WOODWARD

Product Manual 82038
(Revision E)
Original Instructions

Min/Max Control Systems

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 *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, on the *publications page* of the Woodward website:

www.woodward.com/publications

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 *26311* , *Revision Status & Distribution Restrictions of Woodward Technical Publications*, 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 Out-of-date translations are marked with ⚠.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 82038

Contents

Illustrations and Tables

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

Min/Max Control Functions

The Woodward Min/Max control is designed to permit efficient idle, fast-idle, and maximum engine-speed control of spark-ignited gas engines. Most installations will be on city buses using compressed natural gas as a fuel.

The Min/Max control will provide a number of control features which add to the convenience of vehicle operations. Among the features which can be expected from the Min/Max control are:

- Start Fuel Limit
  Controls fuel output to the engine at a pre-set level during cranking. Start Fuel Limit is inactive after the engine reaches idle speed.

- Neutral Fuel Limit
  Limits fuel to a preset point when the transmission is in neutral. This protects the engine from gross acceleration rates and overspeed conditions while there is no transmission load. Neutral Fuel Limit prevents accidental racing of the engine with the pedal fuel control. The limit is removed when the transmission is in gear.

- Door Interlock
  Deactivates the foot pedal and forces the engine to idle when the bus door is open.

- Fast Idle
  Sets a second idle speed to handle parasitic loads such as air conditioning, air compressor, and alternator while the bus is parked. This could also be used for operation of a power take off used with handicapped access lifts or "kneeling buses."

- Pedal Position Read Out
  Provides a signal (either voltage or current) to relay the position of the pedal to the transmission.

- Safety Features
  Fault detectors are built into the control to prevent damage or overspeed from possible faults in the sensors, actuator, or foot pedal control. Overrides are included to make it possible to "drive home" with a speed-sensor or wiring problem.

- Input Sensor Malfunction
  Output indicates when a failure has occurred.

All of the limits are individually set on each control, allowing custom fitting of the control to the particular engine and vehicle.

Engine Efficiency

The Min/Max Control provides precise idle-speed control, regardless of the parasitic loads encountered. This precise control and almost total elimination of speed excursions provides optimum fuel efficiency in idle conditions. The Min/Max Control also limits the production of polluting exhaust normally encountered in these conditions.

The maximum engine speed provides protection against engine runaway and also prevents intentional overspeed of the controlled vehicle, protecting the engine and the passengers.

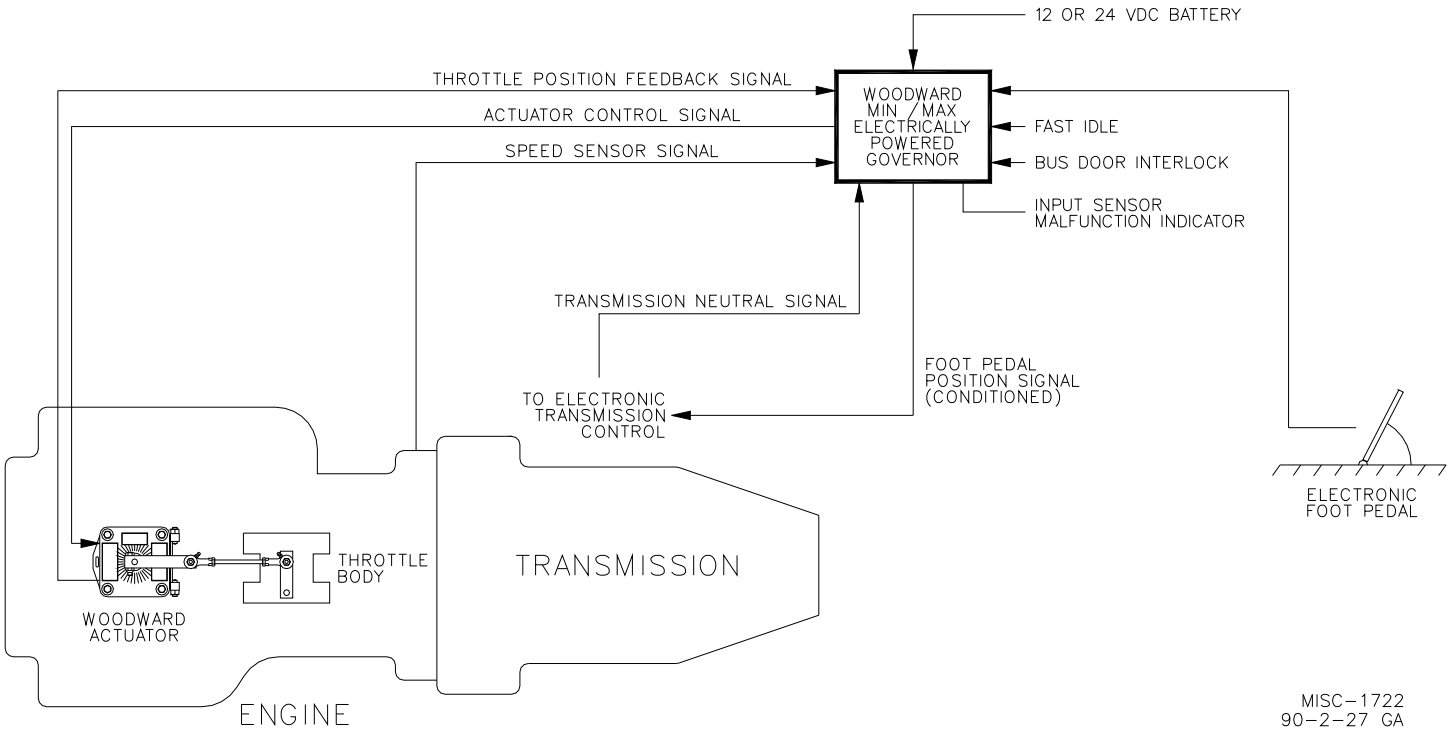


Figure 1-1. Bus Control Block Diagram

Chapter 2.
Theory of Operation

Introduction

This chapter describes the operation of the Min/Max Control and its internal circuits. Information is also supplied about the electric actuator used by the control to position the fuel valve on the engine.

Min/Max Controller

The Min/Max control box contains a single printed-circuit board which mounts the 12 adjustments used to tailor the control to the specific engine and foot pedal being used. The circuit board also holds the 20 position terminal strip and the three LED signal lights. The control board is packaged in a steel case for installation inside the bus. All adjustments are located on the outside of the control, eliminating any need to remove the cover from the control box. This design is used to protect the board from accidental damage.

The controller requires a 24 Vdc supply (20 to 30 Vdc).

The engine speeds in gear-tooth Hz must be specified at the time of ordering. Four speed levels are available (from 1,000 to 6,000 Hz) The speed ranges are set for the individual control at the factory. Should it be necessary to change the speed range the cover must be removed and a switch position changed. The speed being sensed will be the number of teeth in the gear being sensed times the RPM divided by 60.

$$Hz = \frac{No.\,of\ teeth\ x\ RPM}{60}$$

Other switches inside the control set the control for a throttle readout of either 4–20 mA or 1–5 Vdc. The throttle readout switches also tailor the control for either a direct readout (4–20 mA or 1–5 V) or a reverse readout (20–4 mA or 5–1 V).

Other dip switches tailor the readout delay for 0.5 second, 0.005 second, or no delay. The readout delay can slow the signal between the foot pedal and the foot-pedal readout, tailoring the control to the transmission characteristics.

The dip switches are set at the factory for the specifications shown in Figure 3-1 of this manual. Complete switch-setting instructions are provided in Chapter 3 of this manual.

Electronics in the Min/Max controller are protected from electro-magnetic interference (EMI) and Radio Frequency Interference (RFI) with feed-through capacitors between each of the terminals and the printed board. The capacitors, which are not visible from the outside of the control, effectively prevent EMF/RFI signals from traveling into the electronics on the control wires. In addition, all signal wires are to be shielded, with the shields grounded at the control end.

Operational Theory

The Min/Max EPG control compares the signal from the magnetic pickup to a reference idle signal and uses the remaining signal to either maintain or change the actuator position that sets the level of engine fuel.

Position Feedback

Position feedback from the electric actuator is constantly monitored by the control system. The position feedback determines the amplitude of signals calling for more fuel when the governor is controlling idle, fast-idle, or maximum engine speed. This enhances the control's ability to maintain a steady engine speed in spite of large parasitic load changes. The position feedback is also monitored for position failure when the pedal is being used to control fuel (actuator position.) Should the position signal fall outside the range of normal operating conditions, a failure signal is directed through the control, reducing the actuator position to minimum and latching the output at that position. The control must be turned off to free the latch.

The control also latches the actuator to minimum fuel if any of the wires on terminals 5, 6, or 7 disconnect, if 5 or 6 short to either ground or positive (+) Vdc, or if any of the wires short together.

The feedback device is attached to the unused terminal shaft on the actuator. The device is a Hall effect signal modifier. A Hall effect device is used to eliminate wear problems associated with most potentiometers.

Electric Actuator

The actuator is mechanically simple. It has specially designed rotor and stator shapes which provide reliable performance. The rotary design gives 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 preloaded return springs supply shaft torque in the decrease-fuel direction. The preload can be factory reduced to compensate for some external linkage forces acting in the decrease fuel direction.

NOTICE

Sealed bearings are used in the actuator, eliminating the need for any maintenance. Pressure washing of the bearings should be avoided, particularly the clockwise to increase fuel end, as water can enter the actuator around the sealed bearing.

The control provides a pulse signal to the actuator, which reduces the tendency to build heat during steady-state operation. The pulse signal makes it difficult to measure the output of the control to the actuator. Polarity of the signal to the actuator is unimportant.

Normal Operation

Under normal conditions the Min/Max control provides an adjustable start-fuel limit to the engine. This prevents overfueling the engine during cranking. The limit disappears as soon as the engine reaches idle speed.

A second adjustable fuel limit is in place any time the transmission is in neutral. This Neutral Fuel Limit is provided to prevent an overspeed should the foot pedal be depressed quickly while the transmission is in neutral.

When the transmission is moved out of neutral, a positive (+) 24 Vdc signal must be applied to terminal 17 on the Min/Max control to disable the Neutral Fuel Limit.

Both fuel limits are set to positions reported by the position feedback from the actuator. The fuel limits do not regulate speed of the engine, but prevent excessive speed or power output by limiting the actuator position.

Two idle speeds are provided by the Min/Max control system. The normal idle is slightly faster than the minimum speed which would be provided by the pedal under no-load conditions. The control will operate the engine at the desired idle speed regardless of the parasitic loads from air conditioners, fans, heaters, lights, or other devices.

A second Fast Idle speed, is provided for the operator. This speed is adjusted on the control, and then can be put in place when an operator toggles a switch. The fast idle will normally be used to warm up the engine or to provide better use of air conditioning during long stops. The foot pedal is disabled when fast idle is selected. Fast idle is normally used only in neutral, because the fast idle speed is normally too great for the selection of highway gears.

Chapter 3.
Installation and Adjustment

Setting up the Control

Ten DIP switches located on the Min/Max control printed-circuit board allow tailoring the control to the specific application. Before starting the installation process the control should be set for the exact application.

Switches 1, 6, 7, and 10 are set to provide an output from terminal 19 that matches the foot-pedal-position meter. The control will provide either a 4–20 mA or a 1–5 Vdc signal. The signal can be in either the forward (4–20/1–5) or reverse (20–4/5–1) format.

Switches 2 through 5 set the speed range of the control. The speed range is measured in MPU Hz. Only one switch should be in the ON position.

$$HZ = \frac{No.\ of\ Gear\ Teeth\ x\ RPM}{60}$$

The pedal position readout delay is set with switches 8 and 9. The readout delay provides a small time delay in the readout signal from the actual time the pedal position is changed. This delay may be desirable in cases where the transmission shifts too quickly in response to foot-pedal position changes.

⚠WARNING

Components used on the printed circuit board are susceptible to damage from electrostatic discharge. Prevent damage to the board by following the Electrostatic Discharge Awareness instructions on page ii of this manual while the cover is off the control. Damage can be hidden and can cause unexpected changes in control functions, damaging the engine and threatening life.

Mounting the Control

The control is designed to operate within a temperature range of –40 to +70 °C (–40 to +158 °F). It is necessary to stay within this range for proper operation.

The control box will normally be installed in the passenger compartment. Install where the control is protected from rain or frost. The control box will not have to be adjusted after the completion of the installation and adjustment procedure unless changing the setup.

The bolts holding the control must ground to the vehicle chassis.

DIP Switch Settings for Pedal Position Readout

Min Throttle Readout	Max Throttle Readout	Forward-off Reverse-on SW10	Forward-off Reverse-on SW7	Forward-on Reverse-off SW6	Voltage-on Current-off SW1
4 mA	20 mA	open	open	closed	open
20 mA	4 mA	closed	closed	open	open
1 Vdc	5 Vdc	open	open	closed	closed
5 Vdc	1 Vdc	closed	closed	open	closed

Shaded items indicate dip switch settings when shipped from the factory.

$$HZ = \frac{No.\,of\ Gear\ Teeth\ x\ RPM}{60}$$

Speed Range Chart

DIP Switch CLOSED (Others Open)	Speed Range (Hz)	RPM 103 teeth example
5	1000-2000	583-1165
4	1500-3000	874-1748
3	2000-4000	1165-2330
2	3000-6000	1748-3495

DIP Switch Setting to Set Readout Delay

Readout Delay	SW8	SW9
0.5 s	open	closed
0.005 s	closed	closed
none	closed	open

IMPORTANT

The actual speed range may not match any of these settings, so the setting that provides the "best fit" should be selected. If the actual range is "wider" than any of the switch settings, try to select a range that will leave about equal margins on both the top and bottom end. A typical installation using the Number 4 dip switch calls for idle at 1030 Hz (600 rpm with 103 gear teeth), Fast Idle at 1717 Hz (1000 rpm) and Maximum Speed at 3777 Hz (2200 rpm).

Installing the Actuator

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. The position-feedback actuator has only one terminal shaft available for use on the engine. The position-feedback 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. No adjustments of the position-feedback device are available.

The actuator must not be subjected to water or pressure washing when cleaning the engine.

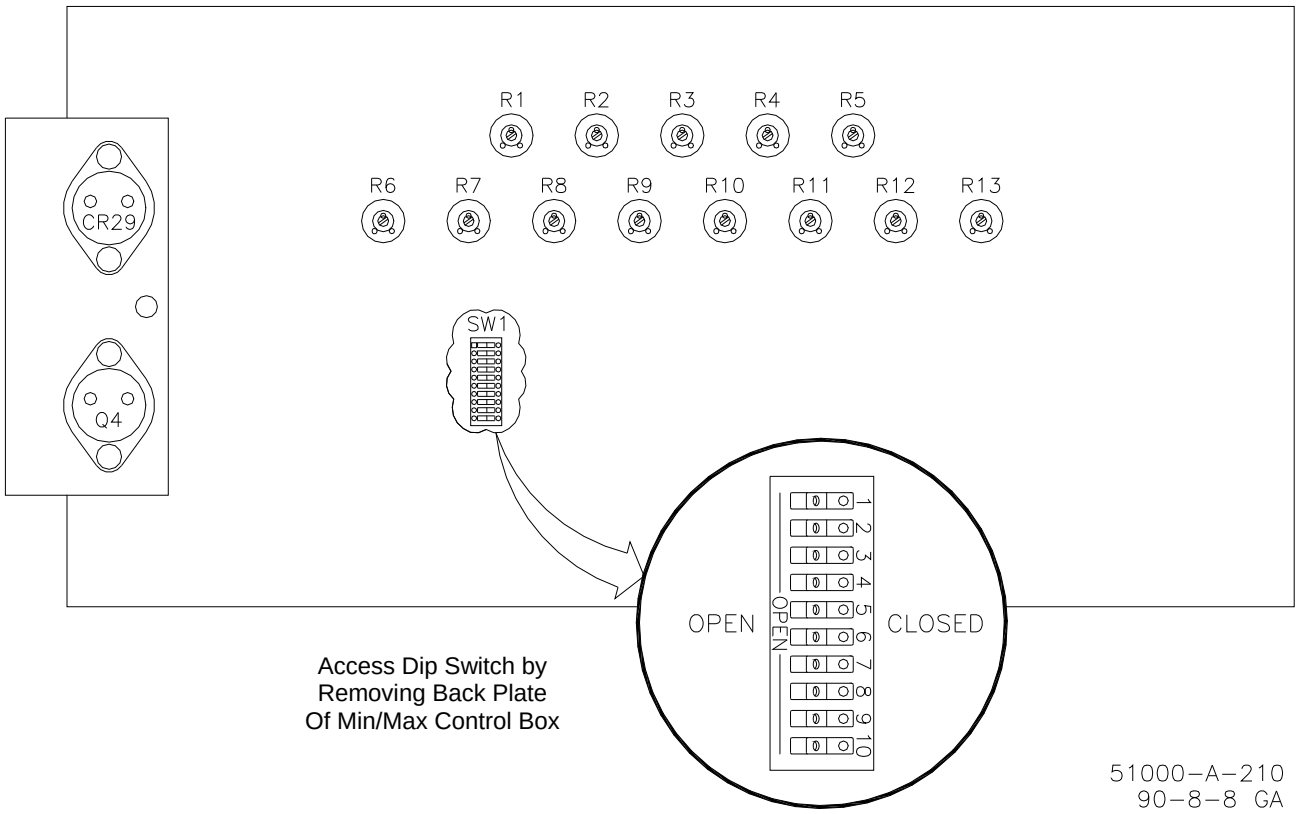


Figure 3-1. DIP Switch Location on Other Side of Printed Circuit Board

Linkage

Proper design and installation of the linkage from the actuator to the engine is critical if the unit is to provide accurate and stable control.

Most installations have the actuator directly controlling the fuel flow to the engine by moving either the fuel valve or butterfly valve. Linkage should be designed to provide a linear relationship between actuator movement and power output from the engine.

The two charts show the difference between the control signal (actuator position) and butterfly valve position.

Two problems are presented:

First the butterfly valve shaft must be rotated about 75 degrees between no fuel and full fuel. The actuator will move a maximum of 35 degrees between stops and even less rotation is recommended as about 2 degrees should be available at the shutdown and full rotation ends of travel to assure that no fuel and full fuel can be attained.

The second problem is illustrated in the power curves depicted in the two charts in Figure 3-2. The butterfly valve presents a very non-linear curve, increase in the fuel flow and thus the power output during the first few degrees of rotation is much greater than during the last few degrees of output. The Min-Max control has a linear output which assumes that each degree of actuator travel will represent a proportional change in the power output of the engine.

Making the 35 degree linear actuator movement compatible with the 75 degree non-linear butterfly valve is accomplished through the design of the linkage between the actuator and the throttle. It will not be possible to design linkage which will allow the actuator to exactly follow the power output curve of the butterfly valve but the linkage illustrated in Figure 3-3 will generally make the two rotational conditions compatible enough to provide stable but responsive engine control.

The linkage must accomplish the following:

- rotating the butterfly valve through its complete 75 degree rotation while using most of the 35 degree rotation of the actuator;
- rotating the butterfly valve in a non-linear manner so the actuator will rotate more than the valve at low fuel and less than the valve at full fuel.

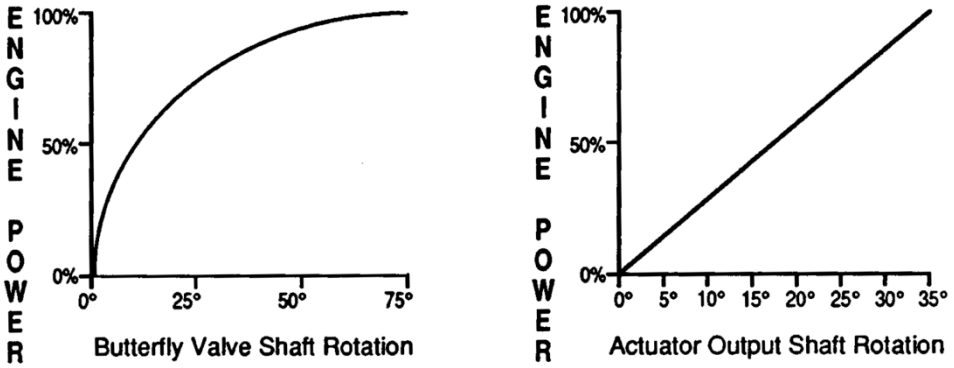


Figure 3-2. Effect of Butterfly Linkage

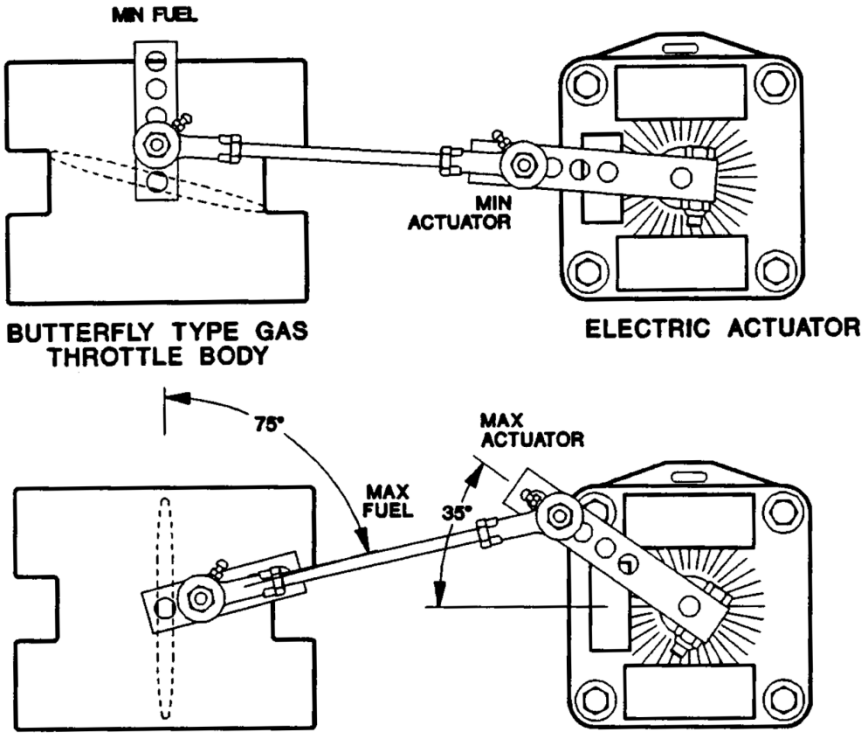


Figure 3-3. Linkage for Non-linear Installations

Additional information on the calculations which can help design non-linear linkage is available in Woodward Application Note 50516, *Governor Linkage for Butterfly Throttle Valves*.

When designing non-linear linkage make sure that the minimum position does not "lock into place." In practice the linkage at minimum fuel cannot be completely flat.

Incorrect actuator output/fuel-setting lever matching 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 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 a part of the engine-fuel system usually don't affect actuator 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 or minimum stop 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 the control system uses for best performance with the Max governor. 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.

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 turn-buckle 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 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 actuator, not less than 21 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.

Wiring The Control

Battery to Control to Actuator Connection

Power to the control connects to terminals 1 (+) and 2 (–). The power should come directly from the battery, not through a distribution point. Use 3 mm² (12 AWG) insulated two conductor wire for the connections.

Use 3 mm² (12 AWG) insulated two conductor wire from the control to the two terminals on the top of the actuator. Polarity is not important. Tie the wire to the top of the actuator with the high temperature wire tie supplied, to prevent vibration damage.

Total distance from the battery to the control and from the control to the actuator must not exceed 46 m (150 ft). (Example: The distance from the battery to the control uses 4.5 m/15 ft of wire, then the wire from the control to the actuator must not be longer than 41 m/135 ft.)

Connecting the Feedback Device

Connect terminals 5, 6, and 7 to the Hall effect position sensor on the actuator. Use 0.5 mm² (20 AWG) or larger shielded, insulated wire. Ground the shield at the control, not at the actuator. (Note that the wire is to be shielded from the device to the control box. If the wiring runs through a connector make sure the continuity of the shield is also carried through the connector. See plant-wiring diagrams for polarity of the various connectors which may have been ordered for your particular installation.)

Connecting the Foot Pedal

Connect the foot pedal potentiometer to terminals 10 (+), 11 (wiper), and 12 (–). Use 0.5 mm² (20 AWG) shielded, insulated wire. Shield the three wires and ground the shield at the control end only.

MPU Connections

Use shielded, insulated 0.5 mm² (20 AWG) or larger wire from the magnetic pickup on the engine-driven gear to terminals 8 and 9 on the control. The magnetic pickup must provide a minimum signal of 2 Vac to run the speed portion of the control. The signal from the MPU must not exceed 30 Vac. Measure the voltage with an ac meter. Failure to achieve the required MPU signal can be because of the distance of the MPU sensor from the gear teeth, the selection of the wrong MPU for the gear size, or the attempt to monitor a non-ferrous gear. Notice that the control must be set to operate at a certain spread in MPU frequency. The proper Speed Range DIP switch must have been selected before attempting to use the control.

Fast Idle and Door Interlock

Connect an ON/OFF switch between terminals 13 and 15. This wiring should be connected through the door switch to open when the door opens. When the switch is open the engine will be at either normal or fast idle and the foot pedal will be disabled.

Connect an ON/OFF fast-idle switch between terminals 14 and 15. When closed, this switch will disconnect the foot pedal from the control and set the engine at fast idle. Note that the door switch will not change the idle speed if this switch is closed. This switch will normally be located on the bus control panel and allow manual selection of fast idle. The foot pedal is not operative while the engine is in fast idle.

Speed Sensor Override

Install a switch between terminals 15 and 16. When closed, this circuit will override a Failed Speed Sensor Shutdown circuit in the control. The Failed Speed Sensor Shutdown circuit is designed to lock the fuel setting at minimum unless an adequate speed is seen by the magnetic pickup (10% of the low idle speed).

The failed-speed-sensor-override circuit is ineffective unless an actual failed speed sensor is detected. If the override switch is left on while the speed sensor is functioning properly, the "override" will not cause changes in control operation. Should the control detect a failed speed sensor, the "override" will cause the fuel position to be set directly from the foot pedal position, without the use of any of the three governors inside the control. This will also cause the Speed Sensor Failure LED to light on the front of the control, and the "Check Control" lamp to light on the dash board.

Special care must be taken when the LED is lighted because the maximum engine-speed governor will not provide engine overspeed protection or road speed limiting. In addition, idle speed must be maintained manually with the foot pedal as the idle-speed governor can not operate without engine-speed information.

The speed-sensor override can be used to allow foot-pedal control should the speed sensor (or wiring from the speed sensor to the control) fail and "drive-home" capability is needed.

Fuel Limiters

Connect a switch to the transmission which will provide a positive (+) 24 Vdc signal to terminal 17 except when the transmission is in neutral. When in neutral no voltage should be present at terminal 17. When no voltage is present at terminal 17 a limit is set on the position taken by the electric actuator. Note that this is not a limit on engine speed, but rather a limit on the position taken by the actuator and likewise an absolute limit on the fuel supplied to the engine.

The Min/Max control limits the fuel setting during starting. This limit is automatically set on the system when the speed drops below 50 Hz. The limit remains on the system until the speed signal advances to 80% of idle speed. The limit prevents over-fueling the engine during start-up.

The actuator position limits are adjustable on the face of the control box.

Foot Pedal Position

Connect the transmission interface input to terminal 19. Terminal 19 provides a signal that will indicate the position of the foot pedal at any time.

External Test Point

Terminal 18 will provide an external test point of a dc voltage which is proportional to the actuator signal. The output to the electronic actuator cannot be easily tested in the field because the output is a pulsed signal.

Wire Size, Length, And Shielding

The wires from the battery and to the actuator should be 3 mm² (12 AWG) or larger insulated pairs. Route the wires as directly as possible, avoiding any sharp bends or areas where friction can damage the insulation. The wires from the battery should be direct, not through a distribution point. Do not depend on chassis ground for one of the connections. No fuses or circuit breakers are necessary in this line since the control has its own internal circuit breaker. The total wire length must be less than 150 feet between the battery to the Min/Max control box to the actuator. Keep all wires as short as possible.

Do not route the wires to the actuator with the wires from the magnetic pickup as this could cause electro-magnetic interference (EMI). The wires to the actuator and the wires from the battery supply do not require shielding.

Signal carrying wires from the actuator feedback, the magnetic pickup, and the accelerator pedal must be shielded 0.5 mm² (20 AWG) or larger. All shields should be open at the connection farthest from the control and grounded at the control. The plant wiring diagram includes specific instructions on shielding.

Maintain shield continuity through connections as though it was a separate circuit. EMI can cause erratic control problems.

It is particularly important that all signal wires be properly shielded because the control will be operating in a transit condition which will expose the system to many different EMI conditions. Woodward Application Note 50532, *EMI Control for Electronic Governing Systems*, contains additional information on this subject.

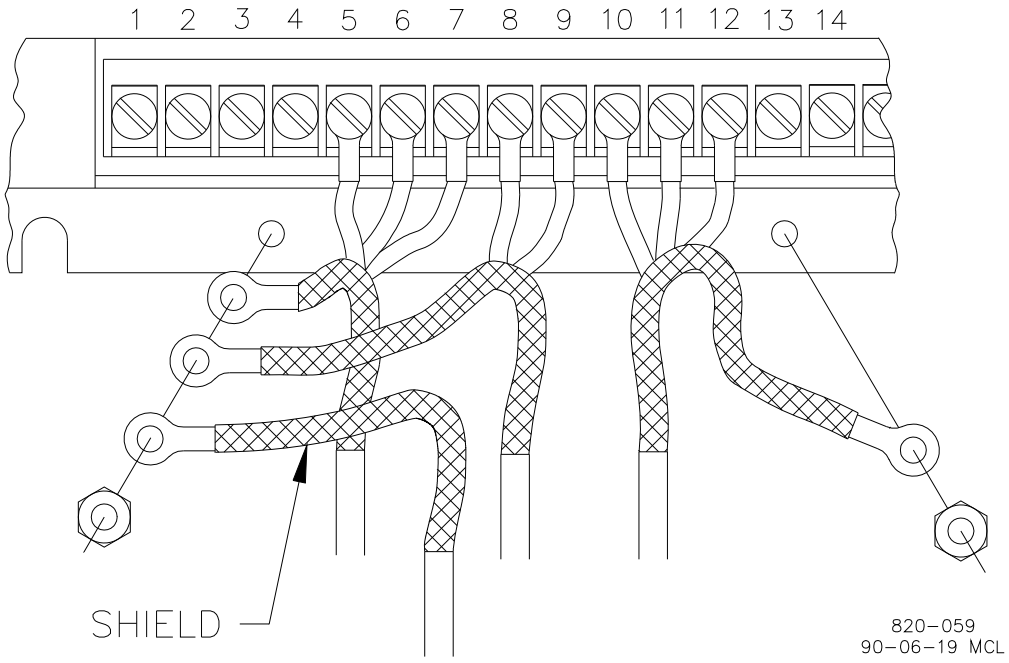


Figure 3-4. Proper Preparation of Shielded Wires

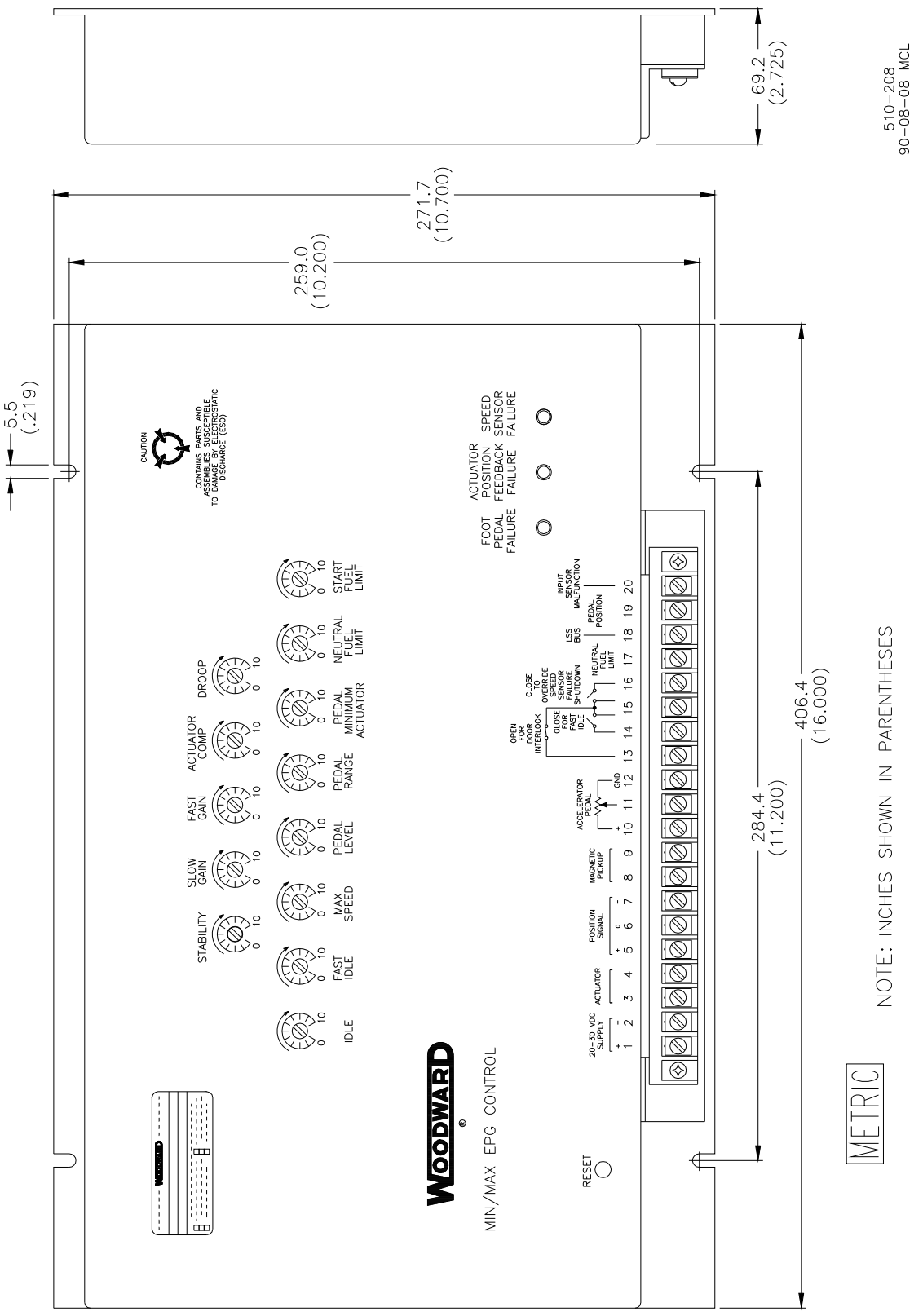
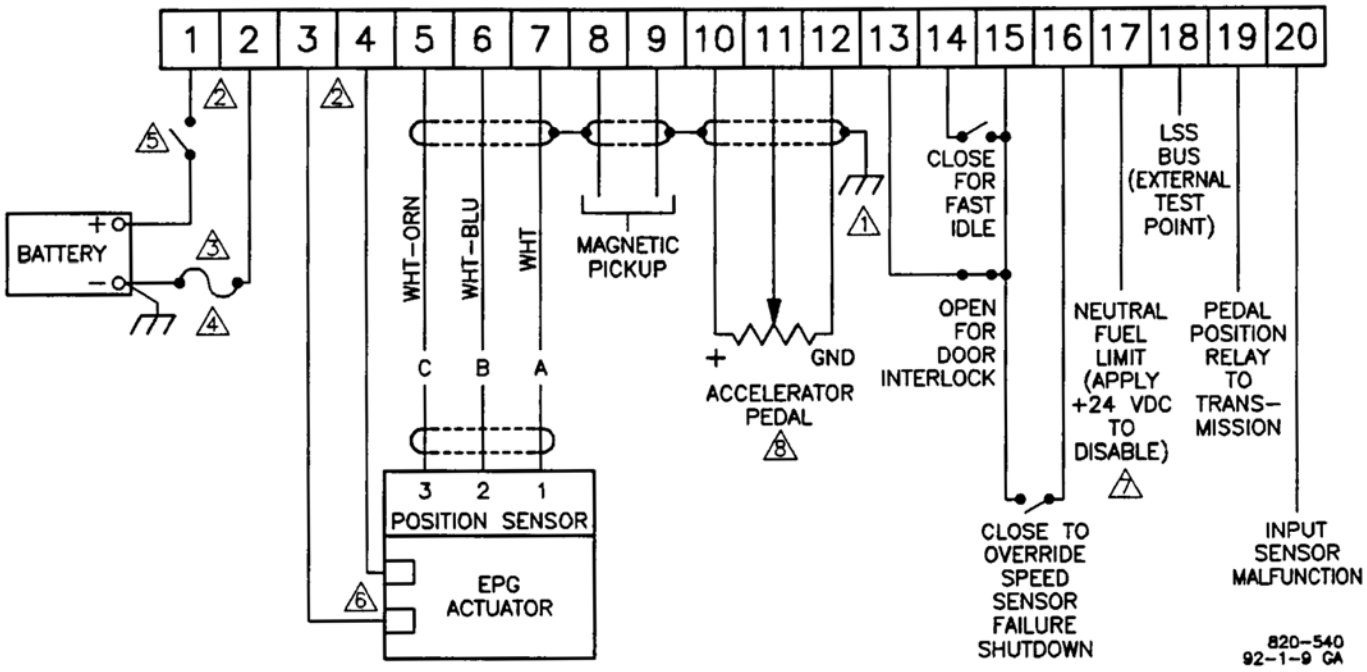


Figure 3-5. Outline Drawing of Min/Max EPG Control



NOTES

1. Shielded wires to be twisted pairs or triples with shield grounded to control mounting bolts only. Use star washers to assure good ground.
2. AWG 12 stranded wire. Must be as short at possible, not more than 75 feet.
3. Leads to terminals 1 & 2 must be direct and not pass through any distribution points.
4. Use a 10 amp (fast blow) fuse (3 AG or GLH type) in series with battery (-) as close to the battery as possible. Fuse is in addition to the internal 6.5 amp breaker in series with battery (+). The fuse has no bearing on safety shutdown protection, but rather is intended to protect electronic components from improper control wiring during installation.
5. Install control power switch in series with battery (+).
6. Actuator has no polarity.
7. Provide +24 Vdc (+) signal to terminal 17 when transmission is in gear, no signal when in neutral. Every effort should be made to locate a source for this signal. Jumper terminal 17 to terminal 1 (+) if signal is not available.
8. 2500 ohm nominal.

Figure 3-6. Min/Max Control Plant Wiring

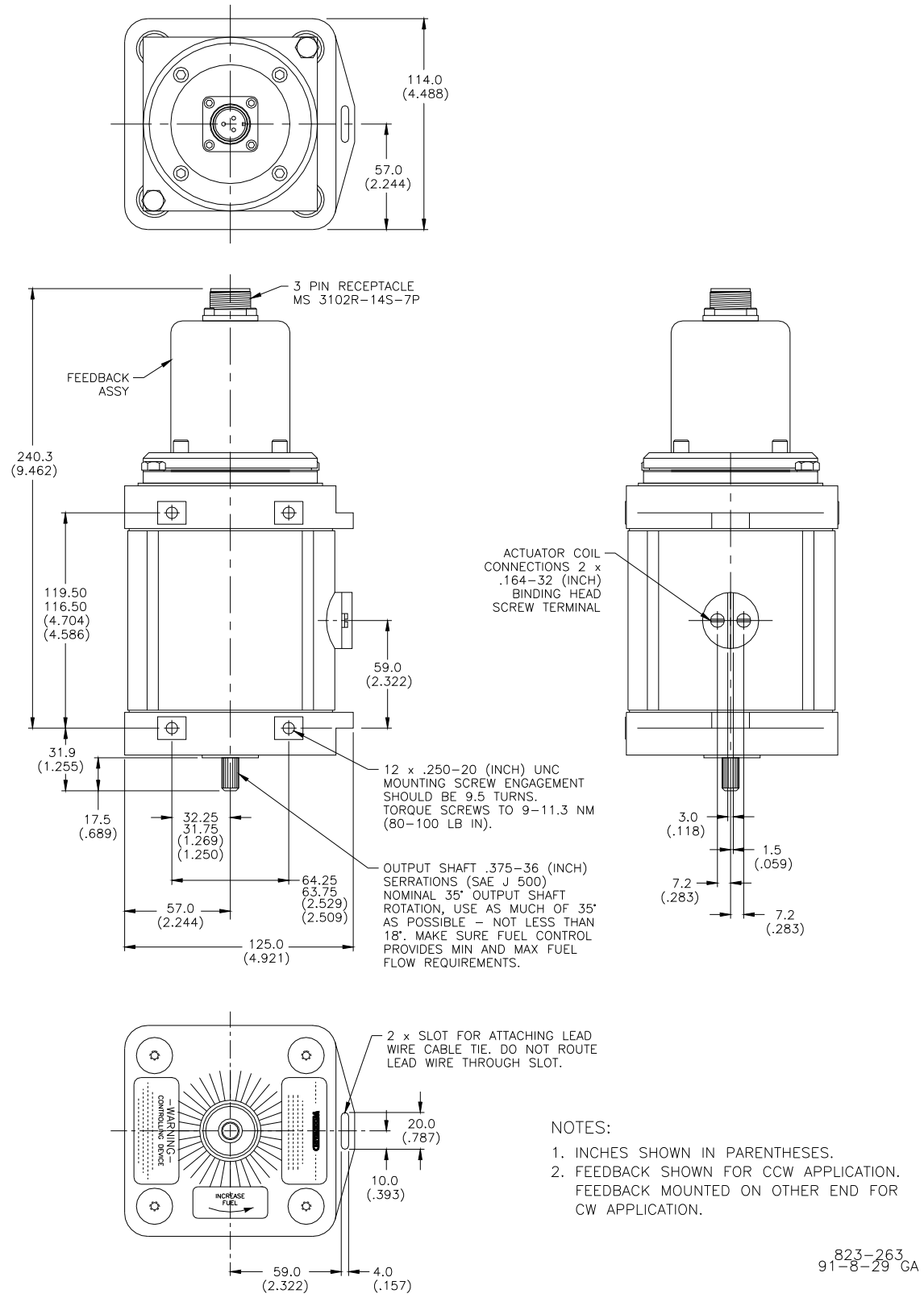


Figure 3-7. 1724 Electric Actuator

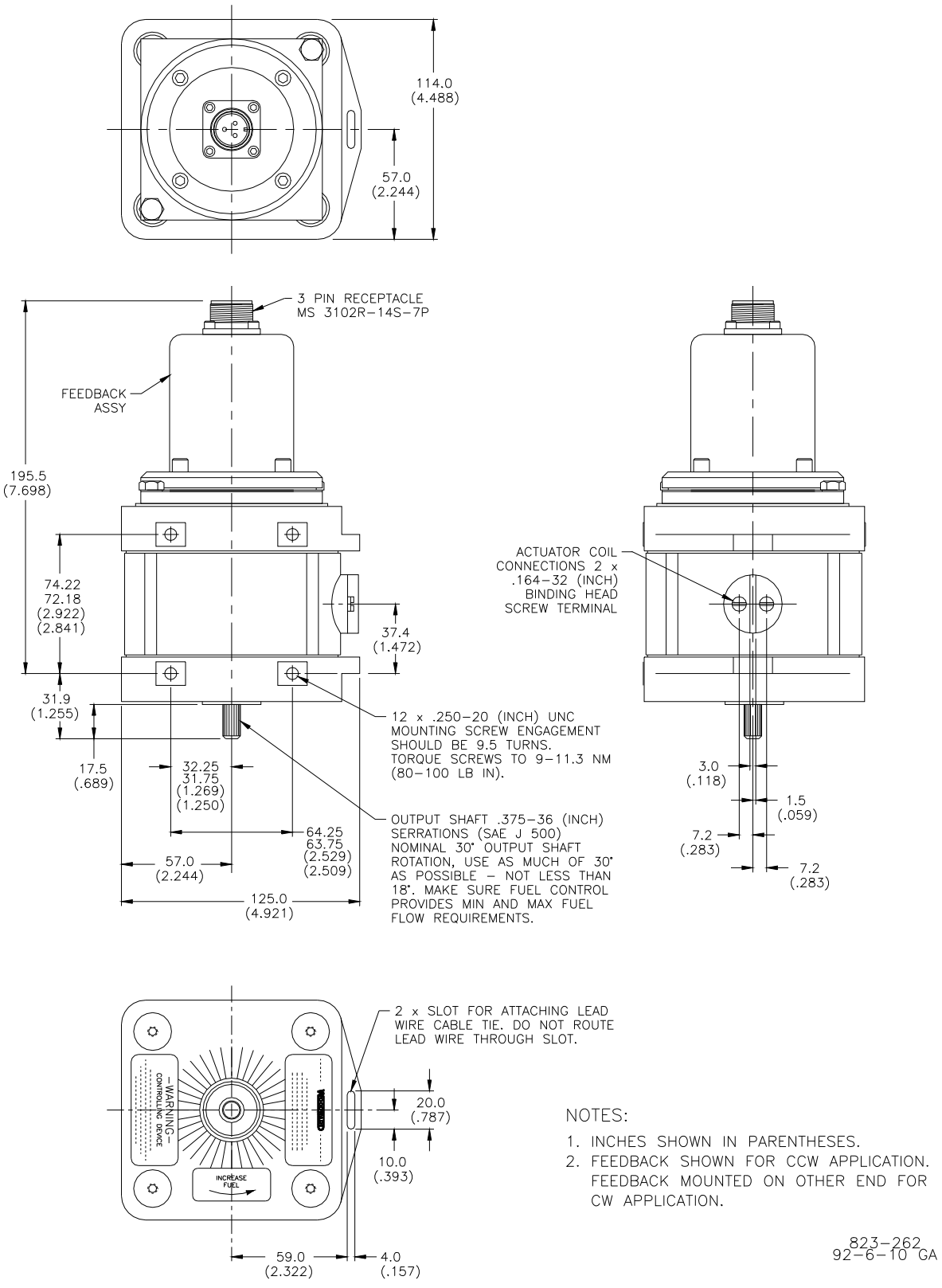


Figure 3-8. 524 Electric Actuator

Chapter 4.
Setting up the Control Box

Introduction

There are a number of adjustments available through the cover of the control. Once made, these adjustments will not require changing unless there is a major change in engine dynamics or in the operation of the bus. The control should not have to be changed to meet the needs of various drivers or to meet seasonal climatic changes.

Before attempting to adjust the control make sure that the DIP switches were properly set during the installation. Improper setting of any of the switches will make it impossible to adequately control the engine. (See Figure 3-1.)

All of the potentiometers which will be adjusted are single-turn units. To eliminate deadband confusion, all settings should be completed as the potentiometer is turned clockwise. (Consider each potentiometer as 0=fully ccw [counterclockwise], 5=mid, and 10=fully cw [clockwise]).

Foot Pedal Calibration

Select a voltmeter or ammeter capable of reading the Foot Pedal Position as set by the DIP switches in the previous chapter. Attach the meter to 19 (+) and ground (–). (If the installation includes a dashboard meter from terminal 19, disconnect this lead from terminal 19 and install an ammeter in series between 19 (+) and the meter wire removed (–).)

IMPORTANT

If the Foot Pedal Failure light is on, foot pedal calibration cannot be obtained. Reset the Foot Pedal Failure light by adjusting the pedal level potentiometer fully cw (10). Shutdown governor or engine power for at least 30 seconds. The light should be out when governor or engine power is reinstated.

Open the fast idle switch (terminals 14 and 15). Close the door interlock switch (terminals 13 and 15).

Power up the control but do not start the engine.

Set the PEDAL LEVEL potentiometer to (7).

Set the PEDAL RANGE potentiometer at mid position (5) and record the reading at terminal 19.

Adjust the PEDAL RANGE potentiometer to provide all of the spread between pedal off and pedal fully depressed which should be available at terminal 19. (16 mA for 4–20/20–4 mA readouts, and 4 Vdc for 1–5/5–1 Vdc readouts.)

Adjust the PEDAL LEVEL potentiometer to set the pedal-off level to its proper setting. Fully depress the pedal to verify the proper pedal-on setting.

Some installations will use the pedal position readout to relay pedal information to the transmission. In these cases the pedal calibration must be done to match the electrical specifications for the input signal to the given transmission. The actuator will follow the foot pedal position between idle and maximum speed.

Speed Reference Adjustments

Adjustments of speed references may be made on a bench with a small amount of specialized test equipment (Option 1) or with the engine running (Option 2).

Preset

IDLE, FAST IDLE, and MAXIMUM ENGINE SPEED potentiometers are preset at the factory at:

Idle	1030 Hz
Fast Idle	1717 Hz
Maximum Speed	3777 Hz

If idle, fast idle, and max engine speeds are not correct for your application set the engine dynamics as follows before trying to adjust the three governor speeds (used for Option 1 and Option 2 methods):

STABILITY	cw (10)
FAST GAIN	ccw (0)
ACTUATOR COMP.	Mid (5)
SLOW GAIN	ccw (0)

Option 1
(Setting up with Test Equipment)

Set the IDLE, FAST IDLE and MAX SPEED potentiometers with test equipment before starting the engine. Woodward frequency Counter/Generator 8909-509 can be used to simulate the MPU signal. A meter capable of measuring 1–5 Vdc is also required. A number of suitcase test devices and engine simulators are also available to make setup easier.

To set the potentiometers the technician must know the number of teeth on the gear being sensed by the magnetic pickup and the desired idle, fast idle, and maximum engine rpm.

Attach a signal generator capable of duplicating the signal which the MPU will generate when the engine is running to terminals 8 and 9. Determine the desired engine rpm for the three set points. Multiply this number by the number of teeth in the sensed gear and divide by 60 to establish the frequencies for the three settings. (Notice that these frequencies are in Hz, as are the ranges set by the DIP switches during installation.)

$$Hz = \frac{No.\,of\ Gear\ Teeth\ x\ RPM}{60}$$

Setting for an engine with 103 gear teeth are shown in the following example:
Idle: 600 rpm =1030 Hz
Fast Idle: 1000 rpm = 1717 Hz
Max Engine Speed: 2200 rpm = 3777 Hz
Note: for this example use DIP switch No. 4 (1500 to 3000 Hz)
[Dip switches are accessible by removing the back cover of the control box (see Figure 3-1).]

Attach a voltmeter to terminal 18 (+) and ground (–). Turn power on to the control.

Turn the NEUTRAL FUEL LIMIT pot fully cw (10) to be sure it will not interfere with the voltage on terminal 18.

Turn the MAX SPEED, FAST IDLE, and the IDLE SPEED potentiometers to 10 (fully cw). Set the signal generator for the desired idle frequency. Turn the IDLE pot toward 0 (ccw) until the meter reading goes low and the actuator lever goes to minimum position. Carefully turn the IDLE potentiometer toward 10 until the meter reading goes high and the actuator lever just starts moving toward maximum. This setting will be close to the desired idle speed.

Jumper terminal 10 to terminal 11 (to simulate maximum foot-pedal position). Set the signal generator for the desired maximum speed frequency. Turn the MAXIMUM SPEED potentiometer toward 0 until the meter reading goes low and the actuator lever moves toward minimum. Carefully turn the potentiometer back toward 10 until the meter goes high and the actuator lever just starts moving toward maximum. Remove the jumper from terminals 10 and 11.

Close the fast-idle switch. Set the signal generator for the desired fast idle frequency. Adjust the FAST IDLE potentiometer toward 0 until the meter goes low and the actuator lever goes to minimum. Carefully turn the FAST IDLE potentiometer back toward 10 until the meter goes high and the actuator lever just starts moving toward maximum. Open the fast-idle switch.

These three settings may require fine tuning with the engine tachometer after all other adjustments have been completed. However, if they were made correctly the engine should be able to operate safely.

⚠WARNING

The setting of the three speed levels on the Min/Max control do not assure that the unit will control engine speed on start up. Be prepared to take emergency measures to prevent overspeed when starting an engine with an untested Min/Max control. Dangerous overspeeds with physical damage and possible loss of life are possible.

Should the above settings not provide initial engine control make sure that the gear teeth count is correct and that mistakes were not made in the calculations of frequencies used for the setup.

Option 2

(Setting up the Control while Running the Engine)

IMPORTANT

The speed settings can be set with the engine running using a tachometer for the desired speeds, if other means are available to prevent engine overspeed until the settings have been made.

The door-interlock switch must be closed to complete the following calibration.

Set the IDLE pot fully counterclockwise and both FAST IDLE and MAXIMUM SPEED at mid-position. Start the engine. It should be running at the mechanical idle speed. Slowly turn the IDLE speed pot clockwise until the Min/Max EPG begins controlling engine idle speed. Continue turning the IDLE pot until the engine is controlled at the desired idle speed, but allow the engine speed to stabilize after each adjustment to ensure proper speed setting. Close the Fast Idle switch and set the FAST IDLE pot in the same fashion. Turn the Fast Idle switch off. Set the Maximum engine speed by slowly depressing the foot pedal until the Maximum governor clearly takes over and pressing the foot pedal farther does not change the engine speed. (If engine speed is too high before the maximum governor takes over, the MAXIMUM SPEED potentiometer may need to be adjusted ccw before continuing.) When the Maximum governor is in control the foot pedal may be fully depressed without increasing engine speed. Allow the engine to stabilize after each adjustment to ensure proper speed setting.

Engine Dynamics

Preset the engine dynamics as follows (consider each potentiometer as 0=fully ccw, 5=mid, and 10=fully cw).

STABILITY	5
FAST GAIN	0
ACTUATOR COMP.	5
SLOW GAIN	0

It will be necessary to adjust these potentiometers to obtain optimum performance.

Start Fuel Limit

The START FUEL LIMIT potentiometer should be set at 10 when first starting the engine. If the engine receives too much fuel while cranking, reduce the setting toward 0.

Response And Engine Dynamics

The most difficult settings will be the engine dynamics. The five potentiometer settings tend to be interrelated, with a change in one of the settings sometimes requiring adjustment of other settings.

Droop

The Max governor speed is affected by about 12% droop which is built into the circuits.

Droop is only active while the engine is running on the max governor and the transmission is not in neutral (while driving on the road at maximum engine speed.) The effect of droop it to decrease the max-governor speed slightly as engine load increases, and to increase the max-governor speed slightly as engine load decreases. This effect simulates the natural response of the engine to load changes and is necessary to improve governor response under constantly changing driving conditions.

The idle and fast-idle governors are isochronous, regardless of transmission setting. They will always govern at the speed set by the respective potentiometers under all engine-load conditions. The max governor is isochronous while the transmission is in neutral to allow accurate max-governor speed set up, even if engine load is changed during set-up.

Fast and Slow Gain

The FAST and SLOW GAIN settings are interrelated. The FAST GAIN setting is only active on very sharp load transients at idle speed, and is used to provide an extra "kick" to the actuator to improve governor response time to large load changes. It has no effect on steady-state operation, except for interaction with the SLOW GAIN. A change in the FAST GAIN adjustment should be compensated for with an equal and opposite offsetting adjustment in the SLOW GAIN, to maintain equivalent steady-state performance.

If the governor either allows the engine speed to drop too low on a sharp load transient such as A/C and transmission at the same time (FAST GAIN should be increased) or kicks the fuel too hard on the same type of load change (FAST GAIN should be decreased). Adjust the SLOW GAIN to set the normal response to load change at an optimum level and to stabilize steady-state operation. CCW will allow larger speed changes on transients, cw will increase the fuel change in response to load change. If adequate adjustment cannot be made with the SLOW GAIN potentiometer, change the FAST GAIN setting one division and readjust the SLOW GAIN.

Stability

Set the STABILITY potentiometer to maintain a constant idle speed, without engine "hunting" or oscillations. Switching between idle and fast idle should not change the stable operation. The STABILITY setting should be as far cw (toward 10) as possible with constant idle speed under varying loads. If the STABILITY setting is below 5 try setting the SLOW GAIN one division ccw and reset the STABILITY SETTING. However, it may be necessary to set this pot below 5 to obtain optimum performance.

With the transmission in neutral, slowly depress the foot pedal to maximum throttle position. The max governor should take control smoothly from the pedal and should provide stable engine operation. If the engine is not stable on the max governor, try adjusting the STABILITY first, and then the SLOW GAIN. Load transient performance should also be tested on the max governor to ensure satisfactory response. Once again, STABILITY and SLOW GAIN are the adjustments that should be changed to improve response time. After all the engine dynamic adjustments are completed, the Min/Max EPG should provide stable/fast response in all three governor modes: Idle, Fast Idle, and Max engine speed.

IMPORTANT

It may be necessary to adjust the actuator linkage to use more of the actuator stroke in order to achieve optimum engine response to load changes. If unable to increase the amount of stroke between minimum and maximum actuator positions, attempt to set the actuator lever so the stroke being used approaches the maximum actuator position.

Some applications may not experience excessive sharp load transients at idle speed, thus the dual dynamics provided by the SLOW GAIN and FAST GAIN adjustments may not be required. Dual dynamics are disabled by turning the SLOW GAIN potentiometer fully cw (to 10) and using the FAST GAIN adjustment to establish the desired response to all load changes. This greatly simplifies the dynamic adjustment process and should be used, if possible. If it is not possible to stabilize the engine under steady-state operation, even with the FAST GAIN fully ccw, it may be necessary to back off the SLOW GAIN from its fully cw position until the engine stabilizes. In all cases it is best to keep the FAST GAIN setting as far ccw as possible, while still providing adequate response to sharp transients at idle, and the SLOW GAIN as far cw as possible while still providing stable steady-state operation. This will keep the relative difference between the two sets of dynamics to a minimum.

Actuator Compensation

The ACTUATOR COMPENSATION potentiometer should be preset at 5 for most applications. If a slow, periodic instability remains, slightly increase the ACTUATOR COMPENSATION (turn the potentiometer clockwise) and repeat the GAIN and STABILITY adjustments. Continue to increase the ACTUATOR COMPENSATION and readjust the GAIN and STABILITY until stable operation is achieved.

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

Neutral Fuel Limit Adjustment

(This setting should be made with the engine cold. The Pedal Minimum Actuator setting should be made with the engine at operating temperature.)

Adjust the NEUTRAL FUEL LIMIT potentiometer fully cw.

With the engine cold, slowly depress the foot pedal until the maximum speed setting takes over governor operation. With the maximum speed governor in control press the pedal all the way to the floor and hold it there. Turn on all the engine parasitic loads such as lights and air conditioning. Adjust the NEUTRAL FUEL LIMIT pot ccw so the engine decreases below the maximum speed setting. Then turn the NEUTRAL FUEL LIMIT pot cw until the governor takes over again and the fuel limit is set just above the fuel required to run the engine at maximum speed with full load in neutral.

Pedal Minimum Actuator

Set the PEDAL MINIMUM ACTUATOR potentiometer fully ccw.

With the engine warm and no load on the engine (none of the lights, air conditioner, air compressor, etc. on) adjust the PEDAL MINIMUM ACTUATOR potentiometer cw so the engine increases in speed above the idle speed. Then back off the PEDAL MINIMUM ACTUATOR potentiometer so the governor takes over once again and the minimum foot-pedal setting is set just below the required fuel to run the engine at no load in neutral.

Final Check

Check to be sure the foot pedal takes over smoothly from the idle governor and then the rated speed governor takes over smoothly from the foot pedal at the top end. Engine dynamics affect how quickly the governor takes over, so the faster the response set by the stability and gain settings the better.

Min/Max Set-up for Buses With Cummins CNG Engines using Standard Carburetors

1. Preset the engine dynamics potentiometers and other controller pots as follows: (consider each potentiometer as 0=fully ccw, 5=mid, and 10=fully ccw)

Stability 5	Maximum Speed 5
Slow Gain 0	Pedal Level 7
Fast Gain 0	Pedal Range 5
Actuator Compensation 5	Pedal Minimum Actuator 0
(It will be necessary to fine tune these four potentiometers to obtain optimum bus performance)	Neutral Fuel Limit 10
	Start Fuel Limit 10
	Fast Idle 0
Idle 0	

2. Foot Pedal Calibration
   a. Place meter on mA scale and attach leads to 19(+) and ground (–).
   b. Power up the control and close all bus doors.
   c. Record the reading at terminal 19.
   d. Adjust the Pedal Range potentiometer to provide a 16 mA spread on the meter attached to terminal 19 between pedal off and pedal fully depressed.
   e. Adjust the Pedal Level potentiometer to set the Pedal Off level at 4.0 mA on the meter attached to terminal 19.

3. Fine tune Idle rpm and Max Speed rpm to match your requirements.

4. Adjust Neutral Fuel Limit Potentiometer. (Adjust with cold engine.)
   a. Turn on all engine parasitic loads such as lights and air conditioning.
   b. Press the pedal all the way to the floor and hold it there.
   c. Adjust the Neutral Fuel Limit potentiometer ccw so the engine decreases below the maximum engine speed setting.
   d. Turn the Neutral Fuel Limit potentiometer cw until the governor takes over again.

5. Pedal Minimum Actuator (with engine warm).
   a. Turn off all parasitic loads, such as lights and air conditioning.
   b. Adjust the Pedal Minimum Actuator potentiometer cw so the engine increases speed to above idle speed.
   c. Adjust the Pedal Minimum Actuator potentiometer ccw until the governor takes control.

6. Final Check: Check to be sure the foot pedal takes over smoothly from the idle governor and then the rated speed governor takes over smoothly from the foot pedal at the top end.

7. Set the Response and Engine Dynamics as shown earlier.

8. Record the final potentiometer settings:

Stability ....._____	Max Speed....._____
Slow Gain ....._____	Pedal Level ....._____
Fast Gain ....._____	Pedal Range ....._____
Actuator Comp..._____	Pedal Min. Actuator...._____
Idle....._____	Start Fuel Limiter....._____

Chapter 5. Troubleshooting

Introduction

This troubleshooting guide is designed to help the mechanic locate errors in the system or in the adjustment of the Min/Max Control. The troubleshooting guide assumes that the engine is running properly, with the carburetion, timing, and electrical system all set according to the manufacturers specifications. Similar assumptions are made about the transmission and the various parasitic loads from the alternators, compressors, air conditioning, and monitoring systems.

Adjustments

Once a control has been adjusted to match an application it is unlikely that the adjustments will change. Do not change the adjustments until all other possible causes of unacceptable engine operation have been carefully inspected.

Pay particular notice to the linkage from the actuator to the engine as this is a likely place for troubles to develop. Rod ends on the linkage can wear and change the apparent calibration. In this case it is better to replace the rod ends than use the control to compensate for worn linkage.

Binding or excessive friction in the linkage can also appear to change the calibration.

Wear in the foot-pedal sending unit may also appear to change the control calibration. Again, it is better to replace the worn element than to use the control to compensate for wear.

Trouble	Possible Cause	Indication	Corrective Action
Engine Won't Start	Start Fuel Limit	Actuator lever does not move far enough to supply sufficient fuel to start the engine.	Make sure that the linkage has not shortened. Start Fuel Limit is in effect until the engine reaches 80% of idle speed after cranking. If necessary, adjust the Start Fuel Limit potentiometer clockwise, one division at a time, until the engine will start.
	MPU Component or Wiring Fault	"Speed Sensor Failure" LED and "Check Control" lamp both on. Less than 2 Vac on terminals 8 and 9 during cranking.	MPU may have backed away from the fly-wheel, decreasing the signal during cranking. If readjusting the MPU, be careful not to touch the gear since this will destroy the sensing unit.
	Actuator Position Feedback Component or Wiring Fault	"Actuator Position Feedback Failure" LED and "Check Control" lamp both on. With power to the control, the voltage from terminal 6 (+) and 7 (–) should be 3.2 ±0.2 Vdc at minimum actuator position, and 4.1 ±0.2 Vdc at maximum actuator position.	Be sure the actuator wires (+), (–), and (out) are connected properly to the control box. A voltmeter may be used to verify the correct voltage at terminal 6 for minimum and maximum actuator position with the control power on. Check the wiring from the control all the way back to the actuator terminals for broken or shorted wires. If the wiring and connection are correct, but the voltage readings at terminal 6 do not fall within the specified limits, it is possible that severe shock or vibration has shifted the Hall-effect feedback device out of calibration. The actuator is designed to prevent this from occurring during normal operation, but should it happen, the actuator must be returned to Woodward for calibration.
	No Power to the Control	Voltage at terminals 1 (+) and 2 (–) does not fall within specified 20–30 Vdc limits. "Check Control" lamp does not light as control is first powered up.	Reset the circuit breaker on the control. Check the wiring from the control all the way back to the battery for broken or shorted wires. Be sure the control power comes directly from the battery, not through a distribution point. Do not use any external fuses in the power lines. (The circuit breaker inside the Min/Max control has been carefully selected and sized to provide maximum safety protection for both the passengers and the control should a wiring or control fault occur.)
	Actuator Drive wiring fault.	The current in line to terminal 3 or 4 should be about 1 A to move the actuator off its minimum stop and about 4 to 5 A for maximum actuator travel.	Check the wiring from the control all the way back to the actuator drive terminals for broken or shorted wires.

Trouble	Possible Cause	Indication	Corrective Action
Engine starts but runs only at mechanical idle speed.	Idle Speed potentiometer set incorrectly.	LEDs and "Check Control" lamp turn off after engine is running. Engine responds to foot pedal but then drops to mechanical idle when foot pedal is released.	Reset the Idle Speed potentiometer as instructed in "Speed Reference Adjustments" in Chapter 4. If using Option 1 to make these adjustments, make sure frequency calculations are correct.
	MPU component or wiring fault.	Engine does not respond to foot pedal unless the "Override Speed Sensor Failure Shutdown" switch is closed. "Speed Sensor Failure" LED and "Check Control" lamp on. Less than 2 Vac on terminals 8 and 9.	MPU may have backed away from the flywheel, decreasing the signal during cranking. If readjusting the MPU, be careful not to touch the gear, since this will destroy the sensing unit.
	Actuator Position Feedback Component or Wiring Fault	"Actuator Position Feedback Failure" LED and "Check Control" lamp both on. With power to the control, the voltage from terminal 6 (+) and 7 (–) should be 3.2 ±0.2 Vdc at minimum actuator position, and 4.1 ±0.2 Vdc at maximum actuator position.	Be sure the actuator wires (+), (–), and (out) are connected properly to the control box. A voltmeter may be used to verify the correct voltage at terminal 6 for minimum and maximum actuator position with the control power on. Check the wiring from the control all the way back to the actuator terminals for broken or shorted wires. If the wiring and connection are correct, but the voltage readings at terminal 6 do not fall within the specified limits, it is possible that severe shock or vibration has shifted the Hall-effect feedback device out of calibration. The actuator is designed to prevent this from occurring during normal operation, but should it happen, the actuator must be returned to Woodward for calibration.
	No Power to the Control	Voltage at terminals 1 (+) and 2 (–) does not fall within specified limits (20–30 Vdc for 24 Vdc systems). "Check Control" lamp does not light when control is first powered up.	Reset the circuit breaker on the control. Check the wiring from the control all the way back to the battery for broken or shorted wires. Be sure the control power comes directly from the battery, not through a distribution point. Do not use any external fuses in the power lines. (The circuit breaker inside the Min/Max control has been carefully selected and sized to provide maximum safety protection for both the passengers and the control should a wiring or control circuitry fault occur.)

Trouble	Possible Cause	Indication	Corrective Action
Engine starts and runs on controlled idle but does not respond to foot pedal. (Fast Idle may still work.)	Door Interlock switch open or faulty.	When the bus doors are closed, terminal 13 should be at ground voltage. When the bus doors are open, terminal 13 should be positive voltage.	Check the switches with an ohmmeter to verify infinite resistance with the switch open and zero resistance with the switch closed.
	Door Interlock wiring open or faulty.	When the bus doors are closed, terminal 13 should be at ground voltage. When the bus doors are open, terminal 13 should be positive voltage.	Check the wiring from the control to the door switches and sensors for broken or shorted wires.
	Foot Pedal component or wiring fault.	"Foot Pedal Failure" LED and "Check Control" lamp both on. The voltage from terminal 11 (+) to 2 (–) (ground) should be 1.8 ±0.5 Vdc at pedal-off position and 6.1 ±0.5 Vdc at pedal-on position.	Be sure the foot pedal wired (+), (–), and (wiper) are connected properly to the control. A voltmeter may be used to verify the correct voltage at terminal 11 for pedal-off and pedal-on position. The control was designed for a pedal sensor with a total resistance from (+) to (–) of 2500 ±500 Ω. The resistance from (–) to (wiper) with pedal-off, and from (+) to (wiper) with pedal-on should be 450 ±150 Ω. If your foot pedal does not meet these specifications, contact Woodward so changes can be made to adapt the control to the situation. Check the wiring from the control all the way to the foot pedal for broken or shorted wires.

Trouble	Possible Cause	Indication	Corrective Action
Engine starts and runs on controlled idle but does not respond to foot pedal (fast idle may still work).	PEDAL RANGE and PEDAL LEVEL set incorrectly.	"Foot Pedal Failure" LED and "Check Control" lamp both on. The voltage from terminal 11 (+) to 2 (–) (ground) should be 1.8 ±0.5 Vdc at pedal-off position and 6.1 ±0.5 Vdc at pedal-on position.)	Reset the PEDAL RANGE and PEDAL LEVEL potentiometers as instructed in "Foot Pedal Calibration in Chapter 4.
The Foot Pedal has a "dead spot" at the beginning of its travel so the engine does not respond until after a certain period of movement is reached.	Pedal Minimum actuator potentiometer set incorrectly.	The voltage from terminal 18 (+) to terminal 2 (–) (ground) should be between .8 and 2.8 Vdc to control the engine at idle speed with the engine warm and no parasitic loads on. When the foot pedal is depressed to speed the engine up and then quickly released, the voltage at terminal 189 will momentarily go to the PEDAL MINIMUM actuator setting until the idle governor takes over again. This setting should be about 0.1 Vdc below the no load idle voltage at terminal 18.	Reset the PEDAL MINIMUM ACTUATOR potentiometer as instructed in the "Pedal Minimum Actuator" section of Chapter 4.
	PEDAL RANGE and PEDAL LEVEL potentiometers set incorrectly.	The signal at Terminal 19 will not be correct for the desired pedal readout as determined by the DIP switch settings.	Reset the PEDAL RANGE and PEDAL LEVEL potentiometers as instructed in "Foot Pedal Calibration" Chapter 4.

Trouble	Possible Cause	Indication	Corrective Action
Full pedal-on does not provide maximum fuel to engine during stall test with transmission in gear and brake applied.	Actuator linkage not installed correctly.	Full actuator travel does not provide full fuel setting travel.	Check linkage installation as described in the "Installing the Actuator " section of Chapter 3.
	Neutral Fuel Limit still active.	The voltage at terminal 17 should be positive (+) Vdc to disable the Neutral Fuel Limit when the transmission is in gear. Terminal 17 will be at ground voltage when the transmission is in neutral.	Check terminal 17 for the proper signal for both transmission in gear and transmission in neutral. Check the wiring from the control to the transmission-signal-output point for a broken or shorted wire.
	Pedal Minimum pot set incorrectly.		Refer to "Pedal Minimum Actuator" in Chapter 4.
	Pedal Range and Level pots set incorrectly.		Refer to "Foot Pedal Calibration" in Chapter 4.
	External return spring force too great for actuator force to overcome.	Actuator lever arm can be moved farther toward maximum position by applying manual force to the lever. If this movement is only slight, the linkage may need adjustment to provide increased fuel at maximum actuator position.	Refer to "Installing the Actuator" in Chapter 3.
Engine "hunts" or oscillates at idle, fast idle, or maximum engine speed.	Engine dynamics set incorrectly.		Refer to "Engine Dynamics" in Chapter 4.
	Friction in actuator linkage or fuel setting lever, or improperly installed linkage.		Refer to "Installing the Actuator" in Chapter 3.

Trouble	Possible Cause	Indication	Corrective Action
Engine speed drops too low or dies when sharp transient loads are applied at idle.	Fast Gain and/or Stability are not set high enough.		Refer to "Engine Dynamics" in Chapter 4.
Engine speed overshoots maximum governor setting when the foot pedal is quickly depressed while the transmission is in neutral.	Bad or improper connection from transmission "neutral" signal to terminal 17.	The voltage at terminal 17 should be at positive Vdc to disable the Neutral Fuel Limit when the transmission is in gear, and should be at ground voltage when the transmission is in neutral to enable the fuel limit.	Check terminal 17 for the proper signal for both transmission in gear and transmission in neutral. Check the wiring from the control to the transmission signal output point for a broken or shorted wire.
	MAXIMUM SPEED potentiometer set incorrectly.		Refer to "Speed Reference Adjustments" in Chapter 4.
	NEUTRAL FUEL LIMIT potentiometer set incorrectly.		Refer to "Neutral Fuel Limit Adjustment" in Chapter 4.
Transmission does not shift properly according to driver demand from the foot pedal.	Bad or improper connection from terminal 19 to the transmission "pedal input."		Check the wiring from the control to the transmission "pedal input" for a broken or shorted wire.
	PEDAL RANGE and LEVEL improperly calibrated.		Refer to "Foot Pedal Calibration" in Chapter 4.
Transmission does not shift properly according to driver demand from the foot pedal.	Linkage adjustment or arrangement between the actuator and the fuel setting lever.	Transmission does not match engine torque to provide smooth acceleration and operation.	The actuator linkage should only be changed after all other corrective actions have been attempted. Always check the transmission for correct operation before changing the linkage arrangement. A compromise may be needed to provide both stable engine operation and a correct engine-torque signal to the transmission interface. The actuator lever must be able to provide full-fuel position to the fuel control as well as the desired lowest fuel setting. Too little actuator movement between full fuel and minimum fuel will tend to make the engine unstable.

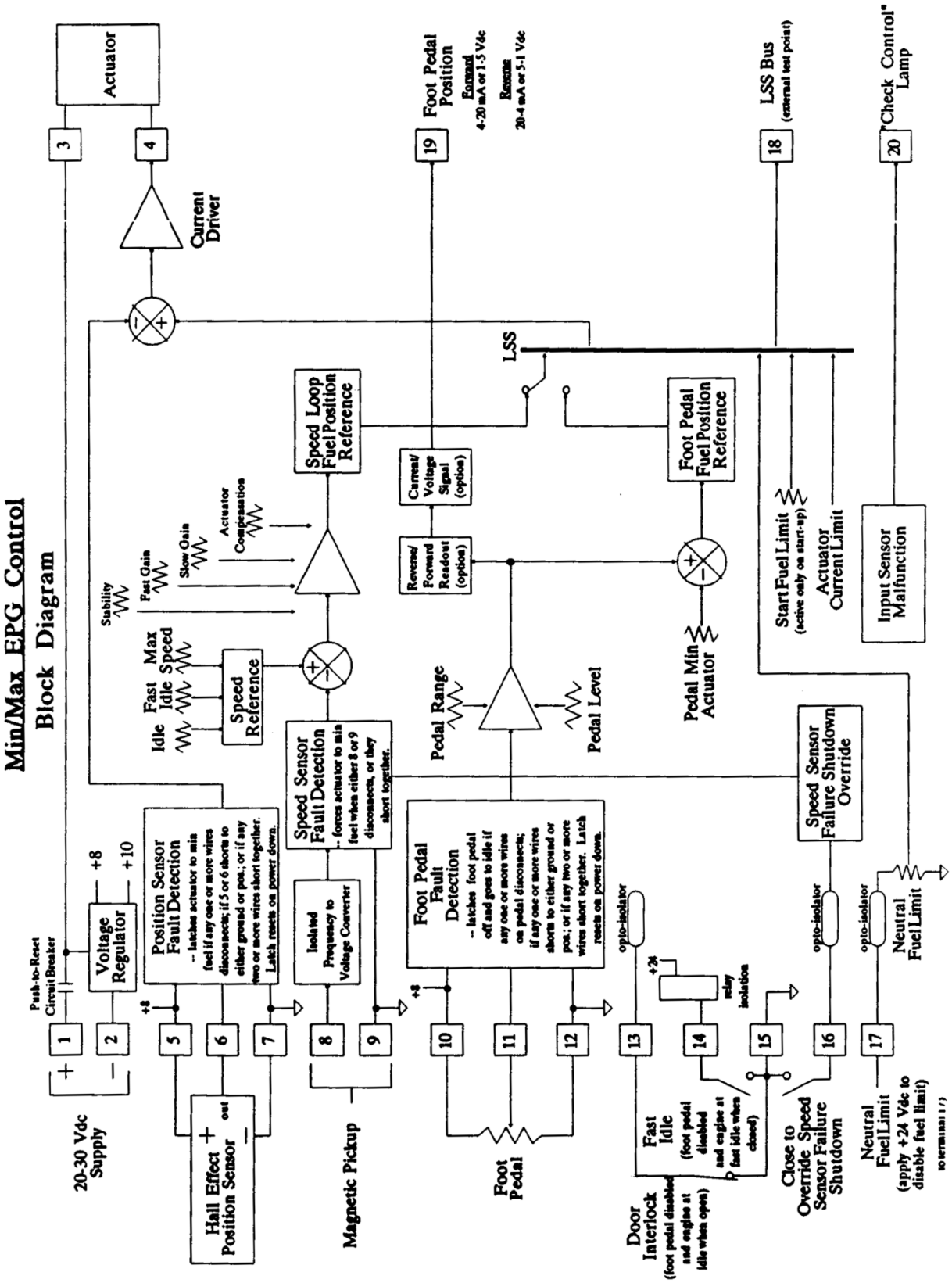


Figure 5-1. Min/Max Control Block Diagram

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**) 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**.

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**.

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**.

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

For the most current product support and contact information, please visit our website directory at **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 _____

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.) _____

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.

We appreciate your comments about the content of our publications.

Send comments to: icinfo@woodward.com

Please reference publication 82038E.

PO Box 1519, Fort Collins CO 80522-1519, USA
1000 East Drake Road, Fort Collins CO 80525, USA
Phone +1 (970) 482-5811 • Fax +1 (970) 498-3058

Email and Website—www.woodward.com

**Woodward has company-owned plants, subsidiaries, and branches,
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.