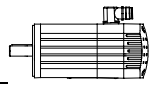
Operating Instructions for

Servocontroller T161

with

Analog Interface +/-10 V



Version	Date	Author	Comments	Effectivity
orig.	1 July 97	SRF	New edition of the former product information to meet CE standards	All
Rev. a	1. Feb. 98	DRK	Corrected version	All
Rev. b	10. Feb. 98	DRK	Further corrected version	All
Rev. c	17. Apr. 98	DRK	Further corrections	All

Contents

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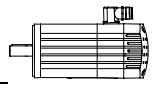
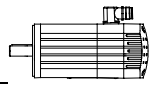


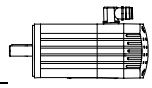
1 Introduction

This manual describes a system with one or more servo drives made by MOOG. The servo drive comprises a brushless AC servomotor, a servocontroller, a power supply, a backplane and a rack. The components described operate with voltages up to 400 V. The safety instructions must be observed.

The manual is intended for the use of qualified personnel.



2 System Description



2.1 Components

A typical MOOG system is made up of the following components:

- **Isolating transformer**
  The transformer serves first of all to adapt the available mains voltage to the input voltage of 3x230 VAC (3-phase operation) required by the power supply. Its second function is to ensure "safe electrical isolation" between the mains voltage and the other extra-low voltages. An autotransformer is not suitable, unless other safety precautions are also taken.
- **Power supply T160-9xx**
  The power supply generates the DC bus voltage by rectifying and smoothing the input voltage of the power supply. The energy generated by a rapidly decelerating servomotor is dissipated via a ballast resistor. The LED status indicator permits rapid diagnosis of any faults occurring. A relay output permits evaluation by the host controller.
- **Servocontroller T161-90x**
  The servocontroller electronically commutates the MOOG brushless servomotors. It closes the speed control loop and delivers a 3-phase sinusoidal motor current which is controlled by a current controller with large bandwidth. The LED status indicator permits rapid diagnosis of faults occurring. Two relay outputs permit evaluation by the host controller.
- **19" rack with backplane**
  The 19" rack accommodates the electronic components and the backplane. The latter connects the power supply and servocontroller(s). It also provides the interfaces to the motor and for the communication with the host controller.
- **Servomotor D31x-xxx / G4xx-xxx**
  The standard MOOG brushless servomotor comprises a wound stator, a rotor with permanent magnets (cobalt-samarium), a 2-pole resolver and a NTC thermistor embedded in the end turns of the stator.

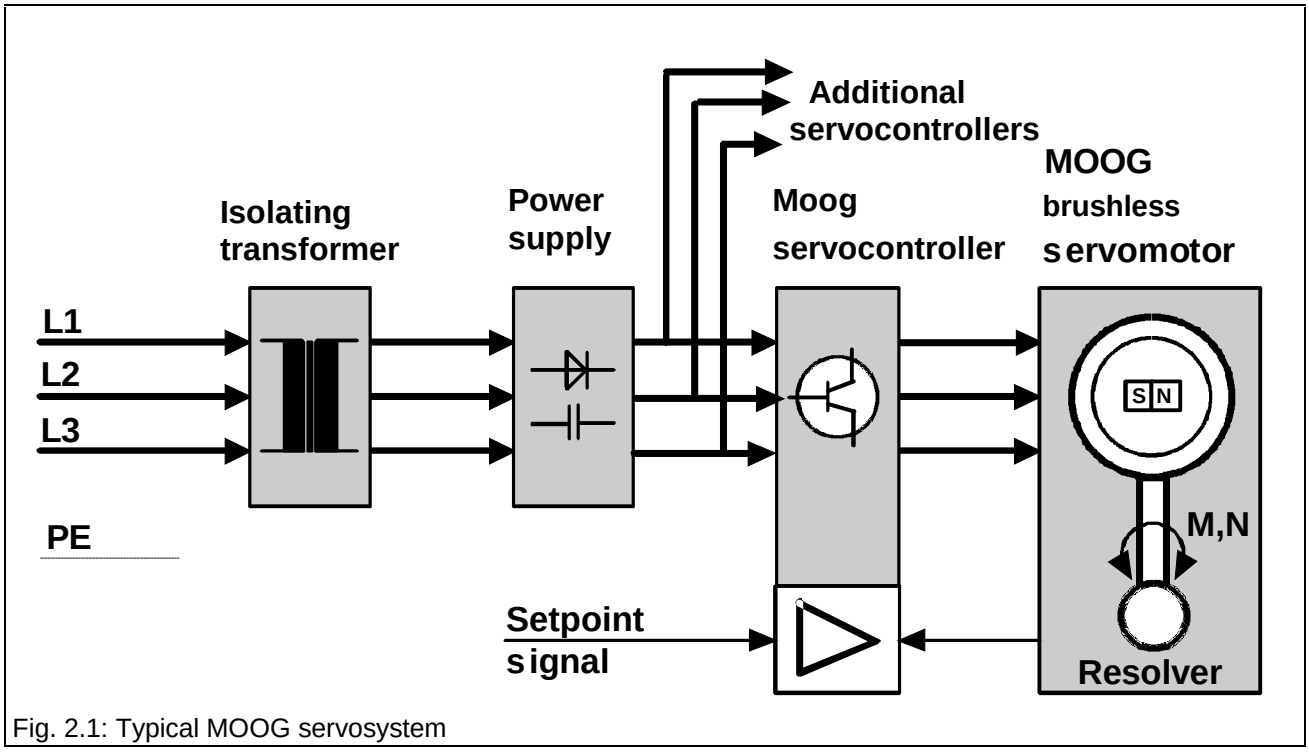
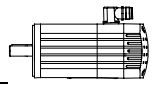


Fig. 2.1: Typical MOOG servosystem



2.2 Mechanical design of the motors and servocontrollers

2.2.1 Selection of motor

a) The motor type is predetermined by parameters M_0, M_{max}, n_{max}, s_1 characteristic in motor catalogue
   --> Determination of k_t.

b) Application specific are required (torque characteristic $M_A(t)$, working cycle)
   --> Determination of cycle time t_C, time intervals t_i, torque values M_i, M_{max}

<table>
<tr><td colspan="3">Motor type G4xx-xxx with k_t.</td></tr>
<tr><td colspan="3">$M_{A,max}(n_{A,max}) \leq M_{max}(n_{A,max})$?</td></tr>
<tr><td colspan="2">YES</td><td>NO</td></tr>
<tr><td colspan="2">Calculation of the effective torque
$M_{eff} = \sqrt{\frac{\sum_i M_i^2 \times t_i}{t_C}}$
Calculation of the mean speed n_m</td><td rowspan="4">Motor unsuitable for this application.</td></tr>
<tr><td colspan="2">Does M_{eff} (n_m) lie inside the s_1 curve?</td></tr>
<tr><td colspan="2">YES NO</td></tr>
<tr><td>Motor selection complete.</td><td>Motor unsuitable for this application.</td></tr>
</table>

Fig. 2.2: Selection of motor

2.2.2 Selection of control unit

Motor type selected: G4xx-xxx (k_t from motor catalogue). Known torque characteristic for the application: ---> Peak torque for the application $M_{A,max}$.

Calculation of the maximum current for the application

$$I_{A,max} = \frac{M_{A,max}}{k_t}$$

The maximum servocontroller current $I_{C,max}$ and continuous current $I_{C,m}$ can be found in chapter 4.

$I_{A,max} \leq I_{C,max}$?

YES / NO

Calculation of the mean current $I_{A,m}$ for the application from the mean torque $M_{A,m}$ of the application

$$M_{A,m} = \frac{\sum_i M_i \times t_i}{t_C}$$

$$I_{A,m} = \frac{M_{A,m}}{\eta \times k_t}$$

with η = 0.85 .. 0.9 due to saturation of the k_t curve

$I_{A,m} \leq I_{C,m}$?

YES / NO

Check motor / servocontroller combination with reference to chapter 4 (paragraph "Setting the MCO jumper L401")

Is a corresponding jumper position listed?

YES / NO

Position jumper. Selection of the servocontroller is complete.

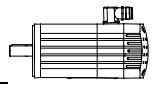
Motor / servocontroller combination not suitable for this application

Servo-controller unsuitable for this application. Repeat procedure with next larger servo-controller.

Servo-controller unsuitable for this application.

Repeat procedure with the next larger servo-controller.

Fig. 2.3: Selection of servocontroller



2.3 Technical data of the system

2.3.1 Standards

DIN VDE 0160 has been taken into account to a particularly strong extent in the development of these products.
The following standards have been taken into account:

Guidelines for engineering design	DIN VDE 0160	prEN 50178
Dimensioning of creepage distances and clearances	VDE 0110 Part 2	
Insulation coordination	VDE 0110 Part 1	IEC 664
General safety requirements	DIN VDE 0160	prEN 50178
Reliable isolation	DIN VDE 0160	prEN 50178
Marking	DIN VDE 0160	prEN 50178
Grounding	DIN VDE 0160	prEN 50178
Overvoltage protection	DIN VDE 0160	prEN 50178
Ambient conditions	IEC 68 Part 2-3, 2-6	
Short-circuit strength	DIN VDE 0160	prEN 50178
Mechanical stresses	IEC 68 Part 2-29	
Protection by limitation of discharge energy	DIN VDE 0160	prEN 50178
Type-testing	DIN VDE 0160	prEN 50178
EMC*	VDE 0871 EN 55011 EN 50082-1	CISPR22

* The MOOG control units series T161 can only conform to the above EMC guidelines if the MOOG EMC installation guidelines are considered and an input filter in the supply voltage lines is installed.

2.3.2 Operating and ambient temperatures

Electronic components:

Temperature for transport and storage: -25 °C to 70 °C
Operating temperature: 0 °C to 55 °C
Humidity: 5 % to 85 %, 1 g/m^3 to 25 g/m^3,
in accordance with prEN50178 class 3k3
Type of protection: Components must be installed into an enclosed rack.
The enclosed rack must provide at least IP54 per standard EN60529.
Ventilation: See component specification.
Installed position: Only vertical.
Overvoltage protection class: Category 2 per standard VDE0110 / IEC664
Noise: The noise depends on the user selected fan and cabinet.
The electronic components do not make noise.

Servomotors and cables:

See Chapter "7 Servomotors"

3 Installation

3.1 Safety Instructions

3.1.1 Explanation of Symbols used

Important!
The symbol on the left and the word "Important" are used to draw attention to safety instructions concerning a potential **hazard for persons.**
Failure to comply with these safety instructions can result in serious damage to health and can even prove fatal in extreme cases.
These safety instructions must be observed without fail.

Warning:
The symbol on the left and the word "Warning!" are used to draw attention to instructions concerning potential **damage to the servo drive or to the system as a whole.**
Such warnings must be observed without fail.

Note:
Notes contain useful information for the operator when starting up and operating the system.

Danger - High voltage (Sticker on the power supply and servomotor)
The symbol on the left indicates that the power supply operates with high voltages which can prove extremely dangerous if touched.

Beware of hot parts (Sticker on servomotor)
In extreme applications, the surface of the servomotor may heat up to more than 100 °C and can cause skin burns if touched. The servomotor must therefore be protected to prevent contact.

Delicate part (Sticker on servomotor)
A hammer must not be used to force the gearing / gear wheel onto the shaft when installing such parts. The screw thread in the center of the shaft must be used for this purpose. An extractor supported on the center of the shaft must be used when dismantling the parts.

3.1.2 Qualified personnel

Important!

The components making up the drive system may only be installed and serviced by duly qualified personnel. The accident prevention regulations (UVV) and particularly VGB 4 and VGB 5 must be taken into account, as must the following VDE safety standards: VDE 100, VDE 105, DIN EN 60204 and prEN 50178.

Unqualified work on the drive components and failure to comply with the warnings contained in this manual or affixed to the components can result in serious physical injury or damage to property.

The work permitted within the scope of this manual may consequently only be undertaken by duly qualified personnel.

This includes the following people:

- **planning and engineering design personnel** familiar with the safety guidelines for measurement and control instrumentation,
- **operating personnel** who have been duly instructed with regard to the handling of measurement and control instrumentation and who are familiar with the operating instructions contained in this manual,
- **commissioning and service personnel** authorized to start up, ground and mark the circuits for components and systems in accordance with safety engineering standards.

3.1.3 Intended use

The drive components have been developed and built for installation and operation in industrial systems.

The electronic components (power supply, servocontroller, backplane) are designed for installation in a rack. These electronic components do not have a separate housing and are therefore not protected against accidental contact. It is therefore absolutely essential that they be installed in a rack. The rack must additionally be installed in a closed control cabinet.

Protection against accidental contact must be ensured by installation.

3.1.4 List of main safety instructions

Danger - High voltage!

The servo drives operate with potentially lethal voltages.
The servocontroller and power supply are individual components and designed for installation in a rack in a control cabinet. The individual components do not have a separate housing and are therefore not protected against accidental contact with high voltages.

For this reason:

- **A rack must be used**

The components must be installed in a rack before being put into operation. The rack must ensure complete protection against accidental contact. If not all the slots in the rack are used, the unused slots must be covered by filler panels.

- **Install the rack in a control cabinet**

High voltages flow through the backplane, which must consequently be protected against accidental contact. The rack must therefore be installed in a control cabinet.

Danger - High voltage!

The servo drives operate with potentially lethal voltages.

For this reason:

- **Disconnect the system from the mains supply.**
  Before starting any work on the drive system, it must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.
- **The servomotors must come to a complete stop.**
  Rotating servomotors can generate potentially lethal voltages by acting as generators.

Beware of charged capacitors!

The capacitors in the power supply may still be charged.

For this reason:

- **Note the discharge time of the capacitors.**
  The power supply contains capacitors which may be charged with up to 400 VDC. Wait at least 5 minutes for the capacitors to become discharged after disconnecting the voltage.
- **The voltage must then be measured between DC+ (X7/1) and DC- (X7/2).**
  Work on the power supply must not start until the voltage has dropped below 5 V.

Beware of mechanical hazards!

Servomotors can accelerate highly dynamically. They also have an enormous torque. The following points must therefore be observed when starting the system.

- **The danger zone of the motor must be cordoned off.**
  The system must feature a guard door preventing personnel from reaching into or entering the danger zone. If the guard door is opened, the drive system must be disconnected from the supply voltage immediately.
- The motor may accelerate inadvertently on account of wiring faults or errors in the application software. Appropriate safety precautions must therefore be taken in the system to ensure that neither personnel nor machine components are endangered in any way.

Danger - High voltage on backplane!

High voltages flow through the backplane, as well as through some screw terminals and the soldering pins.

For this reason:

- Before starting any work on the backplane, the system must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.

3.2 Information on EMC

(Only applies for countries in the European Community)

Exclusion of liability

The information on EMC provided here contains general recommendations to assist the manufacturer when installing RMC components made by MOOG in finished products which must conform to the requirements of EC Directive 89/336/EEC (EMC Directive). Although MOOG has exercised utmost care in compiling these recommendations, we cannot accept any liability whatsoever for claims associated with the user's individual applications. This also applies in particular with regard to non-performance, non-compliance, faults, misunderstandings and mistaken interpretation.

Note:

Responsibility for ensuring that every finished product containing these components conforms to the requirements of the EMC Directive rests entirely with the manufacturer of the finished product. MOOG cannot accept any liability whatsoever for finished products made by other manufacturers and containing 19" RMC components from MOOG.

EMC environment

The 19" RMC components from MOOG are designed for installation in industrial equipment and for operation in industrial areas. The 19" RMC components from MOOG have therefore been tested in accordance with the following EMC standards:

EN55011: Limit values and methods of measuring the radio interference of industrial, scientific and medical high-frequency equipment (ISM devices) (1991), class A limit values.

EN50082-2: Elektromagnetic compatibility (EMC)
Basic standard on immunity to interference
Part 2: Industry (1995).

Installation of the components

The 19" RMC components from MOOG are designed for installation in an assembly comprising a rack, fan and backplane which must in turn be installed in a control cabinet or housing. For the sake of simplicity, the assembly comprising the rack, fan and backplane will henceforth simply be referred to as the rack. The control cabinet or housing will be referred to as a control cabinet. Rack and control cabinet must be provided by the manufacturer of the finished product.

The rack used must have been developed or modified for optimized EMC grounding and shielding (e.g. Schroff Europac Lab HF Subrack, see order information). All 19" RMC components or modules from MOOG must be firmly installed in the rack. All screw connections must be tightly secured.

All metal covers (filler panels, side panels, covers, etc.) belonging to the rack must be fitted and a continuous ground connection guaranteed between all panels. All ground connections between the rack and the control cabinet must be securely mounted and a continuous ground connection guaranteed.

To ensure an optimum EMC shield, the control cabinet should have a continuous ground connection between all metal panels (frame, side panels, top, baseplate, etc.). A control cabinet which has been designed to provide an optimum EMC shield can be used for this purpose.

The manufacturer of the finished product must take into account the effects of additional interference due to other modules, systems or power supplies installed in the finished product, as well as the interaction between actual and potential sources of interference in the finished product. The manufacturer of the finished product is responsible for taking suitable precautions to minimize such interference in the finished product, for example by maintaining a safe distance between such parts or shielding them inside the product. He must decide which is the most efficient method in every single finished product.

Where possible, shielded cables with fully shielded connector housings should always be used. The cable shield must be connected to the connector shields over the full 360° in order to ensure a continuous all-round ground connection. All cable connections to the backplane must be tightly secured. In particular, all screws in the ground connections of the connector shields must be securely tightened. Cables must be routed as far apart as possible to avoid interference in the control cabinet. If cables must be crossed, they should do so at an angle of 90°. This reduces the interference to a minimum. Here too, the manufacturer of the finished product must decide which is the most efficient method for each individual product.

Further details on filtering, grounding and shielding can be found in this manual.

3.3 Installation procedure

This chapter on installation refers to all servocontrollers in series T161 and is therefore very general. The servocontrollers T161 are available with different software versions and different functions. Three versions are currently available:

1. **Servocontroller with analog setpoint for speed or torque**
   This constitutes the basic version. The higher-ranking positioning control specifies a speed for the servocontroller via an analog signal (-10 V .. +10 V). The drive reports its actual position to the control via an encoder simulation (simulation of an incremental encoder).
2. **Servocontroller with connection to the CAN bus and Interpolation Mode protocol**
   In this version, the control system specifies setpoint positions for the servocontroller at fixed intervals (every 6 .. 64 milliseconds) via the CAN bus. The servocontroller interpolates between the individual setpoint positions and follows the specified path.
   Extensive status messages are output to the control system and make troubleshooting easier. The system is fully digital and thus insusceptible to external disturbances and drift.
3. **Servocontroller with connection to the CAN bus and Profile Mode protocol**
   In this version, the control system only sends short commands to the servocontroller via the CAN bus. These commands are evaluated by the servocontroller and executed without further assistance by the control system. Positioning is achieved through specification of the target position, max. speed and max. acceleration. The servocontroller generates its own path and reports to the control system when it reaches the target position. Other functions are also available, such as electrical gearing, cam functions, etc.
   Extensive status messages are output to the control system and make troubleshooting easier. The system is fully digital and thus insusceptible to faults and drift.

Servocontroller versions with different functions ⇒ different wiring
The servocontroller versions with different functions also require different wiring, since the inputs and outputs are differently defined by software.
Attention is therefore drawn to the appropriate servocontroller chapter during the installation procedure.

3.4 Disassembly procedure

The servodrives described here operate with voltages which can cause serious damage to health if touched. The following safety instructions must therefore be observed when dismantling the drives and also when making minor changes to the wiring.

Danger - High voltage!

The servo drives operate with potentially lethal voltages.

For this reason:

- **Disconnect the system from the mains supply.**
  Before starting any work on the drive system, it must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.
- **The servomotors must come to a complete stop.**
  Rotating servomotors can generate potentially lethal voltages by acting as generators.

Beware of charged capacitors!

The capacitors in the power supply may still be charged.

For this reason:

- **Note the discharge time of the capacitors.**
  The power supply contains capacitors which may be charged with up to 400 VDC. Wait at least 5 minutes for the capacitors to become discharged after disconnecting the system from the mains.
- **The voltage must then be measured between DC+ (X7/1) and DC- (X7/2).**
  Work on the power supply must not start until the voltage has dropped below 5 V.

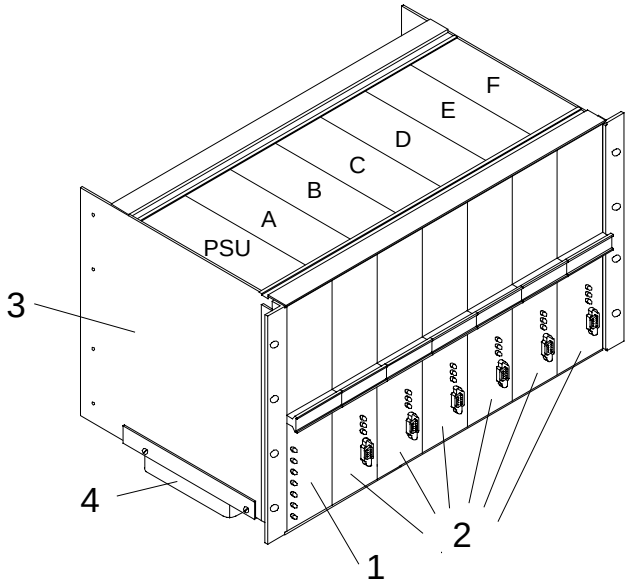
Danger - High voltage on backplane!

High voltages are present at the backplane, as well as through some screw terminals and the soldering pins.

For this reason:

- Before starting any work on the backplane, the system must be disconnected from the mains voltage and secured against inadvertent reconnection by means of the master switch.

3.5 Overview of the overall system



1. Power supply unit (PSU)
2. Servocontroller (6 controllers, A to F)
3. Rack (19 inch)
4. Fan

Fig. 3.1: Rack with 6 axes

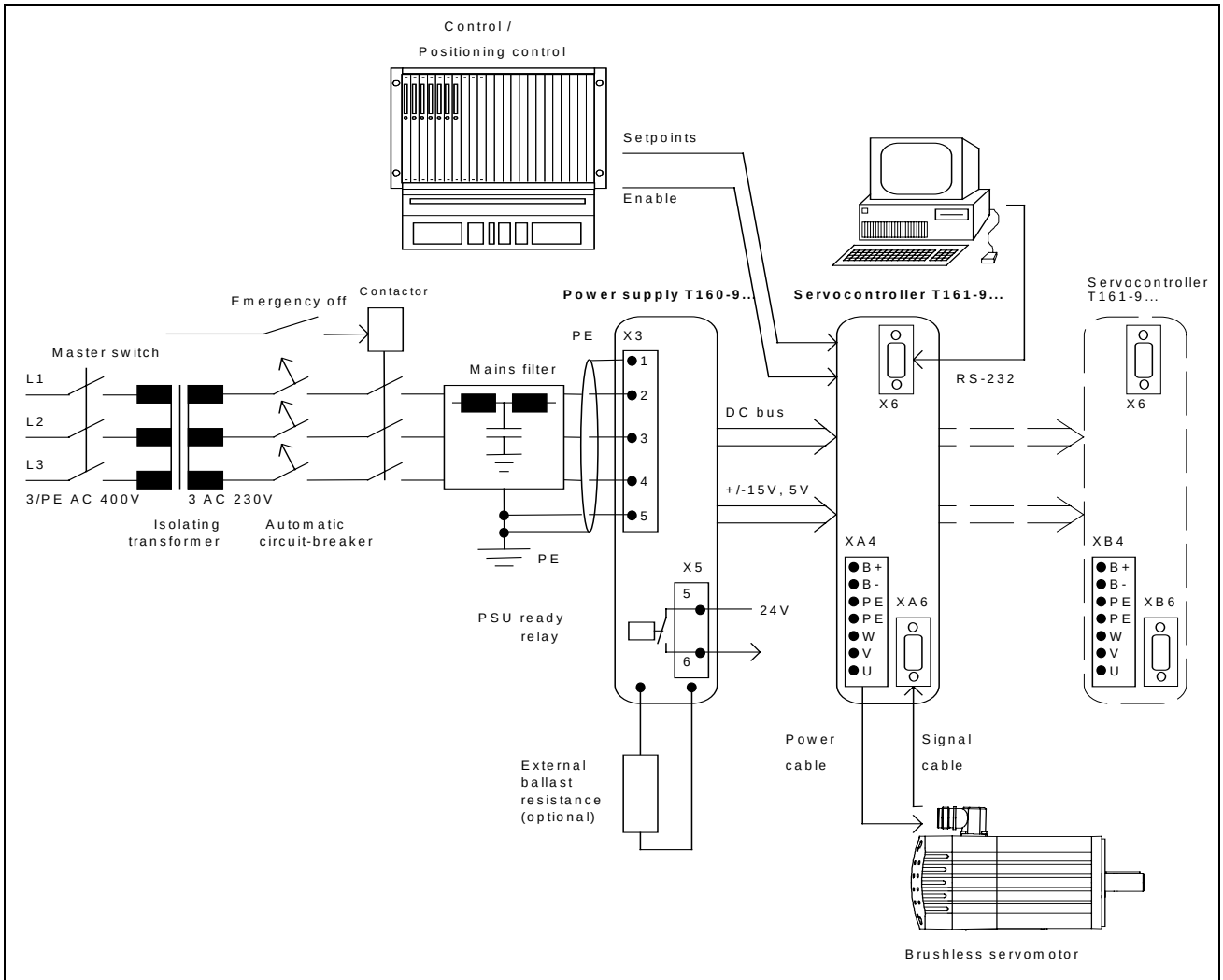


Fig. 3.2: Overall system

3.6 Minimum wiring of the backplane

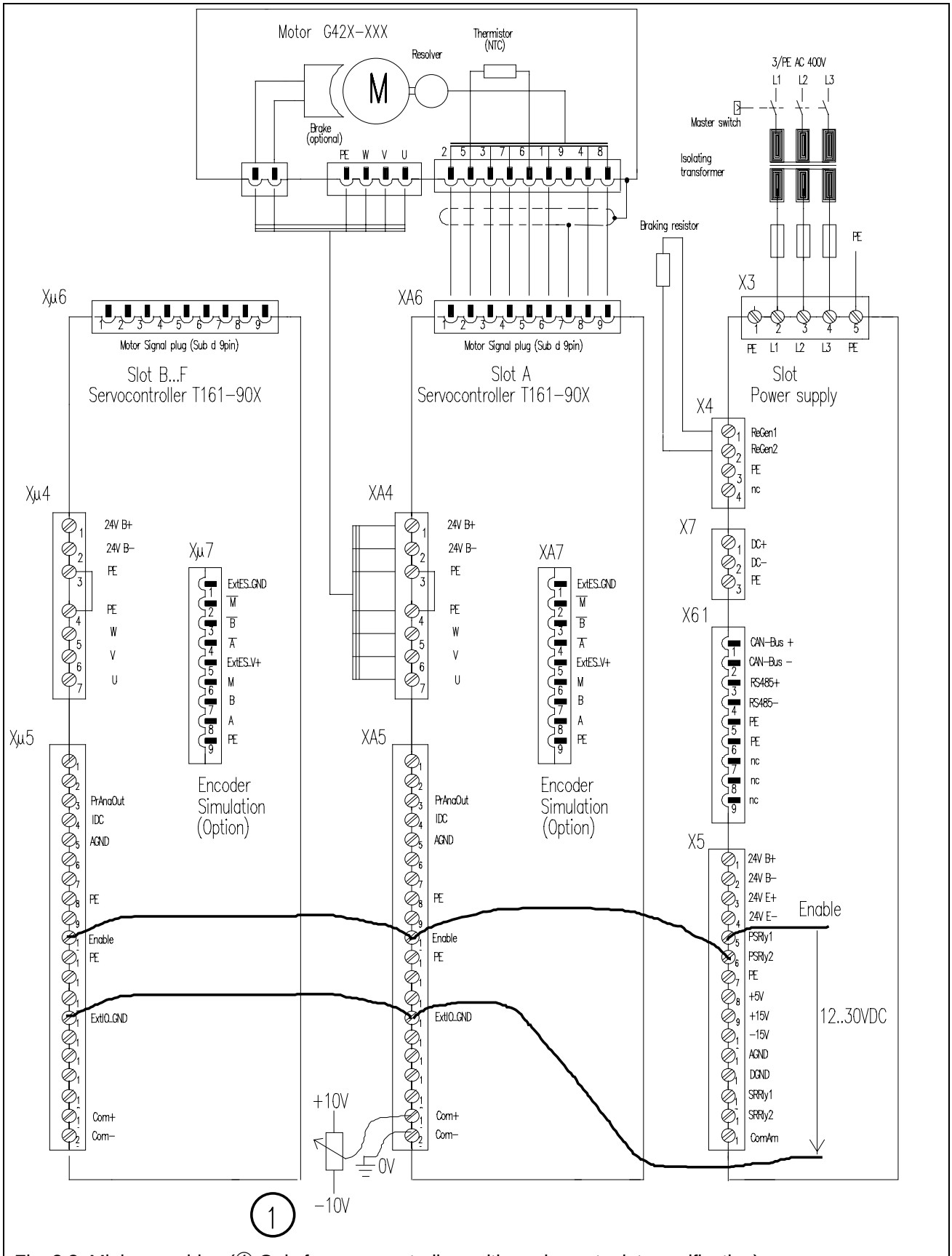


Fig. 3.3: Minimum wiring (① Only for servocontrollers with analog setpoint specification)

3.7 Installing and wiring of the power supply

Danger - High voltage!

The servo drives operate with potentially lethal voltages.

For this reason:

- **Disconnect the system from the mains supply.**
  Before starting any work on the drive system, it must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.
- **The servomotors must come to a complete stop.**
  Rotating servomotors can generate potentially lethal voltages by acting as generators.

Beware of charged capacitors!

The capacitors in the power supply may still be charged.

- **Note the discharge time of the capacitors.**
  The power supply contains capacitors which may be charged with up to 400 VDC. Wait at least 5 minutes for the capacitors to become discharged after disconnecting the system from the mains.
- **The voltage must then be measured between DC+ (X7/1) and DC- (X7/2).**
  Work on the power supply must not start until the voltage has dropped below 5 V.

Warning:
A fan is required if **more than four** servocontrollers are installed.
Then the fans must be switched on as soon as voltage is applied to the power supply.
If the power supply requires an external 24 VDC supply, the fan must be switched on as soon as the 24 VDC supply is connected.

Five points must be noted in addition to the safety instructions when carrying out this work:

1. Does the power supply unit require an external 24 VDC supply?
2. Is the power supply unit operated with one or three phases?
3. Which ballast circuit is planned?
4. Does the power supply unit require a fan?
5. Install a mains filter (EMC precaution).

3.7.1 Check name plate

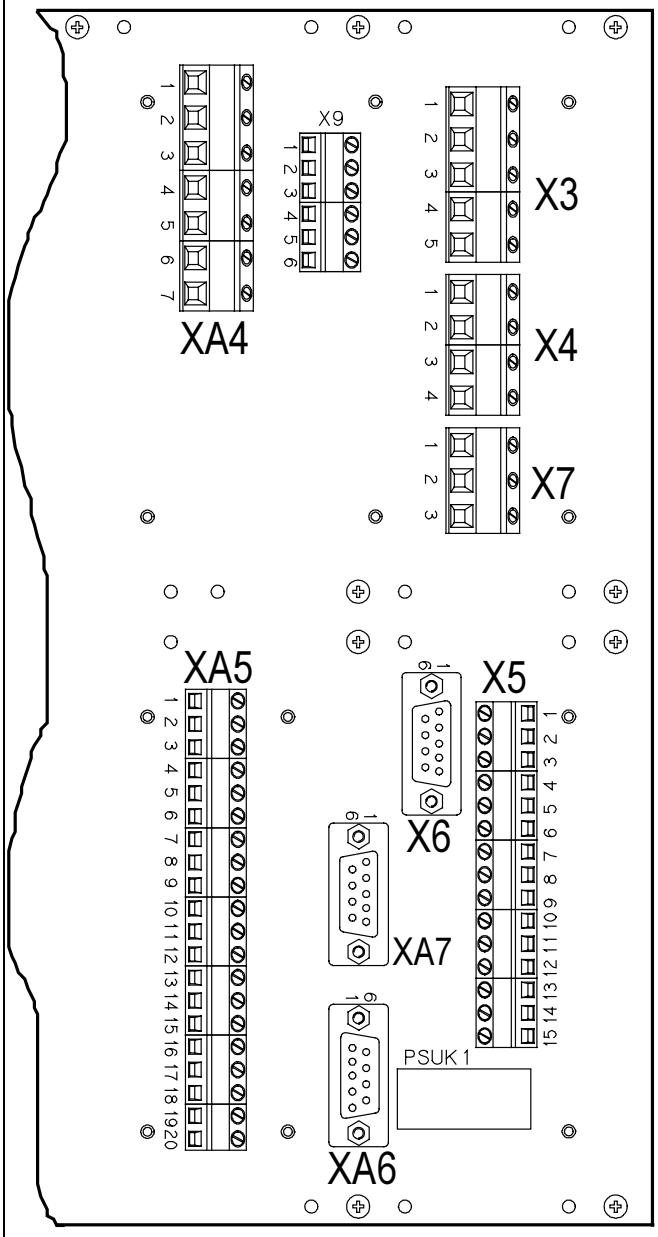
\# indicates the Revision Index.
This manual applies for all revisions.

SerNo: T0123 indicates the serial number.
The serial number is incremented with every part produced.

The name plate serves to identify the product.
For this reason:

- Check whether the name plate on the device matches the name plate illustrated above.
- This documentation must not be used for commissioning and startup if the name plates do not match.
- Devices without name plate are not covered by the manufacturer's warranty and must not be put into operation.

3.7.2 Power supply connections



X3 Power connection

Leads with up to 3 mm²
Pin 1 PE
Pin 2 L1, 230 VAC
Pin 3 L2, 230 VAC
Pin 4 L3, 230 VAC
Pin 5 PE

X4 Ballast connection

Leads with up to 3 mm²
Pin 1 Ballast resistance
Pin 2 Ballast resistance
Pin 3 PE
Pin 4 Not used

X7 DC bus connection

Leads with up to 3 mm²
Pin 1 DC+
Pin 2 DC-
Pin 3 PE

X5 Miscellaneous connections

Leads with up to 1.5 mm²
Pin 1 Power supply for brake, +24 VDC
Pin 2 Reference ground for pin 1
Pin 3 +24 VDC (optional supply for PSU)
Pin 4 Reference ground for pin 3
Pin 5 "PSU ready" output, 1st relay contact
Pin 6 "PSU ready" output, 2nd relay contact
Pin 7 PE
Pin 8 +5 V, Test output
Pin 9 +15 V, Test output
Pin 10 -15 V, Test output
Pin 11 AGND, reference ground to pin 9 and 10
Pin 12 DGND, reference ground to pin 8
Pin 13 "System ready relay" output,
1st relay contact
Pin 14 "System ready relay" output,
2nd relay contact
Pin 15 Digital input for servocontroller
(function depends on servocontroller and backplane type),
Ref.: ExtIO_GND of servocontroller (Xµ5/14)

Abb 3.4: Backplane (power supply slot)

Terminal types for X3, X4 and X7
Type: Phoenix GSMKDS3 (angled screw terminal)
Wire cross-sectional area: max. 3 mm², min. 2.5 mm²

Terminal type for X5
Type: Phoenix SMKDS1.5 (angled screw terminal)
Wire cross-sectional area: max. 1.5 mm²

3.7.3 External 24 VDC supply for power supply unit (optional)

1. **Power supply unit T160 - 901 # - 00 - 1#**
   This power supply unit does not require an external 24 VDC supply.

2. **Power supply unit T160 - 902 # - 00 - 1#**
   Power supply unit T160 - 932 # - 00 - 1#
   These two power supply units require an external 24 VDC supply. The voltage is connected to terminal X5-pin 3 (positive) and terminal X5-pin 4 (negative).

3. The +5 V and ±15 V are generated from this 24 VDC supply. This ensures that the microcomputer, the position measurement and an optional CAN bus remain fully functional if the power has to be disconnected for operational reasons, e.g. following an Emergency SWITCH OFF.

Important: A 24 VDC supply with reliable insulation must be used!

The power supply providing the 24 VDC for the MOOG power supply unit must be reliably insulated from the mains voltage and must conform to standard EN 60950.

EMC recommendation:
The connecting leads must be routed through a ferrite core in order to filter out the conducted DC interference. The ferrite core must be positioned as close to the power supply unit as possible so that the connection between core and terminal is as short as possible.
It must be ensured that both leads are routed in parallel. They must both be inserted into the hole of the core in the same direction and both leads must have the same number of turns (four turns) (see figure below).

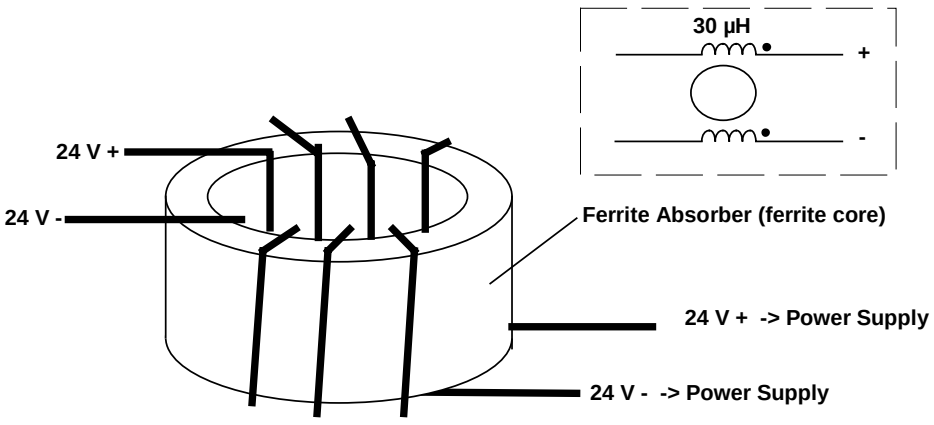


Fig. 3.5: Ferrite core on the 24 V input (signal voltage)

3.7.4 Power connection

The power supply unit can be operated with either a one-phase or three-phase AC voltage:

	Minimum	Nominal	Maximum
Supply voltage	207 VAC	230 VAC	254 VAC
Mains frequency	44 Hz	50 Hz	66 Hz
Fuse		16 A slow-blow *)	

*) A 3-phase automatic circuit-breaker must be used for 3-phase operation in order to ensure that all phases are tripped at the same time in the event of a fault!

Important: Isolating transformer required

The isolating transformer is required in order to maintain the specified isolation (creepage distances and clearances) in relation to unprotected small-signal auxiliary voltages. The isolating transformer must conform to standard EN 60204-1. The protective earth conductor must be connected.

If **other precautions** are taken,
- the power supply unit can be connected directly to the mains supply for one-phase operation,
- an autotransformer can be used to adjust the voltage for three-phase operation.

One-phase operation:

In one-phase operation, the voltage between live and neutral is 230 VAC. An isolating transformer with 1:1 transformation ratio must be used. The secondary terminals of the isolating transformer are connected to terminal X3-pin 2 and X3-pin 3. The protective earth conductor must also be connected.

Three-phase operation:

The nominal voltage between the power supply unit terminals must be equal to 230 VAC. The phase-to-phase voltage of a normal 3x400 VAC 3-phase mains supply must be stepped down to 3x230 VAC by means of an isolating transformer connected to terminal X3. The protective earth conductor must be connected.

Note:

Leakage currents flow on the PE conductor if no isolating transformer is used.
The leakage current may exceed 3.5 mA under corresponding operating conditions. It is therefore recommended to connect an additional PE conductor of at least 10 mm^2 to the rack (see VDE 0160).

The leakage currents are drastically reduced when using an isolating transformer.

3.7.4.1 Configuring the power supply for 1-phase or 3-phase operation

Jumper JW1 must be reconnected for this purpose (see figure 3.8):

Mode of operation	Position of jumper JW 1
1-phase	On the mark 1 ϕ
3-phase	On the mark 3 ϕ

If one phase fails in 3-phase operation, the "power supply ready" relay in the power supply unit opens and the fault is indicated. The red LED 3~ lights up on the front panel. The power supply unit remains operational however. Since the current is no longer distributed over all three phases following a phase failure, the power supply unit may heat up when high power levels are output. The connected servocontrollers are disabled via an internal fault signal when the temperature limit is reached.

3.7.4.2 Important information

Warning: Note the switch-on sequence!

- **Switching on**
  If the power supply unit has an external 24 VDC supply, the 24 VDC must be switched on first. The power can be switched on after a delay of 2 seconds.
- **Switching off**
  Either the power can be switched off first and then the 24 VDC supply or the power and 24 VDC supply can be switched off at the same time (e.g. via the master switch on the machine).

If the 24 VDC supply is switched off but the power remains on due to a fault, the power must be switched off by hand. Wait at least 5 minutes before switching the power supply unit on again.

- **Short time disconnection of the power**
  If the power is only to be disconnected for a short time, a delay of at least 2 seconds must be allowed before reconnecting the power.

Warning: Note the softstart!

- Inrush current limitation(= softstart)
  The power supply unit is protected by an inrush current limitation. The DC bus capacitors are charged via a resistance which is bridged upon expiration of the charging time (1 second).
- None of the servocontrollers must be enabled while the softstart is active, otherwise the charging current will flow into the motor instead of the capacitors, causing the softstart to have no effect. The fuse before the power supply unit will be tripped by the high switch-on current in this case.
- "PSU ready" relay (terminals X5/5 and X5/6)
  The relay contact is closed as soon as the softstart procedure is complete and the power supply unit is ready to supply the servocontrollers with power. The relay contact is opened in the event of a fault.

Note:

MOOG recommends the circuit illustrated in Fig. 3.6 to be used.

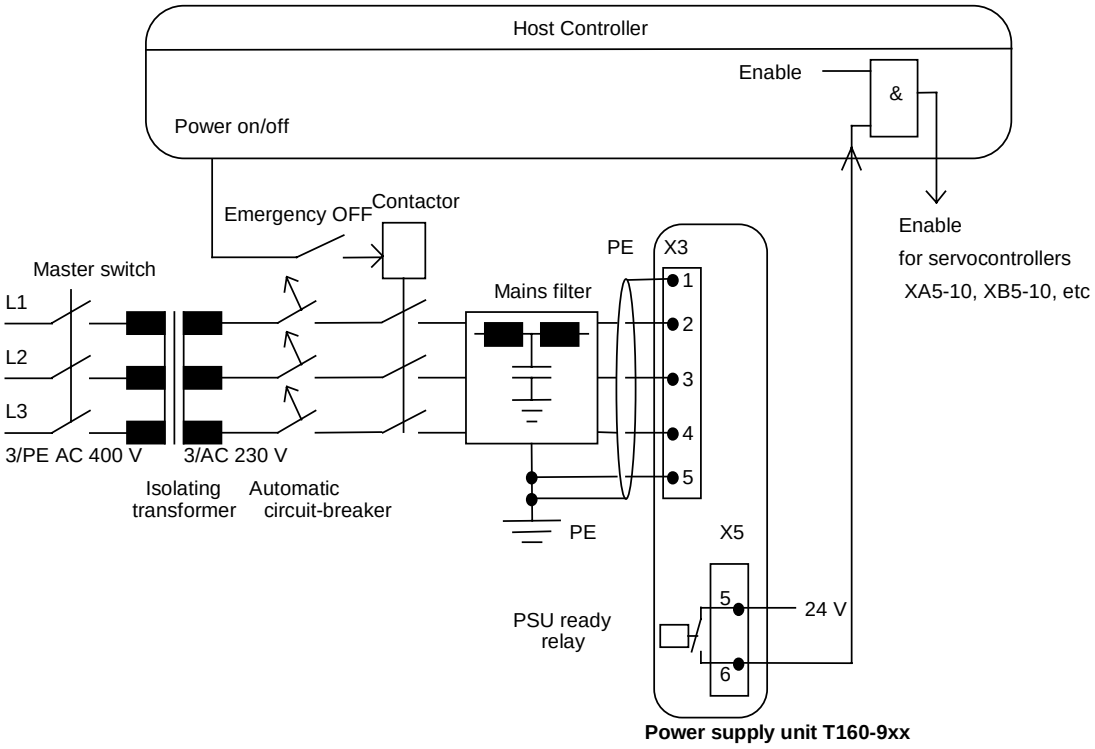


Fig. 3.6: Wiring of the power supply unit

Important: Emergency OFF buttons must be used

The Directive concerning the safety of machines specifies that an Emergency OFF switch must be installed in the system so that the servo drives can be disconnected from the mains voltage in an emergency.

EMC recommendation:

The connecting leads must be routed through a ferrite core in order to filter out the conducted DC interference. The ferrite core must be positioned as close to the power supply unit as possible so that the connection between core and terminal is as short as possible. It must be ensured that all three leads are routed in parallel. They must all be inserted into the hole of the core in the same direction and must all have the same number of turns (see diagram below).

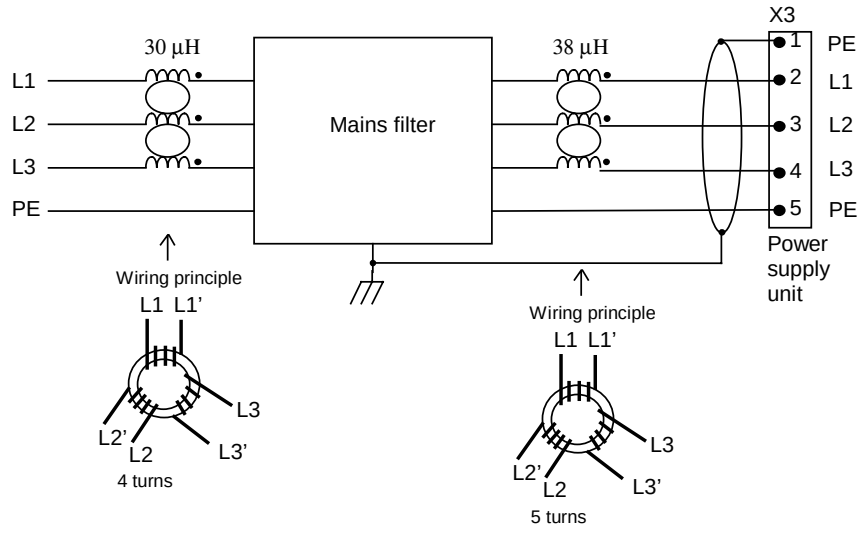


Fig. 3.7: Power connection with mains filter and ferrite core

3.7.5 Configuring the power supply unit for ballast resistance

The following notes must be observed without fail when using an external ballast resistance:

Danger - High voltage!
Voltages of up to 400 VDC may be present at the external ballast resistance. It must therefore be protected against accidental contact.
Recommendation: cover with a perforated metal sheet.
EN 60204 "Safety of electrical machines" requires that the housing of a ballast resistance must be according to at least IP22.

Danger - High temperatures!
The ballast resistance can become very hot during operation. It must therefore be installed so that its high temperature does not constitute a source of danger. The cover (perforated metal sheet) may also become very hot and must therefore be protected against accidental contact.

EMC recommendation:
The ballast resistance should be installed in a perforated case to protect it against accidental contact. The perforated metal sheet also prevents the emission of electromagnetic waves and is consequently required for compliance with EMC regulations. A shielded cable must be used for connection. The shield is connected at both ends to the backplane and to the perforated case.

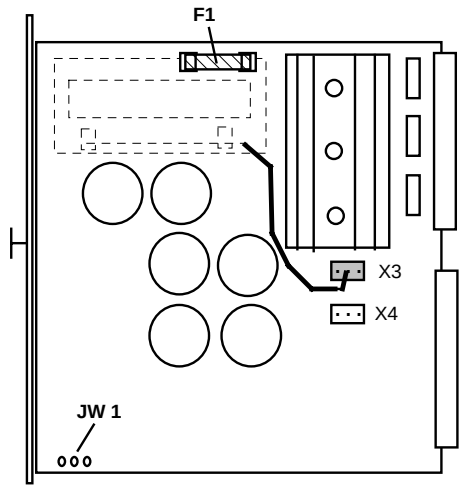


Fig. 3.8: Various positions on the power supply unit

3.7.5.1 Power supply units T160 - 901 # - 00 - 1# and T160 - 902 # - 00 - 1#

These two power supply units can be configured for three different options:

Option	External ballast resistance	Fuse F1	Connector position	Continuous regeneration power	Peak regeneration power
1 (Configuration upon delivery)	None	SIBA 1.6 A / 415 V slow-blow	X 3	40 W	2,800 W for 100 ms
2	50 Ohm	SIBA 2.5 A / 415 V slow-blow	X 4	200 W	2,800 W for 300 ms
3	10 Ohm	SIBA 8 A / 415 V slow-blow	X 3	235 W	16,900 W for 100 ms

1. Plug the connector into the position indicated in the table above.
The connector is plugged into position X3 when the power supply unit is delivered.

2. Replace fuse F1 with the fuse specified in the table (options 2 and 3 only).
A 1.6 A fuse is fitted in the power supply unit upon delivery. The other two fuses are enclosed in the package. Note that the three fuses are differently rated and therefore CANNOT be used as replacements. The fuse may only be replaced by another fuse with the same rating if it is tripped.

3. Connect the external ballast resistance (options 2 and 3 only).
The resistance value of the ballast resistor must not be lower than specified in the table. It must be designed for both the continuous regeneration power and the peak regeneration power as well.
The ballast resistance is connected to terminals X4-pin 1 and X4-pin 2. The protective earth conductor is connected to terminal X4-pin 3 and to the cover of the ballast resistance.

3.7.5.2 Power supply unit T160 - 932 # - 00 - 1#

An external ballast resistance is required for this power supply unit. Operation without external ballast resistance is impossible.

Option	External ballast resistance	Fuse F1	Connector position	Continuous regeneration power	Peak regeneration power
1 (Configuration upon delivery)	10 Ohm	SIBA 10 A / 415 V slow-blow	--	900 W	14,000 W for 160 ms

- Connect the external ballast resistance.

The resistance value of the ballast resistor must not be lower than specified in the table. It must be designed for both the continuous regeneration power and the peak regeneration power as well.
The ballast resistance is connected to terminals X4-pin 1 and X4-pin 2. The protective earth conductor is connected to terminal X4-pin 3 and to the cover of the ballast resistance.

3.8 Connecting the servomotors

Danger - High voltage!

The servomotors operate with potentially lethal voltages. The following points must be noted before starting any work on the servomotors or wiring.

- **Disconnect the system from the power supply.**
  Note the safety regulations specified in Chapter 3.1 "Safety Instructions".
- **The servomotors must come to a complete standstill.**
  Rotating servomotors can generate potentially lethal voltages by acting as generators.
- It is **NOT** sufficient to simply disable the drive.

Important!

The motor must be wired and tested conscientiously.

- **Power cable**

An incorrect phase sequence can cause the motor to accelerate in an uncontrolled manner when switched on. The torque is fed inversely and the control system confused totally by the incorrect phase sequence.

- **Signal cable**

Incorrect connection of the leads can cause the motor to accelerate in an uncontrolled manner when switched on. Due to the reversed polarity, position evaluation is effected in the opposite direction to the sense of the motor rotation and the control system utterly confused.

Two points must be noted in addition to the safety instructions when carrying out this work:

1. Motor type
   This description applies for all MOOG motors with the designation G42x-xxx.
   Customized MOOG motors and motors built by other manufacturers may only be operated in consultation with MOOG.
2. Does the motor have a brake or not?

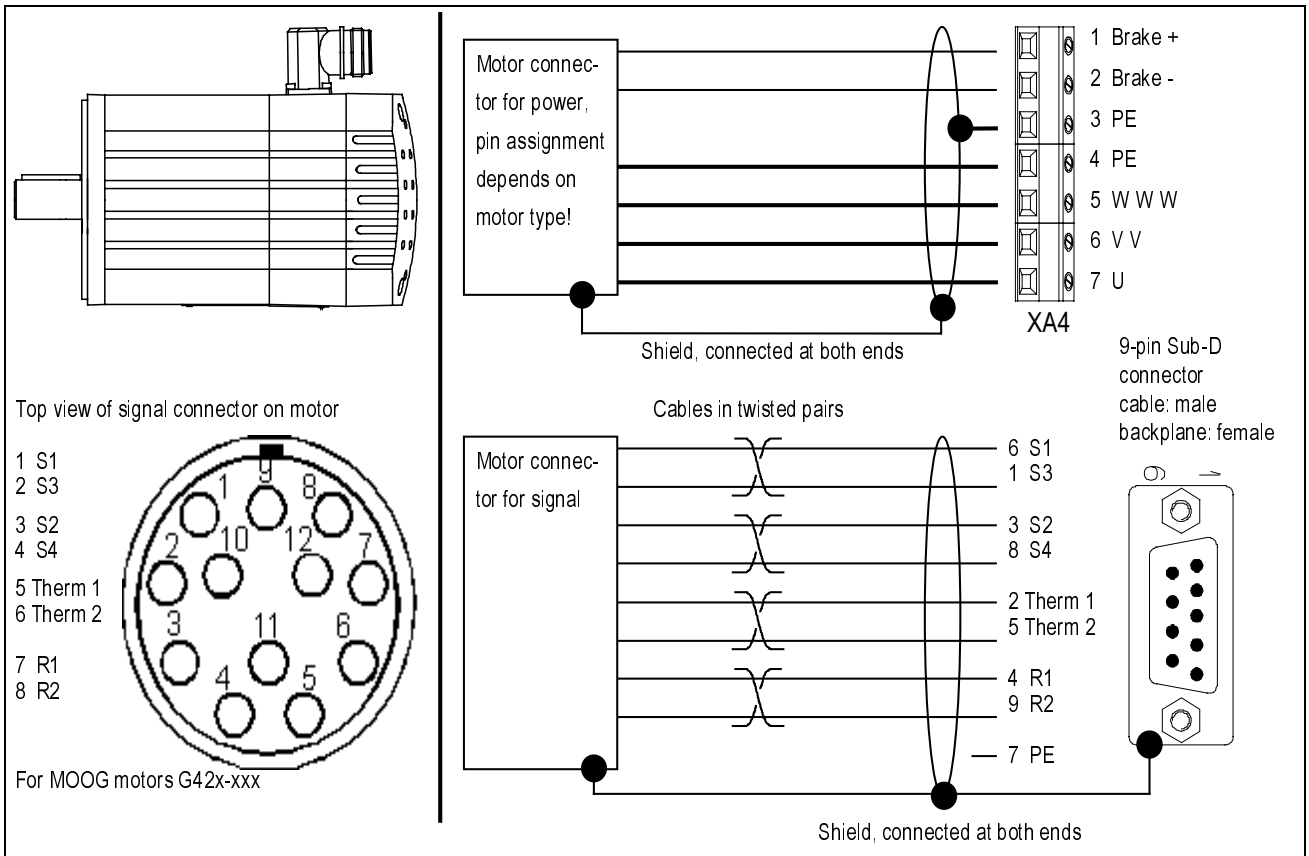


Fig. 3.9: Connection of motor wiring to the backplane

3.8.1.1 Power cable connection

Power connectors XA4, XB4, XC4, .., XF4

Type:	Phoenix GSMKDS3 (angled screw terminal)
wire cross-sectional area:	max. 3 mm^2

Pin 1	24 V B+	Positive pole for 24 VDC brake in motor Important: Note the chapter "Brake control".	Output
Pin 2:	24 V B-	Negative pole for Pin 1	Output
Pin 3:	PE	For shield connection	PE
Pin 4:	PE	Protective earth conductor	PE
Pin 5:	W W W	Motor phase W	Output
Pin 6:	V V	Motor phase V	Output
Pin 7:	U	Motor phase U	Output

3.8.1.2 Signal cable connection

Resolver connectors XA6, XB6, XC6, .., XF6

Type:	female 9 pole sub-D connector on the backplane
wire cross-sectional area:	--

Pin 1	S3	Resolver feedback, SIN+	Input
Pin 2:	Therm 1	Temperature sensor connection (NTC thermistor)	Output, Ref.: Pin 5
Pin 3:	S2	Resolver feedback COS+	Input
Pin 4:	R1	Resolver feeding, positive	Output, Ref.: Pin 9
Pin 5:	Therm 2	Temperature sensor connection (NTC thermistor)	Input
Pin 6:	S1	Resolver feedback, SIN-	Input
Pin 7:	PE	Protective earth conductor	Input/Output
Pin 8:	S4	Resolver feedback COS-	Input
Pin 9:	R2	Resolver feeding, negative	Input

3.8.1.3 Brake control

Information on the motor brake

The following points must be noted with regard to the motor brake:

- **Brake control**
  The brake is released with 24 VDC. It engages as soon as the voltage is interrupted. Only brakes which operate according to this principle can be controlled.
- **Select the appropriate backplane**
  The servocontroller can only control the brake if brake relays are installed on the backplane.
- **Holding brake only**
  The motor brake is a holding brake and holds the motor shaft. If the brake is used for dynamic braking several times, it will become worn and the braking effect will deteriorate. The brake is not designed to take over safety functions.

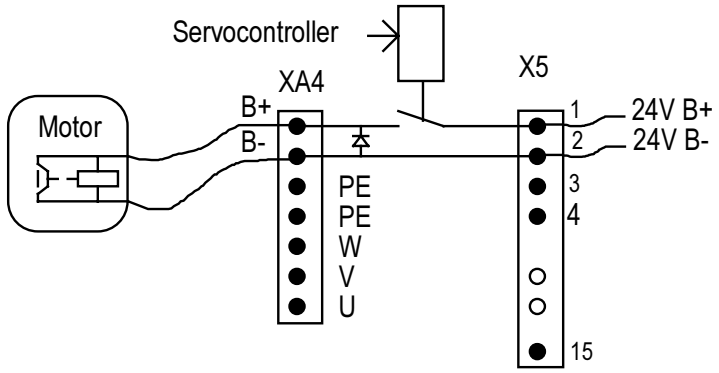


Fig. 3.10: Brake control by the servocontroller.
The brake is released when current flows and engages when de-energized.

EMC recommendation:

The connecting leads must be routed through a ferrite core in order to filter out the conducted DC interference. The ferrite core must be positioned as close to the power supply unit as possible so that the connection between core and terminal is as short as possible. It must be ensured that both leads are routed in parallel. They must both be inserted into the hole of the core in the same direction and both leads must have the same number of turns (four turns) (see diagram below).

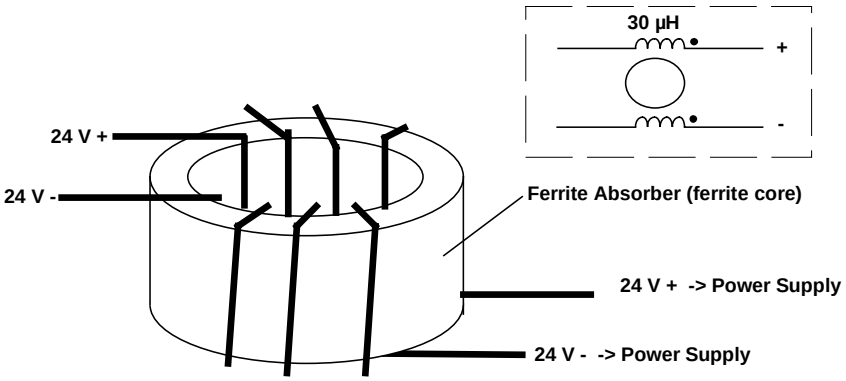
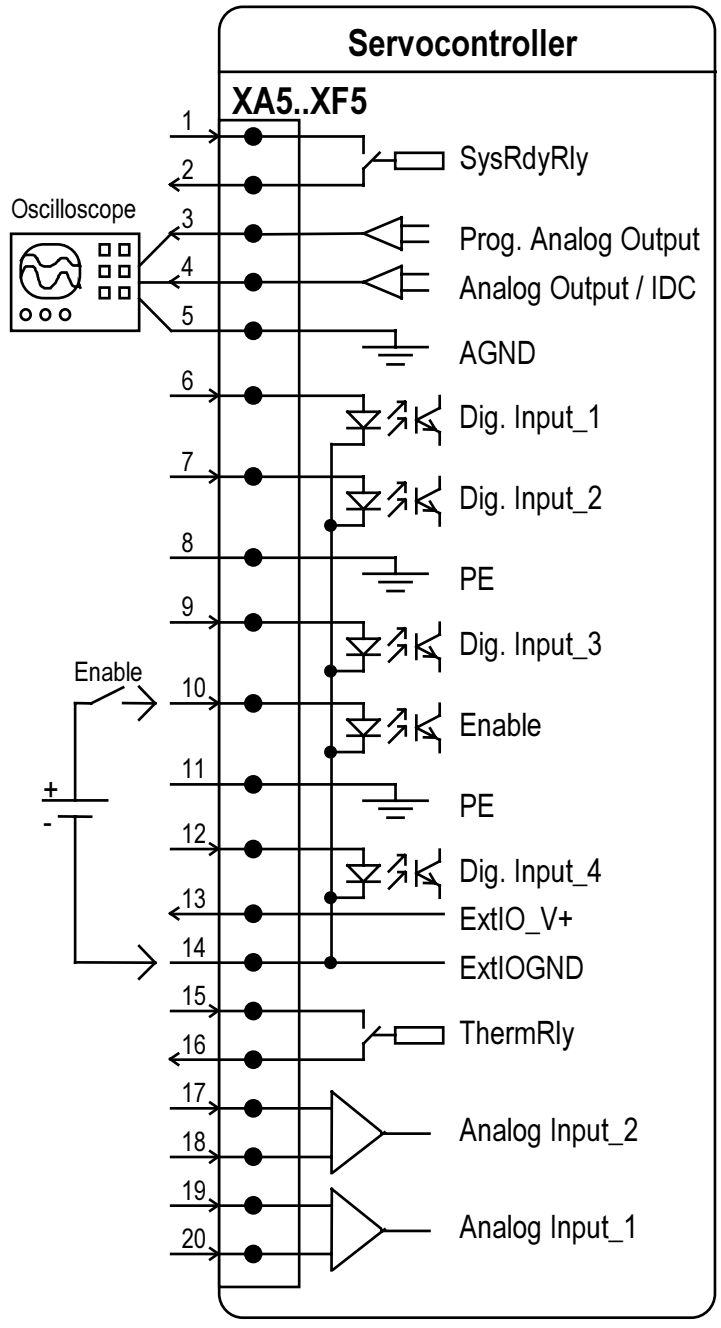


Fig. 3.11: Ferrite core on the 24 V line (signal voltage)

3.9 Wiring the servocontroller inputs and outputs

The inputs and outputs of the servocontroller are illustrated below. Depending on the servocontroller version concerned, the inputs and outputs are activated and evaluated differently by the software. This is described in Chapter "4. Servocontroller T161 ...".



Electrical data:

Relays (SysRdyRly and ThermRly)
U_{max} < 50 V
I_{max} < 100 mA
P_{max} < 10 VA

Analog outputs
U = -10 V .. +10 V
R_{intern} < 100 Ohm

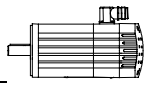
Optocoupler inputs
U = 12 V .. 28 V
R_{intern} = 2 kOhm

Analog input 1
U = -10 V .. +10 V
R_{intern} = 10 kOhm

Analog input 2
U = 0 V .. +10 V
R_{intern} = 10 kOhm

Fig. 3.12: Servocontroller inputs and outputs

4 Servocontroller T161 with Analog Interface +/-10 V



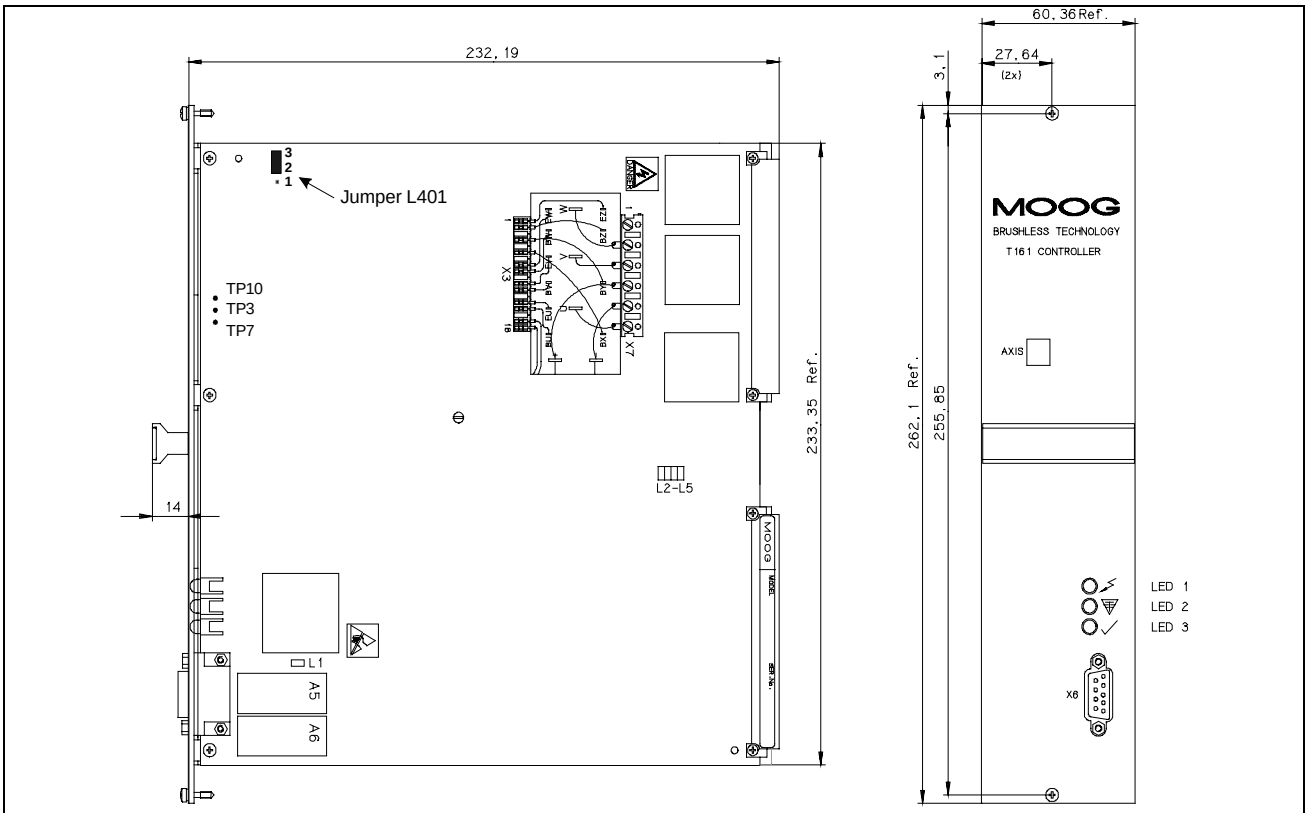


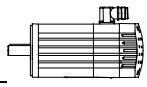
Fig. 4.1: Side and front view of the servocontroller

4.1 Name plate

x	stands for the performance class. This operating instruction applies for all performance classes (from x = 1 to x =4).
#	stands for the revisions index. This operating instruction applies for all revisions.
SerNo: T0123	stands for the serial number. The serial number is incremented with every part produced.

The name plate identifies the product.
For this reason:

- Check whether the name plate on the device matches the name plate illustrated above.
- This documentation must not be used for commissioning and startup if the name plates do not match.
- Devices without name plate are not covered by the manufacturer's warranty and must not be put into operation.



4.2 Functional description

Basic function of the servocontroller

The servocontroller electronically commutates the MOOG brushless servomotors. It closes the speed control loop and delivers a 3-phase sinusoidal motor current which is controlled by a current controller with large bandwidth. The LED status indicator permits rapid diagnosis of faults occurring. Two relay outputs permit evaluation by the host controller.

Higher functions

The host controller applies an analog voltage as a velocity demand to the servocontroller. The scaling between the voltage (-10 V..0 V..+10 V) and the related velocity demand may be selected freely. The servocontroller has a PI velocity controller and sets the demanded velocity immediately. By means of an optional encoder simulation card, the servocontroller can report its actual position to the host controller, which is able to close the position control loop.

The servomotor can also be operated torque controlled. In this case, a torque proportional to the analog demand is generated.

4.3 Technical data

4.3.1 Performance data

All current values are peak values.

Model	Peak current [1)]	Continuous current with fan [2)]	Continuous current without fan	PWM frequency	Power dissipation
T161-901	8 A	6 A	3.5 A	10 kHz	13 W + 11 W/A
T161-902	20 A	11 A	4.7 A	10 kHz	13 W + 11 W/A
T161-903	30 A	15 A	6.5 A	5 kHz	13 W + 8,5 W/A
T161-904	60 A	18 A	---	5 kHz	13 W + 8 W/A

[1)] Velocity > 50 min^{-1}

[2)] Fan performance > 35 m^3 / h

4.3.2 Dimensions and weights

Model:	T161-901 to T161-903	T161-904
Weight:	2.4 kg	3.5 kg
Installation size (W x D x H in mm):	60.96 x 226.90 x 262.90	91.44 x 226.90 x 262.90

4.4 Installation and commissioning

4.4.1 Wiring of the inputs and outputs

Danger - High voltage on the backplane!

High voltages are present at the backplane, as well as at some screw terminals and the soldering pins. Since accidental contact with the live terminals / soldering pins is always possible when working on the backplane, the system must be disconnected from the mains voltage and secured against inadvertent reconnection by means of the master switch before starting any work on the backplane.

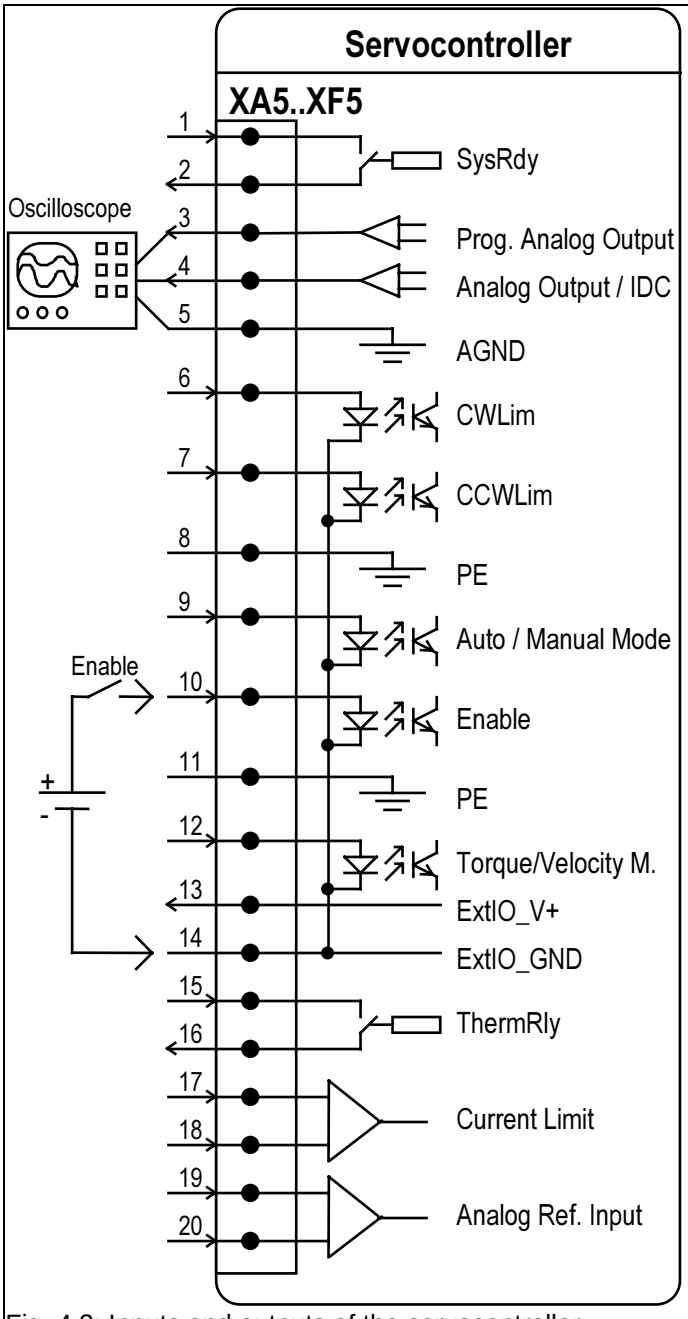
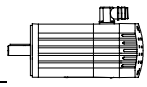


Fig. 4.2: Inputs and outputs of the servocontroller

SysRdy - S*ervocontroller ready* relay
The relay contact closes as soon as power is applied to the servocontroller. The contact opens in the case of a fault.
Prog. Analog Output
Programmable analog output (-10 V .. +10 V).
The default setting is the actual velocity curve.
Analog Output / IDC
Second analog output (-10 V .. +10 V).
The current and hence the torque is output.
AGND - Reference ground for the analog outputs.
CWLim / CCWLim (limit switch inputs)
A current must flow through the limit switch inputs. The limit switch must have a normally-closed contact.
PE - protective earth conductor
Auto / Manual mode switching
If the voltage is removed from this input, the drive switches from Automatic mode to Manual mode.
Enable - Hardware enable
In order to accept the software enable the hardware enable must be present.
Torque / Velocity mode
If a voltage is applied to this input, the servocontroller switches to torque controlled mode.
ExtIIO_V+ - 24 V take off
If the power supply unit is supplied with external 24 VDC, this voltage can be taken off at this terminal.
ExtIO_GND - Reference ground for digital inputs
The digital inputs of the servocontroller are galvanically isolated by optocouplers. All optocouplers use this terminal as their common reference ground.
ThermRly - *Thermal limitation* relay
This relay contact opens whenever the specified torque cannot be achieved as result of a thermal limitation (overheating of the motor or servocontroller).
Current Limit
Analog current limitation
+ = Pin 17 0 V = no limitation
10 V = current is limited to 0 Ampere.
- = Pin 18 (reference to pin 17)
Analog Ref. Input
Analog input (-10 V .. +10 V)
Analog demand for speed or torque control.
+ = Pin 19 0 V = zero speed / torque
10 V = max. speed / torque
- = Pin 20 (reference to pin 19)

Some backplanes do not have screw terminals for connecting the signals. On such backplanes, the signals are wired internally.



4.4.2 Setting the MCO jumper L401

Before the servocontroller is installed in the rack, the MCO jumper L401 must be set to the correct position (see table below).

Motor	T161 - 901		T161 - 902		T161 - 903		T161 - 904	
	Max. current (A)	Jumper position	Max. current	Jumper position	Max. current	Jumper position	Max. current	Jumper position
G422-2xx	2.6	1-2	-	-	-	-	-	-
G422-4xx	5.3	1-2	5.3	1-2	-	-	-	-
G422-6xx	8	2-3	9	2-3	-	-	-	-
G422-8xx	8	2-3	13	2-3	-	-	-	-
G423-2xx	6.5	1-2	6.5	1-2	-	-	-	-
G423-4xx	8	2-3	15	2-3	15	1-2	-	-
G423-6xx	-	-	18	2-3	18	1-2	-	-
G423-8xx	-	-	20	2-3	23	1-2	-	-
G424-2xx	-	-	15	2-3	15	1-2	-	-
G424-4xx	-	-	20	2-3	22	1-2	-	-
G424-6xx	-	-	-	-	30	1-2	-	-
G424-8xx	-	-	-	-	30	2-3	40	1-2
G425-2xx	-	-	-	-	30	2-3	40	1-2
G425-4xx	-	-	-	-	30	2-3	50	1-2
G425-6xx	-	-	-	-	30	2-3	60	1-2
G425-8xx	-	-	-	-	-	-	60	1-2

Status on delivery

- : Not defined at present.

Important: Jumper settings for special motors on request.

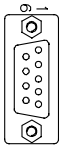
4.4.3 Encoder simulation (optional card)

4.4.3.1 Principle of operation

Higher-ranking positioning control systems require a feedback of the current position. Usually, an incremental position transducer, flange-mounted on the rear of the motor, is used for this purpose. It sends two series of square-wave pulses via the two channels "A" and "B" to the positioning control system. These two pulse series have a phase offset of 90°. The incremental position transducer also provides one pulse per revolution, called the "zero pulse" via a third channel "M".

In contrast to other motors, the MOOG motors operate with a resolver and can thus measure their position exactly themselves. However, the resolver signals cannot be processed directly by the positioning control system. Therefore they are converted with by means of an electronic card (= encoder simulation card) into incremental-transducer signals. That's why the complicated installation of an incremental transducer on the motor is not needed. The inherent disadvantages of an incremental transducer, e.g. its heat and shock sensitivity are avoided as well.

4.4.3.2 Backplane pin assignments

Plug type	Pin assignments for XA7, XB7, XC7, XD7, XE7, XF7		
9-pin Sub-D connector, male 	Pin 1	GNDExtES	External Ground Encoder Simulation
	Pin 2	/M	Negated Reference Pulse M
	Pin 3	/B	Negated Channel B
	Pin 4	/A	Negated Channel A
	Pin 5	VExtES	External Encoder Simulation Supply Voltage
	Pin 6	M	Reference Pulse M
	Pin 7	B	Channel B
	Pin 8	A	Channel A
	Pin 9	PE	Protective Earth Conductor

Note:

The encoder simulation cards are configured by means of jumpers.
To access the jumpers, the encoder simulation card must be unplugged from the servocontroller. To do this, four screws must be loosened.

4.4.3.3 Encoder simulation card C09517-001

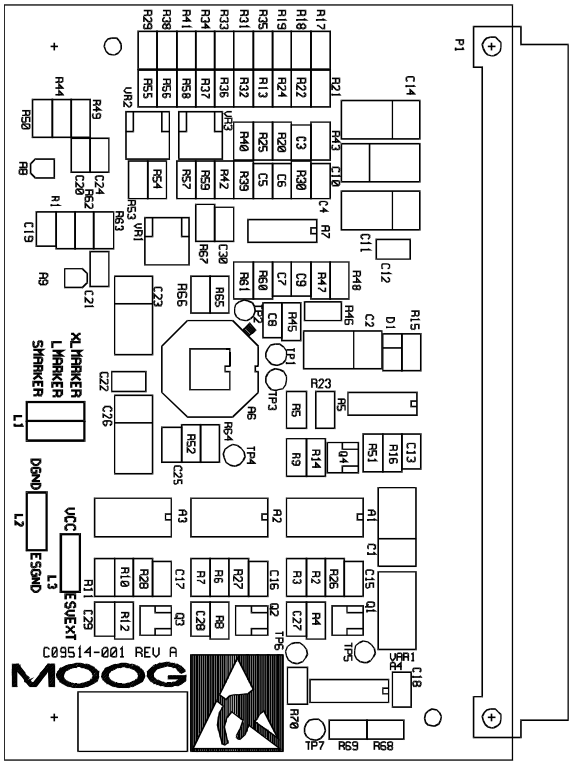


Fig. 4.3: Encoder simulation card C09517-001

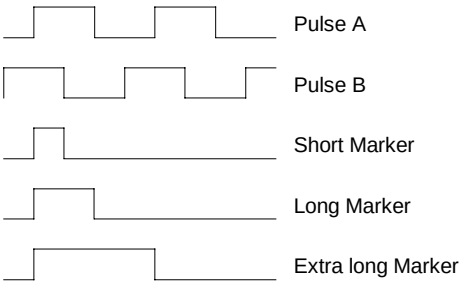


Fig. 4.4: Various zero pulse lengths

Technical data:

Number of pulses per revolution:	1024, fixed
Supply voltage:	+5 Volt, provided internally or externally
Signal level for A, /A, B, /B, M and /M:	+5 Volt
Galvanic isolation:	yes if external supply voltage is used
Max. permissible motor speed:	10 000 rpm

Configuration of the jumpers

1. *Galvanic isolation and external supply voltage*
   - Fit jumper L2 in position "ESGND" and
   - jumper L3 in position "ESVEXT".
   - Connect +5 V to pin 5 of the encoder signal connector X#7 on the backplane and connect the related ground to pin 1.
2. *Internal supply voltage (no galvanic isolation)*
   - Fit jumper L2 in position "DGND" and
   - jumper L3 in position "VCC".
3. *Length of the zero pulse*
   - For an extra-long zero pulse, fit jumper L1 in position "XLMARKER".
   - For a long zero pulse, fit jumper L1 in position "LMARKER".
   - For a short zero pulse, fit jumper L1 in position "SMARKER".

4.4.3.4 Encoder simulation card B94102-001

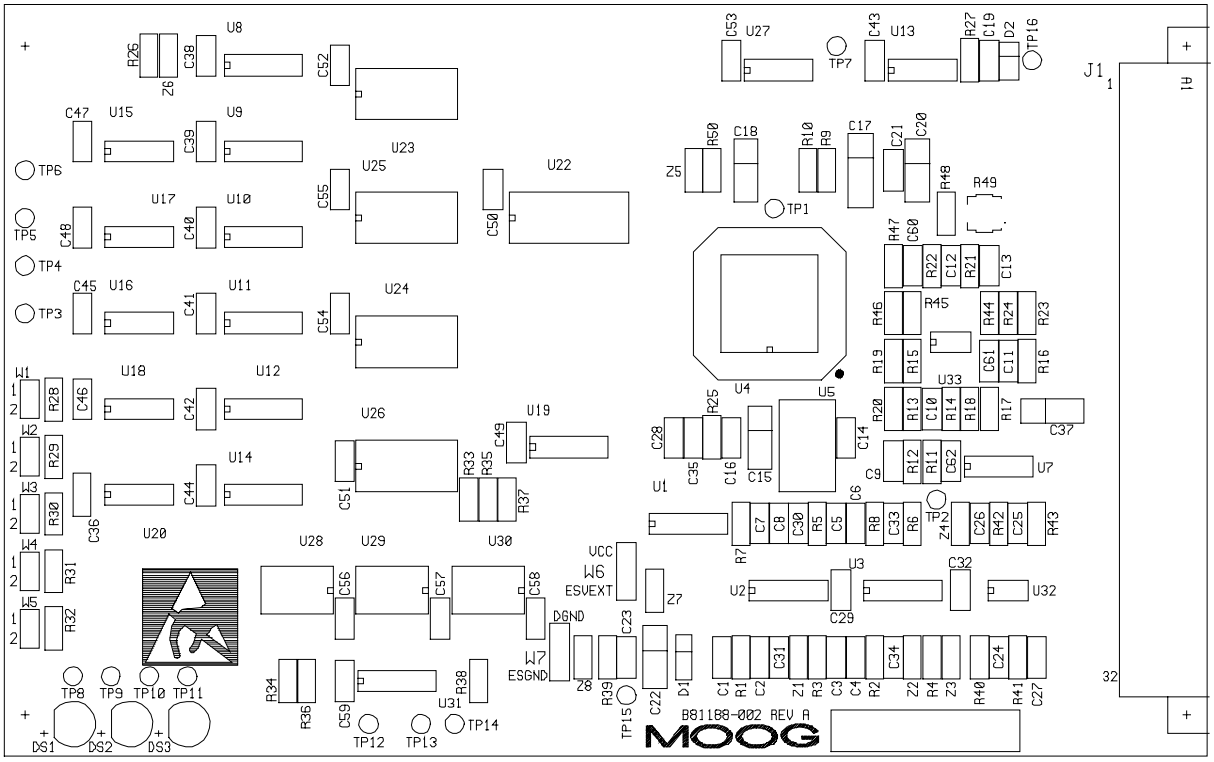
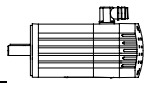


Fig. 4.5: Encoder simulation card B94102-001

Technical data:

Number of pulses per revolution:	Configurable from 128 to 16384 (binary values only)
Supply voltage:	+5 Volt, provided internally or externally
Signal level for A, /A, B, /B, M and /M:	+5 Volt
Galvanic isolation:	yes if external supply voltage is used
Max. permissible motor speed:	depends on number of pulses per revolution



Configuration of the jumpers

1. *Galvanic isolation and external supply voltage*
   - jumper W6 in position "ESVEXT" and
   - Fit jumper W7 in position "ESGND".
   - Connect +5 V to pin 5 of the encoder signal connector X#7 on the backplane and connect the related ground to pin 1.
2. *Internal supply voltage (no galvanic isolation)*
   - jumper W6 in position "VCC" and
   - Fit jumper W7 in position "DGND".
3. *Number of pulses per revolution and length of the zero pulse*

Pulses per rev.	Max. speed rpm	Zero pulse width	Jumper W1	Jumper W2	Jumper W3	Jumper W4	Jumper W5
16384	1400	short	out	out	in	in	in
		long	out	out	in	in	out
8192	1400	short	out	out	out	in	in
		long	out	out	out	in	out
4096	5000	short	out	in	in	in	in
		long	out	in	in	in	out
2048	5000	short	out	in	out	in	in
		long	out	in	out	in	out
1024	15000	short	in	out	in	in	in
		long	in	out	in	in	out
512	15000	short	in	out	out	in	in
		long	in	out	out	in	out
256	15000	short	in	in	in	in	in
		long	in	in	in	in	out
128	15000	short	in	in	out	in	in
		long	in	in	out	in	out

4.4.4 Commissioning interface

The RS232 interface on the component side of the servocontroller is set as the default commissioning interface. The RS485 interface can be selected by moving jumpers.

Jumper	L2	L3	L4	L5
RS 232 (default)	Insert	Insert	Remove	Insert
RS 485	Remove	Remove	Insert	Remove

4.4.5 Terminal program MOOGTERM

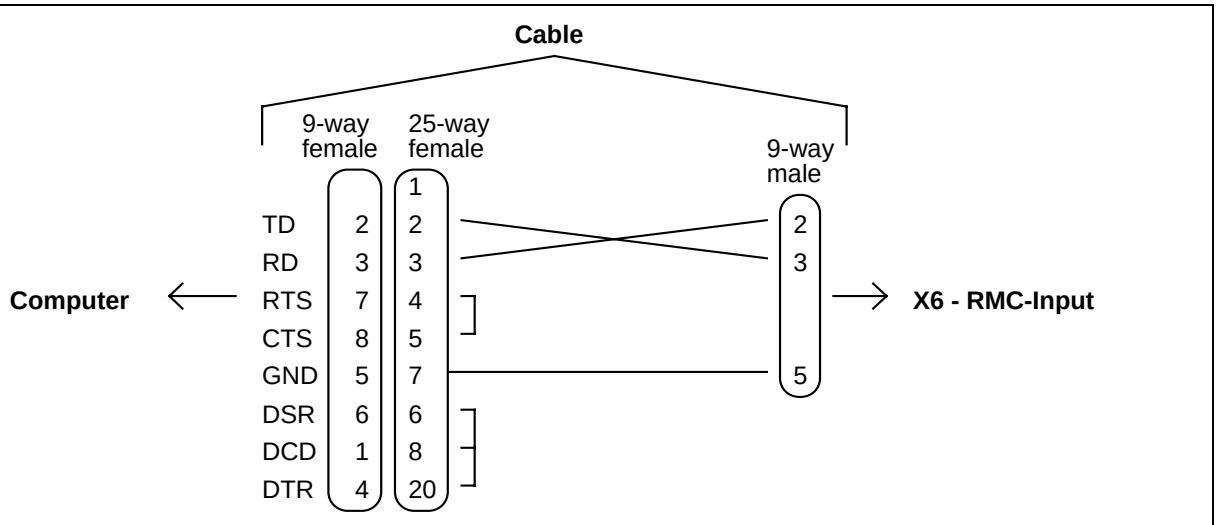


Fig. 4.6: Circuit diagram of the commisioning cable for RS-232

MOOGTERM is a terminal program for commissioning of the servocontroller. MOOGTERM runs under MS-DOS on a personal computer.

MOOGTERM is started by entering its name

A:\> MOOGTERM

Then the program requests various information:

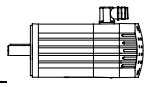
1. Is MOOGTERM to be configured or not?
   The program must be configured when it is started for the first time!
   c - Configure
   <CR> (Enter) - Continue
2. Which type of interface is to be used?
   Press <CR> to select RS232.
3. Which serial interface (COM1 or COM2) is to be used?

The terminal program then starts communication with the servocontroller and determines the software version.

A blue area appears on the left-hand side of the screen. By pressing the Enter key <CR> several times it is checked whether communication is working correctly. The servocontroller responds with the following text:

Enter first
letter of a
command or H
for help>

or simply with the prompt ">".



4.4.6 Configuration and startup of the servocontroller

When the entire system has been wired correctly, the system can be switched on. Various LEDs now light on the power supply unit (see Section "Power supply unit - diagnostics"). The red LED on each servocontroller flashes.

The personal computer is connected with the servocontroller via the start up cable. Now the terminal program MOOGTERM can be started.

After the Enter key <CR> has been pressed several times, the servocontroller responds with the text:

Enter first
letter of a
command or H
for help>

or simply with the prompt “>“.

Enter the motor type

The motor type must now be entered with the command "D":

D
Motor:-
e.g. D314..L10
G424-400
G423-200

Saving the input data

The settings are saved by pressing "C". The servocontroller then requests the input of a four-digit code. This code is used only for outputs and is displayed during the starting up sequence of the servocontroller.

The further settings (control parameters, encoder simulation, scaling) are described in the following sections.

4.5 Digital control loop

4.5.1 Block diagram

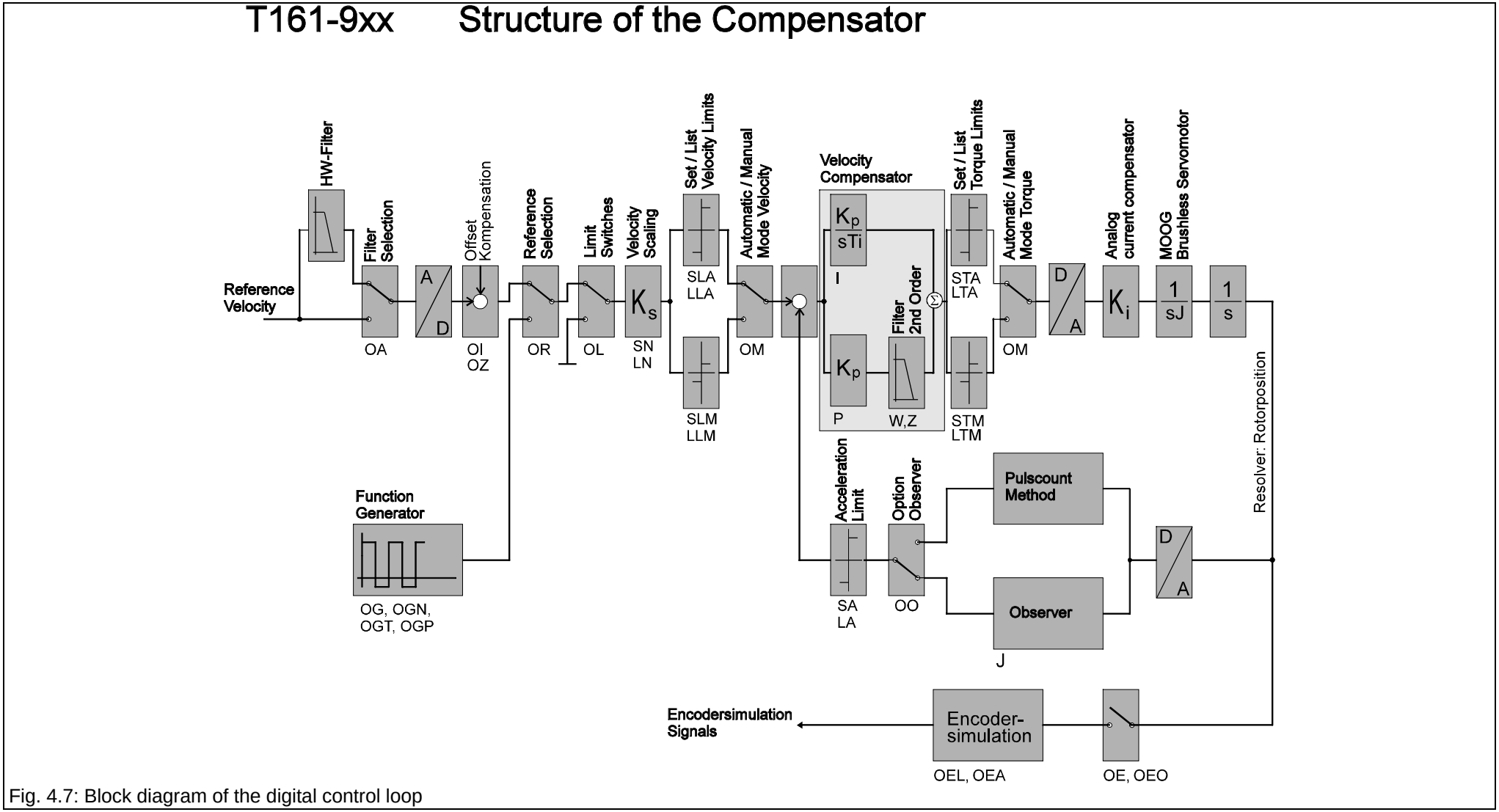
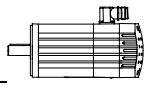


Fig. 4.7: Block diagram of the digital control loop



4.5.2 List of commands

(EPROMs B80806-00# and B80807-00#, # = Revision Index)

S/L	*****	Input/output of all parameters	**PARAMETER INPUT/OUTPUT**
L	**-**	Output of the system configuration	
S/L	**N**	Input/output of the maximum speed for a 10 V input signal	
S/L	**R**	Input/output of the observer position error in [revs/10 V]	
S/L	**P**	Input/output of the proportional gain in [Nm/(rad/s)]	
S/L	**I**	Input/output of the integral time constant in [s]	
S/L	**J**	Input/output of the moment of inertia of the observer in [kgm²]	
S/L	**W**	Input/output of the cut-off frequency of the filter in [Hz]	
S/L	**Z**	Input/output of the attenuation of the filter	
S/L	**A**	Input/output of acceleration limitation for the actual speed (filter function, not a setpoint ramp!) in [rad/s²] (May be adjusted only by trained MOOG engineers!)	
L	**M**	Output of the motor parameters	
L	**D**	Output of the axis number in RS485 mode	
S/L	**TA**	Input/output of the torque limitation in [Nm] in Automatic mode	
S/L	**TM**	Input/output of the torque limitation in [Nm] in Manual mode	
S/L	**LA**	Input/output of the speed limitation [rpm] in Automatic mode	
S/L	**LM**	Input/output of the speed limitation in [rpm] in Manual mode	
S/L	**E**	Braking deceleration for limit-switch inputs	

P		Setting mode for proportional gain	**PARAMETER SETTING MODES**
	U	Increase P by 5%	
	D	Decrease P by 5%	
	Z	Set P to zero	
	Q	Return to main menu	
	RET	Return to main menu	
I		Setting mode for integral time constant	
	U	Increase I gain by 5% (decrease I time constant by 5%)	
	D	Decrease I gain by 5% (increase I time constant 5%)	
	Z	Set I gain to zero (set I time constant to infinite = 3 s)	
	Q	Return to main menu	
	RET	Return to main menu	
J		Setting mode for moment of inertia of observer	
	U	Increase J	
	D	Reduce J	
	Z	Set J to zero	
	Q	Return to main menu	
	RET	Return to main menu	

D	Drive initialization	**SPECIAL COMMANDS**
C	Save parameters permanently in EEPROM	
Control X	Software warmstart	
Control T	Upload/download the system parameter C	
Alt S	Change the axis (active only in RS 485 mode)	

H	Help as help function	**HELP FUNCTION**
+	Upper help level	
-	Reduced help level	

OPTIONAL COMMANDS

OC	Selection of control mode **1** Torque mode **2** Velocity mode
OE	Available only with encoder simulation card B53000-001 (sold only as spare part for repairs) **L** Input of the number of pulses of the encoder simulation (number of lines) **A** Input of the zero pulse angle **O** Disable encoder simulation
OI	Compensation of the input offset
OZ	Automatic offset adjust
OA	Enable/disable reference input filter (input reference filter)
OL	Enable/disable limit-switch inputs
OR	Select reference source (compensator reference source) **1** Analog reference (external setpoint generation, default) **2** Function generator (internal function generator)
OG	Setting the function generator **N** Setting the speed of the function generator (amplitude and offset in [rpm]) **T** Setting the torque of the function generator (amplitude and offset in [Nm]) **P** Setting the period in [s] and the duty cycle in [%] of the function generator
OF	Programmable analog output (front panel options) **1** dP/dt (actual speed) **2** Filtered dP/dt (filtered actual speed) **3** IDC (current monitor, corresponding to a DC motor) **4** Observer estimated velocity **5** Observer position error
OM	Enable/disable Manual mode
OD	Enable/disable thermal protection software
OT	IT limit setting (for motors MOOG INC. 30x-xxx only)
OO	Enable/disable the observer (Observer velocity on/off)

STATUS POLLS

?M	Motor temperature in [°C]
?B	Temperature of the power output stage in [°C]
?P	Rotor position (motor shaft position) [0° .. 360°]
?V	Average speed in [rpm]
?L	Current limitation (limit settings) in [Amps]
?F	Fault messages
?S	Current status of the servocontroller (present controller status)

MOTOR-MODE COMMANDS

MI	Enable the motor
MO	Disable the motor
MB	Enable/disable (optional) motor brake (Release brake = open brake)
MT	Torque mode
MV	Velocity mode

4.6 Tuning the controller

Beware of mechanical hazards!

Servomotors can accelerate highly dynamically. They also have an enormous torque. The following points must therefore be observed when commissioning the system:

- **The danger zone around the motor must be cordoned off.**

The system must feature a guard door preventing personnel from reaching into or entering the danger zone. If the guard door is opened, the drive system must be disconnected from the supply voltage immediately. This is best done by de-energizing the contactor inserted before the MOOG power supply unit.

- **The control parameters determine the dynamic and static behaviour of the servomotor.**
  Incorrectly or wrongly set parameters can cause the servomotor to run at an excessive speed (instable controller settings).
- If the drive is moved with the aid of the function generator, it should be noted that the motor speed and the repetition frequency are used to determine for how long and how far the motor rotates in one direction. This must be noted if the machine is equipped with mechanical end stops.

The integrated function generator and the programmable analog outputs (X#5 Pin 3 and Pin 4) are used to tune the controller.

4.6.1 The integrated function generator

The servocontroller features an integrated function generator which can be used for setting the controller with the aid of its step response. Speed references can be generated and fed into the control loop. With the command "OR", the function generator can be selected as the reference signal source (compensator reference).

4.6.1.1 Generating a reference velocity curve

For the generation of a reference velocity curve, the function generator provides a square-wave signal with programmable frequency and amplitude.

OGN - to enter the amplitude and offset of the velocity reference:
Func. Generator Speed Amplitude (speed amplitude)
Func. Generator Speed Offset (speed offset)
Unit: rpm

OGP - to enter the period of the square-wave signal:
Unit: sec
- to enter the Func. Generator Duty Cycle (share of period of positive speed amplitude):
Unit: %.

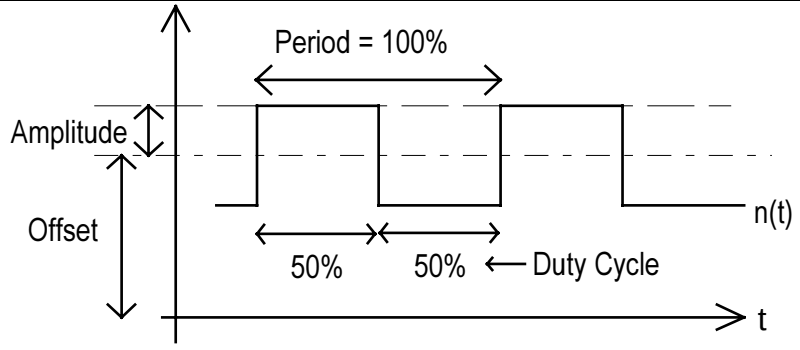


Fig. 4.8: Programming the reference velocity curve n(t) with the function generator

It should be noted that the reference velocity and the period determine how fast and how long the drive moves in one direction. These values must be selected such that the drive does not move against the end stops of the machine.

4.6.2 Analog outputs

The servocontroller has two analog outputs which are used for the output of dynamic control process variables to an oscilloscope. The outputs are available both on the backplane and on the front panel. On the front panel, the outputs are covered by a black Lexan foil. You can either cut a hole in this foil or, preferably, carefully peel off the foil so that it can be fixed again afterwards. The freely programmable output is programmed with the command "OF...":

Output	TP10 or X#5, Pin 3
Actual speed	OF 1 *)
Filtered actual speed	OF 2
Torque (current Idc)	OF 3
Speed calculated by the observer	OF 4
Difference between observer position and real position	OF 5

*) default setting after the servocontroller is switched on (again).

The other analog output "TP3" or "X#5, Pin 4" is permanently set to torque (Idc) output.

Scaling

- **Speed**
  The speed is scaled with the command "SN" (10 V correspond to how many rpm?).
- **Observer Position Error**
  The observer position error is scaled with the command "SR" (10 V correspond to how many revolutions?).

4.6.3 Tuning the controller

This section describes how the controller is tuned by means of the step response. If the machine does not permit this, another method has to be used. The speed control loop must be tuned first. It is important that no saturation occurs during adjustment, since this would cause the controller to leave the linear range. For this reason, the current must be observed (with the analog output TP3 or at X#5 Pin 4 on the backplane) in order to ensure that it is not limited.

4.6.3.1 Tuning the speed control loop

In order to adjust the speed control loop, the drive must be switched to velocity mode and the function generator must be selected as the reference signal source.

OR to select the function generator as the reference source.

The following inputs are then requested:
- Func Generator Speed Amplitude (speed amplitude in rpm): enter the speed.
- Func Generator Speed Offset (speed offset in rpm): enter the value "0".
- Func Generator Torq. Amplitude (torque amplitude in Nm): enter the value "0".
- Func Generator Torq. Offset (torque offset in Nm): enter the value "0".
- Func Generator Period (period in sec): enter a low value.
- Func Generator Duty Cycle (in %): leave this value set to "50".

OC to switch to velocity mode: enter option "2".

MO to cancel the enable signal for the motor.

MB to apply the brake: enter "N" for not releasing the brake.

OGN to enter the Func Generator Speed Amplitude (speed amplitude in rpm).

OGP to enter the period of the square-wave signal (period in sec).

SP to enter the proportional gain of the speed controller (in Nm/(rad/s)).
Start with a low value and increase gradually!

SI to enter the integral time constant (in sec) of the speed controller.
Select the maximum value (3 s)!

OF 1 to program the actual speed to the programmable analog output (TP10 or X#5, pin 3).

MI to enable the motor and release the brake.

Fig. 4.9 shows the reference speed and the actual speed:

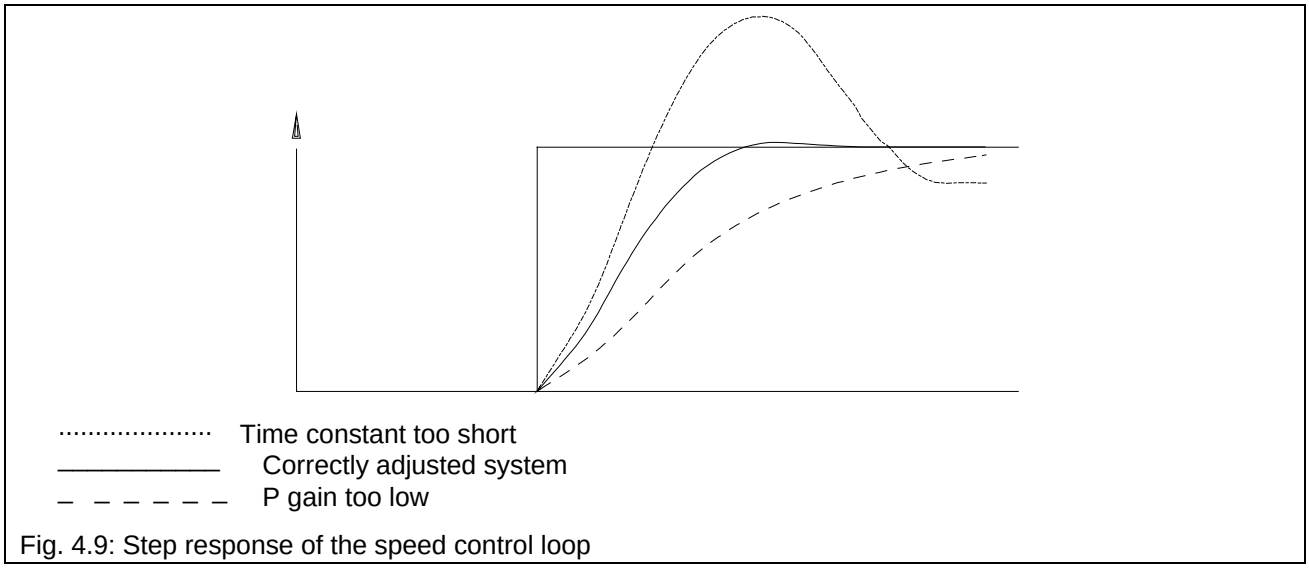


Fig. 4.9: Step response of the speed control loop

The controller should be adjusted in accordance with Fig 4.9. Overshoots will occur if the proportional gain of the controller is set too high. The system will become slow if the controller gain is set too low.

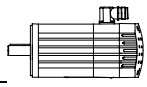
The integral component determines the sensitivity of the control loop to disturbances from the load torque and prevents steady state speed errors. The disadvantage of this is, however, that the integral component has a negative effect on the stability of the control loop.

Note: jog-key mode

Instead of the commands "SP", "SI" and "SJ", the commands "P", "I" and "J" can be used. These commands activate the corresponding jog-key mode, in which the following keys can be used:

- U (Up)
  Increases the current value by 5%.
- D (Down)
  Decreases the current value by 5%.
- S (Set)
  For input of a new value.
- L (List)
  Displays the current value.
- Q (Quit)
  Terminates jog-key mode.

MOOG recommends use of the jog-key mode, since it reduces the risk of incorrect inputs to a great extend.



4.6.3.2 Cooperation with the higher-ranking control system

After the above adjustments, the servocontroller is still in function-generator mode, which means that it ignores the analog interface. Therefore it must be set back to its normal operating mode (speed-controlled with analog reference):

OR to select the analog reference as reference source.

Speed scaling

The control system provides the speed reference for the drive as an analog voltage. This voltage should be scaled such that the available voltage range is fully utilized, since this reduces the effects of disturbing voltages and quantization noise.

An example:

- Assumptions:
  During movement, a maximum speed of 5000 rpm occurs and the control system can generate a maximum output voltage of 8 V.
- Calculation:
  In order to allow for drift and offsets of analog components and possible overshoots of the control loops, a safety margin of 10% is added to the maximum speed, which means that the 5000 rpm become 5500 rpm. When the higher ranking controller wants to set a speed of 5500 rpm, it generates an output voltage of 8 V.

$$\text{Setpoint\_speed} * \text{Scaling\_of\_control\_system} = \text{Output\_voltage}$$

$$\Rightarrow 5500\ \text{rpm} * \frac{8\ \text{V}}{5500\ \text{rpm}} = 8\text{V}$$

$$\text{Input\_voltage} * \text{Scaling\_of\_servocontroller} = \text{Reference\_speed}$$

$$\Rightarrow 8\ \text{V} * \frac{x}{10\ \text{V}} = 5500\ \text{rpm}$$

$$\Rightarrow x = \frac{5500\ \text{rpm} * 10\ \text{V}}{8} = 6875\ \text{rpm}$$

$$\Rightarrow \text{Scaling "SN"} = \frac{6875\ \text{rpm}}{10\ \text{V}}$$

The reference interface of the servocontroller has a range of -10 V .. +10 V.

Remember to save the settings

Once the controllers have been set, the controller parameters should be saved in the EEPROM (command "C"). Before saving the settings, however, the servocontroller should be set back to the correct control mode (speed-controlled) and the correct source for the reference signal (the analog interface) should be selected, since the current control mode and reference signal source are also saved in the EEPROM.

- OR Select the analog interface as the reference source.
- C to save the settings
  The servocontroller requests the input of a 4-digit code number.
  Any desired number, such as 1234, may be entered.

4.6.4 The speed observer

This section describes the commissioning and adjustment of the MOOG speed observer. The use of this observer permits higher control-loop gains and a wider bandwidth of the speed control. With the aid of a model of the control loop (motor and load), the observer calculates the observer estimated velocity. The user needs to change only one optimization parameter in order to tune the observer as described below.

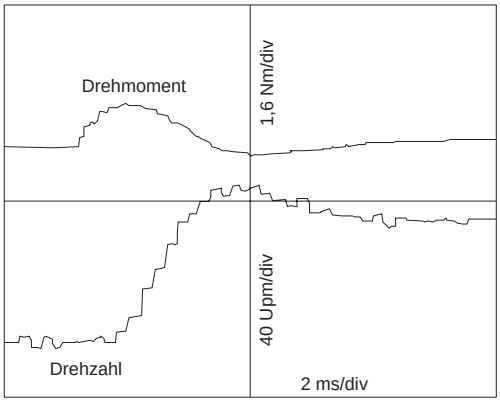


Fig. 4.10: Optimized speed step response

Optimizing the speed control

Fig. 4.10 shows a typical step response of an optimized speed control (the input signal can be generated by the integrated function generator). The torque or current curve can be accessed at the test points of the servocontroller. The same applies to the actual-speed value.

The reference input must be low enough to ensure that the current controller does not reach limitation. Fig. 4.10 shows a single overshoot of 24% in the speed step response and a rise time of 12 ms.

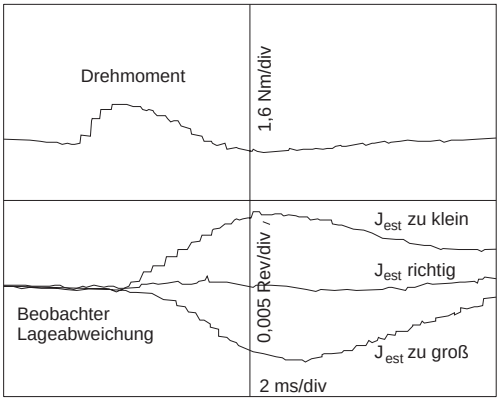


Fig. 4.11: Setting the observer

Tuning the observer

The parameter "Observer moment of inertia J_{est}" is set first. The signal "Observer position error θ_{err}" is set with the command OF5 and is available at the test points TP 3,7,10.

Fig. 4.11 shows the case "motor with load", i.e. Jest is too small (after initialization of the servocontroller, $J_{est}=2 \times J_{Motor}$).

After input of the command J, the following commands are available in observer mode:

U J_{est} up	**D** J_{est} down
S Set J_{est}	**Z** Set J_{est} to zero
L List J_{est}	**Q** Quit (return to main menu)

If the total moment of inertia is already known, this value can be entered with the command "SJ". Fig. 4.11 now shows θ_{err} with J_{est} set correctly.

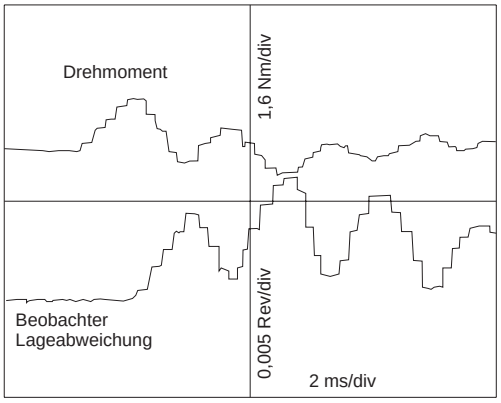


Fig. 4.12: Oscillations in the observer model (do not activate the observer!)

Caution:

If θ_{err} oscillates considerably when the speed changes (see Fig. 4.12), the observer must not be activated! Only a correctly tuned observer model may be inserted into the feedback path.

During the final test of the observer, compare the observerestimated speed (command "OF4") with the actual speed of the drive (command "OF1"). These must be identical.

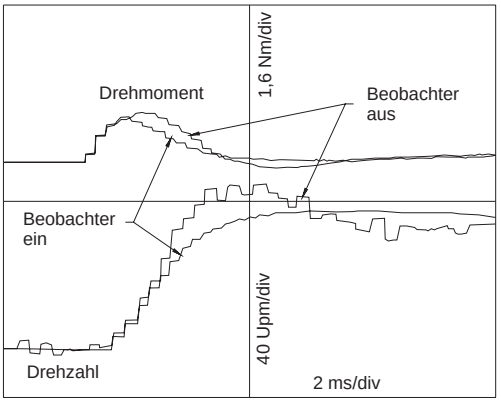


Fig. 4.13: Activating the observer

Activating the observer

The command "OO" activates the observer. Fig. 4.13 shows the effect of the observer on the speed control loop. Note that the overshoot in the velocity curve has disappeared and that the disturbance on the torque curve is considerably reduced as well.

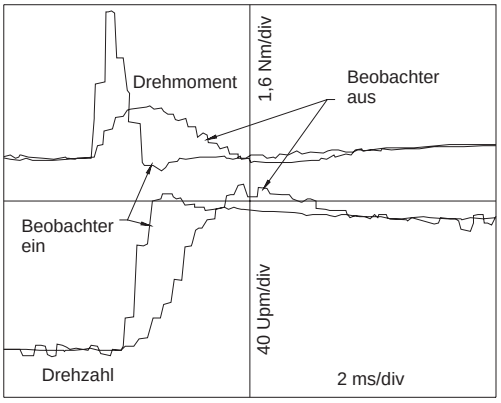


Fig 4.14: System with/without observer

Final tuning of the servocontroller

A higher bandwidth can now be set (command "SW"; value up to about 600 Hz). Now the parameters P and I can also be modified. Fig. 4.14 shows a comparison of system behaviour with and without the observer. The system with observer has a better rise time (2.2 ms instead of 12 ms) and a smaller overshoot.

4.7 Diagnosis

4.7.1 LEDs

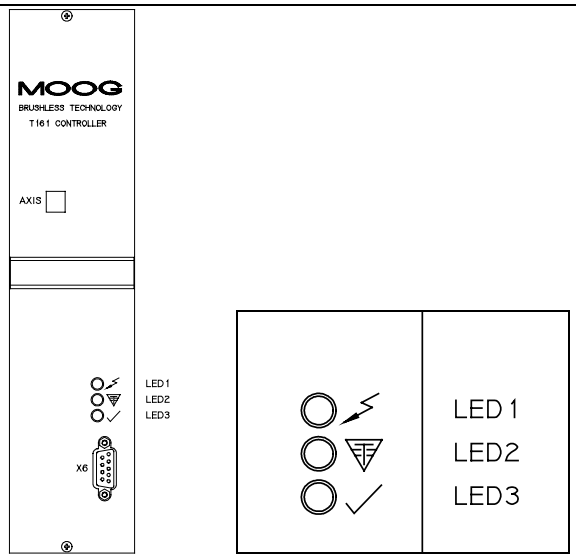


Fig. 4.15: Servocontroller T161 status LEDs

Status LEDs:

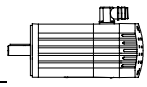
LED 1 (red) **LED flashes**
The servocontroller is booting (getting its parameters from the memory and configuring itself with them).
When the servocontroller has completed booting, this LED goes out.
If the servocontroller has never been configured previously, the LED continues to flash. In this case, the servocontroller must be configured (input of the motor type, etc.) via the serial interface.
LED lights in the case of a fault.
If the servocontroller is enabled and a fault occurs, the green LED 3 goes out and the red LED 1 lights again.
Enabling the servocontroller again deletes the stored faults and LED 1 is switched off.

LED 2 (yellow) **Torque limitation active due to thermal overload**
As long as the torque limitation is active, the contact of the thermal limit relay for (X#5 / Pins 15 and 16) remains open and this LED lights.

LED 3 (green) **Enable**
As soon as the servocontroller is enabled this LED lights up.
It is switched off when the servocontroller is disabled.
LED 3 is switched off as well in the case of a fault (red LED 1 lights).

4.7.2 "System ready" relay

Relay status	Condition
Relay contact remains open.	- When the servocontroller is switched off completely
Relay contact closes.	- If there is no fault present.
Relay contact opens.	- When the servocontroller is switched off. - If a fault is present.



4.7.3 Getting fault information via MOOGTERM

MOOGTERM is the commissioning program for the servocontroller and runs under MS-DOS on a personal computer. A description of this program can be found earlier in this section.

The fault memory of the servocontroller can be read out with the command "**?F**". There are two different types of fault messages:

Fault text	Meaning
Fault occurred	A fault has occurred but is no longer present. The fault message is stored until the servocontroller is enabled again. Then the message is deleted.
Fault present	A fault has occurred and is still present.

Danger - high voltage!

The servo drives operate with potentially lethal voltages.

For this reason:

- **Disconnect the system from the mains supply.**

Before starting any work on the drive system, it must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.

- **The servomotors must come to a complete stop.**

Rotating servomotors can generate potentially lethal voltages by acting as generators.

Beware of charged capacitors!

The capacitors in the power supply may still be charged.

For this reason:

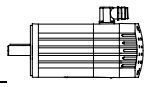
- **Note the discharge time of the capacitors.**

The power supply contains capacitors which may be charged with up to 400 VDC. Wait at least 5 minutes for the capacitors to become discharged after disconnecting the voltage.

- **The voltage must then be measured between DC+ (X7/1) and DC- (X7/2).**

Work on the power supply must not start until the voltage has dropped below 5 V.

Fault message	Meaning and remedial action
Bridge Temperature Fault	The power output stage of the servocontroller has overheated. The servocontroller disables the motor. Remedy: Wait for the power output stage to cool down. Check the fan. If the fault occurs frequently, the servocontroller is being overloaded. Either it is incorrectly dimensioned or there is a mechanical fault (drive elements are jamming and hindering movement).
Motor Temperature Fault	The servomotor has overheated. The servocontroller disables the motor. Remedy: Wait for the servomotor to cool down. If the fault occurs frequently, the servomotor is being overloaded. Either it is incorrectly dimensioned or there is a mechanical fault (drive elements are jamming and hindering movement).
Resolver Fault	Fault in the resolver evaluation. Check the wiring of the motor signal cable: • Is the signal connector connected to the correct interface on the backplane? • Is the signal connector screwed correctly to the motor? • Disconnect the signal cable from the backplane and the motor and check the conductors for electrical continuity, referring to the circuit diagram in the section "Installation". If self made cables are used, also check, using the circuit diagram in the section "Installation": • Are the signal conductors twisted paired? • Is the cable screened and is the screen connected at both ends? • Is the cable made up of one piece (not connected via a terminal box)?
Bus Overvoltage Fault	An overvoltage has occurred on the DC-Bus. Remedy: • Switch off the high voltage for power supply unit T160-9xx, wait 5 seconds and switch on again. This fault will occur if the power supply unit cannot dissipate the energy fed back by the servomotors in braking mode, thus causing the voltage on the DC Bus to increase.
Bridge Short Circuit Fault	Short-circuit in the motor or in the motor power cable or in the servocontroller Check the wiring of the motor power cable: • Are the phases, PE and screen connected correctly (correct phase sequence is important!)? • Disconnect the power cable from the backplane and the motor and check the conductors for short circuits, referring to the circuit diagram in the section "Installation". Check the motor: • Disconnect the power cable. • Measure the resistance between the individual phases of the motor (U-V, U-W and V-W). The resistance values must be approximately equal and must agree with the values in the motor catalogue. If any resistance value differs considerably, there is a short-circuit or open-circuit in the motor. Call MOOG.
Analog Power Supply Fault	Fault in the +5 V or ±15 V supply The voltages are available on the backplane and can be measured with a voltmeter. • If the voltages are within their tolerances (+5 V±0,5 V; ±15 V±1 V), switch off the entire system, wait 5 seconds and switch it on again. • If the voltages are outside the tolerances, remove one servocontroller at a time (Only with the supply voltage switched off!) in order to determine whether there is a short-circuit in a servocontroller or whether the power supply unit is defective.

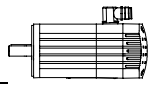


4.8 Ordering information

No.	Description	MOOG Order No.
1	**Servocontroller, 8 Ampere, without encoder simulation**	T161 - 901 # - 00 - B# - 2 -1#
2	**Servocontroller, 20 Ampere without encoder simulation**	T161 - 902 # - 00 - B# - 2 -1#
3	**Servocontroller, 30 Ampere without encoder simulation**	T161 - 903 # - 00 - B# - 2 -1#
4	**Servocontroller, 60 Ampere without encoder simulation**	T161 - 904 # - 00 - B# - 2 -1#
5	**Encoder simulation card ESM III**	C09517-001
6	**Encoder simulation card ESM II**	B94102-001
7	**Commissioning software MOOGTERM** (for IBM-compatible PC) 3,5“ floppy disk 5,25“ floppy disk	 B47214-001 B47214-002
8	**Commissioning cable for PC** (5 metres)	B48424-105
9	**Hand held terminal** (without cable)	B48426-002
10	**Cable for hand held terminal** (5 metres)	B48423-003

= Revision Index for hardware, software and optical design (from left to right)

5 Power supply unit T160-9xx



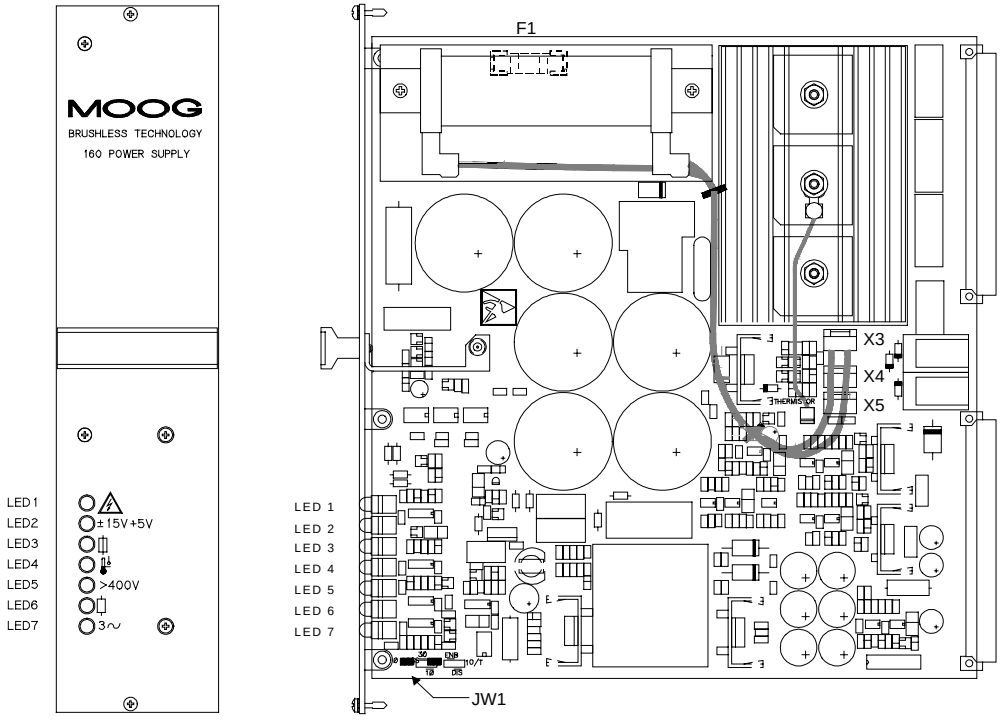


Fig. 5.1: Front and side view of the power supply unit T160-9xx

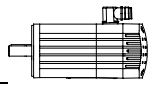
5.1 Name plate

MOOG MOOG Ltd. Made in Ireland	MOOG MOOG Ltd. Made in Ireland	MOOG MOOG Ltd. Made in Ireland
Model: T160-901# -00-1#	Model: T160-902# -00-1#	Model: T160-932# -00-1#
SerNo: T0123	SerNo: T0123	SerNo: T0123

#	stands for the revisions index. This operating instruction applies for all revisions.
SerNo: T0123	stands for the serial number. The serial number is incremented with every part produced.

The name plate identifies the product.
For this reason:

- Check whether the name plate on the device matches the name plate illustrated above.
- This documentation must not be used for commissioning and startup if the name plates do not match.
- Devices without name plate are not covered by the manufacturer's warranty and must not be put into operation.



5.2 Functional description

The power supply unit has two functions:

1. **Power supply for the servocontroller**
   The power supply unit generates the voltages required by the servocontroller:
   - DC bus voltage (nominal value 325 VDC)

   The servocontroller takes its energy from a DC bus buffered by capacitors. This DC voltage is generated by the power supply unit by rectifying the AC voltage (nominal value 230 VAC).
   - +5 V

   The servocontroller includes a microcomputer requiring a +5 V supply.
   - ±15 V

   The servocontroller also includes analog circuits requiring a power supply of ±15 V.
2. **Ballast circuit**
   The power supply unit regulates the DC bus voltage. The DC bus capacitors are charged when the servomotors feed back energy into the power supply unit in generator mode, thus increasing the DC bus voltage. By means of the ballast circuit, the capacitors are partially discharged via the ballast resistor until the nominal DC bus voltage is adjusted again.

Different types of power supply units

The power supply units can primarily be classified in two groups:

1. **Power supplies *with* external 24 VDC supply**
   For these power supply units 24 VDC must be supplied externally. The +5 V and ±15 V supplies are generated from these 24 VDC. This ensures that the microcomputer, the position feedback evaluation and an optional CAN bus remain fully functional if the power must be disconnected for operational reasons, e.g. following an Emergency SWITCH OFF.
2. **Power supplies *without* external 24 VDC supply**
   An external 24 VDC supply is not required for these power supply units. The microcomputer, the position feedback evaluation and an optional CAN bus stop their operation when the power is disconnected. If necessary, homing cycle must be performed after switching the power on again.

The power supply units also differ with regard to the power dissipation of their ballast circuits.

Warning:

Correct dimensioning of the ballast circuit is particularly important in conjunction with the following applications:

- **Lifting axis**
  If the lifting axis does not have a self-locking gear, the servomotor must brake when the load is lowered. The servomotor operates in generator mode in this case. The energy fed back must be converted into heat via the ballast circuit. It is therefore important to ensure that the ballast circuit is dimensioned correctly and can dissipate the energy.
- **Rapid deceleration of large masses**
  Considerable amounts of energy must be dissipated by the ballast circuit as well when large masses are rapidly decelerated from high speeds. It should be noted that the shorter the braking time, the higher becomes the required peak braking power (energy per time unit). The ballast circuit must be dimensioned to dissipate not only the required continuous power, but also the peak power.

5.3 Technical data

5.3.1 Power connection

The power supply unit can be operated either with a one-phase or three-phase AC voltage:

	Minimum	Nominal	Maximum
Supply voltage	207 VAC	230 VAC	254 VAC
Mains frequency	44 Hz	50 Hz	66 Hz
Fuse		16 A slow-blow *)	

*) For 3-phase operation, a 3-phase automatic circuit-breaker must be used in order to ensure that all phases are tripped at the same time in the event of a fault!

Important: Isolating transformer required

The isolating transformer is required in order to maintain the specified isolation (creepage distances and clearances) in relation to unprotected small-signal auxiliary voltages. The isolating transformer must conform to standard EN 60204-1. The protective earth conductor must be connected.

If **other precautions** are taken,
- the power supply unit can be connected directly to the mains supply for one-phase operation,
- an autotransformer can be used to adjust the voltage for three-phase operation.

One-phase operation:

In one-phase operation, the voltage between live and neutral is 230 VAC. An isolating transformer with 1:1 transformation ratio must be used. The secondary terminals of the isolating transformer are connected to terminal X3-pin 2 and X3-pin 3. The protective earth conductor must also be connected.

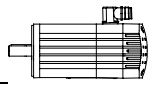
Three-phase operation:

The nominal voltage between the power supply unit terminals must be equal to 230 VAC. The phase-to-phase voltage of a normal 3x400 VAC 3-phase mains supply must be stepped down to 3x230 VAC by means of an isolating transformer connected to terminal X3. The protective earth conductor must be connected.

Note:

Leakage currents flow on the PE conductor if no isolating transformer is used.
The leakage current may exceed 3.5 mA under corresponding operating conditions. It is therefore recommended to connect an additional PE conductor of at least 10 mm^2 to the rack (see VDE 0160).

The leakage currents are drastically reduced when using an isolating transformer.



5.3.2 24 VDC input (optional)

The type of power supply unit used determines whether a 24 VDC power supply is required or not.

Power supply T160 - 901 # - 00 - 1# 24 VDC not required

Power supply T160 - 902 # - 00 - 1# 24 VDC required
Power supply T160 - 932 # - 00 - 1# 24 VDC required

	Minimum	Nominal	Maximum
24 VDC input	20 VDC	24 VDC	35 VDC
Power consumption		20 W plus 25 W per servocontroller	
Recommended fuse		10 Amps, slow-blow	

A 3-phase rectifier is sufficient. It is not necessary to smooth the voltage.
The 24 VDC power supply unit should be capable of delivering a short overload switch-on current.

Important: A 24 V power supply with reliable insulation must be used!

The power supply providing the 24 VDC for the MOOG power supply unit must have a reliable insulation to the mains voltage and must conform to standard EN 60950.

5.3.3 Power output

The power supply unit supplies the servocontroller with power in the form of a DC voltage buffered by capacitors.

	Minimum	Nominal	Maximum
DC bus voltage (no-load operation)	292 VDC	325 VDC	359 VDC

Power:	Continuous power	Short-time for 3 sec	Short-time for 1 sec
3-phase operation with fan	7.5 kW	10.0 kW	15.0 kW
1-phase operation with fan	2.5 kW	3.7 kW	5.0 kW
3-phase operation without fan	2.5 kW	5.0 kW	8.0 kW
1-phase operation without fan	0.8 kW	1.2 kW	1.6 kW

Warning:
A fan is required if more than four servocontrollers are installed.
Then the fans must be switched on as soon as voltage is applied the power supply. If the power supply requires an external 24 VDC supply, the fan must be switched on as soon as the 24 VDC supply is connected.

5.3.4 Power of the ballast circuit

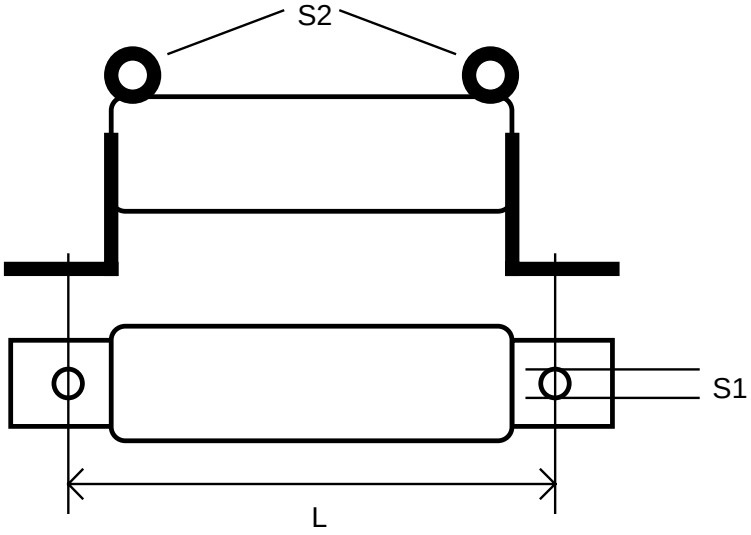
Power supply unit	External ballast resistor	Continuous ballast power	Peak ballast power
T160-901# -00-1# or T160-902# -00-1#	None	40 W	2,800 W for 100 ms
	50 Ohm, 225 Watt	200 W	2,800 W for 300 ms
	10 Ohm, 350 Watt	235 W	16,900 W for 100 ms
T160-932# -00-1#	10 Ohm	900 W	14, 000 W for 160 ms

Maximum permissible DC bus voltage:	400 VDC
Nominal DC bus voltage:	325 VDC
Capacitance in the DC bus:	2,800 µF
Switch on voltage for ballast resistor:	380 VDC ± 5 %
Switch off (again) voltage for ballast resistor:	373 VDC ± 5 %

5.3.5 Dimensions and weights

Model:	T160-901# -00-1# T160-902# -00-1#	T160-932# -00-1#
Weight:	1.9 kg	1.9 kg
Installation size (W x D x H in mm):	60.96 x 226.90 x 262.90	60.96 x 226.90 x 262.90

Ballast resistor



Dimensions:

Ballast resistor 10 Ohm / **350 W**

L (Hole spacing): 283 mm
S1 (Screw hole): 8 mm
S2 (Screw hole): for M4

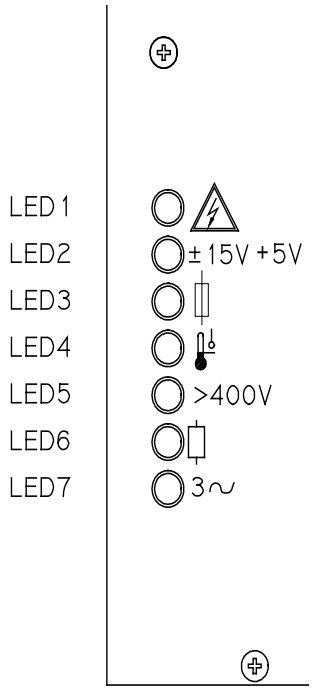
Ballast resistor 10 Ohm / **1000 W**

L (Hole spacing): 421 mm
S1 (Screw hole): 9 mm
S2 (Screw hole): 9.2 mm

Fig. 5.2: Ballast resistor

5.4 Diagnosis

5.4.1 LEDs



LED 1 **DC bus voltage ready (green)**
This LED lights up as soon as the power (230 VAC) is present.
This LED must light during operation.
The LED slowly goes out when the power is switched off.

LED 2 **±15 VDC, +5 VDC ready (green)**
This LED lights up as soon as the ±15 VDCand +5 VDC are present within their tolerances. This LED must light during operation.

LED 3 **Braking resistor fuse defective (red)**
The fuse for the ballast resistor is defective and must be replaced.

LED 4 **Power supply overtemperature (red)**
The power supply unit has overheated. It is being overloaded by the application, or a fault has occurred which has imposed an additional load on the power supply unit.

LED 5 **DC bus voltage >400 VDC (red)**
During braking the load, the motors have fed back too much power in generator mode. The ballast resistor of the power supply unit has been overloaded.

LED 6 **Ballast resistor active (yellow)**
This LED may light up shortly when the servomotors feed back power in generator mode. The ballast resistor is connected as long as the LED remains alight.
The LED lights up when the high voltage is disconnected thus indicating that the DC bus circuit is being discharged via the ballast resistor.

LED 7 **Loss of phase (red)**
One of the phases has failed in 3-phase operation. This fault is also indicated if the power supply unit is configured for 3-phase operation but operated from only one phase.

LED 3, 4, 5, 7:	When a fault occurs the relay "Power supply unit OK" (X5/Pin 5/6) opens. The only fault latched is bus overvoltage (LED 5). This has to be reset.
LED 3, 4, 5:	When a fault occurs, a fault signal is generated in all servocontrollers. The servocontrollers cannot be reenabled in as long as the fault is present.

5.4.1.1 Resetting the bus overvoltage fault message (LED 5)

Power supply 160-901	Switch off power supply unit. Wait 5 seconds and switch on again.
Power supply 160-902 and T160-932	Switch off the mains supply (230 VAC) of the power supply unit. The external 24 VDC supply does not have to be switched off. Wait 5 seconds and switch on again.

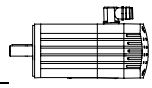
5.4.2 Relay "Power supply unit OK"

Relay status	Condition
Relay remains open	When power supply unit is switched off completely. When only 24 VDC are applied to the power supply unit. During softstart.
Relay contact closes	When there is no fault present AND the softstart sequence is finished.
Relay contact breaks	When the mains voltage is disconnected. When one phase fails in 3-phase operation. When the 24 VDC supply voltage fails. When the +5 V generated by the power supply unit fails (required for the relay). When an overvoltage occurs on the DC bus.

5.5 Scope of delivery

The scope of delivery must be checked to ensure that the correct power supply unit has been ordered and delivered.

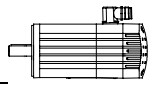
T160 - 901 # - 00 - 1# **and** **T160 - 902 # - 00 - 1#**	**The scope of delivery includes the following parts for these power supply units:**
	- The power supply unit as such - One 1.6 A fuse installed in the power supply - One 2.5 A fuse - One 8 A fuse - One instruction leaflet
T160 - 932 # - 00 - 1#	**The scope of delivery includes the following parts for this power supply unit**
	- The power supply unit as such - One 10 A fuse installed in the power supply The ballast resistor required for operation is **not** included in the scope of supply and must be ordered separately.



5.6 Order data

No.	Description	MOOG Order No.
1	**Power supply unit, no external 24 V supply** **Ballast circuit 40 W/2800 W**	T160 - 901 # - 00 - 1#
2	**Power supply unit with external 24 V supply** **Ballast circuit 40 W/2800 W**	T160 - 902 # - 00 - 1#
3	Ballast resistor 10 Ohm/350 W	A76178-002
4	Spare fuse F1, Siba 1.6 A/415 V/slow-blow	B94138-001-600
5	Spare fuse F1, Siba 2.5 A/415 V/slow-blow	B94138-002-500
6	Spare fuse F1, Siba 8 A/415 V/slow-blow	B94138-008-000
7	Ballast resistor 50 Ohm/200 W as replacement part in existing systems	A76178-001
8	**Power supply unit, with external 24 V supply** **Ballast circuit 900 W/14000 W** (Order ballast resistor together with power supply unit!)	T160 - 932 # - 00 - 1#
9	Ballast resistor 10 Ohm/1000 W	A76178-003
10	Spare fuse F1, Siba 10 A/415 V/slow-blow	B94138-010-000
	EMC accessories	
11	**Ferrite cores**	**External supplier:** Neosid Pemetzrieder KG Postfach 1344 58553 Halver 1 Germany Tel.: +49-2353-710 Fax: +49-2353-7154
12	**Mains filters from Schaffner** 3-phase: FN251-***XX***-07 FN351-***XX***-29 1-phase: FN250-***XX***-07 FN350-***XX***-29 The rated current must be specified in place of ***XX***, e.g. 16 for 16 A	Schaffner Elektronik GmbH Schoemperlenstrasse 12B 76185 Karlsruhe Tel.: +0049-721-569-10 Fax: +0049-721-569-110 Schaffner Elektronik AG CH-4708 Luterbach Switzerland Tel.: +0041-65-802-626 Fax: +0041-65-802-641
13	**Mains filters from Siemens** 3-phase: B84143-A***XX***-R 1-phase: B84142-B***XX***-R The rated current must be specified in place of ***XX***, e.g. 16 for 16 A	Siemens AG Richard Strauss Strasse 76 81679 München Tel.: +0049-89-9221-0 Fax: +0049-89-9221-4390

6 Rack and Backplane



6.1 Rack

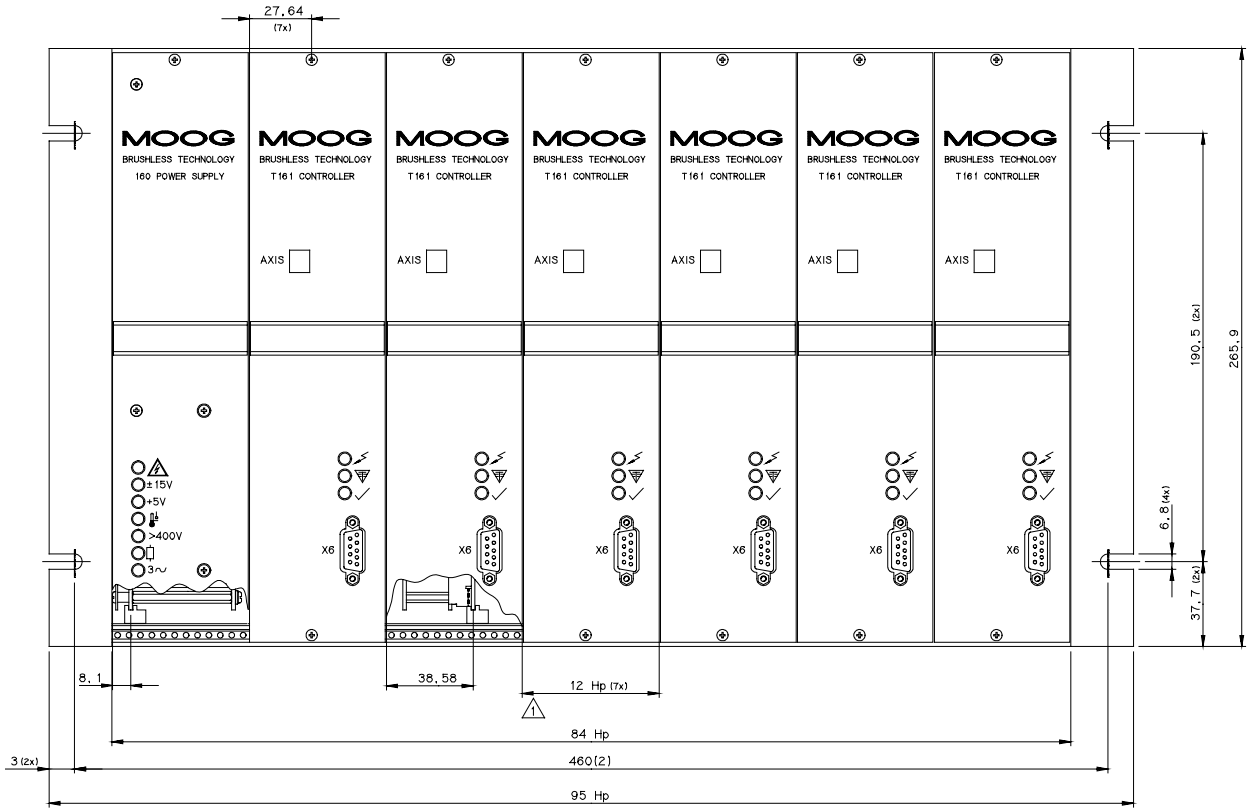


Fig. 6.1: Rack dimensions (1 HP = 5.08 mm)

6.1.1 Filler panels

Width 12 HP: For covering unused slots in the rack.

Width 6 HP: For covering the gap (1/2 slot) when using a T161-904 servocontroller in the rack.

6.1.2 Fans

Warning:
A fan is required if more than four servocontrollers are installed.
Then the fans must be switched on as soon as voltage is applied the power supply. If the power supply requires an external 24 VDC supply, the fan must be switched on as soon as the 24 VDC supply is connected.

Fan unit for the entire 19" rack
MOOG recommends the use of a commercially available 19" fan unit (reference list available on request).

Single fan unit
The single fan unit (see Fig 6.2) is supplied with guide rails and can be installed directly into the rack from below. It is suitable for cooling two servocontrollers of T161-9x1 to T161-9x3 or for one power supply unit T160-9xx and one servocontroller (fan capacity 70 m^3/h).

Note:
The single fan unit can only be installed in a Schroff rack.

Supply voltage: 1 x 230 VAC

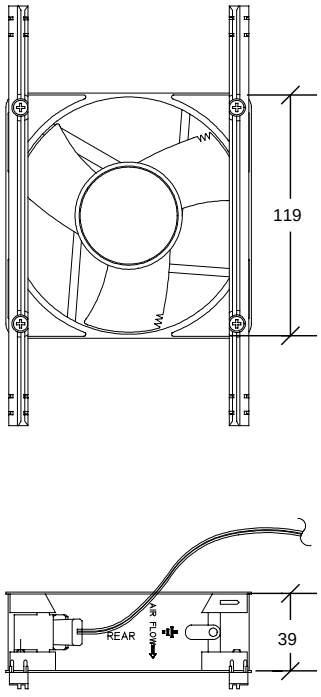


Fig. 6.2: Single fan unit

6.2 Backplanes

6.2.1 Dimensions

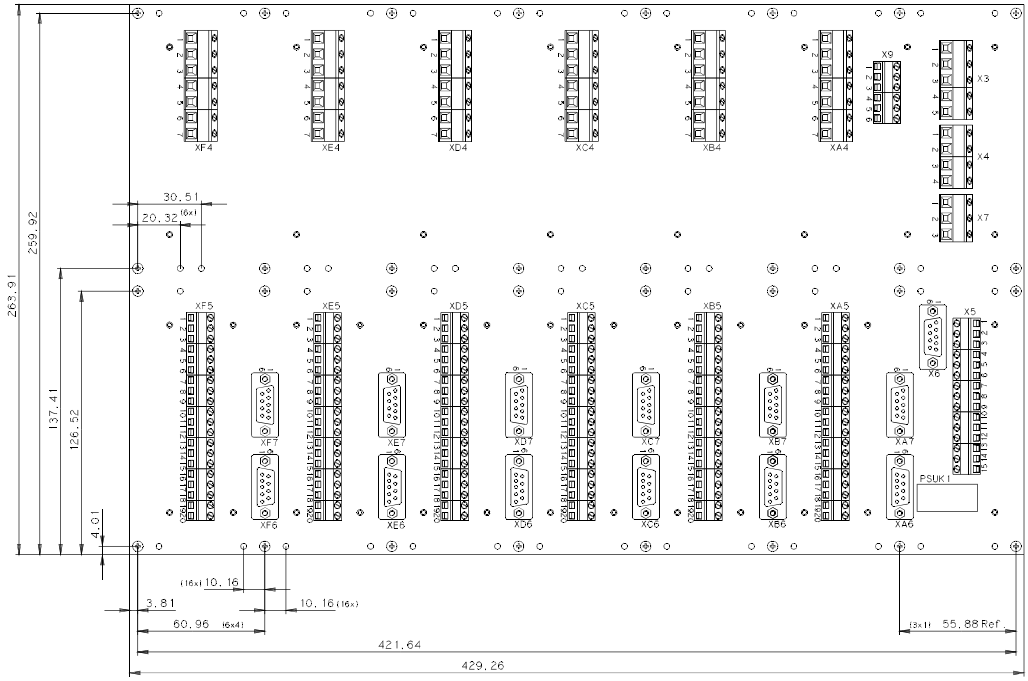


Fig. 6.3: Illustration of a standard backplane

6-axis backplane

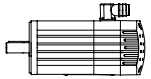
The 6-axis backplane can accommodate a power supply unit and up to six servocontrollers of type T161-9x1 to T161-9x3. It can also be delivered complete with rack. A servocontroller of type T161-9x4 occupies 1.5 slots.
Dimensions (W x H in mm): 429.26 x 263.91

4-axis backplane

The 4-axis backplane can accommodate a power supply unit and up to four servocontrollers of type T161-9x1 to T161-9x3. A servocontroller of type T161-9x4 occupies 1.5 slots.
Dimensions (W x H in mm): 304.8 x 265.9

2-axis backplane

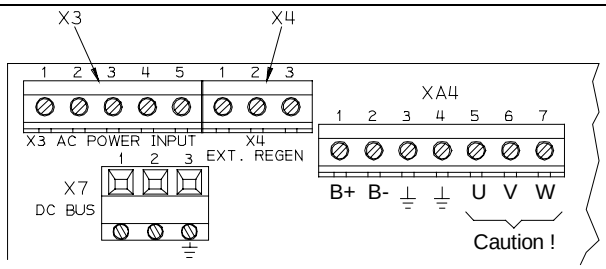
The 2-axis backplane can accommodate a power supply unit and one or two servocontrollers of type T161-9x1 to T161-9x3. A servocontroller of type T161-9x4 occupies 1.5 slots.
Dimensions (W x H in mm): 182.88 x 265.9



6.2.2 Backplane overview

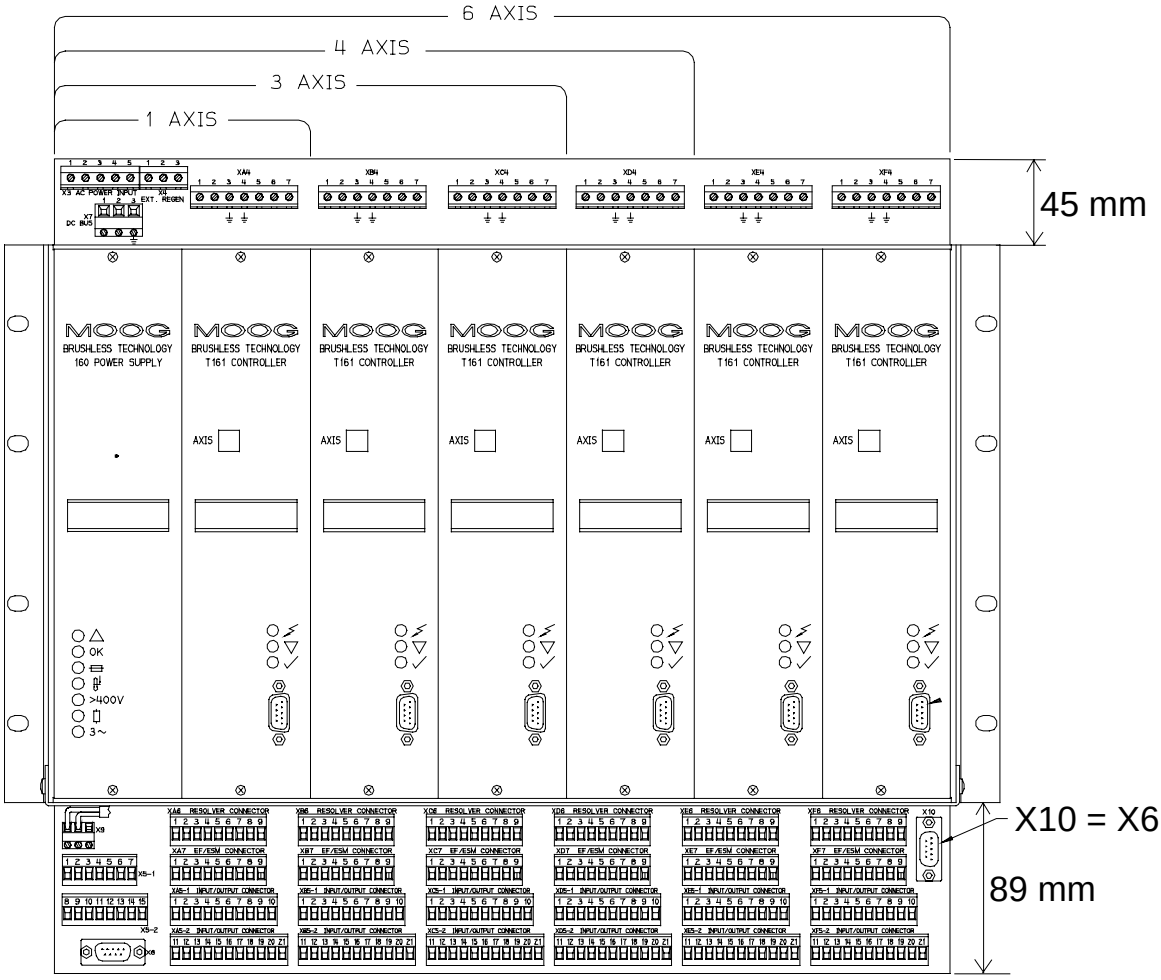
Function	B48332 - 001 (6 axes) B48333 - 001 (4 axes) B48334 - 001 (2 axes)	B94101-006 (6 axes) B94101-004 (4 axes) B94101-003 (3 axes) B94101-002 (2 axes)	BP with front connectors B80168 - 001 (6 axes) B80167 - 001 (4 axes) B80166 - 001 (3 axes) B80165 - 001 (1 axis)	B48332 - 701 (6 axes) B48333 - 701 (4 axes) B48334 - 701 (2 axes) B48336 - 701 (3 axes)	B48332 - 801 (6 axes) B48333 - 801 (4 axes) B48334 - 801 (2 axes) B48336 - 801 (3 axes)
Backplane is recommended for	replacement in existing systems	±10 V speed-/torque-controlled drive systems	±10 V speed-/torque-controlled drive systems	CAN Profile Mode drive systems	CAN Interpolation Mode drive systems
Backplane is recommended for the following, subject to reservations	both CAN drive systems, if brake control is not required	both CAN drive systems, if brake control is not required	both CAN drive systems, if brake control is not required	CAN Interpolation Mode drive systems if external signals are required	CAN Profile Mode drive systems if external signals are not necessary
Suitable for ±10 V reference	yes	yes	yes	yes	no
Suitable for Encoder Simulation board ESM II	no	yes	yes	no	no
Suitable for Encoder Simulation board ESM III	no	yes	yes	no	no
Suitable for CAN	yes from revision F	yes from revision B	yes	yes	yes
Relay for brake control	no	no	no	yes	yes
All signal connectors for servocontroller stuffed	yes	yes	yes	yes	no, no connectors stuffed
"System Ready" relay stuffed	no	no	no	yes	yes
"Servocontroller Ready" relay can be used	yes	yes	yes	no, only "System Ready" relay can be accessed (AND logic)	no, only "System Ready" relay can be accessed (AND logic)
Connectors	Screw terminals	Screw terminals	Plug connectors	Screw terminals	Screw terminals

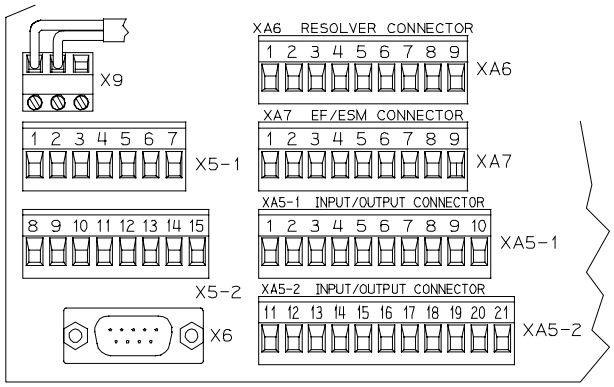
6.3 Backplane with front connectors



Important

The pin assignment of the motor phases U, V, W is different from that of other backplanes!

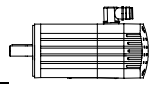




Note

The pin assignment of the resolver terminal and of the encoder interface correspond with the pin assignment of the relevant sub-D connector on the other backplane types.

Fig. 6.4: Backplane with front connectors, pin assignment



6.4 Backplane Connections

6.4.1 T160-9xx Power Supply Connections

6.4.1.1 Power Supply Connector X3

Type:		Phoenix GSMKDS3 (angled screw terminal))	
Wire cross-sectional area:		max. 3 mm^2	
Pin assignment:			
Pin 1:	PE	Protective Earth	Input/Output Reference
Pin 2:	L1	Mains Input, Phase 1, 230 V_{rms} AC 50/60 Hz	Input, Ref: PE (X3/1)
Pin 3:	L2	Mains Input, Phase 2, 230 V_{rms} AC 50/60 Hz	Input, Ref: PE (X3/1)
Pin 4:	L3	Mains Input, Phase 3, 230 V_{rms} AC 50/60 Hz	Input, Ref:PE (X3/1)
Pin 5:	PE	Protective Earth	Input/Output Reference

6.4.1.2 External Bleed Resistor Connector X4

Type:		Phoenix GSMKDS3 (angled screw terminal)	
Wire cross-sectional area:		max. 3 mm^2	
Pin assignment:			
Pin 1:	ReGen1	External Bleed Resistor 1	Output, Ref:ReGen2
Pin 2:	ReGen2	External Bleed Resistor 2	Output
Pin 3:	PE	Protective Earth	Input/Output Reference
Pin 4:	NC	Not Connected	

6.4.1.3 Low Voltage Power and Status Connector X5

Type:		Phoenix GSMKDS1,5 (angled screw terminal)	
Wire cross-sectional area:		max. 1,5 mm^2	
Pin assignment:			
Pin 1:	24 V B+	24 V Brake Supply Plus	Input, Ref:24 V B- (X5/2)
Pin 2:	24 V B-	24 V Brake Supply Ground	Input Reference
Pin 3:	24 V E+	24 V External Supply Plus (Optional)	Input, Ref: 24 V E- (X5/4)
Pin 4:	24 V E-	24 V External Supply Ground (Optional)	Input Reference
Pin 5:	PSRly1	Power Supply OK Relay, Pin 1	Output, Ref: PSRly2 (X5/6)
Pin 6:	PSRly2	Power Supply OK Relay, Pin 2	Output Reference
Pin 7:	PE	Protective Earth	Input/Output Reference
Pin 8:	+5 V	+5 V Power Supply Output	Output, Ref: DGND (X5/12)
Pin 9:	+15 V	+15 V Power Supply Output	Output, Ref: AGND (X5/11)
Pin 10:	-15 V	-15 V Power Supply Output	Output, Ref: AGND (X5/11)
Pin 11:	AGND	Analog Ground	Input/Output Reference
Pin 12:	DGND	Digital Ground	Input/Output Reference
Pin 13:	SRRly1	System Ready Relay, Pin 1 (Optional)	Output, Ref: SRRly2 (X5/14)
Pin 14:	SRRly2	System Ready Relay, Pin 2 (Optional)	Output Reference
Pin 15:	Dig. Input	Digital input for servocontroller (function depends on servocontroller and backplane type)	Input, Ref: ExtIO_GND of servocontroller (Xµ5/14)

6.4.1.4 DC Bus Connector X7

Type:		Phoenix GSMKDS3 (angled screw terminal)	
Wire cross-sectional area:		max. 3 mm^2	
Pin assignment:			
Pin 1:	DC+	High Power DC Bus Plus	Output, Ref:DC- (X7/2)
Pin 2:	DC-	High Power DC Bus Minus	Output Reference
Pin 3:	PE	Protective Earth	Input/Output Reference

6.4.2 T161-90x Servocontroller Connections

Servocontroller µ (µ = A ... F)

6.4.2.1 Power Connector Xµ4

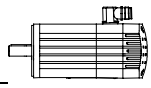
Type:		Phoenix GSMKDS3 (angled screw terminal)	
Wire cross-sectional area:		max. 3 mm^2	
Pinbelegung:			
Pin 1:	Brake+	Motor Brake Connection, Plus (Optional)	Input, Ref: Brake- (Xµ4/2)
Pin 2:	Brake-	Motor Brake Connection, Minus (Optional)	Input Reference
Pin 3:	PE	Protective Earth	Input/Output Reference
Pin 4:	PE	Protective Earth	Input/Output Reference
Pin 5:	Motor_W ***)**	Motor phase W	Output, Ref: PE (Xµ4/4)
Pin 6:	Motor_V ***)**	Motor phase V	Output, Ref: PE (Xµ4/4)
Pin 7:	Motor_U ***)**	Motor phase U	Output, Ref: PE (Xµ4/4)
***) for Backplane B80165-001, B80166-001, B80167-001, B80168-001 applies: Pin5 = Motor phase U, Pin 6 = Motor phase V, Pin 7 = Motor phase W.**			
Motor connector pinout:			
Motor:		Pin assignment (brake+: B+ and brake-: B-)	
G422		Pin 5: B+ Pin 6: B- Pin 1: W Pin 4: V Pin 2: U	
G423		Pin 5: B+ Pin 6: B- Pin 1: W Pin 4: V Pin 2: U	
G424		Pin 5: B+ Pin 6: B- Pin 1: W Pin 4: V Pin 2: U	
G425		Pin +: B+ Pin -: B- Pin W: W Pin V: V Pin U: U	

6.4.2.2 Resolver Connector Xµ6

Type:		9 pin Sub-D connector, female		Motor connector pin assignment
Pin 1:	S3	Resolver Feedback, SIN +	Input	Pin 2
Pin 2:	Thrm1	Motor Thermistor, Pin 1	Input, Ref: DGND (Xµ6/5)	Pin 5
Pin 3:	S2	Resolver Feedback, COS +	Input	Pin 3
Pin 4:	R1	Resolver Supply Plus	Output, Ref: R (Xµ/6)	Pin 7
Pin 5:	Thrm2	Motor Thermistor, Pin 2	Input	Pin 6
Pin 6:	S1	Resolver Feedback, SIN -	Input	Pin 1
Pin 7:	PE	Protective Earth	Input/Output Reference	
Pin 8:	S4	Resolver Feedback, COS -	Input	Pin 4
Pin 9:	R2	Resolver Supply Minus	Input	Pin 8

6.4.2.3 I/O Connector Xµ5

Type:		Phoenix GSMKDS1,5 (angled screw terminal)	
Wire cross-sectional area:		max. 1,5 mm^2	
Pin assignment:			
Pin 1:	SysRdy1	System Ready Relay, Pin 1	Output, Ref: SysRdy2 (Xµ5/2)
Pin 2:	SysRdy2	System Ready Relay, Pin 2	Output
Pin 3:	PrAnaOut	Programmable Analog Output (+/-10 V) Default: Actual Velocity Monitor	Output, Ref: AGND (Xµ5/5)
Pin 4:	IDC	Equivalent DC Motor Current Monitor (+/-10 V)	Output, Ref: AGND (Xµ5/5)
Pin 5:	AGND	Analog Ground	Input/Output Reference
Pin 6:	Dig. Input_1	Digital Input 1 (function: see section 4)	Input, Ref: ExtIO_GND (Xµ5/14)
Pin 7:	Dig. Input_2	Digital Input 2 (function: see section 4)	Input, Ref: ExtIO_GND (Xµ5/14)
Pin 8:	PE	Protective Earth	Input/Output Reference
Pin 9:	Dig. Input_3	Digital Input 1 (function: see section 4)	Input, Ref: ExtIO_GND (Xµ5/14)
Pin 10:	Enable	Axis Enable Input	Input, Ref: ExtIO_GND (Xµ5/14)
Pin 11:	PE	Protective Earth	Input/Output Reference
Pin 12:	Dig. Input_4	Digital Input 1 (function: see section 4)	Input, Ref: ExtIO_GND (Xµ5/14)
Pin 13:	ExtIO_V+	External I/O Supply Voltage Input	Input
Pin 14:	ExtIO_GND	External I/O Ground Input Reference für Xµ5 Pin 6, 7, 9, 10, 12	Input
Pin 15:	ThrmRly1	Thermal Limit Relay, Pin 1	Output, Ref: ThrmRly2 (Xµ5/16)
Pin 16:	ThrmRly2	Thermal Limit Relay, Pin 2	Output
Pin 17:	Analog Input_2+	Analog Input 2, Plus (function: see section 4)	Input, Ref: Analog Input_2- (Xµ5/18)
Pin 18	Analog Input_2-	Analog Input 2, Minus (function: see section 4)	Input
Pin 19:	Analog Input_1+	Analog Input 1, Plus (function: see section 4)	Input, Ref: Analog Input_1- (Xµ5/20)
Pin 20:	Analog Input_1-	Analog Input 1, Minus (function: see section 4)	Input



6.4.2.4 Encoder Simulation Connector Xµ7

Type:		9 pin Sub-D connector, male	
Pin assignment:			
Pin 1:	GNDExtES	External Ground Encoder Simulation	Input/Output Refernce
Pin 2:	/M	Negated Reference Pulse	Output, Ref: GNDExtES or GNDIntES (internal ground encoder simulation); for differential output: Ref: M (Xµ7/6)
Pin 3:	/B	Negated Channel B	Output, Ref: GNDExtES or GNDIntES (internal ground encoder simulation); for differential output: Ref: B (Xµ7/7)
Pin 4:	/A	Negated Channel A	Output, Ref: GNDExtES or GNDIntES (internal ground encoder simulation); for differential output: Ref: A (Xµ7/8)
Pin 5:	VExtES	External Encoder Simulation Supply Voltage	Input, Ref: GNDExtES (Xµ7/1)
Pin 6:	M	Reference Pulse	Output, Ref: GNDExtES or GNDIntES (internal ground encoder simulation); for differential output: Ref: /M (Xµ7/2)
Pin 7:	B	Channel B	Output, Ref: GNDExtES or GNDIntES (internal ground encoder simulation); for differential output: Ref: /B (Xµ7/3)
Pin 8:	A	Channel A	Output, Ref: GNDExtES or GNDIntES (internal ground encoder simulation); for differential output: Ref: /A (Xµ7/4)
Pin 9:	Shield	Shield (connected to Protective Earth)	

6.4.3 Commissioning interface connector X6

6.4.3.1 Interface connector X6/RS232

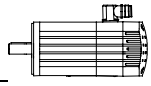
Type:		9 pin sub-D connector, female		
Location:		Front panel of the controller T161-90x		
Pin assignment:				
Pin 1:	N/C	Not Connected		
Pin 2:	RxD	Read Data Input		Input, Ref.: DGND (X6/5)
Pin 3:	TxD	Transfer Data Output		Output, Ref.: DGND (X6/5)
Pin 4:	N/C	Not Connected		
Pin 5:	DGND	Digital Ground		Input/Output Reference
Pin 6:	PE	Protective Earth		Input/Output Reference
Pin 7:	N/C	Not Connected		
Pin 8:	N/C	Not Connected		
Pin 9:	+5 V	+5 V Output Supply Voltage		Output, Ref.: DGND (X6/5)
Interface protocol:		Baudrate:	9600	
		Startbits:	1	
		Databits:	7	
		Paritybit:	ignored	
		Stopbits:	2	

6.4.3.2 Interface connector X6/RS485/CAN

Type:		9 pin sub-D connector, male	
Location:		Backplane	
Pin assignment:			
Pin 1:	CAN-BUS	Digital Serial Input/Output (Option)	
Pin 2:	CAN-BUS	Digital Serial Input/Output (Option)	
Pin 3:	RS485+	RS485 Bus Interface, Plus	Input/Output
Pin 4:	RS485-	RS485 Bus Interface, Minus	Input/Output
Pin 6:	PE	Protective Earth	Input/Output Reference
Pin 7:	N/C		Input/Output Reference
Pin 8:	N/C		
Pin 9:	N/C		

6.4.4 Fan Connector X9

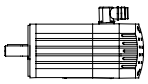
Type:		Phoenix SMKDS1,5 (angled screw terminal)	
Wire cross-sectional area:		max. 1,5 mm^2	
Pin assignment:			
Pin 1:	L1	Mains Phase 1, 230 V_{rms} AC 50/60 Hz	Output, Ref: L2 (X9/2)
Pin 2:	L2	Mains Phase 2, 230 V_{rms} AC 50/60 Hz	Output
Pin 3:	L1	Mains Phase 1, 230 V_{rms} AC 50/60 Hz	Output, Ref: L2 (X9/4)
Pin 4:	L2	Mains Phase 2, 230 V_{rms} AC 50/60 Hz	Output
Pin 5:	L1	Mains Phase 1, 230 V_{rms} AC 50/60 Hz	Output, Ref: L2 (X9/6)
Pin 6:	L2	Mains Phase 2, 230 V_{rms} AC 50/60 Hz	Output



6.5 Order data

No.	Description	MOOG Order No.
1	**Backplanes**	See "Backplane overview"
2	**Rack (basic version)**	B47359-001
3	**Filler panel 12 HP** (for unused slots)	B53473-001
4	**Filler panel 6 HP** (for T161-9x4)	B80016-001
5	**Single fan unit**	B53498-001
6	**Rack conforming to EMC requirements**, comprising: 20845-311, quantity: 1 Europac Lab HF Subrack Kit (84 HP x 6 U x 340 mm) 20845-175, quantity: 1 Shielded backplane (84 TE x 6 HE) 30845-253, quantity: 2 Perforated strip (84 TE) 30819-594, quantity: 4 Threaded strip (84 TE) 21100-275, quantity: 1 Stud bolt 30837-619, quantity: 2 Module rail, rear (84 TE) 30837-200, quantity: 1 Profiled rail (84 TE) 60817-061, quantity: 4 Insulating strip 21100-824, quantity: 1 Locating pins to secure the insulating strip	Schroff GmbH Langenalber Strasse 96-100 D-75334 Straubenhardt Germany Tel.: +0049-7082-794-0 Fax: +0049-7082-794-200 **Important:** This is a standard rack made by Schroff. There are no grommets in the rack upon delivery. They have to be inserted by the customer.

7 Servomotors



7.1 Nameplate

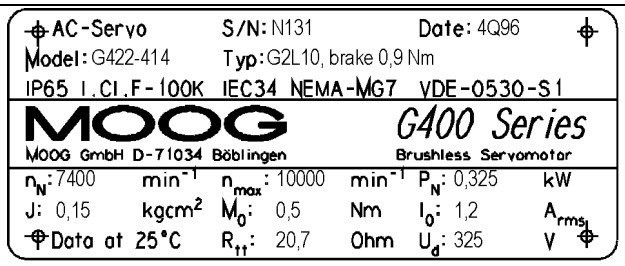


Fig. 7.1: nameplate with engraved data (values merely as example)

S/N:	serial number
Date:	production quarter and year
Model:	motor model number
Type:	electric model, description optional brake
n_N:	nominal speed (speed at P_N)
n_{max}:	maximum speed
P_N:	nominal power (maximum continuous power)
J:	moment of inertia
M_0:	continuous stall torque
I_0:	continuous stall current
R_{tt}:	terminal to terminal resistance
U_d:	bus voltage

Further motor data can be found in the catalogue.

The name plate identifies the product.
For this reason:

- Check whether the name plate on the motor matches the name plate illustrated above.
- This documentation must not be used for commissioning and startup if the name plates do not match.
- Devices without name plate are not covered by the manufacturer's warranty and must not be put into operation.

7.1.1 Motor type for series G400 servomotors

All motor specific data in this handbook is associated to flange size and length of the motors. Flange size and standard length are determined as follows.

Motor size: Determined by the 4th digit of the model number (e.g. Size G4x**2**-in the model number G42**2**-414) and 2nd digit of the model type (e.g. G**2**L10).

Standard length: Can be determined by means of the partnumber cross reference (see table 7.9) by the 6th digit of the model number (e.g. length G4xx-**4**xx in the model number G422-**4**14). The easier way is to look at the 4th and 5th digit of the model type on the nameplate (e.g. G2L**10**).

Model type: A model type designation (e.g. G2L10) is described by the following scheme: GxLyyz with x = motor size; yy = motor length; z = electric model (dropped for standard motors).

Brake: The minimum torque of an optional brake is added to the model type on the nameplate (for instance G2L10, **brake** 0,9 Nm).

7.2 Principal operation of a brushless servomotor

The mechanical design of the brushless (bl.) servomotor is similar to a synchronous machine, while its principle of operation corresponds with that of a conventional DC motor with brushes where rotor and stator are exchanged.
In a conventional DC motor, the rotor rotates in a stationary magnetic field whereas in the bl. servomotor this field is rotating with the rotor. This exciting field can be obtained by an ordinary winding as well as by a permanent magnet. **For MOOG-Motors this is always a high-energy permanent magnet.**

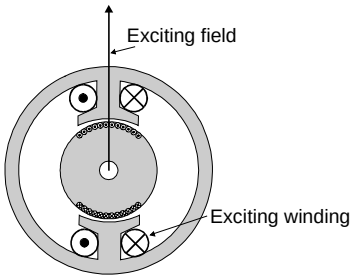


Fig. 7.2: Principle of DC motor

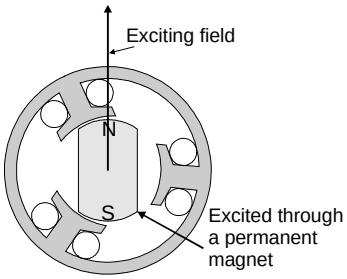


Fig. 7.3: Principle of servomotor

To obtain torque, the motor must have another winding. The current in this winding causes another magnetic field which has to be **rectangular to the exciter field** for maximum torque. When the rotor is turning, in this second winding a voltage is induced (EMF). Those windings are called armature windings in literature. With the DC-motor this winding is in the rotor, whereas in the brushless servomotor it is in the stator.

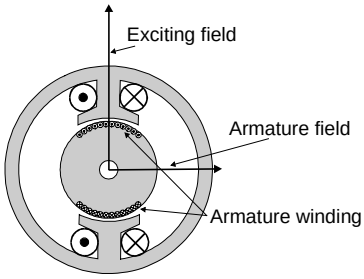


Fig. 7.4: DC motor with magnetic fields

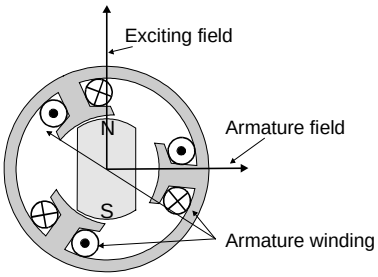


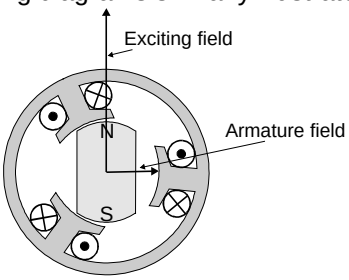
Fig. 7.5: Servomotor with magnetic fields

The decisive disadvantages inherent in the underlying principle of a **DC motor** are:

- Limited static torque
- High degree of wear and mechanical friction
- Large size
- Limited resistance to overloading
- Poor transfer of dissipated heat from the rotor outwards.

In a brushless servomotor, the basic principles of the stator and rotor are exactly the other way round. The magnetic field of the rotor is the exciting field and rotates in accordance with the rotor speed. The rotor position is transmitted to the controller via a resolver and the stator winding is then connected in such a way as to yield a magnetic field which is always offset 90° in relation to the rotor field. In this case, the winding is switched by the power electronics instead of being switched mechanically by the commutator, as in a conventional DC machine. Unlike the mechanical commutator, the power electronics is maintenance-free and wear-free.
Load fluctuations are controlled via the current intensity as in a conventional DC motor. The torque is once again proportional to the current, thus yielding equally good control capabilities.

The following diagrams similarly illustrate two load cases:



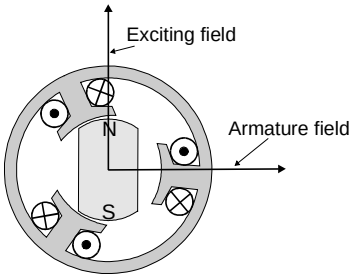
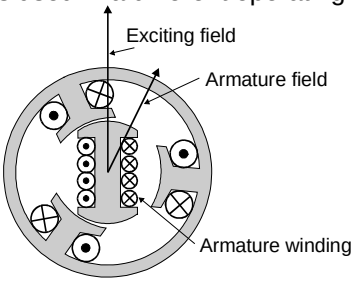


Fig. 7.6: Bl. servomotor, low load **Fig. 7.7: Bl. servomotor, high load**

The synchronous motor (SM), with a mechanical design similar to the servomotor but rarely with permanent magnets, is used in a different operating mode.



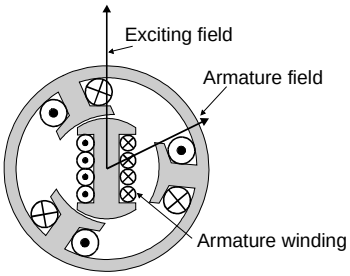


Fig. 7.8: Synchronous motor, low load **Fig. 7.9: Synchronous motor, high load**

Load fluctuations cause different angles between the two magnetic fields, whereas the armature field stays constant.

The decisive disadvantages inherent in the underlying principle of a **synchronous motor** are:

- Bad controllability
- Low efficiency due to reactance currents

The disadvantages listed above for conventional DC motors and synchronous motors do not apply for the brushless motor.
The **MOOG motor** is consequently characterized by the following points:

- High torque yield with small motor size
- High overload capacity
- Full torque over the entire speed range
- Highly dynamic due to the slight inertia
- Good controllability
- High efficiency
- Little friction
- Maintenance-free operation
- Robust design

7.3 Technical data

7.3.1 Standards for MOOG Motors

The brushless MOOG servomotors of series G400 have been designed, assembled and tested in conformity with the following standards.

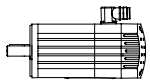
Standard	**International**	**Europe**	**Deutschland**	**USA**
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechnische **N**ormung	**DIN** / **VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA** / **NEC** **N**ational **E**lectric **C**ode MG.-...
Certified company	ISO 9001	EN ISO 9001	DIN ISO 9001	ISO 9001
Quality systems - model for quality assurance in design / development, production, installation and servicing	ISO 9001	EN ISO 9001	DIN ISO 9001	ISO 9001
Machine guidelines (CE Machine safety directive)	89/392/EWG, 91/368/EWG, 93/44/EWG	89/392/EWG, 91/368/EWG, 93/44/EWG	89/392/EWG, 91/368/EWG, 93/44/EWG	
EMC guidelines (CE-EMC directive)	89/336/EWG, 93/68/EWG, 93/44/EWG	89/336/EWG, 93/68/EWG, 93/44/EWG	89/336/EWG, 93/68/EWG, 93/44/EWG	
Low voltage guidelines (CE-Low voltage directive)	73/23/EWG, 93/68/EWG, 93/44/EWG	73/23/EWG, 93/68/EWG, 93/44/EWG	73/23/EWG, 93/68/EWG, 93/44/EWG	
Standard for safety of electric motors				UL 1004 (1994)
Safety of machinery, electrical equipment of machines, part 1: general requirements	IEC 204-1	EN 60204-1	DIN EN 60204-1 VDE 0113-1	

Table 7.1

Relevant standards for electrical equipment

Standard	**International**	**Europe**	**Deutschland**	**USA**
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechnische **N**ormung	**DIN** / **VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA** / **NEC** **N**ational **E**lectric **C**ode MG.-...
Rotating electrical machines, Rating and performance	IEC 34-1 IEC 2/915/CDV: 1995	EN 60034-1	DIN EN 60034-1 VDE 0530-1	MG 1-1.65
Rotating electrical machines, Methods for determing losses and efficiency and performance	IEC 2G/73/FDIS	EN 60034-2	DIN EN 60034-2 VDE 0530-2	
Rotating electrical machines, Classification of degrees of protection provided by enclosure	IEC 34-5	EN 60034-5	DIN EN 60034-5 VDE 0530-5	MG 1-1.25 MG 1-1.26
Rotating electrical machines, Methods of cooling (IC-Code)	IEC 34-6	EN 60034-6	DIN EN 60034-6 VDE 0530-6	MG 1-1.25 MG 1-1.26
Rotating electrical machines, Classification of types of construction and mounting arrangements (IM Code)	IEC 34-7	EN 60034-7	DIN EN 60034-7 VDE 0530-7	MG 1-4.03
Rotating electrical machines, Terminal markings and directions of rotation	IEC 34-8	EN 60034-8	DIN EN 60034-8 VDE 0530-8	MG 1-2.61
Rotating electrical machines, Noise limits	IEC 34-9	EN 60034-9	DIN EN 60034-9 VDE 0530-9	N/A.
Insulation coordination for equipment with low-voltage systems. Part 1: Principles, requirements and tests	IEC 664-1		VDE 0110-1	
Insulation coordinates for equipment with low-voltage systems. Part 2: Partial discharge tests, application guide	IEC 664-2		VDE 0110-2	
Connectors and plug-and-socket-devices, for rated voltages up to 1000 V AC, up to 1200 V DC and rated currents up to 500 A for each pole			DIN VDE 0627	

Table 7.2



Relevant standards for mechanical design

Standard	**International**	**Europe**	**Deutschland**	**USA**
English	**IEC** **I**nternational **E**lectrotechnical **C**ommission	**EN CENELEC** Europäisches Komitee für **E**lektrotechnische **N**ormung	**DIN** / **VDE** **D**eutsche **I**ndustrie **N**orm / **V**erband **D**eutscher **E**lektrotechniker	**NEMA** / **NEC** **N**ational **E**lectric **C**ode MG.-...
Degrees of protection provided by enclosure (IP code)	IEC 529	EN 60529	DIN EN 60529 VDE 0470-1	
Cylindrical shaft ends for electrical machines	IEC 72 ISO/R 775-1969		DIN 748-1 & 3	MG-11...
Mounting flanges for rotating electrical machinery			DIN 42948	
Dimensions, tolerances and mounting				NEMA MG-7
Tolerances of shaft extension run-out and of mounting flanges for rotating electrical machinery	IEC 72		DIN 42955	
Mechanical vibration, balance quality requirements of rigid rotors, determination of permissible residual unbalance	ISO 1940-1		DIN ISO 1940-1	
Mechanical vibration, balance quality requirements of rigid rotors, Balance errors	ISO 1940-2		DIN ISO 1940-2	
Ball bearings, conrad type, for electrical machines, tolerances and radial clearance			DIN 42966	
Drive type fastenings without taper action, parallel keys, keyways, deep pattern			DIN 6885-1	
ISO general purpose metric screw threads. Part 1 coarse pitch threads in diameter range 1 mm to 68 mm, nominal sizes	ISO 724		DIN 13-1	
General tolerances, tolerances for linear and angular dimensions without individual tolerance indications	ISO 2768-1	EN 22768	DIN ISO 2768-1	

Table 7.3

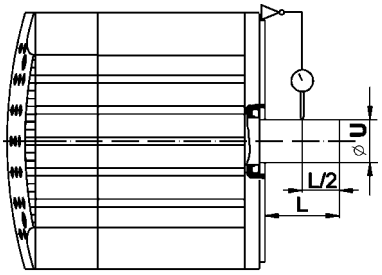
7.3.2 Tolerances of the shaft and flange

7.3.2.1 Runout

Note: All brushless MOOG servomotors of series G400 have been developed in conformity with DIN 42955 / IEC72, runout class R.

Diameter of the shaft extension øU [mm]	maximum runout tolerance class R [mm]
to 10	0.015
over 10 to 18	0.018
over 18 to 30	0.021
over 30 to 50	0.025
L = AH (see table 7.7)	

Table 7.4



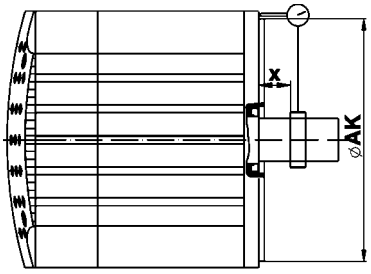
Rundlauf / runout

7.3.2.2 Concentricity and perpendicularity

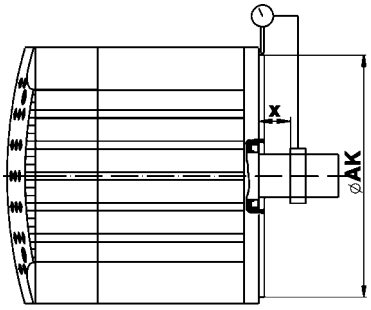
Note: Regarding concentricity and perpendicularity, all brushless MOOG servomotors of series G400 have been developed in conformity with DIN 42955 / IEC72, class R.

Pilot diameter of mounting flange øAK [mm]	maximum concentricity and perpendicularity tolerances class R [mm]
to 22	0.025
over 22 to < 40	0.03
40 to 100	0.04
over 100 to 230	0.05
over 230 to 450	0.063
x = 10 ± 1 mm	

Table 7.5



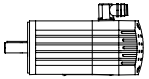
Planlauf / perpendicularity



Koaxialität / concentricity

7.3.3 Operating and ambient conditions

Temperature for transport and storage:	-25 °C to 90 °C
Operating temperature:	-25 °C to 155 °C (higher temperature rating on demand)
Degree of protection:	IP67 (DIN VDE 0470-1, EN 60529, IEC 529) (at shaft extension optional shaft seal is needed)
Installed position:	Any (good heat dissipation permits higher continuous power)
Ambient temperature in operation:	-25 °C to 55 °C (motor continuous power is automatically limited by controller at temperatures over 55 °C)
Runout:	Class R (DIN 42955-R, IEC72)



7.3.4 Performance data

Motor type		Stall data				Nominal data				Miscellaneous data						
		Continuous stall torque ①	Continuous stall current ①	Peak stall torque	Peak stall current	Rated torque ②	Rated current ②	Rated power ②	Rated speed ②	theoret. no load speed ③	maximum permissible speed ④	Torque constant ⑤	Terminal to terminal resistance ⑥	Terminal to terminal inductance ⑥	Moment of inertia without brake	Mass without brake
Model	Type	Mo [Nm]	Io [Arms]	Mmax [Nm]	Imax [Arms]	Mn [Nm]	In [Arms]	Pn [W]	Nn [rpm]	Ntheo [rpm]	Nmax [rpm]	kt [Nm/Arms]	Rtt [Ohm]	Ltt [mH]	J [kgcm²]	m [kg]
G422-2xx	G2L05	0.25	0.65	0.5	1.9	0.18	0.5	150	8100	10200	11500	0.37	50.90	29.7	0.09	1.0
G422-4xx	G2L10	0.5	1.2	1.4	3.7	0.42	1.0	325	7400	9000	10000	0.42	20.70	15.7	0.13	1.2
G422-6xx	G2L20	0.95	2.15	2.6	6.4	0.74	1.6	530	6800	7900	9000	0.46	9.90	9.1	0.22	1.5
G422-8xx	G2L40	1.7	2.85	5	8.3	1.26	2.1	820	6200	6300	7000	0.60	6.30	7.2	0.41	2.3
G423-2xx	G3L05	0.6	1.6	1.5	4.6	0.49	1.2	450	8800	9600	10500	0.40	15.20	18.8	0.16	1.4
G423-4xx	G3L15	1.65	3.2	4.7	10.6	1.44	2.7	950	6300	7200	8000	0.53	4.90	8.5	0.39	2.0
G423-6xx	G3L25	2.55	3.4	8.5	12.4	2.29	3.1	1150	4800	4900	5500	0.75	5.10	10.3	0.62	2.6
G423-8xx	G3L40	3.7	4.2	13	16.3	3.43	3.8	1400	3900	4100	4500	0.90	4.10	8.9	0.97	3.5
G424-2xx	G4L05	1.3	3.1	3.2	9.0	1.0	2.3	580	5800	8800	10000	0.42	5.10	8.52	1.05	3.0
G424-4xx	G4L10	2.6	4.8	6.5	15.0	1.7	3.1	950	5500	6900	8000	0.54	2.70	5.78	1.55	3.6
G424-6xx	G4L20	4.7	6.7	12.5	20.0	4.0	5.7	1800	4300	5200	5800	0.70	1.50	4.60	2.60	4.7
G424-8xx	G4L40	8.2	9.2	22	28.0	6.3	7.1	2310	3500	4200	4700	0.89	0.90	3.50	4.70	6.9
G425-2xx	G5L10	5.8	9.5	12.2	24	4.6	7.5	2310	4800	6100	6800	0.61	0.86	4.29	4.60	7.7
G425-4xx	G5L20	11.2	11	25.8	33	9.2	9.0	3370	3500	3800	4200	1.02	0.74	4.81	8.00	9.9
G425-6xx	G5L30	16.6	12.9	40	38	14.0	10.9	3960	2700	3000	3300	1.29	0.64	4.84	11.50	12.1
G425-8xx	G5L50	25	14.8	60	43	20.0	11.8	4610	2200	2200	2400	1.69	0.56	5.44	18.40	16.6
G426-2xx	G6L15	14	22	37	72	9.1	14.2	3810	4000	5700	6300	0.64	0.23	1.86	27.20	15.1
G426-4xx	G6L30	27	30	73	95	15.5	17.2	4870	3000	4200	4700	0.90	0.14	1.54	52.10	21.1
G426-6xx	G6L45	39	38	108	117	25.5	24.8	6680	2500	3500	3900	1.03	0.11	1.46	77.00	27.1
G426-8xx	G6L60	51	43	146	134	34.0	28.6	7830	2200	3000	3300	1.19	0.10	1.46	102.00	33.1

① Motor flanged onto a steel plate 300 x 300 x 12 mm with the maximum permissible overheating of the winding at 100 K over a still air environment (max. 40 °C)

② The nominal point is the point for maximum continuous power

③ Speed at which the EMF of the motor is equal to the DC-bus voltage

④ Speed at which the EMF of the motor reaches 360 V

⑤ $k_t = \frac{M_N}{I_N} = \frac{[Nm]}{[A_{RMS}]}$

⑥ Measured at 25 °C

Note: Shaded data is printed on the nameplate.

Table 7.6

7.3.5 Mounting dimensions of MOOG motors

	P_{max}	A				B	C	øAJ	øAK	AH	øU	BB_{max}	øBF	XD	R	S1xS2	D	BC	øE	F	G	H	M
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			Nm
	ISO 286							ISO 286	ISO 286	ISO 286	DIN 748, ISO 286	ISO 286	ISO 286	ISO 286 DIN 6885	ISO 286	ISO 286 DIN 6885		ISO 286			DIN 13-1	DIN 912 8.8	DIN 912 8.8
Model		**-2xx**	**-4xx**	**-6xx**	**-8xx**																		
G4x2-	55	109,4	122,4	147,4	198,4	17,0	9,0	63	$40^{+0,011}_{-0,005}$	20	$9^{+0,010}_{+0,001}$	2,5	5,5	14	7,2	3x3	3	0	$24^{+0,033}_{-0}$	-	M2,5 x 8	M5 x 22	5
G4x3-	70	114,3	139,8	165,3	203,3	22,0	9,0	75	$60^{+0,012}_{-0,007}$	23	$11^{+0,012}_{+0,001}$	2,5	5,5	16	8,5	4x4	4	0	$24^{+0,033}_{-0}$	-	M2,5 x 8	M5 x 22	5
G4x4-	100	133,2	146,2	171,2	222,2	21,1	9,8	115	$95^{+0,013}_{-0,009}$	40	$19^{+0,015}_{+0,002}$	3	9	32	15,5	6x6	4	0	$35^{+0,039}_{-0}$	66,3	M4 x 16	M8 x 30	16
G4x5-	140	169,6	194,6	220,1	271,1	14,4	12,2	165	$130^{+0,014}_{-0,011}$	50	$24^{+0,015}_{+0,002}$	3,5	11	40	20	8x7	5	0	$47^{+0,039}_{-0}$	98,8	M4 x 16	M10 x 40	30
G4x6-	190	186,5	224,5	262,5	301,0	37,0	11,0	215	$180^{+0,014}_{-0,011}$	60	$32^{+0,018}_{+0,002}$	4	13,5	40	27	10x8	10	0	$50^{+0,039}_{-0}$	128	M4 x 16	M12 x 40	38

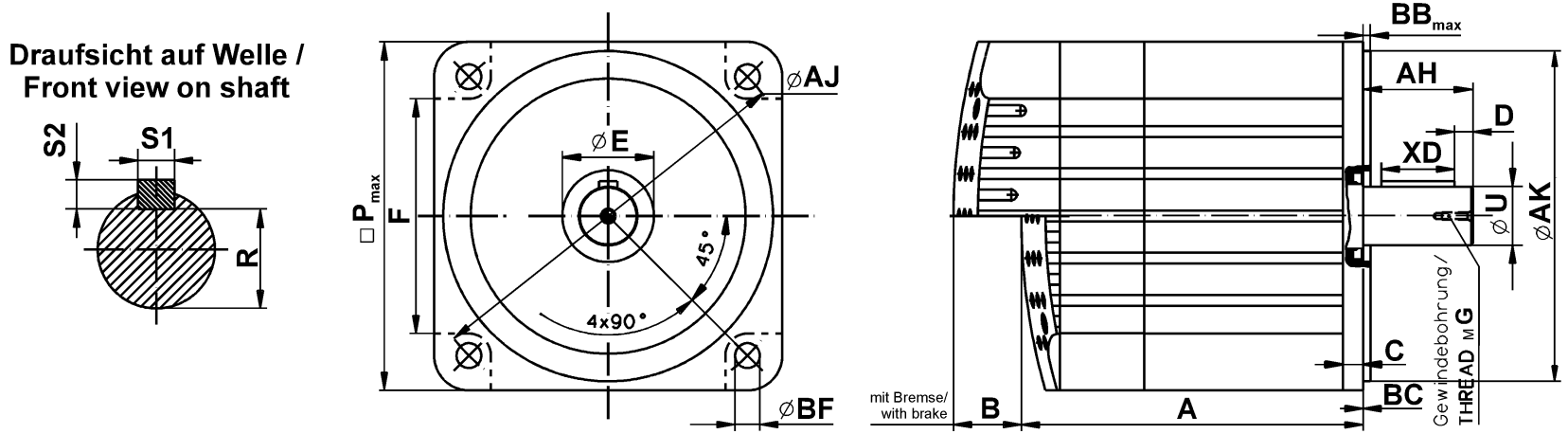
P_{max} Maximum width of motor (end view) excluding terminal housing etc.
A Motor length without shaft, pilot, mating connector
B Additional length of motor for motors with brake
C Thickness of flange plate of motor
øAJ Diameter of mounting bolt circle in flange of motor
øAK Diameter of pilot on flange of motor
AH Mounting surface of flange of motor to end of shaft
øU Diameter of shaft extension

BB_{max} Maximum height of pilot of mounting flange of motor
øBF Clearance hole in mounting flange of motor
XD Usable length of keyseat
R Bottom of keyseat to opposite side of shaft
S1 Width of key
S2 Height of key

D Distance between end of shaft and key
BC Distance between mounting flange of motor to shoulder on shaft (always =0 mm)
øE Diameter of hole for shaft in flange of motor
F Width of motor between recesses for mounting screws
G Thread in motor shaft (type and length)
H Recommended fixing screws (type and length)
M Tightening torque for flange screws

All dimensions without tolerance are according to DIN ISO 2768, part 1, category c

Table 7.7



Additional dimensions, e.g. for connectors and mating connectors can be found in the catalogue.

7.4 Installation instructions

7.4.1 Safety instructions

7.4.1.1 Explanation of symbols used

Important!
The symbol on the left and the word "Important" are used to draw attention to safety instructions concerning a potential **hazard for persons.**
Failure to comply with these safety instructions can result in serious damage to health and can even prove fatal in extreme cases.
These safety instructions must be observed without fail.

Warning:
The symbol on the left and the word "Warning!" are used to draw attention to instructions concerning potential **damage to the servo drive or to the system as a whole.**
Such warnings must be observed without fail.

Note:
Notes contain useful information for the operator when starting up and operating the system.

Danger - High voltage (Sticker on the power supply and servomotor)
The symbol on the left indicates that the power supply operates with high voltages which can prove extremely dangerous if touched.

Beware of hot parts (Sticker on servomotor)
In extreme applications, the surface of the servomotor may heat up to more than 100 °C and can cause skin burns if touched. The servomotor must therefore be protected to prevent contact.

Delicate part (Sticker on servomotor)
A hammer must not be used to force the gearing / gear wheel onto the shaft when installing such parts. The screw thread in the center of the shaft must be used for this purpose. An extractor supported on the center of the shaft must be used when dismantling the parts.

7.4.1.2 Qualified personnel

Important!
The components making up the drive system may only be installed and serviced by duly qualified personnel. The accident prevention regulations (UVV VBG 4, VDE 100, VDE 105) and the installation regulations (EN 60204 Part 1, prEN 50178) must be taken into account.

Unqualified work on the drive components and failure to comply with the warnings contained in this manual or affixed to the components can result in serious physical injury or damage to property.

The work permitted within the scope of this manual may consequently only be undertaken by duly qualified personnel.

This includes the following people:

- **Planning and engineering design personnel** familiar with the safety guidelines for measurement and control instrumentation.
- **Operating personnel** who have been duly instructed with regard to the handling of measurement and control instrumentation and who are familiar with the operating instructions contained in this manual.
- **Commissioning and service personnel** authorized to start up, ground and mark the circuits for components and systems in accordance with safety engineering standards.

7.4.1.3 Intended use

The drive components have been developed and built for installation and operation in industrial systems.

7.4.1.4 List of safety instructions

Danger - High voltage!

The servo drives operate with potentially lethal voltages.

For this reason:

- **Disconnect the system from the mains supply.**
  Before starting any work on the drive system, it must be disconnected from the power supply and secured against inadvertent reconnection by means of the master switch.
- **The servomotors must come to a complete stop.**
  Rotating servomotors can generate potentially lethal voltages by acting as generators.

Beware of mechanical hazards!

Servomotors can accelerate highly dynamically. They also have enormous torque. The following points must therefore be noted when starting the system.

- **The danger zone of the motor must be cordoned off**.
  The system must feature a guard door preventing personnel from reaching into or entering the danger zone. The drive system must be de-energized automatically as soon as the guard door is opened.
- The motor may accelerate inadvertently on account of wiring faults or software errors. Appropriate safety precautions must therefore be taken in the system to ensure that neither personnel nor machine components are endangered in any way.

7.4.2 Mechanical installation

MOOG recommends that hexagon socket head screws to DIN 192 8.8 (see column H in Table 7.5) be used to secure the motor. Assembly is made very much easier by using an Allen key with ball head, particularly in the cases of motor sizes 2 and 3. The screws used to install these motor sizes must not be more than 40 mm long.

MOOG motors can become very hot in operation. Good heat dissipation must therefore be ensured when installing the motor, i.e. it should be flanged onto a suitably solid metal part of the machine. Adequate convection must also be ensured. In individual cases, the motor must furthermore be protected against contact due to the risk of burns. Forced cooling (e.g. with fans) will increase the continuous power, while bad convection may decrease the continuous performance.

Before connecting a coupling to the motor shaft, the latter must be thoroughly degreased. When using a degreasing agent, care must be taken to prevent it from entering the bearing. Otherwise the latter's permanent lubrication can no longer be guaranteed. We recommend the use of a clamp coupling or shrink connection to ensure reliable torque transmission. An inexpensive and service friendly connection is possible with the slot and key option (ensure tight slot tolerances).

Impermissibly high axial and radial forces on the shaft can result in motor damage during installation. The service life of the motor is impaired if the bearing is damaged in any way. Adjusting the rotor shaft by force can impair the correct functioning of the optional brake to such an extent that it has little or no braking effect. Excessive pressure and impacts on the front end of the shaft and rear housing cover must therefore be avoided under all circumstances.

Warning:
The permissible axial and radial forces are **in all cases exceeded** by the pulses due to hammering.

Maximum permissible axial and radial forces for brushless MOOG servomotors during installation

Motor size	G4x2	G4x3	G4x4	G4x5	G4x6
Axial force 1)	150N	150N	300N	400N	500N
Radial force 1)	500N	500N	1000N	1600N	2000N
1): During installation. Lower loads apply for the rotating motor, see catalogue.					

Table 7.8

7.4.3 Electrical interfaces

Use of the made-up cable sets is recommended for connecting the brushless MOOG servomotors. These cable sets are available in lengths of 10 (xxx = 010) and 20 meters (xxx = 020). If MOOG cables are not used, the values specified below with regard to the cable make-up must be maintained **in all cases**.

Warning:
A rotating motor can generate dangerously high voltages.
Always make sure that there are no exposed cables.

Warning:
The servocontroller must always be switched off when assembling or disassembling a plug connector. Simply disabling of the servocontroller is not sufficient.
Particular care must be taken to ensure installation of a protective earth conductor in conformity with the applicable safety regulations.

Note:
Small conductor cross-sections can cause the temperature of the cable to rise impermissibly. This may result in loss of power, particularly when using long cables.

Note:
For installation of cables, we recommend the power and signal cables be shielded.
The shield must be grounded at both ends.

7.4.3.1 Pin assignment and cable details

The pin assignment of the connectors is illustrated in the following diagram.

Pin assignment for power cable and mating plug

(Top view of motor flange socket, mating connector mirrored):

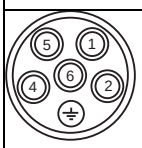
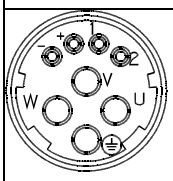
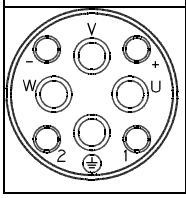
Pin layout	Pin connection	Motor reference	Part number power cables ready-to-connect	Part number mating power connector loose	Part number power cable loose	Cable layout
	1 Phase W 2 Phase U 4 Phase V 5 24V Brake + 6 24V Brake - ⏚ PE	G4x2 G4x3 G4x4	B47914 001 xxx ①	A63472 001	B47890 001	4x1,5mm² power, 2x1,0mm² brake (separate shield), outer shield
	U Phase U V Phase V W Phase W + 24V Brake + - 24V Brake - ⏚ PE	G4x5	B47915 001 xxx ①	B47736 001	B47903 001	4x2,5mm² power, 2x1,0mm² brake (separate shield), outer shield
	U Phase U V Phase V W Phase W + 24V Brake + - 24V Brake - ⏚ PE	G4x6	B47916 001 xxx ①	B47711 001	B47904 001	4x10mm² power, 2x1,0mm² brake (separate shield), outer shield

Table 7.9

Pin assignment for signal cable and mating plug

(Top view of motor flange socket, mating connector mirrored):

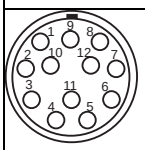
Pin layout	Pin connection	Motor reference	Part number signal cables ready-to-connect	Part number mating signal connector loose	Part number signal cable loose	Cable layout
	1 S1 2 S3 3 S2 4 S4 5 NTC 6 NTC 7 R1 8 R2 9 - 12 n.c.	G4x2 G4x3 G4x4 G4x5 G4x6	D-Sub-connector (Servocontroller T161) B47886 001 xxx ① multicore cable end (Servocontroller T164) B47886 002 xxx ①	A63021 001	B47885 001	4x2x0,25mm² stranded wires, twisted paired, outer shield

Table 7.10

① - xxx is cable length in meters.

Standard lengths: xxx = 010 cable length 10 m.

xxx = 020 cable length 20 m.

7.5 Partnumber cross reference

The order number for motors is made up as follows:

G4xx - xxxR

Global Product

Series 4xx

Configuration

Code	
0	Special design (s. note) *)
1	US
2	Europe

*) Model numbers are defined consecutively for special (customized) motors. The line number consequently does not give any indication of the model properties. These are defined by the Model Master File.

Frame Size

Code	
2	55 mm Flange
3	70 mm Flange
4	100 mm Flange
5	140 mm Flange
6	190 mm Flange

Revision Index

Configuration of shaft extension

Code	Run Out	Shaft Type	Shaft Sealing
4	Reduced	Key	No
5	Reduced	Key	Yes
6	Reduced	Plain	No
7	Reduced	Plain	Yes

Brake Options

Code	G4x2	G4x3	G4x4	G4x5	G4x6
0	-	-	-	-	-
1	0.9 Nm	1.5 Nm	6 Nm	15 Nm	25 Nm
2	-	3 Nm	15 Nm	25 Nm	50 Nm

Active Length (in 0.1 inch)

Code	G4x2	G4x3	G4x4	G4x5	G4x6
2	L05	L05	L05	L10	L15
4	L10	L15	L10	L20	L30
6	L20	L25	L20	L30	L45
8	L40	L40	L40	L50	L60

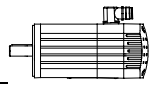
Table 7.11

7.6 If repairs are required

Since correct disassembly cannot be guaranteed by MOOG, all the attachments not fitted by MOOG, such as gearboxes, gear wheels, pinions, etc. must be dismantled if a brushless MOOG servomotor has to be repaired. Any dirt on the front flange of the motor must also be removed. Repairs by external personnel are excluded for reasons associated with product liability, since the applicable safety regulations (e.g. VDE guidelines) and MOOG quality standards normally cannot be met by the customer. **All warranty rights are voided if the sealing varnish on the screws of the servomotors is broken.** If at all possible, a detailed description of the fault or failure should be enclosed with the shipping documents. The words **"For repair"** should feature prominently on the delivery note. The motor must be packed so that it is protected against knocks and bumps, as well as against damage in transit. Especially the shaft and connectors have to be protected. Please send the motor to your regional branch or one of the following service centers:

Europe and Asia MOOG GmbH Hanns-Klemm-Straße 28 71034 Böblingen Germany Telephone: +0049 - 7031 - 622 - 0 Fax: +0049 - 7031 - 622 - 100	**America** MOOG Inc. / NADO Division Jamison Road EAST AURORA, NY 14052 U.S.A. Telephone: +001 - 716 - 687 - 2000 Fax: +001 - 716 - 687 - 4870

8 Maintenance and Service



8.1 Maintenance instructions

The electronic components and servomotors do not require maintenance.

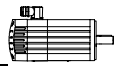
8.2 If repairs are required

Repairs by external personnel are excluded for reasons associated with product liability, since the applicable safety regulations (e.g. VDE guidelines) and MOOG quality standards cannot normally be met by the customer.

All warranty rights are extinguished if the sealing varnish on the screws of the servomotors is destroyed.

Defective components should be returned to MOOG.
Please use the form overleaf when returning components.
Do not attempt to repair the components yourself.
All warranty rights are extinguished if any attempt is made to repair components without authorization.

Repair order



To: MOOG GmbH
- Repair-Center -
Hanns-Klemm-Str. 28
D-71034 Böblingen
Germany

Tel.: +0049 - 7031 - 622 - 191
Fax: +0049 - 7031 - 622 - 100

From: Company : _____ Tel: _____

Name : _____ Fax: _____

P.O.Box : _____

Street : _____

Town : _____

Country : _____

The following components have been sent back to MOOG to be repaired:

☐ 19" rack with 6-axis backplane: Model No.: _____ Serial No.: _____

☐ Backplane: Model No.: _____ Serial No.: _____

☐ Power supply unit: Model No.: _____ Serial No.: _____

☐ Servocontroller: Model No.: _____ Serial No.: _____

☐ MCO Module (only for T161-00x): Model No.: _____

☐ Ballast resistor: Model No.: _____

☐ Servomotor: Model No.: _____ Serial No.: _____

☐ Power cable: Model No.: _____

☐ Signal cable: Model No.: _____

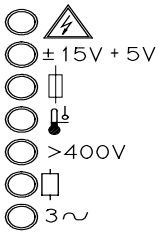
How often does the fault occur? ☐ always ☐ sporadically ☐ after _____ hours

When did the fault occur for the first time?

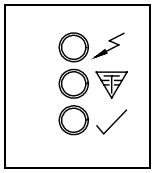
☐ During on-going operation
☐ When switching on again after a break
☐ When commissioning a new system
(Check wiring first, measure voltages, is enable signal present, check limit switches and controller parameters)
☐ When switching on again after maintenance work
(Check that cables have not been connected incorrectly)

Which LEDs lit up (please X as appropriate)?

On the PSU



On the servocontroller



Description of the problem (Please give as many details as possible; use a separate sheet if necessary)