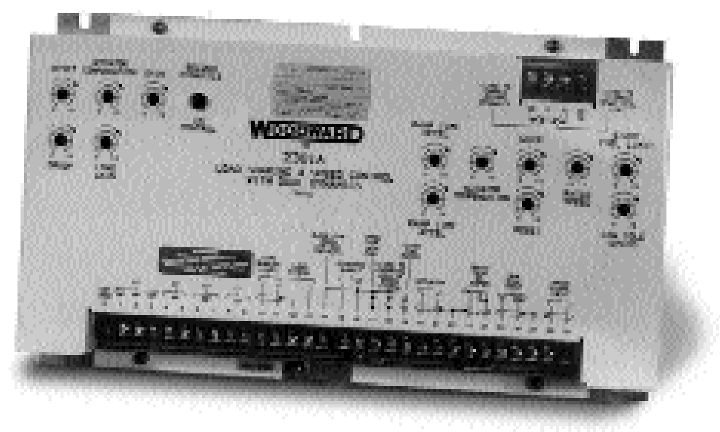
WOODWARD

Installation and Operation Manual



2301A Load Sharing & Speed Control with Dual Dynamics

Manual 82046

WARNING—DANGER OF DEATH OR PERSONAL INJURY

WARNING—FOLLOW INSTRUCTIONS

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.

WARNING—OUT-OF-DATE PUBLICATION

This publication may have been revised or updated since this copy was produced. To verify that you have the latest revision, be sure to check the Woodward website:

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WARNING—OVERSPEED PROTECTION

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—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.

CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY

CAUTION—BATTERY CHARGING

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.

CAUTION—ELECTROSTATIC DISCHARGE

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.**

IMPORTANT DEFINITIONS

- **A WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**
- **A CAUTION indicates a potentially hazardous situation which, if not avoided, could result in damage to equipment or property.**
- **A NOTE provides other helpful information that does not fall under the warning or caution categories.**

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Illustrations and Tables

Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).

2. 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.

3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.

4. 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.

CAUTION—ELECTROSTATIC DISCHARGE

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*.

Chapter 1. General Information

Description

The 2301A controls load sharing and speed of generators driven by diesel or gas engines, or steam or gas turbines. These power sources are referred to as "prime movers" throughout this manual.

The control is housed in a sheet-metal chassis and consists of a single printed circuit board. All potentiometers are accessible from the front of the chassis.

The 2301A provides control in either the isochronous or droop mode.

The isochronous mode is used for constant speed of the controlled prime mover with:

- Single prime mover operation
- Two or more prime movers controlled by Woodward Governor Company load sharing control systems on an isolated bus
- Base loading against an infinite bus with load controlled by an Automatic Power Transfer and Load (APTL) Control, an Import/Export Control, a Generator Loading Control, a Process Control, or another load-controlling accessory

Designations for products covered in this manual:

Supply Voltage	Forward Acting Part Number	Reverse Acting Part Number
10 to 40 Vdc	8272-766	8272-768
88-131 Vac or 90-150 Vdc	8272-767	8272-769

The droop mode is used for speed control as a function of load with:

- Single prime mover operation on an infinite bus or
- Parallel operation of two or more prime movers

The basic 2301A system for a single prime-mover generator consists of:

- A 2301A electronic control
- An external 20 to 40 Vdc power source (low voltage model), or an external 90 to 150 Vdc or 88 to 132 Vac power source (high voltage model)
- A speed-sensing device (MPU)
- A proportional actuator to position the fuel- or steam-metering device
- Current and potential transformers for measuring the load carried by the generator

Dual Dynamics

The 2301A with Dual Dynamics is primarily used in applications where the response time of the prime mover changes dramatically between start-up or unloaded and loaded situations, or in dual fuel applications.

Each set of dynamics has its own gain, reset, and actuator compensation adjustments. The selection of dynamics is made by a switch contact. A light emitting diode (LED) on the front of the 2301A control indicates when the alternate set of dynamics is being used by the control.

System Accommodating Features

2301A Controls with Dual Dynamics are available for forward- or reverse-acting applications. High voltage models accept 88 to 132 Vac, 45 to 440 Hz, or 90 to 150 Vdc. Low voltage models accept 20 to 40 Vdc supply. Changing the supply voltage rating requires exchanging the unit for the properly rated control. The high voltage model is identified as "115 Vac/125 Vdc" on the front of the control. The low voltage model is identified as "24 Vdc" on the front of the control.

A listing of controls and applications is provided on page iv of this manual.

Speed Range

Speed range is set by an internal dip switch, available inside the steel cover of the control. Speeds are set according to the sensor output frequency. The relationship between prime-mover speed and sensor-output frequency is expressed in the formula: Sensor Frequency in Hz equals the number of teeth on the speed-sensing gear times the revolutions per minute of the sensing gear, divided by 60.

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

Switch selectable speed ranges are:
- 500 to 1500 Hz
- 1000 to 3000 Hz
- 2000 to 6000 Hz
- 4000 to 12 000 Hz

The speed range selected should cover the operating speed range of the prime mover.

Reverse Acting

Most reverse acting controls will operate Woodward EGB governor/actuators. In reverse-acting systems, the actuator calls for more fuel when the actuator current decreases. Complete loss of signal to the actuator will drive the actuator to full fuel. This allows a backup mechanical ballhead governor to take control rather than shut down the prime mover as would a direct-acting system.

External wiring connections for reverse-acting controls are identical to those for direct-acting controls. However, the 2301A must be exchanged should a control need to operate the opposite type of actuator. Contact Woodward should it be necessary to change the type of control.

Start Fuel Limit

2301A Dual Fuel Controls include a start fuel limit which allows limiting the fuel setting during start up. The start fuel limit feature may be disabled by a switch at the terminal block. Start Fuel Limit Disable is especially desirable for use with reverse acting controls.

Start-fuel limit should be disabled after start up when used with reverse-acting controls. With loss of speed signal, the reverse acting control will position the actuator at the start-fuel level if the failed-speed-signal override is activated. Reverse-acting systems normally require the control to demand full fuel on loss of speed signal to allow the mechanical backup governor to control the system. The Start Fuel Limit can be deactivated by an auxiliary generator breaker contact which will short terminal 31 to terminal 32. This CLOSE TO DISABLE START FUEL LIMIT contact will disable the start fuel limit after the prime mover has been started and the generator breaker closed.

References

The following Woodward publications contain additional product or installation information on speed controls and related components. These publications are available on the Woodward website (www.woodward.com).

Manual	**Title**
26260	Governing Fundamentals and Power Management
25070	Electric Control Installation Guide
82384	SPM-A Synchronizer
82510	Magnetic Pickups and Proximity Switches for Electronic Controls
82514	Speed Setting Potentiometers
82343	Digital Reference Unit

Product Specification	
82047	2301A Load Sharing & Speed Controls with Dual Dynamics
82383	SPM-A Synchronizer
82516	EG-3P/-6P/-10P Actuator
82575	EGB-1P/-2P Governor/Actuator

Chapter 2. Installation

Unpacking

Before handling the control, read page ii, "Electrostatic Discharge Awareness". 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 of any damage.

Selection of Speed Range

A 4-pole mini-switch is located on the right-hand side of the printed circuit board. This switch sets the controlling speed range as sensed by the MPU. The speeds are related to the MPU frequency, which is proportional to engine RPM. The control is shipped with Switch 3 on for 2000 to 6000 Hz. Switch 1 provides 500 to 1500 Hz, Switch 2 provides 1000 to 3000 Hz, and Switch 4 provides 4000 to 12 000 Hz. Select only one switch on to match the control to the MPU frequency.

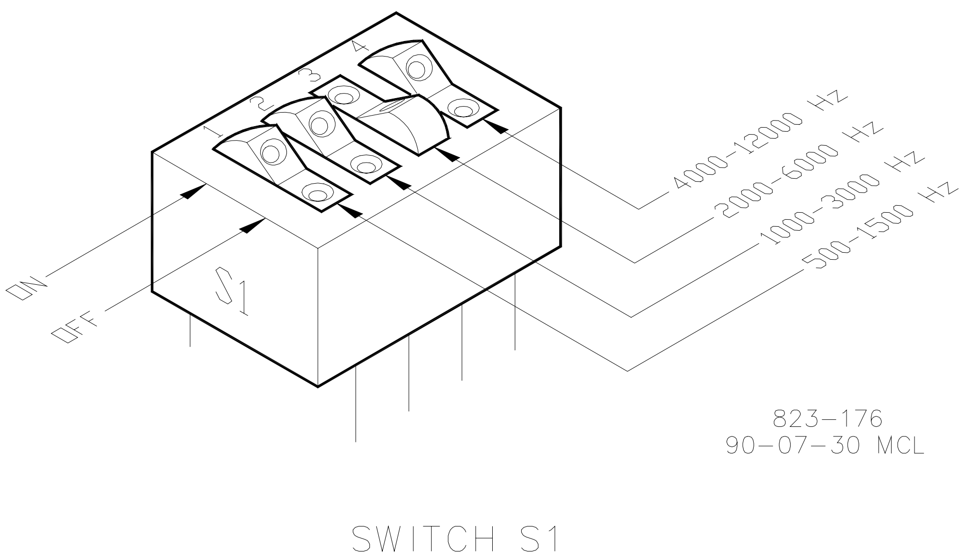


Figure 2-1. Speed Range Switch

Power Requirements

High and low voltage models of 2301A Speed Controls are available.

Low voltage models require a supply of 20 to 40 Vdc, 15 watts maximum.

High Voltage models require a supply of 88 to 132 Vac or 90 to 150 Vdc., 15 watts maximum. The ac supply may be 45 to 440 Hz.

If a battery is used for operating power, an alternator or other battery charging device is necessary to maintain a stable supply voltage.

CAUTION—BATTERY
To prevent damage to the control, make sure that the alternator or other battery-charging device is not connected to the control when the battery is disconnected from the control.

Location Considerations

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling
- Space for servicing and repair
- Protection from direct exposure to water or to a condensation-prone environment.
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference.
- Protection from excessive vibration.
- An ambient operating temperature range of –40 to +85 °C (–40 to +185 °F).

Do not mount the control on the engine.

Electrical Connections

External wiring connections and shielding requirements for a typical control installation are shown in the plant wiring diagram, Figures 2-3 and 2-4. These wiring connections and shielding requirements are explained in the balance of this chapter.

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 grounding terminal indicated in the plant wiring diagram. Keep grounding connections under 6 inches (15 cm) length. Refer to local wiring codes for proper grounding methods.

Wire exposed beyond the shield should be as short as possible, not exceeding 2 inches (5 cm). The other end of the shields must be left open and insulated from any other conductor. Do not run shielded signal wires with other wires carrying large currents. See Application Note 50532, *EMI Control for Electronic Governing Systems*, for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below and shown in Figure 2-2.

1. Strip outer insulation from both ends, exposing the braided or spiral wrapped shield. Do not cut the shield on the control end. Cut off the shield on the end away from the 2301A control.

2. Use a sharp, pointed tool to carefully spread the strands of the shield.

3. Pull the inner conductors out of the shield. Twist braided shields to prevent fraying.

4. Connect lugs to the shield and to the control wires. Number 6 slotted or round crimp-on terminals are used for most installations. Connect the wires to the appropriate terminals on the control.

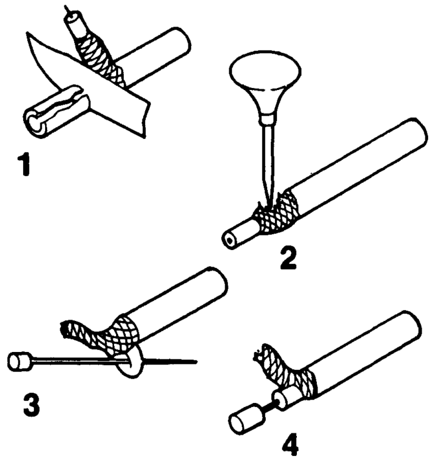


Figure 2-2. Preparation of Shielded Cables

Installations with severe electromagnetic interference (EMI) may require shielded wire run in conduit, double shielded wire, or other precautions. Contact Woodward for additional information.

Power Sensing And Load Sharing Connections

NOTE

The control is phase sensitive. If at all possible be certain of the phase A, B, and C locations before wiring the control. The method of correcting an incorrectly wired control is time consuming and can be avoided only by having the correct wiring of the three phases from the beginning.

Potential Transformer Connections

Connect the potential transformer secondary leads to the following terminals:

- Phase A to terminal 1
- Phase B to terminal 2
- Phase C to terminal 3

The potential transformer secondary line-to-line voltage must be in the 90 to 240 volt RMS range. Refer to the plant wiring diagram, Figures 2-3 and 2-4.

Current Transformer Connections

The standard method of connecting the current transformers is shown in the plant wiring diagram, Figure 2-3. An alternate method is the open delta connection shown in Figure 2-4 of the plant wiring diagram.

The current transformers should be sized to provide 5 amps secondary current when the generator is at full load. A minimum of 3 amps and a maximum of 7 amps secondary current is necessary for proper load sharing operation.

Droop Contact (Isoch-Droop) and Load Sharing Lines

Because the load-sharing-line relay is contained in the control, no relay is required between the control and the load-sharing-line bus. Use shielded cable and connect the load-sharing lines directly to terminals 10 (+) and 11 (–). Connect the shield to terminal 12. When all controls in the system are of the 2301A type, the shields may be connected continuously between the controls. When load sharing with different controls, do not connect the shields at the point where connections are made to the load-sharing-line bus.

The droop contact for selecting droop or isochronous operation is wired in series with the circuit-breaker auxiliary contact between terminal 14 and terminal 16 (terminal 0 on high-voltage controls). When both the droop contact and circuit-breaker auxiliary contact are closed, the control is in the isochronous load-sharing mode. In this mode the internal load-sharing-line relay is energized, the droop signal is disabled permitting isochronous load sharing, and the load-matching circuit is connected to the load-sharing lines.

The control is in the droop mode when EITHER the droop contact or the circuit-breaker auxiliary contact is open. If the droop contact is open, the control remains in the droop mode, even when the circuit-breaker auxiliary contact is closed.

NOTE

The control is in the droop mode whenever the circuit-breaker auxiliary contact is open. If a single prime mover is required to run isochronously with an isolated load, turn the DROOP potentiometer fully counterclockwise.

Droop operation is required when the generator is paralleled with an infinite bus without a Generator Loading Control, Process Import/Export Control, Automatic Power Transfer and Load Control or other load controlling accessory, or when paralleled with incompatible governors. (All Woodward electric load-sharing systems are compatible.) When running a single unit on an infinite bus with a Load controlling accessory, terminal 14 must be connected to terminal 16 (terminal 0 on high-voltage controls) to connect the Load Control Circuit to the load-sharing lines. The load-sharing lines must be wired to the load control accessory's output. The utility feeder's circuit-breaker auxiliary contact would be connected to the load-control accessory to activate it only when the utility is present. when the utility is lost, the generator is then controlled in the isochronous mode at the rated frequency, carrying the plant load (if within the generator capability).

Power Supply

Run the power leads directly from the power source to the control, connecting the negative lead to terminal 15, and the positive lead to terminal 16. If the power source is a battery, be sure the system includes an alternator or other battery-charging device.

WARNING—DO NOT APPLY POWER

Do NOT apply power to the control at this time. A powered up control could allow the prime mover to start before control functions are operational. This could allow a dangerous overspeed which can endanger life, even causing death and which can damage the physical equipment.

External Adjustments

External Speed Trim

A speed trim potentiometer or digital reference unit is connected to terminals 23 and 24. Use a high quality 100 ohm, 10-turn potentiometer (Woodward part 1657-537 or equivalent) to provide about ±5% speed adjustment. The wires to terminals 23 and 24 must be shielded. Connect the shield to terminal 22.

Terminals 23 and 24 must be jumpered if the speed trim potentiometer or digital reference unit is not used. The 2301A control will have a jumper installed in the factory and this must be removed if a speed-trim device is used.

Switch Options

Minimum Fuel Contact

The minimum-fuel contact between terminals 16 and 17 on the low-power models and 0 and 17 on the high-power models is intended as an optional means for a normal shutdown of the prime mover. The contact is connected as shown on the plant wiring diagram for the particular control. If a minimum fuel contact is not used, the terminals must be permanently jumpered.

WARNING—EMERGENCY STOP

Do NOT use the minimum-fuel contact as a part of any emergency stop sequence. The emergency may be caused by a governor malfunction which would also cause a malfunction of the minimum-fuel feature. Use of the minimum-fuel contact for an emergency stop sequence could cause overspeed of the prime mover and mechanical damage and personal injury, including death.

Failed Speed Signal Override

Circuits in the 2301A Speed Control constantly monitor the signal from the MPU. Should this signal be below a minimum threshold, the control sends a minimum fuel signal to the actuator (maximum fuel signal on a reverse acting control).

Before start-up of the prime mover, the speed signal is nonexistent, activating the failed speed signal circuit. On units with cranking motors, the cranking speed is usually sufficient to provide a speed signal, so an override contact is not needed for starting. On some steam turbine systems, the Close for Override of Failed Speed Signal contact must be closed to allow the actuator to open the valve for starting.

The failed speed-signal override switch should be a momentary switch so the failed-speed-sensor circuit will be enabled after start-up. (The failed speed-signal override should be left closed on reverse acting systems if auto transfer to the ballhead is required.)

Idle/Rated Ramp Contact

Connect a single-pole, single-throw switch between terminal 19 and terminal 16 (terminal 0 on high-voltage controls) as shown on the appropriate plant-wiring diagram. Close the contact for rated speed, open for idle. Oil pressure is often used to close this contact. When closed the control ramps up to rated speed. When the contact is open the prime mover's speed ramps down to idle.

When a ramp time potentiometer is full cw the ramp time from idle to rated or rated to idle is 22 ±4 seconds. When a ramp time potentiometer is fully ccw the ramp rate is less than 1 second from idle to rated or rated to idle.

Ramp times are adjusted by setting the RAMP TIME ACCEL and RAMP TIME DECEL potentiometers.

Actuator Output

The actuator wires connect to terminals 20 (+) and 21 (–). Use shielded wires with the shield connected to terminal 22. Do not connect the shield to the actuator or to any other point. The shield must have continuity the entire distance to the actuator and must be insulated from all other conductors.

NOTE

Electromagnetic Interference (EMI) can be an intermittent condition. Improperly shielded installations can provide good control for a while and then cause problems. For this reason it is important to be sure all shields are properly installed.

Speed and Phase Matching With an SPM-A Synchronizer

Connect the SPM-A (optional equipment) wires to terminals 25 (+/–) and 26 (com). Use shielded wire and connect the shield to terminal 27.

Speed Sensor

Connect a speed-sensing device (a magnetic pickup (MPU) is normally used) to terminals 28 and 29. No polarity is observed. Use shielded wire and connect the shield only at terminal 27. The shield must have continuity the entire distance to the MPU. The shield is to be insulated from all other conductors and from the MPU.

Dual Dynamic Contact

Connect a single-pole, single-throw switch from terminal 30 to terminal 31, the Close To Enable Second Dynamics Terminal.

For dual fuel applications, when switching from the primary fuel to the alternate fuel, the contact between terminals 30 and 31 should be closed at the time of the transfer.

In applications where the response time of the prime mover changes between no load and loaded conditions an auxiliary generator-breaker contact is often used.

Start Fuel Limit Disable Contact

Connect a single-pole, single-throw switch between terminals 31 and 32, the Close To Disable Start Fuel Limit Terminal (Optional).

An auxiliary generator breaker contact should be used if the Start-Fuel Limit Disable function is used. The auxiliary generator breaker will enable the START FUEL LIMIT during start up, but will disable it after the generator is on line.

For reverse acting controls that utilize the START FUEL LIMIT, the disable contact MUST be used. This will assure that in case of an electronic failure the mechanical ball head will not be prevented from controlling the engine.

Installation Checkout Procedure

When the installation is completed perform the following checkout procedure before beginning the start-up adjustments in Chapter 3.

1. Visual Inspection:
   a. Check the linkage between the actuator and the prime mover for looseness or binding. Refer to the appropriate actuator manual, and Manual 25070, *Electric Governor Installation Guide*, for additional information on linkage.

WARNING—MINIMUM FUEL POSITION
The actuator lever should be near, but not at, the minimum position when the fuel or steam rack is at the minimum position. This could avoid a dangerous condition caused by an engine which will not shut down.

   b. Check for correct wiring according the plant-wiring diagram. (Figures 2-3 and 2-3a.)
   c. Check for broken terminals and loose terminal screws. Make sure all terminal lugs are carefully and correctly installed. (Incorrectly installed crimp-on terminals can cause governor failure.)
   d. Check the speed sensor (MPU) for visible damage. Check the clearance between the gear and the sensor, and adjust if necessary. See Manual 82510, *Magnetic Pickups and Proximity Switches for Electronic Controls*.

2. Check for Grounds.

   With the power off, check for grounds by measuring the resistance between each terminal and the grounding bolt located below terminal 12. The readings should be infinity except for terminals 12, 22 and 27 (shields).

   Check for additional grounds by measuring the resistance from terminal 11 to terminal 15. The resistance should be infinity. If a resistance other than infinity is obtained, remove the connections from each terminal, one at a time, until the resistance is removed. d Check the line that was removed last to locate the fault.

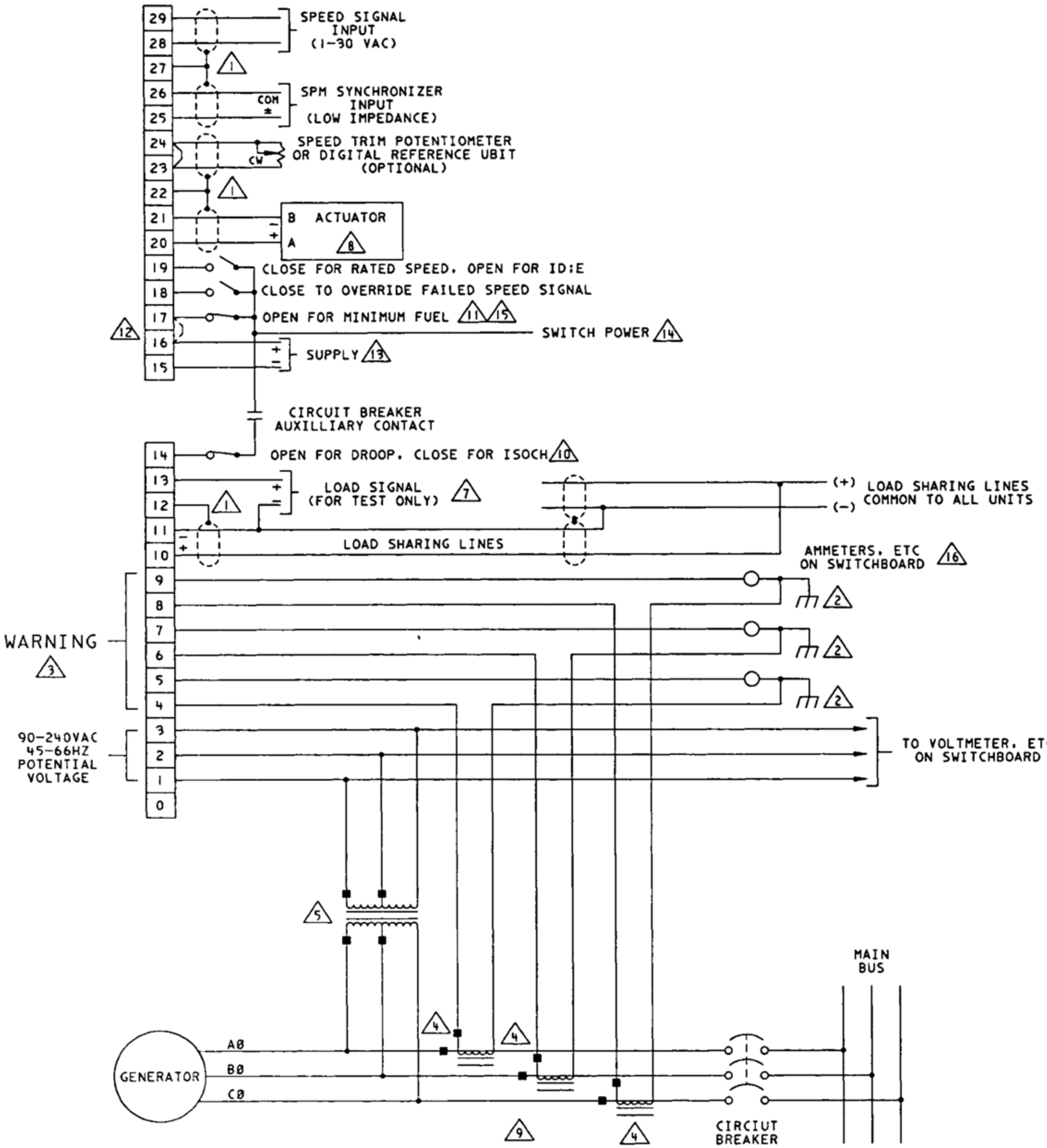
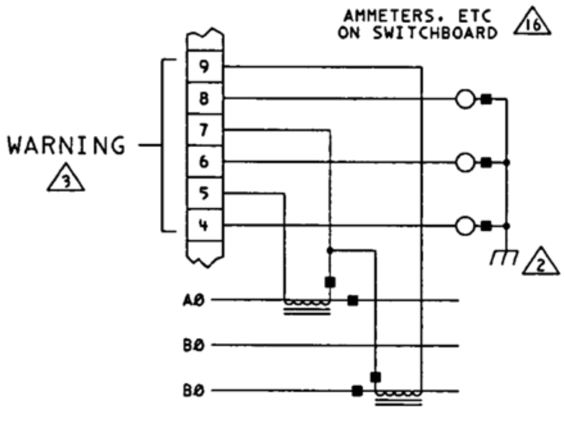
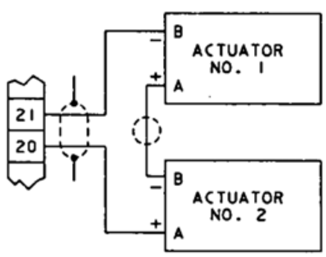


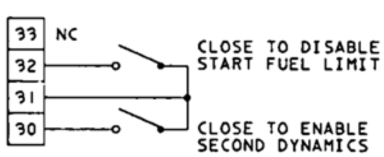
Figure 2-3. Plant Wiring Diagram



DETAIL "A"
OPTIONAL CURRENT
TRANSFORMER CONNECTION



DETAIL "B"
CONNECTION FOR SERIES
OR TANDEM OPERATION



1. SHIELDED WIRES TO BE TWISTED PAIRS, WITH SHIELD GROUNDED AT CONTROL END ONLY.
2. POINT OF GROUNDING IF REQUIRED BY WIRING CODE.
3. INTERNAL CURRENT TRANSFORMERS SHOULD BE CONNECTED ACROSS POWER SOURCE CURRENT TRANSFORMERS AT ALL TIMES, TO PREVENT LETHAL HIGH DOSES.
4. POWER SOURCE CURRENT TRANSFORMERS SHOULD BE SIZED TO PRODUCE 5A SECONDARY CURRENT WITH MAXIMUM GENERATOR CURRENT. CURRENT TRANSFORMER BURDEN IS LESS THAN 0.1VA PER PHASE.
5. WITH A BALANCED THREE PHASED LOAD AND UNITY POWER FACTOR, THE CURRENT TRANSFORMERS SHOULD BE WIRED IN THE CORRECT POTENTIAL LEG AND MUST BE PHASED AT THE CONTROL AS FOLLOWS:
   PHASE A: POTENTIAL TERMINAL 1, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 4 (■) TO 5.
   PHASE B: POTENTIAL TERMINAL 2, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 6 (■) TO 7.
   PHASE C: POTENTIAL TERMINAL 3, WITH RESPECT TO NEUTRAL, IN PHASE WITH CT TERMINALS 8 (■) TO 9.
6. REMOVE JUMPER BETWEEN TERMINALS 23 & 24, IF SPEED TRIM POTENTIOMETER OR DIGITAL REFERENCE UNIT IS USED. IF SPEED TRIM POTENTIOMETER IS USED, A HIGH QUALITY 100 OHM, 10 TURN, POTENTIOMETER SIMILAR TO W.G. CO. P/N 1657-537 IS RECOMMENDED. 100 OHMS WILL GIVE APPROXIMATELY ±5% SPEED ADJUSTMENT.
7. FOR ISOCH CONTROL, WITHOUT ISOCH/DROOP SWITCH, SET DROOP POTENTIOMETER MAX CCW AND REPLACE DROOP SWITCH WITH JUMPER. IF DROOP POTENTIOMETER IS NOT MAX CCW, CONTROL IS IN DROOP WHEN ISOCH/DROOP SWITCH OR CIRCUIT BREAKER AUXILLARY CONTACT IS OPEN.
8. FOR SERIES OR TANDEM OPERATION, SEE DETAIL "B".
9. FOR OPTIONAL CURRENT TRANSFORMER CONNECTION, SEE DETAIL "A".
10. CIRCUIT BREAKER AUXILLARY CONTACT CLOSES WHEN CIRCUIT BREAKER CLOSES.
11. WARNING
    DO NOT USE FOR EMERGENCY SHUTDOWN. THE PRIME MOVER SHOULD BE EQUIPPED WITH A SEPERATE OVERSPEED, OVERTEMPERATURE OR OVERPRESSURE SHUTDOWN DEVICE(S), TO PROTECT AGAINST RUNAWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.
12. REMOVE JUMPER IF MINIMUM FUEL SWITCH IS USED. JUMPER NOT PROVIDED ON CONTROLS SHIPPED BY WOODWARD GOVERNOR COMPANY FOR HIGH VOLTAGE SUPPLY.
13. SEE OPTION CHART.
14. FOR SWITCH POWER: ON LOW VOLTAGE UNITS, CONNECT TO TERMINAL 16.
    ON HIGH VOLTAGE UNITS, CONNECT TO TERMINAL 0.
15. IF MINIMUM FUEL SWITCH IS NOT USED: ON LOW VOLTAGE UNITS, JUMPER TERMINAL 16 TO 17.
    ON HIGH VOLTAGE UNITS, JUMPER TERMINAL 17 TO 0.
16. IF METERS ARE NOT USED, JPRS MUST BE INSTALLED IN CIRCUIT.

88–132 VAC OR 90–150 VDC	6446	8272–769
	6444	8272–767
20–45 VDC	6445	8272–768
	6443	8272–766
SUPPLY	TSP	ASSY NO

OPTION CHART

Figure 2-4. Plant Wiring Diagram and Optional Connections

SWITCH SELECT	HERTZ
1	500–1500
2	1000–3000
3	2000–6000
4	4000–12000

NOTE:

1. LOW VOLTAGE: 20–40 VDC
HIGH VOLTAGE: 88–130 VAC OR 90–150 VDC
2. SPEED RANGE:
(S1 SWITCH ON PCB ASSY)
3. JUMPER NOT INSTALLED ON CONTROLS SHIPPED FROM W.G. CO. FOR HIGH VOLTAGE SUPPLY.

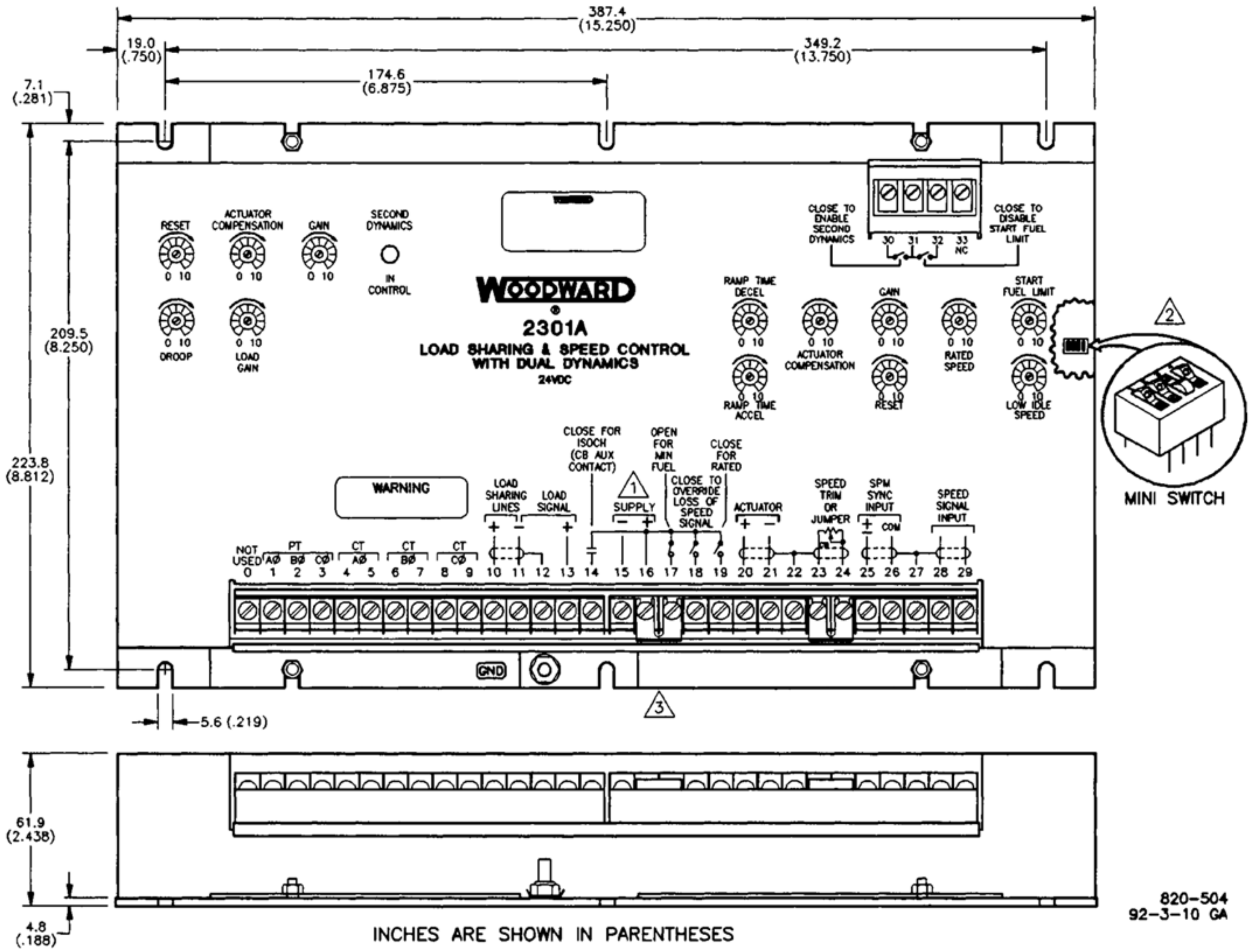


Figure 2-5. Outline Drawing of 2301A Speed Control With Dual Dynamics

Chapter 3.
Operation and Adjustment

Initial Pre-Start Settings

WARNING—OVERSPEED
Overspeed with resultant equipment damage, personal injury, or death is possible when setting up a control system. Read this entire procedure before starting the prime mover for the first time.

1. RATED SPEED

   a. Set the 10-turn RATED SPEED potentiometer to minimum (fully counterclockwise).

   b. Set the external SPEED TRIM, if used, to mid-position.

2. RESET 1--Set the 1-turn pot at mid-position.

3. RESET 2--Set the 1-turn pot at mid-position.

4. GAIN 1--Set the 1-turn pot at mid-position.

5. GAIN 2--Set the 1 turn pot at mid-position.

6. ACTUATOR COMPENSATION (both 1 and 2 are 1 turn pots).

   a. DIESEL, GAS TURBINE, FUEL-INJECTED GASOLINE PRIME MOVERS: Set the ACTUATOR COMPENSATION potentiometer at 2 on the 0 to 10 scale.

   b. CARBURETED GAS OR GASOLINE or STEAM TURBINE PRIME MOVERS: Set the ACTUATOR COMPENSATION potentiometer at 6 on the 0 to 10 scale.

7. ACCEL RAMP TIME--Set the 1-turn pot at maximum (fully clockwise).

8. DECEL RAMP TIME--Set the 1-turn pot at maximum (fully clockwise). (Set fully counterclockwise if deceleration time is not required.

9. LOW IDLE SPEED--Set the 10-turn pot at maximum (fully clockwise).

10. LOAD GAIN--Set the 1-turn pot at maximum (fully clockwise).

11. DROOP--Set the 1-turn pot at minimum (fully counterclockwise).

12. START FUEL LIMIT--Set the 1-turn pot at maximum (fully clockwise).

13. Be sure the actuator is connected to terminals 20 (+) and 21 (–).

14. Open the switch between terminals 30 and 31 to select first dynamics.

CAUTION—CHECK SPEED RANGE SWITCH
Be sure the speed range switch is set on the right speed range for your application as described in Chapter 2.

Start-up Adjustments

1. Complete the installation checkout procedure in Chapter 2, and the initial prestart settings above.

2. Close the Close for Rated contact. Set the control for isochronous operation by closing the droop contact.

NOTE

This is for initial prime mover start-up only. For normal start-up, the Close for Rated contact should be open if the prime mover is to start at idle.

3. Apply input power to the control.

4. Preset rated speed.

   If a signal generator is not used, set the RATED SPEED potentiometer at minimum (fully counterclockwise).

   If a signal generator is used, set the signal for the frequency of the speed sensor at rated speed, and connect it to terminals 28 and 29. (The rated speed frequency in Hz equals the rated engine speed in RPM times the number of teeth on the speed sensing gear, times the ratio of engine speed to speed-sensing-gear speed, divided by 60.) Put the Close For Rated contact in rated (closed) position. Set the speed trim potentiometer (if used) to mid-position. Connect a dc analog voltmeter to terminals 20 (+) and 21 (–) to read actuator voltage.

   If the actuator voltage is at minimum (about 0 volts for forward acting controls and above 6 Vdc for reverse acting controls) slowly turn the RATED SPEED potentiometer clockwise until the voltage just begins to move toward maximum for forward acting controls or towards 0 volts for reverse acting controls.

   If the actuator voltage is at maximum (about 6 volts for forward acting controls and about 0 Vdc for reverse acting controls), slowly turn the RATED SPEED potentiometer counterclockwise until the voltage just begins to move toward minimum for forward acting controls or towards maximum for reverse acting controls.

   Continue to very slowly adjust the RATED SPEED potentiometer in the appropriate direction, trying to stop the actuator voltage between the minimum and maximum voltages. Because it is not possible to stop the motion, cease adjusting when the voltage changes very slowly. The RATED SPEED potentiometer is now set very close to the desired speed. A slight adjustment when the engine is running will achieve the exact speed.

5. Check the speed sensor.

   Minimum voltage required from the speed sensor to operate the electronic control is 1.0 volts RMS, measured at cranking speed or the lowest controlling speed. For this test, measure the voltage while cranking, with the speed sensor connected to the control. Before cranking, 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 (2000 Hz x .05 = 100 Hz).

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.

6. Start the prime mover.

Adjust for Stable Operation

If prime-mover operation is stable, go to the "speed setting adjustment" procedure.

If the prime mover is hunting at a rapid rate, slowly decrease the GAIN for First Dynamics (turn the potentiometer counterclockwise) until performance is stable. Adjusting the GAIN may cause a momentary speed change which can be minimized by turning the GAIN potentiometer slowly.

If the prime mover is hunting at a slow rate, decrease the RESET setting of the First Dynamics (turn the potentiometer counterclockwise) until the prime mover stabilizes. If decreasing the RESET potentiometer setting does not stabilize the prime mover, it also may be necessary to either:

- Slowly increase the GAIN (turn the potentiometer clockwise) or
- Slowly increase the GAIN and decrease the ACTUATOR COMPENSATION of the First Dynamics.

Speed Setting Adjustment

With the prime mover operating stably, and the external speed trim potentiometer (if used) set at mid-position, adjust the RATED SPEED potentiometer to bring the prime mover to the desired operating speed.

Dynamic Adjustment

The object of the GAIN AND RESET potentiometer adjustments is to obtain the optimum, or desired, stable prime-mover-speed response.

NOTE
The following procedure MUST be repeated with the Second Dynamics when these dynamics will be used. THE SECOND DYNAMICS INDICATOR MUST BE ON BEFORE ADJUSTMENTS ARE MADE.

Connect a dc analog voltmeter to terminals 20 (+) and 21 (–) to monitor the actuator voltage.

NOTE
Adjusting the GAIN may cause momentary changes in speed which can be minimized by turning the GAIN potentiometer slowly.

Increasing the setting of the GAIN potentiometer provides faster transient response (decreases the magnitude of the speed change from a sudden change in load). To achieve optimum 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. Step load the generator, or bump the actuator terminal shaft, to make sure that the prime mover returns to the proper speed with little overshoot or undershoot of the speed setting. To reduce overshoot, increase the RESET setting (turn the potentiometer clockwise).

When the RESET potentiometer is in the lower part of its adjustment (0 to 3 on the scale), increasing the RESET clockwise may 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 RESET by turning the potentiometer counterclockwise.

Figure 3-1 illustrates prime mover starts with the RAMP TIME potentiometer fully counterclockwise (no ramp), step loadings at four different RESET potentiometer settings, and stable, steady-state running conditions. These are typical performance curves on a naturally aspirated (not turbocharged) diesel engine.

NOTE

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.

Actuator Compensation Adjustment

If the ACTUATOR COMPENSATION is set as described under INITIAL PRESTART SETTINGS, no further adjustment is normally required. If a slow, periodic instability remains, slightly decrease the ACTUATOR COMPENSATION (turn the potentiometer counterclockwise) and repeat the GAIN and RESET adjustments. Continue to decrease the ACTUATOR COMPENSATION and readjust the GAIN and RESET until stability is achieved.

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

Low Idle Speed Adjustment

1. The prime mover should be at rated speed with the LOW IDLE SPEED potentiometer set at maximum (fully clockwise). Open the external CLOSE FOR RATED contact.

2. Decrease the LOW IDLE SPEED (turn the potentiometer counterclockwise) until the recommended idle speed is reached.

   If the RATED SPEED setting is changed, LOW IDLE SPEED will also be changed and may require readjustment. Changing the LOW IDLE SPEED does not change the RATED SPEED setting.

NOTE
Make certain that the prime-mover speed is controlled by the LOW IDLE SPEED potentiometer in a range above the minimum-fuel position (mechanical stop) of the actuator or prime-mover fuel rack.

NOTE
Low Idle Speed can be set to a minimum of 15 ±3.5% of Rated Speed. (A rated speed of 5000 Hz can not be below 755 ±175 Hz at Low Idle. Low Idle may be set higher than rated speed if the feature is not desired.

Accel Ramp Time Adjustment

Adjust the RAMP TIME ACCEL potentiometer to achieve satisfactory prime mover acceleration from idle to rated speed with minimum overshoot. First start at the fully clockwise (maximum ramp time) position and work back in the counterclockwise direction until the unit ramps as rapidly as desired. (Ramp time will be adjustable from 1 to 22 seconds from idle to rated.)

Decel Ramp Time Adjustment

Adjust the RAMP TIME DECEL potentiometer to achieve satisfactory prime mover deceleration rate from rated to idle. First start at the fully clockwise (maximum ramp time) position and work back in the counterclockwise direction until the unit ramps down as rapidly as desired. (Ramp time will be adjustable from 1 to 22 seconds from rated to idle.)

NOTE
ACCEL and DECEL ramps are only in place at the time the CLOSE FOR RATED switch changes states. The ramps do not affect the response of the control at any other time (during load transients).

Start Fuel Limit Adjustment

NOTE
Start-fuel limit should be disabled after start-up when used with reverse-acting controls. With loss of speed signal, the reverse acting control will position the actuator at the start-fuel level if the failed-speed-signal override is activated. Reverse-acting systems normally require the control to demand full fuel on loss of speed signal to allow the mechanical backup governor to control the system. The Start Fuel Limit can be deactivated by an auxiliary generator breaker contact which will short terminal 31 to terminal 32. This CLOSE TO DISABLE START FUEL LIMIT contact will disable the start fuel limit after the prime mover has been started and put on line.

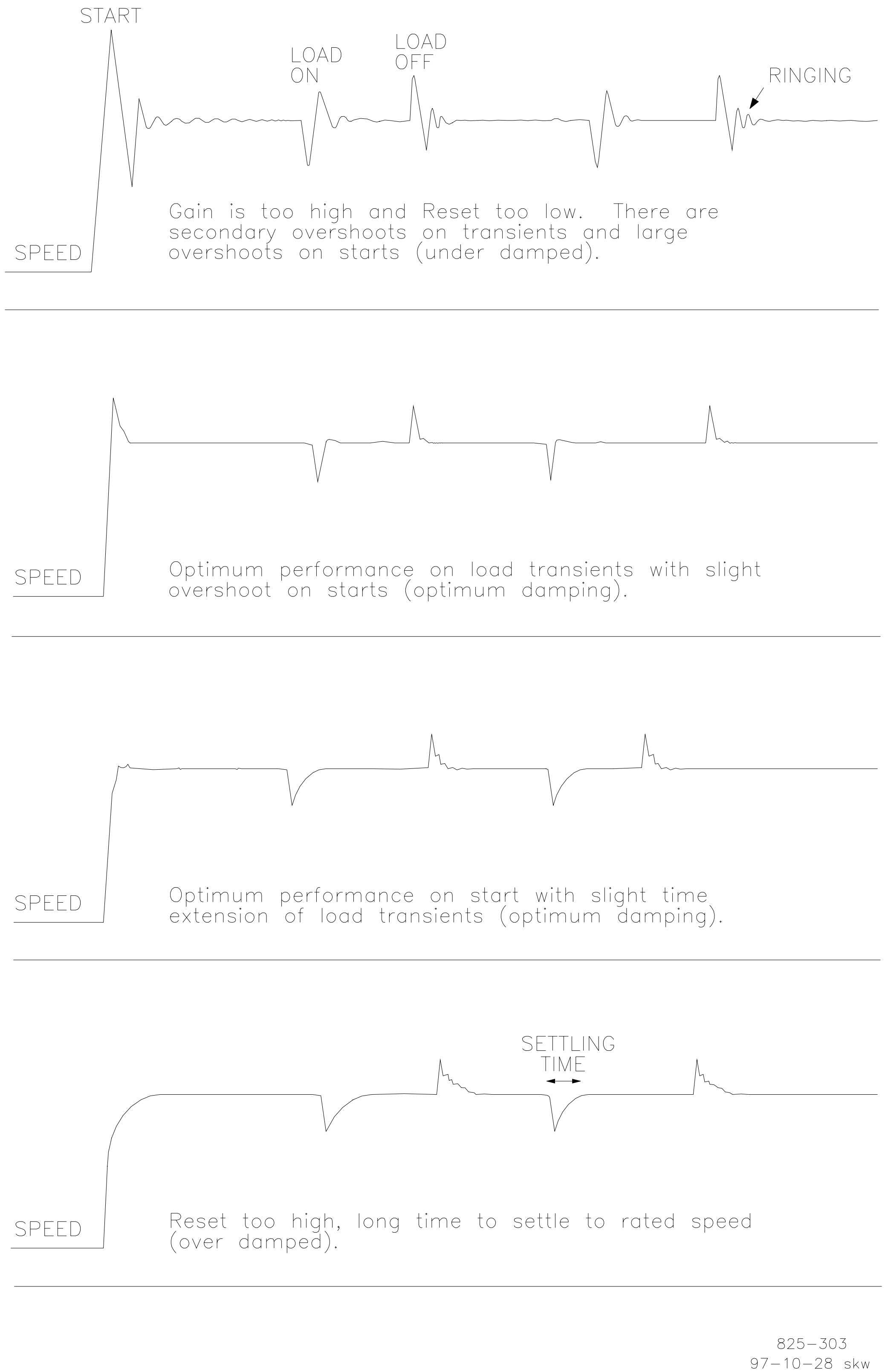


Figure 3-1. Diesel Engine Performance Curves

With the prime mover operating at rated speed and no load, record the voltage across the actuator terminals 20 (+) and 21 (–). Shut down the prime mover and activate the Failed Speed Signal Override by closing the override contact. The voltage to the actuator should now be adjustable by the START FUEL LIMIT potentiometer. Set the actuator voltage about 100 to 150% higher than the voltage obtained at rated speed for forward-acting controls and 100 to 150% lower than rated speed voltage for reverse-acting controls. Remove the Failed Speed Signal Override contact if not required to start the prime mover or to transfer control to the mechanical governor.

Start the prime mover and observe the start time, overshoot of speed setting, and exhaust smoke obtained. If the prime mover does not start, turn the START FUEL LIMIT potentiometer slightly clockwise until the prime mover starts. The START FUEL LIMIT may be adjusted as required to optimize the prime-mover starting characteristics. The fuel-limiting function is turned off automatically when the speed control takes over.

NOTE

For prime movers not requiring start-fuel limiting, the START FUEL LIMIT function can be deactivated by turning the potentiometer fully clockwise or by jumpering terminals 31 to 32.

Speed Sensor Check

If the sensor is a magnetic pickup, measure the voltage across terminals 28 and 29 to be sure there is a minimum of 1.0 volts at cranking speed, and a maximum of 30 volts RMS at rated speed. If the voltage exceeds 30 volts, increase the air gap of the speed sensor and be sure that there is still a minimum of 1.0 volts at cranking speed.

Current Transformer (CT) Phasing Check

NOTE

This control contains internal current transformers. Due to their low impedance, shorting their inputs is not effective. The current input must be removed from the control and shorted externally.

WARNING—HIGH VOLTAGE

Never disconnect any wire attached to load sensor terminals 4 through 9 when the prime mover is running unless temporary 1 ohm, 5 watt resistors are installed as shown in Figure 3-2, and all load is removed. The current transformers can develop dangerously high voltages when open circuited while the prime mover is running.

1. Connect a dc voltmeter to control terminals 11 (–) and 13 (+) to measure the load signal.

2. Start the prime mover. With the generator operating in the isochronous mode and not paralleled, load the generator to as near to full load as possible. Measure the load-signal voltage.

3. Unload and shutdown the prime mover. Disconnect the wire from terminal 5 and connect both wires from phase A CT to terminal 4.

4. Start the prime mover, apply full load (or the same load as obtained in step 2) and again measure the load signal at terminals 11 and 13. If the load-signal voltage is not 1/3 lower that the reading obtained in step 2, the phasing is not correct. Unload and shut down the prime mover. Reconnect phase A CT wire from terminal 4 to terminal 5, maintaining the original polarity.

5. If the phasing is incorrect, proceed to the Phase Correction Procedure.

6. If the phasing appears correct, skip the phase correction procedure and go to the Load Gain Adjustment procedure.

NOTE
If, after completing the LOAD GAIN and DROOP adjustments, the control loading is extremely sensitive to changes in the power factor when operating in parallel, complete the phase-correction procedure.

Phase Correction Procedure

NOTE
This procedure requires a minimum power factor of (.9). If a (.9) power factor cannot be obtained, tracing through the wiring is the only means of correcting the current-transformer phasing.

The highest positive voltage will be obtained when the CTs are correctly matched to the load-sensor terminals in both phase and polarity. The following procedure will assure the correct connection of the current transformers. It is required only if the phasing check indicates incorrect phasing, or loading stability is extremely sensitive to the power factor.

Trial connections of the first CT to all three load-sensor inputs, polarized both ways, are made (a total of six connections). The load-signal voltage is recorded for each connection and the first CT is then connected to the terminals that produce the highest positive voltage, and with the polarity that produces the highest positive voltage.

The second CT is tried on each of the remaining two CT input terminals, in each polarity, and the voltage recorded. The second CT is then connected to the terminals with the polarity that produces the highest positive voltage.

The last CT is then tried on the remaining input terminals, polarized both ways, and the voltage recorded. Connecting the last CT in the polarity that produces the highest voltage completes the procedure.

The Phase Correction Procedure requires that the prime mover be shut down many times to disconnect the current transformers. For convenience, a temporary method of connecting the current transformers, shown in Figure 3-2, is recommended. Connecting a 1 ohm, 5 watt burden resistor across each current transformer allows the current transformers to be disconnected from the terminal strip with the prime mover running, after removing all load.

WARNING/HIGH VOLTAGE
The current transformers can develop dangerously high voltages. Do not disconnect a current transformer while the prime mover is running, unless temporary 1 ohm, 5 watt resistors are installed as shown in Figure 3-2, and all load is removed.

If the temporary burden resistors described above and shown in Figure 3-2 are not used, the prime mover MUST be shut down in addition to removing the load in the following procedure.

Measure the load-signal voltage in this procedure by connecting a voltmeter across the Load Signal terminals 11 (–) and 13 (+).

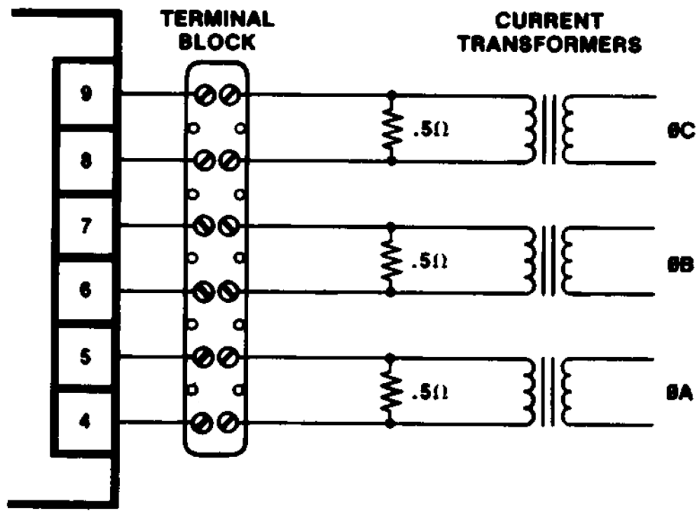


Figure 3-2. Temporary Wiring for Transformer Phase Correction

1. Shut down the prime mover.

2. Label each CT wire with the phase and polarity that you think it should be. Even though this identification may prove to be incorrect, this step is necessary to the individual wire may be identified during the description of the procedure.

3. Disconnect the phase B CT wires from terminals 6 and 7. Connect these two wires together, using a small screw and nut. Tape the connection.

4. Disconnect the phase C CT wires from terminals 8 and 9. Connect and tape these two wires together as in step 3.

5. Connect the two wires from the phase A CT to the phase A input terminals 4 and 5.

6. Start the prime mover, apply full load, and measure the load signal voltage. Start a list and record this voltage.

7. Unload the system and reverse the phase A CT wires on terminals 4 and 5.*

8. Apply full load, measure the load signal, and record this voltage.

9. Unload the system, remove phase A CT wires from terminals 4 and 5 and connect them to phase B input terminals 6 and 7.*

10. Apply full load, measure the load signal, and record this voltage.

11. Unload the system and reverse the phase A CT wires on terminals 6 and 7.*

12. Apply full load, measure the load signal, and record this voltage.

13. Unload the system, remove phase A CT wires from terminals 6 and 7, and connect them to phase C input terminals 8 x 9.*

14. Apply full load, measure the load signal, and record this voltage.

15. Unload the system, reverse the phase A CT wires on terminals 8 and 9*

16. Apply full load, measure the load signal, and record this voltage.

17. Unload the system and compare the six voltage readings.*

18. Remove the phase A CT wires from terminal 8 and 9 and connect the phase A wires to the pair of terminals that produced the highest positive load-signal voltage and in the polarity that produced the highest positive load-signal voltage.

19. Untape and disconnect the phase B CT wires. Connect the phase B CT wires to one pair of the two remaining pairs of CT input terminals on the load sensor.

20. Apply full load and measure the load signal. Start a new list and record this voltage.

21. Unload the system, and reverse the phase B CT wires on the same terminals.*

22. Apply full load, measure the load signal, and record this voltage.

23. Unload the system, remove phase B CT wires and connect them to the other pair of terminals.*

24. Apply full load, measure the load signal, and record this voltage.

25. Unload the system, and reverse the phase B CT wires on the same terminals.*

26. Apply full load, measure the load signal, and record this voltage. Compare the four voltages on the list.

27. Unload the system. Remove the phase B CT wires and connect them to the pair of CT input terminals that produced the highest positive load signal voltage and with the polarity that produced the highest positive load signal.*

28. Untape and disconnect the phase C CT wires. Connect these two wires to the remaining pair of CT input terminals.

29. Apply full load, measure the load signal, and record this voltage.

30. Unload the system and reverse the phase C CT wires on the same terminals.*

31. Apply full load, measure the load signal and record this voltage.

32. Unload and shut down the system. Compare the two voltages.

33. Connect the phase C CT wires to the same pair of CT input terminals, but in the polarity that produced the highest positive load-signal voltage.

34. Label each wire with the phase designation of the terminal to which it is now connected. Remove any inaccurate phase labels.

35. Remove the burden resistors and terminal block.

* Be sure to shut down the prime mover if the temporary burden resistors are not used.

Load Gain Adjustment

For this procedure, the generator must be running isochronously and not paralleled. Connect a dc voltmeter across terminals 11 (–) and 13 (+) to measure the load-signal voltage.

Start the prime mover and apply full load. Measure the load-signal voltage and adjust the LOAD GAIN potentiometer for 6.0 volts.* If full load is not obtainable, decrease the LOAD GAIN proportionally to the load. For example, at 50% load, adjust the LOAD GAIN to 3 volts.

When paralleled in the isochronous mode, generator speeds must be the same. If they are not equal, load sharing will not remain proportional as the load varies. Any difference in loads between the units can be corrected by adjusting the Load Gain Potentiometer. Increasing the LOAD GAIN (turning the potentiometer clockwise) will cause that generator to carry less load, If stability problems occur when paralleled at a particular load signal voltage, reduce the voltage by reducing the LOAD GAIN (turn the potentiometer counterclockwise), and reduce the load-signal voltage setting of all other generators in the system at the same voltage. When the load-signal voltages of all generators in a system are reduced, the load-sharing gain will be reduced and this may result in some loss of load-sharing sensitivity.

* If 6 volts at full load (or a lower voltage proportional to a load less than 100%) cannot be obtained, and the phasing has been checked and is correct, the current transformers are probably the wrong size. The current-transformer output must be from 3 to 7 amps (5 amps nominal) at full load.

It may be necessary to reduce the load-signal voltage of each unit in the system to as low as 3 volts in cases of extremely poor system dynamics. If your system requires a load-signal voltage as low at 3 volts, consult Woodward Governor Company for suggestions for possible remedies.

Droop Adjustment

The amount of droop is not critical in many installations. If the engine needs to run in droop but the amount is not critical set the droop potentiometer in mid-position, then adjust load with the speed-setting potentiometer.

When paralleled with an infinite bus, the generator frequency cannot change and the control must be in droop (or isochronous load sharing with and auxiliary load control) to maintain stable operation. With the droop potentiometer at mid-position, parallel the generator, then increase the Rated Speed potentiometer until the desired amount of load on the engine is achieved.

Too much droop will cause the engine to overspeed should the load be suddenly lost. Excessive droop will also cause the engine to be sluggish in response to load changes.

Too little droop will cause instability, similar to that experienced with improperly adjusted GAIN and RESET.

Units running against an isolated bus often need droop set to a particular level, to prevent excessive off speed when load changes. Droop is usually expressed as a percentage and calculated by the following formula:

$$\% \text{ Droop} = \frac{\text{No Load Speed} - \text{Full Load Speed}}{\text{No Load Speed}} \times 100$$

To set a specified amount of droop using an isolated bus for the load:

1. Open the droop contact connected to terminal 14.

2. Start the prime mover and adjust the RATED SPEED potentiometer for rated speed with no load.

3. Apply full load.*

4. Adjust the droop potentiometers to give desired speed.

5. Remove the load and repeat steps 2 through 4 until engine speed returns to 60 Hz when the load is removed.

   Example: Operating at 60 Hz, 57 Hz at full load indicates 5% droop.

   *If only 50% loading is possible, 58.5 Hz would indicate 5% droop. See Figure 3-3.

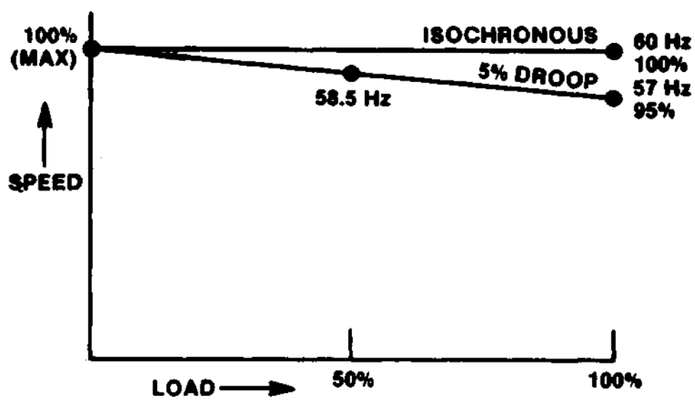


Figure 3-3. Droop Adjustment

Setting Droop and Load Gain, using an Infinite Bus for Load

To set a specified amount of droop on an infinite bus load:

1. With the generator not paralleled, adjust the RATED SPEED potentiometer to give a speed setting above 60 Hz by the percentage of droop required.

   Example: Droop of 5% would require raising the speed to 63 Hz.

2. Mark the potentiometer position and re-adjust the RATED SPEED potentiometer for 60 Hz.

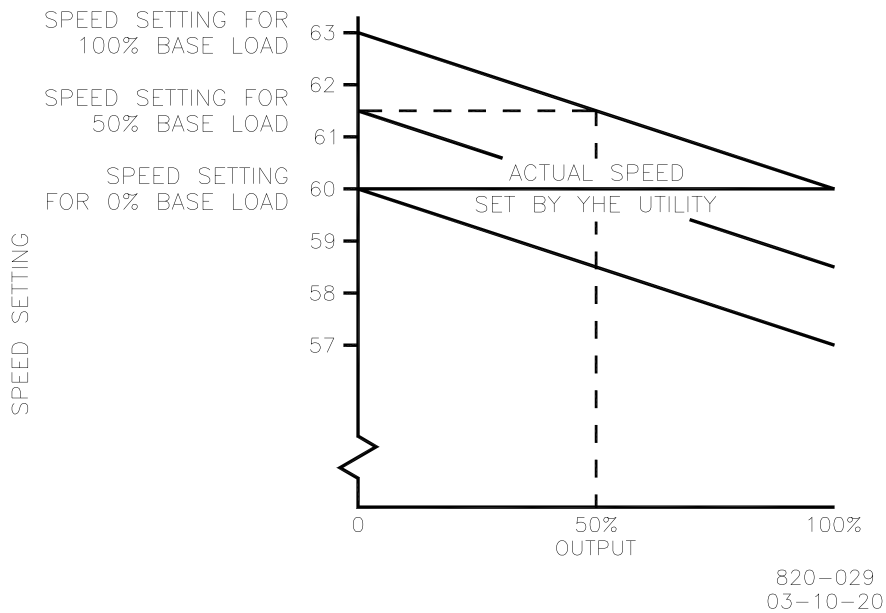


Figure 3-4. Droop Base Load with 5% Droop

3. Turn the DROOP and LOAD GAIN potentiometers full cw for maximum droop and load gain.

4. Open the droop contact connected to terminal 14.

5. Synchronize the generator with the bus and close the tie-breaker.

6. Return the RATED SPEED potentiometer to the mark made in step 2.

7. Load the generator by turning the droop potentiometer counterclockwise until 6 Vdc is measured on LOAD SIGNAL terminals 13 (+) and 11 (–).*

8. Adjust the LOAD GAIN potentiometer counterclockwise, decreasing load gain until 100% load is achieved.

9. Unload the generator by turning the RATED SPEED potentiometer ccw until no load is achieved.

10. Open the tie-breaker and repeat steps 1 though 8 until no further adjustment of the external droop is required in step 7.

* If it is necessary to set the droop with less than full load, set the RATED SPEED potentiometer in step 1 accordingly, for the desired percentage of droop.

Example: At 5% droop, running at only 50% load, the RATED SPEED potentiometer would be set at 61.5 Hz in step 1.

Chapter 4.
Description of Operation

Introduction

The 2301A Load Sharing and Speed Control monitors and controls:

Speed: The speed control section keeps the prime mover at the correct speed, and

Load Sharing: During parallel operation of two or more generators the load-sharing section senses the load carried by its generator and causes the load of all generators in the system to be shared proportionally or

Droop: During parallel operation with dissimilar governors and/or with an infinite bus, the load-sensor section senses the load carried by its generator and causes it to carry the appropriate amount of load as set by the droop, load gain, and speed reference.

Dual Dynamics

Dual Dynamics provide different RESET, GAIN, and ACTUATOR COMPENSATION settings for different responses which the engine or turbine may exhibit under different conditions.

The dynamics are selectable by a switch or contact input into the control. When the switch or contact is closed, as indicated by the SECOND DYNAMICS IN CONTROL LIGHT, the RESET, GAIN, and ACTUATOR COMPENSATION potentiometers located in the upper left-hand side of the control are activated. (See Figure 4-1.)

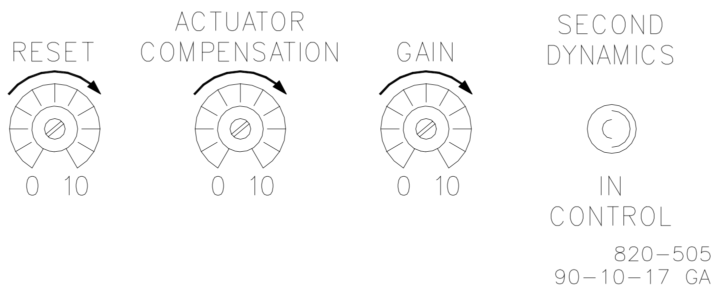


Figure 4-1. Second Dynamics Adjustments

When the switch or contact is open the green LED is off and the first set of dynamics is in operation, responding to the settings made to the RESET, GAIN, and ACTUATOR COMPENSATION potentiometers on the right-hand side of the electrical control box.

Speed Control

The system, as shown in Figure 4-2, consists of:

1. A magnetic pickup (MPU), to sense the speed of the prime mover.

2. A frequency to voltage converter, to convert MPU frequency to a voltage for use in the 2301A internal circuits.

3. A speed reference to which the prime mover speed is compared. (Idle and Rated speed references are provided by the 2301A. The speed reference being used is selected by the operator with an external switch.)

4. A speed summer/amplifier with an output proportional to the amount of fuel or steam required to maintain the reference speed at any given load.

5. An actuator to position the fuel or steam mechanism (injector rack or steam valve) of the prime mover.

6. Selectable dynamics, to change from one preset dynamics to another, with a switch or contact closure, The choice of two sets of dynamics allows optimum engine performance under different response conditions.

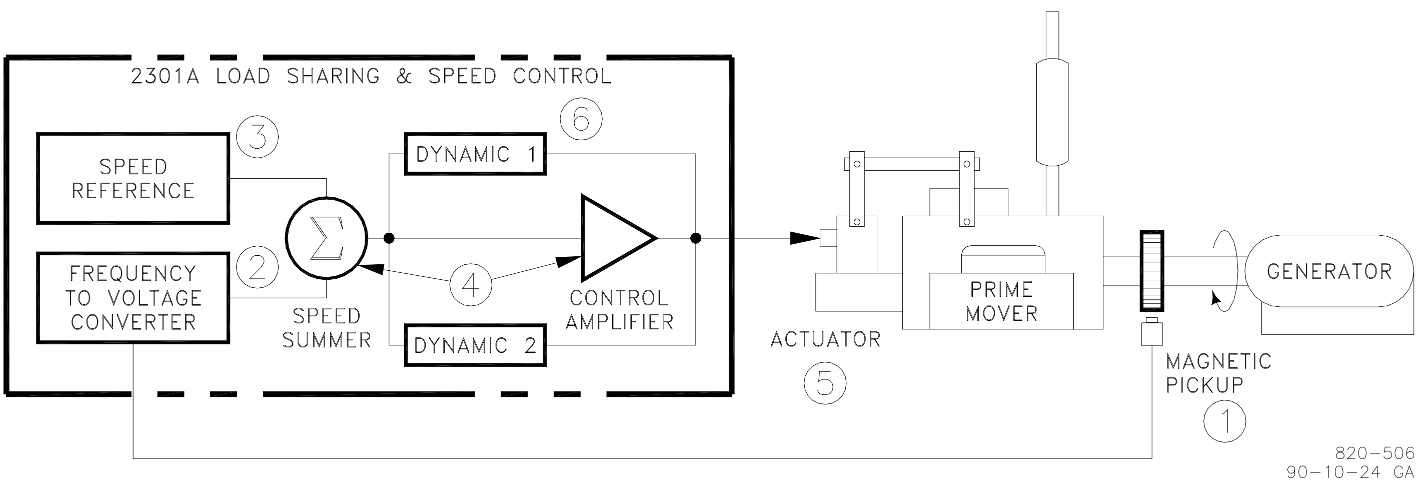


Figure 4-2. Speed Control System

The MPU generates an ac signal with a frequency proportional to speed.

The frequency-to-voltage converter receives the MPU frequency signal and changes it to a proportional dc voltage.

The speed-reference circuit generates a dc reference voltage to which the speed- signal voltage is compared.

The speed-signal voltage is compared to the reference voltage at the summing point. If the speed-signal voltage is lower or higher than the reference voltage, a signal is sent by the control amplifier calling for an increase or decrease in speed. The actuator is controlled by this signal, repositioning the fuel valve or rack and thus changing the speed of the prime mover until the speed-signal voltage and the reference voltage are equal.

Failed Speed Signal Circuit

A failed-speed-signal circuit monitors the speed-signal input. When no signal is detected, it calls for minimum fuel. The minimum-fuel signal is sufficient to cause the actuator to go to the minimum position. Incorrect linkage adjustments or other restrictions in the external system may prevent shutdown.

For controls with actuator current of 20 to 160 mA, minimum fuel is defined as:
- Actuator current of less than 10 mA for forward-acting controls.
- Actuator current greater than 180 mA for reverse-acting controls.

For controls with actuator current of 40 to 320 mA, minimum fuel is defined as:
- Actuator current of less than 20 mA for forward acting controls.
- Actuator current of more than 360 mA for reverse-acting controls.

A contact to override the failed-speed-signal circuit can be connected in series with terminal 18 and low voltage dc power. (This power is available on terminal 16 for units supplied with 20 to 40 Vdc power and from terminal 0 on those units supplied with about 120 V ac or dc power.) (Closing the contact overrides the failed-speed-signal circuit.)

The control must be tuned to each system for optimum performance. The potentiometers for setting and adjusting these circuits are located in the right center of the control as shown in Figure 4-3. They include:
- The RATED SPEED potentiometer is for the desired operating speed.
- The LOW IDLE potentiometer, adjusted so the reference voltage is correct for the desired idle speed.
- The START FUEL LIMIT potentiometer to provide a means of limiting the fuel-rack position when starting diesel engines. Adjustment of the potentiometer sets the maximum actuator position from no speed until the speed control calls for a fuel setting lower than the setting of the start-fuel limit. The limit is automatically reactivated in the circuit whenever the speed monitor input declines below the Failed Speed Signal level. Setting the Start Fuel Limit potentiometer full cw will raise the limit above the maximum fuel position, making the limit non-effective.
- RESET, GAIN, and ACTUATOR COMPENSATION potentiometers adjust the control amplifier to accommodate various types of prime-movers. Reset adjustment affects reaction time when recovering after a sudden load change. The magnitude of the speed correction resulting from a sudden change in load is controlled by adjusting the Gain potentiometer. Actuator Compensation compensates for the time the actuator and prime-mover system take to react to signals from the control.
- The ACCEL and DECEL RAMP TIME potentiometer sets the time required for the prime mover to accelerate from idle to rated speed or from rated to idle.

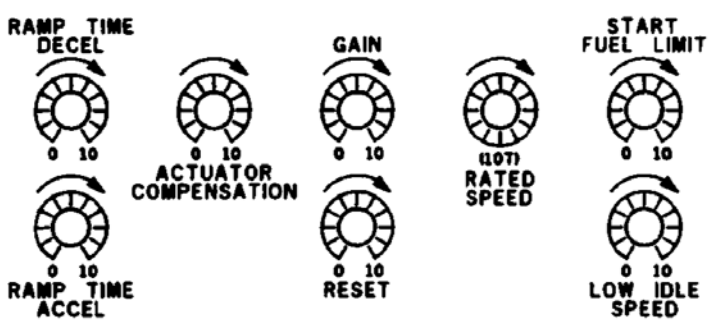


Figure 4-3. Speed Control Adjustments

Acceleration Ramp

The time the control takes to go from idle speed to rated speed (when the IDLE/RATED contacts are closed) can be varied from 0 to about 20 seconds by adjusting the ACCEL RAMP TIME potentiometer.

Deceleration Ramp

The time the control takes to go from rated speed to idle speed (when the IDLE/RATED contacts are open) can be varied from 0 to about 20 seconds by adjusting the DECEL RAMP TIME potentiometer.

Terminals for External Devices

Terminals for the Second Dynamics Circuit and the Start Fuel Limit Disable Circuit are at the upper-right front panel of the control (See Figure 2-3). Additional terminals are included for connecting other external devices as shown in Figure 4-6.

NOTE

Speed Trim settings change at 10% of the existing reference per volt. The Auxiliary input causes a 3% speed change per volt. The Synchronizer input causes a 0.666% change of reference speed per volt.

Actuator Circuit Protection

The speed control is protected from shorts or overloads in the actuator circuit at terminals 20 and 21 by a current limiter to prevent damage to the control and actuator.

Reverse Acting Controls

The reverse-acting 2301A Control and its actuator are designed so that zero voltage to the actuator corresponds to maximum fuel to the prime mover. The actuator usually used with a reverse-acting control has a mechanical governing mechanism included (see Figure 4-4). The speed setting of this mechanical governor is slightly higher than the speed setting of the 2301A. Should the electronics fail, the actuator will try to go to maximum fuel but will be stopped when it gets to the speed setting of the mechanical governor, providing continued operation of the prime mover, although at a speed which is slightly higher than the electronic control speed reference.

NOTE

Start-fuel limit should be disabled after start up when used with reverse-acting controls. With loss of speed signal, the reverse acting control will position the actuator at the start-fuel level if the failed-speed-signal override is activated. Reverse-acting systems normally require the control to demand full fuel on loss of speed signal to allow the mechanical backup governor to control the system. The Start Fuel Limit can be deactivated by an auxiliary generator-breaker contact, which will short terminal 31 to 32. This CLOSE TO DISABLE START FUEL LIMIT contact will disable the start-fuel limit after the p[rime mover has been started and put on line.

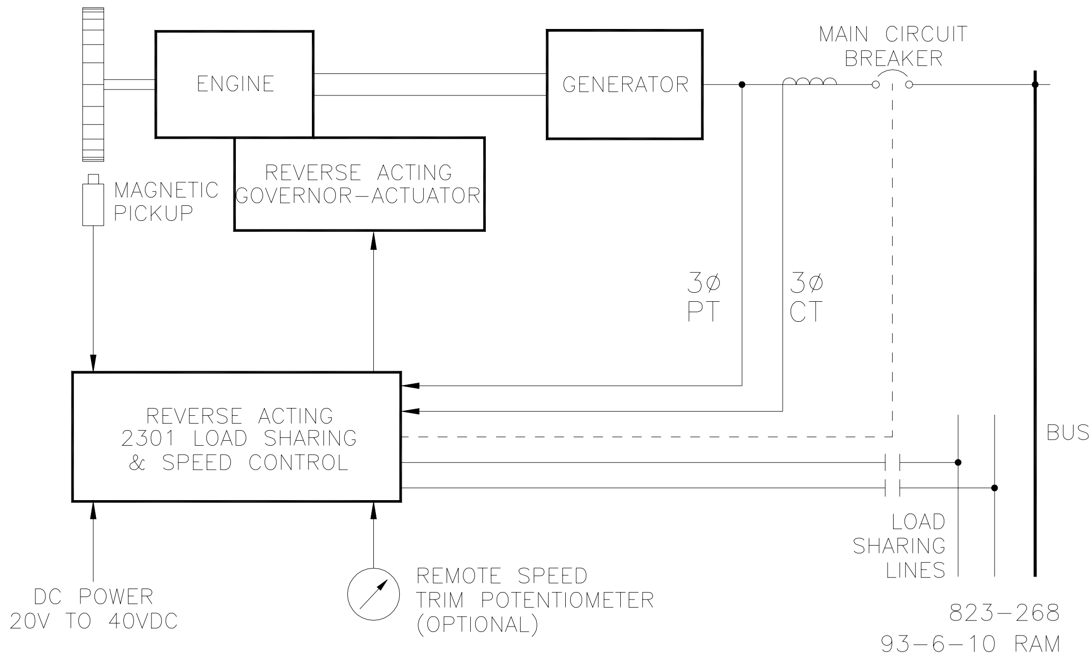


Figure 4-4. Reverse Acting System

Paralleling

Two basic methods are used for paralleling: droop, where speed reference decreases with load, and isochronous, where speed reference remains constant. The paralleling system shown in Figure 4-5 consists of:

- A Load Matching circuit (1)
- A Load Amplifier circuit (2)

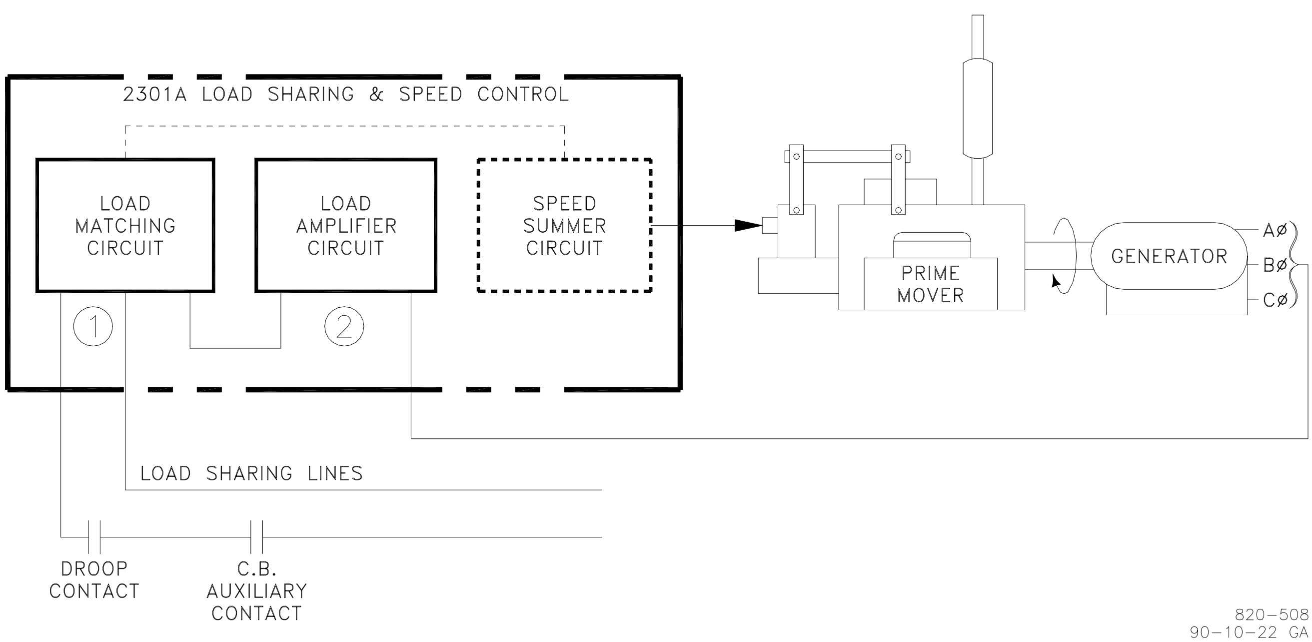


Figure 4-5. Paralleling System

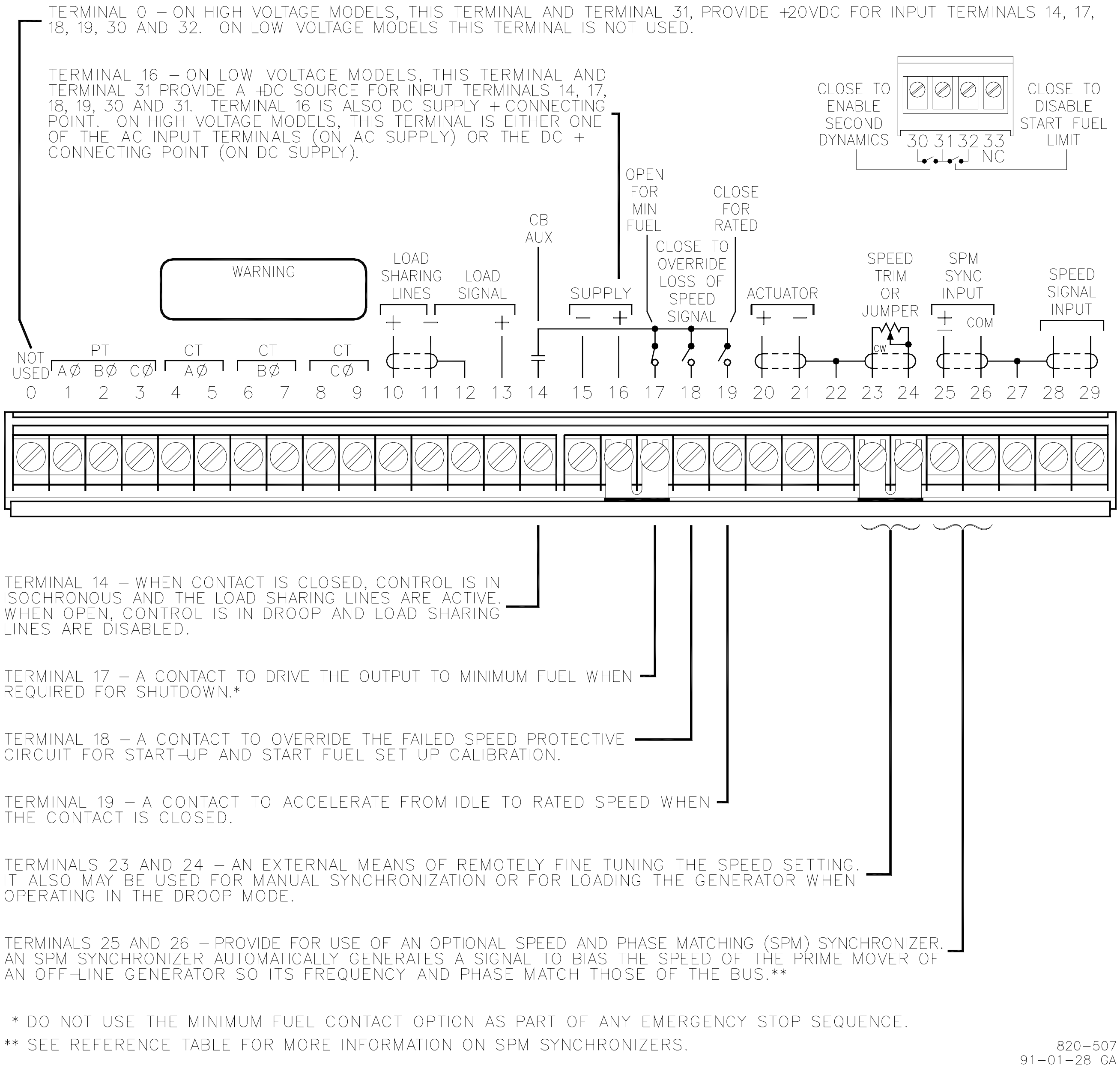


Figure 4-6. Terminal Connections

An auxiliary contact on the generator tie-breaker connected from terminal 16 (terminal 0 on high voltage systems) to terminal 14 is used to select isochronous load-sharing operation. A contact in series with the auxiliary contact may be used to select either the droop or isochronous mode of operation (see Figure 4-6).

If either the auxiliary contact or the droop contact is open, the control is in droop and the load sharing lines are disabled. When they are both closed the control is in isochronous load sharing and the load sharing lines are active.

With only one unit on line, the generator picks up the available load and remains at the isochronous speed. If additional units are on line, the Load Matching circuit corrects the fuel output to proportion load.

An amplifier in the load-sensing circuit computes the load carried by each phase of the generator. The current load on each phase is multiplied by the cosine of the phase difference between the current and the voltage, and the three phases are added to determine the total load.

The output of the load amplifier is adjusted by the LOAD GAIN potentiometer shown in Figure 4-7. By setting the load-gain voltage on each unit to the same level at full load, proportional load sharing is achieved. Regardless of difference in generator-set capacities in the system, each generator set is loaded to the same percentage of its capacity. A final adjustment of the individual LOAD GAIN potentiometers will compensate for minor differences in the generator sets.

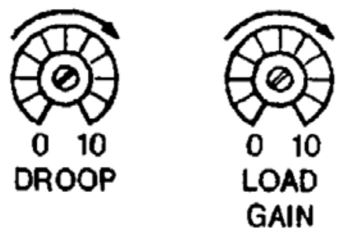


Figure 4-7. Paralleling Adjustments

As mentioned in the general information chapter, droop mode allows operation of a generator on an infinite bus or in parallel with other engine generator units using hydromechanical governors. In droop, speed reference is biased and changes as the load on the generator changes. An increase in load results in a decrease in speed reference due to this bias. The amount of speed reference change or droop is expressed in percent, and is set by the DROOP potentiometer shown in Figure 4-7.

Power Supply

The 2301A Load Sharing and Speed Control is powered by an isolated switching power supply, which allows operation over a wide voltage range without generating excessive heat. This isolation protects the system from interference caused by ground loops, particularly through the load-sharing line, and allows load sharing with earlier models of Woodward load-sharing controls.

Chapter 5.
Troubleshooting

The following trouble-shooting guide is an aid in isolating trouble to the control box, actuator, plant wiring, or elsewhere. The guide assumes that the system wiring, soldering connections, switch and relay contacts, and input and output connections are correct and in good working order. Make the checks in the order indicated.

NOTE

The wrong voltage can damage the control. When replacing a control, check the power supply, battery, etc., for the correct voltage as indicated on the name tag on the control. Both high-voltage and low- voltage models of 2301A controls are available. The low-voltage model will be damaged if connected to a high-voltage supply. The high-voltage model will not operate with a low-voltage supply.

Symptom	Cause	Remedy
Prime mover will not start. Actuator not moving to start-fuel position.	DC supply voltage polarity reversed, no supply voltage, or supply voltage is low.	Check for supply voltage within limits indicated on control name tag. Reverse leads if dc polarity is incorrect.
	Actuator not responding to input signal from control. **NOTE** Hydraulic actuators must have oil pressure and either gear rotation or oil motor rotation to operate.	If there is a voltage at terminals 20 (+) and 21 (–), but the actuator does not move, check the wiring to the actuator for opens or shorts. With the EG3P actuator, remember that terminals C and D of the mating plug must be jumpered. Coil resistance in a Woodward actuator, with terminals 20 and 21 disconnected, is about 35 ohms.
	Start fuel limit set too low.	Turn start fuel limit cw until prime mover starts.
	Mechanical problems.	Check actuator and linkage for proper installation and operation. Problems may be oil supply, direction of rotation, insufficient drainage, linkage, worn actuator components, or improper adjustment.
	No actuator voltage at terminals 20 and 21 while cranking. Check to make sure that the "Open for Min Fuel" contact is closed: <20 Vdc on 17 (+) and 11 (–).	Stop cranking. Check for shorted or grounded actuator leads by removing wires to terminals 20 and 21. Close terminal 18, short terminal 23 to 24. Check for 18 to 22 volts at terminals 20 and 21 for forward acting controls and 0 to 1 volts for reverse acting controls. While cranking, check for at least 1 V RMS at terminals 28 and 29, and at least 5% of the lower value of the control's frequency range. If these readings are not available close terminal 18 to override failed-speed signal while cranking. MPU sensor spaced too far from gear. Make sure there are no metal chips on end of pickup.
	Speed setting too low on initial start.	Control may be set for the wrong speed range. Check speed sensor frequency versus speed range switch. Speed setting may be lower than cranking speed. Control should be set for rated speed. Increase RATED SPEED setting clockwise (cw). **WARNING—RESTORE RATED SPEED** **Be sure and return rated speed setting full ccw if adjusting cw does not produce the correct output.**
	LOW IDLE SPEED setting may be too low.	Adjust LOW IDLE SPEED potentiometer cw.

Symptom	Cause	Remedy
Prime mover will not start. Actuator not moving to start-fuel position (cont.).	Minimum Fuel contact open. See "MINIMUM FUEL CONTACT" in Chapter 2. If voltage exceeds 3 volts, the switch or wiring is faulty.	Check switch at terminal 17. Minimum-fuel contact must be closed for normal operation. Check for 0 to 3 Vdc from terminal 17 (+) to 15 (–) on low-voltage controls. (Between terminals 17 (+) and 0 (–) on high-voltage controls.
	MPU not supplying signal to control.	Check MPU wiring for proper connection, check shields for proper installation. Check MPU resistance with the leads disconnected from the control. Resistance should be about 100 to 300 ohms.
	Terminals 23 and 24 are open.	Verify that terminals 23 and 24 are jumpered if optional external speed trim is not used. If speed trim is used check the voltage from terminal 23 (+) to 24 (–). It should be less than 2 volts.
	Faulty speed trim potentiometer.	With power OFF, check speed-trim potentiometer with an ohmmeter.
	Faulty 2301A Control.	Replace unit.
Prime mover overspeeds only on starts.	Ramp adjustment.	Increase RAMP TIME (cw). This decreases acceleration rate (from low idle to rated.)
	RATED SPEED setting too high.	Set RATED SPEED as described in Chapter 3.
	Amplifier adjustment.	2301A may be adjusted for sluggish operation, causing overspeed on start. Slowly adjust GAIN for fastest stable response. RESET may be adjusted too low. Increase RESET setting.
	Incorrect Dynamics Selected.	Check switch position on terminals 30-31. Selection of Slow Dynamics can cause startup overspeed. (See Chapter 2.)
	Engine is malfunctioning.	Verify that the fuel rack is not binding and the linkage is properly adjusted. Determine if the fuel rack is quickly following the actuator input voltage. Verify proper operation of overspeed protection devices to determine if a shutdown is occurring without an overspeed condition.
	2301A Speed Control.	If the control does not cut back the actuator voltage when the speed setting is completely ccw the 2301A control may be faulty, or may have the wrong speed range. If the voltage is cut back, (increased on reverse acting controls) look for a problem in the linkage or actuator.
Prime mover overspeeds after operating at rated speed for some time.	Prime mover.	Check for proper operation of prime-mover fuel system. If actuator moves toward minimum fuel during overspeed, problem is in fuel system.
	MPU and 2301A control.	Check MPU voltage at speeds above idle (at least 1.0 Vrms). If MPU fails and the switch at terminal 18 is closed, the 2301A will call for maximum fuel.
	2301A dynamics adjustment.	Control the prime mover manually at rated speed and adjust the RATED SPEED setting fully ccw. If the output voltage is not zero, for forward acting controls check the speed range selection. If this is correct, replace the unit. (Voltage should be about 7 volts for 0-200 mA reverse acting controls or maximum current times actuator resis-tance for controls of other ratings.)
Prime mover has momentary speed change when adjusting GAIN.	GAIN adjustment made too quickly.	Make GAIN adjustment slowly. Momentary speed change when adjusting GAIN is normal.

Symptom	Cause	Remedy
Low speed is not regulated by LOW IDLE SPEED potentiometer.	Low idle speed setting. **NOTE** On carbureted prime movers, the minimum fuel stop rpm setting will vary with prime mover temperature. An improper cold setting may interfere with the Low Idle Speed Setting when the prime mover is hot.	The Low Idle Speed setting may be below the min-fuel position of the actuator or prime-mover fuel stop. In this case, the output voltage to the actuator will be zero (greater than 6 Vdc for reverse acting controls). The conditions indicate that the min-fuel position should be decreased by linkage adjustment (diesel) or low-idle set screw (gas engine), or the LOW IDLE SPEED setting should be raised. If this does not correct the problem, the 2301A control may be faulty.
	LOW IDLE SPEED potentiometer.	If adjustment of the LOW IDLE SPEED potentiometer causes erratic behavior, replace the control.
Prime mover does not decelerate when Close for Rated contact is open.	Faulty Close for Rated contact or wiring.	The voltage from terminals 11 (–) to 19 (+) must be less than 2 volts. Replace the contact or wiring as necessary.
	LOW IDLE SPEED set fully cw.	Turn LOW IDLE SPEED setting ccw with terminal 19 open.
	301A ramp circuitry. **WARNING—OVERSPEED** **The speed-setting controls have sufficient range to override the ramp and bring the prime-mover speed up to rated while still in the low-idle mode (because of control or switching defect). A Close for Rated contact that is intermittent may cause the prime mover to overspeed if the RATED SPEED setting is adjusted for rated speed with terminal 19 open.**	A faulty Close for Rated contact may remain in the rated or closed position with the switch open. If the Close for Rated contact is operative, loss of idle control may be due to a faulty circuit. In general, adjustment of LOW IDLE SPEED will vary the speed of the prime mover with the Close for Rated contact in the decelerate (open) position. Adjustment of LOW IDLE SPEED should not affect prime mover speed when the Close of Rated contact is closed.
Prime mover will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic.	2301A Speed Control.	Adjust GAIN, RESET, and ACTUATOR COMPENSATION as described in "Adjust for Stable Operation" and "Dynamic Adjustment" in Chapter 3. Be sure the correct dynamics are selected.
	Speed setting controls.	If adjustment of external speed trim causes instability, check potentiometer with ohmmeter for erratic behavior. (Turn power off). Use non-lubricating electrical cleaner if necessary. If internal potentiometer is faulty, replace control.
	Improper linkage adjustment.	Make sure the actuator moves about 2/3 of its travel from no load to full load. Be sure linkage provides a proportional change in power for every change in actuator terminal-shaft position. Refer to the actuator manual for more detailed linkage instructions.
	Necessary wires not properly shielded.	Electrical noise, caused by wiring carrying an ac voltage or stray magnetic fields, can be picked up by improperly shielded wire. Noise will cause instability. See "Shielding" in Chapter 2.
Prime Mover will not stabilize.	Prime mover not receiving fuel as called for by the actuator.	Check actuator linkage to fuel-controlling mechanism for lost motion, binding, or excessive loading. Check for a steady fuel pressure of proper value.
	Prime mover not operating properly.	Prime mover may be causing speed variations. Control engine manually to determine if instability is in prime mover or governor/actuator control.
	Input voltage low.	Check voltage supply.
Prime mover unstable or will not accept full load.	EGB governor/actuator.	Verify that mechanical speed setting of EGB governor/actuator is above the set electronic speed reference at full load. Mechanical droop can cause speed setting of ballhead governor to be below electronic speed setting at full load.

Chapter 6.
Service Options

Product Service Options

The following factory options are available for servicing Woodward equipment, based on the standard Woodward Product and Service Warranty (5-01-1205) that is in effect at the time the product is purchased from Woodward or the service is performed:

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

If you are experiencing problems with installation or unsatisfactory performance of an installed system, the following options are available:

- Consult the troubleshooting guide in the manual.
- Contact Woodward technical assistance (see "How to Contact Woodward" later in this chapter) and discuss your problem. In most cases, your problem can be resolved over the phone. If not, you can select which course of action you wish to pursue based on the available services listed in this section.

Replacement/Exchange

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

This option allows you to call 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 Woodward facility as explained below (see "Returning Equipment for Repair" later in this chapter).

Charges for the Replacement/Exchange service are based on a flat rate plus shipping expenses. You are invoiced the flat rate replacement/exchange charge plus a core charge at the time the replacement unit is shipped. If the core (field unit) is returned to Woodward within 60 days, Woodward will issue a credit for the core charge. [The core charge is the average difference between the flat rate replacement/exchange charge and the current list price of a new unit.]

Return Shipment Authorization Label. To ensure prompt receipt of the core, and avoid additional charges, the package must be properly marked. A return authorization label is included with every Replacement/Exchange unit that leaves Woodward. The core should be repackaged and the return authorization label affixed to the outside of the package. Without the authorization label, receipt of the returned core could be delayed and cause additional charges to be applied.

Flat Rate Repair

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

Flat Rate Remanufacture

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

Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned to Woodward for repair, please contact Woodward in advance to obtain a Return Authorization Number. When shipping the item(s), attach a tag with the following information:

- 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.

CAUTION—ELECTROSTATIC DISCHARGE

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*.

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.

Return Authorization Number

When returning equipment to Woodward, please telephone and ask for the Customer Service Department [1 (800) 523-2831 in North America or +1 (970) 482-5811]. They will help expedite the processing of your order through our distributors or local service facility. To expedite the repair process, contact Woodward in advance to obtain a Return Authorization Number, and arrange for issue of a purchase order for the item(s) to be repaired. No work can be started until a purchase order is received.

NOTE

We highly recommend that you make arrangement in advance for return shipments. Contact a Woodward customer service representative at 1 (800) 523-2831 in North America or +1 (970) 482-5811 for instructions and for a Return Authorization Number.

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.

How to Contact Woodward

In North America use the following address when shipping or corresponding:

Woodward Governor Company
PO Box 1519
1000 East Drake Rd
Fort Collins CO 80522-1519, USA

Telephone—+1 (970) 482-5811 (24 hours a day)
Toll-free Phone (in North America)—1 (800) 523-2831
Fax—+1 (970) 498-3058

For assistance outside North America, call one of the following international Woodward facilities to obtain the address and phone number of the facility nearest your location where you will be able to get information and service.

Facility	Phone Number
Brazil	+55 (19) 3708 4800
India	+91 (129) 230 7111
Japan	+81 (476) 93-4661
The Netherlands	+31 (23) 5661111

You can also contact the Woodward Customer Service Department or consult our worldwide directory on Woodward's website (**www.woodward.com**) for the name of your nearest Woodward distributor or service facility.

Engineering Services

Woodward Industrial Controls Engineering Services offers the following after-sales support for Woodward products. For these services, you can contact us by telephone, by email, or through the Woodward website.

- Technical Support
- Product Training
- Field Service

Contact information:
Telephone—+1 (970) 482-5811
Toll-free Phone (in North America)—1 (800) 523-2831
Email—icinfo@woodward.com
Website—**www.woodward.com**

Technical Support is available through our many worldwide locations or our authorized distributors, depending upon the product. This service can assist you with technical questions or problem solving during normal business hours. Emergency assistance is also available during non-business hours by phoning our toll-free number and stating the urgency of your problem. For technical support, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Technical Support***.

Product Training is available at many of our worldwide locations (standard classes). We also offer customized classes, which can be tailored to your needs and can be held at one of our locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability. For information concerning training, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Product Training***.

Field Service engineering on-site support is available, depending on the product and location, from one of our many worldwide locations or from one of our authorized 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 field service engineering assistance, please contact us via telephone, email us, or use our website and reference ***Customer Services*** and then ***Technical Support***.

Technical Assistance

If you need to telephone for technical assistance, you will need to provide the following information. Please write it down here before phoning:

General

Your Name____

Site Location______________________________________

Phone Number_____________________________________

Fax Number_______________________________________

Prime Mover Information

Engine/Turbine Model Number_________________________

Manufacturer______________________________________

Number of Cylinders (if applicable)____________________

Type of Fuel (gas, gaseous, steam, etc)_________________

Rating____

Application_______________________________________

Control/Governor Information

Please list all Woodward governors, actuators, and electronic controls in your system:

Woodward Part Number and Revision Letter

____

Control Description or Governor Type

____

Serial Number ____________________________

Woodward Part Number and Revision Letter

____

Control Description or Governor Type

____

Serial Number ____________________________

Woodward Part Number and Revision Letter

____

Control Description or Governor Type

____

Serial Number ____________________________

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 include the manual number from the front cover of this publication.

WOODWARD

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

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

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

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