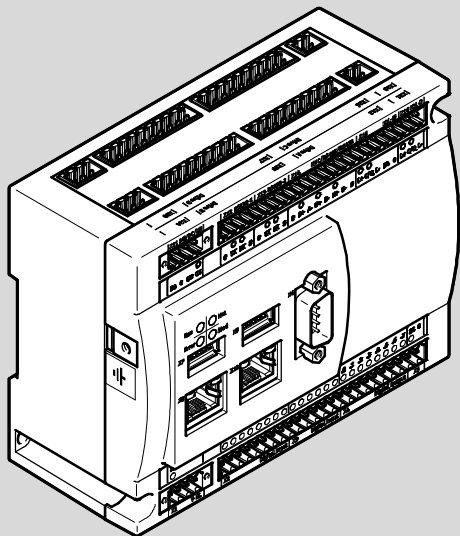


# Controller CECC-X-M1



## FESTO

### Brief description

Controller  
CECC-X-M1  
CECC-X-M1-MV  
CECC-X-M1-MV-S1

8079349  
2017-09a  
[8074647]

PI PROFIBUS PROFINET<sup>®</sup>, CANopen<sup>®</sup>, CODESYS<sup>®</sup>, EtherCAT<sup>®</sup>, EtherNet/IP<sup>®</sup>, IO-Link<sup>®</sup>, and MODBUS<sup>®</sup> are registered trademarks of their respective trademark holders in certain countries.

This product uses open-source software which is subject to the “GNU General Public License, Version 2”. The licensing conditions of the GPL are located either in the product’s engineering tool or at the following address: <http://www.gnu.org/copyleft/gpl.html>


Edition: 2017-09a  
Original instructions

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# 1 Safety

## 1.1 General safety information

- Observe the safety instructions in the corresponding chapters.

 Special safety regulations are placed immediately before the task instruction.



### Warning

#### Electric voltage

Risk of injuries caused by electric shock, damage to the machine and system.

Danger of electric shock from voltage sources.

Before carrying out mounting, installation and/or maintenance work:

- Switch off the supply voltage and safeguard it against being switched on again unintentionally.
- Use only power sources which guarantee reliable electrical isolation of the operating voltage in accordance with IEC 60204-1/EN 60204-1.
- Switch the voltages back on only after completion of work.



### Note

**Unauthorised** access to the product can cause damage or malfunctions.

When connecting the product to a network:

- Protect the network from unauthorised access.

Measures to protect the network include: firewall, Intrusion Prevention System (IPS), network segmentation, virtual LAN (VLAN), virtual private network (VPN), security at physical access level (port security).

Further information → Directives and standards on information technology security, e.g. IEC 62443, ISO/IEC 27001. An access password protects only against accidental changes.

## 1.2 Intended use

The control documented in this brief description is exclusively intended for installation in a machine or automated system.

The product may only be used as follows:

- as intended in an industrial environment
- for installation in a control cabinet
- The product may only be used in its original status without unauthorised modifications.
- Observe the permissible limit values and specifications  
→ 13 Technical data.
- Only use the product if it is in an excellent technical status.



### Note

In the event of damage caused by unauthorised manipulation or other than intended use, the guarantee is invalidated and the manufacturer is not liable for damages.

## 2 Requirements for product use

- Make this brief description available to the design engineer, installer and personnel responsible for commissioning of the machine or system in which these products are used.
- Make sure that the specifications of the documentation are always complied with. Also consider the documentation for the other components and modules → 13 Technical data.
- Take into consideration the legal regulations applicable at the installation site, as well as:
  - regulations and standards
  - regulations of the testing organisations and insurers
  - national specifications

### 2.1 Training of skilled personnel

The following steps must only be carried out by qualified specialists:

- mounting
- installation
- commissioning
- maintenance
- repair

The trained personnel must be familiar with:

- electrical control technology
- the applicable regulations for operating safety-engineered systems
- the applicable regulations for accident prevention and occupational safety

### 3 Scope of delivery

- Controller CECC-X-M1-...
- This brief description



Software for the product can be found in the Festo Support Portal → [www.festo.com/sp](http://www.festo.com/sp).

### 4 Accessories

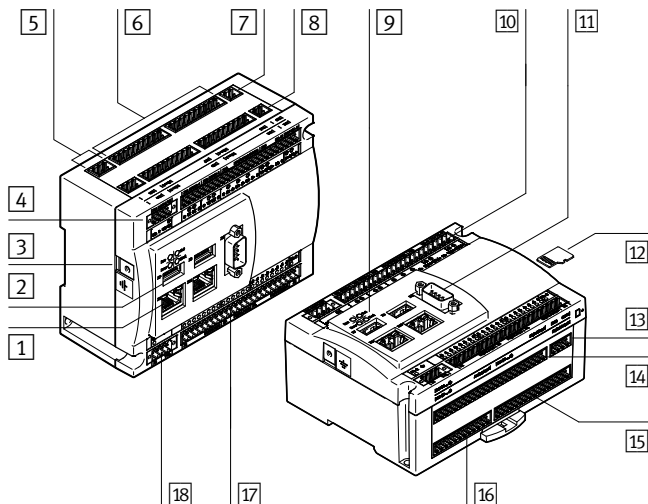
- Camera
- Plug assortment



Catalogue → [www.festo.com/sp](http://www.festo.com/sp)

Please consult your regional Festo contact if you have any technical queries or questions regarding the accessories.

## 5 Overview



- |   |   |    |  |
|---|---|----|--|
| 1 | Ethernet interfaces   | 9  | Status LEDs  |
| 2 | USB interfaces  | 10 | Communication interfaces:<br>ENC, RS232, RS422, RS485<br>and IO-Link |
| 3 | Functional earth connection $\perp$                                       | 11 | CANopen interface CAN 1  |
| 4 | Load voltage supply infeed<br>for IO-Link and power supply<br>for encoder | 12 | MicroSD card slot  |
| 5 | Multi-functional interface  | 13 | CANopen interface CAN 2  |
| 6 | Direct connections for motor<br>controller                                | 14 | Digital inputs   |
| 7 | Torque-off input  | 15 | Digital outputs  |
| 8 | Load voltage supply for motor<br>controller                               | 16 | Analogue inputs  |
|   |   | 17 | I/O interfaces   |
|   |   | 18 | Infeed for I/O power supply  |

Fig. 1 Controller CECC-X-M1-...

## 6 Installation



### Note

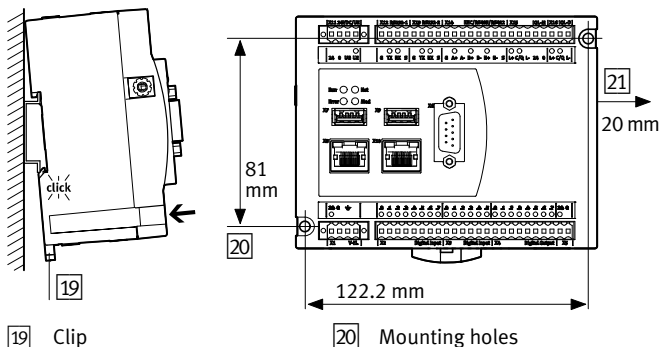
Damage to the product from incorrect handling.

- Never pull out or plug in the plug connectors and interfaces when powered.
- Observe the handling specifications for electrostatically sensitive devices.



The product can be mounted on a H-rail or on a flat surface in any mounting position.

- Ensure sufficient free space:
  - above and below the product for connecting cables
  - to the right of the product for cold-air entry and access to the MicroSD card slot.



19 Clip

21 Distance

Fig. 2



## 6.1 Mounting on H-rail

1. Insert the product into the H-rail.
2. Press the product in the direction of the arrow until it audibly engages.

## 6.2 Dismounting from H-rail

1. Remove the plug connector on the underside of the product.
2. Unlock the product via the clip → Fig. 2 [19].  
Use a suitable tool, e.g. a screwdriver.
3. Remove the product from the H-rail.

## 6.3 Mounting onto mounting surface



### Note

Damage to the product caused by mounting on uneven or flexible surfaces.

- Only mount the product on an even, torsionally rigid surface.

1. Drill two mounting holes [20] in the mounting surface ( $\varnothing$  4.5 mm, spacing → Fig. 2 – hole pattern).
2. Secure the product in place with two M4 screws.
  - Screw head diameter: 7 mm
  - Max. tightening torque: 0.8 Nm

## 6.4 Dismounting from mounting surface

1. Loosen two M4 screws.
2. Remove the product from the mounting surface.



Additional information regarding installation and commissioning can be found in the Festo Support Portal → [www.festo.com/sp](http://www.festo.com/sp).

## 7 Status LEDs

The product is equipped with the following status LEDs → Fig. 1 9:

Status LED	Meaning	Status LED	Meaning
Run	Application status	Net	Device detected
Error	Error	Mod	Reserved

Fig. 3

## 8 Power supplies



### Note

- Use an external overload protection for the power supply of the device.
- Pay attention to the required current consumption.

### 8.1 Power supply [X1] for device, digital/analogue inputs and motor controller direct connection (logic)



Residual current for all supplied ports:  $\leq 750 \text{ mA}$   
of which intrinsic current consumption:  $\leq 200 \text{ mA}$

Terminal	Port	Comments
X1.1	24	U+ power supply
X1.2	0	U- load
X1.3	$\perp$	Functional earth
X1.4	-	Not connected

Fig. 4

## 8.2 Power supply [X5] for digital outputs



Residual current for all supplied ports:  $\leq 5 \text{ A}$

Terminal	Port	Comments
X5.1	24	U+ power supply
X5.2	0	U- load

Fig. 5

## 8.3 Load voltage supply [X21] for motor controller



Residual current for all supplied ports:  $\leq 8 \text{ A}$

Terminal	Comments
X21.1	24 V/48 V load voltage supply feed
X21.2	GND

Fig. 6



### Note

Damage to the product in case of overload.

If there is a load on all digital outputs of 0.5 A each, the residual current can be exceeded as soon as additional consuming devices are used.

- Consider **all** current loads.
- For special configurations, contact the local Festo service.

## 8.4 Load voltage supply [X11] for IO-Link

This port is used for the power supply of an IO-Link device that is connected via the IO-Link master port.



Current consumption for IO-Link:  $\leq 0.75 \text{ A}$



### Note

Damage to the product in the event of a mix-up of the connecting pins.

- When establishing the load voltage supply for the IO-Link master port, make sure that only connecting pins X11.1 and X11.2 are used.

Terminal	Port	Comments	Internal connection
X11.1	24	UA+ Infeed for IO-Link master port	X15.4
X11.2	0	UA- Infeed for IO-Link master port	X15.5

Fig. 7

## 8.5 Power supply [X11] for encoder



Encoder current consumption:  $\leq 0.3 \text{ A}$

Terminal	Port	Comments
X11.3	UG	Encoder power supply (ground)
X11.4	UE	Encoder power supply (5 V)

Fig. 8

## 9 Interfaces, front

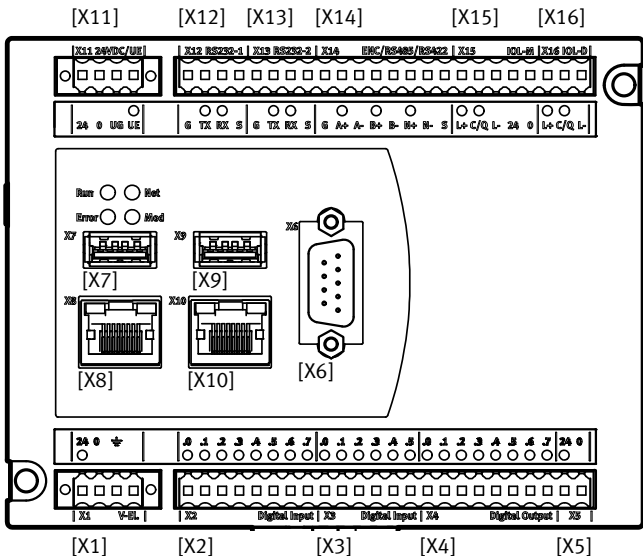


Fig. 9

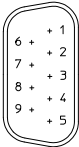
### 9.1 I/O interface [X2, X3, X4]

Terminal	Comments
X2.0 ... X2.1	2 high-speed digital inputs (200 kHz)
X2.2 ... X2.7 <sup>1),2)</sup>	6 digital inputs (1 kHz, IEC type 1)
X3.0 ... X3.5	6 digital inputs (1 kHz, IEC type 1)
X4.0 ... X4.7 <sup>3)</sup>	8 digital outputs (0.7 A per channel, PNP, SSR <sup>4)</sup> )

- 1) X2.2 and X2.3 optionally also serve as MachineVision inputs (e.g. Trigger)
- 2) X2.3 also serves as a latch input for the encoder via the multiple interface X14
- 3) X4.0 ... X4.2 optionally also serve as MachineVision outputs (e.g. flash output)
- 4) SSR: Solid State Relay

Fig. 10

## 9.2 CANopen interface CAN 1 [X6]

Pin	Port	Comments	
	1	–	Not connected
	2	CAN1_L <sup>1)</sup>	CAN-Bus signal 1 (dominant low)
	3	CAN_GND	CAN Ground
	4	–	Not connected
	5	CAN_SHLD	Connection to functional earth
	6	CAN_GND	CAN Ground (optional)
	7	CAN1_H <sup>1)</sup>	CAN-Bus signal 1 (dominant high)
	8	–	Not connected
	9	–	Not connected

- 1) For connection of the device at the end of the line: Connect Pin2 and Pin7 via a resistor. A corresponding plug with resistor (120  $\Omega$ /0.25 W) can be found in Festo's accessories → [www.festo.com/catalogue](http://www.festo.com/catalogue)

Fig. 11

## 9.3 USB interfaces [X7, X9]

The USB interfaces → Fig. 1 [2] are compatible with the USB 3.0 and USB 2.0 standards. They are suitable for USB plug type A.

The following functions are supported (cable length  $\leq$  3 m):

- General data storage
- Connection of a camera
- Connection of hardware extensions



### Note

Damage to the product.

- Only use USB components with a current consumption  $\leq$  0.9 A.

Please consult your regional Festo contact if you have any queries regarding the extensions.

## 9.4 Ethernet interfaces [X8, X10]

The Ethernet interfaces → Fig. 1 1 are designed as an RJ45 socket and support Gigabit LAN. The controller cannot be used as a switch.

The following functions are supported:

X8	X10
<ul style="list-style-type: none"><li>- TCP/IP (e.g. Modbus TCP)</li><li>- UDP (e.g. network variables, EasyIP)</li><li>- EtherNet/IP (e.g. Generic IO-Device)</li><li>- PROFINET IO</li></ul>	<ul style="list-style-type: none"><li>- EtherCAT-Master</li></ul>

Fig. 12



Certain settings can be configured using a web browser and the IP address of the device → <http://192.168.4.2> net mask: 255.255.0.0 gateway: 192.168.1.1

## 9.5 Serial interfaces [X12, X13]

- X12 = RS232-1
- X13 = RS232-2

Terminal	Port	Comments
X12.1, X13.1	G	Load
X12.2, X13.2	Tx	Transmitted data <sup>1)</sup> (output)
X12.3, X13.3	Rx	Received data <sup>1)</sup> (input)
X12.4, X13.4	S	Screening, connection to functional earth

1) Max. level: low -15 V high +15 V; TTL level not permissible!

Fig. 13

## 9.6 Multiple interface for encoder/RS422/RS485 [X14]



### Note

Simultaneous use of the interfaces is not possible.

- Only use the ports of **one** interface → Fig. 14.

Terminal	Port	Encoder	RS422 <sup>1)</sup>	RS485 <sup>1)</sup>
X14.1	G	Load		
X14.2	A+	Track A+	Transmitted data + <sup>2)</sup>	Transmitted/received data + <sup>2)</sup>
X14.3	A-	Track A -	Transmitted data - <sup>2)</sup>	Transmitted/received data - <sup>2)</sup>
X14.4	B+	Track B+	Received data + <sup>3)</sup>	-
X14.5	B-	Track B -	Received data - <sup>3)</sup>	-
X14.6	N+	Zero track+	-	-
X14.7	N-	Zero track-	-	-
X14.8	S	Screening, connection to functional earth		

1) Permissible data rate  $\leq 1$  MHz

2) If the device is connected at the end of the cable: Connect terminals X14.2 and X14.3 via resistor (120  $\Omega$ /0.25 W).

3) If the device is connected at the end of the cable:

Connect terminals X14.4 and X14.5 via resistor (120  $\Omega$ /0.25 W).

Fig. 14



## 9.7 Communication interface for IO-Link [X15, X16]

### IO-Link Master

Terminal	Port	Comments
X15.1	L+	24 V
X15.2	C/Q	IO-Link communication signal
X15.3	L-	0 V
X15.4	24	UA+
X15.5	0	UA-

Fig. 15

### IO-Link device

Terminal	Port	Comments
X16.1	L+	24 V
X16.2	C/Q	IO-Link communication signal
X16.3	L-	0 V

Fig. 16

## 10 Direct connections, top

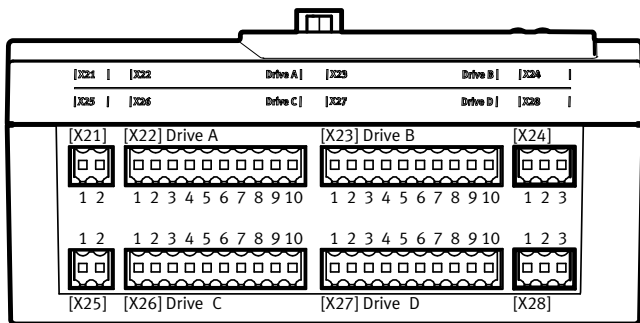


Fig. 17

### 10.1 Motor controller A, B, C, D [X22, X23, X26, X27] with CANopen interface CAN 2



Residual current for all supplied ports:  
cable length:

≤ 8 A  
≤ 3 m

Terminal	Port	Comments	Internal connection
X2x.1	24/48 VDC	Load voltage supply for motor controller <sup>1)</sup>	X21.1
X2x.2	GND		X21.2
X2x.3	24 VDC	Power supply for motor controller (logic)	X1.1
X2x.4	GND		X1.2
X2x.5	CAN2_H	CAN-Bus signal 2 (dominant high)	X18.1
X2x.6	CAN2_L	CAN-Bus signal 2 (dominant low)	X18.2
X2x.7	CAN_GND	CAN Ground	X18.3
X2x.8	CAN_SHLD	Connection to functional earth	X18.4

- 1) Continuous load per output: ≤ 2.0 A  
Impulse current per output: ≤ 4.2 A

Terminal	Port	Comments	Internal connection
X2x.9	GPIO	Home signal (digital in)	X17.0.2/X17.1.2 <sup>2)</sup>
		Multi-functional signal	X24.2/X28.2 <sup>3)</sup>
X2x.10	GND	Power supply (logic)	X1.2

2) Home signal: X22.9 (drive A) at X17.0.2; X26.9 (drive C) at X17.1.2

3) Multi-functional signal: X23.9 (drive B) at X24.2; X27.9 (drive D) at X28.2

Fig. 18

## 10.2 Multi-functional interface [X24, X28]

Terminal	Port	Comments
X2x.1	24 VDC	Power supply
X2x.2	Signal	Multi-functional signal
X2x.3	GND	Load

Fig. 19

## 10.3 Torque-off input [X25]

Terminal	Port	Comments
X25.1	Signal	Torque-off input
X25.2	24 VDC	Power supply

Fig. 20



Load voltage supply [X21] → 8.3.

## 11 Direct connections, bottom

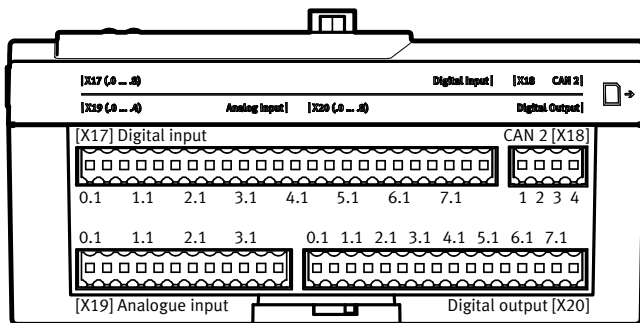


Fig. 21

### 11.1 Digital inputs [X17]

The digital inputs, configured in 3-wire connection technology, are **not** galvanically separated. The ground potential for all inputs relates to GND of the power supply [X1].

- Always use 3 adjacent terminals when connecting a sensor with a 3-wire configuration.

Terminal	Port	Comments
X17.0.1	24 VDC	Connection for digital sensor 1 (1 kHz, IEC type 1)
X17.0.2	Signal 1 / home signal for drive A	
X17.0.3	GND logic	
X17.1.1	24 VDC	Connection for digital sensor 2 (1 kHz, IEC type 1)
X17.1.2	Signal 2 / home signal for drive C	
X17.1.3	GND logic	
X17.2.1	24 VDC	Connection for digital sensor 3 (1 kHz, IEC type 1)
X17.2.2	Signal 3	
X17.2.3	GND logic	

Terminal	Port	Comments
X17.3.1	24 VDC	Connection for digital sensor 4 (1 kHz, IEC type 1)
X17.3.2	Signal 4	
X17.3.3	GND logic	
X17.4.1	24 VDC	Connection for digital sensor 5 (1 kHz, IEC type 1)
X17.4.2	Signal 5	
X17.4.3	GND logic	
X17.5.1	24 VDC	Connection for digital sensor 6 (1 kHz, IEC type 1)
X17.5.2	Signal 6	
X17.5.3	GND logic	
X17.6.1	24 VDC	Connection for digital sensor 7 (1 kHz, IEC type 1)
X17.6.2	Signal 7	
X17.6.3	GND logic	
X17.7.1	24 VDC	Connection for digital sensor 8 (1 kHz, IEC type 1)
X17.7.2	Signal 8	
X17.7.3	GND logic	

Fig. 22



The inputs can be adjusted for PNP or NPN sensors. Configuration is effected via CoDeSys parameters in the control project for all inputs together.

## 11.2 CANopen interface CAN 2 [X18]

Terminal	Port	Comments
X18.1	CAN2_H <sup>1)</sup>	CAN-Bus signal 2 (dominant high)
X18.2	CAN2_L <sup>1)</sup>	CAN-Bus signal 2 (dominant low)
X18.3	CAN_GND	CAN Ground
X18.4	CAN_SHLD	Connection to functional earth

1) No terminating resistor necessary; ports are connected internally via a resistor.

Fig. 23

### 11.3 Analogue inputs [X19]

The analogue inputs, configured in 3-wire connection technology, are **not** galvanically separated. The ground potential for all inputs relates to GND of the power supply [X1].

An incoming signal is digitised with a 14 bit resolution.

Terminal	Port	Comments
X19.0.1	24 VDC	Port analogue sensor 1 (0 ... 10 V; 0 ... 20 mA)
X19.0.2	Signal	
X19.0.3	GND	
X19.1.1	24 VDC	Port analogue sensor 2 (0 ... 10 V; 0 ... 20 mA)
X19.1.2	Signal	
X19.1.3	GND	
X19.2.1	24 VDC	Port analogue sensor 3 (0 ... 10 V; 0 ... 20 mA)
X19.2.2	Signal	
X19.2.3	GND	
X19.3.1	24 VDC	Port analogue sensor 4 (0 ... 10 V; 0 ... 20 mA)
X19.3.2	Signal	
X19.3.3	GND	

Fig. 24



The inputs can be operated either with voltage signal (0 ... 10 V) or current signal (0 ... 20 mA).

Configuration is made via CODESYS parameters in the control project for each input separately.

## 11.4 Digital outputs [X20]

The digital outputs, configured in 2-wire connection technology, are galvanically separated. The current load for each output is 0.5 A. The ground potential for all outputs relates to GND of the power supply [X5].

All outputs are protected against short circuit and thermal overload.

**i** The outputs can be set to PNP or NPN circuitry. Configuration is effected via CoDeSys parameters in the control project for all inputs together.

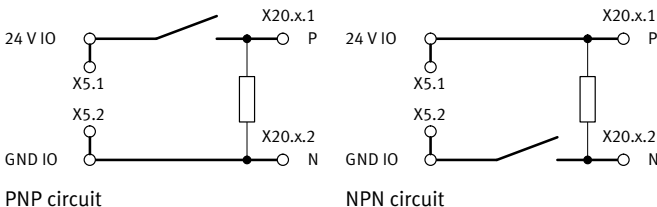


Fig. 25

- Always use 2 adjacent terminals when connecting a consumer.

Terminal	Port	Comments
X20.0.1	Signal P	Port output 1 (0.5 A per channel, SSR <sup>1)</sup> )
X20.0.2	Signal N	
X20.1.1	Signal P	Port output 2 (0.5 A per channel, SSR)
X20.1.2	Signal N	
X20.2.1	Signal P	Port output 3 (0.5 A per channel, SSR)
X20.2.2	Signal N	
X20.3.1	Signal P	Port output 4 (0.5 A per channel, SSR)
X20.3.2	Signal N	

1) SSR: Solid State Relay

Terminal	Port	Comments
X20.4.1	Signal P	Port output 5 (0.5 A per channel, SSR <sup>1</sup> )
X20.4.2	Signal N	
X20.5.1	Signal P	Port output 6 (0.5 A per channel, SSR)
X20.5.2	Signal N	
X20.6.1	Signal P	Port output 7 (0.5 A per channel, SSR)
X20.6.2	Signal N	
X20.7.1	Signal P	Port output 8 (0.5 A per channel, SSR)
X20.7.2	Signal N	

1) SSR: Solid State Relay

Fig. 26

## 12 Port on side

### 12.1 Mass storage card slot

→ Fig. 1 12

#### Supported microSD cards

- microSD
- microSD HC
- microSD XC

#### Supported functions

- Storage of boot projects and check programs (only CECC-X-M1-MV/-S1)
- General data storage



## 13 Technical data

<b>Controller CECC-X-M1-...</b>		
Operating voltage [X1, X5]	[V DC]	19.2 ... 30
Operating voltage [X21]	[V DC]	19.2 ... 50
Current consumption nominal at 24 VDC	[mA]	200
<b>Integrated brake chopper</b>		
Voltage limitation switch-on threshold	[V]	Operating voltage [X21] + 2.0
Voltage limitation switch-off threshold	[V]	Operating voltage [X21] + 0.5
Nominal power	[W]	18
Continuous power	[W]	≤ 5
Pulse power with pulse frequency 1 Hz (switch-on duration ≤ 10 %)	[W]	≤ 50
Braking resistor	[Ω]	15
Protection against incorrect polarity		No
Certification		RCM
CE marking → Declaration of conformity → <a href="http://www.festo.com/sp">www.festo.com/sp</a>		in accordance with EU EMC Directive 1),2)
USB cable length	[m]	≤ 3
Motor cable length	[m]	≤ 3
Other cable lengths	[m]	≤ 10
Degree of protection		IP20
Protection class		III
Vibration and shock resistance (in accordance with IEC/EN 60068-2-6)		SL1 3)
<b>Mass storage devices</b>		
Supported types		microSD, microSDHC, microSDXC, USB
Capacity	[GByte]	≤ 32
File system		FAT32

- 1) The product is intended for use in industrial environments. Measures for interference suppression may need to be implemented in residential areas.
- 2) The product is classified in zone A in accordance with EN 61131-2:2007.
- 3) → 13.2 Explanation on vibration and shock – severity level

## Controller CECC-X-M1-...

Analogue inputs		
Input signal	[U]	0 ... 10 V
Input signal	[I]	0 ... 20 mA
Resolution	Bit	14
Hardware		
Processor (CPU)		Dual core, 2 x 866 MHz
Total main memory	MB	512
Memory for project data (temporary)	MB	19.5
Memory for project data (permanent)	MB	8
Remanent memory → 13.1	KB	4
Ambient temperature	[°C]	0 ... 55
Storage temperature	[°C]	-25 ... 70
Product weight	[g]	410
Fan noise LpAeq (1 m distance)	[dB(A)]	35.7

- 1) The product is intended for use in industrial environments.  
Measures for interference suppression may need to be implemented in residential areas.
- 2) The product is classified in zone A in accordance with EN 61131-2:2007.
- 3) → 13.2 Explanation on vibration and shock – severity level

Fig. 27

### 13.1 Remanent variables

A maximum of 4096 bytes are available on the controller for storing remanent variables. They are automatically distributed based on the variable declaration within the application.

The following sample combinations for distributing the remanent memory are possible.

RETAIN variable		PERSISTENT RETAIN variable
4096	Byte	0 bytes (only if there is no PERSISTENT variable list)
0	bytes	4052 (44 bytes for identification)
300	bytes	4052 – 300 bytes = 3752 bytes (44 bytes for identification)
x	bytes	4052 – x bytes (44 bytes for identification)

Fig. 28



## Note

- Make sure during programming that the total size of all the remanent data does **not** exceed the maximum available range of 4096 bytes.

This will avoid errors when transferring an application to the controller.



Additional information can be found in the Festo Support Portal → [www.festo.com/sp](http://www.festo.com/sp).

## 13.2 Explanation on vibration and shock – severity level

<b>Vibration load</b>					
<b>Frequency range [Hz]</b>		<b>Acceleration [<math>m/s^2</math>]</b>		<b>Deflection [mm]</b>	
<b>SL1</b>	<b>SL2</b>	<b>SL1</b>	<b>SL2</b>	<b>SL1</b>	<b>SL2</b>
2 ... 8	2 ... 8	–	–	±3.5	±3.5
8 ... 27	8 ... 27	10	10	–	–
27 ... 58	27 ... 60	–	–	±0.15	±0.35
58 ... 160	60 ... 160	20	50	–	–
160 ... 200	160 ... 200	10	10	–	–

Fig. 29

<b>Shock load</b>					
<b>Acceleration [<math>m/s^2</math>]</b>		<b>Duration [ms]</b>		<b>Shocks per direction</b>	
<b>SL1</b>	<b>SL2</b>	<b>SL1</b>	<b>SL2</b>	<b>SL1</b>	<b>SL2</b>
±150	±300	11	11	5	5

Fig. 30

<b>Continuous shock load</b>		
<b>Acceleration [<math>m/s^2</math>]</b>	<b>Duration [ms]</b>	<b>Shocks per direction</b>
±150	6	1000

Fig. 31