XINJE

DP3CL series open loop bus stepping driver

User manual

Wuxi Xinje Electric Co., Ltd.

Data No. D3C07 20211218 1.0

Basic description

- Thank you for purchasing Xinje DP3CL series stepping driver. Please read this product manual carefully before operating.
- The manual mainly provides the user with relevant guidance and instructions for the correct use and maintenance of the step driver. The manual involves the function, use method, installation and maintenance of the step driver.
- The contents described in the manual are only applicable to Xinje's DP3CL series stepping driver products.

Notice to user

This manual is applicable to the following personnel:

- The installation personnel of stepper driver
- Engineering and technical personnel (electrical engineers, electrical operators, etc.)
- The designer

Before operating or debugging the stepper driver, the above personnel should carefully read the safety precautions section of this manual.

Statement of responsibility

- Although the contents of the manual have been carefully checked, errors are inevitable and we can not guarantee that they are completely consistent.
- We will always check the contents of the manual and make corrections in subsequent versions. We welcome your comments.
- The contents described in the manual are subject to change without prior notice.

Contact us

If you have any questions about the use of this product, please contact the agent and office that purchased the product, or contact Xinje company directly.

- Tel: 400-885-0136
- Fax: 0510-85111290
- Address: 4th Floor, building 7, creative industry park, No. 100 Dicui Road, Wuxi City
- Postcode: 214072
- Website: www.xinje.com

December 2020

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1. Product introduction

1-1. Model naming rule

Take DP3CL-705 as an example:

DP3CL - 70 5

① ② ③

① : DP3CL series open loop bus stepping driver
② : Driver output maximum peak current 7A
③ : The maximum supply voltage of the driver is 50VDC

1-2. Performance

- Support COE (CANopen over EtherCAT) protocol, conform to CiA402 standard, support 32-axis, support master station with standard EtherCAT protocol, and the communication period between master and slave station can reach 32-axis 1ms.
- The network cable replaces the traditional pulse direction signal cable, and also has power cable and encoder cable, which is simple in wiring. It can reduce the cost of cable, labor and maintenance greatly.
- Relying on the low bus load of EtherCAT bus and the point-to-point physical layer, it can greatly suppress the generation of interference and clutter, and significantly improve the reliability and anti-interference ability of the system.
- EtherCAT bus technology combined with the latest control algorithm has greatly improved the performance.

1-3. Electrical specification

Driver model		DP3CL-305	DP3CL-705	DP3CL-808
Input power supply voltage (VDC)		20-50	20-50	20-80
Output peak current (A)		1-3	1-7	1-8
Matched motor (base)		42	57/60	86
Input signal		origin input, positive and negative limit, emergency stop, clear alarm, user-defined input		
Output signal		Alarm output, holding brake signal output, custom output		
Alarm function		Overcurrent, overvoltage, abnormal communication, etc		
Debugging software		Xinje stepper driver software		
Using environment	Application area	Try to avoid dust, oil mist and corrosive gas, places with high humidity and strong vibration, and combustible gas and conductive dust are prohibited		
	Environment temperature	0℃~50℃		
	Max working temperature	60℃		
	Humidity	40%~90% RH (No condensation or water droplets)		
	Vibration	5.9m/s^2 Max		
	Storage temperature	-25℃～70℃		

1-4. Safety caution

(1) The driver must be installed and operated by professional technicians!

(2) The input voltage of the driver must meet the technical requirements!

(3) It is strictly forbidden to plug and unplug the power terminal of the driver with electricity. When the motor stops, there is still a large current flowing through the coil. Pulling and unplugging the power terminal will produce a huge instantaneous induction, and the electric potential will burn out the driver!

(4) Before power on, please ensure the connection correctness and firmness of power cable, motor cable and signal cable!

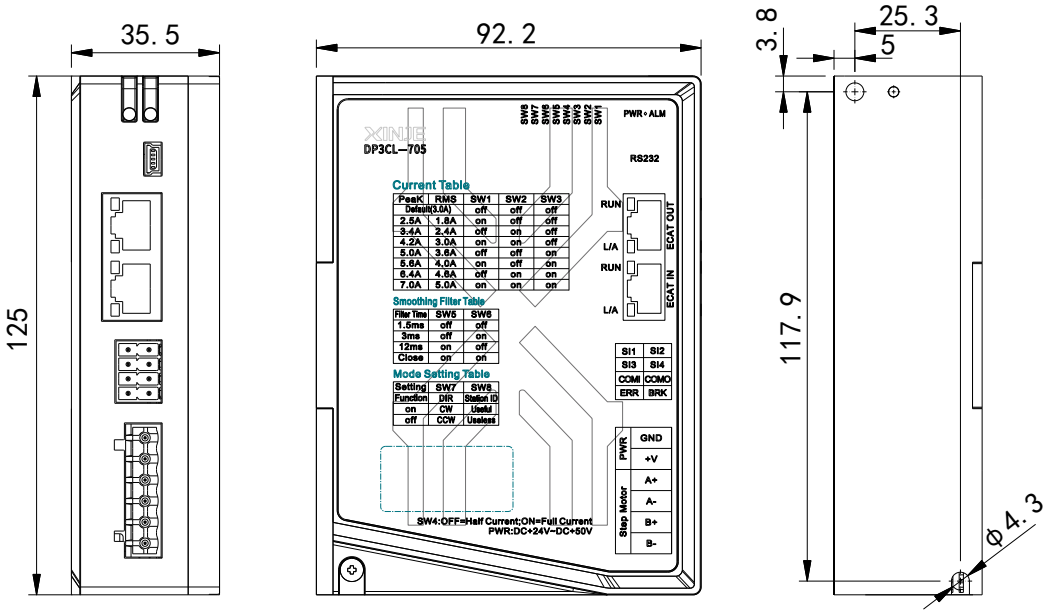
(5) Avoid electromagnetic interference!

2. Installation and wiring

2-1. Installation

2-1-1. Dimension

- DP3CL-305, DP3CL-705, DP3CL-808 Unit: mm

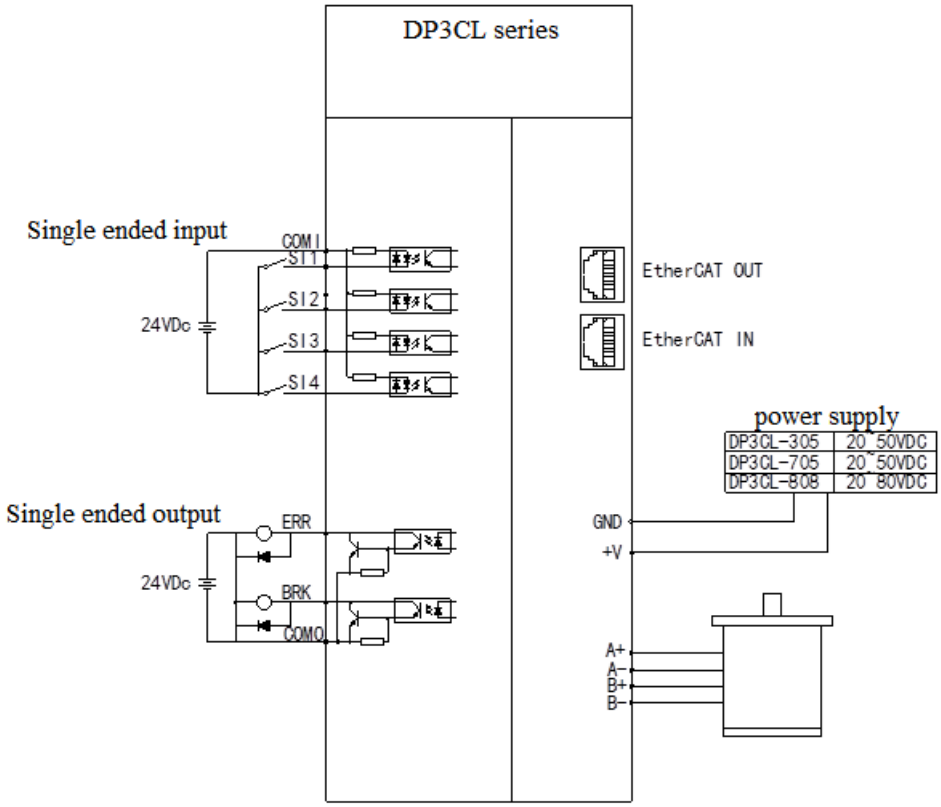


2-1-2. Installation environment

The reliable working temperature of the driver is usually within 60℃, and the working temperature of the motor is within 80℃. To ensure that the driver works within the reliable working temperature range, the driver shall be installed in an electric cabinet with good ventilation and proper protection. If necessary, a fan shall be installed near the driver to dissipate heat forcibly, so as to avoid using in the occasions of dust, oil mist, corrosive gas, too high humidity and strong vibration.

2-2. Wiring

2-2-1. Typical wiring diagram



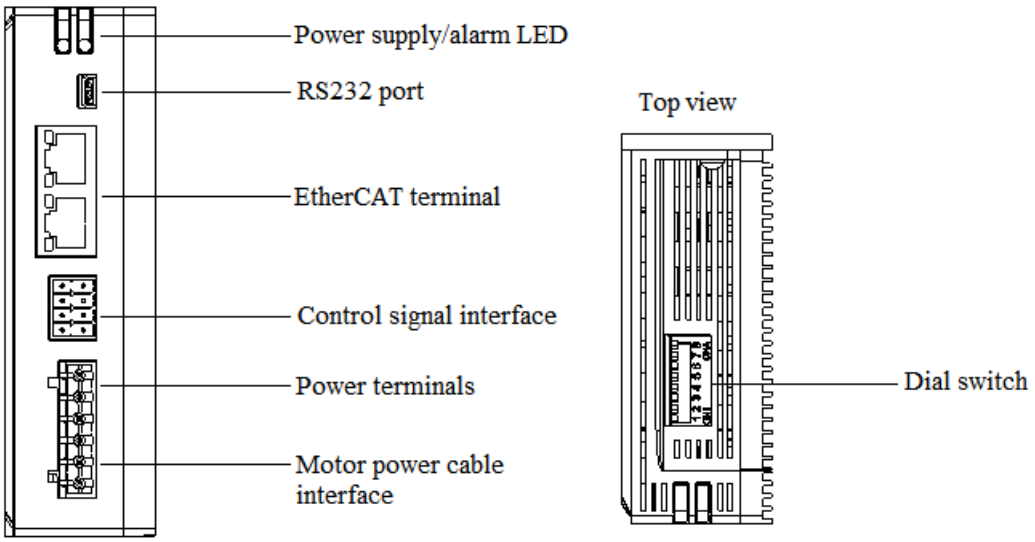
2-2-2. Wiring caution

(1) Please wiring according to the terminal voltage and polarity to prevent equipment damage and personal injury. The DC driver power supply cannot be reversed.

(2) If one power supply supplies multiple drives, parallel connection shall be adopted at the power supply side, and chain connection from one to another is not allowed.

(3) The wiring head shall not be exposed outside the terminal to prevent accidental short circuit from damaging the driver.

3. Driver interface



3-1. Alarm information and solution

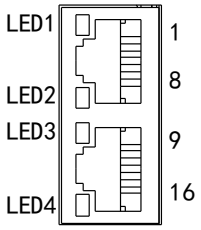
The green LED is the power indicator, which is always on when the driver is powered on. This LED goes off when the drive is powered off.

The red LED is a fault indicator lamp. In case of a fault, the indicator lamp flashes continuously, pauses for one second and then flashes continuously. When the fault is cleared by the user, the red LED is always off. The number of consecutive flashes of red LED represents different fault information, and the specific relationship is shown in the following table.

Flashing	Fault	Reason and solution
Blink once	Over current or short circuit	The possible causes of alarm are: wrong wiring, short circuit of the driver, electromagnetic interference, check the wiring and power on again to clear the alarm
Blink twice continuously	Over voltage	When the driver voltage exceeds the specified voltage, it will enter overvoltage protection. At this time, it is necessary to reduce the power supply and power on again to clear the alarm
Flashes continuously for 3 times	Under voltage	The default parameter is set to 0. The undervoltage alarm is not enabled, and the user can set the undervoltage alarm threshold
Flashes continuously for 4 times	Motor open circuit or poor contact	Detect the motor status when the power on motor parameters are automatically adjusted. During operation, do not detect the motor disconnection and other information. Check the wiring, power on again, and clear the alarm
Always on	Alarm related to EtherCAT	Use the stepping driver software or check the bus alarm information at the PLC end

Note: Since the driver does not have the protection function of reverse connection of the positive and negative poles of the power supply, please confirm the correct connection of the positive and negative poles of the power supply again before powering on. The reverse connection of the positive and negative poles will cause the fuse in the driver to burn out.

3-2. EtherCAT terminals

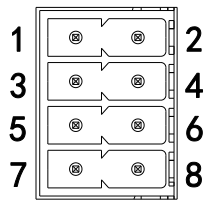
Graphic	Pin	Name	Explanation
	1, 9	E_TX+	EtherCAT data send +
	2, 10	E_TX-	EtherCAT data send -
	3, 11	E_RX+	EtherCAT data receive +
	4, 12	/	/
	5, 13	/	/
	6, 14	E_RX-	EtherCAT data receive -
	7, 15	/	/
	8, 16	/	/
Note: LED1 and LED3 are "RUN" status lights. The yellow light is on during normal connection, but it is not on after connection failure. LED2 is the "L/A OUT" status light. LED4 is the "L/A IN" status light.			

Note: the cable length between EtherCAT bus nodes is recommended to be no more than 50m. It is recommended to use CAT5E Ethernet cable with double-layer shielding or better.

Ethernet port light definition

Name	Color	Status	Description
RUN	Yellow light	ON	Connection normal
		OFF	Connection abnormal
L/A OUT	Green light	ON	Physical layer link establishment
		OFF	Physical layer link not established
		Flash	Interactive data after link establishment
L/A IN	Green light	ON	Physical layer link establishment
		OFF	Physical layer link not established
		Flash	Interactive data after link establishment

3-3. Control signal interface

Graphic	Pin	Name	I/O	Explanation
	1	SI1	Input	Single ended input signals IN1~IN4, 12~24V are valid, the maximum input frequency is 10KHz, and the signal definition is configurable. IN1 defaults to clear alarm, and IN2, IN3, and IN4 defaults to positive and negative limit and origin. COMI is the common terminal of single end input signal, common anode or common cathode
	2	SI2	Input	
	3	SI3	Input	
	4	SI4	Input	
	5	COMI	Input	
	6	COMO	Output	Output signal common GND
	7	ERR	Output	Err single ended output, maximum current 50mA, withstand voltage 30VDC
	8	BRK	Output	Holding brake output, maximum current 500mA, withstand voltage 30VDC, can be directly connected to holding brake without relay

3-4. Strong electricity interface

Interface	Function	Explanation
GND	DC power supply ground	DC power supply ground
＋V	DC power supply +	Select voltage according to demand
A+, A-	Motor phase A coil	Swap A+, A - to change the running direction of the motor
B+, B-	Motor phase B coil	Swap B+, B - to change the running direction of the motor

Note:

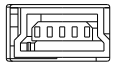
DP3CL-305 range: 20~50VDC: recommended value: 24~36VDC.

DP3CL-705 range is 20~50VDC: the recommended value for 57 motors is 24~36VDC, and the recommended value for 86 or high-speed application scenarios is 48V.

DP3CL-808 range: 20~80VDC: above 48V is recommended.

3-5. Software communication interface

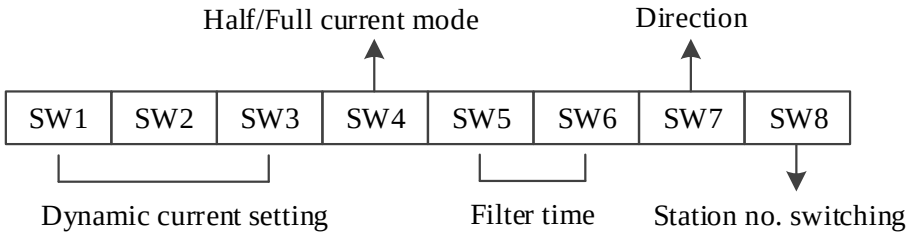
The definition of RS232 interface pin arrangement is shown in the following table:

Diagram	Pin	Function	Notes
	1	TXD	RS232 send
	2	RXD	RS232 receive
	3	GND	RS232 ground

Note: please use the cable supplied by Xinje company.

RS232 default communication parameters: baud rate 19200bps, 8 data bits, 1 stop bit, even parity, station no.1.

3-6. Dial switch



3-6-1. Working (dynamic) current setting

- DP3CL-305

Output peak current	Output average current	SW1	SW2	SW3
Default (1.0A)		OFF	OFF	OFF
0.56A	0.4A	ON	OFF	OFF
0.84A	0.6A	OFF	ON	OFF
1.4A	1.0A	ON	ON	OFF
1.82A	1.3A	OFF	OFF	ON
2.1A	1.5A	ON	OFF	ON

2.66A	1.9A	OFF	ON	ON
3.0A	2.1A	ON	ON	ON

- DP3CL-705

Output peak current	Output average current	SW1	SW2	SW3
Default (3A)		OFF	OFF	OFF
2.5A	1.8A	ON	OFF	OFF
3.4A	2.4A	OFF	ON	OFF
4.2A	3.0A	ON	ON	OFF
5A	3.6A	OFF	OFF	ON
5.6A	4.0A	ON	OFF	ON
6.4A	4.6A	OFF	ON	ON
7A	5.0A	ON	ON	ON

- DP3CL-808

Output peak current	Output average current	SW1	SW2	SW3
Default (4.4A)		OFF	OFF	OFF
2.7A	1.6A	ON	OFF	OFF
3.6A	2.3A	OFF	ON	OFF
4.6A	3.2A	ON	ON	OFF
5.5A	3.7A	OFF	OFF	ON
6.4A	4.4A	ON	OFF	ON
7.3A	5.2A	OFF	ON	ON
8.4A	6.0A	ON	ON	ON

3-6-2. Static current setting

SW4 dial switch can set the static current.

SW4	OFF	Half current mode, the static current is set to half of the dynamic current
	ON	Full current mode, static current is the same as dynamic current

3-6-3. Filter time setting

Filter time	SW5	SW6
1.5ms (default, software)	OFF	OFF
3ms	OFF	ON
12ms	ON	OFF
Close	ON	ON

3-6-4. Direction setting

Dial switch	Function	ON	OFF
SW7	DIR	CW	CCW

3-6-5. Station no. setting

Dial switch	Function	ON	OFF
SW8	Station no. selection	SW1-SW7 can set the station no.	SW1-SW7 can use for filter and current adjustment

SW8 is the station number and general function selector switch, for default OFF state, SW1-SW7 can be used for current and filtering adjustment.

After SW8 is set to ON, select the function of dialing to set station number, SW1-SW7 combination to select station number, and write the new station number after dialing modification, power off holding. After the station number is modified, the new station number has been written into the driver, and SW8 can be set to OFF to select other general function settings.

When SW8 is set to OFF, the description of SW1-SW7 dial setting station number is as follows:

Set the station no.	SW7	SW6	SW5	SW4	SW3	SW2	SW1
0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	OFF	OFF	ON	ON
4	OFF	OFF	OFF	OFF	ON	OFF	OFF
5	OFF	OFF	OFF	OFF	ON	OFF	ON
6	OFF	OFF	OFF	OFF	ON	ON	OFF
7	OFF	OFF	OFF	OFF	ON	ON	ON
8	OFF	OFF	OFF	ON	OFF	OFF	OFF
...	...						

4. Parameter and setting

4-1. Parameter list

Group P0: basic function

Parameter	Address	Meaning	Range	Default	Note
P0-01	0x0001	Subdivision	200~51200	10000	Effective after restart
P0-02	0x0002	Filter time	0~50	0	Effective after restart, shut down the filter when setting to zero
P0-05	0x0005	Open loop current percentage	1~100	100	Open loop running current= Open loop current % × peak current
P0-08	0x0008	Open loop holding current percentage	0~100	50	Open loop holding current (static half current)=open loop holding current % × peak current
P0-11	0x000B	Panel display mode	0~2	0	0: mode 1: address 2: speed per second
P0-12	0x000C	Open loop holding current switching time	1~10000	100	Time for switching from pulse free input to open loop holding current

Group P1: gain control

Parameter	Address	Meaning	Range	Default	Note
P1-00	0x0100	Auto tuning	0~1	1	0: OFF 1: ON
P1-01	0x0101	Current Kp	1~65535	1500	
P1-02	0x0102	Current Ki	1~65535	800	
P1-13	0x010D	In place delay	0~100	3	

Group P2: IO configuration

Parameter	Address	Meaning	Range	Default	Note
P2-02	0x0202	Alarm output	0~65535	1	Bit0~3 output terminal Bit4 effective voltage
P2-03	0x0203	Brake output	0~65535	2	Bit0~3 output terminal Bit4 effective voltage
P2-05	0x0205	Alarm clear	0~65535	1	Bit0~3 output terminal Bit4 effective voltage
P2-06	0x0206	POT	0~65535	2	Bit0~3 output terminal Bit4 effective voltage
P2-07	0x0207	NOT	0~65535	3	Bit0~3 output terminal Bit4 effective voltage
P2-08	0x0208	HOME	0~65535	4	Bit0~3 output terminal Bit4 effective voltage

Group P3: protection function

Parameter	Address	Meaning	Range	Default	Note
P3-01	0x0301	Fault detection selection	0~255	255	
P3-02	0x0302	Under voltage alarm	0~20	0	Shield the alarm when it is 0 in

		threshold			default

Group P4: motor parameters

Parameter	Address	Meaning	Range	Default	Note
P4-00	0x0400	Peak current	305：1~40 705：1~70 808：1~84	305：30 705：70 808：84	Motor peak current (100mA)
P4-01	0x0401	Encoder resolution	200~20000	4000	Quadruple frequency, modification is not supported
P4-02	0x0402	-	0~1	0	

Group 5 to group 7 are reserved.

Group P8: curve collection

Parameter	Address	Meaning	Range	Default	Note
P8-00	0x0800	Sampling channel 1	0~65535	8001	
P8-01	0x0801	Sampling channel 2	0~65535	8003	
P8-02	0x0802	Sampling channel 3	0~65535	0	
P8-03	0x0803	Sampling channel 4	0~65535	0	
P8-04	0x0804	Sampling channel 5	0~65535	8002	
P8-05	0x0805	Sampling channel 6	0~65535	8004	
P8-06	0x0806	Sampling channel 7	0~65535	0	
P8-07	0x0807	Sampling channel 8	0~65535	0	
P8-08	0x0808	Sampling channel 9	0~65535	1008	
P8-09	0x0809	Sampling channel 10	0~65535	1009	
P8-10	0x080A	Sampling channel 11	0~65535	0	
P8-11	0x080B	Sampling channel 12	0~65535	0	
P8-12	0x080C	Sampling channel 13	0~65535	0	
P8-13	0x080D	Sampling channel 14	0~65535	0	
P8-14	0x080E	Sampling channel 15	0~65535	0	
P8-15	0x080F	Sampling channel 16	0~65535	0	
P8-16	0x0810	Sampling mode	0~8	1	
P8-17	0x0811	Sampling interval	1~65535	36	
P8-18	0x0812	Sampling time	0~65535	1024	
P8-19	0x0813	Trigger channel	0~65535	0	
P8-20	0x0814	Trigger threshold low bit	0~65535	0	
P8-21	0x0815	Trigger threshold high bit	0~65535	0	
P8-22	0x0816	Trigger slope	0~65535	0	
P8-23	0x0817	Sampling proportion	0~100	100	
P8-24	0x0818	-	0~1	0	
P8-25	0x0819	-	0~1	0	
P8-26	0x081A	-	0~1	0	

Group U0

Parameter	Address	Contents		Note
U0-01	0x1001	Setting speed		rpm
U0-10	0x100A	Pulse quantity	0~15	Command pulse
U0-11	0x100B		16~31	
U0-12	0x100C		32~47	
U0-13	0x100D		48~62; 63: direction bit	
U0-18	0x1012	Single turn pulse counting	0~15	Command pulse
U0-19	0x1013		16~31	
U0-20	0x1014	Pulse turns	0~15	
U0-21	0x1015		16~31	
U0-25	0x1019	Setting electric angle		
U0-26	0x101A	Phase A feedback current		mA
U0-27	0x101B	Phase B feedback current		mA
U0-28	0x101C	Reference feedback current		mA
U0-29	0x101D	Phase A setting current		mA
U0-30	0x101E	Phase B setting current		mA
U0-31	0x101F	Reference setting current		mA
U0-32	0x1020	Bus voltage		V

Group U1

Parameter	Address	Contents	Note
U1-00	0x1100	Current alarm code	
U1-01	0x1101	Phase A current when alarm occurs	
U1-02	0x1102	Phase B current when alarm occurs	
U1-03	0x1103	Reference current when alarm occurs	
U1-04	0x1104	Bus voltage when alarm occurs	
U1-05	0x1105	Position offset when alarm occurs	
U1-06	0x1106	Speed value when alarm occurs	
U1-07	0x1107	The time when alarm occurs	
U1-08	0x1108	The time when alarm occurs	
U1-09	0x1109	This time operation error code quantity	
U1-10	0x110A	Last second alarm code	
U1-11	0x110B	Last third alarm code	
U1-12	0x110C	Last fourth alarm code	
U1-13	0x110D	Last fifth alarm code	
U1-14	0x110E	Last sixth alarm code	
U1-15	0x110F	Reserved	
U1-16	0x1110	Reserved	
U1-17	0x1111	Reserved	
U1-18	0x1112	Reserved	
U1-19	0x1113	Reserved	
U1-20	0x1114	Reserved	
U1-21	0x1115	Reserved	

Group U2

Parameter	Address	Contents	Note
U2-00	0x1200	Power on times	
U2-01	0x1201	Machine type	
U2-02	0x1202	Series	
U2-03	0x1203	Model	
U2-04	0x1204	Date of production	Year
U2-05	0x1205	Date of production	Month
U2-06	0x1206	Date of production	Day
U2-07	0x1207	Software version	
U2-08	0x1208	Hardware version	
U2-09	0x1209	Power on operation time	Hour
U2-10	0x120A	Power on operation time	Minute
U2-11	0x120B	Power on operation time	Second
U2-12	0x120C	Device serial no.	Low 16-bit
U2-13	0x120D	Device serial no.	High 16-bit
U2-14	0x120E	Firmware generation date: year	
U2-15	0x120F	Firmware generation date: month/day	
U2-16	0x1210	Firmware generation date: hour/minute	

Group U3

Parameter	Address	Contents	Note
U3-00	0x1300	PDI period	
U3-01	0x1301	PDI time	
U3-02	0x1302	PDI period max time	
U3-03	0x1303	PDI period min time	
U3-04	0x1304	Sync0 period	
U3-05	0x1305	Sync0 time	
U3-06	0x1306	Sync0 period max time	
U3-07	0x1307	Sync0 period min time	
U3-08	0x1308	ECAT timer period	
U3-09	0x1309	PID2Sync0 time difference	
U3-10	0x130A	PID2Sync0 max time difference	
U3-11	0x130B	PID2Sync0 min time difference	

Group F0

Parameter	Address	Contents	Note
F0-00	0x2000	Clear the alarm	
F0-01	0x2001	Restore factory settings	
F0-02	0x2002	Save the parameters	

5. EtherCAT communication

5-1. EtherCAT overview

This section mainly introduces the basic concept, system composition, communication specification and connection description of EtherCAT.

5-1-1. EtherCAT overview

EtherCAT, the full name of Ethernet for Control Automation Technology, is developed by Beckhoff Atomization GmbH. It is a real-time Ethernet used for open network communication between master station and slave station. As a mature industrial Ethernet technology, EtherCAT has the characteristics of high performance, low cost, easy use, etc.
The XG2 series controller (master station) and DP3CL step driver (slave station) comply with the standard EtherCAT protocol, support the maximum number of slave stations 32 axes, 32-axis synchronization cycle 1 ms, 2-channel Touch probe function, and multiple control modes of position and speed, which are widely applicable to various industrial applications.

5-1-2. System composition (composition of master station and slave station)

The connection form of EtherCAT is a network system that connects the master station (FA controller) and multiple slave stations in a linear manner.
The number of nodes that can be connected by the slave station depends on the processing or communication cycle of the master station, the number of bytes transmitted, etc.

5-2. EtherCAT communication specification

This section mainly introduces the frame structure, state machine, ESC, SDO, PDO, SII area, communication synchronization mode, etc. of EtherCAT.

5-2-1. Communication specification list

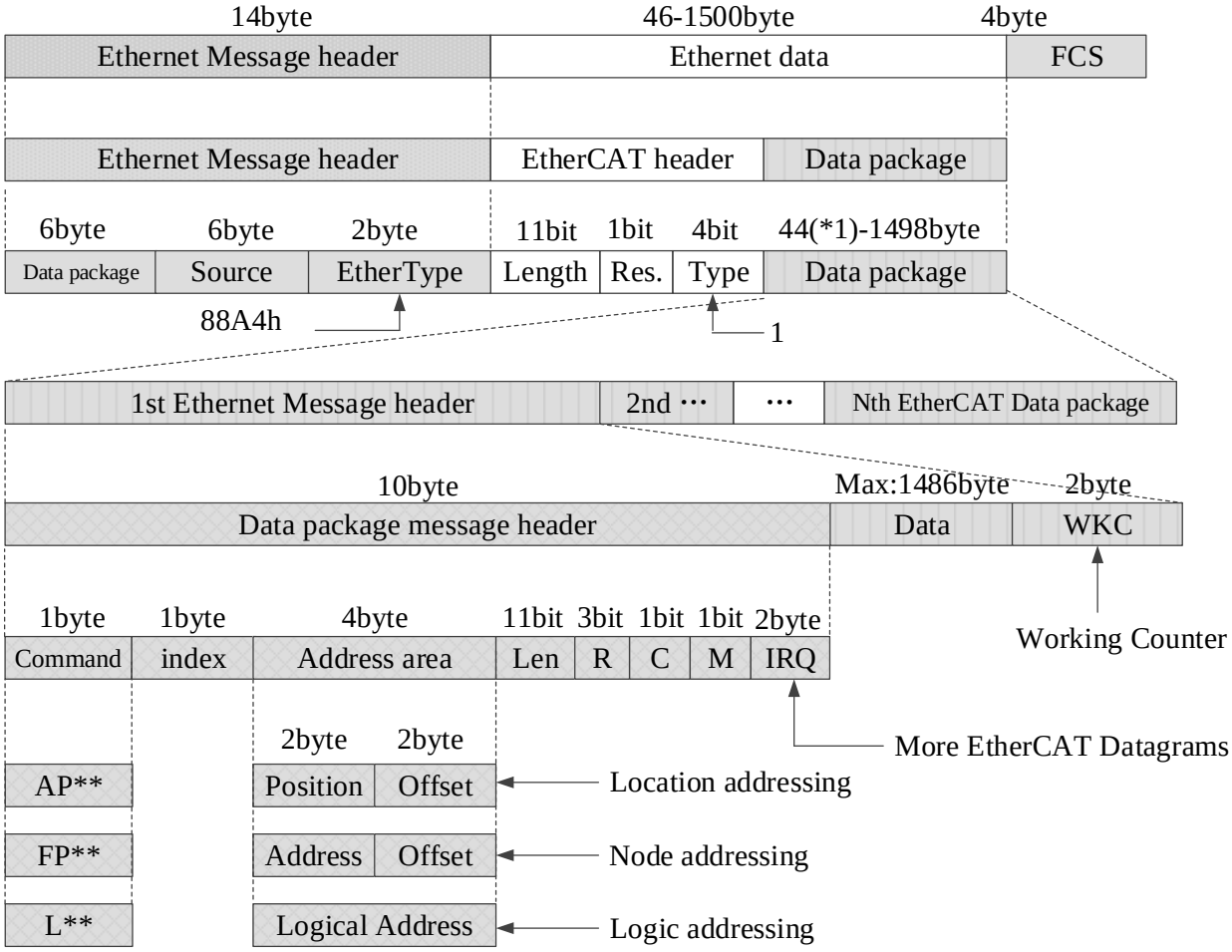
<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Physical layer</td><td>100BASE-TX (IEEE802.3)</td></tr>
<tr><td>Baud rate</td><td>100[Mbps] (full duplex)</td></tr>
<tr><td>Topology</td><td>Line</td></tr>
<tr><td>Connection cable</td><td>JC-CA twisted pair (shielded twisted pair)</td></tr>
<tr><td>Cable length</td><td>The maximum length between nodes is 50m</td></tr>
<tr><td>Communication port</td><td>2 Port (RJ45)</td></tr>
<tr><td>EtherCAT LED</td><td>[Run] RUN LED
[L/A IN] Port0 Link/Activity LED (Green)
[L/A OUT] Port1 Link/Activity LED (Green)</td></tr>
<tr><td>Station Alias (ID)</td><td>Set range: 0~65535
Set address: 2700h</td></tr>
<tr><td>Explicit Device ID</td><td>Cannot support</td></tr>
<tr><td>Mailbox protocol</td><td>COE（CANopen Over EtherCAT）</td></tr>
<tr><td>SyncManager</td><td>4</td></tr>
<tr><td>FMMU</td><td>3</td></tr>
<tr><td>Modes of operation</td><td>
<table>
<tr><th></th><th colspan="2">Control mode</th></tr>
<tr><td rowspan="3">Position</td><td>Csp</td><td>Cyclic synchronous position mode</td></tr>
<tr><td>PP</td><td>Profile position mode</td></tr>
<tr><td>Hm</td><td>Homing mode</td></tr>
<tr><td>Speed</td><td>Pv</td><td>Profile velocity mode</td></tr>
</table>
</td></tr>
<tr><td>Touch Probe</td><td>2 channels</td></tr>
<tr><td>Synchronization mode</td><td>DC (SYNCO Event synchronization)
SM (SM Event synchronization)</td></tr>
<tr><td>Cyclic time (DC Communication cycle)</td><td>500,1000,2000,4000[μs]</td></tr>
<tr><td>Communication object</td><td>SDO[Service Data Object], PDO[Process Data Object]</td></tr>
<tr><td>Single station PDO max distribution number</td><td>TxPDO: 4 [pcs] RxPDO: 4 [pcs]</td></tr>
<tr><td>Single station PDO max byte number</td><td>TxPDO: 24[byte] RxPDO: 24[byte]</td></tr>
<tr><td>Mailbox communication interval in PreOP mode</td><td>1ms</td></tr>
<tr><td>Email</td><td>SDO request and SDO information</td></tr>
</table>

Note: refer to chapter 5-2-3. State Machine ESM for the meanings of SDO and PDO.

5-2-2. EtherCAT frame structure

EtherCAT is an industrial communication protocol that can be controlled in real time based on Ethernet. It is just an extension of IEEE 802.3 Ethernet specification without any change to the basic structure, so it can transfer the data in the standard Ethernet frame.
Since the EtherType of the Ethernet Header is [88A4h], the subsequent Ethernet data is processed as an EtherCAT frame.
The EtherCAT frame is composed of the EtherCAT frame header and more than one EtherCAT submessage. The EtherCAT submessage is further subdivided. Only EtherCAT frames with Type=1 of EtherCAT frame header are processed according to ESC.

EtherNet/EtherCAT frame structure



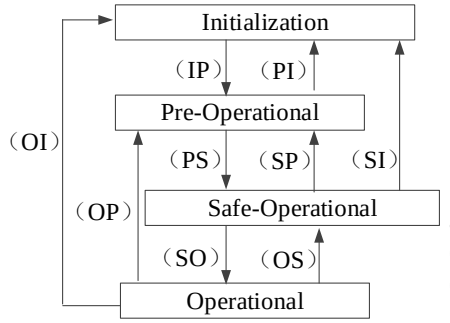
***1:** Ethernet frame is shorter than 64byte, 1~32 byte is added.
(Ethernet message header + Ethernet data + FCS）

5-2-3. State machine ESM

ESM refers to EtherCAT State Machine. The ESM is responsible for coordinating the state relationship between the master and slave applications during initialization and runtime.
The state change request is executed by the master station, which puts forward a control request to the application layer service. The latter generates an application layer control event in the slave station, and the slave station

responds to the application layer control service through the local application layer state write service after the state change request succeeds or fails. If the status change fails, the slave station keeps the status and sets an error flag.

The following figure shows the state transition of ESM:



※(IP) in the state transition diagram is the abbreviation of state transition
(IP): Init→Pre-Operational
(PS): Pre-Operational→Safe-Operational

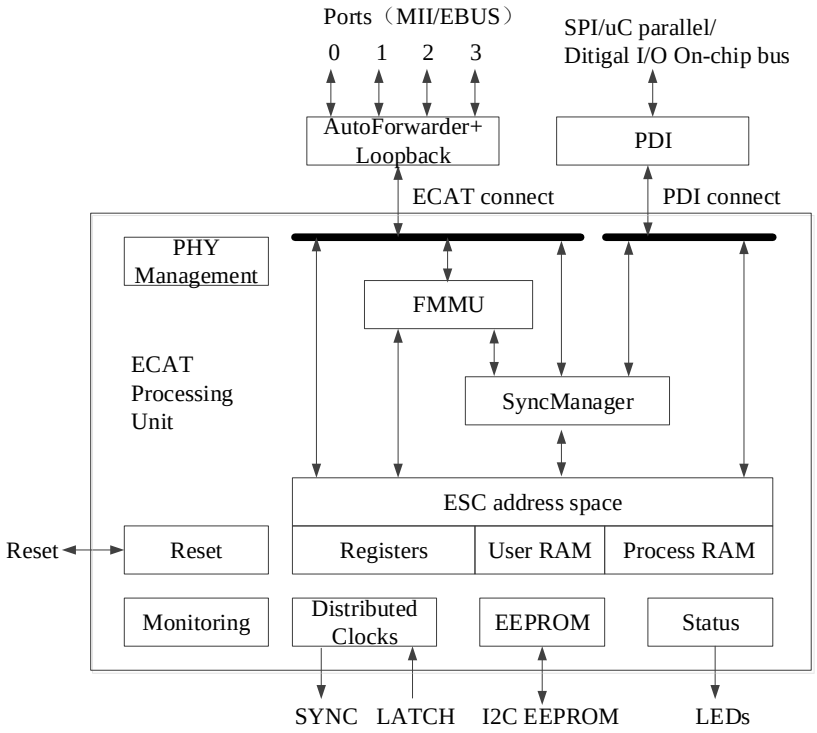
Slave station state	Action in each state	Communication action		
		SDO (mailbox) send and receive message	PDO send message	PDO receive message
Init	Communication initialization, SDO and PDO fail to send and receive message	-	-	-
Pre-operational	Only SDO sending and receiving status	Yes	-	-
Safe-operational	Only SDO sends and receives message, and the status of PDO sends message	Yes	Yes	-
Operational	SDO and PDO send and receive message status	Yes	Yes	Yes

Note:
The access from the master station to the ESC register is independent of the above table and is available at any time.
PDO (Process Data Object) is used to transmit periodic communication data.
SDO (Service Data Object) is used to transmit non periodic communication data.
Command or interface operation during ESM status switching may cause abnormal communication error.

5-2-4. Slave station controller ESC

5-2-4-1. Principle overview

ESC refers to the Ethercat Slave Controller. The communication process is completely handled by ESC, which has four data receiving and transmitting ports, and each port has a TX and RX. Each port can send and receive Ethernet data frames. The data flow direction in ESC is fixed: port 0 -->port 3 -->port 1 -->port 2 -->port 0. If ESC detects that a port has no external PHY, it will automatically close the port and automatically forward to the next port through the internal loopback.



5-2-4-2. Address space

The DP3CL series holds a physical address space of 8Kbyte.

The original 4Kbyte (0000h ~ 0FFFh) is used as a register space, and the other 4Kbyte (1000h ~ 1FFFFh) is used as a process data PDO in the RAM field. For details of registers, please refer to the data table of IP (ET1810/ET1811/ET1812).

ESC register byte address	Length (Byte)	Explanation	Initial value*1
Slave controller information			
0000h	1	Type	04h
0001h	1	Revision	02h
0002h~0003h	2	Build	0040h
0004h	1	FMMUs supported	03h
0005h	1	SyncManagers supported	04h
0006h	1	RAM Size	08h
0007h	1	Port Descriptor	0Fh
0008h~0009h	2	ESC Features supported	0184h
Station address			
0010h~0011h	2	Configured Station Address	-
0012h~0013h	2	Configured Station Alias	-
…			
Data link layer			
…			
0100h~0103h	4	ESC DL Control	-
…			

ESC register byte address	Length (Byte)	Explanation	Initial value*1
0110h~0111h	2	ESC DL Status	-
Application layer			
0120h~0121h	2	AL Control	-
0130h~0131h	2	AL Status	-
0134h~0135h	2	AL Status Code	-
…			
PDI Process data interface			
0140h	1	PDI Control	08h
0141h	1	ESC Configuration	0Ch
0150h	1	PDI Configuration	-
0151h	1	SYNC/LATCH PDI Configuration	66h
0152h~153h	2	Extend PDI Configuration	-
…			
Watchdog			
0400h~0401h	2	Watchdog Divider	-
0410h~0411h	2	Watchdog Time PDI	-
0420h~0421h	2	Watchdog Time Process Data	-
0440h~0441h	2	Watchdog Status Process Data	-
0442h	1	Watchdog Counter Process Data	-
0443h	1	Watchdog Counter PDI	-
…			
FMMU			
0600h~062Fh	3x16	FMMUs[2:0]	-
+0h~3h	4	Logical Start Address	-
+4h~5h	2	Length	-
+6h	1	Logical Start bit	-
+7h	1	Logical Stop bit	-
+8h~9h	2	Physical Start Address	-
+Ah	1	Physical Start bit	-
+Bh	1	Type	-
+Ch	1	Activate	-
+Dh~Fh	3	Reserved	-
…			
Distributed Clocks（DC）-SYNC Out Unit			
0981h	1	Activation	-
…			
0984h	1	Activation Status	-
098Eh	1	SYNCO Status	-
…			
0990h~0993h	4	Start Time Cyclic Operation/Next SYNC0 Pulse	-

ESC register byte address	Length (Byte)	Explanation	Initial value*1
…			
09A0h~09A3h	4	SYNC0 Cycle Time	-
…			

5-2-5. SII area (0000h～003Fh)

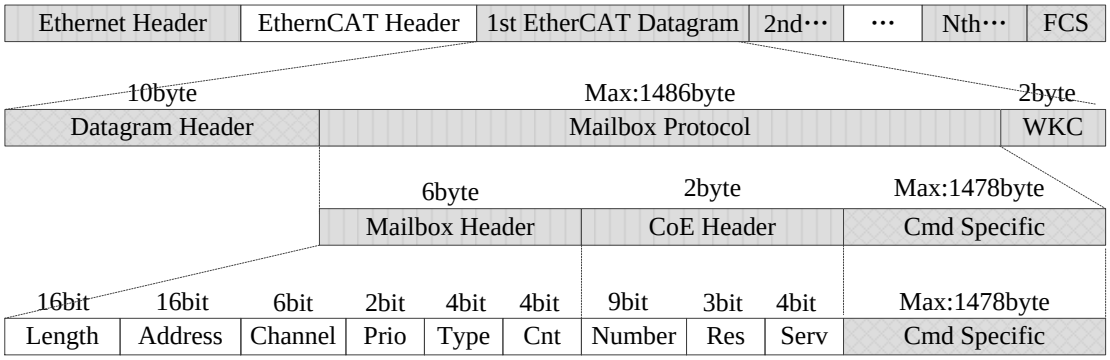
In the ESC configuration area (EEPROM word address 0000h~0007h), Configured Station Alias automatically reads and writes to the ESC register according to ESC after the drive power is started. When the changed value of SII EEPROM is reflected in the ESC register, the power supply needs to be started again. In addition, the initial value of the IP core (ET1810/ET1811/ET1812) is set. For details, please refer to the data sheet of IP core (ET1810/ET1811/ET1812).

5-2-6. SDO

The DP3CL series supports SDO (Service Data Object). The data exchange of SDO uses Mailbox communication, so the data refresh time of SDO becomes unstable.
The master station can read and write data in the records in the object dictionary, and can set objects and monitor various statuses of slave stations. The response to the SDO read/write action takes time. Objects refreshed with PDO should not be refreshed with SDO, but overwritten with PDO values.

5-2-6-1. Mailbox frame structure

The frame structure of Mailbox/SDO is shown below. Please refer to ETG specifications (ETG1000-5 and ETG1000-6) for details.



Frame area	Data area	Data type	Function
MailBox Header	Length	WORD	Mailbox data length
	Address	WORD	The station address of the sending source
	Channel	Unsigned6	(Reserved)
	Prority	Unsigned2	Priority
	Type	Unsigned4	Mailbox type 00h: error 01h: (Reserved) 02h: EoE (Not corresponding) 03h: CoE 04h: FoE (Not corresponding)

Frame area	Data area	Data type	Function
			05h: SoE (Not corresponding) 06h-0Eh: (Reserved) 0Fh: VoE (Not corresponding)
	Cnt	Unsigned3	Mailbox counter
	Reserved	Unsigned1	(Reserved)
CoE Header	Number	Unsigned9	Reserved
	Reserved	Unsigned3	Reserved
	Service	Unsigned4	Message type
Cmd specific	Size Indicator	Unsigned1	Data Set Size use License
	Transfer Type	Unsigned1	Normal transfer/Expedited transfer
	Data Set Size	Unsigned2	Specify data size
	Complete accessibility	Unsigned1	Selection of object access method (not corresponding)
	Command Specfier	Unsigned3	Upload/download Selection of requirements/responses, etc
	Index	WORD	Index of object
	Sub index	BYTE	Sub index of object
			Data of object or Abort message etc.

5-2-6-2. Mailbox timeout

The following timeout settings are made for this stepping driver in Mailbox communication.
Mailbox Request timeout: 100ms
The master station sends a request to the slave station (driver). If the WKC of the sending data of the requested frame is updated, the slave station is considered to receive the request normally. Try again and again until the WKC is updated. However, if the WKC is not updated until this set time, the master station will timeout.
Mailbox Reponse timeout: 10s
The master station receives the response from the slave station (driver) request. If this WKC is updated, it is considered that the response is received normally. Until this set time, if the updated WKC response cannot be received, the master side will timeout.
The maximum time required for a slave (drive) response to complete.

5-2-6-3. Information in case of abnormal alarm

(1) Alarm code

Error code return the same value as 603Fh (Error code).
0000h～FEFFh are defined as IEC61800-7-201.
FF00h～FFFFh are defined by manufacturer.

Index	subindex	Name	Range	Data type	Accessibility	PDO	Op-mode
603Fh	00h	Error code	0-65535	U16	ro	TxPDO	All
		Displays the alarms that are occurring in the servo drive (only the master number). When the alarm does not occur, it displays 0000h. When an alarm occurs, the alarm code is displayed.					

(2) Alarm type (status)

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

<table>
<tr><th>Index</th><th>subindex</th><th>Name</th><th>Range</th><th>Data type</th><th>Accessibility</th><th>PDO</th><th>Op-mode</th></tr>
<tr><td>1001h</td><td>00h</td><td>Error register</td><td>0-65535</td><td>U16</td><td>ro</td><td>TxPDO</td><td>All</td></tr>
<tr><td colspan="8">Displays the type (status) of alarm that is occurring in the servo driver.
When the alarm does not occur, it displays 0000h.
No warnings are displayed.
<table>
<tr><th>Bit</th><th>Content</th></tr>
<tr><td>0</td><td rowspan="4">Not support</td></tr>
<tr><td>1</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td>Alarm defined by AL status code occurs *1</td></tr>
<tr><td>5</td><td>Not support</td></tr>
<tr><td>6</td><td>Reserved</td></tr>
<tr><td>7</td><td>Alarm undefined by AL status code occurs *2</td></tr>
</table>
*1: The "alarm defined by AL status code" refers to EtherCAT communication association fault E-800 ~ 7, E-810 ~ 7, E-850 ~ 7.
*2: The "alarm undefined by AL status code" refers to the fault of EtherCAT communication association E-880~7 and the fault besieds EtherCAT communication association.</td></tr>
</table>

5-2-7. PDO

DP3CL series supports PDO (process data object).
The real-time data transfer based on EtherCAT is carried out through the data exchange of PDO (Process Data Object).
PDO includes RxPDO transferred from master station to slave station and TxPDO transferred from slave station to master station.

	Send	Receive
RxPDO	Master station	Slave station
TxPDO	Slave station	Master station

5-2-7-1. PDO mapping object

PDO mapping refers to the mapping from object dictionary to application object of PDO.
The table used for DP3CL series PDO mapping can use RxPDO (1600h ~ 1603h) and TxPDO (1A00h ~ 1A03h) mapping objects.
The maximum number of application objects that a mapping object can map is as follows:
RxPDO: 24 [byte], TxPDO: 24 [byte]
The following shows an example of PDO mapping settings.
<Setting example>
Allocate the application object 6040h, 6060h, 607Ah, 60B8h to the mapping object 1600h (Receive PDO mapping 1: RxPDO_1).

Index	Sub	Object contents
1600h	00h	04h
	01h	6040 00 10 h
	02h	6060 00 08 h
	03h	607A 00 20 h

	04h	60B8 00 10 h	
	05h	0000 00 00 h	
	…		
	18h	0000 00 00 h	
6040h	00h	Controlword	U16
6060h	00h	Mode of operation	I8
607Ah	00h	Target Position	I32
60B8h	00h	Touch probe function	U16

5-2-7-2. PDO distribution object

In order to exchange PDO data, the table used for PDO mapping must be allocated to SyncManager. The relationship between the table used for PDO mapping and SyncManager is described to the PDO allocation object. As PDO allocation objects, DP3CL series can use RxPDO (SyncManager2) for 1C12h and TxPDO (SyncManager3) for 1C13h.
The maximum number of application objects that a mapping object can map is as follows:
RxPDO: 4 [Table] (1600h~1603h).
RxPDO: 4 [Table] (1A00h~1A03h).
Usually, 1 mapping object is sufficient, so the default does not need to be changed.

Example of setting PDO assignment objects:
Allocation mapping object 1600h to allocation object 1C12h (Sync manager channel 2).

Index	Sub	Object contents
1C12h	00h	01h
	01h	1600h
	02h	0000h
	03h	0000h
	04h	0000h

Allocation mapping object 1A00h to allocation object 1C13h (Sync manager channel 3).

Index	Sub	Object contents
1C13h	00h	01h
	01h	1A00h
	02h	0000h
	03h	0000h
	04h	0000h

5-2-8. Communication synchronization mode

The DP3CL series can select the following synchronization modes.

Synchronous mode	Content	Synchronization method	Features
DC	SYNC0 Event synchronization	Synchronize the time information of other slave stations based on the time of the first axis	high-precision Compensation processing is required at the master station side

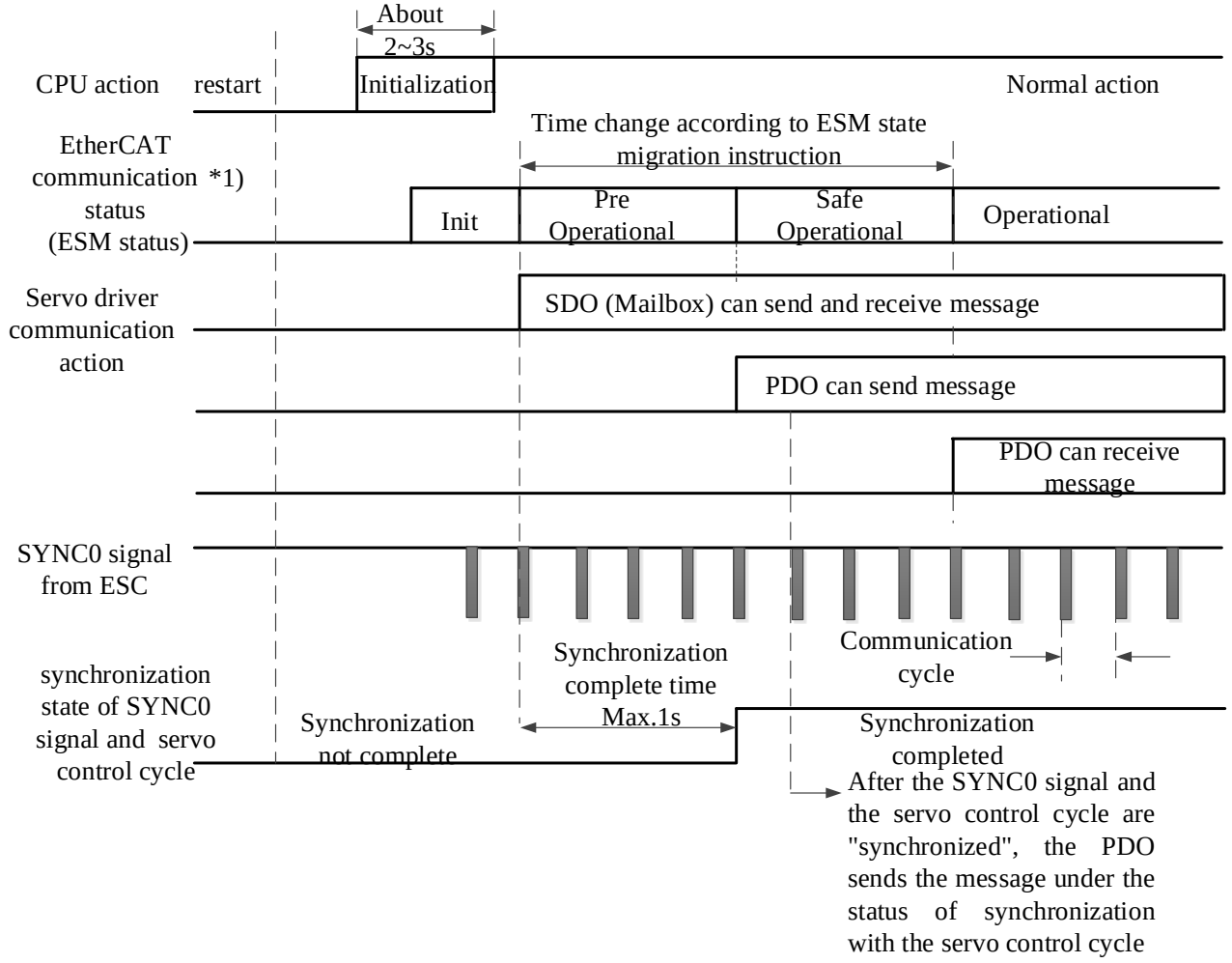
SM2	SM2 Event synchronization	Synchronize according to RxPDO receiving time	No transmission delay compensation, poor accuracy Need to keep transmission time on the controller side (special hardware, etc.)
FreeRun	Asynchronous	Asynchronous	Simple processing and poor real-time performance

5-2-8-1. DC (SYNC0 Event synchronization)

The DP3CL series has a 64-bit DC (Distributed Clock).

The synchronization of EtherCAT communication is based on this DC. According to the DC slave, the synchronization is realized by using the same reference clock (System Time). The local cycle of the slave starts with the SYNC0 event. Because the slave processing (servo processing) starts from the SYNC0 event cycle, it is always synchronized with the SYNC0 event.

The master station needs to perform transmission delay compensation (offset compensation) and regular deviation compensation during communication initialization. The following figure shows the process of synchronous completion from control power input to SYNC0 event and slave station processing (servo processing).



5-2-8-2. SM2 (SM2 Event synchronization）

The local cycle of the slave starts with the SM2 event.
Because the slave processing starts from the SM2 event cycle, it is always synchronized with the SM2 event.
Because the SM2 event occurs when the PDO receiving the message completed, it is necessary to ensure that the upper (master) side sends the message regularly. If the fluctuation (deviation) of the sending time is too large, the synchronization cannot be completed, or an alarm occurs.
If the above problem occurs, please use DC (SYNC0 event synchronization).

5-2-9. LED light

The L/A IN and L/A OUT LED lights indicate the LINK status and action status of the physical layer of each port. The light color is green.

LED status	Content
OFF	LINK not established
Flashing	LINK established, data send and receive
ON	LINK established, no data send and receive

6. EtherCAT operation mode

6-1. Homing Mode

6-1-1. Overview

The user can use this mode to let the driver search for the origin position, and set the homing mode, the speed and acceleration.

6-1-2. Operation steps

P2-06 corresponds to POT, P2-17 corresponds to NOT, and P2-08 corresponds to origin

1. set [control mode: 6060h] to homing mode (0x06).
2. set [homing mode: 6098h], setting range is 1~14, 17~30, 33, 34, 35, 37. Some stepping motors don't have Z phase signal, please select the homing mode carefully.
3. set [homing speed 6099h Sub-1], define the speed to find the origin switch (unit: command unit/s).
4. set [homing speed: 6099h Sub-2], define the speed to find the origin (unit: command unit/s).
5. set [homing acceleration: 609Ah], define the homing acceleration (unit: command unit/s^2).
6. set [control word: 6040h] to (0x06 > 0x07 > 0x0F), enable the driver and make the motor to run.
7. set [control word: 6040h] to (0x0F > 0x1F), find the Home Switch and do the homing operation.
8. read [status word: 6041h] to know the driver status.

6-1-3. Related object list

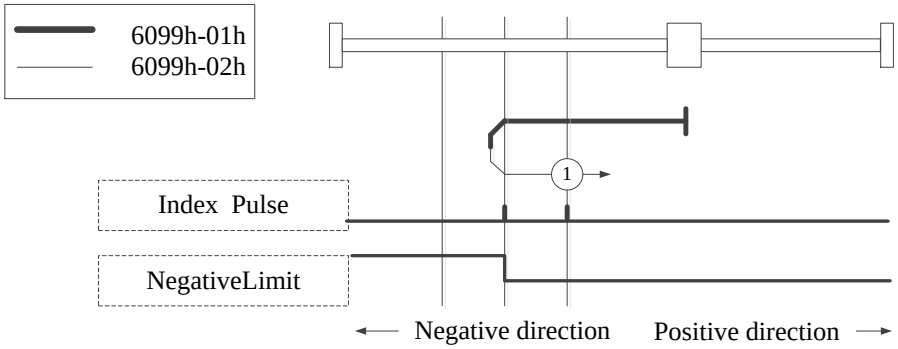
Index	Name	Unit	Read/write
6040h	Controlword	-	RW
6041h	Statusword	-	RO
6060h	Modes of operation	-	RW
6061h	Modes of operation display	-	RO
6098h	Homing method	-	RW
6099h	Homing speed	command unit/s	RW
609A	Homing acceleration	command unit/s^2	RW

6-1-4. Homing mode

At present, the homing mode supported by Xinje DP3CL series servo is 1-14, 17~30, 33, 34, 35, 37. If a slave station of another brand is used, the homing mode shall be subject to the description in the slave station manual of the corresponding brand. Some stepper motors do not have a Z-phase signal and will not stop. Please carefully select the homing mode.

- Mode 1:

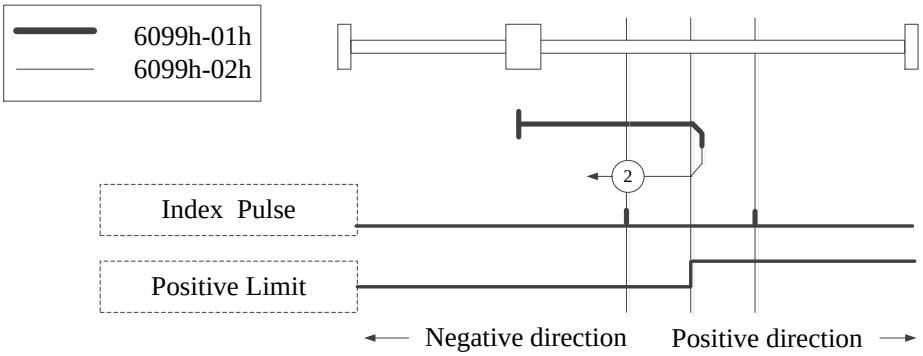
When using homing mode 1, if the reverse limit switch is not triggered, the initial moving direction is left. The origin position is at the first Z-phase pulse on the right of the position where the negative limit switch becomes invalid.



Homing on negative limit switch and index pulse

- Mode 2:

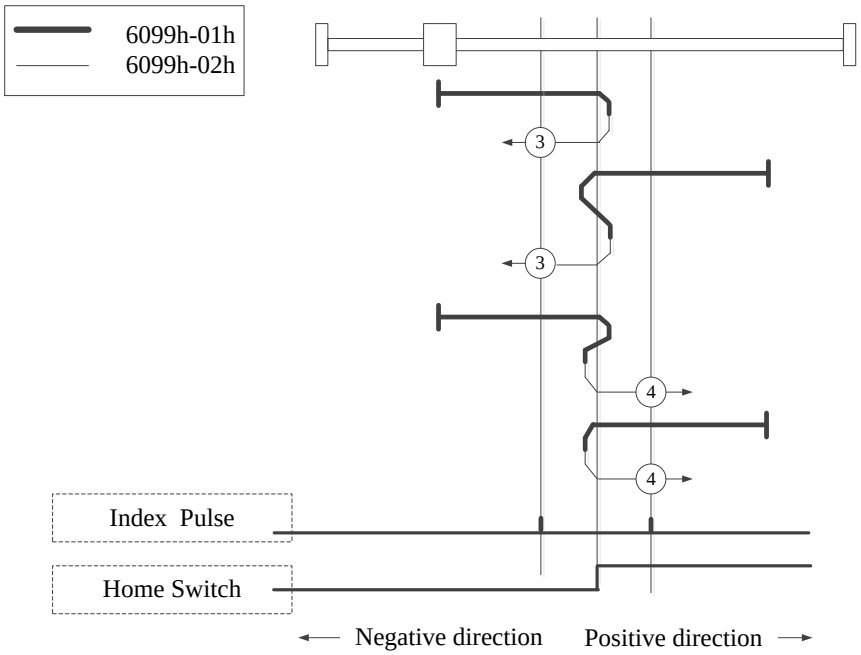
When using method 2, if the forward limit switch is not triggered, the initial movement direction is right. The origin position is at the first Z-phase pulse on the left of the position where the forward limit switch becomes invalid.



Homing on positive limit switch and index pulse

- Mode 3, 4:

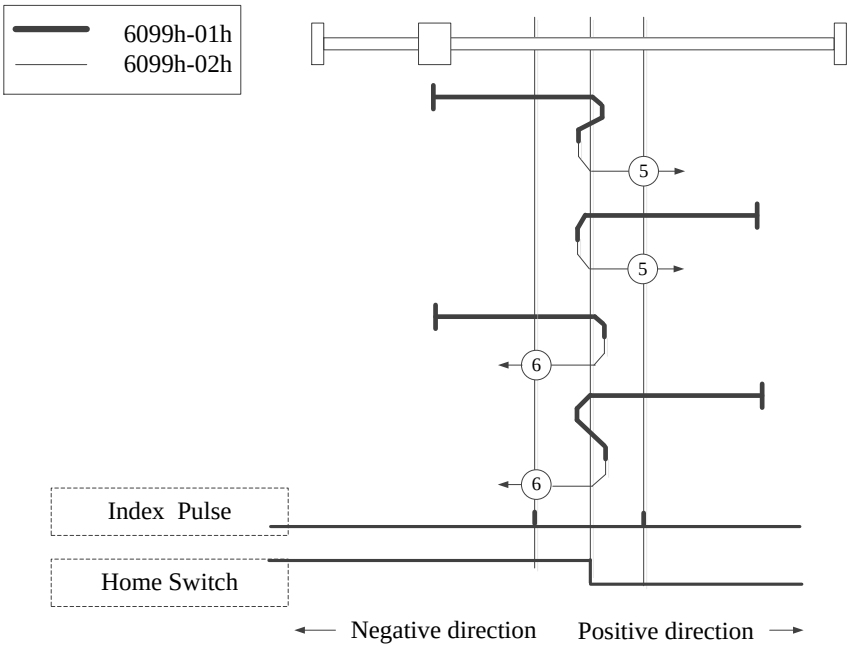
Using method 3 or 4, the initial direction of movement depends on the status of the origin switch. The origin position is on the reverse side of the origin switch or on the Z phase position initially detected in the forward direction.



Homing on positive home switch and index pulse

- Mode 5, 6:

Using method 5 or 6, the initial direction of movement depends on the status of the origin switch. The origin position is on the reverse side of the origin switch or on the Z phase position initially detected in the forward direction.



Homing on negative home switch and index pulse

- Mode 7~14:

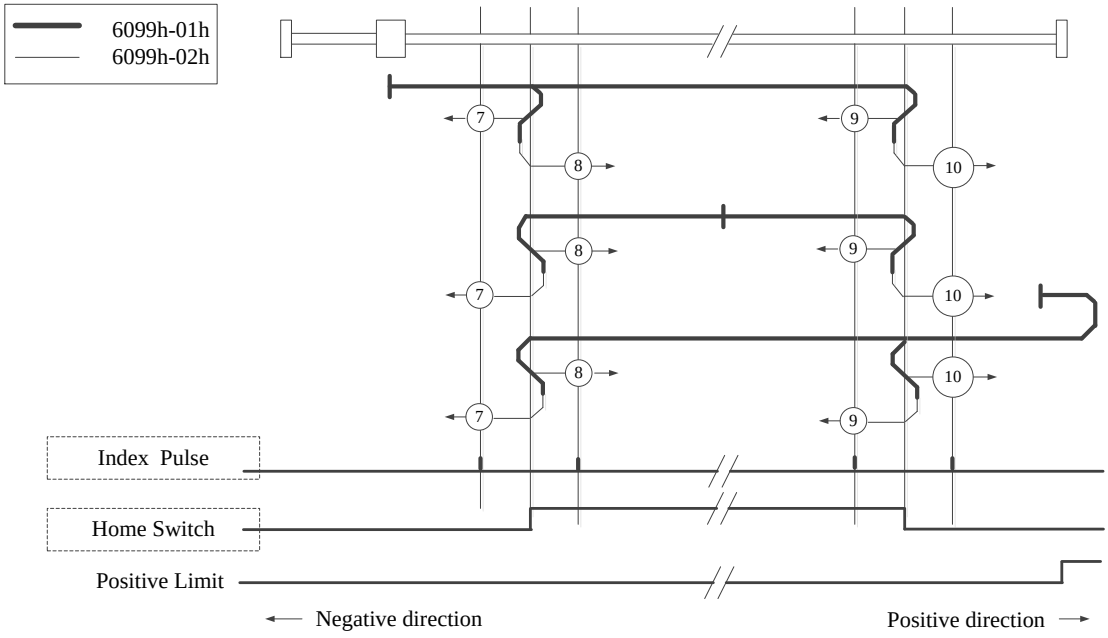
The initial action direction of modes 7 and 8 is negative if the origin switch has been activated at the beginning of action.

The initial action direction of modes 9 and 10 is positive if the origin switch has been activated at the beginning of the action.

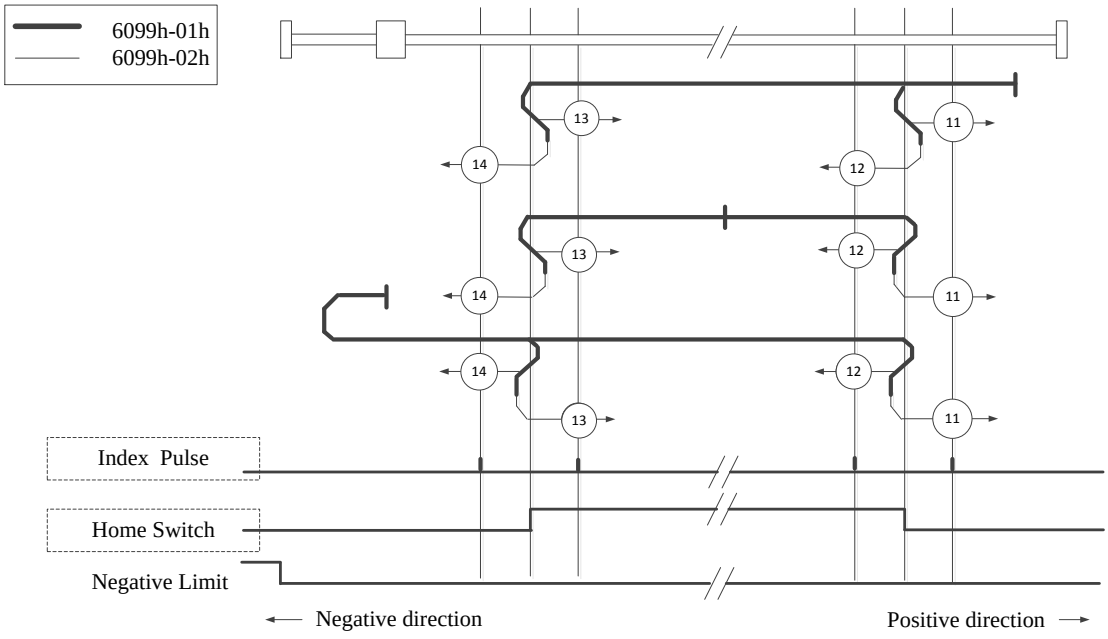
The initial action direction of modes 11 and 12 is positive if the origin switch has been activated at the beginning of the action.

The initial action direction of modes 13 and 14 is negative if the origin switch has been activated at the beginning of the action.

The final homing position is the Z-phase signal near the rising or falling edge of the origin switch.



Homing on home switch and index pulse – positive initial motion



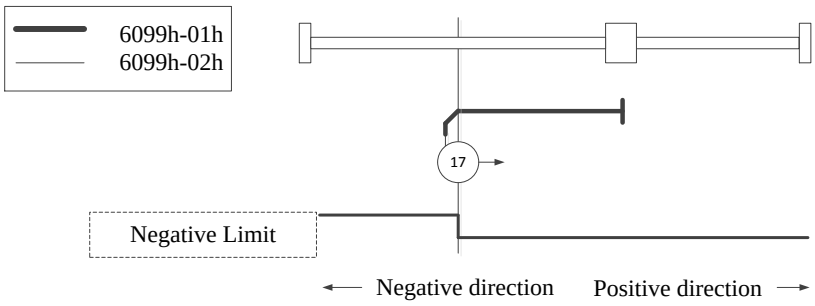
Homing on home switch and index pulse – Negative initial motion

- Mode 17:

This method is similar to Method1.

The difference is that the origin detected position is not the index pulse, but the limit switch change position. (Please refer to the following figure)

When NOT is not assigned, Homing error =1.



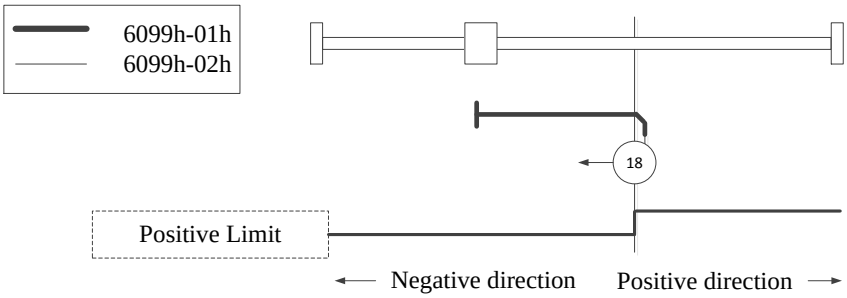
Homing on negative limit switch

- Mode 18:

This method is similar to Method 2.

The difference is that the origin detected position is not the index pulse, but the limit switch change position. (Please refer to the following figure)

When POT is not assigned, Homing error =1.



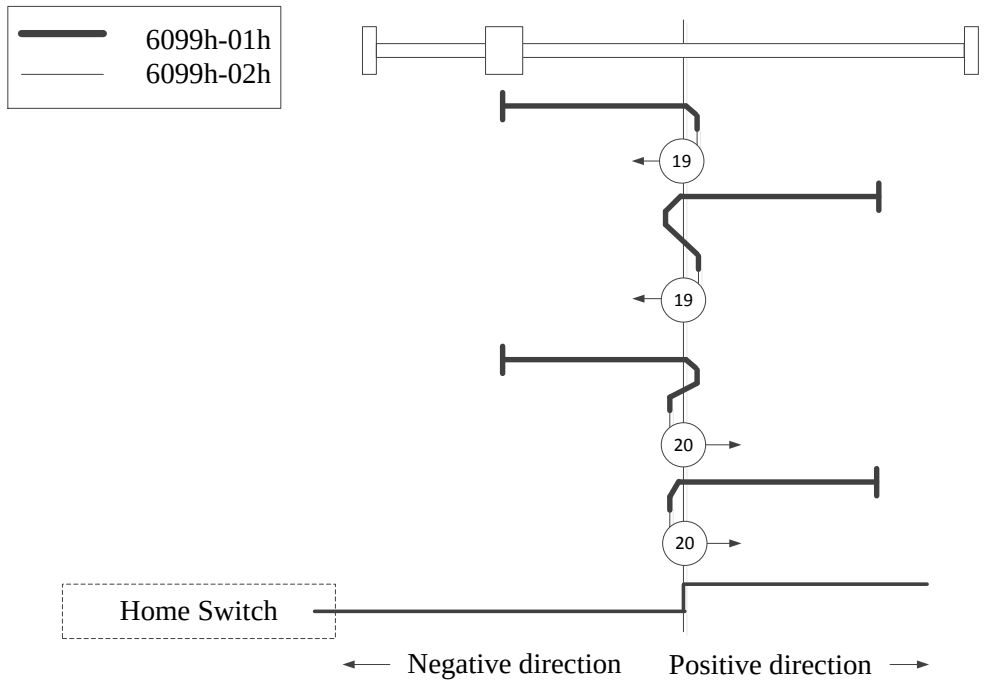
Homing on positive limit switch

- Mode 19, 20:

This method is similar to Method 3, 4.

The difference is that the origin detected position is not the index pulse, but the Home switch change position. (Please refer to the following figure)

When HOME is not assigned, Homing error =1.



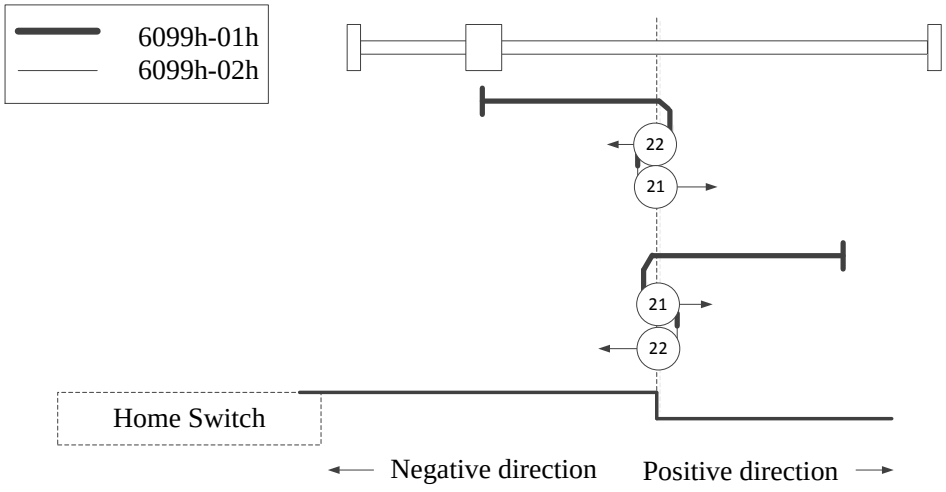
Homing on positive home switch

- Mode 21, 22:

This method is similar to Method 5, 6.

The difference is that the origin detected position is not the index pulse, but the Home switch change position. (Please refer to the following figure)

When HOME is not assigned, Homing error =1.



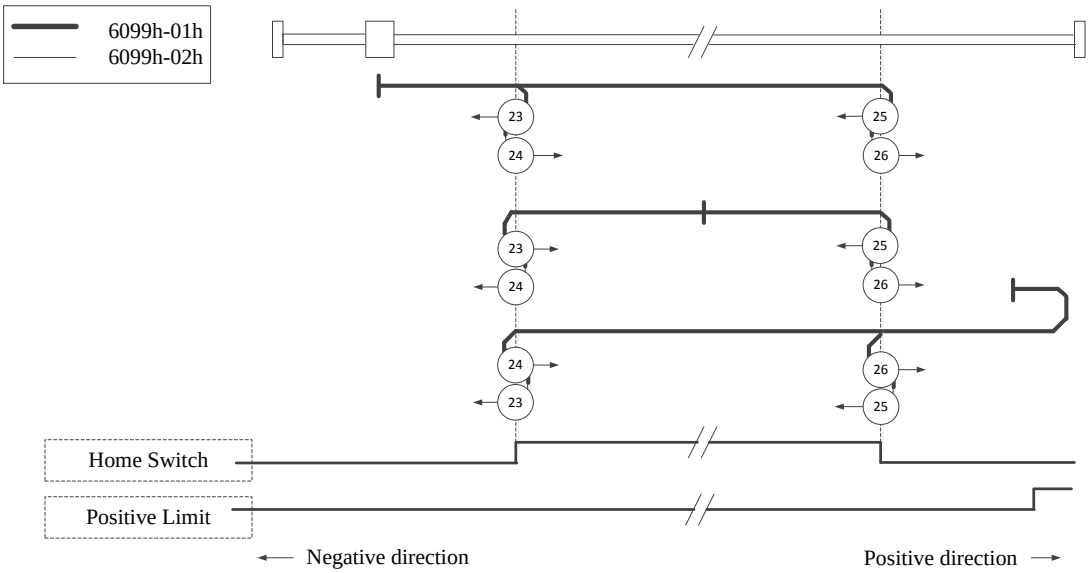
Homing on positive home switch and index pulse

■ Mode 23, 24, 25, 26:

This method is similar to Method 7, 8, 9, 10.

The difference is that the origin detected position is not the index pulse, but the Home switch change position. (Please refer to the following figure)

When HOME, POT are not assigned, Homing error =1.



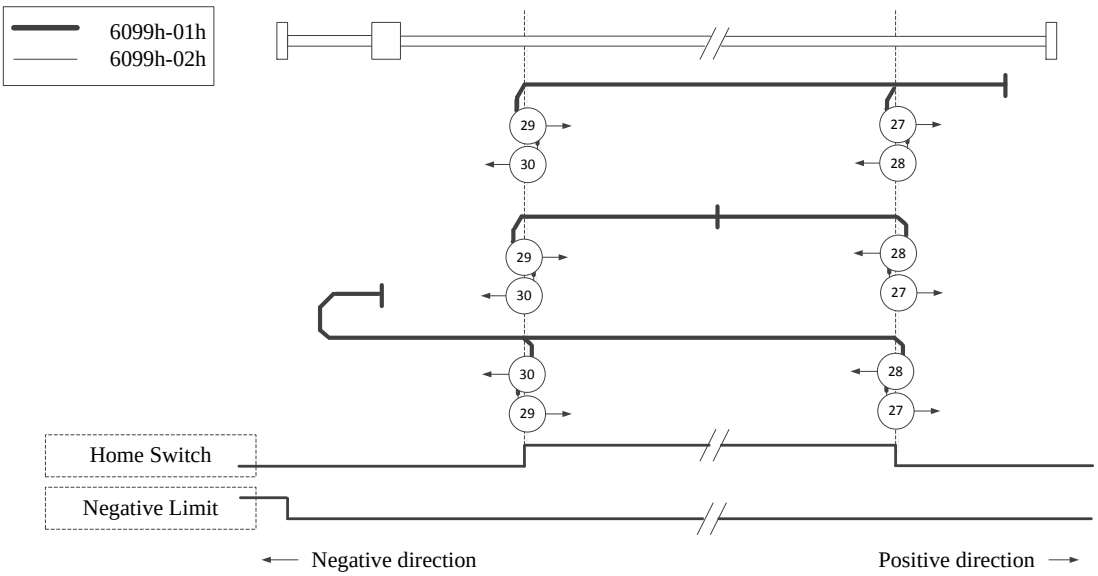
Homing on home switch and index pulse – positive initial motion

■ Mode 27, 28, 29, 30:

This method is similar to Method 11, 12, 13, 14.

The difference is that the origin detected position is not the index pulse, but the Home switch change position. (Please refer to the following figure)

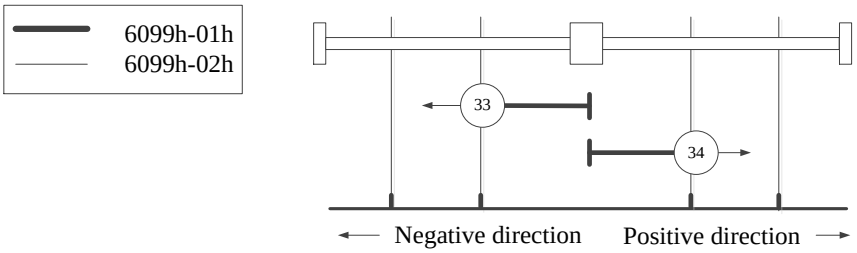
When HOME, NOT are not assigned, Homing error =1.



Homing on home switch and index pulse – Negative initial motion

■ Mode 33, 34:

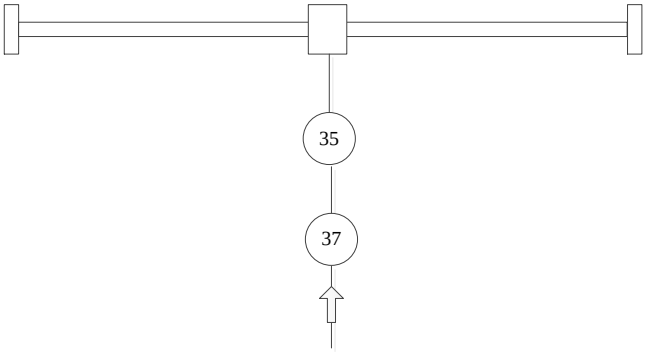
Using method 33 or 34, the homing direction is negative or positive, respectively. The original position is located near the Z phase of the selected direction.



Homing on index pulse

■ Mode 35, 37:

In modes 35 and 37, the position after power on is the origin position.



6-2. Cyclic Synchronous Position Mode

6-2-1. Overview

The upper computer plans the path in CSP mode and sends PDO according to the specified cycle. When transmitting each PDO, the data of target position and control word will be transmitted to the driver at the same time.

6-2-2. Operation steps

1. set [control mode: 6060h】to cyclic synchronous position mode (0x08).
2. set [interpolation time period: 60C2h], the set value must be the same as SYNC0 cycle.
   - 60C2h Sub-1 can be set Interpolation time units, the range is 1ms~20ms.
   - 60C2h Sub-2 can be set Interpolation time index. The value is fixed at -3 which means the time is 10^{-3} second.
3. Drive PDO Rx:
   - 607Ah can set the Target Pos Cmd (32-bit).
   - 6040h Sub-0 can set the controlword.

6-2-3. Related object list

Index	Name	Unit	Read/write
6040h	Control word	-	RW
6072h	Max torque	0.1%	RW
607Ah	Target Position	Command unit	RW
607Dh	Soft Position Limit	-	RW
	Number of entries	-	RW
607Bh	Position range limit	-	RW
	HighestSub-Index numbers	-	RW
60C5h	Max acceleration	Command unit /s^2	RW
60C6h	Max deceleration	Command unit /s^2	RW
60F2h	Positioning option code	-	RW

Csp control mode related detection types

Index	Name	Unit	Read/write
6041h	Statusword	-	RO
6062h	Position demand value	Command unit	RO
6063h	Position actual internal value	pulse	RO
6064h	Position actual value	Command unit	RO
6065h	Following error window	Command unit	RW
6066h	Following error timeout	1ms	RW
606Ch	Velocity actual value	Command unit /s	RO
6076h	Motor rated torque	mN·m	RO
6077h	Torque actual value	0.1%	RO
60F4h	Following error actual value	Command unit	RO
60FAh	Control effort	Command unit	RO
60FCh	Position deamnd internal value	Command unit	RO

6-3. Profile Position Mode

6-3-1. Overview

After receiving the position command from the upper computer controller, the servo driver controls the servo motor to reach the target position.

6-3-2. Operation steps

1. set [control mode: 6060h] to profile position mode (0x01).
2. set [target position: 607Ah] to target position (unit: command unit).
3. set [profile speed: 6081h] to profile velocity control (unit: command unit/s).
4. set [profile acceleration: 6083h], plan the acceleration slope (unit: command unit/s²).
5. set [profile deceleration: 6084h], plan the deceleration slope (unit: command unit/s²).
6. set [control word: 6040h] to (0x06 > 0x07 > 0x0F), make the driver start and the motor run.
7. read [position feedback: 6064h], get the present feedback position of motor
8. read [status word: 6041h], get the driver status, including following error, set-point acknowledge, target reached.

Control word (6040h) < the functions in pp control mode>

Index	Subindex	Name	Range	Data type	Accessibility	PDO	Op-mode
6040h	00h	Control word	0~65535	U16	rw	RxPDO	All

Set control commands for servo drivers such as PDS state transition

Bit information

15	14	13	12	11	10	9	8
r						om	h
7	6	5		4	3	2	1	0
fr	oms				eo	qs	ev	so
	abs/rel	Change set immediately		New set-point				

r = reserved (Not corresponding) fr = fault reset

oms = operation mode specific eo = enable operation

qs = quick stop

h = halt ev = enable voltage

so = switch on

bit6-4 (operation mode specific):

Bit	Name	Value	Definition
4	new set-point	0 -> 1	Start of positioning action, trigger for setting value update Get a new location decided task (607Ah (Target position), 6081h (Profile velocity) etc.
5	change set immediately	0	Complete the currently running positioning action. That is, in the process of movement, if the target position 607A, acceleration 6083, deceleration 6084 are changed, and then the control command is sent, it will not operate according to the new motion parameters. After the last movement is executed, a new command must be sent to execute the new movement.
		1	Interrupt the current positioning action and immediately start the downward positioning action. That is, during the movement, change the target position 607A, acceleration 6083, deceleration 6084, and then send the control command,

			for example, after changing the control word 0x6F (111) → 0x7F (127) (relative mode) or 0x2F (47) → 0x3F (63) (absolute mode), it will immediately run according to the new motion parameters.
6	Absolute/ relative	0	607Ah (target position) is treated as absolute position.
		1	607Ah (target position) is treated as a relative position.

Note:

(1) Please do not change the acceleration and deceleration (*) during motor operation.

If the acceleration and deceleration are changed, please change bit4 (new set-point) from 0 to 1 after the motor stops.

6083h (Profile acceleration)

6084h (Profile deceleration)

60C5h (Max acceleration)

60C6h (Max deceleration)

(2) In the following states, if you execute a set-point (bit4 (new set-point) is changed from 0 to 1), please note that its positioning task is canceled.

--Setting points under 6081h (Profile speed) =0.

(3) In case that the drive is prohibited in deceleration according to the detection of halt=1, all positioning tasks will be voided.

(4) Start the pp action, and keep it for more than 2ms until starting the next pp action (new set-point changes from 0 to 1).

Status word (6041h) <the functions in pp mode >

Index	Subindex	Name	Range	Data type	Accessibility	PDO	Op-mode
6041h	00h	Status word	0~65535	U16	ro	TxPDO	All

Indicates the status of the servo driver

Bit information

15	14	13	12	11	10	9	8
r		oms		ila	oms	rm	r
		Following Error	set- point acknowledge		Target Reached		
7	6	5	4	3	2	1	0
w	sod	Qs	ve	f	oe	so	rsto

r = reserved (Not corresponding) w = warning

sod = switch on disabled

oms = operation mode specific qs = quick stop

(control mode based on bit) ve = voltage enabled

ila = internal limit active f = fault

oe = operation enabled

rm = remote so = switched on

rtso = ready to switch on

bit13,12,10 (operation mode specific):

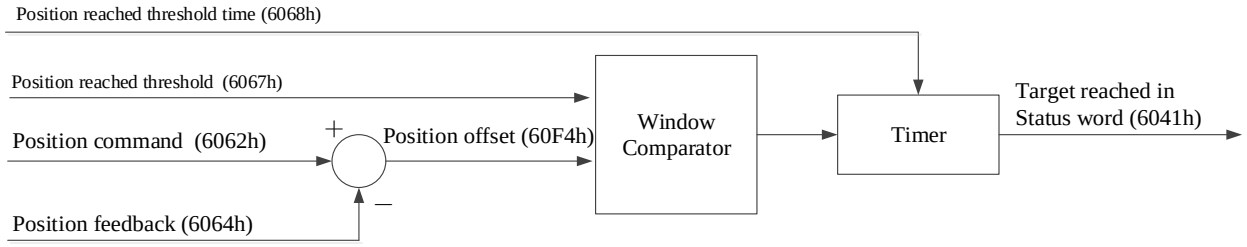
Bit	Name	Value	Definition
10	target reached	0	halt=0 (normally): positioning not complete halt=1 (stop as halt): axis is decelerating
		1	halt=0 (normally): positioning completed halt=1 (stop as halt): axis stop (axis speed is 0)

12	set-point acknowledge	0	The new-setpoint is 0, and the buffer is empty after executing the action of the current target location
		1	The new positioning task uses data to put into the buffer. The buffer is not empty
13	following error	0	60F4h (Following error actual value) (= 6062h(Position demand value) – 6064h(Position actual value), not over the setting range of 6065h (Following error window), or 60F4h value is over the setting value of 6065h, not pass the setting time of 6066h
		1	60F4h (Following error actual value) is over the setting range of 6065h(Following error window), above the setting time of 6066h (Following error time out) , continue

bit10: target reached (Position reached)

The difference between 6062h (required position value) and 6064h (position feedback) is within the range set for 6067h (position arrival threshold) when the servo enable is on (effective operation state) and all set points give the status of completing command generation. If the time set for 6068h (position arrival time window) is over, the bit10 (target reached) of 6041h (status word) becomes 1.

Bit	Name	Value	Definition
10	Target reached	0	halt=0 (normally): positioning not complete halt=1 (stop as halt): axis is decelerating
		1	halt=0 (normally): positioning completed halt=1 (stop as halt): axis stop (axis speed is 0)



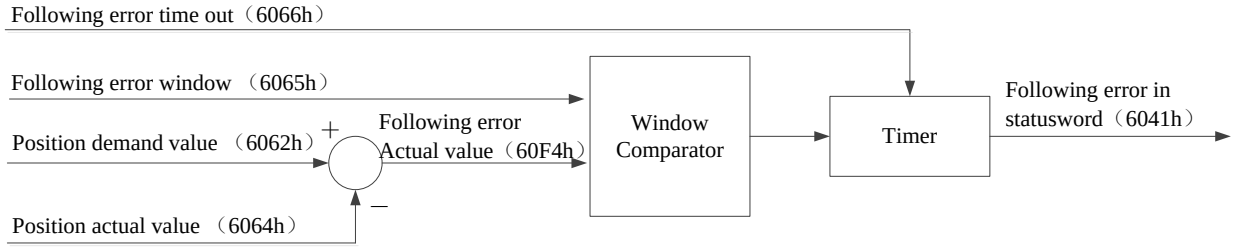
Location arrival diagram

Index	Subindex	Name	Unit	Range	Data type	Accessibility	PDO	OP-mode
6067h	00h	Position reached threshold	Command unit	0~4294967295	U32	rw	RxPDO	PP
		The difference between 6062h (position command) and 6064h (position feedback) is within the set value of this parameter. If the time set in 6068h (position arrival time window) is passed, set the bit10 (target reached) of 6041h (status word) as the threshold value of 1. If the difference is a value other than that set for this parameter, the bit10 of 6041h is 0.						
6068h	00h	Position reached time window	1ms	0~65535	U16	rw	RxPDO	PP
		When the difference between 6062h (position command) and 6064h (position feedback) is in the range of 6067h (position reaching threshold), the time of setting bit10 (target reaching) of 6041h (status word) to be 1						

bit13: follow error

The value of 60F4h (position deviation) exceeds the set range of 6065h (position deviation excessive threshold). If the time set for 6066h (error timeout) continues, the bit13 of 6041h (status word) becomes 1.

Bit	Name	Value	Definition
13	following error	0	60F4h (position deviation) (= 6062h (position command) – 6064h (position feedback), not over the setting range of 6065h (position deviation excessive threshold), or 60F4h value is over the setting value of 6065h, not pass the setting time of 6066h
		1	60F4h (position deviation) is over the setting range of 6065h (position deviation excessive threshold), above the setting time of 6066h(error timeout), continue



Follow error function diagram

Index	Subindex	Name	Unit	Range	Data type	Accessibility	PDO	OP-mode
6065h	00h	position deviation excessive threshold	Command unit	0 ~ 4294967295	U32	rw	RxPDO	PP CSP
		If the value of 60F4h (Following error actual value) is beyond the setting value of this parameter, set the bit13 (following error) of 6041h (status word) as the threshold value of 1.						
6066h	00h	Error timeout	1ms	0~65535	U16	rw	RxPDO	PP CSP
		If the value of 60F4h (position deviation) exceeds the setting range of 6065h (position deviation excessive threshold), this state is the setting value above this parameter. If you continue, set the bit13 of 6041h (status word) to the threshold value of 1.						

6-2-3-1. Action of pp control mode

Action example 1: (basic set-point)

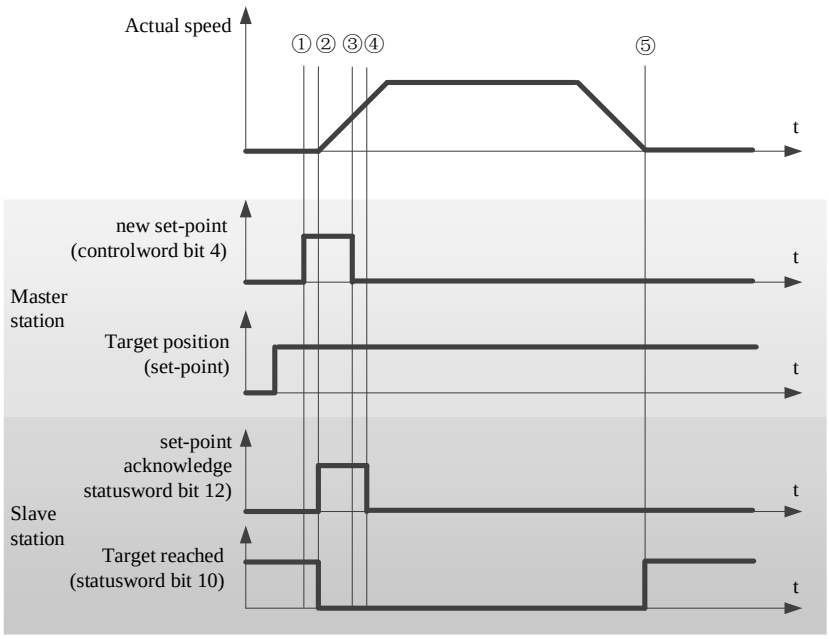
(1) For the master station, after setting the value of 607Ah (target position), changes the bit4 (new set point) of 6040h (control word) from 0 to 1. At this time, please also set 6081h (profile speed). When 6081h (contour speed) is 0, the motor does not act.

(2) For the slave station, confirm the rising edge (0 → 1) of the 6040h bit4 (new set point), and the 607Ah (target position) as the target position to start positioning. At this time, change the bit 12 (set point acknowledge) of 6041h (status word) from 0 to 1.

(3) For master station, confirm that the 6041h bit12 (set point acknowledge) has changed from 0 to 1, 6040h bit4 (new set-point) returns 0.

(4) For slave station, confirm that 6040h bit4 (new set-point) has been 0, 6041h bit12 (set-point acknowledge) changed to 0.

(5) When the target position is reached, the bit10 (target reached) of 6041h changed from 0 to 1.



< Set-point example >

Note:

① 6081h (profile speed) is limited by the smaller one of 607Fh (maximum profile speed) and 6080h (maximum motor speed).

② Changing the set value of 607Fh or 6080h during the action is not reflected in the action.

Action example 2: (Action data change without buffer: single set-point)

When the bit5 (change set immediate) of 6040h is 1, if the data is used for positioning action change, the current positioning action is interrupted, and the next positioning action is started immediately.

(1) Master station, confirm 6041h bit12 (set-point acknowledge) is 0. After changing the value of 607Ah (target position), change the 6040h bit4 (new set point) from 0 to 1.

Note: At this time, please do not change the acceleration and deceleration.

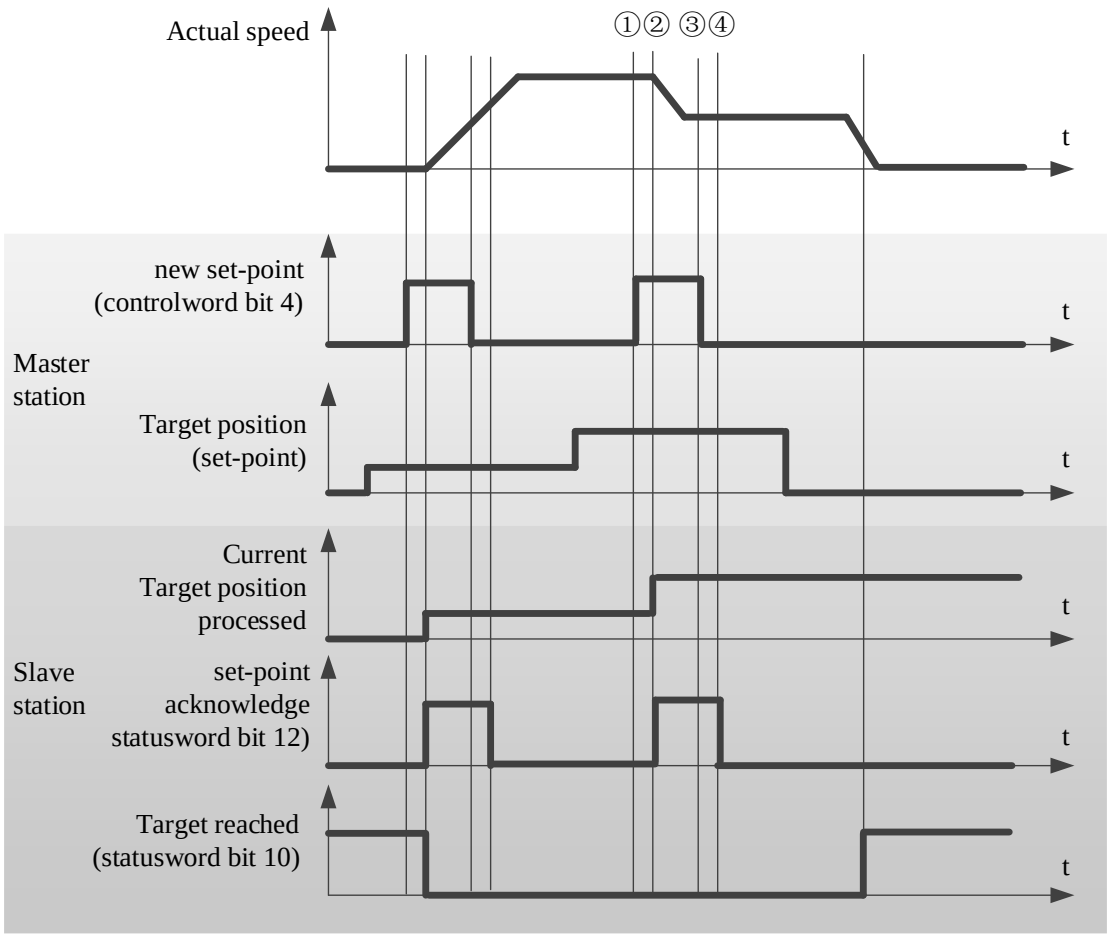
(2) Slave station, confirm 6040h bit4 (new set-point) rising edge is from 0 to 1, 607Ah is updated immediately as a new target location. At this time, the bit 12 (set point acknowledge) of 6041h is changed from 0 to 1.

(3) Master station, confirm 6041h bit12 (set-point acknowledge) has changed from 0 to 1, 6040h bit4 (new set-point) returns 0.

(4) Slave station, confirm 6040h bit4 (new set-point) has changed to 0, 6041h bit12 (set-point acknowledge) is 0.

Note: 6081h (profile speed) can be changed in the same steps (1)~(4).

After changing 607Ah (target position) and 6081h (profile speed), update 607Ah and 6081h simultaneously according to the above steps (1) to (4).



< handshaking procedure for the single set-point method >

6-3-3. Related object list

Index	Name	Unit	Read/write
6040h	Controlword	UNSIGNED16	RW
6041h	Statusword	UNSIGNED16	RO
6060h	Mode of operation	INTEGER8	RW
6061h	Modes of operation display	INTEGER8	RO
6062h	Position demand value [PUU]	INTEGER32	RO
6063h	Position actual value [increment]	INTEGER32	RO
6064h	Position actual value	INTEGER32	RO
6065h	Following error window	UNSIGNED32	RW
6067h	Position window	UNSIGNED32	RW
6068h	Position window time	UNSIGNED16	RW
607Ah	Target position	INTEGER32	RW
6081h	Profile velocity	UNSIGNED32	RW
6083h	Profile acceleration	UNSIGNED32	RW
6084h	Profile deceleration	UNSIGNED32	RW
60F4h	Following error actual value	INTEGER32	RO
60FCh	Position demand value	INTEGER32	RO

6-4. Profile Velocity Mode

6-4-1. Overview

The driver can receive speed commands and plan acceleration and deceleration.

6-4-2. Operation steps

1. set [control mode: 6060h] to profile velocity mode (0x03).
2. set [control word: 6040h] to (0x06 > 0x07 > 0x0F), make the driver start and the motor to run.
3. set [profile acceleration: 6083h], plan acceleration slope (unit: command unit/s²).
4. set [profile deceleration: 6084h], plan deceleration slope (unit: command unit/s²).
5. set [target speed: 60FFh], target speed unit is 0.1 rpm.
6. read [status word: 6041h] to get the driver status.

6-4-3. Related object list

Index	Name	Unit	Read/write
6040h	Controlword	UNSIGNED16	RW
6041h	Statusword	UNSIGNED16	RO
6060h	Modes of operation	INTEGER8	RW
6061h	Modes of operation display	INTEGER8	RO
606Bh	Velocity demand value	INTEGER32	RO
606Ch	Velocity actual value	INTEGER32	RO
606Dh	Velocity window	UNSIGNED16	RW
606Eh	Velocity window time	UNSIGNED16	RW
606Fh	Velocity threshold	UNSIGNED16	RW
60FFh	Target velocity	INTEGER32	RW

7. Mode common function

7-1. Touch Probe Function

7-1-1. Overview

The probe function can be triggered through the SI terminal of CN0 or encoder, and the feedback position can be fixed as the rising edge or falling edge by the input terminals of differential input signals SI1 and SI2. The fixed position time can be less than 5μs. This function can be used for high-speed measurement or packaging applications.

7-1-2. Operation steps

P2-09 corresponds to probe 1 and P2-10 corresponds to probe 2 (it must be assigned to SI1 / SI2 and cannot be modified).
[probe function: 60B8h] disable the corresponding probe in 60B8h, set the input terminal in P5-62/P5-63, then enable the object word 60B8h.
When reading the probe value, you need to add the corresponding probe value object (60BAh-60BDh) to TxPDO.

7-1-3. Related object list

Index	Name	Unit	Read/write
60B8h	Touch probe function	-	RW
60B9h	Touch probe status	-	RO
60BAh	Touch probe pos1 pos value	Command unit	RO
60BBh	Touch probe pos1 neg value	Command unit	RO
60BCh	Touch probe pos2 pos value	Command unit	RO
60BDh	Touch probe pos2 neg value	Command unit	RO

The user can obtain the current setting of the probe function from the object 60B8h. Under the same probe, do not set the rising edge and falling edge at the same time. The following is the bit description of 60B8h.

Bit	Value	Explanation	
0	0	switch off Touch probe 1	Stop/run Touch probe1
	1	enable Touch probe 1	
1	0	Trigger first event	Touch probe1 mode selection
	1	Continuous	
2	0	Trigger with Touch probe1 input	Touch probe1trigger selection (external input/phase Z)
	1	Trigger with zero impulse signal of position encoder	
3	0	Reserved	Unuse
4	0	switch off sampling at positive edge of touch probe1	Touch probe1 rising edge selected
	1	enable sampling at positive edge of touch probe1	
5	0	switch off sampling at negative edge of touch probe1	Touch probe1 falling edge selected
	1	enable sampling at negative edge of touch probe1	
6-7	0	Reserved	
8	0	switch off Touch probe 2	Stop/run Touch probe2

Bit	Value	Explanation	
	1	enable Touch probe 2	
9	0	Trigger first event	Touch probe2 mode selection (single/continuous)
	1	Continuous	
10	0	Trigger with Touch probe2 input	Touch probe2 trigger selection (external input/phase Z)
	1	Trigger with zero impulse signal of position encoder	
11	0	Reserved	not used
12	0	switch off sampling at positive edge of touch probe2	Touch probe 2 rising edge selected
	1	enable sampling at positive edge of touch probe2	
13	0	switch off sampling at negative edge of touch probe2	Touch probe 2 falling edge selected
	1	enable sampling at negative edge of touch probe2	
14-15	0	reserved	

The user can obtain the current state of the probe from the object 60B9h. The following is the description of bit corresponding to 60B9h.

Bit	Value	Explanation	
0	0	Touch probe1 is switch off	Probe 1 action stop
	1	Touch probe1 is enabled	Probe 1 in action
1	0	Touch probe1 no positive edge value stored	Rising edge probe 1 incomplete status
	1	Touch probe1 positive edge value stored	Rising edge probe 1 completion status
2	0	Touch probe1 no negative edge value stored	Falling edge probe 1 incomplete state
	1	Touch probe1 negative edge value stored	Falling edge probe 1 completion status
3-5	-	reserved	not used
6-7	-	Not supported	not used
8	0	Touch probe2 is switch off	Probe 2 action stop
	1	Touch probe2 is enabled	Probe 2in action
9	0	Touch probe2 no positive edge value stored	Rising edge probe 2incomplete status
	1	Touch probe2 positive edge value stored	Rising edge probe 2 completion status
10		Touch probe2 no negative edge value stored	Falling edge probe 2 incomplete state
		Touch probe2negative edge value stored	Falling edge probe 2 completion status
11-13	-	Reserved	not used
14-15	-	Not supported	not used

7-2. Digital input (60FDh)

Each bit of the digital input 60FDh represents the input status of the positive limit switch (POT), negative limit switch (NOT), and home switch (HOME) respectively through the function signals allocated by the DS5C1 series servo parameters P5-22 (POT setting address), P5-23 (NOT setting address), and P5-27 (HOME origin setting address).

Digital input (60FDh)

<table>
<tr><th>Index</th><th>Subindex</th><th>Name</th><th>Range</th><th>Data type</th><th>Accessibility</th><th>PDO</th><th>Op-mode</th></tr>
<tr><td>60FDh</td><td>00h</td><td>Digital inputs</td><td>0~4294967295</td><td>U32</td><td>ro</td><td>TxPDO</td><td>All</td></tr>
<tr><td colspan="8">Indicates the theoretical input state of the external input signal.
Bit information
<table>
<tr><td>31</td><td>30</td><td>29</td><td>28</td><td>27</td><td>26</td><td>25</td><td>24</td></tr>
<tr><td colspan="8">r</td></tr>
<tr><td>23</td><td>22</td><td>21</td><td>20</td><td>19</td><td>18</td><td>17</td><td>16</td></tr>
<tr><td colspan="8">r</td></tr>
<tr><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td></tr>
<tr><td colspan="8">r</td></tr>
<tr><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td colspan="5">R</td><td>hs</td><td>pls</td><td>nls</td></tr>
</table>
r = reserved (Not corresponding) pls= positive limit switch
nls = negative limit switch hs=home switch</td></tr>
</table>

Details of each bit are as follows:

Value	Description
0	Input state OFF
1	Input state ON

The values of bit0 (reverse overtravel switch), bit1 (positive overtravel switch) and bit2 (origin switch) of 60FD (digital input) represent the signal states of positive direction drive limit input, negative direction drive limit input and near origin input respectively.

8. EtherCAT parameter list (refer to XML file for details)

8-1. CoE object word

8-1-1. Communication Profile area

Index		Name	Data type	Read/write
1000h	VAR	device type	UNSIGNED32	RO
1001h	VAR	error register	UNSIGNED8	RO
1600h~03h	RECORD	Receive PDO mapping	UNSIGNED32	RW
1A00h~03h	RECORD	Transmit PDO mapping	UNSIGNED32	RW

8-1-2. Driver Profile area

Index		Name	Data type	Read/write
603Fh	VAR	Error Code	UNSIGNED16	RO
6040h	VAR	Controlword	UNSIGNED16	RW
6041h	VAR	Statusword	UNSIGNED16	RO
605Bh	VAR	Shutdown option code	INTEGER16	RW
605Eh	VAR	Fault reaction option code	INTEGER16	RW
6060h	VAR	Modes of operation	INTEGER8	RW
6061h	VAR	Modes of operation display	INTEGER8	RO
6063h	VAR	Position actual value[increment]	INTEGER32	RO
6064h	VAR	Position actual value	INTEGER32	RO
6065h	VAR	Following error window	UNSIGNED32	RW
6067h	VAR	Position windows	UNSIGNED32	RW
6068h	VAR	Position window time	UNSIGNED16	RW
606Bh	VAR	Velocity demand value	INTEGER32	RO
606Ch	VAR	Velocity actual value	INTEGER32	RO
606Dh	VAR	Velocity window	UNSIGNED16	RW
606Eh	VAR	Velocity window time	UNSIGNED16	RW
606Fh	VAR	Velocity threshold	UNSIGNED16	RW
6071h	VAR	Target torque	INTEGER16	RW
6072h	VAR	Max torque	UNSIGNED16	RW
6074h	VAR	Torque demand value	INTEGER16	RO
6075h	VAR	Motor rated current	UNSIGNED32	RO
6076h	VAR	Motor rated torque	UNSIGNED32	RO
6077h	VAR	Torque actual value	UNSIGNED16	RO
6078h	VAR	Current actual value	INTEGER16	RO
607Ah	VAR	Target position	INTEGER32	RW
607Ch	VAR	Home Offset	INTEGER32	RW
607Dh	ARRAY	Software position limit	INTEGER32	RW
607Eh	VAR	Polarity	UNSIGNED8	RW
607Fh	VAR	Max profile velocity	UNSIGNED32	RW
6080h	VAR	Max motor speed	UNSIGNED32	RW
6081h	VAR	Profile velocity	UNSIGNED32	RW
6083h	VAR	Profile acceleration	UNSIGNED32	RW
6084h	VAR	Profile deceleration	UNSIGNED32	RW

Index		Name	Data type	Read/write
6085h	VAR	Quick stop deceleration	UNSIGNED32	RW
6086h	VAR	Motion profile type	INTEGER16	RW
6087h	VAR	Torque slope	UNSIGNED32	RW
6093h	ARRAY	Position factor	UNSIGNED32	RW
6098h	VAR	Homing method	INTEGER8	RW
6099h	ARRAY	Homing speeds	UNSIGNED32	RW
609Ah	VAR	Homing acceleration	UNSIGNED32	RW
60B8h	VAR	Touch probe function	UNSIGNED16	RW
60B9h	VAR	Touch probe status	UNSIGNED16	RO
60BAh	VAR	Touch probe pos1 pos value	INTEGER32	RO
60BBh	VAR	Touch probe pos1 neg value	INTEGER32	RO
60BCh	VAR	Touch probe pos2 pos value	INTEGER32	RO
60BDh	VAR	Touch probe pos2 neg value	INTEGER32	RO
60C0h	VAR	Interpolation sub mode select	INTEGER16	RW
60C1h	ARRAY	Interpolation data record	UNSIGNED16/32	RW
60C2h	RECORD	Interpolation time period	SIGNED8	RW
60C5h	VAR	Max acceleration	UNSIGNED32	RW
60C6h	VAR	Max deceleration	UNSIGNED32	RW
60F2h	VAR	Positioning option code	UNSIGNED16	RW
60F4h	VAR	Following error actual value	INTEGER32	RO
60FCh	VAR	Position demand value	INTEGER32	RO
60FDh	VAR	Digital inputs	UNSIGNED32	RO
60FFh	VAR	Target velocity	INTEGER32	RW
6502h	VAR	Supported drive modes	UNSIGNED32	RO
Xinje user-defined area				
2000h~ 281Ah	VAR	Parameter Mapping	INTEGER16/32	RW

9. EtherCAT alarm information

Note: the stepper alarm can be cleared by setting SM2013+20*(n-1) or the alarm can be cleared by upper computer F0-00 = 1.

Code	Explanation	Reason	Solution
E-800	Incorrect ESM requires fault protection	Accept state transition requests that cannot be converted from the current state: Init→Safeop Init→OP PreOP→OP ESM status after alarming: stop at the current status when the current status is Init, PreOP, convert to SafeOP when it is SafeOP. ESC register AL Status Code: 0011h	Confirm the status conversion requirements of the upper device
E-801	Undefined ESM requires fault protection	Accept state transition requests except the following: 1: Request Init State 2: Request Pre-Operational State 3: Request Bootstrap State 4: Reauest Safe-operational State 8: Request Operational State ESM status after alarming: stop at the current status when the current status is Init, PreOP, SafeOP. Convert to SafeOP when it is OP. ESC register AL Status Code: 0012h	Confirm the status conversion requirements of the upper device
E-802	Boot state requires abnormal protection	Accept the following state transition requests: 3: Request Bootstrap State ESM status after alarming: Init ESC register AL Status Code: 0013h	Confirm the status conversion requirements of the upper device
E-803	PLL incomplete abnormal protection	1s after synchronization, the phase combination (PLL locking) of communication and servo still cannot be completed ESM status after alarming: PreOP ESC register AL Status Code: 002Dh	Confirm the setting of DC and whether the propagation delay compensation and deviation compensation are correct
E-804	PDO watchdog abnormal protection	PDO communication (SafeOP or OP state), set the time through ESC register address 0400 (Watchdog Divider) and 0420 (Watchdog Time Process Data), 0220 (AL Event Request) bit10 is not ON. ESM status after alarming: Safe OP ESC register AL Status Code: 001Bh	Confirm whether the sending time of PDO from the upper device is fixed (interrupted). Confirm that the PDO watchdog detection delay value is too large. Confirm whether there is any problem with the wiring of EtherCAT communication cable and whether there is excessive noise on the cable.
E-806	PLL abnormal protection	ESM is in the state of SafeOP or OP, communication and servo phase (PLL locking) do	Confirm the setting of DC and whether the propagation delay

Code	Explanation	Reason	Solution
		not match ESM status after alarming: SafeOP ESC register AL Status Code: 0032h	compensation and deviation compensation are correct.
E-807	Synchronous signal abnormal protection	After the synchronization processing is completed, the interrupt processing occurs above the set threshold according to SYNC0 or IRQ ESM status after alarming: SafeOP ESC register AL Status Code: 002Ch	Confirm the setting of DC and whether the propagation delay compensation and deviation compensation are correct.
E-810	Synchronization cycle setting abnormal protection	Set unsupported synchronization cycle: The set value of synchronization cycle is beyond 500us, 1ms, 2ms and 4ms ESM status after alarming: PreOP ESC register AL Status Code: 0035h	Set the correct synchronization cycle
E-811	Mailbox setting abnormal protection	The mailbox setting value SM0/1 is error: The sending and receiving area of the mailbox overlaps with SM2/3, and the sending and receiving area address is odd. The mailbox starting address is at SyncManager0: 1000h~10FFh, SyncManager1: out the range of 1200h~12FFh. SyncManager0/1length (ESC register: 0802h, 0803h/080Ah, 080Bh) setting is error: SyncManager0: out the range of 32~256byte SyncManager1: out the range of 40~256byte SyncManager0/1 Control Register (ESC register 0804h/080Ch) setting is error: Set other than 100110b to 0804h: bit5-0 Set other than 100110b to 080Ch: bit5-0 ESM status after alarming: Init ESC register AL Status Code: 0016h	Set correct SyncManager according to ESI file description
E-814	PDO watchdog setting abnormal protection	PDO watchdog setting is error. PDO watchdog trigger is effective (SyncManager: register 0804h bit6 is 1), PDO watchdog detection timeout value (register 0400h, 0402h) is not meet "communication period *2" ESM status after alarming: PreOP ESC register AL Status Code: 001Fh	Set correct watchdog detection timeout value
E-815	DC setting abnormal protection	DC setting is error. ESC register 0981h (Activation) bit2-0 is set to the value other than the following: bit2-0=000b; bit2-0=011b. ESM status after alarming: PreOP ESC register AL Status Code: 0030h	Confirm the DC setting
E-816	SM event mode setting abnormal protection	Unsupported SM time mode is set, 1C32/1C33-01 set the value other than 00,01,02. ESC register 0981 bit2-0=000b and only SM2 of	Confirm that the settings of 1C32h-01h and 1C33h-01h are consistent and the values are at

Code	Explanation	Reason	Solution
		1C32h-01h and 1C33h-01h are set. ESM status after alarming: PreOP ESC register AL Status Code: 0028h	any one of 00h, 01h and 02h
E-817	SyncManager 2/3 setting abnormal protection	SM2/3 is set to error value. SM2/3 incorrect physical address setting (ESC register: 0810h/0818h), the receiving and transmitting area overlaps, overlaps with SM2/3, the starting address is odd, and the starting address and completion address are outside the range. SM2/3 length setting (ESC register: 0812h/081A) and RxPDO, TxPDO is different. SM2/3 control register (ESC register: 0814h/081Ch) setting is error. Set other than 100110b to bit5-0 ESM status after alarming: PreOP ESC register AL Status Code: 001Dh/001Eh	Set correct SyncManager2/3 according to ESI file description
E-850	TxPDO distribution abnormal protection	TxPDO mapping data size is over 24 bytes ESM status after alarming: PreOP ESC register AL Status Code: 0024h	Make sure the TxPDO mapping data size is in the range of 24 bytes
E-851	RxPDO distribution abnormal protection	RxPDO mapping data size is over 24 bytes ESM status after alarming: PreOP ESC register AL Status Code: 0025h	Make sure the RxPDO mapping data size is in the range of 24 bytes
E-881	Control mode setting abnormal protection	When the set value of 6060h is 0 and the set value of 6061h is 0, the PDS state is converted to "operation enabled". 6060h no corresponding control mode is set. When it is full closed loop control, 6060h is the mode other than position control and to be set. ESM status after alarming: stop at present ESM state ESC register AL Status Code: 0000h	Confirm the setting value of 6060h
E-882	ESM requires abnormal protection during operation	When the PDS status is "operation enabled" or "quick stop active", other ESM status conversion commands are received ESM status after alarming: based on the state transformation requirements from the host computer ESC register AL Status Code: 0000h	Confirm the state transformation requirements from the host computer

WECHAT ID

WUXI XINJE ELECTRIC CO., LTD.

4th Floor Building 7,Originality Industry park, Liyuan Development Zone, Wuxi City, Jiangsu Province

214072

Tel: 400-885-0136

Fax: (510) 85111290

www.xinje.com