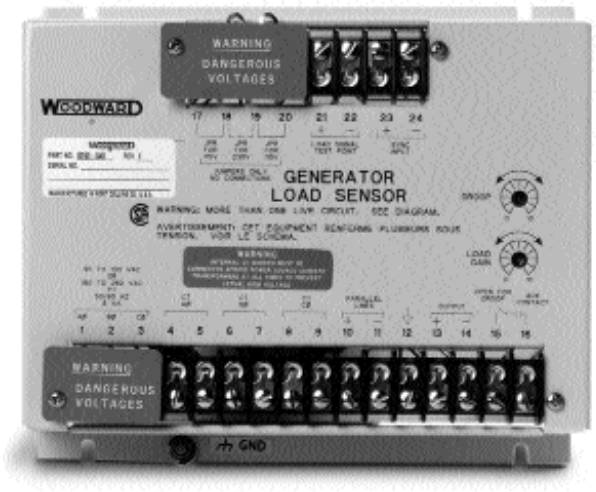
WOODWARD

Product Manual 82313
(Revision F)
Original Instructions



Generator Load Sensor

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 Out-of-date translations are marked with ⚠.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.

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

Description

The Generator Load Sensor provides isochronous and droop load-sharing capability for the Woodward 701, EPG and 2301A electronic speed controls and electrically powered governors in generator set applications. Additional equipment in the control system with the Load Sensor can include the Woodward SPM-A Synchronizer, Paralleling Phase Switch, Process and Import Export Control, and Precision Frequency Control. Figure 1-1 shows a typical system using a Generator Load Sensor.

Additional Information

The literature listed here contains information on the 8290-048, Generator Load Sensor and associated equipment. These publications are available on the Woodward website (www.woodward.com).

Publication	
82493	EPG 512/524 & 1712/1724 Electrically Powered Governor
82384	SPM-A Synchronizer
82461	Paralleling Phase Switch
82010	Process and Import Export Control

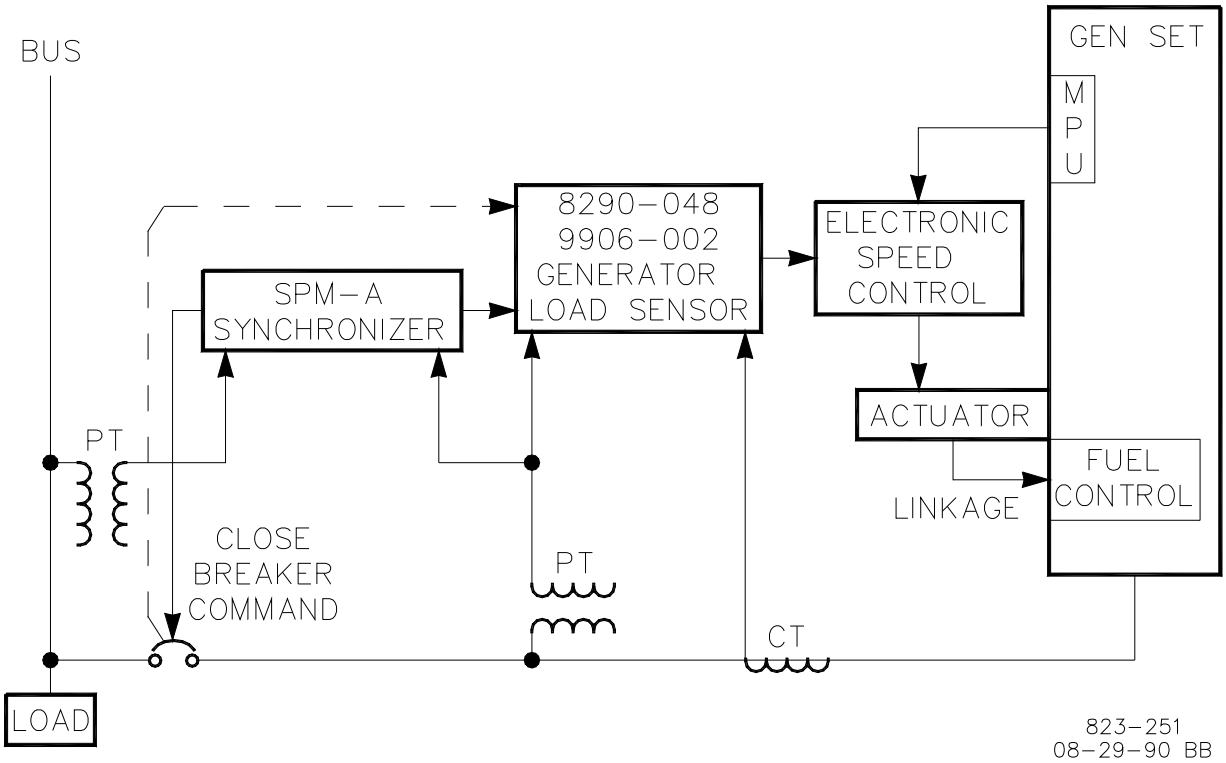


Figure 1-1. Typical System Using a Generator Load Sensor

Chapter 2.
Theory of Operation

Introduction

The Generator Load Sensor senses the power output of a generator and, through paralleling lines which connect all the generator sets in the system, permits isochronous load-sharing between these generator sets. The Load Sensor also provides droop operation, instead of isochronous load-sharing, making it possible to connect this generator set in the droop mode, in parallel with either a generator set which is running isochronously, or with a bus.

Power Supply

The power supply generates a regulated dc voltage for the operation of the circuits in the Load Sensor. The power supply gets its power from two of the three phase-potential connections which are made to the output of the generator set being controlled. Jumper wires on terminals 17 through 20 provide for selection of input voltages of either 95 to 130 Vac or 190 to 260 Vac. The plant wiring diagram (Figure 3-3) shows these connections and jumpers. Do not connect inputs to Terminals 17 through 20.

Power Sensor

Generator kilowatt load is measured by the power sensor circuit of the Load Sensor. The power sensor circuit senses both current amplitude, and phase between voltage and current, of the generator output. The potential input comes from the potential transformer(s) (PT) and the current input comes from the current transformer (CTs). The circuit uses these two inputs to generate a load signal which is then filtered and sent to the controller circuit. The load signal voltage of each generator set will be proportional to the load on that generator set.

Controller Circuit

In the controller circuit, the load signal voltage is adjusted to match the other generator sets in the system. The load signal voltages, at full load, of all generator sets in the system must be equal. The controller circuit of each Load Sensor includes a potentiometer to adjust each generator set’s load signal so that the load signal voltage of each is the same at full load.

Isochronous Load Sharing

The controller circuit compares the voltage on the paralleling lines to the load signal voltage for this generator set and generates an error voltage. This error voltage goes through the summing point and the output terminals of the Load Sensor to the speed control. The Load Sensor output biases the speed loop of the speed control so that the fuel is increased or decreased in order to keep the load signal voltage of this generator set equal to the voltage on the paralleling lines, while not changing the common frequency of the generator sets.

Droop Operation

In droop operation, a portion of the output voltage of the Load Sensor is fed back to the controller circuit; this voltage is proportional to the load sensed. This voltage is used by the controller circuit to reduce the output voltage of the controller circuit by a percentage determined by the DROOP potentiometer. Load Sensor output is reduced, and actuator shaft position is changed according to the desired droop percentage.

When a generator set using the Generator Load Sensor is paralleled in droop with other generator sets, the common load signal on the paralleling lines is not used. The frequency of the generator set could, therefore, vary with load, so it must be determined by a different means. In an isolated system with two or more generator sets paralleled, if isochronous speed control is required, one of the generator sets must be running in the isochronous mode; this generator set determines the frequency of the system. If this generator set is in droop and is paralleled with an infinite bus, either by itself or with other generator sets, the bus determines the frequency. The DROOP potentiometer and the SPEED potentiometer on the speed control determine the amount of the load that is carried by the generator (when running in droop).

If an SPM-A Synchronizer is used with the system, it biases the output of the Load Sensor at the summing point, in order to synchronize the generator set with the bus.

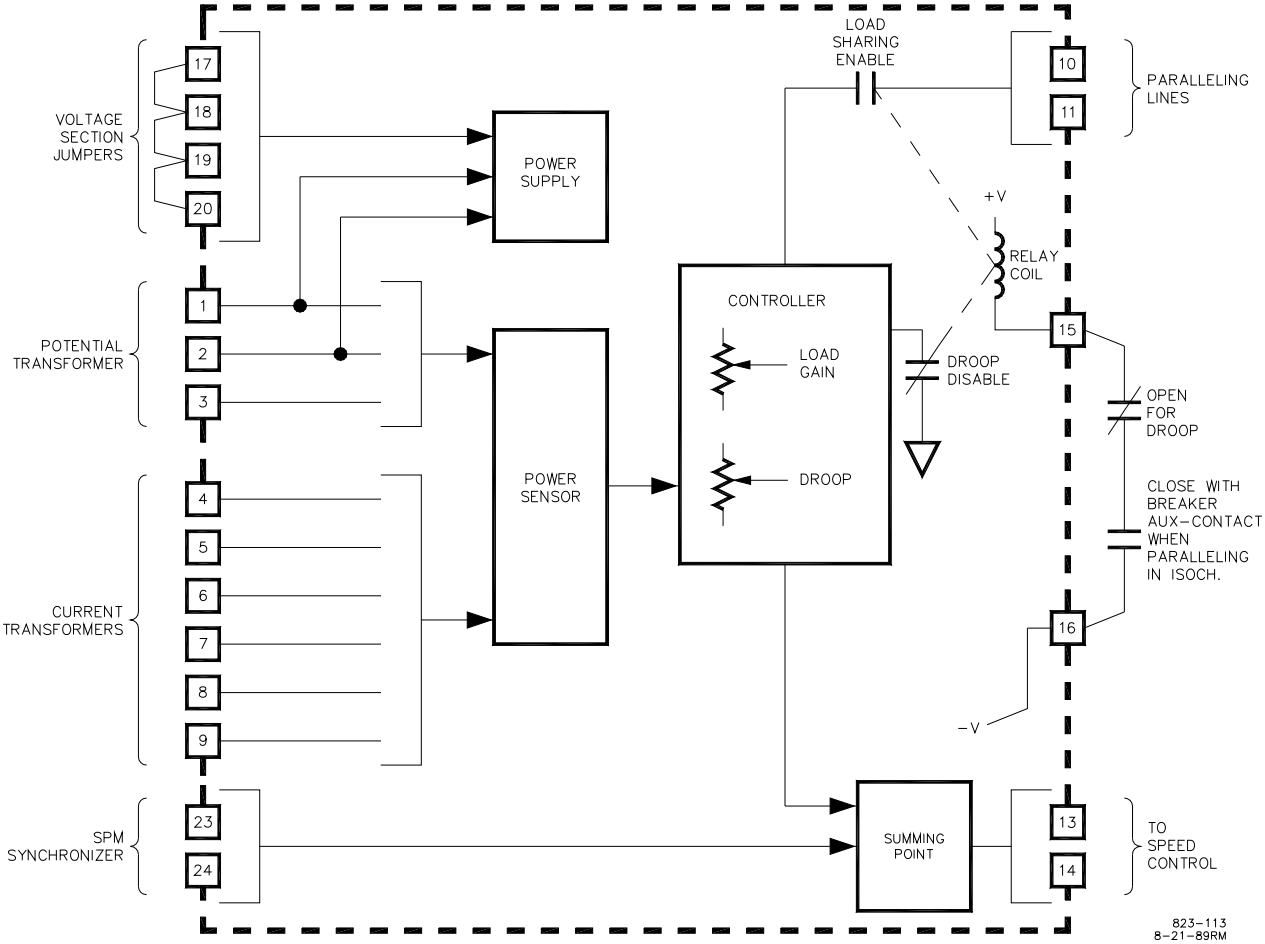


Figure 2-1. Block Diagram

Chapter 3. Installation

Mounting

Figure 3-2 is an outline drawing of the Generator Load Sensor. Mount the unit near the electronic speed control. It may be mounted in any position. Provide adequate ventilation for cooling and space for installation and servicing. Ambient temperature must be between –40 and +75 °C (–40 and +167 °F).

Electrical Wiring

Figure 3-3 is the plant wiring diagram for the Generator Load Sensor. This drawing shows the connections that must be made to this unit, but does not show the actual wiring for a particular system. For this information, see the plant wiring diagram for your specific system. Woodward manual 25070, *Electronic Governor Installation Guide*, also contains general information on wiring for electronic controls.

Some of the wiring to the Load Sensor must be twisted-pair, shielded; these wires are shown in Figure 3-3. This shielding prevents the wires from picking up stray signals which could cause erratic control operation. Ground the shield to the system ground as shown in the plant wiring diagram (Pin 12 or Pin 22 on this (control). The shield on a length of shielded wire must be connected to ground at one end only; do not ground the shields on both ends of a wire. Do not run a shielded wire inside a conduit with a wire which is carrying high current. Do not attempt to tin the braided shields.

Make all wiring connections with insulated terminals.

Power Supply

There are no separate power connections to the Load Sensor; the unit takes its power from the potential transformer connections.

Output

Connect the wiring between the output of the Load Sensor and the auxiliary input of the speed control. Use twisted- pair, shielded wire.

Current Transformers (CTs)

Connect the wiring from the current transformers as shown in the plant wiring diagram. This shows normal current sensing connection using three CTs. Figure 3-1 shows Open Delta Connection, an alternate method of current sensing using only two CTs.

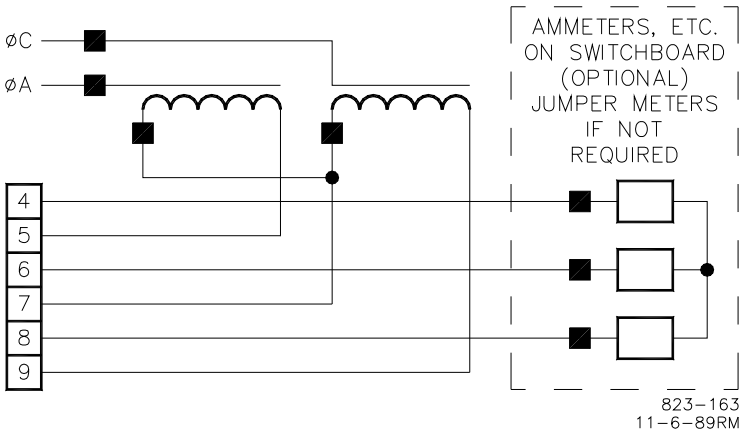


Figure 3-1. Open Delta Connection

Potential Transformer (PT)

Connect the wiring from the potential transformer (or transformers) as shown in the plant wiring diagram.

Droop Contacts

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.

The droop contact for selecting droop or isochronous operation is wired in series with the circuit-breaker auxiliary contact to terminal 16. 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.

SPM Synchronizer

Connect the wiring to the SPM Synchronizer (if used). Use twisted-pair, shielded wire.

Load Sharing Lines

Connect the wiring for the load sharing lines. Use twisted-pair, shielded wire. Load Sharing lines are not required if the Load Sensor is to be used in the droop mode only.

Installation Check

Before initial operation of the Generator Load Sensor, make the following visual and electrical checks.

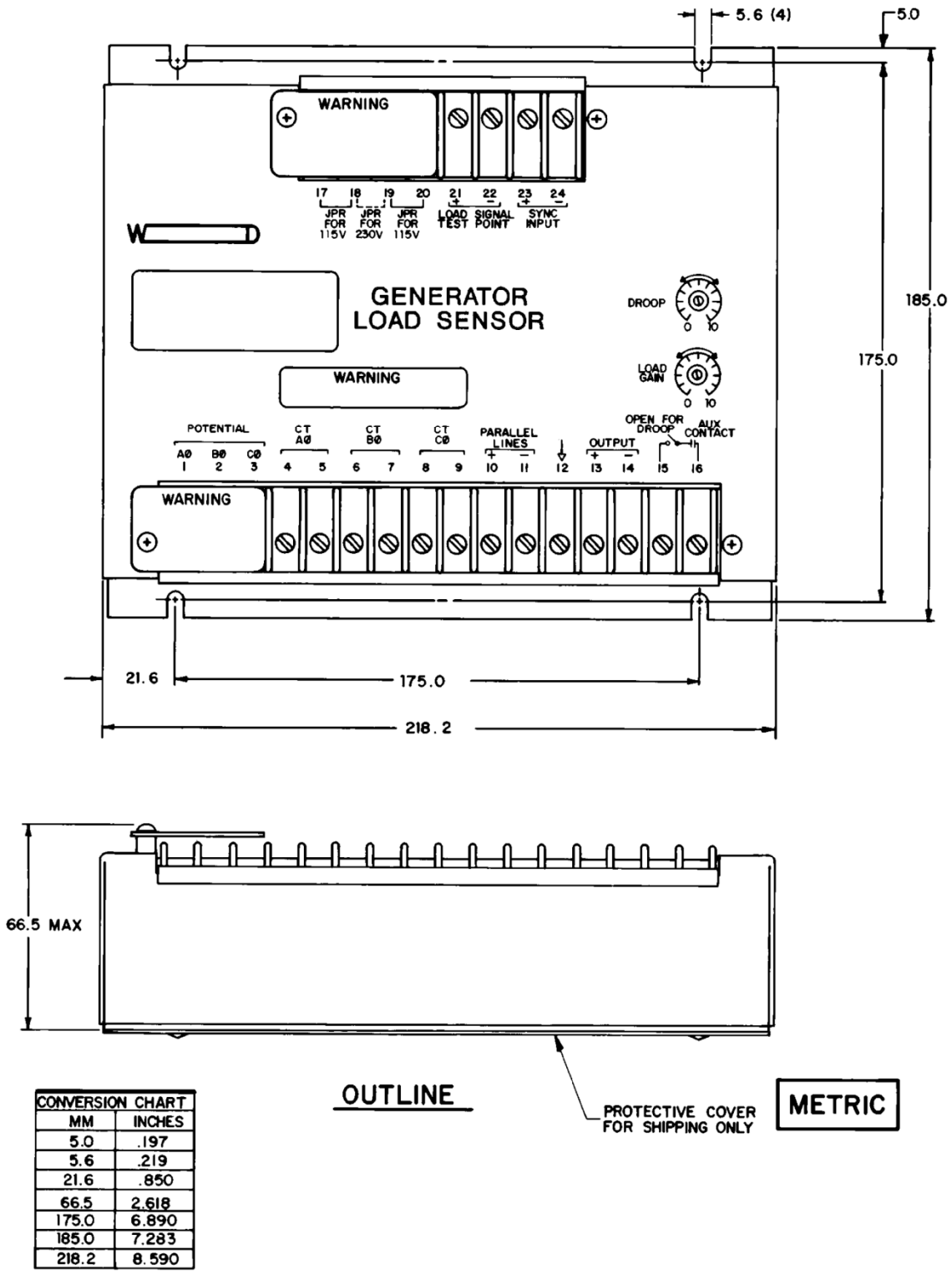
Visual Checks

1. Check that the control is securely mounted.
2. Check that all electrical connections are correctly made and that all terminal screws are tight.
3. Check that shielded wire is installed on the wires indicated in the plant wiring diagram, and that all shields are grounded on one end only.

Electrical Checks

⚠WARNING

Do not start the turbine until the control has been checked for correct installation and operation. To prevent the possibility of damage to equipment or injury to personnel, DO NOT permit the engine or turbine to start during any of the static check and calibration procedures.



CONVERSION CHART	
MM	INCHES
5.0	.197
5.6	.219
21.6	.850
66.5	2.618
175.0	6.890
185.0	7.283
218.2	8.590

Figure 3-2. Outline Drawing of Generator Load Sensor

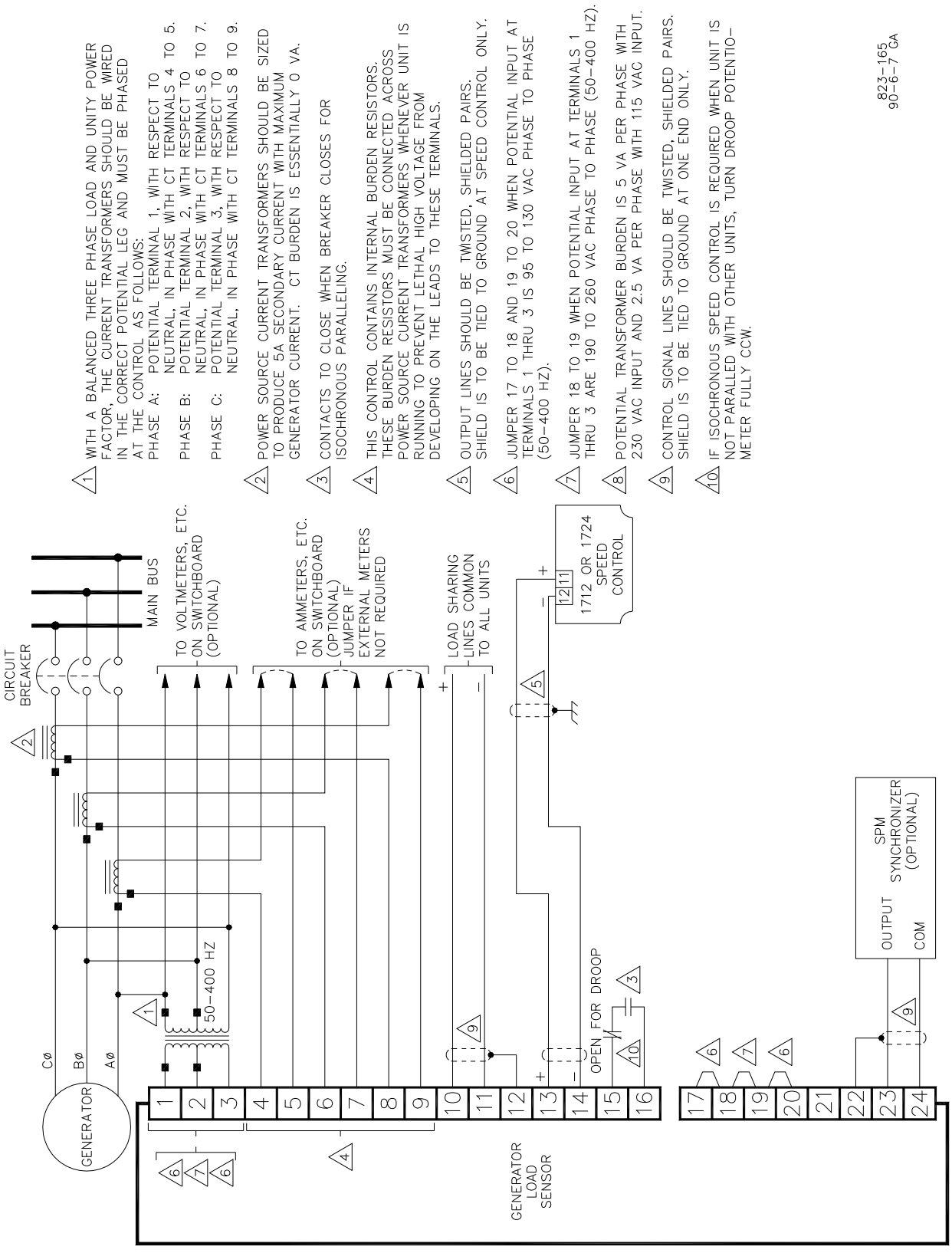


Figure 3-3. Plant Wiring Diagram of Generator Load Sensor

Chapter 4.
Calibration

Introduction

Use this calibration procedure after an Generator Load Sensor is installed on a generator set, to obtain the needed operating characteristics during load sharing.

1. Check that the correct jumpers are installed on terminals 17, 18, 19, and 20 to match your potential transformer secondary voltage. See the plant wiring diagram (Figure 3-3).

2. Remove wires from terminals 10 and 11, and from terminals 23 and 24.

3. Select isochronous operation by shorting terminals 15 and 16.

⚠WARNING

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

4. Start engine and apply full load to generator set.

IMPORTANT

The most accurate calibration is made at full load. However, if it is not possible to run the generator set at full load, run it at less than full load, and reduce the voltage readings given in this calibration procedure proportionally. For example, run a 2 kW gen-set at 1 kW and divide all voltages given in this calibration procedure by 2. If you reduce the load in this manner, however, be sure to reduce it by the same amount throughout this calibration procedure.

5. Set the LOAD GAIN potentiometer fully clockwise.

6. Check the load signal voltage between terminals 21 and 22. Adjust the LOAD GAIN potentiometer for a 6.0 Vdc Load Signal. If this voltage is not obtainable proceed to step 11.

7. Set the LOAD GAIN potentiometer fully counterclockwise.

8. Check the voltage between terminals 21 and 22. If the proper current transformer is being used, and if the power factor is unity, this voltage should be 3.4 ± 0.25 Vdc. If this voltage is not correct, proceed to step 11.

9. Remove the load from the generator set.

10. Check the voltage between terminals 21 and 22. This voltage should be 0.0 ± 0.25 Vdc. If this voltage is not correct, the Load Sensor unit is faulty; return it to Woodward for repair.

Phasing Check

For this check, the generator set must be running isochronously, not paralleled, and with a power factor of unity (1.0 ±0.1).

11. Check that the potential connections are made as follows and correct them if they are not:
    - Phase A to Terminal 1
    - Phase B to Terminal 2
    - Phase C to Terminal 3

12. * Start the engine and apply full load to the generator set.

13. Using a dc voltmeter, measure the load signal at terminals 21 and 22. Adjust the load gain potentiometer to give a 6 Vdc load signal. If 6 Vdc is not obtainable, set the load signal as close as possible to 6 Vdc. Record this voltage.

14. Shut down the generator set.

⚠WARNING **HIGH VOLTAGE—Do not disconnect a current transformer from its burden resistor while the engine is running. The current transformers can develop dangerously high voltages if open circuited while the engine is running.**

15. Disconnect the wire from terminal 5 that comes from the Phase A CT and connect both wires from this CT to Terminal 4.

16. * Start the generator set and apply full load.

17. Measure the load signal at terminals 21 and 22. If the phase B and C current transformers are connected correctly, this voltage will be 1/3 lower than the voltage recorded in step 13. For example; if the reading was 6 V in step 13, the reading in this step should be 4 V.

18. Shut down the generator set.

19. Reconnect the Phase A CT wire to terminal 5.

20. If the reading in step 17 was correct, proceed to step 21. If the reading in step 17 was not correct, proceed to the Phase Correction Procedure.

21. Disconnect the wire from terminal 7 that comes from the Phase B CT and connect both wires from this CT to Terminal 6.

22. Start the generator set and apply full load.

23. Measure the load signal at terminals 21 and 22. If the phase A and C current transformers are connected correctly, this voltage will be 1/3 lower than the voltage recorded in step 13. For example; if the reading was 6 V in step 13, the reading in this step should be 4 V.

24. Shut down the generator set.

25. Reconnect the Phase B CT wire to terminal 7.

26. If the reading in step 23 was correct, proceed to step 27. If the reading in step 23 was not correct, proceed to the Phase Correction Procedure.

27. Disconnect the wire from terminal 9 that comes from the Phase C CT and connect both wires from this CT to Terminal 8.

28. * Start the generator set and apply full load.

29. Measure the load signal at terminals 21 and 22. If the phase A and 8 current transformers are connected correctly, this voltage will be 1/3 lower than the voltage recorded in step 13. For example; if the reading was 6 V in step 13, the reading in this step should be 4 V.

30. Shut down the generator set.

31. Reconnect the Phase C CT wire to terminal 9.

32. If the reading in step 29 was correct, the phasing is correct and there is no need to perform the Phase Correction Procedure. If the reading in step 29 was not correct, proceed to the Phase Correction Procedure.

Phase Correction Procedure

If this procedure is followed, the correct connection of the current transformers is assured; the correct CT will be connected to the correct input on the load sensor with the correct polarity. Use this procedure only if the Phasing Check indicates that the phasing is incorrect.

A CT for any phase (A, B, or C), will produce the most positive load signal voltage when it is connected, in the proper polarity, to the terminals on the load sensor which correspond to the same phase. Any other connections of this CT will produce a less positive load signal voltage. This procedure makes trial connections of the first CT to all three CT inputs on the load sensor, polarized both ways on each CT input. The load signal voltage is recorded for each connection, and the CT is then connected to the CT input terminals that produced the most positive load signal voltage, and with the polarity that produced the most positive load signal voltage.

In a like manner, the second CT is tried on each of the two remaining CT input terminals in each polarity, then connected, in the correct polarity, to the terminals which produced the most positive load signal voltage.

The single remaining CT is then connected to the remaining CT input and the load signal checked for each polarity. This CT is then connected to the CT input, polarized so that it produces the most positive load signal voltage.

When the procedure is completed, all three CTs are connected to the proper CT inputs on the load sensor, with the correct polarity, and are now labeled with their correct designations.

The procedure for correcting phase wiring requires that the generator set be shut down and the current transformers disconnected many times. For convenience during the phasing check, the temporary method of connecting the current transformers shown in Figure 4-1 is recommended. By connecting a burden resistor (a 0.5 Ω, 20 W resistor), across each current transformer, that current transformer can be disconnected from the Load Sensor after removing all load. The connections between the terminal strip and the Load Sensor can be changed with the generator set running, however, remove all load before any changes in connections are made. Do not disconnect a wire from a current transformer with load on the system. After the phase correction procedure has been completed, remove the terminal strip and the resistors.

⚠WARNING

HIGH VOLTAGE—Do not disconnect a current transformer from its burden resistor while the engine is running. The current transformers can develop dangerously high voltages If open circuited while the engine is running and may explode.

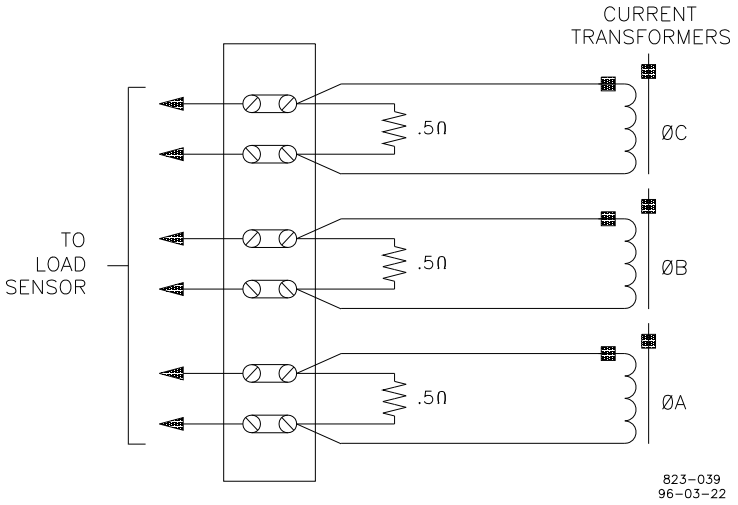


Figure 4-1. Temporary CT Connection

For this procedure, the generator set must be running isochronously, not paralleled, and with a power factor of unity (1.0 ±0.1).

1. Make sure that the turbine is shut down.

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

3. Disconnect the phase B CT wires from terminals 6 and 7 and connect these two wires together. Use a small screw and nut and tape the connection.

4. Disconnect the phase C CT wires from terminals 8 and 9 and connect these two wires together. Use a small screw and nut and tape the connection.

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

6. Start the engine and apply full load.

7. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

8. Shut the generator set down and reverse the phase A wires on terminals 4 and 5.

9. Start the engine and apply full load.

10. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

11. Shut down the generator set.

12. Remove the phase A CT wires from terminal 5 and 6 and connect the phase A CT wires to the phase B input terminals 6 and 7.

13. Start the engine and apply full load.

14. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

15. Shut the generator set down and reverse the phase A CT wires on Terminals 6 and 7.

16. * Start the engine and apply full load.

17. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

18. Shut down the generator set.

19. Remove the phase A CT wires from terminal 6 and 7 and connect the phase A CT wires to the phase C input terminals 8 and 9.

20. Start the engine and apply full load.

21. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

22. Shut the generator set down and reverse the phase A wires on terminals 8 and 9.

23. Start the engine and apply full load.

24. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

25. Shut down the generator set.

26. Remove the phase A CT wires from terminal 8 and 9 and connect the phase A wires to the pair of terminals, in the same polarity, that produced the most positive load signal voltage.

27. Untape and disconnect the Phase B CT wires. Connect the phase B CT wires to one pair of the two remaining CT input terminals on the Load Sensor.

28. Start the engine and apply full load.

29. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

30. Shut the generator set down and reverse the phase 8 wires on the CT input terminals.

31. Start the engine and apply full load.

32. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

33. Shut down the generator set.

34. Remove the phase B CT wires from the terminals they are connected to and connect them to the remaining pair of CT input terminals on the Load Sensor.

35. Start the engine and apply full load.

36. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

37. Shut the generator set down and reverse the phase B CT wires on the CT input terminals

38. * Start the engine and apply full load.

39. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

40. Shut down the generator set.

41. Remove the phase B CT wires from the CT input terminals and connect these phase B CT wires to the pair of CT input terminals, in the same polarity, that produced the most positive load signal voltage.

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

43. * Start the engine and apply full load.

44. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

45. Shut the generator set down and reverse the phase C CT wires on the CT input terminals.

46. Start the engine and apply full load.

47. Measure the load signal voltage between terminals 21 and 22 and record this voltage.

48. Shut down the generator set.

49. Connect the phase C CT wires to the same pair of CT input terminals that they are connected to, but in the polarity that produced the most positive load signal voltage.

50. Label each wire with the designation of the terminal that it is now connected to.

Load Gain Adjustment

For this procedure, the generator set must be running isochronously, not paralleled, and with a power factor of unity (1.0 ±0.1).

1. * Start the generator set and run at full load.

2. Measure the load signal voltage and adjust the LOAD GAIN potentiometer for 6.0 ± 0.1 Vdc.

If the load signal voltage can not be raised to 6 V, and the phasing has been checked and is correct, it will be necessary to use a lower load signal voltage. Set the load signal voltages of all generator sets in the system to the same voltage.

When paralleled, adjustment of a generator set's LOAD GAIN potentiometer clockwise will cause that generator set to carry less load. If stability problems occur when paralleled at a particular load signal voltage, reduce the load signal voltage by adjusting the LOAD GAIN potentiometer and set the load signal voltage of all other generator sets in the system to the same voltage. When the load signal voltages of all generator sets in a system are reduced, the load sharing gain will be reduced and this may result in some loss of load sharing sensitivity.

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

IMPORTANT

The most accurate calibration is made at full load. However, if it is not possible to run the generator set at full load, run it at less than full load, and reduce the voltage readings given in this calibration procedure proportionally. For example, run a 2 kW gen-set at 1 kW and divide all voltages given in this calibration procedure by 2. If you reduce the load, however, be sure to reduce it the same amount throughout this calibration procedure.

Droop Adjustment

Droop is usually expressed as a percentage. The droop in a load sensor is calculated by the following formula.

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

When the generator set is to be operated in the droop mode, the DROOP potentiometer must be adjusted. The method of setting droop depends on whether the load of the generator set is an isolated load or an infinite bus.

Setting Droop for an Isolated Load

1. Open the OPEN FOR DROOP SWITCH (or disconnect the wires from terminals 15 and 16).

2. Start the engine and adjust the RATED SPEED potentiometer on the EPG for rated speed with no load.

3. * Apply full load.

4. Adjust the DROOP potentiometer to give the desired speed.

   For 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 4-2, Droop Adjustment.

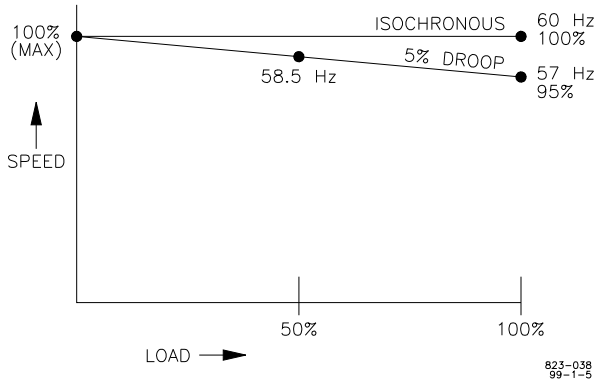


Figure 4-2. Droop Adjustment

Setting Droop for an Infinite Bus Load

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

   For 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.

3. Turn the DROOP potentiometer fully clockwise (for maximum droop).

4. Open the OPEN FOR DROOP switch (or remove the wires from terminals 15 and 16.

5. Synchronize the generator with the bus and parallel it with the bus.

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

7. Adjust the DROOP potentiometer counterclockwise, decreasing droop, until 100% load is achieved.

This completes the calibration of the EPG Load Sensor.

* If it is necessary to set the droop without pulling 100% load, set the RATED SPEED potentiometer (in step 1) accordingly for desired percent droop.

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

Chapter 5. Troubleshooting

If the unit is determined not to be operating correctly, use the following troubleshooting chart to find the problem. The causes for each symptom are given with the most likely cause first.

IMPORTANT

This troubleshooting chapter is intended only as a guide. There may be other causes for a symptom than those given and there may be repairs not given which may be more suited to the particular situation.

Symptoms	Cause	Test/Remedy
Undesirable speed decrease with load increase.	1. Droop mode switch is open or auxiliary contact is open. Load Sensor is in droop mode.	Jumper Load Sensor terminals 15 and 16. Observe engine operation. Replace wiring or switch as required. (The Load Sensor will be in droop when the circuit breaker auxiliary contact is open. See Droop Switch under Chapter 3, Electrical Wiring.)
	2. Improper engine operation. Operate the engine and observe speed while applying load. Note the position of the actuator terminal shaft.	If the droop occurs near the full load point only, it is possible the engine is not producing the horse-power called for by the fuel control, or is being overloaded. Either is indicated if the fuel control is at maximum fuel position.
	3. Faulty engine or speed control. Disconnect the load sensor from the speed control. Load the engine as a single, isolated unit.	If speed decreases with load, engine operation or the speed control may be faulty. You may be exceeding the load rating of the engine or there may be insufficient fuel flow.
Erratic Load Sensor Operation.	1. Open or intermittent wire.	Check all wiring for continuity and tight connections. Repair if necessary.
	2. EMI (Electromagnetic Interference).	Remove ground loops. Shield all wiring, grounding shield at one end only. Route wiring and controls away from high current wires and noise sources. (Equipment containing SCRs are especially noisy.) Keep wire lengths to a minimum. Route wiring through conduit when possible. Use single point grounds. Take control power right off of battery. (Do not use distribution points or take off of starter.) Run additional equipment off of separate battery wires.
Load Signal voltage is low. Adjusting LOAD GAIN won't raise it.	1. Incorrect phasing of CT & PT wiring.	Perform phasing check. If phasing check indicates need, perform procedure for correcting phase wiring.
	2. Insufficient CT output.	Check for 5 A CT output at full load. (CT must be between 3 and 7 A at full load.) Change to a lower primary current CT.

Symptoms	Cause	Test/Remedy
Load Signal voltage is too high. Adjusting LOAD GAIN won't lower it.	CT output too high.	Check for 5 A CT output at full load. (CT must be between 3 and 7 A at full load.) Change to a higher primary current CT.
Engine does not properly share load with other units.	1. Engine not receiving fuel as called for by governor.	Check for maximum voltage to the actuator. If voltage to the actuator is correct but the actuator output shaft is not at maximum position, an actuator or speed control problem if indicated or the linkage or fuel system is restricted.
	2. Unequal speed settings.	Be sure that speed settings of all units at no load are identical. Adjust as necessary.
	3. Unequal load gain voltages.	Check that load gain setting of all load sharing units is correct. See load gain adjustment in Chapter 4. Adjust as necessary.
	4. Improper load sensing phasing.	Perform the transformer phasing check in Chapter 4. Correct wiring as necessary.
	5. Circulating currents between generators. (Noted by unequal power factors between generators.)	Properly adjust the generator voltage controls.
Engine does not properly share load with other units.	Terminals 15 and 16 not shorted. Load Sensor in droop.	Jumper Load Sensor terminals 15 and 16. Observe engine operation. Replace wiring or switch as required.

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 82313F.

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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.

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