

Documentation for FC2001 and FC2002

Lightbus PCI Interface Cards

Version: 1.0
Date: 01.12.2003

BECKHOFF

Table of Contents

FC200x - PCI Cards for Lightbus

1. Foreword	4
Notes on the Manual	4
Safety Instructions	5
2. Product Overview	6
Lightbus System Description	6
Hardware	8
Technical data	10
3. Installation	11
Installation in the PC	11
Installation of the PCI driver	12
4. Configuration using the System Manager	13
FC200x tab	14
DPRAM tab	15
Adding further components	16
5. Diagnosis	18
Diagnosis via the System Manager	18
Status and diagnostic inputs	19
Diagnosis with function blocks	21
6. Appendix	23
Support and Service	23

1. Foreword

Notes on the Manual

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components.

Liability Conditions

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics, and does not represent an assurance of characteristics in the sense of § 459, Para. 2 of the German Civil Code. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

© This manual is copyrighted. Any reproduction or third party use of this publication, whether in whole or in part, without the written permission of Elektro BECKHOFF GmbH, is forbidden.

Safety Instructions

Safety Rules

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

State at Delivery

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Elektro BECKHOFF GmbH.

Personnel Qualification

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.

Description of safety symbols

The following safety symbols are used in this operating manual. They are intended to alert the reader to the associated safety instructions.



Danger

This symbol is intended to highlight risks for the life or health of personnel.



Warning

This symbol is intended to highlight risks for equipment, materials or the environment.



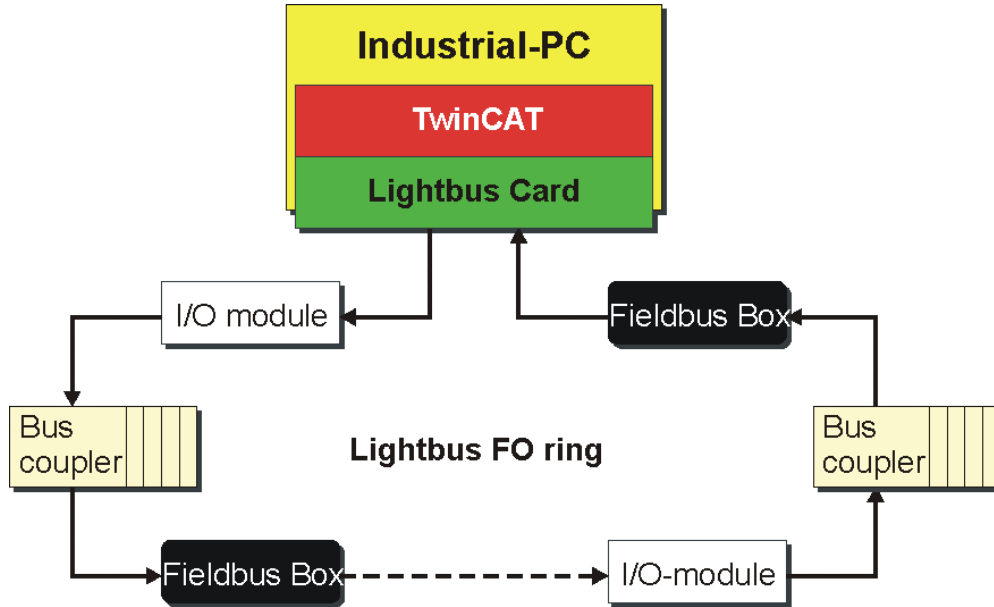
Note

This symbol indicates information that contributes to better understanding.

2. Product Overview

Lightbus System Description

The Lightbus consists of the Lightbus PCI interface card (in short Lightbus card) and an optical fiber-based field-bus.

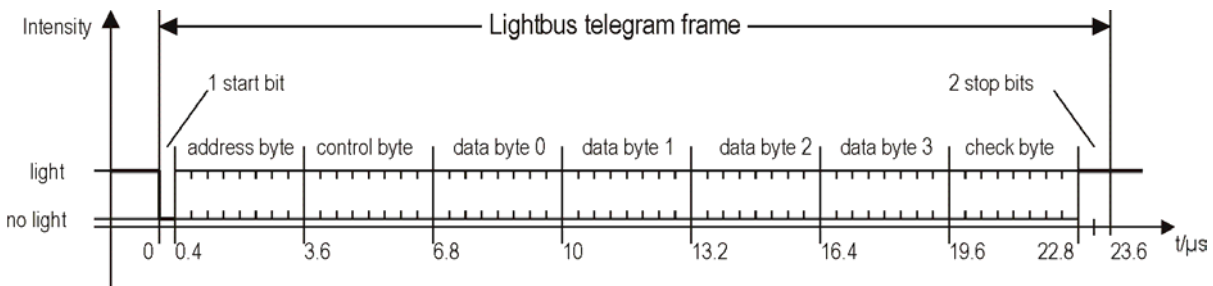


The coupling of the Lightbus with the PC is realised on the Lightbus card via a Dual Ported RAM (DPRAM).

Various I/O modules (Bus Coupler, Bus Terminals, Fieldbus Boxes etc.) are available for input and output of the process images, which are connected through the Lightbus in a ring structure. The use of optical fibers results in low susceptibility to interference and a high transfer rate of 2.5 MBaud. Any errors occurring in the optical fiber ring are detected by the Lightbus card and reported to the PC. TwinCAT provides comprehensive diagnostic functions that support fast detection and correction of any errors.

A communication protocol that is optimised for speed and simplicity is specified for the data transfer between the Lightbus card and the I/O modules. The Lightbus card controls the communication on the optical fiber ring. It sends telegrams that pass through the I/O modules in the optical fiber ring and are then received and checked back at the Lightbus card.

A telegram consists of a telegram frame and the telegram content.



The telegram frame is required for serial data communication and consists of 1 start bit, 6 CRC check bits and 2 stop bits. It is generated and checked independently by the hardware of the Lightbus card. No software support is required.

The telegram content is essentially organised byte-wise. AD0 to AD7 form the address field, through which up to 254 I/O modules can be addressed (the addresses 0x00 and 0x0FF are reserved). The bits CR0 to CR3 specify the telegram type. The following functions can be specified in the telegram:

Functions

CR3	CR2	CR1	CR0	Function	Description
0	0	0	0	Read	The addressed module inserts the input information into data fields <i>D0</i> to <i>D3</i> .
0	0	0	1	Read and write	The addressed module inserts the input information into data fields <i>D0</i> to <i>D3</i> and receives the output information.
0	0	1	0	Address initialisation	The addressed module receives the content of <i>D0</i> as the module address and sets <i>D0</i> to 0.
0	0	1	1	RAM	Special telegram type for the BK2000 Bus Coupler.
0	1	0	0	Address check and count	Each passing module increases the content of <i>D0</i> by 1. The addressed module moves the content of <i>D0</i> to <i>D3</i> .
1	0	0	1	Low intensity	The addressed module reduces the transmission intensity by 20%.
1	0	1	1	Broadcast	Special telegram type for the BK2000 Bus Coupler.

The bytes *D0* to *D3* contain the actual user data. The *control field* specifies the processing of these user data. The last byte in the telegram contains 6 bits for forming a CRC checksum and 2 reserved bits. A user data length of 50 bits thus achieves a hamming distance of $d=3$.

The Lightbus consists of a physical ring, which can be split into up to 8 logical rings for processing the process image. A logical ring only operates for selected I/O modules, which are specified via communication description lists (CDLs).

The Lightbus card makes the process image available to the PC via the DPRAM. The DPRAM is divided into three areas:

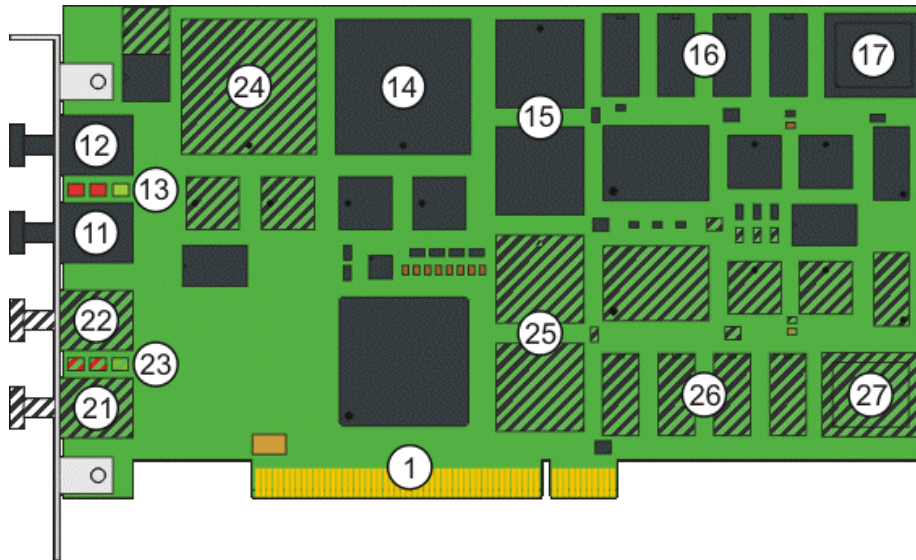
- Data:
Input, output and flags
- Communication:
Initialisation, testing, analysis and configuration of the Beckhoff Lightbus
- Process control:
Updating the Process Image

The DPRAM of the Lightbus cards requires 4 kB per channel in the address space of the PC.

Hardware

As a Lightbus PCI interface card (in short Lightbus card), the FC200x realises the connection of the Lightbus to the PC, and therefore provides access for TwinCAT to the sensors and actuators in the automation process. The FC2002 Lightbus card can operate two optical fiber rings. In logical terms, it behaves like two FC2001 cards, i.e. the FC2002 contains two sets of components for the optical fiber ring.

Lightbus card components

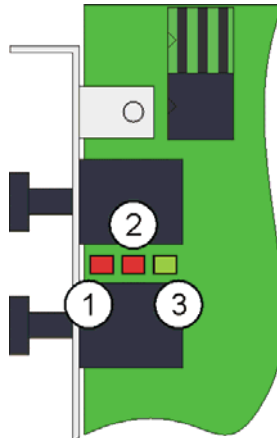


1. PCI bus interface
11. Lightbus output for connecting the outgoing optical fiber for optical fiber ring A
12. Lightbus input for connecting the return optical fiber for optical fiber ring A
13. Three status LEDs for optical fiber ring A
14. Lightbus LCA for optical fiber ring A
15. 4 kB of DPRAM for optical fiber ring A
16. 512 kB of RAM (4 x 128 kB) for optical fiber ring A
17. 256 kB of flash for optical fiber ring A
21. Lightbus output for connecting the outgoing optical fiber for optical fiber ring B
22. Lightbus input for connecting the return optical fiber for optical fiber ring B
23. Three status LEDs for optical fiber ring B
24. Lightbus LCA for optical fiber ring B
25. 4 kB of DPRAM for optical fiber ring B
26. 512 kB of RAM (4 x 128 kB) for optical fiber ring B
27. 256 kB of flash for optical fiber ring B

The hatched components for optical fiber ring B are not populated on the FC2001.

Status display

Each Lightbus channel has 3 status LEDs.



1. Optical Err (Lightbus error):

- If a defect in the optical fiber ring occurs during operation, the red *Optical Err* LED is activated.
- If the optical fiber error is of a general nature, the *Optical Err* flashes.
- If the error has occurred during the resident address test, the *Optical Err* LED is on continuously. The update of the process image is interrupted. The diagnostic functions can be used to determine the cause of the error.

2. CPU Err (CPU error):

- If only the red *CPU Err* LED is on, this indicates a hardware error that cannot be corrected.
- If the *Run* LED is also on, a program error is present that may potentially be rectified through a hardware reset.

3. Run:

- If only the green *Run* LED is on, the FC200x was initialised without errors and is ready for operation.

Technical data

Technical data	FC2001	FC2002
Fieldbus	Lightbus (optical fiber)	
Data transfer rate	2.5 MBaud (32 bits of useful information in 25 µs)	
Number of Lightbus channels	1	2
Communication	8 priority-controlled logical communications channels for each Lightbus channel	
Bus devices	a maximum of 255 bus devices with a maximum of 65280 I/O points per Lightbus channel	
Hardware diagnosis	1 status LED and 2 diagnostic LEDs (Run, CPU Err, Optical Err) per Lightbus channel	
Interface to the PC	32-bit Plug & Play PCI interface	
Address space	4 kB of DPRAM for 8 communication channels, data, control and status register for each Lightbus channel	
Interrupts	Triggering of 2 IRQs is possible	
Supply voltage (PCI bus)	5 V	
Current consumption (PCI bus)	typically 385 mA	typically 700 mA
Permissible ambient temperature during operation	0°C ... +55°C	
Dimensions	approx. 106 mm x 187 mm	

3. Installation

Installation in the PC

**Warning**

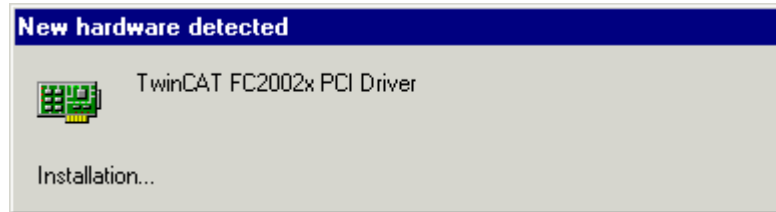
The Lightbus cards are supplied in ESD packaging. Follow the usual ESD guidelines for handling PC cards during installation!

1. Before installing the Lightbus card, switch off the PC and any external power supplies, and separate the PC from the mains.
2. Open the PC case.
3. Remove the protective caps of the optical fibre connections of the Lightbus card.
4. For a free PCI slot on the motherboard, remove the metal plate in the PC case.
5. Insert the Lightbus card into the free PCI slot and fix it with the screw or device provided. Ensure that there is sufficient space between the Lightbus card and other PC components, so that the Lightbus card cannot come into contact with other plug-in cards or memory components etc.
6. Close the PC case.
7. Connect the cables of the optical fibre ring with the optical fibre connections of the Lightbus card:
 - OUT: outgoing Lightbus
 - IN: returning Lightbus
8. Connect the PC to the mains and switch it on.
9. After the PC has booted up, under Windows 2000 and Windows XP the Add Hardware Wizard will install a PCI driver, in order to integrate the Lightbus card into the plug and play interface of the operating system. Under Windows NT 4.0, this driver is not required.

The Lightbus card does not require an external power supply. It is supplied directly from the PC via the PCI bus. The power supply of the PC has to be adequate for meeting the power requirement of the Lightbus cards, particularly if several Lightbus cards are installed.

Installation of the PCI driver

After installation of the Beckhoff Lightbus card, Windows 2000, for example, comes up with the following message during start-up:



The PCI driver for the Lightbus card is supplied with the Beckhoff TwinCAT automation software.

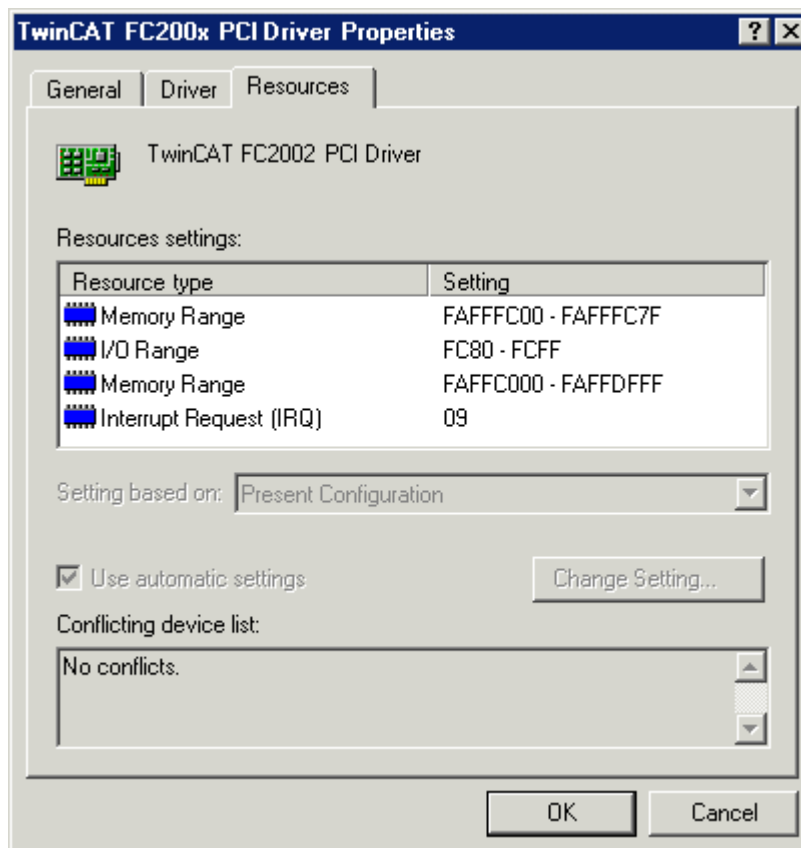
Follow the instructions of the Add Hardware Wizard.

Under Windows XP, the PCI driver is installed in the same way.

Under Windows NT 4.0, the PCI driver is not required.

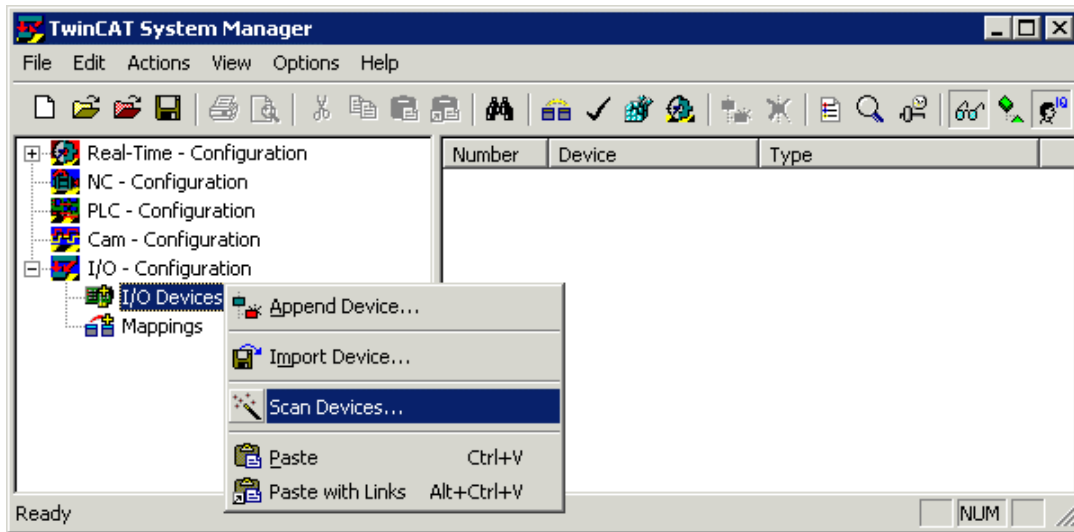
Example for the resources of an FC200x under Windows2000.

(Control Panel / System / Hardware / Device Manager / TwinCAT PNP drivers / TwinCAT FC2002x PCI driver / Resources):

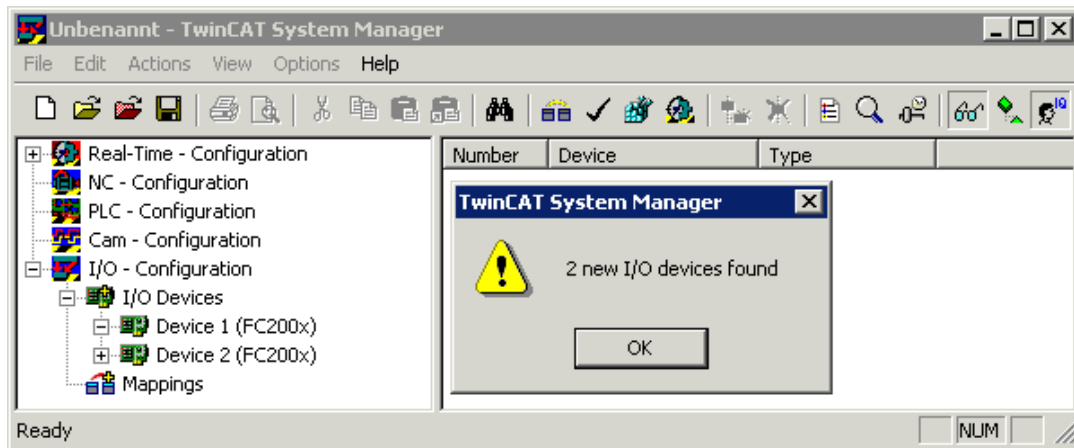


4. Configuration using the System Manager

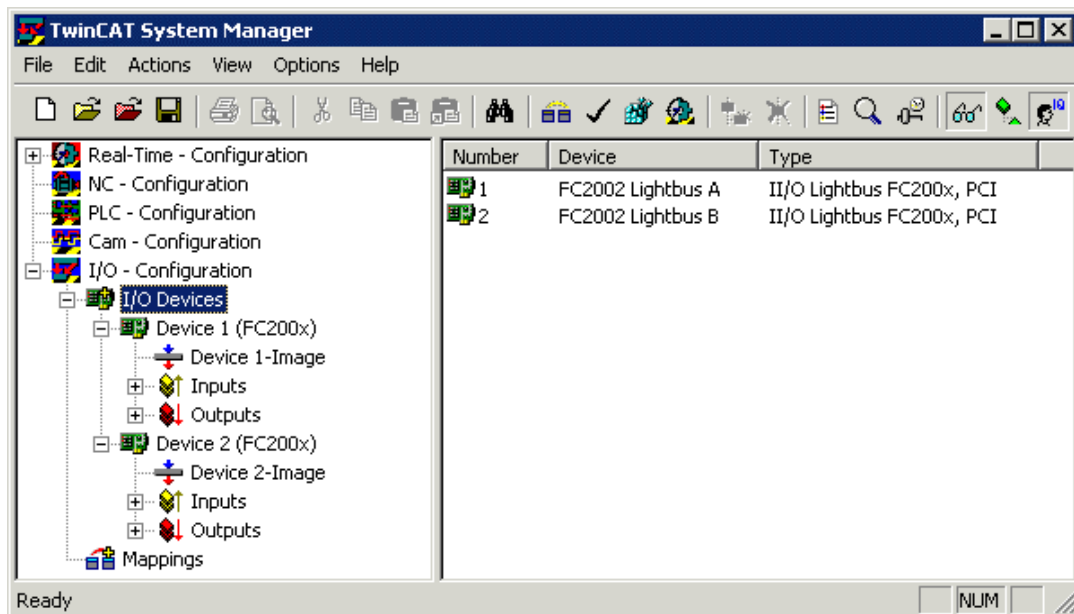
1. Start the TwinCAT System Manager.
2. Using the right mouse button, start searching for new devices *under the branch I/O Configuration \ I/O devices*.



Example: The two Lightbus channels of a FC2002 are displayed as device 1 and device 2.

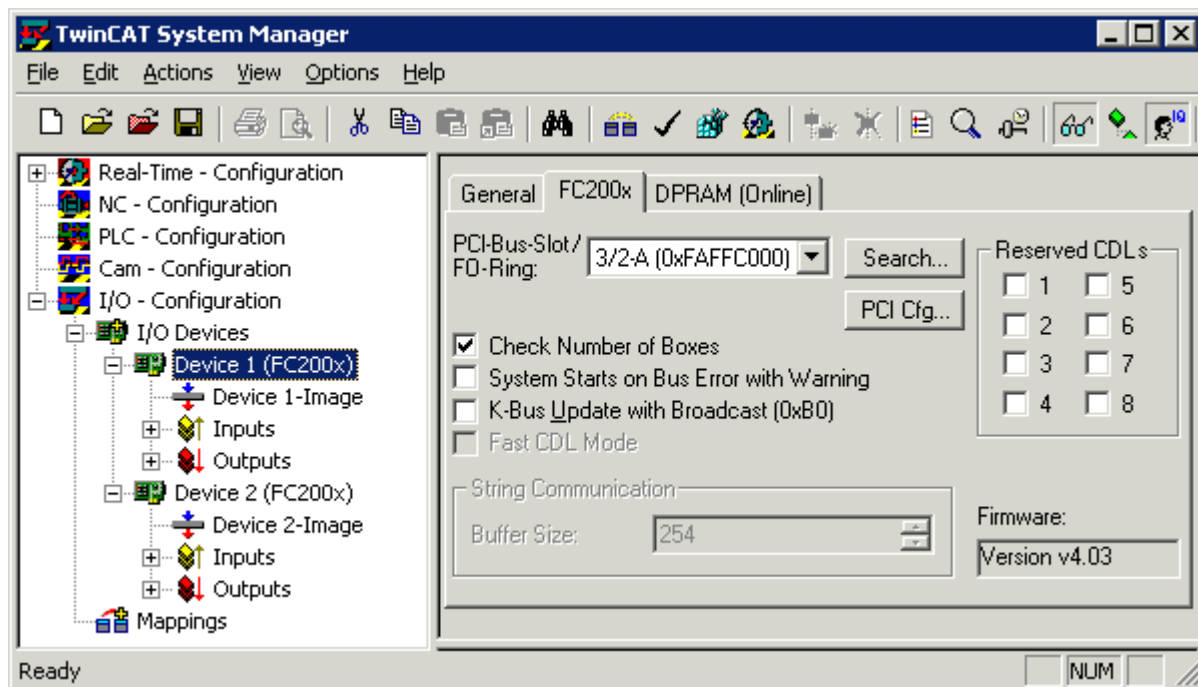


I/O devices may be renamed via a slow double-click (e.g. renaming to *FC2002 Lightbus A*).



The FC200x tab

Further properties of the I/O devices can be found under their respective entries. Use the mouse to select a Lightbus channel (in the example *FC 2002 Lightbus A*) and click on the *FC200x tab*.



PCI-Bus-Slot (Basisadresse) und LWL-Ring

Logical number of the PCI bus slot (or base address in the memory area) allocated to the Lightbus card in the PC. For Lightbus card FC2002, the optical fiber ring (-A or -B) used by this device entry is appended to the number of the PCI bus slot.

Search

Searches the computer for existing Lightbus cards and sets the logical number of the PCI bus slot or the address accordingly.

PCI Cfg

In the delivery state, the base address of the Lightbus card is in the range above 1MB (32-bit address). The *PCI configuration dialog* can be used to place the base address of the Lightbus card in the range below 1MB (DOS address). Only use this option if absolutely required by your PC.

Check number of boxes

If this option is selected, during card initialisation the number of boxes that are physically present (Bus Couplers, modules) is compared with the number that was entered under this card in the System Manager. If the numbers do not match, an error message is generated.

System Start Despite Optical Fiber Error

If this option is selected, system start-up is not aborted if a Lightbus error occurs during TwinCAT start-up. Instead, a warning is issued.

K-Bus update with broadcast telegram (0xB0)

If this option is selected, the K-bus update via broadcast telegram is carried out simultaneously for all Bus Couplers, instead individually for each Bus Coupler.

Reserved CDLs

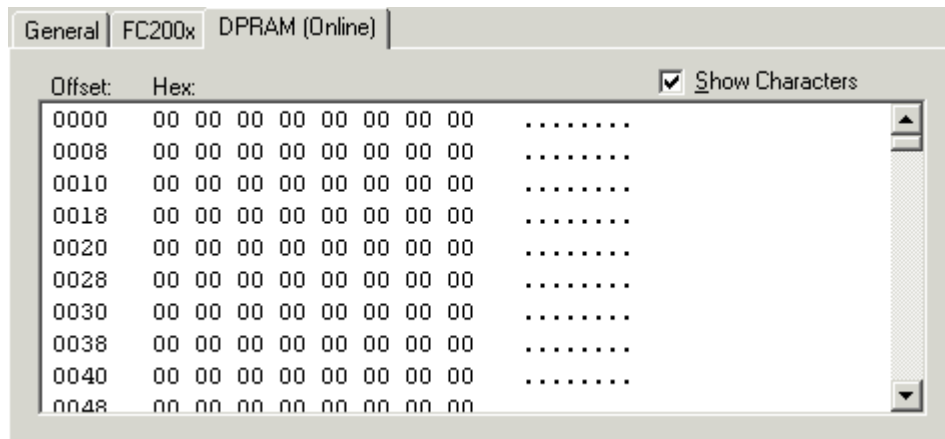
Each fieldbus channel has eight priority channels (CDLs), which can also freely be used by the TwinCAT System Manager. If individual CDLs are to be reserved for special applications, they should be marked here. They are then no longer available for the TwinCAT System Manager.

Firmware

Indicates the firmware version of the Lightbus card. For older Lightbus cards (e.g. C1220) only *Found* is displayed.

The DPRAM (online) tab

If TwinCAT is active, direct read access to the DPRAM of the fieldbus cards is provided for diagnostic purposes.

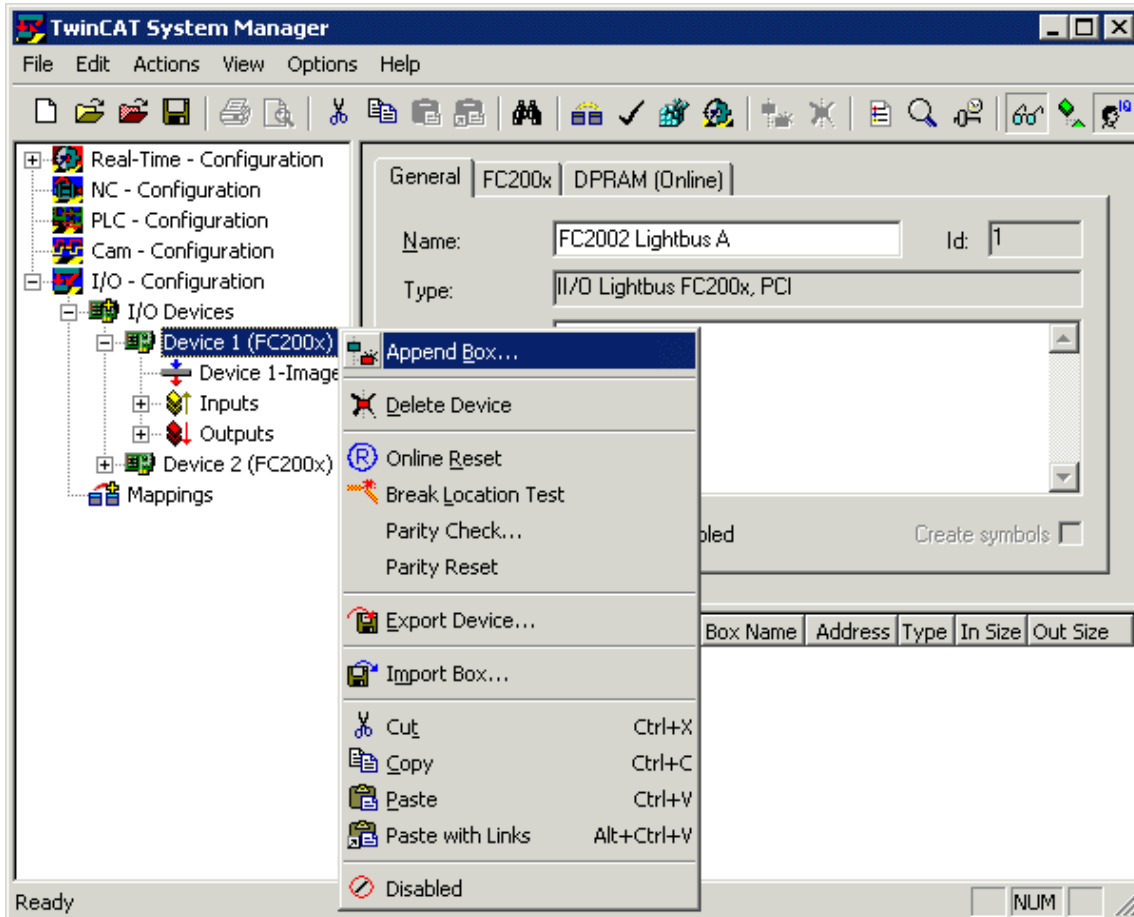


Adding further components

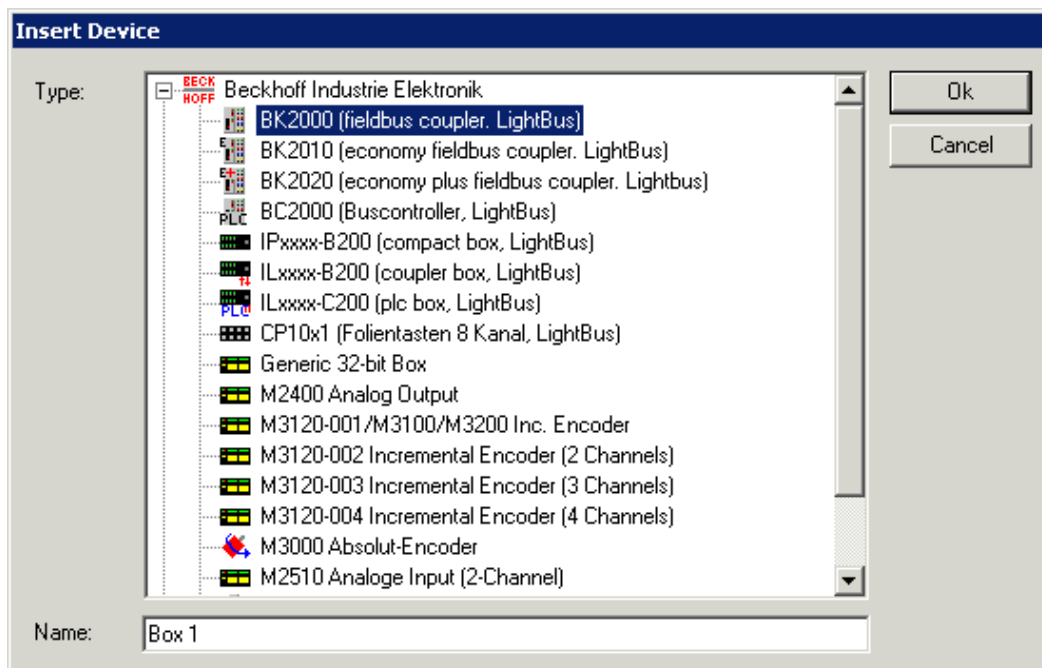
Further components can be added via the right mouse button.

Adding I/O modules

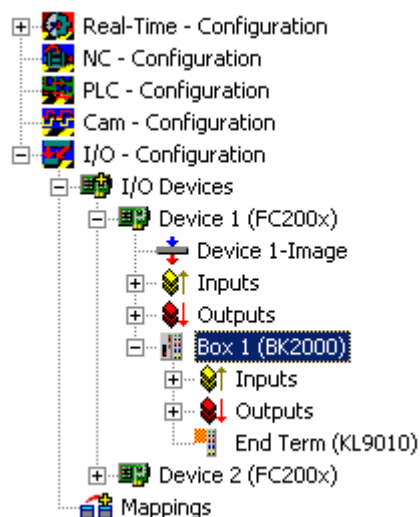
Right-click on the I/O device (FC2002 Lightbus A in the example) to which you would like to add I/O modules and select the menu item *Add box*.



The TwinCAT System Manager now offers various I/O modules for selection.



In the example, the *BK2000* Bus Coupler is selected and inserted as *Box 1*.



In the configuration tree of the example, the *BK2000* Bus Coupler appears as *Box 1*, with inputs and outputs and a *KL9110* end terminal. The desired Bus Terminals can now be added via the menu item *Add terminal* after right-clicking on *Box 1*.

All I/O modules of the Lightbus configuration should be added consecutively to the configuration tree in this way. The resulting order has to match the physical order of the I/O modules in the optical fiber ring!

Instructions for linking the inserted I/O modules to the process image of the Lightbus card can be found in the TwinCAT information system.

5. Diagnosis

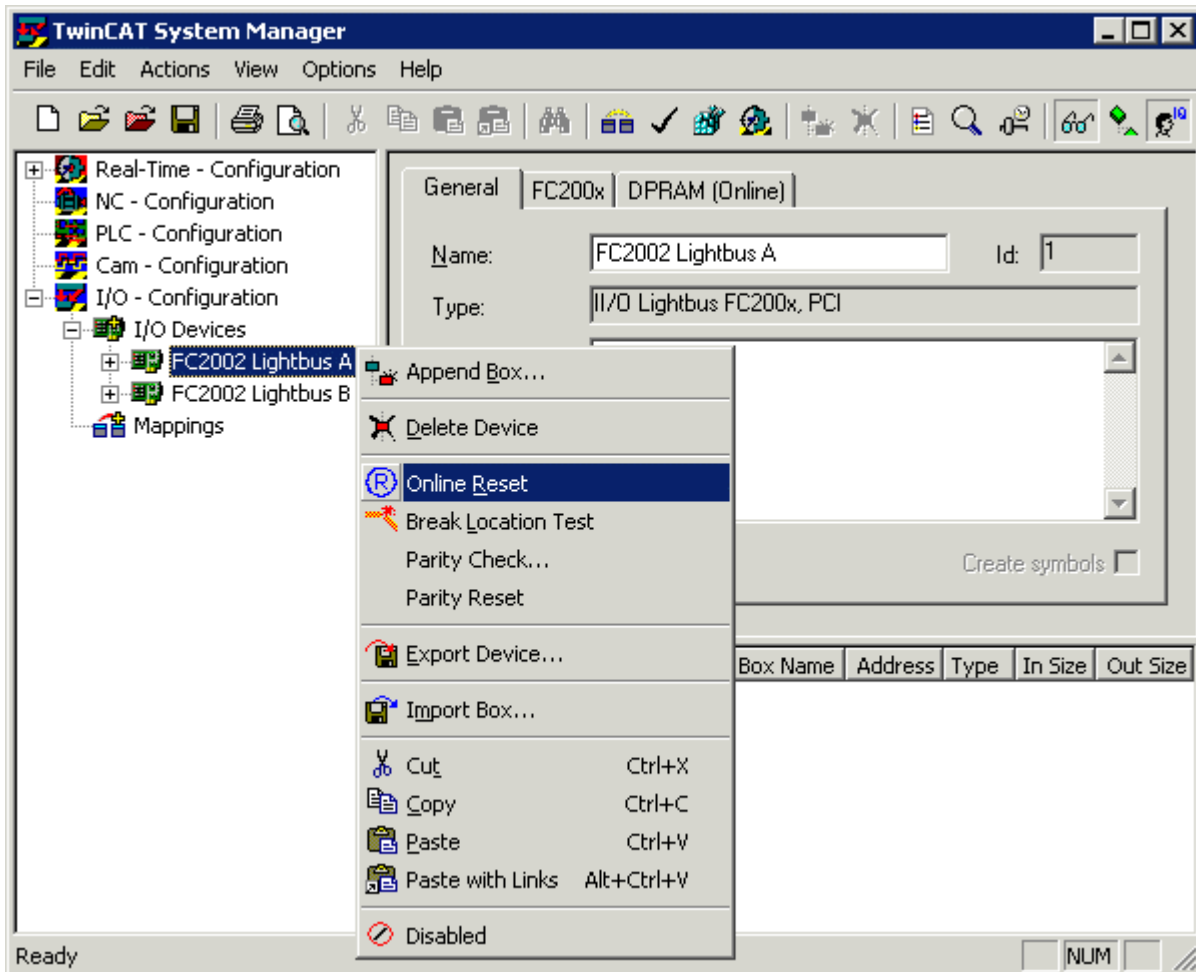
Diagnosis via the System Manager

The TwinCAT System Manager provides various test and analysis functions.

Online Reset

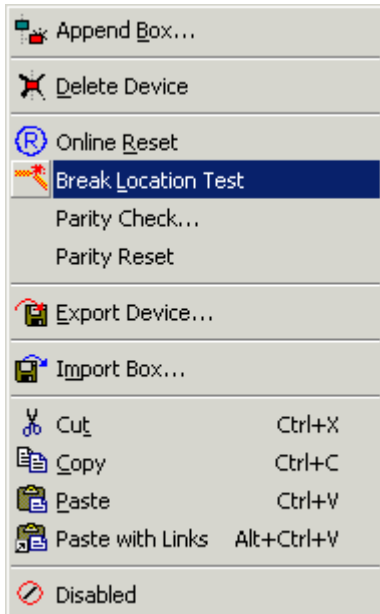
Initiates a reset of the Lightbus card.

The controller, the DPRAM and the optical fiber ring are re-initialised. The Lightbus card determines the number of modules in the ring, allocates the module addresses, tests them and checks the attenuation reserve of the optical fiber ring. Any broken lines are also detected and located.



Optical fiber break test

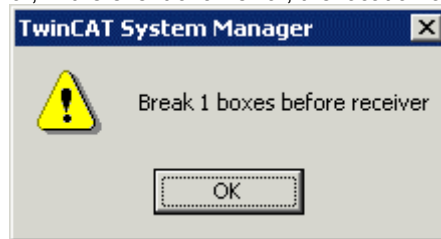
Initiates a ring break test on the optical fiber ring.



The test returns the number of I/O modules (boxes) found in the ring

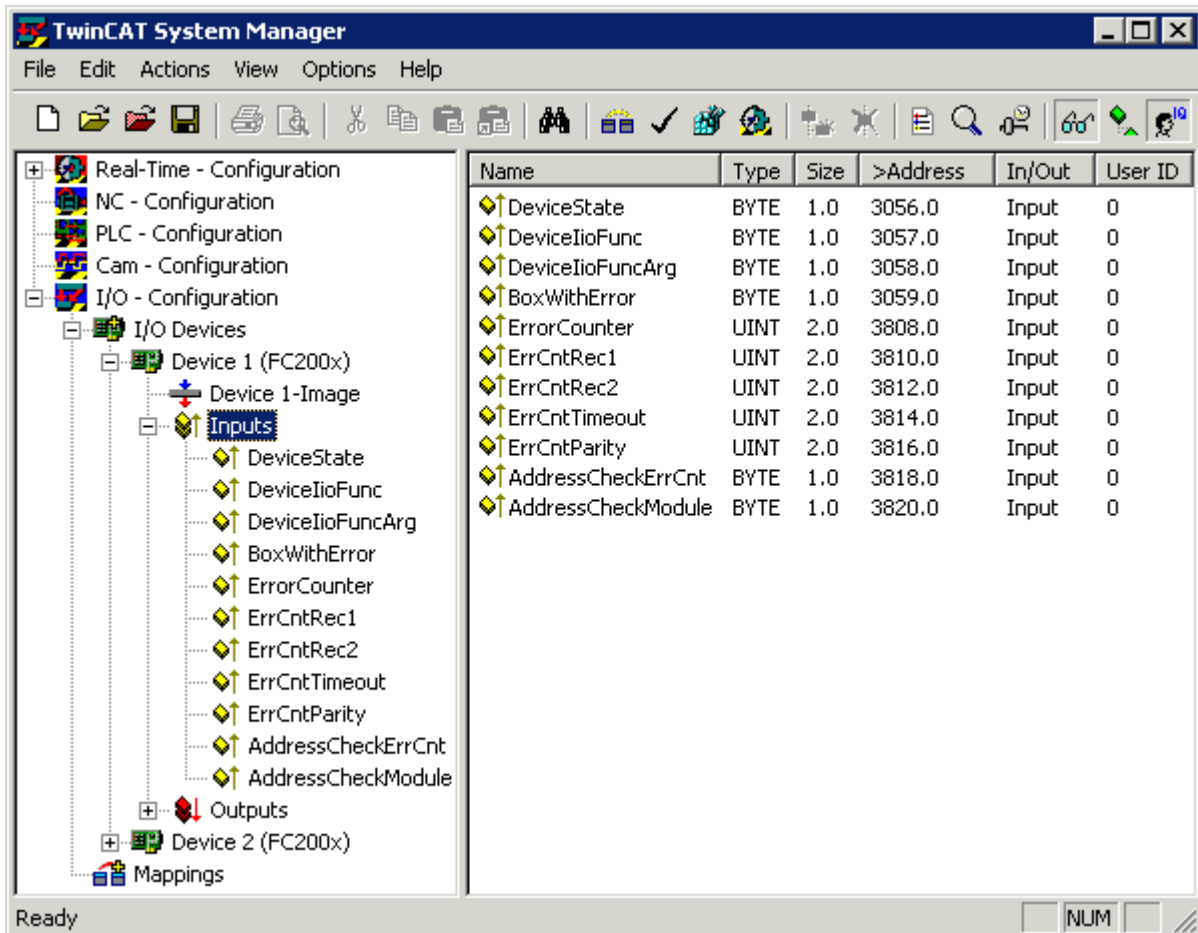


or, in the event of an error, the location of the break point.



Status and diagnostic inputs

The process image of the FC200x contains status registers and error counters, which are displayed in the TwinCAT System Manager.



Status register

The FC200x has input words for each optical fiber ring that describe the state of the Lightbus card and the optical fiber ring:

DeviceState

General status: contains the value *1* in the event of an error, otherwise the value *0* (device OK).

DevicelioFunc

In the event of an error this contains the code of the function that has triggered the error, e.g.:

- 0x01 Optical fiber reset
- 0x02 Code word request
- 0x05 Optical fiber attenuation test (intensity check)
- 0x06 Count I/O modules (counting boxes)
- 0x07 Test I/O module addresses (address check)
- 0x09 Software reset
- 0x0A Optical fiber break test
- 0x0C Re-initialisation of the CDL (CDL Reinit)
- 0x10 Configuration of the CDL (CDL Config)

DevicelioFuncArg

In the event of an error this contains the code of the argument that was appended to the function that triggered the error.

BoxWithError

Contains the number of the I/O module (box) in the optical fiber ring at which the error occurred.

Error counter

For each optical fiber ring, the FC200x includes input words for error counters. The Lightbus card does not deal with overflow processing or resetting of the counters!

ErrorCounter

Sum error (DPRAM offset: 0xEE0):

Register for the sum of all error counters with the exception of *AddressCheckErrCnt*

ErrCntRec1

Counter for errors in receiver 1 (DPRAM offset: 0xEE2):

Received address or control byte not equal transmitted byte.

ErrCntRec2

Counter for errors in receiver 2 (DPRAM offset: 0xEE4):

Received address or control byte not equal transmitted byte.

ErrCntTimeout

Counter for timeout errors (DPRAM offset: 0xEE6):

Timeout during telegram reception

ErrCntParity

Counter for parity errors (DPRAM offset: 0xEE8):

Telegram with CRC error received

AddressCheckErrCnt

Counter for errors during internal address check (DPRAM offset: 0xEEA):

Telegram with logically incorrect content (AD not equal D3) received. This counter does not increment the checksum error!

AddressCheckModule

Module address for errors during internal address check (DPRAM offset: 0xEEC):

Contains the address of the I/O module (box) that caused the error.

Diagnosis with function blocks

The TwinCAT automation software from Beckhoff provides various function blocks (FBs) for diagnostic purposes.

Lightbus-specific function blocks

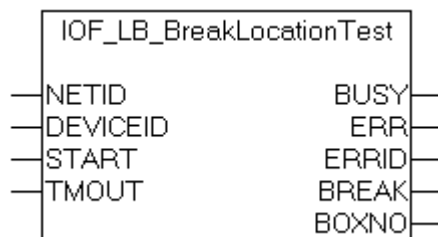
Function Block	Description
IOF_LB_BreakLocationTest	Carries out a break point test in the Lightbus optical fiber ring, in order to locate any break points.
IOF_LB_ParityCheck	Reads the parity error counter of the Lightbus modules (e.g. BK2000).
IOF_LB_ParityCheckWithReset	Reads the parity error counter of the Lightbus modules (e.g. BK2000) and resets the error counters.

General function blocks

Function Block	Description
IOF_GetBoxCount	Counts the number of I/O boxes (box = slave, module, station) of an I/O device (e.g. a fieldbus card).
IOF_GetBoxAddrByName	Determines the physical box number in the optical fiber ring through the box identifier and the device ID (no. of the fieldbus card).
IOF_GetBoxNameByAddr	Determines the box identifier via the physical box number in the optical fiber ring and the device ID (no. of the fieldbus card).

The function blocks *IOF_LB_BreakLocationTest* and *IOF_GetBoxCount* are described as examples below. Detailed documentation about these and further function blocks can be found in the TwinCAT Information System, which is supplied with the TwinCAT automation software and is also included on the *Products & Solutions* CD from Beckhoff.

IOF_LB_BreakLocationTest



The function block *IOF_LB_BreakLocationTest* carries out a break point test in the Lightbus optical fiber ring in order to locate any break points. If no break location is detected during the test, the output variable *BOXNO* returns the current number of Lightbus modules in the ring. If a break location is detected before the Nth module in front of the receiver input, the *BREAK* flag is set and the module number is provided via the output variable *BOXNO*. If the *BOXNO* variable returns a value of *0xFF* the break location is situated immediately in front of the receiver input, and can not be located.

Input variables

NETID	This can be used to transfer the AmsNetId of the computer on which the FB is to be executed. If an empty string is transferred, the FB is executed on the local computer.
DEVICEID	This device ID specifies the device (e.g. the fieldbus card) on which the function is to be executed. The device Ids are specified by the TwinCAT System Manager during the hardware configuration.
START	A rising edge at the <i>START</i> input activates the FB.
TMOUT	Used to specify the length of the timeout that may not be exceeded during execution of the ADS command.

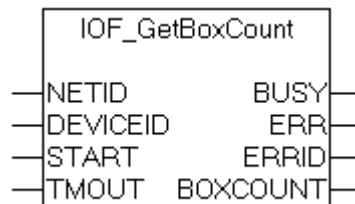
Output variables

BUSY	When activated, the FB sets the output <i>BUSY</i> . The output remains set as long as the FB is active.
ERR	If an ADS error occurs during the transfer of the command, the function block resets the <i>BUSY</i> output and sets the <i>ERR</i> output.
ERRID	In the event of an error, the <i>ERRID</i> output returns the ADS error number.
BREAK	This flag is set if a break location is detected in the optical fiber ring.
BOXNO	The module number before the receiver input in front of which the break location has been detected.

Further information about how to use this function block can be found in the TwinCAT Information System.

IOF_GetBoxCount

The function block *IOF_GetBoxCount* can be used to determine the number of configured and active I/O boxes (modules) of an I/O device (fieldbus card).



Input variables

NETID	This can be used to transfer the AmsNetId of the computer on which the FB is to be executed. If an empty string is transferred, the FB is executed on the local computer.
DEVICEID	This device ID specifies the device (e.g. the fieldbus card) on which the function is to be executed. The device Ids are specified by the TwinCAT System Manager during the hardware configuration.
START	A rising edge at the <i>START</i> input activates the FB.
TMOUT	Used to specify the length of the timeout that may not be exceeded during execution of the ADS command.

Output variables

BUSY	When activated, the FB sets the output <i>BUSY</i> . The output remains set as long as the FB is active.
ERR	If an ADS error occurs during the transfer of the command, the function block resets the <i>BUSY</i> output and sets the <i>ERR</i> output.
ERRID	In the event of an error, the <i>ERRID</i> output returns the ADS error number.
BOXCOUNT	After successful execution of the function block, the output <i>BOXCOUNT</i> returns the number of I/O modules (boxes) found.

Further information about how to use this function block can be found in the TwinCAT Information System.

6. Appendix

Support and Service

BECKHOFF and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to BECKHOFF products and system solutions.

BECKHOFF Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual BECKHOFF products, but also with other, wide-ranging services:

- world-wide support
- design, programming and commissioning of complex automation systems
- and extensive training program for BECKHOFF system components

Hotline:	+49(0)5246/963-157
Fax:	+49(0)5246/963-199
e-mail:	support@beckhoff.com

BECKHOFF Service

The BECKHOFF Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

Hotline:	+49(0)5246/963-460
Fax:	+49(0)5246/963-479
e-mail:	service@beckhoff.com

You will find further support and service addresses on our Internet pages under <http://www.beckhoff.com>. You will also find documentation for BECKHOFF components there.

BECKHOFF Headquarters

BECKHOFF Industrie Elektronik

Eiserstr. 5

33415 Verl

Germany

Phone:	+49(0)5246/963-0
Fax:	+49(0)5246/963-198
e-mail:	info@beckhoff.com

The addresses of BECKHOFF's branch offices and representatives round the world can be found on her internet pages:

<http://www.beckhoff.com>

You will also find further documentation for BECKHOFF components there.