ECATSEMUG

eCAT Servo Motor Example User Guide

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Application note
COMPANY PUBLIC

Document information

Information	Content
Keywords	eCAT, Ethernet for Control Automation Technology, EtherCAT, SSC, EtherCAT Controller, COE, Servo Motor
Abstract	The servo motor example uses TwinCAT software as EtherCAT Master, i.MXRT1180 as EtherCAT Slave, which supports CiA402 profile to drive the motor.

1 Introduction

The servo motor example uses TwinCAT software as EtherCAT Master, i.MXRT1180 as EtherCAT Slave, which supports CiA402 profile to drive the motor.

The EtherCAT Slave Controller (ESC) integrated on i.MXRT1180 takes care of the EtherCAT communication as an interface between the EtherCAT fieldbus and slave application.

The EtherCAT Slave Stack Code (SSC) from Beckhoff Automation is a tool to generate the EtherCAT slave stack code in ANSI C. Based on this stack, this servo motor example currently supports Cyclic Synchronous Position(CSP) and Cyclic Synchronous Velocity (CSV) control modes. The Object Dictionary Tool (OD-Tool) has been integrated into the SSC OD configuration tool, supporting a consistent definition of the offline and online object dictionary.

2 Hardware setup

- **Hardware requirements**
  - MIMXRT1180-EVK REVC
  - FRDM-MC-LVPMSM
  - Teknic 2311P Motor
  - RJ45 Network cable
  - Mini/micro universal serial bus (USB) cable
  - Personal Computer on which the TwinCAT3 has been installed
- **Board settings**

Table 1. Jumper settings

Jumper	Setting	Jumper	Setting	Jumper	Setting
JP1	1-2	J58	2-3	J78	1-2
J4	1-2	J59	2-3	J79	1-2
J6	1-2	J63	1-2	J90	1-2
JP6	1-2	J65	1-2	J91	1-2
J9	1-2	J72	1-2	J93	1-2
J11	2-3	J73	1-2	J97	1-2
J12	1-2	J75	2-3	J98	1-2
J14	1-2	J76	1-2	J99	1-2
J57	2-3	J77	1-2	J100	1-2

For a correct connection, the servo motor application requires you to remove and solder some zero-ohm resistors. Remove and solder zero-ohm resistors according to Table 2.

Table 2. Remove and solder zero-ohm resistors

Add resistors		Remove resistors	
R747	R767	R104	R146
R749	R1049	R105	R148
R760	R1051	R107	R1089
R763		R126	R1090
		R135	

2.1 Hardware assembly

1. Connect the FRDM-MC-LVPMSM shield on top of the MIMXRT1180-EVK board.
   Note: *There is only one possible option.*
2. Connect the 3-phase motor wires to the screw terminals (J7) on the Freedom permanent magnet synchronous motor (PMSM) power stage.
3. Plug the 24 V direct current (DC) power supply to the DC power connector on the Freedom PMSM power stage.

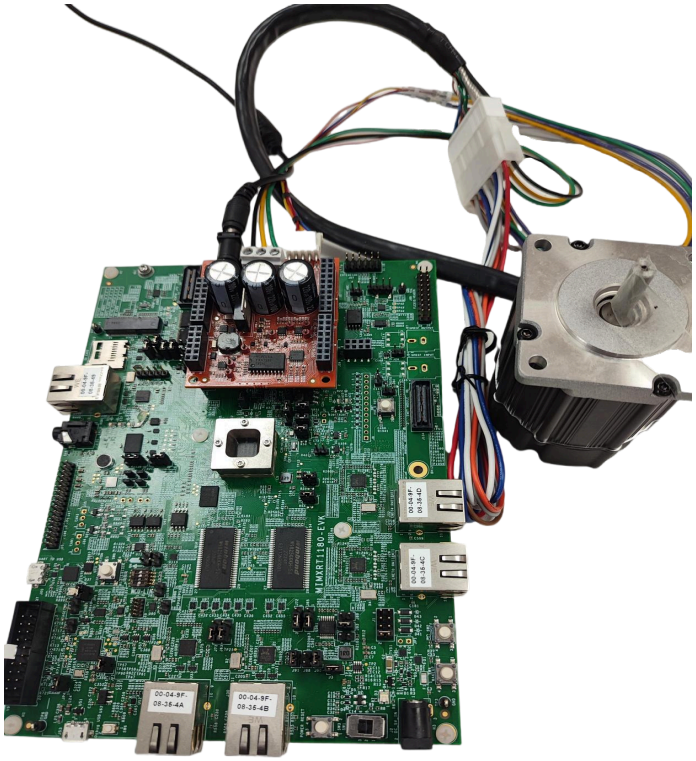


Figure 1. Hardware assembly

2.2 Connection

1. Connect EtherCAT Port 0 (J28 RJ45 Interface) on the MIMXRT1180-EVK board with TwinCAT3 via the Ethernet cable.
2. Connect a USB cable between the host PC and the OpenSDA USB port on the MIMXRT1180-EVK board.
3. Open a serial terminal with the following settings.
   - 115,200 baud rate
   - 8 data bits
   - No parity
   - One stop bit
   - No flow control

3 MCUXpresso SDK download

To configure and download the MCUXpresso SDK for the servo motor example building, perform the following steps.

1. Click the link https://mcuxpresso.nxp.com/en/welcome to go to the MCUXpresso main page.
2. Click the **Select Development Board** button.

Figure 2. Select Development Board

3. Type 1180 in the **Search for Hardware** field.
4. Select *MIMXRT1180-EVK* from the drop-down list. See, Figure 4.

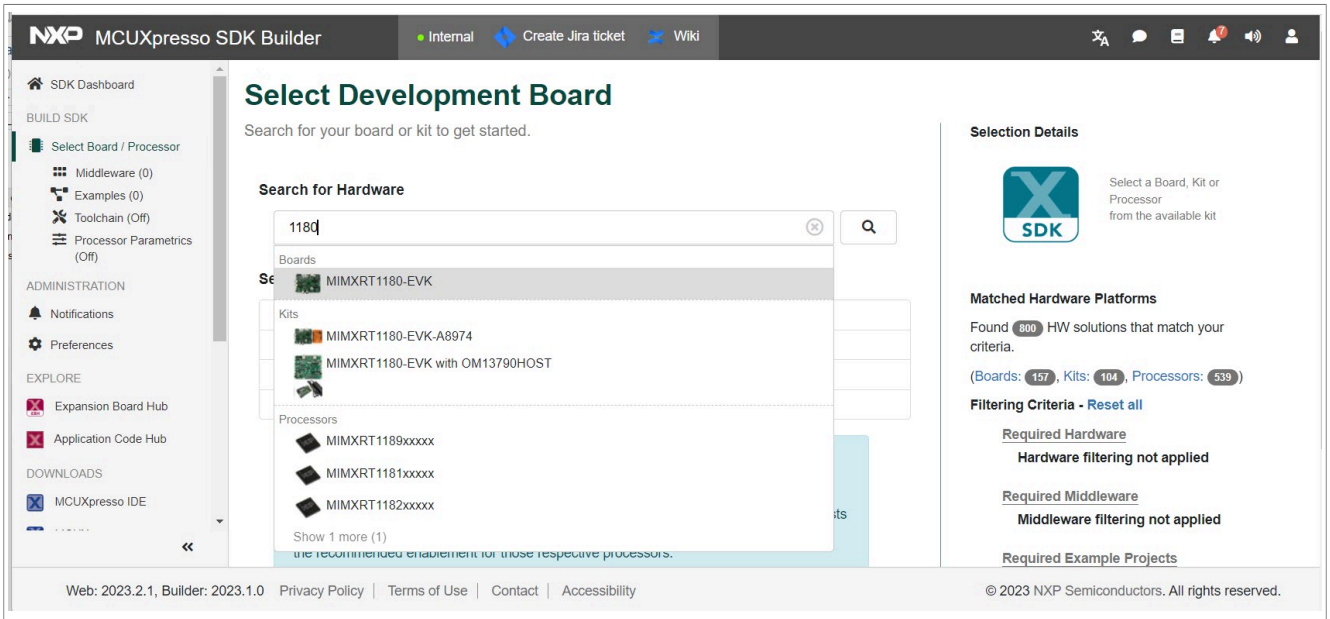


Figure 3. Select a board

5. Select the SDK version from which the SDK will be generated.
6. Click the **Build MCUXpresso SDK** button.

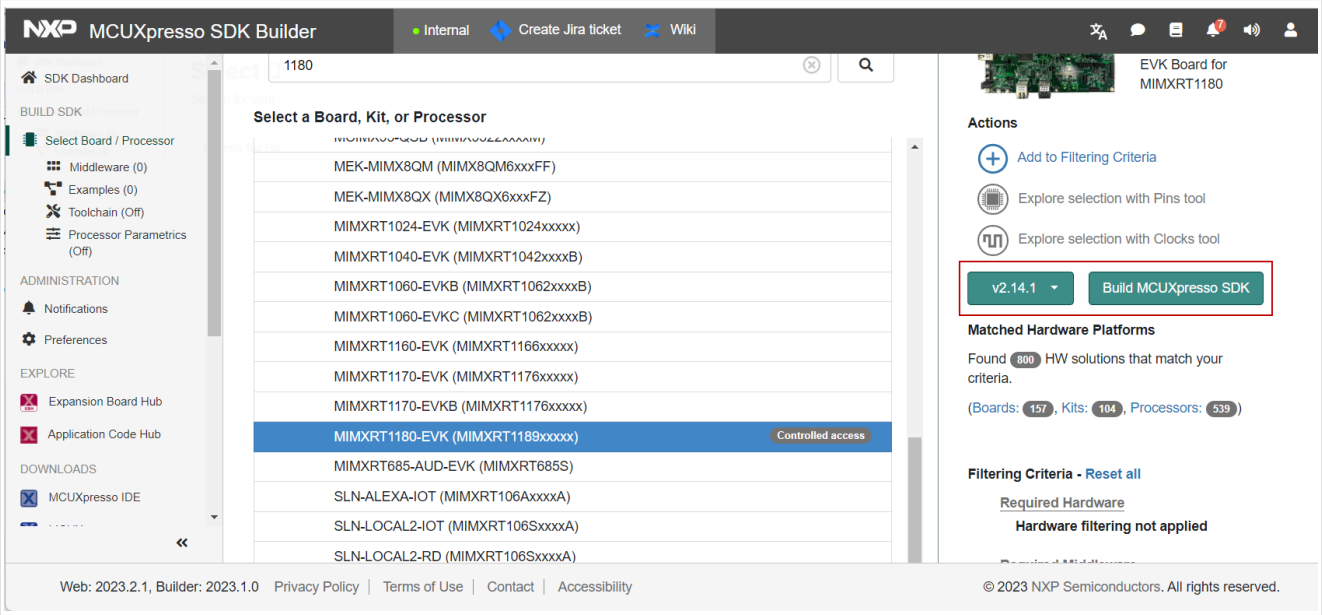


Figure 4. Select the SDK version and build MCUXpresso SDK

7. Select the host operating system.

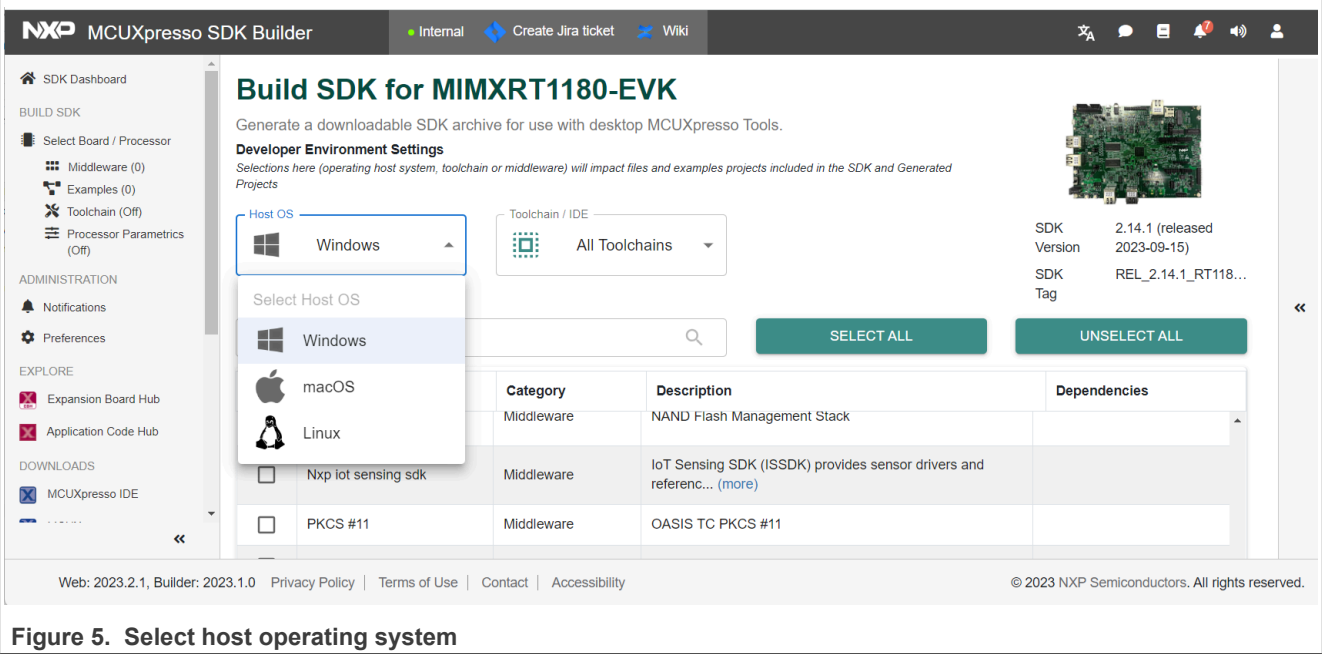


Figure 5. Select host operating system

8. Select the Toolchain/IDE.

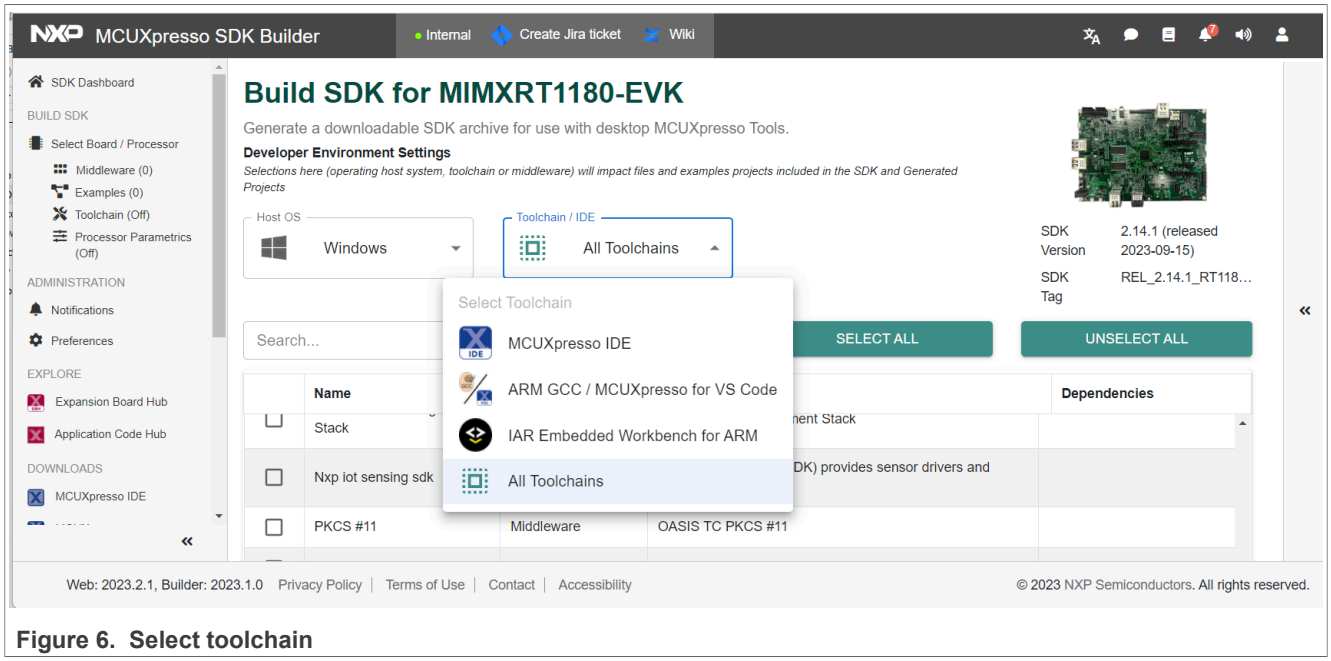


Figure 6. Select toolchain

9. Select the **Motor Control Software** checkbox.

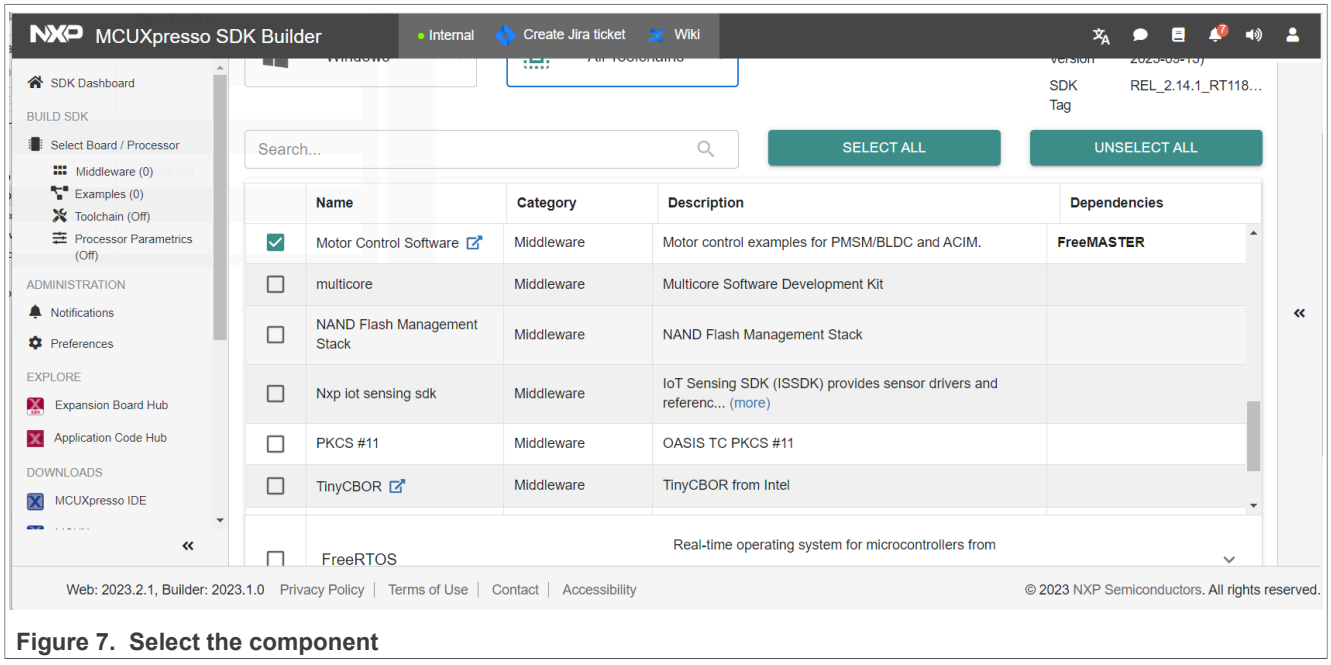


Figure 7. Select the component

10. To download the SDK, click the **Download SDK** button.

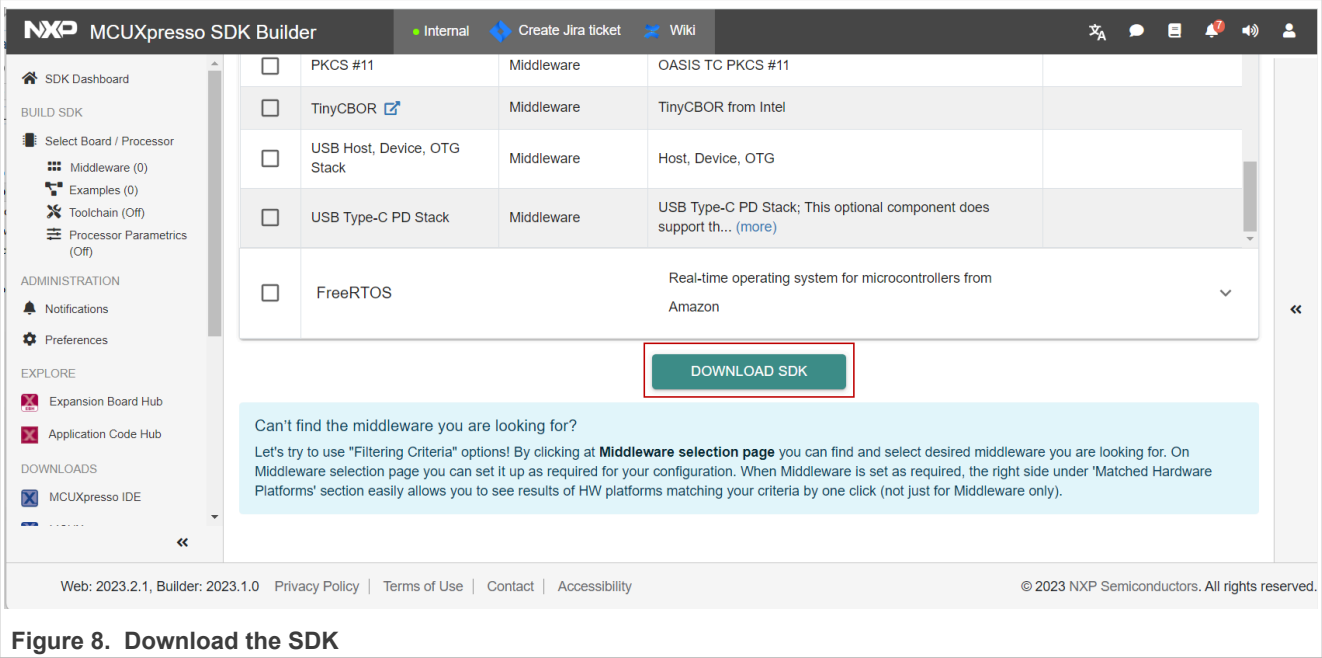


Figure 8. Download the SDK

You can now access, download, and share your requested SDK builds from the **MCUXpresso Dashboard**.

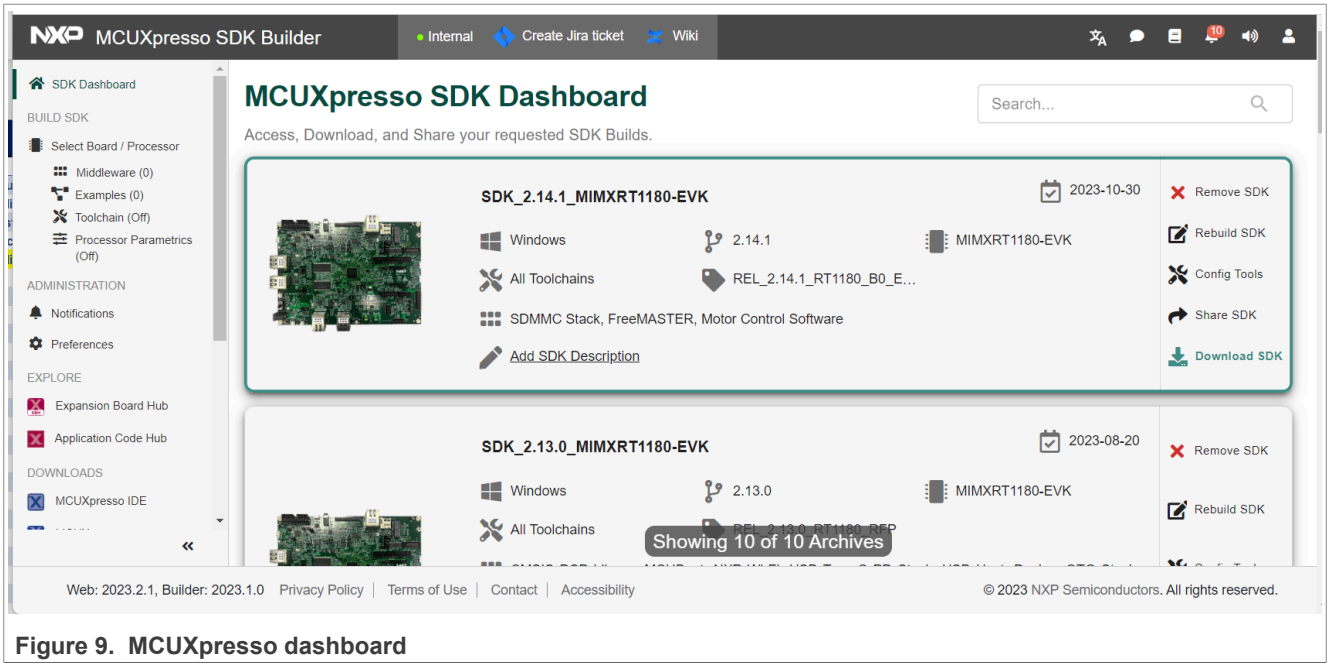


Figure 9. MCUXpresso dashboard

11. Click the **Download SDK** button.

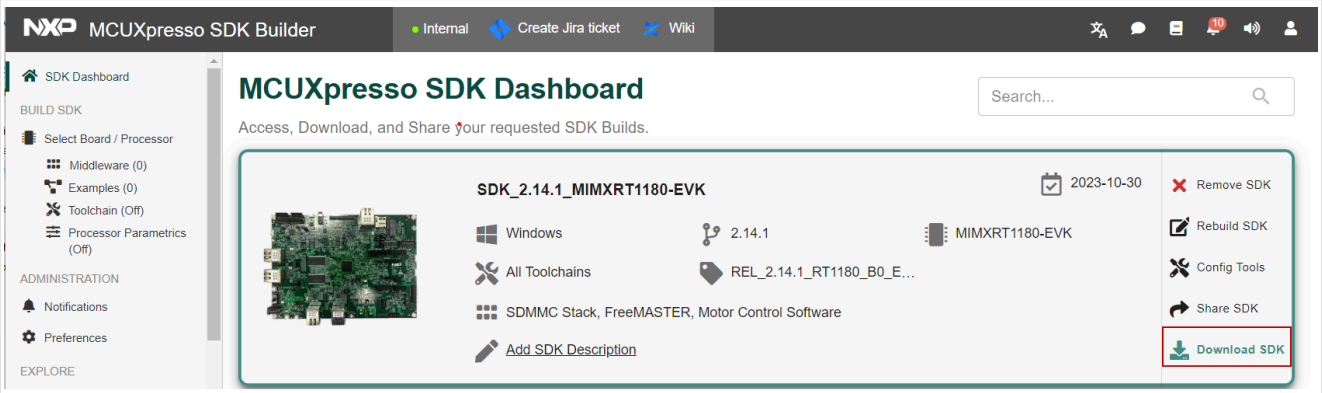


Figure 10. Download SDk

12. Click the **Download SDK archive including documentation** link.

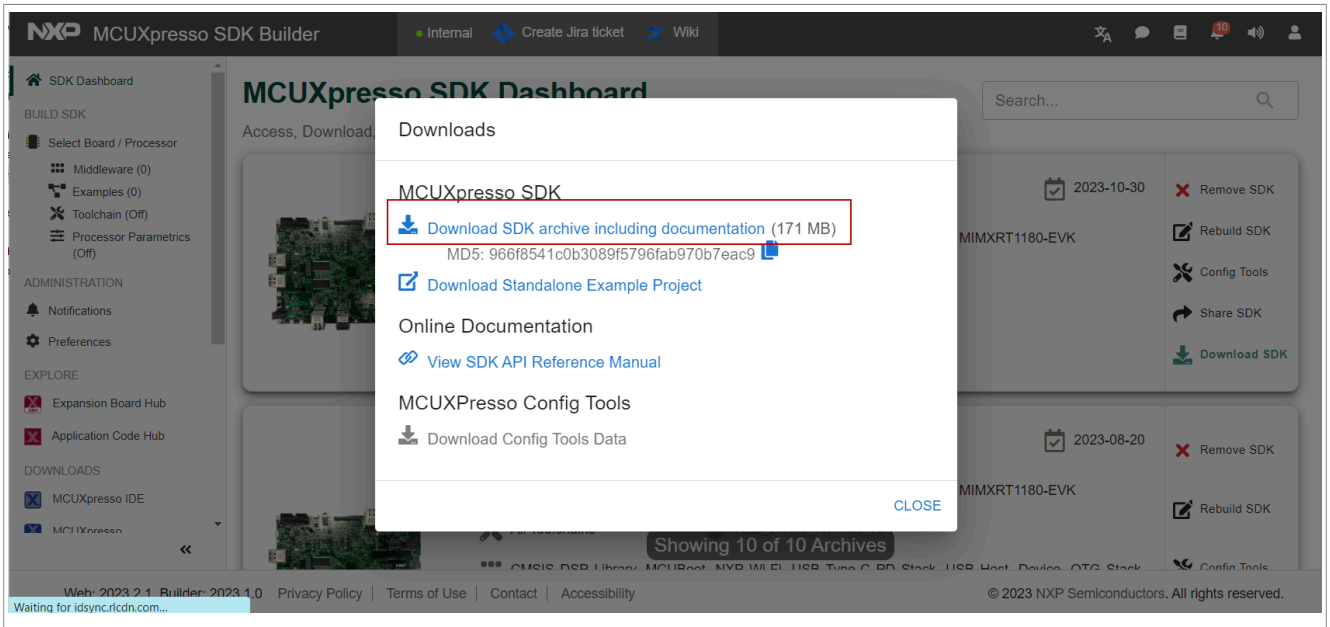


Figure 11. Download the SDK archive

13. Read the end user license agreement (EULA).
14. Click the **Agree** link.

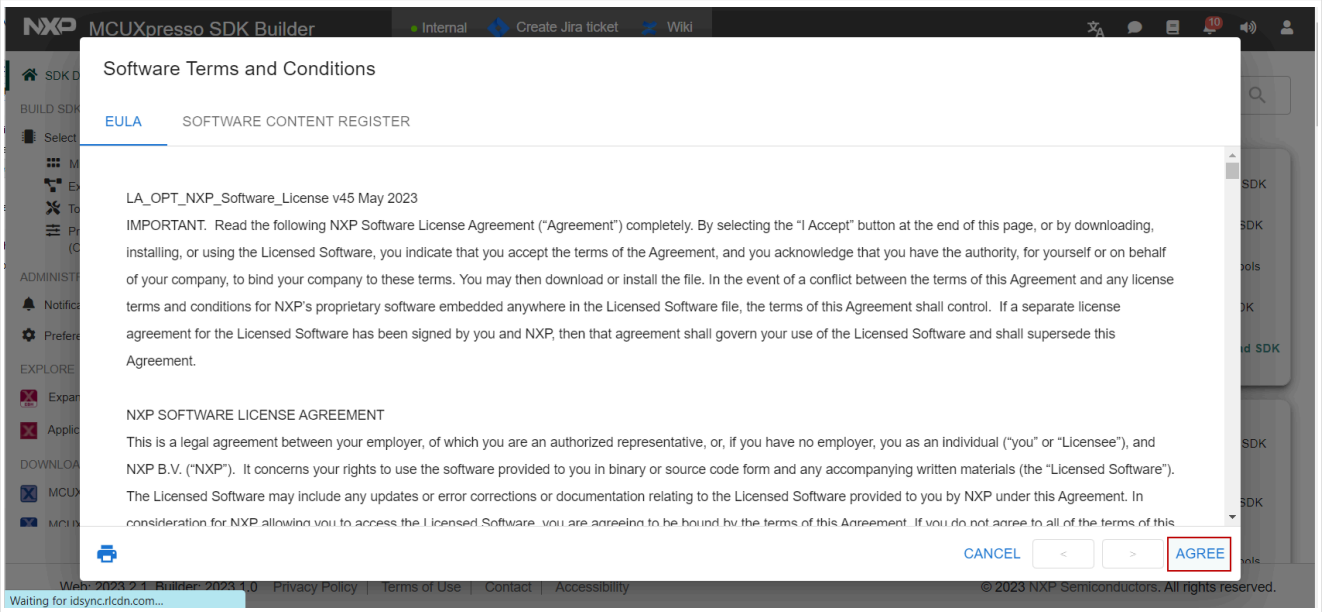


Figure 12. Accept the EULA

Wait until the build finishes and the download the SDK zip file.

4 Generate SSC code for servo motor

Due to the license issue, the MCUXpresso SDK does not include the EtherCAT Slave Stack Code (SSC). The SSC Tool must generate the slave stack code first. This section lists the steps to download the SSC tool and generate the slave stack code for the servo motor example via the SSC tool.

Note: *You must have a Backoff account to download the EtherCAT SSC tool.*

1. Download and install the SSC tool.
   a. Click the link https://www.ethercat.org/en/downloads.html.
   b. Type *SSC* in the **Text Filter** field.
   c. Select the *EtherCAT Slave Stack Code (SSC)* link under the **Description** column.
   Note: *To proceed with the download, you must provide your account credentials, if you are not already logged in.*

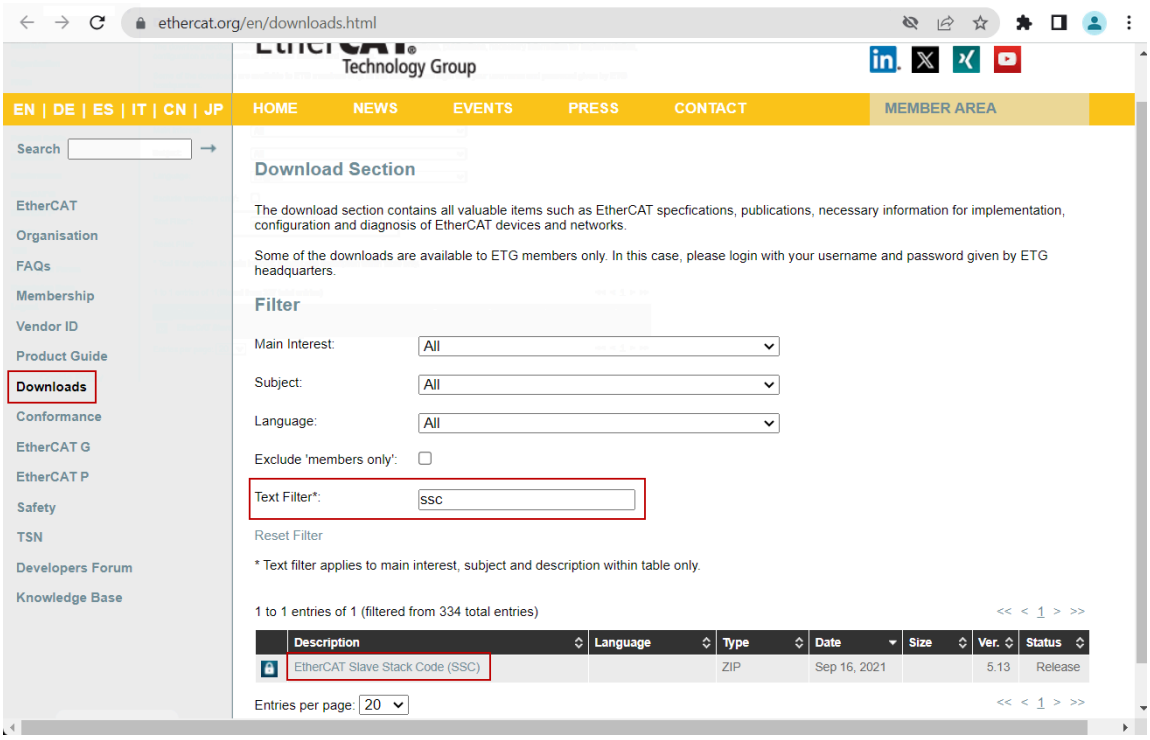
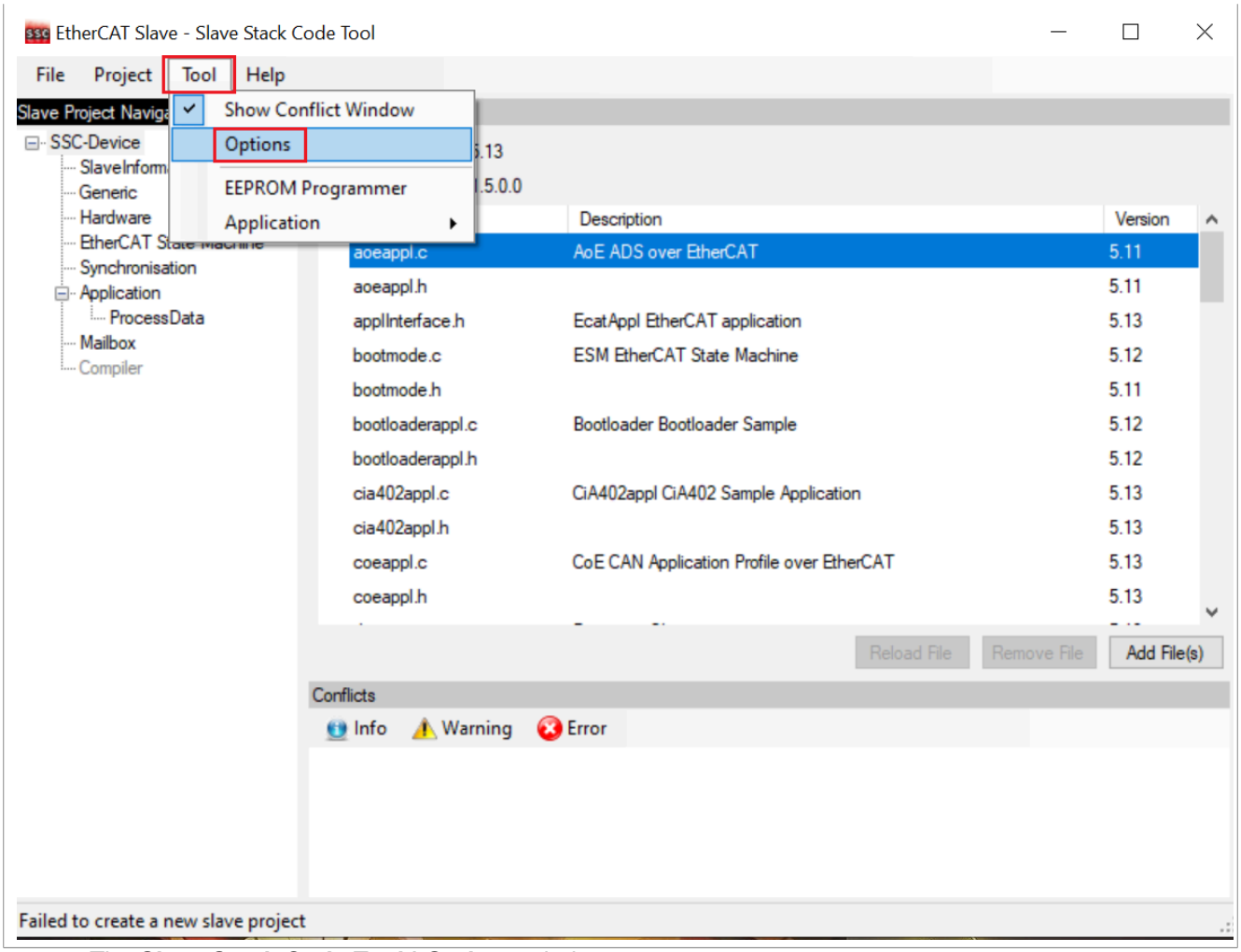


Figure 13. Search and select EtherCAT SSC

d. Install the downloaded SSC tool.
e. Launch the SSC tool.

2. Import the configuration file for the servo motor example.
   a. Select **Tool > Options**.

Figure 14. Select tool options



The **Slave Stack Code Tool | Options** window appears.

b. Click the **Configurations** tab.

c. To open the **Import Configuration file(s)** dialog box, click the + icon.

d. Navigate to the *\boards\evkmimxrt1180\ecat_examples\servo_motor\cm7\SSC* folder.

e. Select the *servo_motor.xml* file.

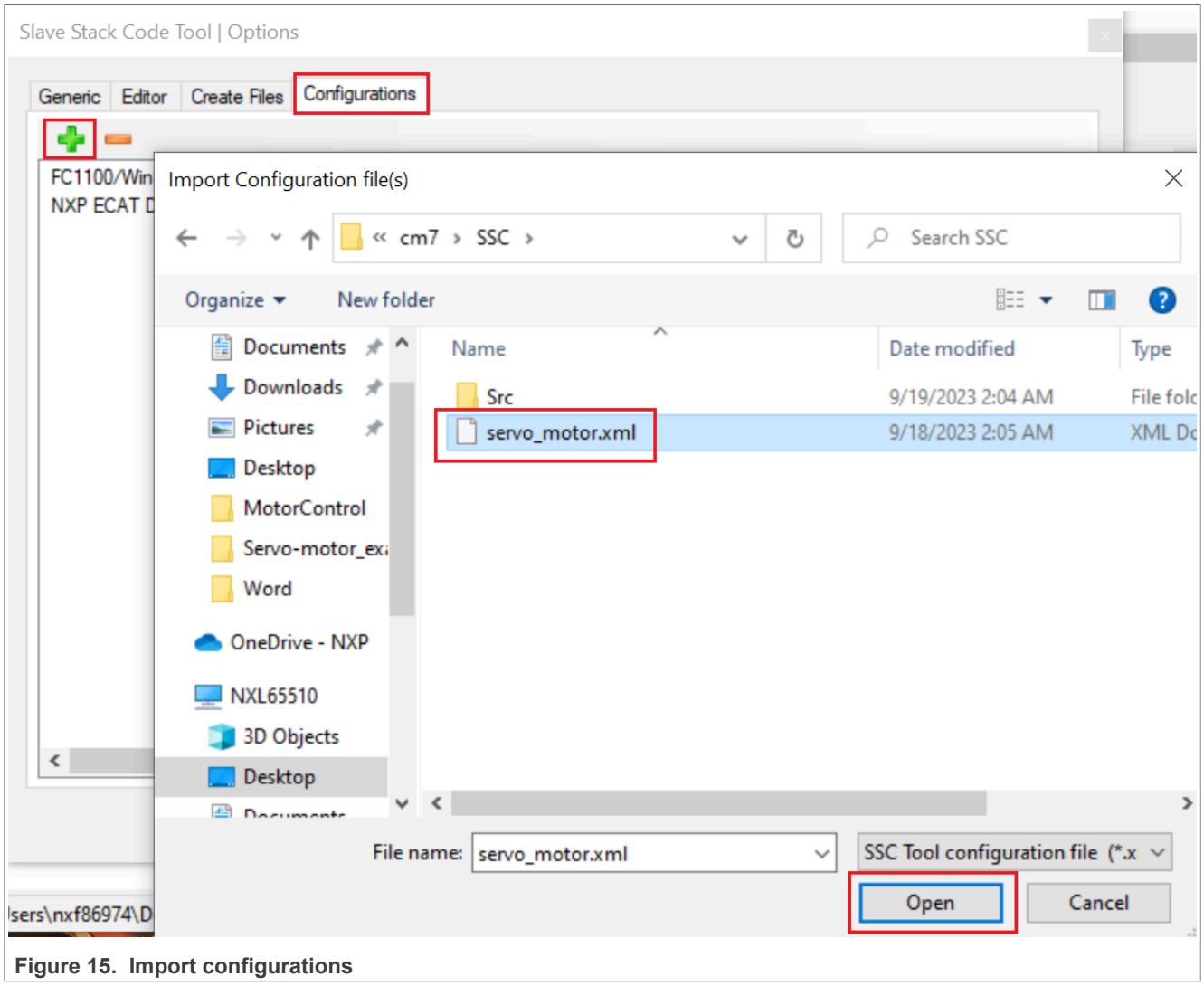


Figure 15. Import configurations

f. Click the **Open** button.
The configuration is imported.

3. Create a new project with the imported configuration.
   a. Select **File > New**.

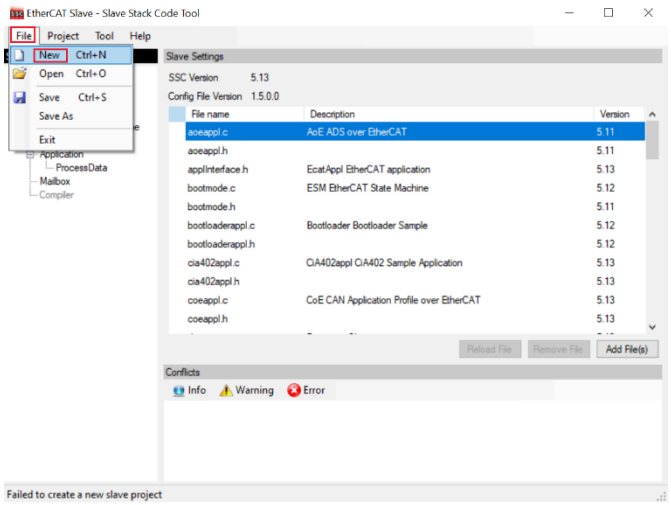


Figure 16. Create new project

The **New Project** dialog box appears.

b. Select the **Custom** option.

c. Select *NXP ECAT Servo Motor modular <NXP>* from the drop-down list.

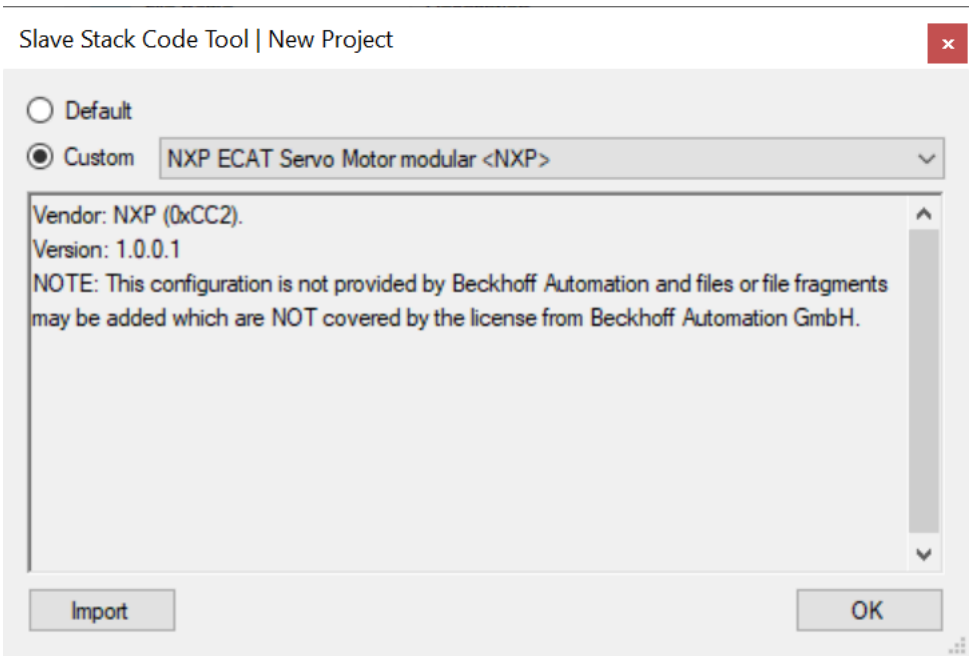


Figure 17. Select the custom project

4. Save this new project as *ECAT-SERVO-MOTOR.esp* to any folder.

a. Select **File > Save**.

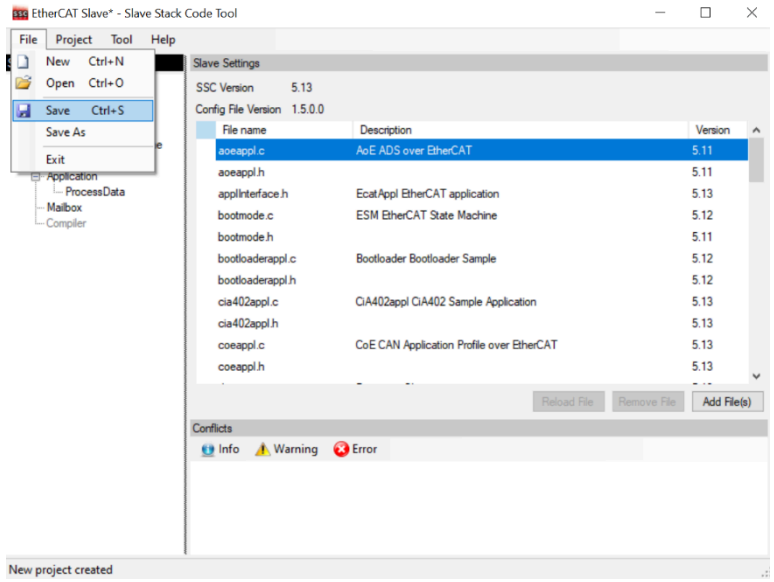


Figure 18. Select File > Save

b. Save the file with an appropriate name. For example, *ECAT-SERVO-MOTOR.esp*.

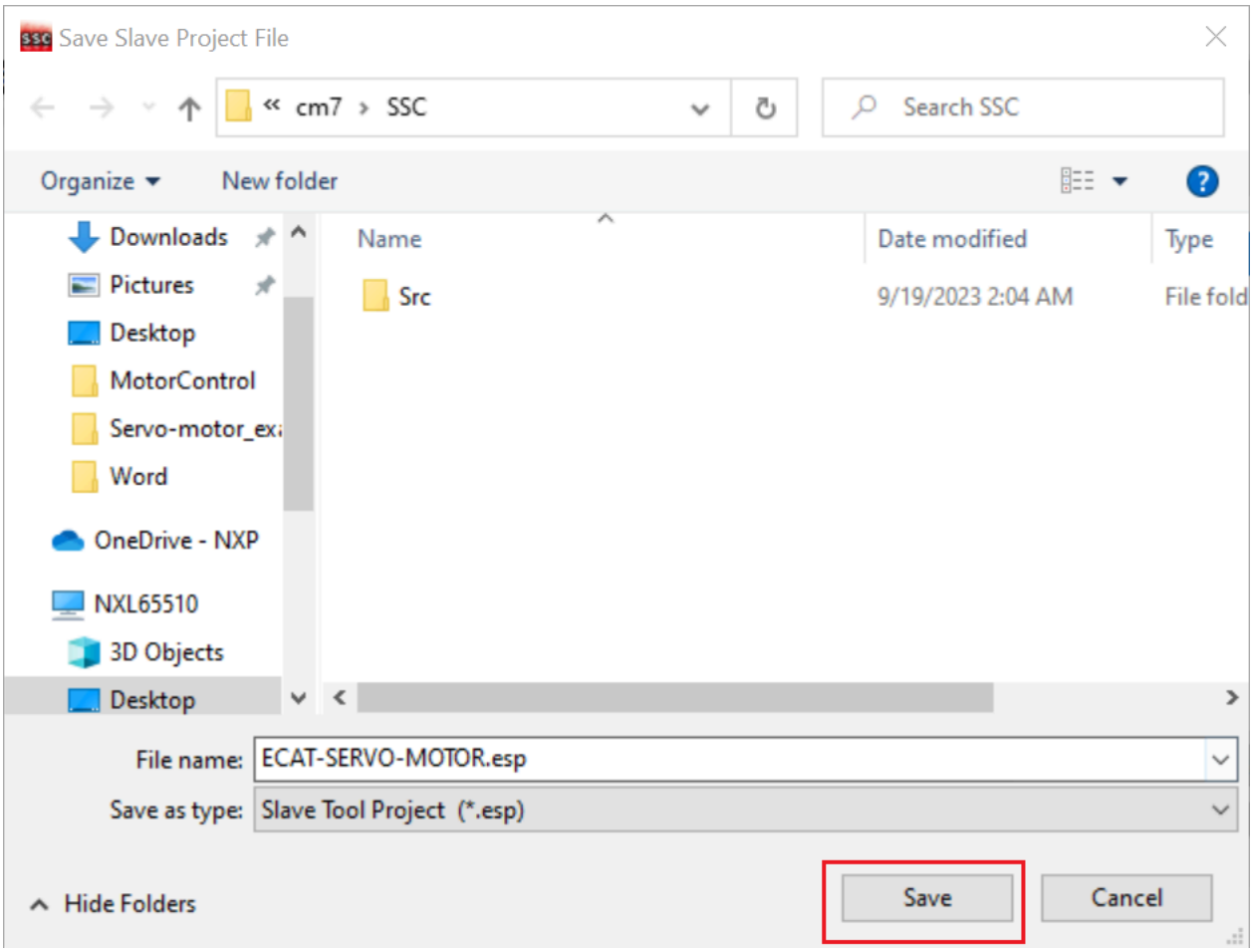


Figure 19. Save the file with the name ECAT-IO.esp

5. Create the slave stack code for the servo motor example.
   a. Click **Project > Create new Slave Files**.

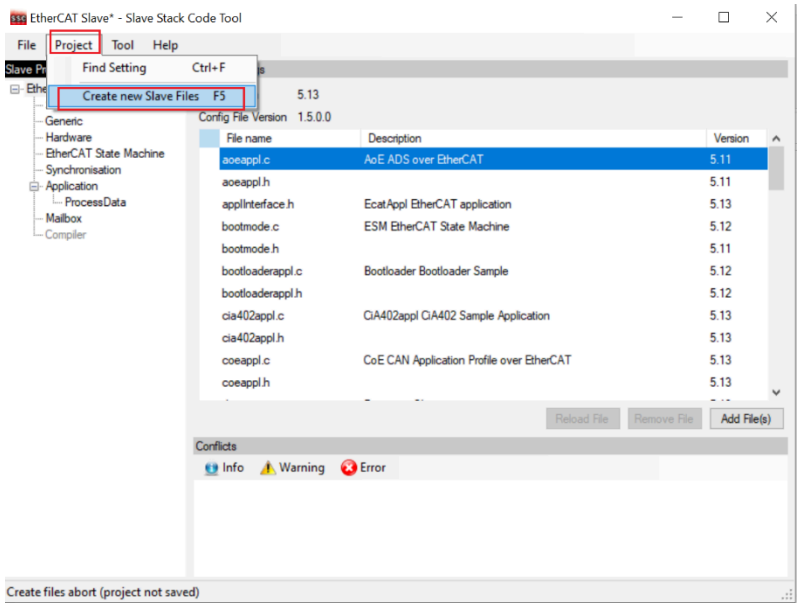


Figure 20. Create new files

The **Create new Slave Files** dialog box appears.

b. To create the code, select **Start**.
By default, the code is located in the *Src* subfolder under the folder where the project is saved.

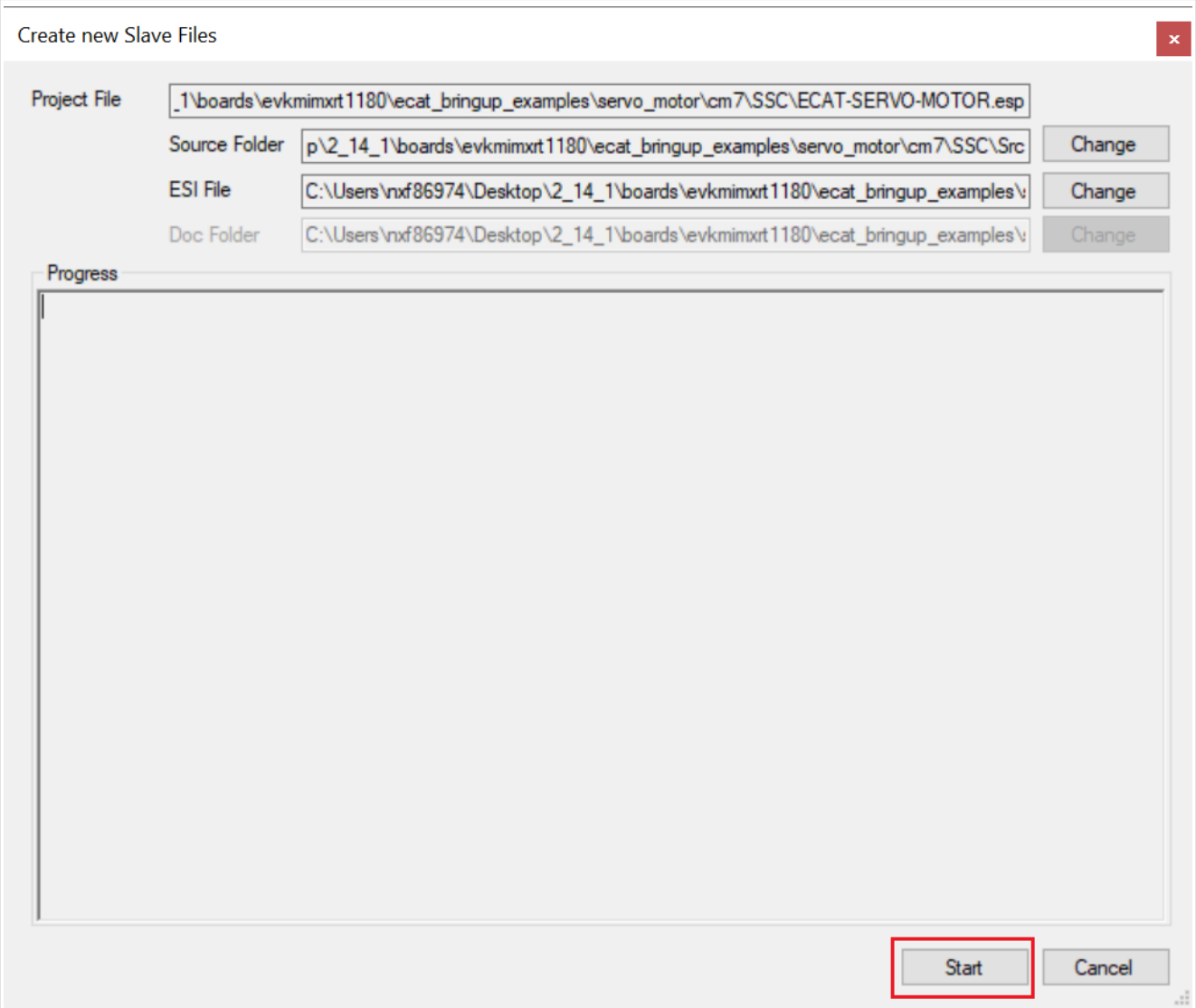
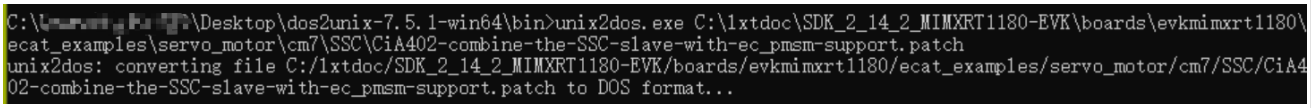


Figure 21. Start to create the code

6. Copy the *Src* subfolder to *boards\evkmimxrt1180\ecat_examples\ servo_motor\cm7\SSC\Src* under the SDK source code.
7. **Apply patch**.
   Change to *.\boards\evkmimxrt1180\ecat_examples\servo_motor\cm7\SSC* path. Install patch tool.
   - To apply the patch on **Linux**:
     a. Download dos2unix command `apt-get install dos2unix`.
     b. Transfer SSC source code format `dos2unix Src/*`.
     c. Apply patch by using the command `patch -d Src < CiA402-combine-the-SSC-slave-with-ec_pmsm-support.patch`.
   - To apply the patch on **Windows**:
     a. Download the `patch.exe` and `Unix2Dos.exe` tools.
        – Download Windows patch utility from http://gnuwin32.sourceforge.net/downlinks/patch-bin-zip.php.
        – Download `Dos2Unix/Unix2Dos-Text` file format converters from https://sourceforge.net/projects/dos2unix/.

b. Transfer the patch format. `$(Dos2Unix/Unix2Dos-DIR)/bin/unix2dos.exe …\boards\evkmimxrt1180\ecat_examples\servo_motor\cm7\SSC\CiA402-combine-the-SSC-slave-with-ec_pmsm-support.patch`.

Figure 22. Transfer patch



c. Apply patch by using the command `./patch.exe -i …\boards\evkmimxrt1180\ecat_examples\servo_motor\cm7\SSC\CiA402-combine-the-SSC-slave-with-ec_pmsm-support.patch -d …\boards\evkmimxrt1180\ecat_examples\servo_motor\cm7\SSC\Src\.`

Figure 23. Apply patch

Note: *Patch and Unix2Dos are command line tools. To check their functions through command like use `patch --help/unix2cos -help`.*

5 Compile and download the image to RT1180

- Toolchain supported
  - GCC Arm Embedded 10.3.1

Note: *For detailed information on the image download and program, see section 4 of the Getting Started with MCUXpresso SDK for MIMXRT1180-EVK document in the SDK package.*

6 TwinCAT project setup

This section lists the steps to set up the TwinCAT project.

6.1 Create a new project

1. Import the ESI file of the servo motor example before TwinCAT starts.
   Copy the ESI file '`ECAT-SERVO-MOTOR.xml`' generated by SSC tool under the SSC project saving directory to `<TwinCAT_installation_folder>/<Version>/Config/io/EtherCAT/`.
2. Select **File > New > Project**.

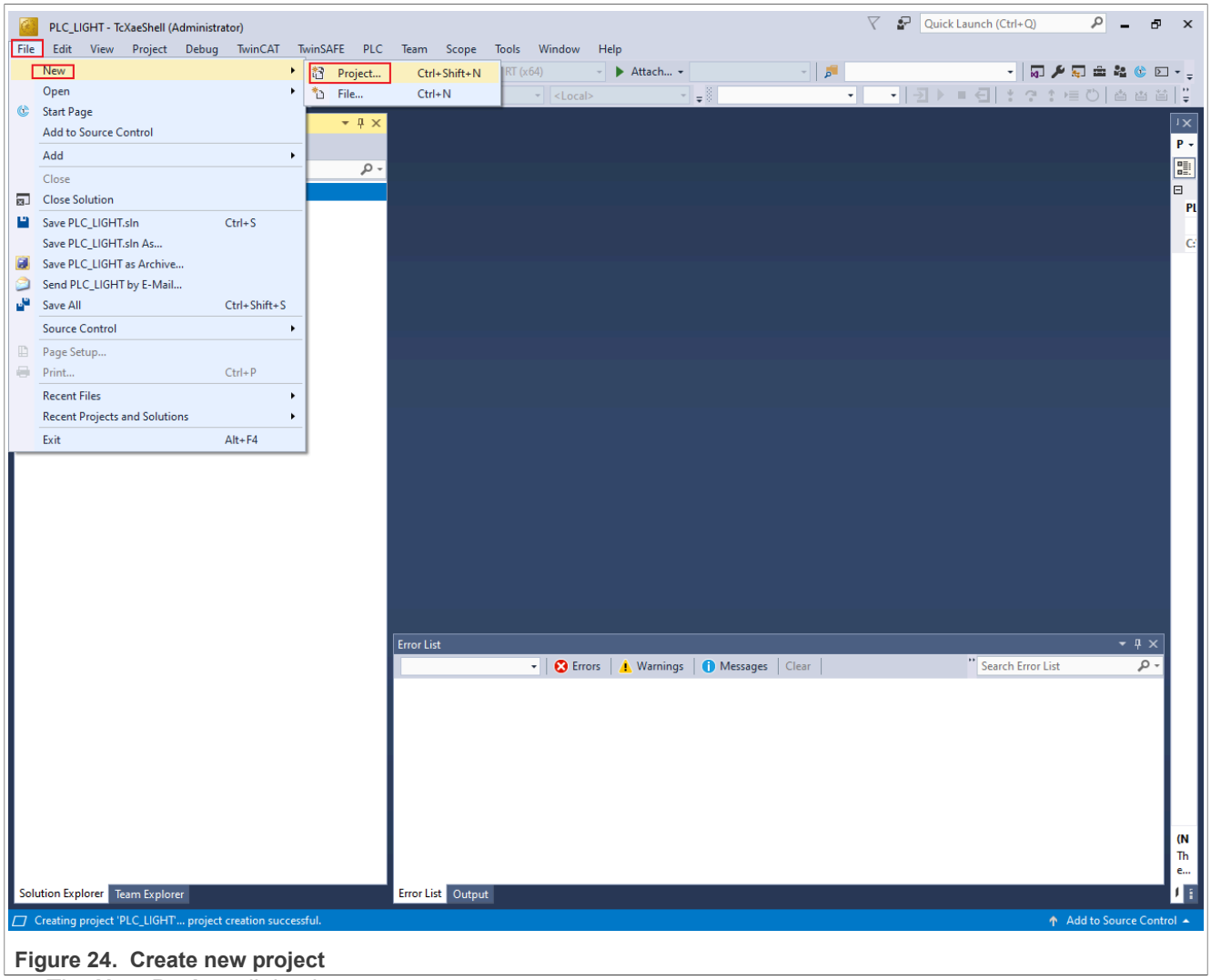


Figure 24. Create new project

The **New Project** dialog box appears.

3. Select **TwinCAT Projects**.
4. Click **OK**.

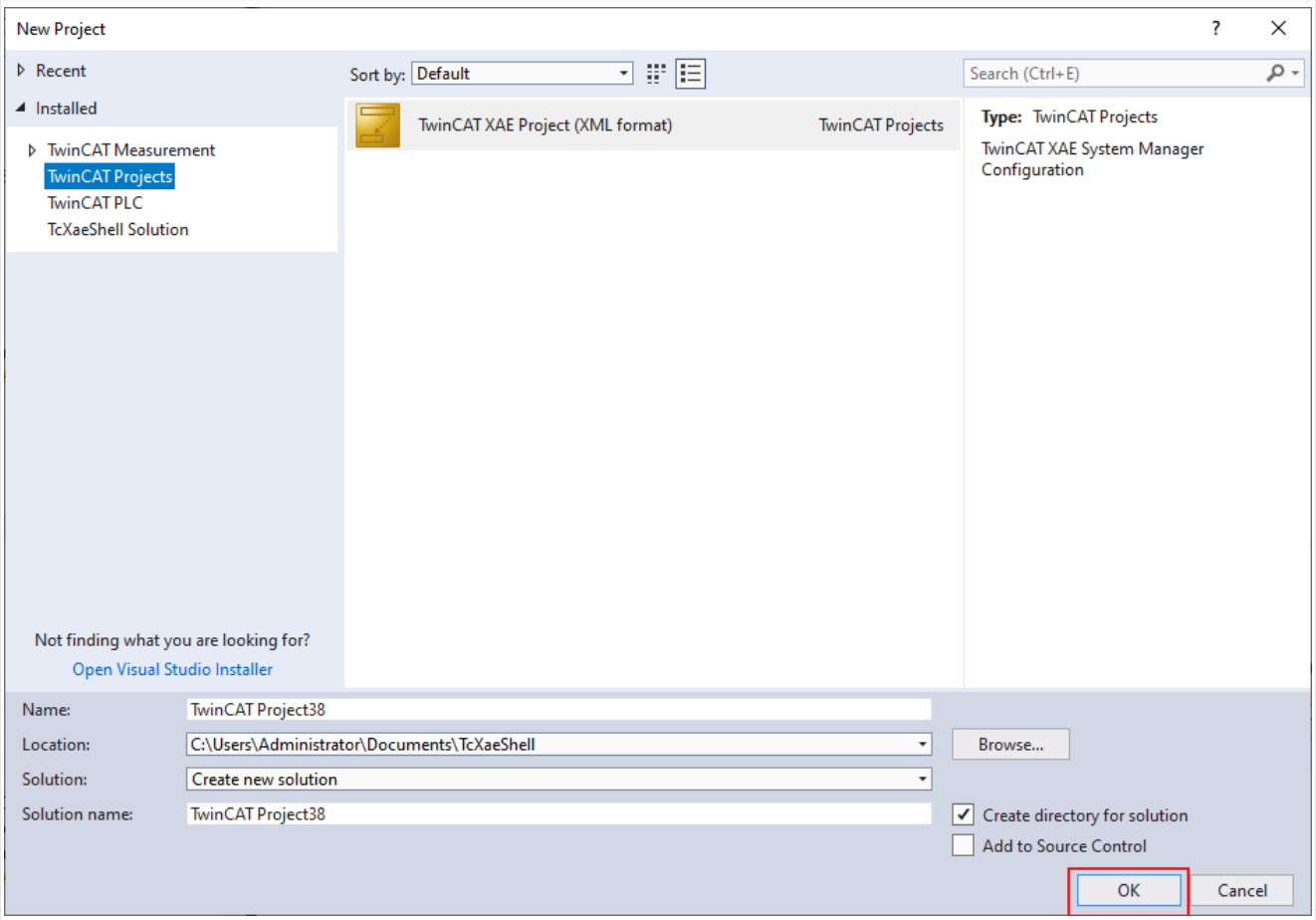


Figure 25. Select project

6.2 Scan the for slave devices

1. In the **Solution Explorer** view, expand **I/O**.
2. Right-click on **Device** and select **Scan**.

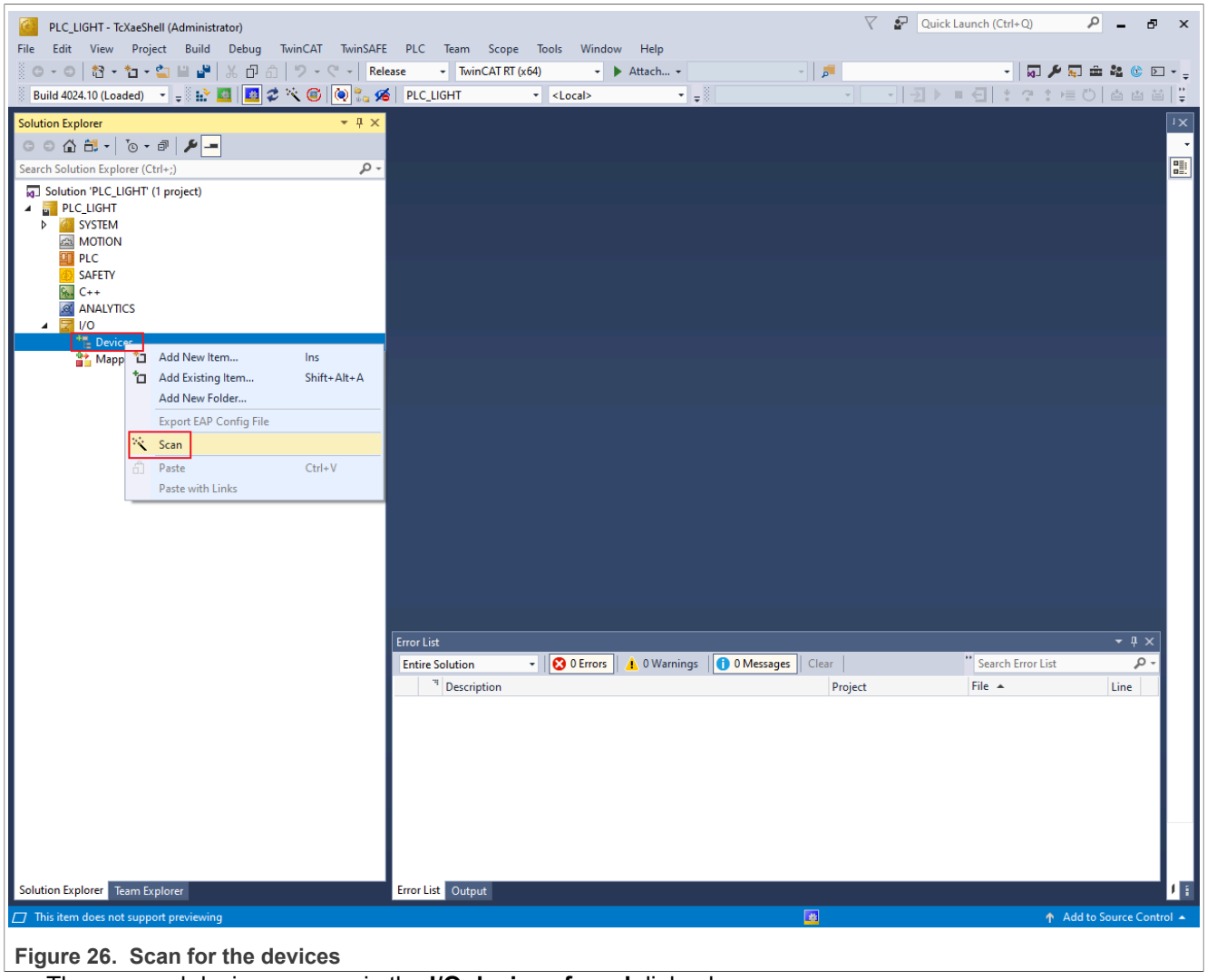


Figure 26. Scan for the devices

The scanned devices appear in the **I/O devices found** dialog box.

3. Select the network interface connected with the MIMXRT1180-EVK board.
4. Click **OK**.

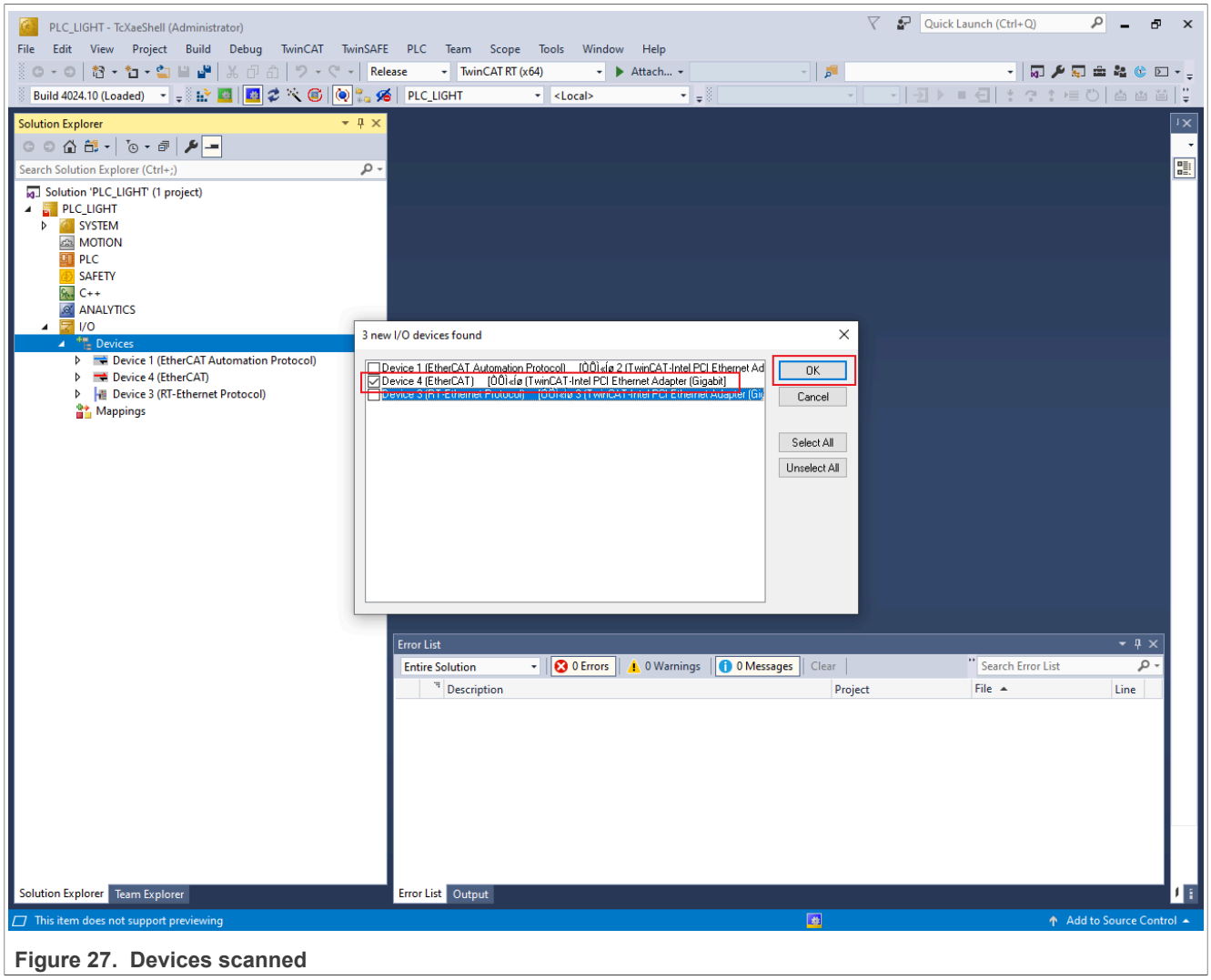


Figure 27. Devices scanned

6.3 Update the ESI file to E2PROM

Note: *The E2PROM must be updated if the servo motor example is set up first time on the MIMXRT1180-EVK.*

1. Under **Device4**, double-click Box 1 (ECAT-SERVO-MOTOR).The **TwinCAT Project** dialog box appears.
2. Click the **EtherCAT** tab.
3. Click the **Advanced Settings** button.
   The **Advanced Settings** dialog box appears.
4. From the left pane of the **Advanced Settings** dialog box, select **ESC Access > Smart View**.
5. Click the **Write E2PROM** button.
6. From the available EEPROM list, **select NXP > ECAT > ECAT-SERVO-MOTOR**.

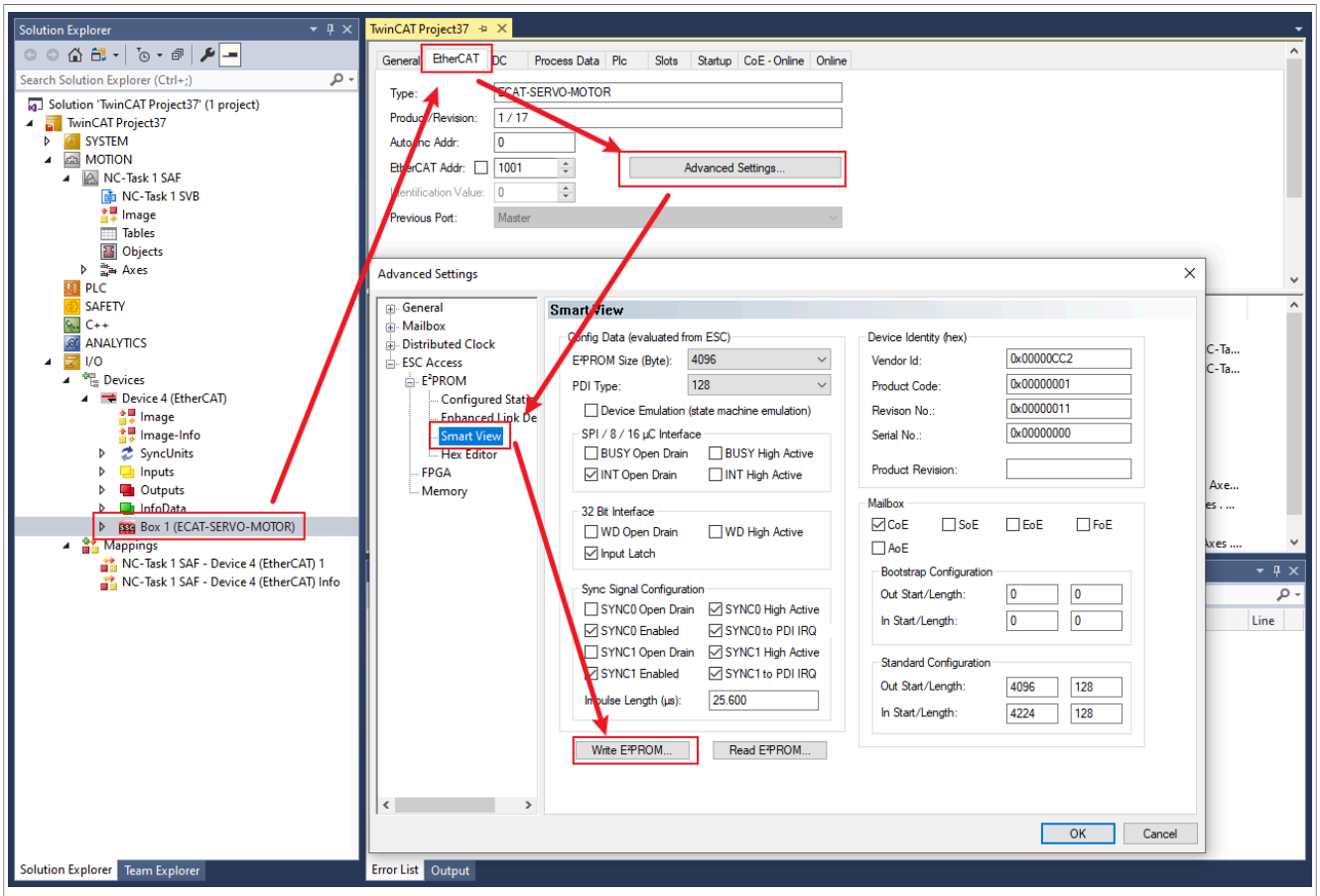


Figure 28. Update the ESI file to E2PROM

7. Click **OK**.

   Note: *Delete Device4, rescan, and add Device4 after Write E2PROM success.*

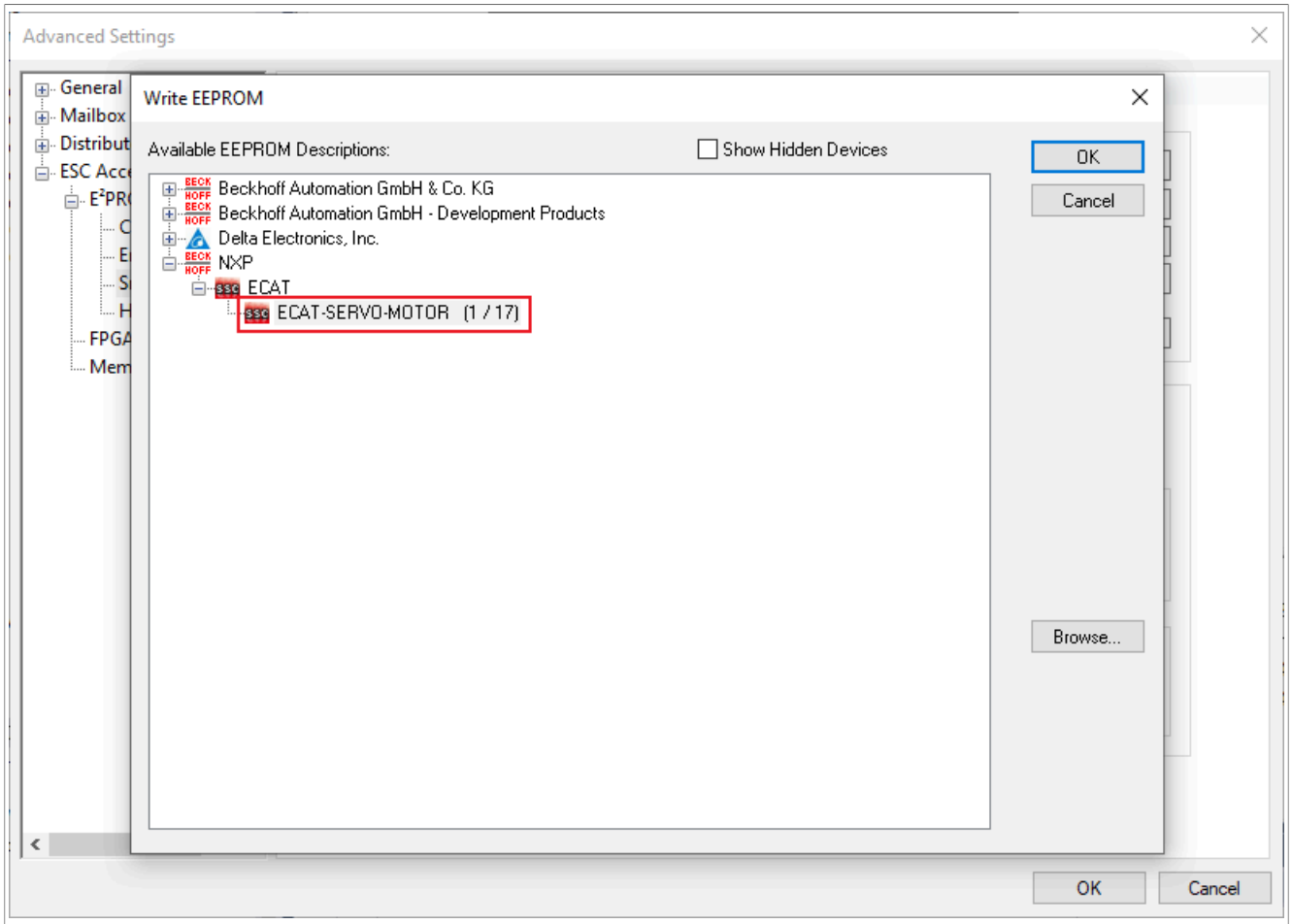


Figure 29. Write EEPROM

6.4 Configure the slave

1. Click **Box 1(ECAT-SERVO-MOTOR)**.
2. Click the **DC** tab.
3. From the **Operation Mode** field, select the **DC-Synchron** option.

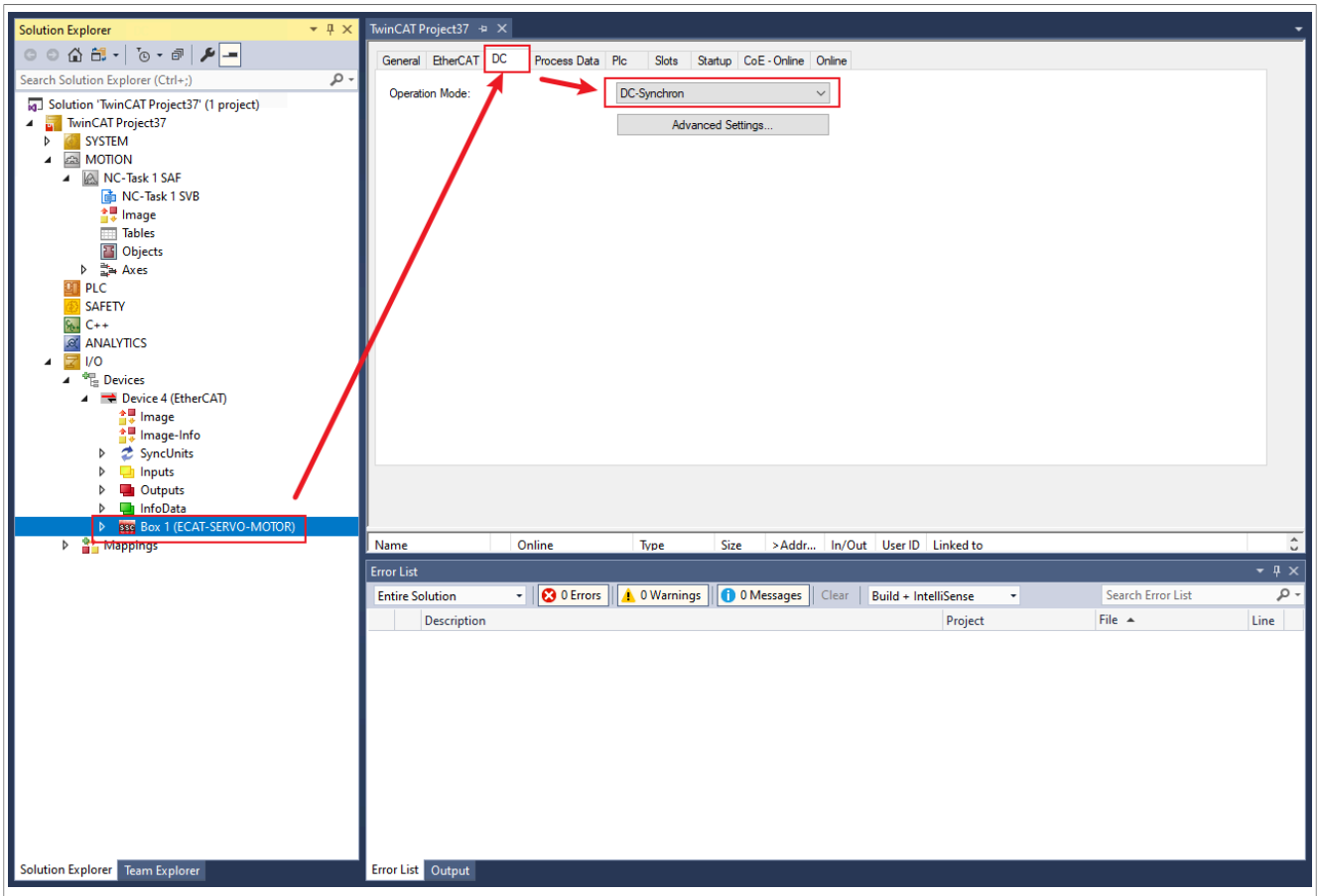


Figure 30. Select the operation mode

6.5 Select the csp mode

1. Click **Box 1(ECAT-SERVO-MOTOR)**.
2. Click the **Slots** tab.
3. Select *Axis 0'* > *'x'*.
4. Click *Axis 0'* > *'csp - axis'* > '<' to select the csp mode.

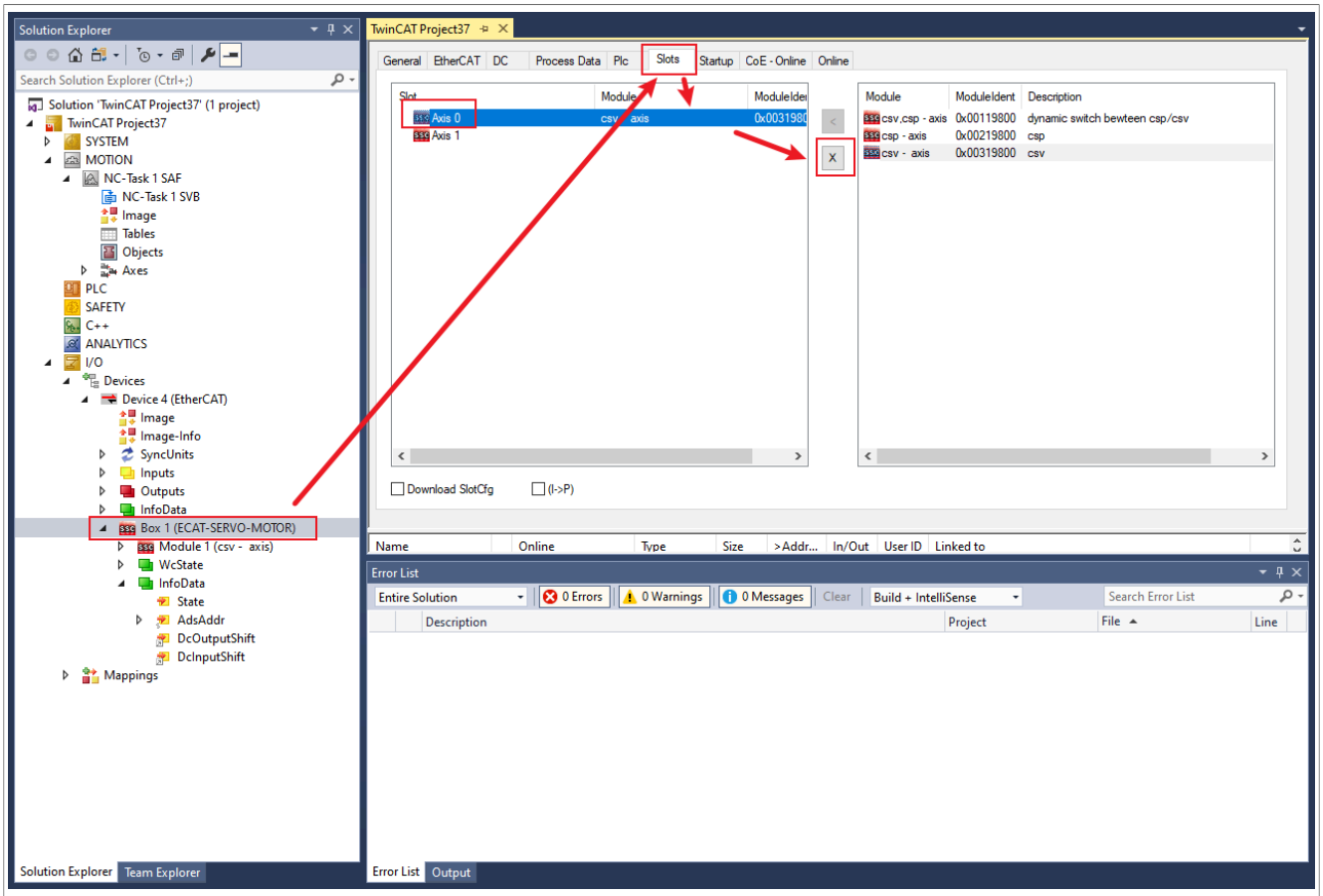


Figure 31. Select slots

The results are shown in Figure 32.

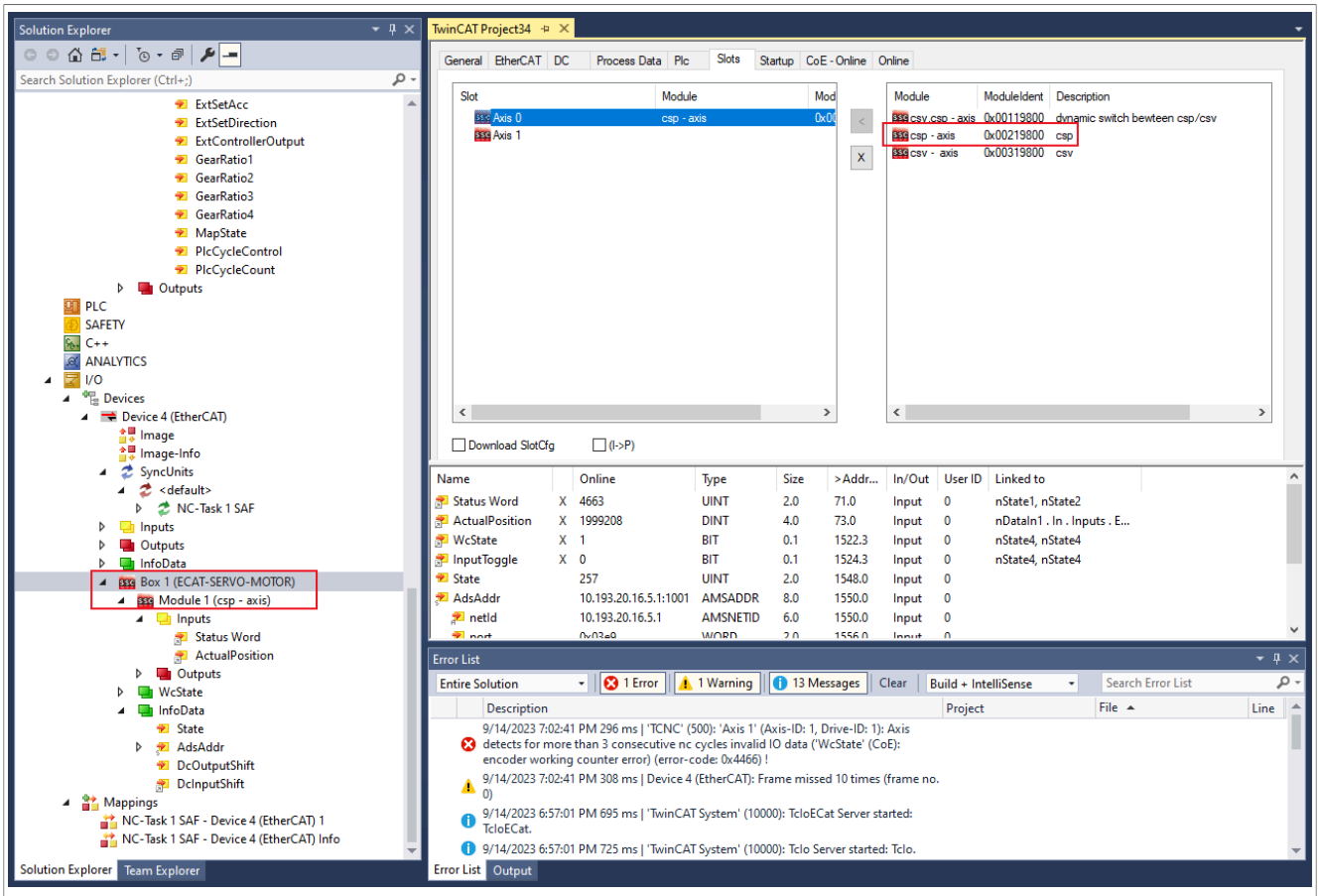


Figure 32. Select the csp mode

6.6 Add new Axes

1. Right-click **MOTION** and click **Add New Item**.

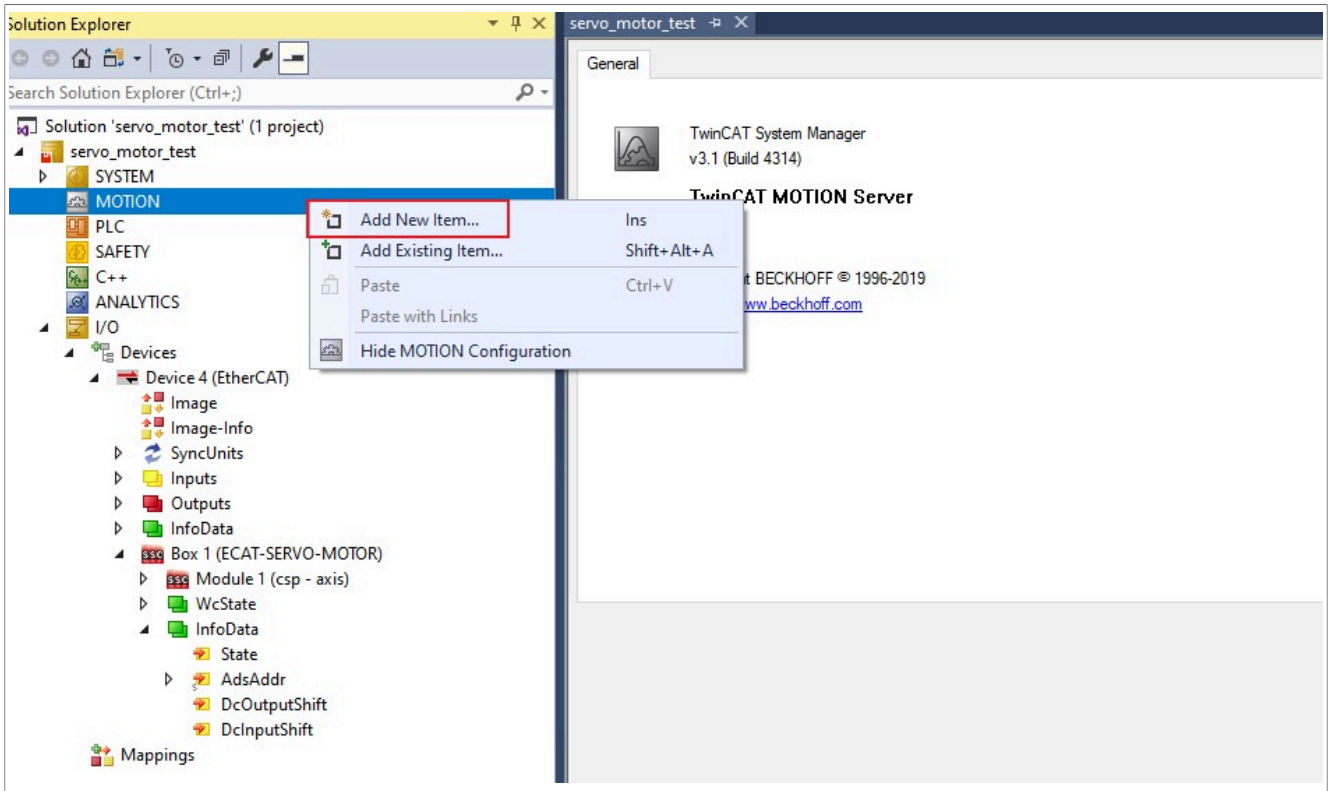


Figure 33. Add new item

The **Insert Motion Configuration** dialog box appears.

2. Select **NC/PTP NCI Configuration**.
3. Click **OK**.

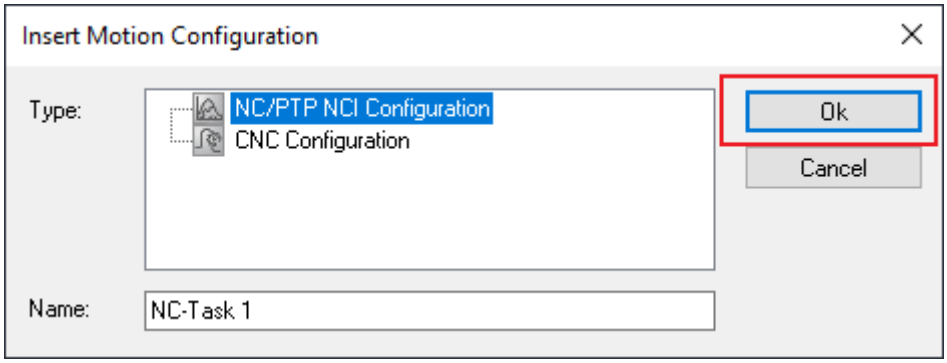


Figure 34. Select NC/PTP NCI configuration

4. Right-click **Axes** and click **Add New Item > OK**.

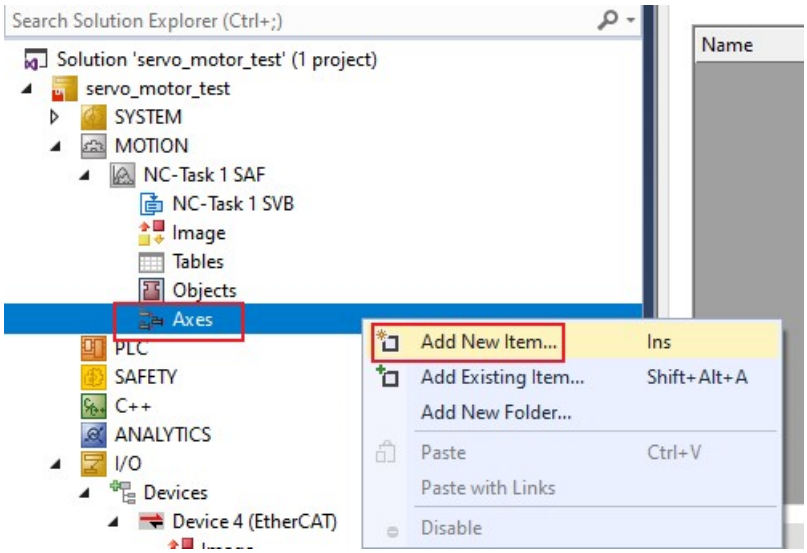


Figure 35. Add axes

The **Insert NC Axis** dialog box appears.

5. Provide the name in the **Insert NC Axis** text box.
6. Click **OK**.

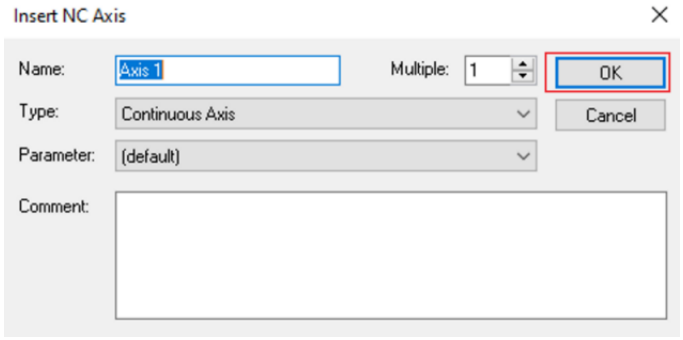


Figure 36. Insert NC Axis

6.7 Link I/O

1. Select **Axes > Axis1** from the **Solution Explorer**,
2. Click the **Settings** tab.
3. Select **Link To I/O > CANopen DS402, EtherCAT CoE**.
4. Click **OK**.

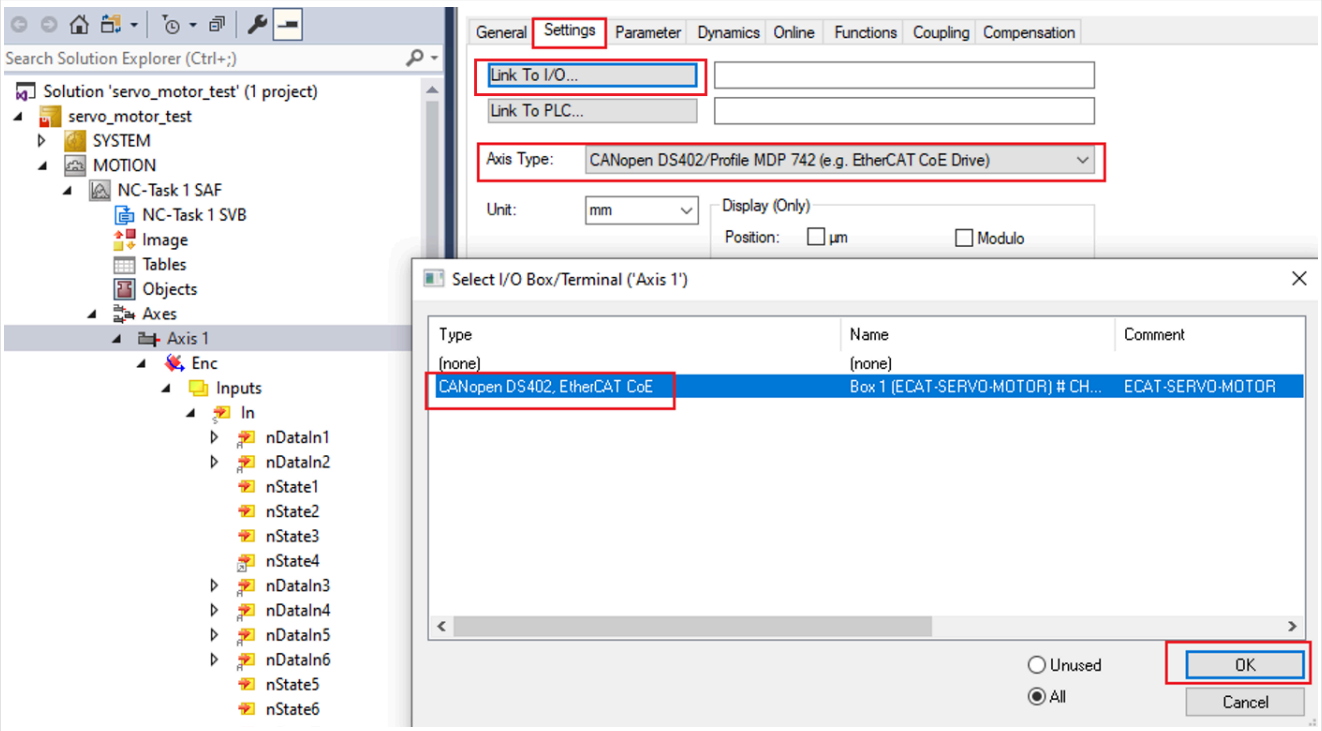


Figure 37. Link I/O

6.8 Configure Enc.

1. Select **Axes > Axis1 > Enc > Inputs > In > nDataIn1** from the **Solution Explorer**.
   The **TwinCAT Project** dialog box appears.
2. Click the **> Linked to** button.
   The **Attached Variable nDataIn1 (Input)** dialog box appears.
3. Select **Box1(ECAT-SERVO-MOTOR) > ActualPosition**.
4. Select **All Types** checkbox on the right to display all variables.
5. Click **OK**.

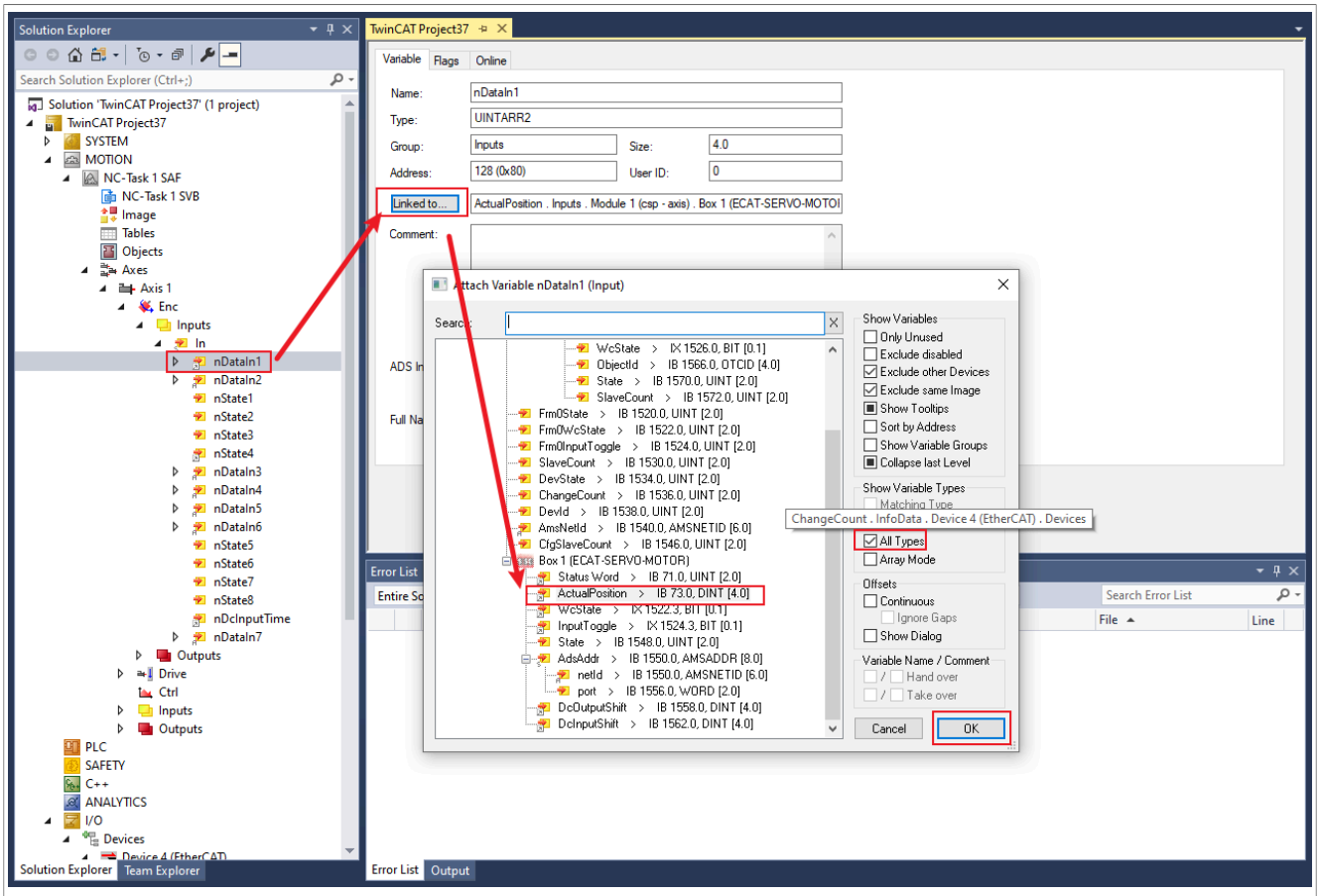


Figure 38. Configure Enc

6. Select **Axis1 > Enc >Inputs > In > nState4 > Linked to** from the **Solution Explorer** to link **InputToggle**.

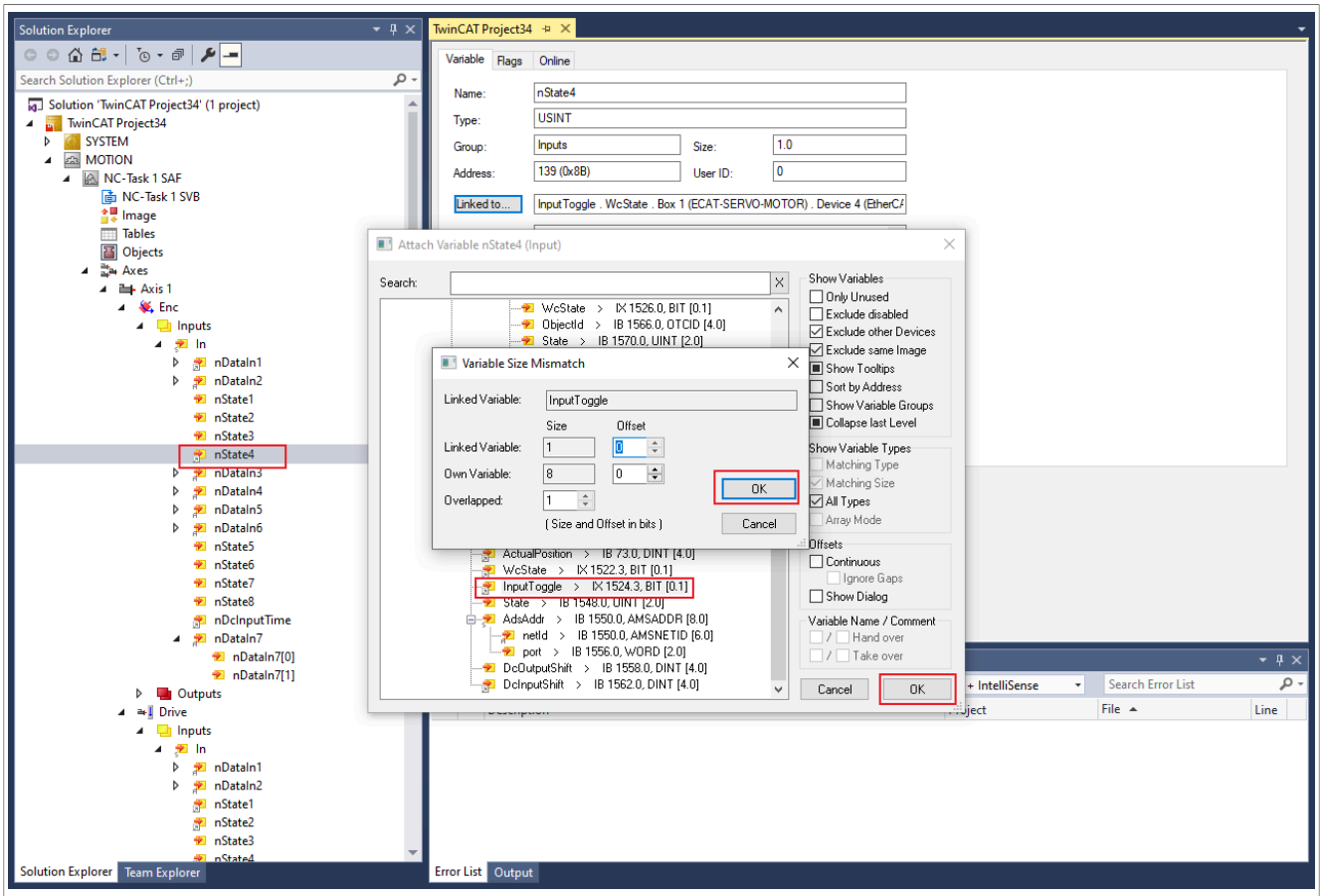


Figure 39. Set InputToggle

7. Select **Axes > Axis1 > Enc > Inputs > In > nDcInputTime > Linked to** to link **DcInputShift**.

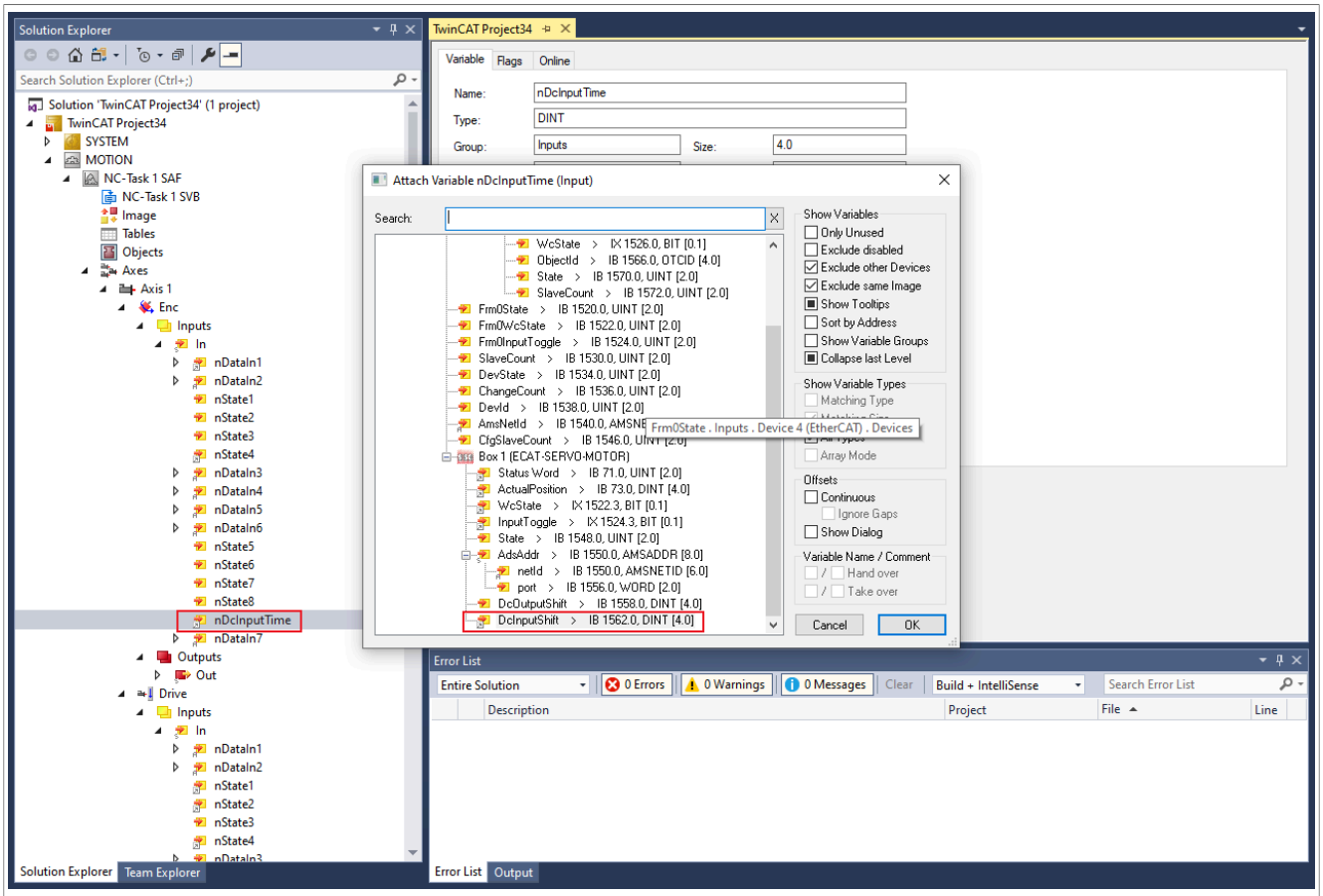


Figure 40. Link DcInputShift

6.9 Configure scaling factor

The encoder density of Tecknic2311P motor is 8,000 counts/rev. Tp configure Scaling Factor 1/8000; convert pulse counters to mm using below formula：

```
Target position(mm) = Motor revolutions(counts) * Scaling Factor
```

1. Select **Axes > Axis1 > Enc** from the **Solution Explorer**.
   The **TwinCAT Project** dialog box appears.
2. Click the **Parameter** tab.
3. Set **Scaling Factor Numerator** to `1`.
4. Set **Scaling Factor Denominator** to `8000`.

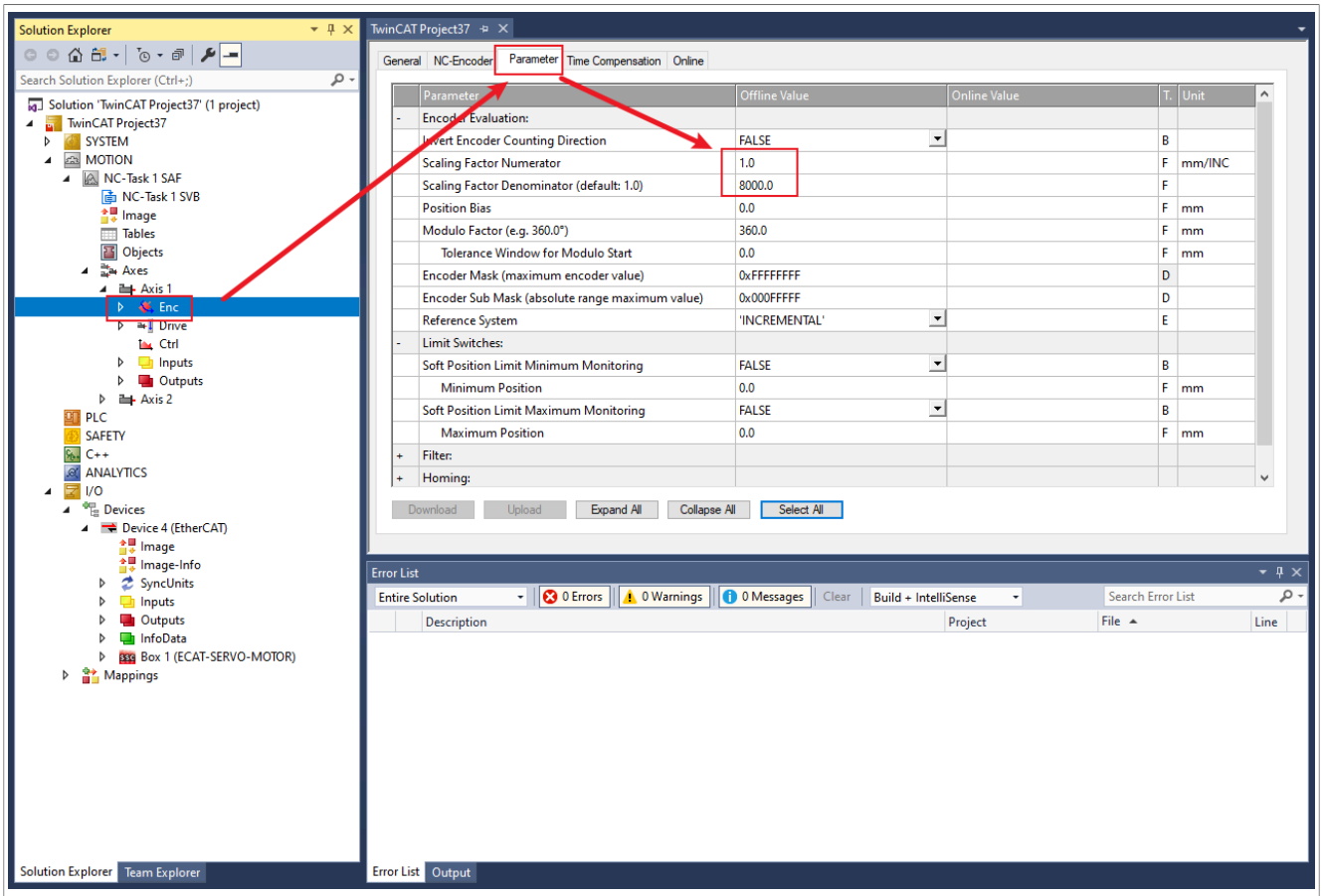


Figure 41. Configure the scaling factor

6.10 Configure drive

1. Select **Axes > Axis1 > Drive > Inputs > In > nState1** from the **Solution Explorer**.
   The **TwinCAT Project** dialog box appears.
2. Click the **Linked to** button.
   The **Attached Variable nState1 (Input)** dialog box appears.
3. Select **Box1(ECAT-SERVO-MOTOR) > Status Word Linked** to link **StatusWord**.
4. Click **OK**.

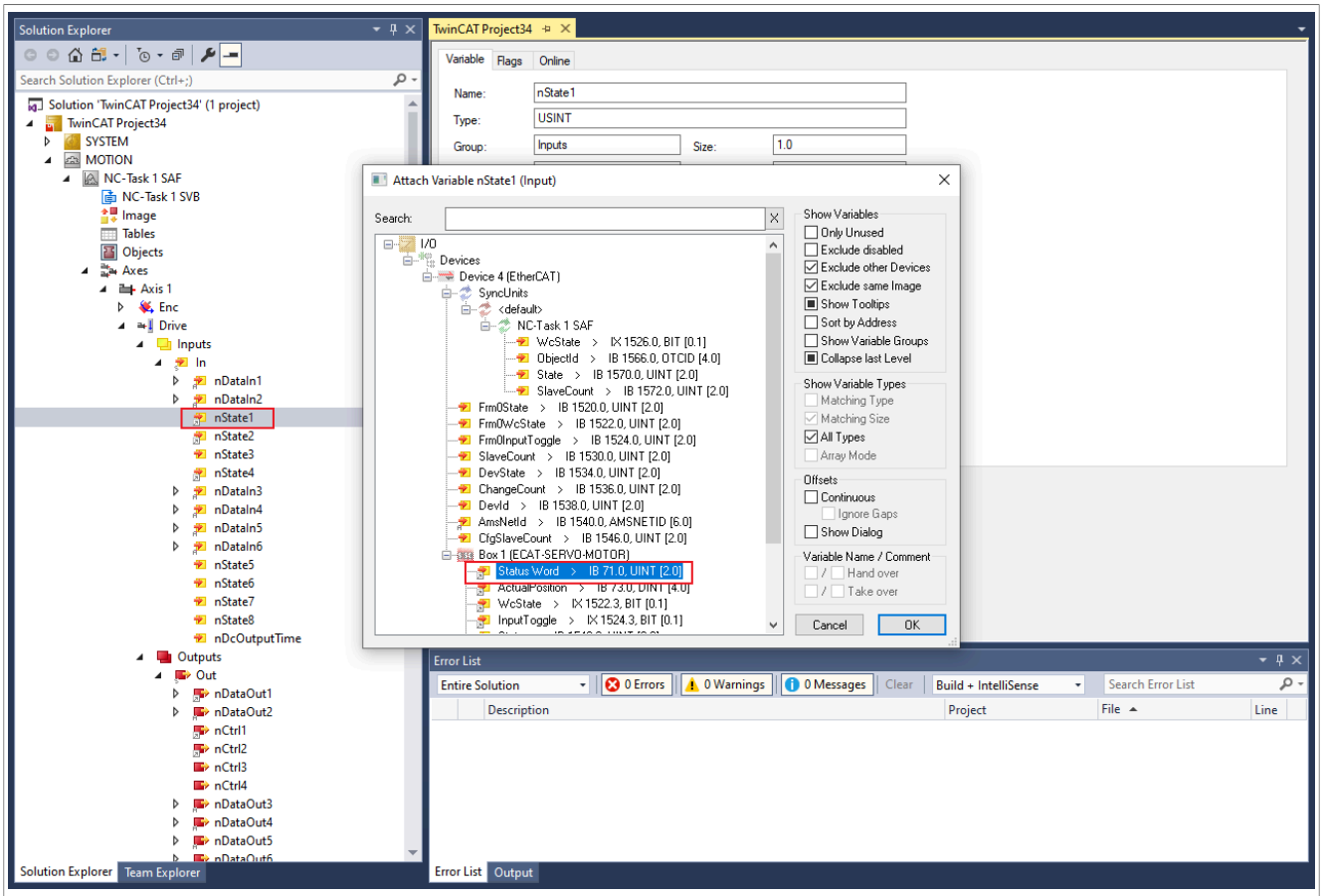


Figure 42. Configure drive

5. Click **OK** to link `StatusWord`.

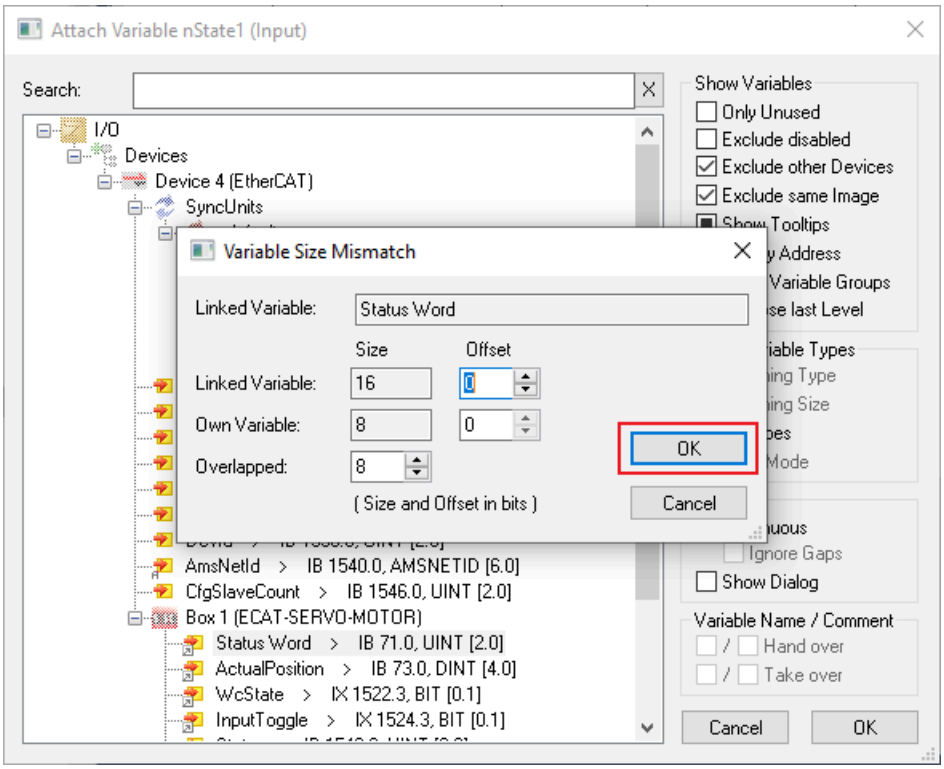


Figure 43. Attach variable nState1

6. Click **Axes > Axis1 > Drive > Inputs > In > nState2 > Linked to** to link `StatusWord`.

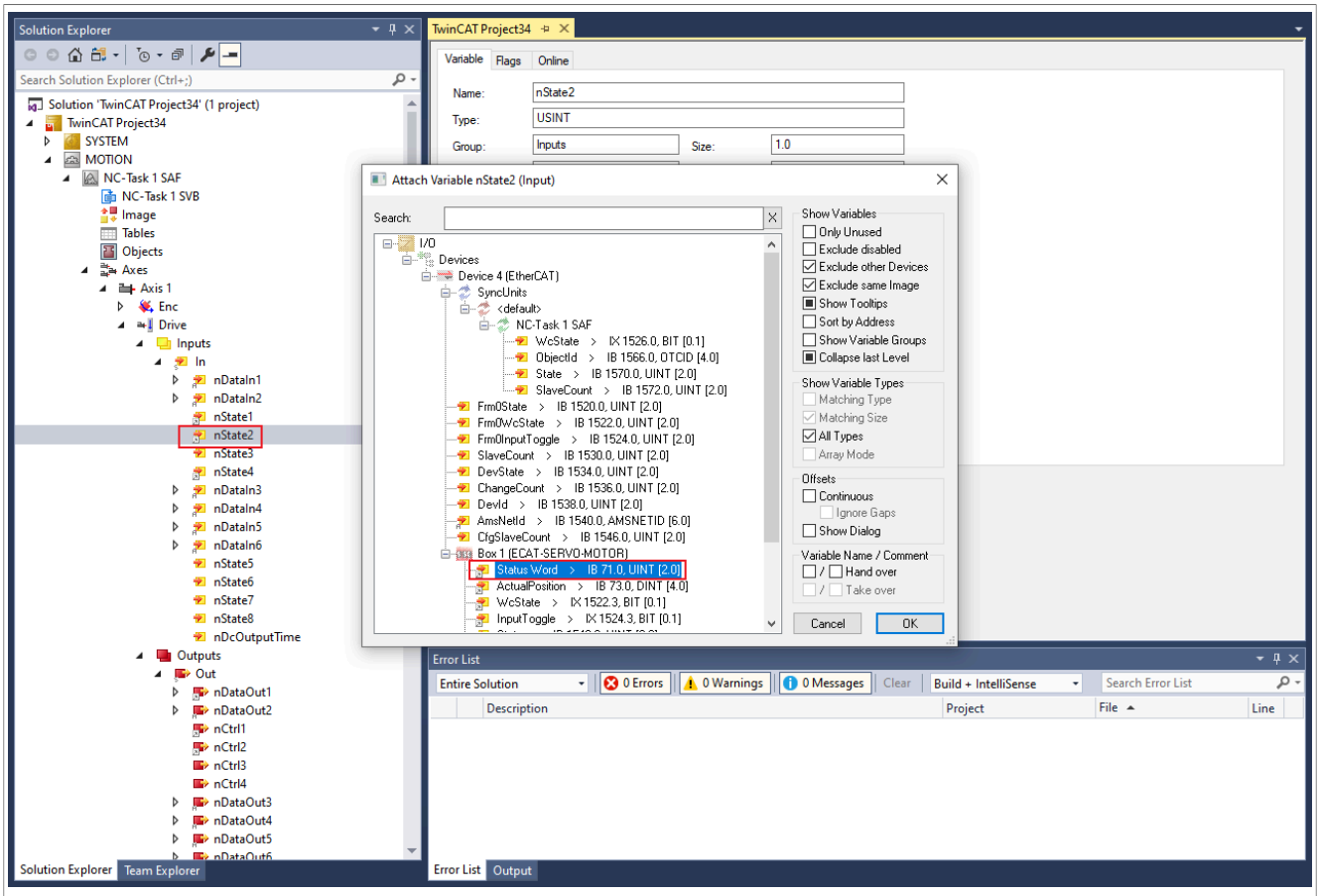


Figure 44. Link StatusWord

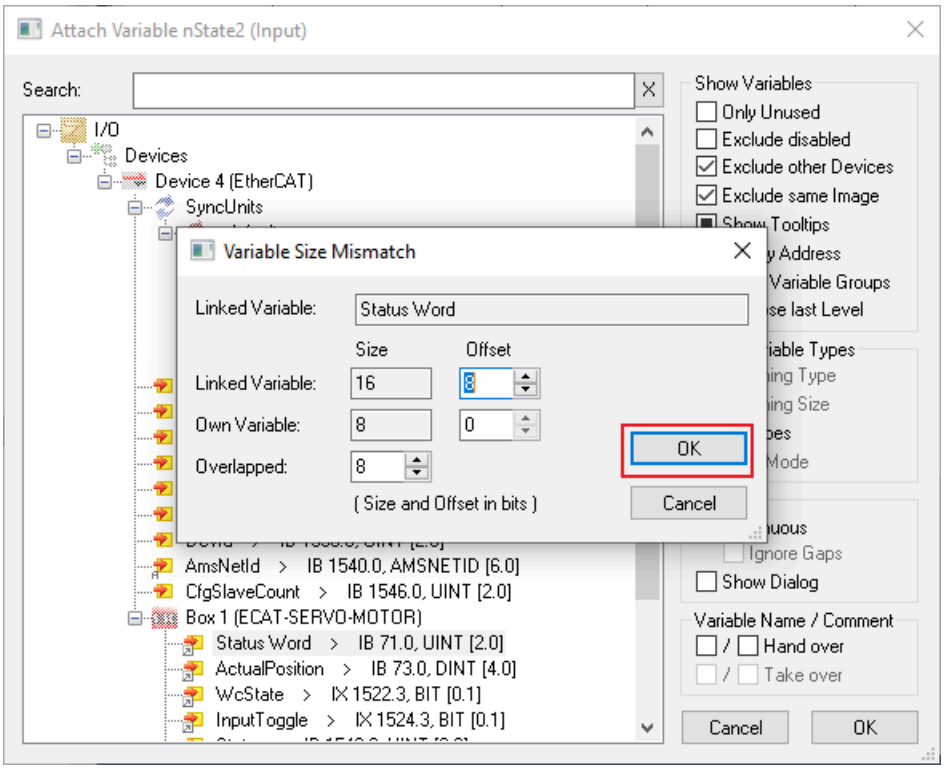


Figure 45. Attach variable nState2

7. Click **Axes > Axis1 > Drive > Inputs > In > nState4 > Linked to** to link **WcState**.

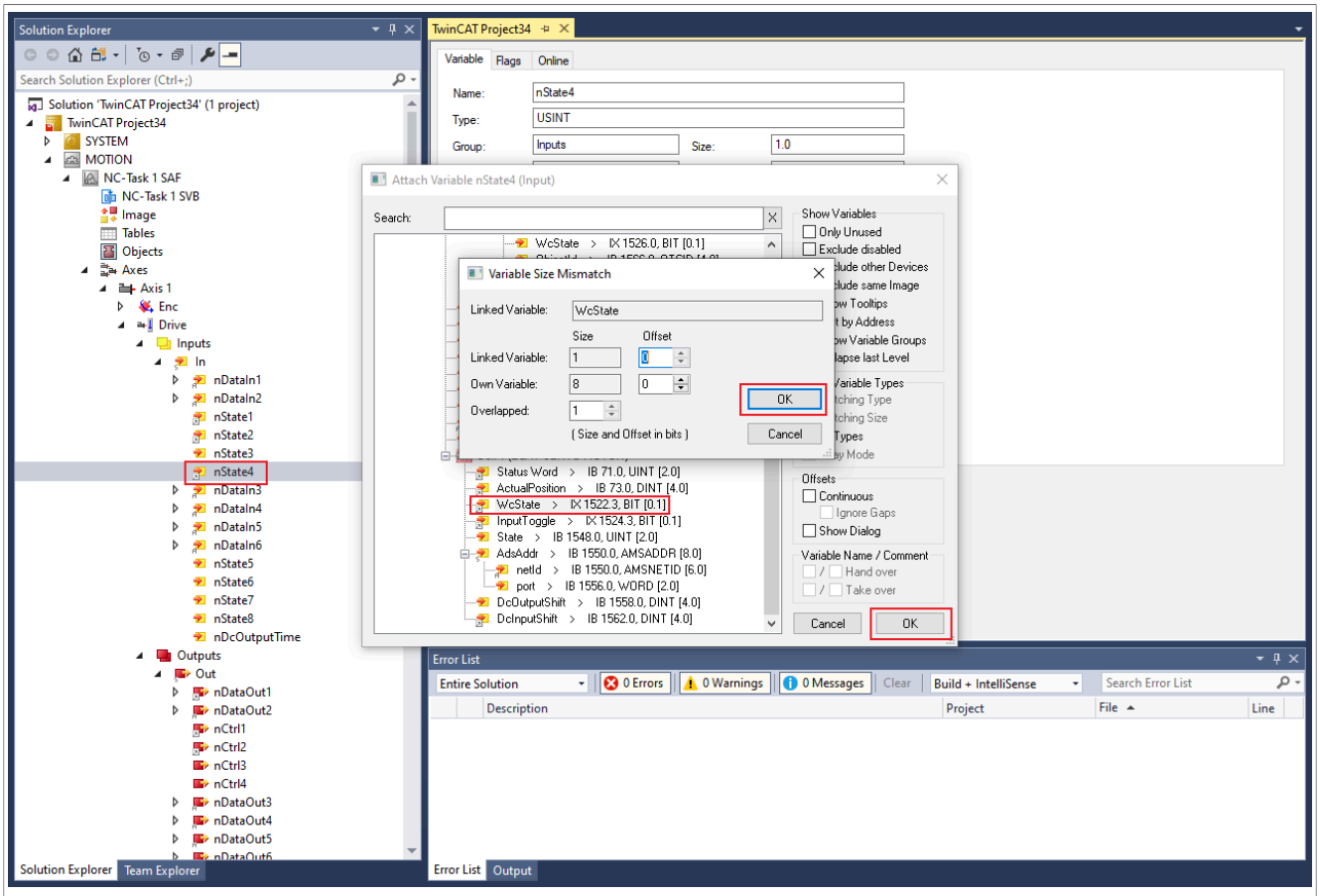


Figure 46. WcState and InputToggle

8. Click **OK**.

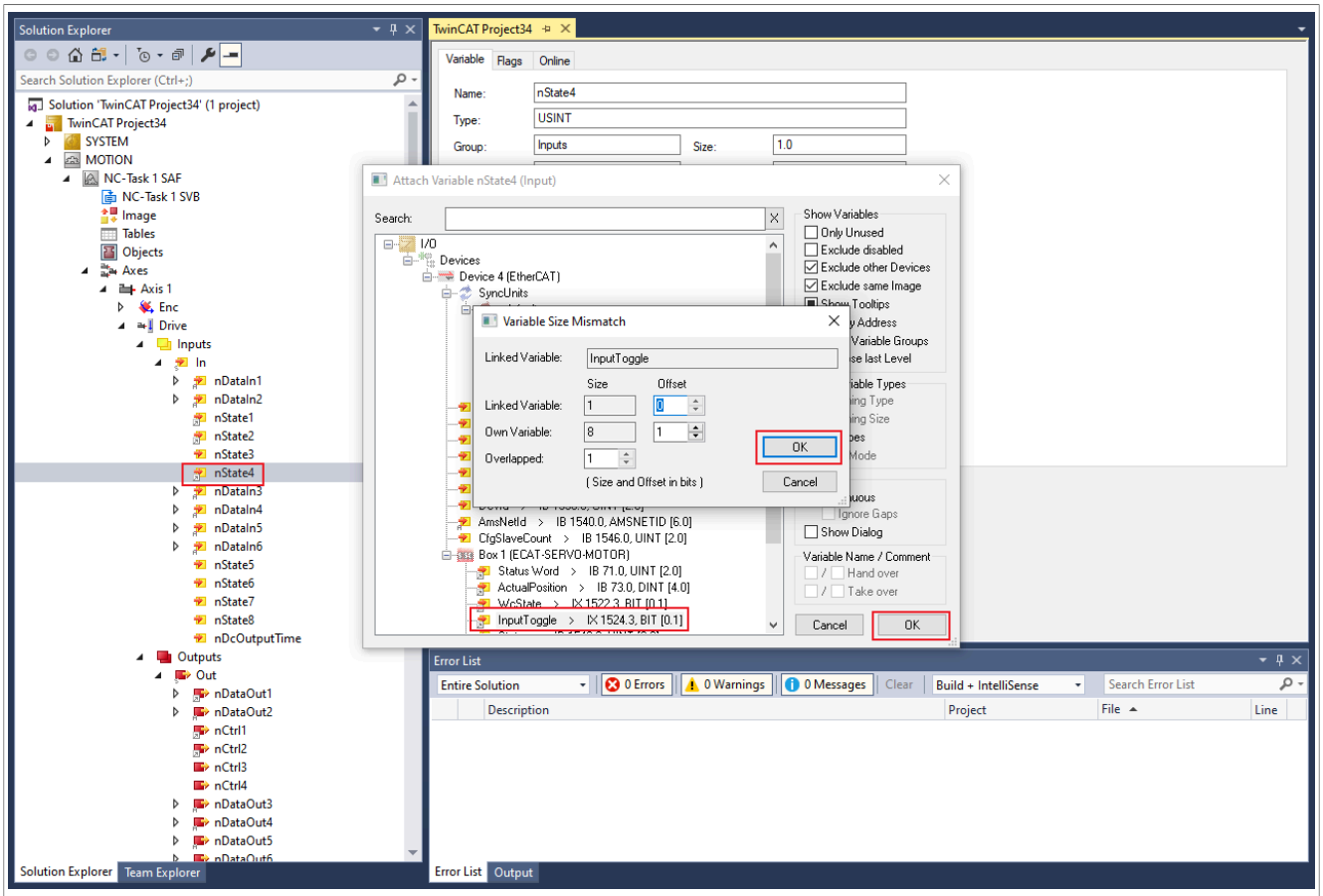


Figure 47. Attach variable nState4

9. Click **Axes > Axis1 > Drive > Outputs > Out > nDataOut1 > Linked to** to link **TargetPosition**.

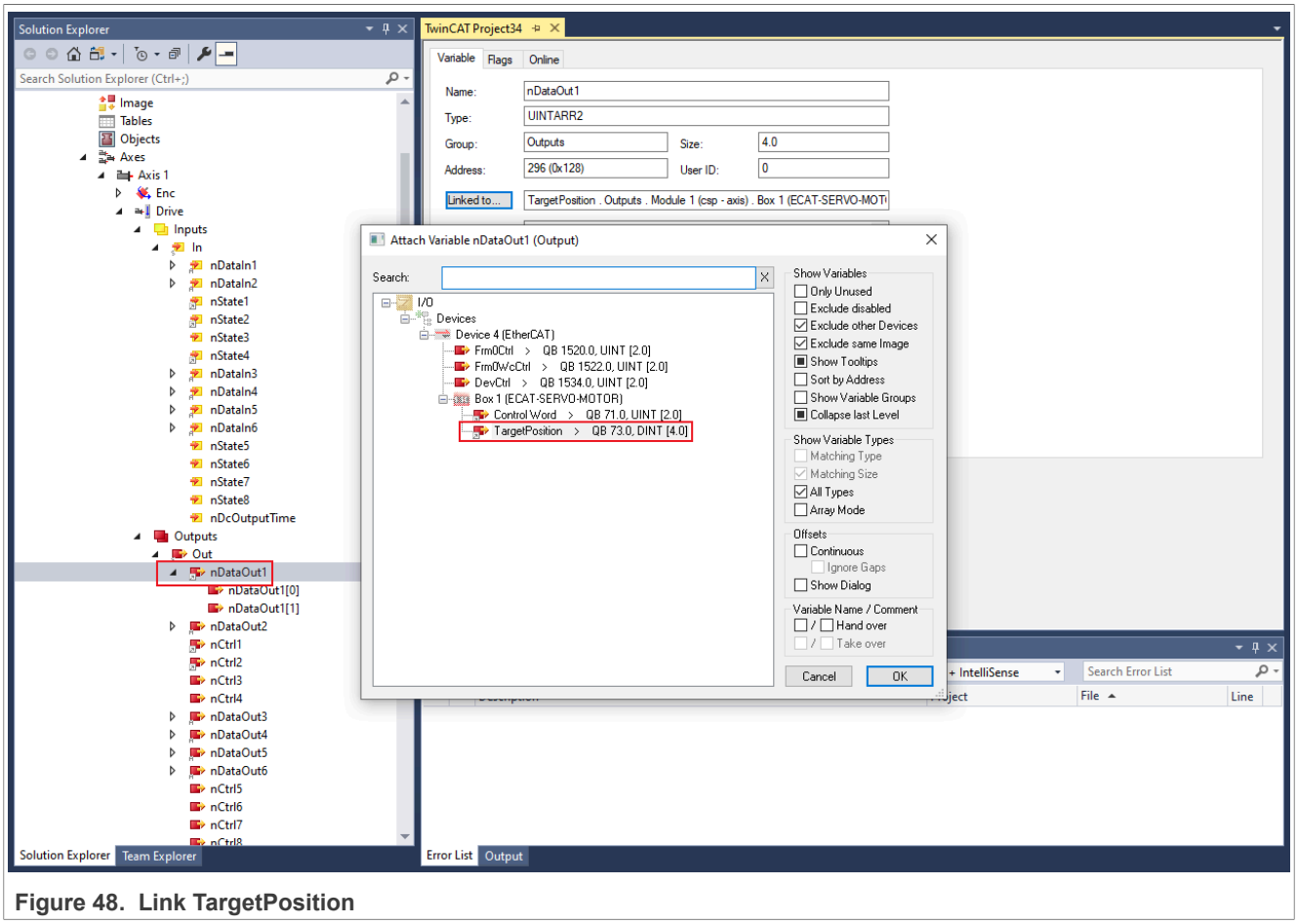


Figure 48. Link TargetPosition

10. Click **Axes > Axis1 > Drive > Outputs > Out > nCtrl1 > Linked to** to link **ControlWord**.

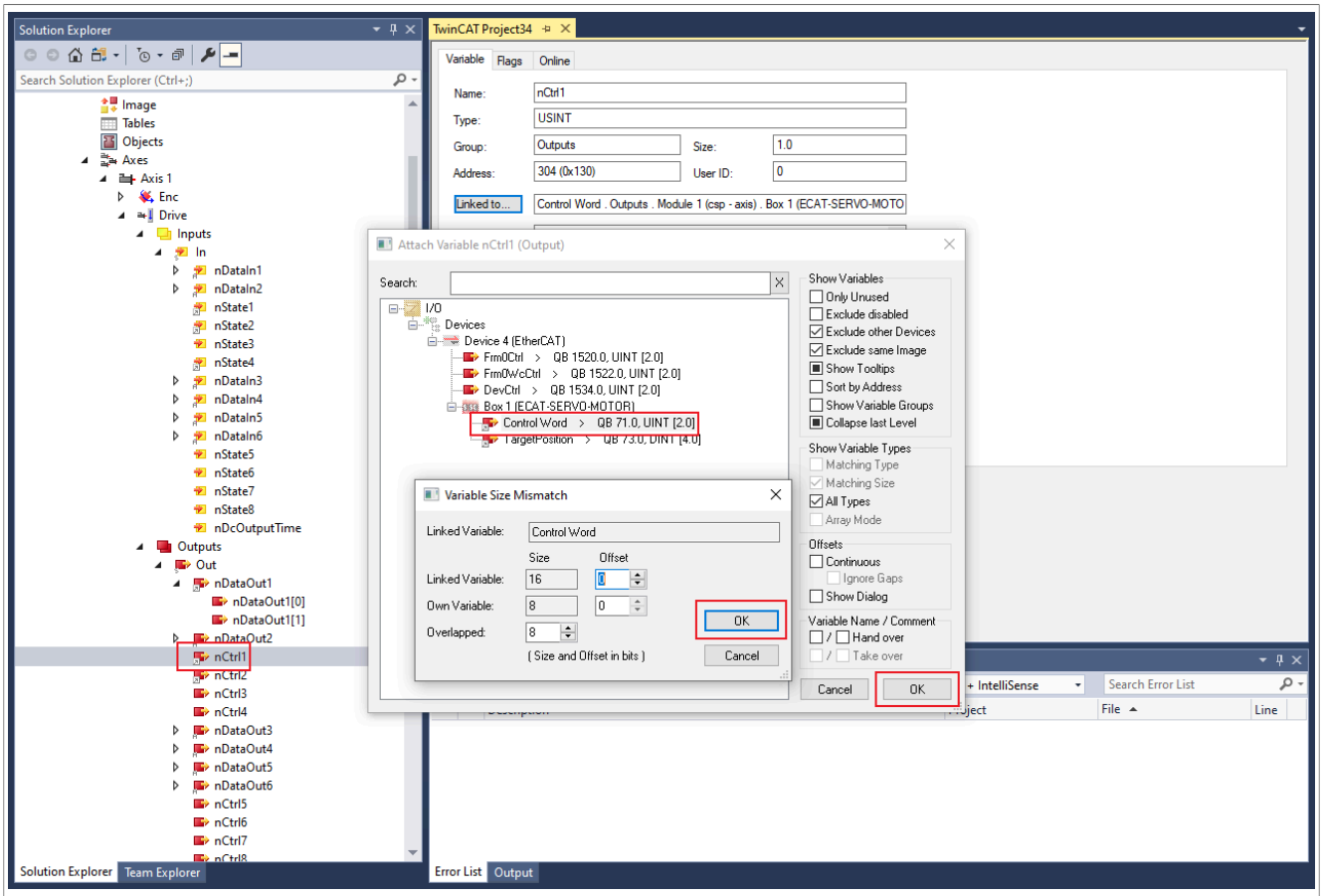


Figure 49. Link ControlWord

11. Click **Axes > Axis1 > Drive > Outputs > Out > nCtrl2 > Linked to** to link **ControlWord**.

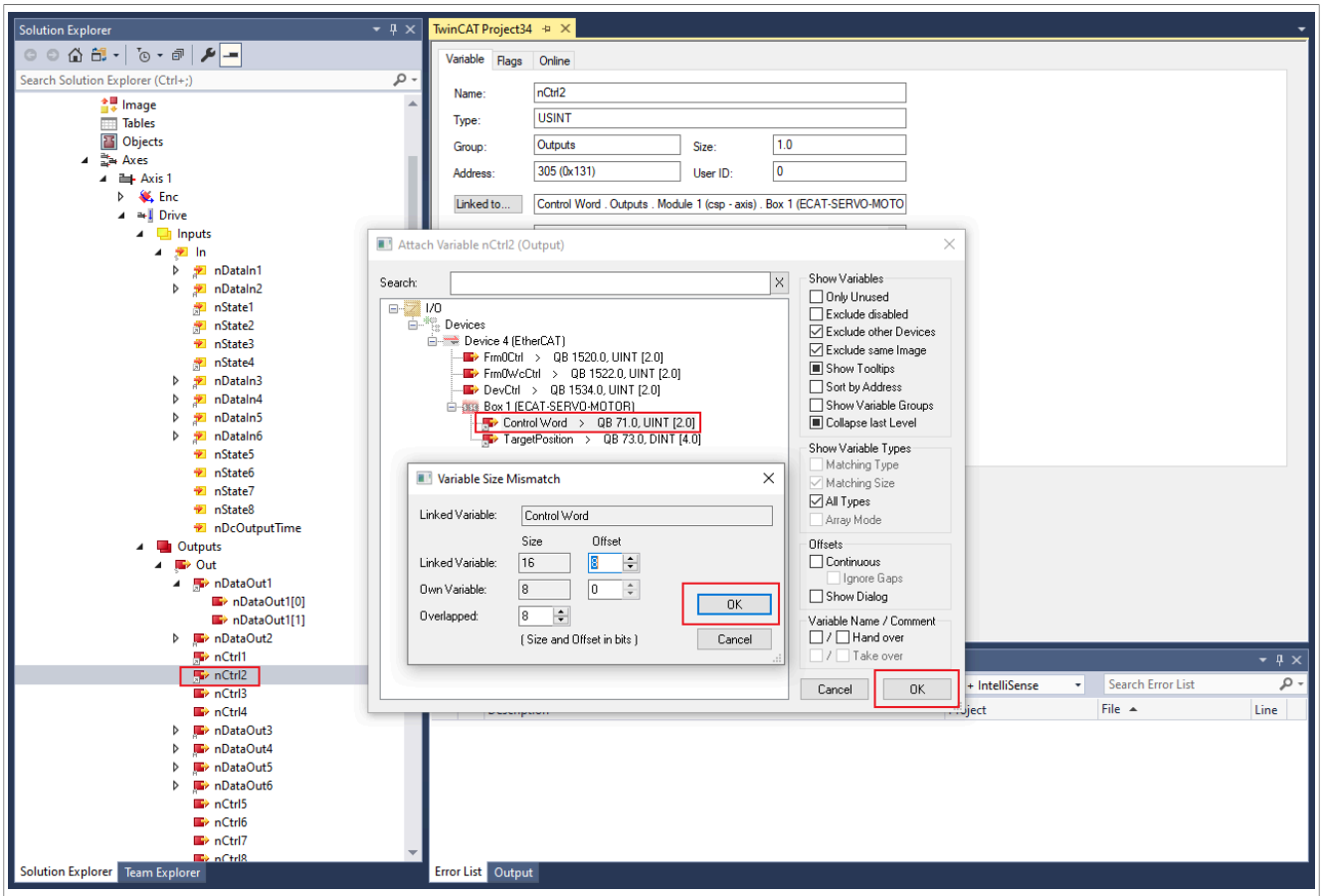


Figure 50. Attach Variable nCTrl2 (Output)

6.11 Stop position lag monitoring

1. Click **Axes > Axis1 > Parameter > Monitoring > Position Lag Monitoring** to choose `FALSE`.

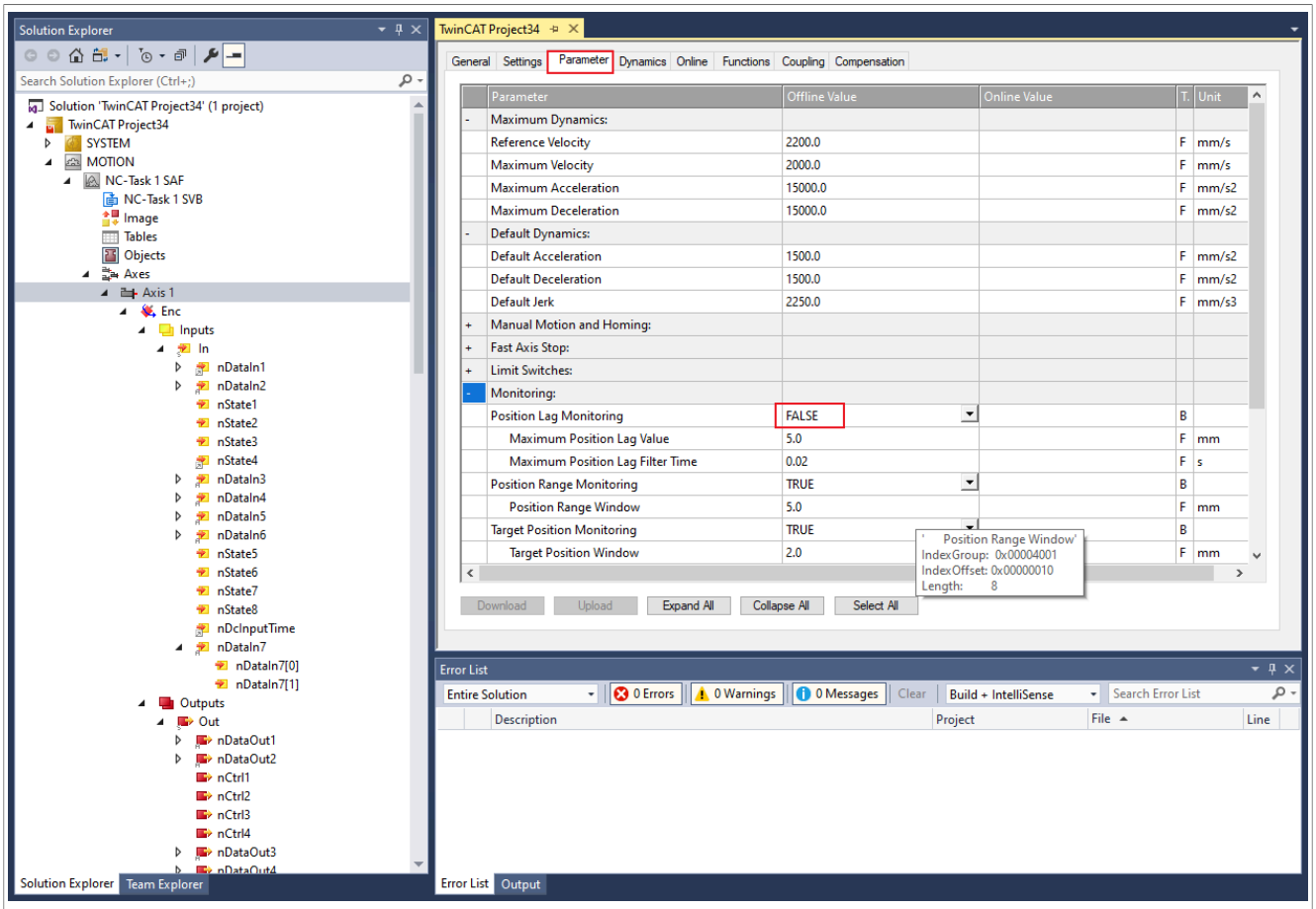


Figure 51. Stop position lag monitoring

6.12 Start to run motor

1. Activate the configuration by clicking **TwinCAT > Activate Configuration**.

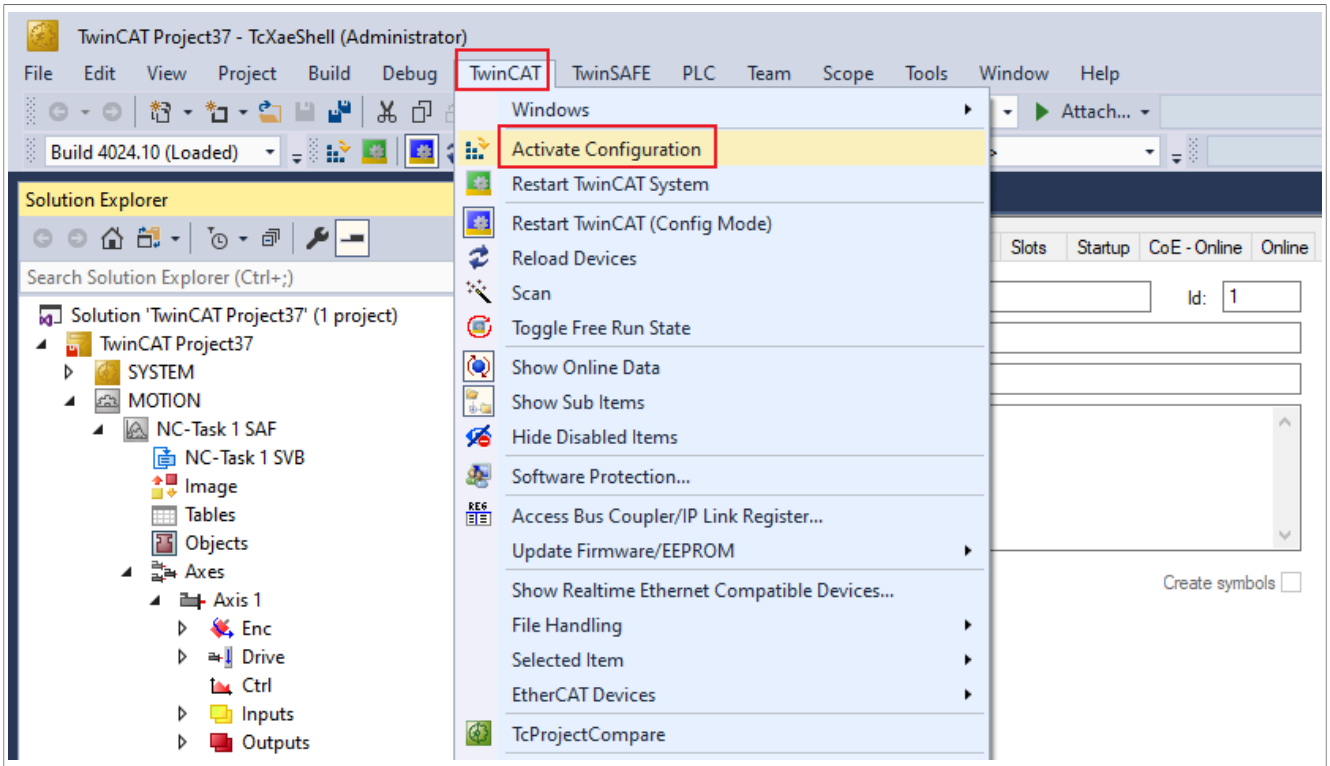


Figure 52. Activate configuration

2. Click **Axes > Axis1.**
3. Click the **Online** tab.
4. Click **Set**.
5. Set enabling and click **All**.

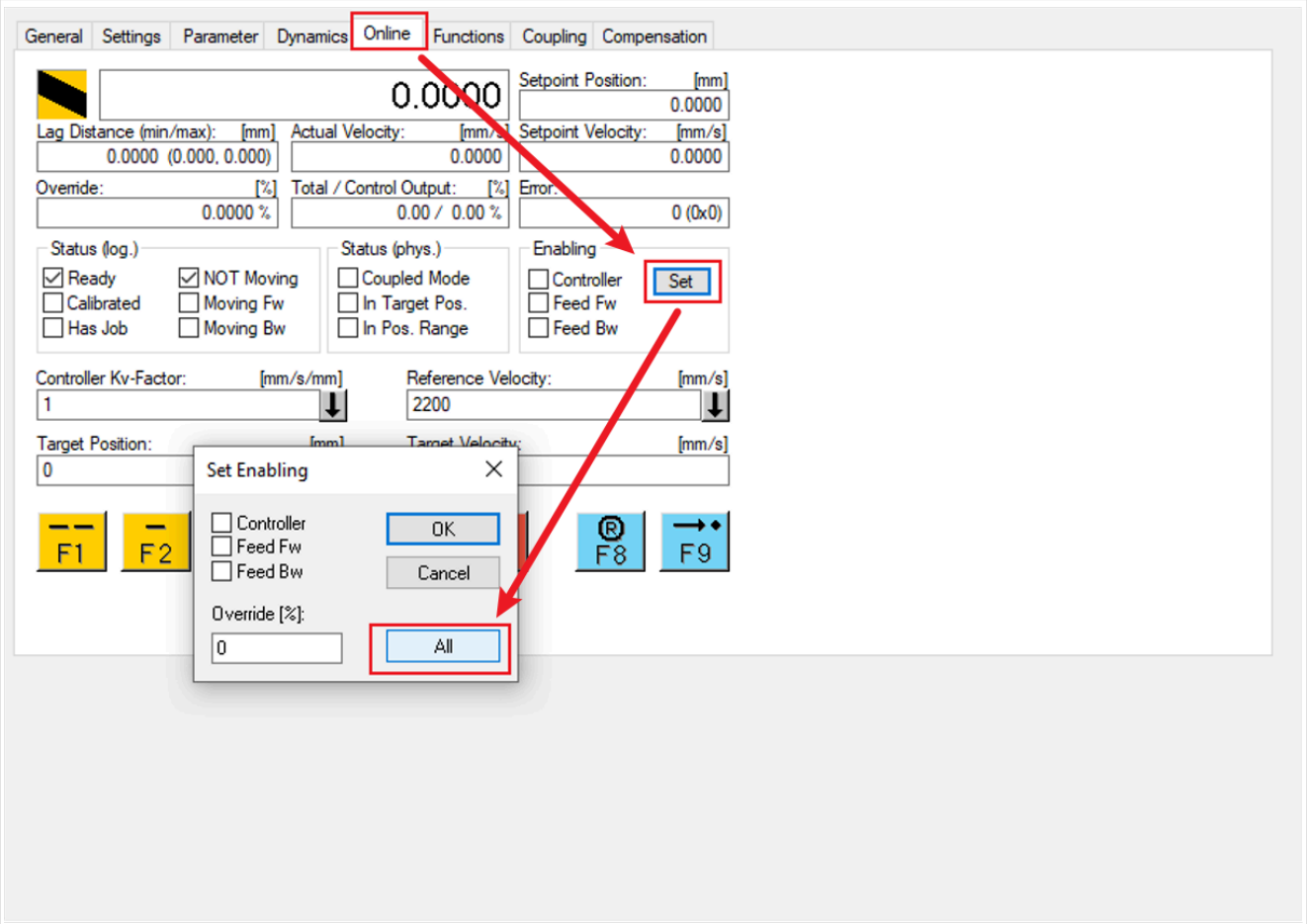


Figure 53. Start to run motor

6. Set **Target Position** and click the **F5** button. The motor will run to the target position.

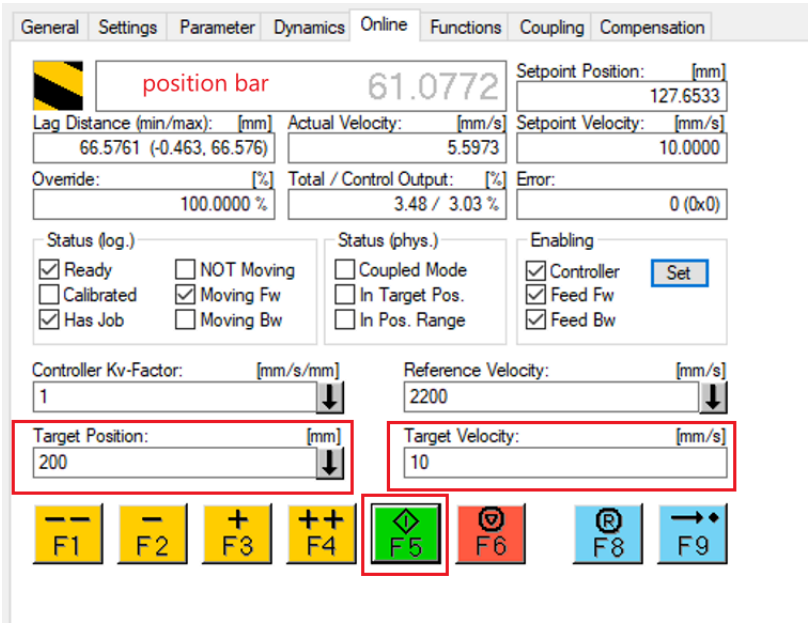


Figure 54. Set target position

Note: *If the motor does not run and the position bar is gray, follow the following steps.*

a. Click **Device 4 > Box 1 > WcState > WcState > Clear Link(s)**.

b. Click **Device 4 > Box 1 > WcState > InputToggle > Clear Link(s)**.

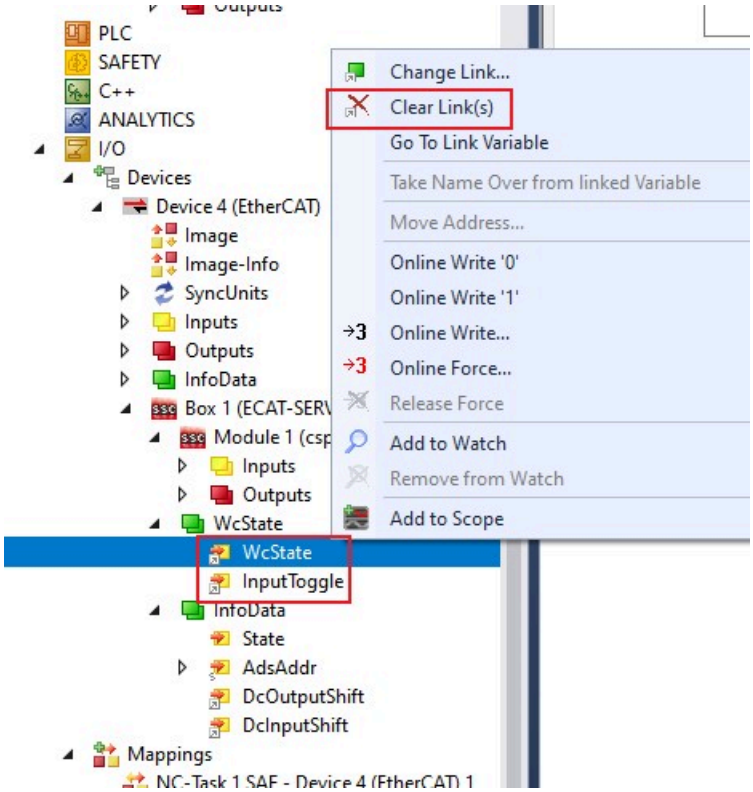


Figure 55. Clear links

7. Repeat step Section 6.12 "Start to run motor"..

7 Tuning motor parameters

Tuning motor parameters, constants and controller parameters can be necessary to achieve the required behavior and responses of a servo control application. There can be another motor type and different conditions than described in this document, so tuning parameters can be important. For the tuning motor parameters, perform the following steps:

1. Download the latest SDK package with the motor control software for permanent magnet synchronous motor (PMSM) from https://mcuxpresso.nxp.com/en/builder?hw=MIMXRT1180-EVK&components=nxp_motor_control.
2. Use the motor control example (*mc_pmsm*) for tuning motor parameters, constants, and so on. For more information about the application tuning, refer to the motor control application tuning (MCAT) training https://www.nxp.com/design/training/motor-control-application-tuning-mcat-tool-pmsm-servo-tuning:TIP-MCAT-PMSM.
3. When the parameters are tuned, use the updated m1_pmsm_appconfig.h header file with tuned parameters in the servo motor example.
   Note: *The application timings (slow state machine, fast state machine) must be the same for the motor control and servo motor examples.*

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9 Revision history

Table 3 summarizes the revisions to this document.

Table 3. Revision history

Revision number	Release date	Description
1	06 November 2023	Initial public release
2	10 January 2023	Updated for MCUXpresso SDK 2.15.000.

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