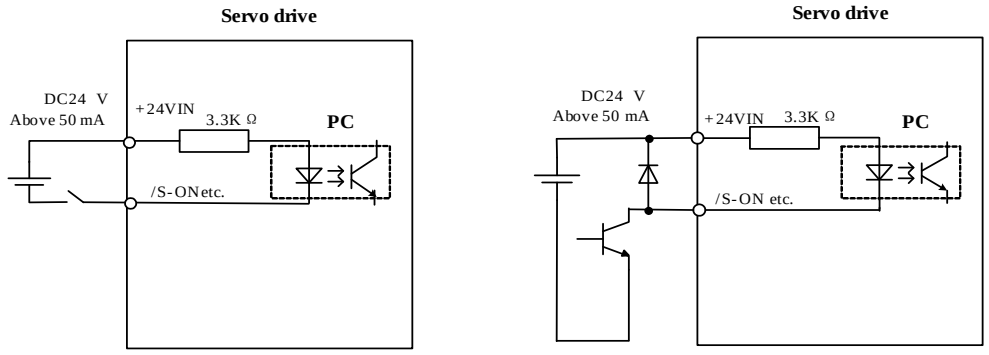


2	SG	GND	1	SG	GND	27	DO3+	Digital output 3 (+)	26	DO4−	Digital output 4 (-)
4			3			29	DO2+	Digital output 2 (+)	28	DO3−	Digital output 3 (-)
6			5			31	DO1+	ALM (+)	30	DO2−	Digital output 2 (-)
8			7			33			32	DO1−	ALM (-)
10			9			35			34		
12			11			37			36		
14			13			39			38		
16			15			41	DI2	Digital input 2	40	DI1	Digital input 1
18			17			43	DI4	Digital input 4	42	DI3	Digital input 3
20			19			45	DI6	Digital input 6	44	DI5	Digital input 5
22			21			47	COM+	External 24V power input	46		
24			23			49	+24V	Internal 24V power supply	48		
			25	DO4+	Digital output 4 (+)				50	24VGND	Internal 24V GND

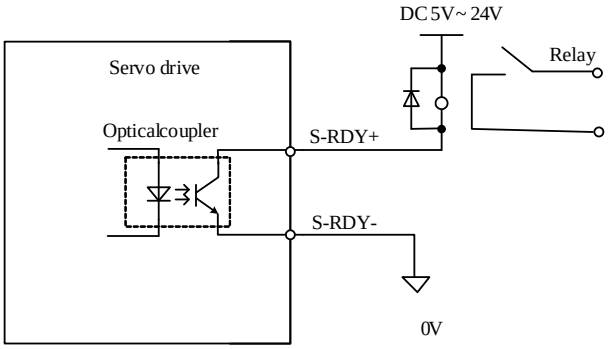
Notes:

1) do not use vacant terminals.
2) Connect the shielding of control line (I/O cable) to the connector housing to achieve FG
3) Maximum output current of internal 24V is 300mA. If internal 24V is used, internal 5V will lose power very quickly.

The typical circuit of input signal is as follows:



Typical output signal circuit is shown in the following diagram:



Maximum allowable voltage: DC 30V
Maximum allowable current: DC 50mA

Input signals:

Mode	Signal	Pin No.	Function	
Universal	S-ON	40	Servo ON: The motor is powered on.	
	C-MOD	41	Control mode switch: Switch between two control modes.	
	POT	42	Forward rotation prohibited	Overtravel prohibited: Stop operation of servo motor when it is on.
	NOT	43	Reverse rotation prohibited	
	CLR	44	Clear position deviation pulses counter during position control.	
	A-RST	45	Reset alarms	
	COM+	47	External 24VDC for I/O signals	

Default input signal allocations

PA	Description	Range	Unit	Default	Effective
PA500	**n.XX□□: DI 1 input signal selection** [00] Servo-on (S-ON) [01] Control mode switch (C-MODE) [02] Forward rotation prohibited (POT) [03] Reverse rotation prohibited (NOT)	n.0000~ n.211F	~	n.0000	Immediate

	[04] Deviation counter clearance (CLR) [05] Alarm reset (A-RST) [06] Pulse input inhibited (INHIBIT) [07] Zero-speed clamp (ZEROSPD) [08] Forward torque limitation (PCL) [09] Reverse torque limitation (NCL) [0A] Gain switch (GAIN) [0B] Reserved [0C] Reserved [0D] Instruction division/ multiplication switch 0 (DIV0) [0E] Reserved [0F] Internal speed register 0 (INSPD0) [10] Internal speed register 1 (INSPD1) [13] Internal torque register 0 (INTor0) [14] Internal torque register 1 (INTor1) [15] HOMESWTICH [16] HOMESTART **n.X□XX: DI 1 signal negation** [0] Not negate [1] Negate **n.□XXX: DI 1 signal status** [0] Controlled by external I/O [1] Normally active [2] Normally inactive				
PA501	DI 2 input signal selection	n.0000~ n.211F		n.0001	Immediate
PA502	DI 3 input signal selection	n.0000~ n.211F		n.0002	Immediate
PA503	DI 4 input signal selection	n.0000~ n.211F		n.0003	Immediate
PA504	DI 5 input signal selection	n.0000~ n.211F		n.0004	Immediate
PA505	DI 6 input signal selection	n.0000~ n.211F		n.0005	Immediate

Default signals and corresponding pins of DI 1~ DI 8:

Parameter No.	Terminal name	CN2 pin	Default signal
PA500	DI 1	40	S-ON
PA501	DI 2	41	C-MOD
PA502	DI 3	42	POT
PA503	DI 4	43	NOT
PA504	DI 5	44	CLR
PA505	DI 6	45	A-RESTART

Output signals:

Mode	Signal	Pin No.	Function
Universal	+24V	49	Internal 24V power supply, can provide for DI and DO signals, can withstand 300mA current
	24VGND	50	Internal 24V power supply ground
	ALM+	31	Servo alarm: OFF when abnormal state is detected.
	ALM-	32	
	COIN+	29	Positioning completed: Under position control mode, when deviation pulse is smaller than PA525, the signal is active.
	COIN-	30	
	CZ+	27	Optocoupler Z phase pulse output
	CZ-	28	
	BK+	25	External brake signal output
	BK -	26	

Default allocations of output signals

PA	Description	Range	Unit	Default	Effective
PA50A	**Output signal selection** **n.XX□□: DO 1 output signal selection** [00] Alarm signal output (ALM) [01] Positioning completed (COIN) [02] Z pulse open-collector signal (CZ) [03] Brake release signal (BK) [04] Servo ready signal (S-RDY) [05] Speed instruction reached (VCMP) [06] Motor rotation detection (TGON) [07] Torque limited signal (TLC) [08] Zero-speed detection signal (ZSP) [09] Warning output (WARN) [0D] Torque reached (TREACH) **n.X□XX: DO1 signal negation** [0] Not negate [1] Negate **n.□XXX: DO1 signal status** [0] Controlled by external I/O [1] Normally active [2] Normally inactive	n.0000 ~ n.211F		**n.0000**	Immediate
PA50B	**DO 2 output signal selection**	n.0000 ~ n.211F		n.0000	Immediate
PA50C	**DO 3 output signal selection**	n.0000		n.0000	Immediate

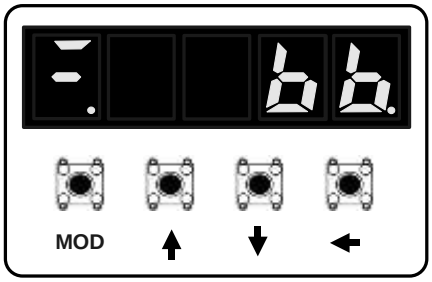
		~ n.211F			
PA50D	**DO 4 output signal selection**	n.0000 ~ n.211F		n.0000	Immediate

Default signals and corresponding pins of DO 1 to DO 4

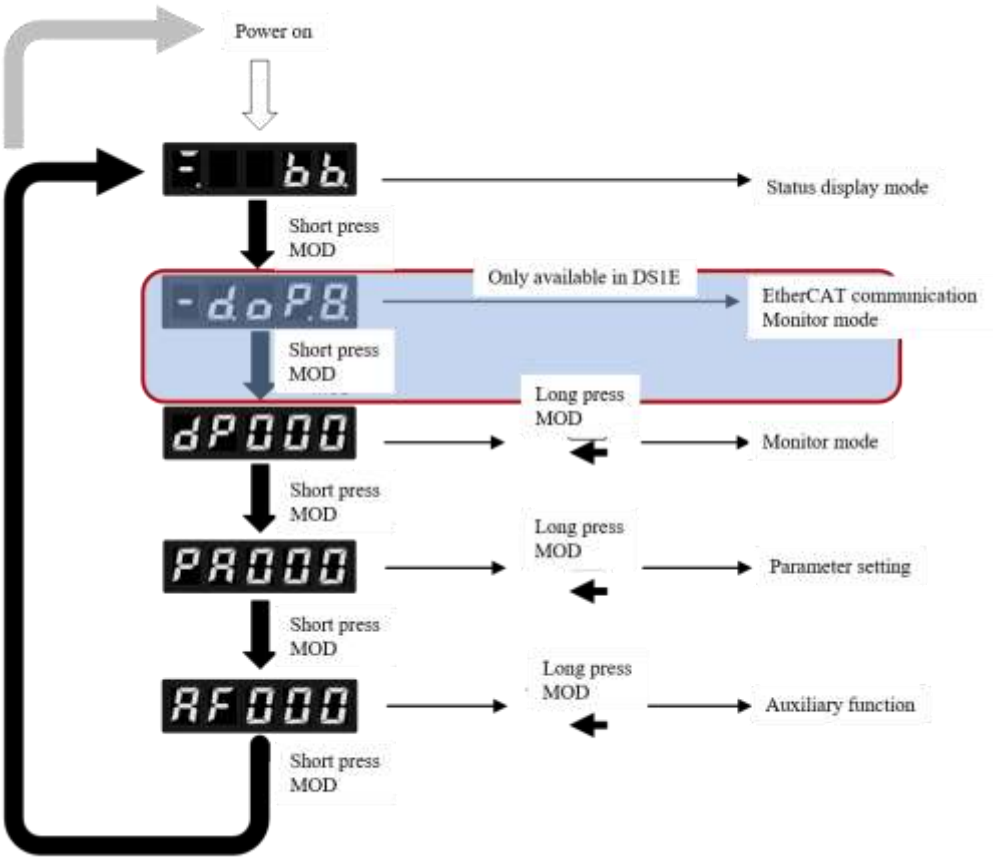
Parameter No.	Terminal name	CN2 pin	Default signal
PA50A	DO1	31, 32	ALM
PA50B	DO2	29, 30	COIN
PA50C	DO3	27, 28	CZ
PA50D	DO4	25, 26	BK

2.5 Panel display

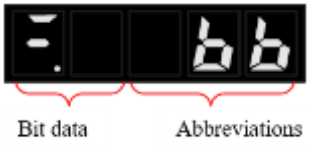
Panel operator consists of a panel display and operating keys. Panel operator is used for displaying status, performing auxiliary functions, setting parameters and monitoring servo drive's status.
Hold & press↑&↓keys together can clear servo drive alarms. BUT please find out the cause of alarms first.



Key	Function description
MOD	Switch between different modes or cancel
↑	Increase value
↓	Decrease value
←	Long press: ENTER Short press: move decimal point



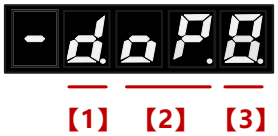
Status of servo drive is displayed by digits.



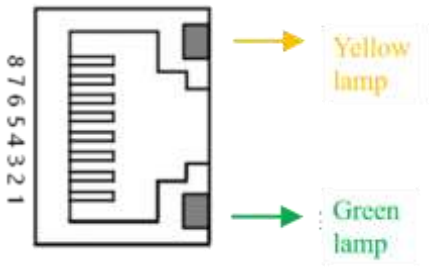
Display	Meaning	Display	Meaning
bb	Base blockade Indicates the state of the servo OFF (the servo motor is not energized).	not	Reverse driving prohibited Indicates that the input signal (N-OT) is in an open state.
run	Running Indicates the status of the servo ON (servo motor energization status).	Hbb	Security function Indicates that the safety function is activated, and the servo drive is in the Hard wire base block state.
Pot	Forward driving prohibited Indicates that the input signal (P-OT) is in an open state.	E020 A910	Alarm status Flashing display alarm number or warning number

Display	Meaning
	Control power ON display Lights when the servo drive's control power is turned ON. Off when the servo drive's control power is OFF.
	Base block display Lights up in the base block (servo OFF state). Off when the servo is turned ON.
	Speed and torque control: for speed consistent (V-CMP) display When the difference between the servo motor speed and the command speed is within the specified value (set by PA513, the factory setting is 10 min-1), it lights up. Off when the specified value is reached. * Always lights up during torque control. <Supplement> When the command voltage is affected by noise, the "-" symbol on the upper left of the panel operator will flash. Please take countermeasures against noise interference. Position control: for positioning completion (COIN) display The deviation between the position command and the actual position of the motor is within the specified value (set by PA522, the factory setting is 7 command units), it lights up; it is extinguished when the specified value is exceeded.
	Rotation detection (TGON) display When the rotation speed of the servo motor is higher than the specified value (set by PA512, the factory setting is 20 min-1), it lights up; when it is lower than the specified value, it is extinguished.
	For speed and torque control: display for speed command input Lights when the speed command in the input is greater than the specified value (set by PA512, the factory setting is 20 min-1), and turns off when it is less than the specified value. For position control: display for command pulse input Lights when there is a command pulse input. Off when no command pulse is input.
	For speed and torque control: display for torque command input Lights when the torque command in the input is greater than the specified value (10% of rated torque) and turns off when it is less than the specified value. For position control: display for clear signal input Lights when there is a clear signal input. Off when there is no clear signal input.
	Power ready display Lights when the main circuit power is turned ON. Off when the main circuit power is OFF.

EtherCAT communication status monitor



Serial number	Abbreviation	meaning
【1】	"F"	EtherCAT data update mode is FreenRun
	" S "	EtherCAT data update mode is SM mode
	"D"	EtherCAT data update mode is DC mode
【2】	"In"	Network status is Init
	"Po"	Network status is Pre-Operational
	"So"	Network status is Safe-Operational
	“ OP ”	Network status is Operational
【3】	1, 2, 3 ... A ... F	The cycle time of EtherCAT data update mode is DC mode, the unit is 125 μs. For example, if it is displayed as 8, the cycle time of DC mode is T = 8 * 125 us = 1 ms.
	-	DC mode cycle time exceeds 1.875 ms

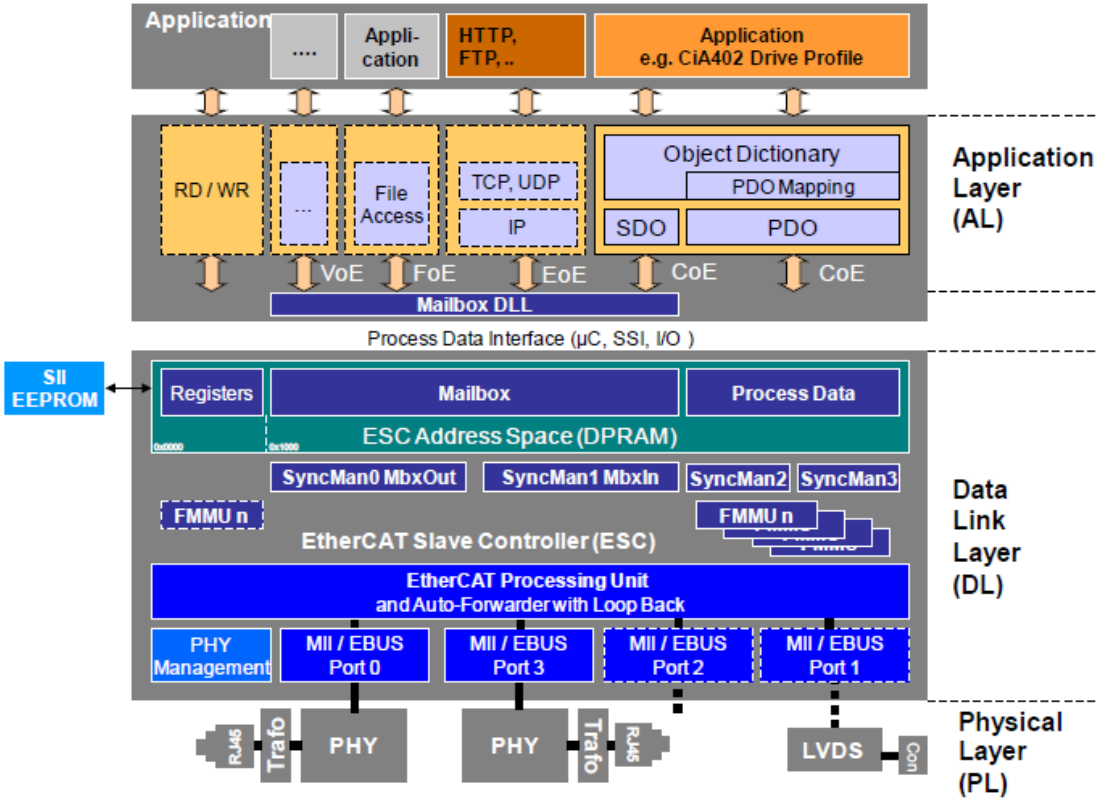


light	Masa	meaning
Yellow light	Off	Network status is Init
	flicker	Network status is Pre-Operational or Safe-Operational
	Always on	Network status is Operational
Green light	Off	Communication is not connected
	flicker	Communication data exchange

3.EtherCAT communication

3.1 CANopen over EtherCAT (CoE) reference model

The description of EtherCAT uses the principles of ISO / IEC 7498. The EtherCAT specification defines a complete top-down OSI protocol stack and functions for some stack users. The EtherCAT application layer provides user features common to the fieldbus application layer.



The EtherCAT (CoE) network reference model is mainly composed of two parts: the data link layer and the application layer. The data link layer is mainly responsible for the EtherCAT communication protocol, and the application layer embeds the CANopen drive Profile (DS402) communication protocol.

3.2 EtherCAT frame structure

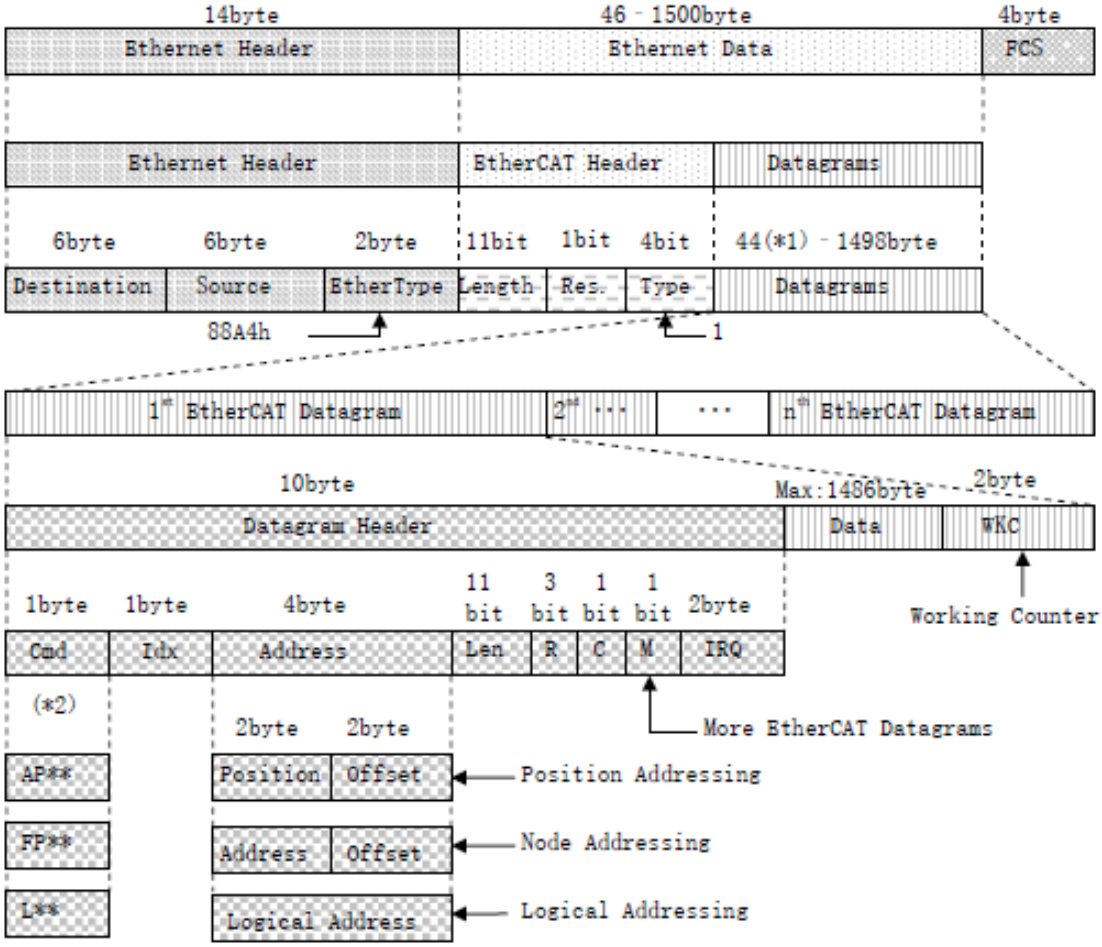
EtherCAT is an industrial communication protocol based on Ethernet that can be controlled in real time.

It is only an extension of the IEEE 802.3 Ethernet specification, without any changes to the basic structure, so it can forward data in standard Ethernet frames.

Since the EtherType of the Ethernet Header is "88A4h", the subsequent Ethernet Data is processed as an EtherCAT frame. An EtherCAT frame is composed of an EtherCAT frame header and more than one EtherCAT sub-message,

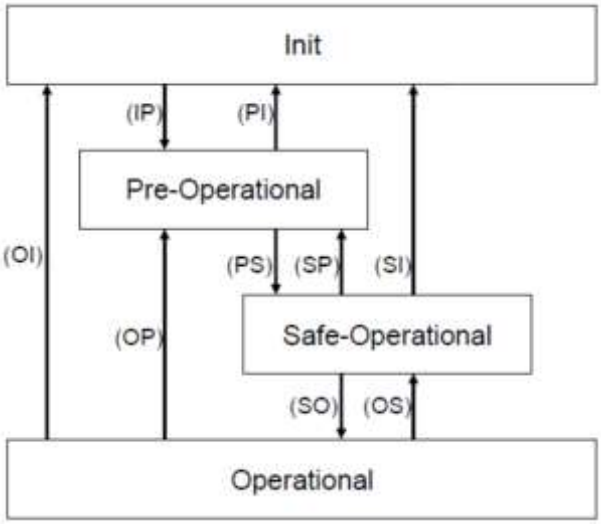
and further subdivides the EtherCAT sub-message. Only EtherCAT frames with Type = 1 in the EtherCAT header are processed according to ESC.

The Ethernet / EtherCAT frame structure is shown below :



3.3 EtherCAT network state machine ESM (EtherCAT State Machine)

The transition diagram of the state (ESM state) of the EtherCAT application layer is shown below.



ESM is responsible for coordinating the master and slaves at startup and working devices. The ESM states are described in the following table.

Status	Description
Init	◆ Can't communicate by mailbox ◆ No PDO communication
Init → Pre-Operational (I P)	◆ Master station configures the link layer address and SM channel, and starts mailbox communication ◆ Master station initializes DC clock synchronization ◆ Master requests to transition to Pre-Op state ◆ The master station sets the AL control register ◆ The slave determines whether the mailbox is initialized normally
Pre- Operational (Pre-Op)	◆Mailbox communication is activated ◆Cannot perform process data communication (PDO)
Pre-Operational → Safe-Operational (PS)	◆ Master station configures Sync Manager channel and FMMU channel for process data ◆ Master station configures PDO data mapping and Sync Manager PDO parameter settings through SOD ◆ Master requests Safe-Op state transition ◆ The slave station checks whether the Sync Manager configuration responsible for PDO data is correct. If the slave station initiates a synchronization request, check whether the distributed clock is set correctly.
Safe- Operational (Safe-Op)	◆ Slave application will transmit the actual input data without operating on the output ◆ Output is set to "safe state"
Safe-Operational → Operational (SO)	◆ Master station sends valid output data ◆ Master request to transition to Op state
Operational (Op)	◆ Email can communicate ◆ Can communicate with PDO

The object dictionary in CoE includes parameters, application data, and PDO mapping information.
The process data object (PDO) consists of objects in the object dictionary that can be PDO mapped, and the content in the PDO data is defined by the PDO mapping. PDO read and write data is periodic, the object does not need to find the word Code; the mail communication (the SDO) are non-periodic communications, when they read the dictionary to find the object.
Note: In order for the SDO and PDO data to be correctly parsed on the EtherCAT data link layer, you need to configure the FMMU and the Sync Manager.

Sync Manager	Assignment	Size
Sync Manager 0	Assigned to Receive Mailbox	32 ~ 256Byte
Sync Manager 1	Assigned to Transmit Mailbox	32 ~ 256Byte
Sync Manager 2	Assigned to Receive PDO	1 ~ 68Byte
Sync Manager 3	Assigned to Transmit PDO	1 ~ 68Byte

3.4 EtherCAT slave information

The EtherCAT slave information file (XML file) is used for master reading and is used to build the configuration of the master and slaves.
The XML file contains the necessary information for EtherCAT communication settings. The xml file provided by the DS1E driver is " DS1E_Ver100.xml".

3.5 PDO process data mapping

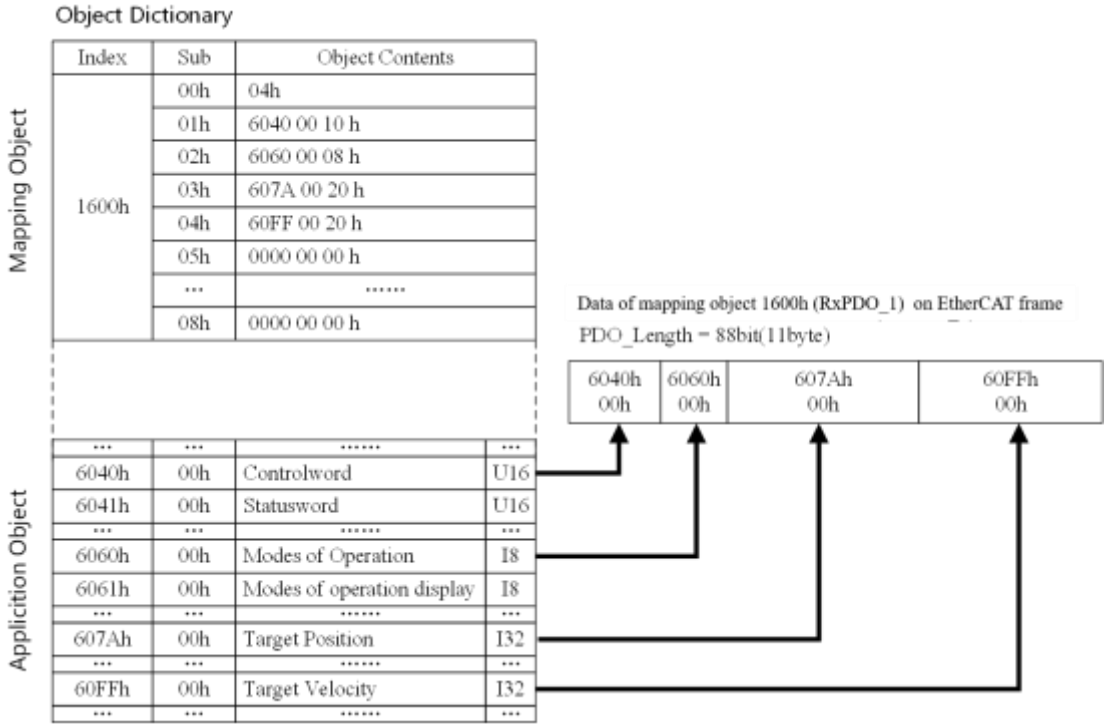
The RxPDO and TxPDO of the PDO mapping object are located at the index 0x1600 to 0x1603 and 0x1A00 to 0x1A03 of the Object Dictionary, respectively.

3.5.1 PDO mapping object

PDO mapping refers to the mapping from the object dictionary to the application object of PDO.
Mapping objects for 1600h to 1603h for RxPDO and 1A00h to 1A03h for TxPDO can be used .
The maximum number of application objects that a mapping object can map is shown below.

Maximum PDO data length	RxPDO: 32 [byte]
	TxPDO: 32 [byte]

The following shows an example of PDO mapping settings.
<Setting example>
When assigning application objects 6040h, 6060h, 607Ah, and 60FFh to the mapping object 1600h (Receive PDO mapping 1: RxPDO_1).



3.5.2 PDO Assigned Object

For PDO data exchange, a table for PDO mapping must be assigned to the SyncManager.

DS1E series driver , as SyncManager PDO distribution object, can use 1C12h for RxPDO (SyncManager2), 1C13h for TxPDO (SyncManager3)

The maximum number of application objects that a mapping object can map is shown below.

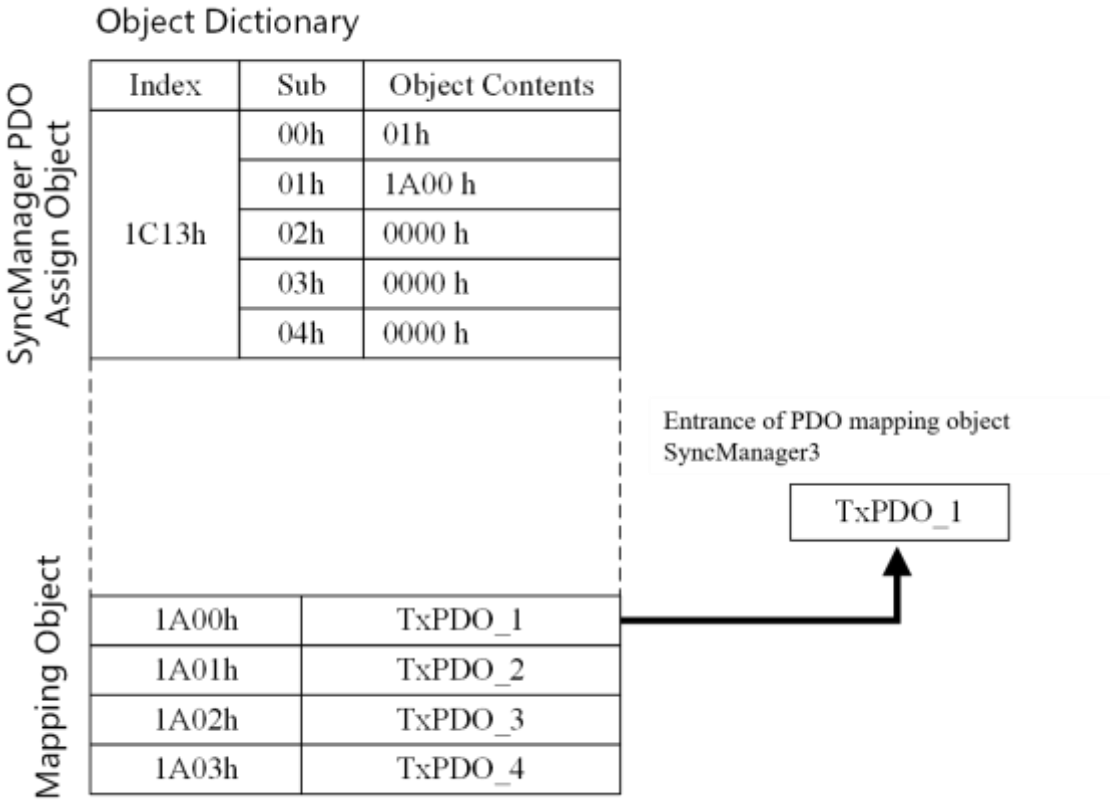
Maximum number of PDO allocations	RxPDO: 4 [Table]
	TxPDO: 4 [Table]

Usually, one mapping object is sufficient, so the default does not need to be changed.

The following is an example of setting the SyncManager PDO assignment target.

<Setting example >

A case where the mapping object 1A00h is allocated to the allocation object 1C13h (Sync manager channel 3).



note:

The PDO mapping objects (0x1600 ~ 0x1603, 0x1A00 ~ 0x1A03) and SM PDO Assign objects (0x1C12, 0x1C13) will take effect when they are written in the Pre-Op state.

3.5.3 default PDO mapping

The following table is the PDO image (default) of DS1E driver for data exchange.

■ The first set of preset P DO mappings (the default PDO assignment)

RxPDO1 (0x1600)	Controlword (0x6040)	Target Position (0x607A)	Target Velocity (0x60FF)	Target Torque (0x6071)	Mode of Operation (0x6060)
TxPDO1 (0x1A00)	Statusword (0x6041)	Position Actual Value (0x6064)	Speed Actual Value (0x606C)	Torque Actual Value (0x6077)	Operation Mode Display (0x6061)

■ The second set of preset P DO mappings

RxPDO2 (0x1601)	Controlword (0x6040)	Target Position (0x607A)
TxPDO2 (0x1A01)	Statusword (0x6041)	Position Actual Value (0x6064)

■ The third set of preset P DO mappings

RxPDO3 (0x1602)	Controlword (0x6040)	Target Velocity (0x60FF)	
TxPDO3 (0x1A02)	Statusword (0x6041)	Position Actual Value (0x6064)	Speed Actual Value (0x606C)

■ The fourth set of preset P DO mappings

RxPDO4 (0x1603)	Controlword (0x6040)	Target Torque (0x6071)	
TxPDO4 (0x1A03)	Statusword (0x6041)	Position Actual Value (0x6064)	Torque Actual Value (0x6077)

Note: Detailed PDO mapping information can be queried in the xml file.

3.5.4 Redefine PDO mapping

PDO heavy steps map:

1. Stop the PDO allocation function (set the sub-index 0 of 0x1C12 and 0x1C13 to 0);
2. Stop the PDO mapping function (set all sub-index 0 of 0x1600 ~ 0x1603 and 0x1A00 ~ 0x1A03 to 0);
3. Set the mapping entry for the PDO mapping objects (0x1600 ~ 0x1603 and 0x1A00 ~ 0x1A03);
4. Set the value of the PDO mapping object (0x1600 ~ 0x1603 and 0x1A00 ~ 0x1A03) mapping entry;
5. Set the PDO allocation object (set the sub-index 1 of 0x1C12 and 0x1C13);
6. Turn on the PDO assignment function again (set sub-index 0 of 0x1C12 and 0x1C13 to 1).

note:

The PDO mapping objects (0x1600 ~ 0x1603, 0x1A00 ~ 0x1A03) and SM PDO Assign objects (0x1C12, 0x1C13) will take effect when they are written in the Pre-Op state.

3.6 synchronous clock distribution network based

Clock Distribution (Distributed Clock) EtherCAT devices can all use the same system time, the respective devices to control tasks with stepping. In the EtherCAT network, the clock of the first slave station with distributed clock function connected to the master station is used as the reference clock for the entire network, and the remaining slave stations and master station are synchronized based on the reference clock.

The EtherCAT communication of the DS1E driver adopts the following synchronization mode. Among them, the switch of the synchronization mode can be configured through the synchronization control register (ESC 0x980, 0x981).

3.6.1 Sync manager 2/3 synchronization(1C32h、1C33h)

The setting of Sync manager2 is performed according to 1C32h (Sync manager 2 synchronization).

The setting of Sync manager3 is performed according to 1C33h (Sync manager 3 synchronization).

◆ Sync manager 2 synchronization

<table>
<tr><th>Index</th><th>Sub</th><th>Name / Description</th><th>Units</th><th>Range</th><th>Data Type</th><th>Access</th><th>PDO</th></tr>
<tr><td rowspan="8">1C32h</td><td>00h</td><td>Number of sub-objects</td><td>-</td><td>0 ~ 255</td><td>U8</td><td>ro</td><td>No</td></tr>
<tr><td colspan="7">Represents the Subindex number of this object .
The value is fixed at 20h.</td></tr>
<tr><td>01h</td><td>Sync mode</td><td>-</td><td>0 ~ 65535</td><td>U16</td><td>rw</td><td>No</td></tr>
<tr><td colspan="7">Set the sync mode of Sync Manager 2.
00h : FreeRun (not synchronized)
01h : SM2 (synchronized with SM 2 Event)
02h : DC SYNC0 (synchronized with Sync0 Event)
03h : Not supported (cannot be set)
According to the combination with the setting of ESC register 0981h (DC-Activation) (table below),
The settings of this object are automatically set when migrating from PreOP to SafeOP.
<table>
<tr><th>ESC register 0981h setting status</th><th>1C32h-01h set value</th><th>⇒</th><th>Value of 1C32h-01h changed during migration from PreOP to SafeOP</th></tr>
<tr><td rowspan="3">DC enable ON</td><td>00h: FreeRun</td><td rowspan="6"></td><td>02h: DC SYNC0</td></tr>
<tr><td>01h: SM2</td><td>02h: DC SYNC0</td></tr>
<tr><td>02h: DC SYNC0</td><td>02h: DC SYNC0</td></tr>
<tr><td rowspan="3">DC enable OFF</td><td>00h: FreeRun</td><td>00h: FreeRun</td></tr>
<tr><td>01h: SM2</td><td>01h: SM2</td></tr>
<tr><td>02h: DC SYNC0</td><td>00h: FreeRun</td></tr>
</table></td></tr>
<tr><td>02h</td><td>Cycle time</td><td>n s</td><td>0 ~ 0xFFFFFFFF</td><td>U32</td><td>rw</td><td>No</td></tr>
<tr><td colspan="7">Set the period of Sync Manager.
<table>
<tr><th>Sync mode (1C32h-01h)</th><th>Features</th></tr>
<tr><td>00h (FreeRun)</td><td>Set the interval between events based on the local clock.</td></tr>
<tr><td>01h (Synchronous with SM2)</td><td>Set the minimum time interval for SM2 events.</td></tr>
<tr><td>02h (DC SYNC0)</td><td>Sync0 Cycle Time (ESC register: 09A0h) is set.</td></tr>
</table>
Please set 125000 (125μs) * n (n = 1,2,3 ... 16). If a value other than the set E would occur. Exx (synchronization cycle setting error protection).</td></tr>
<tr><td>03h</td><td>Shift time</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="7">Not supported</td></tr>
<tr><td>04h</td><td>Sync modes supported</td><td>-</td><td>0 ~ 65535</td><td>U16</td><td>r o</td><td>No</td></tr>
</table>

		Set the supported synchronization types. BIT0: FreeRun mode support 0: Not supported, 1: FreeRun mode supported This servo driver is set to 1. BIT1: SM synchronous mode support 0: Not supported, 1: SM2 event synchronization support This servo driver is set to 1. BIT4-2: DC synchronous mode support 000b: not supported 001b: DC sync0 event support This servo driver is set to 001b. BIT6-5: Output offset support 00b: Not supported 01b: Offset support for local clock This servo driver is set to 00b. BIT15-7: Reserved					
	05h	Minimum cycle time	ns	0 ~ 0xFFFFFFFF	U32	r o	No
		The minimum communication cycle that can be set. This servo drive is 125000. *1) 1C32h-02h, please set 125000 (125μs) * n (n = 1,2,3 ... 16). If a value other than the set E would occur . Exx (synchronization cycle setting error protection).					
	06h	Calc and copy time	ns	0 ~ 0xFFFFFFFF	U32	r o	No
		Time from SM2 event, SYNC0 event to ESC read completion. This time can also be extended when there is a deviation in the signal. This servo drive is 25000.					
	0Ah	Sync0 cycle time	ns	0 ~ 0xFFFFFFFF	U32	r o	No
		When DC SYNC0 (1C32h-01h = 02h), the value of ESA register 09A0h is set. For DC other than SYNC0, set to 0					
	20h	Sync error	-	0 ~ 1	Bool	r o	No
		Not supported					

◆ Sync manager 3 synchronization

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
1C33h	00h	Number of sub-objects	-	0 ~ 255	U8	ro	No
		Represents the Subindex number of this object . The value is fixed at 20h.					
	01h	Sync mode	-	0 ~ 65535	U16	rw	No
		Set the sync mode of Sync Manager 3. Please set the same mode as Sync Manager 2. **00h** : FreeRun (not synchronized) **01h** : SM2 (synchronized with SM 2 Event) **02h** : DC SYNC0 (synchronized with Sync0 Event) **03h** : Not supported (cannot be set)					

According to the combination with the setting of ESC register 0981h (DC-Activation) (table below),

The settings of this object are automatically set when migrating from PreOP to SafeOP.

ESC register 0981h setting status	**1C32h-01h set value**	**⇒**	**Value of 1C32h-01h changed during migration from PreOP to SafeOP**
DC enable ON	00h: FreeRun		02h: DC SYNC0
	01h: SM2		02h: DC SYNC0
	02h: DC SYNC0		02h: DC SYNC0
DC enable OFF	00h: FreeRun		00h: FreeRun
	01h: SM2		01h: SM2
	02h: DC SYNC0		00h: FreeRun

02h	Cycle time	ns	0 ~ 0xFFFFFFFF	U32	rw	No
	Set the period of Sync Manager. Set to the same value as 1C32h-02h					
03h	Shift time	ns	0 ~ 0xFFFFFFFF	U32	rw	No
	Set the time from Sync0 event, SM2 event to the slave CPU writing RxPDO value to ESC. Set a value that is a multiple of 125000 and is smaller than the Cycle time. Usually 0.					
04h	Sync modes supported	-	0 ~ 65535	U16	r o	No
	Set the supported synchronization types. BIT0: FreeRun mode support 0: Not supported, 1: FreeRun mode supported This servo driver is set to 1. BIT1: SM synchronous mode support 0: Not supported, 1: SM2 event synchronization support This servo driver is set to 1. BIT4-2: DC synchronous mode support 000b: not supported 001b: DC sync0 event support This servo driver is set to 001b. BIT6-5: Output offset support 00b: Not supported 01b: Offset support for local clock This servo driver is set to 00b. BIT15-7: Reserved					
0 5 h	Minimum cycle time	n s	0 ~ 0xFFFFFFFF	U32	r o	No
	The minimum communication cycle that can be set. And 1C32h-05 to the same value.					
0 6 h	Calc and copy time	n s	0 ~ 0xFFFFFFFF	U32	r o	No
	Time from SM2 event, SYNC0 event to ESC register write completion.					

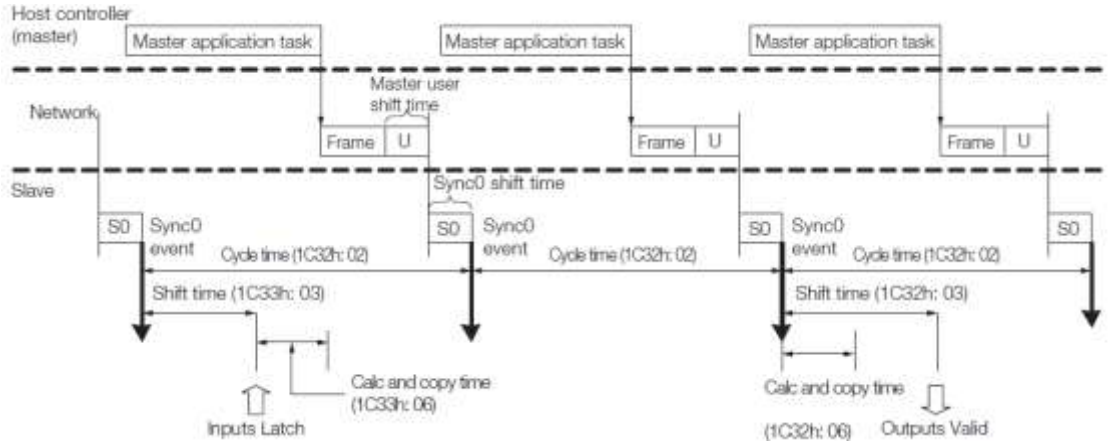
	0 A h	Sync0 cycle tim	n s	0 ~ 0xFFFFFFFF	U32	r o	No
		The same value as 1C32h-0Ah.					
	2 0 h	Sync error	-	0 ~ 1	B ool	r o	No
		Not supported					

3.6.2 DC mode (SYNC0 event synchronization)

In this mode, the local application is synchronized with the Sync0 time.

Synchronization method	Feature
Synchronize the time information of other slaves based on the time of the 1st axis	• High precision • Compensation processing is required on the master station side

The specifications of the DC synchronization mode in this servo driver are as follows.



This drive does not support Sync 1 time synchronization.

3.6.3 Free-Run

In this mode, the servo driver's local application cycle is independent of the communication cycle and the master cycle .

3.7 Emergency the Messages emergency message

The emergency message is in the servo driver (slave station), and when the abnormality (alarm) occurs, the slave station informs the master station based on the Mailbox communication.
No abnormality (alarm) occurs, and no notification is issued when a warning occurs.

The emergency message consists of 8 bytes of data.

Byte	0	1	2	3	4	5	6	7
content	Emergency Error Code (O D: 6 03Fh)		Error register (Object 1001h)	Error Field				
other	L byte	H byte		Panel Error Code		N / A		

1) Error code

Error code returns the same value as 603Fh (Error code).

0000h ~ FEFFh are defined according to IEC61800-7-201.

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
603Fh	00h	Error code	-	0 ~ 65535	U16	ro	TxPDO
		Alarm (only the main number) / warning that occurred in the servo driver . When alarms and warnings have not occurred, 0000h is displayed . When an alarm and a warning occur at the same time, the alarm is displayed.					

2) Error register

Error register returns the same value as 1001h (Error register).

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
1001h	00h	Error register	-	0 ~ 255	U8	ro	TxPDO

Displays the type (status) of the alarm that the servo driver is generating .

When the alarm does not occur, 0000h is displayed .

No warning is displayed.

B it	content
0	(Not supported)
1	
2	
3	
4	Alarm defined by AL status code * 1
5	(Not supported)
6	(reserved)
7	AL status code undefined alarm occurred * 2

* 1) "Alarm defined by AL status code" refers to an alarm related to an EtherCAT communication error .

* 2) "Al status code undefined alarm" refers to alarms other than EtherCAT communication related errors .

3) Panel Error Code

The value is the alarm number displayed on the current drive panel .

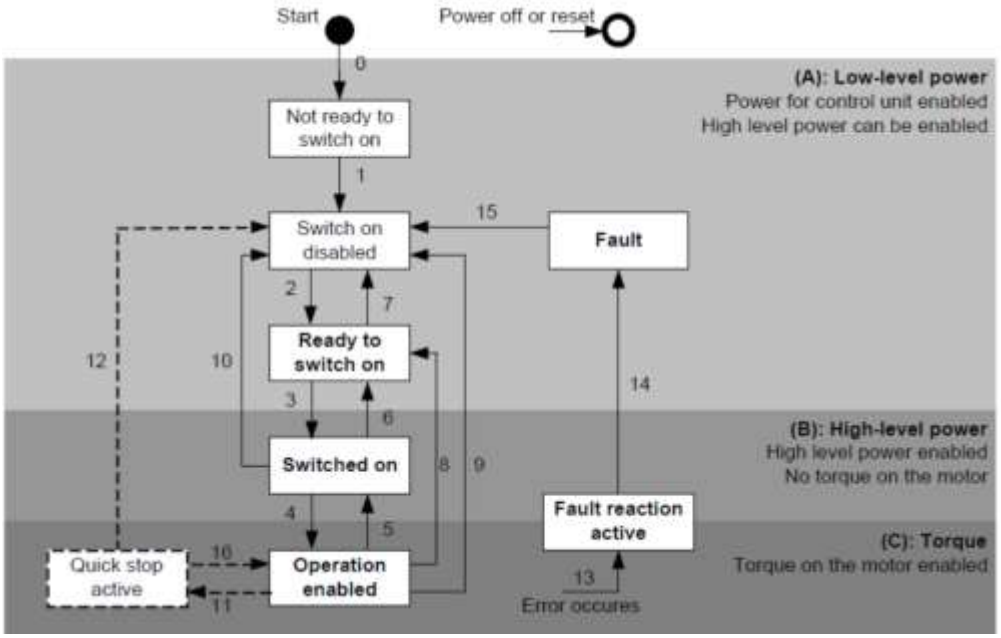
4. CiA 402 equipment protocol

4.1 CANopen over EtherCAT (CoE) state machine

The master station controls the DS1E servo drive through Controlword (control word, 0x6040), reads the current status of the drive by reading Statusword (status word, 0x6041), and the servo drive internally completes the motor control function according to the master station instruction.

CANopen over EtherCAT (CoE) state machine

The state transition (FSA (Finite State Automaton)) of the PDS (Power Drive Systems) associated with the power control of the servo drive is defined in the following figure based on user commands or abnormal detection .



State name	Description
Not Ready to Switch On	The drive is in the process of initialization.
Switch On Disabled	Drive initialization is complete.
Ready to Switch On	The driver is waiting to enter the Switch On state, and the motor is not excited.
Switched On	The driver is ready, and the main circuit power is normal.
Operation Enable	The driver is enabled and controls the motor according to the control mode.
Quick Stop Active	The drive stops according to the set mode.
Fault Reaction Active	The driver detects an alarm and stops according to the set mode. The motor still has an excitation signal at this time.
Fault	The drive is in a fault state and the motor has no excitation signal.

4.2 Equipment control related parameters

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6040 h	00h	Controlword	-	0 ~ 65535	U16	r w	RxPDO
6041 h	00h	Statusword	-	0 ~ 65535	U16	r o	TxPDO

4.2.1 Controlword (0x6040)

The command to control the slave station (servo driver), such as PDS state transition, is set by 6040h (control word).

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6040 h	00h	Controlword	-	0 ~ 65535	U16	r w	RxPDO

The 6040h control word includes the following:

1. bits for status control;

2. Bits related to the control mode;

3. Manufacturer-defined control bits ;

The details of each **bit** of **6040h** are as follows:

15 11	10 9	8	7	6 4	3	2	1	0
manufacturer specific	reserved	halt	Fault reset	Operation mode specific	Enable operation	Quick stop	Enable voltage	Switch on
O	O	O	M	O	M	M	M	M

MSB LSB

MSB: highest place LSB: lowest place
O: optional M: mandatory

BITS 0-3 AND 7 (bits for status control)

Command	Bit of the *controlword*					Transitions
	Fault reset	Enable operation	Quick stop	Enable voltage	Switch on	
Shutdown	0	X	1	1	0	2,6,8
Switch on	0	0	1	1	1	3*
Switch on	0	1	1	1	1	3**
Disable voltage	0	X	X	0	X	7,9,10,12
Quick stop	0	X	0	1	X	7,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	↑	X	X	X	X	15

X: irrelevant ; ↑ : rising edge

BITS 4, 5, 6 AND 8 (bits related to control mode):

Bit	Operation mode		
	Profile position mode	Profile velocity mode	Homing mode
4	New set-point	reserved	Homing operation start
5	Change set immediately	reserved	reserved
6	abs/rel	reserved	reserved
8	Halt	Halt	Halt

BITS 9, 10 : Spare.

BITS 11-15 : Customized by the manufacturer.

4.2.2 Statusword (0x6041)

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6041h	00h	Statusword	-	0 ~ 65535	U16	r o	TxPDO

The 6041h status word includes the following:

1. Current status bit of the drive;

2. Status bits related to the control mode;

3. Manufacturer-defined status bits ;

The detailed description of each **bit** of **6041h is** as follows:

Bit	Description	M / O
0	Ready to switch on	M
1	Switched on	M
2	Operation enabled	M
3	Fault	M
4	Voltage enabled	M
5	Quick stop	M
6	Switch on disabled	M
7	Warning	O
8	Manufacture specific	O
9	Remote	M
10	Target reached	M
11	Internal limit active	M
12 – 13	Operation mode specific	O
14 – 15	Manufacturer specific	O

BIT 0 – 3, 5, AND 6:

Value (binary)	State
xxxx xxxx x0xx 0000	Not ready to switch on
xxxx xxxx x1xx 0000	Switch on disabled
xxxx xxxx x01x 0001	Ready to switch on
xxxx xxxx x01x 0011	Switched on
xxxx xxxx x01x 0111	Operation enabled
xxxx xxxx x00x 0111	Quick stop active
xxxx xxxx x0xx 1111	Fault reaction active
xxxx xxxx x0xx 1000	Fault

X: irrelevant

BIT 4: Voltage enabled . When this bit is 1 , it indicates that the main loop power is normal.

BIT 7: Warning , when this bit is 1 , it means that the drive has an alarm;

BIT 8: DC Calibration Status . When this bit is 1 , it indicates that the internal clock of the driver is synchronized with DC Sync0 .

BIT 9: Remote . When this bit is 1 , it indicates that the slave station is in the OP state. The master station can remotely control the drive through PDO ;

BIT 10: Target reached , this bit has different meanings under different control modes;

BIT 11: Internal limit active , indicating position limit ;

BIT 12 AND 13: This bit has different meanings under different control modes ;

Bit	Operation mode		
	pp	pv	hm
12	Set-point Acknowledge	Speed	Homing attained
13	Following error	Max slippage error	Homing error

BIT 14: When this bit is 1 , it indicates the zero speed state of the motor ;

BIT 15: reserved ;

4.3 Control modes

DS1E servo drive currently supports 4 control modes in CoE :

- homing modes (Homing MODE)
- Cyclic Synchronous Position Mode
- cycle synchronization speed control mode (Cyclic Synchronous the Velocity MODE)
- cycle synchronization torque control mode (Cyclic Synchronous Torque MODE)

This section mainly describes the above several control methods.

4.4 Homing Mode

4 .4.1 Basic description

Homing mode finds the origin position for the driver. The user can set the operating speed of Homing mode.
Note: In this mode, you need to connect the limit switch and origin switch signal to the digital input terminal CN 3 of the driver . If the limit switch signal is connected to the host computer or PLC, you need to use the zero return process led by the host computer.

4.4.2 Parameters related to zero return mode

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6040 h	00h	Control word	-	0 ~ 65535	U16	rw	RxPDO
6041 h	00h	Statusword	-	0 ~ 65535	U16	ro	TxPDO
6060h	00h	Modes of operation	-	-128 ~ 127	I8	rw	RxPDO
6061h	00h	Modes of operation	-	-128 ~ 127	I8	ro	TxPDO
607Ch	00h	Homing offset	Instruction unit	- 80000000 ~ 7FFFFFFF	I32	rw	RxPDO
6098h	00h	Homing method	-	1 ~ 4 1 7 ~ 20 3 3 ~ 35	I8	rw	RxPDO
	・ If the setting value is not in this range, an error is returned.						
6099h	-	Homing speeds	-	-	-	-	-
	00h	Number of entries	-	2	U8	ro	NO
	01h	Speed during search for switch (PA54D)	0.1 rpm	0 ~ 30000	U32	rw	RxPDO
	02h	Speed during search for zero (PA54E)	0.1 rpm	0 ~ 30000	U32	rw	RxPDO
609A	00h	Homing acceleration (P A305 \ PA306)	-	0 ~ 10000	U32	rw	N O
	・ Set acceleration and deceleration in zero return control mode (hm). ・The deceleration of the zero return mode (hm) is also used for this object. ・When each Homing method is finally stopped (when the home position is detected), the setting of this object is not necessary, and the servo lock is stopped.						

Note: For a detailed description of each object, please refer to the CiA DS402 standard.

4.4.3 Controlword (0x6040) of Homing Mode

15 ~ 9	8	7 ~ 5	4	3 ~ 0
*	Halt	*	home_start_operation	*

* See previous chapter

Name	Value	Description
home_start_operation	0	Homing mode inactive
	0 → 1	Start homing mode
	1	Homing mode active
	1 → 0	Interrupt homing mode
Halt	0	Execute the instruction of bit 4
	1	Stop axle

4.4.4 Statusword (0x6041) of Homing Mode

15 ~ 14	13	12	11	10	9 ~ 0
*	homing_error	homing_attained	*	target_reached	*

* See previous chapter

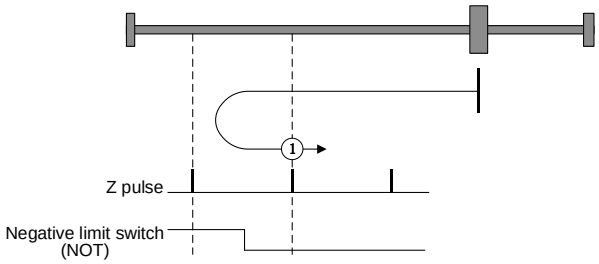
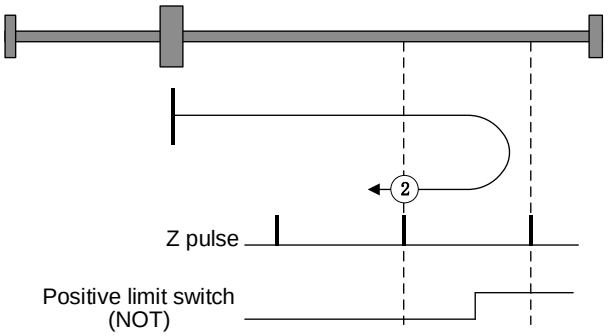
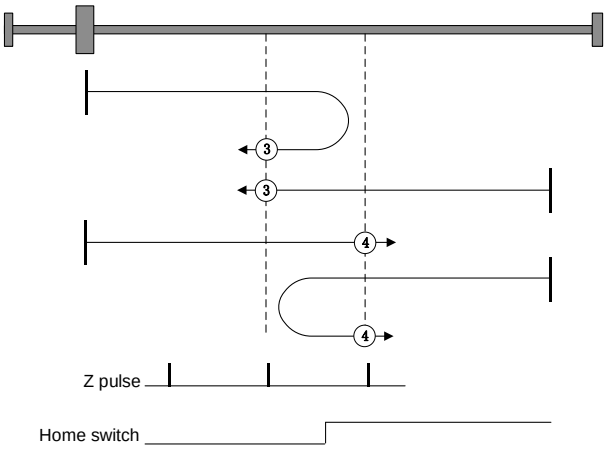
Name	Value	Description
Target reached	0	Halt = 0: Home position not reached Halt = 1: Axle decelerates
	1	Halt = 0: Home position reached Halt = 1: Axle has velocity 0
Homing attained	0	Homing mode not yet completed
	1	Homing mode carried out successfully
Homing error	0	No homing error
	1	Homing error occurred; Homing mode carried out not successfully; The error cause is found by reading the error code

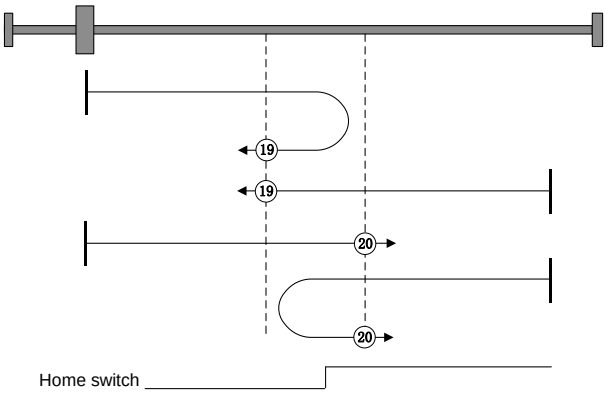
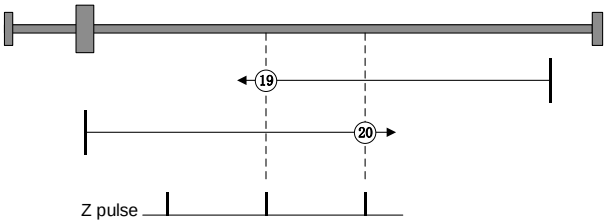
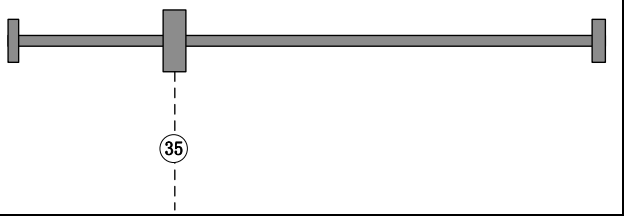
4.4.5 Zero return method

There are 4 types of signals related to the zero return mode: positive limit switch (POT), negative limit switch (NOT), reference point switch (Home Switch) and encoder Z signal (Z pulse).

Return to zero form

DS402	start up direction	aims position	Reference point	Detailed description

Zero return mode			**position**	
1	negative	N OT	Z pulse	Use Z pulse and negative limit switch: the driver first moves to the negative limit switch at high speed , decelerates and stops after reaching NOT, and returns at a slow speed to find the target zero position (the first Z pulse position of the encoder after leaving NOT) . 
2	positive	P OT	Z pulse	Using Z pulse and positive limit switch: The driver first moves to the positive limit switch at high speed , decelerates and stops after reaching the POT, and returns at a slow speed to find the target zero position (the first Z pulse position of the encoder after leaving the POT). 
3	positive	Home Switch	Z pulse	The initial movement of the driver depends on the switching state of the reference point. The target zero position is the first Z pulse position to the left or right of the reference switch. 
4	negative	Home Switch	Z pulse	

<table>
<tr><td>17</td><td>negative</td><td>N OT</td><td>N OT</td><td rowspan="4">These four kinds of zero return methods are similar to 1 ~ 4, except that the Z pulse is no longer used at the target zero position, and it is related to the change of the limit switch or reference switch (Home Switch).
The figure below is a schematic of 19 and 20, similar to methods 3 and 4.
 
</td></tr>
<tr><td>18</td><td>positive</td><td>P OT</td><td>P OT</td></tr>
<tr><td>19</td><td>positive</td><td>Home Switch</td><td>Home Switch</td></tr>
<tr><td>20</td><td>negative</td><td>Home Switch</td><td>Home Switch</td></tr>
<tr><td>33</td><td>negative</td><td>Z pulse</td><td>Z pulse</td><td rowspan="2">These two homing methods are only related to the Z pulse.
 
</td></tr>
<tr><td>34</td><td>positive</td><td>Z pulse</td><td>Z pulse</td></tr>
<tr><td>35</td><td>-</td><td>current position</td><td>current position</td><td>The current position is the system zero.
 
</td></tr>
</table>

4.4.6 Application Examples

When using Homing mode, the steps required are:

1. [Mode of operations: 6060h] set as an origin return mode (MODE Homing) (0x06) ;
2. Set [Home offset: 607Ch] ;
3. Set [Homing method: 6098h]. The setting range is 1 to 35. (Please refer to the definition of OD-6098h below) , this driver supports modes 1 ~ 4, 17 ~ 20, 33 ~ 35 ;
4. Set [Homing speeds: 6099h Sub-1], modified Homing process to find the limit switches speed (of 0 .1 RPM);
5. Set [Homing speeds: 6099h Sub-2], modified Homing process of looking for zero speed (of 0 .1 RPM);

6. Set zero acceleration PA 305 (unit: millisecond from 0rpm to maxspeed), deceleration PA 306 (unit: millisecond from maxspeed to 0rpm), which can be set through the driver panel, or through 3 305 h, 3 306 h (Note that PA 305 and PA 306 are also effective in speed mode);

7. Allocated according to the input signal back to zero mode, such as P OT signal (e.g., PA 502 . 10 = 02h), HomeSwitch signal (e.g., PA 500 . 10 = 15H) and the like;

8 . The [Controlword: 6040h] sequence is set to (0x06 - > 0x07 - > 0x0F), the On the drive Servo , and let the motor in operation ;

9 . The [Controlword: 6040h] sequence set (0x0F - > 0x1F), perform return to zero (Homing Operation Start (Bit4) from **0-> 1** to start, Homing Operation Start from **1-> 0** to interrupt Homing Process);

10. Read [Statusword: 6041h] to get the drive status. Bit 12 in 6041h is used to determine whether the Homing process is complete, and bit 13 is used to determine whether the Homing process is faulty.

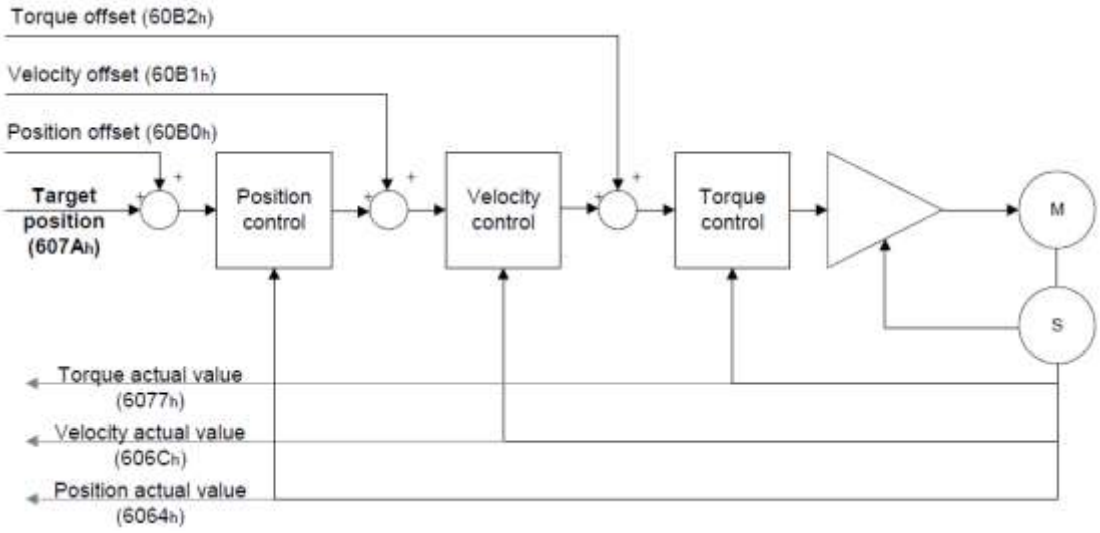
4.5 Cyclic Synchronous Position Mode

4.5.1 basic description

The host computer plans the path in the periodic synchronous position mode (Cyclic Synchronous Position Mode) and sends the PDO regularly. When transmitting each PDO, the target position and controlword data will be transmitted to the driver at the same time. . At the same time, the master station can provide additional speed offset (torque offset) and torque offset (torque offset) instructions .

Interpolation cycle defines the target position (the Target the Position) update time interval, in this mode, the synchronization interpolation cycle EtherCAT periphery of the same.

4.5.2 the CSP model function



4.5.3 Associated object model

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6040h	00h	Control word	-	0 ~ 65535	U16	rw	RxPDO
6041h	00h	Statusword	-	0 ~ 65535	U16	ro	TxPDO
6060h	00h	Modes of operation	-	-128 ~ 127	I8	rw	RxPDO
6061h	00h	Modes of operation	-	-128 ~ 127	I8	ro	TxPDO
6064h	00h	Position actual value	Instruction unit	8 0000000 ~ 7 FFFF FFF	I32	ro	TxPDO
6065 h	00h	Following error window	Instruction unit	0 ~ F FFFFFFF	U32	rw	RxPDO

6066 h	00h	Following error time out	1ms	0 ~ 65535	U16	rw	RxPDO
6067 h	00h	Position window	Instruction unit	0 ~ F FFFFFFF	U32	rw	RxPDO
6068 h	00h	Position window time	1ms	0 ~ 65535	U16	rw	RxPDO
606Ch	00h	Velocity actual value	0 .1rpm	8 0000000 ~ 7 FFFF FFF	I32	ro	RxPDO
6077h	00h	Torque actual value	0.1 %	8 000 ~ 7 FFF	I 16	ro	RxPDO
607 Ah	00h	Target position	Instruction unit	8 0000000 ~ 7 FFFF FFF	I32	rw	RxPDO
60B0h	00h	Position offset	Instruction unit	8 0000000 ~ 7 FFFF FFF	I32	rw	RxPDO
60B1h	00h	Velocity offset	0 .1rpm	8 0000000 ~ 7 FFFF FFF	I32	rw	RxPDO
60B2h	00h	Torque offset	0.1 %	8 000 ~ 7 FFF	I 16	rw	RxPDO

4.5.4 Controlword (0x6040) of the CSP Mode

15 ~ 9	**8**	**7 ~ 0**
*	Halt	*

* See previous chapter

Name	**Value**	**Description**
Halt	0	Execute the instruction of bit 4
	1	Stop axle

4.5.5 Statusword (0x6041) of the CSP Mode

15 ~ 14	**13**	**12**	**11 ~ 0**
*	following error	drive follows command value	*

* See previous chapter

Name	**Value**	**Description**
drive follows command value	0	In Servo OFF , POT , NOT , HALT, quickstop and other states, the position command is not executed.
	1	In other states, the position command is executed.
following error	0	No following error.
	1	Position following error occurred;

		CSP mode carried out not successfully;

4.5.6 Application Examples

1. Set the drive electronic gears PA 20 E, PA 210 (note that the electronic gear needs to be powered on again after modification) ; make the actual running position of the motor consistent with the commanded position. For example: For a 23-bit encoder motor, the command position command 1000 pulses to make the motor rotate once, then set PA20E = 2 ^ 23 = 8388608 and PA20E = 1000 . You can also set PA20E = 1000 and PA210 = 0 (the drive will automatically calculate the electronic gear ratio);

2 . Cycle power. Set [6060h: Mode of operations] to cyclic synchronous position mode (0x08) ;

3 . Successively arranged [6040h: Control Word] is (0x06 - > 0x07 - > 0x0F), so that the servo is ON;

3 . Setting [607Ah: the Target Position Cmd] motor operation target position (Unit: P the U- the U-);

4 . Query [6064h: the Position Actual value] to obtain the actual position of the motor feedback (Unit: P the U- the U-);

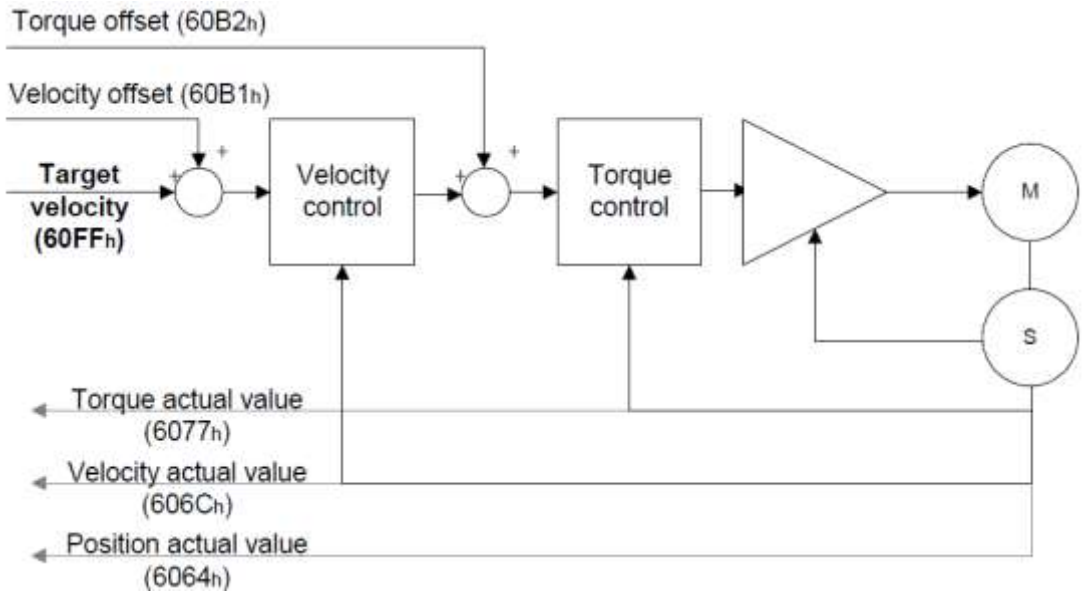
5 . Query [6041h: the Status Word] to obtain the state feedback servo drive (following error , target Reached and Internal LIMT Active);

4.6 Cyclic Synchronous Velocity Mode

4.6.1 basic description

PC cycle synchronous speed mode the speed of programming and periodically transmits PDO (Cyclic Synchronous Velocity Mode), when sending individual PDO, the number will be the target speed (target velocity) and control characters (Controlword) of data transmitted simultaneously to the drive . In addition, velocity offset and torque offset can be used as feedforward control settings for speed and torque.

4.6.2 Functions of CSV Mode



4.6.3 Associated object model

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6040h	00h	Control word	-	0 ~ 65535	U16	rw	RxPDO
6041h	00h	Statusword	-	0 ~ 65535	U16	ro	TxPDO
6060h	00h	Modes of operation	-	-128 ~ 127	I8	rw	RxPDO
6061h	00h	Modes of operation	-	-128 ~ 127	I8	ro	TxPDO
6064h	00h	Position actual value	Instruction unit	8 0000000 ~ 7 FFFFFFF	I32	ro	TxPDO
606Ch	00h	Velocity actual value	0 .1 rpm	- 60,000 - 60,000	I32	ro	TxPDO
60B1h	00h	Velocity offset	0 .1 rpm	- 60,000 - 60,000	I32	rw	RxPDO
60B2h	00h	Torque offset	0 .1 % of rated torque	- 3000 - 3000	I 16	rw	RxPDO
60FFh	00h	Target velocity	0 .1 rpm	- 60,000 - 60,000	I32	rw	RxPDO

4.6.4 Controlword (0x6040) of the CSV Mode

15 ~ 9	8	7 ~ 0
*	Halt	*

* See previous chapter

Name	Value	Description
Halt	0	Execute the instruction of bit 4
	1	Stop axle

4.6.5 Statusword (0x6041) of the CSV Mode

15 ~ 1 3	12	11 ~ 0
*	drive follows command value	*

* See previous chapter

Name	Value	Description
drive follows command value	0	In Servo OFF , POT , NOT , HALT, quickstop and other states, the speed command is not executed.
	1	In other states, the speed command is executed.

4.6.6 Application Examples

When using Profile Speed mode, the steps required are:

1. Set [6060h : Mode of operations] to Cyclic Synchronous Velocity Mode (0x09) ;

2 . Sequentially provided [6040h : Control Word] is (0x06 - > 0x07 - > 0x0F), so that the servo is ON;

3 . Setting 3305H , 3306H modified acceleration and deceleration time ;

4 . Set [60FFh : Target Velocity Cmd] as the target speed. Speed unit is 0 .1 RPM;

6 . Query [6064h : Position Actual value] to obtain the actual position of the motor feedback;

7 . Query [606CH : the Velocity Actual value] to obtain the actual motor speed feedback;

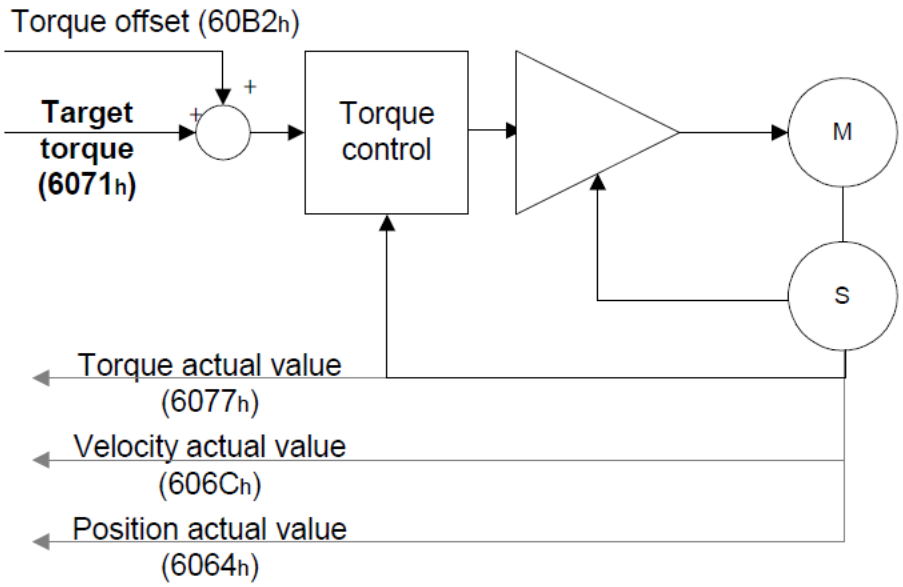
8 . Query [604h: StatusWord] to get the servo drive for status feedback (following error, target reached and internal limit active) .

4.7 Cyclic Synchronous Torque Mode

4.7.1 basic description

The host computer plans the torque in the Cyclic Synchronous Torque Mode. In this mode, the host computer will transmit the target torque and control word data to the driver at the same time when transmitting each PDO . In addition, the torque offset can be set as the torque feedforward control.

4.7.2 CST function mode



4.7.3 Other objects

1. Set [6072h : Max torque] to modify the maximum torque limit (unit: 0.1% of rated torque);
2. Query [6074h : Torque demand value] to get the internal actual torque command (unit: 0.1% of rated torque);
3. Query [6076h : Motor rated torque] to get the rated torque of the motor (unit: m*Nm);
4. Query [6077h : Torque actual value] to obtain actual torque feedback (unit: 0.1% of rated torque);
5. Query [6078h : Current actual value] to get the actual output current (unit: 0.1% of rated torque) .

4 .7.4 Associated object model

Index	Sub	Name / Description	Units	Range	Data Type	Access	PDO
6040h	00h	Control word	-	0 ~ 65535	U16	r w	RxPDO
6041h	00h	Statusword	-	0 ~ 65535	U16	r o	TxPDO
6060h	00h	Modes of operation	-	-128 ~ 127	I8	rw	RxPDO
6061h	00h	Modes of operation	-	-128 ~ 127	I8	ro	TxPDO

6064h	00h	Position actual value	Instruction unit	8 0000000 ~ 7 FFFFFFF	I32	ro	TxPDO
6071h	00h	Target torque	0.1%	-32768 ~ 32767	I16	rw	RxPDO
6072h	00h	Max torque	0.1%	0 ~ 65535	U 16	rw	NO
6073h	00h	Max current	0.1%	0 ~ 65535	U 16	ro	NO
6 074h	00h	Torque demand value	0.1%	0 ~ 65535	U 16	ro	NO
6075h	00h	Motor rated current	mA	0 ~ F FFFFFFF	U32	ro	NO
6076h	00h	Motor rated torque	m n • M	0 ~ F FFFFFFF	U32	ro	NO
6077h	00h	Torque actual value	0.1%	-32768 ~ 32767	I16	ro	TxPDO
6078h	00h	Current actual value	0.1%	-32768 ~ 32767	I16	ro	TxPDO
6079h	00h	DC link circuit voltage	mV	0 ~ F FFFFFFF	U32	ro	NO
607Fh	00h	Max Profile Velocity	0 .1rpm	0 ~ F FFFFFFF	U32	ro	NO

4.7.5 Application examples

When using Cyclic synchronous Torque mode, the steps required are:

1. Set [6060h : Mode of operations] to **10** (Cyclic synchronous torque mode);
2. Set [6040h : Control word] to enable the servo driver and start the motor;
3. Set [6071h : Target torque] to set the target torque (unit: 0.1% of rated torque);
4. Set PA 407 to set the maximum speed (unit rpm) in torque mode ;
5 . Setting [60 87 H : Torque Slope } to modify the torque ramp time.
6 . Setting [6072h : Max Torque] is set to the maximum torque limit (unit: 0.1% rated torque);
7 . Query [6041h : Status Word] to get the servo drive for status feedback (Target Reached) .

5. Object Dictionary

All objects are configured with a 16-bit Index , which is a 4-digit hexadecimal representation, and is configured in the object dictionary for each group.

The DS1E series object dictionary structure is shown below.

DS1E Series Object Dictionary		
Index	**content**	**other**
0000h ~ 0FFFh	Data type area	
1000h ~ 1FFFh	COE communication area	
2000h ~ 2FFFh	Servo parameter area (storage)	
3000h ~ 3FFFh	Servo parameter area (not stored)	
4000h ~ 4FFFh	Reserved	
5000h ~ 5FFFh	Reserved	
6000h ~ 6FFFh	Drive profile area	

5.1 Object Specifications

Object name	**meaning**
VAR	Single variable value, such as: UNSIGNED8, Boolean, float, INTEGER16, etc.
ARRY	An array of multiple data consisting of elementary variables of the same type. Sub-index 0 is a UNSIGNED8 type, which indicates the number of data in the array and is not used as part of the ARRAY data.
RECORD	A structure made up of basic variables of the same type or different types. Sub-index 0 is a UNSIGNED8 type, which indicates the number of data in the structure, and is not used as part of the RECORD data.

5 .2 List of 1000 h target dictionaries

Index	**Object Type**	**Name**	**Data Type**	**Access**
1000 h	VAR	device type	UNSIGNED32	RO
1001 h	VAR	error register	UNSIGNED8	RO
1600h ~ 1603h	RECORD	Receive PDO mapping	UNSIGNED32	RW
1A00h ~ 1A03 h	RECORD	Transmit PDO mapping	UNSIGNED32	RW
1C12h	RECORD	RxPDO assign	-	RW
1C13h	RECORD	TxPDO assign	-	RW

5.2 2000-3000h custom object dictionary list

Index	Object Type	Name	Data Type	Access
2000h ~ 2636h	VAR	Corresponding parameter PA000 ~ PA 636 note: 1. These parameters will be saved after the EtherCAT communication is modified. Do not modify it frequently, which will cause damage to the EEPROM. In addition , do not modify the parameter within 1S before power off . 2. Only 220Eh(PA20E), 2210h(PA210), 2301h (PA301), 2305h(PA305), 2306h(PA306), 2550h (PA 550) and other parameters are supported at this stage .	View corresponding parameters	RW
3000h ~ 3636h	VAR	note: 1,These parameters will not be saved after EtherCAT communication and power off; 2. Only 320Eh(PA20E), 3210h(PA210), 3216h(PA216), 3217h (PA217), 3305h (PA305), and 3306h (PA306) are supported at this stage.	View corresponding parameters	RW
3DF0h	VAR	Drive software version 0x 0100 means the version is V 1.00 0x 0200 means the version is V 2.00	UNSIGNED 16	RO
3DF1h	VAR	Driver rated power in W	UNSIGNED 16	RO
3DF2h	VAR	Rated current drive unit 0 .1 A	UNSIGNED 16	RO
3DF3h	VAR	Motor rated power in W	UNSIGNED 16	RO
3DF4h	VAR	Encoder resolution 17-bit encoder is 131072 ; The 23-bit encoder is 8388608 ;	UNSIGNED 32	RO
3DF5h	VAR	The rated motor current in 0 .1 A	UNSIGNED 16	RO
3DF6h	VAR	The rated motor speed in 0 .1 RPM	UNSIGNED 16	RO
3DF7h	VAR	The maximum motor speed in 0 .1 RPM	UNSIGNED 16	RO
3DF8h	VAR	Motor rated torque in 0.01 NM	UNSIGNED 16	RO
3DF9h	VAR	Motor maximum torque percentage,%	UNSIGNED 16	RO
3E00h	VAR	Motor position, encoder unit, low 3 2 digits	UNSIGNED 32	RO
3E01h	VAR	Motor position, encoder unit, high 3 2 digits	UNSIGNED 32	RO
3E02h	VAR	Encoder single-turn absolute value, encoder unit,	UNSIGNED 32	RO
3E03h	VAR	Encoder multi-turn data	UNSIGNED 16	RO

3E06h	VAR	Command position, encoder unit, lower 3 2 bits	UNSIGNED 32	RO
3E07h	VAR	Command position, encoder unit, high 3 2 digits	UNSIGNED 32	RO
3E08h	VAR	Encoder absolute position (user unit)	INTEGER32	RO
3EE1h	VAR	Alarm number (consistent with the display on the driver panel)	UNSIGNED 16	RO

5.3 6000H Object Dictionary List

Index	Object Type	Name	Data Type	Access	Mappable
603Fh	VAR	Error Code	UNSIGNED16	RO	Y
6040h	VAR	Controlword	UNSIGNED16	RW	Y
6041h	VAR	Statusword	UNSIGNED16	RO	Y
6060h	VAR	Modes of operation	INTEGER8	RW	Y
6061h	VAR	Modes of operation display	INTEGER8	RO	Y
6062h	VAR	Position demand value	INTEGER32	RO	Y
6063h	VAR	Position actual internal value	INTEGER32	RO	Y
6064h	VAR	Position actual value	INTEGER32	RO	Y
6065h	VAR	Following error window	UNSIGNED32	RW	Y
6066h	VAR	Following error time out	UNSIGNED16	RW	Y
6067h	VAR	Position window	UNSIGNED32	RW	Y
6068h	VAR	Position window time	UNSIGNED16	RW	Y
606Bh	VAR	Velocity demand value	INTEGER32	RO	Y
606Ch	VAR	Velocity actual value	INTEGER32	RO	Y
606Dh	VAR	Velocity window	UNSIGNED16	RW	Y
606Eh	VAR	Velocity window time	UNSIGNED16	RW	Y
606Fh	VAR	Velocity threshold	UNSIGNED16	RW	Y
6070h	VAR	Velocity threshold time	UNSIGNED16	RW	Y
6071h	VAR	Target torque	INTEGER16	RW	Y
6072h	VAR	Max torque	UNSIGNED16	RW	Y
6074h	VAR	Torque demand value	INTEGER16	RO	Y
6077h	VAR	Torque actual value	INTEGER16	RO	Y
6078h	VAR	Current actual value	INTEGER16	RO	Y
607Ah	VAR	Target position	INTEGER32	RW	Y
607Bh	ARRAY	Position range limit	INTEGER32	RW	N
607Ch	VAR	Home offset	INTEGER32	RW	Y
607Dh	ARRAY	Software position limit	INTEGER32	RW	N
607Eh	VAR	Polarity	UNSIGNED8	RW	Y
607Fh	VAR	Max profile velocity	UNSIGNED32	RW	Y
6087h	VAR	Torque slope	UNSIGNED32	RW	Y
6098h	VAR	Homing method	INTEGER8	RW	Y
6099h	ARRAY	Homing speeds	UNSIGNED32	RW	N
609Ah	VAR	Homing acceleration	UNSIGNED32	RW	Y

60B0h	VAR	Position offset	INTEGER32	RW	Y
60B1h	VAR	Velocity offset	INTEGER32	RW	Y
60B2h	VAR	Torque offset	INTEGER32	RW	Y
60F4h	VAR	Following error actual value	INTEGER32	RO	Y
60FAh	VAR	Control effort	INTEGER32	RO	Y
60FCh	VAR	Position demand value*	INTEGER32	RO	Y
60FDh	VAR	Digital inputs	UNSIGNED32	RO	Y
60FFh	VAR	Target velocity	INTEGER32	RW	Y
6502	VAR	Supported drive modes	UNSIGNED32	RO	Y

5.4 Object Dictionary List details

Object 1000h: Device Type

INDEX	1000_h
Name	device type
Object Code	VAR
Data Type	UNSIGNED32
Access	RO
PDO Mapping	No
Value Range	UNSIGNED32
Default Value	04020192_h: A2 Series

Object 1001h: Error Register

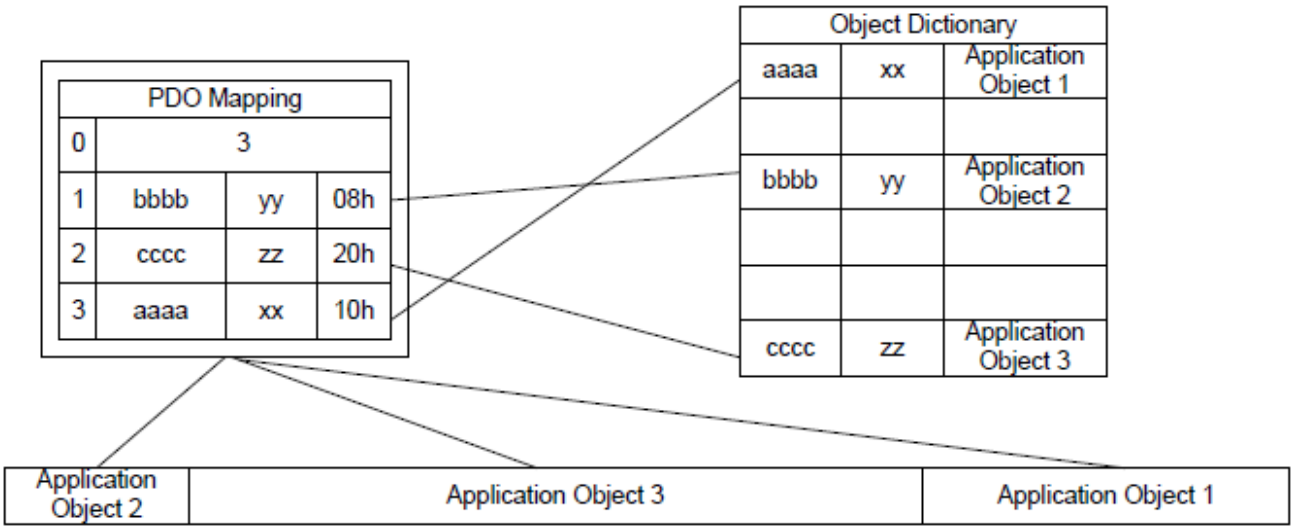
INDEX	1001_h
Name	error register
Object Code	VAR
Data Type	UNSIGNED8
Access	RO
PDO Mapping	Yes
Value Range	UNSIGNED8
Default Value	0

Object 1600h ~ 1603h: Receive PDO Mapping Parameter

INDEX	1600_h ~ 1603_h
Name	Receive PDO mapping
Object Code	RECORD
Data Type	PDO Mapping
Access	RW
PDO Mapping	No

Sub-Index	0
Description	Number of mapped application objects in PDO
Data Type	UNSIGNED8
Access	RW
PDO Mapping	No
Value Range	0: deactivated 1~8: activated
Default Value	0

Sub-Index	1~8
Description	PDO mapping for the nth application object to be mapped
Data Type	UNSIGNED32
Access	RW
PDO Mapping	No
Value Range	UNSIGNED32
Default Value	0



Object 1A00h ~ 1A03h: Transmit PDO Mapping Parameter

INDEX	$1A00_h$ ~ $1A03_h$
Name	Transmit PDO mapping
Object Code	RECORD
Data Type	PDO Mapping
Access	RW
PDO Mapping	No

Sub-Index	0
Description	Number of mapped application objects in PDO
Data Type	UNSIGNED8
Access	RW
PDO Mapping	No
Value Range	0: deactivated 1~8: activated
Default Value	0

Sub-Index	1~8
Description	PDO mapping for the nth application object to be mapped
Data Type	UNSIGNED32
Access	RW
PDO Mapping	No

Value Range	UNSIGNED32
Default Value	0

Object 1C12h : RxPDO assign

INDEX	$1C12_h$
Name	RxPDO assign
Object Code	RECORD
Data Type	PDO Mapping assign
Access	RW
PDO Mapping	No
Sub-Index	0
Description	Number of assigned PDO mapping
Data Type	UNSIGNED8
Access	RW
PDO Mapping	No
Value Range	0：停用 1：指派一个 PDO 映射作为 RxPDO
Default Value	1
Sub-Index	1
Description	Index of assigned PDO mapping
Data Type	UNSIGNED16
Access	RW
PDO Mapping	No
Value Range	1600_h to 1603_h
Default Value	1600_h

Object 1C13h : TxPDO assign

INDEX	$1C13_h$
Name	TxPDO assign
Object Code	RECORD
Data Type	PDO Mapping assign
Access	RW
PDO Mapping	No

Sub-Index	0
Description	Number of assigned PDO mapping
Data Type	UNSIGNED8
Access	RW
PDO Mapping	No
Value Range	0：stopped use 1：Assign a PDO mapping as TxPDO
Default Value	1

Sub-Index	1
Description	Index of assigned PDO mapping
Data Type	UNSIGNED16
Access	RW
PDO Mapping	No
Value Range	$1A00_h$ to $1A03_h$
Default Value	$1A00_h$

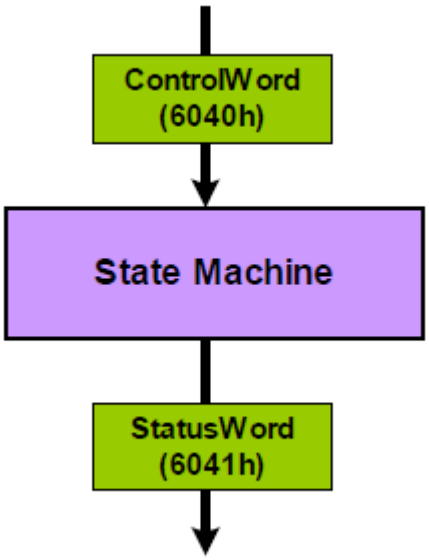
Object 603Fh: Error code (error code of CANopen defined)

INDEX	$603F_h$
Name	Errorcode
Object Code	VAR
Data Type	UNSIGNED16
Access	RO
PDO Mapping	Yes
Value Range	UNSIGNED16
Default Value	0

Object 6040h: Controlword

INDEX	6040_h
Name	Controlword
Object Code	VAR
Data Type	UNSIGNED16
Access	RW

PDO Mapping	Yes
Value Range	UNSIGNED16
Default Value	Default is 0x0000



State machine in system context

Bit definition table

15 ~9	8	7	6 ~ 4	3	2	1	0
N / A	Halt	Fault reset	Operation mode specific	Enable operation	Quick Stop (B-contact)	Enable voltage	Switch on

The user can gradually set 6040h to 0x0006> 0x0007> 0x000F to start the servo.

Bit	HM	CSP	CSV	CST
4	Homing operation start (positive trigger)	N / A	N / A	N / A
5	N / A	N / A	N / A	N / A
6	N /	N /	N /	N /

	A	A	A	A

Object 6041h: Statusword

INDEX	6041_h
Name	Statusword
Object Code	VAR
Data Type	UNSIGNED16
Access	RO
PDO Mapping	Yes
Value Range	UNSIGNED16
Default Value	0

Data Description

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

Bit definition table

0	Ready to switch on			
1	Switch on			
2	Operation enabled (status of servo on)			
3	Fault (the drive will servo off)			
4	Voltage enabled			
5	Quick stop			
6	Switch on disabled			
7	Warning (the drive is still servo on)			
8	N / A			
9	Remote			
10	Target reached			
11	Internal limit active (Not supported)			
	HM	CSP	CSV	CST

12	Homing attained	drive follows command value	drive follows command value	drive follows command value
13	Homing error	N / A	N / A	N / A
14	N / A	N / A	N / A	N / A
15	N / A	N / A	N / A	N / A

Object 6060h: Modes of operation

INDEX	6060_h
Name	Modes of operation
Object Code	VAR
Data Type	INTEGER8
Access	RW
PDO Mapping	Yes
Value Range	INTEGER8
Default Value	0
Comment	0: Reserved 1: Profile position mode 3: Profile velocity mode 4: Profile torque mode 6: Homing mode 7: Interpolated position mode 8: Cyclic synchronous position mode 9: Cyclic synchronous velocity mode 10: Cyclic synchronous torque mode

Object 6061h: Modes of operation display

INDEX	6061_h
Name	Modes of operation display
Object Code	VAR
Data Type	INTEGER8
Access	RW

PDO Mapping	Yes
Value Range	INTEGER8
Default Value	0

Object 6062h: Position demand value

INDEX	6062_h
Name	Position demand value
Object Code	VAR
Data Type	INTEGER32
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	位置命令，Unit：PUU

Object 6063h: Position actual internal value

INDEX	6063_h
Name	Position actual Internal value*
Object Code	VAR
Data Type	INTEGER32
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	Unit：PUU

Object 6064h: Position actual value

INDEX	6064_h
Name	Position actual value
Object Code	VAR
Data Type	INTEGER32
Access	RO

PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	Unit：PUU

Object 6065h: Following error window

INDEX	6065_h
Name	Following error window
Object Code	VAR
Data Type	UNSIGNED32
Access	RW
PDO Mapping	Yes
Value Range	UNSIGNED32
Default Value	3840000
Comment	Unit：PUU

Object 6067h: Position window

INDEX	6067_h
Name	Position window
Object Code	VAR
Data Type	UNSIGNED32
Access	RW
PDO Mapping	Yes
Value Range	UNSIGNED32
Default Value	100
Comment	Unit：PUU

Object 6068h: Position window time

INDEX	6068_h
Name	Position window time
Object Code	VAR
Data Type	UNSIGNED16

Access	RW
PDO Mapping	Yes
Value Range	UNSIGNED16
Default Value	0
Comment	Unit：millisecond

Object 606Bh: Velocity demand value

INDEX	$606B_h$
Name	Velocity demand value
Object Code	VAR
Data Type	INTEGER32
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Comment	Unit：0.1 rpm

Object 606Ch: Velocity actual value

INDEX	$606C_h$
Name	Velocity actual value
Object Code	VAR
Data Type	INTEGER32
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Comment	Unit：0.1 rpm

Object 606Dh: Velocity window

INDEX	$606D_h$
Name	Velocity window
Object Code	VAR
Data Type	INTEGER16
Access	RO

PDO Mapping	Yes
Value Range	0~3000
Default Value	100
Comment	Unit：0.1 rpm

Object 606Eh: Velocity window time

INDEX	$606E_h$
Name	Velocity window time
Object Code	VAR
Data Type	UNSIGNED16
Access	RW
PDO Mapping	Yes
Value Range	UNSIGNED16
Default Value	0
Comment	Unit：millisecond

Object 6071h: Target torque

INDEX	6071_h
Name	Target torque
Object Code	VAR
Data Type	INTEGER16
Access	RW
PDO Mapping	Yes
Value Range	-3000~3000
Default Value	0
Comment	Unit：one rated torque in a thousand

Object 6074h: Torque demand value

INDEX	6074_h
Name	Torque demand value
Object Code	VAR
Data Type	INTEGER16

Access	RO
PDO Mapping	Yes
Value Range	INTEGER16
Comment	Unit：one rated torque in a thousand

Object 6077h: Torque actual value

INDEX	6077_h
Name	Torque actual value
Object Code	VAR
Data Type	INTEGER16
Access	RO
PDO Mapping	Yes
Value Range	INTEGER16
Comment	Unit：one rated torque in a thousand

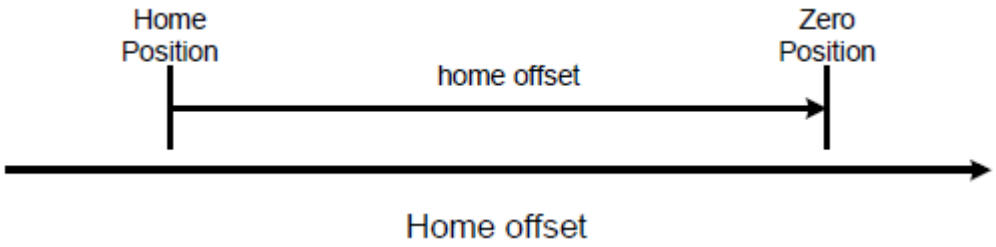
Object 607Ah: Target position

INDEX	$607A_h$
Name	Target position
Object Code	VAR
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	For Profile position mode 6060h = 1 Unit：PUU

Object 607Ch: Home offset

INDEX	$607C_h$
Name	Home offset
Object Code	VAR
Data Type	INTEGER32

Access	RW
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	Unit：PUU



Object 607Dh: Software position limit

INDEX	$607D_h$
Name	Software position limit
Object Code	ARRAY
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes

Sub-Index	0
Description	Number of entries
Data Type	UNSIGNED8
Access	RO
PDO Mapping	Yes
Value Range	2
Default Value	2
Sub-Index	1
Description	Min position limit
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes
Value Range	-2147483648 ~ +2147483647
Default Value	-2147483648
Comment	Unit：PUU

Sub-Index	2
Description	Max position limit
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes
Value Range	-2147483648 ~ +2147483647
Default Value	+2147483647
Comment	Unit：PUU

Object 6087h: Torque slope

INDEX	6087_h
Name	Torque slope
Object Code	VAR
Data Type	UNSIGNED32
Access	RW
PDO Mapping	Yes
Value Range	UNSIGNED32
Default Value	0
Comment	Unit：millisecond (time from 0 to 100％ rated torque)

Object 6098h: Homing method

INDEX	6098_h
Access	RO
PDO Mapping	Yes
Value Range	2
Default Value	2

Sub-Index	1
Description	Speed during search for switch
Data Type	UNSIGNED32
Access	RW
PDO Mapping	Yes
Value Range	1~2000rpm

Default Value	100
Comment	Unit：0.1 rpm

Sub-Index	2
Description	Speed during search for zero
Data Type	UNSIGNED32
Access	RW
PDO Mapping	Yes
Value Range	1~500rpm
Default Value	20
Comment	Unit：0.1 rpm

Object 60B0h: Position offset

INDEX	$60B0_h$
Name	Position offset
Object Code	VAR
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	Unit：PUU

Object 60B1h: Velocity offset

INDEX	$60B1_h$
Name	Velocity offset
Object Code	VAR
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes
Value Range	INTEGER32
Default Value	0
Comment	Unit：0.1 rpm

Object 60B2h: Torque offset

INDEX	$60B2_h$
Name	Torque offset
Object Code	VAR
Data Type	INTEGER16
Access	RW
PDO Mapping	Yes
Value Range	3000 ~ -3000
Default Value	0
Comment	Unit：one rated torque in a thousand

Object 60F2h: Positioning option code

INDEX	$60F2_h$
Name	Positioning option code
Object Code	VAR
Data Type	UNSIGNED16
Access	RW
PDO Mapping	Yes
Value Range	UNSIGNED16
Default Value	0

Object 60F4h: Following error actual value

INDEX	$60F4_h$
Name	Following error actual value
Object Code	VAR
Data Type	INTEGER32
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Comment	Unit：PUU

Object 60FCh: Position demand value*

INDEX	$60FC_h$
Name	Position demand value*
Object Code	VAR
Data Type	INTEGER32
Access	RO
PDO Mapping	Yes
Value Range	INTEGER32
Comment	Unit：increment

Object 60FDh: Digital inputs

INDEX	$60FD_h$
Name	Digital inputs
Object Code	VAR
Data Type	UNSIGNED32
Access	RO
PDO Mapping	Yes
Value Range	UNSIGNED32
Default Value	0

Object function:

Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Bit	Features	Description
Bit 0	Negative limit signal	-
Bit 1	Positive limit signal	-
Bit 2	Origin return signal	-
Bit 3	HWBB	Signal blocked due to safety terminal base

Bit 4 ~ 31	-	Keep

Object 60FFh: Target velocity

INDEX	$60FF_h$
Name	Target velocity
Object Code	VAR
Data Type	INTEGER32
Access	RW
PDO Mapping	Yes
Value Range	INTEGER32
Comment	单位：0.1 rpm

Object 6502h: Supported drive modes

INDEX	6502_h
Name	Supported drive modes
Object Code	VAR
Data Type	UNSIGNED32
Access	Ro
PDO Mapping	Yes
Value Range	UNSIGNED32
Default Value	$3A0_h$

31	16	15	7	6	5	4	3	2	1	0
Manufacturer specific		reserved		ip	hm	reserved	tq	pv	vl	pp
MSB										LSB

6. EtherCAT communication example

This example uses TwinCAT 3.1 software developed by Beckhoff as the real-time master station .

Please prepare before testing:

• Confirm the NIC model and install the NICs required for testing correctly.

• Install TwinCAT software from Beckhoff .

• Copy the device description file (.XML file) to the C: \ TwinCAT \ 3.1 \ Config \ Io \ EtherCAT directory.

• After you finish copying the device description file, restart the TwinCAT software. (Other settings in TwinCAT use are not explained here .)

Then follow these steps:

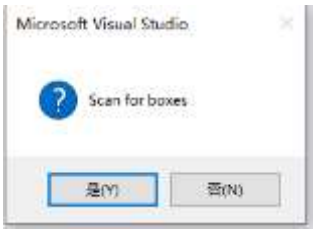
1. Create a new project. After launching TwinCAT software, select "File"- > "New"- > "Project" ;

2. Select "TwinCAT Projects" and select the storage path;

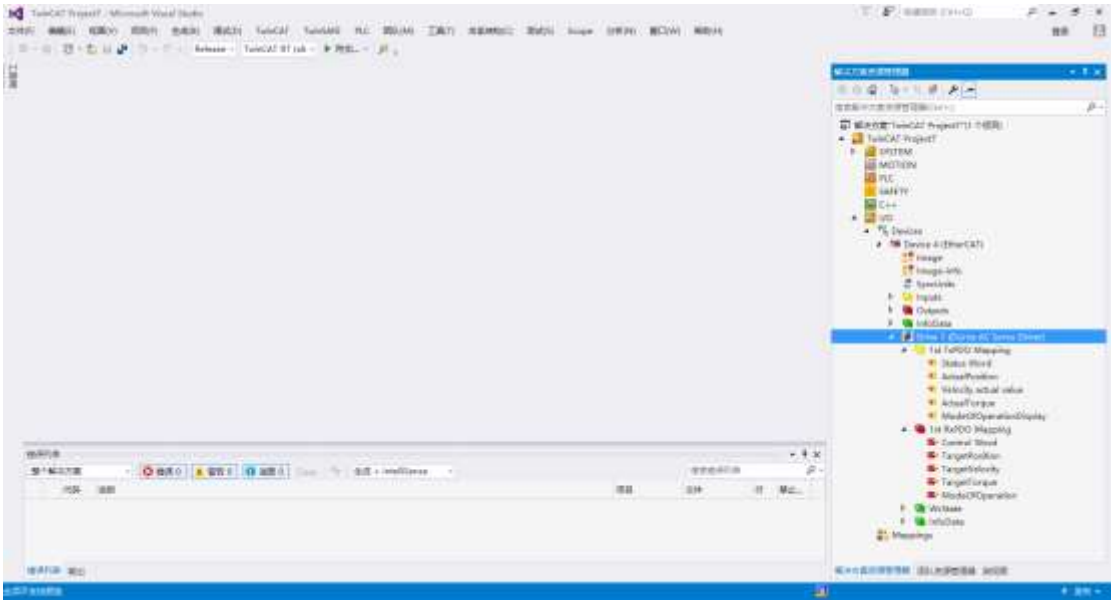
3. After completing the above operations, select "I /O "- > "Devices" in the "Solution Explorer " ;

4. Right- click on " Devices " and select "Scan" to scan the lower computer ;

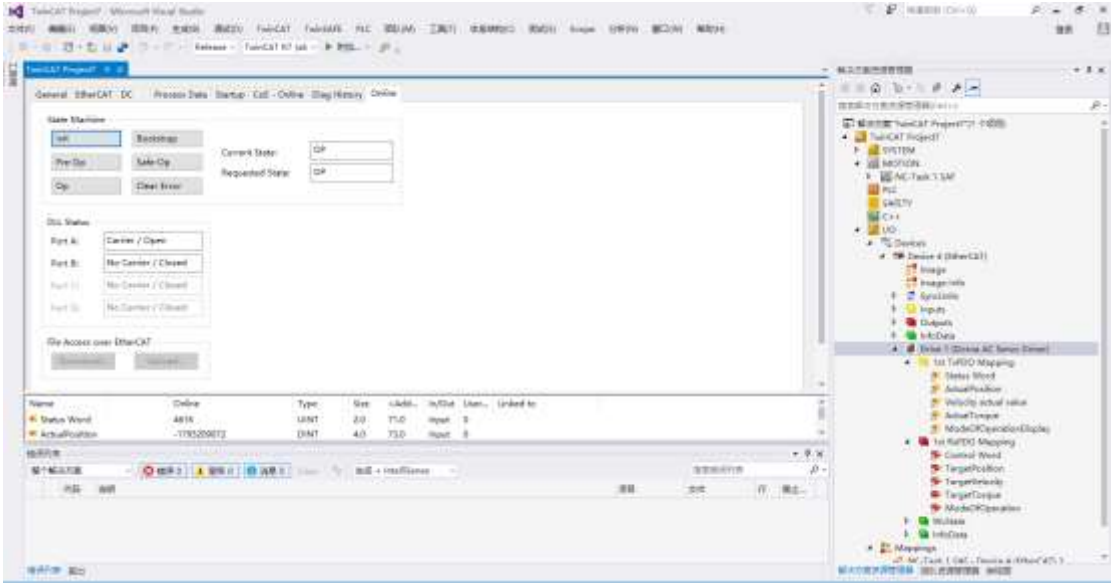
5. After selecting the corresponding network port, some prompts will appear. Select "Yes" and "NC ".



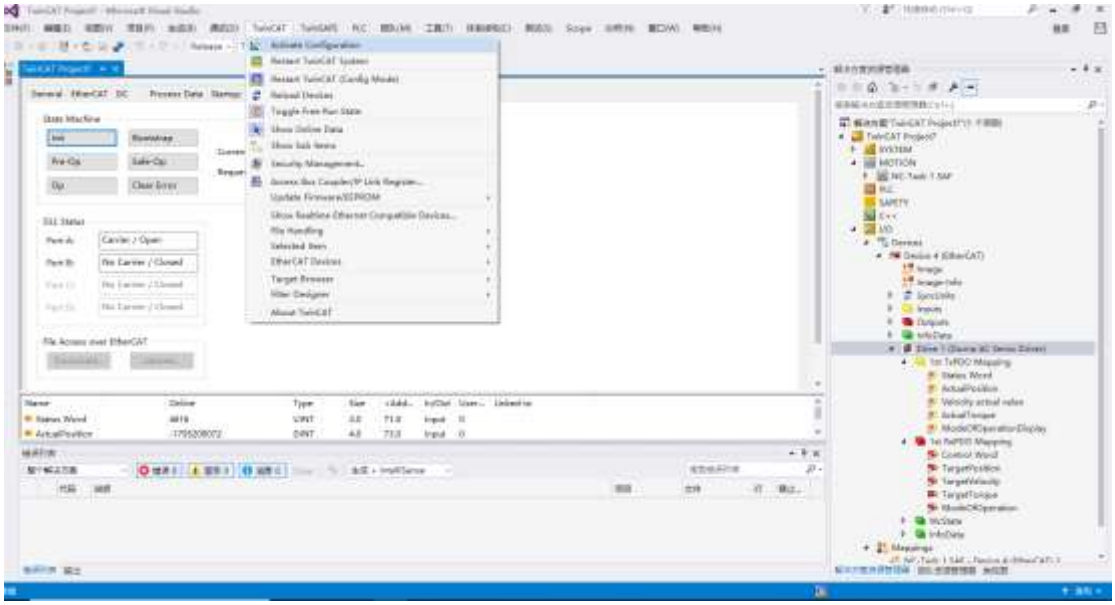
6. After the operation is completed, if the lower computer is successfully scanned, click "Drive 1 ", as shown below;



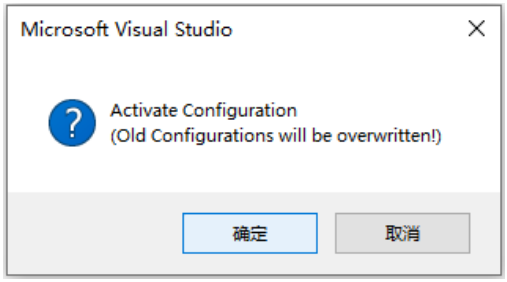
7. Double-click "Drive 1 " to display the status of Drive 1 and the network communication status of EtherCAT in the "Online" interface;

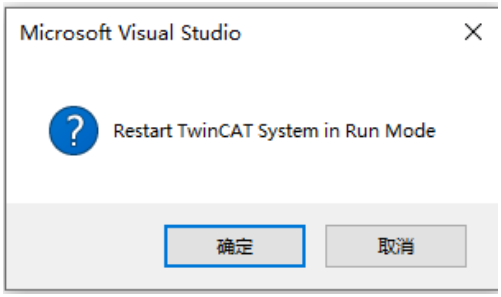


8. Select "TwinCAT"- > "Activate Configuration" in the main menu to enable the NC function;

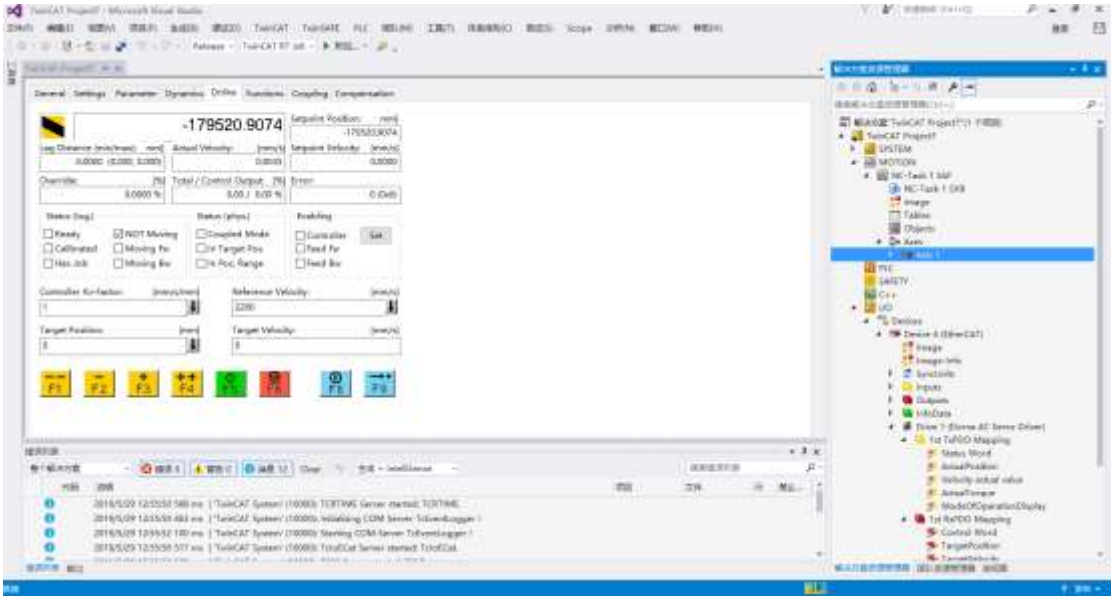


9. After the above operations are completed, some prompts will appear, select "Yes (Y)";

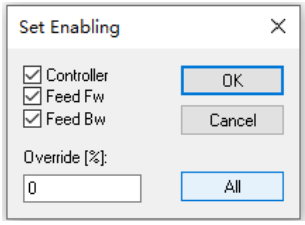




10. In N C mode, double click “Axis 1 ”, it will display as below;

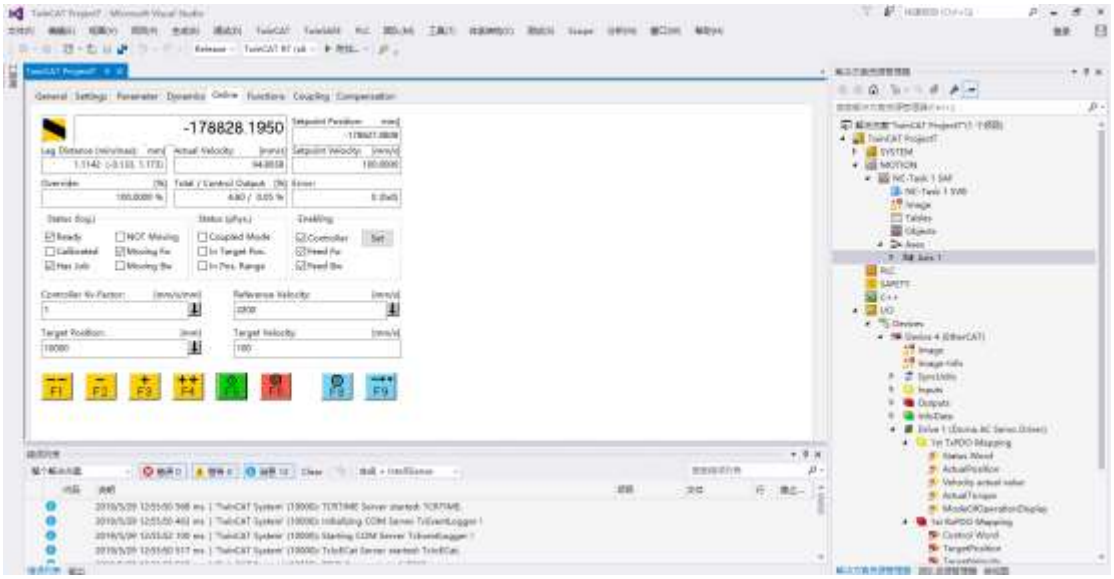


11. Enable the servo through communication and select all the contents of the "SET " box;



12. After the servo is enabled, the servo panel displays "run";

13. Input Target Position and Target velocity;



14, and then press F5, the position and speed can be set to run.

7. Parameters

For detailed description of the parameters, please refer to " DORNA DS1 User Manual".

There are several things to explain:

1. The electronic gear parameters of the driver are valid in the communication mode. PA20E (electronic gear numerator, PA 210 (electronic gear denominator)) can be set after calculation according to the user unit , and it will be effective after re-power on

2, in the EtherCAT communication speed unit is 0 .1 RPM;

3, in the EtherCAT communication, the torque units to 0 .1 % of rated torque;

8. Failure and diagnosis

8.1 EtherCAT communication failure list

Emergency Object

Emergency Object

Byte	0	1	2	3	4	5	6	7
Content	Emergency Code		Error register	Panel	Alarm	Code	N/A	

Alarm number	Alarm name	Alarm content	alarm reset
E .810	Communication interrupted	EtherCAT communication is disconnected .	6040h fault reset
E .813	Communication synchronization failed	Synchronous communication with the host computer failed .	6040h fault reset
E .814	RxPDO communication timeout	The driver did not receive any RxPDO within the set communication cycle .	6040h fault reset
E .815	Communication synchronization instruction timed out	The target position command was not received within 4 consecutive communication cycles. If the field interferences, and can not be excluded by hardware, it may amplify P A020 of the communication cycle to the discharge width E .815 trigger conditions.	6040h fault reset

8.2 Driver alarm list

The alarm list lists the alarm names, alarm contents, and whether or not the alarm can be reset in the order of alarm numbers.

Whether alarm reset

Yes: The alarm can be cleared through alarm reset. However, if the alarm factor still exists, it cannot be removed.

No: Unable to dismiss the alarm

Alarm number	Alarm name	Alarm content	alarm reset
E .020	Parameter check abnormal 1	The parameter data of the servo driver is abnormal.	no
E .021	Parameter check abnormal 2	The parameter data of the servo driver is abnormal.	no
E .022	Parameter memory read and write abnormal	The parameter memory in the servo drive is not read or written properly .	no

E .030	Parameter value is abnormal	The servo drive parameters are out of range.	no
E .040	Parameter setting failure	Beyond the setting range	no
E .042	Parameter combination failure	Parameter combination failure	no
E .0 A 0	Combination error	Outside combinable motor capacity (capacity mismatch)	can
E .0A2	Motor and drive mismatch	Mismatch of voltage type of motor and driver, etc.	can
E .0B3	Internal chip communication error 1	Communication error between internal chips	no
E .0B4	Internal chip communication error 2	Communication error between internal chips	no
E .0F0	Product is not supported	An unsupported product is connected	no
E .100	Overcurrent detection	Power transistor overcurrent or heat sink overheating.	no
E .120	Motor overload (transient overload)	The motor is operated for several seconds to several tens of seconds with a torque exceeding the rated value.	can
E .121	Drive overload (transient overload)	The drive is operated for several seconds to several tens of seconds with a torque that greatly exceeds the rated value.	can
E .130	Motor overload (continuous overload)	The motor is continuously running with torque exceeding the rated value.	can
E .131	Drive overload (continuous overload)	The drive is continuously running with torque exceeding the rated value.	can
E.136	Motor collision error	When the collision protection is turned on, the motor load exceeds the set value.	can
E .180	Overvoltage	The DC voltage of the main circuit is abnormally high.	can
E .190	Undervoltage	The DC voltage of the main circuit is insufficient.	can
E .250	Current detection failure 1	The current detection circuit is faulty.	no
E .252	Current detection failure 2	The current detection circuit is faulty.	no
E .300	Abnormal regeneration	The regeneration circuit is faulty.	no
E .320	Regeneration overload	A regeneration overload has occurred.	can
E .340	Inrush current limiting resistor overload	The main circuit power-on frequency is too high.	no
E .360	Heat sink overheating	The heat sink of the drive is too hot.	can
E .500	Encoder communication failure	Communication encoder communication failure	no

E .502	Encoder communication error multiple times	Encoder communication encountered multiple errors	no
E .504	Encoder communication check error	Communication type communication data check error	can
E .505	Encoder communication frame error 1	Communication type encoder communication frame error (driver side)	can
E .506	Encoder communication frame error 2	Communication frame communication frame error (encoder side)	can
E .507	Encoder communication frame error 3	Communication encoder communication data error	can
E .510	Incremental encoder disconnected	Incremental encoder cable disconnected	no
E .512	Incremental encoder phase error	Incremental encoder phase error	no
E .530	Encoder and calibration alarm	Sum check result of communication type encoder memory is abnormal	can
E .532	Encoder parameter is abnormal	Parameter of communication encoder is abnormal	can
E .550	Encoder count error 1	Communication type encoder count error 1.	can
E .552	Multiturn encoder error	Communication type multi-turn encoder error.	can
E .554	Encoder overspeed	Communication type multi-turn encoder over speed error.	can
E .555	Encoder count error 2	Communication multi-turn encoder count is incorrect.	can
E .556	Encoder count overflow	Communication type multi-turn encoder count overflow error.	can
E .558	Encoder multi-turn data error	Communication multi-turn encoder multi-turn data error.	can
E .55A	Encoder battery alarm	Communication multi-turn encoder low battery voltage alarm	can
E .600	Signal input time failure for safety function	The signal input time of the safety function is abnormal.	no
E .810	EtherCAT communication interrupted	EtherCAT communication is disconnected .	can
E .813	EtherCAT communication failed	EtherCAT synchronization communication with the host computer failed .	can
E .814	EtherCAT communication RxPDO timeout	The drive did not receive any RxPDO within the set EtherCAT communication cycle .	can
E .815	EtherCAT communication synchronization instruction timeout	In continuous within four EtherCAT communication cycle target position	can

		command is not received. If the site interference is large and cannot be eliminated by hardware .	
E .A00	out of control	Detected servo motor out of control	can
E .A10	Speeding	Motor speed exceeds maximum speed	can
E .A20	Vibration alarm	Detected abnormal vibration of motor speed.	can
E .A22	Auto-adjust alarm	Vibration was detected during automatic adjustment.	can
E .A30	Excessive position deviation alarm	In the servo ON state, the position deviation exceeds the excessive position deviation alarm value (P A 520).	can
E .A31	Excessive position deviation alarm when servo ON	When the position deviation during servo OFF exceeds the set value of the excessive position deviation alarm value (P A 526) at servo ON, the servo remains on.	can
E .A32	Excessive position deviation due to speed limitation when servo ON	When the servo is turned on in the position deviation accumulation state, the speed limit is executed by the speed limit value (P A 52 9) when the servo is turned on . When the command pulse is input in this state, the set value of the excessive position deviation alarm value (P A 520) is exceeded without releasing the limit .	can
E .A90	Servo ON command invalid alarm	After executing the auxiliary function of energizing the motor, a servo ON input (S-ON) signal was input from the host device.	can
E .AA2	Main circuit power alarm	The main circuit power supply has an ON → OFF → ON phenomenon, and PA00D.0 != 0 .	can
E .AB0	Overtravel alarm	When the servo detects an overtravel and PA00D.3 = 2 , it will alarm.	can
E .F00	System alarm 0	Internal servo program error 0 occurred.	no
E .F01	System alarm 1	An internal program error 1 of the servo driver occurred .	no
E .F02	System alarm 2	An internal program error 2 of the servo driver has occurred .	no
E .F03	System alarm 3	An internal program failure 3 of the servo driver has occurred .	no

8.3 SDO Error Message List

Abort Code	Description
05040001h	Servo command is invalid or does not exist
06010002h	Attempt to write to a read-only object
06020000 h	Object does not exist in the object dictionary
06040041h	Object cannot be mapped to PDO
06040042h	The number of objects and length of the image exceeds the length of the PDO
06060000h	Access failure due to hardware error (store or restore error)
06070010h	Data type does not match; parameter length does not match
06090011h	Sub-index does not exist
06090030h	Parameter value is out of range (write)
08000000h	General error
08000020h	Cannot transfer data or store data in the application
08000021h	Data cannot be transferred due to restrictions (stored or restored in the wrong state) or stored in the application
08000022h	Object in use