EtherCAT User Manual

For SSDC EtherCAT

EtherCAT®

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Introduction to EtherCAT

EtherCAT (Ethernet for Control Automation Technology) is a real-time Industrial Ethernet technology originally developed by Beckhoff Automation. The main focus during the development of EtherCAT was on short cycle times (≤ 100 μs), low jitter for accurate synchronization (≤ 1 μs) and low hardware costs.

The EtherCAT master sends a telegram that passes through each node. Each EtherCAT slave device reads the data addressed to it "on the fly", and inserts its data in the frame as the frame is moving downstream. The frame is delayed only by hardware propagation delay times. The last node in a segment (or branch) detects an open port and sends the message back to the master using Ethernet technology's full duplex feature.

Line, tree, star, or daisy-chain: EtherCAT supports almost all of topologies. Up to 65,535 devices can be connected to EtherCAT, so network expansion is virtually unlimited.

Commonly Used Acronyms

100Base-Tx	100 MBit/s Ethernet on twisted pairs
AL	Application Layer
CAN	Controller Area Network
CANopen	Application layer protocol for the CAN bus
CoE	CANopen over EtherCAT
DC	Distributed Clocks Mechanism to synchronize EtherCAT slaves and master
DL	Data Link Layer
EMCY	Emergency Object
ESI	EtherCAT Slave Information
ESC	EtherCAT Slave Controller
ETG	EtherCAT Technology Group
PDO	Process Data Object
SDO	Service Data Object
XML	eXtensible Markup Language - used for the ESI file

Protocol

EtherCAT embeds its payload in a standard Ethernet frame. The frame is identified with the Identifier (0x88A4) in the EtherType field. During startup, the master device configures and maps the process data on the slave devices. The EtherCAT frame contains one or more datagrams. The datagram header indicates what type of access the master device would like to execute:

-Read, write, read-write

-Access to a specific slave device through direct addressing, or access to multiple slave devices through logical addressing

Logical Addressing

Logical addressing is used for the cyclical exchange of process data. Each datagram addresses a specific part of the process image in the EtherCAT segment, for which 4 GBytes of address space is available. During network startup, each slave device is assigned one or more addresses in this global address space. If multiple slave devices are assigned addresses in the same area, they can all be addressed with a single datagram. Since the datagrams completely contain all the data access related information, the master device can decide when and which data to access. For example, the master device can use short cycle times to refresh data on the drives, while using a longer cycle time to sample the I/O; a fixed process data structure is not necessary.

In addition to cyclical data, further datagrams can be used for asynchronous or event driven communication. Besides the logical addressing, the master device can also address a slave in two ways:

Auto Increment Addressing

With Auto increment addressing, the master device addresses a slave via its position in the network. This method is used during network boot-up to determine the network topology and compare it to the planned topology.

Fixed Node Addressing

After checking the network configuration, the master device can assign each node a configured node address and communicate with the node via this fixed address. This enables targeted access to devices, even when the network topology is changed during operation.

EtherCAT Frame Structure

In EtherCAT, the data between the master and the slaves is transmitted in Ethernet frames. An EtherCAT Ethernet frame consists of one or several EtherCAT datagrams, each addressing individual devices and/or memory areas. The EtherCAT frame structure is pictured in the following figure. Each EtherCAT datagram consists of a datagram header, the data area and a working counter (WKC), which is incremented by all EtherCAT nodes that are addressed by the datagram and have exchanged associated data.

Ethernet Header (14 bytes)			EtherCAT Data		FSC
Destination	Source	EtherType(88A4h)	EtherCAT Header	EtherCAT Datagrams	FSC
6 bytes	6 bytes	2 bytes	2 bytes	44 ~ 1498 bytes	4 bytes

EtherCAT Datagrams			
1st EtherCAT Datagram	2nd EtherCAT Datagram	···	nth EtherCAT Datagram

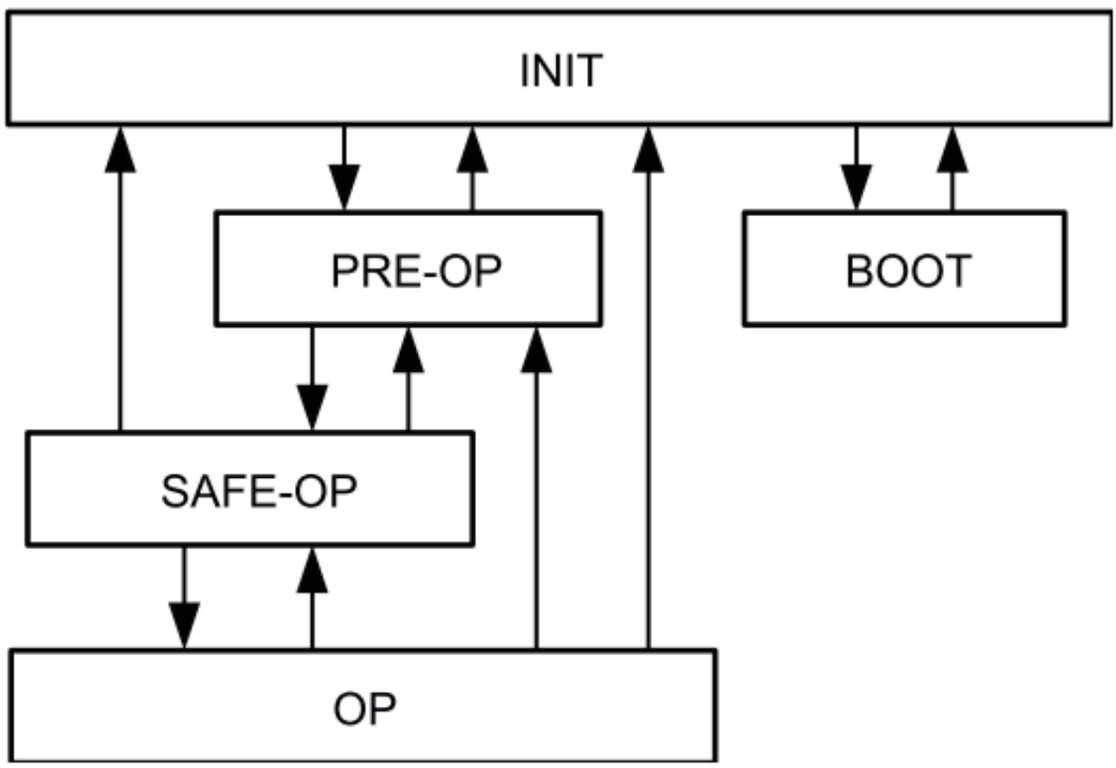
EtherCAT Datagram		
Datagram Header	Data	WKC
10 bytes	max. 1486 bytes	2 bytes

FSC: Frame Check Sequence

WKC: Working Counter

EtherCAT State Machine

Both the master and the slaves have a state machine with the states shown below. After boot the slaves are in INIT state, and then it’s up to the master to request state transitions. The standardized EtherCAT state machine is defined in the following figure. The bootstrap state is not supported.



INIT: initialization

PRE-OP: pre-operational

SAFE-OP: safe-operational

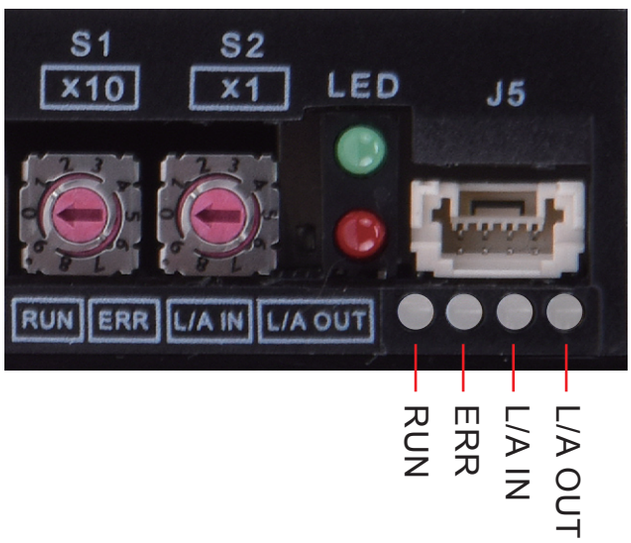
OP: operational

BOOT: bootstrap

State	SDO	RPDO	TPDO	Description
INIT	×	×	×	State after device initialization. No communication on the Application Layer.
PRE-OP	√	×	×	After initialization of communication, device enters into this state. SDO is available at this state.
SAFE-OP	√	×	√	SDO and TPDO are available at this state.
OP	√	√	√	All of the SDO and PDO are available at this state. Drive fully operational.
BOOT	×	×	×	Not used.

EtherCAT Status Indicator LED

The LEDs are used for indicating status of EtherCAT. There are two Link / Activity LEDs and two status LEDs (RUN and ERR).



LED indicator descriptions:

LED	Color	Status	Description
Link / Activity	Green	OFF	no Ethernet connection
		ON	Ethernet is connected
		Flickering	activity on line
RUN	Green	OFF	initialization state
		Blinking	pre-operational state
		Single Flash	safe-operational state
		ON	operational state
ERR	Red	OFF	no error
		Blinking	general error
		Single Flash	sync error
		Double Flash	watch dog error

Notes:

Flickering: Rapid flashing with a period of approx. 50ms (10 Hz)

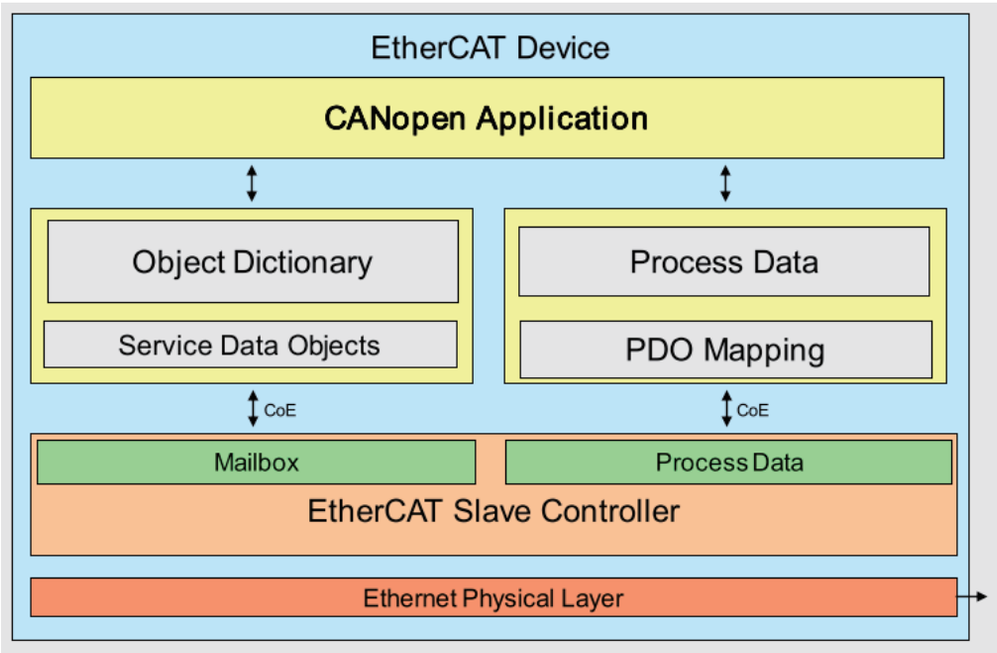
Blinking: Flashing with equal on and off periods of 200ms (2.5Hz)

Single Flash: Repeating ON for 200ms and OFF for 1s

Double Flash: Two flashes with a period of 200ms followed by 1s OFF period

CANopen over EtherCAT

MOONS' EtherCAT drives support CANopen over EtherCAT (CoE) which is the application layer communication protocol. CiA 402 drive profile is supported. The CoE device architecture is as below:



Following message types are used:

SDO (Service Data Object): SDO is used for acyclic data transmission. This communication can be used in PRE-OP, Safe-OP and OP state.

PDO (Process Data Object): PDO is used for cyclic data transmission. Data that will be transmitted or received is defined by PDO mapping.

EMCY (Emergency Object): EMCY is used for error report when a fault has occurred in the drive.

Synchronization

The EtherCAT solution for synchronizing nodes is based on distributed clocks (DC). The calibration of the clocks in the nodes is completely hardware-based. The time from the first DC slave device is cyclically distributed to all other devices in the system. With this mechanism, the slave device clocks can be precisely adjusted to this reference clock. The resulting jitter in the system is significantly less than 1 μs.

Since the time sent from the reference clock arrives at the slave devices slightly delayed, this propagation delay must be measured and compensated for each slave device in order to ensure synchronicity and simultaneousness. This delay is measured during network startup or, if desired, even continuously during operation, ensuring that the clocks are simultaneous to within much less than 1 μs of each other.

MOONS' EtherCAT drives provide three synchronization modes:

Free Run
Slave's application is not synchronized to EtherCAT Master. Master and slave have an individual independent cycle.

SM Event
Slave's application is synchronized to SM Event.

DC SYNC Event
Slave's application is synchronized to SYNC Event.

EtherCAT Slave Information

Every EtherCAT device is delivered with an EtherCAT Slave Information (ESI) file in XML format. It describes the identity and all features of the device. The XML files for MOONS' EtherCAT drive can be downloaded from MOONS' website.

CiA402 Drive Profile

Operation Modes

SSDC EtherCAT drive supports following operation modes (0x6060):

- Profile Position (PP)
- Profile Velocity (PV)
- Torque Profile (TQ)
- Cyclic Synchronous Position (CSP)
- Cyclic Synchronous Velocity (CSV)
- Homing (HM)
- Q Program (MOONS' specific mode)

Profile Position Mode

General Mode Description

Profile Position Mode is a point-to-point operating mode using set-points which consist of velocity, acceleration, deceleration, and target position. Once all these parameters have been set, the drive buffers the commands and begins executing the set-point. When using a set of set-points method, a new set-point can be sent to the drive while a previously sent set-point is still executing.

Enable Profile Position Mode

To enable the Profile Position Mode, the value 0001h must be written to the mode of operation OD entry, located at dictionary address 6060h. The mode of operation can be verified using OD 6061h - mode of operation display - which is updated when the current operation mode is accepted.

Set Running Parameters

Set the distance, velocity, acceleration, and deceleration using OD entries 607Ah, 6081h, 6083h, and 6084h respectively.

Starting/Stopping Motion

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into "ready to switch on" state and is ready to enable drive operation. If the value 0006h is not written to the control word first, the drive operation can not be enabled.

To indicate a new set-point and start motion, toggle bit 4 by sending 001Fh to controlword OD entry 6040h.

To enable drive operation, the value 001Fh must be written to the controlword OD entry, located at dictionary address 6040h. This will also signal that there is a new set-point ready. The drive

acknowledges the receipt of a valid set-point using bit 12 of the statusword at OD 6041h. Because the set-point is edge-triggered, once the drive receives and processes the set-point, the new set-point of the controlword must be cleared by writing 000Fh to the controlword register.
While the drive is acting on a set-point, a new set-point may be entered and triggered using the new set-point. The second set-point will be received as soon as it is processed, or at the end of the previous set-point, which ever is later.

Controlword Bits

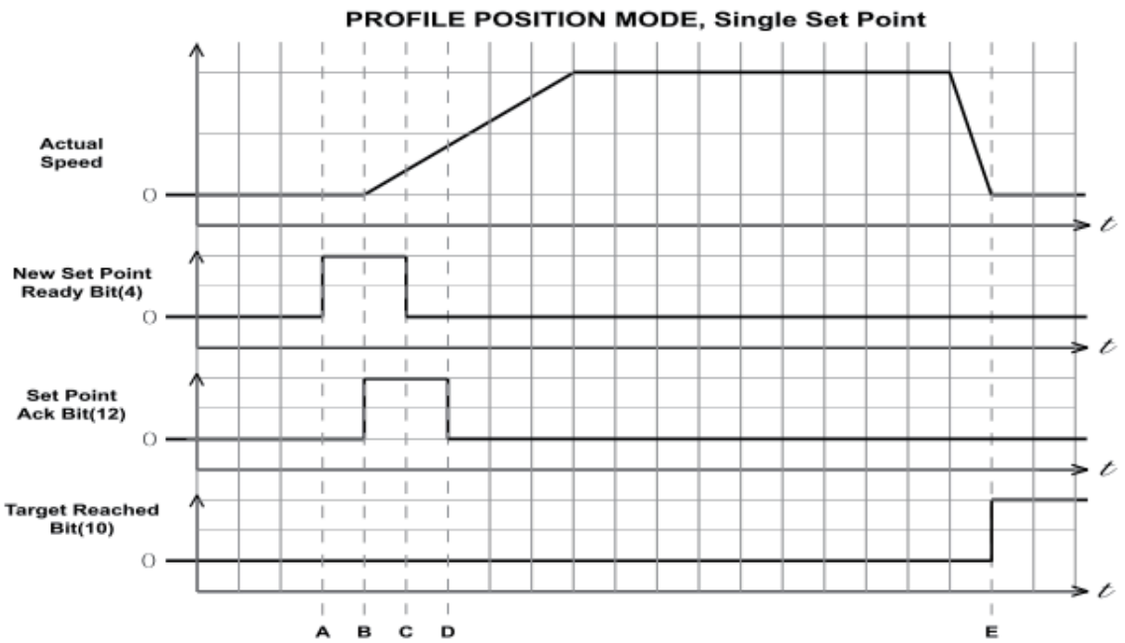
New Set-point (bit 4) - set this bit high to clock in a new set-point. Once the drive has accepted the set-point, it will respond by setting statusword bit 12 high. Controlword bit 4 should then be taken low.

Change of Set-point (bit 9) - if this bit is low, the previous set-point will be completed and the motor will come to rest before a new set-point is processed. If bit 9 is high, the motor will continue at the speed commanded by the previous set-point until it has reached the position commanded by the previous set-point, then transition to the speed of the new set-point.

Change Set-point Immediately (bit 5) - if this bit is high, the new set-point will take effect immediately. The motor speed will transition to the speed and position commanded by the new set-point.

Abs/rel (bit 6) - if this bit is high, the set-point distance is relative. For example, if the previous motor position was 10,000 steps and a new set-point is issued with a distance of 20,000, the final position will be 30,000. If bit 6 is low, the distance is absolute. If the previous motor position was 10,000 and a new set-point is issued with a distance of 20,000, the new position will be 20,000. (The distance traveled from the previous position to the new position will be 10,000 steps.) For best results, do not change this bit while the motor is moving.

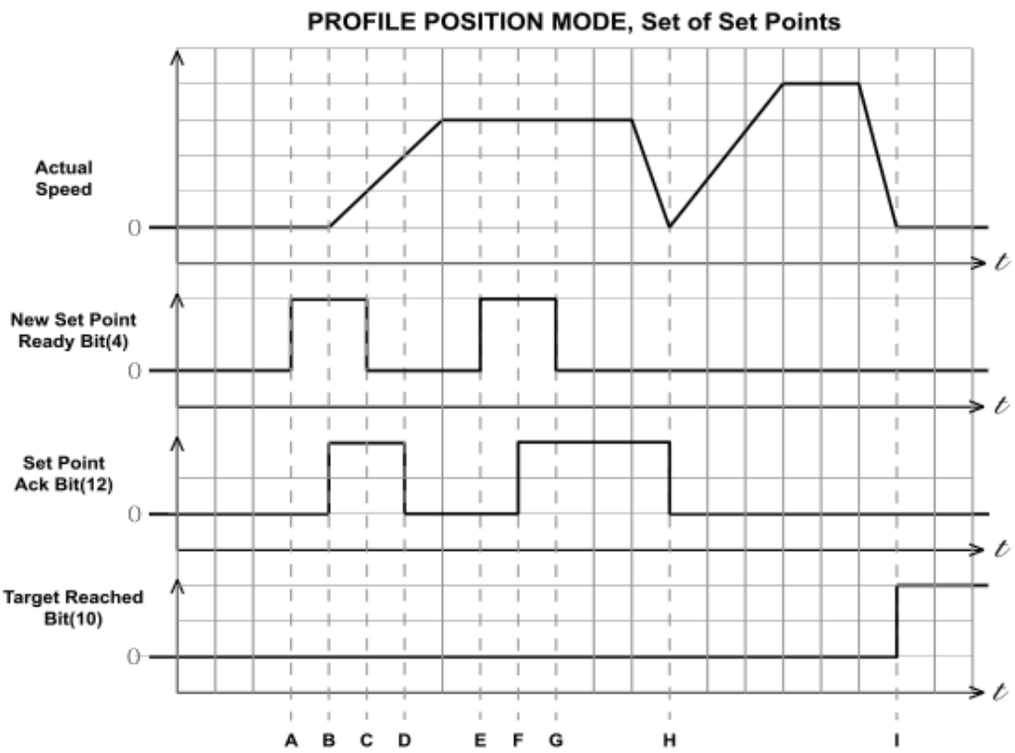
Note:
Two set-points can be set up, but if status bit 12 is high, then the buffer is full and another set-point will be ignored.



Single Set-Point

Graph Point	New Set-Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set-point ack bit low, indicating ready to receive another set-point
E	0	0	1	The set-point is finished, and the Target Reached bit is set

Single Set-Point Profile Position Move

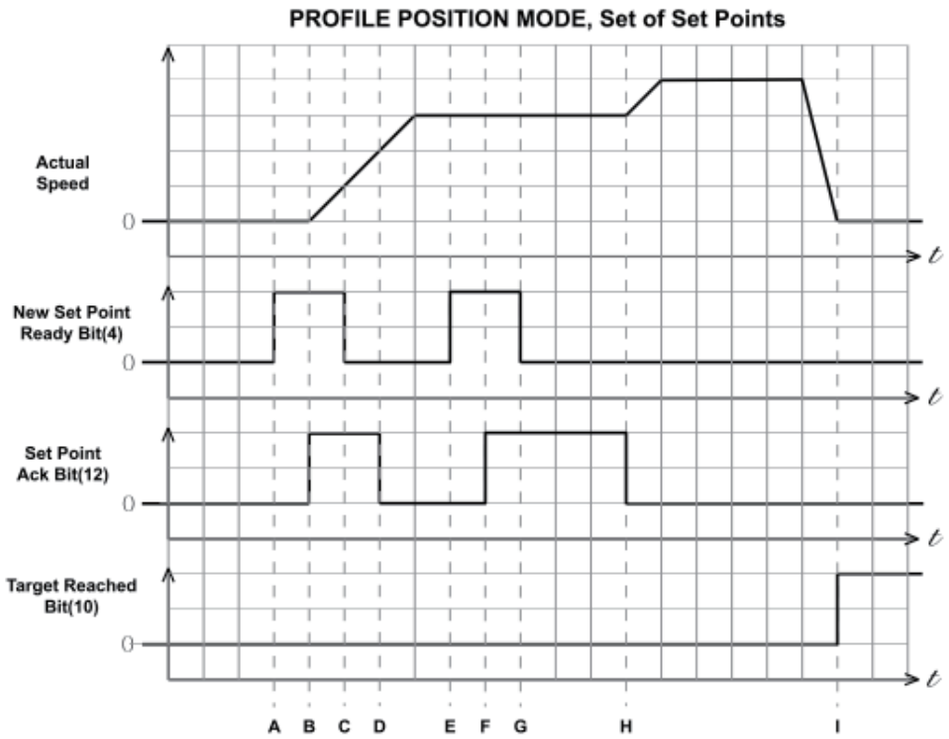


Multiple Set-Points, Stopping Between Moves

In this example, controlword bits 9 (Change of Set-point) and 5 (Change Set Immediately) are 0. The motor comes to rest between moves.

Graph Point	New Set-Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set-point ack bit low, indicating ready to receive another set-point
E	0 -> 1	0	0	User tells drive another set-point is ready
F	1	0 -> 1	0	Drive acknowledges set-point, buffers it as another set-point is still in progress
G	1 -> 0	1	0	User pulls new set-point ready bit low
H	0	1 -> 0	0	Drive pulls set-point ack bit low, starts executing new set-point as soon as old one is finished
I	0	0	1	The set-point is finished, no set-points in buffer, so Target Reached bit is set

Multiple Set-Point Profile Position Move with Stopping Between Moves

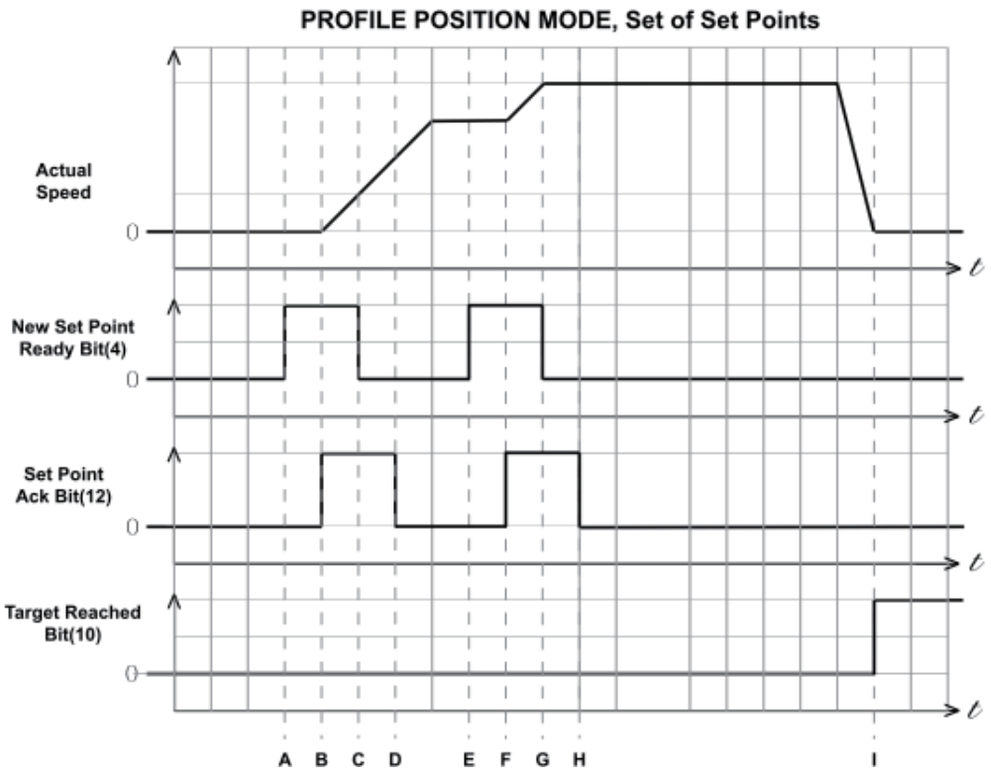


Multiple Set-Points, Continuous Motion

In this example, controlword bit 9 (Change of Set-point) is 1 and controlword bit 5 (Change Set Immediately) is 0. The motor continues at the speed of the first set-point until is reaches the distance of the first set-point, then changes to the new set-point speed. The motion is continuous.

Graph Point	New Set-Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set point ack bit low, indicating ready to receive another set-point
E	0 -> 1	0	0	User tells drive another set-point is ready
F	1	0 -> 1	0	Drive acknowledges set-point, buffers it, as another set-point is still in progress
G	1 -> 0	1	0	User pulls new set-point ready bit low
H	0	1 -> 0	0	Drive pulls set-point ack bit low, starts executing new set-point as soon as the old one is finished
I	0	0	1	The set-point is finished, no set-points in buffer, so Target Reached bit is set

Multiple Set-Point Profile Position Move with Continuous Motion



Multiple Set-Points, Immediate Change in Motion

In this example, controlword bit 9 (Change of Set-point) is 1 and controlword bit 5 (Change Set Immediately) is 1. The motor immediately changes to the new set-point speed without completing the first set-point. The motion is continuous.

Graph Point	New Set Point Ready Bit	Set-Point Acknowledge Bit	Target Reached Bit	What's Going On
Start	0	0	0	Drive waiting for set-point
A	0 -> 1	0	0	User tells drive a set-point is ready
B	1	0 -> 1	0	Drive acknowledges set-point, starts executing set-point
C	1 -> 0	1	0	User pulls new set-point ready bit low
D	0	1 -> 0	0	Drive pulls set point ack bit low, indicating ready to receive another set-point
E	0 -> 1	0	0	User tells drive another set-point is ready
F	1	0 -> 1	0	Drive acknowledges set-point, immediately executes it, beginning transition to new set-point speed and position
G	1 -> 0	1	0	User pulls new set-point ready bit low
H	0	1 -> 0	0	Drive pulls set-point ack bit low
I	0	0	1	The set-point is finished, no set-points in buffer, so Target Reached bit is set

Multi-Set-Point Profile Position Move with Immediate Change in Motion

Profile Velocity Mode

General Mode Description

Profile Velocity Mode is a relatively simple operating mode. Once the velocity, acceleration, and deceleration are set, the drive will either command the motor to accelerate to the running velocity according to the acceleration parameter, or to halt movement according to the deceleration parameter. The figure below shows an example of Profile Velocity Mode. The top graph shows the actual speed of the motor, the middle graph the target speed value, and the bottom graph the halt bit in the controlword.

The table below explains how the halt bit and target velocity may be used together to affect motor speed. Between points B and C, the motor does not come to a complete stop, but decelerates according to the profile deceleration value starting at point B. When the halt bit transitions at point C, it accelerates immediately back to the target speed. At Point E, reducing the target speed to zero has the same effect as enabling the halt bit, since the drive is commanding the motor to move at zero speed.

It should be noted that both enabling the halt bit and setting the target velocity to zero keep torque applied to the motor. In order to allow the shaft to move freely, the drive’s state must be put in the Drive Disabled state.

Enable Profile Velocity Mode

To enable the Profile Velocity Mode, the value 0003h must be written to the mode of operation OD entry, located at dictionary address 6060h.The mode of operation can be verified using OD 6061h - mode of operation display - which is updated when the current operation mode is accepted.

Set Running Parameters

Set the velocity, acceleration, and deceleration using OD entries 60FFh, 6083h, and 6084h respectively.

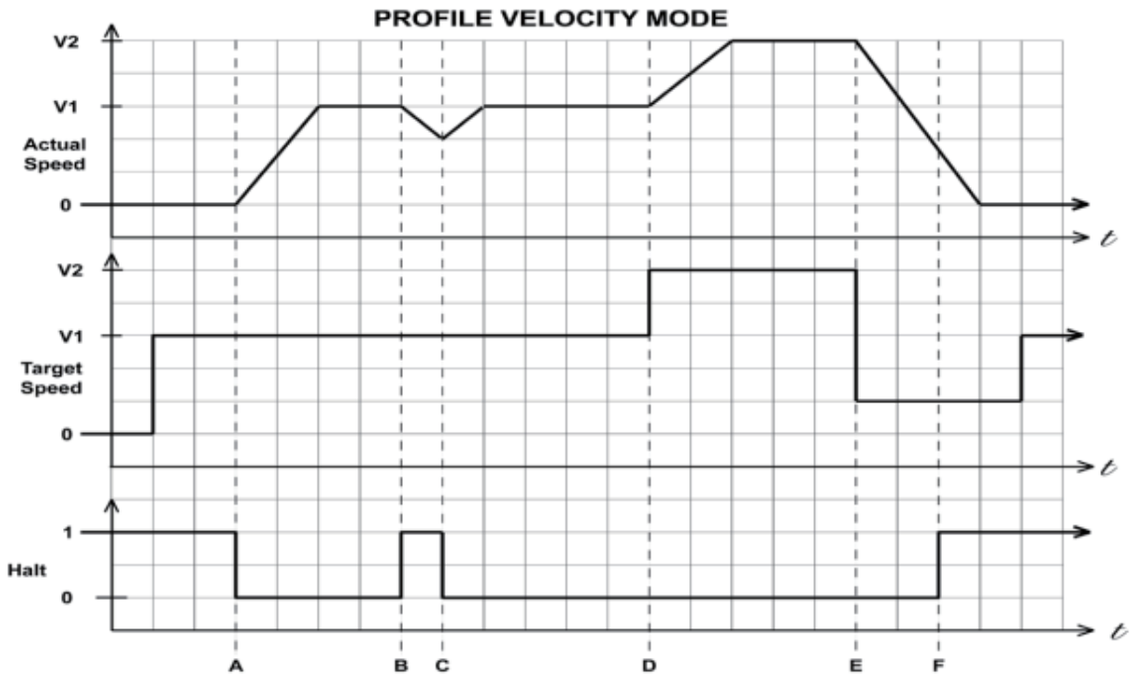
Enable Drive Operation

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006h is not written to the control wordfirst, the drive operation can not be enabled.

To enable drive operation, the value 010Fh must be written to the controlword OD entry, located at dictionary address 6040h. This puts the drive into Operation Enabled state, with the motion halted.

Starting/Stopping Motion

To start and stop motion, toggle the controlword halt bit (bit 8). When the halt bit is set to 0, motion will start or continue; when the halt bit is set to 1, motion will stop. The bit can be toggled by writing 010Fh and 000Fh to controlword OD entry 6040h.



Profile Velocity Mode

Graph Point	Target Speed	Halt Bit	Drive command to Motor
Start	0	1	Motor stopped
A	V1	1 -> 0	Motor accelerates to speed V1
B	V1	0 -> 1	Motor decelerates to stopped
C	V1	1 -> 0	Motor accelerates to V1
D	V1 -> V2	0	Motor accelerates from V1 to V2
E	V2 -> 0	0	Motor decelerates from V2 to 0
F	0	0 -> 1	Motor remains stopped
G	0 -> V1	1	Motor remains stopped

Profile Velocity Mode Example

Torque Profile Mode

General Mode Description

Torque Profile mode is a servo-control torque operating mode. It requires knowledge of the Torque Constant of the motor in N·m/A. This information can be found in the servo motor print.

For Step-Servo products like SSDC EtherCAT, the motor is step motor which does not have a fixed torqueconstant. It is not recommended that Step-Servo products are used in Torque Profile mode.

Enable Torque Profile Mode

To enable Torque Profile Mode, the value 0004h must be written to the mode of operation OD entry, located at dictionary address 6060h. The mode of operation can be verified using OD 6061h - mode of operation display - which is updated when the current operation mode is accepted.

Set Running Parameters

To operate in Torque Profile mode, the following parameters must be set:

Parameter Name	Object Dictionary Entry	Length (in bytes)	Units	Description
Torque Constant	2005_h	2	$\frac{m \cdot Nm}{a}$	Motor paramter, found on the motor print
Target Torque	6071_h	2	m • Nm	Torque to be applied to the motor
Torque Slope	6087_h	4	$\frac{m \cdot Nm}{sec}$	Rate at which to ramp torque to new target

Enable Drive Operation

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, the value 000Fh must be written to the controlword OD entry, located at dictionary address 6040h. This puts the drive into the Operation Enabled state with no torque applied. It should be noted that both enabling the halt bit and setting the target torque to zero will ramp down the torque applied to the motor according to the torque slope. At the end of the slope no torque will be applied to the motor, allowing the shaft to move freely.

Starting/Stopping Torque

To start and stop motion, toggle the controlword halt bit (bit 8). When the halt bit is set to 0, motion will start or continue; when the halt bit is set to 1, motion will stop. The bit can be toggled by writing 010Fh and 000Fh to controlword OD entry 6040h.

Parameter Calculations – Example

An application requires a torque of 50 oz-in. and a torque slope of 25 oz-in/sec. The motor print lists the Torque Constant of the motor as 0.07N·m/A. The N·m/A constant given must first be converted into mN·m/A, as required by the Torque Constant OD entry. The formula used for this is:

$$0.07\ \frac{Nm}{A} \cdot 1000\ \frac{mA}{A} = 70\ \frac{m \cdot Nm}{A}$$

As the drive works primarily in N·m, the desired 50 oz-in of torque must also be converted into N·m, using the conversion factor 141.6 oz-in/N·m.

$$141.6\ \frac{\frac{50\ oz\text{-}in}{oz\text{-}in}}{Nm} = 0.3531\ Nm$$

Now, the resultant torque of 0.3531N·m must be converted into mN·m, as required by the Target Torque OD entry.

$$0.3531\ Nm \cdot 1000\ \frac{m \cdot Nm}{Nm} = 353.1\ m \cdot Nm$$

The result is a value of 353 mN·m, rounded to the nearest whole number, for the Target Torque OD Entry.

Finally, the desired slope must be converted from the given units of oz-in/sec into the required units of mN·m/sec.

$$\left(25\ \frac{oz\text{-}in}{sec}\right) * \left(\frac{1\ Nm}{141.6\ oz\text{-}in}\right) * \left(\frac{1000\ m \cdot Nm}{1\ Nm}\right) = 176.55\ \frac{m \cdot Nm}{sec}$$

Rounding to the nearest whole number results in a Torque Slope of 177 mN·m/sec.

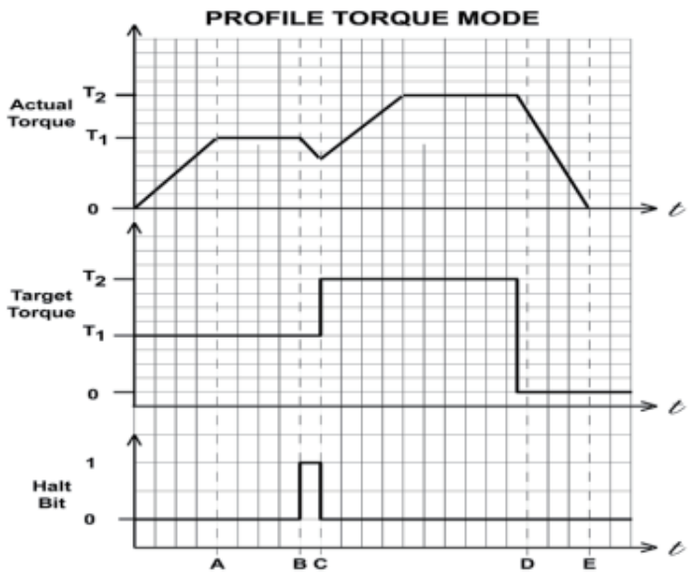
Current Verification – Example

It is important to check that the current required of the drive is within the limits of the servo amplifier. The drive being used, for example, has a continuous rating of 7 amps, and a peak current of 14 amps, which may be held continuously for 2 seconds. This means that a current of 7 amps can be held indefinitely, and currents between 7 and 14 amps may be used in short bursts.

Using the target torque and torque constant from the example above the current draw can be checked, as shown:

$$\frac{0.3531\ Nm}{0.07\ \frac{Nm}{A}} = 5.0443\ A$$

The resultant current, 5.0443A, is below the 7A continuous current rating of the drive, and well below the peak current rating of 14A. It is possible for the drive to maintain a current of 7A indefinitely, and peak up to 14A for up to two seconds continuously. Values between 7A and 14A may be held proportionally long.



Torque Profile Mode

Graph Point	Target Torque	Halt Bit	Drive command to Motor
Start	T1	0	Ramp torque to T1
A	T1	0	Maintain torque at T1
B	T1	0 -> 1	Ramp torque to zero
C	T1 -> T2	1 -> 0	Ramp torque to T2
D	T2 -> 0	0	Ramp torque to zero
E	0	0	Maintain torque at zero

Torque Profile Mode Example

Cyclic Synchronous Position mode

General Mode Description

In this mode the master controller generates a trajectory and sends target position (0x607A) to the drive at every PDO update cycle. The primary feedback from the drive is the actual motor position and optionally, actual motor velocity and torque. Position, velocity, and torque control loops are all closed in the drive which acts as a follower for the position commands.

Enable Cyclic Synchronous Position Mode

To enable the Cyclic Synchronous Position mode, the value 0008h must be written to the mode of operation OD entry, located at dictionary address 6060h. The mode of operation can be verified using OD 6061h - mode of operation display - which is updated when the current operation mode is accepted.

Enable Drive Operation

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, the value 000Fh must be written to the controlword OD entry, located at dictionary address 6040h. This puts the drive into Operation Enabled state.

Cyclic Synchronous Velocity mode

General Mode Description

In this mode the master controller sends target velocity (0x60FF) to the drive at every PDO update cycle. The primary feedback from the drive is the actual motor position and optionally, actual motor velocity and torque. Velocity and torque control loops are closed in the drive. If necessary, position loop is closed in the master controller.

Enable Cyclic Synchronous Velocity Mode

To enable the Cyclic Synchronous Velocity mode, the value 0009h must be written to the mode of operation OD entry, located at dictionary address 6060h. The mode of operation can be verified using OD 6061h - mode of operation display - which is updated when the current operation mode is accepted.

Enable Drive Operation

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, the value 010Fh must be written to the controlword OD entry, located at dictionary address 6040h. This puts the drive into Operation Enabled state, with the motion halted.

Homing Mode

Set Running Parameters

Set the homing and index velocities, acceleration/deceleration, offset and home sensor (if required) using OD entries 6099h, 609Ah, 607Ch, and 2001h respectively.

Note: It is important that the limit switch settings have been defined in configuration software prior to using the CANopen Homing Mode.

Enable Homing Mode

To enable Homing Mode, the value 0006h must be written to the mode of operation OD entry, located at dictionary address 6060h. The mode of operation can be verified using OD 6061h - mode of operation display - which is updated when the current operation mode is accepted.

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into “ready to switch on” state and is ready to enable drive operation. If the value 0006h is not written to the control word first, the drive operation can not be enabled.

To put the drive into Operation Enabled Mode, write 000Fh to the controlword OD entry, located at dictionary address 6040h.

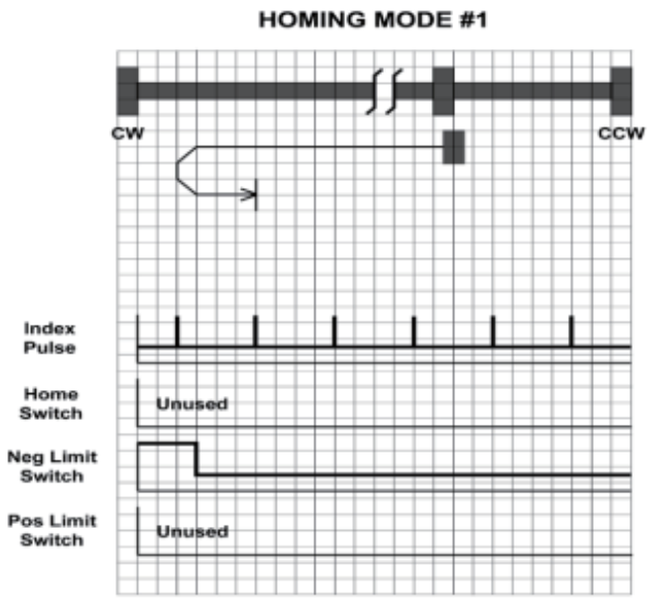
Starting the Homing Procedure

Set the Homing Method required using OD entry 6098h. To start the homing procedure, bit 4 of the controlword OD entry located at dictionary address 6040h, must transition from 0 to 1. The status of the homing procedure can be monitored using the statusword OD entry 6041h.

Homing Method Diagrams

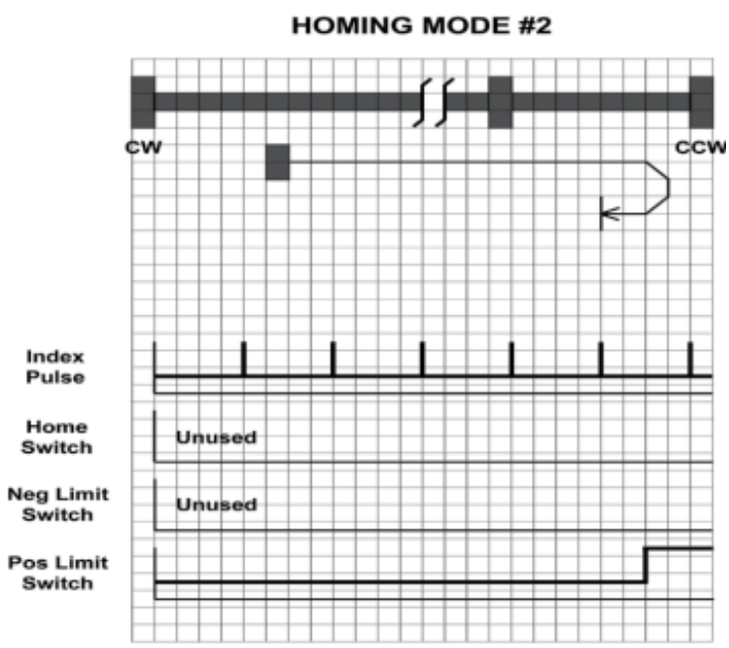
Homing Method 1

Homes to the first index CCW after the CW limit switch is reached.



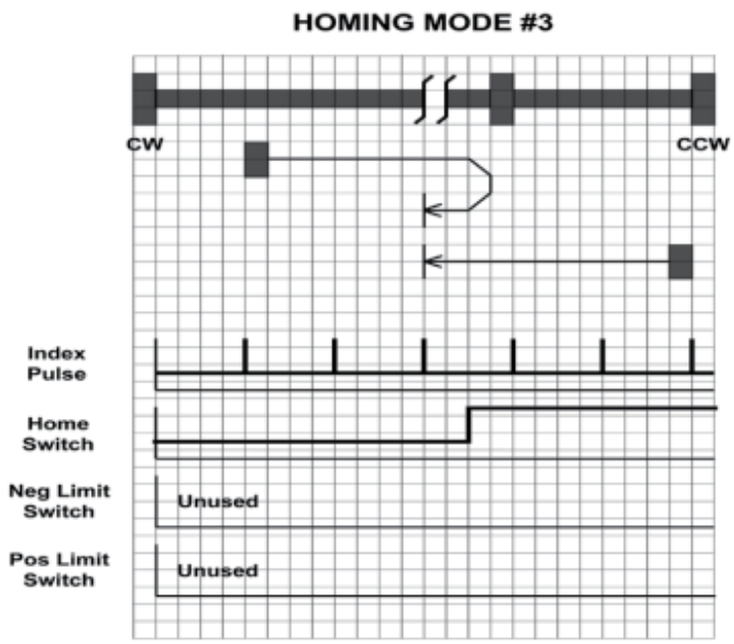
Homing Method 2

Homes to the first index CW after the CCW limit switch is reached.



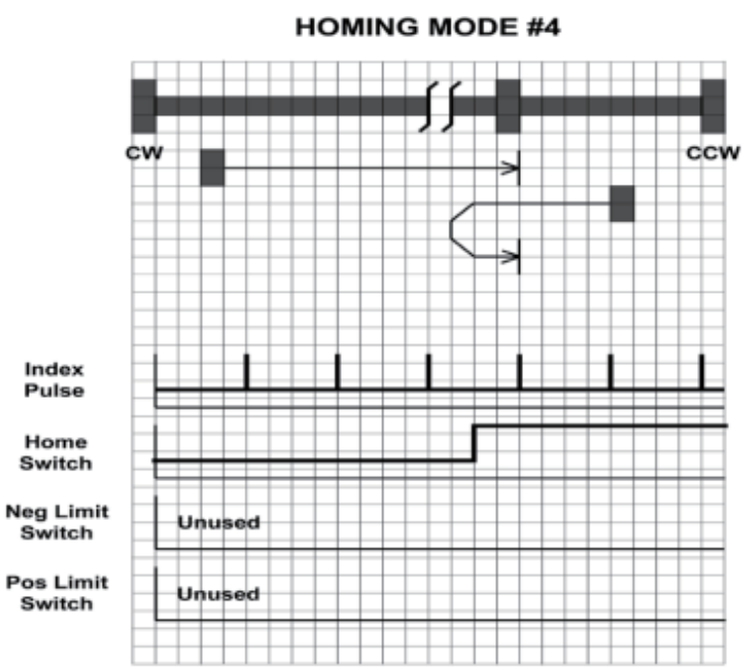
Homing Method 3

Homes to the first index CW after the positive home switch changes state; the initial direction of motion is dependent on the state of the home switch.



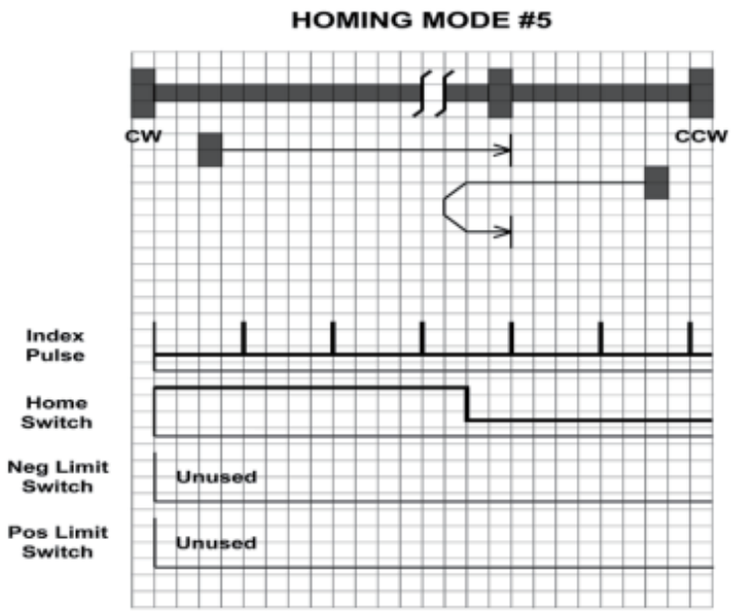
Homing Method 4

Homes to the first index CCW after the positive home switch changes state; the initial direction of motion is dependent on the state of the home switch.



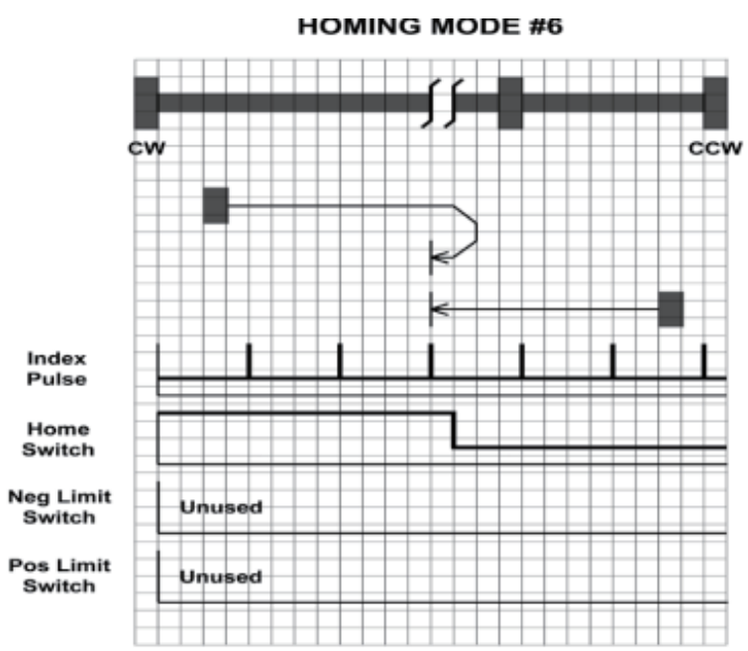
Homing Method 5

Homes to the first index CCW after the negative home switch changes state; the initial direction of motion is dependent on the state of the home switch.



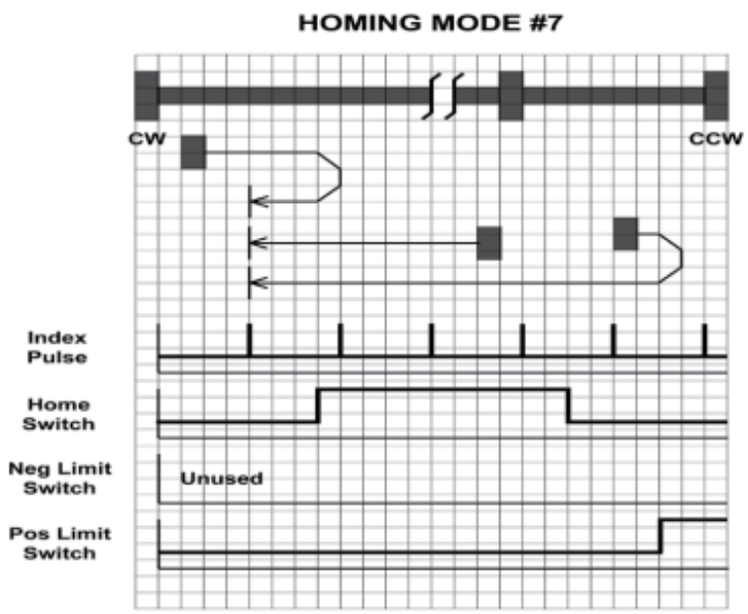
Homing Method 6

Homes to the first index CW after the negative home switch changes state; the initial direction of motion is dependent on the state of the home switch.



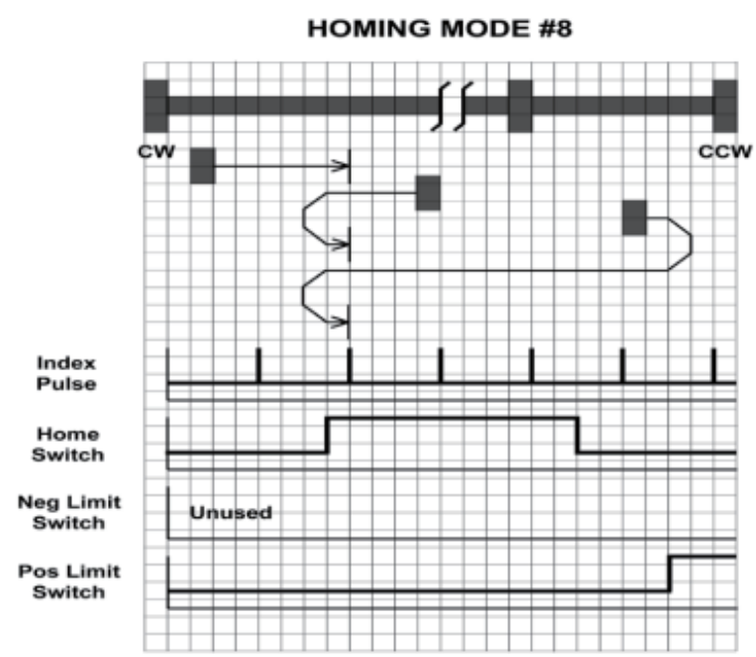
Homing Method 7

Starts moving CCW (or CW if the home switch is active), and homes to the first index CW of the home switch transition.



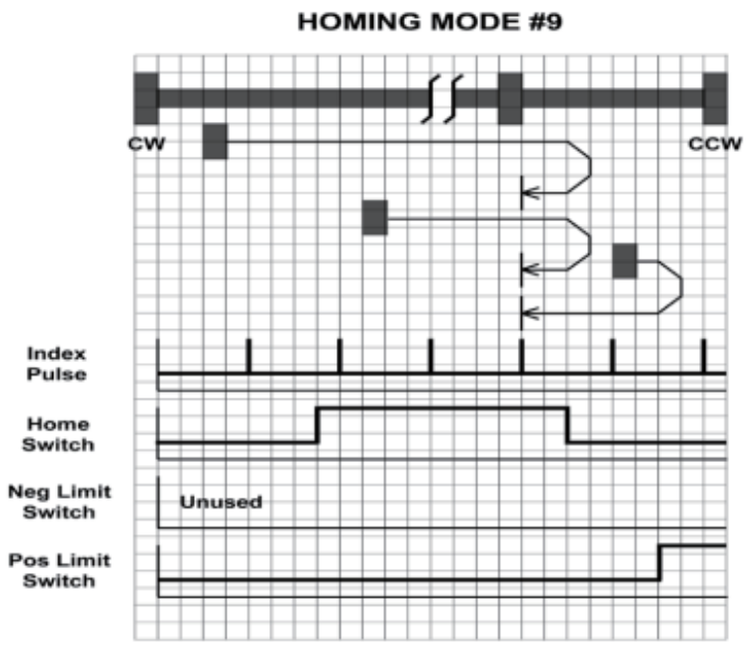
Homing Method 8

Starts moving CCW (or CW if the home switch is active), and homes to the first index CCW of the home switch transition.



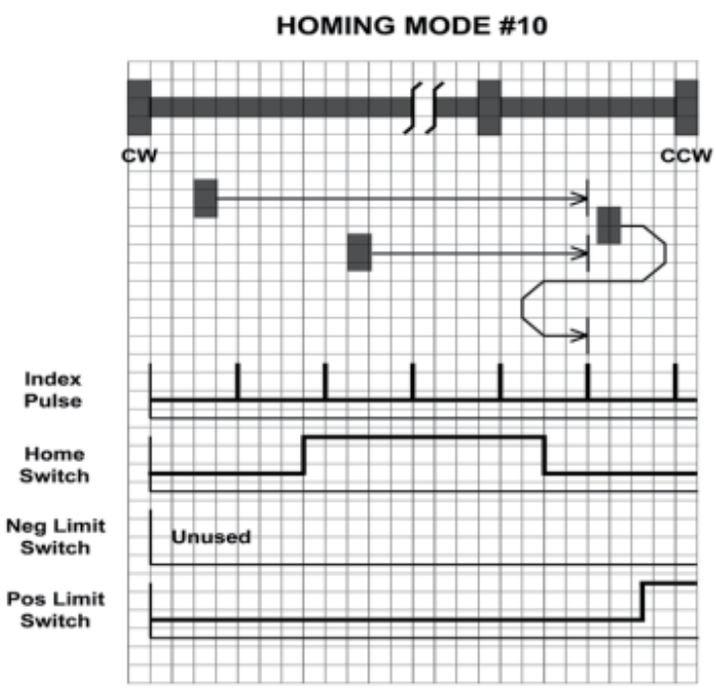
Homing Method 9

Starts moving CCW and homes to the first index CW of the home switch transition.



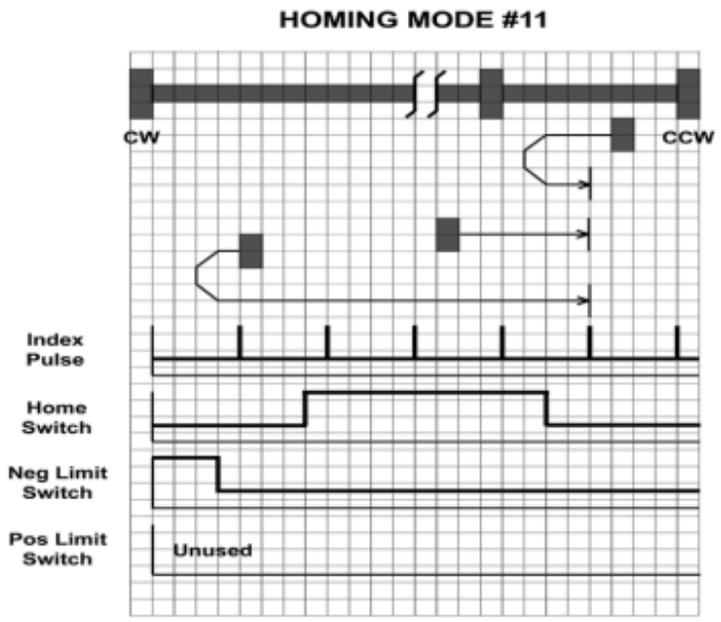
Homing Method 10

Starts moving CCW and homes to the first index CCW of the home switch transition.



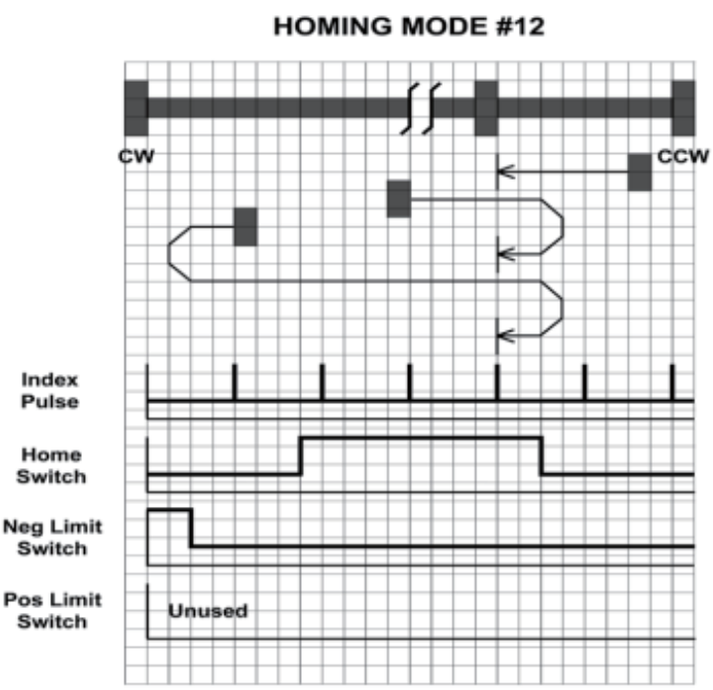
Homing Method 11

Starts moving CW (or CCW if the home switch is active), and homes to the first index CCW of the home switch transition.



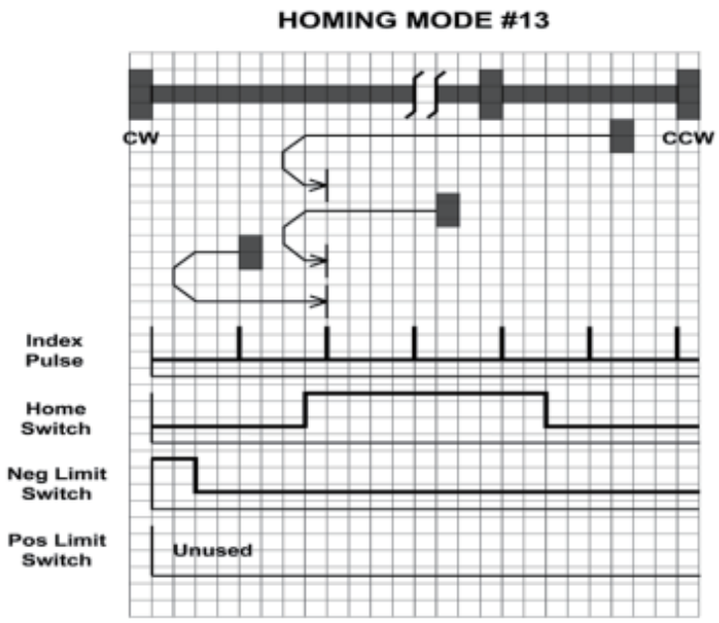
Homing Method 12

Starts moving CW (or CCW if the home switch is active), and homes to the first index CW of the home switch transition.



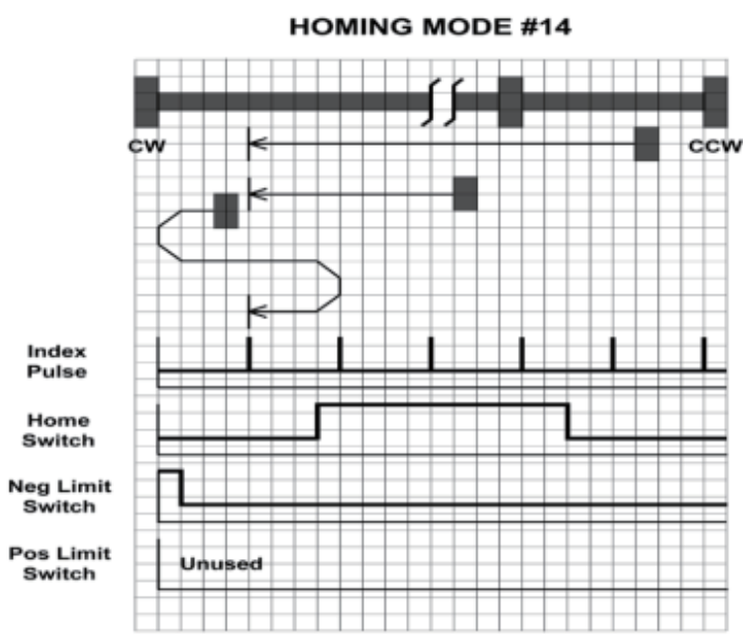
Homing Method 13

Starts moving CW and homes to the first index CCW of the home switch transition.



Homing Method 14

Starts moving CW and homes to the first index CW of the home switch transition shown above.

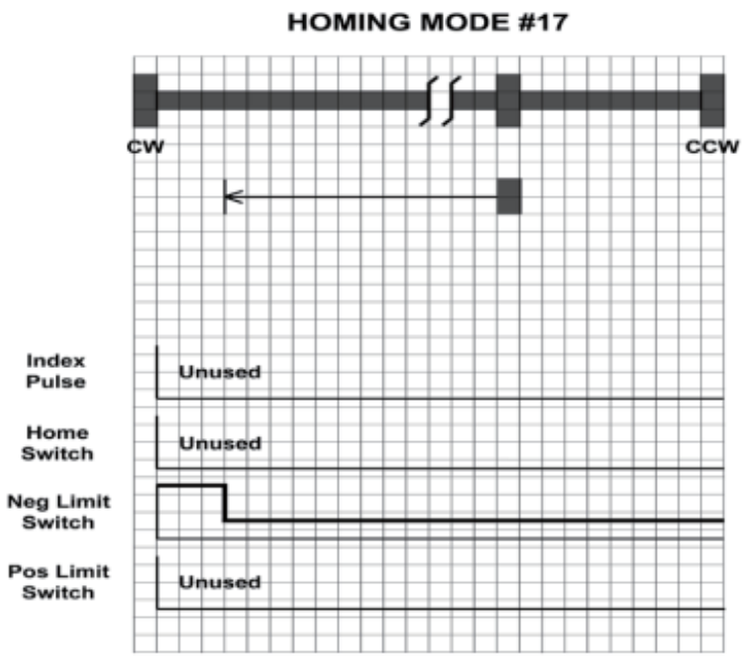


Homing Methods 15 and 16

Homing Methods 15 and 16 are reserved for future expansion.

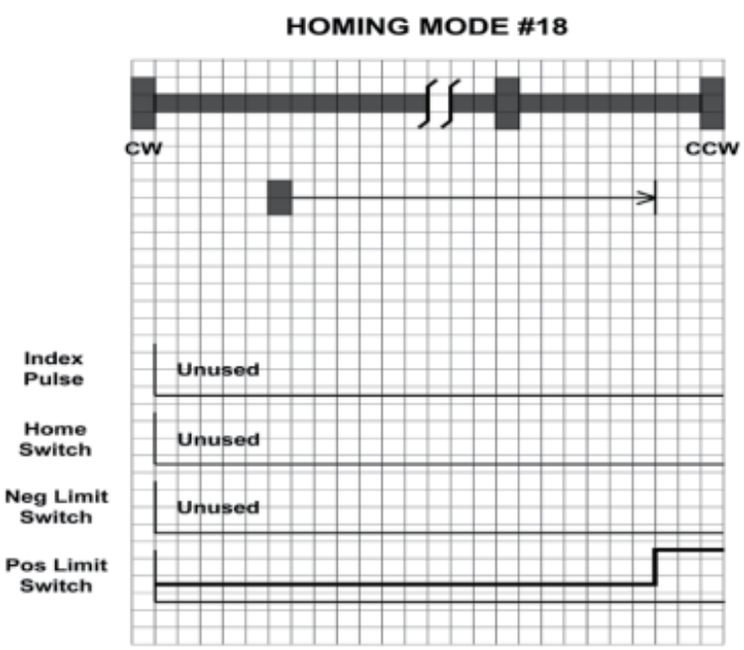
Homing Method 17

Homes to the CW limit switch.



Homing Method 18

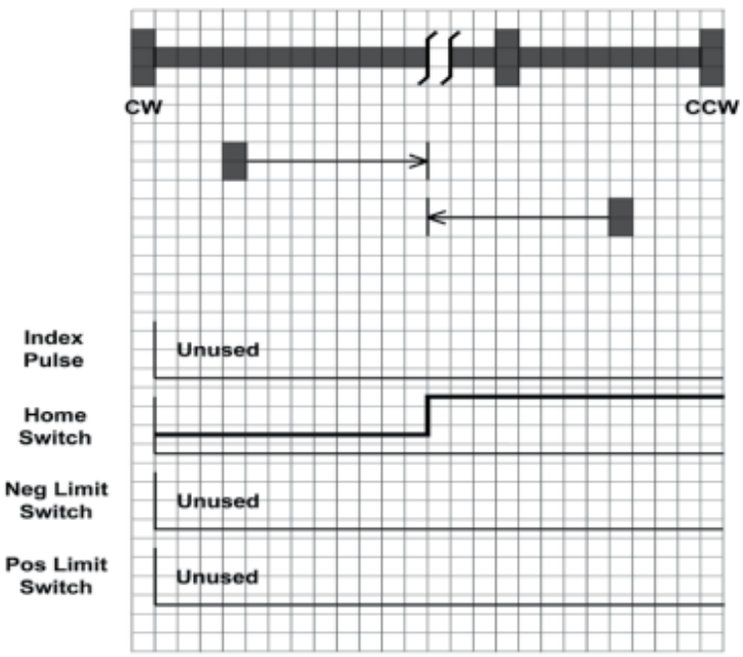
Homes to the CCW limit switch.



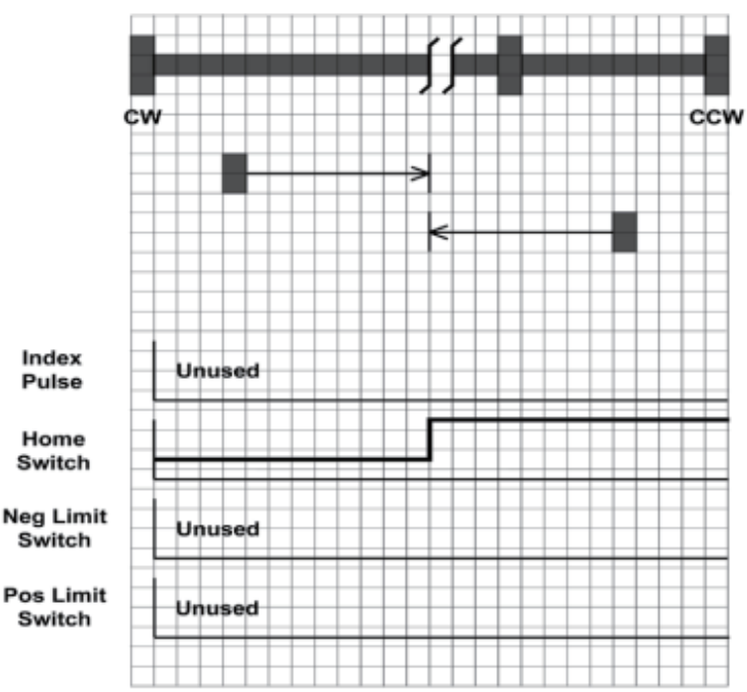
Homing Methods 19 and 20

Home to the home switch transition.

HOMING MODE #19

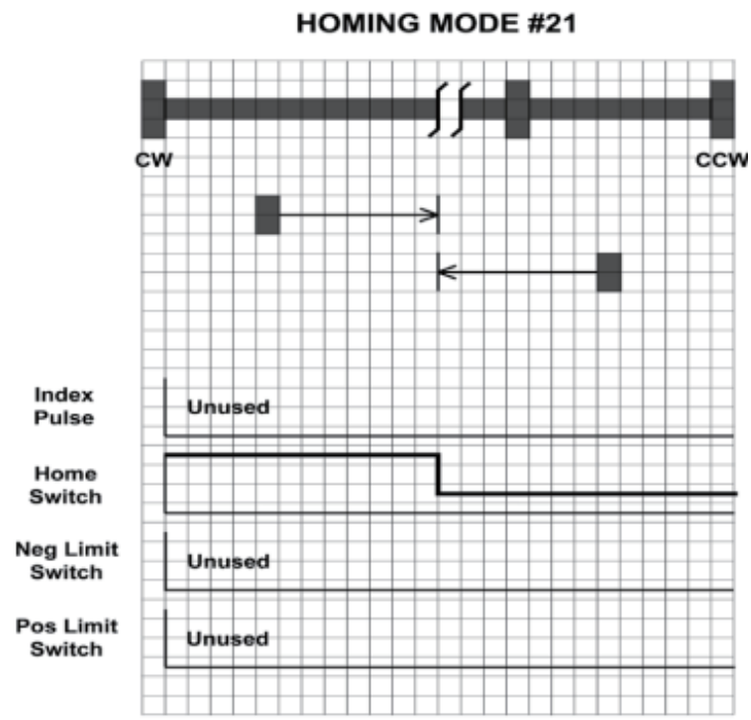


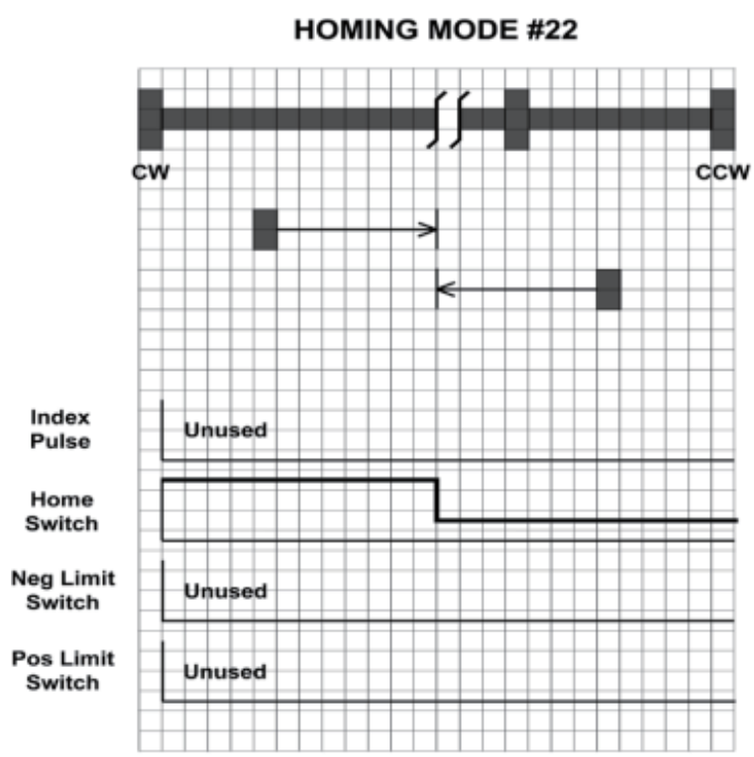
HOMING MODE #20



Homing Methods 21 and 22

Home to the home switch transition.

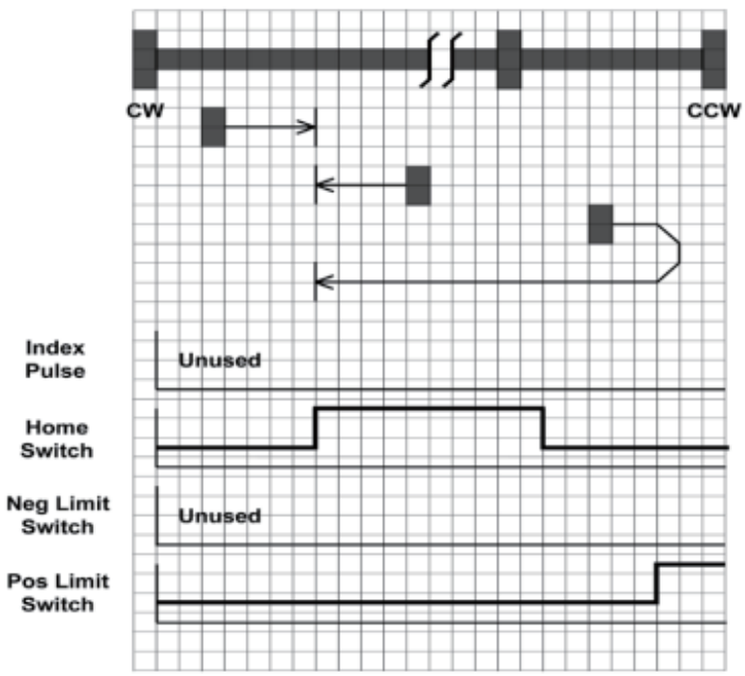




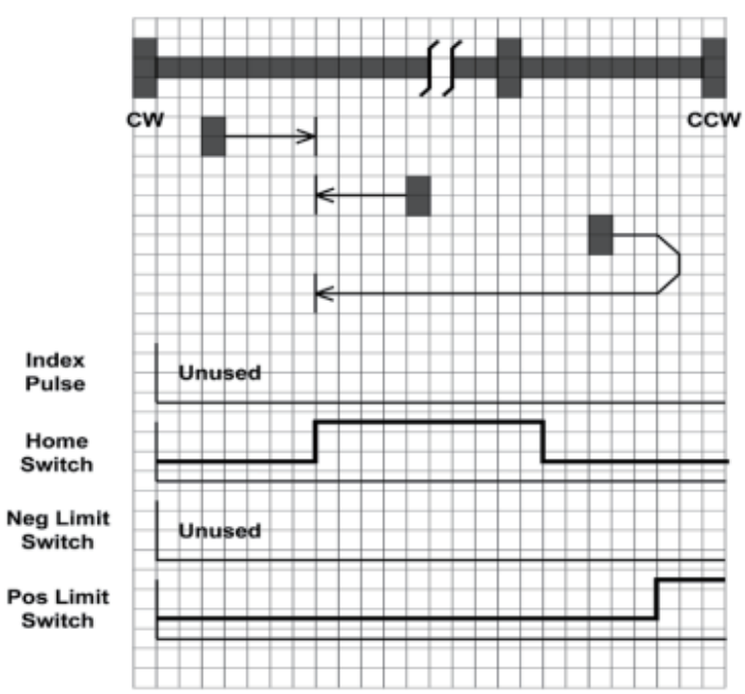
Homing Methods 23 and 24

Home to the home switch transition shown below, and “bounce off” the CCW limit, if required.

HOMING MODE #23



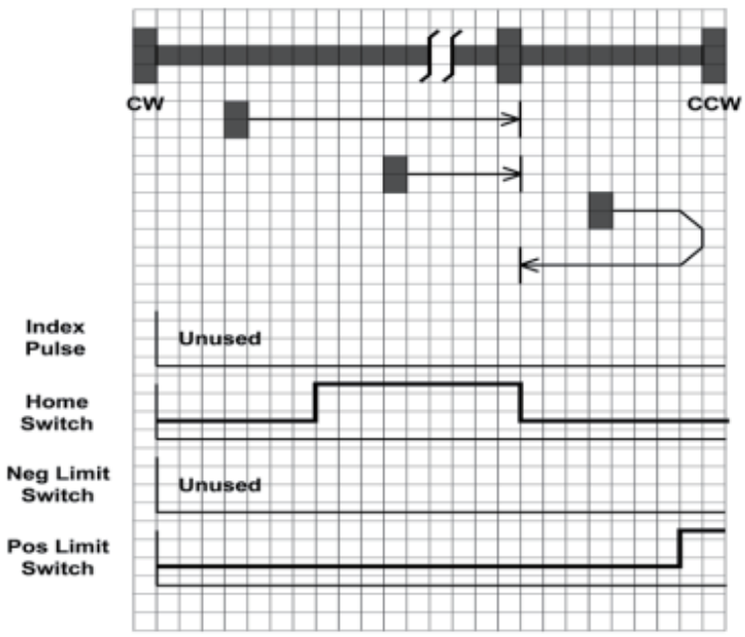
HOMING MODE #24



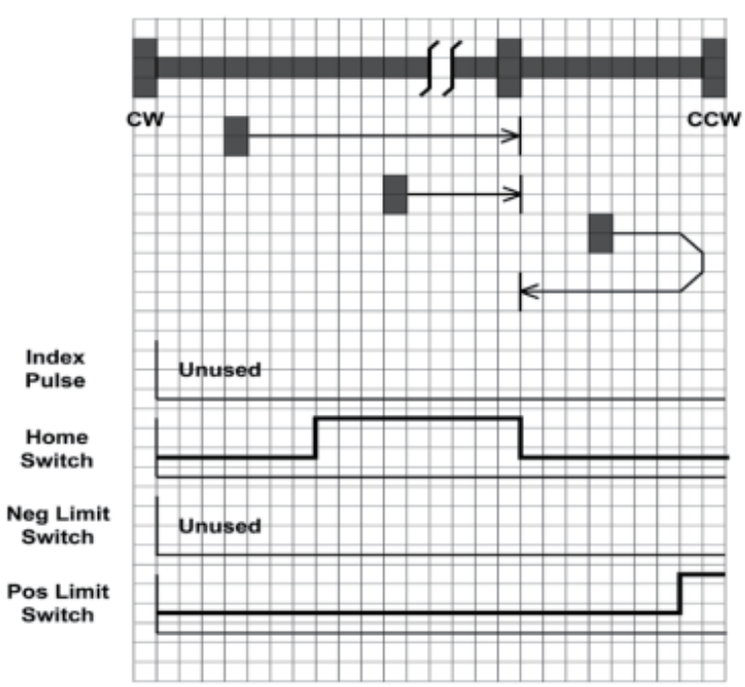
Homing Methods 25 and 26

Home to the home switch transition shown below, and “bounce off” the CCW limit, if required.

HOMING MODE #25



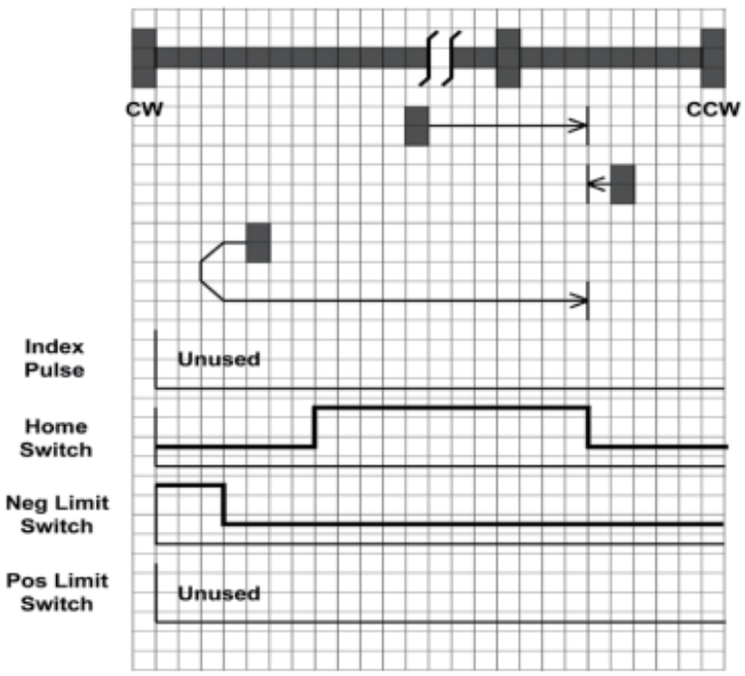
HOMING MODE #26



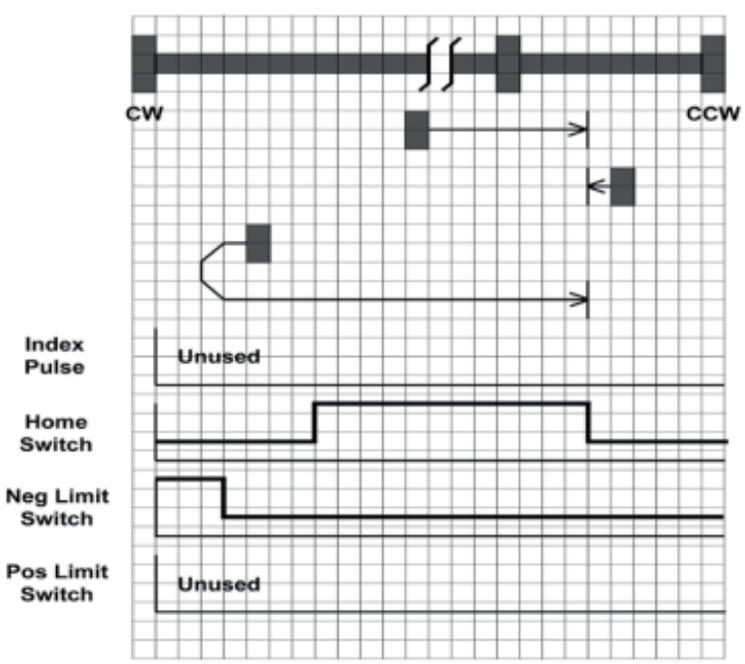
Homing Methods 27 and 28

Home to the home switch transition shown below, and “bounce off” the CW limit, if required.

HOMING MODE #27



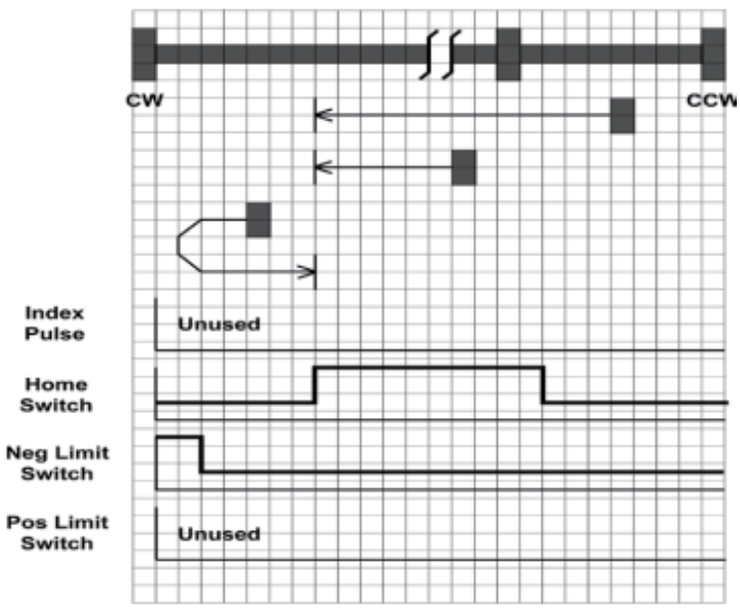
HOMING MODE #28



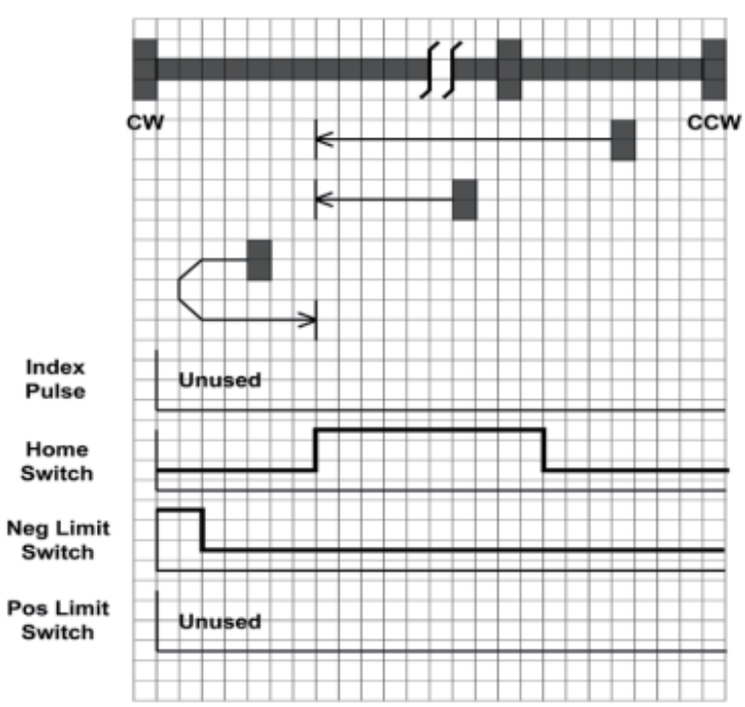
Homing Methods 29 and 30

Home to the home switch transition shown below, and “bounce off” the CW limit, if required.

HOMING MODE #29



HOMING MODE #30

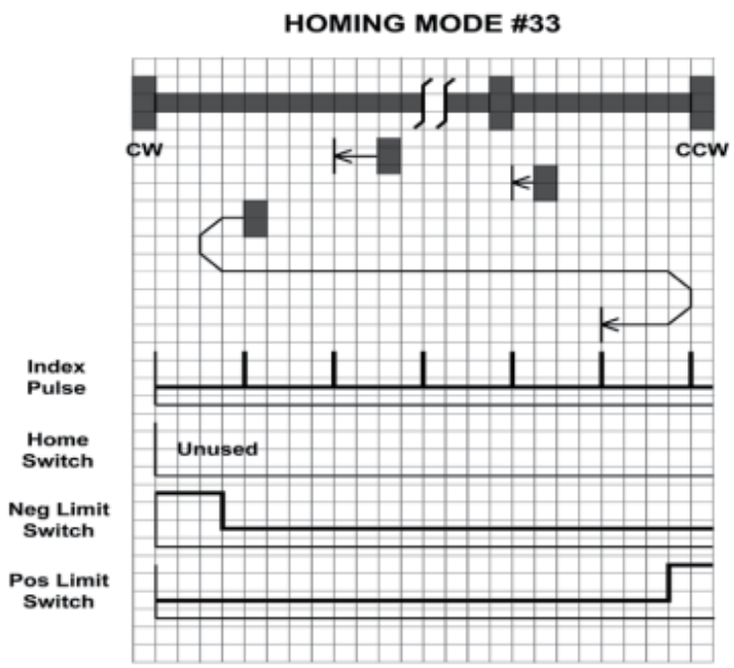


Homing Methods 31 and 32

Homing Methods 31 and 32 are reserved for future expansion.

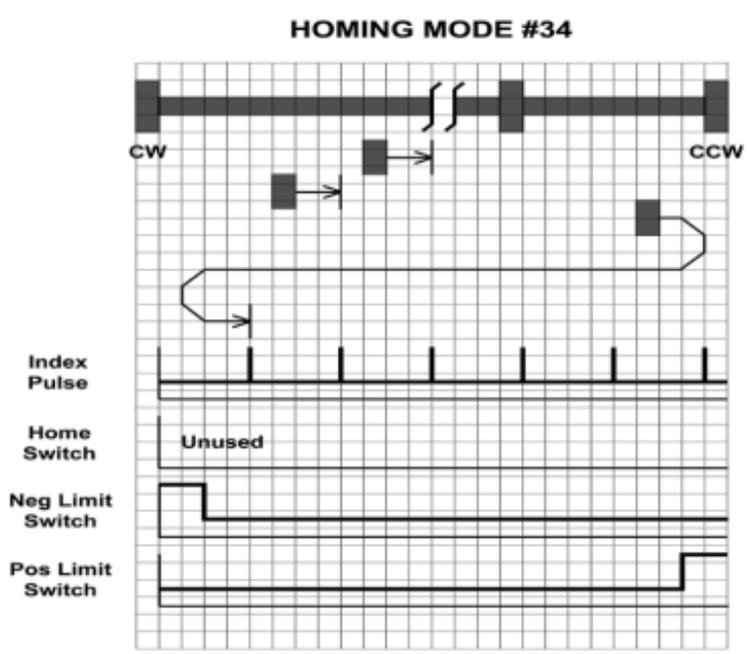
Homing Method 33

Homes to the next index pulse CW from the current position. If the CW limit is hit, the drive resets to the CCW limit, and continues searching for a limit in the CW direction.



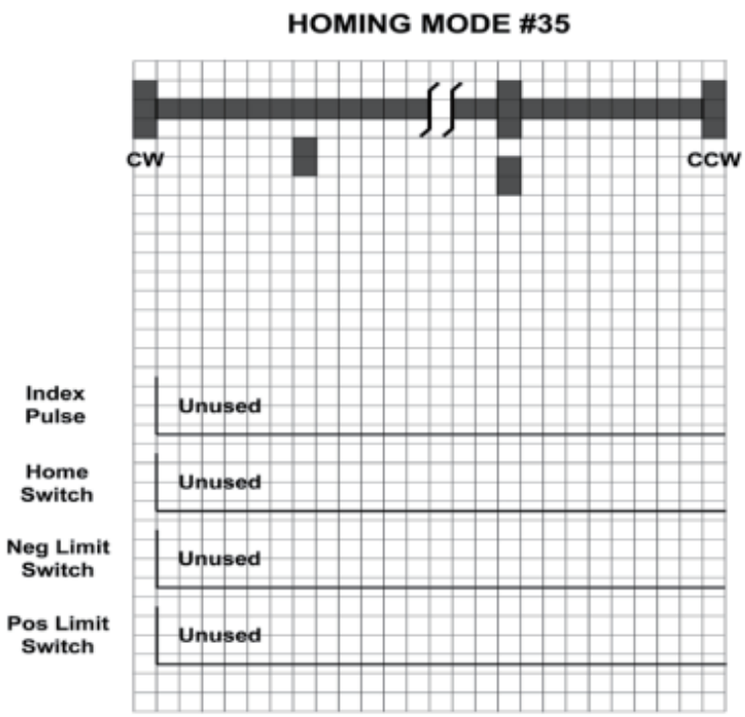
Homing Method 34

Homes to the next index pulse CCW from the current position. If the CCW limit is hit, the drive resets to the CW limit, and continues searching for a limit in the CCW direction.



Homing Method 35

Takes the current position to be the home position; the Home Offset value is ignored, and the motor does not move at all.



Q Program Mode

General Mode Description

In order to expand the functionality of MOONS' EtherCAT drives, the Q programming language may be used to execute complex motion profiles that may not be possible within the scope of CiA 402. The Q program must be written and pre-loaded into the EtherCAT drive using Q programmer integrated in the configuration software.

Q Program Execution

To execute a stored Q program on a single drive, a value of -1 (FFh) must be written to the mode of operation OD entry, located at dictionary address 6060h. The mode of operation can be verified using OD entry 6061h - mode of operation display - which is updated when the current operation mode is accepted.

Next, the desired Q segment number, 1-12, must be written to the Q Segment Number register, located at address 2007h.

After power up or node reset, the drive is in disabled state. The value 0006h must be written to the control word OD entry, located at dictionary address 6040h. This will put the drive into "ready to switch on" state and is ready to enable drive operation. If the value 0006h is not written to the control word first, the drive operation can not be enabled.

To enable drive operation, a value of 000Fh must be written to the controlword OD entry, located at dictionary address 6040h. This puts the drive into Operation Enabled state and ready to run the Q program.

To run the selected Q program, a value of 001Fh must be written to the controlword. The Q program will then run to completion. The Q program may be re-executed by a 0->1 transition of the Q Program start bit (bit 4) in the controlword.

To halt execution of a Q program, the halt bit (bit 8) of the controlword must be set to 1. The Q program will halt immediately and start from the beginning the next time a 0->1 transition is seen on the Q Program start bit after the halt bit has been cleared.

Touch Probe

Touch Probe is a latching function to capture the position value of the encoder by sensing the edge-triggered digital input of the drive. SS EtherCAT drive have two digital inputs for touch probe function. Input X7 is used as the touch probe 1 input. Input X8 is used as the touch probe 2 input.

Related Objects:

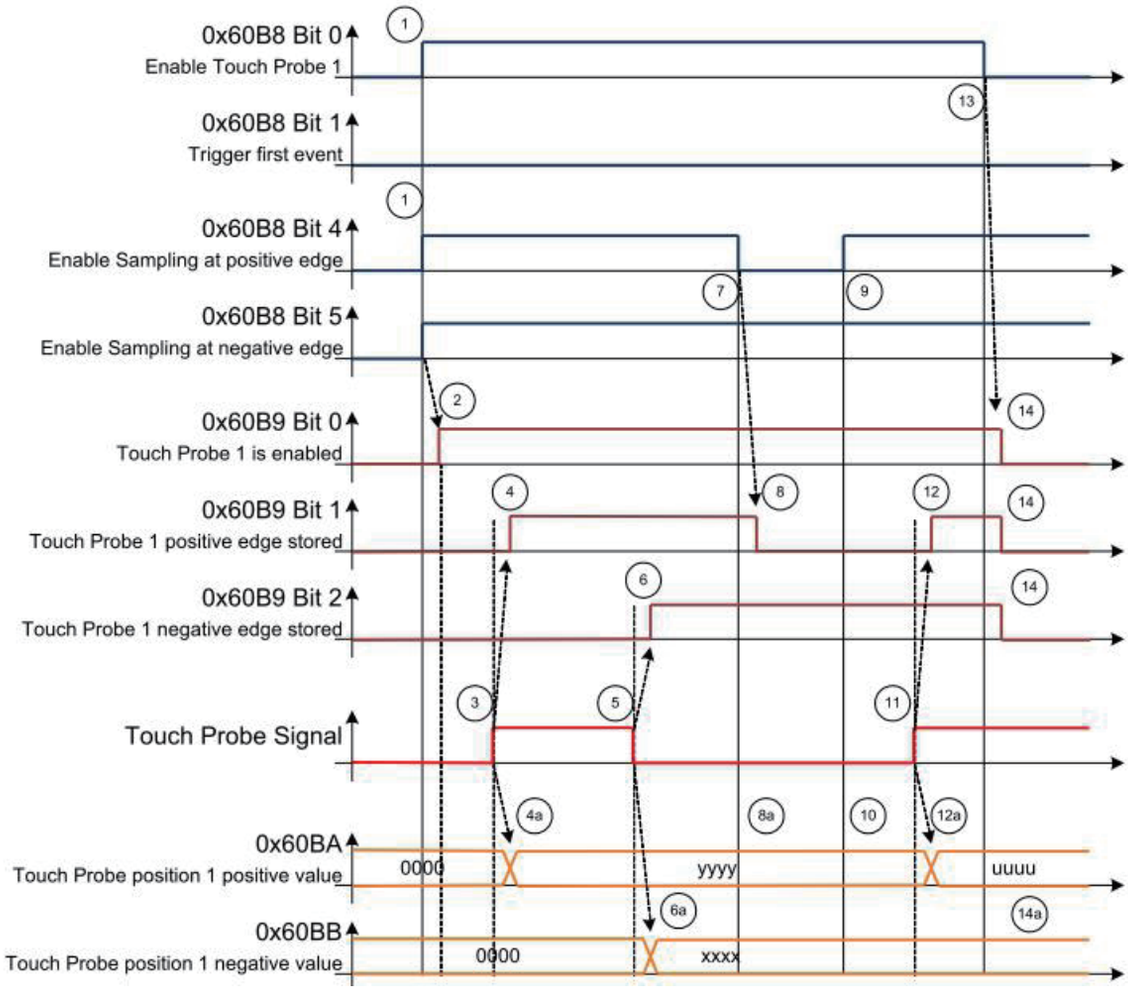
Index	Object
0x60B8	Touch Probe Function
0x60B9	Touch Probe Status
0x60BA	Touch Probe Position 1 Positive Value
0x60BB	Touch Probe Position 1 Negative Value
0x60BC	Touch Probe Position 2 Positive Value
0x60BD	Touch Probe Position 2 Negative Value

Positive value is captured at “rising edge” of digital input. Negative value is captured at “falling edge”of digital input.

When working with inputs and outputs it is important to remember the designations low and high. If current is flowing into or out of an input or output the logic state for that input/output is defined as low or closed. If no current is flowing, or the input/output is not connected, the logic state is high or open.

Rising edge means the status from low to high. Falling edge means the status from high to low.

For more details of each object, please refer to “Object Dictionary” section of this manual.



Timing diagram for Touch Probe example

Number	Touch probe behavior	
(1)	$60B8_h$, Bit 0 = 1 $60B8_h$ Bit 1, 4, 5	Enable Touch Probe 1, Configure and Enable Touch Probe 1 positive and negative edge
(2)	→ $60B9_h$ Bit 0 = 1	Status "Touch Probe 1 enabled" is set
(3)	External touch probe signal has positive edge	
(4)	→ $60B9_h$ Bit 1 = 1	Status "Touch Probe 1 positive edge stored" is set
(4a)	→ $60BA_h$	Touch probe position 1 positive value is stored
(5)	External touch probe signal has negative edge	
(6)	→ $60B9_h$ Bit 2 = 1	Status "Touch Probe 1 negative edge stored" is set
(6a)	→ $60BB_h$	Touch probe position 1 negative value is stored
(7)	$60B8_h$:4	Sample positive edge is disabled
(8)	→ $60B9_h$ Bit 0 = 0	Status "Touch Probe 1 positive edge stored" is reset
(8a)	→ $60BA_h$	Touch probe position 1 positive value is not changed
(9)	$60B8_h$ Bit 4 = 1	Sample positive edge is enabled
(10)	→ $60BA_h$	Touch probe position 1 positive value is not changed
(11)	External touch probe signal has positive edge	
(12)	→ $60B9_h$ Bit 1 = 1	Status "Touch Probe 1 positive edge stored" is set
(12a)	→ $60BA_h$	Touch probe position 1 positive value is stored
(13)	$60B8_h$ Bit 0 = 0	Touch Probe 1 is disabled
(14)	→ $60B9_h$ Bit 0, 1, 2 = 0	Status Bits are reset
(14a)	→ $60BA_h$, $60BB_h$	Touch probe position 1 positive/negative value are not changed

Touch Probe Timing example

Object Dictionary

The most important part of a device profile is the Object Dictionary description. The Object Dictionary is essentially a grouping of objects accessible via the network in an ordered predefined fashion. Each object within the dictionary is addressed using a 16-bit index.

Object can be mainly divided into general object (from 0x1000) for EtherCAT communication, CiA402 device profile object (from 0x6000) for CANopen over EtherCAT (CoE), and manufacturer specific object (from 0x2000) exclusively provided by this drive.

General Objects

0x1000 Device Type

This object describes the type of device and its functionality. It is composed of a 16-bit field which describes the device profile that is used and a second 16-bit field which gives additional information about optional functionality of the device.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	no	0x00020192

Bit 0~15: Device profile number 0x0192: CiA402

Bit 16~31: Additional information 0x0002: Servo Drive

0x1008 Device Name

This object provides the name of the device as given by the manufacturer.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	Visible string	ro	no	EtherCAT Drive

0x1009 Hardware Version

This object provides the manufacturer hardware version description.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	Visible string	ro	no	A2

0x100A Software Version

This object provides the manufacturer software version description.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	Visible string	ro	no	110D

0x1010 Store Parameters

This object supports the saving of parameters in non-volatile memory.

Index	Sub Index	Name	PDO Mapping	Default Value
1010	00	max sub-index	no	1
	01	Store Parameters	no	0

You need to write ‘65766173h’ into sub index 01 to save parameters in non-volatile memory. ‘65766173h’ is the ASCII code for “save”.

	MSB			LSB
ASCII	e	v	a	s
Hex	65h	76h	61h	73h

0x1011 Restore Default Parameters

This object supports the restoring of parameters in non-volatile memory.

Index	Sub Index	Name	PDO Mapping	Default Value
1010	00	max sub-index	no	1
	01	Restore Default Parameters	no	0

You need to write ‘64616F6Ch’ into sub index 01 to restore parameters in non-volatile memory. ‘64616F6Ch’ is the ASCII code for “load”.

	MSB			LSB
ASCII	d	a	o	l
Hex	64h	61h	6Fh	6Ch

The parameters whitch can be stored and restored are:

1600	1st Receive PDO Mapping	2001	Home Switch
1601	2nd Receive PDO Mapping	2007	Q Segment Number
1602	3rd Receive PDO Mapping	2010	Position Loop Proportional Gain
1603	4th Receive PDO Mapping	2011	Position Loop Differential Gain
1A00	1st Transmit PDO Mapping	2012	Position Loop Differential Filter
1A01	2nd Transmit PDO Mapping	2013	Velocity Loop Proportional Gain
1A02	3rd Transmit PDO Mapping	2014	Velocity Loop Integrator Gain
1A03	4th Transmit PDO Mapping	2015	Acceleration Feedforward Gain
6065	Follow Error Window	2016	PID Filter
607C	Home Offset	201A	In Position Counts
607F	Max Profile Speed	201D	In Position Error Range
6085	Quick Stop Deceleration	201E	In Position Timing
6098	Homing Method		
6099	Homing Speed		
609A	Homing Acceleration		

0x1018 Identity

This object contains general information about the device.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Array	UNSIGNED32	ro	no	-

Sub Index	Name	Default Value
00	max sub-index	4
01	Vendor ID	0x00000168
02	Product code	1
03	Revision	1
04	Serial number	-

0x1600 ~ 0x1603 RPDO Mapping Parameter

This object contains the mapping parameters for the PDOs the device is able to receive. The sub-index 00h contains the number of valid entries within the mapping record. The number of valid object entries shall be the number of the application objects that shall be received with the corresponding RPDO. The sub-index from 01h to number of entries contains the information of the mapped application variables. The object describes the content of the PDO by their index, sub-index and length. The length contains the length of the application object in bit. The length contains the length of the application object in bit. This may be used to verify the mapping.

The structure of the entries from sub-index 01h – 0Ch is as follows:

MSB		LSB
index (16 bit)	sub-index (8 bit)	object length (8 bit)

0x1600	1st Receive PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	5	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60400010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60600008	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x607A0020	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60B80010	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FE0120	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1601	2nd Receive PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	5	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60400010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60600008	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FF0020	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60B80010	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FE0120	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1602	3rd Receive PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	5	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60400010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60600008	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x607A0020	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60810020	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FE0120	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1603	4th Receive PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	4	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60400010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60600008	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FF0020	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FE0120	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1A00 ~ 0x1A03 TPDO Mapping Parameter

This object contains the mapping for the PDOs the device is able to transmit. The sub-index 00h contains the number of valid object entries within the mapping record. The sub-index from 01h to number of entries contains the information of the mapped application objects. The object describes the content of the PDO by their index, sub-index and length. The length contains the length of the application object in bit. This may be used to verify the mapping.

The structure of the entries from sub-index 01h – 0Ch is as follows:

MSB		LSB
index (16 bit)	sub-index (8 bit)	object length (8 bit)

0x1A00	1st Transmit PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	11	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x603F0010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60410010	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60610008	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60640020	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60F40020	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60B90010	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BA0020	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BB0020	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BC0020	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BD0020	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FD0020	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1A01	2nd Transmit PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	12	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x603F0010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60410010	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60610008	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60640020	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x606C0020	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60F40020	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60B90010	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BA0020	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BB0020	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BC0020	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60BD0020	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FD0020	rw	no

0x1A02	3rd Transmit PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	7	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x603F0010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60410010	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60610008	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60640020	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x606C0020	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60F40020	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FD0020	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1A03	4th Transmit PDO Mapping			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	0 to 12	7	rw	no
Sub Index 1		**Mapping entry 1**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x603F0010	rw	no
Sub Index 2		**Mapping entry 2**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60410010	rw	no
Sub Index 3		**Mapping entry 3**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60610008	rw	no
Sub Index 4		**Mapping entry 4**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60640020	rw	no
Sub Index 5		**Mapping entry 5**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x606C0020	rw	no
Sub Index 6		**Mapping entry 6**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60F40020	rw	no
Sub Index 7		**Mapping entry 7**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	0x60FD0020	rw	no
Sub Index 8		**Mapping entry 8**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 9		**Mapping entry 9**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 10		**Mapping entry 10**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 11		**Mapping entry 11**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no
Sub Index 12		**Mapping entry 12**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	0 to 0xFFFFFFFF	-	rw	no

0x1C32 Sync Manager Output Parameter

This object is used to configure the output sync manager.

0x1C32	Sync Manager Output Parameter			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	-	32	ro	no
Sub Index 1		**Sync type**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	0x0001	rw	no
Sub Index 2		**Cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 3		**Shift time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 4		**Sync types supported**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	0	ro	no
Sub Index 5		**Minimum cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 6		**Calc and copy time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 7		**Get cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	0	rw	no
Sub Index 8		**Delay time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	-	ro	no
Sub Index 9		**Sync0 cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	-	rw	no
Sub Index 10		**SM event missed**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	-	ro	no
Sub Index 11		**Cycle time too small**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	-	ro	no
Sub Index 12		**Sync error**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
BOOL	-	-	ro	no

0x1C33 Sync Manager Input Parameter

This object reads back the most recent error code generated by the drive.

0x1C33	Sync Manager Input Parameter			
Sub Index 0		**Number of entries**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED8	-	32	ro	no
Sub Index 1		**Sync type**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	0x0022	rw	no
Sub Index 2		**Cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 3		**Shift time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 4		**Sync types supported**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	0x8007	ro	no
Sub Index 5		**Minimum cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 6		**Calc and copy time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	0	ro	no
Sub Index 7		**Get cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	0	rw	no
Sub Index 8		**Delay time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	-	ro	no
Sub Index 9		**Sync0 cycle time**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED32	-	-	rw	no
Sub Index 10		**SM event missed**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	-	ro	no
Sub Index 11		**Cycle time too small**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
UNSIGNED16	-	-	ro	no
Sub Index 12		**Sync error**		
Data Type	Setting Range	Default Value	Access Type	PDO Mapping
BOOL	-	-	ro	no

CiA402 Device Profile Objects

0x603F Error Code

This object reads back the most recent error code generated by the drive.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	ro	yes	0

The error codes are as below:

Error Code	Description
0x7500	EtherCAT communication error
0xFF01	Over Current
0xFF02	Over Voltage
0xFF03	Over Temperature
0xFF04	Open Motor Winding
0xFF05	Internal Voltage Bad
0xFF06	Position Limit
0xFF07	Bad Encoder
0xFF08	reserved
0xFF09	reserved
0xFF0A	reserved
0xFF0B	reserved
0xFF31	CW Limit
0xFF32	CCW Limit
0xFF33	CW Limit and CCW Limit
0xFF34	Current Foldback
0xFF35	Move while Disable
0xFF36	Under Voltage
0xFF37	Blank Q Segment
0xFF41	Save Failed
0xFFFF	Other Error

Note: Items in bold italic represent Drive Faults, which automatically disable the motor.

When Fault happens, after the condition that caused the error has been resolved, write 80h to object 0x6040 to clear the error code in object 0x603F and object 0x200F.

When Warning happens, after the condition that caused the error has been resolved, write 01h to object 0x2006 to clear the error code in object 0x603F and object 0x200F.

0x6040 Control Word

This object is used to control the state and motion of the drive. It can be used to enable / disable the driver power output, start, and abort moves in all operating modes, and clear fault conditions.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	yes	0

The bits of the control word are defined as follows:

Bit	Name
0	Switch On
1	Enable Voltage
2	Quick Stop
3	Enable Operation
4	Operation Mode Specific
5	Operation Mode Specific
6	Operation Mode Specific
7	Fault Reset
8	Halt
9	Operation Mode Specific
10	Reserved
11	Manufacturer Specific
12	Manufacturer Specific
13	Manufacturer Specific
14	Manufacturer Specific
15	Manufacturer Specific

Details on Bits 0 to 3 and 7

Command	Bit of Control word				
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0
Shutdown	0	x	1	1	0
Switch on	0	0	1	1	1
Switch on + Enable operation	0	1	1	1	1
Disable voltage	0	x	x	0	x
Quick stop	0	x	0	1	x
Disable Operation	0	0	1	1	1
Enable Operation	0	1	1	1	1
Fault reset	0 -> 1	x	x	x	x

Details on Bits 4, 5, 6, 8 and 9

For PP mode

Bit	Name	Value	Description
4	New Set Point	0	Toggle this bit from 0->1 to clock in a new set point
		1	
5	Change Set Point Immediately	0	Positioning shall be completed (target reached) before the next one gets started
		1	Next positioning shall be started immediately
6	Abs/Rel	0	Target position shall be an absolute value
		1	Target position shall be a relative value
8	Halt	0	Positioning shall be executed or continued
		1	Axis shall be stopped
9	Change of Set Point	0	The previous set-point will be completed and the motor will come to rest before a new set point is processed
		1	The motor will continue at the speed commanded by the previous set point until it has reached the position commanded by the previous set point, then transition to the speed of the new set point

For HM mode

Bit	Name	Value	Description
4	Homing Operation Start	0	Do not start homing procedure
		1	Start or continue homing procedure
8	Halt	0	Enable bit 4
		1	Stop axis

For Q mode

Bit	Name	Value	Description
4	Q Program Start	0	Toggle this bit from 0->1 to run Q program
		1	
8	Halt	0	Enable bit 4
		1	Stop axis

0x6041 Status Word

The object indicates the current state of the drive. It consists of bits that indicate the state according to the drive and operation mode.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	ro	yes	0

The bits of the status word are defined as follows:

Bit	Name
0	Ready to Switch On
1	Switched On
2	Operation Enabled
3	Fault
4	Voltage Enabled
5	Quick Stop
6	Switch On Disabled
7	Warning
8	Manufacturer Specific
9	Remote
10	Target Reached
11	Internal Limit Active
12	Operation Mode Specific
13	Operation Mode Specific
14	Manufacturer Specific
15	Manufacturer Specific

The following bits indicate the status of the device:

State	Bit 6	Bit 5	Bit 3	Bit 2	Bit 1	Bit 0
Not Ready to Switch On	0	x	0	0	0	0
Switch On Disabled	1	x	0	0	0	0
Ready to Switch On	0	1	0	0	0	1
Switched On	0	1	0	0	1	1
Operation Enabled	0	1	0	1	1	1
Fault	0	x	1	1	1	1
Fault Reaction Active	0	x	1	1	1	1
Quick Stop Active	0	0	0	1	1	1

Bit 9: Remote

This bit indicates Control word has settled.

Bit 10: Target Reached

If bit 10 is set by the drive, then a set point has been reached (torque, speed or position depending on the modes of operation). The change of a target value by software alters this bit. If quick stop option code is 5, 6, 7 or 8, this bit must be set, when the quick stop operation is finished and the drive is halted. If Halt occurred and the drive has halted then this bit is set too.

Bit 11: Internal Limit Active

This bit set by the drive indicates that an internal limitation is active (e.g. position error limit).

For PP mode

Bit	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Target position not reached Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Target position reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	Set Point Ack	0	Previous set point already processed, waiting for new set point
		1	Previous set point still in process, set point overwriting shall be accepted
13	Following Error	0	No following error
		1	Following error

For PV mode

Bit	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Target velocity not reached Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Target velocity reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	Speed	0	Speed is not equal to 0
		1	Speed is equal 0

For CSP and CSV modes

Bit	Name	Value	Description
10	Target Reached	0	Unable to reach the target (position/velocity)
		1	Reached the target (position/velocity)
13	Following Error	0	No following error
		1	Following error

For HM mode

Bit	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Home position not reached Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Home position reached Halt (Bit 8 in controlword) = 1: Velocity of axis is 0
12	Homing Attained	0	Homing Mode not yet complete
		1	Homing Mode carried out successfully
13	Homing Error	0	No homing error
		1	Homing error

For Q program mode

Bit	Name	Value	Description
10	Target Reached	0	Halt (Bit 8 in controlword) = 0: Q program running Halt (Bit 8 in controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in controlword) = 0: Q program finishes or not started Halt (Bit 8 in controlword) = 1: Velocity of axis is 0

0x6060 Mode of Operation

This object is used to set operation mode.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER8	rw	yes	0

This drive provides the following operation modes:

Value	Name
-1	Q Program Mode (MOONS' specific)
1	Profile Position Mode (PP)
3	Profile Velocity Mode (PV)
4	Torque Profile Mode (TQ)
6	Homing Mode (HM)
8	Cyclic Synchronous Position Mode (CSP)
9	Cyclic Synchronous Velocity Mode (CSV)

In SM synchronization mode, PP, PV, TQ, HM and Q modes are supported.

In DC synchronization mode, CSP, CSV and HM modes are supported.

0x6061 Mode of Operation Display

This object displays current operation mode of the drive. Definition of value is same as Mode of Operation (0x6060).

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER8	ro	yes	0

0x6064 Position Actual Value

This object provides the actual value of the position measured by encoder. The unit of this object is count.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x6065 Following Error Window

This object indicates the configured range of tolerated position values symmetrically to the position demand value. If the position actual value is out of the following error window, a following error (Position Limit) occurs. A following error may occur when a drive is blocked, unreachable profile velocity occurs (Jog mode should be Mode 1), or at wrong closed-loop coefficients. The unit of this object is encoder count. If the value of the following error window is 0, the following control shall be switched off.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	no	1000

0x606C Velocity Actual Value

This object provides the actual velocity value derived from encoder. The unit of this object is count/s.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x6071 Target Torque

This object is the input value for the torque controller in Torque Profile Mode. This object can only be accessed in Servo (or Step Servo) drive. The unit of this object is mN·m.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER16	rw	yes	0

This object parameters is related to the other torque values, such as Torque Slope (index 0x6087) and Torque Constant (index 0x2216).

0x6073 Max Current

This object configures the max current permissible value of the drive. The unit of this object is 0.01Amps.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x6074 Torque Demand Value

This parameter is the output value of the torque limit function (if available within the torque control and power-stage function). This object can only be accessed in Servo (or Step Servo) drive. The unit of this object is mN·m.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	ro	yes	0

0x6078 Current Actual Value

This object refers to the instantaneous current in the motor. This object can only be accessed in Servo(or Step Servo) drive. The unit of this object is 0.01Amps.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER16	ro	yes	0

0x607A Target Position

This object specifies the target position in Profile Position (PP) mode and Cyclic Synchronous Position (CSP) mode. The unit of this object is count. It is related to electronic gearing setting.

It is used as absolute coordinate or relative coordinate depending on the Bit 6 (0x6040.6) setting of the Control Word in the PP mode, and is always used as absolute value in the CSP mode.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	rw	yes	0

0x607C Home Offset

This object is the difference between the zero position for the application and the home sensor position (found during homing). During homing the home sensor position is found and once the homing is completed the zero position is offset from the home position by adding the Home Offset to the home position. All subsequent absolute moves shall be taken relative to this new zero position. The unit of this object is count.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	rw	yes	0

0x607E Polarity

This object contains two individual bits to set the polarity of position and velocity in their own mode. The bit7 (position polarity bit) indicates the position demand value (related to the target position object 0x607A) shall be multiplied by 1 of by –1. The polarity flag shall have no influence to the homing mode. And the bit6 (velocity polarity bit) indicates the velocity demand value (related to the profile velocity object 0x60FF) shall be multiplied by 1 or -1.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED8	rw	yes	0

Value	Name
6	Position polarity 0=> multiply by 1(default) 1=> multiply by -1
7	Velocity polarity 0=> multiply by 1(default) 1=> multiply by -1

0x607F Max Profile Speed

This object configures the maximum speed allowed in either direction in a move profile.

The unit of this object is count/s.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	yes	1000000

0x6081 Profile Velocity

This object configures the velocity normally attained at the end of the acceleration ramp during a profiled move and is valid for both directions of motion. This object sets the velocity value except the velocity parameter in Profile Velocity mode (pv). The unit of this object is count/s.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	yes	200000

0x6083 Profile Acceleration

This object configures the acceleration ramp in a profiled move. The unit of this object is count/s2.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	yes	2000000

0x6084 Profile Deceleration

This object configures the deceleration ramp in a profiled move. The unit of this object is count/s2.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	yes	2000000

0x6085 Quickstop Deceleration

This object configures deceleration used to stop the motor when the quick stop function is activated.

The unit of this object is count/s2.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	no	60000000

0x6087 Torque Slope

This object describes the rate of change of torque. The unit of this object is mN·m/s.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	yes	0

0x6087 Homing Method

This object determines the method that will be used during homing.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER8	rw	yes	0

Please see the detail described in Homing Mode.

0x6099 Homing Speed

This object determines the speeds that will be used during homing.

There are two parts to define those speeds.

Sub-index 1 to set the speed to search home switch.

Sub-index 2 to set the speed to search zero position.

The unit of this object is count/s.

Object Type	Data Type	Access Type	Default Value
Array	UNSIGNED32	rw	0

Sub Index	Name	PDO Mapping	Default Value
00	max sub-index	no	2
01	speed during search for switch	yes	0
02	speed during search for zero	yes	0

0x609A Homing Acceleration

This object establishes the acceleration to be used for all accelerations and decelerations with the standard homing modes. The unit of this object is count/s2.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	rw	yes	0

0x60B8 Touch Probe Function

This object configures the function of touch probe.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	yes	0

Bit	Value	Definition
0	0	Switch off touch probe 1
	1	Enable touch probe 1
1	0	Trigger first event
	1	Trigger continuously
2,3	00	Trigger with touch probe 1 input
	01	reserved
	10	reserved
	11	reserved
4	0	Switch off sampling at rising edge of touch probe 1
	1	Enable sampling at rising edge of touch probe 1
5	0	Switch off sampling at falling edge of touch probe 1
	1	Enable sampling at falling edge of touch probe 1
6,7	-	reserved
8	0	Switch off touch probe 2
	1	Enable touch probe 2
9	0	Trigger first event
	1	Trigger continuously
10,11	00	Trigger with touch probe 2 input
	01	reserved
	10	reserved
	11	reserved
12	0	Switch off sampling at rising edge of touch probe 2
	1	Enable sampling at rising edge of touch probe 2
13	0	Switch off sampling at falling edge of touch probe 2
	1	Enable sampling at falling edge of touch probe 2
14,15	-	Definition

Positive value is captured at “rising edge” of digital input. Negative value is captured at “falling edge” of digital input.

When working with inputs and outputs it is important to remember the designations low and high. If current is flowing into or out of an input or output the logic state for that input/output is defined as low or closed. If no current is flowing, or the input/output is not connected, the logic state is high or open.

Rising edge means the status from low to high. Falling edge means the status from high to low.

0x60B9 Touch Probe Status

This object provides the status of touch probe.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	ro	yes	0

Bit	Value	Definition
0	0	Touch probe 1 is switched off
	1	Touch probe 1 is enabled
1	0	Touch probe 1 no rising edge value stored
	1	Touch probe 1 rising edge position stored
2	0	Touch probe 1 no falling edge value stored
	1	Touch probe 1 falling edge position stored
3 - 7	0	reserved
8	0	Touch probe 2 is switched off
	1	Touch probe 2 is enabled
9	0	Touch probe 2 no rising edge value stored
	1	Touch probe 2 rising edge position stored
10	0	Touch probe 2 no falling edge value stored
	1	Touch probe 2 falling edge position stored
11 - 15	0	reserved

0x60BA Touch Probe Position 1 Positive Value

This object provides the position value triggered by Touch Probe 1 at rising edge.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x60BB Touch Probe Position 1 Negative Value

This object provides the position value triggered by Touch Probe 1 at falling edge.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x60BC Touch Probe Position 2 Positive Value

This object provides the position value triggered by Touch Probe 2 at rising edge.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x60BD Touch Probe Position 2 Negative Value

This object provides the position value triggered by Touch Probe 2 at falling edge.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x60F4 Following Error Actual Value

This object displays the actual position error (following error) between the target position and the actual position. The unit of this object is encoder count.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	ro	yes	0

0x60FD Digital Inputs

This object monitors the inputs status of the drive.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	yes	0x00000000

bit 0	CCW Limit	A “0” means no limit alarm. A “1” means bit 1 CW Limit limit alarm occurs.
bit 1	CW Limit	
bit 2	Home Sensor	A “0” means home sensor is not active. A “1” means home sensor is active.
bit 3~15	reserved	
bit 16	Input X1	A “0” means the input is open. A “1” means the input is closed.
bit 17	Input X2	
bit 18	Input X3	
bit 19	Input X4	
bit 20	Input X5	
bit 21	Input X6	
bit 22	Input X7	
bit 23	Input X8	
bit 24~31	reserved	

0x60FE Digital Outputs

This object configures or monitors the digital outputs of the drive.

Object Type	Data Type	Access Type	Default Value
Array	UNSIGNED32	rw	0

Sub Index	Name	PDO Mapping	Default Value
00	max sub-index	no	2
01	physical outputs	yes	0x00000000
02	bit mask	no	0x00000000

Description of physical outputs:

Bit 0~15 are reserved.

Bit 16~19 are for outputs Y1 ~ Y4 correspondingly.

Bit 20~31 are reserved.

A “0” turns an output on (closed). A “1” turns an output off (open).

Example:

0x000F0000 Turn off all four outputs.

0x000A0000 Turn on Y1 and Y3. Turn off Y2 and Y4.

Description of bit mask:

Bit 0~15 are reserved.

Bit 16~19 are for outputs Y1 ~ Y4 correspondingly.

Bit 20~31 are reserved.

A “0” deselects (mask off) an output. A “1” selects an output.

Example:

0x000F0000 Select all four outputs.

0x000A0000 Deselect (mask off) Y1 and Y3. Select Y2 and Y4.

0x60FF Target Velocity

This object configures the velocity parameters in Profile Velocity Mode and Cyclic Sync Velocity Mode. The unit of this object is count/s.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	INTEGER32	rw	yes	0

0x6502 Supported Drive Modes

This object provides information on the supported drive modes.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	no	429

Bit	Description
0	PP: Profile Position Mode
1	VI: Velocity Mode
2	PV: Profile Velocity Mode
3	TQ: Torque Profile Mode
4	reserved
5	HM: Homing Mode
6	IP: Interpolated Position Mode
7	CSP: Cyclic Sync Position Mode
8	CSV: Cyclic Sync Velocity Mode
9	CST: Cyclic Sync Torque Mode
10 ~ 31	reserved

Bit value 0: Not supported.

Bit value 1: Supported.

SSDC EtherCAT drive now supports PP, PV, TQ, HM, CSP, CSV modes.

Manufacturer Specific Objects

0x2001 Home Switch

This object configures which input is used as the home switch in Homing.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED8	rw	no	8

0x2002 Output Status

This object reads back the status of the drive’s outputs.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	no	0x000F0000

Bit 0~15 are reserved.

Bit 16~19 are for outputs Y1 ~ Y4 correspondingly.

Bit 20~31 are reserved.

A “0” means the output is closed. A “1” means the output is open.

Example:

0x000F0000 All four outputs of the drive are open.

0x000A0000 Outputs Y1 and Y3 are closed. Output Y2 and Y4 are open.

0x2006 Clear Alarm

This object provides the feature to clear alarm of the drives. After the condition that caused the error has been resolved, set this value to 01h can clear the error code in object 0x603F and object 0x200F

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED8	wo	no	0

0x2007 Q Segment Number

This object configures the number of Q Segment which will be executed in Q mode.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED8	rw	yes	1

0x200B Status Code

This object represents the current status code of the drive.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	yes	0

Hex Value	Status Code bit definition
0001	Motor Enabled (Motor Disabled if this bit = 0)
0002	Sampling (for Quick Tuner)
0004	Drive Fault (check Alarm Code)
0008	In Position (motor is in position)
0010	Moving (motor is moving)
0020	Jogging (currently in jog mode)
0040	Stopping (in the process of stopping from a stop command)
0080	Waiting (for an input; executing a WI command)
0100	Saving (parameter data is being saved)
0200	Alarm present (check Alarm Code)
0400	Homing (executing an SH command)
0800	Waiting (for time; executing a WD or WT command)
1000	Wizard running (Timing Wizard is running)
2000	Checking encoder (Timing Wizard is running)
4000	Q Program is running
8000	Servo Ready

0x200C Zero Position

This object provides the feature to clear the position value in 0x6064 (Position actual value).

Set this value to 01h can clear the position value in 0x6064 (Position actual value).

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED8	wo	no	0

0x200F Alarm Code

This object reads back a hexadecimal value of the most recent alarm code of the drive.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED32	ro	yes	0

Each bit in alarm code indicates one type of warnings or faults status.

Hex Value	SSDC EtherCAT
00000001	***Position Limit***
00000002	CCW Limit
00000004	CW Limit
00000008	***Over Temperature***
00000010	***Internal Voltage Bad***
00000020	***Over Voltage***
00000040	Under Voltage
00000080	***Over Current***
00000100	***Open Motor Winding***
00000200	***Bad Encoder***
00000400	Communication Error
00000800	Bad Flash
00001000	No Move
00002000	Current Foldback
00004000	Blank Q Segment
00008000	NV Memory Double Error
00010000	-
00020000	-
00040000	-
00080000	-
00100000	-

Note: Items in bold italic represent Drive Faults, which automatically disable the motor.

When Fault happens, after the condition that caused the error has been resolved, write 80h to object 0x6040 to clear the error code in object 0x603F and object 0x200F.

When Warning happens, after the condition that caused the error has been resolved, write 01h to object 0x2006 to clear the error code in object 0x603F and object 0x200F.

0x2019 Drive Temperature

This object reads back the drive’s temperature measured by on board temperature sensor.

The unit of this object is 0.1 centigrade.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	ro	no	-

0x2218 Encoder Resolution

This object reads back the encoder resolution in lines. For step-servo motors, this object is read only.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	ro	no	5000

0x2220 Position Loop Proportional Gain

This object configures the tuning parameter - Position Loop Proportional Gain. This parameter is the primary gain term for minimizing the position error.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x2221 Position Loop Differential Gain

This object configures the tuning parameter - Position Loop Differential Gain. This parameter works to damp low speed oscillations.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x2222 Position Loop Differential Filter

This object configures the tuning parameter - Position Loop Differential Filter. This filter is a simple one-pole, low-pass filter intended for attenuating high frequency oscillations.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x2224 Velocity Loop Proportional Gain

This object configures the tuning parameter - Velocity Loop Proportional Gain. This parameter is used to minimize the velocity error.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x2225 Velocity Loop Integrator Gain

This object configures the tuning parameter - Velocity Loop Integrator Gain. This parameter is used to minimize steady state velocity errors.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x2226 Acceleration Feedforward Gain

This object configures the tuning parameter - Acceleration Feedforward Gain. This parameter improves acceleration control by compensating for the load inertia.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	-

0x2227 PID Filter

This object configures the tuning parameter - PID Filter. It sets the servo control overall filter frequency. The filter is a simple one-pole, low-pass filter intended for attenuating high frequency oscillations.

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	0

0x2252 In Position Counts

This object configures the in position counts to determine if the motor is in position (dynamic).

Object Type	Data Type	Access Type	PDO Mapping	Default Value
Var	UNSIGNED16	rw	no	20

Parameter Unit Scaling

Distance, Velocity, Acceleration and Deceleration

For SS EtherCAT drive, all the parameters for velocity, acceleration, deceleration and distance are based on encoder counts.

If the drive is working with an AM17/23/24/34SS motor, the encoder resolution is 20000 counts/rev.
Distance parameter value for 1 revolution is 20000.
Velocity parameter value for 10 rps is 200000.
Acceleration and Deceleration parameter value for 100rps/s is 2000000.

If the drive is working with an AM11/17/23/24/34RS motor, the encoder resolution is 4096 counts/rev.
Distance parameter value for 1 revolution is 4096.
Velocity parameter value for 10 rps is 40960.
Acceleration and Deceleration parameter value for 100rps/s is 409600.