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Subject to changes without prior notice.

All M3000® modules comply with the standards specified in their relevant declaration of conformity. CE labeling of the M3000® modules is based on proper installation of the automation system with proven electromagnetic compatibility (EMC).
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1 General Information

1.1 About this Manual

This manual is valid only for the M3000® automation system and M3000® modules. It contains most important instructions that must be observed in order to operate the M3000® automation system and M3000® modules in a safe manner.

Every person responsible for machinery planning, mounting, and operation must read, understand, and follow all points covered in this manual. This applies especially to the safety instructions. Following the safety instructions helps to avoid accidents, faults, and material damage!

The following items must be observed as fundamental elements of safety when using the M3000® automation system and M3000® modules:

- All safety instructions contained in this manual
- All safety instructions contained in the documentation of the M3000® modules
- All safety instructions contained in the product related hardware and software documentation required for the relevant application
- All relevant nationally and internationally applicable safety and accident prevention regulations and standards

1.1.1 Reservation of Changes and Validity

The information contained in this manual is valid at the time of this version's release. See footer for version number and release date of this manual. Moog reserves the right to make changes to this manual at any time without specified reasons.

1.1.2 Exclusion of Liability

This manual was prepared with great care and the contents reflect the authors' best knowledge. However, the possibility of error remains and improvements are possible.

Please feel free to submit any comments regarding errors or incomplete information to Moog.

Moog does not offer any guarantee that the contents conform to applicable legal regulations nor does Moog accept any liability for incorrect or incomplete information and the consequences thereof.

1.1.3 Completeness

This manual is complete only when used in conjunction with the product related hardware and software documentation required for the relevant application.

1.1.4 Place of Storage

This manual and all other associated documentation for hardware and software must always be kept in a location where they will be readily accessible and close to the M3000® automation system and M3000® modules or the equipment in which they are installed.
1.2 Selection and Qualification of Personnel

Qualified Users

Only qualified users may work with and on the M3000® automation system or M3000® modules. Qualified users are properly trained experts with the required knowledge and experience. In particular, these experts must have the authorization to bring into operation, ground, and label devices, systems, and power circuits in accordance with safety engineering standards. Those people working on a project must be familiar with safety concepts common in automation.

1.3 Proper Use

Proper Use

The M3000® modular automation system is suitable for control applications in the medium to high end performance ranges.

M3000® is designed for use within the overvoltage category defined by IEC 60364-4-44 for controlling machines and industrial processes in low voltage systems in which the rated supply voltage does not exceed 1,000 V alternating current (50/60 Hz) or 1,500 V direct current.

Qualified project planning and design, proper transportation, storage, installation, and use are required to ensure fault-free, reliable, and safe operation of M3000®.

M3000® and M3000® modules must not be brought into operation until it has been ensured that the equipment in which they are installed complies with the current version of the EU machinery directive.

The M3000® automation system and M3000® modules may be used only under the conditions and situations specified in this manual and in the documentation of the M3000® modules. Any other or more extensive use is not permissible.

The following are also required for proper use:

- Compliance with the requirements detailed in this manual
- Compliance with the requirements of individual M3000® module documentation
- Compliance with all of the product related hardware and software documentation required for the relevant application
- Compliance with the relevant nationally and internationally applicable regulations, standards, and directives, e.g., the regulations specified by a professional organization, such as TÜV or VDE

1.3.1 Safety Related Systems

Safety Related Systems

WARNING As with any electronic automation system, the failure of certain components when using M3000® or M3000® modules might lead to an uncontrolled and/or unpredictable operational condition. The user should take into consideration the system level effects of all types of failures and implement corresponding safety measures.

Special measures are required to use control technology in safety related systems. When planning to use control technology in a safety related system, the user should seek detailed advice in addition to any available standards or guidelines for safety installations.
1.4 Warranty and Liability

Moog's standard delivery and payment conditions apply. The owner/operator will have access to these by the time the contract is closed at the latest.

Warranty and liability claims for personal and material damage will be excluded when they are the result of the following, among others:

- Improper use of the M3000® automation system or M3000® modules
  ⇒ “1.3 Proper Use” on page 2
- Use of the M3000® automation system or M3000® modules in a technically imperfect condition
- Use of the M3000® automation system or M3000® modules by unqualified users
  ⇒ “1.2 Selection and Qualification of Personnel” on page 2
- Failure to comply with this manual, the documentation of the M3000® modules, or the product related hardware and software documentation required for the relevant application
- Failure to comply with the relevant nationally and internationally applicable regulations such as the regulations of a professional association, the TÜV, or the VDE
- Improper deployment of the M3000® automation system or M3000® modules, such as in a potentially explosive, excessively warm, or excessively cold environment
- Improper storage, transportation, mounting, removing, connection, bringing into operation, operation, cleaning, or maintenance of the M3000® automation system or M3000® modules
- Storage or transportation of M3000® modules or accessories outside of the original packaging
  ⇒ “9 Transportation and Storage” on page 57
- Unauthorized or improperly executed structural changes to the M3000® automation system or M3000® modules
- Unauthorized or improperly executed repairs on the M3000® automation system or M3000® modules
  ⇒ “8.2.2 Repair” on page 56
- Damage due to the intrusion of foreign objects or acts of God.

1.5 Inspection of Delivery

After receiving the delivery, please check the original packaging and its contents for any damage. If the packaging or contents exhibit any damage, do not bring the items into operation. In this case, immediately notify Moog or the responsible supplier. In addition, the packaging should be retained. The packaging might be needed to enforce damage compensation claims on the transport company.

After taking the delivery, please check whether all items listed on the delivery docket are present. If anything is missing, immediately notify Moog or the responsible supplier.

It is advisable to retain the original packaging for any future transport or storage needs.
1.6 Environmental Protection

1.6.1 Emissions
M3000® modules do not have any harmful emissions when used properly.

1.6.2 Disposal
The applicable disposal regulations must be observed when disposing of M3000® modules!

1.7 Standards

1.7.1 CE Labeling of M3000® Modules
All M3000® modules comply with the standards specified in their relevant declaration of conformity. CE labeling of the M3000® modules is based on proper installation of the automation system with proven electromagnetic compatibility (EMC).

1.7.2 IEC 61131-2
The M3000® automation system and M3000® modules comply with the requirements of IEC 61131-2.

Where technical requirements lead to deviations from the standard, these are specified in this manual or in the documentation of the relevant M3000® modules.

1.7.3 Electromagnetic Compatibility (EMC)
M3000® modules comply with the requirements and protection targets of the EU directive 89/336/EEC “Electromagnetic Compatibility” (EMC directive) and comply with the harmonized European standards (EN) that were published in the Official Journals of the European Union for programmable controllers.

Especially important are the rules for proper EMC wiring in cabinets and buildings according to IEC 61131-4. Installation in metal, grounded cabinets is preferred.

M3000® modules are designed for use under normal operating conditions in industrial environments and comply with the following standards:

- DIN EN 61000-6-2
- DIN EN 61000-6-4

If suitable additional measures are taken, M3000® modules may also be employed in residential, commercial and light-industrial environments in compliance with the following standards:

- DIN EN 61000-6-1
- DIN EN 61000-6-3

Suitable additional measures:
⇒ "4.2 Use in Special Environments" on page 28
If the system does not comply with the requirements of DIN EN 61000-6-1 and DIN EN 61000-6-3, despite the additional measures, M3000® modules must not be used in residential, commercial and light-industrial environments.

EMC conformity may be presumed only under the following conditions:

- Sufficient shielding

The MSD Motion Controller must be powered from a power supply with SELV (Safety Extra-Low Voltage) according to DIN EN 60950-1. Therefore the EU low voltage directive is not relevant for the M3000® automation system because the specified voltage levels lie below the limits.

### 1.8 Trademarks

Moog and Moog Authentic Repair are registered trademarks of Moog Inc. and its subsidiaries.
M3000® is a trademark of Moog GmbH that is registered in the EU.

All product and company names mentioned in this manual might be protected trademarks or brands of the relevant manufacturer. The absence of the symbols ® or ™ does not indicate that the name is free from trademark protection.

### 1.9 Software Copyrights

The software that is installed on M3000® products at the time of delivery is the property of the manufacturer. At the time of delivery, every piece of installed software is covered by copyright protection. It may be reproduced only with the approval of the manufacturer or in accordance with the license agreements.
2 Safety Instructions

This chapter summarizes the most important safety instructions. When handling the M3000\textsuperscript{\textregistered} automation system or M3000\textsuperscript{\textregistered} modules the safety instructions in the other chapters of this manual must be followed as well as the safety instructions in the product related hardware and software documentation required for the specific application.

Following the safety instructions helps to avoid accidents, faults, and material damage!

2.1 Typographical Conventions

The following symbols and styles are used for identifying the different types of safety instructions:

\begin{itemize}
\item **DANGER** Identifies safety instructions that are intended to warn of an immediate and impending danger to life and limb or major property damage. Failure to observe these safety instructions will lead inevitably to death, serious personal injury (disablement) or major property damage!
\item **WARNING** Identifies safety instructions that are intended to warn of potential danger to life and limb or the potential for major property damage. Failure to observe these safety instructions might lead to death, serious personal injury (disablement) or major property damage!
\item **CAUTION** Identifies safety instructions that are intended to warn of slight personal injury or minor property damage. Failure to observe these safety instructions might lead to slight personal injury or minor property damage.
\end{itemize}

Additional typographical conventions:

\begin{itemize}
\item *"12.1 Typographical Conventions" on page 97*
\end{itemize}

2.2 Safety Instructions

2.2.1 Safety Related Systems

\begin{itemize}
\item **WARNING** As with any electronic automation system, the failure of certain components when using M3000\textsuperscript{\textregistered} or M3000\textsuperscript{\textregistered} modules might lead to an uncontrolled and/or unpredictable operational condition. The user should take into consideration the system level effects of all types of failures and implement corresponding safety measures.
\end{itemize}

More on this subject: *"1.3.1 Safety Related Systems" on page 2*
2.2.2 Environmental Conditions

**WARNING** Maintain under all circumstances the required environmental conditions specified for the M3000® automation system or M3000® modules. This ensures fault-free, reliable, and safe operation.

**WARNING** The PC on which tools such as MACS development environment are installed must be suitable for the environmental conditions in which it will operate. This ensures fault-free, reliable, and safe operation.

**WARNING** It is not permissible to operate the M3000® automation system or M3000® modules in a potentially explosive environment.

**WARNING** The M3000® automation system and M3000® modules must not come into direct contact with liquids, except where explicitly specified. Danger of short-circuit! If they do come into direct contact with a liquid, immediately disconnect the power supply! Before bringing the system back into operation, it is essential that all affected components are completely dry and have been inspected by a suitably qualified technician.

More on this subject:
⇒ "4 Environmental Conditions" on page 27
⇒ "10.2.2 Environmental Conditions" on page 60

2.2.3 ESD

**WARNING** Protect the M3000® automation system, M3000® modules, and the license key from electrostatic discharges! Electrostatic discharges might damage the device's internal components or delete the device's internal memory.
2.2.4 Project Planning and Installation

**WARNING** The vent holes of M3000® modules facilitate convection cooling and must never be covered!
Covered vent holes might result in overheating and fire.

**WARNING** No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!
There is a danger of:
- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected.
Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

**WARNING** M3000® modules must be protected from overvoltages and/or reverse energization from the sensor to the module!
There is a danger of:
- Permanent damage by overheating or fire
- Malfunctions

M3000® modules must have the correct voltage, polarity, and terminal assignments.

**WARNING** The internal electronics of M3000® modules and attached sensors must be supplied with power from a permanently connected (unswitched) power supply that cannot be individually switched off, without switching off the module’s power supply.
If a switched power supply is used, such as when there are intermediate switching devices (emergency stops, manual operators, etc.), the following problems might arise, depending on the state of the power supply for the internal electronics of the module and sensors (table 4 on page 37):
- Reverse energization from sensor to module
- Invalid sensor data
2.2.5 Shutdown and Service

**WARNING**

To avoid damage to M3000® modules or accessories, cleaning, maintenance, and repair tasks may be performed only by Moog or Moog’s authorized service agents.

Warranty and liability claims for personal and material damage are excluded when, among other reasons, they are due to unauthorized repairs or other unauthorized interventions.  

› "1.4 Warranty and Liability" on page 3

**WARNING**

No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!

There is a danger of:
- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.
WARNING The M3000® automation system and M3000® modules must not come into direct contact with liquids, except where explicitly specified. Danger of short-circuit! If they do come into direct contact with a liquid, immediately disconnect the power supply! Before bringing the system back into operation, it is essential that all affected components are completely dry and have been inspected by a suitably qualified technician.

WARNING If an M3000® module is to be taken out of operation, the entire system must always be shut down and disconnected from all power supplies. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.! The M3000® module must be protected against unintentional restarting!

If the M3000® module is connected to other devices and/or facilities, always consider the full consequences and take appropriate precautions before switching off the module.

More on these subjects:
⇒ "8 Shutdown and Service" on page 55

2.2.6 Transportation and Storage

WARNING Maintain, under all circumstances, the required environmental conditions specified for transportation and storage of the M3000® automation system or M3000® modules.

⇒ "9.1 Environmental Conditions" on page 57
This ensures fault-free, reliable, and safe operation.

More on this subject: ⇒ "9 Transportation and Storage" on page 57
2.2.7 Communication Between MSD Motion Controller and MACS

WARNING The MSD Motion Controller’s operational state can be altered with the MACS development environment when the MSD Motion Controller is connected online with MACS. This can be done by means of the following actions, for example:

- Stopping or resetting the program
- Setting breakpoints
- Activating the single step mode
- Downloading application programs
- Writing or forcing values

Therefore, the operator must always consider the effects and take appropriate precautions before altering the operational state of the MSD Motion Controller with MACS.

More on this subject: ⇨ "10.5 Programming and Configuration" on page 68

2.2.8 License Key of the MSD Motion Controller

WARNING The license key of the MSD Motion Controller must be protected from electrostatic discharges! Electrical discharges might damage the license key or delete the contents of the license key's memory.

WARNING The license key may be inserted or removed only when the MSD Motion Controller is powered down! Attempting to insert or remove the license key during operation might damage the license key or the MSD Motion Controller permanently.

WARNING The license key must always remain inserted while the MSD Motion Controller is in operation. Otherwise, the MSD Motion Controller will not work.

If the license key is removed during operation, the application program will stop after a few minutes. If the MSD Motion Controller is connected online to the MACS development environment, a corresponding error message will appear in MACS. In addition, the digital output 'Outputs Enabled' will be switched to the 0 state, thereby disabling all of the MSD Motion Controller's digital outputs and terminating fieldbus communication. ⇨ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85

After switching off the MSD Motion Controller and inserting the license key, the MSD Motion Controller can be brought back into operation.

More on this subject: ⇨ "10.6 License Key" on page 69
2.2.9 Run/Stop/Reset

WARNING

If the most recent status in the online mode (MACS logged in) was 'Run' before the MSD Motion Controller was switched off or reset, the boot project will always be started after the MSD Motion Controller is switched back on or reset.

This will occur regardless of which application program was previously running.
In other words, the application program that will be started automatically after the MSD Motion Controller is switched on or reset might be different from the application program that was executing immediately prior.

More on this subject: ⇒ "10.7 Run/Stop/Reset Switch" on page 72

2.2.10 Switching Back on or Resetting the MSD Motion Controller

WARNING

If the most recent status in the online mode (MACS logged in) was 'Run' before the MSD Motion Controller was switched off or reset, the boot project will always be started after the MSD Motion Controller is switched back on or reset.

This will occur regardless of which application program was previously running.
In other words, the application program that will be started automatically after the MSD Motion Controller is switched on or reset might be different from the application program that was executing immediately prior.

More on this subject:
⇒ "10.8.1 Behavior at Switching on and Switching off" on page 73

2.2.11 'Outputs Enabled' Output of the MSD Motion Controller

WARNING

If there is a defect in an output stage, the 'Outputs Enabled' signal will not necessarily shut down all of the outputs securely.

More on this subject:
⇒ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85
3 Short M3000® System Overview

The M3000® automation system comprises the following hardware and software components:

- **MSC II starter kit**
  Complete package including everything needed to get started with MSC II
  ⇒ “3.2 MSC II Starter Kit” on page 15

- **M3000® modules**
  - **MSC I (Moog Servo Controller)**
    Control module for DIN top-hat rail mounting
    ⇒ “3.3.1 MSC I” on page 16
  - **MSC II (Moog Servo Controller)**
    Control module for DIN top-hat rail mounting
    ⇒ “3.3.2 MSC II” on page 17
  - **QDIO 16/16**
    Digital I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)
    ⇒ “3.3.3.1 QDIO and QAIO” on page 18
  - **QAIO 2/2**
    Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)
    ⇒ “3.3.3.1 QDIO and QAIO” on page 18
  - **QDIO 16/4**
    Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)
    ⇒ “3.3.3.1 QDIO and QAIO” on page 18
  - **QEBUS-CAN**
    CAN extension module for MSC II which can be used to make available the LocalCAN bus of an E-bus group for external CAN bus network stations (over a D-sub front panel connector)
    ⇒ “3.3.3.2 QEBUS-CAN” on page 19
  - **RDIO**
    Remote module with digital I/Os and CANopen interface (connection over CAN bus)
    ⇒ “3.3.4.1 RDIO” on page 20
  - **RDISP**
    Display and operating terminal with TIA/EIA 232 and CANopen interface (connection over CAN bus)
    ⇒ “3.3.4.2 RDISP” on page 20
  - **DialogController**
    Displays with TFT technology and touch screen. Programmable with MACS development environment. Data exchange via Ethernet with MSC II or MSD Motion Controller.
    ⇒ “3.3.4.3 DialogController” on page 21
  - **MSD Motion Controller**
    Motion control module for MSD Servodrives
    ⇒ “3.3.5 MSD Motion Controller” on page 22
  - **MSD Servodrive**
    Modular Multi-Axis Programmable Motion Control Servodrive
    ⇒ “3.3.6 MSD Servodrive” on page 23

- **License keys**
  Hardware keys necessary for the operation of the MSC I, MSC II and MSD Motion Controller.
  ⇒ “3.4 License Key” on page 24
• **MACS (Moog Axis Control Software)**
  Development environment according to IEC 61131 for solving complex control tasks
  ➜ "3.5 Application Programs" on page 25

• **MACS HMI (Moog Axis Control Software Human Machine Interface)**
  Visualization package which can be run without MACS
  ➜ "3.6.1 MACS HMI Visualization Package" on page 26

The M3000® modules mentioned here represent only a part of Moog's current product range. In addition to other M3000® modules, Moog's product range includes a large variety of accessories.
  ➜ "11 Product Range" on page 87

### 3.1 M3000® System Architecture

The M3000® automation system has the hardware and software structure necessary for modular and flexible automation solutions with distributed intelligence.

The MSD Motion Controller can use an Ethernet connection (LAN, company network, peer-to-peer connection) to communicate with another controller, development environment, or visualization package.
  ➜ "7.1 Ethernet" on page 42
  ➜ "10.5.1 Communication Between MSD Motion Controller and MACS" on page 68
  ➜ "10.5.1.1 Ethernet Communication Interface" on page 68

To create real time capable applications, even in distributed systems and to give the application a better structure, M3000® can also be divided hierarchically.
  ➜ "7.4 CAN Bus and CANopen" on page 49

CAN can be used for networking of individual control groups or remote modules.
  ➜ "3.3.4 R-Modules (Remote Modules)" on page 19

In addition, the CAN network can integrate other components with a CAN bus or CANopen interface, such as motor controllers, hydraulic valves, and radial piston pumps.
3.2 MSC II Starter Kit

The MSC II starter kit is available in two versions:
- MSC II with Profibus-DP slave
- MSC II with dual EtherCAT master

It includes everything needed to get started:
- MSC II
- Power supply 24 V 10 A
- License key, green
- QDIO 16/16-0,5
- MACS development environment
- Software maintenance contract
- Crossed Ethernet interface cable, 10 m (10.94 yd)
- CAN bus interface cable, 3 m (3.28 yd)
- 6 Plug-in terminal strips with screw terminals, 18 pole
- 2 Plug-in terminal strip with screw terminals, 9 pole
- 4 Plug-in terminal strips with spring power clamp, 10 pole

The included DIN rail modules MSC II and QDIO are mounted (together with the power supply) on a single mounting plate.

A suitable power cord is the only additional item required to facilitate connection to the power source.
3.3 M3000® Modules

The M3000® modules mentioned here represent only a part of Moog's current product range. In addition to other M3000® modules, Moog's product range includes a large variety of accessories.

⇒ "11 Product Range" on page 87

3.3.1 MSC I

The MSC I digital control module is a fully programmable multi-axis controller. The inputs and outputs of the MSC I can be extended locally by attaching Q-modules. The MSC I and the attached modules then form an E-bus group. MSC I and Q-modules within E-bus groups communicate over the internal E-bus.

The MSC I is programmed and configured with the MACS development environment (complies with IEC 61131).

⇒ "3.5 Application Programs" on page 25
3.3.2 MSC II

The MSC II digital control module is a fully programmable multi-axis controller.
The inputs and outputs of the MSC II can be extended locally by attaching Q-modules. The MSC II and the attached modules then form an E-bus group.
MSC IIs and Q-modules within E-bus groups communicate over the internal E-bus.
The MSC II is programmed and configured with the MACS development environment (complies with IEC 61131).

Detailed information about the MSD Motion Controller:
"10 MSD Motion Controller" on page 58

3.3.3 Q-Modules

Q-Modules are I/O extension modules for MSC I and MSC II.

The following Q-modules are available from Moog:
- QDIO 16/16 (digital I/O extension module)
  ⇒ "3.3.3.1 QDIO and QAIO" on page 18
- QAIO 2/2 (analog I/O extension module)
  ⇒ "3.3.3.1 QDIO and QAIO" on page 18
- QAIO 16/4 (analog I/O extension module)
  ⇒ "3.3.3.1 QDIO and QAIO" on page 18
- QEBUS-CAN (CAN extension module)
  ⇒ "3.3.3.2 QEBUS-CAN" on page 19

Q-modules can be used only as E-bus slaves within E-bus groups.
When using an RDIO as E-bus master, only QDIOs can be used as E-bus slaves.

Refer to the Q-modules' documentation for more detailed information.
3.3.3.1 QDIO and QAIO

QDIO and QAIO I/O extension modules can be used to locally extend the inputs and outputs of an MSC I or MSC II. They have no internal intelligence. Instead, the MSC I or MSC II actuates them via I/O operation directly over the internal E-bus.

**QDIO 16/16-0,5** is a digital I/O extension module with 16 digital inputs and 16 individually configurable digital I/Os. QDIO 16/16-0,5 provides positive switching inputs and I/Os. QDIO 16/16-0,5N provides zero switching inputs and I/Os.

**QAIO 2/2** is an analog I/O extension module with 2 analog inputs (each configurable as ±10 V, ±10 mA, 4–20 mA) and 2 analog voltage outputs (±10 V, 4–20 mA, ±50 mA).

**QAIO 16/4** is an analog I/O extension module with 16 analog inputs and 4 analog voltage outputs (±10 V).

**QAIO 16/4-V** provides 16 voltage inputs (±10 V).

**QAIO 16/4-A** provides 16 current inputs (0–20 mA).
3.3.3.2 QEBUS-CAN

QEBUS-CAN is a CAN extension module which can be used to make the LocalCAN bus of an E-bus group available for external CAN bus network stations (over a D-sub front panel connector).

3.3.4 R-Modules (Remote Modules)

R-Modules are extension modules with CANopen interface.

The following R-modules are available from Moog:

- RDIO (remote module with digital I/Os and CANopen interface)
  ⇒ "3.3.4.1 RDIO" on page 20
- RDISP (display and operating terminal)
  ⇒ "3.3.4.2 RDISP" on page 20

IEC 61131 application programs cannot run on R-modules.

R-modules connect to other network stations over the CAN bus.
⇒ "7.4 CAN Bus and CANopen" on page 49

Refer to the R-modules' documentation for more detailed information.
### 3.3.4.1 RDIO

RDIO is a remote module with digital I/Os and CANopen interface. RDIOs can be parameterized as a CANopen slave according to CiA DS 401.

**RDIO 16/16-0.5** provides 16 positive switching digital inputs and 16 positive switching digital I/Os.

![RDIO 16/16-0.5 Remote I/O Module](image)

**Figure 8: RDIO 16/16-0.5 Remote I/O Module**

### 3.3.4.2 RDISP

RDISP is a versatile display and operating terminal with TIA/EIA 232 and CANopen interface as well as a graphical LCD display and function keys which can be labelled. A slip of paper can be inserted below the keys for labeling purposes.

**RDISP 22** provides 22 function keys and a display with max. 8 lines of 40 characters each or random graphics.

Dimensions of RDISP 22:

- 187 mm × 120 mm × 56 mm (7.36 in × 4.72 in × 2.2 in)

The CPRDISP software (needed to program and configure the RDISP) is not included with RDISP. CPRDISP is available from Moog as an accessory.

["11.5.2 Software for R-Modules" on page 92]
3.3.4.3 DialogController

The DialogController is freely programmable with the Moog Axis Control Software (MACS) development environment. The predefined visualization elements such as buttons, bar graphs, meters, tables and histograms makes it easy to create visualization screens.

In addition it offers TFT technology for brilliant colors, fanless operation, Ethernet communication for programming and operation.

It is available in three sizes:

- **DialogController 5.7 "**  
  Color TFT, ¼ VGA resolution, 320 x 240 pixels with touch screen  
  Dimensions: W x D x H: 194 x 172 x 52 mm / 7.6 x 6.8 x 2.0 inch

- **DialogController 10.4 "**  
  Color TFT, VGA resolution, 640 x 480 pixels with touch screen  
  Dimensions: W x D x H: 360 x 260 x 77 mm / 14.2 x 10.2 x 3.0 inch

- **Display 12.1 "**  
  Color TFT, SVGA resolution, 800 x 600 pixels with touch screen  
  Dimensions: W x D x H: 440 x 300 x 77 mm / 17.3 x 11.8 x 3.0 inch
3.3.5 MSD Motion Controller

Motion control module for MSD Servodrives.

The MSD Motion Controller digital control module is a fully programmable multi-axis controller.

It can coordinate and synchronize multiple axes e.g. of MSD Servodrives and handle the communication to host computers and other PLC’s.

The MSD Motion Controller is programmed and configured with the MACS development environment (complies with IEC 61131).
3.3.6 MSD Servodrive

Modular Multi-Axis Programmable Motion Control Servodrive.
A family of electrical servo drives, available in 6 sizes for currents from 4 to 170 A.

Main features are:
• Controls synchronous motors, asynchronous motors and linear motors.
• Controls current loops (PWM frequencies: 4, 8, 12 and 16 kHz).
• Can close velocity and position control loops.
• Communicates with the MSD Motion Controller via EtherCAT.
• Supports different sensor interfaces.
• Digital I/O’s.

3.3.7 Identification

M3000® modules can be identified by their nameplate.
Nameplate of the MSD Motion Controller: ⇒ "10.15 Nameplate" on page 86

The module’s I/O designations are located on the front panel.
Terminal assignment of the MSD Motion Controller:
⇒ "10.4 View of the Module and Terminal Assignment" on page 63

Refer to the relevant documentation for detailed information about the nameplate and terminal assignment of the other M3000® modules.
3.4 License Key

The license key has to be inserted into the license key slot «LK» of the MSD Motion Controller. The MSD Motion Controller does not work without license key.

The following information is saved in the license key:

- Run-time license of the MSD Motion Controller and list of accessible MACS libraries
  ➞ "10.6.1 Run-Time License and Accessible Libraries" on page 69
- CANopen node-ID of the MSD Motion Controller's CAN bus interfaces
  ➞ "10.6.2 CANopen Node-ID and IP Address" on page 70
- IP address, subnet mask and gateway address of the MSD Motion Controller's Ethernet interface
  ➞ "10.6.2 CANopen Node-ID and IP Address" on page 70

If the MSD Motion Controller is replaced, this information will remain saved in the license key. If the license key is inserted into a different MSD Motion Controller, the run-time license, CANopen node-ID and IP address can be used from that MSD Motion Controller.

The extent of the MSD Motion Controller's features depends on the license key used.

➤ "11.4 License Keys" on page 91
3.5 Application Programs

Application programs have to be downloaded onto the MSD Motion Controller and started to be executed by the MSD Motion Controller. The MACS development environment is needed to create executable IEC 61131 application programs for the MSD Motion Controller. With MACS, the application program can be programmed, compiled, downloaded and started.

- "3.6 MACS Development Environment" on page 25
- "10.5.1 Communication Between MSD Motion Controller and MACS" on page 68

Application programs can be saved and executed in the MSD Motion Controller in the following manner:

- As a boot project in the flash EEPROM
- In RAM

An application program saved as a boot project will be loaded into RAM whenever the MSD Motion Controller’s power supply is switched on or when the MSD Motion Controller is reset.

An application program that is only executed in RAM without being saved as a boot project will not be saved in the MSD Motion Controller when it is switched off or when the power supply fails or the Run/Stop/Reset switch is moved to the Reset position. After the power supply is switched back on or the Run/Stop/Reset switch is released from the Reset position, the application program must be downloaded again from the MACS development environment!

Behavior of the MSD Motion Controller at switching on and switching off the power supply:

- "10.8.1 Behavior at Switching on and Switching off" on page 73

3.6 MACS Development Environment

**WARNING**

The PC on which tools such as MACS development environment are installed must be suitable for the environmental conditions in which it will operate. This ensures fault-free, reliable, and safe operation.

MACS must be installed on a personal computer (PC). This PC then represents the PADT (programming and diagnostic tool) specified in IEC 61131.

**Scope of functionality of MACS**

- Programming, testing, and optimization of IEC 61131 application programs
- Documentation of IEC 61131 application programs
- Visualization of IEC 61131 application programs
- Hardware configuration of M3000® modules
MACS supports the following programming languages:

- Instruction List (IL)
- Structured Text (ST)
- Ladder Diagram (LD)
- Function Block Diagram (FBD)
- Sequential Function Chart (SFC)
- Continuous Function Chart (CFC)

Refer to the documentation for the MACS development environment for more detailed information.

The MACS development environment is available from Moog as an accessory.

3.6.1 MACS HMI Visualization Package

MACS is also available from Moog as a MACS HMI visualization package.

MACS HMI can be used only for the visualization of an application program. It does not include any functionality for creating or editing application programs.
4 Environmental Conditions

**WARNING** Maintain under all circumstances the required environmental conditions specified for the M3000® automation system or M3000® modules. This ensures fault-free, reliable, and safe operation.

**WARNING** The PC on which tools such as MACS development environment are installed must be suitable for the environmental conditions in which it will operate. This ensures fault-free, reliable, and safe operation.

**WARNING** It is not permissible to operate the M3000® automation system or M3000® modules in a potentially explosive environment.

**WARNING** The M3000® automation system and M3000® modules must not come into direct contact with liquids, except where explicitly specified. Danger of short-circuit! If they do come into direct contact with a liquid, immediately disconnect the power supply! Before bringing the system back into operation, it is essential that all affected components are completely dry and have been inspected by a suitably qualified technician.

### 4.1 Requirements of IEC 61131-2

The M3000® automation system and M3000® modules comply with the requirements of IEC 61131-2.

Where technical requirements lead to deviations from the standard, these are specified in this manual or in the documentation of the relevant M3000® modules.

Environmental conditions for the MSD Motion Controller:

* Refer to the relevant documentation for the specified environmental conditions for the other M3000® modules.
4.2 Use in Special Environments

In the following cases, M3000® modules must **not** be used without taking additional measures:

- At sites with difficult operating conditions, like those caused by
  - Large amounts of dust
  - Elevated air humidity
  - Aggressive vapors or gases
  - Corrosive atmospheres
  - Potentially explosive environments

In these cases, the suitable additional measures to be taken may include, for example, installation in specially designed cabinets.

- In systems that require special monitoring, such as:
  - Elevators
  - Electrical systems located in particularly (potentially) hazardous environments
  - In residential, commercial, and light-industrial environments
  - In medical environments

Examples of suitable additional measures in these cases may include:

- Installation in grounded, shielded metal cabinets
- Installation of filters in the power supply cables
- Use of shielded cables outside of cabinets
5 Mechanical Installation

5.1 View of the Module

Figure 14: Front View of MSD Motion Controller
5.2 Dimensions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>58.5 mm (2.30 in)</th>
<th>224 mm (8.82 in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td></td>
<td>(without accessories like mating connectors or plug-in terminal strips)</td>
</tr>
<tr>
<td>Height</td>
<td>295 mm (11.61 in)</td>
<td>When accessories like mating connectors or plug-in terminal strips are used, an installation depth of 50 mm (2 in) is usually required.</td>
</tr>
<tr>
<td>Depth</td>
<td></td>
<td>Overall Height</td>
</tr>
<tr>
<td></td>
<td></td>
<td>355 mm (13.98 in)</td>
</tr>
<tr>
<td>Bottom fastening plate</td>
<td>38.5 mm (1.52 in)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Dimensions of the MSD Motion Controller

Figure 15: Dimensions of the MSD Motion Controller
5.3 Arrangement

To attain the best result for EMC-compatible installation the module must be attached to a vertical, metal mounting plate and connected to the protective earth conductor.

Additional information about the grounding concept for M3000 modules:
⇒ "6.1 Grounding Concept" on page 34

Information about mounting/removing modules:
⇒ "5.4 Mounting" on page 32

Maintain the sufficient distances to ensure:

- Sufficient room for connecting the supply and signal cables
- Sufficient room for mounting or removing the modules
- Convection cooling

<table>
<thead>
<tr>
<th></th>
<th>Mounting clearances</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>E</strong></td>
<td>For direct side by side mounting</td>
</tr>
</tbody>
</table>
| **F** | 100 mm (3.94 in)  
The bending radius of the connecting leads must be accounted for |
| **G** | > 270 mm (10.63 in) |

Table 2: Mounting clearances

Figure 16: Mounting clearances for the MSD Motion Controller
5.4 Mounting

**WARNING** No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!

There is a danger of:
- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

**Procedure for mounting modules:**
1. Mark the position for the tapped holes on the backing plate.
2. Cut a tap for each fixing screw in the backing plate.
3. Mount the module vertically on the backing plate.

5.5 Removing

**WARNING** No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!

There is a danger of:
- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

**Procedure for removing modules:**
1. Loosen the fixing screws
2. Remove the module
6 Project Planning and Installation

The following instructions must be observed in order to ensure that the M3000® automation system will be safely integrated into its application environment:

- **IEC 61131**
  Especially the information contained in IEC 61131-4

- **Safety**
  All safety and accident prevention regulations applicable to the specific application (such as machinery directives, safety instructions contained in documentation, etc.)

- **Emergency stop**
  The emergency stop devices (DIN EN 60204) must remain in effect during all of the system's or facility's operational modes.

- **Restarting**
  Unlocking of the emergency stop devices must not lead to uncontrolled or undefined restarting.
  Dangerous operational conditions of any kind must not arise following interruption or failure of the power supply.

- **Voltage**
  Deviations and fluctuations of the supply and load voltages must not fall below or exceed the specified tolerances.
  Deviations outside the specified operating range might lead to dangerous conditions and functional disturbances in the automation system.

- **Power supply 24 V DC**
  M3000® modules must be supplied only with 24 V DC SELV (Safety Extra-Low Voltage) according to DIN EN 60950-1.
  ⇒ "6.2.1 Power Supply Characteristics" on page 35

- **Wire fault**
  A cable or wire fault must not lead to undefined conditions. All necessary safety precautions must be taken in the hardware and software.

- **Connection**
  All connection and signal cables must be installed in such a way that inductive or capacitive interferences will not impair the M3000® automation system.
6.1 Grounding Concept

For reasons of functional safety, all circuits must be grounded at a centralized point.

The PE-conductor of the module must have a low resistance connection to the protective earth conductor (PE).

Every circuit must be fused (maximum 12 A).

Load-controlled distribution of the circuits (U1…U3)

6.1.1 Front Panel Connectors' Grounding

The metal housings of all front panel connectors of the MSD Motion Controller and the extension modules are connected internally to the grounding of the housing.
6.2 Power Supply

The internal electronics of M3000® modules is usually supplied with power via the power supply terminals of the connectors of the M3000® modules.

Connecting the power supply for the internal electronics:
⇒ "6.2.3 Connecting the Power Supply" on page 36

Power supply terminals of the MSD Motion Controller:
⇒ "10.4.1 Terminal Assignment" on page 64

Refer to the relevant documentation for the exact designations of the power supply terminals of the other M3000® modules.

6.2.1 Power Supply Characteristics

**Output voltage**

- **Rated voltage:** 24 V DC, operates at no-load
  - SELV according to DIN EN 60950-1
  ⇒ "6.2.1.1 Safety Extra-Low Voltage (SELV)"
  on page 35
- **Run-up time (10–90 %):** ≤ 0.2 sec.

To ensure compatibility with other components, Moog recommends maintaining the power supply tolerance band specified in IEC 61131-2 (19.2 V to 30 V).

Refer to the relevant documentation for the specified voltage ranges of the M3000® modules.

Besides the specified voltage ranges, a total alternating voltage component with a peak value of 5% of the rated voltage is also permitted.

**Output current**

If the output current of the power supply is greater than 12 A, the power cable to each M3000® module must be fused to ≤ 12 A or the current must be limited in another way.

**Maximum permissible duration of power interruptions**

- **Under full load (PS1 intensity):** ≤ 1 ms
  (duration of interruption during voltage drops and interruptions to the input voltage)
- **During primary side voltage drops that are 1 ms or shorter in duration,** the output voltage must not fall under 19.2 V when under full load. In addition, the interval between the primary side drops must not be shorter than 1 s.

6.2.1.1 Safety Extra-Low Voltage (SELV)

The safety extra-low voltage is a voltage that will not, under any operating conditions, exceed 25 V AC or 60 V DC peak or direct voltage as measured between conductors or between a conductor and ground. The circuit in which SELV is used must be separated from the mains power supply by a safety transformer or something of equal functionality. Always observe national regulations when choosing the rated insulation voltage.
6.2.2 Power Consumption

<table>
<thead>
<tr>
<th>DIN Rail Module</th>
<th>Power Consumption 1) From 24 V DC (No-Load 2)</th>
<th>From 24 V DC (Full Load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSD Motion Controller Internal Electronics</td>
<td>about 0.3 A</td>
<td>max. 0.8 A</td>
</tr>
<tr>
<td>Digital Outputs</td>
<td>-</td>
<td>max. 2 A</td>
</tr>
<tr>
<td>RDIO</td>
<td>max. 0.3 A</td>
<td>max. 10 A</td>
</tr>
<tr>
<td>QDIO</td>
<td>-</td>
<td>max. 10 A</td>
</tr>
<tr>
<td>QAIO 16/4</td>
<td>about 0.15 A</td>
<td>max. 0.3 A</td>
</tr>
</tbody>
</table>

Table 3: Power Consumption

1) These values are provided only as guidelines for estimating the amount of current required. Refer to the relevant documentation for the exact power consumption by DIN rail modules.

2) No-load, i.e., there are no loads, external to the module, drawing current.

6.2.3 Connecting the Power Supply

**DANGER**
The 24 V power supply terminals of all M3000® modules are protected against reverse polarity. If the polarity of these power supply terminals is reversed, the modules will not work.

**WARNING**
No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!

There is a danger of:
- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

**WARNING**
M3000® modules must be protected from overvoltages and/or reverse energization from the sensor to the module!

There is a danger of:
- Permanent damage by overheating or fire
- Malfunctions

M3000® modules must have the correct voltage, polarity, and terminal assignments.
WARNING

The internal electronics of M3000® modules and attached sensors must be supplied with power from a permanently connected (unswitched) power supply that cannot be individually switched off, without switching off the module's power supply.

If a switched power supply is used, such as when there are intermediate switching devices (emergency stops, manual operators, etc.), the following problems might arise, depending on the state of the power supply for the internal electronics of the module and sensors (table 4 on page 37):

- Reverse energization from sensor to module
- Invalid sensor data

<table>
<thead>
<tr>
<th>Power Supply Conditions of the Module's Internal Electronics and the Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module and sensors are in operation</td>
</tr>
<tr>
<td>Reverse energization from sensor to module</td>
</tr>
<tr>
<td>Invalid sensor data</td>
</tr>
<tr>
<td>Module and sensors are not in operation</td>
</tr>
<tr>
<td>Internal Electronics</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>on</td>
</tr>
<tr>
<td>off</td>
</tr>
<tr>
<td>on</td>
</tr>
<tr>
<td>off</td>
</tr>
</tbody>
</table>

Table 4: Power Supply Conditions of the Module's Internal Electronics and the Sensors

Refer to the relevant documentation for information about the power supply terminals of the other M3000® modules.

Internal module capacities might cause power spikes of up to 50 A when switching on the power supply for the internal electronics of the M3000® module. The duration of these spikes is strongly dependent on the internal resistance of the power supply.

6.2.3.1 Maximum Admissible Current

All of the power supply terminals of M3000® modules and the associated internal connections are designed for a maximum current of 12 A.

If the current is greater than the maximum current, the following must be employed:

- Several separately fused circuits or
- Several separate power supplies in separated circuits
6.2.4 Connecting Sensors

**WARNING** The internal electronics of M3000® modules and attached sensors must be supplied with power from a permanently connected (unswitched) power supply that cannot be individually switched off, without switching off the module’s power supply.

If a switched power supply is used, such as when there are intermediate switching devices (emergency stops, manual operators, etc.), the following problems might arise, depending on the state of the power supply for the internal electronics of the module and sensors ([table on page 37]):

- Reverse energization from sensor to module
- Invalid sensor data

**WARNING** Sensors that are connected to digital inputs of M3000® modules with several I/O groups, such as MSC I, QDIO, or RDIO, must under all conditions be supplied from the same power supply as the corresponding I/O group to which the sensor is connected!

Otherwise, if the power supply for the internal electronics of the module is switched off, there might be reverse energization from the sensor to the module.

There is a danger of:

- Uncontrolled movements
- Fault or failure of a manual control
- Permanent damage to the module
- Malfunctions

Digital I/Os of MSC II and MSD Motion Controller are protected against reverse energization.
The attached sensors must be supplied with power from a permanently connected (unswitched) power supply that cannot be individually switched off, without switching off the module's power supply. Power must not, as shown in figure 19 on page 40, be supplied from switched power circuits!

The sensors within an I/O group must always be supplied with power from the same power supply that supplies the relevant I/O group. They must not, as shown in figure 19 on page 40, be supplied from a separate power supply (due to the danger of reverse energization)!

Outputs may be supplied with power from a switched power supply, for example with intermediate devices (emergency stop, manual operation, etc.).
The attached sensors must be supplied with power from a permanently connected (unswitched) power supply that cannot be individually switched off, without switching off the module’s power supply. Power must not, as shown here, be supplied from switched power circuits!

The sensors within an I/O group must always be supplied with power from the same power supply that supplies the relevant I/O group. They must not, as shown here, be supplied from a separate power supply (due to the danger of reverse energization)!

Figure 19: Wrong Power Supply Connection of Sensors via a QDIO
6.3 Connecting Signal Cables

**WARNING**

No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!

There is a danger of:

- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

The signal cables of M3000® modules are connected over plug-in terminal strips that are inserted into the relevant connectors on the front of the module.

### 6.3.1 Plug-In Terminal Strips

Plug-in terminal strips for the following methods are available from Moog:

- Screw terminals
- Spring loaded terminals

All plug-in terminal strips are suitable for wire cross sections of up to 2.5 mm² (14 AWG).

⇒ "11.8 Plug-In Terminal Strips" on page 94

### 6.3.1.1 Spring Loaded Terminals

**CAUTION**

When connecting a wire, insert the screwdriver only into the rectangular opening of the spring loaded terminal. If a screwdriver is inserted into the round opening for the wire, the spring loaded terminal might be destroyed.

Spring loaded terminals make it easy to rapidly connect supply and signal cables.

Procedure for connecting a wire:

1. Insert the tip of a screwdriver into the rectangular opening of the spring loaded terminal and press the screwdriver downward.
2. Insert the wire into the corresponding round opening.
3. Remove the screwdriver from the opening. The spring will hold the wire in place.
7 Networking M3000® Modules

7.1 Ethernet

WARNING

Do not connect EtherCAT to any other Ethernet networks. The high rate of telegrams which are transmitted by EtherCAT will prevent other devices like computers and servers on the network from transmitting data.

There is a danger of

- Network overload/breakdown
- Malfunction of connected devices
- Data loss at connected devices

It is strongly recommended to use cables of a special color only for EtherCAT connections.

Refer to the following for information about using the Ethernet interface to facilitate communication between the MSD Motion Controller and the MACS development environment:

- "3.1 M3000® System Architecture" on page 14
- "10.5.1 Communication Between MSD Motion Controller and MACS" on page 68
- "10.5.1.1 Ethernet Communication Interface" on page 68

7.1.1 Peer-to-Peer Connections

To establish a peer-to-peer connection between 2 stations in an Ethernet network, 100BaseT cables with twisted pair wires are needed.

Figure 22 on page 43

![Diagram of Peer-to-Peer Connection of 2 Network Stations]

- 100BaseT patch or crossover cable with twisted pair wires for MSC II and MSD Motion Controller
- 10BaseT crossover cable with twisted pair wires for MSC I
7.1.2 Networking of More Than 2 Network Stations

A hub or switch is needed for Ethernet networks that have more than 2 stations. The hub transfers the signals sent from one of the stations to every other station in the network.

![Diagram of an Ethernet network with more than 2 network stations.]

- 100BaseT patch or crossover cable with twisted pair wires for MSC II and MSD Motion Controller
- 10BaseT patch cable with twisted pair wires for MSC I

7.1.3 Ethernet Interface Cables

- **100BaseT Cable with Crossed Twisted Pair Wires (Crossover Cable)**
- **100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable)**

For the terminal assignment of the Ethernet front panel connector of the MSD Motion Controller, see: ☝️ Ethernet connector on page 64
7.2 EtherCAT

**WARNING** Do not connect EtherCAT to any other Ethernet networks. The high rate of telegrams which are transmitted by EtherCAT will prevent other devices like computers and servers on the network from transmitting data.

There is a danger of
- Network overload/breakdown
- Malfunction of connected devices
- Data loss at connected devices

It is strongly recommended to use cables of a special color only for EtherCAT connections.

Technical data:
- 100 Mbit/s transfer rate
- Maximal cable length between two devices: 100 m
- Termination: device internally

### 7.2.1 Bus Topology

The network physical topology is line.

The connection between two devices is a point to point connection. Thus each slave device has an input and an output connector which relays the data to the next slave device in the line.

![EtherCAT Bus Topology](image)

**Figure 24: EtherCAT Bus Topology**

### 7.2.2 EtherCAT Interface Cables

![EtherCAT Interface Cables](image)

**Figure 25: 100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable)**

For the terminal assignment of the EtherCAT front panel connector of the MSD Motion Controller, see: [EtherCAT connector on page 64](#)
7.3 Profibus

7.3.1 Overview

The Profibus is a differential two wire bus. The transmission physics of the serial bus system is defined by the TIA/EIA-485 specification. Shielded twisted pair copper cable with one conductor pair is typically used. The bus structure allows addition or removal of stations or the step-by-step commissioning of the system without influencing other stations.

- Various transmission rates
- Uniform speed for all devices on the bus
- Connection of up to 32 stations without additional repeater possible

7.3.2 M3000® Modules with Profibus DP Interfaces

Information about the Profibus interface cable:

⇒ "7.3.4 Profibus Interface Cable" on page 47

Information about the Profibus interface of the MSD Motion Controller:

⇒ "10.11 Profibus DP Interface" on page 82

The M3000® modules mentioned here represent only a part of Moog's current product range. In addition to other M3000® modules, Moog's product range includes a large variety of accessories.

⇒ "11 Product Range" on page 87

Refer to the relevant documentation for detailed information about the Profibus interfaces of the other M3000® modules.

7.3.3 Profibus Networks

7.3.3.1 Wiring

Always observe the following when wiring Profibus networks:

- EC 61158/EN 50170
  The cables, mating connectors, and termination resistors used in Profibus networks must comply with IEC 61158/EN 50170. It is recommended to use only connections of cable type A, to use the full bandwidth of 12 Mbaud.

- Specifications for interface cables
  ⇒ "7.3.4.4 Suitable Cables" on page 48

- Linear structure of Profibus
  Avoid branching. Short stub cables with a T-adapter or special Profibus connectors with internal T-adapter are permitted.
  ⇒ "7.3.3.2 Bus Structure of the Profibus" on page 46

- Stub cables as short as possible
  Maximum length of all stub cables < 6.6 m at baud rates < 1500 kbit/s. No stub cables recommended at higher baud rates.

- Profibus termination resistors
  At both ends of the Profibus network, termination resistors must be connected to guarantee specified signal levels.

- Adapt transmission rate to cable length
  It is necessary to adapt the transmission rate to the length of the Profibus interface cable.
  ⇒ "7.3.4.3 Cable Lengths" on page 48
• Sources of interference
  Do not lay Profibus interface cables in direct proximity to sources of interference.

7.3.3.2 Bus Structure of the Profibus

All devices are connected in a linear bus structure. Up to 32 stations (master or slaves) can be connected in a single segment. The beginning and the end of each segment is fitted with an active bus terminator. Both bus terminators have a permanent power supply to ensure error-free operation. The bus terminator is usually switched in the connectors. If more than 32 stations are implemented or there is a need to expand the network area, repeaters must be used to link the individual bus segments.

D-sub connectors with Profibus termination resistors are available from Moog.

Profibus networks with M3000® modules can include a maximum of 126 Profibus network stations.
⇒ “7.3.3.3 Number of Network Stations” on page 46

Profibus interface cable
⇒ “7.3.4 Profibus Interface Cable” on page 47

7.3.3.3 Number of Network Stations

Profibus networks with M3000® modules can only include a maximum of 32 Profibus network stations. With repeater stations the network can be expanded to a maximum of 126 stations within the address range of 0 to 125. Each repeater reduces the maximum number of network stations, as a repeater is a passive network station without any address.

IEC 61158/EN 50170 specifies networks with up to 126 Profibus network stations. The performance to the Profibus master may limit the maximum number of slaves. The number of network stations also influences the reaction time that can be achieved by the bus.
7.3.4 Profibus Interface Cable

7.3.4.1 Terminal Assignment

Table 5: Connector Pin out

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Signal</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shield</td>
<td>Shield / grounding</td>
</tr>
<tr>
<td>2</td>
<td>M24</td>
<td>24 V output voltage (ground)</td>
</tr>
<tr>
<td>3</td>
<td>RxD/TxD-P</td>
<td>Receive / transmission data - positive potential</td>
</tr>
<tr>
<td>4</td>
<td>CNTR-P</td>
<td>Control signal for repeater (direction control)</td>
</tr>
<tr>
<td>5</td>
<td>DGND</td>
<td>Potential of transmission data (ground to 5 V)</td>
</tr>
<tr>
<td>6</td>
<td>VP</td>
<td>Power supply of the terminators (+5 V)</td>
</tr>
<tr>
<td>7</td>
<td>P24</td>
<td>24 V output voltage</td>
</tr>
<tr>
<td>8</td>
<td>RxD/TxD-N</td>
<td>Receive / transmission data - negative potential</td>
</tr>
<tr>
<td>9</td>
<td>CNTR-N</td>
<td>Control signal for repeater (direction control)</td>
</tr>
</tbody>
</table>

1) These signals are mandatory and must be provided by the user.
### 7.3.4.3 Cable Lengths

<table>
<thead>
<tr>
<th>Transmission Rate</th>
<th>Maximum Cable Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,000 kBit/s</td>
<td>100 m (109 yd)</td>
</tr>
<tr>
<td>6,000 kBit/s</td>
<td>100 m (109 yd)</td>
</tr>
<tr>
<td>3,000 kBit/s</td>
<td>100 m (109 yd)</td>
</tr>
<tr>
<td>1,500 kBit/s</td>
<td>200 m (219 yd)</td>
</tr>
<tr>
<td>500 kBit/s</td>
<td>400 m (437 yd)</td>
</tr>
<tr>
<td>187.5 kBit/s</td>
<td>1,000 m (1,094 yd)</td>
</tr>
<tr>
<td>93.75 kBit/s</td>
<td>1,200 m (1,312 yd)</td>
</tr>
<tr>
<td>45.45 kBit/s</td>
<td>1,200 m (1,312 yd)</td>
</tr>
<tr>
<td>19.2 kBit/s</td>
<td>1,200 m (1,312 yd)</td>
</tr>
<tr>
<td>9.6 kBit/s</td>
<td>1,200 m (1,312 yd)</td>
</tr>
</tbody>
</table>

Table 6: Maximum Cable Lengths in Profibus Networks (Depending on the Transmission Rate)

The guiding values in table 6 are valid only for Profibus networks that were established in compliance with the requirements in "7.3.3.1 Wiring" on page 45.

<table>
<thead>
<tr>
<th>Transmission Rate</th>
<th>Maximum Stub Cable Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,000 kBit/s</td>
<td>no stub cable allowed</td>
</tr>
<tr>
<td>1,500 kBit/s</td>
<td>&lt; 1.5 m</td>
</tr>
<tr>
<td>500 kBit/s</td>
<td>&lt; 6.6 m</td>
</tr>
</tbody>
</table>

Table 7: Maximum Permissible Stub Cable Length in Profibus Networks (Depending on the Transmission Rate)

### 7.3.4.4 Suitable Cables

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Cable Type A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop resistance at 3-20 MHz</td>
<td>135-165 Ω (150 Ω ±10 %)</td>
</tr>
<tr>
<td>Capacity</td>
<td>&lt; 30 pF/m</td>
</tr>
<tr>
<td>Impedance</td>
<td>&lt; 110 Ω/km</td>
</tr>
<tr>
<td>Wire diameter</td>
<td>&gt; 0.64 mm</td>
</tr>
<tr>
<td>Wire Cross Section</td>
<td>&gt; 0.34 mm²</td>
</tr>
</tbody>
</table>

Table 8: Suitable Cables for Profibus Interface Cables

The selection of a suitable cable also depends on site conditions (towing application, environmental considerations, etc.)
7 Networking M3000® Modules

7.4 CAN Bus and CANopen

7.4.1 CAN Bus

The CAN bus is a differential two wire bus that was originally developed to facilitate rapid and reliable networking of components in motor vehicles. The many advantages and high reliability of the CAN bus have also made it suitable for use in automation systems and have contributed to it becoming a widespread standard.

7.4.2 CAN Bus Characteristics

CAN bus exhibits the following characteristics:

- Linear topology that can be structured hierarchically
- Message oriented protocol
- Prioritization of messages
- Multi master capability
- Zero loss bus arbitration
- Short block length
- High security of data transmission with very short error recovery times
- Network data consistency
- Detection and disconnection of defective network stations
- Short reaction time for high priority messages
- Standardization (ISO/DIS 11898)
- Cost effective protocol implementation

CAN bus network stations can exchange messages between each other in real time over the CAN bus. For example, set points, actual values, control messages, status messages, as well as configuration and parameter data can be transmitted over the CAN bus.

Identifiers act as message labels in the CAN protocol. The messages can be received by all network stations simultaneously, which is very important for consistency of the data in the network and synchronization of the applications. The identifier determines the message's bus access priority.

CAN bus is a multi master system, i.e., every station in the network can send messages. If several stations attempt to send messages at the same time, the highest priority messages will be sent first. This method guarantees bus assignment without destroying the contents of the messages.
7.4.3 CANopen

CANopen is a standardized communication profile that makes it easy to establish a network of CANopen compatible devices from a variety of manufacturers. CANopen is based on CAN bus. The communication profile complies with the standard CiA DS 301.

Various device profiles have been defined by the CiA in order to facilitate the connection of various devices classes, such as drives, controllers, angle transmitters, valves, etc. These device profiles enable uniform control of several devices with the same functionality, regardless of manufacturer and model.

7.4.4 M3000® Modules with CAN Bus Interfaces

<table>
<thead>
<tr>
<th>M3000® Module</th>
<th>Number of Connectors</th>
<th>Number of CAN Bus Controllers</th>
<th>CAN Bus Termination Resistor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSD Motion Controller CAN</td>
<td>2 D-sub front panel connectors 1)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>MSC I and MSC II LocalCAN</td>
<td>2 Q-connectors (lateral)</td>
<td>1 switchable</td>
<td></td>
</tr>
<tr>
<td>MSC I and MSC II WideCAN</td>
<td>2 D-sub front panel connectors 2)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>RDIO</td>
<td>2 D-sub front panel connectors 2)</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>RDISP</td>
<td>1 D-sub connector (on the rear)</td>
<td>1 switchable</td>
<td></td>
</tr>
<tr>
<td>QEBUS-CAN LocalCAN</td>
<td>1 Q-connector (lateral)</td>
<td>0 switchable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 D-sub connector (front)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: M3000® Modules with CAN Bus Interfaces

1) The «CAN» front panel connectors are connected internally 1:1 with each other. As a result, the MSD Motion Controller can be connected directly to the CAN bus without a T-adapter.

2) The «WCAN» or «CAN» front panel connectors are connected internally 1:1 with each other. As a result, the M3000® modules can be connected directly to the CAN bus without a T-adapter.

The M3000® modules mentioned here represent only a part of Moog's current product range. In addition to other M3000® modules, Moog's product range includes a large variety of accessories.

⇒ "11 Product Range" on page 87

Information about the CAN bus interface cable:
⇒ "7.4.6 CAN Bus Interface Cable" on page 53

Information about the CAN bus interfaces of the MSD Motion Controller:
⇒ "10.13 CAN Bus Interfaces" on page 84

Refer to the relevant documentation for detailed information about the CAN bus interfaces of the other M3000® modules.
7.4.5 CAN Bus Networks

7.4.5.1 Wiring

Always observe the following when wiring CAN bus networks:

- **ISO/DIS 11898**
  The cables, mating connectors, and termination resistors used in CAN bus networks must comply with ISO/DIS 11898.

- **Specifications for interface cables**
  When connecting CAN bus network stations, always use shielded cables with 4 twisted pair wires and an impedance of 120 Ω.
  ⇒ "7.4.6 CAN Bus Interface Cable" on page 53

- **Linear structure of CAN bus**
  Avoid branching. Short stub cables with a T-adapter are permitted.
  ⇒ "7.4.5.2 Bus Structure of the CAN Bus" on page 52

- **Stub cables as short as possible**
  Maximum stub cable length: ⇒ table 11 on page 53

- **CAN bus termination resistors**
  At both ends of the CAN bus, a termination resistor of 120 Ω ± 10 % must be connected between CAN_L and CAN_H.

- **Adapt transmission rate to cable length**
  It is necessary to adapt the transmission rate to the length of the CAN bus interface cable.
  ⇒ Table 10 on page 53

- **Sources of interference**
  Do not lay CAN bus interface cables in direct proximity to sources of interference. If this cannot be avoided, double shielded interface cables must be used.

- **Potential equalization at only one point**
  The CAN_GND and CAN_SHLD reference potential may be connected to the signal ground at only one point (at a CAN bus termination resistor, for example).
  ⇒ Figure 29 on page 52

- **Grounding**
  The power supply for M3000® modules must be grounded at the same point as the CAN_GND wire.
7.4.5.2 Bus Structure of the CAN Bus

The CAN bus has a linear structure. Avoid branching. Short stub cables with a T-adapter are permitted.

![Linear Structure of the CAN Bus](image)

1. D-sub connectors with CAN bus termination resistors are available from Moog.
   ⇒ "11.7 CAN Bus Accessories" on page 93

2. CAN bus networks with M3000® modules can include a maximum of 64 CAN bus network stations.
   ⇒ "7.4.5.3 Number of Network Stations" on page 52

3. CAN bus interface cable
   ⇒ "7.4.6 CAN Bus Interface Cable" on page 53

7.4.5.3 Number of Network Stations

CAN bus networks with M3000® modules can include a maximum of 64 CAN bus network stations.

ISO/DIS 11898 only specifies networks with up to 30 CAN bus network stations.

As a result, when integrating other devices than M3000® modules into a CAN bus network with M3000® modules, the maximum number of CAN bus network stations might be limited by any existing, older CAN bus drivers.

CAN Bus Networks with M3000® Modules:
max. 64 Network Stations
7.4.6 CAN Bus Interface Cable

7.4.6.1 Terminal Assignment

To ensure disturbance-free operation, it is required that a CAN_GND wire is used in the cable.

Terminal assignment of the CAN connectors on the front panel of the MSD Motion Controller: ⇒ "10.4.1 Terminal Assignment" on page 64

7.4.6.2 Cable Lengths

The maximum expansion of a CAN bus network will be determined by a variety of variables, such as cable length, transmission rate, and resistance in the cable.

<table>
<thead>
<tr>
<th>Transmission Rate</th>
<th>Maximum Cable Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 kBit/s</td>
<td>25 m (27 yd)</td>
</tr>
<tr>
<td>800 kBit/s</td>
<td>50 m (54 yd)</td>
</tr>
<tr>
<td>500 kBit/s</td>
<td>100 m (109 yd)</td>
</tr>
<tr>
<td>250 kBit/s</td>
<td>250 m (273 yd)</td>
</tr>
<tr>
<td>125 kBit/s</td>
<td>500 m (546 yd)</td>
</tr>
<tr>
<td>100 kBit/s</td>
<td>650 m (710 yd)</td>
</tr>
<tr>
<td>50 kBit/s</td>
<td>1,000 m (1,093 yd)</td>
</tr>
<tr>
<td>20 kBit/s</td>
<td>2,500 m (2,734 yd)</td>
</tr>
<tr>
<td>10 kBit/s</td>
<td>5,000 m (5,468 yd)</td>
</tr>
</tbody>
</table>

Table 10: Maximum Cable Lengths in CAN Bus Networks (Depending on the Transmission Rate)

<table>
<thead>
<tr>
<th>Transmission Rate</th>
<th>Maximum Stub Cable Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td>1,000 kBit/s</td>
<td>2 m (2.1 yd)</td>
</tr>
<tr>
<td>500 kBit/s</td>
<td>6 m (6.5 yd)</td>
</tr>
<tr>
<td>250 kBit/s</td>
<td>6 m (6.5 yd)</td>
</tr>
<tr>
<td>125 kBit/s</td>
<td>6 m (6.5 yd)</td>
</tr>
</tbody>
</table>

Table 11: Maximum Permissible Stub Cable Lengths in CAN Bus Networks

The guiding values in tables 10 and 11 are valid only for CAN bus networks that were established in compliance with the requirements in "7.4.5.1 Wiring" on page 51.
### 7.4.6.3 Suitable Cables

<table>
<thead>
<tr>
<th>Parameters</th>
<th>M3000® Recommendation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Wires</td>
<td>≥ 4, twisted pairs</td>
<td></td>
</tr>
<tr>
<td>Wire Cross Section (for Cu)</td>
<td>0.22–0.34 mm² (24–22 AWG)</td>
<td>When the network is spread out over a greater distance, a larger wire cross section will provide a better signal-to-noise ratio.</td>
</tr>
<tr>
<td>Cable Structure</td>
<td>2 twisted pairs with shielding</td>
<td>Electrically connect the shield to the mating connector’s housing and the shielding shroud of the plug-in devices.</td>
</tr>
<tr>
<td>Impedance (1 MHz)</td>
<td>120 Ω</td>
<td>If different cables are used, make sure they have the same impedance.</td>
</tr>
</tbody>
</table>

Table 12: Suitable Cables for CAN Bus Interface Cables

The selection of a suitable cable also depends on site conditions (towing application, environmental considerations, etc.)

- For normal use Moog recommends the CAN bus data cable "UNITRONIC® BUS LD" supplied by LAPP KABEL ([http://www.lapp.de](http://www.lapp.de)) or "577 FlexLife™ Thin Cable" or the "5710 FlexLife™ Mid Cable" or the "575 FlexLife™ Thick Cable" supplied by Hans Turck GmbH & Co. KG ([http://www.turck.com](http://www.turck.com)).

- CAN bus interface cables are available from Moog as accessories, in a variety of lengths.  
  ⇝ "11.6 Interface Cables" on page 93
8 Shutdown and Service

WARNING To avoid damage to M3000® modules or accessories, cleaning, maintenance, and repair tasks may be performed only by Moog or Moog’s authorized service agents.

Warranty and liability claims for personal and material damage are excluded when, among other reasons, they are due to unauthorized repairs or other unauthorized interventions. ⇒ "1.4 Warranty and Liability" on page 3

WARNING No work of any kind, such as mounting, removing, wiring, or repairs to the M3000® modules may be performed while the modules are in operation!

There is a danger of:
- Uncontrolled movements
- Permanent damage
- Malfunctions

Before performing any work on M3000® modules, it is essential that the system is stopped and the power supply is disconnected.

Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

WARNING The M3000® automation system and M3000® modules must not come into direct contact with liquids, except where explicitly specified. Danger of short-circuit!

If they do come into direct contact with a liquid, immediately disconnect the power supply! Before bringing the system back into operation, it is essential that all affected components are completely dry and have been inspected by a suitably qualified technician.

8.1 Shutdown

WARNING If an M3000® module is to be taken out of operation, the entire system must always be shut down and disconnected from all power supplies.

Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

The M3000® module must be protected against unintentional restarting!

If the M3000® module is connected to other devices and/or facilities, always consider the full consequences and take appropriate precautions before switching off the module.
8.2 Service

**WARNING**  To avoid damage to M3000® modules or accessories, cleaning, maintenance, and repair tasks may be performed only by Moog or Moog's authorized service agents.

Warranty and liability claims for personal and material damage are excluded when, among other reasons, they are due to unauthorized repairs or other unauthorized interventions. ⇒ "1.4 Warranty and Liability" on page 3

**CAUTION**  To avoid damage to the internal components, never attempt to open M3000® modules!

8.2.1 Maintenance/Servicing

M3000® modules are maintenance-free. They do not contain any components (such as batteries) that must be maintained or replaced.

8.2.2 Repair

Only Moog and Moog's authorized service stations perform **Moog Authentic Repairs**. Only Moog and Moog's authorized service agents can access the required and most up-to-date specifications. These specifications make it possible to restore the M3000® modules' original performance and ensure the same high reliability and long service life of the M3000® modules after repairs are completed.

Moog's repair seal is the guarantee that a Moog Authentic Repair has been carried out.

- If Moog receives a repair order for defective M3000® modules, Moog and Moog's authorized service agents reserve the right to repair the defective module or, alternatively, to replace the defective module with a module of identical or compatible specifications.

- If Moog receives a repair order for defective M3000® modules, Moog and Moog's authorized service agents accept no liability for software and data installed by the customer. Like new modules, repaired modules or replacement modules are delivered only with a bootloader.
9 Transportation and Storage

WARNING

Maintain, under all circumstances, the required environmental conditions specified for transportation and storage of the M3000® automation system or M3000® modules.

- "9.1 Environmental Conditions" on page 57
This ensures fault-free, reliable, and safe operation.

CAUTION

To avoid condensation, do not start M3000® modules until they have reached ambient temperature.

CAUTION

To avoid damage, M3000® modules and accessories must be transported and stored in their original packaging.

Warranty and liability claims for personal or material damage will be excluded when they are the result of, among other things, storing or transporting M3000® modules or accessories outside of their original packaging.

- "1.4 Warranty and Liability" on page 3

9.1 Environmental Conditions

Ambient temperature (IEC 61131-2)
–25 °C to +70 °C (–13 °F to +158 °F)

Relative air humidity (IEC 61131-2)
5 % to 95 % non-condensing

Contamination level (IEC 60664)
2

Resistance to corrosion (IEC 60068)
No protection

Air pressure (IEC 61131-2)
≥ 70 kPa (corresponds to an elevation of ≤ 3,000 m (3,280 yd))

Drop height (free fall in the original packaging) (IEC 60068-2-31)
≤ 1 m (39 in)
10 MSD Motion Controller

The MSD Motion Controller is a programmable multi-axis controller that facilitates rapid and precise control of process variables such as position, speed, and power. It is suitable for use with both electric and hydraulic drives.

The MSD Motion Controller is programmed and configured with the MACS development environment (complies with IEC 61131).

3.5 Application Programs" on page 25

10.1 Performance Characteristics

10.1.1 Interfaces

The MSD Motion Controller provides the following interfaces:

- 2 EtherCAT Master interfaces
  - «EC1» and «EC2» front panel connector
  - "10.12 EtherCAT" on page 83
- 1 CAN bus interface
  - «CAN»: 2 front panel connectors (connected internally 1:1)
  - "10.13 CAN Bus Interfaces" on page 84
- 1 Ethernet interface on the front panel
  - «LAN» front panel connector
  - "10.5.1.1 Ethernet Communication Interface" on page 68
- 2 RT-ETH Real Time Ethernet interfaces (optional)
  - «RT-ETH1» and «RT-ETH2» front panel connectors
- 1 USB 1.1 Host interface with USB-A connector
  - «USB» front panel connector
- 1 Fieldbus interface
  - «F-Bus» connector
  (provided for optional fieldbus extension, such as Profibus)
10.1.2 I/Os (Inputs/Outputs)

The MSD Motion Controller provides the following I/Os:

- 4 Digital I/Os
  each individually configurable as an input or an output
  ⇒ "10.10 Digital I/Os" on page 75
- 1 Digital output 'Outputs Enabled'
  ⇒ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85

The I/Os are configured in the PLC Configuration of the MACS development environment.

10.1.3 Safety Functions

The MSD Motion Controller provides the following safety functions:

- Watchdog for monitoring the functionality of the software
  ⇒ "10.14.1 Watchdog" on page 85
- Output 'Outputs Enabled' for signaling the activation of all outputs as well as EtherCAT communication
  ⇒ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85

10.2 General Specifications

Dimensions
Overall W × H × D in mm (in):
58.5 × 355 × 224 (2.3 × 13.98 × 8.82)
⇒ Figure 32 on page 60

Weight
Approx. 2.5 kg (5.5 lb) without plug-in terminal strips, with license key

Processor
PowerPC CPU 400 MHz, 32 Bit, RISC architecture with floating point unit

Memory
32 MB flash EEPROM
128 MB RAM

Data retention
> 10 Years for all data that is saved in the flash EEPROM, i.e., boot project, error messages
10.2.1 Dimensions

![Dimensions of the MSD Motion Controller](image)

Figure 32: Dimensions of the MSD Motion Controller

10.2.2 Environmental Conditions

**WARNING** Maintain under all circumstances the required environmental conditions specified for the M3000® automation system or M3000® modules. This ensures fault-free, reliable, and safe operation.

**WARNING** It is not permissible to operate the M3000® automation system or M3000® modules in a potentially explosive environment.

**WARNING** The M3000® automation system and M3000® modules must not come into direct contact with liquids, except where explicitly specified. Danger of short-circuit! If they do come into direct contact with a liquid, immediately disconnect the power supply! Before bringing the system back into operation, it is essential that all affected components are completely dry and have been inspected by a suitably qualified technician.
10.2.2.1 Climatic Conditions

**Ambient temperature** (IEC 61131-2)
- For operation (when installed properly): +5 °C to +55 °C
  (+41 °F to +131 °F)
- Average temp. over 24 hours: max. +50 °C (+122 °F)
- For transportation and storage (in the original packaging): −25 °C to +70 °C
  (−13 °F to +158 °F)

**Relative air humidity** (IEC 61131-2)
- For operation: 10 % to 95 % non-condensing
- For transportation and storage (in the original packaging): 5 % to 95 % non-condensing

**Contamination level** (IEC 60664)
- 2

**Resistance to corrosion** (IEC 60068)
- No protection

**Operating Elevation** (IEC 61131-2)
- ≤ 2,000 m (2,187 yd) above MSL

**Air pressure for transportation** (IEC 61131-2)
- ≥ 70 kPa (corresponds to an elevation of ≤ 3,000 m (3,280 yd))

10.2.2.2 Mechanical Conditions and Requirements

**Sinusoidal oscillations** (IEC 60068-2-6)
- 10 Hz ≤ f < 57 Hz: 0.0357 mm (0.0014 in) continuous amplitude
  0.075 mm (0.00295 in) random amplitude
- 57 Hz ≤ f < 150 Hz: 0.5 g continuous constant acceleration
  1.0 g random constant acceleration
- f > 150 Hz: not defined

**Shock** (IEC 60068-2-27)
- Random peaks up to 15 g longer than 11 ms, half-sine wave in each of the three orthogonal axes

**Drop height** (free fall in the original packaging) (IEC 60068-2-31)
- ≤ 1 m (39 in)

**Protection class** (IEC 60529)
- IP20

10.2.2.3 Electrical Conditions and Requirements

**Power supply**
- 24 V DC
  (Safety Extra-Low Voltage (SELV) according to DIN EN 60950-1)
  Specified voltage range: 18–36 V DC
  ⇒ "6.2 Power Supply" on page 35

**Insulation resistance**
- Rated voltage: 0–50 V DC
- Test voltage for 2,000 m (2,187 yd) operating elevation: 500 V DC
10.3 Block Diagram

Figure 33: Block Diagram of the MSD Motion Controller

1) Hardware option. When ordering the MSD Motion Controller, the type of the fieldbus interface must be specified.
10.4 View of the Module and Terminal Assignment

![Diagram of MSD Motion Controller](image)

- **X13 F-Bus**: Profibus
- **X12 RT-ETH2, X11 RT-ETH1**: Real-time Ethernet RJ45 10/100 Mbit/s
- **X7 CAN, X6 CAN**: CAN Bus (internally connected 1:1)
- **X5 USB**
- **X4 LAN**: LAN and Programming Interface RJ45 10/100 Mbit/s
- **X1 EC1, X2 EC2**: EtherCAT Master Interfaces

LEDs:
- **OutEN**: 7 6 CAN
- **I/O4**: 8 5 LED4
- **I/O3**: 9 4 LED3
- **I/O2**: 10 3 LED2
- **I/O1**: 11 2 LED1
- **+24 V**: 12 1 Error

**X3 Digital I/O**:
- **OutEN**: 8 7 DGND I/O
- **I/O4**: 9 6 DGND I/O
- **I/O3**: 10 5 DGND I/O
- **I/O2**: 11 4 DGND I/O
- **I/O1**: 12 3 DGND I/O
- **DGND I/O**: 13 2 DGND I/O
- **+24 V I/O**: 14 1 +24 V I/O

Figure 34: Front Panel of the MSD Motion Controller

![Diagram of MSD Motion Controller](image)

- **X10**: Power supply DGND +24 V
- **X9**: Power supply DGND +24 V

Figure 35: Top view of the MSD Motion Controller
### 10.4.1 Terminal Assignment

<table>
<thead>
<tr>
<th>Connector</th>
<th>No.</th>
<th>Assignment</th>
<th>Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>1</td>
<td>Tx+</td>
<td>Transmit data+</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Tx-</td>
<td>Transmit data-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Rx+</td>
<td>Receive data+</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Rx-</td>
<td>Receive data-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X2</td>
<td>1</td>
<td>Tx+</td>
<td>Transmit data+</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Tx-</td>
<td>Transmit data-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Rx+</td>
<td>Receive data+</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Rx-</td>
<td>Receive data-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X3</td>
<td>1</td>
<td>+24 V I/O</td>
<td>+24 V power supply for digital I/Os</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>DGND I/O</td>
<td>Ground for the digital I/Os' power supply</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>DGND I/O</td>
<td>Ground for the digital I/Os' power supply</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>DGND I/O</td>
<td>Ground for the digital I/Os' power supply</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>DGND I/O</td>
<td>Ground for the digital I/Os' power supply</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>DGND I/O</td>
<td>Ground for the digital I/Os' power supply</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>DGND I/O</td>
<td>Ground for the digital I/Os' power supply</td>
</tr>
</tbody>
</table>
|           | 8   | OutEN      | Digital output 'Outputs Enabled'  
  ⇔ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85 |
|           | 9   | I/O4       | Digital I/O 4  
  ⇔ "10.10 Digital I/Os" on page 75 |
|           | 10  | I/O3       | Digital I/O 3 |
|           | 11  | I/O2       | Digital I/O 2 |
|           | 12  | I/O1       | Digital I/O 1 |
|           | 13  | DGND I/O   | Ground for the digital I/Os' power supply |
|           | 14  | +24 V I/O  | +24 V power supply for digital I/Os |
| X4        | 1   | Tx+        | Transmit data+                 |
|           | 2   | Tx-        | Transmit data-                 |
|           | 3   | Rx+        | Receive data+                  |
|           | 4   |            |                                 |
|           | 5   |            |                                 |
|           | 6   | Rx-        | Receive data-                  |
|           | 7   |            |                                 |
|           | 8   |            |                                 |

Table 13: Terminal Assignment of MSD Motion Controller’s Connectors (Section 1 of 3)
## Connector No. Assignment Circuit

<table>
<thead>
<tr>
<th>Connector</th>
<th>No.</th>
<th>Assignment</th>
<th>Circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>X5</td>
<td>1</td>
<td>+5V</td>
<td>+5 V Power supply for slaves</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>D-</td>
<td>Data-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>D+</td>
<td>Data+</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>DGND</td>
<td>Digital Ground</td>
</tr>
<tr>
<td>X6</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>CAN-L</td>
<td>CAN-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>DGND</td>
<td>Ground for the CAN bus interface</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
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</tr>
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<td></td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>CAN-H</td>
<td>CAN+</td>
</tr>
<tr>
<td></td>
<td>8</td>
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</tr>
<tr>
<td></td>
<td>9</td>
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</tr>
<tr>
<td>X7</td>
<td>1</td>
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</tr>
<tr>
<td></td>
<td>2</td>
<td>CAN-L</td>
<td>CAN-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>DGND</td>
<td>Ground for the CAN bus interface</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>CAN-H</td>
<td>CAN+</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X9, X10</td>
<td>1</td>
<td>+24 V</td>
<td>+24 V power supply for the module</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>DGND</td>
<td>Ground for the modules’ power supply</td>
</tr>
<tr>
<td>X11</td>
<td>1</td>
<td>Tx+</td>
<td>Transmit data+</td>
</tr>
<tr>
<td>RT-ETH1</td>
<td>2</td>
<td>Tx-</td>
<td>Transmit data-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Rx+</td>
<td>Receive data+</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Rx-</td>
<td>Receive data-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X12</td>
<td>1</td>
<td>Tx+</td>
<td>Transmit data+</td>
</tr>
<tr>
<td>RT-ETH2</td>
<td>2</td>
<td>Tx-</td>
<td>Transmit data-</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Rx+</td>
<td>Receive data+</td>
</tr>
<tr>
<td></td>
<td>4</td>
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<td></td>
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<td></td>
<td>5</td>
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<td>6</td>
<td>Rx-</td>
<td>Receive data-</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13: Terminal Assignment of MSD Motion Controller's Connectors (Section 2 of 3)
### 10.4.2 LEDs

<table>
<thead>
<tr>
<th>Area</th>
<th>LED</th>
<th>Display</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td>+24 V</td>
<td>+24 V and internal +5 V ok</td>
<td>Illuminates when the power supply for the MSD Motion Controller's internal electronics is OK and the internal power pack is supplying +5 V.</td>
</tr>
<tr>
<td></td>
<td>I/O1</td>
<td>Internal status of the digital I/O 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I/O2</td>
<td>Internal status of the digital I/O 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I/O3</td>
<td>Internal status of the digital I/O 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I/O4</td>
<td>Internal status of the digital I/O 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CAN</td>
<td>CAN transmission activity</td>
<td>Flashes in synchronization with the data that the MSD Motion Controller is sending over the CAN interface.</td>
</tr>
<tr>
<td></td>
<td>OutEN</td>
<td>Outputs enabled</td>
<td>Illuminates when all outputs are under the control of the application program.</td>
</tr>
<tr>
<td>User</td>
<td>LED1</td>
<td>Activated by application program or error display</td>
<td>As long as LED «Error» does not illuminate, the application program can activate these LEDs (provided that the MSD Motion Controller has successfully started and that the application program has started).</td>
</tr>
<tr>
<td></td>
<td>LED2</td>
<td>Activated by application program or error display</td>
<td>The states that these LEDs will indicate while the application program is running are set in the application program.</td>
</tr>
<tr>
<td></td>
<td>LED3</td>
<td>Activated by application program or error display</td>
<td>If «Error» illuminates or flashes in addition to these LEDs, this indicates MSD Motion Controller’s elementary operational states or errors.</td>
</tr>
<tr>
<td></td>
<td>LED4</td>
<td>Activated by application program or error display</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>Error display</td>
<td>Illuminates when there is an error. The type of error is specified in «LED1», «LED2», and «LED3».</td>
</tr>
<tr>
<td></td>
<td>Ethernet</td>
<td>Link</td>
<td>Illuminates when the Ethernet link pulse is available and blinks at activity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed</td>
<td>On = 100 Mbit/s</td>
</tr>
</tbody>
</table>

Table 14: LEDs of the MSD Motion Controller
### 10.4.2.1 Display of Elementary Operational States and Errors

<table>
<thead>
<tr>
<th>State</th>
<th>Explanation</th>
<th>User LEDs</th>
<th>1. LED</th>
<th>2. LED</th>
<th>3. LED</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ready</strong></td>
<td>The MSD Motion Controller was started successfully. The user LEDs «LED1», «LED2» and «LED3» are now available for the application program.</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Booting</strong></td>
<td>Boot process is running</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
| **Firmware update running** | The update process of the firmware is running  
                     | The firmware update process can take up to several minutes.  
                     | The MSD Motion Controller must not be switched off or reset during the update process.  
                     | If it is switched off or reset during the update process, the firmware must be reloaded. |           | 1 | 1 | blinking | 0  |
| **Firmware update finished** | The update process of the firmware is finished | blinking | blinking | blinking | blinking | |
| **Error**            | Error, no firmware loaded                                                  |           | 1      | 0      | 0      | 1     |

1: LED illuminates  
0: LED does not illuminate

Table 15: LEDs for Displaying Elementary Operational States and Errors after Switching on or Resetting the MSD Motion Controller
10.5 Programming and Configuration

The MACS development environment is needed to create IEC 61131 application programs and configure the MSD Motion Controller.

⇒ "3.5 Application Programs" on page 25

10.5.1 Communication Between MSD Motion Controller and MACS

**WARNING**

The MSD Motion Controller’s operational state can be altered with the MACS development environment when the MSD Motion Controller is connected online with MACS.

This can be done by means of the following actions, for example:

• Stopping or resetting the program
• Setting breakpoints
• Activating the single step mode
• Downloading application programs
• Writing or forcing values

Therefore, the operator must always consider the effects and take appropriate precautions before altering the operational state of the MSD Motion Controller with MACS.

The MSD Motion Controller can use the following interface to communicate with the PC on which MACS is installed:

• Ethernet interface
  with «LAN» front panel connector of the MSD Motion Controller

⇒ "7.1 Ethernet" on page 42
⇒ "10.5.1.1 Ethernet Communication Interface" on page 68

The Ethernet interface is configured in the PLC Configuration of the MACS development environment.

Refer to the documentation of the MACS development environment for detailed information about this.

10.5.1.1 Ethernet Communication Interface

**Settings in the MACS development environment**

(communication parameters)

- IP address at delivery = 192.168.1.2 (identical for all MSD Motion Controllers without license key!)
- Port = 1200
- Target-Id = 0
- Motorola Byteorder = Yes

Each IP address may be used only once within a network. Therefore, when operating the MSD Motion Controller within a network, the IP address should be changed only after consulting with the responsible system administrator.

IP address in the license key:

⇒ "10.6 License Key" on page 69

**Interface cables**

⇒ "7.1.3 Ethernet Interface Cables" on page 43
10.6 License Key

WARNING The license key of the MSD Motion Controller must be protected from electrostatic discharges!
Electrical discharges might damage the license key or delete the contents of the license key's memory.

WARNING The license key may be inserted or removed only when the MSD Motion Controller is powered down!
Attempting to insert or remove the license key during operation might damage the license key or the MSD Motion Controller permanently.

WARNING The license key must always remain inserted while the MSD Motion Controller is in operation. Otherwise, the MSD Motion Controller will not work.

If the license key is removed during operation, the application program will stop after a few minutes. If the MSD Motion Controller is connected online to the MACS development environment, a corresponding error message will appear in MACS.
In addition, the digital output 'Outputs Enabled' will be switched to the 0 state, thereby disabling all of the MSD Motion Controller's digital outputs and terminating fieldbus communication.
☞ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85
After switching off the MSD Motion Controller and inserting the license key, the MSD Motion Controller can be brought back into operation.

10.6.1 Run-Time License and Accessible Libraries

The run-time license of the MSD Motion Controller is saved in the license key.
The accessible MACS libraries also depend on the license key. If the application program attempts to access a MACS library that is not released by the license key used, the application program will not be able to start.

Detailed information about the MACS libraries accessible with the various license keys:
☞ Table 24 on page 91
10.6.2 CANopen Node-ID and IP Address

The CANopen node-ID of the MSD Motion Controller's CAN bus interfaces and the IP address of the MSD Motion Controller's Ethernet interface are saved in the license key.

The CANopen node-ID and IP address can be set or modified in the following places:

- In the application program
- With the PLC Browser in the MACS development environment

The IP address is read from the license key only when the power supply is switched on or when the MSD Motion Controller is reset.

The default license key settings are:

- IP address: 10.49.40.1
- CANopen node-ID: 127

10.6.3 Mounting and Removing

![License Key of the MSD Motion Controller with Attachment Screws]

10.6.3.1 Required Tool

The following tool is required to mount and remove the license key:

- 3 mm screwdriver

10.6.3.2 Mounting the License Key

**WARNING** The license key may be inserted or removed only when the MSD Motion Controller is powered down!

Attempting to insert or remove the license key during operation might damage the license key or the MSD Motion Controller permanently.

**WARNING** If an M3000® module is to be taken out of operation, the entire system must always be shut down and disconnected from all power supplies. Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

The M3000® module must be protected against unintentional restarting!

If the M3000® module is connected to other devices and/or facilities, always consider the full consequences and take appropriate precautions before switching off the module.

**CAUTION** When using a screwdriver, use caution to avoid slipping and causing personal injury or damage to the MSD Motion Controller.
Procedure for mounting the license key:

1. Switch off the MSD Motion Controller power supply.
2. Insert the license key into the slot labeled «LK».
3. Fix the license key in place by carefully tightening the attachment screws.

   Incorrectly tightened attachment screws might cause license key errors.

10.6.3.3 Removing the License Key

WARNING The license key may be inserted or removed only when the MSD Motion Controller is powered down!

   Attempting to insert or remove the license key during operation might damage the license key or the MSD Motion Controller permanently.

WARNING If an M3000® module is to be taken out of operation, the entire system must always be shut down and disconnected from all power supplies.

   Therefore, all power supplies must be switched off, including those from attached peripherals such as externally supplied transmitters, programming devices, etc.!

   The M3000® module must be protected against unintentional restarting!

   If the M3000® module is connected to other devices and/or facilities, always consider the full consequences and take appropriate precautions before switching off the module.

CAUTION When using a screwdriver, use caution to avoid slipping and causing personal injury or damage to the MSD Motion Controller.

Procedure for removing the license key:

1. If it is running, stop the application program in the MACS development environment.
2. Switch off the power supply for the MSD Motion Controller.
3. Loosen the license key’s attachment screws.
4. Remove the license key from the slot labeled «LK».
10.7 Run/Stop/Reset Switch

The behavior of the Run/Stop/Reset switch controlling the Run state of the application program:

<table>
<thead>
<tr>
<th>MACS ¹)</th>
<th>Run/Stop/Reset switch</th>
<th>Application program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>Stop</td>
<td>Stop</td>
</tr>
<tr>
<td>Stop</td>
<td>Run</td>
<td>Stop</td>
</tr>
<tr>
<td>Run</td>
<td>Stop</td>
<td>Stop</td>
</tr>
<tr>
<td>Run</td>
<td>Run</td>
<td>Run</td>
</tr>
</tbody>
</table>

Table 16: Behavior of the Run/Stop/Reset Switch

¹) Most recent state in the online mode (MACS logged on)

Regardless of the logging in to the MSD Motion Controller with MACS, if the Run/Stop/Reset switch is at "Stop" position, the application program does not run. If the switch is in position "Run", then the execution state depends on the last state when MACS was logged in.

**WARNING**

If a boot project is stored at the MSD Motion Controller and you perform a reset or power up, then take care that the application program run state is not only influenced by the last state of MACS, but also by the Run/Stop/Reset switch. If you switch from "Stop" to "Run", then a previously stopped application program may start operating again.

**WARNING**

Moving the Run/Stop/Reset switch into position "Stop" stops a running application program of the MSD Motion Controller control module.

The application program will continue execution after switching back the Run/Stop/Reset switch to position "Run".

Moving the Run/Stop/Reset switch into position "Reset" will reset the MSD Motion Controller. The processor will stop as soon as the Run/Stop/Reset switch is moved to position "Reset". No variables will be saved at that time. When the Run/Stop/Reset switch is released from position "Reset", then the MSD Motion Controller will behave as if the power supply has been switched on.

⇒ "10.8.1.1 Switching on the Power Supply" on page 74

In addition, the MSD Motion Controller control module can be reset with the MACS development environment. Refer to the documentation of the MACS development environment for detailed information about this.
10.8 Power Supply

**DANGER**

The 24 V power supply terminals of all M3000® modules are protected against reverse polarity.

If the polarity of these power supply terminals is reversed, the modules will not work.

**WARNING**

M3000® modules must be protected from overvoltages and/or reverse energization from the sensor to the module!

There is a danger of:

- Permanent damage by overheating or fire
- Malfunctions

M3000® modules must have the correct voltage, polarity, and terminal assignments.

Additional information about the power supply

⇒ "10.2.2.3 Electrical Conditions and Requirements" on page 61
⇒ "6.2 Power Supply" on page 35

10.8.1 Behavior at Switching on and Switching off

The following internal data resides in the flash EEPROM of the MSD Motion Controller:

- Boot projects
- Error messages

There is no battery buffered memory area. The MSD Motion Controller is maintenance-free.

**WARNING**

If the most recent status in the online mode (MACS logged in) was 'Run' before the MSD Motion Controller was switched off or reset, the boot project will always be started after the MSD Motion Controller is switched back on or reset.

This will occur regardless of which application program was previously running.

In other words, the application program that will be started automatically after the MSD Motion Controller is switched on or reset might be different from the application program that was executing immediately prior.

Application programs can be saved and executed in the MSD Motion Controller in the following manner:

- As a boot project in the flash EEPROM
- In RAM

An application program saved as a boot project will be loaded into RAM whenever the MSD Motion Controller's power supply is switched on or when the MSD Motion Controller is reset.
10.8.1.1 Switching on the Power Supply

**WARNING**  If the most recent status in the online mode (MACS logged in) was 'Run' before the MSD Motion Controller was switched off or reset, the boot project will always be started after the MSD Motion Controller is switched back on or reset.

This will occur regardless of which application program was previously running.

In other words, the application program that will be started automatically after the MSD Motion Controller is switched on or reset might be different from the application program that was executing immediately prior.

After the power supply for the MSD Motion Controller's internal electronics is switched on, the MSD Motion Controller will perform the following actions:

1. The boot project (if one exists) is loaded into RAM.
2. The values of the RETAIN variables are loaded (assuming that variables of this type are used).
3. The boot project starts (if one exists and the most recent status in the online mode (MACS logged in) was 'Run').

After these actions are complete, the MSD Motion Controller is ready to communicate with the MACS development environment.

10.9 Basetick

The basetick is the global clock source of the MSD Motion Controller. All timings such as task cycle times or hardware access are directly derived from the adjusted basetick value.

The basetick can be adjusted in steps of 1 µs within the range of 100 microseconds up to 3 milliseconds. The cycle time of several application tasks must be a multiple of the adjusted basetick. The basetick value is also significantly involved in the timing of all hardware accesses.

Basetick cycle time can be adjusted within the PLC Configuration of the MACS development environment. The module parameter “Basetick” (index 2 of the root module) may be adjusted within the range of 100 to 3000. This value equals the basetick cycle time in µs. The default value is 1000 = 1 ms.
10.10 Digital I/Os

Each of the 4 digital terminals I/O1…I/O4 of the MSD Motion Controller can be used as either an input or an output. Each digital output is internally connected back to a digital input. This enables the application program to read the status of the digital outputs and compare it to the requested value.

Whether a terminal will be used as an input or an output is set in the PLC Configuration of the MACS development environment.

The following digital output circuits are available:
• Open emitter outputs, switches to +24 V I/O

Basic wiring diagrams: ⇒ figure 37 on page 77

10.10.1 Display of the Operational State

The status LEDs «I/O1»…«I/O4» on the front panel of the MSD Motion Controller show the internal operational state of the digital I/Os. These status LEDs are activated only when the application program is running.

If a terminal is configured to be an input, the associated LED will illuminate when it is internally detected that the input is in the 1 state and the input is used in the application program.

When a terminal is configured to be an output, the associated LED will illuminate if the output in the application program is in the 1 state.

As MSD Motion Controllers have open emitter outputs, the LED will illuminate if the terminal is connected through to +24 V I/O.

Basic wiring diagrams of the digital outputs: ⇒ figure 37 on page 77

The status LEDs «I/O1»…«I/O4» will illuminate also if +24 V I/O or DGND I/O are not connected.

The operational state of the digital I/Os can be queried with the aid of function blocks in the application program.

10.10.2 Power Supply

DANGER
The 24 V power supply terminals of all M3000® modules are protected against reverse polarity. If the polarity of these power supply terminals is reversed, the modules will not work.

WARNING
M3000® modules must be protected from overvoltages and/or reverse energization from the sensor to the module!

There is a danger of:
• Permanent damage by overheating or fire
• Malfunctions

M3000® modules must have the correct voltage, polarity, and terminal assignments.
The internal electronics of M3000® modules and attached sensors must be supplied with power from a permanently connected (unswitched) power supply that cannot be individually switched off, without switching off the module's power supply.

If a switched power supply is used, such as when there are intermediate switching devices (emergency stops, manual operators, etc.), the following problems might arise, depending on the state of the power supply for the internal electronics of the module and sensors (table 4 on page 37):
- Reverse energization from sensor to module
- Invalid sensor data

Sensors that are connected to digital inputs of M3000® modules with several I/O groups, such as MSC I, QDIO, or RDIO, must under all conditions be supplied from the same power supply as the corresponding I/O group to which the sensor is connected!

Otherwise, if the power supply for the internal electronics of the module is switched off, there might be reverse energization from the sensor to the module.

There is a danger of:
- Uncontrolled movements
- Fault or failure of a manual control
- Permanent damage to the module
- Malfunctions

Digital I/Os of MSC II and MSD Motion Controller are protected against reverse energization.

The power supply for the digital I/Os of the MSD Motion Controller is independent of the power supply for the MSD Motion Controller's internal electronics (+24 V / DGND) and is established over the terminals +24 V and DGND I/O.

Power supply characteristics
- "6.2.1 Power Supply Characteristics" on page 35

Connecting sensors to the power supply:
- "6.2.4 Connecting Sensors" on page 38

Connecting the power supply for the internal electronics:
- "6.2.3 Connecting the Power Supply" on page 36
10.10.3 Digital Outputs

The following digital output circuits are available:

- Open emitter outputs, switches to +24 V I/O

A digital open emitter output in the 1 state (conductive) connects the attached load $R_L$ to the power supply terminal +24 V I/O.

The output 'Outputs Enabled' is always an open emitter output.

1. Protective circuit with a limiting voltage of 50 V as protection against induced voltage spikes when there are inductive loads.
   ⇔ "10.10.3.2 Current Limiting and Overload Protection" on page 77

10.10.3.1 Dependence on the 'Outputs Enabled' Signal

If the digital output 'Outputs Enabled' is in the 0 state (LED «OutEN» does not illuminate), all other outputs are disabled.

In this case, although the internal states of the digital outputs are shown on the front panel status LEDs «I/O1»…«I/O4» of the MSD Motion Controller, they are not connected through to the output.
   ⇔ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85

10.10.3.2 Current Limiting and Overload Protection

All digital outputs are protected by an integrated power limiter and a thermal overload protection device.

In an overload condition, the affected output will be automatically disabled. After the output stage has been finished thermal cooling it returns to normal operation. If the overload is still connected, then the disable will happen again.

A protective circuit with a limiting voltage of 50 V with respect to +24 V I/O for open emitter outputs protects all outputs against induced voltage spikes when there are inductive loads.
10.10.3.3 Specifications

Number of digital outputs
Maximum 4
⇒ "10.10 Digital I/Os" on page 75

Type of outputs
Semiconductor, non-capacitive

Protective circuitry for inductive loads
Limiting voltage of 50 V (typ.) with respect to +24 V I/O

Power dissipation of protection devices when limiting
Max. 0.5 W per output
Max. 2 W per MSD Motion Controller

Status display
One status LED per I/O
⇒ "10.10.1 Display of the Operational State" on page 75

Diagnosis function
The operational state of the digital I/Os can be queried with the aid of function blocks in the application program.

Power consumption for the internal control circuit (+24 V I/O / DGND I/O)
≤ 100 mA

10.10.3.4 Load Connection

Total load (100 %)
2 A (4 x 0.5 A), when all 4 terminals are used as outputs

Overload protection
Electronic current limiting and thermal overload protection

Max. short-circuit current
< 8 A

Reverse energization protection
Digital outputs are protected against reverse energization

Output delay (hardware)
From 0 to 1: max. 100 µs
From 1 to 0: max. 100 µs

Update time
The update time corresponds to the task interval of the application program that actuates the output.

The task interval (and thereby the update time of the outputs) is set in the task configuration of the MACS development environment.

Output capacitance
< 20 nF

Rated voltage
+24 V DC

Voltage loss (at rated current)
< 2 V

Rated current in 1 state
0.5 A

Leakage current in 0 state
Max. 0.1 mA
Parallel connection of outputs
Not permissible

10.10.3.5 Insulation Resistance

Insulation resistance
Rated voltage: 0–50 V DC
Test voltage for 2,000 m (2,187 yd) operating elevation: 500 V DC

10.10.4 Digital Inputs

The digital inputs are current consuming inputs of the type 2 according to IEC 61131-2. They are designed for an input voltage rating of 24 V. The input values (0/1 state) are read cyclically. An open input is interpreted as the 0 state.

10.10.4.1 Basic Wiring Diagram

![Basic Wiring Diagram of a Digital Input of the MSD Motion Controller (Current Consuming)](image)

Figure 38: Basic Wiring Diagram of a Digital Input of the MSD Motion Controller (Current Consuming)

10.10.4.2 Pulse Detection and Disturbance Suppression

The digital inputs are read cyclically. The sampling time corresponds to the task interval of the application program that reads the input.

ℹ️ The task interval (and thereby the sampling time of the inputs) is set in the task configuration of the MACS development environment.

For input pulses to be reliably detected, they must be longer than the task interval specified in the application program.

When defining the minimum pulse duration that can be detected by digital I/Os, the following differentiation is made:

- Pulses that are never detected; pulse duration: \( \leq 50 \mu s \)
- Pulses that can be detected (if the system reads the input when the pulse appears); pulse duration: > 50 \( \mu s \)
- Pulses that are always detected; pulse duration: > the set task interval

The user may implement multiple sampling in the application program in order to suppress disturbance impulses. In doing so, the user must consider the tradeoff between the desired level of disturbance suppression and the required reaction time of the system.
10.10.4.3 Specifications

Number of the digital inputs
- Maximum 4
  ⇒ "10.10 Digital I/Os" on page 75

Type
- Type 2 according to IEC 61131-2, current consuming

Wire lengths
- In the control cabinet: The voltage drop must be taken into consideration when choosing the wire cross section; there are no other practical limitations.
- Field wiring: All relevant national regulations as well as the requirements of IEC 61131-3 must be fulfilled.

Load rated voltage +24 V I/O
- 24 V DC (safety extra-low voltage SELV according to DIN EN 60950-1)

Reverse polarity protection
- Digital inputs are protected against reverse polarity

Potential isolation
- Achieved with optocouplers

Status display
- One status LED per I/O
  ⇒ "10.10.1 Display of the Operational State" on page 75

Alarms
- Can be implemented in the application program

Input delay (hardware)
- From 0 to 1: max. 100 µs
- From 1 to 0: max. 100 µs

Sampling time
- The sampling time corresponds to the task interval of the application program that reads the input.
  ⇒ "10.10.4.2 Pulse Detection and Disturbance Suppression" on page 79
  - The task interval (and thereby the sampling time of the inputs) is set in the task configuration of the MACS development environment.

Input capacitance
- Max. 10 nF

Power consumption for the internal control circuit (+24 V I/O / DGND I/O)
- ≤ 100 mA
10.10.4.4 U/I Working Ranges

![Diagram of U/I Working Ranges of MSD Motion Controller's Digital Inputs (Current Consuming)](image)

**Figure 39: U/I Working Ranges of MSD Motion Controller's Digital Inputs (Current Consuming)**

<table>
<thead>
<tr>
<th>Input voltage (DC) of the external power supply +24 V I/O</th>
<th>rated voltage</th>
<th>$U_e = 24$ V</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper limit</td>
<td>$U_{e\text{ max}} = 36$ V</td>
<td></td>
</tr>
<tr>
<td>lower limit</td>
<td>$U_{e\text{ min}} = 18$ V</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Limits for the 1 state</th>
<th>upper limit</th>
<th>$U_{H\text{ max}} = 30$ V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$I_{H\text{ max}} = 30$ mA</td>
<td></td>
</tr>
<tr>
<td>lower limit</td>
<td>$U_{H\text{ min}} = 11$ V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{H\text{ min}} = 6$ mA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Limits for the 0 state</th>
<th>upper limit</th>
<th>$U_{L\text{ max}} = 11/5$ V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$I_{L\text{ max}} = 2/30$ mA</td>
<td></td>
</tr>
<tr>
<td>lower limit</td>
<td>$U_{L\text{ min}} = -3$ V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$I_{L\text{ min}} = \text{ND}$</td>
<td></td>
</tr>
</tbody>
</table>

Table 17: U/I Working Ranges of MSD Motion Controller's Digital Inputs (Current Consuming)

10.10.4.5 Insulation Resistance

**Insulation resistance**

- Rated voltage: 0–50 V DC
- Test voltage for 2,000 m (2,187 yd) operating elevation: 500 V DC

**Insulation Resistance of MSD Motion Controller’s Digital Inputs**
10.11 Profibus DP Interface

The MSD Motion Controller can optionally be equipped with a Profibus DP Slave interface.

The configuration of the Profibus interface is defined in the application program.

Information about Profibus:
⇒ "7.3 Profibus" on page 45

Information about the Profibus interface cable:
⇒ "7.3.4 Profibus Interface Cable" on page 47

10.11.1 Profibus Termination

At the beginning and the end of any Profibus network, termination resistors must be connected to guarantee specified signal levels. These termination resistors are integrated in most common connectors.

10.11.2 Shielding

When connecting the stations, always use shielded cables to ensure high interference immunity of the system against electromagnetic emissions. The shield should be grounded on both sides where possible.

10.11.3 Profibus Slave Address

The slave station address of the Profibus interface of the MSD Motion Controller can be set in the application program.

10.11.4 Profibus Baud Rate

The Profibus baud rate is defined by the Profibus master station. The MSD Motion Controller Profibus slave interface is able to detect the baud rate and synchronize to it.
10.12 EtherCAT

The MSD Motion Controller provides two EtherCAT master interfaces <<EC1>> and <<EC2>>. In addition an EtherCAT slave interface <<RT_ETH1>> and <<RT_ETH2>> is available as option.

The configuration of the network nodes is done in the PLC Configuration of the development environment MACS.

WARNING

Do not connect EtherCAT to any other Ethernet networks. The high rate of telegrams which are transmitted by EtherCAT will prevent other devices like computers and servers on the network from transmitting data.

There is a danger of

- Network overload/breakdown
- Malfunction of connected devices
- Data loss at connected devices

It is strongly recommended to use cables of a special color only for EtherCAT connections.
10.13 CAN Bus Interfaces

The MSD Motion Controller is equipped with the CAN bus interfaces that can be operated within CAN bus networks (2 «CAN» front panel connectors of the MSD Motion Controller).

The «CAN» front panel connectors are connected internally 1:1 with each other. As a result, the MSD Motion Controller can be connected directly to the CAN bus without a T-adapter.

The functionality of the CAN bus interfaces is defined in the application program.

Information about CAN bus and CANopen:

⇔ "7.4 CAN Bus and CANopen" on page 49

Information about the CAN bus interface cable:
⇔ "7.4.6 CAN Bus Interface Cable" on page 53

10.13.1 Setting the CANopen Node-ID

The CANopen node-ID of the CAN bus interface of the MSD Motion Controller can be set or modified in the following places:

• In the application program
• With the PLC Browser in the MACS development environment

The CANopen node-ID is saved in the license key.
⇔ "10.6.2 CANopen Node-ID and IP Address" on page 70

10.13.2 Setting the CAN Bus Baud Rate

The CAN bus baud rate is set in the application program.
10.14 Safety Functions

10.14.1 Watchdog

The MSD Motion Controller provides a function for monitoring whether the software is working properly. When there is a fault, this function switches all digital outputs to zero potential condition and stops fieldbus communication. As a result, the user can set up systems that have a greatly reduced risk of fatal malfunctions.

In the MSD Motion Controller, this function is implemented in the M_WATCHDOG function block, which can be used in the application program to be monitored. If this function block is used, it must be enabled and triggered cyclically in order to keep the outputs enabled. When there is a fault (when the application program can no longer trigger the function block within the set time period), the outputs will be disabled.

If the M_WATCHDOG function block is not used in the application program, the MSD Motion Controller's watchdog will not operate. In this case, the outputs will always be enabled and they will output the value calculated in the application program.

The digital output 'Outputs Enabled' indicates the enabled state of all digital outputs.

10.14.2 'Outputs Enabled' Output (LED «OutEN»)

The digital output 'Outputs Enabled' indicates the enabled state of all digital outputs. It can be used to signalize another controller that all of the MSD Motion Controller's outputs were disabled.

As long as the 'Outputs Enabled' output is in the 1 state, the application program will control all outputs and the fieldbus communication.

If the 'Outputs Enabled' output is switched to the 0 state (LED «OutEN» does not illuminate), all outputs will be disabled and the fieldbus communication will be stopped.

In this case, although the internal states of the digital outputs are shown on the front panel status LEDs «I/O1»…«I/O4» of the MSD Motion Controller, they are not connected through to the output.

The digital output 'Outputs Enabled' will be switched to the 1 state only if the following conditions are fulfilled simultaneously:

- An error-free application program has been loaded onto the MSD Motion Controller and will be started once after every reset of the MSD Motion Controller
- A valid license key is inserted
- The M_WATCHDOG function block is not used or the M_WATCHDOG function block is used in the application program, enabled and triggered cyclically within the set time

WARNING If there is a defect in an output stage, the 'Outputs Enabled' signal will not necessarily shut down all of the outputs securely.
If any one of these conditions is not fulfilled, the 'Outputs Enabled' output will be switched to the 0 state, thereby disabling all of the MSD Motion Controller's other outputs. In addition, the fieldbus communication will be stopped.

### 10.14.2.1 «OutEN» LED

The front panel LED «OutEN», located of the MSD Motion Controller, indicates the status of the 'Outputs Enabled' output. The LED «OutEN» illuminates when the 'Outputs Enabled' output is in the 1 state.

### 10.14.3 Stopping the Application Program

An application program (executed in the MSD Motion Controller) can be stopped in the MACS development environment. After an application program stops, all analog and digital outputs will automatically be switched to a secure state. This secure value can be set for each output individually by modifying the 'Secure' channel parameter in the PLC Configuration.

If the «OutEN» LED does not illuminate (when the 'Outputs Enabled' output is in the 0 state), this secure value will not be at the outputs because the outputs will be disabled.

⇒ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85

### 10.15 Nameplate

![Figure 42: Position of the Nameplate on the MSD Motion Controller](image)

<table>
<thead>
<tr>
<th>Part number</th>
<th>Revision</th>
<th>Date in format (MM = month, YY = year)</th>
<th>Serial number</th>
</tr>
</thead>
</table>

Figure 42: Position of the Nameplate on the MSD Motion Controller
11 Product Range

The following chapter describes only a small part of Moog's extensive product range. In addition to the many different M3000® modules, Moog's current product range includes a large variety of accessories.

11.1 M3000® Starter Kits

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSC I starter kit, including MSC I with Profibus-DP slave</td>
<td>Complete package including everything needed to get started</td>
<td>D147-001-005</td>
</tr>
<tr>
<td>MSC II starter kit, including MSC II with Profibus-DP slave interface</td>
<td>Complete package including everything needed to get started</td>
<td>D147-002-001</td>
</tr>
<tr>
<td>MSC II starter kit, including MSC II with dual EtherCAT master interface</td>
<td>Complete package including everything needed to get started</td>
<td>D147-002-002</td>
</tr>
<tr>
<td>MSD starter kit including one MSD Motion Controller and one 4A MSD Servodrive</td>
<td>Complete package including everything needed to get started</td>
<td>Ordering number not assigned yet</td>
</tr>
</tbody>
</table>

Table 18: Product Range – M3000® Starter Kits
11.2 M3000® Modules

11.2.1 Controller

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSC II</td>
<td>Multi-axis high performance motion controller with PLC functionality 128 MB RAM / 32 MB Flash 4 Digital I/O 4 Position transducer interfaces 2 USB, 1 Ethernet, 2 CAN, 1 TIA/EIA 232</td>
<td>D136-002-002</td>
</tr>
<tr>
<td>MSC II with Profibus-DP interface</td>
<td>As D136-002-002, additional Profibus-DP slave interface</td>
<td>D136-002-001</td>
</tr>
<tr>
<td>MSC II with EtherCAT interface</td>
<td>As D136-002-002, additional dual EtherCAT master interface</td>
<td>D136-002-003</td>
</tr>
<tr>
<td>MSD Motion Controller</td>
<td>Multi-axis high performance motion controller with PLC functionality 128 MB RAM / 32 MB Flash 4 Digital I/O 1 USB, 1 Ethernet, 1 CAN, 2 EtherCAT master</td>
<td>G391-001-001</td>
</tr>
<tr>
<td>MSD Motion Controller with Profibus-DP interface</td>
<td>As G391-001-001, additional Profibus-DP slave interface</td>
<td>G391-001-002</td>
</tr>
<tr>
<td>MSC I Motion Controller</td>
<td>Multi-axis high performance motion controller with PLC functionality 4 MB RAM / 4 MB Flash 8 Digital I/O 8 Analog In (16bit), 2 Analog Out (16bit) 2 Position transducer interface 2 CAN Controller, 1 TIA/EIA 232</td>
<td>D136-001-008</td>
</tr>
<tr>
<td>MSC I Motion Controller with Profibus-DP interface</td>
<td>As D136-001-008, additional Profibus-DP slave interface</td>
<td>D136-001-007</td>
</tr>
</tbody>
</table>

Table 19: Product Range – Controller

The plug-in terminal strips, that may be needed for connection of power and signal cables, are not included in delivery. The plug-in terminal strips are available from Moog as accessories. Only the MSD Motion Controller is delivered with the necessary plug-in terminal strips for power supply and digital I/O.

⇒ "11.8 Plug-In Terminal Strips" on page 94

The MSD Motion Controller does not work without license key. This license key is not included in the standard delivery. It is available from Moog as an accessory.

⇒ "11.4 License Keys" on page 91
### 11.2.2 Q-Modules

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>QDIO 16/16-0,5</td>
<td>Digital I/O extension module for local extension of the inputs and outputs of MSC I, MSC II or RDIO (connection over E-bus) 16 inputs and 16 I/Os Positive switching ⇒ &quot;3.3.3 Q-Modules&quot; on page 17</td>
<td>D137-001-005</td>
</tr>
<tr>
<td>QDIO 16/16-0,5N</td>
<td>Digital I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus) 16 inputs and 16 I/Os Zero switching ⇒ &quot;3.3.3 Q-Modules&quot; on page 17</td>
<td>D137-001-004</td>
</tr>
<tr>
<td>QAIO 2/2-AV</td>
<td>Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus) 2 inputs (±10 V/ ±10 mA/ 4–20 mA) 2 outputs (±10 V/ ±10 mA/ 4–20 mA/ ±50 mA) ⇒ &quot;3.3.3 Q-Modules&quot; on page 17</td>
<td>D137-001-011</td>
</tr>
<tr>
<td>QAIO 16/4-V</td>
<td>Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus) 16 voltage inputs (±10 V) 4 voltage outputs (±10 V) ⇒ &quot;3.3.3 Q-Modules&quot; on page 17</td>
<td>D137-001-007</td>
</tr>
<tr>
<td>QAIO 16/4-A</td>
<td>Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus) 16 current inputs (0–20 mA) 4 voltage outputs (±10 V) ⇒ &quot;3.3.3 Q-Modules&quot; on page 17</td>
<td>D137-001-006</td>
</tr>
<tr>
<td>QEBUS-CAN</td>
<td>CAN extension module which can be used to make available the LocalCAN bus of an E-bus group for external CAN bus network stations (over a D-sub front panel connector) ⇒ &quot;3.3.3.2 QEBUS-CAN&quot; on page 19</td>
<td>D137-001-010</td>
</tr>
</tbody>
</table>

Table 20: Product Range – Q-Modules

The plug-in terminal strips, that may be needed for connection of power and signal cables, are not included in delivery. The plug-in terminal strips are available from Moog as accessories. Only the MSD Motion Controller is delivered with the necessary plug-in terminal strips for power supply and digital I/O.  
⇒ "11.8 Plug-In Terminal Strips" on page 94
11.2.3 R-Modules (Remote Modules)

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDIO 16/16-0,5</td>
<td>Remote module with digital I/Os and CANopen interface (connection over CAN bus) 16 inputs and 16 I/Os Positive switching * &quot;3.3.4 R-Modules (Remote Modules)&quot; on page 19</td>
<td>D137-002-001</td>
</tr>
<tr>
<td>RDISP 22</td>
<td>Display and operating terminal with TIA/EIA 232 and CANopen interface and 22 keys (connection over CAN bus) * &quot;3.3.4 R-Modules (Remote Modules)&quot; on page 19 The CPRDISP software (needed to program and configure the RDISP) is not included with RDISP. CPRDISP is available from Moog as an accessory. * &quot;11.5.2 Software for R-Modules&quot; on page 92</td>
<td>D137-004-001</td>
</tr>
<tr>
<td>DialogController</td>
<td>Displays with TFT technology and touch screen. Programmable with MACS development environment. Data exchange via Ethernet with MSC or MSD Motion Controller Display 5.7*</td>
<td>D137-004-004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D137-004-005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D137-004-006</td>
</tr>
</tbody>
</table>

Table 21: Product Range – R-Modules (Remote Modules)

The plug-in terminal strips, that may be needed for connection of power and signal cables, are not included in delivery. The plug-in terminal strips are available from Moog as accessories. Only the MSD Motion Controller is delivered with the necessary plug-in terminal strips for power supply and digital I/O.

* "11.8 Plug-In Terminal Strips" on page 94

11.3 Power Supply for M3000® Modules

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
</table>

Table 22: Product Range – Power Supply for M3000® Modules
11.4 License Keys

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>License key Controls</td>
<td>gray</td>
<td>D138-002-001</td>
</tr>
<tr>
<td>License key Motion</td>
<td>green</td>
<td>D138-002-002</td>
</tr>
</tbody>
</table>

Table 23: Product Range – License Keys

<table>
<thead>
<tr>
<th>Feature</th>
<th>License Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run-time license of the MSD Motion Controller</td>
<td>•</td>
</tr>
<tr>
<td>CoDeSys operators and standard IEC 61131 library</td>
<td>•</td>
</tr>
<tr>
<td>Library with hardware-related functions: M_HW_MSC II.Lib</td>
<td>•</td>
</tr>
<tr>
<td>Library for control engineering: M_Control.Lib</td>
<td>•</td>
</tr>
<tr>
<td>Library for the TIA/EIA 232 and CAN bus interface: M_SIO.Lib</td>
<td>•</td>
</tr>
<tr>
<td>Support for OPC and DDE interfaces</td>
<td>•</td>
</tr>
<tr>
<td>Ethernet and TIA/EIA 232 communication with the MACS development environment</td>
<td>•</td>
</tr>
<tr>
<td>Library for motion control according to PLCopen: M_PLCopen.Lib</td>
<td>•</td>
</tr>
<tr>
<td>Library with transfer functions (Z-functions): M_Transfer_Functions.Lib</td>
<td>•</td>
</tr>
<tr>
<td>Libraries for CANopen, Profibus DP</td>
<td>•</td>
</tr>
</tbody>
</table>

Table 24: Features Provided by the License Keys

The MSD Motion Controller does not work without license key.

⇒ "3.4 License Key" on page 24
⇒ "10.6 License Key" on page 69
11.5 Software

11.5.1 MACS (Moog Axis Control Software)

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>MACS development environment</td>
<td>Development environment according to IEC 61131 for solving complex control tasks (1 license) ⇒ &quot;3.5 Application Programs&quot; on page 25</td>
<td>D138-001-001</td>
</tr>
<tr>
<td></td>
<td>1 additional license</td>
<td>D138-001-002</td>
</tr>
<tr>
<td></td>
<td>5 licenses</td>
<td>D138-001-005</td>
</tr>
<tr>
<td></td>
<td>10 licenses</td>
<td>D138-001-010</td>
</tr>
<tr>
<td>MACS HMI</td>
<td>Visualization package which can be run without MACS ⇒ &quot;3.6.1 MACS HMI Visualization Package&quot; on page 26</td>
<td>D138-003-001</td>
</tr>
<tr>
<td></td>
<td>Run-time license for 10 systems</td>
<td>D138-003-010</td>
</tr>
<tr>
<td></td>
<td>Run-time license for 50 systems</td>
<td>D138-003-050</td>
</tr>
<tr>
<td>Software maintenance contract</td>
<td>Support and MACS updates for 1 year (for 1 license)</td>
<td>B95914-001-001</td>
</tr>
<tr>
<td></td>
<td>1 additional license</td>
<td>B95914-001-002</td>
</tr>
<tr>
<td></td>
<td>5 licenses</td>
<td>B95914-001-005</td>
</tr>
<tr>
<td></td>
<td>10 licenses</td>
<td>B95914-001-010</td>
</tr>
</tbody>
</table>

Table 25: Product Range – Software – MACS

11.5.2 Software for R-Modules

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPRDISP</td>
<td>Software for programming and configuring RDISP ⇒ &quot;3.3.4.2 RDISP&quot; on page 20</td>
<td>D138-006-001</td>
</tr>
</tbody>
</table>

Table 26: Product Range – Software for R-Modules
11.6 Interface Cables

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossed TIA/EIA 232 interface cable, 5 m (5.47 yd)</td>
<td>Null modem cable which can be used as programming cable for connecting the MSC I and PC (MACS) with 9 pole D-sub mating connectors</td>
<td>B95884-001</td>
</tr>
<tr>
<td>Crossed Ethernet interface cable, 10 m (10.94 yd)</td>
<td>100BaseT Cable with Crossed Twisted Pair Wires (Crossover Cable) with 8 pole RJ45 mating connectors  figure 22 on page 43</td>
<td>B95909-001</td>
</tr>
<tr>
<td>Non-crossed Ethernet interface cable, 1 m (1.09 yd)</td>
<td>100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable) with 8 pole RJ45 mating connectors  figure 23 on page 43</td>
<td>B95909-004</td>
</tr>
<tr>
<td>Non-crossed Ethernet interface cable, 10 m (10.94 yd)</td>
<td>100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable) with 8 pole RJ45 mating connectors  figure 23 on page 43</td>
<td>B95909-002</td>
</tr>
<tr>
<td>CAN bus interface cable, 3 m (3.28 yd)</td>
<td>&quot;7.4.6 CAN Bus Interface Cable&quot; on page 53</td>
<td>B95863-001</td>
</tr>
<tr>
<td>CAN bus interface cable, 10 m (10.94 yd)</td>
<td>&quot;7.4.6 CAN Bus Interface Cable&quot; on page 53</td>
<td>B95863-002</td>
</tr>
</tbody>
</table>

Table 27: Product Range – Interface Cables

11.7 CAN Bus Accessories

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB CAN adapter (for PC only)</td>
<td>Adapter (USB1.1 to CAN bus) with 9 pole D-sub mating connector with pin contacts</td>
<td>C43094-001</td>
</tr>
<tr>
<td>CAN bus termination resistor 120 Ω</td>
<td>9 pole D-sub mating connector with socket contacts</td>
<td>B95864-001</td>
</tr>
<tr>
<td>CAN bus termination resistor 120 Ω/GND</td>
<td>9 pole D-sub mating connector with pin contacts; CAN_GND internally connected to signal ground</td>
<td>B95865-001</td>
</tr>
</tbody>
</table>

Table 28: Product Range – CAN Bus Accessories
11.8 Plug-In Terminal Strips

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plug-in terminal strip with screw terminals</td>
<td>2 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>VK055-002</td>
</tr>
<tr>
<td></td>
<td>8 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>VK055-008</td>
</tr>
<tr>
<td></td>
<td>9 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>VK055-009</td>
</tr>
<tr>
<td></td>
<td>18 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>VK055-018</td>
</tr>
<tr>
<td>Plug-in terminal strip with spring loaded terminals</td>
<td>2 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>B95907-002</td>
</tr>
<tr>
<td></td>
<td>8 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>B95907-008</td>
</tr>
<tr>
<td></td>
<td>9 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>B95907-009</td>
</tr>
<tr>
<td></td>
<td>18 pole (up to max. 2.5 mm² (14 AWG) wire cross section)</td>
<td>B95907-018</td>
</tr>
<tr>
<td>Labels for plug-in terminal strips</td>
<td>For labeling plug-in terminal strips Printed with the numbers 1–108 Includes six labels</td>
<td>B95885-001</td>
</tr>
<tr>
<td>Insertion bridge</td>
<td>For connecting adjoining terminals of the plug-in terminal strips</td>
<td>A69102</td>
</tr>
<tr>
<td>Coding tab</td>
<td>For coding plug-in terminal strips</td>
<td>C43145-001</td>
</tr>
<tr>
<td>Coding profile</td>
<td>For coding plug-in terminal strip connectors of M3000® modules</td>
<td>C43146-001</td>
</tr>
<tr>
<td>Spring power clamp 10-pins</td>
<td>Spring latch terminal for max 0,5 mm² wires (20 AWG)</td>
<td>CA45260-010</td>
</tr>
<tr>
<td>Connector kit for MSD Motion Controller</td>
<td>2 x FMC 1,5/7-ST-3,5GY 2 x MSTB 2,5/2-ST GY Mating connectors for the MSD Motion Controller X3, X9 and X10</td>
<td>CA65115-001</td>
</tr>
</tbody>
</table>

Table 29: Product Range – Plug-In Terminal Strips

The various DIN rail modules require different numbers of plug-in terminal strips.

⇒ "11.8.1 Number of Required Plug-In Terminal Strips" on page 95
11.8.1 Number of Required Plug-In Terminal Strips

<table>
<thead>
<tr>
<th>DIN Rail Module</th>
<th>Number of Plug-In Terminal Strips Required</th>
<th>Number of Required Plug-In Terminal Strips</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 Poles</td>
<td>9 Poles</td>
</tr>
<tr>
<td>MSC I</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>MSC II</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>MSD Motion Controller</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>QDIO</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>QAIO 2/2</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>QAIO 16/4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>QEBUS-CAN</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>RDIO</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RDISP</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DialogController</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 30: Number of Plug-In Terminal Strips

The MSD Motion Controller is delivered with the necessary plug-in terminal strips for power supply and digital I/O.
## 11.9 Training Programs

<table>
<thead>
<tr>
<th>Item Designation</th>
<th>Remarks</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software training, English</td>
<td>Content of the training: • Programming, testing, optimizing, and documenting IEC 61131 application programs</td>
<td>B95992</td>
</tr>
<tr>
<td>MACS and IEC 61131</td>
<td>• Visualization of IEC 61131 application programs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software training, German</td>
<td>Content of the training: • Programming, testing, optimizing, and documenting IEC 61131 application programs</td>
<td>B95993</td>
</tr>
<tr>
<td>MACS and IEC 61131</td>
<td>• Visualization of IEC 61131 application programs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware training, English</td>
<td>Content of the training: • Configuring and using MSC II and extension modules</td>
<td>B95994</td>
</tr>
<tr>
<td>MSC II and extension modules</td>
<td>• Using control-engineering libraries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge about creating IEC 61131 application programs is required to participate in the hardware training. This knowledge is imparted in the MACS and IEC 61131 software training.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware training, German</td>
<td>Content of the training: • Configuring and using MSC II and extension modules</td>
<td>B95995</td>
</tr>
<tr>
<td>MSC II and extension modules</td>
<td>• Using control-engineering libraries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge about creating IEC 61131 application programs is required to participate in the hardware training. This knowledge is imparted in the MACS and IEC 61131 software training.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware and Software training,</td>
<td>Content of the training: • MSD Servo Drive Hardware</td>
<td>CA67627</td>
</tr>
<tr>
<td>English</td>
<td>• MSD Servo Drive Software</td>
<td></td>
</tr>
<tr>
<td>MSD Servodrives and MSD Motion</td>
<td>• MSD Motion Controller</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>Knowledge about creating IEC 61131 application programs is recommended to participate in the hardware training. This knowledge is imparted in the MACS and IEC 61131 software training.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware and Software training,</td>
<td>Content of the training: • MSD Servodrive Hardware</td>
<td>CA67628</td>
</tr>
<tr>
<td>German</td>
<td>• MSD Servodrive Software</td>
<td></td>
</tr>
<tr>
<td>MSD Servodrives and MSD Motion</td>
<td>• MSD Motion Controller</td>
<td></td>
</tr>
<tr>
<td>Controller</td>
<td>Knowledge about creating IEC 61131 application programs is recommended to participate in the hardware training. This knowledge is imparted in the MACS and IEC 61131 software training.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 31: Product Range – Training Programs
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12.1 Typographical Conventions

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<tr>
<th>Typographical Convention</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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<td>DANGER</td>
<td>Identifies safety instructions that are intended to warn of an immediate and impending danger to life and limb or major property damage. Failure to observe these safety instructions will inevitably to death, serious personal injury (disablement) or major property damage!</td>
</tr>
<tr>
<td>WARNING</td>
<td>Identifies safety instructions that are intended to warn of potential danger to life and limb or the potential for major property damage. Failure to observe these safety instructions might lead to death, serious personal injury (disablement) or major property damage!</td>
</tr>
<tr>
<td>CAUTION</td>
<td>Identifies safety instructions that are intended to warn of slight personal injury or minor property damage. Failure to observe these safety instructions might lead to slight personal injury or minor property damage.</td>
</tr>
<tr>
<td>• / –</td>
<td>Identifies listings</td>
</tr>
<tr>
<td>⇔</td>
<td>Identifies references to another chapter, another page, table or figure in this manual</td>
</tr>
<tr>
<td>blue text</td>
<td>Identifies a hyperlink within the PDF file</td>
</tr>
<tr>
<td></td>
<td>Identifies important information</td>
</tr>
<tr>
<td>1., 2., …</td>
<td>Identifies steps in a procedure that should be performed in consecutive order</td>
</tr>
<tr>
<td>1, 2, …</td>
<td>Identifies items in a figure that are explained separately</td>
</tr>
<tr>
<td>«WCAN»</td>
<td>Identifies terminals or connectors (such as: «WCAN») and light emitting diodes (such as: «I/O1») of an M3000® module</td>
</tr>
<tr>
<td>'Frequency'</td>
<td>Identifies parameters of the MACS development environment (such as: 'Frequency') and outputs of M3000® modules (such as: 'Outputs Enabled')</td>
</tr>
</tbody>
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### 12.2 Abbreviations

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<th>Explanation</th>
</tr>
</thead>
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<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog to Digital Converter</td>
</tr>
<tr>
<td>CAL</td>
<td>CAN Application Layer according to CiA DS 201–207</td>
</tr>
<tr>
<td>CAN</td>
<td>Controller Area Network</td>
</tr>
<tr>
<td>CAN_GND</td>
<td>CAN Ground</td>
</tr>
<tr>
<td>CAN_H</td>
<td>CAN High (CAN bus signal (dominant high))</td>
</tr>
<tr>
<td>CAN_L</td>
<td>CAN Low (CAN bus signal (dominant low))</td>
</tr>
<tr>
<td>CAN_SHLD</td>
<td>CAN Shield (optional shield)</td>
</tr>
<tr>
<td>CFC</td>
<td>Continuous Function Chart (random-graphics functional chart editor; programming language for creating PLC programs)</td>
</tr>
<tr>
<td>CiA</td>
<td>CAN in Automation e. V. (international organization of manufacturers and users for CAN users; <a href="http://www.can-cia.org">http://www.can-cia.org</a>)</td>
</tr>
<tr>
<td>CLK</td>
<td>Clock</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
</tr>
<tr>
<td>DAC</td>
<td>Digital to Analog Converter</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DGND</td>
<td>Digital Ground (Ground for the digital I/Os’ power supply of the MSD Motion Controller)</td>
</tr>
<tr>
<td>DIN</td>
<td>Deutsches Institut für Normung e. V. (German Institute for Standardization; <a href="http://www.din.de">http://www.din.de</a>)</td>
</tr>
<tr>
<td>DIS</td>
<td>Draft International Standard (preliminary standard)</td>
</tr>
<tr>
<td>DS</td>
<td>Draft Standard (draft standard)</td>
</tr>
<tr>
<td>E-bus</td>
<td>Extension bus of DIN rail modules</td>
</tr>
<tr>
<td>EEPROM</td>
<td>Electrically Erasable Programmable Read Only Memory</td>
</tr>
<tr>
<td>EIA</td>
<td>Electronic Industries Alliance (<a href="http://www.eia.org">http://www.eia.org</a>)</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>EN</td>
<td>Europa-Norm (European Standard)</td>
</tr>
<tr>
<td>EPROM</td>
<td>Erasable Programmable Read Only Memory</td>
</tr>
<tr>
<td>ESD</td>
<td>Electrostatic Discharge</td>
</tr>
<tr>
<td>EtherCAT</td>
<td>Ethernet-based industrial real-time communication system</td>
</tr>
<tr>
<td>FBD</td>
<td>Function Block Diagram (programming language for creating PLC programs)</td>
</tr>
<tr>
<td>F-Bus</td>
<td>Fieldbus, an industrial communication system such as Profibus</td>
</tr>
<tr>
<td>Flash EEPROM</td>
<td>High speed EEPROM</td>
</tr>
<tr>
<td>FPGA</td>
<td>Field Programmable Gate Array (programmable logic component)</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>HF</td>
<td>High Frequency</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface (MACS HMI: Visualization package which can be run without MACS)</td>
</tr>
<tr>
<td>ID</td>
<td>Identifier</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission (<a href="http://www.iec.ch">http://www.iec.ch</a>)</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers, Inc. (<a href="http://www.ieee.org">http://www.ieee.org</a>)</td>
</tr>
<tr>
<td>IL</td>
<td>Instruction List (programming language for creating PLC programs)</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output</td>
</tr>
<tr>
<td>IP</td>
<td>International Protection (protection type)</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Explanation</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid Crystal Display</td>
</tr>
<tr>
<td>LD</td>
<td>Ladder Diagram (programming language for creating PLC programs)</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>LSB</td>
<td>Least Significant Bit</td>
</tr>
<tr>
<td>M3000®</td>
<td>Moog Automation System</td>
</tr>
<tr>
<td>MACS</td>
<td>Moog Axis Control Software (Development environment according to IEC 61131 for solving complex control tasks)</td>
</tr>
<tr>
<td>Mbit/s</td>
<td>Megabits per second</td>
</tr>
<tr>
<td>MSB</td>
<td>Most Significant Bit</td>
</tr>
<tr>
<td>MSC I</td>
<td>Moog Servo Controller I (Control module for DIN top-hat rail mounting)</td>
</tr>
<tr>
<td>MSC II</td>
<td>Moog Servo Controller II (Control module for DIN top-hat rail mounting)</td>
</tr>
<tr>
<td>MSD</td>
<td>Modular Multi-Axis Programmable Motion Control Servodrive</td>
</tr>
<tr>
<td>MSD Motion Controller</td>
<td>Multi-Axis High Performance Motion Controller</td>
</tr>
<tr>
<td>MSD Servodrive</td>
<td>A modular family of electrical servo drives to run permanent magnet synchronous, linear and asynchronous motors</td>
</tr>
<tr>
<td>MSL</td>
<td>Mean Sea Level</td>
</tr>
<tr>
<td>NC</td>
<td>Not Connected</td>
</tr>
<tr>
<td>ND</td>
<td>Not Defined</td>
</tr>
<tr>
<td>PADT</td>
<td>Programming And Diagnostic Tool (programming and diagnostic tool in IEC 61131, here: PC on which the MACS development environment is installed)</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PE</td>
<td>Protective Earth</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Control(ler)</td>
</tr>
<tr>
<td>Q-Modules</td>
<td>DIN rail modules for local extension of MSC IIs (connected over E-bus)</td>
</tr>
<tr>
<td>Q-Connector</td>
<td>40 pole lateral connector of DIN rail modules</td>
</tr>
<tr>
<td>QAIO</td>
<td>Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)</td>
</tr>
<tr>
<td>QBUS-CAN</td>
<td>CAN extension module which can be used to make available the LocalCAN bus of an E-bus group for external CAN bus network stations (over a D-sub front panel connector)</td>
</tr>
<tr>
<td>QDIO</td>
<td>Digital I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)</td>
</tr>
<tr>
<td>R-Modules</td>
<td>Remote modules such as RDIO and RDISP (connection over CAN bus)</td>
</tr>
<tr>
<td>RAM</td>
<td>Random Access Memory (read and write memory that loses its contents when power is removed)</td>
</tr>
<tr>
<td>RDIO</td>
<td>Remote module with digital I/Os and CANopen interface (connection over CAN bus)</td>
</tr>
<tr>
<td>RDISP</td>
<td>Remote Display (display and operating terminal with TIA/EIA 232 and CANopen interface (connection over CAN bus))</td>
</tr>
<tr>
<td>REF</td>
<td>Reference voltage</td>
</tr>
<tr>
<td>RISC</td>
<td>Reduced Instruction Set Computer</td>
</tr>
<tr>
<td>RT-ETH</td>
<td>Real Time Ethernet Interface</td>
</tr>
<tr>
<td>Rx</td>
<td>Receive Data</td>
</tr>
<tr>
<td>SELV</td>
<td>Safety Extra-Low Voltage (according to DIN EN 60950-1)</td>
</tr>
<tr>
<td>SFC</td>
<td>Sequential Function Chart (programming language for creating PLC programs)</td>
</tr>
<tr>
<td>SHLD</td>
<td>Shield</td>
</tr>
<tr>
<td>SIO</td>
<td>Serial I/O (serial interface of the MSC II)</td>
</tr>
</tbody>
</table>
12.3 Quoted Standards

12.3.1 CiA DS

CiA DS 201–207
CiA Draft Standard: CAN Application Layer (CAL)

CiA DS 301
CiA Draft Standard: CANopen Communication Profile for Industrial Systems – Based on CAL

CiA DS 401
CiA Draft Standard: CANopen Device Profile for Generic I/O Modules

12.3.2 DIN

DIN 41652
Rack and Panel Connectors, Trapezoidal, Round Contacts 1 mm

12.3.3 DIN EN

DIN EN 60715
Dimensions of Low Voltage Switchgear and Controlgear – Standardized Mounting on Rails for Mechanical Support of Electrical Devices in Switchgear and Controlgear Installations

DIN EN 60950-1
Information Technology Equipment – Safety – Part 1: General Requirements

DIN EN 61000-6-1
Electromagnetic Compatibility (EMC) – Part 6-1: Generic Standards; Immunity for Residential, Commercial and Light-Industrial Environments

Table 32: Abbreviations (Section 3 of 3)
12 Appendix Quoted Standards

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; Emission Standard for Residential, Commercial and Light-Industrial Environments

DIN EN 61000-6-4
Electromagnetic Compatibility (EMC) – Part 6-4: Generic Standards; Emission Standard for Industrial Environments

DIN EN 60204
Safety of Machinery – Electrical Equipment of Machines

12.3.4 IEC

IEC 60068
Environmental Testing

IEC 60068-2-6
Environmental Testing – Part 2: Tests; Test Fc: Vibration (Sinusoidal)

IEC 60068-2-27
Environmental Testing – Part 2: Tests; Test Ea and Guidance: Shock

IEC 60068-2-31
Environmental Testing – Part 2: Tests; Test Ec: Drop and Topple, Primarily for Equipment-Type Specimens

IEC 60364-4-44
Electrical Installations of Buildings – Part 4-44: Protection for Safety – Protection against Voltage Disturbances and Electromagnetic Disturbances

IEC 60529
Degrees of Protection Provided by Enclosures (IP Code)

IEC 60664
Insulation Coordination for Equipment within Low Voltage Systems

IEC 60801-2

IEC 61131
Programmable Controllers

IEC 61131-1
Programmable Controllers – Part 1: General Information

IEC 61131-2
Programmable Controllers – Part 2: Equipment Requirements and Tests

IEC 61131-3
Programmable Controllers – Part 3: Programming Languages

IEC 61131-4
Programmable Controllers – Part 1: User Guidelines

12.3.5 ISO/DIS

ISO/DIS 11898
Road Vehicles – Controller Area Network (CAN)
12.3.6 TIA/EIA

TIA/EIA 232 (previously RS 232)
Interface Between Data Terminal Equipment and Data Circuit – Terminating Equipment Employing Serial Binary Data Interchange

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

TIA/EIA 485 (previously RS 485)
Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
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