User Manual

M3000® Automation System

MSD Motion Controller

MOTION CONTROLLER FOR MOOG SERVO DRIVES

WHAT MOVES YOUR WORLD

MOOG

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Hanns-Klemm-Strasse 28
71034 Böblingen (Germany)
Telephone: +49 7031 622-0
Fax: +49 7031 622-100
E-Mail: Info.germany@moog.com
M3000-Support@moog.com
Internet: http://www.moog.com/industrial

Subject to changes without prior notice.

CE 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

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!

Using M3000® Safely (Prerequisites)

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

Reservation of Changes and Validity for this Manual

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.

Exclusion of Liability for this Manual

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

Completeness of this Manual

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

Place of Storage for this Manual

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.

Exclusion of Warranty and Liability

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

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.

Retain the Original Packaging

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.

Environmental Protection: Emissions

1.6.2 Disposal

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

Environmental Protection: Disposal

1.7 Standards

1.7.1 CE Labeling of M3000® Modules

CE

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).

CE Labeling of M3000® Modules

1.7.2 IEC 61131-2

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

M3000® and M3000® Modules Comply with 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.

Electromagnetic Compatibility (EMC)

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

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

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® automation system or M3000® 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

Safety Instructions: Typographical Conventions

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

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!

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!

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.

Additional typographical conventions:
⇨ "12.1 Typographical Conventions" on page 97

2.2 Safety Instructions

2.2.1 Safety Related Systems

Safety Instructions: 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.

More on this subject: ⇨ "1.3.1 Safety Related Systems" on page 2

2.2.2 Environmental Conditions

Safety Instructions: 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 explicitely 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

Safety Instructions: 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

Safety Instructions: 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

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.

More on these subjects:
⇨ "5 Mechanical Installation" on page 29 or
⇨ "6 Project Planning and Installation" on page 33

2.2.5 Shutdown and Service

Safety Instructions: 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 explicitely 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.

Safety Instructions: Transportation and Storage

More on this subject: ⇨ "9 Transportation and Storage" on page 57

2.2.7 Communication Between MSD Motion Controller and MACS

Safety Instructions: 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

Safety Instructions: 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

Safety Instructions: 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

Safety Instructions: 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

Safety Instructions: '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

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
  - **QAIO 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

M3000® System Architecture

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

Ethernet

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

CAN Bus

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

MSC II Starter Kit

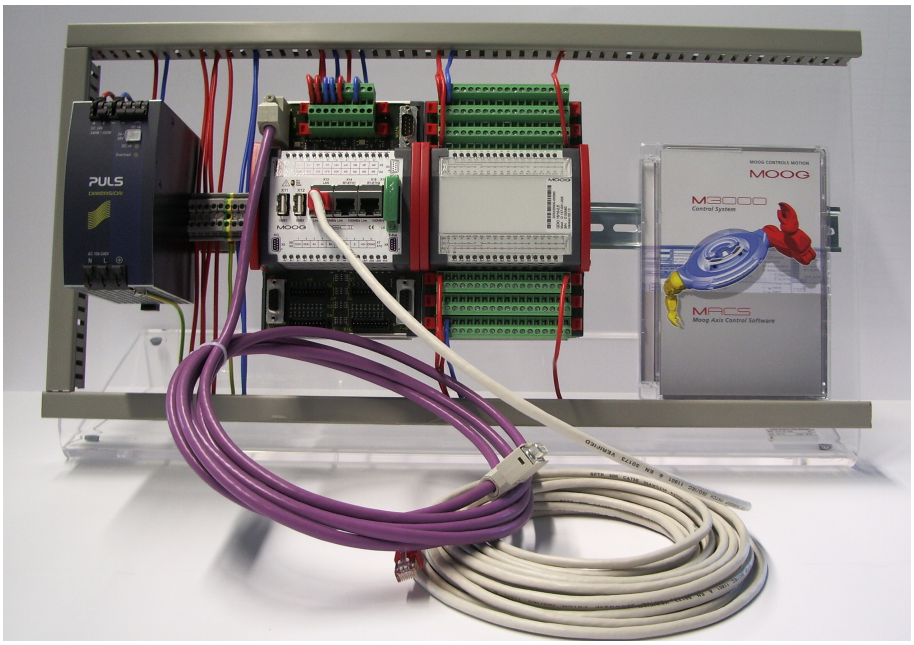


Figure 1: MSC II Starter Kit

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

MSC I

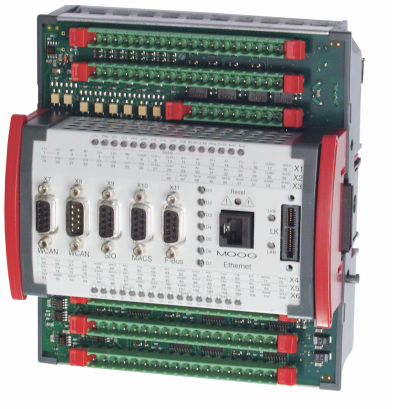


Figure 2: MSC I Control Module

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

MSC II

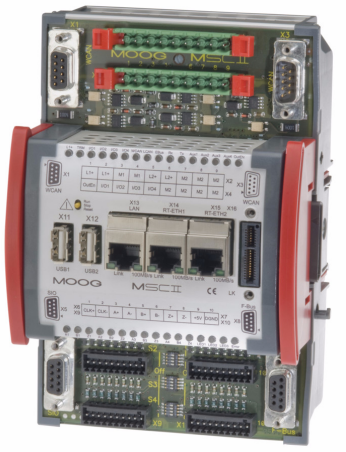


Figure 3: MSC II Control Module

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).
⇨ "3.5 Application Programs" on page 25

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

3.3.3 Q-Modules

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

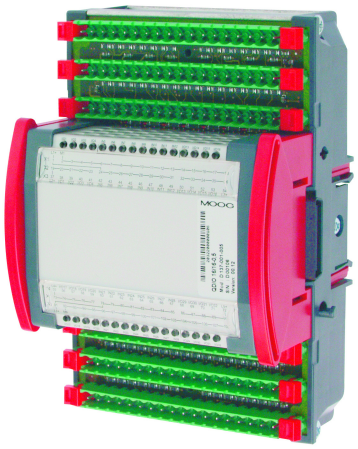


Figure 4: QDIO 16/16

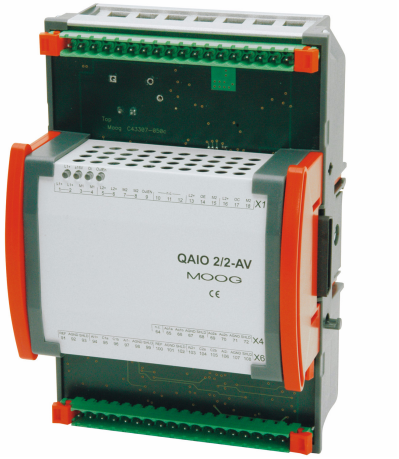


Figure 5: QAIO 2/2

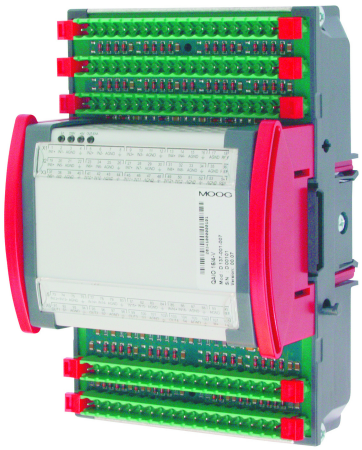


Figure 6: QAIO 16/4

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

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

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 additionally each configurable as ±10 mA, 4-20 mA, ±50 mA).

QAIO 16/4

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

Figure 7: QEBUS-CAN Extension Module

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 (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

Figure 8: RDIO 16/16-0,5 Remote I/O Module

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

RDIO 16/16-0,5 provides 16 positive switching digital inputs and 16 positive switching digital I/Os.

3.3.4.2 RDISP

RDISP

Figure 9: RDISP 22 Display and Operating Terminal

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

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)

CPRDISP

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

DialogController

Figure 10: 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

MSD Motion Controller

Figure 11: 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 axis 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

MSD Servodrive

Figure 12: 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

Identification of M3000® Modules

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

License Key

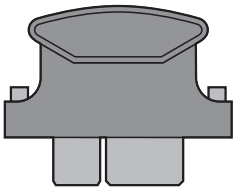


Figure 13: License Key

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.
⇨ "10.6 License Key" on page 69

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

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

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

Programming Languages of MACS

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.
⇨ "11.5 Software" on page 92

3.6.1 MACS HMI Visualization Package

MACS HMI Visualization Package

MACS is also available from Moog as a MACS HMI visualization package.
⇨ "11.5 Software" on page 92

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

Environmental Conditions: Safety Instructions

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 explicitely 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

Environmental Conditions: 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:
⇨ "10.2.2 Environmental Conditions" on page 60

ⓘ Refer to the relevant documentation for the specified environmental conditions for the other M3000® modules.

4.2 Use in Special Environments

Limitations of Using M3000® Modules

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

View of the Module

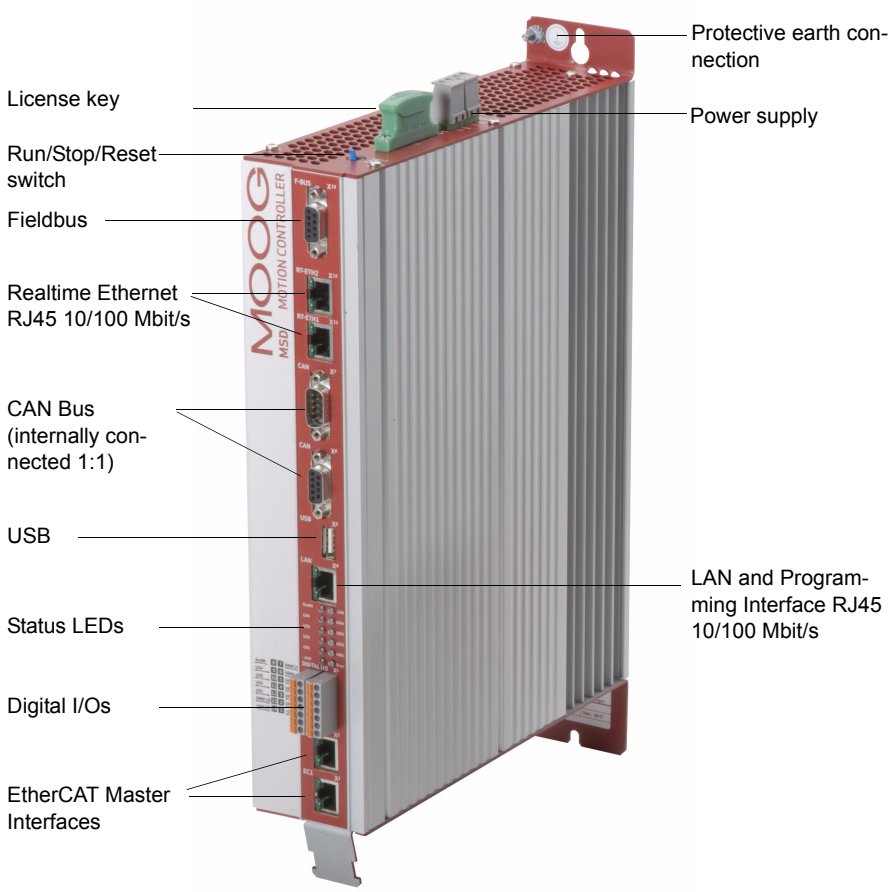


Figure 14: Front View of MSD Motion Controller

5.2 Dimensions

Dimensions

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

Table 1: Dimensions of the MSD Motion Controller

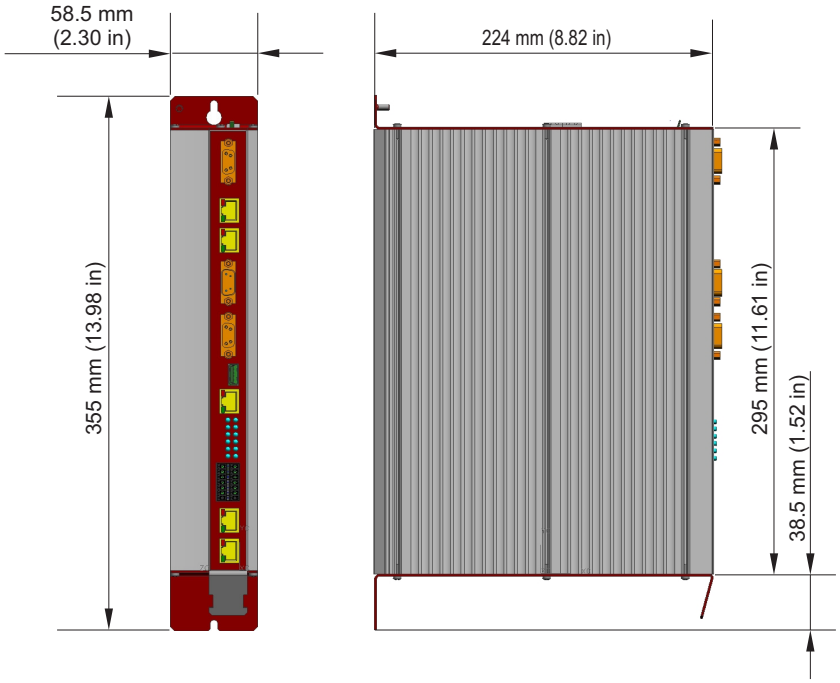


Figure 15: Dimensions of the MSD Motion Controller

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

Mounting clearances

E	For direct side by side mounting
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

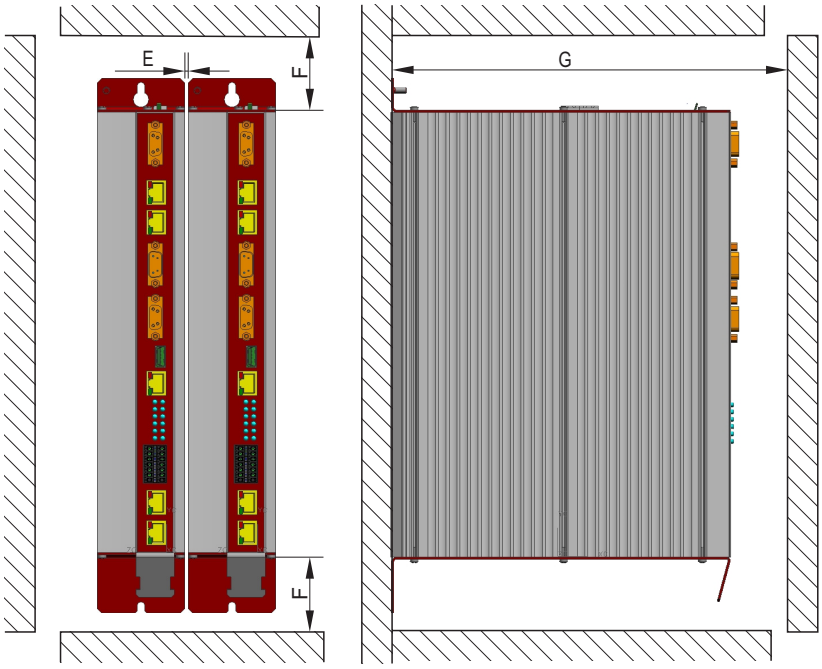


Figure 16: Mounting clearances for the MSD Motion Controller

5.4 Mounting

WARNING

Mounting: Safety Instructions

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.!

Mounting

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

Removing: Safety Instructions

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.!

Removing

Procedure for removing modules:

1. Loosen the fixing screws
2. Remove the module

6 Project Planning and Installation

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

Grounding Concept

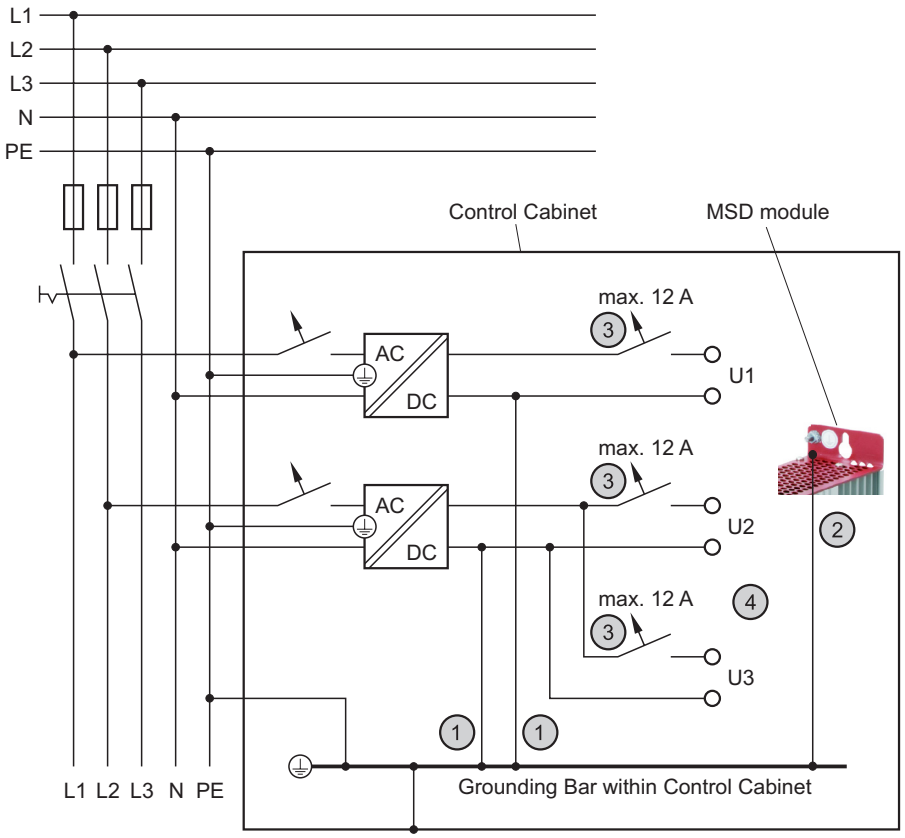


Figure 17: Grounding Concept

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

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

(3) Every circuit must be fused (maximum 12 A).

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

6.1.1 Front Panel Connectors' Grounding

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

Power Supply for M3000® Modules

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

Power Supply Characteristics of M3000® Modules

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)

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

Power Consumption

DIN Rail Module		Power Consumption [1] From 24 V DC (No-Load [2])	From 24 V DC (Full Load)
MSD Motion Controller	Internal Electronics	about 0.3 A	max. 0.8 A
	Digital Outputs	-	max. 2 A
RDIO		max. 0.3 A	max. 10 A
QDIO		-	max. 10 A
QAIO 16/4		about 0.15 A	max. 0.3 A

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

Connecting the Power Supply: Safety Instructions

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

Power Supply for the Module's Internal Electronics and the Sensors

	Power Supply	
	Internal Electronics	**Sensors**
Module and sensors are in operation	on	on
Reverse energization from sensor to module	off	on
Invalid sensor data	on	off
Module and sensors are not in operation	off	off

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

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

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

Maximum Admissible Current for M3000® Modules

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

Connecting Sensors: Safety Instructions

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

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.

Correct Power Supply Connection of Sensors via a QDIO

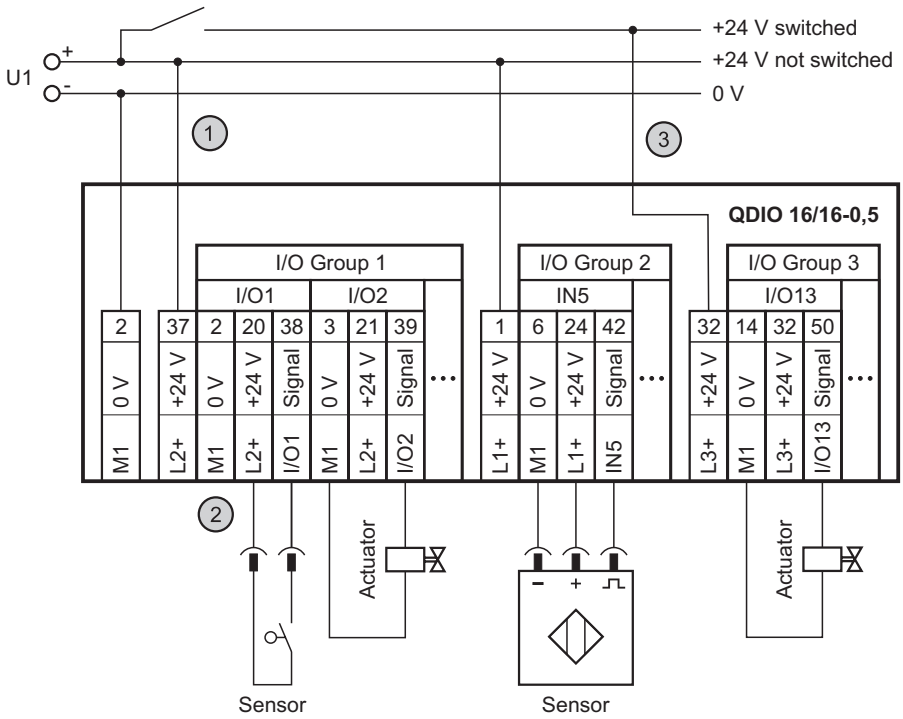


Figure 18: Correct Power Supply Connection of Sensors via a QDIO

(1) 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!

(2) 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)!

(3) Outputs may be supplied with power from a switched power supply, for example with intermediate devices (emergency stop, manual operation, etc.).

Wrong Power Supply Connection of Sensors via a QDIO

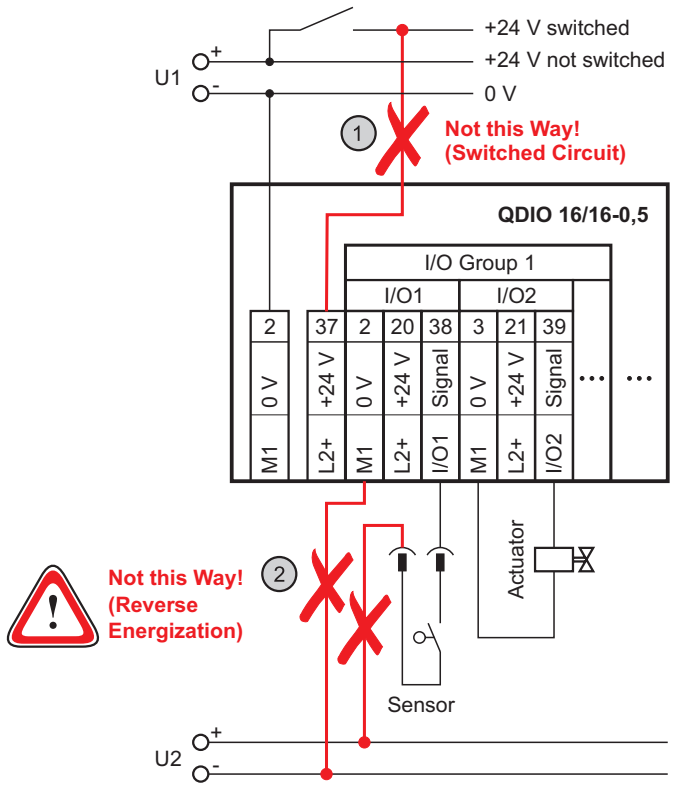


Figure 19: Wrong Power Supply Connection of Sensors via a QDIO

(1) 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!

(2) 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)!

6.3 Connecting Signal Cables

Connecting Signal Cables: Safety Instructions

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.!

Connecting Signal Cables over Plug-In Terminal Strips

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

Connection Methods for Plug-In Terminal Strips of M3000® Modules

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

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

Peer-to-Peer Connection of 2 Network Stations

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

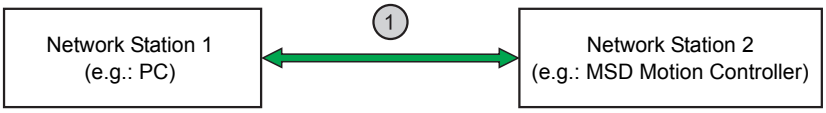


Figure 20: Ethernet Network with exactly 2 Network Stations

1
- 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.

Ethernet Network with more than 2 Network Stations

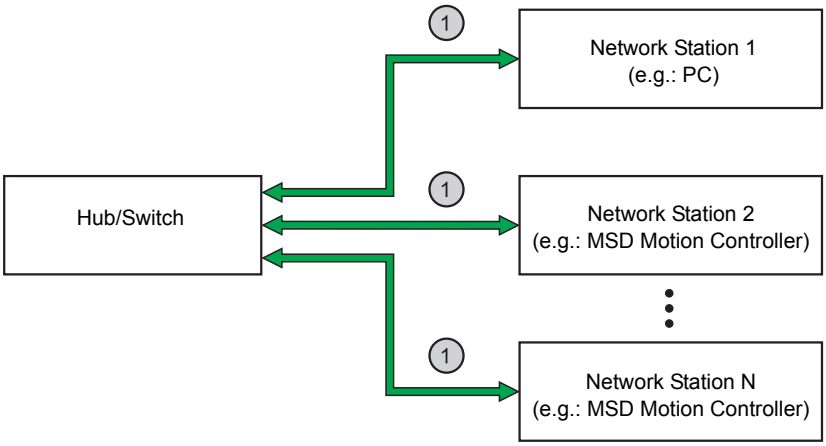


Figure 21: Ethernet Network with more than 2 Network Stations

1

- 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)

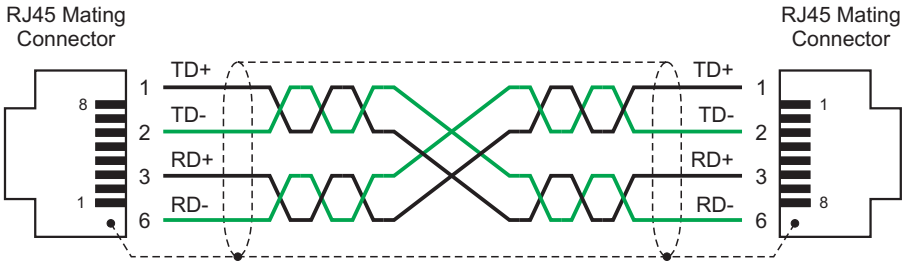


Figure 22: 100BaseT Cable with Crossed Twisted Pair Wires (Crossover Cable) with 8 Pole RJ45 Mating Connectors, Cable Category 5, Wire Cross Section > 0.22 mm² (24 AWG)

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

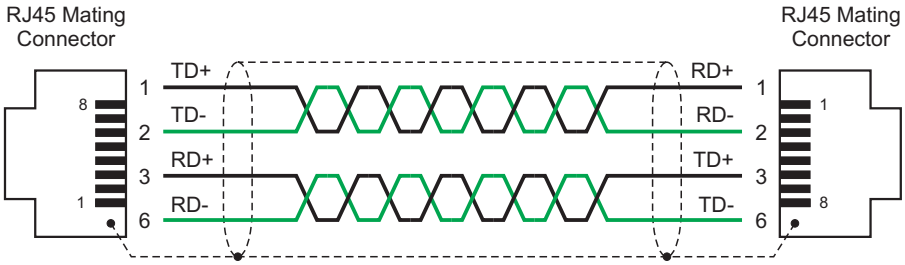


Figure 23: 100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable) with 8 Pole RJ45 Mating Connectors, Cable Category 5, Wire Cross Section > 0.22 mm² (24 AWG)

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

7.2 EtherCAT

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

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

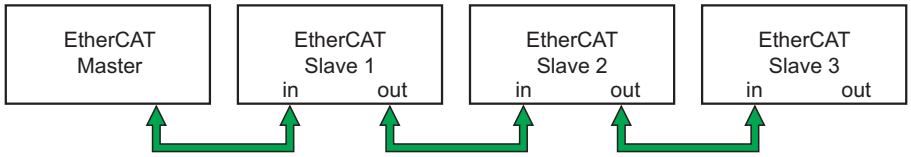


Figure 24: EtherCAT Bus Topology

7.2.2 EtherCAT Interface Cables

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

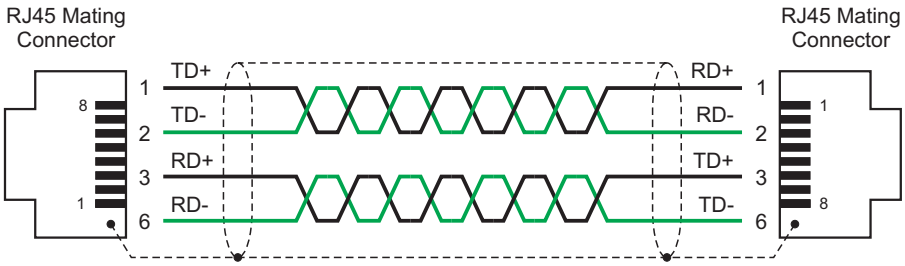


Figure 25: 100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable)
with 8 Pole RJ45 Mating Connectors, Cable Category 5, Wire Cross Section > 0.22 mm² (24 AWG)

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

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

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

Wiring Profibus Networks

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.

Linear Structure of the Profibus with Termination Resistors

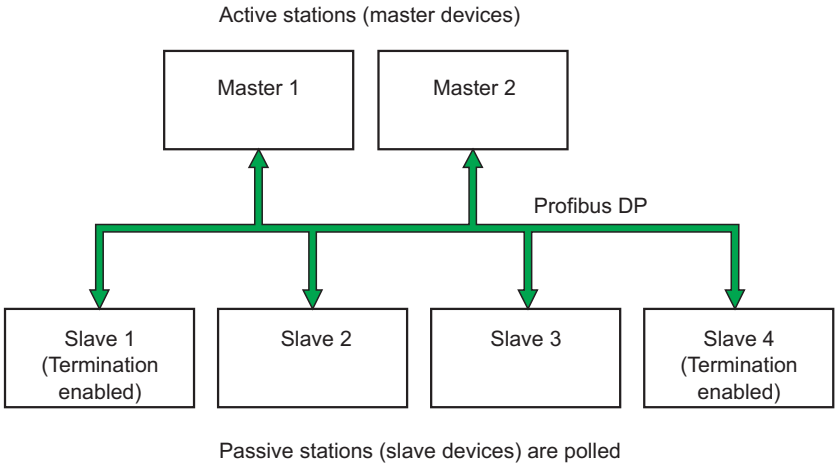


Figure 26: Linear Structure of the Profibus with Termination Resistors

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

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

9 Pole D-sub Mating Connector with switchable termination according to IEC 61158/EN 50170

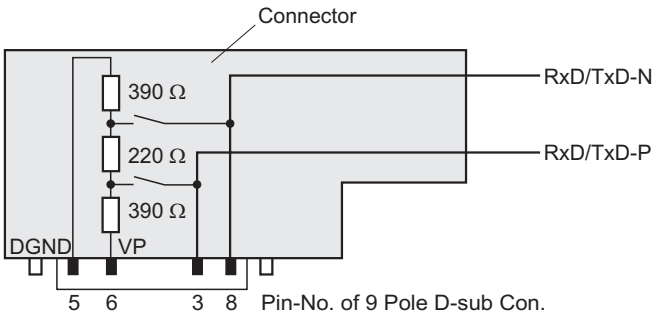


Figure 27: 9 Pole D-sub Mating Connector with switchable termination according to IEC 61158/EN 50170

Profibus Interface - Connector with internal longitudinal inductivity according to IEC 61158/EN 50170

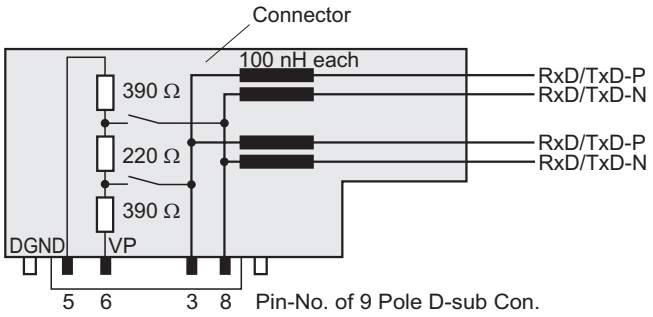


Figure 28: Profibus Interface - Connector with internal longitudinal inductivity according to IEC 61158/EN 50170

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

7.3.4.2 Connector Pin out

Connector Pin out

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

Table 5: Connector Pin out

[1)] These signals are mandatory and must be provided by the user.

7.3.4.3 Cable Lengths

Maximum Cable Lengths in Profibus Networks

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

Table 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.

Permissible Stub Cable Lengths in Profibus Networks

Transmission Rate	Maximum Stub Cable Length
12,000 kBit/s	no stub cable allowed
1,500 kBit/s	< 1.5 m
500 kBit/s	< 6.6 m

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

7.3.4.4 Suitable Cables

Suitable Cables for Profibus Interface Cables

Parameters	Cable Type A
Loop resistance at 3-20 MHz	135-165 Ω (150 Ω ±10 %)
Capacity	< 30 pF/m
Impedance	< 110 Ω/km
Wire diameter	> 0.64 mm
Wire Cross Section	> 0.34 mm²

Table 8: Suitable Cables for Profibus Interface Cables

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

7.4 CAN Bus and CANopen

7.4.1 CAN Bus

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 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

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.

CANopen Device Profiles

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

M3000® Modules with CAN Bus Interfaces

M3000® Module		Number of Connectors	Number of CAN Bus Controllers	CAN Bus Termination Resistor
MSD Motion Controller	**CAN**	2 D-sub front panel connectors [1]	1	-
MSC I and MSC II	**LocalCAN**	2 Q-connectors (lateral)	1	switchable
	WideCAN	2 D-sub front panel connectors [2]	1	-
RDIO		2 D-sub front panel connectors [2]	1	-
RDISP		1 D-sub connector (on the rear)	1	switchable
QEBUS-CAN	**LocalCAN**	1 Q-connector (lateral) 1 D-sub connector (front)	0	switchable

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

Wiring CAN Bus Networks

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

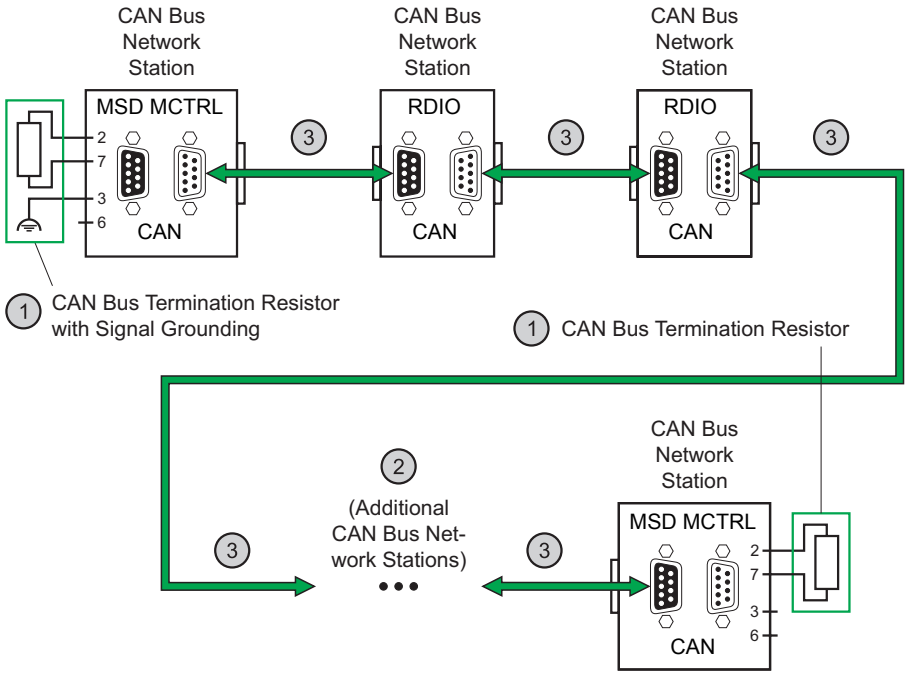


Figure 29: Linear Structure of the CAN Bus
with CAN Bus Termination Resistors and Potential Equalization

(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: max. 64 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.

7.4.6 CAN Bus Interface Cable

7.4.6.1 Terminal Assignment

CAN Bus Interface Cable

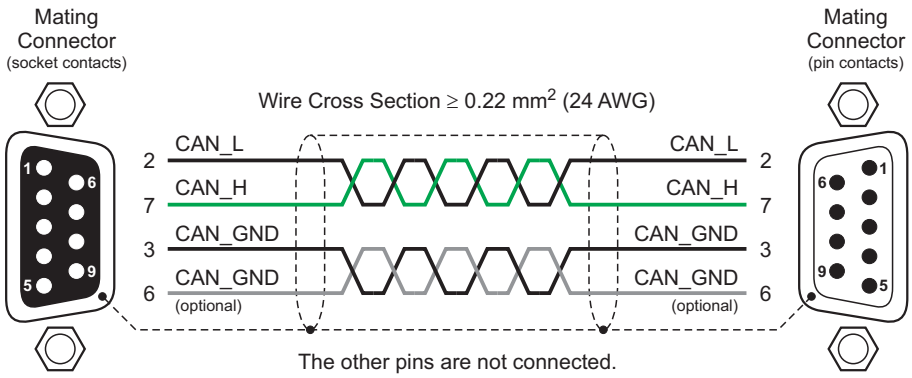


Figure 30: CAN Bus Interface Cable
with 9 Pole D-sub Mating Connectors according to DIN 41652

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.

Maximum Cable Lengths in CAN Bus Networks

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

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

Permissible Stub Cable Lengths in CAN Bus Networks

Transmission Rate	Maximum Stub Cable Length	
	Maximum	Cumulated
1,000 kBit/s	2 m (2.1 yd)	20 m (21.8 yd)
500 kBit/s	6 m (6.5 yd)	39 m (42.6 yd)
250 kBit/s	6 m (6.5 yd)	78 m (85.3 yd)
125 kBit/s	6 m (6.5 yd)	156 m (170.6 yd)

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

Suitable Cables for CAN Bus Interface Cables

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

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) 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).

ⓘ 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

Shutdown and Service: Safety Instructions

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 explicitely 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

Shutdown: Safety Instructions

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

Maintenance/Repair: Safety Instructions

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

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

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.

Repair Seal

Figure 31: Repair Seal

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

Transportation and Storage: Safety Instructions

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

Transportation and Storage: 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

MSD Motion Controller: Programmable Multi-Axis 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

Interfaces of the MSD Motion Controller

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)

I/Os (Inputs/Outputs) of the MSD Motion Controller

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

Safety Functions of the MSD Motion Controller

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

General Specifications of the MSD Motion Controller

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

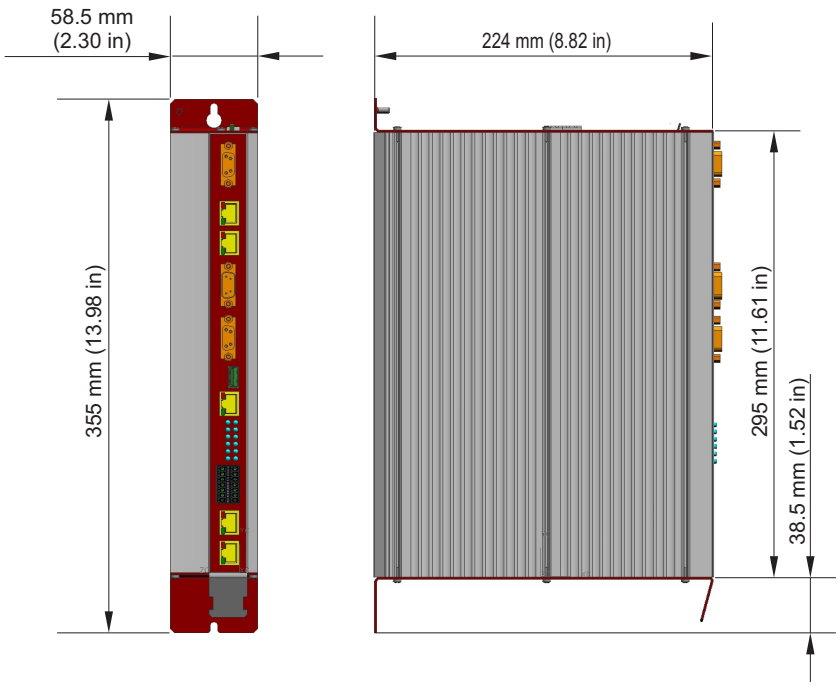


Figure 32: Dimensions of the MSD Motion Controller

10.2.2 Environmental Conditions

Environmental Conditions: Safety Instructions

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 explicitely 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

Environmental Conditions: 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

Environmental Conditions: 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

Environmental Conditions: 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

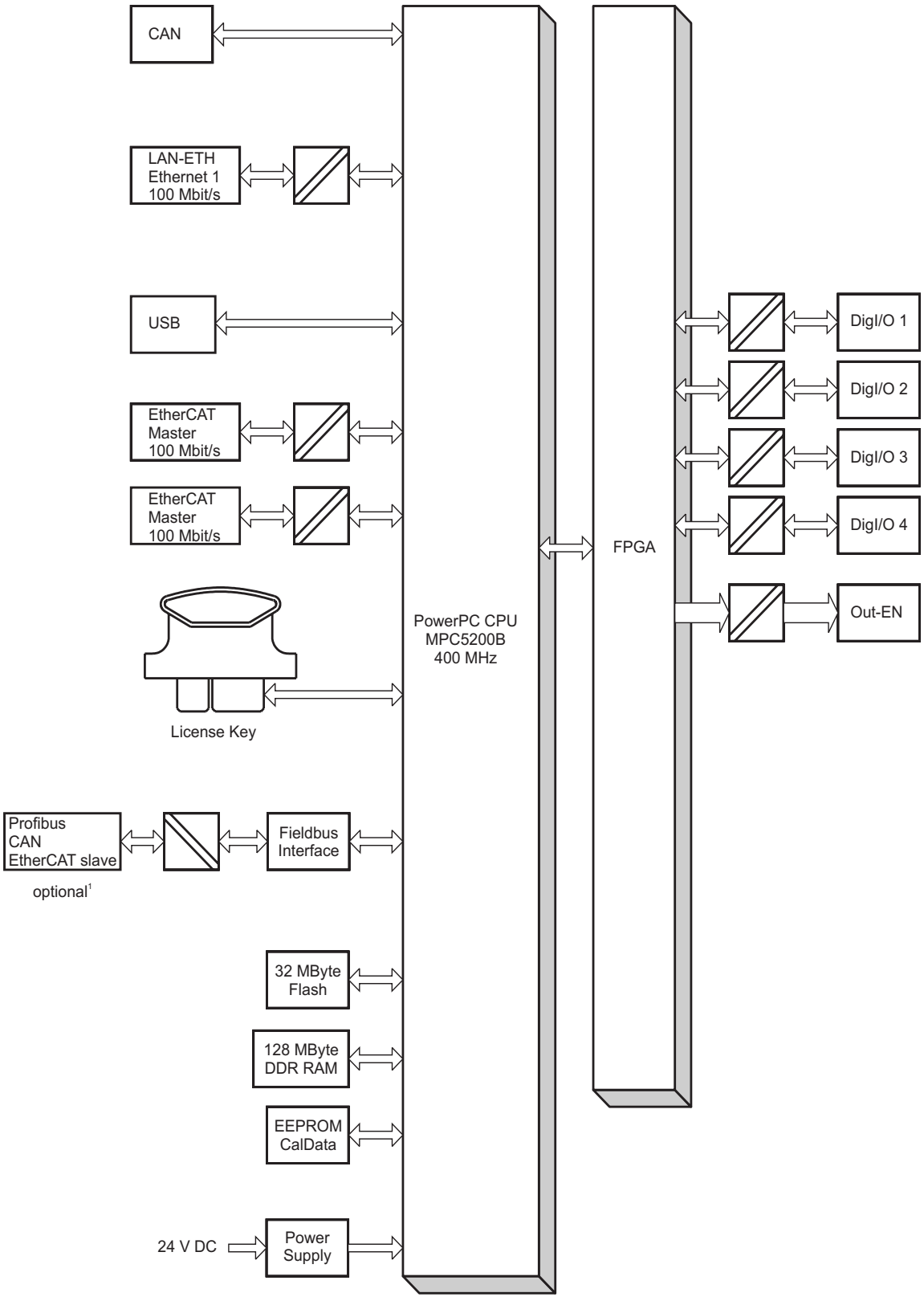


Figure 33: Block Diagram of the MSD Motion Controller

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

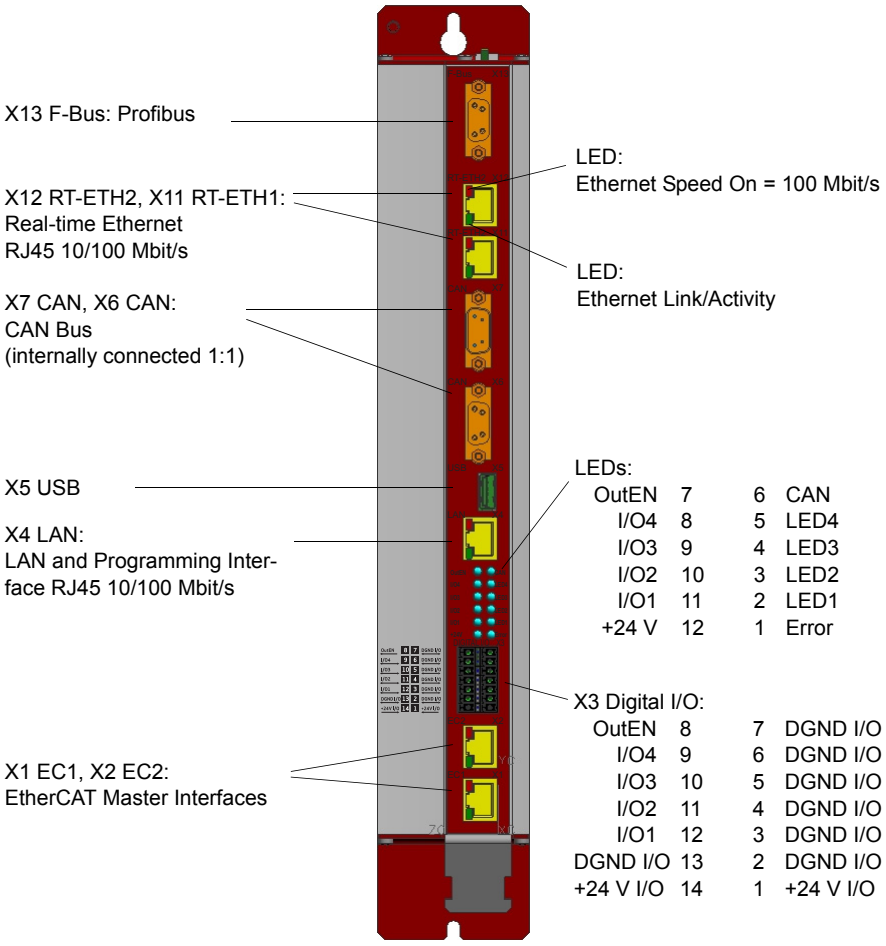


Figure 34: Front Panel of the MSD Motion Controller

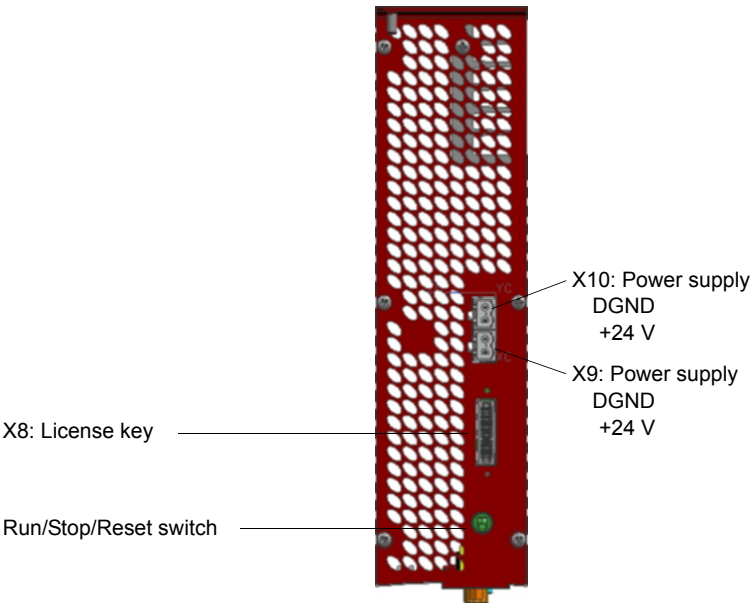


Figure 35: Top view of the MSD Motion Controller

10.4.1 Terminal Assignment

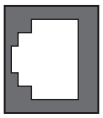
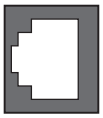
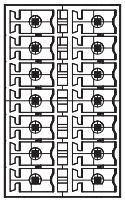
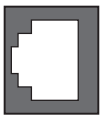
Connector	No.	Assignment	Circuit	
X1  **EC1**	1	Tx+	Transmit data+	**EtherCAT (EC1)**
	2	Tx-	Transmit data-	
	3	Rx+	Receive data+	
	4			
	5			
	6	Rx-	Receive data-	
	7			
	8			
X2  **EC2**	1	Tx+	Transmit data+	**EtherCAT (EC2)**
	2	Tx-	Transmit data-	
	3	Rx+	Receive data+	
	4			
	5			
	6	Rx-	Receive data-	
	7			
	8			
X3 	1	+24 V I/O	+24 V power supply for digital I/Os	**Digital I/Os**
	2	DGND I/O	Ground for the digital I/Os' power supply	
	3	DGND I/O	Ground for the digital I/Os' power supply	
	4	DGND I/O	Ground for the digital I/Os' power supply	
	5	DGND I/O	Ground for the digital I/Os' power supply	
	6	DGND I/O	Ground for the digital I/Os' power supply	
	7	DGND I/O	Ground for the digital I/Os' power supply	
	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  **LAN**	1	Tx+	Transmit data+	**Ethernet (LAN)**
	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)

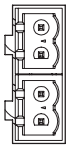
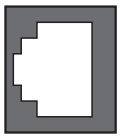
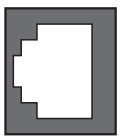
Connector	No.	Assignment	Circuit	
X5  **USB**	1	+5V	+5 V Power supply for slaves	**USB**
	2	D-	Data-	
	3	D+	Data+	
	4	DGND	Digital Ground	
X6  **CAN (female)**	1			**CAN**
	2	CAN-L	CAN-	
	3	DGND	Ground for the CAN bus interface	
	4			
	5			
	6			
	7	CAN-H	CAN+	
	8			
	9			
X7  **CAN (male)**	1			**CAN**
	2	CAN-L	CAN-	
	3	DGND	Ground for the CAN bus interface	
	4			
	5			
	6			
	7	CAN-H	CAN+	
	8			
	9			
X9, X10  **Power Supply**	1	+24 V	+24 V power supply for the module	**Power Supply**
	2	DGND	Ground for the modules' power supply	
X11  **RT-ETH1**	1	Tx+	Transmit data+	**Ethernet (RT-ETH1)**
	2	Tx-	Transmit data-	
	3	Rx+	Receive data+	
	4			
	5			
	6	Rx-	Receive data-	
	7			
	8			
X12  **RT-ETH2**	1	Tx+	Transmit data+	**Ethernet (RT-ETH2)**
	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 2 of 3)

Connector	No.	Assignment	Circuit	
X13  **F-Bus**	1	Shield	Shield / grounding	**Profibus (F-Bus)**
	2	M24	24 V output voltage (ground)	
	3	RxD/TxD-P	Receive / transmission data - positive potential	
	4	CNTR-P	Control signal for repeater (direction control)	
	5	DGND	Potential of transmission data (ground to 5 V)	
	6	VP	Power supply of the terminators (+5 V)	
	7	P24	24 V output voltage	
	8	RxD/TxD-N	Receive / transmission data - negative potential	
	9	CNTR-N	Control signal for repeater (direction control)	

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

10.4.2 LEDs

Area	LED	Display	Explanation
Status	+24 V	+24 V and internal +5 V ok	Illuminates when the power supply for the MSD Motion Controller's internal electronics is OK and the internal power pack is supplying +5 V. ⇨ "6.2 Power Supply" on page 35
	I/O1	Internal status of the digital I/O 1	⇨ "10.10.1 Display of the Operational State" on page 75
	I/O2	Internal status of the digital I/O 2	
	I/O3	Internal status of the digital I/O 3	
	I/O4	Internal status of the digital I/O 4	
	CAN	CAN transmission activity	Flashes in synchronization with the data that the MSD Motion Controller is sending over the CAN interface. ⇨ "10.13 CAN Bus Interfaces" on page 84
	OutEN	Outputs enabled	Illuminates when all outputs are under the control of the application program. ⇨ "10.14.2 'Outputs Enabled' Output (LED «OutEN»)" on page 85
User	LED1	Activated by application program or error display	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). The states that these LEDs will indicate while the application program is running are set in the application program. If «Error» illuminates or flashes in addition to these LEDs, this indicates MSD Motion Controller's elementary operational states or errors. ⇨ Table 15 on page 67
	LED2	Activated by application program or error display	
	LED3	Activated by application program or error display	
	LED4	Activated by application program or error display	
	Error	Error display	Illuminates when there is an error. The type of error is specified in «LED1», «LED2», and «LED3». ⇨ Table 15 on page 67
Ethernet	Link	Ethernet link/activity	Illuminates when the Ethernet link pulse is available and blinks at activity
	Speed	On = 100 Mbit/s	Ethernet connection speed

Table 14: LEDs of the MSD Motion Controller

10.4.2.1 Display of Elementary Operational States and Errors

State	Explanation	User LEDs			
		LED1	LED2	LED3	Error
Ready	The MSD Motion Controller was started successfully. The user LEDs «LED1», «LED2» and «LED3» are now available for the application program.	0	0	0	0
Booting	Boot process is running	1	0	0	0
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	
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

Programming and Configuration of the MSD Motion Controller

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.

Communication Between MSD Motion Controller and 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

Communication Parameters of the Ethernet 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

License Key of the MSD Motion Controller: Safety Instructions

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

License Key of the MSD Motion Controller: 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

License Key of the MSD Motion Controller: 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

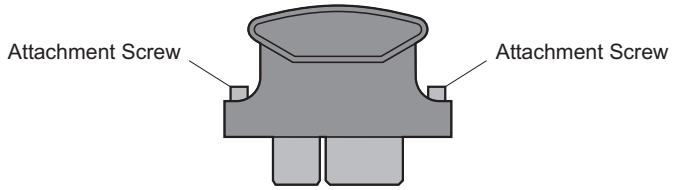


Figure 36: License Key of the MSD Motion Controller with Attachment Screws

10.6.3.1 Required Tool

License Key of the MSD Motion Controller: Tool required for Mounting and Removing

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

- 3 mm screwdriver

10.6.3.2 Mounting the License Key

Mounting the License Key: Safety Instructions

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:

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

Removing the License Key: Safety Instructions

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:

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

Run/Stop/Reset Switch of the MSD Motion Controller

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

MACS [1)]	Run/Stop/Reset switch	Application program
Stop	Stop	Stop
Stop	Run	Stop
Run	Stop	Stop
Run	Run	Run

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

Power Supply of the MSD Motion Controller: Safety Instructions

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

Contents of the Flash EEPROM

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.

Switching Back on or Resetting the MSD Motion Controller: Safety Instructions

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.

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!

10.8.1.1 Switching on the Power Supply

Switching on the Power Supply: Safety Instructions

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.

MSD Motion Controller's Behavior at Switching on the Power Supply

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

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

Digital I/Os I/O1…I/O4 of the MSD Motion Controller

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

Status LEDs «I/O1»…«I/O4»

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

Power Supply of the Digital I/Os of the MSD Motion Controller: Safety Instructions

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.

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

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 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

Digital Outputs of the MSD Motion Controller

The following digital output circuits are available:

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

Basic Wiring Diagram of a Digital Output of the MSD Motion Controller

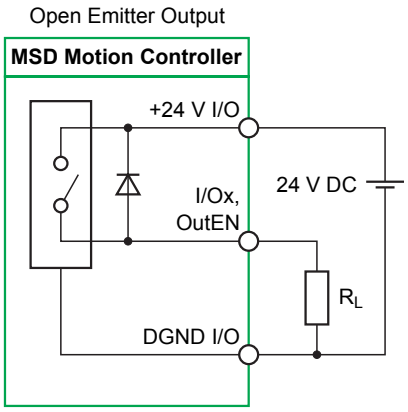


Figure 37: Basic Wiring Diagram of a Digital Open Emitter/Collector Output of the MSD Motion Controller

(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

Open Emitter Output

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

10.10.3.1 Dependence on the 'Outputs Enabled' Signal

Dependence of MSD Motion Controller's Digital Outputs 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

Current Limiting and Overload Protection for Digital Outputs of the MSD Motion Controller

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

Specifications of MSD Motion Controller's Digital Outputs

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

Load Connection of MSD Motion Controller's Digital Outputs

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

Insulation Resistance of MSD Motion Controller's Digital Outputs

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.

Digital Inputs of the MSD Motion Controller

10.10.4.1 Basic Wiring Diagram

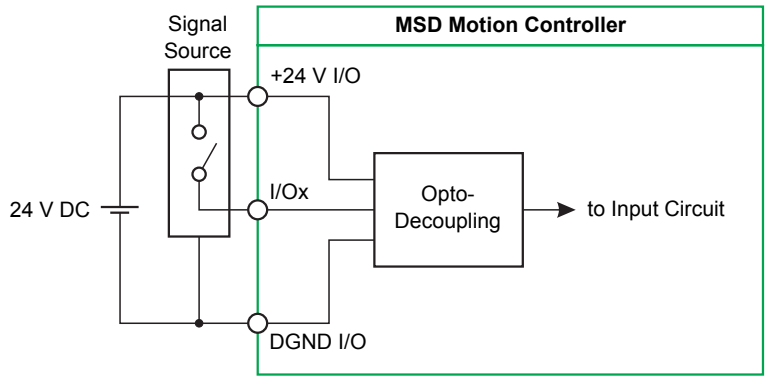


Figure 38: Basic Wiring Diagram of a Digital Input of the MSD Motion Controller (Current Consuming)

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.

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

Pulse Detection and Disturbance Suppression of MSD Motion Controller's Digital Inputs

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: ≤ 50 µs
- Pulses that can be detected (if the system reads the input when the pulse appears); pulse duration: > 50 µs
- 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

Specifications of MSD Motion Controller's Digital Inputs

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

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

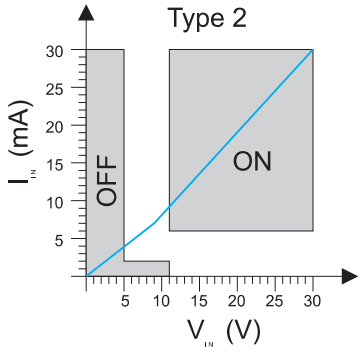


Figure 39: U/I Working Ranges of MSD Motion Controller's Digital Inputs (Current Consuming)

Input voltage (DC) of the external power supply +24 V I/O	rated voltage	U_e = 24 V
	upper limit	$U_{e\ max}$ = 36 V
	lower limit	$U_{e\ min}$ = 18 V
Limits for the 1 state	upper limit	UH_{max} = 30 V IH_{max} = 30 mA
	lower limit	UH_{min} = 11 V IH_{min} = 6 mA
Limits for the 0 state	upper limit	UL_{max} = 11/5 V IL_{max} = 2/30 mA
	lower limit	UL_{min} = -3 V IL_{min} = ND

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

10.10.4.5 Insulation Resistance

Insulation Resistance of MSD Motion Controller's Digital Inputs

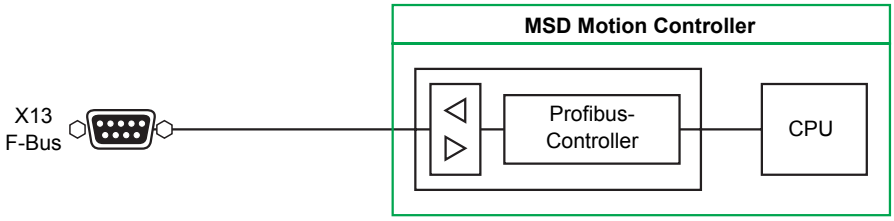
Insulation resistance

Rated voltage: 0–50 V DC

Test voltage for 2,000 m (2,187 yd) operating elevation: 500 V DC

10.11 Profibus DP Interface

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



Profibus DP Interface of the MSD Motion Controller

Figure 40: Profibus DP Interface of the MSD Motion Controller

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

CAN Bus Interfaces of the MSD Motion Controller

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

CAN Bus Interfaces of the MSD Motion Controller

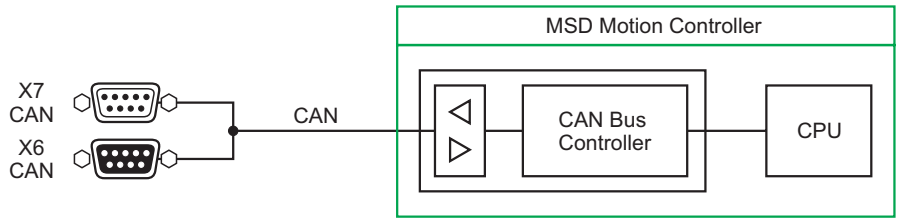


Figure 41: CAN Bus Interfaces of the MSD Motion Controller

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

Setting/Modifying MSD Motion Controller's 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

Watchdog of the MSD Motion Controller

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»)

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

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

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

«OutEN» LED of the MSD Motion Controller

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

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

Nameplate of the MSD Motion Controller

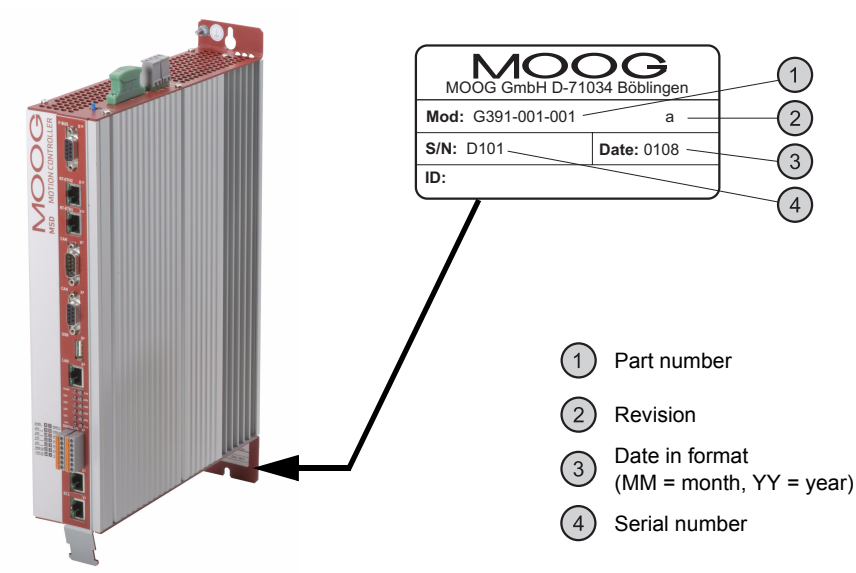


Figure 42: Position of the Nameplate on the MSD Motion Controller

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

Product Range: M3000® Starter Kits

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

Table 18: Product Range – M3000® Starter Kits

11.2 M3000® Modules

11.2.1 Controller

Product Range: Controller

Item Designation	Remarks	Part Number
MSC II	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 ⇨ "3.3.2 MSC II" on page 17	D136-002-002
MSC II with Profibus-DP interface	As D136-002-002, additional Profibus-DP slave interface ⇨ "3.3.2 MSC II" on page 17	D136-002-001
MSC II with EtherCAT interface	As D136-002-002, additional dual EtherCAT master interface ⇨ "3.3.2 MSC II" on page 17	D136-002-003
MSD Motion Controller	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 ⇨ "3.3.5 MSD Motion Controller" on page 22	G391-001-001
MSD Motion Controller with Profibus-DP interface	As G391-001-001, additional Profibus-DP slave interface ⇨ "3.3.5 MSD Motion Controller" on page 22	G391-001-002
MSC I Motion Controller	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	D136-001-008
MSC I Motion Controller with Profibus-DP interface	As D136-001-008, additional Profibus-DP slave interface	D136-001-007

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

Product Range: Q-Modules

Item Designation	Remarks	Part Number
QDIO 16/16-0,5	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 ⇨ "3.3.3 Q-Modules" on page 17	D137-001-005
QDIO 16/16-0,5N	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 ⇨ "3.3.3 Q-Modules" on page 17	D137-001-004
QAIO 2/2-AV	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) ⇨ "3.3.3 Q-Modules" on page 17	D137-001-011
QAIO 16/4-V	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) ⇨ "3.3.3 Q-Modules" on page 17	D137-001-007
QAIO 16/4-A	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) ⇨ "3.3.3 Q-Modules" on page 17	D137-001-006
QEBUS-CAN	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) ⇨ "3.3.3.2 QEBUS-CAN" on page 19	D137-001-010

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)

Product Range: R-Modules (Remote Modules)

Item Designation	Remarks	Part Number
RDIO 16/16-0,5	Remote module with digital I/Os and CANopen interface (connection over CAN bus) 16 inputs and 16 I/Os Positive switching ⇨ "3.3.4 R-Modules (Remote Modules)" on page 19	D137-002-001
RDISP 22	Display and operating terminal with TIA/EIA 232 and CANopen interface and 22 keys (connection over CAN bus) ⇨ "3.3.4 R-Modules (Remote Modules)" 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. ⇨ "11.5.2 Software for R-Modules" on page 92	D137-004-001
DialogController	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" Display 10.4" Display 12.1"	 D137-004-004 D137-004-005 D137-004-006

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

Product Range: Power Supply for M3000® Modules

Item Designation	Remarks	Part Number
Power supply 24 V 10 A	Power-supply for mounting on DIN top-hat rails with short-circuit protection Input: 230 V AC or 115 V AC Output: 24 V DC, 10 A max.	D137-003-001

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

11.4 License Keys

Product Range: License Keys

Item Designation	Remarks	Part Number
License key Controls	gray	D138-002-001
License key Motion	green	D138-002-002

Table 23: Product Range – License Keys

License Keys: Features

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

• Feature included

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)

Product Range: Software – MACS

Item Designation	Remarks	Part Number
MACS development environment	Development environment according to IEC 61131 for solving complex control tasks (1 license) ⇨ "3.5 Application Programs" on page 25	D138-001-001
	1 additional license	D138-001-002
	5 licenses	D138-001-005
	10 licenses	D138-001-010
MACS HMI	Visualization package which can be run without MACS Run-time license for 1 system ⇨ "3.6.1 MACS HMI Visualization Package" on page 26	D138-003-001
	Run-time license for 10 systems	D138-003-010
	Run-time license for 50 systems	D138-003-050
Software maintenance contract	Support and MACS updates for 1 year (for 1 license)	B95914-001-001
	1 additional license	B95914-001-002
	5 licenses	B95914-001-005
	10 licenses	B95914-001-010

Table 25: Product Range – Software – MACS

11.5.2 Software for R-Modules

Product Range: Software for R-Modules

Item Designation	Remarks	Part Number
CPRDISP	Software for programming and configuring RDISP ⇨ "3.3.4.2 RDISP" on page 20	D138-006-001

Table 26: Product Range – Software for R-Modules

11.6 Interface Cables

Product Range: Interface Cables

Item Designation	Remarks	Part Number
Crossed TIA/EIA 232 interface cable, 5 m (5.47 yd)	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	B95884-001
Crossed Ethernet interface cable, 10 m (10.94 yd)	100BaseT Cable with Crossed Twisted Pair Wires (Crossover Cable) with 8 pole RJ45 mating connectors ⇨ figure 22 on page 43	B95909-001
Non-crossed Ethernet interface cable, 1 m (1.09 yd)	100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable) with 8 pole RJ45 mating connectors ⇨ figure 23 on page 43	B95909-004
Non-crossed Ethernet interface cable, 10 m (10.94 yd)	100BaseT Cable with Non-Crossed Twisted Pair Wires (Patch Cable) with 8 pole RJ45 mating connectors ⇨ figure 23 on page 43	B95909-002
CAN bus interface cable, 3 m (3.28 yd)	⇨ "7.4.6 CAN Bus Interface Cable" on page 53	B95863-001
CAN bus interface cable, 10 m (10.94 yd)	⇨ "7.4.6 CAN Bus Interface Cable" on page 53	B95863-002

Table 27: Product Range – Interface Cables

11.7 CAN Bus Accessories

Product Range: CAN Bus Accessories

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

Table 28: Product Range – CAN Bus Accessories

11.8 Plug-In Terminal Strips

Product Range: Plug-In Terminal Strips for DIN Rail Modules

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

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

Number of Required Plug-In Terminal Strips

DIN Rail Module	Number of Plug-In Terminal Strips Required			
	2 Poles	9 Poles	10 Poles	18 Poles
MSC I	-	1	-	5
MSC II	-	2	4	-
MSD Motion Controller	-	-	-	-
QDIO	-	-	-	6
QAIO 2/2	-	1	-	2
QAIO 16/4	-	-	-	6
QEBUS-CAN	1	-	-	-
RDIO	-	-	-	6
RDISP	-	-	-	-
DialogController	-	-	-	-

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

Product Range: Training Programs

Item Designation	Remarks	Part Number
Software training, English MACS and IEC 61131	Content of the training: • Programming, testing, optimizing, and documenting IEC 61131 application programs • Visualization of IEC 61131 application programs	B95992
Software training, German MACS and IEC 61131	Content of the training: • Programming, testing, optimizing, and documenting IEC 61131 application programs • Visualization of IEC 61131 application programs	B95993
Hardware training, English MSC II and extension modules	Content of the training: • Configuring and using MSC II and extension modules • Using control-engineering libraries 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.	B95994
Hardware training, German MSC II and extension modules	Content of the training: • Configuring and using MSC II and extension modules • Using control-engineering libraries 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.	B95995
Hardware and Software training, English MSD Servodrives and MSD Motion Controller	Content of the training: • MSD Servo Drive Hardware • MSD Servo Drive Software • MSD Motion Controller 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.	CA67627
Hardware and Software training, German MSD Servodrives and MSD Motion Controller	Content of the training: • MSD Servodrive Hardware • MSD Servodrive Software • MSD Motion Controller 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.	CA67628

Table 31: Product Range – Training Programs

12 Appendix

12.1 Typographical Conventions

Typographical Conventions

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!

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!

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.

• / –

Identifies listings

⇨

Identifies references to another chapter, another page, table or figure in this manual

blue text

Identifies a hyperlink within the PDF file

Identifies important information

1., 2., …

Identifies steps in a procedure that should be performed in consecutive order

Identifies items in a figure that are explained separately

«WCAN»

Identifies terminals or connectors (such as: «WCAN») and light emitting diodes (such as: «I/O1») of an M3000® module

'Frequency'

Identifies parameters of the MACS development environment (such as: 'Frequency') and outputs of M3000® modules (such as: 'Outputs Enabled')

12.2 Abbreviations

Table 32: Abbreviations

Abbreviation	Explanation
AC	**A**lternating **C**urrent
ADC	**A**nalog to **D**igital **C**onverter
CAL	**C**AN **A**pplication **L**ayer according to CiA DS 201–207
CAN	**C**ontroller **A**rea **N**etwork
CAN_GND	**CAN Grou**nd
CAN_H	**CAN H**igh (CAN bus signal (dominant high))
CAN_L	**CAN L**ow (CAN bus signal (dominant low))
CAN_SHLD	**CAN Shi**e**ld** (optional shield)
CFC	**C**ontinuous **F**unction **C**hart (random-graphics functional chart editor; programming language for creating PLC programs)
CiA	**C**AN **i**n **A**utomation e. V. (international organization of manufacturers and users for CAN users; http://www.can-cia.org)
CLK	**Cl**oc**k**
CPU	**C**entral **P**rocessing **U**nit
DAC	**D**igital to **A**nalog **C**onverter
DC	**D**irect **C**urrent
DGND	**D**igital **Grou**n**d** (Ground for the digital I/Os' power supply of the MSD Motion Controller)
DIN	**D**eutsches **I**nstitut für **N**ormung e. V. (German Institute for Standardization; http://www.din.de)
DIS	**D**raft **I**nternational **S**tandard (preliminary standard)
DS	**D**raft **S**tandard (draft standard)
E-bus	**E**xtension **bus** of DIN rail modules
EEPROM	**E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory
EIA	**E**lectronic **I**ndustries **A**lliance (http://www.eia.org)
EMC	**E**lectro**m**agnetic **C**ompatibility
EN	**E**uropa-**N**orm (European Standard)
EPROM	**E**rasable **P**rogrammable **R**ead **O**nly **M**emory
ESD	**E**lectro**s**tatic **D**ischarge
EtherCAT	Ethernet-based industrial real-time communication system
FBD	**F**unction **B**lock **D**iagram (programming language for creating PLC programs)
F-Bus	Fieldbus, an industrial communication system such as Profibus
Flash EEPROM	High speed EEPROM
FPGA	**F**ield **P**rogrammable **G**ate **A**rray (programmable logic component)
GUI	**G**raphical **U**ser **I**nterface
HF	**H**igh **F**requency
HMI	**H**uman **M**achine **I**nterface (MACS HMI: Visualization package which can be run without MACS)
ID	**Id**entifier
IEC	**I**nternational **E**lectrotechnical **C**ommission (http://www.iec.ch)
IEEE	**I**nstitute of **E**lectrical and **E**lectronics **E**ngineers, Inc. (http://www.ieee.org)
IL	**I**nstruction **L**ist (programming language for creating PLC programs)
I/O	**I**nput/**O**utput
IP	**I**nternational **P**rotection (protection type)
IP	**I**nternet **P**rotocol
ISO	**I**nternational **O**rganization for **S**tandardizing (http://www.iso.org)

Table 32: Abbreviations (Section 1 of 3)

Table 32: Abbreviations

Abbreviation	Explanation
LAN	**L**ocal **A**rea **N**etwork
LCD	**L**iquid **C**rystal **D**isplay
LD	**L**adder **D**iagram (programming language for creating PLC programs)
LED	**L**ight **E**mitting **D**iode
LSB	**L**east **S**ignificant **B**it
M3000®	Moog Automation System
MACS	Moog **A**xis **C**ontrol **S**oftware (Development environment according to IEC 61131 for solving complex control tasks)
Mbit/s	**M**ega**bit**s per **s**econd
MSB	**M**ost **S**ignificant **B**it
MSC I	**M**oog **S**ervo **C**ontroller **I** (Control module for DIN top-hat rail mounting)
MSC II	**M**oog **S**ervo **C**ontroller **II** (Control module for DIN top-hat rail mounting)
MSD	Modular Multi-Axis Programmable Motion Control Servodrive
MSD Motion Controller	Multi-Axis High Performance Motion Controller
MSD Servodrive	A modular family of electrical servo drives to run permanent magnet synchronous, linear and asynchronous motors
MSL	**M**ean **S**ea **L**evel
NC	**N**ot **C**onnected
ND	**N**ot **D**efined
PADT	**P**rogramming **A**nd **D**iagnostic **T**ool (programming and diagnostic tool in IEC 61131, here: PC on which the MACS development environment is installed)
PC	**P**ersonal **C**omputer
PE	**P**rotective **E**arth
PLC	**P**rogrammable **L**ogic **C**ontrol(ler)
Q-Modules	DIN rail modules for local extension of MSC IIs (connected over E-bus)
Q-Connector	40 pole lateral connector of DIN rail modules
QAIO	Analog I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)
QEBUS-CAN	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)
QDIO	Digital I/O extension module for local extension of the inputs and outputs of MSC I or MSC II (connection over E-bus)
R-Modules	Remote modules such as RDIO and RDISP (connection over CAN bus)
RAM	**R**andom **A**ccess **M**emory (read and write memory that loses its contents when power is removed)
RDIO	Remote module with digital I/Os and CANopen interface (connection over CAN bus)
RDISP	**R**emote **Disp**lay (display and operating terminal with TIA/EIA 232 and CANopen interface (connection over CAN bus))
REF	**Ref**erence voltage
RISC	**R**educed **I**nstruction **S**et **C**omputer
RT-ETH	**R**eal **T**ime **Eth**ernet Interface
Rx	**R**eceive Data
SELV	**S**afety **E**xtra-**L**ow **V**oltage (according to DIN EN 60950-1)
SFC	**S**equential **F**unction **C**hart (programming language for creating PLC programs)
SHLD	**Sh**ie**ld**
SIO	**S**erial **I/O** (serial interface of the MSC II)

Table 32: Abbreviations (Section 2 of 3)

Abbreviation	Explanation
SSI	**S**ynchronous **S**erial **I**nterface (digital interface for transferring positioning information, like with position transducers)
ST	**S**tructured **T**ext (programming language for creating PLC programs)
TIA	**T**elecommunications **I**ndustry **A**ssociation (http://www.tiaonline.org)
TPU	**T**ime **P**rocessing **U**nit (programmable microprocessor that processes time functions independently of the CPU)
TÜV	**T**echnischer **Ü**berwachungs**v**erein (German agency performing technical inspections)
Tx	**T**ransmit Data
USB	**U**niversal **S**erial **B**us
V DC	**V**olt **D**irect **C**urrent (unit of direct voltage)
VDE	**V**erband **d**er **E**lektrotechnik Elektronik Informationstechnik (Association for Electrical, Electronic & Information Technologies; http://www.vde.de)
VDMA	**V**erband **D**eutscher **M**aschinen- und **A**nlagenbau e. V. (Federation of Engineering Industries; http://www.vdma.org)
WCAN	**W**ide**C**an
WF	**W**ire **F**ault

Table 32: Abbreviations

Table 32: Abbreviations (Section 3 of 3)

12.3 Quoted Standards

12.3.1 CiA DS

Quoted Standards: 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

Quoted Standards: DIN

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

12.3.3 DIN EN

Quoted Standards: 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

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

Quoted Standards: 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
Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment – Part 2: Electrostatic Discharge Immunity Requirements

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

Quoted Standards: ISO/DIS

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

12.3.6 TIA/EIA

Quoted Standards: 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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Argentina	**+54**	**11 4326 5916**	**info.argentina@moog.com**
Australia	**+61**	**3 9561 6044**	**info.australia@moog.com**
Austria	**+43**	**664 144 65 80**	**info.austria@moog.com**
Brazil	**+55**	**11 5523 8011**	**info.brazil@moog.com**
China	**+86**	**21 2893 1600**	**info.china@moog.com**
Finland	**+358**	**9 2517 2730**	**info.finland@moog.com**
France	**+33**	**1 4560 7000**	**info.france@moog.com**
Germany	**+49**	**7031 622 0**	**info.germany@moog.com**
Hong Kong	**+852**	**2 635 3200**	**info.hongkong@moog.com**
India	**+91**	**80 4120 8799**	**info.india@moog.com**
Ireland	**+353**	**21 451 9000**	**info.ireland@moog.com**
Italy	**+39**	**0332 421 111**	**info.italy@moog.com**
Japan	**+81**	**463 55 3615**	**info.japan@moog.com**
Korea	**+82**	**31 764 6711**	**info.korea@moog.com**
Luxembourg	**+352**	**40 46 401**	**info.luxembourg@moog.com**
Netherlands	**+31**	**252 462 000**	**info.netherlands@moog.com**
Norway	**+47**	**64 94 19 48**	**info.norway@moog.com**
Russia	**+7**	**31713 1811**	**info.russia@moog.com**
Singapore	**+65**	**6773 6238**	**info.singapore@moog.com**
South Africa	**+27**	**12 653 6768**	**info.southafrica@moog.com**
Spain	**+34**	**902 133 240**	**info.spain@moog.com**
Sweden	**+46**	**31 680 060**	**info.sweden@moog.com**
Switzerland	**+41**	**71 394 5010**	**info.switzerland@moog.com**
United Kingdom	**+44**	**1684 296600**	**info.unitedkingdom@moog.com**
USA	**+1**	**716 652 2000**	**info.usa@moog.com**

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WHAT MOVES YOUR WORLD

MOOG