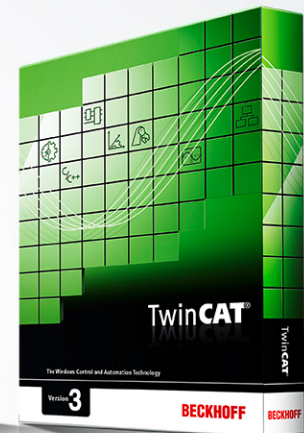
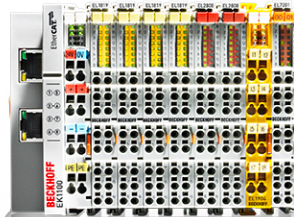


EtherCAT Troubleshooting

BECKHOFF

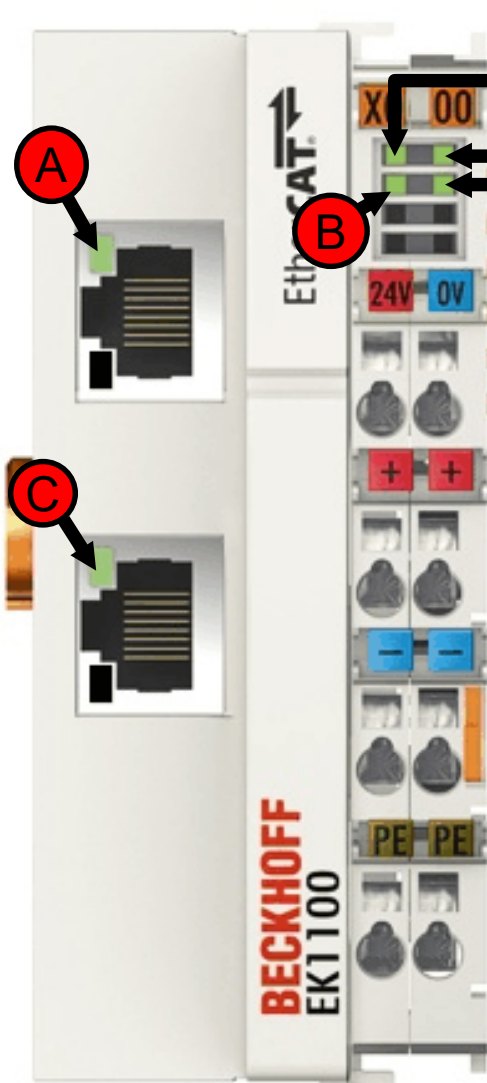


- 1. Troubleshooting using Hardware**
2. Troubleshooting using Software
3. Automating Troubleshooting with PLC Code

- Troubleshooting the EtherCAT fieldbus can be done using hardware or software
 - Hardware troubleshooting is very limited
 - Software troubleshooting offers many excellent features and saves downtime
- Software troubleshooting is fast and preferable

Check Lights for Proper Operation: EK110x

BECKHOFF

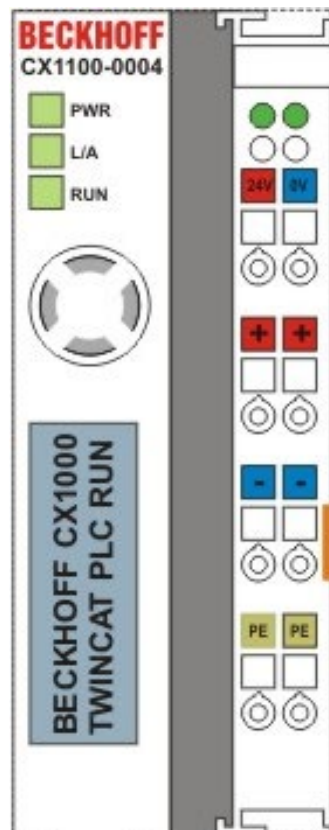


LED		Display	Status	Meaning
Us	green	off	-	No operating voltage connected
		on	-	24 V _{DC} operating voltage connected
Up	green	off	-	No 24V _{DC} power connected to the power contacts
		on	-	24V _{DC} power connected to the power contacts

LED		Display	Status	Meaning
RUN	green	off	Init	State of the EtherCAT State Machine: INIT = Initialization
		blinking	Pre-Operational	State of the EtherCAT State Machine: PREOP = Pre-Operational
		single flash	Safe-Operational	State of the EtherCAT State Machine: SAFEOP = Safe-Operational
		on	Operational	State of the EtherCAT State Machine: OP = Operational
		flashes	Bootstrap	State of the EtherCAT State Machine: BOOT = Bootstrap (Update of the coupler firmware)

LED		Display	Status	Meaning
LINK / ACT E-Bus	green	off	-	No connection/communication with internal E-Bus
		on	linked	Connection with internal E-Bus
		blinking	active	Connection/communication with internal E-Bus
LINK / ACT (X1 IN)	green	off	-	No connection with the previous EtherCAT client
		on	linked	Previous EtherCAT-client connected
		blinking	active	Communication with the previous EtherCAT client
LINK / ACT (X2 OUT)	green	off	-	No connection with the next EtherCAT client
		on	linked	Next EtherCAT client connected
		blinking	active	Communication with the next EtherCAT client

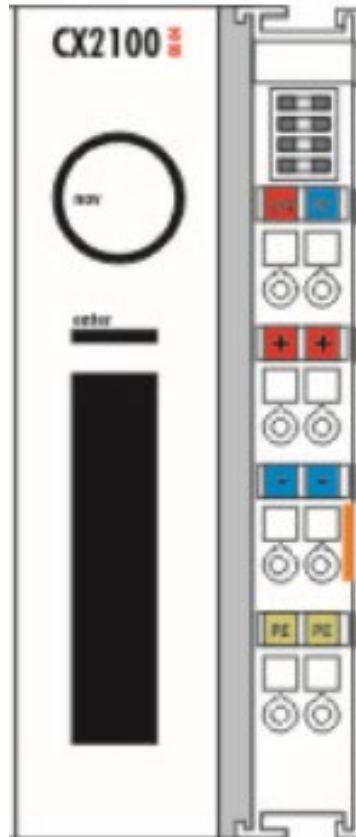
Check Lights for Proper Operation: CX1xxx

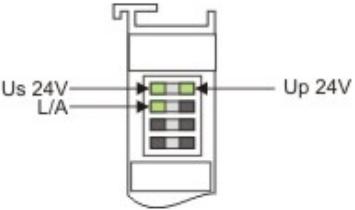
BECKHOFF

Display	LED		Meaning
	PWR		power supply The LED lights up green when the power supply is correct, but red if there is a short circuit.
	L/A	off	E-Bus is not connected
		on	E-Bus is connected / no data traffic on E-bus
		blink	E-Bus is connected / data traffic on E-bus
	RUN	Indicates the state of the EtherCAT bus:	
		off	INIT
		blink	PRE-OPERATIONAL (frequency: 200 ms on / 200 ms off)
		single flash	SAVE-OPERATIONAL (frequency: 200 ms on / 1000ms off)
		on	OPERATIONAL
		flickering	BOOTSTRAP (frequency: 50 ms on / 50 ms off)

Check Lights for Proper Operation: CX2xxx

BECKHOFF

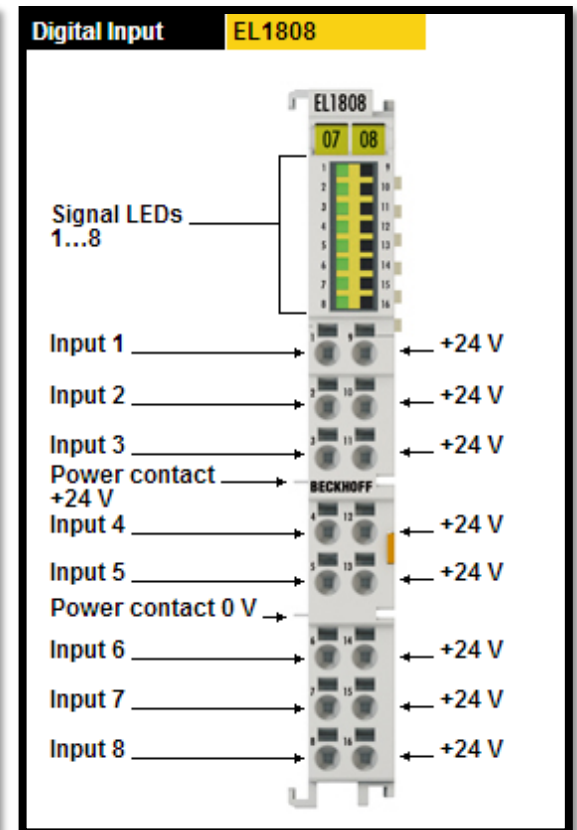
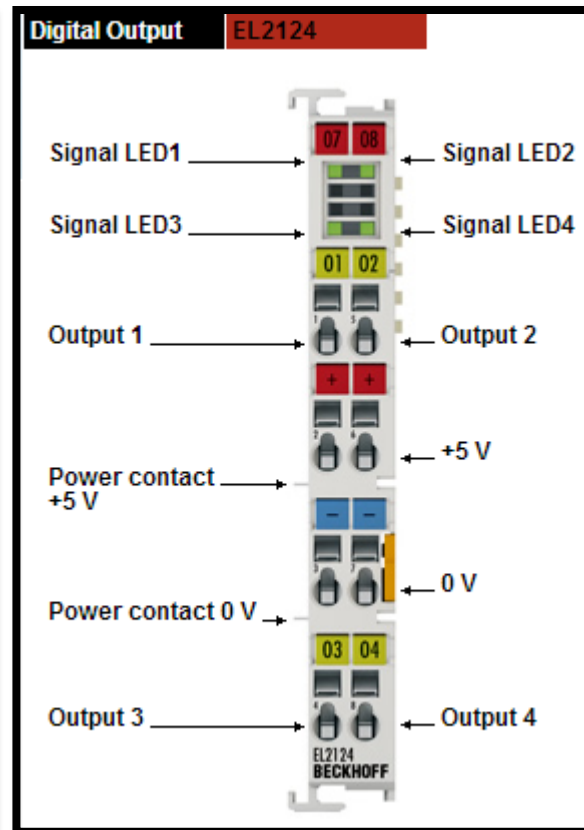
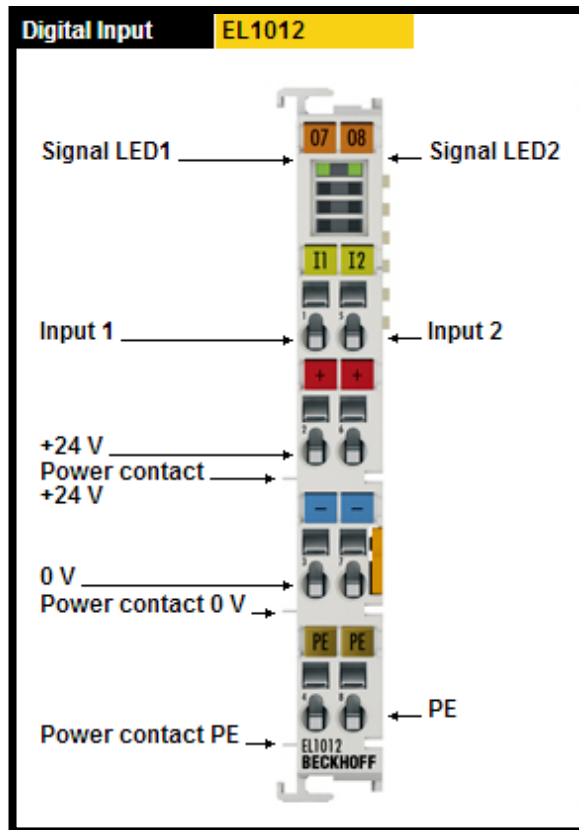


Display	LED		Meaning
	Us 24 V		Power supply for the CPU module The LED lights green if the power supply is correct.
	Up 24V		Power supply for terminal bus. The LED lights green if the power supply is correct.
	L/A	off	E-bus not connected
		on	E-bus connected / no data traffic
		flashing	E-bus connected / data traffic on the E-bus.

Check Lights for Proper Operation: Digital IO

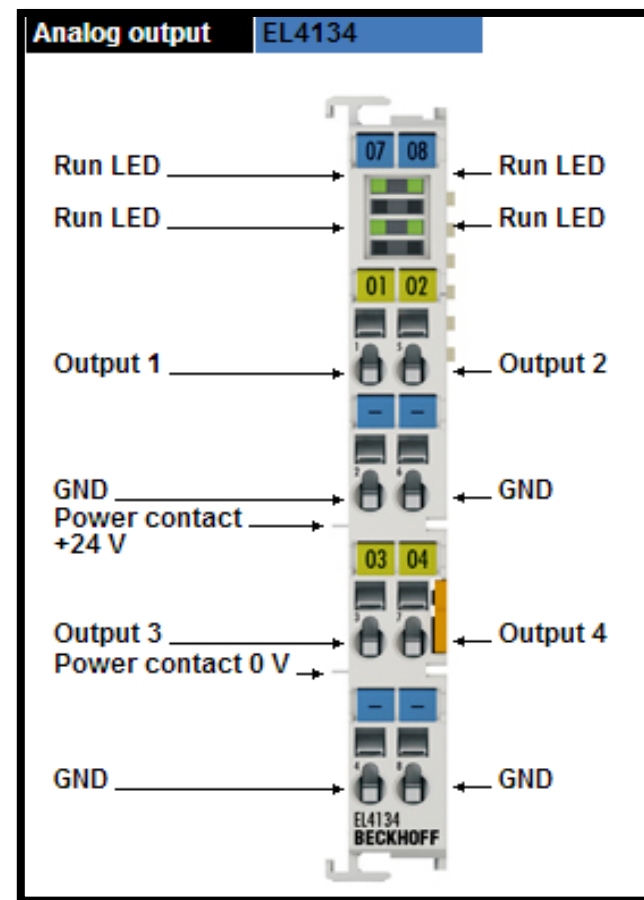
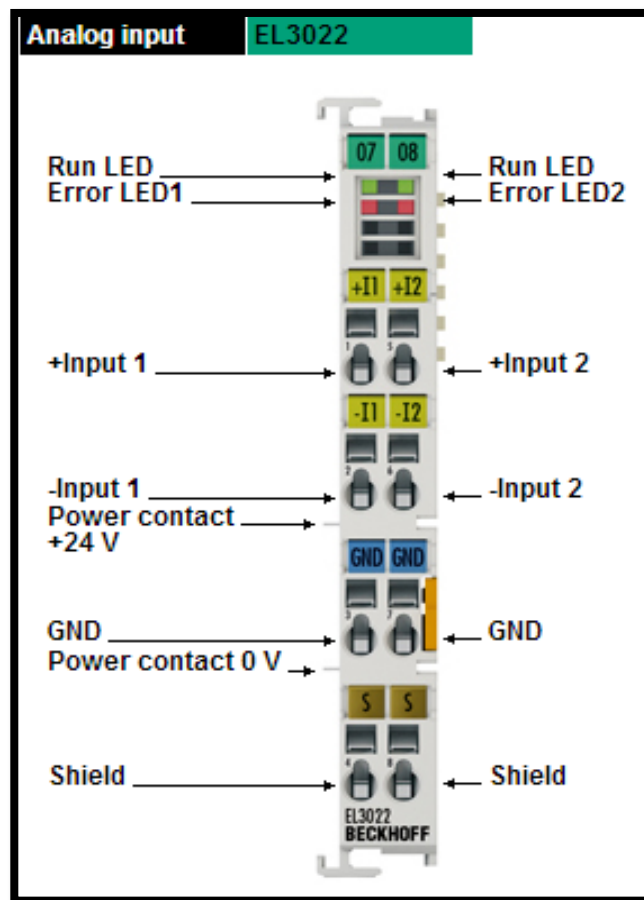
BECKHOFF

- No EtherCAT diagnostics available
- Lights always signify the presence of 24 volts on the channel
 - If Up/ Rail Power present for reference



Check Lights for Proper Operation: Analog IO

- **EtherCAT State Shown by Run LED** (same function for all)
- Blinking means hardware is not in operational mode





See TwinCAT rather than Hardware Lights

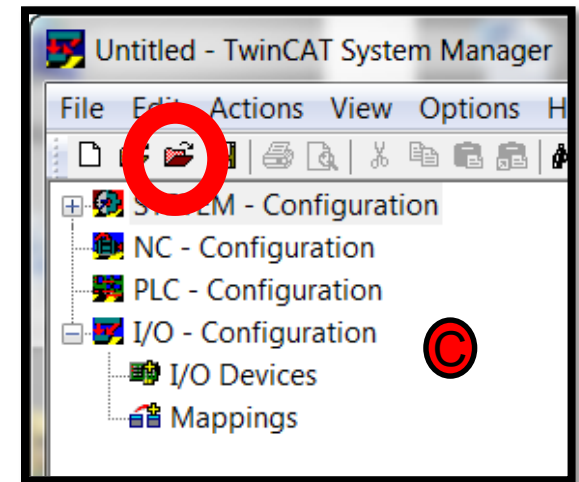
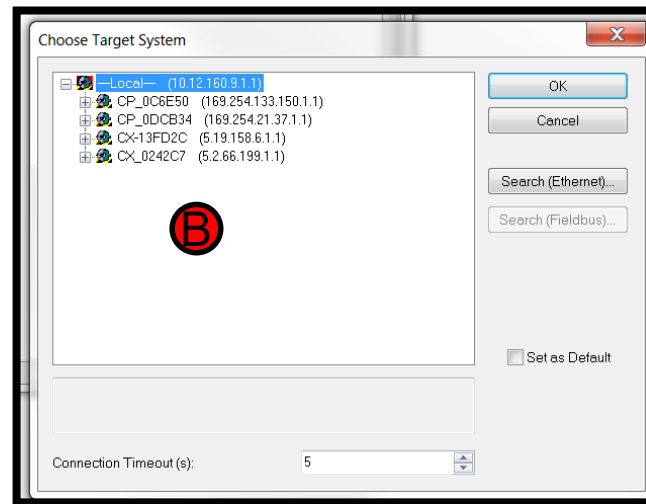
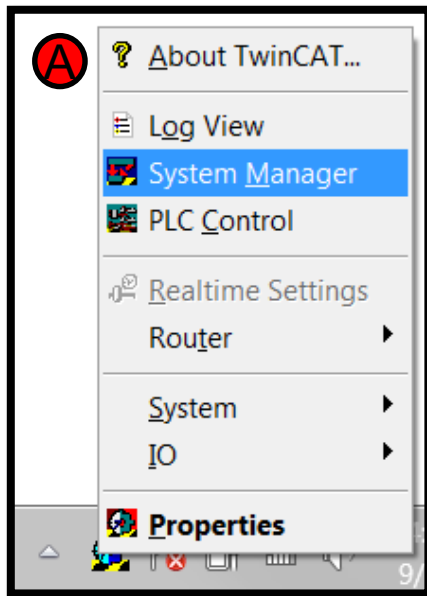
BECKHOFF

- Documentation explains EtherCAT terminal lights
- Use TwinCAT to troubleshoot EtherCAT whenever possible
 - Many features available
 - Easy to use

1. Troubleshooting using Hardware
- 2. Troubleshooting using Software**
3. Automating Troubleshooting with PLC Code

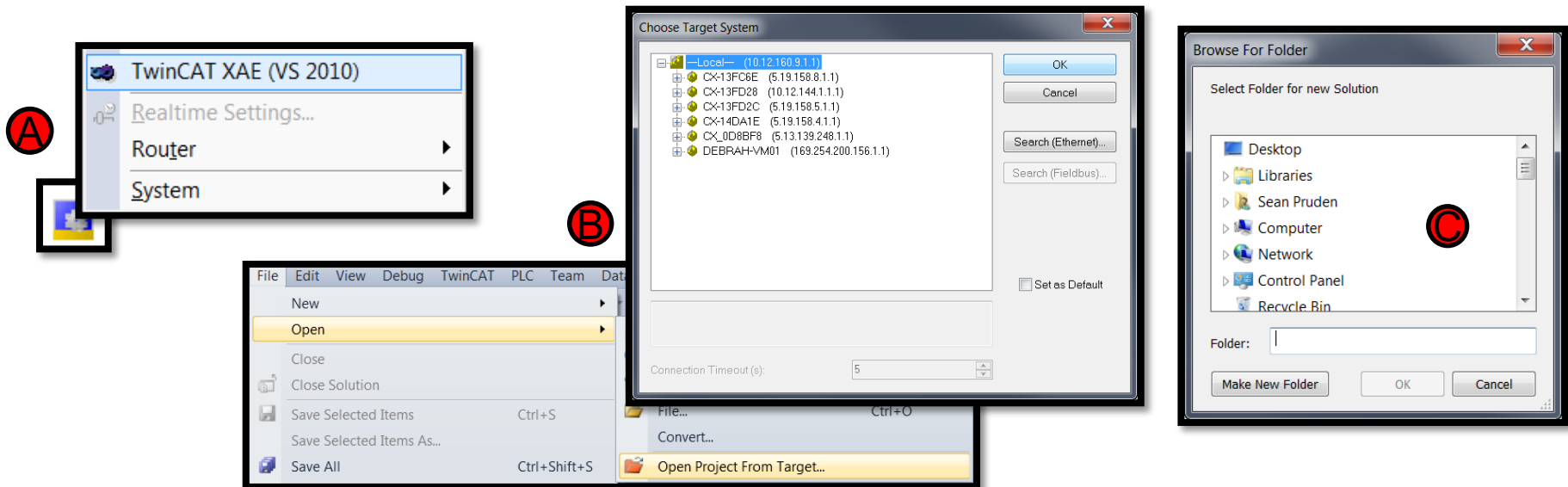
▪ *Navigate to the Current Configuration*

- Open System Manager (A)
- Point at the correct target(if required) (B)
 - *See connect to target presentation*
- Select the Open from Target Button (C)

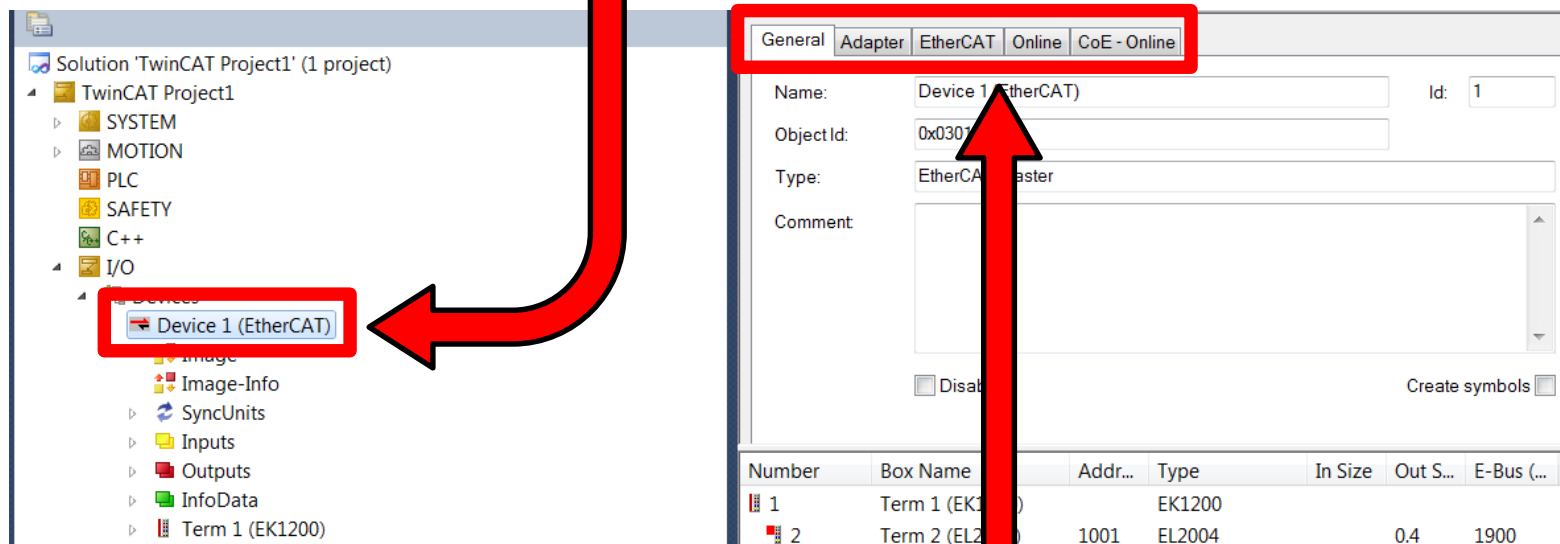


▪ *Navigate to the Current Configuration*

- Open Visual Studio **A**
 - Close the Solution if One Opens
- Select Open from Target Button **B**
- Save the project being opened in the desired location **C**



- Select the desired **EtherCAT Device** in the I/O section of the tree

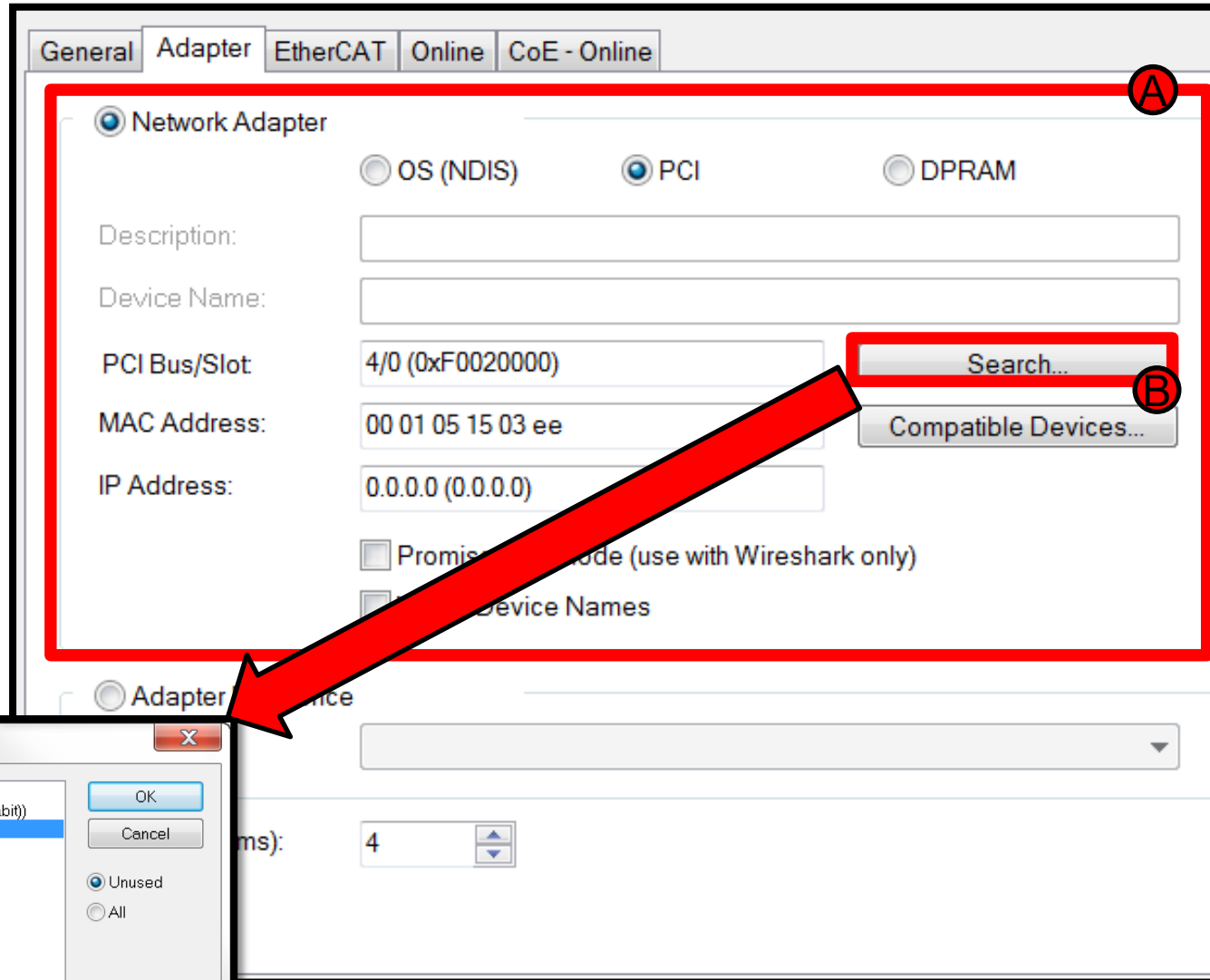


- Notice the tabs which appear
- These are used to troubleshoot the network

The Adapter Tab gives Network Adapter Information

BECKHOFF

- A** The Network Adapter Section shows information about which Hardware EtherCAT uses to 'talk' over the bus.
- B** Search allows for the changing of this hardware



The Adapter Tab gives Network Adapter Information

BECKHOFF

- If an Ethernet port is being used the IP Address will show the address of the port
- Ensure that EtherCAT is never on the same subnet as another port being used for standard Ethernet communication

The screenshot shows the 'Adapter' tab in the Beckhoff configuration software. The 'General' tab is selected, and the 'Network Adapter' radio button is chosen. The 'OS (NDIS)' radio button is selected, while 'PCI' and 'DPRAM' are unselected. The 'Description' field displays 'Local Area Connection 2 (TwinCAT-Intel PCI Ethernet Adapter (Gigabit)'. The 'Device Name' field shows the GUID '\\DEVICE\\{0ECD5C8C-0436-4C19-B1C3-1752147B74E8}'. The 'PCI Bus/Slot' field is empty, with a 'Search...' button to its right. The 'MAC Address' field displays '00 01 05 13 fd 2c', with a 'Compatible Devices...' button to its right. The 'IP Address' field shows '169.254.208.4 (255.255.0.0)'. Below these fields, there are two checkboxes: 'Promiscuous Mode (use with Wireshark only)' which is unchecked, and 'Virtual Device Names' which is checked. The 'Adapter Reference' section is currently empty, with a dropdown menu for 'Adapter:'. At the bottom, the 'Freerun Cycle (ms)' is set to '4' with a spin button.

General Adapter EtherCAT Online CoE - Online

☒ Network Adapter

☒ OS (NDIS) ☐ PCI ☐ DPRAM

Description: Local Area Connection 2 (TwinCAT-Intel PCI Ethernet Adapter (Gigabit)

Device Name: \\DEVICE\\{0ECD5C8C-0436-4C19-B1C3-1752147B74E8}

PCI Bus/Slot: Search...

MAC Address: 00 01 05 13 fd 2c Compatible Devices...

IP Address: 169.254.208.4 (255.255.0.0)

☐ Promiscuous Mode (use with Wireshark only)

☒ Virtual Device Names

☐ Adapter Reference

Adapter:

Freerun Cycle (ms): 4

The Adapter Tab gives Network Adapter Information

BECKHOFF

A Promiscuous Mode enables Windows to access EtherCAT frame information

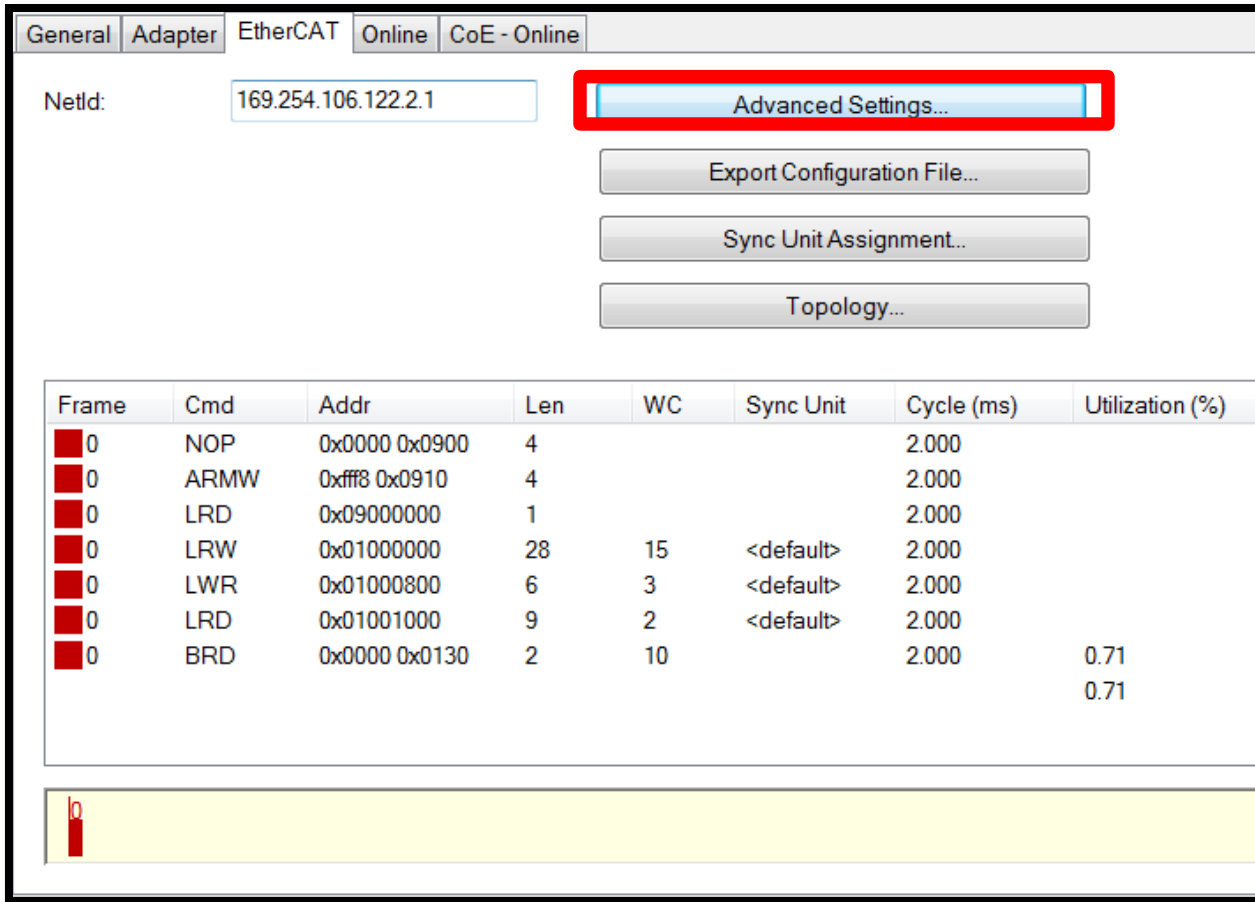
B Virtual Device Names causes TwinCAT to identify each device based on the “Description” and not the “Device Name”

- Use this to enable ‘currentconfig.tsm’ transfers between identical machines

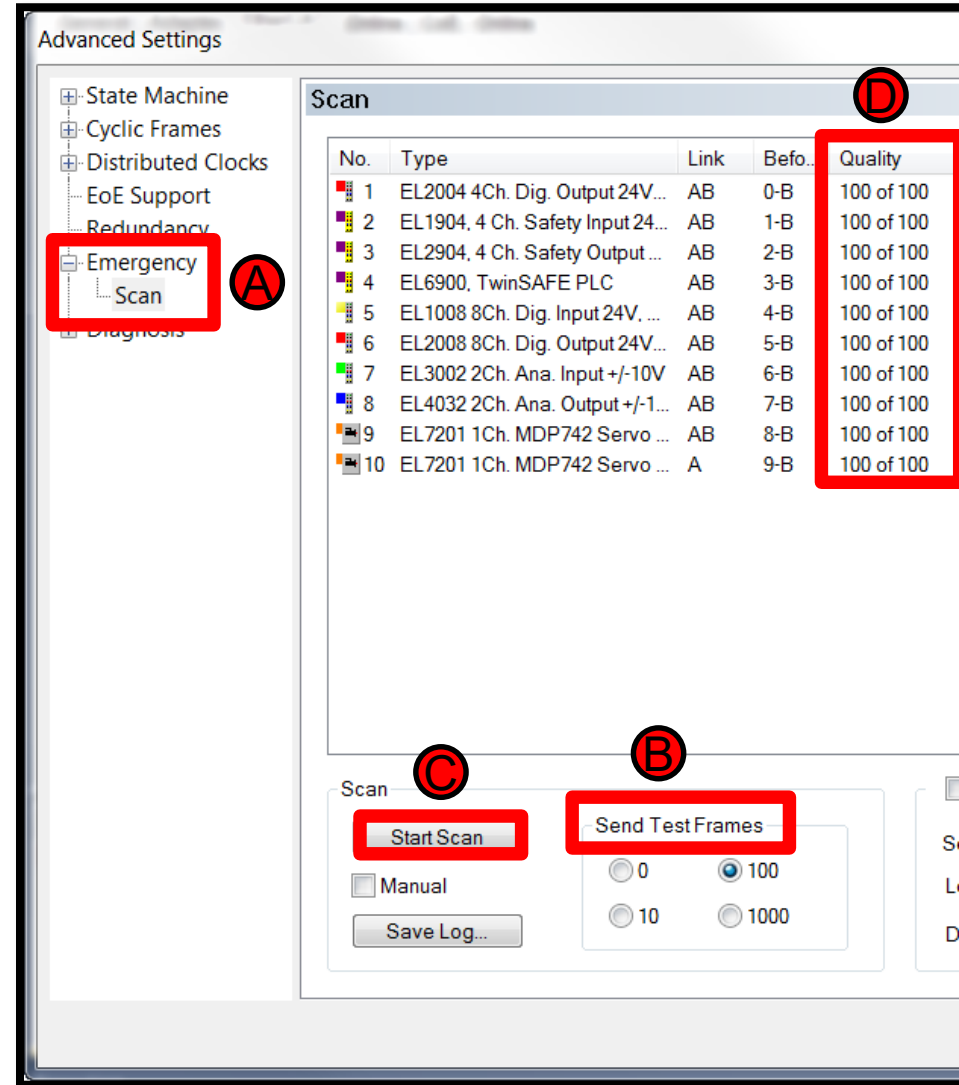
The screenshot displays the 'Adapter' tab in the Beckhoff configuration software. The 'Network Adapter' section is selected, showing options for OS (NDIS), PCI (selected), and DPRAM. Below these are input fields for Description, Device Name, PCI Bus/Slot (4/0 (0xF0020000)), MAC Address (00 01 05 15 03 ee), and IP Address (0.0.0.0 (0.0.0.0)). Two checkboxes are highlighted with a red box: 'Promiscuous Mode (use with Wireshark only)' (labeled A) and 'Virtual Device Names' (labeled B). The 'Adapter Reference' section at the bottom includes a dropdown for 'Adapter' and a 'Freerun Cycle (ms)' field set to 4.

BECKHOFF

- Note: Going into Config mode will stop a running machine

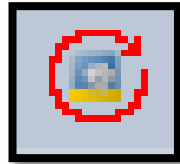
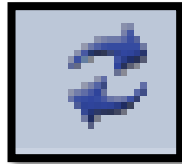


- A** Emergency Scan allows the user to troubleshoot intermittent connections
- B** The number of these frames can be selected under Send Test Frames
- C** Selecting Start Scan will send dedicated frames to each slave on the bus
- D** An incomplete quality means that the frame never reached the slave and then returned to the master
 - This means a contact or wire is not maintaining a proper connection

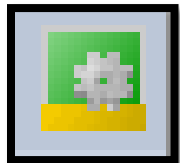


The EtherCAT Tab Provides Detailed Bus Information **BECKHOFF**

- Emergency Scan test frames interrupt regular bus communication
- After completing emergency scan, bus communication must be reinitiated
 - To continue using Config Mode, Press Reload IO Devices and Initiate Free Run

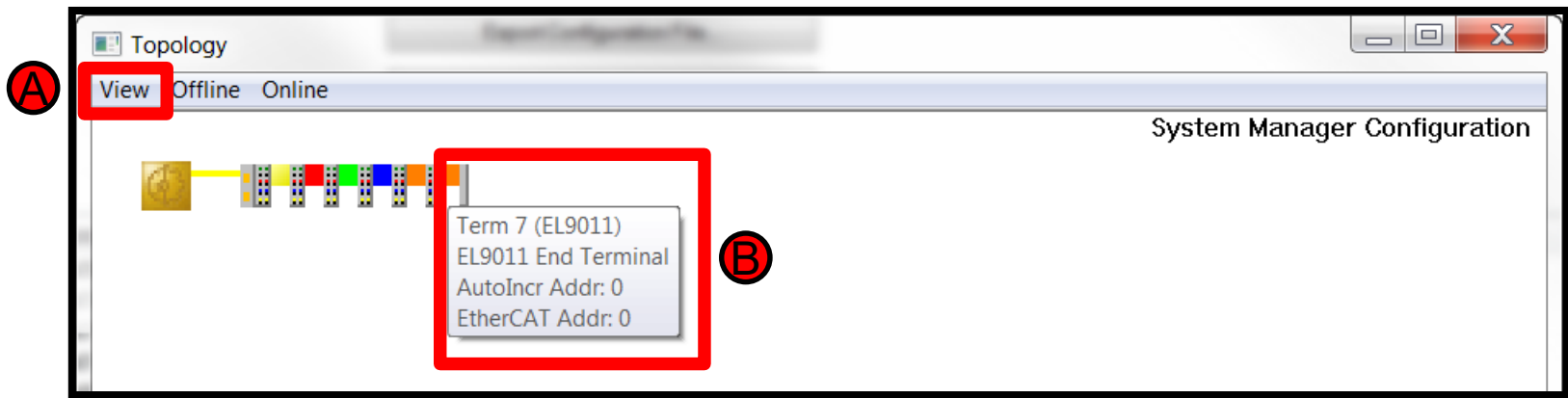


- To go into Run Mode, Restart the TwinCAT System



Topology View

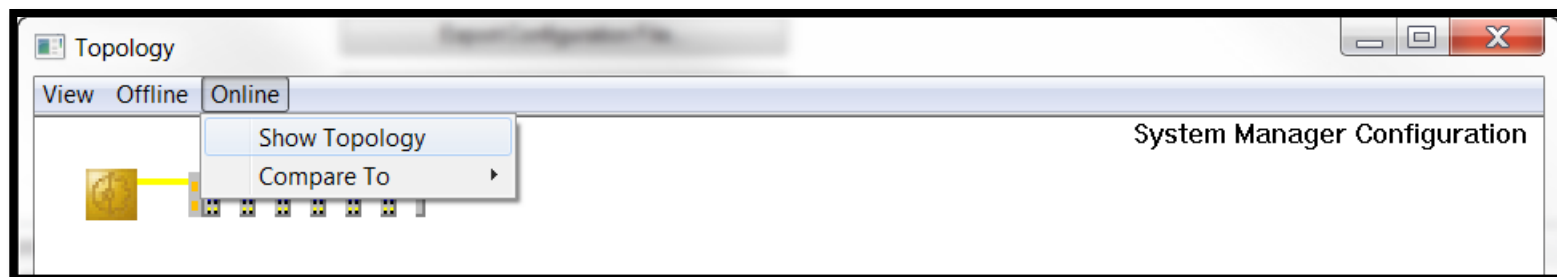
- The Offline Topology View is the default view and shows:
 - The EtherCAT master (TwinCAT)
 - EtherCAT Slaves
 - Cabling



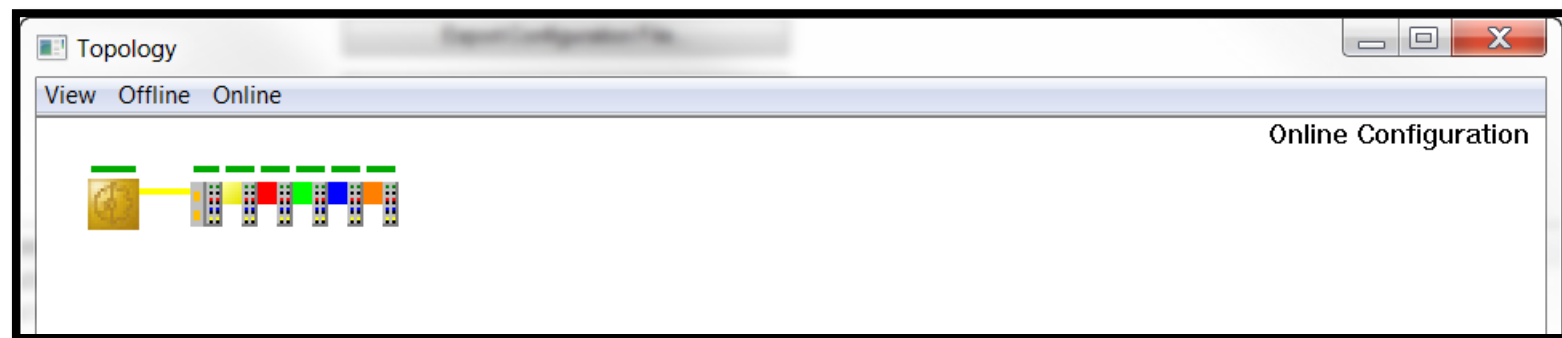
- Ⓐ Use the **View Menu** to increase the picture size
- Ⓑ Hover the mouse over each slave to get its description

Topology View

- Click [Show Topology](#) under the **Online Menu** for the same view with diagnostics



- A healthy network will appear with all green bars and no additional circles or lines

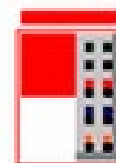


- Each slave picture will change if network health is compromised:

- The color of the bar changes



- A red outline may enclose the device



- Red circles may show up

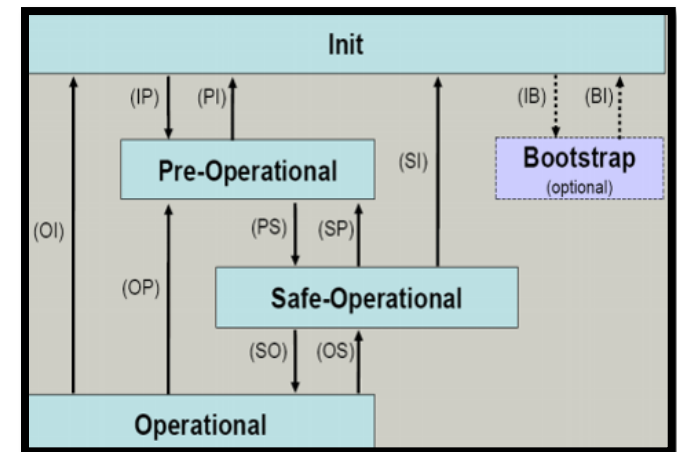


- The bar changes color based on the slave state.
 - Each slave should be in “Operational Mode”



- **Potential Causes** for Other States:

- The PLC program is not running
 - The running PLC tasks update the bus
- TwinCAT may not be in run mode
- Communication problems exist between master and slave (see next slide)

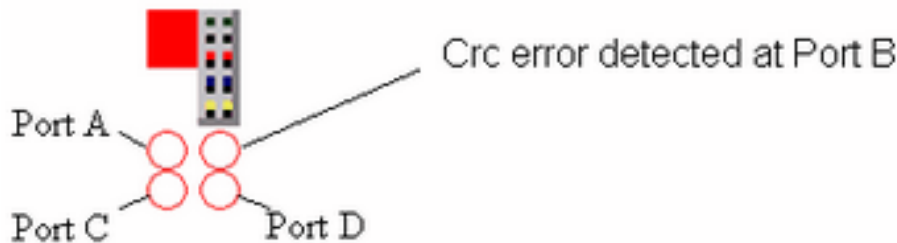




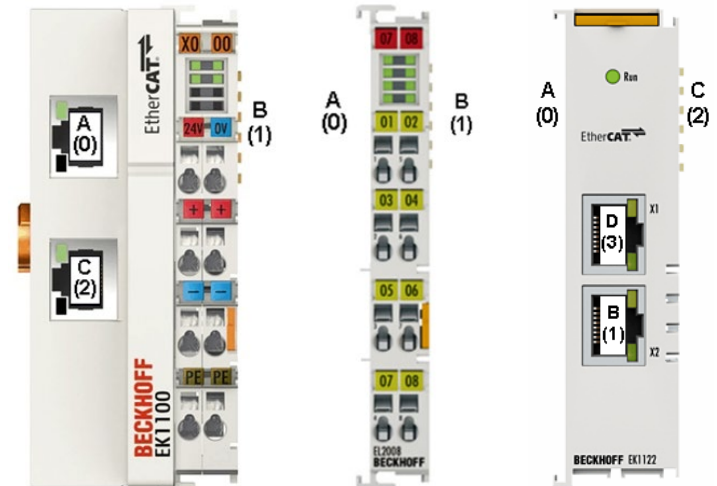
- The red square around a terminal means that no communication is occurring with the slave:

- **Potential Causes** for No Communication:
 - A terminal is not properly seated
 - A terminal has been removed
 - A terminal has gone bad upstream
 - A cable connector is not seated
 - A cable is severed

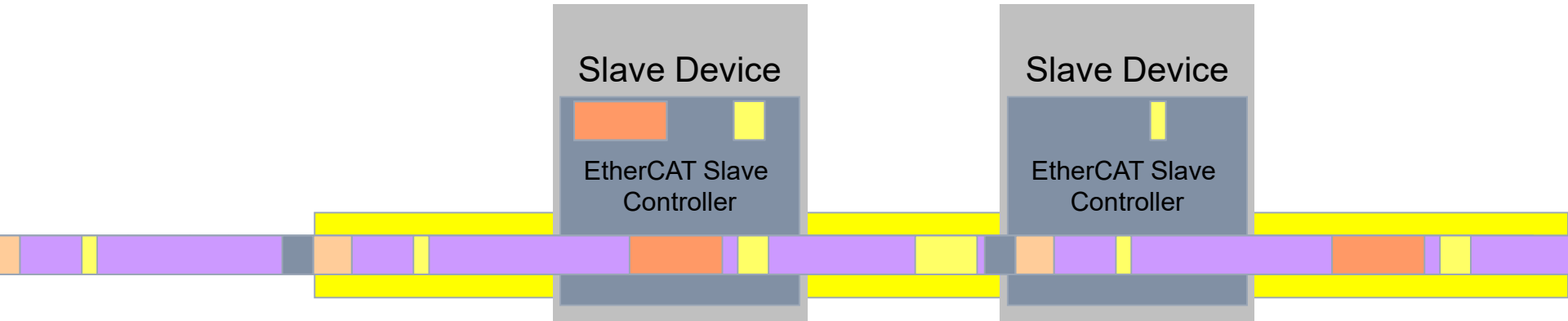
- Red circles below the terminal mean that a CRC error has been detected on the frame coming into that port:



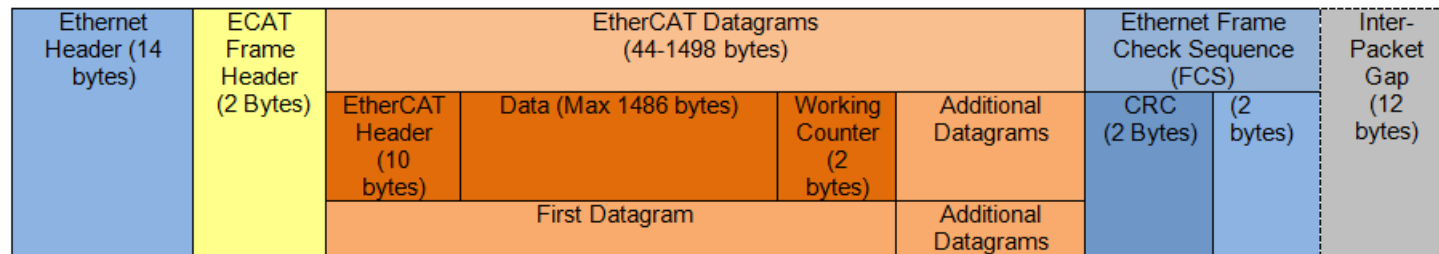
- Potential Causes** for CRC Errors
 - Sources of noise exist near EtherCAT cabling
 - 120, 240, 480 V power lines
 - Motors or other high current devices
 - Any device generating a significant electro-magnetic field



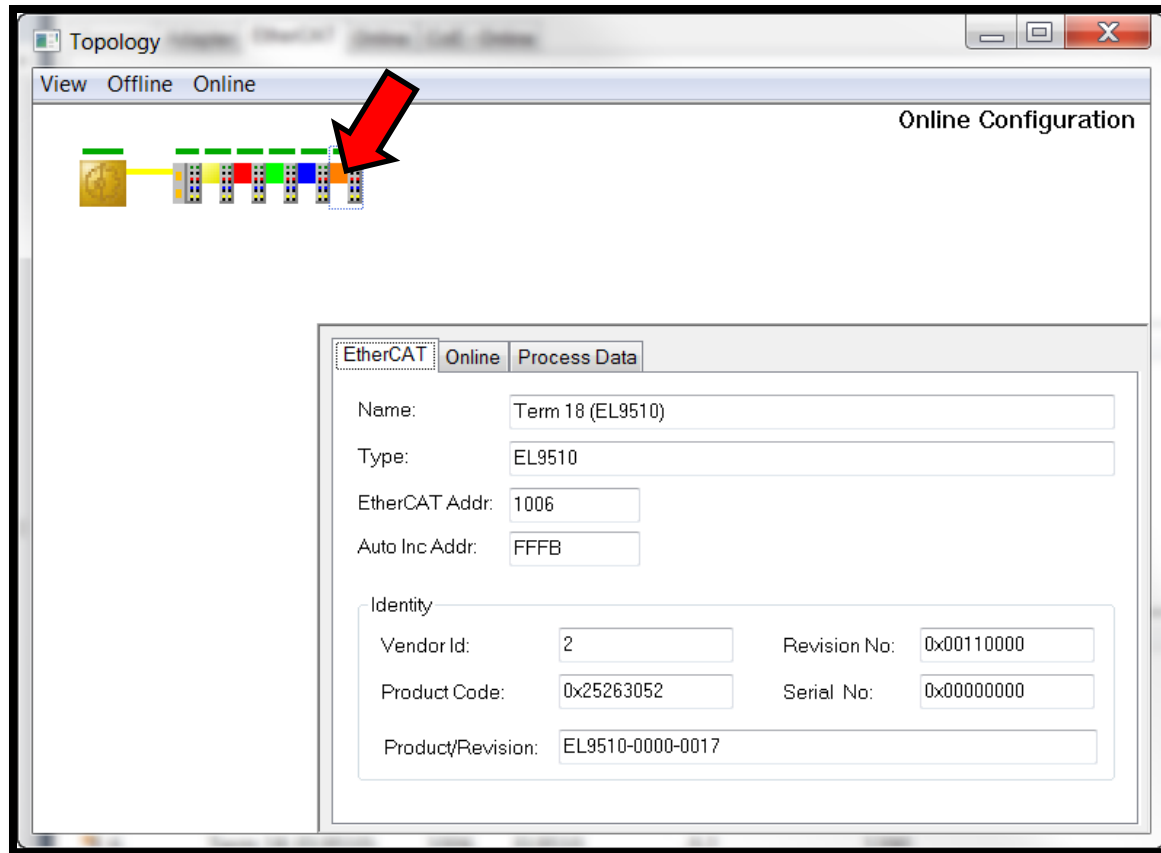
Cyclic Redundancy Checking for Transmission Quality **BECKHOFF**



- Each device checks data passing on the frame
 - A number is calculated by each slave based on the frame content
 - It is checked against the “right answer” also carried on the frame
 - A match means the data is OK
 - A mismatch means that the data has been corrupted
 - Corrupt data is not used other than to report a CRC error

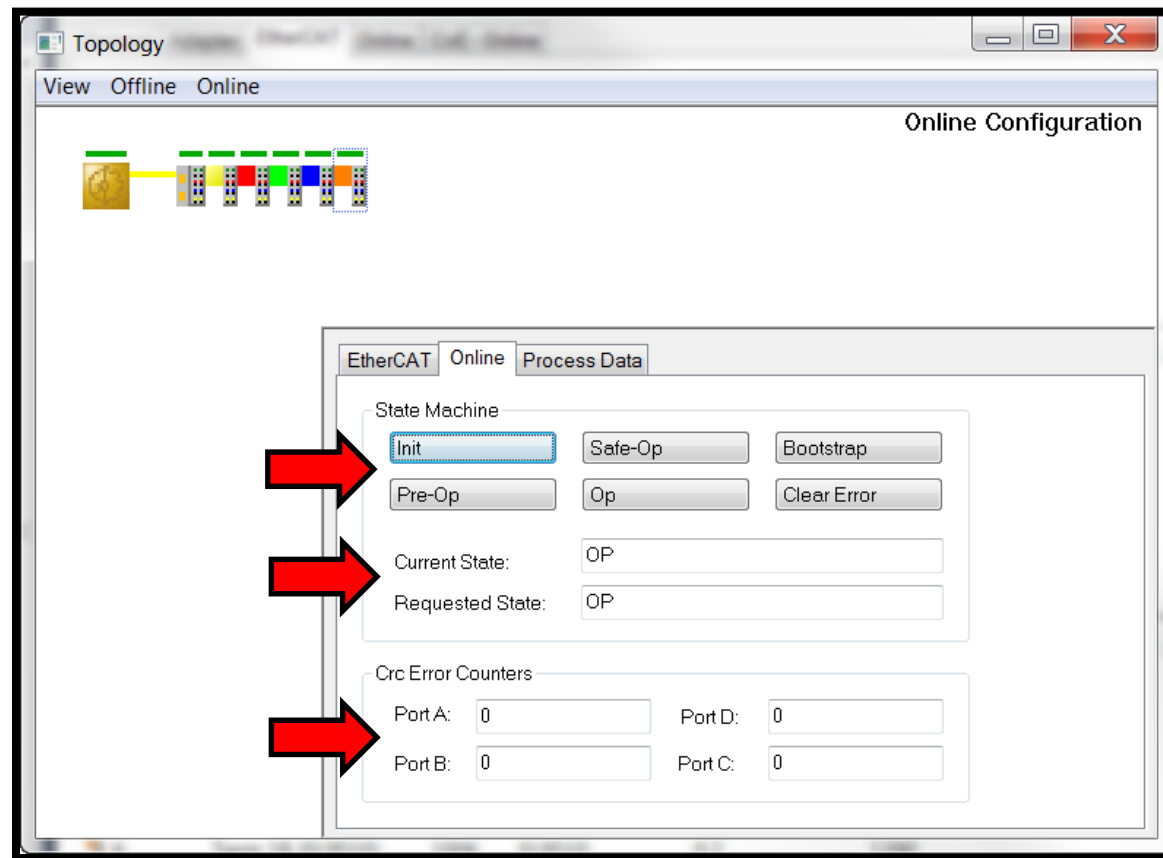


- Left clicking on the terminal causes an information box to appear.



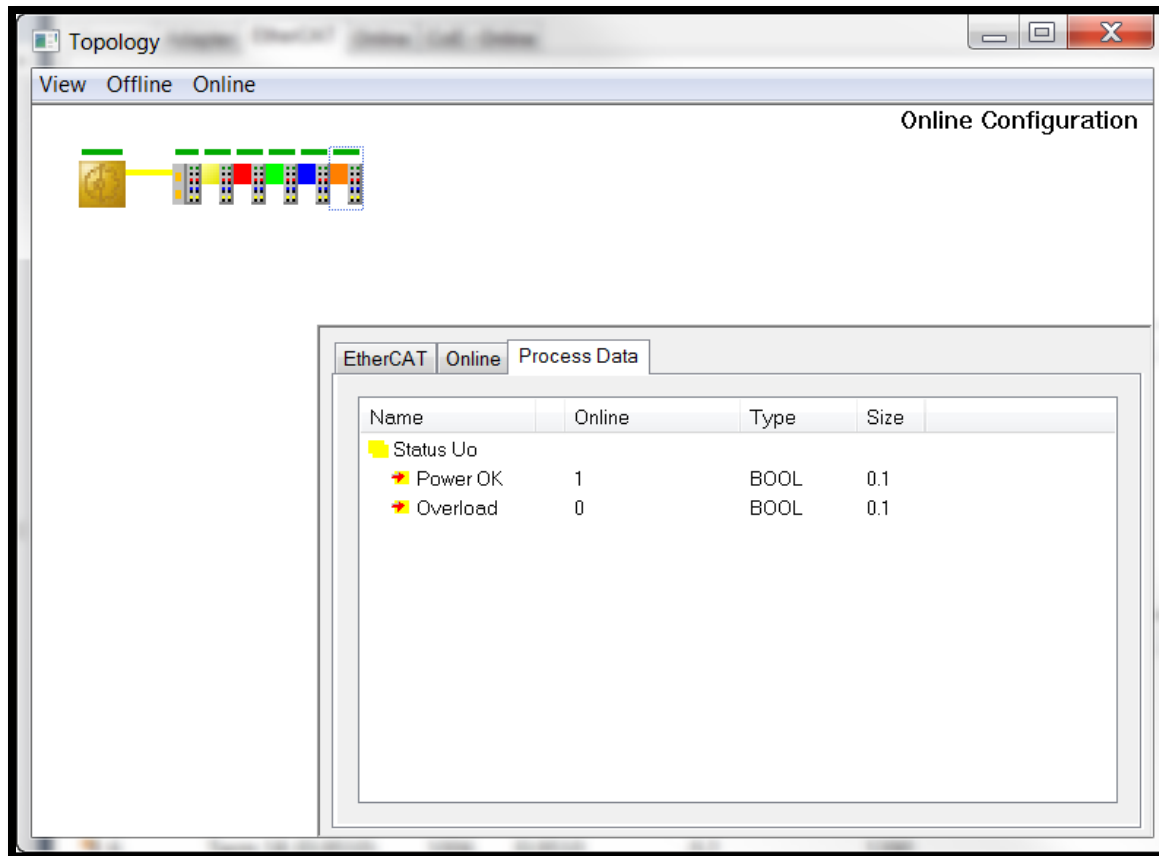
- The EtherCAT tab gives information about the slave

- The Online tab allows the user to change and view the slave state



- The CRC error count is shown

- The Process Data tab shows the values of the cyclic process data



- Right click on a variable to write or force it from here

- Ⓐ Slave states listed
- Ⓑ CRC Errors
 - Only active ports shown
 - Incoming messages only
- Ⓒ Tx/Rx Errors are CRC Errors detected by the EtherCAT NIC
- Ⓓ Lost Frames are Posted
- Ⓔ Queued Frames carry Acyclic Data

The screenshot displays the 'Online' tab of the Beckhoff EtherCAT software. It features a table of slave states and a section for error counters.

No	Ad...	Name	State	CRC
1	1001	Term 13 (EK1100)	OP Ⓐ	0, 0 Ⓑ
2	1002	Term 14 (EL1008)	OP	0, 0
3	1003	Term 15 (EL2034)	OP	0, 0
4	1004	Term 16 (EL3102)	OP	0, 0
5	1005	Term 17 (EL4032)	OP	0, 0
6	1006	Term 18 (EL9510)	OP	0

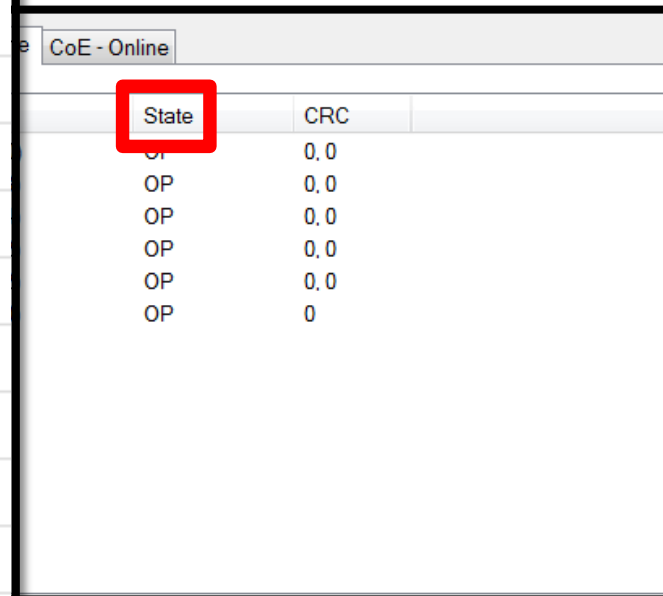
Below the table, the 'Actual State' is set to 'OP'. There are buttons for 'Init', 'Pre-Op', 'Safe-Op', 'Op', 'Clear CRC', and 'Clear Frames'. A red arrow points from label Ⓒ to the 'Clear Frames' button.

Counter	Cyclic	Queued
Send Frames	40101...	+ 154792
Frames / sec	499	+ 19
Lost Frames	0	+ 0 Ⓓ
Tx/Rx Errors	0	/ 0

Red arrows point from label Ⓔ to the 'Queued' column and from label Ⓔ to the 'Tx/Rx Errors' row.

- In the **State Column** the following messages may appear

INIT	Slave is in Init
PREOP	Slave is in Pre-Operational
SAFEOP	Slave is in Safe-Operational
OP	Slave is in Operational
BOOT	Slave is in Bootstrap
ERR	Error state set in slave
VPRS	Vendor Id, product code, revision number or serial number are incorrect
NO_COMM	No communication to the slave is possible
LNK_MIS Port	Link at the given port is missing (Port = A, B, C or D).
LNK_ADD Port	Additional link at given port.
LNK_ERR Port	Link without communication detected



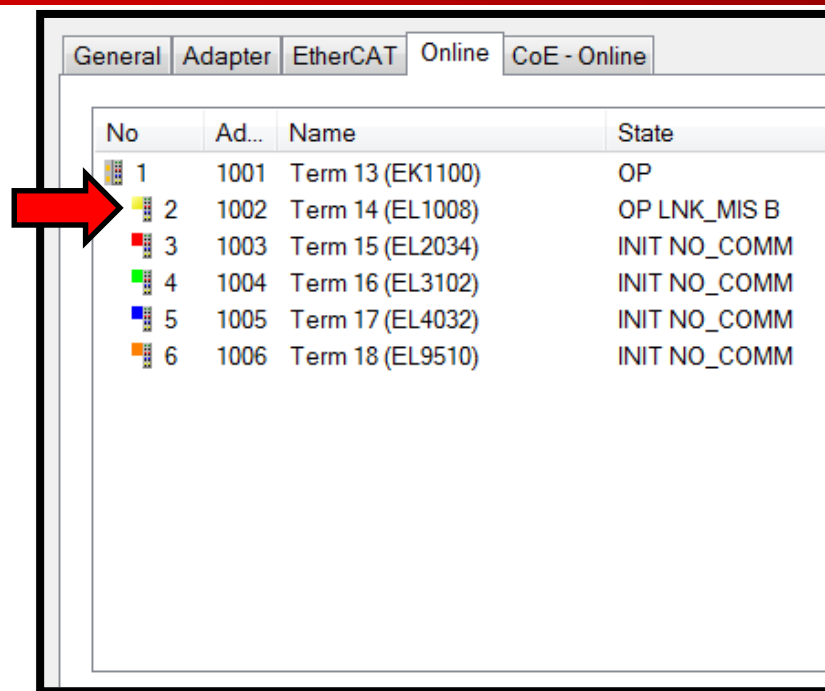
CoE - Online		
State	CRC	
OP	0,0	
OP	0,0	
OP	0,0	
OP	0,0	
OP	0,0	
OP	0	

- Multiple messages can appear in a single line
 - Note: The argument does not always follow the problem type
- Troubleshoot starting with the first slave message and work down

The Online Tab: Troubleshooting Example

BECKHOFF

- A communication break between terminals EL1008 and EL2034 is shown*
- **“OP LINK_MIS B”** is stated
- **“INIT NO_COMM”** is stated
- **Meaning:**
 - EL1008 is in the OP state AND the terminal cannot communicate off of PORT B
 - Subsequent terminals are in the INIT state AND cannot be communicated to
- **Possible Fixes:**
 - Properly install terminal to the right of EL1008
 - Replace terminal to the right of EL1008
 - Replace the EL1008



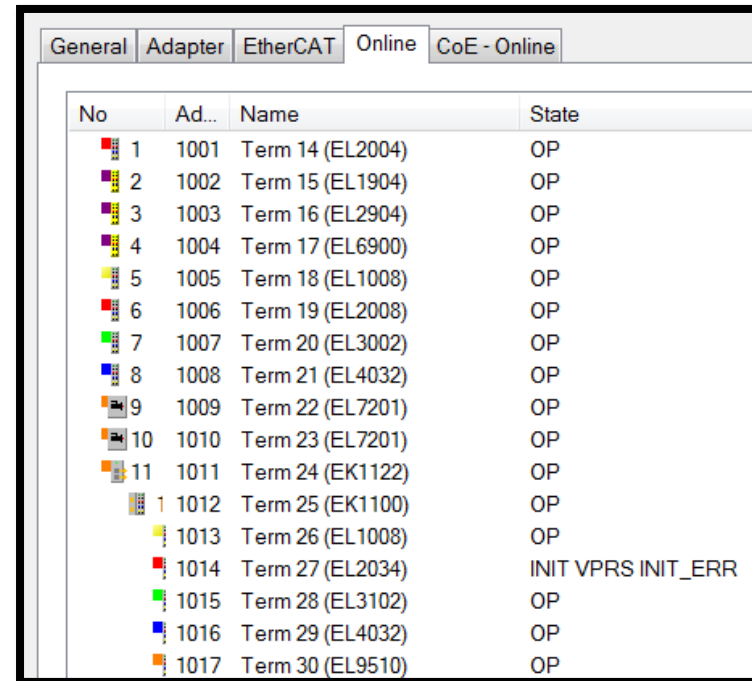
General Adapter EtherCAT Online CoE - Online				
No	Ad...	Name	State	
1	1001	Term 13 (EK1100)	OP	
2	1002	Term 14 (EL1008)	OP LNK_MIS B	
3	1003	Term 15 (EL2034)	INIT NO_COMM	
4	1004	Term 16 (EL3102)	INIT NO_COMM	
5	1005	Term 17 (EL4032)	INIT NO_COMM	
6	1006	Term 18 (EL9510)	INIT NO_COMM	

* EL2034 was pulled from the rack(while unpowered) to cause this break in communication

The Online Tab: Troubleshooting Example

BECKHOFF

- An incorrect terminal type was installed in place of the EL2034*
- “INIT VPRS INIT_ERR” is stated
- **Meaning:**
 - EL2034 is in the INIT state
 - The installed terminal is not a proper replacement for the configured EL2034
 - There is an error initializing the slave
- **Possible Fixes:**
 - Install a terminal with an acceptable VendorID, Product Code, Revision or Serial Number
 - Reconfigure system to accept new terminal (*CAUTION – Not the preferred solution*)

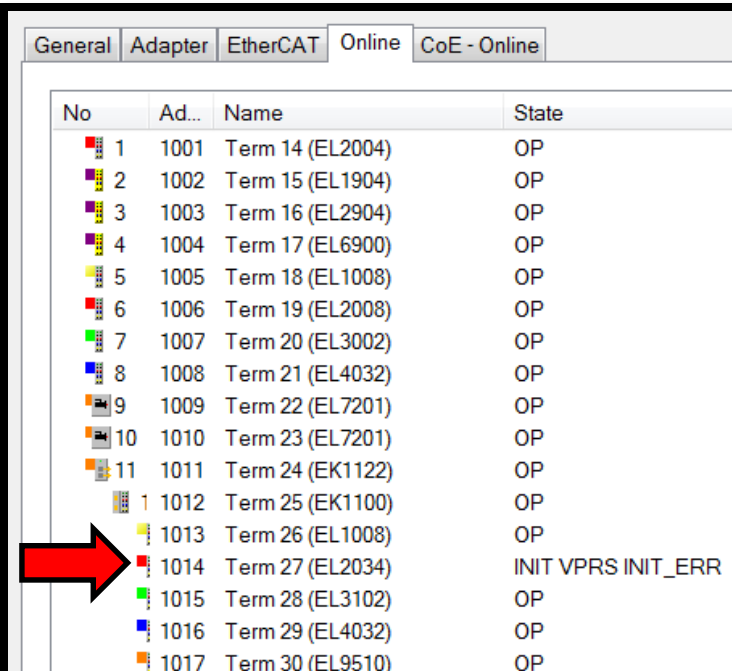


General Adapter EtherCAT Online CoE - Online				
No	Ad...	Name	State	
1	1001	Term 14 (EL2004)	OP	
2	1002	Term 15 (EL1904)	OP	
3	1003	Term 16 (EL2904)	OP	
4	1004	Term 17 (EL6900)	OP	
5	1005	Term 18 (EL1008)	OP	
6	1006	Term 19 (EL2008)	OP	
7	1007	Term 20 (EL3002)	OP	
8	1008	Term 21 (EL4032)	OP	
9	1009	Term 22 (EL7201)	OP	
10	1010	Term 23 (EL7201)	OP	
11	1011	Term 24 (EK1122)	OP	
12	1012	Term 25 (EK1100)	OP	
13	1013	Term 26 (EL1008)	OP	
14	1014	Term 27 (EL2034)	INIT VPRS INIT_ERR	
15	1015	Term 28 (EL3102)	OP	
16	1016	Term 29 (EL4032)	OP	
17	1017	Term 30 (EL9510)	OP	

The Online Tab: Troubleshooting Example

BECKHOFF

- **Vendor ID**: The specific ID given to a company making an EtherCAT device
- **Product Code**: The model number of the device
- **Revision**: The number of significant design changes since product conception
- **Serial Number**: Usually left blank
- ***All of the above can be observed in the CoE online tab***
- **Result:**
 - In most cases, replacing the existing terminal with one having the same part number AND an equal or newer firmware code (see side of terminal) will fix the problem



General Adapter EtherCAT Online CoE - Online				
No	Ad...	Name	State	
1	1001	Term 14 (EL2004)	OP	
2	1002	Term 15 (EL1904)	OP	
3	1003	Term 16 (EL2904)	OP	
4	1004	Term 17 (EL6900)	OP	
5	1005	Term 18 (EL1008)	OP	
6	1006	Term 19 (EL2008)	OP	
7	1007	Term 20 (EL3002)	OP	
8	1008	Term 21 (EL4032)	OP	
9	1009	Term 22 (EL7201)	OP	
10	1010	Term 23 (EL7201)	OP	
11	1011	Term 24 (EK1122)	OP	
1	1012	Term 25 (EK1100)	OP	
	1013	Term 26 (EL1008)	OP	
	1014	Term 27 (EL2034)	INIT VPRS INIT_ERR	
	1015	Term 28 (EL3102)	OP	
	1016	Term 29 (EL4032)	OP	
	1017	Term 30 (EL9510)	OP	

The Online Tab: Troubleshooting Example

BECKHOFF

- A loss of communication between the EK1122 and EK1100 is shown*
- “**OP LINK_MIS LNK_ADD B D**” is stated
- **Meaning:**
 - EK1122 is in the OP state
 - A link is missing on one port
 - A link has been added to the other port
- **Common Fix:**
 - Move the cable from the plugged in port to the available port

2

General		Adapter		EtherCAT		Online		CoE - Online		
No	Ad...	Name			State					
	1	1001	Term 14 (EL2004)			OP				
	2	1002	Term 15 (EL1904)			OP				
	3	1003	Term 16 (EL2904)			OP				
	4	1004	Term 17 (EL6900)			OP				
	5	1005	Term 18 (EL1008)			OP				
	6	1006	Term 19 (EL2008)			OP				
	7	1007	Term 20 (EL3002)			OP				
	8	1008	Term 21 (EL4032)			OP				
	9	1009	Term 22 (EL7201)			OP				
	10	1010	Term 23 (EL7201)			OP				
	11	1011	Term 24 (EK1122)			OP LNK_MIS LNK_ADD B D				
	12	1012	Term 25 (EK1100)			INIT NO_COMM				
	13	1013	Term 26 (EL1008)			INIT NO_COMM				
	14	1014	Term 27 (EL2034)			INIT NO_COMM				
	15	1015	Term 28 (EL3102)			INIT NO_COMM				
	16	1016	Term 29 (EL4032)			INIT NO_COMM				
	17	1017	Term 30 (EL9510)			INIT NO_COMM				

*the cable going for the EK1122 to the EK1100 was switched from the configured port on the EK1122 to the unused port on the EK1122 to cause this



The Online Tab: Troubleshooting Example

BECKHOFF

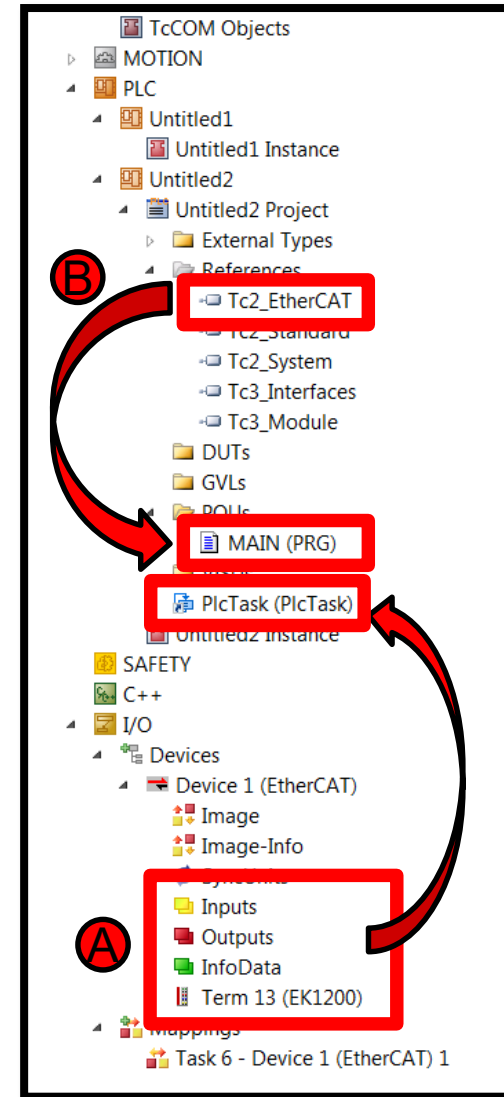
- “OP LINK_ERR B” is stated
- ***Meaning:***
 - The terminal is in the OP state
 - A link is present on PORT B
 - The terminal off of port B is not communicating
- ***Common Fixes:***
 - Replace terminal off of port B

1. Troubleshooting using Hardware
2. Troubleshooting using Software
3. Automating Troubleshooting with PLC Code

Using the PLC to Diagnose EtherCAT

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- PLC Code can be written to automate the diagnosis of EtherCAT
- **Two Methods** Are Used to Accomplish this:
 - Ⓐ Linking *PLC Variables* to *Diagnostic IO Variables*
 - Ⓑ Using Prewritten Code from the EtherCAT Library*



*Tc2_EtherCAT.lib for TwinCAT 3, EtherCAT.lib for TwinCAT2

Using the PLC to Diagnose EtherCAT

BECKHOFF

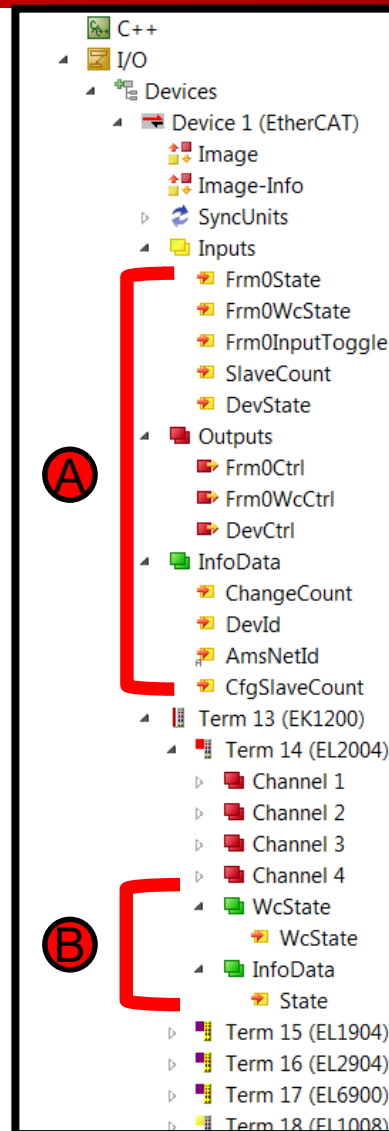
- **Method 1:** Variables Can Be Linked from the PLC to the IO to obtain EtherCAT data
- Two Categories of IO Variables Can be Linked to the PLC

A Master Diagnostic Data

- Information regarding whole bus

B Slave Diagnostic Data

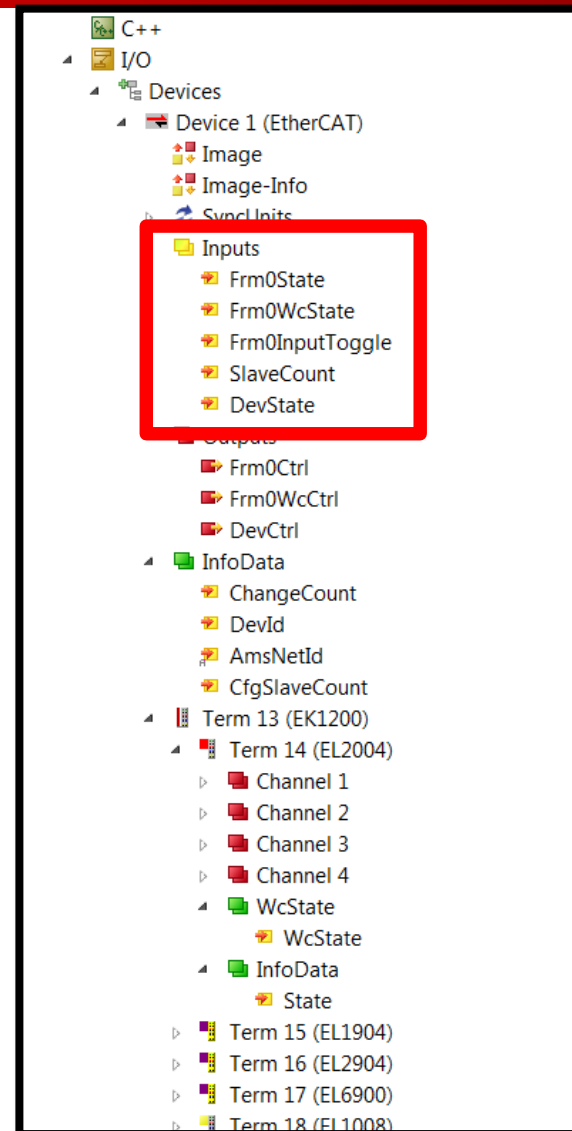
- Information pertaining to a single slave



Using the PLC to Diagnose EtherCAT

■ **Master Diagnostic Data: Inputs**

- Frm0State
 - Read if a frame was transmitted to one or more slaves
- Frm0WCState
 - Read if any slaves did not interact with the frame
- SlaveCount
 - Read the number of slaves currently communicating with the master
- DevState
 - Read the state of the EtherCAT device

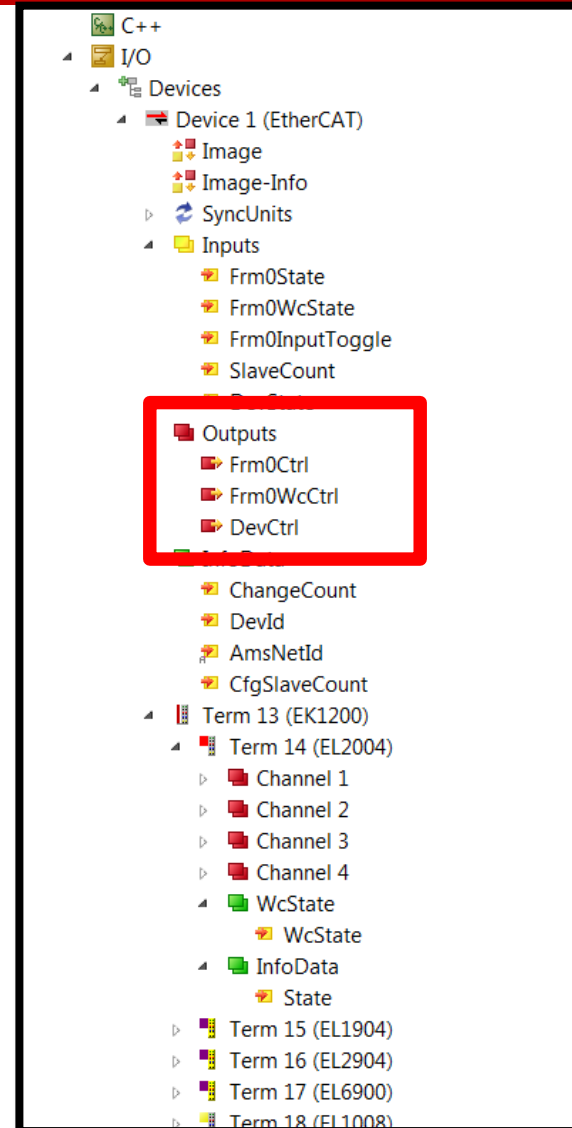


Using the PLC to Diagnose EtherCAT

BECKHOFF

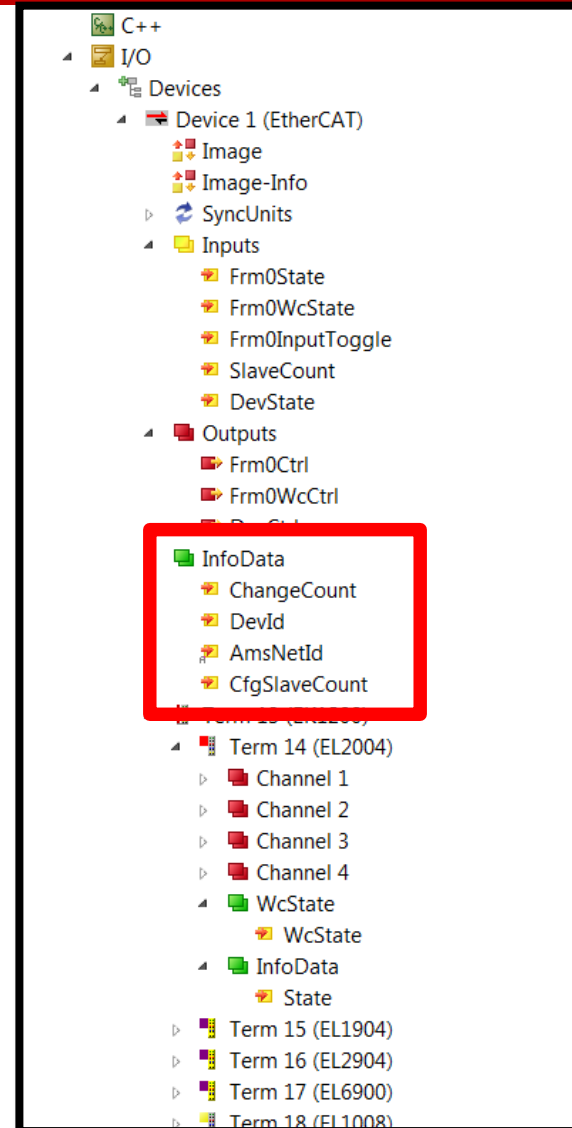
■ **Master Diagnostic Data: Outputs**

- Frm0Ctrl
 - Set to prevent the frame from sending messages to one or more slaves OR prevent the complete frame from being sent
- Frm0WcCtrl
 - Set working counter of frame
- DevCtrl
 - Send a request for state change of the EtherCAT device



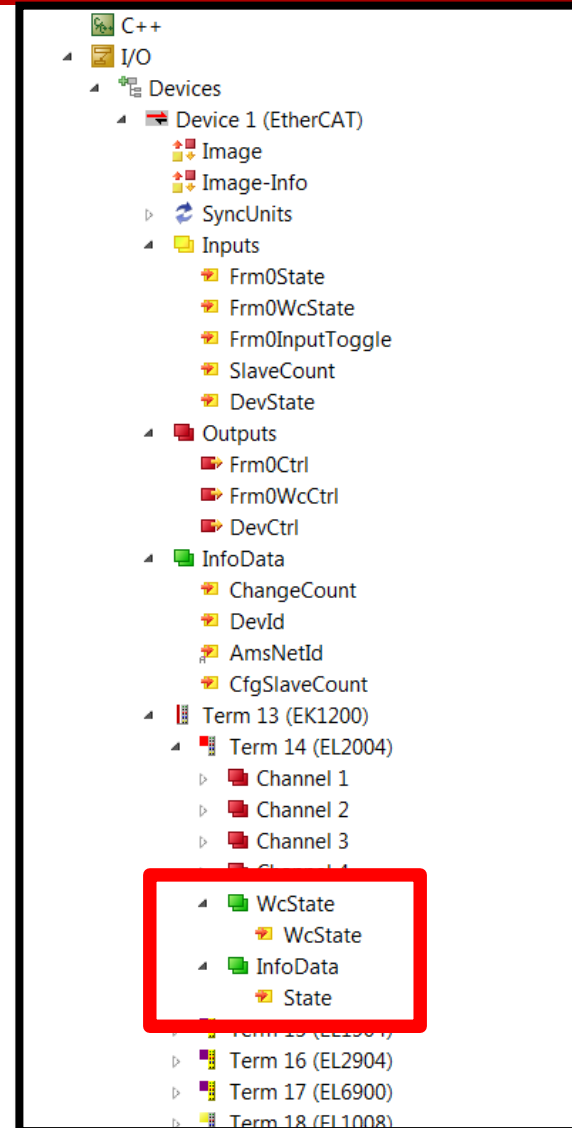
Using the PLC to Diagnose EtherCAT

- **Master Diagnostic Data: InfoData**
 - ChangeCount
 - Read the number of times the EtherCAT device changed its state
 - DevId
 - Read the ID number identifying the EtherCAT device in the IO configuration
 - AMSNetId
 - Read the TwinCAT address for the EtherCAT network card
 - CfgSlaveCount
 - Read the number of slaves originally configured on the bus



Using the PLC to Diagnose EtherCAT

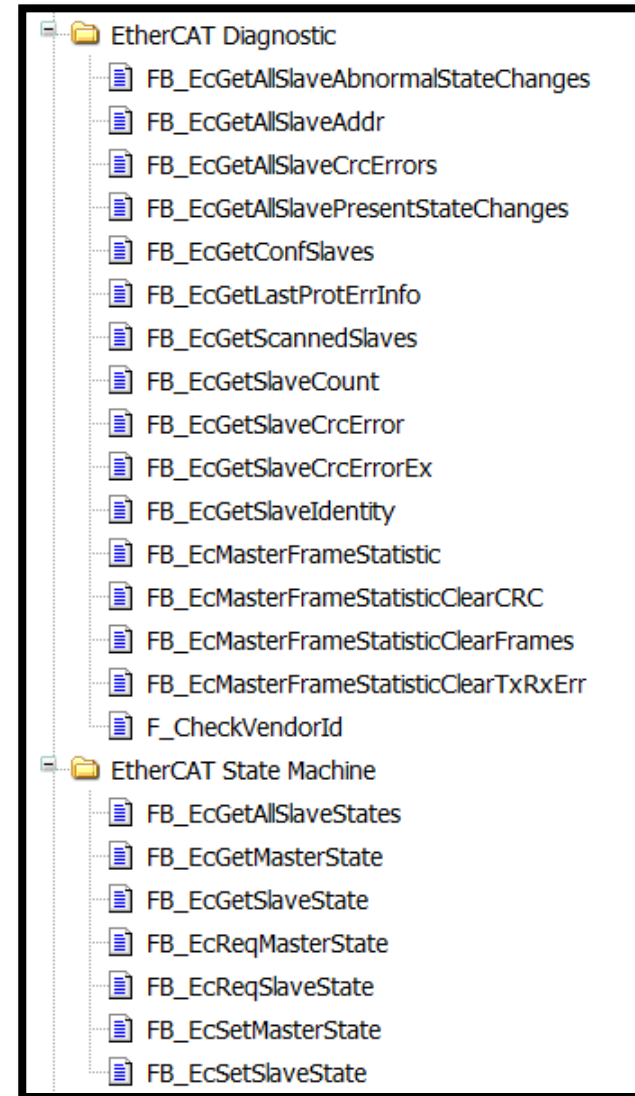
- **Slave Diagnostic Data: WcState**
 - WcState
 - Reads '1' if the datagram of the most recent frame servicing the slave was not able to transfer data with all slaves serviced by that datagram
- **Slave Diagnostic Data: InfoData**
 - State
 - Reads out the current status of the slave



Using the PLC to Diagnose EtherCAT

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- **Method 2:** Function blocks can be used to acquire EtherCAT data
- Information Can Be Read
 - Master or slave states
 - Number of CRC errors
 - Number of configured or active slaves
 - Number of state changes
 - Slave addresses
 - Slave identity information
- Commands Can be Issued
 - Clear bus errors
 - Set master or slave states
 - Set internal memory



Beckhoff Automation LLC

USA Headquarters
13130 Dakota Avenue
Savage, MN 55378
USA

Phone: 1 952 890 0000
Fax: 1 952 890 2888
E-Mail: beckhoff.usa@beckhoff.com
Web: www.beckhoffautomation.com

Beckhoff Automation GmbH & Co. KG

Global Headquarters
Huelshorstweg 20
33415 Verl
Germany

Phone: +49 5246 963-0
Fax: +49 5246 963-198
E-Mail: info@beckhoff.com
Web: www.beckhoff.com

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