Maxsine 迈信电气

Technical white paper

Instruction for NC Connection between EP3E-EC Servo Driver and

BECKHOFF CX9020 Controller

Key words：EtherCAT、EP3E-EC、BECKHOFF、NC axis

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1. Scope of application

Connect the EP3E-EC servo driver to the CX9020, map the NC axis, and use the NC debugging interface to control motor inching, forward and backward rotation, etc; It is also possible to further map the PLC axis and use the MC function block to control motor movement.

2. Principle Overview

TwinCAT NC PTP divides the motion control of a motor into three layers: PLC axis, NC axis, and physical axis.

The axis variable defined in the PLC program is called the PLC axis. The AXIS defined in the NC configuration interface is called the NC axis, and the hardware for motion execution and position feedback scanned or added in the I/O configuration is called the physical axis. Their relationship is shown in the figure:
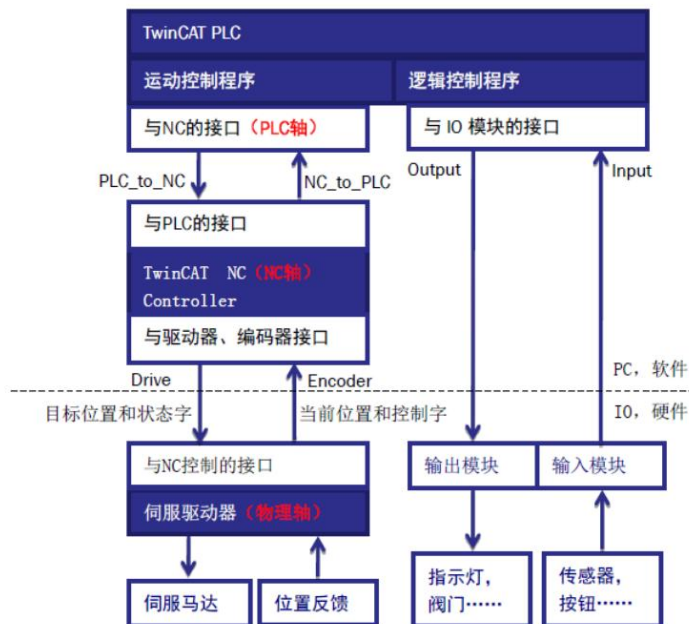
To use the motion control library to control the physical axis, PLC must go through two stages: PLC axis to NC axis; From the NC axis to the physical axis. Through PDO mapping, the physical axis can be connected to the NC axis. The trajectory planning of the physical axis is entirely completed internally by the NC axis. Users can control the NC axis through the NC debugging interface and the PLC axis. All movements of the NC axis can be mapped to the physical axis. The control of the PLC axis refers to the programming in the PLC program and the calling of the function block of the motion control library.

3. Debugging environment

- EP3E - EC servo drive / servo motor
- CX9020 controller

- TwinCAT3 programming software

4. Technical implementation

4.1 Hardware connection

1. Refer to the "EP3E EtherCAT User Manual" to correctly connect the servo driver power supply, motor, etc;

2. Correctly connect the power supply of CX9020;

3. Connect the X5 port of the first servo driver to the network port of CX9020; If there are multiple servo drivers, connect the X6 port of the previous one to the X5 port of the next one; Connect the other network port of CX9020 to the debugging computer.

4.2 XML file installation

For the first time using TwinCAT to connect to EP3E-EC, it is necessary to import the XML file provided by the Maxsine manufacturer into the TwinCAT installation directory, so that the EtherCAT master can integrate the slave device into the EtherCAT network and complete the hardware configuration. The installation path is as follows:

TwinCAT2:　C:\TwinCAT\Io\EtherCAT

TwinCAT3:　C:\TwinCAT\3.1\Config\Io\EtherCAT
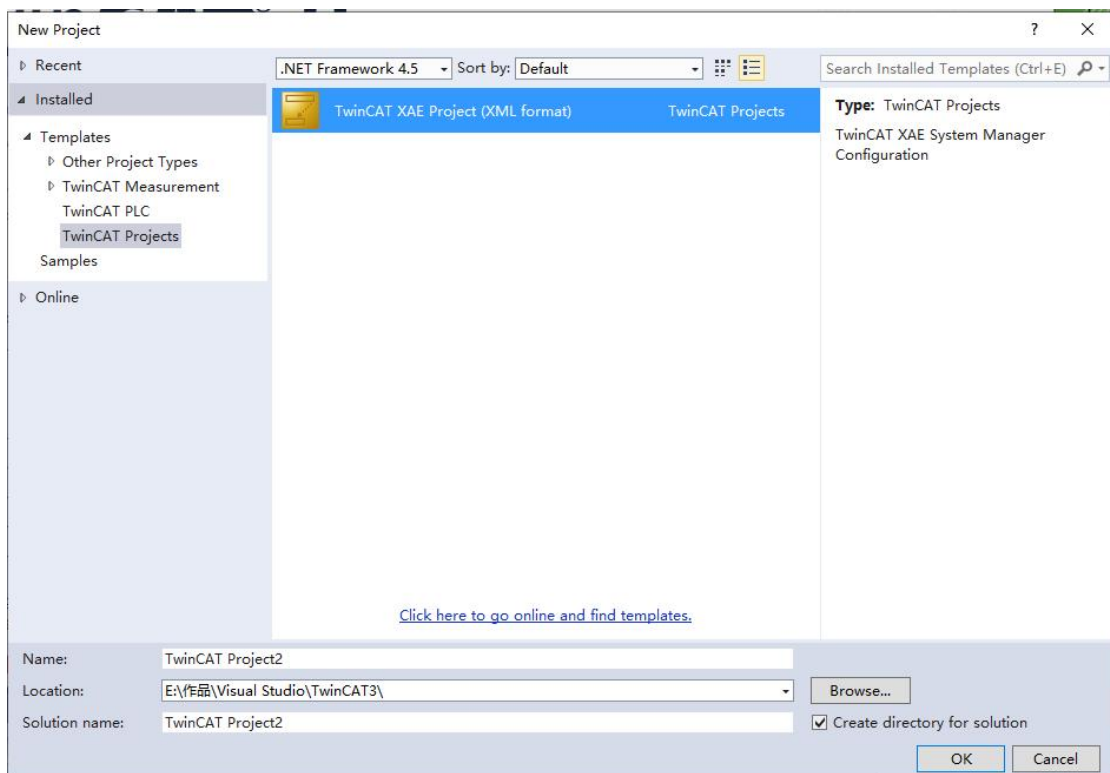
XML file will be sent by email
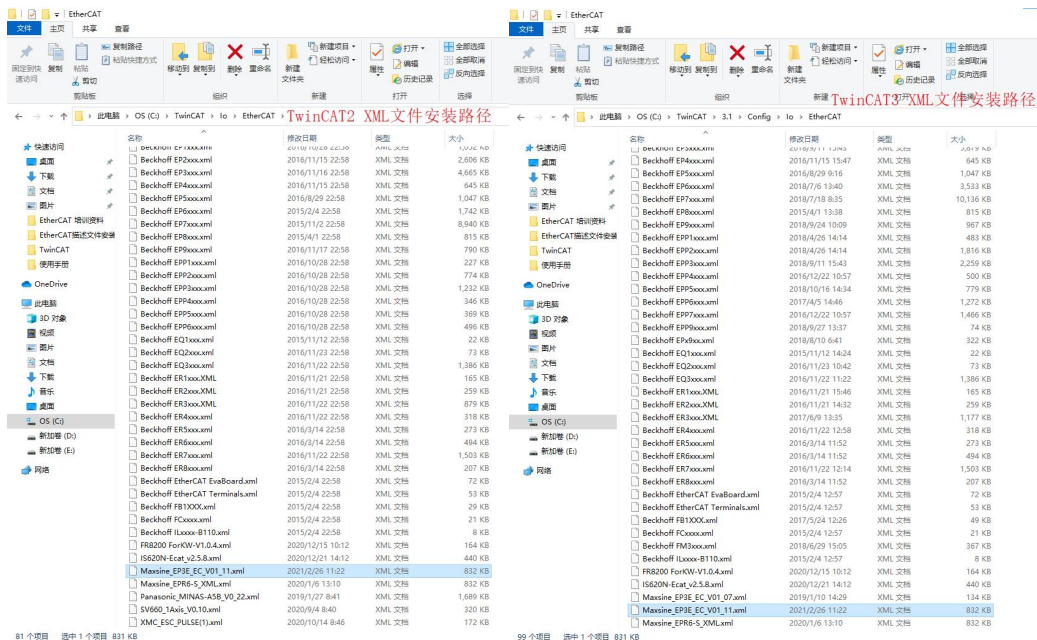
4.3 Engineering Establishment

Open TwinCAT3 software and click on FILE → New → Project

Select TwinCAT Project in the project creation interface, fill in the project name, select the project save address, and click OK
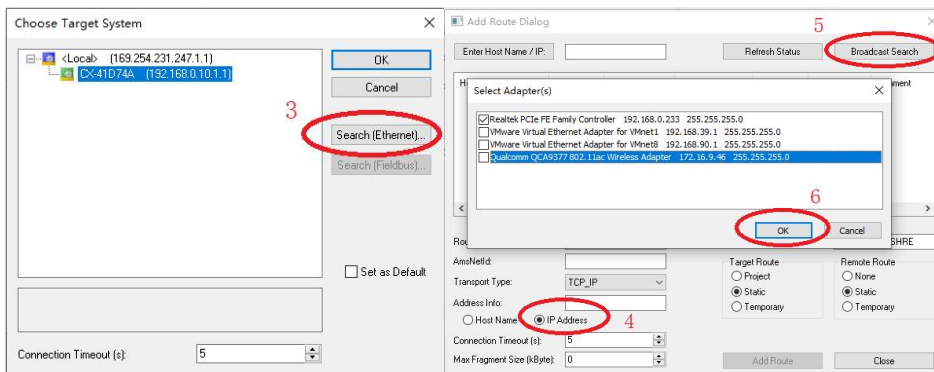
## 4.4　**Connecting the controller**

After the project is established, the first step is to connect the controller. Double click on SYSTEM in the left project bar to open the interface and click on "Choose Target System".
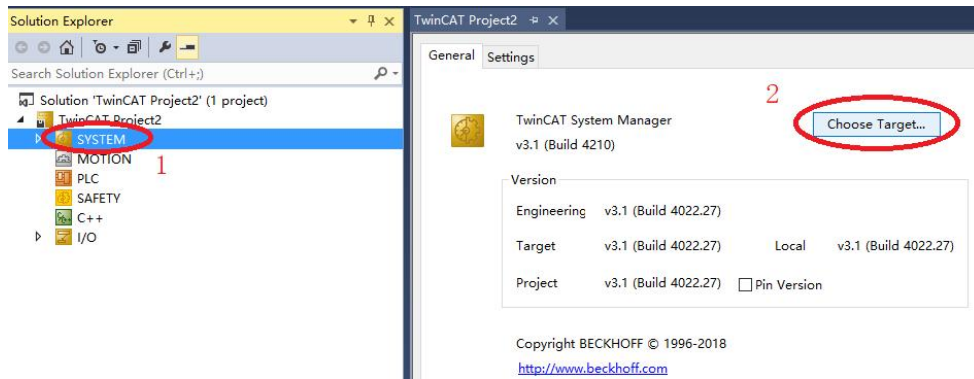
In the pop-up "Choose Target System" window, click "search Ethernet", select IP Address in the new window, click "Broadcast Search", click OK, and add a controller by scanning the IP.

Select the target controller, click Add Route, enter the username and password, click OK to connect to the controller. If successful, the Connected column displays an X mark. Click Close to return to the previous window. You can see that the Routing table item just added appears in the list. Select the controller to be configured and click OK.
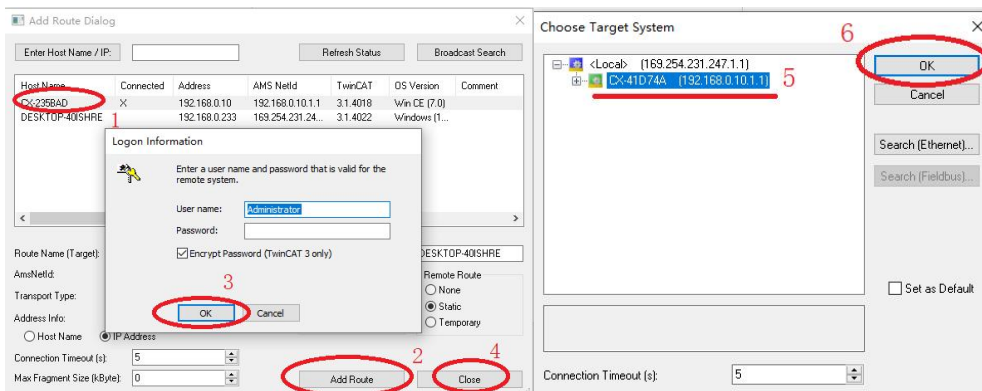
Note: The CE system only supports the IP Address method, and this method is faster when the connection is interrupted and then restored. So it is recommended to use IP Address.
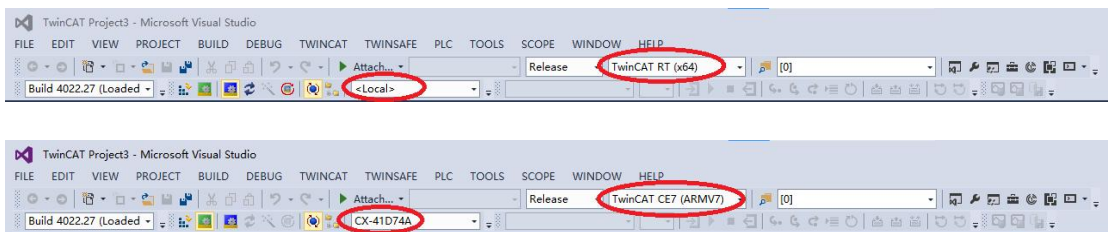
Factory settings: Windows Xp/WIN7, username: Administrator, password: 1;

Factory settings: Windows CE, username and password are blank.

Select yes in the pop-up window to switch the operating system:
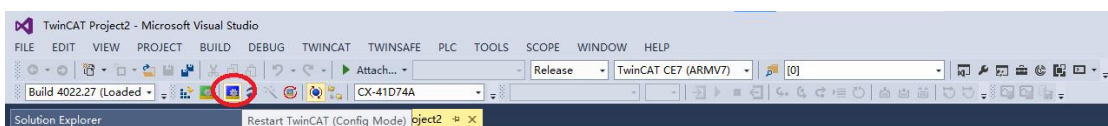

As shown in the figure, the currently connected controller and operating system are switched from local mode to the target system:


4.5 **Add Physical Axis**

After successfully connecting to the controller, click on the following icon to enter Config Mode. Only in Config Mode can the slave station be scanned and configured.

In Config Mode, click on IO in the left engineering column, right-click on Devices, click Scan, and a prompt interface will pop up. Simply click OK, select EtherCAT in the pop-up window, and click OK.
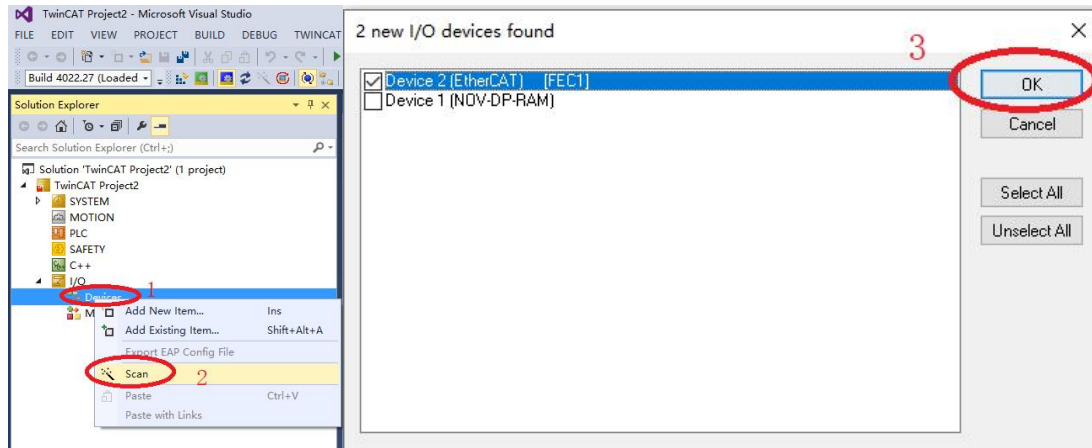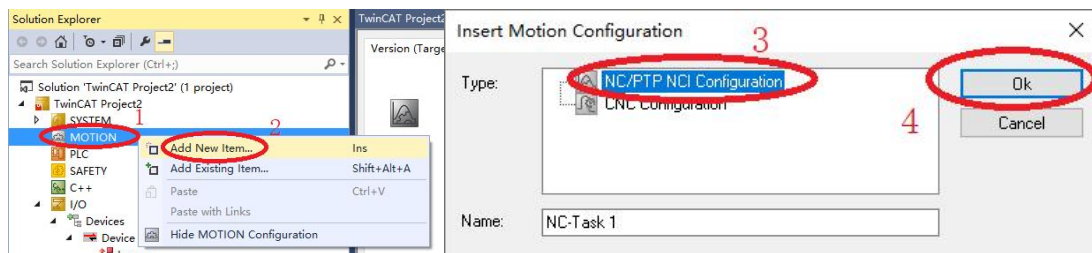
Select YES for Scan for boxes; EtherCAT drive (s) added Select NC – Configuration, click OK to automatically add and link the NC axis, or click Cancel to manually add the NC axis later. Activate Free Run and select NO.
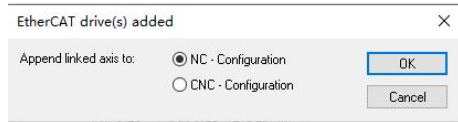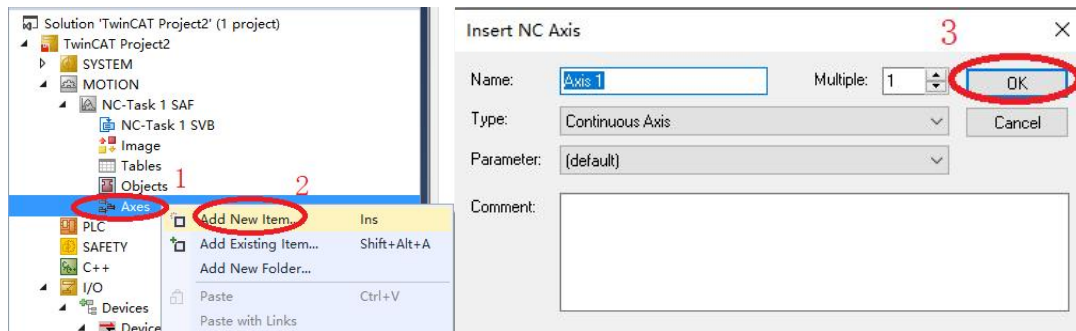

4.6 Adding NC Axis

In Config Mode, right-click MOTION in the left engineering column, click Add New Item, select NC/PTP in the pop-up window, and click OK

Open NC Task 1 SAF, right-click Axes, click Add New Item, and the Insert NC Axis interface will pop up. Click OK to add the NC axis.


The newly added NC axis requires some basic configuration to be used. First, click Axis 1 (the newly added NC axis), then click Settings, click Link To I/O, select the physical axis to be connected, and click OK. This completes the connection between the NC axis and the physical axis.
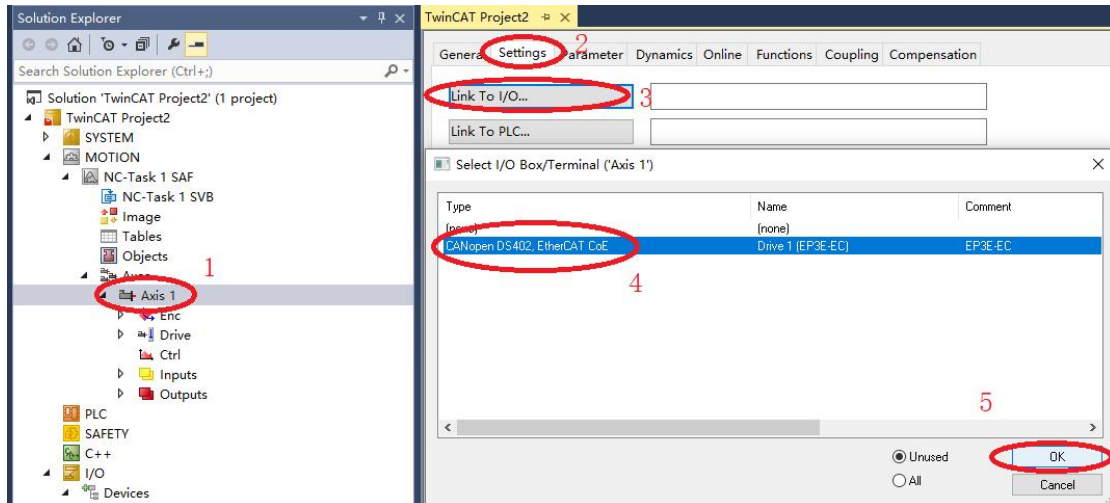
Next, set the pulse equivalent Scaling Factor of the NC axis, which is the most important encoder parameter. It represents the actual movement of the mechanism in millimeters per increment of "1" in the "Current Position" in Process Data, in units of "mm/Inch".

The pulse equivalent of the Encoder in TwinCAT 3 is determined by the numerator and denominator. For example, if the number of pulses per revolution is known to be 131072, open the submenu of Axis 1, click Enc to open the encoder parameter interface, click Parameter, and set the Scaling Factor Numerator to 60 and the Scaling Factor Denominator to 131072. At this time, the NC axis moves 60mm and the physical axis rotates one revolution.

Tip: For no-load debugging, it is customary to set one turn to 60mm, so that a speed of 1mm/s is equivalent to 1r/min. Because the rated speed unit of the motor is rpm, it is more intuitive to use rpm as the speed unit during debugging.
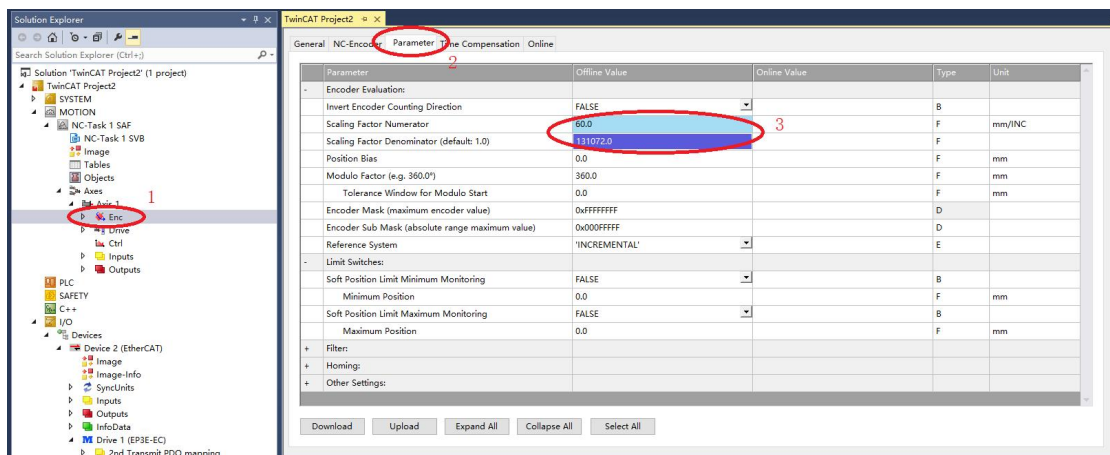
Next, turn off the position out of tolerance detection of the controller, click Ctrl to open the control parameter interface, set the Position Lag Monitoring to FALSE, and the position out of tolerance detection is completed by the driver. The driver P080 sets the position out of tolerance detection range, which defaults to 4r, that is, an alarm will be given if the difference between the actual position and the commanded position exceeds 4r.
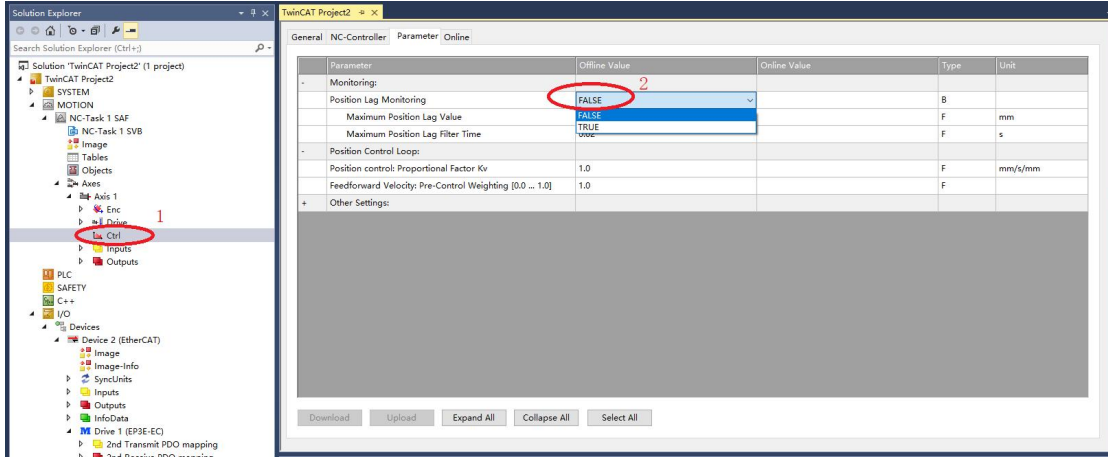

完成配置后，After completing the configuration, click Activate Configuration ◱Activation parameter configuration takes effect。Click "OK" to enter the running mode, and the icon in the lower right corner will turn green⊞13。

In the bottom right corner of the form◱ icons for status，◱ icons for configuration mode，⊞13icons for operating mode。◱icons for stop mode.
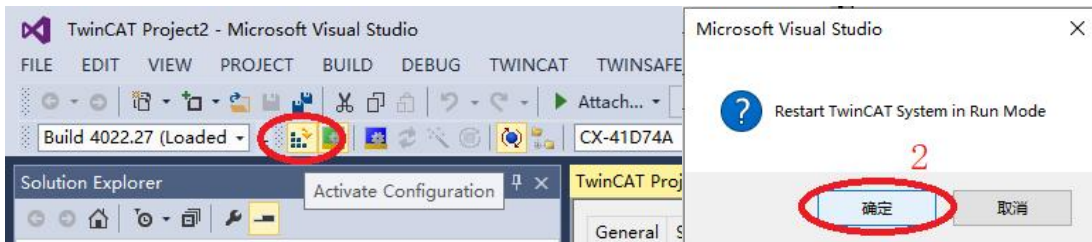
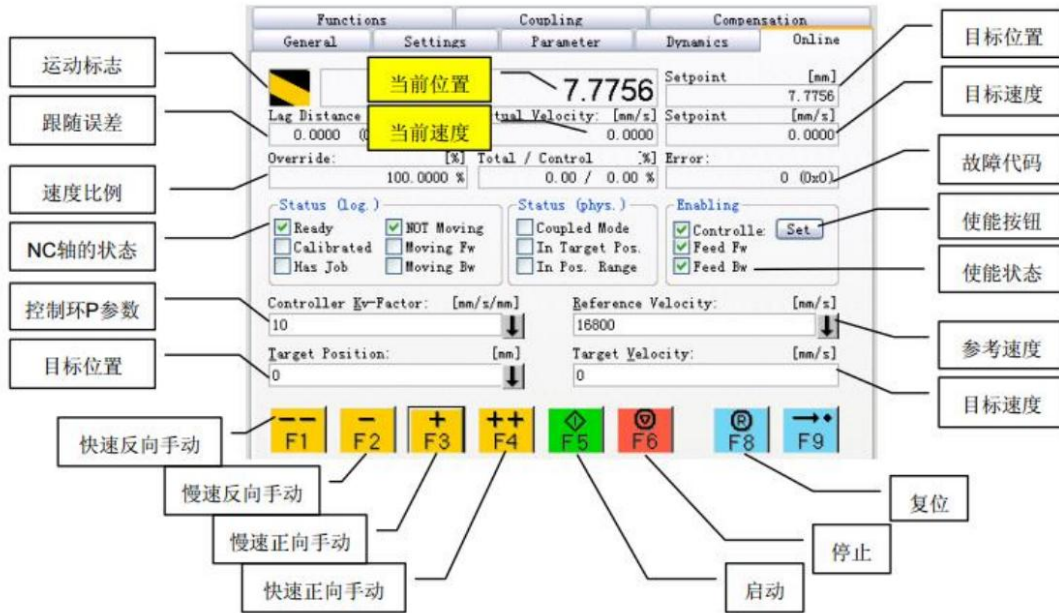## 4.7 **NC Debugging interface**

At this stage, you can use the NC debugging interface to control the motor movement. Click Axis1 → Online → Set → ALL to complete the upper enable, and then use F1~F4 to control the motor jog.
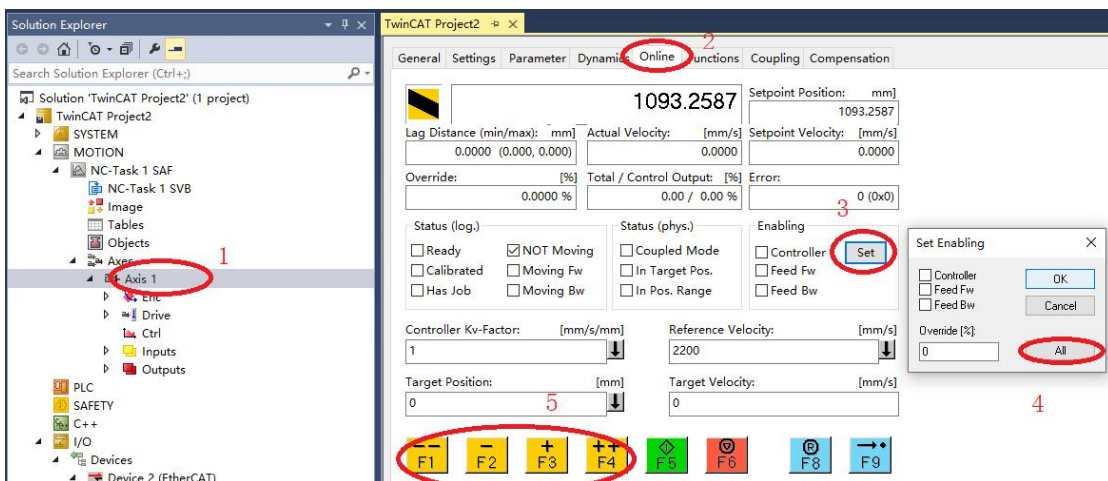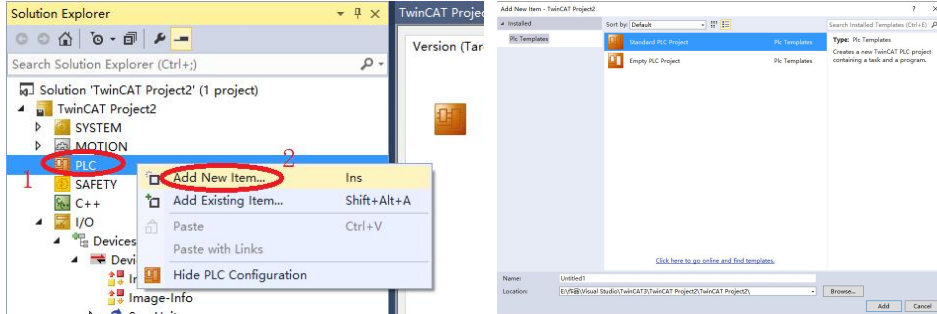
The detailed information of the NC debugging interface is as follows:

4.8 Add PLC axis

Right click on the PLC in the left engineering column, click Add New Item, select Standard PLC Project in the pop-up window, name the PLC, and select the save path. Generally, the default here is to click Add to complete the PLC project addition.


Right click on References, click Add library to add a library, and select Motion → PTP → Tc2 in the pop-up interface_ MC2, click OK, complete Tc2_ Add MC2 motion control library.
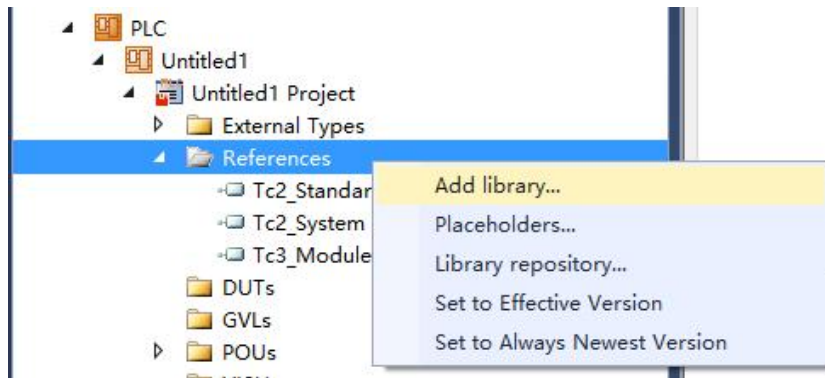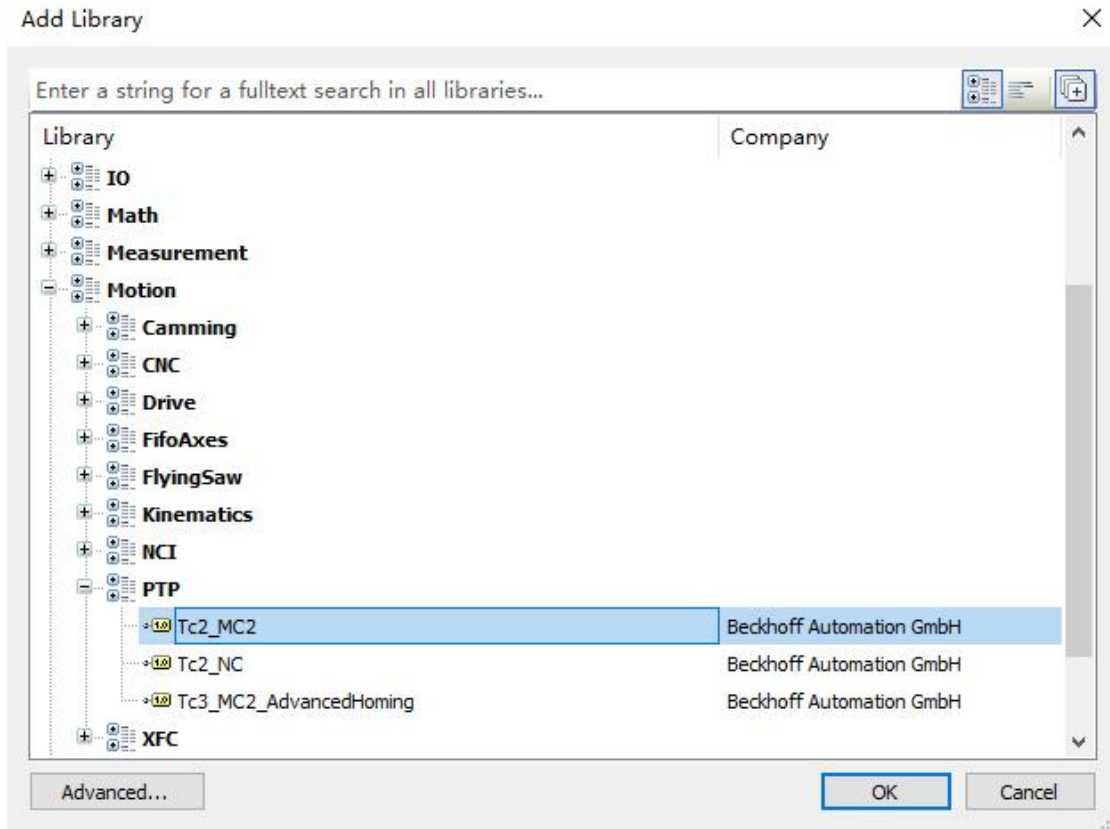
In the PLC program, all control of the NC axis is achieved through Tc2_ Implemented by FB in MC2, which defines the structural type "Axis_Ref", where "Axis_Ref" is the axis variable in PLC. When all FBs want to control an axis, their interface variable type is Axis_ Ref, you need to declare as many axis variables as you have.

Click on the main function, and then you need to create an Axis in the PLC program_ Ref, which is the PLC axis. The declaration format is as follows: Axis1: Axis_ Ref, declare Axis1 as the PLC axis variable.
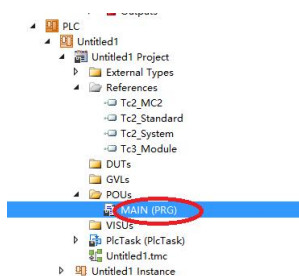
4.9　PLC Programming

Next, we will write a program for forward and reverse cyclic motion, as shown in the figure. The program window is divided into two parts, with the variable declaration area at the top and the program writing area at the bottom.

Place the cursor here, press F2 to pop up Input Assistant, select Function Blocks, and then locate MC_ Power function block, Input Assistant will display the explanation of the selected function block below, double-click to pop up an automatic declaration window, name the function block in the Name: box, and then OK to define and call up the function block.

Notes
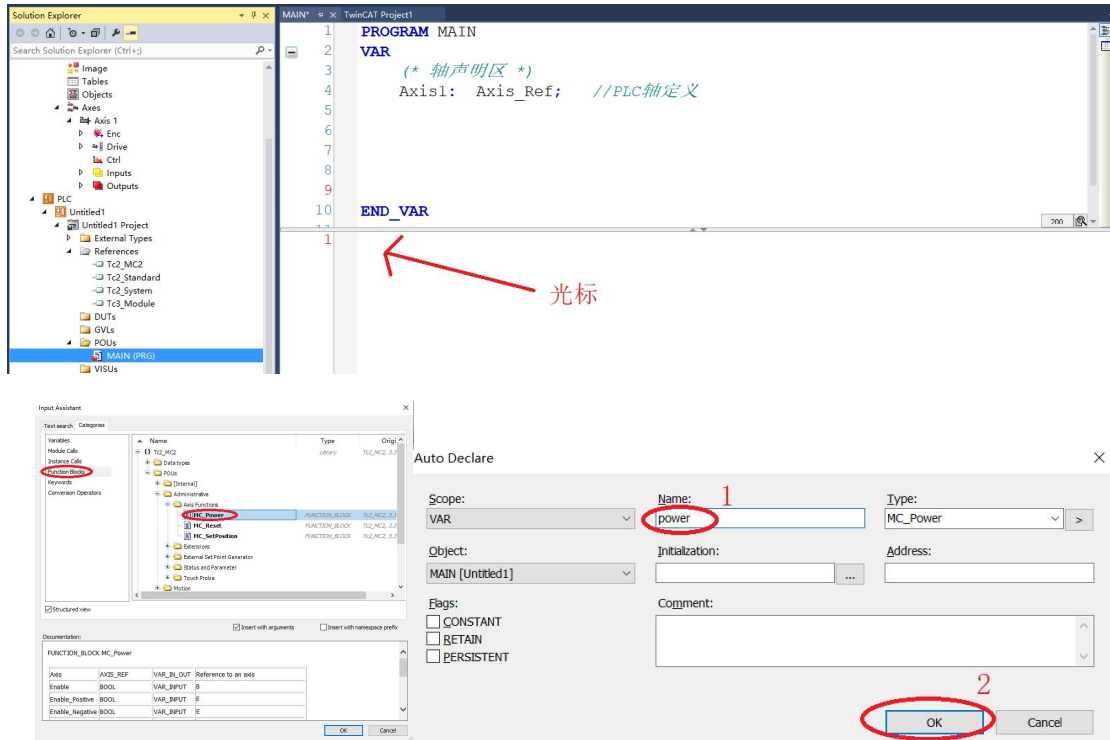
As shown in the figure, the function block called in the previous step is marked in the box, where MC_Power function block: All NC axes must be enabled before they can be activated.

Axis：Axis_ Ref axis variable interface

Enable：Enable signal. The Enable signal is valid continuously and must remain true until the NC axis stops normally. If the enable signal of the NC axis changes to False during operation, the NC immediately triggers an Error alarm.

Enable_positive：BOOL；Allow forward rotation

Enable_Negative：BOOL，Allow Inversion

Override：LREAL；Refers to the speed output ratio. It is a real number from 0 to 100.0. It can be dynamically modified while Enable remains true, and the actual output speed will change proportionally accordingly.

The following shows all interface for MC_Power, in order to facilitate program writing and debugging, we only need to choose the interface we need. Based on our programming habits, in order to facilitate screenshot display, we can delete unused interfaces and call up any deleted interfaces again. As follows:

The work content of the program completion is as follows: after the PLC is enabled, the axis

immediately moves 600mm in the positive direction at a speed of 60mm/s. After completing the action, it immediately moves 600mm in the negative direction at the same speed, and so on; The complete PLC program is shown in the following figure:

Notes

```
PROGRAM MAIN
VAR
    (* 轴声明区 *)
    Axis1:  Axis_Ref;    //PLC轴定义

    (* 功能块声明区 *)
    Power: MC_Power;               //使能块
    Reset: MC_Reset;               //复位块
    Move_Relative: MC_MoveRelative; //相对运动块

    R_T1: R_TRIG;    //上升沿检测块
    F_T1: F_TRIG;    //下降沿检测块

    (* 变量声明区 *)
    power_on:        BOOL := TRUE;    //使能开关，初始值TRUE
    power_on_status:BOOL;             //使能状态信号

    Reset_on:        BOOL;            //复位开关

    Re_on:           BOOL;            //相对运动触发
    Re_on_busy:      BOOL;            //相对运动中
    Re_on_done:      BOOL;            //相对运动完成
    Re_Distance:     LREAL := 600.0; //相对运动行程，赋初始值600mm
    Re_Velocity:     LREAL := 60.0;  //相对运动距离，赋初始值60mm/s
END_VAR
```

变量声明

```
1  (*使能功能块*)
2  Power(
3      Axis:= Axis1,          //PLC轴接口
4      Enable:= power_on,     //使能开关
5      Enable_Positive:= TRUE, //允许正转
6      Enable_Negative:= TRUE, //允许反正
7      Override:= 100,        //速度输出比例
8      Status=> power_on_status, //使能状态，使能状态为true，非使能状态为FALSE
9      );
10
11 (*相对运动功能块*)
12 Move_Relative(
13     Axis:= Axis1,          //PLC轴接口
14     Execute:= Re_on,       //运动触发，上升沿有效
15     Distance:= Re_Distance, //运动距离mm
16     Velocity:= Re_Velocity, //运动速度mm/s
17     Done=> Re_on_done,     //运动完成
18     Busy=> Re_on_busy      //运动中
19     );
20
21 (*复位功能块*)
22 Reset(
23     Axis:= Axis1,          //PLC轴接口
24     Execute:= Reset_on     //复位开关
25     );
26
27 (*R_TRIG上升沿检测，F_TRIG下降沿检测*)
28 R_T1(CLK:= power_on_status, Q=> );
29 F_T1(CLK:= power_on_status, Q=> );
30
31 IF  R_T1.Q  THEN    //检测到使能状态上升沿，
32     Re_on := TRUE;  //触发相对运动功能块
33 END_IF
34
35 IF  F_T1.Q  THEN        //检测到使能状态下降沿，
36     power_on := FALSE;  //关闭使能开关
37     Re_on := FALSE;     //将运动触发置FALSE
38 END_IF
```
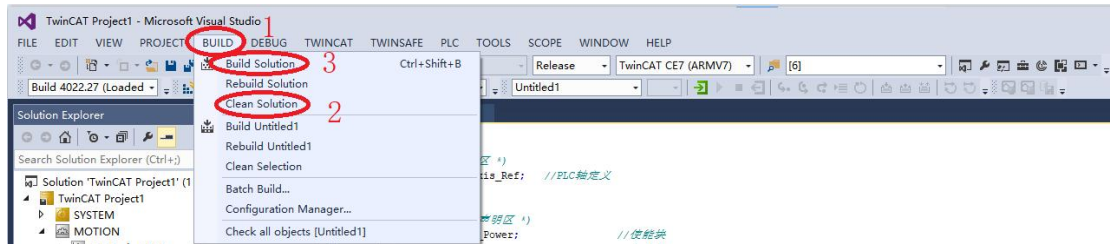
```
39
40  IF  Re_on_busy  THEN      //如果正在运动
41      Re_on := FALSE;       //将运动触发置FALSE，为下一次运动触发准备
42  END_IF
43
44  IF  Re_on_done  THEN          //如果一段运动完成
45      Re_Distance := -Re_Distance;//将运动行程取反（即改变运动方向），
46      Re_on := TRUE;            //触发运动
47  END_IF
```
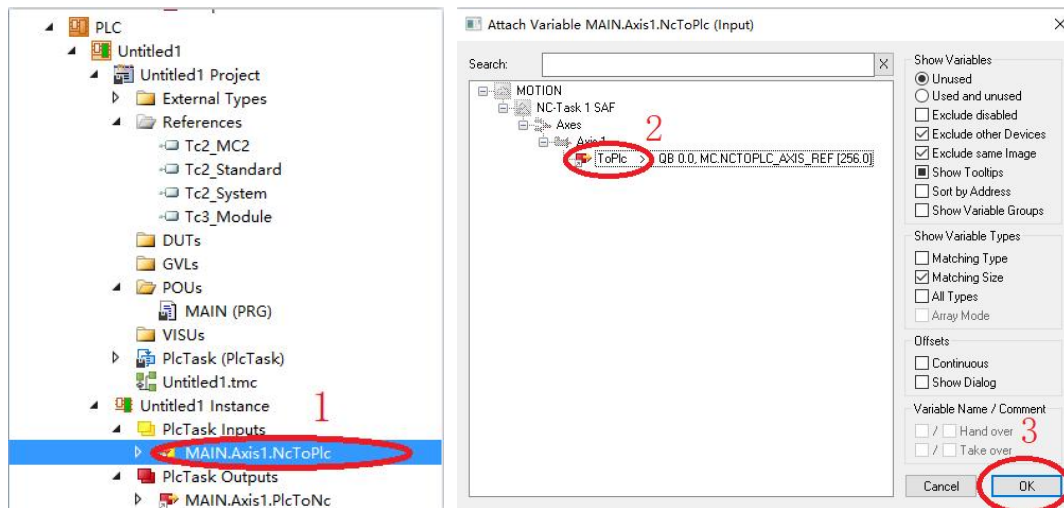
主程序

After completing the program writing, in the menu bar BUILD, first click Clean Solution to clear the solution, and then click Build Solution to generate the solution.

After successfully generating the solution, the interface of the instance variable declared in the PLC program will be generated in the Untitled1 Instance project column. Note that only the input (AT% I *), output (AT% Q *), and Axis will be generated_ Ref will generate an interface here, and intermediate variables will not generate an interface.

Select the interface to be connected, such as the input MAIN.Axis1.ncToPlc for PLC, double-click to open the Attach Variable window, select ToPlc>QB0.0 for NC axis, MC. NCTOPLC_ AXIS_ REF completes the connection and uses the same method to complete all connections.


After completing the variable connection, generate the solution again and click Activate Configuration to activate it. This completes the download of the PLC. If the PLC program is correct but does not work as expected, it may be that the program has not been downloaded into the PLC correctly. In this case, you need to first click Clean Solution in the BUILD menu bar to clear the solution, and then click Rebuild Solution to regenerate the solution and reactivate it to run normally.

After the program is activated, it enters the running mode and can operate the PLC program

online. Click ⬛ to enter the PLC operation interface, enter a value after the variable you want to change, and click ⬛ to write the changed value into the PLC, as shown in the figure:

Notes
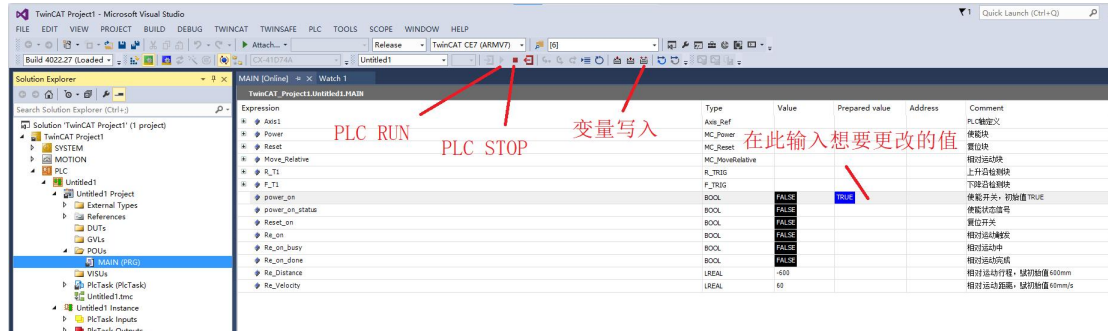
5. References

《TwinCAT NC Practical Guide》

《EP3E EtherCAT user manual》

6. Contact us

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