Contents

1 Product overview

1.1 Introduction

The ECAT-2094DS stepper motor controller is a cost-effective, two-phase bipolar stepper driver. The ECAT-2094DS simultaneously controls up to four stepper motors. A motor voltage range between9 and 29 V DC and a maximum motor coil current of 3.3A (Peak)/phase is being supported. The running motor current and other motion parameters are software selectable.

ECAT-2094DS can be directly connected with a two-phase bipolar stepping motor. Stepper motors are controlled in an open loop operation. It must complete the system configuration through the EtherCAT master station and the application program.

The ECAT-2094DS has four integrated incremental encoder interfaces. Four 32 bit high frequency encoder counter counts the input signal of external incremental encoders. The encoder can for example be used for homing purposes and for consistency checks.

High resolution of up to 256 microsteps per full step is supported for an ensuring smooth and precise motor operation.

For each motor three digital input channels are provided. The digital inputs include positive and negative direction hardware limit switches and an org switch. The positive and negative direction limit switches can automatically stop the motor when triggered, and all three digital inputs can be used to search home position.

The module must be supplied by three power sources. Two motor supplies and a 24Vdc control supply. Two motors share one power supply.

1.2 Technical Data

- Supports 4 stepper motor (2-phase bipolar)
- Stepper motor are controlled in an open loop operation
- Programmable coil current level: up to 3.3 A/phase
- Programmable microstep size: maximum 256 microsteps per full step
- Supported motor voltage range: 9 to 29V_{DC}
- 4 x Encoder interfaces (A, B, Z), differential
- 12 x Digital input. Three DI channels for each axis: hardware limit input, home switch input
- Automatic current reduction to reduce heat when motor is not moving
- Drive protection:
  - Over-temperature
  - Under voltage
  - Short circuit
- Optically isolated I/O
- LED indicators for I/O, EtherCAT and motion status
- Internal memory for storing configuration data
- EtherCAT:
  - 2 x RJ-45 bus interface
  - Distance between stations up to 100 m (100BASE-TX)
  - Support daisy chain connection
  - EtherCAT conformance test tool verified
  - Supports Free-Run and Distributed Clock (DC) operation modes
  - Supports CoE and FoE
  - Supports Control modes: CPS、CSV、Hm and PP
  - Support minimum communication cycle 0.5ms
- Removable terminal block connector

1.3 Hardware Specification

Motors	
Number of outputs	4x stepper motor, 2 phases
Output current	3.3A/phase
Motor voltage range	9 to 29V_{DC}
Maximum step frequency	8.192 MHz
Microsteps per step	256, 128, 64, 32, 16, 8, 4, 2
Encoder inputs	
Number of encoder inputs	4x encoder counter (A, B, Z), differential
Maximum encoder pulse frequency	1 MHz
Digital Inputs	
Number of digital inputs	12 (3 inputs for each motor)
Wet contact	• ON voltage level: +10 to 24V_{DC} • OFF voltage level: +4V_{DC} MAX
Photo-Isolation	3750V_{DC}
LED Indicators	
Diagnostic LED	Power, EtherCAT status, Digital IO, driving, temperature warning, over-temperature error
Communication Interface	
Connector	2 x RJ-45
Protocol	EtherCAT
Distance between stations	Max. 100 m (100BASE-TX)
Data transfer medium	Ethernet/EtherCAT Cable (Min. CAT 5), Shielded
Power	
Input voltage range	20V ~ 30V_{DC}
EMS Protection	
ESD (IEC 61000-4-2)	4 KV Contact for each channel
EFT (IEC 61000-4-4)	Signal: 1 KV Class A; Power: 1 KV Class A
Surge (IEC 61000-4-5)	1 KV Class A
Mechanism	
Installation	DIN-Rail
Dimensions (LxWxH) [mm]	181 x 110 x 33 (without connectors)
Case material	Metal
Environment	
Operating temperature	-25℃ ~ 40℃
Storage temperature	-30℃ ~ 80℃

Relative humidity	10 ~ 90%, No Condensation

2 Wiring

2.1 LED Definition

The ECAT-2094DS provides on the frontside of the connection cap several diagnostic LEDs.
Furthermore there are three LEDs to indicate the network status for EtherCAT. The exact meaning of the LED indication is specified in the following tables:

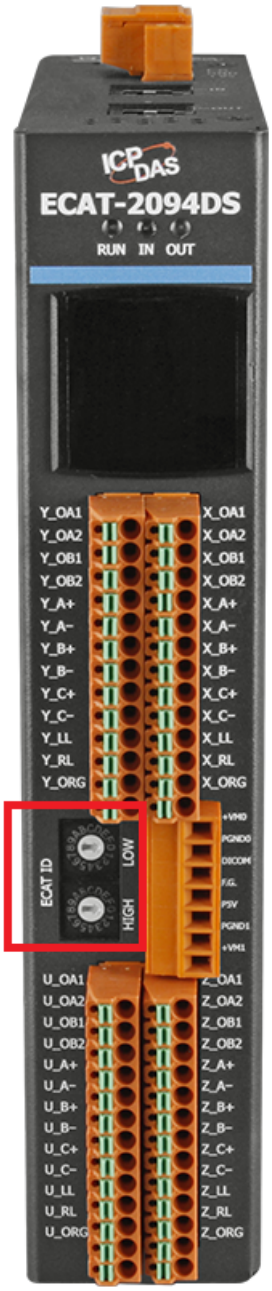
EtherCAT LED	Color	State	Description
RUN	red		This LED indicates the operation state of the EtherCAT slave:
		Off	Device is in INIT state
		Flashing	Device is in PREOP state
		Single flash	Device is in SAFEOP state Outputs remain in safe state
		On	Device is in OP state
IN	green		Indicates the communication status of the EtherCAT port IN
		Off	No connection
		Flashing	Link and activity (e.g. data exchange with the master)
		On	Link without any activity
OUT	green		Indicates the communication status of the EtherCAT port OUT. Further EtherCAT slave can be connected to the port OUT
		Off	No EtherCAT slaves are connected to port OUT
		Flashing	Link and activity (e.g. data exchange connected slaves)
		On	Link without any activity

Control LED	Color	Description
*	red	- Power indicator
* * * * * * * * (first row)	green	- LED 0: AXIS X - Home Switch input

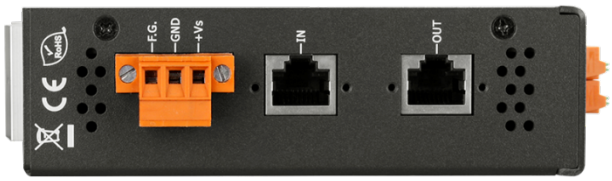
0 1 2 3 4 5 6 7		- LED 1: AXIS X - Positive direction hardware limit input - LED 2: AXIS X - Negative direction hardware limit input - LED 3: AXIS X - Driving - LED 4: AXIS X - Motion chip SPI communication error - LED 5: AXIS X - Short to ground - LED 6: AXIS X - Over temperature warning - LED 7: AXIS X - Over temperature error
* * * * * * * * (second row) 8 9 10 11 12 13 14 15	green	- LED 0: AXIS Y - Home Switch input - LED 1: AXIS Y - Positive direction hardware limit input - LED 2: AXIS Y - Negative direction hardware limit input - LED 3: AXIS Y - Driving - LED 4: AXIS Y - Motion chip SPI communication error - LED 5: AXIS Y - Short to ground - LED 6: AXIS Y - Over temperature warning - LED 7: AXIS Y - Over temperature error
* * * * * * * * (third row) 16 17 18 19 20 21 22 23	green	- LED 0: AXIS Z - Home Switch input - LED 1: AXIS Z - Positive direction hardware limit input - LED 2: AXIS Z - Negative direction hardware limit input - LED 3: AXIS Z - Driving - LED 4: AXIS Z - Motion chip SPI communication error - LED 5: AXIS Z - Short to ground - LED 6: AXIS Z - Over temperature warning - LED 7: AXIS Z - Over temperature error
* * * * * * * * (fourth row) 24 25 26 27 28 29 30 31	green	- LED 0: AXIS U - Home Switch input - LED 1: AXIS U - Positive direction hardware limit input - LED 2: AXIS U - Negative direction hardware limit input - LED 3: AXIS U - Driving - LED 4: AXIS U - Motion chip SPI communication error - LED 5: AXIS U - Short to ground - LED 6: AXIS U - Over temperature warning - LED 7: AXIS U - Over temperature error

2.2 Alias Rotary Swtich

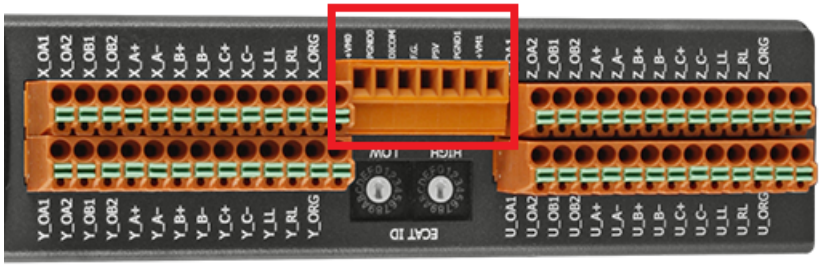
The Alias range is 0x00~0xFF



2.3 Connection Interfaces

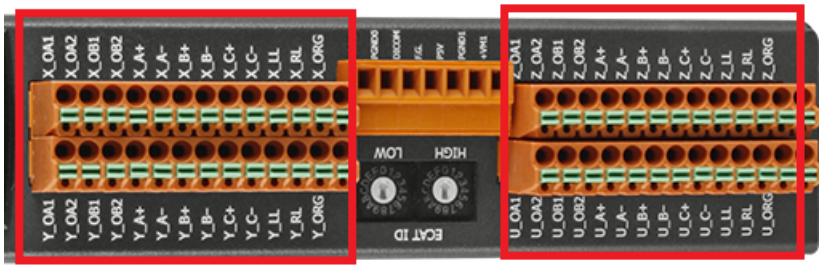


Name	Signal	Description
F.G	Frame ground	
GND	Power supply: Ground 0V (from negative power contact)	ECAT-2094DS power
+Vs	Power supply: +24 V_{DC} (from positive power contact)	
IN	EtherCAT signal input	Incoming EtherCAT cable
OUT	EtherCAT signal output	Outgoing EtherCAT cable



Name	Signal	Description
+VM0	+9 to 29V_{DC} (from positive power contact)	Power supply for motor X and Y Power supply for motor
PGND0	Ground 0V (from negative power contact)	CAUTION: Automatic start of stepper motor! • Risk of death or serious injury for humans working in the machine. It can not ruled out that the stepper motor may perform unplanned movement during the ECAT-2094DS setup and configuration
DI.COM		Common DI X supply: +10 to +24V_{DC}

F.G.		Frame ground
P5V	Output	Power supply to encoder
PGND1	Ground 0V (from negative power contact)	Power supply for motor Z and U Power supply for motor
+VM1	+9 to 29V_{DC} (from positive power contact)	CAUTION: Automatic start of stepper motor! • Risk of death or serious injury for humans working in the machine. It can not ruled out that the stepper motor may perform unplanned movement during the ECAT-2094DS setup and configuration



Name	Signal	Description	
X_OA1	Output	Motor X winding A1	Motor X
X_OA2	Output	Motor X winding A2	
X_OB1	Output	Motor X winding B1	
X_OB2	Output	Motor X winding B2	
X_A+	Input	Encoder X input A+	Encoder X
X_A-	Input	Encoder X input A-	
X_B+	Input	Encoder X input B+	
X_B-	Input	Encoder X input B-	
X_C+	Input	Encoder X input C+	
X_C-	Input	Encoder X input C-	
X_LL	Input	Negative direction hardware limit switch for motor X	limit switch and home switch for motor X
X_RL	Input	Positive direction hardware limit switch for motor X	
X_ORG	Input	home switch for motor X	

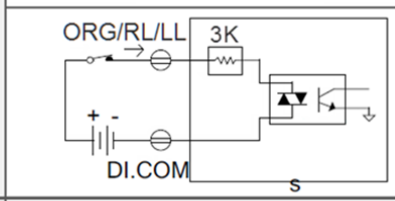
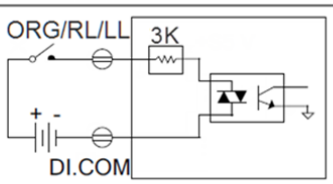
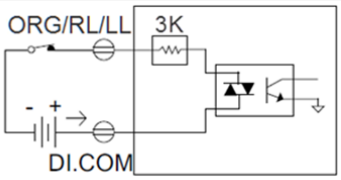
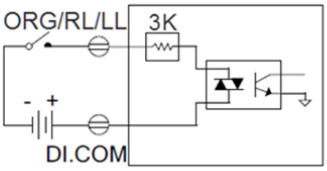
Y_OA1	Output	Motor Y winding A1	Motor Y
Y_OA2	Output	Motor Y winding A2	
Y_OB1	Output	Motor Y winding B1	
Y_OB2	Output	Motor Y winding B2	
Y_A+	Input	Encoder Y input A+	Encoder Y
Y_A-	Input	Encoder Y input A-	
Y_B+	Input	Encoder Y input B+	
Y_B-	Input	Encoder Y input B-	
Y_C+	Input	Encoder Y input C+	
Y_C-	Input	Encoder Y input C-	
Y_LL	Input	Negative direction hardware limit switch for motor Y	limit switch and home switch for motor Y
Y_RL	Input	Positive direction hardware limit switch for motor Y	
Y_ORG	Input	home switch for motor Y	
Z_OA1	Output	Motor Z winding A1	Motor Z
Z_OA2	Output	Motor Z winding A2	
Z_OB1	Output	Motor Z winding B1	
Z_OB2	Output	Motor Z winding B2	
Z_A+	Input	Encoder Z input A+	Encoder Z
Z_A-	Input	Encoder Z input A-	
Z_B+	Input	Encoder Z input B+	
Z_B-	Input	Encoder Z input B-	
Z_C+	Input	Encoder Z input C+	
Z_C-	Input	Encoder Z input C-	
Z_LL	Input	Negative direction hardware limit switch for motor Z	limit switch and home switch for motor Z
Z_RL	Input	Positive direction hardware limit switch for motor Z	
Z_ORG	Input	home switch for motor Z	
U_OA1	Output	Motor U winding A1	Motor U
U_OA2	Output	Motor U winding A2	
U_OB1	Output	Motor U winding B1	
U_OB2	Output	Motor U winding B2	

U_A+	Input	Encoder U input A+	Encoder U
U_A-	Input	Encoder U input A-	
U_B+	Input	Encoder U input B+	
U_B-	Input	Encoder U input B-	
U_C+	Input	Encoder U input C+	
U_C-	Input	Encoder U input C-	
U_LL	Input	Negative direction hardware limit switch for motor U	limit switch and home switch for motor U
U_RL	Input	Positive direction hardware limit switch for motor U	
U_ORG	Input	home switch for motor U	

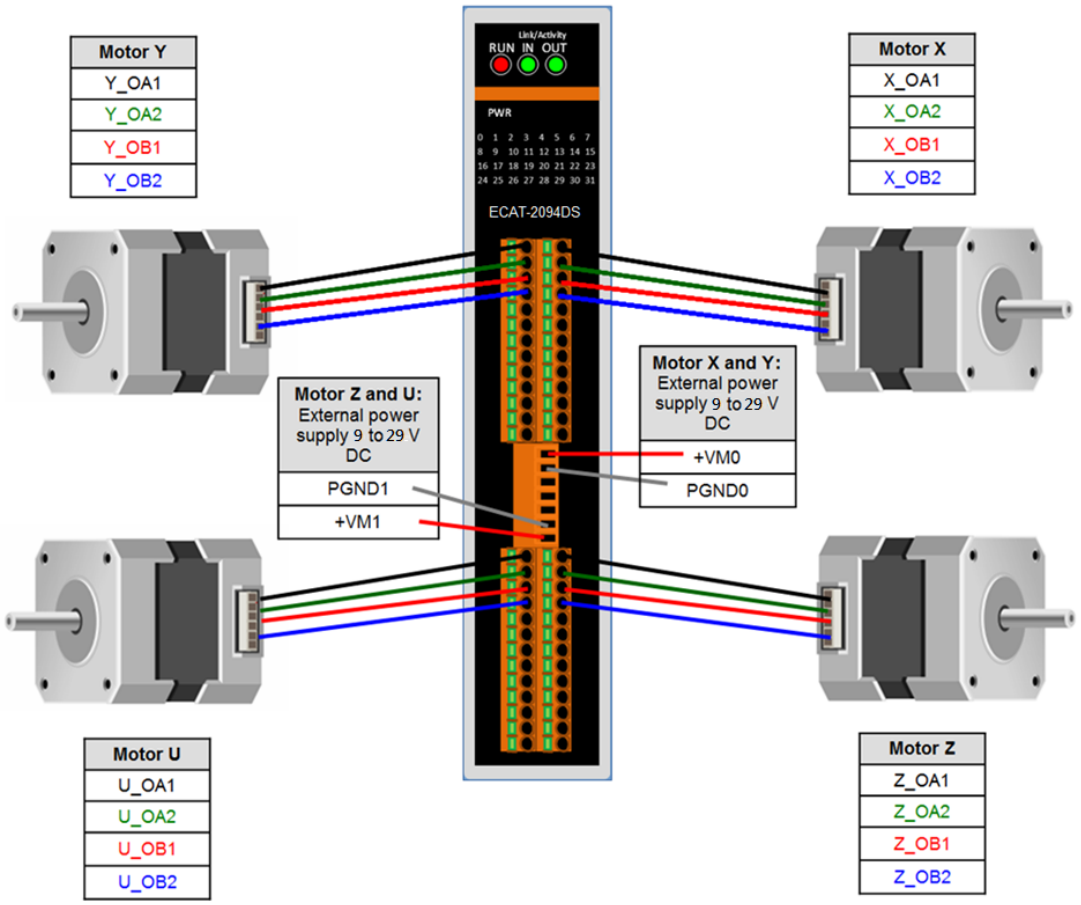
2.4 Digital Input Wiring

Digital Input		
Digital input channels		12 (3 switches for each motor)
Input type		Wet
Wet contact	ON voltage level	+10 to 24 V_{DC}
	OFF voltage level	+5 V_{DC} MAX
Photo-isolation		3750 V_{DC}

The diagram for Positive (RL) and Negative (LL) direction hardware limit switches and home switch (ORG) wiring for axis X, Y, Z, and U is shown below.

Digital Input	Readback as 1	Readback as 0
Sink	+10 ~ +24V DC 	OPEN or <4 VDC 
Source	+10 ~ +24V DC 	OPEN or <4 VDC 

2.5 Stepper Motor Wiring



2.5.1 Four Lead Motor

The Figure 1 below shows an example for a four lead two-phase motor connected to the X output of the ECAT-2094DS.

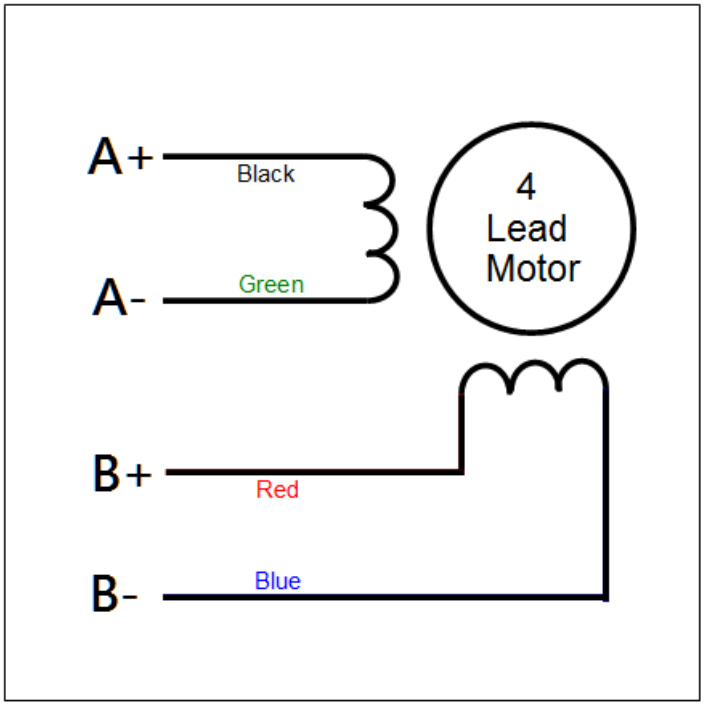


Figure 1: Four lead bipolar motor connected to the first axis output

2.5.1 Six Lead Motor

The Figure 2 below shows an example for a six lead two-phase motor connected to the X output of the ECAT-2094DS.

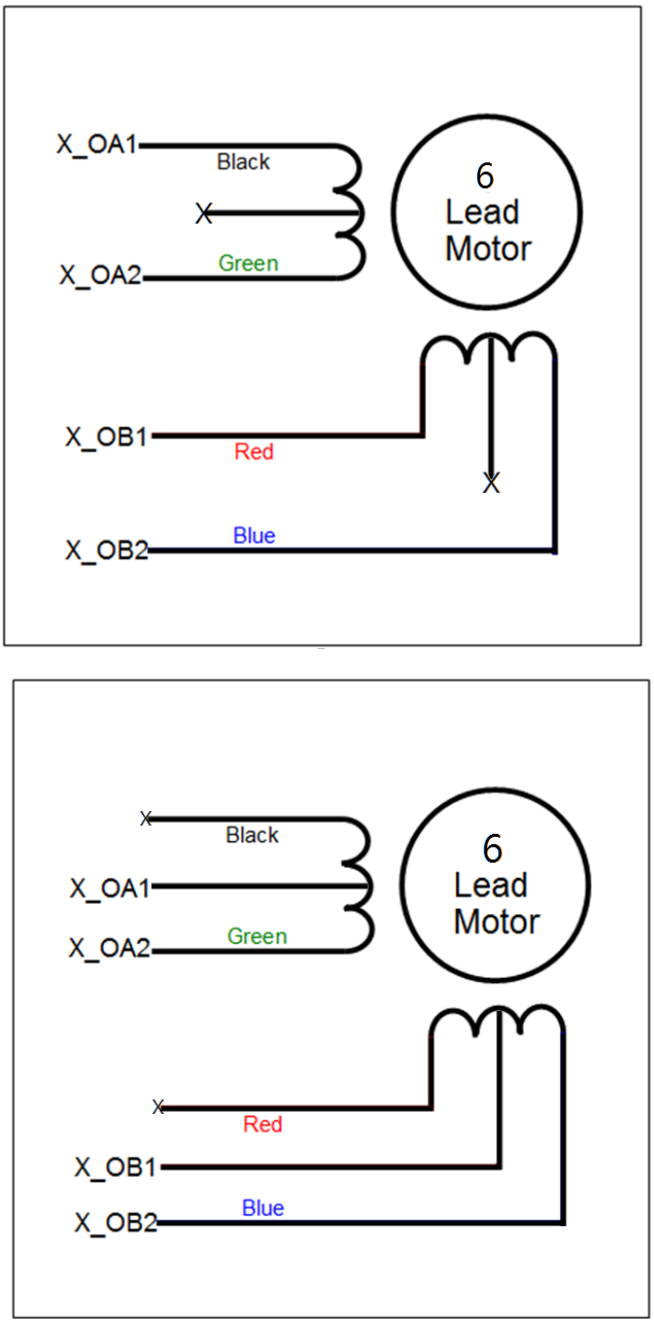


Figure 2: Six lead bipolar motor connected to the first axis output

2.5.2 Eight Lead Motor

Eight lead motors can be connected in series or parallel. A series connected motor needs less current than one that is connected in parallel but it will not be able to run as fast.

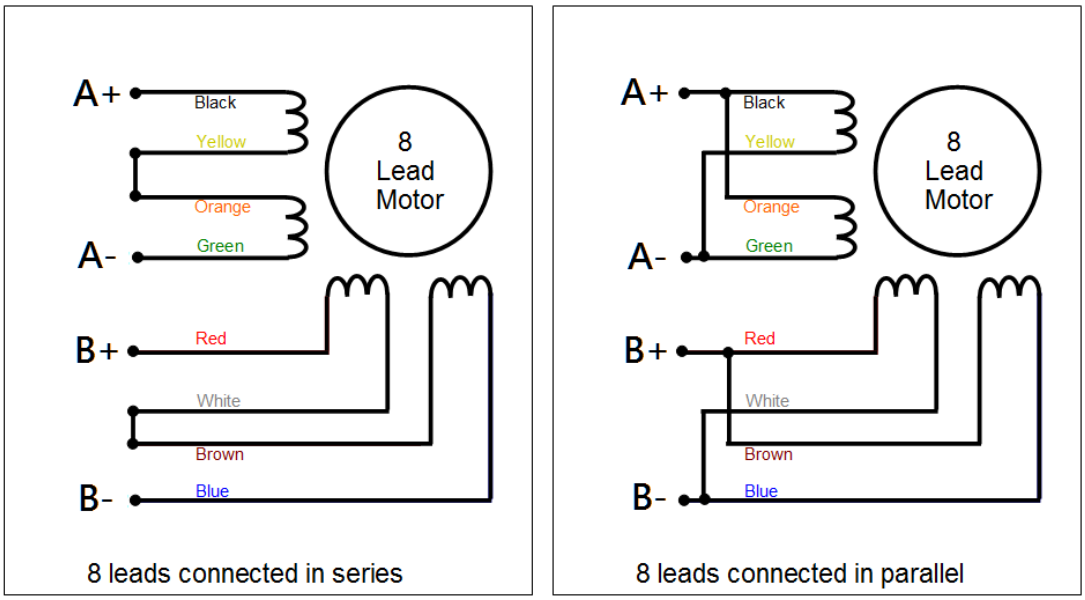


Figure 3: Eight lead bipolar motor connection (left: series, right: parallel)

2.5.3 Encoder Connection

Differential encoder:

The ECAT-2094DS supports differential encoder by default.

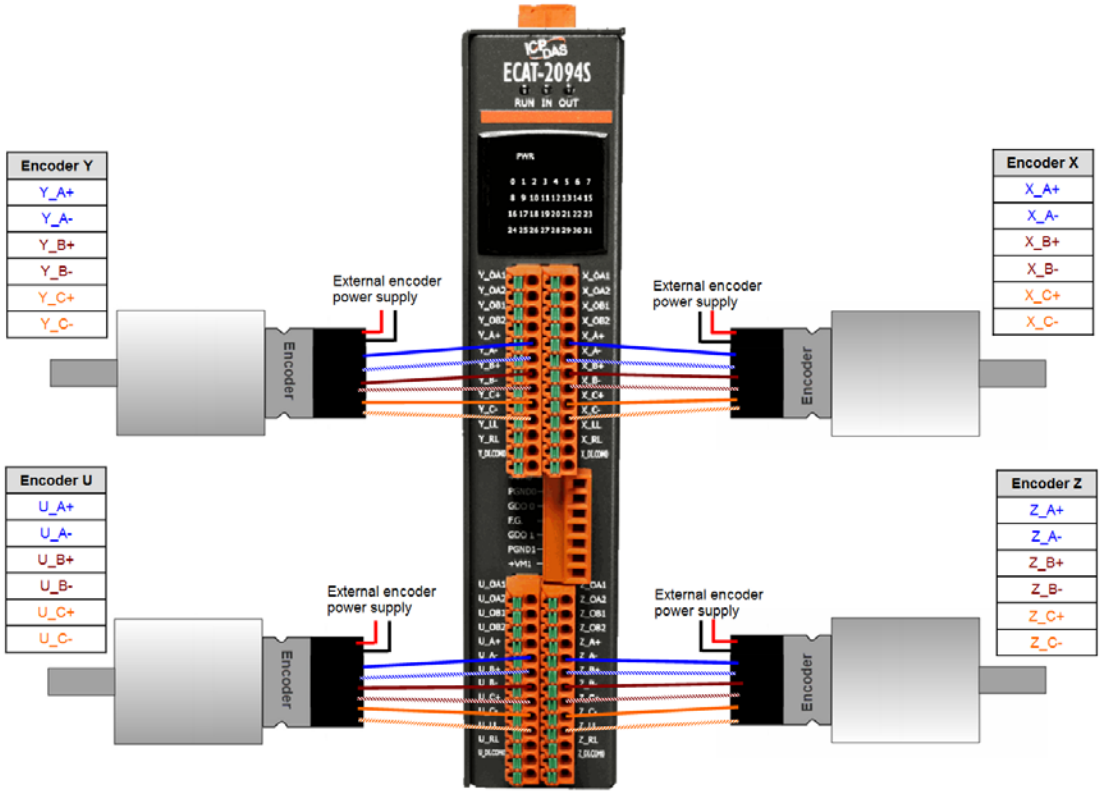


Figure 4: Encoder connection

Open collector type encoder:

For single-ended encoder connection refers to the Figure 5 which lists the possible power supply values with the corresponding resistor sizes.

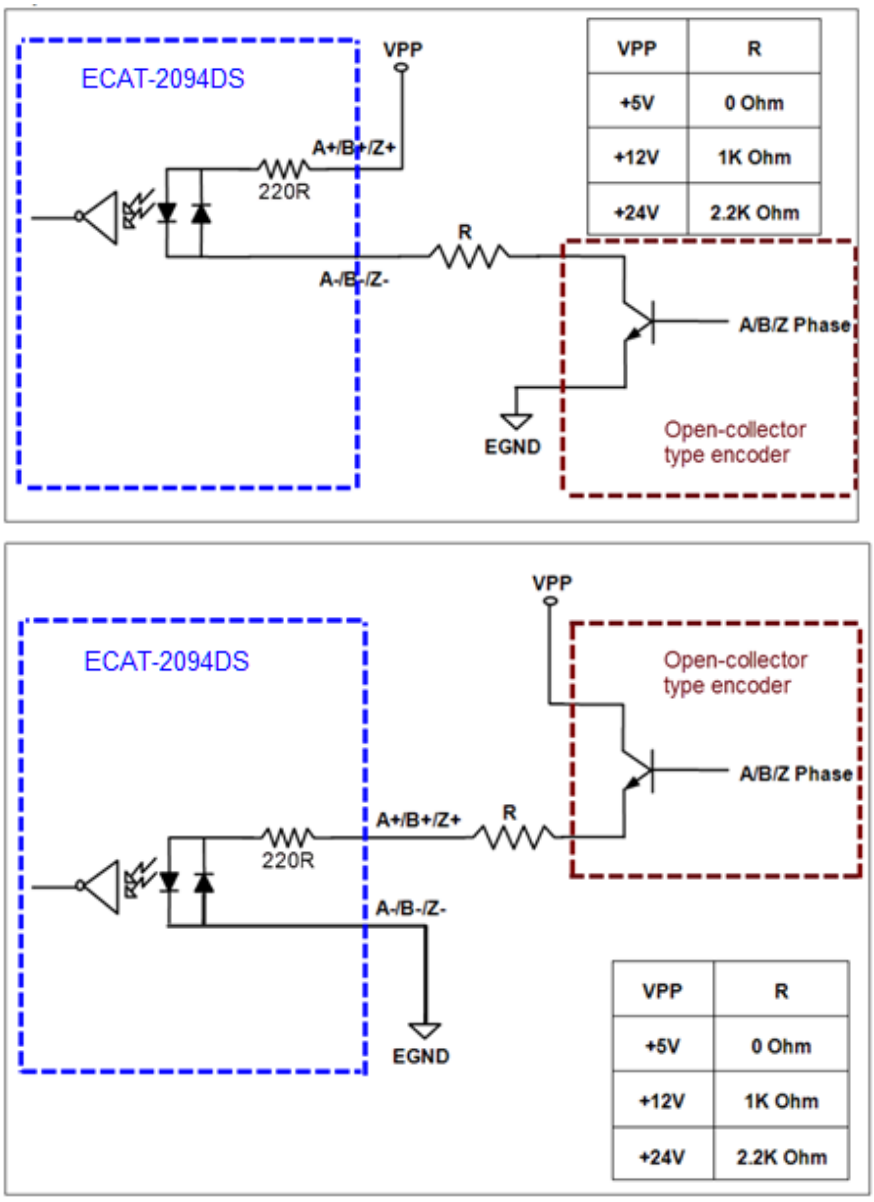


Figure 5: Open collector wiring diagram

3 Basics Communication

3.1 EtherCAT Cabling

The cable length between two EtherCAT devices must not exceed 100 m.

Cables and connectors
For connecting EtherCAT devices only Ethernet connections (cables + plugs) that meet the requirements of at least category 5 (CAt5) according to EN 50173 or ISO/IEC 11801 should be used. EtherCAT uses 4 wires for signal transfer.
The pin assignment is compatible with the Ethernet standard (ISO/IEC 8802-3).

3.2 EtherCAT State Machine

The state of the EtherCAT master and slave is controlled via the EtherCAT State Machine (ESM). The state determines which functions are accessible or executable in the EtherCAT slave. State changes are typically initiated by requests of the master and acknowledged by the slave after the successful initialization. In case of an internal error, the slave automatically changes to a lower state.

Supports four states:

- Init (state after Reset)
- Pre-Operational
- Safe-Operational
- Operational

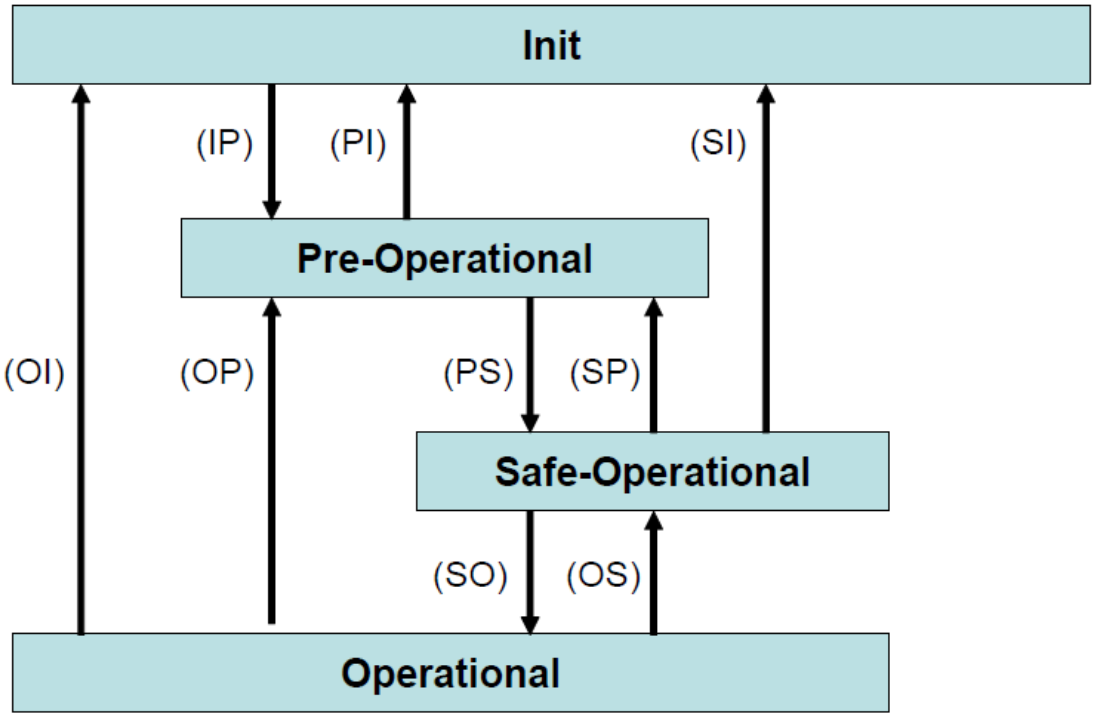


Figure 6: EtherCAT state machine

Init

After switch-on the EtherCAT slave is in the initial state. Only ESC register communication is possible, but no mailbox or process data communication. The slave initializes the service object data with default value or with values previously stored to the local memory. The EtherCAT master assigns the station address and configures the sync manager channels 0 and 1 for acyclic mailbox communication.

Pre-Operational (Pre-Op)

In Pre-Op state acyclic mailbox communication is possible, but not process data communication. In this state the EtherCAT master does the following configurations:

- Set the sync manager 2 and 3 for process data communication (from sync manager channel 2)
- The FMMU channels
- PDO mapping or the sync manager PDO assignment

Safe-Operational (Safe-Op)

In Safe-Op state both mailbox and process data communication is enabled, but the slave keeps its outputs in a safe state, while the input data are updated cyclically. The slave will ignore the output data sent by the master and just return the current input

data (e.g. digital input, encoder value, etc.)

Outputs in Safe-Op state
The sync manager watchdog expires when the master application does not provide new output process data within the configured watchdog time. In this case the slave will automatically go from operational state to ERROR-SAFEOP state and set all the outputs in a safe state. Will stop the stepper motor and the motor current will be adjusted to 0.

Operational (Op)
Here both the process data object (PDO) and service data object (SDP) are fully enabled. Master sends cyclic output data and read input data. This module supports two types of Op modes: Free Run mode and Distributed Clock (DC) mode.

3.3 Synchronization Modes

ECAT-2094DS devices support two different modes

- Free Run: The master cycle time and slave cycle time is independent and not synchronized.
- Distributed Clock (DC): The master cycle time and slave cycle time are synchronized.

3.3.1 Free Run Mode

The slave operates autonomously according to its cycle and is not synchronized with the EtherCAT cycle. The master cycle time and the slave cycle time are fully independent which means each slave device reads/writes its own process data according to its local time, independent of the master's cycle time.

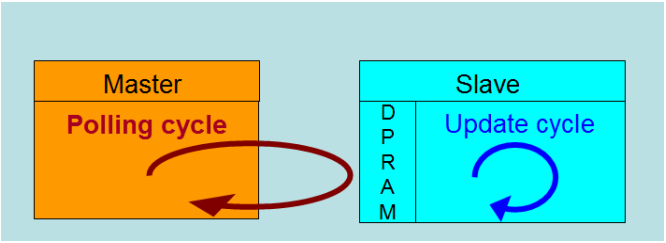


Figure 7: Master-slave cycle in Free Run mode

The following diagram shows the process timing of the slave in Free Run mode in detail:

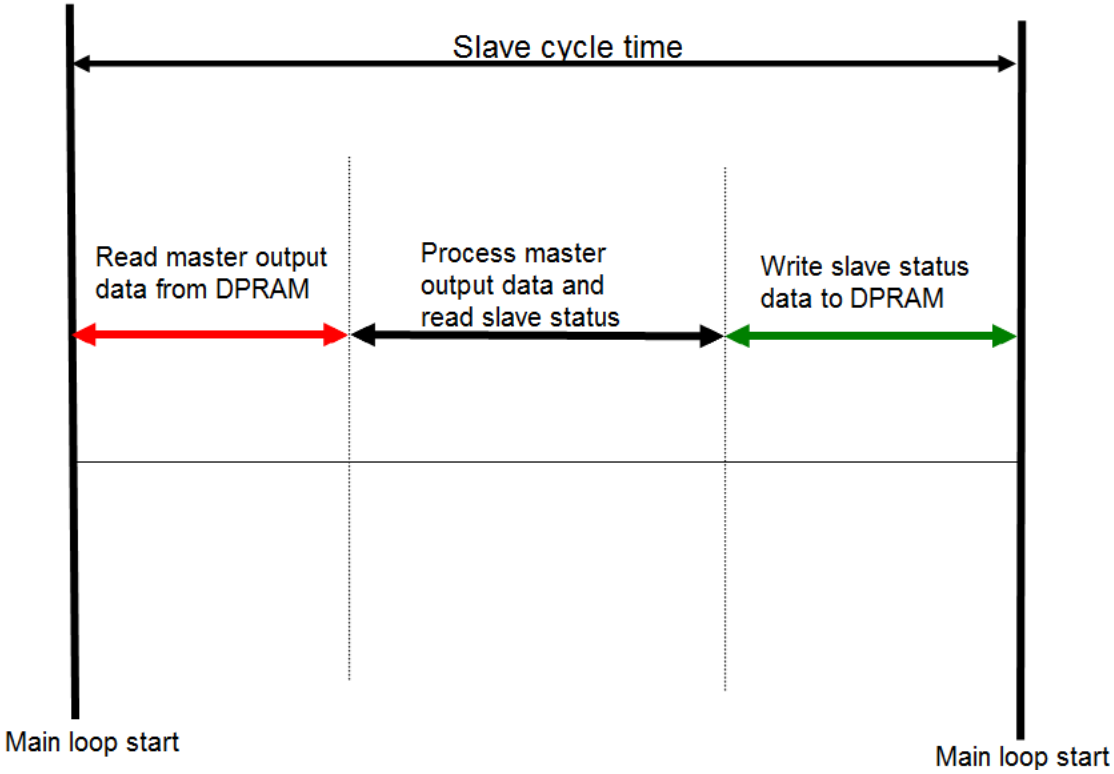


Figure 8: Slave processing sequence in Free-run mode

The slave firmware checks in each cycle time the memory of the EtherCAT slave chip (ESC) whether new output data has been received from the master. Newly received data will be processed and the motion path will be calculated. In the next step motion and digital input status are being read from motion chip. In the final step the read status are being written to the DPRAM, so that the master can retrieve the data ESC DPRAM in the next cycle time.

3.3.2 Distributed Clocks (DC Mode)

DC clock synchronization enables all EtherCAT devices (master and slaves) to share the same EtherCAT system time. The EtherCAT slaves in the network can be synchronized to each other. This enables the master to simultaneously set the output (e.g. digital output, pulse output) or to synchronously read inputs (e.g. digital input, encoder counter) of different slaves in the EtherCAT network.

For system synchronization all slaves are synchronized to one reference clock. Normally the first EtherCAT slave closest to the master with Distributed Clocks capability becomes the clock base for the master as well as for other DC slaves.

The EtherCAT slave is synchronized with the SYNC0 or SYNC1 event of the distributed clock system. After the EtherCAT network has been set into DC communication mode by the master, the ESC (EtherCAT slave chip) of each slave generates fixed time hardware interrupt which triggers the slave firmware to process the PDO data received by the master. The master cycle time and the ESC hardware interrupt time interval are fully synchronized to the first slave in the network that is used as a reference clock with the SYNC0 signal.

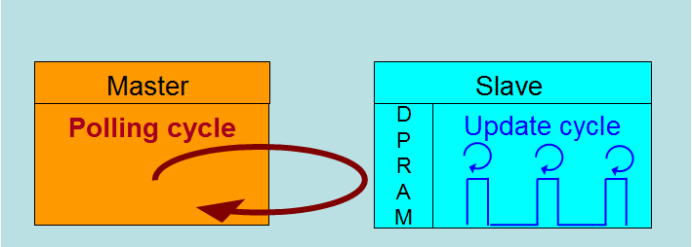


Figure 9: Master-slave cycle in DC mode

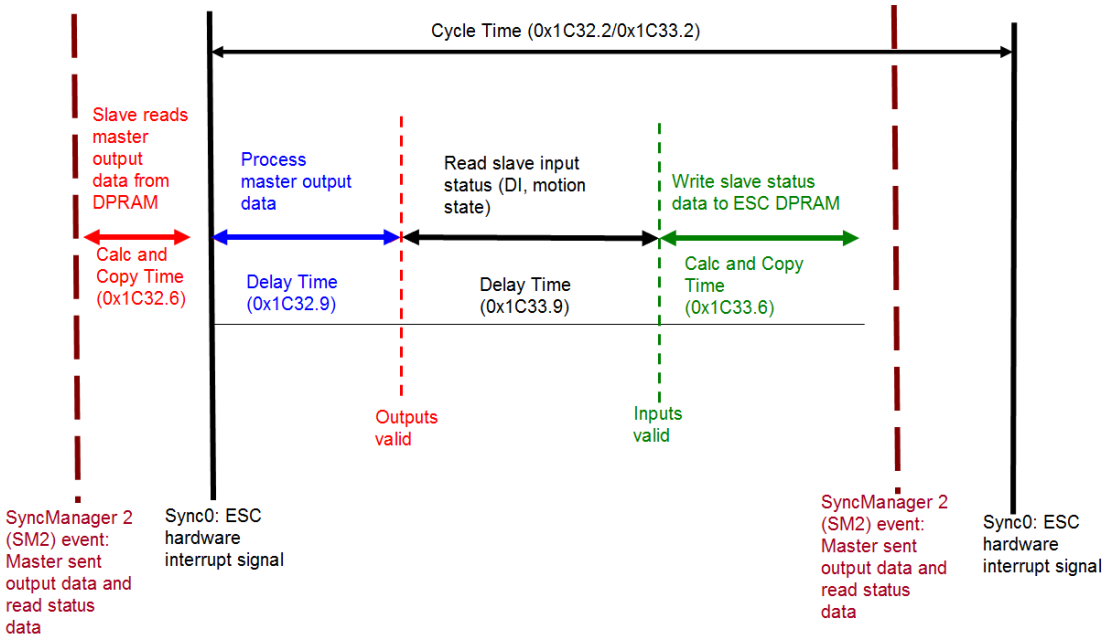


Figure 10: Internal slave processing sequence in DC mode

Once the slave receives process data (RxPDOs) from the master the SM2 event is

triggered which causes the firmware to read the data from the ESC memory. The ESC interrupts the firmware at fixed time interval to process the data received from the master and write the status data to the ESC memory. Every time when the master fails to sent process data within the DC cycle time the internal sync error counter is being increase by three counts. This error counter is being decreased by one count for every successful DC cycle. Once the error counter reached the maximum count (default 4) a sync error will be generated and the slave goes into Safe OP mode (Sync Error 0x1C32:20 true TRUE). The maximum count value can be set by changing the default value of the "Sync Error Counter Limit" (0x10F1:02).

Index	Name	Flags	Value
10F1:0	Error Settings		> 2 <
10F1:01	Local Error Reaction	RW	0x00000001 (1)
10F1:02	Sync Error Counter Limit	RW	0x0004 (4)

Figure 11: Sync error counter limit object

The setting of the sync manager for the output and input data is available at the TwinCAT "CoE online" tab.

Index	Name	Flags	Value
1C32:0	SM output parameter		> 32 <
1C32:01	Synchronization Type	RW	0x0002 (2)
1C32:02	Cycle Time	RO	0x00000000 (0)
1C32:04	Synchronization Types supported	RO	0x401F (16415)
1C32:05	Minimum Cycle Time	RO	0x001E8480 (2000000)
1C32:06	Calc and Copy Time	RO	0x0007A120 (500000)
1C32:08	Get Cycle Time	RW	0x0001 (1)
1C32:09	Delay Time	RO	0x000927C0 (600000)
1C32:0A	Sync0 Cycle Time	RW	0x005B8D80 (6000000)
1C32:0B	SM-Event Missed	RO	0x0000 (0)
1C32:0C	Cycle Time Too Small	RO	0x0000 (0)
1C32:20	Sync Error	RO	FALSE

Figure 12: SyncManager 2 parameters

SyncManager parameter description (time unit: nanosecond):

- Calc and Copy Time (0x1C32.6 / 0x1C33.6): Required time to copy the process data from the ESC to the local memory and calculate the output value.
- Delay Time (0x1C32.9 / 0x1C33.9): Delay from receiving the trigger to set the output or latch the input.
- Cycle Time (0x1C32.2 / 0x1C33.2): The current cycle time for the application. When using DC synchronization the value is read from register 0x9A0:0x9A3.
- 0x1C32.5 / 0x1C33.5 (Min Cycle Time): Minimum cycle time for the application. It

is the total execution time of all slave application related operations.

4 CoE Communication Area (1000h ~ 1FFFh)

4.1 Device information

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
1000h	00h	Device type	0 - 4294967295	U32	ro	N	N	20192h
		Device type of the EtherCAT slave						
1001h	00h	Error register	0 - 255	U8	ro	N	N	00h
1008h	00h	Manufacturer device name		VS	ro	N	N	
		Device name of the EtherCAT slave						
1009h		Manufacturer hardware version		VS	ro	N	N	1.0
		Hardware version of the EtherCAT slave						
100Ah		Manufacturer software version		VS	ro	N	N	1.0
		Software version of the EtherCAT slave						
1018h	--	Identify object						
	00h	Number of entries	0 - 255	U8	ro	N	N	4
	01h	Vendor ID	0 - 4294967295	U32	ro	N	N	00494350h
		Vendor ID of the EtherCAT slave						
	02h	Product code	0 - 4294967295	U32	ro	N	N	20944453h
		Product code of the EtherCAT slave						
	03h	Revision number	0 - 4294967295	U32	ro	N	N	00000000h
		Revision number of the EtherCAT slave						
	04h	Serial number	0 - 4294967295	U32	ro	N	N	00000000h
		Serial number of the EtherCAT slave						
10F1h	00h	Error settings						
	01h	Local error reaction	0 - 4294967295	U32	rw	N	N	00000001h

	02h	Sync error counter limit	0 - 65535	U16	rw	N	N	0004h
		For DC mode only: The Sync Error Counter is incremented with every missing Sync Management Event by three and decremented by one if an event is received. If the Sync Error Counter exceeds this limit the system changes into the SAFEOP state with the "Synchronization Lost" error. The Sync Error Counter is reset when the error was acknowledged.						

4.2 PDO(Process Data Object)Mapping

4.2.1 PDO Assign Object(1C12h ~ 1C13h)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
1C12h	--	Sync manager channel 2						
	00h	Number of assigned PDOs	0 -4	U8	rw	N	N	4
	01h	PDO mapping object of assigned RxPDO 1	1600h – 1630h	U16	rw	N	N	1600h
	02h	PDO mapping object of assigned RxPDO 2	1600h – 1630h	U16	rw	N	N	1610h
	03h	PDO mapping object of assigned RxPDO 3	1600h – 1630h	U16	rw	N	N	1620h
	04h	PDO mapping object of assigned RxPDO 4	1600h – 1630h	U16	rw	N	N	1630h
1C13h	--							
	00h	Number of assigned PDOs	0 -4	U8	rw	N	N	4
	01h	PDO mapping object of assigned TxPDO 1	1A00h – 1A30h	U16	rw	N	N	1A00h
	02h	PDO mapping object of assigned TxPDO 2	1A00h – 1A30h	U16	rw	N	N	1A10h
	03h	PDO mapping object of assigned TxPDO 3	1A00h – 1A30h	U16	rw	N	N	1A20h
	04h	PDO mapping object of assigned TxPDO 4	1A00h – 1A30h	U16	rw	N	N	1A30h

4.2.2 PDO Mapping Object(1600h ~ 1630h、1A00~1A30h)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
1600h	--	Receive PDO mapping 1						

	00h	Number of entries	0 - 16	U8	rw	N	N	4
	01h	1st receive PDO mapped	0 - 4294967295	U32	rw	N	N	60400010h
	02h	2nd receive PDO mapped	0 - 4294967295	U32	rw	N	N	60600008h
	03h	3rd receive PDO mapped	0 - 4294967295	U32	rw	N	N	607A0020h
	04h	4th receive PDO mapped	0 - 4294967295	U32	rw	N	N	600FF0020h
	05h	5th receive PDO mapped	0 - 4294967295	U32	rw	N	N	00000000h
		. . .						
	0Fh	15th receive PDO mapped	0 - 4294967295	U32	rw	N	N	00000000h
1610h	--	Receive PDO mapping 2						
	01h – 0Fh	Subindex 規格同 1600h	0 - 4294967295	U32	rw	N	N	68400010h – 68FF0020h
1620h								
	01h – 0Fh	Subindex 規格同 1600h	0 - 4294967295	U32	rw	N	N	70400010h – 70FF0020h
1630h								
	01h – 0Fh	Subindex 規格同 1600h	0 - 4294967295	U32	rw	N	N	78400010h – 78FF0020h
1A00h								
	00h	Number of entries	0 - 16	U8	rw	N	N	7
	01h	1st transmit PDO mapped	0 - 4294967295	U32	rw	N	N	60410010h
	02h	2nd transmit PDO mapped	0 - 4294967295	U32	rw	N	N	603F0010h
	03h	3rd transmit PDO mapped	0 - 4294967295	U32	rw	N	N	60610008h
	04h	4th transmit PDO mapped	0 - 4294967295	U32	rw	N	N	60640020h

	05h	5th transmit PDO mapped	0 - 4294967295	U32	rw	N	N	606c0020h
	06h	6th transmit PDO mapped	0 - 4294967295	U32	rw	N	N	60FD0020h
	07h	7th transmit PDO mapped	0 - 4294967295	U32	rw	N	N	00000018h
	08h	8th transmit PDO mapped	0 - 4294967295	U32	rw	N	N	00000000h
		. . .						
	0Fh	15th transmit PDO mapped	0 - 4294967295	U32	rw	N	N	00000000h
1A10h								
	01h – 0Fh	Subindex 規格同 1A00h	0 - 4294967295	U32	rw	N	N	680410000h – 68FD0020h
1A20h								
	01h – 0Fh	Subindex 規格同 1A00h	0 - 4294967295	U32	rw	N	N	70410000h – 70FD0020h
1A30h								
	01h – 0Fh	Subindex 規格同 1A00h	0 - 4294967295	U32	rw	N	N	78410000h – 78FD0020h

4.3 Sync manager 2/3 sychronization(1C32h、1C33h)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
1C32h	--	Sync manager 2 synchronization						
	00h	Number of sub-objects	0 - 255	U8	ro	N	N	20h
	01h	Synchronization Type	0 - 65535	U16	rw	N	N	0000h
	02h	Cycle Time	0 - 4294967295	U32	ro	N	N	0000h
	04h	Synchronization Types supported	0 – 65535	U16	ro	N	N	001Fh
	05h	Minimum Cycle Time	0 - 4294967295	U32	ro	N	N	0007A120h
	06h	Calc and Copy Time	0 - 4294967295	U32	ro	N	N	00009C40h
	08h	Get Cycle Time	0 - 65535	U16	ro	N	N	0000h
	09h	Delay time	0 - 4294967295	U32	ro	N	N	00002710h
	0Ah	Sync0 Cycle Time	0 - 4294967295	U32	ro	N	N	00000000h
	0Bh	SM-Event Missed	0 - 65535	U16	ro	N	N	0000h
	0Ch	Cycle Time Too small	0 - 65535	U16	ro	N	N	0000h
	20h	Sync Error	0 - 1	BOOL	ro	N	N	FALSE

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
1C33h	--	Sync manager 3 synchronization						
	00h	Number of sub-objects	0 - 255	U8	ro	N	N	20h
	01h	Synchronization Type	0 - 65535	U16	rw	N	N	0000h
	02h	Cycle Time	0 -	U32	ro	N	N	0000h

			4294967295					
	04h	Synchronization Types supported	0 – 65535	U16	ro	N	N	001Fh
	05h	Minimum Cycle Time	0 - 4294967295	U32	ro	N	N	0007A120h
	06h	Calc and Copy Time	0 - 4294967295	U32	ro	N	N	00009C40h
	08h	Get Cycle Time	0 - 65535	U16	ro	N	N	0000h
	09h	Delay time	0 - 4294967295	U32	ro	N	N	00002710h
	0Ah	Sync0 Cycle Time	0 - 4294967295	U32	ro	N	N	00000000h
	0Bh	SM-Event Missed	0 - 65535	U16	ro	N	N	0000h
	0Ch	Cycle Time Too small	0 - 65535	U16	ro	N	N	0000h
	20h	Sync Error	0 - 1	BOOL	ro	N	N	FALSE

5 Drive parameter Area (2000h ~ 5FFFh)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
0x2001	--	ORG Active Level						
	00h	Highest sub-index supported	4	U8	ro	N	N	4
	01h	ORG0 Active Level	0 - 1	U16	rw	Y	N	01h
	02h	ORG1 Active Level	0 - 1	U16	rw	Y	N	01h
	03h	ORG2 Active Level	0 - 1	U16	rw	Y	N	01h
	04h	ORG3 Active Level	0 - 1	U16	rw	Y	N	01h
0x2002	--	NOT/LL Active Level						
	00h	Highest sub-index supported	4	U8	ro	N	N	4
	01h	NOT0 Active Level	0 - 1	U16	rw	Y	N	01h
	02h	NOT1 Active Level	0 - 1	U16	rw	Y	N	01h
	03h	NOT2 Active Level	0 - 1	U16	rw	Y	N	01h
	04h	NOT3 Active Level	0 - 1	U16	rw	Y	N	01h
0x2003	--	POT/RL Active Level						
	00h	Highest sub-index supported	4	U8	ro	N	N	4
	01h	POT0 Active Level	0 - 1	U16	rw	Y	N	01h

	02h	POT1 Active Level	0 - 1	U16	rw	Y	N	01h
	03h	POT2 Active Level	0 - 1	U16	rw	Y	N	01h
	04h	POT3 Active Level	0 - 1	U16	rw	Y	N	01h
0x3001	--	Axes Run Current unit:mA						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 Run Current	0 - 3368	U16	rw	Y	N	03E8h
	02h	Axis1 Run Current	0 - 3368	U16	rw	Y	N	03E8h
	03h	Axis2 Run Current	0 - 3368	U16	rw	Y	N	03E8h
	04h	Axis3 Run Current	0 - 3368	U16	rw	Y	N	03E8h
0x3002	--	Axes Hold Current unit:mA						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 Hold Current	0 - 3368	U16	rw	Y	N	01F4h
	02h	Axis1 Hold Current	0 - 3368	U16	rw	Y	N	01F4h
	03h	Axis2 Hold Current	0 - 3368	U16	rw	Y	N	01F4h
	04h	Axis3 Hold Current	0 - 3368	U16	rw	Y	N	01F4h
0x3003	--	Axes Encoder PPR pulse per revolution of						

		the encoder						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 Encoder PPR	0 - 4294967295	U32	rw	Y	N	00000000h
	02h	Axis1 Encoder PPR	0 - 4294967295	U32	rw	Y	N	00000000h
	03h	Axis2 Encoder PPR	0 - 4294967295	U32	rw	Y	N	00000000h
	04h	Axis3 Encoder PPR	0 - 4294967295	U32	rw	Y	N	00000000h
0x3004	--	Axes Encoder Mode						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 Encoder Mode	0 - 127	U16	rw	Y	N	0000h
	02h	Axis1 Encoder Mode	0 - 127	U16	rw	Y	N	0000h
	03h	Axis2 Encoder Mode	0 - 127	U16	rw	Y	N	0000h
	04h	Axis3 Encoder Mode	0 - 127	U16	rw	Y	N	0000h

Bit	7	6	5	4	3	2	1	0
Function	-	EZ_INV	EB_INV	EA_INV	-	PULSE_MODE		

PULSE_MODE (R/W):
0: OUT/DIR pulse
1: CW/CCW pulse
2: 1 x AB phase pulse, the minimum pulse width is 80ns
3: 2 x AB phase pulse, the minimum pulse width is 80ns
4: 4 x AB phase pulse, the minimum pulse width is 160ns

EA_INV: Write '1' to invert A signal (default: '0')
EB_INV: Write '1' to invert B signal (default: '0')
EZ_INV: Write '1' to invert C signal (default: '0')

0x3005	--	Axes Torque Off Mode						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 Torque Off Mode	0 - 1	U16	rw	Y	N	0000h
	02h	Axis1 Torque Off Mode	0 - 1	U16	rw	Y	N	0000h
	03h	Axis2 Torque Off Mode	0 - 1	U16	rw	Y	N	0000h
	04h	Axis3 Torque Off Mode	0 - 1	U16	rw	Y	N	0000h
	0: When Servo Off, the motor uses hold current 1: The motor has no current when Servo Off							
0x3006	--	Axes Motor PPR pulse per revolution of the motor						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 Motor PPR	200 - 51200	U16	rw	Y	N	0xC800
	02h	Axis1 Motor PPR	200 - 51200	U16	rw	Y	N	0xC800
	03h	Axis2 Motor PPR	200 - 51200	U16	rw	Y	N	0xC800
	04h	Axis3 Motor PPR	200 - 51200	U16	rw	Y	N	0xC800
	200(Full step) 400 800 1600 3200 6400 12800 25600							

	51200							
0x3007	--	Axes DRVCONF						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 DRVCONF	0 - 4294967295	U32	rw	Y	N	0x000EA071
	02h	Axis1 DRVCONF	0 - 4294967295	U32	rw	Y	N	0x000EA071
	03h	Axis2 DRVCONF	0 - 4294967295	U32	rw	Y	N	0x000EA071
	04h	Axis3 DRVCONF	0 - 4294967295	U32	rw	Y	N	0x000EA071
0x3008	--	Axes CHOPCONF						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 CHOPCONF	0 - 4294967295	U32	rw	Y	N	0x00088475
	02h	Axis1 CHOPCONF	0 - 4294967295	U32	rw	Y	N	0x00088475
	03h	Axis2 CHOPCONF	0 - 4294967295	U32	rw	Y	N	0x00088475
	04h	Axis3 CHOPCONF	0 - 4294967295	U32	rw	Y	N	0x00088475
0x3009	--	Axes SMARTEN						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 SMARTEN	0 - 4294967295	U32	rw	Y	N	0x000A0000
	02h	Axis1 SMARTEN	0 - 4294967295	U32	rw	Y	N	0x000A0000
	03h	Axis2 SMARTEN	0 - 4294967295	U32	rw	Y	N	0x000A0000
	04h	Axis3 SMARTEN	0 - 4294967295	U32	rw	Y	N	0x000A0000

0x300A	--	Axes SGCSCONF						
	00h	Highest sub-index supported	4	U16	ro	N	N	4
	01h	Axis0 SGCSCONF	0 - 4294967295	U32	rw	Y	N	0x000C1508
	02h	Axis1 SGCSCONF	0 - 4294967295	U32	rw	Y	N	0x000C1508
	03h	Axis2 SGCSCONF	0 - 4294967295	U32	rw	Y	N	0x000C1508
	04h	Axis3 SGCSCONF	0 - 4294967295	U32	rw	Y	N	0x000C1508
0x4000	00h	Station Alias	0 - 1	U8	rw	Y	N	00h
		1: 0012h of ESC register reads 0004h of SII (Configured Station Alias) 0: 0012h of ESC register reads ECAT ID rotary switch						
0x4001	00h	ID selector	0 - 255	U16	ro	N	N	0
0x4002	00h	Moving Average	0 - 10	U8	rw	N	N	5
		CSP position command moving average filter, valid in interpolation mode, unit: ms						
0x4003	00h	Motion Mode	0 - 1	U8	rw	N	N	0
		0: interpolation mode 1: high speed mode(It is suitable for high-speed and short-distance commands, and the command execution time should be less than 500ms)						
0x5000	--	Store parameters						
	00h	Number of entries		U8	rw	N	N	3
	01h	Save all Parameters	0 - 4294967295	U32	rw	N	N	00000000h
	02h	Load Factory	0 - 1	U32	rw	Y	N	00000001h
	03h	Save counter	0 - 4294967295	U32	ro	Y	N	00000000h
	To enable EEPROM, please set Load Factory to 0, And set Save all Parameters from 0 to 1 to save the parameters, If the archive fails, the EEPROM Error(0x5001:01) is 1, Please reset Save all Parameters from 0 to 1, If the save is successful, Save counter + 1							

	To restore to the default value, please set Load Factory to 1, And set Save all Parameters from 0 to 1 to restore to the default value, If the archive fails, the EEPROM Error is 1 If the save is successful, Save counter + 1 All parameters will be restored to preset values after power on again							
0x5001	--	Store Status						
	00h	Number of entries		U8	rw	N	N	2
	01h	EEPROM Error	0 - 1	U32	ro	N	N	00000000h
	02h	Load EEPROM	0 - 1	U32	rw	Y	N	00000000h
	If the EEPROM Error is 1 after power-on, it means that the EEPROM reading failed. Please set Load EEPROM from 0 to 1, if successful, EEPROM Error is 0. If the EEPROM Error is still 1, it means that a problem occurred during the last archive, but it was not processed. Please re-archive							

6 Drive Profile Area (6000h ~ 6FFFh)

6.1 Object List

0x6000~0x67FF are the Objects of the first axis

0x6800~0x6FFF are the Objects of the second axis

0x7000~0x77FF are the Objects of the third axis

0x7800~0x7FFF are the Objects of the fourth axis

Object Index + 0x800 * (n-1) is the object of the nth axis

For example:

0x603F is the Object of the first axis

0x683F is the object of the second axis

0x703F is the object of the third axis

0x783F is the object of the fourth axis

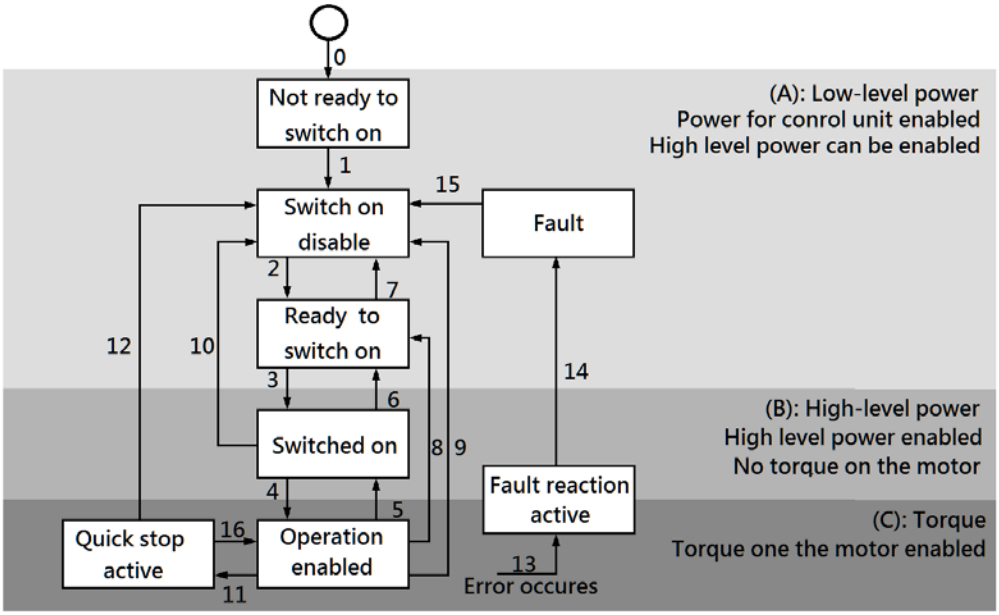
Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
0x603F	00h	ErrorCode	0 - 65535	U16	ro	N	Y	0000h
0x6040	00h	Controlword	0 - 65535	U16	rw	N	Y	0000h
0x6041	00h	Statusword	0 - 65535	U16	ro	N	Y	0000h
0x605A	00h	Quick Stop Option Code	1 - 3 5 - 7	U16	rw	Y	N	0002h
0x605B	00h	Shutdown Option Code	1	U16	rw	Y	N	0001h
0x605C	00h	Disable Operation Option Code	1	U16	rw	Y	N	0001h
0x605D	00h	Halt Option Code	1 - 3	U16	rw	Y	N	0002h
0x605E	00h	Fault Reaction Option Code	1 - 2	U16	rw	Y	N	0002h
0x6060	00h	Modes Of Operation	-128 - 127	I8	rw	N	Y	00h
0x6061	00h	Modes Of Operation Display	-128 - 127	I8	ro	N	Y	00h
0x6064	00h	Position Actual Value	-2147483648 -	I32	ro	N	Y	00000000h

			2147483647					
0x606C	00h	Velocity Actual Value	-2147483648 - 2147483647	I32	ro	N	Y	00000000h
0x607A	00h	Target Position	-2147483648 - 2147483647	I32	ro	N	Y	00000000h
0x607C	00h	Home Offset	-2147483648 - 2147483647	I32	rw	N	N	00000000h
0x607D		Software Position Limit						
	00h	Number of entries	2	U8	ro	N	N	2
	01h	Min position limit	-2147483648 - 2147483647	I32	rw	Y	N	00000000h
	02h	Max position limit	-2147483648 - 2147483647	I32	rw	Y	N	00000000h
0x607E	00h	Polarity	0、224	U8	rw	Y	N	00h
0x607F	00h	Max. Profile Velocity	0 - 4294967295	U32	rw	Y	N	7FFFFFFFh
0x6081	00h	Profile Velocity	0 - 4294967295	U32	rw	Y	N	0000C350h
0x6083	00h	Profile Acceleration	0 - 4294967295	U32	rw	Y	N	0000C350h
0x6084	00h	Profile Deceleration	0 - 4294967295	U32	rw	Y	N	0000C350h
0x6085	00h	Quick Stop Deceleration	0 - 4294967295	U32	rw	Y	N	0007A120h
0x6098	00h	Homing method	-128 - 127	I8	rw	Y	N	00h
0x6099		Homing Speeds					N	
	00h	Number of entries	2	U16	ro	N	N	2
	01h	Speed during search for switch	0 - 4294967295	U32	rw	Y	N	0000C350h
	02h	Speed during	0 -	U32	rw	Y	N	000007D0h

		search for zero	4294967295					
0x609A	00h	Homing acceleration	0 - 4294967295	U32	rw	Y	N	0000C350h
0x60C5	00h	Max Acceleration	0 - 4294967295	U32	rw	Y	N	7FFFFFFFh
0x60C6	00h	Max Deceleration	0 - 4294967295	U32	rw	Y	N	7FFFFFFFh
0x60FD	00h	Digital Inputs	0 - 4294967295	U32	ro	N	Y	00000000h
0x60FF	00h	Target Velocity	-2147483648 - 2147483647	I32	rw	N	Y	00000000h

6.2 PDS State Machine

According to the user command or abnormal detection, etc., the PDS state machine transition of the drive is defined as shown in the figure below



PDS Transition		Event(s)	Action(s)
0	Auto skip 0	Automatically changes after control power-on or after resetting application	The drive functions are self-diagnosed and initialized
1	Auto skip 1	Automatic transition after the completion of initialization	The communication is established
2	Shutdown	The Shutdown command is received	-
3	Switch on	The Switch on command is received	-
4	Enable operation	The Enable operation command is received	The drive functions are validated
5	Disable operation	The Disable operation command is received	The drive functions are disabled
6	Shutdown	The Shutdown command is received	-
7	Disable voltage	The Disable voltage command is received The Quick stop command is	-

		received	
8	Shutdown	The Shutdown command is received	The drive functions are disabled
9	Disable voltage	The Disable voltage command is received	The drive functions are disabled
10	Disable voltage	The Disable voltage command is received The Quick stop command is received	-
11	Quick stop	The Quick stop command is received	The Quick stop function starts
12	Disable voltage	Quick stop function is completed and quick stop option code is 1, 2 or 3. After Quick stop function is completed, received Disable voltage command quick stop option code is 5, 6, or 7.	The drive functions are disabled
13	Error occurs	An error is detected	Performs the established Fault reaction function
14	Auto skip2	After completing the deceleration process due to an error detection, the state transitions automatically	The drive functions are disabled
15	Fault reset	After releasing factor error, The Fault reset command is received	Resets the Fault state when there is no Fault factor
16	Enable operation	When the Quick stop option code is 5, 6, or 7, the Enable operation command is received	The drive functions are validated

6.3 Controlword(6040h)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO
6040h	00h	controlword	0-65535	U16	rw	N	Y
		Set a command to a servo driver including the PDS state transition.					

Bit	15 ~ 10	9	8	7	6 ~ 4	3	2	1	0
	r	oms	h	fr	oms	eo	qs	ev	so

r = reserve
oms = operation mode specific
(Different definitions according to modes of operation)
fr = fault reset
h = halt
eo = Enable operation
qs = quick stop
ev = enable voltage
so = switch on

Bit7, 3 ~ 0(fault reset / Enable operation / quick stop / enable voltage / switch on):
The following table indicates the PDS command.

Command	bits of the controlword					PDS State
	bit 7	bit 3	bit 2	bit 1	bit 0	
	fault reset	enable operation	quick stop	enable voltage	switch on	
Shutdown	0	-	1	1	0	2, 6, 8
Switch on	0	0	1	1	1	3
Switch on + Enable operation	0	1	1	1	1	3+4
Enable operation	0	1	1	1	1	4, 16
Disable voltage	0	-	-	0	-	7, 9, 10, 12
Quick stop	0	-	0	1	-	7, 10, 11
Disable operation	0	0	1	1	1	5
Fault reset	rising edge	-	-	-	-	15

Note: The bit logic of the quick stop command is valid at 0, please note that it is different from other bit logic

The following shows the definition of oms bit under each control mode (modes of operation)

-: reserve

Op-mode	bit 9	bit 6	bit 5	bit 4
csp	-	-	-	-
csv	-	-	-	-
hm	-	-	-	start homing
pp		absolute/ relative	change set immediately	new set-point

6.4 Statuslword(6041h)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
6041h	00h	Statusword	0-65535	U16	ro	N	Y	0
		Displays the servo driver state						

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

r = reserve
oms = operation mode specific
(Different definitions according to modes of operation)
ila = internal limit active
rm = remote
w = warning
sod = switch on disabled
qs = quick stop
ve = voltage enabled
f = fault
oe = operation enabled
so = switched on
rtso = ready to switch on

Bit 6, 5, 3 – 0(switch on disabled/ quick stop/ fault/ operation enabled/ switched on/ ready to switch on): This bit enables to confirm the PDS state

Statusword	PDS State	
xxxx xxxx x0xx 0000 b	Not ready to switch on	Initialization non-completed
xxxx xxxx x1xx 0000 b	Switch on disabled	Initialization completed
xxxx xxxx x01x 0001 b	Ready to switch on	Main circuit power OFF
xxxx xxxx x01x 0011 b	Switched on	Servo-off/servo ready
xxxx xxxx 0x1x 0111 b	Operation enabled	Servo-on
xxxx xxxx x00x 0111 b	Quick stop active	Immediate stop
xxxx xxxx x0xx 1111 b	Fault reaction active	Error (alarm) discriminated
xxxx xxxx x0xx 1000 b	Fault	Error (alarm) state

Bit 5(quick stop):

If 0, it indicates PDS responds to quick stop request.

Quick stop enabled if the bit is '0'.

Please keep in mind that the bit performs reverse operation compared to other bits.

Bit 7(warning):

If 1, it is indicating a warning. The PDS state does not change during the warning, also, continues the motor operation.

Bit 13, 12, and 10(operation mode specific):

Below table shows the behavior of the operation mode (Op-mode) specific bits.

Op-mode	bit 13	bit 12	bit 10
csp	-	drive follows command value	-
csv	-	drive follows command value	-
hm	homing error	homing attained	target reached
pp	-	set-point acknowledge	target reached

6.5 Operation mode Setting

6.5.1 Supported drive modes(6502h)

This driver can confirm the supported control modes (Modes of operation) according to 6502h.

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
6502h	00h	Supported drive modes	0-4294967295	U32	ro	N	N	0x1A1

bit	Modes of operation		
0	Profile position mode	pp	Yes
1	Velocity mode	vl	No
2	Profile velocity mode	pv	No
3	Torque profile mode	tq	No
5	Homing mode	hm	Yes
6	Interpolated position mode	ip	No
7	Cyclic synchronous position mode	csp	Yes
8	Cyclic synchronous velocity mode	csv	Yes
9	Cyclic synchronous torque mode	cst	No

6.5.2 Modes of operation (6060h)

The operation mode is set by 6060h (Modes of operation)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
6060h	00h	Modes of operation	-128 - 127	I8	rw	N	Y	0x00

bit	Modes of operation	
1	Profile position mode	pp
6	Homing mode	hm
8	Cyclic synchronous position mode	csp
9	Cyclic synchronous velocity mode	csv

- Because 6060h (Modes of operation) is default=0 (No mode change/no mode assigned), please set the control mode value before the PDS state transitions to Operation enabled.

6.5.3 Modes of operation display (6061h)

The 6061h (Modes of operation display) enables to confirm the internal operation mode of this servo driver.

After setting 6060h (Modes of operation), monitor this object to confirm that the system operation is set as expected

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
6061h	00h	Modes of operation	-128 - 127	I8	ro	N	Y	0x00
		Displays the operation mode at present.						

bit	Modes of operation	
1	Profile position mode	pp
6	Homing mode	hm
8	Cyclic synchronous position mode	csp
9	Cyclic synchronous velocity mode	csv

6.5.4 Caution for Changing Operation mode

- The operation mode can be switched by changing the value of 6060h (Modes of operation).
- The 6061h (Modes of operation display) enables to confirm the operation mode of the servo driver at present.
- About 2 ms is required from the time when the operation mode is changed until the completion of the change.
- When changing the operation mode, make sure that the motor is stopped.
- If the control mode is changed during a motor operation (including during an origin return operation and deceleration stop), the operation cannot be guaranteed.

6.6 Position Control Function

6.6.1 Software position limit (Software position limit:607Dh)

Index	sub-index	Name	Range	Data Type	Access	EEPROM	PDO	default
0x607D		Software Position Limit						
	00h	Number of entries	2	U8	ro	N	N	2
	01h	Min position limit	-2147483648 - 2147483647	I32	rw	Y	N	00000000h
	02h	Max position limit	-2147483648 - 2147483647	I32	rw	Y	N	00000000h

The following conditions are invalidation of the software limit function

607Dh-01h >= 607Dh-02h

Example) 607Dh-01h = 0

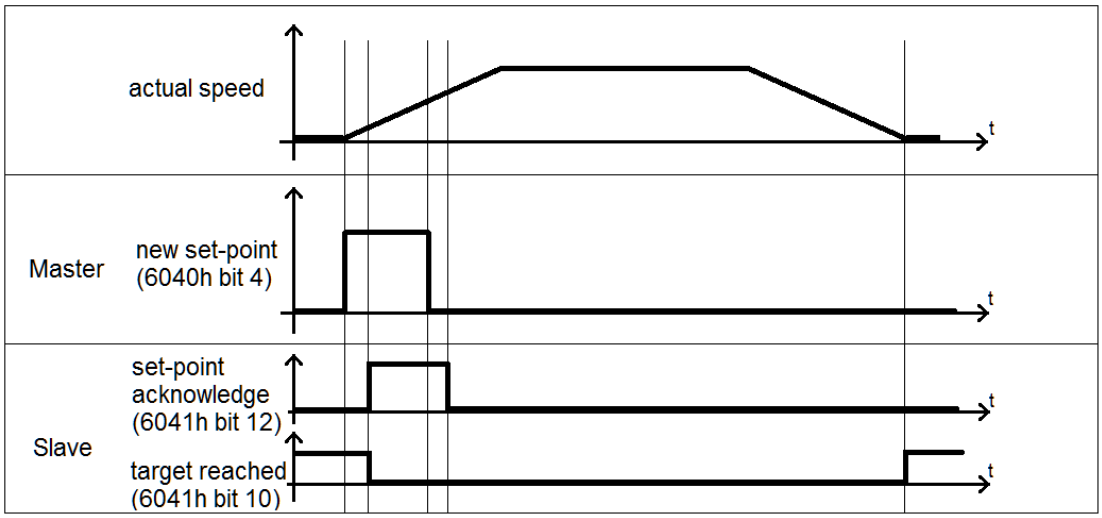
607Dh-02h = 0

6.6.2 Profile Position Mode(pp mode)

In this mode, specify the target position, target speed, acceleration and deceleration, etc., and the driver will drive the motor to move after generating instructions internally in accordance with the motion parameters.

Steps

1. Set the operation mode (Mode of operation: 6060h) to Profile position mode (pp mode) Value = 0x01, and confirm (Mode of operations Display: 6061h) = 0x01.
2. Change (Controlword: 6040h) from the value 0x06 → 0x07 → 0x0F to make the control system Servo On state.
3. Change the target position (Target Position: 607Ah).
4. Change the target velocity (Profile velocity: 6081h), this object is restricted by the setting value of (Max profile velocity: 607Fh).
5. Change acceleration (Profile acceleration: 6083h), this object is limited by the setting value of (Max acceleration: 60C5h).
6. Change the deceleration (Profile decceleration: 6084h), this object is limited by the setting value of (Max decceleration: 60C6h).
7. Set bit 4 (new set-point) of 6040h to change from 0 to 1, and the motor starts to operate.
8. Confirm that bit 12 (set-point acknowledge) of 6041h is from 0 to 1.
9. Confirm that bit10 (target reached) of 6041h is 1, and the positioning is completed.



Control word: 6040h (under pp mode)

Bit	15 ~ 10	9	8	7	6 ~ 4	3	2	1	0
	r	r	h	fr	oms	eo	qs	ev	so
r = reserve fr = fault reset h = halt					eo = Enable operation qs = quick stop ev = enable voltage so = switch on				

bit	Name	Value	Definition
4	new set-point	0 -> 1	Start moving
5	change set immediately	0	After the current positioning action is completed, start the next positioning action
		1	Interrupt the current positioning action and immediately start the next positioning action
6	absolute/ relative	0	(Target position: 607A) is treated as an absolute position
		1	(Target position: 607A) is treated as a relative position

The difference according to the combined action of bit5 and bit4 is as follows

bit 5	bit 4	Definition
change set immediately	new set-point	
0	0 -> 1	The next positioning action is executed after the current positioning action is completed
1	0 -> 1	The next positioning action will be executed immediately

Status word: 6041h (under pp mode)

Bit	15~13	12	11	10	9	8	7	6	5	4	3	2	1	0
	r	set-point acknowledge	ila	target reached	rm	r	w	sod	qs	ve	f	oe	so	rtso

r = reserve	w = warning
ila = internal limit active	sod = switch on disabled
rm = remote	qs = quick stop
	ve = voltage enabled
	f = fault
	oe = operation enabled
	so = switched on
	rtso = ready to switch on

bit	Name	Value	Definition
10	target reached	0	Command not completed
		1	When halt = 0: positioning is complete When halt = 1: the axis stops (speed is 0)
12	set-point acknowledge	0	new-setpoint is 0, and the buffer is empty
		1	new-setpoint is 1, or the buffer is not empty

6.6.3 Cyclic Synchronous Position Mode(csp mode)

It is a position control mode to operate by creating a command position in the host controller (master) and updating (transmitting) the command position in an interpolation cycle.

Step 1: Read (Position Actual Value: 6064h) and write to (Target position: 607Ah).

Step 2: Set (Mode of operation: 6060h) to Cyclic synchronous position mode (csp mode) value = 0x08, and check (Mode of operations Display: 6061h) = 0x08.

Step 3: Change (Controlword: 6040h) from the value 0x06 → 0x07 → 0x0F to make the control system Servo On state, and the drive starts to move according to (Target position: 607Ah).

Control word: 6040h (under csp mode)

Bit	15 ~ 10	9	8	7	6 ~ 4	3	2	1	0
	r	r	h	fr	r	eo	qs	ev	so

r = reserve
fr = fault reset
h = halt
eo = Enable operation
qs = quick stop
ev = enable voltage
so = switch on

Status word: 6041h (under csp mode)

Bit	15~13	12	11	10	9	8	7	6	5	4	3	2	1	0
	r	driver follows command value	ila	r	rm	r	w	sod	qs	ve	f	oe	so	rtso

r = reserve
fe = following error
ila = internal limit active
rm = remote
w = warning
sod = switch on disabled
qs = quick stop
ve = voltage enabled
f = fault
oe = operation enabled
so = switched on
rtso = ready to switch on

bit	Name	Value	Definition
12	driver follows command value	0	Operation is not performed according to the target position
		1	Operation is performed according to the target position

6.6.4 Homing Mode(hm mode)

Specify the action speed, acceleration and homing method, the drive generates a position command and executes homing.

Step 1: Set (Mode of operation: 6060h) to the Homing mode (hm mode) Value = 0x06, and check (Mode of operations Display: 6061h) = 0x06

Step 2: Set (Home offset: 607Ch), the default is 0

Step 3: Set (Homing method: 6098h)

Step 4: Set (Homing speeds: 6099h Sub-1)

Step 5: Set (Homing speeds: 6099h Sub-2)

Step 6: Set (Homing acceleration: 609Ah)

Step 7: Change (Controlword: 6040h) from the value 0x06 → 0x07 → 0x0F to make the control system Servo On state

Step 8: Set (Controlword: 6040h)to 0x1F and start homing

Control word: 6040h (under hm mode)

Bit	15 ~ 10	9	8	7	6 ~ 5	4	3	2	1	0
	r	r	h	fr	r	start homing	eo	qs	ev	so
r = reserve fr = fault reset h = halt					eo = Enable operation qs = quick stop ev = enable voltage so = switch on					

bit	Name	Value	Definition
4	start homing	0 -> 1	Start homing

Status word: 6041h (under hm mode)

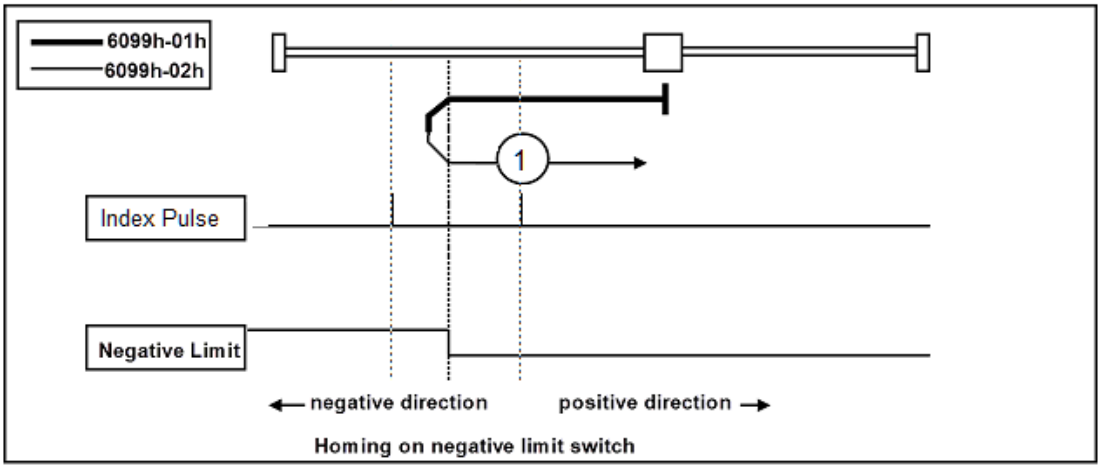
Bit	15~14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	r	homing error	homing attained	ila	target reached	rm	r	w	sod	qs	ve	f	oe	so	rtso

r = reserve
ila = internal limit active
rm = remote
w = warning
sod = switch on disabled
qs = quick stop
ve = voltage enabled
f = fault
oe = operation enabled
so = switched on
rtso = ready to switch on

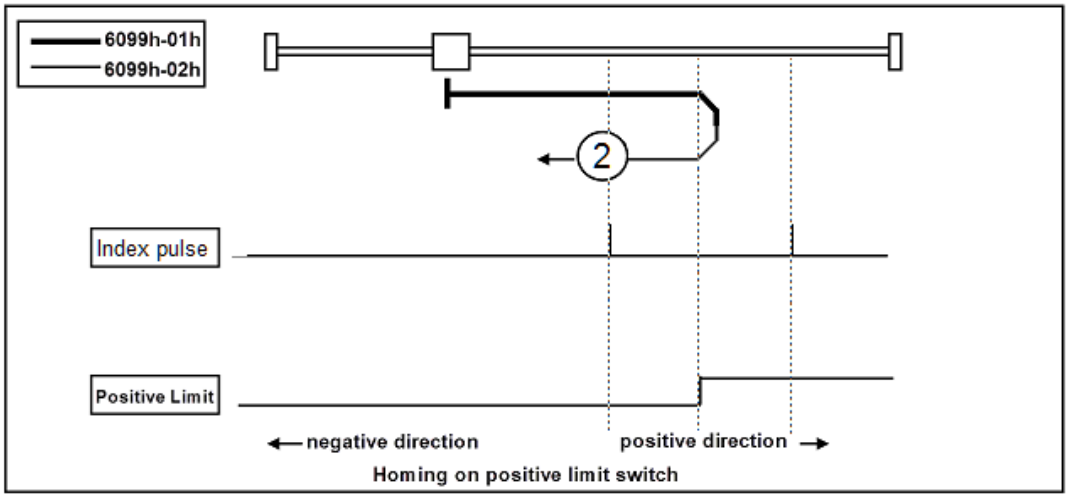
bit	Name	Value	Definition
10	target reached	0	In operation
		1	Stopped state
12	homing attained	0	The homing operation is incomplete
		1	The homing operation complete to be performed successfully
13	homing error	0	A homing error does not occur (normal)
		1	A homing error occurs (The homing operation is not performed successfully)

bit 13	bit 12	bit 10	Definition
0	0	0	Homing
0	0	1	The homing operation is suspended or not started
0	1	0	The homing operation is completed, but the operation does not arrive at the target position
0	1	1	The homing operation is completed successfully
1	0	0	The homing error is detected but still working
1	0	1	The homing error is detected and stopped

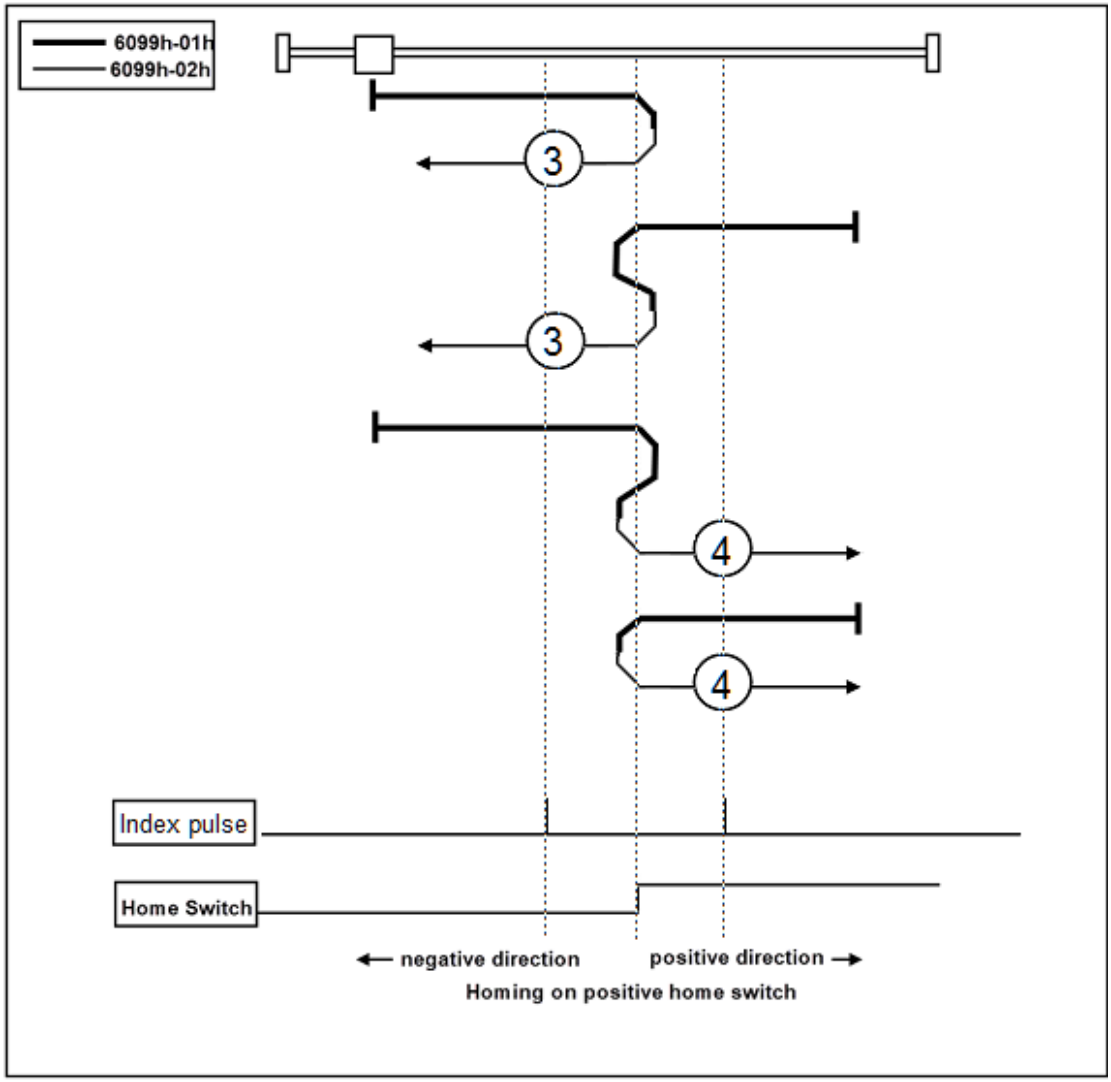
- Method 1
  - If LL switch is not activated at the beginning of the action, the initial action direction is the negative direction.
  - If the LL switch has been activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the first Index pulse detection position in the positive direction after the status change of LL.



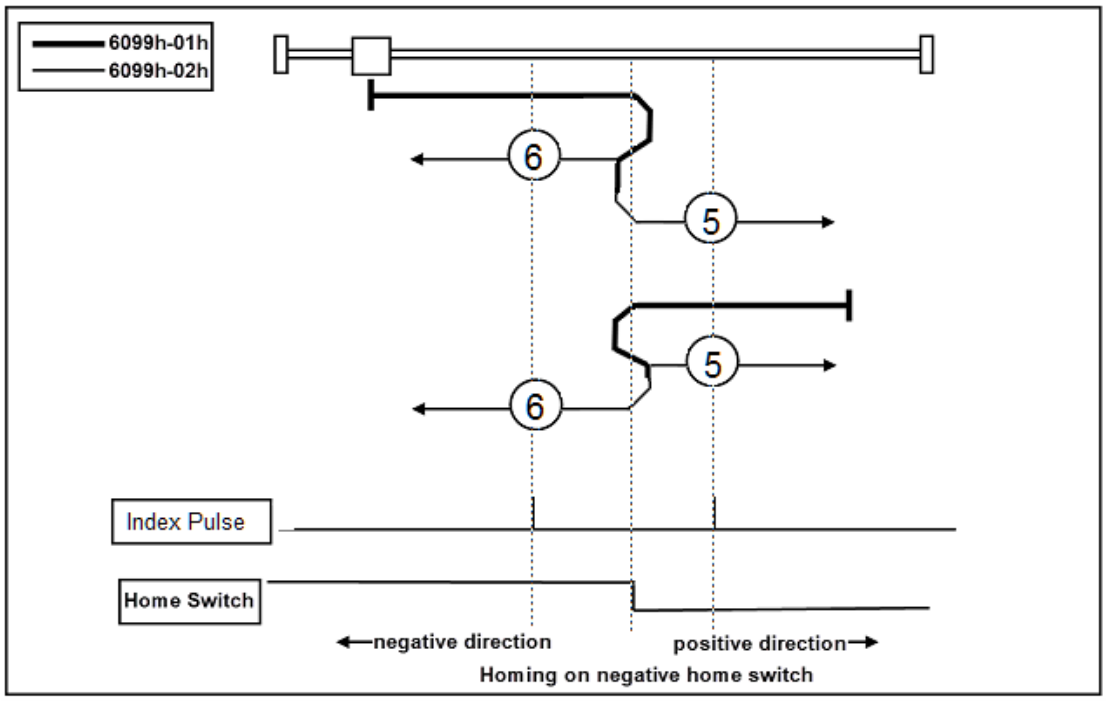
- Method 2
  - If RL switch is not activated at the beginning of the action, the initial action direction is the positive direction.
  - If the RL switch has been activated at the beginning of the action, the initial action direction is the negative direction.
  - The home detection position is the first Index pulse detection position in the negative direction after the status change of RL.



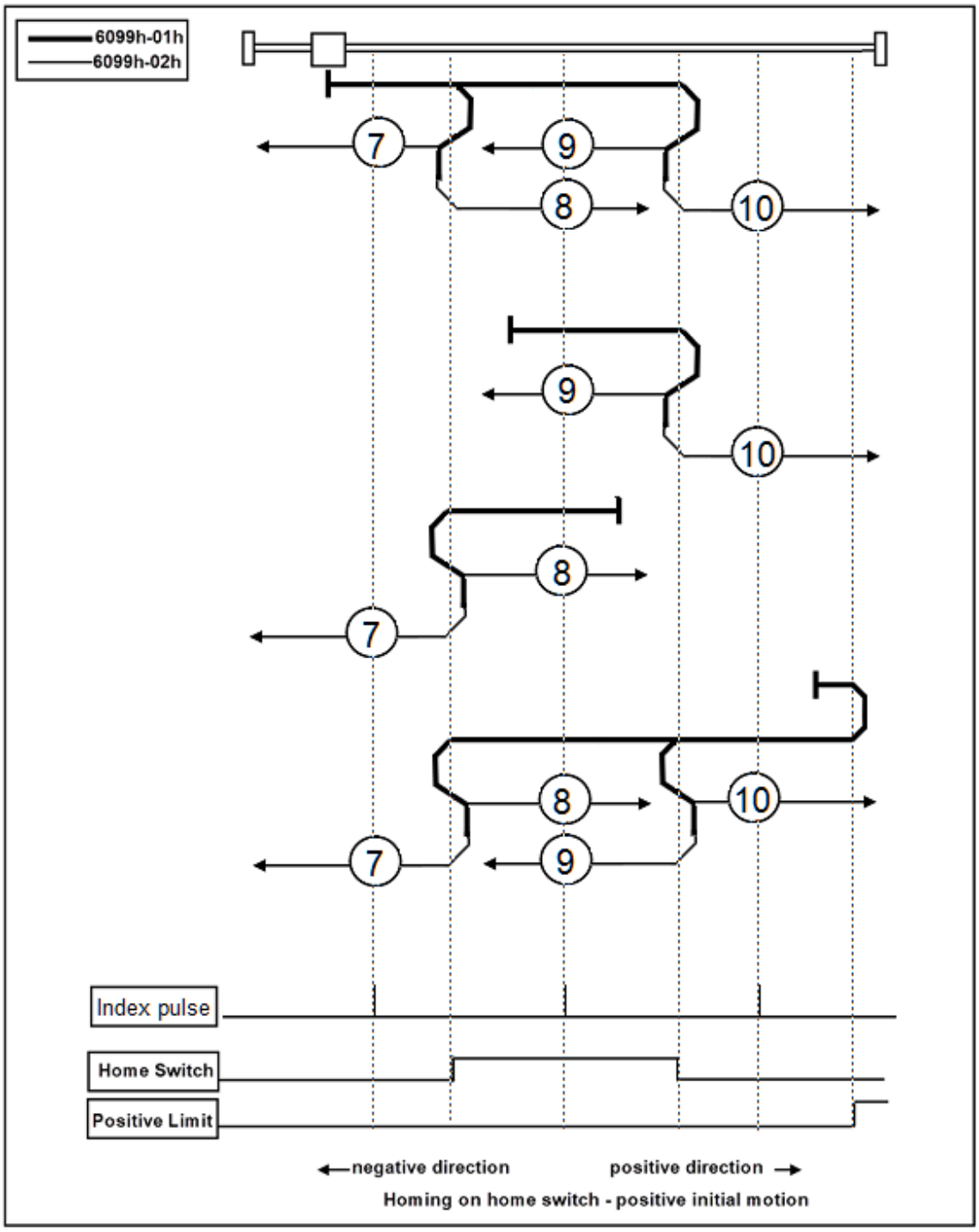
- Method 3、4
  - If Home switch is not activated at the beginning of the action, the initial action direction is the positive direction.
  - If the Home switch has been activated at the beginning of the action, the initial action direction is the negative direction.
  - The home detection position is the first Index pulse detection position in the positive or negative direction after the status change of ORG.



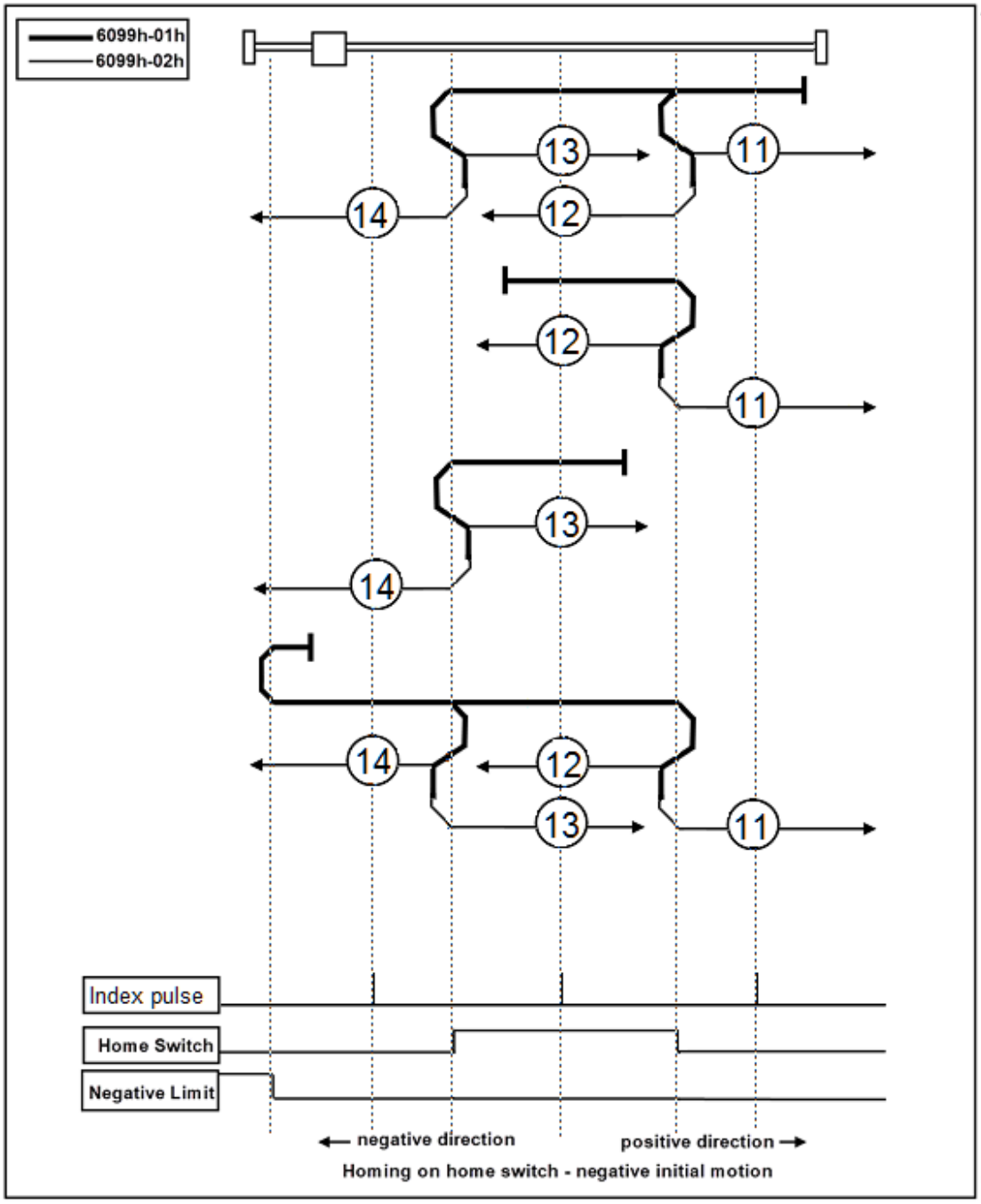
- Method 5、6
  - If Home switch is not activated at the beginning of the action, the initial action direction is the negative direction.
  - If the Home switch has been activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the first Index pulse detection position in the positive or negative direction after the status change of ORG.



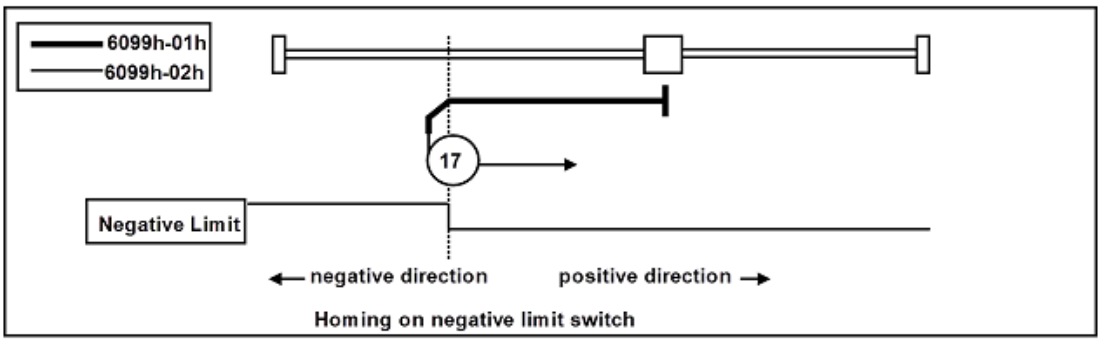
- Method7、8、9、10
  - If Home switch of Method 7 and 8 is activated at the beginning of the action, the initial action direction is the negative direction.
  - If Home switch of Method 9 and 10 is activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the first Index pulse detection position in the positive or negative direction after the status change of ORG.



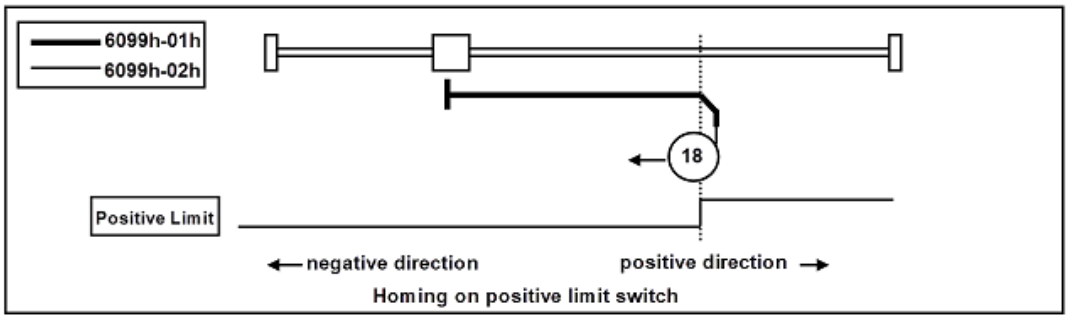
- Method11、12、13、14
  - If Home switch of Method 13 and 14 is activated at the beginning of the action, the initial action direction is the negative direction.
  - If Home switch of Method 11 and 12 is activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the first Index pulse detection position in the positive or negative direction after the status change of ORG.



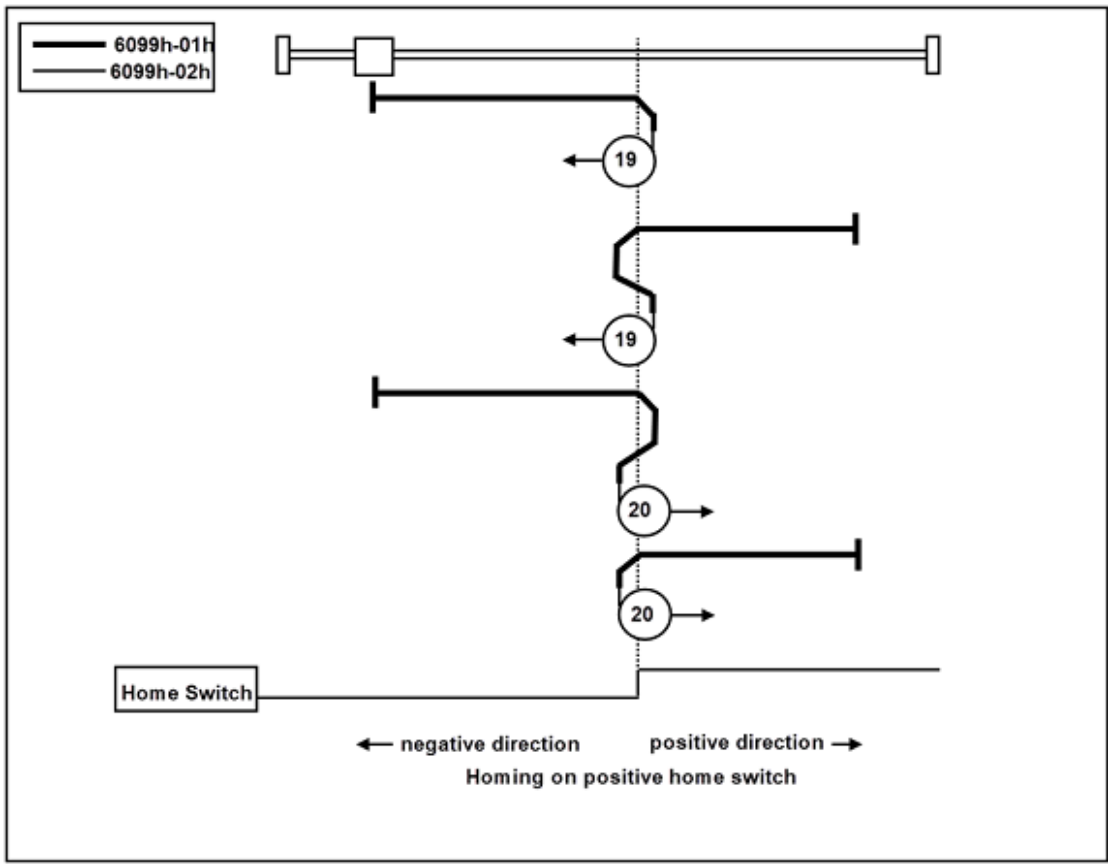
- Method 17
  - If LL switch is not activated at the beginning of the action, the initial action direction is the negative direction.
  - If the LL switch has been activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the position when the status of LL changes.



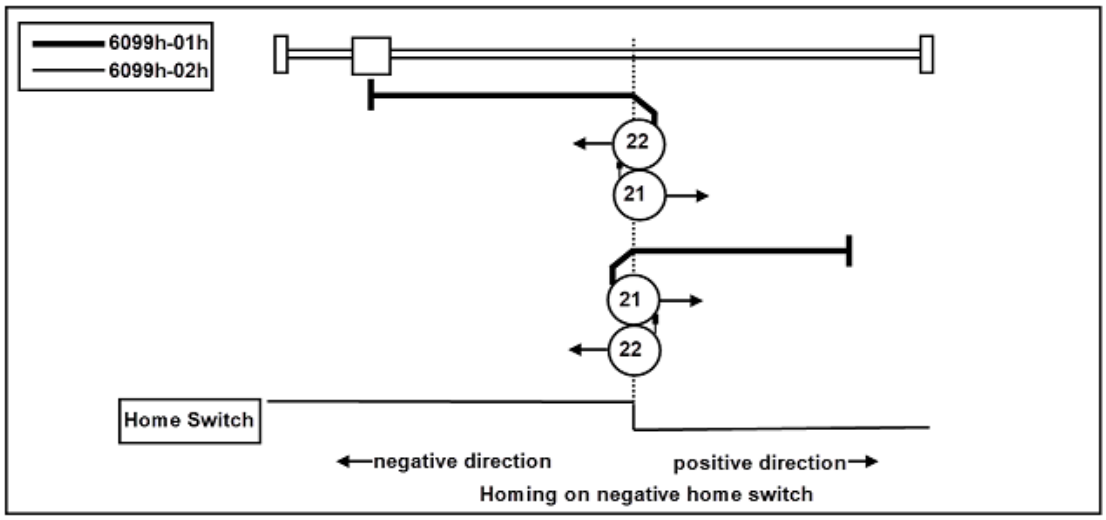
- Method 18
  - If RL switch is not activated at the beginning of the action, the initial action direction is the positive direction.
  - If the RL switch has been activated at the beginning of the action, the initial action direction is the negative direction.
  - The home detection position is the position when the status of RL changes.



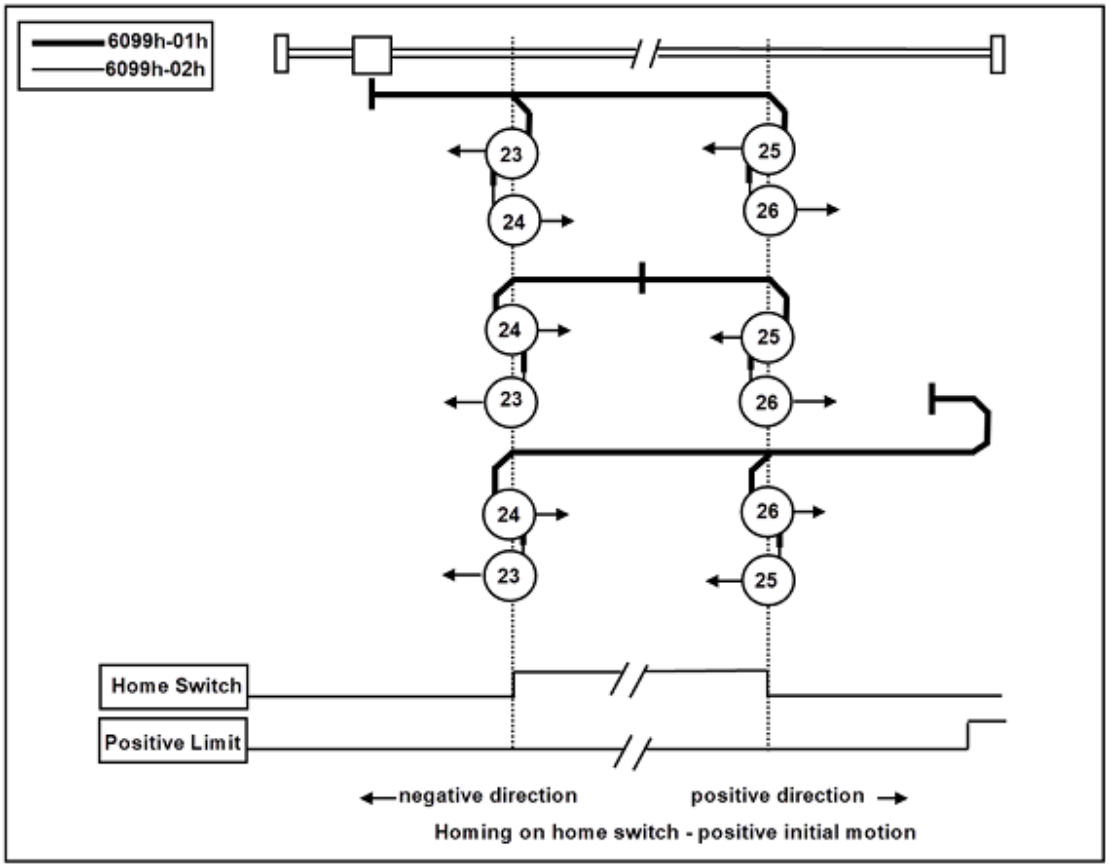
- Method 19、20
  - If Home switch is not activated at the beginning of the action, the initial action direction is the positive direction.
  - If the Home switch has been activated at the beginning of the action, the initial action direction is the negative direction.
  - The home detection position is the position when the status of ORG changes.



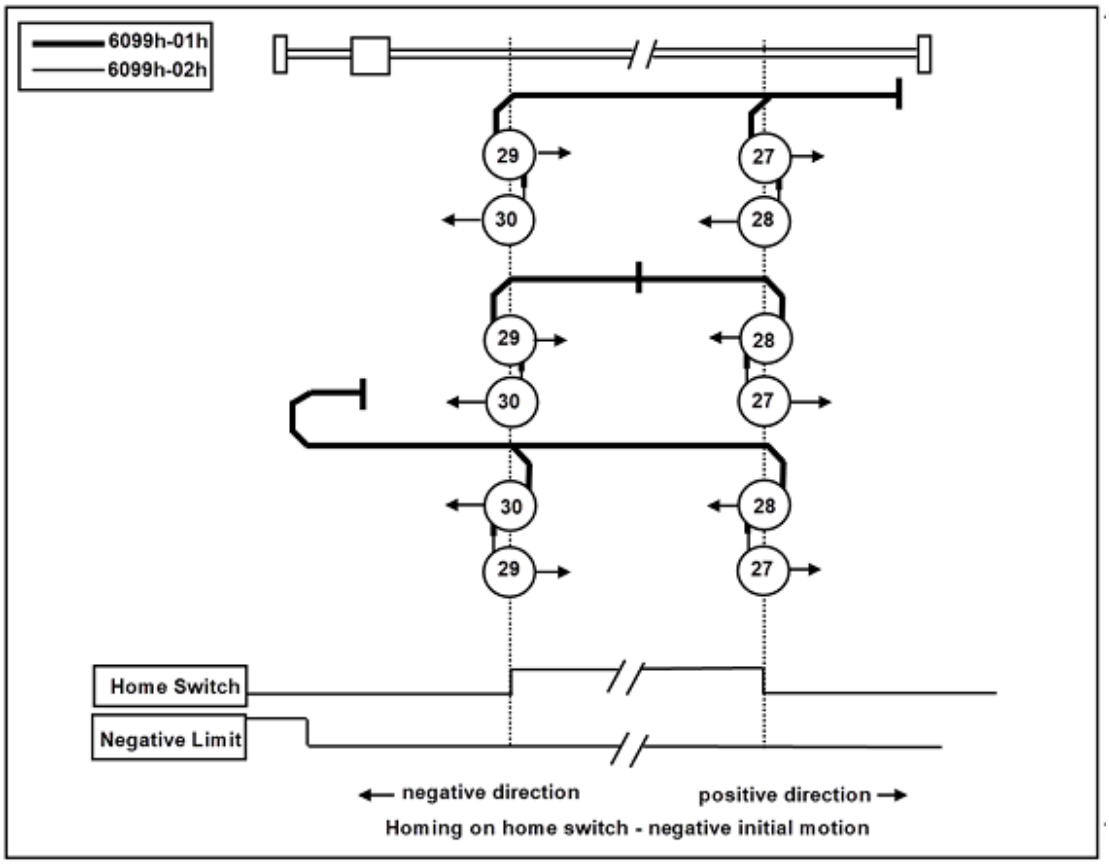
- Method 21、22
  - If Home switch is not activated at the beginning of the action, the initial action direction is the negative direction.
  - If the Home switch has been activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the position when the status of ORG changes.



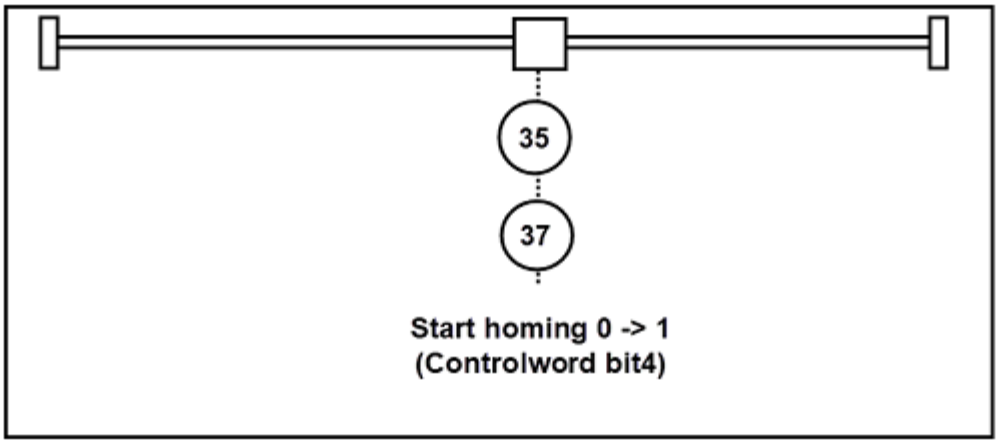
- Method23、24、25、26
  - If Home switch of Method 23 and 24 is activated at the beginning of the action, the initial action direction is the negative direction.
  - If Home switch of Method 25 and 26 is activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the position when the status of ORG changes.



- Method27、28、29、30
  - If Home switch of Method 29 and30 is activated at the beginning of the action, the initial action direction is the negative direction.
  - If Home switch of Method 27 and 28 is activated at the beginning of the action, the initial action direction is the positive direction.
  - The home detection position is the position when the status of ORG changes.



- Method35、37
  - The home detection position is the current position.



6.7 Velocity Control Function

6.7.1 Cyclic Synchronous Velocity Mode(csv mode)

It is a velocity control mode to operate by creating a command velocity in the host controller (master) and updating (transmitting) the command velocity in an interpolation cycle.

Step 1: Set (Target velocity: 60FFh) to 0.

Step 2: Set (Mode of operation: 6060h) to Cyclic synchronous position mode (csv mode) value = 0x09, and check (Mode of operations Display: 6061h) = 0x09.

Step 3: Change (Controlword: 6040h) from the value 0x06 → 0x07 → 0x0F to make the control system Servo On state, and the drive starts to move according to the (target velocity: 60FFh).

Control word: 6040h (under csv mode)

Bit	15 ~ 10	9	8	7	6 ~ 4	3	2	1	0
	r	r	h	fr	r	eo	qs	ev	so

r = reserve
fr = fault reset
h = halt
eo = Enable operation
qs = quick stop
ev = enable voltage
so = switch on

Status word: 6041h (under csv mode)

Bit	15~13	12	11	10	9	8	7	6	5	4	3	2	1	0
	r	driver follows command value	ila	r	rm	r	w	sod	qs	ve	f	oe	so	rtso

r = reserve
fe = following error
ila = internal limit active
rm = remote
w = warning
sod = switch on disabled
qs = quick stop
ve = voltage enabled
f = fault
oe = operation enabled
so = switched on
rtso = ready to switch on

bit	Name	Value	Definition
12	driver follows command value	0	Operation is not performed according to the target velocity
		1	Operation is performed according to the target velocity

7 Alarm List

Alarm	Description
0x7500	EtherCAT Communication error
0xFF03	Changing (mode of operation: 6060h) during the running of the motor
0xFF04	EEPROM failed
0xFF05	over temperature