Freescale Semiconductor
User Guide

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P1025 EtherCAT® PLC Master Reference Platform User Guide

by *Freescale Semiconductor, Inc.*

This document describes the setup and operation of the EtherCAT® programmable logic controller (PLC) master reference platform on Freescale's TWR-P1025 tower system hardware platform, where EtherCAT refers to the industrial Ethernet protocol. The demonstration shows a complete PLC implementation on the TWR-P1025 module.

NOTE

The PLC firmware is configured to require a board reset after four hours of continuous operation. After the reset, the PLC firmware functions as expected for the next four hours. The offline tools are limited to a maximum of four slaves

Contents

1 Benefits of the PLC reference platform

The programmable logic controller (PLC) reference platform is equipped to ease development of industrial control systems. The PLC reference platform implements the

KPA (koenig-pa GmbH) EtherCAT Master protocol with ISaGRAF Firmware and QNX Neutrino® RTOS on the high-performance Freescale QorIQ P1025 processor. It is supported by powerful development tools from all four companies, including the KPA EtherCAT Studio, ISaGRAF 6 Workbench, QNX Momentics® Tool Suite, and Freescale CodeWarrior Development Suite.

For more information, see the EtherCAT PLC Reference Platform for QorIQ Processors page on freescale.com.

1.1 PLC reference platform diagram

This figure shows an overview of the PLC reference platform.

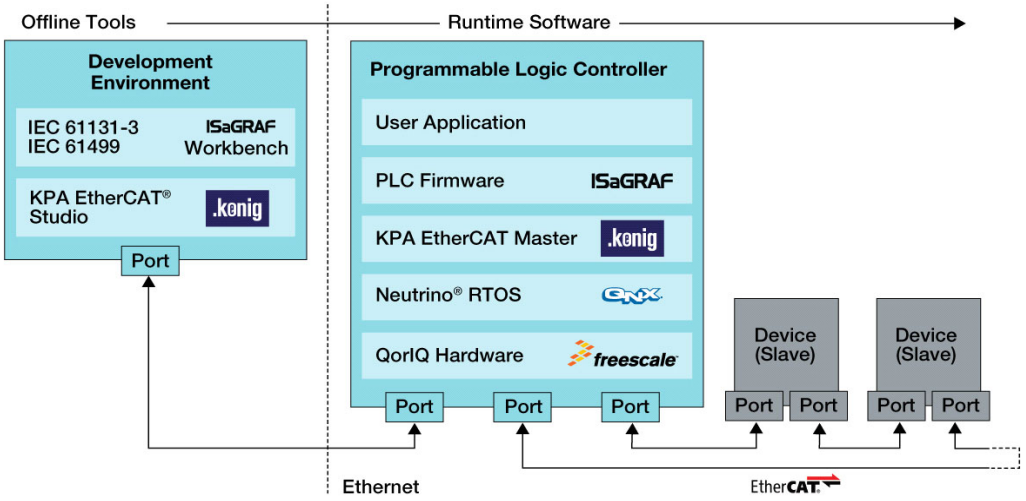


Figure 1. Programmable logic controller reference platform

1.2 Features of the PLC reference platform

Features of the PLC reference platform include the following:

- Integrated ISaGRAF Firmware, KPA EtherCAT Master stack and QNX Neutrino RTOS on the QorIQ P1 Tower module
- EtherCAT master protocol and customer control application run simultaneously on a single QorIQ P1025 processor to deliver one millisecond EtherCAT master cycle time
- QorIQ P1 processors can also provide simultaneous support for complex applications, as well as additional industrial protocols like PROFINET, PROFIBUS and EtherNet/IP™
- Powerful development tools include the KPA EtherCAT Studio, ISaGRAF 6 Workbench, QNX Momentics Tool Suite, and Freescale CodeWarrior Development Suite
- ISaGRAF 6 Workbench and Firmware kernel can fully support all IEC 61499 and IEC 61131-3 standard PLC programming languages
- Software and hardware developed on TWR-P1025 can be easily deployed on a range of QorIQ P1 processors, including the P1012, P1021, P1016 and P1025 processors
- Customers may distribute processing functions across two cores, or isolate real-time control functions on one core while running maintenance and communications functions on the other core.

2 Before you begin

This section outlines the materials needed to complete the setup and offers a list of additional resources.

2.1 What you need

2.1.1 Required components

The table below provides an overview of the components required for PCL evaluation. For the location of the downloads, see Table 2-2, "Required downloads." The customer must supply the following items:

NOTE

The USB flash drive must be compatible with the U-Boot version on the TWR-P1025.

- 4 GB USB flash drive
- Electrical wire
- Two Ethernet cables (RJ45)
- +24 V power supply
- TWR-P1025 box, which includes the following:
  - TWR-P1025 module
  - USB cable
  - +5 V power supply

Table 2-1. Required components

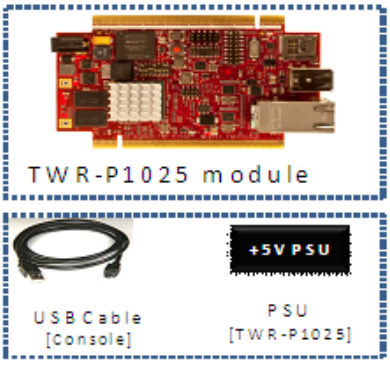
Supplied via...	Required components
TWR-P1025 box	

Table 2-1. Required components (continued)

Download (see Table 2-2)	QNX Neutrino RTOS
	KPA EtherCAT master
	ISaGRAF PLC firmware
	ISaGRAF 6 Workbench (includes the KPA EtherCAT studio)
	TeraTerm
	USB-to-UART driver (FT2232)
Customer	 Windows PC
	 Wire
	 USB stick 4 GBytes
	 PSU
	 Ethernet cable [2 x RJ45]
	 Slave

2.1.2 Required downloads

In Section 3, “Set up the PLC reference platform,” you are prompted to download the following items.

Table 2-2. Required downloads

Item		Location
EtherCAT target slaves	Beckhoff EK1100 EtherCAT coupler	beckhoff.com/english.asp?ethercat/ek1100.htm
	Beckhoff EL1004 4-channel digital input terminal 24 V DC, 3 ms	beckhoff.com/english.asp?ethercat/el1004.htm
	Beckhoff EL2004 4-channel digital output terminal 24 V DC, 0.5 A	beckhoff.com/english.asp?ethercat/el2004.htm
	Beckhoff EL9011 end cap	beckhoff.com/english.asp?ethercat/el9011.htm
PLC reference platform offline tools (ISaGRAF 6 Workbench, including KPA EtherCAT studio) and the TWR-P1025 PLC runtime environment		qnx.com/goplc
TeraTerm for RS232 communications		ttssh2.sourceforge.jp
USB-to-UART driver for console port (FT2232)		ftdichip.com/Drivers/VCP.htm
QNX Neutrino RTOS		qnx.com/partners/plc_reference.html

2.2 Additional resources

For additional help, contact the appropriate party listed in the table below.

Table 2-3. Additional resources

Company	Supported area	Link	Contact
Freescale	TWR-P1025	freescale.com/goplc freescale.com/twr-p1025	ethercat@freescale.com
ISaGRAF	• ISaGRAF 6 workbench and PLC firmware • PLC reference platform demo	isagraf.com/pages/products/Isagraf/ethercat.htm	support@isagraf.com
Koenig PA	EtherCAT and stacks	koenig-pa.com/?p=news_ethercat_qoriq_details	support@koenig-pa.com
QNX	QNX neutrino and stacks	qnx.com/partners/plc_reference.html	sales@QNX.com

3 Set up the PLC reference platform

This section shows how to assemble the hardware and software components required to evaluate the PLC reference platform (PLC). See the figure below for an overview of the complete PLC evaluation setup.

The main hardware modules are as follows:

TWR-P1025 This module houses the PLC runtime, which executes the application.

Target slave devices This module provides the application with something to control.

Windows PC This module runs the offline tools.

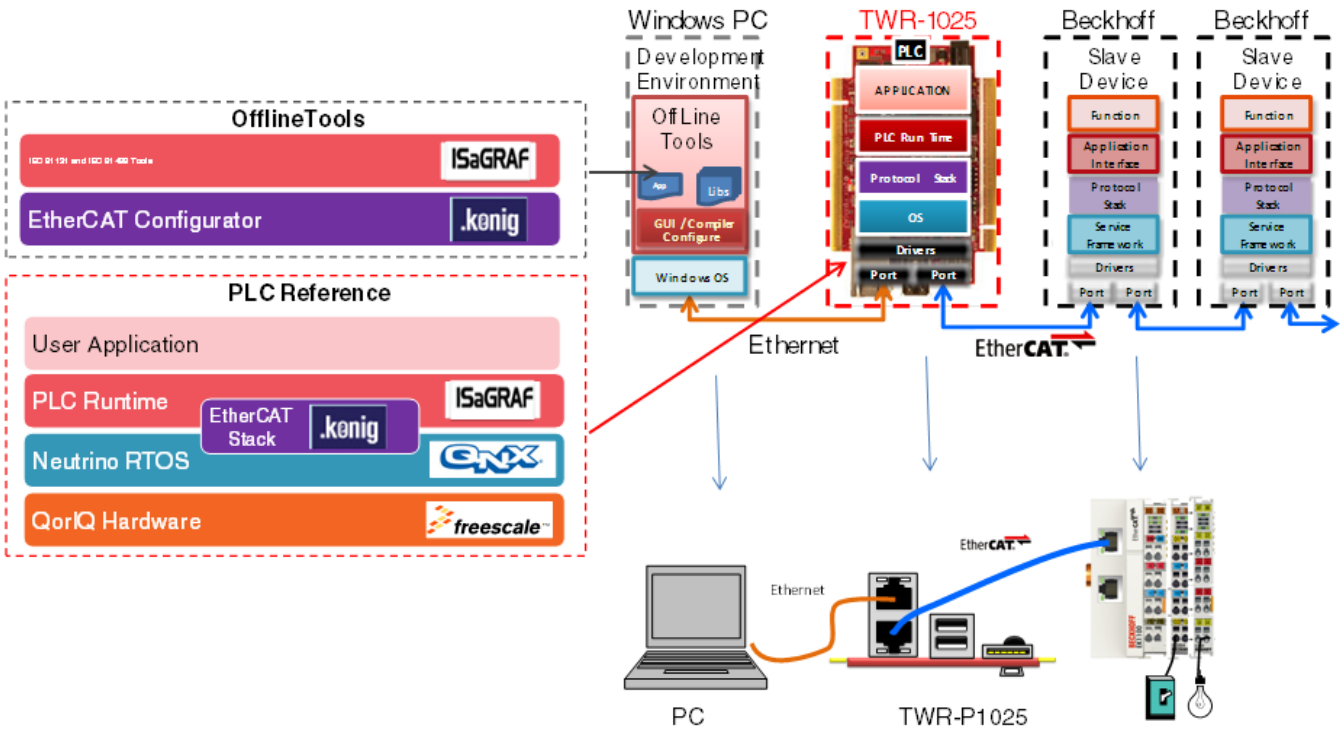


Figure 2. Overview of the PLC reference platform evaluation setup

3.1 Connect the hardware

Follow these steps to set up the PCL reference platform for evaluation.

1. Set the TWR-P1025 configuration switches as shown in the figure below.

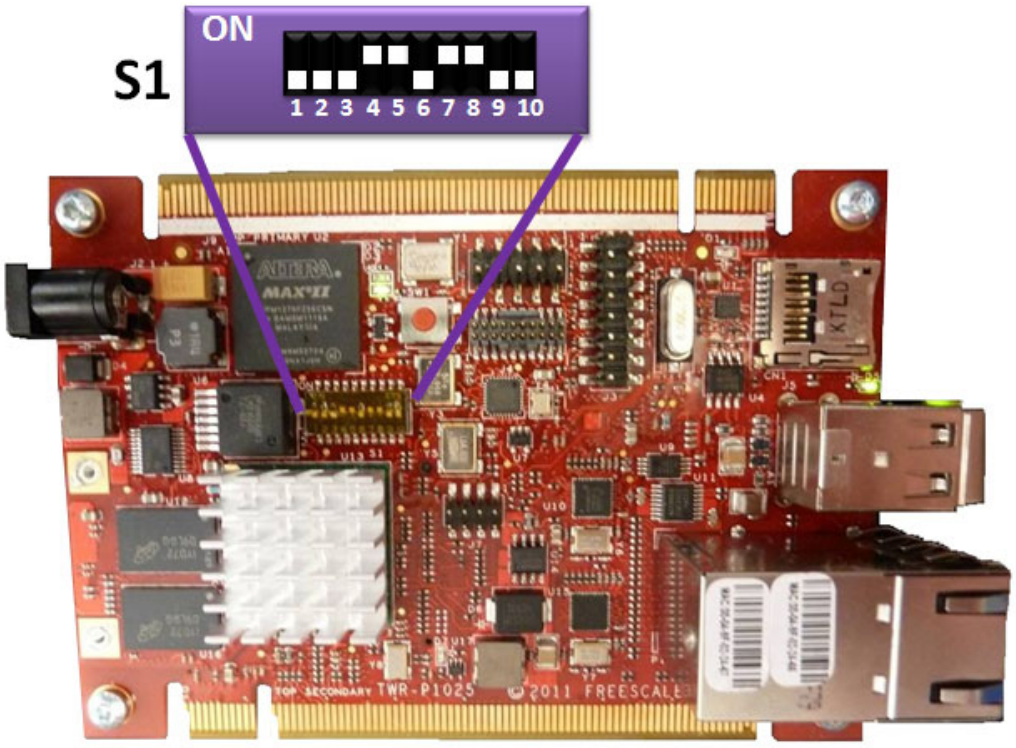


Figure 3. TWR-P1025 switch settings

2. Set the slice order of the target slaves as shown in the figure below, where the slaves appear from left to right as follows: EK1100, EL1004, EL2004 then EL9011.

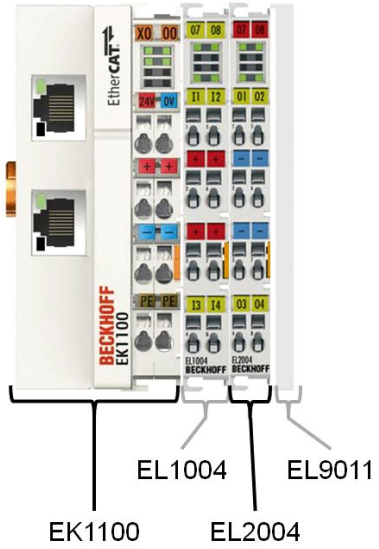


Figure 4. Slice order of target slaves

3. Construct the target slave devices by establishing the power connections shown in the figure below.

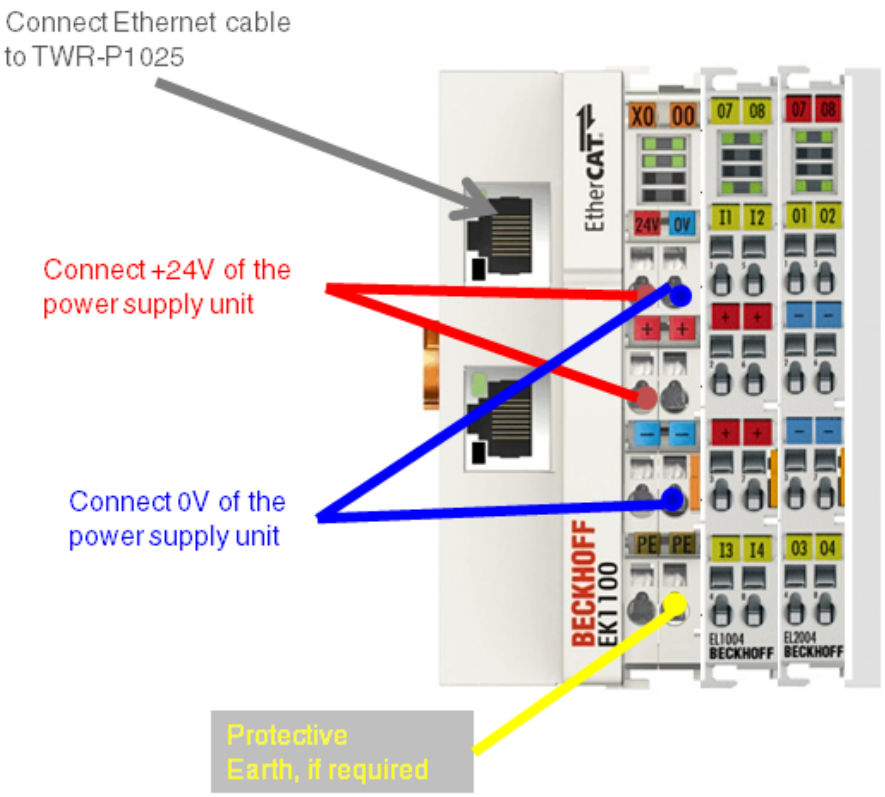


Figure 5. +24V DC power supply connections for target slave devices

4. Establish data connections between the target slave devices, TWR-P1025 and the Windows PC. Note that Figure 6 shows only the data cables.

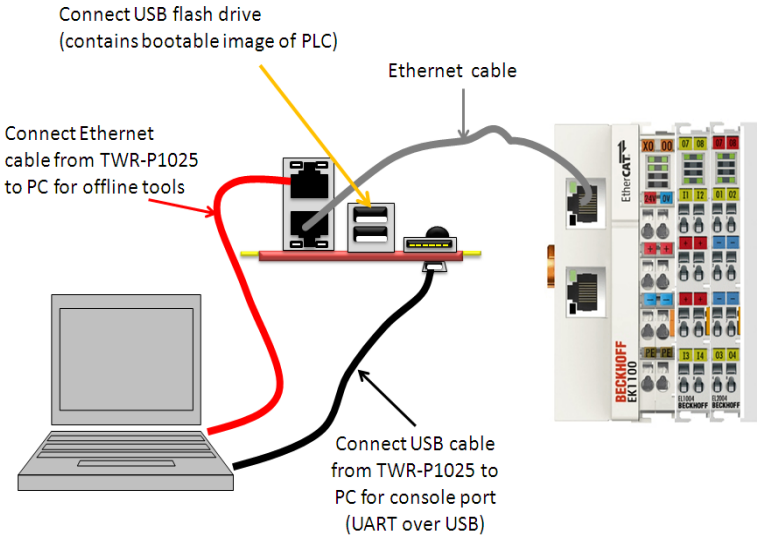


Figure 6. Required data connections

3.2 Download and install the software

After you connect the hardware, follow these steps to download and install the software. For a complete list of the required downloads and their location on the Internet, see Table 2-2.

NOTE

The steps for installing the ISaGRAF tools are provided as a guide. For the official ISaGRAF instructions, see the ISaGRAF installation package.

1. From the Windows PC, download and install the USB-to-UART driver for console port and the terminal emulation program TeraTerm for RS232 communications.
2. Download and install the ISaGRAF 6 Workbench for offline tools.
   a) Extract and open the installation folder. Review the extracted “Readme” file.
   b) To start installation, double-click the Autorun application.

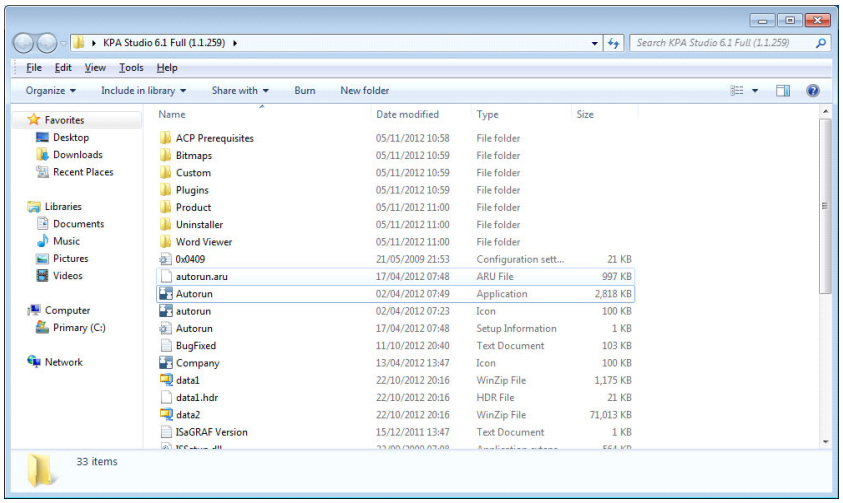


Figure 7. Choose the Autorun application to start installation

   c) On the menu screen, double-click ISaGRAF 6.1 to start installing the tools. The license agreement screen appears.

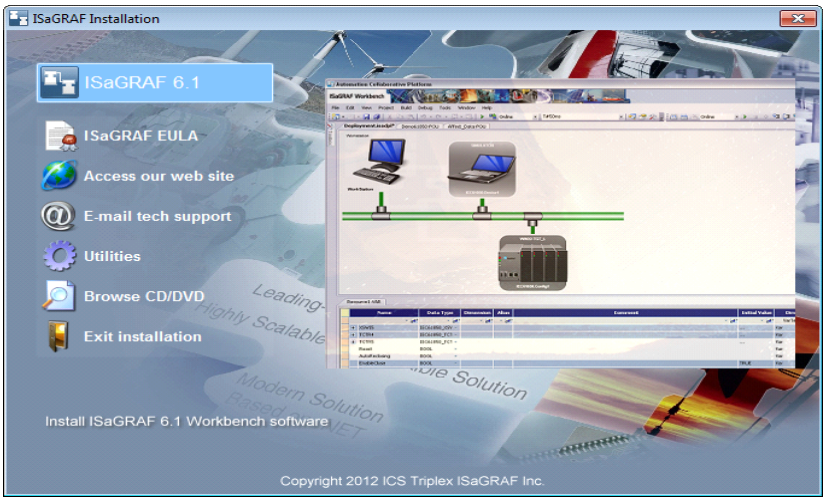


Figure 8. ISaGRAF Installation Menu

d) To accept the terms of the license agreement, select the appropriate radio button and click Next. The Setup Type screen appears.

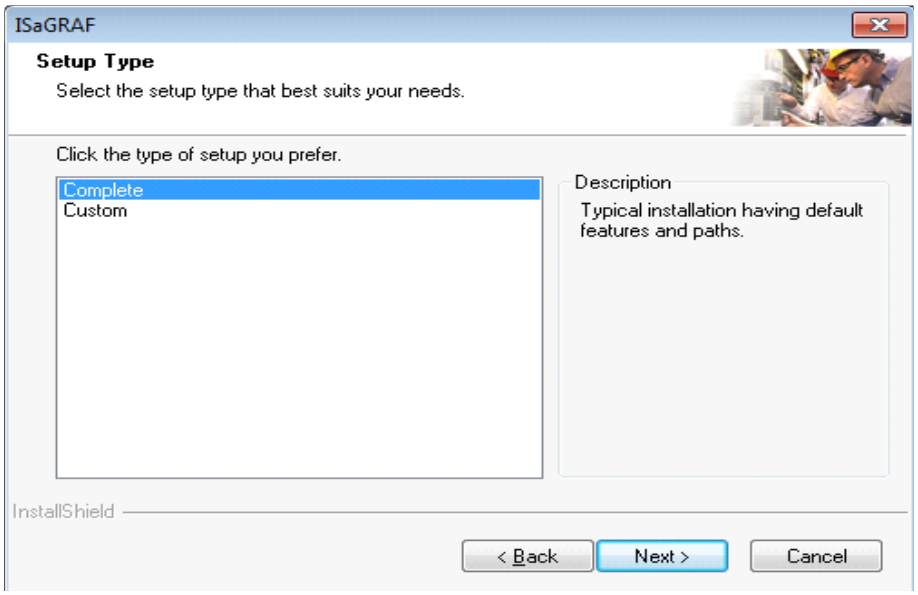


Figure 9. Setup Type screen

e) On the Setup Type screen, select Complete and click Next. The setup application determines whether there are other support elements that need to be installed. When the installation is complete, an ISaGRAF icon appears on the desktop.

Once the software is loaded, follow the directions in Section 3.3, “Build the USB flash drive for use on TWR-P1025,” to build the USB flash drive necessary for evaluating the PCL reference platform.

3.3 Build the USB flash drive for use on TWR-P1025

To build the USB flash drive, perform the following steps.

1. Download the PLC reference platform runtime software and extract the files along with the directory structure to a Windows PC.
2. To format the USB flash drive, insert the drive into a USB port on the PC and perform the following:
   a) From Windows Explorer, right-click on the USB drive and select Format.

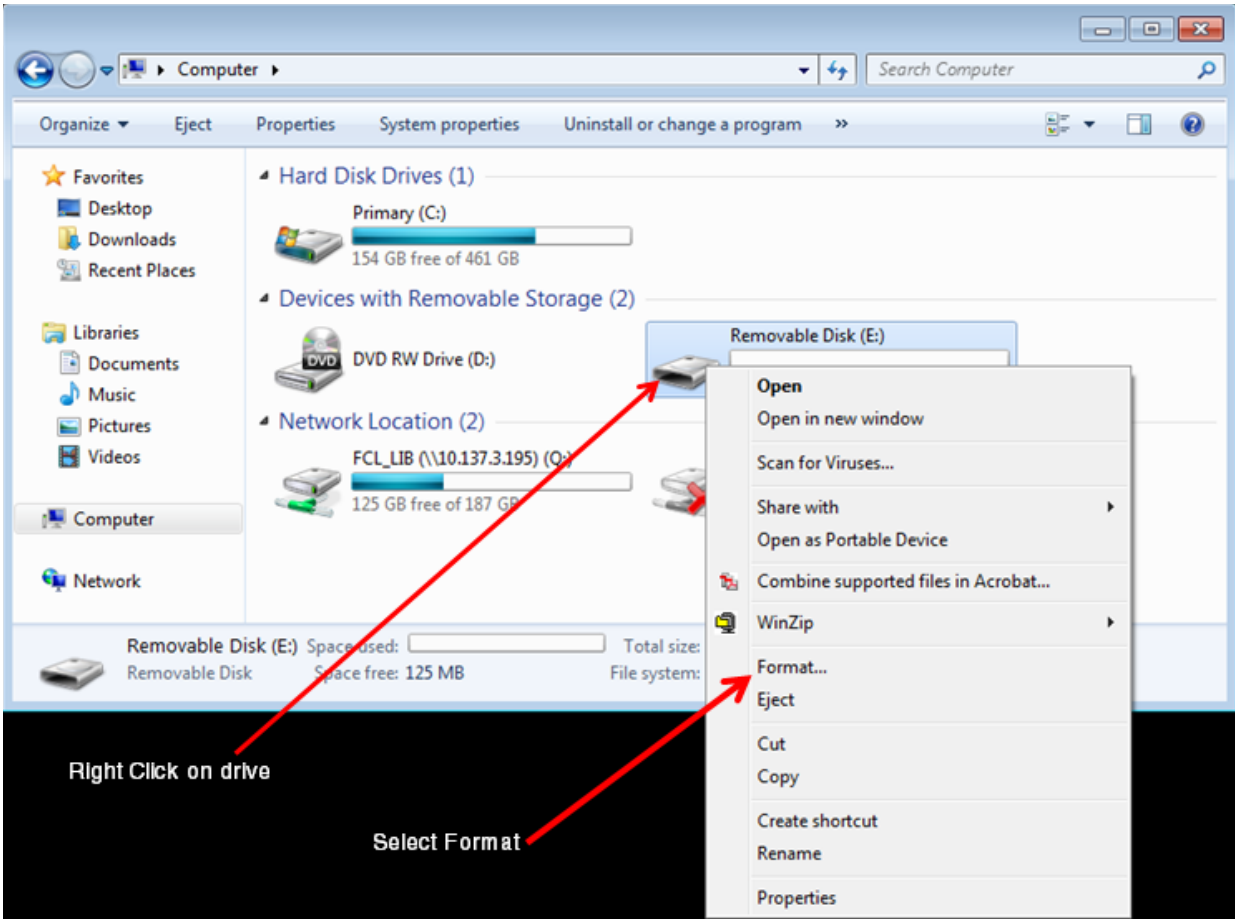


Figure 10. Select Format to format the USB drive

In the dialogue box that appears, under File System, select FAT32 and click Start. A warning that you are about to overwrite the disk appears.

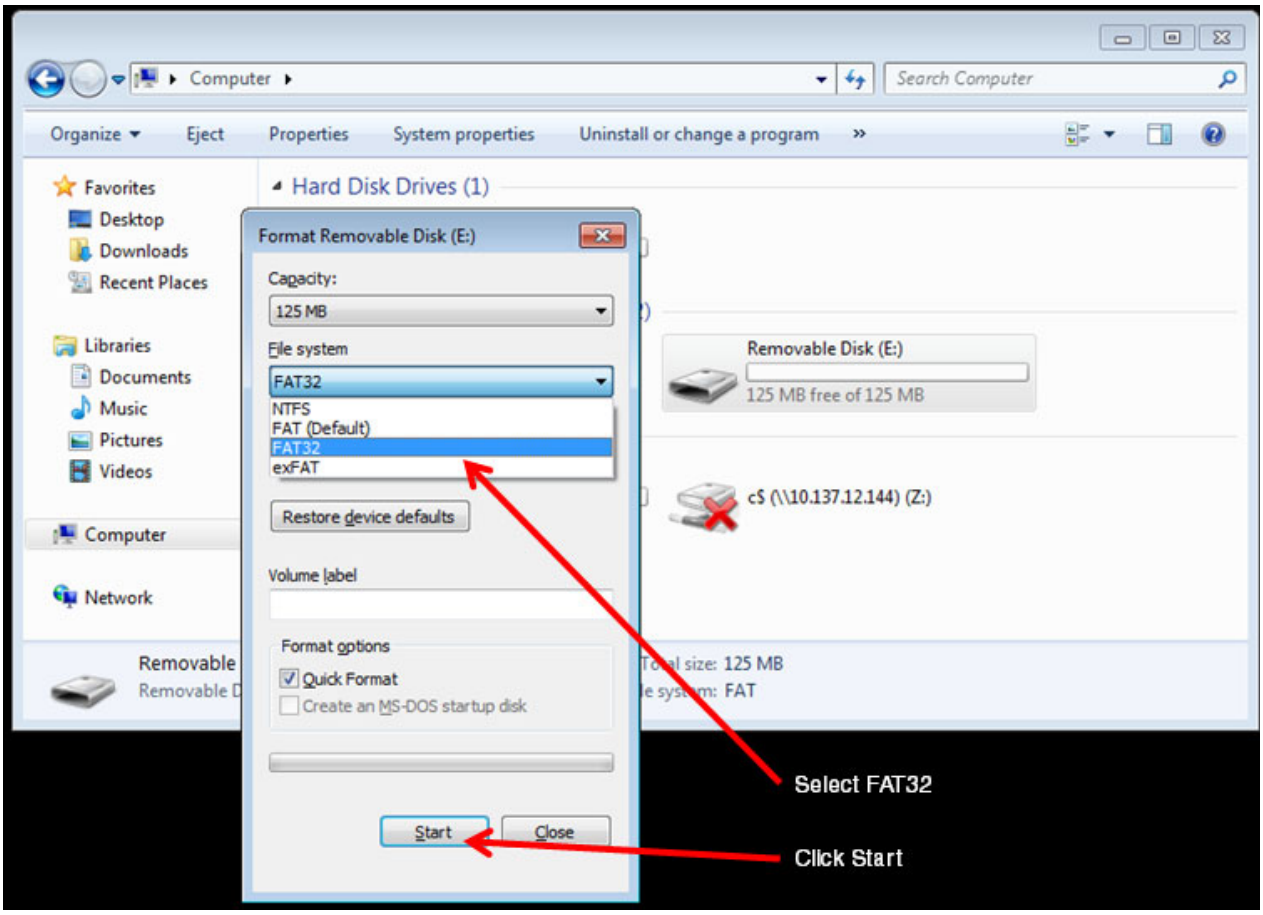


Figure 11. Choose the FAT32 file type

b) Click OK. The USB flash drive is ready to run scripts.

3. Add runtime scripts to the newly formatted USB flash drive
   a) Navigate to .../PLC_Reference_Platform/Software-TWR-P1025.
   b) Copy the file bsp-freescale-p1025-twr.ifs and the directories Lib and ISaGRAF, including their contents, to the USB flash drive.

NOTE

The Lib directory must start with a capital letter.

4. Ensure that the files listed in the following table are on the USB flash drive.

Table 3-4. Files required on the USB flash drive

File type	File name
Boot file containing PLC runtime environment	`bsp-freescale-p1025-twr.ifs`

Table 3-4. Files required on the USB flash drive (continued)

Executable binaries	\isagraf\ETCP \isagraf\EtherCATMaster \isagraf\IsaEcat \isagraf\ISaGRAF \isagraf\IsaRSI \isagraf\IsaVM
Shared libraries	\Lib\EtcpCmon.so \Lib\IKvbEtcp.so \Lib\IKvbHsd.so \Lib\IsaIOEcatDriver.so \Lib\IsaIxd.so \Lib\IsaIXL.so \Lib\IsaKer.so \Lib\IsaKerC.so \Lib\IsaNwl.so \Lib\IsaSrv.so \Lib\IsaSys.so \Lib\IsxlEtcp.so \Lib\IsxlHsd.so \Lib\IsxlRsi.so \Lib\IsxsEtcp.so \Lib\IsxsHsd.so \Lib\IsxsRsi.so \Lib\ISysSoc.so \Lib\RsiCmon.so

Safely remove the USB flash drive from the PC and plug it into the TWR-P1025. The USB flash drive now contains the software required to run the EtherCAT PLC reference implementation on the TWR-P1025.

3.4 Configure the static IP addresses on the PC

To allow communication between the devices, the TWR-P1025 and the PC must be on the same subnet. The option shown below uses a fixed IP address for the PC. To configure the static IP addresses on the PC, follow these steps:

1. Open the Control Panel on the Windows PC and, to open the Network and Sharing Center, double-click on its icon.

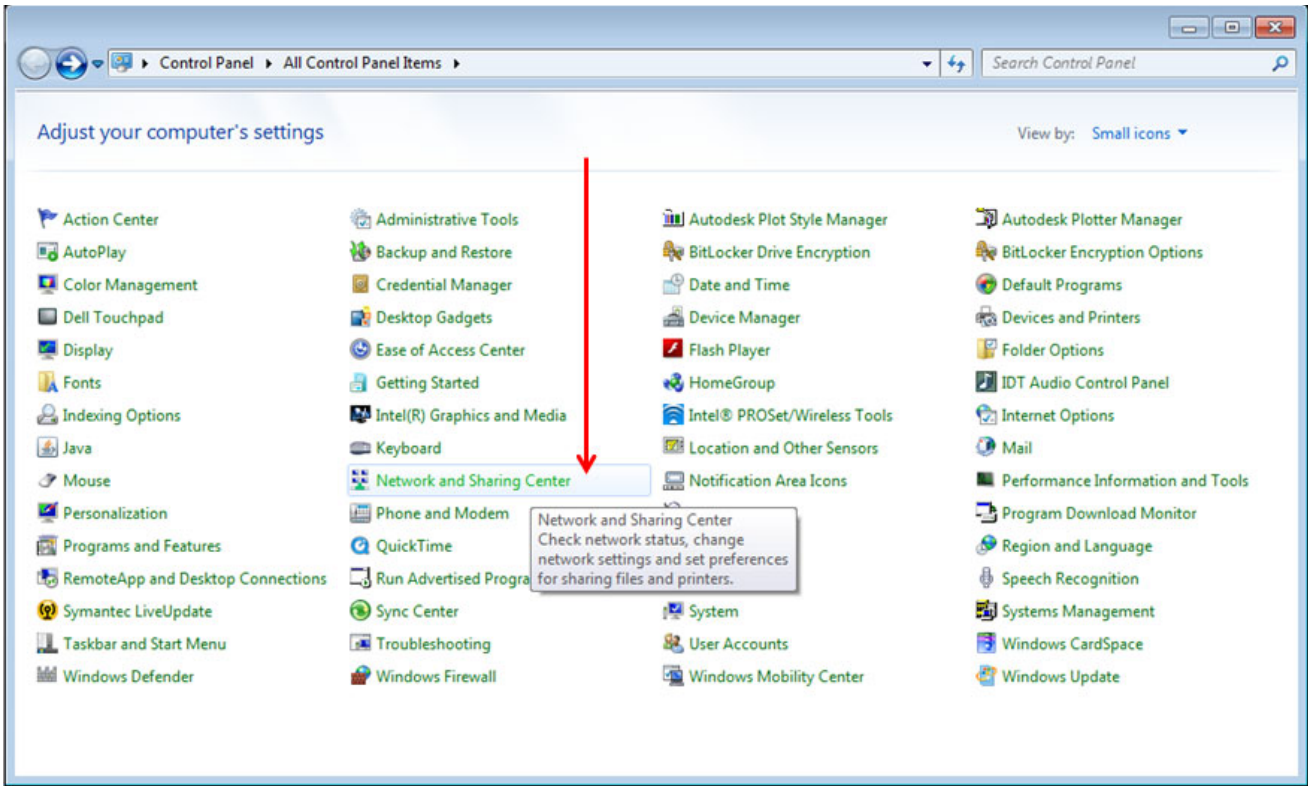


Figure 12. Open the Network and Sharing Center

2. Double-click on Change Adapter Settings.

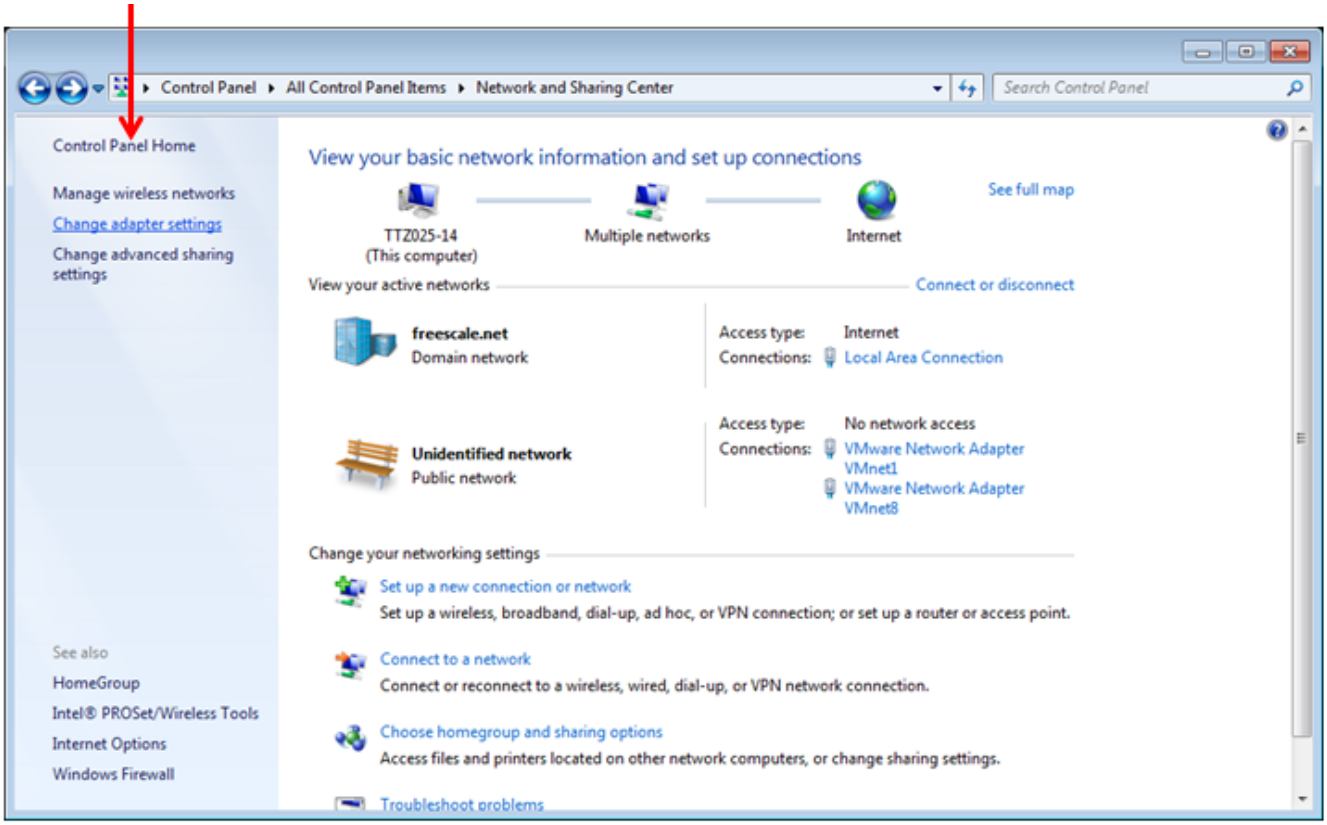


Figure 13. Open Change Adapter settings

3. Right-click on the network connection linked to the TWR-P1025 and select Properties. The Local Area Connection Properties window opens.

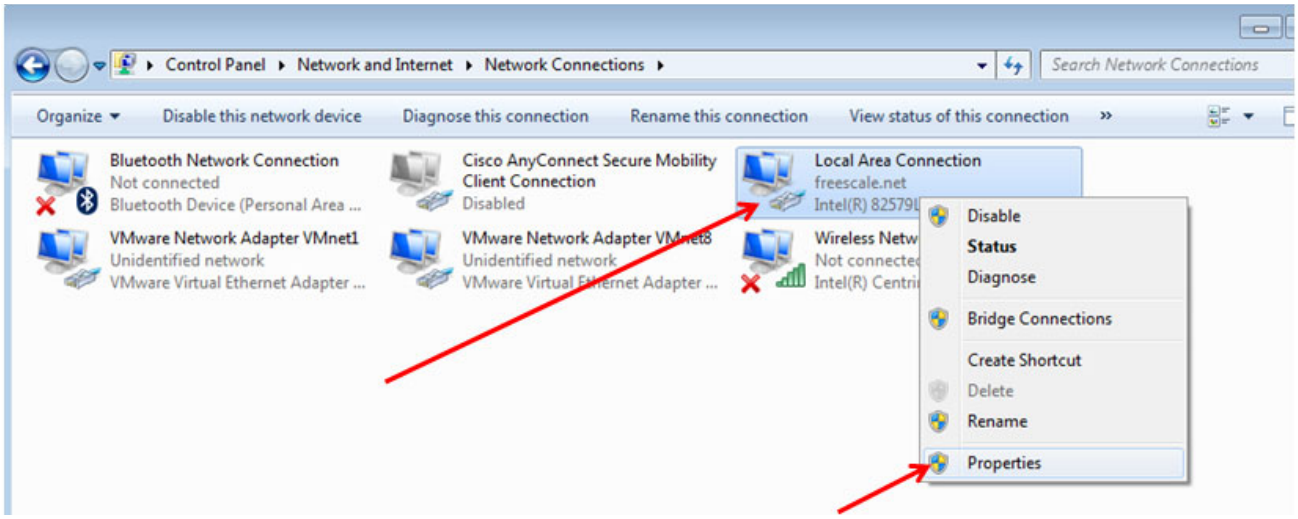


Figure 14. Open the Local Area Connection Properties window

4. Select Internet Protocol Version 4 (TCP/IPv4) and use the following information to complete the fields in the Internet Protocol Properties dialog box.

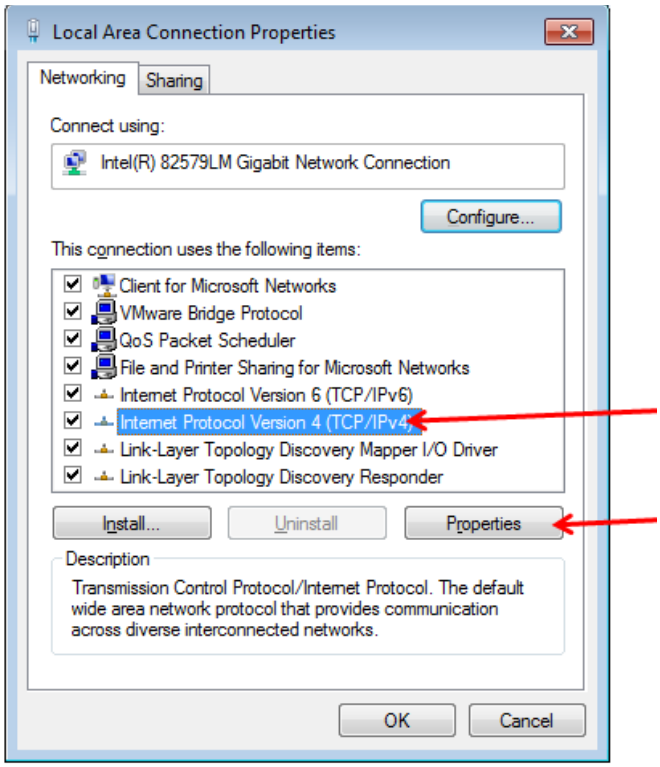


Figure 15. Open the Internet Protocol Version 4 Properties window

a) Select the radio button next to Use the following IP address.
b) Enter 192.168.10.54 for the IP address.
c) Enter 255.255.255.0 for the Subnet mask. Click OK.

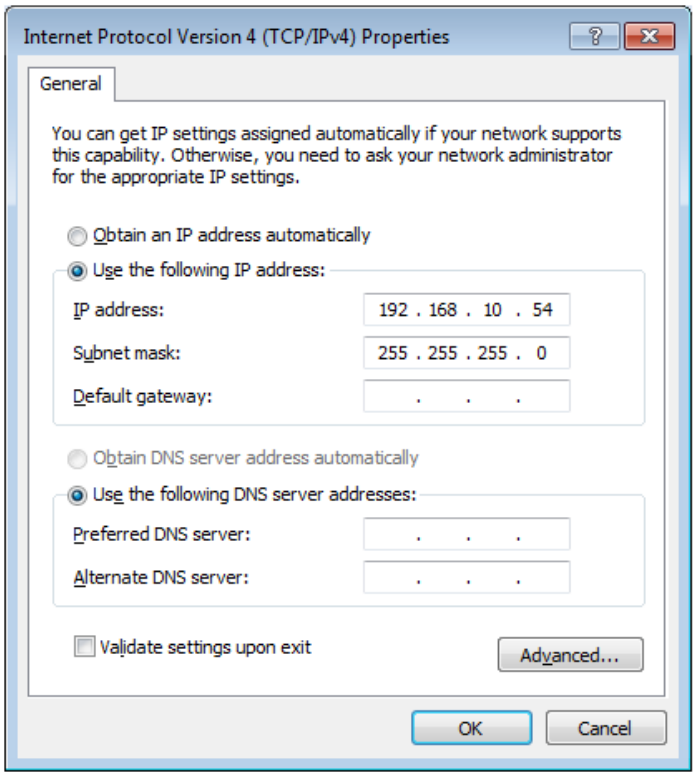


Figure 16. Enter the TCP/IPv4 Properties

To enable communication between the offline tools and the PLC runtime environment on the TWR-P1025, the user may now connect the top Ethernet connector of the TWR-P1025 to the Ethernet port of the PC.

3.5 Configure the TWR-P1025 to autoboot from a USB flash drive

The TWR-P1025 U-Boot supports multiple methods of booting. Usually it boots a version of Linux from the on-board flash. However, to allow booting from the USB flash drive created in Section 3.3, "Build the USB flash drive for use on TWR-P1025," the user must change the boot option in U-Boot. To change the boot option and enable communication, the user must connect a terminal to the console port of the TWR-P1025.

Before performing the following steps, ensure that the USB-to-UART driver is installed and the USB cable is connected between the TWR-P1025 mini USB connector and the Windows PC. Because the console port on the TWR-P1025 uses UART-to-USB transport, configuration of these ports as RS232 is only realized when the USB is connected; otherwise, the Windows operating system does not see them. To check installation, go to ftdichip.com/Drivers/VCP.htm.

To configure the TWR-P1025 to autoboot from a USB flash drive, perform the following steps.

1. Connect the PC to the TWR-P1025 console port.
2. Start the terminal emulation program and configure it to join the USB-RS232 port connecting the TWR-P1025, as shown in Figure 17.

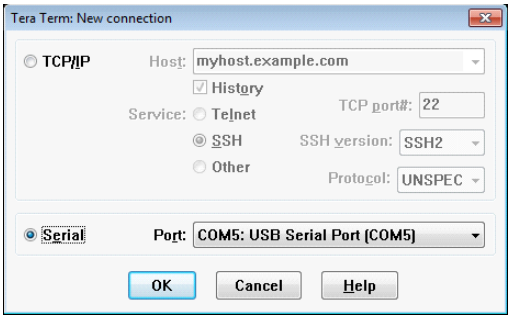


Figure 17. Selecting the serial connection [Tera Term]

3. In the Tera Term: Serial Port setup window that appears, enter the COMs settings shown in Figure 18 below.

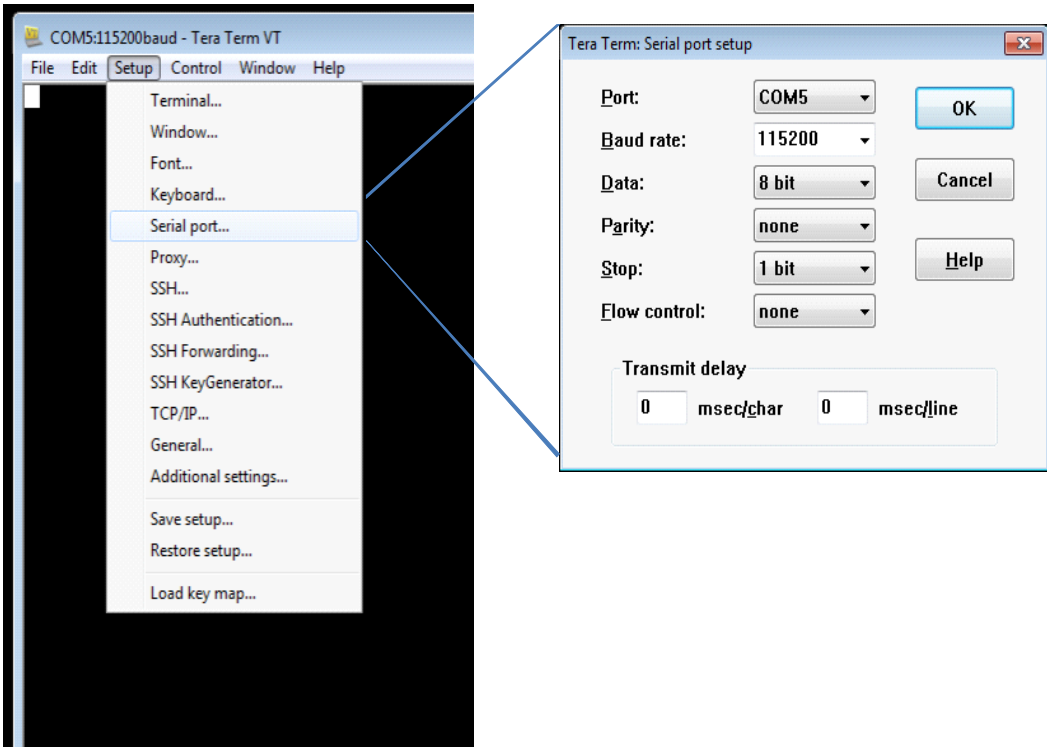


Figure 18. UART COMs settings [Tera Term]

4. Connect +5V PSU to TWR-P1025. The terminal emulation displays the U-Boot booting sequence.
5. When Hit any key to stop autoboot appears, select a key to stop in U-Boot.
6. Set the bootcmd argument for boot from the USB flash drive.
7. On the command line, enter the setenv command below, followed by the saveenv command.

```
setenv usb_phy_type ulpi;usb start;fatload usb 0:1 0x100000
bsp-freescale-p1025-twr.ifs;go 0x100000

saveenv
```

When the TWR-P1025 is configured, the user may evaluate the PLC reference platform.

4 Evaluate the PLC reference platform

This section shows how to Create an application to manipulate the target slaves and how to Use the functional block diagram to construct a simple flasher application. Both applications may be used to evaluate the PLC firmware.

Before building the applications or performing the PLC reference platform evaluations, the user must complete the following:

- Configure the Windows PC
- Connect the hardware
- Build the USB flash drive for use on TWR-P1025
- Configure the TWR-P1025 to autoboot from a USB flash drive

The offline tools on the Windows PC allow the user to configure and implement the application. These tools are required to use the PLC reference platform.

4.1 Create an application to manipulate the target slaves

4.1.1 Set up a new project

To produce a simple application that runs and controls the target slaves, perform the following steps.

1. Start the ISaGRAF 6 Workbench. A screen similar to the ones shown below appears. Click OK.

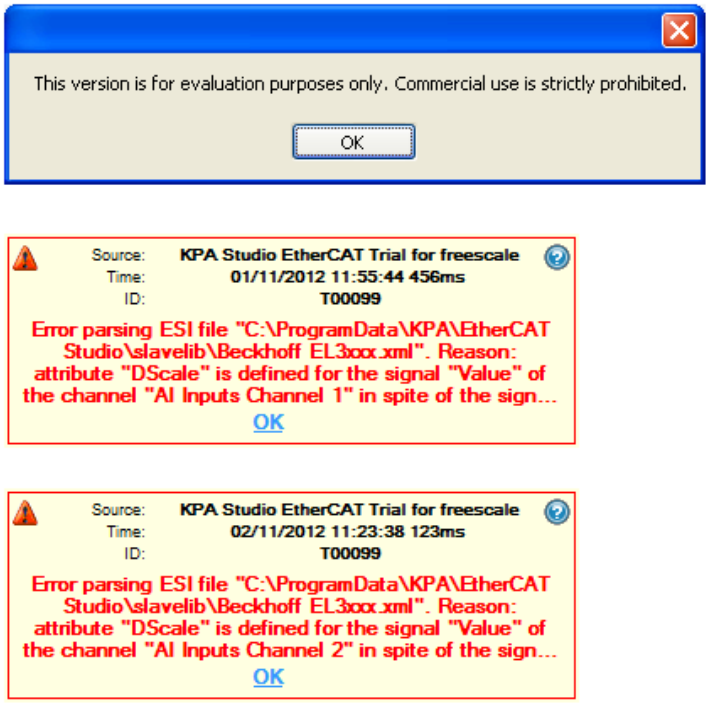


Figure 19. Non-commercial screen

2. Select New Project.

3. Expand CAM Projects and select ISaGRAF 5, as shown in the figure below.

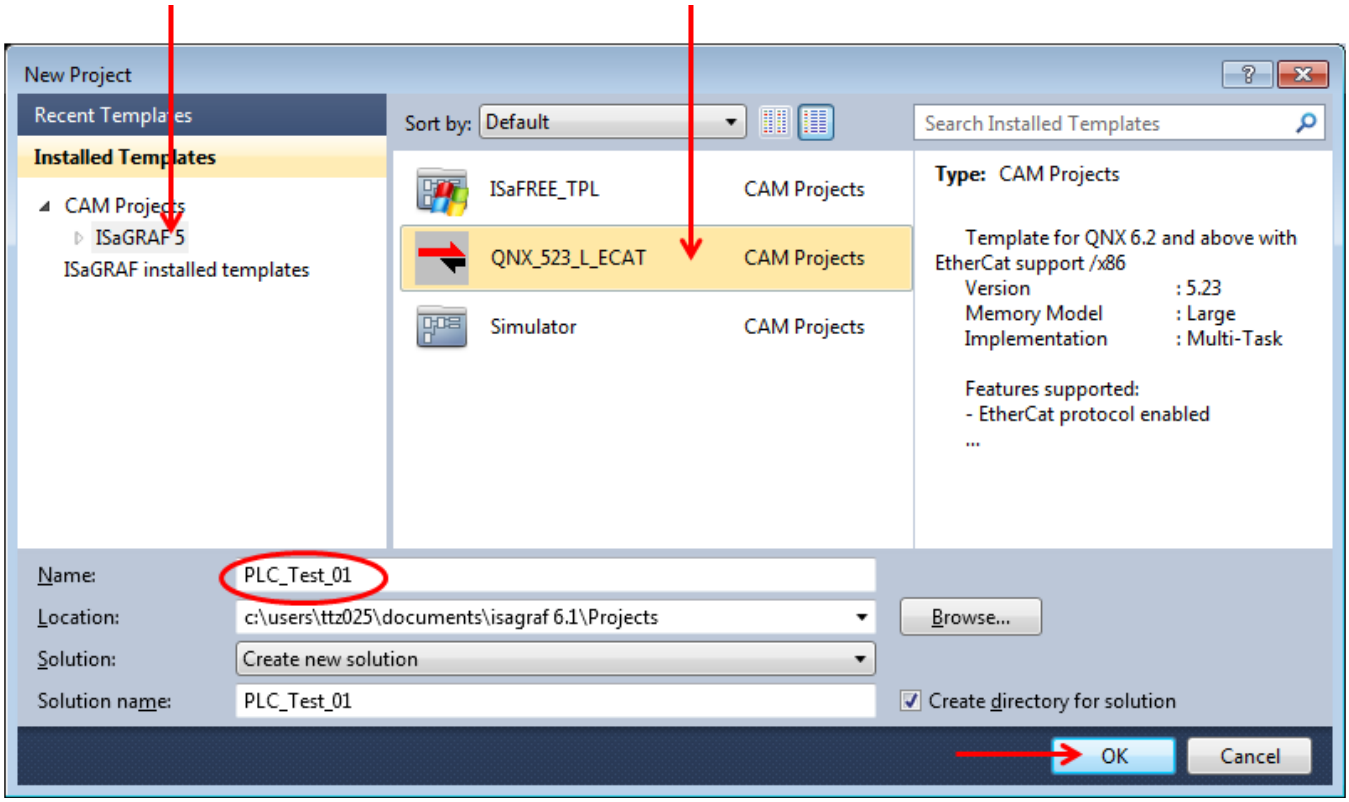


Figure 20. Set up the new project

4. Select QNX_523_L_ECAT and enter project name PLC_Test_01 in the name field. Click OK.

4.1.2 Configure the remote master

Use KPA studio, which is incorporated in the ISaGRAF 6 Workbench, to configure the PLC reference platform. To configure the remote master, first obtain the IP address for TWR-P1025.

1. To obtain the IP address of the TWR-P1025 in use, go to the console widow (TeraTerm) connected to the TWR-P1025 and at the number sign prompt (note: hit any key to produce the #), enter the following command, as shown in the figure below: `ifconfig tsec0`

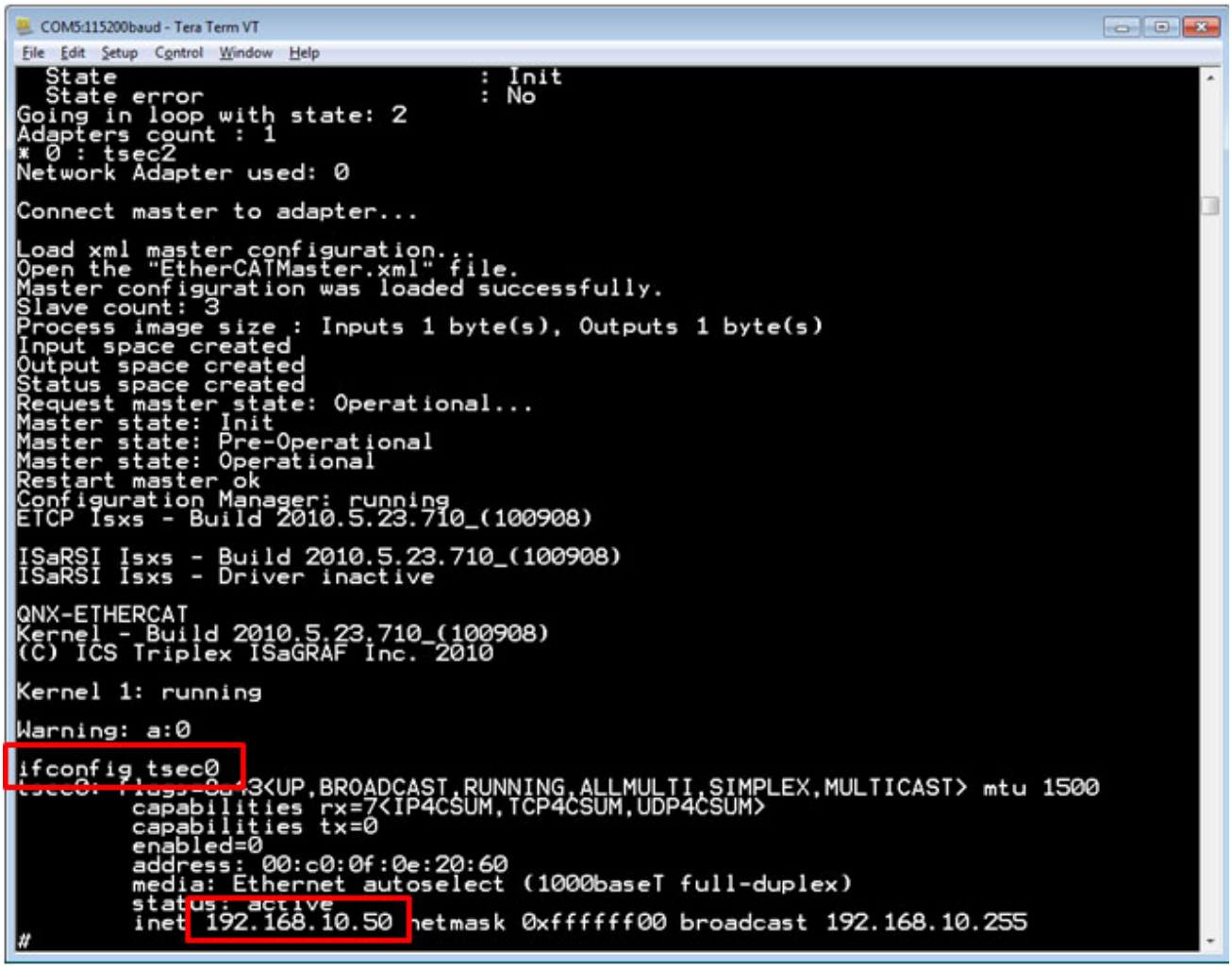


Figure 21. Obtain the IP Address of TWR-P1025

2. To open KPA studio, expand Device1 and double-click EtherCAT.

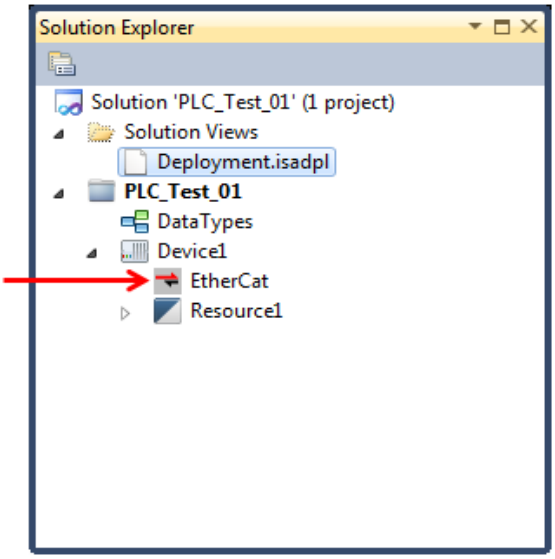


Figure 22. Open KPA studio

3. Select Device1 and, in the Master tab, enter the IP address of TWR-P1025.

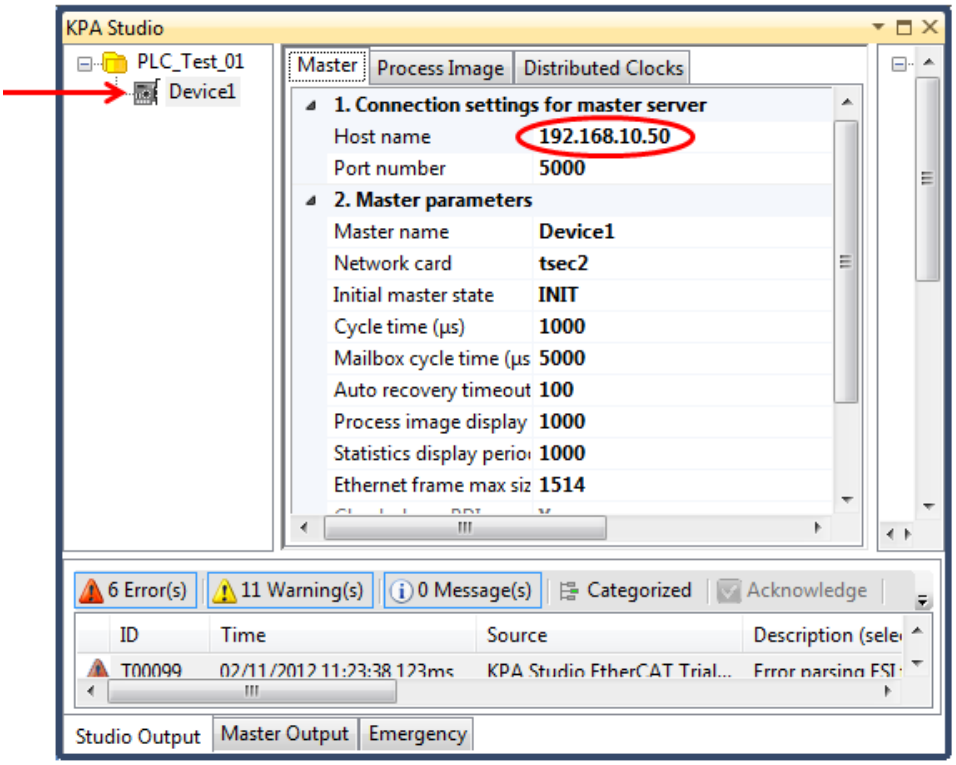


Figure 23. Add the TWR-P1025 IP address

In the example below, the current IP address of the PLC Firmware is 192.168.10.50. The PC connected to the TWR-P1025 Ethernet must be on the same subnet 192.168.10.xxx.

4.1.3 Verify the connection between slave devices

To verify that the slave devices are connected, perform the following steps.

1. Right-click on Device1 and select Scan configuration from the drop-down menu.

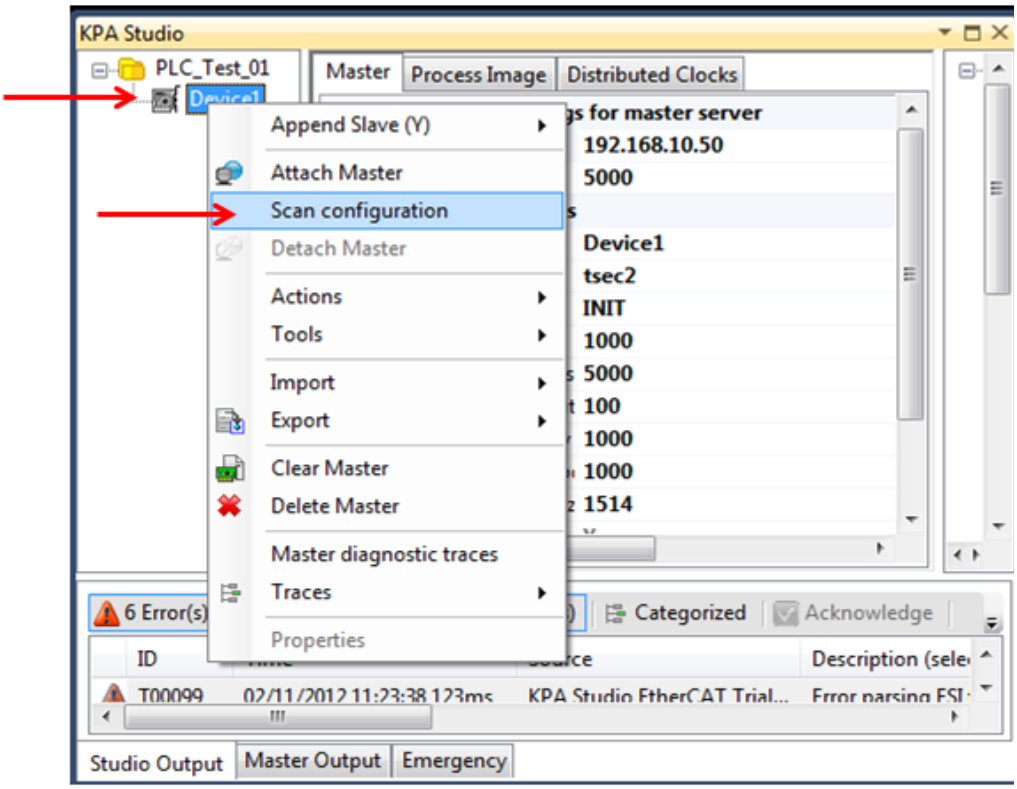


Figure 24. Scan for the slave devices

2. Click to expand the hierarchy in the left-column, as shown in the figure below.

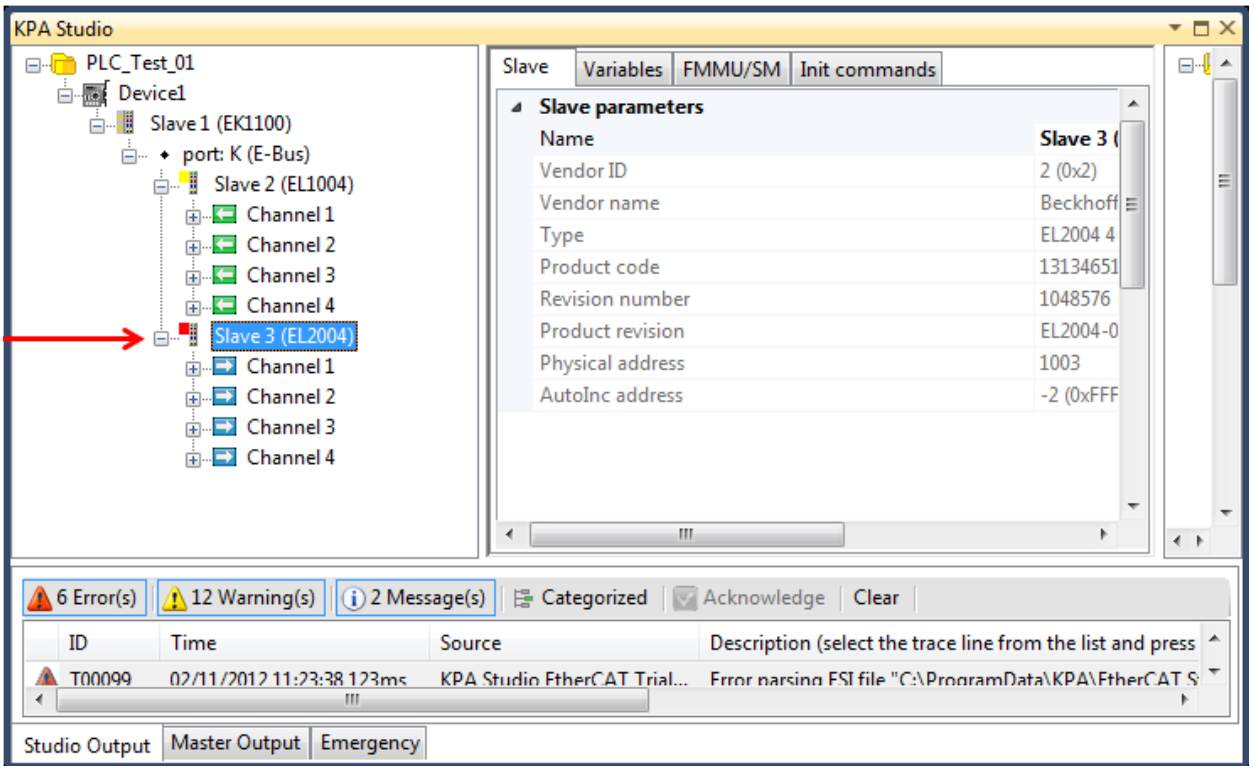


Figure 25. Show the slave devices

4.1.4 Attach the input and output slave devices

To allow the Workbench in the application downloaded to the PLC to access the slaves, they must be attached. To attach the input and output slave devices, perform the following steps.

1. Expand PLC_Test_01 and Device1.

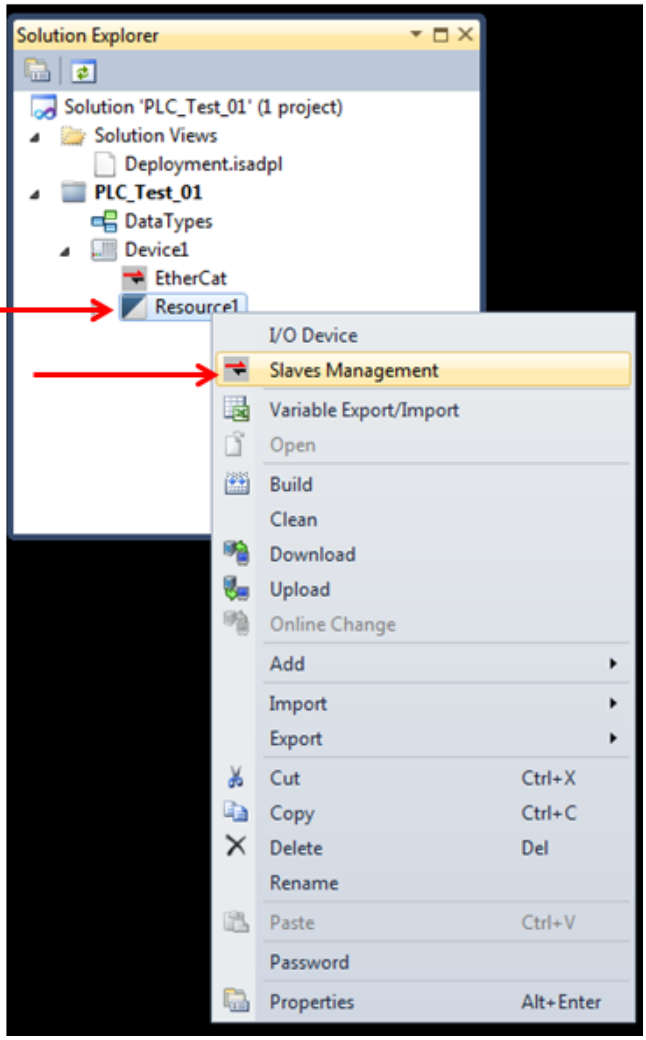


Figure 26. Select Slaves Management option

2. Right-click on Resource1 and select Slave Management. The ISaGRAF Slaves Management: Resource1 screen appears, as shown in the figure below.

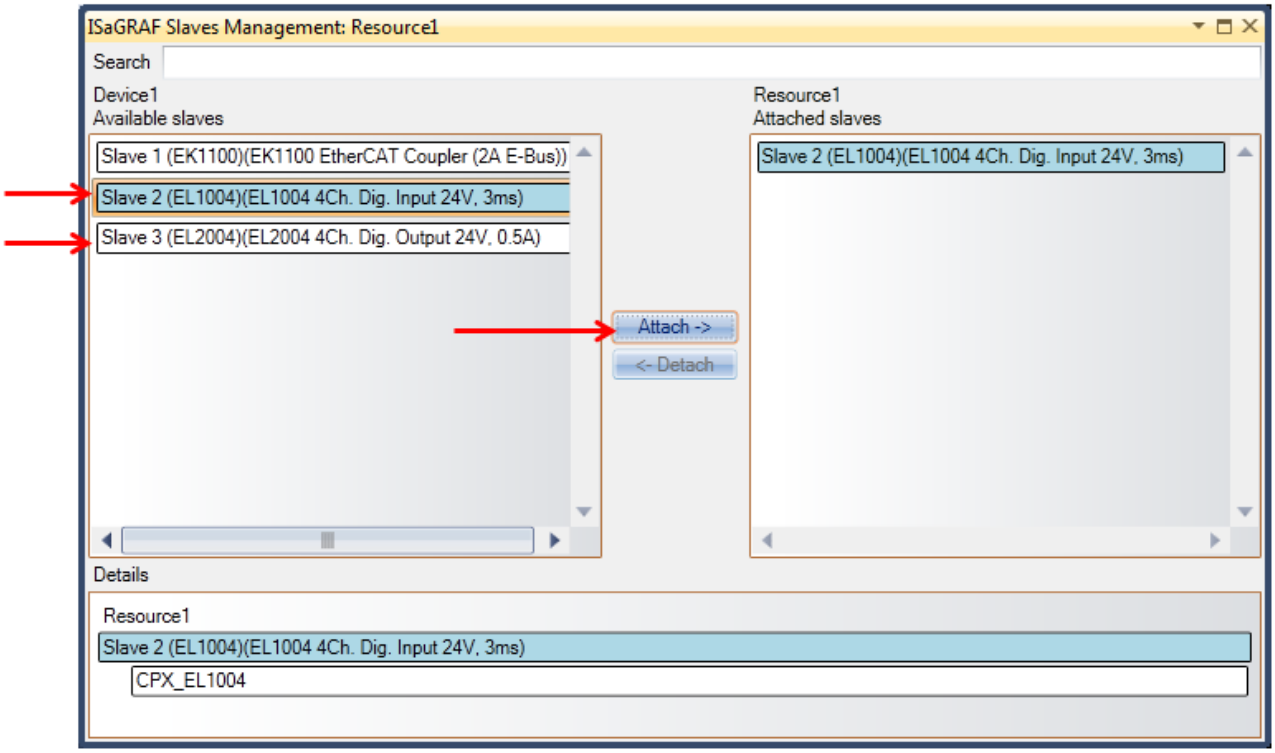


Figure 27. Attach the slave devices

3. Attach the slave devices by selecting the applicable device in the left-hand window and clicking Attach.

4.1.5 View slave device and global variables information

To optionally display the slave device and global variables information, follow these steps.

1. Open the Solution Explorer window and expand PLC_TEST_01.
2. Expand Device1.
3. To display and verify the auto-generated variables for the attached slaves, expand Resource1 and double-click Global Variables.

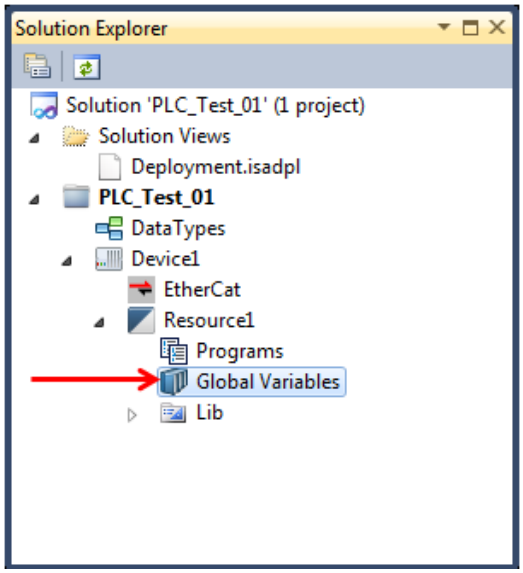


Figure 28. Display the global variables

4. To view the slave devices, right-click Resource1 and select I/O device.

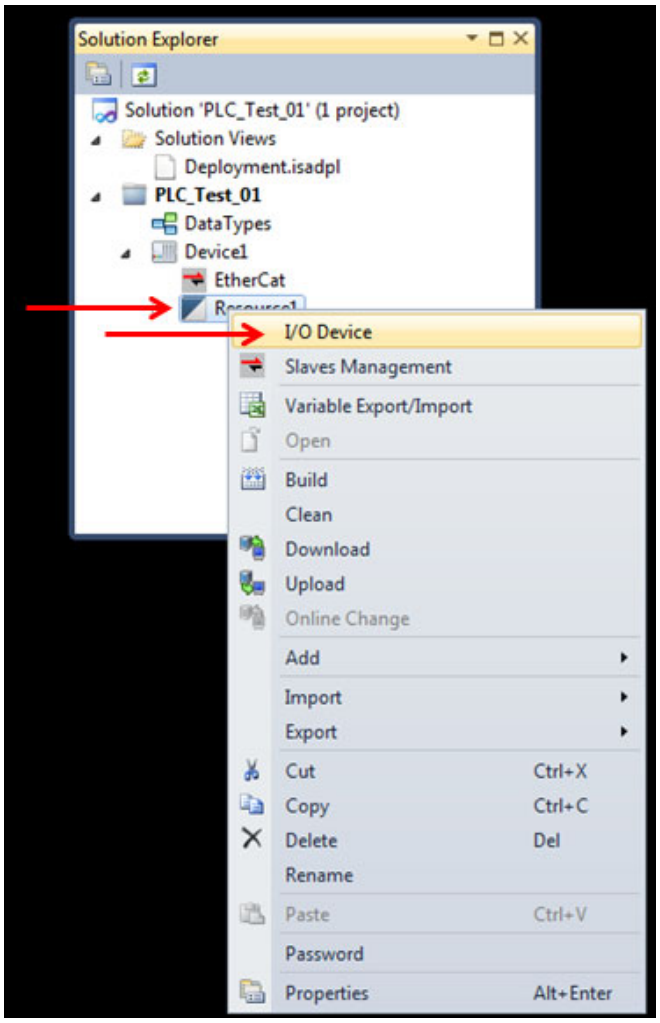


Figure 29. Open the I/O Device window

5. In the Resource1 I/O Device window that appears, expand the applicable slave device for more information, as indicated in the figure below.

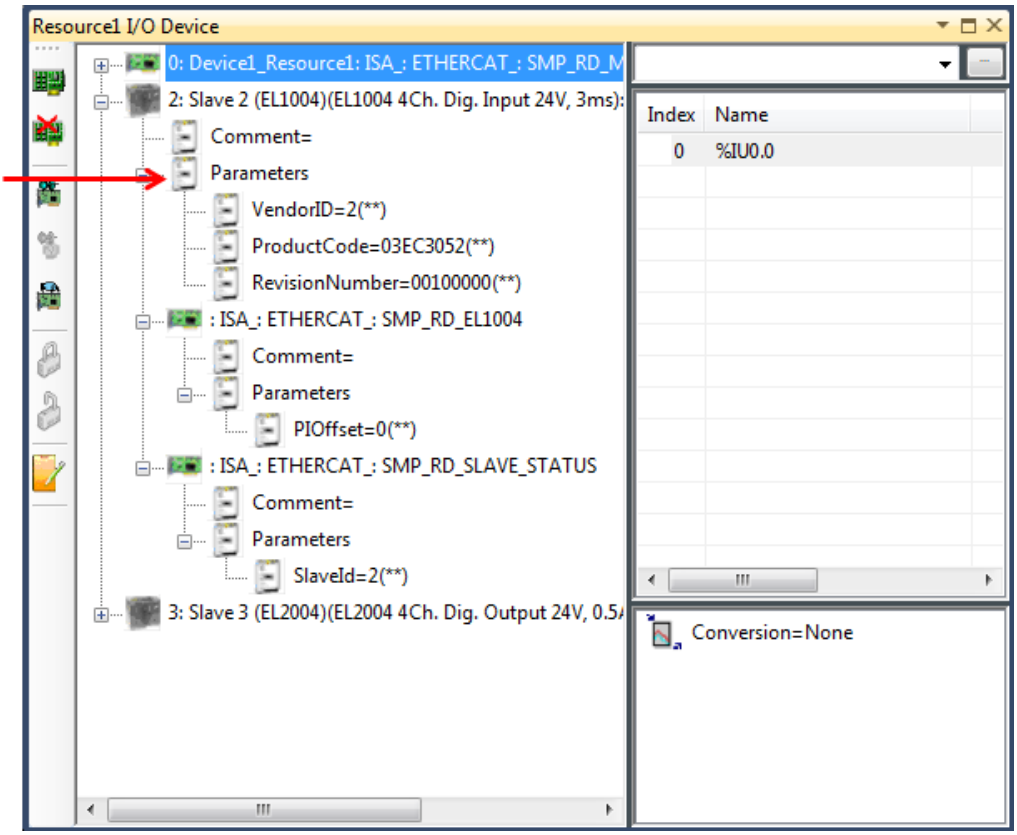


Figure 30. I/O Device window

4.2 Use the functional block diagram to construct a simple flasher application

4.2.1 Flasher application definition

This application makes an OUTPUT the inverse of an INPUT. This figure shows the application using the functional block diagram (FBD).

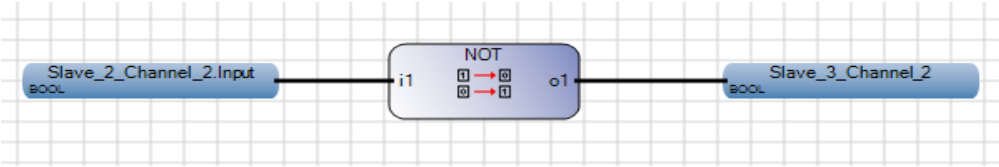


Figure 31. Simple flasher application

The figure below shows the shorting connection to the input and output of the physical target slave devices. This shorting means the output O2 will be the inverse of the input I2 on each scan cycle of the PLC. And this causes an oscillation reflected by the flashing O2 and I2 status LEDs.

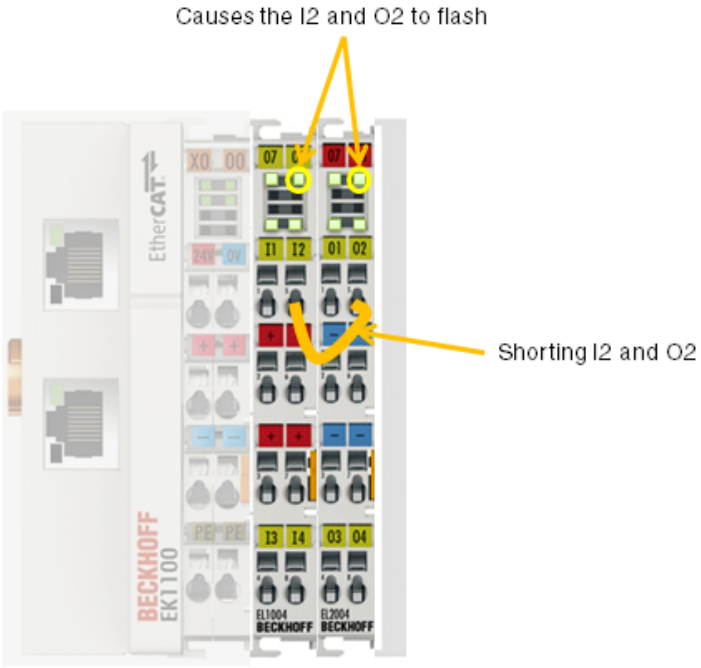


Figure 32. Simple flasher connects on target slave devices

4.2.1.1 Create the functional block diagram

To create the functional block diagram (FBD), follow the steps below.

1. Right-click on Programs and select Add > New FBD: Function Block Diagram.

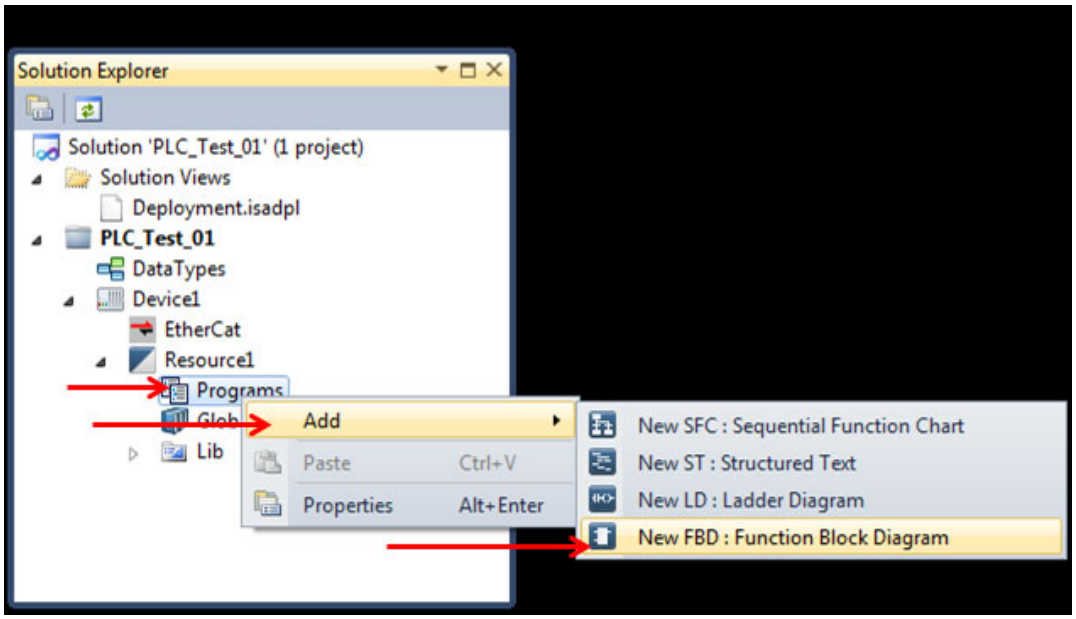


Figure 33. Add a new functional block diagram

2. To open the functional block diagram, expand Programs and double-click on Prog1.

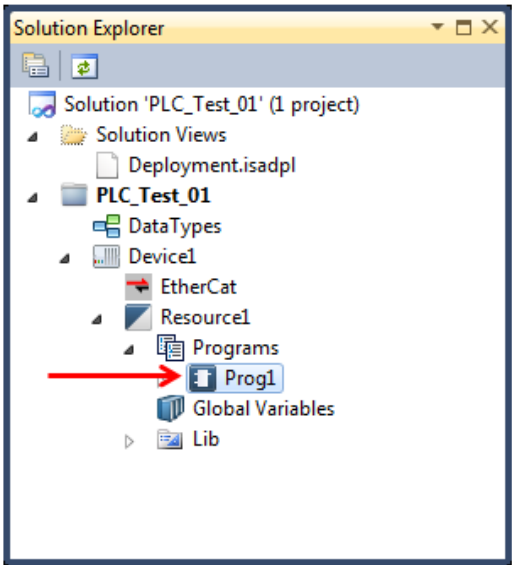


Figure 34. Open the FDB

3. To display the Toolbox menu, select View > Toolbox.

NOTE

When the layout of the slaves devices is the same as Figure 4, the variable created (Slave2_Channel_2) matches I2.

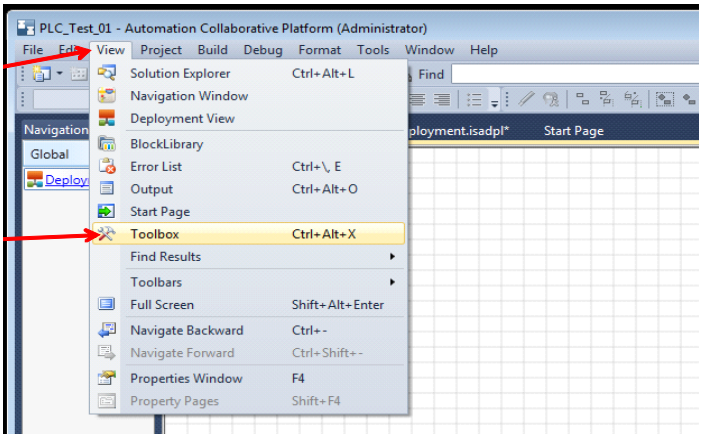


Figure 35. Display the Toolbox menu

4.2.1.2 Add variables to the functional block diagram

To add input variable Slave2_Channel_2 BOOL to the functional block diagram, perform these steps.

1. Drag the Variable from the Toolbox into Prog1, as shown in the figure below.
2. In the Global Scope field, click on Resource1.
3. Expand Slave_2_Channel_2.
4. Double-click BOOL.

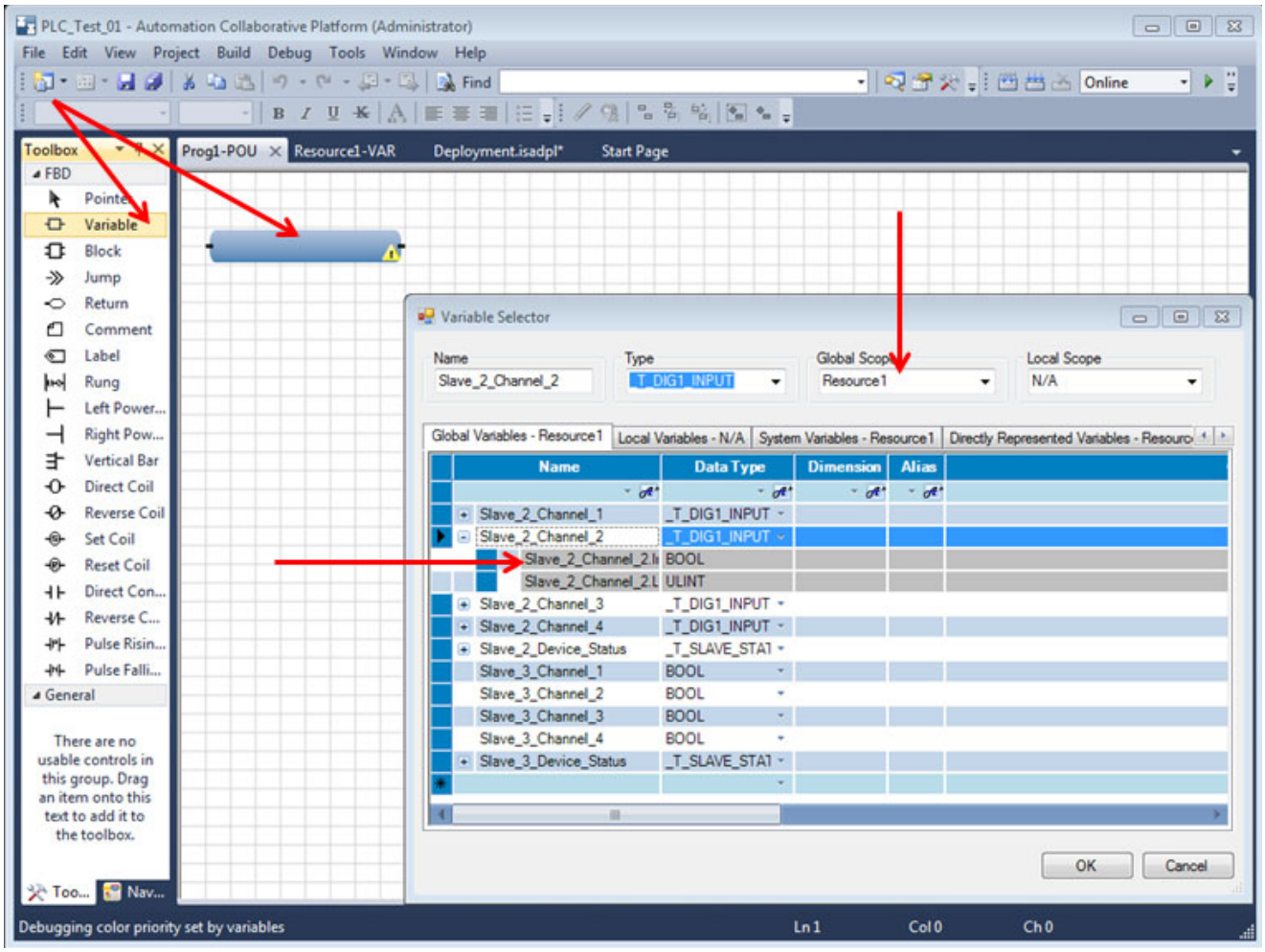


Figure 36. Add input variable Slave2_Channel_2 BOOL to FBD

5. To add the NOT block to the functional block diagram, drag Block from the Toolbox onto Prog1.
6. In the search field of the Block Selector window, type NOT.
7. In the name field, select NOT. Click OK.

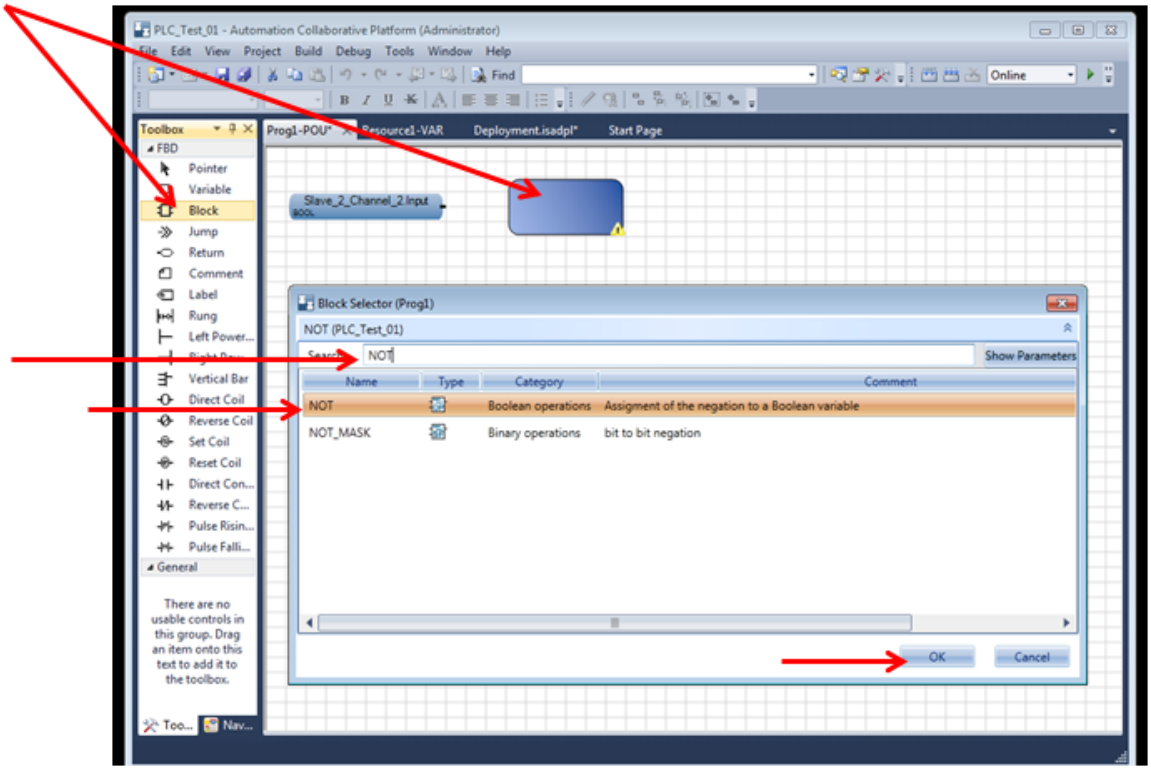


Figure 37. Add the NOT Block to the FBD

8. To wire the blocks, select and drag the connection tab of the variable to meet the corresponding connection tab on the block.
9. To add output variable Slave3_Channel_2 BOOL to FBD, drag Variable from the Toolbox onto Prog1.
10. Select Resource1 and double-click on BOOL. Click OK.

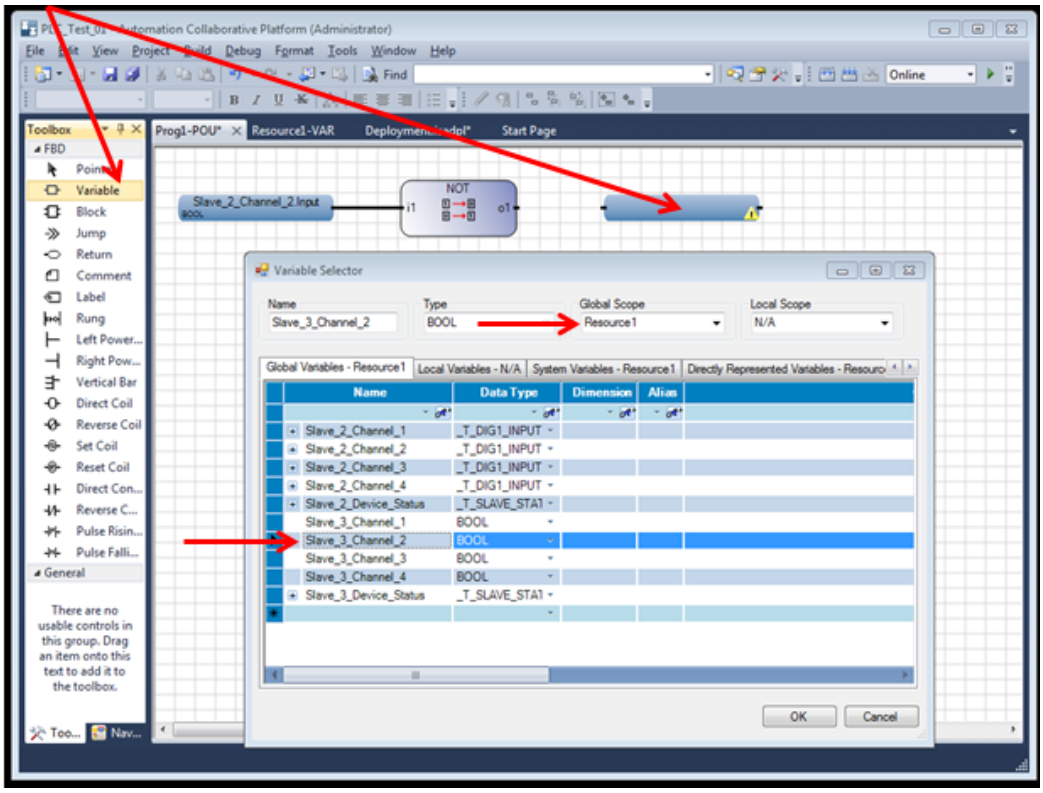


Figure 38. Add output variable Slave3_Channel_2 BOOL to FBD

4.2.1.3 Connect the variables to the block

To connect the variables to the block, perform the following steps.

1. Click on the applicable tag and drag it to meet NOT.
2. Save the project.

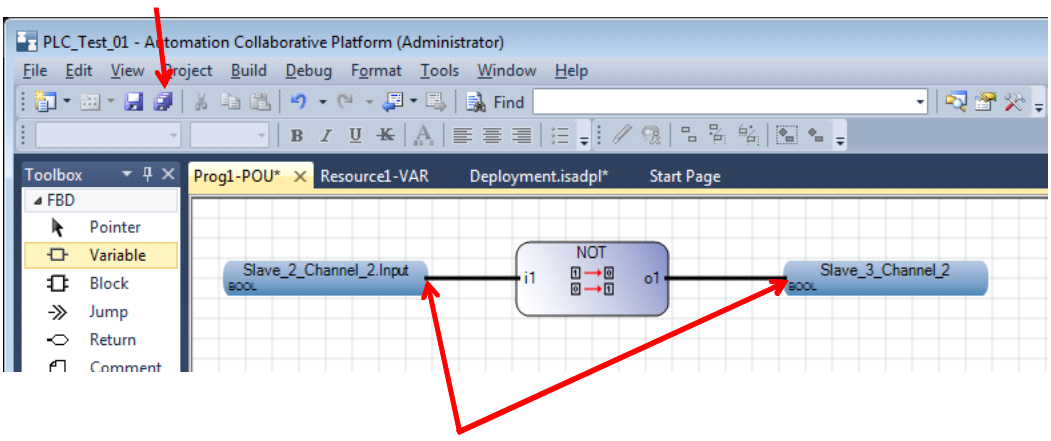


Figure 39. Connect variables to block

4.2.2 Build the application and download it to TWR-P1025

To build the application and download it to TWR-P1025, perform the following steps.

1. To view output messages, click View and select Output.

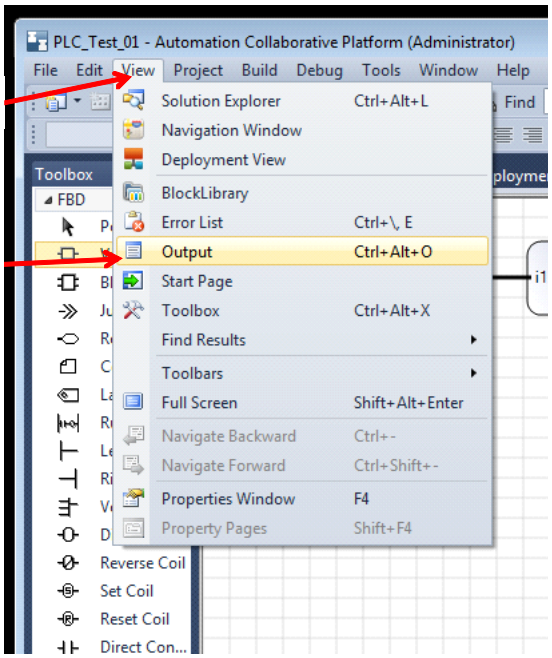


Figure 40. Open the Output form

2. Right-click PLC_TEST_01 and select Build. The Output window opens and shows the status of the build.

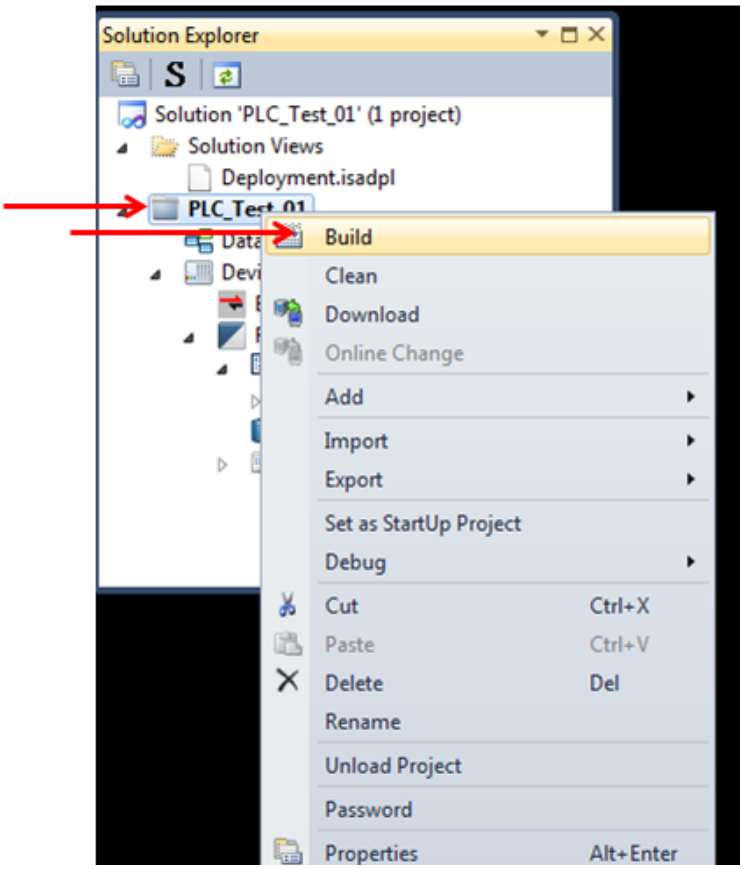


Figure 41. Build the application

3. To download the application to TWR-P1025, right-click PLC_TEST_01 and select Download.

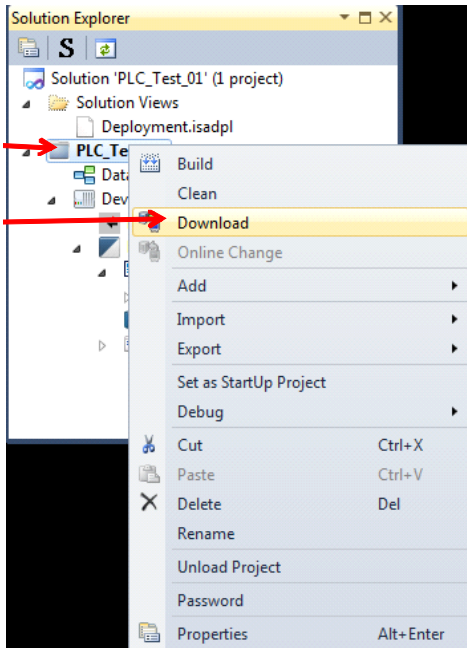


Figure 42. Download the application to TWR-P1025

If the PLC firmware is already running an application then the following is displayed. To stop running the application, select Yes to All.

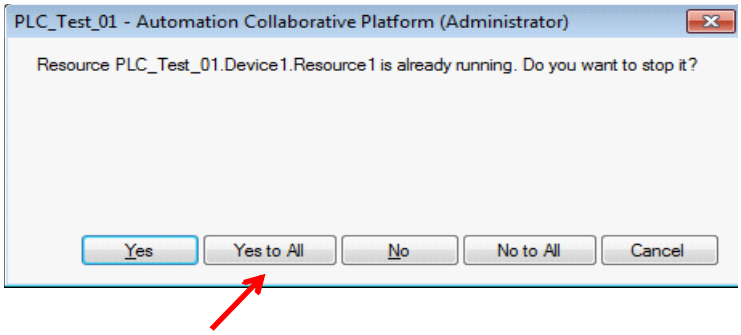


Figure 43. Application already running

When the download completes, the screen below appears and the I2 and O2 status LEDs start flashing.

NOTE

This application is now stored on the TWR-P1025. When the TWR-P1025 is powered on and allowed to boot, this application runs.

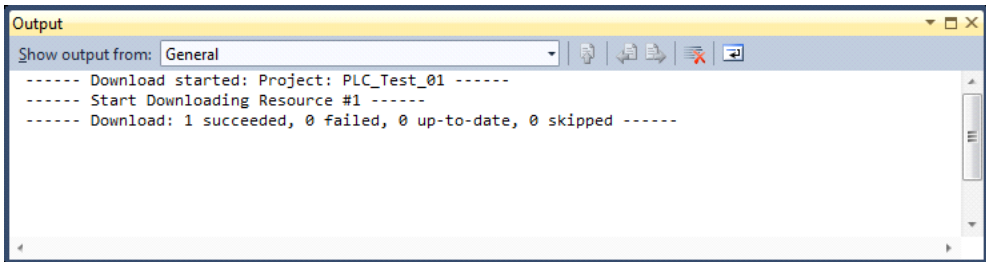


Figure 44. Download successful

5 Additional application examples

In addition to the application in Section 4.2.2, "Build the application and download it to TWR-P1025," the example applications in this section are incorporated into a default application. The project is contained in the directory .../PLC_Reference_Platfrom/PC-utilities/DefaultPLC.

5.1 Direct control application

5.1.1 Direct control application definition

The direct control application uses an INPUT (Slave2_Channel_4) from the target slave to directly control the OUTPUT (Slave3_Channel_4) of target slave devices. The functional block diagram should appear as shown in the figure below.

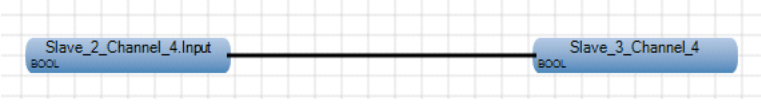


Figure 45. FBD for the direct control application

This figure shows how the direct control application connects to the target slaves.

NOTE

Connecting I4 to +24V causes the O4 status LED to switch to on.
Connecting I4 to 0V causes the O4 status LED to switch to off.

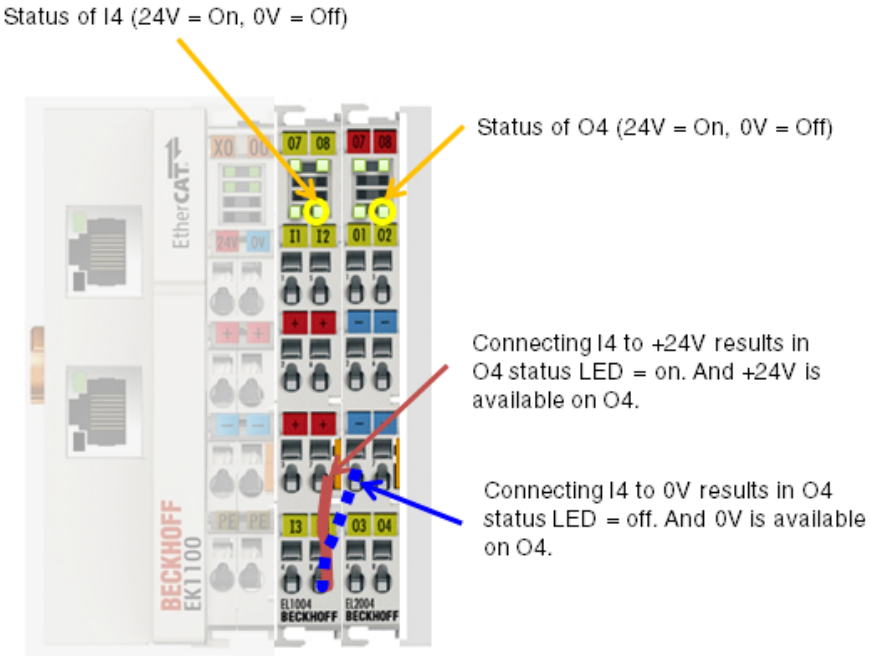


Figure 46. Direct control connects on the target slaves

5.2 Change frequency rate application

5.2.1 Change frequency application definition

The change frequency application uses an INPUT (Slave2_Channel_3) to change the frequency at which an OUTPUT (Slave3_Channel_3) of a target slave device changes state. The blocks used are BLINK, NOT and AND.

This figure shows the FBD setup for the change frequency application.

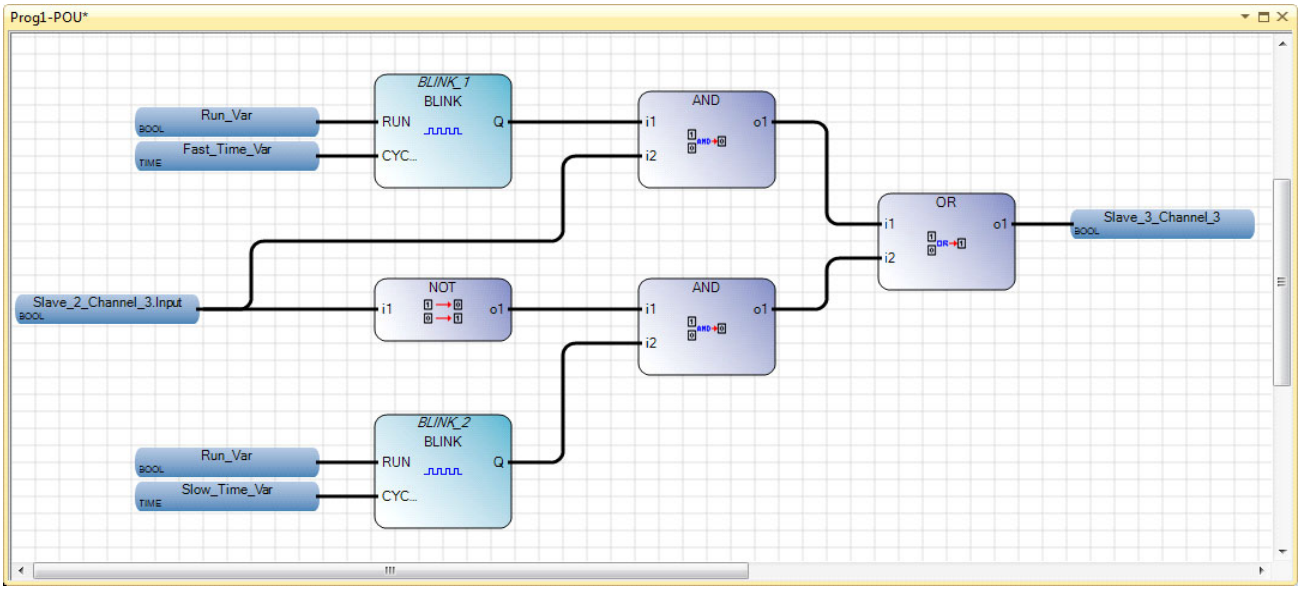


Figure 47. FBD for the change frequency application

This figure shows the slave device connections.

NOTE

Connecting I3 to +24V causes the O4 status LED to switch to on.
Connecting I3 to 0V causes the O3 status LED to switch to off.

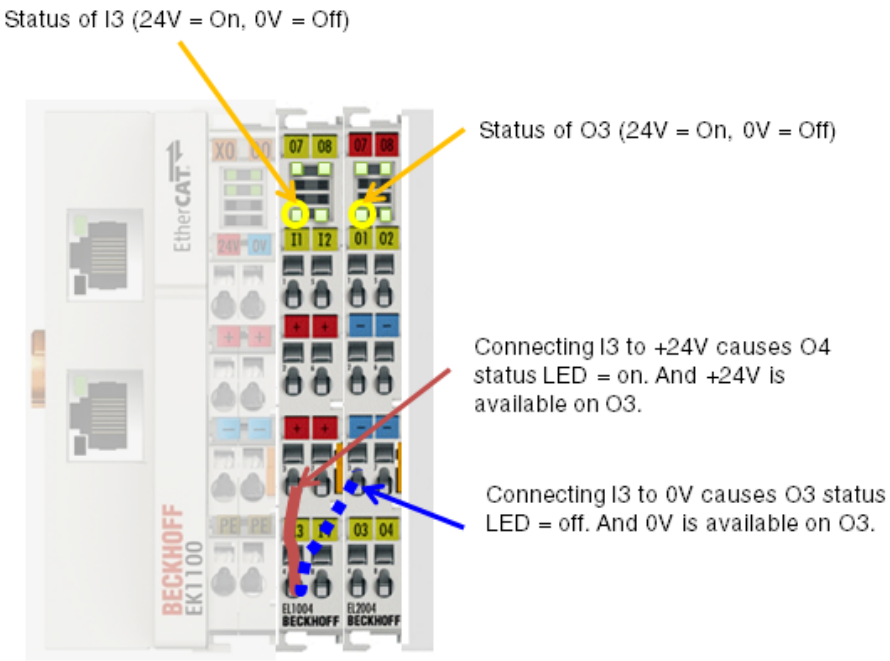


Figure 48. Change frequency connects on the target slaves

To implement the FBD, the user must define and use the three additional global variables. Define these variables, Run_Var, Slow_Time_Var and Fast_time_Var, as shown in Figure 49.

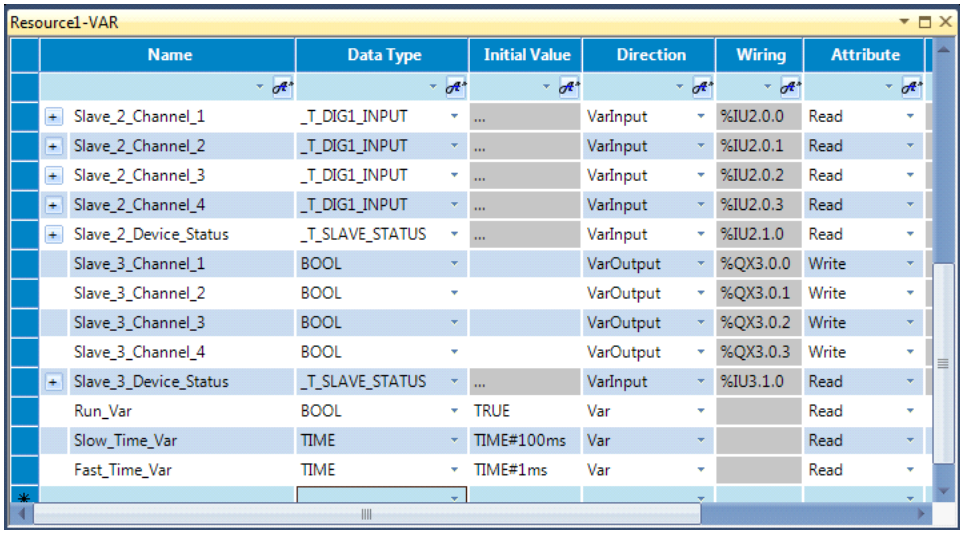


Figure 49. Additional global variables

6 Revision history

This table provides a revision history for this document.

Table 5. Revision history

Rev. number	Date	Substantive change(s)
0	02/2013	Initial public release

How to Reach Us:

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