

Documentation

FC2001 and FC2002

Lightbus PCI Interface Cards

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BECKHOFF

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1 Foreword

1.1 Notes on the documentation

Intended audience

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 documentation and the following notes and explanations are followed when installing and commissioning these components.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

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.

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The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, DE102004044764, DE102007017835 with corresponding applications or registrations in various other countries.

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The logo for EtherCAT, featuring the word "EtherCAT" in a bold, sans-serif font. A red arrow points from the top of the "A" towards the right, ending above the "T". A registered trademark symbol (®) is located to the right of the "T".

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1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability






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 Beckhoff Automation GmbH & Co. KG.

Personnel qualification

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


Description of symbols

In this documentation the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

 DANGER	<p>Serious risk of injury! Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.</p>
 WARNING	<p>Risk of injury! Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.</p>
 CAUTION	<p>Personal injuries! Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.</p>
 Attention	<p>Damage to the environment or devices Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.</p>
 Note	<p>Tip or pointer This symbol indicates information that contributes to better understanding.</p>

2 Product overview

2.1 Lightbus System Description

 Note	<p>System description for FC200x / EL6720</p> <p>The following system description is applicable both for the Beckhoff Lightbus PCI interface card FC200x and for the Lightbus master terminal EL6720.</p>
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The Lightbus consists of the Lightbus PCI interface card (in short Lightbus card) and an optical fiber-based fieldbus.

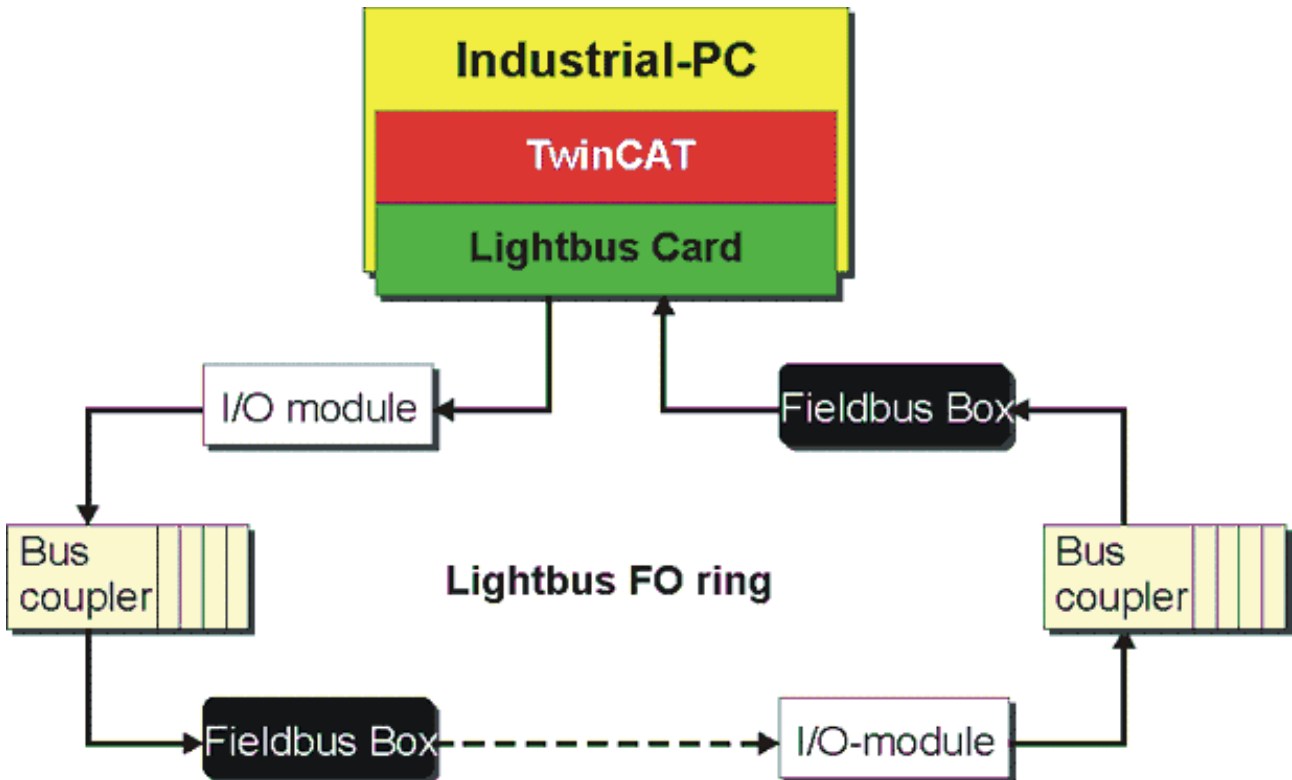


Fig. 1: Lightbus LWL-Ring

The coupling of the Lightbus with the PC is realized 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 optimized 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.

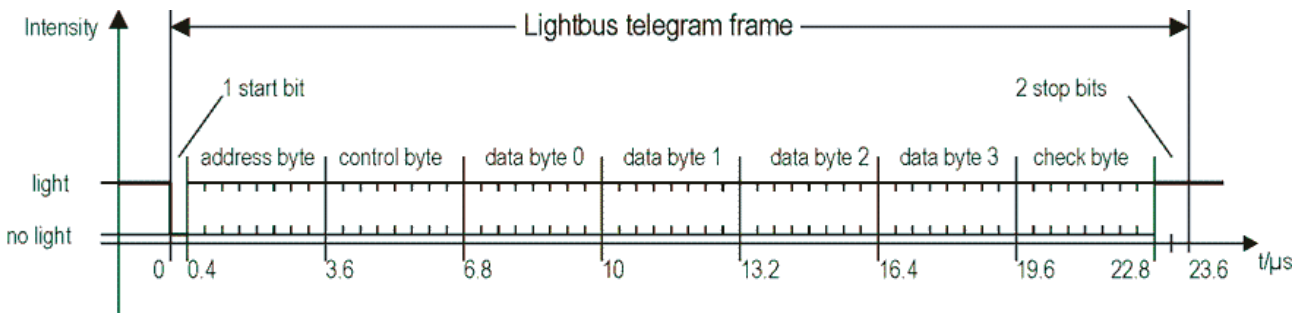


Fig. 2: Lightbus telegram structure

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 organized 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 D0 to D3.
0	0	0	1	Read and write	The addressed module inserts the input information into data fields D0 to D3 and receives the output information.
0	0	1	0	Address initialization	The addressed module receives the content of D0 as the module address and sets D0 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 D0 by 1. The addressed module moves the content of D0 to D3.
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:
Initialization, 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.

2.2 Hardware

As a Lightbus PCI interface card (in short Lightbus card), the FC200x realizes 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

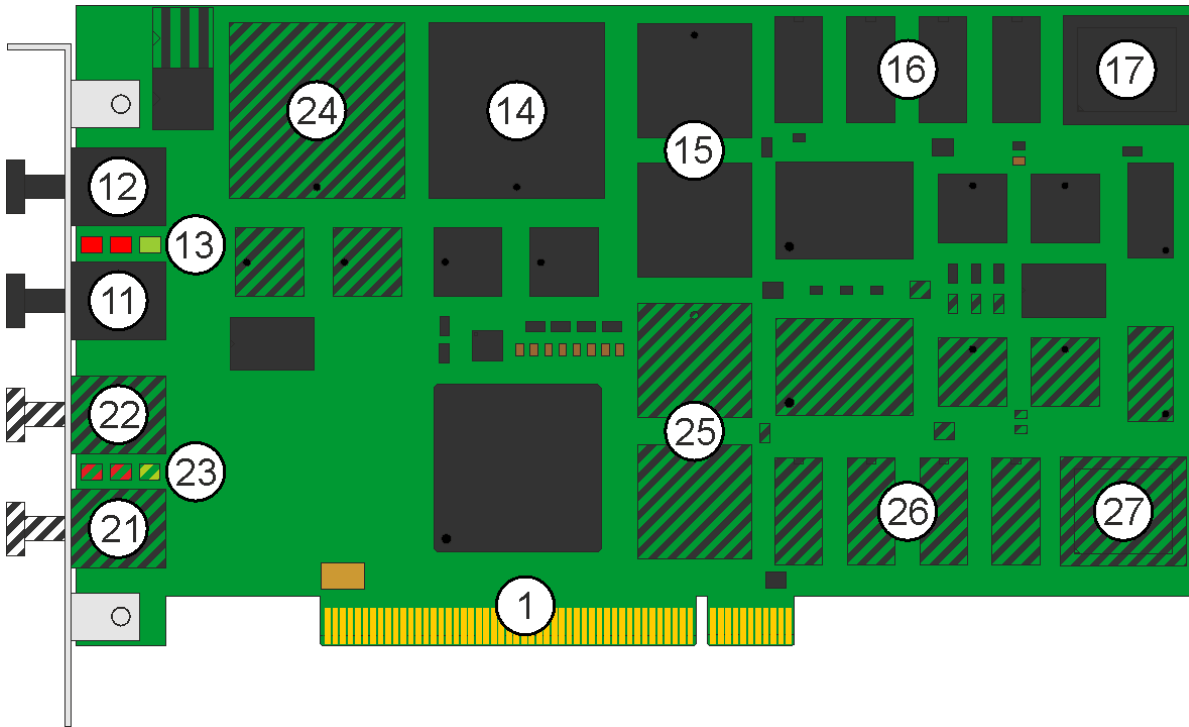


Fig. 3: Lightbus card components

- 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 LEDs for status display for optical fiber ring A
- 14. Lightbus-LCA for optical fiber ring A
- 15. 4 KB DP-RAM for optical fiber ring A
- 16. 512 KB RAM (4 x 128 KB) for optical fiber ring A
- 17. 256 KB 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 LEDs for status display for optical fiber ring B
- 24. Lightbus-LCA for optical fiber ring B
- 25. 4 KB DP-RAM for optical fiber ring B
- 26. 512 KB RAM (4 x 128 KB) for optical fiber ring B
- 27. 256 KB 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.

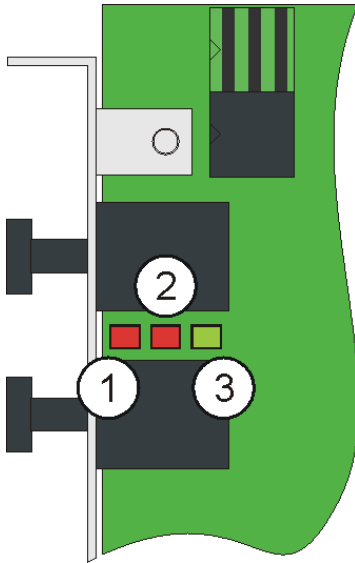


Fig. 4: Status displays

1. Optical Err (Lightbus error):

- If a defect in the optical fiber ring occurs during operation, the red *LWL Err* LED is activated.
- If the optical fiber error is of a general nature, the *LWL Err* LED flashes.
- If the error has occurred during the resident address test, the *LWL 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 initialized without errors and is ready for operation.

2.3 Technical data

Technical data	FC2001	FC2002
Fieldbus	Lightbus (optical fiber)	
Data transfer rate	2.5 Mbit/s (32-bit user 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 diagnostics	1 status LED and 2 diagnostic LEDs (Run, CPU Err, LWL 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

3.1 Installation in the PC



Attention

Risk of damage to the device!

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 fiber 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 fiber ring with the optical fiber 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 \[► 12\]](#), 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 \[► 11\]](#) of the Lightbus cards, particularly if several Lightbus cards are installed.

3.2 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:

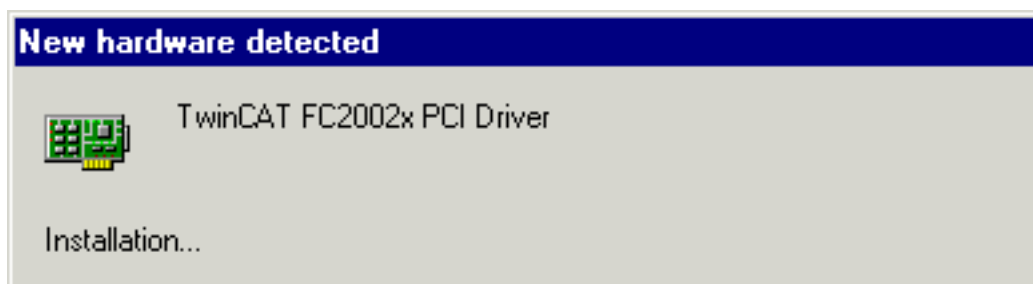


Fig. 5: Installation of the PCI driver – new hardware found

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):

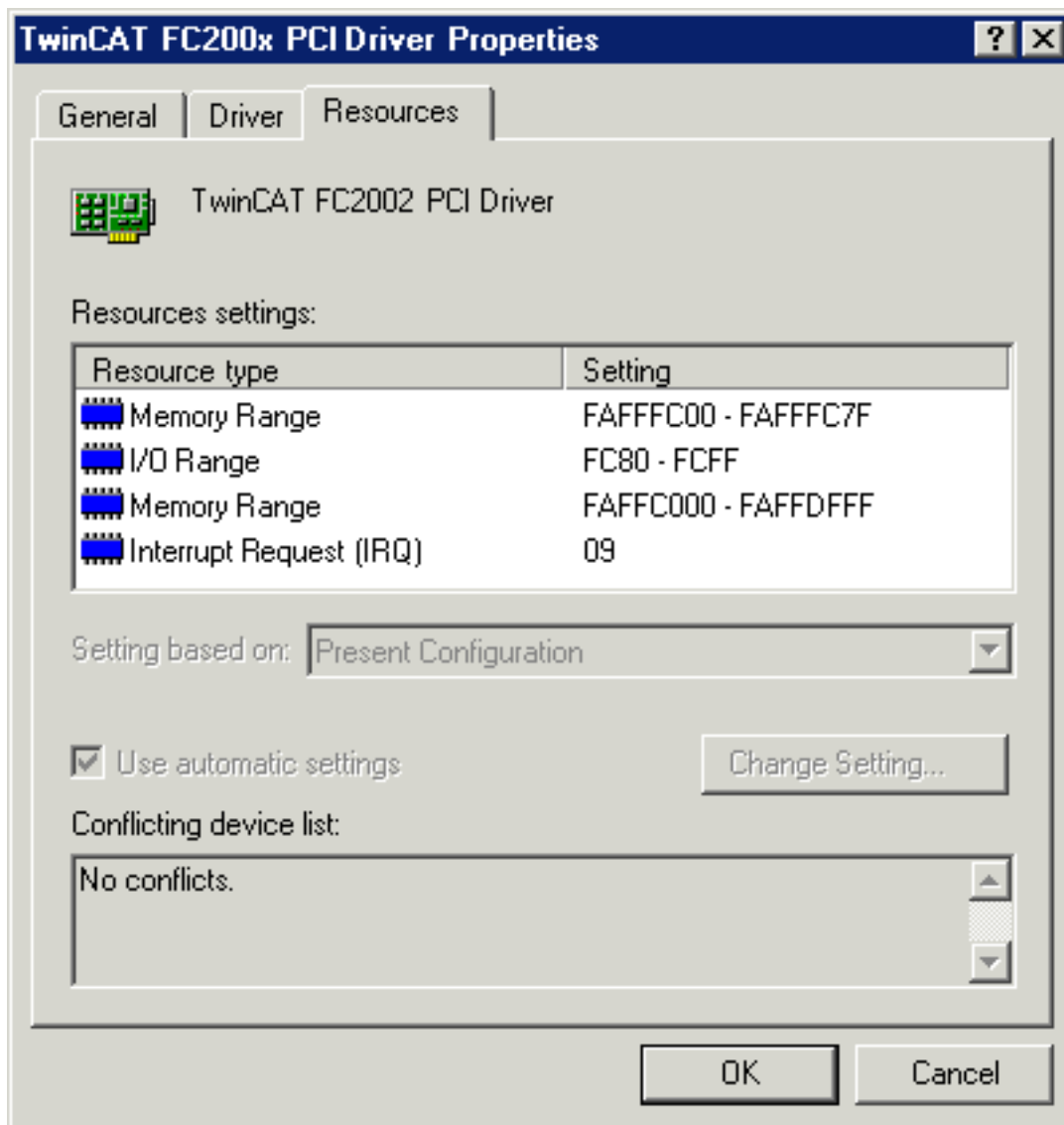


Fig. 6: Installation of the PCI driver – resource settings

4 Configuration by means of the TwinCAT System Manager

4.1 Scanning for the I/O devices

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*.

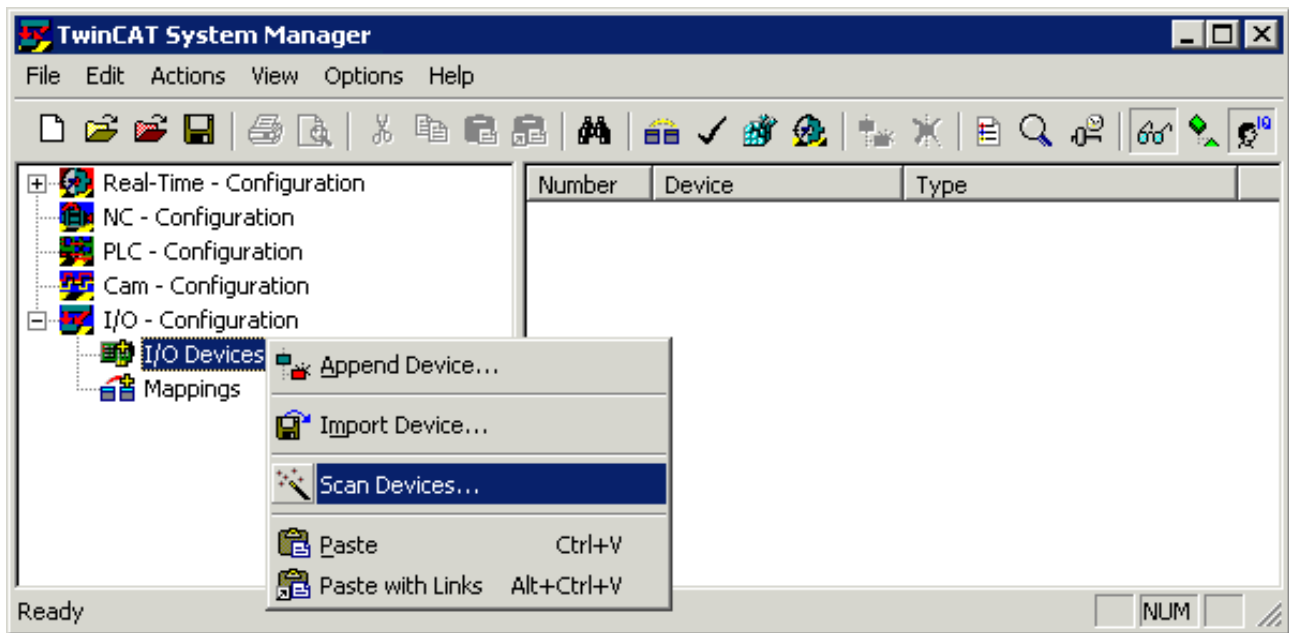


Fig. 7: Configuration using the System Manager – scanning for devices

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

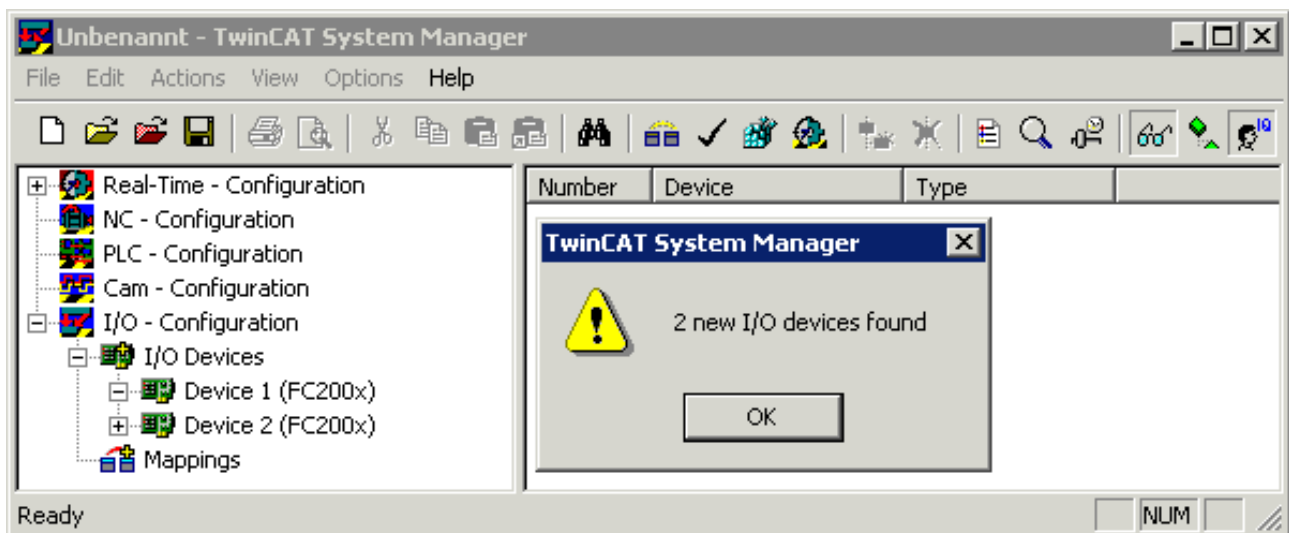


Fig. 8: Configuration using the System Manager – new I/O devices found

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

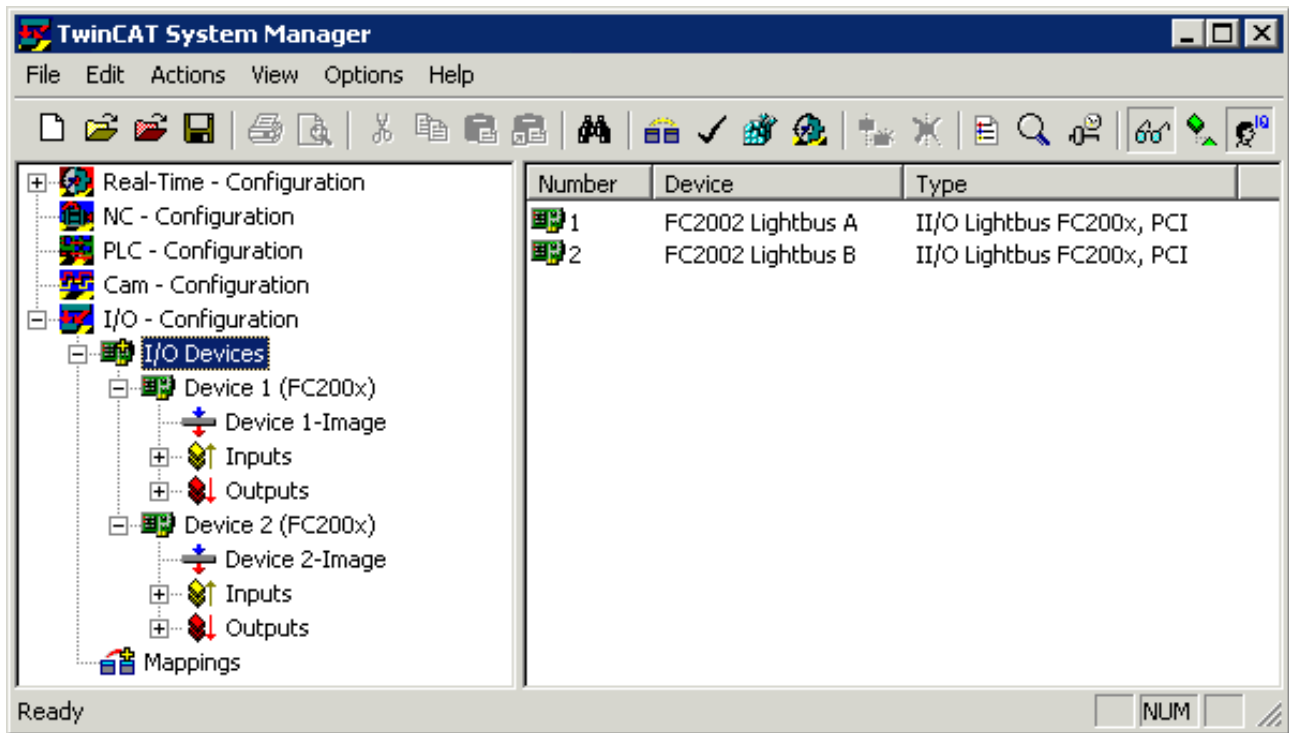


Fig. 9: Configuration using the System Manager – renaming the I/O devices

4.2 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*.

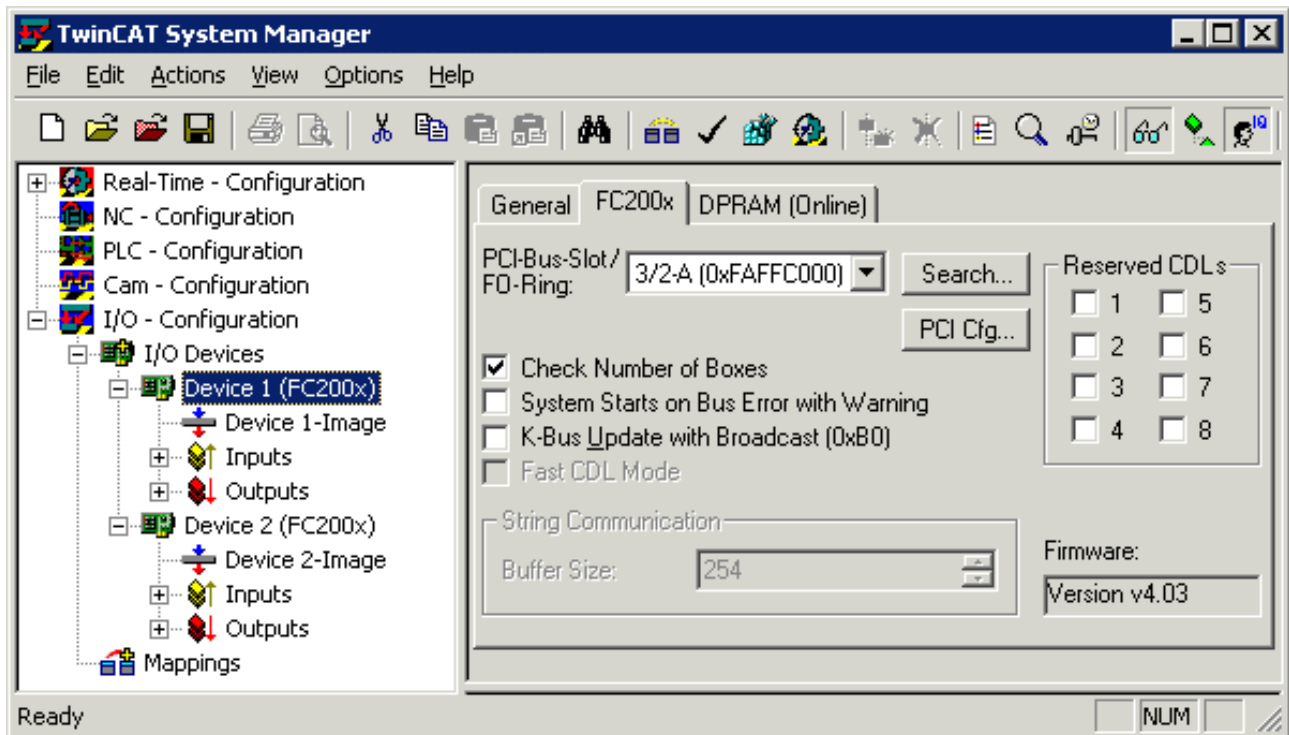


Fig. 10: TwinCAT System Manager – FC200x tab

PCI bus slot (base address) and optical fiber 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 1 MB (32-bit address). The *PCI configuration dialog* can be used to place the base address of the Lightbus card in the range below 1 MB (DOS address). Only use this option if absolutely required by your PC.

Check number of boxes

If this option is selected, during card initialization 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.

4.3 DPRAM (online) tab

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

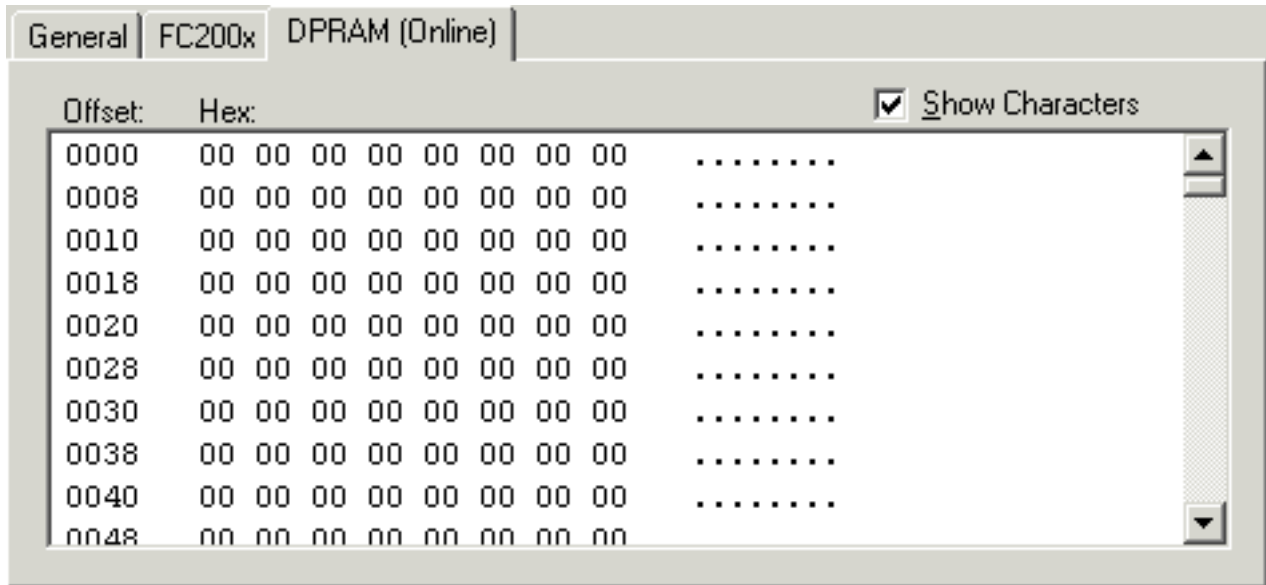


Fig. 11: TwinCAT System Manager – DPRAM (Online) tab

4.4 Appending further components

Further components can be added via the right mouse button.

Appending 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 *Append Box*.

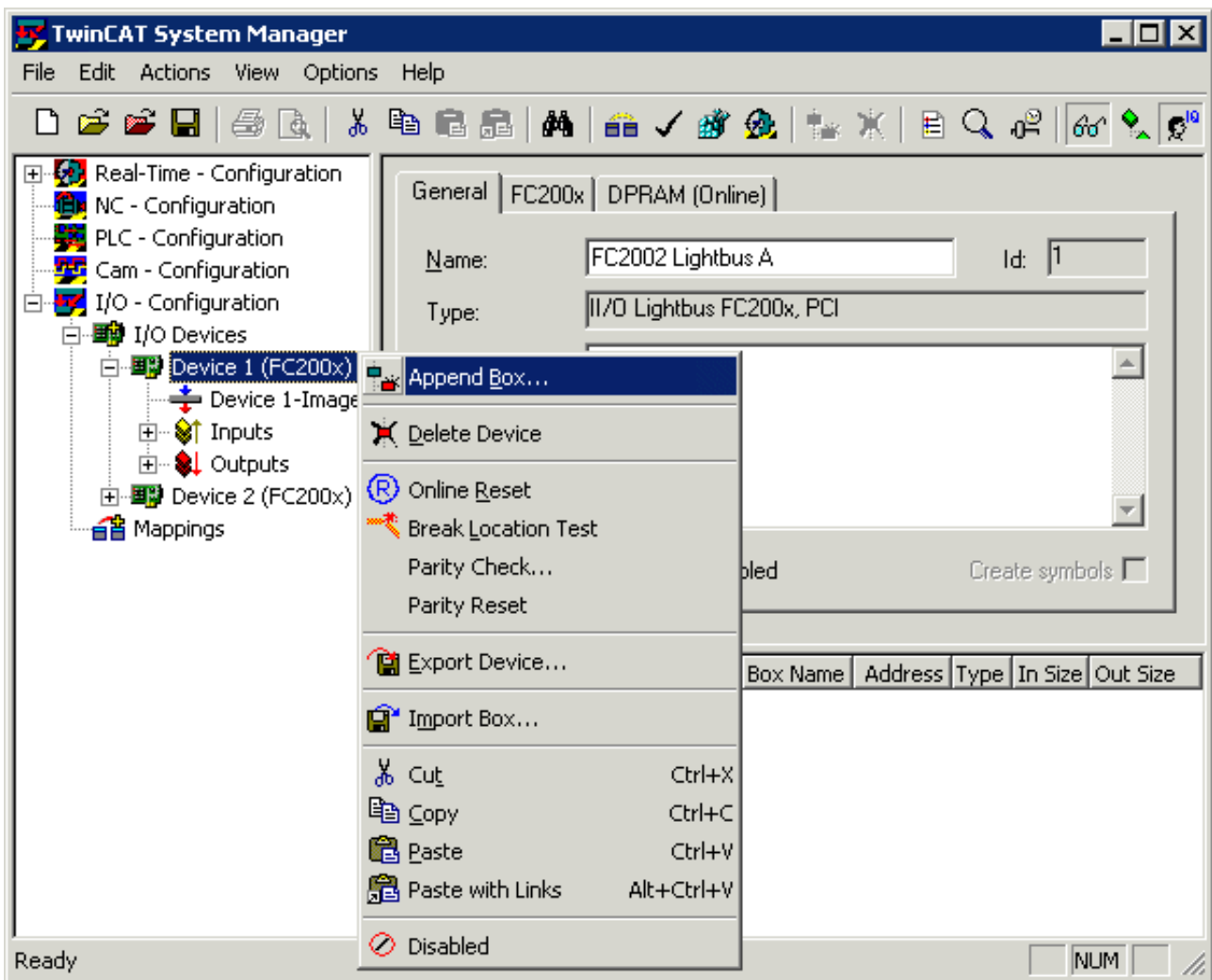


Fig. 12: TwinCAT System Manager – appending further components

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

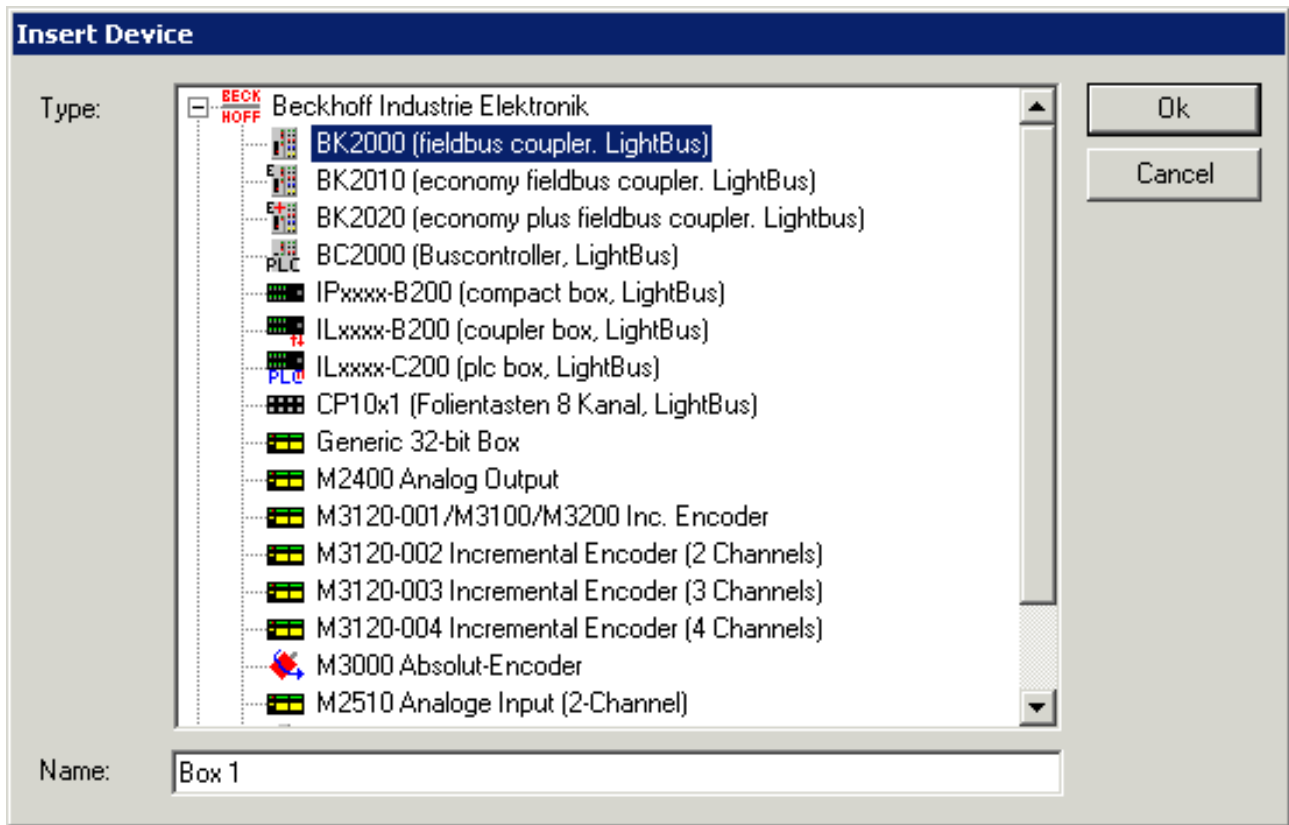


Fig. 13: TwinCAT System Manager – appending a Bus Coupler

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

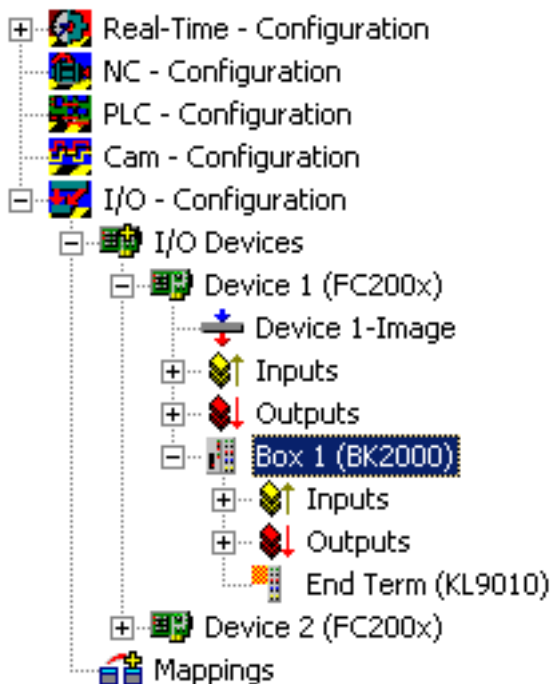


Fig. 14: TwinCAT System Manager – BK2000 appended

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 *Append 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!

Please refer to the Beckhoff Information System for details of how to link the inserted I/O modules with the process image of the Lightbus card.

5 Diagnostics

5.1 Diagnostics 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-initialized. 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.

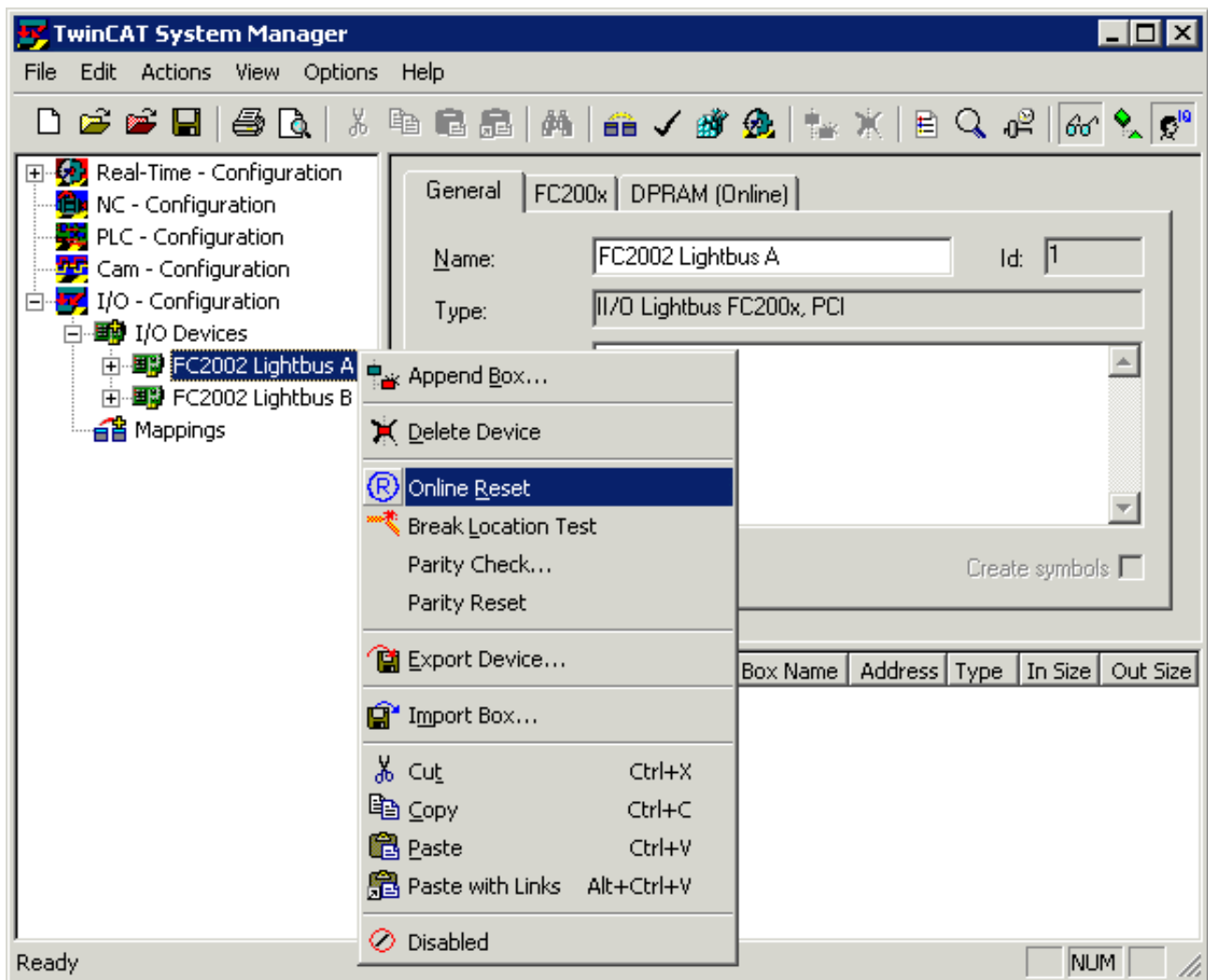


Fig. 15: TwinCAT System Manager – online reset

Optical fiber break test

Initiates a break test on the optical fiber ring.

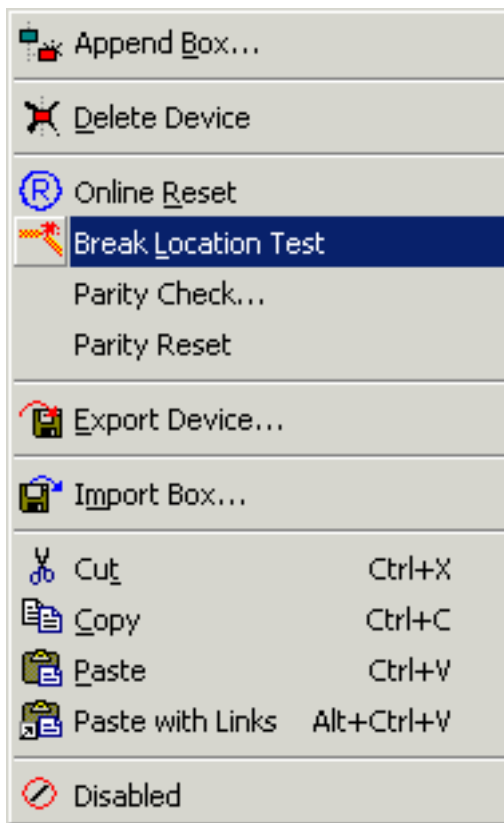


Fig. 16: Break test



Fig. 17: The test returns the number of I/O modules (boxes) found in the ring

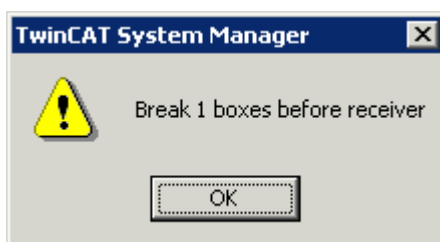


Fig. 18: or, in the event of an error, the location of the break point.

5.2 Status and diagnostic inputs

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

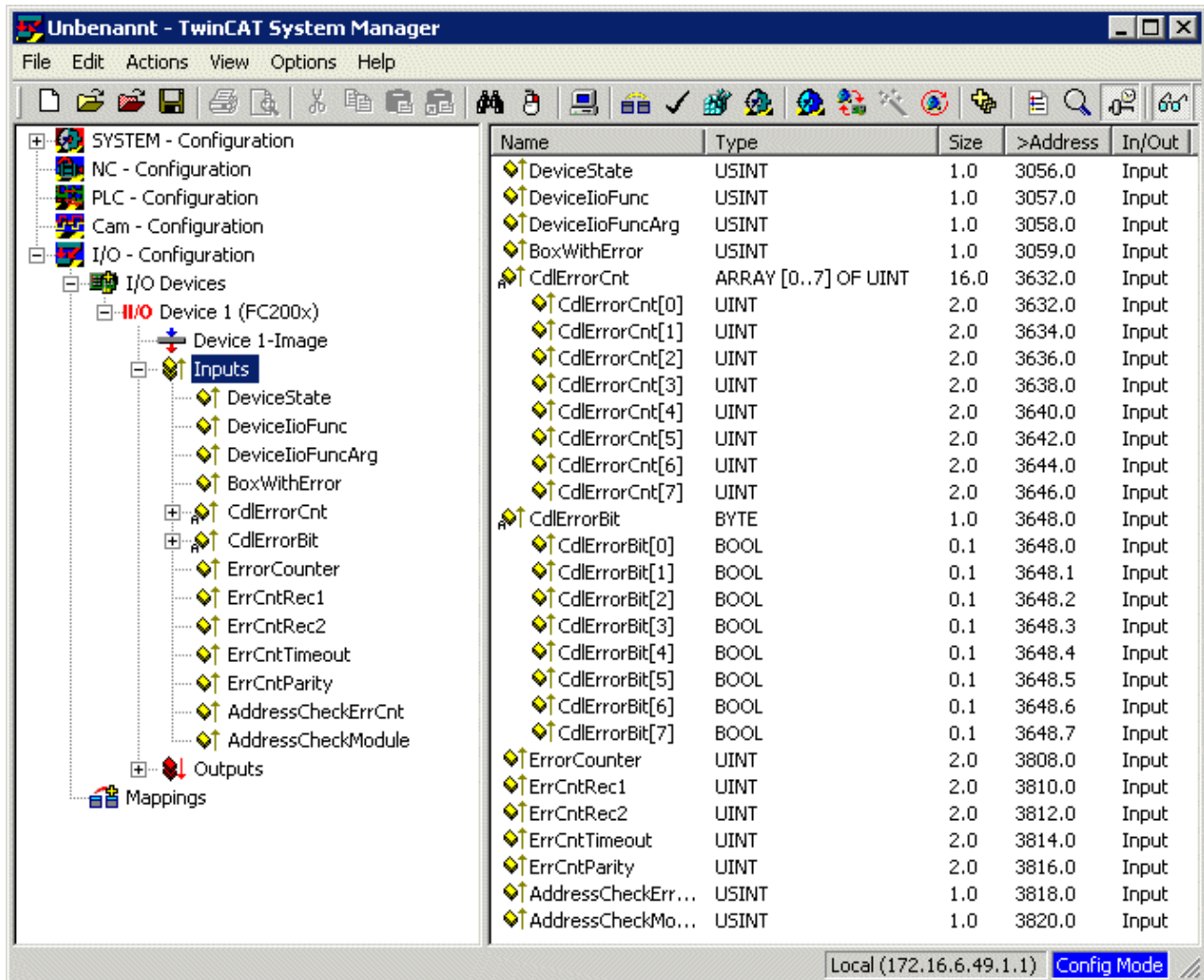


Fig. 19: TwinCAT System Manager – status and diagnostic inputs

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-initialization 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!

CdlErrorCount

Error in the CDL (DPRAM offset: 0xE30):
CdlErrorCount [0] .. [7] counts errors in each individual logical ring (CDL).

CdlErrorBit

The bit is set if CDL has an error (DPRAM offset: 0xE40):
this bit is cleared again if the CDL is successfully transmitted.

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.

5.3 Diagnostics 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 Beckhoff Information System, which is supplied with the TwinCAT automation software and is also included on the *Products & Solutions* CD from Beckhoff.

IOF_LB_BreakLocationTest

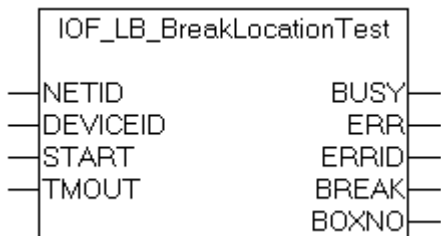


Fig. 20: Function block IOF_LB_BreakLocationTest

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 hardware configuration.
- START A rising edge at the *START* 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 for the use of this function block can be found in the Beckhoff 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).

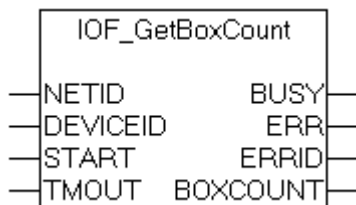


Fig. 21: Function block IOF_GetBox_Count

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.
BOXCOUN T	After successful execution of the function block, the output <i>BOXCOUNT</i> returns the number of I/O modules (boxes) found.

Further information for the use of this function block can be found in the Beckhoff Information System.

6 Appendix

6.1 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's branch offices and representatives

Please contact your Beckhoff branch office or representative for [local support and service](#) on Beckhoff products!

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You will also find further [documentation](#) for Beckhoff components there.

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