WOODWARD

**Installation and Operation Manual**


# MSLC
# Master Synchronizer and Load Control

**9907-004 (4-Wire Wye)**
**9907-005 (3-Wire Delta, 120 V)**
**9907-006 (3-Wire Delta, 240 V)**

**Manual 02022 (Revision B)**

## WARNING—DANGER OF DEATH OR PERSONAL INJURY

### WARNING—FOLLOW INSTRUCTIONS

Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.

### WARNING—OUT-OF-DATE PUBLICATION

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

www.woodward.com/pubs/current.pdf

The revision level is shown at the bottom of the front cover after the publication number. The latest version of most publications is available at:

www.woodward.com/publications

If your publication is not there, please contact your customer service representative to get the latest copy.

### WARNING—OVERSPEED PROTECTION

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

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

### WARNING—PROPER USE

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

## CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY

### CAUTION—BATTERY CHARGING

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

### CAUTION—ELECTROSTATIC DISCHARGE

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts.

- Discharge body static before handling the control (with power to the control turned off, contact a grounded surface and maintain contact while handling the control).
- Avoid all plastic, vinyl, and Styrofoam (except antistatic versions) around printed circuit boards.
- Do not touch the components or conductors on a printed circuit board with your hands or with conductive devices.

## IMPORTANT DEFINITIONS

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

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# Chapter 1.
# General Information

## Introduction

This manual describes the Woodward MSLC Master Synchronizer and Load Control.

## Application

The MSLC is a microprocessor-based overall plant load control designed for use in a system with Woodward DSLC™ (Digital Synchronizer and Load Control) controls on each generator to provide utility synchronizing, paralleling, loading, and unloading of a three-phase generating system.

MSLC functions include:

- Selectable for phase matching or slip frequency synchronizing between the utility and a local bus with voltage matching;
- Automatic system loading and unloading for bumpless load transfer;
- Import/Export level control capability;
- Process control for cogeneration, pressure, maintenance, or other process;
- Proportional loading of associated DSLC controls in isochronous load sharing;
- Adjustable Power Factor control;
- Built in diagnostics with alarm relay driver output;
- Multi-function adjustable high and low limit alarms and adjustable load switches with relay driver outputs;
- Digital communications network to provide loading and power factor control of individual DSLC equipped generators;
- Full setup, metering, and diagnostic capability through a hand held programmer terminal (Figure 1-2).

## Synchronizer

The MSLC uses digital signal processing techniques to derive both true RMS voltages and relative phase angles of the fundamental frequencies of the utility and the local bus voltage wave forms. Digital signal processing techniques offer significantly improved measurement accuracy in the presence of wave form distortions, particularly since the phase measurement does not depend on zero crossings of the voltage wave forms.

Either phase matching or slip frequency synchronizing may be selected. Phase matching provides rapid synchronizing for critical standby power applications. Slip frequency synchronizing ensures that the initial flow of power will be either out of the local system (export) or into the local system (import), depending on whether a positive or negative slip is chosen. For both synchronizing methods, the MSLC uses actual slip frequency and breaker delay values to anticipate an adjustable minimum phase difference between the utility and the local bus.

Additional synchronizer functions include voltage matching, time delayed automatic multi-shot reclosing, auto-resynchronizing, and a synchronizer timeout alarm. Each of these features may be enabled or disabled during setup.

# Load Control

The load control uses digital signal processing techniques to provide significantly improved accuracy and speed of response over conventional analog measurement techniques. Accuracy is improved because the instantaneous measurement of the voltage and current signal wave forms allows true RMS measurement. Measuring true RMS power allows optimal load control in parallel applications even in the presence of power line distortions. This method provides faster response time because it eliminates the long integration times required in analog circuits. Measurement speed is particularly important in power control applications where rapid response to load and speed changes is essential.

Load control begins at breaker closure when the MSLC takes control of the system load. The system load immediately prior to breaker closure is used as the starting base load. On command, the adjustable ramp allows smooth, time-controlled loading into a set import/export level. A ramp pause switch is provided to stop the ramp at any point.

The import/export control is an integrating control. It adjusts the percentage of rated load carried by the individual generators, operating in isochronous load sharing, in order to maintain a set import/export or base load level. The MSLC will therefore maintain a constant base load or import/export level even with changing utility frequencies. The MSLC provides switch inputs to allow raising or lowering the internal digital base load or import/export reference. The control also provides a 4–20 mA (1–5 Vdc) analog input for remote reference setting, if desired.

The MSLC is equipped with a Utility Unload switch, which provides an adjustable time controlled ramp to lower the base load or import/export level. When the level is below an adjustable threshold, the MSLC issues a breaker open command to separate the utility from the local bus. Again, the ramp pause switch can be used to stop the utility unload at any point. The maximum load that the MSLC can tell the individual generators to carry is their rated loads. So, in the event that the plant load is greater than the capacity of the operating generators, the utility unload will stop when 100% rated load is reached on each of the operating generators. This prevents accidental overloading of the local generators when a reduced number are on line.

The MSLC also includes two adjustable load switches which can be used for external functions or warnings when chosen system load levels are attained. The high and low limit switches may also be activated when 100% or 0% base load signal to the generators is reached.

# Process Control

A process controller is provided for cogeneration, fluid level maintenance, pressure control, or other applications. An adjustable bandwidth signal input filter, flexible PID controller adjustments, an adjustable deadband, and control selectable for direct or indirect action, allow the process control to be used in a wide variety of applications.

A 4–20 mA (1–5 Vdc or a 4–12–20 mA) process transmitter provides the process signal to the MSLC. The MSLC includes an internal digital process reference which may be controlled by the raise and lower switch contact inputs or by an external 4–20 mA (1–5 Vdc) remote process reference. The output of the process control, like the import/export control, is the percentage of rated load setpoint to the individual generators in isochronous load sharing.

An adjustable ramp allows smooth entry and exit from the process control mode. When the process control mode is selected, the load reference is ramped in a direction to reduce the error between the process input and the process reference. When the error is minimized or the reference first reaches either the high or low specified pull-in limits, the process controller is activated. When the load reference output reaches either 100% or 0%, the control will maintain that load reference until process control is established. The MSLC is not capable of overloading or reverse powering in order to attempt to meet the process reference. The high and low limit switches mentioned above can be used to indicate that either too many or too few generators are on-line to maintain the process within its limits.

## VAR/PF Control

The VAR/PF function controls the power factor on all of the DSLC equipped machines operating in isochronous load sharing. The PF control begins on breaker closure. The MSLC has three modes of VAR/PF control (which are selected in Menu 4):

- Constant Generator Power Factor—sets the power factor reference on all of the DSLC controls to the internal reference chosen in the MSLC. The power factor can then be adjusted using the voltage raise and lower inputs. The voltage raise command will make the power factor more lagging. Conversely, the voltage lower command will make the power factor more leading.
- Utility Tie Power Factor Control—adjusts the power factor reference on all of the DSLC controls in isochronous load sharing in order to maintain the power factor across the utility tie.
- Utility Tie VAR Control—adjusts the power factor reference on all of the DSLC controls in isochronous load sharing in order to maintain the level of reactive load being imported or exported from the utility.

## Manual Organization

- Chapter 2 covers electrostatic discharge awareness. The MSLC is an electronic device containing sensitive components. While the control is designed for safe handling in the industrial environment, certain cautions must be observed during handling and shipping or when removing the cover.
- Chapter 3 covers MSLC installation and wiring, including each major group of connections, along with any special instructions.
- Chapter 4 covers MSLC configuration, setup, and adjustment. The chapter explains the purpose of each set point and recommended initial value.
- Chapters 5 through 8 explain the major functions of the synchronizer, import/export control, process control, and PF control.
- Chapter 9 describes the Echelon Local Operating Network (LON) used by the MSLC to communicate to the individual DSLC controls.
- Chapter 10 provides a troubleshooting guide. Due to the extensive built-in diagnostics, MSLC installation may be tested and verified quickly.
- Chapter 11 describes how to return the control to Woodward in the event of damage or failure of an internal component.
- Appendix A contains a work sheet to aid in setup and to provide a place to record setup values for future reference.
- Appendix B lists the MSLCs physical and electric specifications.

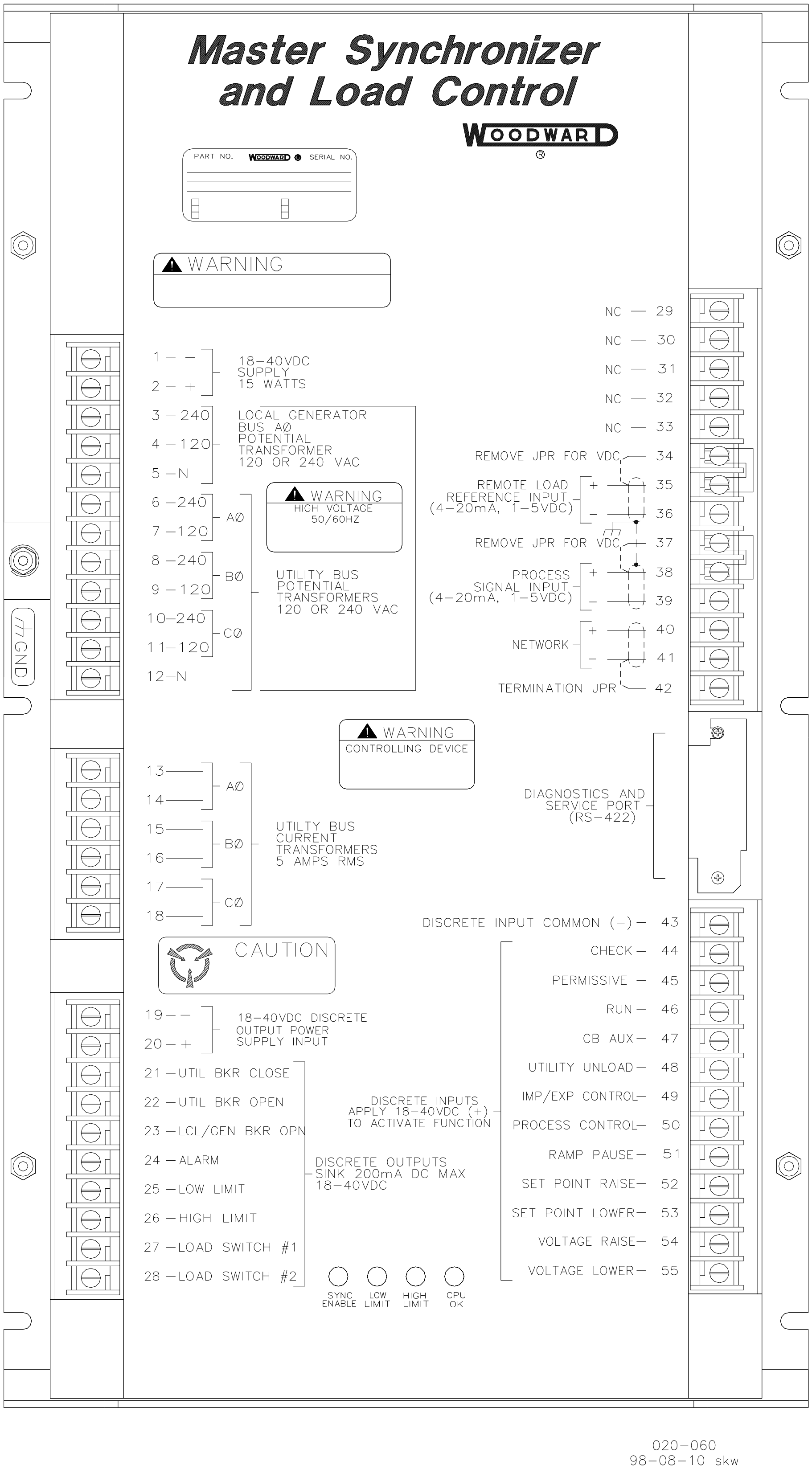



Figure 1-1a. MSLC (wye version shown)

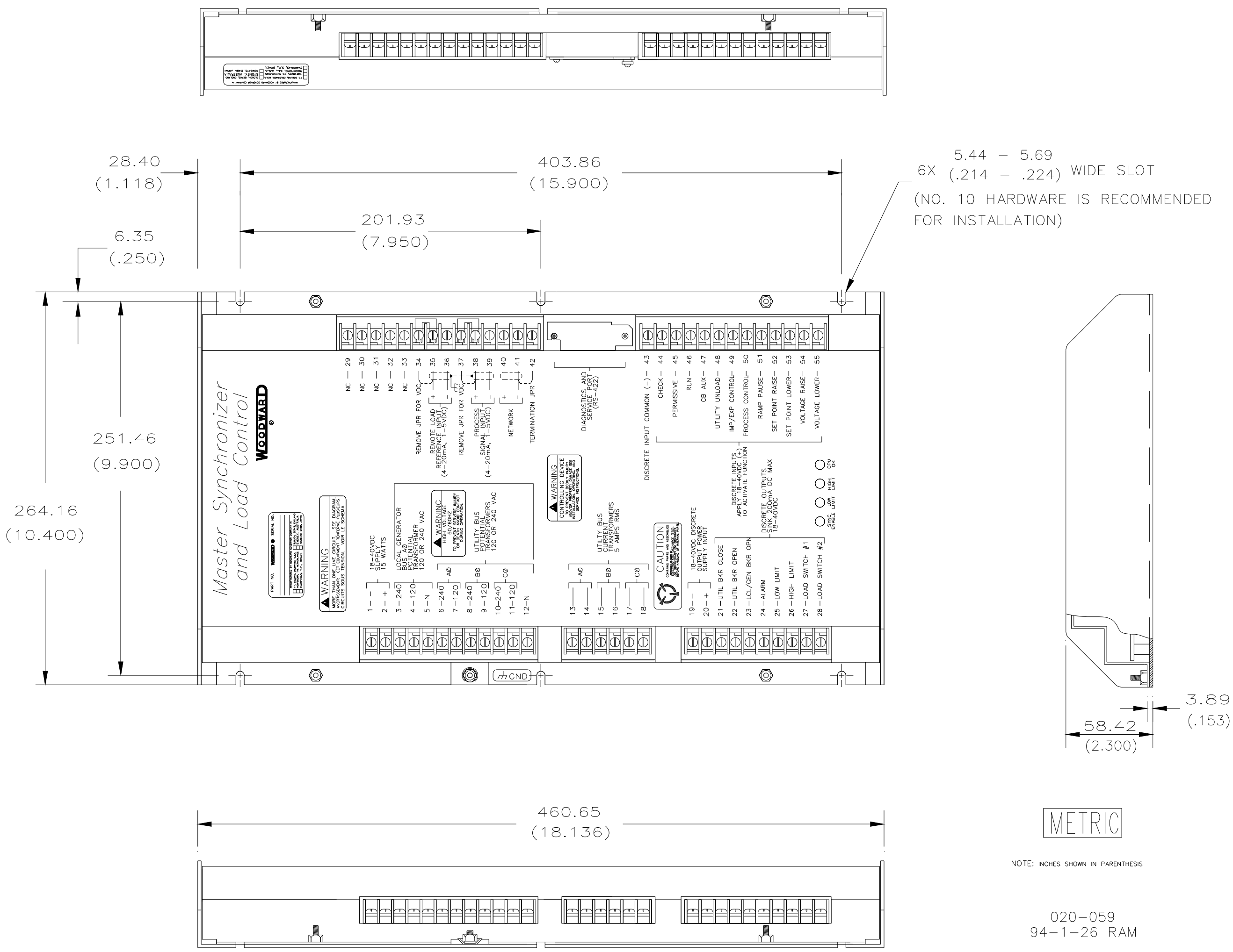



Figure 1-1b. MSLC Dimensions (wye version shown)

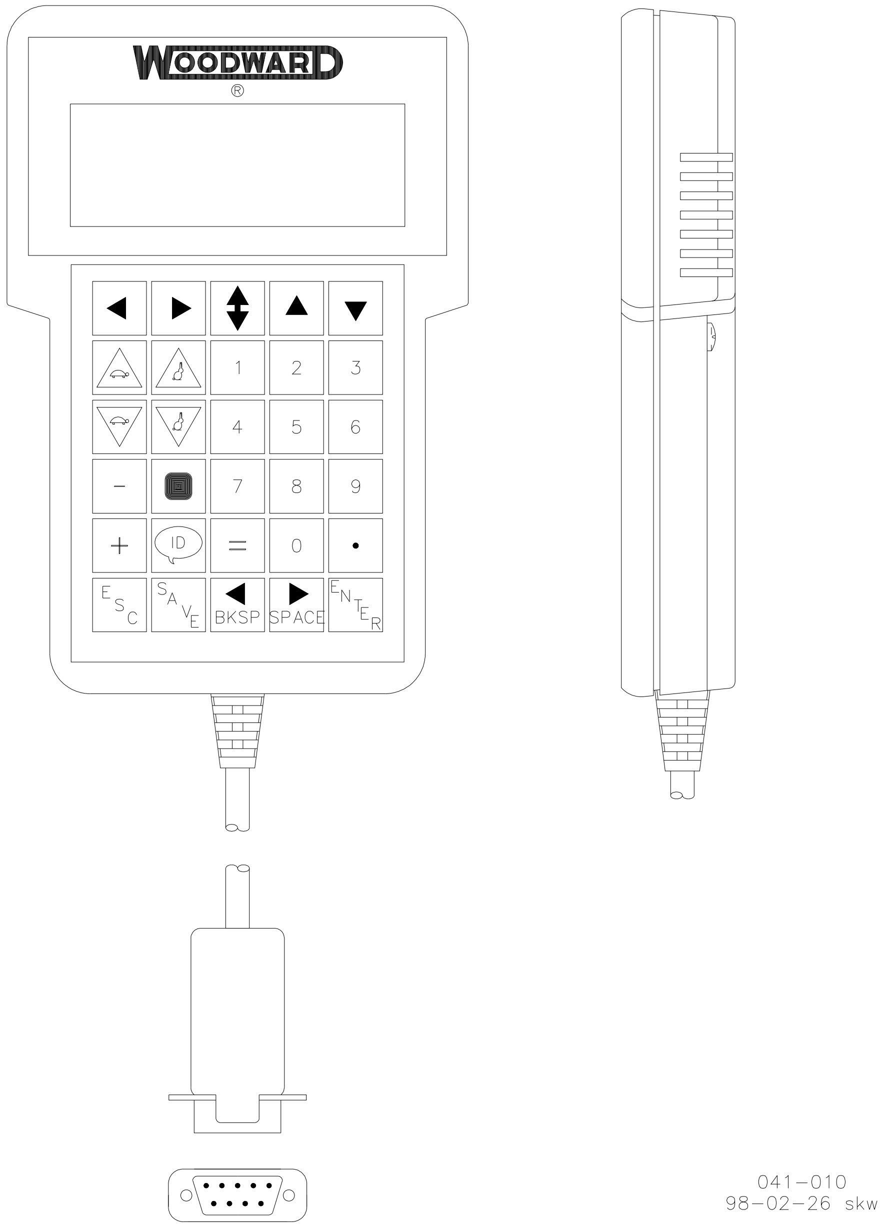



Figure 1-2. Hand Held Programmer

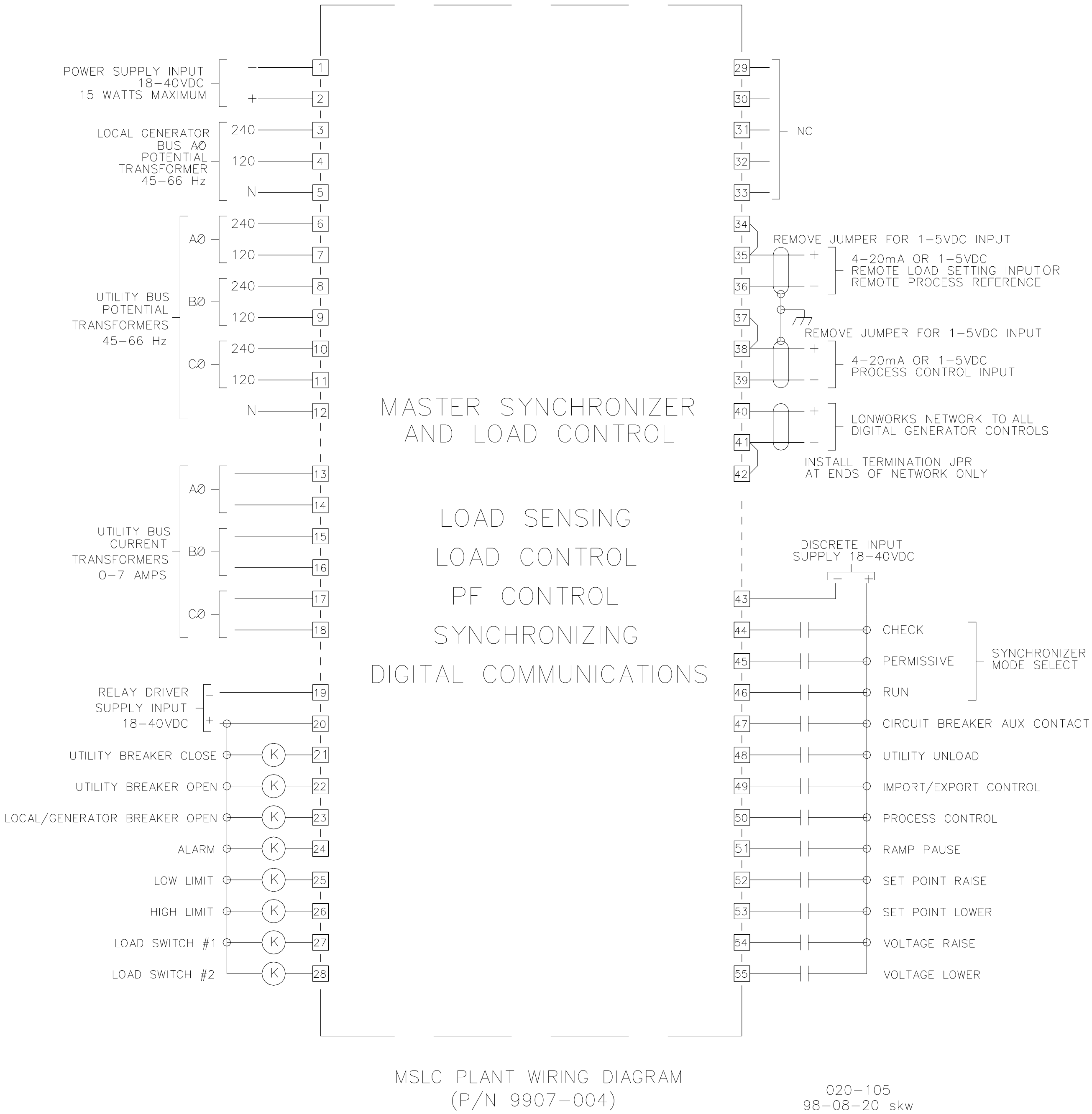



Figure 1-3. Typical Wiring Connections
(9907-004 for 120/240 V wye switchgear configuration)

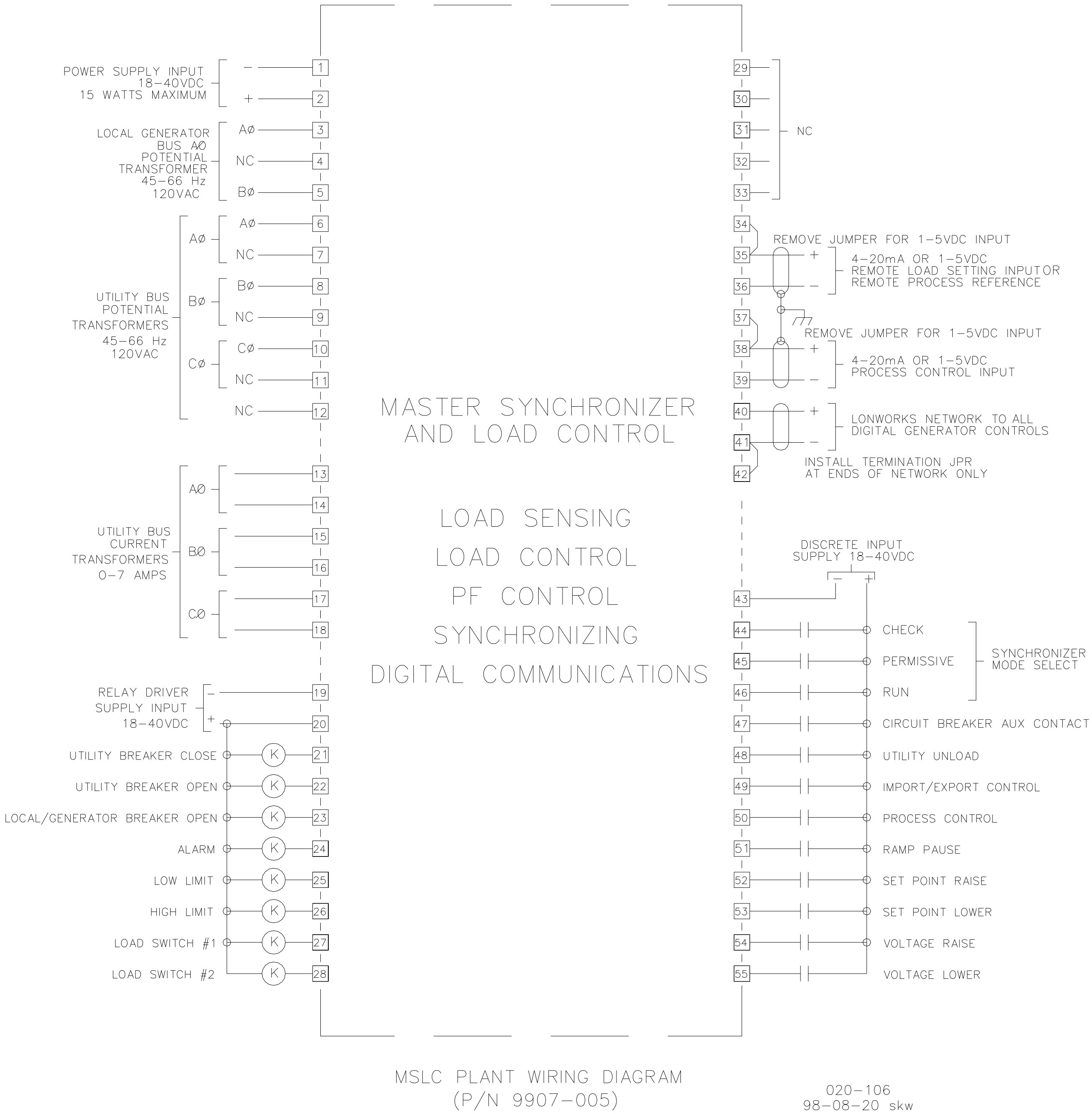



Figure 1-4. Typical Wiring Connections
(9907-005 for open delta, 120 V switchgear configuration)

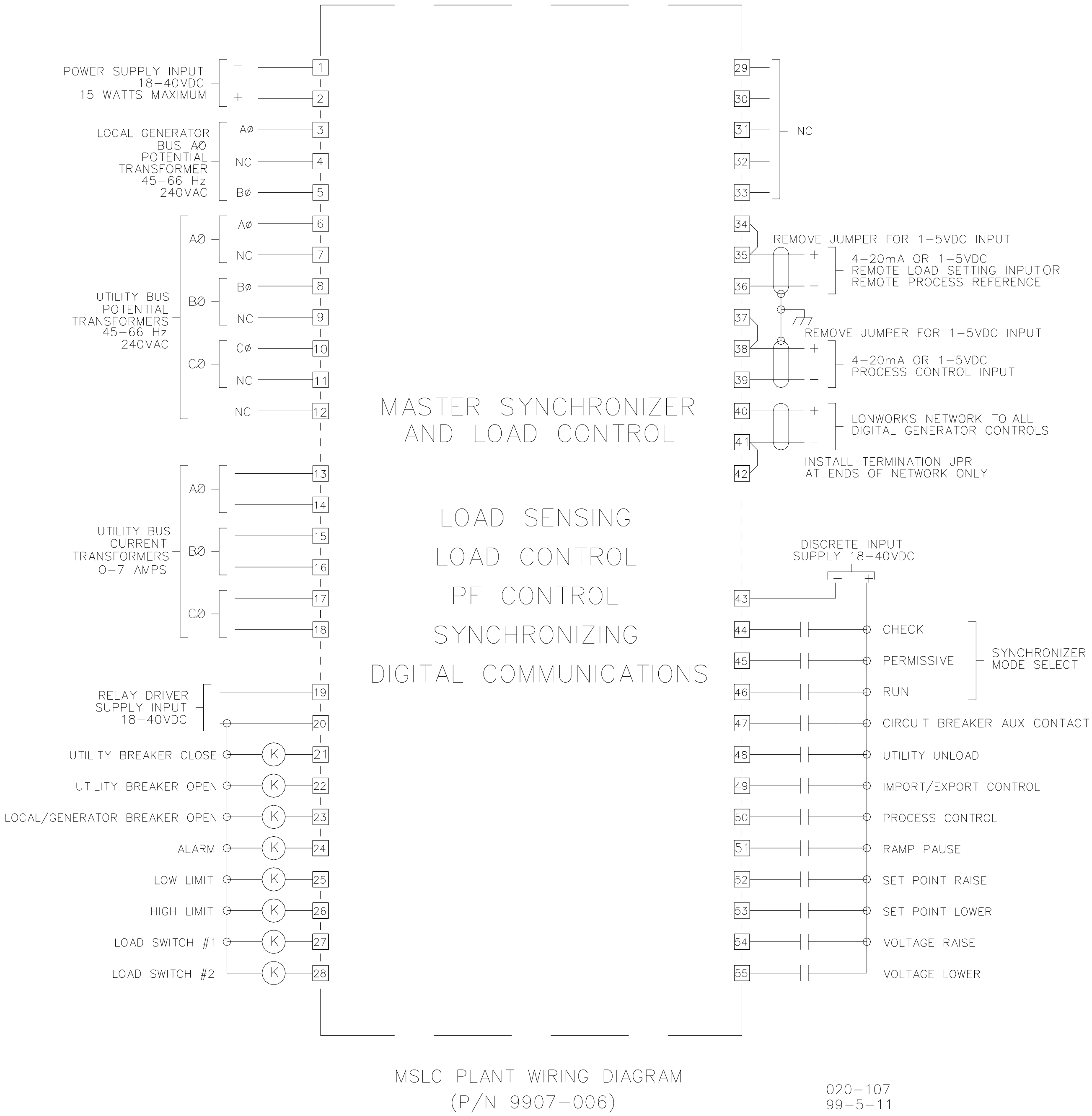



Figure 1-5. Typical Wiring Connections
(9907-006 for open delta, 240 V switchgear configuration)

# Chapter 2.
# Electrostatic Discharge Awareness

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

Follow these precautions when working with or near the control.

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

2. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.

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

4. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:

    - Do not touch any part of the PCB except the edges.

    - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.

    - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

**CAUTION—ELECTROSTATIC DISCHARGE**

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

# Chapter 3. Installation

## Introduction

This chapter provides the general information for site selection, installation, and wiring of the MSLC.

## Unpacking

Before unpacking the control, refer to the inside front cover of this manual for WARNINGS and CAUTIONS. Be careful when unpacking the control. Check for signs of damage such as bent or dented panels, scratches, loose or broken parts. If any damage is found, immediately notify the shipper.

## Location

When selecting a location for mounting the MSLC, consider the following:

- Protect the unit from direct exposure to water or to a condensation-prone environment.
- The continuous operating range of the MSLC is –40 to +70 °C (–40 to +158 °F).
- Provide adequate ventilation for cooling. Shield the unit from radiant heat sources.
- Do not install near high-voltage, high-current devices.
- Allow adequate space in front of the unit for servicing.
- Do not install where objects can be dropped on the terminals.
- Ground the chassis for proper safety and shielding.
- The control must NOT be mounted on the engine.

## Installation

Select a mounting location for the MSLC (see considerations above). Locate and drill six (6) holes for mounting hardware (not furnished; see Figure 1-1 for locations). Tap the holes for machine screws or bolts. Install the unit and secure with the mounting hardware.

## Electrical Connections

This section covers typical wiring connections, as shown in Figure 1-3. For other applications, contact Woodward Governor Company for assistance.

Connect the terminals as shown in Figure 1-3. When making the connections, observe the following:

- Make all connections using insulated terminals. Use 0.5 $mm^2$ (20 AWG) or larger stranded wire.
- Make sure that all wires shown as shielded on the wiring diagram are stranded, twisted-pair, shielded wire.
- Do not place shielded wires in the same cable conduits with high-voltage or high-current carrying cables.

- Connect the cable shields to chassis ground. Shields are grounded at the control end only for inputs and at the speed control and voltage regulator end for outputs.
- Make sure that cable shields are carried through all intermediate terminal blocks from signal source to signal termination.
- Do not subject any wiring to temperatures above 100 °C (212 °F).
- Avoid kinks or sharp bends in the wiring. Make sure that all connections are tight.

For additional wiring information, see Woodward manual 25070, *Electronic Control Installation Guide*.

Install and wire the other units and actuators in your system using instructions in applicable manuals.

## Shielded Wiring

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Wire exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches). The other end of the shields must be left open and insulated from any other conductor. Do NOT run shielded signal wires along with other wires carrying large currents. See Woodward application note 50532, *Interference Control in Electronic Governing Systems* for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below.

1. Strip outer insulation from BOTH ENDS, exposing the braided or spiral wrapped shield. DO NOT CUT THE SHIELD.

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

3. Pull inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.

4. Remove 6 mm (1/4 inch) of insulation from the inner conductors.

5. Connect wiring and shield as shown in plant wiring diagram.

Installations with severe electromagnetic interference (EMI) may require additional shielding precautions, such as wire run in conduit or double shielding.

## Power Supply

The MSLC requires a nominal voltage source of 20 to 40 Vdc. Power to the control should be maintained whenever the generator set is available for service.

**CAUTION—APPLY POWER**

**Power must be applied to the MSLC at least 15 seconds prior to expected use. The control must have time to do its power up diagnostics and establish its location in the local area network to become operational. Failure of the diagnostics will disable control function and de-energize the alarm relay.**

Power supply output must be of a low impedance type for proper operation of the control. DO NOT power a control from a high voltage source containing dropping resistors and zener diodes. If batteries are used for operating power, an alternator or other battery charging device is necessary to maintain a stable supply voltage.

Run power supply leads directly from the power source to the control, connecting the negative (neutral) lead to terminal 1, and the positive lead (line) to terminal 2. DO NOT POWER OTHER DEVICES WITH LEADS COMMON TO THE CONTROL. Avoid long wire lengths.

**CAUTION—DO NOT APPLY POWER**

**Do NOT apply power to the control at this time. Applying power may damage the MSLC.**

**NOTE**

**The MSLC receives its current and voltage input signals from standard metering current transformers (CTs) and potential transformers (PTs). The selection of these PTs and CTs will have an effect on synchronizer voltage and phase matching and load sensing accuracy. Identical potential transformers should be used for the generator and bus voltages. CTs should provide 5 A RMS at full load for best performance of the system.**

**The following sections describe the potential connections for the synchronizer and power sensor functions. The MSLC real power sensor is available in either a four-wire, three-sensor device, which measures only line-to-neutral voltages, or in a three-wire, three-sensor device which measures only line-to-line voltages. The voltage sensing configuration options are described by the “WYE” and “Delta” part number versions.**

**When connected to 4-wire wye systems with 120/240 Vac line-to-neutral voltages, no potential transformers are required. Higher voltage systems require potential transformers to reduce voltages to the 120/240 nominal range.**

**Typically, 3-wire delta systems will always require potential transformers to reduce the line-to-line voltages to the proper levels needed at the input to the control (either 120 or 240 Vac, depending on the control part number).**

## Local Bus Potential Transformers

The synchronizer potential input on the MSLC is connected to the secondary of a 120 or 240 Vac potential transformer. The local bus phase A must correspond to phase A of the utility as wired into the MSLC load sensor. The voltage difference between these inputs must not exceed 150 Vac RMS on inputs labeled 120V, or 300 Vac RMS on inputs labeled 240V respectively. Local bus phase rotation must correspond to the phase rotation of the utility or tie bus for proper synchronization.

**NOTE**
**If the local bus PT input is not connected in the same configuration as the utility bus PT inputs, a phase offset will have to be calibrated into the local bus PT (see Chapter 4, Phase Matching Synchronizer).**

**For example, if a WYE version MSLC has the utility bus PT inputs connected in a four-wire WYE configuration, and the local bus PT input is connected to sense line-to-line voltage, a phase offset will need to be calibrated into the synchroscope for proper phase angle indication, and synchronizer operation. See Chapter 4, Phase Matching Synchronizer for more information.**

## Utility Potential Transformers

Connect the utility potential inputs on the MSLC secondary as shown in the plant wiring diagrams of Figures 1-3, 1-4, or 1-5 as determined by the part number of the MSLC, and system application.

When connected to 4-wire wye systems with 120/240 Vac line-to-neutral voltages, no potential transformers are required. Higher voltage systems require potential transformers to reduce voltages to the 120/240 nominal range. Typically, 3-wire delta systems will always require potential transformers to reduce the line-to-line voltages to the proper levels needed at the input to the control (either 120 or 240 Vac, depending on the control part number).

Utility Bus phase rotation must correspond to the phase rotation of the local bus for proper synchronization. The MSLC does not sense phase rotation.

## Utility Current Transformers

Connect the utility current inputs on the MSLC to the output of current transformers, which in turn is placed around one conductor of one phase of the utility bus being monitored. **Phasing is away from the utility** (see Figure 5-2 for the wiring diagram).

For proper operation, it is important that the current transformers be connected correctly. This means that the corresponding phase current transformer and potential transformer must be connected to the same phase terminals on the MSLC, and that the correct polarity be observed.

**WARNING—ELECTRIC SHOCK**
**Because of the risk of fatal electric shock, never disconnect any wire attached to the utility current transformers (terminal 13 through 18) when the utility feeder is energized or has the potential of becoming energized, unless a shorting terminal block and temporary 1 A, 5 W resistors are installed as shown in Figure 3-1.**

## Discrete Outputs

The discrete outputs are the relay driver output commands from the MSLC. Each optically isolated discrete output is designed as a low-side driver capable of sinking a maximum of 200 mA. The use of drivers allows the user to supply relays of a contact rating appropriate for the particular application.

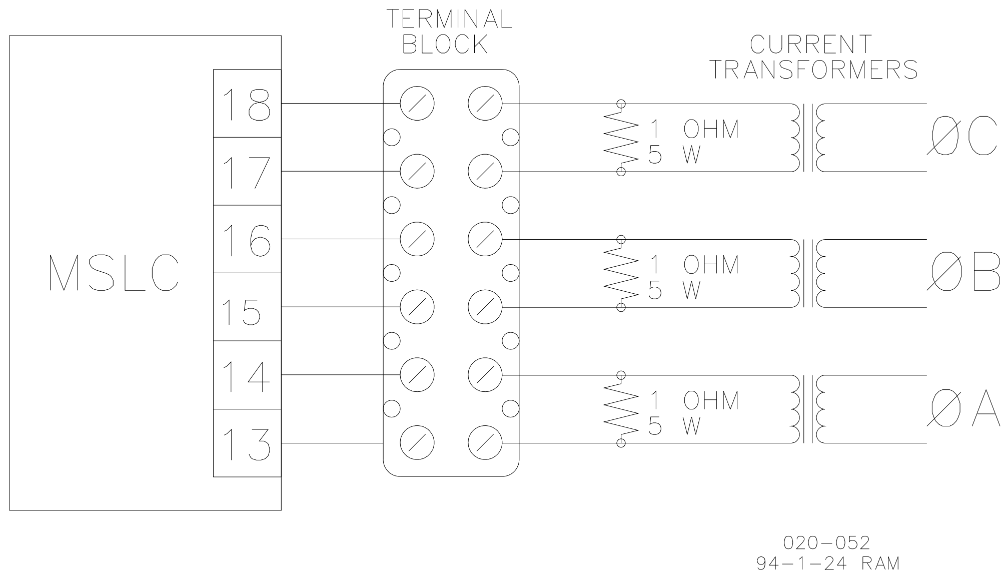



Figure 3-1. Temporary Wiring for Transformer Phase Correction

Discrete outputs require approximately 10 mA at 24 Vdc to power. The discrete outputs should be powered by the same voltage source as the control power. Connect the 24 Vdc common (–) to terminal 19, and +24 Vdc to terminal 20. The +24 Vdc is also routed through the appropriate external relay coil to the discrete output.

Each discrete output contains a diode to suppress the fly-back spikes that occur when a relay coil is de-energized. For optimum EMI suppression, however, we recommend the use of relays with self-contained suppression diodes.

## Circuit Breaker Relays

Make connections from the utility tie breaker close relay to terminal 21, the utility tie breaker open relay to terminal 22, and the local bus to generator bus tie breaker open relay to terminal 23 as shown in Figure 1-3.

## Load Management Relays

The MSLC provides two adjustable load switches and high and low limit relay drivers. The load switches can be adjusted for any generator load level, and the high and low limits are set at 100% and 0% respectively. The high and low limits are selectable to a particular high/low limit or as an indication of a high/low limit condition for voltage, process, or load. Make connections to terminals 24–27 as shown in Figure 1-3.

## Alarm Relay

Make the alarm relay connection as shown in Figure 1-3 to terminal 28 of the MSLC. Alarm conditions are selectable by the user (see tables in Chapter 4).

# Discrete Inputs

The discrete inputs are the switch input commands to the MSLC. Discrete inputs are optically isolated from the control and require 10 mA at 24 Vdc each to activate. Discrete inputs may be powered by the same source as control power. All contacts used in the discrete circuits should be the isolated dry contact type to work properly with the low currents used in these circuits.

Connect the 24 Vdc supply common (–) to terminal 43. Route +24 Vdc through the appropriate external contact to the discrete input.

## Synchronizer Mode Switch

The synchronizer mode switch (single-pole, four-position) controls the operating mode of the synchronizer. The switch must be wired to terminals 44, 45, and 46, as shown in Figure 1-3. The four positions are Off, Check mode, Permissive mode, and Run mode. When the switch is off, the synchronizer is out of operation.

## CB Aux Contact

Connect the utility breaker auxiliary (CB Aux) contact that opens and closes when the utility tie breaker opens and closes. Wire the breaker auxiliary contact in series between the +24 Vdc voltage source and terminal 47 of the MSLC. In addition, it may be desirable to put an MSLC ON/OFF switch in series with this input.

## Utility Unload Contact

Connect the utility unload switch to terminal 48.

## Import/Export Control Contacts

The import/export mode of control is initiated by closing the CB Aux contact 47 and closing the import/export contact 49.

## Process Control Mode Contact

If the MSLC will be used as a process control, connect a switch from +24 Vdc to the Process Control discrete input, terminal 50. When this contact is closed, load on the associated DSLC™ equipped generators in isochronous load sharing is controlled at a level required to maintain the analog process input at a chosen reference.

## Ramp Pause Contact

Connect the load ramp pause switch contact to terminal 51. When closed, this contact will hold any load ramp in progress at its current setting until the contact is opened.

### Raise and Lower Set Point Contacts

Connect a center off, double-pole double-throw switch to the Raise and Lower Load inputs, terminals 52 and 53. If the remote reference will be used, install a second double-pole double-throw switch to simultaneously select both the Raise and Lower inputs.

### Local Bus Voltage Adjustment Contacts

The Local Bus voltage adjustment contact inputs allow manual voltage control of the operating generator's voltages for manual paralleling. Note, if the individual generators are in VAR/PF control, they will return to VAR/PF control as soon as the MSLC's raise/lower switches are returned to OFF. The switches may also be used to change the constant generator power factor reference if operating in that mode.

## Local Area Network

Proper installation of the network wiring is critical to assure that the network (and thus the power generation system) operates correctly. The following requirements must be met:

1. Use only recommended shielded twisted pair cabling for the LonWorks network. Correct cable is available from Woodward, Belden, or other suppliers providing an equivalent cable.
   Belden
   PO Box 1980
   Richmond, IN 47375
   983-5200

| Belden Part Number | Description |
|---|---|
| 9207 | PVC 20 AWG shielded. NEC Type CL2, CSA Cert. PCC FT 1. |
| 89207 | Teflon 20 AWG shielded, Plenum version. NEC Type CMP, CSA Cert. FT 4. Woodward P/N 2008-295. |
| YR28867 | PVC 22 AWG shielded. |
| YQ28863 | Plenum 22 AWG shielded. |

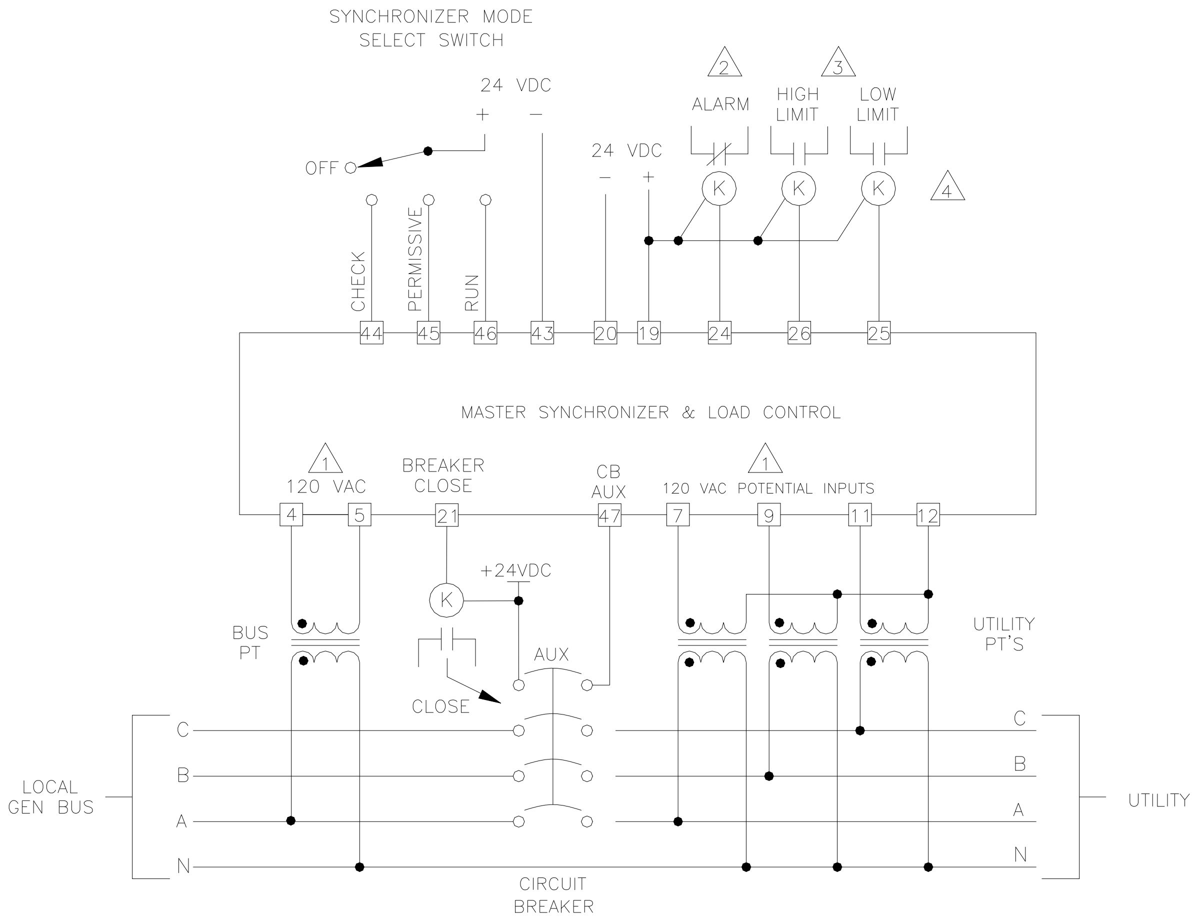
2. Maximum cable length for a LonWorks 1.25 MBPS network is 500 m (1640 feet).

3. Maximum number of network nodes is 64, but the maximum number of MSLC and DSLC controls combined is 16.

4. Maximum stub or drop length from the network bus is 300 mm (12 inches).

5. Shields must be carried through all junction boxes and should be grounded at one central location only.

6. The network must be correctly terminated at each end of the bus. Internal termination components are provided in each MSLC/DSLC. A jumper is installed between terminals 41 and 42 on the MSLC/DSLC at each end of the network bus to provide proper termination. The network cannot be installed in a loop. It must be linear with two distinct ends.




WIRING DIAGRAM FOR MSLC, WYE VERSION, SYNCHRONIZER FUNCTIONS

1. CONNECTIONS SHOWN ARE FOR 120 VAC POTENTIAL INPUTS.

2. ALARMS FOR VOLTAGE LIMITS, VOLTAGE RANGE, SYNC TIMEOUT, AND EXCEEDING MAXIMUM RECLOSE ATTEMPTS ARE SOFTWARE SELECTABLE.

3. VOLTAGE HIGH LIMIT AND VOLTAGE LOW LIMIT INDICATIONS ARE SOFTWARE

4. RELAYS ARE EXTERNAL TO THE CONTROL AND SUPPLIED BY END USER TO CORRESPOND TO EACH INDIVIDUAL APPLICATION.

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Figure 3-2. MSLC in a Parallel Bus/Utility Parallel Application

## Process Control Input

To avoid ground loop problems and resulting poor control performance, the process transmitter should have an isolated output. If the process transmitter is not isolated, we recommend installation of a loop isolator. A number of manufacturers offer 20 mA loop isolators.

Make connections from the process transmitter to the MSLC terminals as shown in Figure 1-3. For a 4–20 mA transmitter, a jumper must be installed across terminals 37 and 38. For a 1–5 Vdc transmitter, the jumper should not be installed. Connect the cable shields to ground at the MSLC only.

## Remote Load Setting Input

To avoid ground loop problems and resulting poor control performance, the remote load setting transmitter should have an isolated output. If the transmitter is not isolated, we recommend installation of a loop isolator. A number of manufacturers offer 20 mA loop isolators.

Make connections from the process transmitter to the MSLC terminals as shown in Figure 1-3. For a 4–20 mA transmitter, a jumper must be installed across terminals 34 and 35. For a 1–5 Vdc transmitter, the jumper should not be installed. Connect the cable shields to ground at the MSLC only.

## Installation Checkout Procedure

When the installation is complete as described in this chapter, do the following checkout procedure before beginning the calibration and adjustments in the next chapter.

1. Check for correct wiring in accordance with the wiring diagram, Figure 1-3.

2. Check for broken terminals and loose terminal screws.

3. Check for shield faults by measuring the resistance from control terminals to chassis. If a resistance less than infinite is obtained, remove the connections from each terminal one at a time until the resistance is infinite. Check the last line removed to locate the fault.

# Chapter 4.
# Calibration and Adjustments

## Introduction

Because of the variety of installations, plus system and component tolerances, the MSLC must be tuned to each system for optimum performance.

This chapter contains information on control calibration. It includes initial prestart-up and start-up settings and adjustments.

## Using the Hand Held Programmer

The Hand Held Programmer is a small computer terminal that gets its power from the MSLC. The terminal connects to the RS-422 Diagnostics and Service Port on the control. To connect the terminal, slightly loosen the right hand screw in the cover over J1 and rotate the cover clockwise to expose the 9-pin connector. Then firmly seat the connector on the terminal into J1.

The programmer does a power-up self-test whenever it is plugged into the control. When the self-test is complete, the screen will be blank. Press the ID key to display the part number and revision level of the software in the control. Refer to this number and revision level in any correspondence with Woodward Governor Company.

The programmer screen is a four-line, backlighted LCD display. The display permits you to look at two separate functions or menu items at the same time. Use the Up/Down Arrow" key to toggle between the two displayed items (the first letter of the active menu item will blink).

The programmer keys do the following functions (see Figure 4-1):

| | |
|---|---|
| (left arrow) | Not used. |
| (right arrow) | Not used. |
| (up/down arrow) | Toggles between the two displayed items (the first letter of the active menu item will blink). |
| (up arrow) | Moves backward through each menu, one step at a time. |
| (down arrow) | Advances through each menu, one step at a time. |
| (turtle up) | Increases the displayed set point value slowly. |
| (turtle down) | Decreases the displayed set point value slowly. |
| (rabbit up) | Increases the displayed set point value quickly. |
| (rabbit down) | Decreases the displayed set point value quickly. |
| – (minus) | Not used. |
| + (plus) | Not used. |
| (solid square) | Not used. |
| ID | Displays the MSLC control part number and software revision level. |
| ESC | Not used. |
| SAVE | Saves entered values (set points). |
| BKSP | Not used. |
| SPACE | Not used. |
| ENTER | Not used. |
| = (equals) | Not used. |
| . (decimal) | Used to retrieve current network status (see Menu 8 description) |
| 1 | Selects Menu 1. |
| 2 | Selects Menu 2. |
| 3 | Selects Menu 3. |

| | |
|---|---|
| 4 | Selects Menu 4. |
| 5 | Selects Menu 5. |
| 6 | Selects Menu 6. |
| 7 | Selects Menu 7. |
| 8 | Selects Menu 8. |
| 9 | Selects Menu 9. |
| 0 | Selects Menu 0. |

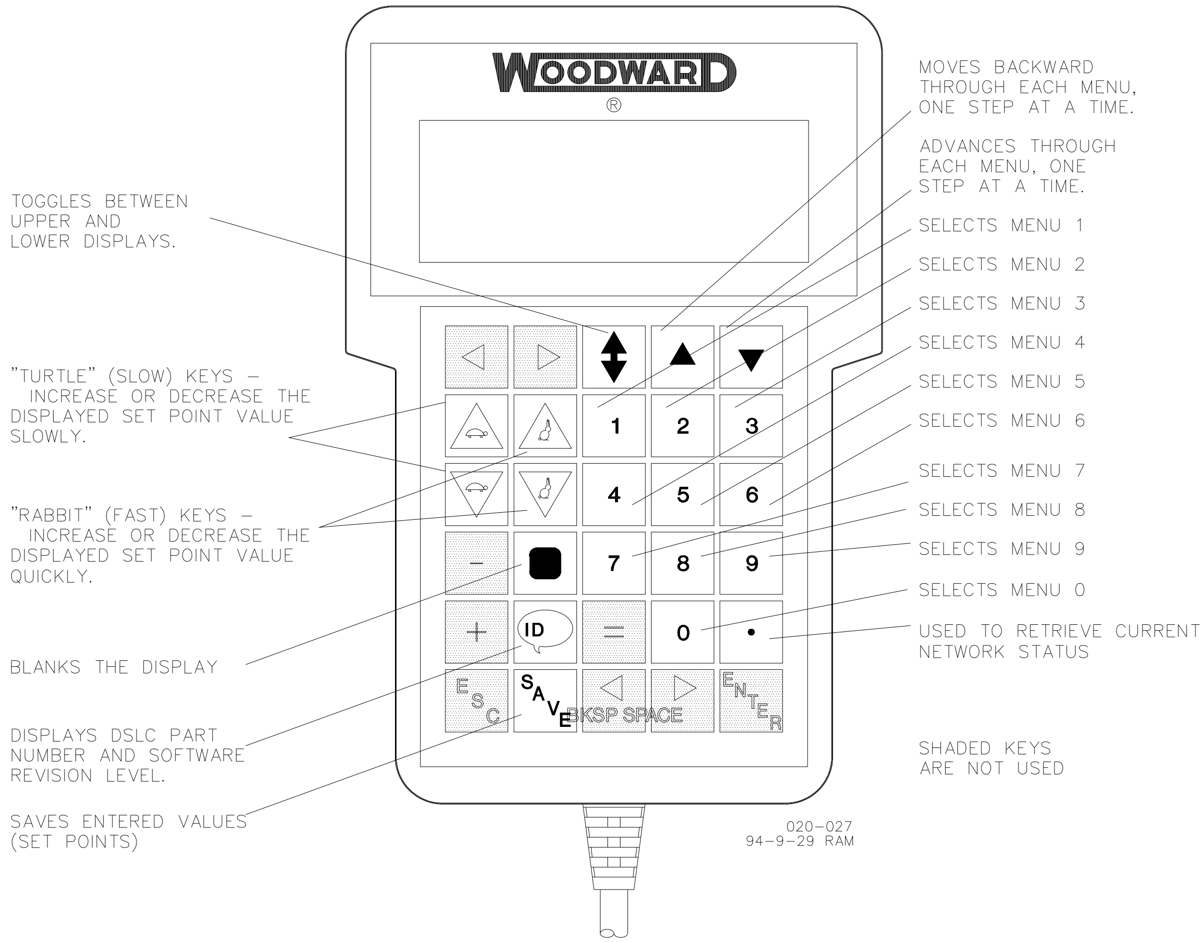


Figure 4-1. Hand Held Programmer Functions

The DSLC™ set points or adjustments are arranged in ten menus. You access these menus with the 1, 2, 3, 4, 5, 6, 7, 8, 9, and 0 (zero) keys. Pressing the appropriate key selects the first item on each menu. To step through the menu, use the "Up Arrow" and "Down Arrow" keys. The "Down Arrow" key advances through the menu and the "Up Arrow" key moves backward through the menu. The menus are continuous; that is, pressing the "Down Arrow" key at the last menu item takes the menu to the first item, or pressing the "Up Arrow" key at the beginning of the menu takes the menu to the last item.

To adjust a set point, use the "Turtle Up" or the "Rabbit Up" keys to increase the value, and the "Turtle Down" or "Rabbit Down" keys to decrease the value. The "Rabbit Up" and "Rabbit Down" keys will make the rate of change faster than the "Turtle Up" and "Turtle Down" keys. This is useful during initial setup where a value may need to be changed significantly.

When a monitor set point is selected, the control will update the selected value automatically once a second.

Finally, use the “SAVE” key to save entered values. After you are satisfied with all entries and adjustments, press the “SAVE” key to transfer all new set point values into EEPROM memory. The EEPROM retains all set points when power is removed from the control.

**CAUTION—SAVE SET POINTS**

**To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.**

The control ignores all other keys on the Hand Held Programmer.

## Menu 1—Synchronizer

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. Sync Gain | 0.00 | 100.00 | 0.10 | |
| 2. Sync Stability | 0 | 20.00 | 1.00 | Sec |
| 3. Slip Frequency Ref | 0.25 Slow | 0.25 Fast | 0 | Hz (Slow or Fast) |
| 4. Slip Window | 5 | 1.00 | 0.05 | Hz |
| 5. Max Phase Window | 2 | 20 | 10 | Degrees |
| 6. Voltage Matching | Disabled | Enabled | Disabled | |
| 7. Voltage Window | 0 | 10.0 | 1.0 | % |
| 8. Breaker Delay | 0 | 10.00 | 0.10 | Sec |
| 9. C.B. Close Hold Time | 0.1 | 10.0 | 1.0 | Sec |
| 10. Close Attempts | 1 | 20 | 1 | |
| 11. Reclose Delay | 1 | 1000 | 20 | Sec |
| 12. Sync Reclose Alarm | Disabled | Enabled | Disabled | |
| 13. Sync Timeout | 0 | 1000 | 0 | Sec |
| 14. Sync Timeout Alarm | Disabled | Enabled | Disabled | |
| 15. Auto Re-Synchronize | Disabled | Enabled | Disabled | |

## Menu 2—Load Control

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. Imp/Exp Control Gain | 0.000 | 100.000 | 1.000 | |
| 2. Imp/Exp Stability | 0 | 20.000 | 1.000 | Sec |
| 3. Imp/Exp Derivative | 0 | 20.000 | 0 | Sec |
| 4. Imp/Exp Deadband | 0.01 | 100.00 | 0 | % |
| 5. Load Input Filter | 0.05 | 5.00 | 2.00 | Hz |
| 6. Import/Export Droop | 0 | 100.0 | 0 | % |
| 7. Rated Load | 0 | 30 000 | 1000 | W, kW, MW |
| 8. Import/Export Level | 30 000 import | 30 000 export | –500 | W, kW, MW |
| 9. Import/Export 4 mA | –30 000 import | 30 000 export | 0 | W, kW, MW |
| 10. Import/Export 20 mA | –30 000 import | 30 000 export | –1000 | W, kW, MW |
| 11. Baseload 4 mA | 0 | 100.0 | 0 | % |
| 12. Baseload 20 mA | 0 | 100.0 | 100.0 | % |
| 13. Unload Ramp Rate | 0.01 | 100.00 | 1.00 | %/Sec |
| 14. Load Ramp Rate | 0.01 | 100.00 | 1.00 | %/Sec |
| 15. Raise Load Rate | 0.01 | 100.00 | 1.00 | %/Sec |
| 16. Lower Load Rate | 0.01 | 100.00 | 1.00 | %/Sec |
| 17. Utility Unload Trip | 0 | 30 000 | 20 | W, kW, MW (Imp/Exp) |
| 18. Gen Unload Trip | 0 | 100.0 | 5.0 | % |
| 19. Util High Limit PU | –30 000 import | 30 000 export | 1000 | W, kW, MW |
| 20. Util High Limit DO | –30 000 import | 30 000 export | 900 | W, kW, MW |
| 21. Utility High Limit | Disabled | Enabled | Alarm Disabled | |
| 22. Utility Low Limit PU | –30 000 import | 30 000 export | –1000 | W, kW, MW |
| 23. Utility Low Limit DO | –30 000 import | 30 000 export | –900 | W, kW, MW |
| 24. Utility Low Limit | Disabled | Enabled | Alarm Disabled | |
| 25. Util Limit Switches | Disabled | Enabled | Disabled | |
| 26. Generator Load High | Disabled | Enabled | Alarm Disabled | |
| 27. Generator Load Low | Disabled | Enabled | Alarm Disabled | |
| 28. Gen Limit Switches | Disabled | Enabled | Disabled | |
| 29. Gen Load Switch 1 PU | 0 | 100.0 | 0 | % |
| 30. Gen Load Switch 1 DO | 0 | 100.0 | 10.0 | % |
| 31. Gen Load Switch 2 PU | 0 | 100.0 | 100.0 | % |
| 32. Gen Load Switch 2 DO | 0 | 100.0 | 90.0 | % |

**NOTE: The units on all power measurement displays are chosen internally using the following scheme:**

| | 120 Volt Inputs | 240 Volt Inputs |
|---|---|---|
| Watts | PT x CT ratio < 10 | PT x CT ratio < 10 |
| Kilowatts | 10 < PT x CT < 75 000 | 10 < PT x CT < 37 500 |
| Megawatts | PT x CT > 75 000 | PT x CT > 37 500 |

## Menu 3—Process Control

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. Process Control Gain | 0.0001 | 10.0 | 1.000 | |
| 2. Process Stability | 0.0 | 20.0 | 1.00 | Sec |
| 3. Process Derivative | 0.0 | 20.0 | 0 | Sec |
| 4. Process Deadband | 0.0 | 20.0 | 0 | mA |
| 5. Process Droop | 0.0 | 100.0 | 0 | % |
| 6. Process Filter | 0.1 | 5.0 | 1.00 | Hz |
| 7. Process Reference | 0.0 | 20.0 | 12.0 | mA |
| 8. Raise Reference Rate | 0.01 | 20.0 | 0.10 | mA/Sec |
| 9. Lower Reference Rate | 0.01 | 20.0 | 0.10 | mA/Sec |
| 10. High Limit PU | 0.0 | 25.0 | 15.0 | mA |
| 11. High Limit DO | 0.0 | 25.0 | 15.0 | mA |
| 12. High Limit Alarm | Disabled | Enabled | Disabled | |
| 13. Low Limit PU | 0.0 | 25.0 | 10.0 | mA |
| 14. Low Limit DO | 0.0 | 25.0 | 10.0 | mA |
| 15. Low Limit Alarm | Disabled | Enabled | Disabled | |
| 16. Process Switches | Disabled | Enabled | Disabled | |

## Menu 4—VAR/PF Control

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. VAR/PF Control Mode | VAR Control | Constant Gen PF | PF Control | |
| 2. VAR/PF Gain | 0.01 | 20.0 | 1.00 | |
| 3. VAR/PF Stability | 0.0 | 20.0 | 2.50 | Sec |
| 4. Rated kVARS | 0 | 30 000 | 750 | kVAR |
| 5. kVAR Reference | 30 000 | 30 000 | 20 | kVAR |
| 6. PF Reference | 0.0 Lagging | 0.0 Leading | 0.80 Lagging | |
| 7. Const_Gen_PF_Ref | 0.0 Lagging | 0.0 Leading | 0.80 Lagging | |
| 8. PF Deadband | 0.0 | 1.0 | 0.025 | |
| 9. Voltage Low Limit | 50.0 | 300xPT | 60xPT | Volts, kV |
| 10. Voltage Low Alarm | Disabled | Enabled | Disabled | |
| 11. Voltage High Limit | 50.0 | 300xPT | 80xPT | Volts, kV |
| 12. Voltage High Alarm | Disabled | Enabled | Disabled | |
| 13. Voltage Switches | Disabled | Enabled | Disabled | |

**NOTE: Different voltage units displayed are chosen in Menu 5.**

## Menu 5—Configuration

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. Configuration Key | 0 | 100 | 0 | |
| 2. PT Winding Ratio | 1:1 | 1000:1 | 1.0:1 | |
| 3. CT Rating | 5:5 | 10 000:5 | 5:5 | Amperes |
| 4. PT Voltage Input | 120 | 240 | 120 | |
| 5. Voltage Display ***** | V L–N | kV L–N | Volts L–L | Volts L–N |
| 6. System Frequency | 50 | 60 | 60 | Hz |
| 7. Process Action | Direct | Indirect | Direct | |
| 8. Network Address | 1 | 16 | 16 | |
| 9. Network Service Pin | | | | |
| 10. Revert Status | Lock In Last | Hardware | Lock In Last | |
| 11. Net Dropout Time | 0.50 | 50.00 | 5.00 | Sec |
| 12. Utility Breaker Open Logic | Direct | Indirect | Indirect | |

*** NOTE: Use kV only when Primary Voltage is greater than 33 kV.**

## Menu 6—Calibration

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. Calibration Key | 0 | 100 | 0 | |
| 2. Process Input | 0 | 22 | 0 | mA |
| 3. Remote Input | 0 | 22 | 0 | mA |
| 4. PT Phase A | 0 | 300xPT | | Volts, kV |
| 5. PT Phase B | 0 | 300xPT | | Volts, kV |
| 6. PT Phase C | 0 | 300xPT | | Volts, kV |
| 7. CT Phase A | 0 | 7xCT | | Amps |
| 8. CT Phase B | 0 | 7xCT | | Amps |
| 9. CT Phase C | 0 | 7xCT | | Amps |
| 10. Gen Bus Voltage | 0 | 300xPT | | Volts, kV |
| 11. Synchroscope | –57.3 | 57.3 | | Degrees |
| 12. Command Input | Hardware | Network | Hardware | |

## Menu 7—Electrical Parameters

| Name | Min Value | Max Value | Initial Value | Dimension |
|---|---|---|---|---|
| 1. Active Power (P) ***** | –30 000 | +30 000 | | Watts, kW, MW |
| 2. Apparent Power (S) | 0 | 30 000 | | VA, kVA, MVA |
| 3. Reactive Power (Q) | 30 000 Generate | 30 000 Absorb | | VAR, kVAR (Absorb or Generator) |
| 4. Power Factor (PF) | 0.0 Lagging | 0.0 Leading | | Lagging, Leading |
| 5. Phase A | 40xPT | 300xPT | | Volts, kV |
| 6. Phase A | 0.0 | 7xCT | | Amps |
| 7. Phase A PF | 0.0 Leading | 0.0 Lagging | | Lagging, Leading |
| 8. Phase B | 40xPT | 300xPT | | Volts, kV |
| 9. Phase B | 0.0 | 7xCT | | Amps |
| 10.Phase B PF | 0.0 Leading | 0.0 Lagging | | Lagging, Leading |
| 11. Phase C | 40xPT | 300xPT | | Volts, kV |
| 12. Phase C | 0.0 | 7xCT | | Amps |
| 13. Phase C PF | 0.0 Leading | 0.0 Lagging | | Lagging, Leading |
| 14. Utility Frequency | 0 | 66 | | Hz |
| 15. Gen Bus Frequency | 0 | 66 | | Hz |
| 16. Gen Bus Voltage | 40xPT | 300xPT | | Volts, kV |
| 17. Synchroscope | –180 | 180 | | Degrees |
| 18. Slip Frequency | –1.0 Slow | 5.0 Fast | | Hz (Fast or Slow) |
| 19. System Load | –100 | +120 | | % |
| 20. System PF | 0.5 Lagging | 0.5 Leading | | Lagging, Leading |

*** NOTE: Active Power is positive when exporting power, and negative when importing power.**

# Menu 8—Control Status Monitor

| | |
|---|---|
| 1. Synchronizer Mode | Off<br>Auto-Off<br>Permissive<br>Check<br>Run<br>Sync Timer<br>Synchronized |
| 2. Load Control Mode | Off Line<br>Baseload<br>Baseload Lower<br>Baseload Raise<br>Baseload Remote<br>Utility Unload<br>Process Ramp<br>Process Control<br>Process Lower<br>Process Raise<br>Process Remote<br>Import_Export Ramp<br>Import_Export Control<br>Import_Export Lower<br>Import_Export Raise<br>Import_Export Remote |
| 3. Import/Export Ref | Low Limit PU<br>High Limit PU |
| 4. Process Reference | Low Limit PU<br>High Limit PU |
| 5. Load Command Output | 0 to 100% |
| 6. PF Command Output | |
| 7. PF Reference | |
| 8. Synchronizer Timeout | Alarm On/Alarm Off |
| 9. Sync Reclose Limit | Alarm On/Alarm Off |
| 10. Utility High Limit | Alarm On/Alarm Off |
| 11. Utility Low Limit | Alarm On/Alarm Off |
| 12. Generator High Limit | Alarm On/Alarm Off |
| 13. Generator Low Limit | Alarm On/Alarm Off |
| 14. High Process Limit | Alarm On/Alarm Off |
| 15. Low Process Limit | Alarm On/Alarm Off |
| 16. Low Voltage Limit | Alarm On/Alarm Off |
| 17. High Voltage Limit | Alarm On/Alarm Off |

# Menu 9—Discrete Inputs/Outputs

| | |
|---|---|
| 1. Synch Check Mode | Contact Open/Closed |
| 2. Synch Permissive | Contact Open/Closed |
| 3. Synch Run Mode | Contact Open/Closed |
| 4. Utility C.B. Aux | Contact Open/Closed |
| 5. Utility Unload | Contact Open/Closed |
| 6. Import / Export | Contact Open/Closed |
| 7. Process Control | Contact Open/Closed |
| 8. Ramp Pause | Contact Open/Closed |
| 9. Setpoint Raise | Contact Open/Closed |
| 10. Setpoint Lower | Contact Open/Closed |
| 11. Raise Voltage | Contact Open/Closed |
| 12. Lower Voltage | Contact Open/Closed |
| 13. Test Key | 0 100 |
| 14. Breaker Close Relay | Energized/**De-energized** |
| 15. Utility Breaker Open | **Energized**/De-energized |

| | |
|---|---|
| 16. Gen Breaker Open | **Energized**/De-energized |
| 17. Alarm Relay | **Energized**/De-energized |
| 18. Low Limit Relay | Energized/**De-energized** |
| 19. High Limit Relay | Energized/**De-energized** |
| 20. Load Switch 1 Relay | Energized/**De-energized** |
| 21. Load Switch 2 Relay | Energized/**De-energized** |
| 22. Sync Enable LED | On/Off |
| 23. High Limit LED | On/Off |
| 24. Low Limit LED | On/Off |
| 25. Watchdog LED | On/Off |

**NOTE: Items 15, 16, and 17 are normally energized relay driver outputs. All others are normally de-energized relay driver outputs.**

## Menu 0—Diagnostics

| | |
|---|---|
| 1. CPU Diagnostics | |
| 2. ROM Checksum | |
| 3. Active M/DSLCs | 1 16 |
| 4. Retrieve LON Status | Press "." Key/Status Retrieved |
| 5. Transmit Errors | 0 65535 |
| 6. Transaction Timeouts | 0 65535 |
| 7. Rcv Transaction Full | 0 65535 |
| 8. Lost Messages | 0 65535 |
| 9. Missed Messages | 0 65535 |
| 10. Last Reset Cause | Power Up Reset<br>External Reset<br>Watchdog Reset<br>Software Reset<br>Cleared<br>Unknown |
| 11. Node State | NoAppl, Unconfigured<br>Appl, Unconfigured<br>Configured, Off-line<br>Soft Off-line<br>Bypass Off-line<br>Configured, On-line<br>Unknown |
| 12. LON Error Log | No Error<br>Bad Event<br>NV Length Mismatch<br>NV Msg Too Short<br>EEPROM Write Fail<br>Bad Address Type<br>Preemption Timeout<br>Already Preempted<br>Sync NV Update Lost<br>Invalid Resp Alloc<br>Invalid Domain<br>Read Past EndOfMsg<br>Write Past EndOfMsg<br>Addr Table Index<br>Incomplete Msg<br>Update On Output NV<br>No Msg Avail<br>Illegal Send<br>Unknown PDU<br>Invalid NV Index<br>Divide by Zero<br>Invalid Appl Error |

| | |
|---|---|
| | Memory Alloc Fail |
| | Write Net Buffer |
| | Appl CS Error |
| | Cnfg CS Error |
| | Invalid Xcvr Reg |
| | Xcvr Reg Timeout |
| | Write Appl Buffer |
| | IO Ready |
| | Self Test Failed |
| | Subnet Router |
| | Authentication |
| | Self Inst Semaphore |
| | Read Write Semaphore |
| | Appl Signature Bad |
| | Router Firmware |
| | Unknown |
| 13. LON Interface Errors | 0 65535 |
| 14. A/D Errors | 0 65535 |
| 15. Network Loop | True/False |
| 16. Hardware Loop | True/False |
| 17. DI Commands | Network/Hardware |

# Menu (Set Point) Descriptions

## Menu 1—Synchronizer

1. **Sync Gain** (proportional term) determines how fast the synchronizer responds to an error in speed or phase. Adjust gain to provide stable control during synchronizing. Lower value to slow response.

2. **Sync Stability** (integral term) compensates for delay in the synchronizer control loop. Prevents low frequency hunting and damping (overshoot or undershoot) when the synchronizer is enabled or a speed transient occurs during synchronizing.

3. **Slip Frequency Ref** specifies the positive or negative (fast or slow) slip frequency reference used for slip frequency synchronizing. Setting the slip frequency reference to 0 selects phase matching synchronizing.

4. **Slip Window** is the maximum allowed deviation in slip (+ or +) from the slip frequency reference when initiating breaker closure.

5. **Max Phase Window** is the maximum allowable electrical phase angle (+ or +) between the bus and generator when the synchronizer initiates breaker closure.

6. **Voltage Matching** enables or disables the synchronizer voltage matching function.

7. **Voltage Window** is the maximum allowable percent the local bus voltage may differ from the utility voltage for the synchronizer to issue a breaker closure command, if voltage matching is enabled. If the slip frequency reference is positive (fast) the local bus voltage may not be less than the utility voltage. If the slip frequency reference is negative (slow) the local bus voltage may not be greater than the utility voltage. This ensures that the initial reactive power flow is in the same direction as the initial real power flow.

8. **Breaker Delay** specifies the time required for the circuit breaker blades to engage after receiving a closure command. Set to 0 when doing phase matching.

9. **CB Close Hold Time** specifies the maximum elapsed time the synchronizer will maintain the breaker closure relay driver output low. Failure to receive the CB Aux contact signal during this interval results in a failed close attempt. The breaker closure relay driver returns high when the CB Aux contact signal is received or the specified time expires.

10. **Close Attempts** is the number of attempts the synchronizer will make to close the circuit breaker. The sync fail alarm (if enabled) will be activated and the synchronizer will enter the OFF mode if the breaker fails to close in the specified number of tries. The synchronizer discrete inputs must be set to OFF to clear the current close attempts and alarm.

11. **Reclose Delay** is the number of seconds between attempts to close the circuit breaker if a failed attempt occurs. If the CB Aux contact remains closed for one reclose delay interval, synchronization is assumed to have occurred.

12. **Sync Reclose Alarm** enables or disables the alarm generated when reaching the maximum close attempts.

13. **Sync Timeout** is the interval over which the synchronizer will attempt to get synchronization. A value of 0 seconds disables the Sync Timeout function. The interval begins when generator voltage is detected and either the run or permissive mode select input is activated. Failure to get a CB Aux contact closure within the specified time will result in a synch timeout alarm. The synchronizer must be set to off mode to clear the interval timer and alarm.

14. **Sync Timeout Alarm** enables or disables the alarm generated by exceeding the synch timeout interval without getting synchronization.

15. **Auto Re-Synchronize** enables or disables the synchronizer function after achieving synchronization. Synchronization is assumed to have been achieved if one Reclose Delay time interval passes with the CB Aux contact closed. If this set point is set to disabled, the synchronizer is set to auto-off mode after synchronizing. The synchronizer must be set to the off mode and then back to the desired operating mode to resume operation. If this set point is set to Enabled, the synchronizer will automatically restart in the selected operating mode when synchronization is lost, as indicated when the CB Aux contact opens. On restart, the synch timeout timer and close attempts count are reset to their specified values.

## Menu 2—Load Control

1. **Imp/Exp Gain** (proportional term) determines how fast the load control responds to an import/export load error. Gain is set to provide stable control.

2. **Imp/Exp Stability** (integral term) compensates for lags in the load control loop. It prevents slow hunting and controls damping (overshoot or undershoot) after a load disturbance.

3. **Imp/Exp Derivative** adjusts the rate of change in the load command during a load transient.

4. **Imp/Exp Deadband** selects the maximum error band within which the import/export control does not respond. A wider deadband prevents response to noise, but allows larger steady state errors to exist without action.

5. **Load Input Filter** adjusts the bandwidth of the digital low pass filter on the load controller input. Higher frequency settings result in a faster control response.

6. **Import/Export Droop** is the droop setting for the import/export controller. The effect of droop is to make the control more resistant to variations from the import/export reference. This droop has the effect of causing the target import/export level to go towards a zero power transfer situation with increasing load. When set to the default value of zero the import/export control has no droop.

7. **Rated Load** is the 100% maximum load setting of the entire plant. It is equal to the sum of 100% load on all generators, or the maximum allowable import/export level.

8. **Import/Export Level** sets the desired import/export level at which the MSLC controls. Note: If droop is non-zero, the MSLC will actually control at a slightly lower import/export level.

9. **Import/Export 4 mA** is the desired import/export reference when the remote load setting input is equal to 4 mA. This setting may be higher or lower than the 20 mA remote load setting. The control linearly interpolates between the 4 and 20 mA settings.

10. **Import/Export 20 mA** is the desired import/export reference when the remote load setting input is equal to 20 mA. This setting may be higher or lower than the 4 mA remote load setting. The control linearly interpolates between the 4 and 20 mA settings.

11. **Baseload 4 mA** is the desired base load reference when the remote load setting input is equal to 4 mA. This setting may be higher or lower than the 20 mA remote load setting. The control linearly interpolates between the 4 and 20 mA settings.

12. **Baseload 20 mA** is the desired base load reference when the remote load setting input is equal to 20 mA. This setting may be higher or lower than the 4 mA remote load setting. The control linearly interpolates between the 4 and 20 mA settings.

13. **Load Ramp Rate** is the rate at which the control ramps between modes in %/sec. Remember, this refers to loading the utility, which is then unloading the generator set.

14. **Unload Ramp Rate** is the rate at which the control ramps between modes in %/sec. Remember, this refers to unloading the utility, which is then loading the generator set.

15. **Raise Load Rate** is the rate at which the control changes the load reference when the set point raise switch is activated.

16. **Lower Load Rate** is the rate at which the control changes the load reference when the set point lower switch is activated.

17. **Utility Unload Trip** is the import/export load level that the MSLC must be below before issuing the utility breaker open command during a utility unload.

18. **Gen Unload Trip** is the percentage system load level that the MSLC must be below before issuing the Local/Gen Bus breaker open command during a Local/Gen Bus unload.

19. **Util High Load PU** is the import/export load level where (if enabled) the high limit discrete output is energized and the high limit alarm is activated. It is also limits the maximum import/export reference setting.

20. **Util High Load DO** is the import/export load level where (if enabled) the high limit discrete output is de-energized and the high limit alarm is deactivated.

21. **Utility High Limit** specifies if the high load limit will activate (de-energize) the alarm relay.

22. **Utility Low Limit PU** is the import/export load level where (if enabled) the low limit discrete output is energized and the low limit alarm is activated. It is also limits the minimum import/export reference setting.

23. **Utility Low Limit DO** is the import/export load level where (if enabled) the low limit discrete output is de-energized and the low limit alarm is deactivated.

24. **Utility Low Limit** specifies if the low load Limit will activate the (de-energize) the alarm relay.

25. **Util Limit Switches** specifies if the high and low load limit discrete outputs will activate on high or low load.

26. **Generator Load High** specifies if the generator high limit alarm will activate the alarm relay. The generator high limit alarm is activated when the MSLC is required to output a system load of 100% to the DSLC controls in order to meet its reference.

27. **Generator Load Low** specifies if the generator low limit alarm will activate the alarm relay. The generator low limit alarm is caused when the MSLC is required to output a system load of 0% to the DSLC controls in order to meet its reference.

28. **Gen Limit Switches** specifies if the high and low limit discrete outputs will activate when the system load set point reaches 100% or 0% respectively.

29. **Gen Load Switch 1 PU** sets the percentage system load level at which load switch #1 discrete output is activated.

30. **Gen Load Switch 1 DO** sets the percentage system load level at which load switch #1 discrete output is de-activated.

31. **Gen Load Switch 2 PU** sets the percentage system load level at which load switch #2 discrete output is activated.

32. **Gen Load Switch 2 DO** sets the percentage system load level at which load switch #2 discrete output is de-activated.

## Menu 3—Process Control

1. **Process Control Gain** (proportional term) determines how fast the process control responds to an error between the process variable and reference. The gain is set to provide stable control of the process.

2. **Process Stability** (integral term) compensates for delay in the process control loop. It prevents low frequency hunting and damping (overshoot or undershoot) when a process disturbance occurs.

3. **Process Derivative** adjusts the rate of change of the system load percentage sent to the associated DSLC controls during a process level transient.

4. **Process Deadband** is the error window within which the process control integrator is not updated. This is used for control of high noise processes. Set to 0.0 mA for normal, non-deadband control.

5. **Process Droop** is the load droop desired based on process level.

6. **Process Filter** adjusts the bandwidth of the filter on the process input. Higher frequency settings result in faster control response, but also more response to process noise.

7. **Process Reference** is the internal reference for the process control.

8. **Raise Reference Rate** is the rate at which the internal process reference is increased when the setpoint raise command is initiated in the process control mode.

9. **Lower Reference Rate** is the rate at which the internal process reference is decreased when the setpoint lower command is initiated in the process control mode.

10. **High Limit PU** is the process input level where (if enabled) the high limit discrete output is energized and the high limit alarm is activated. It also limits the maximum internal process reference set point.

11. **High Limit DO** is the process input level where (if enabled) the high limit discrete output is de-energized and the high limit alarm is de-activated.

12. **High Limit Alarm** specifies if the process high limit alarm will activated (de-energize) the alarm relay.

13. **Low Limit PU** is the process input level where (if enabled) the low limit discrete output is energized and the low limit alarm is activated. It also limits the minimum internal process reference set point.

14. **Low Limit DO** is the process input level where (if enabled) the low limit discrete output is de-energized and the low limit alarm is de-activated.

15. **Low Limit Alarm** specifies if the process low limit alarm will activated (de-energize) the alarm relay.

16. **Process Switches** specifies if the process high and low limits will activate the high and low limit discrete outputs.

## Menu 4—VAR/PF Control

1. **VAR/PF/Constant Gen PF Control Mode** selects the reactive load control mode for the MSLC. There are three options:
**A) VAR control**, which will maintain a constant VAR load level across the utility tie by varying the reactive load on the generators to maintain the kVAR reference level.
**B) PF control**, which will maintain a constant PF across the utility tie by varying the reactive load on the generators to maintain the PF reference level.
**C) Constant Gen PF control** which will maintain a constant PF on any generators operating under the MSLC command. The generators will use the Constant Gen PF reference of the MSLC as their individual generator PF reference value.

2. **VAR/PF Gain** (proportional term) determines how fast the control responds to a VAR/PF error, and is set to obtain stable control.

3. **VAR/PF Stability** (integral term) compensates for lag in the control loop. It prevents slow hunting and controls damping (overshoot and undershoot) after a load disturbance.

4. **Rated kVARS** is the rated kVAR loading of the utility. Normally in systems rated for 0.8 PF, this will be 0.75 of the rated kW loading and 0.6 of the kVA rating.

5. **kVAR Reference** is the internal set point which the control maintains when in VAR control mode.

**NOTE**
- **A kVAR reference showing "Absorb" will absorb VARs from the utility into the generators/load (typically a Leading generator PF).**
- **A kVAR reference showing "Generate" will generate VARs from the generators/load into the utility (typically a Lagging generator PF).**

6. **PF Reference** is the internal set point which the control maintains when in PF control mode.

**NOTE**
- **A PF reference showing "Leading" will absorb VARs from the utility into the generators/load (typically a Leading generator PF).**
- **A PF reference showing "Lagging" will generate VARs from the generators/load into the utility (typically a Lagging generator PF)**

7. **Const_Gen_PF_Ref** is the constant reference the MSLC sends to the DSLC controls (the reference level at which to maintain each DSLC control's generator) when in constant generator power factor control mode. In this mode the DSLC control will maintain a constant generator PF level regardless of the amount of VARs being absorbed/generated across the utility tie.

**NOTE**
**It is recommended that the Constant Generator Power Factor control mode be used in applications where the total generator kVAR capacity is less than the kVAR load of the system.**

8. **PF Deadband** is the error window within which the VAR/PF control does not react.

9. **Voltage Low Limit** specifies the voltage low limit alarm set point. It is also the lower limit for the synchronizing voltage matching function (**below which it will not allow a breaker closure command**) and the minimum manual voltage set point.

10. **Voltage Low Alarm** specifies if the voltage low limit alarm will activate (de-energize) the alarm relay.

11. **Voltage High Limit** specifies the voltage high limit alarm set point. It is also the higher limit for the synchronizing voltage matching function (**above which it will not allow a breaker closure command**) and the maximum manual voltage set point.

12. **Voltage High Alarm** specifies if the voltage high limit alarm will activate (de-energize) the alarm relay.

13. **Voltage Switches** specifies if the voltage high and low limits will activate the high and low limit relay drivers.

## Menu 5—Configuration

1. **Configuration Key** is set to 49 to allow changing configuration set points. All discrete input switches must be open to adjust configuration of set points.

2. **PT Winding Ratio** is set to correspond to the potential transformer winding ratio. NOTE: Local Gen Bus and Utility Bus potential transformer ratios must be the same.

3. **CT Rating** is set to correspond to the current transformer ratio.

4. **PT Voltage Input** specifies whether the 120 or 240 voltage inputs are used.

**NOTE**

**The 120 and 240 volt inputs are rated to handle up to 150 and 300 volts respectively. A line-to-neutral voltage from a 480 volt line-to-line system can be used on the 240 volt input as it would provide a 277 Vac signal at the designated PT input.**

5. **Voltage Display** specifies whether the voltages displayed on the Hand Held Programmer for menus 4 and 7 are line-to-line or line-to-neutral. Use only kV when primary voltage is greater than 33 kV.

6. **System Frequency** specifies the nominal system operating frequency (50 or 60 Hz).

7. **Process Action** specifies if the process variable is direct or indirect acting. If the process variable increases when the associated generators' load increases, the action is direct. Conversely, if the process variable decreases when the associated generators' load increases, the action is indirect.

8. **Network Address** is a unique address for the MSLC in a system. It must be different from all DSLC controls in that system and is a number between 1 and 16. It is preferable to set the MSLC in the system to a network address of 16, because the associated DSLC controls begin looking for MSLCs at address 16. After setting the network address, press the “SAVE” key to put the new address into effect.

**NOTE**

**In systems where the MSLC is installed with Echelon equipped devices other than its associated DSLC controls (see Chapter 9) using a network management tool, the network management tool automatically assigns the MSLC a unique address. In this case, the network address cannot be changed using the Hand Held Programmer. It will revert to its previous value after the “SAVE” key is pressed.**

9. **Network Service Pin** causes a unique identification code (set at the Echelon manufacturing plant) to be transmitted on the network. This is used for network management in systems containing devices other than MSLC and DSLC controls.

10. **Revert Status** is used only in applications which use 723 speed controls that communicate over the LON network to the DSLC. This is a “don’t care” setpoint for all other applications. Revert status sets the failure mode the DSLC will assume if it has been receiving network commands, and these commands fail. The revert status setpoint can be set for either hardware or network.

    If set to **hardware**, the DSLC/MSLC will revert immediately and without consideration to transient changes to the hardware inputs upon a network failure. Once the network is recovered, the DSLC will immediately revert back to the network command inputs without consideration to transient changes.

    If set to **lock in last**, the DSLC/MSLC will lock the last valid network command input in its memory. This input will remain in place unless:

    A) The network recovers, and the network command of the recovered network matches that of the last valid network command input received prior to network failure. This is referred to as the “Network Loop” (displayed as **Loop 3** in menu 0 of the DSLC hand held programmer).

    B) The hardware discrete inputs match those of the last valid network command. If the hardware discrete inputs match, the control will use the hardware inputs from that point on, until the network recovers. Once the network recovers, the new network command input on the recovered network must match the hardware input before the transition back to the network command inputs becomes active. This is referred to as the “Hardware Loop” (displayed as **Loop 4** in menu 0 of the DSLC hand held programmer).

**NOTE**

**The command inputs can be "forced" at any time to Hardware by setting the Command Input setpoint in menu 6 to "Hardware". This action will cause an immediate transition to all hardware inputs (analog and discrete) of the DSLC/MSLC.**

**The specific command groups (USE_DS, USE_CBAUX, USE_RR, and USE_PS) can be forced to hardware at any time by changing the 723 setpoint for these tunable values from TRUE (network) to FALSE (hardware).**

**The USE_PS and USE_RR inputs will always revert to the hardware inputs on a network failure, and automatically reset back to the network inputs when the network recovers, regardless of the Revert Status setting in the DSLC/MSLC.**

11. **Net Dropout Time** is used only in applications which use 723 speed controls that communicate over the LON network to the DSLC. This is a "don't care" setpoint for all other applications.

    The network dropout time is a counter, which can be incremented in 0.5 second steps between 0.5 and 50 seconds. This timer sets the maximum allowable time which will elapse, and within which at least three valid messages must be received by the DSLC/MSLC. If less than three valid messages are received in this time, the network is considered to have failed.

    The network time is also used to establish the parameters for a recovered network. The DSLC must receive three valid messages within three times (3x) the network dropout time for the network to be considered OK. This is a fixed multiplier, and a failed network will always take at least three times the Network Dropout Time to recover.

**NOTE**

**The Network Dropout Time is updated only on power up of the DSLC/MSLC. This value may be changed and stored in memory using the hand held programmer, but changes to this setting will not affect operation until power is cycled to the DSLC/MSLC.**

12. **Util Breaker Open Logic** selects the logic used for the MSLC Utility Breaker Open output on terminal 22.

**NOTE**

**Any changes to the Utility Breaker Open Logic setpoint must be saved using the hand held programmer, and power must be cycled to the MSLC before the new setting will be active. This is to protect the system against accidental changes made to this setpoint causing an accidental opening of the utility tie breaker.**

INDIRECT
If set for Indirect, the Breaker Open Command Output will be normally energized, and will de-energize to issue a utility breaker open command. The Utility Breaker Open command is issued during normal operation in Utility Unload mode.

**NOTE**
**An indirect setting will cause the utility breaker open command to de-energize (open the utility breaker) on loss of power to the MSLC, or on MSLC CPU failure (CPU OK LED ON COVER OF MSLC IS OFF).**

DIRECT
If set for direct, the Breaker Open Command Output will be normally de-energized, and will energize to issue a utility breaker open command. The Utility Breaker Open Command is issued during normal operation in the Utility Unload Mode.

**NOTE**
**A direct setting will cause the utility breaker open command to remain de-energized (no action to open the utility tie breaker) on loss of power to the MSLC, or on MSLC CPU failure (CPU OK LED ON COVER OF MSLC IS OFF).**

## Menu 6—Calibration

1. **Calibration Key** is set to 49 to allow changing calibration set points. This is normally used to display analog input or output during installation or troubleshooting. Calibration should be done using calibrated reference meters.

2. **Process Input** displays the current value on the 4–20 mA process variable input. Raise or lower the displayed value to correspond to the actual input value during calibration.

3. **Remote Input** displays the current value on the 4–20 mA remote input. Raise or lower the displayed value to correspond to the actual mA input value during calibration.

4. **PT Phase A** displays the sensed utility bus phase A voltage at the DSLC terminal strip. When potential is applied to the control, adjust the displayed value such that the voltage in Menu 7 corresponds to the actual utility phase A voltage. NOTE: This must be calibrated as part of the installation on the actual switchboard.

5. **PT Phase B** displays the sensed utility bus phase B voltage at the DSLC terminal strip. When potential is applied to the control, adjust the displayed value such that the voltage in Menu 7 corresponds to the actual utility phase B voltage. NOTE: This must be calibrated as part of the installation on the actual switchboard.

6. **PT Phase C** displays the sensed utility bus phase C voltage at the DSLC terminal strip. When potential is applied to the control, adjust the displayed value such that the voltage in Menu 7 corresponds to the actual utility phase C voltage. NOTE: This must be calibrated as part of the installation on the actual switchboard.

7. **CT Phase A** displays the sensed phase A current. When currents are applied to the control, adjust the displayed value to equal the actual phase A current. NOTE: This must be calibrated as part of the installation on the actual switchboard.

8. **CT Phase B** displays the sensed phase B current. When currents are applied to the control, adjust the displayed value to equal the actual phase B current. NOTE: This must be calibrated as part of the installation on the actual switchboard.

9. **CT Phase C** displays the sensed phase C current. When currents are applied to the control, adjust the displayed value to equal the actual phase C current. NOTE: This must be calibrated as part of the installation on the actual switchboard.

10. **Gen Bus Voltage** displays the sensed local/gen bus phase A voltage at the DSLC terminal strip. When potential is applied to the control, adjust the displayed value such that the voltage in Menu 7 corresponds to the actual local/gen phase A voltage. NOTE: This must be calibrated as part of the installation on the actual switchboard.

11. **Synchroscope** compensates for phase shift between the utility and local/gen bus potential transformers. If the synchroscope does not remain at 0.00 (in the Check Mode) during phase matching synchronizing (see adjustment later in this chapter), adjust this set point until the synchroscope remains at 0.00. After the breaker is closed, do a final adjustment for 0.00. NOTE: If line-to-line voltage is used for the single phase local/gen bus input, a 300 phase error will initially exist. This must be adjusted as mentioned above before automatic operation is initiated. THE "SAVE" KEY MUST BE PRESSED TO STORE THE PROPER PHASE OFFSET AFTER IT HAS BEEN CALIBRATED!

12. **Command Input** is used only in applications which use 723 speed controls that communicate over the LON network to the DSLC. This is a "don't care" setpoint for all other applications.

    The command input setpoint can be set for either "**hardware**", or "**network**". If set to hardware, the DSLC will only recognize the hardware discrete and analog (4–20 mA) inputs it is receiving, regardless of the presence of messages on the LON network. If set to network, the DSLC will monitor the network for active command input messages and only recognize these messages, regardless of the hardware input status, unless there is a network failure. If there is a network failure, the DSLC will operate on command inputs according to the Revert Status setpoint.

    The status of the network and of the network and hardware loops can be monitored in menu 0 of the DSLC/MSLC hand held programmer.

    The **DI COMMANDS** monitor in menu 0 has three states:

- HARDWARE—indicates that the MSLC is using the hardware discrete inputs
- NETWORK—indicates that the MSLC is using the network discrete inputs
- FAULT—indicates that the network has failed

**NOTE**

**A cycling between network and hardware may be seen in the DI COMMANDS menu item if the control is set for command inputs from hardware, but a valid message is being seen on the network.**

The DI Commands monitor shows only the status of the USE_DS command inputs. The USE_CBAUX and USE_PS, USE_RR status is not indicated by this display.

The status of the **Network Loop** (displayed as "**Loop 3**") and **Hardware Loop** (displayed as "**Loop 4**") can also be monitored in menu 0. These loops are normally false, but when there is a failure of the network, and the DSLC/MSLC revert status is set to Lock In Last, the Network Loop or the Hardware Loop will transition from false to true. The Network Loop and the Hardware Loop cannot both be true at the same time. The indication of which loop is true will assist operators in deciding whether the recovered network must match the last valid network input prior to network failure, or match the current hardware inputs for a transition back to the recovered network command inputs.

## Menu 7—Electrical Parameters

1. **Active Power (P)** is the real power (kW) flowing across the utility tie. Negative values indicate power imported and positive values indicate power exported. In more recent software versions, the terms "import" and "export" replace the ± indications.

2. **Apparent Power (S)** is the apparent power (kVA) flowing across the utility tie. Apparent Power is displayed as an absolute value.

3. **Reactive Power (Q)** is the reactive power (kVAR) flowing across the utility tie.

**NOTE**

- **A kVAR reading showing "Absorb" indicates absorbed VARs from the utility into the generators/load (typically a Leading generator PF).**
- **A kVAR reading showing "Generate" indicates generated VARs from the generators/load into the utility (typically a Lagging generator PF).**

4. **Power Factor (PF)** is the power factor of the power flowing across the utility tie breaker.

**NOTE**

- **A PF reading showing "Leading" indicates absorbed VARs from the utility into the generators/load (typically a Leading generator PF).**
- A PF reading showing "Lagging" indicates generated VARs from the generators/load into the utility (typically a Lagging generator PF).

5. **Phase A** is the voltage on phase A of the utility bus. This voltage is used for voltage matching and is compared to the high and low limits in menu 4.

6. **Phase A** is the current on phase A of the utility bus.

7. **Phase A PF** is the power factor on phase A of the utility bus.

8. **Phase B** is the voltage on phase B of the utility bus.

9. **Phase B** is the current on phase B of the utility bus.

10. **Phase B PF** is the power factor on phase B of the utility bus.

11. **Phase C** is the voltage on phase C of the utility bus.

12. **Phase C** is the current on phase C of the utility bus.

13. **Phase C PF** is the power factor on phase C of the utility bus.

14. **Utility Frequency** is the frequency of the utility bus.

15. **Gen Bus Frequency** is the frequency of the local/gen bus.

16. **Gen Bus Voltage** is the voltage of the local/gen bus.

17. **Synchroscope** is the phase difference between the utility and local/gen bus phase A voltage wave forms. This should track with the switchgear's analog synchroscope (if installed). If it does not calibration in Menu 6 is required.

18. **Slip Frequency** is the difference in frequency between the utility and local/gen bus phase A voltage wave forms.

19. **System Load** is the current system (load sharing) load percentage. NOTE: This is the value seen on the DSLC controls in isochronous load sharing. The output of the MSLC for system load is displayed in Menu 8 as the Load Command Output.

20. **System PF** is the current system power factor, which is the average power factor of all generators being controlled by the MSLC. This is the same value seen on the DSLC controls in menu 8.

## Menu 8—Control Status Monitor

1. **Synchronizer Mode** is the current operating mode of the synchronizer function.

2. **Load Control Mode** is the current operating mode of the load control function.

3. **Import/Export Ref** is the current import/export load reference level.

4. **Process Reference** is the current process reference level.

5. **Load Command Output** is the current output from the MSLC telling the associated DSLC controls what level to set their system load percentage.

6. **PF Command Output** is the current PF command being sent from the MSLC to the DSLC controls operating under control of the MSLC (parallel mode indicated in menu 8 of the DSLC as the Load Control Mode). The MSLC will adjust the PF Command Output as necessary to maintain a VAR, PF, or Constant Generator PF level. A lagging PF command output will drive the DSLC controlled generators operating under the MSLC control to a more lagging generator PF. A leading PF command output will drive the DSLC controlled generators operating under the MSLC control to a more leading generator PF.

7. **PF Reference** is the internal reference setpoint of the MSLC.

8. **Synchronizer Timeout** is the status of the alarm for exceeding the synchronizer timeout interval.

9. **Sync Reclose Limit** is the status of the alarm for exceeding the synchronizer close attempts limit.

10. **Utility High Limit** is the status of the alarm for exceeding the high import/export load limit set point.

11. **Utility Low Limit** is the status of the alarm for exceeding the low import/export load limit set point.

12. **Generator High Limit** is the status of the alarm when the MSLC load command output reaches 100%.

13. **Generator Low Limit** is the status of the alarm when the MSLC load command output reaches 0%.

14. **High Process Limit** is the status of the alarm for exceeding the process control input high limit set point.

15. **Low Process Limit** is the status of the alarm for exceeding the process control input low limit set point.

16. **Low Voltage Limit** is the status of the alarm for exceeding the low voltage limit set point.

17. **High Voltage Limit** is the status of the alarm for exceeding the high voltage limit set point.

## Menu 9—Discrete Inputs/Outputs

1. **Synch Check Switch** is the status of the synchronizer Check Mode switch input.

2. **Synch Permissive** is the status of the synchronizer Permissive Mode switch input.

3. **Synch Run Mode** is the status of the synchronizer Run Mode switch input.

4. **Utility C.B. Aux** is the status of the CB Aux contact input.

5. **Utility Unload** is the status of the Utility Unload contact input.

6. **Import / Export** is the status of the Import/Export contact input.

7. **Process Control** is the status of the process control contact input.

8. **Ramp Pause** is the status of the ramp pause contact input.

9. **Setpoint Raise** is the status of the set point raise contact input.

10. **Setpoint Lower** is the status of the set point lower contact input.

11. **Raise Voltage** is the status of the voltage raise contact input.

12. **Lower Voltage** is the status of the voltage lower contact input.

13. **Test Key** must be set to 49 to allow closing of discrete outputs for test purposes. In addition, all discrete inputs must be open to allow testing of discrete outputs.

14. **Breaker Close Relay** is the status of the circuit breaker closure command relay.

15. **Utility Breaker Open** is the status of the utility breaker open command relay.

16. **Gen Breaker Open** is the status of the local/gen bus breaker open command relay.

17. **Alarm Relay** is the status of the alarm Relay.

18. **Low Limit Relay** is the status of the Low Limit relay.

19. **High Limit Relay** is the status of the High Limit relay.

20. **Load Switch 1 Relay** is the status of the load switch #1 relay.

21. **Load Switch 2 Relay** is the status of the load switch #2 relay.

22. **Sync Enable LED** is the status of the SYNC ENABLE LED.

23. **High Limit LED** is the status of the HIGH LIMIT LED.

24. **Low Limit LED** is the status of the LOW LIMIT LED.

25. **Watchdog LED** is the status of the CPU OK LED.

## Menu 0—Diagnostics

1. **CPU Diagnostics** is the result of power up diagnostics. A value of 49 indicates no problems found. Any other value indicates an internal failure in the microprocessor or memory.

2. **ROM Checksum** is the result of doing a "checksum" test on program memory. This value is verified each time the control is powered up. This number is for factory test only. A failure in the ROM checksum test will also result in a Diagnostic Result other than 49.

3. **Active M/DSLCs** is the number of MSLC/DSLC controls currently powered on the network. This value is used to verify that all MSLC/DSLC controls in the network are in communication with each other.

4. **Retrieve LON Status** retrieves the network error statistics accumulators, the cause of the last reset, the state of the node, and the last run-time error logged. Pressing the "." key will retrieve the current statistics which can be observed with the following set points.

   Transmission errors will occur on occasion. Frequent occurrence of transmission errors (up to several per second in large systems) indicates an overloaded network, faulty network wiring, or a defective control in the network.

5. **Transmit Errors** is the number of CRC (Cyclic Redundancy Check) errors detected during packet reception. These may be due to collisions or noise on the transceiver input. Pressing the "." key will retrieve the current number of transmission error statistics.

6. **Transaction Timeouts** is the number of times that the node failed to receive expected acknowledgments after retrying the configured number of times. These may be due to destination nodes being inaccessible on the network, transmission failures because of noise on the channel, or if any destination node has insufficient buffers or receive transaction records. When using Request/Response service or network variable polling, a transaction timeout can also occur if the destination node application program does not return to the scheduler frequently enough because responses are synchronized with the application tasks.

7. **Rcv Transaction Full** is the number of times than an incoming packet was discarded because there was no room in the transaction database. These may be due to excessively long receive timers, or inadequate size of the transaction database.

8. **Lost Messages** is the number of times than an incoming packet was discarded because no application buffer was available. These may be due to an application program being too slow to process incoming packets, due to insufficient application buffers, or due to excess traffic on the channel. Messages will be lost when power is initially applied to a DSLC while power up diagnostics are being performed (the number will depend on the number of DSLC controls in the system).

9. **Missed Messages** is the number of times that an incoming packet was discarded because there was no network buffer available. These may be due to excess traffic on the channel, to insufficient network buffers, or to the network buffers not being large enough to accept all packets on the channel, whether or not addressed to this node.

10. **Last Reset Cause** is the cause of the last reset of the network processor.

11. **Node State** indicates the current state of the network processor. The normal node state is “Configured, On-line”. Other states can occur during installation of the control using network management tools.

12. **LON Error Log** is the last run-timer error logged.

13. **LON Interface Errors** is the number of errors detected by the MSLC processor software during communicating with the network processor. Errors can occur during custom installation of the control with network management tools. Occasional errors will not effect control operation. Frequent errors indicate a defective control.

14. **A/D Errors** is the number of errors detected by the MSLC software during communication with the A/D (analog-to-digital) converter. Occasional errors will not effect control operation. Frequent errors may be caused by excessive electrical noise or extreme voltage transients on the wiring, or by a defective control.

15. **Network Loop** is a TRUE/FALSE indication which, when true, indicates a network command input failure has occurred, causing the MSLC control to lock into the last valid network operating command. See Chapter 4, “Menu 5 Configuration” section, for more details on network command operations.

16. **Hardware Loop** is a TRUE/FALSE indication which, when true, indicates a network command input failure has occurred, causing the MSLC control to lock into the current hardware input operating commands. See Chapter 4, “Menu 5 Configuration” section, for more details on network command operations.

17. **DI Commands** is an indication of the current state of operating command input status to the control. See Chapter 4, “Menu 5 Configuration” section, for more details on network command operations.

# Prestart Setup Procedure

Connect the Hand Held Programmer to the Diagnostics and Service Port. Apply dc power (terminals 1 & 2) to the MSLC. Verify that the MSLC passes its power-up diagnostics by checking that the Diagnostic Result in Menu 0 is 49. Failure to get 49 indicates that an internal component in the MSLC is defective. See chapter 11 for instructions on getting service for the control.

## Configuration Menu

Select Menu 5 and adjust the Configuration Key to 49. Set the following set points to their appropriate value as described above.

1. Potential Transformer Ratio
2. Current Transformer Ratio
3. Voltage Input
4. Voltage Display—use kV only when primary voltage is greater than 33 kV
5. System Frequency
6. Process Control Action (if process control is to be used)
7. Network Address (must be unique from other units in the circuit)

Press the “SAVE” key, and verify in Menu 0 that the MSLC sees the proper number of DSLC controls in the system. If not, see Chapter 10 for corrective action.

## Prestart Synchronizer Setup

Set all Synchronizer, Menu 1, set points according to the description above and the work sheet in Appendix A. Leave unknown values, such as Gain and Stability, at their default values until dynamic adjustments can be made.

## Prestart Load Control Setup

Set all Load Control, Menu 2, set points according to the descriptions above and the work sheet in Appendix A. Leave unknown values, such as Gain and Stability, at their default values until dynamic adjustments can be made. Set the utility unload trip to a value that ensures stable operation on the maximum number of generators that the MSLC will be controlling.

## Prestart Load Limits and Switches Setup

Set all load limits and switches according to the descriptions above and the specific plant application. Document these values in the worksheet in Appendix A for future reference and installations.

### Prestart Process Control Setup

Set all Process Control, Menu 4, set points according to the descriptions above and the work sheet in Appendix A. If Gain and Stability values are unknown, leave at their default values.

## MSLC Adjustments

When the prestart setup procedures above have been completed, the MSLC may be installed into the system, and the following adjustment procedures must be followed.

After the unit has been installed and before applying power to the PT and CT inputs, verify the following:

1. The MSLC sees the proper number of DSLC controls on the network (see Menu 0).
2. The MSLC recognizes the synchronizer switch inputs (see Menu 9).
3. The synchronizer is in the "OFF" mode.

## Calibration Check

Temporarily disconnect the network interconnection wires at terminals 40 & 41 on the MSLC (this will prevent the MSLC from giving commands to the associated DSLC controls). Load the system up to a typical import/export level. Check Menu 7 to ensure that the MSLC is sensing the proper voltages, currents, power levels, and power factor.

**NOTE**

**These are calibrated at the factory, but they must be checked for accuracy in order for the MSLC to accurately track to the proper load levels. The MSLC can only be verified against calibrated, true RMS meters. If not in calibration see chapter 10 – troubleshooting.**

**All DSLC controls must be appropriately calibrated according to the DSLC manual prior to further MSLC adjustment.**

- Break the parallel with the Utility.
- Ensure that the MSLC synchronizer mode is "OFF" (Menu 8).
- Re-connect the network (terminals 40 & 41).
- Verify that the MSLC sees the proper number of MSLC/DSLC controls (Menu 0).

## Synchronizer Adjustment

This section is for adjusting the synchronizer functions, including procedures for phase matching and slip frequency synchronizing. Note that dynamic adjustments for gain and stability will be different for each method.

To assist in setup and adjustments, you can monitor synchronizer mode of operation on Menu 8 and Synchronizer Mode and Slip Frequency and Synchroscope values on Menu 7.

## Preliminary Synchronizer Adjustments

1. Set the Voltage Matching set point to Disabled.

2. Select Menu 1 and verify that the Sync Gain and Sync Stability set points are at their default values.

3. Set the Max Phase Window and Max Slip Window set points to desired values or use the default values if unknown.

4. Set Breaker Delay to the closure time specified by the breaker manufacturer. Add delay time for any interposing relays if required.

5. Set CB Close Hold Time to the time desired for the MSLC to hold the breaker closure signal. This time should at least exceed the Breaker Delay time.

6. Set the Close Attempts set point to 1.

7. Set the Sync Timeout set point to 0.

8. Set Auto Re-Synchronize to Disabled.

Proceed to the Phase Matching Synchronizer or Slip Frequency Synchronizer section as required.

# Phase Matching Synchronizer

Do the following steps to set up the synchronizer dynamics for use as a phase matching synchronizer. For slip frequency synchronizing, see the procedure below.

1. Set the Slip Frequency Ref set point to 0.0 Hz to select phase matching.

2. Close the synchronizer Check Mode switch.

3. With utility and bus active, adjust the synchronizer Gain set point for stable control of the utility frequency as indicated by the synchroscope's holding steady at zero phase.

**NOTE**

**If the system (not the MSLC) synchroscope does not lock close to zero phase, but at some other value(such as 30, 60, 180, 210, etc. degrees), verify bus and utility potential wiring to either the synchroscope or MSLC. DO NOT PROCEED WITH ANY ACTION RESULTING IN BREAKER CLOSURE UNTIL THE PROBLEM IS DETERMINED AND CORRECTED.**

**If you have a WYE version MSLC (part number 9907-004), and if line-to-line voltage is used on the Bus PT input, the synchroscope adjustment in Menu 6 must be changed in order to indicate proper phase (compensate for the 30 degree phase shift between the wye and delta inputs). Manually parallel the two power sources in question using a proven device (a panel synchroscope, or phase indication lamps). When the utility breaker is closed, adjust the synchroscope in Menu 6 of the MSLC hand held until the synchroscope reading in menu 6 is 0.0 degrees (±1 degree).**

**If you have a DELTA version MSLC (part numbers 9907-005 or 9907-006), and if line-to-neutral voltage is used on the Bus PT input, the synchroscope adjustment in Menu 6 must be changed in order to indicate proper phase (compensate for the 30 degree phase shift between the delta and wye inputs). Manually parallel the two power sources in question using a proven device (a panel synchroscope, or phase indication lamps). When the utility breaker is closed, adjust the synchroscope in Menu 6 of the MSLC hand held until the synchroscope reading in menu 6 is 0.0 degrees (±1 degree).**

4. Turn the synchronizer mode to Off. Allow the phase to drift until the synchroscope indicates approximately 150 degrees fast. It may be necessary to adjust the engine speed setting slightly fast to achieve the desired phase drift.

5. Turn the synchronizer mode to Check. The synchronizer should pull the generator smoothly into phase lock.

   If the synchronizer action is too slow, increase Sync Gain by a factor of two. If increasing Sync Gain results in unstable operation, reduce the value by at least one-half and proceed to step 6. Otherwise, repeat steps 4 and 5.

6. Do step 4 and then turn the synchronizer mode to Check. The synchronizer should pull the generator smoothly into phase lock. If the synchronizer is too slow, or “over-damped,” decrease Sync Stability by a factor of two to decrease damping, and increase Sync Gain by a factor of two. If the synchronizer is too fast, or “under-damped” as indicated by excessive over-shoot of zero phase when pulling in, decrease Sync Gain by a factor of two, and increase Sync Stability by a factor of two to increase damping.

7. Repeat steps 4, 5 and 6, with smaller adjustment steps until satisfactory performance is obtained.

8. Turn the synchronizer mode to Off. Allow the phase to drift until the synchroscope indicates approximately 150 degrees slow. It may be necessary to adjust the engine speed setting slightly slow to achieve the phase drift. Repeat steps 5 and 6 if necessary to get the desired performance.

9. Verify synchronizer performance under all expected operating conditions, such as synchronizing at higher or lower speeds.

10. If voltage matching is to be used, do the setup in the Voltage Matching section below.

11. Proceed to Final Synchronizer Setup.

## Slip Frequency Synchronizer

Do the following steps to set up the synchronizer dynamics for use as a slip frequency synchronizer. For phase matching synchronizing, see the procedure above.

1. Set the Slip Frequency Ref set point initially to 0.0 Hz to select phase matching.

2. Close the synchronizer Check Mode switch.

3. With utility and bus active, adjust the synchronizer Gain set point for stable control of the utility frequency as indicated by the synchroscope's holding steady at zero phase.

**NOTE**

**If the system (not the MSLC) synchroscope does not lock close to zero phase, but at some other value(such as 30, 60, 180, 210, etc. degrees), verify bus and utility potential wiring to either the synchroscope or MSLC. DO NOT PROCEED WITH ANY ACTION RESULTING IN BREAKER CLOSURE UNTIL THE PROBLEM IS DETERMINED AND CORRECTED.**

**If you have a WYE version MSLC (part number 9907-004), and if line-to-line voltage is used on the Bus PT input, the synchroscope adjustment in Menu 6 must be changed in order to indicate proper phase (compensate for the 30 degree phase shift between the wye and delta inputs). Manually parallel the two power sources in question using a proven device (a panel synchroscope, or phase indication lamps). When the utility breaker is closed, adjust the synchroscope in Menu 6 of the MSLC hand held until the synchroscope reading in menu 6 is 0.0 degrees (±1 degree).**

**If you have a DELTA version MSLC (part number 9907-005 or 9907-006), and if line-to-neutral voltage is used on the Bus PT input, the synchroscope adjustment in Menu 6 must be changed in order to indicate proper phase (compensate for the 30 degree phase shift between the delta and wye inputs). Manually parallel the two power sources in question using a proven device (a panel synchroscope, or phase indication lamps). When the utility breaker is closed, adjust the synchroscope in Menu 6 of the MSLC hand held until the synchroscope reading in menu 6 is 0.0 degrees (±1 degree).**

4. Turn the synchronizer mode to Off. Allow the phase to drift until the synchroscope indicates approximately 150 degrees fast. It may be necessary to adjust the engine speed setting slightly fast to achieve the desired phase drift.

5. Turn the synchronizer mode to Check. The synchronizer should pull the generator smoothly into phase lock.

   If the synchronizer action is too slow, increase Sync Gain by a factor of two. If increasing Sync Gain results in unstable operation, reduce the value by at least one-half and proceed to step 6. Otherwise, repeat steps 4 and 5.

6. Turn the synchronizer mode to Off. Set the Slip Frequency Ref set point to the desired slip rate. Set engine speed slightly slow.

7. Turn the synchronizer mode to Check. The synchronizer should drive engine speed so that phase rotation is smooth and at the correct rate as indicated on a synchroscope or by observing the Slip Frequency set point on Menu 7. If the synchronizer is too slow to react when switched from off to check mode, increase Sync Gain by a factor of two. If the synchronizer action is too aggressive when switched to check mode, reduce the Sync Gain by a factor of two. Repeat until the synchronizer picks up correct phase rotation at a satisfactory rate.

8. Observe the smoothness of phase rotation. If a slow hunt is observed, as indicated by slowing and speeding up of the synchroscope during rotation, increase Sync Stability by a factor of two and repeat step 7. If rapid changes in slip frequency occur, decrease Sync Stability by a factor of two.

9. Repeat steps 7 and 8 with smaller adjustment steps until satisfactory performance is obtained. Note that it may not be possible to remove all slow hunting in slip frequency, and this will not adversely affect synchronization.

10. Verify synchronizer performance under all expected operating conditions, such as synchronizing from higher or lower speeds.

11. If Voltage Matching or the VAR/PF Control is to be used, do the setup in the Voltage Matching Adjustment section below.

12. Proceed with Final Synchronizer Setup.

## Final Synchronizer Setup

1. With the circuit breaker closed, select the Calibration Menu 6 and adjust the Calibration Key to 49. Select the Synchroscope set point and adjust for 0.0 ± 0.3 degrees.

2. Open the breaker to disconnect the local generator bus from the utility bus.

3. Set Close Attempts to the desired number of times the synchronizer should attempt to close the circuit breaker. Set to 1 if only one close attempt should be made.

4. Set Reclose Delay to the desired interval between close attempts. This should be greater than the time required to recharge the circuit breaker arming mechanism.

5. If an alarm is desired when the maximum Close Attempts has been reached, set Sync Reclose Alarm to Enabled.

6. Set the Sync Timeout to the maximum number of seconds the synchronizer should attempt to achieve synchronization. Set to 0 for no timeout.

7. If an alarm is desired when the Sync Timeout interval expires, set the Sync Timeout Alarm set point to Enabled.

8. If it is desired to automatically attempt to reclose the circuit breaker on loss of synchronization, set the Auto Re-Synchronize set point to Enabled. If set point is set to Disabled, the synchronizer will enter an auto-off mode when synchronization is obtained. It will be necessary to set the synchronizer mode switch to Off and back to the desired operating mode to restart the synchronizer.

9. If synchronizer setup and performance is satisfactory, press the “SAVE” key on the Hand Held Programmer to store the dynamic settings.

10. Record all Menu 1 set point values in the spaces provided in Appendix A.

This completes the MSLC synchronizer setup.

## Voltage Matching Adjustment

Do the following steps to verify the correct operation of the voltage matching function. With the utility tie breaker open and at least one generator on line, momentarily raise and lower the voltage on the local generator bus (inputs to terminals 54 & 55).

**NOTE**
**Individual DSLC controls must be setup for proper voltage regulator control prior to adjusting the MSLC control (See the DSLC manual).**

### Preliminary Voltage Regulator Setup

1. With the utility tie breaker closed, calibrate the bus voltage and the phase A voltage to read the same voltage.

2. Select Menu 1 and set the Voltage Matching set point to “Enabled”.

3. Select Menu 3 and set the Voltage High Limit 5% higher than the maximum expected value. Set the Voltage Low Limit 5% lower than the final minimum expected value.

### Final Setup

1. Select Menu 7 and display both Phase A and local generator bus voltages.

2. With the synchronizer “OFF”, manually raise the local bus voltage until it is approximately 5% higher than the utility voltage.

. Set the synchronizer mode to “CHECK”. The MSLC should adjust the local bus voltage until it is within the voltage window selected in Menu 1.

4. If the voltage cycles through the window without settling into it, the voltage adjusting potentiometer on the DSLC controls may need to be adjusted. See the DSLC manual.

5. Set the synchronizer to “OFF”, manually lower the local bus voltage until it is approximately 5% lower than the utility voltage.

6. Set the synchronizer mode to “CHECK”. The MSLC should adjust the local bus voltage until it is within the voltage window selected in Menu 1.

**NOTE**
**If the slip frequency reference is set to zero, the voltage window is ± the set point chosen in Menu 1. If the slip frequency reference is set to a negative or slow slip, the voltage window is such that the local bus voltage must be less than the utility voltage. Conversely, if the slip frequency reference is set to a positive or fast slip, the voltage window is such that the local bus voltage must be greater than the utility voltage. This ensures that the initial flow of reactive power is in the same direction as the initial flow of real power.**

### Final Voltage Matching Setup

1. Set the Voltage High/Low limits in Menu 3 to their desired values.

2. Enable the voltage alarms and voltage switches in Menu 3 if it is desired to activate the alarm or the high-low limit relay drivers upon exceeding a set point.

3. When the voltage matching function is satisfactory, press “SAVE” key on the Hand Held Programmer.

## Load Control Adjustment

This section contains the instructions for setup of the MSLC load control functions. Set all load control (Menu 2 & 3) set points according to the descriptions above and the work sheet. Menu 8 displays for Load Control Mode, Import/Export Reference, and Load Command Output are provided to assist in setup and verification of correct operation.

### Base Load Mode Setup

The Base Load Mode is used when manual control of the operating generators is required, or whenever the generators are desired to be maintained at a set percentage of their rated load without regard to plant loading or import/export levels.

1. Adjust the set points in Menu 2 & 3 as described above.

2. Break the parallel between the local bus and the utility. Place at least one generator in isochronous load sharing.

3. Set the Hand Held Programmer to display Load Command (Menu 8) and the system load (Menu 7). Re-synchronize and parallel the local bus to the utility. Verify that, when the utility tie breaker shuts, the load command assumes the value of system load immediately prior to paralleling.

4. Temporarily issue a lower set point command, and then a raise set point command. Verify that the load command changes appropriately and that the engines in isochronous load sharing respond appropriately.

## Remote Base Load

Do the following steps if the 4–20 mA remote base load reference is to be used. The value of the remote input may be viewed in Menu 6.

1. Set the 4 mA and 20 mA Base Load set points (Menu 2). Either set point may be higher or lower than the other. The MSLC will linearly interpolate between those two set points.

2. Synchronize and parallel the local bus to the utility in the base load mode. Adjust the 4–20 mA input to a level different from the present base load level.

3. Close both the raise and lower set point contacts to select the Remote Mode. The Load Control Mode in Menu 8 should indicate baseload remote, and the load command should ramp to the specified level.

4. Raise and Lower the 4–20 mA signal. The load will ramp at the rates chosen in Menu 2 Load and Unload Ramp Rates. These rates may be adjusted to achieve satisfactory performance.

5. Open the Raise and Lower Set Point contacts. The Load Control Mode should indicate Base Load, and the control should lock at the last base load level chosen by the 4–20 mA input.

This completes the remote base load reference setup procedure.

## Import/Export Mode Setup

1. Do the Base Load Setup described above.

2. Set the import/export reference to an appropriate level different from the current operating level. **NOTE: Do not chose an export level if it is not allowed by the utility.**

3. Ensure that the import/export gain, stability, and derivative are at their default values.

4. Place the control in import/export control while monitoring load control mode (Menu 8). The control will ramp the Load Command Output until the import/export level is within 5% of its target. Then the MSLC will enter dynamic import/export control.

5. If you see instability, adjust the gain, stability, and derivative. If the chosen import/export level is not obtainable within the 0–100% load command range, the control will stop at 0% or 100%.

6. Temporarily issue a lower set point command, and then a raise set point command. Verify that the load command changes appropriately and that the engines in isochronous load sharing respond appropriately.

This completes the import/export setup.

## Remote Import/Export Setup

Do the following steps if the 4–20 mA remote import/export load reference is to be used. The value of the remote input may be viewed in Menu 6.

1. Set the 4 mA and 20 mA import/export load set points (Menu 2). Either set point may be higher or lower than the other. The MSLC will linearly interpolate between those two set points.

2. Synchronize and parallel the local bus to the utility in the base load mode. Place the control in import/export mode at some desirable import/export level. Adjust the 4–20 mA input to a level different from the present import/export level.

3. Close both the raise and lower set point contacts to select the Remote Mode. The Load Control Mode in Menu 8 should indicate import/export remote, and the load command should ramp to the specified level.

4. Raise and Lower the 4–20 mA signal. The load will ramp at the rates chosen in Menu 2 Load and Unload Ramp Rates. These rates may be adjusted to achieve satisfactory performance.

. Open the Raise and Lower Set Point contacts. The Load Control Mode should indicate Base Load, and the control should lock at the last import/export level chosen by the 4–20 mA input. Toggling the import/export contact will cause the control to return to its internally chosen import/export level.

This completes the remote import/export reference setup procedure.

## Final Load Control Setup

1. Set the Load and Unload Rates to their desired values (Menu 2).

2. Set the Load and Unload Ramp Rates to their desired values (Menu 2).

3. Set the Utility and Generator Unload Trip levels to their desired values (Menu 2).

4. Set the High Limit PU (pick up) and DO (drop out) set points to their final values. The High Limit PU set point should be set to limit the load reference even if the alarm and high limit switch will not be used.

5. Set the Low Limit PU and DO set points to their final values. The Low Limit PU set point should be set to limit the load reference even if the alarm and low limit switch will not be used.

6. If it is desired that the Alarm output will also de-energize the alarm relay when load reaches the High Limit PU, set the High Limit Alarm set point to Enabled. The alarm will be automatically cleared when load drops below the High Limit DO switch point.

7. If it is desired that the Alarm output will also de-energize the alarm relay when load reaches the Low Limit PU, set the Low Limit Alarm set point to Enabled. The alarm will be automatically cleared when load increases to above the Low Limit DO switch point.

8. If it is desired that the high and low limit switches also activate the High Limit and Low Limit relay driver outputs, set the Load Limit Switches set point to Enabled.

9. Set the Load Switch PU and Load Switch DO set points to their desired operating levels.

10. When all load control setup is completed, press the “SAVE” key on the Hand Held Programmer to store modified set points.

11. Record all Menu 2 and Menu 3 set points in their respective locations in Appendix A.

## Process Control Adjustment

This section contains instructions for setup of the MSLC Process Control. The Menu 6 display for Process Input and Menu 8 display for Process Target and Load Command are provided to assist in setup and verification of process control operation.

1. Set Menu 4 set points for Process Control Gain, Process Stability, Process Derivative, Process Deadband, Process Droop, and Process Filter to their default values.

2. Set Menu 5 Configuration Key to 49. Set Menu 5 Process Control Action to Direct or Indirect as required for the process. If increasing load also increases the process input signal level, use Direct. If increasing load decreases the process input signal level, use Indirect.

3. Set the Process Reference set point to a value requiring approximately 50% load to maintain the process signal level. If the required process reference is not known at start-up, operate the MSLC in base load mode. Use the Raise and Lower Set Point inputs to adjust the load until the desired process level is obtained. Observe the process input in Menu 6 to determine the required process reference value.

4. Close the Process switch. Select “RUN” on the MSLC to parallel the local bus with the utility. The MSLC will ramp into process control.

5. If the Process Control is unstable when taking control, decrease the Process Control Gain to achieve stability. If decreasing Process Control Gain increases instability, increase Process Control Stability. If the Process Control Gain is too slow, increase the Process Control Gain by a factor of two. If a slow hunt is observed or excessive overshoot of the process reference settings occurs, increase the Process Stability by a factor of two.

6. In systems experiencing rapid fluctuations of the process input, reducing the process filter and increasing the process deadband will provide a slower but more stable response.

7. Introduce Process Droop if required.

8. Set the Process High Limit PU and DO set points to the desired values. The Process High Limit PU set point must be set to limit the range of the process reference even if the alarm will not be used.

9. Set the Process Low Limit PU and DO set points to the desired values. The Process Low Limit PU set point must be set to limit the range of the process reference even if the alarm will not be used.

10. If it is desired that the Alarm output will also de-energize the alarm relay when the process input reaches the Process High Limit PU, set the Process High Limit Alarm set point to Enabled. The alarm will be automatically cleared when the process input level drops below the Process High Limit DO switch point.

11. If it is desired that the Alarm output will also de-energize the alarm relay when the process input reaches the Process Low Limit PU, set the Process Low Limit Alarm set point to Enabled. The alarm will be automatically cleared when the process input increases to a level above the Process Low Limit DO switch point.

12. If it is desired that the high and low limit switches also activate the High Limit and Low Limit relay driver outputs, set the Process Switches set point to Enabled.

13. Verify dynamic performance is satisfactory under all expected operating conditions, then press the “SAVE” key on the Hand Held Programmer to save the dynamic and other modified settings.

14. Record all set points in Menu 4 in their respective locations in Appendix A.

This completes setup of the MSLC Process Control function.

## Conclusion of Setup Procedures

This completes the adjustment chapter. Be sure to save the set points by pressing the “SAVE” key on the Hand Held Programmer. Run through all the set points and record them for future reference in Appendix A. This can be useful if a replacement control is necessary or for start-up of another similar unit. Power down the control for about 10 seconds. Restore power and verify that all set points are as recorded.

**CAUTION—SAVE SET POINTS**

**To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.**

Disconnect the Hand Held Programmer from the control. Close the cover over J1 and re-tighten the retaining screw.

# Chapter 5.
# Synchronizer Description

## Introduction

Synchronization as applied to the generation of electricity, is the matching of the output voltage wave form of one synchronous alternating current electrical generator with the voltage wave form of another alternating current electrical system. For the two systems to be synchronized and connected in parallel, five conditions must be considered:

- the number of phases in each system
- the direction of rotation of the phases
- the voltage amplitudes of the two systems
- the frequencies of the two systems
- the phase angle of the voltages of the two systems

The first two conditions are determined when the equipment is specified, installed, and wired. The synchronizer matches the remaining conditions (voltage, frequency, and phase) before the paralleling breakers are closed.

## Functional Description

This section describes how generator and bus matching occurs and how all conditions are verified by the synchronizer functions. Figure 5-1 shows the functional block diagram of the synchronizer for reference during the following descriptions.

### Operating Modes

The operation of the synchronizer is determined by the mode switch as shown in Figure 5-2. The four modes are Off, Run, Check, and Permissive. When the switch is off, the synchronizer is out of operation.

Run mode allows normal synchronizer operation and breaker closure signals. The speed bias signal (explained below) is maintained throughout the breaker closure signal. When the specified closure signal time has elapsed or the CB (circuit breaker) aux contact closure signal is received at terminal 47, the synchronizer is disabled. The synchronizer may optionally be reset automatically when the generator is disconnected from the bus.

Check mode allows normal synchronizing and voltage matching, but does not issue a breaker closure signal.

Permissive mode enables the synch-check function for proper synchronization, but synchronizer operation does not affect the engine's speed or generator voltage. If phase, frequency, and voltage are within proper limits, the synchronizer issues the breaker closure command.

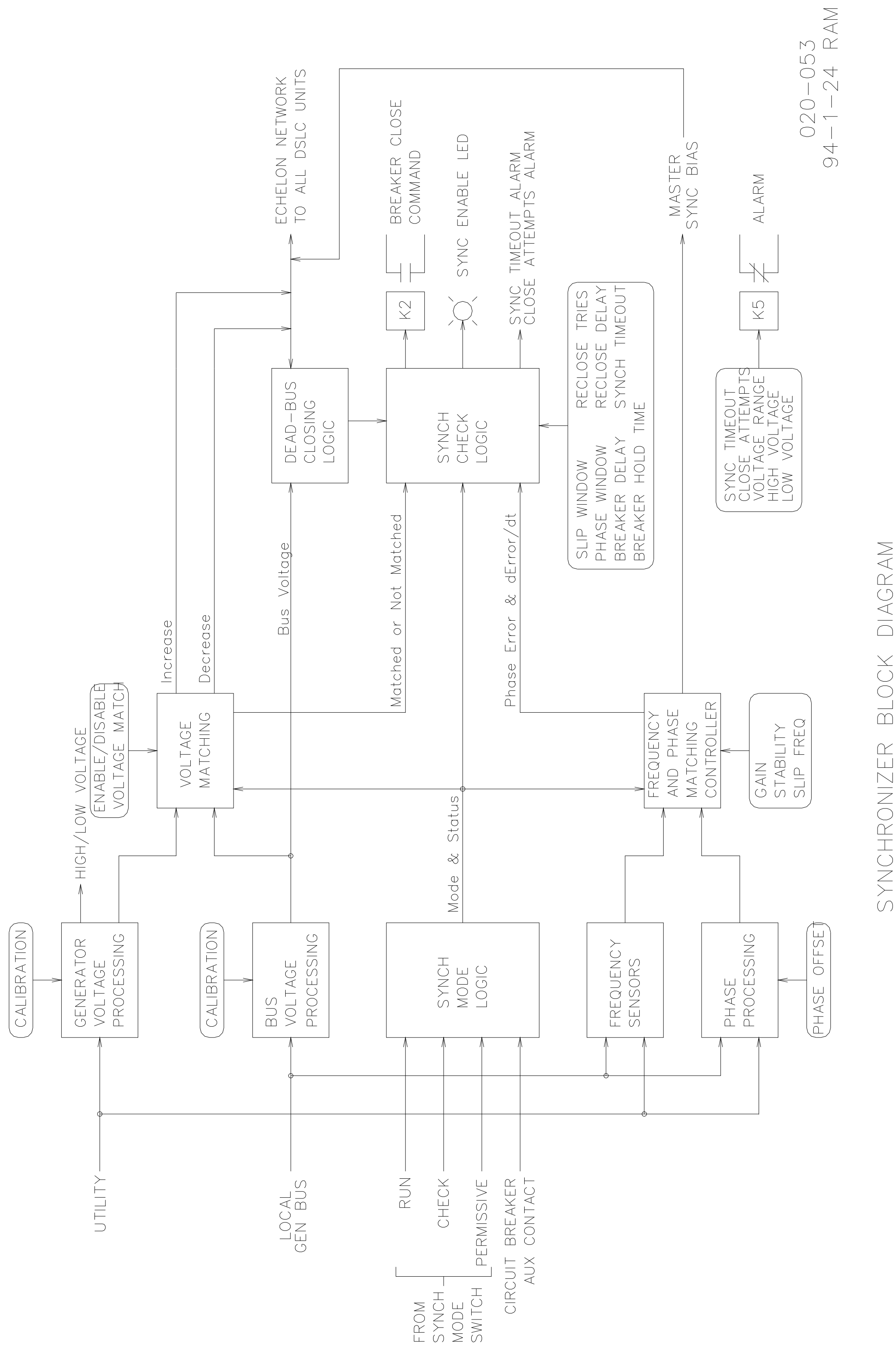


Figure 5-1. Synchronizer Block Diagram

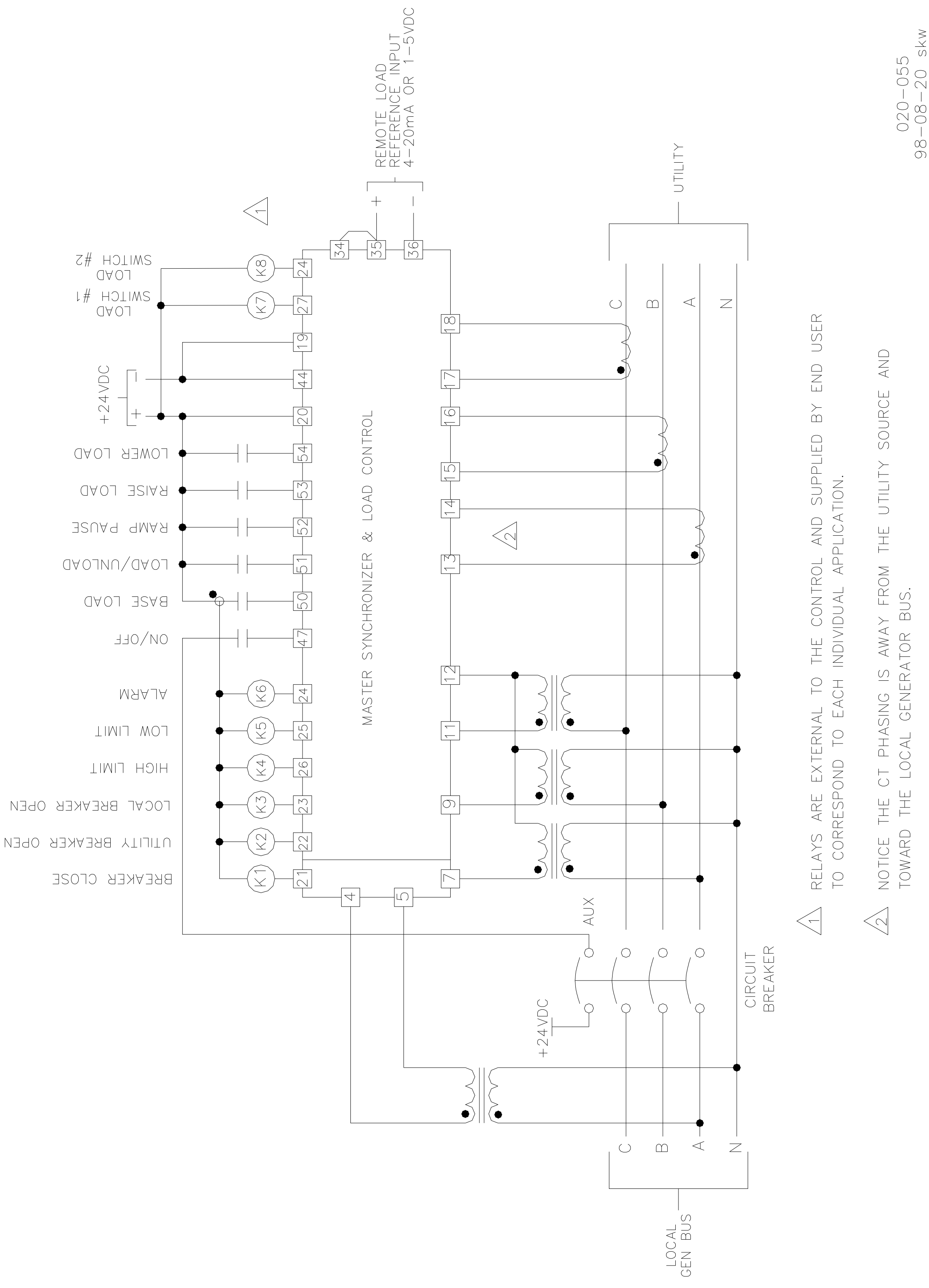


Figure 5-2. Synchronizer Wiring Diagram
(120 V wye configuration shown)

## Voltage Matching

The voltages of two systems in parallel must be matched within a small percentage to minimize the unnecessary reactive power flow in the system. If a local plant is paralleled to the main grid with unequal voltages, the local plant will, in most cases, follow the utility voltage. The difference in voltage will cause reactive power either to be absorbed or generated.

If the system is initially at a lower voltage than the utility, reactive power will be absorbed by the system. If the system voltage was initially higher, the local plant will provide extra reactive power to the utility. In either case the breaker across which the parallel is made will experience unnecessary wear and tear created by the arcing across different voltages.

Figure 5-3 shows the voltage matching circuits of the synchronizer function in the MSLC. The voltages proportional to the local generator bus phase A and the utility phase A are input to the sample-and-hold circuits of the A/D (analog-to-digital) converter, where they are held until actually read by the A/D converter. This process is repeated for the desired number of samples and cycles of the ac input wave forms.

The microprocessor then computes the RMS values of the voltages. The processor issues appropriate raise or lower commands, or voltage bias adjustment to all of the DSLC™ controls over the digital network. The MSLC will continue this process until the difference between local bus and utility voltage is within a specified window. The automatic voltage matching function may be enabled or disabled with a configuration set point. When enabled, voltage matching will occur in both the Check and Run modes, and is verified to be within the window in the Permissive mode.

## Phase Matching Synchronizer

The phase matching synchronizer mode corrects the frequency and phase of the system to lock it to the utility bus frequency and phase. The phase matching method of synchronizing is automatically selected by setting the slip frequency reference set point to zero. The microprocessor uses signal processing techniques to derive the phase differences between the phase A voltages of the local bus and the utility. When an error exists between these voltages, the MSLC sends a bias signal over the digital network to the DSLC controls to increase or decrease the local bus frequency. A PI (proportional/integral) controller provides the correction signal. Gain and stability adjustments are provided to allow stable operation of the automatic synchronizer function over a wide range of system dynamics.

## Slip Frequency Synchronizing

Slip frequency is defined as the difference between the frequencies of the two electric power sources to be paralleled. In certain applications it may be desirable to ensure that the initial flow over power be either from or to the utility. Depending on the requirement, the local bus can be brought into parallel with a slightly higher or lower frequency than the main. This will ensure that the initial power flow is out of or into the plant. The slip frequency method of paralleling is selected when the slip frequency reference is set to a non-zero value.

The synchronizer automatically controls the generator at the specified slip frequency. The MSLC outputs an error signal over the LON to the DSLC controls to change their bias on the electronic speed controls. Gain and stability adjustments to the slip frequency PI controller are provided to allow stable operation of the automatic synchronizer function over a wide range of system dynamics.

## Sync-check

The sync-check function determines when all conditions for proper synchronization are met and energizes the breaker closure relay driver. The voltages of the two sources to be paralleled are verified to be within the chosen window if the voltage matching function is enabled.

To minimize voltage transients and limit wear and tear on the breakers, the parallel must be made when the phase difference between the utility and the local bus is near zero. Due to delays inherent in the breaker closure relays and breaker mechanisms, the synchronizer must issue the breaker closure command ahead of the zero phase difference point. The control compares the slip frequency to the breaker closure delay in order to anticipate the breaker actually closing at the zero phase difference. The phase and slip frequency windows provide maximum and minimum conditions for this calculation. When all conditions of voltage and phase are achieved, the breaker closure command is issued.

## Multiple Shot Reclosing

The multiple shot reclosing set point allows the user to determine the number of times the MSLC is allowed to attempt to close the breaker. The control also provides an adjustable reclose delay which chooses the amount of time the control waits between breaker closure attempts. Failure to achieve synchronization after the specified number of closure attempts sets the synchronizer to the “OFF” mode, requiring the synchronizer mode selector switch to be toggled to “OFF” and then back to “RUN” before the control will again attempt synchronization. An alarm is provided which if enabled will energize the alarm relay driver, terminal 24, if the closure attempts limit is exceeded. The multiple shot closing function is disabled by setting the close attempt set point to one, the default value. This allows only one shot at closing the breaker.

## Synchronizer Timers

The synchronizer function is equipped with two adjustable timers. The first is the circuit breaker close hold time. This timer has two functions. First, it determines the amount of time the control maintains the utility breaker close relay driver energized. Second, it sets the period the breaker must remain closed for the control to assume that a proper synchronization and parallel has been achieved.

The other timer is the sync timeout. The sync timeout chooses how long the control is allowed to attempt to achieve synchronization. If synchronization is not attained in this period of time from the issuing of the “RUN” command, the synchronizer goes to the “OFF” mode, requiring the synchronizer mode selector switch to be toggled to “OFF” and then back to “RUN” before the control will again attempt synchronization. An alarm is provided which if enabled will energize the alarm relay driver, terminal 24, if the a sync timeout occurs. The sync timeout function is disabled by setting it to zero.

# Chapter 6.
# Real Power Control

## Introduction

The MSLC provides several modes of system load control. These are:

- Base Loading
- Import/Export Level Control
- Process Controlled System Load

Automatic ramping functions provide bumpless transfers when adding or removing generators from the local plant and when unloading the utility or the local generators.

## Power Sensor Theory of Operation

The digital signal processing (DSP) power measurement technique used by the MSLC involves periodic sampling of the voltage and current over an integral number of wave forms. The microprocessor computes the product of the voltage and current samples, then sums and averages the products to give a computation of power.

The average power measured over an interval of *n* samples is given by

$$P = \frac{1}{n}\sum_{i=1}^{n} V_i I_i$$

where $V_i$ and $I_i$ are simultaneous samples of voltage and current equally spaced in time. The average power in the three phase system is the sum of the power in each phase.

While the power measurement is of the greatest interest, other functions may also be derived from the raw data. These are

$$rms\ Volts \quad \vec{V} = \left[\frac{1}{n}\sum_{i=1}^{n} V_i^2\right]^{\frac{1}{2}}$$

$$rms\ Amps \quad \vec{I} = \left[\frac{1}{n}\sum_{i=1}^{n} I_i^2\right]^{\frac{1}{2}}$$

$$Volt\text{-}Amps \quad S = \vec{V}\vec{I}$$

$$Reactive\ Power \quad Q = (S^2 - P^2)^{\frac{1}{2}}$$

$$Power\ Factor \quad pf = \frac{P}{S}$$

$$Phase\ Angle \quad \theta = \tan^{-1}\left(\frac{Q}{P}\right)$$

$$Frequency \quad f = \frac{1}{T}$$

where *T* is the sampling period. The sampling period is derived from the zero crossings of the A phase voltage signal.

## Load Sensor Hardware Description

The digital load sensor gets timing information from the generator A phase voltage signal. Voltages proportional to the voltage and load current for each phase are routed to the sample-and-hold circuits of the A/D converters. The simultaneous sampled values representing voltage and current are held when a conversion-store signal is received from the microprocessor. Each input is then converted and an interrupt is generated when all inputs are converted. The microprocessor then reads the digital values from A/D registers. This procedure is repeated at regular intervals to provide input for further signal processing.

To provide accuracy in the presence of noise and harmonics on the inputs, multiple samples of each wave form over a number of cycles of the input are taken to get the power measurement.

## MSLC/DSLC™ Interface

The MSLC controls only those DSLC™ controls which are set up for isochronous load sharing, in the "parallel mode" of load control. In the parallel mode, DSLC controls normally average the percentage of rated load seen by all machines on the network. This average is called the system load. Without an MSLC present, the DSLC controls use the calculated system load as their load reference. The MSLC takes control of this system load to vary the load on the individual DSLC controls.

## Base Load Mode

In this mode, the MSLC takes the system load percentage immediately prior to paralleling with the utility or upon entering the base load mode from another mode, as seen by the individual DSLC controls in the system, and uses this as its initial reference. Changing the raise/lower set point inputs raises or lowers the operating system load percentage. All DSLC controls in isochronous load sharing will then maintain a set percentage of their rated load, and the utility will pick up all load swings. Therefore, if local plant load were to decrease from the initial point, the local plant will begin to export power. Conversely, if the local plant load were to increase from the initial point, the local plant will import power to make up the difference. The MSLC will not respond to any changes in the PT or CT inputs of the control. It merely sends out (in an open loop) a reference at which the DSLC controls will control their associated generators. Lowering the base load signal below the generator unload trip set point will activate (de-energize) the generator breaker open relay driver output.

## Import/Export Mode

In this mode of system load control, the MSLC measures the real power flow to or from the main power grid. It then controls all individual DSLC controls which are in the isochronous load sharing mode, by setting their system load. The individual DSLC controls will control to this percentage of their rated loads, and the MSLC will adjust this system load up or down to achieve the proper import/export level. For safety, the MSLC is limited to controlling generators between 0% and 100%.

**NOTE**
**Any DSLC set for base loading will maintain its individually set base load, regardless of the MSLC signal. Therefore, a sufficient number of generators must be in isochronous load sharing in order to handle plant load swings and still maintain the import/export level.**

## Process Control Mode

This mode is described in detail in Chapter 8, but is implemented essentially the same way as the import/export mode. The MSLC will again control the DSLC equipped generators by adjusting the system load. The MSLC will not respond to any changes in the PT or CT inputs of the control. It will simply change the reference at which the DSLC controls control their associated generators in order to maintain the process input to a chosen level. Again, the MSLC is limited to changing the reference signal to the DSLC controls between 0 and 100%.

## Remote Control

In any of the above modes, the reference can be determined by a 4-20 mA (1-5 Vdc) input at terminals 35 & 36. The remote mode is selected by activating both the set point raise and lower at the same time. The 4 mA and 20 mA targets are set in Menu 2, and the control linearly interpolates for intermediate values.

## Automatic Power Transfer Control Functions

### Ramping Between Modes

Whenever the mode of load control is changed, the MSLC will ramp at a user chosen rate until it is within 5% of its new reference. Then, it will begin dynamic control. This provides smooth (bumpless) transitions between all modes.

### Utility Unload

When the utility unload command is issued, the MSLC will adjust the import/export level until a specified level about the zero power transfer point is obtained. It will then issue a utility breaker open command. If the local plant is initially operating at some export level, supplying power to the utility, the MSLC will lower the system load set point to obtain a zero power transfer condition. If the local plant is initially operating at some import level, absorbing power from the utility, the MSLC will raise the system load set point to obtain a zero power transfer condition. If the MSLC cannot bring the import/export level within the chosen band prior to reaching a system load set point of 0% or 100%, the unload will stop and if enabled the appropriate high/low limit alarms will activate.

### Local Unload

When the MSLC is in base load mode and the set point lower command is continuously activated, the control will lower on the system load reference until it is below a chosen percentage. It will then issue a local generator bus breaker open command. This will transfer the plant load back to the utility power grid.

The mode of power transfer is determined by the position of the inputs to terminals 47 through 53. A convenient table is provided on the next page to illustrate the different modes.

| | CB AUX | UTLTY UNLD | I/E | PROC CTRL | RAMP PAUSE | STPT RAISE | STPT LOWER |
|---|---|---|---|---|---|---|---|
| NO CONTROL | 0 | X | X | X | X | X | X |
| BASE LOAD | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| RAISE BASE LOAD | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| LOWER BASE LOAD | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| REMOTE BASE LOAD[1] | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| UTILITY UNLOAD[2] | 1 | 1 | X | X | 0 | X | X |
| LOCAL UNLOAD[3] | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| RAMP PAUSE[4] | 1 | X | X | X | 1 | X | X |
| I/E MODE | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| I/E RAISE | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| I/E LOWER | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| I/E REMOTE[1] | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| PROCESS CONTROL | 1 | 0 | X | 1 | 0 | 0 | 0 |
| PROCESS RAISE | 1 | 0 | X | 1 | 0 | 1 | 0 |
| PROCESS LOWER | 1 | 0 | X | 1 | 0 | 0 | 1 |
| PROCESS REMOTE[1] | 1 | 0 | X | 1 | 0 | 1 | 1 |

**NOTES:**

1. Remote reference is activated by closing both set point raise and set point lower switches at the same time.

2. The MSLC can only load the associated generators to 100%. If this is not enough capacity to unload the utility, the unload ramps stops at 100% rated load on the associated generators. The generator high limit alarm, if enabled, will activate at this time.

3. The local plant unload is accomplished by switching to base load mode and supplying a continuous set point lower command.

4. The ramp pause command will pause all ramps in any mode.

# Chapter 7.
# VAR/PF Control

When a local plant is paralleled with the main utility power grid, the synchronizer voltage matching function adjusts the individual generator voltages to match the local bus to the main grid. Voltage fluctuations may occur in the utility system after paralleling. This results in corresponding fluctuations in the reactive load on the local plant. The MSLC has three modes of controlling reactive load:

- **Constant Generator Power Factor**. The MSLC sets the power factor reference of the generators according to the value chosen by the hand held programmer. This reference remains constant, and will not change with changing reactive load across the utility tie.
- **Power Factor Control**. The MSLC adjusts the power factor references of the generators in order to maintain a chosen power factor level across the utility tie.
- **VAR Control**. The MSLC adjusts the power factor reference of the generators in order to maintain a chosen VAR level across the utility tie.

Manual VAR/PF control can be attained by using the raise and lower voltage inputs in the Constant Generator Power Factor mode. The raise voltage command will make the power factor reference more lagging and the lower voltage command will make the power factor reference more leading.

The MSLC implements power factor control over the LON, setting the power factor reference on all DSLC™ controls in isochronous load sharing. The DSLC controls then either adjust their analog outputs to their associated voltage regulators or adjust their associated voltage trim motor operated potentiometers, depending on the individual installation.

When a utility unload command is issued, the control automatically shifts from VAR control to power factor control in order to ensure a minimum amount of current flow across the utility tie when it is opened.

It is important to note that, as with the real load functions, the VAR/PF control in the MSLC controls only those DSLC controls which are in isochronous load sharing. Any DSLC controls which are in base load mode will control the reactive power on their associated generators in accordance with their own internal reference and chosen mode of VAR/PF control.

# Chapter 8. Process Control

## Introduction

The process control function of the MSLC controls any process where the controlled parameter is determined by the load on the local generators. The controlled parameter can be monitored as a 4-20 mA or 1-5 Vdc signal.

The control compares the input signal to the process reference set point, or the remote reference if used, and adjusts the local generator loading to maintain the desired set point.

## Description

Figure 8-1 shows a block diagram of the process control function. The process control mode is selected when the process input switch contact is closed. The process input signal is compared with the process reference, which may be either the internal fixed reference or the 4-20 mA remote input. In process control mode, the raise/lower set point discrete inputs operate on the process control reference rather than on the load reference. The 4-20 mA remote reference input becomes the process reference and is selected when both the raise and lower set point contact inputs are closed.

When the process function is initially selected, the reference is set equal to the internal or remote process reference. If the process input and process reference are not equal, the control ramps the load reference in the appropriate direction to reduce the difference error. When the process error reaches zero or the percentage system load command reaches the maximum (100%) or minimum (0%) values, the process control is enabled.

When the process control is enabled, the error signal between the process reference and process signal is the input to a PID (proportional/integral/derivative) controller operating in cascade with the load control. The output of the controller is the system load percentage to all associated DSLC™ controls operating in the parallel mode. The individual DSLC controls then control their associated speed controls to maintain the commanded percentage of their individual rated loads (thereby maintaining the process level at the desired set point).

Additional features of the process control are an adjustable process input signal filter and adjustable deadband on the integrator. The adjustable filter allows reducing bandwidth when controlling a noisy process. The deadband is useful in both noisy applications as well as for very slow processes.

The process control function is configurable for direct and inverse action. Direct process control is where the sensed input signal increases as the load increases. An inverse action control is where the sensed input signal decreases as the load increases.

**NOTE**
**The MSLC system load command is obeyed only by the associated DSLC controls which are in isochronous load sharing. Base load or process control mode will ignore the MSLC load command signal and maintain its set base load reference.**

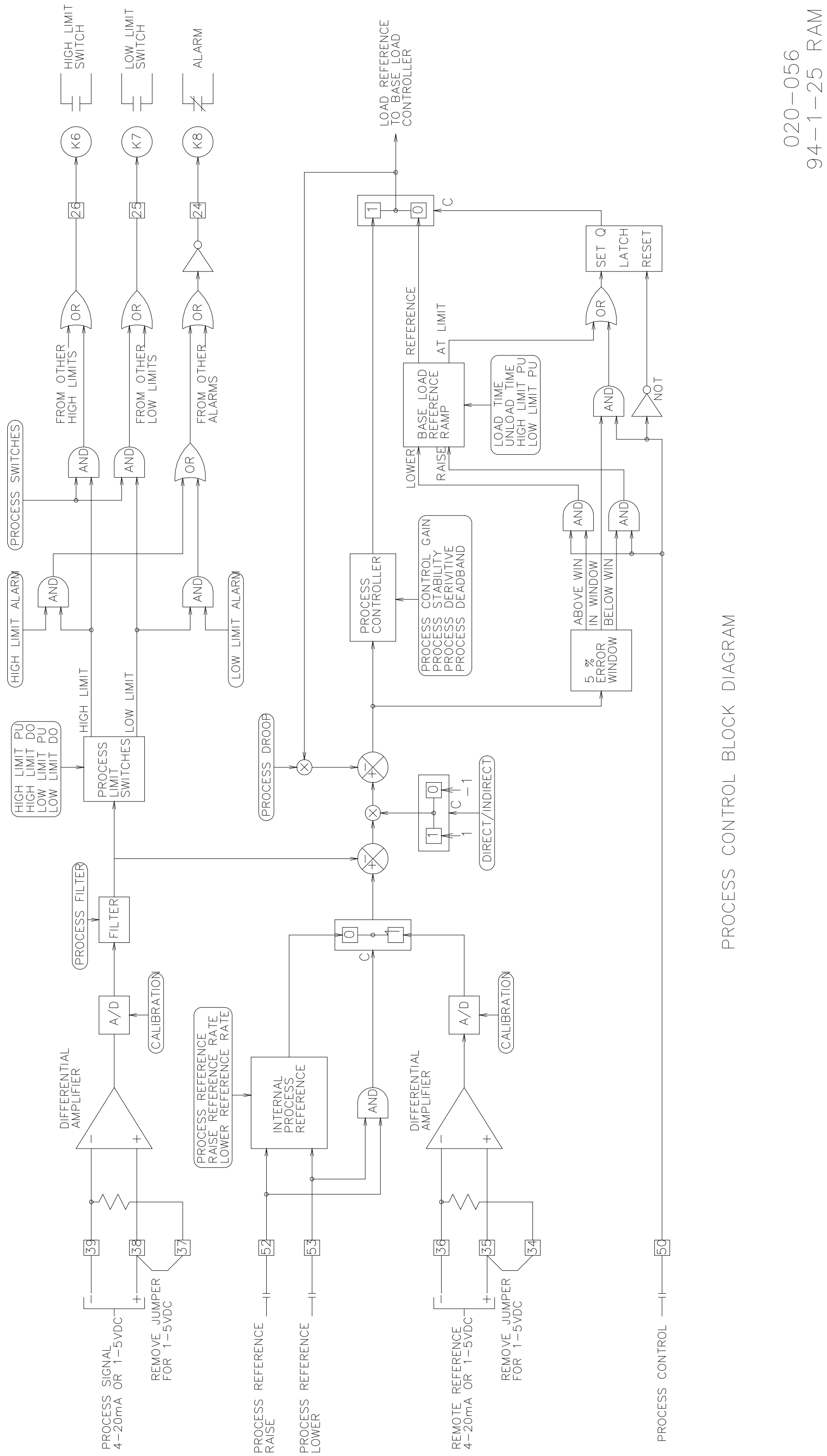


Figure 8-1. Process Control Block Diagram

# Chapter 9.
# Echelon® Lonworks™ Network

## Introduction

The communications network used by the MSLC is Echelon® Corporation's LonWorks™ technology. An Echelon Neuron® chip operates as a slave processor to the MSLC main processor. As described in previous chapters, LonWorks provides the interconnection between the MSLC and all of its associated DSLC™ controls over which the MSLC will control the loading of generators, generator power factor, and local bus/utility synchronization.

The MSLC contains diagnostics software to assist in verifying proper operation of the network and to aid in troubleshooting in case of problems. Diagnostic and other network test information is contained in Chapter 10 (Troubleshooting).

The MSLC also provides optional remote metering, control status, alarm monitoring, and full remote control capability over the network when connected to the appropriate LonWorks-compatible devices through a custom installation. This chapter provides information on network specifications and the optional capabilities of the MSLC. Contact the Woodward Governor Company for full information on optional devices to take advantage of these features.

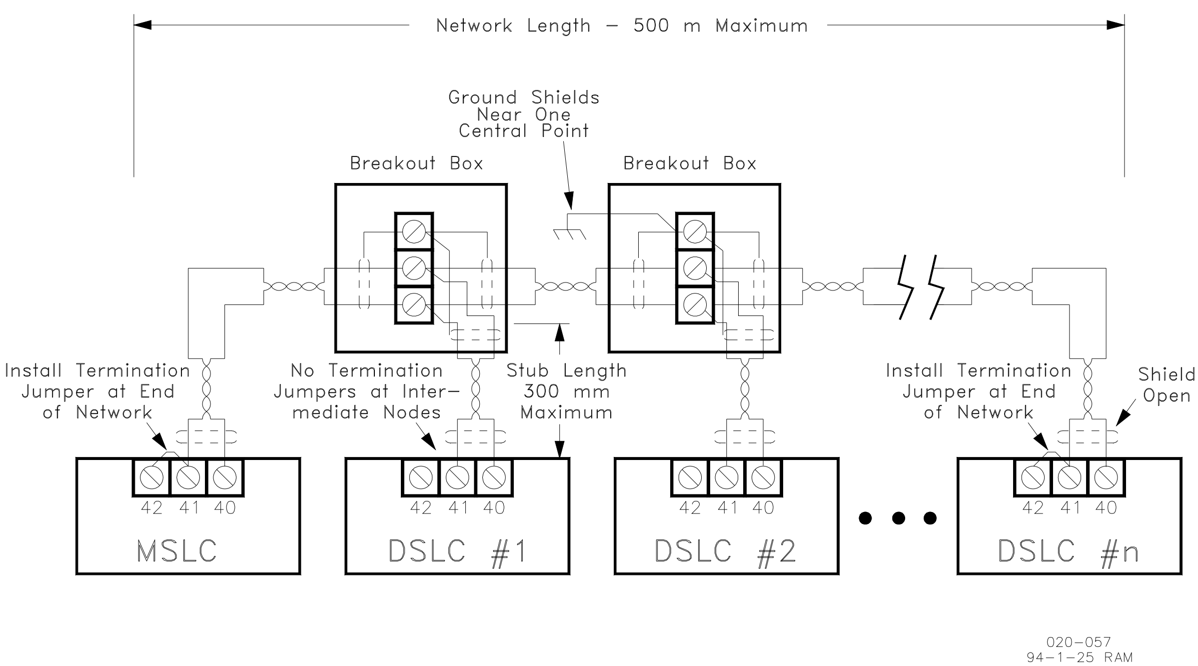


Figure 9-1. Typical LON Setup

# Remote Metering

The following listing shows the actual values as applied to the MSLC. The values are not necessarily the same as the values displayed on the Hand Held Programmer. The Hand Held Programmer displays values which are, in some cases, multiplied by the PT or CT ratios (voltages may also be displayed as line-to-line). All described values are available as SNVT_count (Standard Network Variable Type, count is 16-bits). Values area also in standard 2's complement integer form stored such that the most significant byte is at the lowest address. Metering values are updated at a 1.0 second rate and are intended for monitoring purposes only.

The following signals are available through the LonWorks network:

**V_a, V_b, V_c** are the actual three-phase, line-to-neutral RMS voltages on the PT inputs to the MSLC. The voltage has a times-10 scaling (that is, 1146 would represent 114.6 volts RMS).

**I_a, I_b, I_c** are the actual three-phase RMS current inputs on the CT inputs to the MSLC. The currents have a times-100 scaling (485 would represent 4.85 A RMS). Negative currents represent current flowing into the local plant (import current).

**P** is the actual three-phase RMS real power in watts. Negative watts indicates power import. The value is not multiplied by the CT and PT ratios, so does not reflect actual real power across the utility tie, but instead a proportional value to the actual power flow.

**S** is the apparent power in volt-amperes (VA). The value is not multiplied by the CT and PT ratios, so does not reflect actual apparent power across the utility tie, but instead a proportional value to the actual power flow. Displayed as an absolute value.

**Q** is the actual three-phase RMS reactive power in volt-amperes-reactive (VARs). Negative VARs indicates power absorbed. The value is not multiplied by the CT and PT ratios, so does not reflect actual reactive power across the utility tie, but instead a proportional value to the actual power flow.

**V_gen** is the actual line-to-neutral RMS voltage on the local bus PT input to the MSLC. The voltage has a times-10 scaling (that is, 1146 would represent 114.6 volts RMS).

**Gen_frequency** is the local generator bus frequency. The frequency has a times-100 scaling (that is, 6002 would represent 60.02 Hz).

**Util_frequency** is the utility bus frequency. The frequency has a times-100 scaling (that is, 6002 would represent 60.02 Hz).

**pf** is the average of the A, B, and C phase power factors. Power factor has a times-20000 scaling (that is, 20000 would represent a 1.0 and +20000 would represent +1.0). Power factor is further encoded such that 1.0 represents 0.0 lagging power factor, +1.0 represents 0.0 leading power factor, and 0.0 represents a power factor of 1.0. (Note: power factor across the utility tie is available at a 200 ms rate.)

# Commands to DSLC Controls

The following listing shows the actual values as applied to the MSLC. The values are not necessarily the same as the values displayed on the Hand Held Programmer. All described values are available as SNVT_count (Standard Network Variable Type, count is 16-bits). Values area also in standard 2's complement integer form stored such that the most significant byte is at the lowest address. Command values are updated at a 200 ms rate.

**lc_load_level** is the percentage of rated load command to the associated DSLC controls. It has a times-200 scaling (that is, 20000 would represent 100% load command).

**pf_ref** is the power factor command to the associated DSLC controls. Power factor has a times-20000 scaling (that is, 20000 would represent a 1.0 and +20000 would represent +1.0). Power factor is further encoded such that 1.0 represents 0.0 lagging power factor, +1.0 represents 0.0 leading power factor, and 0.0 represents a power factor of 1.0.

**master_flag** is a 16-bit word containing the status of the MSLC flags. A bit value of “0” indicates the specified flag is “ON”. A bit value of “1” indicates that the specified flag is “OFF”. The bit representation is as follows:

| | |
|---|---|
| 0—Loadshare Flag | Not used on MSLC |
| 1—PF Share Flag | Not used on MSLC |
| 2—Deadbus Flag | Indicates the MSLC senses a deadbus |
| 3—Not Used | |
| 4—System Master Flag | Identifies the MSLC to the DSLC controls |
| 5—Lower Voltage Flag | Commands DSLC controls to lower voltage |
| 6—Raise Voltage Flag | Commands DSLC controls to raise voltage |
| 7—Slave Enable Flag | Tells the DSLC controls that the MSLC is in control |
| Bits 8–15—not used | |

# Control Status

All described values are available as SNVT_count (Standard Network Variable Type, count is 16-bits). Discrete inputs, outputs, and alarm values are in unsigned integer form stored such that the most significant byte is at the lowest address, with each bit representing a discrete value. Integer values are signed 2's complement, and are updated once per second.

**discrete_in** is a 16-bit word containing the status of the discrete inputs of the MSLC and the watchdog function. A bit value of “0” indicates the specified input is not active (does not have 20-40 Vdc applied). A bit value of “1” indicates that the specified input is active. The bit representation is:

0—Synchronizer Check Mode
1—Synchronizer Permissive Mode
2—Synchronizer Run Mode
3—Circuit Breaker Auxiliary Contact
4—Utility Unload
5—Import/Export Control
6—Process Control
7—Ramp Pause
8—Set Point Raise
9—Set Point Lower
10—Voltage Raise

11—Voltage Lower
12—0
13—0
14—0
15—Watchdog Status

**discrete_out** is a 16-bit word containing the status of the discrete outputs of the MSLC. A bit value of “0” indicates the specified relay driver output is not active (has not gone low). A bit value of “1” indicates that the specified output is active. The bit representation is:

0—Low Limit Relay Driver
1—High Limit Relay Driver
2—Load Switch #1
3—Load Switch #2
4—Alarm Relay Driver
5—Generator Breaker Open
6—Utility Breaker Open
7—Utility Breaker Close
Bits 9–15 are not used.

**alarm_status** is a 16-bit word containing the status of the alarms within the MSLC. A bit value of “0” indicates the specified alarm is not active. A bit value of “1” indicates that the specified alarm is active. The bit representation is:

0—Synchronizer Timeout
1—Synchronizer Reclose Attempt Limit
2—Utility High Load Limit
3—Utility Low Load Limit
4—Process Input High Limit
5—Process Input Low Limit
6—Voltage High Limit
7—Voltage Low Limit

**load_control_state** is a 16-bit word containing the state of the load control function within the MSLC. The state is encoded as an unsigned value which represents the present load control state. The load control state is updated once per second. The value representation is:

0—Offline
1—Baseload
2—Baseload Lower
3—Baseload Raise
4—Baseload Remote
5—Utility Unload
6—Process Ramp
7—Process Control
8—Process Lower
9—Process Raise
10—Process Remote
11—Import/Export Ramp
12—Import/Export Control
13—Import/Export Lower
14—Import/Export Raise
15—Import/Export Remote

**synchronizer_state** is a 16-bit word containing the state of the synchronizer function within the MSLC. The state is encoded as an unsigned value which represents the present load control state. The load control state is updated once per second. The value representation is:

0—Off
1—Check Mode
2—Permissive Mode
3—Run Mode
4—Circuit Breaker Close Command Timer
5—Reclose/In-synch Timer
6—In Synchronization
7—Auto Off

**imp_exp_ref** is the import/export reference level normalized to a percentage of rated load of the plant. The import/export reference has a times-200 scaling (that is, 20000 would represent 100%). The import/export reference is updated once per second.

**pc_target** is the current process control reference when in process control. The Process reference has a times-10 scaling (that is, 200 would represent 20 mA). The process reference is updated once per second.

**gen_high_low_limits** is a 16-bit word containing the status of the generator command high/low limit alarms within the MSLC. A bit value of “0” indicates the specified alarm is not active. A bit value of “1” indicates that the specified alarm is active. The generator high/low limits are updated once per second. The bit representation is:

0—Generator High Limit
1—Generator Low Limit
The other 14 bits are not used.

## Remote Control Inputs

**net_remote_in** is a network remote load or process control reference input. The MSLC hardware remote input must be at 0.0 mA for the network remote input to operate. The remote input has a times-1000 scaling (that is, 20000 would represent 20.0 mA).

**net_process_in** is a network input from a LonWorks-compatible process transmitter. The MSLC hardware process input must be at 0.0 mA for the network process input to operate. The process input has a times-1000 scaling (20000 represents 20.0 mA).

**net_discrete_in** is a network input from a remote sequencer. The input must be in the same format as discrete_in described above. All inputs must be written each time the network discrete input value is updated. The hardware discrete inputs must not be used when the network input is used. Changing any hardware discrete input causes the MSLC to look at all the hardware discrete inputs.

## Specifications

| | |
|---|---|
| Data Rate: | 1.25 MBPS (million bits per second) |
| Network Isolation: | 0–60 Hz: 1000 Vrms (for 60 seconds) |
| | 0–60 Hz: 277 Vrms (continuous) |
| Common Mode Range: | 277 Vrms |
| Electrostatic Discharge: | 15 kV |
| Maximum Nodes per Bus: | 64 (0 to +70 °C) |
| | 32 (+20 to +85 °C) |
| | 20 (+40 to +85 °C) |
| Network Bus Length: | 500 m (+20 to +85 °C) typical |
| | 150 m (+40 to +85 °C) typical |
| Maximum Stub Length: | 300 mm (+40 to +85 °C) |
| | 600 mm (0 to +70 °C) |
| Network Termination: | Required at both ends of the network |

# Chapter 10. Troubleshooting

## General

The following troubleshooting guide is an aid in isolating trouble to the control box, actuator, plant wiring, or elsewhere. Troubleshooting beyond this level is recommended ONLY when a complete facility for control testing is available.

**CAUTION—CORRECT VOLTAGE**
**The control can be damaged with the wrong voltage. When replacing a control, check the power supply, battery, etc., for the correct voltage.**

## Bench Tests

The following tests provide a complete test procedure for the MSLC. Do each test in the order described, as results of tests depend on the results of prior tests. Failure of any of these tests indicates a failure of the control. See Chapter 11 for instructions for returning a control for repair.

Accuracy of tests requiring an external meter will be dependent on instrument accuracy. For best results, use only properly calibrated instruments providing precision exceeding the calibration tolerance.

Unless otherwise specified, all inputs to the control should be disconnected or deactivated during bench tests. Several of the tests cannot be done when the MSLC is in operation. The internal test software verifies that bus and generator potentials are dead prior to executing the test or calibration procedure.

After doing a calibration step as described in the following sections, save the calibration value by pressing the “SAVE” key on the Hand Held Programmer. Removal of power prior to saving will result in loss of calibration data.

### General

Do the following checks on the MSLC. Then verify the functioning of set points and adjustments.

1. Connect the Hand Held Programmer to the control in accordance with the instructions in Chapter 4. Verify that correct voltage and polarity are applied to the control. Verify that the programmer does its power-up test. Failure to do the power up test indicates that either the control or Hand Held Programmer has failed. Replace the MSLC or Hand Held Programmer.

2. Press the “ID” key. The message “MSLC P/N 54XX-XXX” should appear. Failure to display this message indicates either the control or Hand Held Programmer has failed. Replace the MSLC or Hand Held Programmer.

3. Select the Diagnostics menu by pressing “0”. The Self Test Result should display a value of 49. If any other value is displayed, replace the control.

4. Select each of the menus described in Chapter 4 and verify that all set points are as recorded during installation. If any differences are found, change the set point(s) to the correct value. Press the “SAVE” key. The message “Set Points Saved” should be displayed. Remove power from the control for at least 10 seconds. Restore power and verify that correct values were retained during power down. Failure to save values indicates the control has failed and should be replaced.

## Power Supply

To verify that the MSLC power supply functions over its full operating range, set the power supply voltage to the minimum specified (18 Vdc). Apply power to the control and verify that the Self Test Result in Menu 0 is 49. If any other value is displayed, replace the control. Set supply voltage to the maximum specified for the model being tested and repeat the diagnostic check.

## Discrete Inputs

These tests verify the correct function of each of the switch inputs.

Connect a jumper between terminals 1 and 43 of the MSLC to connect the discrete input common. Connect a wire to terminal 2 which will provide the voltage source to test each of the discrete inputs.

With all discrete inputs disconnected, select Menu 9. Step through the menu and verify that all switch inputs indicate Open.

Connect the wire from terminal 2 to terminal 44, the Synchronizer Check Mode switch input. Verify that the Check Switch indication on Menu 9 indicates Closed. Repeat the above step for each of the remaining discrete inputs, terminals 45 through 55, and verify that the corresponding switch input indicates Closed.

An optional minimum voltage test with an external dc power source may be done on the discrete inputs. Connect the dc source to terminal 43 (+) and repeat the previous tests with the voltage source set to 12 Vdc.

## Process Input

This test verifies the operation and calibration of the Process Variable Input.

Connect a jumper between terminals 37 and 38 for testing with a milliamp source. If a voltage source is to be used, do not install the jumper. Calibrate the control with the type of source to be used in service. There is a slight difference in calibration between milliamp and voltage input. Select the Process Input on Menu 6. The value displayed should be 0.0 ± 0.1 mA. Connect an adjustable mA (dc voltage) source to terminals 38 (+) and 39 (+). Set the source for 4.0 mA (1.0 Vdc). The Process Input on Menu 6 should indicate 4.0 ± 0.1 mA. Set the source for 20.0 mA (5.0 Vdc). The Process Input should indicate 20.0 ± 0.1 mA.

To calibrate the Process Input, select Calibration Menu 6. Set the Calibration Key to 49. Select the Process Input set point. Set the mA source to 20.0 mA (5.0 Vdc). Adjust the Process Cal set point for 20.0 ± 0.1 mA. Be sure to save the calibration information by pressing the “SAVE” key on the Hand Held Programmer. Repeat the above process input tests to verify correct calibration over the input range.

## Remote Load Reference Input

This test verifies the operation and calibration of the Remote Load Reference Input.

Connect a jumper between terminals 34 and 35 for testing with a milliamp source. If a voltage source is to be used, do not install the jumper. Calibrate the control with the type of source to be used in service as there is a slight difference in calibration between milliamp and voltage input. Select the Remote Input on Menu 6. The value displayed should be 0.0 ± 0.1 mA. Connect an adjustable 20 mA source (or 1-5 Vdc source) to terminals 35 (+) and 36 (+). Set the source to 4.0 mA (1.0 Vdc). The Remote Input on Menu 6 should indicate 4.0 ± 0.1 mA. Set the source for 20.0 mA (5.0 Vdc). The Remote Input should indicate 20.0 ± 0.1 mA.

To calibrate the Remote Input, select Calibration Menu 6 and set the Calibration Key to 49. Select the Remote Input set point, also on menu 6. Set the mA source to 20.0 mA (5.0 Vdc). Adjust the Remote Cal set point for 20.0 ± 0.1 mA. Repeat the above test to verify correct calibration over the input range.

## Relay Driver Outputs

This section tests the operation of each of the relay driver outputs from the control. Tests require a voltmeter and a 250 to 1000 ohm resistor. Generator Voltage must be removed, all discrete inputs open, and the Test Key set point on Menu 9 set to 49 to do the following tests.

Apply 24 Vdc power to terminals 19 (+) and 20 (+). Connect the resistor from the +24 Vdc source to the Breaker Close terminal 21. Connect the dc voltmeter to terminal 19 (+) and terminal 21 (+). The meter should indicate +24 Vdc. Select Breaker Close Relay on Menu 9. Press either “Rabbit Up” or “Turtle Up” key. The output should energize for approximately one second as indicated by a 0 Vdc indication on the test meter.

Move the resistor and meter connection from terminal 21 and connect to Breaker Open terminal 22. The meter should indicate +24 Vdc. Select the Breaker Open Relay set point on Menu 9. Press either “Rabbit Up” or “Turtle Up” key. The output should energize for approximately one second as indicated by a 0 Vdc indication on the test meter.

Repeat the above test procedure for each of the relay driver outputs and corresponding Menu 9 selection.

## Utility Potential Inputs

This section tests the operation and calibrates the Utility Potential Inputs. Both the high voltage (240 Vac) and low voltage (120 Vac) inputs may be optionally tested. Calibration of the input must be done for the appropriate voltage used in service.

Select Menu 5 and set Configuration Key to 49. Then set the PT Winding Ratio to 1:1. Verify the System Frequency set point is 50 or 60 Hertz as appropriate. Set the PT Voltage Input set point to 240 Vac or 120 Vac (nominal) as supplied for this test. Connect the line potential to the Utility A phase terminal 6 for 240 Vac or terminal 7 for 120 Vac. The actual potential is not important, but should be within 20% of the nominal of 120 or 240 Vac. Connect neutral to terminal 12. Connect an AC voltmeter in parallel with the potential. Select Menu 6 and set the Calibration Key to 49. Select PT Phase A set point, also on Menu 6. Adjust the set point to read the same as the calibration meter ± 0.1%.

Repeat the above procedure for the PT Phase B and PT Phase C utility potential inputs.

Restore the PT Winding Ratio, System Frequency, and PT Voltage Input set points to their previous values.

### Utility Current Inputs

This section tests and calibrates the Utility Current Transformer (CT) inputs.

Select Menu 5 and set Configuration Key to 49. Then set the CT Rating to 5:5. Connect a 0-5 ampere current source to the Utility A Phase CT input at terminals 13 and 14. A resistive load that consumes approximately 5 A at nominal line voltage may be used in series with line voltage to provide the current source. Actual current is not critical, but should be between 4 and 6 A for best results. Connect a current meter in series with the current source.

Activate the current source and select Menu 6. Set the Calibration Key to 49. Select the CT Phase A set point. Adjust the set point to equal the calibration meter ± 0.1%.

Repeat the above steps for the utility CT Phase B and CT Phase C inputs.

Return the CT Rating set point to its previous value.

### Bus Potential Input

This section tests and calibrates the voltage and phase of the bus potential input to match that of the utility A phase input.

Connect the same test potential to Bus A phase PT input and Utility A phase PT input in parallel. Use the 120 or 240 Vac inputs as desired. Select Menu 6 and set the Calibration Key to 49. Read the PT Phase A set point. Select the Bus Voltage set point and adjust to be ± 0.1% of the voltage read for the Utility phase A Voltage.

Select Menu 6 Synchroscope set point. With the voltage input to the Bus and Utility Phase A inputs connected in parallel, adjust the Synchroscope value to 0.0 ± 0.1 degrees.

## LonWorks Network

Menu 0 (Diagnostics Menu), beginning with item 3, contains information to aid in verifying operation and troubleshooting of network operation.

## Active DSLCs

Active DSLCs is the number of MSLC/DSLC™ controls currently in communication. For example, if six units are installed and powered, the value displayed by this set point should be 6. If a value less than the number of MSLC/DSLC controls you have installed is shown, check Menu 5, Network Address, on all MSLC/DSLC controls to verify that each unit has a unique address assigned. Press the "SAVE" key on each unit to be sure the address has been made effective. After the "Set Points Saved" message is displayed, refresh the screen by pressing the "Up/Down Arrow" key twice and verify that the Menu 5 Network Address set point remains at the desired value. While checking each MSLC/DSLC control's address assignment, also note the Menu 0 Active DSLCs set point on each off these units to further aid in troubleshooting.

If Active DSLCs still indicates the wrong value after all addresses are verified, refer to the Active DSLCs information noted when checking each of the units. The following are the most probable causes:

1. If one unit indicates one active MSLC/DSLC and the other units indicate the number is one less than the actual number of units installed, verify the wiring to the MSLC/DSLC reporting one active unit. Replace that MSLC/DSLC if necessary to correct the problem.

2. If one or more units indicate some number less than the correct value, power down one MSLC/DSLC at a time (or carefully disconnect the network wires from each MSLC/DSLC, one at a time) to observe its effect on the other units' Active DSLCs values. If MSLC/DSLC controls on far ends of the network are determined not to be in communication with each other, do the tests described below under Installation Verification below.

If Active DSLCs still indicates the wrong value after doing the above steps, continue with the tests described below under Neuron Status.

## Neuron Status

"Neuron Status" is a set of data that may be retrieved at any time by pressing the "." key on the Hand Held Programmer. This action causes the Echelon Neuron network communications processor to read its status registers and pass this information to the main processor so that it may be observed on the Hand Held Programmer.

**NOTE**

**When the "Retrieve Net Status" setpoint in Menu 0 is toggled from "False" to "True", all status registers are cleared and the current network status is retrieved. The transaction and message information displayed has been accumulated since the control was powered up or status was last retrieved. The following information can be used to determine if the MSLC is operating correctly.**

Menu 0 **Transmit Errors** is a communications accuracy test. Errors result from message collisions and weak or noisy signals. The number of errors from message collisions is a function of the number of messages presented to the network. More than five or ten errors per second indicates the network function should be checked.

1. If the network being used by the MSLCs for load sharing is heavily loaded with other non-load sharing devices, separate the network used by the MSLCs and their associated devices from the other devices. Routers may be used if necessary to communicate between the separated networks.

2. Verify network wiring installation is to specifications.

**Transaction Timeouts** is the number of timeouts that occurred while the unit was waiting for a response from a message. The MSLC expects responses only by the deadbus closing functions. If timeout errors occur during deadbus closing, verify that network wiring installation is to specifications. Otherwise, transaction timeout errors should not normally occur with MSLCs unless a non-standard custom installation has been done and another device to which the MSLC has been connected is not responding.

**Rcv (Receive) Transactions Full** is the number of times an incoming message was lost because no more transaction buffers were available. Frequent errors indicate an overloaded network.

**Lost Messages** is the number of times the application processor received more messages at one time than it could process. It is possible in large systems that enough MSLCs may send out their load sharing information at nearly the same time that lost messages may occur. Occasional errors will not affect operation. If frequent errors occur in systems where a custom network installation has been done, contact the installer. If no custom installation has been done and sufficient errors are occurring to cause load sharing problems, contact Woodward Governor Company.

**Missed Messages** is the number of times the network processor received more messages at one time than it could process. It is possible that enough MSLCs may send out their load sharing information at nearly the same time that Rcv Transaction Full errors may occur. Frequent errors indicate an overloaded network.

**NOTE**
**Missed and lost message errors will occur during power up when connected to an active network. This is normal as messages are not processed during power up diagnostics.**

**Last Reset Cause** is the method by which the Echelon Neuron network chip was reset. After power-up, “Watchdog Reset” should initially be the indicated reset cause. This will switch to “Cleared” on subsequent retrievals of the diagnostic data. “External Reset” indicates the main MSLC processor reset the Neuron chip after losing communication with it. The number of times this occurs is logged in Net(work) Interface Errors described below.

**Network State** should always be “Configured, On-line”. Any other state indicates either a defective MSLC or an improper custom installation using a network management tool.

**Network Error Log** should always display “No Error”. Any logged error should be reported to Woodward Governor Company.

**Net(work) Interface Errors** is the number of times the main MSLC processor had to reset the Neuron chip due to loss of communications. Errors may occur during a custom installation and will cease when installation is complete. Interface errors should not normally occur in operation, but occasional errors that may be caused by extreme transient interference are possible and will not affect control function. Frequent errors indicate extreme interference or a defective MSLC.

## Installation Verification

Verify that the overall network wiring has been done according to specification in Chapters 3 and 9:

1. Wire is a recommended data cable;
2. Bus length is less than 500 m;
3. Stubs are less than 300 mm in length;
4. There are less than 32 devices on the network;
5. Wires exposed beyond shields are minimized;
6. Verify shield continuity through the entire network;
7. Verify that shields are grounded at one central location;
8. Verify that terminations have been made, but only at each end of the network;
9. Make sure wiring is not routed with power lines or other high-electrical-noise lines.

**NOTE**
**See Chapter 9 for a complete list of network specifications.**

If problems still exist, you may disconnect or replace a MSLC or other device attached to the network to investigate its effect on the network. If a custom installation has been done, it will be necessary to use the installation network management tool to properly install a replacement device on the network.

Table 10-1. System Troubleshooting

| PROBLEM | PROBABLE CAUSE | ACTION |
|---|---|---|
| Unit does not power up | No input power supply | Check +24 V power supply. |
| | Input power supply polarity reversed | Ensure proper polarity of +24 V power supply. |
| | Software PROMs installed backwards or in wrong slot (U32 & U46) | Ensure proper installation of PROMs* |
| Unit freezes up after short period of time | Faulty LON PROM (U27) | Check number of active DSLC controls (Menu 0) immediately after power up. If in error, replace LON PROM (U27). |
| Power factor of ±0.5 indicated for a resistive load | Phase ordering of either the current or potential transformers is in the wrong order | Reverse the order of the two phases with negative power factors. |
| Power factor of +1 indicated for a resistive load | Current transformer leads for that phase are reversed | Reverse current transformer leads for the phase in question. |
| Phase currents do not track linearly across their entire range (Menus 6 & 7) | Improper current transformer ratios (Menu 5) | Check transformers and settings in Menu 5 to ensure that they are the same. |
| Phase or Bus voltages do not track linearly across their entire range (Menus 6 & 7) | Improper potential transformer ratios (Menu 5) | Check transformers and settings in Menu 5 to ensure that they are the same. |

*—NOTE 1: Installing PROMs backwards will result in the destruction of the chips. PROMs that have been powered up while installed backwards will need to be replaced.

# Chapter 11.
# 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.

A current list of Woodward Business Partners is available at **www.woodward.com/support**.

# 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 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.

**CAUTION—ELECTROSTATIC DISCHARGE**

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

# 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 and reference **www.woodward.com/support**, and then ***Customer Support***.

## 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 |
|---|---|
| Australia | +61 (2) 9758 2322 |
| Brazil | +55 (19) 3708 4800 |
| China | +86 (512) 6762 6727 |
| Germany: Kempen | +49 (0) 21 52 14 51 |
| Germany: Stuttgart | +49 (711) 78954-0 |
| India | +91 (129) 4097100 |
| Japan | +81 (43) 213-2191 |
| Korea | +82 (51) 636-7080 |
| Poland | +48 12 618 92 00 |
| United States | +1 (970) 482-5811 |

### Engine Systems

| Facility | Phone Number |
|---|---|
| Australia | +61 (2) 9758 2322 |
| Brazil | +55 (19) 3708 4800 |
| China | +86 (512) 6762 6727 |
| Germany: Stuttgart | +49 (711) 78954-0 |
| 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 |
|---|---|
| Australia | +61 (2) 9758 2322 |
| 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 |
| United States | +1 (970) 482-5811 |

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

For the most current product support and contact information, please refer to the latest version of publication **51337** at **www.woodward.com/publications**.

# Technical Assistance

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

## General

Your Name______________________________________________________
Site Location____________________________________________________
Phone Number____________________________________________________
Fax Number______________________________________________________

## Prime Mover Information

Engine/Turbine Model Number_______________________________________
Manufacturer_____________________________________________________
Number of Cylinders (if applicable)__________________________________
Type of Fuel (gas, gaseous, steam, etc)______________________________
Rating__________________________________________________________
Application_______________________________________________________

## Control/Governor Information

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

Woodward Part Number and Revision Letter
______________________________________________
Control Description or Governor Type
______________________________________________
Serial Number ___________________________________

Woodward Part Number and Revision Letter
______________________________________________
Control Description or Governor Type
______________________________________________
Serial Number ___________________________________

Woodward Part Number and Revision Letter
______________________________________________
Control Description or Governor Type
______________________________________________
Serial Number ___________________________________

*If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.*

# Appendix A. MSLC Setup Work Sheet

## Synchronizer Menu 1

| | |
|---|---|
| Sync Gain | __________ |
| Sync Stability | __________Seconds |
| Slip Frequency Ref | __________Hertz |
| Slip Window | __________Hertz |
| Max Phase Window | __________Degrees |
| Voltage Matching | Enabled \| Disabled |
| Voltage Window | __________% |
| Breaker Delay | __________Seconds |
| C.B. Close Hold Time | __________Seconds |
| Close Attempts | __________ |
| Reclose Delay | __________Seconds |
| Sync Reclose Alarm | Enabled \| Disabled |
| Sync Timeout | __________Seconds |
| Sync Timeout Alarm | Enabled \| Disabled |
| Auto Re-Synchronize | Enabled \| Disabled |

## Load Control Menu 2

| | |
|---|---|
| Imp/Exp Control Gain | __________ |
| Imp/Exp Stability | __________Seconds |
| Imp/Exp Derivative | __________Seconds |
| Imp/Exp Deadband | __________% |
| Load Input Filter | __________Hertz |
| Import/Export Droop | __________% |
| Rated Load | __________kW |
| Import/Export Level | __________kW |
| Import/Export 4 mA | __________kW |

| | |
|---|---|
| Import/Export 20 mA | __________kW |
| Baseload 4 mA | __________% |
| Baseload 20 mA | __________% |
| Unload Ramp Rate | __________%/second |
| Load Ramp Rate | __________%/second |
| Raise Load Rate | __________%/second |
| Lower Load Rate | __________%/second |
| Utility Unload Trip | __________kW |
| Gen Unload Trip | __________% |
| Util High Load PU | __________kW |
| Util High Load DO | __________kW |
| Utility High Limit | Enabled \| Disabled |
| Utility Low Limit PU | __________kW |
| Utility Low Limit DO | __________kW |
| Utility Low Limit | Enabled \| Disabled |
| Util Limit Switches | Enabled \| Disabled |
| Generator Load High | Enabled \| Disabled |
| Generator Load Low | Enabled \| Disabled |
| Gen Limit Switches | Enabled \| Disabled |
| Gen Load Switch 1 PU | __________% |
| Gen Load Switch 1 DO | __________% |
| Gen Load Switch 2 PU | __________% |
| Gen Load Switch 2 DO | __________% |

## Process Control Menu 3

| | |
|---|---|
| Process Control Gain | __________ |
| Process Stability | __________Seconds |
| Process Derivative | __________Seconds |
| Process Deadband | __________mA |
| Process Droop | __________% |

| | |
|---|---|
| Process Filter | __________Hertz |
| Process Reference | __________mA |
| Raise Reference Rate | __________mA/Second |
| Lower Reference Rate | __________mA/Second |
| High Limit PU | __________mA |
| High Limit DO | __________mA |
| High Limit Alarm | Enabled \| Disabled |
| Low Limit PU | __________mA |
| Low Limit DO | __________mA |
| Low Limit Alarm | Enabled \| Disabled |
| Process Switches | Enabled \| Disabled |

## VAR/PF Control Menu 4

| | |
|---|---|
| VAR/PF/Constant Gen PF Control Mode | __________ |
| VAR/PF Gain | __________ |
| VAR/PF Stability | __________Seconds |
| Rated kVARS | __________kVAR |
| kVAR Reference | __________kVAR |
| PF Reference | 0.0 lag \| 0.0 lead |
| Const-Gen-PF-Ref | __________ |
| PF Deadband | __________ |
| Voltage Low Limit | __________V, kV |
| Voltage Low Alarm | Enabled \| Disabled |
| Voltage High Limit | __________V, kV |
| Voltage High Alarm | Enabled \| Disabled |
| Voltage Switches | Enabled \| Disabled |

# Configuration Menu 5

| | |
|---|---|
| PT Winding Ratio | ____________:1 |
| CT Rating | ____________:5 |
| Voltage Input | ______120 ______240 Vac |
| Voltage Display | Line-to-Line \| Line-to-Neutral \| Volts \| Kilovolts |
| System Frequency | 50 Hz \| 60 Hz |
| Process Action | Direct \| Indirect |
| Network Address | __________ |
| Network Service Pin | __________ |
| Revert Status | Hardware\|Lock In Last |
| Net Dropout Time | _________ seconds |
| Util Breaker Open Logic | Direct \| Indirect |

# Appendix B. MSLC Specifications

## Part Numbers

| | |
|---|---|
| 9907-004 | MSLC, 4-wire wye configuration, 120 or 240 V |
| 9907-005 | MSLC, 3-wire delta configuration, 120 V |
| 9907-006 | MSLC, 3-wire delta configuration, 240 V |
| 9907-205 | Hand Held Programmer |

## Electrical Specifications

### Control Power Supply Input

| | |
|---|---|
| Operating | 12 to 40 Vdc continuous |
| Maximum | 7 to 77 Vdc for up to 5 minutes |
| Reverse | +56 Vdc continuous |
| Burden | 18 W |

### Synchronizer Input

| | |
|---|---|
| Voltage | 75 to 150 Vac RMS (120Vac input)<br>150 to 300 Vac RMS (240Vac input) |
| Phases | Single |
| Frequency | 45 to 66 Hz |
| Burden | less than 0.1 VA per phase |
| Accuracy | 0.1% of full scale |

### Voltage Sensing Inputs

| | |
|---|---|
| Voltage | 75 to 150 Vac RMS (120Vac input)<br>150 to 300 Vac RMS (240 Vac input) |
| Phases | Three |
| Frequency | 45 to 66 Hz |
| Burden | less than 0.1 VA per phase |
| Accuracy | 0.1% of full scale |

### Current Inputs

| | |
|---|---|
| Current | 0 to 5 A RMS |
| Frequency | 45 to 66 Hz |
| Burden | less than 0.1 VA per phase |
| Accuracy | 0.1% of full scale |

### Discrete Inputs

| | |
|---|---|
| Voltage | 12 to 40 Vdc |
| Burden | 10 mA nominal |

### Relay Driver Outputs

| | |
|---|---|
| Voltage | 12 to 40 Vdc |
| Current | 200 mA sink (max) |

### Analog Inputs

| | |
|---|---|
| Current | 4 to 20 mA |
| Voltage | 1 to 5 Vdc |
| Resistance | 243 Ω current mode<br>10 kΩ voltage mode |

### Local Area Network
ECHELON LONWORKS® Technology

### Calibration and Diagnostics Port
RS-422

## Environmental Specifications

Exceeds:

### Temperature

| | |
|---|---|
| Operating | –40 to +70 °C |
| Storage | –55 to +105 °C |

### Humidity

| | |
|---|---|
| Operating | 95% at 38 °C |

### Mechanical Vibration

| | |
|---|---|
| Level | 2.5 G |
| Frequency | 24 to 2000 Hz |

### Mechanical Shock

| | |
|---|---|
| Test Methods | US MIL-STD-810C, Method 516.2, Shock<br>Procedure I, Figure 516.2-2, basic design test<br>Procedure II, transit drop test<br>Procedure V, bench handling test |

### Electromagnetic Susceptibility

| | |
|---|---|
| Test Method | ANSI/IEEE C37.90.2 |
| Electrostatic Discharge | 6000 Volts |
| Electrical Transients<br>Test Method | <br>ANSI C37.90.1-1989 |

# MSLC Menu Summary

**1—Synchronizer**
1. Sync Gain
2. Sync Stability
3. Slip Frequency Ref
4. Slip Window
5. Max Phase Window
6. Voltage Matching
7. Voltage Window
8. Breaker Delay
9. C.B. Close Hold Time
10. Close Attempts
11. Reclose Delay
12. Sync Reclose Alarm
13. Sync Timeout
14. Sync Timeout Alarm
15. Auto Re-Synchronize

**2—Load Control**
1. Imp/Exp Control Gain
2. Imp/Exp Stability
3. Imp/Exp Derivative
4. Imp/Exp Deadband
5. Load Input Filter
6. Import/Export Droop
7. Rated Load
8. Import/Export Level
9. Import/Export 4 mA
10. Import/Export 20 mA
11. Baseload 4 mA
12. Baseload 20 mA
13. Unload Ramp Rate
14. Load Ramp Rate
15. Raise Load Rate
16. Lower Load Rate
17. Utility Unload Trip
18. Gen Unload Trip
19. Util High Limit PU
20. Util High Load DO
21. Utility High Limit
22. Utility Low Limit PU
23. Utility Low Limit DO
24. Utility Low Limit
25. Util Limit Switches
26. Generator Load High
27. Generator Load Low
28. Gen Limit Switches
29. Gen Load Switch 1 PU
30. Gen Load Switch 1 DO
31. Gen Load Switch 2 PU
32. Gen Load Switch 2 DO

**3—Process Control**
1. Process Control Gain
2. Process Stability
3. Process Derivative
4. Process Deadband
5. Process Droop
6. Process Filter
7. Process Reference
8. Raise Reference Rate
9. Lower Reference Rate
10. High Limit PU
11. High Limit DO
12. High Limit Alarm
13. Low Limit PU
14. Low Limit DO
15. Low Limit Alarm
16. Process Switches

**4—VAR/PF Control**
1. VAR/PF Control Mode
2. VAR/PF Gain
3. VAR/PF Stability
4. Rated kVARS
5. kVAR Reference
6. PF Reference
7. Const_Gen_PF_Ref
8. PF Deadband
9. Voltage Low Limit
10. Voltage Low Alarm
11. Voltage High Limit
12. Voltage High Alarm
13. Voltage Switches

**5—Configuration**
1. Configuration Key
2. PT Winding Ratio
3. CT Rating
4. PT Voltage Input
5. Voltage Display
6. System Frequency
7. Process Action
8. Network Address
9. Network Service Pin
10. Revert Status
11. Net Dropout Time

**6—Calibration**
1. Calibration Key
2. Process Input
3. Remote Input
4. PT Phase A
5. PT Phase B
6. PT Phase C
7. CT Phase A
8. CT Phase B
9. CT Phase C
10. Gen Bus Voltage
11. Synchroscope
12. Command Input

**7—Electrical Parameters**
1. Active Power (P)
2. Apparent Power (S)
3. Reactive Power (Q)
4. Power Factor (PF)
5. Phase A
6. Phase A
7. Phase A PF
8. Phase B
9. Phase B
10. Phase B PF
11. Phase C
12. Phase C
13. Phase C PF
14. Utility Frequency
15. Gen Bus Frequency
16. Gen Bus Voltage
17. Synchroscope
18. Slip Frequency
19. System Load
20. System PF

**8—Control Status Monitor**
1. Synchronizer Mode
2. Load Control Mode
3. Import/Export Ref
4. Process Reference
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6. PF Command Output
7. PF Reference
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11. Utility Low Limit
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15. Low Process Limit
16. Low Voltage Limit
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2008/9/Fort Collins