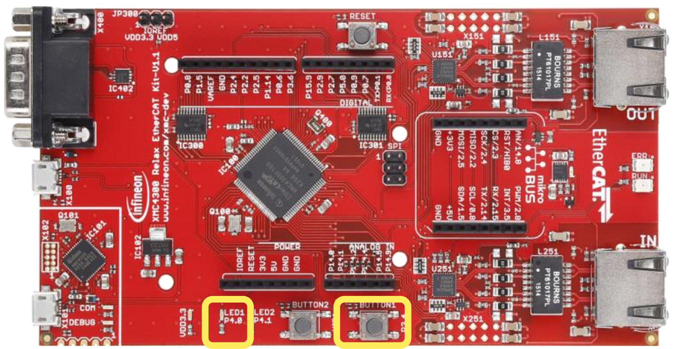
XMC4300 EtherCAT APP SSC Slave Example

Getting Started V3.0

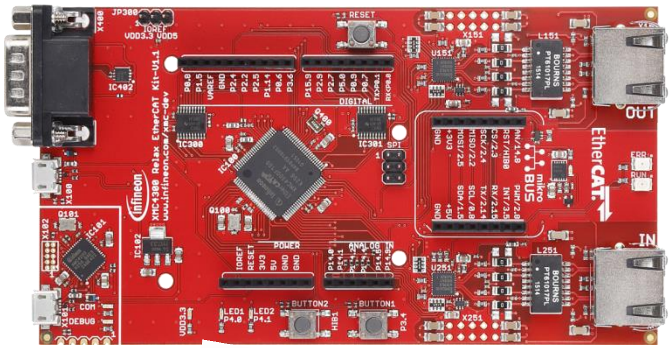
Overview



This example demonstrates the implementation of a EtherCAT slave node using the Beckhoff SSC Tool to generate the slave stack code for „XMC4300 Relax EtherCAT Kit“.

While reviewing this example you will see in output direction the EtherCAT master controlling LED1 on the „XMC4300 Relax EtherCAT Kit“. In input direction you will monitor inside the master device the status of BUTTON1. You will observe inside the source code how to modify the mapping of the data structures to the I/Os for your own evaluations and testing. Furthermore you will learn how to modify the data structures and generate a slave stack code which fits to your needs. In this example we will demonstrate how easy it is to setup a proper EtherCAT communication by using the EtherCAT APP.

Requirements



XMC4300 Relax EtherCAT Kit

RJ45 Ethernet Cable

Windows Laptop installed

- DAVE v4 (Version4.1.4 or higher)
- TwinCAT2 or TwinCAT3 Master PLC
- Slave Stack Code Tool **Version 5.12**

Micro USB Cable (Debugger connector)

Requirements - free downloads

TwinCAT2 (30 day trial; 32bit Windows only)
Link: [Download TwinCAT2]

or

TwinCAT3 (no trial period; usability limited; 32bit and 64bit Windows)
Link: [Download TwinCAT3]

ATTENTION: According our experience TwinCAT is best compatible with Intel™ ethernet chipset.
For details on compatibility with your hardware, additional driver and general installation support please get into contact with your local BECKHOFF support.

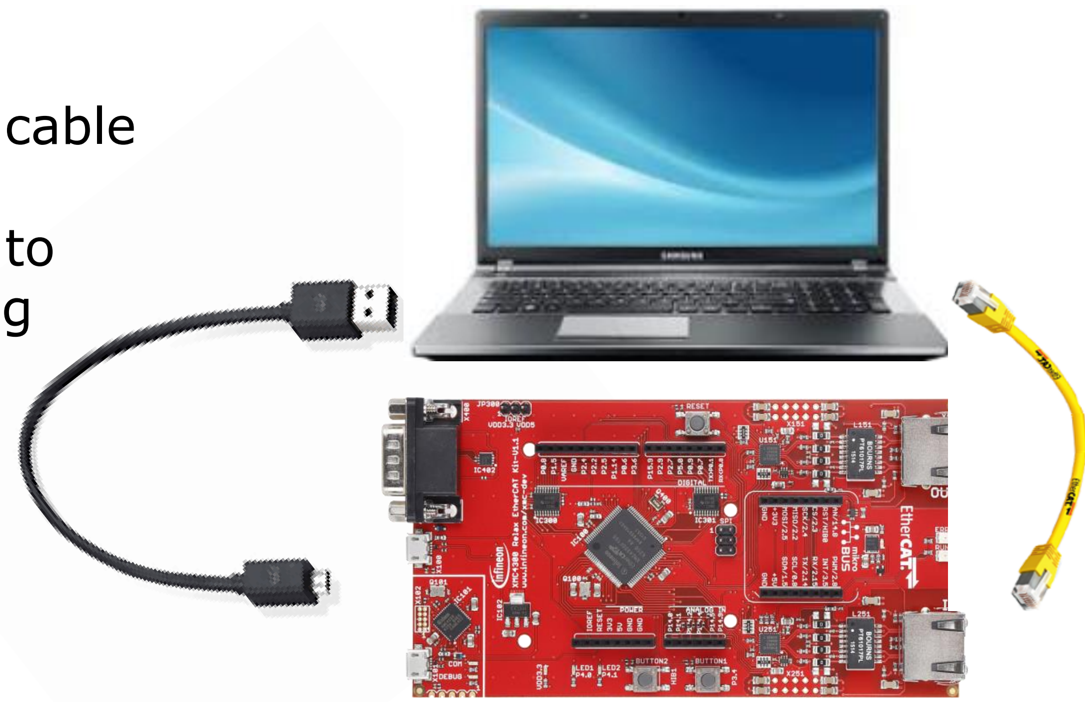
Requirements - free downloads

DAVE (v4.1.4 or higher)
Link: Download DAVE (Version 4)

EtherCAT Slave Stack Code Tool
Version 5.12
(ETG membership obligatory)
Link: Slave Stack Code Tool

Setup – Hardware

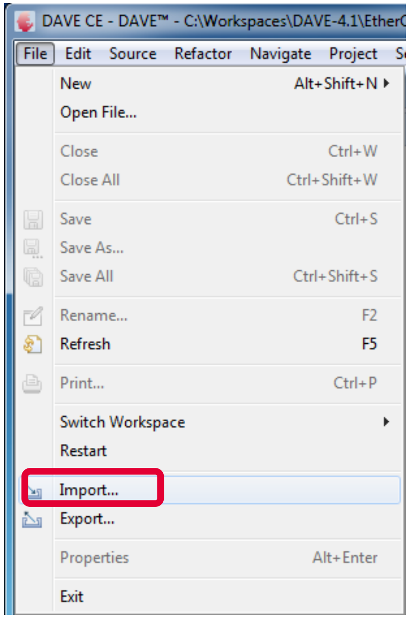
Micro USB cable Debugger connected to X101 debug connector



Ethernet Cable connected to IN-port

Setup – Import example project into DAVE

1



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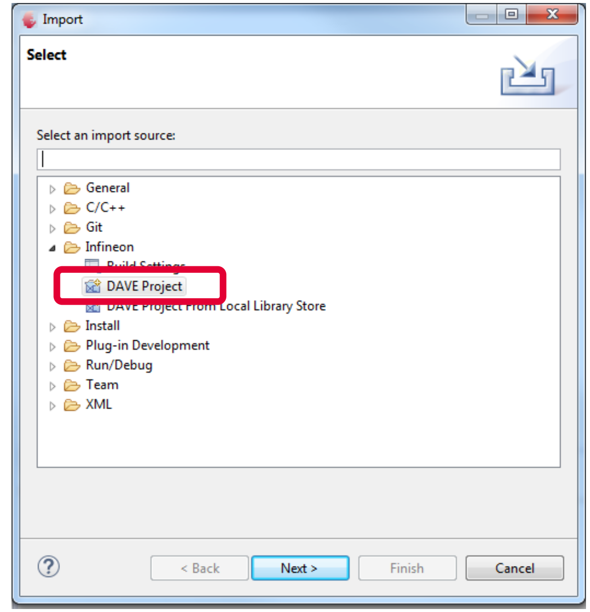

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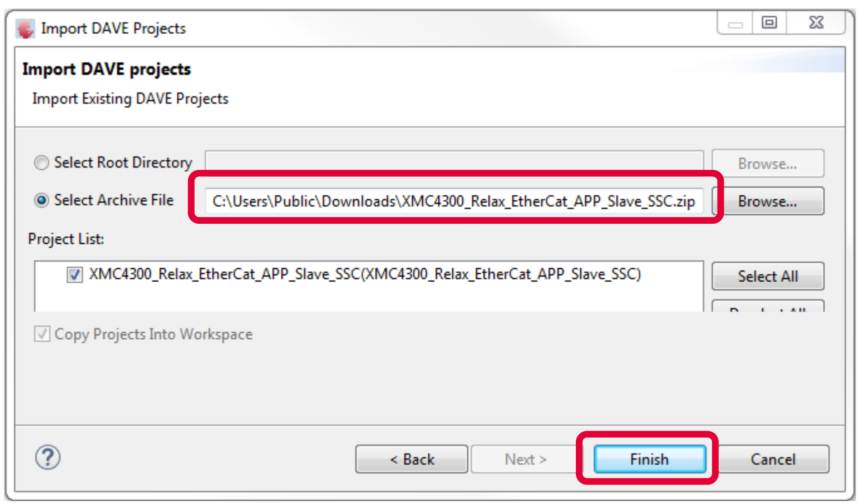
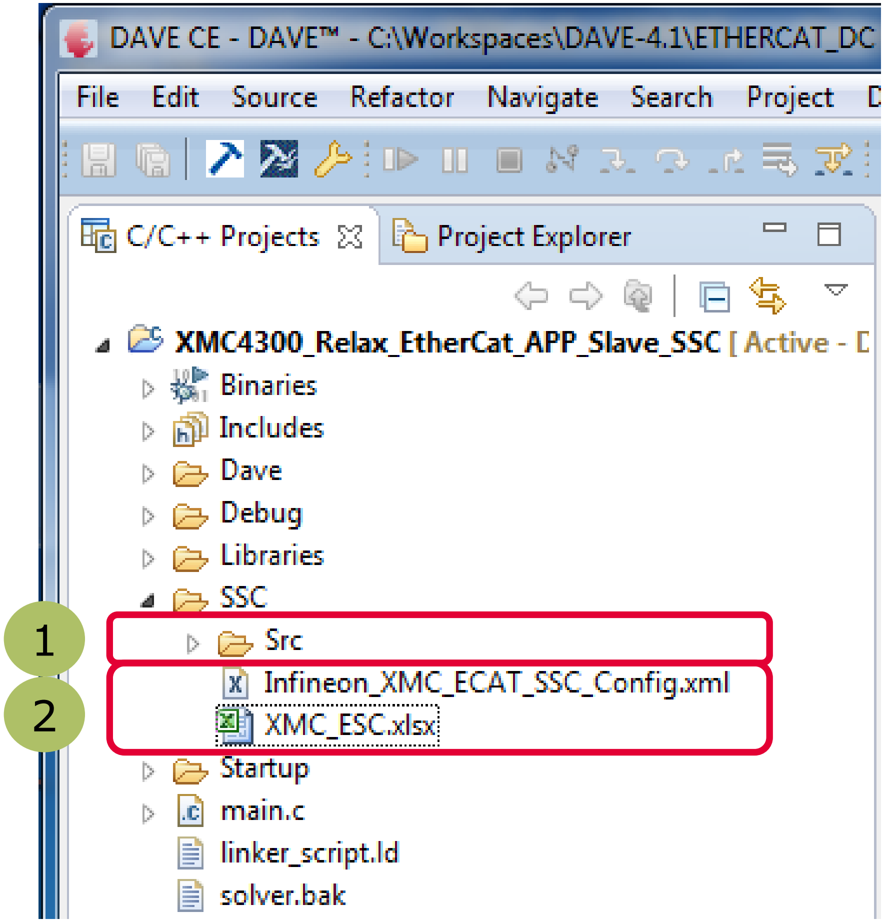


Setup – Import example project into DAVE



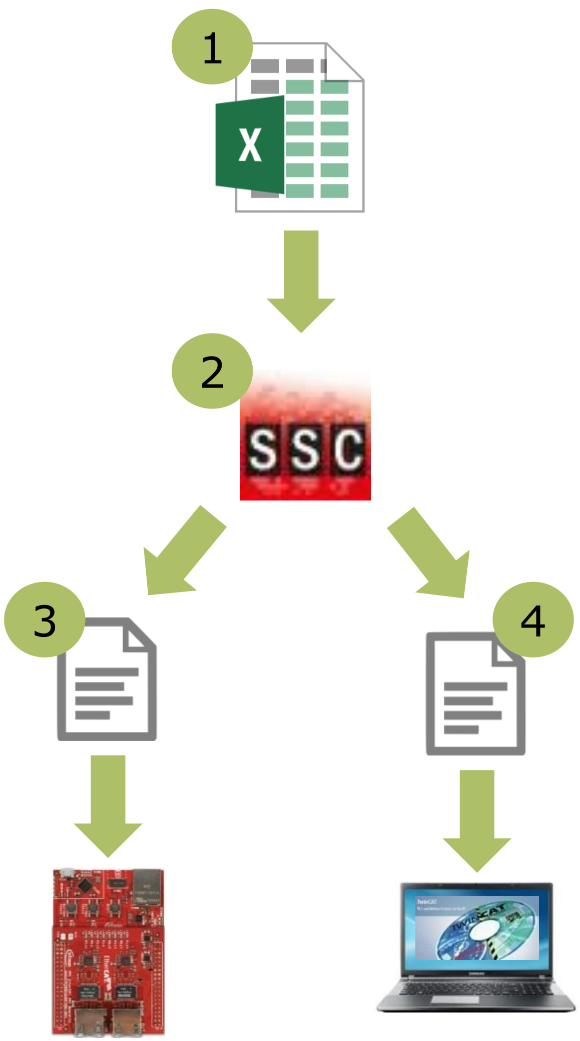
After the project import you will find this project folder structure.

1 The project is nearly complete for building, it only misses the EtherCAT slave stack code. For these files the Src folder has been already prepared.

2 The EtherCAT slave stack code for the XMC4300 can be generated by configuration files. These configuration files are included in the project already.

The following slides show in detail how to define your EtherCAT slave node interface and to generate the slave stack code.

The flow to define the EtherCAT slave node interface



1 Take the Excel Worksheet provided inside the example project to define your EtherCAT slave node interface.

2 The Beckhoff SSC-tool uses the excel sheet as an input to generate the output-files.

3 The generated EtherCAT slave stack code does apply for the XMC4300.

4 The generated **E**therCAT **S**lave **I**nformation file (ESI) does apply for the EtherCAT host. There the relevant interface information about the slave is stored.

Defining the interface of EtherCAT slave node

1

- SSC
  - Src
  - Infineon_XMC_ECAT_SSC_Config.xml
  - XMC_ESC.xlsx

2

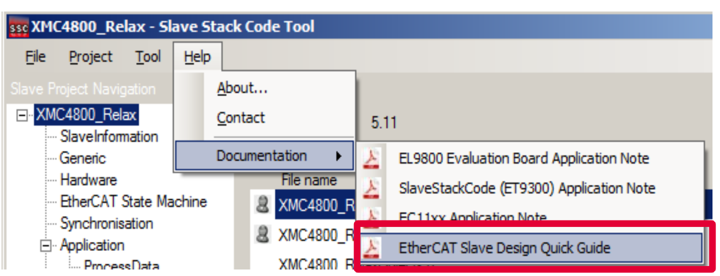
Index	ObjectCode	SI	DataType	Name
//0x6nnx	Input Data of the Module (0x6000 - 0x6FFF)			
0x6000	RECORD			IN_GENERIC
		0x01	UINT	IN_GEN_INT1
		0x02	UINT	IN_GEN_INT2
		0x03	UINT	IN_GEN_INT3
		0x04	UINT	IN_GEN_INT4
		0x05	BOOL	IN_GEN_Bit1
		0x06	BOOL	IN_GEN_Bit2
		0x07	BOOL	IN_GEN_Bit3
		0x08	BOOL	IN_GEN_Bit4
		0x09	BOOL	IN_GEN_Bit5
		0x0A	BOOL	IN_GEN_Bit6
		0x0B	BOOL	IN_GEN_Bit7
		0x0C	BOOL	IN_GEN_Bit8

//0x7nnx	Output Data of the Module (0x7000 - 0x7FFF)			
0x7000	RECORD			OUT_GENERIC
		0x01	UINT	OUT_GEN_INT1
		0x02	UINT	OUT_GEN_INT2
		0x03	UINT	OUT_GEN_INT3
		0x04	UINT	OUT_GEN_INT4
		0x05	BOOL	OUT_GEN_Bit1
		0x06	BOOL	OUT_GEN_Bit2
		0x07	BOOL	OUT_GEN_Bit3
		0x08	BOOL	OUT_GEN_Bit4
		0x09	BOOL	OUT_GEN_Bit5
		0x0A	BOOL	OUT_GEN_Bit6
		0x0B	BOOL	OUT_GEN_Bit7
		0x0C	BOOL	OUT_GEN_Bit8

1 Double click on the excel file to open it.

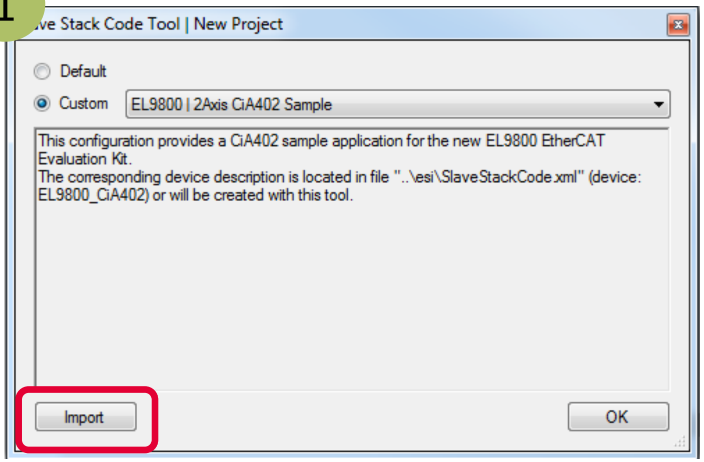
2 Check the content of the file. The data defined in both I/O directions is 4x16bit integers and 8x1bit booleans.

3 For further details on how to define your own interface you may want to follow the instructions inside *EtherCAT Slave Design Quick Guide.pdf* inside SSC tool.



Generating Slave Stack Code and ESI file

1



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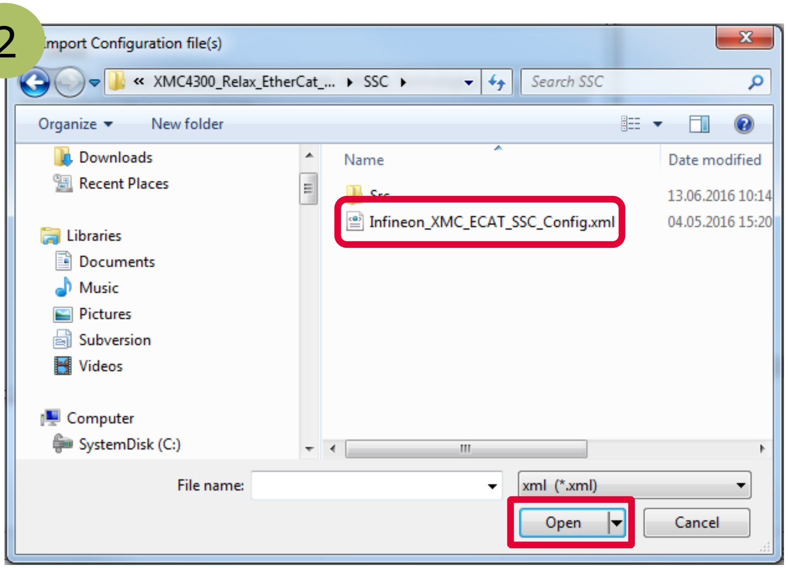
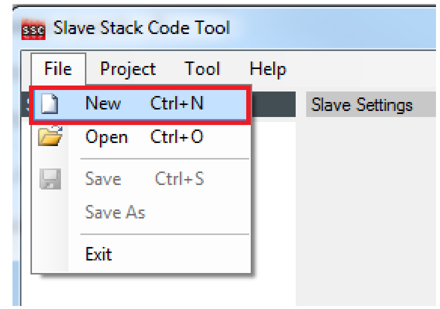


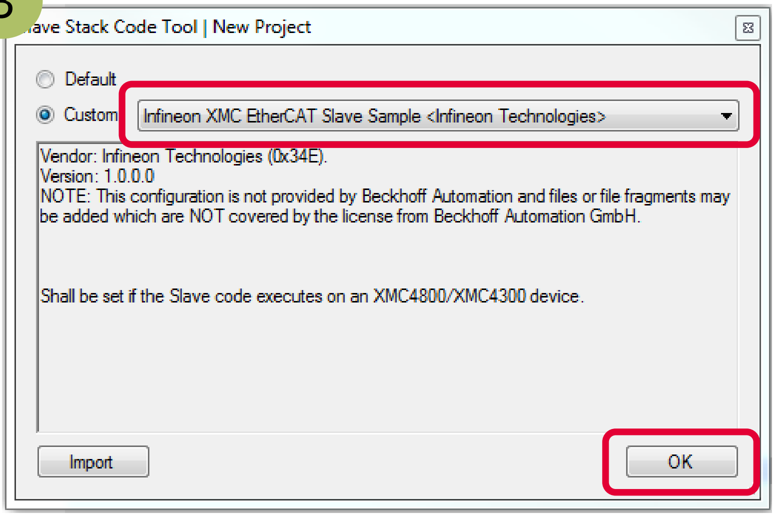
1 Start the SSC tool and create a new project **File** >> **New**



2 Select the configuration file which you find inside the example project.

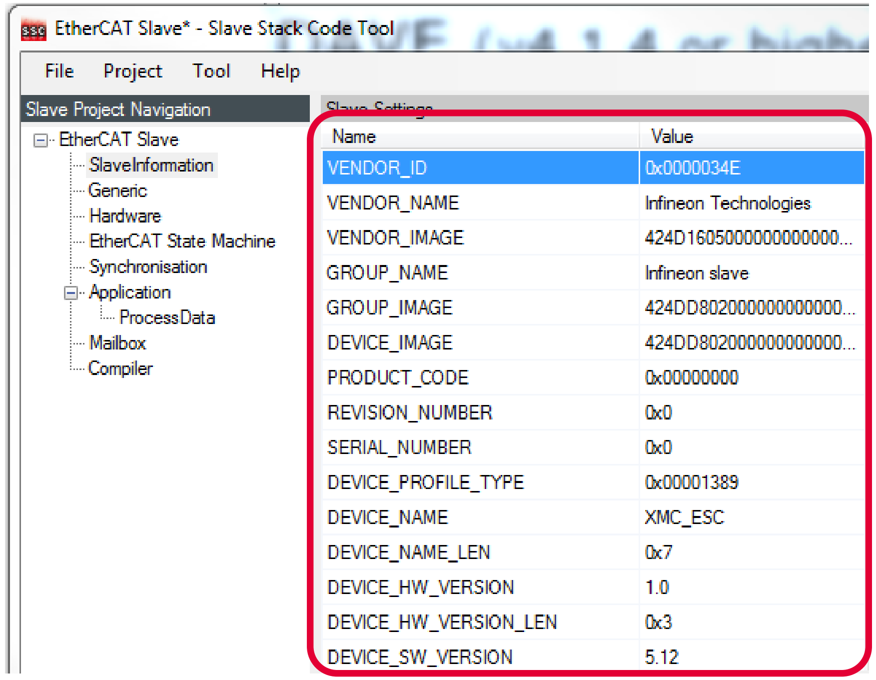
Generating Slave Stack Code and ESI file

3



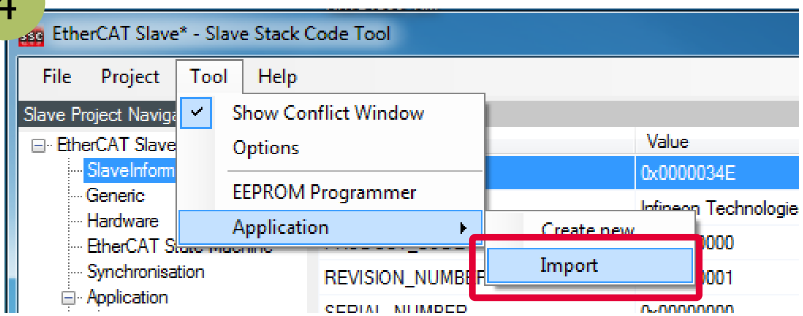
3 Select the Infineon device inside the drop down list and confirm with the OK button. Your project will be created.

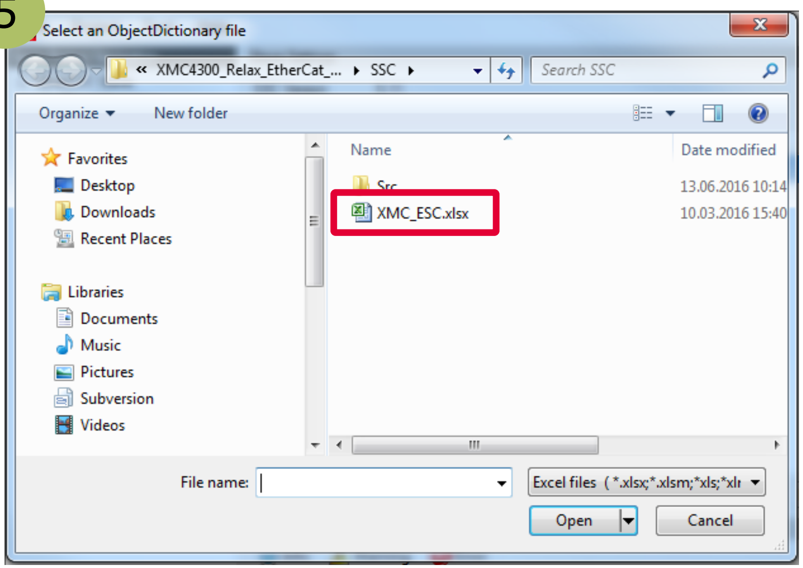
Generating Slave Stack Code and ESI file



- Check the settings inside SlaveInformation: vendor ID, vendor name, product ID and product code are customer specific and are used by the host to identify the slave.
- Define revision number, serial number, device name, HW/SW version according to your needs.
- The vendor ID/name and product code assigned to infineon may be used for evaluation purpose only. For productive purpose your own vendor ID/name assigned by the EtherCAt Technology Group is obligatory.

Generating Slave Stack Code and ESI file



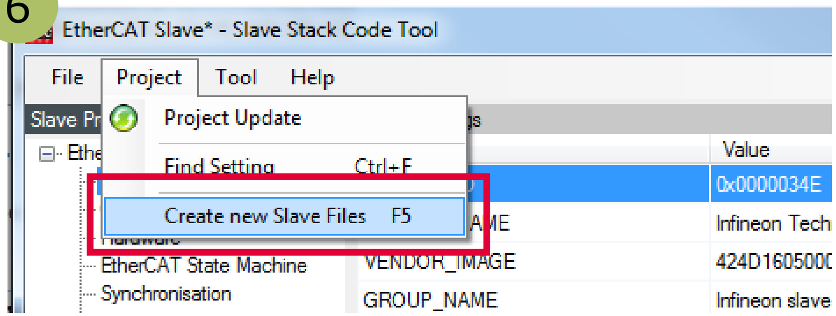


4 Import the EXCEL-sheet which defines the interface of your EtherCAT node.

5 Select the EXCEL-file provided inside the example project.

Generating Slave Stack Code and ESI file

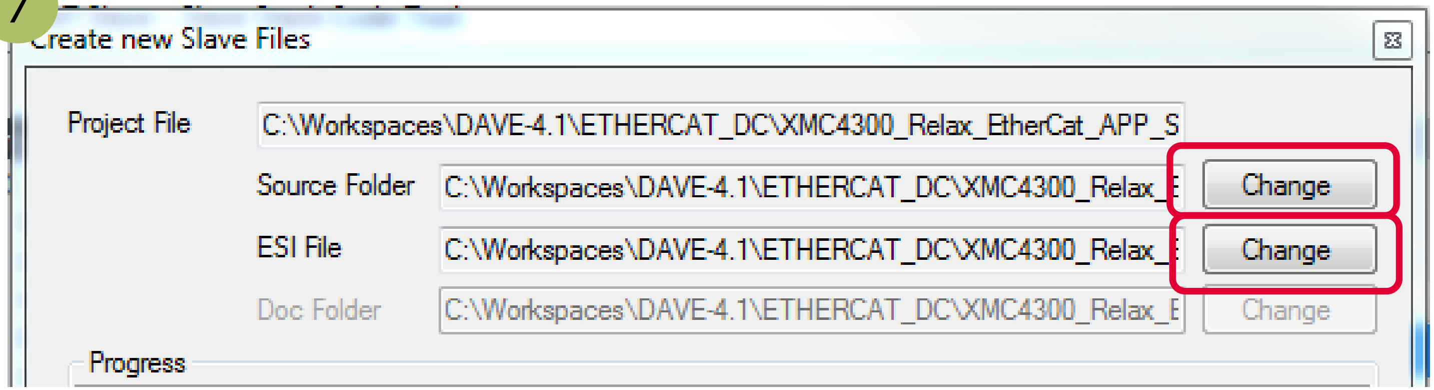
6



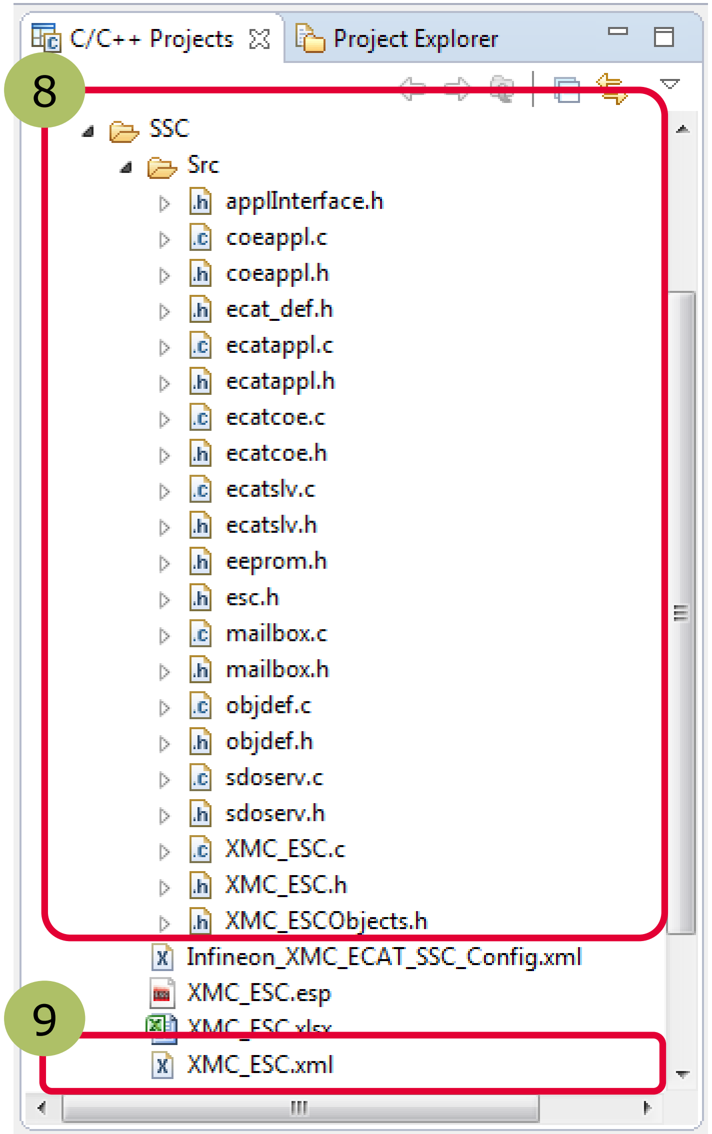
6 Click on **Project >> Create new Slave Files** to start file generation.

7 In this step the destination folder for the EtherCAT Slave Stack Code and the ESI file can be adapted. For this example it is recommended to take the default settings.

7



Find and use your result



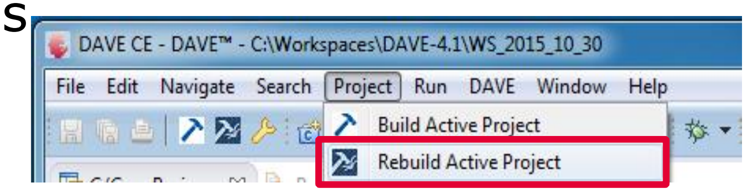
After the generation process the respective files are inside the project space:

8 Check the availability of the generated slave stack code

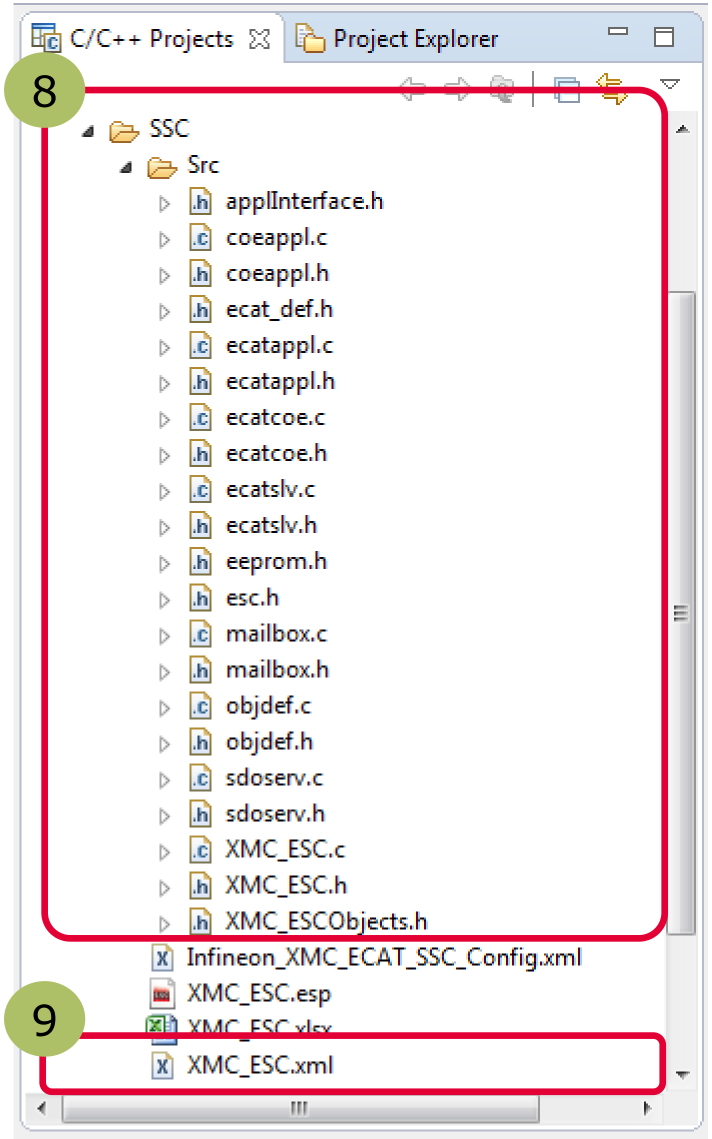
9 Check the availability of the ESI-file and download to the host by these 3 steps:

1. Stop TwinCAT System Manager
2. Copy the ESI file to your TwinCAT installation *C:\TwinCAT\Io\EtherCAT*
3. Restart TwinCAT System Manager to start re-work of the device description cache.

10 Rebuild the DAVE project with the new files



Find and use your result



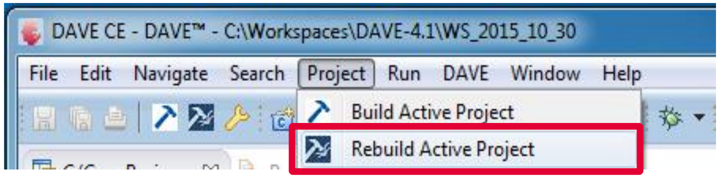
After the generation process the respective files are inside the project space:

8 Check the availability of the generated slave stack code

9 Check the availability of the ESI-file and download to the host by these 3 steps:

1. Stop TwinCAT System Manager
2. Copy the ESI file to resp. destination
   for TwinCAT2:
   C:\TwinCAT\Io\EtherCAT
   for TwinCAT3:
   C:\TwinCAT\3.1\Config\Io\EtherCAT
3. Restart TwinCAT System Manager to start re-work of the device description cache.

10 Rebuild the DAVE project with the new files.



Copy data from/to local data to/from ESC memory

Inside the generated file *XMC_ESC.c* the link to your application must be implemented. Modify the source code accordingly which copies the application data to/from ESC memory to the local application memory:

Originally generated code:

```
////////////////////////////////////////////////////////////////////////////////////////
/**
\param      pData  pointer to input process data

\brief      This function will copies the inputs from the local memory to the ESC memory
            to the hardware
*////////////////////////////////////////////////////////////////////////////////////////
void APPL_InputMapping(UINT16* pData)
{
#if _WIN32
   #pragma message ("Warning: Implement input (Slave -> Master) mapping")
#else
    #warning "Implement input (Slave -> Master) mapping"
#endif
}
```

```
////////////////////////////////////////////////////////////////////////////////////////
/**
\param      pData  pointer to output process data

\brief    This function will copies the outputs from the ESC memory to the local memory
            to the hardware
*////////////////////////////////////////////////////////////////////////////////////////
void APPL_OutputMapping(UINT16* pData)
{
#if _WIN32
   #pragma message ("Warning: Implement output (Master -> Slave) mapping")
#else
    #warning "Implement output (Master -> Slave) mapping"
#endif
}
```

Modified code:

```
////////////////////////////////////////////////////////////////////////////////////////
/**
\param      pData  pointer to input process data

\brief      This function will copies the inputs from the local memory to the ESC memory
            to the hardware
*////////////////////////////////////////////////////////////////////////////////////////
void APPL_InputMapping(UINT16* pData)
{
  memcpy(pData,&(((UINT16 *)&IN_GENERIC0x6000)[1]),SIZEOF(IN_GENERIC0x6000)-2);
}
```

```
////////////////////////////////////////////////////////////////////////////////////////
/**
\param      pData  pointer to output process data

\brief    This function will copies the outputs from the ESC memory to the local memory
            to the hardware
*////////////////////////////////////////////////////////////////////////////////////////
void APPL_OutputMapping(UINT16* pData)
{
  memcpy(&(((UINT16 *)&OUT_GENERIC0x7000)[1]),pData,SIZEOF(OUT_GENERIC0x7000)-2);
}
```

Implement application specific slave node behaviour

Inside the generated file *XMC_ESC.c* file the function APPL_Application is implemented. This function implements the application specific code to handle input and output…
A) … from mainloop or
B) … if synchronisation is active from ISR
Inside main.c of the example, the function
*void process_app(TOBJ7000 *OUT_GENERIC, TOBJ6000 *IN_GENERIC);*
implements the mapping of the input/output data to buttons and LEDs. Therefore please modify the function APPL_Application to call process_app in the following way:

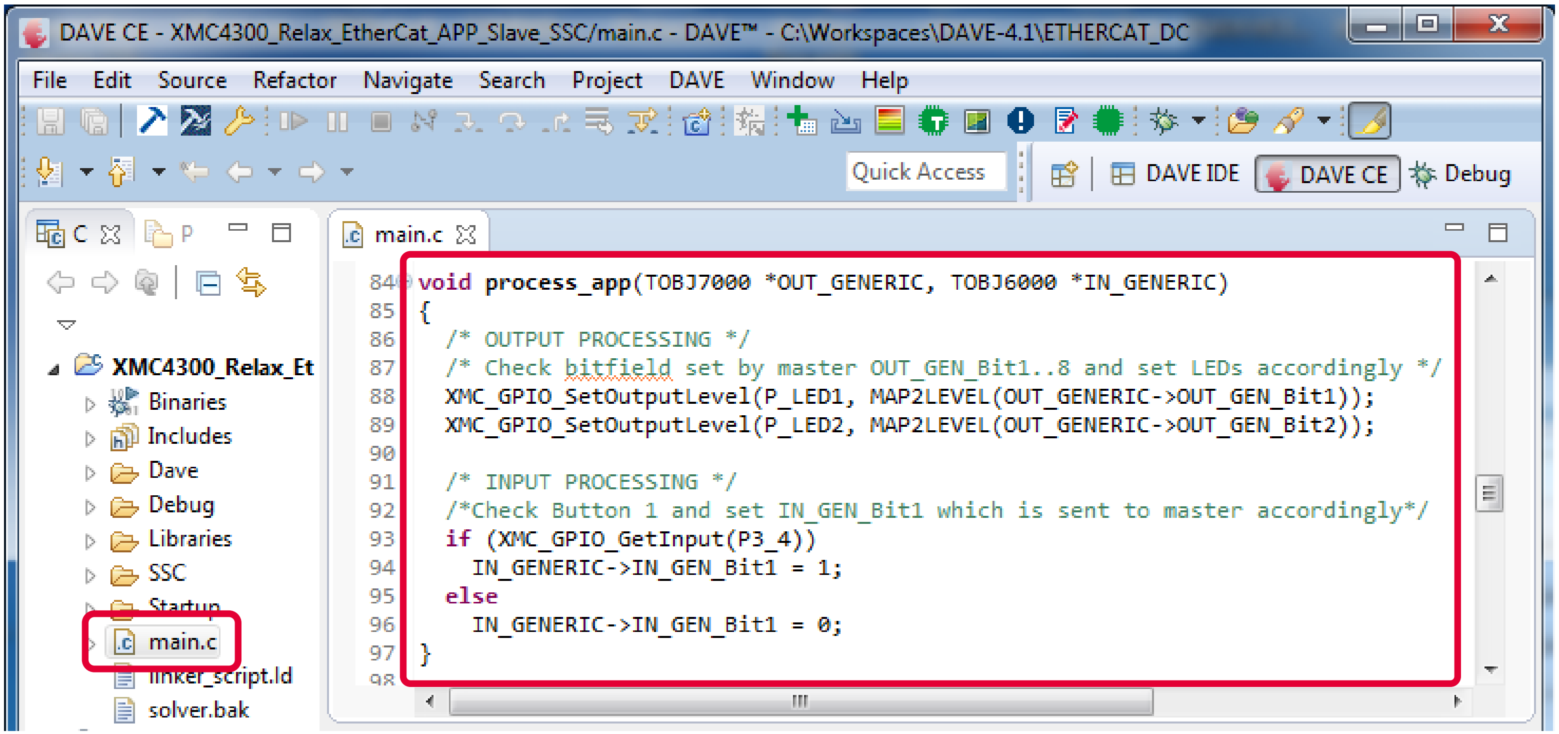
Originally generated code:

```c
//////////////////////////////////////////////////////////////////////////////////////////
/**
\brief    This function will called from the synchronisation ISR
            or from the mainloop if no synchronisation is supported
*////////////////////////////////////////////////////////////////////////////////////////
void APPL_Application(void)
{
#if _WIN32
   #pragma message ("Warning: Implement the slave application")
#else
    #warning "Implement the slave application"
#endif
}
```

Modified code:

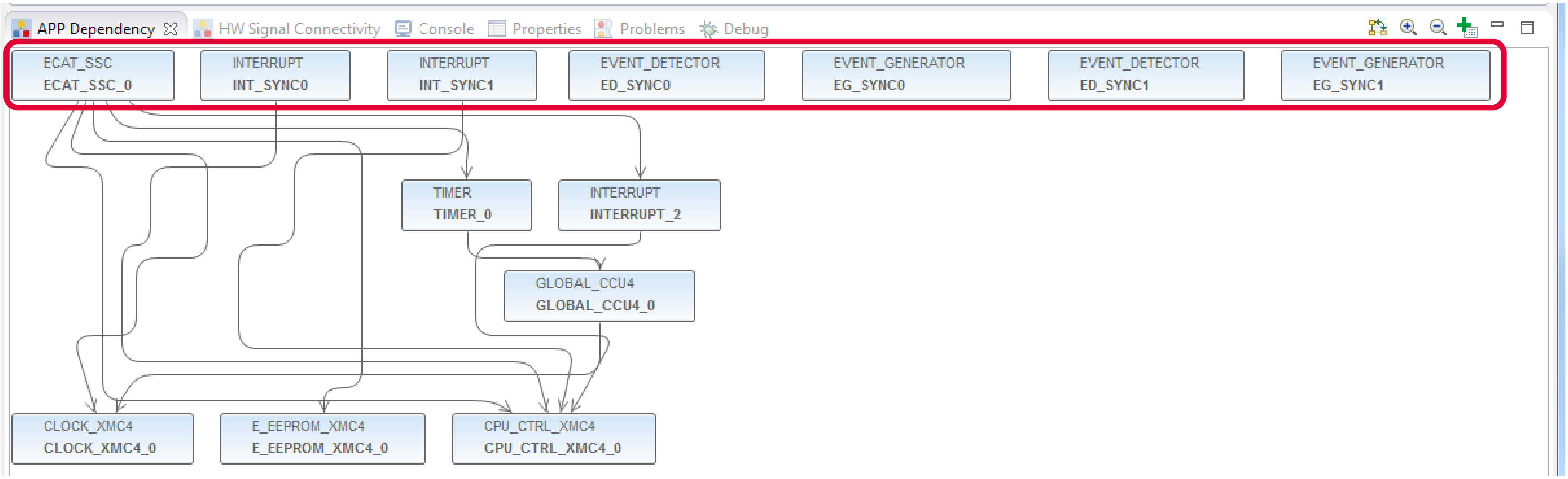
```c
//////////////////////////////////////////////////////////////////////////////////////////
/**
\brief    This function will called from the synchronisation ISR
            or from the mainloop if no synchronisation is supported
*////////////////////////////////////////////////////////////////////////////////////////
void process_app(TOBJ7000 *OUT_GENERIC, TOBJ6000 *IN_GENERIC);
void APPL_Application(void)
{
    process_app(&OUT_GENERIC0x7000, &IN_GENERIC0x6000);
}
```

Description – process of input and output



Within the slave stack code the function process_app is called. This process_app function process the binary output data (master->slave) to set the LED1 „XMC4300 Relax EtherCAT Kit". The states of the BUTTON1 is checked and propagated to the input data (slave->master).

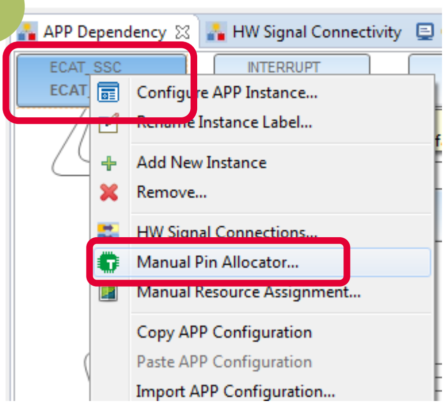
Description – Overview on used APPs



The ECAT_SSC APP assigns the system resources (automatically done by DAVE by using the respective lower level apps) and pins (by manual configuration) to setup a proper EtherCAT communication. The EVENT_DETECTOR, EVENT_GENERATOR and INTERRUPT APPs are used inside this example to connect the sync_out_0 and sync_out_1 of the ECAT_SSC APP to the interrupt service routines of the SSC-stack.

Description – EtherCat ports and physical connection

1



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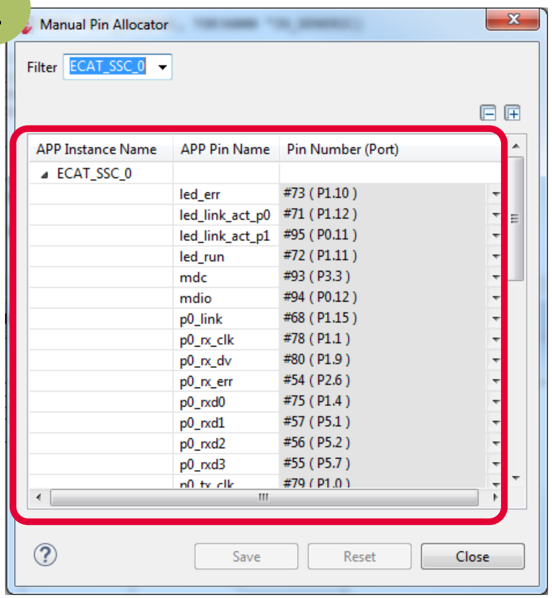
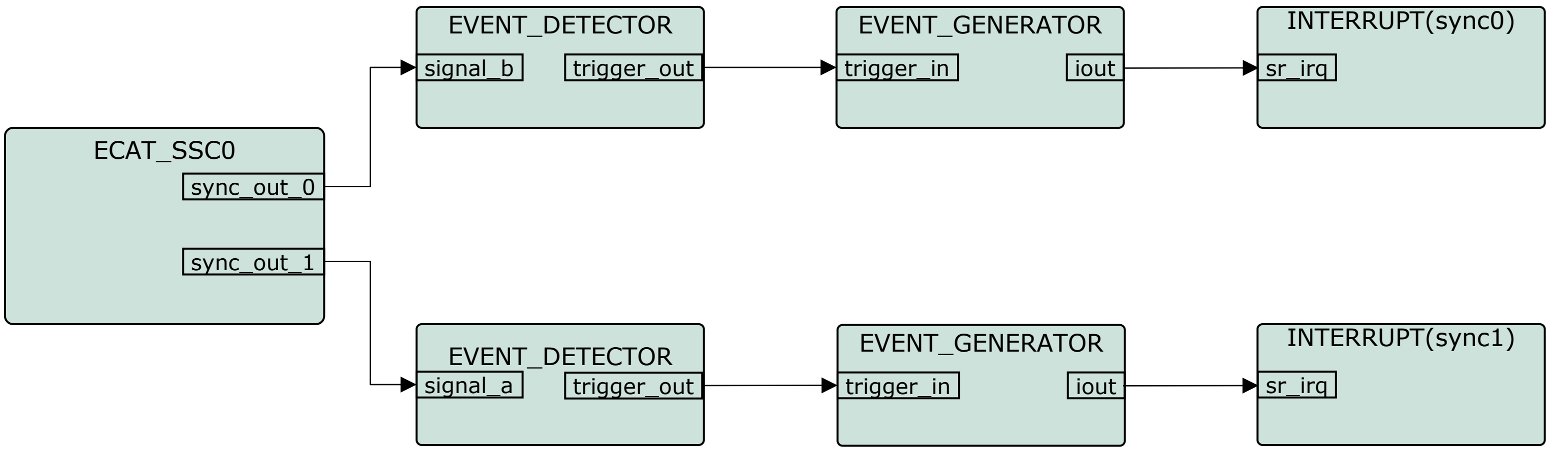


1 Right click on the ECAT_SSC APP. From the context menu select „Manual Pin Allocator“ to open the pin allocation for the EtherCAT module.

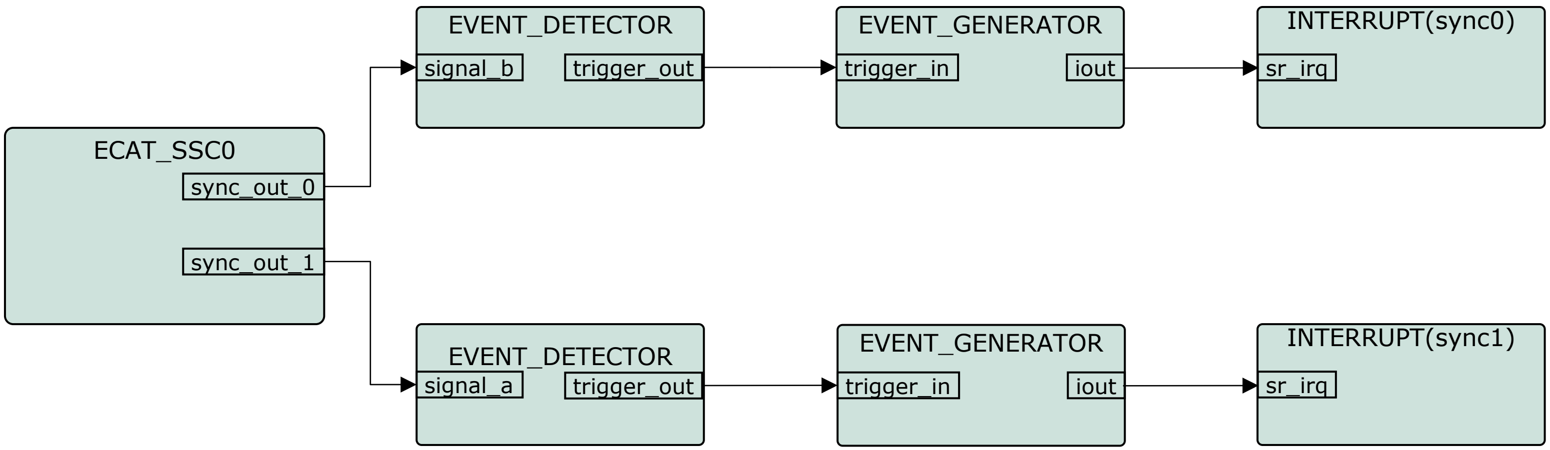
2 Inside Manual Pin Allocator you can configure the EtherCAT ports for your application. For the example provided, the configuration fits to the XMC4300 Relax EtherCAT Kit.

Description – Distributed clock support



For distributed clock support, the sync0 and sync1 signals coming from the ethercat peripheral are used to trigger interrupts. Inside the interrupt service routines the respective API functions of the SSC protocol stack are called.

Description – Overview on propagating the sync0 and sync1 signals to ISR

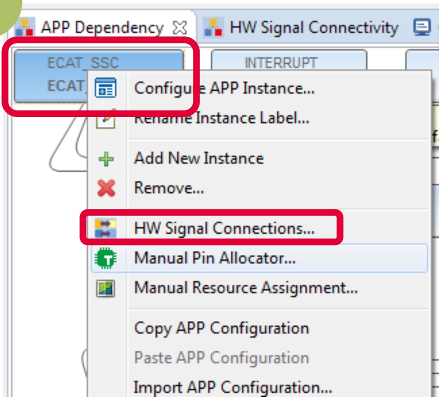


EVENT_DETECTOR and EVENT_GENERATOR APPs are instances of the event request unit (ERU) peripheral. Inside this example the ERU is used to propagate the signals sync0 and sync1 to the interrupt service routines.
Please see next slides how to setup this configuration inside DAVE™.

ATTENTION: With the same approach sync0 and sync1 signals can also be connected to other resources. For example: ADC, ports and timers.

Description – DAVE™settings for distributed clock support

1



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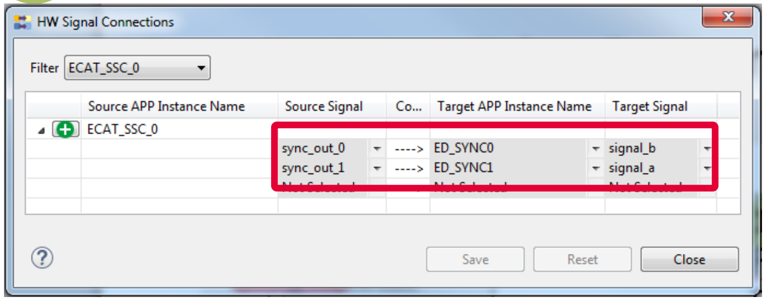
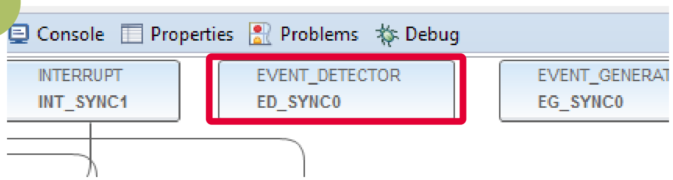


1 Right click on the ECAT_SSC APP. From the context menu select „HW Signal Connections “ to open the HW Signal Connection dialog of the ECAT_SSC APP.

2 Connect the sync_out_0 and sync_out_1 signal to the a/b input of the event detection unit.

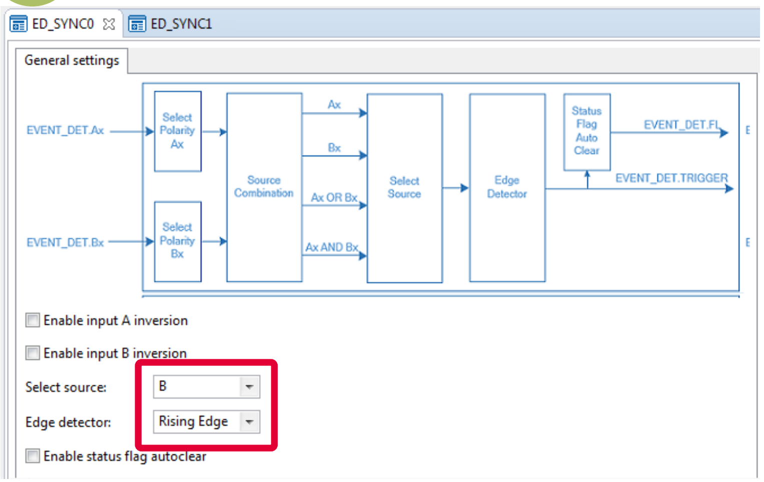
Description – DAVE™settings for distributed clock support

3



3 Double click on the EVENT_DETECTOR APP for SYNC0 and EVENT_DETECTOR APP for SYNC1.

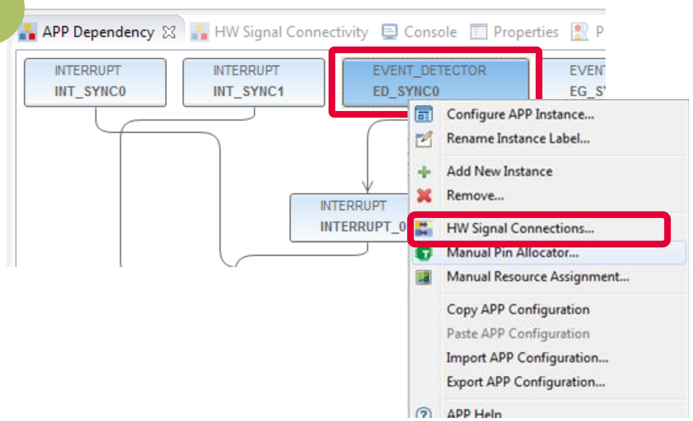
4



4 Select the respective source signal („A" for SYNC0 and „B" for SYNC1) and edge detection „Rising Edge".

Description – DAVE™settings for distributed clock support

5



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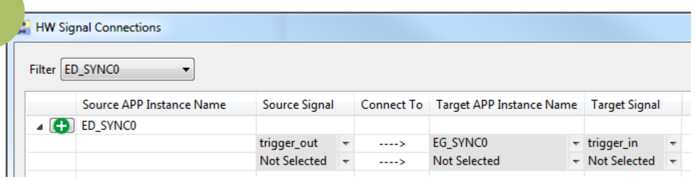
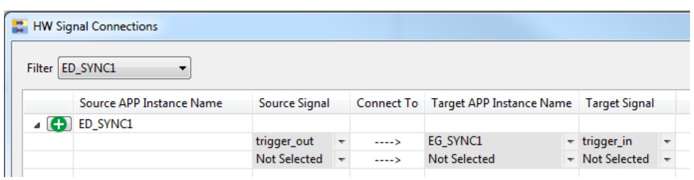


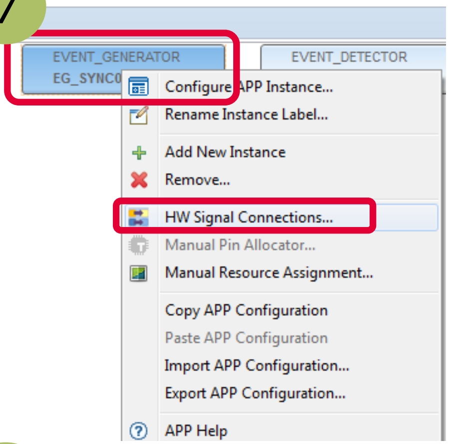


5 Right click on the EVENT_DETECTOR APP for SYNC0 and SYNC1. From the context menu select „HW Signal Connections “ to open the HW Signal Connection dialog of the ECAT_SSC APP.

6 Connect the trigger_out signals of the event detection units to the trigger_in signals of the event generation units.

Description – DAVE™settings for distributed clock support

7



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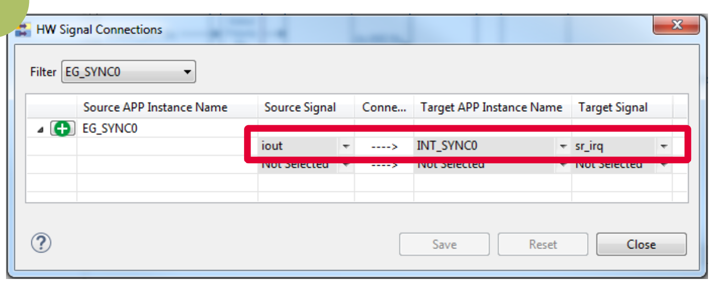
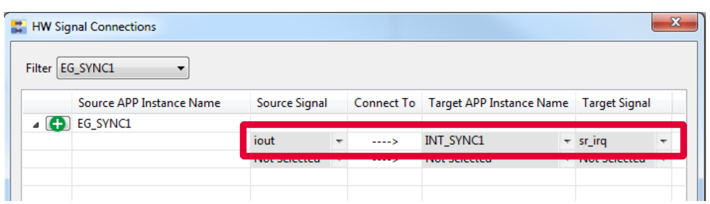
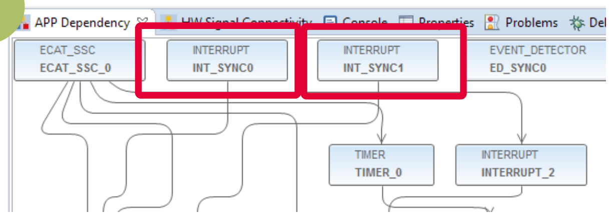




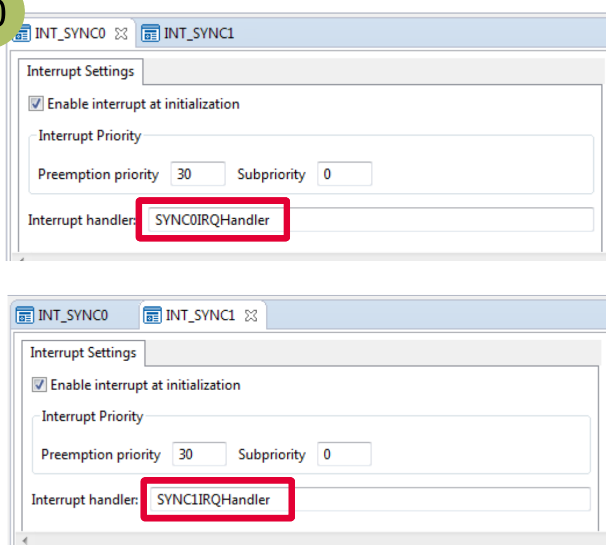
7 Right click on EVENT_GENERATOR for sync0 and sync1. From the context menu select „HW Signal Connections “ to open the HW Signal Connection dialog of the EVENT_GENERATOR APP.

8 Connect the iout of the EVENT_GENERATOR APP for sync0 to INTERRUPT APP of sync0. Proceed respectively for sync1.

Description – DAVE™settings for distributed clock support

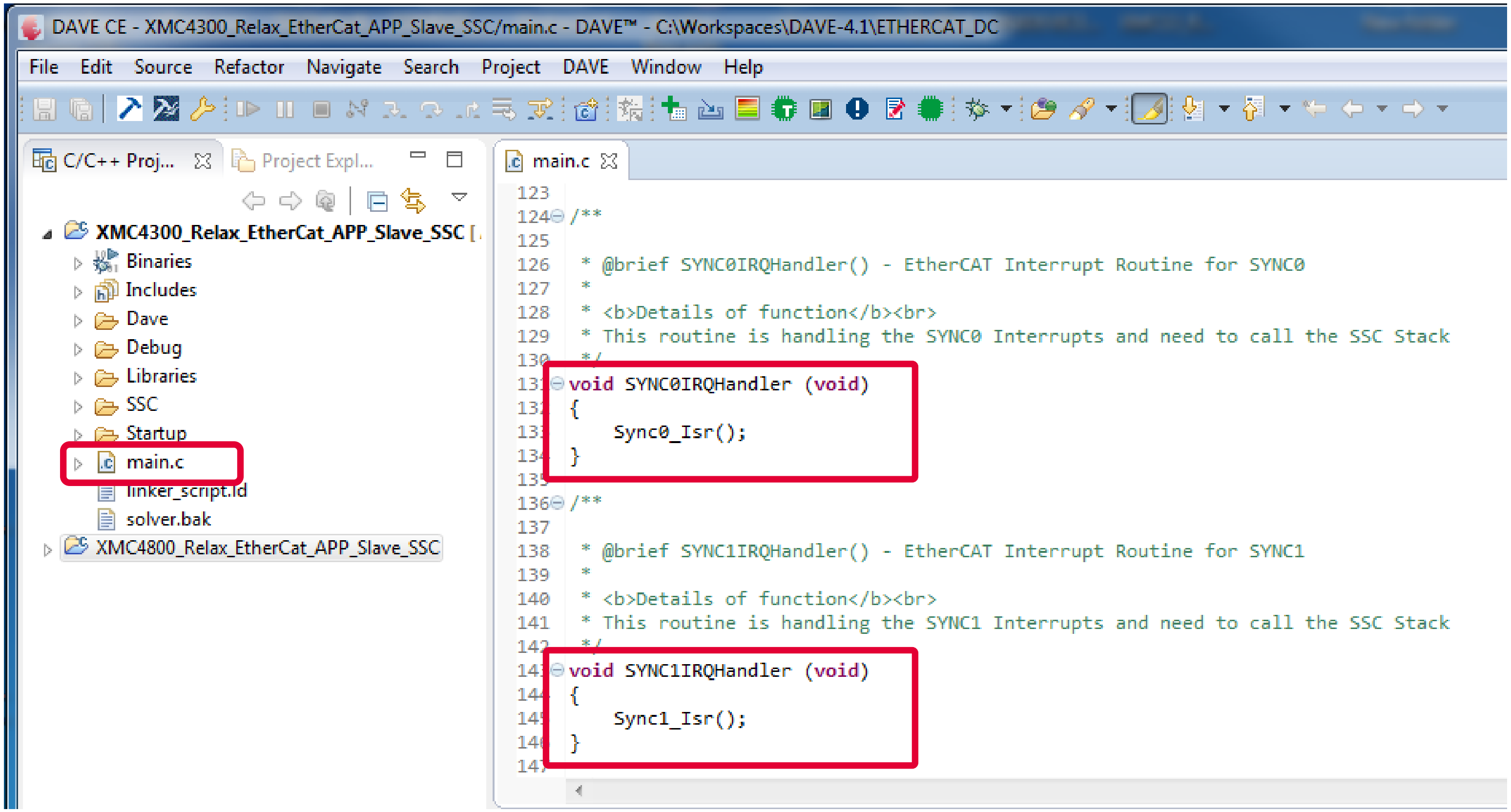


9 Double click on the INTERRUPT APP for sync0 and INTERRUPT for sync1.



10 Set the interrupt service routine for sync0 and sync1 inside the configuration of the respective INTERRUPT APP.

Description – DAVE™settings for distributed clock support



Inside main() the interrupt handlers for sync0 and sync1 are implemented. The implementation is calling the respective functions of the SSC protocol stack.

Description – SSC specific enabling/disabling of interrupts [1/2]

Please see ET9300 application note published by the ETG on details about the SSC code structure and interrupt handling (chapter 4).

In v1.8/2017-11-14 of this document inside chapter 5/hardware access it is specified:
„If interrupts are used also two macros shall be defined "ENABLE_ESC_INT" and "DISABLE_ESC_INT". These shall enable/disable **all four interrupt** sources".

These macros are implemented inside ECAT_APP. Timer- and PDI-interrupt are handled by the ECAT_APP. As Sync0 and Sync1 are routed through ERU (see before) these interrupts need to be handled in addition by the user.
For this purpose ECAT_APP is implementing a callback function for user specific implementation:
ENABLE_ESC_INT_USER and DISABLE_ESC_INT_USER.

Description – SSC specific enabling/disabling of interrupts [2/2]

Within this example you find the implementation of ENABLE_ESC_INT_USER and DISABLE_ESC_INT_USER inside main.c:

main.c

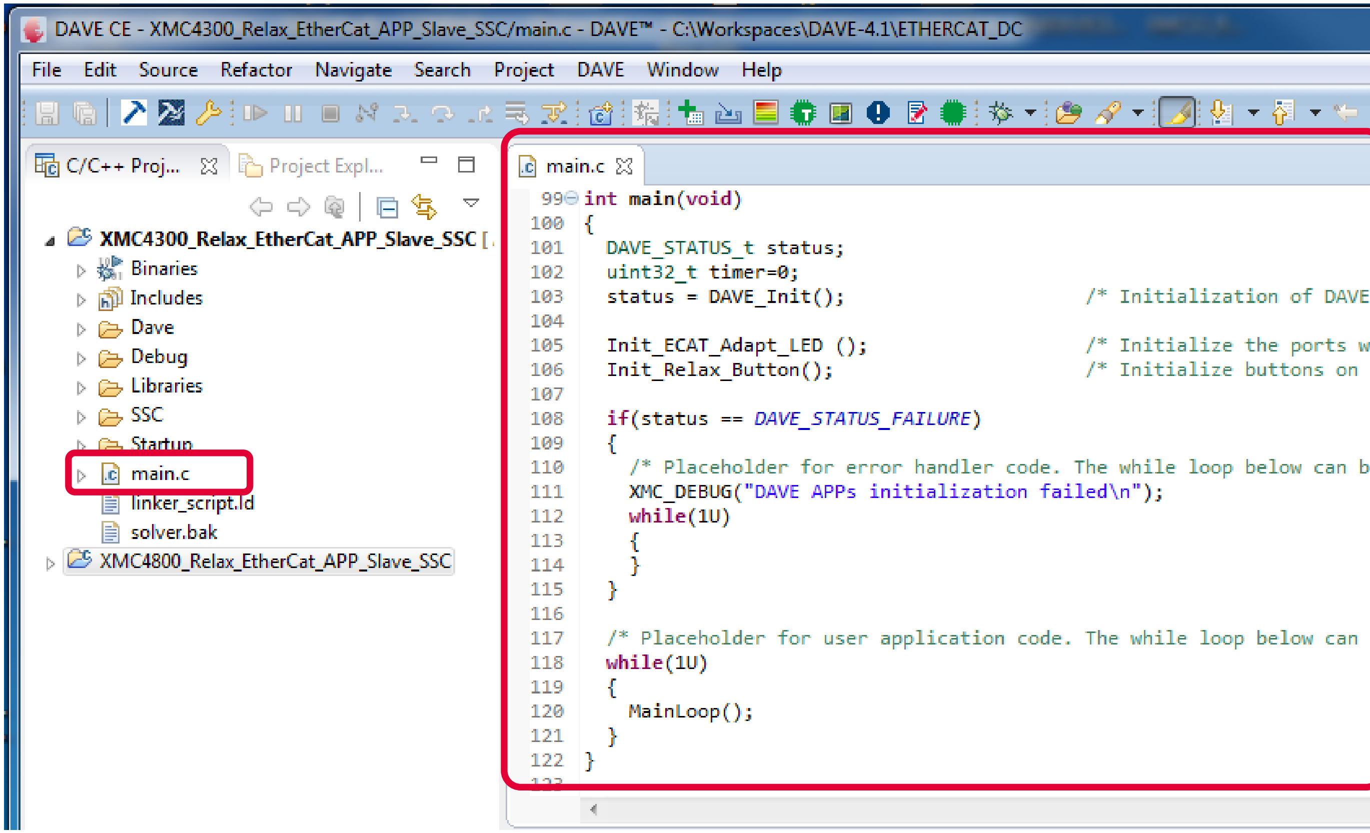
```c
/**

 * @brief ENABLE_ESC_INT_USER() - Enabling of user specific EtherCAT Interrupt Routines
 *
 * <b>Details of function</b><br>
 * This routine is called from ECAT_APP on request of SSC stack once interrupts (sync1/sync0) need to be enabled
 */
void ENABLE_ESC_INT_USER()
{
    INTERRUPT_Enable(&INT_SYNC0);
    INTERRUPT_Enable(&INT_SYNC1);
}

/**

 * @brief DISABLE_ESC_INT_USER() - Disabling of user specific EtherCAT Interrupt Routines
 *
 * <b>Details of function</b><br>
 * This routine is called from ECAT_APP on request of SSC stack once interrupts (sync1/sync0) need to be disabled
 */
void DISABLE_ESC_INT_USER()
{
    INTERRUPT_Disable(&INT_SYNC0);
    INTERRUPT_Disable(&INT_SYNC1);
}
```

Description – initialization inside main.c

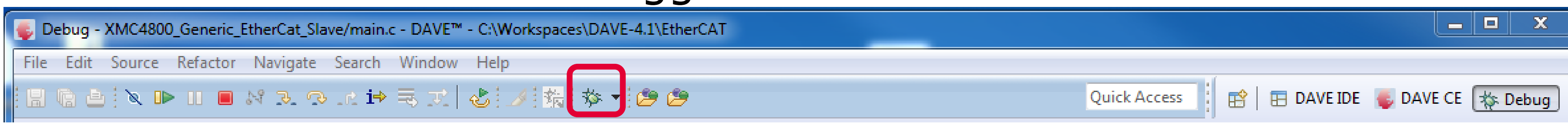


Inside main() DAVE and its APPs (PWM_CCU8, ECAT_SSC) are initialized. InitECAT_Adapt_LED() and Init_Relax-Button() are used to initialize the buttons and LED1 to 8 of the „XMC4300 Relax EtherCAT Kit“. Finally the MainLoop is called cyclically to process the state machine of the slave stack code.

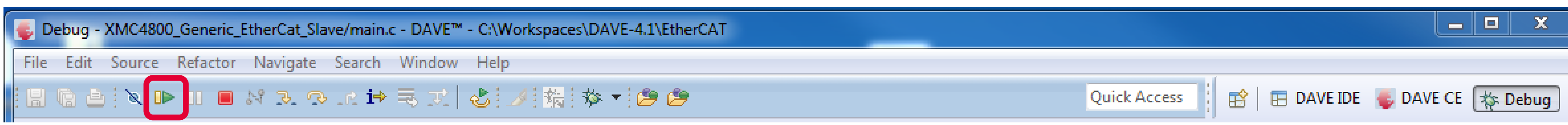
How to test – start the slave to run

ACTIONS

1. Build and download the example application software to the XMC4300 and start the debugger



2. Start the software by the run button

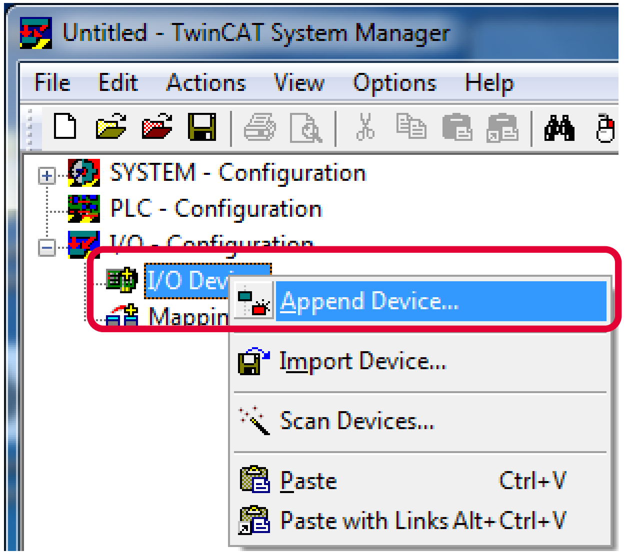


OBSERVATIONS

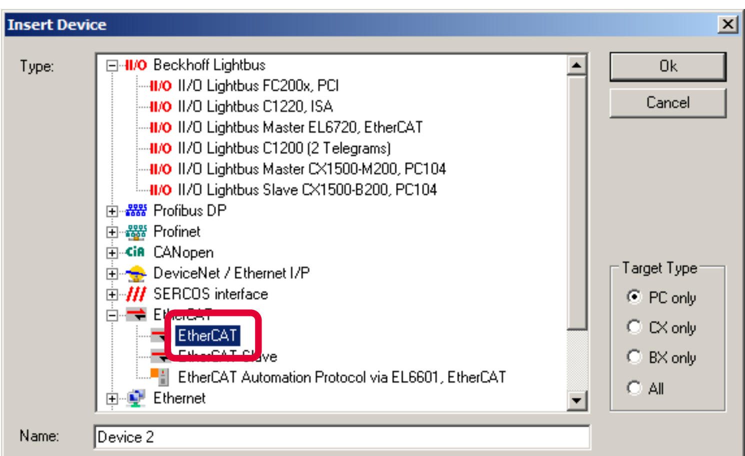
The ERR-LED on the „XMC4300 Relax EtherCAT Kit“ will turn on and immediately turn off again.

How to test – start the TwinCAT 2 master to run (1/4)

1



2



ACTIONS

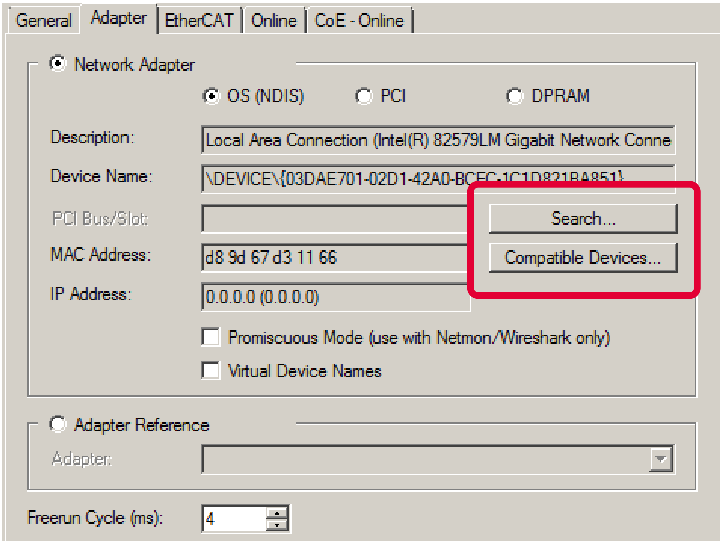
After starting the TwinCAT System Manager from windows start menu:

1 Right Click I/O-Devices and select „Append Device…“

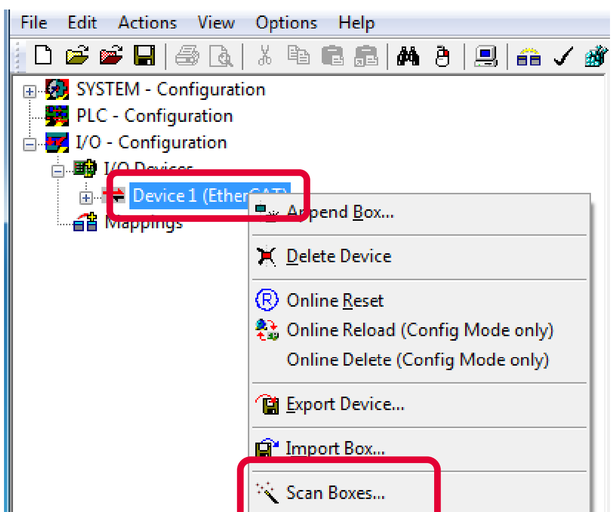
2 Create an EtherCAT master device by double click

How to test – start the TwinCAT 2 master to run (2/4)

3



4



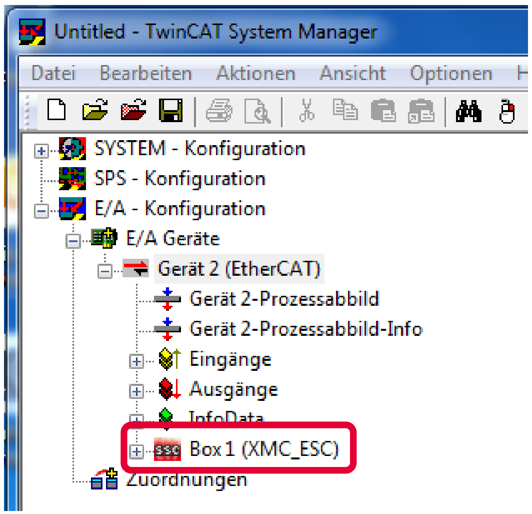
ACTIONS

3 Select the network adapter you want to use (search and select).
Application hint:
In case the device is not found please install the respective device driver by following the instructions given by TwinCAT through the „Compatible Devices...“ button.

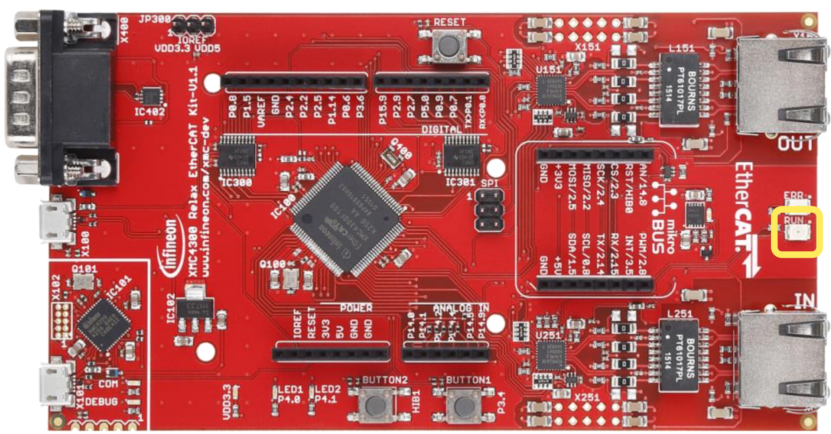
4 Right Click EtherCAT master and select „Scan Boxes...“

How to test – start the TwinCAT 2 master to run (3/4)

1



2



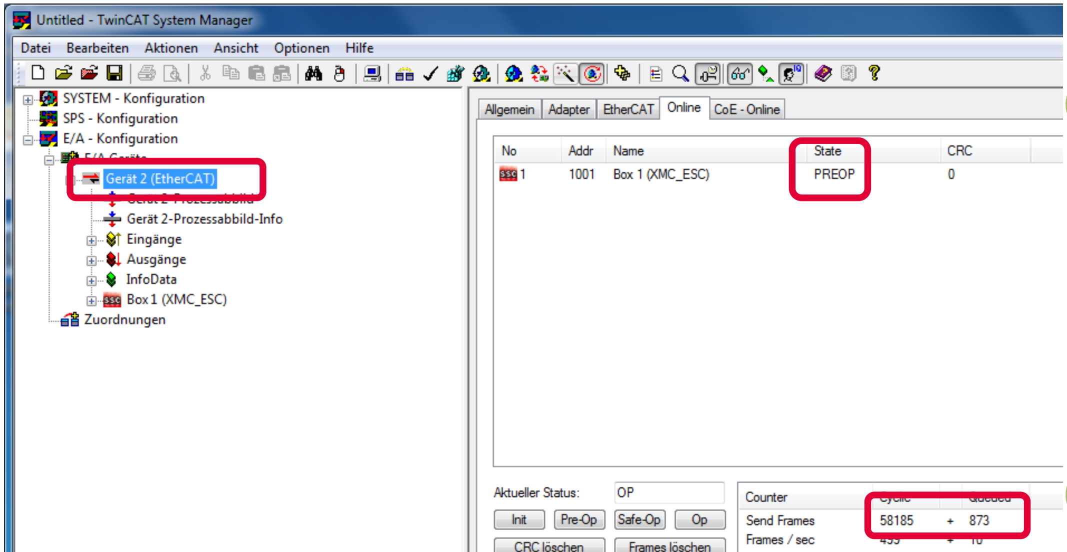
OBSERVATIONS

1 The slave appears as a node on the EtherCAT master bus.

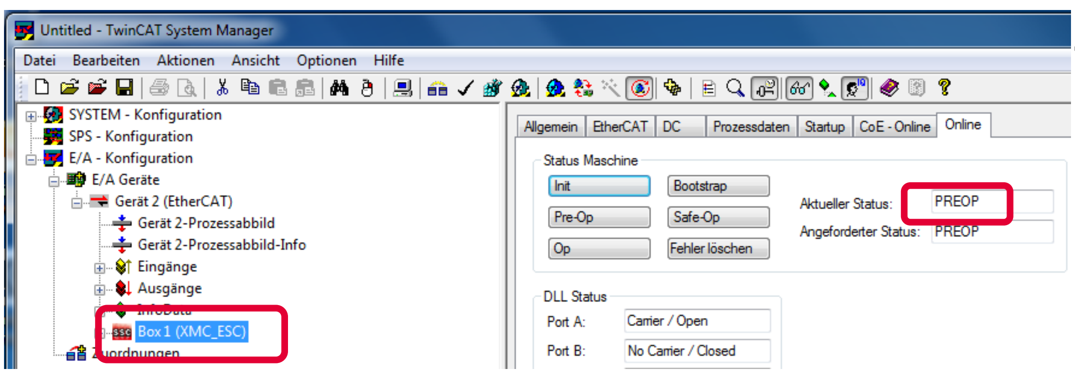
2 The RUN-LED is flashing indicating PREOP-state

How to test – start the TwinCAT 2 master to run (4/4)

3



4



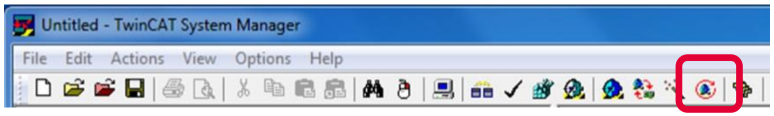
OBSERVATIONS

3 EtherCAT master view: Inside the EtherCAT master online state you see the queued frames counting up, the connected slave and its PREOP state.

4 EtherCAT slave view: The PREOP-state of the slave is indicated within the TwinCAT system manager .

How to test – Setting slave to operational mode

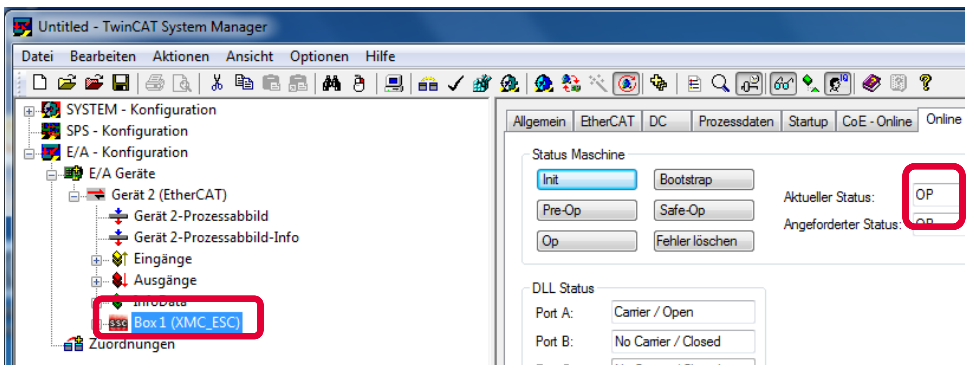
ACTION



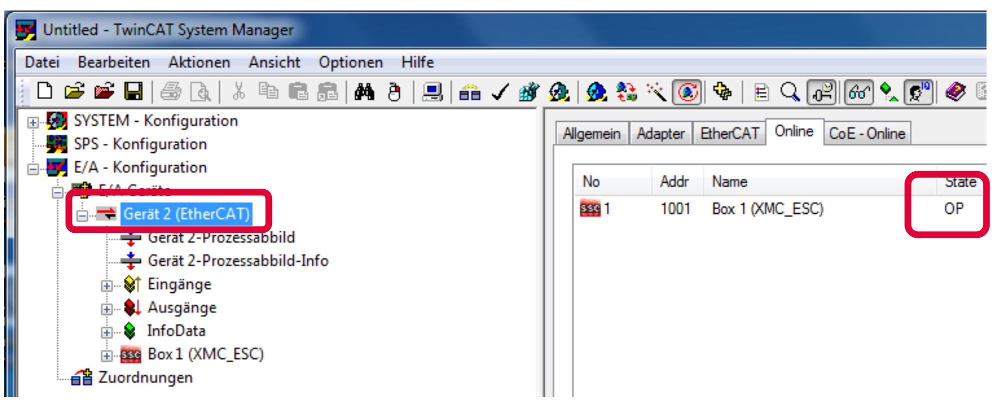
Set master device to free run mode

OBSERVATIONS

1



2



1 EtherCAT slave view: Online status of slave shows the slave in OP state

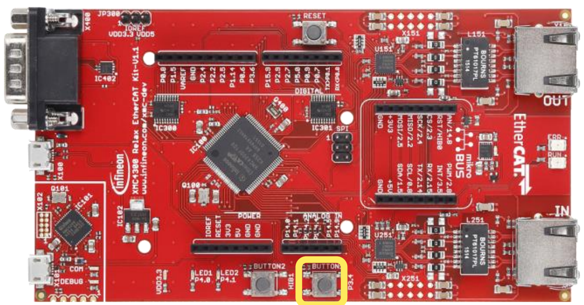
2 EtherCAT master view: Online status of master shows the slave in OP state. Cyclic counter is incrementing.

3 „XMC4300 Relax EtherCAT Kit“: RUN-LED is static turned on indicating OP-state.

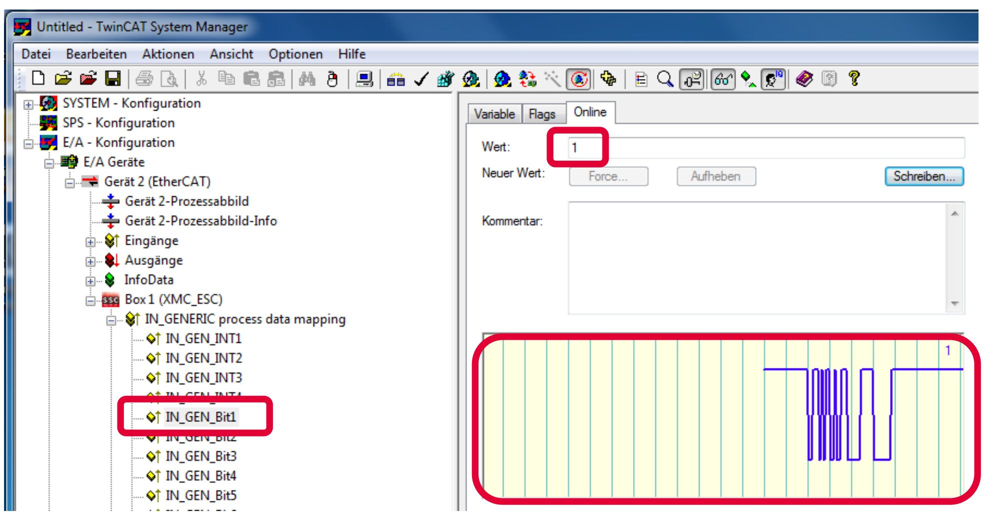
How to test – Monitoring slave inputs on master

ACTIONS

While pushing BUTTON1 on „XMC4300 Relax EtherCAT Kit“ the button state is updated on the host.



OBSERVATIONS

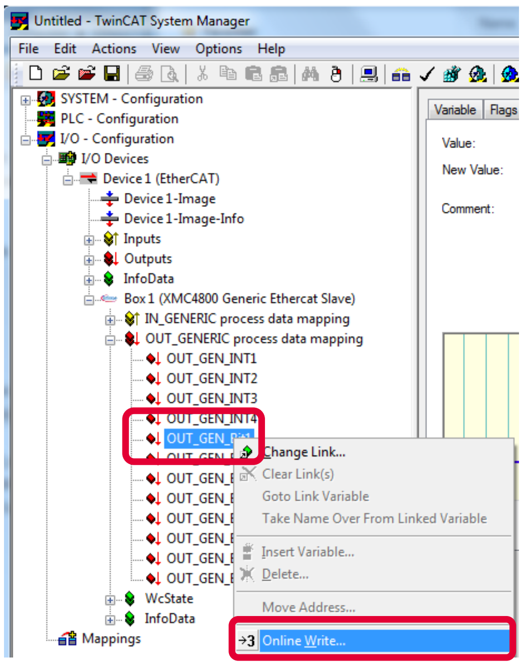


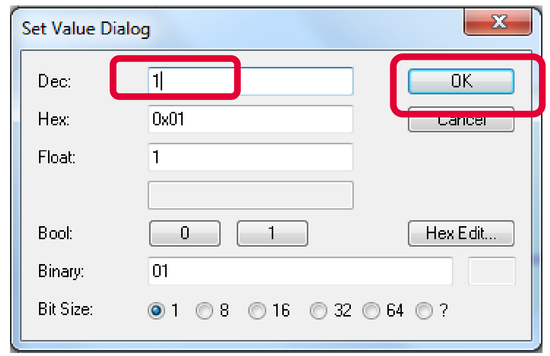
State of IN_GEN_Bit1 changes according to the state of BUTTON1.

How to test – Setting slave outputs on master (1/2)

ACTIONS

Right click on OUT_GEN_Bit1 of the slave node and select „Online Write…“ inside the context menu. Change the value from 0 to 1 to switch on LED1 from 1 to 0 to switch off LED1.





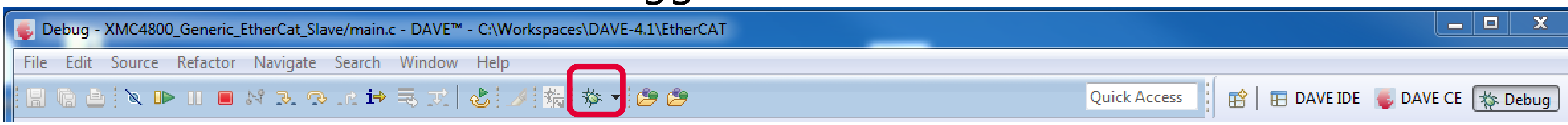
OBSERVATION

LED1 „XMC4300 Relax EtherCAT Kit“ is turned on/off according to OUT_GEN_Bit1 setting.

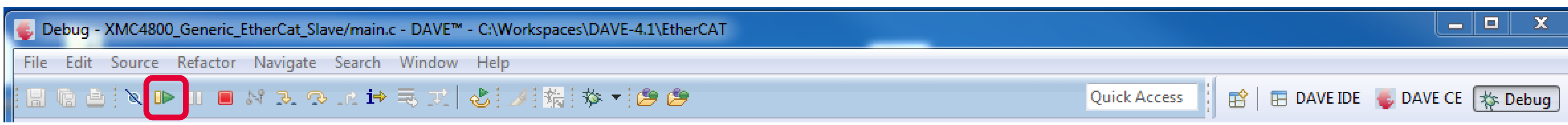
How to test – start the slave to run

ACTIONS

1. Build and download the example application software to the XMC4300 and start the debugger



2. Start the software by the run button

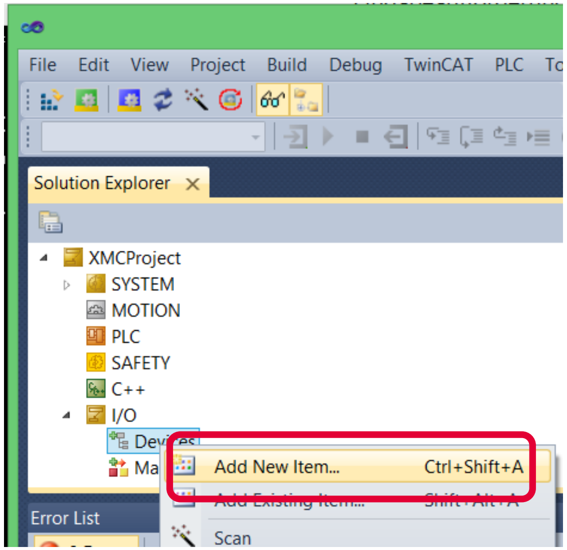


OBSERVATIONS

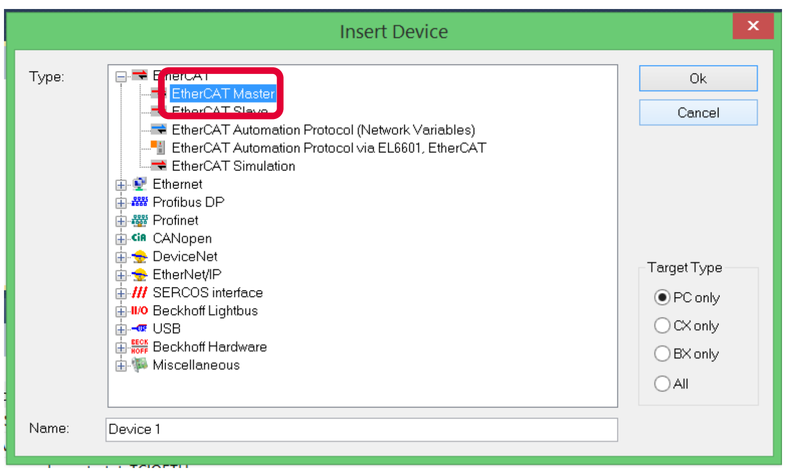
1. The ERR-LED on the "XMC4300 Relax EtherCAT Kit" will turn on and immediately turn off again.

How to test – start the TwinCAT 3 master to run (1/4)

1



2



ACTIONS

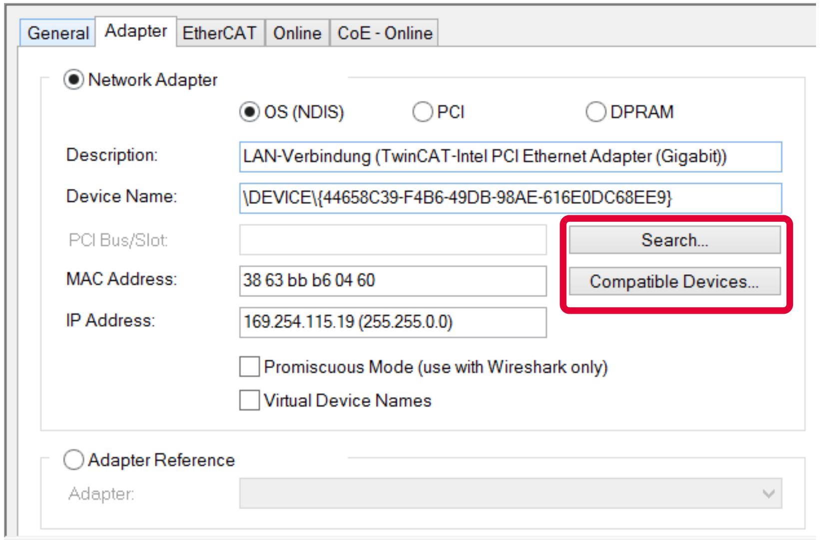
After starting the TwinCAT System Manager from windows start menu:

1 Right Click I/O-Devices and select „Add New Item…"

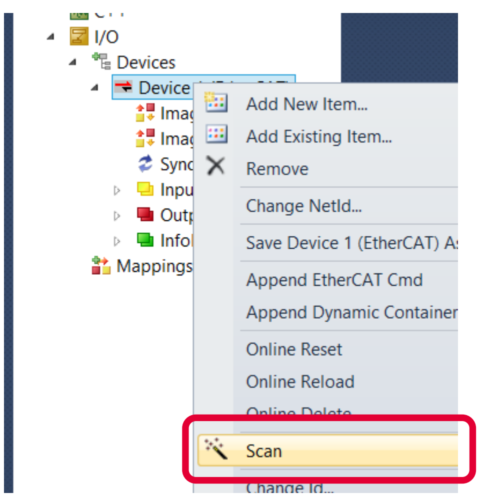
2 Create an EtherCAT master device by double click

How to test – start the TwinCAT 3 master to run (2/4)

3



4



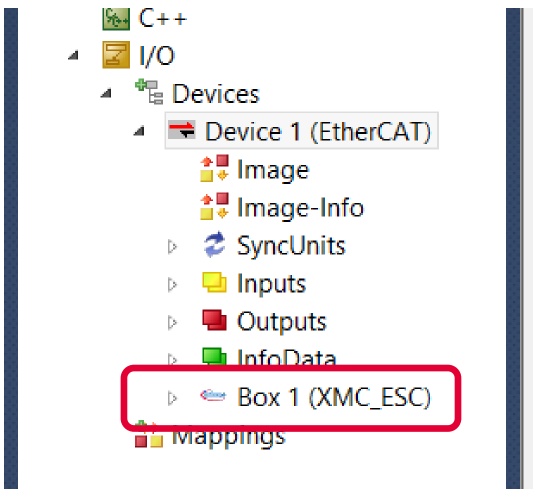
ACTIONS

3 Select the network adapter you want to use (search and select).
Application hint:
In case the device is not found please install the respective device driver by following the instructions given by TwinCAT through the „Compatible Devices…“ button.

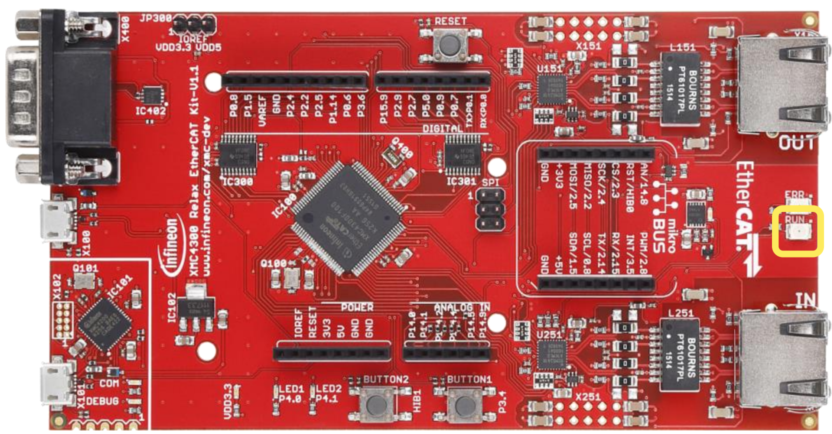
4 Right Click EtherCAT master and select „Scan Boxes…“

How to test – start the TwinCAT 3 master to run (3/4)

1



2



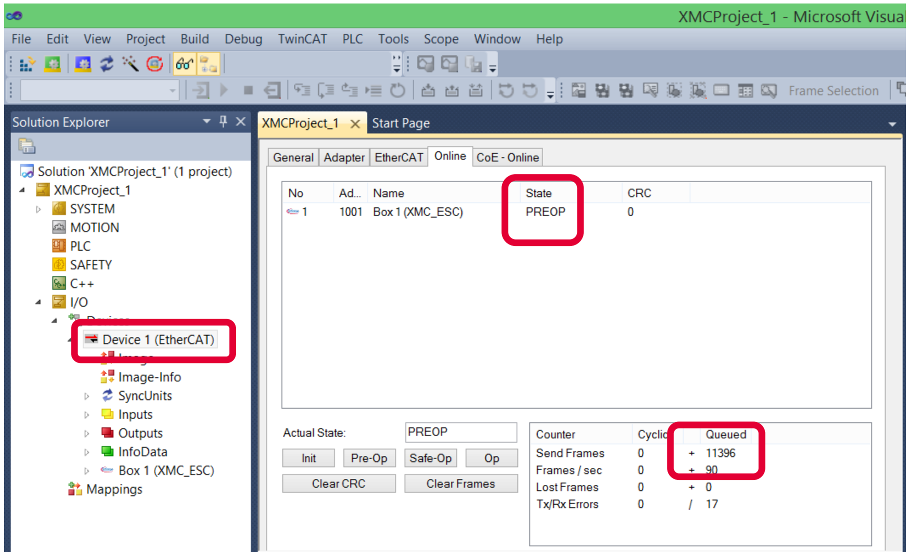
OBSERVATIONS

1 The slave appears as a node on the EtherCAT master bus.

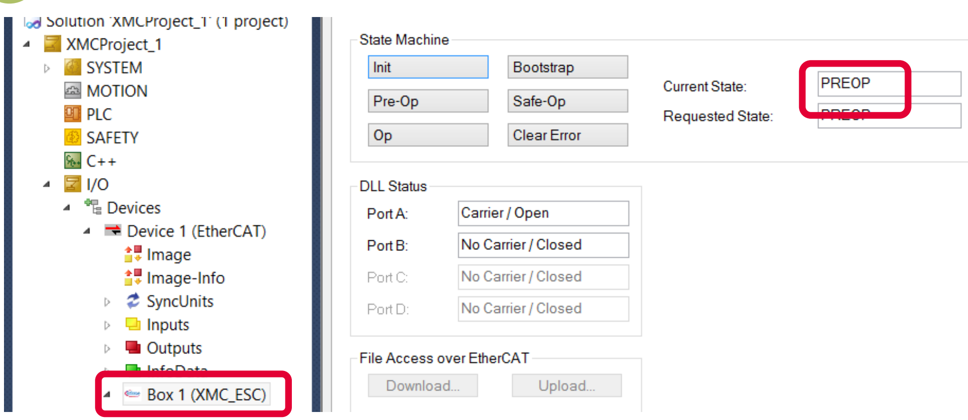
2 The RUN-LED is flashing indicating PREOP-state

How to test – start the TwinCAT 3 master to run (4/4)

3



4



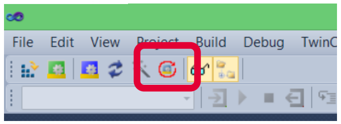
OBSERVATIONS

3 EtherCAT master view: Inside the EtherCAT master online state you see the queued frames counting up, the connected slave and its PREOP state.

4 EtherCAT slave view: The PREOP-state of the slave is indicated within the TwinCAT system manager .

How to test – Setting slave to operational mode

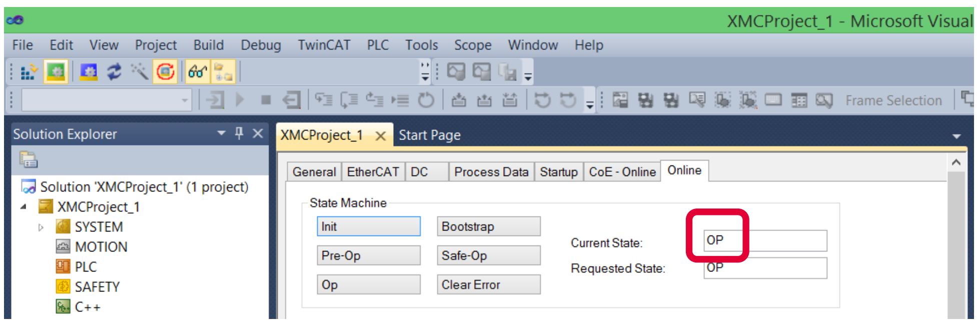
ACTION



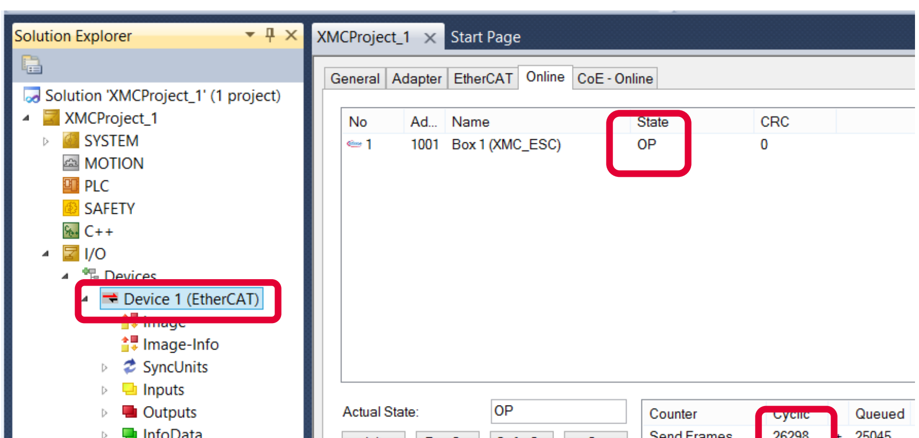
Set master device to free run mode

OBSERVATIONS

1



2



1 EtherCAT slave view: Online status of slave shows the slave in OP state

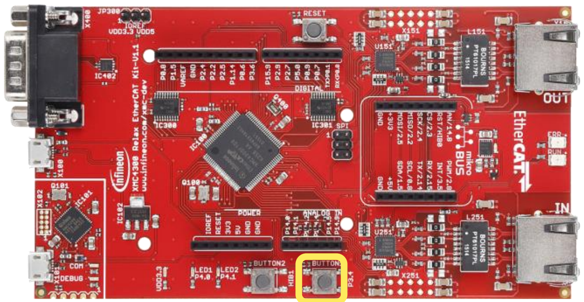
2 EtherCAT master view: Online status of master shows the slave in OP state. Frames are no more queued. Cyclic counter is incrementing.

3 „XMC4300 Relax EtherCAT Kit“: RUN-LED is static turned on indicating OP-state.

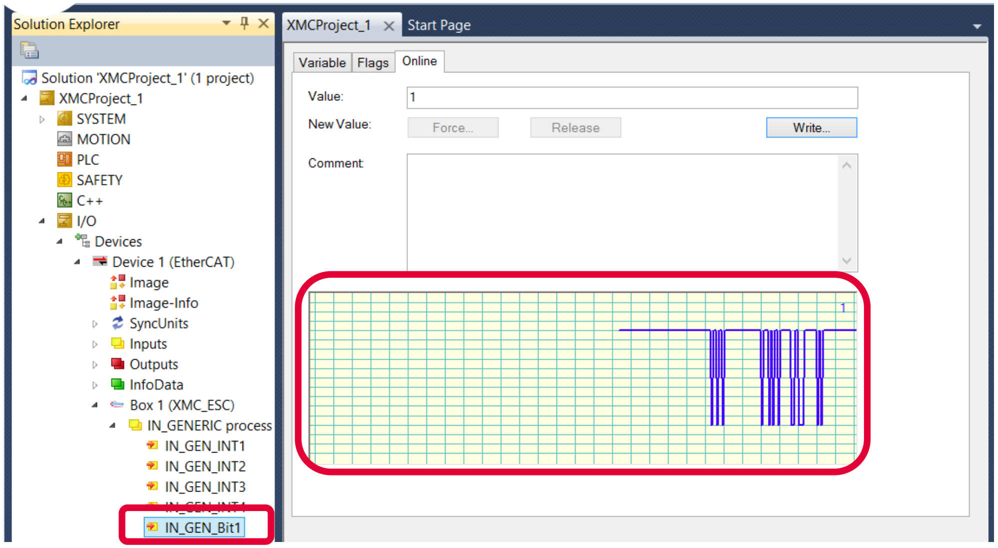
How to test – Monitoring slave inputs on master

ACTIONS

While pushing BUTTON1 on „XMC4300 Relax EtherCAT Kit“ the button state is updated on the host.



OBSERVATIONS

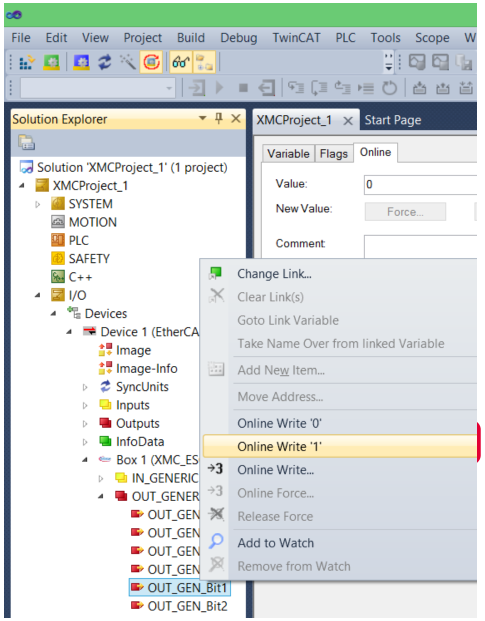


State of IN_GEN_Bit1 changes according to the state of BUTTON1.

How to test – Setting slave outputs on master (1/2)

ACTIONS

Right click on OUT_GEN_Bit1 of the slave node and select „Online Write…“ inside the context menu. Change the value from 0 to 1 to switch on LED1 from 1 to 0 to switch off LED1.



OBSERVATION

LED1 „XMC4300 Relax EtherCAT Kit“ is turned on/off according to OUT_GEN_Bit1 setting.

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