
Documentation EtherCAT Library for LabVIEW 3

This document describes the usage and installation of the “EtherCAT Library for LabVIEW“ version 3.00.

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1 General Information

The “EtherCAT Library for LabVIEW” allows direct data exchange with EtherCAT slaves. LabVIEW acts as an EtherCAT Master and controls the slaves in the EtherCAT topology. A Connection can be made with a normal network adapter (NIC). The EtherCAT Master can be run with a real-time driver for controlling the NIC. This allows a deterministic bus rate of up to 10 kHz and the usage of Distributed Clocks. As an alternative, the EtherCAT Master can also be run in Windows mode without real-time behavior.

The library provides a wide set of EtherCAT functionality like:

- Cyclic process data exchange
- CAN over EtherCAT (CoE)
- Servo Profile over EtherCAT (SoE) protocol
- Access to Slave EEPROM and Registers
- File Transfer over EtherCAT (FoE) mailbox protocol
- Synchronization with Distributed Clocks (DC) including Master Synchronization (DCM)

2 System Requirements

2.1 Operating system

The library can be used on Windows 7, 8.1 and 10 with 32 and 64 bit.

2.2 PC System

In real-time Mode

The real-time driver requires PC Systems with ACPI (Advanced Configuration and Power Interface) or APIC (Advanced Programmable Interrupt Controller).

In Windows Mode

No restrictions regarding PC hardware.

2.3 Network adapter

In real-time Mode

EtherCAT protocol is run on a normal network adapter, which is controlled by a real-time environment. This requires the installation of a real-time driver for the NIC and limits the supported network adapters to chipsets from **Intel** and **Realtek**.

In Windows Mode

No restrictions regarding Network adapter.

2.4 LabVIEW

The library can be used with LabVIEW 2013 to LabVIEW 2019 in 32 and 64 bit.

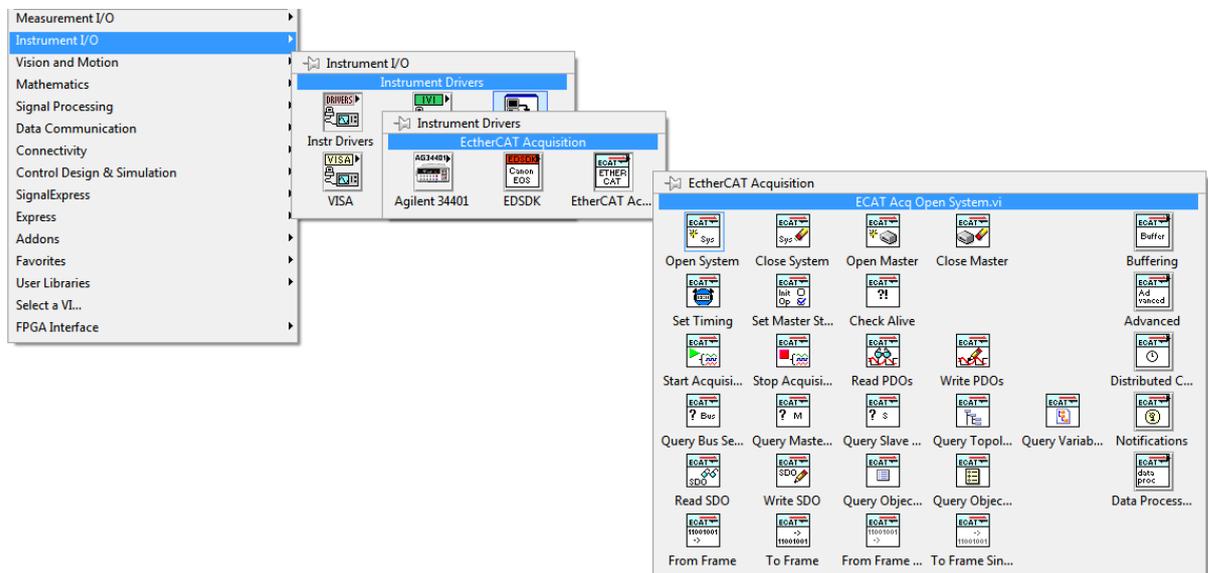
3 Installation

3.1 LabVIEW Library

The installer installs files directly to the LabVIEW folder (..\program files\National Instruments\LabVIEW xx\..)

The library is installed into the intr.lib folder in the subfolder "_Ackermann Automation\EtherCAT Library".

The functions palette is installed under Instrument Drivers.



3.2 LabVIEW Examples

The examples are installed in the LabVIEW examples folder “..\Program Files\National Instruments\LabVIEW xx\examples\Ackermann Automation\EtherCAT Library”.

3.3 Tools and Documents

All further tools and documents can be found in:

“..\ProgramData\Ackermann Automation\EtherCAT Library\3.x”

3.4 Network Card Driver

In real-time Mode

This topic is covered in the document "Installation real-time Driver".

In Windows Mode

In Windows mode the WinPcap or NPcap driver has to be installed. These drivers can be downloaded from:

www.winpcap.org

www.nmap.org

4 Basic Programming

This chapter describes the principals of programming with the library. The detailed VI information can be found in the help file.

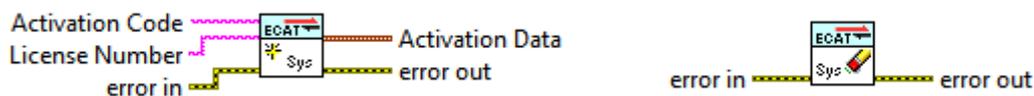
4.1 System Driver

The function “Open System Driver” has to be called before all other function calls.

This function prepares the real-time environment and checks the license activation status. If the license is not using a USB dongle, the license key has to be entered. If no dongle or valid license key is found, the library is running in demo mode for 10 minutes.

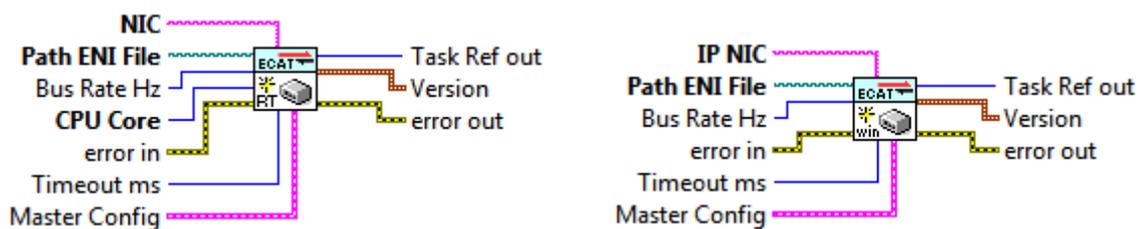
The driver has to be closed when finishing execution. This will shut down the resources of the real-time environment.

Avoid stopping execution without using the Close System function call!



4.2 EtherCAT Master

After the system driver has been opened, the EtherCAT Master can be started. The EtherCAT Master can be run with the real-time Driver or in Windows mode. Which option is selected is determined by the Open Master function. The Windows mode does not support the whole functionality of the library due to the lack of deterministic timing behavior.



In both cases an ENI file is required to run the master with cyclic process data. This XML file contains the information about the whole EtherCAT system including the slave and process data description. The ENI file is described in the chapter "ENI Files".

All actions that do not require Master state higher PreOp (CoE, memory access, bus scan, etc.) can be done without an ENI file.

If no ENI file path is entered, a basic configuration is created by the master. In this configuration the physical slave addresses start from 1. In common ENI configuration tools like TwinCAT or EC Engineer physical slave addresses start from 1001.

In real-time Mode

Opening the EtherCAT Master requires the network adapter information and the CPU core selection.

The network adapter (NIC) has to be selected. The network adapter has to be assigned to the real-time (see document "Installation real-time Driver"). There are 4 different types of network adapter classes supported. Intel 100 and 1000 Mbit NICs and Realtek 100 and 1000 Mbit NICs. The type is identified by the following strings:

"Intel1000"

"Intel100"

"Realtek1000"

"Realtek100"

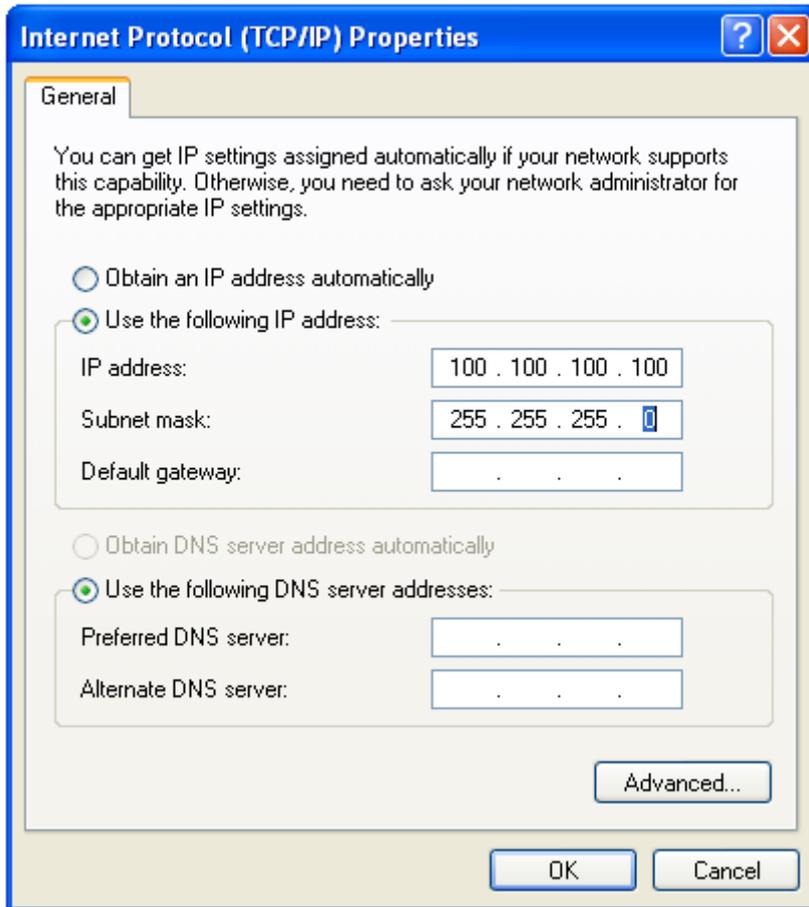
The processor parameter defines the CPU core usage of the real-time driver. The real-time driver can be used in two different modes. In shared mode, Windows and the real-time driver share a CPU core. In exclusive mode, the real-time driver uses one CPU core exclusively. This core has to be taken from Windows (see document " Installation real-time Driver ").

On 64bit Systems, only exclusive mode is available!

In Windows Mode

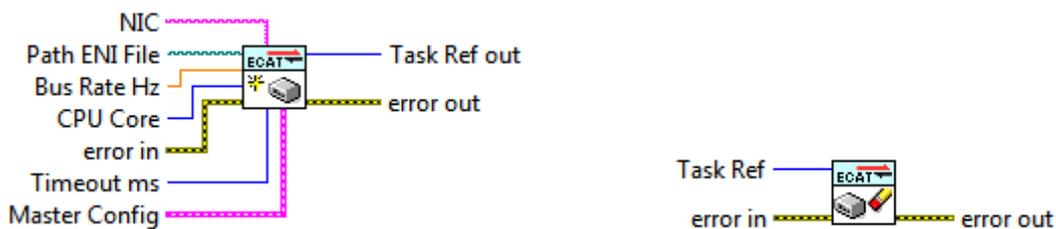
Opening the EtherCAT Master only requires the network adapter information.

The windows network adapter to be used has to be given a static IP address in the Windows network configuration. This IP address is used to identify the network adapter.



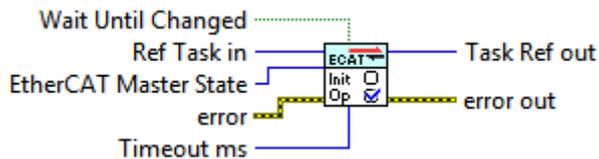
The bus cycle rate determines the rate in which the cyclic process data is sent. In Windows mode this rate is limited to 1 kHz with non deterministic Windows timing. In real-time mode the bus cycle rate can be up to 10 kHz.

The function returns a task ref, which all other functions use as input.

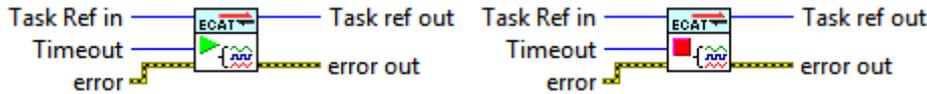


4.3 Bus State

The EtherCAT bus states "Init", "PreOp", "Boot", "SafeOp" and "Op" can be set with the function Set Bus State. The state is set for the master which tries to set all connected slaves into this state. Cyclic process data exchange is executed in the states "SafeOp" and "Op". In "SafeOp" no outputs are set in the slaves.



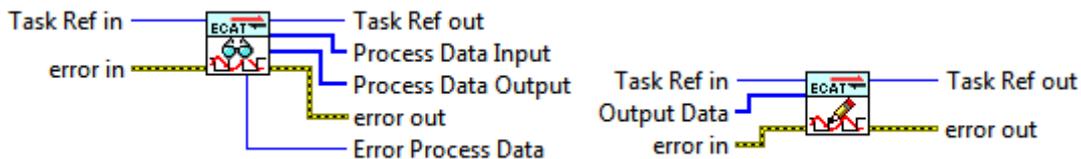
The functions start and stop are shortcuts to "Op" and "Init" state.



4.4 Reading And Writing Cyclic Process Data (PDO)

The cyclic process data is organized in an input data image and a output data image. These data sections contain all the input and output process data from the slaves in the topology. The single frame read and write calls give access to these data sections.

These functions give direct access and have no buffering. That means, if the bus cycle rate is faster than the LabVIEW loop, process data is lost.

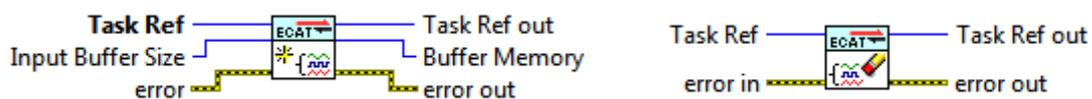


4.5 Buffered Reading Cyclic Process Data (PDO)

Only supported in realtime mode.

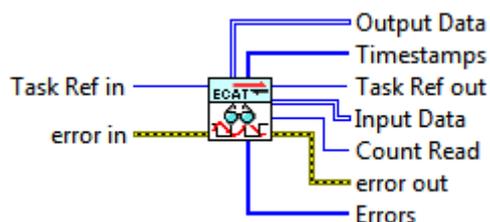
With the buffered data exchange of cyclic process data, the cyclic bus rate can be greater than the LabVIEW loop to handle the process data. Data is transferred in packets. Input data can be acquired without data loss.

If cyclic process data is to be transferred in buffered mode, a buffer has to be created before. The buffer size is determined in count of frames. So for example a size of 1000 can hold data for 1000 cycles. When running a cycle rate of 1 kHz, the buffer can hold data for 1 second. The input buffer always uses the full input process data.



The read function uses a 2D arrays for the data exchange. A row of the array is the data of one cycle.

The input data contains the data of inputs and outputs of one process data cycle. A timestamp in μs of the time the telegram was sent is taken in the real-time environment and an error value for every process data cycle is transferred.

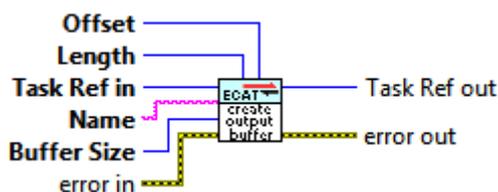


4.6 Buffered Writing Cyclic Process Data (PDO)

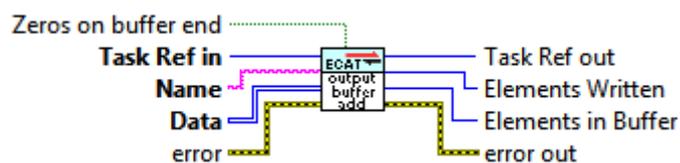
Only supported in real-time mode.

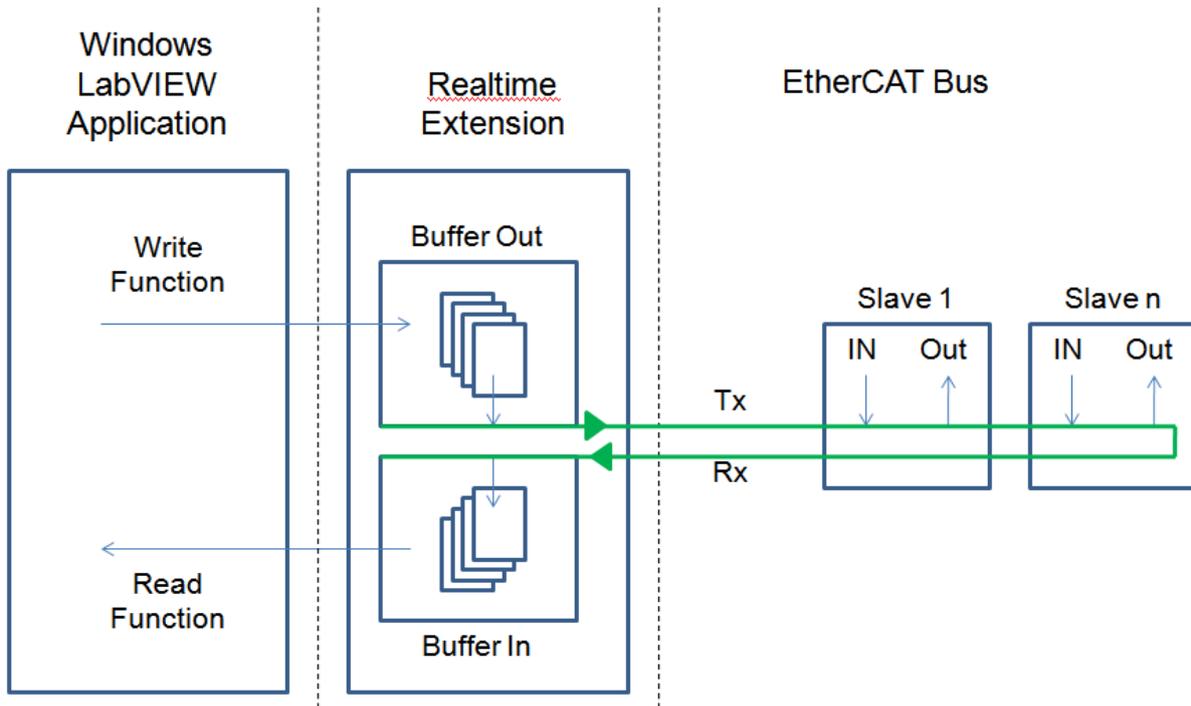
Also output process data can be transferred using buffers. Here it is possible to create multiple buffers for different output process data segments. By this it is possible to have some outputs creating buffered signals, while other outputs respond to fast single write operation.

A buffer is created by giving a name for later reference and the data area.



This buffer can be filled with the cyclic process data to write





4.7 Topology And Slave Information

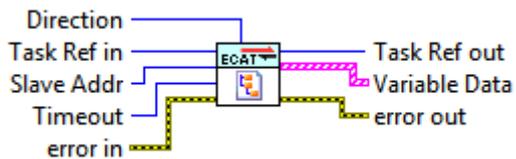
The topology information containing the general slaves data can be queried from the bus. The data is returned as a slave data array.



Specific Slave information can be read online from each slave.

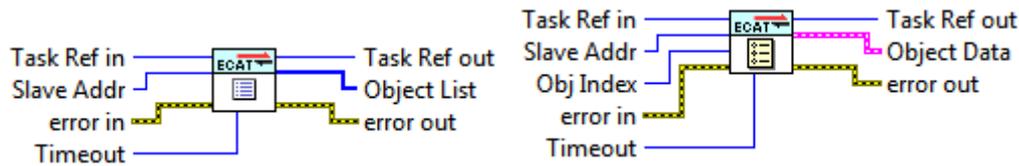


Each slave has a set of input and output variables in the process data. The information about these sets can be queried. The returned data contains the positions in the input and output process data images with byte and bit offsets.



4.8 Object Dictionary

The object dictionaries of connected slaves can be read, if they support mailbox communications.



4.9 Reading and Writing Service Data Objects (SDO)

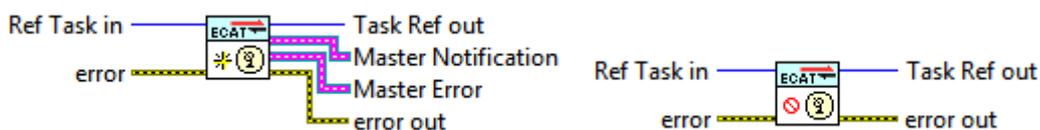
Service data objects (SDOs) can be accessed via CoE. The addressing is done by index and subindex.



4.10 EtherCAT Master Events

Only supported in real-time mode.

The EtherCAT Master sends notifications and errors as LabVIEW User Events. These Events have to be registered in a LabVIEW event structure to be received.



5 Data Processing Functions

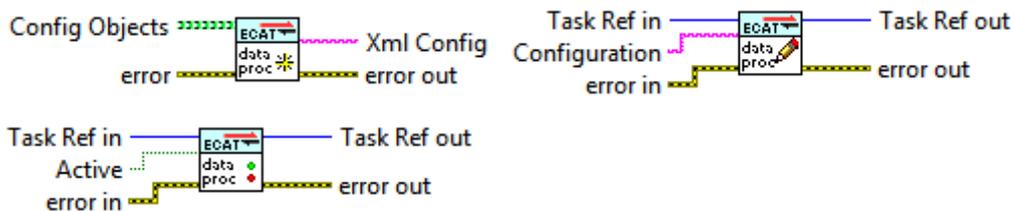
Only supported in real-time mode.

Data Processing Functions are predefined functions that work on the process data and are executed in the real-time environment in the time between receiving and sending of frames. These functions run with the bus cycle rate of up to 10 kHz.

The following functions are available:

- Limit Monitor
- Boolean Logic
- PID Control Loop
- Bit Copy
- Analog Copy

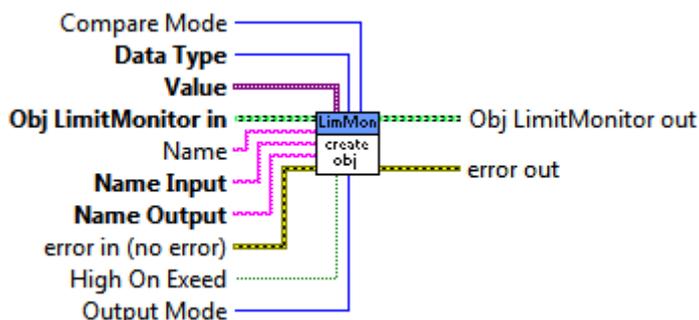
The functions are configured by creating a LabVIEW object array in which different function types can be combined. This object array is converted into a XML string, which is downloaded to the real-time environment. Here the XML configuration is creating the corresponding functions, which can be activated and deactivated.



The Xml configuration is generated with the following Vis.

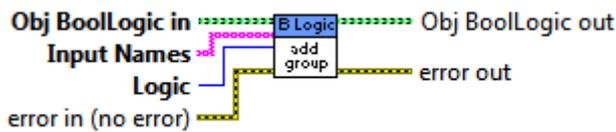
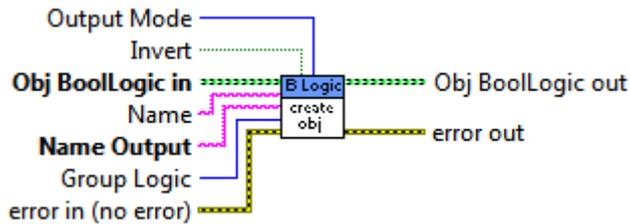
5.1 Limit Monitor

The Limit Monitor function compares a threshold value with a current analog input and writes the result to a boolean output variable or to a single bit, as usually required when working with drives.



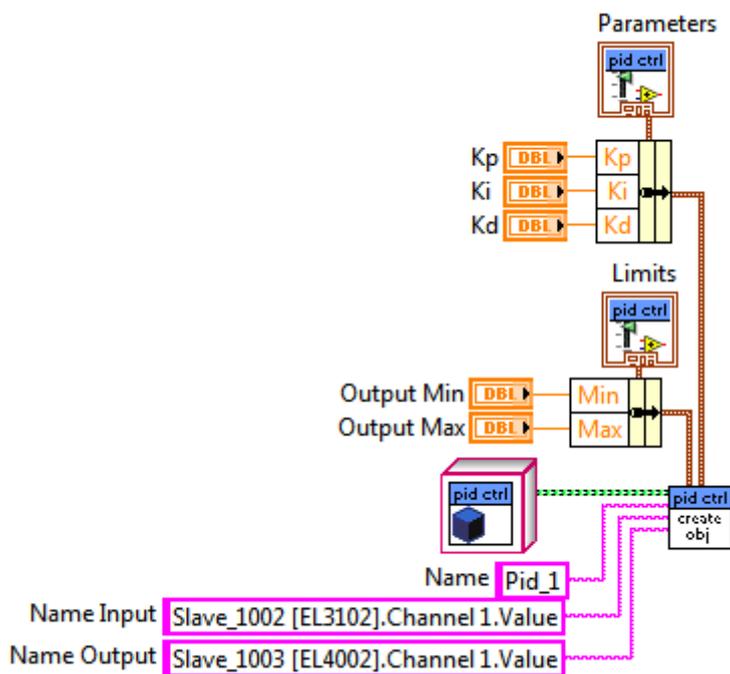
5.2 Bool Logic

The Bool Logic function evaluates boolean groups and writes the result to a boolean output variable.



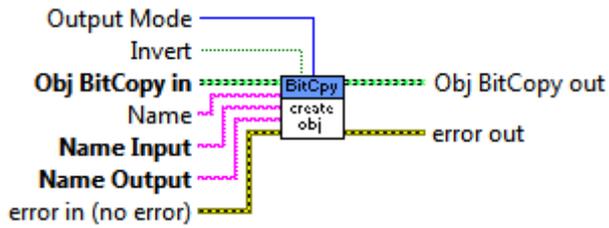
5.3 PID Control Loop

Executing PID control loops in the real-time of the EtherCAT Master with up to 10 kHz deterministic cycle time.



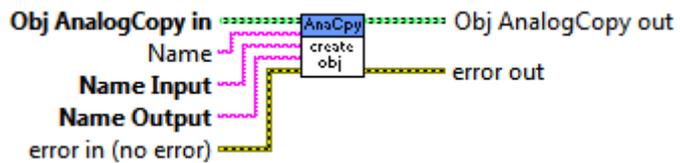
5.4 Bit Copy

The Bit Copy function copies the data of a boolean input variable to a boolean output variable.



5.5 Analog Copy

The Analog Copy function copies the data of an analog input variable to an analog output variable.



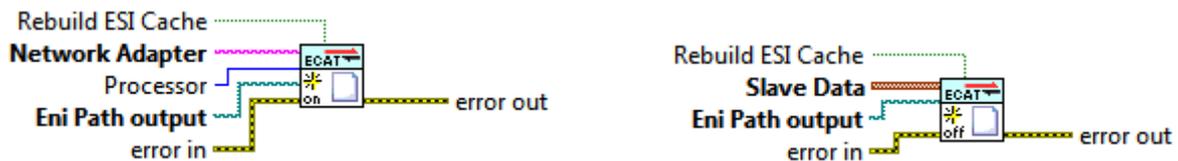
6 ENI Files

For cyclic process data exchange, the EtherCAT Master needs a valid EtherCAT ENI file (EtherCAT Network Information) that describes the bus topology and the process data setup of all slaves. There are several ways to create these ENI files.

6.1 Creation with LabVIEW

The EtherCAT Acquisition library provides the functionality to create ENI files.

For ENI file creation the slave identification data vendor ID, product Code and Revision number have to be known. There are alternatives for creating the ENI files. One is to scan the topology online and create the ENI file. The other is to enter the slave data offline.



The ENI file creation is based on slave ESI files. Make sure to have the most recent ESI files of your slaves in the ESI file folder. The ESI file folder can be accessed from a shortcut in the Start Menu (Ackermann Automation -> EtherCAT Acquisition -> 2.x).

Regarding licensing it is distinguished between a basic mode, which comes with the runtime license and a ENI Creation option, which has to be licensed as an addition. The basic mode can only handle straight topologies without EtherCAT junctions. Meaning that all slaves are connected to Port B of the previous slave. This can for example be one Beckhoff EK1100 with connected terminals. Two EK1100 will not work, because the second EK1100 is connected to Port C of the first EK1100. Also these files only contain the standard (default) process data configuration for the slaves. This standard is defined in the slave ESI files. And Distributed Clocks settings cannot be configured.

See examples "Example - Create ENI File Online Basic.vi" and "Example - Create ENI File Offline Basic.vi" in "..\examples\EtherCAT Acquisition\EtherCAT Library"

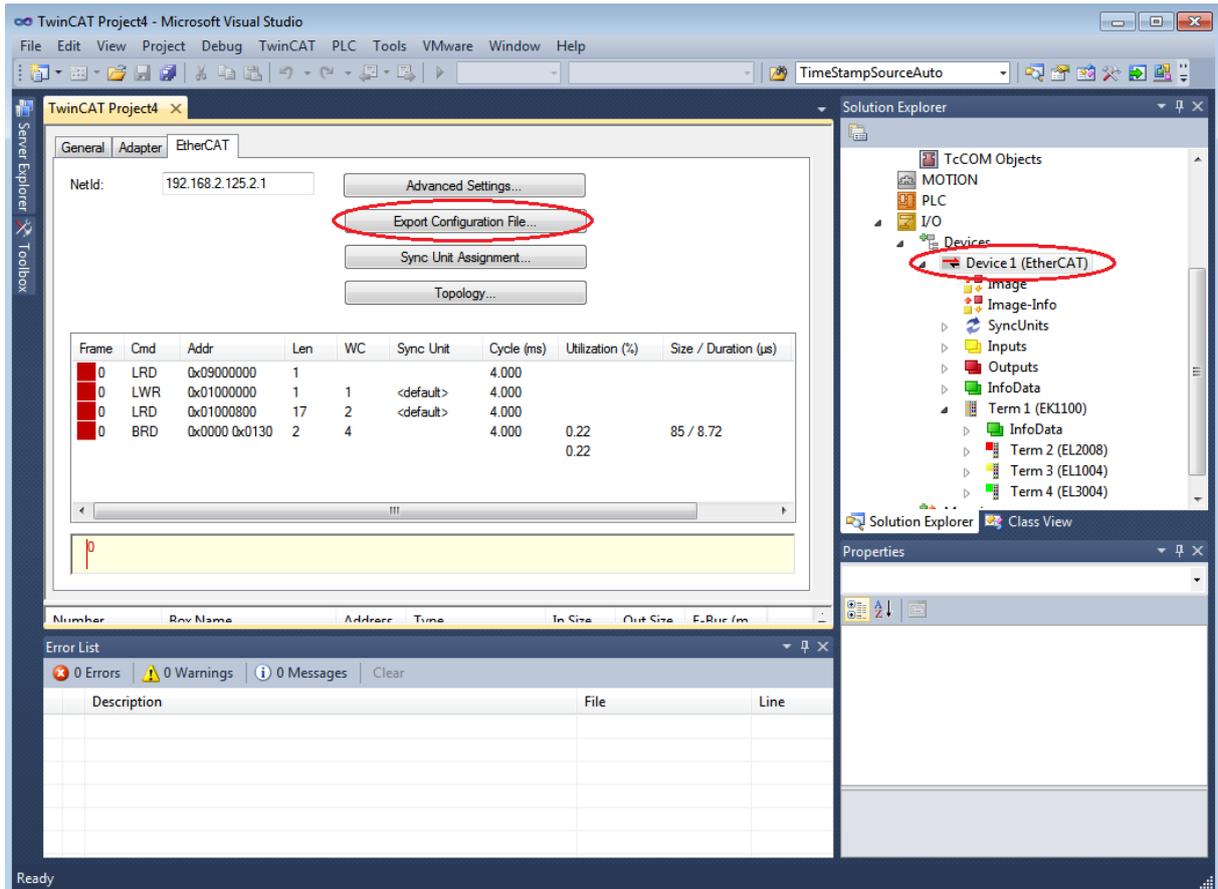
More complex systems can be handled with the ENI Creator Library.

See the examples in "..\examples\EtherCAT Acquisition\ ENI Creation Library"

6.2 Creation with TwinCAT

ENI files can be created in TwinCAT System Manager. The EtherCAT Topology can be entered manually or by bus scan. The export function located in the EtherCAT tab. The exported XML file is the ENI file.

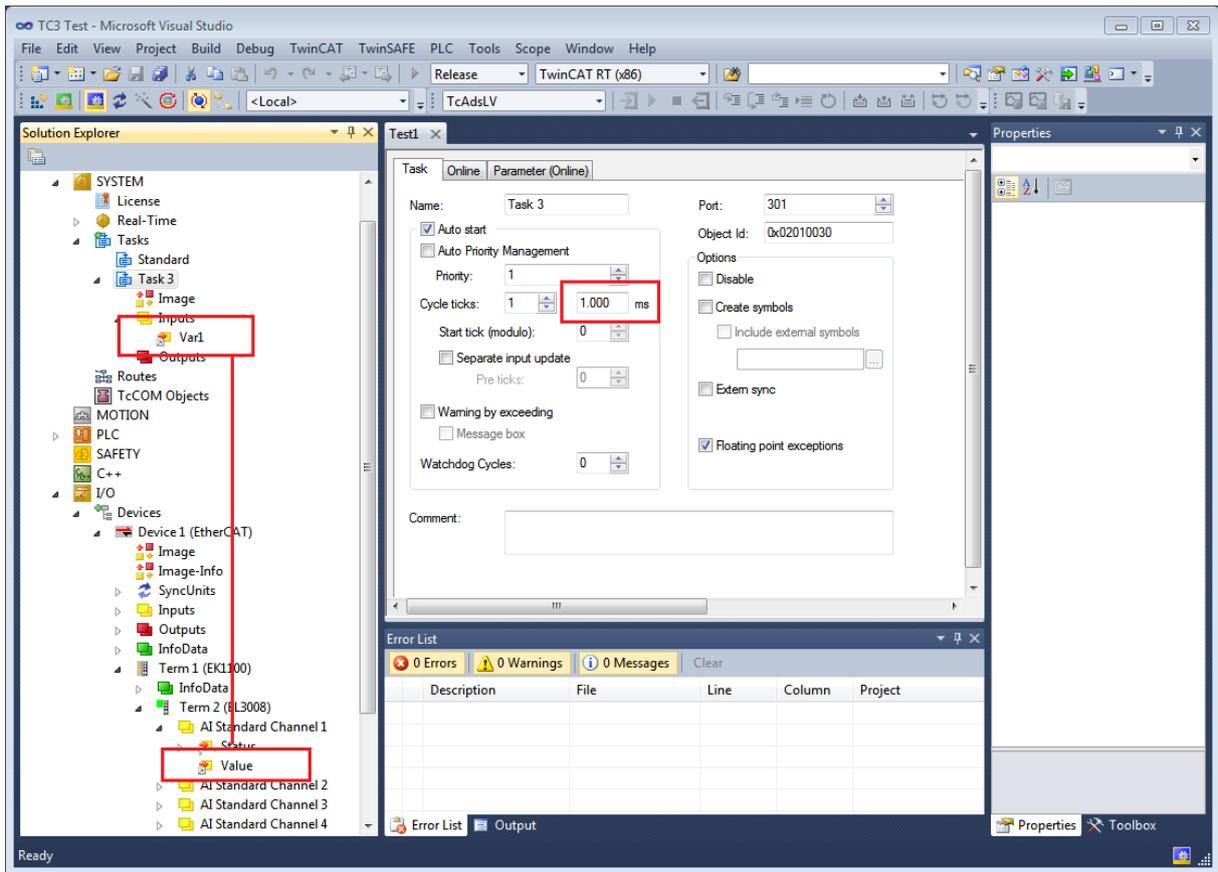
TwinCAT 2.x or 3.x can be used. The TwinCAT System Manager comes with the free TwinCAT CP installation.



If Distributed Clocks is used, it is important to have the bus cycle time information in the setup. For this an IO Task has to be connected to the EtherCAT Master.

Proceed as follows:

1. Create an IO task with image
2. Enter the cycle time that is going to be used with LabVIEW
3. Make a connection between IO task and EtherCAT Master by linking one variable from the IO task with one variable in the EtherCAT system.



6.3 Creation with EC Engineer

The EC Engineer software allows the ENI file creation as well as bus diagnosis.

The software works with any network adapter including USB network adapters. Make sure a standard IP address is set for the adapter (No DHCP).

Switch the view to "Expert", to have the full set of functionality.

EC-Engineer [D:\Temp\config.ecc]

File View Settings Help

Configuration Mode Export ENI Diagnosis Mode

EtherCAT Network-Editor

- Bus (Class-A Master)
 - Slave_001 [EK1100] (0001)
 - Slave_002 [EL2008] (0002)
 - Slave_003 [EL2008] (0003)
 - Slave_004 [EL1008] (0004)
 - Slave_005 [EL1008] (0005)
 - Slave_006 [EL4132] (0006)
 - Slave_007 [EL3162] (0007)
 - Slave_008 [EK1122-0080] (0008)
 - Slave_009 [VIPA 053-1EC00] (0009)
 - 001 : Terminals [032-1BB30]
 - 002 : Terminals [022-1BB20]
 - 003 : Terminals [040-1CA00]
 - 004 : Terminals [050-1BA00]
 - f, Axis 1 (0010)
 - f, Axis 2 (0011)
 - f, Axis 3 (0012)
 - f, Axis 4 (0013)

General Variables Groups Advanced Options

Fixed Process Image Offset

Input Offset = Output Offset

Offset (Byte)

Output Offset (Byte)

Hot-Connect Group-Settings

Identification Value:

Identification Offset: 0x0012

Fixed Position in Topology

Previous slave:

Classic View Flat View

Short Info

Information

Name

Description

Vendor

Messages

Severity	Time	Message
INF	08:17:06	Configuration saved to D:\Temp\config.ecc
INF	08:07:29	EC-Engineer ready. Version 0.9.9

Master/Bus: 1 | Slaves: 17 | Mode: CONFIG | EXPERT

7 Licensing

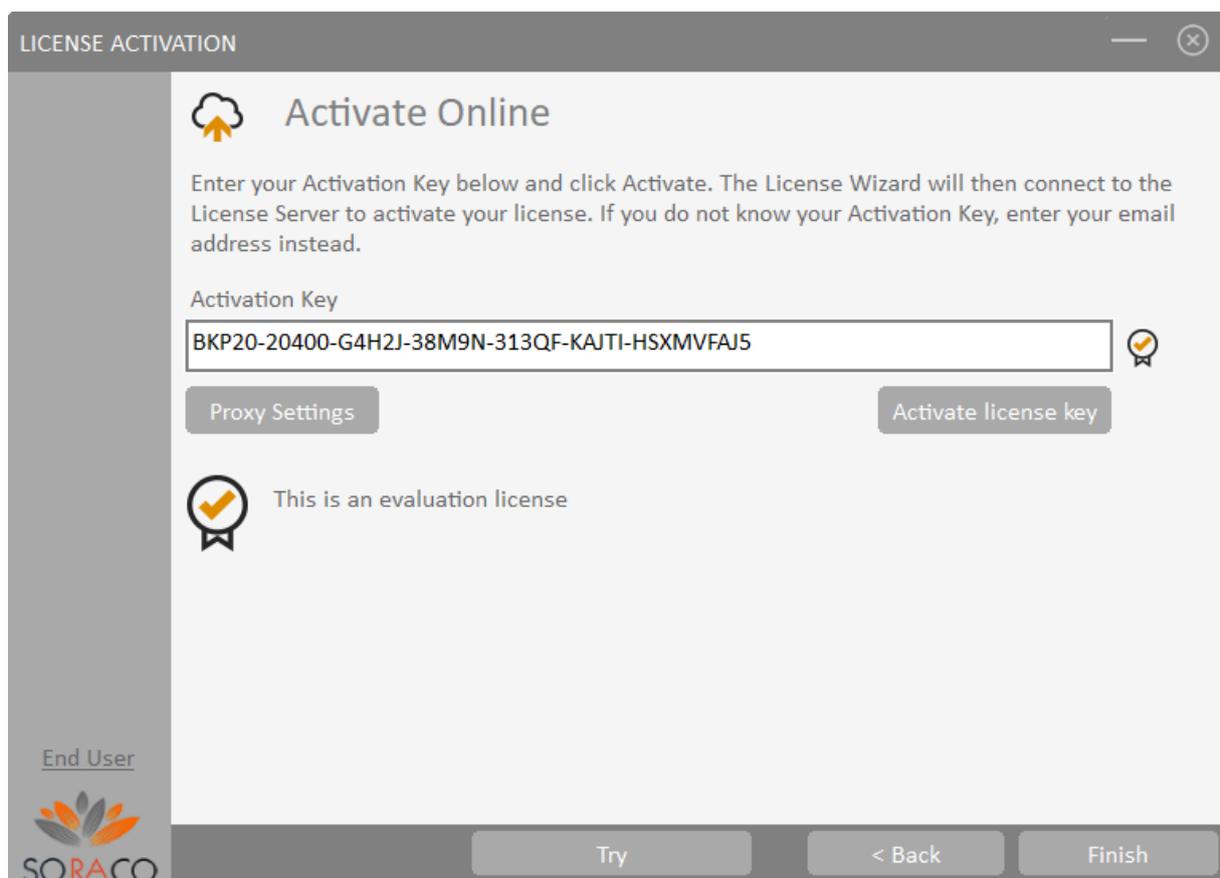
Licensing of the EtherCAT Library is done in form of run-time licenses. There is no difference made between LabVIEW Development System or LabVIEW Run-Time system. There are no development licenses. Activation of a license can be done using the license server or by using a USB dongle.

7.1 License Server

If the license server is used, the activation and deactivation can be done online and offline.

For online activation open the License Activation Dialog from the start menu (EtherCAT Library LabVIEW) and enter your activation key. You will receive the activation key when purchasing a license. For a 30 days trial license use the “Try” button or go to:

<https://qlm2.net/ackermann-automation/qlmcustomersite/QLmRegistrationForm.aspx>



For offline activation go to:

QLM Self Help: <https://qlm2.net/ackermann-automation/qlmcustomersite>

Here you can get an activation key for your offline computer.

7.2 USB Dongle

If a USB dongle is used, the license is active, when the dongle is plugged into the PC. This gives more flexibility to use a license on multiple systems like development PC and target PC. Also it can reduce down-times of production systems, if a PC has to be changed.

8 Getting Started

There are different tutorial videos available on the product page.

Then the best way to get started is testing and understanding the examples.

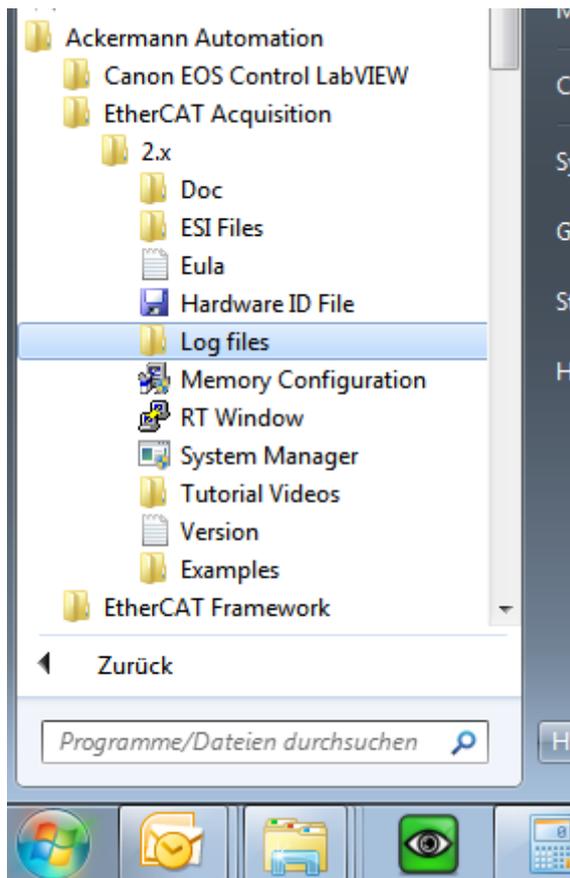
The examples can be found in:

...\Program files\National Instruments\LabVIEW xx\examples\Ackermann Automation\EtherCAT Acquisition

9 Troubleshooting

9.1 Log Files

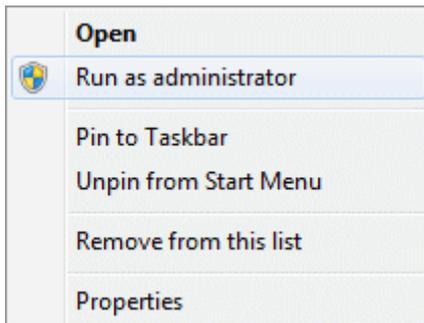
If a support request is sent to support@ackermann-automation.de, please include the log files. These can be found here:



9.2 Administrator Rights

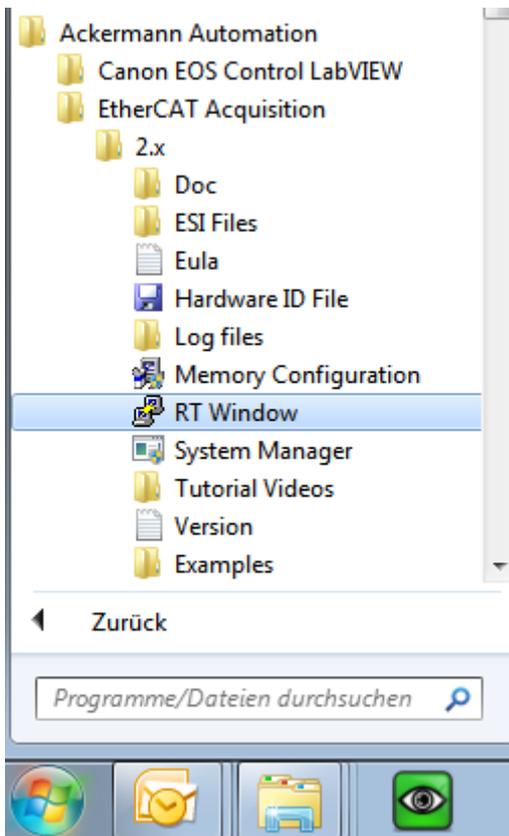
In some cases the system settings or registry keys have to be adjusted by the real-time environment. This requires usually administrator rights. If a error message is received, that says systems settings or registry keys need to be accessed, it is necessary to start the LabVIEW.exe or the LabVIEW executable with administrator rights using the right mouse click.

This has to be done only once.



9.3 Real-Time Window

As the EtherCAT Master runs in a real-time environment, it has its own separate execution system. The RT Window shows the status output of the EtherCAT Master execution. Some error cases require to analyze this status output.



9.4 Windows requires a digitally signed driver

The real-time driver components have digitally signed drivers, which require SHA-256 encryption. This is not included in Windows 7 and has to be added using Windows updates. So before installing the real-time driver a full Windows update is recommended.

9.5 Windows not booting after installation real-time driver

In really rare cases, it is possible, that after installation of the real-time driver Windows does not boot anymore. In this case, do the following steps

- In boot menu go to command line through repair options
- execute command: „ren c:\Windows\System32\Drivers\rtosdrv.sys rtosdrv_org.sys“
- execute command: „bcdedit /deletevalue {default} badmemorylist“
- execute command: „bcdedit /deletevalue {default} firstmegabytepolicy“
- execute command: “exit”

The lines are entered without quotation marks (“”).

The system should then boot normally again.

10 Support

For support contact:

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