

Challenge 01: PLC App





Let's Start!

Let's Start!

Inform

The setup of the ctrlX AUTOMATION Starter Kit consists of:

- ctrlX CORE X3 Controller
- ctrlX EtherCAT[®] Bus Coupler
- ctrlX Digital Input (DI) 16-channels, 1-wire, 24VDC
- ctrlX Digital Output (DO), 16-channels, 1-wire, 24VDC
- Inputs: 2x Push Buttons and 1x Selector Switch
- Outputs: 2x Pilot Lamps and 1x Buzzer

The system is set up in the order shown in the adjacent image. They are already connected mechanically, and electrically. The installation allows the setup, operation and monitoring of a complete automation process.

ctrlX AUTOMATION Starter Kit



Let's Start!

Inform

ctrlX AUTOMATION – PLC

ctrlX PLC is a versatile solution that combines classic PLC automation with IoT communication needs, making it ideal for future factories. It runs on Embedded Linux Ubuntu Core with real-time capabilities, and you can easily enhance its functionality with apps. You can tailor ctrlX PLC to specific tasks using apps from the ctrlX Store or third-party sources. Security is a top priority, with options for secure configuration and certified security apps.

Information about the ctrlX PLC App can be found online:

- [ctrlX PLC App | ctrlX AUTOMATION Community](#)
- [ctrlX PLC App | Application Manual](#)

Information about the ctrlX CORE platform can be found online:

- [ctrlX CORE on YouTube](#)
- [ctrlX CORE Operating Instructions](#)

Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

1. Open the software ctrlX WORKS on Windows. A ctrlX CORE is shown in the table “Devices” after it was identified in the connected network. To open the start page of the control, click on the device IP address (192.168.1.1).

ctrlX WORKS

Devices

Engineering Tools

App Build Environments

Settings

About

Devices

Engineering Tools

App Build Environments

Number of listed ctrlX CORE and ctrlX CORE Virtual controls

Provides an overview of all stand-alone Windows applications in the ctrlX AUTOMATION environment

Provides the option to automatically create Linux build environments on a Windows PC to develop ctrlX CORE apps in the ctrlX AUTOMATION environment.

ctrlX WORKS

Devices

EN

?

rexroth

ctrlX WORKS

Device overview

Find the ctrlX CORE hardware in the network or add a ctrlX COREvirtual and develop your applications - even without hardware.

Go to documentation

Device-centered engineering

Navigate to the ctrlX CORE or ctrlX COREvirtual homepage and start engineering.

1 item

Name	State	Type	IP addresses	Actions
ctrlX-CORE	Online	ctrlX CORE	192.168.1.1	

5

Bosch Rexroth Academy
© Bosch Rexroth AG 2020. Alle Rechte vorbehalten, auch bzgl. jeder Verfügung, Verwertung, Reproduktion, Bearbeitung, Weitergabe sowie für den Fall von Schutzrechtsanmeldungen.

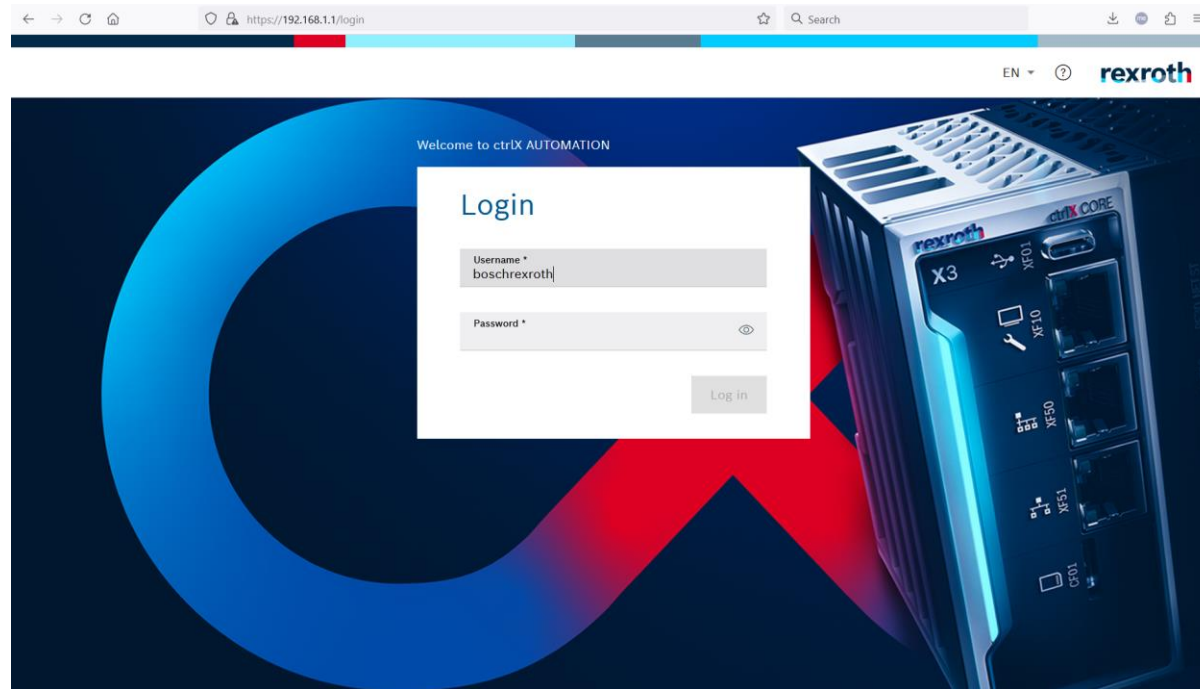
rexroth
A Bosch Company

Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

2. A web browser will open the Login page of the ctrlX web-based user interface.
Enter the Login details (Username: **boschrexroth**, Password: **B0schrexroth**).

ctrlX Web-Based User Interface – Login Page



Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

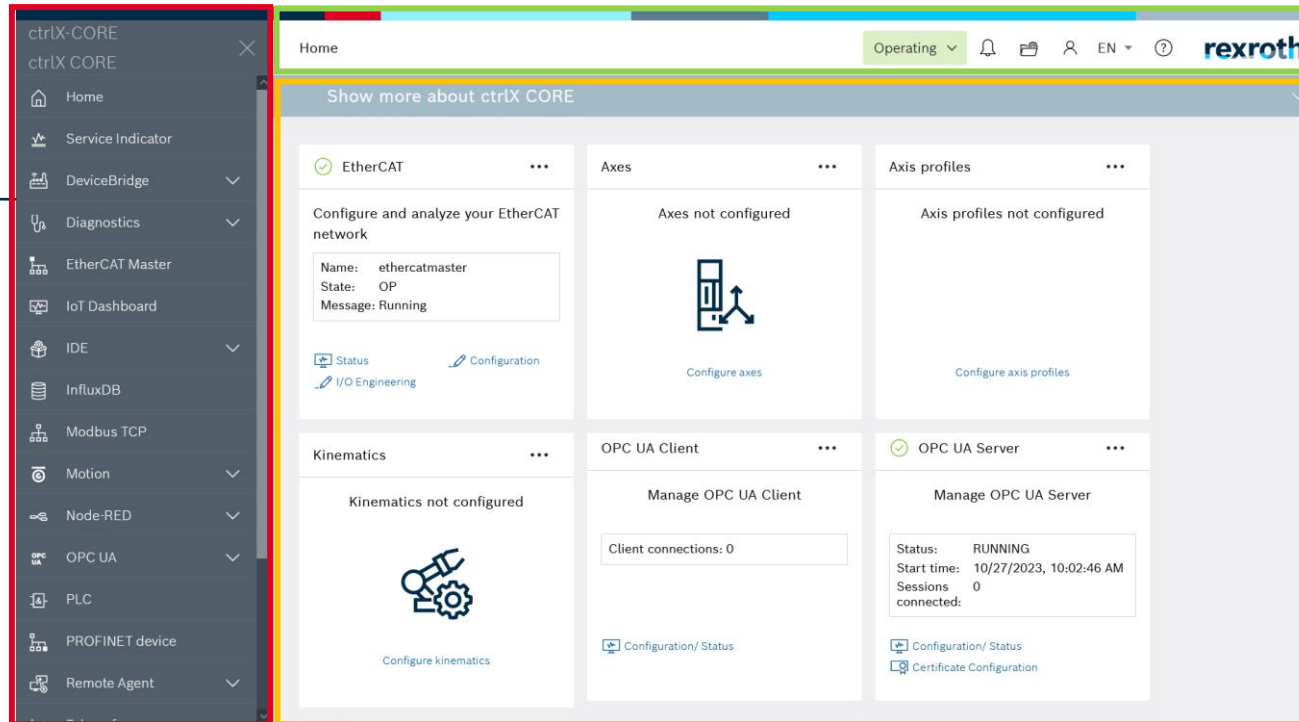
Steps

3. After successfully logging in, you will be greeted with the Home Page of the ctrlX CORE Web Based User Interface.

ctrlX CORE Web-Based User Interface – Home Page

Side navigation/ sidebar

To navigate between Apps and General functions in the ctrlX CORE web interface



Header

To shows the status of the ctrlX CORE. manage the app data and other user settings

Workspace / Window

To configure the settings for the selected Apps or other functions

Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

4. On the Sidebar, click on the PLC App, then click on the ctrlX PLC App icon.

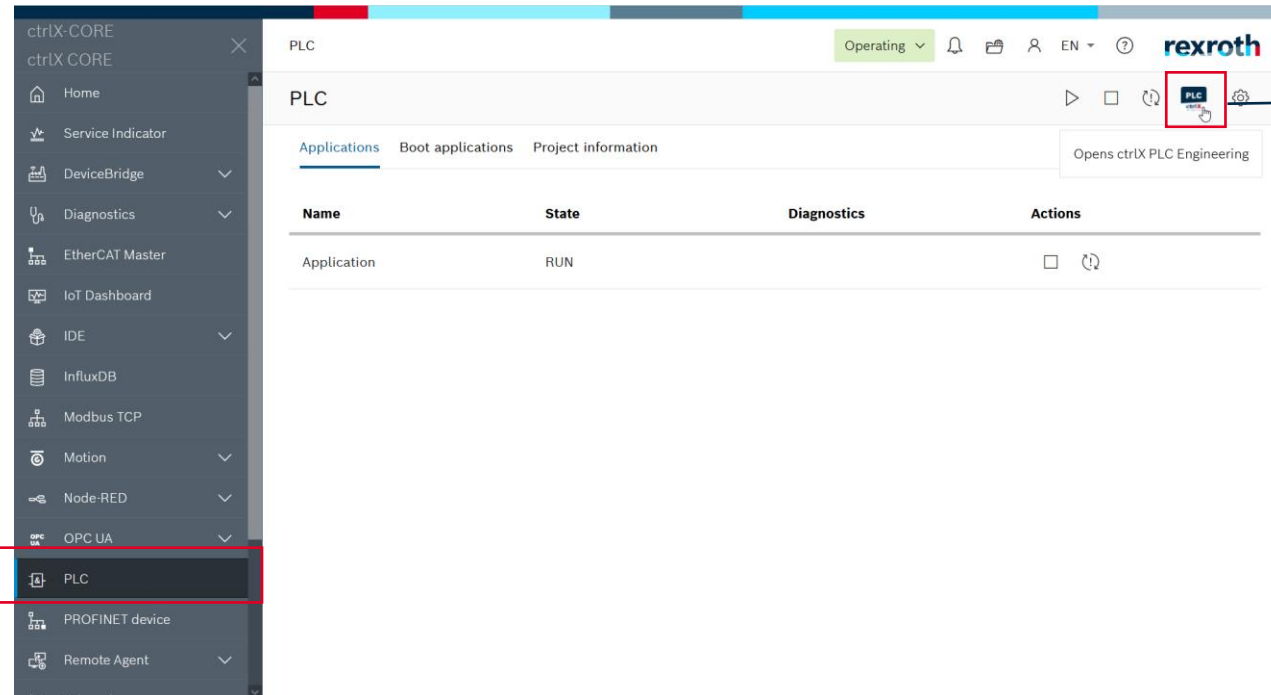
It will open the software tool **ctrlX PLC Engineering** to create and manage your PLC project.

ctrlX PLC App

Information about the ctrlX

PLC App can be found online:

- [ctrlX PLC App, Application Manual](#)

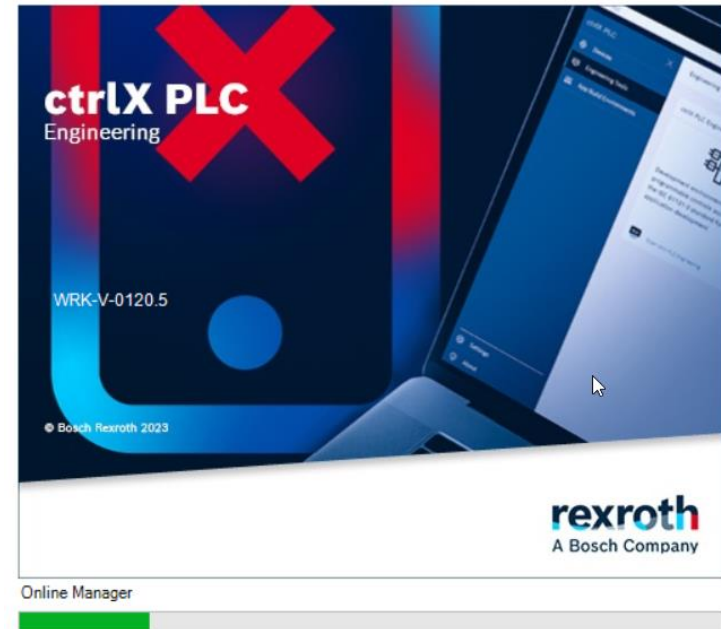
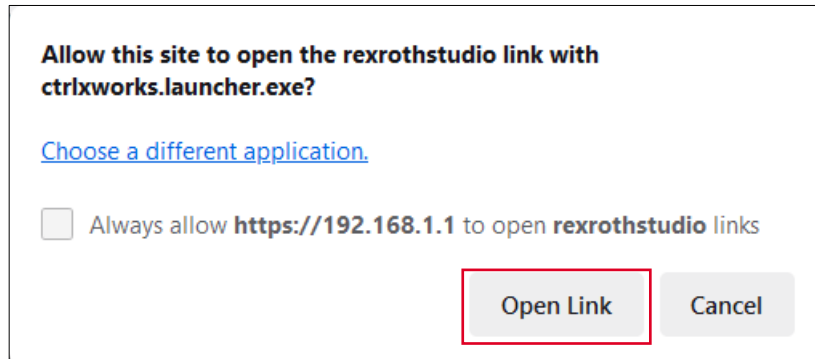


Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

5. Click on “Open Link” in the popup message and ctrlX PLC Engineering will start to load.

ctrlX PLC Engineering



Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

6. Once ctrlX PLC Engineering have been loaded, you will view the PLC Engineering programming interface.

ctrlX PLC Engineering

In a “Standard project”, ctrlX PLC Engineering automatically creates the project with the project node in the device tree. The “PLC Logic” node contains the following objects and sub nodes:-

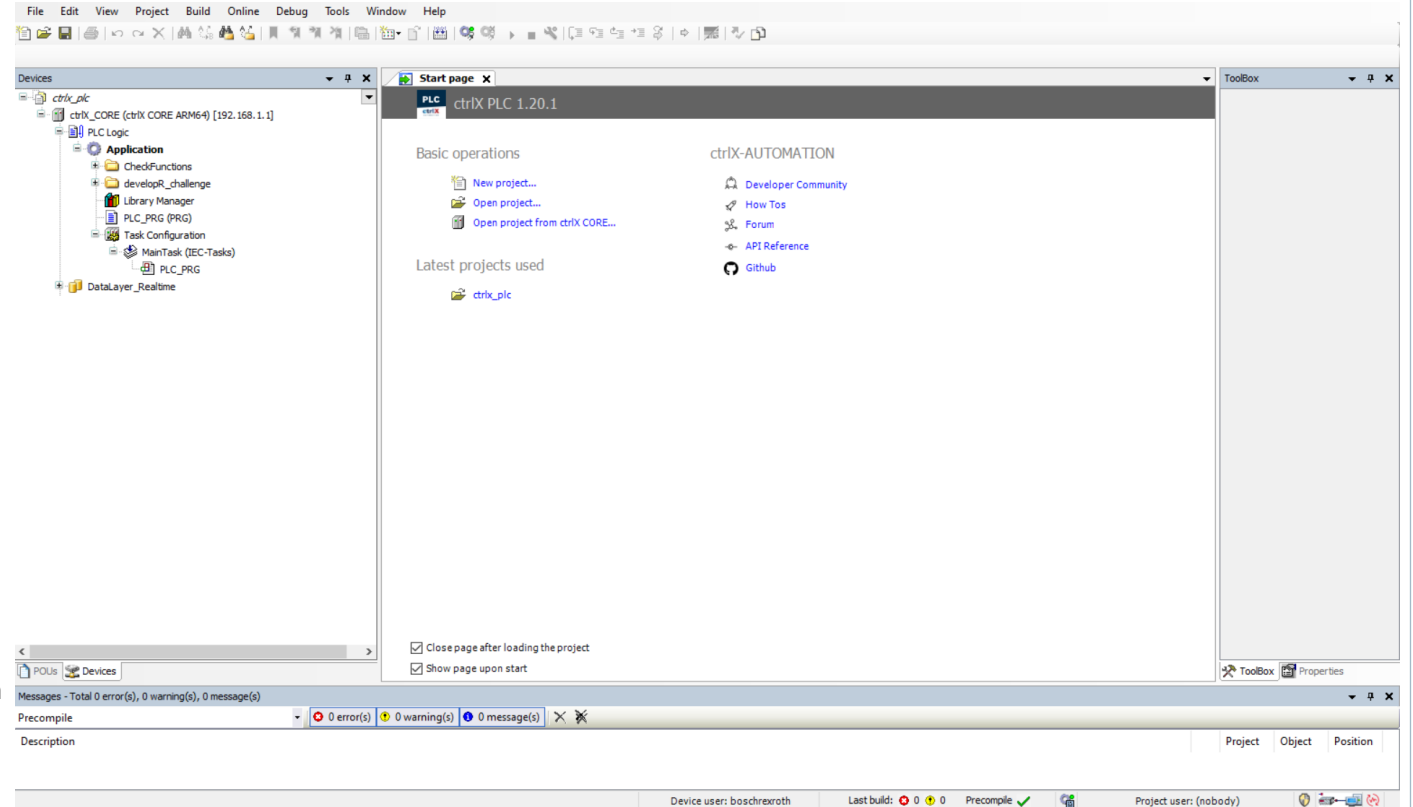
Application

Library Manager

- The library manager automatically receives the libraries, the selected device requires.

PLC_PRG (PRG)

- Standard POU (Program Organization Unit)
- If a correct code is added to the “PLC_PRG”, the POU can be loaded to the control and executed on the control without requiring other programming objects.



Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

6. Once ctrlX PLC Engineering have been loaded, you will view the PLC Engineering programming interface.

ctrlX PLC Engineering

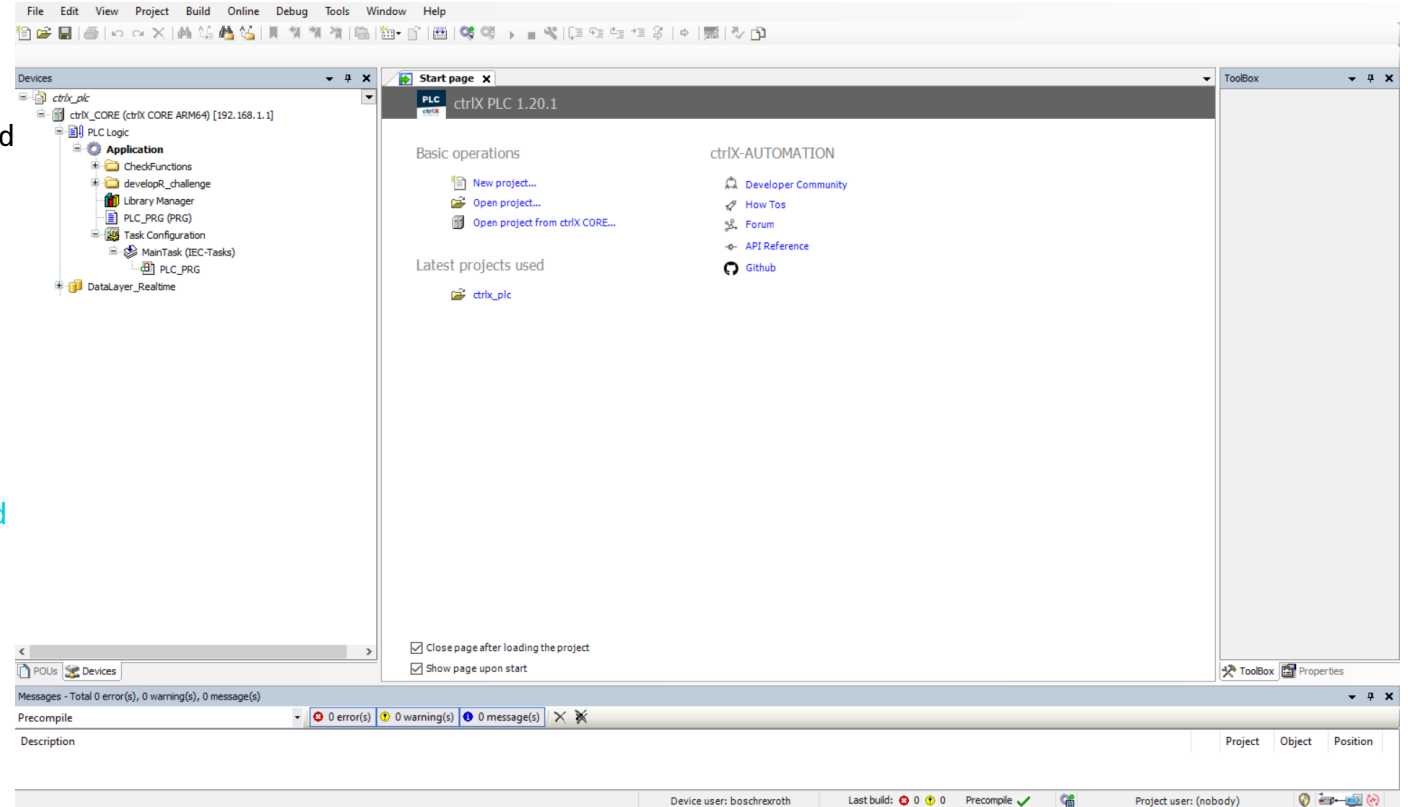
Task Configuration

- Defines the “MainTask” for processing of the standard POU “PLC_PRG”

DataLayer_Realtime

- The Data Layer on ctrlX devices facilitates the exchange of real-time data from EtherCAT I/O.

Information about the ctrlX PLC Engineering can be found [online: ctrlX PLC Engineering, Application Manual](#)



Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

7. The Data Layer exchanges real-time data from EtherCAT I/O and used by ctrlX PLC Engineering to include I/O points in the PLC project.

ctrlX I/O

EtherCAT Bus Coupler XB-EC-12

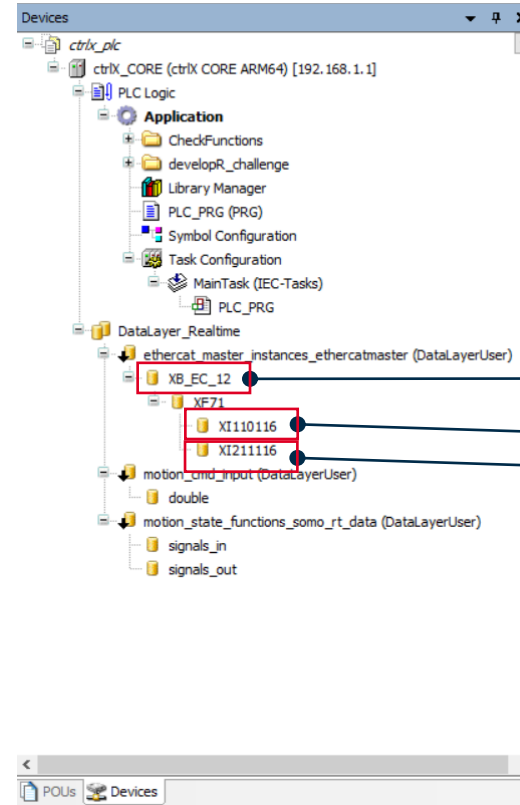
- The bus coupler connects the EtherCAT network and the ctrlX I/O system. The bus coupler supplies the connected I/O modules with the logic voltage UL and the peripheral voltage UP.

16-channel Digital Input Terminal XI110116

- The digital input terminal is used to detect binary 24 V control signals in a ctrlX I/O station. The terminal has 16 channels in a 1-wire technique.

16-channel Digital Output Terminal XI211116

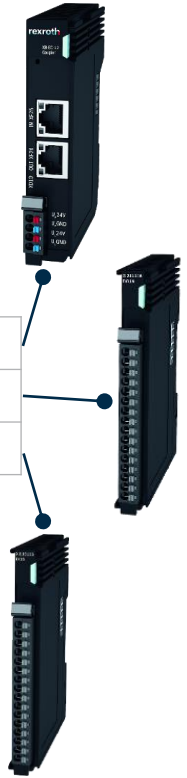
- The digital output terminal is used to output binary 24 V control signals in a ctrlX I/O station. The terminal has 16 channels in a 1-wire technique.



EtherCAT Bus Coupler

16-channel Digital Input Terminal

16-channel Digital Output Terminal



Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

8. If data from the Data Layer real-time is to be processed in the PLC, they have to be mapped as input values (%I).

ctrlX I/O Digital Input

- The integration of PLC-specific data as real-time data into the PLC project is realized via Global Variable Lists (GVL), which contain the data to be exchanged.
- Channel 1 and 2 of the Digital Input terminal is pre-wired to 2 input elements:
 - Push Button (Green)
 - Push Button (Red)

Information about the ctrlX I/O Digital Input Terminal can be found online: [ctrlX I/O, Digital Input Terminal, 16-channel](#)

The screenshot displays the 'DataLayerNode I/O Mapping' window. On the left, a tree view shows the project structure with 'ctrlX_CORE (ctrlX CORE ARM64) [192.168.1.1]' and 'PLC Logic'. Under 'PLC Logic', 'Application' is expanded, showing 'MainTask (IEC-Tasks)' and 'PLC_PRG'. A red box highlights 'XI1101116' under 'DataLayer_Realtime'. A blue arrow points from this box to the 'Mapping' table in the main window.

Variable	Mapping	Channel	Address	Type
		Channel_1.Value	%IX0.0	BIT
		Channel_2.Value	%IX0.1	BIT
		Channel_3.Value	%IX0.2	BIT
		Channel_4.Value	%IX0.3	BIT
		Channel_5.Value	%IX0.4	BIT
		Channel_6.Value	%IX0.5	BIT
		Channel_7.Value	%IX0.6	BIT
		Channel_8.Value	%IX0.7	BIT
		Channel_9.Value	%IX1.0	BIT
		Channel_10.Value	%IX1.1	BIT
		Channel_11.Value	%IX1.2	BIT
		Channel_12.Value	%IX1.3	BIT
		Channel_13.Value	%IX1.4	BIT
		Channel_14.Value	%IX1.5	BIT
		Channel_15.Value	%IX1.6	BIT
		Channel_16.Value	%IX1.7	BIT

Annotations on the right side of the table:

- Address: %IX0.0 : Push Button (Green)
- Address: %IX0.1 : Push Button (Red)

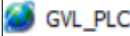
At the bottom of the window, there are buttons for 'Reset Mapping', 'Always update variables', and 'Use parent device setting'. A legend at the bottom left indicates 'Create new variable' (blue icon) and 'Map to existing variable' (blue icon with a dot).

Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

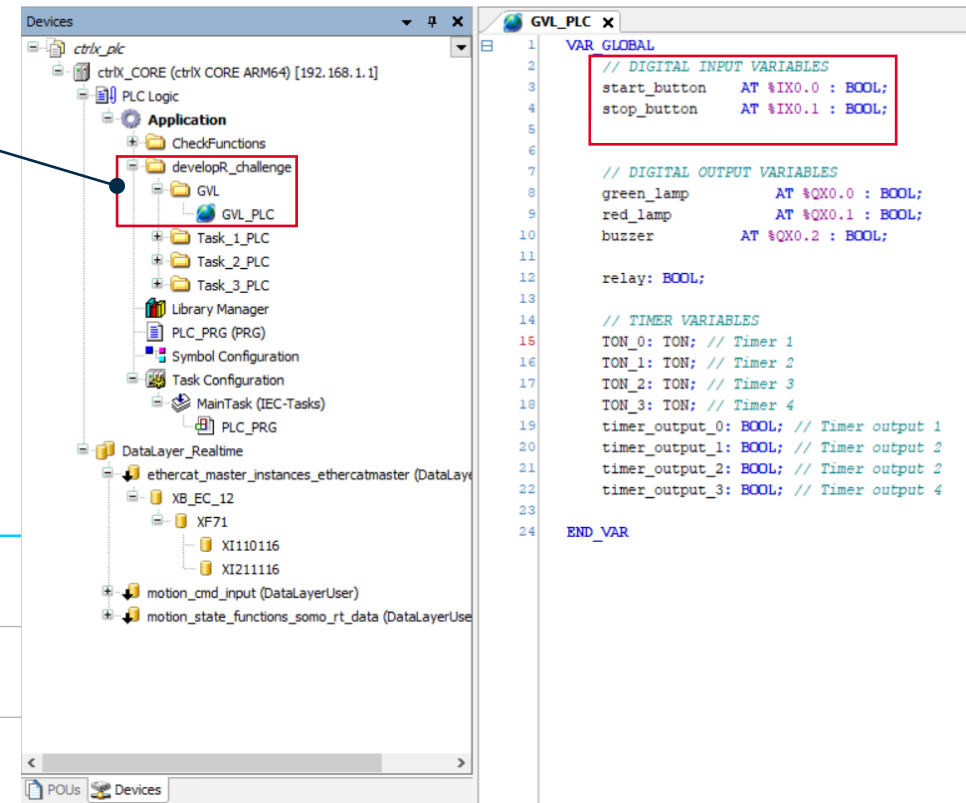
Steps

8. If data from the Data Layer real-time is to be processed in the PLC, they have to be mapped as input values (%I).

ctrlX I/O Digital Input

- The GVL  is located within the “developR_challenge” folder
- The inputs are assigned with Variables via the Global Variable Lists (GVL), which contain the data to be exchanged.

Designation	Variable	Channel	Address	Type
Push Button (Green)	start_button	Channel_1.Value	%IX0.0	BOOL
Push Button (Red)	stop_button	Channel_2.Value	%IX0.1	BOOL



The screenshot displays the ctrlX PLC Engineering interface. On the left, the 'Devices' tree shows the project structure, with the 'developR_challenge' folder highlighted. Inside this folder, the 'GVL' (Global Variable List) is selected. On the right, the 'GVL_PLG' window shows the configuration of the GVL. It lists digital input variables: 'start_button' at address %IX0.0 and 'stop_button' at address %IX0.1, both of type BOOL. It also lists digital output variables: 'green_lamp' at %QX0.0, 'red_lamp' at %QX0.1, and 'buzzer' at %QX0.2, all of type BOOL. The 'relay' variable is also listed as a BOOL. The 'TIMER VARIABLES' section shows four timers (TON_0 to TON_3) and their corresponding outputs (timer_output_0 to timer_output_3), all of type BOOL. The 'END_VAR' statement is at the bottom of the GVL configuration.

Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

Steps

9. If PLC data is to be made known on the Data Layer real-time, the data is to be mapped to output values (%Q).

ctrlX I/O Digital Output

- The integration of PLC-specific data as real-time data into the PLC project is realized via Global Variable Lists (GVL), which contain the data to be exchanged.
- Channel 1, 2 and 3 of the Digital Output terminal is pre-wired to 3 output elements:
 - Pilot Lamp (Green)
 - Pilot Lamp (Red)
 - Buzzer

Information about the ctrlX I/O Digital Output Terminal can be found online: [ctrlX I/O, Digital Output Terminal, 16-channel](#)

The screenshot displays the 'DataLayerNode I/O Mapping' window in the ctrlX PLC Engineering software. The left pane shows the project tree with the 'DataLayer_Realtime' folder expanded, revealing the 'XI110116' device. The right pane shows a table mapping variables to output channels. A red box highlights the first three rows of the table, which are linked to callouts on the right.

Variable	Mapping	Channel	Address	Type
		Channel_1.Value	%QX0.0	BIT
		Channel_2.Value	%QX0.1	BIT
		Channel_3.Value	%QX0.2	BIT
		Channel_4.Value	%QX0.3	BIT
		Channel_5.Value	%QX0.4	BIT
		Channel_6.Value	%QX0.5	BIT
		Channel_7.Value	%QX0.6	BIT
		Channel_8.Value	%QX0.7	BIT
		Channel_9.Value	%QX1.0	BIT
		Channel_10.Value	%QX1.1	BIT
		Channel_11.Value	%QX1.2	BIT
		Channel_12.Value	%QX1.3	BIT
		Channel_13.Value	%QX1.4	BIT
		Channel_14.Value	%QX1.5	BIT
		Channel_15.Value	%QX1.6	BIT
		Channel_16.Value	%QX1.7	BIT

Callouts on the right side of the table:

- Address: %QX0.0 : Pilot Lamp (Green)
- Address: %QX0.1 : Pilot Lamp (Red)
- Address %QX0.2 : Buzzer

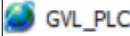
At the bottom of the window, there are buttons for 'Reset Mapping', 'Always update variables', and 'Use parent device setting'. A legend at the bottom left indicates that a blue icon represents 'Create new variable' and a green icon represents 'Map to existing variable'.

Challenge 01: ctrlX PLC App | Setting up ctrlX PLC Engineering

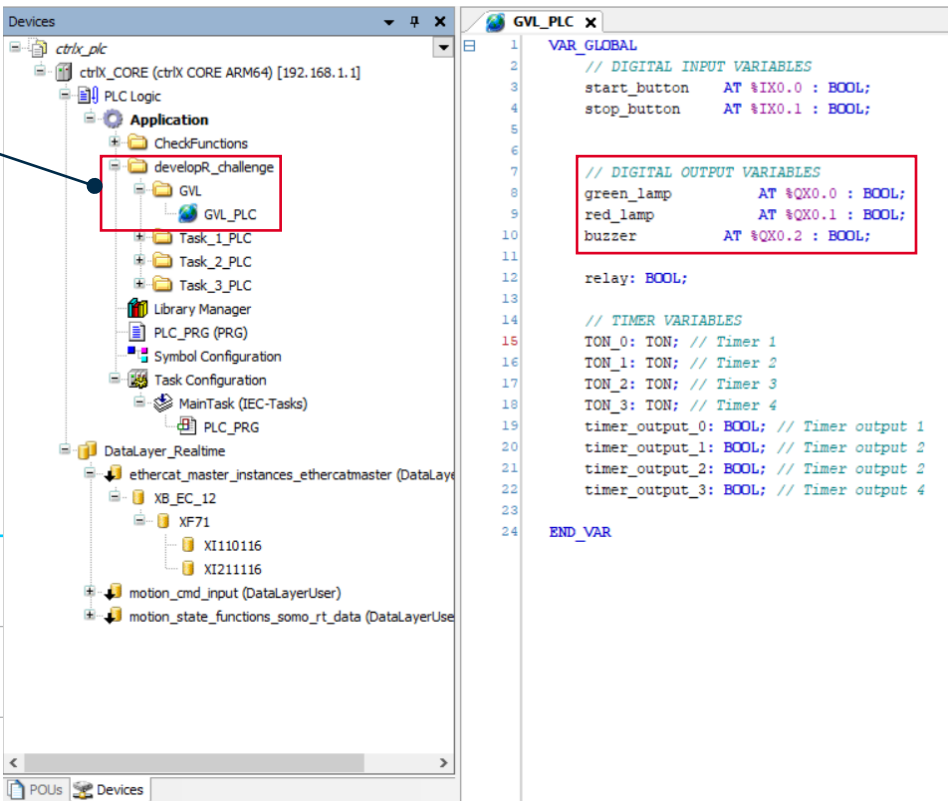
Steps

9. If PLC data is to be made known on the Data Layer real-time, the data is to be mapped to output values (%Q).

ctrlX I/O Digital Output

- The GVL  is located within the “developR_challenge” folder
- The outputs are assigned with Variables via the Global Variable Lists (GVL), which contain the data to be exchanged.

Designation	Variable	Channel	Address	Type
Pilot Lamp (Green)	green_lamp	Channel_1.Value	%QX0.0	BOOL
Pilot Lamp (Red)	red_lamp	Channel_2.Value	%QX0.1	BOOL
Buzzer	buzzer	Channel_3.Value	%QX0.2	BOOL



The screenshot displays the ctrlX PLC Engineering interface. On the left, the 'Devices' tree shows the project structure, with the 'developR_challenge' folder highlighted. Inside this folder, the 'GVL' (Global Variable List) is selected. On the right, the 'GVL_PLG' window shows the configuration of the GVL. It includes a section for 'DIGITAL OUTPUT VARIABLES' where the following variables are defined:

```
// DIGITAL OUTPUT VARIABLES
green_lamp    AT %QX0.0 : BOOL;
red_lamp      AT %QX0.1 : BOOL;
buzzer        AT %QX0.2 : BOOL;
```

Below this section, there is a 'relay' variable defined as a BOOL, and a section for 'TIMER VARIABLES' with four TON (Timer On Delay) variables and their corresponding outputs.

Challenge 01: PLC App

Task 01

Challenge 01: ctrlX PLC App | Task 01



Description

You're given a simple control task. A conveyor system needs to be turned on when a Start button is pressed, and the conveyor stops when a Stop button is pressed. When the system is on, a green light and a buzzer audible sound should indicate its status. When the system is off, a red light should indicate its status.

Task

This task will test your understanding on latching circuits in PLC programming. Solve the problem in the Ladder Logic Diagram (LD) PLC Program in the CtrlX Core PLC Engineering to accomplish this task. Use appropriate symbols and connections.

Challenge 01: ctrlX PLC App | Task 01

Safety instructions for the project exercise

In order to ensure the operational capability and to identify the possible hazards of machines and systems, the safety regulations must be observed before and during the order execution.

The ctrlX CORE may only be operated in technically perfect condition. The intended use, performance data and operating conditions may not be changed. No protective devices/components may be deactivated.



In case of emergency, failure or other irregularities:

- Before connecting or disconnecting any electrical components, ensure that the power to the ctrlX CORE unit and associated equipment is turned off.

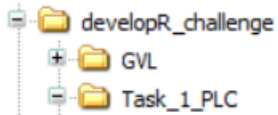
Challenge 01: ctrlX PLC App | Task 01

Steps

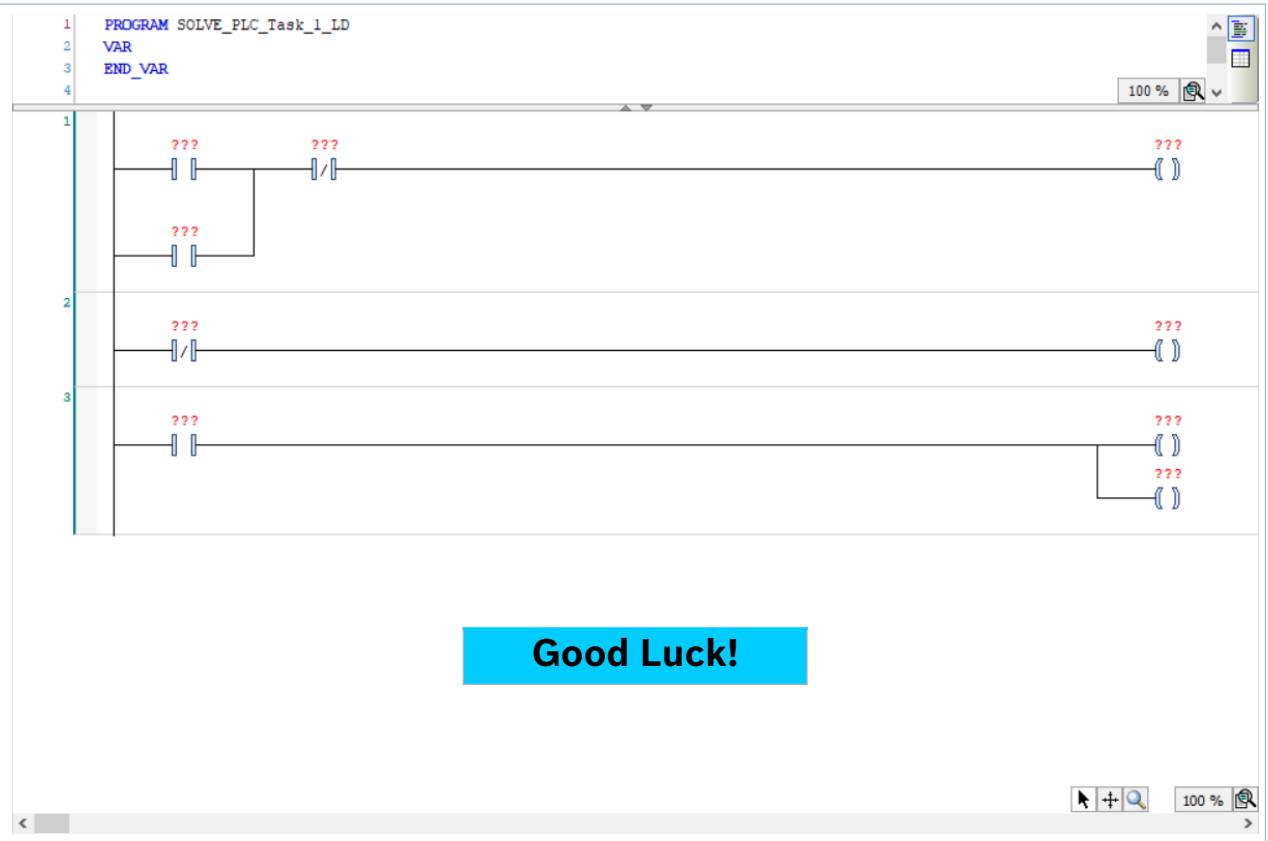
1. The task to be completed is located inside the “**developR_challenge**” folder in the Device tree.

Where to find Task 1 PLC Program (POU)

- The POU for Task 1 is located inside “**Task_1_PLC**” folder



- Open the “**SOLVE_PLC_Task_1_LD (PRG)**”
- This will open a POU editor (right photo)
- The PLC program is created with Ladder Logic Diagram (LD) language based on IEC 61131-3 standard developed by the International Electrotechnical Commission (IEC).
- The PLC program however is not in working condition and requires your help to solve it.
- **Hint:** Use the correct Input and Output variables from **GVL_PLC** global variables list
- From time to time, make sure to Save your program (with Ctrl + S)




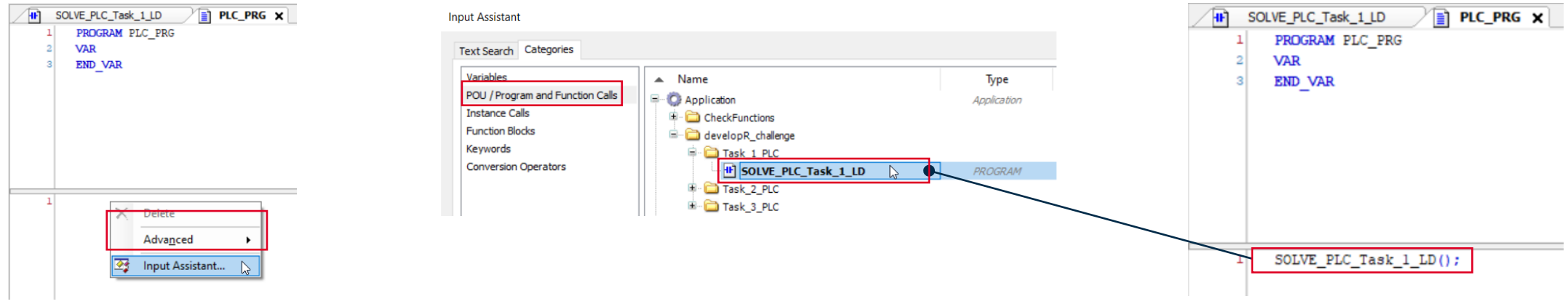
Challenge 01: ctrlX PLC App | Task 01

Steps

2. Once you have completed Task 1 and ready to download the PLC Program to the ctrlX CORE, follow the steps below.

How to insert Task 1 PLC Program (POU) into PLC_PRG

- Open “**PLC_PRG**”  in the Device tree
- Right click on the empty page of the POU editor
- Select “**Input Assistant...**”
- Under the POU / Program and Function Calls Categories, select the PLC Program “**SOLVE_PLC_Task_1_LD**” and click **OK**
- **Important!** In the POU editor of PLC_PRG, there should be the name of the program which you selected. This means that the selected program will be uploaded to the controller. The name of the program has to match with the name of the POU including **()**;



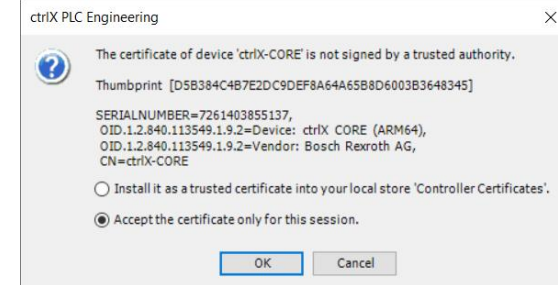
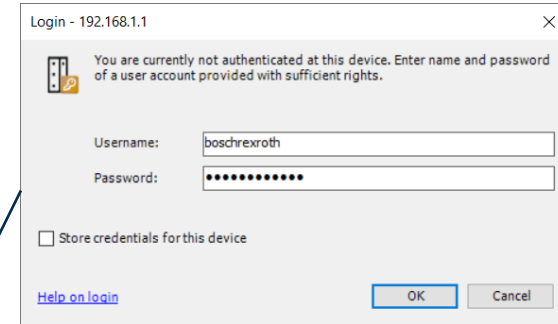
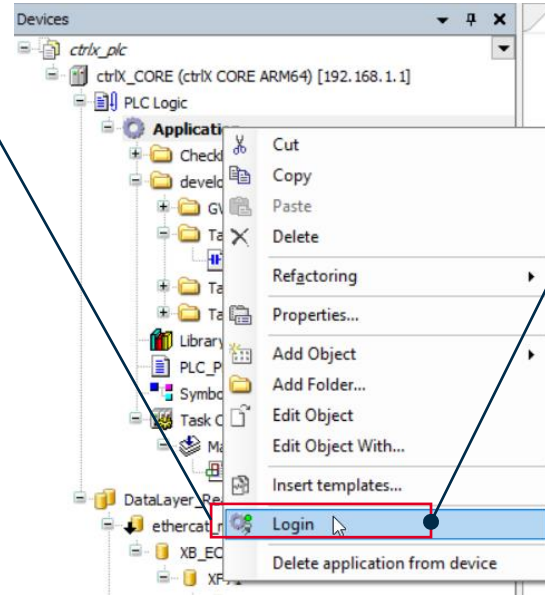
Challenge 01: ctrlX PLC App | Task 01

Steps

2. Once you have completed Task 1 and ready to download the PLC Program to the ctrlX CORE, follow the steps below.

How to download Task 1 PLC Program (POU) to the ctrlX CORE

- In the Device tree, right click on the “**Application**” object
- Click on “**Login**”
- This will open a popup message requesting to Login to the control. Enter the **Username: boschrexroth** and **Password: B0schrexroth**
- Another popup message will open requesting to trust the Certificate of the device, click **OK**



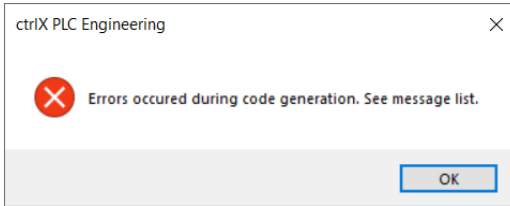
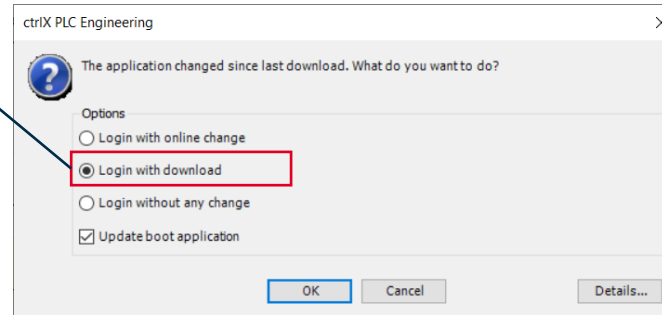
Challenge 01: ctrlX PLC App | Task 01

Steps

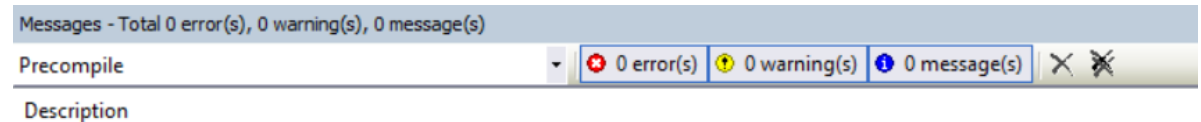
2. Once you have completed Task 1 and ready to download the PLC Program to the ctrlX CORE, follow the steps below.

How to download Task 1 PLC Program (POU) to the ctrlX CORE

- In the next popup message, select the option: **Login with download** and click **OK**
- The PLC program will be compiled and build. Only when there are no errors that the download will start.
- If there are any errors, you will see a popup message below



- Look at the bottom section of PLC Engineering window for the error messages



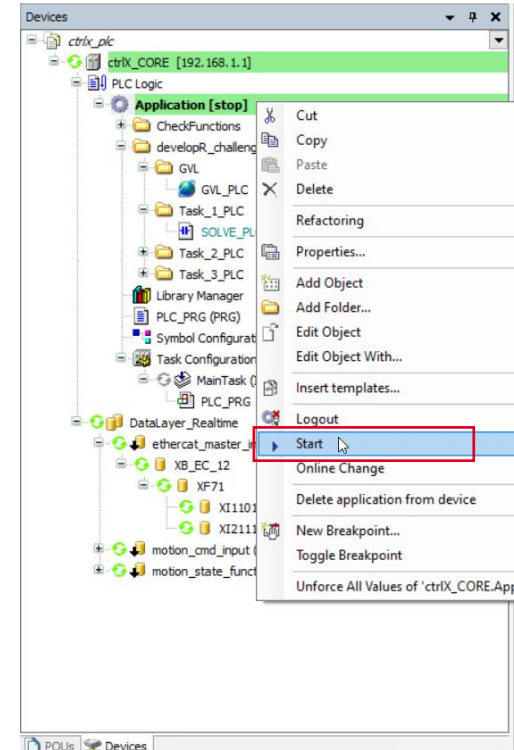
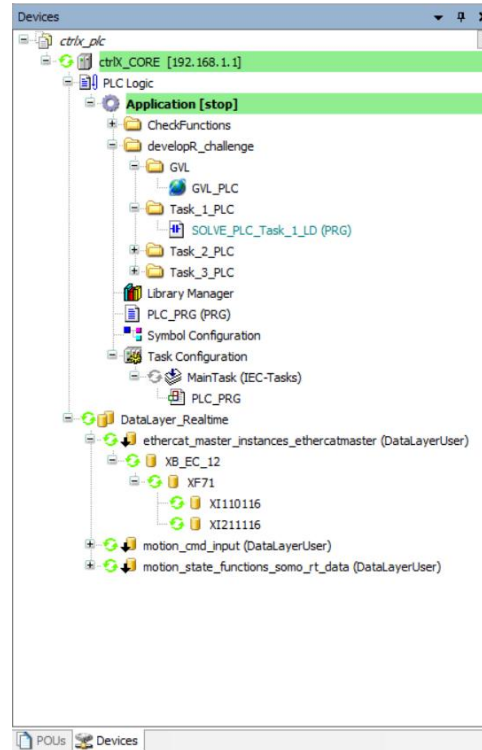
Challenge 01: ctrlX PLC App | Task 01

Steps

2. Once you have completed Task 1 and ready to download the PLC Program to the ctrlX CORE, follow the steps below.

How to download Task 1 PLC Program (POU) to the ctrlX CORE

- If the download is successful, your Application object will be highlighted in **Green** and a **[stop]** status will be displayed.
- This means that the PLC is in Stop mode and no PLC program is running in this mode.
- To change the mode, you can right click on the **“Application”** object again and Click on **“Start”**

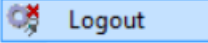


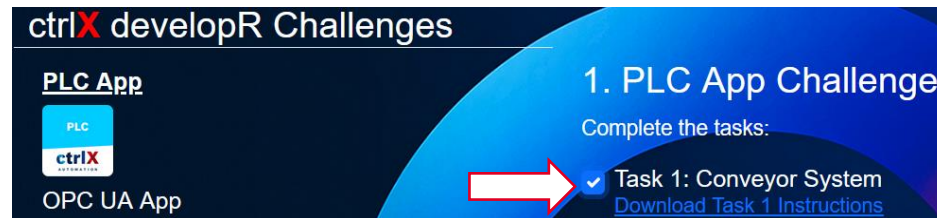
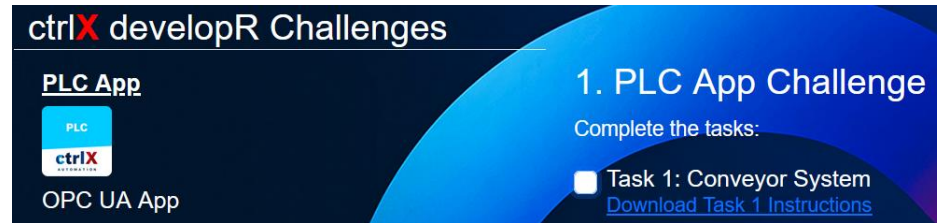
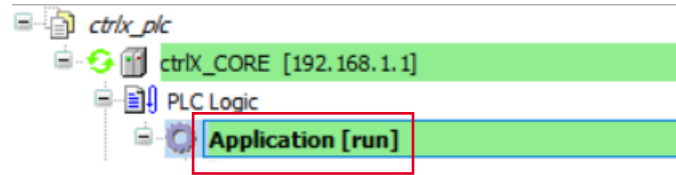
Challenge 01: ctrlX PLC App | Task 01

Steps

2. Once you have completed Task 1 and ready to download the PLC Program to the ctrlX CORE, follow the steps below.

How to download Task 1 PLC Program (POU) to the ctrlX CORE

- This will change the mode from **[stop]** to **[run]**
- You can test your program against the Task description
- Once it satisfies the task requirements, confirm that you have completed the task by informing the available instructor for verification
- In the ctrlX developR challenge [website](#), under the PLC App challenge section, tick [✓] the Task 1 checkbox
- If you are done with testing, you can logout by right clicking the Application object and select Logout 



Congratulations on completing Task 1!

Proceed to Task 2!