Nexcobot Co., Ltd.

IoT Automation Solutions Business Group

AXE-5904

User Manual

Nexcobot Co., Ltd.
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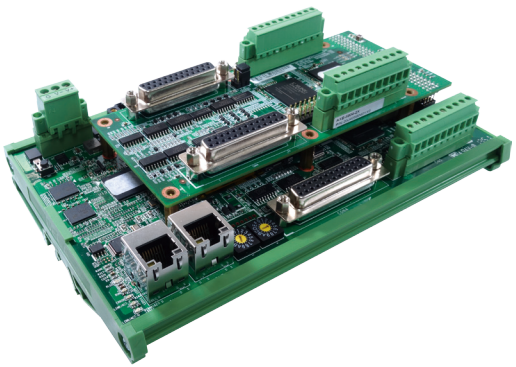
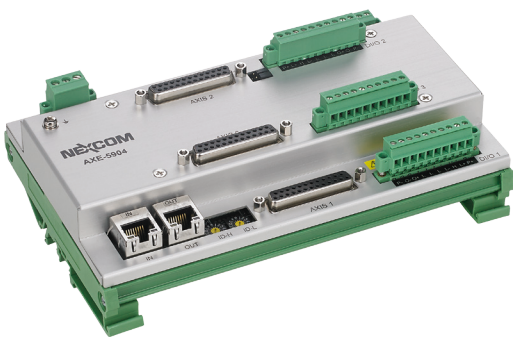
Chapter 1: Product Introduction

Overview



Without Metal Cover



With Metal Cover

Key Features

- 4-axis pulse/direction for step motor or servo drive
- Pulse output up to 4M pps (pulse per second)
- Pulse output format options: CW/CCW, OUT/DIR
- EtherCAT slave protocol communication
- Support CiA 402 device profile
- Support Mode of Operation: PP, PV, HM & CSP
- Differential encoder phase for each axis, format option: 1x, 2x, 4x AB phase
- Three General Purpose DI for each axis: (4 Axis, Total 12 DI)
- One high speed compare trigger output for each axis (4 Axis, Total 4 Channels)

Hardware Specifications

Pulse Type Motion Control

- Number of axes: 4
- Pulse output rate: up to 4Mpps
- Pulse command output: CW/CCW, OUT/DIR
- Committed I/O signal: LS±/CMP±/HS/SVON/RDY/INP/ALM/ARST/DCLR

Encoder Input

- Encoder input type: Incremental, 32-bit
- Encoder signal: CW/CCW, AB/Z
- Positioning Range: -2,147,483,648 through 2,147,483,647 pulse (32-bit)
- Max. input frequency: 4MHz

General I/O

- General-purpose input: 3 channels per axis (total 12 channels)
- Input type: photo-coupler input (corresponding to current sink output)
- Response time of DO (Max.): 100 µsec

Power Requirements

- DC input range: DC 24V ±10% with over-voltage and reversed-voltage protection

EtherCAT Section

- Data transfer medium: Ethernet cable (CAT5e), shield type: S/STP or S/UTP
- Ethernet interface: 2x RJ-45
- Data transfer rate: 100Mbps, full duplex
- Protocol: EtherCAT
- Device profile: CiA 402

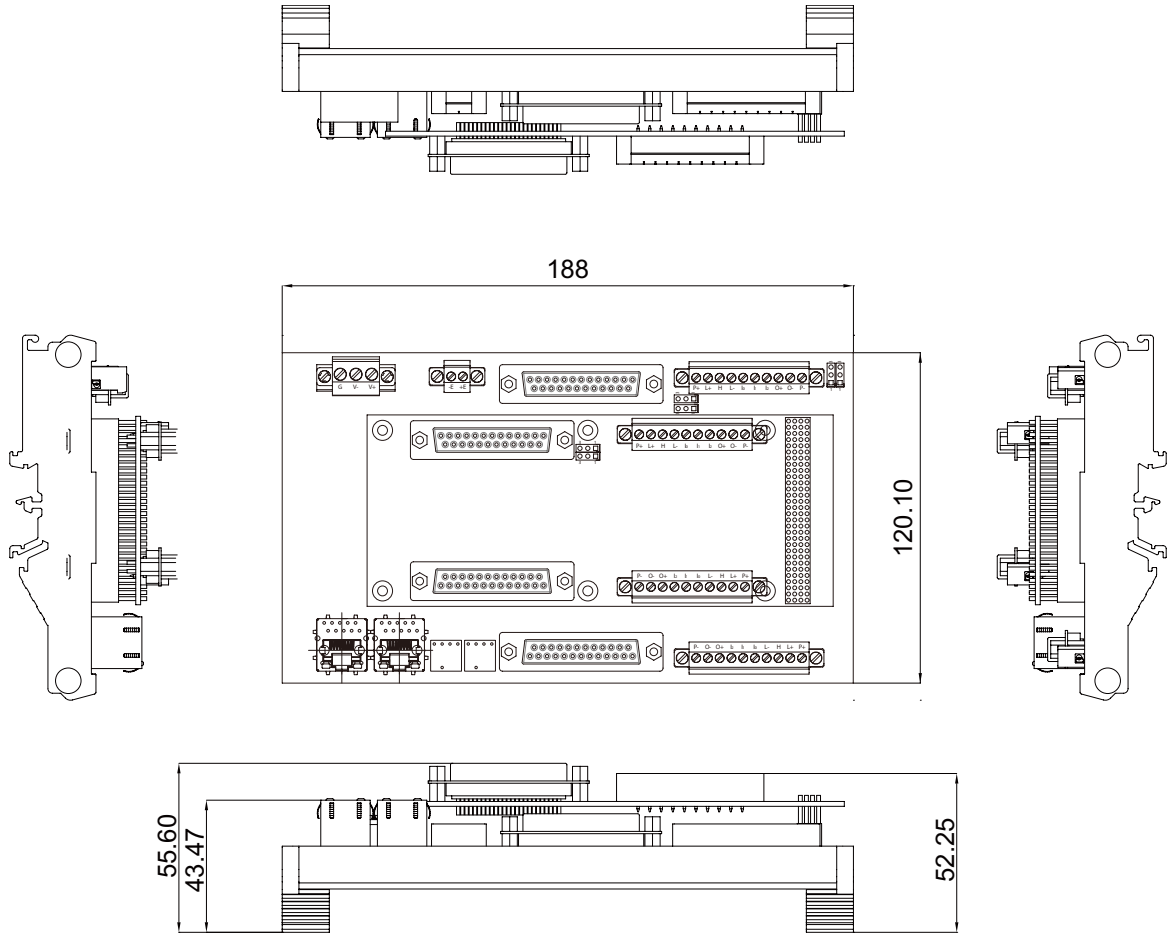
Environment Section

- Operating temperature: 0°C to 50°C
- Relative humidity:
- 35~85%, non-condensation, operating
- 10~90%, non-condensation, non-operating
- Shock: IEC 60068 2-27
- Vibration: IEC 60068-2-6, IEC 60068-2-64
- Enclosure type rating: IP00
- Mounting type: DIN-rail
- Dimension (mm): 120.1(W) x 188(L) x 55.6(H)

Certifications

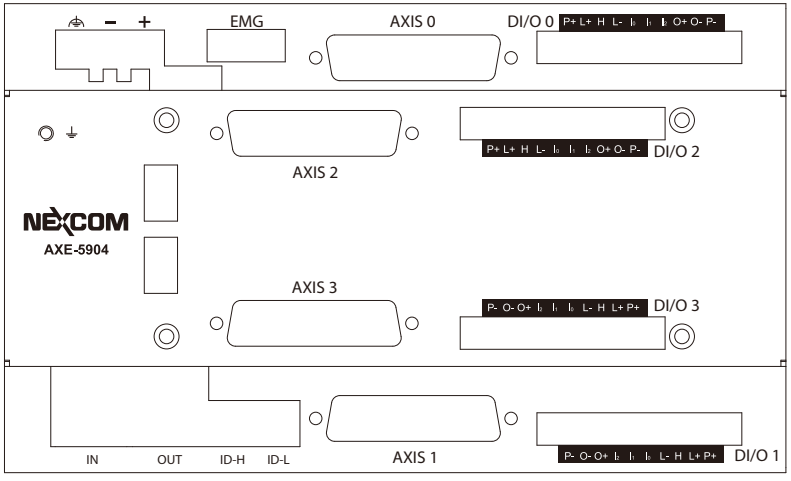
- CE
- FCC Class A

Mechanical Dimensions

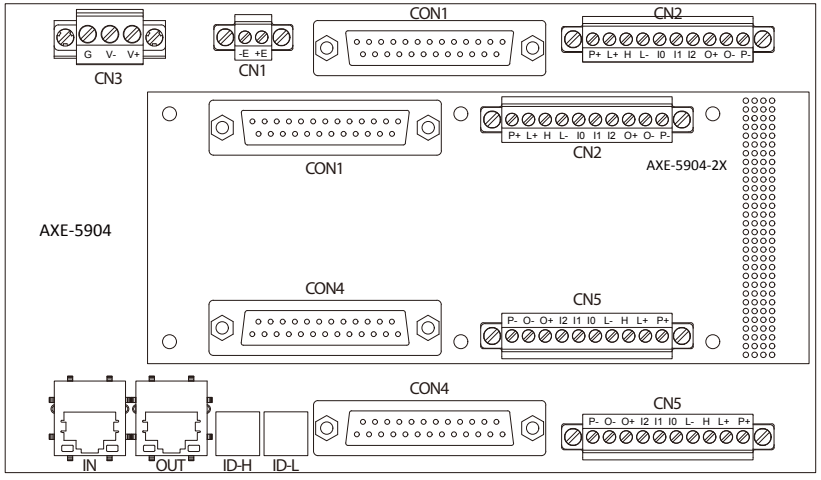


Chapter 2: Connector Pinout Assignments and Wiring Diagrams

AXE-5904 Pin Definition Mapping Table

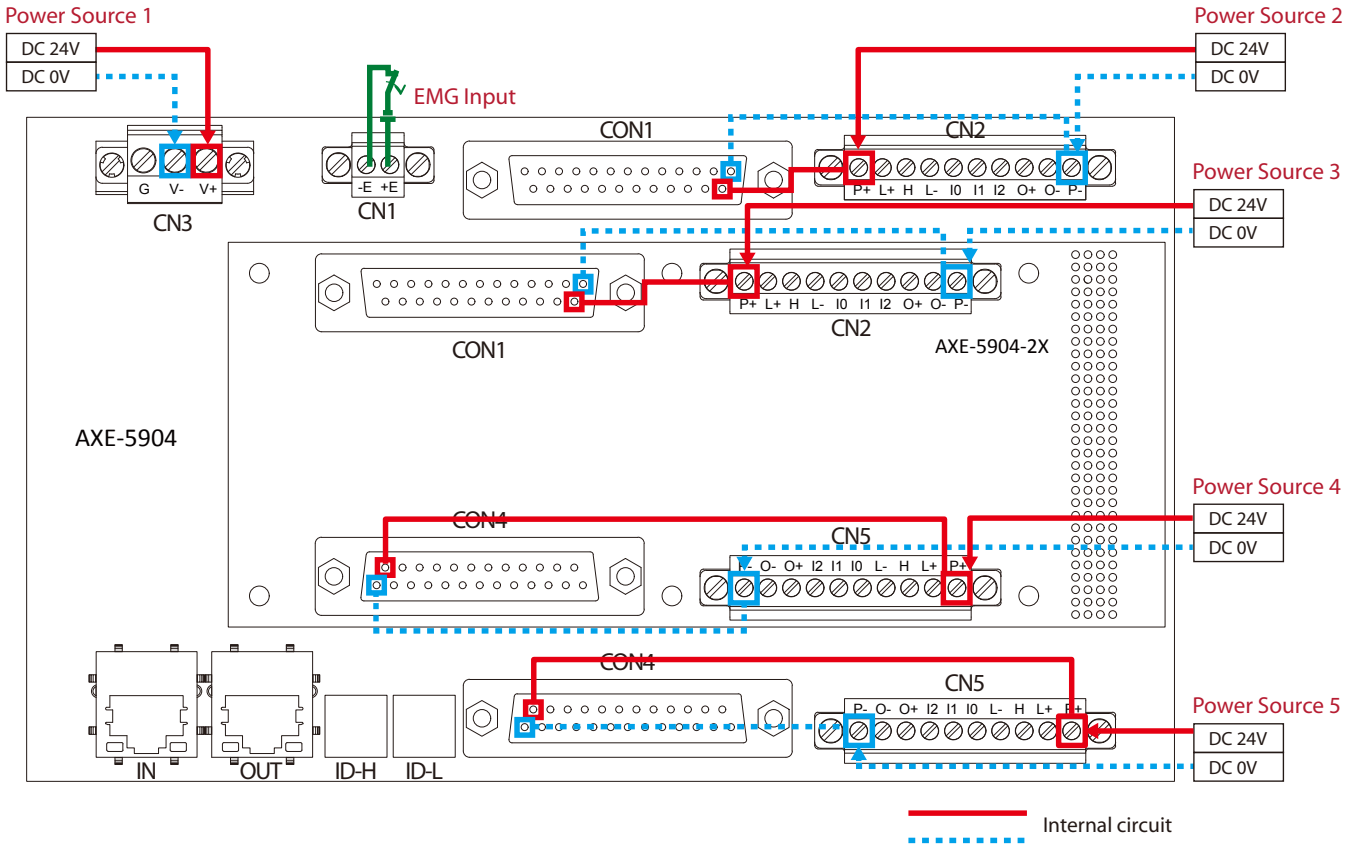


AXE-5904 with Metal Cover

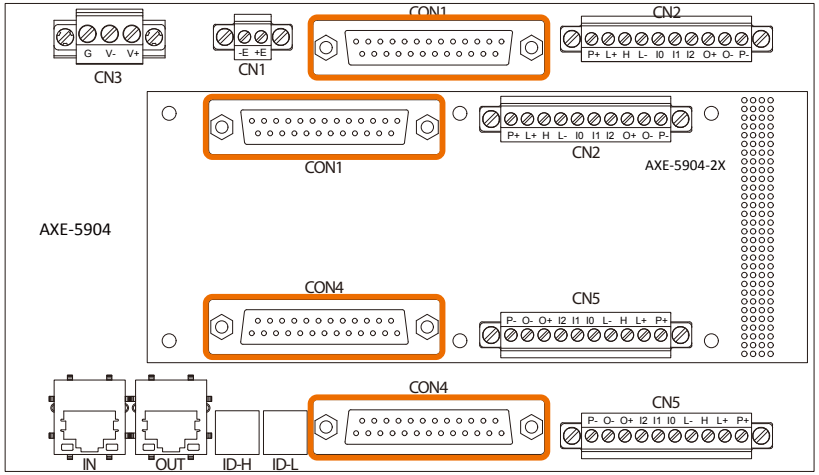


AXE-5904 without Metal Cover

AXE-5904 Power Wiring Diagram

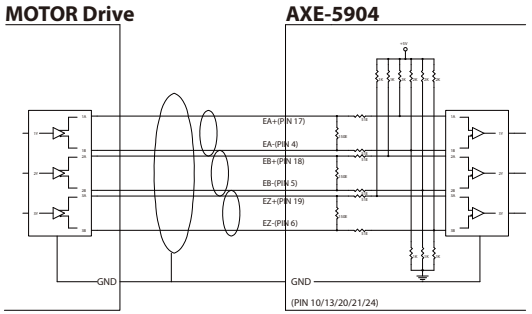


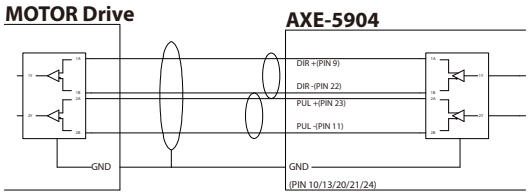
AXE-5904 Drive I/O Connector Wiring Diagram

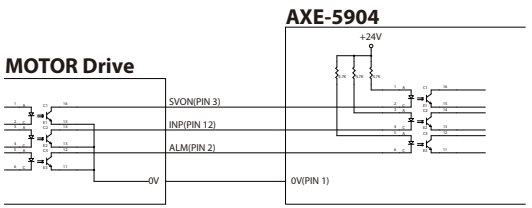


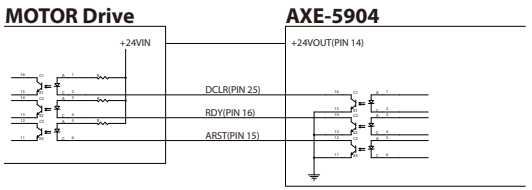
CON1/CON4 (AXIS 0~3) Servo Control Connector

Pin	Symbol	Definition	Pin	Symbol	Definition
1	0V	Current return path for I/O (COM-)	2	ALM	Alarm input
3	SVON	Servo enable output	4	EA-	Differential encoder signal A, Negative
5	EB-	Differential encoder signal B, Negative	6	EZ-	Differential encoder signal Z, Negative
7	N/C	N/C	8	N/C	N/C
9	DIR+	Differential command signal DIR, Positive	10	DGND	Digital ground for differential signals
11	PUL-	Differential command signal PULSE, Negative	12	INP	In-position input
13	DGND	Digital ground for differential signals	14	+24V Output	Current source for I/O (COM+)
15	ARST	Alarm reset output	16	RDY	Servo ready input
17	EA+	Differential encoder signal A, Positive	18	EB+	Differential encoder signal B, Positive
19	EZ+	Differential encoder signal Z, Positive	20	DGND	Digital ground for differential signals
21	DGND	Digital ground for differential signals	22	DIR-	Differential command signal DIR, Negative
23	PUL+	Differential command signal PULSE, Positive	24	DGND	Digital ground for differential signals
25	DCLR	Deviation counter clear output			

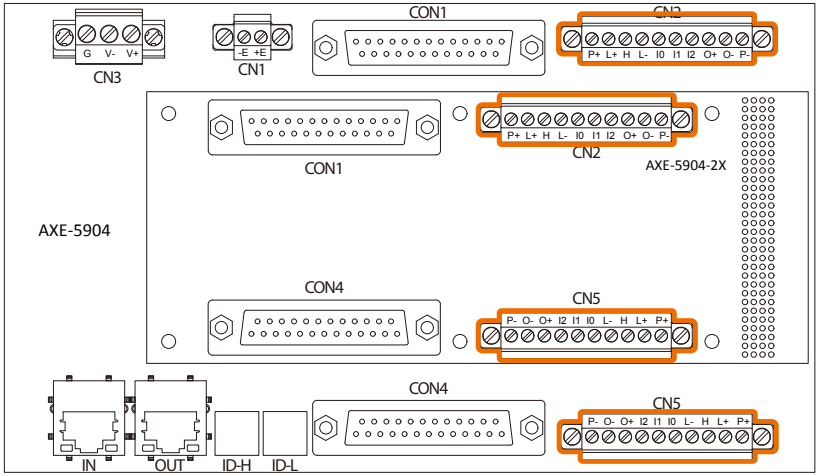








DI/O 0 ~ DI/O 4 Wiring Diagram



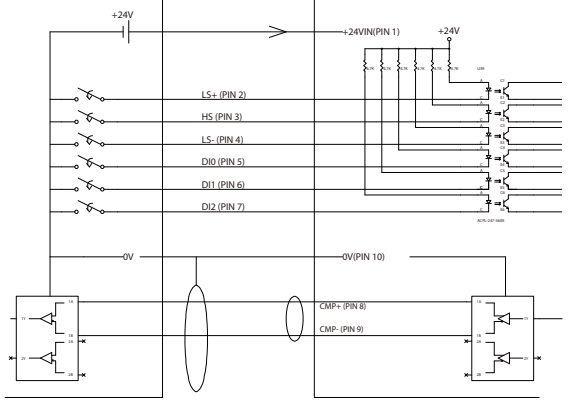
CN2/CN5 (DI/O 0~3) Safety DI/O Connector

Pin	Symbol	Label	Definition
1	+24V Input	P+	Positive potential of Isolated Power (COM+)
2	LS+	L+	Forward Limit sensor input
3	HS	H	Home sensor input
4	LS-	L-	Reverse Limit sensor input
5	DI0	I0	Uncommitted digital input 0
6	DI1	I1	Uncommitted digital input 1
7	DI2	I2	Uncommitted digital input 2
8	CMP+	O+	Compare Trigger Output (CMP+)
9	CMP-	O-	Compare Trigger Output (CMP-)
10	0V	P-	Negative potential of Isolated Power (COM-)

Warning: Pin 8 and Pin 9 cannot connect with 24V.

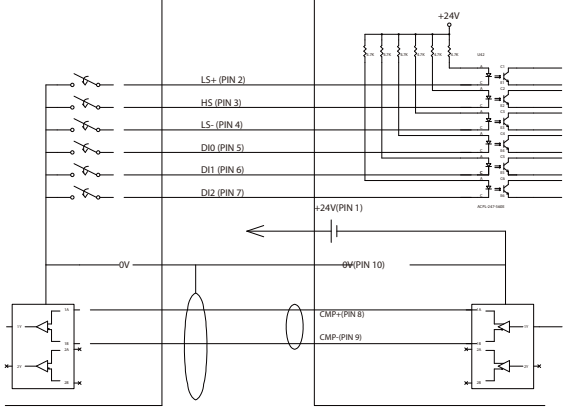
Machine Limit

AXE-5904 (CN2) / AXE-5904-2X (CN2)



Machine Limit

AXE-5904 (CN5) / AXE-5904-2X (CN5)



CN3: Power Input Connector

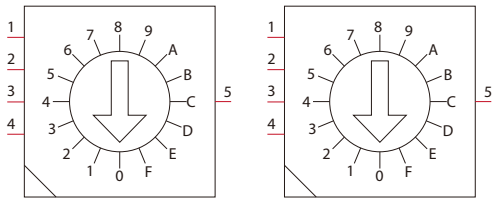
Pin	Symbol	Label	Definition
1	+24V Input	V+	Positive supply voltage for the module (+24V Input)
2	0V	V-	Positive supply voltage for the module
3	GND	G	Earth ground

CN1: (EMG) Emergency Input Connector

Pin	Symbol	Label	Definition
1	EMG+	E+	Emergency Stop Input +
2	EMG-	E-	Emergency Stop Input -

AXE-5904 SH & SL ROTARY (EtherCAT Station Address Alias)

ROTARY SWITCH 16 POSITIONS 180 degrees for EtherCAT Low Word Address Adjustment



ID-H **ID-L**

The EtherCAT Station Address alias is used to identify the physical location of the slave on the EtherCAT bus.

Two way you can read the switches value:

1. EtherCAT Station Address Alias in EtherCAT Slave Controllor register (0x0012)

EtherCAT Station Address Alias			
4th Byte	3rd Byte	2nd Byte	1st Byte
0	0	SH (ID-H)	SL (ID-L)

P.S. In Hexadecimals, Note: Station alias register (0x0012) is set from the switches once when system power on.

2. CoE object index: 0x2005, read the switch value directly by this object.

Application example:
If slave (station) cabling order is changed, you colud read the switch value (station address alias) from each EC-slave.

And compare the value to know your physical configuration on the network topology.

Chapter 3: Operation

3.1 EtherCAT Slave Information (ESI)

According to EtherCAT standard document ETG.2000, every EtherCAT slave must be delivered an ESI file (a XML format to describe EtherCAT slave information) for the EtherCAT Master. The ESI file contains the necessary communication settings for the AXE-5904.

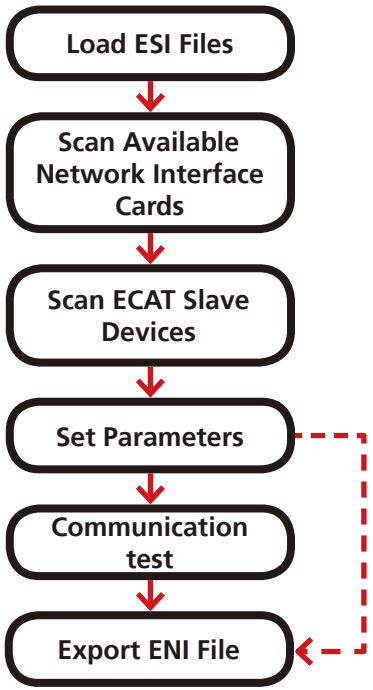
The following file is provided for AXE-5904:

- Nexcom AXE-5904.xml

3.2 Trial operation

3.2.1 Operation with NexCAT

The basic operation flow of NexCAT is as follow:

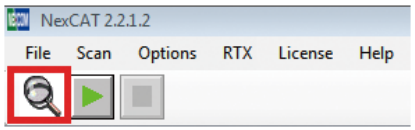


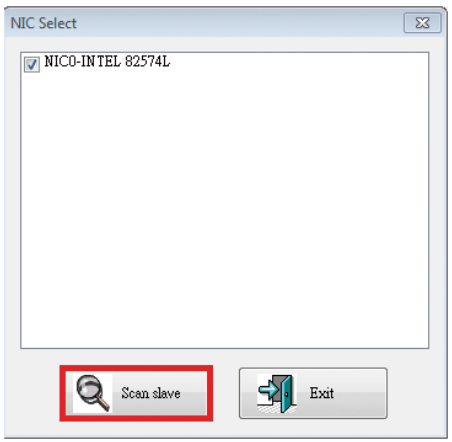
Check the ESI file is loaded into NexCAT.
When NexCAT program starts, it will automatically import all the files in the folder which location is "\ESI" of NexCAT installation path, the file name extension is * .xml

I. Run NexCAT and Scan Slave

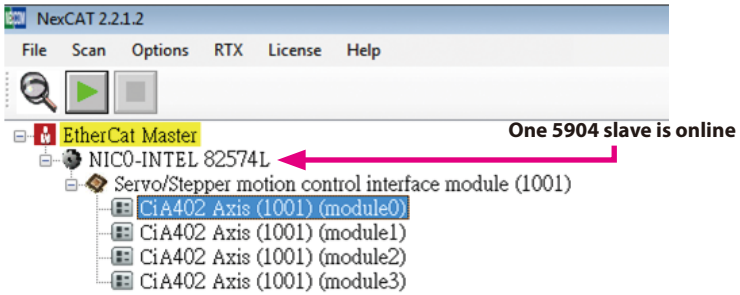
Please click **NexCAT.exe** on the Desktop to open the NexCAT. You can also open NexCAT via **Programs** > **NEXCOM** > **NexECMRtx** > **x32** > **tools** > **NexCAT.exe**.

Step 1: Press **Scan** to search the network port for EtherCAT.

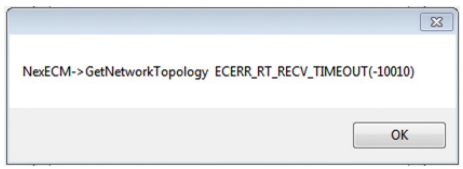




Step 2: Press **Scan Slave**, to scan the EtherCAT slave devices connected to Len-port.

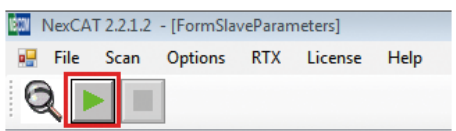


Note: If the "-10010" error occurs, please check connection of devices.



(Popup Error Message)

Step3: Start Communication, click **Start** to start EtherCAT communication between Master and AXE-5904.



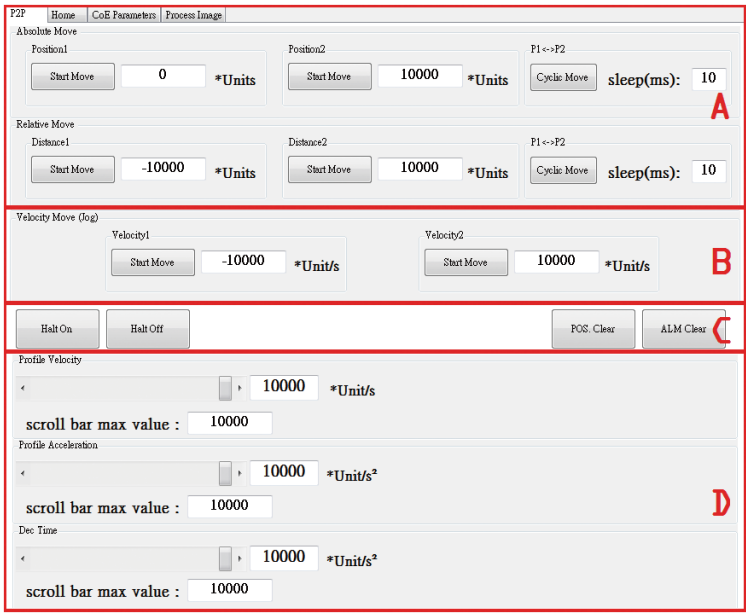
II. Test the CiA402 Functions

Double click the left side tree node to open the page for motion control. The page supports the following:

- Profile Position mode (P2P page, Section A)
- Profile Velocity mode (P2P page, Section B)
- Home mode (Home page)

Please refer to the CiA 402 standard for more information about the three modes.

Each part of the page is described as below.



A. Profile Position Mode

Provides two method for users: **Absolute move** / **Relative move**.

B. Profile Velocity Mode

Decided velocity and start move, the velocity curve will follow "profile acc. (0x6083)" and "profile dec.(0x608A)".

C. Halt and other function

Halt On: Quick stop. Follow "quick stop option (0x605A)", the default value is 2.
Halt Off: Remove "Halt On" and run continuously.
POS. Clear: Reset Target Position & Actual Position.
ALM Clear: Fault Reset.

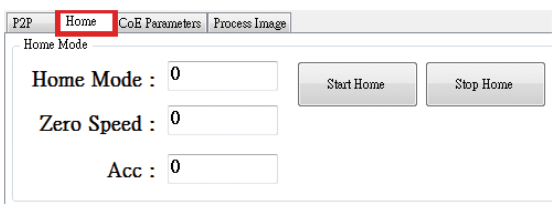
D. Velocity / Acceleration / Deceleration

Change those velocity parameters by moving scroll bar.

E. Home Mode (Home Page)

Key in the "**Home Mode**" set the way of homing which you want. Please refer to the CiA 402 standard for more information.

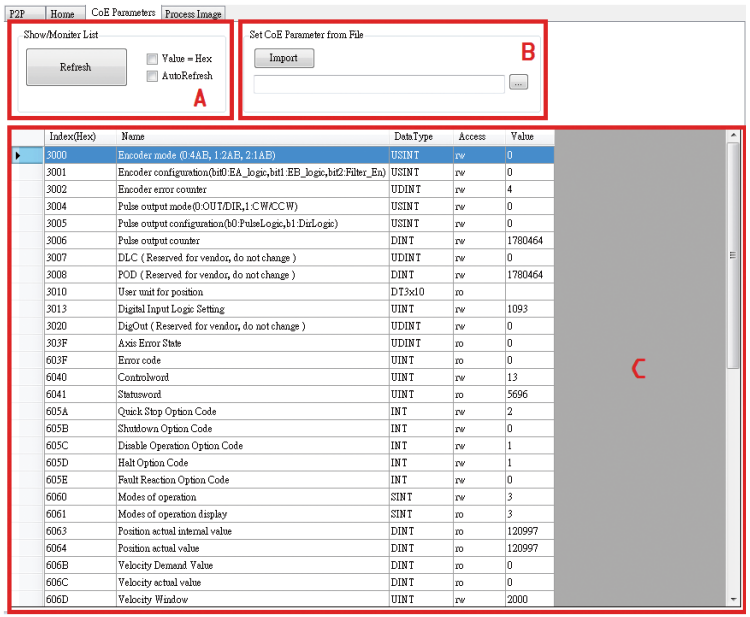
Key in the Velocity and Acceleration.



Home Page

III. CoE-SDO Operation page

In the Motion Form, change the tab to **CoE Parameters**, the CoE operation menu will appear. NexCAT will automatically determine whether the slave device supports CiA 402.



Index(Hex)	Name	DataType	Access	Value
3000	Encoder mode (0:4AB, 1:2AB, 2:1AB)	USINT	rw	0
3001	Encoder configuration(bit0:EA_logic,bit1:EB_logic,bit2:Filter_En)	USINT	rw	0
3002	Encoder error counter	UDINT	rw	4
3004	Pulse output mode(0:OUT/DIR,1:CW/CCW)	USINT	rw	0
3005	Pulse output configuration(b0:PulseLogic,b1:DirLogic)	USINT	rw	0
3006	Pulse output counter	DINT	rw	1780464
3007	DLC (Reserved for vendor, do not change)	UDINT	rw	0
3008	POD (Reserved for vendor, do not change)	DINT	rw	1780464
3010	User unit for position	DT3x10	ro	
3013	Digital Input Logic Setting	UINT	rw	1093
3020	DigOut (Reserved for vendor, do not change)	UDINT	rw	0
303F	Axis Error State	UDINT	ro	0
603F	Error code	UINT	ro	0
6040	Controlword	UINT	rw	13
6041	Statusword	UINT	ro	5696
605A	Quick Stop Option Code	INT	rw	2
605B	Shutdown Option Code	INT	rw	0
605C	Disable Operation Option Code	INT	rw	1
605D	Halt Option Code	INT	rw	1
605E	Fault Reaction Option Code	INT	rw	0
6060	Modes of operation	SINT	rw	3
6061	Modes of operation display	SINT	ro	3
6063	Position actual internal value	DINT	ro	120997
6064	Position actual value	DINT	ro	120997
606B	Velocity Demand Value	DINT	ro	0
606C	Velocity actual value	DINT	ro	0
606D	Velocity Window	UINT	rw	2000

Section A:

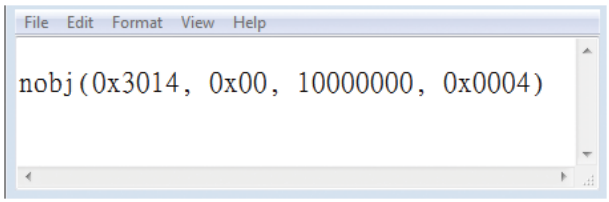
Press the **Refresh** button and this will update parameter values automatically, the user can choose to display in decimal or hexadecimal format. If a parameter is float, then the parameter from binary system will display in float.

Section B:

If user wants to write parameters by .txt file, this function can be used. The user needs to browse the files which the users need, then press Import button.

Note: Please follow the below format:

Ex: nobj(Index, Sub Index, Value, byte Length)

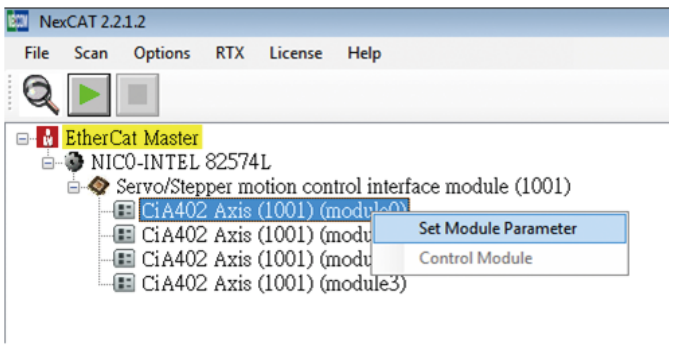


Section C:

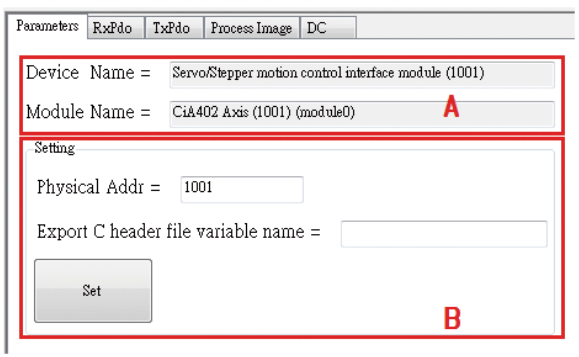
If the user wants to change parameters value, you can use the mouse, click the left mouse button twice quickly, you may edit the parameters value. After editing is completed, press the **Enter** key or leave the table then it can be successfully written. If the write fails or does not meet the standard written format data form, the parameter values will automatically go back to the state before editing.

IV. Set Slave Parameters

Select the slave device and right click to show a pop-up menu, choose "**set slave parameters**". Slave device setting page must be used before start of the Network, because all the parameters changed are valid only before start of Network. If user changed the setting after the start of Network, the network must be restarted.



1. Parameters Tab



A.

Device Name: Show the name of current selected slave device.
Module Name: Show the name of current selected moduler device.

B.

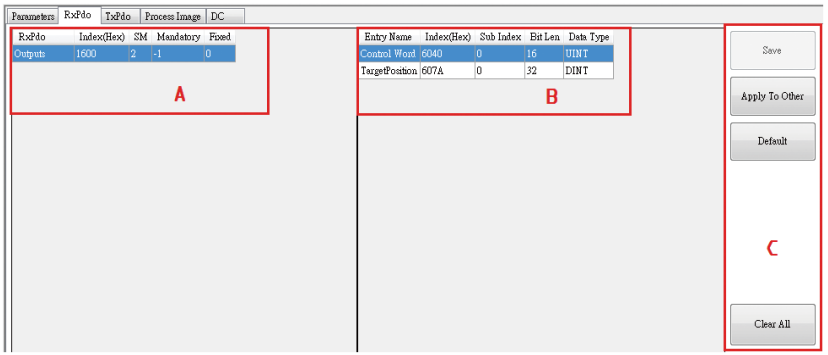
Physical Addr: Define the node address (configured address) for a slave device.
Export C header file variable name: Export the process image for each slave, it must be used with function "Export C file" of Master Parameters setting.

```
#define _Physical Addrdsss(+variable name)_ObjectName
[ProcessData offset]
```

Example:
Export C header file variable name= "_AXIS"
Export C header will be:

```
#define _1001_AXIS_Statusword 16777216
#define _1001_AXIS_PositionActualValue 16777218
#define _1001_AXIS_VelocityActualValue 16777222
#define _1001_AXIS_Controlword 16777216
#define _1001_AXIS_TargetPosition 16777218
```

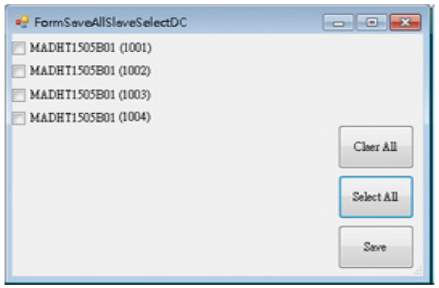
2. RxPdo & TxPdo Tab



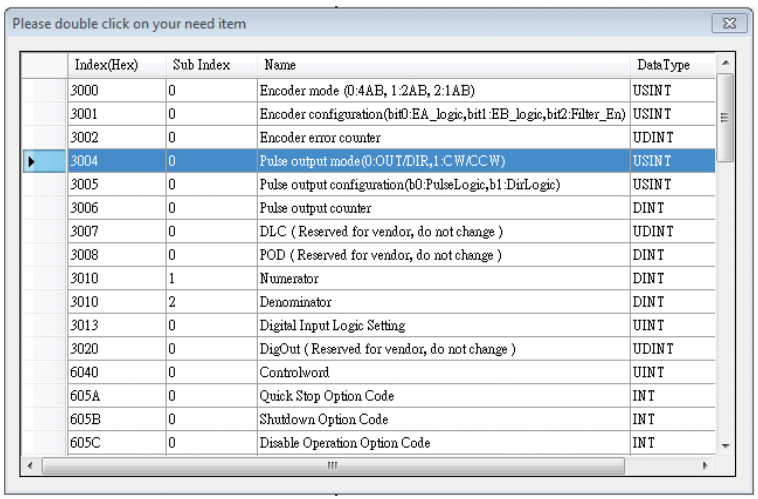
A.
RxPdo(TxPdo) Name: Default name is from ESI file, user can change and then export to ENI
Index: Parameters from CoE. Changes are not recommended
SM: Number of Sync Manager, user can change
Mandatory: Define the necessary parameters
Fixed: Defines the parameter whether the user can change

B.
Entry Name: From CoE, user can change, export to ENI
Indicator: Parameter from CoE. Changes are not recommended
Sub Indicator: Parameter from CoE. Changes are not recommended
BitLen: Parameter from CoE. Changes are not recommended
DataType: Parameter from CoE. Changes are not recommended
Save Button: Save after the editing
Default Button: Back to default ESI setting
Clear All Button: Clear PDO setting

Apply To Other: Apply current slave device's settings to other slaves. Click the button pop up following dialog.

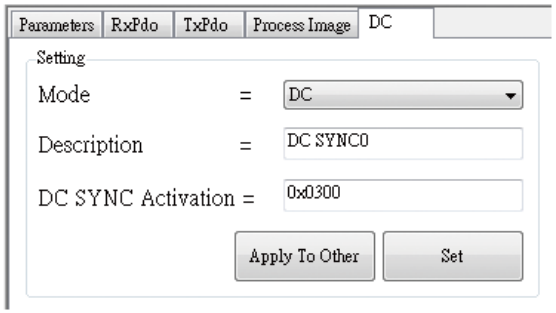


Note: Please double click the item what you want to add/insert/edit.



3. DC tab

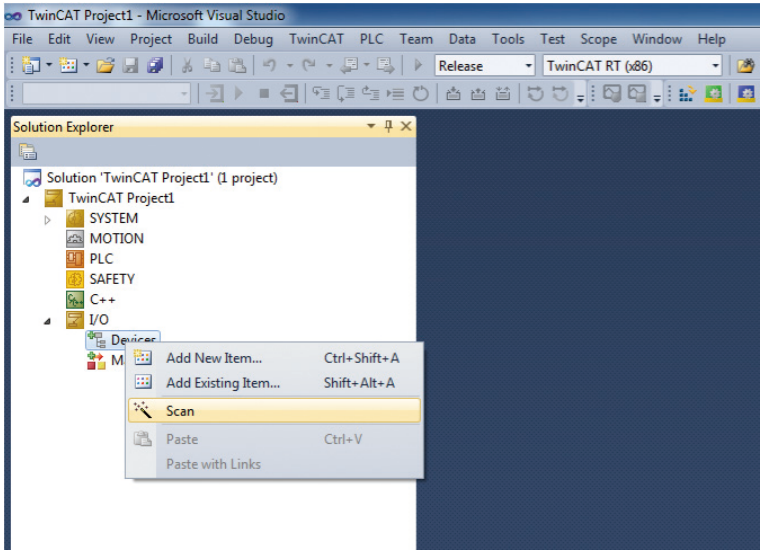
This tab is used to set DC mode. Default DC settings are from ESI file.

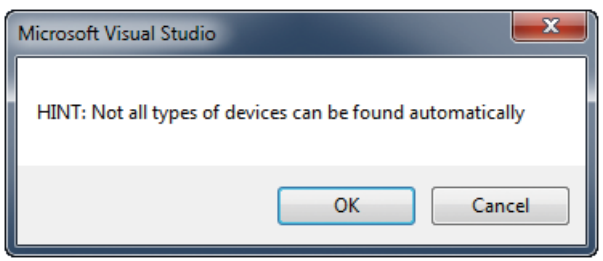


3.2.2 Operation with TwinCAT

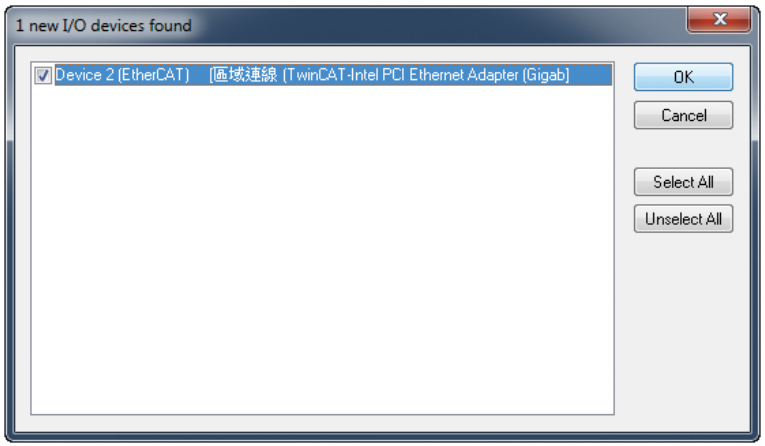
I. Scan AXE-5904

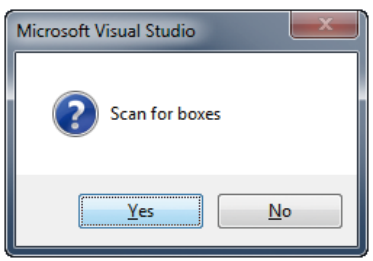
Create a new TwinCAT project, then right click the **Devices**, click "**Scan**"



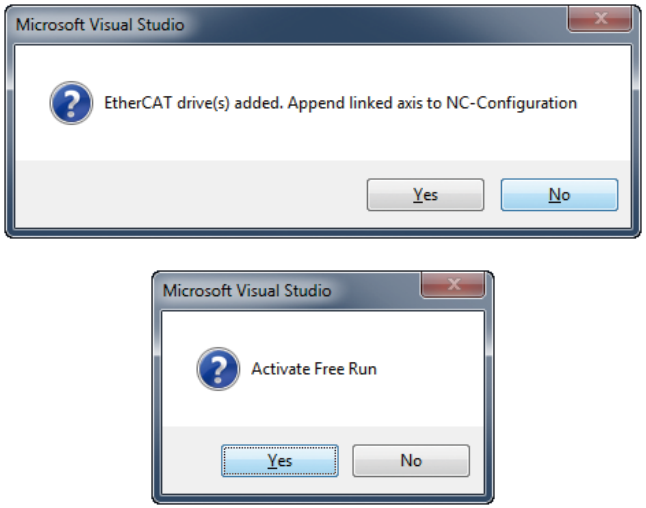


Choose the network interface card which you assigned to TwinCAT, and click "**OK**".

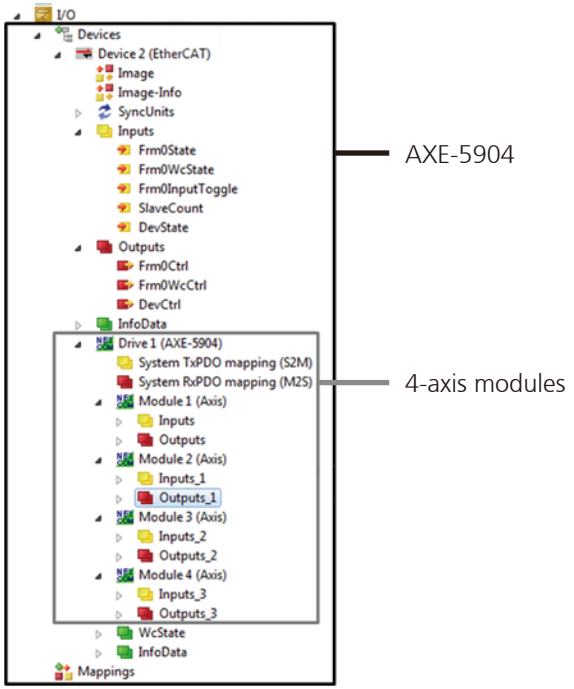




Don't append linked axis to NC-Configuration and activate **Free Run**.



After successful scanning, you can see the AXE-5904 in TwinCAT project.



AXE-5904 has 4 expansion modules, one module is expanded in this case, after successful scanning, double click this module, user can see Statusword and actual position in "**Inputs**", Controlword and target position in "**Outputs**".

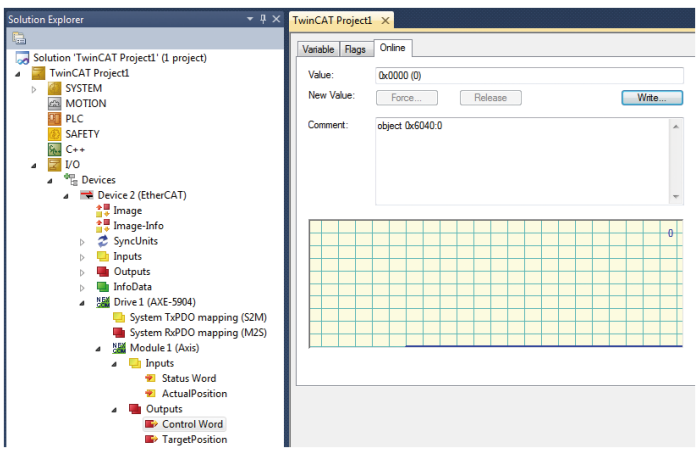
We can use Controlword and Statusword to control and monitor the CiA 402 state machine in a module of AXE-5904.

II. Operation Enabled

The AXE-5904 can support CiA 402 operation mode as follows:

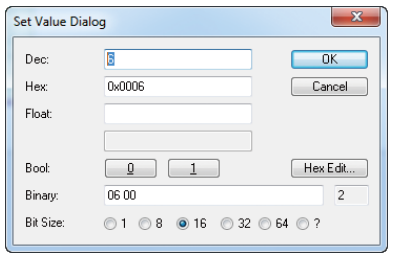
- Profile Position mode
- Homing mode
- Profile Velocity mode
- Cyclic Sync Position mode

Before executing these operations, the state machine must transit into "**Operation Enabled**" state. We can change the state via "**Control Word**".

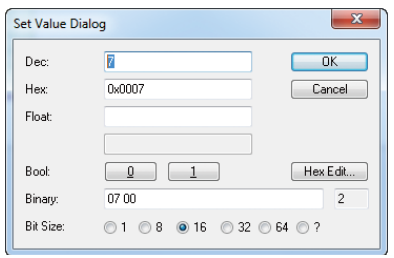


Double click "**Control Word**", then click "**Write...**", type **6** -> **7** -> **15**, the Statusword will show **0x0237** then it will be in "**operation enabled**" state.

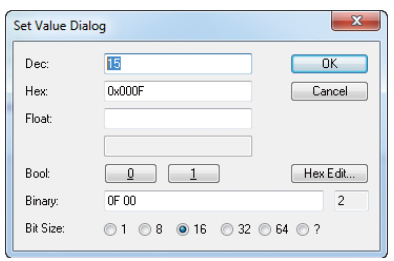
6: Shutdown



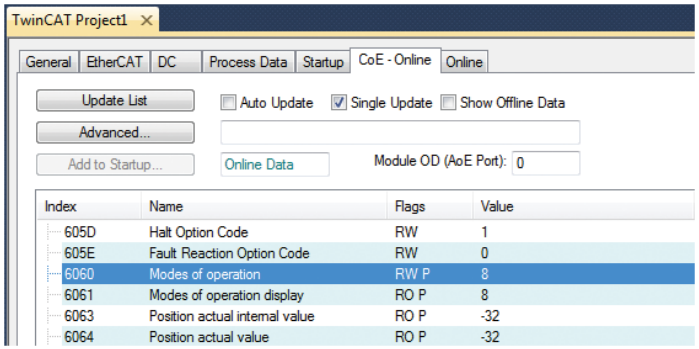
7: Switch on



15: Enable operation



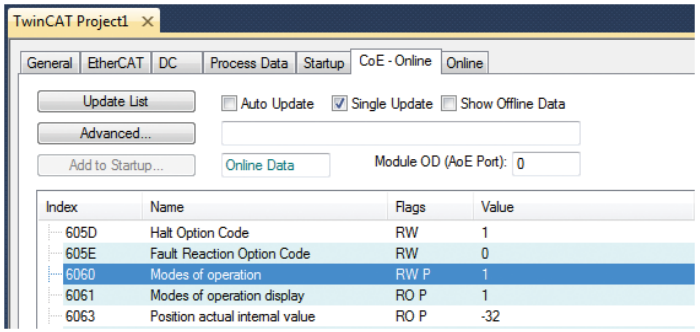
III. Mode of Operation setting



Number	Operation Mode
1	Profile Position mode
3	Profile Velocity mode
6	Homing mode
8	Cyclic Sync Position mode

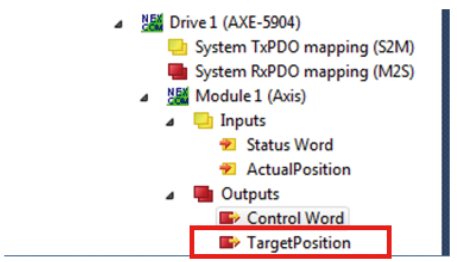
The default operation mode is Cyclic Sync Position mode (CSP).

IV. Operation Example: PP Mode



Change the Modes of operation from 8(CSP) to 1(PP), then we can begin the PP mode operation.

Set the target position value in the "Outputs". Then Set Control Word bit4 from 0 to 1, the PP mode will be activated immediately. The motor should rotate according to target position.



3.3 NexECM Programming Guide

After NexECM is ready, you can use NexECMRtx sample to control AXE-5904. The following steps describe how to use NexECMRtxStartup.exe to control AXE-5904. In this case, AXE-5904 is connected with a pulse motor.

Step1: Open NexECMRtx Sample and modify it

Open the sample solution which is located in "**C:\Program Files\NEXCOM\NexECMRtx\Samples**" and choose the project **SampleCiA402P2p** which use **NexECMRtx API** to start/control EtherCAT master and use **NexCoEMotion API** to control CiA 402 servo motor. After the sample is opened, find the `NEC_CoE402GetAxisId()` and replace with `NEC_CoE402GetAxisIdEx()*1`. Then, build the project to produce RTSS executable file running in the RTX environment.

`*1 NEC_CoE402GetAxisId()` is for "**single device single axis**" and `NEC_CoE402GetAxisIdEx()` is for "**single device multi-axes"**. (Please refer to Nexcom EtherCAT master CiA 402 servo control API manual to know the details about these two APIs.)

Step 2: Open NexCAT and export ENI file

NexCAT can import ESI file and export ENI file. After scanning and starting the network successfully, the ENI file will be exported automatically to the default location "**C:\ENI_NexCAT_Export.xml**". For more about NexCAT, please refer to NexECMRtx user manual.

Step 3: NexECMRtxStartup

NexECMRtxStartup.exe is a convenient tool for developer. Based on NexECMRtxConfig.ini, the tool offers 3 functions:

1. Load EtherCAT Master - NexECMRtx.rtss
2. Download ENI file (EtherCAT Network Information)
3. Load user's RTX application (ex: User RTXApp.rtss)

You can modify NexECMRtxConfig.ini content using "Notepad" or other text editing software to meet your current files placed circumstances. Usually, you only need to modify the Application path. You can find those two files at "**C:\Program Files\NEXCOM\NexECMRtx\tools**" path. For more information please refer to the section **NexECMRtxStartup** in **NexECMRtx** user manual.

After following the above steps, double click the **NexECMRtxStartup.exe** to execute **NexECMRtx**, load ENI and execute your program.

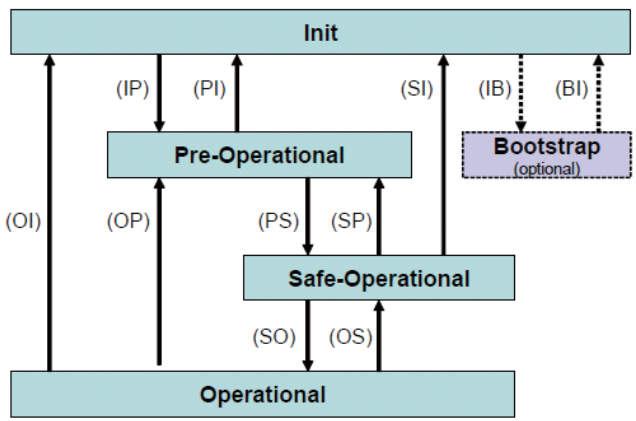
For more information on how to program using **NexECM**, please refer to **NEXCOM EtherCAT master for RTX user manual** and **NEXCOM EtherCAT Master CiA 402 Servo Control API manual**.

3.4 EtherCAT State Machine

According to EtherCAT(EC) standard, EC slave is responsible for maintaining a state machine to co-ordinate the slave applications at start up and during operation. Typically, state change is requested by the master. There are 5 states:

1. Init (INIT)
2. Pre-operation (PREOP)
3. Safe-operation (SAFEOP)
4. Operation (OP)
5. Bootstrap (Not used)

The following figure shows the possibility of state change.



The behavior of AXE-5904 for each EtherCAT state:

State / Transition	Service for Master
INIT	▪ DL-register can be access ▪ No process data (PDO) communication ▪ No mailbox communication (SDO)
PREOP	▪ Mailbox communication (SDO) is active ▪ No process data (PDO) communication
SAFEOP	▪ Mailbox communication is active ▪ Process data communication (PDO) for input is active ▪ No Process data communication for output
OP	▪ Mailbox communication is active ▪ Process data communication (PDO) is active

3.5 PDO Mapping

PDO mapping are the mapping of application objects (real time process data) from the object dictionary to the PDOs. The PDO mapping tables of each axis are allocated to index 1600h to 1630h for the RxPDOs and 1A00h to 1A30h for the TxPDOs in the object dictionary.

The default mapping objects are as below:

Axis0

RxPDO (0x1600)	Controlword (0x6040)	Target Position (0x607A)
TxPDO (0x1A00)	Statusword (0x6041)	Actual Position (0x6064)

Axis1

RxPDO (0x1610)	Controlword (0x6840)	Target Position (0x687A)
TxPDO (0x1A10)	Statusword (0x6841)	Actual Position (0x6864)

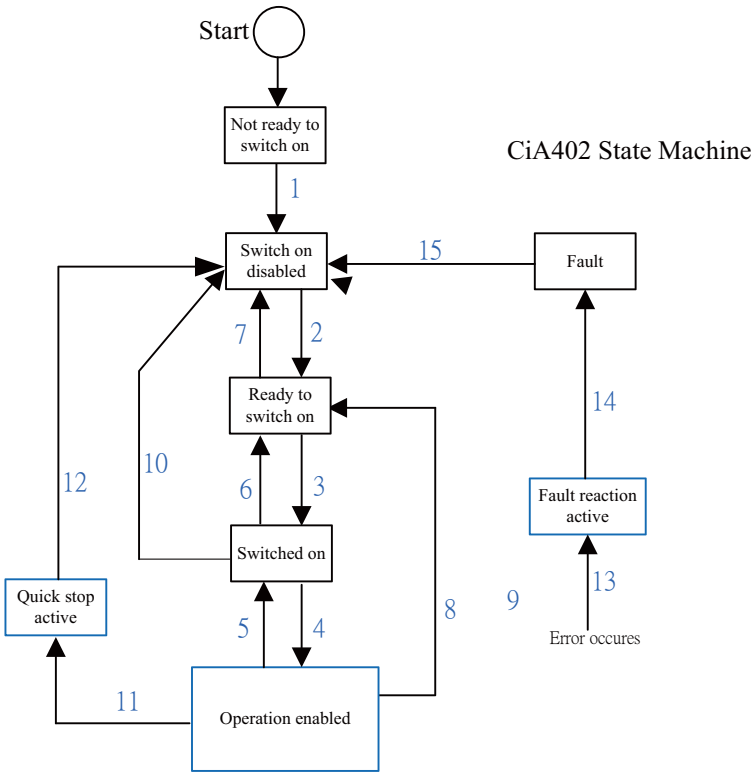
Axis2

RxPDO (0x1620)	Controlword (0x7040)	Target Position (0x707A)
TxPDO (0x1A20)	Statusword (0x7041)	Actual Position (0x7064)

Axis3

RxPDO (0x1630)	Controlword (0x7840)	Target Position (0x787A)
TxPDO (0x1A30)	Statusword (0x7841)	Actual Position (0x7864)

3.6 CiA 402 Device State Machine



CiA402 State Machine

*1. When power is on, AXE-5904 will automatically transition to "**Switch on disabled**" state.

State Machine Controlling Command and Transition
(Object 6040h + 800h * n Axis, n = 0~3)

Transition Number	Command	Bit7	Bit3	Bit2	Bit1	Bit0	Comment
1 or 14	—	—	—	—	—	—	Automatic transition
13	—	—	—	—	—	—	Fault signal occurs Automatic transition
2 or 6 or 8	Shutdown	0	—	1	1	0	
3	SwitchOn	0	0	1	1	1	
3 + 4	SwitchOn + EnableOP	0	1	1	1	1	
7 or 9 or 10 or 12	Disable Voltage	0	—	—	0	—	
11	Quick stop	0	—	0	1	—	
5	Disable Operation	0	0	1	1	1	
4	Enable operation	0	1	1	1	1	
15	Fault Reset	0->1	—	—	—	—	

Please refer to section 2.6.3 for more information about the value of statusword in each state.

3.7 Modes of operation

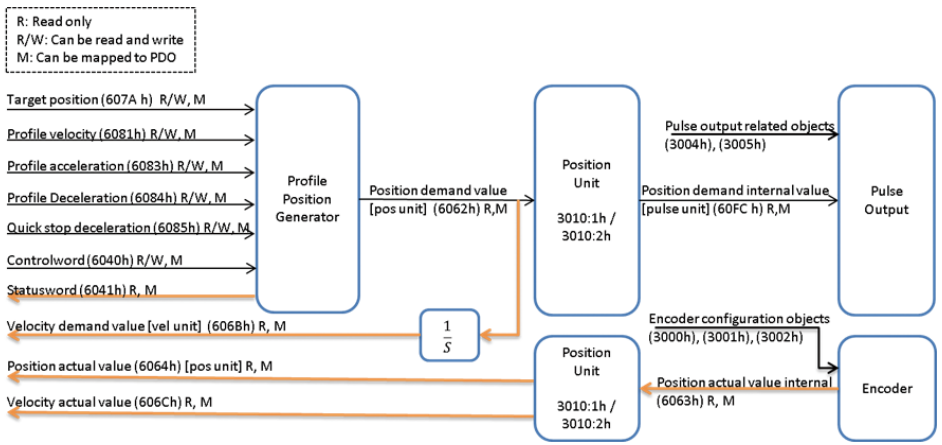
AXE-5904 supports the following modes of operation:

1. Profile position mode (PP)
2. Profile velocity mode (PV)
3. Homing mode (HM)
4. Cyclic Sync Position mode (CSP)

The related object:
(Mode of operation: 6060h + 800h * n Axis, n = 0~3)
(Mode of operation Display: 6061h + 800h * n Axis, n = 0~3)

3.7.1 Profile Position Mode

The "**profile position mode**" is used to start positioning to the target position with the profile velocity and the profile acceleration.
The following figure shows the block diagram of the profile position mode.

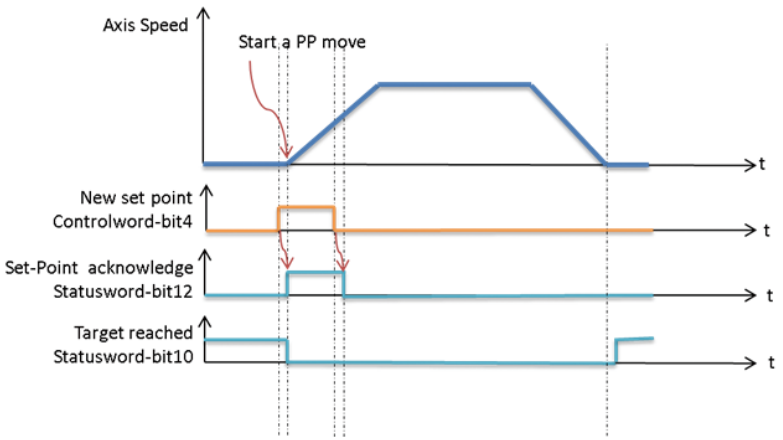


Related Objects

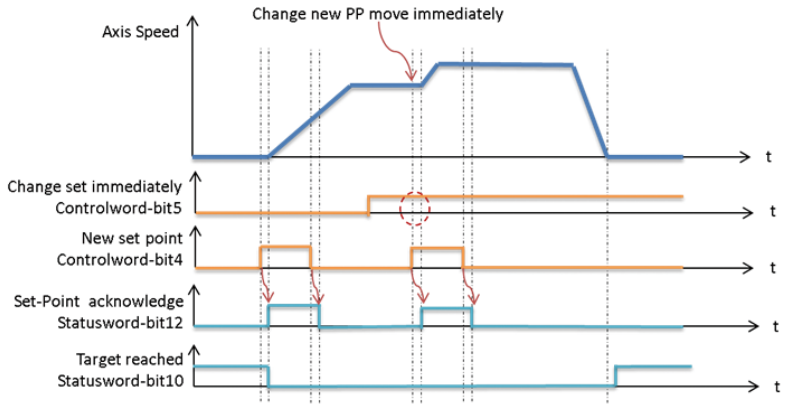
Index	Sub	Name	Data Type	Access	PDO Mapping	Unit
0x6040	0	Controlword	UINT	RW	Yes	—
0x6041	0	Statusword	UINT	RO	Yes	—
0x607A	0	Target Position	DINT	RW	Yes	Pos units
0x6081	0	Profile Velocity	UDINT	RW	Yes	Vel units
0x6083	0	Profile Acceleration	UDINT	RW	Yes	Acc units
0x6084	0	Profile Deceleration	UDINT	RW	Yes	Acc units
0x6085	0	Quick Stop Deceleration	UDINT	RW	Yes	Acc units
0x6064	0	Position Actual Value	DINT	RO	Yes	Pos units

The operation flow of start a position move (PTP):

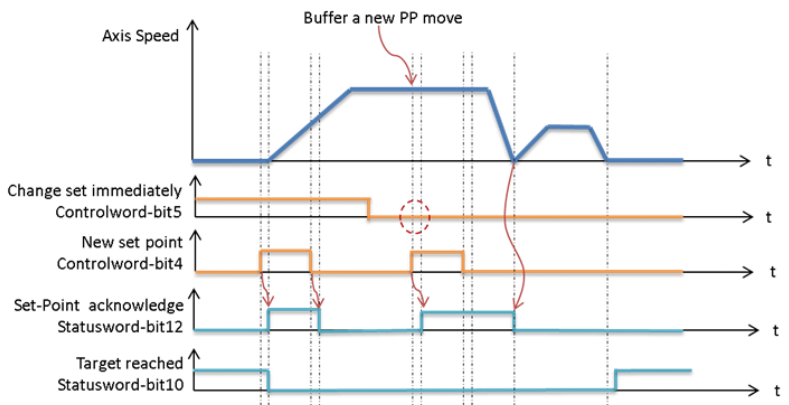
- Set profile velocity, acceleration, deceleration and quick stop deceleration objects (optional)
- Set "target position"
- Set controlword bit 4 on
- Check statusword bit 12 is turned on
- Set controlword bit 4 off



Change a PP move on the fly (Change set immediately bit = = 1)



Buffer a PP move. (Change set immediately bit = = 0)

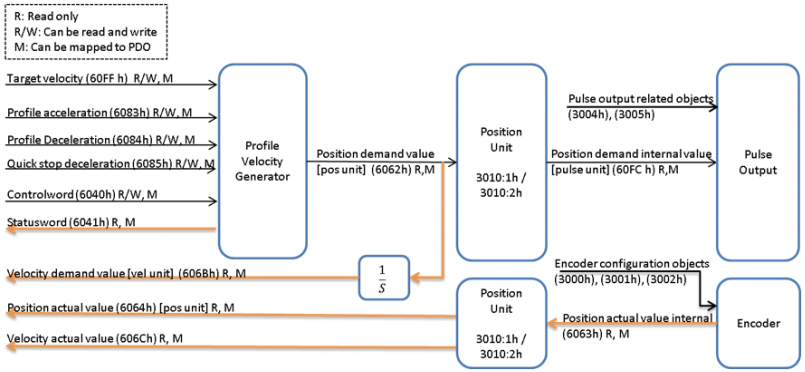


Note: Buffer size is 1. If a change PP on the fly is performed, buffer will also be cleared.

3.7.2 Profile Velocity Mode

In the "**profile velocity mode**", the speed is output in accordance with the "**Profile Acceleration**" and "**Profile Deceleration**", until it reaches the target velocity.

The following figure shows the block diagram of the Profile Velocity mode.

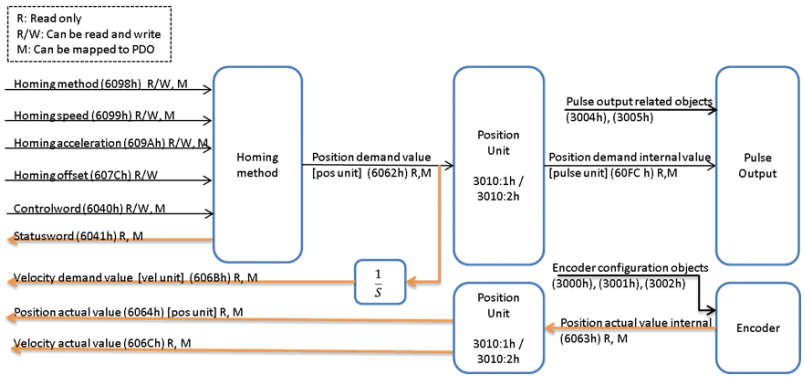


Related Objects

Index	Sub	Name	Data Type	Access	PDO Mapping	Unit
0x6040	0	Controlword	UINT	RW	Yes	—
0x6041	0	Statusword	UINT	RO	Yes	—
0x60FF	0	Target Velocity	DINT	RW	Yes	Vel units
0x6083	0	Profile Acceleration	UDINT	RW	Yes	Acc units
0x6084	0	Profile Deceleration	UDINT	RW	Yes	Acc units
0x6085	0	Quick Stop Deceleration	UDINT	RW	Yes	Acc units
0x606C	0	Velocity Actual Value	DINT	RO	Yes	Vel units

3.7.3 Homing Mode

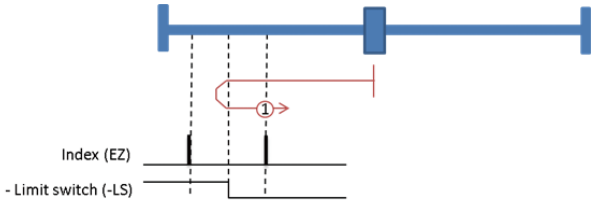
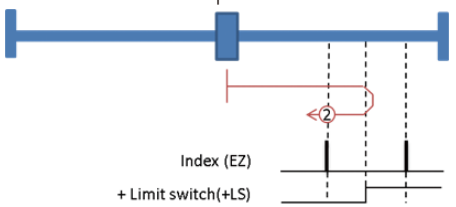
The following figure shows the defined input objects as well as the output objects. The user may specify the speeds, acceleration and the method of homing. There is a further object home offset, which allows the user to displace zero in the user's co-ordinate system from the home position.

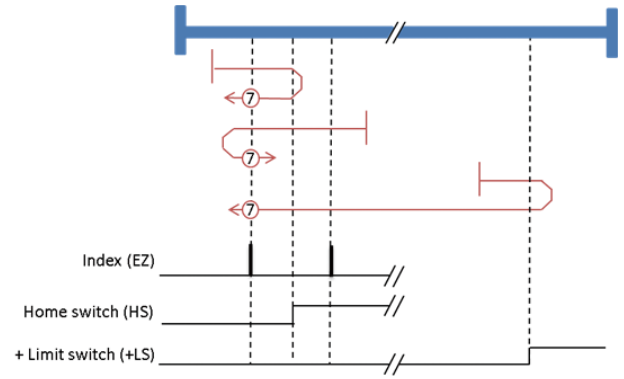
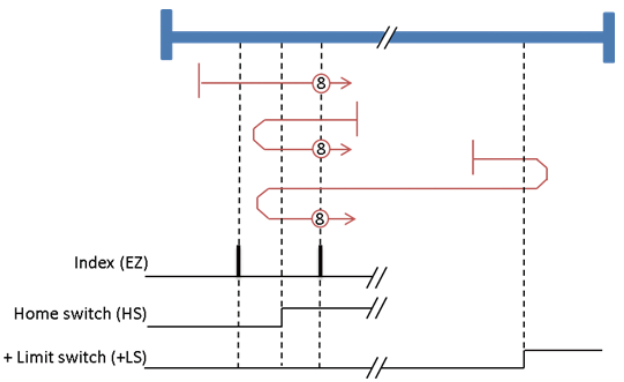


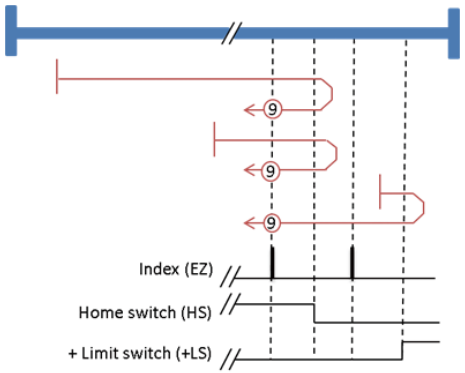
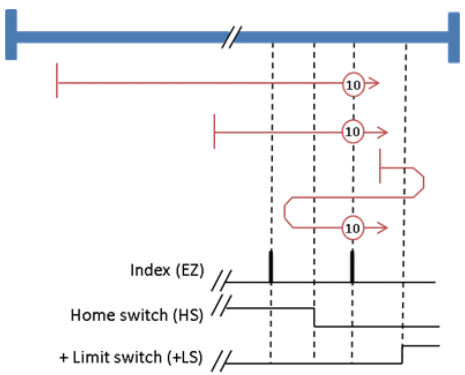
Related Objects

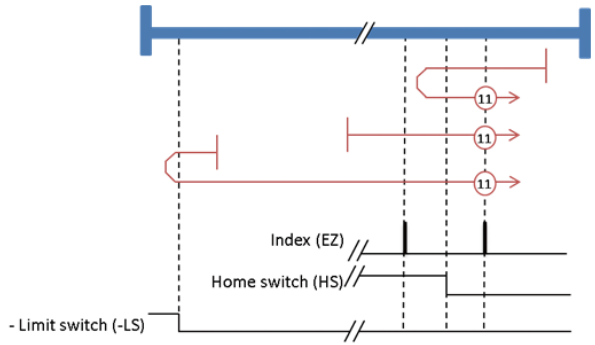
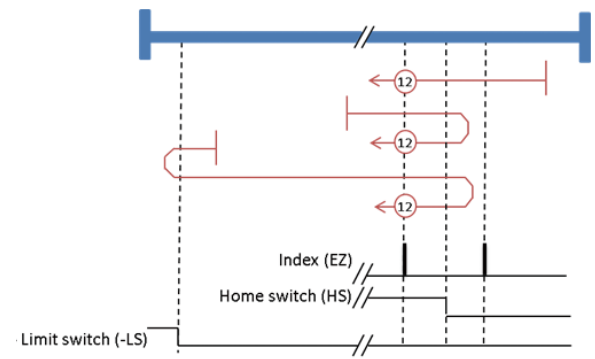
Index	Sub	Name	Data Type	Access	PDO Mapping	Unit
0x6040	0	Controlword	UINT	RW	Yes	—
0x6041	0	Statusword	UINT	RO	Yes	—
0x607C	0	Home Offset	DINT	RW	No	Pos units
0x6098	0	Homing Method	SINT	RW	Yes	—
0x6099	—	Homing Speeds	—	—	—	—
	1	Speed during search for switch	UDINT	RW	Yes	Vel units
	2	Speed during search for zero	UDINT	RW	Yes	Vel units
0x609A	0	Homing Acceleration	UDINT	RW	Yes	Acc units

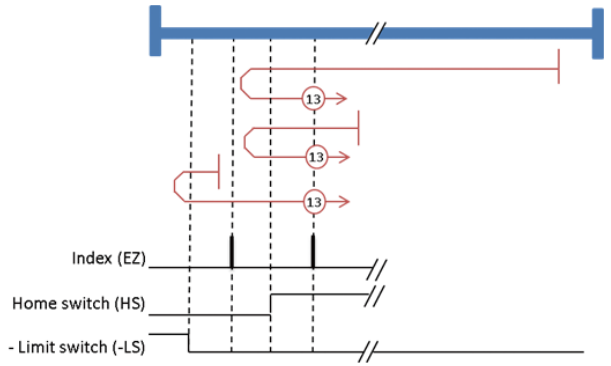
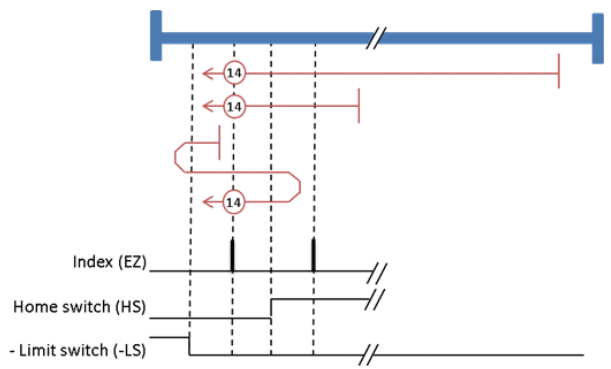
Homing Method

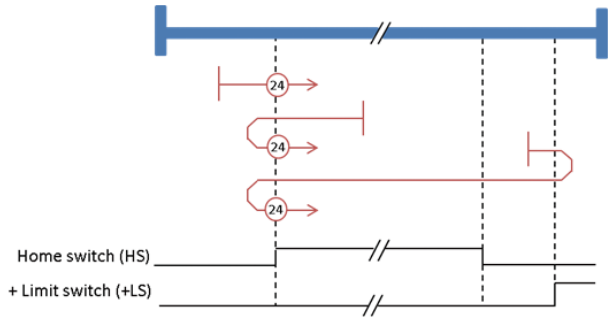
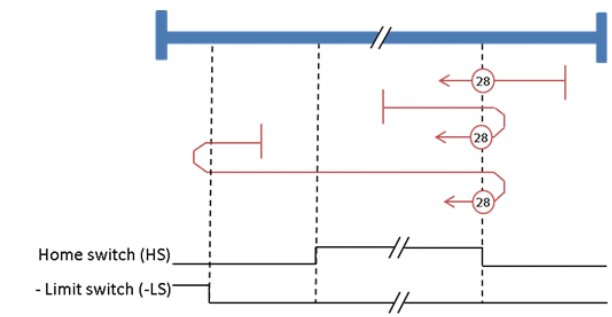
Value	Description
0	No homing
1	Homing on the negative limit switch and index pulse 
2	Homing on the positive limit switch and index pulse 

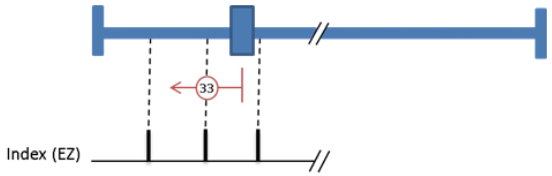
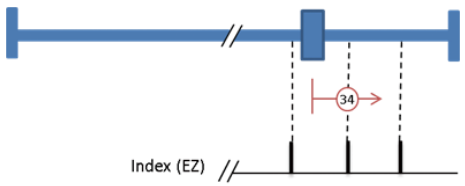
Value	Description
7	Homing on falling edge of home switch and negative side of index pulse Positive initial motion direction 
8	Homing on rising edge of home switch and positive side of index pulse Positive initial motion direction 

Value	Description
9	Homing on rising edge of home switch and negative side of index pulse Positive initial motion direction 
10	Homing on falling edge of home switch and negative side of index pulse Positive initial motion direction 

Value	Description
11	Homing on falling edge of home switch and positive side of index pulse Negative initial motion direction 
12	Homing on rising edge of home switch and negative side of index pulse Negative initial motion direction 

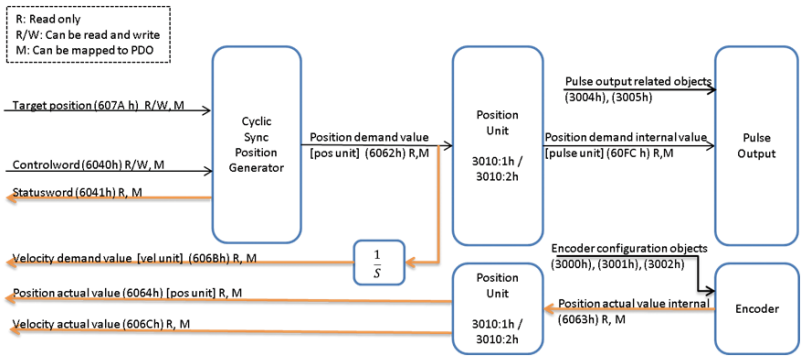
Value	Description
13	Homing on rising edge of home switch and positive side of index pulse Negative initial motion direction 
14	Homing on falling edge of home switch and negative side of index pulse Negative initial motion direction 

Value	Description
24	Homing on home switch Positive initial motion direction 
28	Homing on home switch Negative initial motion direction 

Value	Description
33	Homing on index pulse Negative initial motion direction 
34	Homing on index pulse Positive initial motion direction 
35	Homing on the current position. Can be operation without enable state

3.7.4 Cyclic Sync Position Mode

The Cyclic Synchronous Position mode is used for the interpolated positioning. The interpolation time period defines the interval at which the target position is updated. Interpolation is performed in accordance with this setting. The target position is interpreted as absolute value.
The following figure shows the block diagram of the Cyclic Synchronous Position mode.

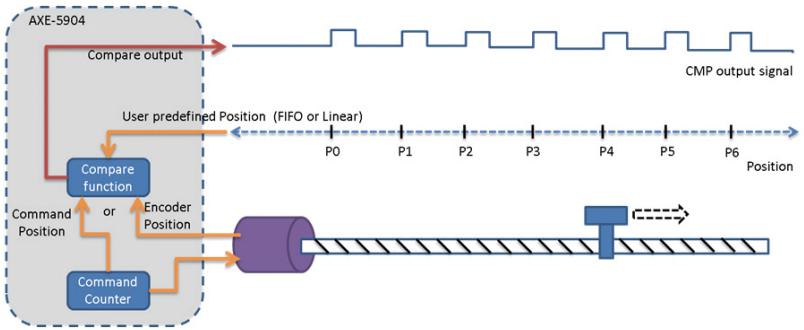


Related Objects

Index	Sub	Name	Data Type	Access	PDO Mapping	Unit
0x6040	0	Controlword	UINT	RW	Yes	—
0x6041	0	Statusword	UINT	RO	Yes	—
0x607A	0	Target Position	DINT	RW	Yes	Pos units
0x6064	0	Position Actual Value	DINT	RO	Yes	Pos units

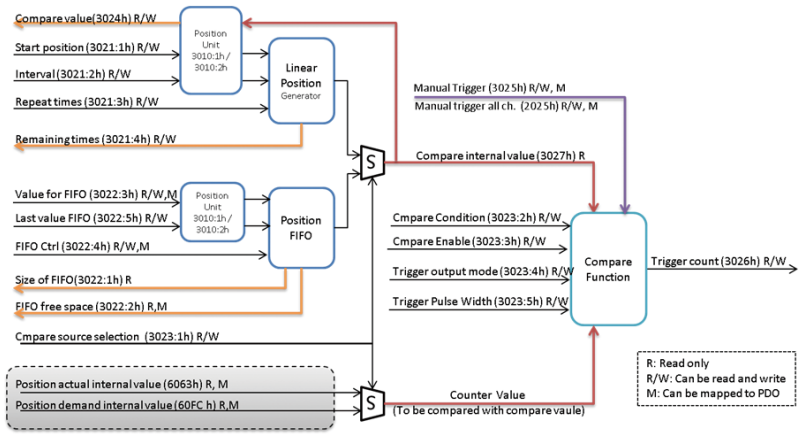
3.8 Compare Trigger Functions

AXE-5904 provides 4 channel hardware based high-speed compare trigger output for each axis.



Users can predefine the position (or say compare value) into the hardware and when compare function is enabled it compares the counter value and pre-defined value continuously. When comparing condition is matched the AXE-5904 will output a pulse signal to connected devices.

The following figure shows the function block of the compare function of a channel:



Each channel provides two sources of compare value:

- Linear position generator: Can generate linear positions for compare function
- Position FIFO: Can define any position value to FIFO

For position sources, the unit of position is "pos unit". When you configure the objects of these two sources, the compare position will be translated into "pulse unit" according to current co-ordinate system. Therefore, if the co-ordinate system is changed, you should re-configure the position sources.

Two sources of counter value:

- Position actual internal value: Pulse counts encode from AB phase signal and the encoder counter value is maintained by hardware.
- Position demand internal value: A pulse output counter which is maintained by hardware

User could set compare sources via object 3023:1h.

For “linear position generator”, it can generate linear positions automatically to compare function. It has 3 objects to be set.

Index	Sub	Name	Data Type	Access	PDO Mapping	Description
3021h	1	Start Position	I32_T	RW	No	The first point of linear position
	2	Interval	I32_T	RW	No	Linear interval, can be negative value
	3	Repeat times	U32_T	RW	No	Repeat times of linear position

The linear position formula:
Linear position = Start Position + Interval x N (N = 0 ~ Repeat times)
The amount of trigger count will be: Repeat times + 1

For example:
Case1: Start position = 0, Interval = 10, Repeat times = 3

NO.	P0	P1	P2	P3
Position	0	10	20	30

Case 2: Start position = -10, Interval = -20, Repeat times = 5

NO.	P0	P1	P2	P3	P4	P5	P6
Position	-10	-30	-50	-70	-90	-110	-130

For "Position FIFO", you can set any position to FIFO. The related objects are as follows:

Index	Sub	Name	Data Type	Access	PDO Mapping	Description
3021h	1	Size of FIFO	U16_T	RO	No	Show the depth of FIFO
	2	FIFO free space	U16_T	RO	Yes	Show how many free space in FIFO
	3	Value for FIFO	I32_T	RW	Yes	FIFO will not be push to FIFO until FIFO Ctrl be set
	4	FIFO Ctrl	U8_T	RW	Yes	B0: FIFO Reset (0->1) B1: FIFO Push (0->1 or 1->0) B2: FIFO Pop(0->1or 1->0)
	5	Last value in FIFO	I32_T	RW	No	"For Read: Read Last value in FIFO For Write: Pust the value into FIFO"

There are two ways to push value to FIFO:

1. Using object 3022:3h and 3022:4h
- Write position value to 3022:3h
- Change the state of bit 1 of 3022:4h, when bit state is inversed, the value stored in 3022:3 will be pushed to FIFO
- To read 3022:5h, you can check the last value in FIFO

2. Using object 3022:5h
- Write position value to 3022:5h, the value will be pushed to FIFO directly
- To read 3022:5h, you can check the last value in FIFO

The major difference between these two ways is object 3022:3h and 3022:4h can be mapped to process data, but object 3022:5h cannot. If you want to feed the FIFO (dynamically) when compare trigger is running. You can use "**way 1**" and map those objects to "**PDO**". It can speed up the feed rate. On the other hand, the "**way 2**" is an easy way to feed the FIFO but in lower feed rate (because it can only go through SDO command). If you don't care about the feed rate, you can use this way to feed the FIFO more easily.

3.8.1 Setting flow using linear position generator

The operation flow of comparing using linear position generator:

- Disable CMP (object 3023:3h set 0)
- Select value source as linear (object 3023:1h)
- Set start, interval, repeat (object 3021:1, 3021:2, 3012:3)
- Set CMP condition (object 3023:2h)
- Enable CMP (object 3023:3h set 1)

When CMP is enabled, those setting is loaded. You cannot change the setting when CMP is enabled.

The other parameter can be set no matter if CMP is enabled or disabled.

- Pulse output logic (object 3023:4h)
- Pulse / Toggle output mode (object 3023:4h)
- Pulse width (object 3023:5h)

3.8.2 Setting flow using position FIFO

The operation flow of comparing using position FIFO:

- Disable CMP (object 3023:3h set 0)
- Select source as FIFO (object 3023:1h)
- Reset FIFO, Push FIFO value (Option, cannot shift the FIFO before Enable CMP)
- Set CMP condition (object 3023:2h)
- Enable CMP (object 3023:3h set 1)

When CMP is enabled, those setting is loaded. You cannot change the setting when CMP is enabled.

The other parameter can be set no matter if CMP is enabled or disabled.

- Reset, Push FIFO
- Pulse output logic (object 3023:4h)
- Pulse / Toggle output mode (object 3023:4h)
- Pulse width (object 3023:5h)

Note: The FIFO must be re-feed when position unit is changed or homing operation is done.

Chapter 4: Object Dictionary

4.1 Architecture of Object Dictionary

Index (Hex)	Meaning
0x0000~0x0FFF	Reserved
0x1000~0x1FFF	CoE communication objects
0x2000~0x5FFF	Manufacturer specific, special function for AXE-5904 For Axis
0x6000~0x7FFF	CANOpen profile specific for CiA 402 for AXE-5904

Index (Hex)	Meaning
0x3000~0x37FF	For Axis 0
0x3800~0x3FFF	For Axis 1
0x4000~0x47FF	For Axis 2
0x4800~0x4FFF	For Axis 3

Index (Hex)	Meaning
0x6000~0x7FFF	CANOpen profile specific for CiA 402 for AXE-5904 For Axis
0xF000~0xF100	Modular device profile

Index (Hex)	Meaning
0x3000~0x37FF	For Axis 0
0x3800~0x3FFF	For Axis 1
0x4000~0x47FF	For Axis 2
0x4800~0x4FFF	For Axis 3

4.2 Object Type and Attributes

4.2.1 Object Data Type

Code	C/C++ type	Description	Size (byte)	Range
USINT	U8_T	unsigned char	1	0 ~ 255
UINT	U16_T	unsigned short	2	0 ~ 65535
UDINT	U32_T	unsigned int	4	0 ~ 4294967295
SINT	I8_T	char	1	-128 ~ 127
INT	I16_T	short	2	-32768 ~ 32767
DINT	I32_T	int	4	-2147483648 ~ 2147483647
STRING	N/A	String value	--	Depend on string length

4.2.2 Object Attributes

Attribute	Description
RO	This object is only for read.
WO	This object is only for write
RW	This object can be read and write

4.3 CoE Communication Objects

4.3.1 Device Type

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1000	0	Device type	UDINT	RO	No	5001

4.3.2 Device Identity

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1018	0	Number of entries	USINT	RO	No	4
	1	Vendor ID	UDINT	RO	No	0x00000752
	2	Product code	UDINT	RO	No	0x59040001
	3	Revision number	UDINT	RO	No	0x00000001
	4	Serial number	UDINT	RO	No	0x00000000

4.3.3 Receive PDO Mapping (Master to Slave)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1600	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x60400010
	2	Mapping entry 2	UDINT	RW	No	0x607A0020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1610	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x68400010
	2	Mapping entry 2	UDINT	RW	No	0x687A0020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1620	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x70400010
	2	Mapping entry 2	UDINT	RW	No	0x707A0020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1630	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x78400010
	2	Mapping entry 2	UDINT	RW	No	0x787A0020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1700	0	Number of objects in this PDO	USINT	RW	No	0
	1	Mapping entry 1	UDINT	RW	No	0x00000000
	2	Mapping entry 2	UDINT	RW	No	0x00000000
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

- The mapping entry is 32 bit value,
  Bit 0~7: Length of object
  Bit 8~15: Sub-index of object
  Bit 16~31: Index of object
- Index: 0x16x0, x = 0~3 for Axis0~3 objects
- Index: 0x1700 for system specific objects
- These objects can be changed only in the EtherCAT Pre-operation state.

4.3.4 Transmit PDO Mapping (Slave to Master)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1A00	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x60410010
	2	Mapping entry 2	UDINT	RW	No	0x60640020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1A10	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x68410010
	2	Mapping entry 2	UDINT	RW	No	0x68640020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1A20	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x70410010
	2	Mapping entry 2	UDINT	RW	No	0x70640020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1A30	0	Number of objects in this PDO	USINT	RW	No	2
	1	Mapping entry 1	UDINT	RW	No	0x78410010
	2	Mapping entry 2	UDINT	RW	No	0x78640020
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1B00	0	Number of objects in this PDO	USINT	RW	No	0
	1	Mapping entry 1	UDINT	RW	No	0x00000000
	2	Mapping entry 2	UDINT	RW	No	0x00000000
	3	Mapping entry 3	UDINT	RW	No	0x00000000
	4	Mapping entry 4	UDINT	RW	No	0x00000000
	5	Mapping entry 5	UDINT	RW	No	0x00000000
	6	Mapping entry 6	UDINT	RW	No	0x00000000
	7	Mapping entry 7	UDINT	RW	No	0x00000000
	8	Mapping entry 8	UDINT	RW	No	0x00000000

- The mapping entry is 32 bit value,
- Bit 0~7: Length of object
- Bit 8~15: Sub-index of object
- Bit 16~31: Index of object
- Index: 0x1Ax0, x = 0~3 for Axis0~3 objects
- Index: 0x1B00 for system specific objects
- These objects can be changed only in the EtherCAT Pre-operation state.

4.3.5 Sync Manager Type

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1C00	0	Number of SyncManager channels	USINT	RO	No	4
	1	Type of SyncManager 0	USINT	RO	No	1: Mailbox M2S
	2	Type of SyncManager 1	USINT	RO	No	2: Mailbox S2M
	3	Type of SyncManager 2	USINT	RO	No	3: ProcessData M2S
	4	Type of SyncManager 3	USINT	RO	No	4: ProcessData S2M

4.3.6 Sync Manager PDO Assignment

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1C12	0	Number of RxPDO assignment	USINT	RW	No	0 to 5 (default = 5)
	1	RxPDO mapping index 1	UINT	RW	No	0x1600
	2	RxPDO mapping index 2	UINT	RW	No	0x1610
	3	RxPDO mapping index 3	UINT	RW	No	0x1620
	4	RxPDO mapping index 4	UINT	RW	No	0x1630
	5	RxPDO mapping index 5	UINT	RW	No	0x1700

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1C13	0	Number of TxPDO assignment	USINT	RW	No	0 to 5 (default = 5)
	1	TxPDO mapping index 1	UINT	RW	No	0x1A00
	2	TxPDO mapping index 2	UINT	RW	No	0x1A10
	3	TxPDO mapping index 3	UINT	RW	No	0x1A20
	4	TxPDO mapping index 4	UINT	RW	No	0x1A30
	5	TxPDO mapping index 5	UINT	RW	No	0x1B00

- These objects can be changed only in the EtherCAT Pre-operation state.

4.3.7 Sync Manager Synchronization

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x1C32	0	Number of parameters	USINT	RO	No	1
	1	Synchronization type	UINT	RO	No	0: No sync (Free run)
0x1C33	0	Number of parameters	USINT	RO	No	1
	1	Synchronization type	UINT	R	No	0: No sync (Free run)

- 0x1C32 for SyncMgr 2, 0x1C33 for SyncMgr3.

4.4 Manufacturer Specific Objects – General (0x2000~0x2FFF)

4.4.1 Software Version

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x2000	0	Firmware version (Application)	UDINT	RO	No	--
0x2001	0	Boot loader version	UDINT	RO	No	--
0x2002	0	FPGA version	UDINT	RO	No	--

4.4.2 Manual ID Switch Value

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x2005	0	Manual ID SW Value	UINT	RO	No	--

4.4.3 Manual Trigger Output for All Channel

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x2025	0	Manual Trigger Out All Ch.	USINT	RW	Yes	--

4.5 Manufacturer Specific Objects – Axis (0x3000~0x5FFF)

Index (Hex)	Meaning
0x3000~0x37FF	For Axis 0 manufacturer specific objects
0x3800~0x3FFF	For Axis 1 manufacturer specific objects
0x4000~0x47FF	For Axis 2 manufacturer specific objects
0x4800~0x4FFF	For Axis 3 manufacturer specific objects

The following sections describe object-profiles of Axis0. Axis1~Axis3 are identical as Axis0.

4.5.1 Encoder Mode (0x3000 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3000	0	Encoder mode	USINT	RW	No	0

- Encoder modes:
  - 0:4xAB phase 1:2xAB phase 2:1xAB phase

4.5.2 Encoder Configuration (0x3001 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3001	0	Encoder configuration	USINT	RW	No	0

- Encoder configuration:
  - bit 0: EA logic
  - bit 1: EB logic
  - bit 2: Filter Enable
  - bit 3~7: Reserved (0)

4.5.3 Encoder Error Counter (0x3002 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3002	0	Encoder error counter	UDINT	RW	No	0

- This register indicates the error number of encoder decoded.
- Write any value to clear the encoder error counter.

4.5.4 Pulse Output Mode (0x3004 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3004	0	Pulse output mode	USINT	RW	No	0

- Pulse Output Mode:
  - 0: OUT/DIR 1: CW/CCW
  - 5 ~ 7: disable, not output.

4.5.5 Pulse Output Configuration (0x3005 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3005	0	Pulse output configuration	USINT	RW	No	0

- Bit 0: PUL signal output logic:
  - 0: not inverse, 1: inverse
- Bit1: DIR signal output logic:
  - 0: not inverse, 1: inverse

4.5.6 Axis Configuration (0x3011 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3011	0	Axis Configuration	UINT	RW	No	0

- In homing mode, user can select if the motor has the encoder feedback (actual position).
  - 0: motor with encoder, 1: motor without encoder
- For the motor without encoder feedback, command counter will be used in homing process.

4.5.7 Digital Input Logic Setting (0x3013 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3013	0	DI logic setting	UINT	RW	No	0x0445

- Bit 15~11: Reserved
- Bit 10: Logic Inverse EMG 1: Inverse, 0: Not inverse
- Bit 9: Logic Inverse RDY 1: Inverse, 0: Not inverse
- Bit 8: Logic Inverse EZ 1: Inverse, 0: Not inverse
- Bit 7: Logic Inverse INP 1: Inverse, 0: Not inverse
- Bit 6: Logic Inverse ALM 1: Inverse, 0: Not inverse
- Bit 5: Logic Inverse DI2 1: Inverse, 0: Not inverse
- Bit 4: Logic Inverse DI1 1: Inverse, 0: Not inverse
- Bit 3: Logic Inverse DI0 1: Inverse, 0: Not inverse
- Bit 2: Logic Inverse -LS 1: Inverse, 0: Not inverse
- Bit 1: Logic Inverse HS 1: Inverse, 0: Not inverse
- Bit 0: Logic Inverse +LS 1: Inverse, 0: Not inverse

4.5.8 Maximum Pulse Speed Setting (0x3014 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3014	0	Max Pulse Speed Setting	UINT	RW	No	500

- The unit is Kpps: kilo pulse per second
- The value must be between 10 and 6500 (10Kpps ~ 6500Kpps)
- The value must be setting according to the maximum input pulse frequency allowed by motor drive

4.5.9 Configuration of Linear Position Generator (0x3021 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3021	0	Number of entry	USINT	RO	No	4
	1	Start Position	DINT	RW	No	0
	2	Interval	DINT	RW	No	1
	3	Repeat times	UDINT	RW	No	0
	4	Remaining times	UDINT	RO	No	-

- 0x3021:1 Start Position: The first point of linear position, this parameter is loaded only when CMP enable.
- 0x3021:2 Linear interval, can be negative value, this parameter is loaded only when CMP enable.
- 0x3021:3 Repeat times of linear position, this parameter is loaded only when CMP enable.
- 0x3021:4 Remaining times, display residue points in linear generator.

4.5.10 FIFO Configuration (0x3022 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3022	0	Number of entries	USINT	RO	No	5
	1	Size of FIFO	UINT	RO	No	32
	2	FIFO free space	UINT	RO	Yes	-
	3	Value for FIFO	DINT	RW	Yes	0
	4	FIFO Ctrl	USINT	RW	Yes	0
	5	Last value in FIFO	DINT	RW	No	0

- 0x3022:1 Size of FIFO, show FIFO depth. (This is a fixed value)
- 0x3022:2 FIFO free space, show how many free space in FIFO.
- 0x3022:3 Value for FIFO, it will not be pushed to FIFO until FIFO Ctrl be set.
- 0x3022:4 FIFO Ctrl.
  - B0: FIFO Reset (0->1) Clear data stored in FIFO.
  - B1: FIFO Push (0->1 or 1->0), push the value stored in 0x3022:3 to FIFO.
  - B2: FIFO Pop (0->1or 1->0), drop the oldest value from FIFO, FIFO pop is available when CMP enable
- 0x3022:5, Value in FIFO, "For Read: Read Last value in FIFO, For Write: Push the value into FIFO"

4.5.11 Compare Configuration (0x3023 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3023	0	Number of entries	USINT	RO	No	5
	1	Compare source	UINT	RW	No	0
	2	Compare condition	USINT	RW	No	0
	3	Compare(CMP) enable	USINT	RW	No	0
	4	Trigger output mode	USINT	RW	No	0
	5	Trigger pulse width	UDINT	RW	No	1000

- 0x3023:1 Compare source. Source of compare value and counter, this parameter is loaded only when CMP enable.
  - Bit 0: Source of compare counter
    0: Encoder counter
    1: Command counter
  - Bit 2: Source of compare value
    0: Position FIFO
    1: Linear position generator
  - Other bits are reserved and set zero.
- 0x3023:2 Compare condition, this parameter is loaded only when CMP enable.
  - 0: directionless: Both count direction will trigger the compare event.
  - 1: Positive direction, Only incremental counting direction will trigger the compare event.
  - 2: Negative direction, Only decremental counting direction will trigger the compare event.
- 0x3023:3 Compare (CMP) enable, Enable the compare function.
  - Bit 0: Enable Compare function
    0: Disable
    1: Enable
- Trigger output mode,
  - Bit 0: Output mode selection
    0: Output pulse signal
    1: Output toggle signal
  - Bit 2: Output Logic
    0: Not Inverse
    1: Inverse"

4.5.12 Compare Value (0x3024 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3024	0	Compare value	DINT	RW	No	0

The value in compare function and to be compared with counter value.

4.5.13 Manual Trigger (0x3025 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3025	0	Manual Trigger	USINT	RW	Yes	0

Inverse the bit0 to force trigger compare event. (0->1, 1->0 change of state)

4.5.14 Trigger Counter (0x3026 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x3026	0	Trigger counter	UDINT	RW	No	0

For Read, show the count of compare event (trigger count).
For Write, write any data to clear counter.

4.6 CANOpen CiA 402 Profile Specific Objects (0x6000~0x7FFF)

Index (Hex)	Meaning
0x6000~0x67FF	CiA 402 profile for Axis 0
0x6800~0x6FFF	CiA 402 profile for Axis 1
0x7000~0x77FF	CiA 402 profile for Axis 2
0x7800~0x7FFF	CiA 402 profile for Axis 3

The following sections describe object-profiles of Axis0. For Axis1~Axis3 are identical the same as Axis0.

4.6.1 Error Code (0x603F + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x603F	0	Error code	UINT	RO	Yes	0

- Last error of the axis. The meaning of error codes are defined in "Troubleshooting" chapter.

4.6.2 Controlword (0x6040 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6040	0	Controlword	UINT	RW	Yes	0x0000

- Control word bits description.

Bit	Meaning
0	Switch on
1	Enable voltage
2	Quick stop
3	Enable operation
4~6	<Operation mode specific>
7	Fault reset
8	Halt
9~15	<operation mode specific>

- Control command for axis's state.

Command	Bit7	Bit3	Bit2	Bit1	Bit0
Shutdown	0	-	1	1	0
SwitchOn	0	0	1	1	1
SwitchOn + EnableOP	0	1	1	1	1
Disable Voltage	0	-	-	0	-
Quick Stop	0	-	0	1	-
Disable Operation	0	0	1	1	1
Enable Operation	0	1	1	1	1
Fault Reset	0->1	-	-	-	-

- Bits description for Cyclic sync position (CSP) mode.

Bit	Meaning
4	Reserved, set 0.
5	Reserved, set 0.
6	Reserved, set 0.
8	Halt 0: Motion is executed 1: Halt axis according to halt option code (0x605D)
9~15	Reserved, set 0.

- Bits description for profile position (PP) mode.

Bit	Meaning
4	New command set point, 0 -> 1: Start new command.
5	Start new positioning immediately, (reference when bit 4 rising edge) 0: Buffered positioning until current positioning finish. 1: Start new positioning immediately.
6	Relative /Absolution position 0: Target position(0x607A) as absolution position 1: Target position(0x607A) as relative position
8	Halt 0: Motion is executed 1: Halt axis according to halt option code (0x605D)
10~15	Reserved, set 0

- Bits description for profile velocity (PV) mode.

Bit	Meaning
4	Reserved, set 0.
5	Reserved, set 0.
6	Reserved, set 0.
8	Halt 0: Motion is executed 1: Halt axis according to halt option code (0x605D)
9~15	Reserved, set 0.

- Bits description for homing (hm) mode.

Bit	Meaning
4	Homing enable. 0: Not stop homing 1: Start or continue homing
5	Reserved, set 0.
6	Reserved, set 0.
8	Halt 0: Motion is executed 1: Halt axis according to halt option code (0x605D)
9~15	Reserved, set 0.

4.6.3 Statusword (0x6041 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6041	0	Statusword	UINT	RO	Yes	-

- The Statusword indicates the current state of the drive.
- Statusword bits.

Bits	Status	Description
0	Ready to switch on	See <Details on Bits 0 to 7>
1	Switched on	
2	Operation enabled	
3	Fault	
4	Voltage enabled	
5	Quick stop	
6	Switch on disabled	
7	Warning	
8	Active mode stop	1: Active mode function operating
9	Remote	Controlword (6040h) is processed
10	Operation mode specific	See <Details on Bits 10, 12, and 13>.
11	Internal limit active	Not used
12	Operation mode specific	See <Details on Bits 10, 12, and 13>.
13		
14	Torque limit active	Not used
15	Safety active	Not used

- Details on Bits 0 to 7 (for current state)

Drive State	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Not ready to switch on	—	0	—	—	0	0	0	0
Switch on disabled	—	1	—	—	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
Quick stop active	—	0	0	—	0	1	1	1
Fault reaction active	—	0	—	—	1	1	1	1
Fault	—	0	—	—	1	0	0	0
Main Power On	—	—	—	1	—	—	—	—
Warning is occurred	1	—	—	—	—	—	—	—

- Details on Bits 10,12 and 13
  - PP mode

Bit	Description	Value	Definition
10	Target reached	0	Halt (Bit 8 in Controlword) = 0: Target not reached Halt (Bit 8 in Controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in Controlword) = 0: Target reached Halt (Bit 8 in Controlword) = 1: Velocity of axis is 0
12	Set-point acknowledge	0	Speed is not equal 0
		1	Speed is equal 0
13	—	0	Reserved

  - PV mode

Bit	Description	Value	Definition
10	Target reached	0	Halt (Bit 8 in Controlword) = 0: Target not reached Halt (Bit 8 in Controlword) = 1: Axis decelerates
		1	Halt (Bit 8 in Controlword) = 0: Target reached Halt (Bit 8 in Controlword) = 1: Velocity of axis is 0
12	Speed	0	Speed is not equal 0
		1	Speed is equal 0
13	—	0	Reserved

- Home mode

Definition	Bit 13	Bit 12	Bit 10
	Homing error	Homing attained	Target reached
Homing procedure is in progress	0	0	0
Homing procedure is interrupted or not started	0	0	1
Homing procedure is completed successfully	0	1	1
Homing error occurred, velocity is not 0	1	0	0
Homing error occurred, velocity is 0	1	0	1

- CSP mode

Bit	Description	Value	Definition
10	—	0	Reserved
12	—	0	Reserved
13	—	0	Reserved

4.6.4 Quick Stop Option Code (0x605A + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x605A	0	Quick stop option code	INT	RW	No	2

- 0: Disable drive function
- 1: Slow down stop
- 2: Quick stop
- 3: Emergency stop

4.6.5 Shutdown Option Code (0x605B + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x605B	0	Shutdown option code	INT	RW	No	0

- 0: Disable drive function
- 1: Slow down stop

4.6.6 Disable Operation Option Code (0x605C + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x605C	0	Disable operation option code	INT	RW	No	0

- 0: Disable drive function
- 1: Slow down stop

4.6.7 Halt Option Code (0x605D + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x605D	0	Halt option code	INT	RW	No	1

- 1: Slow down stop
- 2: Quick stop
- 3: Emergency stop

4.6.8 Fault Reset Option Code (0x605E + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x605E	0	Fault reset option code	INT	RW	No	0

- 0: Disable drive function

4.6.9 Mode of Operation (0x6060 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6060	0	Mode of operation	SINT	RW	Yes	8

- 1: PP mode
- 3: PV mode
- 6: Homing mode
- 8: CSP mode

4.6.10 Mode of Operation Display (0x6061 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6061	0	Mode of operation display	SINT	RO	Yes	8

- 1: PP mode
- 3: PV mode
- 6: Homing mode
- 8: CSP mode

4.6.11 Position Demand Value (0x6062 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6062	0	Position demand value	DINT	RO	Yes	-

- This object provides the value of the command position in pulse units.

4.6.12 Position Actual Internal Value (0x6063 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6063	0	Position actual internal value	DINT	RO	Yes	-

- This object provides the actual value of the encoder in encoder pulse units.

4.6.13 Position Actual Value (0x6064 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6064	0	Position actual value	DINT	RO	Yes	

- This object provides the actual value of the encoder in user position units.

4.6.14 Velocity Demand Value (0x606B + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x606B	0	Velocity demand value	DINT	RO	Yes	

- This object provides the demand velocity value derived from the demand position.

4.6.15 Velocity Actual Value (0x606C + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x606C	0	Velocity actual value	DINT	RO	Yes	

- This object provides the actual velocity value derived from the position encoder.

4.6.16 Target Velocity (0x60FF + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60FF	0	Target velocity	DINT	RW	Yes	

- This object specifies the target velocity for Profile Velocity mode in velocity units (pulse per second).

4.6.17 Target Position (0x607A + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x607A	0	Target position	DINT	RW	Yes	

- This object is the target position in the Profile Position mode and Cyclic Synchronous Position mode.

4.6.18 Profile Velocity (0x6081 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6081	0	Profile velocity	UDINT	RW	Yes	

- The profile velocity is the velocity normally attained at the end of the acceleration ramp during a profiled move and is valid for both directions of motion.

4.6.19 Profile Acceleration (0x6083 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6083	0	Profile acceleration	UDINT	RW	Yes	

- This object specifies the acceleration for profile modes.

4.6.20 Profile Deceleration (0x6084 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6084	0	Profile deceleration	UDINT	RW	Yes	

- This object specifies the deceleration for profile modes.

4.6.21 Quick Stop Deceleration (0x6085 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6085	0	Quick stop deceleration	UDINT	RW	Yes	

- The quick stop deceleration is the deceleration used to stop the motor if the 'Quick Stop' command is given and the Quick Stop Option Code (see 605Ah) is set to 2.

4.6.22 Home Offset (0x607C)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x607C	0	Home offset	DINT	RW	No	-

- The home offset is the difference between the zero position for the application and the machine home position (found during homing).

4.6.23 Homing Method (0x6098 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6098	0	Homing Method	SINT	RW	Yes	-

- This object specifies the homing method.

Method	Data Description
0	No homing operation required
1	Homing on the negative limit switch and index pulse
2	Homing on the positive limit switch and index pulse
7 - 14	Homing on the home switch and index pulse
24	Homing on the home switch Same homing as Method 8 (without an index pulse)
28	Homing on the home switch Same homing as Method 12 (without an index pulse)
33,34	Homing on index pulse
35	Homing on the current position

4.6.24 Homing Speed (0x6099 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6098	0	Number of entries	SINT	RO	No	2
	1	Speed during search for switch	UDINT	RW	Yes	5000
	2	Speed during search for zero	UDINT	RW	Yes	1000

- This object entries define the speeds used during homing and is given in user velocity units.

4.6.25 Homing Acceleration (0x609A + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x609A	0	Homing Acceleration	UDINT	RW	Yes	1000

- This object specifies the acceleration and deceleration for homing in acceleration units.

4.6.26 Touch probe function (0x60B8 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60B8	0	Touch probe function	UINT	RW	Yes	0

- This object indicates the configured function of the touch probe.

Bit	Description	R/W	Default
15:14	Reserved	R/W	0
13	Touch probe2 negative edge enable 0: Switch off sampling at negative edge of touch probe 2 1: Enable sampling at negative edge of touch probe 2	R/W	0
12	Touch probe2 positive edge enable 0: Switch off sampling at positive edge of touch probe 2 1: Enable sampling at positive edge of touch probe 2	R/W	0
11	Reserved.	R/W	0
10	Touch probe 2 Trigger selection 0: Trigger with touch probe 2 input (DI1) 1: Trigger with zero impulse signal	R/W	0
9	Touch probe 2 Trigger operation 0: Trigger first event 1: Continuous	R/W	0
8	Touch probe 2 switch enable 0: Switch off touch probe 2 1: Enable touch probe 2	R/W	0
7:6	Reserved	R/W	0
5	Touch probe1 negative edge enable 0: Switch off sampling at negative edge of touch probe 1 1: Enable sampling at negative edge of touch probe 1	R/W	0
4	Touch probe 1 positive edge enable 0: Switch off sampling at positive edge of touch probe 1 1: Enable sampling at positive edge of touch probe 1	R/W	0
3	Reserved.	R/W	0
2	Touch probe 1 Trigger selection 0: Trigger with touch probe 1 input (DI0) 1: Trigger with zero impulse signal	R/W	0
1	Touch probe 1 Trigger operation 0: Trigger first event 1: Continuous	R/W	0
0	Touch probe 1 switch enable 0: Switch off touch probe 1 1: Enable touch probe 1	R/W	0

4.6.27 Touch Probe Status (0x60B9 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60B9	0	Touch probe status	UINT	RO	Yes	0

- This object provides the status of the touch probe

Bit	Description	R/W	Default
15	Touch probe 2 input monitor (User-defined: for testing) 0: Photocoupler is off 1: Photocoupler is on	R/-	0
14	Touch probe 2 trigger selection monitor(User-defined for testing) 0: Tigger with touch probe 2 input mode 1: Trigger with zero impulse mode	R/-	0
13:11	Reserved.	R/-	0
10	Touch probe 2 negative edge value stored monitor. 0: Touch probe 2 no negative edge value stored. 1: Touch probe 2 negative edge position stored	R/-	0
9	Touch probe 2 positive edge value stored monitor. 0: Touch probe 2 no positive edge value stored 1: Touch probe 2 positive edge position stored	R/-	0
8	Touch probe switch enable monitor 0: Touch probe 2 is switched off 1: Touch probe 2 is enabled.	R/-	0
7	Touch probe 1 input monitor (User-defined: for testing) 0: Photocoupler is off 1: Photocoupler is on	R/-	0
6	Touch probe 1 trigger selection monitor (User-defined for testing) 0: Trigger with touch probe 1 input mode 1: Reserved	R/-	0
5:3	Reserved.	R/-	0
2	Touch probe 1 negative edge value stored monitor. 0: Touch probe 1 no negative edge value stored. 1: Touch probe 1 negative edge position stored.	R/-	0
1	Touch probe 2 positive edge value stored monitor. 0: Touch probe 1 no positive edge value stored. 1: Touch probe 1 positive edge position stored.	R/-	0
0	Touch probe switch enable monitor. 0: Touch probe 1 is switched off. 1: Touch probe 1 is enabled.	R/-	0

4.6.28 Touch Probe 1 Position Value Positive Edge (0x60BA + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60BA	0	Touch probe 1 position value (positive edge)	DINT	RO	Yes	0

- This object provides the position value of the touch probe 1 in positive edge.

4.6.29 Touch Probe 1 Position Value Negative Edge (0x60BB + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60BB	0	Touch probe 1 position value (negative edge)	DINT	RO	Yes	0

- This object provides the position value of the touch probe 1 in negative edge.

4.6.30 Touch Probe 2 Position Value Positive Edge (0x60BC + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60BC	0	Touch probe 2 position value (positive edge)	DINT	RO	Yes	0

- This object provides the position value of the touch probe 2 in positive edge.

4.6.31 Touch Probe 2 Position Value Negative Edge (0x60BD+ n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60BD	0	Touch probe 2 position value (negative edge)	DINT	RO	Yes	0

- This object provides the position value of the touch probe 2 in negative edge.

4.6.32 Digital Inputs (0x60FD + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60FD	0	Digital Inputs	UDINT	RO	Yes	-

- This object indicates the digital inputs state.

Bit	Description	Value	Definition
31:27	Reserved	20	DI1
26	EMG	19	DI0
25	RDY	18:3	Reserved
24	EZ	2	HS
23	INP	1	+LS
22	ALM	0	-LS
21	DI2		

4.6.33 Digital Outputs (0x60FE + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x60FE	0	Number of entries	USINT	RO	No	2
	1	Physical outputs	UDINT	RW	Yes	0
	2	Bit mask	UDINT	RW	No	0

- This object controls the digital outputs state.
  - Data description of Physical outputs

Bit	Signal	Description
31:27	Reserved	--
26	DCLR	0: Switch off, 1: Switch on
25	ARST	0: Switch off, 1: Switch on
24	SVON	Read only
23:0	Reserved	--

  - Data description of Output mask

Bit	Signal	Description
31:27	Reserved	--
26	DCLR	0: Disable output, 1: Enable
25	ARST	0: Disable output, 1: Enable
24:0	Reserved	--

4.6.34 Supported Drive Mode (0x6502 + n * 0x800)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0x6502	0	Supported drive mode	UDINT	RO	No	0x000000A5

- This object provides an overview of the implemented operating modes in the device

Bit	Signal	Description
31:10	Reserved	0
7	CSP mode	1: Supported
6	Reserved	0
5	Homing mode	1: Supported
4:3	Reserved	0
2	PV mode	1: Supported
1	Reserved	0
0	PP mode	1: Supported

4.7 Modular Device Profile (0xF000~0xF100)

Index	Sub	Name	Data Type	Access	PDO Mapping	Default Value
0xF000	0	Number of entries	U8_T	RO	No	2
	1	Index distance	U16_T	RO	No	0x800
	2	Maximum number of modules	U16_T	RO	No	4
0xF010	0	Number of entries	U8_T	RO	No	4
	1	Profile number on position 1	U32_T	RO	No	0x000002E6
	2	Profile number on position 2	U32_T	RO	No	0x000002E6
	3	Profile number on position 3	U32_T	RO	No	0x000002E6
		Profile number on position 4	U32_T	RO	No	0x000002E6

Chapter 5: Troubleshooting

5.1 Error Code List

When one of these errors occurs, the state machine of CiA 402 will be in "Fault" state.

Error Code	Name	Meaning
0x7500	Communication error	The EtherCAT AL state became not "OP" while the DS402 drive state is in "Operation enabled."
0xFF01	Emergency activated	The Emergency signal is triggered.
0xFF02	Driver alarm activated	The motor driver alarm connected to DI signal "ALM" is triggered.

5.2 Troubleshooting

Problem	Cause	Action
Motor does not start	Servo-on signal does not output	Check the wiring and the CiA 402 state must be in "operation enabled".
	Limit switch is activated	Check the limit switch status in DI object: 0x60FD.
	Operation mode is not correct	Check the mode of operation object: 0x6060 / 0x6061
	The alarm of driver is activated	Check the Driver status display
The actual position display is wrong	The wiring about encoder or pulse out is incorrect.	Check the wiring of encoder and pulse output.
	The mode of encoder or pulse out is incorrect.	Check the mode setting of encoder and pulse out by manufacture specific object: 0x3000 0x3001 0x3004 0x3005.