

## **EPG (Electric Powered Governor) with Position Feedback**

**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

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### 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.



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# Warnings and Notices

## 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.

**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.

# Chapter 1.

## General Information

### Introduction

This manual is designed to provide the installer and operator of the Woodward Electric Powered Governor with Position Feedback (EPG-PF) the information needed to successfully install the actuator and speed control and to provide for operation, maintenance, and troubleshooting of the system.

### Description

The EPG-PF system provides extremely accurate, responsive, control of speed on gas and diesel engines and steam and gas turbines. The position feedback actuator is available for either 12 or 24 V systems in a small 512/24 and a larger 1712/24 designation.

Work outputs of the actuators are:

Actuator Model	Work Output	Travel from Min to Max	Part No. CW to Max	Part No. CCW to Max
512	0.7 J 0.5 ft-lb	30 degrees	8256-068	8256-069
524	1.0 J 0.75 ft-lb	30 degrees	8256-066	8256-067
1712	1.6 J 1.2 ft-lb	35 degrees	8256-062	8256-063
1724	2.3 J 1.7 ft-lb	35 degrees	8256-064	8256-065

Position feedback actuators provide increased work capacity in the increase-fuel direction because of a transient current to the actuator in response to a large speed-error signal. Decrease fuel rotation of the actuator is provided by a return spring. The ability to overcome control hesitation caused by friction or other static conditions is greatly improved by the addition of position feedback which allows the control to sense these conditions.

Speed Range:

Part Number	Voltage	Speed Range
8290-103	24 Vdc	3000 to 6000 Hz
8290-104	12 Vdc	3000 to 6000 Hz
8290-119	24 Vdc	750 to 1500 Hz
8290-120	24 Vdc	1500 to 3000 Hz
8290-121	24 Vdc	6000 to 12 000 Hz

The engine speed in gear-tooth Hz must be specified with the part number. The speed being sensed will be the number of teeth on the gear being sensed times the RPM divided by 60.

$$Hz = \frac{\text{No. of teeth} \times \text{RPM}}{60}$$

## Optional Wiring Harness

Part number 8924-865 provides a made-up wiring harness for installation of the EPG with position sensor system. This harness includes all of the wiring needed for installation, including the shields and special connectors. The wires are sized to provide optimal operation over the lengths specified. Individual wiring can be ordered by the part number indicated in the following table.

Length	Connects from Control Box To:	Part Number
7.6 m 25 feet	Position Sensor on Actuator	5415-480
4.6 m 15 feet	Magnetic Pickup on Engine	5405-508
7.6 m 25 feet	Battery	5405-507
7.6 m 25 feet	Actuator	5405-506

## Droop

The EPG-PF control may be operated in either isochronous (constant rated speed regardless of load) or in droop (a decrease in rated speed as a straight-line function of increased load).

Droop is typically adjustable from 0 to 6.67% of rated speed between no load and full load. Load is measured by actuator position and the maximum percentage of droop is based on the no-load to full-load rotation of the actuator required by the engine or turbine.

Typically 2/3 of the total actuator rotation is used for a no-load to full-load fuel setting. If only half of the actuator rotation is used, 0 to 5% droop will be available.

Droop operation is used when the engine is being paralleled with other engines on a common load or when a generator set is paralleled with an infinite bus. Droop must be used with an infinite bus as the infinite bus forces the engine to run at the bus frequency. Without droop the control will attempt to take the entire system load, or will go to minimum fuel, thus motoring the generator

## Isochronous

The isochronous mode is used for constant engine speed when a single engine is being controlled. Under this control system speed will always be constant within the ability of the engine to carry the load.

Isochronous mode is also used when the EPG system is combined with a load sensor in a multiple generator system, sharing load as a function of the PT and CT feedback, not engine speed.

## Start Fuel Limit

Position feedback from the actuator permits start-fuel limiting.



The adjustable start-fuel limit (fuel-control-lever position limit) is set on the control. The limit is automatically enabled whenever the engine shuts down. The limit is disabled when the engine reaches idle or rated speed as selected. If the feature is not needed, the limit must be set fully clockwise so it will not keep the fuel control from going to maximum during start-up.

### **MPU Failed Circuit**

The MPU failed circuit will shut down the actuator upon loss of the MPU signal. It may, if required, be overridden with momentary contacts. The override feature is particularly valuable for slow starting engines and turbines where the cranking speed does not generate an adequate signal from the magnetic pickup. The failed circuit should not be permanently disabled as it is a safety feature, provided in the event of a failure in the magnetic pickup or associated transmission wires.

## **Accessories**

This manual contains some information about accessories often used with EPG controls.

### **Generator Load Sensor**

The Generator Load Sensor provides isochronous load sharing between engines in an EPG multi-generator system by comparing the power output as measured by PT and CT from each of three phases from each generator and biasing a single load sharing line between the various EPG controls to compensate for differences in load. The Load Sensor also provides a method to attach an SPM-A Synchronizer and other specialized control items to the generator control system.

### **SPM-A Synchronizer**

The SPM-A Synchronizer, attached to the EPG system through a load sensor, will automatically bias the rated-speed setting until an engine/generator is in parallel with the bus. When the speed is synchronized with the bus the synchronizer will call for a breaker closure, tying the generator with the bus.

### **EPG Actuator Driver**

A separate EPG Actuator Driver is available to use with the EPG Speed Control or with a 2301A control system. The driver will accept the 1 to 5 Vdc signal from terminals 19 (+) and 20 (–) of the EPG Speed Control to position a second actuator in the identical position as the actuator driven from terminals 3 and 4 on the speed control. The driver also allows using an EPG actuator with the more sophisticated 2301A control system, accepting the 20 to 160 mA output from the 2301A Load Sharing and Speed Control or 2301A Speed Control. The driver will work with any control which puts out a 4 to 20 mA or 1 to 5 V output signal to control speed or a process.

A plant wiring diagram of the driver is shown in Figure 2-6. See Chapter 2 (EPG Driver) for information on the calibration and installation of the EPG driver. Additional information about the driver is found in Chapter 4 (EPG Driver Option).

## Acceleration/Deceleration Ramp Generators

A Ramp Generator, or an external capacitor, can be used to increase the time to go from idle to rate speed and from rated speed to idle.

The Ramp Generator provides a linear ramp with times adjustable to 25 seconds in a typical case. It is useful in smoke limiting and other applications. Use the 8271-909 with a 24 V system and the 8271-910 with a 12 V system. Using a capacitor provides about one second of ramp time per 50  $\mu\text{F}$ , 500  $\mu\text{F}$  maximum. The plant wiring diagram provides additional details about the use of a capacitor to achieve ramp times.

## Chapter 2. Installation

### Introduction

This chapter contains general installation instructions for the EPG with Position Feedback. Power requirements, ambient temperature limits, and location considerations are included to determine the best location for the control.

Custom actuator installation kits, including actuator mounting hardware, are available for some specific engines. Contact Woodward for more information.

### Installation of Speed Controller

#### Unpacking

Be careful when unpacking the electronic control. Check the control for signs of damage such as bent or dented panels, scratches, and loose or broken parts. Notify the shipper and Woodward if damage is found.

#### Mounting

The control box is designed to operate within a temperature range of -40 to +75 °C (-40 to +167 °F).

Mount the control in a location with space for adjustment and wiring access. Do not expose the control to sources of radiant heat such as exhaust manifolds or turbochargers. Choose a protected location so the control won't be damaged when moving the prime mover or when near-by equipment is moving. Mount the control close enough to the actuator and battery to meet the wire-length requirements. (See wiring instructions in this chapter.)

The control will generate a little heat and surfaces must be open to normal air movement. No special ventilation is required.

Ideally the control should be mounted flush to the metal side of a control cabinet, protected from the weather and high humidity, and close to the engine being controlled. The location should provide protection from high-voltage or high-current devices, or devices which produce electro-magnetic interference. After initial adjustments are completed all functions may be selected with remote switches on the control panel. Ready access to the control will not be required for normal engine operation.

Do not install the control box directly on the engine.

### Actuator Mounting and Linkage

The actuator is designed to operate within a temperature range of -40 to +93 °C (-40 to +200 °F). Do not expose the actuator to sources of excessive heat.

Actuator location must allow installation of suitable linkage. If an actuator installation kit has not been purchased from Woodward, see application note 50530, *Installation and Control Choices for EPG Actuators*, for suggestions on installations.

The position-feedback actuator has only one terminal shaft available for use on the engine. The position-sensor device is operated by the other terminal shaft. Clockwise or counterclockwise rotation of the shaft is determined at the time of ordering the actuator and should not be changed in the field. (See chart in Chapter 1 for part-number designation.) No adjustments of the position-sensor device are available.

## Linkage

Proper design and installation of the linkage from the actuator to the engine is necessary if the unit is to give good control.

Most installations have the actuator directly controlling the fuel flow to the engine or turbine, by moving either the fuel valve, butterfly valve, or fuel rack. Some installations have the actuator controlling the speed-setting shaft on a mechanical governor. This type of installation can give adequate control for generator sets, but may not provide control from full load to idle or shutdown. When controlling the speed setting of a mechanical governor, the mechanical governor must have at least 5% droop, preferably 8 to 10%.

The linkage is often connected to the shutdown lever or shaft. When this type of installation is used, the mechanical governor functions as a high speed limit. Note that when the shutdown lever is selected for control, the emergency and safety shutdown features are often disconnected.



**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.**

Linkage should be designed to provide a linear relationship between actuator movement and power from the prime mover. Most diesel engines are linear, and in these cases a movement of about 2 degrees of actuator-shaft position (10% of the total movement available) should cause about a 10% change in the position of the fuel control shaft and the power output of the engine. Figure 2-1 shows this type of linkage between the actuator and the fuel control lever. (See Figure 2-3 for additional information on actuator travel.)

Carburetors and some diesel engines have non-linear fuel controls. In these cases the actuator must be linked to the engine as shown in Figure 2-2. This compensating linkage requires more actuator movement to make a change in fuel at minimum fuel than at maximum fuel.

The power output must remain linear with either type of linkage.

Study the control features of the engine being fitted with the EPG control to determine the type of linkage required. Contact Woodward for additional linkage information.

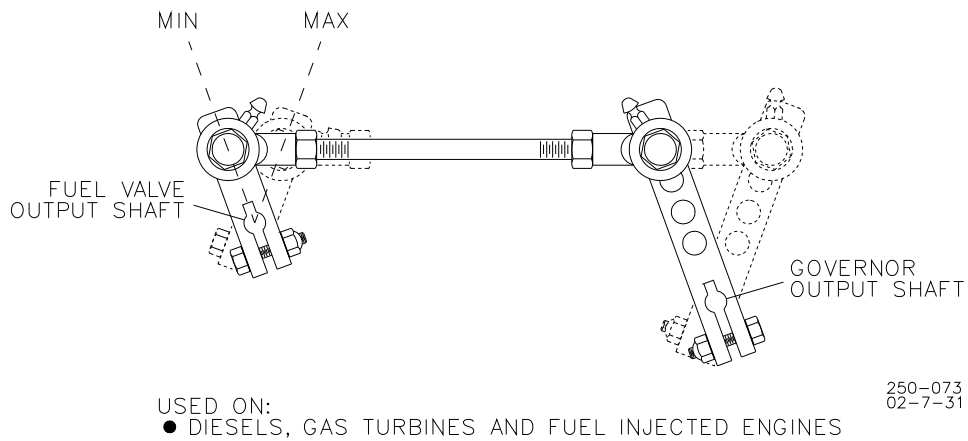


Figure 2-1. Linear Linkage

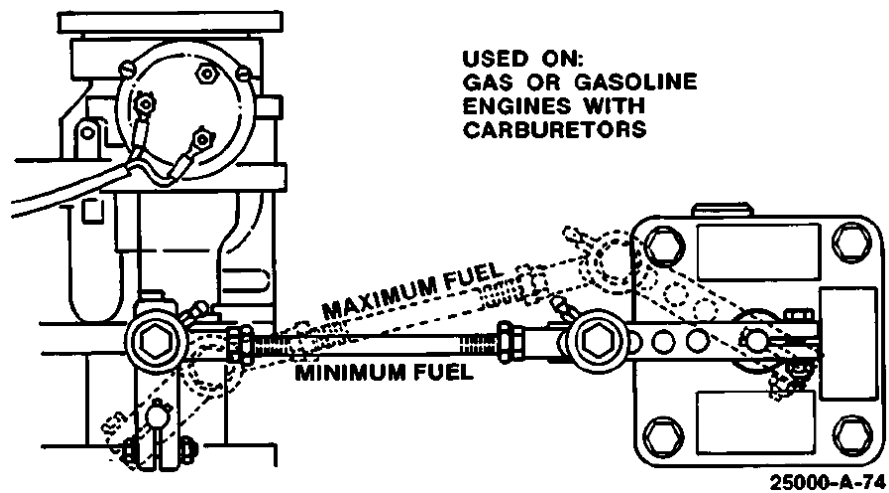


Figure 2-2. Carburetor Compensating Linkage

Incorrect matching of the actuator output and fuel-setting lever is the most common cause of unstable operation, and can cause stable operation at some fuel settings but oscillation at other fuel settings.

Manually stroke 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. Lubricate or replace worn linkage or fuel control parts as required.

A return spring is included in the actuator. Do not use an additional return spring. (Low force return springs that may be part of the engine fuel system usually don't affect EPG performance.)

Make sure the actuator is capable of moving the fuel control to maximum and minimum limits. Let the fuel control limit actuator travel. Set the linkage so the actuator is just above minimum when the fuel control is at its minimum stop and so the actuator is just below maximum when the fuel control is at its maximum stop. (Some fuel systems will bind if the stops are reached. In these cases it is possible to use the maximum and minimum stops of the actuator. This will require a more precise final adjustment of the control-rod length.)

Using too little actuator rotation can cause control instability and other control problems. Too little actuator rotation will also limit the amount of droop which can be adjusted into the control system. If it is necessary to use less than the recommended rotation adjust the linkage so the actuator approaches or reaches the maximum position at maximum fuel.

Use good rod-end connectors with as little slack as possible. Select rod ends which will not become loose and which will wear well during the nearly constant movement associated with precise speed control. Low friction, long wearing rod ends are available from Woodward.

The link connecting the actuator lever to the fuel-control lever must not be so long that it flexes when the prime mover is running. In most cases a piece of threaded rod is used for the link. Assemble the rod and rod ends with jam nuts at both ends. A rod end will have to be removed from either the actuator or engine end to change the length of the rod. However, this is usually preferred over the use of a turnbuckle type of rod with left and right hand screws because it prevents accidental speed changes should the jam nuts work loose and because it allows both rod ends to have more common right-hand threads.

If a long connecting rod between the actuator and the engine fuel control is required, use a hollow tube to reduce weight while maintaining strength. The hollow tube will usually be less subject to vibration than will a solid connecting rod.

Actuator levers are available from Woodward which allow adjustment of the rod-end location in respect to the center of the actuator shaft. The lever used must have a 0.375-36 serration to fit on the actuator.

Adjust the location of the rod end on the lever to achieve the desired rotation of the actuator shaft between minimum and maximum positions. (Use as much of the 35 degrees rotation as possible on the 1712/24 actuator, not less than 21 degrees. Use as much of the 30 degrees rotation as possible on the 512/24 actuator, not less than 18 degrees.) To increase the amount of rotation, move the rod end closer to the actuator shaft or farther away from the shaft controlling fuel flow. To decrease the amount of rotation used, move the rod end farther from the actuator shaft or closer to the shaft controlling fuel flow.

If less actuator rotation than recommended is necessary, maintain the maximum setting near the maximum actuator rotation with a majority of the unused rotation at the minimum-fuel direction. Using less than the recommended amount of rotation will often cause instability in the governor system.

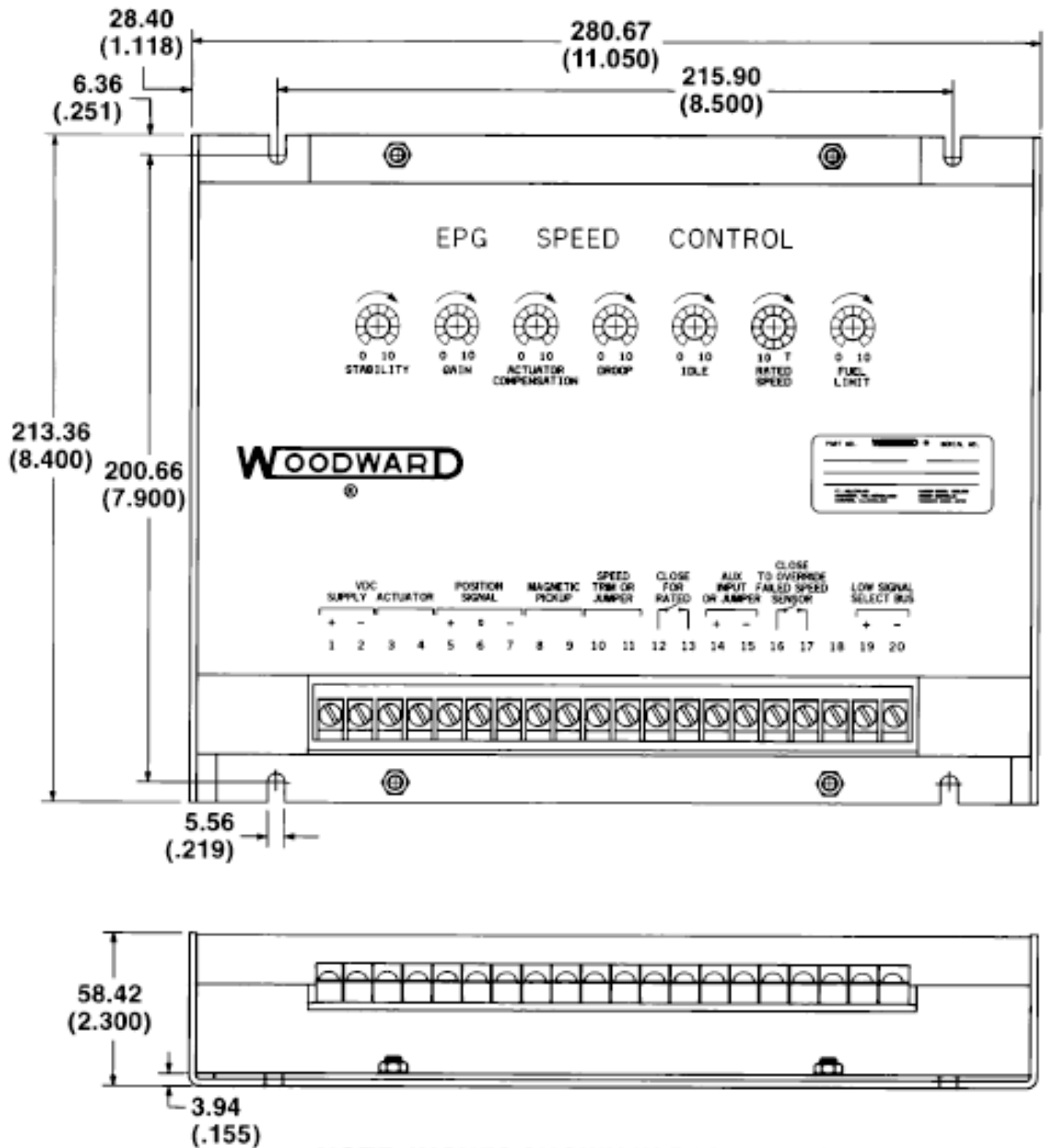


Figure 2-3. Position Feedback EPG Control Outline

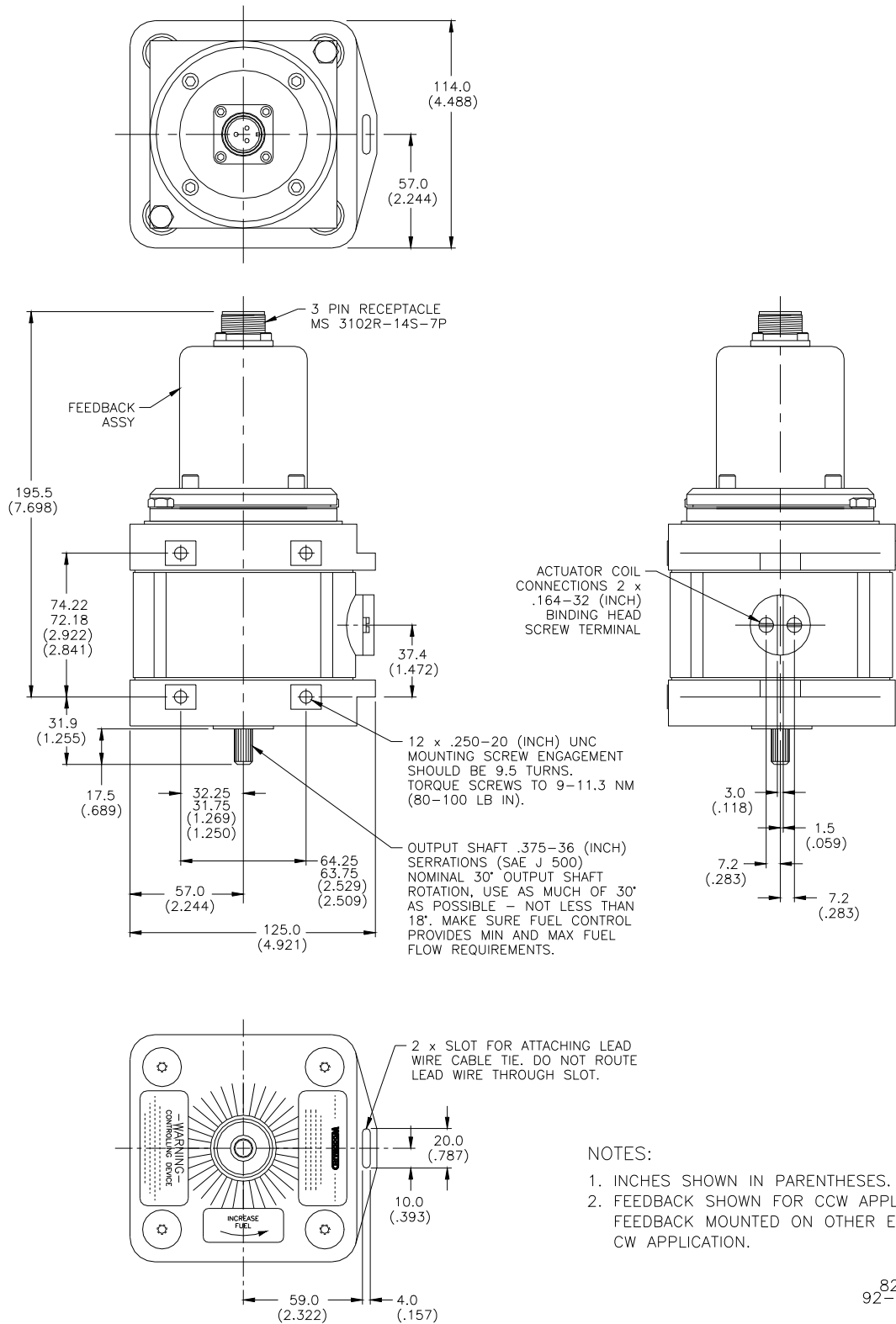


Figure 2-3a. EPG Position Feedback 512/24 Actuator Outline



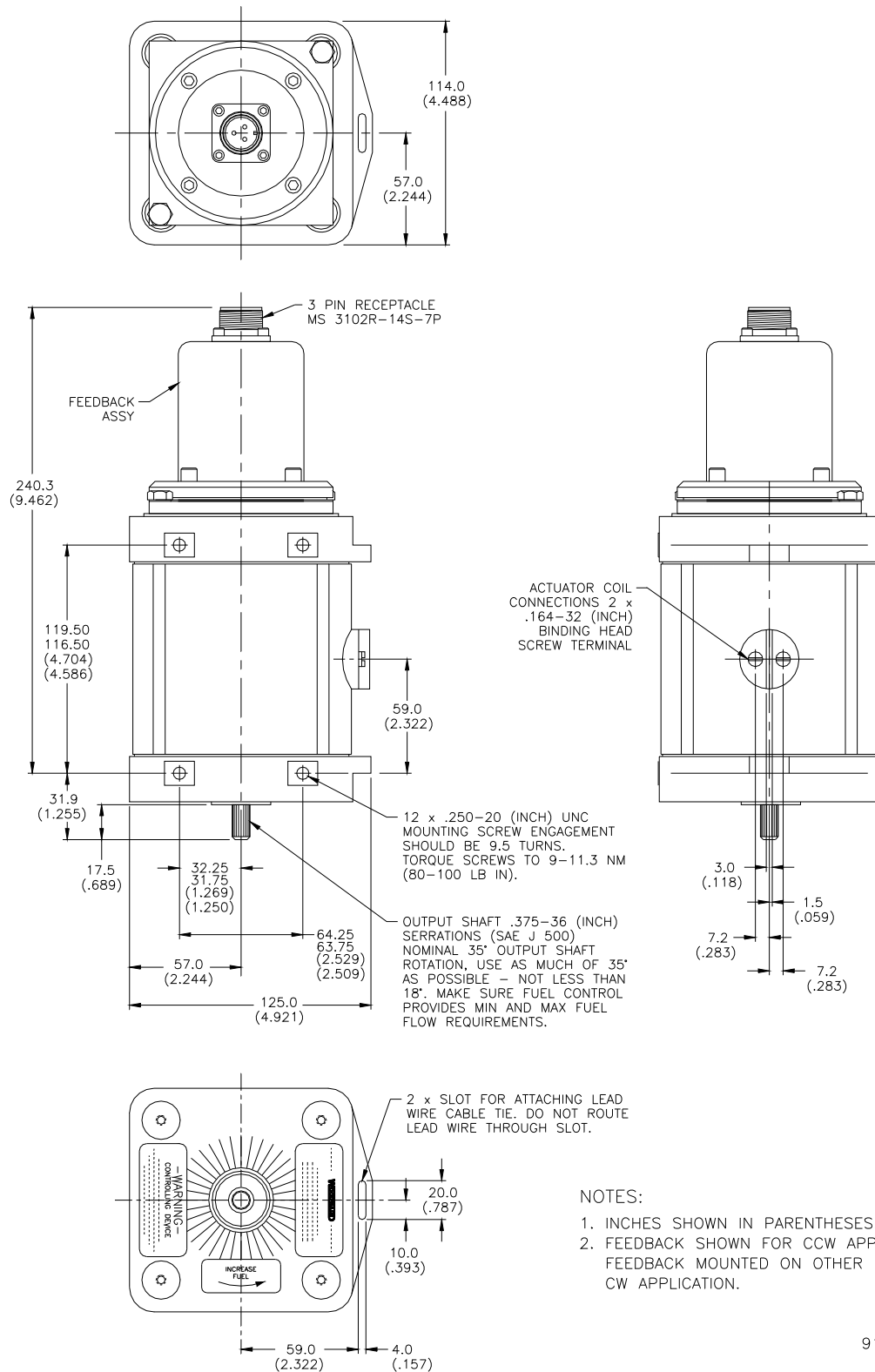
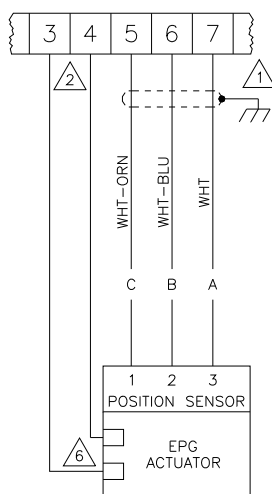
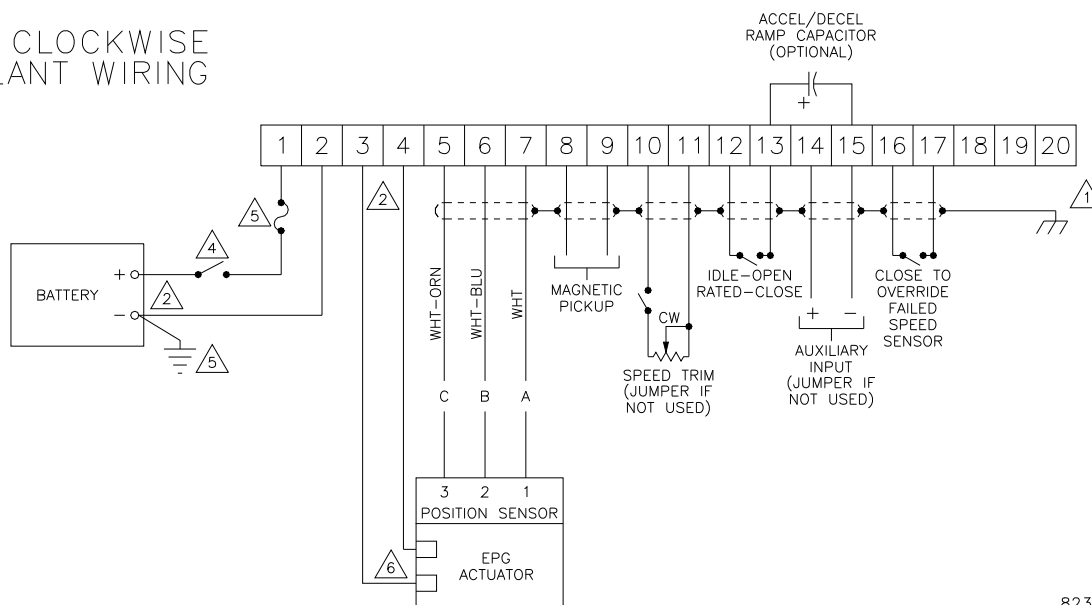


Figure 2-3b. Position Feedback EPG 1712/24 Actuator Outline

COUNTERCLOCKWISE  
PLANT WIRING

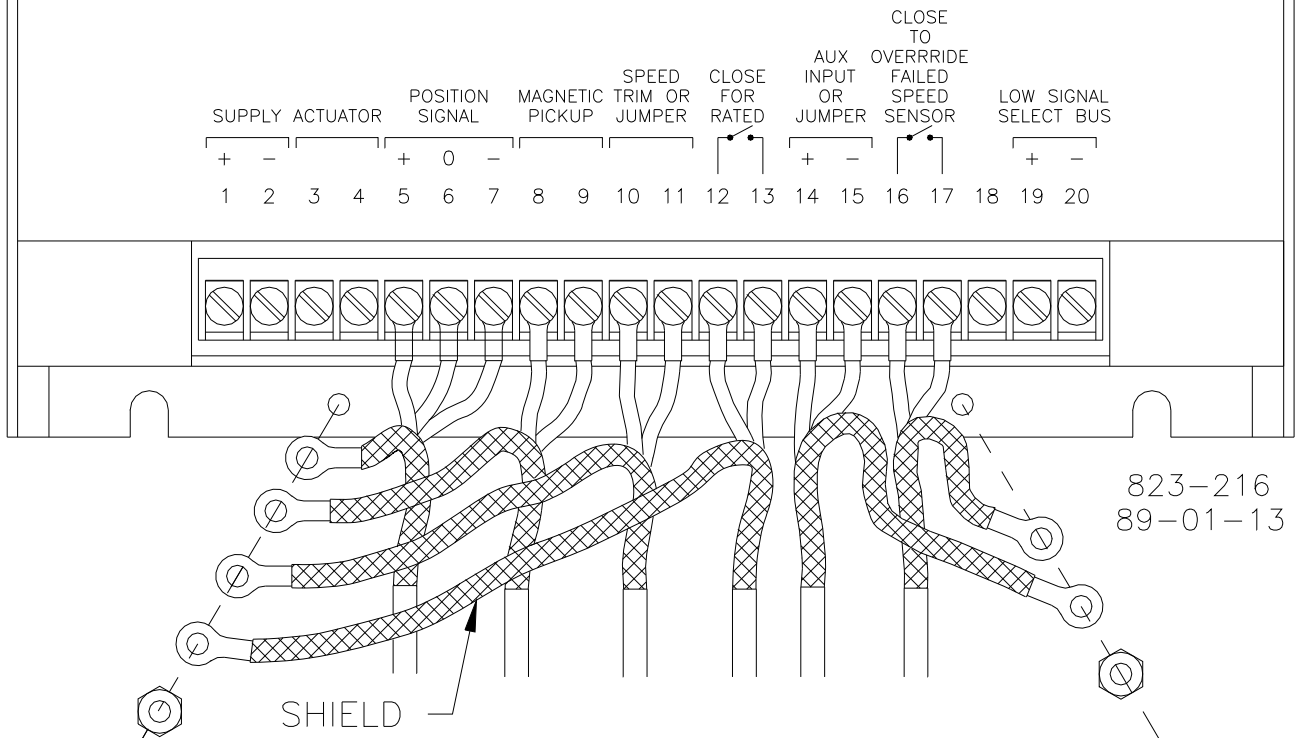
## NOTE:

- 1 SHIELDED WIRES TO BE TWISTED PAIRS OR TRIPLES WITH SHIELD GROUNDED AT ONE END ONLY.
- 2 NO. 12 AWG OR 14 AWG STRANDED WIRE. MUST BE AS SHORT AS POSSIBLE.
- 3 JUMPER REQUIRED FOR 4-20mA INPUT. MUST BE OUT FOR 1-5 INPUT.
- 4 FOR POSITIVE GROUND SYSTEMS, SWITCH AND FUSE TO BE LOCATED IN SERIES WITH BATTERY (-) AND TERMINAL 2. POSITIVE TERMINAL BECOMES CHASSIS GROUND. LEADS FROM BATTERY TO TERMINALS 1 & 2 MUST BE DIRECT AND NOT PASS THROUGH DISTRIBUTION POINTS.
- 5 USE A 10 AMP FUSE (3AG OR GLH TYPE).
- 6 ACTUATOR HAS NO POLARITY.

CLOCKWISE  
PLANT WIRING

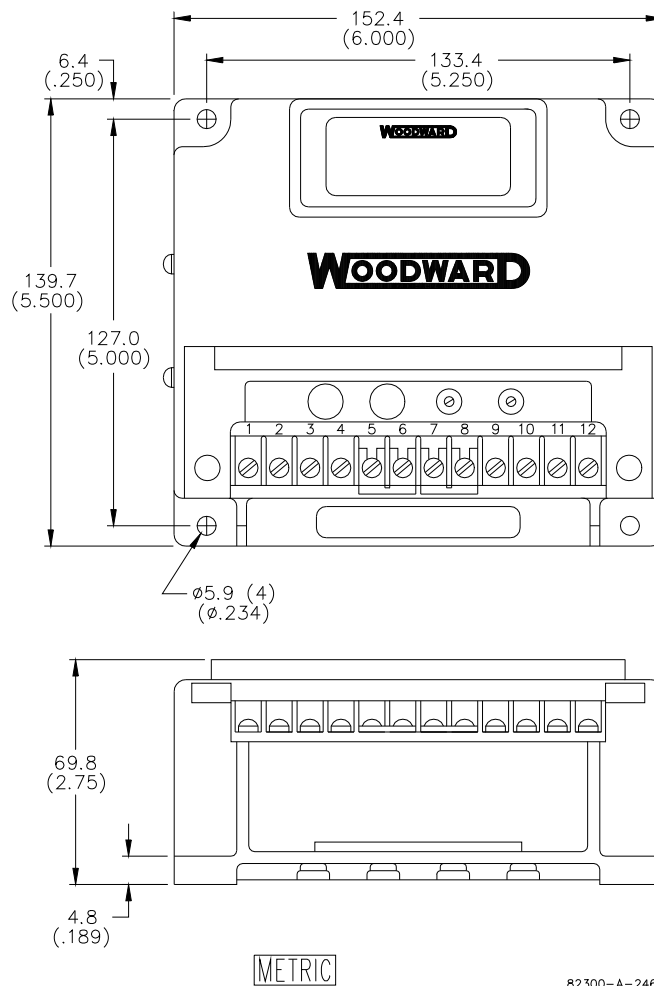
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Figure 2-4. Plant Wiring Diagram and Shield Grounding

**WOODWARD****NOTES:**

- 1 SHIELDED WIRES TO BE TWISTED PAIRS WITH SHIELD GROUNDED AT ONE END ONLY.
- 2 NO 12 AWG OR 14 AWG STRANDED WIRE. MUST BE AS SHORT AS POSSIBLE (SEE MAX LENGTH IN OPTION CHART).
- 3 SEE OPTION CHART.
- 4 OPEN FOR MINIMUM FUEL.
- 5 FOR POSITIVE GROUND SYSTEMS, SWITCH AND FUSE TO BE LOCATED IN SERIES WITH BATTERY (-) AND TERMINAL 2. POSITIVE TERMINAL BECOMES CHASSIS GROUND. LEADS FROM BATTERY TO TERMINAL 1 & 2 MUST BE DIRECT AND NOT PASS THROUGH DISTRIBUTION POINTS.
- 6 APPROXIMATE SPEED CHANGE WITH TRIM POTENTIOMETER:  
 $\pm 2.5\%$  USING A 1K OHM POTENTIOMETER  
 $\pm 5\%$  USING A 2K OHM POTENTIOMETER
- 7 APPROXIMATELY ONE SECOND RAMP TIME PER UF.  
 CAPACITOR SPECIFICATIONS: 500 UF MAXIMUM, 15 WVDC MINIMUM,  
 LESS THAN 30 UA DC LEAKAGE CURRENT OVER TEMPERATURE RANGE.
- 8 USE A 10 AMP FUSE (3 AG OR GLH TYPE).
- 9 ACTUATOR HAS NO POLARITY.
- 10 CONTACT MUST BE MOMENTARY CONTACT TO BE OPEN AFTER START UNLESS MAXIMUM PRIME MOVER SPEED IS LIMITED BY A MECHANICAL GOVERNOR OR SIMILAR DEVICE..

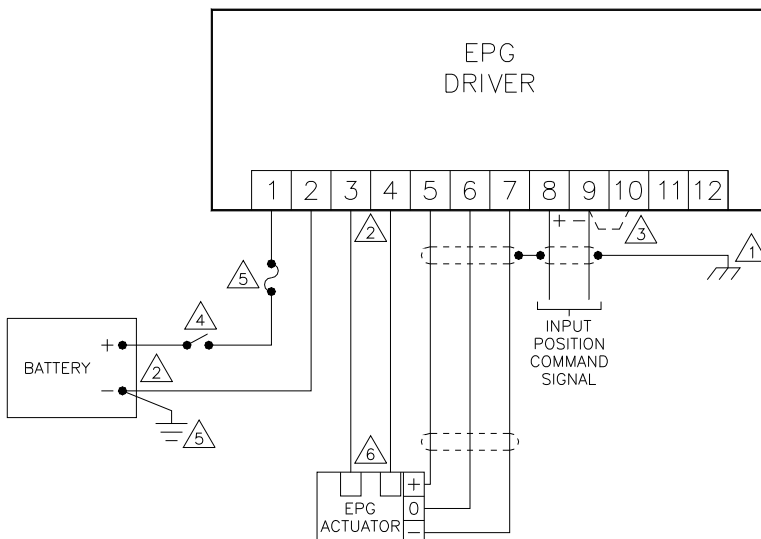
Figure 2-5. Proper Wiring of EPG Position Feedback Control



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90-05-17 MCL

## NOTE:

- 1 SHIELDED WIRES TO BE TWISTED PAIRS OR TRIPLES WITH SHIELD GROUNDED AT ONE END ONLY.
- 2 NO. 12 AWG OR 14 AWG STRANDED WIRE. MUST BE AS SHORT AS POSSIBLE.
- 3 JUMPER REQUIRED FOR 4-20mA INPUT. MUST BE OUT FOR 1-5 INPUT.
- 4 FOR POSITIVE GROUND SYSTEMS, SWITCH AND FUSE TO BE LOCATED IN SERIES WITH BATTERY (-) AND TERMINAL 2. POSITIVE TERMINAL BECOMES CHASSIS GROUND. LEADS FROM BATTERY TO TERMINALS 1 & 2 MUST BE DIRECT AND NOT PASS THROUGH DISTRIBUTION POINTS.
- 5 USE A 10 AMP FUSE (3AG OR GLH TYPE).
- 6 ACTUATOR HAS NO POLARITY.



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Figure 2-6. EPG Position Feedback Driver Outline and Plant Wiring

## Magnetic Pickup

Install the magnetic pickup to work with the selected gear through a housing or rigid bracket. Make sure the sensed gear is of magnetic material. Set the gap between the gear and the end of the magnetic pickup according to instructions which accompany the pickup.

Magnetic pickups of various sizes are available from Woodward.

The standard models of magnetic pickups require mating connectors, MS 3102R-18-3P. The connectors can be furnished with the magnetic pickup ordered from Woodward.

Manual 82510 Magnetic Pickups for Electric Governors contains detailed information on the installation of the sensing device.

## Wiring Instructions

External wiring connections and shielding requirements for a typical control installation are shown in the plant wiring diagram, Figure 2-4. These wiring connections and shielding requirements are explained in the balance of this chapter.

Electromagnetic interference (EMI) is the undesirable interaction of electronic circuits with each other and sometimes with themselves.

Woodward has established procedures to prevent most EMI which will affect prime-mover-control circuits. Following these procedures is a slight extra expense in planning and installing electronic governing systems, but is inexpensive insurance over the life of the plant. Follow all of the shielding instructions to assure maximum efficiency and dependability of the electronic governing system.

Application Note 50532, *EMI Control for Electronic Governing Systems*, has additional information on EMI causes and prevention.

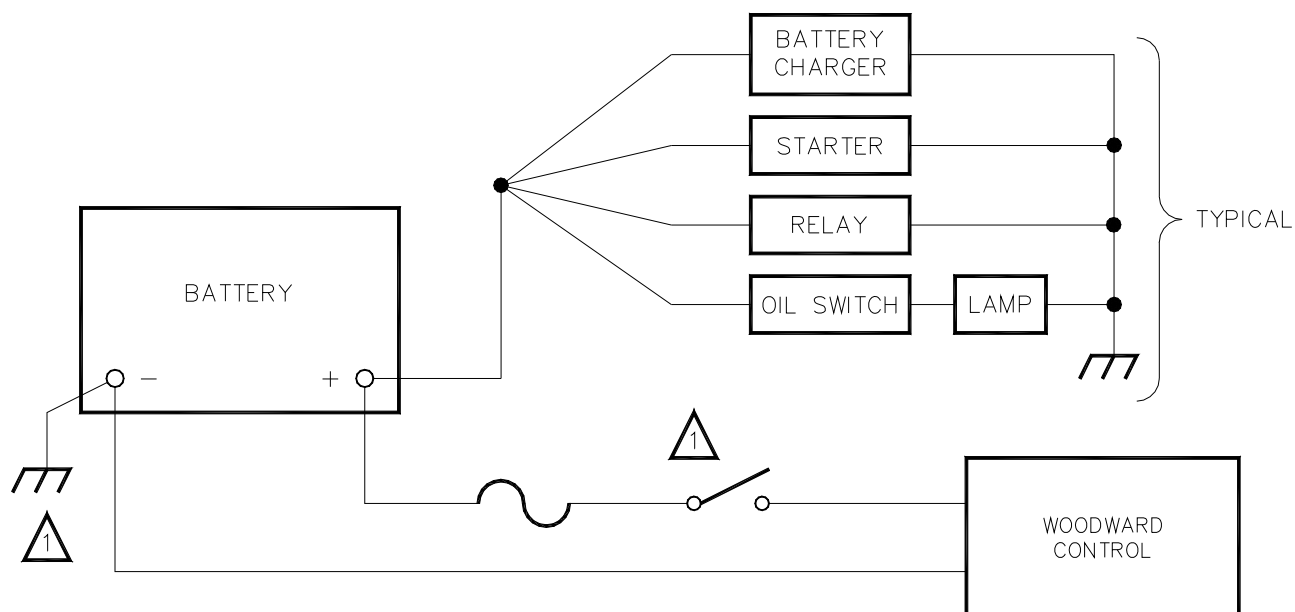
## Shielded Wiring

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the control case as shown in Figure 2-4, and the plant wiring diagram. Wire exposed beyond the shield should be as short as possible, not exceeding six inches. The other end of the shields must be left open and insulated from any other conductor. Do not run shielded signal wires with high voltage or high current wires.

Use 2 mm<sup>2</sup> (14 AWG) or 3 mm<sup>2</sup> (12 AWG) wire throughout the EPG circuit. The total distance from the battery to the control and from the control to the actuator must not exceed the maximum wire length shown in the following chart:


### Maximum Wire Length

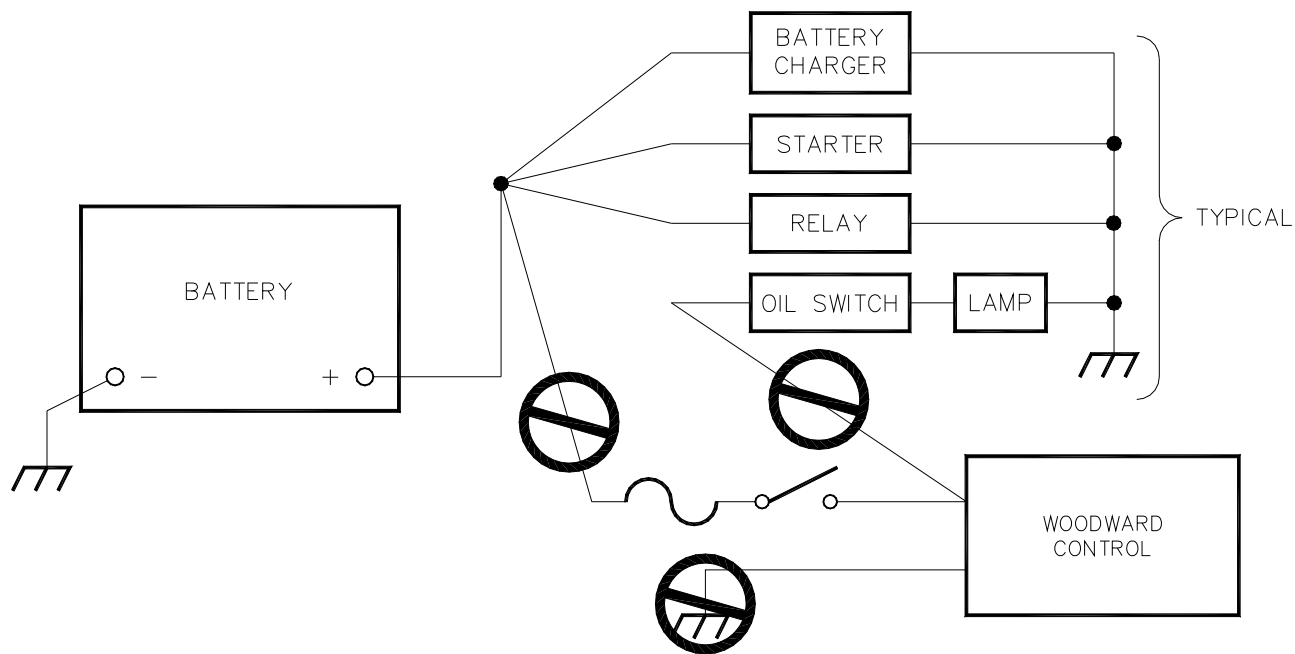
2 mm <sup>2</sup> /14 AWG Wire	3 mm <sup>2</sup> /12 AWG Wire	Voltage
3 m (10 ft)	6 m (20 ft)	12 V
11 m (35 ft)	23 m (75 ft)	24 V



NOTE:

RIGHT

 A NEGATIVE GROUND SYSTEM IS SHOWN. IF A POSITIVE GROUND SYSTEM IS USED, THE SWITCH AND FUSE MUST BE LOCATED IN SERIES WITH BATTERY (-) AND TERMINAL (TB1-2) ON THE WOODWARD CONTROL. THE POSITIVE TERMINAL BECOMES CHASSIS GROUND.

WRONG

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Figure 2-7. Wiring Direct from Battery to Control

## Battery to Control Wires

Run an insulated 2 or 3 mm<sup>2</sup> (12 or 14 AWG) wire directly from the positive (+) battery terminal through a switch and a 10 A fuse to terminal 1 on the control (see Figure 2-5). Run a second insulated 2 or 3 mm<sup>2</sup> (12 or 14 AWG) wire directly from the negative (-) terminal of the battery to terminal 2 of the control. Neither of these connections needs to be shielded.

Run insulated 2 or 3 mm<sup>2</sup> (12 or 14 AWG) wires from terminals 3 and 4 of the control to the two terminals on the electric actuator. Polarity of these connections is not important. The total length of wire used from the battery to the control and from the control to the actuator must not exceed the maximum wire length listed above.

## Control/Actuator Connections

The feedback mechanism may be installed on either side of the actuator, allowing either clockwise or counterclockwise rotation of the actuator output shaft toward maximum fuel. The control wiring between the position sensor and the control panel is set to reflect the rotation of the output shaft used to control the fuel setting. The position sensor wiring must be changed if the device is moved to the other side of the actuator.

### Clockwise to Maximum Fuel

(Actuator numbers 8256-062, -064, -066, -068)

Actuators come equipped with a factory wired pigtail from the position sensor, terminating with a male plug. (The female mating plug is included in the optional EPG wire harness kit 8924-865.) Terminals in both plugs are numbered 1, 2, 3, and 4. (Other types of connectors are available.)

Use 0.5 to 0.8 mm<sup>2</sup> (18 to 20 AWG) shielded three-conductor cable. Connect terminal 5 on the control (+) to post 3 on the plug. Connect terminal 6 on the control to post 2 on the plug. Connect terminal 7 on the control (–) to post 1 on the plug. Connect the shield to the shield ground at the control and to post 4 on the plug.

### Counterclockwise to Maximum Fuel

(Actuator numbers 8256-063, 065, -067, -069)

Actuators come equipped with a factory wired pigtail from the position sensor, terminating with a male plug. (The female mating plug is included in the optional EPG wire harness kit 8924-865.) Terminals in both plugs are numbered 1, 2, 3, and 4. (Other types of connectors are available.)

Wiring a counterclockwise to maximum control is identical with the clockwise system because the wires have been reversed at the actuator position sensor. No changes need to be made in the installation.

## Replacement of the Pigtail

Should it be necessary to replace the wiring from the position sensor note that the posts on the sensor are numbered 1, 2, 3. The shield is to be left open at the position sensor, but connected to post 4 in the plug so there will be continuity to the shield ground at the control. Notice that the wiring is reversed in the counterclockwise units.

## EPG Actuator

Connect the actuator to the control with 3 mm<sup>2</sup> (12 AWG) insulated wire between terminals 3 and 4 on the control and the connections on top of the actuator. Polarity is not important. Tie the wire to the top of the actuator with the blue high-temperature wire tie provided with the actuator to prevent breakage due to vibration.

## Control/Actuator Connections

Use 0.5 to 0.8 mm<sup>2</sup> (18 or 20 AWG) shielded three-conductor cable from terminals 5, 6, and 7 to pins 3, 2, and 1 on the female connecting plug, if a plug is used. These wires continue through the plug to terminals 3, 2, and 1 on the clockwise acting actuator position sensor. Leave the shield open at the actuator and ground the shield to the control case at the same point other shields are to be grounded.

Notice on the plant wiring diagram that the shield is carried through the plug used to connect to the shield wire that is grounded at the control.

## Magnetic Pickup Connections

Use 0.5 to 0.8 mm<sup>2</sup> (18 or 20 AWG) shielded two-conductor cable from the magnetic pickup to terminals 8 and 9 on the control. Leave the shield open at the magnetic pickup and ground the shield at the control. Polarity is unimportant.

## Speed Trim Connections

If a speed-trim pot is to be used, it should be connected to terminals 10 and 11, as shown on the plant wiring diagram. Use 0.5 to 0.8 mm<sup>2</sup> (18 or 20 AWG) shielded cable with the shield open at the potentiometer and switch connections and tied to the chassis ground at the control end.

A 1 k $\Omega$  pot will provide about  $\pm 2.5\%$  speed change from maximum to minimum setting. A 2 k $\Omega$  pot will offer about  $\pm 5\%$  change in speed. Install a single-pole, single-throw switch between terminal 10 and the pot to provide minimum fuel or shutdown when open. If a speed-trim pot is not desired, install a jumper (Woodward part number 1606-899) across terminals 10 and 11.



### **WARNING**

**Do not use the switch in the speed trim circuit for emergency shutdown of the engine. The emergency shutdown must be completely separate from the speed control circuit, not depending on the actuator or control to provide the shutdown. Life threatening overspeed is possible if a separate overspeed system is not used.**



A speed-trim pot is often required for loading when the control or load sensor is used in the droop mode.

A speed-trim pot is not needed for most isochronous applications. The rated speed is set on the control box with a 10-turn potentiometer which provides precise calibration. The control exhibits extremely close control of speed with negligible temperature drift, eliminating most reasons for a speed-trim adjustment.

### Idle/Rated Switch

Use 0.5 to 0.8 mm<sup>2</sup> (18 or 20 AWG) shielded two-conductor cable to install a single pole, single throw switch between terminals 12 and 13 on the control. Ground the shield with the other shields on the case.

When the switch is open the engine will operate at the idle speed. When the switch is closed the engine will operate at the rated speed. Leave the shield open at the switch and tie the shields to the control chassis.

The installation should take into account that the engine will go directly to high speed should the engine or turbine restart before the switch is opened.

### Auxiliary Input

If a synchronizer, load sensor, or other speed modifying equipment is used, attach it to terminals 14 (+) and 15 (-). Use 0.5 to 0.8 mm<sup>2</sup> (18 or 20 AWG) shielded, twisted-pair wire to make the connection. Tie the shield to the speed-control chassis. Jumper terminal 14 to 15 if special speed-modifying equipment is not used.

### Accel/Decel Ramp

If a ramp generator or a capacitor is used to control acceleration and deceleration rates, connect positive (+) to terminal 13 and negative (-) to terminal 15. Using a capacitor between terminals 13 and 15 will provide about one second of ramp time per 50  $\mu$ F. Use a 50 to 500  $\mu$ F capacitor, 15 Vdc minimum working voltage. The capacitor must have less than 30  $\mu$ A dc leakage current over the temperature range. If a Woodward Ramp Generator (8271-909 for 24 V or 8271-910 for 12 V) is attached to terminals 13 and 15 the ramp can be adjusted up to 25 seconds from idle to rated speed.

### MPU Failed Circuit

If the installation is a slow cranking unit which needs to override the failed MPU circuit, attach a momentary switch between terminals 16 and 17. When the switch is held closed the actuator will be driven to maximum fuel or the start-fuel-limit setting, in spite of the low MPU signal which would otherwise cause the actuator to remain at minimum fuel.

The MPU Failed Circuit is included in the control as a safety condition, preventing runaway should the MPU circuit fail for any reason. It is mandatory that the override failed MPU switch be opened when the engine or turbine speed is sufficient to clear the failed MPU circuit.

## Shields

Ground all shields to one of the bolts used to mount the control. Do not have any of the shields tied to ground at the other end.

When passing shields through connectors and terminal blocks treat each shield as if it were a signal wire. Each shield must be given its own pin or terminal and be kept insulated from nearby wires and metal conductors. Do not tin (solder) braided shields.

Connect the speed-control chassis to system ground.

## EPG Driver

The level and range pots allow setting up two EPG actuators exactly the same to provide dual settings from a single control. To setup the EPG driver put in a minimum signal and set the actuator for the minimum position with the Level potentiometer. With a maximum signal input set the desired maximum actuator position with the Range potentiometer. Repeat the two adjustments until there is no change in the minimum and maximum actuator position. This procedure must be repeated whenever the actuator or driver is changed.

## Chapter 3.

# Calibration and Operation

### Introduction

Initial calibration and troubleshooting of the EPG are identical. Many of the settings are interrelated and for this reason if trouble is experienced the best procedure is to follow the initial installation routine completely to see if the problem is cured by adjustment of the system.

### Signal Generator

A signal generator to simulate the output of the MPU will make setup or troubleshooting of the electronic control system easier and safer since it will allow the technician to set idle and rated speeds and check all wiring without running the engine. The wave form can be sine, square, or triangular. The signal generator must be capable of generating the frequency of the control system, not the rpm of the engine. The frequency will be the number of teeth on the sensed gear times the desired rpm divided by 60 (or revolutions per second).

$$Hz = \frac{\text{No. of teeth} \times RPM}{60}$$

If a signal generator is not available, all checks can be made with the engine, but overspeeds are possible.



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.

### Installation Checks

Perform the checks in the order indicated. Terminal numbers in this chapter refer to the speed control.

1. Check that all electrical connections are correctly made and terminal screws tightened, the magnetic pickup is properly installed and the jam nut tightened, and the actuator and linkage are securely fastened.
2. Do not start the engine now. Turn on governor power. Check the battery voltage at terminals 1 (+) and 2 (-). It must be from 10 to 16 Vdc for 1712/512 controls and from 18 to 32 Vdc for 1724/524 controls.
3. If a signal generator is available: Attach the output to terminals 8 and 9, leaving the MPU connections off. Set the signal-generator output between 2 and 10 Vrms. if a signal generator is not available proceed to step 8.
4. Set the signal-generator frequency to about half of idle speed. Close the idle/rated switch. Turn the signal generator and governor power on. The actuator must move to maximum-fuel position. (Start Fuel Limit must be fully cw.)

5. Close the Override Failed Speed Sensor, if used. Turn the signal generator off. The actuator should remain at maximum fuel. Open the failed MPU override switch and the actuator should go to the minimum-fuel position. (If the override is not used the actuator should have gone to minimum fuel when the signal generator was turned off.)
6. Set the signal generator for MPU frequency at rated speed. Close the idle/rated switch. Set the external speed trim pot (if used) at mid position. Observe the linkage position.
  - a. If the linkage is at max-fuel position slowly turn the rated-speed potentiometer ccw until the linkage just begins to move to min-fuel.
  - b. If the linkage is at min-fuel position slowly turn the rated-speed potentiometer cw until the linkage just begins to move to max-fuel.

Continue to very slowly adjust the rated-speed pot, trying to stop the linkage between the minimum- and maximum-fuel stops. Stop adjusting when the linkage moves slowly. It will not be possible to stop the motion. The rated-speed reference is now set very close to desired speed.

7. Open the idle/rated switch. Set the signal generator for MPU frequency at idle speed. (Preset the idle speed only after presetting rated speed.)
  - a. If the linkage is at maximum-fuel position slowly turn the idle-speed potentiometer ccw until the linkage begins to move to minimum-fuel.
  - b. If the linkage is at the minimum-fuel position slowly turn the idle-speed potentiometer cw until the linkage just begins to move to maximum-fuel.

Continue to very slowly adjust the idle-speed pot, trying to stop the linkage between the minimum- and maximum-fuel stops. Stop adjusting when the linkage moves slowly. It will not be possible to stop the motion. The idle-speed reference is now set very close to desired idle speed.

If a signal generator is not available turn the rated-speed pot fully ccw. Turn the idle-speed pot fully cw.

9. Remove the MPU wires from the speed control and measure between 85 and 300  $\Omega$  resistance across the MPU wires. If the resistance is correct replace the connection.

## Initial Pre-Start Settings

1. Rated Speed: If RATED SPEED was not set with a signal generator, set the RATED SPEED potentiometer to minimum (fully ccw). Set the external speed trim, if used, to mid-position.
2. Stability: Set the STABILITY potentiometer to mid-position.
3. Gain: Set the GAIN potentiometer to mid-position.
4. Idle Speed: If IDLE SPEED was not set with a signal generator, set the IDLE SPEED potentiometer at maximum (fully cw).

5. Droop: If NOT required set the DROOP potentiometer at minimum (fully ccw). If droop is required set the DROOP potentiometer at mid position.
6. Actuator compensation:  
  
For diesel, small gas turbine, or fuel-injected gasoline prime movers set the ACTUATOR COMPENSATION potentiometer at 2 on the 0 to 10 scale.  
  
For carbureted gas or gasoline prime movers, large gas turbines, and steam turbines set the ACTUATOR COMPENSATION potentiometer at 6 on the 0 to 10 scale.
7. Fuel Limit: Set the FUEL LIMIT pot at maximum (fully cw).
8. Close the circuit between terminals 12 and 13 (Close for Rated).

### Start Up Adjustments

1. Prepare to start the engine. Read this entire chapter before attempting to start the engine. Interrelated problems can occur and an understanding of all possibilities is needed before using a control for the first time.

It is possible that the untried EPG speed control will not control engine speed. Be prepared to remove the power from the control with the switch between the battery and terminal 1 and to initiate emergency shutdown procedures including manually shutting off the fuel supply should speed not be controlled when the engine starts.



#### **WARNING**

**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.**

### Adjust for Stable Operation

Immediately after the initial start up it will be necessary to adjust the governor for stable operation. Should the engine start and run at a constant speed, bump the actuator lever to see if instability can be induced into the system.

If the prime mover is hunting at a rapid rate, slowly decrease the GAIN (turn the potentiometer counterclockwise) until performance is stable.

If the prime mover is hunting at a slow rate, increase the STABILITY (turn the potentiometer clockwise) until the prime mover stabilizes. If increasing the STABILITY potentiometer does not stabilize the prime mover, it also may be necessary to either:

- slowly decrease the GAIN (turn the potentiometer counterclockwise) or
- slowly decrease the GAIN and increase the ACTUATOR COMPENSATION.

1. Start cranking the engine. If the actuator does not go to maximum fuel check the speed sensor (MPU).

Minimum voltage required from the speed sensor to operate the electronic control is 1.0 Vrms, measured at cranking speed or the lowest controlling speed. Measure the voltage while cranking with the speed sensor connected to the control. Be sure to prevent the prime mover from starting. At 5% of the lower value of the control's speed range the failed speed-sensing circuit is cleared. For example 100 Hz is required on the 2000 to 6000 Hz speed range.

If the MPU signal cannot be adjusted to provide enough signal to clear the MPU failed circuit during cranking, use a momentary MPU failed override switch. Hold the failed MPU override switch closed until the fuel lever moves toward maximum and the engine starts.

2. If the control increases the engine speed above its cranking speed, release the magnetic pickup override switch and the engine should continue to operate at the rated speed. (If the running speed is too low it may be necessary to slightly increase the Rated Speed setting by turning the rated-speed pot a little clockwise.) If the engine stops it indicates a magnetic-pickup-signal problem. The magnetic pickup must produce a minimum of 1 Vac rms to activate the control. Failure to produce the minimum signal can be caused by improper MPU installation, selection of an incorrect gear, improper wiring between the magnetic pickup and the control or a defective magnetic pickup.
3. It will be necessary to immediately adjust the control for stable operation after the engine starts.
4. With the engine running and stable slowly increase the rated-speed setting with the rated-speed pot until the desired rated speed is reached.

## Dynamic Adjustment

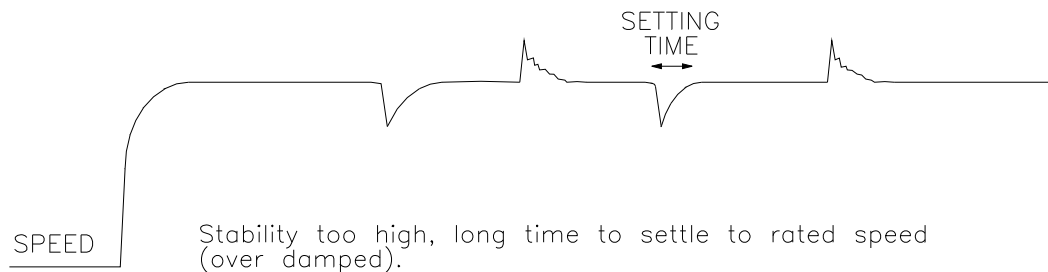
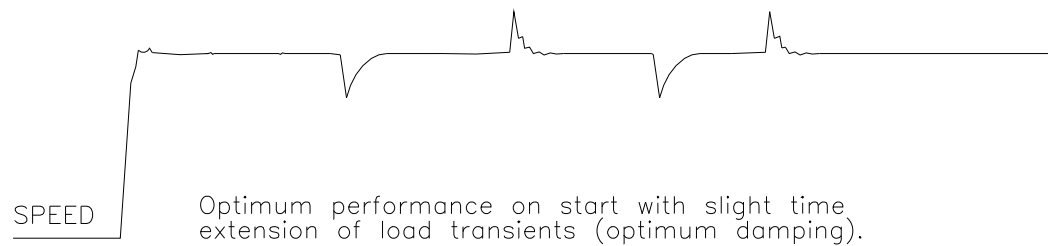
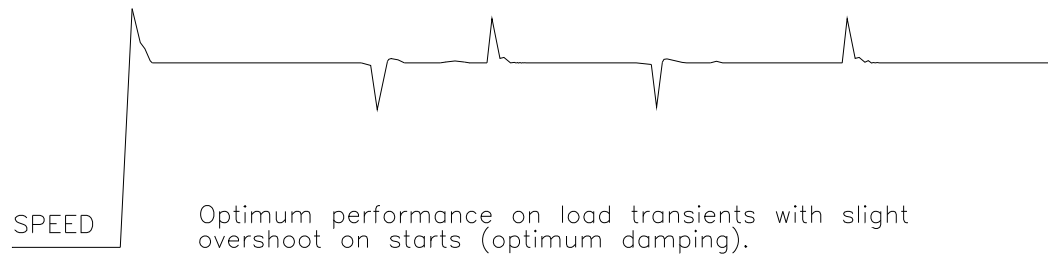
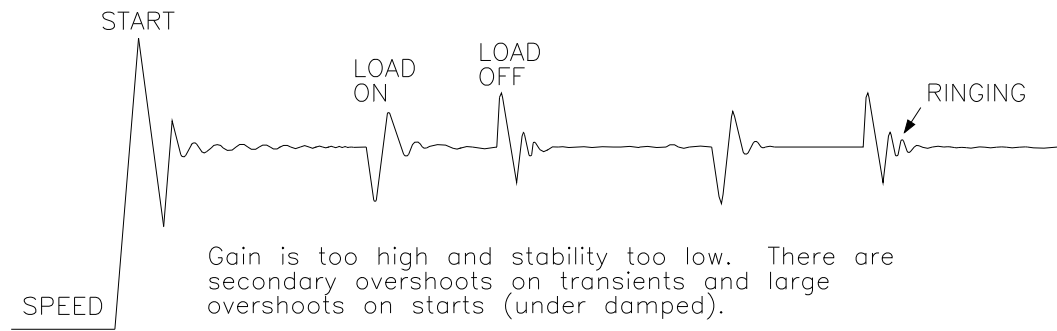
The object of the GAIN and STABILITY potentiometer adjustments is to obtain the optimum, or desired, stable prime-mover-speed response. See Figure 3-1.

Increasing the setting of the GAIN potentiometer provides faster transient response (decreases the amount of speed change from a sudden change in load). To achieve the best response, slowly increase the GAIN (turn the potentiometer clockwise) until the actuator becomes slightly unstable, then slowly turn the GAIN back counterclockwise as necessary to stabilize the actuator and engine speed.

Step load the engine or bump the actuator terminal lever to make sure the prime mover returns to the proper speed with little overshoot or undershoot of the speed setting. (To reduce overshoot, increase the STABILITY setting by turning the potentiometer clockwise).

Increasing the STABILITY clockwise will require decreasing the GAIN (turning the GAIN potentiometer counterclockwise) to maintain stable operation.

If the prime mover is slow in returning to the proper speed, decrease the STABILITY by turning the potentiometer counterclockwise.



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Figure 3-1. Diesel Engine Response Curves

Figure 3-1 illustrates prime mover starts with no ramp or capacitor connected to the control, step loadings at four different STABILITY potentiometer settings, and stable, steady-state running conditions. These are typical performance curves on a naturally aspirated (not turbocharged) diesel engine.

Optimum performance is not necessarily obtained with the GAIN potentiometer at the maximum stable clockwise position. In some cases, the gain must be reduced slightly to ensure stability under widely varying conditions.

5. **ACTUATOR COMPENSATION ADJUSTMENT:** If the ACTUATOR COMPENSATION is set as described under initial pre-start setting, no further adjustment is normally required. If a slow, periodic instability remains, slightly increase the compensation by turning the potentiometer clockwise, then repeat the gain and stability adjustments. Continue to increase the compensation and readjust the gain and stability until stability is achieved.

If a fast instability or an extremely active actuator is evident, slightly decrease the ACTUATOR COMPENSATION. If necessary, the ACTUATOR COMPENSATION may be set fully counterclockwise. This may be required when engine torsionals cause excessive fuel-linkage movement.

If ACTUATOR COMPENSATION is set fully ccw, the GAIN will usually have to be set low (0 to 4 out of 10 marks) and the STABILITY will usually have to be set relatively high (7 to 10 out of 10 marks).

6. **LOW IDLE SPEED ADJUSTMENT:** The prime mover should be at rated speed with IDLE SPEED potentiometer set at maximum (fully clockwise). Open the external CLOSE FOR RATED contact.
7. Decrease the IDLE SPEED (turn the potentiometer counterclockwise) until the desired idle speed is reached.

## IMPORTANT

**Make certain the prime-mover speed is controlled by the IDLE speed potentiometer in a range above the minimum-fuel position mechanical stop of the actuator or prime mover fuel rack.**

## Start Fuel Limit

1. The START FUEL LIMIT was moved fully cw (out of the way) during initial start up procedures. If START FUEL LIMIT is to be used it should be adjusted after engine stability and response rates are correctly adjusted.
2. Adjusting the START FUEL LIMIT ccw will keep the actuator from going to maximum position until the selected speed (Idle or Rated) is reached. Adjust for desired engine performance during start up.



## **Chapter 4.**

# **Description of Operation**

### **Introduction**

The Woodward Electric Powered Governor (EPG) with position feedback provides precise speed control of an engine or turbine.

### **Electronic Circuits**

All circuits in the EPG control are solid state and are not serviceable in the field. The printed circuit board is manufactured by Woodward to provide maximum tolerance to temperature and vibration. Components are wave soldered to the board and the circuits are computer tested to assure maximum dependability and accuracy.

Potentiometers, accessible through the control-box case or input through the terminal board, provide all of the adjustments to the control system. A 10-turn potentiometer provides precise adjustment of the rated-speed setting. One-turn potentiometers provide adjustment for idle speed, fuel limit, droop, actuator compensation, gain, and stability. In addition the speed control can be fitted with an external potentiometer to trim the rated speed from a remote location.

### **Speed Control**

The control converts the signal from the magnetic pickup on the engine into a dc voltage level which is proportional to the engine or turbine speed. This voltage level is compared to the rated or idle speed setting. If droop is used, the speed setting is lowered by a factor proportional to the actuator position. After the speed error is modified by GAIN, STABILITY, DROOP, and Speed Trim, the result is sent to a pulse-width modulator that controls the output to the actuator. The pulse-width modulator circuit monitors the actuator position and compares it to the commanded position. Any error in position signal creates a correction signal to the actuator.

### **Actuator Position Signal**

The actuator is positioned by a 12 or 24 V square wave voltage signal from the control driver. The position of the actuator is roughly determined by the duration of the pulses.

For this reason it is difficult to measure the output to the actuator. (An analog meter, placed across actuator terminals 3 (+) and 4 (-) will average out the pulses and give an approximate indication of actuator position.)

Pulse width modulating the output to the actuator rather than having a constant-voltage drive keeps the driver from becoming too hot.

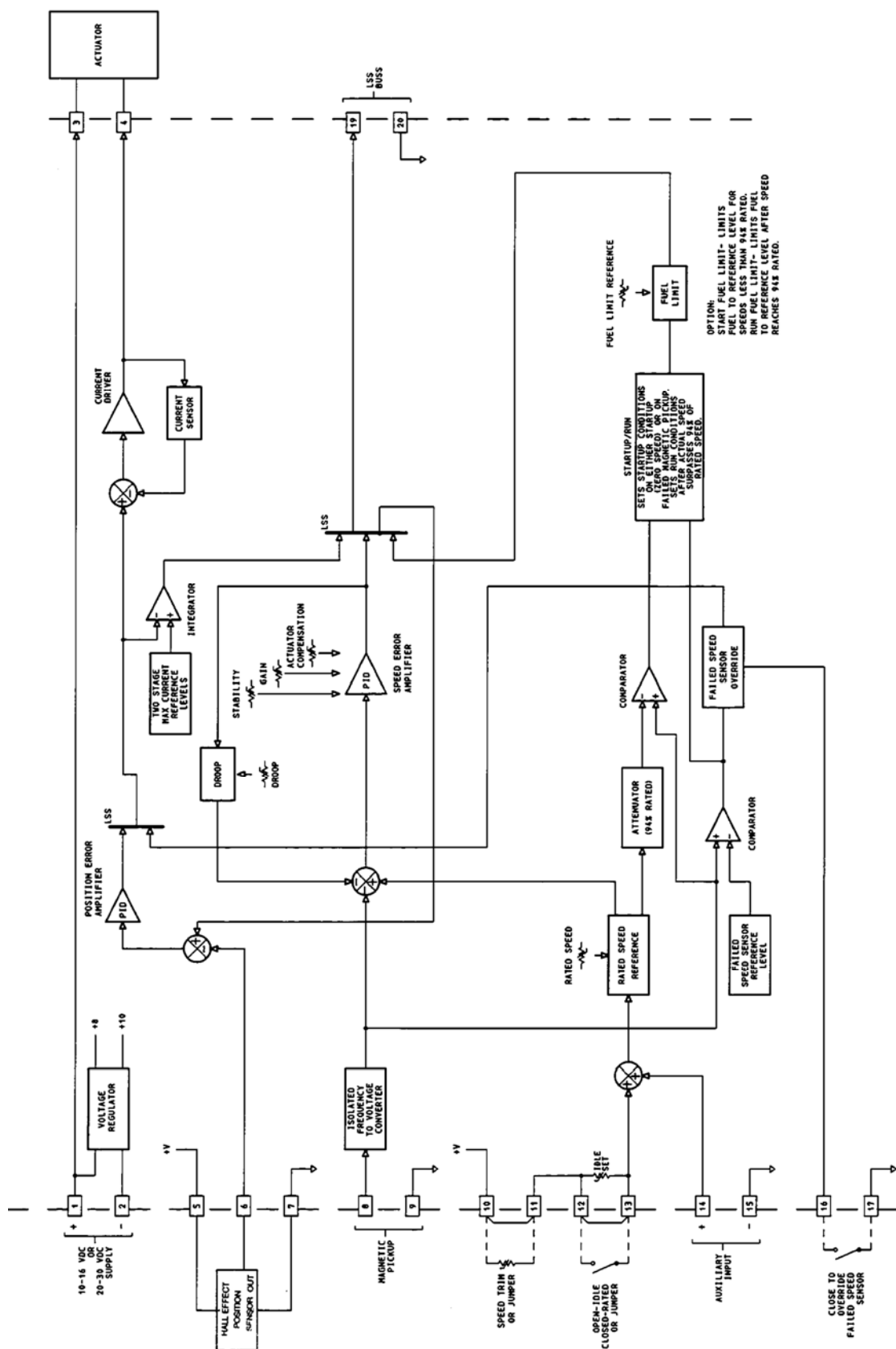


Figure 4-1. Block Diagram of Electronics

## Droop and Feedback

The droop potentiometer modifies the rated-speed signal to a lower speed as the signal from the feedback device increases. Droop is used when controlling an engine which is driving a common load with other engines. In some installations speed is controlled by the largest engine in the system or by an infinite bus and the drooped engine control sets the load on the engine rather than the speed. More commonly the speed of the engine will be determined by the load applied.

Generators paralleled with a utility bus require droop control, since the utility controls the engine speed. With droop set into the control, load on an infinite bus is changed by changing the rated-speed setting, either with the rated-speed pot or with the auxiliary speed-trim pot.

The feedback device provides a voltage signal to the control which is proportional to the rotational position of the actuator. This signal is compared to the signal to the actuator driver. If the two signals are not identical an error signal is created which causes the actuator to move to a position where the feedback signal and the signal to the driver are identical.

The feedback device is located on the closed shaft of the actuator. The device is a Hall effect transducer which issues a dc voltage proportional to the location of the shaft. The rotating part of the unit does not touch the stationary part, therefore eliminating any wear problems.

## Stability, Gain, And Actuator Compensation

The stability, gain, and actuator-compensation adjustments on the EPG speed control allow tailoring of the response rates to match the engine being controlled.

STABILITY, GAIN, and ACTUATOR COMPENSATION potentiometers adjust the control amplifier to accommodate various types of prime-mover systems.

STABILITY adjustment affects prime mover reaction time when recovering after a sudden load change. The magnitude of the speed change resulting from a sudden change in load is controlled by adjusting the GAIN.

ACTUATOR COMPENSATION compensates for the time the actuator and fuel system require to react to signals from the control.

## Start Fuel Limit

A one-turn pot is available to set a start fuel limit. The Start Fuel Limit provides a maximum actuator position until the engine is at idle or rated speed as selected. When the fuel-limit potentiometer is set fully counterclockwise the actuator will go to a low-fuel position until selected speed is reached. Fuel limiting can prevent smoke during start up, can aid starting on some types of engines, or can be used to prevent excessive overspeed as an engine reaches rated or idle speed. Fuel limit is automatically enabled when the MPU signal falls to zero.

## Failed Speed Sensor

A safety circuit is included in the EPG control to cause the actuator to go to minimum position if the signal from the magnetic pickup fails. This is protection against loss of control should either the magnetic pickup instrument or the wiring from the magnetic pickup to the control fail. Without this safety circuit the actuator would go to maximum or to the fuel limit should the control lose the magnetic pickup signal.

The failed-speed-sensor safety circuit may be overridden with contacts on the terminal board to allow start up of slow cranking engines. This override should always be accomplished with a momentary switch which will reestablish the safety circuit after start up. The override is also used during troubleshooting and setup of the control, allowing a check of actuator action while the engine is not running. The override does not effect the Start Fuel Limit of actuator position.

## Auxiliary Input

The auxiliary input is provided to allow the EPG control to be used with a load sensor. A Load Sensor is used with the EPG control for isochronous or electrical droop paralleling. With an isolated bus, isochronous load sharing is usually selected. In isochronous operation, the Load Sensor produces a load signal which is shared with the other Load Sensors on line through the parallel lines. The parallel-line voltage represents the average load of the units on line. By comparing the paralleling-line voltage to its own load the load sensor calculates an output applied to the auxiliary input of the EPG control. This output raises or lowers, as necessary, the generator output to make the load of its unit equal to the average load. The load-sensor output directly biases the speed-loop circuit of the speed control to affect the actuator fuel-level setting and precisely maintain its proportional share of system load while maintaining a fixed frequency.

## Ramp Generator

A Ramp Generator may be attached to terminals 13 (+) and 15 (-) to slow the speed change between idle and rated speeds. Once set it provides a constant speed change per second by biasing the speed reference when changing from idle to rated and vice versa. Accel and Decel pots on the ramp generator control the rate of change.

A capacitor can be connected between terminals 13 and 15 to provide a nonlinear ramp between idle and rated and between rated and idle. This method provides the same rate for both accel and decel, about one second of ramp time per 50  $\mu\text{F}$  of capacitance. (500  $\mu\text{F}$  maximum.) The capacitor must be 15 Vdc minimum working voltage with less than 30  $\mu\text{A}$  dc leakage over the operating temperature range.

## Speed Trim

A potentiometer can be installed to terminals 10 (ccw) and 11 (cw and wiper) to provide remote trim of rated speed. A 1 k $\Omega$  potentiometer will provide  $\pm 2.5\%$  change of rated speed. a 2 k $\Omega$  potentiometer will provide  $\pm 5\%$  change in rated speed. The control is not subject to temperature drift and the potentiometer for remote speed trim is not usually needed in a single-engine application.

If the circuit between terminals 10 and 11 is opened the reference idle or rated speed signal is removed and the control calls for minimum actuator position.

## Actuator

The actuator is mechanically simple. It has specially designed rotor and stator shapes which provide reliable performance. The rotary design gives 30 or 35 degree shaft rotation to low-mass, low-friction fuel controls. The magnetic circuit, when powered by the speed control, applies torque in the increase fuel direction. Two internal return springs supply shaft torque in the decrease-fuel direction.

Sealed bearings are used in the actuator eliminating the need for any maintenance. Pressure washing of the bearings should be avoided however, particularly on the clockwise to increase fuel end, as water can enter the actuator around the sealed bearing. The feedback mechanism attaches to the output shaft not being used to control the engine. The device is enclosed in a metal shield which is not sealed against elements. Pressure washing of the position sensor side of the actuator must be avoided.

## EPG Driver Option

The EPG Actuator Driver is designed to permit the use of a 1712/24 electric proportional actuator with some other control source (a 2301A Speed and Load Sharing control or a speed control of another manufacturer).

Minimum actuator position is set by adjusting the Level potentiometer of the Driver control to provide the minimum-fuel position required for the minimum output from the controller. The Range potentiometer on the Driver is then set for the position desired with a maximum signal to the Driver. The settings must be repeated until the minimum and maximum positions are achieved with no changes in either potentiometer.

The driver allows the use of either 20–160 mA, 4–20 mA, or 1–5 Vdc output speed control with the EPG actuator, or the ability to control fuel to multiple engines according to a single speed or load control signal.

## Chapter 5. Troubleshooting

### Introduction

Improper prime-mover operation is often the result of factors other than governor operation. The following paragraphs are provided to give tips about engine problems which can resemble governor problems. Make sure the engine is operating correctly before making any changes in the governor.

Attempting to correct engine or load problems with untimely governor adjustment can add to the problems involved with solving improper operation.

If possible, isolate the governor from the prime mover to determine if the problem is with the governor and not with the prime mover or the load on the prime mover.

Governor faults are usually caused by problems in the installation or the linkage between the actuator and the prime mover. Carefully review all of the wiring connections, the power supply, and the linkage before making any adjustments to the control box or the actuator. The actuator used with the EPG system is only suitable for control of systems with low force requirements. 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 position because of a hesitation or binding in the fuel-control stroke.

Where friction is a problem using the larger 1712 or 1724 is recommended over the 512 or 524 actuator as they provide roughly three times the work capacity.

Butterfly valve controls can cause troubles under load as air flow can add to the resistance to movement of the valve. The linkage must also compensate for non-linearity of the carburetor.

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 resemble faulty governor control.

### When The Governor Is At Fault

Before making any adjustments to the EPG control, review Chapters 3 and 4 to better understand the interrelated workings of the various adjustments and features.

With the prime mover shut down, engine linkage disconnected from the actuator, and power to the governor system, the actuator should be at the minimum stop. Close the failed-speed-sensor override at terminals 16 and 17. The actuator should stroke from minimum to maximum (or the Start Fuel Limit setting) and remain while the contacts at 16 and 17 are closed. When the contacts at 16 and 17 are open the actuator should return to minimum.

If the actuator does not stroke from min to max and back to min:

Is the circuit between terminals 10 and 11 closed? The governor is in a shutdown mode if this circuit is open. Jumper the two terminals to make sure the speed trim pot (if used) or the shutdown switch is not faulty. Inspect the existing jumper if a shutdown switch and speed trim pot are not used.

Is the start fuel limit preventing the actuator movement?

Is the 12 or 24 V supply present at terminals 1 and 2?

Is the voltage to the position sensor at terminals 5 (+) and 7 (-) at  $8.0 \pm 0.4$  Vdc?

Is the position signal at terminals 6 (+) and 7 (-) at  $3.5 \pm 0.25$  Vdc? Make this measurement only with a high impedance, preferably digital, voltmeter.

## Stability Problems

Stability problems not caused by the prime mover or linkage require careful following of the setup procedure provided in Chapter 3. Follow every step when readjusting the control.

If the prime mover oscillates when cold and stabilizes when warm, turn the gain pot slightly ccw. Turn the stability pot slightly cw if required to maintain stability.

## Speed Setting and Droop

The droop setting can cause problems in achieving the desired speed under load. If droop operation is being used, with the unit on an infinite bus, and the unit does not take on full load, either increase the rated speed setting slightly or decrease the amount of droop. Use a minimum of 3% droop for droop paralleling applications. Adjusting droop will require readjustment of rated speed.

If droop is removed from the governor it will sometimes require resetting of the gain, stability, and actuator compensation adjustments according to the procedure in Chapter 3. Adding droop to the governor will often make the system more stable at the expense of precise rated speed.

## Feedback

The position sensor is attached to the unused terminal shaft of the actuator and gives a precise actuator position reading to the driver section of the EPG control. The device is mounted on a steel bracket and connected to the terminal shaft with a coiled spring clip.

At minimum-fuel position the position sensor should provide a reading of  $3.5 \pm 0.25$  Vdc across terminals 6 (+) and 7 (-). Voltage should increase as the actuator shaft is rotated in the maximum-fuel direction. Measure the output of the sensor only with a high impedance, preferably digital, voltmeter.

## Magnetic Pickup

The magnetic pickup must provide a minimum pulse signal of 1.5 V to the control. It is highly unusual for a magnetic pickup to fail if it is properly installed. The most common failure is due to the pickup being screwed in too far and hitting the gear it is sensing. Should the magnetic pickup not produce the required signal check the installation to make sure it is properly located on the sensed wheel. Several different sizes of magnetic pickups are available to fit different size gears.

Check that the gear is of magnetic material, necessary to drive the magnetic pickup. Check the rotation of the sensed gear. Check the wiring from the magnetic pickup to the control.

Refer to manual 82510, *Magnetic Pickups and Proximity Switches for Electronic Controls*, for more information about required gear shapes, sizes and surface speeds.

Note that the magnetic pickup generates a voltage signal when a tooth of the sensed gear breaks the magnetic field emitted from the tip of the pickup. The pickup does not require an excitation voltage from the control.



## Chapter 6.

# 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:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email ([EngineHelpDesk@Woodward.com](mailto:EngineHelpDesk@Woodward.com)) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further 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 Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at [www.woodward.com/directory](http://www.woodward.com/directory).

### Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- 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 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.

**Flat Rate Repair:** Flat Rate Repair is available for many of the standard mechanical products and some of the electronic 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.

**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. 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 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's Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- 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.

**Product Training** is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor 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 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 one of the Full-Service Distributors listed at [www.woodward.com/directory](http://www.woodward.com/directory).

## Contacting Woodward's Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at [www.woodward.com/directory](http://www.woodward.com/directory).

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		Products Used In Engine Systems		Products Used In Industrial Turbomachinery Systems	
<u>Facility</u> -----	<u>Phone Number</u>	<u>Facility</u> -----	<u>Phone Number</u>	<u>Facility</u> -----	<u>Phone Number</u>
Brazil -----	+55 (19) 3708 4800	Brazil -----	+55 (19) 3708 4800	Brazil -----	+55 (19) 3708 4800
China -----	+86 (512) 6762 6727	China -----	+86 (512) 6762 6727	China -----	+86 (512) 6762 6727
Germany:		Germany-----	+49 (711) 78954-510	India -----	+91 (129) 4097100
Kempen----	+49 (0) 21 52 14 51	India -----	+91 (129) 4097100	Japan-----	+81 (43) 213-2191
Stuttgart--	+49 (711) 78954-510	Japan-----	+81 (43) 213-2191	Korea -----	+82 (51) 636-7080
India -----	+91 (129) 4097100	Korea -----	+82 (51) 636-7080	The Netherlands-	+31 (23) 5661111
Japan-----	+81 (43) 213-2191	The Netherlands-	+31 (23) 5661111	Poland-----	+48 12 295 13 00
Korea -----	+82 (51) 636-7080	United States----	+1 (970) 482-5811	United States----	+1 (970) 482-5811
Poland-----	+48 12 295 13 00				
United States----	+1 (970) 482-5811				

For the most current product support and contact information, please visit our website directory at [www.woodward.com/directory](http://www.woodward.com/directory).

## 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 \_\_\_\_\_

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### Prime Mover Information

Manufacturer \_\_\_\_\_

Engine Model Number \_\_\_\_\_

Number of Cylinders \_\_\_\_\_

Type of Fuel (gas, gaseous, diesel,  
dual-fuel, etc.) \_\_\_\_\_

Power Output Rating \_\_\_\_\_

Application (power generation, marine,  
etc.) \_\_\_\_\_

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### Control/Governor Information

#### Control/Governor #1

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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#### Control/Governor #2

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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#### Control/Governor #3

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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### 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.*

**We appreciate your comments about the content of our publications.**

**Send comments to: [icinfo@woodward.com](mailto:icinfo@woodward.com)**

**Please reference publication 82354C.**



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**Email and Website—[www.woodward.com](http://www.woodward.com)**

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