

# 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

# 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

#### Contents

1.	Benefits of the PLC reference platform 1
2.	Before you begin 3
3.	Set up the PLC reference platform $\ldots \ldots 5$
4.	Evaluate the PLC reference platform 19
5.	Additional application examples



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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.

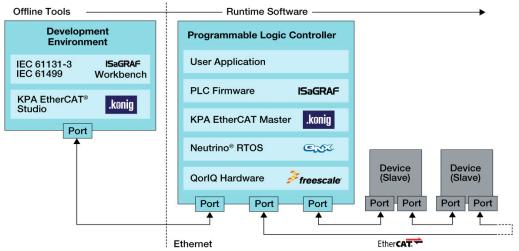


Figure 1. Programmable logic controller reference platform

## **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<sup>TM</sup>
- 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	TWR-P1025 module
	<b>+5V PSU</b>
	USBCable PSU [Console] [TWR-P1025]



Before you begin

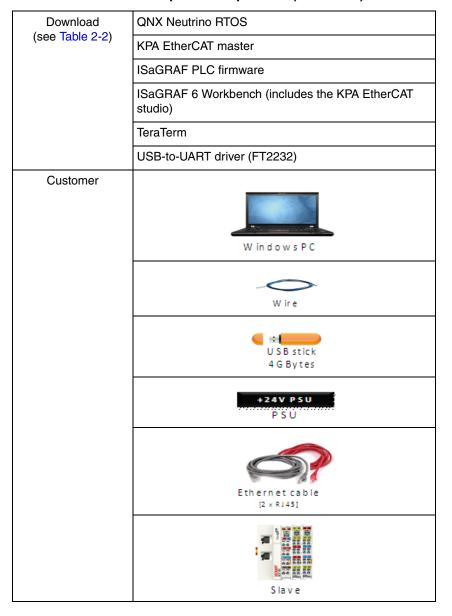


Table 2-1. Required components (continued)

## 2.1.2 Required downloads

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





	Item	Location		
EtherCAT	Beckhoff EK1100 EtherCAT coupler	beckhoff.com/english.asp?ethercat/ek1100.htm		
target slaves	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		

Table 2-2. Required downloads

## 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	<ul> <li>ISaGRAF 6 workbench and PLC firmware</li> <li>PLC reference platform demo</li> </ul>	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.



Set up the PLC reference platform

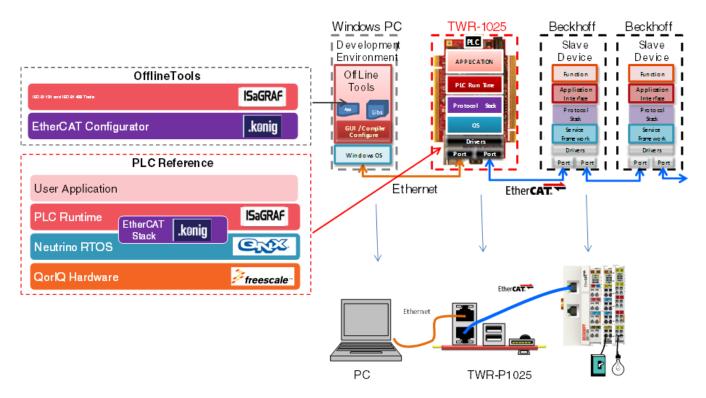


Figure 2. Overview of the PLC reference platform evaluation setup

## 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.



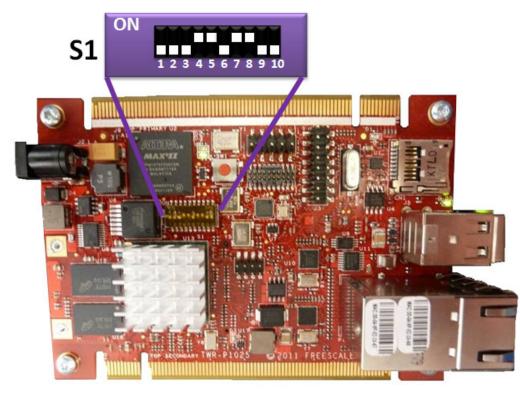
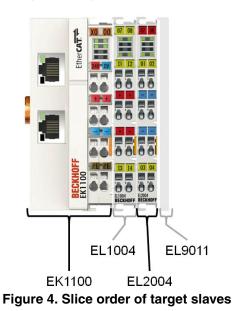


Figure 3. TWR-P1025 switch settings

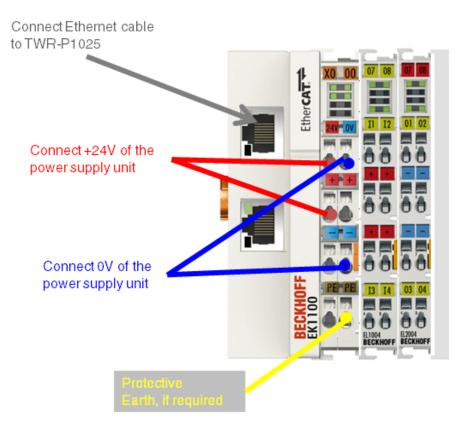
2. Set the slice order of the target slaves as shown in the figure below, where the slaves appear from left to right as follows: EK1100, EL1004, EL2004 then EL9011.



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

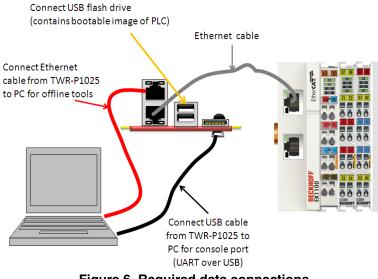


Set up the PLC reference platform



#### 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.

				1.500			
Eile Edit ⊻iew <u>T</u> oo							
Organize 🔻 Include	in library 👻 Share with 👻 Burn	New folder			800	• 🗇	
🔆 Favorites	Name	Date modified	Туре	Size			
E Desktop	ACP Prerequisites	05/11/2012 10:58	File folder				
🗼 Downloads	🍌 Bitmaps	05/11/2012 10:59	File folder				
🔛 Recent Places	퉬 Custom	05/11/2012 10:59	File folder				
	🎍 Plugins	05/11/2012 10:59	File folder				
ز Libraries	퉬 Product	05/11/2012 11:00	File folder				
Documents	Dninstaller	05/11/2012 11:00	File folder				
👌 Music	퉬 Word Viewer	05/11/2012 11:00	File folder				
E Pictures	0x0409	21/05/2009 21:53	Configuration sett	21 KB			
🚼 Videos	autorun.aru	17/04/2012 07:48	ARU File	997 KB			
	Autorun	02/04/2012 07:49	Application	2,818 KB			
🖳 Computer	autorun	02/04/2012 07:23	Icon	100 KB			
🏭 Primary (C:)	a Autorun	17/04/2012 07:48	Setup Information	1 KB			
	BugFixed	11/10/2012 20:40	Text Document	103 KB			
🗣 Network	E Company	13/04/2012 13:47	Icon	100 KB			
	🖳 datal	22/10/2012 20:16	WinZip File	1,175 KB			
	data1.hdr	22/10/2012 20:16	HDR File	21 KB			
	📮 data2	22/10/2012 20:16	WinZip File	71,013 KB			
	ISaGRAF Version	15/12/2011 13:47	Text Document	1 KB			
	A 100-100 JU	22/00/2000 07:00	A	CCA VD			

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.



#### Set up the PLC reference platform



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.

ISaGRAF	×
Setup Type Select the setup type that best suits your needs.	
Click the type of setup you prefer.	
Complete	Description
Custom	Typical installation having default features and paths.
InstallShield	ack Next > Cancel

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.

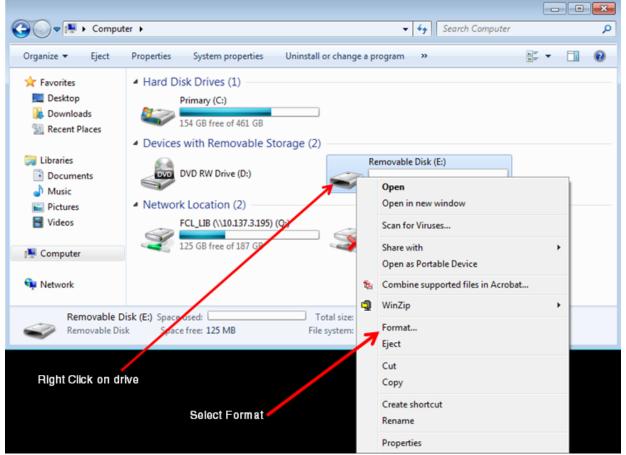


Figure 10. Select Format to format the USB drive

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.



#### Set up the PLC reference platform

Comp	uter > - 4 Search Computer	
Organize 👻 Eject	Properties System properties Uninstall or change a program >>	÷ • 🗊 🔞
🔆 Favorites	<ul> <li>Hard Disk Drives (1)</li> </ul>	
Desktop	Format Removable Disk (E:)	
Recent Places	Cagadity:	
🥽 Libraries	Ele system Removable Disk (E:)	
<ul> <li>Documents</li> <li>Music</li> <li>Pictures</li> </ul>	FAT32 T25 MB free of 125 MB FAT (Default) FAT32	
Videos	exFAT Restore device defaults CS (\\10.137.12.144) (Z:)	
🗣 Network	Volume (abel	
Removable Removable D	Format gotions     Total size: 125 MB       Quick Format     e system: FAT	
	Select FAT32	
	Start Close Click Start	

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



Executable binaries	\isagraf\ETCP \isagraf\EtherCATMaster \isagraf\IsaEcat \isagraf\ISaGRAF \isagraf\IsaRSI \isagraf\IsaVM
Shared libraries	<pre>\Lib\EtcpCmon.so \Lib\IKvbEtcp.so \Lib\IsaIOEcatDriver.so \Lib\IsaIAd.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\IsxsEtcp.so \Lib\IsxsEtcp.so \Lib\IsxsEtcp.so \Lib\IsxsEtcp.so \Lib\IsxsEtcp.so \Lib\IsxsEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so \Lib\IsxSEtcp.so</pre>

Table 3-4. Files rec	uired on the USB fla	sh drive (continued)
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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.



#### Set up the PLC reference platform

Control Panel > All Cont				
Adjust your computer's settings				View by: Small icons 🔻
Action Center	administrative Tools		🖮 Autodesk Plot Style Manager	Autodesk Plotter Manager
AutoPlay	🚯 Backup and Restore		🏘 BitLocker Drive Encryption	itLocker Encryption Options
Color Management	Credential Manager		Pate and Time	👦 Default Programs
Dell Touchpad	📑 Desktop Gadgets		🚔 Device Manager	Devices and Printers
Display	Ease of Access Center		Flash Player	Folder Options
Fonts	🔒 Getting Started		🜏 HomeGroup	IDT Audio Control Panel
Gamma Indexing Options	Maintel(R) Graphics and M	Media	Thtel® PROSet/Wireless Tools	🔁 Internet Options
🕹 Java	E Keyboard		M Location and Other Sensors	Mail
Mouse	Network and Sharing	Center	E Notification Area Icons	Performance Information and Tools
Personalization	Phone and Modem	Network and S	haring Center	Program Download Monitor
Programs and Features	QuickTime		c status, change gs and set preferences	🔗 Region and Language
RemoteApp and Desktop Connections	Run Advertised Progra			Speech Recognition
9 Symantec LiveUpdate	Sync Center		🕎 System	Systems Management
L Taskbar and Start Menu	Troubleshooting		& User Accounts	📑 Windows CardSpace
Windows Defender	Windows Firewall		Windows Mobility Center	Windows Update

Figure 12. Open the Network and Sharing Center

2. Double-click on Change Adapter Settings.



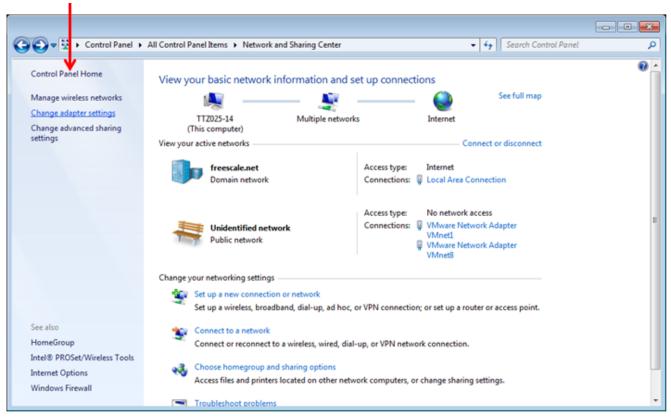


Figure 13. Open Change Adapter settings

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

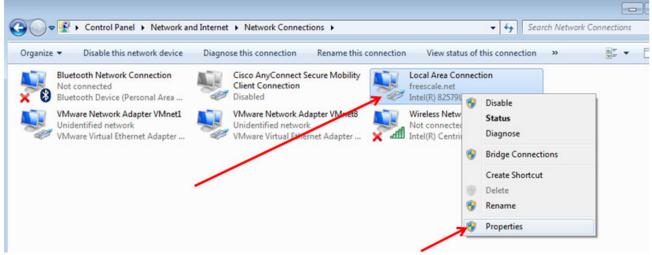


Figure 14. Open the Local Area Connection Properties window

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

Set up the PLC reference platform

🖳 Local Area Connection Properties	
Networking Sharing	
Connect using:	
Intel(R) 82579LM Gigabit Network Connection	
Configure This connection uses the following items:	
<ul> <li>✓ Internet Protocol Version 4 (TCP/IPv4)</li> <li>✓ Link-Layer Topology Discovery Mapper I/O Driver</li> <li>✓ Link-Layer Topology Discovery Responder</li> </ul>	
Install Uninstall Properties	
Description Transmission Control Protocol/Internet Protocol. The default wide area network protocol that provides communication across diverse interconnected networks.	
OK Cancel	

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.



Internet Destant (Version 4 (TCD (D.4)	Properties
Internet Protocol Version 4 (TCP/IPv4)	
General	
You can get IP settings assigned auton this capability. Otherwise, you need to for the appropriate IP settings.	
Obtain an IP address automatical	y
• Use the following IP address:	
IP address:	192.168.10.54
Subnet mask:	255.255.255.0
Default gateway:	
Obtain DNS server address autom	natically
• Use the following DNS server add	resses:
Preferred DNS server:	
<u>A</u> lternate DNS server:	
Validate settings upon exit	Ad <u>v</u> anced
	OK Cancel

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.



Set up the PLC reference platform

© TCP <u>/</u> IP	Hos <u>t</u> : <b>my</b>	nost.example	.com
	V F	ist <u>o</u> ry	
	Service: 🔘 T	elnet	TCP port#: 22
	) <u>s</u>	SH SS	H version: SSH2
	C	ther	Protocol: UNSPEC
Serial	Port: CO	v15: USB Seri	al Port (COM5)

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.

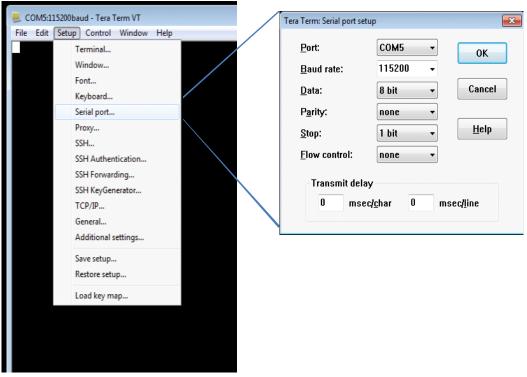


Figure 18. UART COMs settings [Tera Term]

- 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.



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.

	X
This version is for evaluation purposes only. Commercial use is stric	tly prohibited.
ОК	
Source: KPA Studio EtherCAT Trial for freescale (2) Time: 01/11/2012 11:55:44 456ms ID: T00099	
Error parsing ESI file "C:\ProgramData\KPA\EtherCAT Studio\slavelib\Beckhoff EL3xxxxII". Reason: attribute "DScale" is defined for the signal "Value" of the channel "AI Inputs Channel 1" in spite of the sign	
<u>OK</u>	
Source: KPA Studio EtherCAT Trial for freescale Time: 02/11/2012 11:23:38 123ms ID: T00099	
Error parsing ESI file "C:\ProgramData\KPA\EtherCAT Studio\slavelib\Beckhoff EL3xxxml". Reason: attribute "DScale" is defined for the signal "Value" of the channel "Al Inputs Channel 2" in spite of the sign OK	

Figure 19. Non-commercial screen

2. Select New Project.



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

New Project				? 💌
Recent Templa es		Sort by: Default		Search Installed Templates
Installed Templates		ISaFREE_TPL	CAM Projects	Type: CAM Projects
<ul> <li>ISaGRAF 5</li> <li>ISaGRAF installed t</li> </ul>	emplates	QNX_523_L_ECAT	CAM Projects	Template for QNX 6.2 and above with EtherCat support /x86 Version : 5.23
		Simulator	CAM Projects	Memory Model : Large Implementation : Multi-Task
				Features supported: - EtherCat protocol enabled 
<u>N</u> ame:	PLC_Test_01			
Location:	c:\users\ttz025\d	locuments\isagraf 6.1\Projects	•	Browse
Solution:	Create new solut	ion	•	
Solution name:	PLC_Test_01			Create directory for solution

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

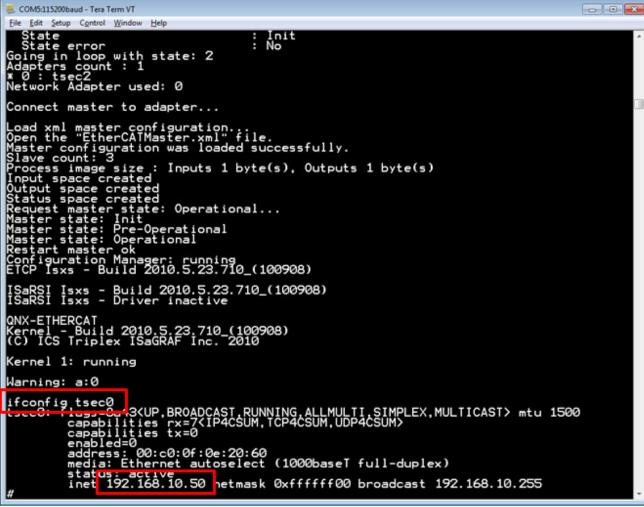


Figure 21. Obtain the IP Address of TWR-P1025

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



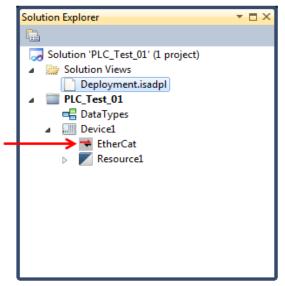


Figure 22. Open KPA studio

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

	Master Process Image Distributed Clocks	
Device1	<ul> <li>A 1. Connection settings for master server</li> <li>Host name</li> <li>192.168.10.50</li> <li>Port number</li> <li>5000</li> <li>A 2. Master parameters</li> </ul>	
	Master name     Device1       Network card     tsec2       Initial master state     INIT       Cycle time (μs)     1000       Mailbox cycle time (μs     5000       Auto recovery timeout     100       Process image display     1000	
	Statistics display perior 1000 Ethernet frame max siz 1514	< •
▲ 6 Error(s) ▲ 11 W	arning(s) 1 0 Message(s) 🛱 Categorized 🔯 Acknowledge Source Description	
	Source         Description           012 11:23:38 123ms         KPA Studio EtherCAT Trial         Error parsing	

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.

		The second s	age Distributed Clocks	
<del></del>	evice.	Append Slave (Y)	ps for master server	
	<b>e</b>	Attach Master	192.168.10.50 5000	
	>	Scan configuration	5	
	Ð	Detach Master	Device1	
		Actions	tsec2	
		Tools	INIT	
		TOOIS	• 1000	
		Import	s 5000 t 100	
		Export	, 1000	
		Clear Master	1000	
	*	Delete Master	2 1514	
		Master diagnostic traces		< >
A 6 [	E	Traces		
▲ 6 Error(s)		Properties	) 🗄 Categorized 🛛 🐼 Acknowledge	
ID			Description (	
▲ <u>T00099</u>	0	2/11/2012 11:23:38 123ms	KPA Studio EtherCAT Trial Error parsing	ESI:

Figure 24. Scan for the slave devices

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

KPA Studio		▼ □ ×
⊡-∰ PLC_Test_01 ⊡-∰ Device1	Slave Variables FMMU/SM Init commands	
Slave 1 (EK1100) 	Name       Slave 3 (         Vendor ID       2 (0x2)         Vendor name       Beckhoff         Type       EL2004 4         Product code       13134651         Revision number       1048576         Product revision       EL2004-0         Physical address       1003         AutoInc address       -2 (0xFFF	=
6 Error(s) 12 Warning(s)	age(s) E Categorized Acknowledge Clear	• •
ID Time T00099 02/11/2012 11:23:38 123ms III	Source Description (select the trace line from the list an KPA Studio EtherCAT Trial Error parsing ESI file "C:\ProgramData\KPA\Ether	
Studio Output Master Output Emergency		

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.

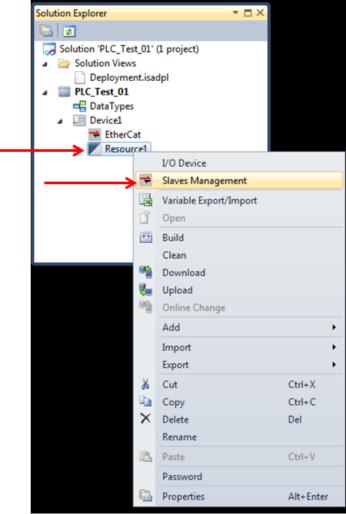


Figure 26. Select Slaves Management option

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



	*
Resource1 Attached slaves	
Slave 2 (EL1004)(EL1004 4Ch. Dig. Input	:24V, 3ms)
4	
	Attached slaves

#### 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.

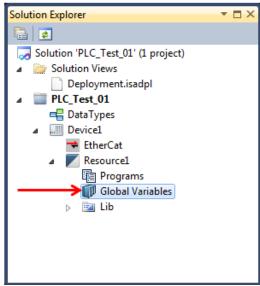


Figure 28. Display the global variables

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



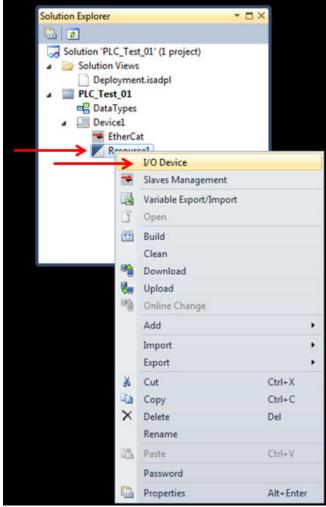


Figure 29. Open the I/O Device window

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

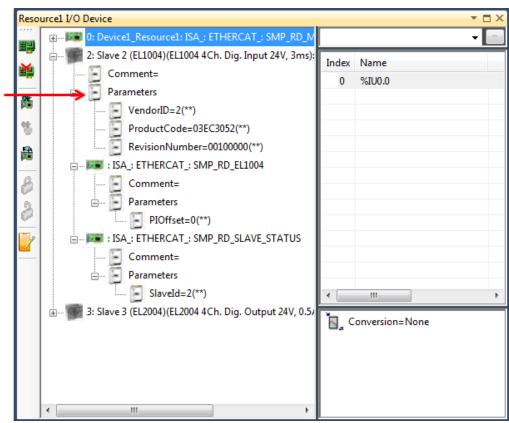


Figure 30. I/O Device window

# 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).

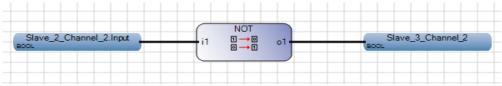


Figure 31. Simple flasher application



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.

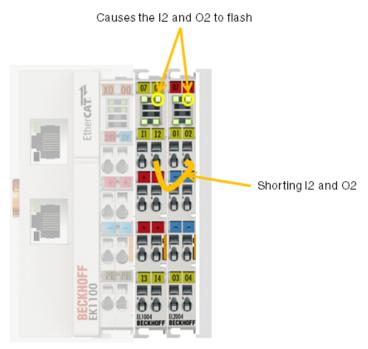


Figure 32. Simple flasher connects on target slave devices

## 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.



Solution Explorer			* 🗆 X		
<ul> <li>Solution 'PLC_Test_</li> <li>Solution Views</li> <li>Deployment</li> <li>PLC_Test_01</li> <li>DataTypes</li> <li>Device1</li> <li>EtherCat</li> <li>Resource</li> <li>Prog</li> </ul>	isadp.				
- Glob	>	Add		• 🗄	New SFC : Sequential Function Chart
D 🚾 Lib		Paste	Ctrl+V		New ST : Structured Text
		Properties	Alt+En	iter 🚥	New LD : Ladder Diagram
	_	_	_		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.

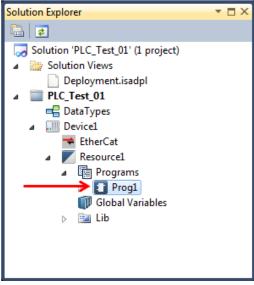


Figure 34. Open the FDB

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.



File Edi	View	Project Build Deb	ug Format Tools	Window Help	
i 🛅 - 🖮	2	Solution Explorer	Ctrl+Alt+L	Find	
:	5	Navigation Window			/ 🥵 🕾 🕾 🛍 🖭 🤇
Navigation		Deployment View		ployment.isadpl*	Start Page
Global	li 📾	BlockLibrary		pioyment.isadpi	Start Page
	- 🐻	Error List	Ctrl+ E		
<b>Deploy</b>		Output	Ctrl+Alt+O		
		Start Page			
	N.	Toolbox	Ctrl+Alt+X		
		Find Results	•		
		Toolbars	•		
		Full Screen	Shift+Alt+Enter		
	43	Navigate Backward	Ctrl+-		
	Ξ,	Navigate Forward	Ctrl+Shift+-		
	<b>P</b>	Properties Window	F4		
		Property Pages	Shift+F4		

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.



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Ð	Variable							
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->>	Jump							
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5	Right Pow	Clabal	Variables Descurrent 1					
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-0-	Direct Coil		Name	Data Type	Dimension	Alias		
-	Sector Management			ot - ot	· d*	· 01*		
\$	Reverse Coil		Slave_2_Channel_1	_T_DIG1_INPUT -				
•	Set Coil		Slave_2_Channel_2	_T_DIG1_INPUT +				
-@-	Reset Coil		Slave_2_Channe					
41	Direct Con		Slave_2_Channel_3	_T_DIG1_INPUT *				
-11-	Reverse C		Slave_2_Channel_4	_T_DIG1_INPUT -				
44	Pulse Risin		Slave_2_Device_Status	_T_SLAVE_STA1 .				
-14-	Pulse Falli		Slave_3_Channel_1	BOOL -				
Gene	ral		Slave_3_Channel_2	BOOL -				
			Slave_3_Channel_3	BOOL -				
	re are no		Slave_3_Channel_4	BOOL -		_		
	controls in roup. Drag		Slave_3_Device_Status	_T_SLAVE_STA1 -				
an iter	m onto this							
	o add it to							
the	toolbox.							

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.



٩

Toolbox • 9 ×		
# FBD	Prog1-POU" Resource1-VAR Deployment.isadpl" Start Page	
Pointer		
Variable	Cours 2 Coursed 2 hours	
E Block	Slave_2_Channel_2.inp.t	
->> Jump		
- Return		
Comment		
C Label	Block Selector (Prog1)	
He Rung	NOT (PLC_Test_01)	
Left Power	Search NOT	Show Paramete
		Show Paramete
Vertical Bar O Direct Coil	Name Type Category Comment	
Or Direct Coll     Or Reverse Coll	NOT Boolean operations Assigment of the negation to a Boolean variable	
-®- Set Coil	NOT_MASK Binary operations bit to bit negation	
- Reset Coil		
+I+ Direct Con		
-1/- Reverse C		
++ Pulse Risin		
++ Pulse Falli		
▲ General		
There are no usable controls in		
this group. Drag		)
an item onto this text to add it to		OK Cancel

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.

3 <b>- 1</b> - 🖬 🥔 🕷		💶 💭 🕶 🖏 🔜 Fir					•   🧟 🖉 🛠 •	i 🗂 📇 🗻 Online	- >
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FBD									
Point									
O Variable	Slave_2_Channe	al 2 log t		TOT		~			
Block	800.		i1 8	-B 01-		>	4		
->> Jump			-						
<ul> <li>Return</li> </ul>									
Comment	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Variable Selector							
Label		lame	Туре		Global Scop	~	Local Sco	~	
ee Rung		Slave 3 Channel 2	BOO		Resource1		<ul> <li>N/A</li> </ul>	•	
Left Power									
Right Pow		John Mariables - Description							
+ Vertical Bar		ilobal Variables - Resource	Local				ectly Hepresented Va	stables - Hesouro	
-O- Direct Coil		Name		Data Type	Dimension				
- Reverse Coil			·		· 101	~ of*			
		<ul> <li>Slave_2_Channel</li> <li>Slave_2_Channel</li> </ul>		_T_DIG1_INPUT -					
				_T_DIG1_INPUT + _T_DIG1_INPUT +		_			
-B- Set Coil			2						
+ Reset Coil		<ul> <li>Slave_2_Channel</li> <li>Slave_2_Channel</li> </ul>	4	T DIG1 INPUT -					
+ Reset Coil + Direct Con		<ul> <li>Slave_2_Channel</li> </ul>		_T_DIG1_INPUT + _T_SLAVE_STA1 +					
+ Reset Coil + Direct Con + Reverse C			Ratus	_T_DIG1_INPUT + _T_SLAVE_STA1 + BOOL +					
<ul> <li>Reset Coil</li> <li>Direct Con</li> <li>Reverse C</li> <li>Pulse Risin</li> </ul>		Slave_2_Channel     Slave_2_Device_5	Ratus 1	_T_SLAVE_STA1 *					
<ul> <li>Reset Coil</li> <li>Direct Con</li> <li>Reverse C</li> <li>Pulse Risin</li> <li>Pulse Falli</li> </ul>		Slave_2_Channel,     Slave_2_Device_3     Slave_3_Channel,     Slav	Ratus 1 2 3	_T_SLAVE_STAT + BOOL + BOOL + BOOL +				_	
Reset Coil     Direct Con     Reverse C     Pulse Risin     Pulse Falli		Slave_2_Channel     Slave_2_Device_     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel	Ratus 1 2 3 4	_T_SLAVE_STA1 + BOOL + BOOL + BOOL + BOOL +					
<ul> <li>Reset Coil</li> <li>Direct Con</li> <li>Reverse C</li> <li>Pulse Risin</li> <li>Pulse Falli</li> <li>General</li> </ul>		Slave_2_Channel,     Slave_2_Device_3     Slave_3_Channel,     Slav	Ratus 1 2 3 4	_T_SLAVE_STAT + BOOL + BOOL + BOOL +					
Reset Coil     Direct Con     Reverse C     Pulse Risin	_	Slave_2_Channel     Slave_2_Device_     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel	Ratus 1 2 3 4	_T_SLAVE_STA1 + BOOL + BOOL + BOOL + BOOL +					
Reset Coil     Direct Con     Pulse Risin     Pulse Risin     Pulse Risin     General     There are no usable controls in     this group. Drag		Slave_2_Channel     Slave_2_Device_     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel	Ratus 1 2 3 4	_T_SLAVE_STA1 + BOOL + BOOL + BOOL + BOOL +					
Reset Coil     Direct Con     Preverse C     Pulse Risin     Pulse Risin     General     There are no     usable controls in     this group. Drag     an item onto this		Save 2 Channel     Save 2 Channel     Save 2 Device 2     Save 3 Channel     Save 3 Channel     Save 3 Channel     Save 3 Channel     Save 3 Device	Ratus ,1 ,2 ,3 ,4 Ratus	_T_SLAVE_STA1 + BOOL + BOOL + BOOL + BOOL +					
Reset Coil     Direct Con     Pulse Risin     Pulse Risin     Pulse Risin     General     There are no usable controls in     this group. Drag	_	Slave_2_Channel     Slave_2_Device_     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel     Slave_3_Channel	Ratus 1 2 3 4	_T_SLAVE_STA1 + BOOL + BOOL + BOOL + BOOL +					

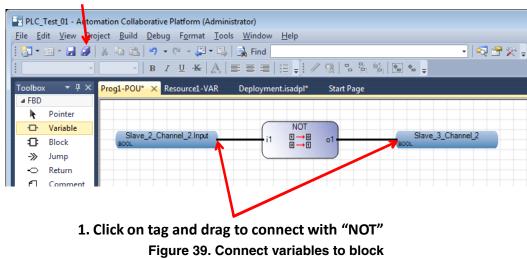
Figure 38. Add output variable Slave3\_Channel\_2 BOOL to FBD

## 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.

2. Save Project

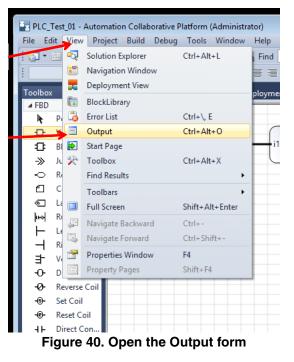




## 4.2.2 Build the application and download it to TWR-P1025

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

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



2. Right-click PLC\_TEST\_01 and select Build. The Output window opens and shows the status of the build.



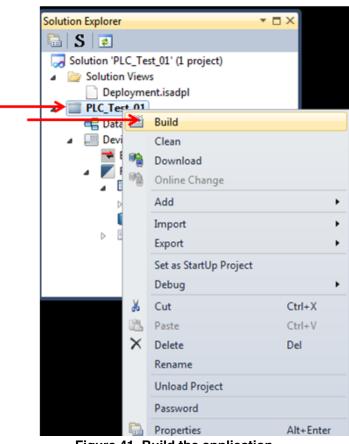


Figure 41. Build the application

3. To download the application to TWR-P1025, right-click PLC\_TEST\_01 and select Download.

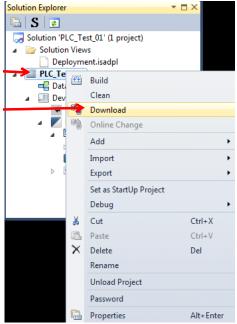


Figure 42. Download the application to TWR-P1025



#### Additional application examples

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

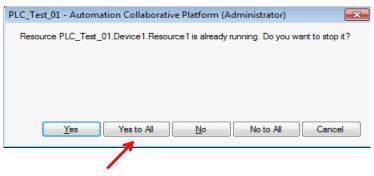


Figure 43. Application already running

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.

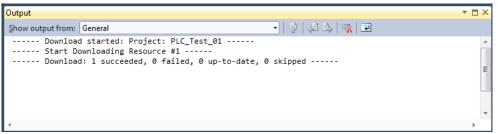


Figure 44. Download successful

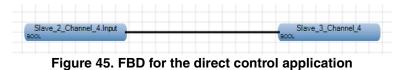
# 5 Additional application examples

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.







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.

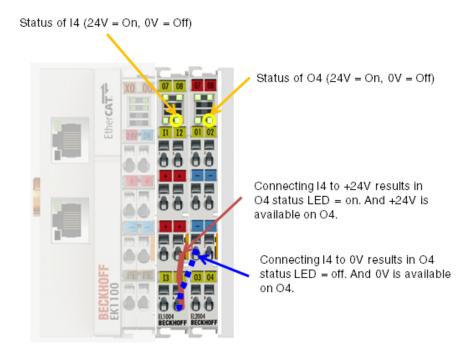


Figure 46. Direct control connects on the target slaves

## 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.



#### Additional application examples

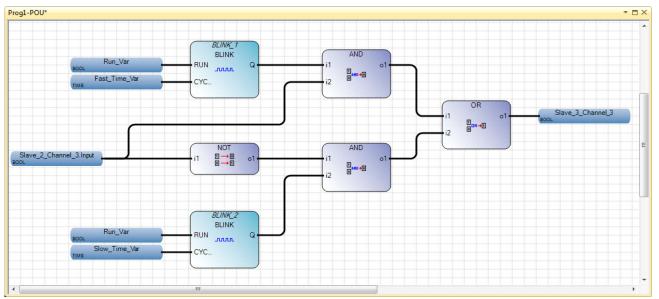
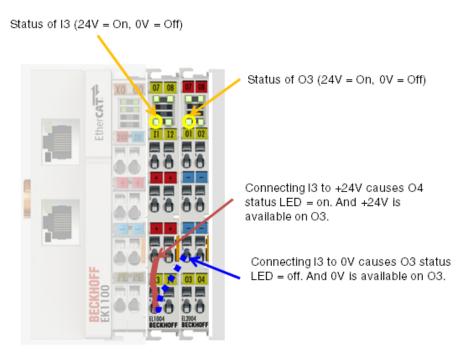


Figure 47. FBD for the change frequency application

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.





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.



	Name	Data Type		Initial Value	Direction	n	Wiring	Attribut	te
	-	A*	A	- A*		A*	- A*	•	A
+	Slave_2_Channel_1	_T_DIG1_INPUT	-		VarInput	-	%IU2.0.0	Read	-
+	Slave_2_Channel_2	_T_DIG1_INPUT	-		VarInput	*	%IU2.0.1	Read	-
+	Slave_2_Channel_3	_T_DIG1_INPUT	•		VarInput	-	%IU2.0.2	Read	-
+	Slave_2_Channel_4	_T_DIG1_INPUT	-		VarInput	-	%IU2.0.3	Read	-
+	Slave_2_Device_Status	_T_SLAVE_STATUS	•		VarInput	-	%IU2.1.0	Read	-
	Slave_3_Channel_1	BOOL	-		VarOutput	-	%QX3.0.0	Write	*
	Slave_3_Channel_2	BOOL	•		VarOutput	-	%QX3.0.1	Write	-
	Slave_3_Channel_3	BOOL	-		VarOutput	-	%QX3.0.2	Write	-
	Slave_3_Channel_4	BOOL	+		VarOutput	+	%QX3.0.3	Write	+
+	Slave_3_Device_Status	_T_SLAVE_STATUS	-		VarInput	-	%IU3.1.0	Read	-
	Run_Var	BOOL	+	TRUE	Var	+		Read	+
	Slow_Time_Var	TIME	-	TIME#100ms	Var	-		Read	•
	Fast_Time_Var	TIME	+	TIME#1ms	Var	+		Read	+
e.			-			-			

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



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