Application Note

FESTO

CPX-AP with Universal Robots (UR) Controllers and Modbus TCP

How to commission a CPX-AP system on Modbus TCP with a Universal Robot controller

CPX-AP-I-EP
CPX-AP-A-EP

100345

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1 Components/Software used

Type/Name	Version Software/Firmware	Date of manufacture
CPX-AP-I-EP-M12	Rev1.3.1	Released May 26, 2021
CPX-AP-I-4DI4DO-M12-5P	Rev1.46.4	
CPX-AP-I-8DI-M8-3P	Rev1.46.4	
VAEM-L1-S-24-AP	Rev1.46.4	
CPX-AP-I-4IOL-M12	Rev1.4.9	
CPX-AP-I-4AI-U-I-RTD-M12	Rev0.5.9	
UR robot controller		
UltraVNC_1_3_2_X64 Viewer		

Table 1.1: 1 Components/Software used

Revision History	Modified by	Date
Rev 0 – initial document	fpl	Aug 2021

2 Introduction

The CPX-AP-I/A-EP are industrial ethernet adapters that supports both EtherNet/IP and Modbus TCP. This is a gateway that connects Festo CPX-AP modules to either protocol. This note will cover commissioning of the CPX-AP-I system to a Universal Robot (UR) controller. With respect to parameterization, there are 2 primary methods.

1. Using "Stored Parameters" for storing the parameters in the CPX-AP-I-EP adapter.
    - This is easily done by using the web server of the CPX-AP system.
    - This can also handle the maximum number of parameters of the system.
    - The disadvantage is if the CPX-AP-I-EP adapter needs to be replaced, the parameter settings are lost, and need to be re-installed manually from a file.
2. Using the UR controller to program the parameters in the adapter. This is possible, but not covered in this App Note.
    - The advantage is for disaster recovery situations. If the adapter is damaged, a replacement is automatically re-configured by the robot controller.

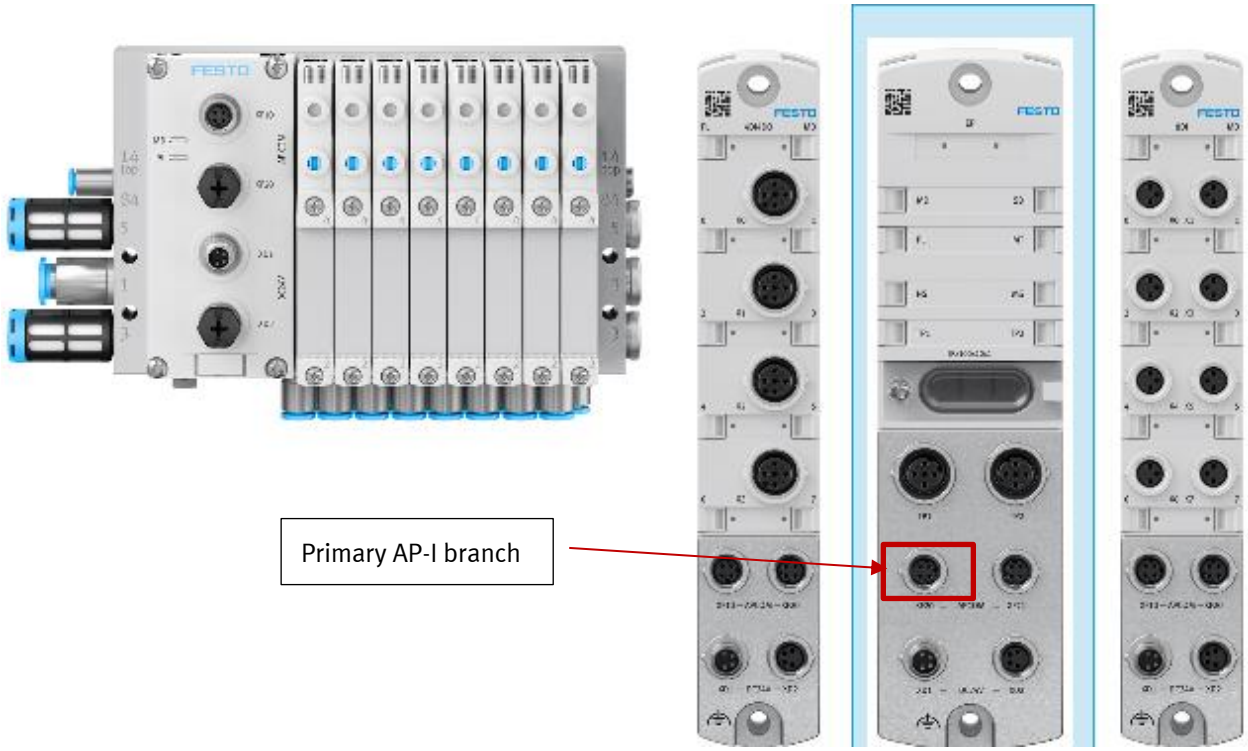
Festo provides documentation in a user manual to configure and use the AP-I system. This application note is intended to provide details and hints specific for use when using a UR robot controller. It is a prerequisite to this note that the user must use the Festo documentation of the AP-I system modules for valves, I/O, and EtherNet/IP. This is needed to become especially familiar with the following:

- Use of the Rotary switches of the CPX-AP-I-EP module
- Understanding of the LEDs of the system
- Understanding of the power, communication, and network cables used for the system
- Understanding power requirements, power distribution, and grounding of the system
- Understanding the use of module parameters

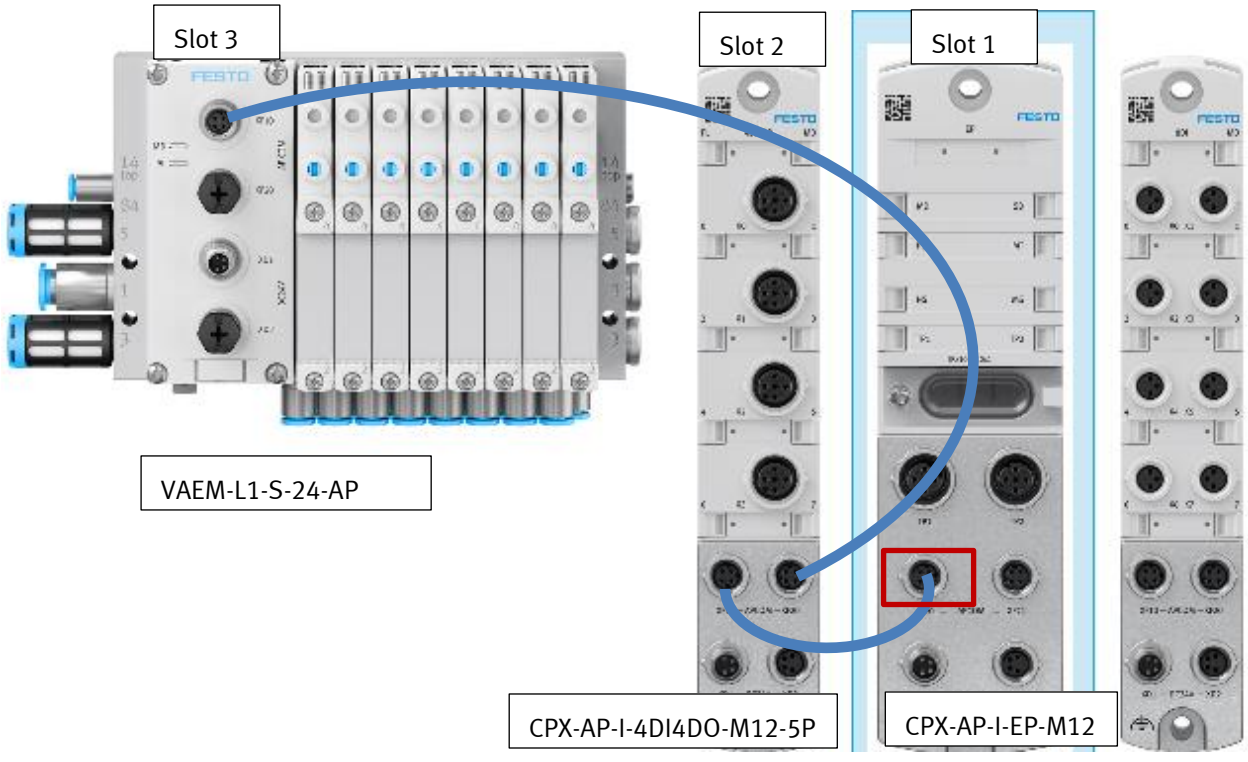
3 Terminal View for AP Modules

3.1.1 AP-I System Primary and Secondary Branches

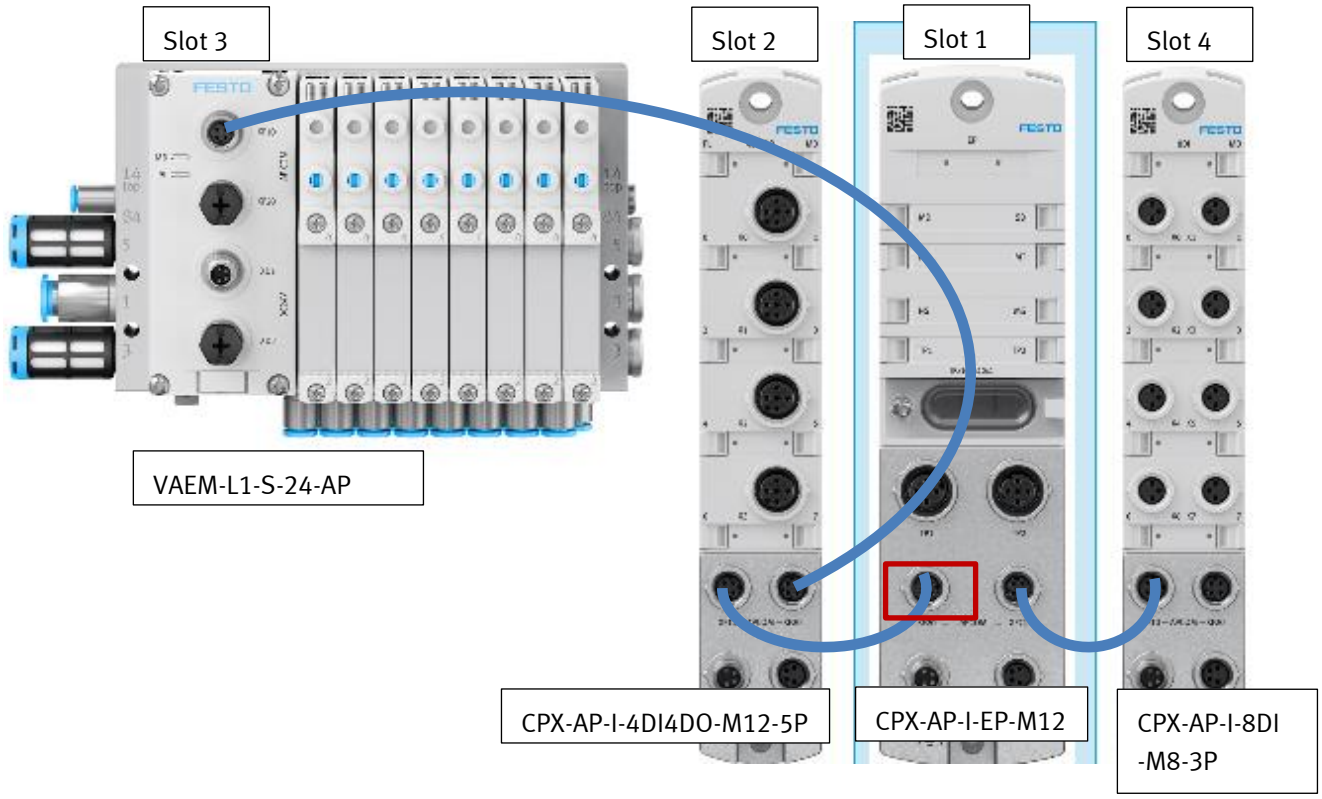
The AP-I system starts with a network adapter that has 2 branches for distributing I/O.



The CPX-AP-I-EP adapter is always slot 1 of the AP system. The left AP-I connector is the primary branch. All modules connected to the primary branch consume the next available slot numbers, in order of connection. The leftmost AP-I connector is the incoming branch (topmost for pneumatic), the rightmost is the outgoing branch.



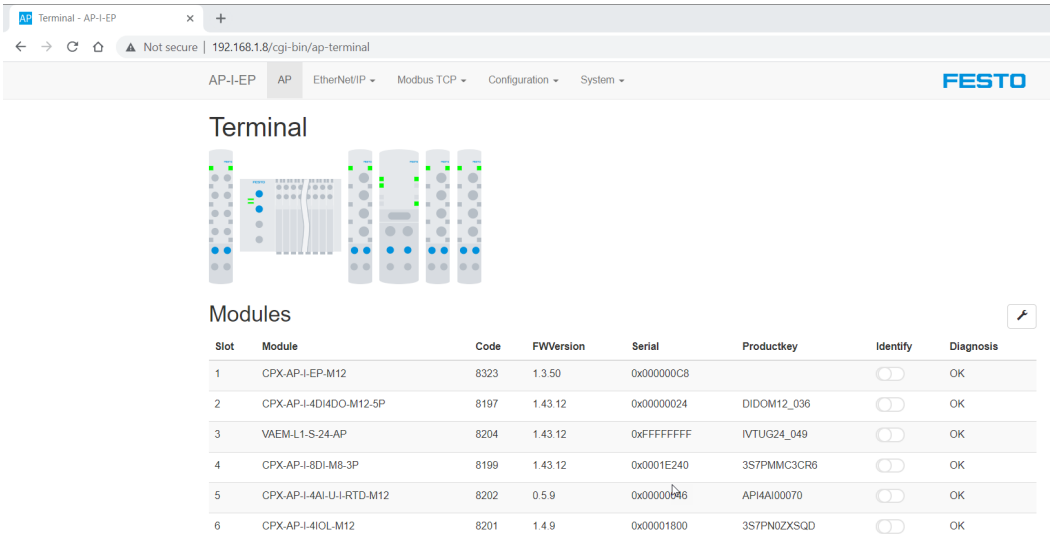
Example of primary branch, modules in slots 1, 2, and 3.



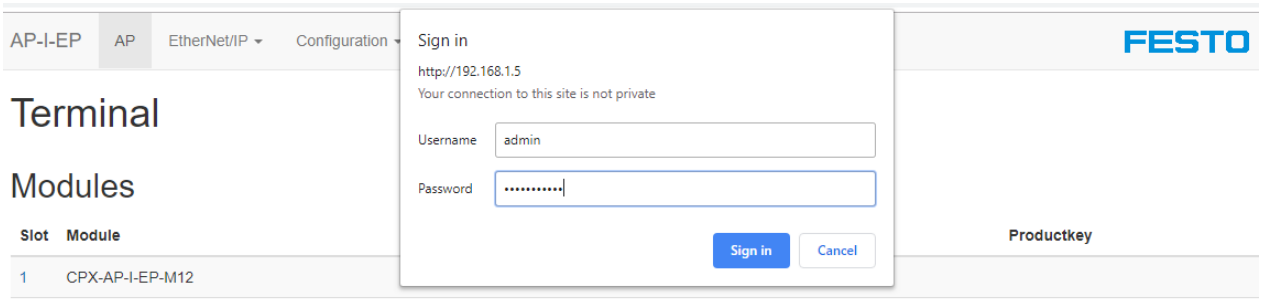
The right AP-I connector is the Secondary branch of the AP-I system. Modules connected to the Secondary branch start consuming slot numbers after the last slot number of the Primary branch. The above example shows the completed test system with all 4 slots consumed.

3.1.2 AP – Terminal and Parameters

The CPX-AP…EP webserver shows the connected configuration of the modules, slots 1 to 6 in this example. The module description, code, FW version, serial numbers, and product key are displayed. The EP product key is not displayed since this is the password for the web access. This is the 11 digit alpha/numeric code found on the adapter.



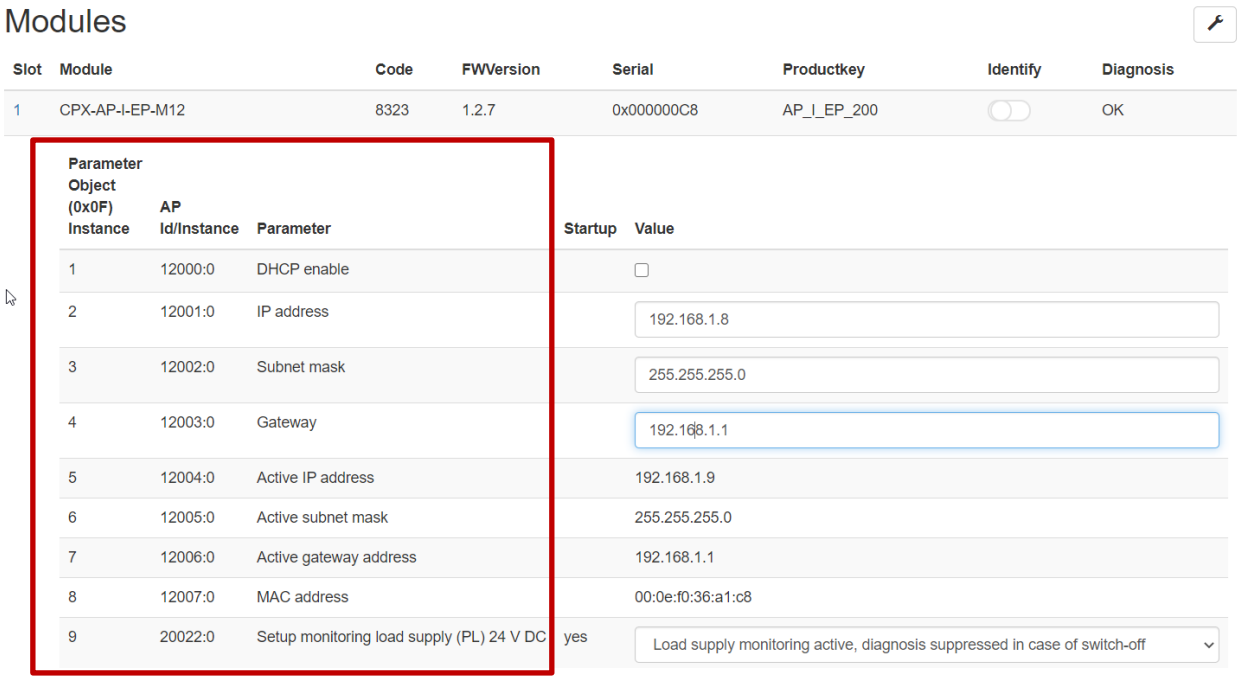
When selecting a module, a Sign-in access is required for the first time in a session. The credentials are:
User: admin
Password: the product key of the EP adapter found on label



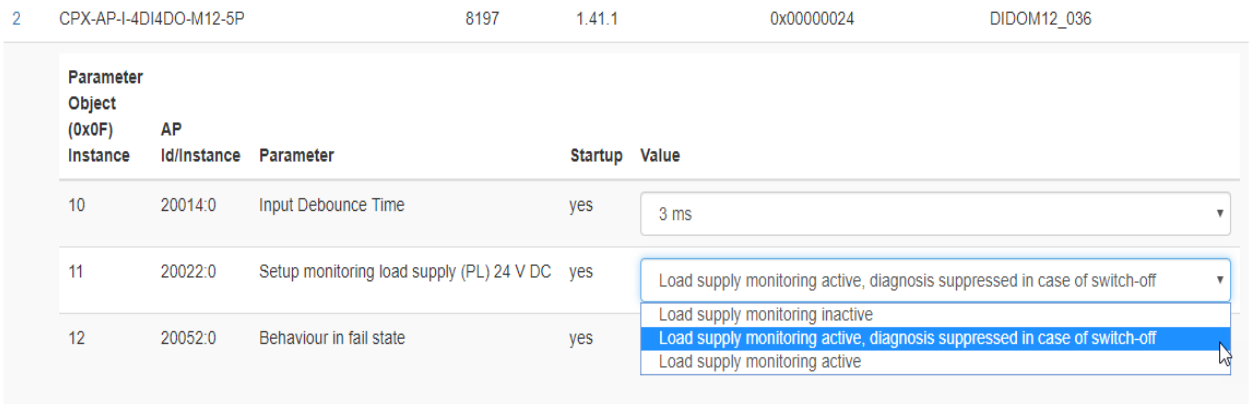
Each module can be configured by clicking on it. For example, slot 1 is the Modbus adapter. One click on the module opens the parameter selection list for the module.

Slot 1. The CPX-AP-I-EP module has configuration parameters for IP address maintenance and supply voltage diagnostics.

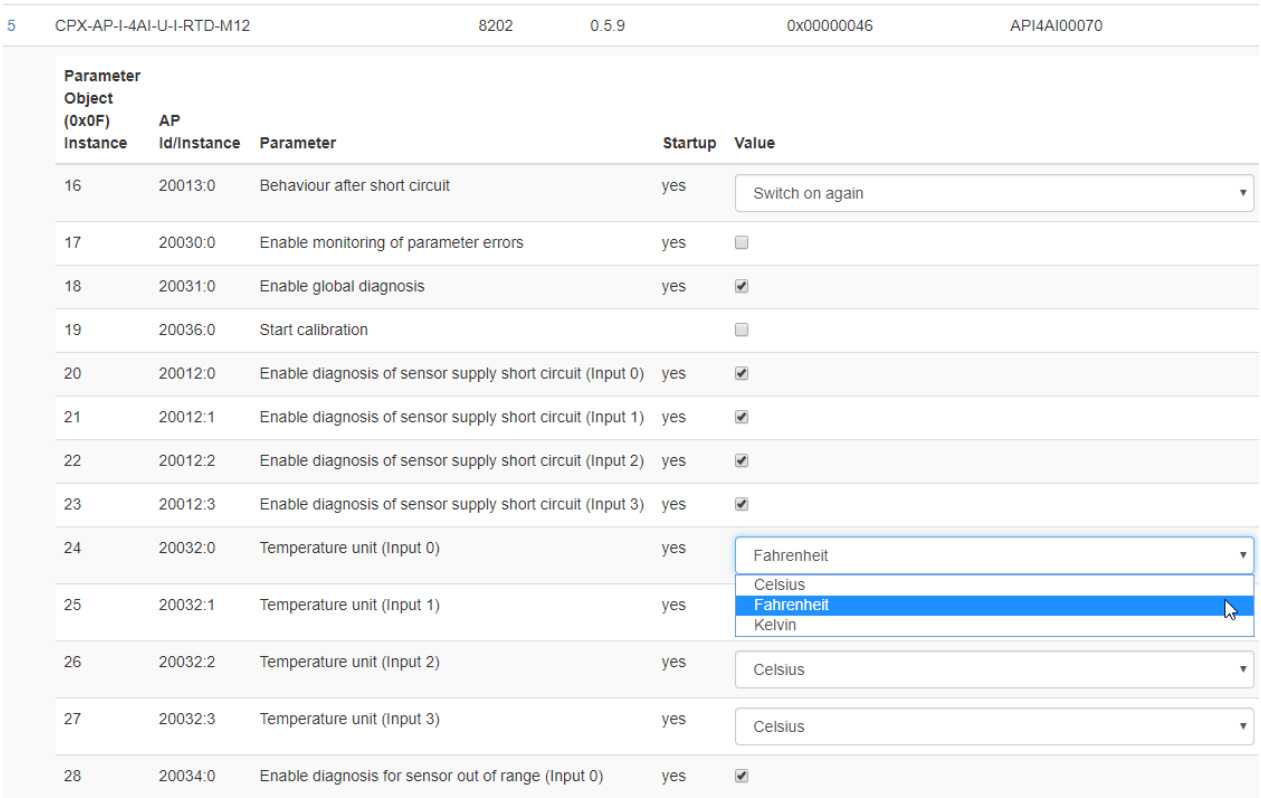
NOTE: Each parameter has instance numbers for the CIP Parameter Object and AP ID instance. This facilitates easy look-up for module parameters. Every module has this list.



Slot 2 example. The CPX-AP-I-4DI4DO-M12-5P has configuration parameters for debounce time, and fail safe state for outputs (default off or hold last state).



Some modules, such as the 4 channel analog input may have an extensive list of parameters. The 4AI module has 52 parameters for configuring the 4 analog channels. Some parameters are required, such as the signal range, so it matches the sensor connected.



The IO-Link module also requires parameterization. By default, all the channels are deactivated. When using the IO-Link master(s), certain parameters need to be configured. Primarily:

- The port mode. If Autostart is used, then no need for Validation and Backup
- The Variant Selection must be selected. Default is 8 bytes per channel

After all parameter selections are made, use Stored Parameters, section 3.1.4, for storing them in the CPX-AP adapter.

For more information on IO-Link usage, see section 6 for using the Festo IO-Link SW Tool.

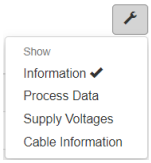
6	CPX-AP-I-4IOL-M12	8201	0.26.5	0x00001800	3S7PN0ZXSQD

Parameter Object (0x0F) Instance	AP Id/Instance	Parameter	Startup	Value
68	20022:0	Setup monitoring load supply (PL) 24 V DC	yes	Load supply monitoring active, diagnosis suppressed in case of switch-off
69	20049:0	Nominal Cycle Time (Port 0)	yes	as fast as possible
70	20049:1	Nominal Cycle Time (Port 1)	yes	as fast as possible
71	20049:2	Nominal Cycle Time (Port 2)	yes	as fast as possible
72	20049:3	Nominal Cycle Time (Port 3)	yes	as fast as possible
73	20050:0	Enable diagnosis of IO-Link device lost (Port 0)	yes	☑
74	20050:1	Enable diagnosis of IO-Link device lost (Port 1)	yes	☑
75	20050:2	Enable diagnosis of IO-Link device lost (Port 2)	yes	☑
76	20050:3	Enable diagnosis of IO-Link device lost (Port 3)	yes	☑
77	20071:0	Port Mode (Port 0)	yes	DEACTIVATED
78	20071:1	Port Mode (Port 1)	yes	IOL_AUTOSTART
79	20071:2	Port Mode (Port 2)	yes	DEACTIVATED
80	20071:3	Port Mode (Port 3)	yes	DEACTIVATED
81	20072:0	Validation & Backup (Port 0)	yes	No Device check
82	20072:1	Validation & Backup (Port 1)	yes	Type compatible Device V1.1, Backup + Restore
83	20072:2	Validation & Backup (Port 2)	yes	No Device check
84	20072:3	Validation & Backup (Port 3)	yes	No Device check
85	20073:0	Nominal Vendor ID (Port 0)	yes	0
86	20073:1	Nominal Vendor ID (Port 1)	yes	0
87	20073:2	Nominal Vendor ID (Port 2)	yes	0
88	20073:3	Nominal Vendor ID (Port 3)	yes	0
89	20080:0	DeviceID (Port 0)	yes	0
90	20080:1	DeviceID (Port 1)	yes	0
91	20080:2	DeviceID (Port 2)	yes	0
92	20080:3	DeviceID (Port 3)	yes	0
93	20074:0	Port status information (Port 0)		DEACTIVATED
94	20074:1	Port status information (Port 1)		OPERATE
95	20074:2	Port status information (Port 2)		DEACTIVATED
96	20074:3	Port status information (Port 3)		DEACTIVATED

97	20075:0	Revision ID (Port 0)		0
98	20075:1	Revision ID (Port 1)		17
99	20075:2	Revision ID (Port 2)		0
100	20075:3	Revision ID (Port 3)		0
101	20076:0	Port transmission rate (Port 0)		NOT_DETECTED
102	20076:1	Port transmission rate (Port 1)		COM2
103	20076:2	Port transmission rate (Port 2)		NOT_DETECTED
104	20076:3	Port transmission rate (Port 3)		NOT_DETECTED
105	20077:0	Actual cycle time in 100 us (Port 0)		0
106	20077:1	Actual cycle time in 100 us (Port 1)		72
107	20077:2	Actual cycle time in 100 us (Port 2)		0
108	20077:3	Actual cycle time in 100 us (Port 3)		0
109	20078:0	Actual VendorID (Port 0)		0
110	20078:1	Actual VendorID (Port 1)		888
111	20078:2	Actual VendorID (Port 2)		0
112	20078:3	Actual VendorID (Port 3)		0
113	20079:0	Actual DeviceID (Port 0)		0
114	20079:1	Actual DeviceID (Port 1)		330248
115	20079:2	Actual DeviceID (Port 2)		0
116	20079:3	Actual DeviceID (Port 3)		0
117	20108:0	InputDataLength (Port 0)		0
118	20108:1	InputDataLength (Port 1)		1
119	20108:2	InputDataLength (Port 2)		0
120	20108:3	InputDataLength (Port 3)		0
121	20109:0	OutputDataLength (Port 0)		0
122	20109:1	OutputDataLength (Port 1)		8
123	20109:2	OutputDataLength (Port 2)		0
124	20109:3	OutputDataLength (Port 3)		0
-	20090:0	Variant selection	yes	CPX-AP-I-4IOL-M12 Variant 8

3.1.3 AP Terminal – Tool View

As of FW version 1.2.7, the AP Terminal page has a Tool View which allows the user to change the page with a different focus. The options are as follows:

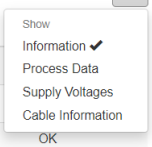


Select the “wrench” icon to change the focus to display process data, supply voltage, or cable info.

The Information page is the default page. In addition to the module name, code, FW version, serial number, product key, and diagnostic status, there is an identify slide. Select “Identify” to flash the MD LED of the module to locate it in a system.

Modules

Slot	Module	Code	FWVersion	Serial	Productkey	Identify	
1	CPX-AP-I-EP-M12	8323	1.2.27	0x000000C8			
2	CPX-AP-I-4DI4DO-M12-5P	8197	1.43.12	0x00000024	DIDOM12_036		
3	VAEM-L1-S-24-AP	8204	1.43.12	0xFFFFFFFF	IVTUG24_049		OK
4	CPX-AP-I-8DI-M8-3P	8199	1.43.12	0x0001E240	3S7PMMC3CR6		OK
5	CPX-AP-I-4AI-U-I-RTD-M12	8202	0.5.9	0x00000046	API4AI00070		OK
6	CPX-AP-I-4IOL-M12	8201	1.4.9	0x00001800	3S7PN0ZXSQD		OK



The Process Data focus shows the actual I/O status, dynamically, with an update rate of about 1 second.

Modules

Slot	Module	Code	FWVersion	Process Data In (hex)	Process Data Out (hex)	Identify	Diagnosis
1	CPX-AP-I-EP-M12	8323	1.2.27				OK
2	CPX-AP-I-4DI4DO-M12-5P	8197	1.43.12	00	03		OK
3	VAEM-L1-S-24-AP	8204	1.43.12		ff ff 00 00 40 00		OK
4	CPX-AP-I-8DI-M8-3P	8199	1.43.12	00			OK
5	CPX-AP-I-4AI-U-I-RTD-M12	8202	0.5.9	c5 1b c5 1b bd 1b bf 1b			OK
6	CPX-AP-I-4IOL-M12	8201	1.4.9	00 00 00 00 00 00 00 00 04 00 00 00 00 00 00 00 00 50 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 a0 a0 00	00 00 00 00 00 00 00 00 06 24 01 04 00 00 03 00 00 00 00 00 00 00 00 00 00 03 00 00 00 00 00 00		OK

The Supply Voltage focus shows the dynamic value of the various voltage supplies of each module.

Modules

Slot	Module	Code	FWVersion	U Sen/El.	U Load	Identify	Diagnosis
1	CPX-AP-I-EP-M12	8323	1.2.27	24.222 V	24.166 V		OK
2	CPX-AP-I-4DI4DO-M12-5P	8197	1.43.12	24.288 V	24 V		OK
3	VAEM-L1-S-24-AP	8204	1.43.12	24.222 V	23.833 V		OK
4	CPX-AP-I-8DI-M8-3P	8199	1.43.12	24.09 V	0 V		OK
5	CPX-AP-I-4AI-U-I-RTD-M12	8202	0.5.9	24.288 V	0 V		OK
6	CPX-AP-I-4IOL-M12	8201	1.4.9	23.958 V	24.072 V		OK

The Cable Information focus shows the cable lengths detected by the system.

Modules

Slot	Module	Code	FWVersion	Cable Length	Identify	Diagnosis
1	CPX-AP-I-EP-M12	8323	1.2.27	2 m		OK
2	CPX-AP-I-4DI4DO-M12-5P	8197	1.43.12	2 m		OK
3	VAEM-L1-S-24-AP	8204	1.43.12	0.6 m		OK
4	CPX-AP-I-8DI-M8-3P	8199	1.43.12	1 m		OK
5	CPX-AP-I-4AI-U-I-RTD-M12	8202	0.5.9	2 m		OK
6	CPX-AP-I-4IOL-M12	8201	1.4.9	1.9 m		OK

The information in the various focus views provide useful troubleshooting information during commissioning and routine maintenance.

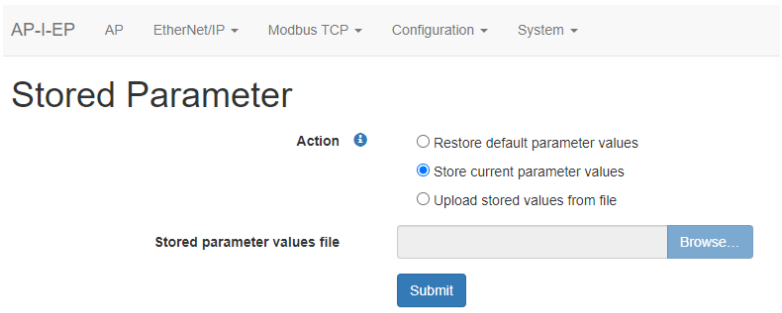
3.1.4 AP Configuration – Stored Parameters

The CPX-AP system for EtherNet/IP and Modbus TCP can store parameters internally in FW 1.2.7 or later.

First set all desired parameters. You can then store them by going to the Configuration->Stored Parameter option.

Your first time before storing, your options will be as follows.

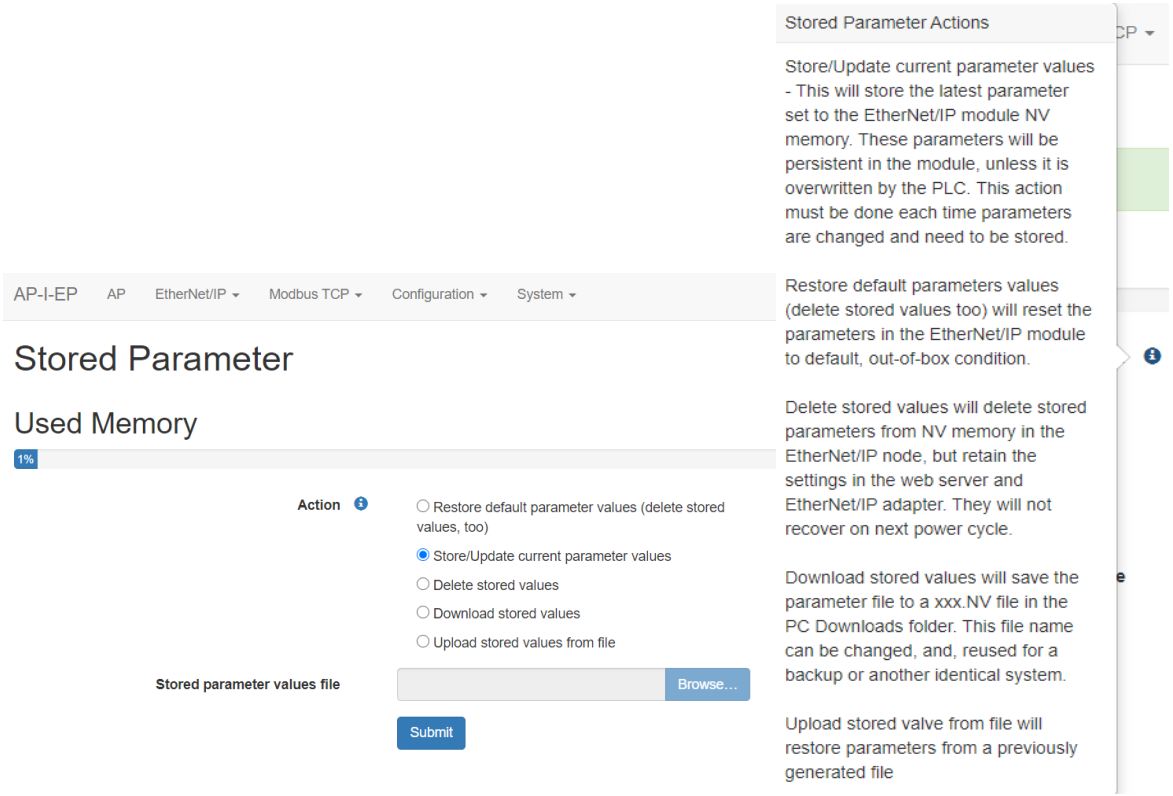
- Default is to store current values.
- You can use this page to restore all values to their default.
- If you have a file from the same or a previous system with an EXACT configuration, you can also upload the values from that file.



After submitting the values, they are stored in the CPX-AP adapter. There are now additional options:

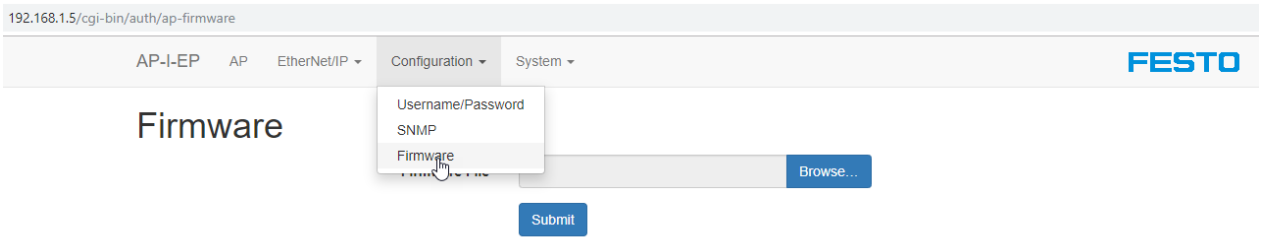
- Delete stored values
- Download Stored Values

Note
The Info Button has detailed information on the actions within Stored Parameters


Stored Parameter Actions
Store/Update current parameter values - This will store the latest parameter set to the EtherNet/IP module NV memory. These parameters will be persistent in the module, unless it is overwritten by the PLC. This action must be done each time parameters are changed and need to be stored.
Restore default parameters values (delete stored values too) will reset the parameters in the EtherNet/IP module to default, out-of-box condition.
Delete stored values will delete stored parameters from NV memory in the EtherNet/IP node, but retain the settings in the web server and EtherNet/IP adapter. They will not recover on next power cycle.
Download stored values will save the parameter file to a xxx.NV file in the PC Downloads folder. This file name can be changed, and, reused for a backup or another identical system.
Upload stored valve from file will restore parameters from a previously generated file
AP-I-EP
AP
EtherNet/IP
Modbus TCP
Configuration
System
Stored Parameter
Used Memory
1%
Action
Restore default parameter values (delete stored values, too)
Store/Update current parameter values
Delete stored values
Download stored values
Upload stored values from file
Stored parameter values file
Browse...
Submit

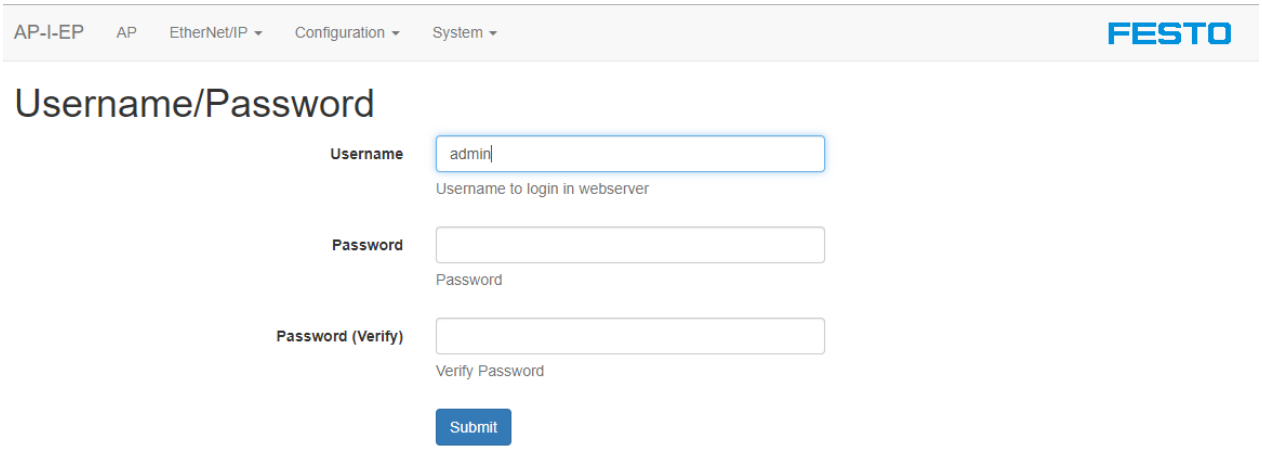
3.1.5 AP Configuration - Firmware

The CPX-AP EtherNet/IP module can load new FW simply by browsing a FFWU file on a PC.



3.1.6 AP Configuration – Username/Password

The username / password can be changed. Follow user manual to reset to default values if forgotten.

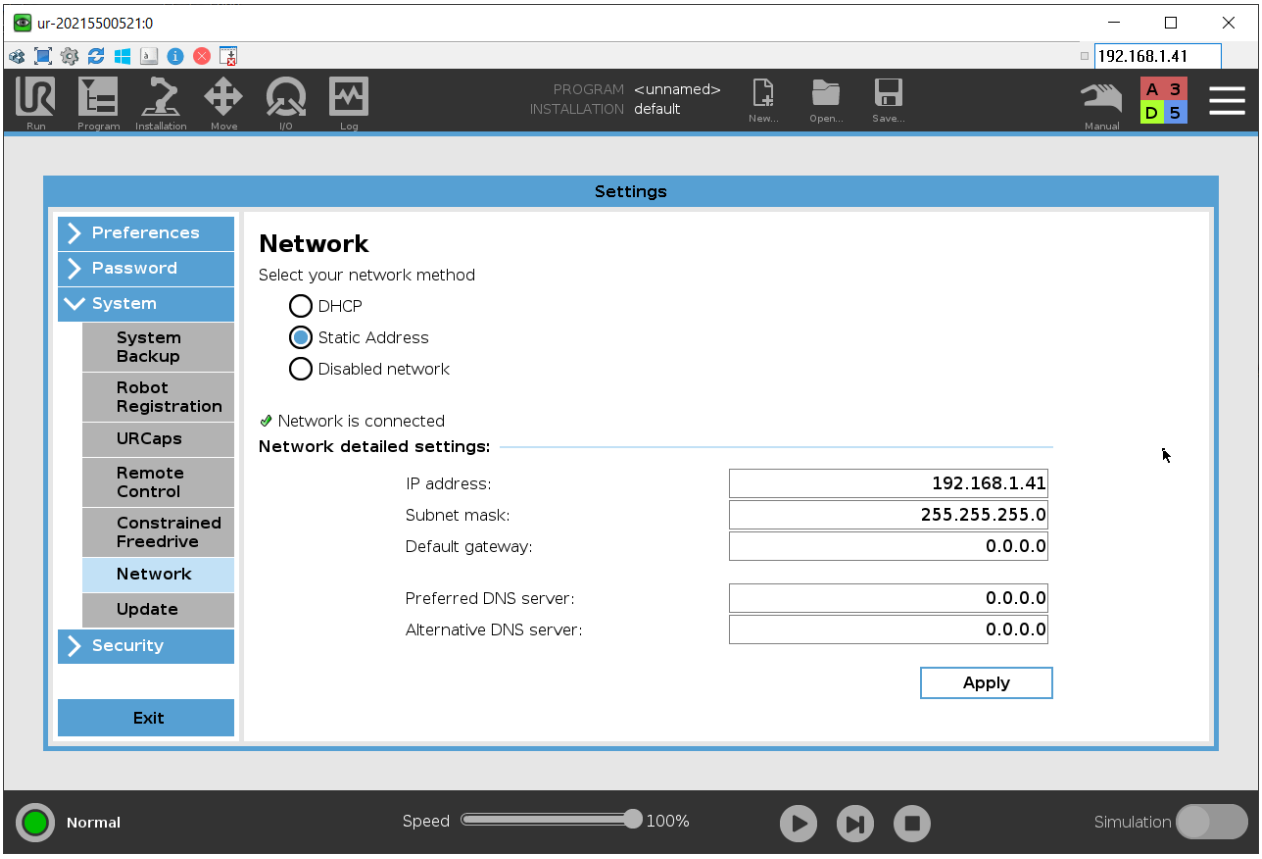


4 Getting Started with UR and Modbus TCP

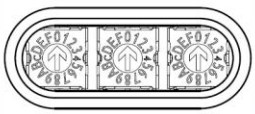
The commissioning of the UR robot controller Modbus TCP client is quite easy. Commissioning can be done directly form the robot pendant station, or from a PC using a remote viewer. In this case, UltraVNC_1_3_2_X64 Viewer was used.

4.1.1 IP Addresses

- Be sure the robot controller, PC (if used), and CPX-AP system are all on the same IP address subnet.
- In this example, the IP address for UR is 192.168.1.41. Go to Settings -› System -› Network. Make the method Static. Enter IP address, Subnet, and apply.



- The CPX-AP has multiple methods for setting IP address.
  - Any DHCP server
  - Rotary switches for last octet of public IP address 192,.168.1.xxx
  - Festo Field Device Tool can change any IP address already entered into the CPX-AP
  - Festo Automation Suite 2021 Winter Release will have a DHCP server that can be used with this device.
- In this example, the rotary switches were used to set the IP address to 192.168.1.8

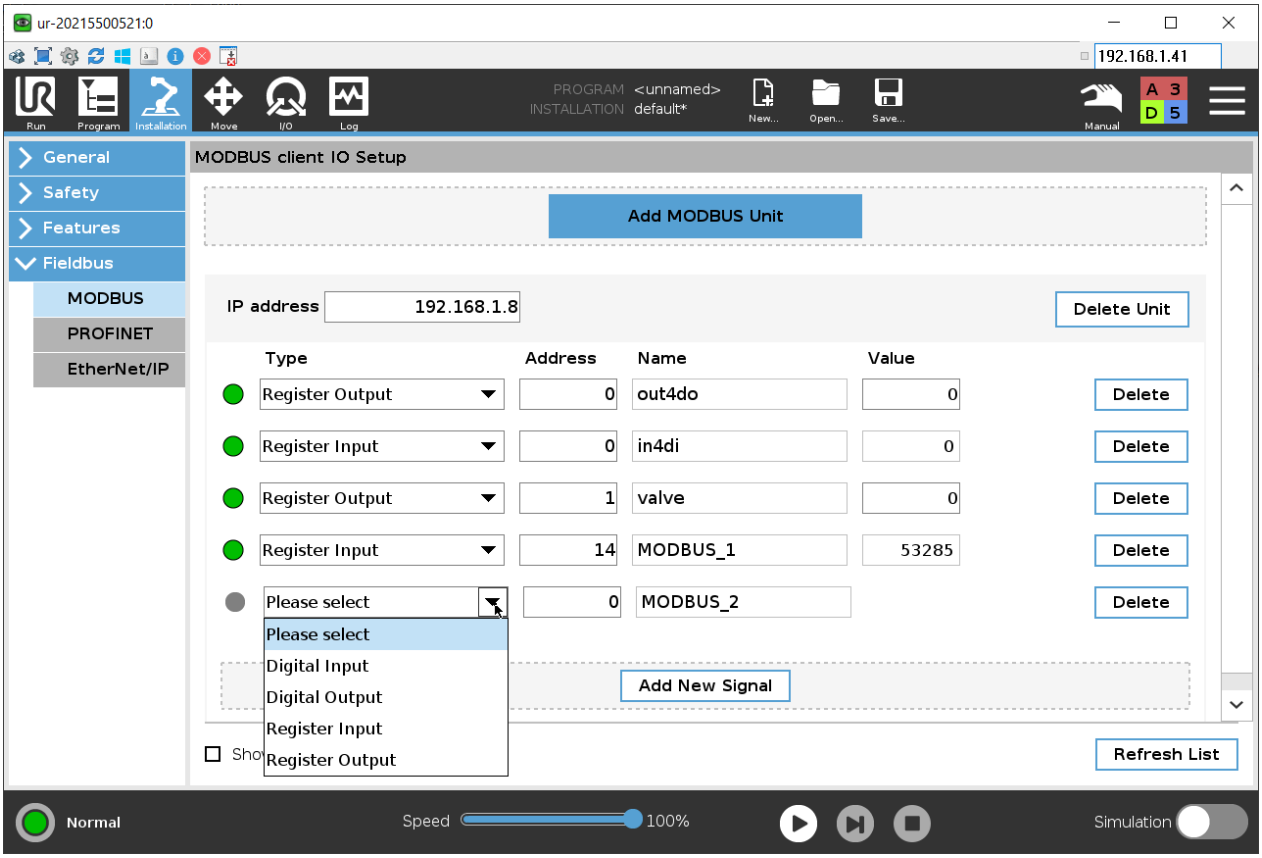
Rotary switch	Function
IPx100x10x1 	The 3 rotary switches are used to set the 4th octet of the IP address (192.168.1.XXX). Possible settings: – 0 = dynamic addressing via DHCP (factory setting) – 1 … 255 = permissible address range Valid values: – EtherNet/IP: 300 … 555 (IP address = value – 300) – Modbus TCP: 600 … 855 (IP address = value – 600) – Reset to factory setting: 900 If values are invalid, the IP parameters are reset to the factory settings. In the range 0 … 255 both network protocols are active. The network protocol that first sets outputs has priority over the outputs.

- From Festo manual p/n 8099750, set switches to 608, 600 being the least significant value for Modbus

4.1.2 Installation Setup

Once the IP addresses are set, we can go into the Installation Set-up of the UR controller to set the CPX-AP Modbus TCP server information.

- Go the Installation icon -› Fieldbus -› Modbus option:



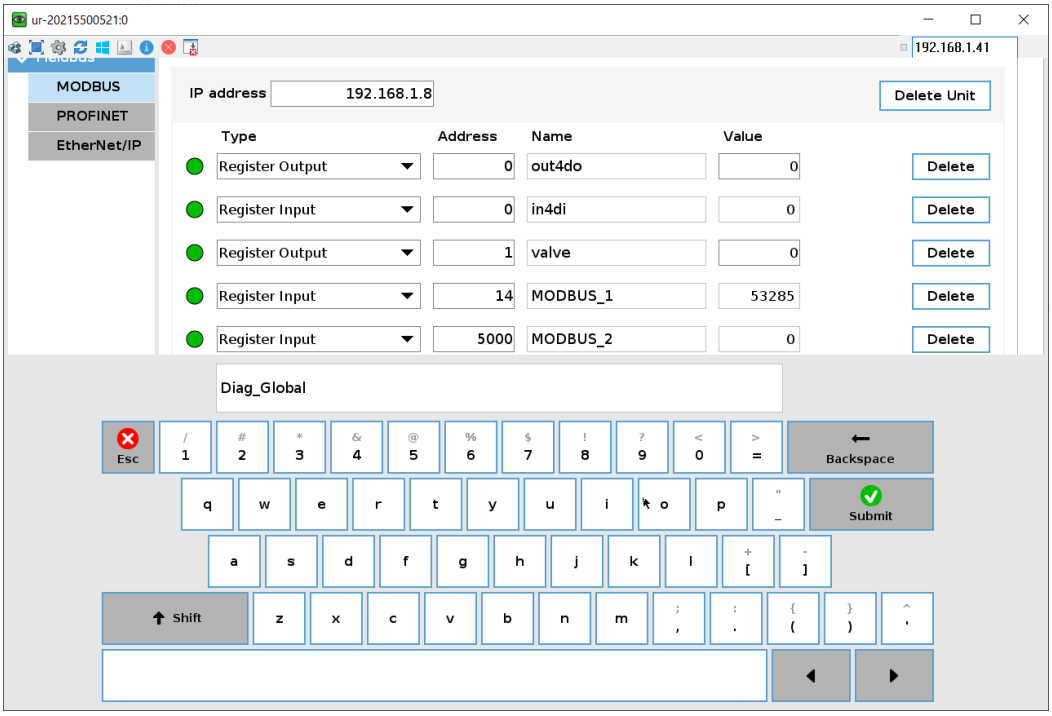
- Enter the IP address of the CPX-AP adapter.
- The robot controller gives options to use registers or digital function codes of Modbus. In the first line item we selected Register Output (Holding Register in CPX-AP).
  - In this case, Address Register 0 is the first output module of the CPX-AP system.
  - The name was changed to out4do to match the first module
  - A connection is immediately made, as indicated by the green indicator in this line.
  - A decimal value will set the boolean equivalents of the output module. For example, 3dec are bits 0011 of the 4 DO module. So outputs 0 and 1 would be active.

- In addition, the CPX-AP adapter should indicate a connection is made. Observe the following LED function:

NS	Green static: Device is online and has at least one connection. Green blink: Device is online and got an IP address, but no active connection Off: Device is offline

- The NS LED should be solid green at this point.

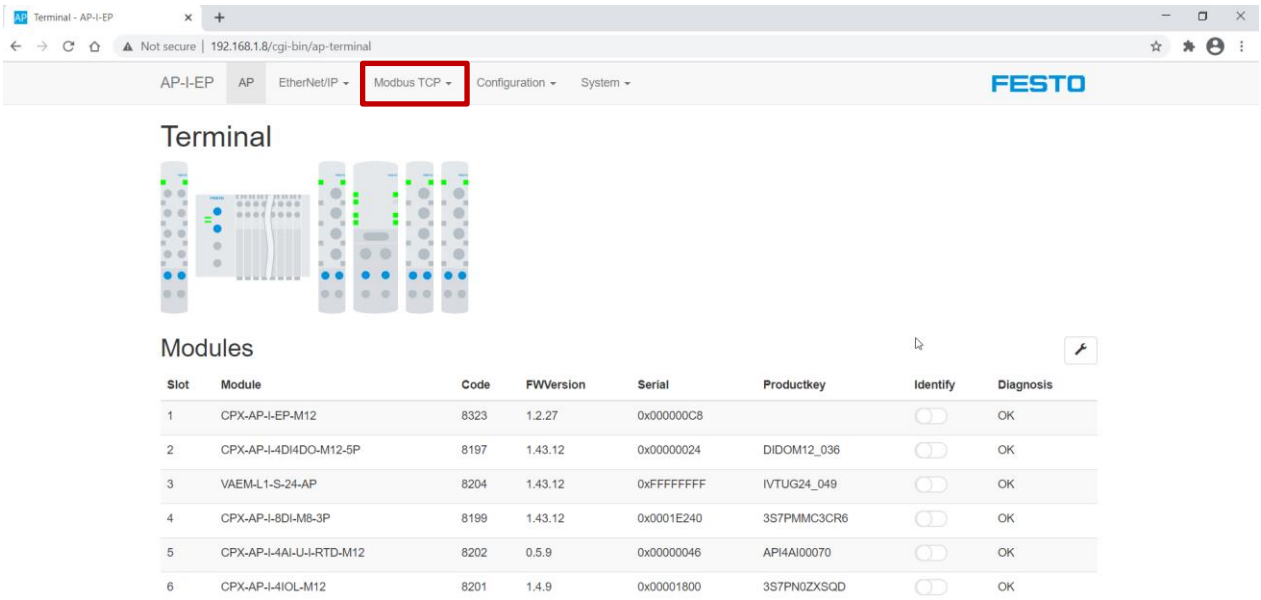
Names can be changed by selecting the name field:



5 Modbus TCP View – Modbus Addresses for CPX-AP System

At this point, it is necessary to know how the Modbus Addresses are assigned in the CPX-AP system. A Modbus View is included in the CPX-AP webserver to facilitate the addressing of a CPX-AP system with a Modbus controller. The registers can also be calculated based on the CPX-AP configuration.

Modbus TCP View in Webserver:



5.1 Modbus TCP Overview for the CPX-AP System

The CPX-AP system has Modbus register addresses for I/O, Diagnostics, Parameters, Module, and IO-Link data points. In addition, other pertinent information is as follows:

a. Registers are assigned in the order of the connected modules. Refer to examples in Chapter 3 on how the ordering is done based on the Primary and Secondary branches.
b. UR Output Registers = CPX-AP Holding Registers
c. Each module starts at the beginning of the next available Register.
d. Modules will consume a varying amount of data. This depends on the modules maximum size. This information can be found in the module datasheets or user manual.

e. CPX-AP Modbus Holding (Output) Register Description:

Register	Length	Access	Name
0	4096	rw	Outputs
5000	4096	r	Inputs
10000	1000	r/w	Parameter
11000	1000	r	Diagnosis
12000	1	r	Module Count
14000	2	r/w	Timeout (default 100 ms)
14002	1	r/w	Webserver Enable
14003	1	r/w	Webserver Write Access Enable
14004	1	r/w	SNMP Enable
15000	18500	r	Module Information
34000	200	r/w	IO-Link ISDU Mailbox

f. Timeout

Address info:

14000	2 Int	r/w	Timeout (default 100 ms)

Description:

Modbus connection timeout in ms (default=100 ms).
Value is stored in non-volatile memory
Value of 0 turns the timeout off.

g. Parameter Execution

Description:

1	Read
2	Write
3	Busy (read or write currently running)
4	Error (request failed - status code in the upper 8 bit)
16	Done (request successfully completed)

A parameter read or write is initiated by writing the Exec register as last register of the request.
Steps to execute a request:

Step	Register	Description
1	10000	write module number
2	10001	write parameter id
3	10002	write parameter instance
4	10004 and 10010..(10010 + datalen written in 10004)	write datalen and data (only for write request)
5	10003	write 1 or 2 to exec register
6	10003	read back exec register until done or error
7	10004 and 10010...	read datalen and data (only for read request)

h. IO-Link ISDU Access

Description:

Holding register	Attribute	Description
34000	ISDU Status	0 = OK 254 = Error 255 = Busy
34001	Read/Write Command	50 = Read (with byte swap) 51 = Write (with byte swap) 100 = Read 101 = Write
34002	Module	Module number of an IO-Link Master
34003	Channel	
34004	Index	ISDU Index
34005	Subindex	ISDU Subindex
34006	Length of data	in Bytes (for read always zero)

34007..34126	Data	(max 238 bytes)

Transfer is initiated by writing command (read / write), all other values have to be correctly set up before. After command is written check input register (ISDU Status). Module and channel number start counting at 1.

i. CPX-AP Modbus Input Register Description:

Register	Length	Access	Name
0	4096	r	Inputs
5000	1000	r	Diagnosis

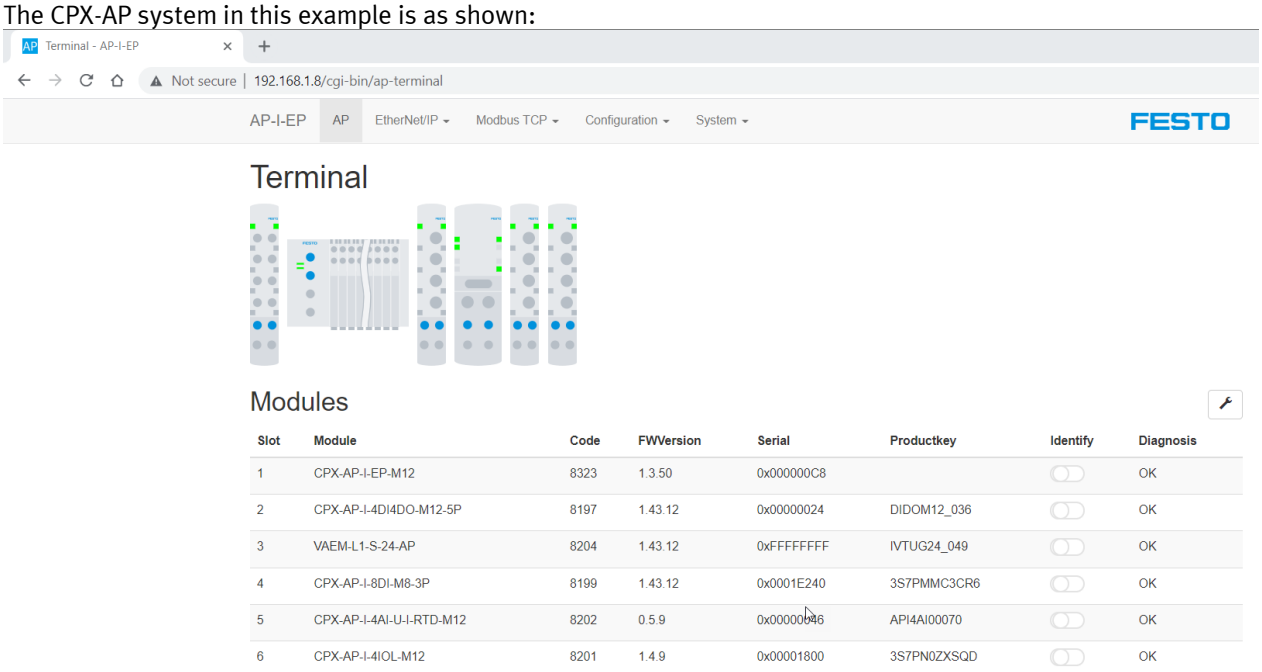
j. CPX-AP General Diagnosis Description:

- There are always 12 bytes (6 registers) of global diagnostics
- There are always 12 bytes (6 registers) of module diagnostics
- Each module has its own set of diagnostics
- The diagnostic field will be structured as follows: Size is 12 bytes + mod count * 12 bytes

Byte offset	Len	Description
0	4	Global diagnosis state
4	2	Count of currently active diagnosis
6	2	Module which has latest diagnosis
8	4	Latest diagnosis code
Array of Module Diagnosis with module number (=n) as index		
12 + n * 12	1	Module no
13 + n * 12	1	Submodule
14 + n * 12	1	Channel
15 + n * 12	1	Module present state
16 + n * 12	4	Module diagnosis state
20 + n * 12	4	Diagnosis Code

5.2 Modbus TCP Example for the CPX-AP System

The CPX-AP system in this example is as shown:



Holding Registers assignment

Mod#	Desc	In Holding Registers	Out Holding Registers	Comments
1	EP-M12	n/a	n/a	No I/O for the adapter module
2	4DI4DO	5000	0	Starts at the beginning of register list. Only consumes 1 register each, since 1 reg = 16 bits. This module consumes 4 bits in/out
3	VAEM...24	n/a	1 - 3	No inputs for VAEM Outputs start at Reg 1. Since this consumes 6 bytes, this is 3 registers; 1,2,3
4	8 DI	5001	n/a	No outputs for 8DI Inputs start at next avail reg, 5001. Since this is only 1 byte, this consumes 1 reg.
5	4AI	5002 5003 5004 5005	n/a	No outputs for 4AI Inputs start at next avail reg, 5002. Since this consumes 8 bytes (4 ch X 2 bytes each), this is 4 registers.
6	4 IOL	5006- 5009 5010 – 5013 5014 – 5017 5018 - 5021	4 – 7 8 – 11 12 – 15 16 - 19	The IOL module data consumption is based on a parameter setting (see IO-Link variant selection). In this case, this is set to consume 8 bytes I/O per channel. Next starting input reg is 5006. This requires 16 registers. Four per channel. Next starting output reg is 4. This requires 16 registers. Four per channel.
Diag	Global	11000 11001	n/a	Global diagnosis state
DIag	Global	11002	n/a	Count of currently active diagnosis
Diag	Global	11003	n/a	Module which has latest diagnosis
Diag	Global	11004 11005	n/a	Latest diagnosis code
Diag	Module 1	11006	n/a	Module number (LSB) and submodule number (MSB)
DIag	Module 1	11007	n/a	Channel (LSB) and module present state (MSB)
Diag	Module 1	11008 11009	n/a	Module Diagnosis state
Diag	Module 1	11010	n/a	Diagnosis code

		11011		
Diag	Module 2	11012	n/a	Module number (LSB) and submodule number (MSB)
DIag	Module 2	11013	n/a	Channel (LSB) and module present state (MSB)
Diag	Module 2	11014 11015	n/a	Module Diagnosis state
Diag	Module 2	11016 11017	n/a	Diagnosis code
Continue pattern to complete all 6 modules in this example				

Input Registers assignment

Mod#	Desc	In Input Registers	Out Input Registers	Comments
1	EP-M12	n/a	n/a	No I/O for the adapter module
2	4DI4DO	0	n/a	Starts at the beginning of register list. Only consumes 1 register each, since 1 reg = 16 bits. This module consumes 4 bits in/out
3	VAEM…24	n/a	n/a	No inputs for VAEM
4	8 DI	1	n/a	No outputs for 8DI Inputs start at next avail reg, 1. Since this is only 1 byte, this consumes 1 reg.
5	4AI	2 3 4 5	n/a	No outputs for 4AI Inputs start at next avail reg, 2. Since this consumes 8 bytes (4 ch X 2 bytes each), this is 4 registers.
6	4 IOL	6 - 9 10 – 13 14 – 17 18 - 21	n/a	The IOL module data consumption is based on a parameter setting (see IO-Link variant selection). In this case, this is set to consume 8 bytes I/O per channel. Next starting input reg is 6. This requires 16 registers. Four per channel.
Diag	Global	5000 5001	n/a	Global diagnosis state
DIag	Global	5002	n/a	Count of currently active diagnosis
Diag	Global	5003	n/a	Module which has latest diagnosis
Diag	Global	5004 5005	n/a	Latest diagnosis code
Diag	Module 1	5006	n/a	Module number (LSB) and submodule number (MSB)
DIag	Module 1	5007	n/a	Channel (LSB) and module present state (MSB)
Diag	Module 1	5008 5009	n/a	Module Diagnosis state
Diag	Module 1	5010 5011	n/a	Diagnosis code
Diag	Module 2	5012	n/a	Module number (LSB) and submodule number (MSB)
DIag	Module 2	5013	n/a	Channel (LSB) and module present state (MSB)
Diag	Module 2	5014 5015	n/a	Module Diagnosis state
Diag	Module 2	5016 5017	n/a	Diagnosis code
Continue pattern to complete all 6 modules in this example				

5.3 Modbus TCP Holding Register View

The CPX-AP webserver provides a Holding and Input register view of the system connected to the CPX-AP adapter. This provides an easy check of the actual register assignment based on the configuration. The system must be connected and powered-up to use this view.

Example Holding Register View

AP-I-EP AP EtherNet/IP Modbus TCP Configuration System FESTO

Holding Register View

Search:

Register	Offset (bit)	Bit length	Module	Channel	Datatype	Name
			Outputs			
0	0	1	2	0	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Output 0
0	1	1	2	1	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Output 1
0	2	1	2	2	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Output 2
0	3	1	2	3	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Output 3
1	0	1	3	0	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 0
1	1	1	3	1	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 1
1	2	1	3	2	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 2
1	3	1	3	3	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 3
1	4	1	3	4	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 4
1	5	1	3	5	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 5
1	6	1	3	6	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 6
1	7	1	3	7	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 7
1	8	1	3	8	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 8
1	9	1	3	9	BOOL	Module 3 - VAEM-L1-S-24-AP - Coil 9
16 - 19	0	64	6	3	USINT[8]	Module 6 - CPX-AP-I-4IOL-M12 - Port 3
			Inputs			
5000	0	1	2	0	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 0
5000	1	1	2	1	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 1
5000	2	1	2	2	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 2
5000	3	1	2	3	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 3
5001	0	1	4	0	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 0
5001	1	1	4	1	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 1
5001	2	1	4	2	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 2
5001	3	1	4	3	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 3
5001	4	1	4	4	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 4
5001	5	1	4	5	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 5
5001	6	1	4	6	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 6
5001	7	1	4	7	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 7
5002	0	16	5	0	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 0
5003	0	16	5	1	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 1
5004	0	16	5	2	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 2
5005	0	16	5	3	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 3
5006 - 5009	0	64	6	0	USINT[8]	Module 6 - CPX-AP-I-4IOL-M12 - Port 0

5023	8	8	6	7	USINT	Module 6 - CPX-AP-I-4IOL-M12 - Port 7 - PQI
Parameter Mailbox						
10000	0	16	-	-	UINT	Parameter Mailbox - Module Number
10001	0	16	-	-	UINT	Parameter Mailbox - AP Parameter ID
10002	0	16	-	-	UINT	Parameter Mailbox - AP Parameter Instance
10003	0	16	-	-	UINT	Parameter Mailbox - Execute / Command
10004	0	16	-	-	UINT	Parameter Mailbox - Data Length
10010 - 10521	0	8192	-	-	Array Of Byte	Parameter Mailbox - Data
Diagnosis						
11000 - 11001	0	32	-	-	DWORD	Global Diagnosis State
11002	0	16	-	-	INT	Count of currently active diagnosis
11003	0	16	-	-	INT	Module which has latest diagnosis
11004 - 11005	0	32	-	-	DINT	Latest Diagnosis Code
11006	0	8	1	0	SINT	Diagnosis - Module 1
11006	8	8	1	0	SINT	Diagnosis - Module 1 - Submodule
11007	0	8	1	0	SINT	Diagnosis - Module 1 - Channel
11007	8	8	1	0	SINT	Diagnosis - Module 1 - Present State
11008 - 11009	0	32	1	0	DINT	Diagnosis - Module 1 - Module Diagnosis State
11010 - 11011	0	32	1	0	DINT	Diagnosis - Module 1 - Diagnosis Code
11012	0	8	2	0	SINT	Diagnosis - Module 2
11012	8	8	2	0	SINT	Diagnosis - Module 2 - Submodule
11040 - 11041	0	32	6	0	DINT	Diagnosis - Module 6 - Diagnosis Code
General Information						
12000	0	16	-	-	UINT	Module Count
System Parameter						
14000 - 14001	0	32	-	-	UDINT	Modbus Timeout (msec)
14002	0	1	-	-	BOOL	Webserver Enable
14003	0	1	-	-	BOOL	Webserver Write Access Enable
14004	0	1	-	-	BOOL	SNMP Enable
Module Information						
15000 - 15001	0	32	1	0	UDINT	Module Information - Module 1 - Module Code
15002	0	16	1	0	UINT	Module Information - Module 1 - Module Class
15003	0	16	1	0	UINT	Module Information - Module 1 - Communication Profiles
15004	0	16	1	0	UINT	Module Information - Module 1 - Input Size (Bytes)
15005	0	16	1	0	UINT	Module Information - Module 1 - Input Channels
15006	0	16	1	0	UINT	Module Information - Module 1 - Output Size (Bytes)
15007	0	16	1	0	UINT	Module Information - Module 1 - Output Channels
15008	0	16	1	0	UINT	Module Information - Module 1 - Hardware Version
15009	0	16	1	0	UINT	Module Information - Module 1 - Firmware Version Major
15010	0	16	1	0	UINT	Module Information - Module 1 - Firmware Version Minor
15011	0	16	1	0	UINT	Module Information - Module 1 - Firmware Version Patch
15012 - 15013	0	32	1	0	UDINT	Module Information - Module 1 - Serial Number
15014 - 15019	0	96	1	0	STRING	Module Information - Module 1 - Product Key

15199 - 15204	0	96	6	0	STRING	Module Information - Module 6 - Product Key
15205 - 15221	0	272	6	0	STRING	Module Information - Module 6 - Order Text
				IO-Link Mailbox		
34000	0	16	-	-	UINT	IO-Link Mailbox - ISDU Status
34001	0	16	-	-	UINT	IO-Link Mailbox - Read/Write Command
34002	0	16	-	-	UINT	IO-Link Mailbox - Module Number
34003	0	16	-	-	UINT	IO-Link Mailbox - Channel
34004	0	16	-	-	UINT	IO-Link Mailbox - ISDU Index
34005	0	16	-	-	UINT	IO-Link Mailbox - ISDU Subindex
34006	0	16	-	-	UINT	IO-Link Mailbox - Data Length
34007 - 34125	0	1904	-	-	Array Of Byte	IO-Link Mailbox - Data

5.4 Modbus TCP Input Register View

Example Input Register View

AP-I-EP AP EtherNet/IP Modbus TCP Configuration System FESTO

Input Register View

Search:

Register	Offset (bit)	Bit length	Module	Channel	Datatype	Name
				Inputs		
0	0	1	2	0	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 0
0	1	1	2	1	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 1
0	2	1	2	2	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 2
0	3	1	2	3	BOOL	Module 2 - CPX-AP-I-4DI4DO-M12-5P - Input 3
1	0	1	4	0	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 0
1	1	1	4	1	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 1
1	2	1	4	2	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 2
1	3	1	4	3	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 3
1	4	1	4	4	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 4
1	5	1	4	5	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 5
1	6	1	4	6	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 6
1	7	1	4	7	BOOL	Module 4 - CPX-AP-I-8DI-M8-3P - Input 7
2	0	16	5	0	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 0
3	0	16	5	1	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 1
4	0	16	5	2	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 2
5	0	16	5	3	INT	Module 5 - CPX-AP-I-4AI-U-I-RTD-M12 - Input 3
6 - 9	0	64	6	0	USINT[8]	Module 6 - CPX-AP-I-4IOL-M12 - Port 0

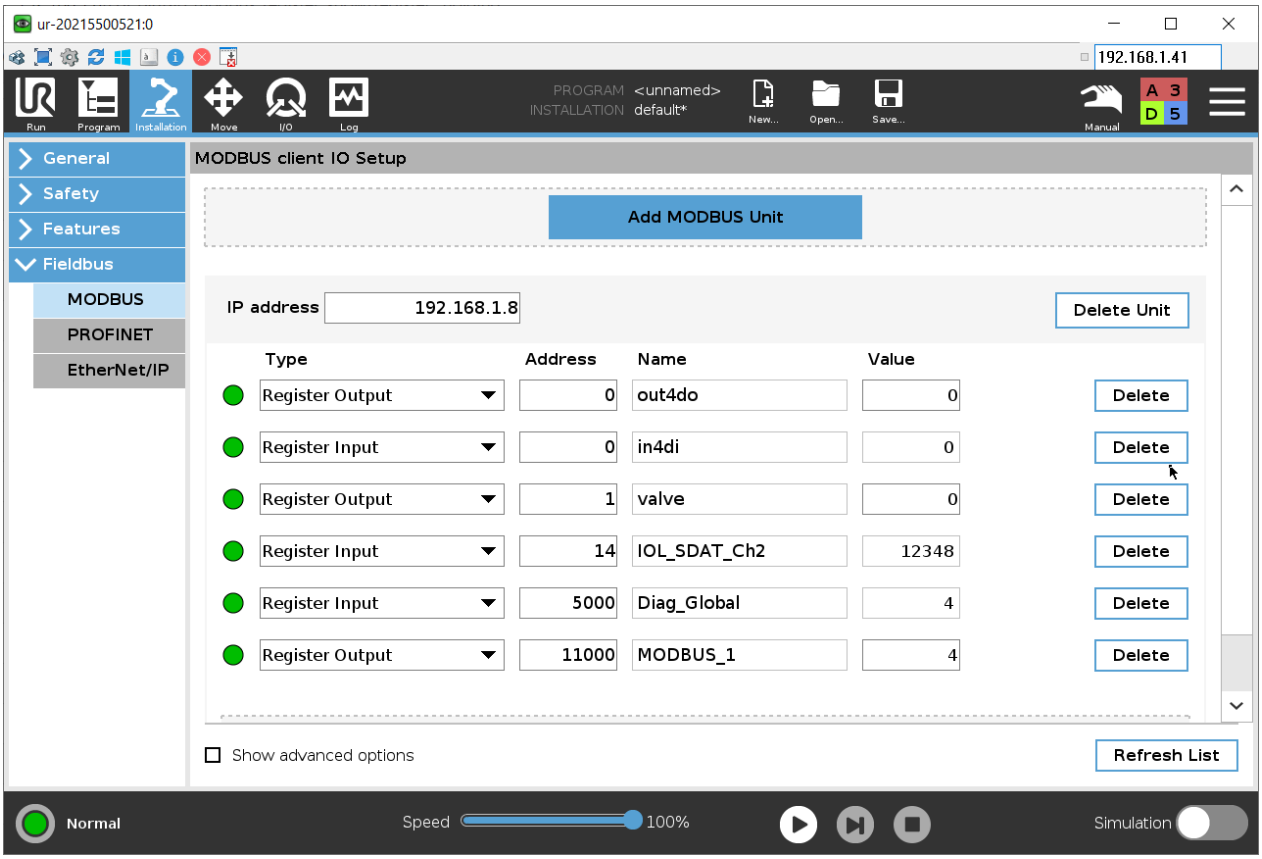
23	8	8	6	7	USINT	Module 6 - CPX-AP-I-4IOL-M12 - Port 7 - PQI
				Diagnosis		
5000 - 5001	0	32	-	-	DWORD	Global Diagnosis State
5002	0	16	-	-	INT	Count of currently active diagnosis
5003	0	16	-	-	INT	Module which has latest diagnosis
5004 - 5005	0	32	-	-	DINT	Latest Diagnosis Code
5006	0	8	1	0	SINT	Diagnosis - Module 1
5006	8	8	1	0	SINT	Diagnosis - Module 1 - Submodule
5007	0	8	1	0	SINT	Diagnosis - Module 1 - Channel
5007	8	8	1	0	SINT	Diagnosis - Module 1 - Present State
5008 - 5009	0	32	1	0	DINT	Diagnosis - Module 1 - Module Diagnosis State
5010 - 5011	0	32	1	0	DINT	Diagnosis - Module 1 - Diagnosis Code
5012	0	8	2	0	SINT	Diagnosis - Module 2
5012	8	8	2	0	SINT	Diagnosis - Module 2 - Submodule
5013	0	8	2	0	SINT	Diagnosis - Module 2 - Channel
5013	8	8	2	0	SINT	Diagnosis - Module 2 - Present State
5014 - 5015	0	32	2	0	DINT	Diagnosis - Module 2 - Module Diagnosis State
5016 - 5017	0	32	2	0	DINT	Diagnosis - Module 2 - Diagnosis Code
5018	0	8	3	0	SINT	Diagnosis - Module 3
5018	8	8	3	0	SINT	Diagnosis - Module 3 - Submodule
5019	0	8	3	0	SINT	Diagnosis - Module 3 - Channel
5028 - 5029	0	32	4	0	DINT	Diagnosis - Module 4 - Diagnosis Code
5030	0	8	5	0	SINT	Diagnosis - Module 5
5030	8	8	5	0	SINT	Diagnosis - Module 5 - Submodule
5031	0	8	5	0	SINT	Diagnosis - Module 5 - Channel
5031	8	8	5	0	SINT	Diagnosis - Module 5 - Present State
5032 - 5033	0	32	5	0	DINT	Diagnosis - Module 5 - Module Diagnosis State
5034 - 5035	0	32	5	0	DINT	Diagnosis - Module 5 - Diagnosis Code
5036	0	8	6	0	SINT	Diagnosis - Module 6
5036	8	8	6	0	SINT	Diagnosis - Module 6 - Submodule
5037	0	8	6	0	SINT	Diagnosis - Module 6 - Channel
5037	8	8	6	0	SINT	Diagnosis - Module 6 - Present State
5038 - 5039	0	32	6	0	DINT	Diagnosis - Module 6 - Module Diagnosis State
5040 - 5041	0	32	6	0	DINT	Diagnosis - Module 6 - Diagnosis Code

6 Integrating the CPX-AP to the UR Controller via Modbus TCP

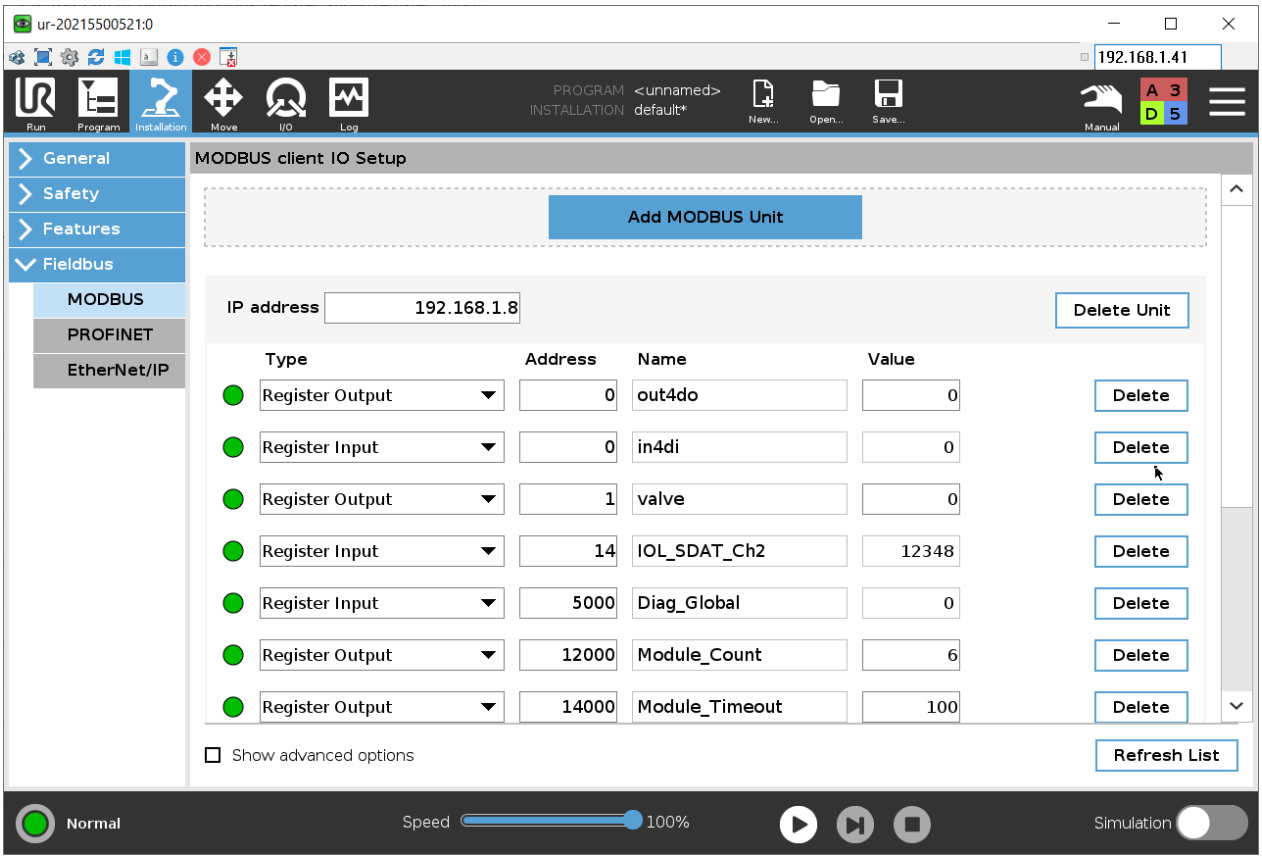
With a general understanding of the Modbus mapping in the CPX-AP system, further integration into the UR controller is simple.

6.1.1 Using Registers

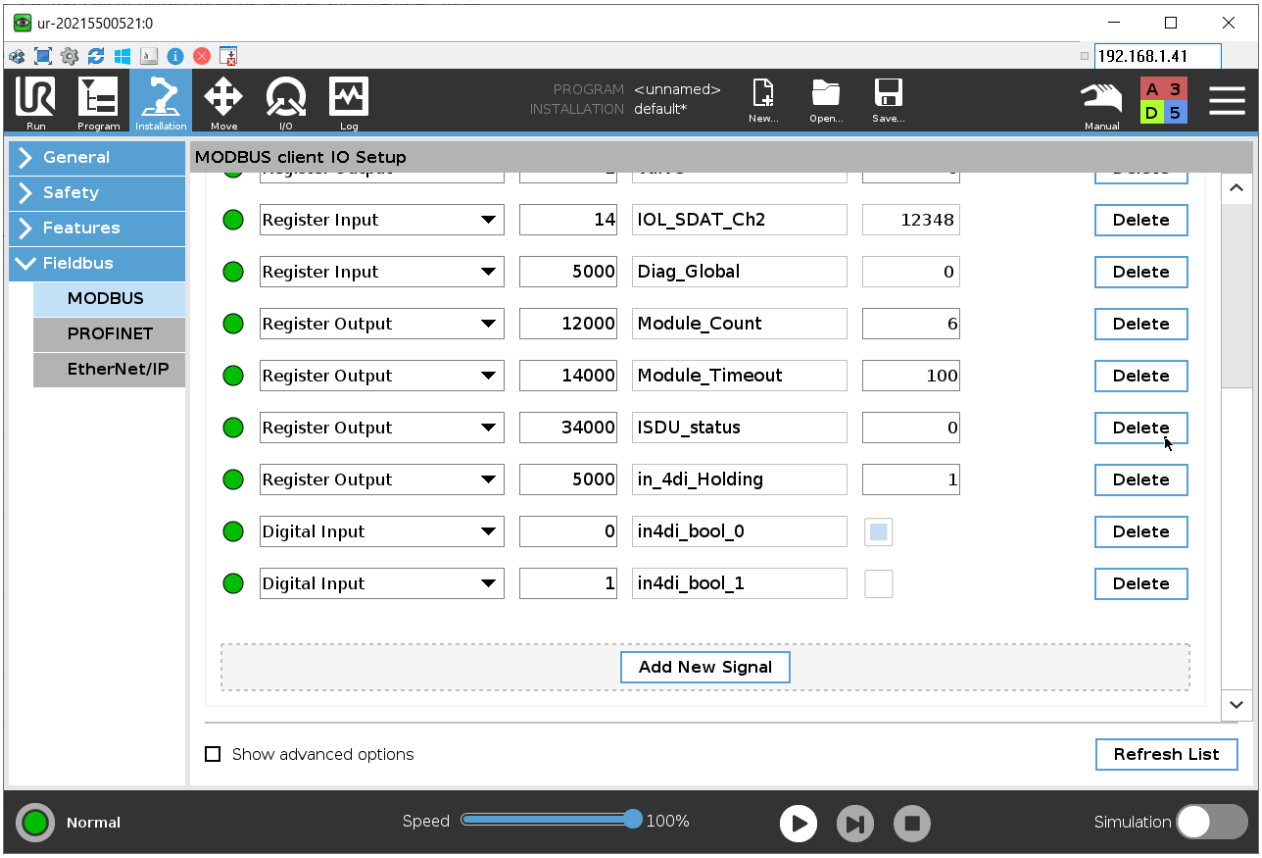
- Go the Installation icon -› Fieldbus -› Modbus option:



- By following the Modbus register mapping example, there are different functions that can be achieved.
- Use Register Output to set any of the CPX-AP outputs. This can be a physical output, or writing to a parameter or IO-Link index. In this case, Digital outputs and solenoid valves can be activated by setting their value ON by entering a decimal value in “out4do” and “valve” respectively. These names were changed to reflect the actual CPX-AP module.
    - Example, a decimal value of 3 will set the first 2 bits (0000 0000 0000 0011).
- Use either Register Output or Register Input to Read a Diagnostic value. Be sure to use the correct address for each register type:
    - Example, the Global Diagnosis State can be read by either a Holding Register or an Input Register.
    - Register Input is address 5000
    - Register Output (Holding) is address 11000
    - You see the same value, 4 in this case for the least significant register. This was triggered by a low power condition.



- General information such as Module Count and Module Timeout can be read. Find the address in the address in the holding register description and add new signal to enter
  - Module Count is a read only value based on the CPX-AP configuration
  - Module Timeout is Read / Write. Enter a value in the value column, and change the Timeout if necessary (default is 100ms).

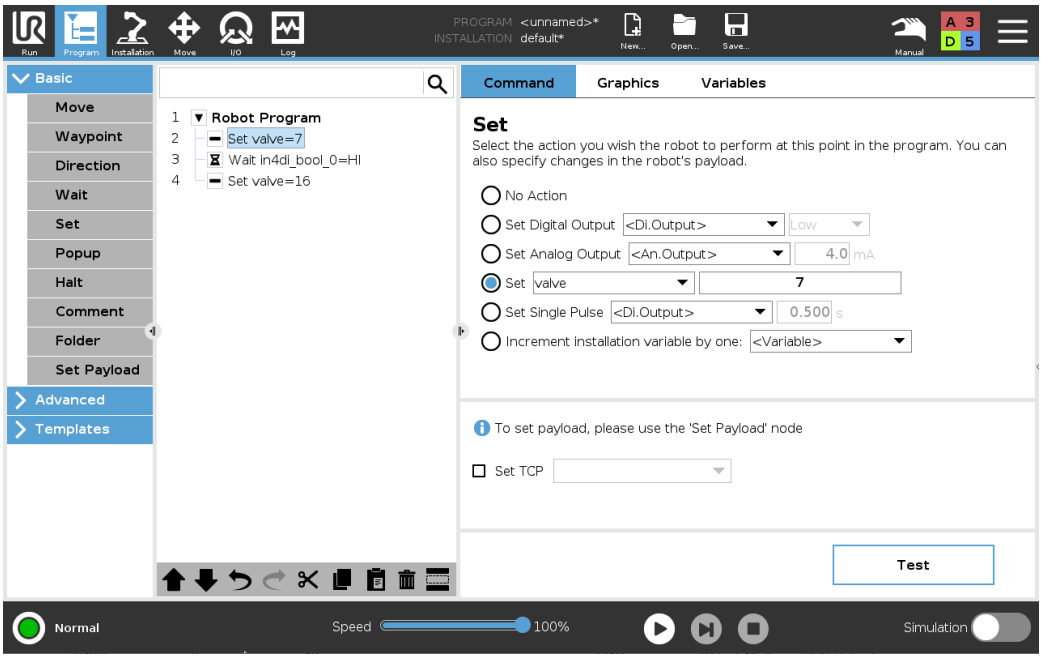


- You can also use Digital Input and Digital Output to set coils and read limit switches individually

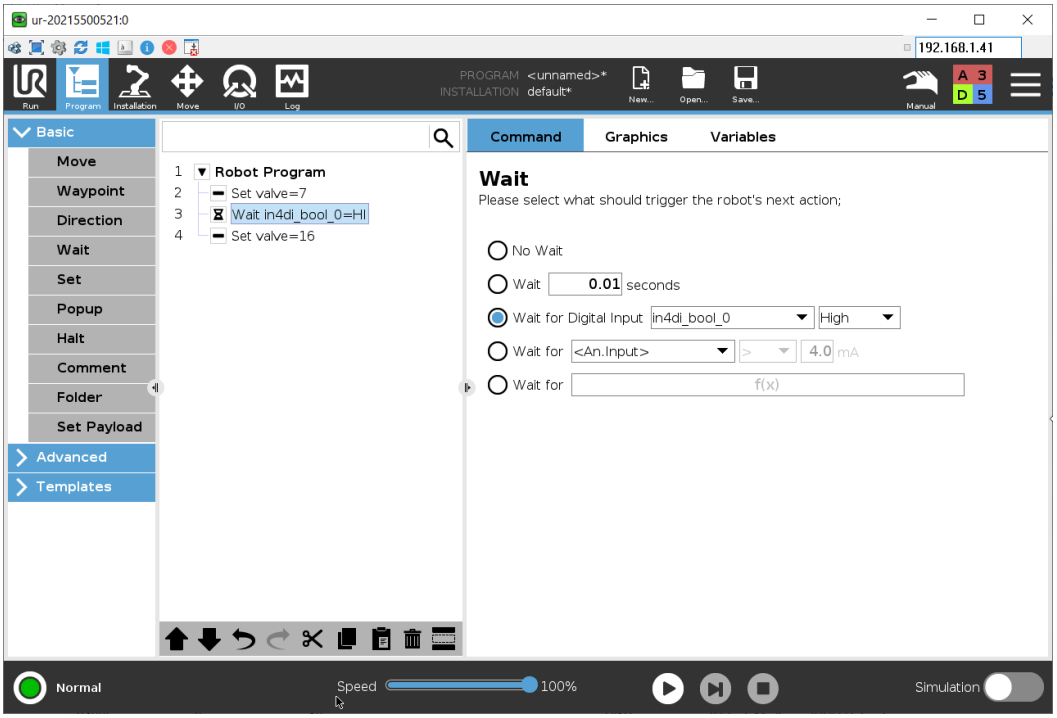
- In this case Digital Input uses the same starting address as Register Input. Register Output (Holding Register) has a different address, 5000.
- When the first input of the 4DI4DO module is triggered, a 1 appears at register 5000. Additionally, the Boolean indicator appears for bit 0, the LSB of the digital input registers

6.1.2 Simple Control from the UR Controller

Under the Program -› Basic menu, a simple sequence of instructions can be created.



- In this case, a value of 7 is set to the name “valve”, which was assigned to the first Output Register of the VAEM module of the VTUG valve manifold. This is address 1 in this example. When this sequence is executed, the value 7 (0000 0000 0000 0111) is set, and the first 3 coils are energized.



- In this case, a delay is added. A new value of 16 (0000 0000 0001 0000) is set. The 5th coil only is now energized.

7 Festo IO-Link Tool

The Festo IO-Link Tool is a software tool to configure a CPX-AP IO-Link master. It uses the IODD file of any IO-Link device to allow it to be parameterized from a PC, and for storage of the settings to be placed in the master. This tool is available from the Festo website. Be sure to review the user manual that comes with the tool.

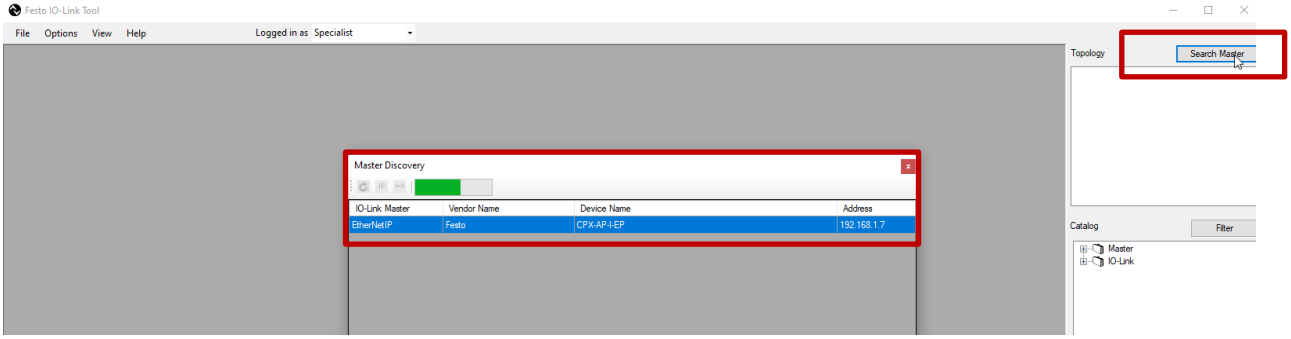
7.1.1 Getting Started

- Follow the installation instructions that comes with the IO-Link Tool software.
- Be sure the appropriate CPX-AP IOLM master description file for EtherNet/IP is installed. Since EtherNet/IP is shared with Modbus TCP, use EtherNet/IP instructions.
- Be sure the IODD files necessary are imported or are already present in the IOL Tool, shown in the catalog window.

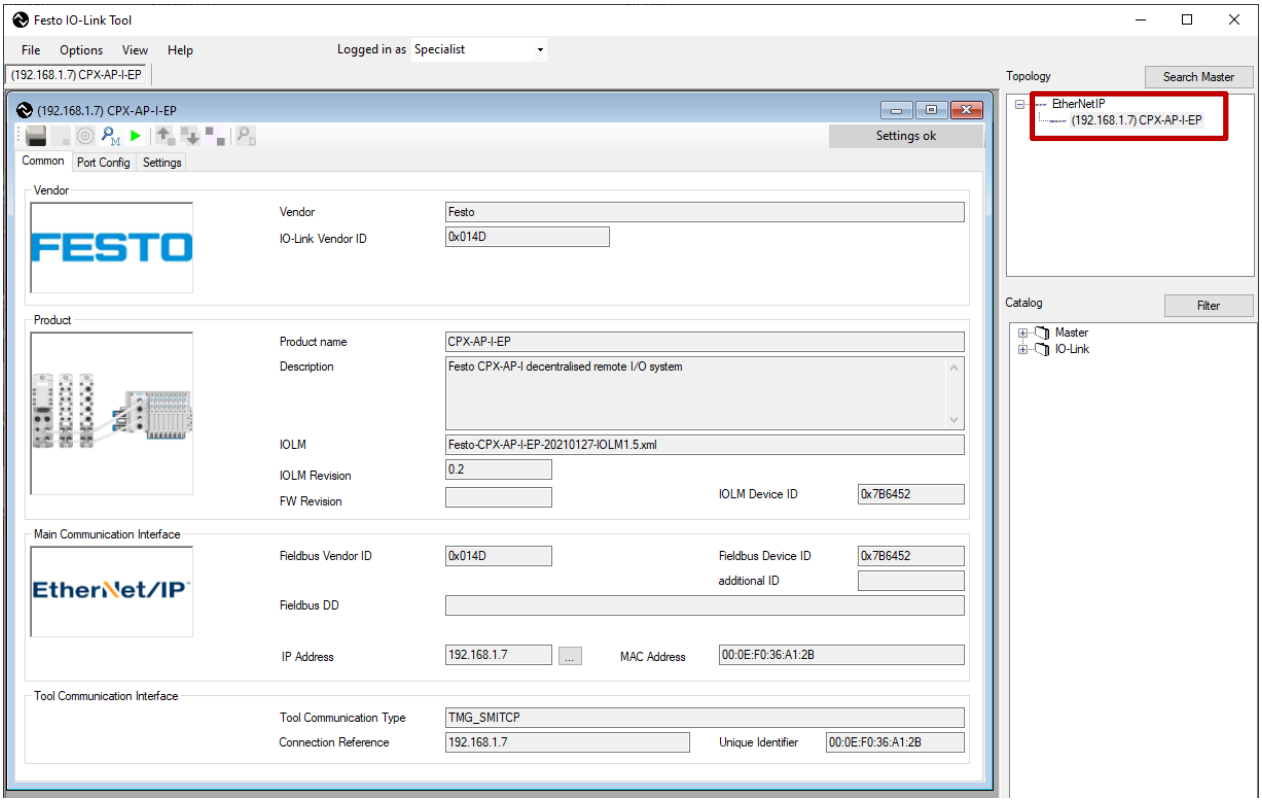
7.1.2 Sequence of Commissioning

- We will follow a Use Case of when devices are connected to the IO-Link master, the CPX-AP system is commissioned, and ready to go on-line. There is no PLC on-line, or the PLC does not yet have configuration parameters for the CPX-AP system. There are no stored parameters in the CPX-AP system.

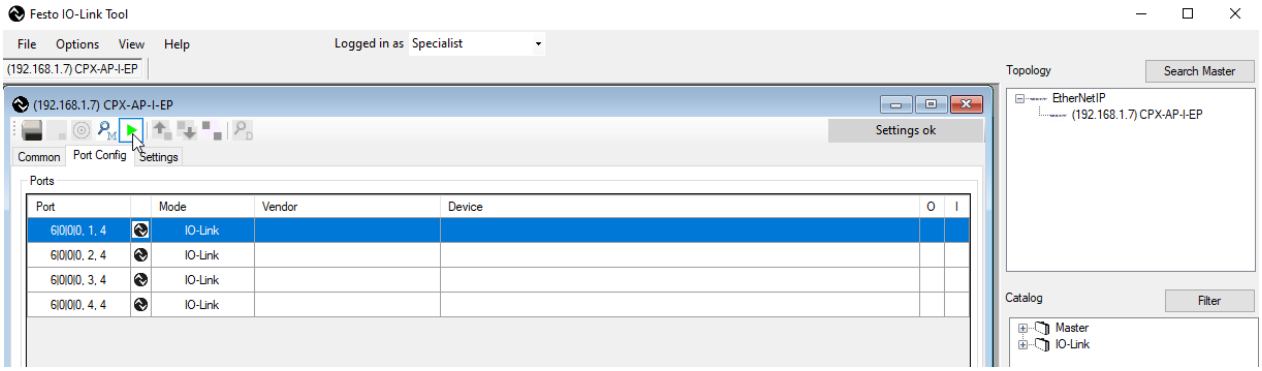
1. Go on-line. In a new project, select “Search Master”. The module discovery window will appear. A green bar will show progress identifying all masters.



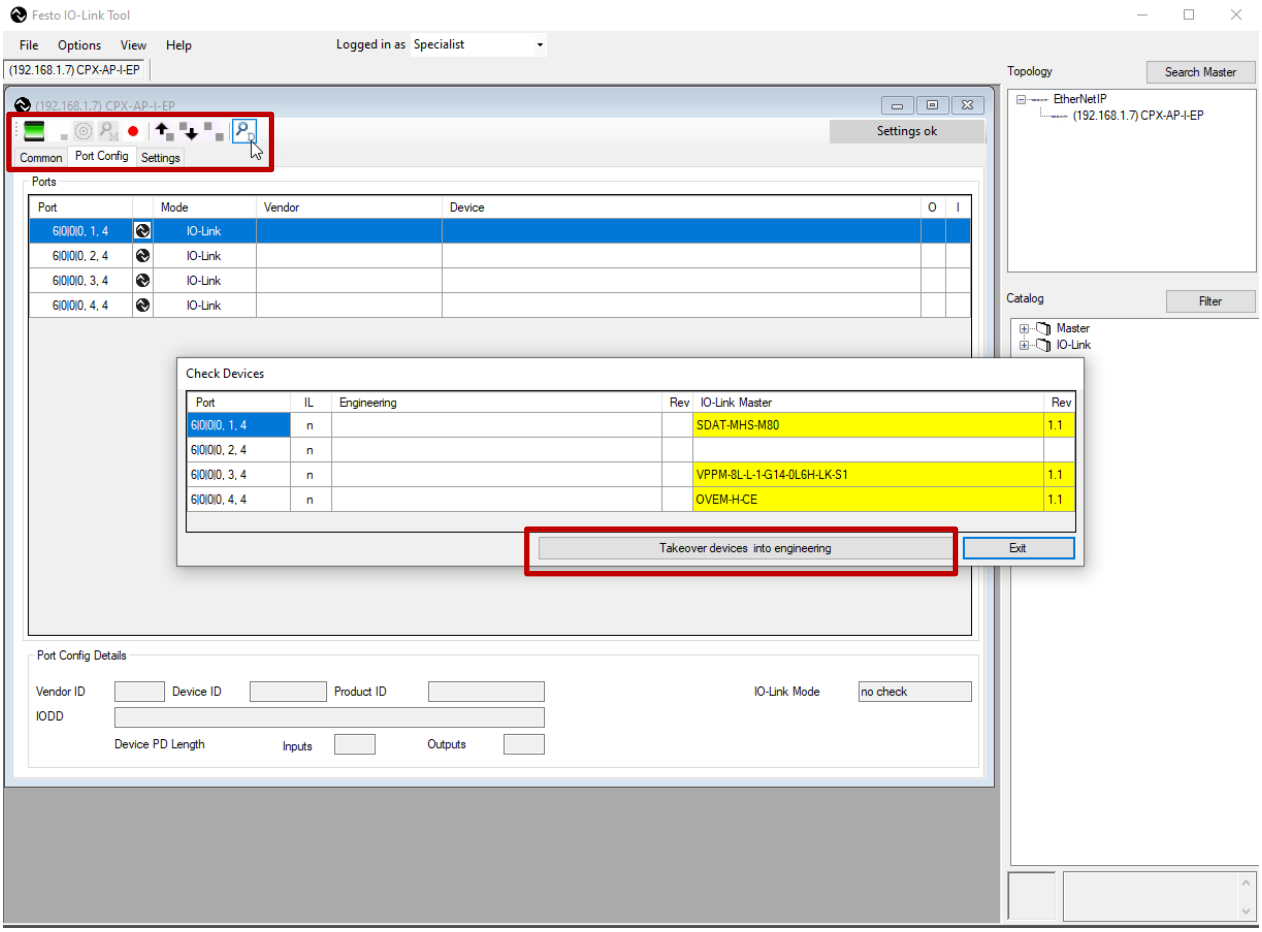
2. When complete, double click on EtherNet/IP master. The master page will appear. The master will be shown in the Topoloogy Window.



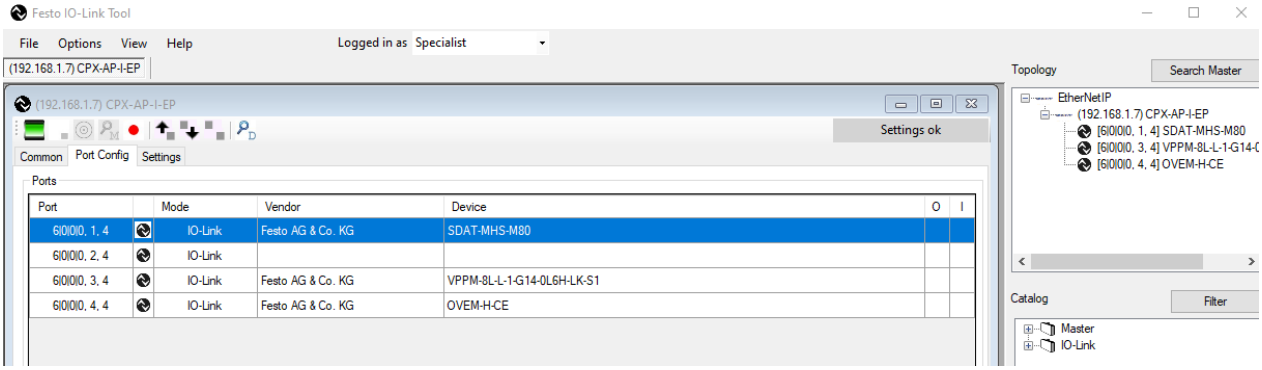
3. Go to the Port Config tab. The Port addresses of the IOL master will be represented by the module number, and port number of the module. Press the Green Arrow to go on-line.



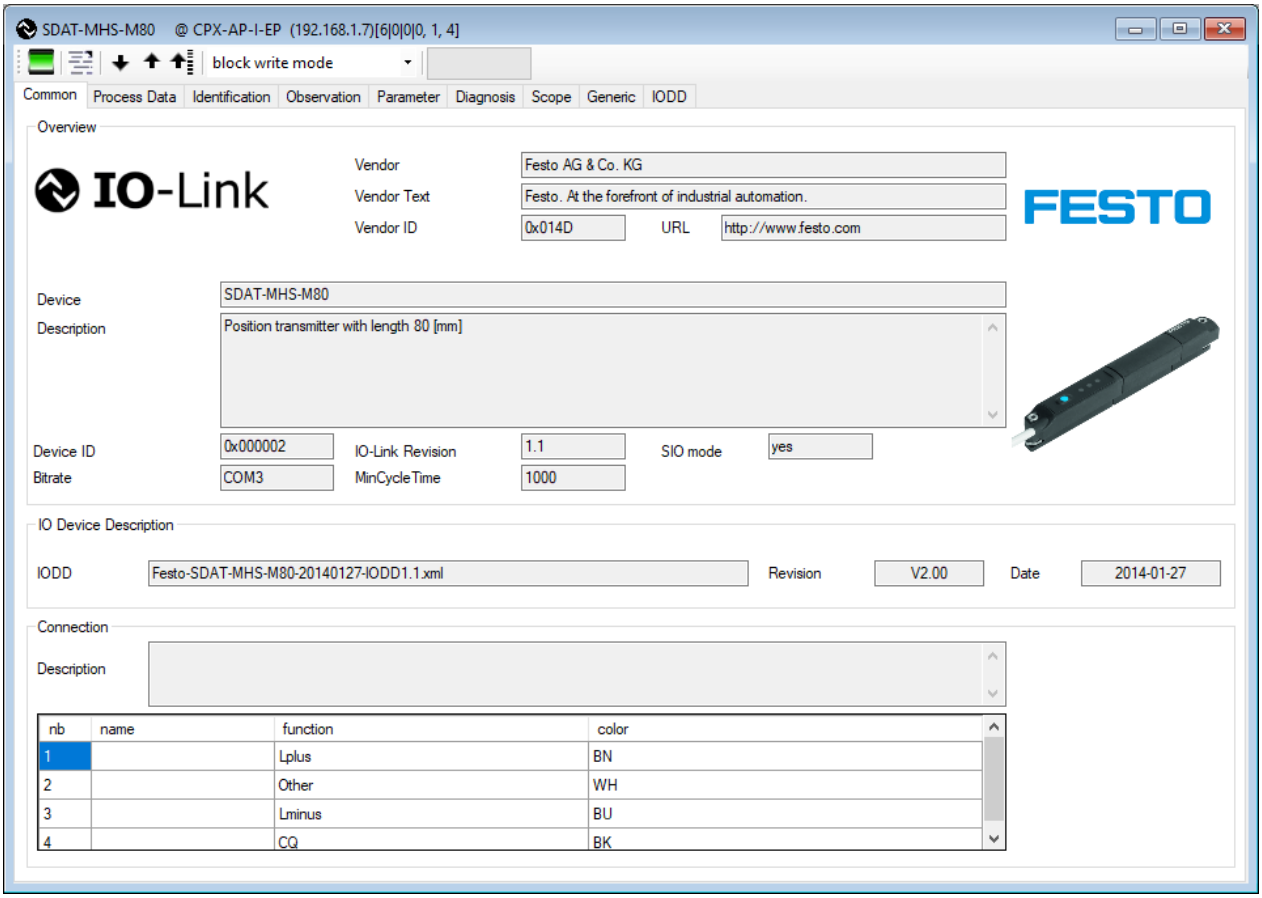
4. Once on-line, a Green Bar will indicate on-line is active. Click on “Check Devices”, and a window will appear showing the connected devices at each port. Select “Takeover devices into engineering”.



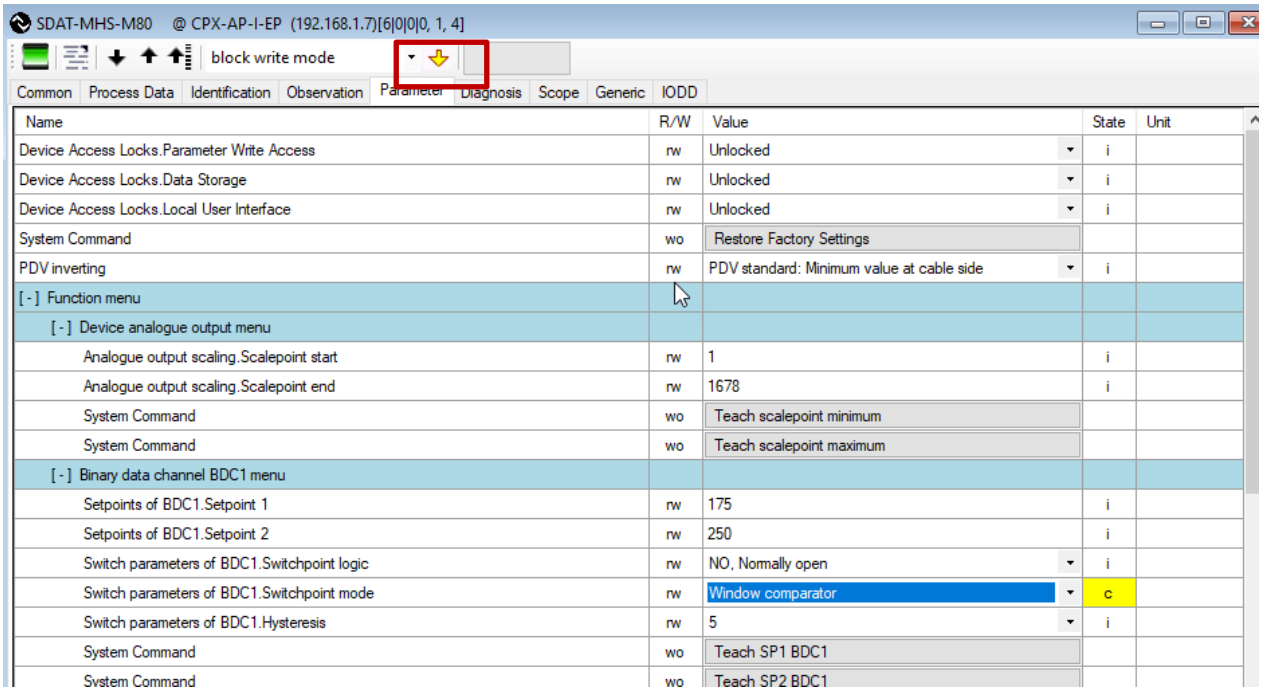
Once taken-over, the Port Config page will contain the devices connected.



5. Double click on a device to open its IODD parameters and other information available from the IODD file. Follow the manufacturer's instructions from each device on setting parameters or other actions. In this example, the SDAT Position Transmitter is opened.



Go to the parameter TAB, and change the BDC1 Switchpoint mode from deactivated to Window comparator. Note the yellow "c" for changed, edited vs. "i" for initial.



Select the yellow down button for "write all changed values to device". The yellow "c" changes to a green "d" indicating the tool is synchronized with the device. Go off-line from the IO-Link Tool.

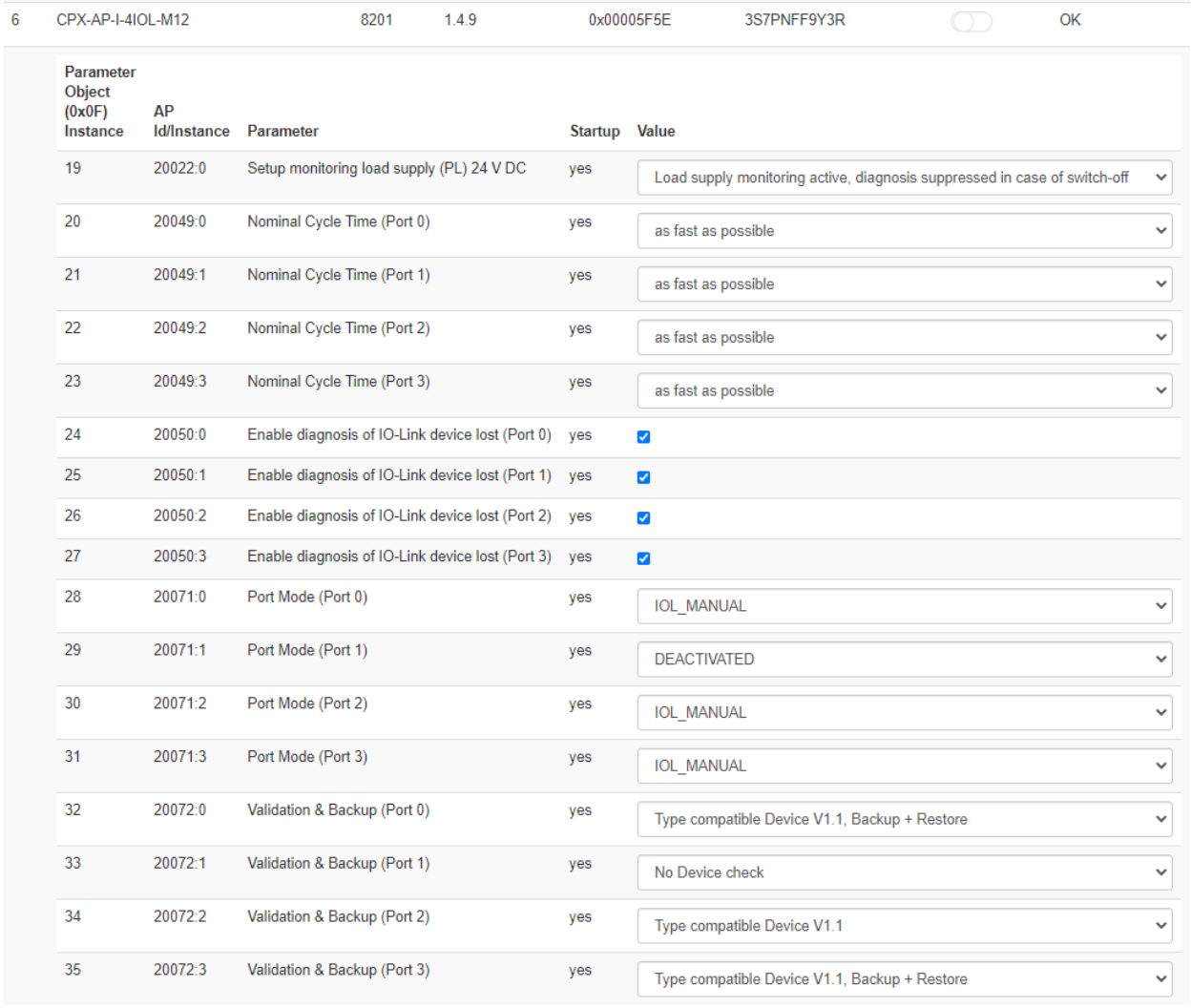
6. Go to the webserver of the CPX-AP system. Click on the IOL master module. Set basic IOL module parameters for the master.

   Many of the parameters are self-explanatory, but some require explanation:

Port Mode IOL_MANUAL	The target device will operate via IO-Link based on the user defined configuration including validation from the choices below. Use this mode with Backup & Restore.
Port Mode IOL_AUTOSTART	The target device will operate via IO-Link without the user defined configuration and validation. This will not work with Backup, Restore, etc.
Port Mode DI_CQ	The target device will operate as a digital input in SIO mode
Port Mode PREOPERATE	The master can assign parameters to the target device via ISDUs, but it must be operating to exchange process data.

Type Compatible Device V1.1 – Backup & Restore	The target device supports V1.1 and data storage is enabled for both upload and download. When replacing a device, the device is automatically parameterized with the parameters stored in the master. But if the device was e.g. pre-parameterized with a USB IO-Link master, then the data is loaded from the device into the master.
Type Compatible Device V1.1 – Restore	The target device supports V1.1 and data storage is enabled for download. This is usually configured when an application has been accepted and the settings should no longer be changed.

   In this example, IOL_MANUAL, and Backup + Restore for compatible devices are selected for each port with a device. There may be a discrepancy error at this time, ie, No Device Eventcode. Incompatible device type, etc.



In addition, for best usability with the IO-Link Tool, also manually enter the actual vendor and device ID (AP ID 20078 and 20079 of the IOL module) to the Nominal vendor and device ID (AP ID 20073 and 20080).

60	20078:0	Actual VendorID (Port 0)	333
61	20078:1	Actual VendorID (Port 1)	0
62	20078:2	Actual VendorID (Port 2)	333
63	20078:3	Actual VendorID (Port 3)	333
64	20079:0	Actual DeviceID (Port 0)	2
65	20079:1	Actual DeviceID (Port 1)	0
66	20079:2	Actual DeviceID (Port 2)	1025
67	20079:3	Actual DeviceID (Port 3)	62

From default:

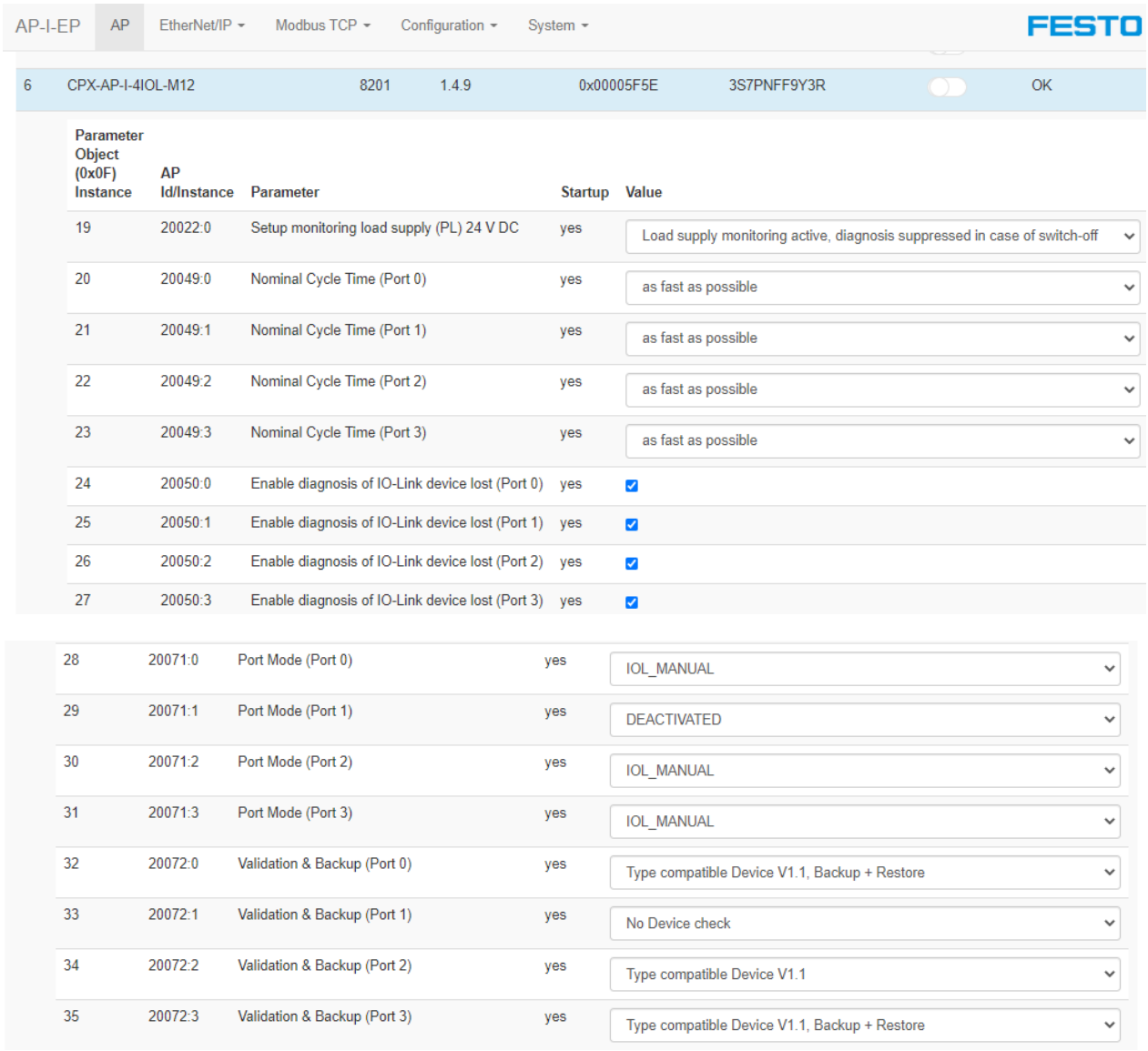
36	20073:0	Nominal Vendor ID (Port 0)	yes	0
37	20073:1	Nominal Vendor ID (Port 1)	yes	0
38	20073:2	Nominal Vendor ID (Port 2)	yes	0
39	20073:3	Nominal Vendor ID (Port 3)	yes	0
40	20080:0	DeviceID (Port 0)	yes	0
41	20080:1	DeviceID (Port 1)	yes	0
42	20080:2	DeviceID (Port 2)	yes	0
43	20080:3	DeviceID (Port 3)	yes	0

To actual:

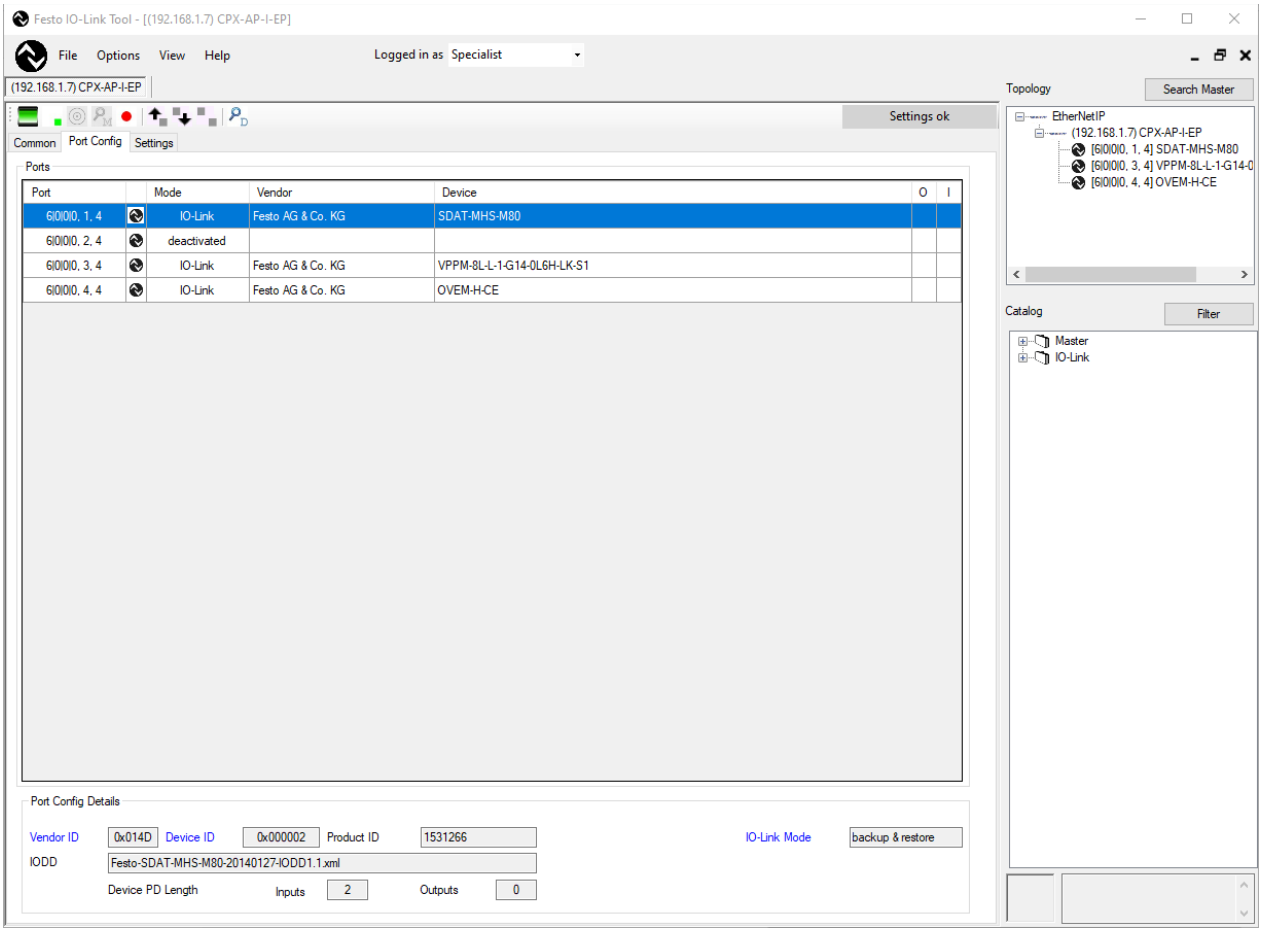
36	20073:0	Nominal Vendor ID (Port 0)	yes	333
37	20073:1	Nominal Vendor ID (Port 1)	yes	0
38	20073:2	Nominal Vendor ID (Port 2)	yes	333
39	20073:3	Nominal Vendor ID (Port 3)	yes	333
40	20080:0	DeviceID (Port 0)	yes	2
41	20080:1	DeviceID (Port 1)	yes	0
42	20080:2	DeviceID (Port 2)	yes	1025
43	20080:3	DeviceID (Port 3)	yes	62

7. Export this configuration to the controller using Stored Parameters to save this configuration in the CPX-AP Ethernet adapter. Connect the controller and RUN.

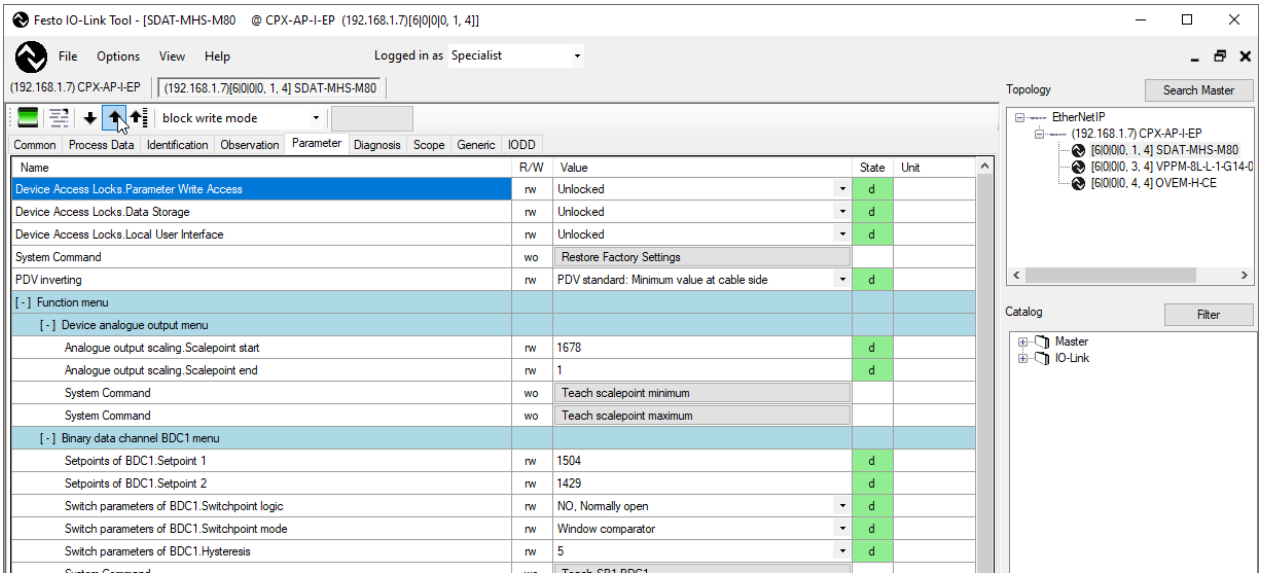
Any refresh of the webserver will not show any discrepancy errors, if the devices listed are connected, compatible, and operating properly.



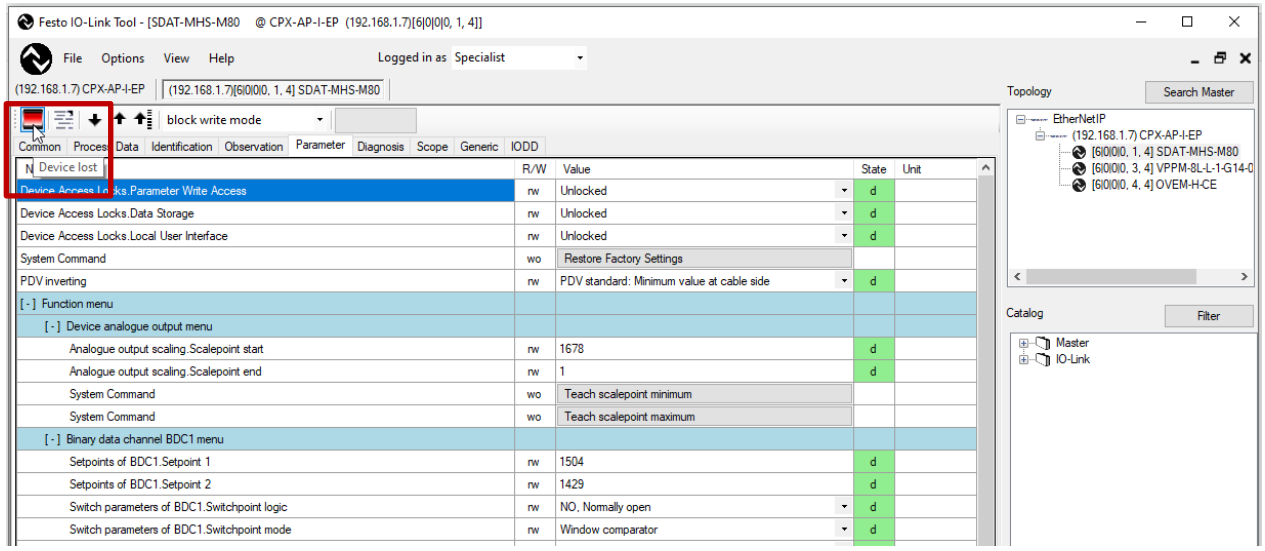
8. Go back to the IO-Link SW Tool to check. Going back on-line will now show the port configuration from the data stored in the CPX-AP from the Stored Parameters.



9. Double click on the SDAT device in this example in port 1. Go to the parameter tab and then select the up-arrow for “upload from device”. The state of each parameter is synchronized with the device and the window comparator setting is still loaded in the device.



10. If the device is disconnected, the status of the IO-Link Tool should show the device lost.



Reconnecting a new SDAT with the same part number will show the same values in step 9 if uploaded, since Backup + Restore is active. These values will be loaded into the new device.