Control III Programming in C (small PLC)

Description of the commands

Revision date: 2013-02-21

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1. Symbol Catalog

Information!

This symbol indicates important information.

2. General

2.1 Product information

Control III performs all the tasks of a powerful small PLC and allows you to pre-process all sensor and actuator information.

2.2 Introduction

Control III, the AS-i Master PLC functionality integrated into the AS-i Master works together with standard AS-i I/O modules to form a small PLC with up to 248 in- and outputs per AS-i circuit, or up to 496 I/Os in a dual master. Standard C is used for all programming tasks of the small PLC.

Use of **Control III** in the gateways makes it possible to preprocess the sensor/actuator information. Typical applications include preprocessing of data as well as rapid execution of time-critical operations directly in the gateway.

The program for **Control III** is created on a standard PC and then uploaded to the AS-i master. A specially created Eclipse version (IDE) is provided as the programming tool. This includes all the tools needed for creating and testing the **Control III** program.

Control III is written in the widely used and very powerful “C” programming language. Various library functions serve to assist you and make programming easier.

The **Control III** program is loaded through one of the ports on the gateway and stored non-volatile in flash memory.

3 Safety

3.1 Intended use

Warning!

This symbol warns of a possible danger. The protection of operating personnel and the system against possible danger is not guaranteed if the control interface unit is not operated in accordance to its intended use.

3.2 General safety information

Warning!

Safety and correct functioning of the device cannot be guaranteed if any operation other than described in this operation manual is performed. Connecting the equipment and conducting any maintenance work under power must exclusively be performed by appropriately qualified personnel. In case a failure cannot be eliminated, the device must be taken out of operation and inadvertently operation must be prevented. Repair work must be performed by the manufacturer only. Additions or modifications to the equipment are not permitted and will void the warranty.

Information!

The operator is responsible for the observation of local safety standards.

3.3 Disposal

Information!

Electronic waste is hazardous waste. Please comply with all local ordinances when disposing this product!

The device does not contain batteries that need to be removed before disposing it.

4 Programming Control III

Programming of **Control III** is based on the widely-used and highly modular programming language ‘C’. To create a Control III program, all the tasks that the gateway must assume must be written in ‘C’ and loaded into the gateway.

To program with **Control III**, the header file ‘control.h’ contains a series of library functions which can be used for running certain master functions. These functions are listed and explained in the following.

4.1 Overview

`AASiDataExchange`	AS-i Data Exchange is used for exchanging AS-i data and reads the ‘execution control’ flags.
`AASiReadIDI`	Reads the slave input data and the ‘execution control’ flags.
`AASiWriteODI`	Writes the slave output data.
`AASiReadODI`	Reads the output data from the AS-i master.
`AASiWritePP`	Writes the permanent parameters of a slave in the master.
`AASiReadPP`	Reads the permanent parameters of a slave in the master.
`AASiSendParameter`	Sends the parameters to a slave.
`AASiReadPI`	Reads the current parameters of a slave
`AASiStorePI`	Stores the current slave parameters as permanent parameters.
`AASiReadDuplicateAdrList`	Reads the list of all duplicate addresses.
`AASiReadFaultDetector`	Reads overvoltage, noise, EFLT and duplicate addresses.
`AASiWritePCD`	Writes the projected configuration of a slave.
`AASiReadPCD`	Reads the projected configuration of a slave.
`AASiStoreCDI`	Stores the current configuration as a permanent configuration.
`AASiReadCDI`	Reads the current configuration of a slave.
`AASiWriteExtID1`	Writes the extended ID code 1 of Slave 0.
`AASiWriteLPS`	Writes the projected slave.
`AASiReadLPS`	Reads the projected slaves.
`AASiReadLAS`	Reads the activated slaves
`AASiReadLDS`	Reads the detected slaves.
`AASiReadLCS`	Reads all defective slaves.
`AASiWriteLOS`	List of the slaves which should go offline when there is a configuration error.
`AASiReadLOS`	Reads the list of the slaves which should go offline when there is a configuration error.
`AASiReadLPF`	Reads the list of slaves having a peripheral error.

AASiReadEcFlags	Reads the 'execution control' flags
AASiSetConfigMode	Sets the AS-i master to Configuration mode or to protected operating mode.
AASiWriteHiFlags	Writes the Host-Interface-Flags of the AS-i Master.
AASiReadHiFlags	Reads the Host-Interface-Flags of the AS-i Master.
AASiAddressSlave	Changes the address of a slave.
AASiExecuteCommand	AS-Interface command to be sent directly.
AASiReadAllConfig	Reads all configuration data (e.g. LPS, PP[ ] and PCD [ ]) for all connected slaves.
AASiWriteAllConfig	Writes all configuration data (e.g. LPS, PP[ ] and PCD [ ]) for all connected slaves.
AASiReadErrorCounters	Reads the Slave-Error-Counter
AASiMailbox	Generic Mailbox function.
AASiWrite16BitODI	Writes four channels of 16-bit ODI to an AS-i-Slave having e.g. Analog-Slave profile 7.3 or 7.4.
AASiRead16BitODI	Reads four channels of 16-bit ODI to an AS-i-Slave having e.g. Analog-Slave profile 7.3 or 7.4.
AASiRead16BitIDI	Reads four 16-bit IDI channels of an AS-i slave having e.g. Analog-Slave profile 7.3 or 7.4.
AASiReadCtrlAccODI	Reads the Control III authorization in order to change output data.
AASiWriteCtrlAccODI	Writes the Control III authorizations of the slave in order to change output data.
AASiReadCtrlAccAODI	Reads the Control III authorization in order to change analog output data.
AASiWriteCtrlAccAODI	Writes the Control III authorizations of the slave in order to change analog output data.
CCtrlInitTimer	Initialization of a timer function
CCtrlDelay	Delay in ms
CCtrlInitWdg	Initialization of the Control III watchdog
CCtrlTriggerWdg	Trigger Control III Watchdog.
CCtrlEvalCycletime	Evaluates the Control III cycle time.
CCtrlReadParameter	Reads Control NV-Parameter.
CCtrlWriteParameter	Writes Control NV-Parameter.
CCtrlReadFlags	Reads Control-Flags.
CCtrlWriteFlags	Writes Control-Flags.
CCtrlReadkey	Reads user-defined unique control key.
CCtrlPrintf	Printf function
CCtrlBreakpoint	Initializes the Debugger
CCtrlDisplay	Control III display function

4.1.1 ASi Data Exchange

AS-i Data Exchange is used for exchanging AS-i data between the master and the application and reads the ‘execution control’ flags.

```
int (*AASiDataExchange) (unsigned char Circuit, AASiProcessData
ODI, AASiProcessData IDI, AASiEcFlags *EcFlags);
```

Parameter:

`Circuit:`	AS-i Master circuit
`ODI:`	32 bytes output data

Return:

`IDI:`	32 bytes input data
`EcFlags:`	Execution control flags (2 Bytes) of the AS-i Master.

AS-i circuit 1 / 2 : Input data image IDI

Bit	7	6	5	4	3	2	1	0	Bit	7	6	5	4	3	2	1	0
Byte	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**	**Byte**	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**
0	Slave 1/1A				Slave 0/0A				1	Slave 3/3A				Slave 2/2A			
2	Slave 5/5A				Slave 4/4A				3	Slave 7/7A				Slave 6/6A			
4	Slave 9/9A				Slave 8/8A				5	Slave 11/11A				Slave 10/10A			
6	Slave 13/13A				Slave 12/12A				7	Slave 15/15A				Slave 14/14A			
8	Slave 17/17A				Slave 16/16A				9	Slave 19/19A				Slave 18/18A			
10	Slave 21/21A				Slave 20/20A				11	Slave 23/23A				Slave 22/22A			
12	Slave 25/25A				Slave 24/24A				13	Slave 27/27A				Slave 26/26A			
14	Slave 29/29A				Slave 28/28A				15	Slave 31/31A				Slave 30/30A			
16	Slave 1/1B				Slave 0/0B				17	Slave 3/3B				Slave 2/2B			
18	Slave 5/5B				Slave 4/4B				19	Slave 7/7B				Slave 6/6B			
20	Slave 9/9B				Slave 8/8B				21	Slave 11/11B				Slave 10/10B			
22	Slave 13/13B				Slave 12/12B				23	Slave 15/15B				Slave 14/14B			
24	Slave 17/17B				Slave 16/16B				25	Slave 19/19B				Slave 18/18B			
26	Slave 21/21B				Slave 20/20B				27	Slave 23/23B				Slave 22/22B			
28	Slave 25/25B				Slave 24/24B				29	Slave 27/27B				Slave 26/26B			
30	Slave 29/29B				Slave 28/28B				31	Slave 31/31B				Slave 30/30B			

Tab. 4-1. Input data image IDI

AS-i circuit 1 / 2 : Output data image ODI

Bit	7	6	5	4	3	2	1	0	Bit	7	6	5	4	3	2	1	0
Byte	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**	**Byte**	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**
0	Slave 1/1A				Slave 0/0A				1	Slave 3/3A				Slave 2/2A			
2	Slave 5/5A				Slave 4/4A				3	Slave 7/7A				Slave 6/6A			
4	Slave 9/9A				Slave 8/8A				5	Slave 11/11A				Slave 10/10A			
6	Slave 13/13A				Slave 12/12A				7	Slave 15/15A				Slave 14/14A			
8	Slave 17/17A				Slave 16/16A				9	Slave 19/19A				Slave 18/18A			
10	Slave 21/21A				Slave 20/20A				11	Slave 23/23A				Slave 22/22A			
12	Slave 25/25A				Slave 24/24A				13	Slave 27/27A				Slave 26/26A			
14	Slave 29/29A				Slave 28/28A				15	Slave 31/31A				Slave 30/30A			
16	Slave 1/1B				Slave 0/0B				17	Slave 3/3B				Slave 2/2B			
18	Slave 5/5B				Slave 4/4B				19	Slave 7/7B				Slave 6/6B			
20	Slave 9/9B				Slave 8/8B				21	Slave 11/11B				Slave 10/10B			
22	Slave 13/13B				Slave 12/12B				23	Slave 15/15B				Slave 14/14B			
24	Slave 17/17B				Slave 16/16B				25	Slave 19/19B				Slave 18/18B			
26	Slave 21/21B				Slave 20/20B				27	Slave 23/23B				Slave 22/22B			
28	Slave 25/25B				Slave 24/24B				29	Slave 27/27B				Slave 26/26B			
30	Slave 29/29B				Slave 28/28B				31	Slave 31/31B				Slave 30/30B			

Tab. 4-2. Output data image ODI

4.1.2 AS-i Read IDI

AS-i Read IDI reads the input data from slaves and the execution control flags.

```
int (*AASiReadIDI) (unsigned char Circuit, AASiProcessData IDI,
AASiSlaveAddr First, unsigned char Amount, AASiEcFlags
*EcFlags);
```

Parameter:

`Circuit:`	AS-i Master circuit
`First:`	Index of the first slaves
`Amount:`	Number of slaves to read

Return:

`IDI:`	32 bytes input data Each slave uses 4 bits (nibble) of a byte. Unused bytes are set to null
`EcFlags:`	Execution control flags (2 Bytes) of the AS-i master

4.1.3 AS-i Write ODI

AS-i Write ODI writes the output data from slaves.

```
int (*AASiWriteODI) (unsigned char Circuit, AASiProcessData ODI,
AASiSlaveAddr First, unsigned char Amount);
```

Parameter:

`Circuit:`	AS-i Master circuit
`ODI:`	32 bytes output data
`First:`	Index of the first slave
`Amount:`	Number of slaves to be written

Each slave uses 4 bits (nibble) of a byte. Unused bytes are set to null.

Return: —

4.1.4 AS-i Read ODI

AS-i Read ODI reads the output data from the AS-i Master.

```
int (*AASiReadODI) (unsigned char Circuit, AASiProcessData ODI);
```

Parameter:

`Circuit`	AS-i Master circuit

Return:

`ODI:`	32 bytes output data Each slave uses 4 bits (nibble) of a byte. Unused bytes are set to null.

4.1.5 AS-i Write Permanent Parameter

AS-i Write Permanent Parameter writes the permanent parameters of a slave in the Master.

```
int (*AASiWritePP) (unsigned char Circuit, AASiSlaveAddr
Address, AASiSlaveData PP);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`PP:`	Permanent Parameters (low Nibble)

Return: —

4.1.6 AS-i Read Permanent Parameter

AS-i Read Permanent Parameter reads the permanent parameters of a slave in the Master.

```
int (*AASiReadPP) (unsigned char Circuit, AASiSlaveAddr Address,
AASiSlaveData *PP);
```

Parameter

`Circuit:`	AS-i Master circuit
`Address:`	Slave address

Return:

`PP:`	Permanent parameters (low nibble)

4.1.7 AS-i Send Parameter

AS-i Send Parameter sends the parameters to a slave.

```
int (*AASiSendParameter) (unsigned char Circuit, AASiSlaveAddr
Address, AASiSlaveData PI, AASiSlaveData *Return);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`PI:`	Parameters to be sent (low Nibble)

Return:

`Return:`	In case of error PI is returned inverted. .

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4.1.8 AS-i Read PI

AS-i Read PI reads the current parameters of a slave.

```
int (*AASiReadPI) (unsigned char Circuit, AASiSlaveAddr Address,
AASiSlaveData *PI);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address

Return:

`PI:`	Parameters to be sent (low Nibble)

4.1.9 AS-i Store PI

AS-i Store PI stores the current slave parameters as permanent parameters.

```
int (*AASiStorePI) (unsigned char Circuit);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address

Return: —

4.1.10 AS-i Read Duplicate Address List

AS-i Read Duplicate Address List reads the list of all duplicate addresses.

```
int (*AASiReadDuplicateAdrList) (unsigned char Circuit,
AASiSlaveList, *DpAdrList);
```

Parameter:

`Circuit:`	AS-i Master circuit

Return:

`DpAdrList:`	List of duplicate addresses

4.1.11 AS-i Read Fault Detector

AS-i Read Fault Detector reads overvoltage, noise, EFLT and duplicate addresses.

```
int (*AASiReadFaultDetector) (unsigned char Circuit,
unsigned char *pucFaultDetectorActiv,
unsigned char *pucFaultDetectorHistoric);
```

Parameter:

`Circuit:`	AS-i Master circuit

Return:

`PucFaultDetectorActiv:`	Active fault detector
`PucFaultDetectorHistoric:`	Historic fault detector

4.1.12 AS-i Write PCD

AS-i Write PCD writes the projected configuration of a slave.

```
int (*AASiWritePCD) (unsigned char Circuit, AASiSlaveAddr
Address, AASiConfigData PCD);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address

Return:

`PCD:`	Projected slave configuration to be written

Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**
0	Slave ID				I/O Configuration			
1	Extended ID2				Extended ID1			

Tab. 4-3. PCD configuration

4.1.13 AS-i Read PCD

AS-i Read PCD reads the projected configuration of a slave.

```
int (*AASiReadPCD) (unsigned char Circuit, AASiSlaveAddr
Address, AASiConfigData *PCD);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address

Return:

`PCD:`	Projected Slave configuration (see Tab. <PCD configuration>).

4.1.14 AS-i Store CDI

AS-i Store CDI stores the current configuration as a permanent configuration.

```
int (*AASiStoreCDI) (unsigned char Circuit);
```

Parameter:

`Circuit:`	AS-i Master circuit

4.1.15 AS-i Read CDI

AS-i Read CDI reads the current configuration of a slave.

```
int (*AASiReadCDI) (unsigned char Circuit, AASiSlaveAddr
Address, AASiConfigData *CDI);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address

Return:

`CDI:`	Slave configuration

Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**
0	Slave ID				I/O Configuration			
1	Extended ID2				Extended ID1			

Tab. 4-4. CDI configuration

4.1.16 AS-i Write Extended ID1

AS-i Write Extended ID1 writes the extended ID-Code 1 von Slave 0.

```
int (*AASiWriteExtID1) (unsigned char Circuit, AASiSlaveData
ID1);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`ID1:`	Extended ID-Code 1

Return:

Special error codes which describe the reason for the faulty transmission.

4.1.17 AS-i Write LPS

AS-i Write LPS writes the projected slaves.

```
int (*AASiWriteLPS) (unsigned char Circuit, AASiSlaveList LPS);
```

Parameter:

`Circuit:`	AS-i Master circuit
`LPS:`	8-byte Slave list

Each bit in the LPS corresponds to a slave as follows:

Bit	Slave	Bit	Slave	Bit	Slave	Bit	Slave
0	Slave 0/0A cannot be set!	16	Slave 16/16A	32	Slave 0/0B cannot be set!	48	Slave 16/16B
1	Slave 1/1A	17	Slave 17/17A	33	Slave 1/1B	49	Slave 17/17B
2	Slave 2/2A	18	Slave 18/18A	34	Slave 2/2B	50	Slave 18/18B
3	Slave 3/3A	19	Slave 19/19A	35	Slave 3/3B	51	Slave 19/19B
4	Slave 4/4A	20	Slave 20/20A	36	Slave 4/4B	52	Slave 20/20B
5	Slave 5/5A	21	Slave 21/21A	37	Slave 5/5B	53	Slave 21/21B
6	Slave 6/6A	22	Slave 22/22A	38	Slave 6/6B	54	Slave 22/22B
7	Slave 7/7A	23	Slave 23/23A	39	Slave 7/7B	55	Slave 23/23B
8	Slave 8/8A	24	Slave 24/24A	40	Slave 8/8B	56	Slave 24/24B
9	Slave 9/9A	25	Slave 25/25A	41	Slave 9/9B	57	Slave 25/25B
10	Slave 10/10A	26	Slave 26/26A	42	Slave 10/10B	58	Slave 26/26B
11	Slave 11/11A	27	Slave 27/27A	43	Slave 11/11B	59	Slave 27/27B
12	Slave 12/12A	28	Slave 28/28A	44	Slave 12/12B	60	Slave 28/28B
13	Slave 13/13A	29	Slave 29/29A	45	Slave 13/13B	61	Slave 29/29B
14	Slave 14/14A	30	Slave 30/30A	46	Slave 14/14B	62	Slave 30/30B
15	Slave 15/15A	31	Slave 31/31A	47	Slave 15/15B	63	Slave 31/31B

Tab. 4-5. LPS

The slave is projected if the bit is set.

4.1.18 AS-i Read LPS

AS-i Read LPS reads the projected slaves.

```
int (*AASiReadLPS) (unsigned char Circuit, AASiSlaveList *LPS);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`LPS:` 8-byte slave list (see Tab. <LPS>)

The slave is projected if the bit is set.

4.1.19 AS-i Read LAS

AS-i Read LAS reads the activated slaves.

```
int (*AASiReadLAS) (unsigned char Circuit, AASiSlaveList *LAS);
```

Parameter:

`Circuit:` AS-i Master circuit

`LAS:` 8-byte slave list

Each bit in the LAS corresponds to a slave.

Bit	Slave	Bit	Slave	Bit	Slave	Bit	Slave
0	Slave 0/0A	16	Slave 16/16A	32	Slave 0/0B	48	Slave 16/16B
1	Slave 1/1A	17	Slave 17/17A	33	Slave 1/1B	49	Slave 17/17B
2	Slave 2/2A	18	Slave 18/18A	34	Slave 2/2B	50	Slave 18/18B
3	Slave 3/3A	19	Slave 19/19A	35	Slave 3/3B	51	Slave 19/19B
4	Slave 4/4A	20	Slave 20/20A	36	Slave 4/4B	52	Slave 20/20B
5	Slave 5/5A	21	Slave 21/21A	37	Slave 5/5B	53	Slave 21/21B
6	Slave 6/6A	22	Slave 22/22A	38	Slave 6/6B	54	Slave 22/22B
7	Slave 7/7A	23	Slave 23/23A	39	Slave 7/7B	55	Slave 23/23B
8	Slave 8/8A	24	Slave 24/24A	40	Slave 8/8B	56	Slave 24/24B
9	Slave 9/9A	25	Slave 25/25A	41	Slave 9/9B	57	Slave 25/25B
10	Slave 10/10A	26	Slave 26/26A	42	Slave 10/10B	58	Slave 26/26B
11	Slave 11/11A	27	Slave 27/27A	43	Slave 11/11B	59	Slave 27/27B
12	Slave 12/12A	28	Slave 28/28A	44	Slave 12/12B	60	Slave 28/28B
13	Slave 13/13A	29	Slave 29/29A	45	Slave 13/13B	61	Slave 29/29B
14	Slave 14/14A	30	Slave 30/30A	46	Slave 14/14B	62	Slave 30/30B
15	Slave 15/15A	31	Slave 31/31A	47	Slave 15/15B	63	Slave 31/31B

Tab. 4-6. LAS, LDS, LOS and LPF

The slave is activated if the bit is set.

4.1.20 AS-i Read LDS

AS-i Read LDS reads the detected slaves laves.

```
int (*AASiReadLDS) (unsigned char Circuit, AASiSlaveList *LDS);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`LDS:` 8-byte slave list

Each bit in the LDS corresponds to a slave (see Tab. <LAS, LDS, LOS and LPF>).

4.1.21 AS-i Read LCS

AS-i Read LCS reads all faulty slaves.

```
int (*AASiReadLCS) (unsigned char Circuit, AASiSlaveList *LCS);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`LCS:` 8-byte slave list

Each bit in the LCS corresponds to a slave (see Tab. <LAS, LDS, LOS and LPF>).

Information!

The list is reset after reading!

4.1.22 AS-i Write LOS

AS-i Write LOS writes the list of those slaves which should go offline when there is a configuration error.

```
int (*AASiWriteLOS) (unsigned char Circuit, AASiSlaveList LOS);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`LOS:` 8-byte slave address list

Each bit in the LOS corresponds to a slave (see Tab. <LAS, LDS, LOS and LPF>).

4.1.23 AS-i Read LOS

AS-i Write LOS reads the list of those slaves which should go offline when there is a configuration error.

```
int (*AASiReadLOS) (unsigned char Circuit, AASiSlaveList *LOS);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`LOS:` 8-byte slave address list

Each bit in the LOS corresponds to a slave (see Tab. <LAS, LDS, LOS and LPF>).

4.1.24 AS-i Read LPF

AS-i Read LPF reads the list of slaves with a peripheral error.

```
int (*AASiReadLPF) (unsigned char Circuit, AASiSlaveList *LPF);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`LPF:` 8-byte slave address list

Each bit in the LPS corresponds to a slave (see Tab. <LAS, LDS, LOS and LPF>).

4.1.25 AS-i Read Ec Flags

AS-i Read Ec Flags reads the execution control flags.

```
int (*AASiReadEcFlags) (unsigned char Circuit, AASiEcFlags
*EcFlags);
```

Parameter:

`Circuit:` AS-i Master circuit

Return:

`EcFlags:` Two-byte EcFlags.

4.1.26 AS-i set Config Mode

AS-i set Config Mode sets the AS-i Master to Configuration mode or to protected operating mode.

```
int (*AASiSetConfigMode) (unsigned char Circuit, unsigned char
Mode);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Mode:`	1 = Configuration mode
	0 = Protected operating mode

Return: —

4.1.27 AS-i Write Hi Flags

AS-i Write Hi Flags writes Host-Interface-Flags of the AS-i master.

```
int (*AASiWriteHiFlags) (unsigned char Circuit, AASiHiFlags
HiFlags);
```

Parameter:

`Circuit:`	AS-i Master circuit
`HiFlags:`	Host-Interface-Flags (one byte)

Return: —

4.1.27.1 AS-i Read Hi-Flags

AS-i Read Hi-Flags reads the Host-Interface-Flags of the AS-i master.

```
int (*AASiReadHiFlags) (unsigned char Circuit, AASiHiFlags
*HiFlags);
```

Parameter:

`Circuit:`	AS-i Master circuit

Return:

`HiFlags:`	Host-Interface-Flags (one byte)

4.1.28 AS-i Address Slave

AS-i Address Slave changes the address of a slave.

```
int (*AASiAddressSlave) (unsigned char Circuit, AASiSlaveAddr
OldAddress, AASiSlaveAddr NewAddress);
```

Parameter:

`Circuit:`	AS-i Master circuit
`OldAddress:`	Old slave address
`NewAddress:`	New slave address

Return:

Special error codes which describe the reason for the defective transmission.

4.1.29 AS-i Execute Command

AS-i Execute Command is an AS-i command to be sent directly.

```
int (*AASiExecuteCommand) (unsigned char Circuit, AASiSlaveAddr
Address, AASiSlaveData Request, AASiSlaveData *Response);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`Request:`	AS-i Request command

Return:

`Response:`	AS-i Request

4.1.30 AS-i Read All Config

AS-i Read All Config reads all configuration data (e.g. LPS, PP[ ] and PCD [ ]) for all connected slaves.

```
int (*AASiReadAllConfig) (unsigned char Circuit, AASiConfig
*Configurations );
```

Parameter:

`Circuit:`	AS-i Master circuit
`Configurations:`	Array for recording the configuration data

Return:

The configuration data in Configurations [ ]

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4.1.31 AS-i Write All Config

AS-i Write All Config writes all configuration data (e.g. LPS, PP[ ] and PCD [ ]) for all connected slaves.

```
int (*AASiWriteAllConfig) (unsigned char Circuit, AASiConfig
Configurations);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Configurations:`	Array for recording the configuration data

Return: —

4.1.32 AS-i read Error Counter

AS-i read Error Counter reads the Slave-Error-Counter.

```
int (*AASiReadErrorCounters) (unsigned char Circuit,
AASiErrorCounters Counters);
```

Parameter:

`Circuit:`	AS-i Master circuit

Return:

`Counters:`	64 bytes (one byte per slave)

Information!

The list is reset after reading!

4.1.33 AS-i Mail Box

Generic Mailbox function

```
int (*AASiMailbox) (unsigned char Circuit, AASiMbRequestType
Request, int ExpResLen, AASiMbResponseType *Response);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Request:`	Structure for Mailbox query
`ExpResLen:`	Expected length of the response (-1 = unknown)

Return:

`Response:`	Structure for Mailbox response

4.1.34 AS-i Write 16-bit ODI

AS-i Write 16Bit ODI writes four 16-bit ODI channels of an AS-i slave having e.g. Analog-Slave-Profile 7.3 or 7.4.

```
int (*AASiWrite16BitODI) (unsigned char Circuit, AASiSlaveAddr
Address, AASi16BitData Out);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`ExpResLen:`	Expected length of the response (-1 = unknown)
`Out:`	4 channels with 16-bit values Word 0 : Channel 1 Word 1 : Channel 2 Word 2 : Channel 3 Word 3 : Channel 4

Return:—

4.1.35 AS-i Read 16Bit ODI

AS-i Read 16Bit ODI reads four 16-bit ODI channels of an AS-i slave having e.g. Analog-Slave-Profile 7.3 or 7.4.

```
int (*AASiRead16BitODI) (unsigned char Circuit, AASiSlaveAddr
Address, AASi16BitData In);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`In:`	4 channels with 16-bit values Word 0 : Channel 1 Word 1 : Channel 2 Word 2 : Channel 3 Word 3 : Channel 4

4.1.36 AS-i Read 16Bit IDI

AS-i Read 16Bit IDI reads four 16-bit ODI channels of an AS-i slave having e.g. Analog-Slave-Profile 7.3 or 7.4.

```
int (*AASiRead16BitIDI) (unsigned char Circuit, unsigned char
Address, AASi16BitData In);
```

Parameter:

`Circuit:`	AS-i Master circuit
`Address:`	Slave address
`In:`	4 channels with 16-bit values Word 0 : Channel 1 Word 1 : Channel 2 Word 2 : Channel 3 Word 3 : Channel 4

4.1.37 AS-i Read Ctrl Acc ODI

AS-i Read Ctrl Acc ODI reads the Control III authorizations for writing slave output data.

```
int (*AASiReadCtrlAccODI) (unsigned char Circuit,
AASiCtrlAccODI ODI );
```

Parameter:

`Circuit:`	AS-i Master circuit

Return:

`ODI:`	32 bytes Ctrl access data

4.1.38 AS-i Write Ctrl Acc ODI

AS-i Write Ctrl Acc ODI writes the Control III slave authorizations for changing output data.

```
int (*AASiWriteCtrlAccODI) (unsigned char Circuit,
AASiCtrlAccODI ODI, AASiSlaveAddr First, unsigned char Amount);
```

Parameter:

`Circuit:`	AS-i Master circuit
`ODI:`	32 bytes Ctrl access data
`First:`	Index of the first slave
`Amount:`	Number of slaves following the first

Return:—

4.1.39 AS-i Read Ctrl Acc AODI

AS-i Read Ctrl Acc AODI reads the Control III authorizations for writing analog slave output data.

```
int (*AASiReadCtrlAccAODI) (unsigned char Circuit,
AASiCtrlAccAODI AODI);
```

Parameter:

`Circuit:`	AS-i Master circuit

Return:

`AODI:`	16 bytes output data Ctrl access

Bit	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Bit**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Channel	**3**	**2**	**1**	**0**	**3**	**2**	**1**	**0**	**Channel**	**3**	**2**	**1**	**0**	**3**	**2**	**1**	**0**
Byte	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**	**Byte**	**D3**	**D2**	**D1**	**D0**	**D3**	**D2**	**D1**	**D0**
0	Slave 1/1A				Slave 0/0A				1	Slave 3/3A				Slave 2/2A			
2	Slave 5/5A				Slave 4/4A				3	Slave 7/7A				Slave 6/6A			
4	Slave 9/9A				Slave 8/8A				5	Slave 11/11A				Slave 10/10A			
6	Slave 13/13A				Slave 12/12A				7	Slave 15/15A				Slave 14/14A			
8	Slave 17/17A				Slave 16/16A				9	Slave 19/19A				Slave 18/18A			
10	Slave 21/21A				Slave 20/20A				11	Slave 23/23A				Slave 22/22A			
12	Slave 25/25A				Slave 24/24A				13	Slave 27/27A				Slave 26/26A			
14	Slave 29/29A				Slave 28/28A				15	Slave 31/31A				Slave 30/30A			
16	Slave 1/1B				Slave 0/0B				17	Slave 3/3B				Slave 2/2B			
18	Slave 5/5B				Slave 4/4B				19	Slave 7/7B				Slave 6/6B			
20	Slave 9/9B				Slave 8/8B				21	Slave 11/11B				Slave 10/10B			
22	Slave 13/13B				Slave 12/12B				23	Slave 15/15B				Slave 14/14B			
24	Slave 17/17B				Slave 16/16B				25	Slave 19/19B				Slave 18/18B			
26	Slave 21/21B				Slave 20/20B				27	Slave 23/23B				Slave 22/22B			
28	Slave 25/25B				Slave 24/24B				29	Slave 27/27B				Slave 26/26B			
30	Slave 29/29B				Slave 28/28B				31	Slave 31/31B				Slave 30/30B			

Tab. 4-7. Output data image AODI

4.1.40 AS-i Write Ctrl Acc AODI

AS-i Write Ctrl Acc AODI writes the Control III slave authorizations for changing analog output data.

```
int (*AASiWriteCtrlAccAODI)( unsigned char Circuit, AASiCtrlAccAODI AODI, AASiSlaveAddr First, unsigned char Amount;
```

Parameter:

`Circuit:`	AS-i Master circuit
`AODI:`	16 bytes Ctrl access data (see Tab. <Output data image AODI>)
`First:`	Index of the first slave
`Amount:`	Number of slaves following the first

Return:—

4.1.41 Ctrl Init Timer

Initialization of a Timer Interrupt

```
int (*CCtrlInitTimer) (unsigned long ticks_ms, void (*timer_func)( void ) );
```

Parameter:

`Circuit:`	AS-i Master circuit
`ticks_ms:`	Interrupt Time in ms
`timer_func:`	Callback function of the timer interrupt

Return:—

4.1.42 Ctrl Delay

Delay function

```
int (*CCtrlDelay) ( unsigned long ticks_ms );
```

Parameter:

`Circuit:`	AS-i Master circuit
`ticks_ms:`	Delay in ms

Return:—

4.1.43 Ctrl Init wgd

Initialization of a watchdog for Control III

```
int (*CctrlInitWdg) ( unsigned long ticks );
```

Parameter:

`Circuit:`	AS-i Master circuit
`ticks:`	Watchdog time in ms

Return:—

4.1.44 Ctrl Trigger wdg

Triggers the Control III Watchdogs

```
int  (*CctrlTriggerWdg)  ( void );
```

Parameter: —

Return:—

4.1.45 Ctrl Eval Cycle time

The function determines the cycle time of the Control III program.

```
int  (*CctrlEvalCycletime)  ( void );
```

Parameter: —

Return:—

4.1.46 Ctrl Read Parameter

Ctrl Read Parameter reads non-volatile data from the flash memory.

```
int  (*CctrlReadParameter)  (unsigned char *buffer, unsigned
short len, unsigned short adr);
```

Parameter:

`len:`	Length of the memory to be read
`adr:`	Address of the first byte in the data to be read

Return:

`buffer:`	Read-buffer

4.1.47 Ctrl Write Parameter

Ctrl Write Parameter writes non-volatile data to the flash memory.

```
int  (*CctrlWriteParameter)  ( unsigned char *buffer, unsigned
short len, unsigned short adr );
```

Parameter:

`buffer:`	Write-buffer
`len:`	Length of the buffer
`adr:`	Address of the first byte to which the data should be written

Return:—

4.1.48 Ctrl Read Flags

Ctrl Read Flags reads the AS-i-Control-Flags.

```
int  (*CctrlReadFlags)  ( unsigned char *flags );
```

Parameter: —

Return:

`flags` AS-i-Control-Flags

4.1.49 Ctrl Write Flags

Ctrl Write Flags writes the AS-i-Control-Flags.

```
int  (*CctrlWriteFlags)  ( unsigned char  flags );
```

Parameter:

`flags:` AS-i-Control-Flags

Return:—

4.1.50 Crtl Read Key

Crtl Read Key reads user-defined, unique Control III keys.

```
int  (*CctrlReadKey)  ( unsigned int *key );
```

Parameter: —

Return:

`key:` User-defined Control III key

4.1.51 Ctrl printf

Printf function

```
int  (*CCtrlPrintf)  ( const char *format, ... );
```

Parameter: —

Return:—

4.1.52 Ctrl Breakpoint

Debugger initialization; “First” Breakpoint.

```
void (*CCtrlBreakpoint) (void);
```

Parameter: —

Return:—

4.1.53 Ctrl Display

Self-defined display on the gateway display

```
int (*CCtrlDisplay)( unsigned char mode, cctrl_disp_t disp_buffer );
```

Parameter:

`mode`	CCTRL_DISP_MODE_TRADITIONAL CCTRL_DISP_MODE_SPONTANEOUS
`disp_buffer.show:`	0 = Clear 1 = Show
`disp_buffer.type:`	CCTRL_DISP_TYP_4LINES = 4 lines of text CCTRL_DISP_TYP_BIGNUM = Large number + 1 line of text
`disp_buffer.time:`	Time for showing on the Display (min 2 sec.)
`disp_buffer.big:`	Buffer for large number
`disp_buffer.lines:`	Buffer for 4 lines of text

Return: 0 = OK
!0 = not OK

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5 Getting Started

Eclipse is a widely used and open-source programming tool for developing various kinds of software. Eclipse has been adapted for using **Control III** so that it assists the user in implementing his software program.

5.1 Installing Eclipse Control III

Run the ‘setup.exe’, select a destination directory and click on the ‘Install’ button. Installation may take several minutes.

Information!

No entries are made in the Windows Start menu. The files are simply extracted and saved to the corresponding directory.

5.2 Enabling Control III

If your gateway is not yet enabled for using **Control III**, you can request enabling.

If you already have an enabling code for your gateway, you will find an unlock control tool under the Eclipse configuration tools (see Sec. <Unlock Control:>).

Select your gateway and enter the corresponding enable code. The **Control III** function is enabled by clicking on ‘Unlock/Lock’. After successful activation you are prompted to start the gateway. Additional information can be found in the document “Control_enabling.pdf”.

6. Using Eclipse

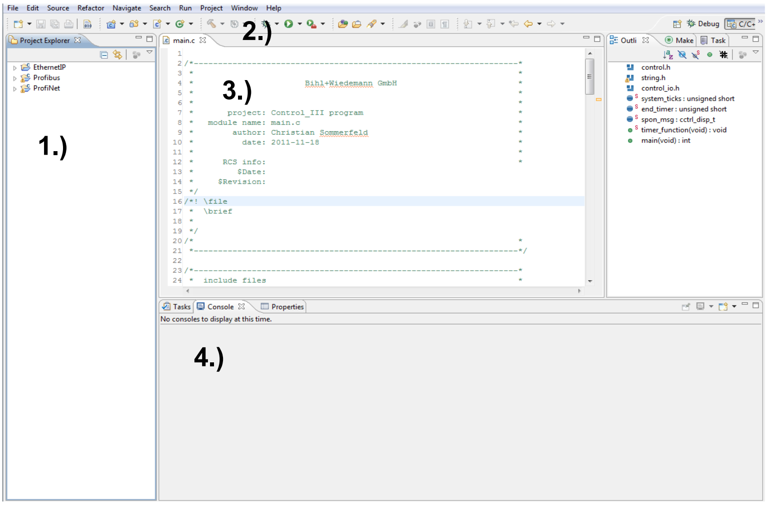
After successful installation you may proceed directly creating your own **Control III** program.

6.1 Starting

Follow the installation path (default C:/Programs) to the "eclipse_control" folder and from there run "eclipse.exe".

6.2 Eclipse overview

The Eclipse start screen is clearly divided into the most important areas.



```

/*------------------------------------------------------------------*
 *                                                                  *
 *                      Bihl+Wiedemann GmbH                         *
 *                                                                  *
 *                                                                  *
 *        project: Control_III program                              *
 *    module name: main.c                                           *
 *         author: Christian Sommerfeld                             *
 *           date: 2011-11-18                                       *
 *                                                                  *
 *       RCS info:                                                  *
 *          $Date:
 *      $Revision:
 */
/*! \file
 *  \brief
 *
 */
/*                                                                  *
 *------------------------------------------------------------------*/

/*------------------------------------------------------------------*
 *  include files                                                   *
```

No consoles to display at this time.

Fig. 6-1. Eclipse **Control III** start window

1. Project Explorer
2. Toolbar
3. Editor
4. Console

6.2.1 The Project Explorer

In the Project Explorer you will find three sample projects which you can directly use and adapt. In the Project Explorer you can manage, adapt and test all your projects. After a new installation each project contains the following files:

- control_io.c
- control_io.h
- control.h
- main.c
- startup.c
- *.ld

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- *.mak
- settings.mak

6.2.2 Toolbar

The Toolbar includes all the tools needed for working with **Control III**.

6.2.2.1 Compiler

- **clean**:
  Used to clean the project folder. Clean deletes all the files and folders created by compiling.
- **debug**:
  Compiles the currently selected project without optimization. The resulting control.bin is used for debugging. (See Sec. <The Debugger>).
- **release**:
  Compiles the currently selected project. The resulting control.bin is optimized for time in order to achieve the fastest possible cycle times for your program code.

6.2.2.2 Debugging

This button is used among other things for starting the debugger. To debug you must set the corresponding port. More information can be found in Sec. <Start the Debugger>.

Information!

If the Control III program is at a 'breakpoint', the entire operating system freezes and the fieldbus interface is no longer processed

6.2.2.3 Configuration tools

The Configuration tools button is used for communicating with the gateway and has the following functions:

Unlock Control:

Tool for unlocking Control III in the gateway (See Sec. <Enabling Control III>).

Download Control:

The file "control.bin" is written to the gateway.

Start Control:

The **Control III** program in the gateway is started.

Information!

To start a new program, after downloading the running program must first be stopped.

Download + Start Control:

The **Control III** program is first stopped, then the new program is loaded into the gateway and then started.

Stop Control:

The **Control III** program is stopped

Set Auto Start:

The Auto Start flag is set. The **Control III** program starts up automatically after each power-on.

Clear Auto Start:

The Auto Start flag is cleared.

Read Flags:

The Control III flags are read and displayed in the console.

Read Flags Cyclically:

The Control III flags are read and the display in the console refreshed cyclically. This allows for example variables to be monitored during run time.

Cycle time:

The current cycle times are displayed.

Reset Cycle Time:

The cycle time of the **Control III** is reset and recalculated.

6.2.3 Editor

In this window the entire C-code is written and adapted. The Editor also supports errors in the ‘C’ syntax.

6.2.4 Console

The console serves as an information window. It outputs for example error messages or status messages and displays how much memory is being used by the **Control III** program after compiling.

6.3 File information

As already described in <The Project Explorer>, each project folder contains various files. In this section the individual files are described in greater detail.

control_io.c

This file is used for example to break down a C program into multiple sub-modules so that it is clearer and easier to read.

Both functions 'read_bit' and 'write_bit' read and write a corresponding output or input bit.

int read_bit	(AASiProcessData idi, int slave_addr, int bit)
idi	= Slave input data
slave_addr	= Address of the corresponding slave
bit	= Slave input bit (0-3)

void write_bit	(AASiProcessData odi, int slave_addr, int bit, int value)
odi	= Slave output data
slave_addr	= Address of the corresponding slave
bit	= Slave output bit (0-3)
value	= Output bit value (0 or 1)

control_io.h

Header for control_io.c. This file contains the function definitions for 'read_bit' and 'write_bit'.

control.h

The header file ’control.h’ contains all data types and library functions. In addition it explains the way the function and are used (See Sec. <Programming Control III>).

main.c

The ’main’ function is the “starting point” of the actual program code. It also contains the main loop of the program (for ; ;).

startup.c

This file is used for initializing various memory ranges. The file has no meaning for the user.

****.ld***

This is the linker file and specifies the corresponding memory ranges in the gateway. The file has no meaning for the user.

****.mak***

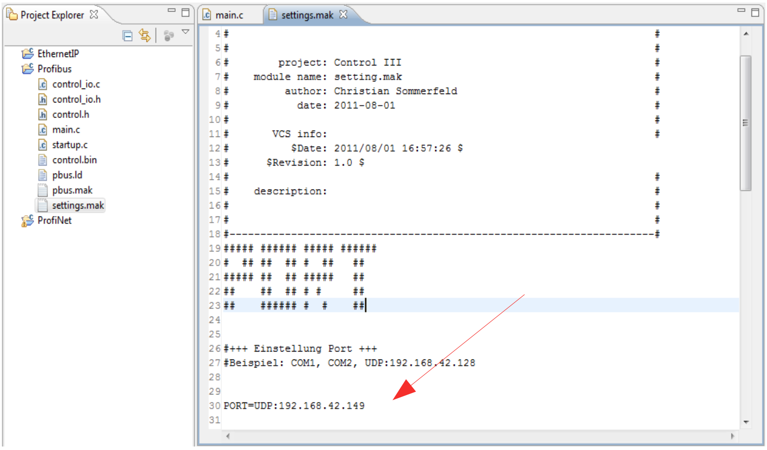
This file specifies all the information needed by the compiler. The file has no meaning for the user.

settings.mak

In this file the communication port for the gateway is specified. More detailed information can be found in Sec. <Setting the port>.

6.4 Setting the port

Each project folder contains a file called settings.mak `PORT=COM3`. In this file you can set the port for communicating with the gateway. To do this, select the corresponding file and enter the connection to the gateway. If for example you are using COM Port 3 on your PC, then enter `PORT=COM3` in line 30 of the settings.mak. If you are using an Ethernet port, then enter for example `PORT=UDP:192.168.42.149`.



```
 4 #                                                                     #
 5 #                                                                     #
 6 #        project: Control III                                         #
 7 #    module name: setting.mak                                         #
 8 #         author: Christian Sommerfeld                                #
 9 #           date: 2011-08-01                                          #
10 #                                                                     #
11 #       VCS info:                                                     #
12 #          $Date: 2011/08/01 16:57:26 $
13 #      $Revision: 1.0 $
14 #                                                                     #
15 #    description:                                                     #
16 #                                                                     #
17 #                                                                     #
18 #---------------------------------------------------------------------#
19 ##### ###### ##### ######
20 #  ## ##  ## #  ##   ##
21 ##### ##  ## #####   ##
22 ##    ##  ## # #     ##
23 ##    ###### #  #    ##
24
25
26 #+++ Einstellung Port +++
27 #Beispiel: COM1, COM2, UDP:192.168.42.128
28
29
30 PORT=UDP:192.168.42.149
31
```

Fig. 6-2. Eclipse settings.mak

6.5 Creating a new project

After a new installation the Project Explorer contains sample projects for each gateway having **Control III**. This makes it possible to start programming directly after installing Eclipse **Control III**.

If you still want to create a new project, proceed as follows:

- ☐ Select a new ‘C Project’ under 'File' -> 'New'.
- ☐ Assign a new project name and select an empty ‘Makefile Project’.
- ☐ Confirm the prompt with 'Finish'.

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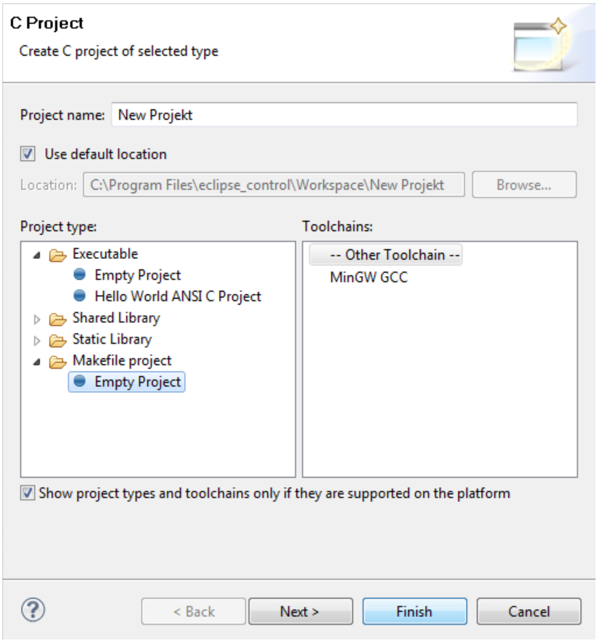

C Project

Create C project of selected type

Project name: New Projekt

☑ Use default location

Location: C:\Program Files\eclipse_control\Workspace\New Projekt

Project type:
- Executable
  - Empty Project
  - Hello World ANSI C Project
- Shared Library
- Static Library
- Makefile project
  - Empty Project

Toolchains:
- -- Other Toolchain --
- MinGW GCC

☑ Show project types and toolchains only if they are supported on the platform

Fig. 6-3. New Control III project

Now you will find a new empty project folder in the Project Explorer. Right-clicking on the new project and ‘Import…’ allows you to add all the necessary project files for your gateway.

- Select 'File System' and then click on 'Next'.
- Now select 'Browse...' and navigate to your Eclipse installation .../eclipse_control/Templates/
- Now select the gateway you are using.
  - EthernetIP
  - Profibus
  - ProfiNET
- Select 'Select All' and Finish.
- To apply all settings, select 'Yes to All' in the following prompt.

6.6 A sample project

In the following section the complete procedure for writing the code up to starting in the gateway is explained.

6.6.1 The C-code

In the sample program the outputs on a 4I/4O slave having Address 1 are set and cleared one after the other every second. To do this change the main.c as follows:

```
/*-------------------------------------------------------------------*
 *  include files                                                    *
 *-------------------------------------------------------------------*/
#include "control.h"
#include "string.h"
#include "control_io.h"

/*-------------------------------------------------------------------*
 *  local definitions                                                *
 *-------------------------------------------------------------------*/

/*-------------------------------------------------------------------*
 *  external declarations                                            *
 *-------------------------------------------------------------------*/

/*-------------------------------------------------------------------*
 *  public data                                                      *
 *-------------------------------------------------------------------*/

/*-------------------------------------------------------------------*
 *  private data                                                     *
 *-------------------------------------------------------------------*/


static unsigned short system_ticks;
static unsigned short end_timer;

/*-------------------------------------------------------------------*
 *  private functions                                                *
 *-------------------------------------------------------------------*/

static void timer_function ( void )
{
        /* timer interrupt every 10 ms */
        system_ticks++;
}

/*-------------------------------------------------------------------*
 *  public functions                                                 *
 *-------------------------------------------------------------------*/
int main ( void )
{
//initialization of the Debugger
//cctrl_func.CCtrlBreakpoint();
unsigned charctrl_flags;
int             i = 0;
int             x = 1;

AASiProcessData odi[2];
AASiProcessData idi[2];
AASiCtrlAccODI acc_odi;
AASiEcFlags     ecflags;
/* We want to access all odis */
for (i=0;i<32;i++)
{
        acc_odi[i] = 0xFF;
}
cctrl_func.AASiWriteCtrlAccODI ( 0, acc_odi, 0, 64 );

/* init timer function with 10ms ticks */
cctrl_func.CCtrlInitTimer ( 10, timer_function );

/* init watchdog */
//cctrl_func.CCtrlInitWdg( 10 );

    // clear outputs from slave 1
    odi[0][0] = 0x00;
for(;;)
        {
                /* trigger watchdog */
                //cctrl_func.CCtrlTriggerWdg();

                 /* Define data exchange for AS-i Circuit 1 and 2*/
                 cctrl_func.AASiDataExchange(0, odi[0], idi[0], &ecflags);
                 cctrl_func.AASiDataExchange(1, odi[1], idi[1], &ecflags);

                //Timer 1 100 * 10ms = 1sec.
                if ( ((unsigned short)(system_ticks - end_timer)) > 100)
                {
                // set and clear outputs circuit=1, slave=1, output=0-3
                if (x == 1) write_bit(odi[0], 1, 0, 1);
                else if (x == 2) write_bit(odi[0], 1, 1, 1);
                else if (x == 3) write_bit(odi[0], 1, 2, 1);
                else if (x == 4) write_bit(odi[0], 1, 3, 1);
                else if (x == 5) write_bit(odi[0], 1, 0, 0);
                else if (x == 6) write_bit(odi[0], 1, 1, 0);
                else if (x == 7) write_bit(odi[0], 1, 2, 0);
                else if (x == 8) write_bit(odi[0], 1, 3, 0);
                x++;

                if (x == 9) x = 1;

                end_timer = system_ticks;
                }

                /* to check Cycletime */
                cctrl_func.CCtrlEvalCycletime();

                /*read flags if we should stop control*/
                cctrl_func.CCtrlReadFlags( &ctrl_flags );
                if ( !( ctrl_flags & CCTRL_FLAG_RUN ) )
                {
                return 1;
                }

        }
}
```

6.6.2 Compiling

The C-code you have created must now be translated for the processor. To do this, select “release” under the option “Compiler” in the toolbar. A “release” folder is created and your project folder now contains the corresponding binary file ‘control.bin”.

6.6.3 Downloading

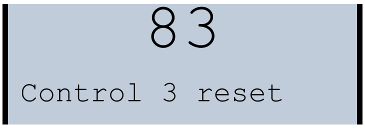
To load the newly created program into the gateway, go to your project folder and select the file settings.mak and enter the corresponding port for your gateway. For additional information see Sec. <Setting the port>.

Next go to the toolbar and under the configuration tools select: Download Control. If the download was successful the following message appears in the Eclipse console:

```
-----------------------
 ++++ CONTROL III ++++
-----------------------


 communication port set to UDP:192.168.42.157.

 writing C-Control control.bin to Master ...
 .......................................
 o.k.

 closing control.bin ...

 have a nice day.
```

6.6.4 Starting Control III

To start and test the program, go to Toolbar / Configuration tools and select the Start Control button. The following message is displayed:



```
83
Control 3 reset
```

6.7 The Debugger

A Debugger is a programming tools used for diagnostics and identifying programming errors. If the debugger function is used, the entire operating system is suspended during diagnostics.

Information!

The debug function serves only to test how your program runs. The Debugger cannot be used for diagnosing your hardware configuration.

6.7.1 Initializing

To be able to use the Debugger, it must be initialized in C-code. This is done using the following code line:

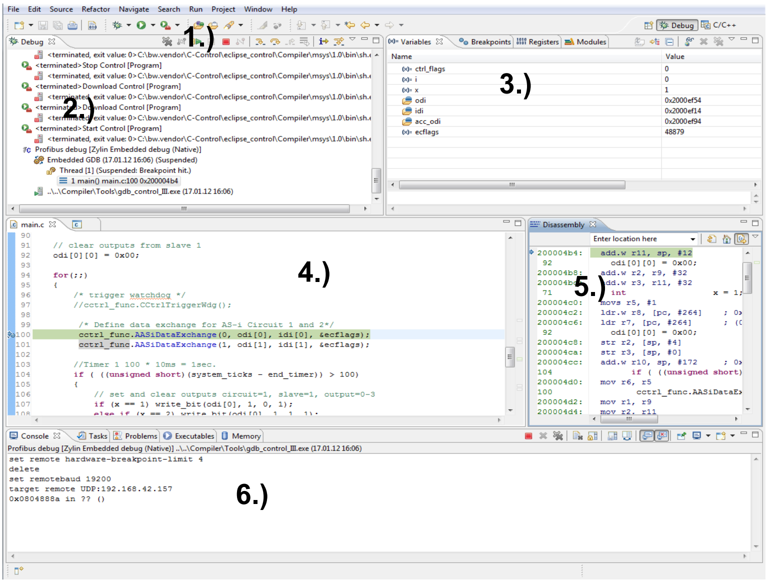
```
//initialization of the Debugger
cctrl_func.CCtrlBreakpoint();
```

Using this line stops the operating system and allows Eclipse to communicate with the processor. At this point the Debugger is given the program data and it jumps to the next user-defined breakpoint of the **Control III** program.

Information!

The Debugger should not be initialized in the main loop of the program code (for (;;)), since this breakpoint is not controlled by Eclipse and therefore cannot be stopped.

6.7.2 Debugger overview



```
<terminated, exit value: 0>C:\bw.vendor\C-Control\eclipse_control\Compiler\msys\1.0\bin\sh.e
<terminated>Stop Control [Program]
<terminated, exit value: 0>C:\bw.vendor\C-Control\eclipse_control\Compiler\msys\1.0\bin\sh.e
<terminated>Download Control [Program]
<terminated, exit value: 0>C:\bw.vendor\C-Control\eclipse_control\Compiler\msys\1.0\bin\sh.e
<terminated>Download Control [Program]
<terminated, exit value: 0>C:\bw.vendor\C-Control\eclipse_control\Compiler\msys\1.0\bin\sh.e
<terminated>Start Control [Program]
<terminated, exit value: 0>C:\bw.vendor\C-Control\eclipse_control\Compiler\msys\1.0\bin\sh.e
Profibus debug [Zylin Embedded debug (Native)]
  Embedded GDB (17.01.12 16:06) (Suspended)
    Thread [1] (Suspended: Breakpoint hit.)
      1 main() main.c:100 0x200004b4
  ..\..\Compiler\Tools\gdb_control_III.exe (17.01.12 16:06)
```

Name	Value
ctrl_flags	0
i	0
x	1
odi	0x2000ef54
idi	0x2000ef14
acc_odi	0x2000ef94
ecflags	48879

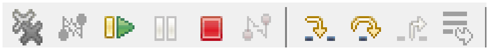
```c

    // clear outputs from slave 1
    odi[0][0] = 0x00;

    for(;;)
    {
        /* trigger watchdog */
        //cctrl_func.CCtrlTriggerWdg();

         /* Define data exchange for AS-i Circuit 1 and 2*/
         cctrl_func.AASiDataExchange(0, odi[0], idi[0], &ecflags);
         cctrl_func.AASiDataExchange(1, odi[1], idi[1], &ecflags);

        //Timer 1 100 * 10ms = 1sec.
        if ( ((unsigned short)(system_ticks - end_timer)) > 100)
        {
            // set and clear outputs circuit=1, slave=1, output=0-3
            if (x == 1) write_bit(odi[0], 1, 0, 1);
            else if (x == 2) write_bit(odi[0], 1, 1, 1);
```

```
200004b4:   add.w r11, sp, #12
 92           odi[0][0] = 0x00;
200004b8:   add.w r2, r9, #32
200004bc:   add.w r3, r11, #32
 71           int                 x = 1;
200004c0:   movs r5, #1
200004c2:   ldr.w r8, [pc, #264]     ; 0x
200004c6:   ldr r7, [pc, #264]       ; (0
 92           odi[0][0] = 0x00;
200004c8:   str r2, [sp, #4]
200004ca:   str r3, [sp, #0]
200004cc:   add.w r10, sp, #172      ; 0x
104               if ( ((unsigned short)
200004d0:   mov r6, r5
100                cctrl_func.AASiDataEx
200004d2:   mov r1, r9
200004d4:   mov r2, r11
```

```
Profibus debug [Zylin Embedded debug (Native)] ..\..\Compiler\Tools\gdb_control_III.exe (17.01.12 16:06)
set remote hardware-breakpoint-limit 4
delete
set remotebaud 19200
target remote UDP:192.168.42.157
0x0804888a in ?? ()
```

1. Control Panel
2. Tasks
3. Debugger Overview
4. Code Overview
5. Disassembly
6. Console

6.7.2.1 The Control Panel



The Control Panel is used for controlling the Debugger.

Resume (F8):

The 'Resume' button causes the **Control III** program to continue until it reaches a new breakpoint. If no new breakpoint is reached within 10 seconds, the Debugger in Eclipse automatically stops and a corresponding message appears in the console.

Information!

When using the Debugger no delays of longer than 10 seconds are possible, since the Debugger is automatically stopped. This is for quitting the Debugger when communication is absent or incorrect.

Terminate (Ctrl + F2):

Terminate quits the Debugger and allows the **Control III** program to continue running even if there are no breakpoints in the code.

Step Into (F5):

The 'Step Into' button is used for jumping by one program line in the code.

Information!

The StepInto function can only work reliably if the program code has been translated as "debug".

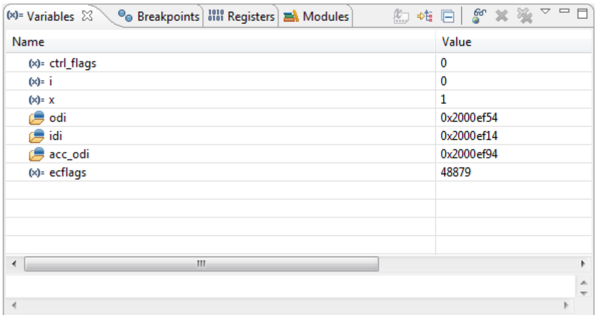
Step Over (F6):

'Step Over' is used for example to skip a function call.

6.7.2.2 Tasks

In this window all programs being used which are controlled by Eclipse are displayed. This window has no great meaning for the user.

6.7.2.3 Debugger Overview



Name	Value
ctrl_flags	0
i	0
x	1
odi	0x2000ef54
idi	0x2000ef14
acc_odi	0x2000ef94
ecflags	48879

Issue date: 21.02.2013

Variables:

In the Variables tab of the “Debugger overview” all the existing variables and their values can be displayed. Right-clicking in the window allows you to use ‘Add Global Variables’ to add additional variables to the view. The value of the variables is always displayed in hex format. The view can be changed to binary or decimal by right-clicking on ‘Format’.

Breakpoints:

The Breakpoints tab contains an overview of all breakpoints controlled by and used in Eclipse including the program line. Individual breakpoints can be deleted by right-clicking.

6.7.2.4 Code overview

This window allows you to always see at which point in the program code the Debugger is currently located. Double-clicking n ext to the corresponding code line allows you to set or delete a breakpoint.

Information!

As soon as the Debugger is started you first see an empty window with the text “Source not found.” At this point the Debugger is in the operating system and does not know the associated C-code.

6.7.2.5 Disassembly

Like the Code overview window, the Disassembly window shows exactly where the Debugger is currently. Here both the memory address and the associated assembler code are displayed.

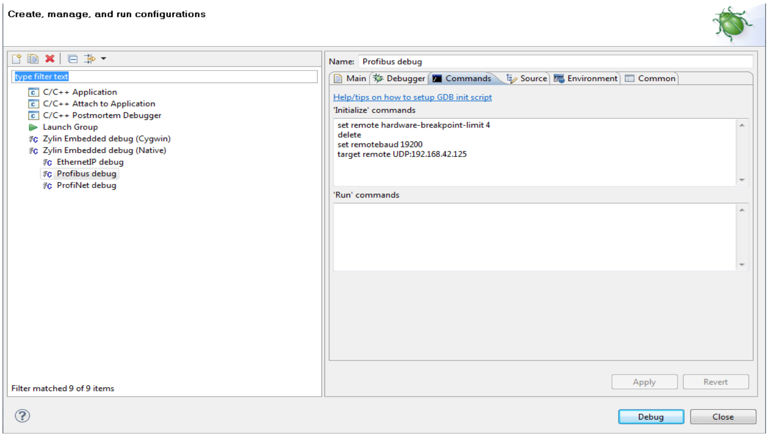
6.7.2.6 Console

The console serves as an output window and tells you about the Debugger status.

6.7.3 Start the Debugger

The Debugger is started from the Control Panel.

Before you can establish a connection with the target, you must define the port for the gateway under ‘Debug-Configuration’. To do this, click on the ‘Commands’ tab and under target remote enter the port. (e.g. target remote `UDP:192.168.42.33 or COM3)`.


Create, manage, and run configurations

type filter text

- C/C++ Application
- C/C++ Attach to Application
- C/C++ Postmortem Debugger
- Launch Group
- Zylin Embedded debug (Cygwin)
- Zylin Embedded debug (Native)
  - EthernetIP debug
  - Profibus debug
  - ProfiNet debug

Filter matched 9 of 9 items

Name: Profibus debug

Main | Debugger | Commands | Source | Environment | Common

Help/tips on how to setup GDB init script

'Initialize' commands

```
set remote hardware-breakpoint-limit 4
delete
set remotebaud 19200
target remote UDP:192.168.42.125
```

'Run' commands

Fig. 6-4. Debug Configuration...

6.7.4 Example

To illustrate the Debugger, here is a sample program which sets an output bit (0-3) of the slave having Address 1 in every main loop pass. Following is the corresponding program code.

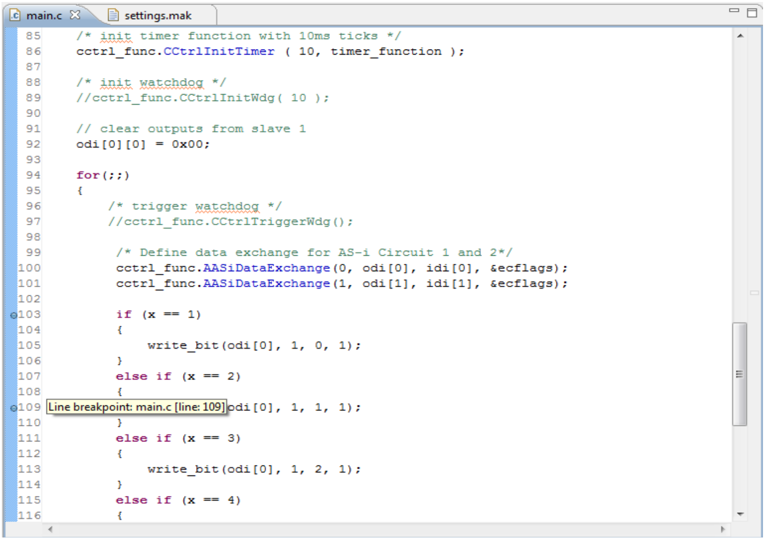
Issue date: 21.02.2013

```
*-------------------------------------------------------------------*
 *  include files                                                    *
 *-------------------------------------------------------------------*/
#include "control.h"
#include "string.h"
#include "control_io.h"

/*-------------------------------------------------------------------*
 *  local definitions                                                *
 *-------------------------------------------------------------------*/

/*-------------------------------------------------------------------*
 *  external declarations                                            *
 *-------------------------------------------------------------------*/

/*-------------------------------------------------------------------*
 *  public data                                                      *
 *-------------------------------------------------------------------*/

/*-------------------------------------------------------------------*
 *  private data                                                     *
 *-------------------------------------------------------------------*/


static unsigned short system_ticks;
static unsigned short end_timer;

/*-------------------------------------------------------------------*
 *  private functions                                                *
 *-------------------------------------------------------------------*/

static void timer_function ( void )
{
        /* timer interrupt every 10 ms */
        system_ticks++;
}

/*-------------------------------------------------------------------*
 *  public functions                                                 *
 *-------------------------------------------------------------------*/
```

```
int main ( void )
{
        //initialization of the Debugger
        cctrl_func.CCtrlBreakpoint();

        unsigned charctrl_flags;
        int      i = 0;
        int      x = 1;

        AASiProcessData odi[2];
        AASiProcessData idi[2];
        AASiCtrlAccODI acc_odi;
        AASiEcFlags ecflags;

        /* We want to access all odis */
        for (i=0;i<32;i++)
        {
                 acc_odi[i] = 0xFF;
        }
        cctrl_func.AASiWriteCtrlAccODI ( 0, acc_odi, 0, 64 );

        /* init timer function with 10ms ticks */
    cctrl_func.CCtrlInitTimer ( 10, timer_function );

    /* init watchdog */
        //cctrl_func.CCtrlInitWdg( 10 );

    // clear outputs from slave 1
    odi[0][0] = 0x00;
```

```
        for(;;)
        {
                /* trigger watchdog */
                //cctrl_func.CCtrlTriggerWdg();

                 /* Define data exchange for AS-i Circuit 1 and 2*/
                 cctrl_func.AASiDataExchange(0, odi[0], idi[0], &ecflags);
                 cctrl_func.AASiDataExchange(1, odi[1], idi[1], &ecflags);

                 if (x == 1)
                 {
                 write_bit(odi[0], 1, 0, 1);
                 }
                 else if (x == 2)
                 {
                 write_bit(odi[0], 1, 1, 1);
                 }
                 else if (x == 3)
                 {
                 write_bit(odi[0], 1, 2, 1);
                 }
                 else if (x == 4)
                 {
                 write_bit(odi[0], 1, 3, 1);
                 x = 1;
                 }
                 x++;

                /* check Cycletime */
                cctrl_func.CCtrlEvalCycletime();

                /*read flags if we should stop control*/
                cctrl_func.CCtrlReadFlags( &ctrl_flags );
                if ( !( ctrl_flags & CCTRL_FLAG_RUN ) )
                {
                return 1;
                }

        }
}
/*-------------------------------------------------------------------*
 *  eof                                                              *
 *-------------------------------------------------------------------*/
```

Now create two breakpoints by double-clicking in the margin of the program code on the corresponding code line. In our example we use both lines 103 and 109. The line in which a breakpoint was added is indicated by a period. These lines are shown later in the Debugger overview under Breakpoint and this information conveyed to the processor during initialization.



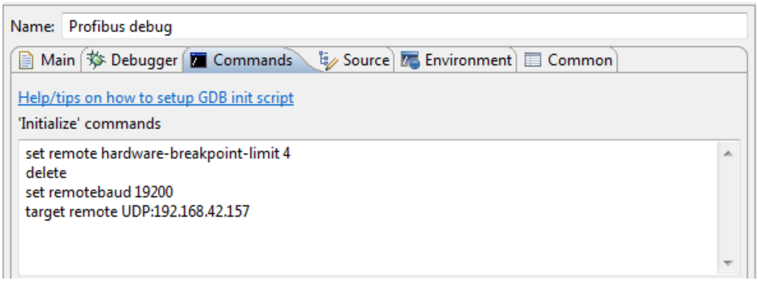
```
    /* init timer function with 10ms ticks */
    cctrl_func.CCtrlInitTimer ( 10, timer_function );

    /* init watchdog */
    //cctrl_func.CCtrlInitWdg( 10 );

    // clear outputs from slave 1
    odi[0][0] = 0x00;

    for(;;)
    {
        /* trigger watchdog */
        //cctrl_func.CCtrlTriggerWdg();

         /* Define data exchange for AS-i Circuit 1 and 2*/
         cctrl_func.AASiDataExchange(0, odi[0], idi[0], &ecflags);
         cctrl_func.AASiDataExchange(1, odi[1], idi[1], &ecflags);

         if (x == 1)
         {
             write_bit(odi[0], 1, 0, 1);
         }
         else if (x == 2)
         {
Line breakpoint: main.c [line: 109]odi[0], 1, 1, 1);
         }
         else if (x == 3)
         {
             write_bit(odi[0], 1, 2, 1);
         }
         else if (x == 4)
         {
```

Fig. 6-5. Marking a breakpoint in the program code

Now compile the program by clicking on ‘Debug’ in the toolbar under Compiler. A new control.bin file without optimization is created. Load this file into the gateway as already described under <Editor>.

6.7.4.1 Starting the Debugger

Before you can begin debugging, you must set the port. Click in the toolbar under Debugger on ‘Debug Configurations…’ Here open the ‘Commands’ tab and under ‘target remote’ enter your port (e.g. UDP:192.168.42.157 or COM1) for the gateway and click on 'Apply'.



Name: Profibus debug

'Initialize' commands

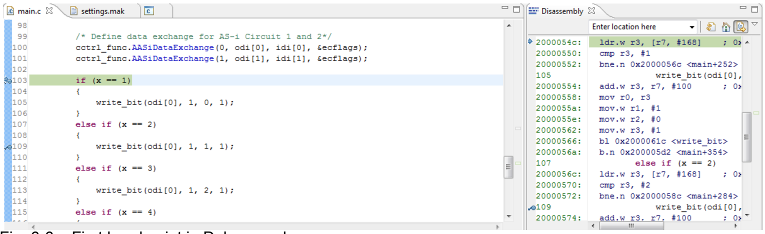
```
set remote hardware-breakpoint-limit 4
delete
set remotebaud 19200
target remote UDP:192.168.42.157
```

Of your **Control III** program is already at a breakpoint, you can start the Debugger directly from ‘Debug’. A breakpoint is displayed in the gateway with number ‘79’.

If this is not the case, quit entry with ‘Close’ and start your program. You can now directly start the Debugger by clicking for example on ‘Profibus debug’ in the toolbar.

6.7.4.2 Using the Debugger

After you have started the Debugger, it is configured for the application. The Debugging window is automatically opened by Eclipse. Under Breakpoints you now see the first breakpoint which is run by the program code. This is the Debugger initialization. In this case you are shown an empty window. Click on ‘Resume’. The program code is run up to the corresponding line with the first breakpoint and stopped.

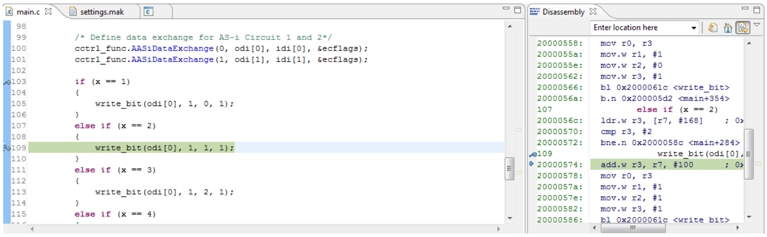


```
 98
 99         /* Define data exchange for AS-i Circuit 1 and 2*/
100         cctrl_func.AASiDataExchange(0, odi[0], idi[0], &ecflags);
101         cctrl_func.AASiDataExchange(1, odi[1], idi[1], &ecflags);
102
103         if (x == 1)
104         {
105             write_bit(odi[0], 1, 0, 1);
106         }
107         else if (x == 2)
108         {
109             write_bit(odi[0], 1, 1, 1);
110         }
111         else if (x == 3)
112         {
113             write_bit(odi[0], 1, 2, 1);
114         }
115         else if (x == 4)
```

```
2000054c:   ldr.w r3, [r7, #168]     ; 0x
20000550:   cmp r3, #1
20000552:   bne.n 0x2000056c <main+252>
105                     write_bit(odi[0],
20000554:   add.w r3, r7, #100       ; 0x
20000558:   mov r0, r3
2000055a:   mov.w r1, #1
2000055e:   mov.w r2, #0
20000562:   mov.w r3, #1
20000566:   bl 0x2000061c <write_bit>
2000056a:   b.n 0x200005d2 <main+354>
107                 else if (x == 2)
2000056c:   ldr.w r3, [r7, #168]     ; 0x
20000570:   cmp r3, #2
20000572:   bne.n 0x2000058c <main+284>
109                     write_bit(odi[0],
20000574:   add.w r3, r7, #100       ; 0x
```

Fig. 6-6. First breakpoint in Debug-mode

You can also click on ‘Variables’ in the Debugger overview to display all the variables which are used (see Sec. <Debugger overview>). Click on ‘Resume’. The Debugger again stops at this point and not at the second breakpoint. This is because the second breakpoint is not reached until the variable ‘x’ in our sample program has a value of 2. You can display the value of the variable by moving the mouse cursor over the corresponding variable. The variable x now has a value of 2. Click again on ‘Resume’ to jump to the breakpoint in line 109.



```
 98
 99         /* Define data exchange for AS-i Circuit 1 and 2*/
100         cctrl_func.AASiDataExchange(0, odi[0], idi[0], &ecflags);
101         cctrl_func.AASiDataExchange(1, odi[1], idi[1], &ecflags);
102
103         if (x == 1)
104         {
105             write_bit(odi[0], 1, 0, 1);
106         }
107         else if (x == 2)
108         {
109             write_bit(odi[0], 1, 1, 1);
110         }
111         else if (x == 3)
112         {
113             write_bit(odi[0], 1, 2, 1);
114         }
115         else if (x == 4)
```

```
20000558:   mov r0, r3
2000055a:   mov.w r1, #1
2000055e:   mov.w r2, #0
20000562:   mov.w r3, #1
20000566:   bl 0x2000061c <write_bit>
2000056a:   b.n 0x200005d2 <main+354>
107                 else if (x == 2)
2000056c:   ldr.w r3, [r7, #168]     ; 0x
20000570:   cmp r3, #2
20000572:   bne.n 0x2000058c <main+284>
109                     write_bit(odi[0],
20000574:   add.w r3, r7, #100       ; 0x
20000578:   mov r0, r3
2000057a:   mov.w r1, #1
2000057e:   mov.w r2, #1
20000582:   mov.w r3, #1
20000586:   bl 0x2000061c <write_bit>
```

Fig. 6-7. Second breakpoint in Debug-mode

For this code line you can choose from between ‘Step over’ and ‘Step into’. ‘Step over’ causes the program to skip to line 120, in other words skips the function call ‘write_bit(…)’ and continues from the next valid line in the code. ‘Step into’ opens the corresponding file (control_io.c) and continues ‘Debug-mode’ from the corresponding location. If you want to jump to the next breakpoint, click again on the ‘Resume’ button. Quit the Debugger by clicking on ‘Terminate’.

7. Technical Data

The following section provides an overview of all the key technical data for Control III.

7.1 Overview

- 28 kB program memory (can be split between ROM and RAM)
- 1kB non-volatile parameters
- 256 bytes of flag memory
- Control program and parameters also on chip card
- A configurable timer interrupt which can be used to create any number of timers
- Programmable timer times from 1 to 2^{32} ms
- Up to 248 I/O and 248 analog values using AS-i slaves
- Unique 32-bit ID in the device
- Simple determination of the cycle time
- Eclipse with GCC and GDB as a complete development environment

7.2 Flags

The flag area is transparent and administered by the user.

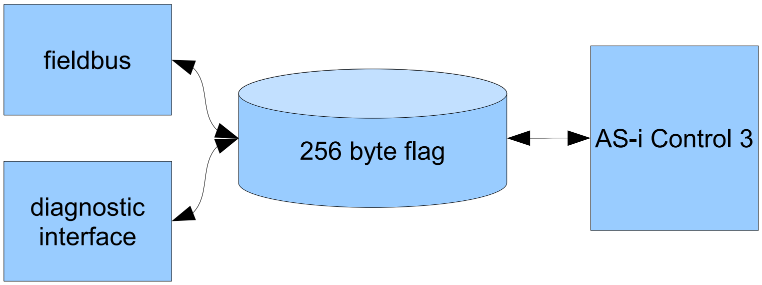


Fig. 7-8. Flag area

7.3 Non-volatile parameters

The non-volatile parameters are transparent and administered by the user.

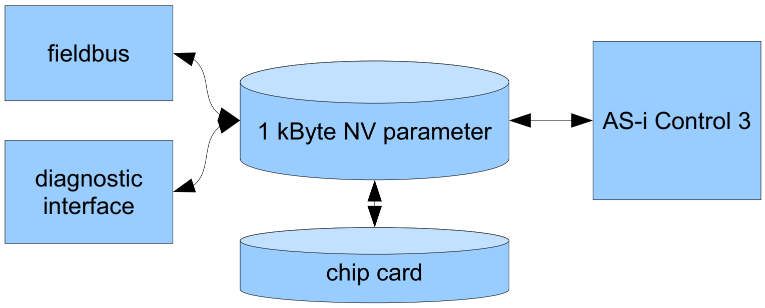


Fig. 7-9. Non-volatile parameters

7.4 Access rights to the output data area

Fieldbus and the Control III program can both set outputs at the same time. Access rights can be assigned by the bit or by channel.

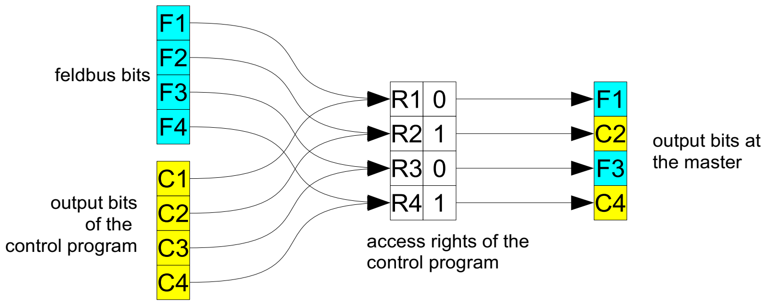

feldbus bits
F1
F2
F3
F4
output bits of the control program
C1
C2
C3
C4
R1 0
R2 1
R3 0
R4 1
access rights of the control program
F1
C2
F3
C4
output bits at the master

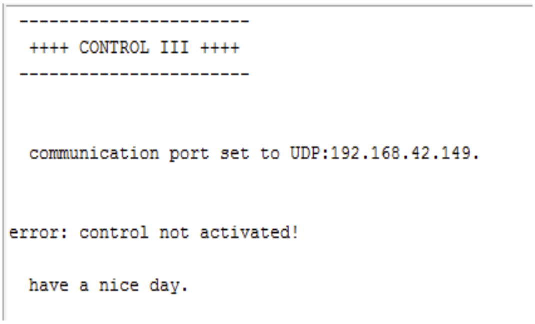
Fig. 7-10. Access rights for the output data area

8. Error Messages

This section is intended to help you to troubleshoot and resolve any problems which may arise.

8.1 error: control not activated!

If the Eclipse console displays the following message, Control III needs to be enabled for your gateway (see Sec. <Enabling Control III>).

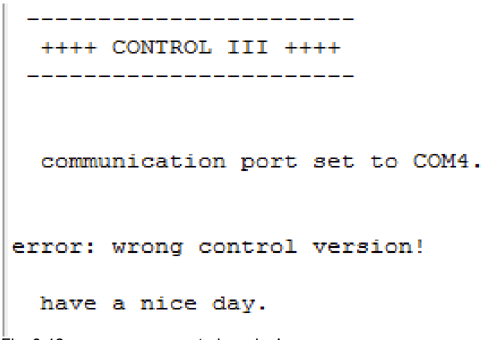


```
 -----------------------
  ++++ CONTROL III ++++
 -----------------------


  communication port set to UDP:192.168.42.149.


error: control not activated!

  have a nice day.
```

Fig. 8-11. error: control not activated

8.2 error: wrong control version

If the message 'error: wrong control version' is displayed in the Eclipse console, you are using a gateway having a different Control version which is not capable of ‘C’ programming. In this case refer to manufacturer’s support.

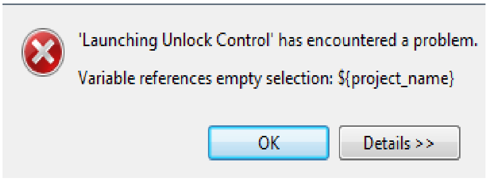


```
 -----------------------
  ++++ CONTROL III ++++
 -----------------------


  communication port set to COM4.


error: wrong control version!

  have a nice day.
```

Fig. 8-12. error: wrong control version!

8.3 Launching problem

This error message indicates that Eclipse is not associated with your project. Simply click in the Editor window and make your entry again.


'Launching Unlock Control' has encountered a problem.

Variable references empty selection: ${project_name}

Fig. 8-13. Launching problem

8.4 No or an incorrect cycle time is displayed.

If you read the cycle time on Eclipse and a value of 0 keeps appearing, the following line is missing in the program code:

```
/* check Cycletime */
cctrl_func.CCtrlEvalCycletime();
```

8.5 The gateway doesn’t stop at a breakpoint.

If the gateway doesn’t stop at a breakpoint, it is possible that the auto-start flag is set or the following line for initializing the Debugger is missing in the program code:

```
//initialization of the Debugger
cctrl_func.CCtrlBreakpoint();
```

8.6 The program always goes to the same breakpoint.

If this happens and there is no Debugger initialization in the code, the error is in the program code. The most frequent cause is an un-initialized pointer. Please check your program code. If you have also set the Autostart flag, you can perform a reset when starting the gateway. To do this, press both the ‘Mode’ and ‘Set’ keys while turning on the gateway. The existing program code is deleted and the gateway starts back up.

8.7 The Control III can’t affect any outputs.

Check whether the slaves are correctly projected and the gateway indicates no configuration error. If needed, project the slaves again. If the error persists, you may not have access rights. These are assigned by the following function:

```
cctrl_func.AASiWriteCtrlAccODI ( … );
```

Additional information can be found in Sec. <AS-i Read Ctrl Acc AODI>.

Issue date: 21.02.2013