FOX-10 / FOX-20
Basic-Module

Technical Documentation

Sub-Modules for FOX-10 / FOX-20

MDI 8	8 digital inputs, 24 VDC
MDO 8	8 digital outputs, 24 VDC/0.5A
MDR 8	8 relay outputs
MAC 8	8 digital AC inputs, 110 VAC/220 VAC
MDM 8	8 digital DMOS outputs, 24 VDC/2.0A
MAI 4	4 analog inputs
MAO 4	4 analog outputs
MSSI 2	2 SSI absolute encoder interfaces
MINC 2	2 incremental encoder interfaces
MPWM 2	2 pulse width modulation outputs

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Revision History

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Note:
The cover of this document shows the current revision status and the corresponding date. Since each individual page has its own revision status and date in the footer, there may be different revision statuses within the document.

Documentations that are in the appendix have their own revision history.

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Reorganisation of the document	15.12.1998

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1 System Description

1.1 The TRS FO-II/O System

The TRS Fiber Optic Industrial Input/Output System, which is referred to as the FO-II/O system to save space, consists of an intelligent central module and an optical waveguide-based field bus. The TR-Systemtechnik Industrial Input/Output System is a universal input/output system for industrial control technology.

Depending on the system (PC/AT, SMP, AMS, AT96, VME, SIMATIC, Mitsubishi etc.), the link between the FO-II/O system and the host is implemented by means of a Logic Cell Array. This guarantees fast, convenient communications. Various FO-II/O peripheral modules are available for processing the process image. These modules are connected together in a ring structure.

By contrast with other types of communication, which are based on handshaking, in a fiber optic ring only the central unit is active and the other input and output modules that are connected in the ring are passive. This makes possible rapid data communication with these modules.

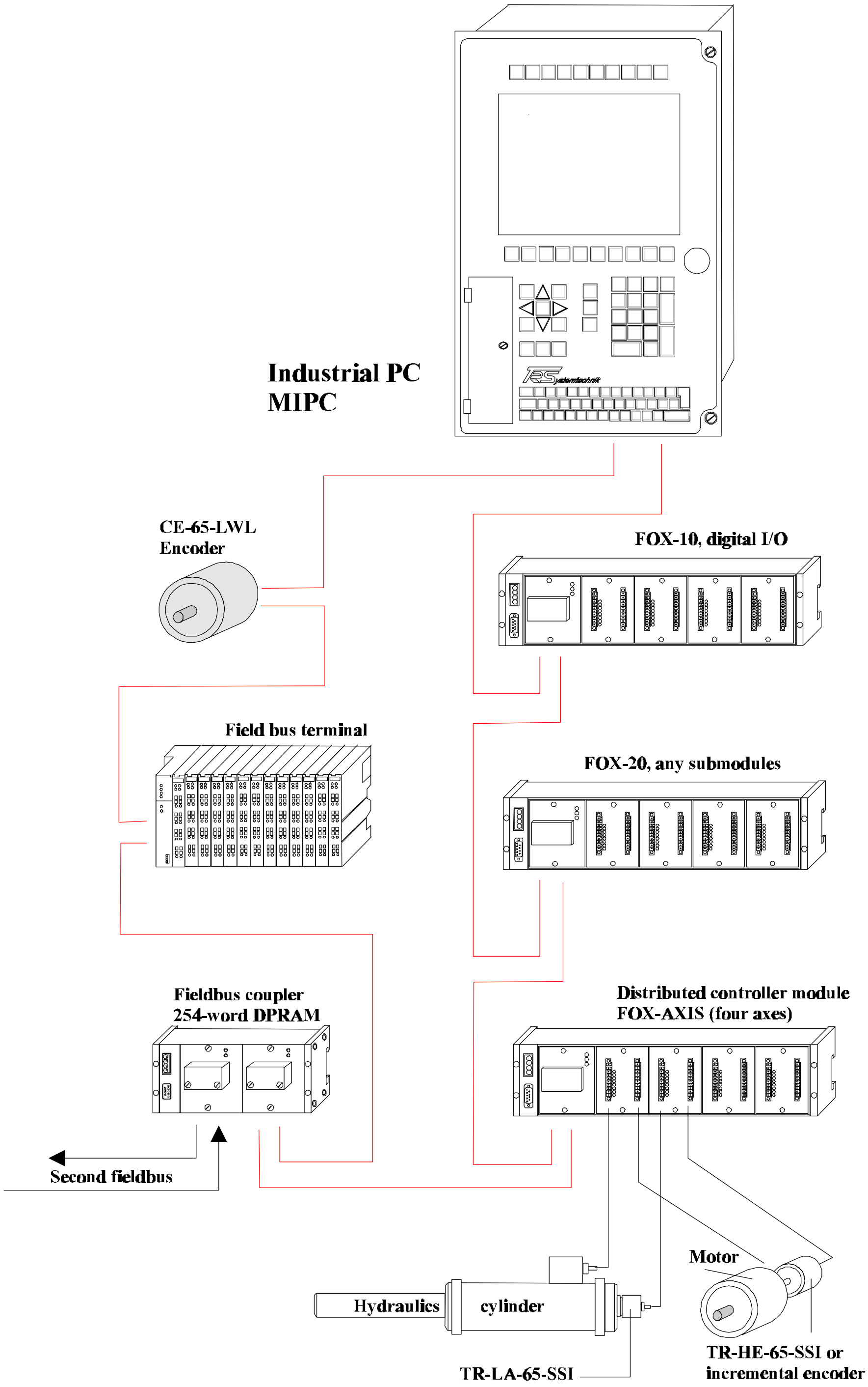
Data transfer on the optical waveguide is specified by a communications protocol that is optimized for speed and simplicity. This type of communication means that the message that the central unit transmits is received by each module, which interprets it and passes it on with a delay of approximately 1.5 µs. With a wavelength of 660 nm, the fiber optic-bus achieves a maximum transfer rate of 6 Mbps. The system that TRSystemtechnik uses has a transfer rate of 2.5 Mbps; in this connection, the entire transfer time of 25 µs is needed for one 32-bit message. This means that with a central unit connected to ten modules, the system triggers and updates all the modules in approximately 300 µs. The central module detects any faults that may occur in the fiber optic ring and reports them to the host system. The implemented ring diagnostics functions then make possible rapid troubleshooting and removal of faults.

The central module controls communication in the fiber optic ring. It transmits messages that run through the individual modules in the fiber optic ring and finally receives them again and checks them.

The use of optical waveguides provides significant advantages compared with conventional copper cabling:

- **High transfer capacity**
- **Low signal attenuation**
- **No electromagnetic disturbances**
- **Potential freedom**
- **Low weight**

Figure 1 Sketch of structure of the II/O-System



1.2 Message Structure

The messages that are available fulfill the functions of layers 1 and 2 of the ISO/OSI model. We will now go into the structure of a message and the functions that are provided.

A message consists of seven bytes plus one start bit and two stop bits. It is composed of a fixed message frame, which is necessary for serial asynchronous data transfer, and the message contents.

A message consists of a message frame and the message contents.

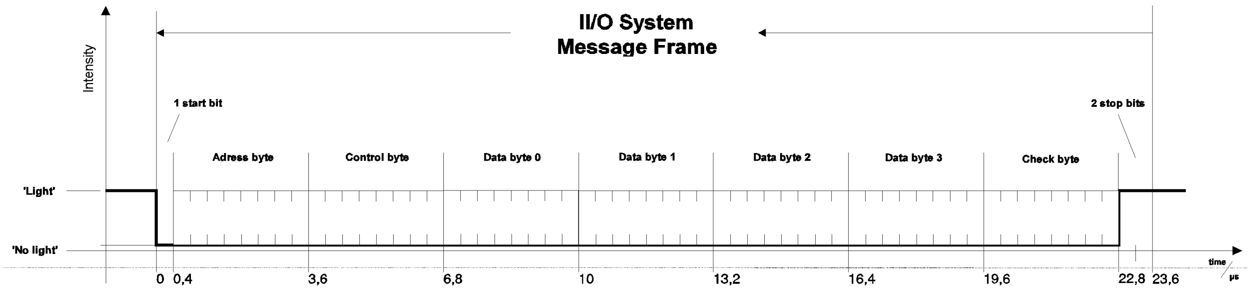


Figure 2: Message Structure of II/O-System

The message consists of:

* 1 start bit
* 6 CRC check bits
* 2 stop bits

The send and receive hardware generates and checks the message frame and does not need any software support. The message contents have a fixed structure that is optimized for the IIO system:

* 8 bits, address
* 4 bits, interrupt inputs/outputs
* 4 bits, control
* 32 bits, user data
* 2 bits, spare

The eight-bit address of the receiver is at the start of the message. Each module in the fiber optic ring is given an address by means of which it can be addressed.

Each receiver module processes the four interrupt bits regardless of the address. The transfer chip used in the modules has four interrupt inputs and four interrupt outputs. When a message advances, the system passes the received interrupt bits to the chip's interrupt outputs, logically ORs them with its interrupt inputs and passes on the interrupt bits.

The four control bits are used to define the type of message. The following types of message are defined:

Read:	Read module data
Read/Write:	Write data to module and read data of module
Address Initialization:	Address assignment to a module
Address Check:	Position determination of an address in the ring
Intensity Test:	Reduction of the transmission intensity

Apart from this, the message contains 32 bits of user data organized in into four bytes. The type of module and of message determines processing of the data bytes.

1.3 Message Structure for FOX-10

We will now describe how communication with a module by means of the messages described above is possible. A module with digital inputs and outputs will be used as an example:

The central unit transmits a message to the module whose user data contains a bit pattern, which the addressed module passes to its digital outputs. At the same time, the system transfers to the central unit the bit pattern of the module's inputs with the user data of the same returning message. This allows the central unit to use one message to not only set the outputs in a module but also to read the module's inputs.

If possible, you should always use Read/Write messages for data communication to and from the FOX-10 (regardless of whether only inputs, only outputs, or inputs and outputs are used in the module).
In this case, the code in the message's control byte always a value of 10 hexadecimal.
The system always transfers 32 bits of user data in the message frame, i.e. 32 input/output bits.
This means that it is only possible to address digital inputs/outputs.

Message Type	Control Byte	Function
Read/Write:	10 hex	Write data to module and read data of module
Address Set	20 hex	Address assignment to a module
Address Check and BoxCount	40 hex	Read module address and count modules
Low Intensity	90 hex	Reduce module's transmitter to 70% of transmission power

Important: With a FOX-20, there is a different control byte for Read/Write:

FOX-20 Read/Write	30 hex	Write data to module and read data of module

1.4 Message Structure for FOX-20

In addition to digital submodules, FOX-20 allows the use of analog ones.
In this case, there are only 16 bits of user data in the message. One data byte is used for addressing the slot and the channel number (KanalNr.) within a slot.

The structure of the relevant data in the message looks like this:

1.) Every analog channel access is carried out by a (1) message.
Every access to a digital submodule (SubModul) is carried out by a (1) message.

2.) A new code (30 hex) is defined as the ControlByte.
30 hex means FOX-20 message.

3.) In data byte (DatenByte) 0 of the message, the FOX-20-internal channel address.
DB0 is divided into two:
The upper nibble contains the number of the submodule. The first submodule that is fitted on the left-hand slot of the FOX-20 basic module is given submodule number 1.
This means that, reading from left to right, the possible numbers are 1, 2, 3 and 4.
The lower nibble defines the channel of the submodule. Example: Analog input channel 1 is given channel number 1, etc.
MAI4 and MAO4 have four input and output channels respectively that have the addresses 1, 2, 3, 4.
If you plug digital submodules in the FOX-20, they are addressed with the slot number. In this case, the channel number with digital submodules is always 0.

4.) The actual user information is in DB2 and DB3.
DB2 contains the low byte, and DB3 contains the high byte.
With analog inputs, the system always returns the value as a 16-bit word; the value appears virtually left-justified in the word even at 12-bit resolution.
The missing four bits are interpreted as the least significant ones and the system pads them with 0000.
The advantage is that you can use MAI4-12 or MAI4-16 software-independently.
The improved resolution of MAI4-16 fills only the least significant four bits in this case and improves the resolution.

5.) The first slot (submodule no. 1) in the FOX-20 can take only analog submodules.
You can fit the rest of the slots (submodule nos. 2 to 4) with a mixture of analog or digital submodules.

1.5 Overview of Messages for FOX-20 (Digital and Analog Submodules):

Message structure:

ADR	=	Module Address	= 1 .. 254 dec		
ContrlByte	=	Read/Write FOX-20	= 30 hex		
DB0	=	ChannelSelect	= HighNibble	:= SubModuleSlot 1..4	
			LowNibble	:= ChannelNumber 1..15	
DB1	=	Must be 80 hex			
DB2	=	LSB data			
DB3	=	MSB data			

ADR (1..254)	ControlByte	DB0 (Bit0..7)		DB1(Bit8..15)	DB2(Bit16..23)	DB3(Bit24..31)
e.g. **1** (Box 1)	**0011 0000**	**Slot**	**Channel**	**1000 0000**	**Data LSB**	**Data MSB**

Message Table:

Range	DB0		DB1	DB2	DB3
	Slot No./Channel No.		Constant	Low Byte	High Byte
Digital submodule in slot 1	0001	0000	-----------	Not allowed	Not allowed
Digital submodule in slot	0010	0000	1000 0000	LSB bit pattern	xxxx xxxx
Digital submodule in slot 3	0011	0000	1000 0000	LSB bit pattern	xxxx xxxx
Digital submodule in slot 4	0100	0000	1000 0000	LSB bit pattern	xxxx xxxx
Analog channel 1 in slot 1	0001	0001	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 2 in slot 1	0001	0010	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 3 in slot 1	0001	0011	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 4 in slot 1	0001	0100	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 1 in slot 2	0010	0001	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 2 in slot 2	0010	0010	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 3 in slot 2	0010	0011	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 4 in slot 2	0010	0100	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 1 in slot 3	0011	0001	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 2 in slot 3	0011	0010	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 3 in slot 3	0011	0011	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 4 in slot 3	0011	0100	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 1 in slot 4	0100	0001	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 2 in slot 4	0100	0010	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 3 in slot 4	0100	0011	1000 0000	LSB bit pattern	MSB bit pattern
Analog channel 4 in slot 4	0100	0100	1000 0000	LSB bit pattern	MSB bit pattern

1.6 FOX-20 Message Examples:

ADR (1..254)	ControlByte	DB0 (Bit0..7)		DB1(Bit8..15)	DB2(Bit16..23)	DB3(Bit24..31)
e.g. **1** (Box 1)	**0011 0000**	**Slot**	**Channel**	**1000 0000**	**Data LSB**	**Data MSB**

Example 1: **FOX-20 fitted in slot 1 = MAI4 4 analog inputs**
in slot 2 = MAO4 4 analog outputs
in slot 3 = MDI8 8 digital inputs
in slot 4 = MDO8 8 digital outputs

1.1) Access to slot 1/analog input channel 1: Analog input voltage is +5V, for example

ADR	Control	Slot	Channel	Fixed 80H	Corresponds to + 5V	
z.B **1** (Box 1)	**0011 0000**	**0001**	**0001**	**1000 0000**	**0000 0000**	**0100 0000**

1.2) Access to slot 2/analog output channel 3: Analog output voltage is +9V, for example

ADR	Control	Slot	Channel	Fixed 80H	Corresponds to + 7.5V	
e.g. **1** (Box 1)	**0011 0000**	**0010**	**0011**	**1000 0000**	**0000 0000**	**0110 0000**

1.3) Access to slot 2/analog output channel 4: Analog output voltage is -1V, for example

ADR	Control	Slot	Channel	Fixed 80H	Corresponds to -1V	
e.g. **1** (Box 1)	**0011 0000**	**0010**	**0100**	**1000 0000**	**0011 0100**	**1111 0011**

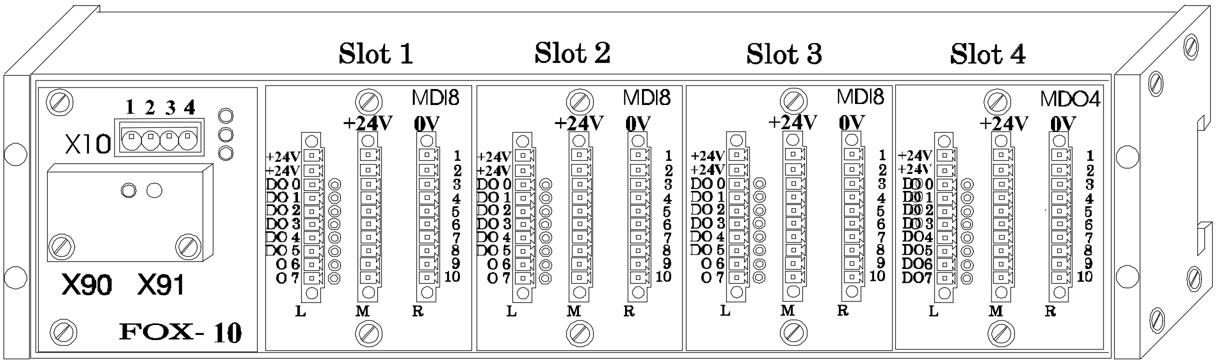
1.4) Access to slot 3/Digital input MDI8: Bit pattern 0101 1010

ADR	Control	Digital channel		Fixed 80H		**Bit Pattern**
e.g. **1** (Box 1)	**0011 0000**	**0011**	**0000**	**1000 0000**	**0101 1010**	**xxxx xxxx**

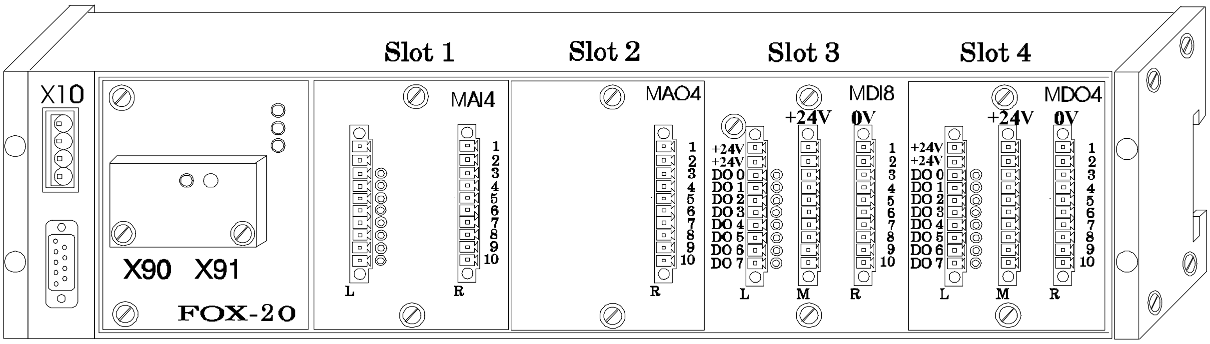
1.5) Access to slot 4/Digital output MDO8: Bit pattern 1100 0011

ADR	Control	Digital channel		Fixed 80H		**Bit Pattern**
e.g. **1** (Box 1)	**0011 0000**	**0100**	**0000**	**1000 0000**	**1100 0011**	**xxxx xxxx**

2 Functional Description of Hardware, FOX-10 and FOX-20



FOX-10 Basic Module Fitted with Four Input/Output Modules



FOX-20 Basic Module with Four Analog Inputs, Four Analog Outputs, Eight Digital Inputs, Eight Digital Outputs

General

The FOX-10 Basic Module is the basis of the digital input/output modules for operation in the II/O system with 32 inputs/outputs divided into four eight-bit ports. Ports D0..D3 correspond to the data bytes in the optical waveguide transfer protocol; depending on the application, they can be configured as inputs or outputs with a wide range of different modules.
The basic module contains the fiber optic adapter, the mains unit as well as four slots for plugging in the submodules.

The following submodules are currently available:

- MDI8 — 8 digital inputs
- MDO8 — 8 digital outputs, 24V/0.5A
- MDM8 — 8 digital power outputs, 24V/2.2A
- MDR8 — 8 digital relay outputs, 220V/1A
- MAC8-110 — 8 AC inputs, 110V AC
- MAC8-220 — 8 AC inputs, 220V AC

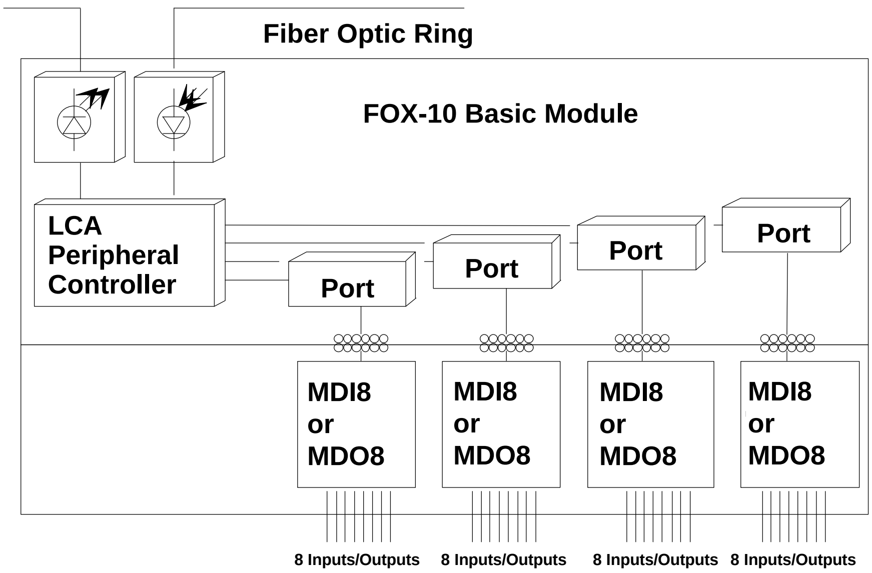
In FOX-20, you can use the following additional submodules:

- MAI4 4 analog inputs
- MAO4 4 analog outputs
- MSSI2 2 SSI interfaces
- MINC2 2 incremental counters
- MPWM2 2 pulse width modulation outputs

You can now fit the FOX-10-Basis basic module's four slots with any four submodules from the available range. In the FO message, each of these submodules is represented by one byte.
Reading from left to right, data bytes D0, D1, D2 and D3 correspond to the four slots.

In the FOX-20, you can fit three of the slots with any analog and digital submodules from the available range. The first slot can take only analog submodules.

Three diagnostic LEDs are fitted for the II/O fiber optic ring. If there is an interruption in the cable, the red ‘ERROR’ LED lights up. The ‘Watchdog’ LED is switched on for 100 ms when the module is addressed in a cable message, i.e. when it is receiving a message intended for it. For safety reasons, if an error occurs the system resets any outputs of subsequent output modules that may be fitted. The 'Cycle' LED lights up every time a message is received.



2.1 Technical Data

Inputs/Outputs	Max. of 32 digital I/Os or max. of 16 analog I/Os, or a mixture of both via up to four galvanically decoupled submodules. Divided into four ports that can be fitted byte-by-byte with input or output modules (MDI8, MDO8 etc.). LED status indicator on all MD modules
Input Specifications	Refer to input modules for FOX-10/FOX-20
Output Specifications	Refer to output modules for FOX-10/FOX-20
Output Monitoring	Watchdog circuit
Connections	Toshiba PCS Fiber Optic System or APS Fiber
Data Connection	Fiber Optic Ring II/O System
Transfer Rate	2.5 Mbps, 25 µs for 32 bits
Supply Voltage	24 V DC (±20%)
Current Consumption	Approx. 0.1 A (without submodules)
Housing	Closed, can be screw-mounted on a device mounting rail complying with DIN EN 50022, 50035
Dimensions (W x H x D)	FOX-10: 305 x 76 x 68 mm FOX-20: 315 x 76 x 68 mm
Weight	Approx. 750 g
Operating Temperature	±0..+55° C
Storage Temperature	-20..+70° C

2.2 Installation Information

Assembly

You connect the FOX-10/FOX-20 to the II/O Fiber Optic Ring using (Toshiba TOCP155) fiber optic cable plug-in connectors. The maximum length of the fiber optic cable to the next box should not exceed 45 meters with plastic cables and 600 meters with glass fiber ones. These values only apply if you lay the cables with bending radii of at least 30 mm. With plastic fiber optic cables, you do not need any special tools to assemble the connectors.

Commercially available three-wire (+,-, signal) actuators and sensors are directly connected to the input and output modules' inputs and outputs.

You mount the FOX-10/FOX-20 decentrally on the machine or in the switching cabinet by simply screwing it to a device mounting rail that complies with DIN EN 50022 or DIN EN 50035.

Configuration

FOX-10: You can configure every port in the FOX-10 – independently of all the others – as an input module or as an output module. You do not need to make any settings (of DIP switches, for example) to differentiate between input and output modules. Simply fitting the appropriate modules in the four possible ports is enough to define the 32 possible inputs/outputs.

FOX-20: You can only fit an analog submodule in the first slot on the left-hand side (Slot 1). In the rest of the slots, you can fit analog and/or digital submodules.

Power Supply

You connect the power supply for the control logic via the four-pin connection terminal, X10.

2.3 Pin Assignments

Connector X10:

Pin	**Signal**	**Description**
1	+24 V logic	Control voltage supply
2	GND logic	Ground of logic
3	+24 V logic	Control voltage supply
4	GND logic	Ground of logic

Connectors X90 / X91:

Pin	**Signal**	**Description**
X90	FO-OUT	Fiber optic ring OUTPUT
X91	FO-IN	Fiber optic ring INPUT

2.4 Meanings of the LEDs

Three LEDs provide information about the status of the module.
The LEDs are from top to bottom:

LED	Color	Meaning
1	Green	Watchdog that is triggered on each write message
2	Red	Error LED: the module reports a faulty message
3	Green	Cycle: shows message traffic

2.5 Setting the Transmission Power

In the LED connection cap, there is a rotary switch that you can turn from outside using a small screwdriver. A green LED shows the switch setting: if the LED is lit up, the transmission power is set to 10 m .. 45 m; otherwise, the system runs at a power reduced by 4 dB with fiber optic cable lengths of 0.2 m .. 15 m.

3 Appendix

3.1 Types of Fiber Optic Cable

Two basic types of fiber optic cable are available, i.e. all plastic fiber, APF and plastic cladding silica fiber, PCS. You can lay both types on a trailing cable chain, since the varying load meets the requirements. The fiber optic cable transmission and reception chips are designed for APF as well as PCS cables. APF cables guarantee safe data transmission up to 45 meters; with PCS cables, this distance is 300 meters. Using special transmission chips with PCS cables, you can achieve distances of up to 1000 meters.

PCS cables need different connectors from APF cables, however the II/O modules are identical (up to 300 meters). In addition, you need special tools for PCS cables.

You can use a measuring instrument to measure the attenuation of the cable or of the connector.

The II/O modules are connected to the bus link via fiber optic plug-in connectors X90 and X91 as shown in figure 2.

3.2 Preparing the Fiber Optic Connector

It is quite easy to prepare the fiber optic connector on the APF cable. First of all, you strip about 25 mm of the 6-mm polyurethane jacket and cut off the Kevlar strain relief appropriately without damaging the black internal sheath. After this, strip 7 mm of the black internal sheath using a cable stripper or a special cable-stripping tool. Under no circumstances must you damage the transparent fiber while doing this. Ensure that the cut surface of the fiber does not split. By feeding in red light at the other end of the fiber, you can check the end of the fiber. You then push the fiber from the back all the way in to the connector and then push in the clamping fixture in to the connector using a screwdriver or similar tool. After this, sand the end of the fiber that is sticking out of the connector at right angles to the connector; to do this, first use 600 grain and then 1000 grain emery paper. You must not sand the connector itself. Do not use any chemical-based polishing pastes, as they harden the fiber. It is sensible to use a magnifying glass to check the results.

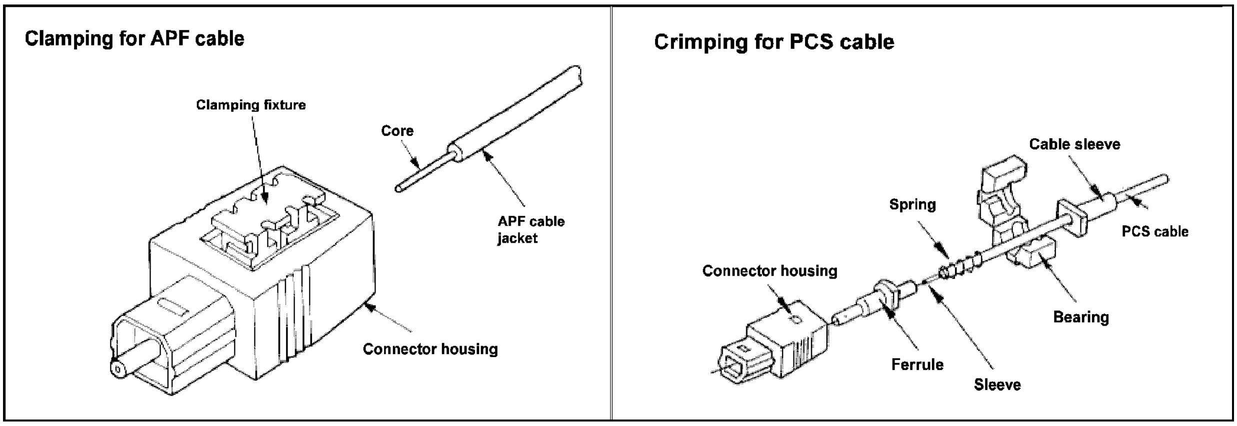


Figure: Preparation of Fiber Optic Connectors

3.3 Information on Laying Fiber Optic Cables

- Unroll cables from the drum or the coil do not pull them off in loops.

• Max. tensile load per wire:	One off	80 N
• Minimum bending radius:	One off	10 mm
	Continuous	20 mm (0.5 dB attenuation)
	With varying load:	50 mm

- With duplex fibers, slit the last 150 mm before the connection.
- Protect the ends of the fibers from dirt.

It is sensible to measure the signal arriving at the receiver using a fiber optic cable measuring instrument. The reception level must be between **-15 dB and -27 dB.**

3.4 Attenuation Calculations

The distances that can be covered by optical fiber cables depend on the highest and lowest transmission and reception powers and the attenuation of the transmission link. The red light transmitted by the fiber optic transmitters has a wavelength of 650 nm. The transmission power is approximately -11 dB. Some II/O modules can be switched between -10 dB and -14 dB.

The reception power must be between **31 µW = -15 dB and 2 µW = -27 dB.**

The reception power reduces by half for every ten meters of APF cable, this corresponds to -3 dB.

Depending on the workmanship, a connector connection has an attenuation of between -1.5 dB and -3 dB. With particularly careful workmanship, it is possible to achieve values below -1 dB.

The level n in dBm specifies the power, P, as a logarithmic number relative to 1 mW = 1000 µW. In this calculation, you should note the minus sign for the attenuation (this corresponds to the plus sign for the gain).

$$n = 10 * \log P/mW = 10 * \log \frac{P/\mu W}{1000}$$

Example: if 30 µW = 10 log, 0.03 mW = -15.2 dBm

In practice, you carry out the calculation directly in dB, whereby you simply add up the individual attenuation values.

Example:

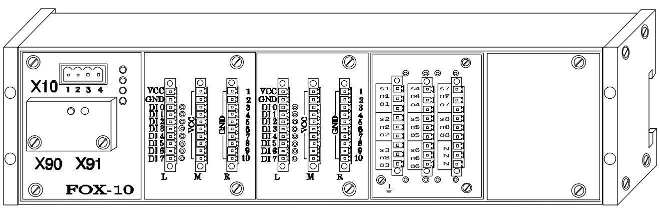
Transmission power:	= -11	dBm
Attenuation:	=Two	-2-dB connectors, 20 m fiber optic cable = -6 dB
Reception power:	= -11	dBm -4 dB -6 dB = -21 dBm

3.5 Type Code

FOX -10 -A - B - C - D

- Type of slot 4 (on right)
- Type of slot 3
- Type of slot 2
- Type of slot 1
- Type of basic module (on left)

Type	Designation	Description
	FOX	Fiber Optic Box System, basic module for max. of 4 Interface modules
FOX-10	FOX-10	Basic module for a maximum of four submodules of type
		MDI8, MDO8, MDL8, MDM8, MDR8, MAC8
FOX-20	FOX-20	Basic module for a maximum of four submodules of type
		MDI8, MDO8, MDL8, MDR8, MAC8, MAI4, MAO4
		Submodules:
-A	MAB	Blanking plate instead of a submodule
-B	MDI8	Submodule 8 digital inputs, 24 V DC
-C	MDO8	Submodule 8 digital outputs 24 V DC / 0.5 A
-D		
-E	MDR8-001	Submodule 8 relay, same as F without protective circuitry
-F	MDR8	Submodule 8 relay outputs, 220 V AC / 2.0 A max.
-G	MAC8-110	Submodule 8 digital AC inputs, 110 V AC
-H	MAC8-220	Submodule 8 digital AC inputs, 220 V AC
-K	MDM8	Submodule 8 digital DMOS power outputs, 24 V / 2.0 A
-L	MAI4-12	Submodule 4 analog inputs
-N	MAI4-16	Submodule 4 analog inputs
-M	MAO4	Submodule 4 analog outputs
-O	MSSI-2	Submodule 2 SSI interfaces
-P	MINC-2	Submodule 2 incremental counters
-R		
	Example: Order No. :	Basic module fitted with (from left to right): 8 digital inputs 8 digital outputs 8 relay outputs, 220V Empty spare slot **FOX-10-BCFA**



MDI 8 MDO 8 MDR 8 MDAB

FOX-10 - B - C - F - A