



Installation and Operation Manual



DSLTM Digital Synchronizer and Load Control

Manual 02007 (Revision D)

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.



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WARNING—OVERSPEED PROTECTION

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

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



WARNING—PROPER USE

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

CAUTION—POSSIBLE DAMAGE TO EQUIPMENT OR PROPERTY



CAUTION—BATTERY CHARGING

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



CAUTION—ELECTROSTATIC DISCHARGE

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

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

IMPORTANT DEFINITIONS

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

Revisions—Text changes are indicated by a black line alongside the text.

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Electrostatic Discharge Awareness

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

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).
2. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.
4. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
 - Do not touch any part of the PCB except the edges.
 - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
 - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.



CAUTION—ELECTROSTATIC DISCHARGE

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

Chapter 1.

General Information

Introduction

This manual describes the Woodward DSLC™ Digital Synchronizer and Load Control, both full and reduced function models (see Figure 1-1). The reduced function models do not include the VAR/Power Factor Control or the Process Control.

Application

The DSLC control is a microprocessor-based generator load control designed for use with a Woodward speed control and an automatic voltage regulator to provide synchronizing, paralleling, loading, and unloading of three-phase generator sets. All transitions between DSLC functions are coordinated to provide smooth operation.

DSLCL functions include:

- Selectable for phase matching or slip frequency synchronizing with voltage matching and automatic dead bus closure capability;
- Automatic generator loading and unloading for bumpless load transfer;
- Droop, base load, and isochronous load control capability;
- Process control for cogeneration, import/export, pressure control, or other processes;
- Isochronous load sharing with other sets equipped with DSLCL controls;
- VAR or power factor (PF) control (full function models only);
- Built in diagnostics;
- Multi-function adjustable high and low limit alarms and load switch with relay driver outputs;
- Digital communications network to provide load sharing, VAR/PF sharing, and other information exchange between controls;
- Full setup, metering, and diagnostic capability through a hand held programmer terminal (Figure 1-2);
- Reverse power relay.

Synchronizer

The DSLCL control uses digital signal processing techniques to derive both true RMS voltages and relative phase of the fundamental frequencies of the bus and generator 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 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 guarantees that initial power flow is out of the machine for larger generators. For both synchronizing methods, the DSLCL control uses actual slip frequency and breaker delay values to anticipate a minimum phase difference between bus and generator at actual breaker closure.

The DSLC control provides a safe automatic dead-bus closure function. Dead-bus closing permission is granted to only one DSLC control through locking techniques done over the communications network. This assures that a race condition will not cause two or more breakers to close simultaneously on the dead bus.

Additional synchronizer features 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 with analog circuits.

Load control begins at breaker closure when the load control function takes control of the DSLC speed bias output directly from the synchronizer. The matching of synchronizer slip frequency to initial load (unload trip level) can result in a bumpless transfer to load control. On command, the adjustable ramp allows smooth, time-controlled loading into base load, isochronous load sharing, or process control. A ramp pause switch input allows holding of the load ramp for warm-up or other purposes.

The base load control is selectable as either a proportional or integrating controller. The proportional control provides smooth, stable control of load for operation in parallel with frequency-stable systems. The integrating base load control provides accurate load control when in parallel with a bus where frequency may vary. The DSLC control provides switch inputs to allow raising or lowering the internal digital base load reference. The control also provides a 4–20 mA (or 1–5 Vdc) analog input for remote load setting, if desired.

When unloading, an adjustable unload ramp provides time controlled unloading to the unload trip level. When load reaches the unload trip level, the control issues a breaker open command to separate the generator set from the system. The ramp pause switch input is in effect while unloading to allow holding of the unload ramp for cool-down or other purposes.

The load and unload ramps also provide smooth transition between base load, isochronous load sharing, and process control any time the operating mode is changed.

The DSLC control includes several additional load control features:

- Simple load droop operation provides safe operation in parallel bus applications in the event of a circuit breaker aux contact failure;
- A frequency trimmer function provides accurate frequency control in isochronous load sharing systems by compensating for small variations in speed setting between units;
- Adjustable load switch output with independent pick-up and drop-out points provides a signal when the specified load is exceeded. The load switch output can be selected as a reverse power trip.

- Load raise and lower inputs can be used to adjust speed before synchronizing.
- Voltage raise and lower inputs can be used to adjust voltage before synchronizing.

Process Control (full function models)

A cascade PID process controller is provided for cogeneration, import/export control, pond level maintenance, pressure maintenance, or other application. 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 (or 1–5 Vdc) process transmitter provides the process signal to the DSLCL control. The control includes an internal digital process reference which may be controlled by raise and lower switch contact inputs or by an external 4–20 mA (or 1–5 Vdc) remote process reference. The output of the process control provides the cascade load reference to the base load control.

Adjustable ramps allow smooth entry to or exit from the process control mode. When the process control mode is selected, an adjustable ramp moves the load reference in a direction to reduce the process control error. When the error is minimized, or the reference first reaches either the specified high or low load pick-up limits, the process controller is activated. When a limit is reached, the control will hold the load reference at that limit until process control is obtained.

When unloading from the process control, an adjustable unload ramp provides time controlled unloading to the unload trip level. When load reaches the unload trip level, the DSLCL control automatically issues a breaker open command to remove the generator set from the system. The ramp pause switch input allows holding of the unload ramp for cool-down or other purposes.

Additional functions include selectable and adjustable process high and low limit switches and alarm activation.

VAR/PF Control (full function models)

The VAR/PF functions control the reactive power component of the generator in parallel systems. In an infinite bus system, the controller compares either the kVAR load or power factor (selectable) on the generator with an adjustable internal reference and makes corrections to the voltage regulator until the desired kVAR load or power factor is obtained. For higher performance, an analog output can be directly connected to compatible voltage regulators with analog voltage setting input. The control has raise and lower voltage discrete inputs for manual voltage adjustment. The control also has raise and lower contact outputs to activate a voltage regulator MOP when an analog input is not provided on the AVR.

The DSLCL control provides power factor sharing between units for isolated bus or isochronous parallel systems. The control computes an average power factor for the system and uses it as the reference input to the power factor controller. The control includes an adjustable voltage reference and voltage trim function in the sharing function to maintain system voltage at the desired level.

The DSLC control has a selectable voltage range alarm which is activated if the analog output to the voltage regulator reaches high or low saturation. The DSLC control also has selectable and adjustable high and low voltage limit switches and alarm outputs.

Manual Organization

See page iv for important electrostatic discharge awareness information. The DSLC control is an electronic device containing sensitive components. While the control is designed for safe handling in the industrial environment, certain precautions must be observed during handling and shipping.

Chapter 2 covers DSLC control installation and wiring, including each major group of connections, along with any special instructions.

Chapter 3 covers DSLC control configuration, setup, and adjustment. The chapter explains the purpose of each set point and recommended initial value.

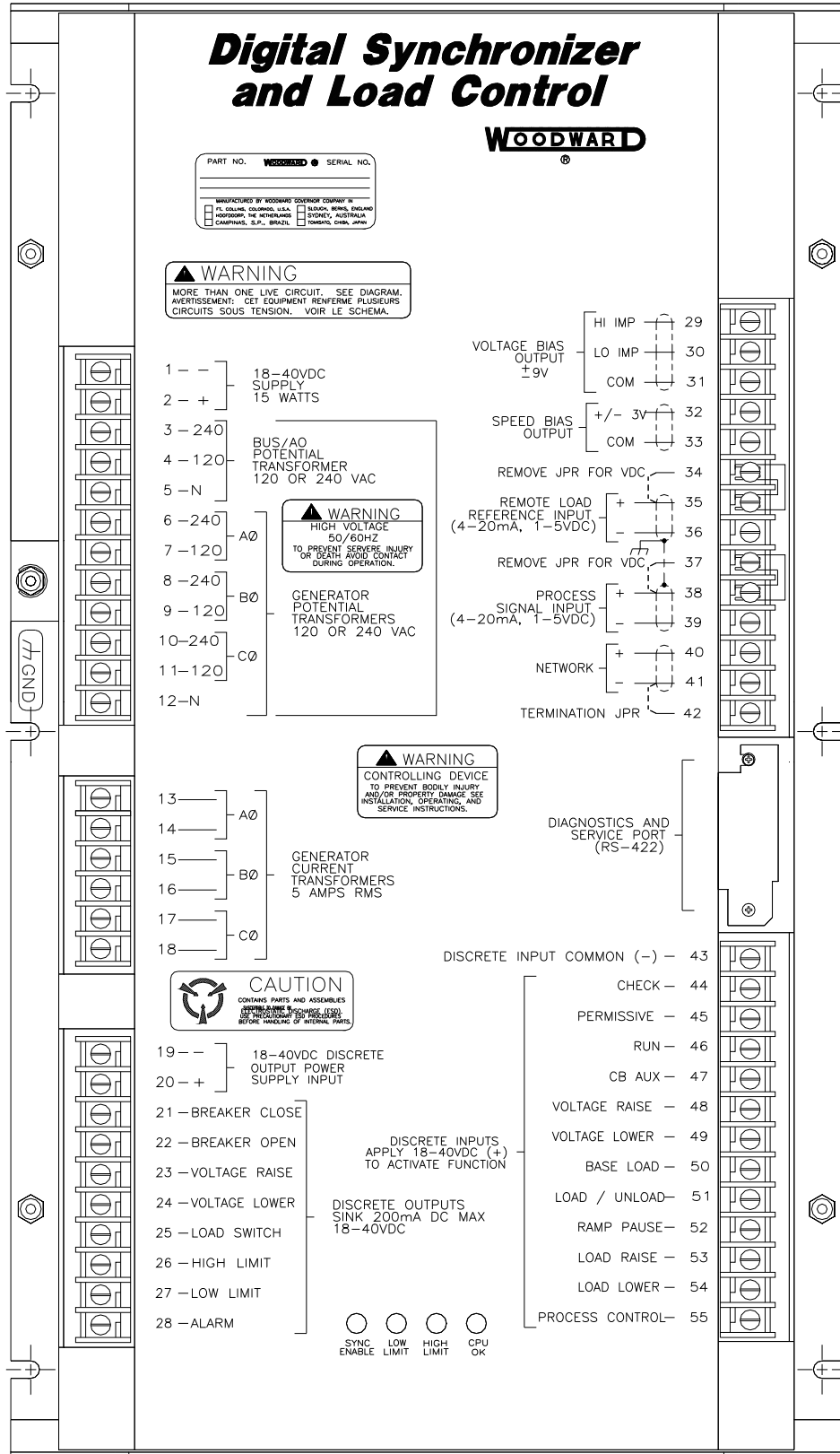
Chapters 4 through 7 explain the major functions of automatic synchronizing, load control, process control, and kVAR and power factor control.

Chapter 8 describes the Echelon Local Operating Network (LON) used by the DSLC control to communicate between units.

Chapter 9 provides a troubleshooting guide. Due to extensive built-in diagnostics, DSLC control installation may be tested and verified quickly.

Chapter 10 describes how to return a control to Woodward in the event of damage or failure of an internal component.

At the end of the manual is a setup work sheet that provides a guide to setup and a place to record setup values for future reference.



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Figure 1-1a. DSLCL Control (wye version shown)

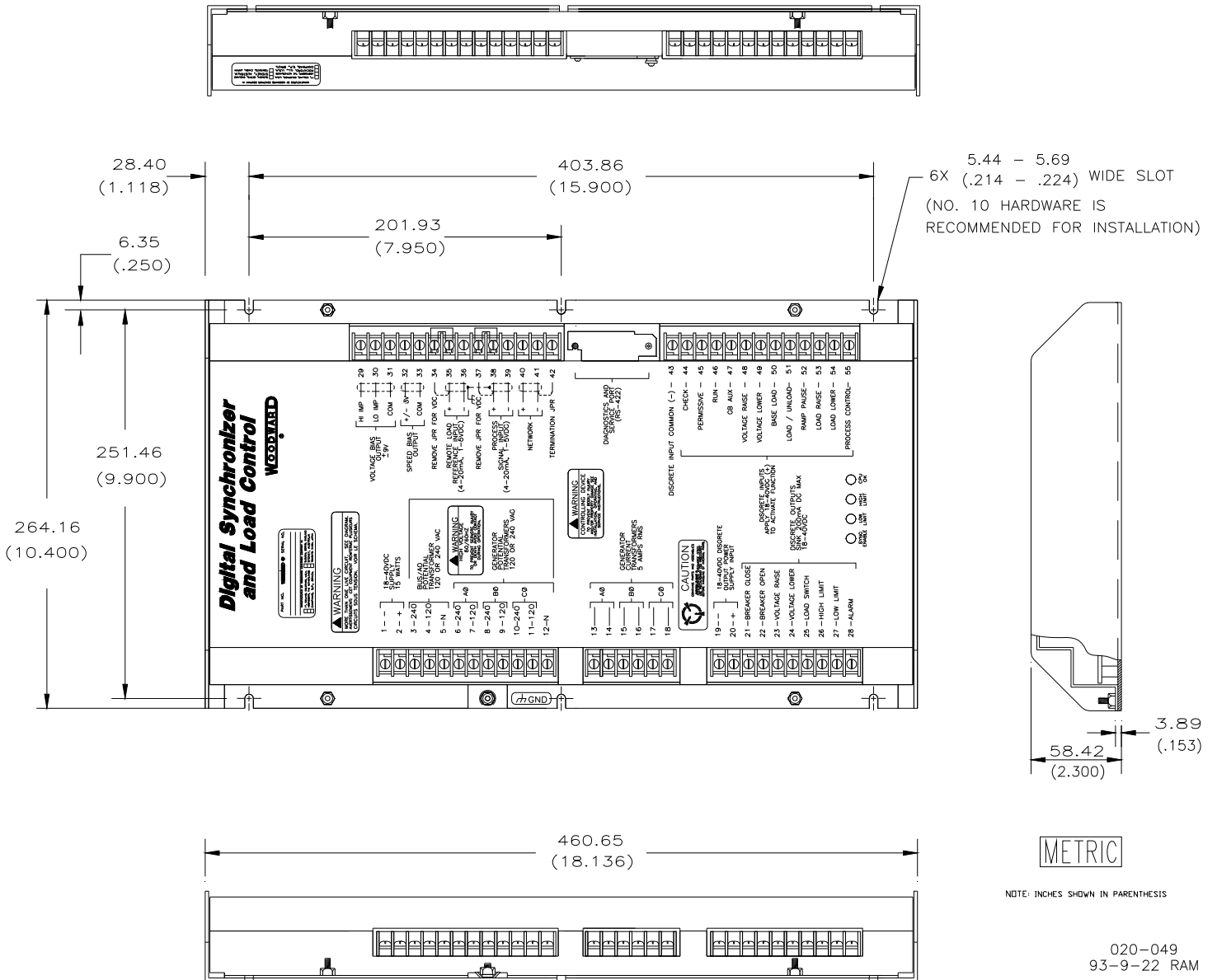


Figure 1-1b. DSL/C Control Dimensions (wye version shown)

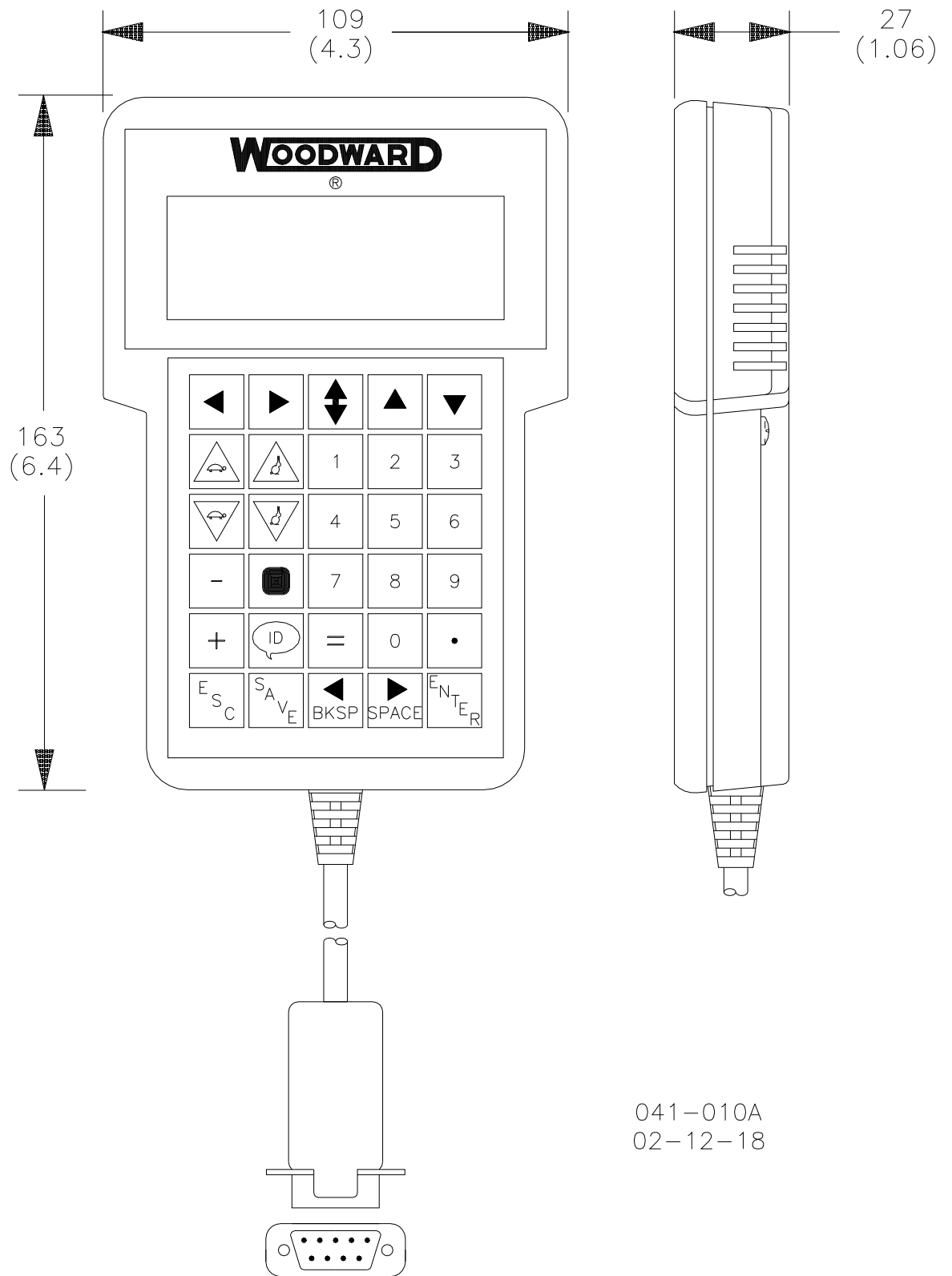


Figure 1-2. Hand Held Programmer

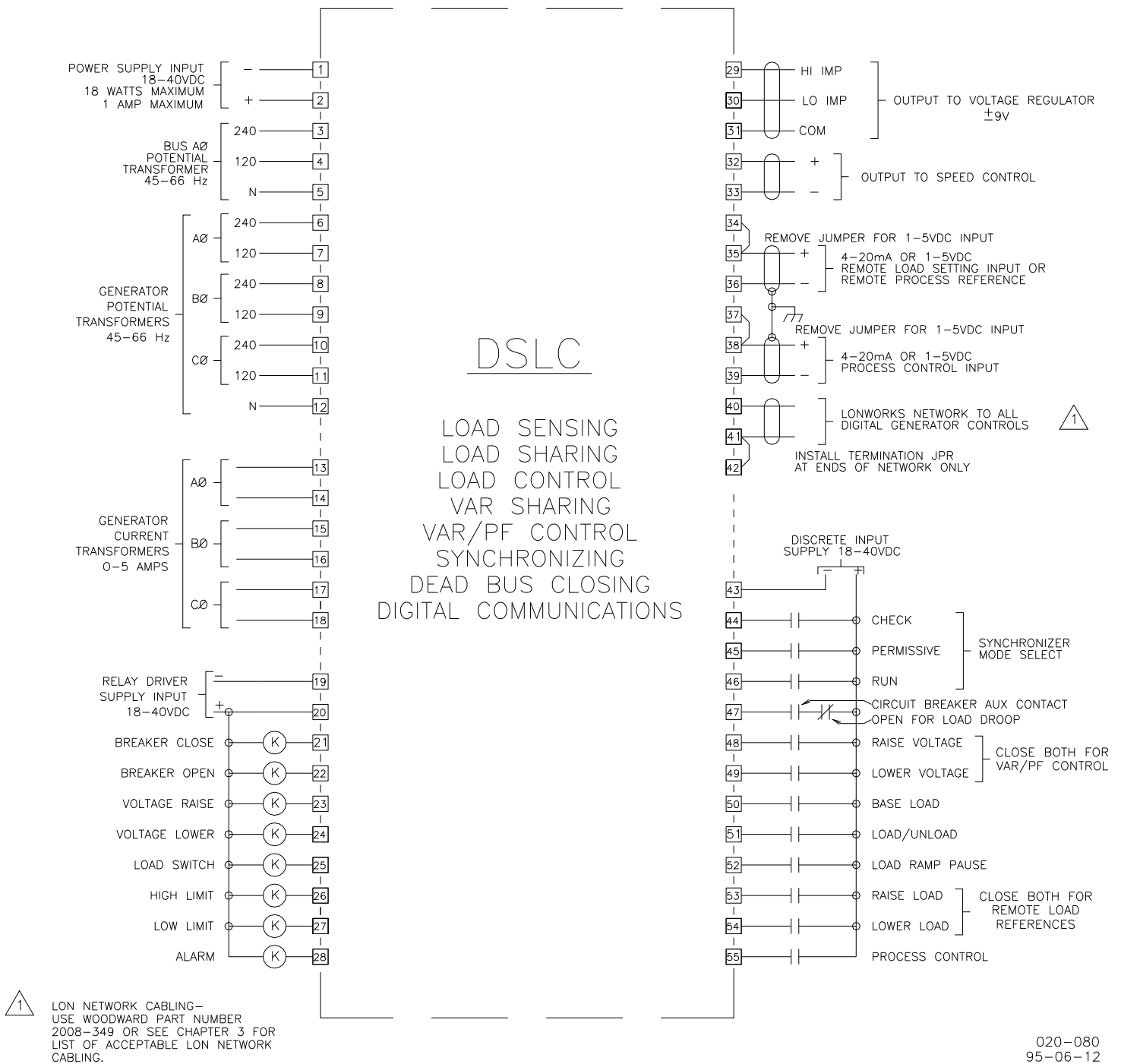


Figure 1-3a. DSL/C Plant Wiring Diagram
(for 120/240 V wye switch gear configurations)

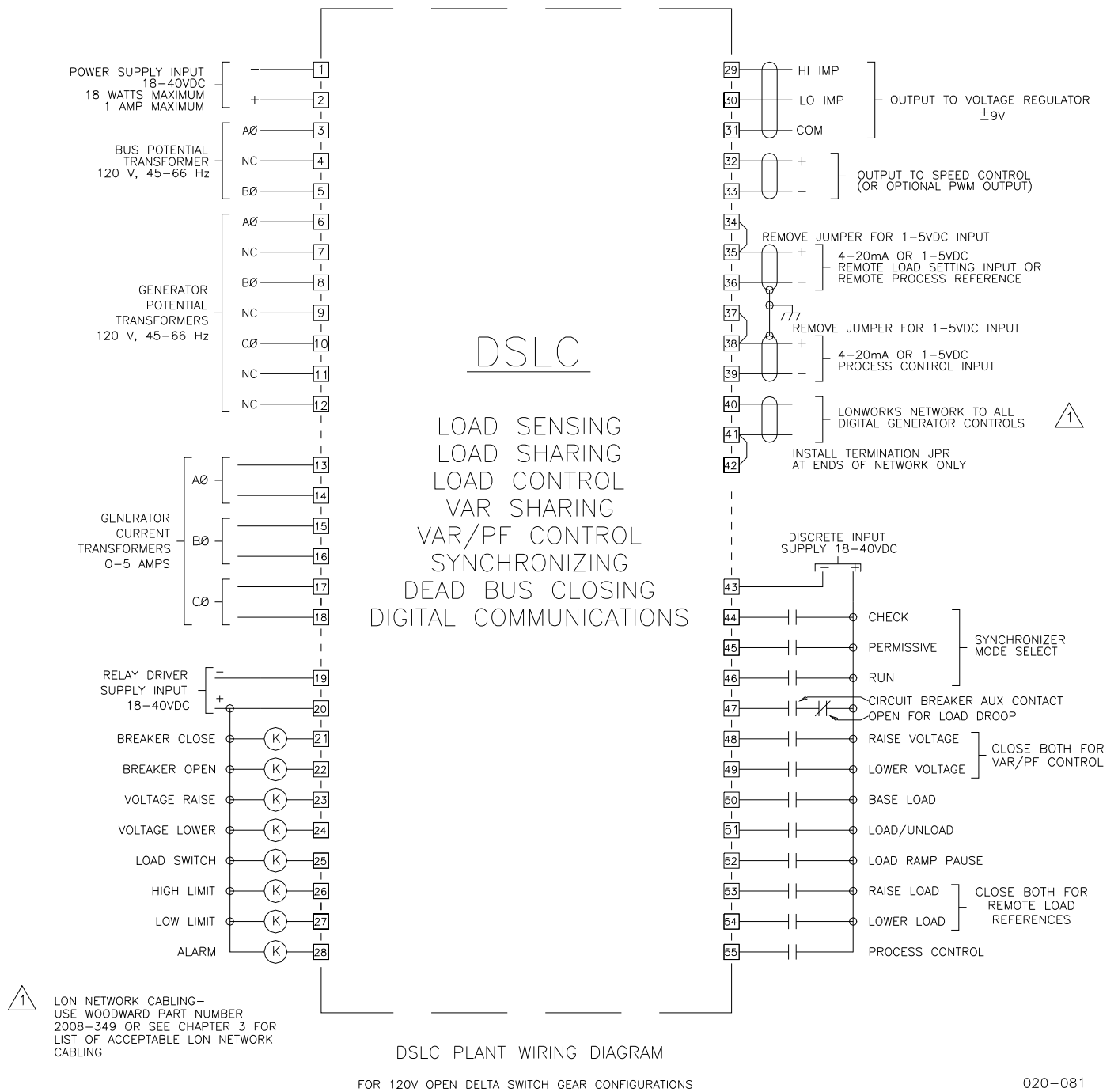


Figure 1-3b. DSLCL Plant Wiring Diagram (for 120 V open delta switch gear configurations)

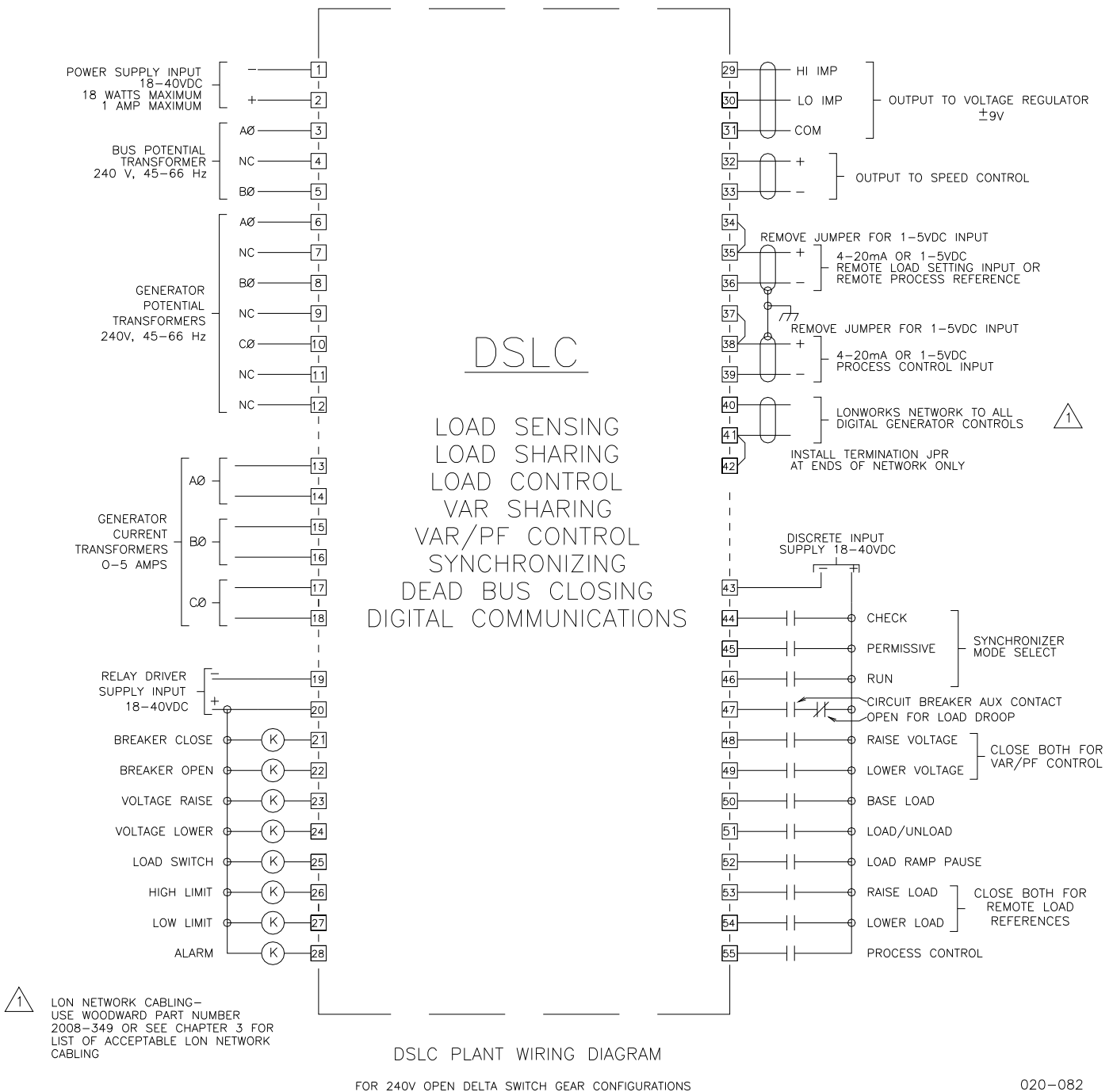


Figure 1-3c. DSLC Plant Wiring Diagram
(for 240 V open delta switch gear configurations)

VOLTAGE RAISE	VOLTAGE LOWER	CB AUX CONTACT	BASE LOAD	LOAD / UNLOAD	RAISE LOAD	LOWER LOAD	PROCESS CONTROL	
X	X	0	X	X	X	X	X	DROOP
X	X	1	0	0	X	X	X	BASE LOAD AT LESSOR OF UNLOAD TRIP LEVEL OR SYSTEM LOAD LEVEL
X	X	1	1	0	X	X	X	BASE LOAD AT UNLOAD TRIP LEVEL
X	X	1	1	┘	0	0	0	RAMP TO BASE LOAD AT INTERNAL BASE LOAD REFERENCE
X	X	1	1	1	0	0	0	BASE LOAD AT INTERNAL LOAD REFERENCE
X	X	1	1	1	1	0	0	RAISE INTERNAL BASE LOAD REFERENCE
X	X	1	1	1	0	1	0	LOWER INTERNAL BASE LOAD REFERENCE
X	X	1	1	┘	1	1	0	RAMP TO BASE LOAD AT REMOTE LOAD SETTING INPUT LEVEL
X	X	1	1	1	┘	┘	0	RAISE/LOWER RATE RAMP TO REMOTE LOAD SETTING INPUT LEVEL
X	X	1	1	1	1	1	0	BASE LOAD AT REMOTE LOAD SETTING INPUT LEVEL
X	X	1	1	1	┘	┘	0	BASE LOAD AT INTERNAL BASE LOAD REFERENCE ¹
X	X	1	X	┘	X	X	X	RAMP TO UNLOAD TRIP ²
X	X	1	0	┘	X	X	0	RAMP TO ISOCHRONOUS LOAD SHARING
X	X	1	0	1	X	X	0	ISOCHRONOUS LOAD SHARING
X	X	1	0	┘	X	X	1	RAMP TO PROCESS SLAVE AT SYSTEM LOAD LEVEL ³ ⁷
X	X	1	0	1	X	X	1	PROCESS SLAVE AT SYSTEM LOAD LEVEL ⁷
X	X	1	1	┘	0	0	1	RAMP TO PROCESS MASTER AT INTERNAL PROCESS REFERENCE ⁷
X	X	1	1	1	0	0	┘	RAMP TO PROCESS MASTER AT INTERNAL PROCESS REFERENCE ⁷
X	X	1	1	1	0	0	1	PROCESS MASTER AT INTERNAL PROCESS REFERENCE ⁷
X	X	1	1	1	1	0	1	RAISE INTERNAL PROCESS REFERENCE ⁷
X	X	1	1	1	0	1	1	LOWER INTERNAL PROCESS REFERENCE ⁷
X	X	1	1	1	┘	┘	1	RAMP TO PROCESS MASTER AT REMOTE PROCESS REFERENCE INPUT ⁷
X	X	1	1	┘	1	1	1	RAMP TO PROCESS MASTER AT REMOTE PROCESS REFERENCE INPUT ⁷
X	X	1	1	1	1	1	1	PROCESS MASTER AT REMOTE PROCESS REFERENCE INPUT ⁷
X	X	1	1	1	┘	┘	1	PROCESS MASTER AT INTERNAL PROCESS REFERENCE ⁴ ⁷
X	X	1	1	1	0	0	┘	BASE LOAD AT INTERNAL BASE LOAD REFERENCE ⁵
X	X	1	1	1	1	1	┘	RAISE OR LOWER TO BASE LOAD AT REMOTE LOAD REFERENCE INPUT LEVEL ⁶
1	0	X	X	X	X	X	X	RAISE VOLTAGE REGULATOR EXCITATION
0	1	X	X	X	X	X	X	LOWER VOLTAGE REGULATOR EXCITATION
1	1	1	1	1	X	X	X	VAR/PF CONTROL AT VAR/PF REFERENCE ⁷
1	1	1	0	1	0	0	0	PF SHARE AT SYSTEM PF (ISOCHRONOUS) ⁷

0 = CONTACT OPEN
 1 = CONTACT CLOSED
 X = DON'T CARE
 ┘ = OPEN TO CLOSED CONTACT TRANSITION
 ┘ = CLOSED TO OPEN CONTACT TRANSITION

- ¹ THE INTERNAL LOAD REFERENCE IS EQUAL TO THE REMOTE REFERENCE AT THE TIME REMOTE WAS DE-SELECTED
- ² UNLOAD RAMP TERMINATES AND BREAKER OPEN COMMAND IS ISSUED WHEN LOAD DROPS BELOW THE UNLOAD TRIP LEVEL.
- ³ PROCESS SLAVE MODE IS ISOCHRONOUS LOADSHARING. A MASTER PROCESS CONTROL SPECIFIES THE SYSTEM LOAD LEVEL TO ALL SLAVES.
- ⁴ THE INTERNAL PROCESS REFERENCE IS EQUAL TO THE REMOTE PROCESS REFERENCE AT THE TIME REMOTE WAS DE-SELECTED.
- ⁵ THE BASE LOAD REFERENCE IS EQUAL TO THE PROCESS REFERENCE AT THE TIME PROCESS CONTROL WAS DE-SELECTED.
- ⁶ NOT RECOMMENDED. SELECT BASE LOAD, SWITCH REMOTE REFERENCE INPUT FROM PROCESS REFERENCE TO LOAD REFERENCE, AND THEN SELECT REMOTE.
- ⁷ FULL FUNCTION MODELS ONLY

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Figure 1-4. Control Options

Chapter 2. Installation

Introduction

This chapter provides the general information for site selection, installation, and wiring of the DSLC™ control.

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 DSLC control, consider the following:

- Protect the unit from direct exposure to water or to a condensation-prone environment.
- The continuous operating range of the DSLC control 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 DSLC control (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 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 mm² (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. 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. Contact Woodward for more information.

Power Supply

The DSLCL control requires a nominal voltage source of 18 to 40 Vdc, 18 W. Power to the control should be maintained whenever the generator set is available for service.



CAUTION—APPLY POWER

Power must be applied to the DSLCL control 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 (activate) 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 DSLC control.

**NOTES**

The DSLC control 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 amperes RMS at full load for best performance of the system.

The following sections describe the potential connections for the synchronizer and power sensor functions. Various DSLC controls have been designed to accommodate PTs wired in 120 Vac wye, 240 Vac wye, 120 Vac open delta, and 240 Vac open delta. Contact your local authorized distributor or Woodward for the latest DSLC control part numbers (Appendix B shows part numbers as of publication date of this manual).

Bus Potential Transformers

The synchronizer potential input on the DSLC control is connected to the secondary of 120 or 240 Vac potential transformers. The bus phase A must correspond to phase A of the generator as wired to the load sensor. See Figure 1-3 for bus potential transformer wiring. Bus phase rotation must correspond to the generator rotation for proper synchronizer operation.

Generator Potential Transformers

The generator potential inputs on the DSLC control are connected to the secondary of 120 or 240 Vac potential transformers. Generator phase rotation must correspond to the bus rotation for proper synchronizer operation. See Figure 1-3 for generator potential transformer wiring.

Generator Current Transformers

The generator current inputs on the DSLC control are connected to the output of current transformers, which in turn is placed around one conductor of one phase of the generator circuit being monitored.

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 DSLC control, and that the correct polarity be observed.



WARNING—ELECTRIC SHOCK

Because of the risk of fatal electric shock, never disconnect any wire attached to generator current transformer terminals 13 through 18 when the engine is running unless a shorting terminal block and temporary 1 ohm, 5 watt resistors are installed as shown in as shown in Figure 2-1.

Discrete Outputs

The discrete outputs are the relay driver output commands from the DSLC control. 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 application.

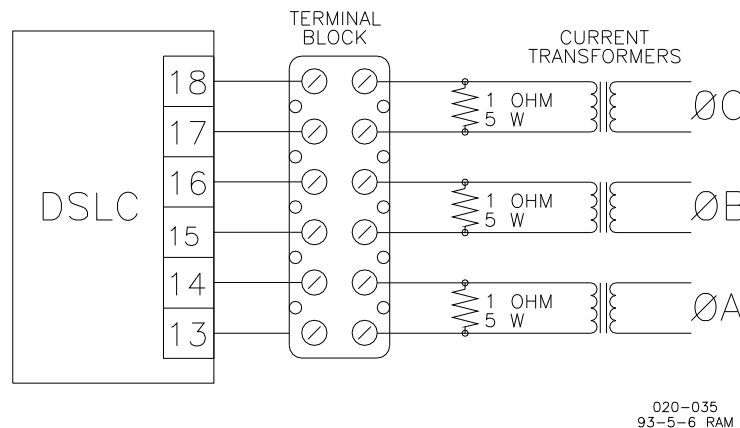


Figure 2-1. Temporary Wiring for Transformer Phase Correction

Discrete outputs require approximately 10 mA at 24 Vdc to power. The discrete outputs should be powered by the same voltage source as 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 occurring 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 breaker close relay coil to terminal 21 and breaker open relay coil to terminal 22 of the control as shown in Figure 1-3. The breaker open relay is normally energized. It de-energizes to open the breaker.

Voltage Matching Relays

Optional voltage matching relays are connected to the raise and lower inputs on the voltage regulator MOP (motorized potentiometer). Do not attempt to drive MOP inputs directly with discrete outputs. Make the connections as shown in Figure 1-3 as required to terminals 23 and 24 of the control.

Load Management Relays

The DSL/C control provides three relay drivers for connection to customer-supplied relays for load management. These drivers include an adjustable set point load switch and high and low limit switches that are user-selectable as adjustable load switches or as alarm indicators for reaching other high and low limits. Make the connections as shown in Figure 1-3 as required to terminals 25, 26 and 27 of the control.



NOTE

If the load switch (terminal 25) is enabled as a reverse power trip, the load switch is disabled.

Alarm Relay

Make the alarm relay connection as shown in Figure 1-3 to terminal 28 of the control. Alarm conditions are selectable by the user.

Discrete Inputs

The discrete inputs are the switch input commands to the DSL/C control. 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 circuit breaker auxiliary (CB Aux) contacts that open and close when the generator breaker opens and closes. Wire the breaker auxiliary contacts in series between the +24 Vdc voltage source and terminal 47 of the DSL/C control. Wire an isochronous/droop switch in series with the circuit breaker auxiliary contacts if both isochronous and droop operation are required (closed for isochronous and open for droop; see Figure 1-3).

Generator Voltage Adjustment Contacts

The generator voltage adjustment contact inputs allow manual voltage adjustment by operating a motorized potentiometer with the voltage raise and lower discrete outputs or by the voltage bias output tied directly to the voltage regulator. The analog voltage adjustment input may be used for voltage setting rather than a motorized potentiometer. Closing both voltage raise and lower contacts enables the VAR/PF control function (available on full-function models). Wire the voltage raise and lower switch contacts in series between the +24 Vdc voltage source and terminals 48 and 49 of the DSLCL control. If a separate switch to enable the VAR/PF control is installed, wire a double-pole, double-throw switch with one contact in parallel with the voltage raise switch contact and the other contact in parallel with the voltage lower switch contact to simultaneously select both the raise and lower voltage inputs.

Load Control Mode Contacts

The load control mode is determined by the status of the CB Aux contact input (terminal 47), the Base Load contact input (terminal 50), and the Load/Unload contact inputs (terminal 51). The status of these three contact inputs determines the five load control operating modes:

Mode	CB Aux Contact	Base Load Contact	Load/Unload Contact
Droop	open	open/closed	open/closed
Isochronous Load Sharing (at unload trip)	closed	open	open
Isochronous Load Sharing	closed	open	closed
Base Load (at unload trip)	closed	closed	open
Base Load (infinite bus systems)	closed	closed	closed

Refer to the load control section of this manual for sequencing information.

Ramp Pause Contact

Connect the load ramp pause switch contact to terminal 52. When this contact is closed, any load/unload ramps are held at their current setting until the contact is opened.

Raise and Lower Load Contacts

Connect a center off, double pole double throw switch to the Raise and Lower Load inputs, terminals 53 and 54. If the remote reference will be used, install a second double pole double throw switch to simultaneously select both the Raise and Lower inputs.

Process Control Mode Contact

If the DSLCL control will be used as a process control (available on full-function models), connect a switch from +24 Vdc to the Process Control discrete input, terminal 55. When this contact is closed, load is controlled at a level required to maintain the required analog Process Input.

LonWorks® Network

Proper LonWorks® * network wiring geometry is critical to assure that the network (and thus the power generation system) operates correctly (see Chapter 8 for LonWorks network specifications). Figure 2-2 illustrates a typical DSL/C system. The system may include other LonWorks-compatible devices, such as an MSLC (Master Synchronizer and Load Control) or Gateway, in addition to the DSL/C controls. The following requirements must be met:

*—LonWorks is a trademark of Echelon Corporation

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.

Woodward part number 2008-349

Belden
 PO Box 1980
 Richmond, IN 47375
 (317) 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.
YR28867	PVC 22 AWG shielded.
YQ28863	Plenum 22 AWG shielded.

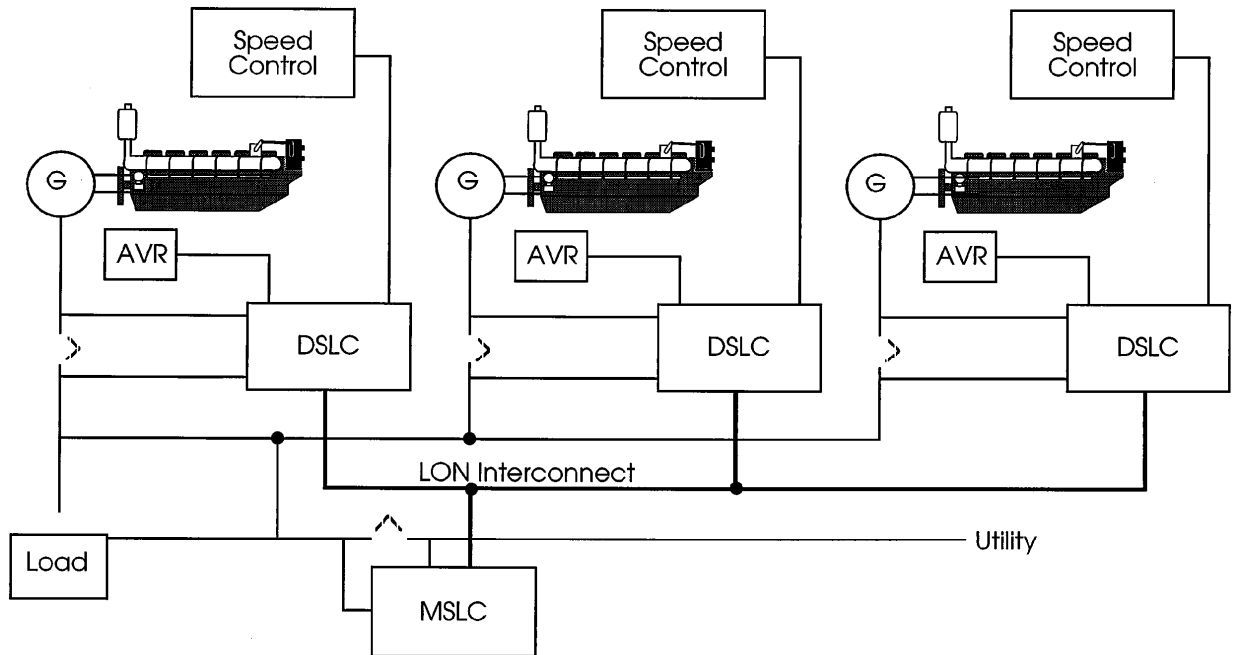
2. Maximum cable length for a LonWorks 1.25 Mbps network is 500 m (1640 ft).
3. Stubs, or wiring drops, connecting intermediate devices to the main cable are limited to 300 mm in length.
4. Shields must be carried through all breakout boxes to provide a continuous shield throughout the network.
5. The network must be properly terminated at each end of the cable. Internal components are provided in all Woodward DSL/C, MSLC, or LonWorks-compatible synchronizers which provide proper network termination with installation of a jumper on the controls at each end of the cable. Intermediate nodes should not have the termination jumper installed.

Speed Control Output

Make connections to the DSL/C control terminals as shown in Figure 1-3. Connect the cable shields to ground at the speed control end only. Connect to the aux input on speed controls or the load sharing line input on load sharing and speed controls.

Analog Voltage Regulator Output

Make connections to the DSL/C control terminals as shown in Figure 1-3. Connect the cable shields at the voltage regulator end only. Best performance is obtained when the voltage regulator used has an auxiliary dc voltage input.



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93-11-5

Figure 2-2. DSLC Control 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. Consult Woodward for further information.

Make connections from the process transmitter to the DSLC control 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 DSLC control end 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. Consult Woodward for further information.

Make connections from the load setting transmitter to the DSLC control 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 at the DSLC control end 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 line that was last removed to locate the fault.

Chapter 3.

Calibration and Adjustment

Introduction

Because of the variety of installations, plus system and component tolerances, the DSLC™ control 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 DSLC control. The terminal connects to the RS-422 Diagnostics and Service Port on the control. 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.

The programmer screen is a four-line, backlit 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 3-1):

(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)	Blanks the display.
ID	Displays the DSLC control software part number and 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.

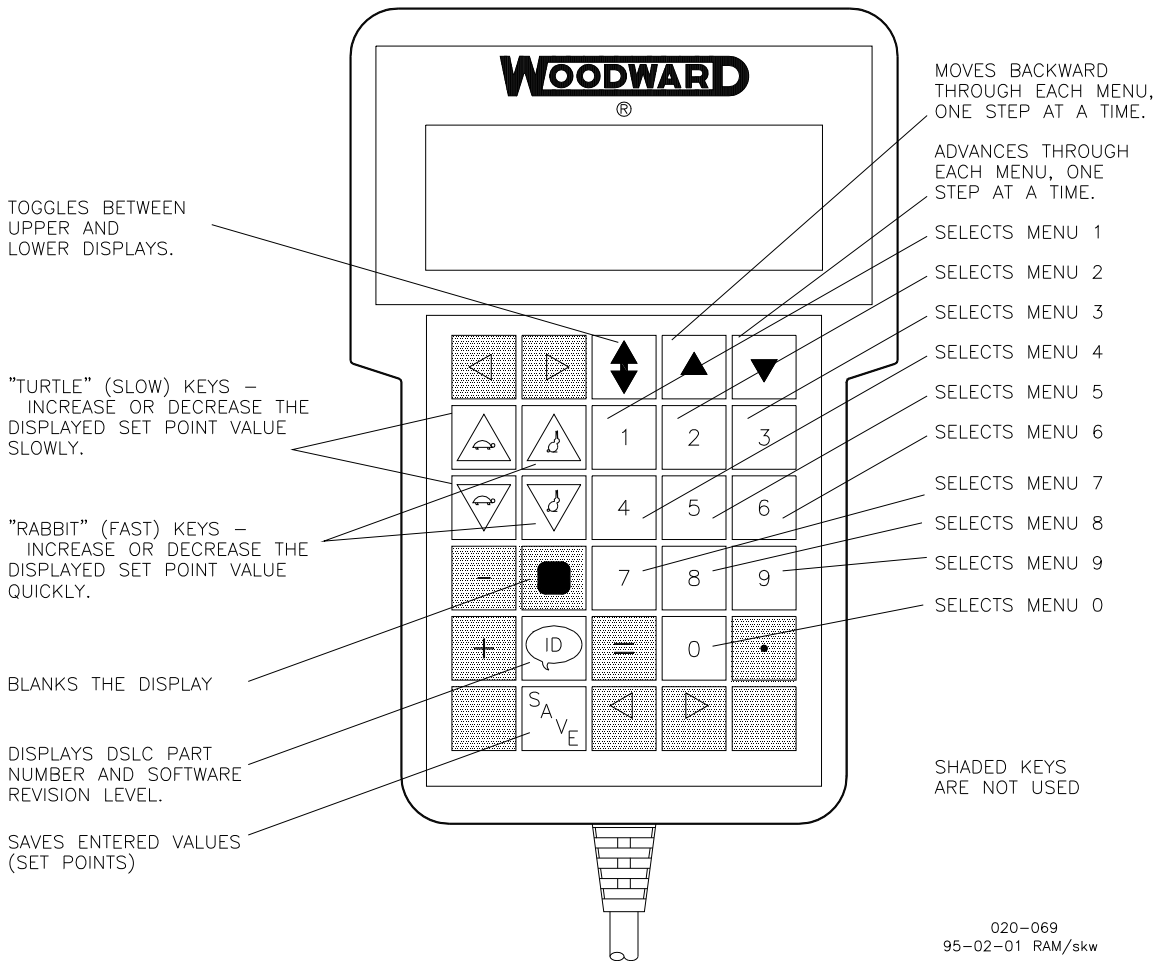


Figure 3-1. Hand Held Programmer Functions

The DSLС control 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.

	Name	Min. Value	Max. Value	Initial Value	Dimen- sion
Menu 1—Synchronizer					
1.	Sync Gain	0.01	100.0	0.10	
2.	Sync Stability	0.00	20.00	1.00	seconds
3.	Slip Frequency Ref	0.00	0.25	0.05	Hz
4.	Slip Window	0.00	1.00	0.05	Hz
5.	Max Phase Window	2	20	10	degrees
6.	Voltage Matching	Enabled/Disabled			Enabled
7.	Voltage Window	0.0	10.0	1.0	%
8.	Dead-bus Closure	Enabled/Disabled			Disabled
9.	Breaker Delay	0.00	2.00	0.10	seconds
10.	CB Close Hold Time	0.0	5.00	1.0	seconds
11.	Close Attempts	1	20	1	
12.	Reclose Delay	1	1000	20	seconds
13.	Sync Reclose Alarm	Enabled/Disabled			Enabled
14.	Sync Timeout	0	1000	0	seconds
15.	Sync Timeout Alarm	Enabled/Disabled			Disabled
16.	Auto Re-Synchronize	Enabled/Disabled			Disabled
Menu 2—Load Control					
1.	Load Control Gain	0.0001	100.0000	0.2500	
2.	Load Stability	0.00	20.00	1.00	seconds
3.	Load Derivative	0.00	20.00	0.00	seconds
4.	Load Control Mode	Integrating/Proportional		Proportional	
5.	Load Control Filter	0.1	10.0	1.0	Hz
6.	Loadshare Gain	0.10	2.00	0.72	
7.	Frequency Trimmer	Enabled/Disabled			Disabled
8.	Rated Load	0	30 000	1000	kW
9.	Base Load	0	30 000	1000	kW
10.	Unload Trip	0	30 000	0	kW
11.	Load Droop	0.0	100	5.0	%
12.	Load Time	1	7200	20	seconds
13.	Unload Time	1	7200	20	seconds
14.	Raise Load Rate	0.01	100.00	1.00	%/sec
15.	Lower Load Rate	0.01	100.00	1.00	%/sec
16.	4mA Remote Load	0	30 000	0.0	W,kW,MW
17.	20mA Remote Load	0	30 000	1000	W,kW,MW
18.	High Limit PU	0	30 000	1000	W,kW,MW
19.	High Limit DO	0	30 000	900	W,kW,MW
20.	High Limit Alarm	Enabled/Disabled			Disabled
21.	Low Limit PU	30 000	30 000	10	W,kW,MW
22.	Low Limit DO	30 000	30 000	10	W,kW,MW
23.	Low Limit Alarm	Enabled/Disabled			Disabled
24.	Load Limit Switches	Enabled/Disabled			Disabled
25.	Load Switch PU	30 000	30 000	300	W,kW,MW
26.	Load Switch DO	30 000	30 000	200	W,kW,MW
27.	Reverse Power Trip	Enabled/Disabled			Disabled
28.	Instant Reverse Power	50.0	1.0	10	% load
29.	Rev Pwr Time Delay	0.1	20.0	20.0	seconds
30.	Reverse Power Level	50.0	1.0	1.0	% load

	Name	Min. Value	Max. Value	Initial Value	Dimension
Menu 3—Process Control					
1.	Process Control Gain	0.0001	100.0000	0.1000	
2.	Process Stability	0.00	20.00	1.00	seconds
3.	Process Derivative	0.00	20.00	0.00	seconds
4.	Process Deadband	0.00	20.00	0.10	mA
5.	Process Droop	0.0	100.0	0.0	%
6.	Process Filter	0.1	5.0	1.0	Hz
7.	Process Reference	0.0	20.0	12.0	mA
8.	Raise Reference Rate	0.01	20.00	0.10	mA/sec
9.	Lower Reference Rate	0.01	20.00	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	Enabled/Disabled			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	Enabled/Disabled			Disabled
16.	Process Switches	Enabled/Disabled			Disabled
Menu 4—VAR/Power Factor Control					
1.	VAR/PF Control Mode	Disabled/ PF Control/ VAR Control		Disabled	
2.	VAR/PF Gain	0.01	22.00	1.00	
3.	VAR/PF Stability	0.00	20.00	2.50	seconds
4.	Rated KVARs	0	30 000 (gen.)	100	KVAR
5.	KVAR Reference	30 000 (abs.)	30 000 (gen.)	20 (gen.)	KVAR
6.	PF Reference	0.00 lagging	0.00 leading	0.8 lagging	
7.	PF Deadband	0.000	1.000	0.025	
8.	Voltage Reference	50.0	300xPT ratio	70xPT ratio	V (L-L,L-N)
9.	Voltage Trim	Enabled/Disabled			Disabled
10.	Voltage Regulation	1.0	10.0	2.0	%
11.	Voltage Low Limit	50	300xPT ratio	60xPT ratio	V (L-L,L-N)
12.	Voltage Low Alarm	Enabled/Disabled			Disabled
13.	Voltage High Limit	50	300xPT ratio	80xPT ratio	V (L-L,L-N)
14.	Voltage High Alarm	Enabled/Disabled			Disabled
15.	Voltage Switches	Enabled/Disabled			Enabled
16.	Voltage Range Alarm	Enabled/Disabled			Disabled
17.	Voltage Ramp Time	1	600	60	seconds
Menu 5—Configuration					
1.	Configuration Key	0	100	0	
2.	PT Winding Ratio	1:1	1000.0:1	1.0:1	
3.	CT Rating	5:5	10 000:5	5:5	
4.	PT Voltage Input	120/240		120	
5.	Voltage Display	V (L-L), V (L-N)		kV (L-L), kV (L-N)	V (L-N)
6.	System Frequency	50/60		60	Hz
7.	Process Control Action	Direct/Indirect			Indirect
8.	Network Address	1	16	0 (unconfigured)	
9.	Network Service Pin	transmits unique ID code to network			
Menu 6—Calibration					
1.	Calibration Key	0	100	0	
2.	Process Input	0	22	n/a	mA
3.	Remote Input	0	22	n/a	mA
4.	Speed Bias Output	100	+100	n/a	%
5.	Voltage Bias Output	100	+100	n/a	%
6.	PT Phase A	0	300	n/a	volts
7.	PT Phase B	0	300	n/a	volts
8.	PT Phase C	0	300	n/a	volts
9.	CT Phase A	0	7xCT rating	n/a	amperes
10.	CT Phase B	0	7xCT rating	n/a	amperes
11.	CT Phase C	0	7xCT rating	n/a	amperes
12.	Bus Voltage	0	300	n/a	volts
13.	Synchroscope	57.3	+57.3	n/a	degrees

	Name	Min. Value	Max. Value	Initial Value	Dimen- sion
Menu 7—Generator Electrical Parameters					
1.	Active Power (P)	30 000	30 000	n/a	kW
2.	Apparent Power (S)	30 000	30 000	n/a	kVA
3.	Reactive Power (Q)	30 000 (abs.)	30 000 (gen.)	n/a	kVAR
4.	Power Factor (PF)	0.0 leading	0.0 lagging	n/a	
5.	Phase A Volts	40xPT ratio	300xPT ratio	n/a	volts
6.	Phase A Amperes	0	7xCT rating	n/a	amperes
7.	Phase A PF	0.0 leading	0.0 lagging	n/a	
8.	Phase B Volts	40xPT ratio	300xPT ratio	n/a	volts
9.	Phase B Amperes	0	7xCT rating	n/a	amperes
10.	Phase B PF	0.0 leading	0.0 lagging	n/a	
11.	Phase C Volts	40xPT ratio	300xPT ratio	n/a	volts
12.	Phase C Amperes	0	7xCT rating	n/a	amperes
13.	Phase C PF	0.0 leading	0.0 lagging	n/a	
14.	Gen Frequency	0	66	n/a	Hz
15.	Bus Frequency	0	66	n/a	Hz
16.	Bus Voltage	40xPT ratio	300xPT ratio	n/a	volts
17.	Synchroscope	180	+180	n/a	degrees
18.	Slip Frequency	1.0 slow	+5.0 fast	n/a	Hz
19.	System Load	100	+120	n/a	%
20.	System PF	0.0 leading	0.0 lagging	n/a	
Menu 8—Control Status Monitor					
1.	Synchronizer Mode	Off/ Auto-Off/ Permissive/ Check/ Run/ Sync Timer/ Synchronized/ Close Timer			
2.	Load Control Mode	Droop/ At Unload Trip/ Base Load Ramp/ Base Load/ Base Load Lower/ Base Load Raise/ Remote Ramp/ Remote/ Unload Parallel/ Parallel Ramp/ Parallel/ Unload Ramp/ Process Ramp/ Process Master/ Process Lower/ Process Raise			
3.	Load Reference	0 kW/ Load Low Limit PU/ Load High Limit PU			
4.	Process Reference	0 mA/ Process Low Limit PU/ Process High Limit PU			
5.	Synchronizer Timeout	Alarm On/Alarm Off			
6.	Sync Reclose Limit	Alarm On/Alarm Off			
7.	High Load Limit	Alarm On/Alarm Off			
8.	Low Load Limit	Alarm On/Alarm Off			
9.	High Process Limit	Alarm On/Alarm Off			
10.	Low Process Limit	Alarm On/Alarm Off			
11.	Low Voltage Limit	Alarm On/Alarm Off			
12.	High Voltage Limit	Alarm On/Alarm Off			
13.	Voltage Range Limit	Alarm On/Alarm Off			

Name	Min. Value	Max. Value	Initial Value	Dimension
Menu 9—Discrete Inputs/Outputs				
1. Check Switch		Open/Closed		
2. Permissive Switch		Open/Closed		
3. Run Switch		Open/Closed		
4. Aux Contact Switch		Open/Closed		
5. Raise Voltage Switch		Open/Closed		
6. Lower Voltage Switch		Open/Closed		
7. Base Load Switch		Open/Closed		
8. Load/Unload Switch		Open/Closed		
9. Ramp Pause Switch		Open/Closed		
10. Raise Load Switch		Open/Closed		
11. Lower Load Switch		Open/Closed		
12. Process Switch		Open/Closed		
13. Test Key	0	100	0	
14. Breaker Close Relay		Energized/De-energized		
15. Breaker Open Relay		Energized/De-energized		
16. Voltage Raise Relay		Energized/De-energized		
17. Voltage Lower Relay		Energized/De-energized		
18. High Limit Relay		Energized/De-energized		
19. Low Limit Relay		Energized/De-energized		
20. Load Switch Relay		Energized/De-energized		
21. Alarm Relay		Energized/De-energized		
22. Sync Enable LED		On/Off		
23. High Limit LED		On/Off		
24. Low Limit LED		On/Off		
25. CPU OK LED		On/Off		

Menu 0—Diagnostics

1. Diagnostic Result				
2. ROM Check Sum				
3. Active DSL/Cs	1	16		
4. Retrieve Net 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/ External Reset/ Watchdog Reset/ Software Reset/ Cleared/ Unknown		
11. Network State		NoAppl, Unconfigured/ Appl, Unconfigured/ Configured, Off-line/ Soft Off-line/ Bypass Off-line/ Configured, On-line/ Unknown		

	Name	Min. Value	Max. Value	Initial Value	Dimension			
12.	Network Error Log							
					No Error/ Bad Event/ NV Length Mismatch/ NV Msg Too Short/ EEPROM Write Fail/ Bad Address Type/ Preemption Timeout/ Already Preempted/ Sync NV Update Lost/ Invalid Resp Alloc/ Invalid Domain/ Read Past EndOfMsg/ Write Past EndOfMsg/ Addr Table Index/ Incomplete Msg/ Update On Output NV/ No Msg Avail/ Illegal Send/ Unknown PDU/ Invalid NV Index/ Divide by Zero/ 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.	Net Interface Errors	0	65535					
14.	A/D Errors	0	65535					

Menu (Set Point) Descriptions

Menu 1—Synchronizer

1. **Sync Gain** 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** 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 (fast) slip frequency reference (generator frequency higher than bus frequency) when slip frequency synchronizing is desired. 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 generator voltage may exceed the bus voltage for the synchronizer to initiate breaker closure when voltage matching is enabled. Generator voltage may not be less than bus voltage.
8. **Dead-bus Closure** enables or disables the synchronizer's automatic dead-bus detection and breaker closure functions. When enabled, the synchronizer will insure a breaker closure signal when a dead-bus is detected.

**NOTE**

See Appendix C for compatibility with obsolete DSLC controls when dead-bus closing is set to Enabled.

9. **Breaker Delay** specifies the time required for the circuit breaker blades to engage after receiving a closure command.
10. **CB Close Hold Time** specifies the maximum elapsed time the synchronizer will maintain the breaker closure relay driver output low (energized). Failure to receive the CB Aux contact signal during this interval results in a failed close attempt. The breaker closure relay driver returns high (de-energized) when the CB Aux contact signal is received, the specified time expires, the generator is out of the phase window, the generator exceeds the slip window, or the generator voltage exceeds the voltage window (if voltage matching is enabled).
11. **Close Attempts** is the number of attempts the synchronizer will make to close the circuit breaker. The synch fail alarm (if enabled) will be activated and the synchronizer will enter the auto-off mode if the breaker fails to close in the specified number of tries. The synchronizer mode must be set to the off mode to clear the current close count and the alarm. Set Close Attempts to one if operating in droop.
12. **Reclose Delay** is the number of seconds between attempts to close the circuit breaker. If the CB Aux contact remains closed for one reclose delay interval, synchronization is assumed to have occurred. If the CB Aux contact opens during the reclose delay interval, it is considered a failed closed attempt. The DSLC control will remain in the selected operating mode (run, check, or permissive) during the Reclose Delay interval.
13. **Sync Reclose Alarm** enables or disables the alarm generated when reaching the maximum close attempts.

14. **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 (generator A phase voltage above 40 V L-N) 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.
15. **Sync Timeout Alarm** enables or disables the alarm generated by exceeding the synch timeout interval without getting synchronization.
16. **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. **Load Control Gain** determines how fast the load control responds to a load error. Gain is set to provide stable load control. For integrating load control mode, use 0.05 as the initial load control gain. In proportional load control mode, the load control gain is the gain setting in base load mode and during load control ramp time. In proportional load control mode, use 0.25 as the initial setting.
2. **Load Stability** compensates for lags in the load control loop. It prevents slow hunting and controls damping (overshoot or undershoot) after a load disturbance. This adjustment is in effect only in the integrating load control mode.
3. **Load Derivative** adjusts the rate of change in speed bias output during a load transient. This adjustment is in effect only in the integrating load control mode.
4. **Load Control Mode** selects the operating mode of the base load control algorithm. In proportional mode, the speed bias output is proportional to the error between load and load reference. In proportional mode, a shift in bus frequency will result in a shift in load. Use proportional mode when bus frequency remains stable over time.

In integrating mode, speed bias output integrates to the level required to get zero error between load and the load reference. Load Stability and Load Derivative set points are only in effect in the integrating load control mode. Use this mode in applications where utility frequency may vary.



NOTE

An integrating load control will react dynamically with the engine speed control and any other system control, and with the DSLDC Process and VAR/PF control functions. Dynamic adjustment of each of these functions must be repeated until satisfactory performance is obtained under all operating conditions.

5. **Load Control Filter** adjusts the bandwidth of the filter on the load controller input. Higher frequency settings than default result in faster control response, but also more response to system noise. Lower frequency settings result in slower control response and less response to noise.
6. **Loadshare Gain** adjusts ratio of speed bias output voltage to load error in proportional load control mode. Do not change from the specified default value unless necessary to get load sharing system stability.
7. **Frequency Trimmer** enables or disables the isochronous load sharing mode speed trim function. When disabled, bus frequency in a load sharing system will be determined by the average of the speed settings on all units. When enabled, the DSLC control compensates slowly for small speed setting errors between generator sets to maintain the specified bus frequency set in Menu 5, step 6, within 0.1%.
8. **Rated Load** is the 100% load rating of the generator.
9. **Base Load** is the default base load operating mode reference.
10. **Unload Trip** is the kW load level where the breaker open command is given when the generator is automatically unloaded by opening the Load/Unload switch. The Unload Trip is also set immediately after synchronization is obtained in base load mode. In load sharing mode, the load reference is set to the unload trip reference or the load indicated for load sharing, whichever is less.

**NOTE**

If the load reference reaches zero, and generator load does not drop to the Unload Trip, the CB Open relay driver will not de-energize. This can occur in the proportional load control mode when the governor speed setting holds load above the Unload Trip.

11. **Load Droop** is the load droop operation setting. Droop is the default mode when load is applied to the generator when the CB Aux contact input to the DSLC control is open. [The Load Droop setting is only approximate due to dependence on the gain of the speed control's bias input.]
12. **Load Time** is the time required to automatically ramp the load from the unload trip level to the internal base load reference. Ramp time in the increase load direction between isochronous load sharing, remote base load, and process control, is proportional to the load time set point.
13. **Unload Time** is the time required to automatically ramp the load from the internal base load set point to the unload trip. Ramp time in the decrease load direction between isochronous load sharing, remote base load, and process control, or other load than that specified by the Base Load set point, is proportional to the unload time set point.
14. **Raise Load Rate** is the rate at which the load is increased when the raise load command input is activated. This is also the maximum rate at which load is increased when the 4–20 mA remote load setting input is changed in the increase load direction. [In droop, the Raise Load Rate setting is only approximate due to dependence on the gain of the speed control's bias input.]

15. **Lower Load Rate** is the rate at which the load is decreased when the lower load command input is activated. This is also the maximum rate at which load is decreased when the 4–20 mA remote load setting input is changed in the decrease load direction. [In droop, the Lower Load Rate setting is only approximate due to dependence on the gain of the speed control's bias input.]
16. **4mA Remote Load** is the desired 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.
17. **20mA Remote Load** is the desired load level 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.
18. **High Limit PU** (pick up) is the generator load where (if enabled) the High Limit discrete output is energized and (if enabled) the high limit alarm is activated. The High Limit PU set point also limits the maximum load reference setting.
19. **High Limit DO** (drop out) is the load where (if enabled) the High Limit discrete output is de-energized and (if enabled) the high limit alarm deactivated.
20. **High Limit Alarm** specifies if the high limit alarm will activate (de-energize) the alarm driver, terminal 28.
21. **Low Limit PU** is the generator where (if enabled) the Low Limit discrete output is energized and (if enabled) the low limit alarm is activated. The Low Limit PU set point is also the minimum load reference setting.
22. **Low Limit DO** is the generator load where (if enabled) the Low Limit discrete output is de-energized and (if enabled) the low limit alarm deactivated.
23. **Low Limit Alarm** specifies if the low limit alarm will activate (de-energize) the alarm driver, terminal 28.
24. **Load Limit Switches** specifies if the High or Low Limit outputs, terminals 26 and 27, will activate on high or low limit alarm.
25. **Load Switch PU** is the load level where the load switch will activate (terminal 25) if Reverse Power Trip is disabled.
26. **Load Switch DO** is the load level where the load switch will deactivate (terminal 25) if Reverse Power Trip is disabled.
27. **Reverse Power Trip** enables or disables the load switch output, terminal 25, as the Reverse Power Trip.
28. **Instant Reverse Power** activates the load switch output, terminal 25, immediately when the %KW is below this setting, if the Reverse Power Trip is enabled.
29. **Rev Pwr Time Delay and Reverse Pwr Level** are used to determine the time delay before energizing the load switch output when the generator is being motored, and the Reverse Power Trip is enabled.

30. **Reverse Pwr Level and Rev Pwr Time Delay** are used to determine the time delay before energizing the load switch output when the generator is being motored, and the Reverse Power Trip is enabled.

Menu 3—Process Control

1. **Process Control Gain** 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** 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 in speed bias output 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 process reference is increased when the raise command input is activated.
9. **Lower Reference Rate** is the rate at which the process is decreased when the lower command input is activated.
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. The High Limit PU set point also limits the maximum process reference setting.
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 deactivated.
12. **High Limit Alarm** specifies if the process high limit alarm will activate (de-energize) the alarm driver, terminal 28.
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. The Low Limit PU set point is also the minimum process reference setting.
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 deactivated.
15. **Low Limit Alarm** specifies if the low limit alarm will activate (de-energize) the alarm driver, terminal 28.
16. **Process Switches** specifies if the High and Low Limit discrete outputs, terminals 26 and 27, will activate on high or low process alarm.

Menu 4—VAR/Power Factor Control

1. **VAR/PF Control Mode** enables or disables the VAR or Power Factor control functions.
2. **VAR/PF Gain** determines how fast the VAR/PF control responds to an error between kVARs/PF and VAR or PF reference. The gain is set to provide stable control of kVARs or power factor.
3. **VAR/PF Stability** compensates for delay in the reactive power control loop. This prevents low frequency hunting and damping (overshoot or undershoot) when a change in reactive power occurs.
4. **Rated KVARs** is the generator manufacturer's kVAR rating. If unknown, set to 60% of the kVA rating, which is the kVAR load at 0.8 lagging power factor at rated kVA.
5. **KVAR Reference** specifies the desired kVAR load at which to control in the VAR control mode. Active when the Base Load input is closed.
6. **PF Reference** specifies the desired power factor at which to control in the power factor control mode. Active when the Base Load input is closed.
7. **PF Deadband** specifies an error window about the PF Reference or KVAR Reference, inside of which the VAR/power factor control will not adjust the voltage regulator. Deadband is especially useful in systems using a MOP to adjust voltage.
8. **Voltage Reference** specifies the bus voltage reference for VAR/PF sharing when in isochronous load sharing mode.
9. **Voltage Trim** enables or disables the isochronous load sharing mode voltage trim function. When disabled, the bus voltage in an isochronous load sharing system will be determined by the average of the voltage settings of all units. When enabled and in power factor sharing, the DSLC control will adjust the bus voltage to within the voltage regulation percentage before correcting for a power factor error.
10. **Voltage Regulation** determines how close the bus voltage will be kept to the voltage reference when the voltage trim function is enabled and the operating mode is isochronous power factor sharing.
11. **Voltage Low Limit** specifies the voltage low limit alarm trip point. This set point is also the lower limit for the synchronizer voltage matching and manual lower voltage functions.
12. **Voltage Low Alarm** specifies if the voltage low limit alarm will activate (de-energize) the alarm driver, terminal 28.
13. **Voltage High Limit** specifies the voltage high limit alarm trip point. This set point is also the raise limit for the synchronizer voltage matching and manual raise voltage functions.
14. **Voltage High Alarm** specifies if the voltage high limit alarm will activate (de-energize) the alarm driver, terminal 28.
15. **Voltage Switches** specifies if the voltage high or low limit outputs, terminals 25 and 26, will activate the high or low limit relay driver outputs.

16. **Voltage Range Alarm** enables or disables the voltage regulator bias output limit alarm. This alarm activates if the limit of the voltage bias output is exceeded (above 100% or below 100% voltage bias output).
17. **Voltage Ramp Time** specifies the time required to ramp the voltage bias output over its full range when a MOP is used for voltage adjustment. It also adjusts the rate of change in voltage bias output by the synchronizer voltage matching function.

Menu 5—Configuration

1. **Configuration Key** is set to 49 to allow changing configuration set points. All discrete input switches must be open, and the generator voltage must be below 40 V L-N, to adjust configuration of set points.
2. **PT Winding Ratio** is set to correspond to the potential transformer winding ratio. NOTE: Bus and generator potential transformers must be the same ratio.
3. **CT Rating** is set to correspond to the current transformer rating.
4. **PT Voltage** Input specifies whether the 120 or 240 PT voltage inputs are used.
5. **Voltage Display** specifies whether voltages are displayed on the Hand Held Programmer as volts line-to-neutral, volts line-to-line, kilovolts line-to-neutral, or kilovolts line-to-line.
6. **System Frequency** is set to nominal system operating frequency (50/60 Hz).
7. **Process Control Action** specifies if the process variable is direct or indirect acting. If the process variable increases when generator load increases, the action is direct. If the process variable decreases when generator load increases, the action is indirect.
8. **Network Address** is a unique address for each DSLC control in a system. You assign a number from 1 to 16 to the Network Address (each DSLC control in a system must have a unique number). After setting the network address, press the “SAVE” key to put the new address into effect.



NOTE

In systems where the DSLC control is installed with other devices (see Chapter 8) using a network management tool, the management tool automatically assigns each DSLC control a unique address. In this case, any network address change you make will not take effect when the “SAVE” key is pressed. This is indicated by the Network Address set point reverting to its previous value.

9. **Network Service Pin** causes a unique identification code to be transmitted on the network. This is used for network management in systems containing other network devices than DSLC controls.

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 values 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. **Speed Bias Output** displays the percent of full positive or negative range currently on the speed bias output. This is used only to “zero” the Speed Bias Output.
5. **Voltage Bias Output** displays the percent of full positive or negative range currently on the voltage bias output. This is used only to “zero” the Voltage Bias Output.
6. **PT Phase A** displays the sensed generator A phase voltage. When potentials are applied to the control, adjust until the displayed value is equal to the actual generator A phase voltage as seen on the DSLCL terminals.
7. **PT Phase B** displays the sensed generator B phase voltage. When potentials are applied to the control, adjust until the displayed value is equal to the actual generator B phase voltage as seen on the DSLCL terminals.
8. **PT Phase C** displays the sensed generator C phase voltage. When potentials are applied to the control, adjust until the displayed value is equal to the actual generator C phase voltage as seen on the DSLCL terminals.
9. **CT Phase A** displays the sensed phase A current. When currents are applied to the control, adjust until the value is equal to the generator A phase current as seen on the DSLCL terminals.
10. **CT Phase B** displays the sensed phase B current. When currents are applied to the control, adjust until the value is equal to the generator B phase current as seen on the DSLCL terminals.
11. **CT Phase C** displays the sensed phase C current. When currents are applied to the control, adjust until the value is equal to the generator C phase current as seen on the DSLCL terminals.
12. **Bus Voltage** displays the sensed bus voltage. When the bus A phase voltage is applied to the control, adjust until the displayed value is equal to the measured bus voltage as seen on the DSLCL terminals.
13. **Synchroscope** compensates for phase shift between the bus and generator potential transformers. If the synchroscope does not remain at 0.0 degrees (in the check mode), the phase offset should be adjusted to center the synchroscope indicator. After breaker closure is obtained, final adjust for 0.0 degrees.

**NOTE**

The calibration items may require fine tuning during installation.

Menu 7—Generator Electrical Parameters

1. **Active Power (P)** is the generator KW load.
2. **Apparent Power (S)** is the generator kVA load.
3. **Reactive Power (Q)** is the generator kVAR load.
4. **Power Factor (PF)** is the average of the power factors on each phase of the generator.
5. **Phase A (Volts)** is the voltage on the generator A phase.
6. **Phase A (Amperes)** is the amperes on the generator A phase.
7. **Phase A PF** is the power factor on the generator A phase.
8. **Phase B (Volts)** is the voltage on the generator B phase.
9. **Phase B (Amperes)** is the amperes on the generator B phase.
10. **Phase B PF** is the power factor on the generator B phase.
11. **Phase C (Volts)** is the voltage on the generator C phase.
12. **Phase C (Amperes)** is the amperes on the generator C phase.
13. **Phase C PF** is the power factor on the generator C phase.
14. **Gen Frequency** is the frequency of the generator.
15. **Bus Frequency** is the frequency of the bus.
16. **Bus Voltage** is the voltage on the bus A phase.
17. **Synchroscope** is the phase difference between the generator and bus A phase voltage wave forms.
18. **Slip Frequency** is the difference in frequency between the generator and bus A phase voltage wave forms.
19. **System Load** is the current system (load sharing) load.
20. **System PF** is the current average system power factor.

Menu 8—Control Status Monitor

1. **Synchronizer Mode** is the current operating mode of the synchronizer.
2. **Load Control Mode** is the current operating mode of the load control.
3. **Load Reference** is the current load reference value.

4. **Process Reference** is the current process control reference.
5. **Synchronizer Timeout** is the status of the alarm for exceeding the synchronizer timeout interval.
6. **Sync Reclose Limit** is the status of the alarm for exceeding the synchronizer close attempts limit.
7. **High Load Limit** is the status of the High Load Limit alarm generated when generator kW load exceeds the Load High Limit Pick Up set point.
8. **Low Load Limit** is the status of the Low Load Limit alarm generated when generator kW load drops below the Load Low Limit Pick Up set point.
9. **High Process Limit** is the status of the High Process alarm generated when the process variable input exceeds the High Process Limit Pick Up set point.
10. **Low Process Limit** is the status of the Low Process Limit alarm generated when the process variable input drops below the Low Process Limit set point.
11. **Low Voltage Limit** is the status of the alarm generated when generator voltage is below the Low Voltage Limit set point.
12. **High Voltage Limit** is the status of the alarm generated when generator voltage exceeds the High Voltage Limit set point.
13. **Voltage Range Limit** is the status of the Voltage Range Limit alarm generated when the voltage bias output reaches maximum positive or negative.

Menu 9—Discrete Inputs/Outputs

1. **Check Switch** is the status of the synchronizer Check Mode switch input.
2. **Permissive Switch** is the status of the synchronizer Permissive Mode switch input.
3. **Run Switch** is the status of the synchronizer Run Mode switch input.
4. **Aux Contact Switch** is the status of the CB Aux contact input.
5. **Raise Voltage Switch** is the status of the Raise Voltage switch input.
6. **Lower Voltage Switch** is the status of the Lower Voltage switch input.
7. **Base Load Switch** is the status of the Base Load switch input.
8. **Load/Unload Switch** is the status of the Load/Unload switch input.
9. **Ramp Pause Switch** is the status of the Load Ramp Pause switch input.
10. **Raise Load Switch** is the status of the Raise Load switch input.
11. **Lower Load Switch** is the status of the Lower Load switch input.

12. **Process Switch** is the status of the Process Control Mode select input.
13. **Test Key** must be set to “49”, generator voltage must be below 40 Vac L-N, and the discrete inputs must all be open, to allow closing of discrete outputs for test purposes.
14. **Breaker Close Relay** is the status of the Circuit Breaker Closure Command Relay.
15. **Breaker Open Relay** is the status of the Circuit Breaker Open Command Relay.
16. **Voltage Raise Relay** is the status of the Voltage Raise Command Relay.
17. **Voltage Lower Relay** is the status of the Voltage Lower Command Relay.
18. **High Limit Relay** is the status of the High Limit Switch Relay.
19. **Low Limit Relay** is the status of the Low Limit Switch Relay.
20. **Load Switch Relay** is the status of the Load Switch Relay.
21. **Alarm Relay** is the status of the Alarm 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. **CPU OK LED** is the status of the CPU OK LED.

Menu 0—Diagnostics

1. **Diagnostic Result** 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 Check Sum** 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 DSLCs** is the number of DSLC controls currently powered on the network. This value is used to verify that all DSLC controls in the network are in communication with each other.
4. **Retrieve Net 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 (that is, several per minute) indicates an overloaded network, faulty network wiring, or a defective control in the network.

Status information is used during network installation to verify correct operation.

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 acknowledgements 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 DSLDC control while power up diagnostics are being performed (the number will depend on the number of DSLDC 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. **Network 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. **Network Error Log** is the last run-timer error logged.
13. **Net Interface Errors** is the number of errors detected by the DSLDC 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 DSLDC 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.

Prestart Setup Procedure

Connect the Hand Held Programmer to the Diagnostics and Service Port. Apply power to the DSLC control. Verify that the DSLC control passes its power up diagnostics by checking that Diagnostic Result on Menu 0 is 49. Failure to get 49 indicates that an internal component in the DSLC control is defective. See Chapter 10 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. PT Winding Ratio
2. CT Rating
3. PT Voltage Input
4. Voltage Display
5. System Frequency
6. Process Control Action (If process used)
7. Network Address

Prestart Synchronizer Setup

Set all Synchronizer, Menu 1, set points according to the descriptions above and the work sheet. Leave unknown values, such as Gain and Stability, at their default values.

Prestart Load Control Setup

Set all Load Control, Menu 2, set points according to the descriptions above and the work sheet. Proportional load control mode should be used during initial setup of the DSLC control. Set the Unload Trip set point to approximately 10% of rated load.

Prestart Process Control Setup

Set all Process Control, Menu 3, set points according to the descriptions above and the work sheet. If Gain and Stability values are unknown, leave at their default values.

Prestart VAR/Power Factor Control Setup

Set all VAR/Power Factor Control, Menu 4, set points according to the descriptions above and the work sheet. Set VAR/PF Control Mode to Disabled until doing the VAR/PF Control adjustment section below.

DSLCL Control Adjustments

When the prestart setup procedures described above have been completed, the generator set may be activated. A resistive artificial load bank is preferred to do some of the following adjustment procedures.

Load Control Droop Adjustment

It is important to set up the DSLCL control for correct kW droop operation first. This will verify correct wiring and operation of the unit in the safest possible manner. The preferred procedure uses a load bank. Only use a utility or other bus of sufficient capacity for a load if a load bank is not available.

With Load Bank

Do the following steps to verify correct wiring and operation between the DSLCL control and the engine speed control when an artificial load bank is available.

1. Select Menu 2 and the Load Droop set point. Set droop to the desired value or 5.0%.



NOTE

The load droop setting is approximate as it depends on the actual gain of the input circuits of the engine speed control.

2. Open the isoch/droop switch in series with the CB Aux contact input to terminal 47 of the DSLCL control. If such a switch is not installed, temporarily remove the connection to terminal 47.
3. Close the circuit breaker to the load bank. Apply kW load to at least 50% of rated. Observe that engine speed decreases as load increases. Verify correct load sensor operation by observing for correct voltage, current, and power readings on Menu 7. If incorrect load sensor operation is observed, verify configuration values on Menu 6 and wiring connections to the DSLCL control. If load sensor values are correct and a decrease in speed does not occur when the unit is loaded, verify wiring between the DSLCL control and engine speed control.
4. Apply full load to the generator. Adjust the load droop set point as necessary to get the correct speed droop.

Example: Operating at 60 Hz, 57 Hz at full load indicates 5% droop. If only 50% load is possible, then 58.5 Hz indicates 5% droop. [The load droop setting is only approximate due to dependence on the gain of the speed control's bias input.]

5. Press the "SAVE" key to store current set point values.

Without Load Bank

Use this procedure for droop setting when an artificial load bank is not available.



WARNING—CT/PT PHASING

Operation of the engine/generator set with incorrect CT and PT phasing could cause serious injury or damage to equipment. If the load on the unit increases rapidly when you close the breaker, immediately open the breaker and shut the unit down. Check the phasing of the CTs and PTs. **DO NOT permit the unit to continue to pick up load or to operate the system without correcting this condition.**

1. Select Menu 2 and the Load Droop set point. Set to the desired value or use 5.0%.



NOTE

The load droop setting is approximate as it depends on actual gain of the input circuits of the engine speed control.

2. Open the isoch/droop switch in series with the CB Aux contact input to terminal 47 of the DSLC control. If such a switch is not installed, temporarily remove the connection to terminal 47.
3. Calculate the engine speed required to pick up 50% and 100% of rated load.

Example: Rated frequency = 60.0 Hz

Desired droop = 5% (0.05) or 3.0 Hz

Desired test frequency = 60.0 Hz + %Load x 3.0 Hz

(at 50% [0.5] load) = 60.0 + 0.5 x 3.0 = 61.5 Hz

(at 100% [1.0] load) = 60.0 + 1.0 x 3.0 = 63.0 Hz

4. Use the raise and lower load inputs to set the desired speed with the generator circuit breaker open. Record the speed bias output percentage at the engine speed required to pick up 50% and 100% load.
5. Use the Load Raise and Load Lower inputs (terminals 53 and 54) to both manually synchronize to the bus and increase the engine load to 10%.
6. Verify correct load sensor operation by observing for correct voltage, current, and power readings on Menu 7. If incorrect load sensor operation is observed, verify configuration values on Menu 6, phasing, and other wiring connections to the DSLC control.
7. Increase the engine speed setting to increase load. When the speed bias output reaches the value required for 50% load as measured in step 4, trim the Load Droop set point for 50% load.
8. Increase the engine speed setting to the speed bias output value required for 100% load as measured in step 4. Trim the Load Droop set point to get 100% load.

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 DSLC control 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. The DSLC control will indicate 90° when the switchboard synchroscope is at 3:00 o'clock and +90° at 9:00 o'clock.

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

**NOTES**

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

If line-to-line voltage is used on the Bus PT input on DSLC controls that required a neutral connection on the generator PT inputs, the synchroscope adjustment in Menu 6 must be changed in order to indicate proper phase. With the generator in droop, manually parallel the two power sources in question and adjust the synchroscope in Menu 6 from 30 to 0. Verify that the switchboard synchroscope reads the same as the DSLC control. See the previous note if you have to adjust the synchroscope more than 35 or if the synchroscope and DSLC control do not match.

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 overshoot 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. If correct droop mode operation described above has been obtained, proceed to step 12. Otherwise, verify correct droop operation described above.

12. Open the isoch/droop switch in series with the CB Aux contact input to terminal 47 of the DSLC control. If such a switch is not installed, temporarily remove the connection to terminal 47 to select droop mode.
13. Turn the synchronizer mode switch to Run. The synchronizer should pull the generator smoothly into phase lock and issue a breaker closure command. Increase the engine speed setting slightly to add generator load.
14. 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. Complete the phase matching synchronizer setup before continuing.
2. Turn the synchronizer mode to Off. Set the Slip Frequency Ref set point to the desired slip rate. Set engine speed slightly slow.
3. 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.
4. 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 4. If rapid changes in slip frequency occur, decrease Sync Stability by a factor of two.
5. Repeat steps 3 and 4 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.
6. Verify synchronizer performance under all expected operating conditions, such as synchronizing from higher or lower speeds.
7. If Voltage Matching or the VAR/PF Control is to be used, do the setup in the Voltage Matching Adjustment section below.
8. If correct droop operation described above has been obtained, proceed to step 9. Otherwise, verify correct droop operation described above.
9. Open the isoch/droop switch in series with the CB Aux contact input to terminal 47 of the DSLC control. If such a switch is not installed, temporarily remove the connection to terminal 47 to select droop mode.
10. Turn the synchronizer mode switch to Run. The synchronizer should pull the generator smoothly into the correct slip rate and issue a breaker closure command. If the synchronizer will not issue a closure command, verify that the Max Slip Window and Max Phase Window set points are set correctly. Wider window settings will decrease the time required to synchronize.

11. 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 circuit breaker to disconnect the generator from the bus.
3. Close the isoch/droop switch in series with the CB Aux contact input to terminal 47 of the DSLC control. If such a switch is not installed, verify that the connection to terminal 47 is restored.
4. Select Menu 1 and set the Deadbus Closure set point to Enabled or Disabled as desired.
5. 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.
6. 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.
7. If an alarm is desired when the maximum Close Attempts has been reached, set Sync Reclose Alarm to Enabled.
8. Set the Sync Timeout to the maximum number of seconds the synchronizer should attempt to achieve synchronization. Set to 0 for no timeout.
9. If an alarm is desired when the Sync Timeout interval expires, set the Sync Timeout Alarm set point to Enabled.
10. 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.
11. If synchronizer setup and performance is satisfactory, press the "SAVE" key on the Hand Held Programmer to store the dynamic settings.
12. Record all Menu 1 set point values in the spaces provided in Appendix A.

This completes the DSLC control synchronizer setup.

Voltage Matching Adjustment

Do the following steps to verify correct operation of the synchronizer voltage matching function. Two procedures are given. The first is for systems where voltage adjustment is done with a MOP, and the Voltage Raise and Voltage Lower discrete outputs of the DSLC control are used to drive relays that operate the MOP. The second adjustment procedure is for systems using the direct Voltage Bias Output from the DSLC control directly connected to the voltage regulator.

Preliminary Voltage Matching Setup

1. Select Menu 1 and set the Voltage Matching set point to Enabled.
2. Select Menu 4 and set the Voltage High Limit 5% higher than the final expected value. Set the Voltage Low Limit 5% lower than the final expected value.

Voltage Matching with MOP Driven Voltage Regulator

1. Set the synchronizer mode switch to Off. Set the Voltage Ramp set point on Menu 4 to a value 10% greater than the time required to slew the voltage regulator MOP through its full range.
2. Select Menu 7 and display Phase A Volts. Select the other screen on the Hand Held Programmer by pressing the "Up/Down Arrow" key. Select Menu 7 and display the bus voltage set point.
3. Use Voltage Raise or Lower to adjust the generator voltage until generator Phase A voltage is approximately 5% higher than bus voltage plus the Voltage Window.
4. Set the synchronizer mode switch to Check. The DSLC Lower Voltage discrete output should energize the lower voltage relay to drive the voltage regulator MOP in the decrease voltage direction. The Lower Voltage discrete output should de-energize the lower voltage relay when Phase A voltage enters the voltage window as determined by the Voltage Window set point.
5. If generator voltage drops to a value less than the bus voltage, indicated by the DSLC Raise Voltage discrete output energizing the raise voltage relay, increase the Voltage Window set point or set the MOP up for a slower rate of change in voltage if cycling occurs.
6. Set the synchronizer mode switch to Off. Manually lower the generator voltage until generator Phase A voltage is approximately 5% lower than Bus Voltage.
7. Set the synchronizer mode switch to Check. The DSLC Raise Voltage discrete output should energize the raise voltage relay to drive the voltage regulator MOP in the increase voltage direction. The Raise Voltage discrete output should de-energize the raise voltage relay when Phase A voltage reaches Bus Voltage.

8. If generator voltage goes to a value greater than the bus voltage plus the amount determined by the Voltage Window set point, indicated by the DSLC Lower Voltage discrete output energizing the lower voltage relay, increase the Voltage Window set point or set the MOP up for a slower rate of change in voltage if cycling through the Voltage Window occurs.
9. Proceed to Final Voltage Matching Setup.

Voltage Matching with Voltage Bias Input to Voltage Regulator

1. Set the synchronizer mode switch to Off. Set the Voltage Range potentiometer across the DSLC control output fully counterclockwise.
2. Set the Voltage Regulator manual voltage adjustment for the desired center of generator voltage adjustment range (normally set for rated voltage).
3. Close the Raise Voltage contact input to the DSLC control. Observe that the Voltage Raise Relay set point on Menu 9 indicates Energized when the Raise Voltage contact input is closed. Hold the Raise Voltage command until the Voltage Raise Relay set point indicates De-energized even with the Raise Voltage contact closed. This indicates that the upper limit of the Voltage Bias Output has been reached. If enabled, a Voltage Range Alarm will also be activated.
4. Adjust the Voltage Range potentiometer to get the maximum generator voltage desired.
5. Close the Lower Voltage contact input to the DSLC control. Observe the Voltage Lower Relay set point on Menu 9 indicates Energized when the Lower Voltage contact input is closed. While monitoring generator voltage to insure it does not go lower than desired, hold the Lower Voltage command until the Voltage Lower Relay set point indicates De-energized even with the Lower Voltage contact closed. This indicates that the lower limit of the Voltage Bias Output has been reached. If enabled, a Voltage Range Alarm will also be activated. The voltage cannot be manually adjusted below the voltage low limit set point.
6. If the minimum generator voltage obtained is satisfactory, proceed to step 7. If not, adjust the voltage regulator voltage setting potentiometer and the Voltage Range potentiometer while repeating steps 3 through 5 until the desired voltage range is obtained.
7. Select Menu 7 and display Phase A Volts. Select the other screen on the Hand Held Programmer by pressing the "Up/Down Arrow" key. Select Menu 7 and display the Bus Voltage set point.
8. Use Voltage Raise or Lower to adjust the generator voltage until generator Phase A voltage is approximately 5% higher than Bus Voltage plus the Voltage Window.
9. Set the synchronizer mode switch to Check. The DSLC control should decrease the Voltage Bias to the voltage regulator to lower the generator voltage. The Voltage Bias should stop changing when Phase A voltage enters the voltage window as determined by the Voltage Window set point.

10. If generator voltage drops to a value less than the bus voltage, increase the Voltage Window set point or increase the Voltage Ramp Time set point on Menu 4 for a slower rate of change in voltage so that cycling through the window does not occur.
11. Set the synchronizer mode switch to Off. Manually lower the generator voltage until generator Phase A voltage is approximately 5% lower than Bus Voltage.
12. Set the synchronizer mode switch to Check. The DSLC control should increase the Voltage Bias to the voltage regulator to raise the generator voltage. The Voltage Bias should stop changing when Phase A voltage reaches the Bus Voltage.
13. If generator voltage increases to a value greater than the bus voltage and the voltage window, increase the Voltage Window set point or increase the Voltage Ramp Time set point on Menu 4 for a slower rate of change in voltage so that cycling through the window does not occur.
14. Continue with Final Voltage Matching Setup.

Final Voltage Matching Setup

1. Set the Voltage Low Limit and Voltage High Limit set points on Menu 4 to the desired values. Voltage adjustments by the Synchronizer and VAR/PF Control will not adjust voltage beyond these limits.
2. If the High Voltage Alarm or the Low Voltage Alarm are desired when generator voltage exceeds the above specified limit values, set the alarm set points to Enabled.
3. If generator voltage exceeds the Voltage High Limit and Voltage Low Limit range and it is desired to operate the High Limit and Low Limit relay driver outputs, set the Voltage Switches set point to Enabled.
4. If the Voltage Bias Output reaches either end of its operating range, indicating its range of control has been exceeded, and it is desired to activate an alarm, set the Voltage Range Alarm set point to Enabled.
5. When synchronizer voltage matching performance is satisfactory, press the "SAVE" key on the Hand Held Programmer to store the settings.

This completes adjustments of the synchronizer voltage matching function.

Load Control Adjustment

This section contains the instructions for setup of the DSLC Load Control. Set all Load Control, Menu 2, set points according to the descriptions above and the work sheet. Menu 8 set points for load control mode, load reference, and system load are provided to assist in setup and verification of correct operation.

Preliminary Setup

Do the following steps prior to activating the generator and load control.

1. Select Menu 2 and set Load Control Mode to Proportional.
2. Set Load Control Filter to 1.0 Hz.
3. Verify the Rated Load set point is set to the generator kW rating.
4. Set Base Load to 50% of Rated Load.
5. Set Unload Trip to 10% of Rated Load.
6. If the Load Droop setup procedure described above has not been done, do the Load Control Droop Adjustment before proceeding.
7. Set Loadshare Gain to 0.72.
8. Set Frequency Trimmer to Disabled.
9. Set Load Time and Unload Time as desired. If times faster than 20 seconds will be required in normal service, use 20 seconds during the following setup procedures to allow time to react if the control fails to operate as expected. Faster load and unload times may be specified after setup is complete.
10. Set Raise Rate and Lower Rate as desired. During setup, 1.0% per second or slower is recommended.
11. Set High Limit PU to Rated Load and Low Limit PU to 0.0 during setup.

Proportional Base Load Control Setup

Proportional control should be used when paralleling with a frequency stable bus, or when the process control will be used. The following procedure is used to set up the proportional base load control mode. A utility bus or an isolated bus with sufficient capacity is required to do this setup.

1. Set the Load Control Gain to 0.25.
2. Carefully set engine speed to get synchronous speed as indicated by little or no drift on the synchroscope. Proportional load control is sensitive to variations in bus frequency and engine speed setting.
3. Close the Base Load switch contact. Open the Load/Unload and Process contacts. Close the isoch/droop switch and be sure the connection to the CB Aux contact input, terminal 47, is connected so that the DSLC control will receive the closure indication.
4. Select the synchronizer run mode to parallel the generator with the bus.
5. Verify that the generator is carrying the 10% of rated kW load specified by the Unload Trip set point. Load may not be exactly the specified level, but should be close depending on the accuracy at which engine speed and bus frequency are matched.

**NOTE**

If load instability is observed, it may be necessary to adjust the dynamic settings of the engine governor to get stability.

6. Close the Load/Unload contact to start the ramp to the Base Load setting. When load has started increasing, close the Ramp Pause switch to verify its operation. Then open the Ramp Pause switch and verify the load ramp continues to the Base Load reference setting.
7. Close the Raise Load contact. Observe that load increases at the rate specified by the Raise Load Rate set point. The raise load cannot adjust the load reference greater than that set by the High Limit PU (Menu 2).
8. Close the Lower Load contact. Observe that load decreases at the rate specified by the Lower Load Rate set point. The lower load cannot adjust the load reference less than that set by the Low Limit PU (Menu 2).
9. If the synchronizer Auto-resync set point is set to Enabled, set the synchronizer mode switch to Off to prevent an immediate reclose of the circuit breaker.
10. Open the Load/Unload contact. Load should begin to ramp down. When load reaches the Unload Trip set point, the DSLC control should issue a breaker open command by de-energizing the breaker open relay. The generator should now be isolated from the bus.
11. If the Integrating Base Load Control will be used, do setup and adjustments described in the following section. Otherwise, proceed to Isochronous Load Sharing Adjustment

Integrating Base Load Control Setup

The following procedure is used to setup the integrating base load control mode. The integrating control is desirable when paralleling with a bus where frequency drift is a problem. A utility bus or an isolated bus with sufficient capacity is required to do this setup.

1. Do the proportional load control setup described above.
2. Select Menu 2 and set the Load Control Mode to integrating.
3. Set Load Control Gain to 0.05, Load Stability to 1.00, and Load Derivative to 0.00.
4. Close the Base Load switch contact. Open the Load/Unload and Process contacts. Close the isoch/droop switch.
5. Select the synchronizer Run mode to parallel the generator with the bus.
6. Verify that the generator is carrying the 10% of rated kW load specified by the Unload Trip set point.



NOTE

If load instability is observed, it will be necessary to adjust dynamic settings of the load control. Because the Integrating Load Control operates in cascade with the engine speed control, it may also be necessary to adjust the dynamics of the speed control to get the desired performance. The first attempt to get stability will be to reduce the Load Control Gain set point. If stability decreases when gain is decreased, increase Load Stability. If stability cannot be achieved with DSLC control dynamic adjustments, it will be necessary to adjust the engine speed control dynamics. Stable control is required to proceed.

7. Close the Load/Unload switch. Load should increase smoothly to the Base Load setting. Load will normally lag slightly behind the reference during ramping. If the lag is excessive, increase Load Control Gain by a factor of two. If a slow hunt is observed during the ramp, or if overshoot of the Base Load setting occurs, increase the Load Stability by a factor of two.
8. Ramp the load up and down by alternately opening and closing the Load/Unload switch. Be sure to reclose the switch before load drops to the Unload Trip level or the DSL/C control will issue a command to open the circuit breaker. Adjust Load Control Gain and Load Stability to get the desired performance.

**NOTE**

Correct dynamic adjustment may be more easily observed if the Load Ramp Time set point is set somewhat faster than will be used in service.

9. In power systems experiencing rapid fluctuations in power (such as digester gas fuel systems), reducing the Load Control Filter set point will reduce control sensitivity to the fluctuations. Slower, but more stable, performance can be obtained.
10. In most systems it will not be necessary to change Load Derivative from the default value of 0.0 seconds or Load Control Filter from the default value. In higher performance systems, the filter frequency may be increased for greater control bandwidth, and Load Derivative may be increased to increase the rate of change in Speed Bias Output during a transient.

This completes the integrating load control setup. Continue with Isochronous Load Sharing Adjustments or Final Load Control Setup if Base Load is the only operating mode to be used.

Isochronous Load Sharing Adjustment

This procedure sets up and verifies the isochronous load sharing mode of operation. In Isochronous Load Sharing, the unit load is compared to the system load to generate a proportional error signal to safely operate in parallel with another system. An isolated load sharing bus may be used to do this setup for simple load sharing systems.

This mode is also selected when operating as a slave, when another DSL/C control, operating in the process control master mode, is used to set the system load level. The unit may be paralleled against a utility bus to do this slave setup, as long as a master DSL/C control is paralleled to the utility bus with the slave unit.

1. Verify the Menu 2 Rated Load set point is set to the desired 100% load rating of the machine. Load sharing is on a per-unit basis to allow for differences in the kW rating of various machines in the system. For example, assume system load demand is 50% of the capacity of the units operating in the load sharing mode. If one unit's Rated Load is 100 kW, that unit will be operating at 50 kW. If another unit's Rated Load is 500 kW, that unit will be operating at 250 kW, etc.
2. Select the Menu 0 Active DSL/Cs set point. Verify that the number displayed corresponds to the number of DSL/C controls currently installed and powered up.

**NOTE**

It is desirable to power all DSLCL controls in the system and verify that all units show the correct number of active DSLCL controls. Duplicate Menu 5 Network Address set points, wiring errors, an overloaded network, or defective DSLCL controls can cause an incorrect result. To aid troubleshooting, a DSLCL control can be powered down to determine what effect it had on the other controls.

3. Set Loadshare Gain to 0.72. This value has been determined to be correct for most load sharing systems.
4. Open the Base Load and Load/Unload switch contacts.
5. Select Menu 8, System Load menu item. The current percent of total system load should be displayed. Note that System Load may be the load specified by a master unit.
6. Select the synchronizer Run mode to synchronize and parallel the unit to the load sharing system.
7. When the circuit breaker closes, the machine should pick up the load specified by the Unload Trip set point on Menu 2 and operate in the Unload Parallel (actually base load) load control mode. If total system load percent is less than the unit load percentage as defined by the Unload Trip set point, the unit will simply load share with the system until the system load exceeds that unit load percentage.
8. Close the Load/Unload switch contact. The unit should ramp until the unit load percentage equals the system load percentage, and then enter the isochronous load sharing mode of operation.
9. If sufficient system load is available, close the Base Load contact. The unit should ramp until unit load matches the Base Load Reference level. Open the Base Load contact. The unit should ramp back into load sharing.
10. Open the Load/Unload switch contact. The DSLCL control should ramp load to the Unload Trip level, de-energize the CB Open relay, and disconnect the unit from the system.
11. If system transient testing may be done, with load banks or large loads switching on and off, the Loadshare Gain set point may be adjusted only if necessary. If the unit picks up load too quickly compared to the system, as may occur on a small, fast machine, operating with large and slower ones, reduce the gain setting. Conversely, if the unit is slow, increase the gain setting.
12. With the unit operating in isochronous parallel, adjust the engine speed setting slightly to cause an error in load sharing percentage. Set Frequency Trimmer to Enabled. The load should slowly return to the correct percentage.

This completes the isochronous load sharing adjustments. Do the 4–20 mA Remote Load Reference Setup if applicable, or proceed to the Final Load Control Setup section.

4–20 mA Remote Load Reference Setup

Do the following steps if the 4–20 mA Remote Load Reference is to be used. The value of the 4–20 mA Remote Load Reference Input may be observed on Menu 6.

1. Set Menu 2 4mA Remote Load and 20mA Remote Load set points to the kW load to operate at the respective input levels. The kW load for the 4mA setting may be higher than that of the 20mA setting for an inverse-acting system. The DSL/C control will linearly interpolate the reference between the two settings.
2. Synchronize, parallel, and load the machine to Base Load. Apply the 4–20 mA Remote Load Reference Input signal to the DSL/C control. Adjust the Remote Reference to some level different than Base Load or use the Raise Load or Lower Load contacts to shift the unit load to a different level.
3. Close both the Raise Load and Lower Load contacts to select the 4–20 Remote Load Reference Input. The Load Control Mode on Menu 8 should indicate Remote Ramp and the load should ramp to the level specified by the 4–20 mA input.
4. Raise and lower the 4–20 mA signal. Load will ramp at the rate of change in reference specified by the Menu 2 Raise Rate and Lower Rate set points. Raise Rate and Lower Rate set points may be adjusted to achieve satisfactory performance.
5. Open the Raise Load and Lower Load contacts. The Load Control Mode should indicate Base Load. The load reference will remain at the current value. The raise and lower contacts will now raise and lower the Base Load Reference as before.
6. Momentarily open and close the Load/Unload switch contacts. The load should ramp to the Base Load Ref setting.

This completes the remote load reference setup procedure. Proceed with Final Load Control Setup.

Final Load Control Setup

1. Set Menu 2 Load Time and Unload Time times to their final desired values.
2. Set Raise Rate and Lower Rate to their final desired values.
3. Set Unload Trip and Base Load set points to their final desired values.
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 or set the Reverse Power Trip, Instant Reverse Power, Rev Pwr Time Delay, and Reverse Pwr Level to use the load switch output for a reverse power relay.
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 set points in their respective locations in Appendix A.

Process Control Adjustment

This section contains instructions for setup of the DSLC Process Control. Menu 6 set point for Process Input and Menu 8 set points for Process Reference and Load Reference 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 Menu 2 Load Control Mode to Proportional. The Process Control will compensate for changes in bus frequency.
4. 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 DSLC control in base load mode. Use manual adjustment of load with the Raise Load and Lower Load switches until the desired process level is obtained. Observe the Process Input signal on Menu 6 to determine the required Process Reference value.
5. Close the Base Load and the Process switch contacts. Close the Load/Unload switch contacts.
6. Select the synchronizer run mode to parallel the machine with the bus. The DSLC control will ramp into process control.



NOTE

In a slow pressure or level maintenance system, the load reference may ramp to either limit as defined by the High Limit PU or Low Limit PU on Menu 2 and remain there for some time. It will be necessary to get closed loop control of the process between limits in order to proceed with dynamic adjustments.

7. If the Process Control is unstable when taking control, decrease the Process Control Gain set point to get stability. If decreasing Process Control Gain results in increased instability, increase Process Stability. If the Process Control action is too slow, increase Process Control Gain by a factor of two. If a slow hunt is observed or excessive overshoot of the process reference setting occurs, increase the Process Stability by a factor of two.
8. Ramp the Process Reference as shown on Menu 9 up and down by operating the Raise Load and Lower Load switches. Note that in the process control mode, these switches operate on the Process Reference at the rate specified by the Raise Reference Rate and Lower Reference Rate set points on Menu 3. With an indirect process, the actual effect on load will be reversed.

Continue to adjust Process Control Gain and Process Stability until satisfactory control performance is obtained.

**NOTE**

Correct dynamic adjustment may be more easily observed if the Raise Reference Rate and Lower Reference Rate set points are set somewhat faster than will be used in service.

9. In systems experiencing rapid fluctuations in the process reference (such as digester gas fuel pressure maintenance), reducing the Process Control Filter set point and increasing the Process Deadband will reduce control sensitivity to the fluctuations. Slower, but more stable, performance can be obtained.
10. Introduce Process Droop, if required, to increase stability of the process control loop.
11. In most systems it will not be necessary to change Process Derivative from the default value of 0.0 seconds or Process Control Filter from the default value. In higher performance systems, the filter frequency may be increased for greater control bandwidth, and Process Derivative may be increased to increase the rate of change in Load Reference during a transient.
12. Set Raise Reference Rate and Lower Reference Rate to their final values.
13. 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.
14. 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.
15. 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.
16. 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.

17. 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.
18. 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.
19. Record all set points on Menu 3 in their respective locations in Appendix A.

This completes setup and adjustment of the DSLCL Process Control function.

VAR/PF Control Adjustments

This section describes the setup and adjustment of the DSLCL VAR/PF Control function. The VAR/PF control input is the average of A, B, and C phase power factors in PF control, and the sum of A, B, and C kVARs in VAR control. The values of kVARs and average power factor are available on Menu 7.



NOTE

VAR/PF Control effectiveness depends on voltage regulator performance. Adjustment of voltage through raise commands to a MOP will result in slow reference tracking. It may also be necessary to adjust the voltage regulator stability to achieve desired results. Consult the voltage regulator manual for instructions.

1. Verify that the voltage matching adjustments above have been done.
2. Select Menu 4 and set VAR/PF Gain and VAR/PF Stability to their default values.
3. Set Rated KVARs set point to the generator manufacturer's kVAR rating. If a kVAR rating is not provided, set to 60% of the kVA rating.
4. Set KVAR Reference set point to desired kVAR load.
5. Set PF Reference to desired power factor.
6. Parallel the generator with the utility bus or an isolated bus capable of absorbing unit load. Adjust load to approximately 50% of machine capacity.
7. Open both the Voltage Raise and Voltage Lower switch contacts by selecting "Manual" position on the VAR/PF Control Mode switch. Select Menu 4 and set VAR/PF Control Mode set point to PF Control.
8. Manually raise or lower the voltage to shift the power factor 0.1 to 0.2 away from the PF Reference set point. Select the "Auto" position on the VAR/PF Control Mode switch. The Power Factor Control should adjust the voltage regulator to bring the power factor smoothly into control.
9. If the power factor is unstable, reduce VAR/PF Gain. If reducing VAR/PF Gain increases instability, adjust VAR/PF Stability in the direction required to achieve stability.

10. Alternately disable the VAR/PF Control by selecting “Manual” and raising or lowering voltage to shift the power factor away from the PF Reference, and then switch the mode back to “Auto”. This switching will cause a disturbance to aid in doing the following dynamic adjustments.

An alternate, but less convenient, method of creating a reactive power disturbance is to switch VAR/PF Control Mode to Disabled, manually change voltage to get an offset in power factor or kVAR load, and then set VAR/PF Control Mode to the desired operating mode of PF Control or VAR Control.

11. If the control action is too slow to bring the PF or kVAR load into control, increase the VAR/PF Gain. If increasing the gain results in instability, decrease the VAR/PF Stability. If the control action is too fast, reduce the VAR/PF Gain. If overshoot of the set point occurs, increase VAR/PF Stability.

Repeat adjustments of VAR/PF Gain and Stability until satisfactory control of the reactive load during transients is obtained.

12. Select the desired operating mode, either PF Control or VAR Control. Set the appropriate reference for the desired operating point.
13. Ramp load up and down throughout the expected normal load operating range. The power factor or kVAR load should smoothly control with only a small time delay.
14. Set the PF Deadband set point to minimize control response to small variations in power factor. This is especially important in systems where a MOP is used for voltage adjustment, to prevent excessive wear of MOP components.
15. If desired, set the voltage trim function to enabled. Set the voltage regulation to the desired percentage. If enabled, the DSLC controls operating in isochronous automatic power factor sharing mode will adjust the bus voltage to the voltage reference (within the voltage regulation percentage) before making corrections to share power factor.
16. When you have obtained satisfactory performance of the VAR/PF Control, press the “SAVE” key on the Hand Held Programmer.
17. Record values of set points in Appendix A for future reference.

When the VAR/PF Control is enabled for either PF Control or VAR Control, power factor sharing will be done automatically when in isochronous load sharing mode.

This completes VAR/PF Control adjustments.

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.

Chapter 4.

Synchronizer Description

Introduction

Synchronization, as normally 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 voltage 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 4-1 shows the functional block diagram of the synchronizer for reference during the following descriptions.

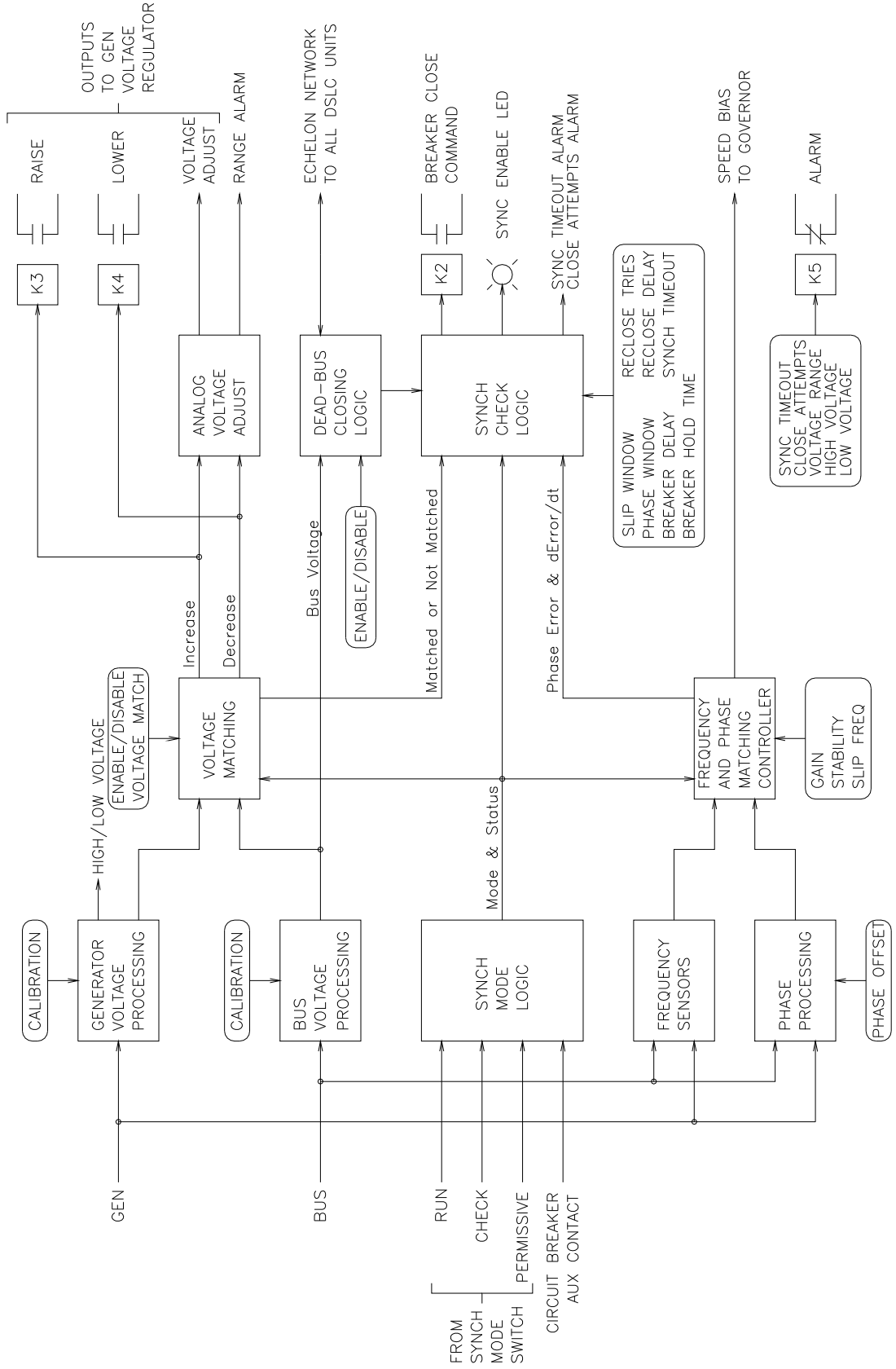
Operating Modes

The operation of the synchronizer is determined by the mode switch as shown in Figure 4-2. 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.

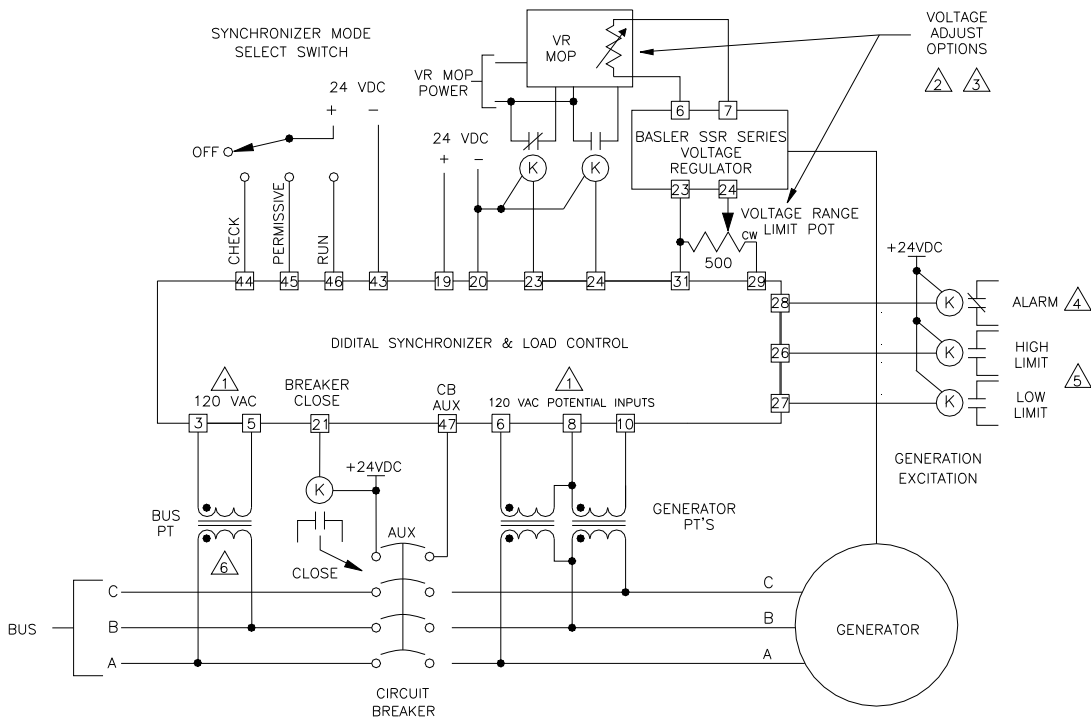
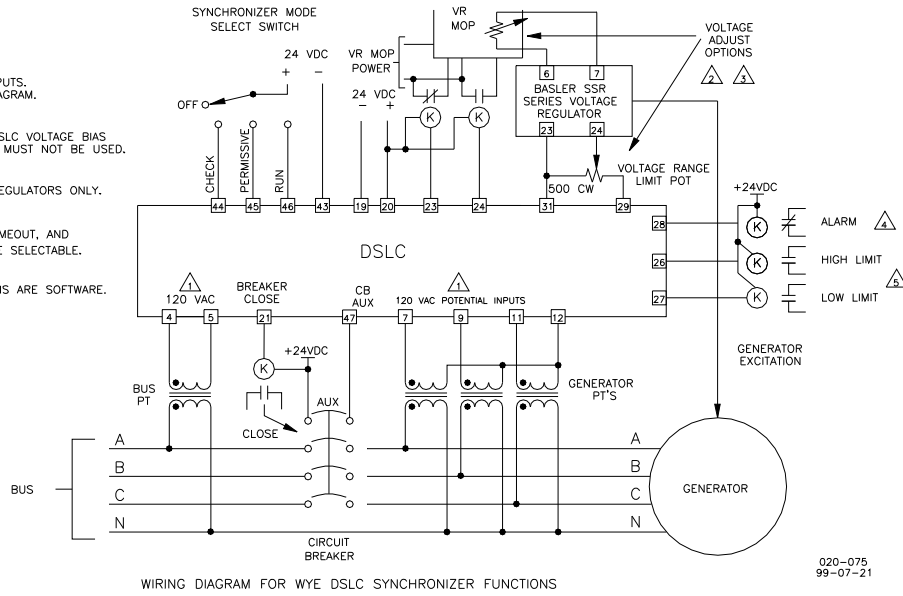
Permissive mode enables the synch-check function for proper synchronization, but synchronizer operation does not affect the engine's speed or generator voltage. If phase, frequency, and voltage are within proper limits, the synchronizer issues the breaker closure command.



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Figure 4-1. Synchronizer Block Diagram

- ⚠ CONNECTIONS SHOWN ARE FOR 120 VAC POTENTIAL INPUTS. FOR 240 VAC INPUT WIRING, CONSULT DSLC WIRING DIAGRAM.
- ⚠ DO NOT USE BOTH OPTIONS SIMULTANEOUSLY. WHEN DSLC VOLTAGE BIAS OUTPUT IS USED, VOLTAGE RAISE/LOWER CONNECTIONS MUST NOT BE USED.
- ⚠ WIRING SHOWN IS FOR BASLER SSR SERIES VOLTAGE REGULATORS ONLY.
- ⚠ ALARMS FOR VOLTAGE LIMITS, VOLTAGE RANGE, SYNC TIMEOUT, AND EXCEEDING MAXIMUM RECLOSE ATTEMPTS ARE SOFTWARE SELECTABLE.
- ⚠ VOLTAGE HIGH LIMIT AND VOLTAGE LOW LIMIT INDICATIONS ARE SOFTWARE.



- ⚠ CONNECTIONS SHOWN ARE FOR 120 VAC POTENTIAL INPUTS. FOR 240 VAC INPUT WIRING, CONSULT DSLC WIRING DIAGRAM.
 - ⚠ DO NOT USE BOTH OPTIONS SIMULTANEOUSLY. WHEN DSLC VOLTAGE BIAS OUTPUT IS USED, VOLTAGE RAISE/LOWER CONNECTIONS MUST NOT BE USED.
 - ⚠ WIRING SHOWN IS FOR BASLER SSR SERIES VOLTAGE REGULATORS ONLY.
 - ⚠ ALARMS FOR VOLTAGE LIMITS, VOLTAGE RANGE, SYNC TIMEOUT, AND EXCEEDING MAXIMUM RECLOSE ATTEMPTS ARE SOFTWARE SELECTABLE.
 - ⚠ VOLTAGE HIGH LIMIT AND VOLTAGE LOW LIMIT INDICATIONS ARE SOFTWARE
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Figure 4-2. Synchronizer Wiring Diagrams (wye and open delta)

Dead Bus Closing

When a dead bus is detected and dead bus closing mode is enabled, the synchronizer will attempt to get an exclusive lock on permission to issue a breaker closure command. This security is required to prevent two or more units from closing their breakers at the same time. To provide this security, a network message requesting the lock is made to all other DSLC™ controls currently active on the network.

When a DSLC control receives a lock request, it does the following actions:

1. If a deadbus permission request is not also currently being made, a deadbus condition is indicated, and the AUX CONTACT discrete input is inactive (the DSLC control returns a reply message to the requesting unit).



NOTE

The AUX CONTACT open requirement backs up the deadbus condition in the event of a bus PT failure. If a deadbus condition is indicated by lack of bus voltage, but the generator breaker is closed, a reply will not be sent.

2. If a deadbus permission request is also being made and that request sequentially precedes the received request, the received request is retained, otherwise the reply is sent. (In the event of a sequential tie, the unit with the lower assigned address wins.)

When all other units have replied verifying that they also indicate a dead bus (bus input less than 40 Vac L-N) and do not hold a lock, the requesting unit then holds lock permission and may attempt to close its circuit breaker. The lock is released automatically after issuing the circuit breaker closure command. This will allow any other unit to get permission to lock if the breaker fails to close.

The dead bus closing function may be enabled or disabled by the user with a set point.



NOTE

See Appendix C for compatibility with obsolete DSLC controls when dead-bus closing is set to Enabled.

Voltage Matching

The voltages of the generators in a parallel system must be matched within a small percentage to minimize the reactive power flow in the system. If two synchronous generators of unequal voltage are paralleled, the combined voltage will have a value different from the voltage generated by either of the generators. The difference in voltages results in reactive currents flowing in the system with subsequent lowered system efficiency.

If a synchronous generator is paralleled to a larger system such as a utility, a difference in voltages before paralleling will not change the voltage of the bus. If the generator voltage is lower than the bus voltage, reactive power will be drawn from the bus and used to excite the generator to the higher bus voltage. In the case where the generator voltage is low enough, the reactive power flow could motorize the generator with potential damage to the generator windings.

The voltage matching circuits of the synchronizer function in the DSLC control are shown in Figure 4-3. The voltages proportional to the generator A phase and bus A phase are input to the sample and hold circuits of the A/D (analog-to-digital) converter where they 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.

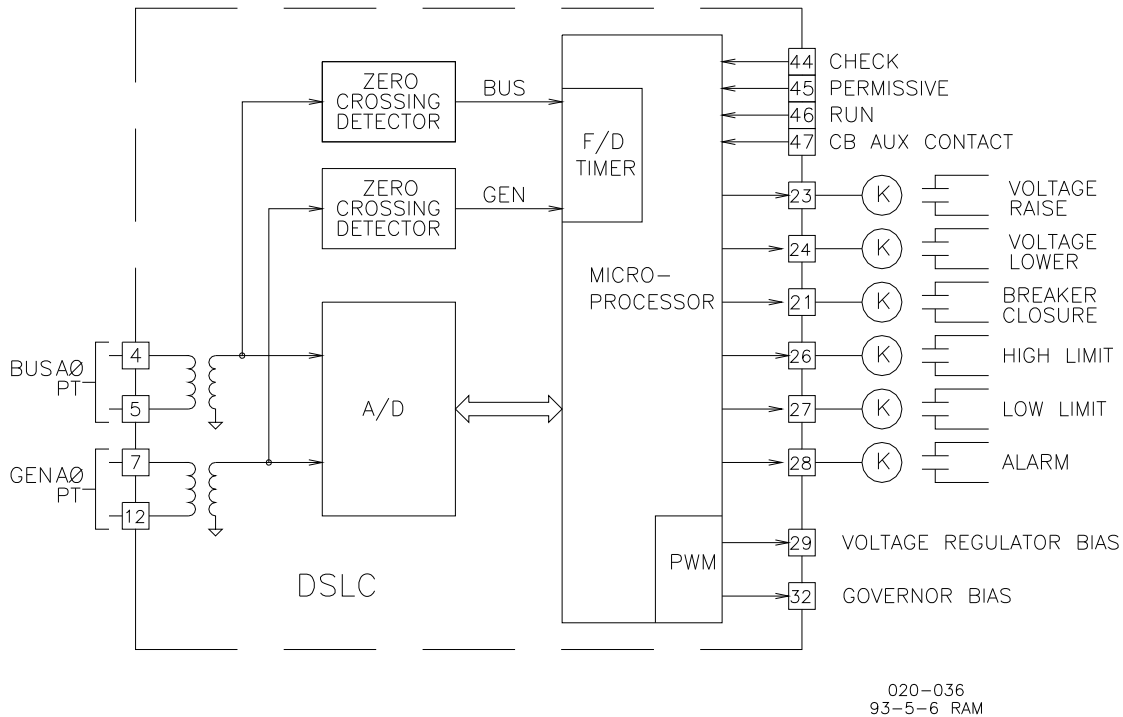


Figure 4-3. Synchronizer Block Schematic

The microprocessor then computes the RMS values of the voltages. The processor issues appropriate raise or lower commands to the voltage regulator MOP, or adjustment of the voltage bias signal if used, to the voltage regulator to bring the generator voltage within the specified window above the bus voltage. To guarantee that reactive power will be generated, window range is from equal to bus voltage to the specified percentage above bus voltage.

The automatic voltage matching function may be enabled or disabled with a set point. When enabled, voltage matching will occur in both the Check and Run modes and is verified only by the sync-check function in Permissive mode.

Phase Matching Synchronizing

The phase matching synchronizing mode corrects the frequency and phase of the generator to lock it to the bus frequency and phase. Phase matching synchronizing is automatically selected when the slip frequency reference set point is set to zero. The microprocessor uses signal processing techniques to derive the difference in phase of the generator A and bus A phase voltage signals. When there is a difference, the synchronizer sends a correction signal to the speed control. The correction signal from the speed bias output increases or decreases engine speed depending on whether the slip is faster or slower than the bus. A PI (proportional, integral) controller provides the correction signal. Gain and Stability adjustments to the PI controller are provided to allow stable operation of the automatic synchronizer function over a wide range of system dynamics.

Slip Frequency Synchronizing

In larger systems, it is often desirable for the oncoming generator speed to be slightly higher than the bus when the generator breaker is closed. This assures that power immediately flows out of the generator and into the system. The slip frequency automatic synchronizing function is enabled when the slip frequency reference set point is set to a non-zero value.

The synchronizer automatically controls the generator at the specified slip frequency. The DSLDC control outputs an error signal to the auxiliary or summing point of an electronic speed control to provide the correction. 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.

Synch-check

The synch-check function determines when all conditions for proper synchronization are satisfied and energizes the breaker closure relay. The generator and bus voltage comparison is made if the voltage matching function is enabled. The generator voltage must be within the specified voltage window above bus voltage before the breaker closure command may be given.

To minimize transients, the breaker must be closed when the phase difference between the generator and bus is near zero. Due to delays in any interposing relays and to the delay in closing the circuit breaker, the synchronizer must initiate the breaker closing ahead of the zero phase point. The control uses slip frequency and the specified breaker delay to predict breaker closure. The phase and slip frequency windows provide maximum and minimum conditions on the prediction. When all conditions of voltage and phase are met, then the breaker closure command is given.

Multiple Shot Reclosing

The multiple shot reclosing function allows multiple closing attempts. The control provides set points for the number of close tries and the reclosure delay timing. Failure to get closure after the specified number of tries locks out the synchronizer by setting it to the auto-off mode and, if the alarm is enabled, de-energizing the alarm relay. The synchronizer must then be reset by cycling the mode switch to off and back to run. The multiple shot closing function is disabled by setting the reclosing count to one.

Chapter 5.

Real Power Control Description

Introduction

The DSL_C™ control provides several modes of generator load operation. These are:

- isochronous load sharing;
- system bus parallel or isolated unit droop based on real power;
- system bus parallel base loading;
- process controlled generator load.

Base Load operation controls generator set real power, which in integrating mode is independent of variations in bus frequency. With the VAR/Power Factor control, reactive power may also be controlled independent of bus voltage variations.

Automatic ramping functions provide bumpless transfer of load when adding or removing generator capacity to a system or changing the mode of load control operation.

Power Sensor Theory of Operation

The digital signal processing (DSP) power measurement technique used by the DSL_C control 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

$$\begin{aligned}
 \text{rms Volts} \quad \vec{V} &= \left[\frac{1}{n} \sum_{i=1}^n V_i^2 \right]^{\frac{1}{2}} \\
 \text{rms Amps} \quad \vec{I} &= \left[\frac{1}{n} \sum_{i=1}^n I_i^2 \right]^{\frac{1}{2}} \\
 \text{Volt-Amps} \quad S &= \vec{V}\vec{I} \\
 \text{Reactive Power} \quad Q &= (S^2 - P^2)^{\frac{1}{2}} \\
 \text{Power Factor} \quad pf &= \frac{P}{S} \\
 \text{Phase Angle} \quad \theta &= \tan^{-1} \left(\frac{Q}{P} \right) \\
 \text{Frequency} \quad f &= \frac{1}{T}
 \end{aligned}$$

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.

Power System Management Concepts

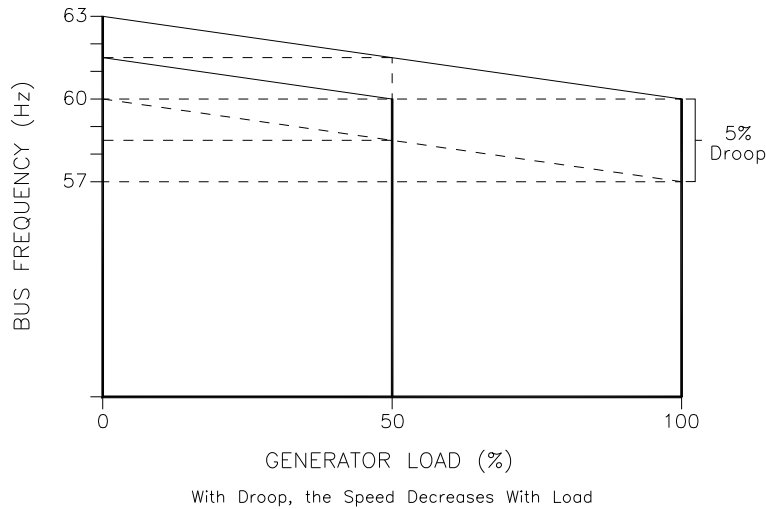
This section provides a review of the operation of droop, isochronous, droop/isochronous, isochronous load sharing, and base load. These concepts provide an understanding for power management.

Droop

Droop is a decrease in speed or frequency, proportional to load. That is, as the load increases, the speed or frequency decreases as illustrated in Figure 5-1. This reduction in speed is accomplished with negative feedback. The feedback increases as the system is loaded.

Droop is expressed as the percentage reduction in speed that occurs when the generator is fully loaded. With a given droop setting, a generator set will always produce the same power output at a particular speed or frequency. Droop sometimes is called the percent speed regulation.

If all generator sets in a droop system have the same droop setting, they will each share load proportionally. The amount of load will depend on their speed settings. If the system load changes, the system frequency will also change. A change in speed setting will then be required to offset the change in feedback and return the system to its original speed or frequency. In order for each generator set in the system to maintain the same proportion of the shared load, each generator will require the same change in speed setting.



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Figure 5-1. Droop Mode

Isynchronous

Isynchronous means repeating at a single rate or having a fixed frequency or period. A generating set operating in the isynchronous mode will operate at the same set frequency regardless of the load it is supplying up to the full load capability of the generator set, as illustrated in Figure 5-2. This mode can be used on one generator set running by itself in an isolated system.

The isynchronous mode can also be used on a generator set connected in parallel with other generator sets. Unless the governors are load sharing and speed controls, however, no more than one of the generator sets operating in parallel can be in the isynchronous mode. If two generator sets operating in the isynchronous mode without load sharing controls are tied together to the same load, one of the units will try to carry the entire load and the other will shed all of its load. In order to share load with other units, some additional means must be used to keep each generator set from either trying to take all the load or from motorizing.

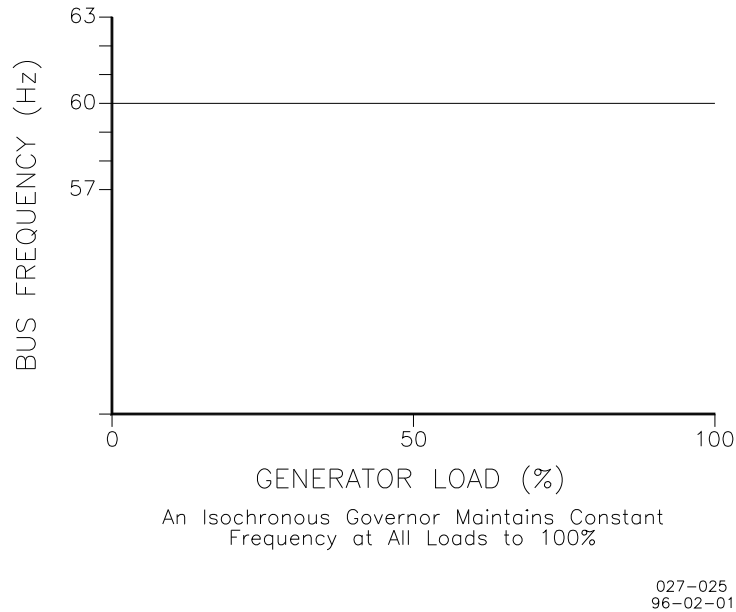


Figure 5-2. Isochronous Mode

Droop/Isochronous Load Sharing on an Isolated Bus

Droop/Isochronous combines the first two modes. All generator sets in the system except one are operated in the droop mode. The one unit not in droop is operated in the isochronous mode. It is known as the swing machine. In this mode, the droop machines will run at the frequency of the isochronous unit. The droop and speed settings of each droop unit are adjusted so that each generates a fixed amount of power as illustrated in Figure 5-3. The output power of the swing machine will change to follow changes in the load demand.

Maximum load for this type of system is limited to the combined output of the swing machine the total set power of the droop machines. The minimum system load cannot be allowed to decrease below the output set for the droop machines. If it does, the system frequency will change, and the swing machine can be motorized.

The machine with the highest output capacity should be operated as the swing machine, so that the system will accept the largest load changes within its capacity.

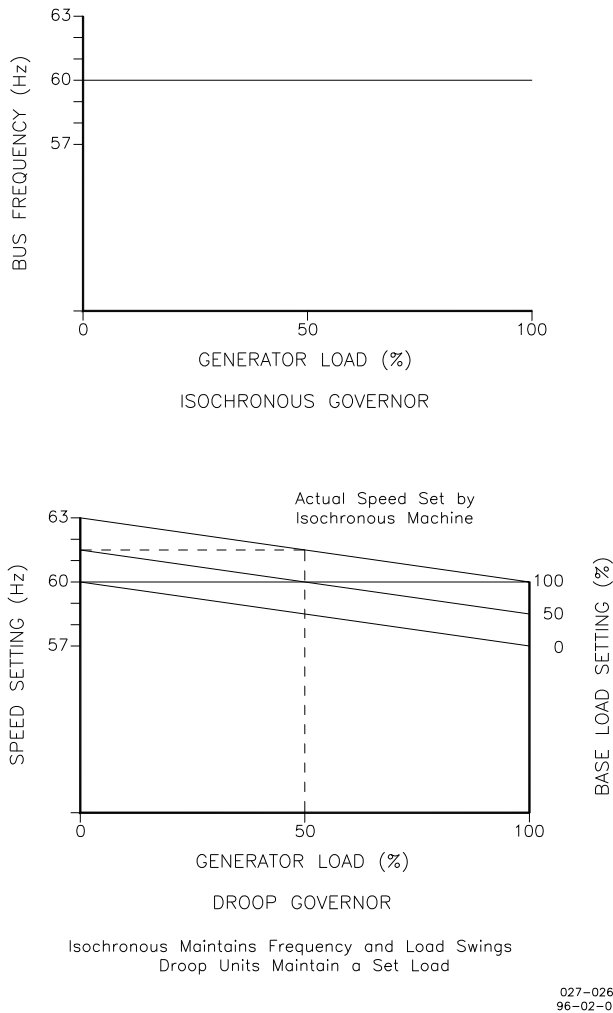


Figure 5-3. Droop/Isochronous Load Sharing

Isochronous Load Sharing on an Isolated Bus

Isochronous load sharing operates all generator sets in a system in the isochronous mode. Load sharing is accomplished by adding a load sensor to each electronic isochronous governor. The load sensors are interconnected by the load sharing lines, which in the case of the DSLC control is done digitally via the network. Any imbalance in load between units will cause a change to the regulating circuit in each governor. While each unit continues to run at isochronous speed, these changes force each machine to supply a proportional share of power to meet the total load demand on the system as illustrated in Figure 5-4.

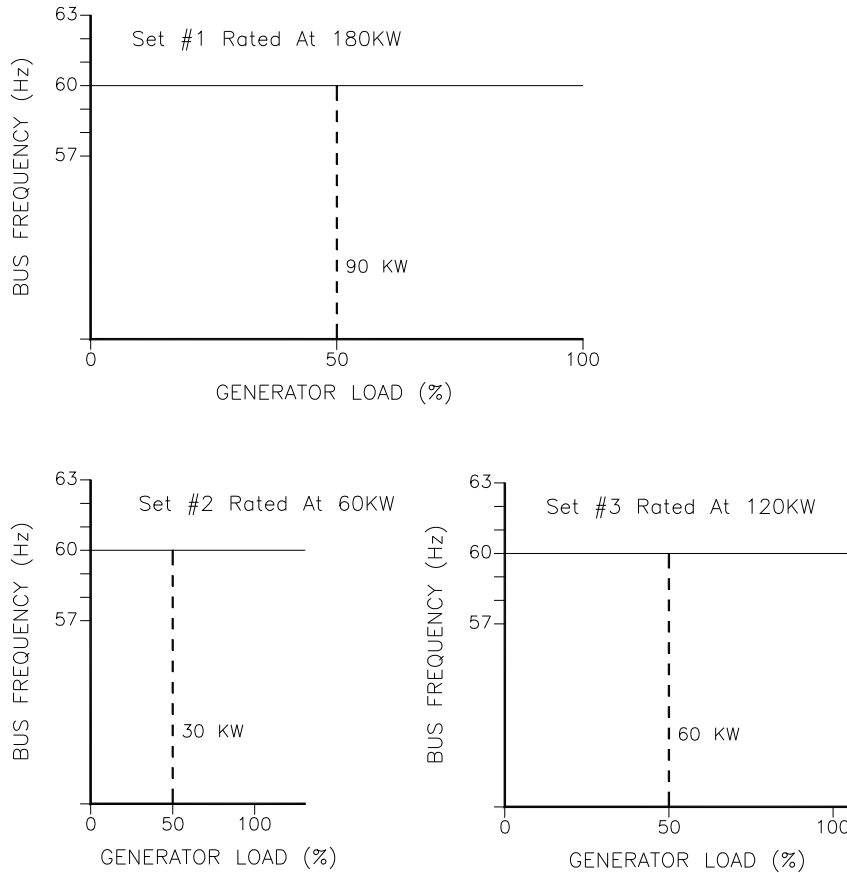
Base Load on an Isolated Bus

Base Load is a method of setting a base or fixed load on a machine operating in parallel with an isolated bus. This is accomplished by using an isochronous load control and providing a reference at which to control the load. The governor will force the generator output to increase or decrease until the output of the load sensor is equal to the reference setting. At this point, the system is in balance.

This method can be used only where other generator sets are producing enough power to meet the change in load demand. This operating mode is ideal for either soft loading additional units into an isochronous system, or for derating or unloading a machine.

Base Load

Base Load for a system paralleled to an infinite bus or utility is the same as Base Load in an isolated system. The advantage of base loading over droop is that when separating from a utility, there is no frequency change. Simply removing the bias signal on breaking from the utility returns the system to isochronous.



When Properly Set Up, Each Engine-Generator Set Supplies Its Proportional Share of the Load

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Figure 5-4. Isochronous Load Sharing

Automatic Generator Loading Functions

The automatic generator loading functions of the DSLC control are designed to be used with the speed control to automatically control the loading and unloading of the generator. This accomplishes a bumpless transfer when paralleling the generator to a load sharing or infinite bus system, or when separating a generator from a system.

Load Control Mode Switching

Load control operation is determined by the status of the contacts to the CB Aux contact input, terminal 47, and the load control mode select contact inputs. When the CB Aux contact input is open, droop is the only available operating mode. In single unit operation, speed will decrease as load increases, as described above. In parallel with a bus, the generator is loaded by increasing the speed reference. The DSLC control will provide the droop signal required for stability.

When the CB Aux contact input is closed when the generator is paralleled to a bus, the load control operating mode contact inputs become effective. These inputs are Base Load, terminal 50, Load/Unload, terminal 51, and Process Control, terminal 55, as shown in Figure 5-5. For a description of operation with the process control switch contact closed, see Chapter 7. With the Process Control contact open, the load control operating modes are:

1. Both open —isochronous load sharing at unload trip level
2. Base Load only closed —base load at unload trip level
3. Load/Unload only closed —isochronous load sharing system
4. Both closed —base load in parallel bus systems.

The DSLC control base load mode is selected by a closed base load contact and a closed load/unload contact. This function can be used in one of two modes, either as a control to load against a utility or to isolate a single generator set from a load sharing system and load that set to a specific load. The second mode can also be used when a controlled unload is desired without taking the generator set off line.

The DSLC control also includes a ramp pause function that allows for temperature, oil pressure, etc., to reach the desired operating point. The pause function is activated by an external contact closure to terminal 52. If at any time during the load or unload ramp, the pause contact is closed, the load ramp is held until the pause command is removed.

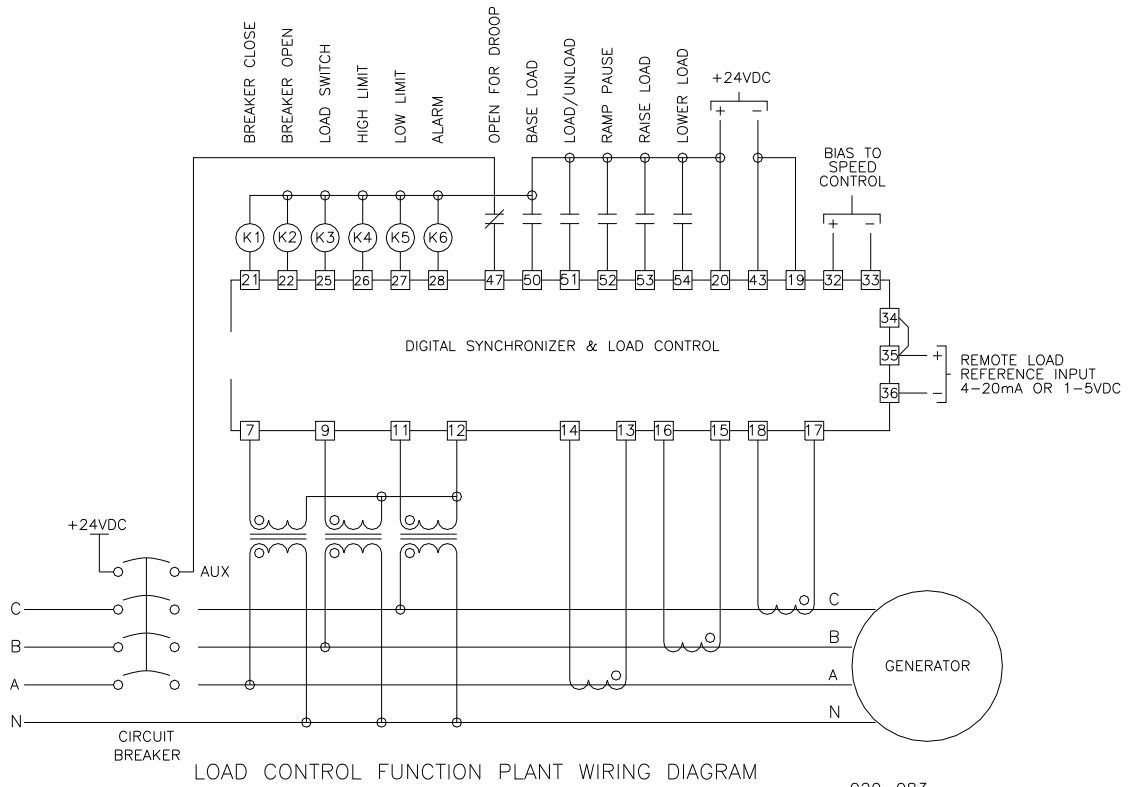
Automatic Load Control Applications

Soft Loading into a Load Sharing System

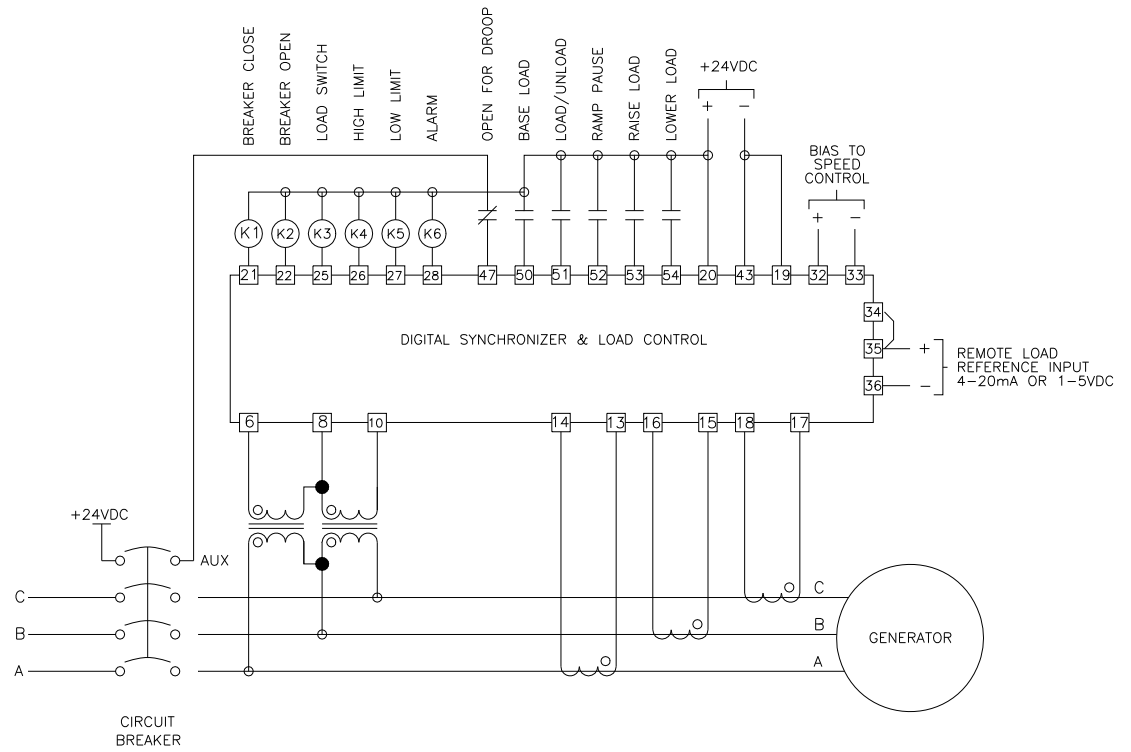
The mode for automatic soft loading into a load sharing system is selected with an open Base Load contact input, terminal 50. The Load/Unload input, terminal 51, activates the soft loading function after the oncoming generator set is properly synchronized and the paralleling generator breaker closes, which also closes the generator CB Aux contacts to terminal 47.

When the CB Aux contact is closed with the Base Load and Load/Unload inputs open, isochronous load sharing mode at a derated load is automatically selected. The derated load will be at the specified unload trip level unless the system load indicates that the unit load should be less than the unload trip level. In that case, the unit will load share at the lower level. This condition will occur on lightly load systems, or if the unit is the only one (first) in the load sharing system and no load is applied.

When this DSLC control is the first unit on line in a load sharing system, the Load/Unload contact should already be closed when the CB Aux contact is closed. This allows the unit to accept applied load immediately. The operating mode will be single unit isochronous in this case.



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Figure 5-5. Load Control Plant Wiring Diagrams (wye and open delta)

If the Load/Unload contact input was closed when the CB Aux contact was closed, the soft loading ramp will be started immediately. Otherwise, load sharing at the derated load will continue. When the loading ramp is activated, the soft loading function compares the load on the oncoming unit with the load on the load sharing system. The load ramp then linearly increases the load on the unit at the rate set by the Load Ramp Time set point. When the loads match, the ramp is shut off. In the case of an unloaded system, or when derated shared load is below the unload trip level, the unit enters load sharing without the ramp function. The pause command may be used to hold the ramp if desired.

Soft Unloading from a Load Sharing System

The unload sequence is initiated by opening the Load/Unload contact. The DSLC control then ramps the load down to zero at the preset rate. When the load reaches the Unload Trip Level set point, the low side driver for the Breaker Open relay, terminal 22, is momentarily deactivated to initiate the opening of the generator breaker. This command can be used to separate the engine generator set from the paralleled system.

Base Loading Against a Utility

The base load function is selected by connecting the Base Load contact input, terminal 50, to a set of utility breaker auxiliary contacts. The CB Aux contact input, terminal 47, is connected to a set of generator breaker auxiliary contacts.

When both generator and utility breakers are closed, the unit load will be set to the unload trip level. When the Load/Unload contact connected to terminal 51 is closed, the load ramp starts and the unit load is increased to match the base load set point. The base load can be adjusted up or down while in the base load mode with the Raise Load and Lower Load contact inputs. The Load Raise and Lower inputs cannot adjust the base load reference above the High Limit PU or below the Low Limit PU (Menu 2). The load will follow at a rate set by the appropriate raise or lower rate set points. When both the Raise and Lower Load contacts are closed, the external 4–20 mA load setting input will take precedence over the internal base load set point when above 2 mA (0.5 Vdc).

The Load/Unload input, terminal 51, will initiate the unload sequence. Opening the unload switch contacts commands the ramp to decrease the demand on the generator to the unload trip level. When the trip level is reached, the breaker open command relay is momentarily deactivated to separate the generator from the utility. When the CB Aux contacts open, the DSLC control will remove the bias signal from the speed control and reset the loading function for the next breaker closure.

Base Load and Load Sharing Systems

When the generator is paralleled and load sharing, closing the Base Load contact to terminal 50 activates the base load function. Load on any parallel load sharing units is disregarded. Load will ramp in the increasing or decreasing direction until the unit load matches the Base Load set point. The load will follow at a rate set by the appropriate load or unload time set points. The base load can be adjusted up or down while in the base load mode with the Raise Load and Lower Load contact inputs. The load will follow at a rate set by the appropriate raise or lower rate set points.

When both the Raise and Lower Load contacts are closed, the external 4–20 mA load setting input will take precedence over the internal base load set point when above 2 mA (0.5 Vdc). Opening the Base Load contact initiates the return of the system to load sharing. The unit load is ramped up or down until it matches the system load sharing level, and then ramps are disabled.

Reverse Power Relay Description

Setting Reverse Power Trip (Menu 2) to ENABLE selects terminal 25 as the reverse power trip output. The load switch will not operate based on the Load Switch PU and Load Switch DO settings when the Reverse Power Trip is enabled. The time required to activate the load switch output is calculated using the following formula:

$$\text{Time to trip} = \frac{\text{Reverse Pwr Level (\%KW)} * \text{Rev Pwr Time Delay}}{\text{Actual Load (\%KW)}}$$

Example:

Reverse Power Trip = Enabled
 Instant Reverse Power = -10%
 Rev Pwr Time Delay = 20 s
 Reverse Power Level = -1%
 Actual Load = -4%

$$\text{Time to trip} = \frac{-1\% * 20 \text{ s}}{-4\%} = 5 \text{ s}$$

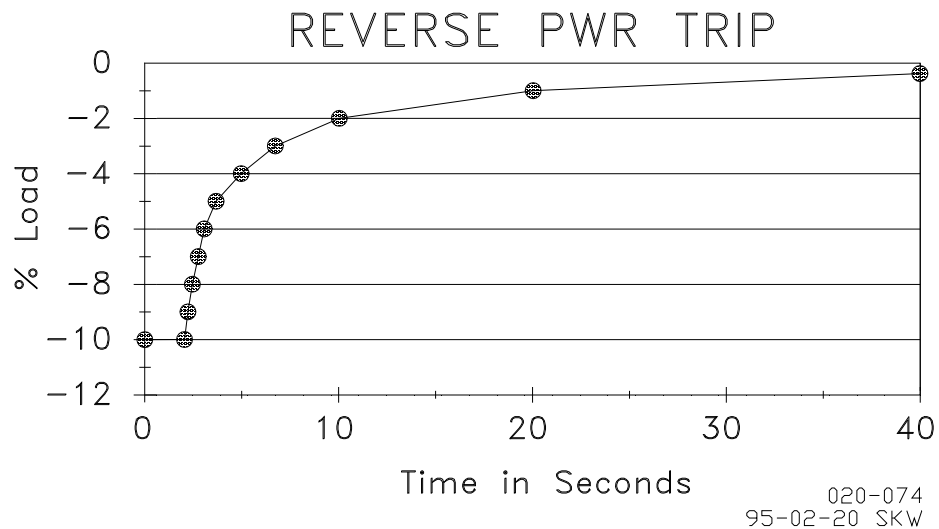


Figure 5-6. Reverse Power Trip



NOTE

If actual load falls below the instant reverse power setting, the time to trip is 0 second, as represented by the horizontal line at 10% load.

Chapter 6.

VAR/Power Factor Control Description

Introduction

The VAR/PF control is operational in full-function DSLC™ models only.

When a small generator is paralleled with a utility, the synchronizer voltage matching function adjusts the generator voltage to match that of the utility. Voltage variations that may occur in the utility system after paralleling can cause large changes in reactive current in the generator. The VAR/Power Factor Control provides closed loop control of either VARs or power factor when operating in parallel with another power system when that system can accept the reactive load.

Voltage adjustment, however, can only affect reactive power when another system is available to accept the reactive load. So the VAR/Power Factor control functions are automatically switched to Power Factor sharing when single unit or isochronous load sharing modes of operation are selected (Base Load contact to terminal 50 is open).

The VAR/PF control mode of operation is selected by setting the VAR/PF Control Mode set point on Menu 4. When either VAR or PF control mode is selected, the control function is set to Auto by closing both the Voltage Raise and Voltage Lower contacts. The VAR/PF control is disabled when both switch contacts are open. Manual operation of voltage level is provided by closing the Voltage Raise or Voltage Lower contacts individually.

The voltage bias output is reset to 0% when automatic VAR/PF control is selected and the CB Aux input is opened.



NOTE

If cross-current compensation is installed on the voltage regulator, it must be removed prior to using the VAR/PF mode of control, or instabilities may result. The droop CTs must remain connected to their voltage regulator.

VAR Control

The VAR control adjusts generator voltage to maintain a constant reactive power (kVAR) load on the generator throughout the KW operating range. This assures sufficient excitation of the generator field under all load conditions. A set point is provided to set the desired VARs. The VAR control function may be enabled with VAR/PF Control mode selection set point.

Power Factor Control

The power factor control adjusts generator voltage to maintain a constant power angle throughout the KW operating range. A set point is provided to set the desired power factor reference. The power factor control function may be enabled with the VAR/PF Control mode selection set point.

Power Factor Sharing

When either VAR or Power Factor Control is selected, and the DSLDC control is operating in isochronous load sharing mode, power factor sharing is automatically selected. Power factor sharing adjusts the voltage regulators so that all generators carry the same proportion of reactive load by balancing the power factor on all units. A voltage reference set point is provided to define the system operating voltage. If enabled, the voltage trim function will maintain the bus voltage to the voltage reference plus-or-minus the voltage regulation percentage.

Chapter 7.

Process Control Description

Introduction

The process control is operational in full-function DSL/C models only.

The process control function of the DSL/C control will control any process where the controlled parameter is determined by the generator load, and the controlled parameter can be monitored as a 4–20 mA or 1–5 Vdc input signal.

The control compares the input signal to the process set point, or the external load reference signal if it is used, and adjusts the generator load to maintain the desired set point.

Description

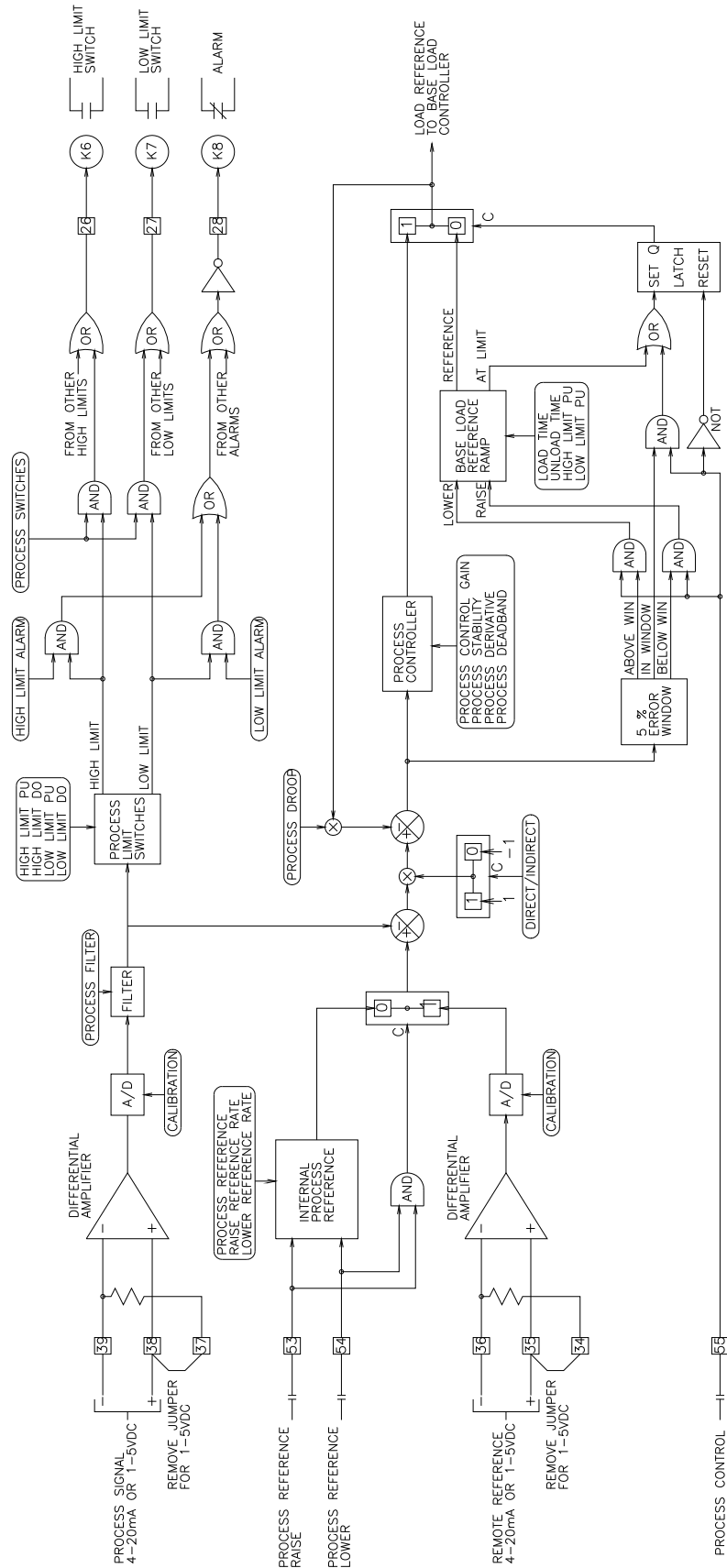
Figure 7-1 shows a block diagram of the process control function. The process control mode is selected when the process input, base load, CB Aux, and load/unload switch contacts are closed. The process input signal is compared with the process reference, which may be either the internal fixed reference or the 4–20 mA remote process reference input. In process control mode, the Raise Load and Lower Load contact inputs operate on the process control reference rather than on the load reference. When the internal reference is used, the Raise Load and Lower Load contact inputs raise and lower the process reference rather than generator load. The 4–20 mA remote reference input becomes the process reference and is selected when both the Raise Load and Lower Load 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 load reference reaches the maximum or minimum values, the process control is enabled.

When the process control is enabled, the error signal between the process reference and process signal is input to a PID (Proportional, Integral, Derivative) controller operating in cascade with the load control. The output of the controller is a load reference which is limited by the high and low load limit set points to prevent overload or reverse power on the generator. The load setting signal is output from the load control to the speed control to set control at the required load to maintain the desired process level.

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 such as experienced in digester gas fuel applications. 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 (such as where the sensed input is exhaust pressure or export power). An inverse action control is where the sensed input signal decreases as the load increases (such as when controlling import power where the import power will decrease as the generating system picks up more of the local load).



020-033
93-5-6 RAM

Figure 7-1. Process Control Block Diagram

Chapter 8. Echelon LonWorks® Network

Introduction

The communications network used by the DSLCL™ control is Echelon Corporation's LonWorks® technology. An Echelon Neuron® chip operates as a slave processor to the DSLCL control main processor. As described in previous chapters, LonWorks provides the interconnection between all DSLCL controls over which information for deadbus breaker closing permission, load sharing, and power factor sharing occurs (see Figure 8-1).

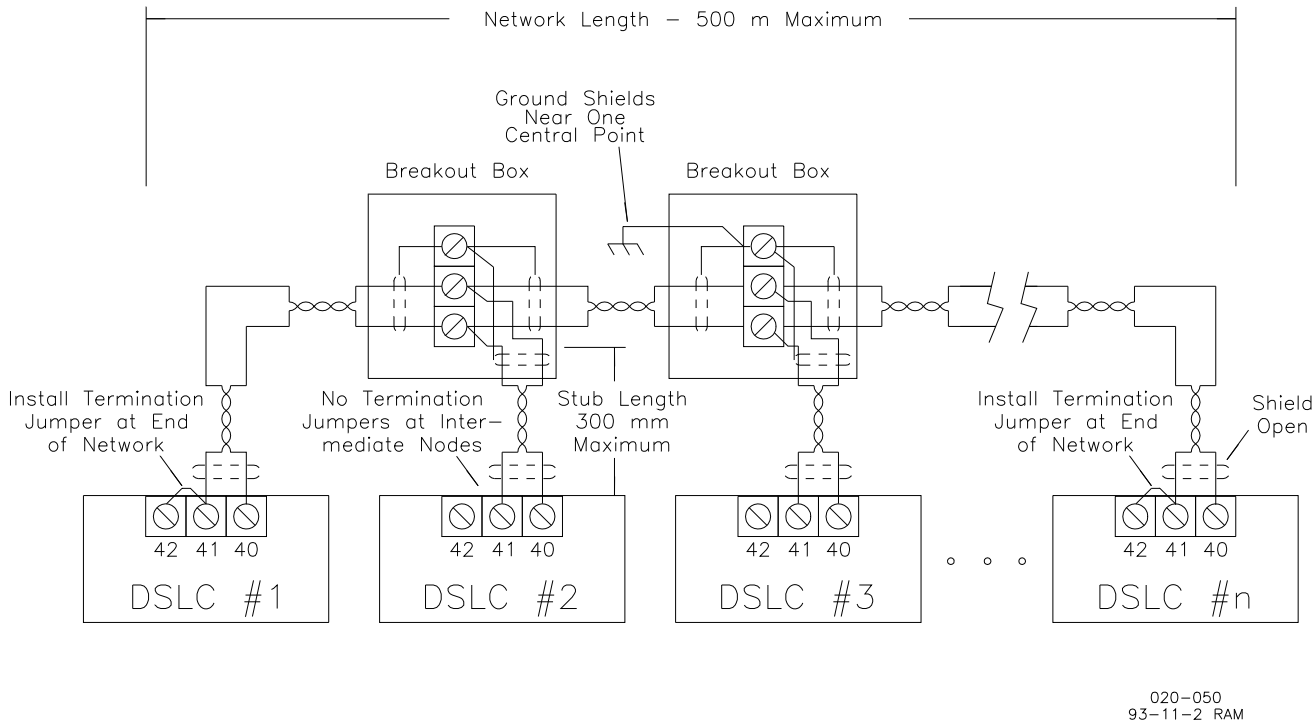


Figure 8-1. Typical LON Setup

The network may also include a Woodward Master Synchronizer or Master Synchronizer and Load control (MSLC). One of the optional devices may be included in the system with no additional wiring between it and the DSLCL controls other than the twisted pair wiring of the network. Information on operation with an MSLC or Master Synchronizer is contained in their respective manuals.

The DSLCL control 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 9 (Troubleshooting).

The DSLC control also provides optional remote metering, control status and 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 DSLC control. Contact Woodward for full information on optional devices to take advantage of these features.

Remote Metering

The following listing shows the actual values as applied to the DSLC control. The values are not necessarily the same as the values displayed on the Hand Held Programmer. The Hand Held Programmer displays values which are multiplied by the PT and CT ratios (voltages may be displayed as line-to-line or line-to-neutral voltages). Metering values are updated at a one-second rate and are intended for monitoring purposes only. All the information is contained in three structures of the following format and are labeled ELEC_PARA_OUT1, ELEC_PARA_OUT2, ELEC_PARA_OUT3:

Output Structures	DATA 1 Unsigned Long	(16-BIT)
	DATA 2 Long int	(16-BIT)
	DATA 3 Long int	(16-BIT)
	DATA 4 Long int	(16-BIT)
	DATA 5 Long int	(16-BIT)
	DATA 6 Long int	(16-BIT)
	DATA 7 Long int	(16-BIT)

The following signals are available through the LonWorks network:

ELEC_PARA_OUT1

<u>DATA1:</u>	Discrete output and PT configuration mask.
0x0001	If set DO alarm relay driver is energized.
0x0002	If set DO low limit relay driver is energized.
0x0004	If set DO high limit relay driver is energized.
0x0008	If set DO load limit relay driver is energized.
0x0010	If set DO voltage lower relay driver is energized.
0x0020	If set DO voltage raise relay driver is energized.
0x0040	If set DO breaker open relay driver is energized.
0x0080	If set DO breaker close relay driver is energized.
0x0100	If set Delta configured Potential Transformers, else WYE.
0x0200	Not used.
0x0400	Not used.
0x0800	Not used.
0x1000	Not used.
0x2000	Not used.
0x4000	This bit is set to indicate that this is the first type of electrical parameter out.
0x8000	This bit is not set but is reserved for type of electrical parameter out.
<u>DATA2:</u>	A-Phase voltage encoded as 10 times the voltage sensed on the DSLC terminal.
	$V_a = (DATA2/10) * (PT_RATIO)$
<u>DATA3:</u>	B-Phase voltage encoded as 10 times the voltage sensed on the DSLC terminal.
	$V_b = (DATA3/10) * (PT_RATIO)$
<u>DATA4:</u>	C-Phase voltage encoded as 10 times the voltage sensed on the DSLC terminal.
	$V_c = (DATA4/10) * (PT_RATIO)$

- DATA5: Bus A-Phase voltage encoded as 10 times the voltage sensed on the DSLC terminal.
 $V_{bus} = (DATA5/10) * (PT_RATIO)$
- DATA6: Power Factor encoded as follows: Unity power factor appears as 0, leading power factors appear as negative values ranging from 0 to -20,000, and lagging power factors appear as positive values ranging from 0 to 20,000.
 $PF = 1 - (DATA6/20,000)$ for $DATA6 \geq 0$
 $PF = 1 + (DATA6/20,000)$ for $DATA6 < 0$
- DATA7: PT Ratio - PT Ratio is scaled by 10 for resolution.
 $PT_RATIO = DATA7/10$

ELEC_PARA_OUT2

- DATA1: Active alarms in the DSLC.
- 0x0001 If set SYNC_TIMEOUT alarm is active.
- 0x0002 If set SYNC_RECLOSE alarm is active.
- 0x0004 If set LOAD_HIGH_LIMIT alarm is active.
- 0x0008 If set LOAD_LOW_LIMIT alarm is active.
- 0x0010 If set PROCESS_HIGH_LIMIT alarm is active.
- 0x0020 If set PROCESS_LOW_LIMIT alarm is active.
- 0x0040 If set VOLTAGE_RANGE alarm is active.
- 0x0080 If set VOLTAGE_LOW_LIMIT alarm is active.
- 0x0100 If set VOLTAGE_HIGH_LIMIT alarm is active.
- 0x0200 Not used.
- 0x0400 Not used.
- 0x0800 Not used.
- 0x1000 Not used.
- 0x2000 Not used.
- 0x4000 This bit is not set but is reserved for type of electrical parameter out.
- 0x8000 This bit is set to indicate that this is the second type of electrical parameter out.
- DATA2: A-Phase Current encoded as 100 times the current sensed on the DSLC terminal.
 $I_a = (DATA2/100) * (CT_RATIO)$
- DATA3: B-Phase Current encoded as 100 times the current sensed on the DSLC terminal.
 $I_b = (DATA3/100) * (CT_RATIO)$
- DATA4: C-Phase Current encoded as 100 times the current sensed on the DSLC terminal.
 $I_c = (DATA4/100) * (CT_RATIO)$
- DATA5: Load Reference - The present load reference in percentage of rated load to which the DSLC is controlling. It is scaled by 200 for resolution.
 $LOAD_REF = DATA5/200$ (100 is equal to 100%)
- DATA6: Process Reference - The present process reference to which the DSLC is controlling. It is scaled by 200 for resolution.
 $PROCESS_REF = DATA6/200$ (20 is equal to 20 mA)
- DATA7: CT Ratio - Encoded as primary circuit amps that give 5 amps on the secondary.
 $CT_RATIO = DATA7/5$

ELEC_PARA_OUT3

DATA1: Synchronizer (high byte) and Load Control (low byte) active state within the DSLCL. These are packaged as two short integers in one unsigned integer.

Synchronizer State:

ss_off	0
ss_check	1
ss_perm	2
ss_run	3
ss_close_timer	4
ss_sync_timer	5
ss_in_sync	6
ss_auto_off	7

Load Control State:

lcs_droop	0
lcs_unload_baseload	1
lcs_baseload_ramp	2
lcs_baseload	3
lcs_baseload_lower	4
lcs_baseload_raise	5
lcs_remote_ramp	6
lcs_remote	7
lcs_unload_parallel	8
lcs_parallel_ramp	9
lcs_parallel	10
lcs_unload_ramp	11
lcs_process_ramp	12
lcs_process_local	13
lcs_process_lower	14
lcs_process_raise	15
lcs_process_remote	16

0x4000 This bit is set to indicate that this is the third type of electrical parameter out.

0x8000 This bit is set to indicate that this is the third type of electrical parameter out.

DATA2: Real Power sensed by the DSLCL.

$$P = \text{DATA2} \times \text{CT_RATIO} \times \text{PT_RATIO}$$

DATA3: Reactive Power sensed by the DSLCL.

$$Q = \text{DATA3} \times \text{CT_RATIO} \times \text{PT_RATIO}$$

DATA4: Apparent Power sensed by the DSLCL.

$$S = \text{DATA4} \times \text{CT_RATIO} \times \text{PT_RATIO}$$

DATA5: Generator Frequency sensed on the A-Phase voltage input. It is scaled by 100 for resolution.

$$\text{GEN_HZ} = \text{DATA5}/100$$

DATA6: Bus Frequency sensed on the bus voltage input. It is scaled by 100 for resolution.

$$\text{BUS_HZ} = \text{DATA6}/100$$

DATA7: Discrete Inputs actually seen on the DSLCL terminal strip.

0x0001	sync_chk_sw_pos
0x0002	sync_perm_sw_pos
0x0004	sync_run_sw_pos
0x0008	cb_aux_sw_pos
0x0010	voltage_raise_sw_pos
0x0020	voltage_lower_sw_pos
0x0040	baseload_sw_pos
0x0080	load_sw_pos

0x0100	ramp_pause_sw_pos
0x0200	load_raise_sw_pos
0x0400	load_lower_sw_pos
0x0800	process_sw_pos

Remote Control Inputs

net_remote_in is a network remote load or process control reference input. The DSLC control 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, and 4000 would represent 4.0 mA).

net_process_in is a network input from a LonWorks-compatible process transmitter. The DSLC control hardware process input must be at 0.0 mA for the network process input to operate. The process input has a times-1000 scaling (that is, 20000 would represent 20.0 mA, and 4000 would represent 4.0 ma).

net_discrete_in is a network input from a remote sequencer. The input must be in the same format as hw_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.

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 9.

Troubleshooting

Introduction

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 DSLC™ control. 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 10 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 DSLC control 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 DSLC control. 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 3. 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 DSLC control or Hand Held Programmer.
2. Press the “ID” key. The message “DSLCL P/N 5412-xxx xxx” or “DSLCL P/N 5413-xxx xxx” should appear. Failure to display this message indicates either the control or Hand Held Programmer has failed. Replace the DSLCL control 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, contact Woodward.

4. Select each of the menus described in Chapter 3 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 DSLC control 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 DSLC control 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.

Speed Control Output

This procedure “zeros” the Speed Bias Output. Open all discrete input switches. Select Calibration Menu 6 and set the Calibration Key to 49. Connect a dc voltmeter to terminals 32 (+) and 33 (–). Select Speed Bias Output on Menu 6. Verify that the speed bias output is at 0%. Cycle the power to the DSLCL control to reset the speed bias output back to 0%. Press either “Turtle Up” or “Rabbit Up” key until the meter indicates 0.0 ± 0.1 Vdc.

Note that the range calibration of this output is not required for closed loop operation.

Voltage Regulator Output

This procedure “zeros” the Voltage Bias Output for voltage regulators with a dc Voltage Aux input. Select VAR/PF Control Mode on Menu 4 and set to Disabled. Press the “SAVE” key. Remove power to the DSLCL control for 10 seconds. Open all discrete input switches. Turn on power to the DSLCL control. Select Calibration Menu 6 and set the Calibration Key to 49. Connect a dc voltmeter to terminals 30 (+) and 31 (–). Select Voltage Bias Output on Menu 6. Press either “Turtle Up” or “Rabbit Up” key until the meter indicates 0.0 ± 0.1 Vdc.

If the VAR/PF Control Mode was previously Enabled, select VAR/PF Control Mode on Menu 4 and set to Enabled. Press the “SAVE” key.

Note that range calibration of this output is not required for closed loop operation.

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 (minimum 3 watts). 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 0 Vdc (normally energized). Select the Breaker Open Relay set point on Menu 9. Press either “Rabbit Up” or “Turtle Up” key. The output should de-energize for approximately one second as indicated by a +24 Vdc indication on the test meter.

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

Generator Potential Inputs

This section tests the operation and calibrates the Generator Potential Inputs. 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 according to the DSLC being tested. Set to 120 Vac for 120 V open delta DSLC versions. Set to 240 Vac for 240 V open delta DSLC versions. Connect the generator potential inputs according to the plant wiring diagram (Figure 1-3). The actual potential is not important, but should be within 20% of the nominal input voltage (120 Vac or 240 Vac). Connect an ac voltmeter in parallel with the A phase (A phase to neutral for wye DSLC versions or A phase to B phase for open delta DSLC versions).

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 \pm 0.1%.

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

NOTE: For open delta PTs, use:

$\phi A = A$ to B

$\phi B = B$ to C

$\phi C = C$ to A

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

Generator Current Inputs

This section tests and calibrates the Generator 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 Generator 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 $\pm 0.1\%$.

Repeat the above steps for the generator 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 generator A phase input.

Connect the test potential used for the generator potential input to both the generator input and the bus potential input. For open delta DSLC versions, jumper generator potential A phase (terminal 6) to the bus potential A phase (terminal 3), and jumper generator potential B phase (terminal 8) to the bus potential B phase (terminal 5). For wye DSLC versions, jumper generator potential A phase (terminal 6 for 240 V or terminal 7 for 120 V) to the bus potential A phase (terminal 3 for 240 V or terminal 4 for 120 V), and jumper generator neutral (terminal 12) to the bus neutral (terminal 5).

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 $\pm 0.1\%$ of the voltage read for the Generator phase A Voltage.

Select Menu 6 Synchroscope set point. With the voltage input to the Bus and Generator 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 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 DSLC controls you have installed is shown, check Menu 5, Network Address, on all 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 DSLC control's address assignment, also note the Menu 0 Active DSLCs set point on each of these units to further aid in troubleshooting.

**NOTE**

If **Network Address** cannot be changed as indicated by its reverting to some other value after saving set points, this indicates that a LonWorks network management tool has been used to do a custom network installation. If all DSLC control addresses are unique and contain values between 1 and 16, then the installation has probably been done correctly. If an address greater than 16 is obtained on any unit, custom installation has not been done correctly, and you should do an installation that results in all DSLC control addresses between 1 and 16.

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 DSLC control and the other units indicate the number is one less than the actual number of units installed, verify the wiring to the DSLC control reporting one active unit. Replace that DSLC control if necessary to correct the problem.
2. If one or more units indicate some number less than the correct value, power down one DSLC control at a time (or carefully disconnect the network wires from each DSLC control, one at a time) to observe its effect on the other units' Active DSLCs values. If 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: It is not necessary to have the Menu 0 **Retrieve Net Status** set point displayed when retrieving network status. All status registers are also cleared when status is retrieved. The 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 DSLC control 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 hour indicates the network function should be checked.

1. If the network being used by the DSLC controls for load sharing is heavily loaded with other non-load sharing devices, separate the network used by the DSLC controls 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 DSLC control 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 DSLC controls unless a non-standard custom installation has been done and another device to which the DSLC control 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 DSLC controls 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.

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 DSLC controls 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 DSLC control 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 DSLC control 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.

Net(work) Interface Errors is the number of times the main DSLC control 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 DSLC control.

Installation Verification

Verify that the overall network wiring has been done according to specification in Chapters 2 and 8:

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 8 for a complete list of network specifications.

If problems still exist, you may disconnect or replace a DSL/C control 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 9-1. 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 DSL/C 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.

Problem	Probable Cause	Action
DSLDC control doesn't load to specified base load	Either the phase currents or the phase voltages are improperly calibrated	Check the phase currents and voltages (Menu 6) and properly calibrate.
	A proportional dc speed error exists on the speed control unit (no-load speed not set to match bus frequency)	Adjust rated speed of speed control unit**, or change to integrating load control***.
Unit unstable in the Process control mode	Load control set for integrating control instead of proportional as specified by manual	Unload and set unit up for proportional load control (Menu 2).
	Process control dynamics are improperly set up	Go through the Process Control Adjustment procedure in Chapter 3.
Unit unstable in the VAR/PF control mode	VAR/PF control dynamics are improperly set up	Go through the VAR/PF Control Adjustment procedure in Chapter 3.
	Cross-current compensation installed on voltage regulators	Remove cross-current compensation from the voltage regulator circuit.
Unit carries improper proportion of load during isochronous load sharing	Rated load set point (Menu 2) at wrong value	Set the rated load to proper value for the generator (see the generator technical manual).
	A proportional dc speed error exists on the speed control unit (no-load speed not set to match bus frequency)	Adjust rated speed of speed control unit**, or change to integrating load control***.

**** NOTE 2**—If DSLDC control loads the generator to a higher value than specified by the base load set point (Menu 2), lower the rated speed set point of the speed control unit until proper loading is obtained. If DSLDC control loads the generator to a lower value than specified by the base load set point, raise the rated speed set point of the speed control unit until proper loading is obtained.

***** NOTE 3**—Changing load control modes from integrating to proportional or vice-versa while the generator is loaded may cause temporary instabilities and is not advised.

Chapter 10.

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		Engine Systems		Turbine Systems	
<u>Facility</u>	<u>Phone Number</u>	<u>Facility</u>	<u>Phone Number</u>	<u>Facility</u>	<u>Phone Number</u>
Australia	+61 (2) 9758 2322	Australia	+61 (2) 9758 2322	Australia	+61 (2) 9758 2322
Brazil	+55 (19) 3708 4800	Brazil	+55 (19) 3708 4800	Brazil	+55 (19) 3708 4800
China	+86 (512) 6762 6727	China	+86 (512) 6762 6727	China	+86 (512) 6762 6727
Germany:		Germany:			
Kempen	+49 (0) 21 52 14 51	Stuttgart	+49 (711) 78954-0		
Stuttgart	+49 (711) 78954-0	Stuttgart	+49 (711) 78954-0		
India	+91 (129) 4097100	India	+91 (129) 4097100	India	+91 (129) 4097100
Japan	+81 (43) 213-2191	Japan	+81 (43) 213-2191	Japan	+81 (43) 213-2191
Korea	+82 (51) 636-7080	Korea	+82 (51) 636-7080	Korea	+82 (51) 636-7080
		The Netherlands	+31 (23) 5661111	The Netherlands	+31 (23) 5661111
Poland	+48 12 618 92 00				
United States	+1 (970) 482-5811	United States	+1 (970) 482-5811	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.

DSLCL Control Setup Worksheet

Synchronizer Menu 1

Sync Gain	_____
Sync Stability	_____ Seconds
Slip Frequency Ref	_____ Hertz
Slip Window	_____ Hertz
Max Phase Window	_____ Degrees
Voltage Matching	<u>Enabled Disabled</u>
Voltage Window	_____ Percent
Deadbus Closure	<u>Enabled Disabled</u>
Breaker Delay	_____ Seconds
C.B. Close Hold Time	_____ Seconds
Close Attempts	_____
Reclose Delay	_____ Seconds
Sync Reclose Alarm	<u>Enabled Disabled</u>
Sync Timeout	_____ Seconds
Sync Timeout Alarm	<u>Enabled Disabled</u>
Auto Re-Synchronize	<u>Enabled Disabled</u>

Load Control Menu 2

Load Control Gain	_____
Load Stability	_____ Seconds
Load Derivative	_____ Seconds
Load Control Mode	<u>Integrating Proportional</u>
Load Control Filter	_____ Hertz
Loadshare Gain	_____
Frequency Trimmer	<u>Enabled Disabled</u>
Rated Load	_____ kW

Base Load	_____ kW
Unload Trip	_____ kW
Load Droop	_____ Percent
Load Time	_____ Seconds
Unload Time	_____ Seconds
Raise Load Rate	_____ Percent/Second
Lower Load Rate	_____ Percent/Second
4mA Remote Load	_____ kW
20mA Remote Load	_____ kW
High Limit PU	_____ kW
High Limit DO	_____ kW
High Limit Alarm	<u>Enabled Disabled</u>
Low Limit PU	_____ kW
Low Limit DO	_____ kW
Low Limit Alarm	<u>Enabled Disabled</u>
Load Limit Switches	<u>Enabled Disabled</u>
Load Switch PU	_____ kW
Load Switch DO	_____ kW
Reverse Power Trip	<u>Enabled Disabled</u>
Instant Reverse Power	_____ Percent Load
Rev Pwr Time Delay	_____ Seconds
Reverse Power Level	_____ Percent Load

Process Control Menu 3

Process Control Gain	_____
Process Stability	_____ Seconds
Process Derivative	_____ Seconds
Process Deadband	_____ mA
Process Droop	_____ Percent
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	<u>Enabled Disabled</u>
Low Limit PU	_____ mA
Low Limit DO	_____ mA
Low Limit Alarm	<u>Enabled Disabled</u>
Process Switches	<u>Enabled Disabled</u>

VAR/Power Factor Control Menu 4

VAR/PF Control Mode	<u>Disabled PF Control VAR Control</u>
VAR/PF Gain	_____
VAR/PF Stability	_____ Seconds
Rated KVARs	_____ kVAR
KVAR Reference	_____ kVAR Generate Absorb
PF Reference	_____ Lagging Leading
PF Deadband	_____
Voltage Reference	_____ Volts kV
Voltage Trim	<u>Enabled Disabled</u>
Voltage Regulation	_____ %
Voltage Low Limit	_____ Volts kV
Voltage Low Alarm	<u>Enabled Disabled</u>
Voltage High Limit	_____ Volts kV
Voltage High Alarm	<u>Enabled Disabled</u>
Voltage Switches	<u>Enabled Disabled</u>
Voltage Range Alarm	<u>Enabled Disabled</u>
Voltage Ramp Time	_____ Seconds

Configuration Menu 5

PT Winding Ratio _____:1

CT Rating _____:5

PT Voltage Input _____ 120 _____ 240 Vac

Voltage Display V Line-to-Line | V Line-to-Neutral |
kV Line-to-Line | kV Line-to-Neutral

System Frequency 50 Hz | 60 Hz

Process Control Action Direct | Indirect

Network Address _____

Appendix B.

DSLCL Control Specifications

DSLCL Control Part Numbers

	Speed Bias Output (1)	PT Config. (2)	Voltage Input (3)	Functions (4)
9905-355	0.5-4.5 Vdc	Wye	120/240	Full
9905-363	±3.0 Vdc	Open delta	240	Full
9905-367	0.5-4.5 Vdc	Open delta	120	Full
9905-373	500 Hz PWM	Open delta	120	Full
9905-603	1-5 Vdc	Wye	120/240	Full
9905-708	1-5 Vdc	Open delta	120	Full
9905-795	±3.0 Vdc	Wye	120/240	Full
9905-797	±3.0 Vdc	Open delta	120	Full
9905-799	500 Hz PWM	Wye	120/240	Full
9905-292—Hand Held Programmer				

NOTES:

(1) Speed Bias Output.

±3.0 Vdc—Compatible with Woodward analog and digital speed controls, via the Aux Inputs or the load sharing lines on the 2301/2301A LSSC.

0.5-4.5 Vdc—Compatible with the Detroit Diesel Corporation DDEC-III control, and any other control requiring a 0-5 Vdc input.

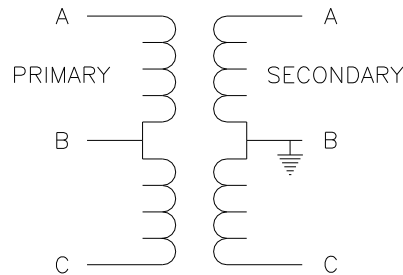
500 Hz PWM—Compatible with Woodward GenDec controls, and with Caterpillar speed controls.

1-5 Vdc—Compatible with Woodward products and others requiring 1-5 volts across a 243 ohm resistance.

(2) PT Configuration.

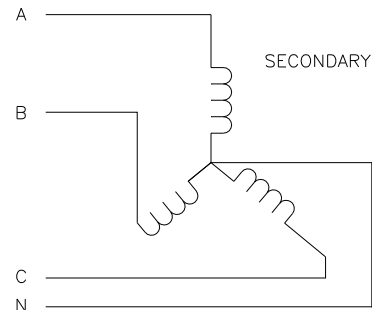
Open Delta—Switch gear configuration used in the US and Canada which consists of two PTs between A-B and B-C phases with the B-phase grounded to the switch gear ground (see drawing).

Wye—Switch gear configuration used in Australia and Europe which consists of three star-connected PTs with the center of the PTs connected to ground.



Open Delta

020-067
95-2-1 SKW



Wye

020-068
95-2-1 SKW

(3) **Voltage Input.** The voltage input is the line-to-line voltage seen on the secondary of the switch gear potential transformers.

(4) **Functions.** The reduced function unit does not have stand-alone VAR/PF control, but will respond to signals from an MSLC for VAR/PF control. The reduced function unit also does not have process control.

Electrical Specifications

Control Power Supply Input

Operating	18 to 40 Vdc continuous
Maximum	10 (1.8 A max) to 77 Vdc for up to 5 minutes
Reverse	-56 Vdc continuous
Burden	18 W, 1 A max

Synchronizer Input

Voltage	Wye PT Configuration
	120 Vac input (L-N), terminals 4 to 5, 65 to 150 Vac
	240 Vac input (L-N), terminals 3 to 5, 150 to 300 Vac
	120 Vac Open Delta PT Configuration
65 to 150 Vac, terminals 3 to 5	240 Vac Open Delta PT Configuration
	150 to 300 Vac, terminals 3 to 5
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	Wye PT Configuration
	120 Vac input, terminals 7 to 12, 9 to 12, and 11 to 12, 65 to 150 Vac
	240 Vac input, terminals 6 to 12, 8 to 12, and 10 to 12, 150 to 300 Vac
	120 Vac Open Delta PT Configuration
65 to 150 Vac, terminals 6 to 8, 8 to 10, and 10 to 6	240 Vac Open Delta PT Configuration
	150 to 300 Vac, terminals 6 to 8, 8 to 10, and 10 to 6
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, 7 A rms max
Frequency	45 to 66 Hz
Burden	less than 0.1 VA per phase
Accuracy	0.1% of full scale

Discrete Inputs

Voltage	18 to 40 Vdc
Burden	10 mA nominal

Relay Driver Outputs

Voltage	18 to 40 Vdc
Current	200 mA sink

Analog Inputs

Current	4 to 20 mA
Voltage	1 to 5 Vdc
Resistance	243 Ω current mode
	10 k Ω voltage mode

Analog Outputs

Speed Bias	± 2.5 Vdc, 0.5-4.5 Vdc, 1-5 Vdc across 243 Ω or 500 Hz PWM
Voltage Bias	± 9 Vdc
Current	50 mA

Local Area Network

ECHELON LONWORKS® Technology

Calibration and Diagnostics Port

RS-422

Environmental Specifications

TemperatureOperating -40 to +70 °C
Storage -55 to +105 °C**Humidity**

Operating 95% at 38 °C

Mechanical VibrationLevel 2.5 G
Frequency 24 to 2000 Hz**Mechanical Shock**Test Methods US MIL-STD-810C, Method 516.2, Shock
 Procedure I, Figure 516.2-2, basic design test
 Procedure II, transit drop test
 Procedure V, bench handling test**Electromagnetic Susceptibility**

Test Method ANSI/IEEE C37.90.2

Electrostatic discharge 6000 Volts

Electrical Transients

Test Method ANSI C37.90.1-1989

Appendix C.

Part Number Changes

The following part numbers were made obsolete in March, 1995, and replaced by the new part numbers shown:

obsolete number	replacement (new) number
9905-287	9907-007
9905-288	9905-795
9905-360	9905-796
9905-361	9905-797
9905-712	9905-603
9905-893	9905-798
9905-895	9905-799

The obsolete DSLC part numbers will function correctly with the new DSLC part numbers in all functions except dead bus closing.

The format of the data available over the Echelon® network on the obsolete part numbers is different. The format used in the obsolete controls sends one message for each variable onto the network, while the current format sends one message for up to seven variables. Woodward does not support the old format in new applications.

To answer any questions you may have on the compatibility of obsolete DSLC part numbers or on the data format of the network variables, please contact the Woodward Technical Assistance Group in Fort Collins, Colorado, USA, at (800) 648-9110 or (970) 482-5811, or fax (970) 498-3058.

Also see Service Bulletin 01098 for additional information.

DSLTM Control 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. Dead-bus Closure
9. Breaker Delay
10. CB Close Hold Time
11. Close Attempts
12. Reclose Delay
13. Sync Reclose Alarm
14. Sync Timeout
15. Sync Timeout Alarm
16. Auto Re-Synchronize

2—Load Control

1. Load Control Gain
2. Load Stability
3. Load Derivative
4. Load Control Mode
5. Load Control Filter
6. Loadshare Gain
7. Frequency Trimmer
8. Rated Load
9. Base Load
10. Unload Trip
11. Load Droop
12. Load Time
13. Unload Time
14. Raise Load Rate
15. Lower Load Rate
16. 4mA Remote Load
17. 20mA Remote Load
18. High Limit PU
19. High Limit DO
20. High Limit Alarm
21. Low Limit PU
22. Low Limit DO
23. Low Limit Alarm
24. Load Limit Switches
25. Load Switch PU
26. Load Switch DO
27. Reverse Power Trip
28. Instant Reverse Power
29. Rev Pwr Time Delay
30. Reverse Power Level

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. PF Deadband
8. Voltage Reference
9. Voltage Trim
10. Voltage Regulation
11. Voltage Low Limit
12. Voltage Low Alarm
13. Voltage High Limit
14. Voltage High Alarm
15. Voltage Switches
16. Voltage Range Alarm
17. Voltage Ramp Time

5—Configuration

1. Configuration Key
2. PT Winding Ratio
3. CT Rating
4. PT Voltage Input
5. Voltage Display
6. System Frequency
7. Process Control Action
8. Network Address
9. Network Service Pin

6—Calibration

1. Calibration Key
2. Process Input
3. Remote Input
4. Speed Bias Output
5. Voltage Bias Output
6. PT Phase A
7. PT Phase B
8. PT Phase C
9. CT Phase A
10. CT Phase B
11. CT Phase C
12. Bus Voltage
13. Synchroscope

7—Gen. Elec. Parameters

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

8—Cont. Status Monitor

1. Synchronizer Mode
2. Load Control Mode
3. Load Reference
4. Process Reference
5. Synchronizer Timeout
6. Sync Reclose Limit
7. High Load Limit
8. Low Load Limit
9. High Process Limit
10. Low Process Limit
11. Low Voltage Limit
12. High Voltage Limit
13. Voltage Range Limit

9—Discrete I/O

1. Check Switch
2. Permissive Switch
3. Run Switch
4. Aux Contact Switch
5. Raise Voltage Switch
6. Lower Voltage Switch
7. Base Load Switch
8. Load/Unload Switch
9. Ramp Pause Switch
10. Raise Load Switch
11. Lower Load Switch
12. Process Switch
13. Test Key
14. Breaker Close Relay
15. Breaker Open Relay
16. Voltage Raise Relay
17. Voltage Lower Relay
18. High Limit Relay
19. Low Limit Relay
20. Load Switch Relay
21. Alarm Relay
22. Sync Enable LED
23. High Limit LED
24. Low Limit LED
25. CPU OK LED

0—Diagnostics

1. Diagnostic Result
2. ROM Check Sum
3. Active DSLCs
4. Retrieve Net Status
5. Transmit Errors
6. Transaction Timeouts
7. Rcv Transaction Full
8. Lost Messages
9. Missed Messages
10. Last Reset Cause
11. Network State
12. Network Error Log
13. Net Interface Errors
14. A/D Errors

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