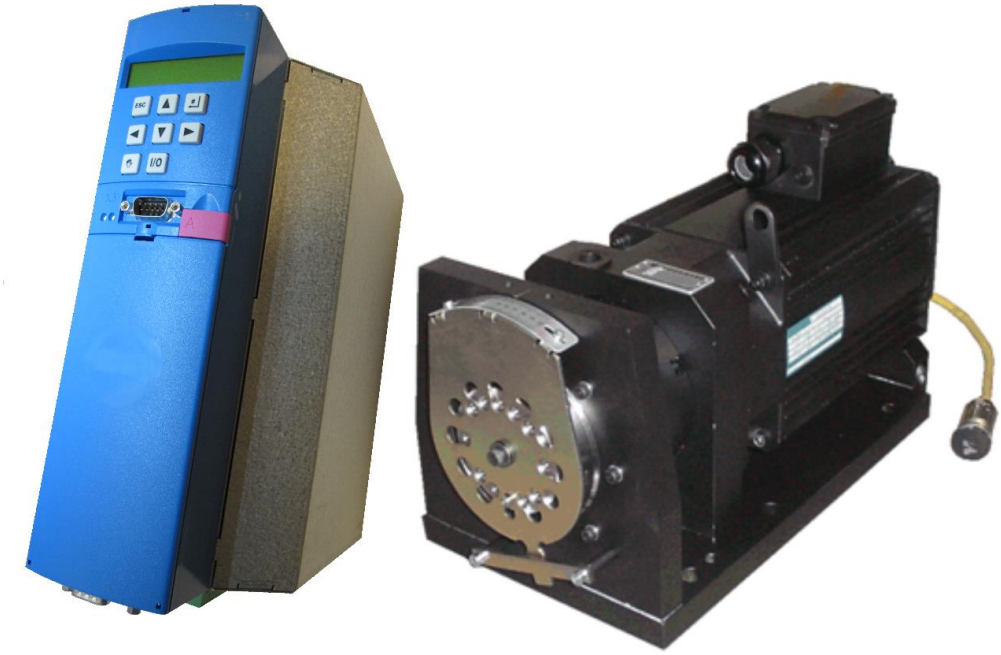
WOODWARD

Product Manual 26761
(Revision D, 9/2017)
Original Instructions



EM-80/EM-300 Actuator System

Installation and Operation Manual

General Precautions

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment.

Practice all plant and safety instructions and precautions.

Failure to follow instructions can cause personal injury and/or property damage.

Revisions

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, on the *publications page* of the Woodward website:

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The latest version of most publications is available on the *publications page*. If your publication is not there, please contact your customer service representative to get the latest copy.

Proper Use

Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

Translated Publications

If the cover of this publication states "Translation of the Original Instructions" please note:

The original source of this publication may have been updated since this translation was made. Be sure to check manual *26455*, *Customer Publication Cross Reference and Revision Status & Distribution Restrictions*, to verify whether this translation is up to date. Out-of-date translations are marked with ⚠. Always compare with the original for technical specifications and for proper and safe installation and operation procedures.

Manual 26761

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Important Definitions

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

⚠WARNING

Overspeed / Overtemperature / Overpressure

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.

⚠WARNING

Personal Protective Equipment

The products described in this publication may present risks that could lead to personal injury, loss of life, or property damage. Always wear the appropriate personal protective equipment (PPE) for the job at hand. Equipment that should be considered includes but is not limited to:

- **Eye Protection**
- **Hearing Protection**
- **Hard Hat**
- **Gloves**
- **Safety Boots**
- **Respirator**

Always read the proper Material Safety Data Sheet (MSDS) for any working fluid(s) and comply with recommended safety equipment.

⚠WARNING

Start-up

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

⚠WARNING

Automotive Applications

On- and off-highway Mobile Applications: Unless Woodward's control functions as the supervisory control, customer should install a system totally independent of the prime mover control system that monitors for supervisory control of engine (and takes appropriate action if supervisory control is lost) to protect against loss of engine control with possible personal injury, loss of life, or property damage.

WARNING

EMC Compliance

This device is PDS category C3 second environment.

This device is not intended to be used on a low-voltage public network which supplies domestic premises.

Radio frequency interference is expected if used on such a network.

Follow installation manual to avoid EMC issues.

NOTICE

Battery Charging Device

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

Electrostatic Discharge Awareness

NOTICE

Electrostatic Precautions

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts:

- **Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).**
- **Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.**
- **Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual *82715*, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Follow these precautions when working with or near the control.

1. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
2. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
   - Do not touch any part of the PCB except the edges.
   - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
   - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

Regulatory Compliance

European Compliance for CE Mark (Stöber):

Low Voltage Directive: Directive 2014/35/EU on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits.

EMC Directive: Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility (EMC).

Compliance with the following European Directive does not qualify this product for application of the CE Marking:

Machinery Directive Compliant as partly completed machinery with DIRECTIVE 2006/42/EC of the European Parliament and the Council of 17 May 2006 on machinery.

North American Compliance

No North American Listings

Marine Type Approval Compliance

American Bureau of Shipping: Part 1 – 2015Steel Vessels Rules 1-1-4/7.7, 1-1-A3, 1-1-A4 and 2015 Offshore Units and Structures 1-1-4/9.7, 1-1-A2, 1-1-A3, which covers the following: Mobile Offshore Drilling Units 2015: 4-3-1/15, 17.1

Bureau Veritas: Rules for Classification of Steelships – January 2013 Part C, Machinery, Electricity, Automation and Fire Protection, Part C, Chapter 3, Section 6

Lloyd's Register of Shipping: Lloyd's Type Approval System – Test Specification No. 1, 2002.
EM-80/-300 Driver: ENV2
EM-80/-300 Actuator: ENV4

Russian Maritime Register of Shipping: Russian Maritime Register of Shipping – Section 10, Part IV, RS Rules for Technical Supervision, during Construction of Ships and Manufacture of Materials and Products for Ships, 2012. Code of Nomenclature: 15100105

Special Conditions for Safe Use

- Field wiring must be suitable for at least 90 °C.
- Grounding is required by the input PE terminal.
- A fixed wiring installation is required.
- An emergency switch or circuit breaker shall be included in the installation that is in close proximity to the equipment and within easy reach of the operator and is clearly marked as the disconnecting device for the equipment. The switch or circuit breaker shall not interrupt the protective earth conductor.
- Wiring must be in accordance with the authority having jurisdiction.

Chapter 1.
General Information

Introduction

This manual covers components of the EM-80/-300 Actuator System and does not include operating instructions for the prime mover or the driven devices or processes. For information about other Woodward products used in conjunction with the EM-80/-300, please refer to the specific Woodward documentation supplied with each product.

For specific operating information such as start-up, shutdown, and the prime mover's response to signals from the Woodward control, refer to the prime mover manufacturer's manual.

Description of Components

The EM-80/-300 system provides an all-electric actuation system for various prime mover control applications.

The system is intended for use on large diesel, gas, and gasoline engines, and on all types of turbines, to control the position of the engine fuel racks, turbine fuel racks, turbine and turbocharger variable geometry, and to perform timing control.

The EM Driver controls the EM-80/-300 Actuator position proportional to a position demand signal received from a controlling device. The EM-80/-300 Actuator consists of a high-performance three-phase brushless ac motor that drives a precision planetary gearbox.

⚠WARNING

Use of this equipment by untrained or unqualified personnel could result in damage to the control or the installation's equipment and possible loss of life or personal injury. Make sure personnel using or working on this equipment are correctly trained.

A complete system consists of:

- Actuator (Woodward-supplied)
- EMI filter when required (Woodward-supplied) see Chapters 3 and 6 for recommendations
- Driver (Woodward-supplied)
- Resolver cable or resolver retrofit cable adapter (Woodward-supplied)
- Shielded power cables
- Shielded motor drive cables
- Metal cabinet enclosure
- Protected 24 Vdc power source

The actuator is available in two versions: the EM-80 and the EM-300. Both consist of a high-performance, three-phase brushless AC motor that drives a precision planetary gearbox. A resolver on the motor provides a position feedback signal.

The EM-driver controls the EM-80/-300 actuator position and consists of a power board and a controller in one housing. The driver is programmable to accommodate custom requirements.

A customer-supplied standard three-phase cable, including a ground wire, is required to connect the Power board of the Driver to the Actuator. The maximum cable length that should be used is 100 m (328 ft). For further information on wire length considerations, please see “EMC Remarks for Cable Length” later in this manual.

The resolver cable is a dedicated cable to ensure correct feedback of the resolver signal. The absolute maximum cable length that should be used is 100 m (328 ft), however it is recommended not to exceed 60 m to ensure signal integrity. Resolver cables can be purchased from Woodward, and are shown in Table 5-7.

Identification plates are installed on the side of the actuator and on the driver. They contain the part numbers and serial numbers which should be provided in any correspondence with Woodward.

IMPORTANT

Installation of other electronic equipment inside the cabinet that encloses the EM-80/EM-300 requires that the cabling for this equipment meet the same requirements that the cabling for the EM-80/EM-300 meets. See Appendix A for further details.

General Safety Precautions

⚠WARNING

Read and obey these safety precautions before you operate the equipment or perform maintenance.

- Obey all cautions or warnings given in all applicable procedures.
- Never bypass or override machine safety devices.
- Always use sufficient personnel and/or lifting equipment to move the actuator.
- Do not contact the actuator drive shaft, either directly or indirectly, unless the system is de-energized, as injury may occur.
- This equipment contains high voltage and rotating parts (fans). Ignoring the safety and warning information may result in death, severe personal injury, or damage to property.
- Do not conduct maintenance procedures unless the equipment is de-energized.
- Do not begin work on the power stage and the connections until you have made sure that the system has been de-energized.
- Observe all applicable regulations and verify the proper operation of all safety devices when performing installation, repair, and maintenance procedures.
- Due to technical requirements, devices or motors may include individual components that contain dangerous materials.

- Do not replace or substitute Woodward products and components with non-Woodward devices without authorization from Woodward.
- Observe all applicable regulations during installation.
- PE (protective earth ground]) connections as shown in this document are required to avoid personal injuries caused by high voltages.
- This driver may not be compatible with certain types of earth leakage circuit breakers (e.l.c.b.s or sometimes called ground fault breakers) due to the normal AC current leakage through the driver's EMC filter network and the motor distributed capacitance.
- See the installation section of the manual for special requirements pertaining to isolated (IT) power networks.
- Make sure the plastic covers over the power supply connections are in place before applying power.
- Before switching on the drive, you must carefully check the functions of all higher level safety equipment to prevent injury to people.
- Some movement of the actuator drive shaft is possible during the initial application of power. Proper precautions should be taken to avoid personal injury or damage to property.

Retrofit Option

In cases where a previous EM-80/EM-300 driver model (Woodward PN 3522-1004, 3522-1005, or 3522-1009 for example) needs to be replaced with a new version (such as Woodward PN 3522-1042), detailed information for this retrofit is available in the driver conversion manual, Woodward Application Note 51492.

Chapter 2.
Shipping

The components are packed at the factory. Handle the components carefully and avoid unnecessary shocks, such as when setting them down on the ground.

Before moving or unpacking the components, carefully examine the crate and packaging for damage caused during transportation to the installation site. Damage that has occurred to the crate or packaging can be an indication that damage may have occurred to the components themselves.

If external damage has occurred, assess the damage that may have also occurred to the components. If the components may have been damaged, contact the transportation carrier and Woodward. Make sure the carrier completes a transportation damage report immediately.

If any parts are missing, contact Woodward.

⚠WARNING

If the components have been damaged in transit, do not connect any parts to the mains until appropriate high-voltage testing has been carried out.

Ignoring this information can result in death, severe personal injury, or considerable damage to property.

IMPORTANT

Do not remove the packaging as that can invalidate any claims that may be made.

Fiberboard, cartridge paper, and/or wood are used as packaging materials and they can be disposed of in accordance with local regulations.

Chapter 3.
System Description

EM-80/-300 System Description

The EM-80/-300 system consists of an actuator, a driver, an AC line filter (required for marine TN/TT only), and interconnection cables.

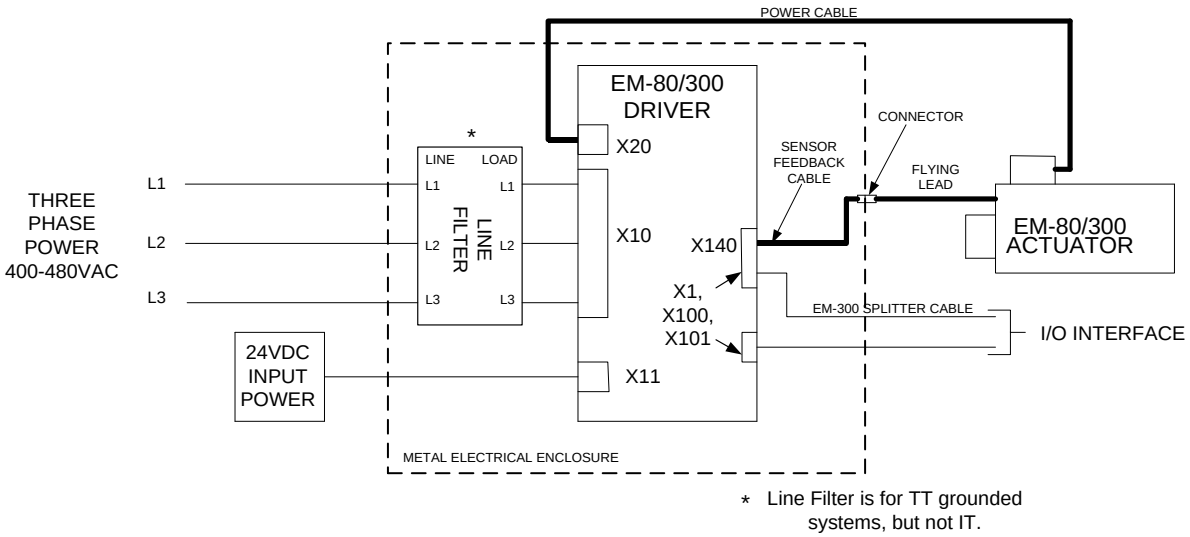


Figure 3-1 System Overview

The EM-80 and EM-300 are all-electric actuator systems that provide a nominal 40° of actuator output rotation. Each system consists of a three-phase brushless ac motor which drives a high-precision planetary reduction gear box. A dedicated driver controls the actuator position.

Actuator

The actuator is available in two versions, offering two work output levels, EM-80 and EM-300. Both versions use the same three-phase brushless AC motor.

The difference in output is achieved by the use of two different gearboxes. The EM-80 uses a single-stage planetary 1:7 gear ratio, while the EM-300 uses a two-stage planetary 1:20 gear ratio.

The motor–gearbox combination comes assembled on a mounting bracket with a fixed hole pattern. Although the EM-300 is longer than the EM-80, both use the same mounting hole pattern, allowing the actuators to be interchangeable.

The output flange provides an easy mounting surface for a variety of lever configurations, and is equipped with a rugged pointer and scale for quick output position reference while working on the prime mover. A breakaway extension and two stop pins form a simple means of detecting whether the actuator has been driven outside its operating boundaries.

Electrical connections are made in a standard, shielded, three-phase terminal box mounted on the motor, and will accommodate standard cable. The resolver cable has a 1 m (39”) flying lead that removes the connector from the high vibration environment of the prime mover. The use of the specified resolver cable and connector will help ensure correct connections to the driver.

The EM-80 and EM-300 actuators have different position-sensing systems. Both systems use the same hollow shaft resolver, producing a sine and cosine wave output with an overall accuracy of 12 arc-minutes. This resolver is mounted at the rear of the motor and looks at the relative position of the motor shaft.

The EM-80 uses only the resolver since the 1:7 gear ratio within the gearbox allows full stroke of the actuator output flange with less than one full revolution of the motor shaft.

The EM-300 has a 1:20 gearbox ratio to achieve the required torque output. Because of this, the motor shaft rotates more than one full revolution to achieve full stroke. To ensure proper position indication over the full range, a 10-turn potentiometer is added behind the resolver to supply a coarse position signal from which the correct rotor revolution is deduced. The same resolver as used on the EM-80 gives the accurate position within that revolution.

⚠WARNING

Actuator Travel

EM actuator may move or reposition suddenly when power is applied or if not correctly installed or connected to the driver. Ensure that personnel are clear of actuator and fuel rack area to prevent injury when power is applied.

Driver

Both actuator versions use the same dedicated driver. This driver converts three-phase 400–480 Vac, 50–60 Hz power into a controlled supply for the motor. The driver outputs a peak current sufficient to develop the rated transient output torque. After a one-second delay, the current drops back to a maximum steady state current to maintain the rated steady-state torque. The driver's internal logic, Ready For Use output and common alarm output require a separate 24 Vdc power supply.

This driver is designed for installation in a control cabinet and should not be installed directly on the prime mover. For the EM-300, the potentiometer branched out cable from the resolver allows the signals to be fed into the correct driver connector. For details on the driver, see Chapter 5.

AC Power Line Filter

A 3-phase AC power line filter is used to reduce the influence of any interference that may occur due to the power source. It also protects the power source from emissions that may occur due to the driver. The line filter should be mounted as described in the wiring diagram. For details on the line filter, see Chapter 6.

A power line filter (P/N 1326-1125) is only required for marine-compliant systems which incorporate a grounded power network (e.g. TN or TT). For land-based systems which incorporate a grounded power network, the customer may elect to purchase the filter for added robustness, however it is not required for CE Mark compliance.

WARNING

For marine- and land-based systems which incorporate isolated power (e.g. IT), a power filter is NOT recommended due to possible safety and EMI concerns. See the Installation section for further details.

Ignoring this information can result in death, severe personal injury, or considerable damage to property.

Necessary Cables

Mains Power Cable

The end user must provide the power input connection to the suppressor filter. It must be standard industry three-phase with ground (PE) wire, rated for 480 Vac, 50–60 Hz, 16 A, and giving consideration for the intended environment (temperature and chemical exposure).

Driver Power Cable

The end user must provide the power connection between the suppressor filter and the driver input. It must be standard industry shielded, three-phase, rated for 480 Vac, 16 A, and giving consideration for the intended environment (temperature and chemical exposure).

Actuator Power Cable

The end user must provide the power connection between the driver and the actuator. It must be shielded three-phase with ground wire, suitable for 480 Vac, 24 A, and giving consideration for the intended environment (temperature and chemical exposure). The maximum cable length between the driver and the actuator can be up to 50 m (164 ft) without the need for additional equipment. Power cable length up to 100 m is also permissible, but may require a line reactor to overcome excessive cable capacitance that is common in long wire installations. Actuator performance can be affected without this correction, but ultimately will need to be evaluated by the customer for each application and cable installation.

Resolver Feedback Cable

The resolver connection between the driver and the actuator is a dedicated cable using special connectors on each end. This cable must be connected between the actuator (round 12 pin connector) to the X140 connector on the driver. The cable length is 10 m (98 ft), 20 m (65 ft), 30 m (98 ft) ,40 m (131 ft), and 60 m (196 ft) according to customer requirements. The Woodward item numbers for these cables are shown in Table 5-7.

If the customer wishes to reduce the length of the feedback cable or lead it through a gland into the cabinet, careful attention should be given to splicing the wires and shielding in order to maintain the proper performance of the EM 80/EM 300 system. Modification of this cable can have an influence on overall system EMC robustness, so any changes must be performed with close attention to grounding and shielding.

EMC and Safety Grounding

The actuator, driver housing, and the housings of any power line filters must be bonded to protective earth for safety and proper EMC performance. The ideal method for grounding is to ensure a low impedance bond between the base and the metallic installation structure. When such a bond cannot be guaranteed through mounting, low impedance ground wires (10 AWG or larger) or braids (1.25 cm or wider) shall be used to ensure proper grounding. Braided ground straps are preferred for best performance.

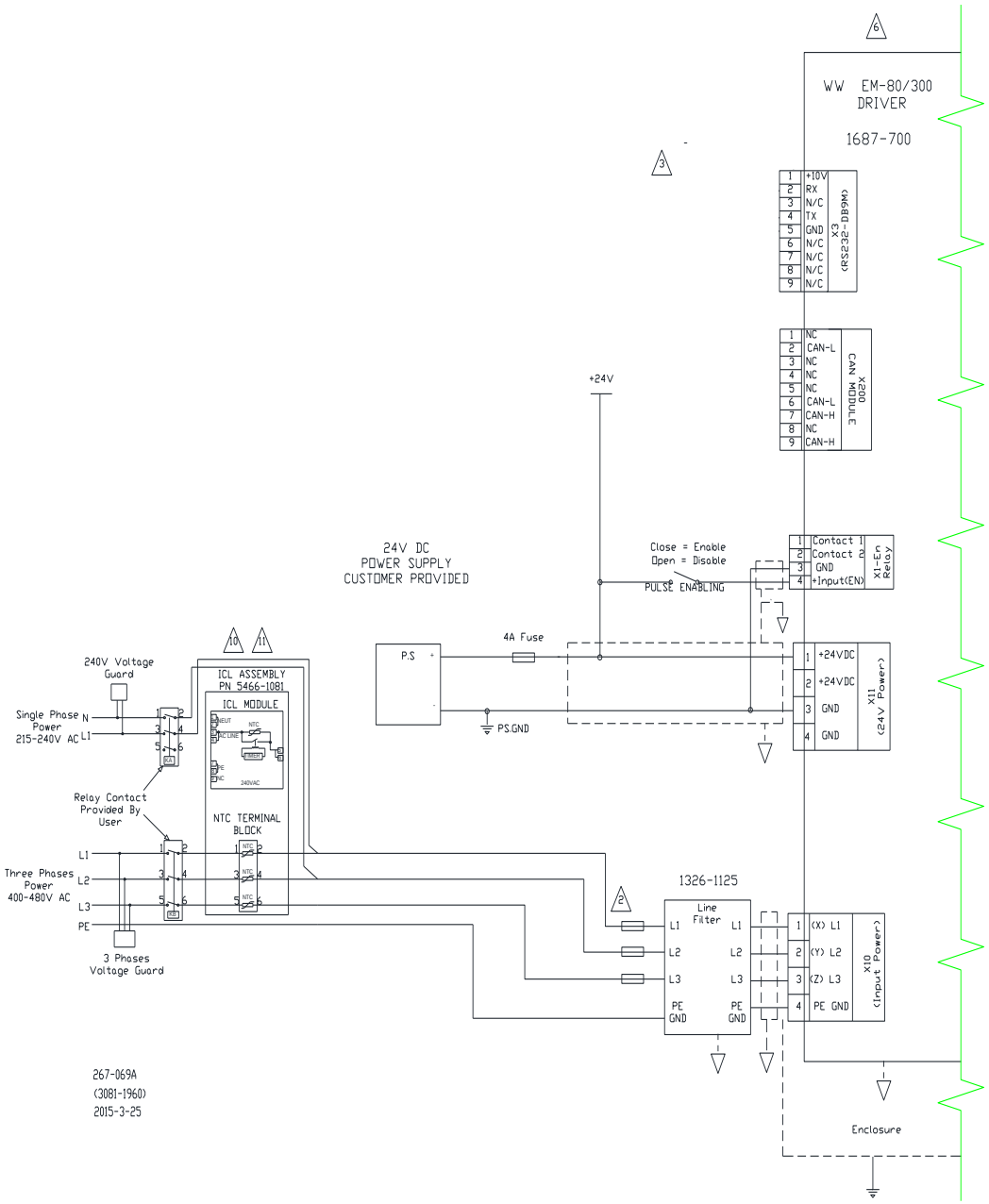


Figure 3-2a. Control Wiring Diagram (left half)
(see Notes in Figure 3-2c)

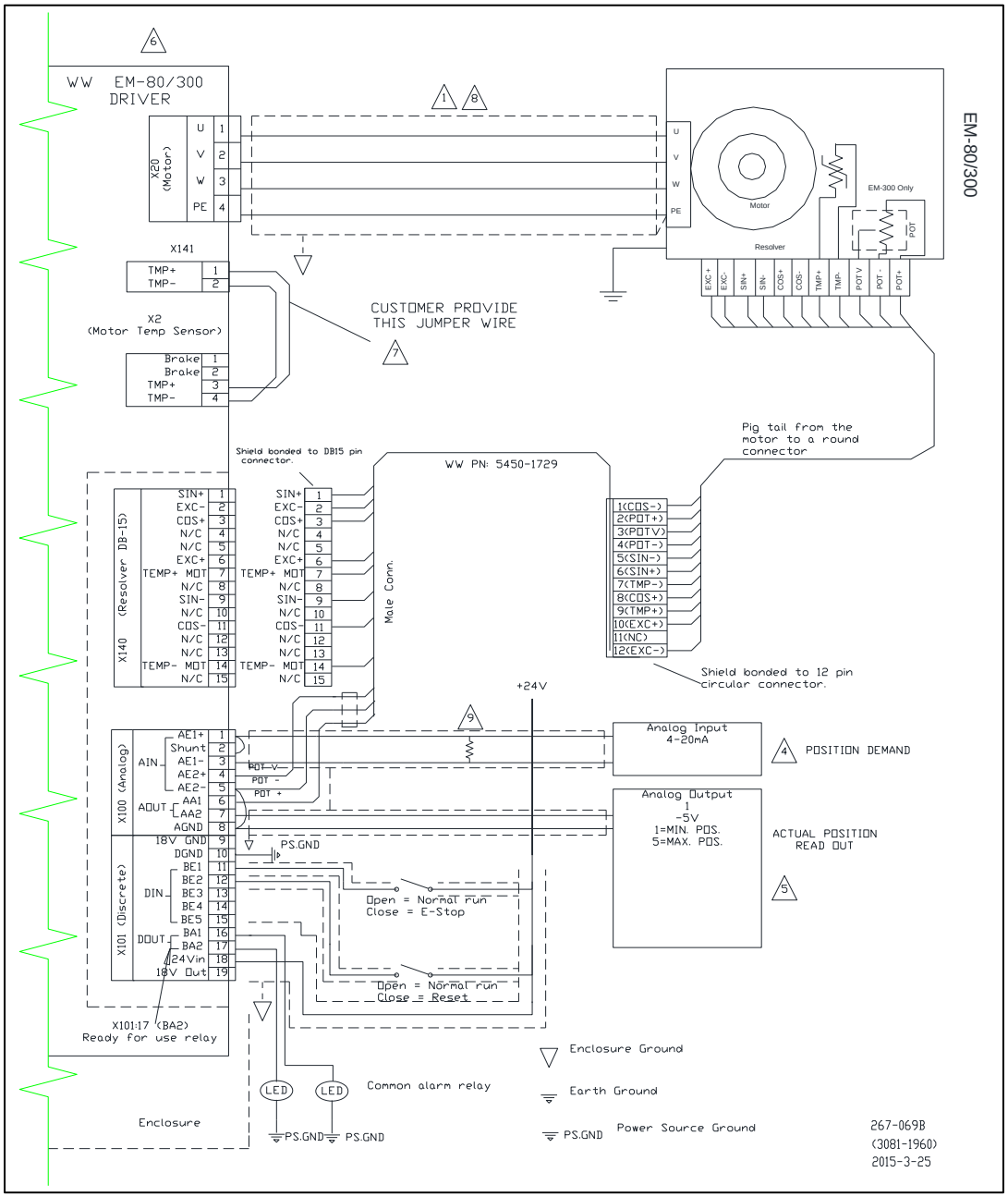


Figure 3-2b. Control Wiring Diagram (right half)
(see Notes in Figure 3-2c)

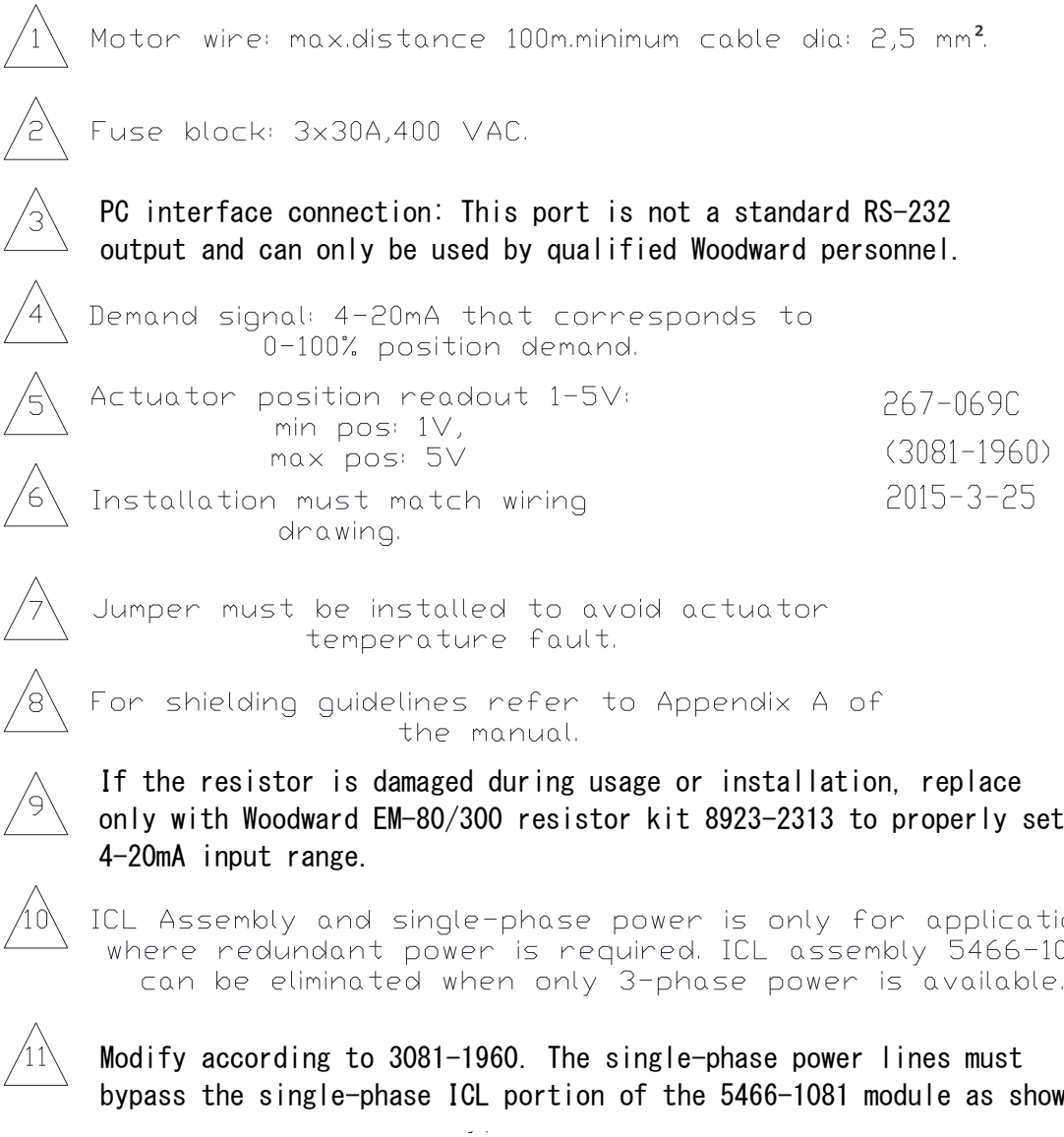


Figure 3-2c. Control Wiring Diagram (notes)

Metal Electrical Enclosure

The EM driver must be installed inside a metal electrical enclosure (cabinet) that is grounded (bonded) to earth. Cable shields must be electrically grounded (bonded) to the enclosure. See Figures A-1 and A-3 in Appendix A for additional details.

IMPORTANT

A special EMC-type enclosure with conductive door gaskets, etc, is NOT required. However, if openings are made to the walls of the enclosure, such as for the installation of cooling fans/vents, it is recommended that special EMC-type screens are installed over the openings in order to maintain the shielding integrity of the enclosure.

EMC Limitations on Cable Length

All system wiring, with the exception of the motor, resolver, and input AC power, must be limited to < 30 m for proper EMC performance.

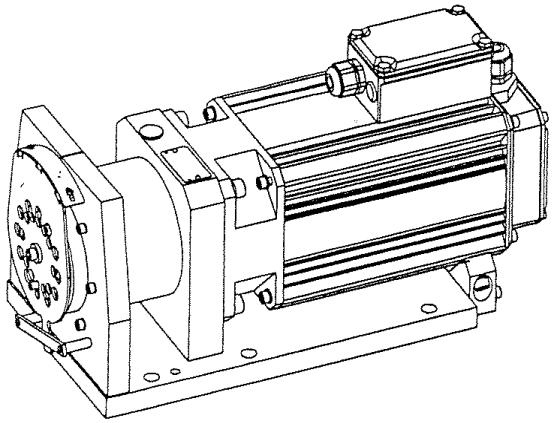
Note: The wiring listed under the exception may exceed 30 m without affecting EMC performance; however these lines must still be limited to the maximum lengths described in the Installation section for proper system operation. For the AC input, motor driver lines, and resolver feedback, it is permissible to have lines longer than 50 m (up to 100 m MAX), but it may be necessary to add a line reactor to manage cable parasitic capacitance. The length will ultimately be determined by the amount of cable loss that is allowable to the customer in a specific application.

Cable Shielding

For proper EMC performance, shielded cabling must be utilized where indicated by the Control Wiring Diagram (Figure 3-2) and is especially important for resolver feedback. Additional shielding information can be found in Appendix A.

Chapter 4.
EM-80/-300 Actuator

General



The EM-80 and EM-300 actuators include:

- a bracket for mounting on the engine or turbine
- an ISO 9409 actuator output flange
- an output position indicator

The actuators are equipped with a flying-lead position-sensor cable (including connector) to connect the actuator to the driver. This cable is the same for both the EM-80 and the EM-300.

⚠WARNING **Read and follow all safety instructions given in Chapter 1, General Safety Precautions.**

⚠CAUTION **The EM actuator is heavy. Use lifting equipment of sufficient capacity and the eyebolts provided while moving the actuator.**

The EM-80 actuator weighs 35 kg (77 lb), and the EM-300 actuator weighs 38 kg (84 lb). On the motor, two eyebolts have been mounted to allow the unit to be moved by lifting equipment. Be careful to balance the actuator in the correct mounting position—in some positions the center of gravity of the combined unit may be close to the forward lifting eye.

EM-80/-300 Actuator Mounting

The EM-80 and EM-300 actuator both use a similar mounting pattern (see Figure 4-1). Six 12 mm or 0.5” fasteners are used to attach the EM-80 actuator to its mounting surface. Eight 12 mm or 0.5” fasteners are used to attach the EM-300 actuator to its mounting surface.

Both mounting patterns are positioned such that the distance from the front flange to the first row of holes is identical at 68.0 mm (2.68”). This allows the actuators to be interchangeable without having to rearrange the linkage layout.

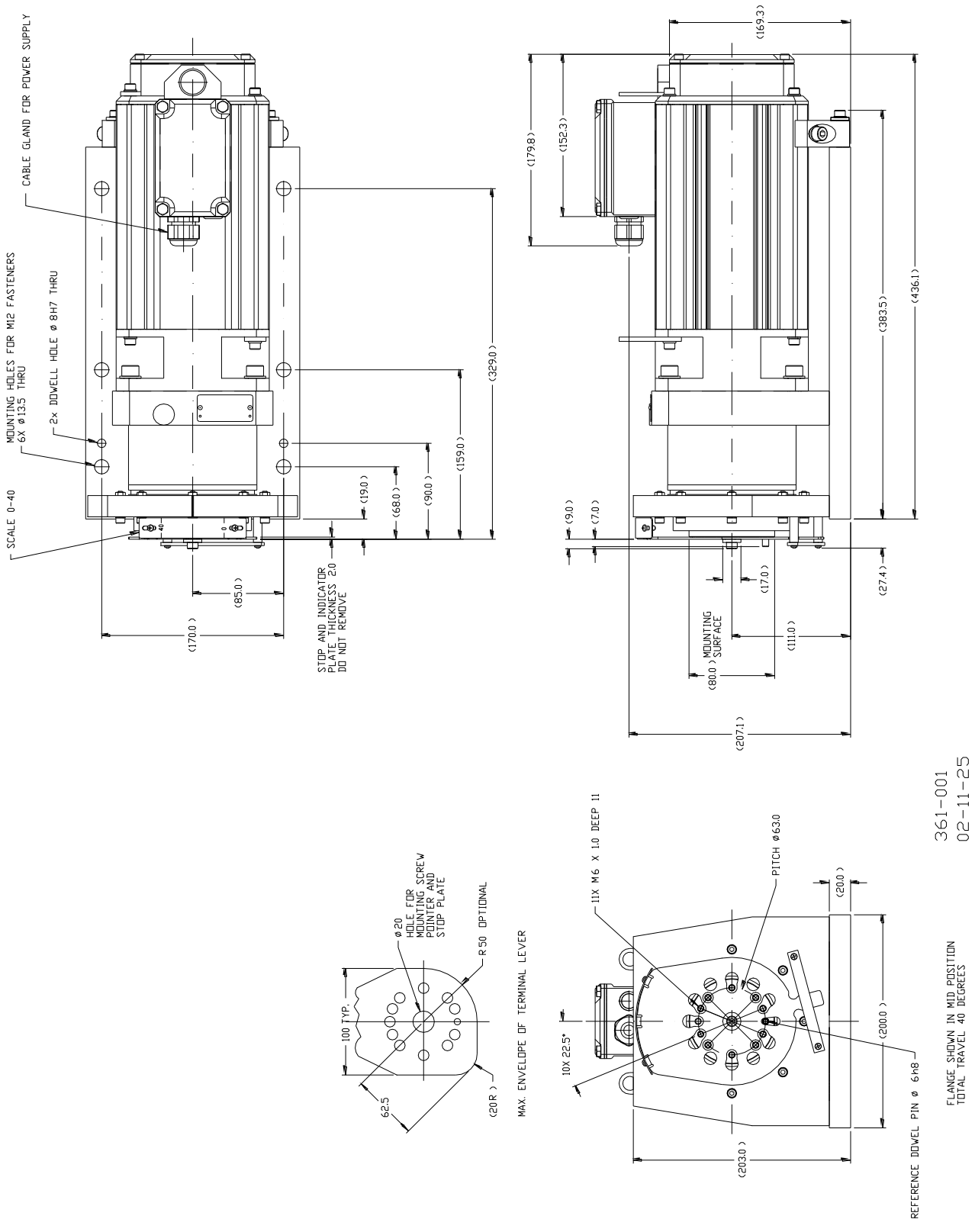


Figure 4-1a. Actuator Outline Drawing (EM-80)

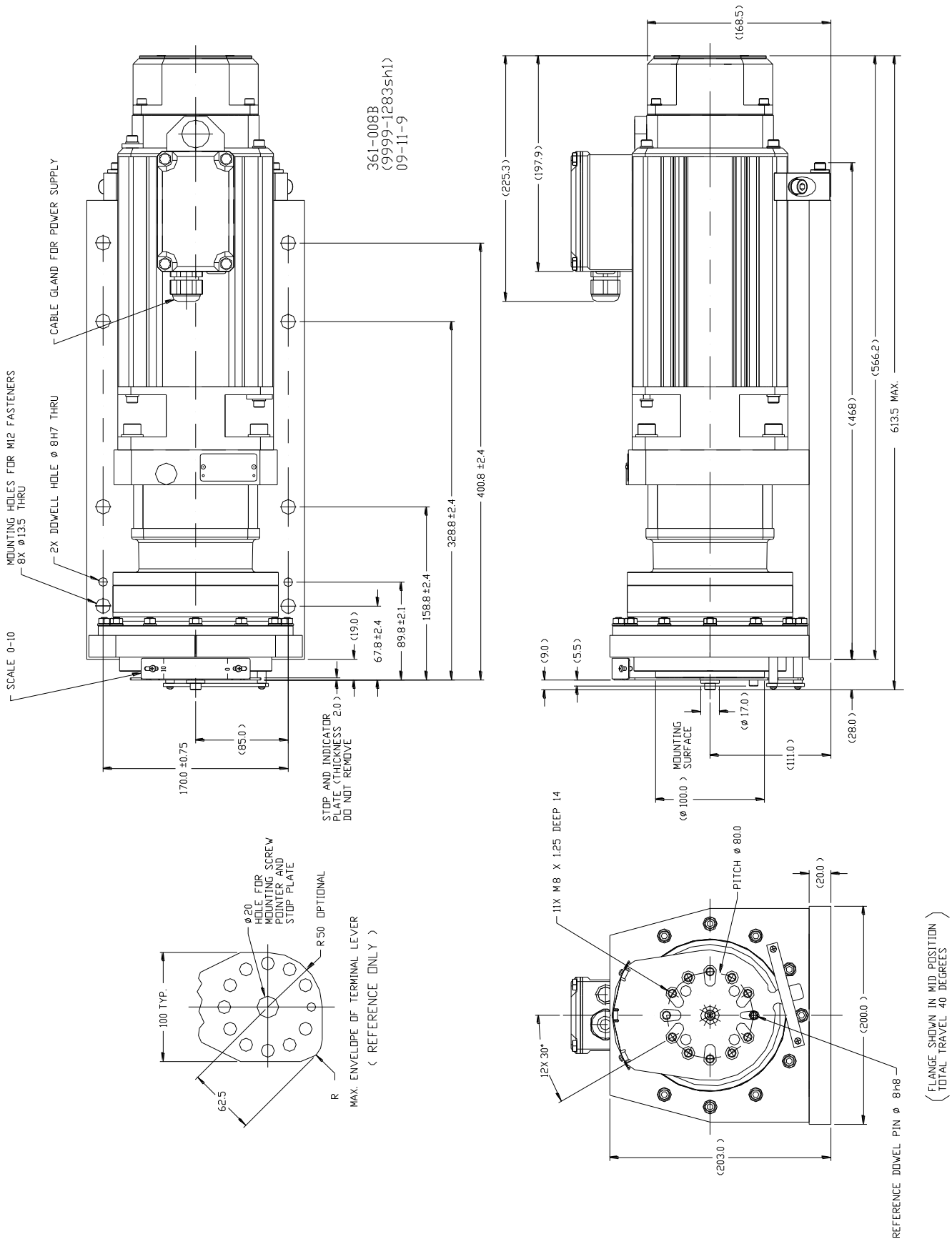


Figure 4-1b. Actuator Outline Drawing (EM-300)

To ensure interchangeability, the actuator mounting bracket contains two 8 mm (0.3”) H7 dowel pin holes close to the front flange. This hole pattern should be copied onto the engine mounting flange to be used to position the actuator mounting bracket.

The flatness of the mounting surface should be less than 0.2 mm (0.008”), and free of any nicks and burrs. Surfaces exceeding this flatness could introduce unacceptably high stresses in the actuator and actuator mounting bracket when torqueing the fasteners. The actuator must be mounted such that the output flange is not more than 45 degrees above or below the opposite end of the actuator. The actuator can be mounted at any angle of rotation about the shaft axis of the motor.

EM-80/-300 Actuator Temperature Derating

The ambient air temperature surrounding the actuator must not exceed 85 °C. In addition, the temperature of the mounting surface must be controlled such that the mounting plate of the actuator never exceeds 85 °C.

In addition to this 85 °C limitation, the continuous torques listed in the specification section are acceptable to 40 °C. Above this temperature, the user must ensure that the continuous torque driven by the actuator falls below the envelopes defined by the graph below. Otherwise, overheating of the motor can lead to loss of torque or driver shutdown. Application of the actuators at this high a continuous torque is rare, but the limitation must be observed. In contrast, the listed transient torques are acceptable over the entire operating temperature range.

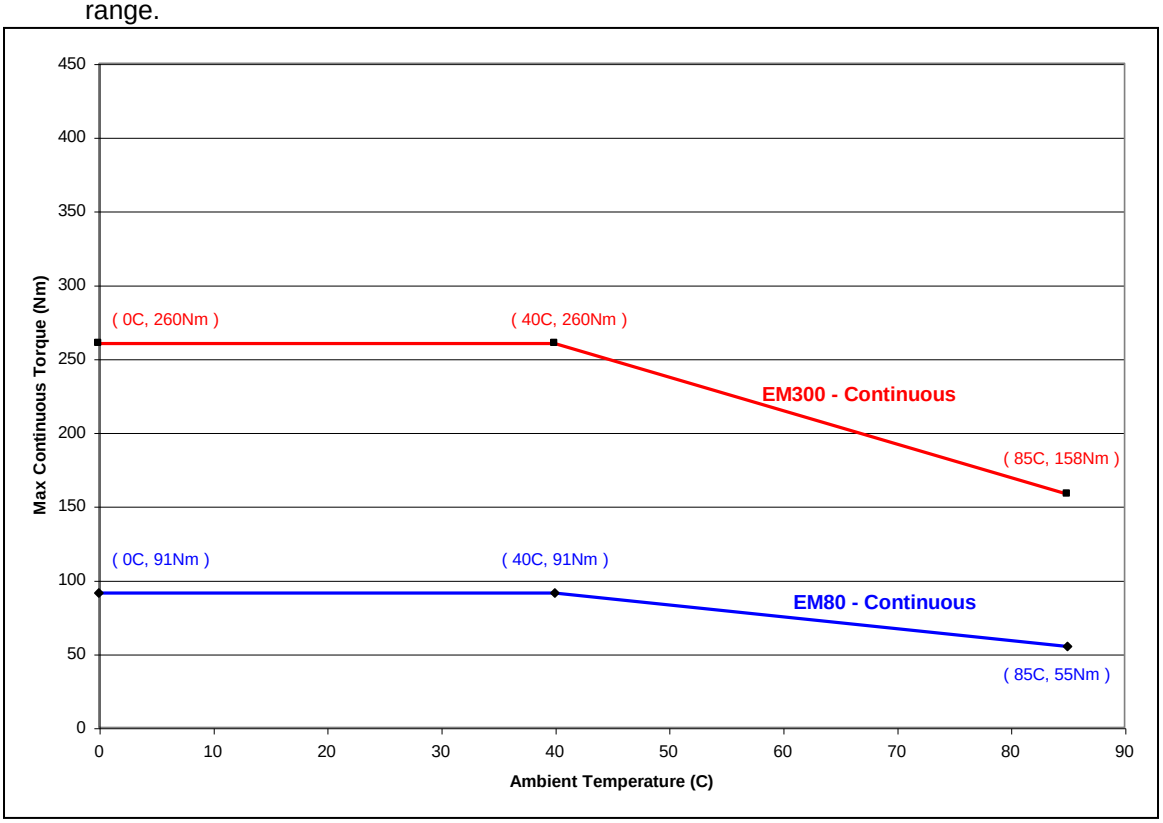


Figure 4-2. Ambient Temperature vs Torque

Engine Linkage Information

Output Flanges

Figure 4-1 shows the hole pattern for the EM-80 and EM-300 actuator output flange. The EM-80 has 11 M6x1 holes with a maximum flange depth of 11 mm. The EM-300 has 11 M8x1.25 holes with a maximum flange depth of 14 mm. In each instance, the thickness of the stop plate and the indicator plate (2 mm each) should be taken into consideration when determining the length of the fastener to be used. Use all 11 holes when attaching the lever onto the actuator output flange. The material of both the flange and the stop and indicator plate is steel.

Terminal Lever Design

The terminal lever for the EM-80 and EM-300 should have a flange mounting.

IMPORTANT

All usual recommendations for highly loaded flange mountings should be observed. Make sure the mounting surfaces of both the lever and the stop and indicator plate are clean and flat. Do *not* remove the stop and indicator plate.

Use all 11 fasteners and torque them to the correct value.

The following requirements must be considered in the lever design:

- The lower end of the lever must have a maximum radius of 62.5 mm (2.46”) as measured from the center of the actuator output flange in order to avoid contacting the protective strip.
- The lever needs to have a 20 mm (0.8”) diameter hole in the rotation center to clear the mounting screw which secures the stop and indicator plate.
- The output flange has a 6 mm (0.2”) dowel pin to position the stop and indicator plate. It is recommended to drill a hole of a larger diameter in the terminal lever at this location in order to avoid damage to the lever or the dowel pin. This pin could be used as a reference for the lever position.

The minimum length of the terminal lever should be at least 150 mm (6”), measured from the center of the actuator output flange to the center of the linkage connection.

Linkage Design—Effects on Slew Time and Acceleration

In designing the linkage required between the EM-80/EM-300 and the driven load, keep in mind the effect that the load torque and the inertia of the linkage have on dynamic performance.

Acceleration of the actuator, linkage, and load system is governed by the following general equation:

$$\alpha := \frac{T}{J}$$

Where:

α = Rotational Acceleration (rad/s²)
T = Net available torque (N·m)
J = Total linkage and load inertia at the actuator shaft (kgm²)

Note 1—The net available torque is the torque that is available for acceleration. This is the maximum torque of the actuator after correction for temperature (refer to the graph in Figure 4-2) minus the torque required to move the rack and overcome friction.

Note 2—The inertia at the actuator shaft is the combined inertia of the linkage and load plus the inertia of the actuator. The inertia of the actuators is:

EM-80 0.209 kgm²
EM-300 1.715 kgm²

Therefore, as the inertia of the linkage and load systems is increased, the acceleration of the system decreases proportionally. Also, as the net torque decreases due to higher and higher loads, the acceleration decreases proportionally.

Additionally, the slew time (time required to travel from stop to stop) of the system is defined by the following equation:

$$\text{Slew\_Time} := \sqrt{2 \cdot \frac{\text{Travel}}{\alpha}}$$

This requires the travel to be in radians, and gives the slew time in seconds.

Substituting for α gives:

$$\text{Slew\_Time} := \sqrt{\frac{2 \cdot \text{Travel} \cdot J}{T}}$$

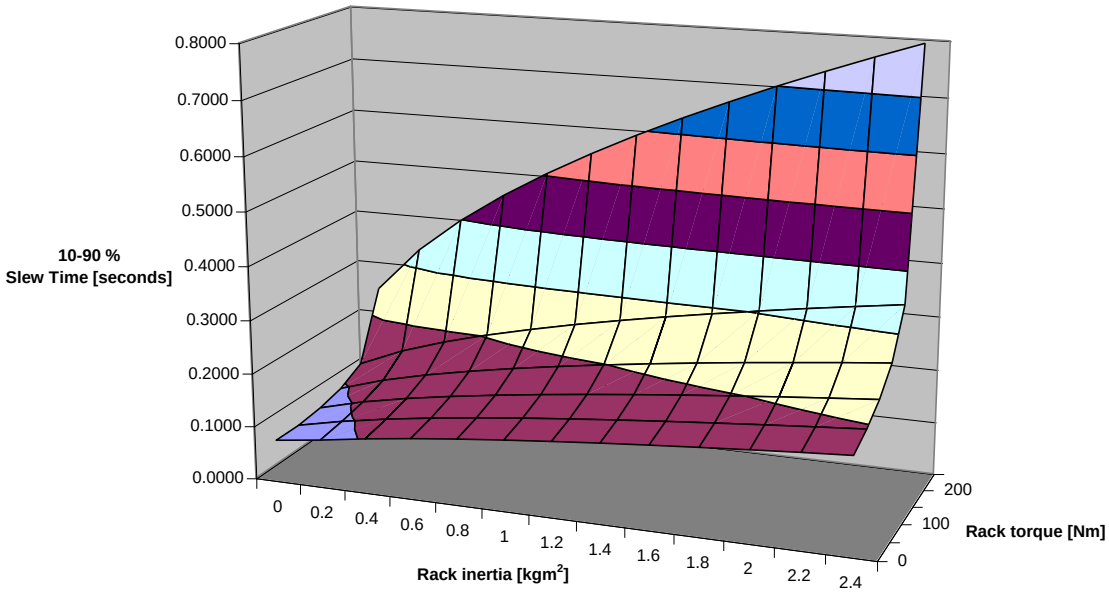
Therefore, as J, load and linkage inertia, increases, the slew time increases by the square root. For instance, if the user doubles the inertia coupled to the actuator, then the unit's acceleration will be 1/2 as fast and the total slew time will be doubled. Also, decreasing the net torque by increasing the load will decrease the acceleration as noted above and therefore also increase the slew time.

Keep in mind that the transient torque which the actuator can produce is limited to a maximum period of one second. Therefore, slew times close to or over one second should be avoided.

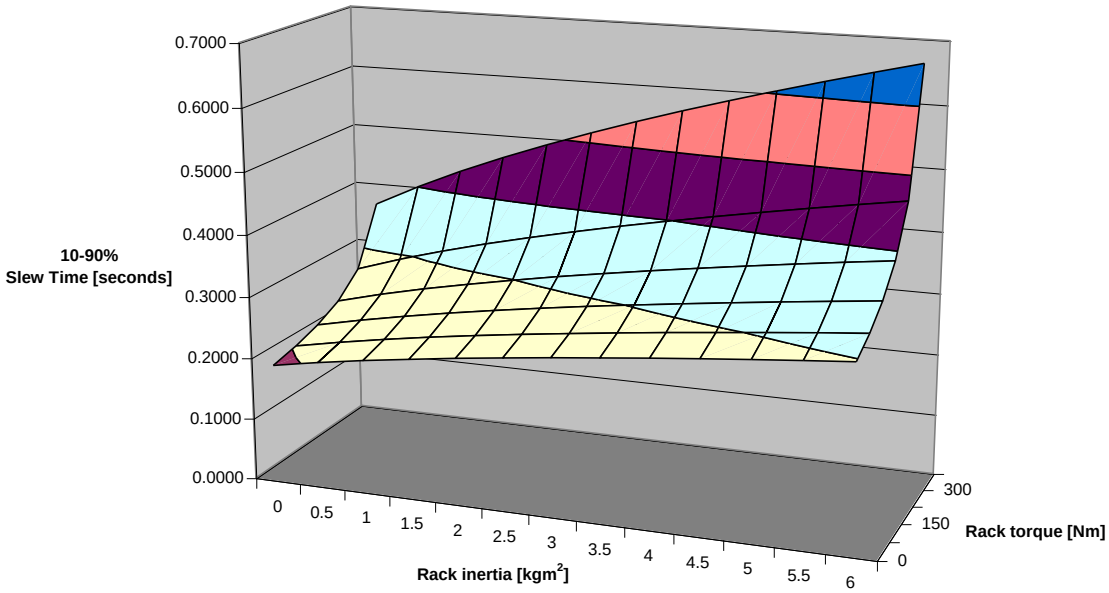
All these factors should be taken into consideration when designing the linkage and load levels to ensure that dynamic performance is not jeopardized.

Using the equations above plus actuator inertia values, the following graphs approximating slew time can be produced. These graphs are for reference in determining slew time changes with changing loads and inertias. The terms Rack Inertia and Rack Torque are the total inertia and torque of the linkage and load system as described above. Therefore, zero Rack Inertia and zero Rack Torque would correspond to a standalone actuator not attached to any load.

EM-80 10-90% Slew Time Approximations



EM-300 10-90% Slew Time Approximations



WARNING

Actuator installation

The end user/OEM is responsible to insure that the actuator leverage and mechanical components are adequately protected or identified with appropriate warnings to avoid pinching or injury to personnel when the fuel rack is positioned

Stops and Pointer Design

The EM-80 and EM-300 actuator does not have internal stops. The stroke of the actuator output flange is limited electronically in the driver to 40°.

For clockwise rotation, the relation between degrees and V:
1 V = 0° on the scale
5 V = 40° on the scale

For counterclockwise rotation, the relation between degrees and V is reversed such that:
1 V = 40° on the scale
5 V = 0° on the scale
Clockwise and counterclockwise rotations are defined looking at the stop and indicator plate end of the actuator where the output lever is attached.

The relation between degrees and the scale can be reversed by reversing the scale on the stop and indicator plate.

The engine linkage and optional mechanical stops should be designed to accept the induced peak loads of the actuator (see specifications in Chapter 9).

If mechanical stops are positioned inside the 40° travel range of the actuator, the stops should be capable of absorbing the actuator mass moment of inertia plus the linkage inertia (see table below) in order not to overstress the actuator.

NOTICE

The EM-80 and EM-300 actuators are capable of creating high loads at maximum slew rate. If stopped suddenly, these loads create high levels of stress to the gearbox as well as to the external mechanical stops and the fuel linkage.

	EM-80	EM-300
Peak theoretical torque	300 N·m (221 lb-ft)	650 N·m (479 lb-ft)
Maximum kinetic energy	7.1 J (5.2 ft-lb)	15.1 J (11.1 ft-lb)
Minimum required spring scale of external stop at an equivalent radius of 0.15 m.	285 N/mm (1627 lbf/in)	625 N/mm (3569 lbf/in)

The system is designed to prevent the actuator from traveling outside the safe 40° zone. Under extreme conditions, it is possible that external influences can cause the actuator to go outside this zone. There are two soft stops at 47.5°, equally placed around the normal operating zone. Inside the 47.5° zone, the actuator can still recover from a power failure and find the correct working zone.

If the actuator travels outside the 47.5° zone, the actuator may not be able to re-locate the proper working zone. Therefore the actuator has a stop plate at the front with an indicator lip at the bottom underneath the protective strip. These stops are designed to prevent accidental rotation by hand of the output flange outside the 47.5° actuator range, but the stops cannot withstand the actuator peak torque. If the actuator travels outside the safe 47.5° zone, the strip will bend and the actuator must be recalibrated by Woodward.

A simple pointer device is installed on the top of the output flange, indicating the position of the output flange on a scale from 0–40°.

WARNING

Actuator installation

To prevent possible damage to the actuator gear box it is recommended that two stops be designed for the fuel rack that would limit actuator travel in the range between the normal 40˚of travel and the safe 47.5˚range. These stops should be engineered to handle the full operating torque of the actuator.

Please note that the stops are NOT installed at Woodward, and the actuator can travel outside of the prescribed angular travel range without the stops. In addition to potentially damaging the gearbox, this may also damage the linkage or cause an overspeed condition.

ALWAYS include an independent over-speed protection device on the engine, even when the mechanical stops are used and ESPECIALLY if the mechanical stops are not used.

Unit to Unit Output Flange Position Repeatability

The variation in the position of the output flange of any actuator relative to its mounting plate is less than ±0.45°. Therefore, exchanging actuators should require minimal recalibration of the linkage system.

IMPORTANT

The pitch circular diameter for the output lever on the EM-80 is different from the one on the EM-300.

Maximum Side Loading

Actuator	Maximum Radial Load
EM-80	1.3 kN
EM-300	2.9 kN

EM-80/-300 Actuator Specifications

A complete listing of specifications and regulatory compliance is available in Chapter 9.

Chapter 5.
Driver Overview and Installation

General Description

Read and follow all safety instructions given in Chapter 1, General Safety Precautions.

The driver is the device which receives the actuator position command signal from the controller and positions the actuator by means of controlling the current and potential of the three phases of the actuator electromotor. The driver is field-configurable for the type of actuator (EM-80 or EM-300) and the desired direction of output shaft rotation (CW or CCW). The default parameters as shipped from Woodward for the general market driver, 3522-1042, are pre-adjusted to the EM-300 actuator with a counter-clockwise rotation, but can be changed during installation. The adjustment procedure of the driver's application parameters is described in Appendix E.

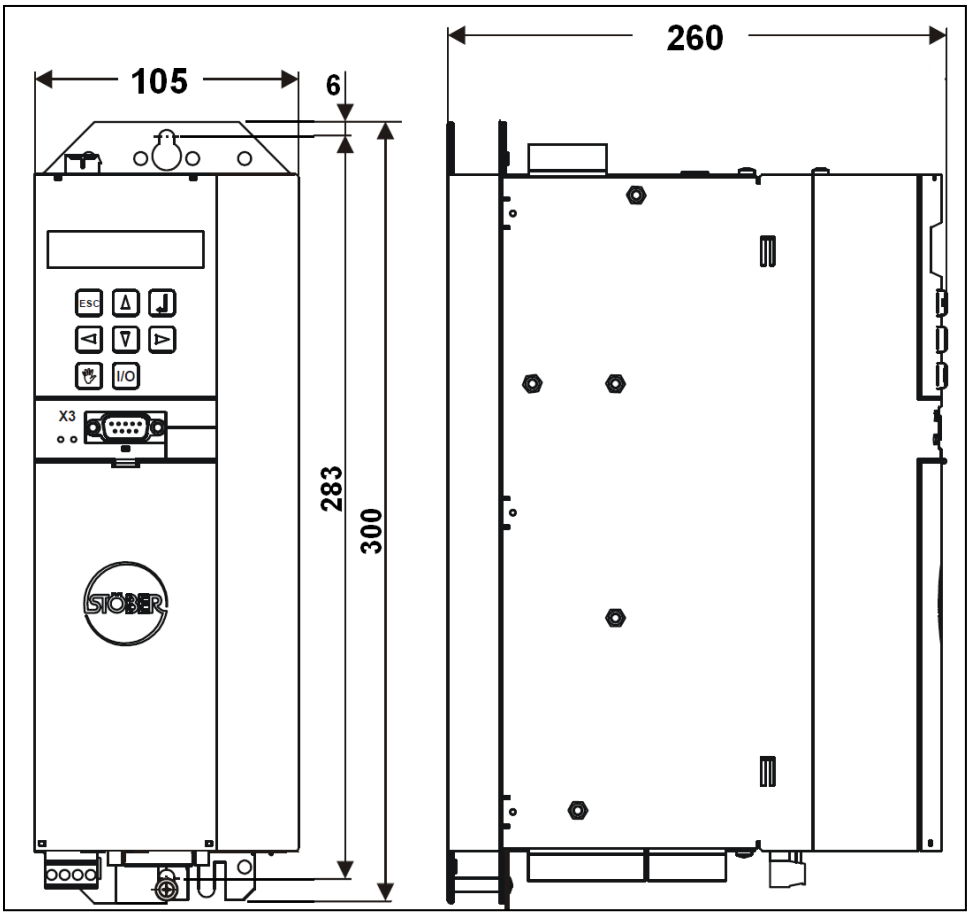


Figure 5-1. EM-80/300 Driver Dimensions (mm)

Installation

WARNING

HIGH VOLTAGE—The power converter's power cables are energized.

WARNING

The Contact of the Ready for Use Output on X101 of the EM-80/-300 driver must be integrated into the Emergency Shutdown system of the prime mover.

WARNING

Stopping the drive using the enable inputs of the control electronics does not by itself represent a safe stop condition. A disturbance in the driver's control electronics can lead to accidental starting of the motor.

The owner is responsible for assembly of the described device in accordance with safety regulations, such as DIN or VDE. You must ensure that all other relevant national and local regulations are met with regard to cable ratings and protection, grounding, disconnectors, overcurrent protection, etc.

In emergency shut down situations, the driver should be shut down by simultaneously closing the STOP input contacts and setting the command input to 3.8 mA or less.

Make sure that electrical components are not mechanically damaged or impaired as this could lead to personal injury!

NOTICE

During operation, the principles on which the driver and the motor work lead to leakage currents to earth that are dissipated via the specified protective earths and may result in a current-operated earth leakage circuit breakers (e.l.c.b.) on the input side blowing prematurely.

Make sure that components have not been warped or damaged during transportation and handling.

Avoid touching electronic components and contacts. The driver contains components which can be damaged by electrostatic energy caused by incorrect handling.

WARNING

ELECTRIC SHOCK HAZARD—Before installing accessories to the driver, turn off all voltage supplies! Then wait for 5 minutes for the DC link capacitors to discharge. Never begin with accessory installation shortly after the power is off. Death or serious injury could result.

Installation of the Driver in the Switch Cabinet

NOTICE

It is essential to comply with the following installation instructions to avoid device and property damage.

- The driver must be installed in the switching cabinet. The installation site must be free of dust, corrosive fumes and all kinds of liquids.
- The installation site must be free of atmospheric moisture.
- Avoid condensation (e.g., use anti-condensation heating elements).
- Use mounting plates where conductive surfaces (e.g. unpainted) for EMC considerations.
- Secure the driver to mounting plate with M5 screws.
- Mount to a vertical plate or to the side or back of the cabinet. The unit must be supported from the side for vibration resilience.
- The drivers must be installed vertically. Mounting attitude and examples of support assemblies are shown in Figure 5-2.

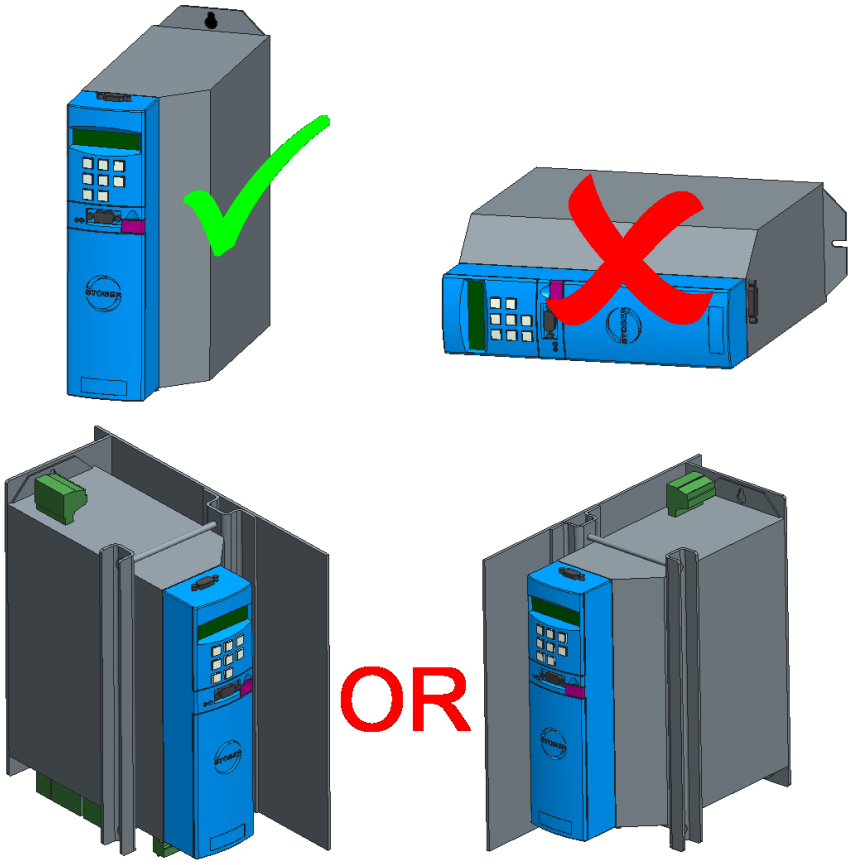


Figure 5-2. Driver Position in Cabinet

Ventilation and Cooling

NOTICE

You must comply with the ventilation requirements listed below. Ignoring these requirements can lead to the device overheating.

Ensure that there is no blockage of cooling air flowing into and out of the equipment and that there is enough space above and below the equipment to prevent overheating.

The units must be installed in commercially available cabinets that meet the following requirements.

- Ventilation must be in the specified direction from the bottom to the top.
- Ensure that the flow of air is not obstructed.
- There must be a minimum clearance of 100 mm above and below, and 5 mm left and right from the driver for better ventilation pathway. There should not be any blockage of cooling air flowing into and out of the driver.
- The temperature of the coolant 50 mm below the devices may be up to 45 °C. At higher temperatures (up to a maximum of 55 °C), you must reduce the power of the devices by 3% per °C.
- Do not locate any additional sources of heat above or below the devices.

Mounting Dimension

Secure the unit to the panel with two M5 type screws. The larger hole is provided for clearance of the head of the fastener.

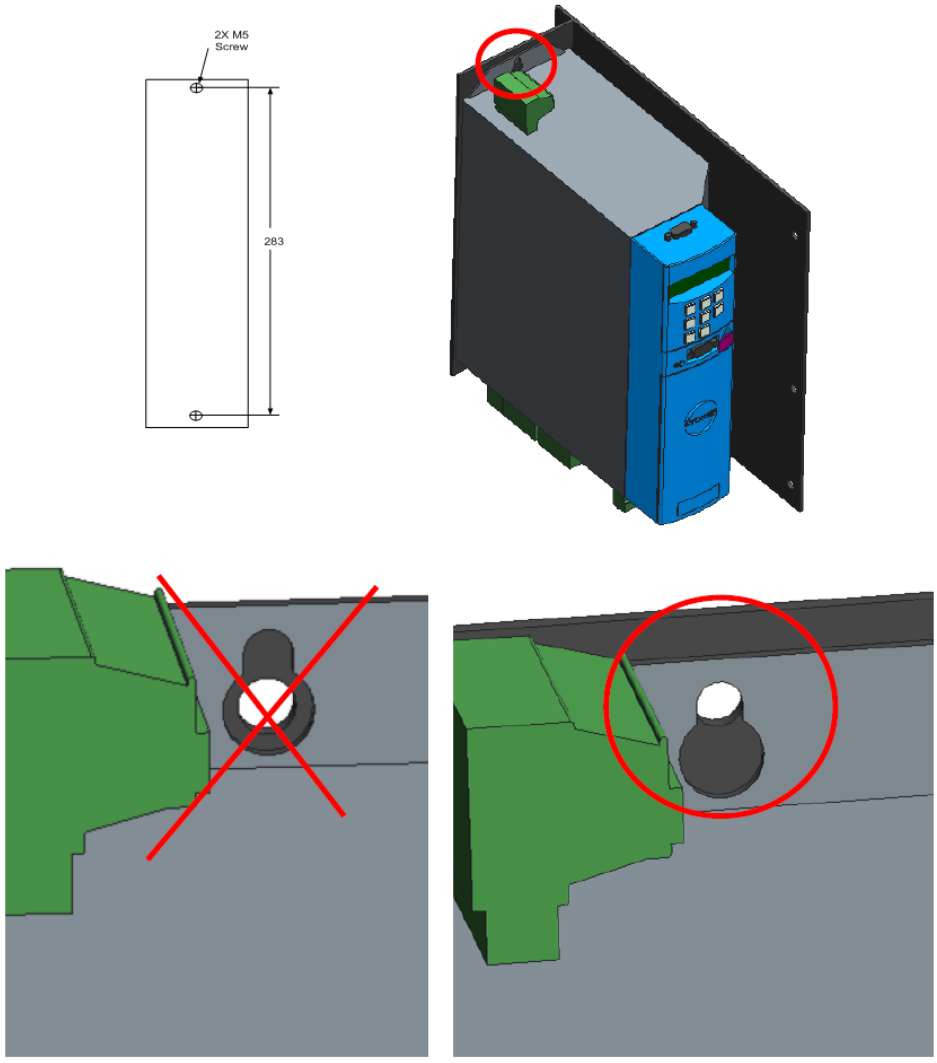


Figure 5-3. Driver Mounting Profile Dimension

NOTICE **There must be a minimum clearance from the driver to any cable or panel for better venting to the unit.**

It is important to keep a minimum free spacing from the driver to provide better ventilation during the installation. Ensure that there is no blockage of cooling air flowing into and out of the driver for a safe operation.

Min. Free Space (dimensions in mm)	Up	Down	To Right	To Left	Screws
Without EMC Shield Plate	100	100	5	5	M5

Table 5-1. Minimum Free Space Requirement

Electrical Connections

Driver Terminal and Connectors Overview

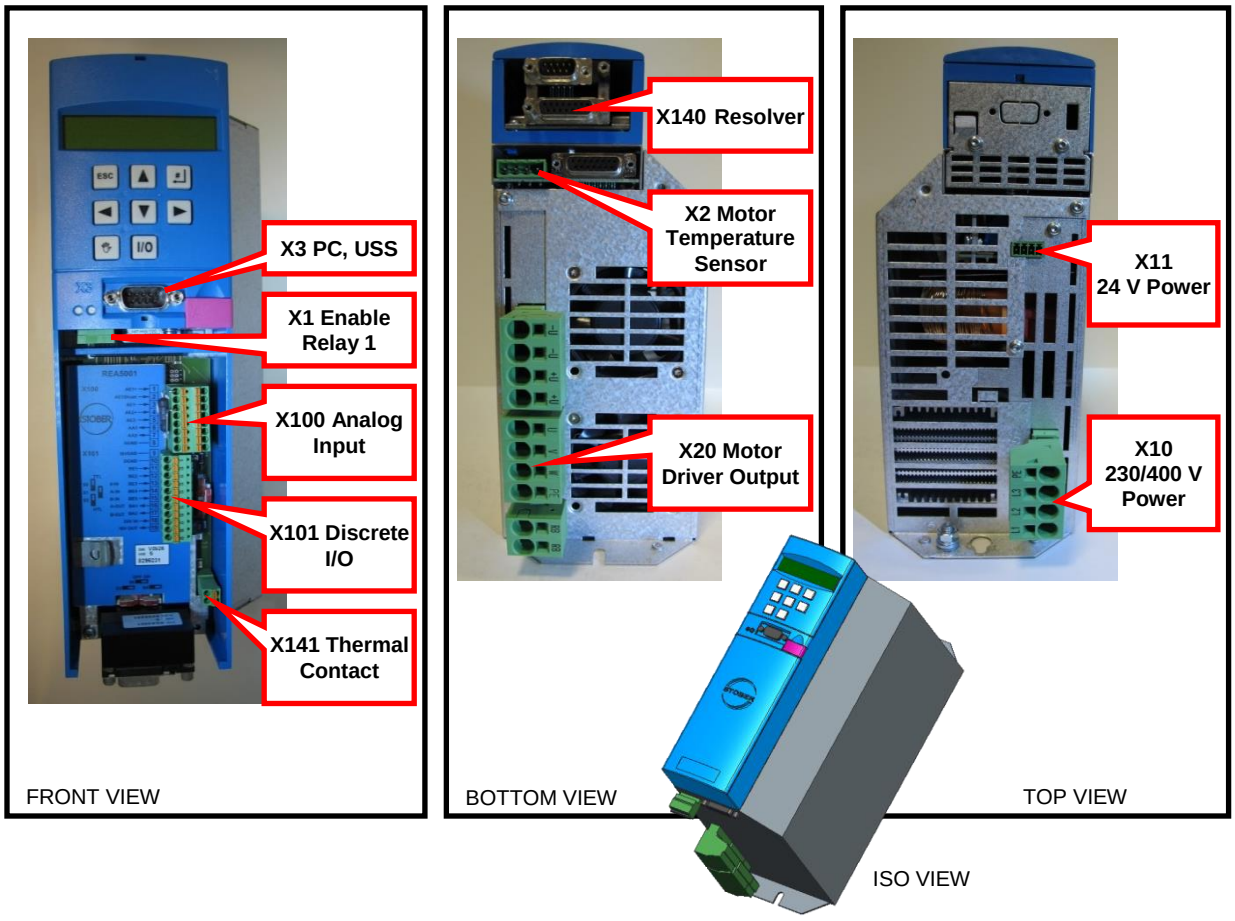


Figure 5-4. Driver Electrical Connection

Proper Torque Recommendation

Wires secured to all power connectors require proper torque to ensure no wires will loosen from the terminal block.

Connector	Minimum Stud Torque Recommendation	
Unit	N·m (metric)	lbf-in (imperial)
X10	2.5	22
X11	0.5	4.4
X20	2.5	22
X21	1.2	11
X22	1.2	11

Table 5-2. Minimum Torque Requirement

24 Vdc Power Supply

The X11 connector is the main power connector to the motor controller module. The power supply must be 24 Vdc ±10%, rated for 55 W or more. The positive terminal of the power supply is connected to X11-1, negative to X11-3. It is recommended that a 4 A slow blow fuse be installed in the positive side of the supply. In order to comply with marine certification requirements, the power supply output must be electrically isolated from the driver chassis and actuator housing.

NOTICE

For EMC compliance purposes, 24 Vdc power must always be provided through a dedicated system supply. The driver should NOT be connected to a plant-wide distributed DC power network

NOTICE

Over or under voltage of the 24 Vdc supply can lead to loss of position control of the actuator and/or damage to the controller. For reliable operation, the EM-80/-300 requires this source to be in the range of 20.4 Vdc to 28.8 Vdc.

⚠WARNING

An external low voltage detection may be necessary for the 24 Vdc line monitor to avoid system damage. Emergency shutdown valves and other safety devices necessary to avoid damage or injury should be set to activate any time a shutdown fault is detected.

X11 – 24 V Power Terminal

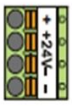
PIN		Signal / Function	Description
	+	+ 24 V	**Auxiliary voltage** For powering the control electronics
	+	+ 24 V	
	-	GND	**Reference potential** for +24 V
	-	GND	

Table 5-3. 24 V Power

3-phase Input Power

Three-phase input power is connected to the driver X10 connector, terminals L1, L2, and L3 through a suppressor filter as described in '3-Phase AC Power Filtering' in this chapter. The protective earth or shield must be connected to the ground terminal adjacent to terminal L3. The input power specification is 400–480 Vac ±10% line-to-line. The relative phasing of the input terminals is unimportant.

In some field applications that have chosen to power the driver with redundant single-phase back-up power, the driver may be subjected to high in-rush currents if switched quickly to and from the single-phase power supply. Refer to Appendix D for further wiring installation and operation details.

The device's cables and output are protected with the aid of the line protection. For this purpose various protective devices may be used:

- Full range fuse (class "gG" in accordance with IEC class specification or "slow blow" in accordance with VDE)—For UL conformance, use fuses of the class RK1 (e.g., Bussmann KTS-R-xxA/600 V).
- Circuit breaker—Use line circuit breakers with tripping characteristic C as per EN 60898. Woodward recommends the usage of hydraulic-magnetic breakers to avoid thermal effects on tripping characteristics. This breaker technology allows wide swings in ambient temperature, but preserves the desired over-current trip point.

See Table 5-4(b) for nominal input current and protection rating information. Note that the values in the table are for the maximum current capabilities of the driver hardware, and that 3 x 30 A fusing will be adequate for the EM-80/-300 driver applications, providing the installation wiring can handle these currents comfortably.

WARNING

To prevent over-heating of wiring and associated damage or the possibility of fire, ensure that the wiring used in the installation can handle the necessary currents. Also ensure that the chosen fusing or breaker protection is also selected to protect not only the driver, but also the wiring.

X10 – AC Input Power Terminal

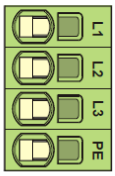
Pin	Designation	Function
	L1	Input voltage
	L2	
	L3	
	PE	Protective conductor

Table 5-4a. AC Input Power Wiring

Input current I_{Nom}	Protection rating		
	Recommended	for UL-compliant use	for DC link connection in group 1
3 x 32,6 A	3 x 50 A	3 x 50 A	3 x 50 A

Table 5-4b. AC Input Power Current/Protection Ratings

3-phase AC Power Filtering

A power-line filter (P/N 1326-1125) is only required for marine-compliant systems which incorporate a grounded power network (e.g., TN or TT). For land-based systems which incorporate a grounded power network, the customer may elect to purchase the filter for added robustness; however, it is not required for CE Mark compliance.

For marine or land-based systems which incorporate isolated power (e.g., IT), a power filter is NOT recommended due to the possible safety and reliability concerns associated with the filter's internal RC networks to earth, particularly during an input phase or motor phase fault condition. Additionally, the normal leakage current through the filter's internal RC network may not be compatible with insulation monitors used in IT power networks and may cause nuisance faults.

The driver is also equipped with the option of removing the internal EMC filters by removing two identified screws on the side of the housing. For TN and TT power networks, the internal filters must remain installed for proper EMC performance. For IT power networks, it is also recommended that the internal filters remain installed unless the filters are determined to be incompatible with the leakage monitor limits in the system. In this case, the customer can elect to remove the internal filtering (by removing the screws on the housing), however it should be noted that this could result in decreased EMC immunity performance.

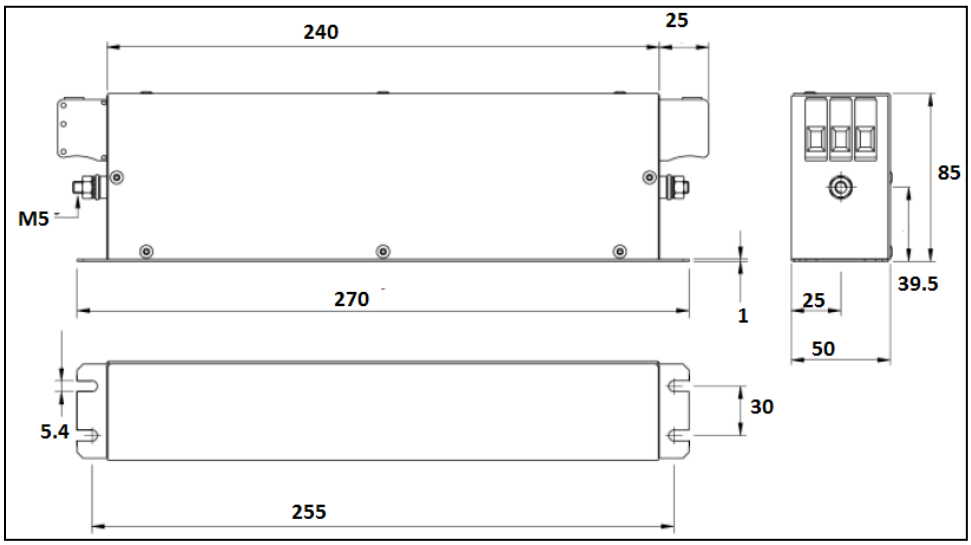


Figure 5-5. 1326-1125 Filter Assembly (mm)

NOTICE

Overcurrent protection devices recommended in this manual are intended to provide protection against faults which result in increased current flow, and therefore, increased heating and the probability of the start and spread of fire.

3-Phase Actuator Power

The driver power outputs to the actuator are at connector X20 terminals U, V, W, and the protective earth/shield terminal adjacent to W. Proper phasing between the output terminals and the actuator terminals must be observed.

X20 – Actuator Motor Terminal

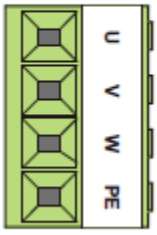
	Designation	Function
	U	Motor connection, phase U
	V	Motor connection, phase V
	W	Motor connection, phase W
	PE	Protective conductor

Table 5-5. Actuator (Motor) Connection

WARNING

An incorrect wiring of the actuator connection could cause the motor to operate unpredictably, possibly resulting in an overspeed of the prime mover. Please thoroughly check all connections before operation, especially if performing a retrofit from an older driver. The previous version of the EM-80/-300 driver is wired differently.

NOTICE

Woodward recommends independent input power phase monitoring to ensure annunciation of a failed 3-phase power source.

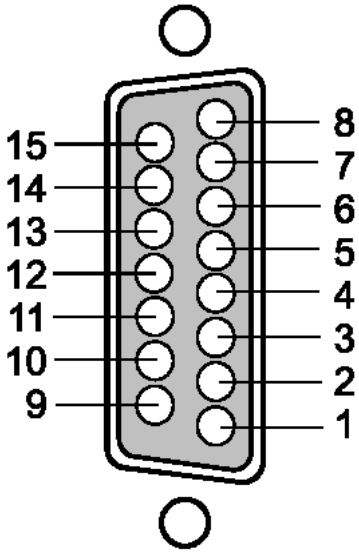
Actuator Resolver Input Signal (X140)

The X140 connector is the resolver interface port that consisted of DB 15 connector.

Electrical Spec:

Encoder Supply = 5–15 V
I max = 500 mA
Frequency = 7–9 kHz

Motor Controller Connectors



Pin No.	Assignment
1	Resolver sin+
2	EXC–
3	Resolver cos+
4	N/C
5	N/C
6	EXC+
7	TEMP+MOT
8	N/C
9	Resolver sin–
10	N/C
11	Resolver cos–
12	N/C
13	N/C
14	TEMP - MOT
15	N/C

Table 5-6. Resolver Pins Designation

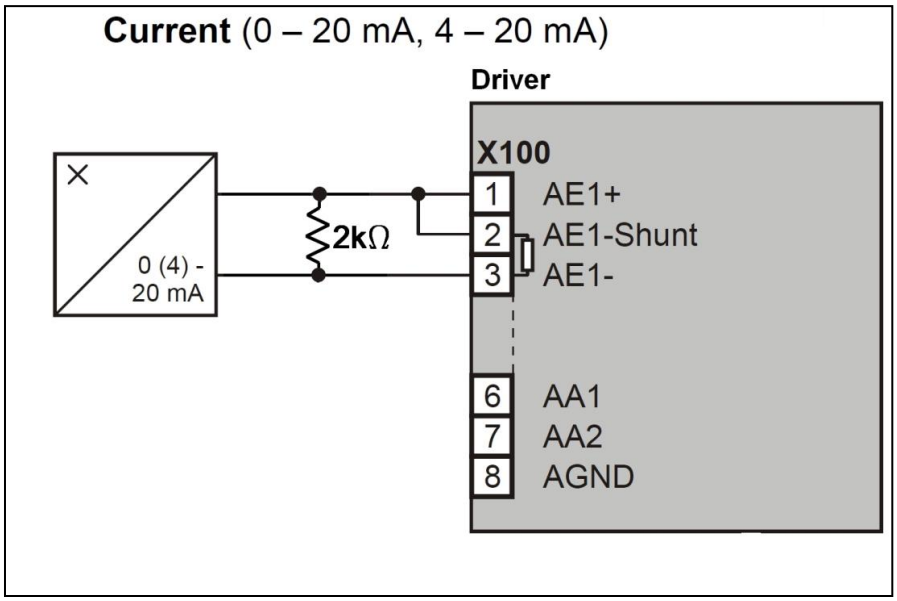
In addition to the DB-15 connector at one end of the cable, this cable has three flying leads for EM-300 potentiometer feedback signals: POT_V, POT(+), POT(–). For usage with an EM-80 actuator, the unused flying leads need to be electrically insulated from touching metallic surfaces, or one another, and secured to the harness using tie wraps or similar. Woodward provides a resolver cable for new installations. The Woodward item number for the resolver cable in various lengths are shown in Table 5-7.

Woodward P/N	Length (meters)
5450-1729.10	10
5450-1729.20	20
5450-1729.30	30
5450-1729.40	40
5450-1729.60	60
5450-1738	(RETROFIT ADAPTOR)

Table 5-7. Resolver Cables Available from Woodward

Position Command Input (X100)

This is the signal from the engine controller and represents the required actuator position. The analog input (analog input 1) of the driver accepts a 4–20 mA input with a shunt load of 406 Ohm provided by the parallel combination of an internal and external resistor. The 4–20 mA input corresponds to 0–40 degree stroke on the actuator.



NOTICE

The 2 kΩ external shunt resistor attached to the connector for X100 is REQUIRED for proper operation of the driver. It is installed and tested at the factory. Do not remove.

NOTICE

When the position demand signal falls below 3.6mA fault #64 "Pos DMS lost" will appear on LCD display. By default, when fault #64 appears the output torque is not powered even if the position demand signal is restored. See Appendix E "Fault #64 (Pos DMD lost) Behavior" to setting up desired action

X100 Terminals

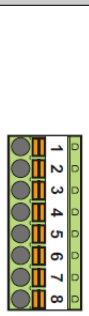
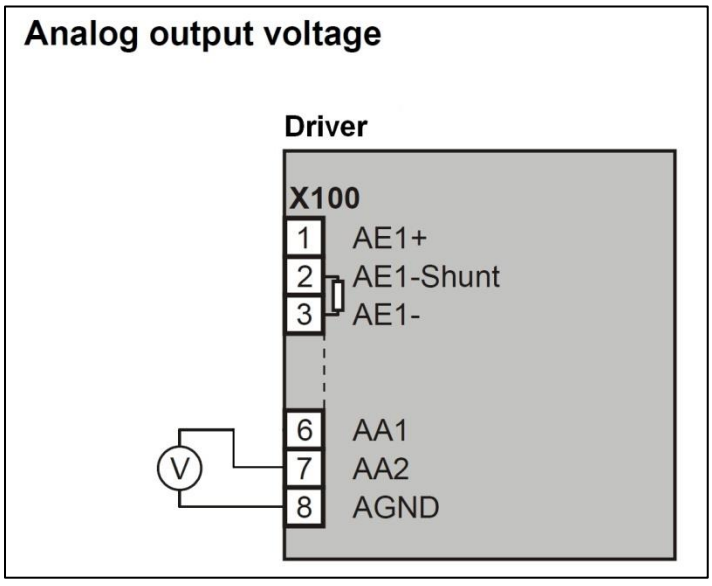
Pin	Designation	Function
 1	AE1+	+ Input of the analog input AE1;
2	AE1-Shunt	Current input; shunt connection Pin 2 must be jumpered with pin 1.
3	AE1-	Inverted input of analog input AE1

Table 5-8. Analog Input Wiring

Actual Position Readout (X100)

The analog output (analog output 2) provides a 1–5 V indication of the actuator's actual position. The 1–5 V output signal corresponds to 0–40 degree stroke of the actuator's output shaft.



NOTICE

Woodward recommends that the end user monitors the Position Readout for enhanced system error detection.

The Position Readout signal is meant only as an indicator of output shaft position. Do NOT use this output for any type of closed loop control.

X100 Terminals

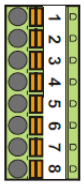
Pin		Designation	Function
	7	AA2	Analog output 2
	8	AGND	Reference ground for analog signals

Table 5-9. Analog Output Wiring

EM-300 Potentiometer Feedback (X100)

Connect the EM-300 potentiometer feedback signal according the control wiring diagram to enable the operation of the EM-300. This input signal is connected to analog input 2.

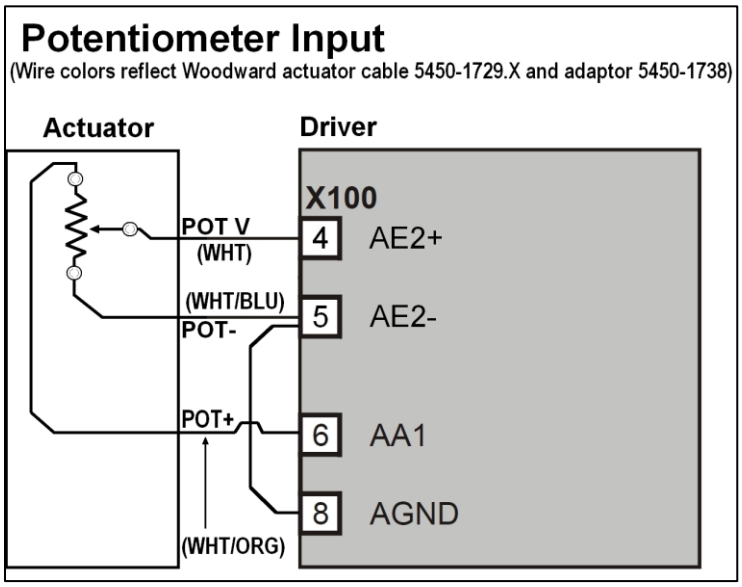
POT_V, POT–, POT+ are built into the resolver cable (WW PN: 5450-1729). All three ends are flying leads and they should be connected to X100 terminal per wiring diagram (Figure 3-2) when either an EM-80 or EM-300 actuator is in use. While the EM-80 does not use the potentiometer input, this wiring can help detect an incorrect configuration when using the configurable version of the driver. This feedback signal is constantly monitored when used with EM-300 installations and provides useful error detection.

The potentiometer used is a 10 kΩ, 10-turn pot and it is added behind the resolver to supply a coarse position signal from which the correct rotor revolution is deduced.

Following installation, it is recommended to check the potentiometer is in calibrated range by moving the actuator to the minimum and maximum position and verify that no out-of-range faults are detected by the driver. The value of this potentiometer is constantly monitored and a fault will occur if the EM-300 actuator steps outside the proper range, or the potentiometer or associated wiring fails.

NOTICE

While only functional in EM-300 applications, Woodward recommends connecting the Potentiometer Feedback wiring in ALL EM-80 or EM-300 installations for enhanced error detection, especially when using a driver that is configurable for both actuators (e.g., 3522-1042).



X100 Terminals

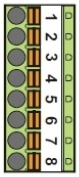
Pin	Designation	Function
 4	AE2+	+ Input of analog input AE2
5	AE2-	Inverted input of analog input AE2
6	AA1	Analog output 1 **(drives potentiometer)**

Table 5-10. Potentiometer Input Wiring

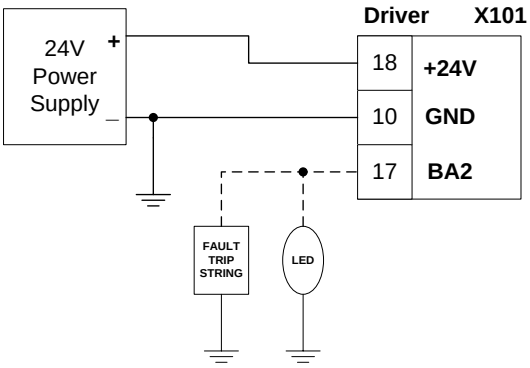
Ready for Use Output (X101 Connector)

This discrete output can be used by an external system to indicate the status of the actuator system. The output is energized (closed) when all driver faults are cleared, indicating the unit is ready for use. The Ready for Use output is configured to be in a normally off state.

WARNING

The Ready for Use signal is de-energized when the 24 Vdc supply drops below 16.8 Vdc or the PLC stops functioning. Emergency shutdown valves and other safety devices necessary to avoid damage or injury should be set to activate any time a shutdown fault is detected by the EM-80/-300 driver.

See Figure 3-2 for the most common wiring scheme for the Ready for Use output.



X101 Terminals

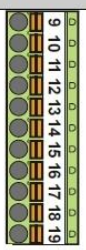
Pin[1]	Designation	Function
 10	DGND	Reference ground for pins 11 to 18
17	BA2	Binary output

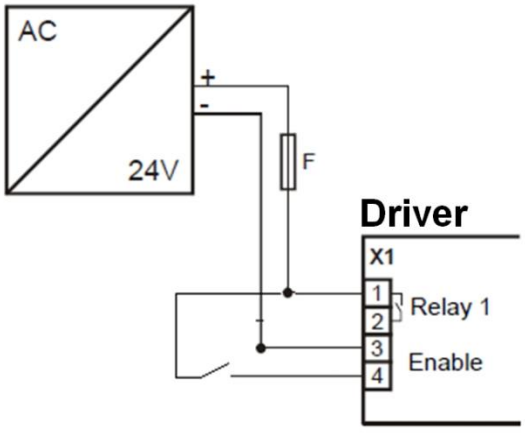
Table 5-11. Ready For Use Output Wiring

NOTICE

Whenever the Ready For Use output changes state, the Common Alarm output will ALSO change state, making the Common Alarm output a convenient indicator of a failure in the Ready For Use wiring or circuitry.

Pulse Enabling (X1 Connector)

This signal is an isolated digital input which needs to be set “high” to enable the power pack of the driver, allowing for proper actuator operation. When open (low), power to the driver output is removed.



X1 Terminals

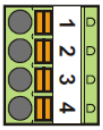
Pin		Designation	Function
	3	GND	Enable of the power pack
	4	+ Input	

Table 5-12. Pulse Enable Signal Wiring

E-Stop Discrete Input (X101 Connector)

This signal is a digital input which, when active, will move the actuator to its minimum position For the general market version of the product, this input is configurable such that it can be active-high (E-Stop when 24 V applied) or active-low (E-Stop when 0 V or open). Instructions for configuring this input can be found in Appendix E.

X101 Terminals

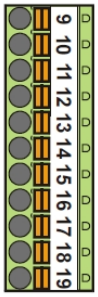
Pin		Designation	Function
	10	DGND	Reference ground for pins 11 to 18
	11	BE1	Binary input

Table 5-13. E-Stop Signal Wiring

WARNING

In drivers that allow configuration of the E-Stop input (such as 3522-1042), Woodward recommends using the 'active-low' setting. This will help to ensure that the actuator system will go to minimum position in the event of a broken wire into X101, BE1 (pin 10).

To further enhance safety, Woodward also recommends that if E-Stop is wired in systems, also configure the system supervisory controller (supplied by end user) to command the analog demand input to minimum position when E-Stop is activated. This will provide for two independent means of moving the actuator to a minimum position.

Reset Discrete Input (X101 Connector)

This signal is a digital input which, when active, will serve as means to acknowledge active alarms and if the cause of the fault has been removed, reset the device for proper function. The same functionality can be achieved be pressing the “ESC” key in the front panel.

X101 Terminals

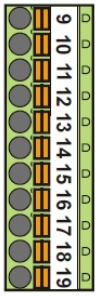
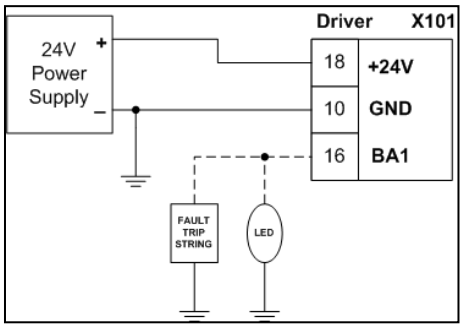
Pin		Designation	Function
	10	DGND	Reference ground for pins 11 to 18
	12	BE2	Binary input

Table 5-14. Reset Signal Wiring

Common Alarm Output (X101 Connector)

This signal is a discrete contact output for indicating the health of the 3-phase driver and actuator position errors. If the driver circuitry goes off-line, or a position error is detected, the common alarm output will change state from closed to open. This output will also change state whenever the Ready For Use output changes state. This behavior is useful for detecting any open-wire or functional faults within the Ready For Use output circuitry. This output is normally closed to allow for its usage in a system error trip string. It will only open in the case of a genuine fault or in the case of a broken wire connected to this circuit.

The output is driven by the supply that is wired to X101, pin 18, which is normally the same 24 Vdc source that is driving into X11. It will be necessary to bring 24 V to X101, pin 18, as this is not wired to X11 internally.



X101 Terminals

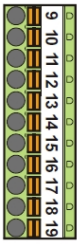
Pin	Designation	Function
 10	DGND	Reference ground for pins 11 to 18
16	BA1	Binary output

Table 5-15. Common Alarm Output Wiring

Chapter 6.
Driver Functional Indicators

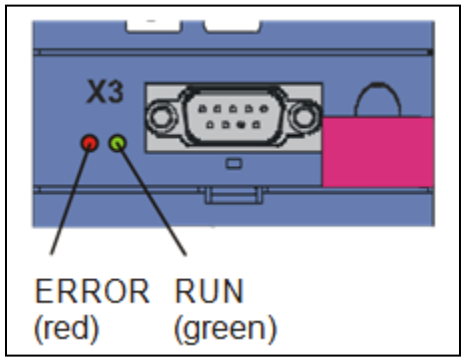
Driver Displays

LCD Status Display

The LCD panel is used for monitoring and changing parameter values. The panel consists of a two-line display with 16 characters per line and a keyboard. The keyboard has six keys for menu prompting and two keys for local operation.

Except monitoring and changing the parameter functionality – LCD display provides the status of the motor controller module.

LED – Diagnosis



The LEDs on the front of driver give user a quick overview of the state of the driver. A green and red LED which light up in a different combination and frequencies provide information on the device's status based on a following table.

LEDs			State of the Driver
ERROR (red)	●	OFF	No power
RUN (green)	●	OFF	
ERROR (red)	●	OFF/ON	Device initialization (startup phase) or data
RUN (green)	✳	Flashing at 8 Hz	action. Para module is not installed correctly.
ERROR (red)	●	OFF	Ready for operation (not enabled)
RUN (green)	✳	Flashing at 1 Hz	
ERROR (red)	●	OFF	Operation (enabled)
RUN(green)	✳	ON	
ERROR (red)	✳	Flashing at 1 Hz	Warning (See LCD display for relevant
RUN(green)	✳	ON or flashing	warning information)
ERROR (red)	✳	ON	Fault (See LCD display for relevant fault
RUN(green)	●	OFF	information)
ERROR (red)	✳	Flashing at 8 Hz	No configuration active
RUN (green)	●	OFF	

Before proceeding with commissioning, it is recommended to check the cable connection. Woodward provides a resolver cable in various lengths (see Table 5-7).

Event Indications

Events

Event indications on the display give the user information on a state of the device. The event list (Appendix B) gives user a list of event indications.

The device provides notes on the cause of some of the events. These events are marked with a number and appear alternatively to the event indicators on the display. Causes which are not documented with a number in the event description are only an indication of possible faults. They do not appear on a display. See Appendix B for greater detail on the fault types and potential causes.

Chapter 7.
Maintenance

Read and follow all safety instructions given in Chapter 1, General Safety Precautions.

WARNING

HIGH VOLTAGE—Do not begin work on the power stage or the intermediate circuit until you have made sure that the unit is not carrying potential or a voltage (remnant charge).

NOTICE

Before touching the modules, you must discharge electrostatic energy from your body to protect electronic components from high voltages resulting from electrostatic discharge. The easiest way to do this is to touch a grounded conductive object before handling components.

NOTICE

The units supplied are maintenance-free. Do not attempt to make modifications.

Under normal operating and environmental conditions as described in this manual, the actuator requires no interval maintenance.

Prolonged usage at the maximum temperature of 85 °C may require replacement of the gearbox oil after a period of approximately five years. If a unit is being used in such an extreme environment, it is advised that the customer contact Woodward for assistance in having the oil replaced by the gearbox manufacturer at five-year intervals. The gearbox is sealed, and it is not possible to replace the oil without complete disassembly.

Chapter 8. Troubleshooting

Introduction

Read and follow all safety instructions given in Chapter 1, General Safety Precautions.

Improper engine operation is often the result of factors other than governor operation. This chapter gives tips about engine problems which can resemble governor problems. Make sure the engine is operating correctly before making any changes in the governor. The following troubleshooting guide is an aid in isolating trouble to the control box, actuator, wiring, or elsewhere. Troubleshooting beyond this level is recommended ONLY when a complete facility for control testing is available.

Attempting to correct engine or load problems with untimely governor adjustment can make problems worse. If possible, isolate the governor from the engine to determine if the problem is with the governor and not with the engine or the load on the engine. Governor faults are usually caused by problems in the installation or the linkage between the actuator and the engine.

Carefully review all the wiring connections, the power supply, and the linkage before making any adjustments to the actuator or driver. Always check the fuel-control linkage from stop to stop as if the actuator were moving it. The linkage must move freely without friction and without backlash. Some fuel controls will present problems at particular fuel or rack positions because of a hesitation or binding in the linkage.

Fuel supply and injector conditions can also present problems which resemble governor problems. On spark-ignited engines, distributor, coil, points, and timing problems can all cause improper operations which may resemble faulty governor control.

NOTICE

The control can be damaged by the wrong input voltage. When replacing a control, check the power supply, battery, etc., for the correct voltage.

Troubleshooting Procedure

This chapter is a general guide for isolating system problems. The guide assumes that the system wiring, soldering connections, switch and relay contacts, and input and output connections are correct and in good working order. Make the checks in the order indicated. Various system checks assume that the prior checks have been properly done.

General System Troubleshooting Guide

The following is a general troubleshooting guide for areas to check which may present potential difficulties. By making the checks appropriate to your engine/turbine before contacting Woodward for technical assistance, your system problems can be more quickly and accurately assessed.

Actuators

- Is the actuator wiring correct?
- Is the direction of the stroke correct?
- Has the feedback signal been calibrated?

Linkage

- Is there slop or lost motion?
- Is there misalignment, binding, or side loading?
- Is there visible wear or scarring?
- Does the linkage move smoothly?

Mechanical Troubleshooting Guide

Linkage and Actuator Stroke

Use as much of the 40 degrees of actuator stroke as possible. Carefully follow the guidelines in Chapter 4 in making linkage arrangements. Using less than optimum actuator movement will make stability more difficult, and will make the actuator more sensitive to external loading forces and friction.

Actuator exhibits “hunt” or large limit cycle:

- Check for loose terminal lever.
- Check for loose or worn linkage.
- Verify correct mounting hardware.
- Verify mounting bolts are tightened to appropriate torque values.

Unable to rotate stand-alone actuator in unpowered condition:

- Internal mechanical failure—replace actuator.

Actuator Problems

If the EM-80/-300 actuator fails to run, do the following actions.

Verify any fault indications on the driver. If the actuator appears jammed, then:

- Monitor the actuator current. If the current is low, the actuator is not jamming.
- Remove the linkage from the actuator and verify that the linkage moves freely.

Electrical Troubleshooting Guide

EM-Actuator Cabling

To verify electrical connections within the actuator and cables, disconnect the electrical cables at the EM driver and measure resistances between connector terminals. Note that the following resistances are approximate and do not include tolerances or electric cable resistance. This test is to check for open or short circuits only.

Motor Windings:

- X20 pins U to V: approximately 0.5 Ω
- X20 pins V to W: approximately 0.5 Ω
- X20 pins W to U: approximately 0.5 Ω

Resolver Connector:

- X140 pins 1 to 2: approximately 65 Ω
- X140 pins 5 to 9: approximately 85 Ω
- X140 pins 7 to 8: approximately 85 Ω

Resolver

If the Resolver Feedback is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded.
- Check the wiring. Look for a loose connection at the connector and disconnected or misconnected cables. Make sure the cable is connected to the X140 connection.
- Verify cabling impedances per ‘EM Actuator Cabling’ section above.

Analog Input

If the Analog Input is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded.
- Using an ammeter, measure the input current on the terminal block. It should be in the range of 4–20 mA from terminal X100, pin 1 and 3.
- Verify that there are minimal or no ac components to the Analog Input signal. AC components can be caused by improper shielding.
- Check the wiring. Look for a loose connection at the connector and disconnected or misconnected cables.
- Verify that the external 2 kΩ resistor is in place across X100 pins 1 and 3. A resistance measurement across this resistor equals approximately 406Ω (because it is in parallel with an internal 510Ω resistor)
- Verify the jumper is in place between X100, pins 1 and 2. This jumper connects the internal resistor for proper scaling.

Analog Output

If the Analog Output is not functioning properly, verify the following:

- Check that the cable is shielded and the shield is properly grounded.
- Check the load resistance, ensure that it is less than the specification limit for the output current. The output can only source 10 mA, so to reach 5 V, the output resistance cannot be less than 500 Ω.
- Check to ensure that the load wiring is isolated.
- Check the wiring, look for a loose connection at the terminal blocks and disconnected or misconnected cables.
- Disconnect the field wiring and connect a 1 kΩ resistor across the output. If the output is correct across the resistor, there is a problem with the field wiring.

Discrete Inputs (Reset, E-Stop)

If a discrete input is not functioning properly, verify the following:

- Measure the input voltage on the terminal block. It should be in the range of 18–28 Vdc.
- Check the wiring, look for a loose connection at the connector and disconnected or misconnected cables.

Alarm or Shutdown Conditions

If the driver has any fault conditions, refer to Appendix B for details on the exact cause of the condition. The display will indicate a - code for fault conditions.

Discrete Output

If the discrete outputs are not functioning properly, verify the following:

- Check the wiring, look for a loose connection at the connector and disconnected or misconnected cables.
- Verify that the 24 V source is properly wired to the driver and is active

Potentiometer Input (EM-300)

If the potentiometer input is not functioning properly, verify the following:

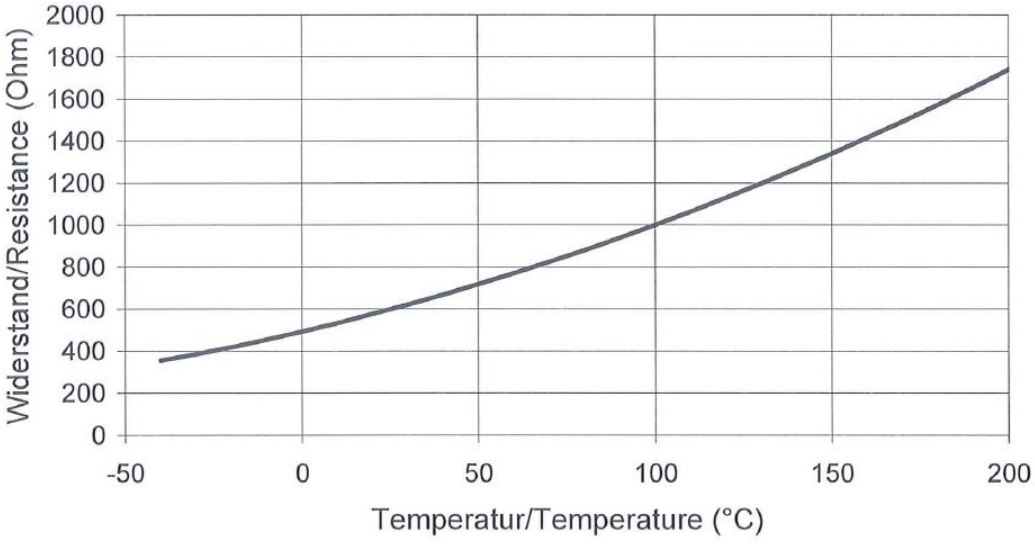
- Check the wiring, look at the connections at X100 pins 4, 5 and 6 for disconnected or misconnected cables.
- Verify that the application is correct. This input is only active for the EM-300 actuator
- Verify that X100 pin 6 measures 10 V +/- 0.1V when referenced to X100 pin 8.
- Manually move the actuator to approximately 20° position then disconnect resolver feedback cable from flying lead cable of actuator and measure potentiometer resistance between pins 2 and 4 and pins 3 and 4 inside of 12-pins round connector. Measured value should meet to the value in table below.

Potmeter (pins 2, 4) [ohm]	Actuator mid position 20 degrees @ Rpot (pins 3, 4) [ohm]
10300	5477
10200	5438
10100	5400
10000	5361
9900	5323
9800	5284
9700	5245

Motor Temperature Input

If the motor temperature input is not functioning properly, verify the following:

- Check the wiring, look at the connections at X140 pins 7 and 14 for disconnected or misconnected cables.
- Measure across X140 pins 7 and 14 to verify resistance of the motor temperature sensor according to the chart below.



- Verify that jumpers are in place at X141 pins 1 and 2 to X2 pins 3 and 4, respectively. See wiring diagram for more details.

Performance Troubleshooting Guide

General Performance Problems

If the actuator buzzes, or has a fast limit cycle:
- Check for loose linkage.

If the actuator overshoots on steps, or is poorly damped:
- Verify that as much of the 40° of travel as possible is being utilized.

If the actuator has a slow limit cycle:
- Check for excessive friction in linkage.

If the actuator has steady state position error:
- Supply voltage too low.
- Actuator load too large or actuator too small.
- Free stuck linkage.
- Actuator fault—replace actuator.

Chapter 9.
Specifications

Specifications

General Specifications	EM-80	EM-300
Nominal Torque Output (continuous) *	91 N·m (67 lb-ft)	260 N·m (192 lb-ft)
Maximum Torque Output (1 second max)	190 N·m (140 lb-ft)	429 N·m (316 lb-ft)
Output Travel	40°, no internal mechanical stops	40°, no internal mechanical stops
10–90% Slew Time	78 ms with no load	192 ms with no load
System Accuracy	< ±0.579° at the output shaft at room temperature. < ±0.699° at the output shaft over a range of 25-55°C (Driver Temperature). (includes driver, resolver and gearbox accuracies)	
Unit to Unit Repeatability	±0.45 degrees	

* Continuous torque output is limited for actuator ambient environments over 40 °C per "Actuator Temperature Derating" in Chapter 4.

Actuator Specifications	EM-80	EM-300
Storage Temperature Range	–30 to +100 °C (–22 to +212 °F)	
Ambient Temperature Working Range	0 to +85 °C (+32 to +185 °F)	
Mounting	Actuator needs to be mounted within 45º of horizontal.	
Vibration	Random: 0.01 G²/Hz at 10 Hz, 0.1 G²/Hz at 100 Hz, 0.1 G²/Hz at 1000 Hz, 0.05 G²/Hz at 2000 Hz (12.8 Grms) 3 hours per axis.	
Shock Qualification Testing	MS1 – 40 G 11 ms sawtooth	
Ingress Protection	IP64	
Humidity Qualification Test (pending test)	55 °C, 95% RH for two days at one cycle per day	
Actuator Inertia	0.209 kgm²	1.715 kgm²
Approximate Weight (including bracket)	35 kg (77 lb)	38 kg (84 lb)
Service Life	>20 000 hours between overhaul. Full speed impacts into a optional external stop of minimum spring scale: 10 000	

DRIVER GENERAL SPECIFICATIONS	
General Driver Electrical Specifications	
Command Input	4–20 mA
Power Supply Rated Input Current	3 phase, 400–480 Vac, 50–60 Hz, ±10% 20 A
Rated Output Current	15 A (12 A eff.), 0 to 45 °C, derated to 10.5 A (8.4 A eff.) at 55 °C
Maximum Output Current	30 A (24 A eff.), 0 to 45 °C, derated to 21 A (16.8 A eff.) at 55 °C
Low Voltage Power Supply	24 V ±10% (55 W max)
Storage Temperature Range	–30 to +70 °C (–22 to +158 °F)
Ambient Temperature Working Range	0 to +55 °C (+32 to +131 °F)
Marine Vibration	ABS Steel Vessel Rules 2013, Test No. 5; BV Pt. C, Ch 3, Sec. 6 Test No. 7; DNV Class A, Lloyd's Register Vibration Test No. 1; RMRS Vol. 2, Part III, Sect. 3.6.1.2 – 13.2 Hz (+3 Hz/-0 Hz) 1.0 mm Displacement, 13.2 – 100 Hz; ±0.7 G (6.9 ms^{-2})
Marine Humidity	ABS Steel Vessel Rules 2013 Test No. 4: BV Pt. C, Ch. 3, Sec. 6 Test No. 6; DNV Class B: Lloyd's Register Humidity Test 1 : Cyclic Damp Heat Test
Relative Humidity	Up to 85% (no condensation)
Site Altitude	Below 2000 m (6500 ft) above sea level (higher altitudes on request)
Ingress Protection	IP20 per IEC60529
Electromagnetic Compatibility (EMC)	EN 61800-3 (Category 3, second environment)
Pollution Degree	2 as per EN50178
High Voltage Category	Category III per EN61800-5-1
Mounting	The driver box is designed for installation on the control cabinet and should not be installed directly on the engine.
Weight	3.8 kg (8.38 lb)
Cabling	Two cables are required between driver and actuator. 3-phase Power supply cable Position sensor cable The maximum length between driver and actuator is 100 m (328 ft).
Switch-on: Ready for Operation After	≤ 1.5 s
Power Switching off from 3-phase	Minimum time after switch-off of a 3-minute cool-down time must be observed.
Output Voltage	0 to Connection voltage
Output Power	15 kVA
Typical Motor Power	4.5 kW
Power Loss in Rated Operation without Low-Voltage Supply, without Ballast	280 W
Mechanical Specifications	
Dimensions (W x H x D)	105 x 300 x 260 mm

DRIVER CIRCUIT SPECIFICATIONS	
Circuit Specifications	
4–20 mA Analog Input Specifications	
Input Resolution	15 bits
Total shunt resistance	2 kΩ (external) || 510Ω (internal) ➔ 406 Ω total
Low Signal Fault Detection	< 3.6 mA
High Signal Fault Detection	> 24 mA
Analog Position Output Specifications	
Output Voltage Range	1 V to 5 V (corresponding to 0-100% shaft position)
Maximum Output Current	10 mA
Output Resolution	10 bits
EM-300 Potentiometer Input Specifications	
Potentiometer Input Resolution	15 bits
Voltage Sourced to Potentiometer	10 V (max rated output current at 10 mA)
Ready For Use Output Specifications	
Output type	Binary, normally 'high' when ready for use
Output Voltage	0 V when drive not ready, 24 V when ready for use
Maximum Output Current	20 mA
Output load recommendations	LED, Logic fault trip string
Common Alarm Output Specifications	
Output type	Binary, normally 'high' when no faults/alarms active
Output Voltage	0 V when active faults/alarms are present, 24 V when all faults are cleared.
Maximum Output Current	20 mA
Output load recommendations	LED, Logic fault trip string
Pulse Enabling	
Input Type	Relay input for enabling the driver
Low Input	<8 V (disabled driver)
High Input	>12 V (enabled driver)
Maximum Input Current	16 mA
Absolute Maximum Input Current	30 Vdc (Damage can occur above this level)
E-Stop Discrete Input	
Input Type	Binary Input
Low Input	<8 V (See Appendix E for configuration)
High Input	>12 V (See Appendix E for configuration)
Maximum Input Current	16 mA
Absolute Maximum Input Current	30 Vdc (Damage can occur above this level)
Reset Discrete Input	
Input Type	Binary Input
Low Input	<8 V (No action)
High Input	>12 V (Toggles master reset function)
Maximum Input Current	16 mA
Absolute Maximum Input Current	30 Vdc (Damage can occur above this level)

DRIVER CIRCUIT SPECIFICATIONS (cont'd)

Filter Specifications	
Rated Current	30 A
Peak Current	32.9 A for < 1 min per hour at 40 °C
Connection Voltages	3 x 520 Vac, 50–60 Hz, ±10%
Ambient Operating Temperature Range	–25 to +100 °C (–13 to +212 °F)
Leakage Current	33 mA
Maximum Altitude for Site at Rated Loading	1000 m (3300 ft) above MSL
Relative Humidity	
Marine Humidity	ABS Steel Vessel Rules 2013 Test No. 4: BV Pt. C, Ch. 3, Sec. 6 Test No. 6; DNV Class B: Lloyd's Register Humidity Test 1 : Cyclic Damp Heat Test
Marine Vibration	ABS Steel Vessel Rules 2013, Test No. 5; BV Pt. C, Ch 3, Sec. 6 Test No. 7; DNV Class A, Lloyd's Register Vibration Test No. 1; RMRS Vol. 2, Part III, Sect. 3.6.1.2 – 13.2 Hz (+3 Hz/-0 Hz) 1.0 mm Displacement, 13.2 – 100 Hz; ±0.7 G (6.9 ms^{-2})
Storage Temperature Range	–25 to +100 °C (–13 to +212 °F)
Dimensions (L x W x H)	240 x 50 x 85 mm (9.45 x 1.97 x 3.34 in)
Weight	1.2 kg (2.65 lb)

Chapter 10.
Product Support and Service Options

Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact the manufacturer or packager of your system.
- Contact the Woodward Full Service Distributor serving your area.
- Contact Woodward technical assistance (see "How to Contact Woodward" later in this chapter) and discuss your problem. In many cases, your problem can be resolved over the phone. If not, you can select which course of action to pursue based on the available services listed in this chapter.

OEM or Packager Support: Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

Woodward Business Partner Support: Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at **www.woodward.com/directory**.

Product Service Options

The following factory options for servicing Woodward products are available through your local Full-Service Distributor or the OEM or Packager of the equipment system, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is originally shipped from Woodward or a service is performed:

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

Replacement/Exchange: Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime. This is a flat-rate program and includes the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205).

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned within 60 days, a credit for the core charge will be issued.

Flat Rate Repair: Flat Rate Repair is available for the majority of standard products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be. All repair work carries the standard Woodward service warranty (Woodward Product and Service Warranty 5-01-1205) on replaced parts and labor.

Flat Rate Remanufacture: Flat Rate Remanufacture is very similar to the Flat Rate Repair option with the exception that the unit will be returned to you in “like-new” condition and carry with it the full standard Woodward product warranty (Woodward Product and Service Warranty 5-01-1205). This option is applicable to mechanical products only.

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return authorization number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

NOTICE

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

Engineering Services

Woodward offers various Engineering Services for our products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Technical Support is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward's worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact. Emergency assistance is also available during non-business hours by phoning Woodward and stating the urgency of your problem.

Product Training is available as standard classes at many of our worldwide locations. We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

Field Service engineering on-site support is available, depending on the product and location, from many of our worldwide locations or from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact us via telephone, email us, or use our website: **www.woodward.com**.

Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory at **www.woodward.com/directory**, which also contains the most current product support and contact information.

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

Products Used in Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany:	
Kempen	+49 (0) 21 52 14 51
Stuttgart	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Products Used in Engine Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (711) 78954-510
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
United States	+1 (970) 482-5811

Products Used in Industrial Turbomachinery Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
India	+91 (129) 4097100
Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080
The Netherlands	+31 (23) 5661111
Poland	+48 12 295 13 00
United States	+1 (970) 482-5811

Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

General

Your Name _____

Site Location _____

Phone Number _____

Fax Number

Prime Mover Information

Manufacturer _____

Turbine Model Number _____

Type of Fuel (gas, steam, etc.) _____

Power Output Rating _____

Application (power generation, marine, etc.)

Control/Governor Information

Control/Governor #1

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #2

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Control/Governor #3

Woodward Part Number & Rev. Letter _____

Control Description or Governor Type _____

Serial Number

Symptoms

Description _____

_____

If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.

Appendix A.
Electromagnetic Compatibility (EMC)

Introduction

The information in this appendix is intended to allow you to configure your system on the basis of the latest knowledge in the field of EMC (electromagnetic compatibility) and to comply with legal regulations.

To ensure EMC, you must observe the configuration information below.

IMPORTANT

Installation of other electronic equipment inside the cabinet that encloses the EM-80/EM-300 requires that the cabling for this equipment meet the same requirements that the cabling for the EM-80/EM-300 meets. See this appendix for further details.

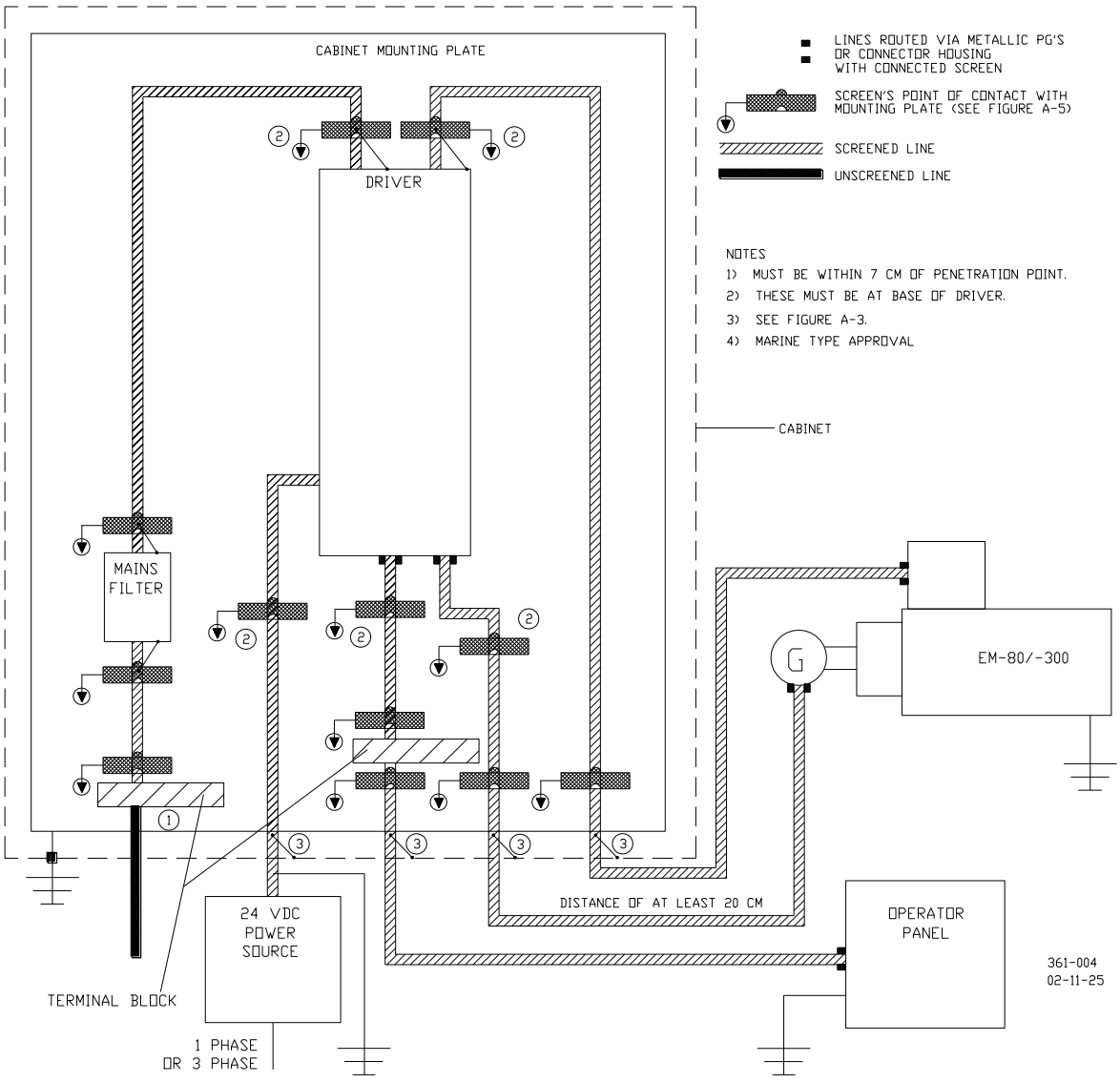


Figure A-1. Cabling

Cabling

To suppress radiated noise outside the converter, you should screen all the connected cabling. See also "Screening" later in this appendix.

Cables (wires) can act as an antenna, picking up (or transmitting) undesirable signals. Reduce effective antenna height by routing cables directly on the ground of the metallic rack.

Route all lines as close as possible to the conductors of the ground system to reduce the effective loop area for magnetic coupling.

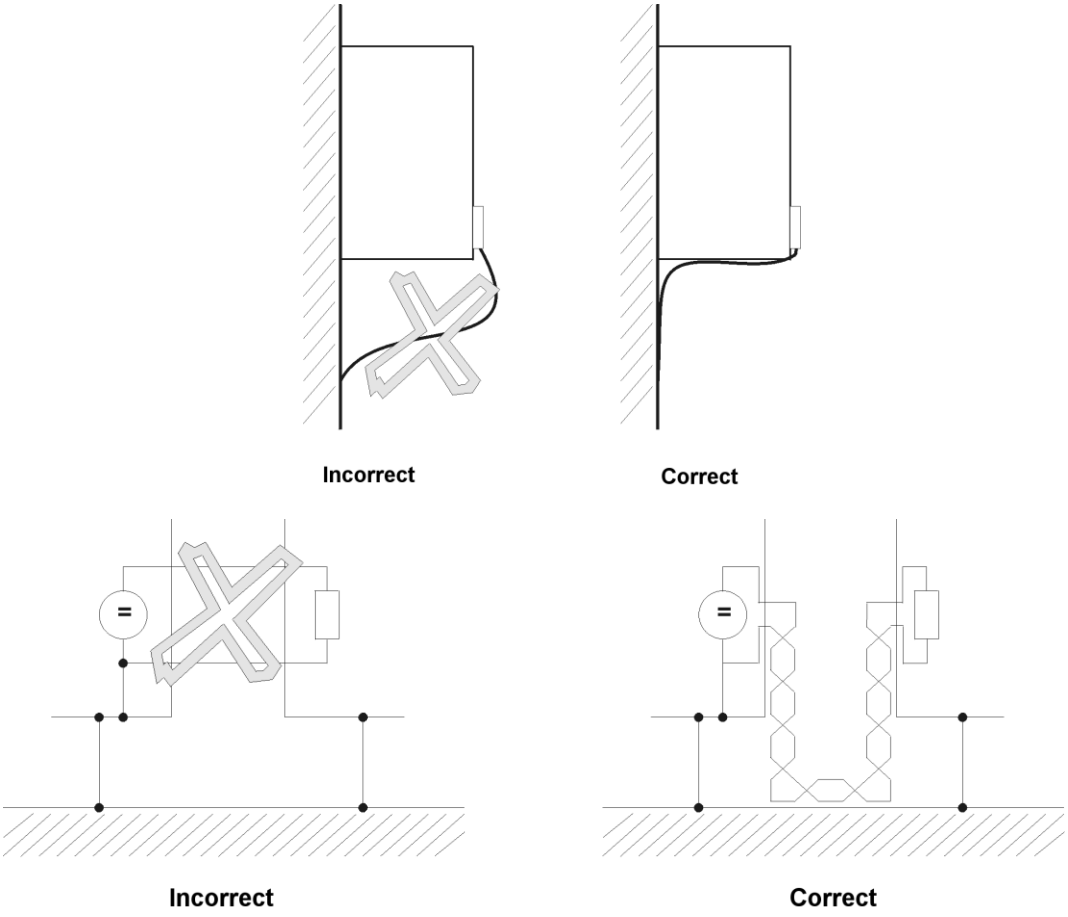


Figure A-2. Cable Routing

- When parallel-routing signal and control lines across power cables, the conductors must be at least 20 cm (8”) apart.
- Lines of different EMC categories should only cross at an angle of 90°.
- In the case of symmetrical signal transfer (such as differential amplifier inputs for the speed specified value), twist the conductors of each pair of wires together and twist the pairs of wires together.
- The driver-to-ground plate earth connection should be as short as possible (less than 30 cm/12”). Use large cross-sections (more than 10 mm²/7 AWG).
- Sources of interference such as fuses, transformers and chokes, and modules that are sensitive to interference like microprocessors, bus systems, etc., should be located at least 20 cm (8”) away from the converter and its cabling.

- Avoid reserve loops on overlong cables.
- You must ground spare lines at both ends (this has an additional screening effect, and avoids capacitive-coupled, dangerous touch voltages).

Grounding

- From an EMC point of view, classical “star” grounding is no longer adequate for reducing the influence of disturbances at relatively high frequencies that occur as a result of converter operation. Better results can be achieved by a reference surface that must be linked to the devices' frame grounds over a wide area (form example, a bare, metallic mounting plate and parts of the housing).
- If it is not possible to use a broad reference place, it is sensible to mount the main equipotential bus bar directly next to the converter, since this device generates the greatest potential jumps, compared with the other components in the switching cabinet, due to the steep switching edges (the ground connection should be less than 30 cm/12” long if possible).
- Route all earth conductors and screens as closely as possible above the frame ground to prevent earth circuits.
- If it is possible to earth the controller reference voltage, make this connection with cabling that has as large a cross-section as possible and is less than 30 cm (12”) long.
- Remove insulating layers, such as varnish, adhesives, etc., from the frame ground connections. If necessary, use serrated lock washers to ensure a permanent, conductive contact. To prevent corrosion of frame ground connections, use suitable pairs of metals (electrochemical displacement series), and keep conductive electrolytes away from the connection by means of a protective coating (such as grease).
- Always connect screens at both ends to the frame ground—the connection should be over a wide area and conductive. This is the only way to suppress the effects of magnetic or high-frequency noise interference fields. If there are problems with earth circuits (such as double earth fault of the specified value conductor screen), the receive side should be galvanically connected and the transmit side capacitively connected.
- When routing cable screens through panels that separate different EMC areas, the cables must be in contact with the panel.
- Cables that are routed through the outer panels of screening housings without special measures (such as filtering), can have an adverse effect on the screening capability of the housing. For this reason, you must make a conductive connection of the cable screens to the screening outer panel at the point at which the cable enters the housing.

The distance of the last screen contact point to the exit from the cabinet must be as short as possible.

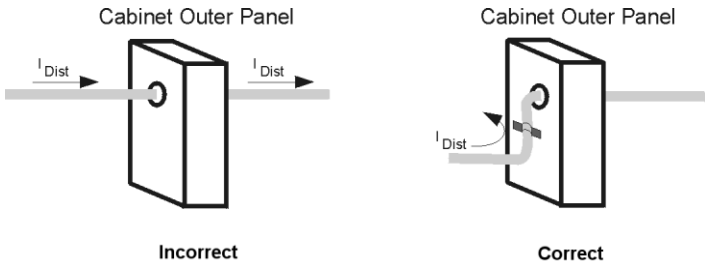


Figure A-3. Screening Contact

Screening

- The screen is effective against magnetic fields if it is connected to frame ground at both ends.
- With electrical fields, the screen is effective when it is connected to frame ground at one end. However, in the case of (electrical or magnetic) fields with high frequencies (depending on the length of the line), you must always connect the screen at both ends due to the linkage (electromagnetic field).

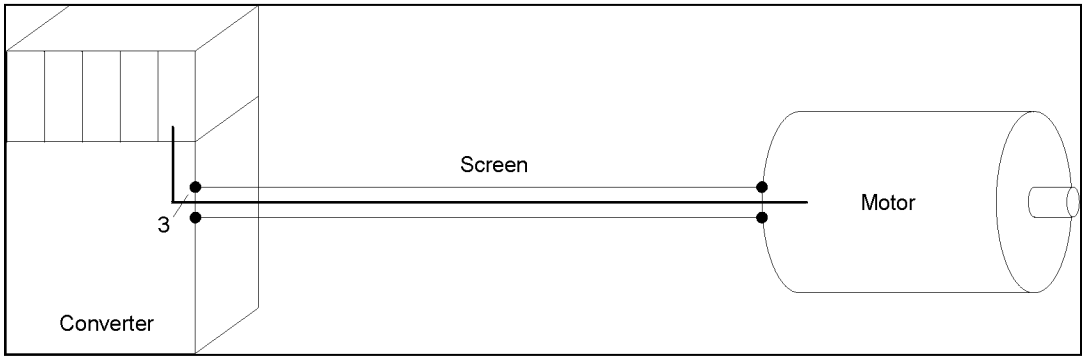


Figure A-4. Screening

Connecting the screen to frame ground at both ends ensures that the conductor does not leave the screening "system housing".

- Frame-grounding of conductor screens on both sides does not entirely rule out the influence of earth circuits (potential differences on the frame ground system). However, this is very rare if you carry out the measures described in the previous sections ("Cabling" and "Grounding").
- You can also make a capacitive RF connection of a screen to frame ground. This prevents low-frequency interference due to earth circuits.
- Screened cables that pass through different EMC areas must not be separated at terminals, since screen damping would otherwise be considerably reduced. The cables should be routed to the next module without interruption.
- Make the screen connection low-impedance and over a wide surface area. Cable tails that are only 3 cm (1.2”) long (1 cm of wire = 10 nH; 1” of wire = 25 nH) reduce the screening effect in the MHz range by up to 30 dB!

IMPORTANT **The braided screen must have a coverage of at least 85%.**

The following lines have particularly high levels of interference potential:

- The motor drive lines
- The line between the mains filter and the converter
- The DC power line between the converter and the cabinet penetration point
- The resolver cable
- The I/O Interface cables

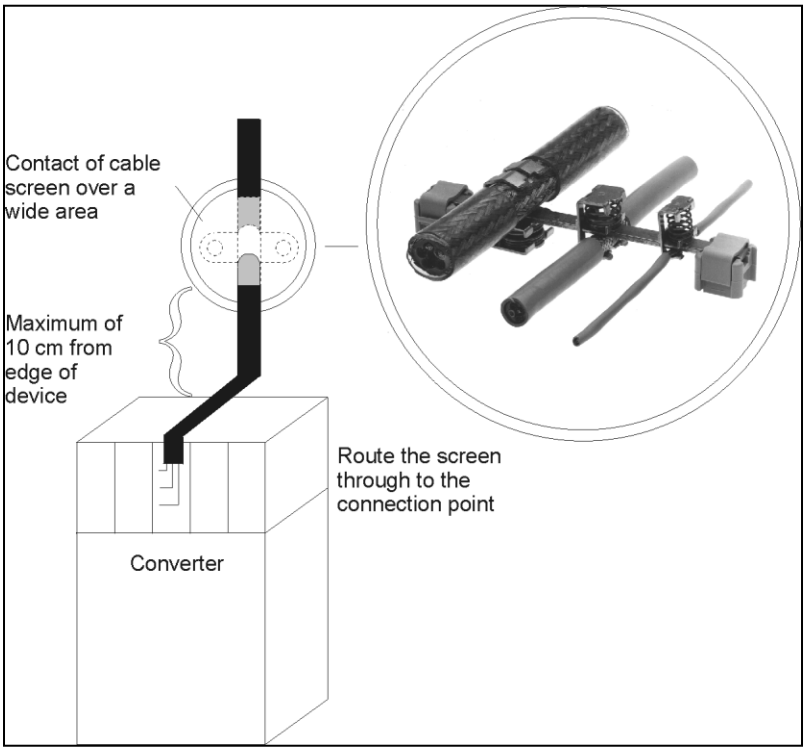


Figure A-5. Suggestion for Screen Connection

Appendix B.
Driver Error Events

31:Short/ground

Trigger	Level	Reaction	Acknowledgement
The hardware short-circuit switch-off is active	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Interwinding fault	Check the motor windings (see “Electrical Troubleshooting Guide”)	Replace/repair the EM actuator
Fault in motor power cable	Check the integrity of the cable and its connections to the motor and driver (see “Electrical Troubleshooting Guide”)	Replace/repair the cable/connection

32:Short/gr. int

Trigger	Level	Response	Acknowledgement
An internal test is performed control at boot-up. An existing short-circuit causes a malfunction	Fault	The driver cannot be enabled	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

33:Overcurrent

Trigger	Level	Reaction	Acknowledgement
The total motor current exceeds the permitted maximum value	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

34:Hardware fault

Trigger	Level	Response	Acknowledgement
Hardware error	Fault	The driver cannot be enabled	Cannot be acknowledged

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

35:Watchdog

Trigger	Level	Response	Acknowledgement
CPU fault	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

36:High voltage

Trigger	Level	Response	Acknowledgement
The voltage in the intermediate circuit exceeds the permitted maximum	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Supply voltage too high	Check whether the supply voltage exceeds the permitted input voltage	Take measures to adjust the supply voltage.
Internal fault	None	Contact your service supplier

37:Encoder

Trigger	Level	Response	Acknowledgement
Error due to encoder	Fault	The motor coasts down Fault #63 “Wrong Reference” is triggered	Switch the device off/on, reset input depending on the cause

Potential Cause	Test	Measure
Faulty resolver signal	Check the integrity of the resolver signal through the feedback cable, check also the actuator’s flying lead (see “Electrical Troubleshooting Guide”)	Replace/repair the feedback cable and/or actuator’s flying lead
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward’s recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram Apply Woodward’s recommendation for correct grounding/shielding
Internal fault	None	Contact your service supplier

38:TempDev.sens

Trigger	Level	Response	Acknowledgement
The temperature measured by the device sensor exceeds either the maximum or minimum value	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
The ambient/control cabinet temperatures are too high or too low	Ensure the ambient temperature around the driver remains inside the operating range. Make sure the mounting instructions have been followed	Take measures to match the ambient temperature to the operating conditions of the driver Follow mounting instructions
Fan fault	Switch on the control part power supply and check whether the fan(s) start up	Contact your service supplier
Internal fault	None	Contact your service supplier

39:TempDev. i^2t

Trigger	Level	Response	Acknowledgement
The i^2t model calculated for the driver exceeds the thermal overload threshold	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Faulty or incorrect motor temperature sensor wiring	Check temperature sensor wiring to verify it is correct and there is not damage.	If wiring is found to be faulty, replace or reconnect to correct the issue. Power the driver off, then on and clear the fault.
Internal fault (if other steps fail)	None	Contact your service supplier

40:Invalid data

Trigger	Level	Response	Acknowledgement
A data error was detected when initializing the non-volatile memory	Fault	The driver cannot be enabled	Cannot be acknowledged

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

41:TempMotor TMS

Trigger	Level	Response	Acknowledgement
Motor temperature sensor reports over temperature	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
The motor is overloaded	Ensure the load torque doesn't exceed the torque specifications Make sure the actuator is able to stroke full range with no hard stop/obstacle in the way	Take measures to adapt the torque requirements to the specification
The motor temperature sensor is not connected	Check whether the motor temperature sensor is properly connected on terminals X2 and X141 Check the integrity of temperature signal through the resolver feedback cable, check also the actuator's flying lead	Correct the connection Replace/repair the resolver feedback cable and/or actuator's flying lead
The ambient temperature is too high	Ensure the ambient temperature around the motor remains inside the operating range	Take measures to match the ambient temperature to the operating conditions of the motor
Motor temperature sensor is defective	Check integrity of temperature sensor (see "Electrical Troubleshooting Guide")	Repair/replace the EM actuator

44: Actuator blocked

Trigger	Level	Response	Acknowledgement
The load torque exceeds the peak torque output within the first ten seconds after boot-up	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
The load torque exceeds the peak torque output	Ensure the load torque doesn't exceed the torque specifications Make sure the actuator is able to stroke full range with no hard stop/obstacle in the way	Take measures to adapt the torque requirements to the specification
Wrong connection of the power cable	Make sure the phase consistency (U, V, W) has been kept	Correct the connection
Fault in motor power cable	Check the integrity of the cable and its connections to the motor and driver (see "Electrical Troubleshooting Guide")	Replace/repair the cable/connection

45:oTempMot..i²t

Trigger	Level	Response	Acknowledgement
The i^2t model calculated for the motor exceeds the thermal overload threshold for more than 30 seconds	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
The motor is overloaded	Ensure the load torque doesn't exceed the torque specifications Make sure the actuator is able to stroke full range with no hard stop/obstacle in the way	Take measures to adapt the torque requirements to the specification

46:Low voltage

Trigger	Level	Response	Acknowledgement
The intermediate voltage has dropped below 180 V for more than 5 seconds ***or*** DC link voltage has dropped below 135 V	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
While operation, supply voltage has dropped	Check whether minimum the supply voltage requirements are met	Take measures to adjust the supply voltage

47:Torque limit

Trigger	Level	Response	Acknowledgement
The output torque reaches its peak value	Alarm	The motor keeps running After approximately 1 second, the output torque is limited to the rated torque value	Self-acknowledge

Potential Cause	Test	Measure
The load torque exceeds the peak torque output	Ensure the load torque doesn’t exceed the torque specifications Make sure the actuator is able to stroke full range with no hard stop/obstacle in the way	Take measures to adapt the torque requirements to the specification

52:Communication

Trigger	Level	Response	Acknowledgement
Communication fault	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

55:Option Board

Trigger	Level	Response	Acknowledgement
Error when operating with option board	Fault	The motor coasts down	Switch the device off/on, reset input depending on the cause

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

56:Overspeed

Trigger	Level	Response	Acknowledgement
The measured motor shaft speed exceeds the overspeed threshold.	Fault	The motor coasts down Fault #68 “Resolver error” is triggered	Switch the device off/on or reset input

Potential Cause	Test	Measure
Faulty resolver signal	Check integrity of the resolver signal through the feedback cable, check also the actuator’s flying lead (see “Electrical Troubleshooting Guide”)	Replace/repair the feedback cable and/or actuator’s flying lead
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward’s recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram Apply Woodward’s recommendation for correct grounding/shielding

57:Runtime usage

Trigger	Level	Response	Acknowledgement
CPU overload	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

58:Grounded

Trigger	Level	Response	Acknowledgement
Asymmetrical motor currents	Fault	The motor coasts down	Switch the device off/on or programmed acknowledgement

Potential Cause	Test	Measure
Interwinding fault	Check the motor windings (see “Electrical Troubleshooting Guide”)	Replace/repair the EM actuator
Fault in motor power cable	Check the integrity of the cable and its connections to the motor and driver (see “Electrical Troubleshooting Guide”)	Replace/repair the cable/connection

59:TempDev. i^2t

Trigger	Level	Response	Acknowledgement
The i^2t model calculated for the driver exceeds 105% of thermal overload threshold	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

60:Wrong Actuator (EM-80 only)

Trigger	Level	Response	Acknowledgement
Voltage measured in AE2 >3 V	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
Wrong driver configuration or wrong EM actuator	Make sure your driver’s configuration matches the correct EM actuator	Contact your supplier

60:Pot Out of Range (EM-300 only)

Trigger	Level	Response	Acknowledgement
Voltage measured in AE2 <3.6 V or >6.1 V	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
Faulty potentiometer feedback signal	Check the integrity of the potentiometer signal through the feedback cable, check also the actuator's flying lead (see "Electrical Troubleshooting Guide")	Replace/repair the feedback cable and/or actuator's flying lead
Wrong potentiometer feedback connection	Make sure the feedback cable's pigtail is correctly connected	Correct the connection
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward's recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram. Apply Woodward's recommendation for correct grounding/shielding
Actuator's output shaft moved out of range	Check whether the output shaft position indicated is outside the 0˚-40˚ degree range	Ensure the driver boots up while the actuator is inside the designed 40˚ position
Wrong calibration of the potentiometer	Check the calibration of potentiometer (see "Electrical Troubleshooting Guide")	Contact your supplier
Wrong driver configuration or wrong EM actuator	Make sure your driver's configuration matches the right EM actuator	Contact your supplier

61:High mA signal

Trigger	Level	Response	Acknowledgement
Current measured in AE1>24 mA	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
Wrong configuration and/or faulty mA source	Check whether the position demand signal stays within the 4-20 mA range	Adjust position demand source accordingly
Wrong position demand input connection	Make sure the position demand input is correctly connected, (shunt connection and external resistor included)	Correct the connection

IMPORTANT: after event 61:High mA, check whether the resistance across AE1 falls within the correct range (see “Electrical Troubleshooting Guide”). Contact your service supplier if the test fails.

62:Contact Service

Trigger	Level	Response	Acknowledgement
Hardware does not match software application	Fault	The driver cannot be enabled	Self-acknowledge

Potential Cause	Test	Measure
There has been a change in hardware	None	Contact your service supplier

63:Wrong reference

Trigger	Level	Response	Acknowledgement
Fault #37 ”Encoder” has been triggered ***or*** The measured output shaft position goes below -3.5˚ or above 43.5˚ ***or*** There is a mismatch between the measured output shaft position and the measured potentiometer signal (EM-300 only)	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
Faulty resolver signal	Check the integrity of the resolver signal through the feedback cable, check also the actuator’s flying lead (see “Electrical Troubleshooting Guide”)	Replace/repair the feedback cable and/or actuator’s flying lead
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward’s recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram Apply Woodward’s recommendation for correct grounding/shielding
Internal fault	None	Contact your service supplier
Actuator’s output shaft moved out of range	Check whether the output shaft position indicated is outside the 0˚-40˚ degree range	Ensure the driver boots up while the actuator is inside the designed 40˚ position range
Wrong calibration of the potentiometer	Check the calibration of the potentiometer (see “Electrical Troubleshooting Guide”)	Contact your supplier

64:Pos DMD lost

Trigger	Level	Response	Acknowledgement
Current measured in AE1<3.6 mA	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Wrong configuration and/or faulty mA source	Check whether the position demand signal stays within the 4-20 mA range	Adjust position demand source accordingly
Wrong position demand input connection	Make sure the position demand input is correctly connected, (shunt connection and external resistor included)	Correct the connection
External and/or shunt resistor is defective	Check whether the resistance across AE1 falls within the correct range (see “Electrical Troubleshooting Guide”)	Contact your service supplier

65:Position error

Trigger	Level	Response	Acknowledgement
The measured output shaft position differs ±1° from the position command for more than one second	Alarm	The motor keeps running	Self-acknowledge

Potential Cause	Test	Measure
The load torque exceeds the peak torque output	Ensure the load torque doesn't exceed the torque specifications Make sure the actuator is able to stroke full range with no hard stop/obstacle in the way	Take measures to adapt the torque requirements to the specification
Wrong connection of the power cable	Make sure the phase consistency (U, V, W) has been kept	Correct the connection
Fault in motor power cable	Check the integrity of the cable and its connections to the motor and driver (see "Electrical Troubleshooting Guide")	Replace/repair the cable/connection

66:3 phase off

Trigger	Level	Response	Acknowledgement
The intermediate voltage level is below 500 V	Alarm	The motor may keep running if a back-up supply source is available (see Appendix D)	Self-acknowledge

Potential Cause	Test	Measure
3 phase supply voltage is too low or unavailable	Check whether minimum the supply voltage requirements are met	Take measures to adjust the supply voltage

67:Enable low

Trigger	Level	Response	Acknowledgement
Enable input is low	Alarm	The motor remains disabled	Self-acknowledge

Potential Cause	Test	Measure
Wiring fault	Check whether discrete input BE1 is properly wired	Take measures to correct the wiring fault
Enable input is set to low	-	-

68:Resolver error

Trigger	Level	Response	Acknowledgement
Fault #56 “Overspeed” is triggered ***or*** the measured output shaft speed exceeds the overspeed threshold.	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
Faulty resolver signal	Check the integrity of the resolver signal through the feedback cable, check also the actuator’s flying lead (see “Electrical Troubleshooting Guide”)	Replace/repair the feedback cable and/or actuator’s flying lead
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward’s recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram Apply Woodward’s recommendation for correct grounding/shielding

69:Motor connect.

Trigger	Level	Response	Acknowledgement
Motor connection error	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Description	Measure
Wrong connection of the power cable	Make sure the phase consistency (U, V, W) has been kept	Correct the connection
Fault in motor power cable	Check the integrity of the cable and its connections to the motor and driver (see “Electrical Troubleshooting Guide”)	Replace/repair the cable/connection

70:Param.consistency

Trigger	Level	Response	Acknowledgement
The parametrization is contradicory	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Configuration or internal fault	None	Contact your service supplier

71:Firmware

Trigger	Level	Response	Acknowledgement
Configuration error	Fault	The motor coasts down	Switch the device off/on or reset input

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

#xxx:undef'd Int

Trigger	Level	Response	Acknowledgement
Configuration error	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward's recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram Apply Woodward's recommendation for correct grounding/shielding

(All of the errors in this list are detailed in the table below)
#004:illeg.Instr
#006:illSlotInst
#009:CPU AddrErr
#00a:DMADTCAdErr
#00c:StackOverfl

Trigger	Level	Response	Acknowledgement
Configuration error	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
EMI (Electromagnetic Interference)	Ensure all shielding specified in the wiring diagram has been followed. Make sure Woodward's recommendations for correct grounding/shielding have been followed	Apply all shielding specified in the wiring diagram Apply Woodward's recommendation for correct grounding/shielding
Internal fault	None	Contact your service supplier

#00b:NMI occurred

Trigger	Level	Response	Acknowledgement
There is a hardware fault	Fault	The motor coasts down	Cannot be acknowledged

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

(All of the errors in this list are detailed in the table below)
*****

ParaModul ERROR: update firmware
***ParaModul ERROR: checksum error**
***ParaModul ERROR: ksb write error**
***ParaModul ERROR:PMLoad: unknown**
***ConfigStartERROR remnents lost**
***ConfigStartERROR unknown block**
***ConfigStartERROR unknown string**
***ConfigStartERROR unknown scale**
***ConfigStartERROR unknown limit**
***ConfigStartERROR unknown post-wr**
***ConfigStartERROR unknown pre-rd**
***ConfigStartERROR unknown hiding**
***ConfigStartERROR KsbRUN:unknown**

Trigger	Level	Response	Acknowledgement
Configuration error	Fault	The driver cannot be enabled	Switch the device off/on

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

no configuration paramodul error
no configuration start error

Trigger	Level	Response	Acknowledgement
Boot-up error	Fault	The driver cannot be enabled	Switch the device off/on

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

configuration stopped

Trigger	Level	Response	Acknowledgement
Configuration stopped	Fault	The motor coasts down	Switch the device off/on

Potential Cause	Test	Measure
Internal fault	None	Contact your service supplier

***ParaModul ERROR: file not found**
no configuration

Trigger	Level	Response	Acknowledgement
Configuration missing	Fault	The driver cannot be enabled	Switch the device off/on

Potential Cause	Test	Measure
Missing memory module	None	Contact your service supplier
Defective memory module	None	Contact your service supplier

Appendix C.
Safe Disposal

Disposal of Driver/Actuator

The equipment consists of the following components and materials:

Component	Material
Housing, various intermediate panels, fan impeller, mounting panels	Sheet steel
Heat sink in the power stage	Aluminum
Various spacer bolts	Steel
Various spacers, housing of current converter and unit fan, etc.	Plastic
Bus bars in the power stage	Copper
Cable harnesses	PVC-insulated copper wire
Power electronics: Module thyristors mounted on a heat sink, ICL Assembly	Metal base plate, semiconductor chip, plastic housing, various insulation materials
PCBs on which all the open and closed loop electronics are mounted	Base material: Epoxy-resin fiberglass woven material, copper-coated on both sides and plated-through, various electronic components such as condensers, resistors, relays, semiconductors, etc.
Actuator and gearbox	Steel, aluminum, copper; PVC-insulated copper wire; various electronic components.

Disposal of Filter

The equipment consists of the following components and materials:

Component	Material
Housing	Sheet steel / aluminum
Several mechanical parts	Steel
Various spacers, housing of current converter and unit fan, etc.	Plastic
Cable harnesses	Copper wire
PCBs on which all electronics are mounted	Base material: Epoxy-resin fiberglass woven material, copper-coated on both sides and plated-through.
Potting compound	Synthetic resin

Electronic components must not be opened, since beryllium oxide is used as internal insulation (for example in various semiconductors). The beryllium dust set free when the components are opened is dangerous to your health.

Hazardous materials may be created or released in case of fire.

WARNING

For technical reasons, electronic components might need to contain dangerous materials, so you should not open them.

In case of fire, dangerous compounds may result or hazardous materials may be released.

If the components are used correctly, there is no danger to humans or to the environment.

You must dispose of or recycle equipment or components according to national regulations as well as any applicable local or regional regulations.

Appendix D. EM-80/-300 Driver Power Redundant Application

Introduction

This appendix covers the application where a customer has a mission-critical purpose for keeping their engine running upon failure of the primary three-phase power system that is used for operating the EM-80/300 driver. The EM-80/300 driver has the ability to operate under single-phase conditions to keep the prime mover under operation, so the customer may elect to install a backup single-phase system and the associated switchgear to take advantage of this feature. The switchover should occur with no loss of actuator control.

NOTICE

Woodward requires that three-phase primary power is supplied to the EM-80/-300 driver as the *normal* operating condition, and the single-phase backup power is only used in the case where primary power fails. When three-phase power is restored, the driver should once again be connected to operate from this source.

Operation

3-Phase Emergency Restore Sequence

Should the 3 phase supply power fail during operation, the following sequence must be followed in order to maintain normal operation. In order to carry out this sequence, it is necessary to have a back-up single phase power supply (230 VAC).

1. **3 phase power is lost:** after some delay the driver shows message “3 PHASE OFF” and common alarm output changes state.
2. **Switch on 1 phase power:** to maintain normal operation, the switching should occur within the time window below. Values are counted from the moment the 3 phase power is lost:

Time window	
Min.	Max.
No restriction	140 ms

3. **Wait for voltage stabilization:** the voltage level on the actuator’s side has to stabilize to around 315 V. Follow the time window below counting from the moment the 3 phase power is lost:

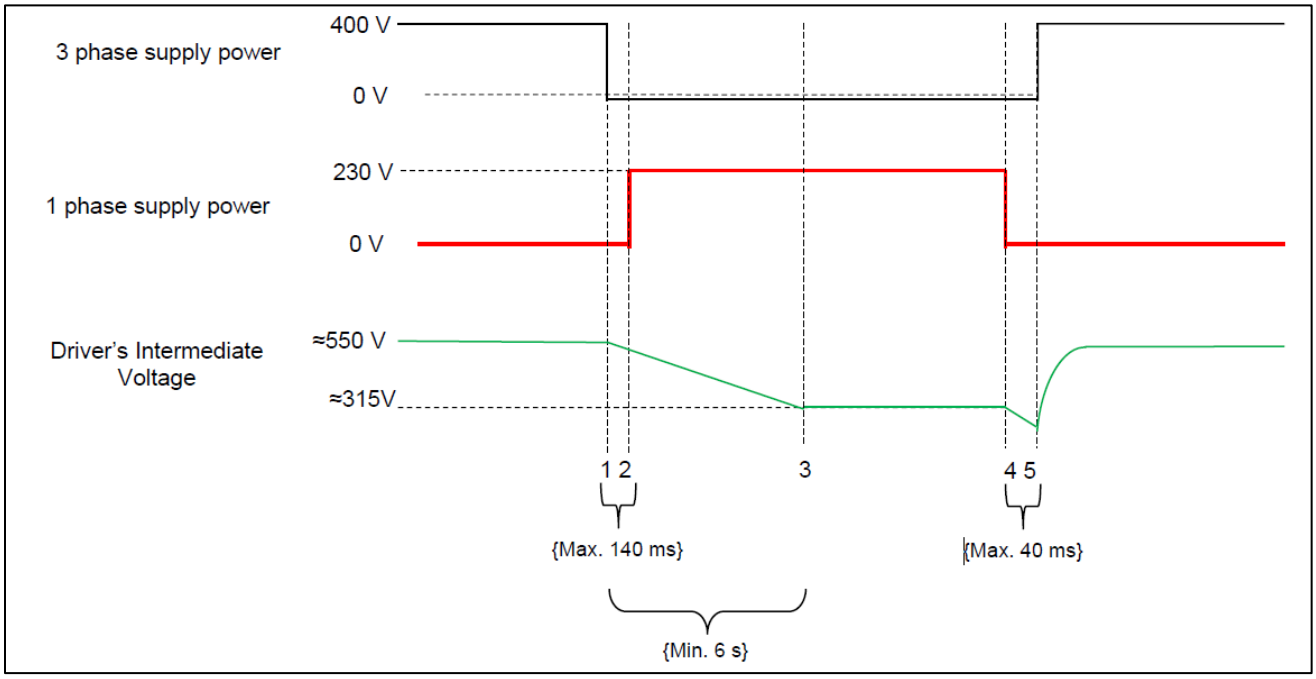
Time window	
Min.	Max
6 s	No restriction

4. **Switch off 1 phase power.**
5. **Switch on 3 phase power:** to maintain normal operation, the switching should occur inside the time window below. Values are counted from the moment the 1 phase power is switched off:

Time window	
Min.	Max.
No restriction	40 ms

Important: *These limits are set considering the worst case scenario. The value of the maximum limits increase as the load applied to the output shaft at the moment of switching decreases. For this sequence to be effective under all circumstances,* ***it must operate within the above limits.***

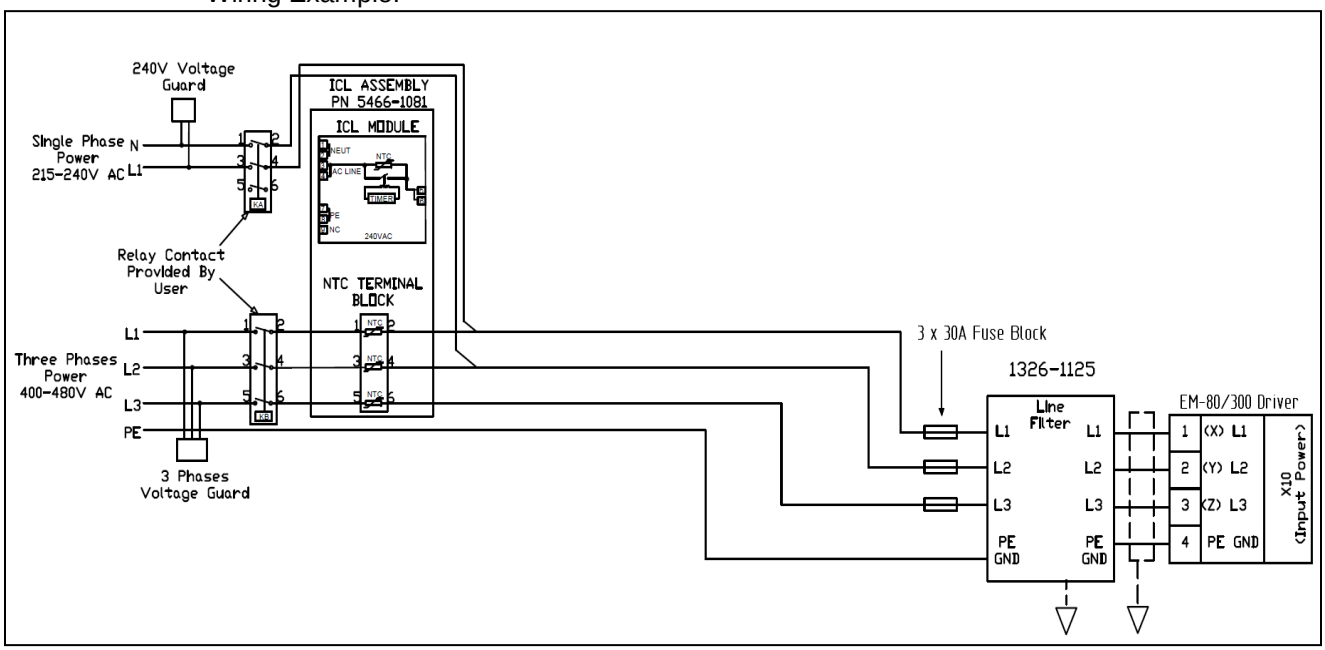
The following figure shows a graphical description of the 3 phase emergency restore sequence:



Normal Operation of the Driver: 1 Phase

In case the 3-phase supply power is not available due to failure, the driver is able to operate normally with a single phase power supply (230 VAC). Note that Alarm#66: "3 phase off" will remain present until 3-phase is available.

Wiring Example:



NOTICE

In the wiring diagram, note that the ICL module is bypassed for single-phase backup power when using this driver. This wiring detail is especially important for retrofit applications.

NOTICE

Woodward recommends that end users implement a 3-minute wait period whenever switching 3-phase power to off. This ensures a sufficient amount of time for the EM-80/-300 Driver to cool.

Before Applying Power

Carefully check all cable wiring to ensure proper connection before applying any power to the system.

WARNING

Failure to follow this procedure may result in serious personal injury or death, or property damage.

Appendix E.
Driver Application Type Setup

WARNING

Woodward strongly recommends that the following procedure is performed only by a qualified installer, possessing a solid working knowledge of the system in which this product is utilized. If the application changes described in this appendix are performed without full consideration of the prime mover system, the result may be serious personal injury or death, or property damage.

NOTICE

The following procedure is ONLY applicable to the configurable version of the EM-80/-300 driver.

This is currently limited to Woodward PN 3522-1042.

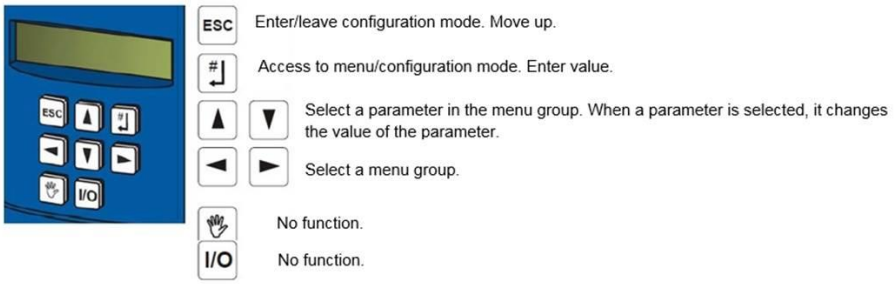
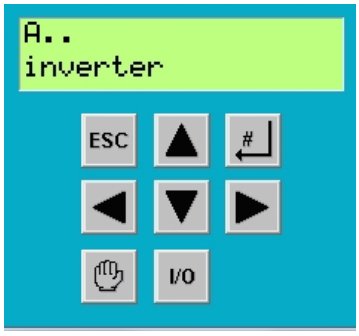


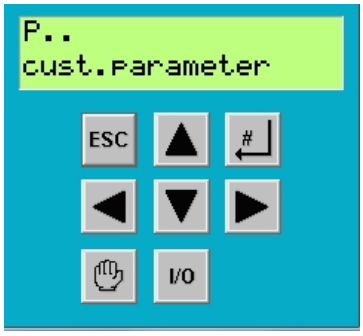
Figure E-1. Keypad Description

Make sure that the driver is powered-up and **not enabled** (enable input is de-energized).

1. In the driver's front panel, press "**ESC**" for five seconds and then "**Enter key**" to access to configuration mode. The driver displays:



2. Navigate to the "P.. cust. Parameter" menu, using the **right and left keys**:



3. Press "**Enter key**".
4. Navigate to the parameter **P11** using the **up and down keys**, then press "**Enter key**".
   Depending on the current configuration, either "0: EM-80" or "1: EM-300" appears blinking on the second line of the display:

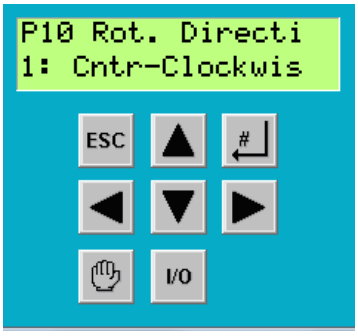
Blinkin g →

5. By using the **up and down keys** set the value of **P11** according to the motor type (see table below):

P11 value	Corresponding key	Motor type
0	Down key	EM-80
1	Up key	EM-300

6. Press "**Enter key**". The selected value should not blink anymore.
7. Press "**ESC**" and subsequently press "**Enter key**".
8. Navigate to the parameter **P10** using the **up and down keys**, then press "**Enter key**". Depending on the current configuration, either "0: Clockwise" or "1: Cntr-Clockwis" appears blinking on the second line of the display:

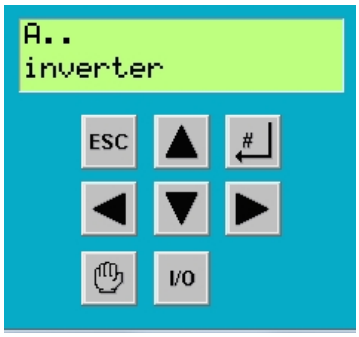
Blinking →



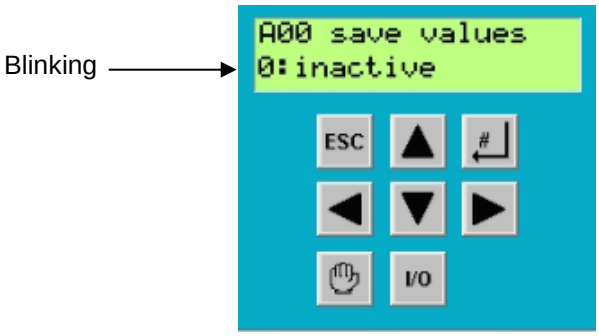
9. By using the **up and down keys**, set the value of **P10** according to the direction of rotation (see table below):

P10 value	Corresponding key	Rotation sense
0	Down key	CW
1	Up key	CCW

10. Press "**Enter key**". The selected value should not blink anymore.
11. Press "**ESC**".
12. Navigate to the "A. inverter" menu using the **right and left keys**.



13. Press "**Enter key**".
14. Navigate to the parameter **A00** using the **up and down keys** if needed, then press "**Enter key**". "0: inactive" should appear blinking on the second line of the display.



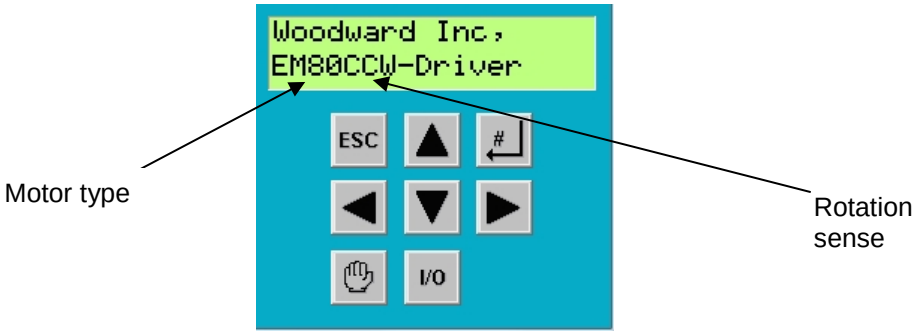
15. Press the **up key** to save the values. This will save the changes made to the control.
16. After a few seconds, the driver displays "0: error free" if the values are saved correctly.

17. If values are not saved correctly proceed to step 18 and repeat the steps 1–12-13–14–15–16 until the values are saved correctly.

18. Press "**ESC**" to leave configuration mode. If there is a fault present after saving the values, "**ESC**" needs to be pressed three times.
19. Power cycle the driver.

WARNING

Once the driver is installed, Woodward recommends stroking the actuator to verify the rotation sense. Make sure the actuator is not connected to any linkage and that there are no potential damages to personnel and/or equipment during the stroke test. The current configuration is displayed on the driver's front display provided that there are no faults. See example below:

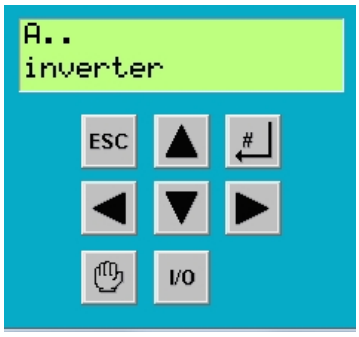


E-stop Function Selection

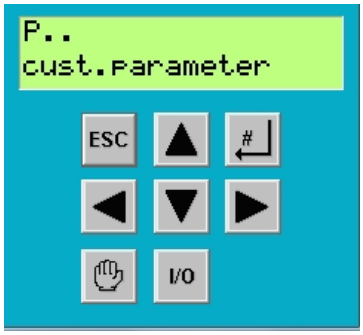
By default, the E-stop input (X101:11) will trigger the E-stop function (drive actuator to minimum position) when the input goes high. However, in PN 3522-1042 is possible to invert the behavior of this input so that the E-stop function will be triggered when the input goes low. This is done by setting parameter P14. The sequence to follow is similar to the one used for setting the application type:

Make sure that the driver is powered-up and not enabled (enable input is de-energized).

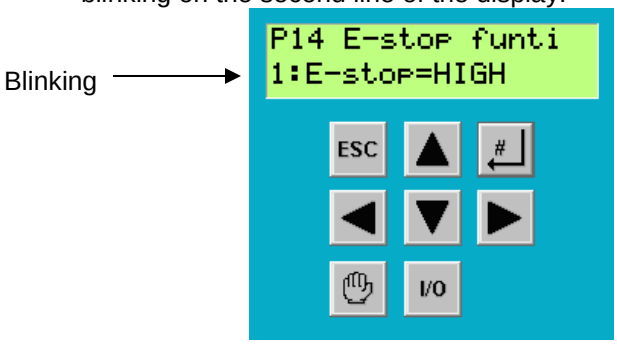
1. In the driver's front panel, press "**ESC**" for five seconds and then "**Enter key**" to access to configuration mode.



2. Navigate to the "P.. cust. Parameter" menu, using the **right and left keys**.



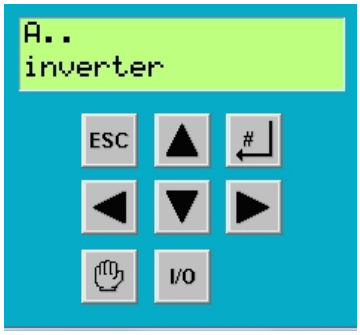
3. Press "**Enter key**".
4. Navigate to the parameter **P14** using the **up and down keys**, then press "**Enter key**". Depending on the current configuration a value appears blinking on the second line of the display.



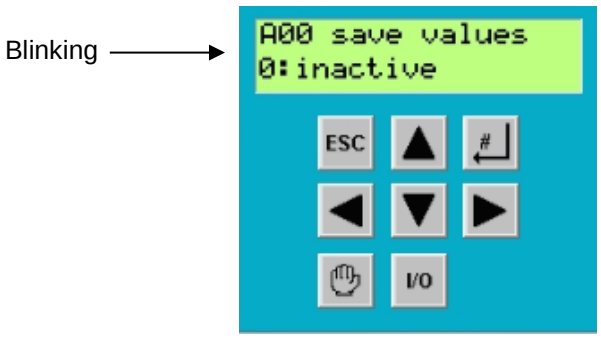
5. By using the up and down keys, set the value of P14 according to the motor type (see table below):

P14 Value	Corresponding Key	E-Stop Behavior
0	Down key	"E-stop=LOW". The actuator will close when the E-stop input is **low**
1	Up key	"E-stop=HIGH". The actuator will close when the E-stop input is **high**

6. Press "Enter key". The selected value should not blink anymore.
7. Press "ESC".
8. Navigate to the "A. inverter" menu using the right and left keys.



9. Navigate to the parameter A00 using the up and down keys if needed, then press “Enter key”. “0: inactive” should appear blinking on the second line of the display.



10. Press the up key to save the values. This will save the changes made to the control.
11. After a few seconds, the driver displays “0: error free” if the values are saved correctly.
12. If values are not saved correctly, proceed to step 13 and repeat steps 1–8-9–10–11–12 until the values are saved correctly.
13. Press “SC” to leave configuration mode. If there is a fault present after saving the values, “ESC” needs to be pressed three times.

Fault #64 (“Pos DMD lost) Behavior

When the position demand input falls below 3.6 mA, fault #64 (“Pos DMD lost) is displayed on the LCD screen. By default, when Fault #64 appears, the output torque is not powered even if the position demand signal is restored above 3.6 mA until a reset is initiated (ie., as configured by the factory, this shutdown fault is of a “latching” nature). However, if using PN 3522-1042, it is possible to change the behavior of this fault so that there is no need to reset the fault #64 while position demand signal is restored to above 3.6 mA. In this case the output torque remains powered at 0% position all the time while the demand signal is below 3.6mA. This is helpful in applications where the speed control sends 0mA position demand due to a controlled / uncontrolled shutdown, but the user would like the actuator to run at a known position without losing torque during the fault and return to service without resetting the driver when the fault is resolved.

IMPORTANT

Please note that special consideration should be given when using this mode because the actuator’s output will respond to the demand signal when it is restored and will do so without human intervention. Sudden movement of the actuator is possible. This will have implications that the system designer needs to be aware of with respect to the overall prime mover function and personal safety, and should be carefully considered in each application where this functionality is desired.

WARNING

Sudden Movement

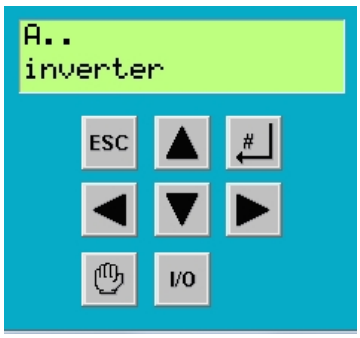
When the parameter P15 is set to '1', the actuator output shaft will remain powered at all times and will park at the minimum position during a demand position fault below 3.6mA. In this mode, the actuator requires NO acknowledgement from the operator to resume normal function and CAN SUDDENLY MOVE as it attempts to reach a desired demand position when the command signal is restored. This can be especially hazardous if the demand signal is intermittent for any reason.

When using this mode, all personnel must keep clear of the actuator's output and any associated linkage, as sudden and unexpected movement can cause serious personal injury or death.

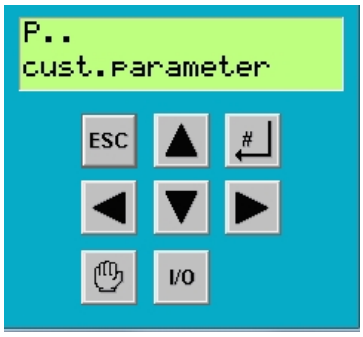
When using this mode, remove power from the EM80/300 actuator system before performing system maintenance or functional troubleshooting if such work requires close proximity to the actuator's output or fuel rack linkage.

Make sure that the driver is powered-up and not enabled (enable input is de-energized).

1. In the driver's front panel, press "**ESC**" for five seconds and then "**Enter key**" to access to configuration mode.

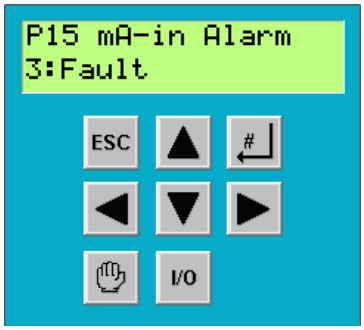


2. Navigate to the "P.. cust. Parameter" menu, using the **right and left keys**.



3. Press "**Enter key**".
4. Navigate to the parameter **P15** using the **up and down keys**, then press "**Enter key**". Depending on the current configuration a value appears blinking on the second line of the display.

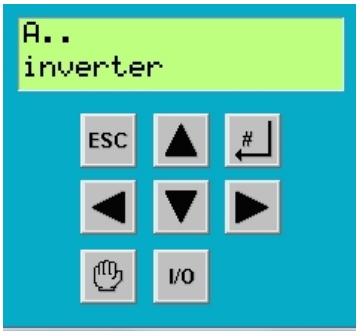
Blinking →



5. By using the up and down keys, set the value of P15 according to the required action (see table below):

P15 value	Corresponding Key	Fault #64 Behavior
1	Down key	"Alarm". No need to reset the fault, output torque powered
3	Up key	"Fault". Need to reset the fault, output torque not powered

6. Press "Enter key". The selected value should not blink anymore.
7. Press "ESC".
8. Navigate to the "A. inverter" menu using the right and left keys.



9. Navigate to the parameter **A00** using the **up and down keys** if needed, then press "**Enter key**". "0: inactive" should appear blinking on the second line of the display.

Blinking →

10. Press the **up key** to save the values. This will save the changes made to the control.
11. After a few seconds, the driver displays "0: error free" if the values are saved correctly.
12. If values are not saved correctly proceed to step 13 and repeat the steps 1–8-9–10–11–12 until the values are saved correctly.
13. Press "**ESC**" to leave configuration mode. If there is a fault present after saving the values, "**ESC**" needs to be pressed three times.

Revision History

Changes in Revision D—

- Updates for wiring and software functions
- Updated EMC information

Changes in Revision C—

- Updates for wiring and software functions

Changes in Revision B—

- Updated EMC information

Changes in Revision A—

- Updated for product release

Revision NEW—

- Preliminary manual

Declarations

EU Declaration of Conformity

ID	442541
Edition	04
Date	09.08.16
Page	1 of 1

STÖBER ANTRIEBSTECHNIK GmbH & Co. KG
Kieselbronner Straße 12
D-75177 Pforzheim

- Translation -

We, STÖBER ANTRIEBSTECHNIK GmbH & Co. KG, declare that the following described product groups of the 5th generation inverters

POSIDRIVE® FDS 5000A	POSIDRIVE® FDS 5000A	POSIDRIVE® MDS 5000A	POSIDYN® SDS 5000A
FDS 5004A/L	FDS 5004A/H	MDS 5007A/L	SDS 5007A/L
FDS 5007A/L	FDS 5007A/H	MDS 5008A/L	SDS 5008A/L
FDS 5008A/L	FDS 5008A/H	MDS 5015A/L	SDS 5015A/L
FDS 5015A/L	FDS 5015A/H	MDS 5040A/L	SDS 5040A/L
FDS 5022A/L	FDS 5022A/H	MDS 5075A/L	SDS 5075A/L
FDS 5040A/L	FDS 5040A/H	MDS 5110A/L	SDS 5110A/L
FDS 5055A/L	FDS 5055A/H	MDS 5150A/L	SDS 5150A/L
FDS 5075A/L	FDS 5075A/H	MDS 5220A/L	SDS 5220A/L
		MDS 5370A/L	SDS 5370A/L
		MDS 5450A/L	SDS 5450A/L

meet the relevant requirements of the **(Machine) Directive 2006/42/EC**.

In addition, the products are complied with the requirements of the **(Low Voltage) Directive 2014/35/EU** and the **(EMC) Directive 2014/30/EU**.

An EC-type examination certificate was issued by the "Institute for Occupational Safety and Health of the German Social Accident Insurance" (European notified body; ID number 0121) with the document number IFA 1601194.

IFA Institute for Occupational Safety and Health of the German Social Accident Insurance
Alte Heerstraße 111
53757 Sankt Augustin

The certificate is valid until 28.07.2021.

The following harmonized standards were applied during the development and the product maintenance:

DIN EN	61800-5-1:2008-04 + Berichtigung 1:2010-04
DIN EN	61800-5-2:2016-04
DIN EN	61800-3:2012-09 + Berichtigung 1:2014-02
DIN EN ISO	13849-1:2016-06
DIN EN ISO	13849-2:2013-02

This declaration certifies conformity with the stated documents, but it does not guarantee any properties.

Observe the safety instructions of the product documentation

The following person(s) are authorized to compile the technical documents:
STÖBER ANTRIEBSTECHNIK GmbH & Co. KG
Dr. Martin Hornung
Head of Power Electronics

09. Aug. 2016

Pforzheim, 09.08.2016
Stephan Scholze, Head of Management Center Electronics

DECLARATION OF INCORPORATION
Of Partly Completed Machinery
2006/42/EC

File name: 00283-04-EU-MD-02-03
Manufacturer's Name: WOODWARD INC.

Manufacturer's Address: 1041 Woodward Way
Fort Collins, CO 80524 USA

Model Names: EM-80/300 Actuators and Drivers

This product complies, where applicable, with the following Essential Requirements of Annex I: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

The relevant technical documentation is compiled in accordance with part B of Annex VII. Woodward shall transmit relevant information if required by a reasoned request by the national authorities. The method of transmittal shall be agreed upon by the applicable parties.

The person authorized to compile the technical documentation:

Name: Dominik Kania, Managing Director
Address: Woodward Poland Sp. z o.o., ul. Skarbowa 32, 32-005 Niepolomice, Poland

This product must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of this Directive, where appropriate.

The undersigned hereby declares, on behalf of Woodward, Inc. of Loveland and Fort Collins, Colorado that the above referenced product is in conformity with Directive 2006/42/EC as partly completed machinery:

MANUFACTURER

Signature

Joe Driscoll
Full Name

Engineering Manager
Position

Woodward Inc., Fort Collins, CO, USA
Place

11-Aug-2017
Date

Document: 5-09-1182 (rev. 16)

Released

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 26761D.

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Email and Website—www.woodward.com

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as well as authorized distributors and other authorized service and sales facilities throughout the world.**

Complete address / phone / fax / email information for all locations is available on our website.