ctrlX I/O

Communication Module XI531001
1-channel, M-Bus Master Interface

DOK-XIO***-XI531001***-DA02-EN-P

R911428124
Edition 02

1 Functional description

The XI531001 communication module is used to read meter devices according to DIN-EN 13757-2 via the M-Bus (meter bus) and to forward the data to a ctrlX I/O station.

The logic and peripheral supply as well as the EtherCAT-based module communication are routed through the module.

ℹ For an application manual of the ctrlX I/O modules, refer to the Download Center ➦ www.boschrexroth.com/mediadirectory and enter the search term ➦ "R911423458".

ℹ Ensure that the current documentation is consulted. For the current documentations, go to ➦ www.boschrexroth.com/mediadirectory and enter the module type as search term.

ℹ For the integration into the parent system, the respective ESI files are available. For the ESI files, go to ➦ http://www.boschrexroth.com/electrics, search term "➦ ESI-Files".

ℹ For the currently valid declarations of conformity and certificates, go to: ➦ "DCTC-30455"

2 Ordering data

Type	Part number	Description
XI531001	R911423593	1-channel communication module, M-Bus master

ℹ For more ordering data (accessories), go to the product catalog under ➦ www.boschrexroth.com/electrics.

3 Technical data

3.1 General technical data

Number of channels	1
Connection method	Push-in terminal
Connection technique	2-wire connection
Signal type	Meter bus (M-Bus)
Transmission rate (bps)	300, 600, 1200, 2400 (default), 4800, 9600, 19200, 38400; (configurable)
Maximum number of supported devices	50
Collision detection	Yes
Data buffer	511 byte transmit buffer (TxD), 511 byte receive buffer (RxD)
Max. distance between module and devices	350 m (1.5 mm ²), Max. length of the topology 1000 m (1.5 mm²)
Overload protection	Yes, short-circuit proof
Nominal voltage (U_L/U_P)	24 V DC (19.2 V to 30 V, including tolerance and residual ripple) PELV/SELV (safety extra-low voltage)
Current consumption U_L	36 mA
Current consumption U_P, without external load	50 mA
Maximum current consumption U_P	210 mA
Maximum thermal power consumption of the module, without external load	2.5 W
Data width in the process data image (incl. fill bits)	32-byte output, 36-byte input (payload width Rx and Tx 30 bytes each)
Parameterization	Via ctrlX Works (start parameter)
Configuration	No address or configuration setting required
Dimensions	12 mm × 105 mm × 99 mm (Width × height × depth)
Weight	90 g (module including peripheral plug)
Electrical isolation	DC 1200 V U_P to U_L, DC 707 V U_L/U_P to FE, each tested for 60 s (not evaluated by UL)
EMC resistance	Acc. to EN 61000-6-2 and EN 61000-6-4
Mounting position	Vertical, on a horizontal mounting rail
Labeling, approvals	CE, UKCA, UL

3.2 Internal schematic diagram

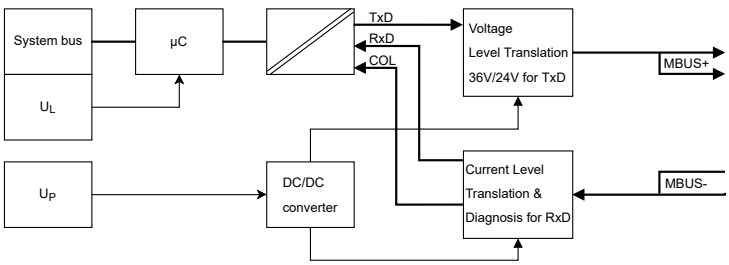


Fig. 1: Internal schematic diagram

3.3 Ambient conditions

Ambient temperature	-25 to +55 °C

≤ 2,000 m	
2,000 m to 3,000 m	-25 to +50 °C
3,000 m to 4,000 m	-25 to +45 °C
4,000 m to 5,000 m	-25 to +40 °C
Maximum operating altitude Acc. to DIN 60204	5,000 m
Ambient temperature (storage and transport)	-40 to +70 °C
Permitted air humidity according to DIN EN 61131-2 (Operation, storage, transport)	10 to 95 %
Degree of protection Acc. to DIN EN 60 529	IP20 (not evaluated by UL)
Protection class Acc. to DIN EN 61010-2-201	III
Overvoltage category Acc. to IEC 60664-1	2
Contamination level Acc. to EN 61010-1	2, no condensation

NOTICE

Defective device due to contaminated air!

- The ambient air must not contain acids, alkaline solutions, corrosive agents, salts, metal vapors and other electrically conductive contaminants in high concentrations.
- The devices to be installed into the housings and installation compartments must at least comply with the degree of protection IP 54 according to DIN EN 60529.
- The device shall be provided in a suitable fire enclosure in the end-use application.

NOTICE

Defective device due to gases jeopardizing functions

Due to the risk of corrosion, avoid sulphureous gases (e.g. sulphur dioxide (SO_2) and hydrogen sulphide (H_2S)). The device is not resistant against these gases.

NOTICE

Defective device due to overheating

To avoid overheating and to ensure a trouble-free operation of the device, the ambient air has to circulate. Also refer to the chapter "Installation notes" in the application manual.

3.4 Mechanical tests

Vibration resistance Acc. to DIN EN 60068-2-6	Oscillations, sinusoidal in all three axes, 5 Hz - 8,4 Hz with 3.5 mm amplitude 8.4 Hz -150 Hz with 1 g peak acceleration
Shock test Acc. to DIN EN 60068-2-27	Shock stress: Shock resistance in all three axes 11 ms semi-sinusoidal 15 g
Broadband noise Acc. to DIN EN 60068-2-64	20-500 Hz with 1.22 g RMS (Root Mean Square), 30 min in all three axes

ℹ For the current approvals, go to
➦ www.boschrexroth.com/electrics.

4 For your safety

4.1 Intended use

Use the module only as specified in the data sheet.

4.2 User qualification

The product use described in this data sheet is only intended for qualified electricians and staff trained by these qualified electricians. The user has to be familiar with the known safety concepts on automation technology, applicable standards and other guidelines.

4.3 Electrical safety

NOTICE

Loss of electric safety

Unintended handling can affect the device safety! Observe the notes in the present data sheet during installation, commissioning and operation.

5 Signal processing

5.1 General information on signal processing

This communication module connects devices with an M-Bus interface. The module transmits data transparently between the communication devices (M-Bus slaves) and the control.

The M-Bus is a bus system to network and remotely read supply meters, e.g. to measure gas or water consumption. The protocol is defined in DIN-EN 13757-2. Each device at the bus uses its own register set, so that the functions to access the various functionalities have to be implemented individually.

All communication data for the M-Bus protocol is calculated on the control side and transmitted transparently via EtherCAT and via this module to the devices on the M-Bus. It is not dealt with the protocol on the XI531001 module.

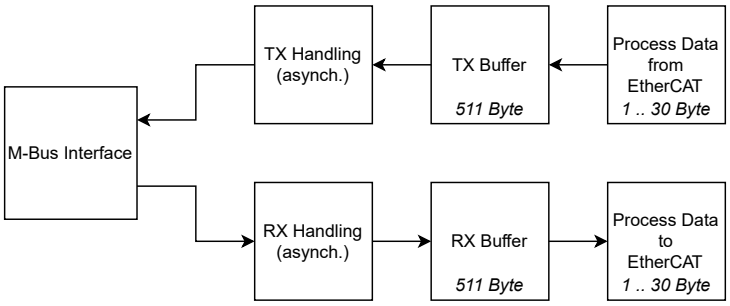


Fig. 2: Overview on data processing

On the EtherCAT, the process data image has a data width of 30 bytes in both the transmitting and receiving directions. A handshake mechanism signals that new data is available.

Between the actual M-Bus interface and the EtherCAT bus interface, there is a buffer of 511 bytes each to transmit and receive data.

If data cannot be sent fast enough, the respective buffer becomes full and data is lost. This can be in the transmit direction if the data rate of the interface is lower than the data rate of the data transmitted by the EtherCAT. This can be in the receiving direction if the data rate of the interface is higher than that of the data transmitted via the EtherCAT.

5.1.1 Possible transmission rates

An EtherCAT process data image contains 30 bytes of user payload in the transmit and receive direction. Up to 30 bytes can be sent and received in every second EtherCAT cycle:

- In the first cycle, data is transferred in the process data.
- In the second cycle, the remote station acknowledges the data reception.

Example

With a cycle time of 10 ms, 30 bytes per second can be transferred 50 times. If the data format "8E1" is set, each transmitted byte is composed as follows:

- one start bit
- eight data bits
- one parity bit
- one stop bit

This corresponds to 11 bits for each byte of process data to be transferred.

The previously mentioned settings result in a continuous transmission rate of:

`50[1/s] × 30[byte] × 11[bit] = 16500baud(bit/s)`

The maximum M-Bus transmission rate is 38400 baud. The next lowest M-Bus standard transmission rate is 9600 baud. With a cycle time of 10 ms, continuous transmission at a maximum of 9600 baud can be ensured.

If the control cannot retrieve data from the module quickly enough, data is temporarily stored in the receive buffer of the module. When the receive buffer is full, all further data is lost. A buffer is also available for the transmit data. When this buffer is full, all further data is lost.

The following maximum data rates result for continuous data transmission:

Cycle time	Calculated data rate	Standard data rate
1 ms	165.000 bit/s	38.400 baud
5 ms	33.000 bit/s	19.200 baud
10 ms	16.500 bit/s	9.600 baud
20 ms	8.250 bit/s	4.800 baud
30 ms	5.500 bit/s	4800 baud
50 ms	3.300 bit/s	2400 baud
100 ms	1.650 bit/s	600 baud

5.2 Synchronizing the application

The application is synchronized in the "SM synchronous" mode.

5.3 Data transmission

5.3.1 Data transmission via PLC function block

For ctrlX PLC Engineering, Bosch Rexroth provides various PLC function blocks with the "CXA_MBus" PLC library, which simplify communication data handling with M-Bus devices and the ctrlX I/O module, see ➦ https://docs.automation.boschrexroth.com/doc/115493275/introduction-and-overview/latest/en/. Based on the CXA_MBus library, Bosch Rexroth provides an SDK with the CXA_MBusSDK library. The SDK provides specific function blocks for M-Bus devices.

5.3.2 Basics of data transmission

The module has a separate receive buffer and a separate transmit buffer. Data is transferred between the module and the control via a handshake mechanism.

A data transmission can be divided into three parts:

- Initialization
- Sending (transmitting) data
- Receiving data

The following explanation of an exemplary data transmission is seen from the perspective of the control (EtherCAT master).

Only values in the process data are used, both the actual data and the "Control" and "State" objects.

5.3.3 Initializing

It is initialized before the first transmission and the first reception.

Proceed as follows:

1. Set "Init request" in the "Control" process data object to "1". The successful initialization is confirmed by the module by setting "Init accepted".
2. Reset "Init request" to "0". The module also resets "Init accepted" to 0.
   ➡ The module is now ready for data exchange.

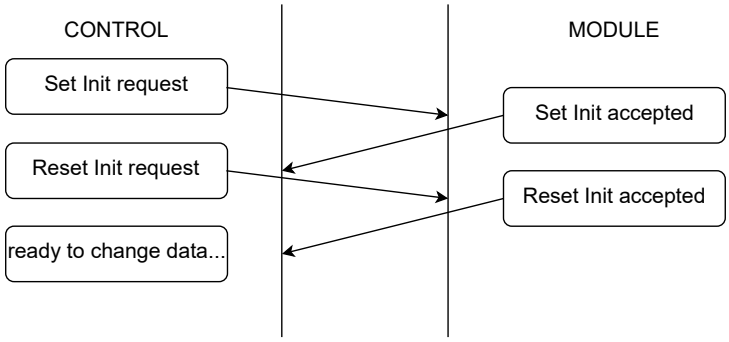


Fig. 3: Initialization procedure

5.3.4 Sending data

Data can be sent after initialization.

Proceed as follows:

1. Write data to be sent to the "Transmit data[0..29]" output variable.
2. Set the "Transmit data length" parameter to the number of bytes to be sent.
3. Invert the "Transmit request" bit to signal to the module that new data is available.
4. The module acknowledges the data transmission via the "Transmit accepted" parameter by setting this parameter to the same value as the "Transmit request" bit. If all data was applied, "Transmit request" and "Transmit accepted" are in the same state.

Process data and handshake information can be written in the same step.

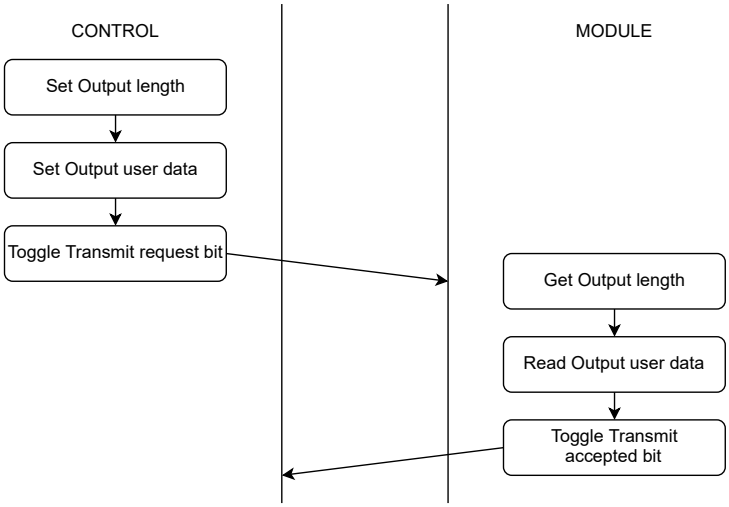


Fig. 4: Data flow diagram to "send data"

Data is sent by the module immediately when received. Stop sending via the process data bit 7001:03(hex) "Transmit disable" if required. In this state, a complete telegram can be transferred to the transmit buffer of the module for example. It is then sent as one as soon as the bit is reset.

5.3.5 Receiving data

Data can be received after initialization.

Proceed as follows:

1. When the module received data, it stores it in the process data from "Receive data[0..29]", sets the data length "Receive Data Length" and inverts the "Receive request" bit.

2. If the control detects a change in the "Receive request" bit, new data is available.
   - Data is available in the input variables "Receive data[0..29]". The data received first is in "Receive data" byte 0.
   - After reading, the control writes the "Receive accepted" bit to the value identical to the "Receive request" bit. This confirms data reception.
   - The module only transfers new data from the reception buffer to the master after confirming the process data.

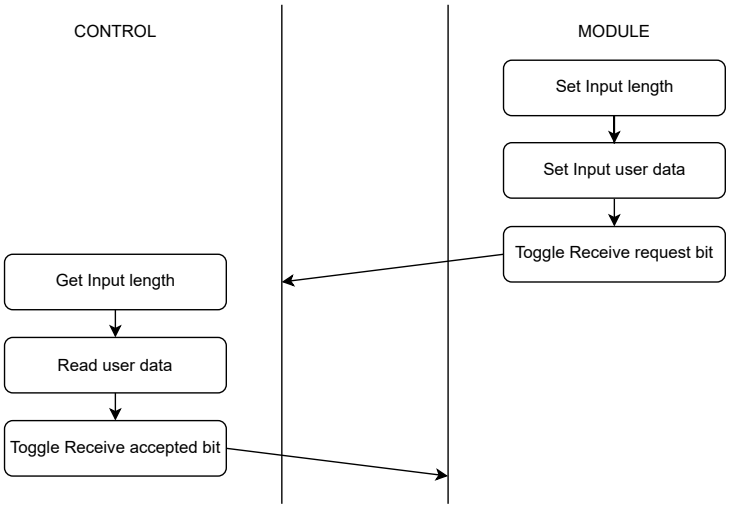


Fig. 5: Data flow diagram to "receive data"

5.4 Error detection and error response

The module detects parity and framing errors on the receiving end.

The "Buffer full" state is reached when there are more than 450 bytes in the transmit or receive buffer. The overflow - in which data loss occurred - is signaled separately.

The module is also protected against M-Bus interface overload. The maximum short-circuit current is <1 A. Overcurrent is detected at an output current >250 mA.

There is also a collision detection function. A collision is detected if the signal current of one or more slaves is higher than ~30 mA for the transmission time of 2 bits depending on the baud rate.

The possible error reactions are listed in the following:

Transmit buffer Tx full	Diagnostic message: 8152(hex) Module status LED flashes yellow Status bit in process data: 6001:02(hex) set to 1
Transmit buffer Tx overflow	Diagnostic message: 8153(hex) Module status LED is red Status bit in process data: 6001:03(hex) set to 1
Receive buffer Rx full	Diagnostic message: 815A(hex) Module status LED flashes yellow Status bit in process data: 6001:07(hex) set to 1
Receive buffer Rx overflow	Diagnostic message: 815B(hex) Module status LED is red Status bit in process data: 6001:08(hex) set to 1
Parity error	Diagnostic message: 1010(hex) Module status LED is red Status bit in process data: 6001:0A(hex) set to 1
Data frame error	Diagnostic message: 1010(hex) Module status LED is red Status bit in process data: 6001:0B(hex) set to 1
Collision	Diagnostic message: 0x8950(hex) Module status LED flashes yellow Status bit in process data: 6001:0C(hex) set to 1
Overload	Diagnostic message: 2310(hex) Module status LED flashes yellow Status bit in process data: 6001:0D(hex) set to 1

6 Object directory

6.1 CoE standard objects

The object directory of the module contains objects that can be triggered via SDO services. These are defined in the ETG standards:

Index (hex)	Name
1000	Device type
1001	Error register
1008	Device name
1009	Hardware version
100A	Software version
1018	Identify
10F1	Error settings
10F3	Diagnosis history
10F8	Timestamp object
16nn	PDO mapping RxPDO
1Ann	PDO mapping TxPDO
1C00	Sync manager type
1C12	Sync manager 2 assignment
1C13	Sync manager 3 assignment
1C32	SM output parameter
1C33	SM input parameter
F000	Modular device profile
F100	Device state

6.2 Module-specific CoE objects

Objects with a module-specific design are described in the following table.

Index (hex)	Object name	Data type	Access	Description
A000	**Module identification**			
A000:0	Material number	String(20)	RO	Material number of the module
A010:0	Full serial number	String(20)	RO	Complete serial number of the module
F100	**Module diagnostics and information**			
F100:01	Periphery voltage OK	BIT1	RO	Indicates the peripheral voltage state, 1 = OK; 0 = Not OK
F100:02	Error	BIT1	RO	General module error

6.3 CoE objects for parameterization

The module can be parameterized using these objects.

ℹ The module does not remanently store the parameter values. To automatically load the settings required upon each bus start, set the values in the start parameters of the Engineering.

Index (hex)	Object name	Data type	Access	Description	Default (hex)
8000	**Settings**				
8000:01	Baud rate	BIT5, ENUM	RW	Data rate (baud) 0: 300 1: 600 2: 1200 3: 2.400 4: 4.800	03: 2400 baud

Index (hex)	Object name	Data type	Access	Description	Default (hex)
				6: 9.600 7: 19.200 8: 38.400	
8000:02		BIT11		Fill bits	

The object for parameterization can only be written in the "PreOP" state.

6.4 Writing "Configured Station Alias"

The "Configured Station Alias" allows the fixed address assignment for the module within the EtherCAT topology. The address is saved in the EEPROM of the module.

Bring the system into the safe state to write the "Configured Station Alias" before starting the programming. Apart from the "Configured Station Alias", no other values of the EEPROM content may be changed. After writing, the respective module has to be restarted via a voltage cycle of the complete station to use the value.

7 Process data

7.1 Process data

Data is transferred via a handshaking mechanism, refer to ➦Chapter 5.3 “Data transmission” on page 3.

7.1.1 Input process data

Index (hex)	Object name	Data type	Access	Description	Default (hex)
6000	**Receive Data**				
6000:01	Value	Array [0..29] of Byte	RO	Receive Data	0
6001	**State**				
6001:01	Transmit accept	BOOL	RO	Handshake bit for transmit data. After transmit data has been applied, the bit is set to the value from 7001:02(hex) "Transmit request".	0
6001:02	Transmit buffer full	BOOL	RO	Signals that the transmit buffer is filled with more than 450 bytes.	0
6001:03	Transmit buffer over-flowed	BOOL	RO	Signals that there is an overflow of the transmit buffer. Data loss occurred.	0
6001:04		BIT5		Fill bits	
6001:05	Receive data length	UINT8	RO	Length of received data in object 6000:01(hex)	0
6001:06	Receive request	BOOL	RO	Handshake bit for receive data. If new data is available in the process data, this bit is toggled.	0
6001:07	Receive buffer full	BOOL	RO	Signals that the receive buffer is filled with more than 450 bytes.	0
6001:08	Receive buffer over-flowed	BOOL	RO	Signals that there is an overflow of the receive buffer. Data loss occurred.	0
6001:09	Init accept	BOOL	RO	Signals that the module processed the "Init Request" 7001:05(hex).	0
6001:0A	Parity error	BOOL	RO	An error was detected during the parity check upon reception.	0
6001:0B	Framing error	BOOL	RO	An error was detected in the data frame upon reception.	0
6001:0C	Collision	BOOL	RO	Signals that two or more slaves are responding to a master request at the same time	0
6001:0D	Overcur-rent	BOOL	RO	Indicates that the output is over-loaded (>250mA)	0
6001:0E		BIT8		Fill bits	

7.1.2 Output process data

Index (hex)	Object name	Data type	Access	Description	Default (hex)
7000	**Transmit Data**				
7000:01	Value	Array [0..29] of Byte	RW	Transmit Data	0
7001	**Control**				
7001:01	Transmit data length	UINT8	RW	Length of data to be transmitted in object 7000:01(hex)	0
7001:02	Transmit request	BOOL	RW	Handshake bit for transmit data. If new data is available in the process data, this bit is toggled.	0
7001:03	Transmit disable	BOOL	RW	Disables transmitting data from the transmit buffer to the interface. If the transmission is disabled (state "True"), the buffer can be further filled with data. Data in the buffer is sent as soon as the transmission is enabled again.	0
7001:04	Receive accept	BOOL	RW	Handshake bit for receive data. After the application has applied the data, it sets the bit to the value from 6001:06(hex) "Receive request".	0
7001:05	Init request	BOOL	RW	Initializes the interface that clears the buffers and sets the handshaking bits to "0".	0
7001:06		BIT4		Fill bits	

8 Diagnostic strategy

8.1 Mechanisms

Different mechanisms are used for the diagnostics of the module.

Mechanism	Diagnostics
EtherCAT state machine	EtherCAT system diagnostics
EtherCAT hardware watchdog	
Diagnostic objects in the CoE object directory	Extended diagnostics, e.g. peripheral errors
10F1(hex)	Error settings
Diagnosis history object	20 diagnostic messages can be stored
10F3(hex)	Diagnosis history
Module status LED	Shows the general module status
Channel status LED	Signaling the activity of TxD and RxD

8.2 Diagnosis history

All diagnostics from the module are written to the Diagnosis history object. This is implemented in the CoE object 10F3(hex) as ring buffer in overwrite mode. The last 20 diagnostic messages are saved, older messages are deleted.

The diagnostics can be retrieved from these CoE objects. The diagnostic messages are displayed in ctrlX I/O Engineering for each module in the module-specific diagnostics tab if the module is connected via the network

For further information on the function of the "Diagnosis history", refer to the application manual.

8.3 Status codes

Error, warning, information	Text ID (hex)	Text
E	1000	Module error <opt. info>
E	1010	Error at channel <Channel no.> <opt. info>
W	1020	Error during update, data corrupted, please update again
W	2310	Continuous overcurrent at channel <Channel no.>
E	3400	Periphery supply voltage (U_P) missing <opt. info>
W	6820	Complete Access of subindex <index>:<sub-index> not allowed
W	8152	Transmit buffer full at channel <Channel no.>
E	8153	Transmit buffer overflowed at channel <Channel no.> <opt. info>
W	815A	Receive buffer full at channel <Channel no.>
E	815B	Receive buffer overflowed at channel <Channel no.> <opt. info>
W	8950	Data collision at channel <Channel no.>

8.4 Module status LED (diagnostic and device status)

Device state	LED flashing pattern
Booting or firmware update	BU BU BU BU BU -- -- -- -- -- ⮌
Initialization or firmware update completed	BU BU BU BU BU BU BU BU BU BU ⮌
It is currently configured. Module not yet ready.	GN GN GN GN GN -- -- -- -- -- ⮌
Process data transmission, outputs inactive.	GN GN GN GN GN GN GN GN GN -- ⮌
Module in "Run" state	GN GN GN GN GN GN GN GN GN GN ⮌
Error and warning states	
Logic or peripheral voltage error	RD RD RD RD RD RD RD RD RD RD ⮌
Communication or configuration error	RD RD RD RD RD -- -- -- -- -- ⮌
Channel error	YE YE YE YE YE -- -- -- -- -- ⮌

ℹ One square corresponds to a period of 200 ms.
The arrow represents the end of a cycle.

-- LED is not on.

BU LED is blue.

GN LED is green.

RD LED is red.

YE LED is yellow.

ℹ A new status is only displayed after the previous flashing cycle has elapsed. A change in status can thus be delayed up to two seconds.

8.5 Channel status LED

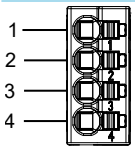
The serial receive channel TxD and the transmit channel RxD of the module have a channel status LED at the RTB plug. Refer to ➦ Chapter 9.1 “Clamping point assignment” on page 6.

Meaning of the channel status LED:

LED	Meaning
Green	Data is transmitted via the line
Off	No data is transmitted via the line

9 Installation

9.1 Clamping point assignment

Clamping point	Signal	LED	Pusher
	M-Bus +	green (TX)	Grey
	M-Bus +	None	Grey
	M-Bus -	green (RX)	Grey
	M-Bus -	None	Grey

9.2 Connection instructions

9.2.1 Cable and shielding

NOTICE

Electronic damages and measuring errors

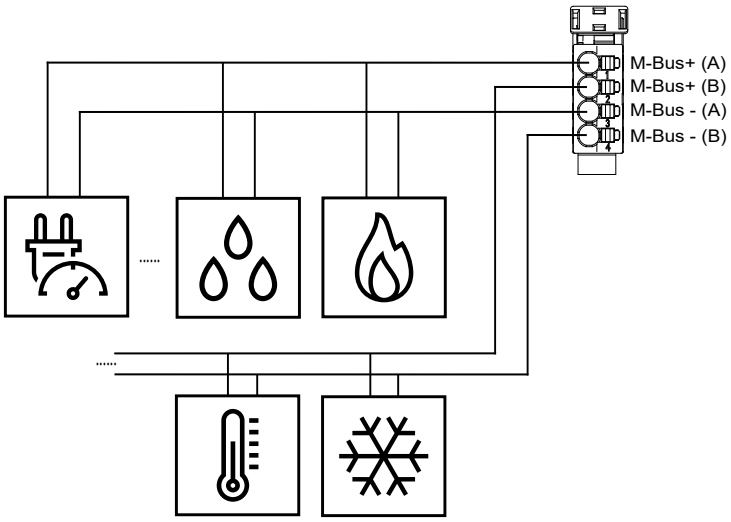
Unshielded cables can cause that tolerance limits are exceeded in an environment prone to interferences.

It is recommended to connect the devices with shielded cables twisted in pair.

Connect the cable shielding to the functional earth immediately after entering the control cabinet. Route the cable with its shielding up to the module. The signal cables should only be routed the shortest possible without shielding.

For the best connection directly in front of the module, the shield connection set (R911173030) is provided together with the bus bar (R911173283).

9.3 Wiring example



9.4 Mounting and installation

The application manual for the ctrlX I/O modules contains notes on installation, mounting and dismounting. For the application description, go to:

- ➦www.boschrexroth.com/MediaDirectory,
  Search term: ➦"R911423458"
  or
- ➦https://docs.automation.boschrexroth.com/doc/4126711705/ctrx-i-o-anwendungsbeschreibung/latest/en/.

NOTICE

Destruction of the device due to non-compliance with the application manual

Follow the mounting instructions in the application manual to ensure a correct mounting and to prevent damage to the device.

10 Firmware update via FoE

⚠ WARNING

Risk of injury due to unsafe machine states

The machine has to be in a safe state before updating.

The firmware of the module can be updated via FoE. For new firmware files, go to ➦www.boschrexroth.com/mediadirectory and search for the type code of the module.

A firmware module can be updated with all EtherCAT Masters supporting the file download via FoE. The module has to be in the BOOTSTRAP state. Entering a password or a file name is not required.

If the update has been completed successfully, the module is restarted as soon as the module state changes from BOOTSTRAP to another state. The reloaded firmware is started.

ℹ Do not disconnect the voltage supply of the module during the file transfer.
Please note that the logic voltage supply is temporarily interrupted for the following modules when completing the firmware update of the module and a subsequent restart.

ℹ If switching to INIT is not possible, disconnect the ctrlX I/O system from the power supply and connect it again.

ℹ The new firmware version might require an updated description file in the Engineering to use new functions. For details, refer to the release notes.
Check whether the latest version of the description file is installed.

10.1 ctrlX I/O Engineering

Within ctrlX I/O Engineering, the required user interface is only displayed for modules supporting a firmware update.

1. Switch the EtherCAT Master of the ctrlX CORE to the "INIT" state.
2. First change to the active state in the ctrlX I/O Engineering by enabling “Show online data”.
   ➡ This is the prerequisite to update the firmware. The corresponding user interface tab is only displayed if the prerequisite is met.
3. To open the device editor, double-click on the module in the ctrlX I/O Engineering device tree and select the “FoE” tab.
4. In the “Download” section, select the firmware file (*.EFW) under “Local file name”. Ensure that this is the correct file for the module to be updated.
5. Check that the option “Required state” is active under “Details” and that "BOOTSTRAP" is selected.
6. Use the “Download” button to start the firmware update.

11 License information

11.1 EtherCAT®

The ctrlX I/O modules use EtherCAT® technology. "EtherCAT®" is a registered trademark and patented technology licensed by the Beckhoff Automation GmbH, Germany. EtherCAT is an open, internationally standardized standard and developed further by the "EtherCAT Technology Group" (ETG).

11.2 Libhydrogen

ISC License

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11.3 Ring-buffer

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Bosch Rexroth AG
Bgm.-Dr.-Nebel-Str. 2
97816 Lohr a.Main
Germany
Tel. +49 9352 18 0
Fax +49 9352 18 8400
www.boschrexroth.com/electrics