## Chapter 22 ROBOTS and VISION and PLCs Oh My

#### Introduction



From left to right it is Josh Chaney, Sam Kahle, Wyatt Smith, Derek Rose, Tanner Durham

**"How to Win Connect 4 Every Time, According to the Computer Scientist Who Solved It -** <u>Lauren Cahn</u>Updated: Nov. 01, 2023



#### Ready to discover new expert-approved Connect 4 strategies? Learn how to win Connect 4 and conquer your opponent every time.

Since 1974, the board game Connect 4 has been delighting people of all ages. While Hasbro bills it as fun for ages 6 and up, winning Connect 4 is by no means mere child's play. Sure, school-age kids have been keeping this <u>classic board game</u> flying off the shelves for 50 years, but it is a mind-bender of a game. So much so that how to win Connect 4 was the topic of Dutch computer scientist Victor Allis's master's thesis. In fact, he's credited with literally solving the game in 1988.

"What is beautiful about Connect 4 is that [while it's not simple], it's not so complicated that it's difficult to learn," says Allis. "You can play many, many times and still be discovering new strategies."

Connect 4 has been a cultural phenomenon for decades, with life-size versions available for pub, office and backyard play, as well as online versions that challenge those who are "game" to attempt the near impossible—beating AI. To get the inside scoop on how to always win Connect 4 (or at least most of the time), we got tips from Allis and other leading experts on <u>strategy games</u>. So if you prefer to compete in (and win at) <u>games for two people</u>, you've come to the right place. Here's what you need to know."

Why are we introducing this chapter with a Capstone Group and a Game?

Simply because they were the first group to successfully combine a system of PLC, Vision and Robot in a single application and make it work. There had been other attempts that came close but this was the first that truly linked all three successfully.

It has taken a long time to break through to write a  $22^{nd}$  chapter to this text. The first twenty came pretty fast, but chapter 21 was a stretch with AI. And that was all that was ever envisioned for the topic of automation. But, along came robots and then vision and they had to be included. Today all three: the PLC, the robot and vision are used to control many processes and the inclusion of all three should be a standard for most texts.

The purchase of the equipment below has just occurred and will be part of the ongoing move to have a variety of different robotic arms, plcs and vision systems. We have has Fanuc robots for a number of years but recently added the robot shown above – the CRX collaborative Fanuc robot (white one). The purchase of a new Universal collaborative robot will add to the group of robots with its own programming style and hardware.

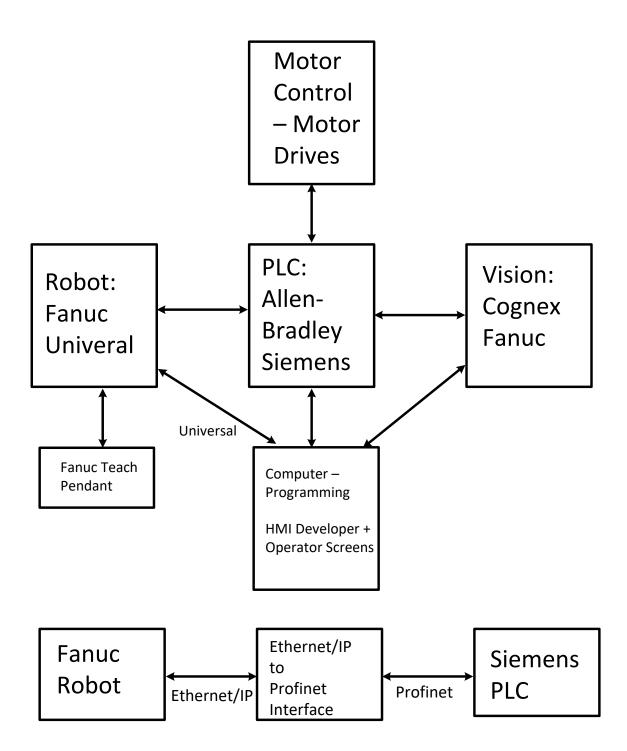
The new vision system – the Cognex 3805 – is a step toward AI with the promise of full AI down the road. It has the full features of the 7802 cameras previously purchased.

The following is a description of the purchases just made for the robotics/plc/vision course to truly take on the description of the capstone project above.

001	1.00	0.00	1.00 EA	6ES72151AG404AB1	EA		2,020.0000	2,020.00
			1.0	TRAINING SIX-PACK CPU 1215C DC/DC/DC	2	1.0		
				INCLUDES 6X CPU 1215C DC/DC/DC & 6X				
				DVD STEP 7 BASIC SW & 6X PN CBL				
				LEAD TIME: 28-30 WEEKS ARO				
002	6.00	0.00	6.00 EA	6EP13321LB00	EA		93.8200	562.92
			1.0	SITOP PSU100L 24V/2.5A		1.0		
				LEAD TIME: 3-4 WEEKS ARO				
003	6.00	0.00	6.00 EA	6GK50050BA001AB2	EA		113.0000	678.00
			1.0	SCALANCE XB005 UNMANAGED		1.0		
				INDUSTRIAL ETHE				
				EMI STOCK				
004	6.00	0.00	6.00 EA	1722.122MASTER	EA		1,198.0000	7,188.00
			1.0	HILSCHER NT 151-RE-RE/+ML		1.0		
				LOADABLE DEVICE FOR ANY				
				SLAVE/MASTER OR SLAVE/SLAVE				
				PROTOCOL COMBINATION				
				LEAD TIME: 2-3 WEEKS ARO				
005	10.00	0.00	10.00 EA	30-3060-3M	EA		95.2857	952.86
			1.0	8020 300MM X 60MM T-SLOT EXTRUS 3M		1.0		
				LEAD TIME: 2-3 WEEKS ARO				

Item	Product Id	Description	Qty	Net Unit Price	Net Total (Extended)
1	IS3805MP- 14621-LAB	In-Sight 3805 (5MP) Mono Performance LAB Model with 16mm High Speed Liquid Lens, Multi Torch Light, & Diffused Cover	3	6,360.00	19,080.00
2	CCB-PWRIO-05	Cognex Power I/O Cable, IP67, M12 to 12 Flying Leads, 5 meters (15 feet)	3	114.00	342.00
3	CCB-84901- 2001-02	Cognex X-Coded Ethernet Cable, IP67, M12 to RJ45, 2 meters (6 feet)	15	93.00	1,395.00

				Standard	EDU	
[tem#	Qty	Description	Part #	List Price	Price	Extended
1	1	Universal Robot 5e	110305	\$36,515.00	\$29,062.00	\$29,062.0
		Includes: Integrated Force Torque Sensor				
		Payload: 11 Pounds				
		Reach: 33.5 Inches				
		6 Rotating Joints DOF				
		Robot Weight: 45.4 Pounds				
		I/O Ports: Digital In (2) Digital Out (2) Analog I				
		Control Box I/O Ports: Digital In (16) Digital Ou	Analog Out (2)			
		Robotiq Grippers				
2	1	Hand-E Gripper	HND-ES-UR-KIT	\$4,725.00	\$4,181.00	\$4,181.0
		ALL UR Package Includes:				
		Access to the UR Online Academy- FREE				
		Access to the UR EDU Resources - FREE				



Collaborative W Fanuc Robot		ree Yellow Fanuc bots
Internet		
Ethernet	I/P	Etherne
Vision Or	nly	ernet I/P

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# S7-1200 Communication to Fanuc Robot with EIP Interface and Starting the Robot Via the PLC - Michael Smith - MIME5450

#### Objective

The objective of this lab is to establish communication between a Siemens S7-1215 PLC that has a ProfiNet interface to a Fanuc Robot R30-ib controller that has an Ethernet IP interface and to add logic to start the robot.

#### Method

The method I used to accomplish this task was to use the LCCF\_EnetScanner which allows the S7-1215 to function as an ethernet IP scanner rather than using a physical device to link the PLC's ProfiNet interface to the robot controllers EIP interface. The upside of this method is that no physical device is required and the configuration is not to difficult. The downside is that this block uses a substantial amount of the PLC's memory.

#### LCCF Enet Scanner Library

The LCCF\_EnetScanner block is not standard in TIA Portal. A library containing the block and UDTs will need to be downloaded from Siemens at the below website and installed as a library in TIA Portal. An example program already containing the library can also be downloaded from this web address.

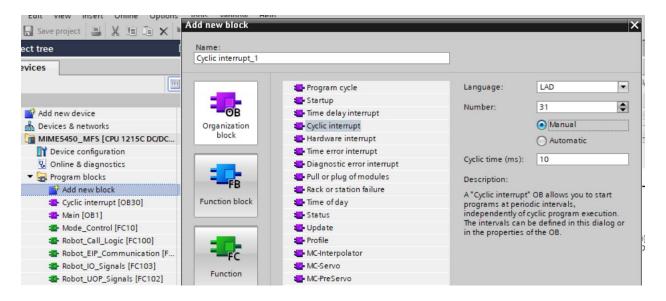
<u>https://support.industry.siemens.com/cs/document/109782314/ethernet-ip-scanner-</u> <u>%E2%80%93-connecting-third-party-i-o%E2%80%99s-using-ethernet-ip?dti=0&lc=en-</u> WW

A library can be installed in a TIA Portal by clicking on the 'Libraries' tab on the right hand side of the screen and then pressing the 'Create New Library' icon. A pop up box will be displayed were the downloaded library previously mentioned can be selected and installed.

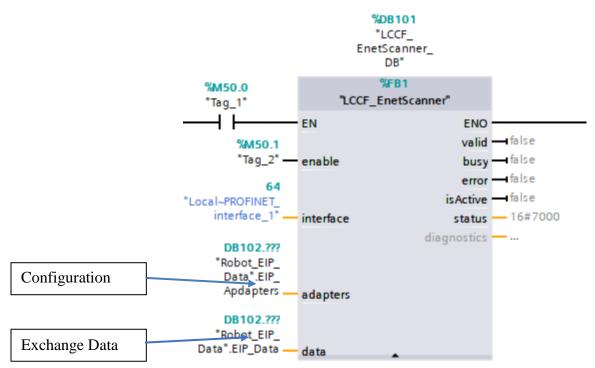
Create new global library Library name : Path: Version: Author: Comment:	Library1 C:\Users\NZ8MUG.GCC\Documents\Automation\L( V16 NZ8MUG	<ul> <li>Global libraries</li> <li>Image: Second state of the seco</li></ul>	Tasks 🔤 Li 🐂 les
	Create Cancel		Add-ins

LCCF\_EnetScanner Programming and Configuration

I chose to program the LCCF\_EnetScanner block in a cyclic interrupt so the first thing I did was to create a cyclic interrupt block where the call for the LCCF\_EnetScanner block will take place.



Another task that needed to be completed before any programming could be performed was to create a data block that will contain the configuration data and data that will be exchanged between the PLC and robot.

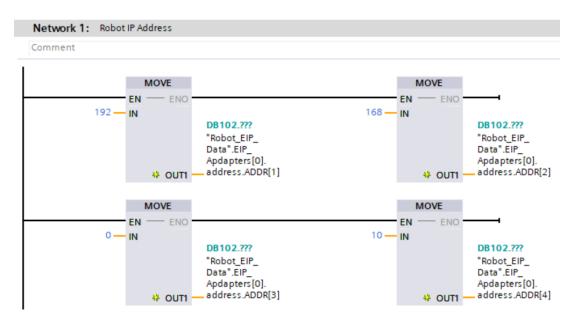


When the before mentioned library was created not only was the scanner function block installed but several UDTs or data types were also installed. The data block will

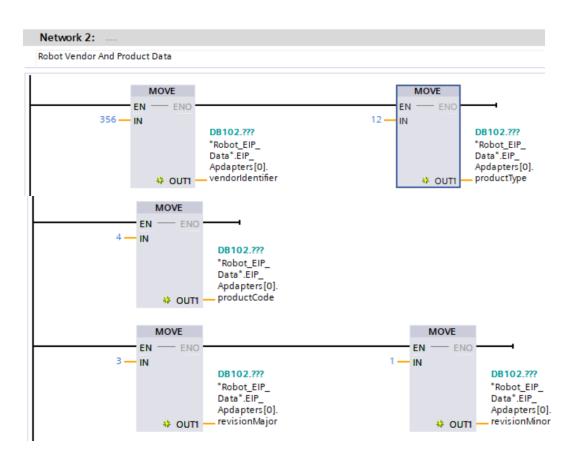
need to use these data types. An array of the data type LCCF\_typeEnetAdaptConfig and an array of data type LCCF\_typeEnetAdaptData will need to be contained within the data block. For this lab the array only needed to contain 2 elements. I am not sure why the array is necessary when only one instance of the scanner is used but it is. For my labe I used 102 for the data block number and named the block 'Robot\_EIP\_Data' See the image below for the structure of the data block used in my lab.

			Robot_EIP_Data					
PLC data types	^	-	Name			Data type	0	
🗳 Add new data type		1		•	Static			
🕨 🔚 data types		2		•	EIP_Apdapters	Array[01] of "LCCF_typeEnetAdaptConfig"		
▼ 1200		3		•	EIP_Data	Array[01] of "LCCF_typeEnetAdaptData"		
🔻 🔚 data types								
LCCF_typeDiagnostics								
LCCF_typeEnetAdaptConfig								
🚯 LCCF_typeEnetAdaptData								

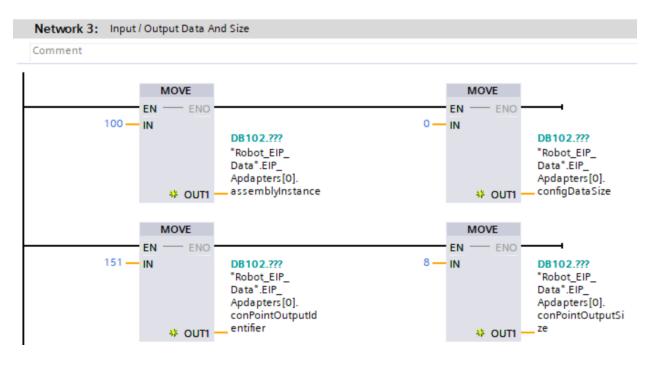
The programming in the cyclic interrupt where the LCCF\_EnetScanner will be called will require additional programming that contains configuration parameters for the scanner connection. Below is the required programming to set the parameters for the scanner. In the first network I set the IP address of the robot controller as 192.168.0.10. Notice that the IP address octet values are being moved into the data block previously created.

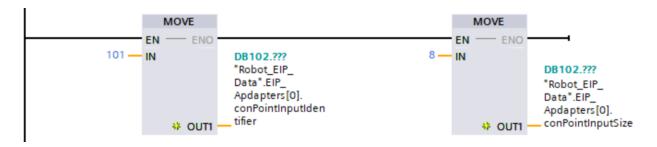


In network 2 more parameters are set pertaining specifically to the Fanuc robot such as the vendor ID and product data. Note that the LCCF\_EnetScanner block can be used to connect to any ethernet IP device not just the Fanuc robot controller. The values that the following parameters are set to can found in the corresponding devices EDS file. The values shown in the image below were found in the EDS file for the Fanuc R30-ib robot controller.



Network 3 contains parameters values pertaining to the data exchange between the PLC and robot controller. Notice in the image below that the size of the data exchange is 8 bytes for both the inputs and outputs.

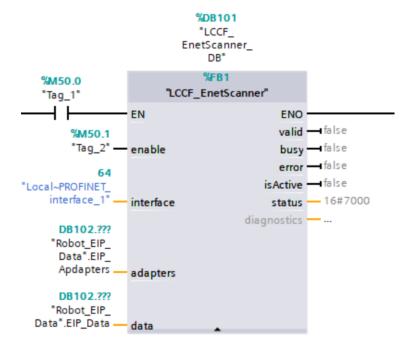




In network 4 the parameter for the rate at which the data is to be exchanged is set. Notice in the image it is set to 20ms.

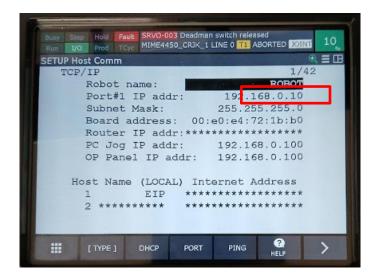
Network 4:	
Comment	
T#20ms — IN	DB102.??? "Robot_EIP_ Data".EIP_ Apdapters[0]. packetInterval

Finally in network 5 the LCCF\_EnetScanner block is called. If communication is succesfully established the value at the status output will be a hex value of 7000.



#### **Robot Setup**

The robot controller used in this lab needed several parameters changed to establish communication with the PLC. The first step was to set the IP address of the robot. This can be done from the teach pendant by selecting menu / setup / host com. Notice I set the IP address to 192.168.0.10.



Run 1/O Prod TCyc Mir I/O EtherNet/IP		and the second second	STATISTICS OF THE	🕀 🖽
EtherNet/IP Lis	st (Ra	ck 89)	1	./64
Description	TYP	Enable	Status	Slot
Connection1	ADP	TRUE	RUNNING	1
Connection2	ADP	FALSE	OFFLINE	2
Connection3	ADP	FALSE	OFFLINE	3
Connection4	ADP	FALSE	OFFLINE	4
Connection5	ADP	FALSE	OFFLINE	5
Connection6	ADP	FALSE	OFFLINE	6
Connection7	ADP	FALSE	OFFLINE	7
Connection8	ADP	FALSE	OFFLINE	8
Connection9	ADP	FALSE	OFFLINE	9
ConnectionA	ADP	FALSE	OFFLINE	10
				-

From the screen shown in the image above I selected 'config' to display the screen shown in the image. From this screen the amount of data in words that is exchanged between the PLC and robot controller can be adjusted. However, for connection 1 it appears that it is set at 4 words for both the input and output data.

Busy Step Hold Fault SRVO-003 Deadman switch released Run 1/0 Prod TCyc MIME4450_CRJK_1 LINE 0 11 ABORTED DOINT	10
I/O EtherNet/IP	€.Œ
Adapter config(Read-only):	
Description : Connection1	
Input size (words) : 4	
Output size (words) : 4	
Alarm Severity : WARN	
Scanner IP : 192.168.0.3	
API O=>T : 20	
API T=>0 : 20	
HELP	

Also, from the screen above if the PLC and robot controller have successfully established a connection then the IP address of the PLC will be displayed in the Scanner IP value. For my lab I set to PLC IP address to 192.168.0.3 and you can see that is visible on the screen.

Next I configured a range of inputs and outputs to signal to the PLC. In the lab I configure the input and output group 1 for rack 89, slot 1 starting at bit 17. Rack 89 is a

Fanuc defined code for an Ethernet IP connection and I set the start bit to 17 because the user inputs and outputs will be assigned to bits 1 through 16.

Busy Step Run <b>1/0</b>	Street of the street of the street	ault SR\ Cyc MIN	VO-003 ME4450_	Deadman _CRJK_1 L	switch rei INE 0 <mark>T1</mark>	leased ABORTED	D'AR	10		
I/O Digital	Out							e. 🖪		
						1	L/8			
#	F	RANGE		RACK	SLOT	START	STAT.			
1	DO[	1-	48]	89	1	17	ACTIV			
2	DO[	49-	80]	0	0	0	UNASG			
3	DO[	81-	84]	48	1	21	ACTIV			
4	DO[	85-	100]	0	0	0	UNASG			
5	DO[ 1	L01-	120]	48	1	1	ACTIV			
6	DO[ ]	L21-	184]	89	1	1	ACTIV			
7	DO[ 1	L85-	264]	89	2	1	ACTIV			
8	DO[ 2	265-1	024]	0	0	0	UNASG			
Device Name : EthernetIP										
	[TYPE]	MONI	TOR	IN/OUT	DELETE	E 🥐				

I configured the digital inputs with the same settings as the outputs. The user inputs and outputs I configured as a range of 1 -16 a rack value of 89 a slot value of 1 and a start value of 1. With these settings the first 16 bits from the PLC sent to the robot will be for user inputs and the next 48 bits will be for general digital inputs. Below is an image of the user output configuration.

Busy Run	Step I/O	Hold Prod	Fault TCyc MIN	1E5450_	MFS LINE	E 7 AUTO	RUNNING	ov <b>A</b>	50
I/O U	OP O	ut							* Œ
							1	1/2	
	Ŧ		RANGE		RACK	SLOT	START	STAT.	
	1	] OU		16]	89	1	1	ACTIV	
	2	lon	17-	20]	0	0	0	UNASG	
	evi	ce Na	ame : 1	Sthe	rnetII	2			
		[ TYPE ]		TOR	IN/OUT	DELETI	E 🤗 HEL?	0	

The next step was to modify a few settings from the robot pendant that will allow the robot to be started remotely via the user input signals from the PLC. The first few settings can be accessed from the system configuration screen which can be accessed on the teach pendant by pressing the Menu key then System and then Configuration.

From this screen setting 7, Enable UI Signals, needs to be set to True and setting 42 needs to be set to remote. Setting 44 I set to Simple but I am not sure if this is required.



Next, I had to configure the method by which the robot is started. This can be accessed from the Program Select screen on the Teach Pendant by pressing the Menu key and then Setup followed by Program Select. From this screen set the Program Select Mode to Other and the Production Start Method to UOP. With 'OTHER' highlighted press Detail on the pendant. This will display another screen allowing for a program to be selected to run when the robot is started.

Buay Step Hold Fault Run 1/O Prod TCyc MIMES450_MFS LINE 22 AUTO RUNNING	g 17 1 50
Prog Select	÷. E
OTHER Program select mode is enab	1/1 pled.
With this selection method, the application must set the variable \$shell_wrk.\$cust_name to the desi program name.	
\$shell_wrk.\$cust_name : MIME5450	MFS
[Түре] [Сногсе] не	LP



The next step was to add logic to the PLC program to start the robot via the user inputs. In order to start the robot user inputs 1, 2, 3 and 8 need to be on and user input 5 needs to be pulsed on for at least 10ms. I created a separate function call and data block in the PLC to contain this logic. I used

Network 2:	
Comment	
	<b>%DB110.DBX0.0</b> "Robot_Inputs". UOP_ Immediate_Stop 
%M10.2 "Auto_Cycleing"	%DB110.DBX0.1 "Robot_Inputs". UOP_Hold { }
%M45.0 "Robot_Start"	
	<b>%DB110.DBX0.2</b> "Robot_Inputs". UOP_Safe_ speed
	<b>%DB110.DBX0.7</b> "Robot_Inputs". UOP_Motion_ Enable
	()

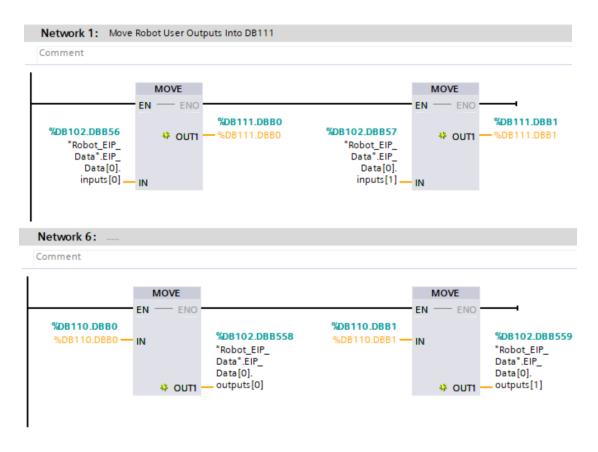
In an actual manufacturing environment the logic would not be this simple. Below is the logic I created for user input 5 which is the cycle start signal. Note that this signal can not remain on. The robot will start after this signal goes low. Notice I am using a pulse timer to keep the signal on for only a second.

Comment					
%M10.2 *Auto_Cycleing*	<b>%M0.0</b> *Always_Off	%DB111.DBX0.2 "Robot_ Outputs".UOP_ Program_ Running	%DB111.DBX0.1	%DB111.DBX2.0 "Robot_ Outputs".At_ Home_Pos	T# 0MS         %DB100         %DB110.DBX0.           "IEC_Timer_0_DB"         "Robot_Inputs"         "Robot_Inputs"           Time         UOP_Cycle         Start           IN         Q            T#1s         PT         ET         T# 0ms
"Robot_Start"				"Always_On"	

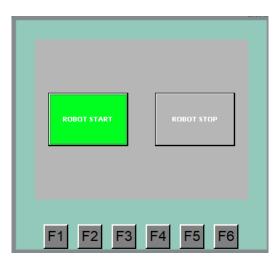
In the following networks I added logic for the cycle stop and fault reset user inputs.



In order to send this information to the robot we need to move the first 2 bytes from DB110 into the LCCF\_EIPScanner block as shown in the image below.



Finally I created a simple HMI that start and stops the robot by turning on and off bit M45.0.



### **Rockwell to Fanuc Robot**

FANUC ROBOTS INTEGRATION USING ETHERNET / IP

By AutomationTop Team Posted on September 4, 2020

The choice of communication protocol between the PLC controller and the peripheral device most often depends on the main device, i.e. usually the PLC controller. Of course, it is not always possible, then various types of converters come into play, but this is a separate topic.

In other words, we choose what we know and like, but it is not always the most optimal choice. Occasionally, certain devices offer slightly more functionality with certain network protocols. In this article, I would like to present an example of communication configuration via EtherNet / IP between a PLC and a FANUC robot. In the first part, I will present the method of establishing communication step by step. In the second part, I would like to discuss some non-obvious features related to the EtherNet / IP option in FANUC robots that give you an advantage over other methods.

Robot Controller1							
BusyStepHoldFaultRunI/OProdTCyc		T-RESET Released NE 16 <mark>T2</mark> PAUSE		<i>i</i> 5 "			
I/O SOP Out		POSITION		■.			
# STATUS	0/15	Joint	T	ool: 3			
MENU 1	I/O 1	/0 2					
1 UTILITIES	1 Cell Intface		J2: 30.576 J3:				
2 TEST CYCLE	2 Custom	LLink Device	J5: -44.140 J6:	22.613			
3 MANUAL FCTNS	3 Digital	2 Flag	ction: -10.924				
4 ALARM	4 Analog	3 EtherNet/IP					
· · · · · · · · · · · · · · · · · · ·		4					
5 I/O 🕨	5 Group		1				
6 SETUP	6 Robot	-	-				
7 FILE	7 UOP		-				
8	8 SOP	[	-				
9 USER	9 Interconnect	5	-				
0 NEXT	0 NEXT	9	-				
	Ľ	ง NEXT					
Sorted by port pumber Menu Favorites (press and hold to set)							
mena ravences (press and no							
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			-				

#### STEP1-I/O MAP

Before starting the robot-PLC communication setup, it is worth preparing a list of signals that we want to send between devices. FANUC has some predefined groups of signals that are worth, and some should be included in such a list.

The most important of these groups is UOP – User Operator Panel, here are the signals necessary for the cooperation of the robot with the PLC. With their help, we can run the robot program using the PLC controller. Cell Interface and SOP (Standard Operator Panel) groups contain a set of useful signals for integrators. Similarly, Interconnect where we can, for example, "pass" the status of internal safety signals to the controller (For monitoring purposes only).

As a rule, for a given process, the most important groups will be 3 – Digital (digital inputs / outputs) and 5 – Group (digital inputs / outputs grouped in packages). It is here that we assign signals controlling the course of a given process (process variables).

d	A	В	C	D	E	F	G	н	I
1			WEJŚCIA		WYJŚCIA				
2		PLC	FANUC	Komentarz	P	LC	FANUC	Komentarz	BIT
3	Address	Zmienna	DI		Address	Zmienna	DO		60 99
4	0.0		UI1	IMSTP	0.0		U01	Cmd Enabled	1
5	0.1		UI2	HOLD	0.1	_	UO2	System ready	2
6	0.2		UI3	SFSPD	0.2	8	UO3	Prg running	
7	0.3		U14	Cycle Stop	0.3		U04	<b>Prg paused</b>	4
8	0.4		U15	Faultreset	0.4	8	U05	Motion held	5
9	0.5		UI6	Start	0.5		U06	Fault	6
10	0.6		UI7	Home	0.6		U07	At perch	7
11	0.7		UI8	Enable	0.7		U08	TP enabled	8
12	1.0		UI17	PNS strobe	1.0		U09	Batt alarm	9
13	1.1	÷	UI18	Prod start	1.1	8	UO10	Busy	10
14	1.2				1.2		UO19	SNACK	11
15	1.3		-	81	1.3	5	15	G r	12
16	1.4				1.4		80		13
17	1.5			10	1.5				14
18	1.6			80	1.6		15		19
19	1.7	1		19. 62	1.7		1. 		16
20	2.0		U19	RSR1/PNS1/STYLE1	2.0	e	U011	ACK1/SNO1	17
21	2.1		UI10	RSR2/PNS2/STYLE2	2.1		U012	ACK2/SNO2	18
22	2.2	-	UI11	RSR3/PNS3/STYLE3	2.2	8	U013	ACK3SNO3	19
23	2.3	0	UI12	RSR4/PNS4/STYLE4	2.3		U014	ACK4/SNO4	20
24	2.4		UI13	RSR5/PNS5/STYLE5	2.4		U015	ACK5/SNO5	21
25	2.5		UI14	RSR6/PNS6/STYLE6	2.5		UO16	ACK6/SNO6	22
26	2.6	-	UI15	RSR7/PNS7/STYLE7	2.6	<u>[</u>	U017	ACK7/SNO7	23
27	2.7		UI16	RSR8/PNS8/STYLE8	2.7		U018	ACK8/SNO8	24
28	3.0		DI1		3.0		D01		25
29	3.1	5	D12	8	3.1	8	DO2		26
30	3.2		DI3	9.	3.2		DO3		27
31	3.3		DI4		3.3		D04		28
32	3.4		D15	53 20	3.4		D05		29
33	3.5	<u>.</u>	D16	20 20	3.5		D06		30
34	3.6		D17	20	3.6		D07		31

An example signal map may look like this:

As you can see, at the beginning I put the UOP signals which are 3 bytes long. Then I put digital inputs and outputs. As a rule, between them I also put I / O used as standard in each application (cell interface), signals monitoring the robot status, etc. For demonstration purposes, however, it is not necessary, so I present here a simplified version.

From the PLC side, the number of inputs / outputs can be set practically freely, we are limited only by the size of the Ethernet / IP frame (about 1400 bytes) and the number of adapters (slaves) working with a given scanner (master). The frame is divided into all slave devices, so if we have more devices on ENIP, this should be taken into account when planning. By default, a certain number of I / O, registers and positional registers are set in the robot. However, there is nothing to prevent these values from being changed as needed. To do this, enter the MAINTENANCE mode using the Controlled Start function.

STEP2 – Connection

From the controller side, the network connection settings obviously depend on the type used. There is an AOP (add-on-profile) ready for AB controllers. I, on the other hand, use B&R controllers which, despite the need to buy an EtherNet / IP communication module, also allow very easy and quick integration.

We add the Fanuc robot EDS file to Automation Studio:

	<u>▼ # ×</u> st I	xplicitMsg::Cyclic.st [Structure	-	× 🕅 IF1.9	ST1.SS1.I	F1 [Device Configuration]
	(FB)	🗳 亟 🖃 📜 津 津口	2			
	^ <u>.</u>	CYCLIC				
oonents nction blocks		<pre>// read position reg</pre>	isters	- 10 off		
3rd-Party Device Manager Automation Studi This dialog allows you to manage		arty Device Manag	er			
😽 🐗 Search					2	
Name	Version	Vendor	DTM	Protocol(s)	^	Import DTM Device(s)
S-C.A, Extended Addressing M	v.1 v.1	Hilscher GmbH Hilscher GmbH	:	ASi ASi		Update DTM Catalog
S-C.F. No Profile S-E.A. Extended Addressing M ENIP Generic Adapter	v.1 1.1100.5.5611	Hilscher GmbH Hilscher GmbH	:	ASi EthernetlP		
S-E.A, Extended Addressing M ENIP Generic Adapter S-E.F. No Profile ENIP Modular Generic Adapter IO-Link minimal device IODD1	1.1100.5.5611 v.1 1.1100.5.5611 1.0	Hilscher GmbH Hilscher GmbH Hilscher GmbH IO-Link (IODDs)	· · ·	EthernetlP ASi EthernetlP IO-Link		Import Fieldbus Device(s)
S-E.A, Extended Addressing M ENIP Generic Adapter S-E.F. No Profile ENIP Modular Generic Adapter	1.1100.5.5611 v.1 1.1100.5.5611	Hilscher GmbH Hilscher GmbH Hilscher GmbH	· · ·	EthernetIP ASi EthernetIP		
S-E.A. Extended Addressing M ENIP Generic Adapter S-E.F. No Profile ENIP Modular Generic Adapter IO-Link minimal device IODD1 FANUC Robot R30/B V2.4	1.1100.5.5611 v.1 1.1100.5.5611 1.0 2.4	Hilscher GmbH Hilscher GmbH Hilscher GmbH IO-Link (IODDs) FANUC Robotics North Ameri		EthernetIP ASi EthernetIP IO-Link EthernetIP	~	Import Fieldbus Device(s) Delete Selected Device(s)
S-EA, Extended Addressing M ENIP Generic Adapter S-E.F. No Profile ENIP Modular Generic Adapter IO-Link minimal device IODD1 FANUC Robot R30iB V2.4 IV-G Series V1.1	1.1100.5.5611 v.1 1.1100.5.5611 1.0 2.4	Hilscher GmbH Hilscher GmbH Hilscher GmbH IO-Link (IODDs) FANUC Robotics North Ameri		EthernetlP ASi EthernetlP IO-Link EthernetlP EthernetlP	~	

After adding the EDS file, add the robot to the device list:

<ul> <li>@ -</li> </ul>	
Toolbox - Hardware Catalog	(IV_G_Series_V1_1)
Catalog Favorites Recen	t
📕 🐼 🗱 🕶 🍕 🖗 fa	anuc ×
Product Group	^
3rd Party Devices	
Network Type	
	¥
Name	Description
FANUC Robot R30iB	DTM generic Ethernet/IP device, Vendor: FANUC .

We set the scanner's IP address (master):

IO Device: NETX	100 RE/EIM								Device ID:	0x0102	
	er GmbH								Vendor ID:	0x011B	
Navigation Area		_				N	otw	ork	Settings		
Settings						14	CLAA	UIK	oetungs		
Licensing	Description:	X20IF1	LOD1_1								
Configuration											
Hetwork Settings	IP Settings										
Scanlist	DHCP										
Process Data	BootP										
Address Table	Fixed Address	ses									
Quick Connect Table		-	100	1.00				70			
Scanner Settings	IP Address:	-	192	. 168		0		70			
	Network Mask		255	. 255		255	$^{\circ}$	0			
	Gateway Addr	ress:	0	. 0		0		0			
	Notes The			- 01/00							
	Note: The p	priority se	quence i	S DHCP,	BOOL	P, Fixe	a.				
	Port 1										
	Operation mode:	All cap	able, Au	o Negoti	iation	enabl	ed				
	MDI mode:	Auto M	DI-X								
	Port 2										
					_	_	_	_			-
									ОК	Cancel App	ly
		_	_	_			_	_			_

Frame size – in my case 64 bits in both directions:
---

General Electronic Keying Connection       Select connection:       [Connection1] Adaptor on Slot 1         Connection       Connection settings       Connection parameters          Description EDS Viewer       Connection 1       Value:         Instance ID       Size       Para_Parameter name       Bit Size       Parameter name       Min       Max       Unit Description         Instance ID       Size       Instance ID       Size       Parameter name       Bit Size       Parameter name       Min       Max       Unit Description         Size       Format       Format       Format       Instance ID       Size       Size       Instance ID       Size       Size       Instance ID       Size       Size       Instance ID       Size       Instance ID       Instance ID       Size       Size       Instance ID       Instance ID       Size       Instance ID       Size       Size       Size       Size       Size       Size       Size		IC Robot R30IB IC Robotics North America	[Device Configuration]	(IF1.ST1.SS1.IF1.ST1 [De	Device ID: Vendor ID:	x 0x0002 0x0164	
Connection     Value:       EDS Viewer     Connection1     Value:       Instance ID     Instance ID       Image: Size     Format       Image: T->O     Image:	Configuration General	Select connection:	[Connection1] Ada		~	1	
	Description	Connection1	Value: 8 (0x08) Bytes		in. Max Unit Desc		3

From the robot's side, we go to the network settings on the teach pendant, where we set the robot's IP address:

Robot Controller1				- 🗗 🛛 🗙
Busy Step Hold Fault Run I/O Prod TCyc		e 16 <mark>T2</mark> Pause		<sup>1</sup> 5 <sub>%</sub>
SETUP Host Comm TCP/IP	⊇ ≡ 1/42	POSITION Joint	To	<b>Q</b> ∰ ol: 3
MENU 1	SETUP 1			
1 UTILITIES	1 Prog Select	ETUP 2	SETUP 3	-41.500 22.613
2 TEST CYCLE	2 ZDT Client	User Alarm	1 Diag Interface	22.015
3 MANUAL FCTNS	3 General	Error Table	2 Host Comm	
4 ALARM	4 Coll Guard	Pendant Setup	3 Passwords	
5 I/O 🕨	5 Frames	BG Logic	4	1
6 SETUP	6 Macro	Resume Offset	5	1
7 FILE 🕨	7 Ref Position	Resume Tol.	6	
8	8 Port Init	Stroke limit	7	1
9 USER	9 Ovrd Select	Space fnct.	8	1
0 NEXT	0 NEXT	Motion DO	9	
12 ********* *****	****	⊥- NEXT	0 NEXT	
Menu Favorites (press and ho	ld to set)			
				>

### SETUP> SETUP2> Host Comm> TCP / IP

We ping and check if both devices are visible in the network.

Robot Controller1			<u>⊼</u> ⊿• Q ×
Busy     Step     Hold     Fault       Run     I/O     Prod     TCyc		2 PAUSED JOINT	5 "
I/O EtherNet/IP EtherNet/IP List(Rack 89)	Q I/64 POSITIO I/64 Joir		<b>Q</b> ∰ Cool: 3
MENU 1	I/O 1		
1 UTILITIES	1 Cell Intface	J2: 30.576 J3: vice J5: -44.140 J6:	
2 TEST CYCLE	2 Custom		22.615
3 MANUAL FCTNS	3 Digital	ction: -10.924	
4 ALARM	4 Analog	et/IP	
5 I/O 🕨	5 Group		
6 SETUP	6 Robot		
7 FILE 🕨	7 UOP		
8	8 SOP 7		
9 USER	9 Interconnect		
0 NEXT	0 NEXT 9		
ConnectionK ADP FALSE	OFFLINE 20 0 NEX	T	
Menu Favorites (press and ho	d to set)		
C <sup>×</sup>			>

Then go to the Ethernet IP settings. MENU> I / O>> Ethernet / IP

We choose the available connection that we want to use (we can have more than one ENIP adapter in the robot controller), then select F4 - Config

Robot Controller1				Ð	
BusyStepHoldFaultRunI/OProdTCycMO	VEFX_1_2	LINE 16 T2 I	PAUSED JOIN	Т	5 "
I/O EtherNet/IP					🖽 🍋
EtherNet/IP				1/64	
Description		Enable	Status	Slot	
Connection		TRUE	OFFLINE	1	
Connection		FALSE	OFFLINE	2	
Connection		FALSE	OFFLINE	3	
Connection		FALSE	OFFLINE	4	
Connection		FALSE	OFFLINE	5	
Connection		FALSE	OFFLINE	6	
Connection		FALSE	OFFLINE	7	
Connection		FALSE	OFFLINE	8	
Connection		FALSE	OFFLINE	9	
Connection	A ADP	FALSE	OFFLINE	10	
			_		
[ TYPE ] PIN	IG		CONFIG	<b>?</b>	<u> </u>
				HELP	

In the configuration window, we set the amount of data transferred, remember that the values are given as words, i.e. groups of 16 bits. So 4 words / 8 bytes / 64 bits, that is as set in the PLC.

Robot Controller1
Busy     Step     Hold     Fault       Run     I/O     Prod     TCyc     MOVEFX_1_2 LINE 16     T2 PAUSED     JOINT     Image: Constraint of the second s
I/O EtherNet/IP
Adapter config(Read-only):
Description : Connection1 Input size (words) : 4 Output size(words) : 4 Alarm Severity : WARN Scanner IP : **********************************
[TYPE] PREV ()

If we want to change the number of words, first we have to deactivate the connection on the previous screen.

Robot Controller1				D T	- <b>- - - - - - - - - -</b>
Busy         Step         Hold         Fault           Run         I/O         Prod         TCyc         MOVE	FX_1_2	LINE 16 <mark>T2</mark> F	PAUSED JOIN	T	5 "
I/O EtherNet/IP					🔍 🖽
EtherNet/IP Li	.st (Ra	ck 89)	:	1/64	
Description	TYP	Enable	Status	Slot	
Connection1	ADP	TRUE	OFFLINE	1	
Connection2	ADP	FALSE	OFFLINE	2	
Connection3	ADP	FALSE	OFFLINE	3	
Connection4		FALSE	OFFLINE	4	
Connection5	ADP	FALSE	OFFLINE	5	
Connection6	ADP	FALSE	OFFLINE	6	
Connection7	ADP	FALSE	OFFLINE	7	
Connection8	ADP	FALSE	OFFLINE	8	
Connection9	ADP	FALSE	OFFLINE	9	
ConnectionA	ADP	FALSE	OFFLINE	10	
	_	_			
[ TYPE ] PING			TRUE	FALSE	
				ALSE	
				_	

Change the configuration:

Robot Controller1									
Busy Step Hold Run I/O Prod	Fault TCyc MOVEFX_1_2 LINE 16 T2 PAUSED JOINT 5								
I/O EtherNet/IP	<b>€ □</b>								
Adap	ter configuration : 1/3								
	Description : Connection1 Input size (words) : 10 Output size(words) : 4 Alarm Severity : WARN								
	Scanner IP : **********************************								
Changes will take effect at power-up.									
[ ТҮРЕ	E] PREV (?) HELP								

Activate and restart the robot controller.

Robot Controller1	S≩₽®X
Busy         Step         Hold         Fault           Run         I/O         Prod         TCyc         MOVEFX_1_2 LINE 16         T2         PAUSED         JOINT	5 "
I/O EtherNet/IP	۵
EtherNet/IP List(Rack 89) 1/64	1
Description TYP Enable Status Slo	ot
Connection1 ADP TRUE PENDING	1
Connection2 ADP FALSE OFFLINE	2
Connection3 ADP FALSE OFFLINE	3
Connection4 ADP FALSE OFFLINE	4
Connection5 ADP FALSE OFFLINE	5
Connection6 ADP FALSE OFFLINE	6
Connection7 ADP FALSE OFFLINE	7
Connection8 ADP FALSE OFFLINE	8
Connection9 ADP FALSE OFFLINE	9
ConnectionA ADP FALSE OFFLINE 1	L0
[TYPE] PING TRUE FALSE	-

If everything is set correctly on the PLC side, after restarting the controller, we should see the status change OFFLINE -> RUNNING. I was using ROBOGUIDE offline when writing the article, so the connection is inactive.

Ok, this is how we established the connection between the controller and the robot. Unfortunately, this does not yet lead to an exchange of process data.

STEP3 – I / O configuration

To do this, go to MENU> I / O> Digital

Robot Controller1				S ≹ d € X
BusyStepHoldFaultRunI/OProdTCyc	MOVEFX_1_2 LI	NE 16 <mark>T2</mark> PAUSE	D JOINT	<b>1</b> 5 %
I/O Cell Outputs				🕀 🕀
MENU 1	I/O 1		1/1	
1 UTILITIES	1 Cell Intface	/0 2	IM STAT U ***	
2 TEST CYCLE	2 Custom	L Link Device	U ***	r
3 MANUAL FCTNS	3 Digital	2 Flag	U ***	
4 ALARM	4 Analog	8 EtherNet/IP	U *** U ***	
5 I/O	5 Group	+	U ***	r
6 SETUP	6 Robot	5	U ***	
7 FILE	7 UOP	5	U *** U ***	
8	8 SOP	7	U ***	r
9 USER	9 Interconnect	3		
0 NEXT	0 NEXT	9		
	Ľ	0 NEXT	]	
Menu Favorites (press and hol	d to set)			
<b>×</b>				>

After clicking ENTER, you should see a screen similar to the following:

Robot Controller1				X D k K
Busy Step Hold Fa		1 2 I INE 16 T	2 PAUSED JOINT	<b>1</b> 5
		_1_2 cine 10 1		%
I/O Digital Out				🕀 🖸
#			148/10	)24
	-	OFF [		
	-	OFF [	-	
_	-	OFF [	-	
DO[1 DO[1	-	OFF [ OFF [		
DO[ 1		OFF [ * [	-	
DO[ 1	-	т Т	-	
DO[ 1		* [		
DO[ 1		* [	-	
DO[ 1		* [		
DO[ 1		* [	]	
	CONFIG			
[ TYPE ]	CONFIG	IN/OUT	SIMULATE UNS	

Some inputs may already be assigned, while uninitialized (inactive) inputs / outputs will be marked with an asterisk \*.

Press F2 (Config) and go to the configuration screen. This is where our inputs / outputs will be assigned to the appropriate places, i.e. in the case of FANUC – racks and slots.

Robot Controller1								C I	T 🗗 💽 🗴
Busy Step	Hold	Fault		X 1 2	LINE 16	T2 PAI	JSED JOI	NT	5
Run I/O	Prod	ТСус	MOVE	~_1_2			JOL 101	.111	%
I/O Digital C	)ut								🔍 🕀
			DANCE		DACK	GT OT		8/8	
	<b>#</b> 1		RANGE 1-	01	RACK 0	5L0T	START	ACTIV	
	2	DO [ DO [	1- 9-	8] 16]	0	1		ACTIV	
	3	DO[	17-	20]	0 0	1	37		
	4	DO [	21-	24]	Ő	0		UNASG	
	5	DO[	25-	64]	0	2	1		
	6	DO [	65- 3	104]	0	3		ACTIV	
	7	DO [	105- 3	144]	0	4	1	ACTIV	
	8	DO [	145–1	024]	0	0	0	UNASG	
								?	
	[ TYPE	]	MONITOR	t I	N/OUT	DEL	ETE	HELP	
								NELP	

EtherNe / IP is rack 89, we have only one robot arm plugged into the controller, so one adapter – slot 1.

Enter the range of inputs that interest us, which we want to use, assign them to the appropriate rack and slot, give the start bit, i.e. where in the communication frame the given group of inputs / outputs will be located. To determine the start bit, we refer to the prepared table and read where the given I / O group is to be mapped.

In the example below, for inputs 1-40 it will be bit 25

							â 🖆 🔜	1~
Busy Step		Fault TCvc KM_SIM_V3 I				1	10	0
Run I/O	Prod			2 ABORI				96
I/O Digital (	Dut						<b>A</b>	Ш
						L/5		
	#	RANGE		Concern constru	START	a contraction of the second second		
		0[ 1- 40]	89	1		PEND		
		0[ 41- 64]	0	0		UNASG		
		0[ 65- 104]		3		ACTIV		
		0[ 105- 144] 0[ 145-1024]		4		ACTIV UNASG		
	JL	0[ 143-1024]	0	0	0	UNASG		
	Power	OFF then ON	to ena	able d	change:	3 -		
	[ TYPE ]	MONITOR	IN/OUT	DEL	ETE	<b>?</b> HELP		

As you can see after making changes, the STATUS of the edited inputs / outputs has changed to PENDING. For the changes to take effect, restart the robot controller or select Cycle Power with FCTN.

We configure group outputs depending on the needs, if we want to send values other than the bool type. We can group 2 to 16 lines that may overlap with digital I / O.

Robot Controller1						1		D	t 🖍	<b>Q</b> X
Busy <mark>Step</mark> Run <b>I/O</b>	Hold Prod	Fault TCyc	MOVE	FX_1_2 L	INE 16	T2 PAUSED	JOINT		Ø	5 "
I/O Group O	ut									🔍 田
		ŧ		VALUE			1/3	00		
	GO [	1]		*	[			]		
	GO [	2]		*	[			]		
	GO[	3]		*	L		:	]		
	GO [ GO [	4] 5]		*	L T		:	J 1		
	GO [	6]		*	ſ		:	1		
	GO [	7]		*	ř		:	i		
	GO [	8]		*	Ē			1		
	GO [	9]	*	*	[			<b>]</b> (1)		
	GO [	10]		*	[			]		
	GO [	11]		*	[			]		
	Sorteo	i by	port	: numb	er.					
	[ TYPE ]	(	CONFIG	G IN	/OUT	SIMULATE	UNS	SIM	/	>
	-									

We do the same in the case of UOP signals:

Robot Controller1		1		* <b>-</b> • • ×
	ult Cyc MOVEFX_1_2	LINE 16 T2 PAUSED	IOINT	<b>9</b> 5 %
I/O UOP Out				🖽 🔍
יסט[	#       STATUS         1]       OFF         2]       ON         3]       OFF         4]       ON         5]       OFF         6]       OFF         7]       OFF         8]       ON         9]       OFF         10]       OFF         11]       OFF         by port numb	[Cmd enabled [System ready [Prg running [Prg paused [Motion held [Fault [At perch [TP enabled [Batt alarm [Busy [ACK1/SNO1 per.	1/20 ] ] ] ] ] ] ] ] ]	
[ ТҮРЕ ]	CONFIG I	N/OUT ON	OFF	>

Since in step 1 I determined that the UOP signals will occupy the first three bytes, I set the configuration as follows:

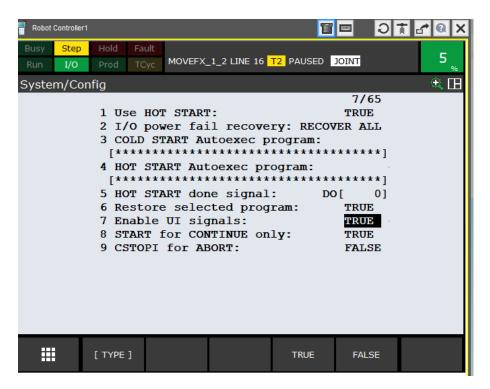
1/3         # RANGE RACK SLOT START STAT.         1 UI[ 8] 89 1       1 ACTIV         2 UI[ 9- 16] 89 1       17 ACTIV         3 UI[ 17- 18] 89 1       9 ACTIV         Device Name : EthernetIP       [TYPE] MONITOR IN/OUT DELETE Property HELP	I/O UOP	P In				
	# 1 U 2 U	RANGE UI[ <b>1</b> - UI[ 9- 1	8] 89 1 6] 89 1	START STAT. 1 ACTIV 17 ACTIV		
[ TYPE ] MONITOR IN/OUT DELETE 🖓 HELP	Device	Name : Et	hernetIP			
	[	TYPE ]	MONITO	DR IN/OUT	DELETE	

I/O UOP Out				,	
	1 89 1 1 89 1 1 1 89 1 1	1/4 RT STAT. 1 ACTIV 9 ACTIV 17 ACTIV 11 ACTIV			
[ TYPE ]	MONITOR	IN/OUT	DELETE	P HELP	

Moreover, to enable the exchange of UOP signals between the robot controller and the controllers, this option must be activated in the controller. To do this, go to the system configuration menu on the Teach Pendant

Robot Controller1					
Busy <mark>Step</mark> Hold Fault					
Run I/O Prod TCyc	MOVEFX_1_2 LINE 16 T2 PAUSED JOINT 5				
I/O Group Out 🔍 🕀 田					
MENU 2	SYSTEM 1 1/300				
1 SELECT	START PT NUM PTS 1 Clock 0 0				
2 EDIT	2 Variables 0 0				
3 DATA	3 OT Release 0 0				
4 STATUS	4 Axis Limits 0 0				
5 4D GRAPHICS	5 Config 0 0				
6 SYSTEM	6 Motion 0 0				
7 USER2	7 DCS 0 0				
8 BROWSER	0 0 0 0				
9					
0 NEXT					
Menu Favorites (press and hold to set)					
Ľ	>				

We find position number 7 – Enable UI Signals



If the value is set to FALSE, the external signals (UI [1 to 18]) are disabled. Set this value to TRUE to allow programs to be started with the PLC. In addition, you need to make sure how the UOP signals are assigned. In the same menu we find position 44:

Robot Controller1		
	ult <sub>Syc</sub> MOVEFX_1_2 LINE 16 T2 PAUS	
35 Set 36 Sim 37 Set 38 Set 39 Out 40 Sig 41 Han 42 Rem 43 E		0.00 sec DO[ 0] DO[ 0] <*DETAIL*> DO[ 0] <*GROUPS*> note DI [ 0]
[ TYPE ]	[сного	CE]

We choose the signal allocation method (FULL).

Robot Controller1	× 🛚 🛧 🕻 🗠
Busy <mark>Step</mark> Hold Run I/O Prod	
System/Config	۵ 🕮
	44/65
3.	UT SIMULATED DO[ 0]
1	PUT SIMULATED DO[ 0]
1 None	nple(JRM18) Wait Delay: 0.00 sec
1 None	. Skip Enabled: DO[ 0]
2 Full	compt displayed: DO[ 0]
3 Full(Slave)	h WAIT on Input:<*DETAIL*>
4 Full(CRMA16)	$\frac{\text{DVERRIDE} = 100  \text{DO}[ 0]}{\text{h}} = \frac{3}{2} $
5 Simple	al setup: Remote
6 Simple(Slave)	I/O(ON:Remote):DI [ 0]
7 Simple(CRMA16)	ssignment: None
8next page	hext page
[ TYP	E ] [CHOICE]

# Universal Robot Connection to Siemens PLC – from Universal Robots website:

**PROFInet How-To Guide E-series** 

This guide provides instructions for how to start using PROFINET with Universal Robots.

Last modified on Sep 30, 2024

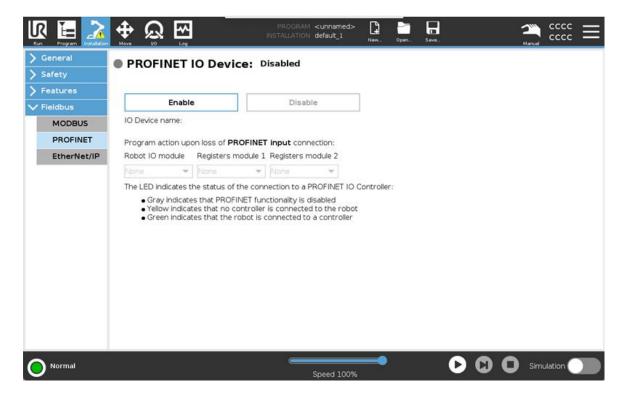
#### NOTE: All files are available for download at the bottom of this page.

This guide is valid for: e-Series Software version 5.12 Note: older or newer software versions may behave differently.

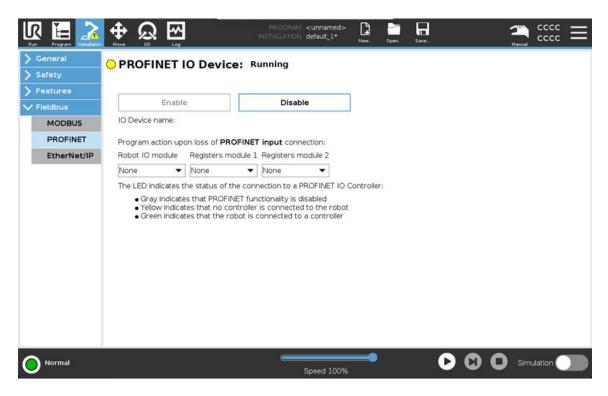
1. setup

1. **ROBOT:** Tap the Installation tab and, under Fieldbus, select **PROFINET**. Tap **Enable**.

• Save the installation for the changes to take effect the next time the installation is loaded.

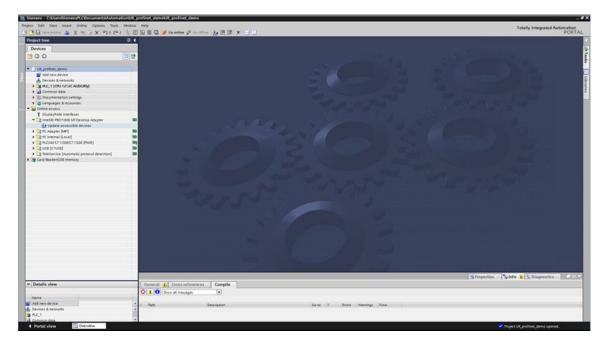


2. **ROBOT:** The yellow LED indicates PROFINET is running on the robot. No PLC/IO controller is connected to the robot.



3. PLC: Open a project in Siemens TIA Portal.

- In the Project Tree of the Project view, navigate to: **Online access -> {your network adapter}.**
- Click Update accessible devices.



ROBOTS and VISION and PLCS Oh My

4. **PLC**: Identify the robot and the PLC you want to connect. Assign IP addresses and names to the equipment.

- Expand the desired accessible device and double-click **Online & diagnostics**.
- In the device's diagnostics page, expand Functions and click Assign IP address.
- Enter the desired IP address and subnet mask, and tap Assign IP address.
- Still in the diagnostics page click Assign name.
- Set the PROFINET device name and click Assign name .

Star man & X to G X 514	No. 10 March 19 10 10 10 10 10 10 10 10 10 10 10 10 10	Stannin Sta		Totally Istegrated Automat PO
ct 1004			1000 Mt Desktop Adapter + ur3 (10.1.1.222) + ur3 (10.1.1.222) 💷 📽 🗮 🗙	Outine tests
dices .	and the second			Options
0	1 1 Diagnee	ia.	Asign name	and the second se
	• Function			V CPU operator panel
UK profinet, demo		# #ddress		
💕 Add new device		L DATE	Configured PROFINIT device	Hot supported
📥 Devices & networks	1000	to factory settings	Configured Provide	
# PLC_1 [ORU 1212C ACIDORIA]			MORNET device name: U1	
Common data			Device type	
Documentation settings				
Canguages & resources				
Online access				
Y Osplayhide interfectes	_			
Intel00 PRO/1000 MT Decktop Adapter	-			
AP Update accessible devices			Oeving filter	
■ plc_1 [10.1.1.21]				✓ Cycle time
[10.1.1.22]     [10.1.1.64]     [10.1.1.64]			Chiji khum data kuti tu tina tiga	- Shee min
				Not supported.
(a) (10.1.1.222]				Service Control of Con
Online & diagnostics     PC Adapter (MPI)	-		Conjultane de cara a de cara a de cara	
			Accessible devices in the network:	
PC internal [Local] PLCSAV57-1200157-1500 (PNIE)	10		Pladows MACaddess Device PEOPERT device name Status	
US8 (S7US8)	2		Padreu Micappeu Dece PETRETatultane Jaci	
TeleService (Automatic protocol detection)				
and ReaderUSE memory				
an anterest record				
			( )	
			EED faches Resign name	
	12		Shoperties Auto Subsportice	1
alls view	Canada	Cross-referenc		
		Show all messages		
a l	Nomeica	ges exist which meet fit		
	0 Meioe	He .	Gets 7 Date Ting	
				1000 C
				> Memory

5. PLC: Import the Universal Robots' GSD file.

- Navigate to **Options ->Manage general station description files (GSD)**.
- Select to the right GSD and install.

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toject Edit View Insert Onlin	ne Options Tools sainteen metp	The second se	Totally Integrated Automation
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6. PLC: In the top of the project tree access Devices & networks.

- Locate the UR I/O device in the catalog path: Other field devices->PROFINET IO->I/O->Universal Robots A/S->Collaborative Robot->V1.0
- Drag-and-drop it into the network view and connect the PLC and the I/O device by dragging a line between their (green) PN/IE ports.

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7. **PLC**: Double-click the I/O device in the Network view.

- All modules are pluggable, and are named according to their corresponding slot numbers.
- Each module can be drag-and-dropped from the **Catalog->Module** to the empty fields in the Device overview.
- In this example all modules are plugged in. Notice how the input addresses (I) and output addresses (Q) are assigned, since you will need these to access the data.

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8. PLC: Double-click the I/O device in the Device view to get the module description.

- In the General tab select **Ethernet addresses**, and select **Use IP protocol.**
- Set the same IP address as those assigned to the online device.
- Deselect Generate PROFINET device name automatically and type in the same PROFINET device name as the one assigned to the online device.

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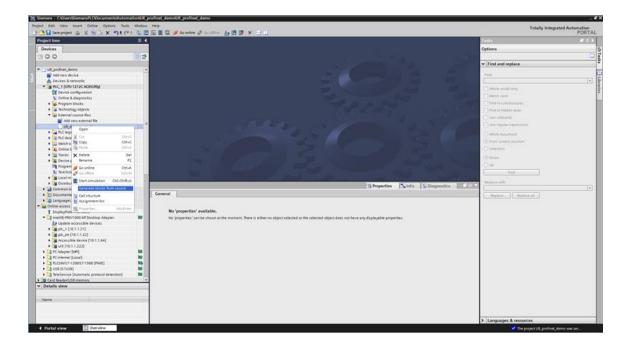
### 9. PLC:

This step requires PLC firmware version 4.0 or higher.

- Navigate to **External source files**.
- In the project tree, double-click **Add new external file** to open the file **UR\_datastruct.udt**.
- Import the user-defined data types by right clicking the newly added external source file and select **Generate blocks from source**.
- In the PLC tags (or your own Data Block), create tags corresponding to the modules you have enabled. Make sure the input addresses (I) and output addresses (Q) of the tags match those of the modules.

If all modules are enabled and placed in order in the IO memory, create a single PLC input tag of the data type: UR\_T2O and a single PLC output tag of the data type: UR\_O2T to map all data.

Both are visible in PLC data types in the project tree.



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10. **PLC:** Download the program to the PLC.

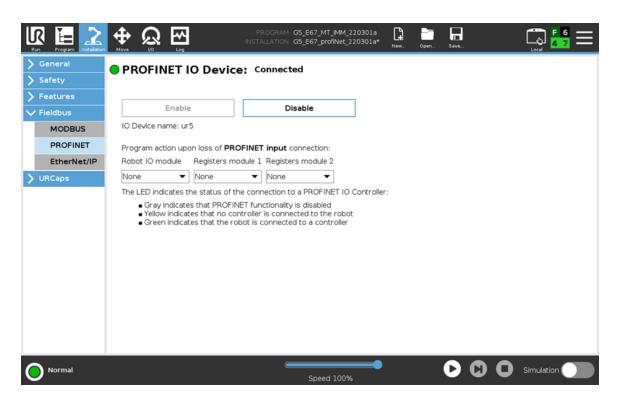
- In the menu bar click the download icon and tap **Start search** in the download dialog.
- Select the PLC and click **Load**.

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11. PLC: Confirm all blocks, tags and modules in the project tree are green.

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12. **ROBOT:** Confirm the LED in the Installation tab is green.



13. **PLC:** In the project tree, navigate to your tag table (or Data Block) and expand your input tag to inspect values sent from the robot.

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# 2. Specifications

The following sections provide an overview of some important information to get started.

# 2.0.1. Demo Sample Program

Sample files for this example are available for download at the bottom of this page:

- UR\_profinet\_demo.zap13: archived project file that can be loaded into the TIA Portal v13 (select **Project->Retrieve**)
- ur-pn-demo.urp: demo program for the robot

## PLC (used in example)

- Siemens S7-1200, 1212C AC/DC/Rly
- Totally Integrated Automation Portal V13, STEP 7 Basic

### Robot

• UR3, UR5 or UR 10 running PolyScope v. 3.3

# 2.0.2. I/O Message Format

For details about how the IO format is distributed between the modules, see: <u>pn-iomessage.pdf</u>

The robot has 10 pluggable modules:

- Seven modules containing the data that can be read from the robot
- Three modules containing data that can be set on the robot

All modules are optional, but are fixed to a specific slot according to their names: e.g. the UR\_3\_T2O\_Joints can be plugged into slot 3, contain data from the robot (T) to the PLC (O), namely joint measurements.

Note: When using output I/Os, it is important to set the mask accordingly.

## **User-defined Data Types**

- For PLCs S7-1200 and S7-1500 (PLC Firmware v4.0 or higher): *UR\_datastruct.udt* (can be imported into TIA Portal)
- For PLCs S7-200, S7-300 and S7-400: URI.AWL, URO.AWL (can be imported into SIMATIC and TIA Portal)

The UDT/AWL files contain user-defined data types and can be used to import the message format.

**Note:** If you import the UR data structure (the .udt file) and only plug in some of the modules, make sure to use the right user defined data types and match the input address (I) or output address (Q) of the module with the address of the data types in the tag table. This is also necessary if you drag the modules in "out of order", e.g. the module to slot 5 before the module to slot 2.

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## GSD file

GSDML-V2.42-UR-PROFIsafe-20220517.xml.zip. (Note that the folder name is *PROFIsafe but some of the files are compatible with PROFInet*)

# 2.0.3. Script Functions

Script Functions for synchronizing a program with a PLC:

- read\_input\_boolean\_register(address)
- read\_input\_float\_register(address)
- read\_input\_integer\_register(address)
- read\_output\_boolean\_register(address)
- read\_output\_float\_register(address)
- read\_output\_integer\_register(address)
- write\_output\_boolean\_register(address, value)
- write\_output\_float\_register(address, value)
- write\_output\_integer\_register(address, value)

## 2.0.4. Notes

- If you change the IP of the robot in Network Settings while PROFINET is enabled, disable PROFINET and enable it again before the changes take effect.
- If the IP of the robot is changed using external PROFINET tools, e.g. through the TIA software, the changes will take effect immediately.
- The lower range (bool[0:63], int[0:23], float[0:23]) of the gp input and output registers is reserved for FieldBus/PLC interface usage. The upper range (bool[64:127], int[24:47], float[24:47]) can be used by external RTDE clients (i.e URCAPS).

3. Demo

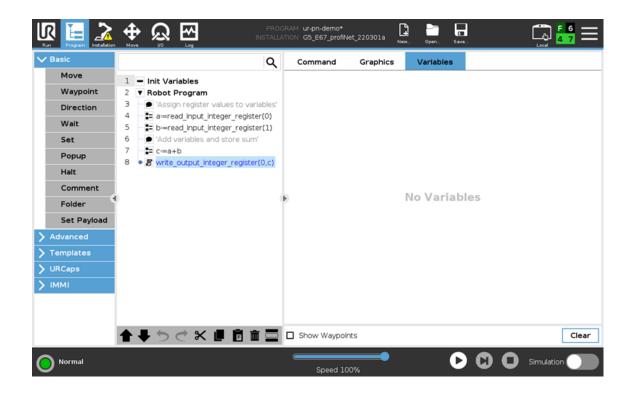
This demo is provided to show a basic example of how to communicate between the PLC and the UR robot. The demo allows you to set two numbers in PLC output registers.

The robot retrieves the numbers, calculates their sum and stores the result in a PLC input register.

1. **PLC:** Navigate to the Main Program Block and set integer registers URO."Reg 1".Ints.Register[0] and URO."Reg 1".Ints.Register[1] to some values and download the program to the PLC

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2. **ROBOT:** Open ur-pn-demo.urp and run the program. Navigate to the Variables tab and confirm the numbers are received.



## 4. Robot Modes

Mode	Description
-1	ROBOT_MODE_NO_CONTROLLER
0	ROBOT_MODE_DISCONNECTED
1	ROBOT_MODE_CONFIRM_SAFETY
2	ROBOT_MODE_BOOTING
3	ROBOT_MODE_POWER_OFF
4	ROBOT_MODE_POWER_ON
5	ROBOT_MODE_IDLE
6	ROBOT_MODE_BACKDRIVE
7	ROBOT_MODE_RUNNING
8	ROBOT_MODE_UPDATING_FIRMWARE

# 5. Video Guides

Italian Original : Profinet connection between robot and PLC - YouTube

English Translated : Profinet connection between robot and PLC - YouTube

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# 6. Example image of FailSafe Library

## **Attached files**

GSDML-0361-0001-UR.bmp

GSDML-V2.42-UR-PROFIsafe-20220517.xml.zip

IMMI\_Euromap67\_input\_output\_bits.pdf

URI.AWL

URO.AWL

UR\_datastruct.udt

Universal\_Robots\_TIA\_Library\_FailSafe\_Robot\_Programs.zip

Universal\_Robots\_TIA\_Library\_FailSafe\_V16\_20231016\_1159.zal16

Universal\_Robots\_TIA\_Library\_FailSafe\_V17\_20231016\_1333.zal17

Universal\_Robots\_TIA\_Library\_FailSafe\_V18\_20231016\_1502.zal18

pn-iomessage.pdf

<u>ur-pn-demo.urp</u>

To implement a connection between the older Universal 5 robot, use the following. Remember that the communication to the Universal Robot here is Modbus/TCPIP.

https://s3-eu-west-1.amazonaws.com/ur-supportsite/66329/UR%20Modbus\_bba\_mods\_0.1.4.pdf

# Ethernet IP guide

This is an Ethernet IP guide to help you when using this with Universal Robots

Last modified on Sep 30, 2024

### NOTE: All files are avalable for download at the bottom of this page.

Examples are valid for: CB3 Software version: 3.2.18654 e-Series Software version: All versions Note that newer software versions may behave differently.

These examples can be used on CB3/CB3.1 from software 3.2 and e-Series.

#### **Specifications**

Here is an overview of some important information to get started.

**PLC** (used in example)

- Allen-Bradley Compact Logix L16ER
  - Studio 5000 Logix Designer Note:
  - UR only supports Ethernet/IP Class 1 implicit or "I/O" messaging, not Ethernet/IP Class 3 explicit or "client/server" messaging.
  - Remember to change/select the correct CPU

#### Robot

• UR3, UR5, & UR 10 running Polyscope v. 3.2

#### Sample Programs:

The files listed are available for download at the bottom of this page and are used in the example (ACD project files are compatible with Logix Designer v.24):

- UR.ACD
- ur-eip-demo.urp

#### **Conveyor Tracking example:**

• EIP\_conveyor\_example.ACD

• UR-EIP-conveyor-tracking.urp

### EDS file:

• UniversalRobot.eds

### **User-defined Data Types:**

• UR\_DataTypes.L5X

Note: The L5X file contains user-defined data types and can be used to import the message format into Rockwell Studio 5000 Logix Designer

#### I/O Message Format:

• eip-iomessage.pdf

Note: When using output registers, it is important to set the mask accordingly.

#### Script

Script Functions for synchronizing a program with a PLC:

- read\_input\_boolean\_register(address)
- read\_input\_float\_register(address)
- read\_input\_integer\_register(address)
- read\_output\_boolean\_register(address)
- read\_output\_float\_register(address)
- read\_output\_integer\_register(address)
- write\_output\_boolean\_register(address, value)
- write\_output\_float\_register(address, value)
- write\_output\_integer\_register(address, value)

#### Notes

The lower range (bool[0:64], int[0:23], float[0:23]) of the gp input and output registers is reserved for FieldBus/PLC interface usage. The upper range (bool[64:127], int[23:47], float[23:47]) can be used by external RTDE clients (i.e URCAPS).

#### **Trouble Shooting**

• It is important to consider and set an RPI value that corresponds with the requirements of the installation. The valid range of RPI is 2ms - 3200ms where a smaller value means more frequent data synchronization but also requires more resources from the PLC, Robot and Network.

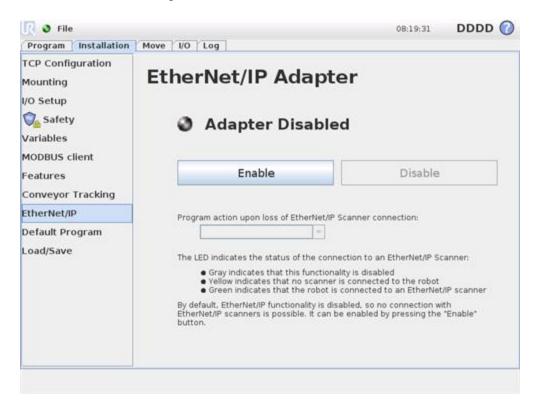
• If you experience connection issues between a scanner and the robot make sure that you have configured the scanner for unicast connection (point-to-point) and that you have sufficient network bandwidth between the scanner, the Robot and other devices to avoid colliding packets etc.

#### Setup

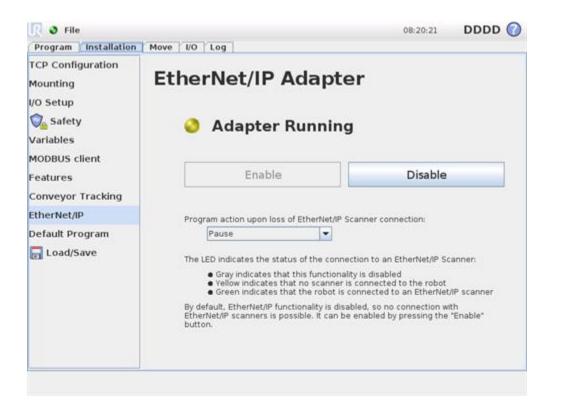
This guide gives step-by-step instruction on how to start using Ethernet/IP with Universal Robots or watch the video

Video: How to connect your UR robot to an Allen Bradley PLC

1. ROBOT: Enable Ethernet/IP in the Installation tab. Remember to save the installation afterwards for the changes to take effect the next time the installation is loaded.



2. ROBOT: The yellow LED indicates Ethernet/IP is running on the robot but no PLC/scanner is connected to the robot



3. PLC: Open UR.ACD project in Studio 5000 Logix Designer. If your version of Logix Designer is incompatible with the project file (i.e. older than v.24), you can create a new project and import the user-defined data types from the UR\_DataTypes.L5X file.

4. PLC: Navigate to I/O Configuration -> Ethernet -> Ethernet-Module UR

5. PLC: Set IP Address of Robot and Press "Apply"

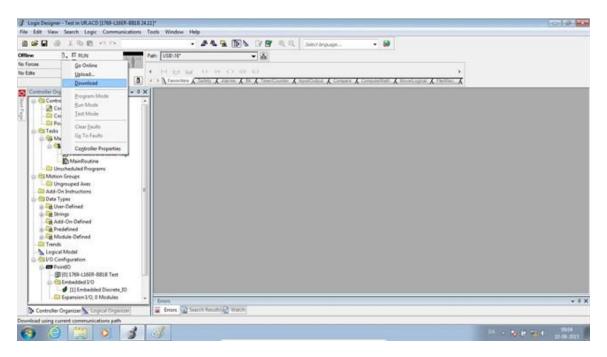
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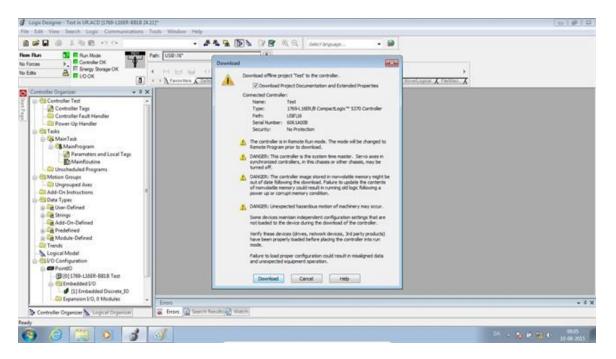
6. PLC: Navigate to "Connection" Tab and ensure that the RPI matches your requirements and that the check box next to "Use Unicast Connection over Ethernet/IP" is checked.

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7. PLC: Download the program to the PLC



8. PLC: Confirm that "I/O OK" is solid green



9. ROBOT: Confirm that LED in Installation tab is also green



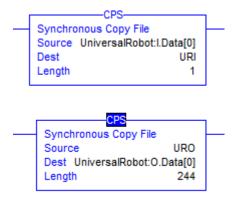
10. PLC: Navigate to Tasks -> Main Task -> Main Program -> Parameters and Local Tags

10.1. IF You did not use the demo, but will implement communication to your own code, you need to enable communication between the robot and the AB PLC. First set up URI and URO in your local or global variables, using the provided User Define Data Types:

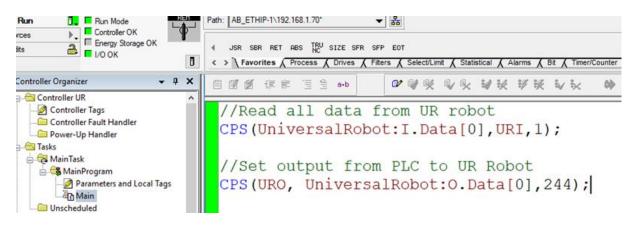
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- Power-Up Handler		+ URI.Safety		()	{}		UR_T20_Safety	Uni
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Parameters and Local Tags	⊩	+ URLTCP		()			UR_T20_TCP	Uni
- an Main	⊩	F URLBt		()			UR_BtRegisters	Uni
Unscheduled     Motion Groups	⊫	H URLint		{}			UR_IntRegisters	Uni
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Add-On Instructions		URO	Local	{}			UR_02T_Assembly_Combined	
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		+ URO.Outputs		()			UR_02T_Outputs	Uh
UR_BitRegisters		+ URO.Bt		()			UR BtRegisters	Uni
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#### 10.2. Then setup CPS between the robot and the PLC

#### Ladder:



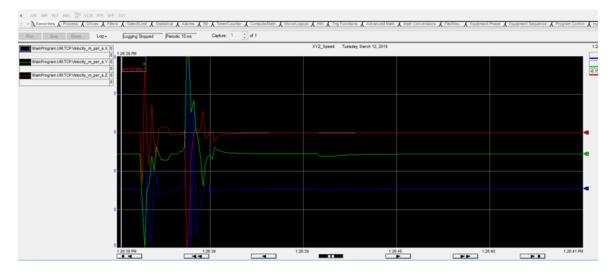
#### ST:



11. PLC: Navigate to URI -> URI.Robot inspect values sent from the robot

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11.1. Example to test - Trend Velocity of XYZ



#### Demo

This demo is provided to show a basic example of how to communicate between the PLC and Robot. The demo allows the user to set two numbers in PLC output registers. The robot retrieves the numbers, calculate their sum and stores the result in a PLC input register.

1. ROBOT: Open ur-eip-demo.urp

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Simulation Real Robot	🛛 🚺 📄 Speed	💠 Previou	s Next 🗭

- 2. ROBOT: Run program
- 3. ROBOT: Navigate to variables tab

4. PLC: Set integer registers URO.Int.Registers[0] and URO.Int.Registers[1] to some values

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5. ROBOT: Go to the Variables tab and confirm that the numbers are received

6. PLC: Validate that the URI.Int.Registers[0] contains the sum

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## **Attached files**

EIP\_conveyor\_example.ACD

UR.ACD

UR\_DataTypes.L5X

UniversalRobot.eds

eip-iomessage.pdf

ur-eip-conveyor-tracking.urp

ur-eip-demo.urp

## Fanuc CRX E Robots:

CRX E-Learning (Co-Bot) Training on the Fanuc America website.

PDF documents in CRX Folder:

02a Open and Run a Program Tutorial - Fanuc CRX 10IA Collaborative Robot: Open and Run Program

03a Creating a Program - Fanuc CRX 10IA Collaborative Robot: Creating a Program

By: Matthew Jourden - Brighton High School

# **Cognex Communication**

Examples are at the end of Chapter 16 – See Lab 16.5.

From RealPars:

Introduction to Machine Vision for Controls Engineers

https://www.youtube.com/watch?v=emPWRQshsXQ&list=PLln3BHg93SQ9SEN8jXvhy cxAeFcmkjTNs&index=155

How to Use AI in Industrial Automation: Machine Vision https://www.youtube.com/watch?v=NGPwaExODXQ



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