AX58x01(2) TwinCAT User Guide

Revision 1.00
September 16th, 2025

Revision History

Revision	Date	Description
1.00	2025/09/16	Initial release

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1. Introduction

This document introduces how to setup entire environment for BECKHOFF TwinCAT engineering (XAE) on AX58x01(2) evaluation platform. The IDE rely Microsoft Visual Studio 2010 / 2013. We can execute the application through the mentioned IDE or pure BECKHOFF runtime package (XAR).

2. Requirements

Before starting to setup the environment, we should prepare some software and hardware. Of course, they are all running based on general desktop PC with windows 10 / 11 operation systems. We list software / hardware requirements as following:

[Software at EtherCAT MainDevice side]

- Windows 10 / 11 operation system
- Microsoft Visual Studio 2010 / 2013
- Beckhoff TwinCAT XAE v3.1.4022.28 or later

Figure 2-1

Note: You can download the BECKHOFF TwinCAT here.

3. Basic Operation of TwinCAT

Before starting up the AX58x01(2) series evaluation platform first time, you MUST download available contents into AX58x01(2) series EEPROM first. If there are no available contents in AX58x01(2) series EEPROM, the MCU will be reset forcibly by ESC.

Assume you already installed the BECKHOFF TwinCAT XAE in your environment.
Please follow below sections for EEPROM download.

3-1 Open XAE through Visual Studio 2010 / 2013

Open the XAE by clicking below system tray icon:

Figure 3-1

3-2 Project creation & download EEPROM

Any common deploy or applications through TwinCAT XAE all should process under a TwinCAT project. We create an empty TwinCAT project and scan out EtherCAT SubDevice that linked to the MainDevice. If you have a Beckhoff real-time compatible network adapter (ex: Intel I-350) in the system, TwinCAT MainDevice can bundle the adapter as main EtherCAT port. If you have 2 adapters, the second adapter can be used for deploy redundancy. Whatever, you should create a TwinCAT project first for any EtherCAT related affairs under TwinCAT XAE.

Be Attention Please! The subsequent steps involve using AX58101_GpioAio for demonstration purposes. If you are using other products of the AX58x01(2) series, you can also refer to it.

Please refer to below steps:

- Step 1: Click the "**New TwinCAT Project…**".

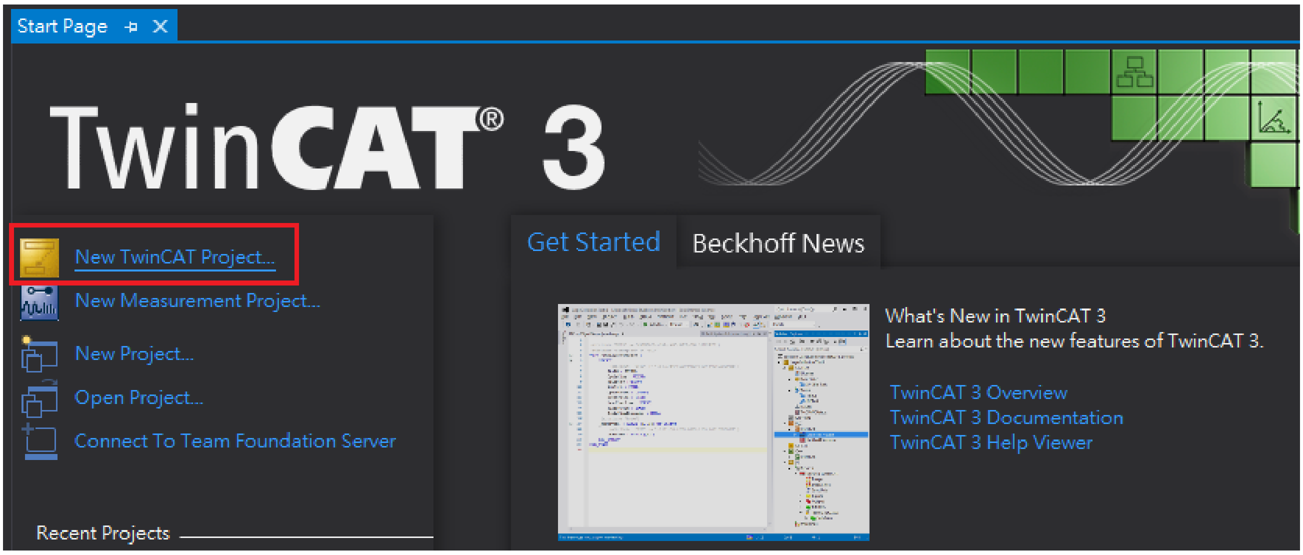

Figure 3-2

- Step 2: Specify "**Name**" and "**Location**" and click "**OK**".

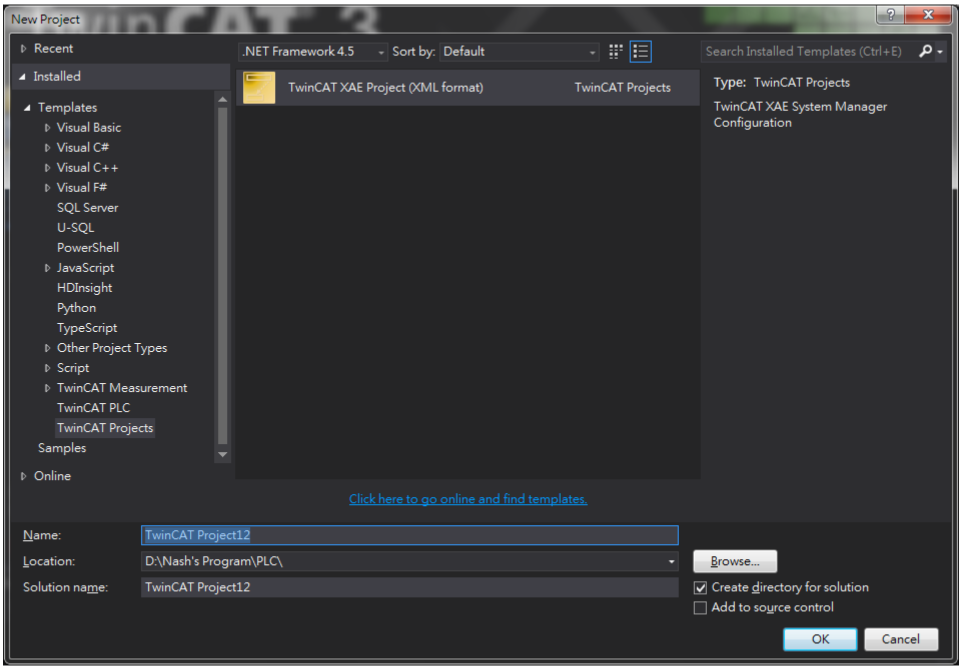

Figure 3-3

- Step 3: Click the "**TWINCAT -> Show Realtime Ethernet Compatible Devices…**"

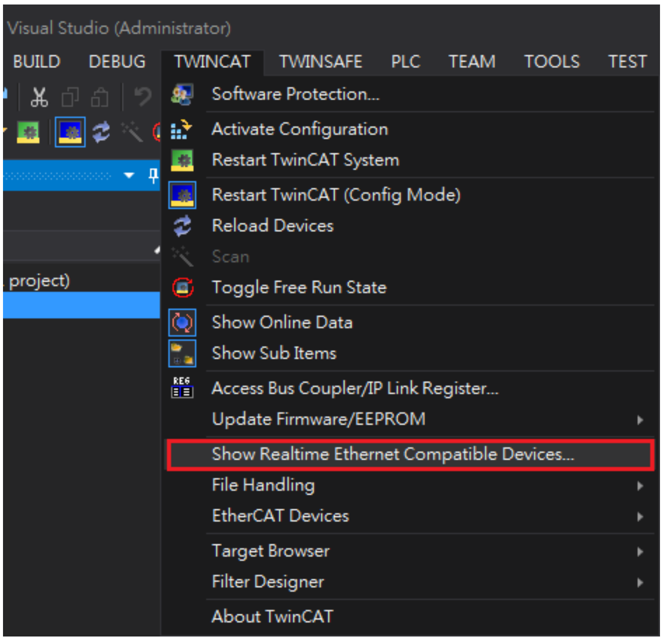

Figure 3-4

- Step 4: Make sure your network adapter installed BECKHOFF EtherCAT real-time driver If not installed, please click "**Install**".

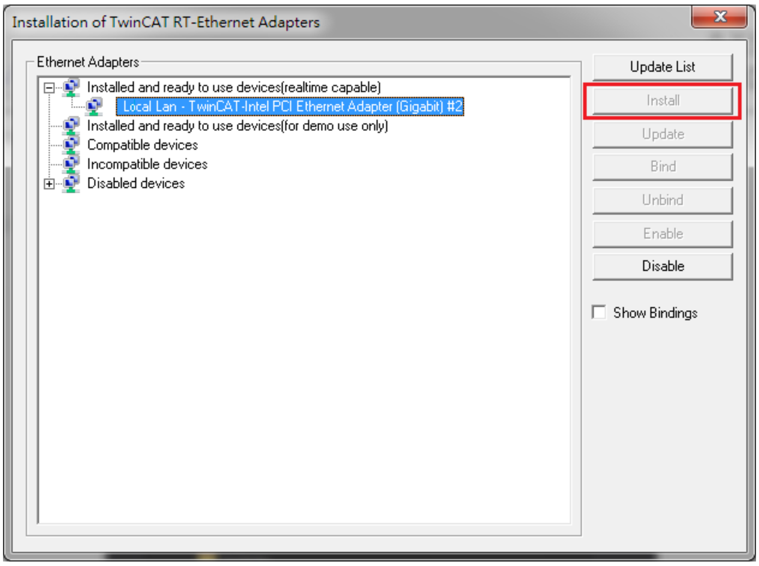

Figure 3-5

- Step 5: Please copy the ESI (EtherCAT SubDevice Information) file from the BSP directory: "**BSP_ROOT\SampleCode\(ANY_AX58X01_SERIES)\For_TwinCAT\ESI**"

Figure 3-6

- Step 6: Copy the AX58x01 series ESI file to TwinCAT directory: "**C:\TwinCAT\3.1\Config\Io\EtherCAT**"

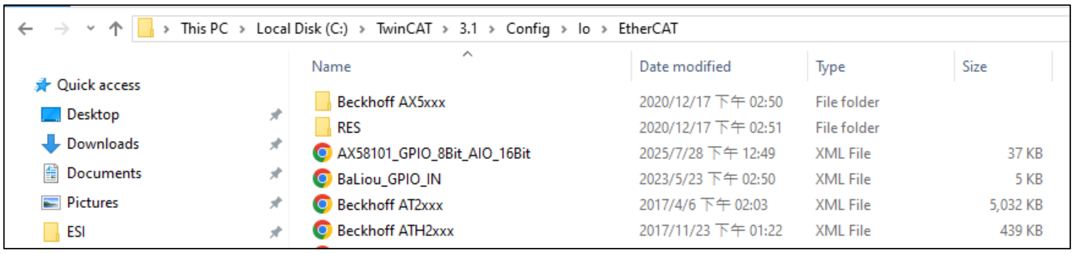

Figure 3-7

Note: If the ESI file already exists in **C:\TwinCAT\3.1\Config\Io\EtherCAT**, you must overwrite it.

- Step 7: Click "**TWINCAT -> EtherCAT Devices -> Reload Device Descriptions**".

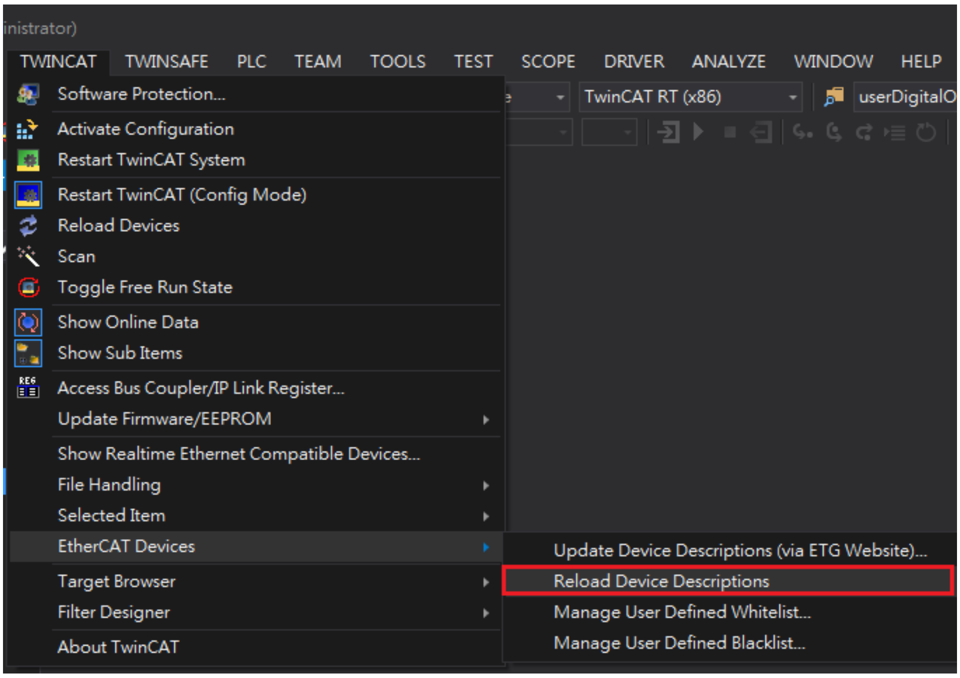

Figure 3-8

- Step 8: Plug USB power to any of the AX58x01 series evaluation platform and connect ESC port0 to TwinCAT MainDevice port (generally PC or IPC).

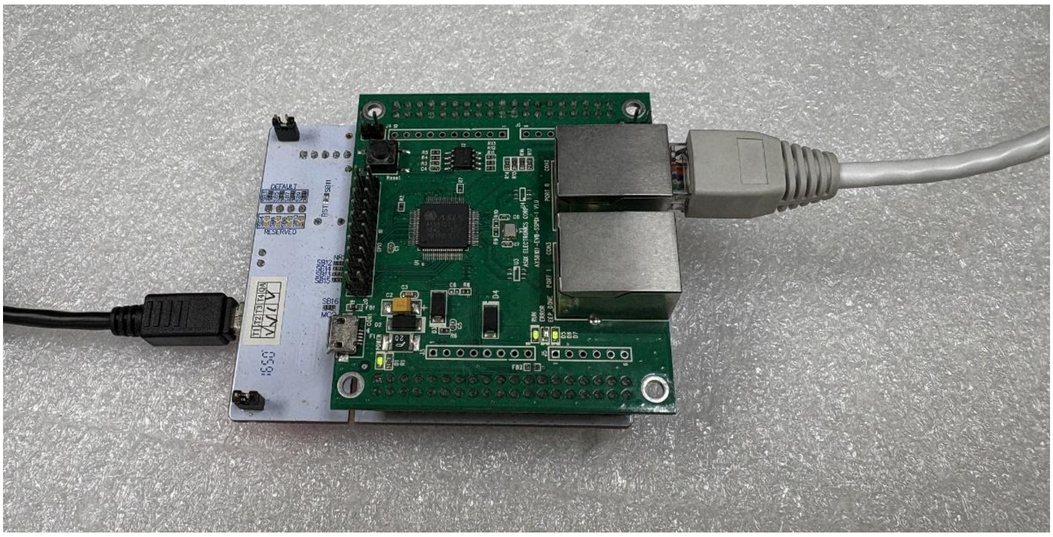

Figure 3-9

- Step 9: Right-click on “IO / Devices” and select “Scan”.

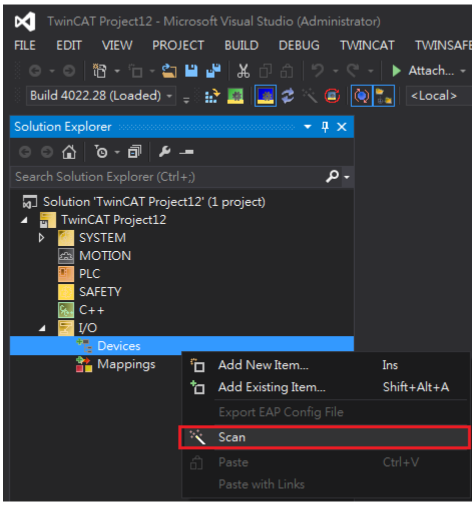

Figure 3-10

- Step 10: Choose main network adapter.

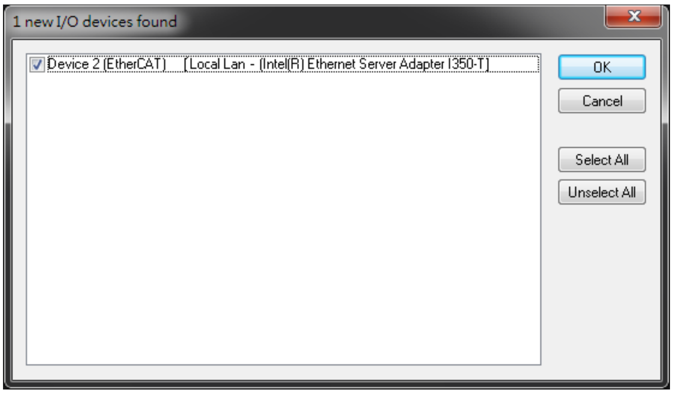

Figure 3-11

- Step 11: Click “**Yes**”.

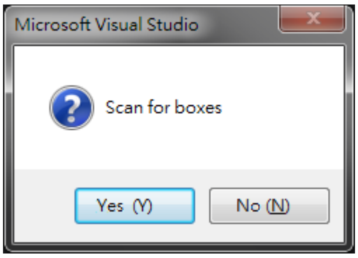

Figure 3-12

- Step 12: Click "**Yes**".

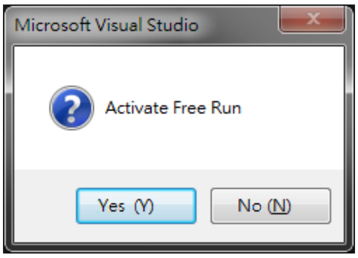

Figure 3-13

- Step 13: Double click "**Device N (EtherCAT)**" and you will see the TwinCAT MainDevice scanned out the EtherCAT SubDevice

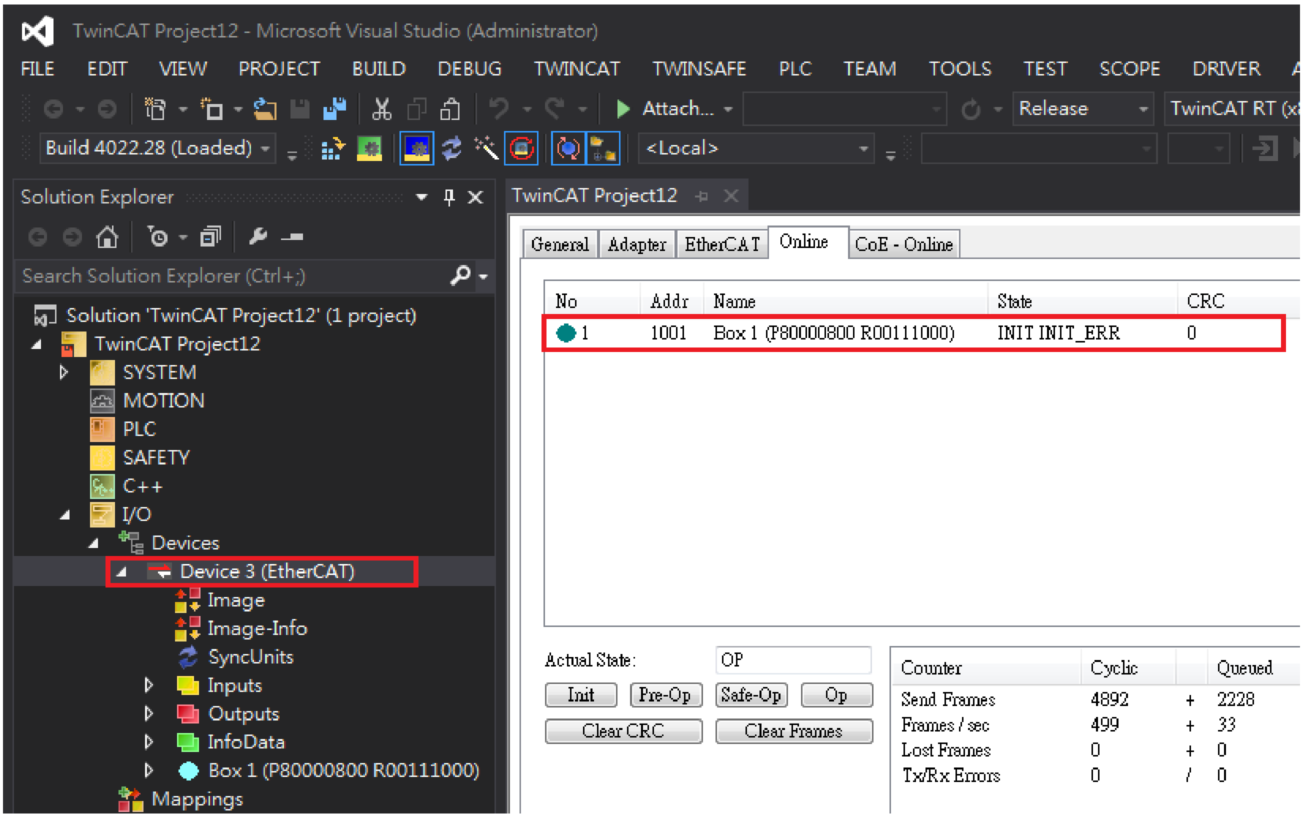

Figure 3-14

- Step 14: Select the SubDevice, right-click and choose “**EEPROM Update…**”

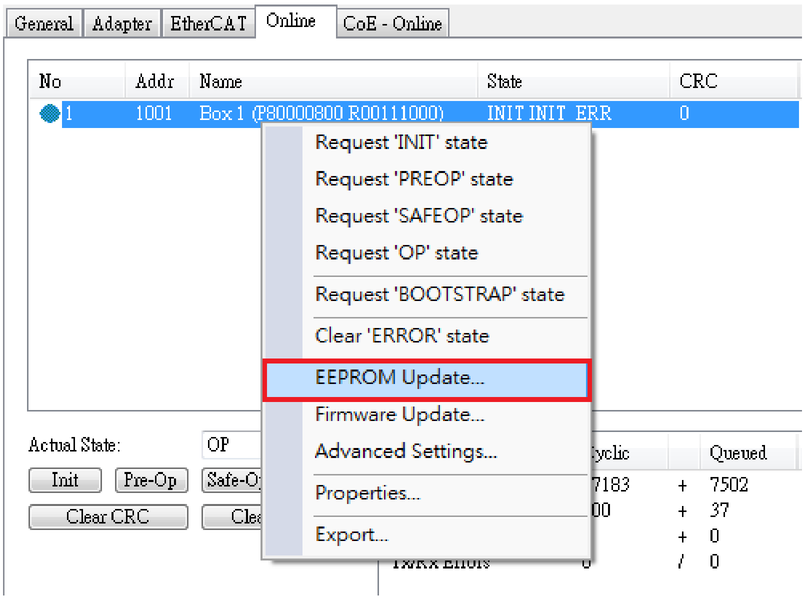

Figure 3-15

- Step 15: Select the ESI file for your AX58x01 series application and click “OK”.

Notes: If several items have the same name, please select the item with the “**ProductCode**” and “**RevisionNo**” values that matching your target ESI file.

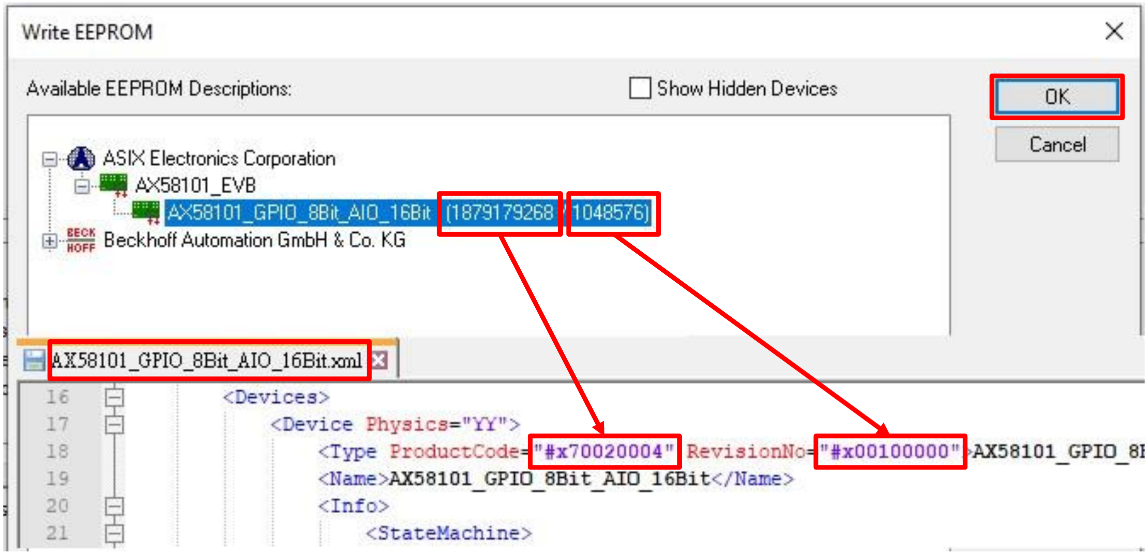

Figure 3-16

- Step 16: Wait for progress bar at lower right corner of the TwinCAT screen.

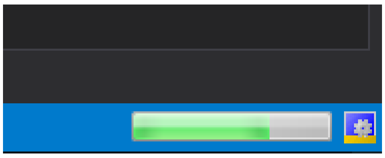

Figure 3-17

- Step 17: Select "**Device N (EtherCAT)**", right-click and choose "**Remove**".

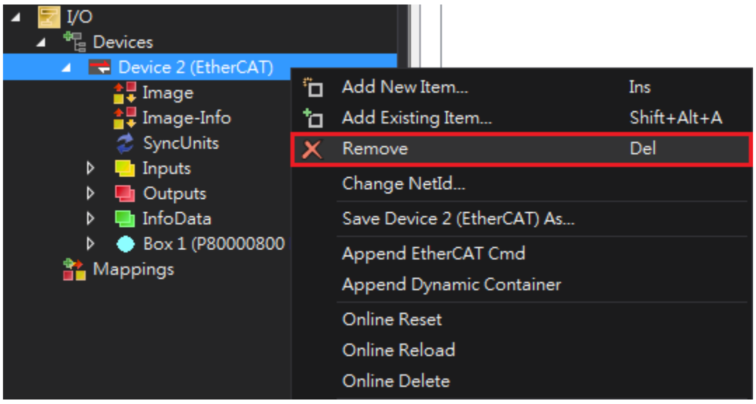

Figure 3-18

- Step 18: Click "**Yes**".

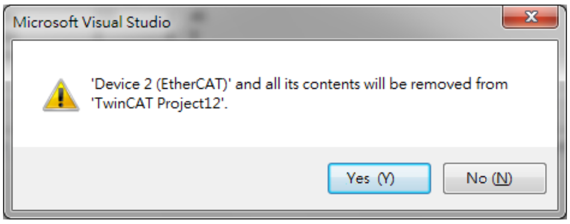

Figure 3-19

- Step 19: Execute “**Scan**” again (repeat Step 7 ~ 11) and you will see below screen. Assume AX58x01 series did not download available firmware with SubDevice Stack Code yet. So, the state field “**INIT INIT_ERR**” is properly / reasonable.

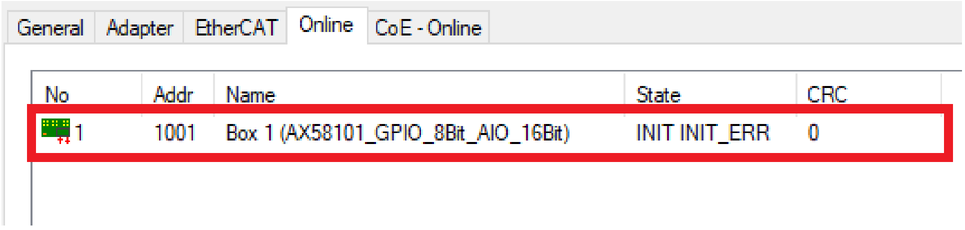

Figure 3-20

If there is an available firmware with SubDevice Stack Code in AX58x01 series, you should see below screen. The “State” field is “OP” mode.

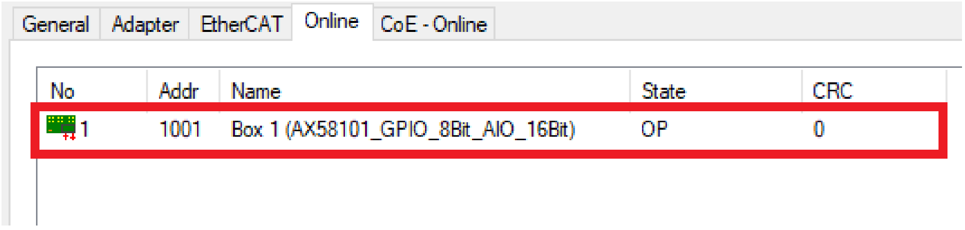

Figure 3-21

Notes: Please refer to AX58x01 series user guide the Chapter download firmware.

4. AX58x01 Series ESI File Adding Secondary Vendor ID

AX58x01 series ESI file added the secondary vendor ID. The “E” indicates the secondary vendor ID (which is available for all vendors) and is intended to be used for development products. Secondary vendor ID are not valid for final EtherCAT products and the final product vendor need to assign their own vendor ID to their final product.

Because the AX58x01 series ESI file changed, so, if you already have any of the AX58x01 series products you must upgrade the firmware (refer to AX58x01 series user guide) and the EEPROM (refer to Chapter 3). Please note! The early AX58x01 series firmware doesn’t match the new ESI (which added a secondary vendor ID) file.

You can see any of the AX58x01 series product ESI file in the “PROJECT_ROOT/ For_TwinCAT/ESI” folder that the vendor ID was changed “E0000B95”.

Figure 4-1

Open the ESI file and will see the vendor ID.

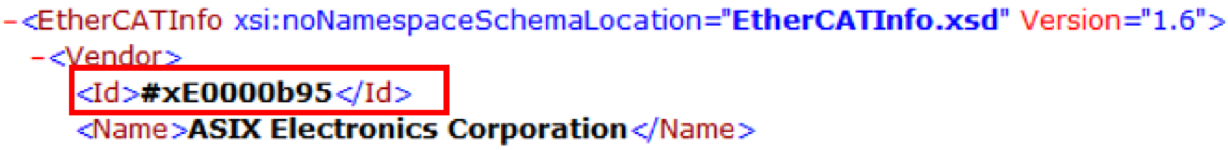

Figure 4-2

4-1 Expected Errors During CTT Certification

According to the ETG9002 EtherCAT Vendor ID Policy information, since the Secondary Vendor ID is not the final product, so, In the context of conformance testing a Secondary Vendor ID is not considered a valid Vendor ID.

The picture below shows the description of CTT Secondary Vendor ID test item.

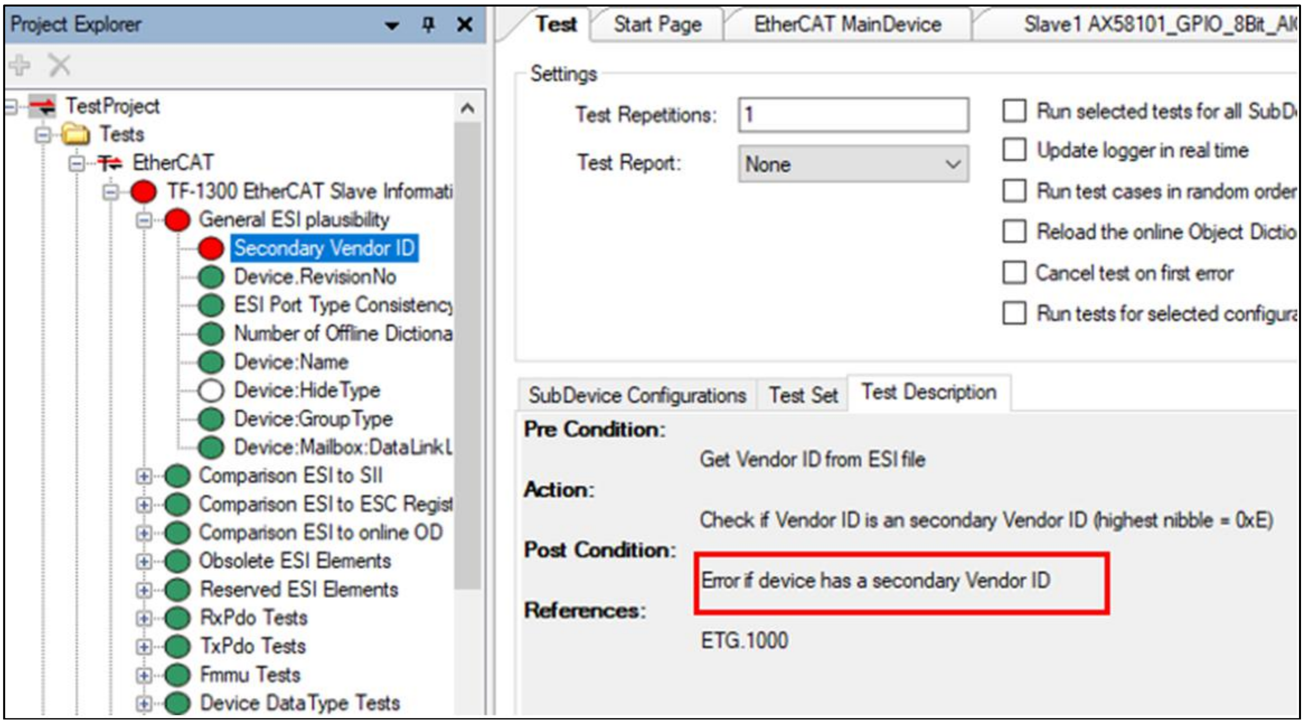

Figure 4-3

To resolve this issue, users should refrain from using the Secondary Vendor ID, and this will ensure them to pass the conformance test.

5. PLC Application

Here will introduces the setup procedure and manipulation about TwinCAT PLC program for the demonstration with AX58x01 Reference Design.

Before starting, assume the AX58x01 device has been firmware and EEPROM programmed with a suitable reference design, and can be brought into OP mode on TwinCAT MainDevice. For example, it shall look like this for “**AX58101_GpioAio**”.

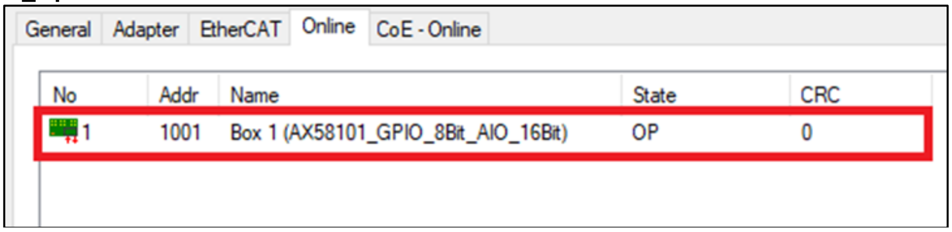

Figure 5-1

5-1 Import PLC Source Package

The PLC program source package has come with AX58x01 Reference Design BSP, you can find them in the path below

- AX58101(2)_BSP
  - Ax58101_GpioAio

BSP_ROOT\SampleCode\Ax58101_GpioAio\For_TwinCAT\PLC\AxGpioAio_v100.tpzip

  - Ax58101_MotorControl

BSP_ROOT\SampleCode\Ax58101_MotorControl\For_TwinCAT\PLC\AxMotorControl_v100.tpzip

The import procedure for the above PLC program packages is the same. For example, to import the **AX58101_GpioAio,** please follow the steps below.

- Step 1: Right-click on “**PLC**” entry and select “**Add Existing Item…**”

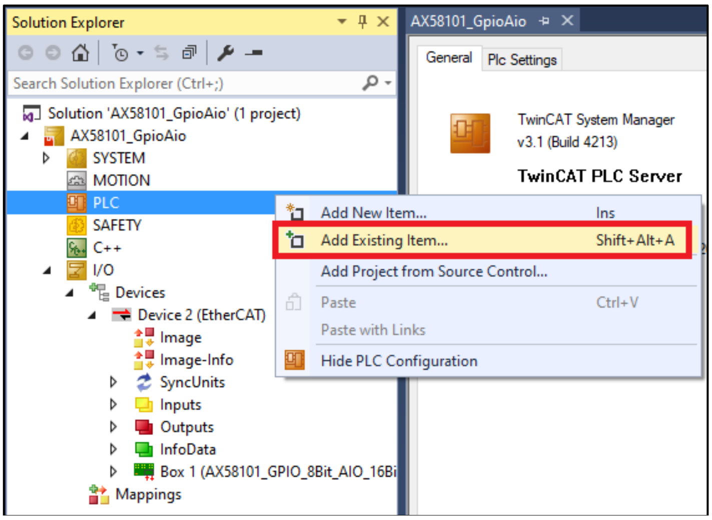

Figure 5-2

- Step 2: Select the PLC package.
  Here shall select the package in the path:
  BSP_ROOT\SampleCode\Ax58101_GpioAio\For_TwinCAT\PLC\AxGpioAio_v100.tpzip.

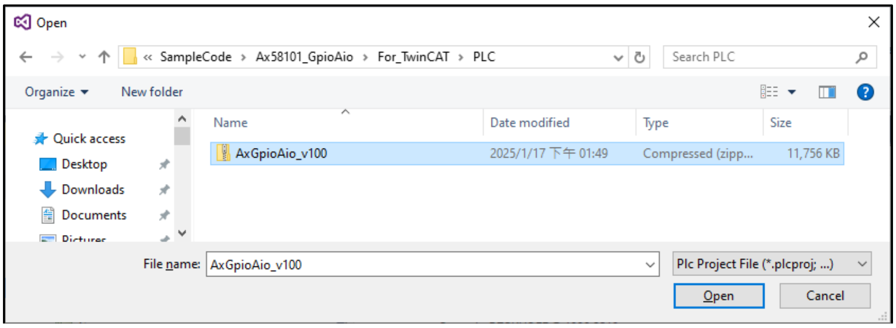

Figure 5-3

Then you will see the result as the below figure.

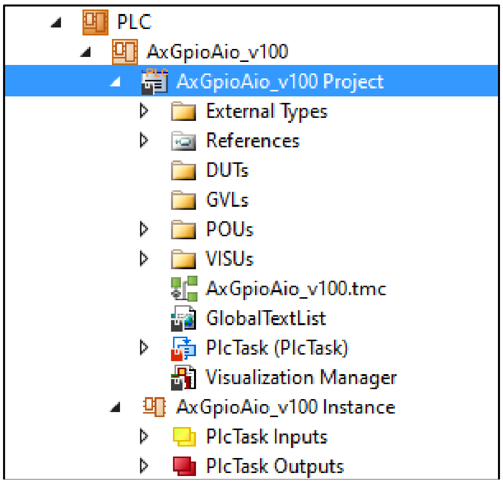

Figure 5-4

- Step 3: Check if the "**Referenced Task**" exists. If it does, jump to Step 10; otherwise, continue with the following steps.

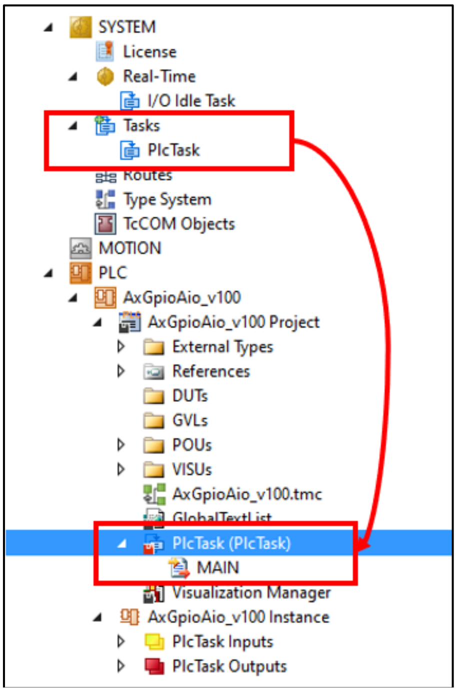

Figure 5-5

- Step 4: Right-click on "**SYSTEM -> Tasks**" and select "**Add New Item…**"

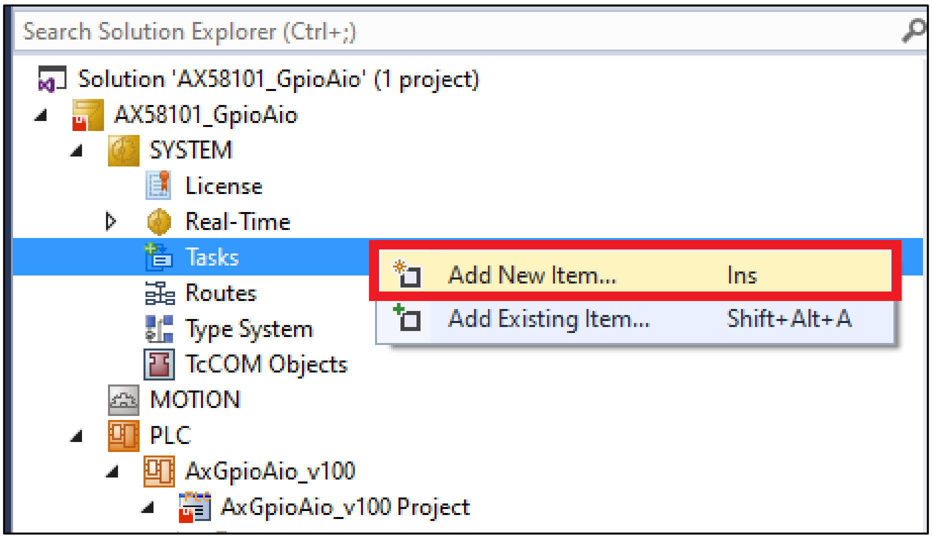

Figure 5-6

- Step 5: Type “**Plc Task**” on “**Name**” field and click “**OK**”.

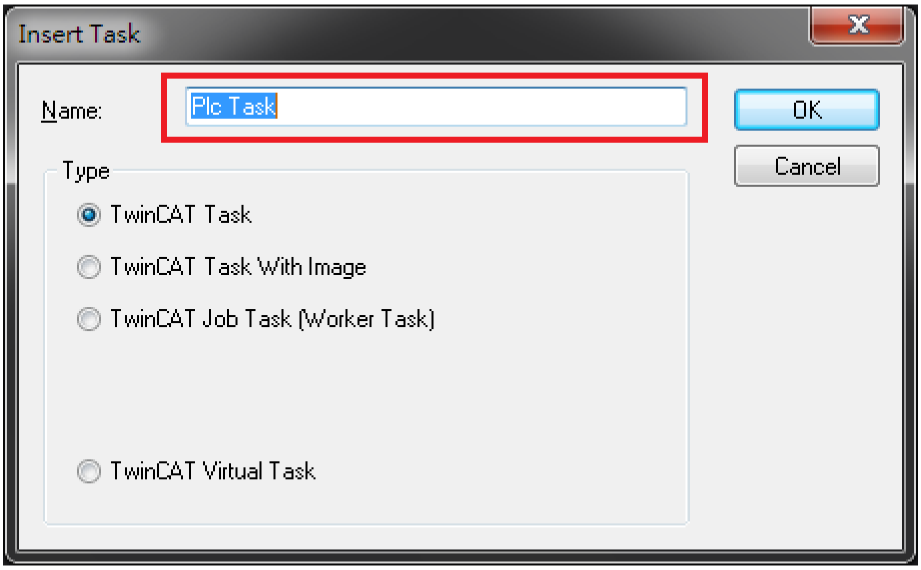

Figure 5-7

- Step 6: Click “**AxGpioAio Project -> Add -> Referenced Task…**”

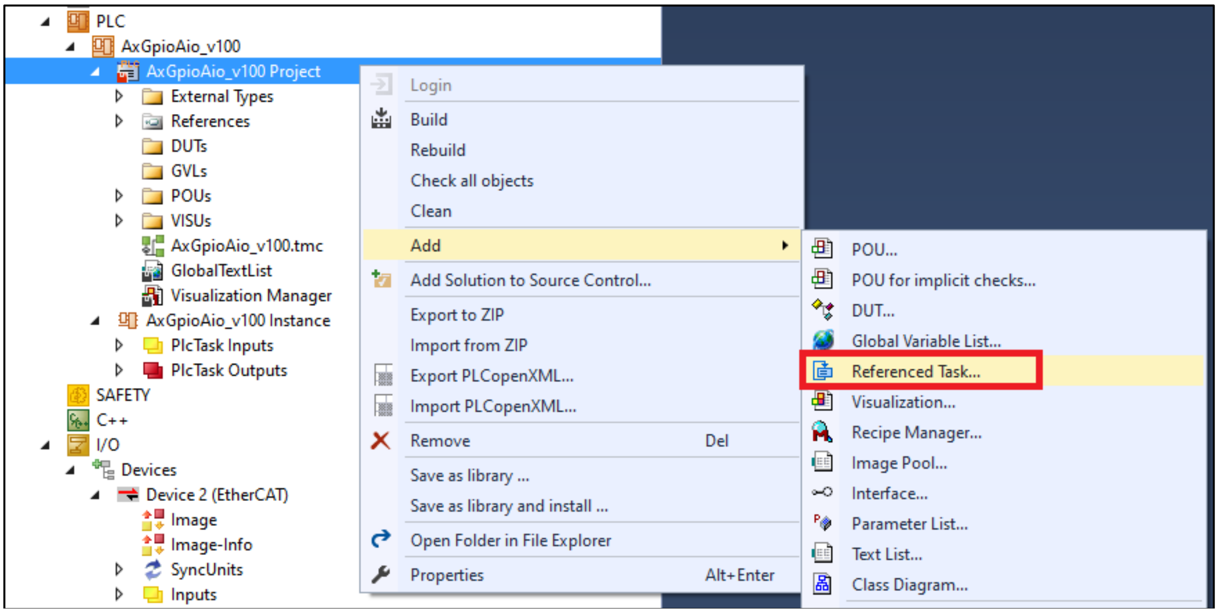

Figure 5-8

- Step 7: Select the "**Plc Task**" and click "**Open**".

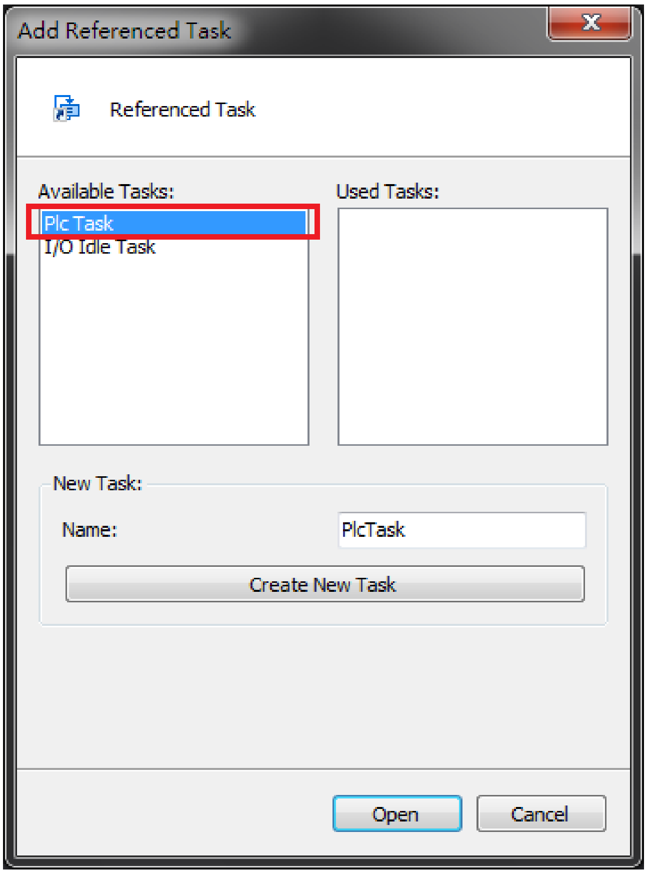

Figure 5-9

- Step 8: Right-click on "**AxGpioAio Project -> Plc_Task -> Add**" and select "**Existing Item…**"

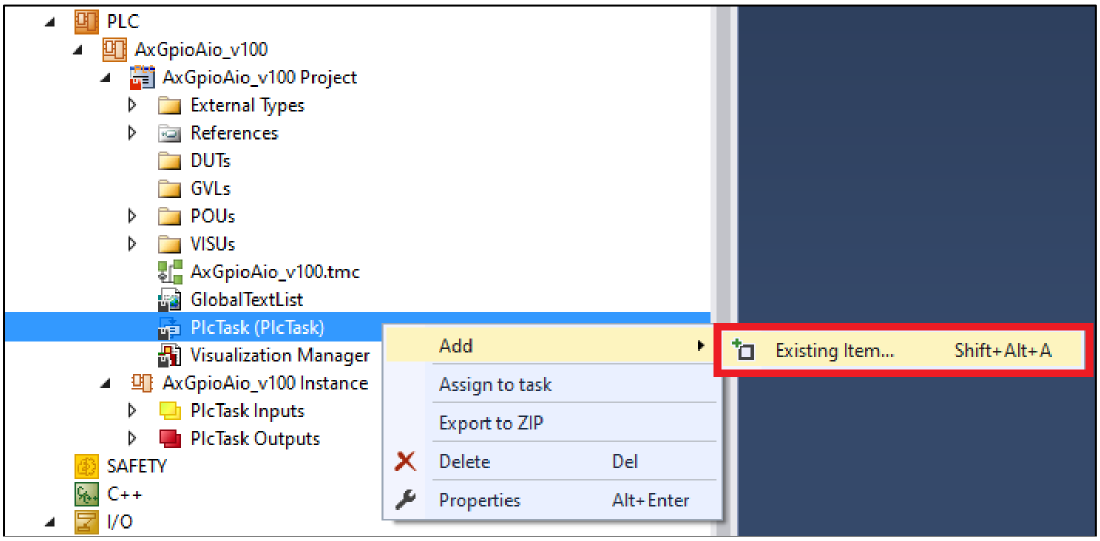

Figure 5-10

- Step 9: Select the "**AxGpioAio -> POUs -> MAIN**" and click "**OK**".

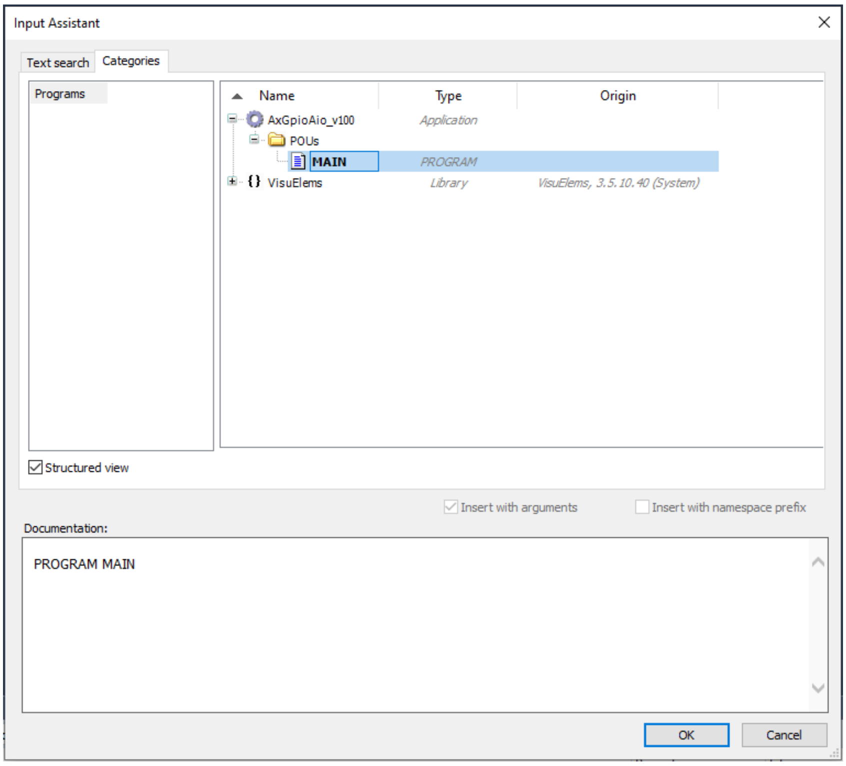

Figure 5-11

- Step 10: Right-click on **AxGpioAio PLC Project -> Propertice -> Visualization Profile -> Select your lib version -> Active** and save it**.**

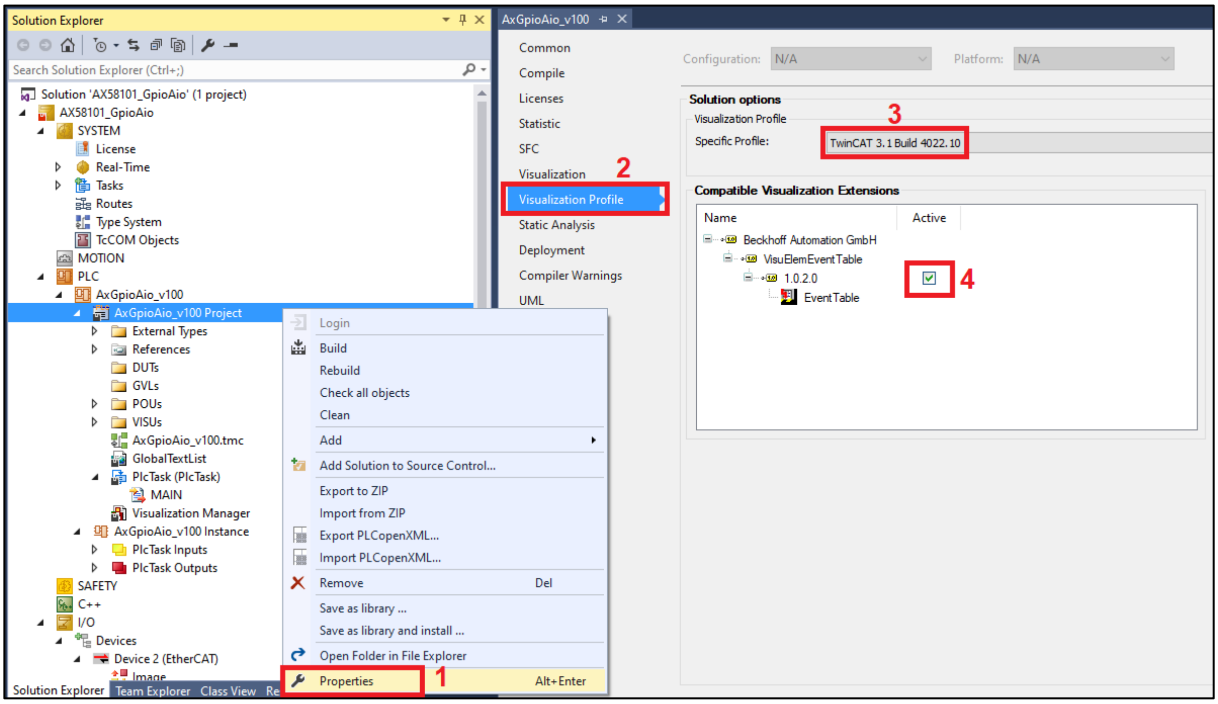

Figure 5-12.

- Step 11: Right-click on "**AxGpioAio Project**" and select "**Build**".

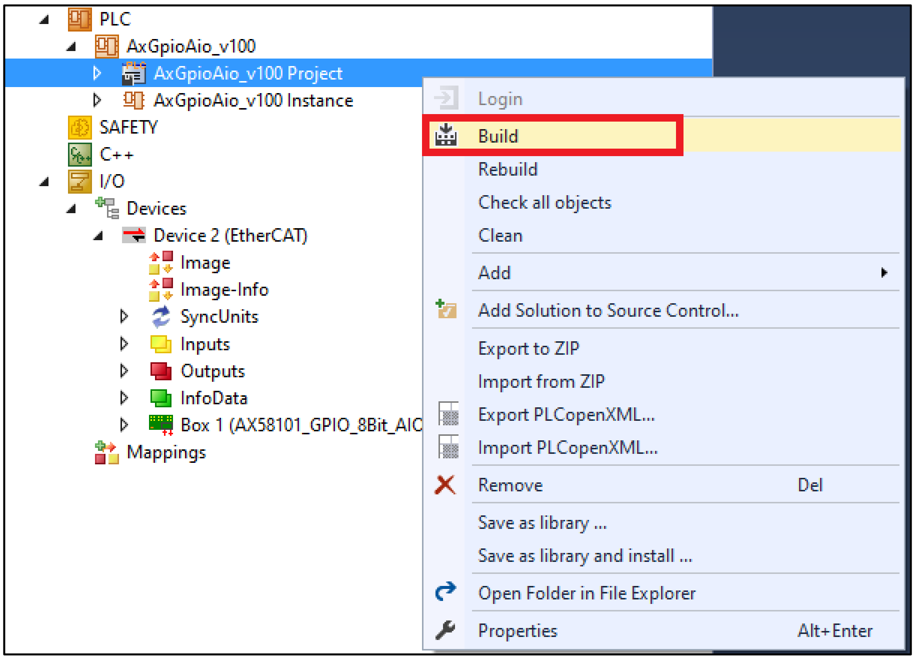

Figure 5-13

5-2 AxGpioAio PLC Operation

Here introduces the manipulation about AxGpioAio PLC program.
If the PLC program package has imported successfully, the PLC PD entries under instance node shall look like the figure below.

Yellow color indicates the software variables are used for read PD (Process Data) input from SubDevice.
Red color indicates the software variables are used for write PD (Process Data) output to SubDevice.

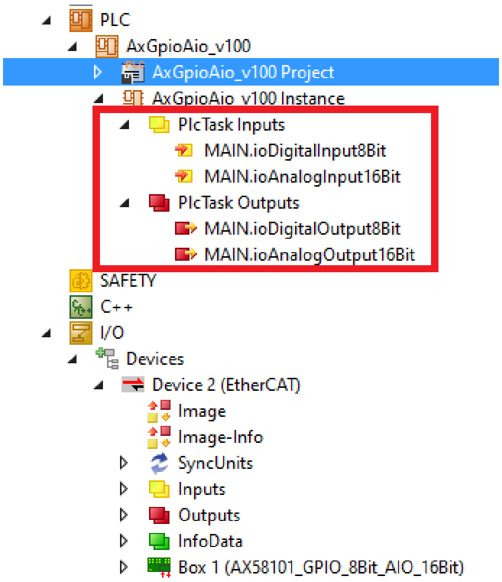

Figure 5-14

5-2-1 PD Link

TwinCAT XAE provides a powerful function that software variables could link to PD of EtherCAT SubDevice. In this application, we use many 4 PD links for access digital and analog input / output of EtherCAT SubDevices. We declare the PD (Process Data) in ESI file for each known EtherCAT SubDevices. TwinCAT XAE list all available PDs of every EtherCAT SubDevices after scanning them out. We can assign some software variable mapping to some PD in the list under “IO” entry so that the application could access the PD directly. But please attention, all PD links should have same data types (ex: BYTE → BYTE, WORD → WORD) between software variables and PDs.

We illustrate procedure of PD link here. If you want to create a PD link, please follow below procedure:

- Step 1: Right-click on specific software variable and select "**Change Link…**"

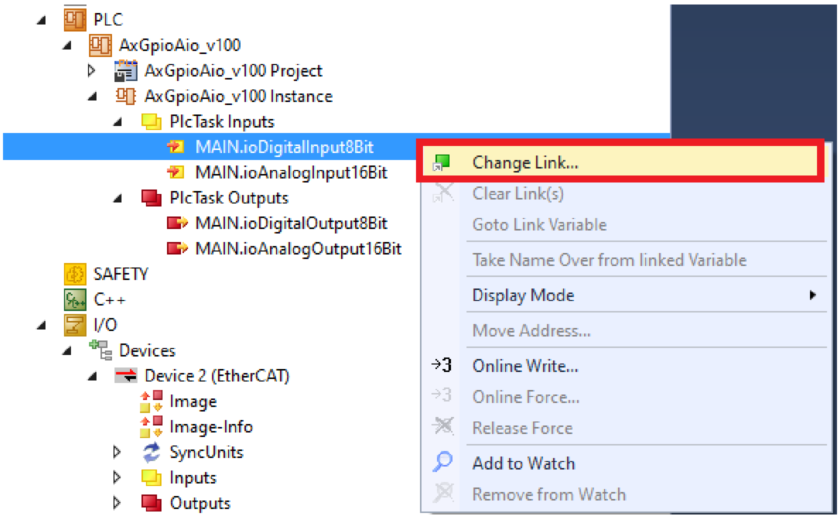

Figure 5-15

- Step 2: Select specific PD and click "OK"

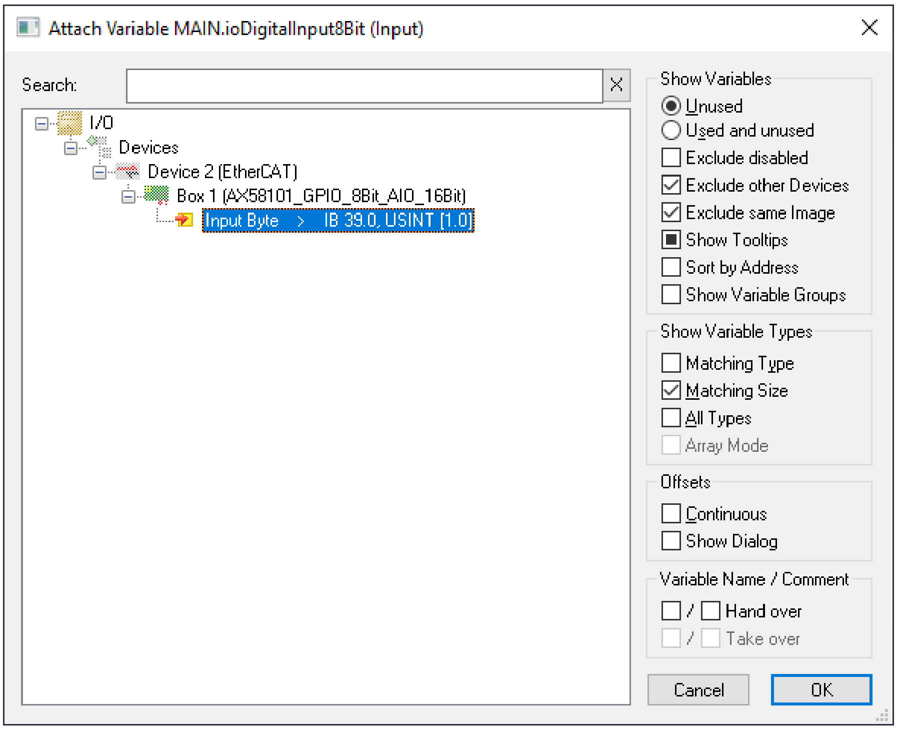

Figure 5-16

Then you will see the black arrow icon appears.

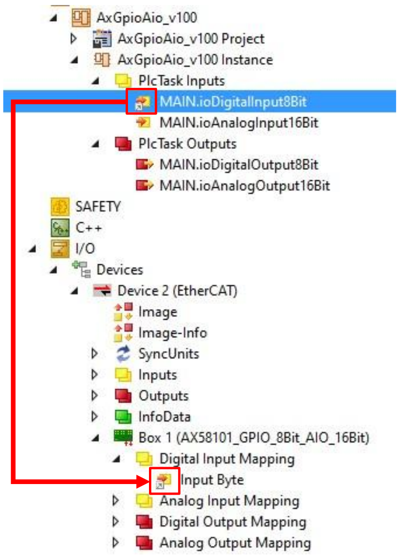

Figure 5-17

If you want to check out linked PD, just right click on the software variable and select "**Goto Link Variable**".
If you want to check out linked software variable while mouse focus the PD, just do same above motion.

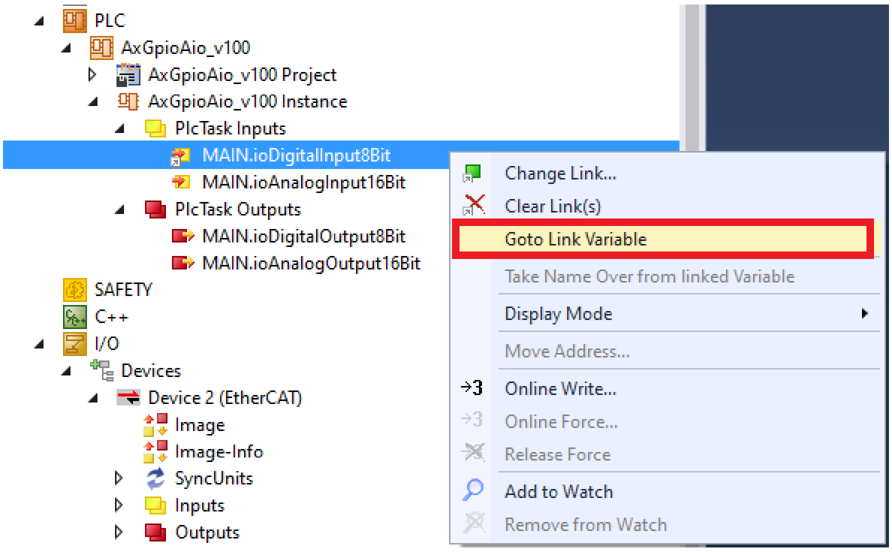

Figure 5-18

If you want to clear the link, just right click on the software or PD and select “**Clear Link(s)**”.

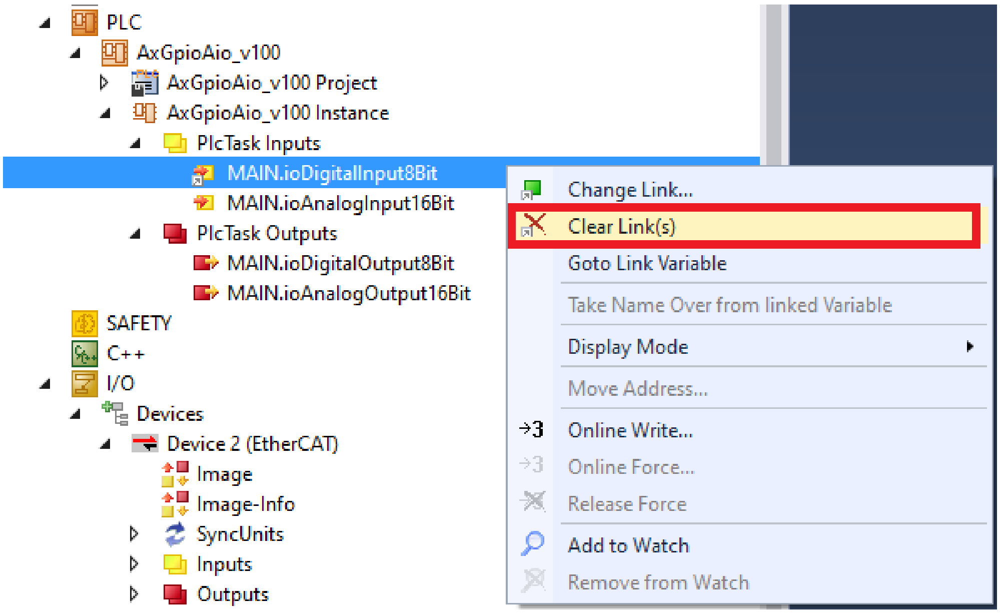

Figure 5-19

5-2-2 Link Reference

In this application, the PLC reference PDs as below table.

AxGpioAio		
Software Variable	**PD**	**Description**
MAIN.ioDigitalInput8Bit	InputByte	PD link for digital input in 8bit.
MAIN.ioDigitalOutput8Bit	OutputByte	PD link for digital output in 8bit.
MAIN.ioAnalogInput16Bit	InputWord	PD link for analog input in 16bit.
MAIN.ioAnalogOutput16Bit	OutputWord	PD link for analog output in 16bit.

Table 5-1

5-2-3 Execution PLC

If you understand and ready for above mentioned chapters, here we can start to execute the PLC program. We should active / re-active the TwinCAT configuration after any configurations changed or your TwinCAT MainDevice in configure mode.
Note: You **MUST** setup PD link so that TwinCAT MainDevice can let the SubDevice enter OP mode.

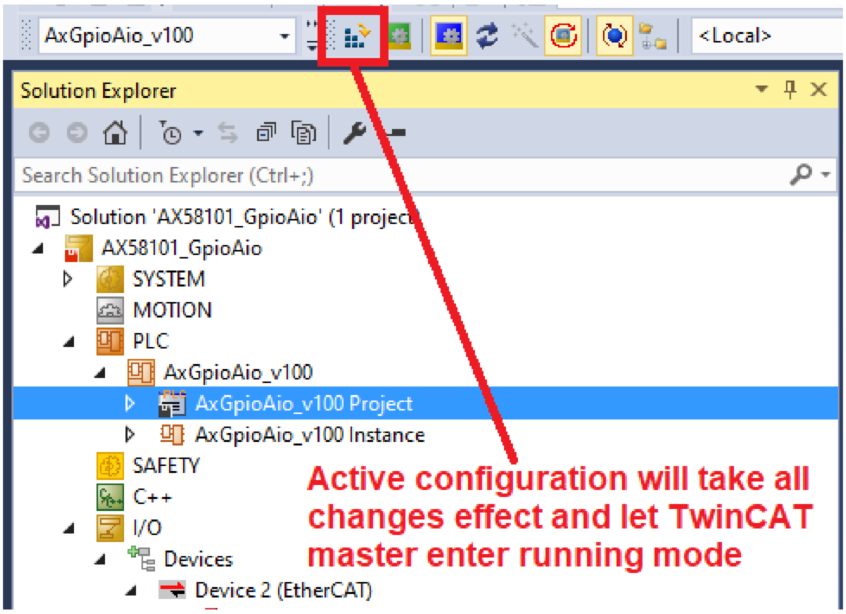

Figure 5-20

Please follow below steps for execute PLC application:

- Step 1: Confirm the device in "OP" state

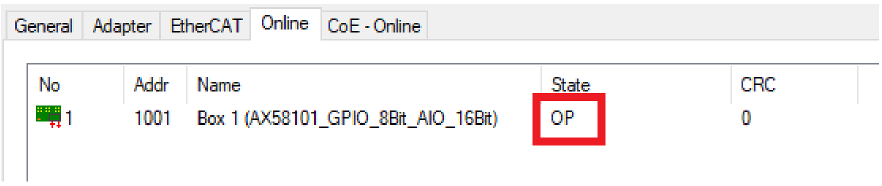

Figure 5-21

- Step 2: Click "Login"

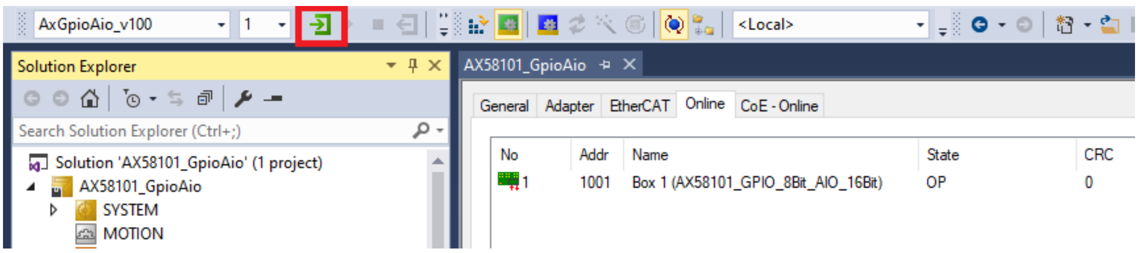

Figure 5-22

- Step 3: Click “Yes”

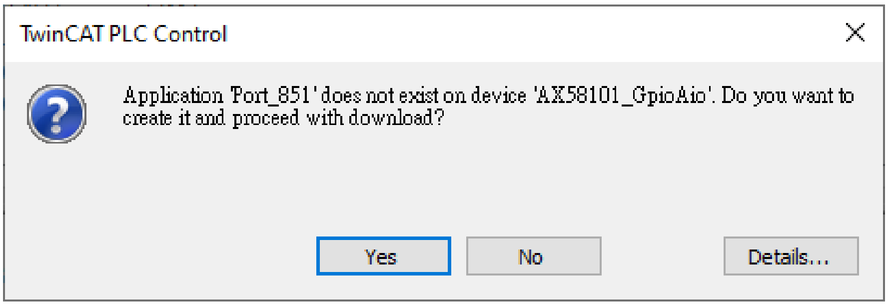

Figure 5-23

- Step 4: Click “Start” icon

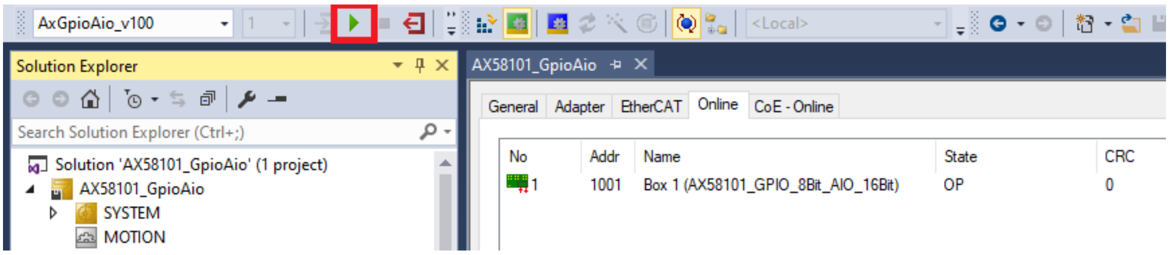

Figure 5-24

- Step 5: Double click “Visualization” to let PLC GUI pop out

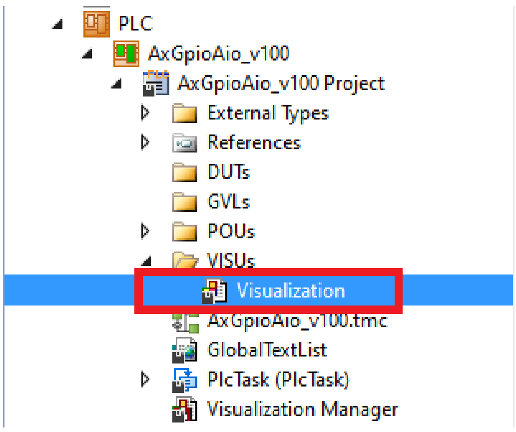

Figure 5-25

If you want to play this GUI, please turn on the power by clicking "PWR" button.
Each field description as following:
- Highlight 1: Power button.
- Highlight 2: 8 LEDs indicates digital input from "DIP Switch" of EXB-ADIO board.
- Highlight 3: 8 toggle switches for control digital output to "LED" of EXB-ADIO board.
- Highlight 4: Hex value indicates analog input from "ADC" voltage of EXB-ADIO board.
- Highlight 5: Input hex value here for control analog output to "DAC" voltage of EXB-ADIO board.

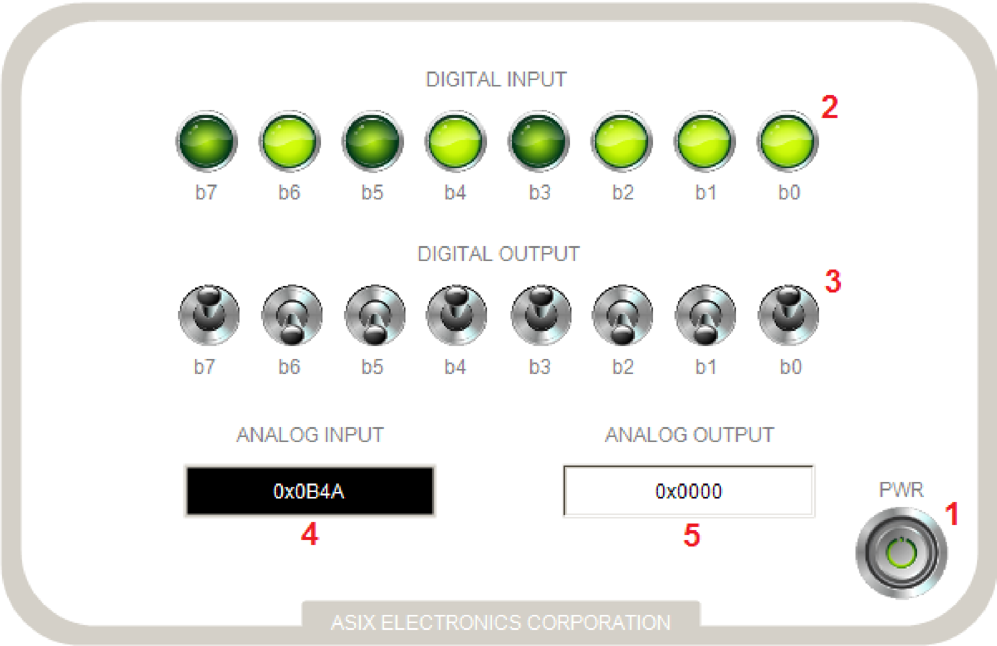

Figure 5-26

5-2-4 Adjustable Factors

This PLC example supports GPIO/AIO example programs for AX58101(2). Since the ADC and DAC resolution of the MCU peripherals may vary between models, the voltage display gauge in this PLC example also needs adjustment to reflect the actual voltage. The following explains how to make these adjustments.

According to the formula, we can adjust the following parameters
ADC Formula:
estimatedADCVoltage = ((floatAnalogInput-floatReferenceAdcOffset) / (floatReferenceAdcBase-floatReferenceAdcOffset)) * floatReferenceVoltage

DAC Formula:
estimatedDACVoltage = (floatAnalogOutput / floatReferenceDacBase) * floatReferenceVoltage

```
floatReferenceVoltage       :   REAL := 3.3;
floatReferenceAdcBase       :   REAL := 4095;
floatReferenceAdcOffset     :   REAL := 0;
floatReferenceDacBase       :   REAL := 4095;
floatAnalogInput            :   REAL := 0;
estimatedADCVoltage         :   REAL := 0;
floatAnalogOutput           :   REAL := 0;
estimatedDACVoltage         :   REAL := 0;
```

Figure 5-27

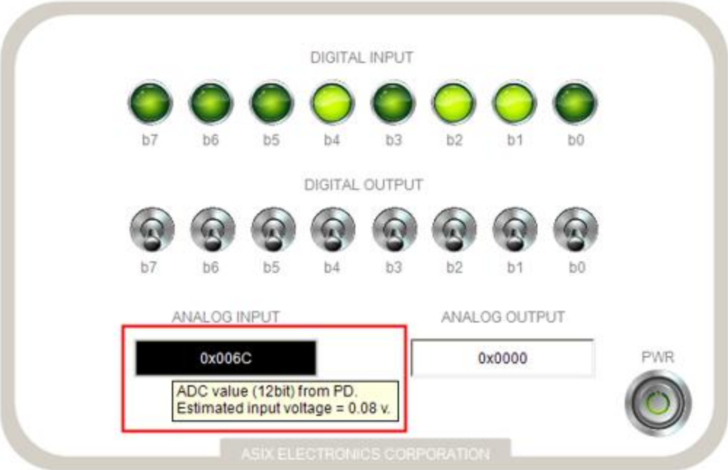

Figure 5-28

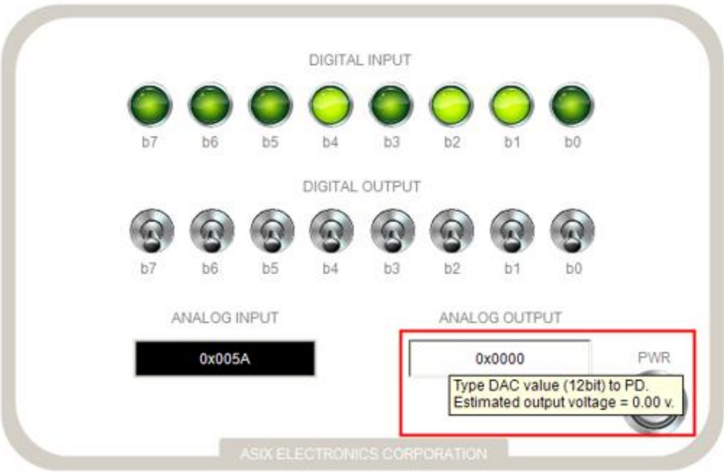

Figure 5-29

5-3 AxMotorControl PLC Operation

If your PLC project has been imported successful, you will see related software variables listed under "**AxMotorControl_vXXX Instance**":
Yellow color indicates the software variables are used for read PD (Process Data) input from SubDevice.
Red color indicates the software variables are used for write PD (Process Data) output to SubDevice.

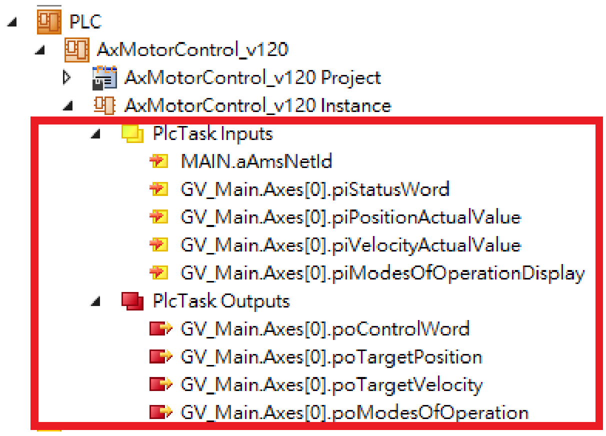

Figure 5-30

5-3-1 PD Link

TwinCAT XAE provides a powerful function that software variables could link to PD of EtherCAT SubDevice. In this application, we declare the PD (Process Data) in ESI file for each known EtherCAT SubDevices. TwinCAT XAE list all available PDs of every EtherCAT SubDevices after scanning them out. We can assign some software variable mapping to some PD in the list under "IO" entry so that the application could access the PD directly. But please attention, all PD links should have same data types (ex: BYTE → BYTE, WORD → WORD) between software variables and PDs.

We illustrate procedure of PD link here. If you want to create a PD link, please follow below procedure:

- Please follow steps below then press "**OK**" to complete PD link of "**MAIN.aAmsNetId**" variable.

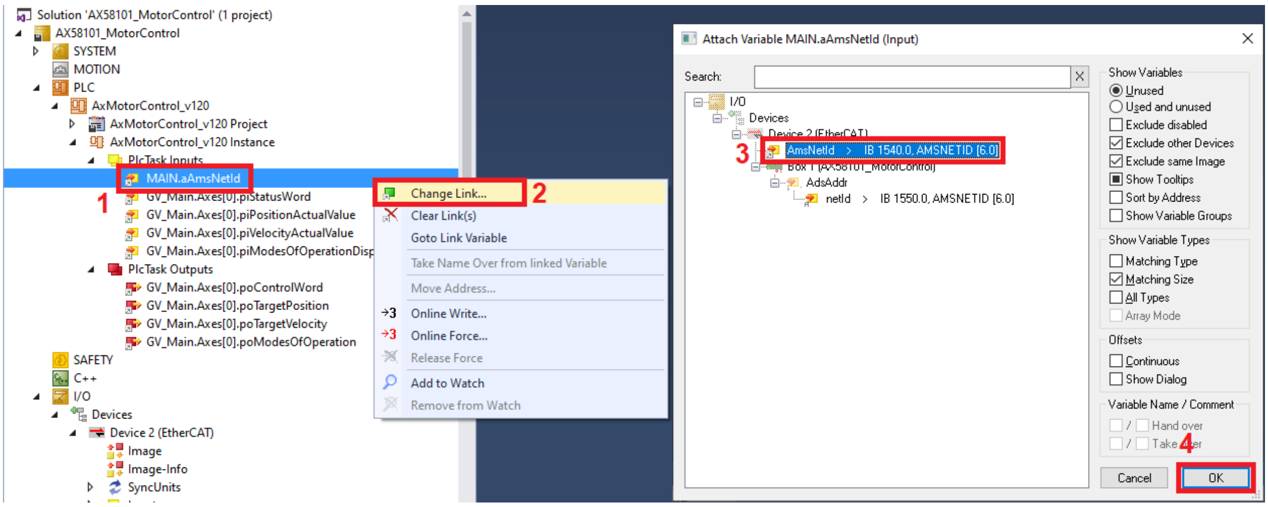

Figure 5-31

Then you will see the black arrow icon appears.

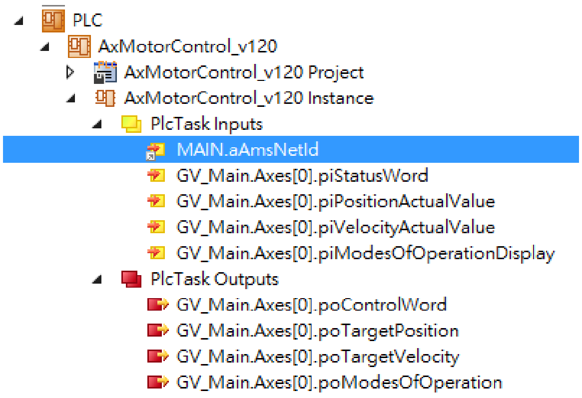

Figure 5-32

- Next, you need to complete remaining PD link in the same way.

  Link “**GV_Main.Axes[0].piStatusWord**” variable.

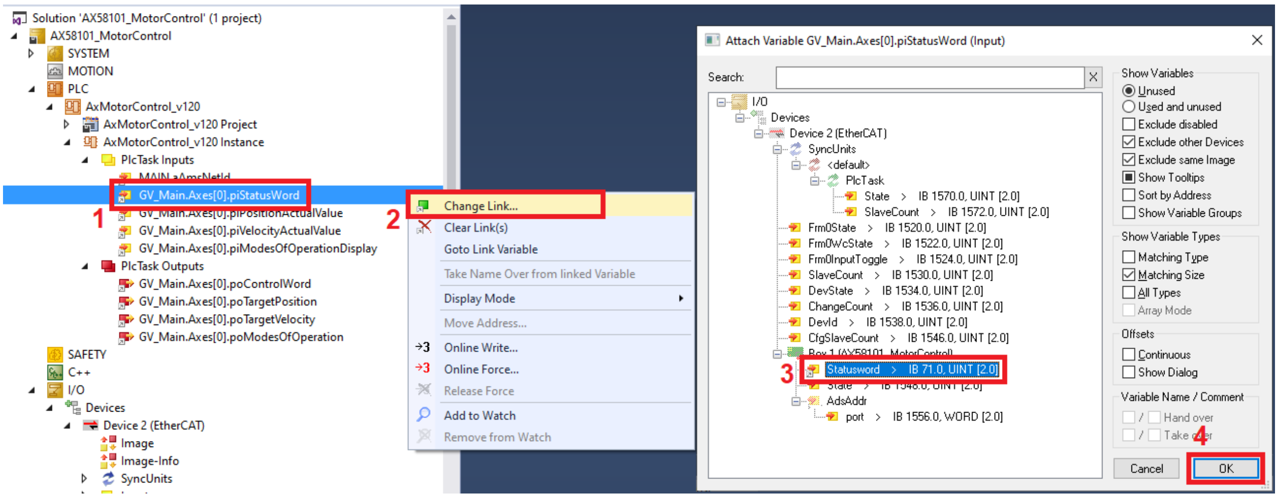

Figure 5-33

Link “**GV_Main.Axes[0].piPositionActualValue**” variable.

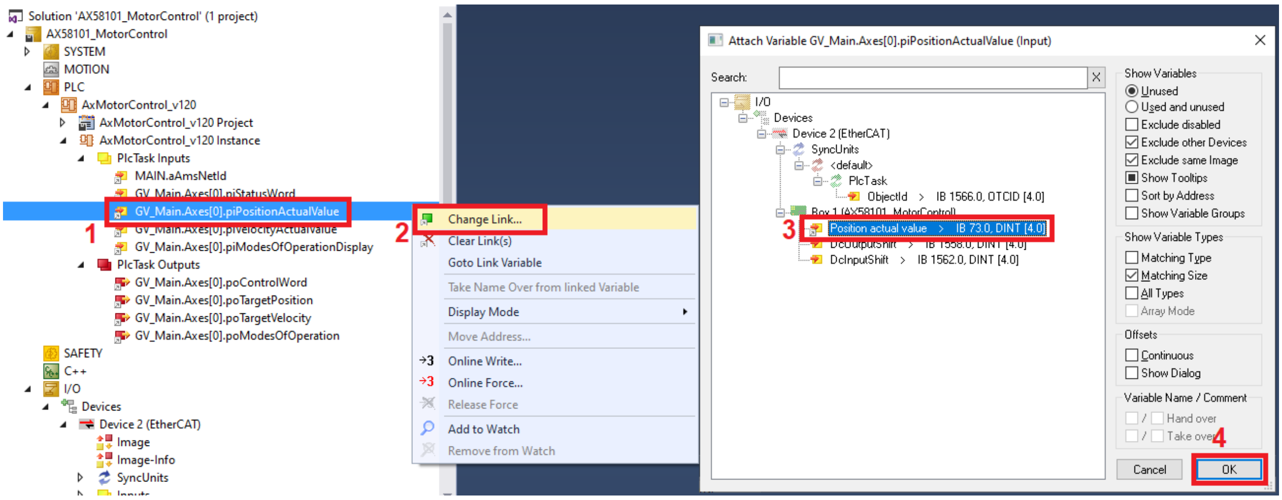

Figure 5-34

Link “**GV_Main.Axes[0].piVelocityActualValue**” variable.

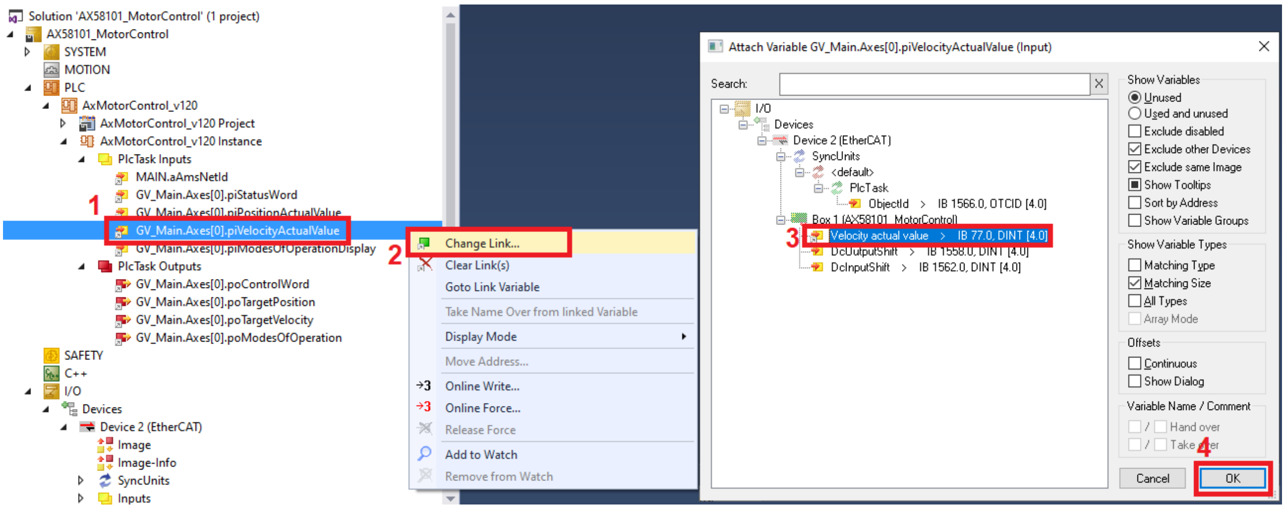

Figure 5-35

Link “**GV_Main.Axes[0].piModeOfOperationDisplay**” variable.

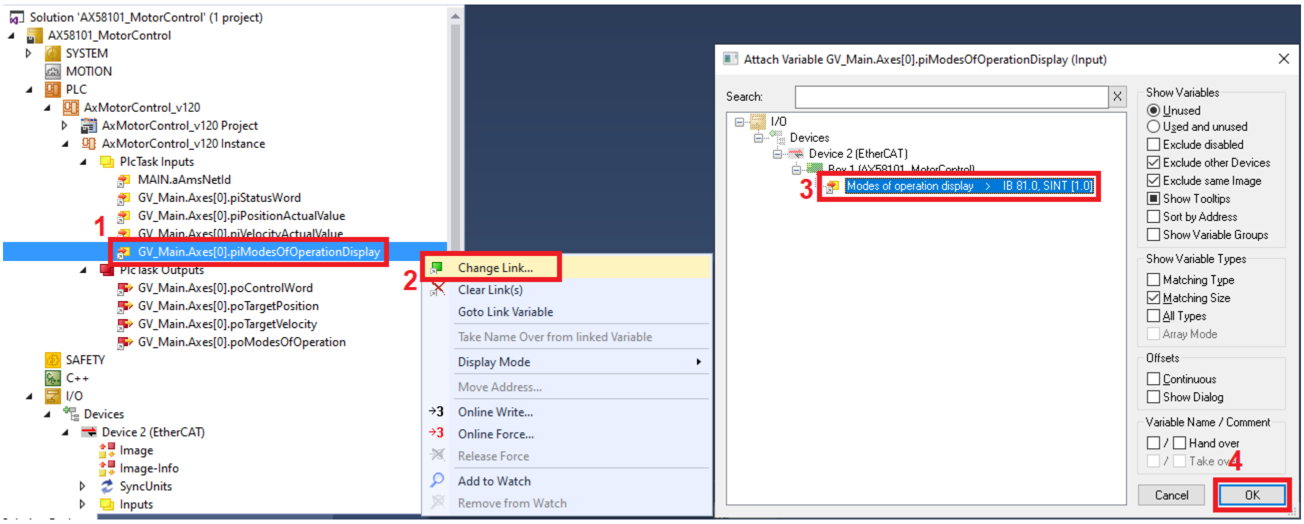

Figure 5-36

Link “**GV_Main.Axes[0].poControlWord**” variable.

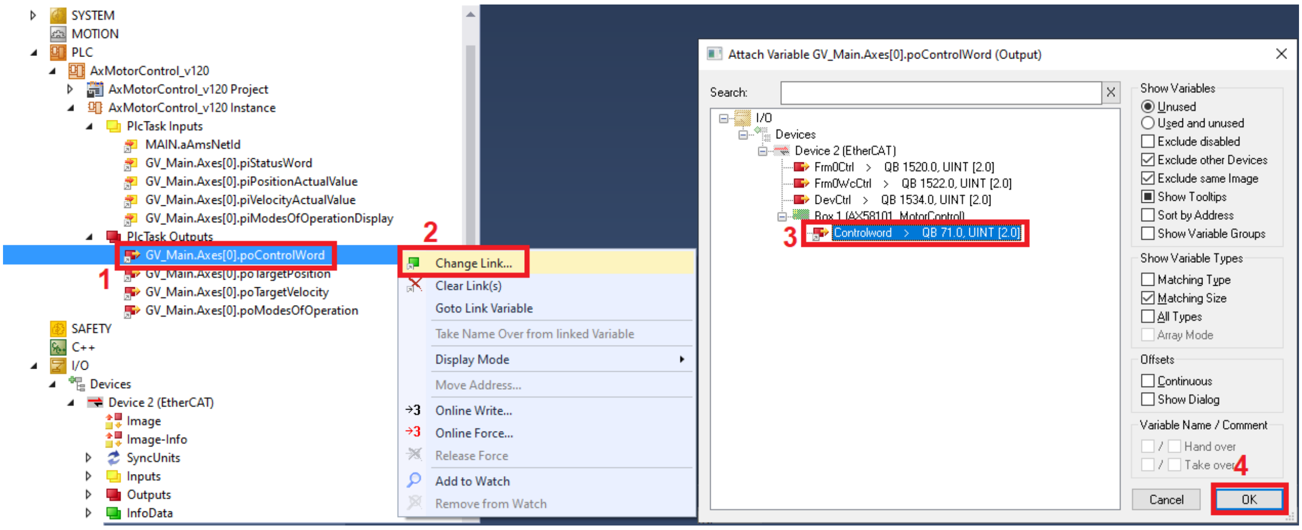

Figure 5-37

Link "**GV_Main.Axes[0].poTargetPosition**" variable.

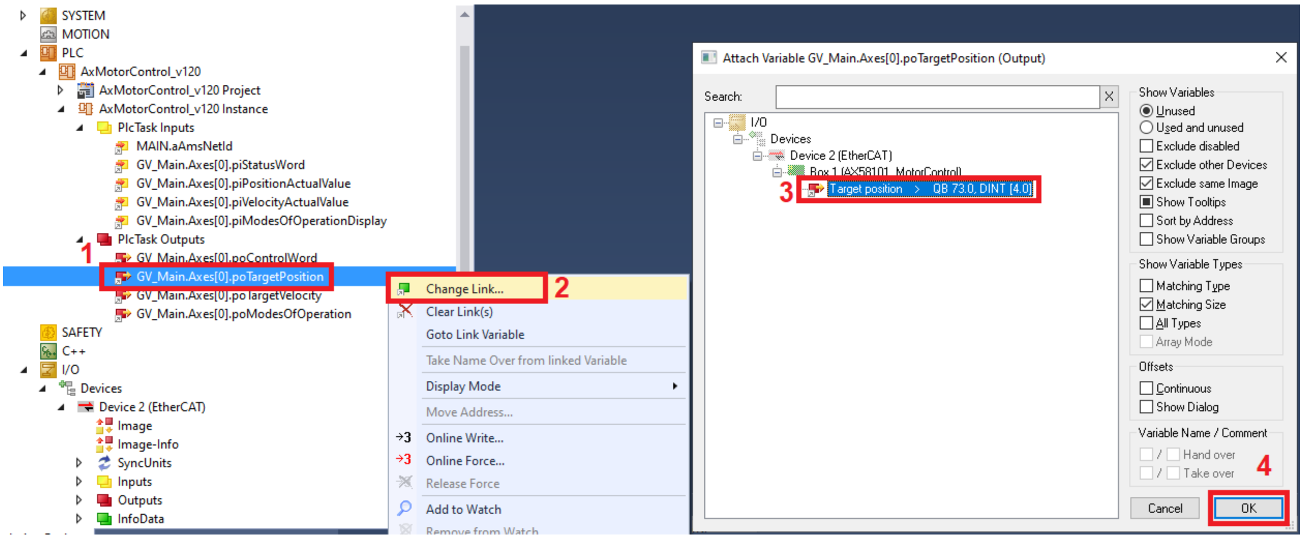

Figure 5-38

Link "**GV_Main.Axes[0].poTargetVelocity**" variable.

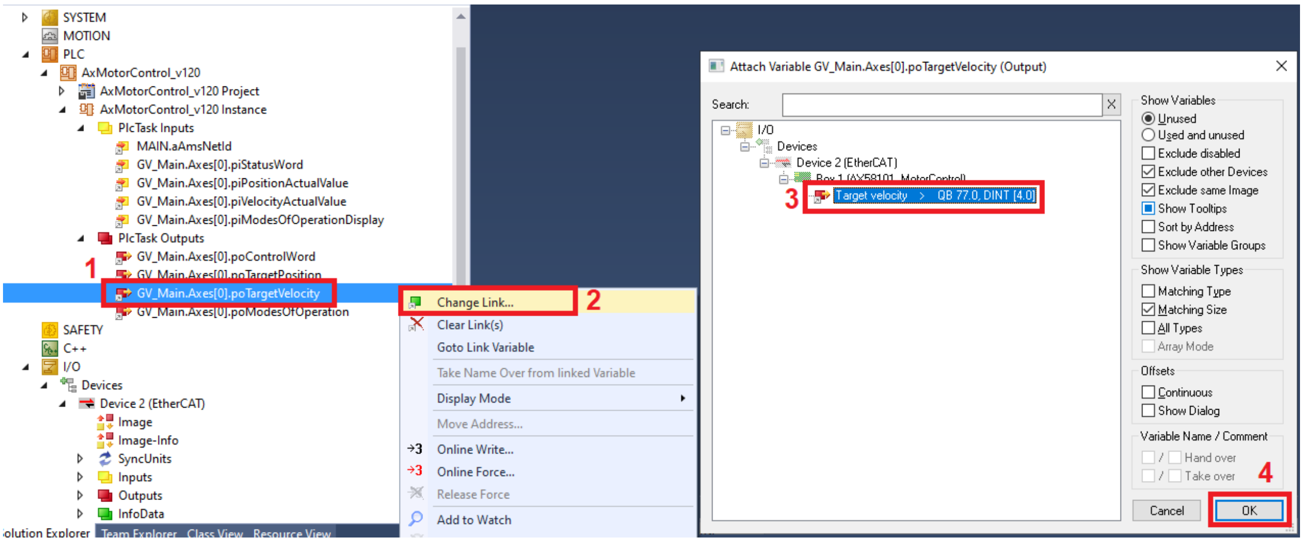

Figure 5-39

Link “**GV_Main.Axes[0].poModesOfOperation**” variable.

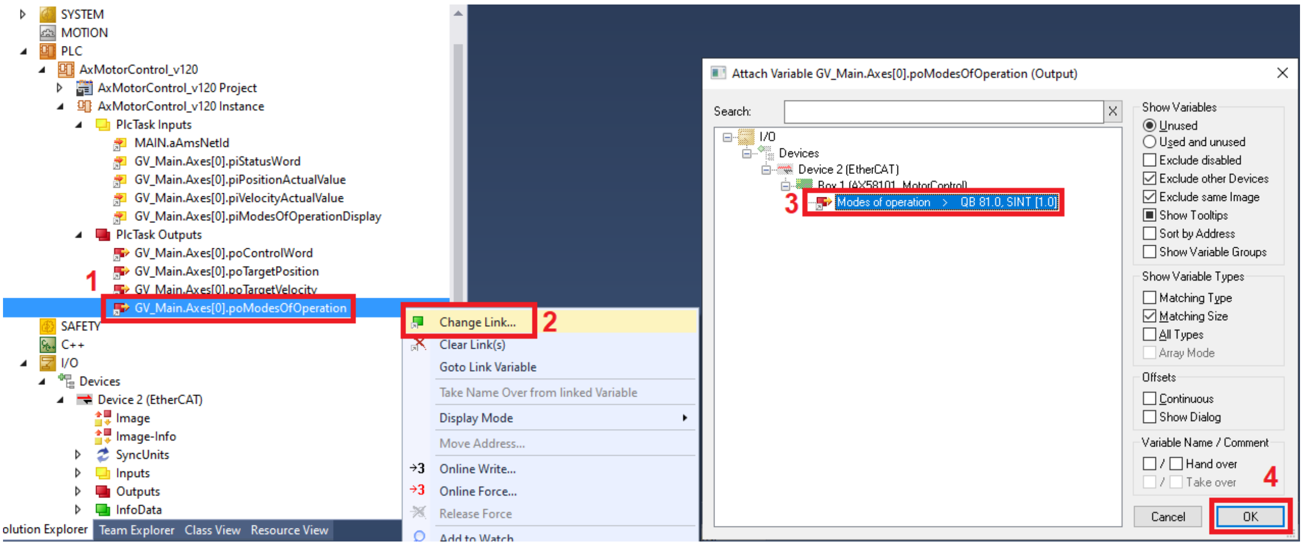

Figure 5-40

If you want to check out linked PD, just right click on the software variable and select “**Goto Link Variable**”. If you want to check out linked software variable while mouse focus the PD, just do same above motion.

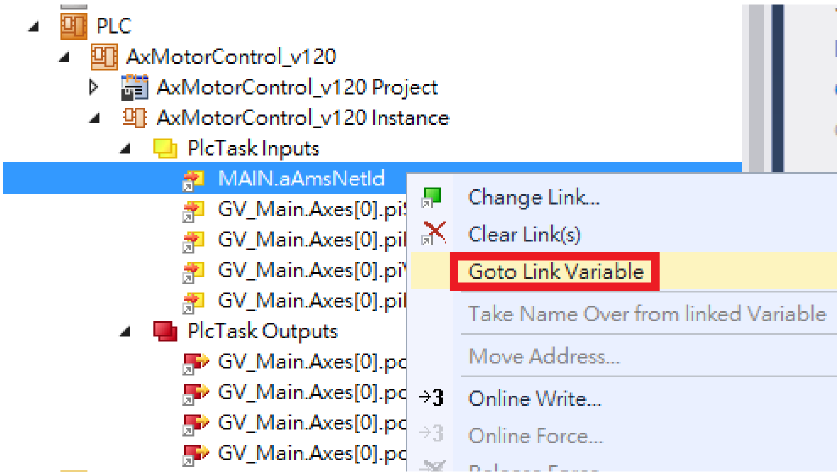

Figure 5-41

If you want to clear the link, just right click on the software or PD and select "**Clear Link(s)**".

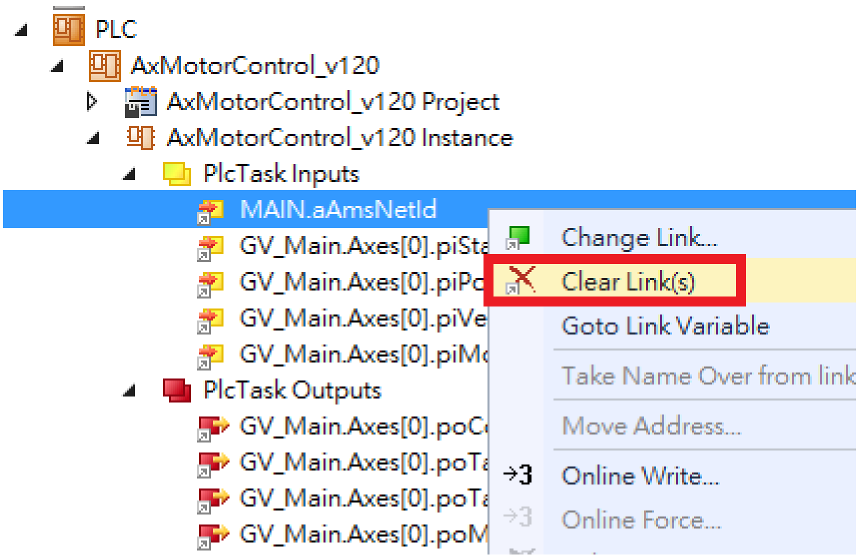

Figure 5-42

5-3-2 Link Reference

In this application, the PLC reference PDs as below table.

AxMotorControl PD Link		
PLC Side Variable	**SubDevice Side Object**	**Description**
MAIN.aAmsNetId	N/A	Input 6bytes AMS NetId of MainDevice
GV_Main.Axes[0].piStateWord	Status word	Input 2bytes
GV_Main.Axes[0].piPositionActualValue	Position actual value	Input 4bytes for CSP mode
GV_Main.Axes[0].piVelocityActualValue	Velocity actual value	Input 4bytes for CSV mode
GV_Main.Axes[0].piModesOfOperationDisplay	Modes of operation display	Input 1byte for current operation mode status
GV_Main.Axes[0].poControlWord	Control word	Output 2bytes
GV_Main.Axes[0].poTargetPosition	Target position	Output 4bytes for CSP mode
GV_Main.Axes[0].poTargetVelocity	Target velocity	Output 4bytes for CSV mode
GV_Main.Axes[0].poModesOfOperation	Modes of operation	Output 1byte for operation mode control

Table 5-2

By the way, because this PLC program can work with AX58x01 MotorControl Reference Design, so the "GV_Config" file provides some settings to do adaption, like this.

The Electronic Gear setting for AX58101 MotorControl:
aElecGearPositionN[0] : 1
aElecGearPositionD[0] : 1
aElecGearVelocityN[0] : 1
aElecGearVelocityD[0] : 360

The "GV_Config" file can be found in the "Solution Explorer" as below path.
"AxMotorControl_v120 Project > GVLs > GV_Config"

5-3-3 Set DC Cycle Time

Before entering the DC mode, you need to set the system clock first. Please follow the steps below.

- Step 1: Double click Real Time and set Real Time 1ms (the shortest task cycle time 1ms)

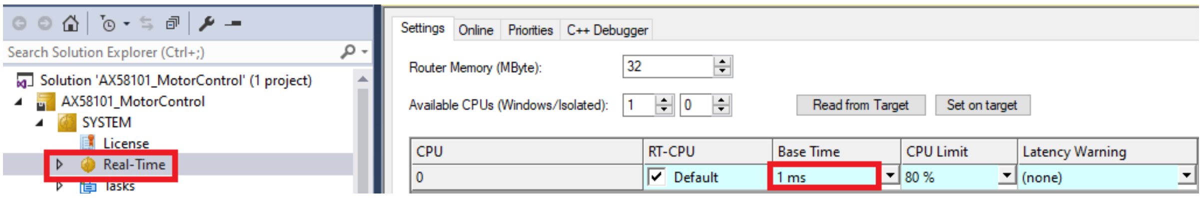

Figure 5-43

- Step 2: Click "**I/O Idle Task**" and set "**Cycle ticks"** a 1ms

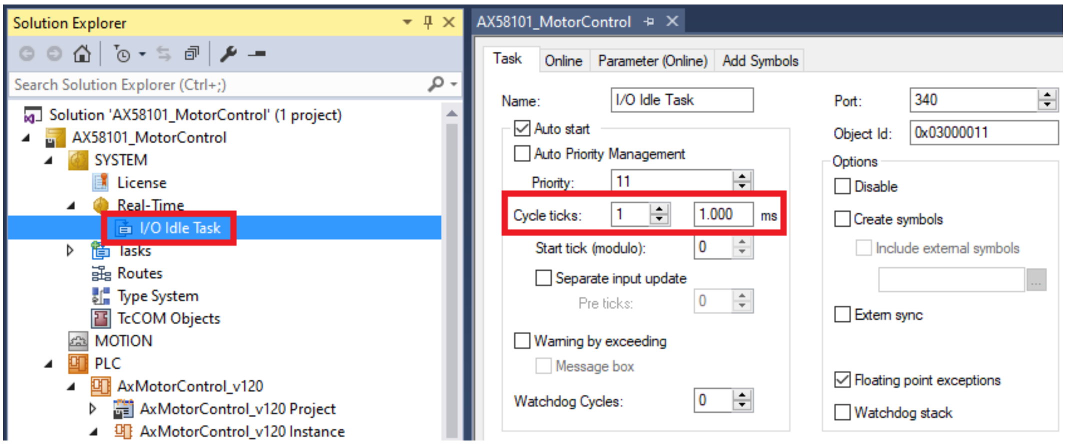

Figure 5-44

- Step 3: Click "**Plc Task**" and set "**Cycle ticks"** a 1ms

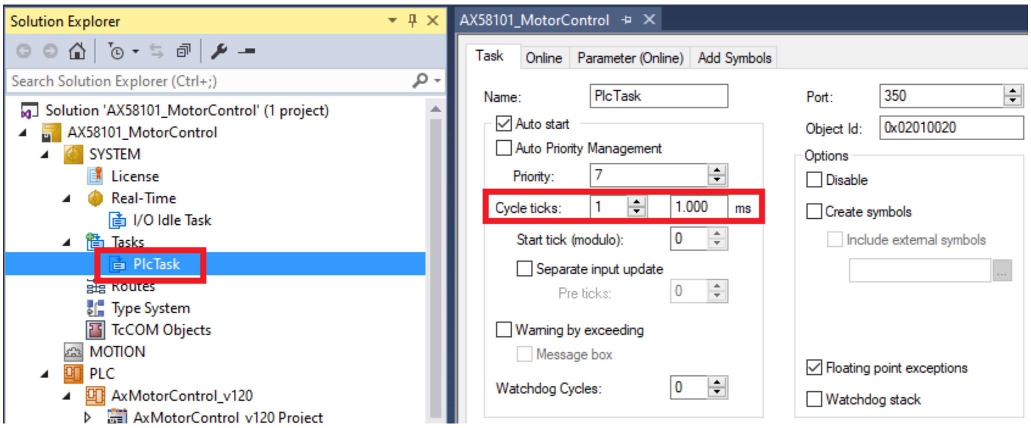

Figure 5-45

- Step 4: Double click “**Device N (EtherCAT)**” and click “**Advanced Settings…**”.

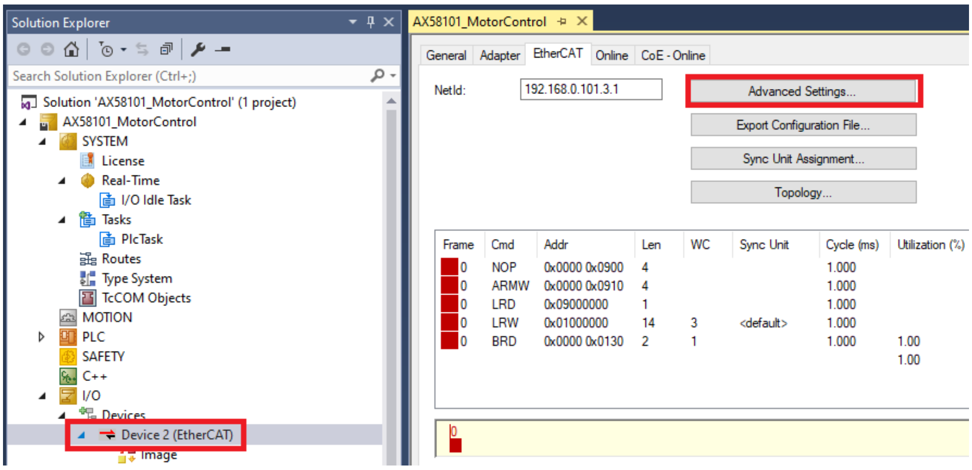

Figure 5-46

- Step 5: Click “**Distributed Clocks**” and select “**DC in use**”.

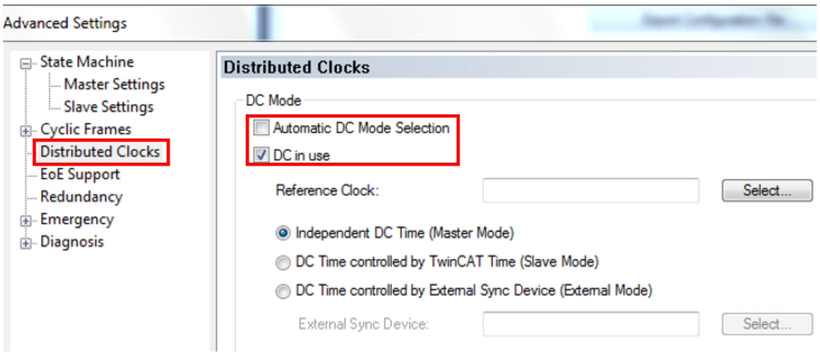

Figure 5-47

- Step 6: Click “**Box 1**”, enter the DC tab, and click “**Advanced Settings…**”.

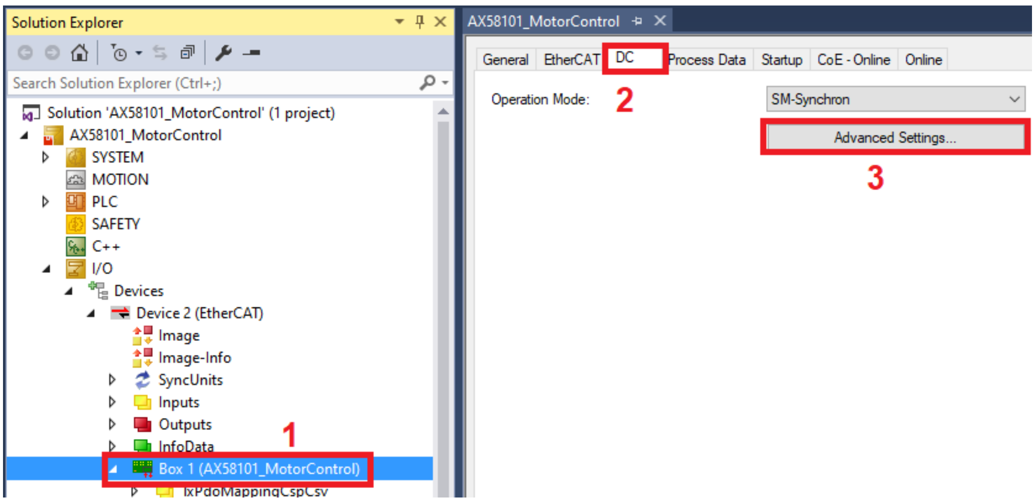

Figure 5-48

- Step 7: Select “**DC-Synchron**”, click “**Use as potential Reference Clock**”, and click “**OK**”.

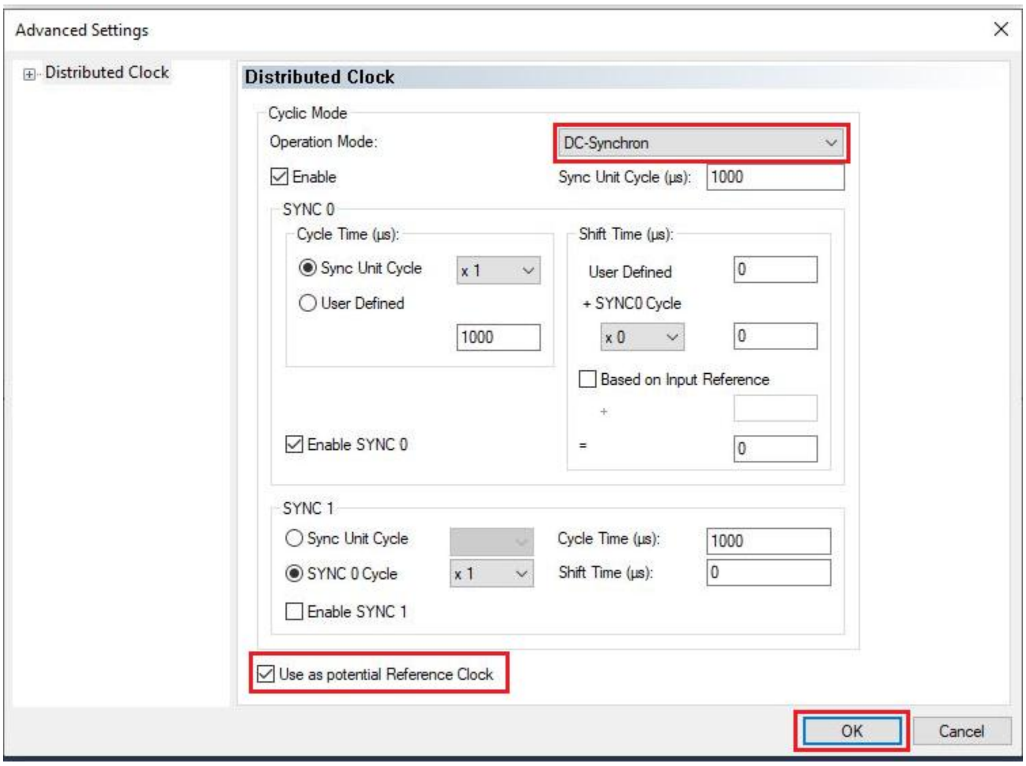

Figure 5-49

5-3-4 Execution PLC

If you understand and ready for above mentioned chapters, here we can start to execute the PLC program. We should active / re-active the TwinCAT configuration after any configurations changed or your TwinCAT MainDevice in configure mode.
Note: You **MUST** setup PD link so that TwinCAT MainDevice can let the SubDevice enter OP mode.

Please follow below steps for running mode and then execute PLC application:

- Step 1: Click "**Activate Configuration**".

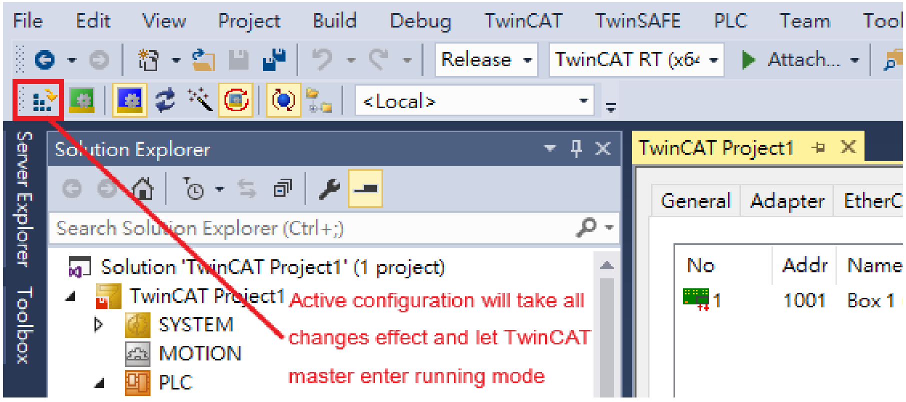

Figure 5-50

- Step 2: Click "**OK**".

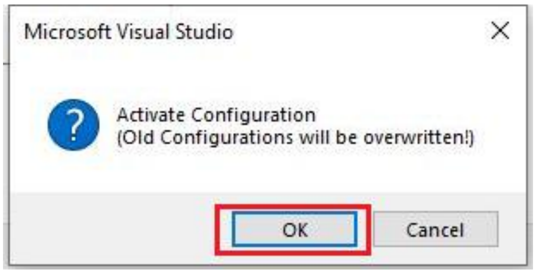

Figure 5-51

- Step 3: Click "**OK**".

Figure 5-52

- Step 4: Confirm the running mode is setting.

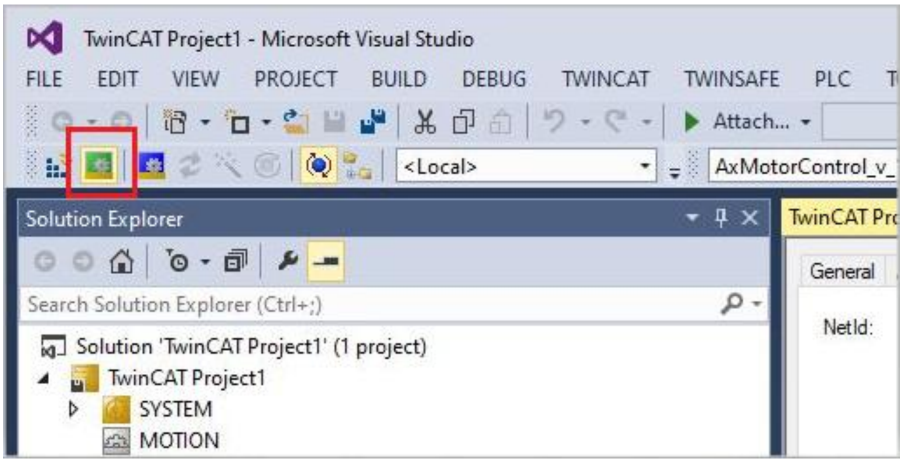

Figure 5-53

- Step 5: Confirm the EtherCAT state is in “**OP**” state.

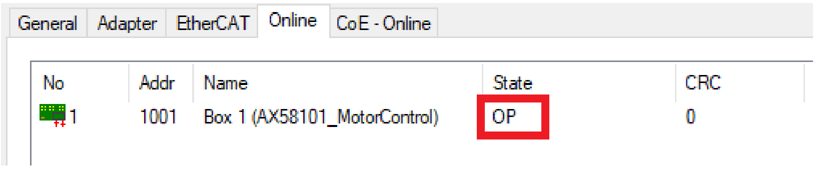

Figure 5-54

- Step 6: Click “**Login**”.

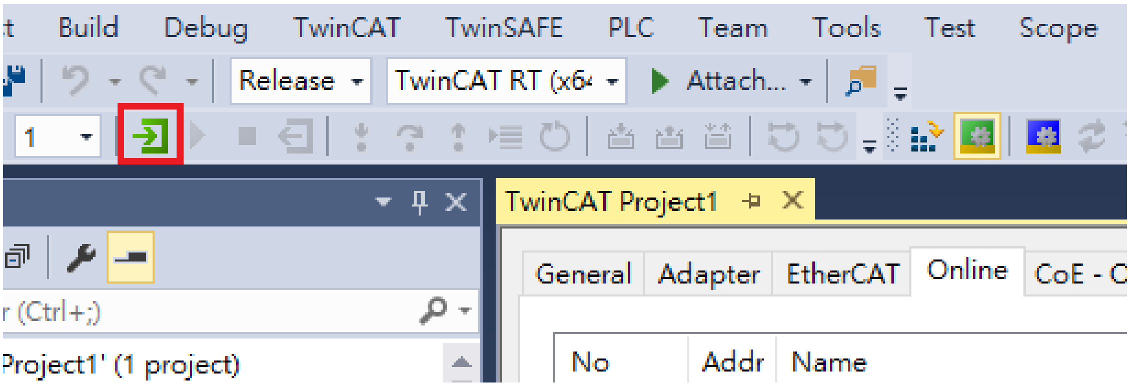

Figure 5-55

- Step 7: Click "**Yes**".

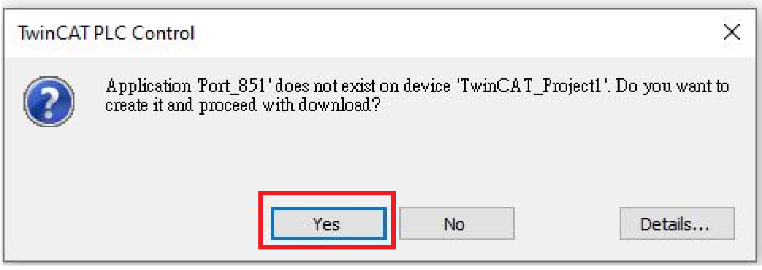

Figure 5-56

- Step 8: Click "**Start**".

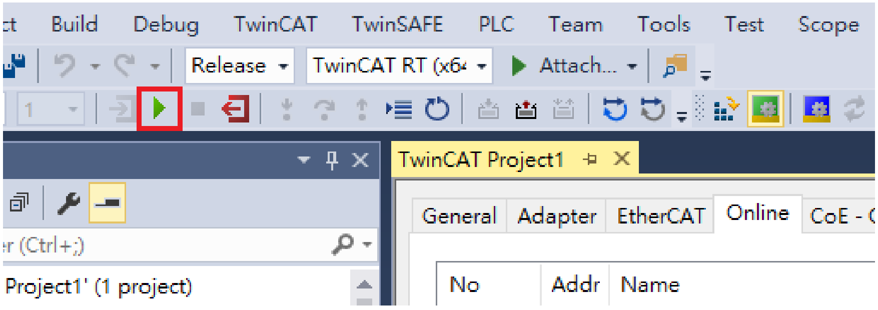

Figure 5-57

- Step 9: Double click "**Demonstration**" to open PLC GUI.

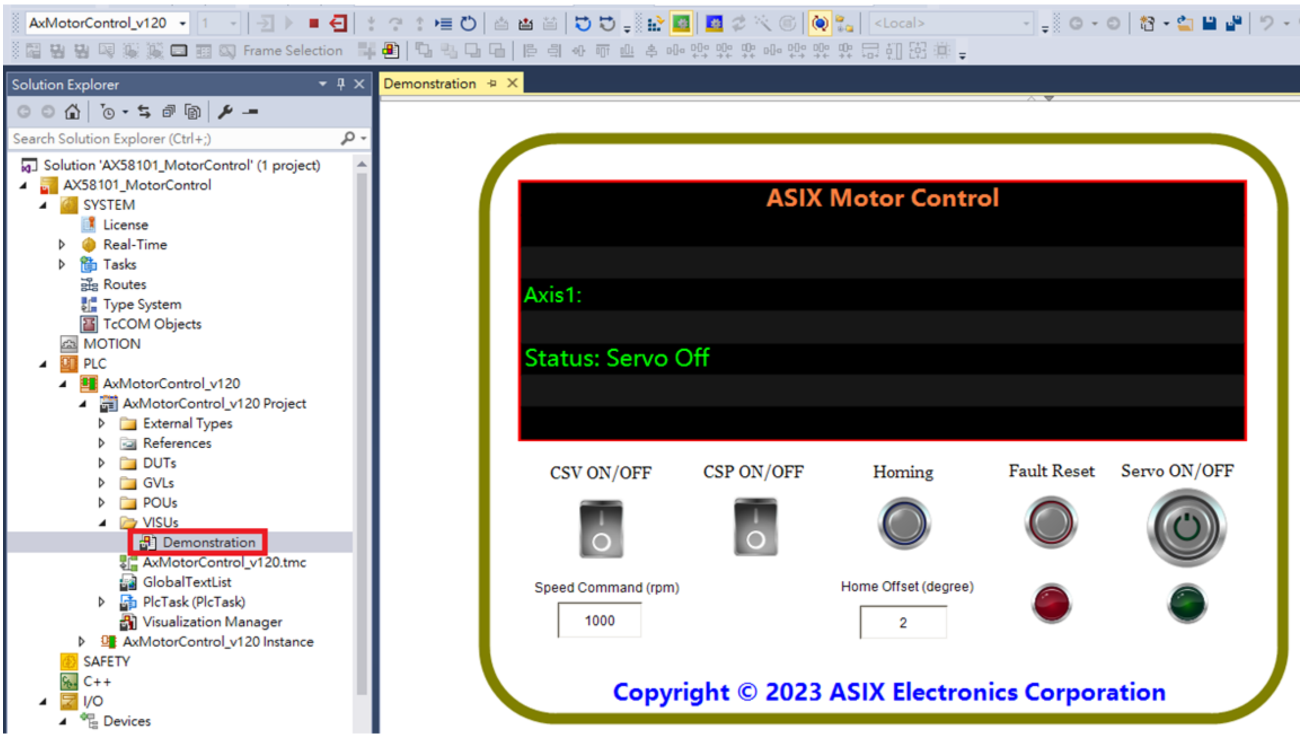

Figure 5-58

- Step 10: Power On

Figure 5-59

- Step 11: Run Demonstration, each field description is as following
  1. Demonstration status.
  2. Servo drive status.
  3. Servo ON/OFF control button.
  4. Servo ON/OFF indicator lamp.
  5. Fault reset button.
  6. Fault state indicator lamp.
  7. Home offset setting.
  8. Homing control button.
  9. CSP demonstration control button.
  10. CSV demonstration control button.
  11. CSV speed command.

Figure 5-60

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