EC-Master Quick Start Guide

Setup an EtherCAT network with acontis products

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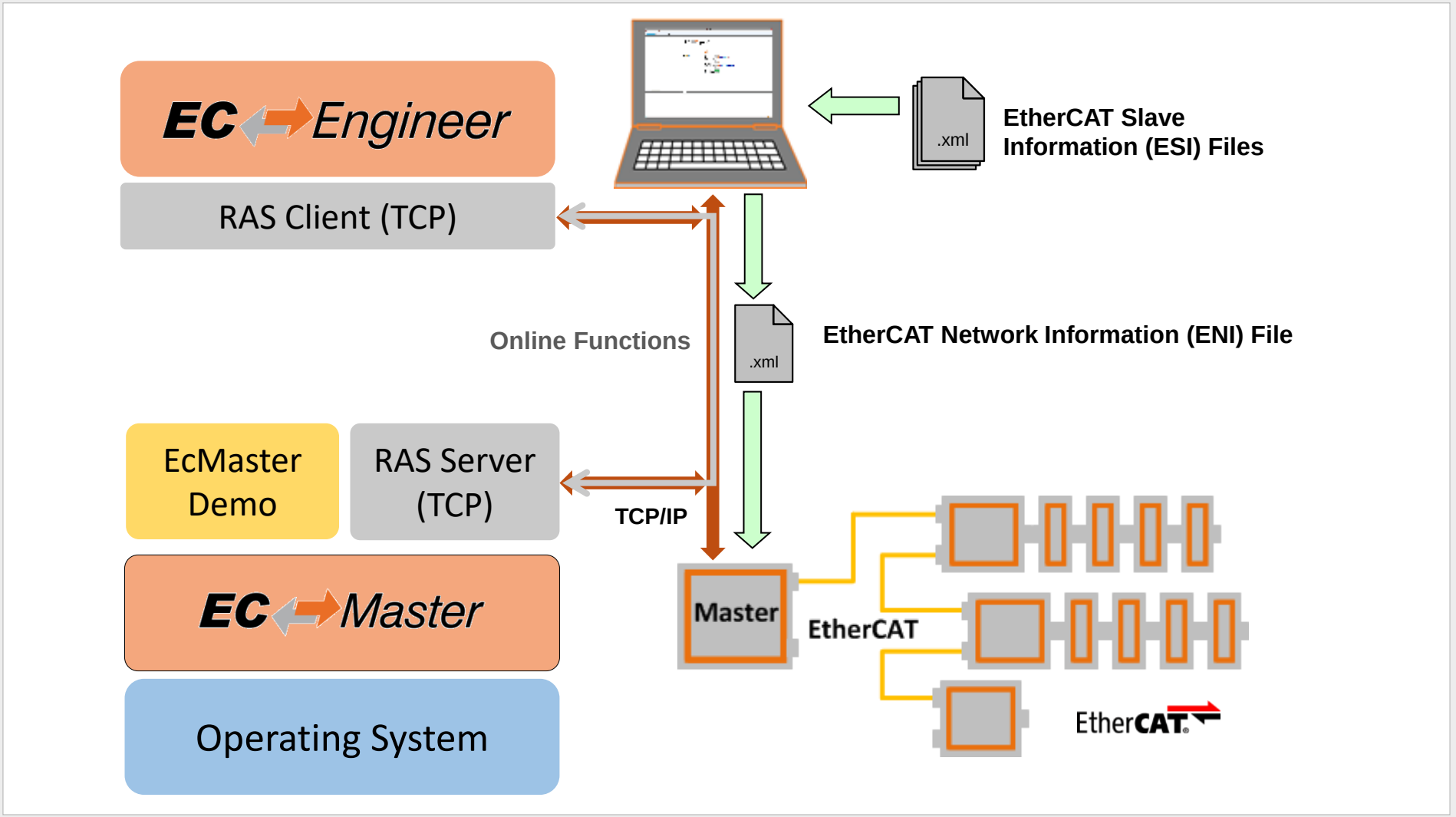
- Install EC-Master
- Run EcMasterDemo without configuration (ENI file)
- Create network configuration with EC-Engineer
- Run EcMasterDemo with configuration (ENI file)
- Online diagnosis of network with EC-Engineer
- EC-Master Application Programming Interface
- EC-Master Demo Application Overview
- Next steps

EtherCAT System Architecture



Install EC-Master

- Install the EC-Master from the compressed file
- Optionally extract add-ons and Real-time Ethernet drivers into the installation folder
- Follow operating system-specific steps described in chapter “Platform and Operating Systems (OS)” of the user manual

Run EcMasterDemo without ENI file

- Connect the EtherCAT slave(s)
- Check which network adapter is used for EtherCAT, e.g. eth1
- Run EcMasterDemo on Windows
  - `cd Bin\Windows\x64`
  - `EcMasterDemo.exe -ndis <ip-address> 1 -v 3 -b 4000`
- Run EcMasterDemo on Linux
  - `cd Bin/Linux/x64`
  - `./EcMasterDemo -sockraw eth1 -v 3 -b 4000`
- Run EcMasterDemo on QNX
  - `ifconfig en1 destroy`
  - `cd Bin/QNX71/x64`
  - `LD_LIBRARY_PATH=. ./EcMasterDemo -i8254x 1 1 -v 3 -b 4000`

For other operating systems, please follow steps described in chapter
“Platform and Operating Systems (OS)” of the user manual

Run EcMasterDemo without ENI file

- Master commands all slaves to PREOP state:

```
0000003094: Line Crossed........: no
0000003094: Line Crossed Flags..: 0x0
0000003094: Cfg Station Address.: 0x03e9 (1001)
0000003094: ***************************************************************************
0000003094: Slave ID............: 0x00000001
0000003094: Bus Index...........: 1
0000003094: Bus AutoInc Address.: 0xffff
0000003094: Bus Station Address.: 0x03ea (1002)
0000003094: Bus Alias Address...: 0x000d (  13)
0000003094: Vendor ID...........: 0x00000002 = Beckhoff Automation GmbH
0000003094: Product Code........: 0x07D43052 = EL2004
0000003094: Revision............: 0x00100000   Serial Number: 0
0000003094: ESC Type............: Beckhoff ET1200 (0x12)  Revision: 0  Build: 2
0000003094: Connection at Port A: yes (to 0x00000000)
0000003094: Connection at Port D: no (to 0xFFFFFFFF)
0000003094: Connection at Port B: no (to 0xFFFFFFFF)
0000003094: Connection at Port C: no (to 0xFFFFFFFF)
0000003094: Line Crossed........: no
0000003094: Line Crossed Flags..: 0x0
0000003094: Cfg Station Address.: 0x03ea (1002)
0000003094: PD OUT   Byte.Bit offset: 0.0   Size: 4 bits
0000003094: ***************************************************************************
0000003101: Master state changed from <UNKNOWN> to <INIT>
0000003127: Master state changed from <INIT> to <PREOP>
```

Generate bus configuration with EC-Engineer

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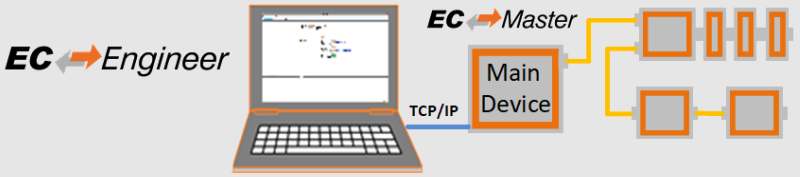
EC-Engineer Operating Modes

Offline
Create network configuration with ESI files

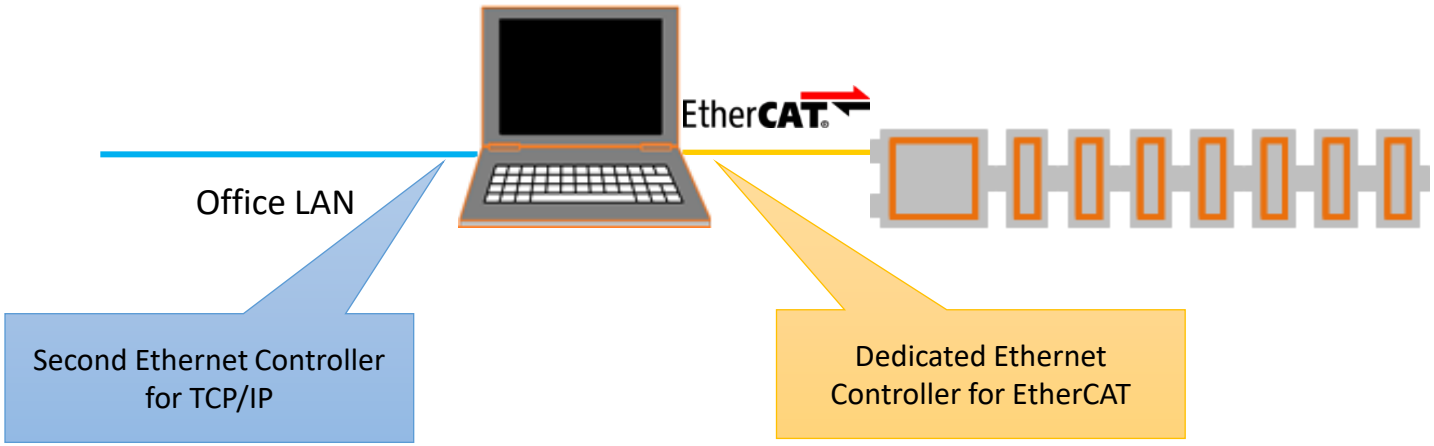
Online Local
Scan network connected to Local system

Online Remote
Scan network connected to Remote system

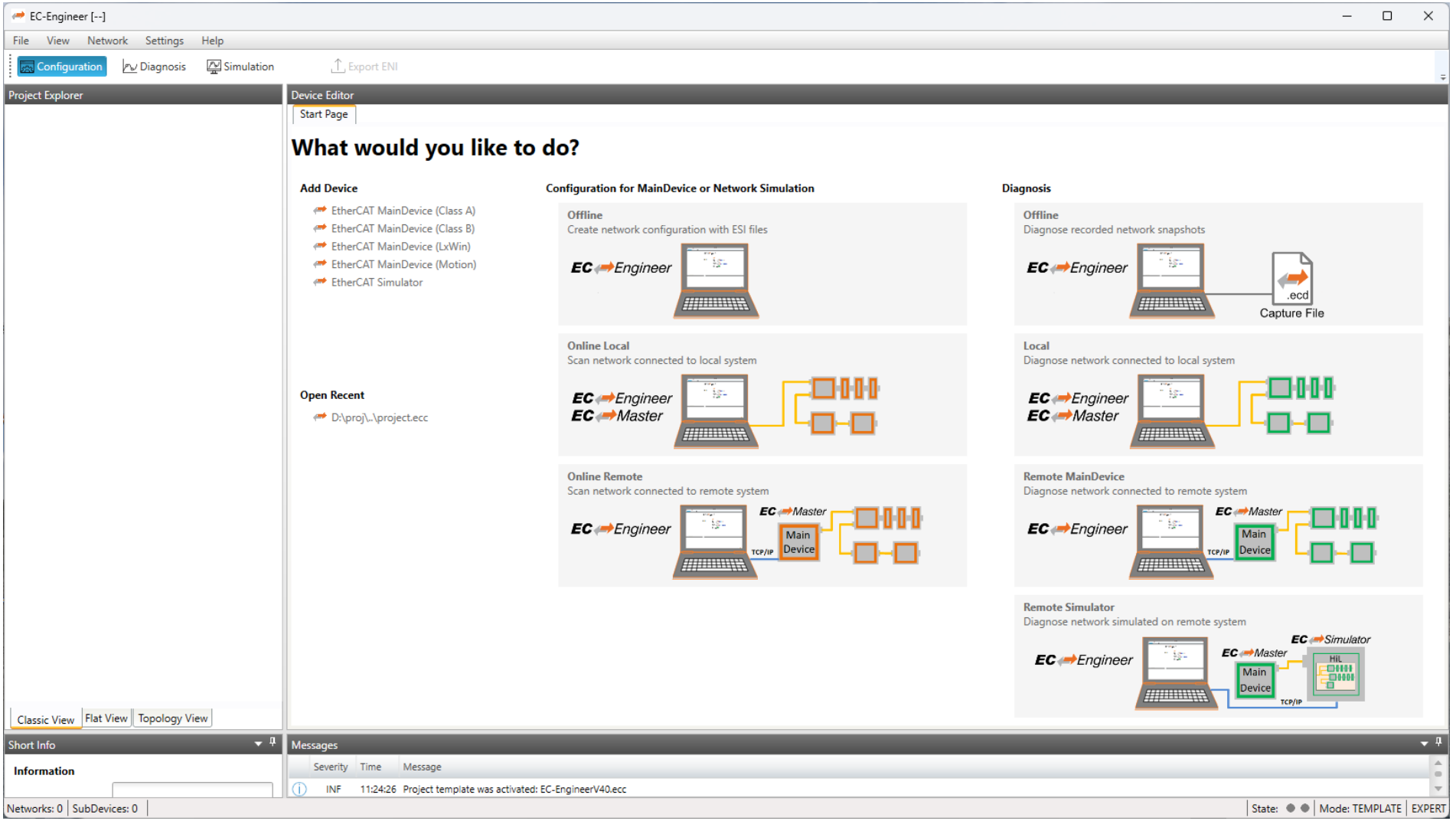


Generate bus configuration with EC-Engineer
Step 1: Connect EtherCAT Slaves

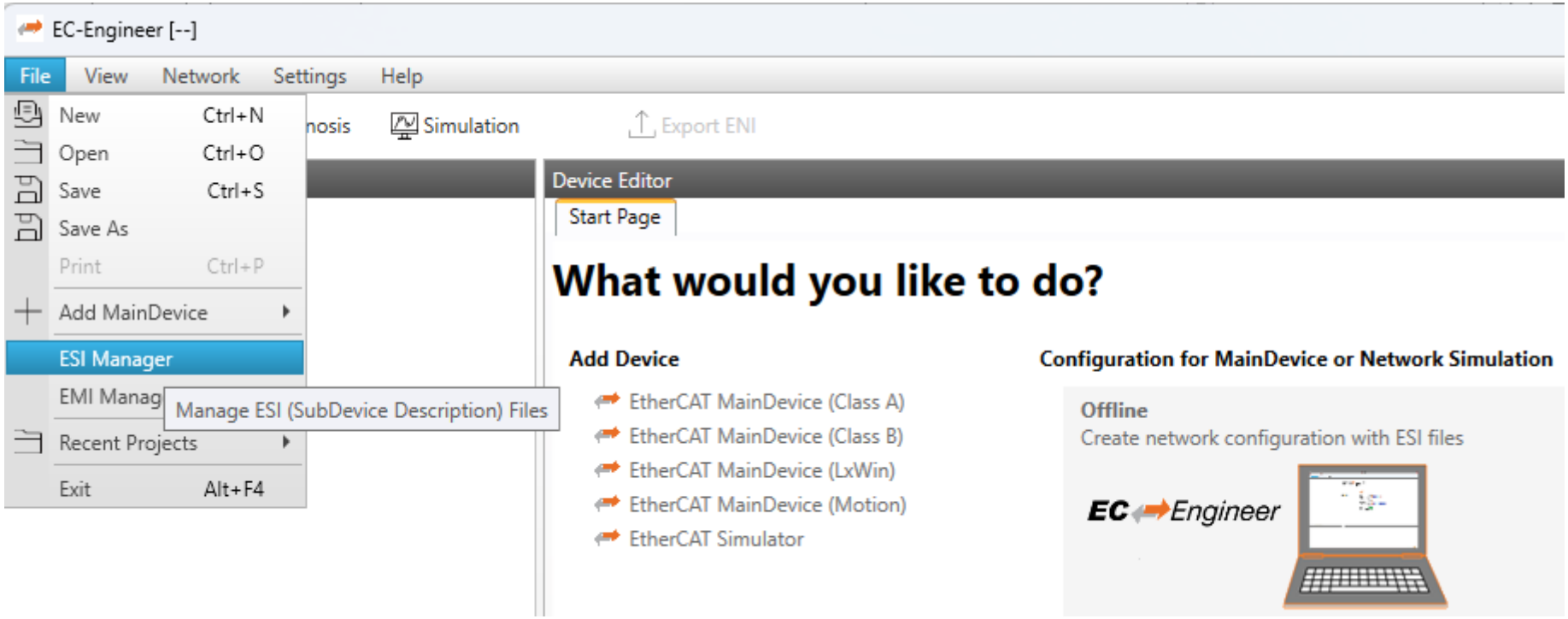
- EC-Engineer comes with an integrated EtherCAT master for scanning the connected EtherCAT slaves
- Every Ethernet Network Interface with a valid Windows driver can be used
- **Warning**: Do not connect any EtherCAT slaves to your Office LAN
- A second, dedicated Network Interface for EtherCAT is recommended



Generate bus configuration with EC-Engineer
Step 2: Install and start EC-Engineer

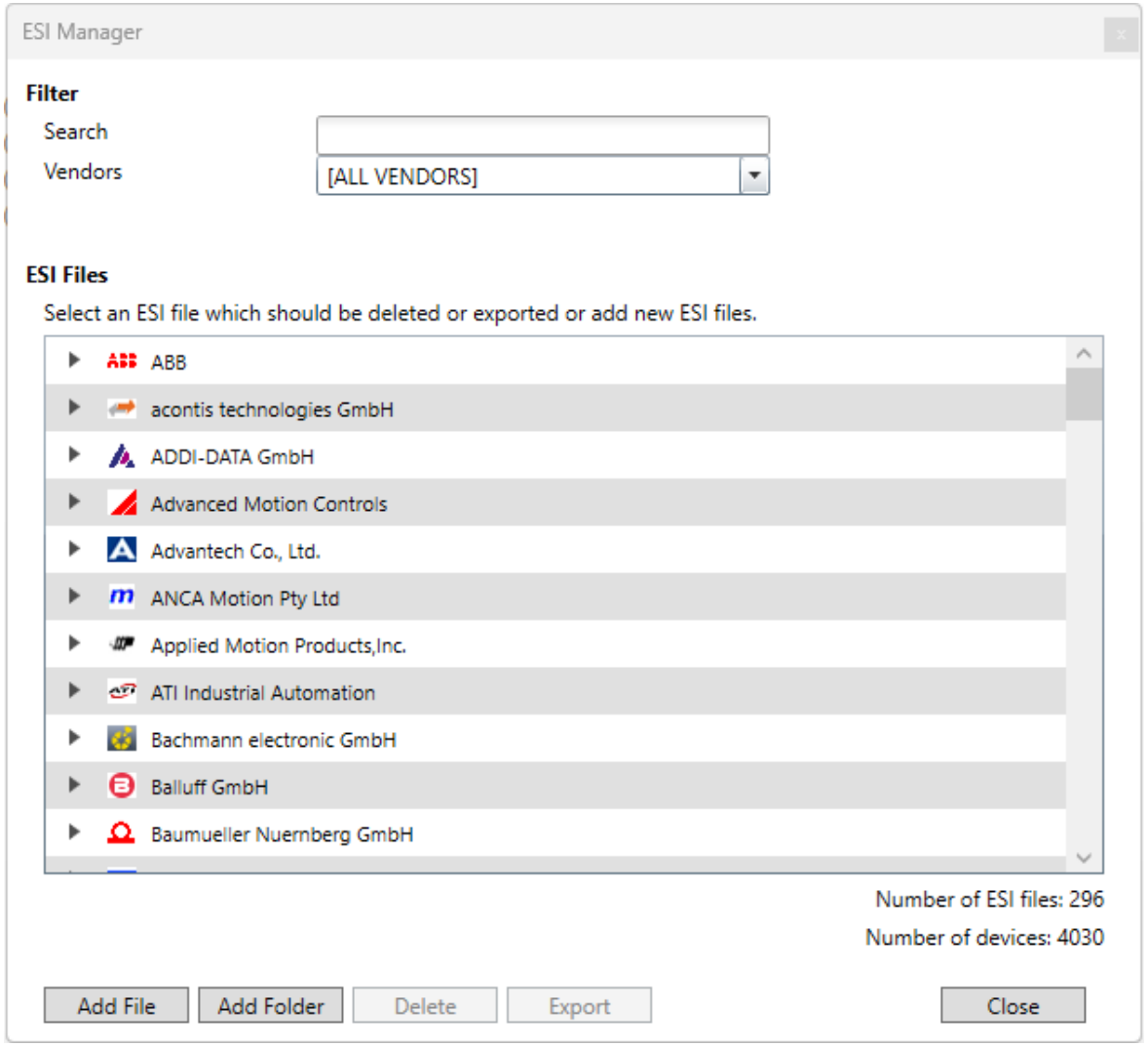


Generate bus configuration with EC-Engineer
Step 3: Open ESI Manager



Generate bus configuration with EC-Engineer
Step 4: Add the appropriate ESI File

EC Engineer



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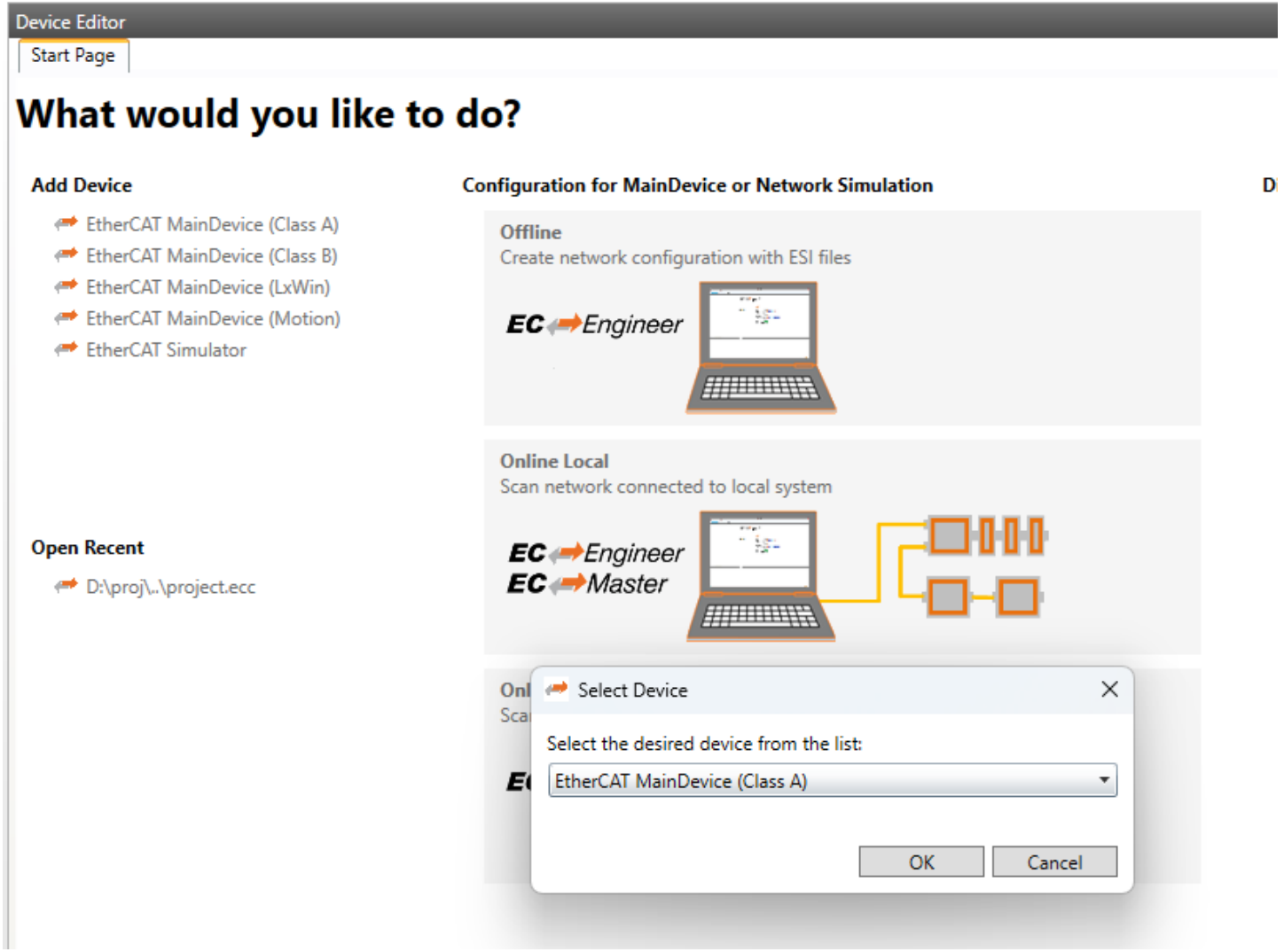
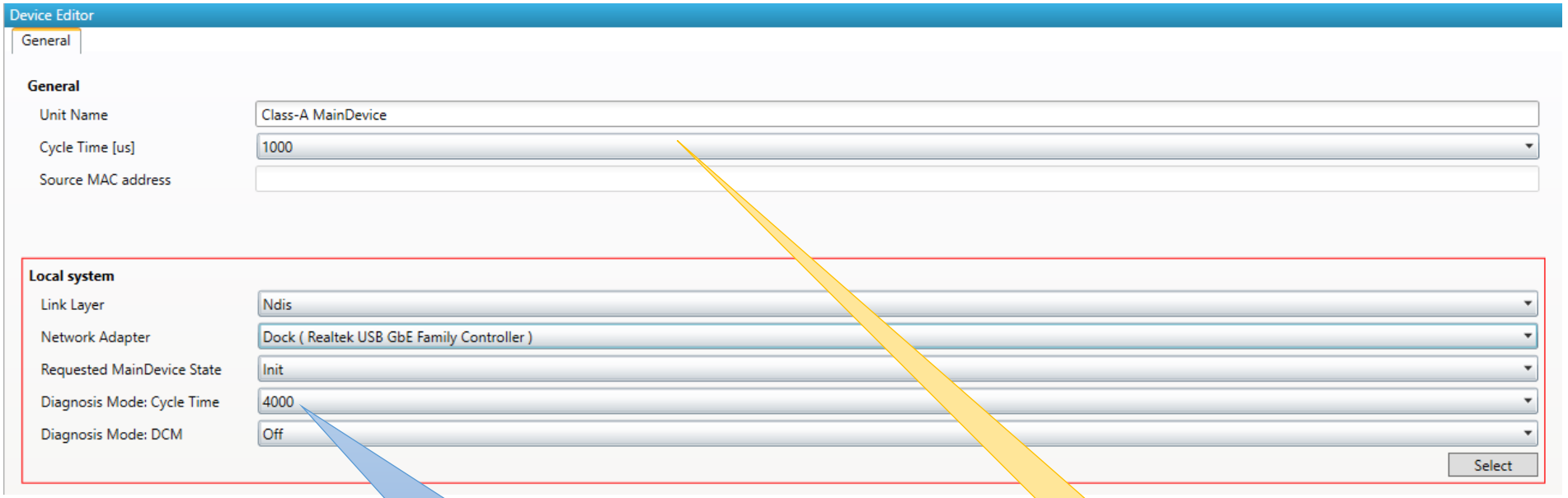
Generate bus configuration with EC-Engineer
Step 5: Select “Online Configuration” and “EtherCAT Master Unit (Class A)”



Generate bus configuration with EC-Engineer
Step 6: Select a Cycle Time of 4000 us

EC Engineer



Define Cycle Time for integrated EC-Master

Define Cycle Time for EC-Master controller

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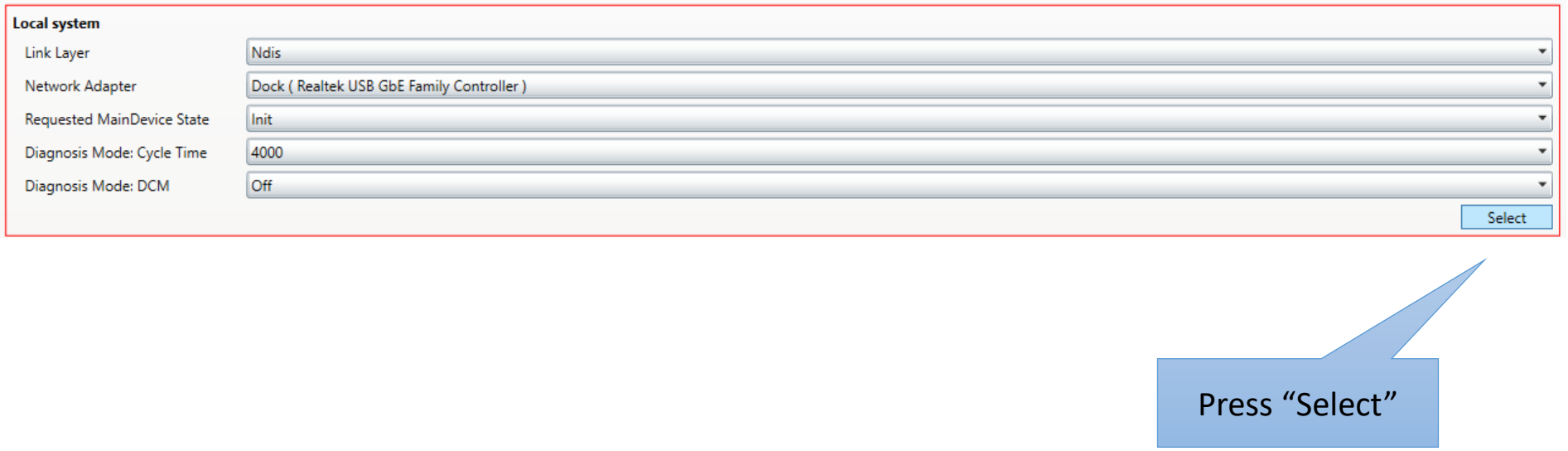
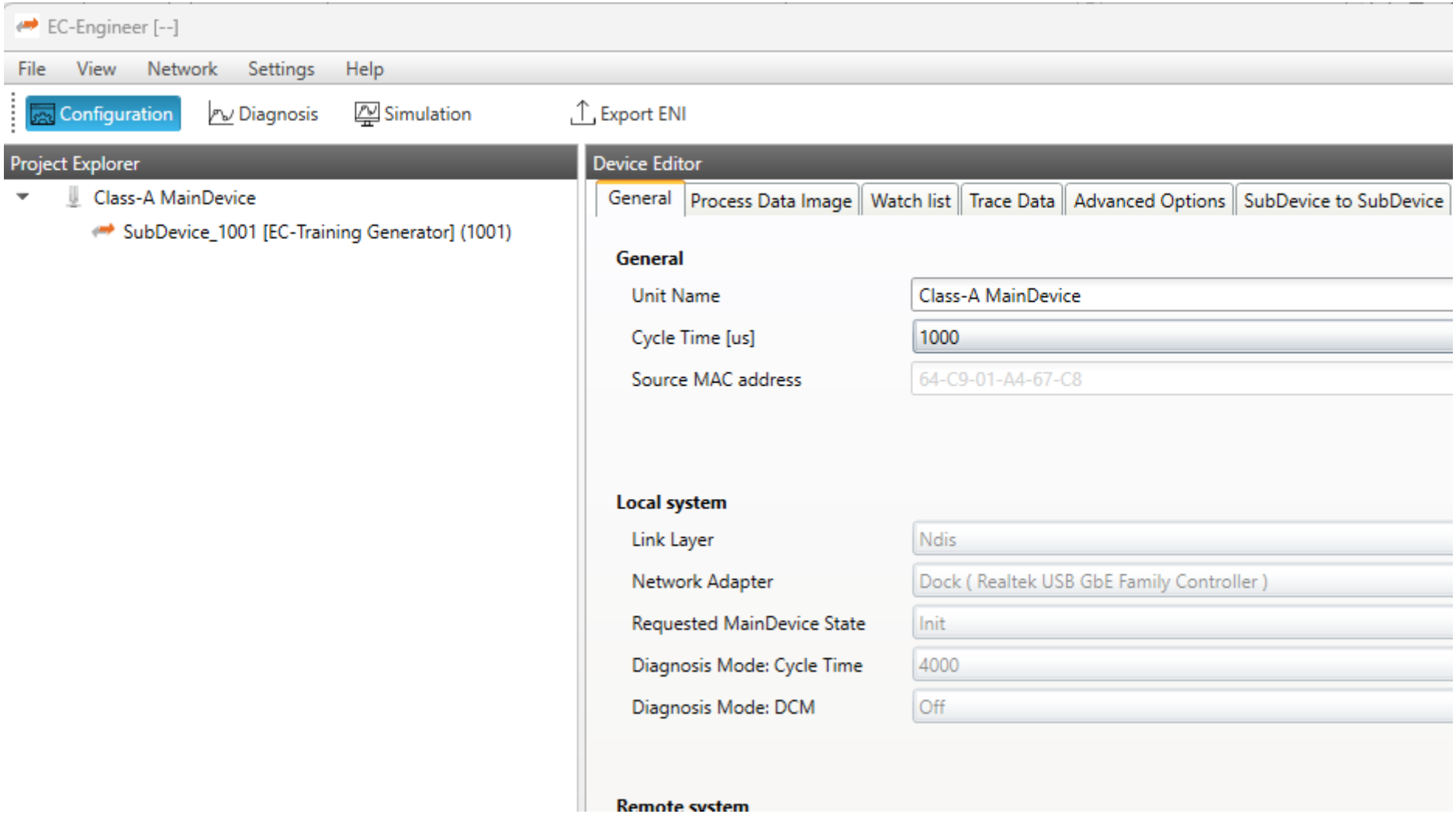
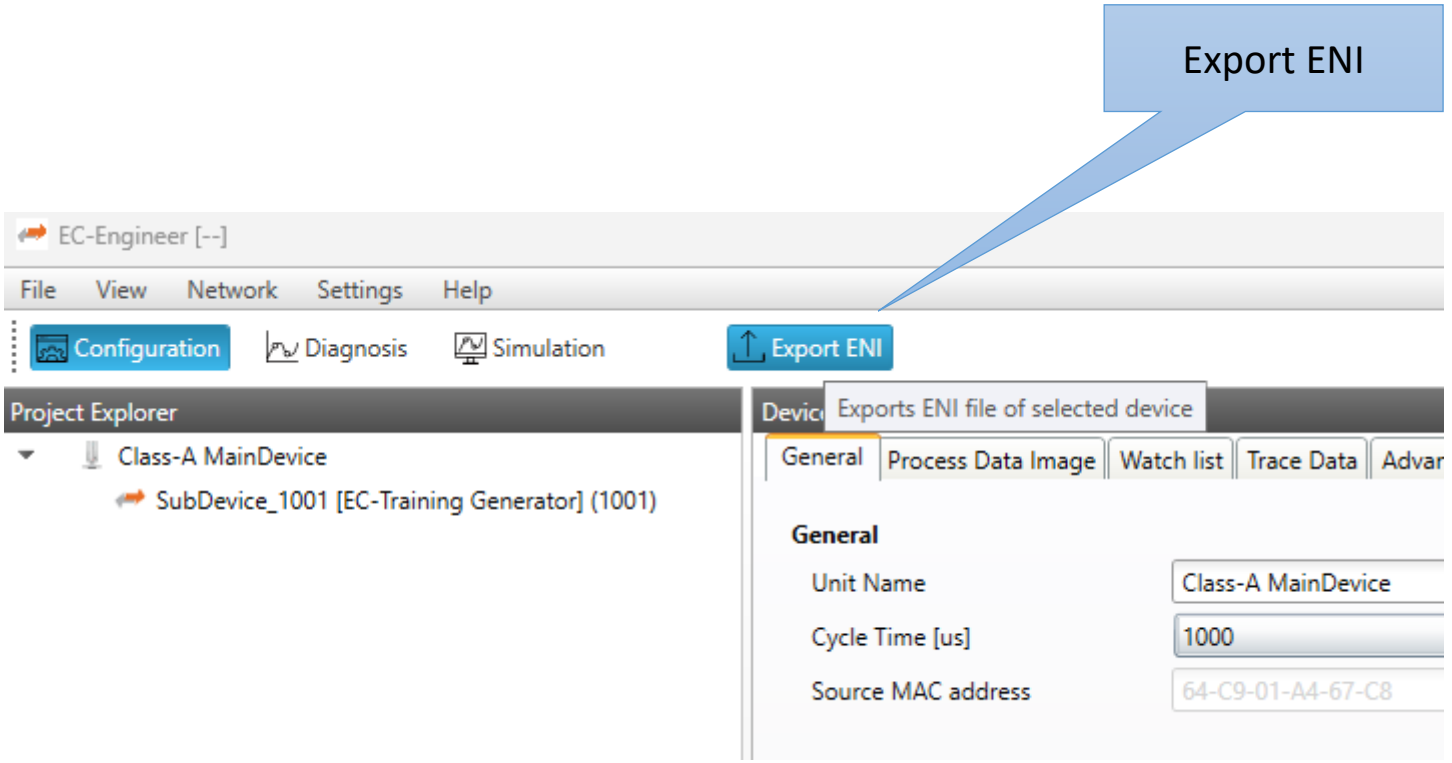
Generate bus configuration with EC-Engineer
Step 7: Choose network adapter from list and press “Select”



Generate bus configuration with EC-Engineer
Step 8: The found slave devices are listed in the tree



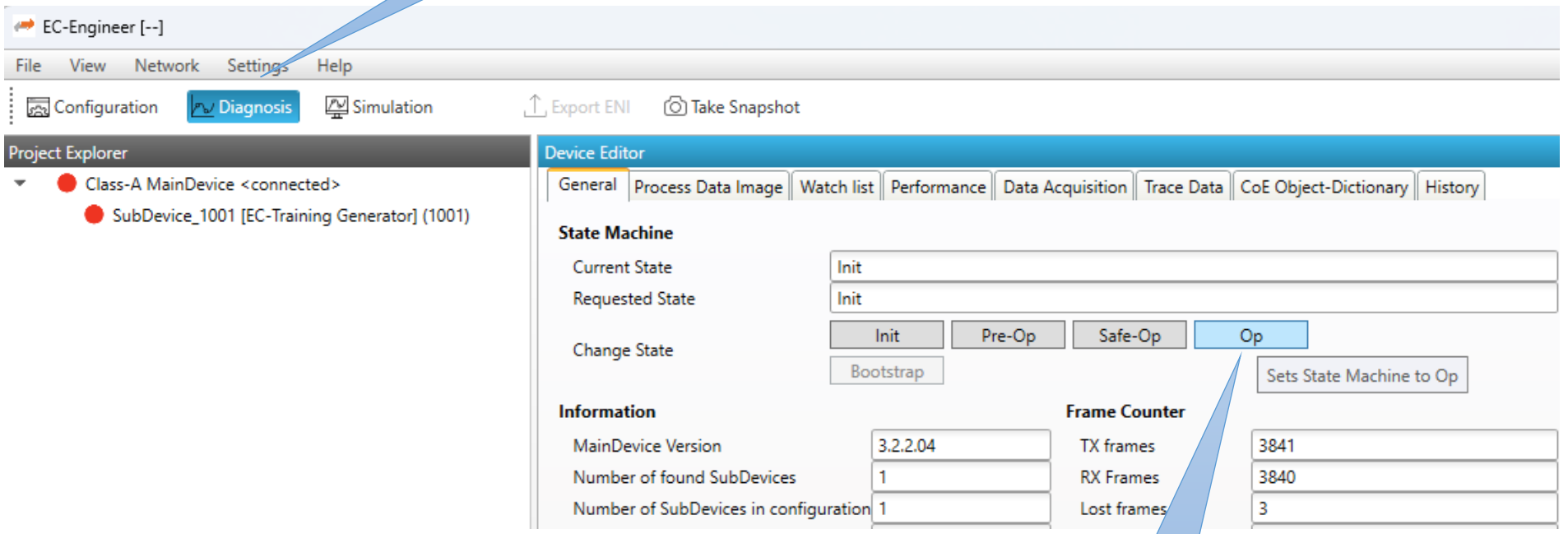
Generate bus configuration with EC-Engineer
Step 9: Export ENI file to, e.g., *D:\eni.xml*



Generate bus configuration with EC-Engineer
Step 10: Switch to “Diagnosis Mode” and set state to OPERATIONAL

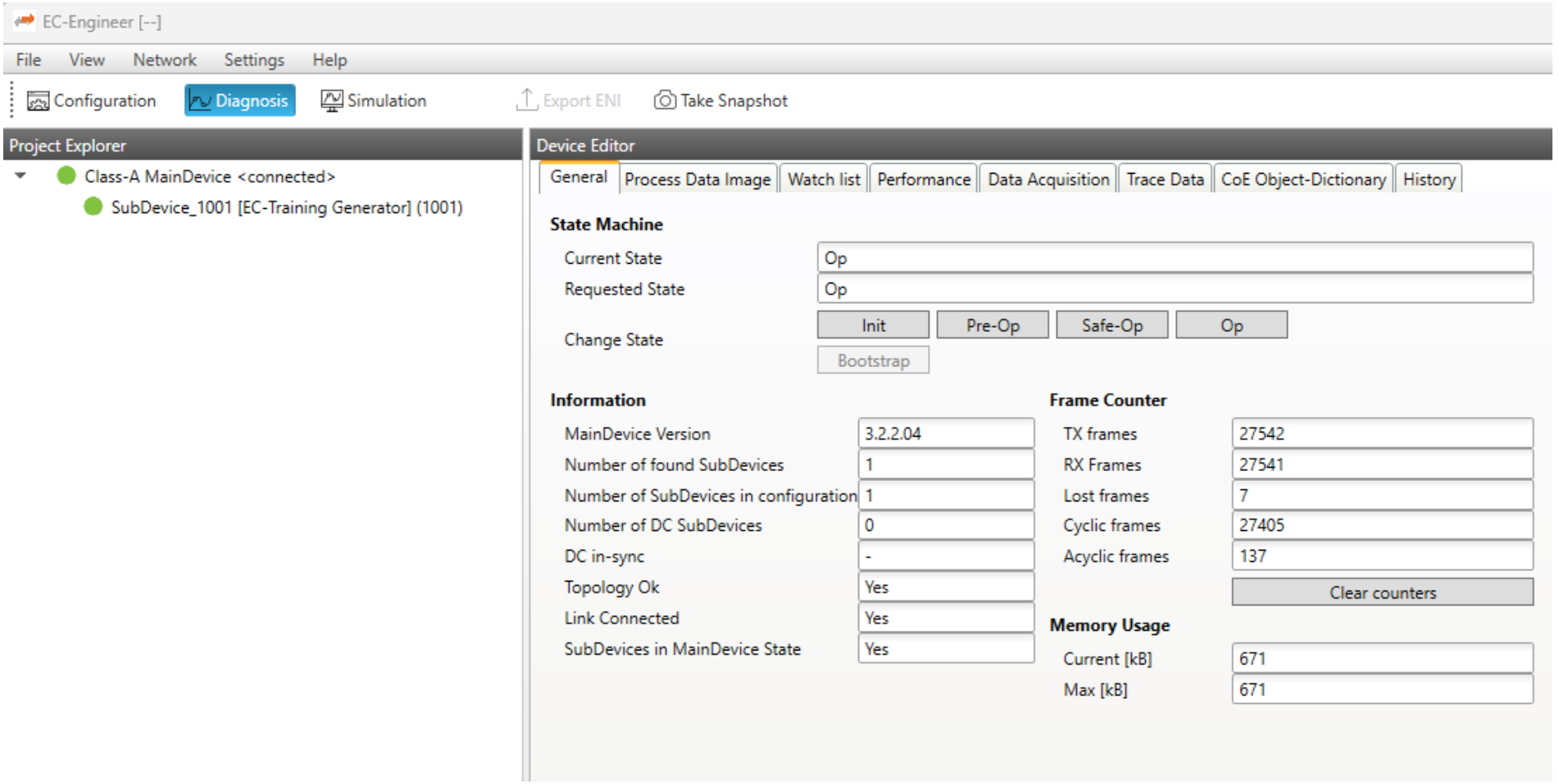
EC Engineer

Switch to “Diagnosis Mode”

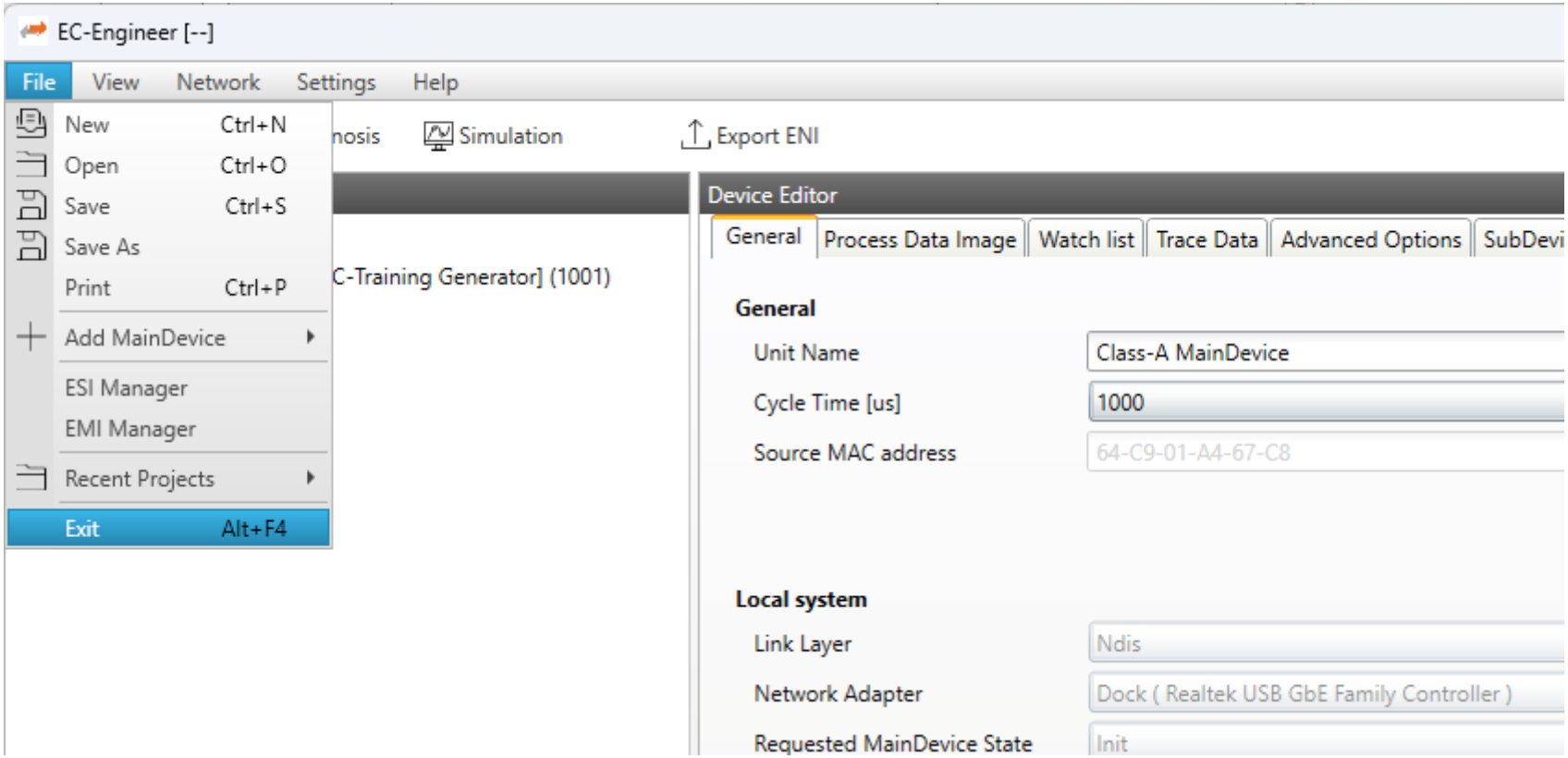


Set state to OPERATIONAL

Generate bus configuration with EC-Engineer
Step 11: Network is OPERATIONAL



Generate bus configuration with EC-Engineer
Step 12: Switch back to “Configuration Mode” and Exit



Run EcMasterDemo with ENI file

- Transfer ENI to target device (if not Windows)
- Append ENI path, e.g. *-f D:\eni.xml* to Command Line Parameters
- Master commands all slaves to OP state:

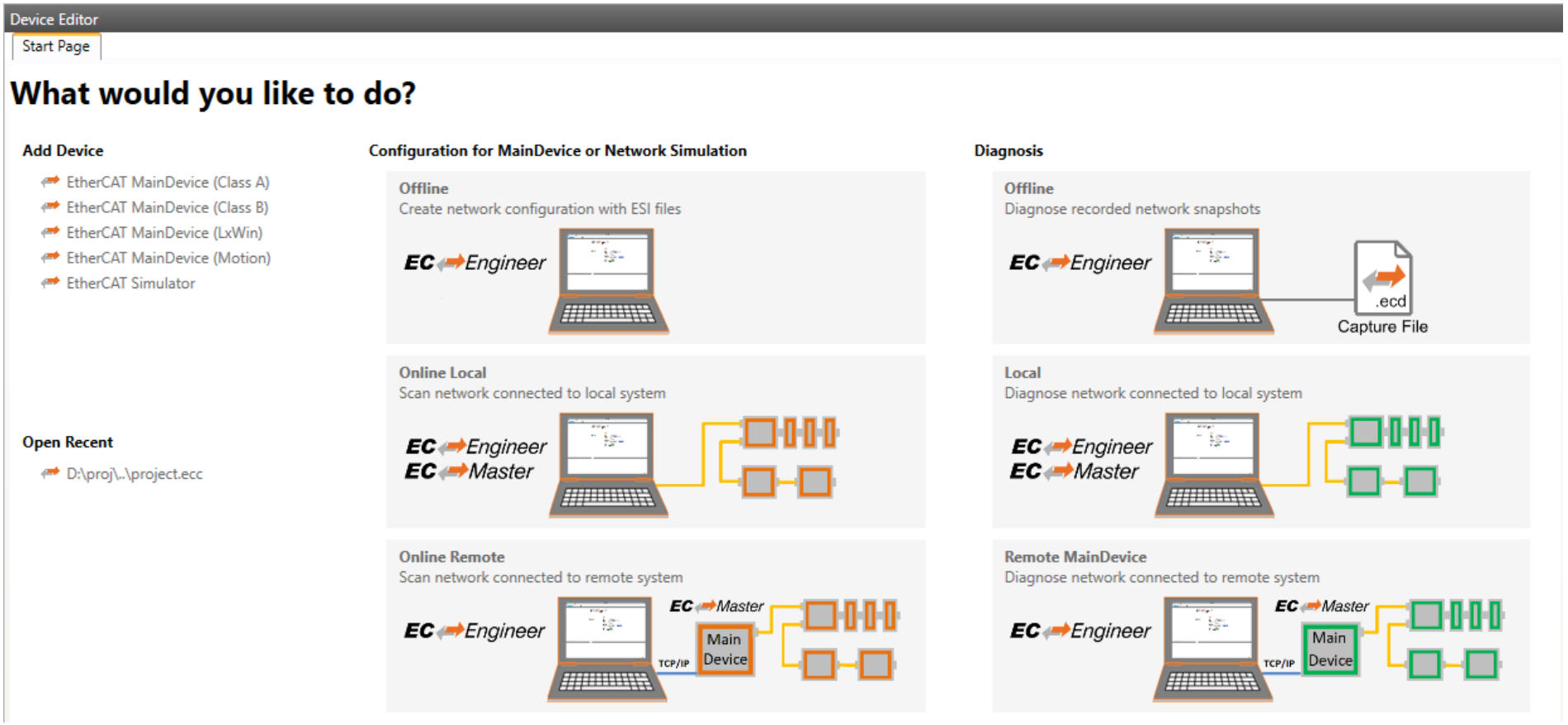
```
0000000182: Bus scan successful - 1 slaves found
0000000185: ***************************************************************************
0000000185: Slave ID.............: 0x00000000
0000000185: Bus Index............: 0
0000000185: Bus AutoInc Address.: 0x0000 (   0)
0000000185: Bus Station Address.: 0x03e9 (1001)
0000000185: Bus Alias Address...: 0x0000 (   0)
0000000185: Vendor ID............: 0x00004154 = acontis technologies GmbH
0000000185: Product Code.........: 0x00000101 = Unknown
0000000185: Revision.............: 0x00000000   Serial Number: 0
0000000185: ESC Type.............: Infineon (0x98)  Revision: 1  Build: 1
0000000185: Connection at Port A: yes (to 0x00010000)
0000000185: Connection at Port D: no (to 0xFFFFFFFF)
0000000185: Connection at Port B: no (to 0xFFFFFFFF)
0000000185: Connection at Port C: no (to 0xFFFFFFFF)
0000000185: Line Crossed.........: no
0000000185: Line Crossed Flags..: 0x0
0000000185: Cfg Station Address.: 0x03e9 (1001)
0000000185: PD IN    Byte.Bit offset: 0.0   Size: 72 bits (MSU  0)
0000000185: PD OUT   Byte.Bit offset: 0.0   Size: 72 bits (MSU  0)
0000000185: ***************************************************************************
0000000217: Master state changed from <UNKNOWN> to <INIT>
0000000361: Master state changed from <INIT> to <PREOP>
0000000471: Master state changed from <PREOP> to <SAFEOP>
0000000520: Master state changed from <SAFEOP> to <OP>
0000000525: EcMasterDemo will stop in 600s...
```

Online diagnosis of network with EC-Engineer
Step 1: Start EcMasterDemo

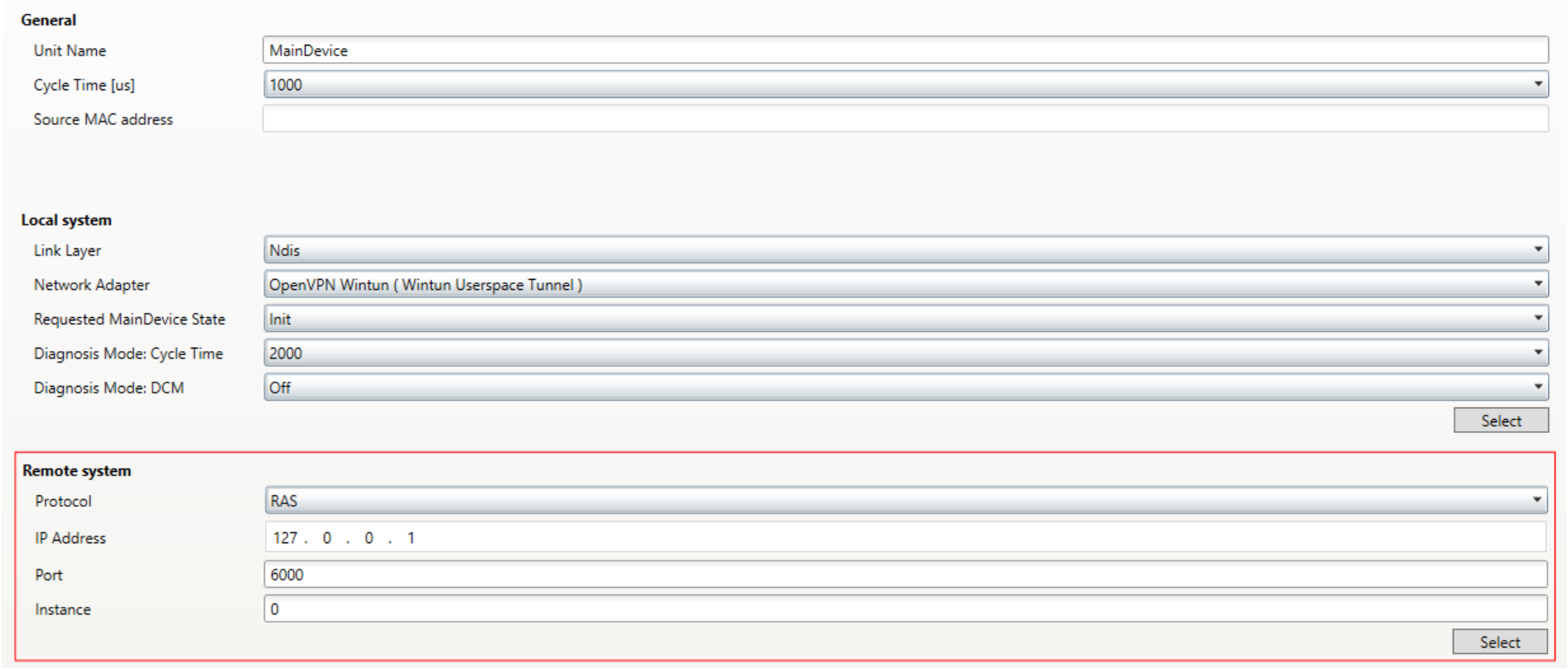
- Append *-sp* to Command Line Parameters
- Start EcMasterDemo

```
0000000019: emllNdis(\DEVICE\{866DDD08-2B16-4778-84F7-D985180E2DA6}): Ecat Ndis Driver Version 3.1.3.4
0000000019: EtherCAT network adapter MAC: 00-1B-21-AB-D1-93
0000000072: Protected version, stop sending ethernet frames after 60 minutes if not licensed!
0000001966: Bus scan successful - 1 slaves found
0000001992: ***************************************************************************
0000001992: Slave ID.............: 0x00000000
0000001992: Bus Index............: 0
0000001992: Bus AutoInc Address.: 0x0000 (   0)
0000001992: Bus Station Address.: 0x03e9 (1001)
0000001992: Bus Alias Address...: 0x0000 (   0)
0000001992: Vendor ID............: 0x00004154 = acontis technologies GmbH
0000001992: Product Code.........: 0x00000101 = Unknown
0000001992: Revision.............: 0x00000000   Serial Number: 0
0000001992: ESC Type.............: Infineon (0x98)  Revision: 1  Build: 1
0000001992: Connection at Port A: yes (to 0x00010000)
0000001992: Connection at Port D: no (to 0xFFFFFFFF)
0000001992: Connection at Port B: no (to 0xFFFFFFFF)
0000001992: Connection at Port C: no (to 0xFFFFFFFF)
0000001992: Line Crossed.........: no
0000001992: Line Crossed Flags..: 0x0
0000001992: Cfg Station Address.: 0x03e9 (1001)
0000001992: PD IN    Byte.Bit offset: 0.0   Size: 72 bits (MSU  0)
0000001992: PD OUT   Byte.Bit offset: 0.0   Size: 72 bits (MSU  0)
0000001992: ***************************************************************************
0000002250: Master state changed from <UNKNOWN> to <INIT>
0000003433: Master state changed from <INIT> to <PREOP>
0000004331: Master state changed from <PREOP> to <SAFEOP>
0000004739: Master state changed from <SAFEOP> to <OP>
0000004761: EcMasterDemo will stop in 600s...
```

Online diagnosis of network with EC-Engineer
Step 2: Start EC-Engineer and select “Diagnosis / Remote MainDevice”

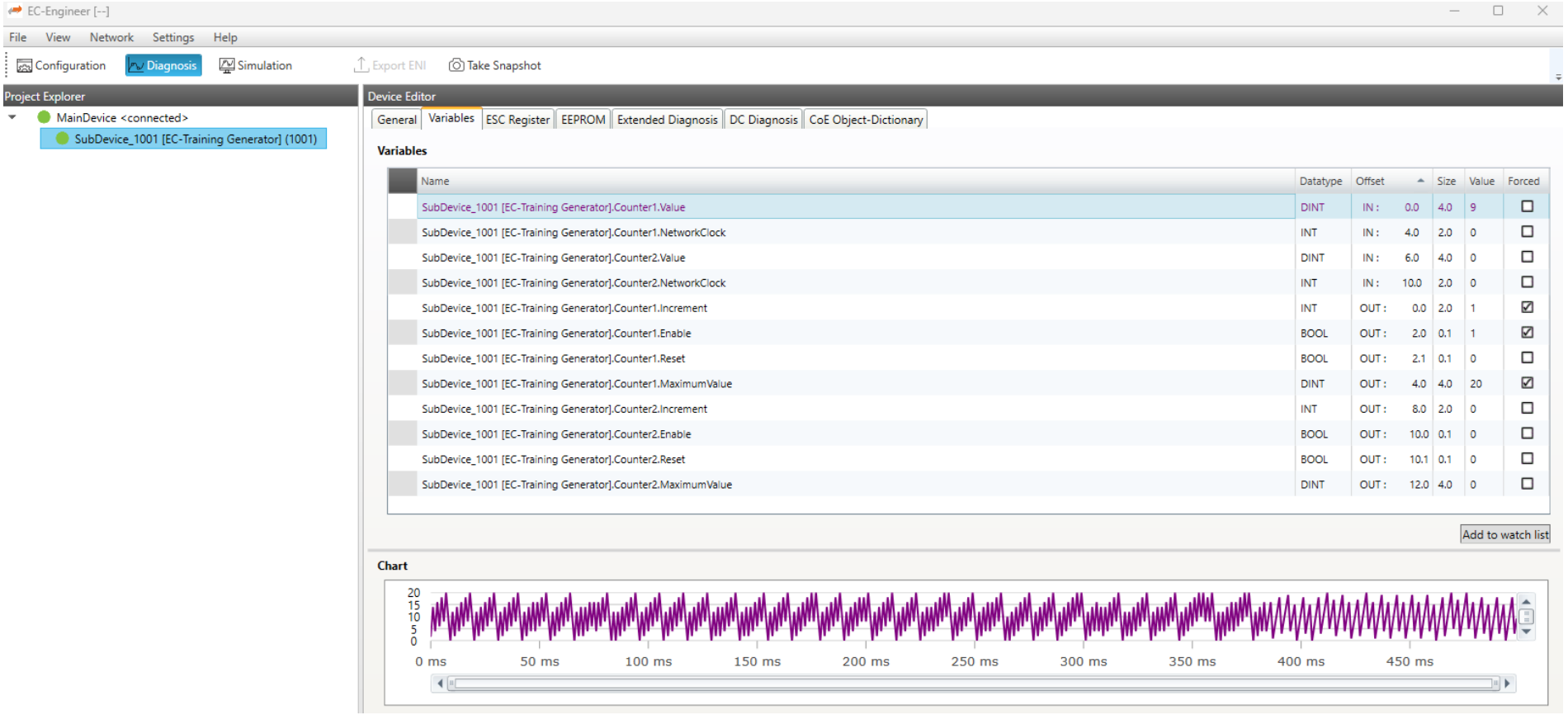


Connect EC-Engineer to EcMasterDemo
Step 3: Set IP address and press “Select”



Press “Select”

Online diagnosis of network with EC-Engineer
Step 4: Select device, check inputs, force outputs, etc.



Test EC-Engineer online functions

- Monitor inputs
- Force outputs
- Slave states
- Change master and/or slave state
- CoE Object Dictionary
- Extended Diagnosis

Application Programming Interfaces

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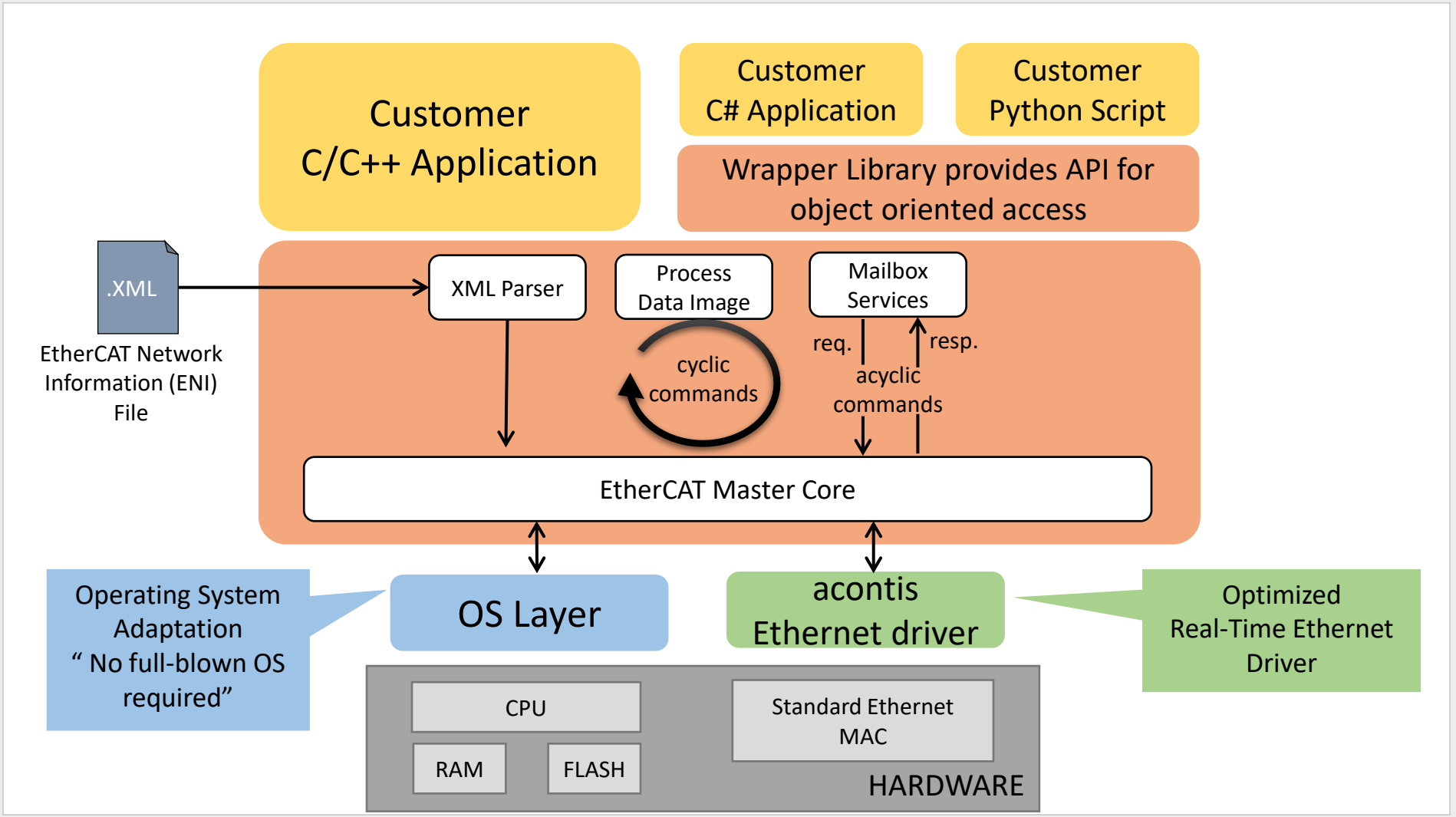
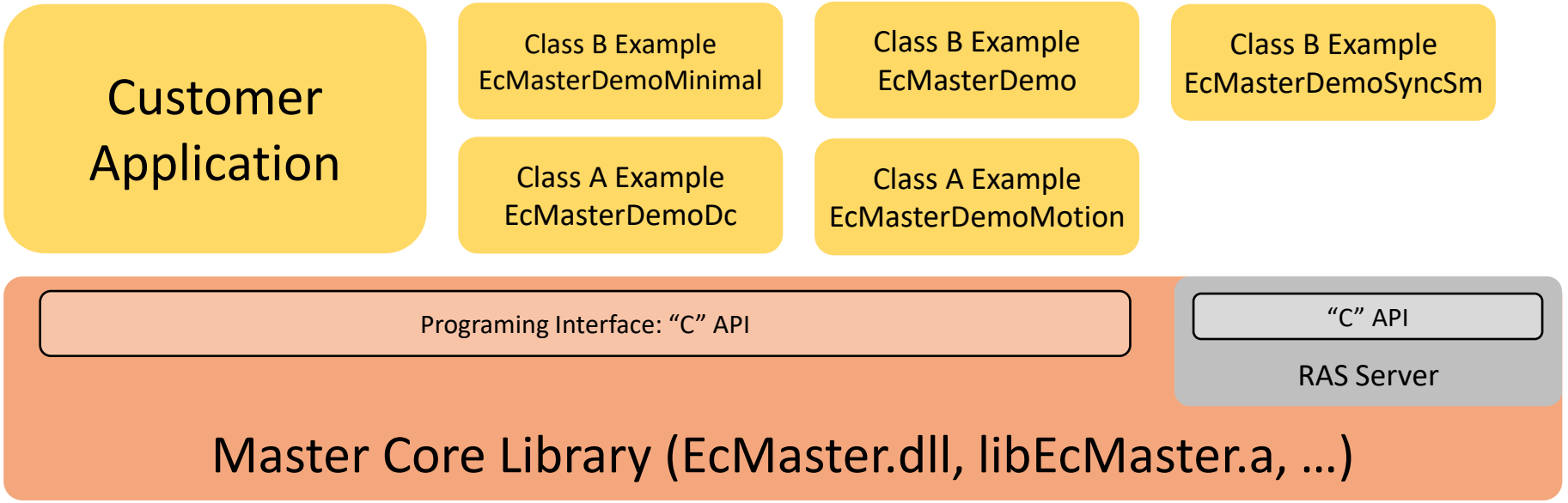
EC-Master Architecture



Programming the Master Core Library in C/C++



The EtherCAT Master Core Library and the RAS Server Module are implemented in C++. The API interfaces are C language interfaces, thus the master can be used in ANSI-C as well as in C++ environments.

C/C++ Example applications

- **EcMasterDemo** is the basic example application for EC-Master. The example shows how to initialize the master and how to put the network into operational state. Based on the provided ENI file this example can handle all kind of EtherCAT Slaves.
- **EcMasterDemoMinimal** is a more simple demo to ease into the EC-Master code. The simple demo focuses just on the necessary APIs and functions to startup the EC-Master along with the attached network and bring everything into operational state.
- **EcMasterDemoSyncSm** demonstrates a different network timing which requires the interrupt from the Ethernet controller used by the master. This cyclic frame is transmitted at the begin of the cycle and the process data are updated immediately after the frame returns.
- **EcMasterDemoDc** is a good starting point for application requiring the accurate synchronization of slaves based on the Distributed Clocks (DC) technology. To synchronize the master controller with the slaves several modes can be selected.
- **EcMasterDemoMotion** comes with a simple motion control library to control drives implemented according to the profile CiA402 and the ETG Implementation Directive ETG.6010. The example supports the operation modes Cyclic Synchronous Position (CSP) and Cyclic Synchronous Velocity (CSV).

EC-Master Demo Application Overview

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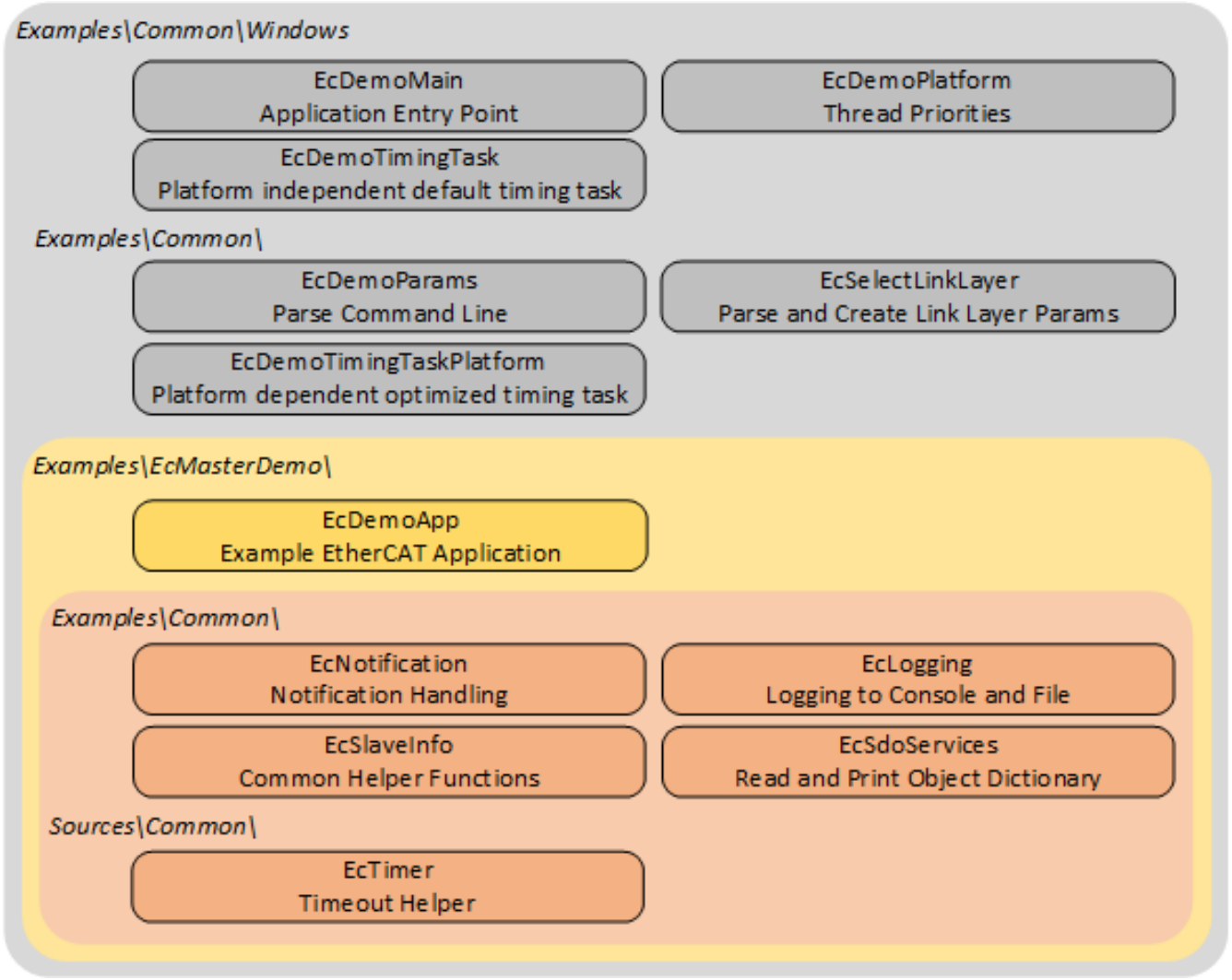
Demo Application

- Source code identical for all supported platforms
- Demonstrates basic EtherCAT communication
- Master stack initialization
- Set all slaves into OPERATIONAL state
- The output messages of the demo application will be printed on the console as well as in some files. The following log files will be created:
  - ecmaster0.log: all messages
  - error0.log: application error messages (logged via LogError function)

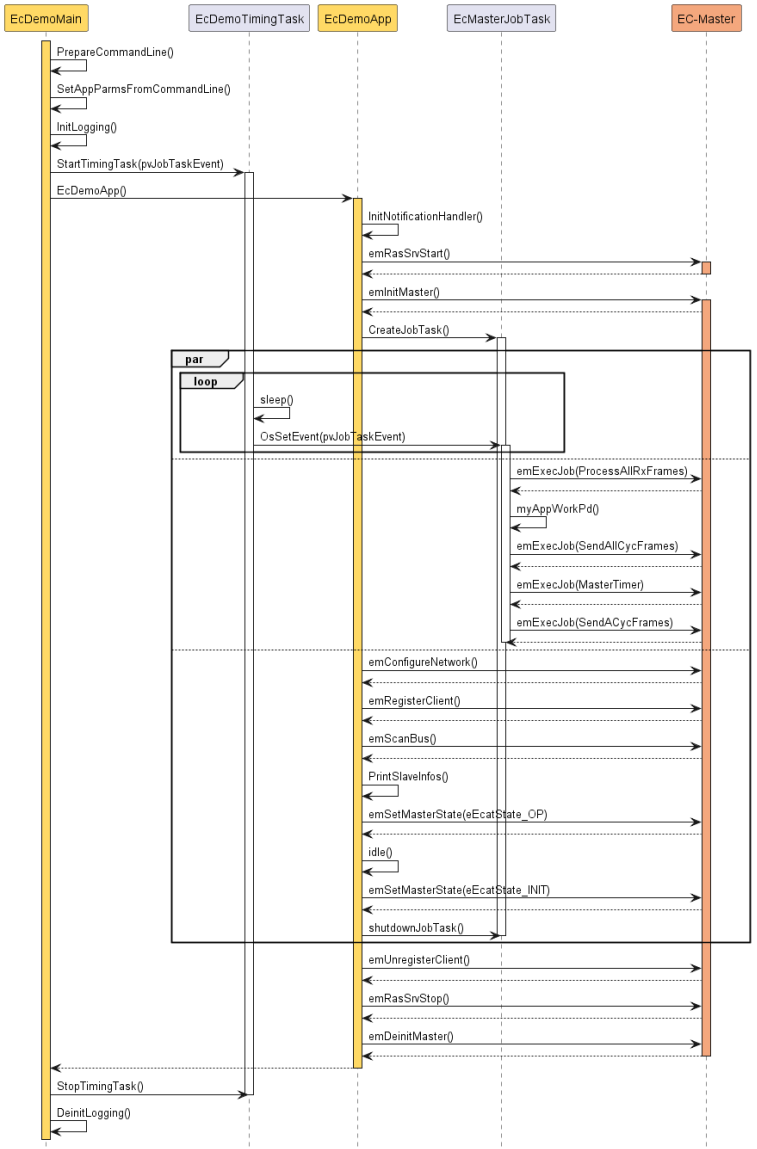
Demo Files


Examples\Common\Windows
EcDemoMain
Application Entry Point
EcDemoPlatform
Thread Priorities
EcDemoTimingTask
Platform independent default timing task
Examples\Common\
EcDemoParams
Parse Command Line
EcSelectLinkLayer
Parse and Create Link Layer Params
EcDemoTimingTaskPlatform
Platform dependent optimized timing task
Examples\EcMasterDemo\
EcDemoApp
Example EtherCAT Application
Examples\Common\
EcNotification
Notification Handling
EcLogging
Logging to Console and File
EcSlaveInfo
Common Helper Functions
EcSdoServices
Read and Print Object Dictionary
Sources\Common\
EcTimer
Timeout Helper

The EC-Master Demo application consists of the following files

EcDemoMain.cpp	Entrypoint for the different operating systems
EcDemoPlatform.h	Operating system specific settings (task priorities, timer settings)
EcDemoTimingTask.h/.cpp	Operating system independent default timing task implementation (base class)
EcDemoTimingTaskPlatform.h/.cpp	Operating system dependent performance increasing overrides of EcDemoTimingTask
EcDemoApp.cpp	Initialize, start and terminate the EtherCAT master
EcDemoApp.h	Application specific settings for EcDemoApp
EcDemoParms.cpp	Parsing of command line parameters
EcDemoParms.h	Basic configuration structs and parameters (EtherCAT master parameter)
EcSelectLinkLayer.cpp	Common functions which abstract the command line parsing into Link Layer parameters
EcNotification.cpp	Slave monitoring and error detection (function emNotify())
EcSdoServices.cpp	Read CoE object dictionary example
EcSlaveInfo.cpp	Slave information services (bus scan, slave properties, getting information of slaves connected to the EtherCAT bus)
EcLogging.cpp	Message logging functions
EcTimer.cpp	Start and monitor timeouts

Demo Life Cycle



Important demo functions

- EcDemoMain()
  Operating system specific main function to start the demo.
  Implement command line parsing for individual parameter settings.
- EcTimingTask()/CEcDemoTimingTaskPlatform class
  Timing thread.
  This thread sets the timing event that triggers the EcMasterJobTask() for the next cycle.
  Do not use sleep() herein, since with DCM, the event **must** trigger with extreme low drifting cycle (average 999.4 - 1000.6). Using sleep() leads to too high drift!
- EcDemoApp()
  Demo application. The function takes care of starting and stopping the master and all related tasks. In between, the function runs idle, while all relevant work is done by the EcMasterJobTask()
- EcMasterJobTask()
  Thread that does the necessary periodic work.
  Very important here is myAppWorkPd() between *eUsrJob_ProcessAllRxFrames* and *eUsrJob_SendAllCycFrames*.
  Application-specific manipulations of the process image, which must be synchronous with the bus cycle, can be carried out here

Important EC-Master API functions

- emInitMaster()
  Prepare the master for operation and set operational parameters, e.g. used Link Layer, buffer sizes, maximum number of slaves, … .
- emConfigureMaster()
  Loads the configuration from the ENI (XML file)
- emRegisterClient()
  Register the application as a client at the EC-Master to receive event notifications
- emSetMasterState()
  Startup the EtherCAT master and switch the bus to the different states from INIT to OPERATIONAL.
- emDeinitMaster()
  Free allocated resources and unbind from devices.

Next Steps

Next steps

- Read EC-Master User Manual Chapter 2 “Getting Started”
- Read EC-Master User Manual Chapter 3 “Software Integration”
- More Information
  - acontis Developer Center: https://developer.acontis.com/
  - EC-Master User Manuals, Tutorials, Training Slides, etc.: https://developer.acontis.com/ec-master
  - acontis technologies YouTube channel