User Manual
ELECTRICAL INTERFACES

DESCRIPTION OF THE ELECTRICAL INTERFACES FOR THE SERIES D636, D637, D638, D639, D67X, D930, D94X AND THE RKP-D

CA63420-001; Version 1.1, 13/07

WHAT MOVES YOUR WORLD

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For your notes.

1 General Information

1.1 Notes on user information

Completeness

This user information is only complete in conjunction with the product-related documentation required for the relevant application.
➩ Chapter "1.1.2 Completeness", page 2

Please refer to the product-specific valve/pump user information for details on intended operation, selection and qualification of personnel, responsibilities, and warranty and liability.

This user information is concerned exclusively with the electrical connections of the valves/pumps. The instructions contain the most important information for ensuring proper and correct establishment of these connections.
➩ Chapter "1.2 Intended operation", page 4
➩ Chapter "2.1 Handling in accordance with safety requirements", page 7

The contents of this user information and the product-related documentation relevant to the particular application must be read, understood and followed in all points by each person responsible for machine planning, assembly and operation before work on the valves/pumps is started. This requirements applies in particular to the safety instructions.
➩ Chapter "1.1.2 Completeness", page 2
➩ Chapter "1.3 Selection and qualification of personnel", page 5
➩ Chapter "2.1 Handling in accordance with safety requirements", page 7

This user information has been prepared with great care in compliance with the relevant regulations, state-of-the-art technology and our many years of knowledge and experience, and the full contents have been generated to the best of the authors' knowledge.
However, the possibility of error cannot be ruled out and improvements may be possible.
We would be pleased to receive your comments about possible errors and incomplete information.

1.1.1 Changes and validity

Subject to change without notice and validity of the user information

The information contained in this user information is valid and correct at the moment of release of this version of the user information. The version number and release date of this user information are indicated in the footer.
Changes may be made to this user information at any time and without reasons being given.

1.1.2 Completeness

Completeness of the user information

The user information is complete when the following documents have been taken into consideration:

- Product-specific valve/pump user information (safety instructions and the product-specific documentation covering the hydraulic and mechanical functions)
- "Firmware" User Manual (product-specific documentation covering the programmed device and field-bus functions)
- "Electrical Connections" user information (this document)
- "Installation and Start-up Instructions" user information
- Valve/pump type specification

Additional application instructions and information are available on request.

1.1.3 Storage location

Storage location of the user information

This user information together with all the product-related documentation relevant to the particular application must at all times be kept to hand close to the valve/pump or the higher-level machine.

1.1.4 Typographical conventions

Typographical conventions

DANGER	**Denotes safety instructions which are intended to warn against an immediately imminent danger to life or limb or against serious damage to property.** **Failure to comply with these safety instructions will inevitably result in fatalities, serious injuries (crippling/disablement) or serious damage to property!**
WARNING	**Denotes safety instructions which are intended to warn against a possible danger to life or limb or against possible serious damage to property.** Failure to comply with these safety instructions may result in fatalities, serious injuries (crippling/disablement) or serious damage to property!
CAUTION	Denotes safety instructions which are intended to warn against minor injuries or minor damage to property. Failure to comply with these safety instructions may result in minor injuries or minor damage to property.
ⓘ	Denotes important notes/information
• or -	Denotes lists/enumerations
⇨	Denotes references to another chapter, another page, table or illustration in the user information
"…"	Denotes headings to the chapters or titles of the documents to which reference is being made
Blue text	Denotes hyperlinks in the PDF file
1., 2., …	Denotes steps in a procedure which must be carried out in succession
«MS»	Denotes light emitting diodes on the valves/pumps (e.g.: «MS»)
'ACTIVE'	Denotes the valve/pump status (e.g.: 'ACTIVE')

1.2 Intended operation

Intended operation

WARNING

The valves/pumps may be operated exclusively within the framework of the data and applications specified in the product-specific valve/pump user information.
Use for other purposes or for purposes that extend beyond this description is not permitted.

Correct, reliable and safe operation of the valves/pumps requires qualified project planning as well as proper utilization, transportation, storage, installation, removal, electric and hydraulic connection, starting-up, configuration, operation, cleaning and maintenance.

The valves/pumps may only be started up when the following is ensured:

- The higher-level machine with all its installed components complies with the latest versions of the relevant national and international regulations, standards and guidelines (such as, for example, the EU Machinery Directive, the regulations of the trade association and of TÜV or VDE).
- The valves/pumps and all the other installed components are in a technically fault-free and operationally reliable state.
- No signals which can lead to uncontrolled movements in the machine are transmitted to the valves/pumps.

Intended operation also includes the following:

- Observation of all the product-related user information relevant to the particular application
⇨ Chapter "1.1.2 Completeness", page 2
- Handling of the valves/pumps in accordance with safety requirements
⇨ Chapter "2.1 Handling in accordance with safety requirements", page 7
- Adherence to all the inspection and maintenance instructions of the manufacturer and the operator of the machine
- Observation of all safety standards of the manufacturer and the operator of the machine relevant to the particular application
- Observation of all the latest versions of the national and international regulations, standards and guidelines relevant to the particular application (such as, for example, the EU Machinery Directive, the regulations of the trade association and of TÜV or VDE)

1.3 Selection and qualification of personnel

WARNING **Only properly qualified and authorized users may work with and on the valves/pumps.**

Selection and qualification of personnel

Qualified users

Qualified users are specialized personnel with the required knowledge and experience who have been trained to carry out such work. The specialized personnel must be able to recognize and avert the dangers to which they are exposed when working with and on the valves/pumps.
In particular, these specialized personnel must be authorized to operate, earth/ground and mark hydraulic and electrical devices, systems and power circuits in accordance with the standards of safety engineering. Project planners must be fully conversant with the safety concepts of automation engineering.

Warranty and liability claims in the event of personal injury or damage to property are among others excluded if such injury or damage is caused when the valves/pumps are worked on or handled by non-qualified personnel.

1.4 Trademarks

Trademarks

Moog and Moog Authentic Repair® are registered trademarks of Moog Inc. and its subsidiaries.
EtherCAT® is registered trademark and patented technology licensed by Beckhoff Automation GmbH, Germany.

All the product and company names mentioned in this document are possibly proprietary names or trademarks of the respective manufacturers. The use of these names by third parties for their own purposes may infringe the rights of the manufacturers.
It cannot be inferred from the absence of the ® or ™ symbol that the designation is a free brand name.

For your notes.

2 Safety

The safety instructions set out in the product-specific valve/pump user information must be observed. These are in particular:

- Handling in accordance with safety requirements
- Occupational safety and health
- General safety instructions
- Safety instructions for installation and maintenance

2.1 Handling in accordance with safety requirements

WARNING

It is the responsibility of the manufacturer and the operator of the machine to ensure that the valves/pumps are handled in accordance with safety requirements.

WARNING

As in any electronic control system, the failure of certain components in valves/pumps as well can give rise to an uncontrolled and/or unforeseeable operational sequence. All types of failure on a system level must be taken into consideration and appropriate protective measures taken.
The use of automatic control technology in a machine calls for special measures.
If automatic control technology is to be used, the user should, in addition to all the potentially available standards or guidelines on safety-engineering installations, consult the manufacturers of the components used in great depth.

Handling in accordance with safety requirements

In order to ensure that the valves/pumps are handled in accordance with safety requirements and operated without faults, it is essential to observe the following:

- All the safety instructions in the user information
  ⇨ Chapter "1.1.2 Completeness", page 2
- All the safety instructions in the safety standards of the manufacturer and the operator of the machine relevant to the particular application
- All the relevant national and international safety and accident prevention regulations, standards and guidelines, such as for example the safety regulations of the trade association, of TÜV or VDE, in particular the following standards pertaining to the safety of machinery:
  - DIN EN ISO 12100
  - DIN EN 982
  - DIN EN 60204
  - DIN EN 954-1

Observing the safety instructions and the safety and accident prevention regulations, standards and guidelines will help to prevent accidents, malfunctions and damage to property!

2.2 Occupational safety and health

Occupational safety and health measures and equipment

CAUTION

Falling objects, such as e.g. valve/pump, tool or accessory, can cause injury.
Suitable safety equipment, such as e.g. safety shoes, must be worn to provide protection against injury.

CAUTION

Valves/pumps and hydraulic port lines can become very hot during operation.
To protect yourself against injury, wear suitable safety equipment, such as work gloves, before touching valves/pumps or the port lines during such operations as mounting, removal, electrical and hydraulic connection, trouble shooting or servicing.

CAUTION

Depending on the application, significant levels of noise may be generated when the valves/pumps are operated.
If necessary, the manufacturer and operator of the machine must take appropriate soundproofing measures or stipulate that suitable safety equipment, e.g., ear defenders, be worn.

CAUTION

When handling hydraulic fluids, observe the safety provisions applicable to the hydraulic fluid used.
If necessary, suitable safety equipment, such as e.g. safety shoes, must be worn to provide protection against injury.

2.3 General safety instructions

General safety instructions

WARNING

Only properly qualified and authorized users may work with and on the valves/pumps.
⇨ Chapter "1.3 Selection and qualification of personnel", page 5

WARNING

Observe and adhere to the technical data and in particular the information given on the valve/pump nameplate.

CAUTION

All the product-related user information relevant to the particular application must be inserted in the machine operating instructions.

2.4 ESD

WARNING

Electrical discharges can damage internal device components.
Protect the valve/pump, accessories and spare parts against static charging.
In particular, avoid touching the connector contacts.

ESD

2.5 Safety instructions for installation and maintenance

WARNING

When starting up valves/pumps on the field bus for the first time, we recommend that the component be operated in a depressurized state.

Depressurized state during initial starting-up

WARNING

Before connecting valves/pumps to the field bus, it is essential to complete the electrical and if necessary hydraulic connection of the component properly as described in the user information.
⇨ Chapter "4 Electrical Interfaces", page 19
⇨ Chapter "1.1.2 Completeness", page 2

WARNING

The protective conductor connection (⏚), if provided, is connected to the electronics housing or valve/pump body. The insulating elements used are designed for the safety extra low voltage range.
The circuits of the field bus connections, if provided, are only functionally isolated from other connected circuits.
Compliance with the safety regulations requires that the equipment be isolated from the mains system in accordance with DIN EN 61558-1 and DIN EN 61558-2-6 and that all voltages be limited in accordance with DIN EN 60204-1.
We recommend the use of SELV/PELV power packs.

Isolation from the mains system

CAUTION

Unsuitable or defective accessories or unsuitable or defective spare parts may cause damage, malfunctions or failure of the valve/pump or the machine.
We recommend that original accessories and original spare parts be used.
Warranty and liability claims for personal injury and damage to property are among other things excluded if they are caused by the use of unsuitable or defective accessories or unsuitable or defective spare parts.

Original accessories

CAUTION

Dirt or moisture can get into the valve/pump electronics through unplugged connectors, i.e., if a mating connector is not inserted, which may result in the valve or the pump being damaged.
Unplugged connectors must be covered and sealed.
The plastic dust protection caps which are attached to service connectors X5, X6, X7 and X10 on delivery are suitable for use as sealing covers.
The plastic dust protection caps which are attached to field bus connectors X3 and X4 on delivery are not suitable for use as sealing covers.
Suitable metallic dust protection caps for field bus connectors X3 and X4 are available as accessories.
⇨ Chapter "9.2 Accessories", page 84

Cover unplugged connectors with dust protection caps

CAUTION

Do not lay valve/pump connection cables in the immediate vicinity of high-voltage cables or together with cables that switch inductive or capacitive loads.

Laying connection cables

CAUTION

For the floating analog inputs of connector X1, the potential difference (measured to supply zero) must be between -15 V and 32 V.

CAUTION

The input current of the analog inputs with current input signal must be between -25 mA and 25 mA!
Voltage levels in excess of 5 V can cause the destruction of the integrated valve/pump electronics at analog inputs on connector X1.

CAUTION

In the signal range 4–20 mA input currents < 3 mA (e.g., due to a faulty electric cable) indicate a fault.

2.5.1 Protective grounding and electrical shielding

WARNING

The equipotential bonding and protective conductor system for a machine in which the valves/pumps are to be used must be designed in accordance with DIN EN 60204-1.

Equipotential bonding / protective conductor system

WARNING

This protective conductor is not a replacement for the normal equipotential bonding system.
⇨ Chapter "6.2.2.1 General principles", page 50
The protective conductor must not be used for equipotential bonding.

WARNING

Good equipotential bonding is often not provided for in many industrial applications. An effective equipotential bonding system must be set up in compliance with DIN EN 60204-1, Section 8, here.
If this is not possible, the machine will not comply with DIN EN 60204-1!
Extreme caution must be exercised here as very high currents can pass through the protective conductor connection of the valve/pump.

2.5.2 Moog Valve Configuration Software

Safety instructions on using the Moog Valve Configuration Software

WARNING

For safety reasons, the Moog Valve Configuration Software must not be used inside a machine for visualization purposes or as an operator terminal.

WARNING

It is only permitted to activate valves/pumps via the Moog Valve Configuration Software if this does not cause any dangerous states in the machine and in its surroundings.
It is not permitted to operate the Moog Valve Configuration Software on a field bus while the machine is running.

CAUTION

Activating valves/pumps via the Moog Valve Configuration Software within a network can give rise to unforeseeable events if field bus communication takes place simultaneously between the machine controller or to other bus nodes!

CAUTION

Messages from the Moog Valve Configuration Software can also be received by other bus nodes. This may trigger off unforeseeable events!

CAUTION

If completely safe operation of the valves/pumps via the Moog Valve Configuration Software cannot be guaranteed even with deactivated field bus communication with the machine controller and other bus nodes, the valves/pumps are only permitted to communicate in a depressurized state and in a direct link (point-to-point) with the Moog Valve Configuration Software.

CAUTION

Data communication between the valve/pump electronics and the Moog Valve Configuration Software may be disrupted if other field bus nodes (e.g., a controller) are accessing the valve/pump electronics at the same time.

For your notes.

3 Function and Method of Operation

3.1 Block diagram

Block diagram of the valve/pump electronics

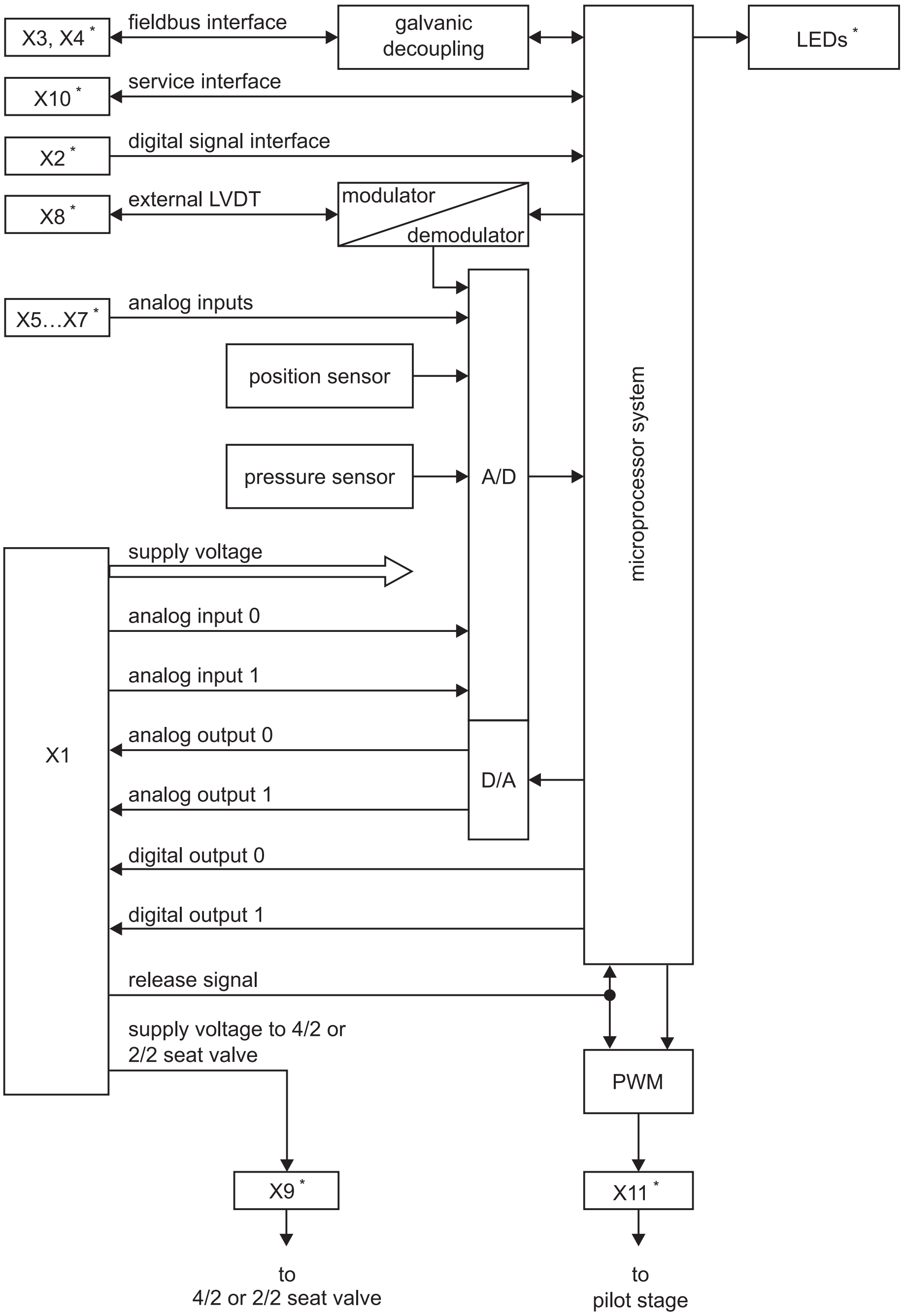


Figure 1: Block diagram of the valve/pump electronics

* Depending on the model, the valves/pumps can have different electrical connections and light emitting diodes.

Allocation of interfaces to connectors

The valve/pump electronics are equipped with connectors which are designated X1 through X11.
The table below shows which interfaces are accommodated in the different connectors.

Allocation of interfaces to connectors

Interface type	Interface	Connector
Analog input	Analog input 0	X1
	Analog input 1	X1
	Analog input 2	X5
	Analog input 3	X6
	Analog input 4	X7
Analog output	Analog output 0	X1
	Analog output 1	X1
Digital input	Release signal	X1
Digital output	Digital output 0	X1
	Digital output 1	X1
Digital signal interface	SSI transducers, incremental transducers, LocalCAN transducers	X2
Field bus interface	CANopen, Profibus-DP, EtherCAT®	X3, X4
External LVDT	Not for customer use	X8
Supply to the 4/2- or 2/2-way seat valve	Not for customer use	X9
Service interface		X10
Pilot valve interface	Not for customer use	X11

Table 1: Allocation of interfaces to connectors

ⓘ Information on the position of the connectors on the housing can be found in the product-specific valve/pump user information.

3.2 Analog inputs/outputs

Analog inputs/outputs

The analog inputs/outputs are available on connector X1 and optionally on connectors X5, X6 and X7. The analog inputs can measure both current and voltage.
Specific technical data:
➩ Chapter "4.1.5 Analog inputs", page 23
➩ Chapter "4.1.6 Analog outputs", page 25
➩ Chapter "4.4 Analog input connectors X5, X6 and X7", page 35

3.3 Digital inputs/outputs

Digital inputs/outputs

The digital inputs/outputs are available on connector X1. The digital input serves as the release signal. The digital output indicates specific events, such as for example the occurrence of a fault.
➩ Chapter "4.1.7 Digital inputs", page 25
➩ Chapter "4.1.8 Digital outputs", page 25

3.4 Digital signal interface

Digital signal interface

The digital signal interface is available on connector X2. This interface is for SSI transducers, incremental transducers and LocalCAN transducers
➩ Chapter "4.2 Connector X2 for digital signal interface", page 26

3.5 Field bus interfaces

General information on field bus interfaces

Modern automation technology is characterized by an increasing decentralization of processing functions via serial data communication systems. The use of serial bus systems in place of conventional connection technologies guarantees greater system flexibility with regard to alterations and expansions and additionally opens up considerable potential for saving project planning and installation costs in many areas of industrial automation. Further possibilities of parameterization, better diagnostic options and a reduction of the variety of variants are advantages which have only been made possible by the use of field buses.

Valves/pumps with field bus interfaces are activated, monitored and configured via the field bus interface (connectors X3 and X4).
To reduce the amount of wiring, the field bus interface is provided with two connectors. The valve/pump electronics can thus be directly looped into the field bus, i.e., without the use of external T-pieces.

Available field bus interfaces

The following field bus interfaces are possible:

- CANopen, CAN
- Profibus-DP V1
- EtherCAT®

⇨ Chapter "4.3 Field bus connectors X3 and X4", page 31

3.5.1 CAN bus interface

CAN bus interface

The CAN bus is a differential 2-wire bus and was developed to facilitate rapid and interference-free networking of components. CANopen is based on the CAN bus and is a standardized communications profile, which allows communication between CANopen-compatible devices of all kinds of manufacturers. Thanks to its flexibility and high reliability, the CAN bus is suitable for diverse applications.

The CAN bus has the following features:

- Multi-master system: Each node can transmit and receive
- Topology: Line structure with short stub cables
- Network expansion and transmission rates:
  25 m (27.340 yd) at 1 Mbit/s to 5,000 m (5,468 yd) at 25 kbit/s
- Addressing type: Message-orientated via identifiers
  Priority assignment of messages possible via identifiers
- Safety: Hamming distance = 6, i.e., up to 5 individual errors per message are detected
- Bus physics: ISO/DIS 11898
- Max. number of nodes: 127 (via repeaters)

⇨ Chapter "4.3.1 CAN connectors", page 31
⇨ Chapter "6.7 Wiring CAN networks (X2, X3, X4)", page 64

3.5.2 Profibus-DP interface

Profibus-DP interface

The Profibus-DP is a differential 2-wire bus and was developed to facilitate rapid and simple networking of components. Profibus-DP has gained acceptance as a widely used standard.

The Profibus-DP has the following features:

- Standardized in accordance with DIN EN 61158-2 (type 3)
- Multi-master system:
  Masters share access time and initiate communication.
  Slaves react only on request.
- Topology: Line structure with short stub cables
- Network expansion and transmission rates:
  100 m (109.361 yd) at 12 Mbit/s to 1,200 m (1,312 yd) at 9.6 kbit/s per segment
  Use of repeaters possible
- Addressing type: Address-orientated
  Priority/cycle time assignment of messages via master configuration
- Bus physics: RS 485 in accordance with TIA/EIA-485-A
- Max. number of nodes: 127

⇨ Chapter "4.3.2 Profibus-DP connectors", page 32
⇨ Chapter "6.8 Wiring Profibus-DP networks (X3, X4)", page 68

3.5.3 EtherCAT® interface

EtherCAT® interface

The EtherCAT® bus was developed to facilitate networking of components with very short cycle times and high real time requirements.

EtherCAT® is based on Ethernet technology and is suitable for applications in machines.

The EtherCAT® bus has the following features:

- Standardized in accordance with IEC 62407
- Single-master system:
  The master initiates communication.
  Slaves react only on request.
- Topology:
  Line, star, tree and ring structure based on the daisy chain principle
- Network expansion and transmission rates:
  100 m (109.361 yd) between two nodes at 100 Mbit/s
- Addressing type: Address-orientated, one telegram for all nodes
- Bus physics: Fast Ethernet
- Max. number of nodes: 65,535

⇨ Chapter "4.3.3 EtherCAT® connectors", page 33
⇨ Chapter "6.9 Wiring EtherCAT® networks (X3, X4)", page 71

3.6 External LVDT

External LVDT

The external LVDT is available on connector X8. This interface is used for 2nd stage position feedback.
➪ Chapter "4.5 Connector X8 for external LVDT", page 38

CAUTION ! This connection is not intended for customer use.

3.7 Service interface

Service interface

This interface serves to connect diagnostic and starting-up tools and is available on connector X10.
➪ Chapter "4.7 Service connector X10", page 39

3.8 Pilot valve interface

Pilot valve interface

The connection to the pilot valve is established with connector X11.

CAUTION ! This connection is not intended for customer use.

3.9 Status LEDs

Status LEDs

The electronics housing can feature as an option multi-colored light emitting diodes (status LEDs) for indicating the operating state of the valves/pumps and the network state.
➪ Chapter "5 Status display", page 41

For your notes.

4 Electrical Interfaces

4.1 Connector X1

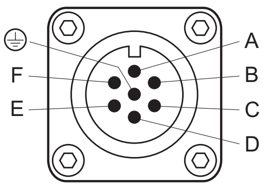
Connector X1 is designed in accordance with DIN EN 175201-804 and is available in the following versions:

- 6+PE-pin connector with protective conductor contact
  ➪ Chapter "4.1.1.1 Pin assignment of 6+PE-pin connector", page 19
- 11+PE-pin connector with protective conductor contact (variant Q)
  ➪ Chapter "4.1.1.2 Pin assignment, 11+PE-pin connector (variant Q)", page 20
- 11+PE-pin connector with protective conductor contact (variant p/Q, pump)
  ➪ Chapter "4.1.1.3 Pin assignment, 11+PE-pin connector (variant p/Q, pump)", page 21

4.1.1 Pin assignment of connector X1

4.1.1.1 Pin assignment of 6+PE-pin connector

6+PE-pin connector X1



View of connector X1
(external thread, pin contacts)

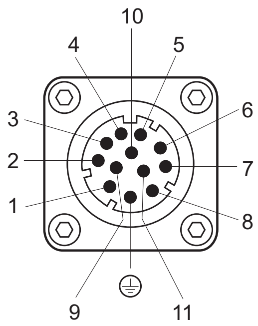
Pin	Assignment	Description
A	Supply voltage	Nominal 24 V (18–32 V) DC based on GND
B	GND	Supply zero or signal zero
C	Release signal	Enable referred to GND
D	Analog input 0	Current or voltage input referred to pin E
E	Reference point for analog input 0	Reference point for pin D
F	Analog output 0	4–20 mA or 2–10 V referred to GND
PE ⏚	Protective conductor contact	Leading contact; connect protective grounding: ➪ Chapter "6.2 Protective grounding and electrical shielding", page 48

Figure 2: 6+PE-pin connector X1

➪ Chapter "6.4 Wiring connector X1", page 59

4.1.1.2 Pin assignment, 11+PE-pin connector (variant Q)

11+PE-pin connector X1 (variant Q)



View of connector X1
(external thread, pin contacts)

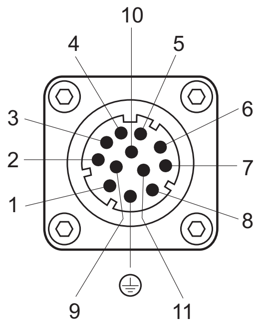
Pin	Assignment	Description
1	Optional	Supply to the 4/2- or 2/2-way seat valve (for fail-safe valves only): Nominal 24 V (22.8–26.4 V) DC, max. 1.2 A
2	Optional	Supply to the 4/2- or 2/2-way seat valve (for fail-safe valves only): 0 V
3	Release signal	Enable referred to GND
4	Analog input 0	Current or voltage input referred to pin 5
5	Reference point for analog input 0	Reference point for pin 4
6	Analog output 0	4–20 mA or 2–10 V referred to GND
7		Not assigned
8	Digital output 0	High: valve ready
9	Supply voltage	Nominal 24 V (18–32 V) DC based on GND
10	GND	Supply zero or signal zero
11	Digital output 1	Monitoring (negative logic)
PE ⏚	Protective conductor contact	Leading contact; connect protective grounding: ⇨ Chapter "6.2 Protective grounding and electrical shielding", page 48

Figure 3: 11+PE-pin connector X1 (variant Q)

⇨ Chapter "6.4 Wiring connector X1", page 59

4.1.1.3 Pin assignment, 11+PE-pin connector (variant p/Q, pump)

11+PE-pin connector X1 (variant p/Q, pump)



View of connector X1
(external thread, pin contacts)

Pin	Assignment	Description
1	Optional	Supply to the 4/2- or 2/2-way seat valve (for fail-safe valves only): Nominal 24 V (22.8–26.4 V) DC, max. 1.2 A
2	Optional	Supply to the 4/2- or 2/2-way seat valve (for fail-safe valves only): 0 V
3	Release signal	Enable referred to GND
4	Analog input 0	Current or voltage input referred to pin 5
5	Reference point for analog input 0 and input 1	Reference point for pin 4 and pin 7
6	Analog output 0	4–20 mA or 2–10 V referred to GND
7	Analog input 1	Current or voltage input referred to pin 5
8	Analog output 1	4–20 mA or 2–10 V referred to GND
9	Supply voltage	Nominal 24 V (18–32 V) DC based on GND
10	GND	Supply zero or signal zero
11	Digital output 1	Monitoring (negative logic)
PE ⏚	Protective conductor contact	Leading contact; connect protective grounding: ➪ Chapter "6.2 Protective grounding and electrical shielding", page 48

Figure 4: 11+PE-pin connector X1 (variant p/Q, pump)

➪ Chapter "6.4 Wiring connector X1", page 59

4.1.2 Mating connector for connector X1

Mating connector for connector X1

The mating connector for the 6+PE- and 11+PE-pin connector X1 is available as an accessory.
➪ Chapter "9.2 Accessories", page 84
➪ Chapter "6.3 Permissible lengths for connection cables", page 54

4.1.3 Power supply

Isolation from the mains system

WARNING

The protective conductor connection (⏚), if provided, is connected to the electronics housing or valve/pump body. The insulating elements used are designed for the safety extra low voltage range.
The circuits of the field bus connections, if provided, are only functionally isolated from other connected circuits.
Compliance with the safety regulations requires that the equipment be isolated from the mains system in accordance with DIN EN 61558-1 and DIN EN 61558-2-6 and that all voltages be limited in accordance with DIN EN 60204-1.
We recommend the use of SELV/PELV power packs.

CAUTION

Electrical connection must be conducted in compliance with EMC requirements.

Requirement of supply voltage

The supply voltage must be nominally 24 V (18–32 V) DC referred to supply zero. Supply voltages of less than 18 V are detected by the valve/pump electronics as undervoltage.

The valve/pump electronics are protected against polarity reversal of the connections.

The nominal power consumption of the valves/pumps varies from model to model. The power consumption varies with the operating conditions.

ⓘ Detailed information can be found in the product-specific valve/pump user information.

4.1.4 Supply to the 4/2- or 2/2-way seat valve

Supply to the 4/2- or 2/2-way seat valve

CAUTION

We recommend that an EMC-compliant SELV/PELV power pack in accordance with DIN EN 60204-1 be used to power the 4/2- or 2/2-way seat valve. Electrical connection must be conducted in compliance with EMC requirements.

4/2- or 2/2-way seat valves are additional safety valves. They are powered via connector X9.
⇨ Figure 1, page 13
⇨ Chapter "4.6 Plug connection X9 for 4/2- or 2/2-way seat valve", page 38

ⓘ Please refer to the product-specific valve/pump user information for detailed information on using a 4/2- or 2/2-way seat valve.

Description		Values	Additions
Nominal voltage		24 V	Direct voltage (22.8–26.4 V)
Nominal power	2/2-way seat valve	26 W	
	4/2-way seat valve	36 W	

Table 2: Nominal voltage/nominal power of the 4/2- or 2/2-way seat valve

4.1.5 Analog inputs

All current and voltage inputs are differential, but can be connected to ground (single-ended) by means of external wiring. The analog inputs of connector X1 have a resolution of 12 bits.
⇨ Chapter "6.4.1 Single-ended command signals", page 60

4.1.5.1 Signal types

Signal types of the analog inputs on connector X1

The analog inputs are available in the following versions:

- ±10 V
- 0–10 V
- ±10 mA
- 0–10 mA
- 4–20 mA

Which signal type is set for the analog inputs on delivery is dependent on the valve/pump model. The signal types can be configured via the firmware.

ⓘ Detailed information can be found in the "Firmware" User Manual.

Signal type for the analog input: ±10 V

Analog input: ±10 V

In the case of this signal type, the input is configured as a differential voltage input with a ±10 V input range.

The differential input resistance is 20 kΩ.

The input resistance referred to supply zero is approx. 150 kΩ.
The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no differential analog source available, the reference point of the analog input (pin 5) must be connected to 0 V of the analog source.

Signal type for the analog input: 0–10 V

Analog input: 0–10 V

In the case of this signal type, the input is configured as a differential voltage input with a 0–10 V input range.

The differential input resistance is 20 kΩ.

The input resistance referred to supply zero is approx. 150 kΩ.

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no differential analog source available, the reference point of the analog input (pin 5) must be connected to 0 V of the analog source.

Signal type for the analog input: ±10 mA

Analog input: ±10 mA

With this signal type, the input current to be measured is directed via the two input pins to an internal shunt.

The differential input resistance is 200 Ω.

The input resistance referred to supply zero is approx. 150 kΩ.

CAUTION (!) The input current must be between -25 mA and 25 mA! Input currents outside this permissible range will destroy the input.

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no floating analog source available, the reference point of the analog input (pin 5) must be connected to 0 V of the analog source.

Signal type for the analog input: 0–10 mA

Analog input: 0–10 mA

With this signal type, the input current to be measured is directed via the two input pins to an internal shunt.

The differential input resistance is 200 Ω.

The input resistance referred to supply zero is approx. 150 kΩ.

CAUTION ! The input current must be between -25 mA and 25 mA! Input currents outside this permissible range will destroy the input.

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no floating analog source available, the reference point of the analog input (pin 5) must be connected to 0 V of the analog source.

Signal type for the analog input: 4–20 mA

Analog input: 4–20 mA

With this signal type, the input current to be measured is directed via the two input pins to an internal shunt.

The differential input resistance is 200 Ω.

The input resistance referred to supply zero is approx. 150 kΩ.

CAUTION ! The input current must be between -25 mA and 25 mA! Input currents outside this permissible range will destroy the input.

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no floating analog source available, the reference point of the analog input (pin 5) must be connected to 0 V of the analog source.

In the 4–20 mA signal range signals of I_{In} < 3 mA (e.g., due to a defective electric cable) signify a fault, which can be evaluated by the valve software.

4.1.6 Analog outputs

4.1.6.1 Analog outputs 4–20 mA

Analog output: 4–20 mA

The reference point for the 4–20 mA analog outputs is supply zero.

The load impedance must be in the range of 0–500 Ω.

Cable break detection of the connected cable can be effected with the 4–20 mA analog outputs.

The 4–20 mA analog outputs are short-circuit protected.

4.1.6.2 Analog outputs 2–10 V

Analog output: 2–10 V

The reference point for the 2–10 V analog outputs is supply zero.

The internal resistance is 500 Ω.

Cable break detection of the connected cable can be effected with the 2–10 V analog outputs.

Voltage drops in the supply cable to the valve/pump electronics can result in deviations from the actual value.
⇨ Chapter "6.4.1 Single-ended command signals", page 60

Recommendation: Use a 4–20 mA analog output and terminate directly at the measurement input with 500 Ω.
⇨ Chapter "6.4.2 Conversion of actual value output signals I_{out}", page 61

4.1.7 Digital inputs

4.1.7.1 Release signal input

Release signal input

Signals between 8.5 V and 32 V supply voltage referred to supply zero at the release signal input allow the valve to go active.

Signals of less than 6.5 V at the release signal input are identified as enable not issued. The electrical output stage is deactivated if no release signal input. This input is also used to acknowledge a valve/pump fault state via an analog signal.

The input current of the release signal input is 2.3 mA when connected to 24 V.

ⓘ Please refer to the Firmware user information and the product-specific valve/pump user information for further details.

4.1.8 Digital outputs

Valve ready and monitoring

The digital outputs are short-circuit protected and switch off in the event of overload. After a period of cooling down, the digital output switches itself back on. Overload means a current load in excess of 1.5 A.

Logic level

High Supply voltage connected.
Low Supply voltage disconnected (10 kΩ to supply zero).

4.2 Connector X2 for digital signal interface

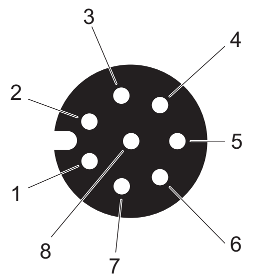
Digital transducers such as incremental, SSI or CAN transducers can be connected to the digital signal interface.

Connector X2 is available in the following versions:

- 8-pin M12 incremental transducer connector X2
  ➪ Chapter "4.2.1 Incremental transducer", page 26
- 8-pin M12 SSI connector X2
  ➪ Chapter "4.2.2 SSI transducer", page 28
- 5-pin M12 LocalCAN connector X2
  ➪ Chapter "4.2.3.1 Pin assignment, LocalCAN connector X2 (M12, 5-pin)", page 30
- 3-pin M8 LocalCAN connector X2
  ➪ Chapter "4.2.3.2 Pin assignment, LocalCAN connector X2 (M8, 3-pin)", page 31

4.2.1 Incremental transducer

Incremental transducer connector X2 (M12, 8-pin)



View of incremental transducer connector X2 (internal thread, socket connectors)

Pin	Assignment	Description
1	Z+	Zero pulse
2	Z-	Zero pulse inverted
3	A+	Counting pulses
4	A-	Counting pulses inverted
5	B+	Counting pulses by 90° out of phase
6	B-	Counting pulses by 90° out of phase, inverted
7	Sensor supply	Supply voltage to incremental transducer 24 V / 5 V / 0 V (configurable; see "Firmware" User Manual) I_{max} (X2+X5+X6+X7)= 300 mA
8	Supply zero	

Figure 5: Incremental transducer connector X2 (M12, 8-pin)

This digital signal interface is suitable in accordance with TIA/EIA 422 (formerly RS 422) for connecting e.g., position transducers or rotary transducers with incremental transducer signals.
➪ Chapter "6.5 Wiring incremental transducers (X2)", page 62

Supported transducer types

The following transducer types are supported:

- Standard with negative logic
- Standard with positive logic
- Pulse train with negative logic
- Pulse train with positive logic
- Frequency modulation with positive logic
- Frequency modulation with negative logic

The digital signal interface must be configured.

ⓘ Detailed information can be found in the "Firmware" User Manual.

The signal levels conform to the standard TIA/EIA 422 (formerly RS 422).

Recommended cable types

Recommended cable types for incremental transducer

Use exclusively shielded cables with copper braiding shielding with min. 80 % overlap.
Copper conductors with a cross section of at least 0.25 mm^2 (AWG 24 or lower).
Use cables with twisted-pair conductors in environments with high background noise levels.

Cable break monitoring

Cable break monitoring

Inputs A, B and Z of the digital signal interfaces are monitored for cable break – irrespective of which transducer type is connected.
The status of cable break monitoring can be read out via field bus. The reaction to a cable break is configurable.

ⓘ Detailed information can be found in the "Firmware" User Manual.

Power supply to the transducer

Power supply to the transducer

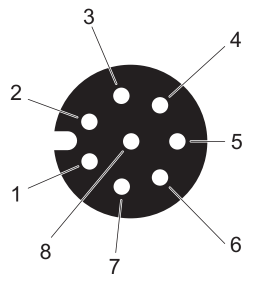
Power is supplied to the transducer via pin 7 on connector X2.
⇨ Figure 6, page 28

ⓘ There is joint fusing of this power supply for X2, X5, X6 and X7. The total supply current must therefore not exceed the following value:
I_{max} (X2+X5+X6+X7) = 300 mA

The 24 V or 5 V supply voltage is configurable (see "Firmware" User Manual).
An external power supply to the transducer is also possible. However, the 0 V transducer supply must be connected to supply zero.
The supply voltage is cut off in the event of a possible short circuit in the supply voltage to the transducer. A fault reaction can be configured (see "Firmware" User Manual). The voltage is available again as soon as the short circuit has been eliminated.

4.2.2 SSI transducer

SSI transducer connector X2 (M12, 8-pin)



View of SSI transducer connector X2
(internal thread, socket connectors)

Pin	Assignment	Description
1	CLK+	Clock pulse output
2	CLK-	
3	DATA+	Data input for transducer data
4	DATA-	
5	Not assigned	
6	Not assigned	
7	Sensor supply	Supply voltage to SSI transducer 24 V / 5 V / 0 V (configurable; see "Firmware" User Manual) I_{max} = 300 mA
8	Supply zero	

Figure 6: SSI transducer connector X2 (M12, 8-pin)

This digital signal interface is suitable in accordance with TIA/EIA 422 (formerly RS 422) for connecting e.g., position transducers or rotary transducers with an SSI interface.
⇨ Chapter "6.6 Wiring SSI transducers (X2)", page 63

Supported types of SSI transducers

The following transducer types are supported:

- Coded with binary code
- Coded with Gray Code

The digital signal interface must be configured.

ⓘ Detailed information can be found in the "Firmware" User Manual.

The signal levels conform to the standard TIA/EIA 422 (formerly RS 422).

Recommended cable types

Recommended cable types for SSI transducer

Use exclusively shielded cables with copper braiding shielding with min. 80 % overlap.
Copper conductors with a cross section of at least 0.25 mm^2 (AWG 24 or lower).
Use cables with twisted-pair conductors in environments with high background noise levels.

Cable break monitoring

Cable break monitoring

Inputs CLK and DATA of the digital signal interfaces are monitored for cable break – irrespective of which transducer type is connected.
The status of cable break monitoring can be read out via field bus. The reaction to a cable break is configurable.

ⓘ Detailed information can be found in the "Firmware" User Manual.

Power supply to the transducer

Power supply to the transducer

Power is supplied to the transducer via pin 7 on connector X2.
⇨ Figure 6, page 28

ⓘ There is joint fusing of this power supply for X2, X5, X6 and X7. The total supply current must therefore not exceed the following value:
I_{max} (X2+X5+X6+X7) = 300 mA

The 24 V or 5 V supply voltage is configurable (see "Firmware" User Manual). An external power supply to the transducer is also possible. However, the 0 V transducer supply must be connected to supply zero.
The supply voltage is cut off in the event of a possible short circuit in the supply voltage to the transducer. A fault reaction can be configured (see "Firmware" User Manual). The voltage is available again as soon as the short circuit has been eliminated.

4.2.3 LocalCAN

The local CAN interface enables transducers, actuators and further valves/pumps to be networked. The interface is not electrically isolated; short cables and equipotential bonding must therefore be provided.

Technical data for the LocalCAN interface

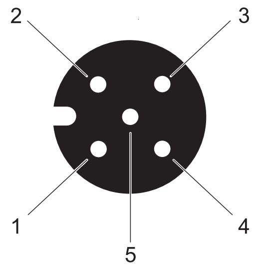
EMC protection requirements	Immunity to interference as per DIN EN 61000-6-2 (evaluation criterion A) Emitted interference as per DIN EN 61000-6-4
Physical	ISO/DIS 11898 CAN-HIGH SPEED
Maximum voltage capacity	±40 V long-term (between CAN_H and CAN_L) ±2.5 kV ESD (classification A: Human Body Model, C = 100 pF, R = 1.5 kΩ)
Maximum permissible number of CAN bus nodes	32 or 110 ⇨ Chapter "6.7.2 Permissible number of CAN bus nodes", page 67

Table 3: Technical data for the LocalCAN interface

To connect the valves/pumps to a CAN network, we recommend molded cord sets with an integral straight mating connector.
⇨ Chapter "6.7 Wiring CAN networks (X2, X3, X4)", page 64

4.2.3.1 Pin assignment, LocalCAN connector X2 (M12, 5-pin)

LocalCAN connector X2 (M12, 5-pin)



View of LocalCAN connector X2
(internal thread, socket connectors)

Pin	Assignment	Description
1	CAN_SHLD	Shield (fitted on control cabinet side)
2	CAN_V+	Transducer supply +24 V; I_{max} = 300 mA
3	CAN_GND	Ground connected to supply zero
4	CAN_H	Transceiver H
5	CAN_L	Transceiver L

Figure 7: LocalCAN connector X2 (M12, 5-pin)

CAUTION

To prevent the connector from being damaged, pay attention to the alignment of the key.

Transducers can be supplied directly by the applied supply voltage.

Power supply to the transducer

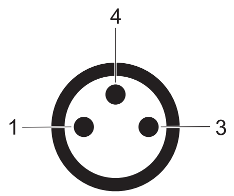
Power supply to the transducer at LocalCAN connector X2

Power is supplied to the transducer via pin 2 on connector X2.
⇨ Figure 7, page 30

An external power supply to the transducer is also possible. However, the 0 V transducer supply must be connected to supply zero.
The supply voltage is cut off in the event of a possible short circuit in the supply voltage to the transducer. The voltage is available again as soon as the short circuit has been eliminated.

4.2.3.2 Pin assignment, LocalCAN connector X2 (M8, 3-pin)

LocalCAN connector X2 (M8, 3-pin)



View of LocalCAN connector X2
(external thread, pin contacts)

Pin	Assignment	Description
1	CAN_H	Transceiver H
3	CAN_GND	Not assigned
4	CAN_L	Transceiver L

Figure 8: LocalCAN connector X2 (M8, 3-pin)

ⓘ No transducers can be supplied via this connector.

4.3 Field bus connectors X3 and X4

Versions of the field bus connector

Field bus connectors X3 and X4 are available in the following versions:

- 5-pin CAN connector
  ➪ Chapter "4.3.1 CAN connectors", page 31
- 5-pin Profibus-DP connector
  ➪ Chapter "4.3.2 Profibus-DP connectors", page 32
- 4-pin EtherCAT® connector
  ➪ Chapter "4.3.3 EtherCAT® connectors", page 33

4.3.1 CAN connectors

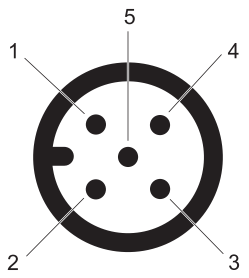
4.3.1.1 Technical data for the CAN bus interface

EMC protection requirements	Immunity to interference as per DIN EN 61000-6-2 (evaluation criterion A) Emitted interference as per DIN EN 61000-6-4
Connectors X3 and X4	5-pin connector with pin contacts and one with socket connectors (both M12x1, coding A) ➪ Chapter "4.3.1.2 Pin assignment, CAN connectors", page 32
Physical	ISO/DIS 11898 CAN-HIGH SPEED
Maximum voltage capacity	±40 V long-term (between CAN_H and CAN_L) ±500 V long-term referred to supply zero (optical isolation) ±2.5 kV ESD (classification A: Human Body Model, C = 100 pF, R = 1.5 kΩ)
Maximum permissible number of CAN bus nodes	32 or 110 ➪ Chapter "6.7.2 Permissible number of CAN bus nodes", page 67

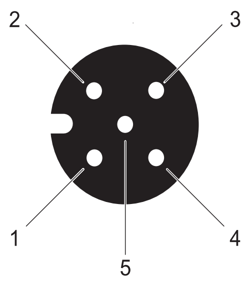
Table 4: Technical data for the CAN bus interface

4.3.1.2 Pin assignment, CAN connectors

CAN connectors X3 and X4 (M12, 5-pin)



View of CAN connector X3
(external thread, pin contacts)



View of CAN connector X4
(internal thread, socket connectors)

Pin	Assignment	Description
1	CAN_SHLD	Shield (fitted on control cabinet side)
2	CAN_V+	Not connected in the valve
3	CAN_GND	Isolated ground to supply zero
4	CAN_H	Transceiver H
5	CAN_L	Transceiver L

Figure 9: CAN connectors X3 and X4 (M12, 5-pin)

CAUTION
!

To prevent the connector from being damaged, pay attention to the alignment of the key.

To connect the valves/pumps to a CAN bus network, we recommend molded cord sets with an integral straight mating connector.
⇨ Chapter "6.7 Wiring CAN networks (X2, X3, X4)", page 64

4.3.2 Profibus-DP connectors

4.3.2.1 Technical data for the Profibus-DP interface

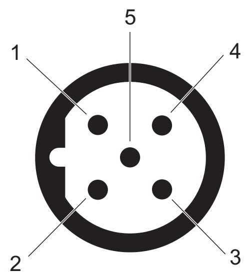
Technical data for the Profibus-DP interface

EMC protection requirements	Immunity to interference as per DIN EN 61000-6-2 (evaluation criterion A) Emitted interference as per DIN EN 61000-6-4
Connectors X3 and X4	5-pin connector with pin contacts and one with socket connectors (both M12x1, coding B) ⇨ Chapter "4.3.2.2 Pin assignment, Profibus-DP connectors", page 33
Physical	Conformity as per test specification "PROFIBUS slaves Version 2.0 of the PNO, Order-No: 2.032"
Maximum voltage capacity	-9 V to 14 V (long-term) from signal cable to Profi GND ±500 V long-term referred to supply zero (optical isolation) ±40 V with a pulse of 15 µs via a resistance of 100 Ω with an edge duration < 100 ns.
Maximum permissible number of Profibus-DP nodes	32 bus nodes without repeater With repeater up to 126 nodes

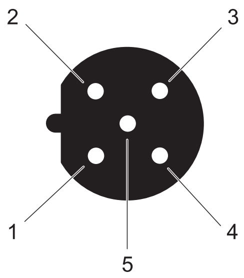
Table 5: Technical data for the Profibus-DP interface

4.3.2.2 Pin assignment, Profibus-DP connectors

Profibus-DP connectors X3 and X4 (M12, 5-pin)



View of Profibus-DP connector X3 (external thread, pin contacts)



View of Profibus-DP connector X4 (internal thread, socket connectors)

Pin	Assignment	Description
1	Profi V+	Supply voltage +5 V for terminal resistors
2	Profi A	RXD/TXD-N
3	Profi GND	Isolated ground to supply zero
4	Profi B	RXD/TXD-P
5	Shield	Positioned on control cabinet side

Figure 10: Profibus-DP connectors X3 and X4 (M12, 5-pin)

CAUTION

To prevent the connector from being damaged, pay attention to the alignment of the key.

To connect the valves/pumps to a Profibus-DP network, we recommend molded cord sets with an integral straight mating connector.
⇨ Chapter "6.8 Wiring Profibus-DP networks (X3, X4)", page 68

4.3.3 EtherCAT® connectors

4.3.3.1 Technical data for the EtherCAT® interface

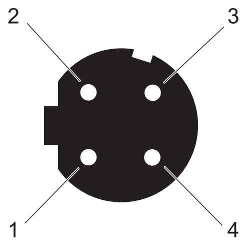
Technical data for the EtherCAT® interface

EMC protection requirements	Immunity to interference as per DIN EN 61000-6-2 (evaluation criterion A) Emitted interference as per DIN EN 61000-6-4
Connectors X3 and X4	4-pin connector with socket connectors (both M12, coding D) as per DIN EN 61076-2-101, Appendix 1 ⇨ Chapter "4.3.3.2 Pin assignment, EtherCAT® connectors", page 34
Physical	4-core, paired cable as per CAT 5 for 100-Base-TX transmission Network topology: Tree and line Termination: Inside device Transmission rate: 100 Mbit/s As per DIN EN 61158-2 Type 12 EtherCAT®, "PHYSICAL LAYER SPECIFICATION AND SERVICE DEFINITION" and ISO/IEC 8802-3 100 Base-TX (IEEE 802.3 Section 24)
Maximum voltage capacity	±500 V long-term referred to supply zero (optical isolation)
Maximum permissible number of EtherCAT® bus nodes	65,536 The maximum number of nodes in a field bus line is 216.

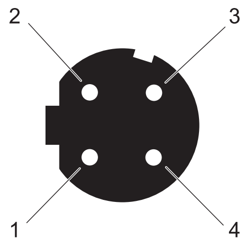
Table 6: Technical data for the EtherCAT® interface

4.3.3.2 Pin assignment, EtherCAT® connectors

EtherCAT® connectors X3 and X4 (M12, 4-pin)



View of EtherCAT® connector X3
(internal thread, socket connectors)



View of EtherCAT® connector X4
(internal thread, socket connectors)

Pin	Assignment	Description
1	TX+	Transmit
2	RX+	Receive
3	TX-	Transmit
4	RX-	Receive
Housing	Shield	Positioned on control cabinet side

Figure 11: EtherCAT® connectors X3 and X4 (M12, 4-pin)

CAUTION

To prevent the connector from being damaged, pay attention to the alignment of the key.

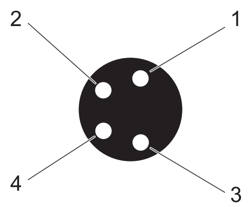
To connect the valves/pumps to an EtherCAT® network, we recommend molded cord sets with an integral straight mating connector.
⇨ Chapter "6.9 Wiring EtherCAT® networks (X3, X4)", page 71

4.4 Analog input connectors X5, X6 and X7

The analog inputs of connectors X5, X6 and X7 have a resolution of 14 bits.

4.4.1 Pin assignment, analog input connectors X5, X6 and X7

Analog input connectors X5, X6 and X7 (M8, 4-pin)



View of analog input connectors
X5, X6 and X7
(internal thread, socket connectors)

Pin	Assignment	Description
1	Transducer supply	+24 V, I_{max} (X2+X5+X6+X7) = 300 mA referred to pin 3
2	Reference point of analog input	Reference point for pin 4
3	Transducer supply 0 V	Supply zero
4	Analog input	Current or voltage input referred to pin 2

Figure 12: Analog input connectors X5, X6 and X7 (M8, 4-pin)

⇨ Chapter "6.10 Wiring analog inputs (X5, X6, X7)", page 74

Power supply to the transducer

Power supply to the transducer at connectors X5, X6, X7

The transducer is supplied with power via pin 1 of connectors X5, X6 and X7. ⇨ Figure 12, page 35

ⓘ There is joint fusing of this power supply for X2, X5, X6 and X7. The total supply current must therefore not exceed the following value:
I_{max} (X2+X5+X6+X7) = 300 mA

An external power supply to the transducer is also possible. However, the 0 V transducer supply must be connected to supply zero. An interruption of the transducer supply current can be identified as a cable break (see "Firmware" User Manual).
The supply voltage is cut off in the event of a possible short circuit in the supply voltage to the transducer. A fault reaction can be configured (see "Firmware" User Manual). The voltage is available again as soon as the short circuit has been eliminated.

4.4.2 Signal types

Signal types of the analog inputs at connectors X5, X6, X7

The analog inputs are available in the following versions:

- ±10 V
- 0–10 V
- 0–10 mA
- 4–20 mA

The inputs can be operated in each case differentially or single-ended (one input cable referred to supply zero).

Which signal type is set for the analog inputs on delivery is dependent on the valve/pump model. The signal types can be configured via the firmware.

ⓘ Detailed information can be found in the "Firmware" User Manual.

4.4.2.1 Signal type for the analog input: ±10 V

Analog input: ±10 V

In the case of this signal type, the input is configured as a single-ended voltage input with a ±10 V input range.
➪ Chapter "4.4.3 Input resistances", page 37

The potential difference of each input to supply zero must be between -15 V and 32 V.

4.4.2.2 Signal type for the analog input: 0–10 V

Analog input: 0–10 V

In the case of this signal type, the input is configured as either a differential or a single-ended voltage input with a 0–10 V input range.
➪ Chapter "4.4.3 Input resistances", page 37

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no differential analog source available, the reference point of the analog input (pin 5) must be connected to 0 V of the analog source.

If there is no differential analog source available, the reference point of the analog input (pin 2) must be connected to 0 V of the analog source.

4.4.2.3 Signal type for the analog input: 0–10 mA

Analog input: 0–10 mA

In the case of this signal type, the input is configured as either a differential or a single-ended current input with a 0–10 mA input range.
➪ Chapter "4.4.3 Input resistances", page 37

The analog input is deactivated in the event of an excessively high input current.

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no floating analog source available, the reference point of the analog input (pin 2) must be connected to 0 V of the analog source.

4.4.2.4 Signal type for the analog input: 4–20 mA

Analog input: 4–20 mA

In the case of this signal type, the input is configured as either a differential or a single-ended current input with a 4–20 mA input range.
⇨ Chapter "4.4.3 Input resistances", page 37

The analog input is deactivated in the event of an excessively high input current.

The potential difference of each input to supply zero must be between -15 V and 32 V.

If there is no floating analog source available, the reference point of the analog input (pin 2) must be connected to 0 V of the analog source.

In the 4–20 mA signal range signals of I_{In} < 3 mA (e.g., due to a defective electric cable) signify a fault, which can be evaluated by the valve software.

4.4.3 Input resistances

Input resistances

The input resistances of the analog inputs are dependent on the set signal type and the version.

Signal type	Version	R_D	R_1	R_2
Voltage ±10 V; 0–10 V	Differential	200 kΩ	250 kΩ	10 kΩ
	Single-ended	200 kΩ	250 kΩ	< 5 Ω
Current 0–10 mA; 4–20 mA	Differential	210 Ω	100 kΩ	10 kΩ
	Single-ended	210 Ω	100 kΩ	< 5 Ω

Table 7: Input resistances X5, X6, X7

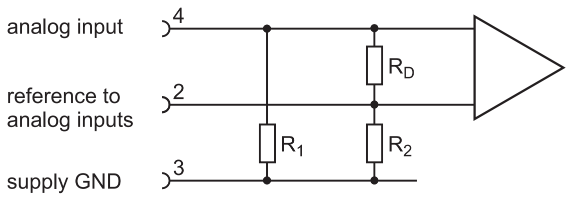
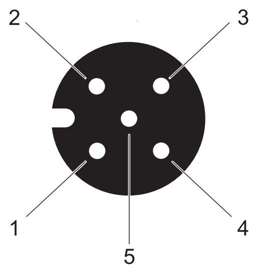


Figure 13: Equivalent circuit diagram of analog input

4.5 Connector X8 for external LVDT

External LVDT connector X8 (M12, 5-pin)



View of connector X8
for external LVDT
(internal thread, socket connectors)

Pin	Assignment	Description
1	A1	Start of primary winding
2	A21	Start of secondary winding 1
3	E1	End of primary winding
4	E2	End of secondary windings 1+2
5	A22	Start of secondary winding 2

Figure 14: External LVDT connector X8 (M12, 5-pin)

CAUTION This connection is not intended for customer use.

4.6 Plug connection X9 for 4/2- or 2/2-way seat valve

Block diagram of the plug connection of the 4/2- or 2/2-way seat valve (with free-wheeling and light emitting diode)

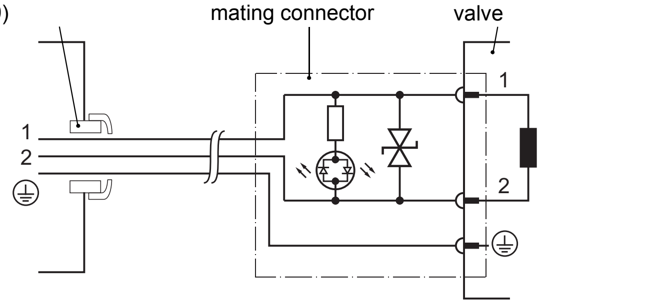
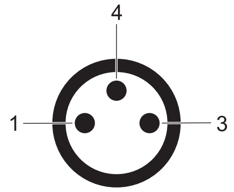


Figure 15: Block diagram of the plug connection of the 4/2- or 2/2-way seat valve
(with free-wheeling and light emitting diode)

CAUTION This connection is not intended for customer use.

4.7 Service connector X10

Service connector X10 (M8, 3-pin)



View of service connector X10
(external thread, pin contacts)

Pin	Assignment	Description
1	CAN_H	Transceiver H
3	CAN_GND	Not assigned
4	CAN_L	Transceiver L

Figure 16: Service connector X10 (M8, 3-pin)

Valves/pumps without CAN bus interfaces can be started up and configured via the service interface (service connector X10) with the Moog Valve Configuration Software.

4.8 Pilot valve connector X11

Pilot valve connector X11

The connection to the pilot valve is established with connector X11.

CAUTION This connection is not intended for customer use.

For your notes.

5 Status display

The module status LED «MS» indicates the device status.
The network status LED «NS» indicates the status of the field bus network.
The number and the function of light emitting diodes are dependent on the field bus.

5.1 Module status LED «MS»

The module status LED «MS» indicates the operating state of the valve/pump electronics.

States of the module status LED «MS»

Module status LED «MS»	Description	Valve status (status word) as per VDMA profile
Off	No power supply.	
Blinking green	Standby operational mode (valve).	'INIT' or 'DISABLED'
Green	Normal operation.	'HOLD' or 'ACTIVE'
Blinking red	Correctable fault (see Fault Reaction Settings in "Firmware" User Manual).	'FAULT' or 'FAULT_HOLD'
Red	Unrecoverable error (see Fault Reaction Settings in "Firmware" User Manual).	'NOT_READY'

Table 8: States of the module status LED «MS»

5.2 Network status LED «NS»

The network status LED «NS» indicates the status of the field bus network.

5.2.1 Valves/pumps with CAN bus interface

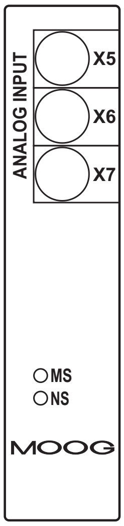


Figure 17: Layout of LEDs on front of housing of valve/pump electronics with CAN bus interface

States of the network status LED «NS» on valves/pumps with CAN bus interface

Network status LED «NS»	Description	Network management status (NMT) as per CANopen
Off	No power supply or in the 'STOPPED' status.	'STOPPED'
Blinking green	This status is indicated after powering up. SDO communication is possible.	'PRE-OPERATIONAL'
Green	This status must be requested by the CANopen master. SDO and PDO communication is possible.	'OPERATIONAL'

Table 9: States of the network status LED «NS» on valves/pumps with CAN bus interface

5.2.2 Valves with Profibus-DP interface

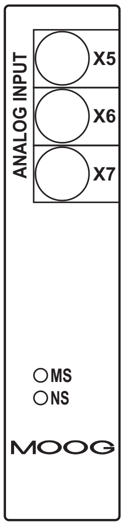


Figure 18: Layout of LEDs on front of housing of valve/pump electronics with Profibus-DP interface

States of the network status LED «NS» on valves/pumps with Profibus-DP interface

Network status LED «NS»	Description	Profibus-DP network status
Off	No power supply.	
Blinking orange	The valve is searching for the correct baud rate.	'BAUD_SEARCH'
Orange	The valve has identified the baud rate and is expecting a parameter telegram.	'WAIT_PRM'
Blinking green	The valve is expecting a configu-ration telegram.	'WAIT_CFG'
Green	The valve is in data exchange mode.	'DATA_EXCH'

Table 10: States of the network status LED «NS» on valves/pumps with Profibus-DP interface

5.2.3 Valves with EtherCAT® interface

The Link/Activity LEDs «L/A in» and «L/A out» indicate the physical connection of the Ethernet-/EtherCAT® connections X3 (Input) and X4 (Output).
The Run LED «RUN» indicates the network communication state of the device.

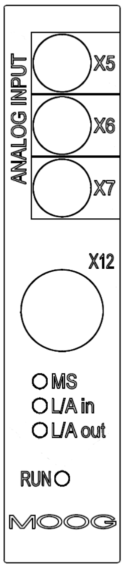


Figure 19: LEDs on front of the housing of valve/pump electronics with EtherCAT® interface

States of the Run LED «RUN» on valves/pumps with EtherCAT® interface

LED «RUN»	Network Communication State
Off	Device is in state 'INIT'.
Blinking	Device is in state 'PRE-OPERATIONAL'.
Single flash	Device is in state 'SAFE-OPERATIONAL'.
On	Device is in state 'OPERATIONAL'.

Table 11: States of the Run LED «RUN» on valves/pumps with EtherCAT® interface

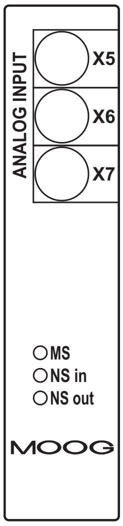
States of the Link/Activity LEDs «L/A in» and «L/A out» on valves/pumps with EtherCAT® interface

LEDs «L/A in» or «LA out»	Network Link/Activity State	Link	Activity
Off	No physical connection.	No	No
Flickering	Physical connection established and data transfer.	Yes	Yes
On	Physical connection established. No data transfer.	Yes	No
Blinking fast	Physical connection incomplete.	No	No

Table 12: States of the Link/Activity LEDs «L/A in» and «L/A out» on valves/pumps with EtherCAT® interface

The state "Blinking fast" is e.g. caused by a cable break of a single wire. To distinguish between the states "Blinking fast" and "Flickering", stop the network master to avoid network traffic. If the L/A LED is still blinking fast, please check the cabling.

On previous valves you will find the network status LEDs «NS in» and «NS out».



States of the network status LEDs «NS in» and «NS out» on valves/pumps with EtherCAT® interface

Network status LEDs «NS in» or «NS out»	EtherCAT® state machine (ESM)	Description
Off		No power supply or not connected.
Orange	'INIT'	Link up.
Green blinking	'PRE-OPERATIONAL' 'SAFE-OPERATIONAL'	Connected. SDO communication is possible.
Green	'OPERATIONAL'	Connected. SDO and PDO communi-cation are possible.
Red		A network major error has occurred.

Table 13: States of the network status LEDs «NS in» and «NS out» on valves/pumps with EtherCAT® interface

For your notes.

6 Wiring

CAUTION

Dirt or moisture can get into the valve/pump electronics through unplugged connectors, i.e., if a mating connector is not inserted, which may result in the valve or the pump being damaged.
Unplugged connectors must be covered and sealed.
The plastic dust protection caps which are attached to service connectors X5, X6, X7 and X10 on delivery are suitable for use as sealing covers.
The plastic dust protection caps which are attached to field bus connectors X3 and X4 on delivery are not suitable for use as sealing covers.
Suitable metallic dust protection caps for field bus connectors X3 and X4 are available as accessories.
⇨ Chapter "9.2 Accessories", page 84

Cover unplugged connectors with dust protection caps

6.1 General notes on wiring

6.1.1 Tools and materials required

Tool required

The following are required for electrically connecting the valves/pumps:

- Mating connector for connector X1 (6+PE-pin or 11+PE-pin, depending on model)
- Connection cables for mating connector
- Crimping tool for mating connector with corresponding crimping insert
- Installation tool

The above-mentioned connectors, cables and tools are not included in the valve/pump scope of delivery. They are supplied separately.
⇨ Chapter "9.2 Accessories", page 84

6.1.2 Procedure

Procedure for electrical connection

Procedure for electrically connecting the valves/pumps:

1. Conduct electrical connection in accordance with the pin assignment.
⇨ Chapter "4.1 Connector X1", page 19
2. Establish equipotential bonding, protective grounding and electrical shielding.
⇨ Chapter "6.2 Protective grounding and electrical shielding", page 48
⇨ Chapter "6.3 Permissible lengths for connection cables", page 54
3. Valves/pumps with field bus interface: carry out field bus wiring.
⇨ Chapter "6.7 Wiring CAN networks (X2, X3, X4)", page 64
⇨ Chapter "6.8 Wiring Profibus-DP networks (X3, X4)", page 68
⇨ Chapter "6.9 Wiring EtherCAT® networks (X3, X4)", page 71
4. Check whether all the connectors and if necessary the service connector to which no mating connector is attached are covered with a suitable dust protection cap.
5. If necessary, attach a dust protection cap.

6.1.3 Wiring supply cables and digital and analog signals

Evaluating the different signal types

Supplying the analog inputs with differential signals is to be preferred. If the signal cannot be transmitted differentially, the reference point of the input at the valve must be connected to ground (supply zero).
➪ Chapter "6.4.1 Single-ended command signals", page 60

Because current inputs have a lower input resistance than voltage inputs and are thus immune to interference, using current signals is to be preferred.

Benefits of the different signal types for analog inputs

Signal type	Benefits
±10 V or 0–10 V	Direct, non-interruptive measurement of the signal, e.g., with an oscilloscope.
±10 mA or 0–10 mA	Large transmission lengths are possible.
4–20 mA	Detection of faults in the electrical line and large transmission lengths are possible.

Table 14: Benefits of the different signal types for analog inputs

6.2 Protective grounding and electrical shielding

6.2.1 Overview

Guidelines for protective grounding

Our valves/pumps with integrated electronics are equipped with a protective conductor connection (⏚) in the connector or on the valve/pump body in accordance with the requirements of the standard DIN EN 60204.
This chapter contains guidelines on protective grounding and electrical shielding of cables in applications in which our valves/pumps with integrated electronics are used.

Isolation from the mains system

WARNING

The protective conductor connection (⏚), if provided, is connected to the electronics housing or valve/pump body. The insulating elements used are designed for the safety extra low voltage range.
The circuits of the field bus connections, if provided, are only functionally isolated from other connected circuits.
Compliance with the safety regulations requires that the equipment be isolated from the mains system in accordance with DIN EN 61558-1 and DIN EN 61558-2-6 and that all voltages be limited in accordance with DIN EN 60204-1.
We recommend the use of SELV/PELV power packs.

CAUTION

The valves/pumps should only be used in such machines and plants which comply with the requirements of the standard DIN EN 60204-1 and this chapter.

6.2.2 Equipotential bonding and protective grounding

Equipotential bonding and protective grounding of machines

- The purpose of equipotential bonding is to establish as small a potential difference as possible within the machine.
- Protective grounding serves to maintain safety while the machine is in operation.
- The term protective earth or PE denotes only one single point inside the machine: the terminal of the external protective conductor. All further connections to ground (⏚) are established via protective and equipotential bonding conductors.

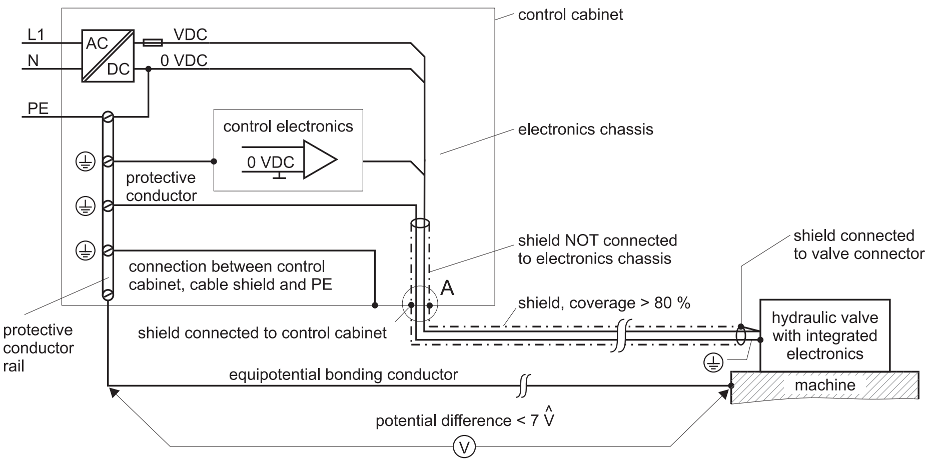


Figure 20: Equipotential bonding and protective grounding of machines (see also DIN EN 60204-1) and electrical shielding of our valves/pumps with integrated electronics

6.2.2.1 General principles

CAUTION The equipotential bonding and protective conductor system for a machine in which the valves/pumps are to be used must be designed in accordance with DIN EN 60204-1.

Performing equipotential bonding

Observe the following points when performing equipotential bonding and protective grounding:

- Connect all elements of the machine to each other via equipotential bonding conductors.
- Connect all elements of the machine which have exposed metal surfaces via protective conductors to the protective conductor rail.
- Connect all the protective conductors and the equipotential bonding conductor in the main cabinet via the protective conductor rail to the protective earth (PE) terminal.

Required cross section of the protective conductor

The cross section of the protective conductor is specified in DIN EN 60204-1, Section 8. The following cross section have proven successful for equipotential bonding conductors:

Up to 200 m (218 yd) cable length: 16 mm^2 (AWG 6)

Over 200 m (218 yd) cable length: 25 mm^2 (AWG 4)

Maximum potential difference

The potential difference between any two points within the machine should not be more than 7 V peak (7 $\hat{V}$).

- Connect the electrical shielding and the electrical ground of the electronics chassis point-to-point to the protective conductor rail.
- Before releasing a machine for normal operation, always check that all equipotential bonding and protective conductors are in proper working order in accordance with DIN EN 60204-1, Section 18.

6.2.2.2 Protective conductor

Requirements of the protective conductor

The protective conductor acts as a diverter to ground in the event of a short circuit of a hazardous voltage to a protective-conductor-connected, conducting part which can be touched.

CAUTION This protective conductor is not a replacement for the normal equipotential bonding system.
⇨ Chapter "6.2.2.1 General principles", page 50
The protective conductor must not be used for equipotential bonding.

Always connect the valves/pumps via a protective conductor to the machine's protective earth (PE). Observe the following points when connecting the protective conductor:

- The protective conductor must be made of copper.
- When using supply cables with a cross section $S \leq 16$ mm^2 (AWG 6 or lower), make sure that the protective conductor has the minimum cross section S.
- The protective conductor should be guided within the cable shield. ⇨ Chapter "6.2.4.1 Cables", page 51
- The connection is made via the leading protective conductor terminal post (⏚) of the valve connector or via the valve body terminal (⏚).

6.2.2.3 Ground loops

Avoiding ground loops

If a valve/pump is connected to protective earth (PE) both via the equipotential bonding system and via the valve/pump protective conductor, a compensating current can split in the resulting ground loop. This current can cause serious malfunctions in the machine.
Observe the following points in order to minimize as much as possible malfunctions caused by a ground loop:

- Route the valve/pump supply and signal cables as closely as possible to the equipotential bonding conductor.
  ➪ Chapter "6.2.3 Machines with deficient equipotential bonding", page 51
- The impedance of the equipotential bonding system should be less than 10 % of the impedance of the systems comprising cable protective conductors and shields.

6.2.3 Machines with deficient equipotential bonding

Deficient equipotential bonding

Only poor equipotential bonding is provided in many industrial applications. An effective equipotential bonding system must be set up in compliance with DIN EN 60204-1, Section 8, here.
➪ Chapter "6.2.2 Equipotential bonding and protective grounding", page 49

CAUTION

If this is not possible, the machine will not comply with DIN EN 60204-1!
Extreme caution must be exercised here as very high currents can pas through the protective conductor ⏚ connection of the valve/pump.
➪ Chapter "6.2.4.3 Insulated shielding", page 53

6.2.4 Electrical shielding

Electrical shielding

An effectively shielded machine is to a high degree immune to external interference sources. Furthermore, the interference emitted by the machine is reduced considerably by effective shielding.

A functioning equipotential bonding system provides the basis for an effectively shielded machine. To ensure that the cables are effectively shielded, it is essential to satisfy the general requirements with regard to equipotential bonding and protective grounding.
➪ Chapter "6.2.2 Equipotential bonding and protective grounding", page 49

6.2.4.1 Cables

Requirements of cables

Observe the following points when choosing cables for connecting the valves/pumps:

- Only use shielded cables.
- The cable shield should be made of copper braiding with a minimum 80 % coverage.
- The individual conductors must be made of copper and have a minimum cross section of 0.2 mm^2 (AWG 24 or lower) in accordance with DIN EN 60204-1, Table 5.
- Use cables with twisted pair conductors in environments with high background noise levels.
- The protective conductor should be guided within the cable shield.
  ➪ Chapter "6.2.2.2 Protective conductor", page 50

6.2.4.2 Connecting the shield

ⓘ When connecting the shield, use metal shell connectors with a leading protective earth contact (⏚) in accordance with DIN EN 60204-1.

Connection on valve/pump side

Connecting the shield on the valve/pump side

Connect the cable shield conductively to the metal shell of the connector.

Connection on control cabinet side

Connecting the shield on the control cabinet side

Connection on the control cabinet side can be completed with either lead-through cables or connectors.

Cable leadthrough

Connecting the shield with cable leadthrough

Observe the following points when connecting the shield on the control cabinet side:

- Connect the control cabinet's wall conductively to the protective conductor rail (⏚).
  ⇨ Figure 20, page 49
- Connect the cable shield correctly (flat, conductively) to the control cabinet's wall.

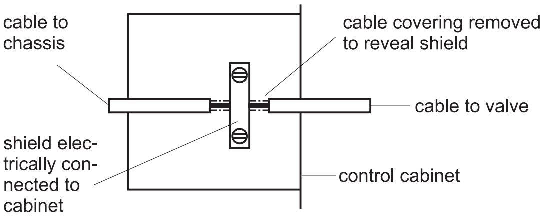


Figure 21: Connecting the shield to the control cabinet's wall (detail A from Figure 20)

- Lead the cable shield without interruption through the wall of the EMC-compliant control cabinet as closely as possible to the electronics chassis, e.g., by means of a cable gland.

  ⓘ The cable shield must not be connected to the electronics chassis!

Plug connection

Connecting the shield with plug connection

Observe the following points when connecting the shield on the control cabinet side:

- Connect the control cabinet's wall conductively to the protective conductor rail (⏚).
  ⇨ Figure 20, page 49
- Connect the shield of the cable coming from the valve to the housing of the removable connector.

  ⓘ The housing of the connector permanently mounted in the control cabinet must demonstrate a good-conducting connection with the wall of the control cabinet.

- Connect the connector mounted in the wall of the control cabinet to the shield inside the cabinet.

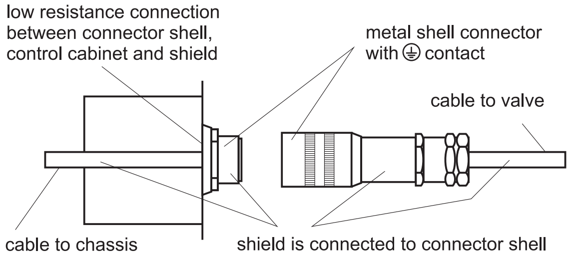


Figure 22: Connecting the cable shield via connector to the control cabinet's wall (detail A from Figure 20)

- Lead the shield inside the control cabinet as closely as possible to the electronics chassis.

  ⓘ The cable shield must not be connected to the electronics chassis!

6.2.4.3 Insulated shielding

Insulated shielding in the event of deficient equipotential bonding

If connecting the shield to both ends of the cable is not desirable, such as e.g., in a machine with deficient equipotential bonding, insulated shielding may be required. However, this is normally only necessary if it is not possible to establish a good equipotential bonding system.

Observe the following points when connecting insulated shielding:

- Use metal shell connectors with a leading protective earth contact (⏚) in accordance with DIN EN 60204-1.
- Connect the cable shield conductively to the metal shell of the connector.
- Connect the control cabinet's wall conductively to the protective conductor rail (⏚).
  ⇨ Figure 20, page 49
- Connect the cable shield via a capacitor (e.g., 10 nF / 100 VDC ceramic capacitor) to the control cabinet's wall.

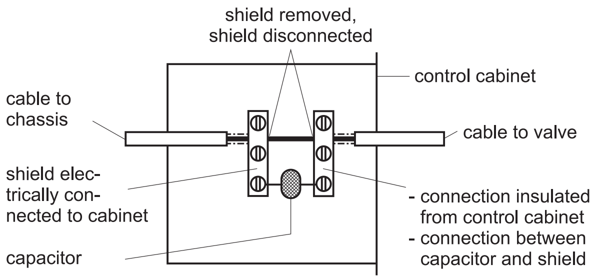


Figure 23: Connecting the insulated shielding to the control cabinet's wall (detail A from Figure 20)

- Install a separate shield connected to the control cabinet's wall inside the control cabinet. Lead this shield as closely as possible to the electronics chassis.

  ⓘ This shield must not be connected to the electronics chassis!

6.2.4.4 Cable routing

Cable routing inside the machine

The routing of the cable inside a machine must comply with the following general guidelines:

- Route supply and signal cables in separate cable conduits.
- In order to minimize malfunctions caused by a ground loop, route the valve/pump connection cables as closely as possible to the equipotential bonding conductor.
⇨ Chapter "6.2.2.3 Ground loops", page 51
- Do not route cable conduits near strong electromagnetic interference sources, such as e.g., electric motors or transformers.
- If the cable routing cannot eliminate the risk of lightning strokes completely, suitable protective measures must be taken, as described in DIN EN 60204-1.

6.3 Permissible lengths for connection cables

6.3.1 Introduction

Dimensioning of supply and signal cables

Our valves/pumps with integrated electronics are usually supplied with 24 V via supply cables and controlled via analog or digital signal cables.

This section of the chapter is intended to serve as a guide to dimensioning and configuring supply and signal cables in order to guarantee adequate supply voltage and signal quality for all the permissible valve/pump operating states.

The maximum permissible length of supply and signal cables is limited by the resistance and the capacitance per unit length of the cables.

6.3.2 Typical values for copper cables

The typical values specified here are used in the example calculations in the following sections.

6.3.2.1 Resistance of cable

Calculating the resistance

The typical resistance R_{typ} of a copper cable of length ℓ is calculated as follows:

$$R_{typ} = \frac{\rho_{Cu}}{q_{typ}} \cdot \ell = 23.73 \frac{m\Omega}{m} \cdot \ell$$

$q_{typ} = 0.75\ mm^2 (AWG19)$	Typical cross section used for connection cables
$\rho_{Cu} = 0.0178 \frac{\Omega mm^2}{m}$	Resistivity of copper at 20 °C (68 °F)

6.3.2.2 Capacitance of cable

Calculating the capacitance

The typical capacitance per unit length of copper cables is 50 pF/m.
The typical capacitance C_{typ} of a copper cable of length ℓ is calculated as follows:

$$C_{typ} = 50 \frac{pF}{m} \cdot \ell$$

6.3.3 24V supply cables

Calculating the maximum length of supply cables

The maximum permissible length ℓ_{max} of the supply cable is calculated as follows:

$$\ell_{max} = \frac{U_{dr\_max}}{\left(\frac{U_{ab}}{\ell}\right)_{typ}}$$

$$U_{dr\_max} = \ell_{max} \cdot \left(\frac{U_{ab}}{\ell}\right)_{typ}$$

U_{min} = 18 V	Lowest permissible supply voltage for valve/pump
U_{dr_max} = 6 V	Maximum permissible voltage drop over the supply cable U_{dr_max} = 24 V - U_{min}
$\left(\frac{U_{ab}}{\ell}\right)_{typ}$	Voltage drop per unit length ⇨ Chapter "6.3.3.1 Voltage drop per unit length", page 55

ⓘ This calculation does not take into account a possible reduction of the power pack output voltage on account of the connected load. Nor does it take into account any voltage dips which can occur at the moment when further loads are connected.

6.3.3.1 Voltage drop per unit length

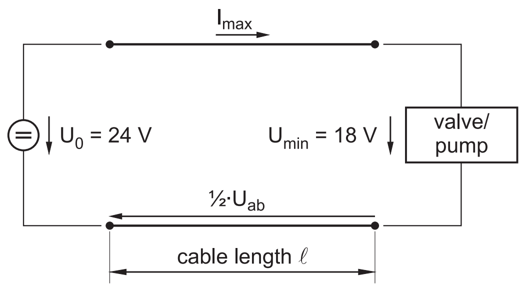


Figure 24: Voltage drop on the supply cable

The voltage drop per unit length over the forward and return lines of the supply cable is calculated as follows:

$$\left(\frac{U_{ab}}{\ell}\right)_{typ} = 2 \cdot I_{max} \cdot \left(\frac{R_{typ}}{\ell}\right) = 2 \cdot I_{max} \cdot 23.73 \, \frac{m\Omega}{m}$$

I_{max}	Maximum current consumption of valve/pump (see product-specific valve/pump user information)
R_{typ}	Typical resistance of the cable ⇨ Chapter "6.3.2.1 Resistance of cable", page 54
ℓ	Length of the supply cable

6.3.3.2 Examples of the voltage drop of supply cables

Examples of the voltage drop of supply cables

Valve series	**Max. current consumption I_{max}**	**Voltage drop $\left(\frac{U_{ab}}{\ell}\right)_{typ}$**	**Max. permissible cable length ℓ_{max}**
D661	300 mA	14 mV/m	428 m (468 yd)
D941	350 mA	17 mV/m	364 m (398 yd)
D681	800 mA	38 mV/m	157 m (171 yd)
D636/8	1,200 mA	57 mV/m	106 m (115 yd)
D634	2,200 mA	104 mV/m	58 m (63 yd)

Table 15: Examples of the voltage drop of supply cables as a function of the cable length for a cable cross section of 0.75 m^2

6.3.4 Analog signal cables

Influence of resistance R

Influence of resistance R

The influence of the resistance R of the cable used on the maximum cable length ℓ_{max} for signal cables is very low, as the currents flowing through signal cables are very small.

Example:
For a cable length ℓ of 428 m (468 yd) the resistance R according to the formula below is only 10 Ω.

$$R = \frac{\rho_{Cu}}{q_{typ}} \cdot \ell = 23.73\ \frac{m\Omega}{m} \cdot 428\ m \approx 10\ \Omega$$

Influence of capacitance per unit length

Influence of capacitance per unit length

The influence of the capacitance per unit length of the cable used on the maximum cable length ℓ_{max} for signal cables is considerably greater.

Calculating the limit frequency

The coupling capacitance C that increases with the cable length forms with the input resistance R of an analog input a high pass of the first order, which can couple high-frequency interference for example at signal inputs. The limit frequency f_l of the high pass is calculated as follows:

$$f_l = \frac{1}{2 \cdot \pi \cdot R \cdot C}$$

The longer the cable, the lower the limit frequency f_l of the high pass.

Example:
A cable length ℓ of 10 m (10.936 yd) and a typical analog input resistance R of 10 kΩ produce according to the formula below a limit frequency f_l of 32 kHz.

$$f_l = \frac{1}{2 \cdot \pi \cdot R \cdot C} = \frac{1}{2 \cdot \pi \cdot R \cdot 50 \frac{pF}{m} \cdot \ell}$$

$$f_l = \frac{1}{2 \cdot \pi \cdot 10\,k\Omega \cdot 50 \frac{pF}{m} \cdot 10\,m}$$

$$f_l = 32\,kHz$$

Recommendations

With a differential voltage command signal and a cable length ℓ of 10 m (10.936 yd) the EMC test was conducted in accordance with DIN EN 61000-6-2. The interference on the spool position during the interference (electromagnetic coupling, transient) was below 1 %. This can worsen as the cable is lengthened.

Current input with cable length > 15 m (16.404 yd)

Experience shows that with cable lengths over 15 m (16.404 yd) a current input should be used, as here the input resistance is smaller by a factor of 50.
The limit frequency f_l of the high pass also increases by the same factor, and with it the input becomes more immune to interference.
⇨ Chapter " Influence of capacitance per unit length", page 57

Furthermore, the voltage drop on the cable does not have an effect in the event of a current command signal.

Recommendation: differential input

A differential input is always to be recommended, regardless of whether a voltage or current signal is used as the command signal, since interference coupled on the two input cables is subtracted to virtually zero.

6.3.5 Digital signal cables

6.3.5.1 Digital signal input cables

Length of digital signal cables

Digital signal input cables, such as e.g., enable, are more non-critical with regard to their cable lengths, because the currents are low (< 20 mA) and a greater noise level distance is easier to maintain, since only two states/levels must be differentiated.

6.3.5.2 Digital signal output cables

With digital signal output cables, such as e.g., monitoring and standby, currents up to 1.5 A are encountered. In these cases, the voltage drop over longer cables can no longer be neglected. Thus, these cables are subject to the same requirements as supply cables.
⇨ Chapter "6.3 Permissible lengths for connection cables", page 54

6.3.5.3 Field bus cables

Length of field bus cables

The maximum lengths of field bus cables vary considerably. Most cable ends are terminated with low resistance (power adaptation) in order to avoid signal reflections, which permits longer cable lengths. The maximum possible cable lengths are laid down in the standards of the relevant field buses and depend among other things on the transmission rate used.

6.4 Wiring connector X1

Wiring the 6+PE-pin connector X1

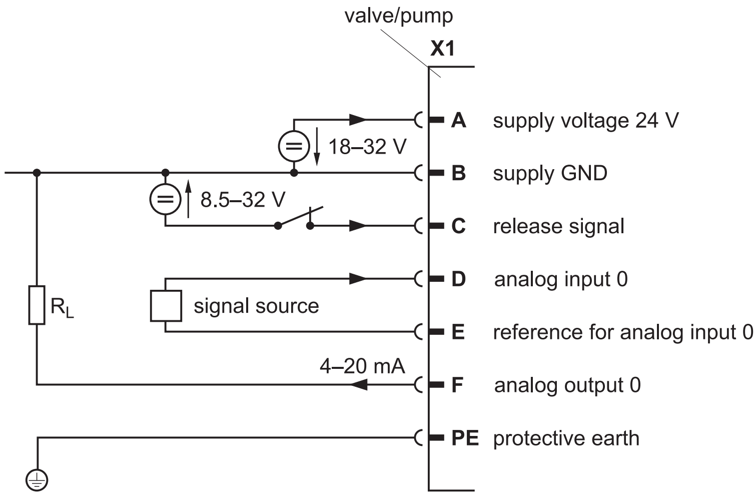


Figure 25: Wiring the 6+PE-pin connector X1

Wiring the 11+PE-pin connector X1

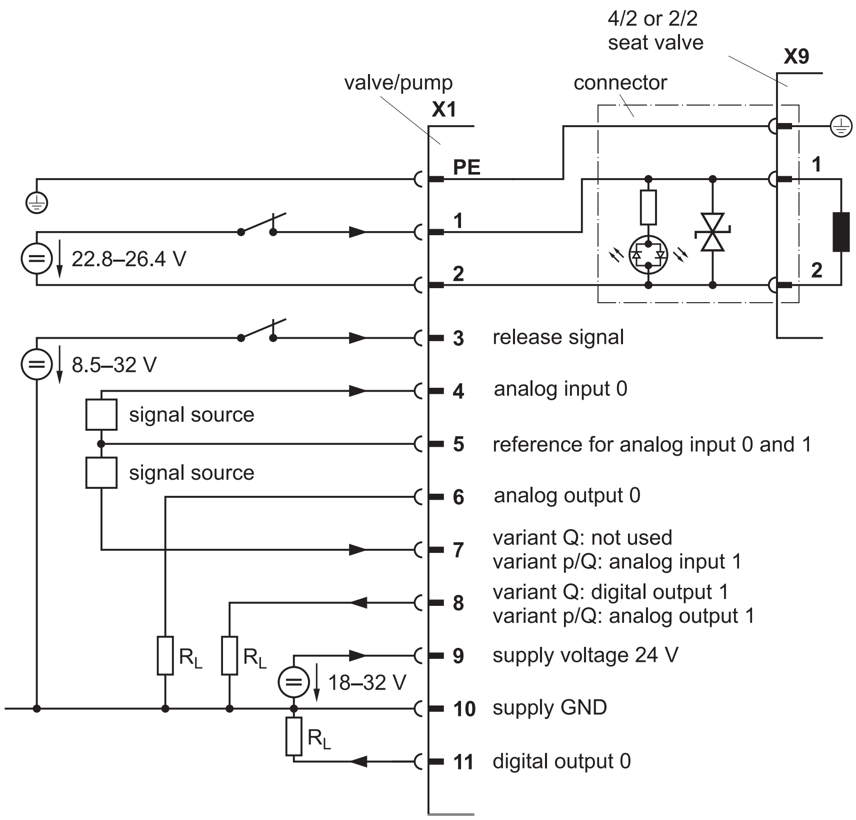


Figure 26: Wiring the 11+PE-pin connector X1

6.4.1 Single-ended command signals

Basically, activation of the command inputs with differential signals is to be preferred. If the command signal cannot be transmitted differentially, the reference point of the command input at the valve or at the pump must be connected to ground (supply zero).

Circuit for single-ended command signals

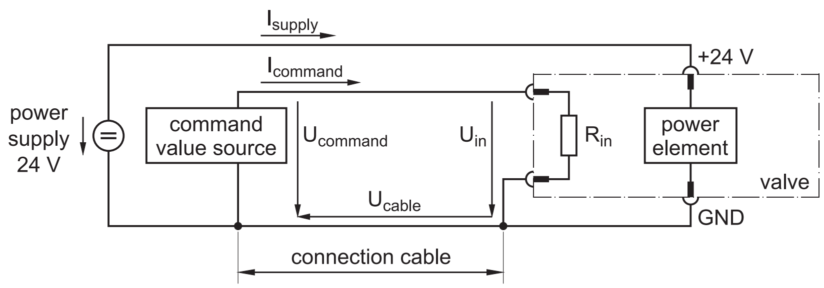


Figure 27: Circuit for single-ended command signals

Single-ended connection of the command inputs

If the command inputs are connected to ground (single-ended), the connection cable must be as short as possible and have an appropriately large cross section in order to keep the voltage drop as low as possible.
The voltage drop on the forward and return lines is generated by the supply current I_{supply} of the valve/pump electronics power circuit. It is proportional to the length of the connection cable and varies according to the valve/pump status.
Maximum permissible cable lengths:
⇨ Chapter "6.3 Permissible lengths for connection cables", page 54

Input voltage $U_{in} = U_{command} – U_{cable}$

The voltage drop U_{cable} on the return line and the resulting potential shift does not result in the command signal $U_{command}$. U_{in} is being applied at the command input in accordance with the following equation:

$$U_{in} = U_{command} - U_{cable}$$

Command signal sources with impressed current $I_{command}$

In the case of command signal sources with impressed current $I_{command}$, the potential shift of ground (supply zero) has no effect on the signal. However, changes in the voltage drop resulting from the valve's/pump's varying current consumption must be corrected by the command signal source. If current control does not follow the voltage change in terms of time, the command signal at the valve/pump input may also be affected here.

ⓘ The function of single-ended command inputs is identical to the function of differential command inputs.

6.4.2 Conversion of actual value output signals I_{out}

The actual value output signals I_{out} 4–20 mA can be converted into U_{out} 2–10 V in accordance with the following circuit.

Conversion of actual value output signals I_{out} 4–20 mA into 2–10 V

6.4.2.1 Valves/pumps with 6+PE-pin connector X1

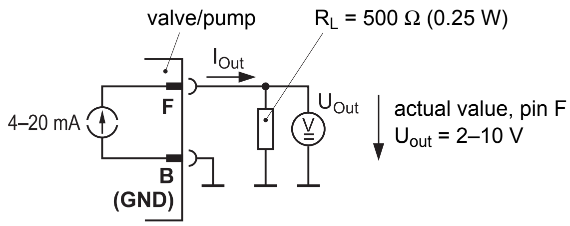


Figure 28: Circuit for converting the actual value output signals I_{out} (for valves with 6+PE-pin connector X1)

6.4.2.2 Valves/pumps with 11+PE-pin connector X1 (variant p/Q)

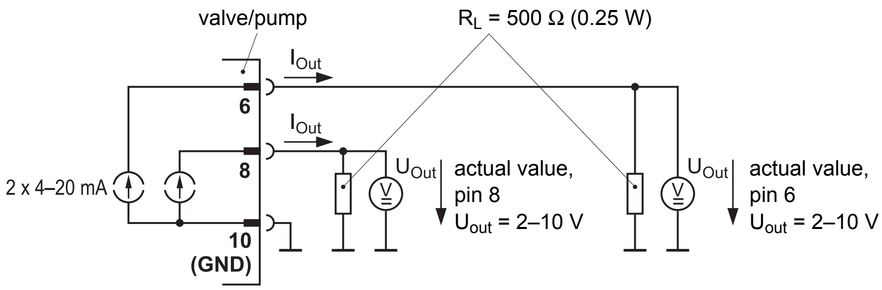


Figure 29: Circuit for converting the actual value output signals I_{out} (for valves with 11+PE-pin connector X1)

6.5 Wiring incremental transducers (X2)

Wiring incremental transducers (X2)

Incremental transducers measure a relative position or angle signal. Here, pulse trains with a frequency of up to 4 MHz are detected without faults and evaluated. The 32-bit actual value is altered as a function of the leading or lagging signal sequence of A and B signals. 4-edge evaluation is used exclusively here.

Example:
A transducer with 1,024 marks per rotation delivers with 4-edge evaluation 4,096 increments per rotation.
With each rising and falling edge of signals A and B, the system checks whether signal B lags behind signal A. If this is the case, the actual value is increased by 1. If signal A lags behind signal B, the actual value is decreased by 1.

Wiring diagram with incremental transducer

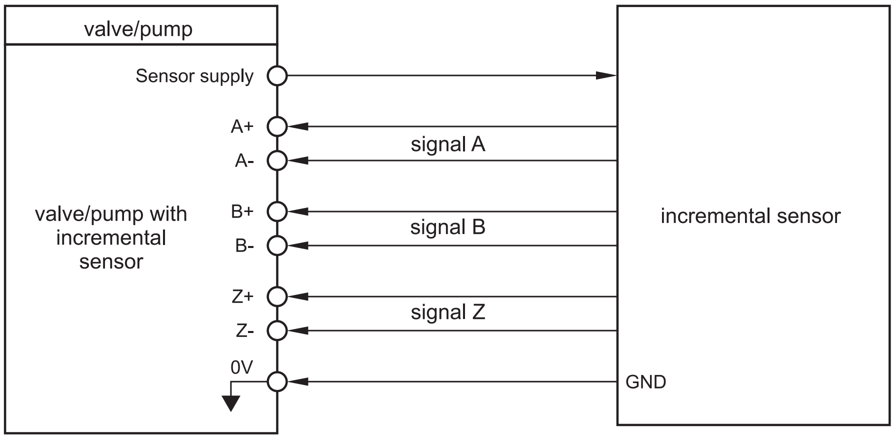


Figure 30: Wiring diagram with incremental transducer

Incremental transducer signals A and B with reversal point and speed variation

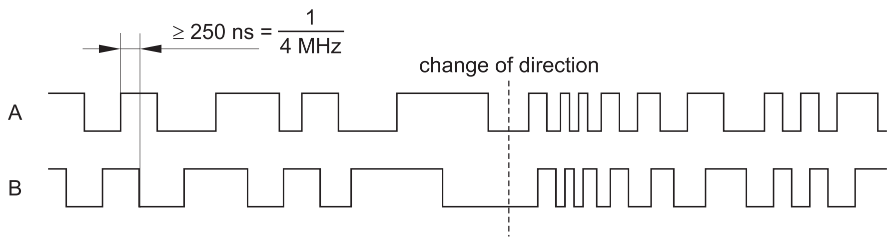


Figure 31: Incremental transducer signals A and B with reversal point and speed variation

In Figure 31 signal B to the left of the reversal point leads signal A. The actual value is decreased by 1 with each edge of A and B.
To the right of the reversal point signal A leads and thus the actual value is increased by 1 with each edge of A and B.

The signal levels conform to the standard TIA/EIA 422 (formerly RS 422).

Signal Z can be used for referencing. A pulse on signal Z marks for example a specific position. The incremental transducer counter can thus be reset (see "Firmware" User Manual).

The designations of the connections vary depending on the manufacturer of the incremental transducer:

Designations of incremental transducer connections

	Connection designation					
Valve/pump	A+	A-	B+	B-	Z+	Z-
Heidenhain transducers	U_{a1}	$\overline{U_{a1}}$	U_{a2}	$\overline{U_{a2}}$	U_{a0}	$\overline{U_{a0}}$
Hengstler transducers	A	$\overline{A}$	B	$\overline{B}$	N	$\overline{N}$
Stegmann transducers	A	$\overline{A}$	B	$\overline{B}$	M	$\overline{M}$
Allen-Bradley transducers	A	$\overline{A}$	B	$\overline{B}$	Z	$\overline{Z}$

Table 16: Designations of incremental transducer connections (incremental transducers of different manufacturers)

6.6 Wiring SSI transducers (X2)

Wiring SSI transducers (X2)

An SSI transducer delivers an absolute position or angle signal, which can be read in via the digital signal interface.

6.6.1 SSI master mode

In SSI master mode the integrated electronics generate internally the SSI clock signal (CLK) with settable frequencies in the range between 78 kHz and 5 MHz.

ⓘ Detailed information can be found in the "Firmware" User Manual.

In the idle state the clock signal is at 1. The first falling edge of the clock signal signals to the SSI transducer to maintain its current value. The following rising edge of the clock signal starts the data transmission of the SSI transducer. The output starts with the highest-value bit (MSB). After a complete data record has been transmitted, the SSI transducer holds the data signal at 0 until it is ready for a new transmission. The switching back of the data signal to 1 simultaneously satisfies the start condition for the SSI interface for triggering a new read-in cycle.

⇨ Chapter "4.2.2 SSI transducer", page 28

Wiring diagram with SSI transducer

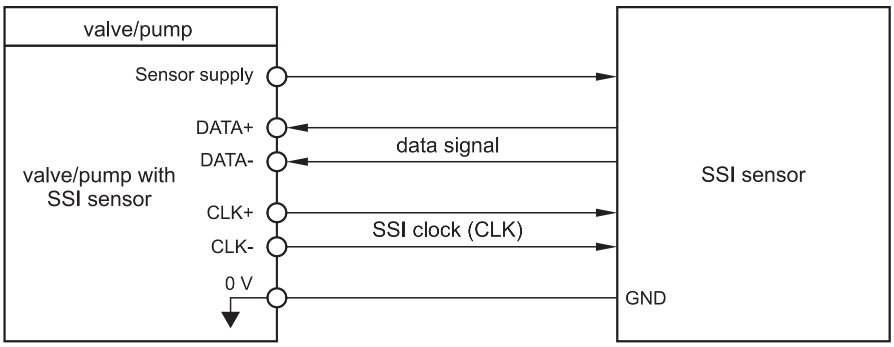


Figure 32: Wiring diagram with SSI transducer

Signals between valve/pump and a 16-bit SSI transducer (example)

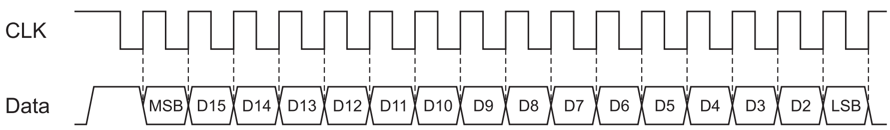


Figure 33: Signals between valve/pump and a 16-bit SSI transducer (example)

The signal levels conform to the standard TIA/EIA 422 (formerly RS 422).

SSI transducers can be used with delivery either Gray codes or binary coded data. A maximum of 32 bits is possible.

ⓘ Detailed information can be found in the "Firmware" User Manual.

6.7 Wiring CAN networks (X2, X3, X4)

X3, X4 are equipped with an electrically isolated CAN interface. The CAN interface is supplied internally.

Procedure for connecting the valves/pumps to the CAN bus

Procedure

ⓘ Please observe all the safety instructions prior to and during starting-up.
⇨ Chapter "1.1.2 Completeness", page 2
⇨ Chapter "2 Safety", page 7

1. Establish the electrical connection to the CAN bus.
⇨ Chapter "4.3.1 CAN connectors", page 31
2. Configure the module address.
⇨ Chapter "6.7.3 CAN module address (node ID)", page 67
3. Configure the transmission rate.
⇨ Chapter "6.7.4 CAN transmission rate", page 67
4. Check the configuration of the valve software and the controller settings.

Observe the following points when wiring CAN networks:

- All cables, plug connectors and terminal resistors used in CAN networks must comply with ISO/DIS 11898.
- Correct version of protective grounding and electrical shielding.
⇨ Chapter "6.2 Protective grounding and electrical shielding", page 48
- Use shielded cables with four cores (twisted pair) and surge impedance of 120 Ω (CAN_H, CAN_L, CAN_GND and CAN_SHLD grounded).
- A CAN bus cable must not branch but short stub cables with T-connectors are permitted.
- Stub cables must be as short as possible.
- Maximum stub cable length:
⇨ Chapter "6.7.1 Cable lengths and cable cross sections", page 66
- The cable between CAN_L and CAN_H at both CAN bus cable ends must be ended by a terminal resistor of 120 Ω ± 10 %.
- A connector with terminal resistor can be omitted if the valve-internal terminal resistor (deactivated as standard) is activated (for configuration, see "Firmware" User Manual).
- Reference potential CAN_GND and CAN_SHLD may be connected to protective earth (PE) at one point only (e.g., on a connector with terminal resistor).
- The transmission rate must be adapted to the CAN bus cable length.
⇨ Chapter "6.7.1 Cable lengths and cable cross sections", page 66

- The maximum permissible number of CAN bus nodes in the CAN network must not be exceeded.
⇨ Chapter "6.7.2 Permissible number of CAN bus nodes", page 67
- Do not lay CAN Bus cables in the immediate vicinity of disturbance sources. If interference sources cannot be avoided, use double-shielded cables.

Wiring diagram of the CAN network

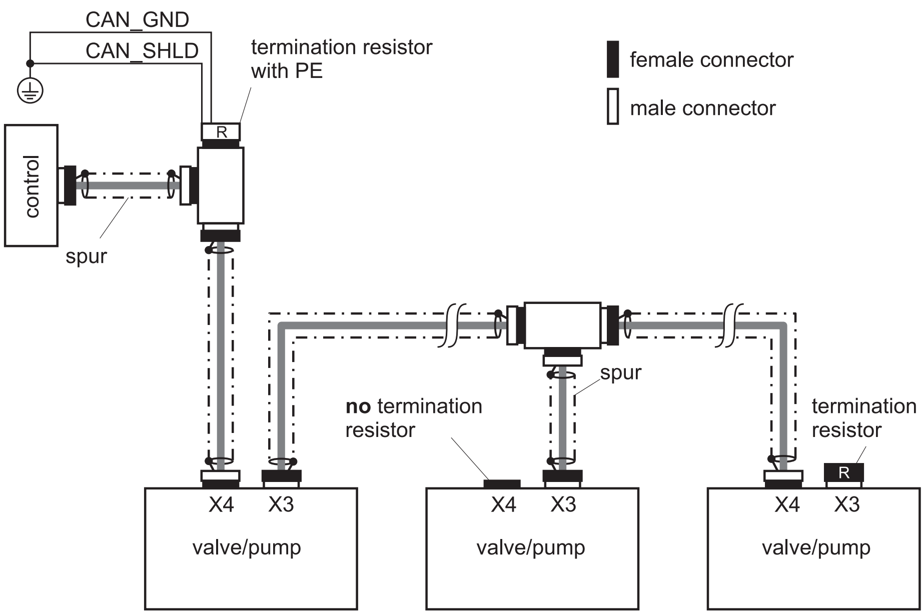


Figure 34: CAN wiring diagram

Interference immunity in CAN networks

For CAN bus nodes without an isolated CAN bus interface, CAN_GND is generally connected to supply voltage GND inside the device.
In these cases, the supply voltage connection cable must be grounded at the same point inside the machine as the CAN_GND connection cable.
Maximum interference immunity is achieved in extensive CAN networks by using solely CAN bus nodes with isolated CAN bus interfaces.
If it is not possible to dispense with CAN bus nodes without isolated CAN bus interfaces, arrange these nodes in the immediate vicinity of the central ground point. The cable length to this central ground point should be kept as short as possible. It is particularly important in this respect to ensure that the equipotential bonding line is properly dimensioned!

Connection of valve/ pump to a PC via the CAN bus interface

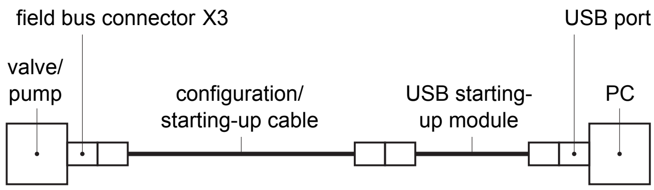


Figure 35: Connection of valve/pump to a PC via the CAN bus interface (connector X3)

Connection of valve/pump to a PC via the service interface

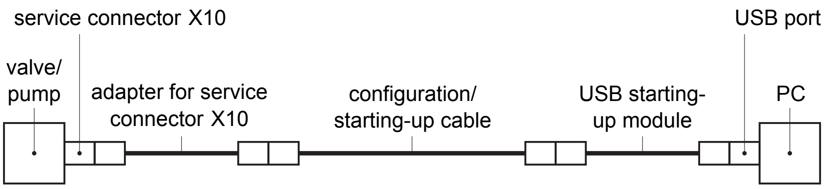


Figure 36: Connection of valve/pump to a PC via the service interface (service connector X10)

6.7.1 Cable lengths and cable cross sections

Cable lengths and cable cross sections

Transmission rate	Maximum cable length
1,000 kbit/s	25 m (27 yd)
800 kbit/s	50 m (54 yd)
500 kbit/s	100 m (109 yd)
250 kbit/s	250 m (273 yd)
125 kbit/s	500 m (546 yd)
100 kbit/s	650 m (710 yd)
50 kbit/s	1,000 m (1,093 yd)
20 kbit/s	2,500 m (2,734 yd)

Table 17: Recommendation for maximum cable lengths in CAN networks, depending on the transmission rate

Maximum cable length

	Maximum cable length for n CAN bus nodes		
Cable cross section	n = 32	n = 64	n = 100
0.25 mm^2 (AWG 24)	200 m (218 yd)	170 m (185 yd)	150 m (164 yd)
0.50 mm^2 (AWG 21)	360 m (393 yd)	310 m (339 yd)	270 m (295 yd)
0.75 mm^2 (AWG 19)	550 m (601 yd)	470 m (513 yd)	410 m (448 yd)

Table 18: Recommendation for maximum cable lengths in CAN networks, depending on the cable cross section and the number n of CAN bus nodes

Maximum length of stub cables

	Maximum stub cable length	
Transmission rate	Maximum	Cumulative
1,000 kbit/s	2 m (6 ft 7 in)	20 m (21 yd)
500 kbit/s	6 m (19 ft 8 in)	39 m (42 yd)
250 kbit/s	6 m (19 ft 8 in)	78 m (85 yd)
125 kbit/s	6 m (19 ft 8 in)	156 m (170 yd)

Table 19: Maximum permissible stub cable lengths in CAN networks

6.7.1.1 Suitable cable types for CAN networks

Suitable cable types for CAN networks

Parameter	Value
Surge impedance	120 Ω

Table 20: Specification of electrical data for CAN bus cables

Manufacturer	Cable type
Hans Turck GmbH & Co. KG Witzlebenstrasse 7 D-45472 Mülheim an der Ruhr Tel.: (+49) 208 4952-0 Fax: (+49) 208 4952-264 Web: http://www.turck.com	5723 PUR bus cable

Table 21: Suitable cable types for CAN networks

6.7.2 Permissible number of CAN bus nodes

Maximum number of CAN bus nodes

The CAN bus interface for the valve/pump electronics supports integration in CAN networks with up to 110 CAN bus nodes.

However, the maximum permissible number of CAN bus nodes can be restricted by other nodes with an older CAN bus driver to 32.

A maximum of 127 nodes can be operated in a CAN network thanks to the use of repeaters. However, it is necessary to bear in mind here the additionally inserted signal propagation time, which limits the maximum expansion of the CAN network.

6.7.3 CAN module address (node ID)

CAN module address (node ID)

CAUTION ! Each module address may only be used once within a CAN bus network.

The factory setting for the module address of the valve/pump electronics is 127.

The module address can be changed with the LSS services (Layer Setting Services) via the CAN bus.
If there are no further nodes present on the CAN bus, it is possible to set the node ID via the LSS Service Switch Mode Global.

To change the module address of the valve/pump electronics with a CAN bus network, it is essential to address the valve/pump electronics unambiguously via the LSS address. The node ID is then set via the LSS Service Switch Mode Selective.

It is also possible to configure the module address via service interface X10.

ⓘ The module address of the valve/pump electronics can also be altered with the Moog Valve Configuration Software.

6.7.4 CAN transmission rate

CAN transmission rate

CAUTION ! The transmission rate must be set to the same value for all the CAN bus nodes within a CAN bus network.

The factory setting for the transmission rate is 500 kbit/s.

ⓘ The transmission rate can be changed with the LSS services (Layer Setting Services) via the CAN bus.

ⓘ The transmission rate of the valves/pumps can also be altered with the Moog Valve Configuration Software.

6.8 Wiring Profibus-DP networks (X3, X4)

Wiring Profibus-DP networks

The valves/pumps are equipped with an electrically isolated Profibus-DP interface. The Profibus-DP interface is supplied internally.

Procedure

Procedure for connecting the valves/pumps to the Profibus-DP

ⓘ Please observe all the safety instructions prior to and during starting-up.
➪ Chapter "1.1.2 Completeness", page 2
➪ Chapter "2 Safety", page 7

1. Establish the electrical connection to the Profibus-DP.
➪ Chapter "4.3.2 Profibus-DP connectors", page 32
2. Set the module address.
➪ Chapter "6.8.3 Profibus-DP module address (node ID)", page 70
3. Check the configuration of the valve software and the controller settings.

Observe the following points when wiring Profibus-DP networks:

- It is recommended to use 2-core Profibus cables so as to prevent the power supply to the terminal resistors from being connected in parallel.
- The specification DIN EN 61158-2 describes two cable types. Type B does not correspond to the latest state-of-the-art technology and should no longer be used.
- Stub cables must be as short as possible.
- Avoid stub cables in the case of transmission rates in excess of 1,500 kbit/s.
- If stub cables are used, do not use any terminal resistors in this branch.
- The stub cable length in the case of transmission rates in excess of 1,500 kbit/s should not exceed 6.6 m (21 ft 7 in) in total.

Wiring diagram of the Profibus-DP networks

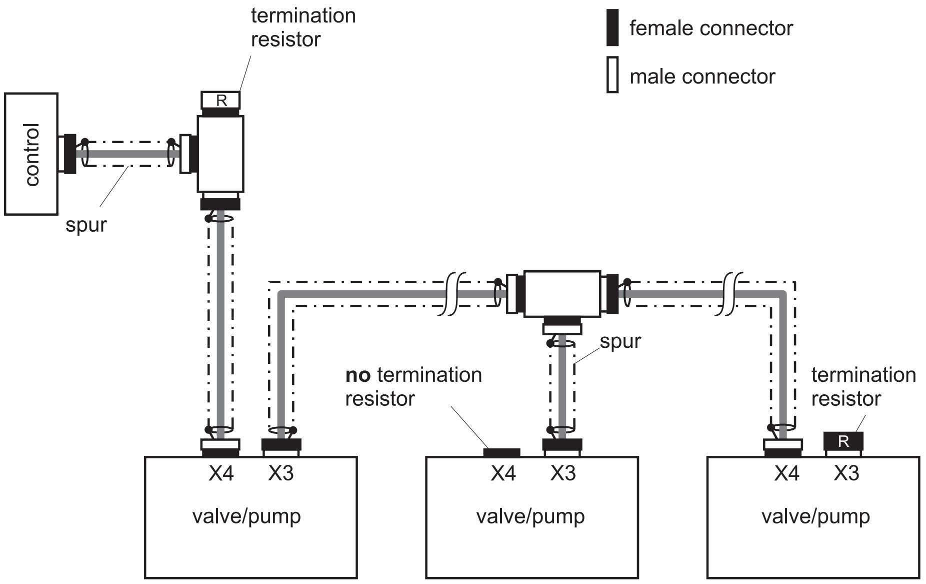


Figure 37: Profibus-DP wiring diagram

6.8.1 Cable lengths and cable cross sections

Cable lengths and cable cross sections

Transmission rate	Maximum cable length without repeaters
12,000 kbit/s	100 m (109 yd)
1,500 kbit/s	200 m (218 yd)
500 kbit/s	400 m (437 yd)
187.5 kbit/s	1,000 m (1,093 yd)
93.75 kbit/s	1,200 m (1,312 yd)
45.45 kbit/s	1,200 m (1,312 yd)
19.2 kbit/s	1,200 m (1,312 yd)
9.6 kbit/s	1,200 m (1,312 yd)

Table 22: Recommendation for maximum cable lengths in Profibus-DP networks, depending on the transmission rate

6.8.1.1 Suitable cable types for Profibus-DP networks

Suitable cable types for Profibus-DP networks

Parameter	Value
Characteristic cable impedance (Ω)	135–165 at 3–20 MHz
Effective capacitance (pF/m)	< 30
Loop impedance (Ω/km)	< 110
Cable diameter (mm)	> 0.64 (AWG 22 or lower)
Cable cross section (mm^2)	> 0.34 (AWG 22 or lower)

Table 23: Specification of electrical data for Profibus-DP cables (as per type A)

Manufacturer	Cable type
Hans Turck GmbH & Co. KG Witzlebenstrasse 7 D-45472 Mülheim an der Ruhr Tel.: (+49) 208 4952-0 Fax: (+49) 208 4952-264 Web: http://www.turck.com	Prefabricated bus cable type 451 with connector and socket Order designation: RSSW-RKSW451-xx, (length = xx)

Table 24: Suitable cable types for Profibus-DP networks

6.8.2 Permissible number of Profibus nodes

Permissible number of Profibus-DP nodes

The Profibus-DP interface of the valve/pump electronics supports integration into Profibus-DP networks with up to 32 Profibus nodes.

A maximum of 126 nodes can be operated in a Profibus-DP network thanks to the use of repeaters.

6.8.3 Profibus-DP module address (node ID)

Profibus-DP module address (node ID)

CAUTION ! Each module address may only be used once within a Profibus-DP network.

The module address can be configured by sending a Set_Slave_Add telegram from a controller. There is also the option of configuring the module address by writing to the Profibus module identifier.

It is also possible to configure the module address via service interface X10.

The factory setting for the module address of the valve/pump electronics is 126.

ⓘ The module address of the valve/pump electronics can also be altered with the Moog Valve Configuration Software.

6.8.4 Profibus-DP transmission rate

Profibus-DP transmission rate

The valve/pump electronics are automatically set to the transmission rate specified by the Profibus master. It is not possible, nor is it necessary, to configure the transmission rate on the valve/pump side.

6.9 Wiring EtherCAT® networks (X3, X4)

Wiring EtherCAT® networks

The valves/pumps are equipped with an electrically isolated EtherCAT® interface. The EtherCAT® interface is supplied internally.

Procedure

Procedure for connecting the valves/pumps to the EtherCAT® bus

ⓘ Please observe all the safety instructions prior to and during starting-up.
⇨ Chapter "1.1.2 Completeness", page 2
⇨ Chapter "2 Safety", page 7

1. Establish the electrical connection to the EtherCAT® bus.
⇨ Chapter "4.3.3 EtherCAT® connectors", page 33
2. Optional: Set the module address.
⇨ Chapter "6.9.3 EtherCAT® module address (node ID)", page 73
3. Check the configuration of the valve software and the controller settings, in particular the command signal source.

   ⓘ Detailed information can be found in the "Firmware" User Manual.

Observe the following points when wiring EtherCAT® networks:

- All cables must be designed as shielded cables with twisted-pair multistrand wires as per ISO/IEC 8802-3 100 Base-TX and CAT 5 as per ANSI/TIA/EIA-568-B.1.
- The cable length between two nodes must not exceed 100 m (109 yd) as per ISO/IEC 8802-3 100 Base-TX.
- The maximum permissible number of EtherCAT® nodes must not exceed 65,536.
- The cable between the nodes must not branch.
- An external cable termination (terminal resistor) as in CAN or Profibus-DP networks is not necessary.

Wiring diagram of the EtherCAT® network

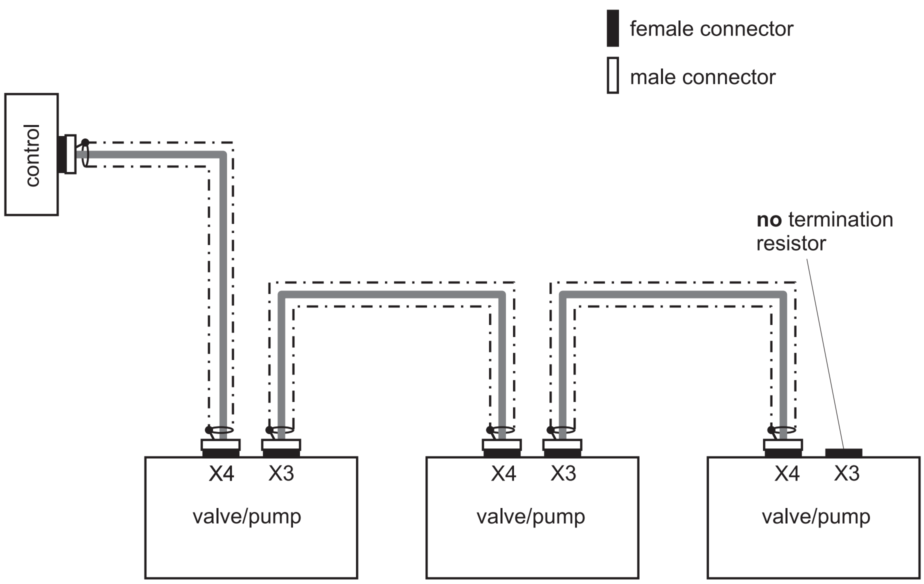


Figure 38: EtherCAT® wiring diagram

Pin assignment for the EtherCAT® cable

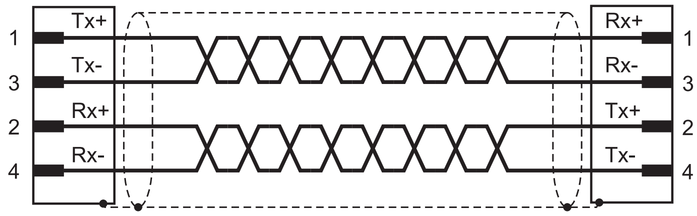


Figure 39: Twisted-pair wires in Ethernet/EtherCAT® cables with M12 connectors

An RJ45 connector is usually used on the controller side. The colors of the wires are standardized in accordance with IEEE 802.3 for Ethernet.

Signal	M12	Wire (M12, 4-core cable)	RJ45	Wire (RJ45, 4-core cable)
TX+	1	yellow	1	orange/white (yellow/white)
RX+	2	white	3	green/white
TX-	3	orange	2	orange
RX-	4	blue	6	green
Shield	Housing			

Table 25: Assignment of Ethernet/EtherCAT® signals with mixed connector types

6.9.1 Suitable cable types for EtherCAT® networks

CAT 5 cable in accordance with ANSI/TIA/EIA-568-B.1.

Suitable cable types for EtherCAT® networks

Manufacturer	Description
Lumberg Connect GmbH Im Gewerbepark 2 D-58579 Schalksmühle Tel.: (+49) 2355-83 01, Fax: (+49) 2355-83 263 Web: http://www.lumberg.com	M12 RJ45 Ethernet adapter; from D-coded M12 socket to RJ45 socket, angled 90 ° Order designation: 0981 ENC 100
Phoenix Contact GmbH & Co. KG Flachsmarktstr. 8 D-32825 Blomberg Tel.: (+49) 5235-300, Fax: (+49) 5235-34 12 00 Web: http://www.phoenixcontact.com	M12 cable, connector on both sides, D-coding Order designation: 1523081

Table 26: Suitable cable types for EtherCAT® networks

6.9.2 Permissible number of EtherCAT® nodes

Permissible number of EtherCAT® nodes

The EtherCAT® interface of the valve/pump electronics supports integration into EtherCAT® networks with up to 65,535 EtherCAT® nodes.
The maximum number of nodes in a field bus line is 216.

The number of nodes determines the signal propagation time of the data packets and the resulting possible cycle times.

6.9.3 EtherCAT® module address (node ID)

EtherCAT® module address (node ID)

CAUTION

Each module address may only be used once within an EtherCAT® network.

EtherCAT® nodes can be addressed using the physical position within the network. This procedure is known as auto-increment addressing.

If position-independent addressing is preferred, a static module address can also be allocated. This addressing type is known as fixed node addressing.

6.9.3.1 Auto-increment addressing

Each EtherCAT® node is identified using the physical position within the network segment. For this purpose, each EtherCAT® node increments a 16-bit address field within a telegram, which is sent through the entire network. The advantage of this mechanism lies in the fact that no module address has to be set manually for the field bus nodes.

6.9.3.2 Fixed node addressing

With fixed node addressing a node is addressed via the so-called Configured Station Alias. This address can be configured by the network master in the Slave Information Interface (SII).

There is also the option of configuring the module address by writing to the EtherCAT® module identifier.

The advantage of fixed node addressing over auto-increment addressing lies in the fact that the nodes can still be addressed at the same address even after the network topology has been changed or after nodes have been added or removed.

The factory setting for the module address of the valve/pump electronics is 0.

It is also possible to configure the module address via service interface X10.

ⓘ The module address of the valve/pump electronics can also be altered with the Moog Valve Configuration Software.

6.9.4 EtherCAT® transmission rate

EtherCAT®-DP transmission rate

EtherCAT® works with a fixed transmission rate of 100 Mbit/s.

6.10 Wiring analog inputs (X5, X6, X7)

Maximum current of transducer supply

The supply voltage for powering the transducers is available at pin 1.

There is joint fusing of this power supply for X2, X5, X6 and X7. The total supply current must therefore not exceed the following value:
I_{max} (X2+X5+X6+X7) = 300 mA

An external power supply to the transducer is also possible. However, the 0 V transducer supply must be connected to supply zero. An interruption of the transducer supply current can be identified as a cable break (see "Firmware" User Manual).
The supply voltage is cut off in the event of a possible short circuit in the supply voltage to the transducer. A fault reaction can be configured (see "Firmware" User Manual). The voltage is available again as soon as the short circuit has been eliminated.

The supply current for each transducer is monitored for the purpose of detecting cable breaks. Supply currents under 1 mA can trigger a configurable fault reaction.

2/3/4-wire transducers with a voltage or current output can be connected to X5, X6 and X7. Each input can be individually adapted.

6.10.1 2-wire transducers

2-wire transducers can only be operated in the signal type for the 0–10 mA or 4–20 mA analog input in the single-ended version.

Wiring the 2-wire transducer

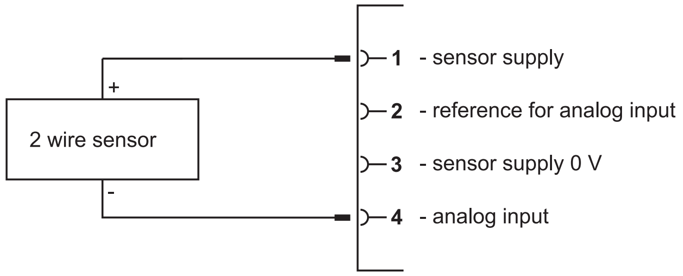


Figure 40: Connecting a 2-wire transducer to analog input connectors X5, X6 or X7

6.10.2 3-wire transducers

3-wire transducers can only be operated in the single-ended version.

Wiring the 3-wire transducer

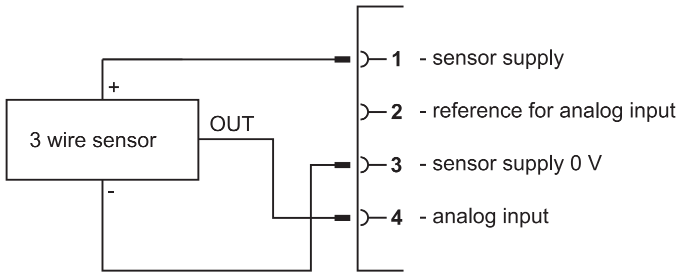


Figure 41: Connecting a 3-wire transducer to analog input connectors X5, X6 or X7

6.10.3 4-wire transducers

4-wire transducers should be operated in the differential version.

Wiring the 4-wire transducer

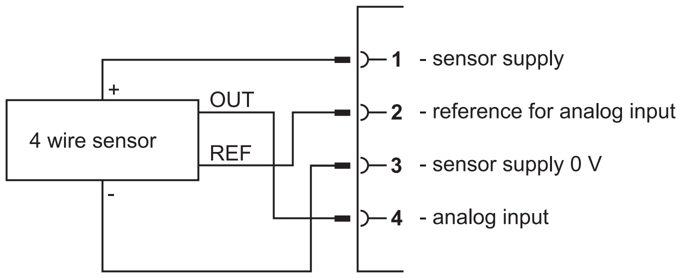


Figure 42: Connecting a 4-wire transducer to analog input connectors X5, X6 or X7

For your notes.

7 Starting-up

CAUTION

Dirt or moisture can get into the valve/pump electronics through unplugged connectors, i.e., if a mating connector is not inserted, which may result in the valve or the pump being damaged.
Unplugged connectors must be covered and sealed.
The plastic dust protection caps which are attached to service connectors X5, X6, X7 and X10 on delivery are suitable for use as sealing covers.
The plastic dust protection caps which are attached to field bus connectors X3 and X4 on delivery are not suitable for use as sealing covers.
Suitable metallic dust protection caps for field bus connectors X3 and X4 are available as accessories.
➪ Chapter "9.2 Accessories", page 84

Cover unplugged connectors with dust protection caps

7.1 Electromagnetic compatibility (EMC)

EMC requirements

The machine manufacturer is responsible for complying with the EMC Directive.

The valves/pumps satisfy the EMC protection requirements for interference immunity as per DIN EN 61000-6-2 (evaluation criterion A) and for emitted interference as per DIN EN 61000-6-4 (CAN bus and Profibus-DP) or as per DIN EN 61000-6-3 (EtherCAT®).

The following technical requirements must be in place so that the EMC protection requirements can be satisfied:

- Use of the mating connectors recommended for the valves/pumps.
  ➪ Chapter "9.2 Accessories", page 84
- Adequate shielding.
- Correct execution of equipotential bonding system, protective grounding and electrical shielding.
  ➪ Chapter "6.2 Protective grounding and electrical shielding", page 48

7.2 Communication via the Moog Valve Configuration Software

WARNING

For safety reasons, the Moog Valve Configuration Software must not be used inside a machine for visualization purposes or as an operator terminal.

WARNING

It is only permitted to activate valves/pumps via the Moog Valve Configuration Software if this does not cause any dangerous states in the machine and in its surroundings.
It is not permitted to operate the Moog Valve Configuration Software on a field bus while the field bus is communicating with the machine.

CAUTION

Activating valves/pumps via the Moog Valve Configuration Software within a CAN network can give rise to unforeseeable events if field bus communication takes place simultaneously between the machine controller or to other CAN nodes!

CAUTION

If completely safe operation of the valves/pumps via the Moog Valve Configuration Software cannot be guaranteed even with deactivated field bus communication with the machine controller and other CAN nodes, the valves/pumps are only permitted to communicate in a depressurized state and in a direct link (point-to-point) with the software.

CAUTION

CAN telegrams of the Moog Valve Configuration Software can also be received by other CAN bus nodes. This may trigger off unforeseeable events!

CAUTION

Data exchange with the valve/pump electronics may be disrupted if other bus nodes (e.g., a controller) simultaneously access the device.

Operation of the Moog Valve Configuration Software

The Moog Valve Configuration Software communicates with the valves/pumps via the CAN interface. The CAN interface is available either in service interface X10, in LocalCAN interface X2 or in CAN field bus interface X3 and X4.

Possible faults

If the Moog Valve Configuration Software is operated within a CAN network with field bus communication of the machine running, the following faults can occur:

- Data exchange with the valves/pumps may be disrupted if another device (e.g., a controller) simultaneously accesses the valves/pumps.
- Node guarding may be activated only if no other field bus node is monitoring the valves/pumps via this service.
- Field bus telegrams can also be received by other field bus nodes. This may trigger off unforeseeable events!

To establish a direct connection between Moog Valve Configuration Software and valve, detach the field bus cable from the valve and connect the valve directly to the USB CAN interface of the service PC. A 120 Ω ± 10 % terminal resistor is required here.

The configuration/starting-up cable not included in the scope of delivery already features a terminal resistor.
⇨ Chapter "9.2 Accessories", page 84

8 Trouble shooting

8.1 Communication problems in networks

ⓘ If the fault cannot be corrected by means of the measures set out below, please contact Moog or one of its authorized service outlets.

ⓘ Field bus diagnostic tools allow you to monitor data traffic on the field bus, making it easier to identify the causes of problems.

8.1.1 General trouble shooting

8.1.1.1 LED «MS» not shining

General trouble shooting

Measures:

- Check the status LEDs.
  ⇨ Chapter "5 Status display", page 41
- Check the cable connection on connector X1 for secure seating and damage.
  Check the 24V power supply.
  Typical fault causes:
  - Open circuit
  - Corroded, loose, incorrectly seated or missing connectors
  - Valve/pump has no supply voltage

  ⇨ Chapter "6.4 Wiring connector X1", page 59

8.1.2 Trouble shooting CANopen

8.1.2.1 No or disrupted communication

Trouble shooting CANopen

Measures:

- Check the status LEDs.
  ⇨ Chapter "5 Status display", page 41
- Check the field bus cable and connections on connectors X3 and X4 for secure seating and damage.
  Check the 24V power supply.
  Check the field bus topology.
  Typical fault causes:
  - Absence of terminal resistors
  - Open circuit
  - Corroded, loose, incorrectly seated or missing connectors
  - Valve/pump has no supply voltage
  - Cables too long, unsuitable topology

  ⇨ Chapter "6.7 Wiring CAN networks (X2, X3, X4)", page 64
- Check the module address of the field bus nodes.
  Each module address may only be used once within a field bus network.
  ⇨ Chapter "6.7.3 CAN module address (node ID)", page 67
- Check to make sure that the transmission rate of the field bus nodes matches the transmission rates of the other field bus nodes.
  ⇨ Chapter "6.7.4 CAN transmission rate", page 67

- Check the communication parameters of the valve software.
  Typical fault causes:
  - NMT status is not set to 'OPERATIONAL' (only during process data transmission).
  - SDO CAN identifiers are not correctly set.
  - PDO CAN identifiers are not correctly set (only during process data transmission).
  - PDO mapping parameters are not correctly set (only during process data transmission).

  ⓘ Detailed information can be found in the "Firmware" User Manual.

8.1.3 Trouble shooting Profibus-DP

8.1.3.1 No or disrupted communication

Trouble shooting Profibus-DP

Measures:

- Check the status LEDs.
  ⇨ Chapter "5 Status display", page 41
- Check the field bus cable and connections on connectors X3 and X4 for secure seating and damage.
  Check the 24V power supply.
  Check the field bus topology.
  Typical fault causes:
  - Absence of terminal resistors
  - Open circuit
  - Corroded, loose, incorrectly seated or missing connectors
  - Valve/pump has no supply voltage
  - Cables too long, unsuitable topology

  ⇨ Chapter "6.8 Wiring Profibus-DP networks (X3, X4)", page 68
- Check the module address of the field bus nodes.
  Each module address may only be used once within a field bus network.
  ⇨ Chapter "6.8.3 Profibus-DP module address (node ID)", page 70
- Check the communication parameters of the valve software.
- Check for matching configuration telegrams.
- Check the parameterization telegrams.

  ⓘ Detailed information can be found in the "Firmware" User Manual.

8.1.4 Trouble shooting EtherCAT®

The following lists possible fault causes sorted by network layers (lowest layer [hardware layer] first) followed by software configuration errors.

8.1.4.1 LED «NS» not shining, no communication

Trouble shooting EtherCAT®

Measures:

- Check the field bus cable and connections on connectors X3 and X4 for secure seating and damage.
- Check the field bus topology.
  Typical fault causes:
  - Open circuit
  - Corroded, loose, incorrectly seated or missing connectors

  ⇨ Chapter "6.9 Wiring EtherCAT® networks (X3, X4)", page 71

8.1.4.2 LED «NS» flashing/shining orange, no or disrupted communication

Measures:

- Check the status LEDs.
  ⇨ Chapter "5 Status display", page 41
- Check the module address of the field bus nodes.
  ⇨ Chapter "6.9.3 EtherCAT® module address (node ID)", page 73
- Check the communication parameters of the valve software and in the network master.
  Typical fault causes:
  - Missing or incorrect valve description file (XML Slave Description File) on the network master.

  ⓘ Detailed information can be found in the "Firmware" User Manual.

8.1.4.3 LED «NS» flashing/shining, network status does not reach 'PRE-OPERATIONAL

Measures:

- Check the error messages in the network master.
- Check the mailbox configuration.
- Check the network configuration in the master with regard to the field bus topology.
  Typical fault causes:
  - The field bus topology was altered without the configuration being adapted and restarted in the network master.
  - The valve description file used (XML Slave Device Description File) does not suit the valve.

  When using TwinCAT:
- Check the TwinCAT run time system.
- Check the TwinCAT system status.
  Typical fault causes:
  - The TwinCAT system manager has no connection to the TwinCAT run time system, run time system was not started.
  - The configuration was altered, but the altered configuration has not yet been activated.

ⓘ Detailed information can be found in the "Firmware" User Manual.

8.1.4.4 LED «NS» flashing/shining orange, network status does not reach 'SAVE-OPERATIONAL' or 'OPERATIONAL'

Measure:

- Check the PDO configuration.
  Typical fault causes:
  - The number and/or size of the parameters allocated in the PDO configuration are not identical on the master and valve sides.
    Solution:
    Adjust the PDO configuration of the valve (SDO parameters 0x1600 and 0x1A00) with the valve description file (XML Slave Device Description File) on the master.
    The factory setting of the valve corresponds to the configuration in the valve description file.

ⓘ Detailed information can be found in the "Firmware" User Manual.

9 Additional Documentation and Accessories

9.1 Additional documentation

Item designation	Comments	Order number
User information Series D636/D638, German D636/D638, English D941, German D941, English RKP-D, English	Product-specific user information Not included in the scope of delivery	 CA45707-002 CA45707-001 CA43357-002 CA43357-002 CA58548-001
Firmware User Manual Digital Interface Valve (DIV) with CAN bus interface	User information "Firmware - Digital Interface Valves (DIV) with CAN Bus Interface" Not included in the scope of delivery	B99224-DVXXX-BE400[1]
Firmware User Manual Digital Interface Valve (DIV) with Profibus-DP interface	User information "Firmware - Digital Interface Valves (DIV) with Profibus-DP Interface" Not included in the scope of delivery	B99225-DVXXX-BE400[1]
Firmware User Manual Digital Interface Valve (DIV) with EtherCAT bus interface	User information "Firmware - Digital Interface Valves (DIV) with EtherCAT Bus Interface" Not included in the scope of delivery	B99226-DVXXX-BE400[1]
Firmware User Manual Axis Control Valve (ACV) with CAN bus interface	User information "Firmware - Axis Control Valves (ACV) with CAN Bus Interface" Not included in the scope of delivery	B99224-DVXXX-DE400[1]
Firmware User Manual Axis Control Valve (ACV) with Profibus-DP interface	User information "Firmware - Axis Control Valves (ACV) with Profibus-DP Interface" Not included in the scope of delivery	B99225-DVXXX-DE400[1]
Firmware User Manual Radial Piston Pump (RKP-D) with CAN bus interface	User information "Firmware - Radial Piston Pump (RKP-D) with CAN Bus Interface" Not included in the scope of delivery	B99224-DVXXX-CE400[1]

Table 27: Additional documentation

[1] XXX corresponds to firmware version, e.g., 010

9.2 Accessories

Item designation	Number required	Comments	Order number
Dust protection caps		Not included in the scope of delivery	
for field bus connector X3 with external thread	1	Metal cap with O-rings	C55823-001
for field bus connector X4 with internal thread	1	Metal cap with O-rings	CA24141-001
Mating connector 6+PE-pin (for connector X1)	1	Not included in the scope of delivery Watertight IP65 Usable cable with min. ∅ 8 mm (0.315 in), max. ∅ 12 mm (0.472 in)	B97007-061
Tool set for 6+PE-pin mating connector of valve connector X1	1	Crimping tool, tool insert, installation and removal tool	C2166-001
Tools for 6+PE-pin mating connector of valve connector X1	1	Crimping tool for mating connector	C21162-001
	1	Tool set for crimping tool for contact sizes 16 and 20	C21163-001
	1	Installation tool for contact sizes 16 and 20	C21164-001
	1	Removal tool for contact sizes 16 and 20	C21165-001
Mating connector 11+PE-pin (for connector X1)	1	Not included in the scope of delivery Watertight IP65 Usable cable with min. ∅ 11.5 mm (0.453 in), max. ∅ 13 mm (0.512 in)	B97067-111
Tool set for 11+PE-pin mating connector of valve connector X1	1	Crimping tool, tool insert, installation and removal tool	B97138-001
Tools for 11+PE-pin mating connector of valve connector X1	1	Crimping tool for mating connector	B97136-001
	1	Removal tool	B97137-001
Connection cable for valve connector X1, 3 m (9.843 ft)		Not included in the scope of delivery	
with 6+PE-pin mating connector	1		C21033-003-001
with 11+PE-pin mating connector	1		C21031-003-001
Configuration/ starting-up software	1	Not included in the scope of delivery	on request
Configuration/starting-up cable, 2 m (6.562 ft)	1	Not included in the scope of delivery	TD3999-137
Adapter for service connector X10 (M8 to M12)	1	Not included in the scope of delivery	CA40934-001
USB starting-up module (for service connector X10)	1	Not included in the scope of delivery	C43094-001
SELV power pack (10 A, 24 V DC)	1	Not included in the scope of delivery	D137-003-001
Power supply cable, 2 m (6.562 ft)	1	Not included in the scope of delivery	B95924-002
Mating connector with connection cable for analog inputs X5, X6, X7		Not included in the scope of delivery Pin 1 brown (BN) Pin 2 white (WH) Pin 3 blue (BU) Pin 4 black (BK)	
L = 2 m (6.562 ft)	1		C72977-002
L = 5 m (16.404 ft)	1		C72977-005

Table 28: Accessories

10 Index

Numerics

A

B

C

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

D

E

F

G

H

I

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

L

M

N

O

P

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Q

R

S

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

11 Appendix

11.1 Abbreviations, symbols, specialist terms

Tab. 29: Abbreviations, symbols, specialist terms

Abb.	Explanation
6+PE	6-pin connector with protective conductor contact
11+PE	11-pin connector with protective conductor contact
A	Pin of 6+PE-pin valve connector X1
B	Pin of 6+PE-pin valve connector X1
C	Pin of 6+PE-pin valve connector X1
AC	**A**lternating **C**urrent
CAN	**C**ontroller **A**rea **N**etwork
CAN_GND	CAN Ground (ground of CAN connectors X3 and X4)
CAN_H	CAN High (CAN bus signal (dominant high))
CAN_L	CAN Low (CAN bus signal (dominant low))
CAN_SHLD	CAN Shield (shield of CAN connectors X3 and X4)
CAN_V+	Supply voltage for CAN bus nodes
CANopen	Standardized communication profile
CAT 5	Category for twisted-pair cables (standardized in ANSI/TIA/EIA-568-B.1-2001)
CD	**C**ollision **D**etection
CiA	**C**AN **in A**utomation e. V. (International Manufacturers' and Users' Organization for CAN Users; http://www.can-cia.org)
CSMA	**C**arrier **S**ense **M**ultiple **A**ccess
C_{typ}	Symbol for typical capacitance
D	Pin of 6+PE-pin valve connector X1
DC	**D**irect **C**urrent
DIN	**D**eutsches **I**nstitut für **N**ormung e. V. (German Institute for Standardization)(http://www.din.de)
DIS	**D**raft **I**nternational **S**tandard (initial standard)
DS	**D**raft **S**tandard
DSP	**D**raft **S**tandard **P**roposal
E	Pin of 6+PE-pin valve connector X1
EIA	**E**lectronic **I**ndustries **A**lliance (http://www.eia.org)
EMC	**E**lectro**m**agnetic **C**ompatibility
EN	**E**uropa-**N**orm (European standard)
ESD	**E**lectro**s**tatic **D**ischarge
EtherCAT®	**Ether**net for **C**ontrol **A**utomation **T**echnology
EU	**E**uropean **U**nion
F	Pin of 6+PE-pin valve connector X1
f_l	Symbol for limit frequency
GND	**Ground**
ID	**Id**entifier
IEC	**I**nternational **E**lectrotechnical **C**ommission (http://www.iec.ch)
IEEE	**I**nstitute of **E**lectrical and **E**lectronics **E**ngineers, Inc. (http://www.ieee.org)
I_{in}	Symbol for input current
I_{max}	Symbol for maximum current
I_{out}	Symbol for output current
$I_{command}$	Symbol for current command signal
I_{supply}	Symbol for supply current

Table 29: Abbreviations, symbols, specialist terms (part 1 of 3)

Tab. 29: Abbreviations, symbols, specialist terms

Abb.	Explanation
ISO	**I**nternational **O**rganization for **S**tandardization (http://www.iso.org)
LED	**L**ight **E**mitting **D**iode
l_{max}	Symbol for maximum length
LSB	**L**east **S**ignificant **B**it (lowest-value bit)
LSS	**L**ayer **S**etting **S**ervices as per CiA DSP 305 (LSS offers the option of setting the node parameters, such as e.g., module address or baud rate, of a CAN node via the CAN bus)
LVDT	**L**inear **V**ariable **D**ifferential **T**ransformer (position transducer; senses the position of the spool in the valve)
MoVaCo	**Mo**og **Va**lve **Co**nfiguration Software
MS	**M**odule **S**tate LED
MSB	**M**ost **S**ignificant **B**it (highest-value bit)
n	Number
NMT	**N**etwork **M**anagemen**t** (for configuration, initialization and fault handling in CAN networks)
Node	Node in a network
NS	**N**etwork **S**tate LED
P	Symbol for pressure
PC	**P**ersonal **C**omputer
PDO	**P**rocess **D**ata **O**bject (message object which contains cyclic process data)
PE	**P**rotective **E**arth
PE	Pin of 6 or 11+PE-pin valve connector X1
PELV	**P**rotective **E**xtra **L**ow **V**oltage
Q	Symbol for flow
q_{typ}	Symbol for typical cross section
Repeater	Signal amplifier for bus communication
ρ_{Cu}	Symbol for resistivity of copper
R	Symbol for resistance
RKP-D	Radial piston pump with digital control
R_L	Symbol for load impedance
R_{typ}	Symbol for typical resistance
SELV	**S**afety **E**xtra **L**ow **V**oltage
SDO	**S**ervice **D**ata **O**bject (for communicating service data)
SHLD	**Sh**ie**ld**
SII	**S**lave **I**nformation **I**nterface
TIA	**T**elecommunications **I**ndustry **A**ssociation (http://www.tiaonline.org)
TN	**T**echnical **N**ote
TÜV	**T**echnischer **Ü**berwachungs**v**erein (German Technical Inspection Agency)
U_{dr_max}	Symbol for maximum voltage drop on the supply cable
U_{in}	Symbol for input voltage
U_{cable}	Symbol for voltage drop on the cable
U_{min}	Symbol for minimum supply voltage
U_{out}	Symbol for output voltage
$U_{command}$	Symbol for input voltage command signal
USB	**U**niversal **S**erial **B**us

Table 29: Abbreviations, symbols, specialist terms (part 2 of 3)

Tab. 29: Abbreviations, symbols, specialist terms

Abb.	Explanation
VDE	**V**erband **d**er **E**lektrotechnik Elektronik Informationstechnik e. V. (German Association of Electrical Engineering, Electronics and Information Technology) (http://www.vde.de)
VDI	**V**erein **D**eutscher **I**ngenieure e. V. (Association of German Engineers) (http://www.vdi.de)
VDMA	**V**erband **D**eutscher **M**aschinen- und **A**nlagenbau e. V. (German Machinery and Plant Manufacturers' Association) (http://www.vdma.org)
X1…X11	Designations for the valve connectors
XML	E**x**tensible **M**arkup **L**anguage (XML is a versatile language which combines text content with information on the text content)

Table 29: Abbreviations, symbols, specialist terms (part 3 of 3)

11.2 Additional literature

11.2.1 CAN fundamentals

Additional literature: CAN fundamentals

CAN in Automation e. V.:
http://www.can-cia.org

Etschberger, Konrad (editor):
CAN - Controller-Area-Network - Grundlagen, Protokolle, Bausteine, Anwendungen; Carl Hanser Verlag

Lawrenz, Wolfhard (editor):
CAN - Controller Area Network - Grundlagen und Praxis; Hüthig Verlag

11.2.2 Profibus fundamentals

Additional literature: Profibus fundamentals

PROFIBUS Users' Organization:
http://www.profibus.com

- Test Specification for PROFIBUS Slaves, Version 2.0
- PROFIBUS Start-up Directive, Version 1.0.2, November 2006, Order No.: 8.031
- Profibus-DP Profile, Fluid Power Technology, Version 1.5

VDMA Head Office
http://www.vdma.org

- Profile Fluid Power Technology
  Proportional Valves and Hydrostatic Transmissions

Popp, Manfred:
PROFIBUS-DP/DPV1 - Grundlagen, Tipps und Tricks für Anwender; Hüthig Verlag

11.2.3 EtherCAT® fundamentals

Additional literature: EtherCAT® fundamentals

EtherCAT® Technology Group:
http://www.ethercat.org

- EtherCATDeviceDescription
  Description of the XML-Schema of the EtherCAT® XML Slave Device Description File
- Technical Introduction and Overview
- EtherCAT® Introduction

11.2.4 Moog publications

Additional literature: Moog publications

Press releases:
http://www.moog.com/Industrial/News

Newsletters:
http://www.moog.com/Industrial/Newsletter

Articles in technical journals:
http://www.moog.com/Industrial/Articles

Presentations and scientific publications:
http://www.moog.com/Industrial/Papers

User information, TNs, catalogs, and similar:
http://www.moog.com/

11.3 Quoted standards

11.3.1 CiA DSP

Quoted standards: CiA DSP

CiA DSP 305
CiA Draft Standard Proposal: CANopen Layer Setting Services and Protocol (LSS)

11.3.2 DIN EN

Quoted standards: DIN EN

DIN EN 954-1
Safety of machinery – Safety-related parts of control systems – Part 1: General design principles

DIN EN 982
Safety of machinery – Safety requirements for fluid power systems and their components – Hydraulics

DIN EN 60204
Safety of machinery – Electrical equipment of machines

DIN EN 61000-6-2
Electromagnetic compatibility (EMC) – Part 6-2: Generic standards; immunity for industrial environments

DIN EN 61000-6-3
Electromagnetic compatibility (EMC) – Part 6-3: Generic standards - Emitted interference for residential, commercial and light-industrial environments

DIN EN 61000-6-4
Electromagnetic compatibility (EMC) – Part 6-4: Generic standards; emitted interference for industrial environments

DIN EN 61076-2-101
Connectors for electronic equipment - Part 2-101: Circular connectors - Detail specification for circular connectors M8 with screw- or snap-locking, M12 with screw-locking for low voltage applications

DIN EN 61158-2
Digital data communication in instrumentation and control – Field bus for industrial control systems

DIN EN 61558-1
Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests

DIN EN 61558-2-6
Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1,100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers

DIN EN 175201-804
Detail specification: Circular connectors – Round contacts, size diameter 1.6 mm (0.063 in), threaded coupling

11.3.3 DIN EN ISO

Quoted standards: DIN EN ISO

DIN EN ISO 12100
Safety of machinery – Basic concepts, general principles for design

11.3.4 IEC

Quoted standards: IEC

IEC 62407
Real-time Ethernet control automation technology (EtherCAT®)

11.3.5 IEEE

Quoted standards: IEEE

IEEE 802.3
Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer

11.3.6 ISO/DIS, ISO/IEC

Quoted standards: ISO/DIS, ISO/IEC

ISO/DIS 11898
Road vehicles – CAN protocol

ISO/IEC 8802-3
Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks; Specific requirements - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications

11.3.7 TIA/EIA

Quoted standards: TIA/EIA

ANSI/TIA/EIA-568-B.1
Commercial Building Telecommunications Cabling Standard Part 1: General Requirements

TIA/EIA 422 (formerly RS 422)
Electrical Characteristics of Balanced Voltage Digital Interface Circuits

TIA/EIA-485-A
Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

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