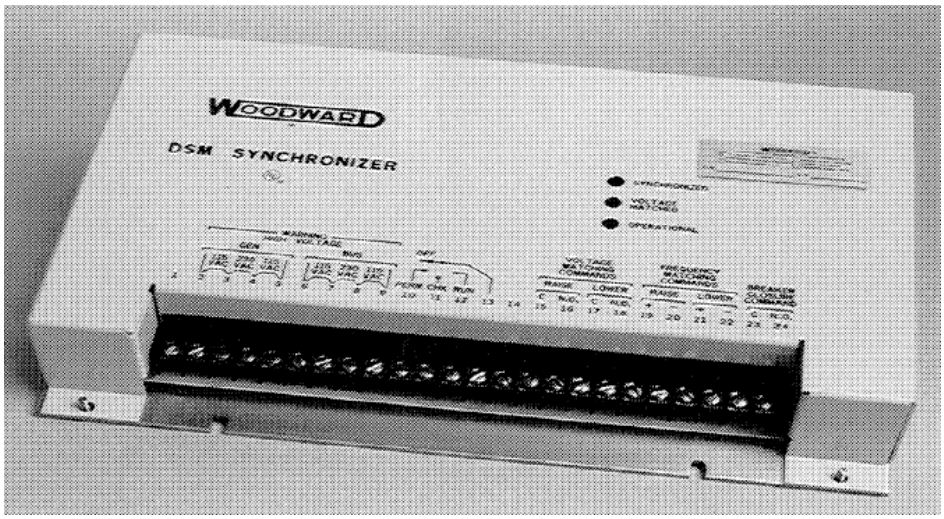
WOODWARD

Product Manual 85100
(Revision L)
Original Instructions



Digital Speed Matching Synchronizer (DSM)

UL Listed—8239-001, -002, -013;
9905-203, -204, -346, -347
Other—8239-017, -018, -069

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:

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

Proper Use

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

Translated Publications

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

The original source of this publication may have been updated since this translation was made. Be sure to check manual *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 Out-of-date translations are marked with ⚠.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

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Important Definitions

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

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

⚠WARNING

Overspeed / Overtemperature / Overpressure

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

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

⚠WARNING

Personal Protective Equipment

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

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

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

⚠WARNING

Start-up

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

⚠WARNING

Automotive Applications

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

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

Control Function

The DSM Synchronizer automatically synchronizes the speed of an oncoming generator to a bus by sending raise or lower signals to the speed reference of the speed control. Models with voltage matching also include circuitry which matches the generator and the bus voltages by sending raise or lower signals to the generator voltage regulator.

Part Number	Speed Synch Window	UL Listed	Voltage Matching
8239-001	SMALL	YES	NO
8239-002	SMALL	YES	YES 1%
8239-013	SMALL	YES	YES 5%
8239-017	SMALL	NO	NO
8239-018	SMALL	NO	YES 1%
9905-203	SMALL	YES	NO
9905-204	SMALL	YES	YES 1%
9905-346	LARGE	YES	YES 1%
9905-347	LARGE	YES	NO
8239-069	LARGE	NO	YES 5%

Application

The DSM Synchronizer is recommended for use in power generation systems using steam or gas turbines. It is designed for use with electronic controls requiring raise and lower contact signals, including digital controls such as the Woodward 501, 503, 509, 505, and the NetCon® system.

Construction

All components of the DSM Synchronizer are mounted on a single printed circuit board (PCB). The PCB is enclosed in a rugged steel housing. The terminal block, located at the lower front of the housing, is soldered directly to the PCB, eliminating the need for internal wiring harnesses. Control dimensions are shown in the outline drawing, Figure 1-1.

Generator Input

For 115 Vac, remove the jumper that's between terminals 3 and 4. Connect the generator to terminals (2 and 3) and (4 and 5). For 230 Vac, remove the jumpers between terminals (2 and 3) and (4 and 5). Connect the generator to Terminals (2), (3 and 4), and (5).

Features

Here is a brief description of the features that add convenience, safety, and reliability to the operation of the DSM Synchronizer. Actual adjustments and calibration are discussed in Chapter 3, and a more detailed explanation of the DSM Synchronizer is available in Chapter 4, Description of Operation.

Switch-Selectable Operating Dynamics

Operating dynamics such as breaker closure timing, maximum slip frequency, and voltage pulse duration are each switch-selectable to one of eight settings. Operating dynamics are explained in Chapter 3, Adjustment and Calibration, under "Optional Switch Selections for Dynamic Adjustments."

Two Breaker Commands

The DSM Synchronizer sends a correcting signal to the electronic speed control until the speed and phase angle of the generator and bus match the selected operating dynamics. When they match, the DSM Synchronizer generates a contact closure pulse to close the breaker and lock the oncoming generator unit onto the bus.

Two types of beaker commands can be selected: One-Shot, where the synchronizer is immediately disabled after the breaker close command is issued, and Automatic Retry, which continues to monitor the bus and generator lines for 30 seconds after the breaker closes. If the breaker does not close or if it reopens within 30 seconds, the Automatic Retry will continue to resynchronize and close the breaker. After the breaker remains closed for 30 seconds, the synchronizer is automatically disabled.

Four Operating Modes

The DSM Synchronizer offers a choice of four operating modes: RUN, CHECK, PERMISSIVE, and OFF. The RUN mode synchronizes the bus and generator by trimming speed (and voltage for the voltage matching models), then automatically closing the breaker. CHECK mode is for synchronization testing. It synchronizes the bus and the generator by trimming speed (and voltage on the voltage matching models), but does not close the breaker. In the PERMISSIVE mode, the DSM Synchronizer verifies synchronization and automatically closes the breaker, but it will not adjust speed or voltage.

Built-In Safety

Several safety features have been designed into the circuitry of the DSM Synchronizer to ensure that the breaker closes only at the correct time. Breaker closure commands will be issued only when the generator frequency is slightly higher than the bus frequency. In addition, breaker closure commands will be issued only when the following conditions are met:

- Power must be on
- No frequency raise or lower command is in effect
- No voltage raise or lower command is in effect
- The Sync enable signal is active
- There must be an active breaker close signal
- Either RUN or PERMISSIVE mode is selected
- On models 8239-002, 8239-013, 8239-018, 8239-069, 9905-204 and 9905-346 with voltage matching, the generator and bus voltage must match
- Switch settings for breaker closure timing and maximum slip frequency must be valid. (Combinations of switch settings that would cause a breaker closure command to be issued at a phase angle greater than 20 degrees are not valid. Invalid switch combination settings are listed in Table 3-2.)

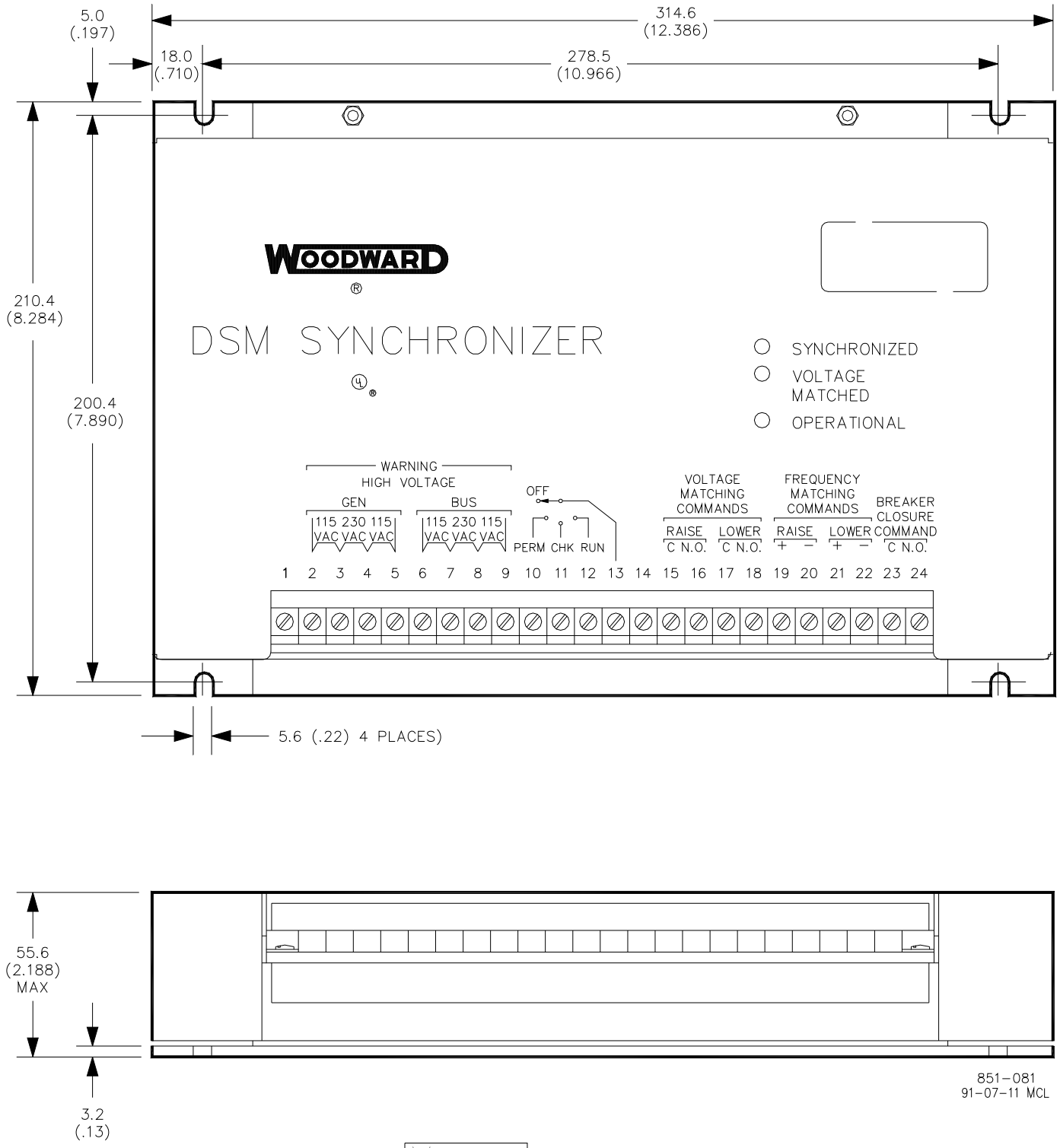


Figure 1-1. Outline Drawing

Chapter 2. Installation

Unpacking

Be careful when unpacking the DSM Synchronizer. Inspect the unit for bent or dented panels, scratches, and loose or broken parts. If any damage is found, notify the carrier and Woodward.

Environmental Precautions

The synchronizer is designed to operate within an ambient temperature range of –40 to +185 °F (–40 to +85 °C). It can be mounted in any attitude.

Location Considerations

When selecting a location, make sure there is adequate ventilation and room for servicing and repair. For optimum performance, choose a location that will minimize the length of potential transformer wiring and breaker wiring.

Mounting

Mount the DSM Synchronizer using the four mounting holes located at each corner of the back plate. The cover can be removed without removing the backing plate or PCB by removing the two nuts from the cover's top flange and the two mounting screws from the lower flange.

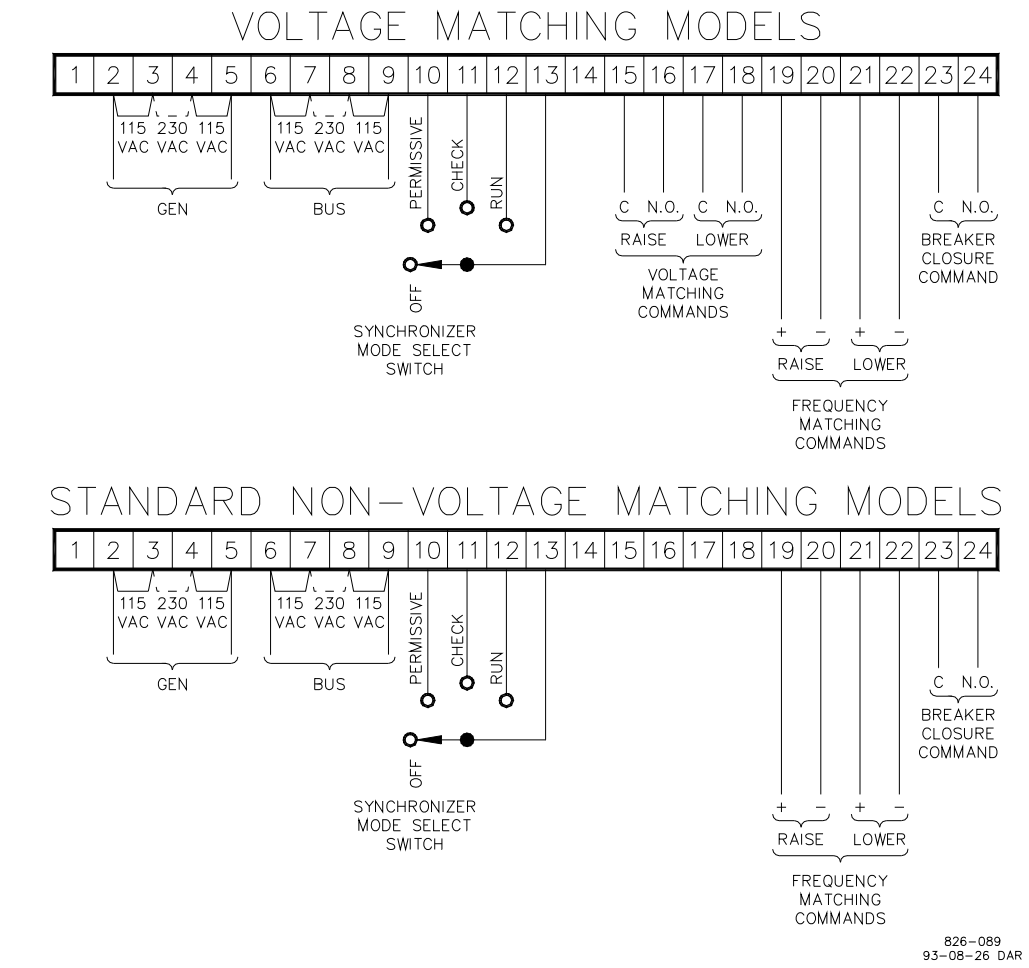
Power Requirements

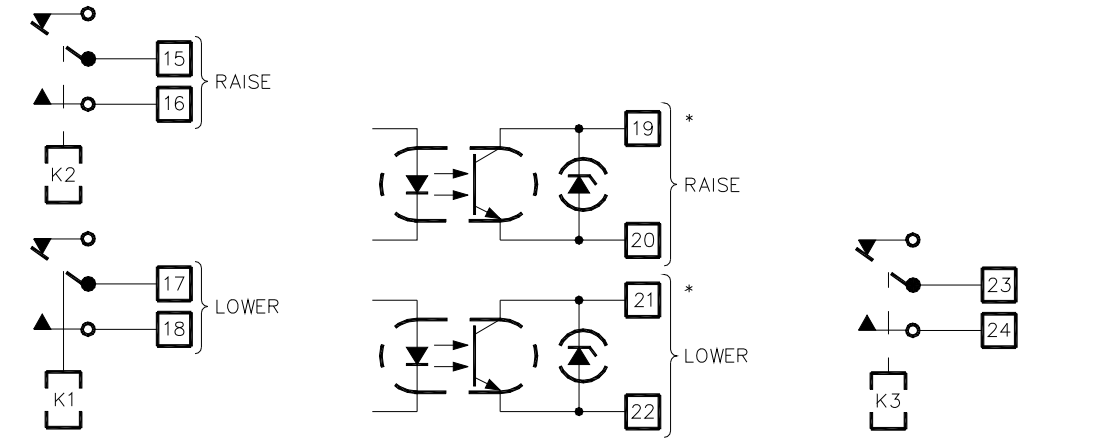
The DSM Synchronizer is powered by voltages supply connections to the generator potential transformers. It accepts nominal input voltages of either 115 Vac, 60 Hz or 230 Vac, 60 Hz.

The actual permissible range is:

Input	Vac	Hz
115 Vac	90–130	45–65
230 Vac	185–265	45–65

Worst case loading for generator potential transformers is 2.5 W for 8239-001 and 8239-002 and 7.5 W for 8239-017, 8239-018, 9905-203, and 9905-204. Loading for bus potential transformers is less than 5.0 mW.





* CURRENT RATING :
12mA @ 30V FOR 8239−001. −002, −013
35mA @ 30V FOR 9900−203, −204, −346, −347

826−090
93−08−26 DAR

Figure 2-1. Plant Wiring Diagram

Electrical Connections

External wiring connections are explained below and shown in the plant wiring diagram, Figure 2-1. The diagrams shown are for a typical installation using either the standard DSM Synchronizer (8239-001, 8239-017, 9905-203, and 9905-347) or the voltage matching DSM Synchronizer (8239-002, 8239-018, 8239-069, 9905-204, and 9905-346).

Inputs

Generator Input

For 115 Vac, remove the jumper that's between terminals 3 and 4. Connect the generator to terminals (2 and 3) and (4 and 5). For 230 Vac, remove the jumpers between terminals (2 and 3) and (4 and 5). Connect the generator to terminals (2), (3 and 4), and (5).

Bus Input

For 115 Vac, remove the jumper that's between terminals 7 and 8. Connect the bus to terminals (6 and 7) and (8 and 9). For 230 Vac, remove the jumpers between terminals (6 and 7) and (8 and 9). Connect the bus to terminals (6), (7 and 8), and (9).

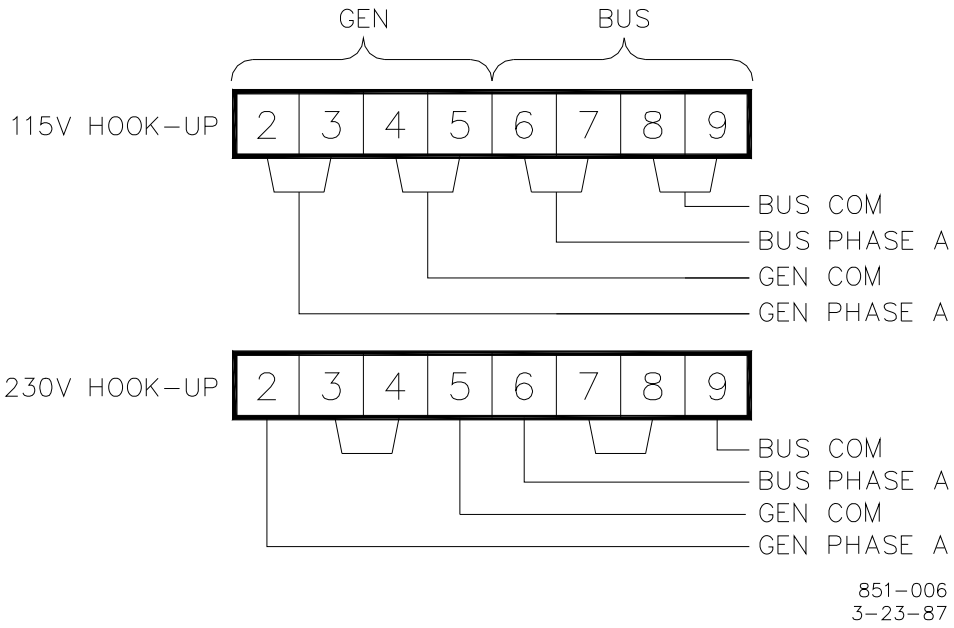


Figure 2-2. Connecting Generator and Bus Inputs

Mode Selection

An external multi-position switch connected to terminals 10 through 13 provides three operating modes plus OFF. Connect the switch as follows:

Terminal 10—PERMISSIVE mode
Terminal 11—CHECK mode
Terminal 12—RUN mode
Terminal 13—OFF (monitor) mode

Outputs

Voltage Matching Commands
On models 8239-002, 8239-013, 8239-018, 8239-069, 9905-204, and 9905-346 with voltage matching, relays connect the voltage matching circuit to terminals 15 through 18. By opening and closing contacts on these internal relays, raise or lower signals are sent to the voltage regulator until the bus voltage and the generator voltage are equal. The voltage raise relay is connected to terminals 15 and 16; the voltage lower relay is connected to terminals 17 and 18. Ratings of the voltage raise and lower relay contacts are listed in Table 2-1.

Table 2-1. Relay Contact Ratings for Voltage Matching and Breaker Closure

Resistive Loads
10 A at 28 Vac, 50/60 Hz
3 A at 120 Vac, 50/60 Hz

Inductive Loads
6 A at 28 Vdc
2 A at 120 Vac, 50/60 Hz

Frequency Matching Commands
Frequency matching circuits adjust generator frequency to match the bus by issuing speed raise or lower commands to the speed control. Terminals 19 and 20 are used to issue raise commands, and terminals 21 and 22 are used to issue lower commands. Opto-couplers connecting the frequency matching circuits to the terminals isolate the circuits from stray signals. The opto-coupled contacts for the frequency matching commands are rated at +30 Vdc, 12 mA for 8239-001 and 8239-002 and 35 mA for 8239-017, 8239-018, 9905-203, and 9905-204.

Breaker Closure Commands
Connect the breaker to terminals 23 and 24. The terminals are connected to the breaker closure circuit by an internal relay. When the breaker closure relay is energized, closure commands are issued to close the breaker. Ratings of the breaker closure command relay contacts are listed in Table 2-1.

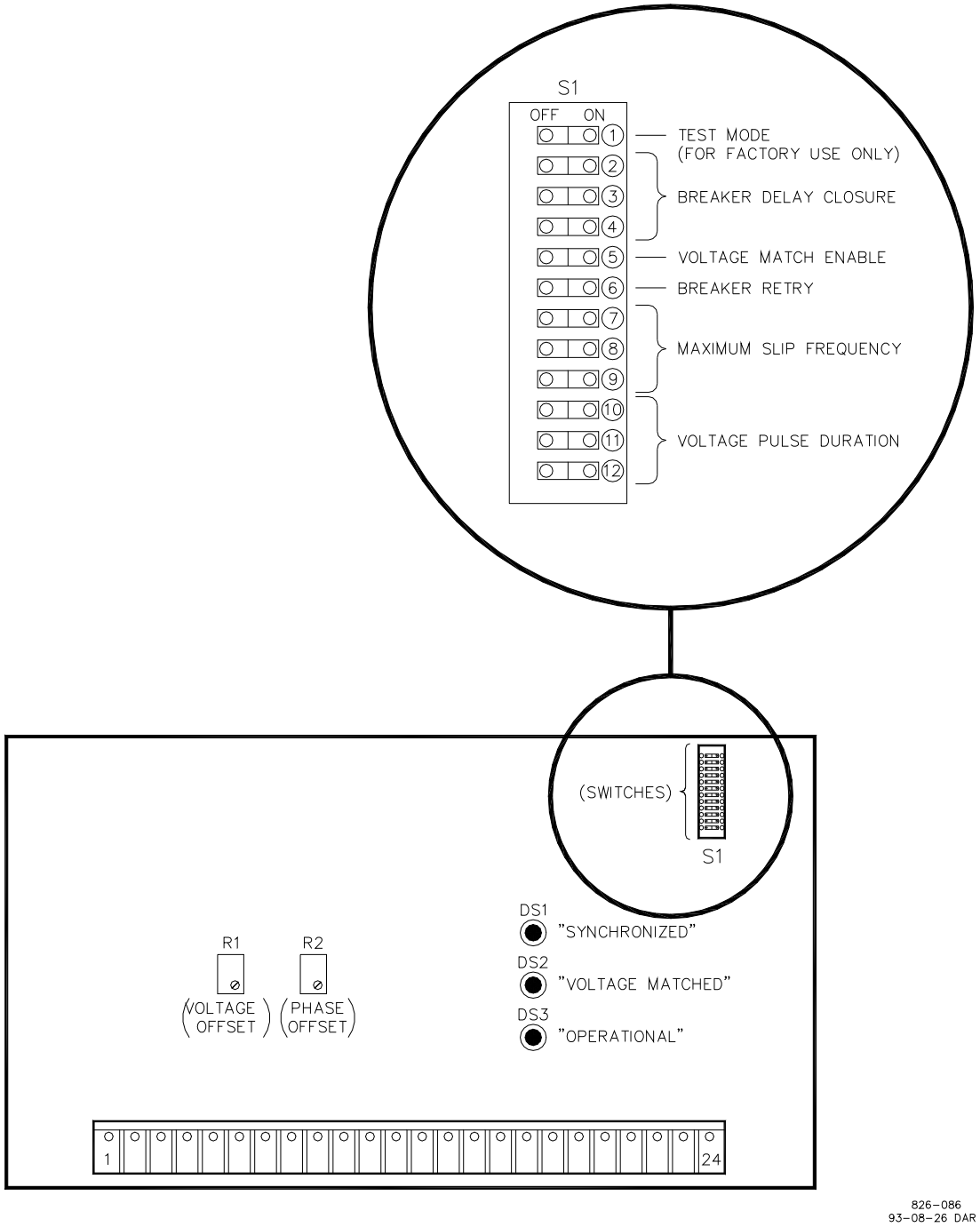


Figure 3-1. Function and Location of Switches, LEDs, and Potentiometers on the Circuit Board

Chapter 3.
Adjustment and Calibration

General Information

The calibration procedure may require readjustment of the Phase Offset and Voltage Offset potentiometers on the 8239-002, 8239-013, 8239-018, 8239-069, 9905-204, and 9905-346 and the Phase Offset potentiometer on the 8239-001, 8239-017, 9905-203, and 9905-347. These 25-turn potentiometers are on the PCB just to the left of center (see Figure 3-1). To access the PCB, remove the cover by removing the two nuts located on the cover's top flange and the two mounting screws in the lower flange as shown in Figure 1-1.

IMPORTANT

Figure 3-1 shows only the primary functions of the LEDs. The LEDs' secondary functions are described under "Invalid DSM States."

Table 3-1 lists the optional values and switch positions for each dynamic adjustment option.

Calibration Procedure

Each DSM Synchronizer is calibrated to nominal specifications at the factory. Some readjustment of the Phase Offset (and Voltage Offset for models 8239-002, 8239-013, 8239-018, 8239-069, 9905-346, and 9905-204) may be necessary, however, to compensate for component tolerances and to match the control circuitry to input signals. Adjustment of the phase or voltage trim potentiometers is outlined in the following procedures.

General Instructions

1. Make sure the synchronizer power is off.
2. Tie the generator and bus inputs together.
3. Make sure the mode select switch is turned to OFF.
4. Remove the synchronizer cover.
5. For models 8239-002, 8239-013, 8239-018, 8239-069, and 9905-204, 9905-346 (with voltage matching) only, enable the voltage matching circuit (turn on optional switch 5).

Phase Offset Adjustment

1. Set the R2 Phase Offset potentiometer fully counterclockwise. See Figure 3-1 for the location of R2.
2. Turn on the power to the synchronizer.
3. Turn the R2 Phase Offset potentiometer clockwise until DS1, the SYNCHRONIZED LED (light emitting diode), just comes on and stays on. (See Figure 3-1 for the SYNCHRONIZED LED location.) Note the position. Continue to turn the potentiometer clockwise until the LED turns off. Note the position again. Adjust the potentiometer counterclockwise to a point midway between positions 1 and 2.

Table 3-1. Optional Switch Settings for Dynamic Adjustments

OPTIONAL SWITCH SETTINGS

OPTION	SWITCH NO./FUNCTION
TEST MODE	SWITCH 1 (FOR FACTORY USE ONLY)—SWITCH MUST REMAIN IN OFF POSITION OFF – DISABLED ON – ENABLED
BREAKER DELAY CLOSURE	SWITCH 2, 3, 4 OFF OFF OFF – 0.0 SEC ON OFF OFF – 0.1 SEC OFF ON OFF – 0.2 SEC ON ON OFF – 0.4 SEC OFF OFF ON – 0.6 SEC ON OFF ON – 0.8 SEC OFF ON ON – 1.0 SEC ON ON ON – 1.5 SEC
VOLTAGE MATCH ENABLED	SWITCH 5 OFF – DISABLED ON – ENABLED
BREAKER RETRY	SWITCH 6 OFF – ONE-SHOT ON – AUTOMATIC RETRY
MAXIMUM SLIP FREQUENCY	SWITCH 7, 8, 9 OFF OFF OFF – 0.015 HZ ON OFF OFF – 0.030 HZ OFF ON OFF – 0.050 HZ ON ON OFF – 0.070 HZ OFF OFF ON – 0.100 HZ ON OFF ON – 0.150 HZ OFF ON ON – 0.210 HZ ON ON ON – 0.255 HZ
VOLT PULSE DURATION	SWITCH 10, 11, 12 OFF OFF OFF – 0.25 SEC ON OFF OFF – 0.50 SEC OFF ON OFF – 0.75 SEC ON ON OFF – 1.00 SEC OFF OFF ON – 1.25 SEC ON OFF ON – 1.50 SEC OFF ON ON – 1.75 SEC ON ON ON – 2.00 SEC

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4. For models 8239-001, 8239-017, 9905-203, and 9905-347 only, go to step 7. For models 8239-002, 8239-013, 8239-018, 8239-069, 9905-204, and 9905-346, proceed with step 5.

Voltage Offset Adjustment

5. Set the R1 Voltage Offset potentiometer fully counterclockwise. See Figure 3-1 for the location of R1.
6. Adjust the R1 Voltage Offset potentiometer clockwise until DS2, the VOLTAGE MATCHED LED, just comes on and stays on. See Figure 3-1 for the VOLTAGE MATCHED LED location. Note the position. Continue to turn the potentiometer clockwise until the LED turns off. Note the position again. Adjust the potentiometer counterclockwise to a point midway between positions 1 and 2.
7. Turn off the power to the synchronizer.
8. Remove the tie between the bus and generator inputs.

Check Mode Procedure

CHECK mode is used to test the operating dynamics of the DSM Synchronizer. This mode will issue raise or lower commands to the speed control until the frequency and phase of the generator matches that specified by the option switches. During this procedure you must monitor all three LEDs to verify proper operation. The SYNCHRONIZED and VOLTAGE MATCHED LEDs will be enabled for two seconds to indicate the command to close the breaker. The generator frequency will remain equal to the bus frequency plus the slip frequency specified by the option switches. For models 8239-002, 8239-018, 9905-204, and 9905-346, the voltage matching circuit will issue raise and lower commands to the voltage regulator until the generator voltage is within 1% of the bus voltage (5% for 8239-013 and 8239-069).

1. Set the MODE select switch to OFF.
2. Remove the DSM top cover so the LED status may be observed, and switch positions accessed.
3. Set the optional switch selections to match operating dynamics (see "Invalid Switch States"). It is suggested that you select breaker retry (switch 6 on for Automatic Retry). This will allow continuous attempts to close the breaker.
4. Set the mode select switch to CHECK. Synchronization of the generator to the bus will begin. The SYNCHRONIZED and VOLTAGE MATCHED LEDs will turn on for two seconds to indicate breaker closure.
5. If the LEDs blink other than as indicated in step 4, see "Invalid DSM States."
6. If the optional switch selection is changed, repeat this procedure beginning with step 1.
7. Set the mode select switch to OFF.
8. Replace the synchronizer cover.

Optional Switch Selections for Dynamic Adjustment

Changes in the operating dynamics usually will be required to achieve maximum stability. The dynamics for the options shown in Table 3-1 can be set to any of the values listed by setting the appropriate switch(es) in the on or off position. The switches are located at S1 on the PCB. See Figure 3-1. The switch numbers associated with each option are on the right. Also listed on the right is the state (on or off) each switch must be in for each function or value. Note that switch position on is the same as closed and that switch position off is the same as open.

IMPORTANT **Optional switch selections DO NOT affect the phase offset adjustment or voltage offset adjustment.**

Test Mode

The TEST mode is used for factory adjustments only. Make sure the TEST mode switch is in the off position before setting the dynamic adjustments.

IMPORTANT **The TEST mode switch must remain in the OFF (disabled)position at all times.**

Breaker Delay Closure

This option provides a means of adjusting the system to compensate for the time required by different breakers to close after receiving a closure signal. By positioning switches 2, 3, and 4 as indicated in Table 3-1, one of eight delay values can be selected. For example, to compensate for a breaker needing 0.4 seconds to close, switches 2 and 3 must be on and switch 4 must be off.

⚠WARNING **Recheck after setting the breaker delay closure switches to be sure they are set correctly. The wrong choice of breaker closure delay can cause the breaker to close before the generator is properly synchronized to the bus, resulting in a disturbance to the system when the breaker closes.**

Some combinations of switch settings for breaker delay closure and slip frequency are not allowed. These combinations are rejected by the DSM circuitry. See "Invalid DSM States" and Table 3-2, Invalid Combinations of Switch States, for an explanation and listing of combinations of switch positions that CANNOT be used.

Voltage Match Enabled

This option provides a means of deactivating the voltage match circuit on models 8239-002, 8239-013, 8239-018, 8239-069, 9905-204, and 9905-346. On models 8239-001, 8239-917, 9905-203, and 9905-347 (without voltage matching), place switch 5 in the off position.

Breaker Retry

One-Shot
When switch 6 is in the off position, the synchronizer will be automatically disconnected after the breaker is closed.

Automatic Retry
When switch 6 is in the on position, the synchronizer will close the breaker and monitor the generator and bus inputs for 30 seconds. If the system remains synchronized for 30 seconds, the synchronizer automatically will disconnect from the system.

If the system does not remain synchronized (breaker does not close, or if it reopens within 30 seconds), the control will resynchronize the system and reissue the control will resynchronized the system and reissue a breaker close command. The process will be repeated until the breaker remains closed for 30 seconds, at which time the synchronizer automatically will disconnect from the system.

Maximum Slip Frequency

The generator frequency must be slightly higher than the bus frequency before the DSM Synchronizer will issue a breaker close signal. This is referred to as "high sync closure only." It is a safety feature designed into the control for minimum system disturbance when the breaker closes and to make sure the generator will not motor. Any one of the eight values listed in Table 3-1 can be selected with switches 7, 8, and 9.

The frequency difference between the generator and the bus represents the amount of load the generator will pick up when the breaker closes. The approximate amount of load represented by the slip frequencies in Table 3-1 are:

Slip Frequency	Load
0.015 Hz	0.5%
0.030 Hz	1.0%
0.050 Hz	1.7%
0.070 Hz	2.3%
0.100 Hz	3.3%
0.150 Hz	5.0%
0.210 Hz	7.0%
0.255 Hz	8.5%

Some combinations of breaker delay closure and maximum slip frequency switch settings are not acceptable. These combinations are called invalid combinations and are rejected by the DSM circuitry. Read "Invalid DSM States," and see Table 3-2 for an explanation and listing of switch combinations which are NOT allowed.

Volt Pulse Duration

Through switches 10, 11, and 12, any one of the eight values listed in Table 3-1 can be selected for the voltage raise/lower minimum pulse duration.

The volt pulse duration switches provide a means of matching the output of the generator voltage regulator to the bus voltage.

Invalid DSM States

Invalid Switch States

It is the combination of breaker delay closure and maximum slip frequency switch settings that determines the phase angle at which the DSM Synchronizer will issue a close breaker signal. To prevent damage caused by the breaker closing at too large a phase angle (as might occur by selecting incorrect switch settings), the maximum phase angle at which a breaker close a signal will be issued has been set at 20 degrees. Combinations of switch settings that result in phase angles greater than 20 degrees are automatically rejected by the DSM circuitry. These invalid combinations are shown in Table 3-2.

Table 3-2. Invalid Combinations of Switch States

Switches 2–3–4	**Switches 7–8–9**
Breaker Delay Closure of:	**Maximum Slip Frequency of:**
0.4 s AND	0.150 Hz or greater
0.6 s AND	0.100 Hz or greater
0.8 s AND	0.100 Hz or greater
1.0 s AND	0.070 Hz or greater
1.5 s AND	0.050 Hz or greater

Synchronization cannot occur while one of the invalid combinations listed in Table 3-2 is selected. See "Secondary LED Functions."

Secondary LED Functions

Blinking LED	**Indicates**
Operational	Generator frequency is < 44 Hz
Synchronized	Bus frequency is < 44 Hz
Voltage Matched	Bus frequency is not stable
Operational and Synchronized	Generator frequency is not stable
Voltage Matched and Synchronized	Illegal switch setting

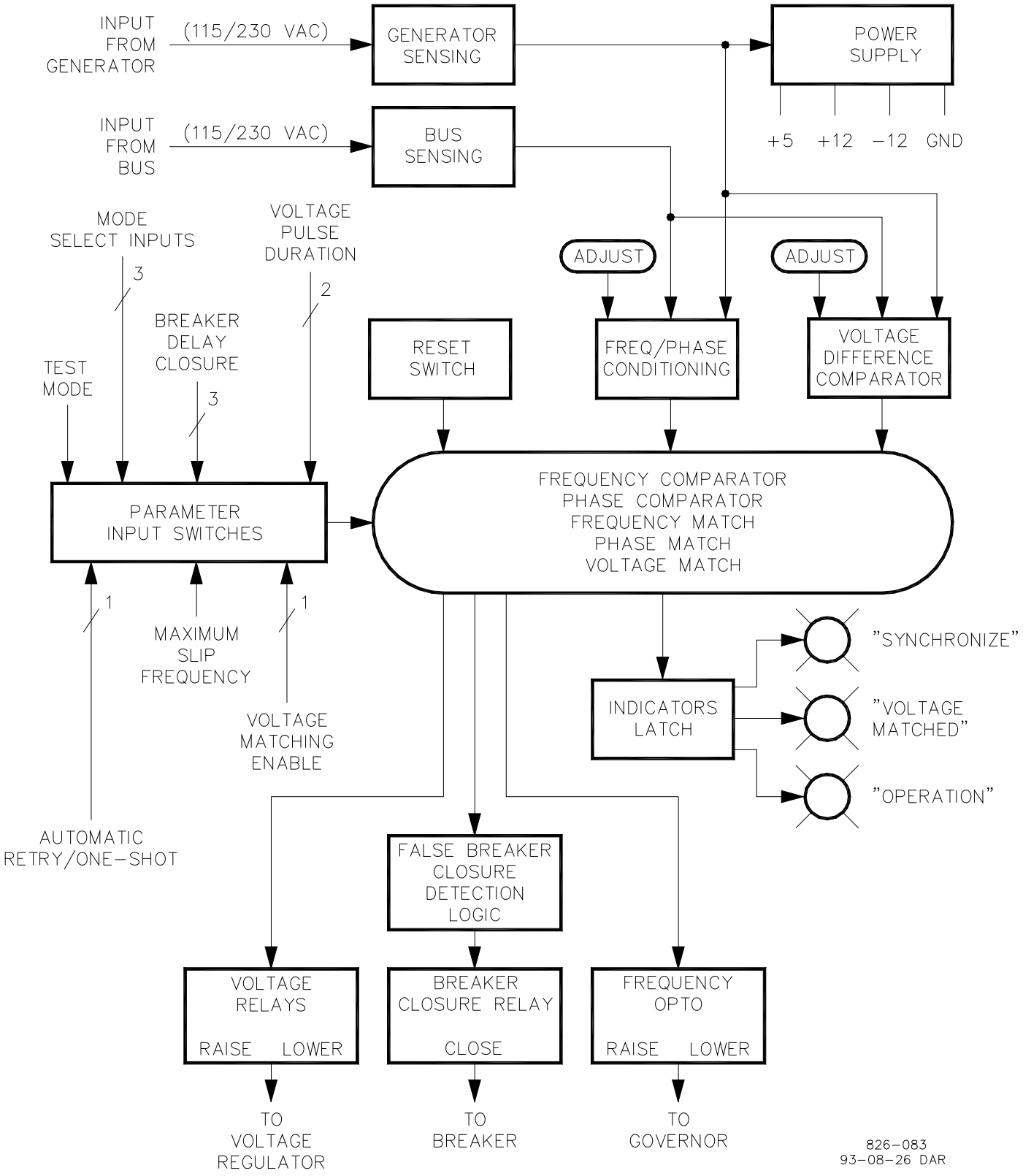

Figure 3-2. Functional Block Diagram

Chapter 4.
Description of Operation

Signal Conditioner

Internal transformers change the generator and bus inputs into 12 Vac signals. These signals are then filtered and shaped by a signal conditioner circuit into the square wave forms required by the digital speed matching circuitry. A phase offset adjustment is provided to compensate for any phase errors that might be introduced by the input transformers or potential transformers.

Voltage Difference Comparator

On models 8239-002, 8239-013, 8329-018, 8230-069, 9905-204, and 9905-346 with voltage matching, the generator and bus inputs are also processed through a voltage difference comparator circuit. This circuit compares the generator voltage to the bus voltage. Raise or lower signals are issued until the two voltages are equal. A voltage offset adjustment is provided to compensate for component tolerances.

Microcontroller

The outputs from the signal conditioner circuit and the voltage difference comparator circuit are sent to an internal micro controller along with data from the input switches. The controller compares and matches frequency and phase, and for models 8239-002, 8239-013, 8239-018, 8239-069, 9905-204, and 9905-346, voltage. The timing of the controller output signals is set to nominal specifications at the factory by internal switch selection. The type of output signals from the controller are dependent upon the operating mode selected.

When the mode selection switch is in the RUN or CHECK mode, the frequency and phase detection circuits of the controller will issue raise or lower commands to the speed control until the frequency and phase of the generator matches that specified by the option switches. The voltage matching circuit will issue raise or lower commands to the voltage regulator until the generator voltage is within 1% of the bus voltage.

When the mode selection switch is in the RUN mode, the microcontroller's breaker closure circuit will issue a breaker close command when frequency, phase, and voltage are matched. When the breaker retry switch is on position, the close commands will continue until synchronization is successfully established for 30 seconds.

When the mode selection switch is in the PERMISSIVE mode, the microcontroller only monitors the generator and bus inputs. It does not adjust frequency or voltage, but will issue breaker closure commands when the inputs are within synchronization parameters. When the switch is in the OFF mode, all synchronizer functions are disabled.

LEDs for SYNCHRONIZED, VOLTAGE MATCHED, and OPERATIONAL also are controlled by the microcontroller. The SYNCHRONIZED LED turns on to indicate the bus and generator are synchronized. The VOLTAGE MATCHED LED turn on to indicate the bus and generator voltages match. The OPERATIONAL LED turns on to indicate that the DSM Synchronizer is powered and operational.

WARNING

(for 8239-001 and -002 only)

To guarantee proper operation after initial start-up, the generator potential transformer outputs must be within the following ranges BEFORE power is applied to the synchronizer. The unit may fail to operate if this action is not followed.

Input	Vac	Hz
115 Vac	90–130	45–65
230 Vac	185–265	45–65

Interposing voltage-sensing relays may be required if the generator voltage applied to the system is less than 90 Vac.

Operating Modes

Off Mode

With Terminal 13 not connected to Terminal 10, 11, or 12, the DSM Synchronizer will operate in a Monitor Mode. In this mode power is still applied internally and the DSM monitors the frequency, phase, and voltage of the bus and generator. It does not trim speed, adjust voltage, or close the breaker. The SYNCHRONIZED LED will be illuminated if the bus and generator frequencies are equal, and the phase angle is less than 0.5 degrees (5 degrees on the 8239-069, 9905-346, and 9905-347).

The VOLTAGE MATCHED LED will be enabled if Voltage Matching is enabled (Option Switch 5), the SYNCHRONIZED LED is illuminated and the generator frequency is within 1% of the bus frequency. This mode is used to calibrate the phase- and voltage- matching logic. Refer to Chapter 3 for Calibration Instructions.

Permissive Mode

The Permissive Mode (Terminal 13 connected to Terminal 10) monitors the bus and generator for acceptable synchronization and closes the breaker when it occurs. It will not adjust speed or voltage. The VOLTAGE MATCHED LED will be illuminated if Voltage Matching (Option Switch 5) is enabled, and if the generator and bus frequencies are within 1%. The SYNCHRONIZED LED is illuminated and a Breaker-Closure Command is issued if the actual slip frequency matches the selected slip frequency (Option Switches 7, 8, and 9), and if the phase angle is within the breaker-closure phase-angle window.

Assuming that the voltage-matching option is installed and selected, the following conditions must be met in order for the DSM Synchronizer to close the breaker:

- The generator frequency is between 0.05 and 0.3 Hz greater than the bus frequency.
- Voltage matching is tested at zero degrees phase shift. The VOLTAGE MATCHED LED illuminates if the voltages match.

- The generator frequency is adjusted to match the selected slip frequency (Option Switches 7, 8, and 9).
- The SYNCHRONIZED LED illuminates and the breaker-closure command is issued when the phase angle is within the breaker-closure phase-angle window.

Check Mode

The Check Mode (Terminal 13 connected to Terminal 11) is for testing synchronization. When operating in the Check Mode, the DSM Synchronizer synchronizes the bus and generator by trimming speed (and voltage on voltage matching models, but does not close the breaker. The SYNCHRONIZED LED illuminates for two seconds to indicate when the Breaker Closure Command would have been issued if the DSM were operating in the Run Mode.

Run Mode

When operating in the Run Mode (Terminal 13 connected to Terminal 12), the DSM Synchronizer synchronizes the bus and generator by trimming speed (and voltage for voltage matching models), then closes the breaker. This mode uses one of two paths:

- Path 1 is followed when the selected slip frequency is 0.015, 0.030, or 0.050 Hz.
- Path 2 is followed when the selected slip frequency is 0.07, 0.100, 0.150, 0.210, or 0.255 Hz.

Path 1

- The DSM adjusts generator frequency until it is between 0.050 and 0.150 Hz greater than the bus frequency. (This equals a synchroscope loop time of between 7 and 20 seconds.)
- The DSM matches voltage prior to adjusting the slip frequency to that selected by Option Switches 7, 8, and 9. Voltage-matching adjustments are made only if the slip frequency is between 0.050 and 0.150 Hz and the phase angle is plus or minus 5 degrees. During the remainder of the 7–20 second loop time, the DSM monitors and adjusts generator frequency to maintain the frequency between 0.050 and 0.150 Hz.
- The VOLTAGE MATCHED LED illuminates when the generator voltage is within 1% of the bus voltage (5% for 8239-013 and 8239-069).
- The DSM monitors and adjusts generator frequency to maintain the slip frequency between 0.050 and 0.150 Hz until the phase angle is less than the 90 degree adjustment angle (phase difference between generator and bus).
- When the phase angle is less than or equal to the 90 degree adjustment angle, the DSM adjusts the generator frequency downward to the selected slip frequency.
- The DSM monitors and adjusts the generator frequency until the breaker-closure phase-angle window is entered.
- The SYNCHRONIZED LED illuminates and the breaker-closure command is issued.
- If the DSM misses the closing-phase-angle window, the DSM rechecks the voltage and repeats the above sequence.

Path 2

- The DSM adjusts generator frequency until it is between 0.050 and 0.150 Hz greater than the bus frequency. (This is equal to a synchroscope loop time of between 7 and 20 seconds.
- The DSM matches voltage prior to adjusting the slip frequency to that selected by Option Switches 7, 8, and 9. Voltage-matching adjustments are made only if the slip frequency is between 0.050 and 0.150 Hz and the phase angle is plus or minus 5 degrees. During the remainder of the 7–20 second loop time, the DSM monitors and adjusts the generator frequency to maintain the slip frequency between 0.050 and 0.150 Hz.
- The VOLTAGE MATCHED LED illuminates when the generator voltage is within 1% of the bus voltage (5% for 8239-013 and 8239-069).
- The DSM adjusts the generator frequency to obtain the selected slip frequency.
- The DSM monitors and adjusts the generator frequency until the breaker-closure phase-angle window is entered.
- The SYNCHRONIZED LED illuminates and the breaker-closure command is issued.
- If the DSM misses the closing-phase-angle window, the DSM rechecks the voltage and repeats the above sequence.

Software Procedures

Setup Parameters Procedure

The DSM executes the following software steps in the order indicated after a power-up reset or mode selection change:

- Disable all LEDs.
- Test for active generator frequency. The DSM will loop here indefinitely until an active generator frequency is detected.
- Test for active bus frequency. The DSM will loop here indefinitely until an active bus frequency is detected. The DSM will not operate with a dead bus.

A Testing Parameters Procedure

- Test for generator frequency greater than 44 Hz. If less than 44 Hz, the OPERATIONAL LED flashes approximately 2.5 times/second; return to *A*.
- Test for bus frequency greater than 44 Hz. If less than 44 Hz, the SYNCHRONIZED LED Flashes approximately 2.5 time/second; returning to *A*.
- Read Option Switches and initialize parameter tables.
- Set up parameters used in the synchronizing process.
- Test for illegal option-switch states. An illegal state is any combination of breaker-closure delay and maximum-slip frequency switch settings that results in a phase angle greater than 20 degrees when the breaker-closure command is given. Refer to Chapter 3, Invalid DSM States for more detail. If an illegal option-switch state is detected, both the VOLTAGE MATCHED AND SYNCHRONIZED LEDs are flashed approximately 2.5 times/second; return to *A*.
- The OPERATIONAL LED illuminates; Set Up Parameter Testing is complete.
- Branch to the selected mode.

Frequency Raise/Lower Pulse Self Calibration Procedure

The self-calibration procedure determines the pulse width of the frequency raise/lower signals. The self-calibration procedure is executed only when the RUN or CHECK Mode is selected.

To determine the pulse width, the DSM issues a series of frequency-raise pulses with increasing pulse duration of from 1 to 200 milliseconds. It locks in the shortest of these frequency-raise pulse widths that gets a response from the system.

Breaker Retry Procedure

This procedure is executed if Option Switch 6 was set ON and the breaker-closure command is issued.

- Issue breaker-closure command.
- Delay 3 seconds.
- Monitor bus and generator frequencies and phase angle for 30 seconds. If there is no change, exit to OFF (MONITOR) Mode. In order to re-enable the DSM Synchronizer, either the mode selection must be reselected or the DSM must be powered down and powered up again.
- If the breaker is detected open, return to beginning of selected mode (refer to "Operating Modes").

Chapter 5.
Service Options

Product Service Options

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

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

OEM and 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 **Recognized Turbine Retrofitter (RTR)** is an independent company that does both steam and gas turbine control retrofits and upgrades globally, and can provide the full line of Woodward systems and components for the retrofits and overhauls, long term service contracts, emergency repairs, etc.

You can locate your nearest Woodward distributor, AISF, RER, or RTR on our website at:

www.woodward.com/directory

Woodward Factory Servicing Options

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

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

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

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

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

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

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

Returning Equipment for Repair

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

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

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

Packing a Control

Use the following materials when returning a complete control:

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

NOTICE

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

Replacement Parts

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

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

Engineering Services

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

- Technical Support
- Product Training
- Field Service

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

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

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

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

How to Contact Woodward

For assistance, call one of the following 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.

Electrical Power Systems

Facility	Phone Number
Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727
Germany	+49 (0) 21 52 14 51
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

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

Turbine 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

You can also locate your nearest Woodward distributor or service facility on our website at:

www.woodward.com/directory

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:

Your Name	
Site Location	
Phone Number	
Fax Number	
Engine/Turbine Model Number	
Manufacturer	
Number of Cylinders (if applicable)	
Type of Fuel (gas, gaseous, steam, etc)	
Rating	
Application	
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	

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 85100L.

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**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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