Operation and Installation

SPECTRUM®

DETROIT DIESEL

Switchgear

Models:

ISAS

ISO 9001
INTERNATIONALLY REGISTERED
SPECTRUM®

MP-5758 1/98

Table of Contents

Notes

Switchgear, like any other electromechanical device, can pose potential dangers to life and limb if improperly maintained or operated. The best way to prevent accidents is to be aware of potential dangers and act safely. Please read and follow the safety precautions and instructions below to prevent harm to yourself and others. This manual contains several types of safety precautions which are explained below. SAVE THESE INSTRUCTIONS.

This manual contains several types of safety precautions which are explained below.

DANGER

Danger indicates the presence of a hazard that *will* cause *severe* personal injury, death, or substantial property damage.

WARNING

Warning indicates the presence of a hazard that *can* cause *severe* personal injury, death, or substantial property damage.

CAUTION

Caution indicates the presence of a hazard that *will* or *can* cause *minor* personal injury or property damage.

NOTICE

Notice communicates installation, operation, or maintenance information that is important but not hazard related.

Safety decals affixed to the switchgear in prominent places advise the operator or service technician of potential hazards and how to act safely. The decals are reproduced here to improve operator recognition. Replace missing or damaged decals.

Hazardous Voltage/ Electrical Shock

WARNING

Hazardous voltage.
Can cause severe injury or death.

Disconnect all power sources before opening enclosure.

(under 600 Volt)

WARNING

Hazardous voltage.
Can cause severe injury or death.

Multiple power sources can automatically energize switchgear. Disconnect all power sources before working behind panels.

(under 600 Volt)

Heavy Equipment

WARNING

Unbalanced weight.
Improper lift can cause severe injury or death and/or equipment damage.

Use lifting bars inserted through shipping pallet or lifting eyes to lift switchgear.

NOTICE

Foreign material contamination! Cover switchgear during installation to keep dirt, grit, metal drill chips, etc., out of components. After installation, operate circuit breaker(s) and/or transfer switch(es) to ensure that they operate freely.

NOTICE

When replacing hardware, do not substitute with inferior grade hardware. Screws and nuts are available in different hardness ratings. Metric hardware uses a numeric system to indicate hardness. Check markings on bolt head and nuts for proper identification.

Notes

Introduction

All information in this publication represents data available at time of print. Spectrum® reserves the right to change this literature and the products represented without incurring obligation.

Read through this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with equipment for future reference.

Equipment service requirements are minimal but are very important to safe and efficient operation; therefore, inspect parts often and perform required service at the prescribed intervals. An authorized service distributor/dealer should perform required service to keep equipment in top condition.

Service Assistance

For sales and service in the U.S.A. and Canada check the yellow pages of the telephone directory under the heading GENERATORS—ELECTRIC for an authorized Spectrum® service distributor/dealer.

For sales and service outside the U.S.A. and Canada, contact your local distributor.

For further information or questions, contact the company directly at:

Spectrum
N7650 County Trunk LS
Sheboygan, Wisconsin 53083 U.S.A.
Phone: 920-459-1877
Fax: 920-459-1825 (U.S.A. Sales)
920-459-1614 (International)

To ensure supply of correct parts or information, make note of the following identification numbers in the spaces provided:

Notes

1.1 Preparation for Unpacking

Read the following instructions carefully before unpacking, installing, or operating the equipment. Pay special attention to the safety precautions listed in the front of this manual.

1.2 Inspection at Time of Delivery

Inspect the switchgear and all loose parts for signs of damage at the time of delivery. If damage and/or rough handling is evident, file a damage claim immediately with the transport company and promptly notify the factory sales office.

1.3 Unpacking

Allow equipment stored in an area with a lower temperature than the unpacking area to warm to room temperature for 24 hours prior to unpacking.

Unpack the switchgear and loose parts immediately to avoid problems making claims for damage not evident upon receipt. Use care when unpacking to avoid damaging any of the switchgear components. Check that no loose parts are missing or left in the packing material. Remove dirt and packing material from the switchgear and its components.

1.4 Storage

Store the switchgear in a clean, dry location if not permanently installed immediately upon receipt.

1.5 Handling

⚠ WARNING

Unbalanced weight.
Improper lift can cause severe injury or death and/or equipment damage.

Use lifting bars inserted through shipping pallet or lifting eyes to lift switchgear.

To avoid damage, do not turn the switchgear backward or tilt more than 15 degrees from vertical while handling. Do not lay the switchgear down.

1.5.1 Moving Sections

Move sections carefully in an upright position. Do not drop or bump. Mishandling the sections causes damage to delicate meters and instruments as well as distortion to doors and steel frame work.

Leave sections secured to their shipping skid during moves. The skid provides extra rigidity to the frame, preventing distortion to the bottom while moving.

1.5.2 Lifting Sections

Size lifting equipment according to switchgear weight displayed on the outside of each crate.

Lift switchgear vertically from the base using spanner or spreader bars to avoid crushing or distorting the frame and paint finish. Rigging must lift upright. To minimize rigging tension and compressive load on sections, do not exceed a 45 degree angle between the lifting cables and vertical.

To allow top lifting with lifting plates, use spanner or spreader bars when lifting vertically.

1.6 Switchgear Installation

NOTICE

Foreign material contamination! Cover switchgear during installation to keep dirt, grit, metal drill chips, etc., out of components. After installation, operate circuit breaker(s) and/or transfer switch(es) to ensure that they operate freely.

1.6.1 Permanent Floor Mounting

After moving the switchgear into its permanent position, level and fasten it securely to the floor.

1.6.2 Bus and Power Connections

Install all splice plates and bus pieces removed for shipment.

Refer to the bus bar bolt torque decal located on the switchgear back panel or Figure 1-2. There is a decal on either side of the shipping break. The bus bar bolt torque decal lists torque specifications for connecting the bus bar to the splice plates. Bus bar bolt sizes are 3/8-16 or 1/2-13.

Assemble with the bolt extending toward the back of the switchgear cubicle so the flat washer is against the bus; then install the spring washer and nut.

Check all power cables for damage and verify phasing before connecting power cables to the generators and switchgear.

Use the torque values printed on the **Torque values for dual-rated screw connection** decal located outside of the switchgear back panel or on the connector manufacturer's torque specs when connecting the cables. Switchgear connectors are sized for #2 AWG or larger circular mil sized cables.

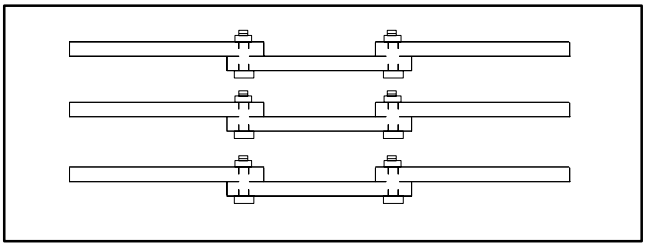


Figure 1-1. Splice Plate Installation

Socket Size across flats in. (mm)	Torque in.-lbs (Nm)
1/8 (3)	45 (3)
5/32 (4)	100 (11)
3/16 (5)	120 (14)
7/32 (6)	150 (17)
1/4 (7)	200 (23)
5/16 (8)	275 (31)
3/8 (9)	375 (42)
1/2 (12)	500 (56)
9/16 (14)	600 (68)

Figure 1-2. Torque values for sockethead screw connectors

1.7 Interconnection Wiring

Refer to the interconnection drawings for external connections to other equipment. For interconnects requiring shielded wire, use Belden cable #8780 or its equivalent. Ground the shield as indicated. Torque screws supplying control circuit wiring to the specifications printed on the **Torque values for dual rated screw connections** decal located on the switchgear back panel.

Use standard wire (#14 AWG, minimum) with insulated compression lugs when making control interconnects between the switchgear and generator sets. Consider the load current and length of the run when sizing wire and cable. Refer to the drawing in the Wiring Diagram Manual for all other drawings pertaining to the switchgear.

Use instructions provided with test equipment for hi-pot and meggar tests of electrical cables and equipment. Check all wiring terminations, bus, and circuit breaker lug connections for tightness before energizing the equipment.

Test switchgear equipped with ground fault protection using manufacturer's instructions supplied with the ground fault equipment. Cabinets containing ground fault protection equipment are labeled.

1.8 Dry Contact Kit

The ten-relay dry contact kit activates warning devices and other customer-provided accessories to allow remote monitoring of the industrial system. The kit links lamps, audible alarms, and other devices to ten generator functions selected by the customer. Typical accessories include signals for engine overspeed, overcrank, high engine temperature, low oil pressure, and low coolant temperature conditions. Interface with the switchgear requires the contact kit.

NOTE

Connect no more than three dry contact kit relays to each microprocessor controller terminal block output.

Customer-provided accessories require their own electrical power source. Do not exceed the relay contact rating given below. Do not use terminals 42A and N of dry contact kit terminal strip to supply voltage to relay contacts. Size leads according to electrical codes.

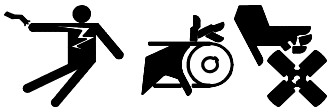
Relay Contact Ratings

Maximum Switching Voltage	120 volts
AC Maximum Switching Current	10 amps
Minimum Switching Power	10 milliamps (at 28 volts DC or equivalent)

NOTE

Observe local, state, and national electrical codes when installing the alarm contact kit and related accessories.

⚠ WARNING



Accidental starting.
Can cause severe injury or death.

Disconnect battery cables before working on generator set. (Remove negative (–) lead first when disconnecting battery. Reconnect negative (–) lead last when reconnecting battery.)

Disabling generator set. Accidental starting can cause severe injury or death. Before working on the generator set or connected equipment, disable the generator set as follows: 1) Turn the generator set master switch to OFF position. 2) Disconnect power to battery charger. 3) Remove battery cables (remove negative (–) lead first). Reconnect negative (–) lead last when reconnecting battery. Follow these precautions to prevent starting of generator set by an automatic transfer switch or remote start/stop switch.

1.9 Dry Contact Kit Installation

Perform the following steps to install a dry contact kit.

Gain Access to Junction Box

1. Position the generator set master switch to OFF. Disconnect the engine starting battery, negative (–) lead first.
2. Remove the upper and lower junction box access panels and controller cover. See Figure 1-3.

Preparation for Dry Contact Kit Installation

3. Position the dry contact assembly enclosure (A-342410) against the lower left side of the junction box (facing controller), as shown in Figure 1-3.

NOTE

Visually inspect inside the junction box for clearance before drilling mounting holes.

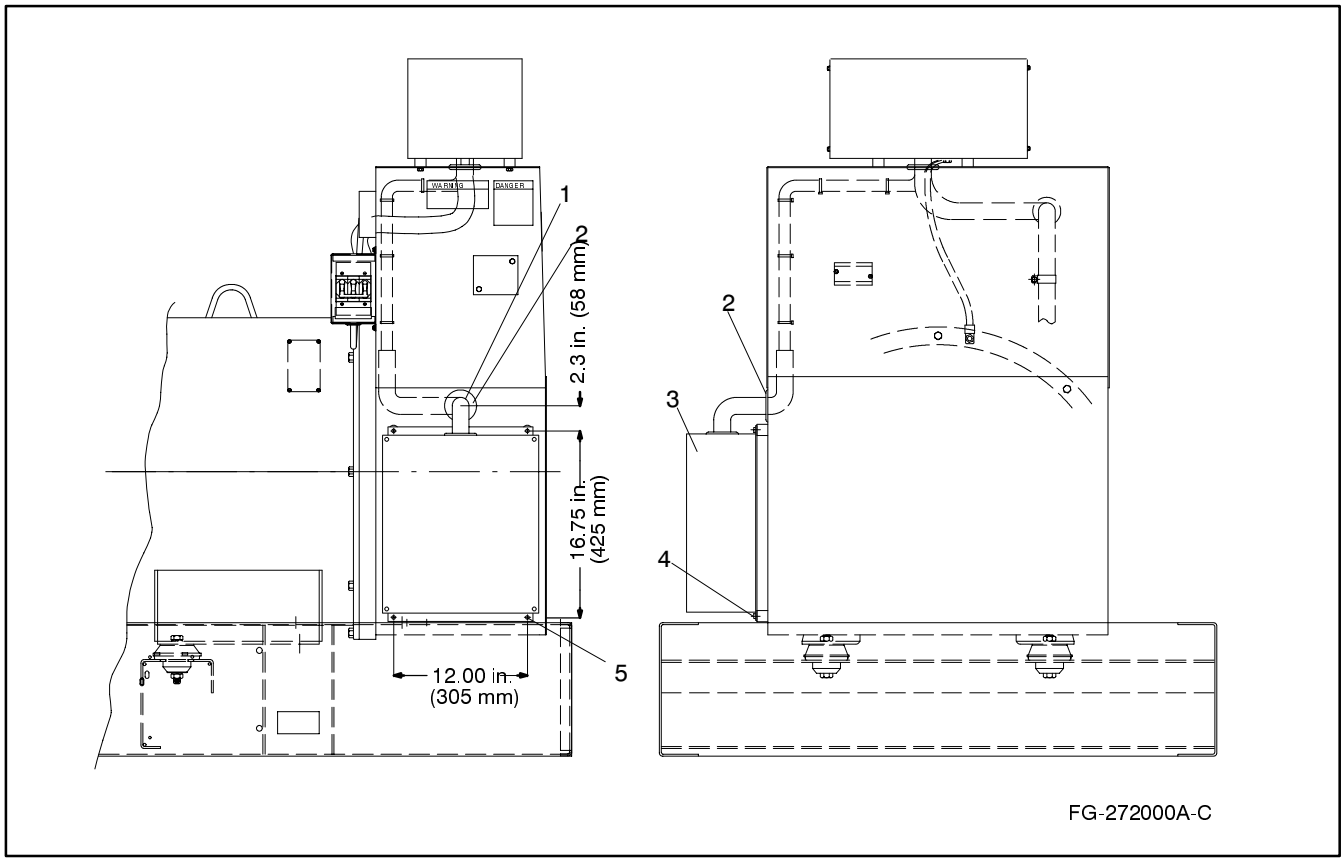
4. Using the contact enclosure as a template, drill four 0.312 in. (7.92 mm) diameter mounting holes in the junction box.
5. Draw a horizontal line connecting the upper mounting holes drilled in step 4.
6. Drill a 2.5 in. (63.50 mm) diameter hole 2.3 in. (58.42 mm) above the midpoint of the horizontal line drawn in step 5. See Figure 1-3.
7. Install grommet (X-284-10) in 2.5 in. (63.50 mm) hole.

Dry Contact Kit Installation

8. Mount contact assembly enclosure to junction box with four 1/4-20 x 0.75 in. r.h.m. screws (X-51-30), bumpers (255443), and whiz nuts (X-6210-2)
9. Insert harness through grommet in junction box and route harness along the junction box to the controller assembly. Secure harness with cable ties, not supplied, as needed.
10. Connect the ten-relay dry contact kit to controller circuit board with spade terminals.
11. Connect the controller/junction box terminals 2 (ground) and 42A (battery voltage) to the dry contact kit terminal strip to provide an electrical source to operate the K1-K10 relays.

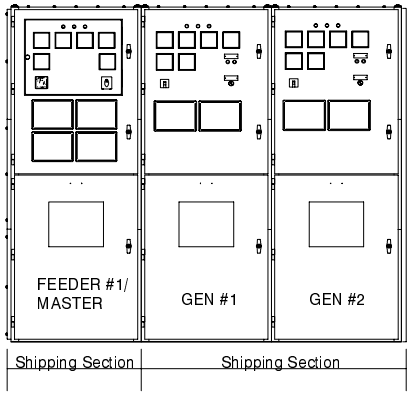
The kit supports ten required functions. The wiring diagram indicates typical functions.

A generator fault condition energizes the contact kit relay (K1-K10) linked to that function and sends a signal to the switchgear.

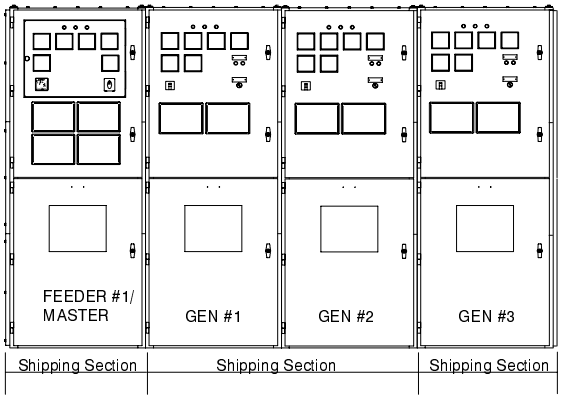


1. One 2.5 in. (63.50 mm) diameter hole
2. Grommet (X-284-10)
3. Dry contact assembly (A-342410)
4. Bumpers (255443), screws (X-51-30), and whiz nuts (X-6210-2)
5. Four 0.312 in. (7.92 mm) diameter mounting holes

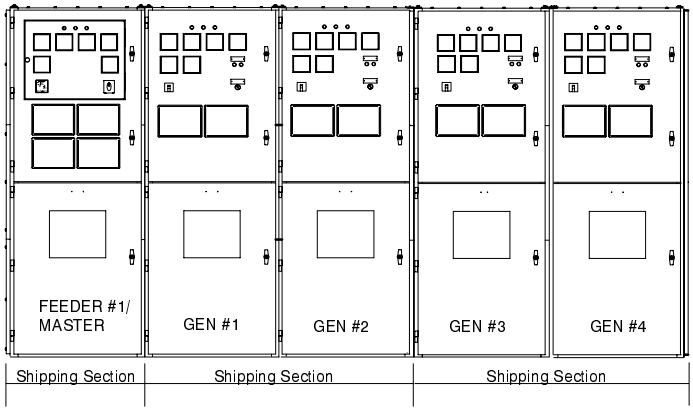
Figure 1-3. Ten-Relay Dry Contact Kit Placement



1 Feeder/Master Controls Cubicle and 2 Generator Set Cubicles

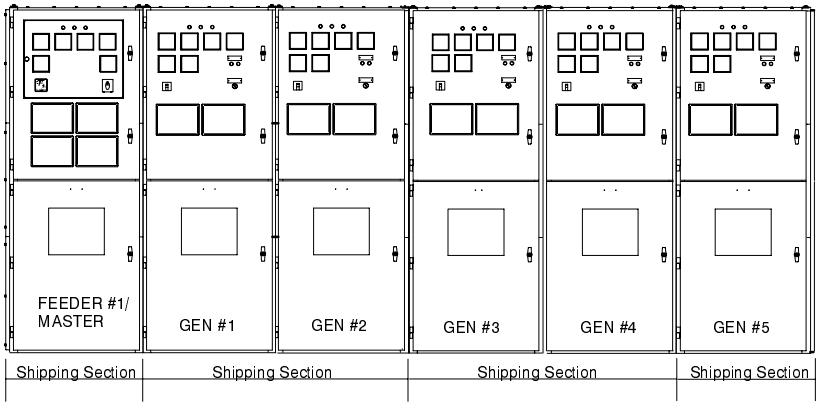


1 Feeder/Master Controls Cubicle and 3 Generator Set Cubicles

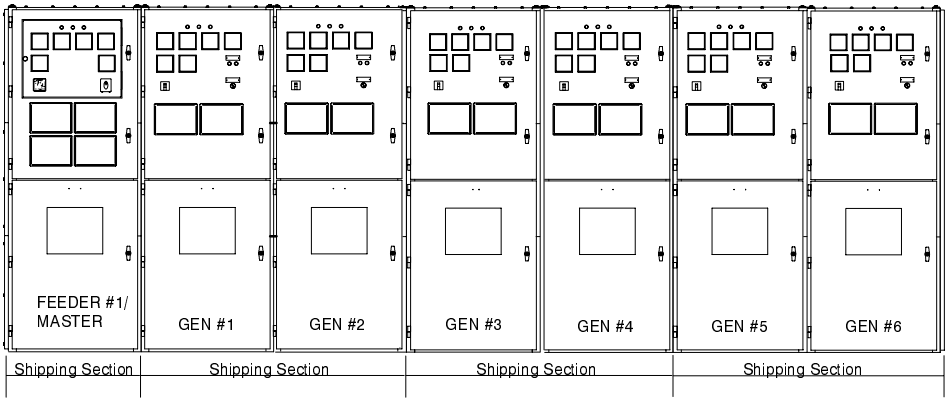


1 Feeder/Master Controls Cubicle and 4 Generator Set Cubicles

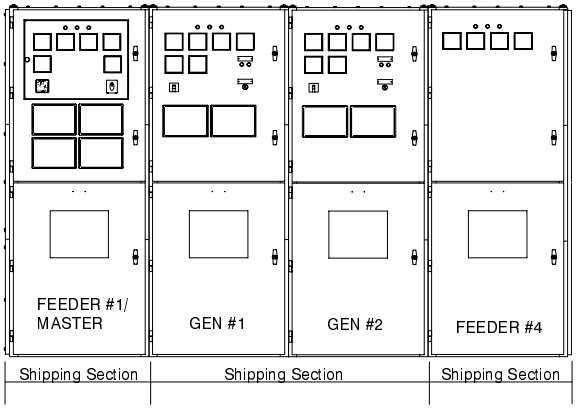
Figure 2-1. Cubicle Arrangement and Shipping Splits



1 Feeder/Master Controls Cubicle and 5 Generator Set Cubicles

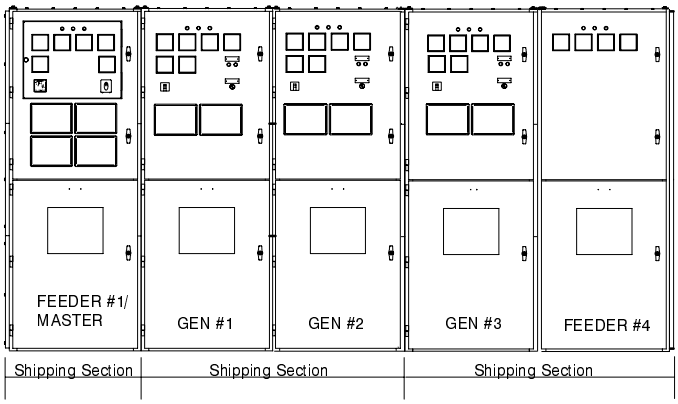


1 Feeder/Master Controls Cubicle and 6 Generator Set Cubicles

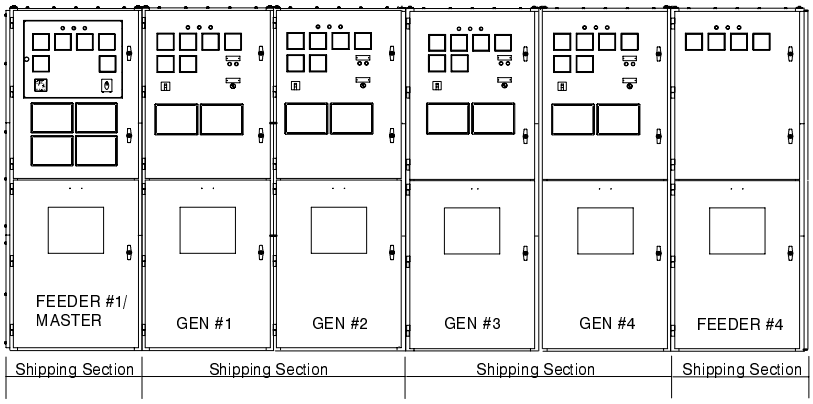


1 Feeder/Master Controls Cubicle, 2 Generator Set Cubicles and 1 Feeder Cubicle

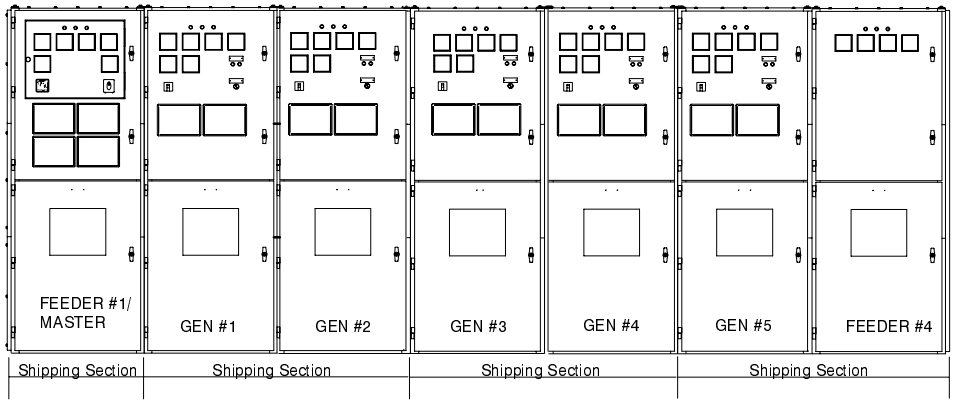
Figure 2-2. Cubicle Arrangement and Shipping Splits



1 Feeder/Master Controls Cubicle, 3 Generator Set Cubicles and 1 Feeder Cubicle

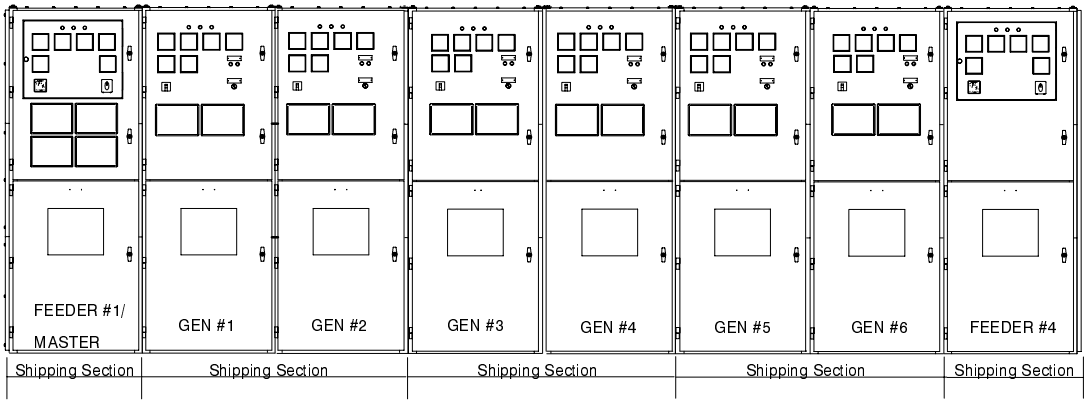


1 Feeder/Master Controls Cubicle, 4 Generator Set Cubicles and 1 Feeder Cubicle

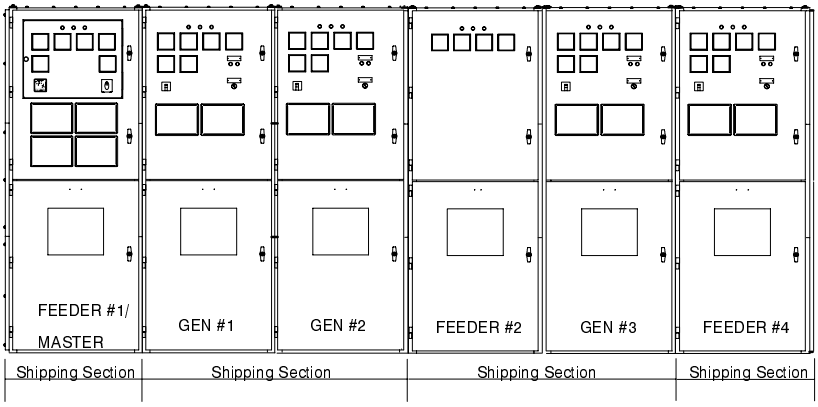


1 Feeder/Master Controls Cubicle, 5 Generator Set Cubicles and 1 Feeder Cubicle

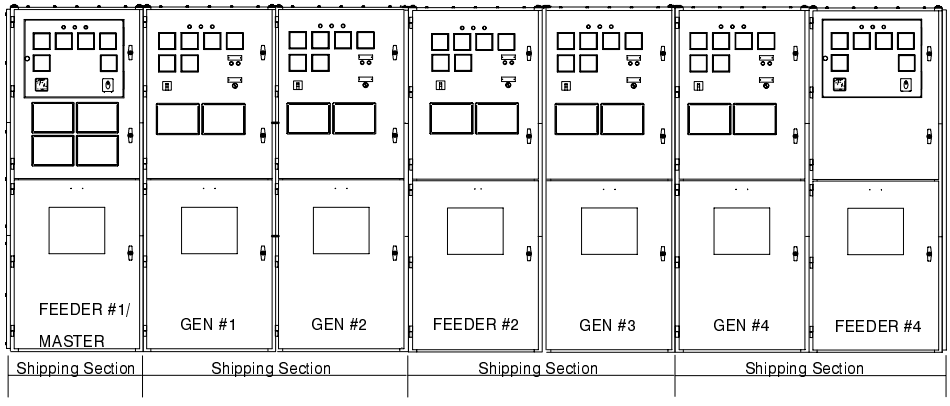
Figure 2-3. Cubicle Arrangement and Shipping Splits



1 Feeder/Master Controls Cubicle, 6 Generator Set Cubicles and 1 Feeder Cubicle

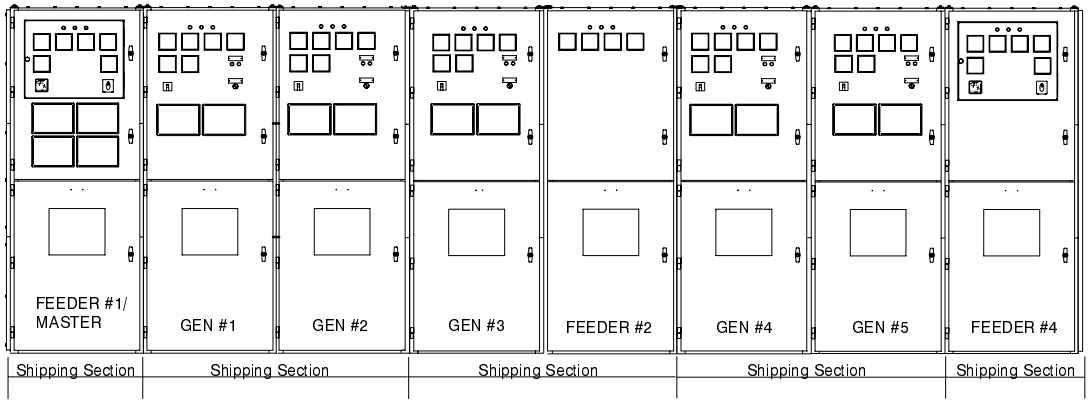


1 Feeder/Master Controls Cubicle, 3 Generator Set Cubicles and 2 Feeder Cubicles

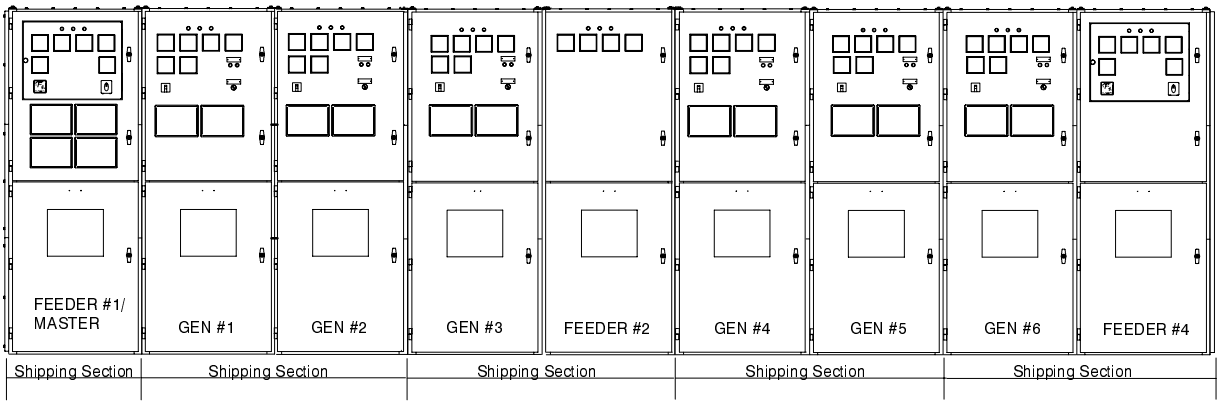


1 Feeder/Master Controls Cubicle, 4 Generator Set Cubicles and 2 Feeder Cubicles

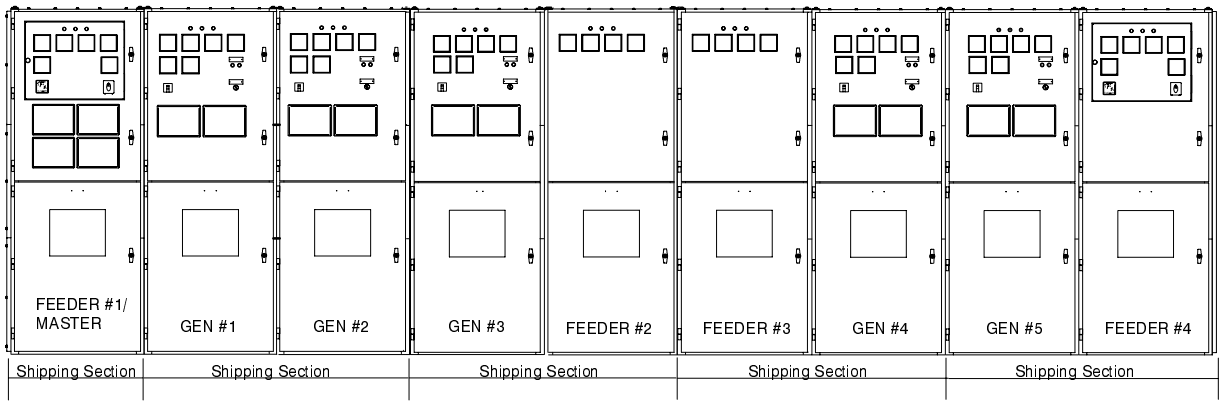
Figure 2-4. Cubicle Arrangement and Shipping Splits



1 Feeder/Master Controls Cubicle, 5 Generator Set Cubicles and 2 Feeder Cubicles

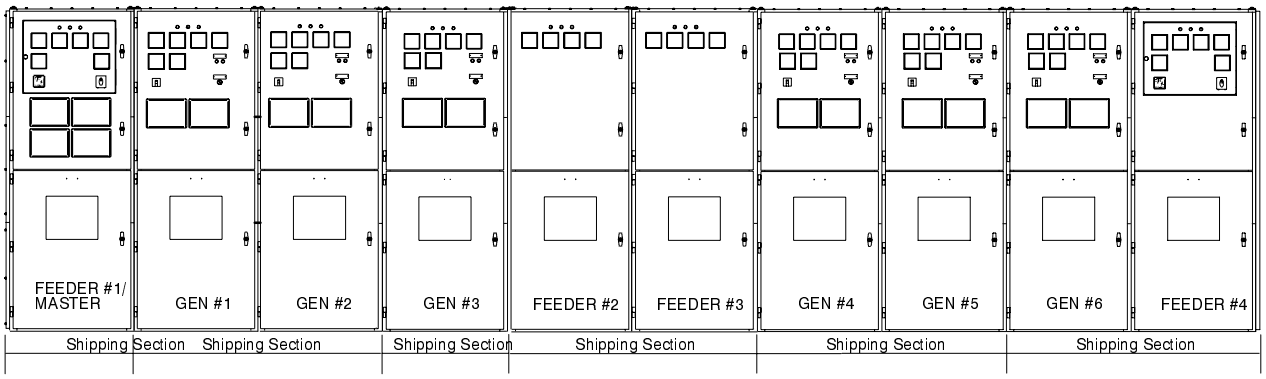


1 Feeder/Master Controls Cubicle, 6 Generator Set Cubicles and 2 Feeder Cubicles



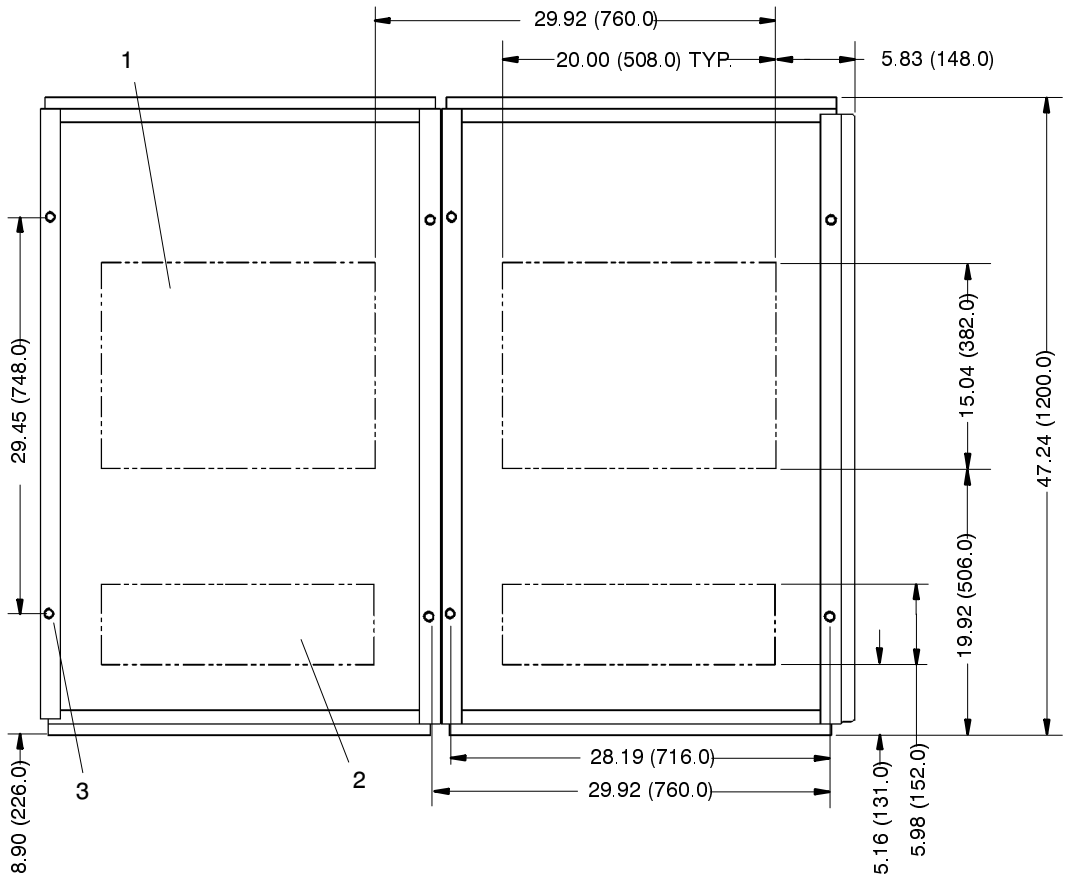
1 Feeder/Master Controls Cubicle, 5 Generator Set Cubicles and 3 Feeder Cubicles

Figure 2-5. Cubicle Arrangement and Shipping Splits



1 Feeder/Master Controls Cubicle, 6 Generator Set Cubicles and 3 Feeder Cubicles

Figure 2-6. Cubicle Arrangement and Shipping Splits



1. Conduit entry area for power cables
2. Conduit entry area for control cables
3. Mounting holes 4 places per cubicle 0.688 in. (17.50 mm)

Figure 2-7. Cubicle Plan View (typical)

3.1 Applications

Series ISAS automatic paralleling switchgear automatically operates up to six Spectrum® generator sets in parallel. The design allows automatic generator set starting, stopping, and paralleling. The switchgear includes meters, safety shutdown circuits, fixed-mounted motor-operated power circuit breakers, and a minimum number of options. The ISAS switchgear primary application is standby and prime-power installations.

Each generator set in the power system has a generator cubicle. The cubicle contains the required meters, controls and circuit breaker for the generator set to operate in parallel with the other generator set(s) in the system. The generator control cubicle interfaces with the advanced features of the generator set-mounted Spectrum Microprocessor-Plus controller. Generator sets used with the paralleling switchgear system must contain the Microprocessor-Plus controller electronic governor, reactive droop compensator, load-sharing module, remote speed-adjusting potentiometer, remote voltage-adjusting switch, and ten-relay dry contact relay kit.

Feeder cubicles house the output load circuits which allow the switchgear bus interconnection with the electrical system and distribute the power supplied. Feeder cubicles consist of standard cable connection points or an optional, molded-case, manually operated feeder circuit breaker.

The master control section contains meters, special controls, and logic circuits. The controls coordinate the interactive operation of the paralleled generator sets, the load transfer equipment, and the generator set programmed logic controller (PLC).

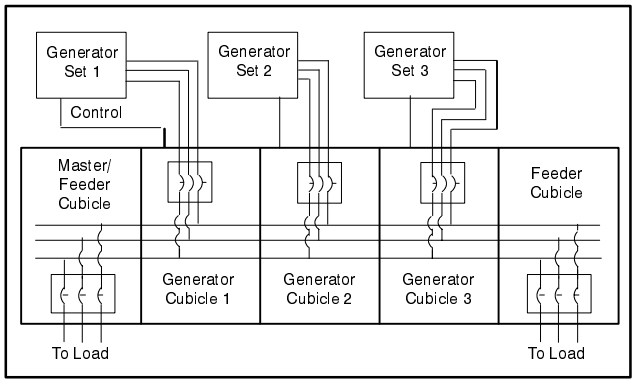


Figure 3-1. Switchgear Lineup

3.1.1 Standby

Standby systems provide backup power for the normal utility power system. To minimize power interruptions, the paralleling switchgear automatically starts, parallels, and connects two or more generator sets to the electrical distribution system as signaled by a remote source.

3.1.2 Prime Power

Prime power switchgear systems provide the only source of site power. The paralleling switchgear automatically controls the on-line generator sets.

3.2 Construction

3.2.1 Cubicles

The free-standing switchgear cubicles are fabricated from welded and bolted sheet metal for indoor installation. Removable top, side, and rear covers provide access to bus and cable connections. The cubicles allow top and bottom cable entry. Barriers isolate low-voltage controls from adjacent cubicles, circuit breakers, bus, and cable.

3.2.2 Finish

Sheet metal parts undergo a 14-stage cleaning and priming process prior to painting. An electro-coat process paints parts ANSI gray to provide a high-quality, corrosion-resistant finish.

3.2.3 Bus System

The bus is constructed of silver-plated, round-edge copper bars for phases, neutral, and ground sized to IEC standards for the total generator output. Neutral is rated for 100%.

3.2.4 Cable Connections

Drilled bus bars are standard equipment. Cable lugs are not provided.

3.2.5 Meters

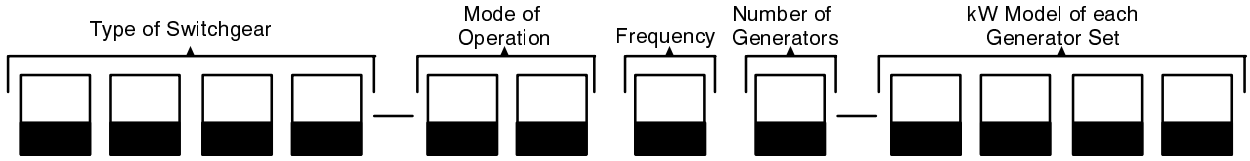
Standard meters are 3.5 in. (96 mm), 2% accuracy, and square panel board type.

3.2.6 Generator Circuit Breakers

The standard fixed-mounted, motor-operated, power circuit breakers are IEC rated and equipped with shunt, and adjustable solid-state trip units for overload and short circuit protection.

3.3 Interpreting a Switchgear Part Number

Record the Switchgear part number in the boxes below. The switchgear part number defines characteristics and ratings as explained in the accompanying chart.



SpectrumPart Number Key

This chart explains the Spectrum switchgear part numbering code system. The sample part number shown is for International Switchgear with automatic operation rated at 220/380 volts, 50 hertz, with three 1600 kW generator sets.

SAMPLE PART NUMBER

ISAS-71A3-1600

Type of Switchgear
IS- International Switchgear

Mode of Operation
AS- Automatic

Voltage

60-346/600	64-139/240
66-277/480	70-231/400
71-220/380	73-240/416

Frequency
A = 50 Hz
B = 60 Hz

Number of Generator Sets

kW Model of each Generator Set

Figure 3-2. Switchgear Part Number

3.4 Weights and Dimensions

Cubicle	Est. weight in lbs. (kg)	Dimensions H x W x D in. (mm)
Feeder with Master Controls	715 (325)	79 x 30 x 48 (2000 x 760 x 1200)
Generator	825 (375)	79 x 30 x 48 (2000 x 760 x 1200)
Feeder	510 (230)	79 x 30 x 48 (2000 x 760 x 1200)

4.1 Generator Cubicle Standard Features

The generator cubicle contains the metering, switches, and control circuits required for generator set operation.

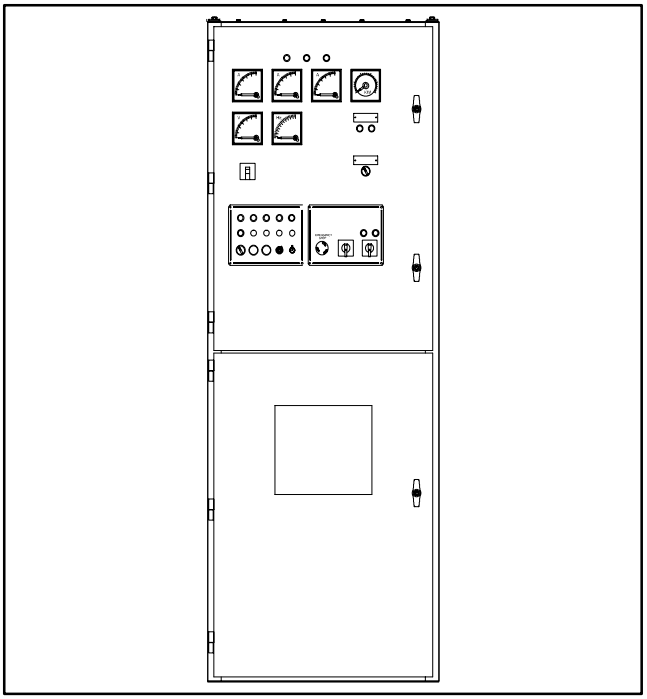


Figure 4-1. Generator Cubicle

4.1.1 Lights

- **Source Available Lights.** Lights to indicate voltage present on the line side of the generator circuit breaker.
- **Synch Lights with ON/OFF Switch.** Synch lights flash on and off as the generator phase moves in and out of synch with bus phase. Close the breaker when the lights are off. Switch controls the operation of the synch lights for manual paralleling.
- **Common Fault Light.** Lights to indicate a generator set common fault. Check the generator set Microprocessor-Plus controller for details and to reset the fault.
- **Reverse-Power Light.** Lights when the reverse power relay detects reverse power to the generator set and trips the generator breaker.
- **Voltage Frequency Failure Light (Optional).** Lights when generator set breakers trip because the voltage frequency relays detect generator set voltage or frequency outside the preset operating range. Voltage sensing is on the generator side of the breaker and affects only generators with closed circuit breakers.
- **Overcurrent Trip Light.** Lights to indicate generator set breaker tripped because of an overcurrent condition.
- **Fail-to-Parallel Light.** Lights to indicate that the generator set failed to automatically parallel to the bus.
- **Cooldown Light.** Lights during the generator set cooldown cycle.
- **Circuit Breaker Position Indicating Lights.** Lights to indicate generator circuit breaker position: TRIP or CLOSED.

4.1.2 Meters

- **3 Ammeters**. Meters indicate the generator set output current to the bus on each phase.
- **Wattmeter.** Meter indicates the generator set kilowatt output.
- **Voltmeter with Voltage Selector Switch.** Meter indicates generator set line-to-line and line-to-neutral voltage as selected by the voltage selector switch.
- **Frequency Meter.** Meter indicates generator set frequency.

4.1.3 Potentiometer

- **Speed-Adjust Potentiometer.** Potentiometer adjusts generator set frequency.

4.1.4 Pushbuttons

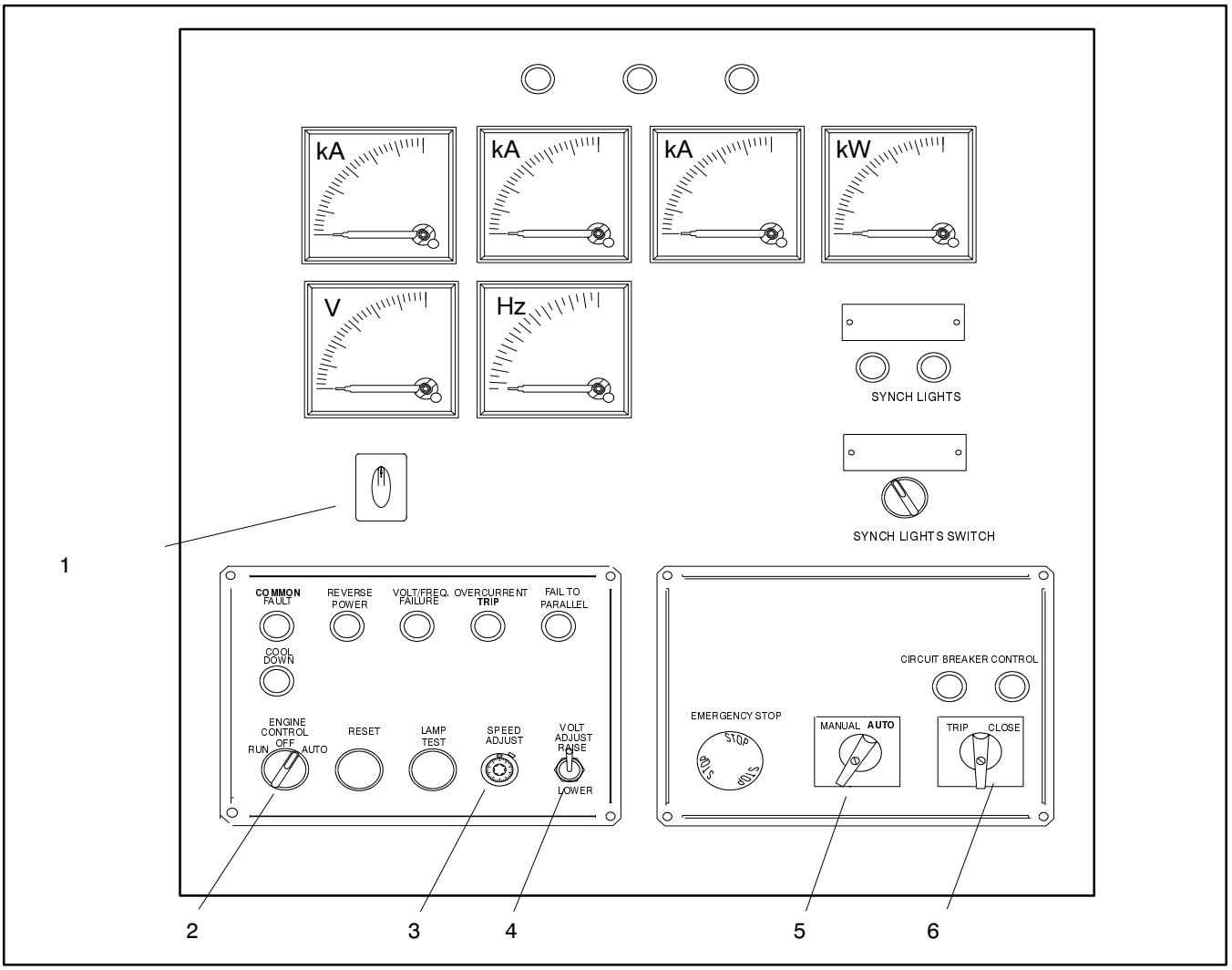
- **Reset Pushbutton.** Resets alarms and shutdown circuits within a cubicle.
- **Lamp-Test Pushbutton.** Tests the panel lights.
- **Emergency Stop Pushbutton.** Immediately shuts down the generator set in emergency situations.

4.1.5 Switches

- **Engine Control Switch RUN/OFF/AUTO.** The generator cubicle Engine Control Switch works only with the Microprocessor-Plus Engine Control Switch Microprocessor-Plusin the AUTO position. The RUN position starts the generator set.Microprocessor-Plus The OFF position begins the generator set cooldown cycle. The AUTO position transfers generator set control to the automatic start/stop circuits.
- **Voltage Adjust RAISE/LOWER Switch.** Adjusts generator set output voltage.
- **Circuit Breaker Control Switch MANUAL/AUTO (CBAM).** Controls the circuit breaker operating mode. The AUTO position allows the control circuits to operate the circuit breakers. The MANUAL position allows operator-control of the circuit breakers for manual paralleling operation.
- **Circuit Breaker TRIP/CLOSE Switch.** Allows the operator to manually trip or close the generator set circuit breaker. This switch works with the CBAM switch in the AUTO position.
- **Horn-Silence Switch.** Silences the alarm horn.

4.1.6 Internal Components

- **Automatic Synchronizer.** Matches incoming generator frequency and phase to bus frequency and phase.
- **Fixed-Mounted, Motor-Operated Circuit Breaker.** Connects the generator set to the switchgear bus. Stationary mounted, electrically operated power circuit breaker for each generator set.
- **Isochronous Load-Sharing Module.** Controls and balances the power level of a generator set paralleled to other generator sets.
- **Reverse-Power Relay.** Provides reverse-power protection for the generator set.
- **Synch-Check Relay.** Checks for synchronization and permits the breaker to close when the generator set is synchronized to the bus.



1. Voltmeter Switch
2. Engine Control Switch
3. Speed Adjust Potentiometer
4. Voltage Adjust Switch
5. Circuit Breaker Switch AUTO/MANUAL
6. Circuit Breaker Switch TRIP/CLOSE

Figure 4-2. Generator Cubicle Controls

4.2 Feeder Cubicle

The feeder cubicle provides the output load circuits which distribute generated power to the electrical system.

4.2.1 Standard Features

- **Cross Bus with Drilling for Load Cables.** Consists of silver-plated, round edge copper bars. Lugs are not provided.
- **Source available Lights.** Lights to indicate voltage present on bus cable connections or on the line side of the optional feeder breaker.

4.2.2 Optional Features

- **Molded-Case Load Circuit Breakers.** Fixed-mounted and connects load cables to the switchgear bus. Lugs are not provided.

4.3 Master Controls Option Group 1 Standard Features

The master controls contain the lights, meters, switches, and control circuits required for the switchgear lineup to function as a complete system. See Figure 4-3

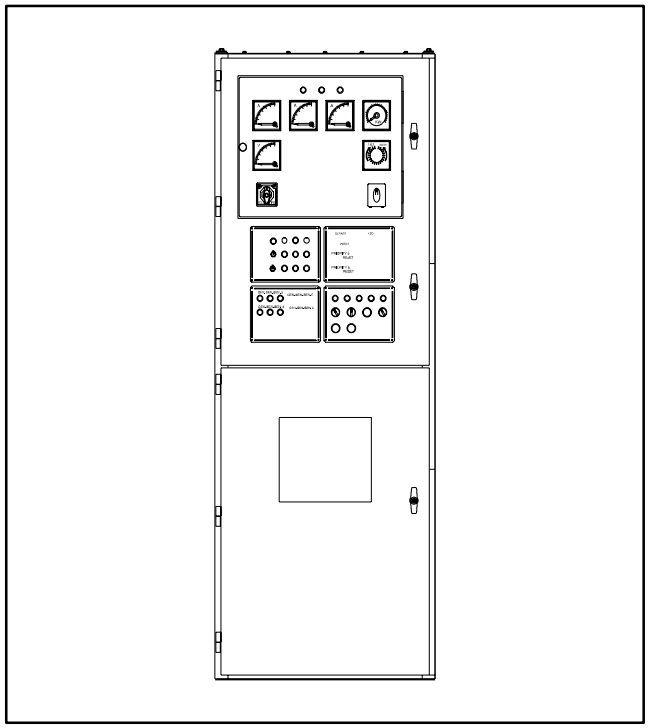


Figure 4-3. Feeder Cubicle with Optional Master Controls Option Group 1, 2, and 3

4.3.1 Standard Features

- **First-on Circuit.** Monitors generator set frequency and voltage upon startup and closes the first available generator set to the bus.
- **Bus Over/Undervoltage Relay.** Relay energizes to open generator set circuit breakers when bus voltage is outside preset limits.
- **Bus Over/Underfrequency Relay.** Relay energizes to open generator set circuit breakers when bus frequency is outside preset limits.
- **Bus Potential Transformers.** Convert high bus voltage to the low voltage used by the meters and system controls. Provided on 50/60 Hz systems 440 volts and above.

4.3.2 Lights

- **Source Available Lights.** Lights to indicate voltage present on the line side of the load circuit breaker.

4.3.3 Meters

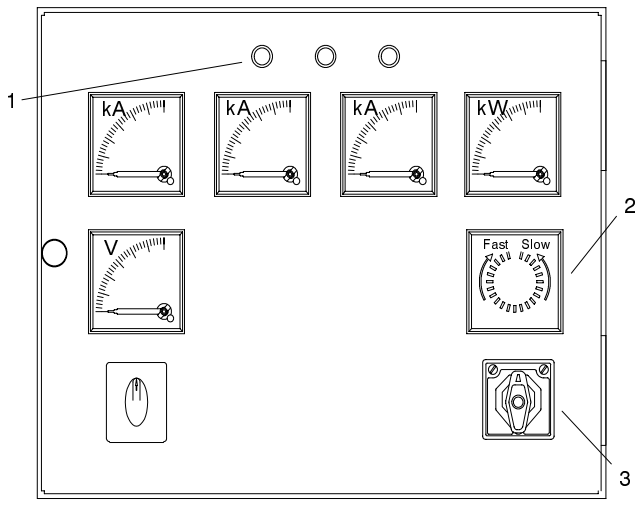
- **Three Bus Ammeters.** Indicate the bus output current to the load on each phase.
- **Bus Wattmeter.** Measures load kW at its load take-off point.
- **Bus Voltmeter with Voltage Selector Switch.** Indicates bus line-to-line and line-to-neutral voltage as selected by the bus voltmeter phase selector switch.
- **Synchroscope.** Indicates generator set synchronization during manual system operation.

4.3.4 Switches

- **Synchroscope Switch OFF/G1/.../G6.** Controls synchroscope operation for manual generator set paralleling. Switch off when not in use.

4.3.5 Components

- **Bus Current Transformers.** Convert high bus current to low current used by the meters and system controls.



1. Phase lights (red, amber, blue)
2. Synchroscope
3. Synchroscope switch

Figure 4-4. Option Group 1, Bus Metering

4.4 Option Group 2 Load Control Includes Option Group 1

4.4.1 Lights

- **Priority-1 Load-Add Light.** Lights to indicate the priority 1 (most critical) load has been signalled to connect to the generator load bus.
- **Priority-2 through -6 Load-Shed Lights.** Lights to indicate when the priority-2 through -6 loads have been signalled to disconnect (shed) from the generator load bus. One priority is provided for each generator set in the system.
- **Priority-2 through -6 Load-Add Lights.** Lights to indicate when priority-2 through -6 loads have been signalled to connect (add) to the generator load bus. The number of priority load-add lights match the number of generator sets in the system. The number of lights lit represents the number of generator sets on line.
- **Priority-2 through -6 Load Bypass Lights.** Lights to indicate the operator bypass of a priority-2 through -6 load shed.
- **System Test Light.** Lights to indicate system test mode.

4.4.2 Switches

- **Priority-2 through -6 Load Control Switch RESET/BYPASS.** Manually controls the load-add and load-shed circuits. The RESET position clears load shed signals. The BYPASS position overrides automatic load-add shed signals and allows operator control of individual loads.
- **System Test Switch NORM/TEST.** Tests switchgear system.

4.4.3 Pushbuttons

- **Reset Pushbutton.** Resets frequency shed circuits.
- **Lamp-Test Pushbutton.** Tests the panel lights.

4.4.4 Components

- **Load-Add Circuit (one per generator).** Signals priority loads to connect to generator power.
- **Load-Shed Circuit (one per generator).** Signals priority loads to disconnect from generator power.

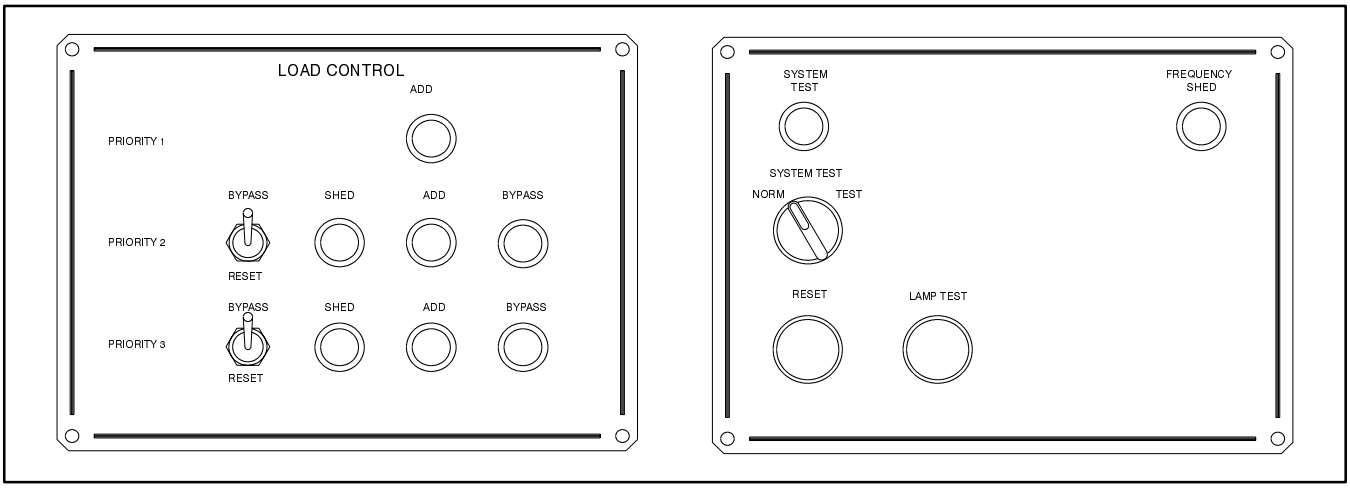


Figure 4-5. Option Group 2, Load Control (3-Generator Set System Shown)

4.5 Option Group 3 Generator Management Includes Option Group 2

4.5.1 Lights

- **Lead Generator Lights.** Lights to indicate the generator set selected as lead generator set.
- **Standby Generator Lights.** Lights to indicate generator(s) in the automatic mode and available for generator management.
- **System Test Light.** Lights to indicate system test mode.
- **Generator Management Active Light.** Lights upon completion of the generator start management time cycle when generator sets begin to sequence on- and off-line to match connected load.
- **Select Lead Unit Light.** Lights to indicate when the operator can select a new lead generator set.
- **PLC Malfunction Light.** Lights to indicate PLC problems.
- **Frequency Shed Light.** Lights to indicate loads were shed because of a underfrequency condition on the generator load bus.

4.5.2 Switches

- **System Test Switch NORM/TEST.** Tests switchgear system. Load Add, Load Shed, and Generator Management features are disabled during a system test.

- **Generator Management Switch.** Controls the generator management function. OFF disables generator management, AUTO places the controls in the automatic mode, and RESTART restarts all shutdown generator sets.
- **Plant Control Switch.** START starts all generator sets. AUTO transfers generator sets control to the switchgear circuits and activates the Load Add, Load Shed, and Generator Management features.

4.5.3 Pushbuttons

- **Select Lead Unit Pushbutton.** Allows operator to select lead unit.
- **Reset Pushbutton.** Resets the frequency shed circuits.
- **Lamp-Test Pushbutton.** Tests the lights on the door.

4.5.4 Components

- **Generator Management using PLC Logic.** Optimizes the number of running generator sets to the size of the connected kW load. A programmable logic controller (PLC) monitors the connected load at each feeder. Adjustable load settings (kW) with time delays control individual generator set starting and stopping.

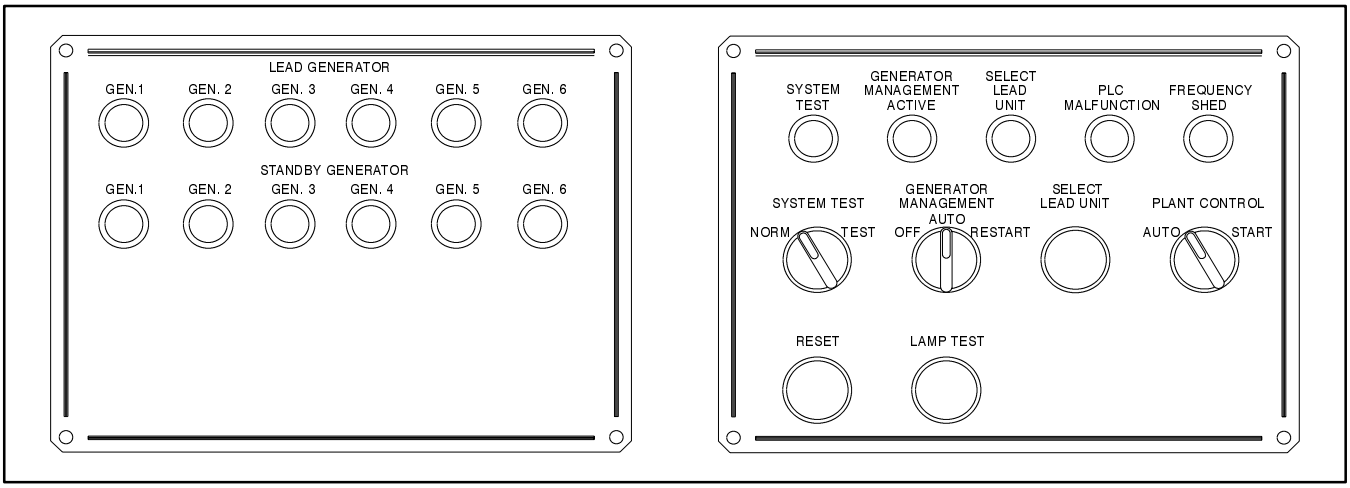


Figure 4-6. Option Group 3, Generator Set Management (6-Generator Set System Shown)

Notes

5.1 Standard Option Group Automatic Operation

The following section describes switchgear response to various operating conditions.

5.1.1 Normal Power

With the normal power source supplying loads, configure the switchgear for rapid power recovery if normal power fails.

Press the RESET and LAMP-TEST pushbuttons on each control panel to clear faults and test lights. Position the engine control switch (ECS) to AUTO and the Circuit Breaker AUTO/MANUAL (CBAM) switch to AUTO.

With these switches in the indicated positions, the switchgear logic signals the generator(s) to start and their associated generator breakers to close.

5.1.2 Loss of Normal Power

Loss of normal power at the remote transfer switch signals all generator sets to start and accelerate to rated voltage and frequency.

The first generator set to reach 90 percent of rated voltage and frequency closes its circuit breaker, energizing the main bus.

As subsequent generator sets reach 90 percent of rated voltage and frequency, their automatic synchronizing circuits close their circuit breakers. Load-sharing modules equally divide the load.

5.1.3 Restoration of Normal Power

When normal power is restored and the transfer switch transfers loads back to the normal power source, the remote start signal to the switchgear clears. The generator set circuit breakers open, clearing all load add/shed signals.

The generator sets cycle through a 5-minute cooldown period prior to shutting down and returning to the standby state. If normal power fails during the cooldown cycle, switchgear logic sends a remote start signal, interrupting the cooldown period.

5.1.4 Generator Set Failures

When a generator set fails to start after three 15-second cranking cycles, an overcrank shutdown locks it off until the cause is corrected.

When a generator set fails while running and supplying the bus, the switchgear locks the generator set off, opens its circuit breaker, and issues the appropriate load-shed signal.

A shutdown indicating light on the failed generator set's controller indicates the type of failure.

Follow the same sequence of operations regardless of the failure type.

How to reset a fault.

1. Position the alarm silence switch on the generator set controller to SILENCE.
2. Position the failed generator set's ECS to OFF.
3. Repair failure(s) indicated by the generator set controller.
4. Position the generator master switch on the failed generator set's controller to OFF/RESET to clear the fault indicating light.
5. Press the LAMP-TEST pushbutton to check the operation of fault lights.
6. Position the ECS to AUTO to restart the generator set.

5.2 Manual Operation

The following section describes required operator actions during various operating conditions.

5.2.1 Loss of Normal Power

With the system in manual operating mode, loss of the normal power supply requires the following operator actions.

Transfer Loads to Generator Power

1. Press the RESET and LAMP-TEST pushbuttons on the control panels to clear faults and test lights.
2. Position the engine control switch (ECS) to RUN.
3. Position the Circuit Breaker AUTO/MANUAL (CBAM) switch to MANUAL.
4. Position the synchroscope switch (SSW) to select the desired generator set.
5. When the first generator is ready to supply the bus, position the circuit breaker switch (CBS) to CLOSE.
6. Position the SSW to select the next generator set.
7. Observe the synchroscope and synch lights to indicate synchronization to the bus.
8. Adjust generator set speed and voltage as necessary to aid in synchronizing.

When the synchroscope lights rotate slowly through the twelve o'clock position and the flashing synch lights extinguish the system is synchronized.

NOTE

Synchronize out-of-phase generators prior to paralleling to prevent severe damage to circuit breakers and switchgear. A synch-check relay in the ISAS switchgear prevents out-of-phase paralleling in the manual operating mode, eliminating operator error.

---

9. Position the CBS to CLOSE to close the generator circuit breaker.

5.2.2 Restoration of Normal Power

The restoration of normal power with the system in the manual operating mode requires the following operator actions:

Transfer Loads to Normal Power

1. Open the generator set circuit breakers when power returns and the remote-mounted transfer switch transfers loads back to the normal power supply.
2. Run the unloaded generator sets for a 5-minute cooldown period.
3. Position the ECS to OFF to shut down the generator sets.

5.2.3 Generator Set Failures

When a generator set fails to start after three 15-second cranking cycles, an overcrank shutdown locks it off until the cause is corrected.

When a generator set fails while running and supplying the bus, the failure locks the generator set off and opens its circuit breaker.

A shutdown indicating light on the failed generator set's controller indicates the type of failure that has occurred.

How to reset a fault.

1. Position the alarm silence switch on the generator set controller to SILENCE.
2. Position the failed generator set's ECS to OFF.
3. Repair the failure(s) indicated on the generator set controller.
4. Position the generator master switch on the failed generator set's controller to OFF/RESET to clear the fault indicating light.
5. Press the LAMP-TEST pushbutton to test the fault lights.
6. Position the ECS to RUN to restart the generator set.

5.3 Option Group 1

5.3.1 Energizing a Dead Load Bus

When manually connecting a generator set to a dead load bus, position the Synchroscope Switch (SSW) to select the desired generator set and close the circuit breaker by positioning the Circuit Breaker Switch to CLOSE, energizing the load bus.

Parallel subsequent generator sets to the energized load bus by synchronizing generator set output to the power supply, energizing the load bus.

5.3.2 Synchronizing Multiple Power Supplies

Perform the following steps to ensure the proper synchronization of multiple power supplies.

1. Position the Synchroscope Switch (SSW) to select the desired generator set.
2. Observe the synchroscope and synch lights for indication of synchronization. When the synchroscope lights rotate slowly through the twelve o'clock position and the flashing synch lights extinguished, the power supplies are synchronized.
3. Use the potentiometer as necessary to adjust speed and voltage to aid in synchronization.
4. When the synchroscope and synch lights give positive indication of synchronization, position the circuit breaker switch (CBS) to CLOSE.

5.4 Option Group 2 Load Management

NOTE

Option Group 2 includes standard ISAS and Option Group 1 features.

5.4.1 Load Management

Load management ISASautomatically adds or sheds system loads during a power failure. Loads have priority based upon their importance.

Priority-1 loads never shed from the load bus. The switchgear system assigns a generator set to each priority classification. The generator set to which a priority is assigned changes depending on the generator set selected as the lead unit and those selected as standby units.

Loads shed one priority at a time starting with the lowest priority in service at the time of the load-shed signal.

A system test disables Load Management.

5.4.2 Engine Failure Load Shed/Add

An engine failure indicated by a common fault light on the generator set cubicle energizes the Load Shed Relay and lights a Priority ( ) Load-Shed light indicating the ISAS switchgear response to the loss of a power source.

Reset the fault and restore the generator set to service as described in Section 5.1.4. Position the Priority ( ) Load Control RESET/BYPASS Switch to RESET to return shed loads to service. The Priority ( ) Load-Add Light indicates the restoration of priority ( ) loads to service.

If the common fault cannot be reset and the shed loads must be restored to service, position the Priority ( ) Load Control RESET/BYPASS Switch to BYPASS. The Priority ( ) Load Bypass Light indicates the manual restoration of priority ( ) loads to service.

5.4.3 Frequency Failure Load Shed/Add

A frequency failure indicated by a frequency-shed light on the generator set cubicle energizes the Load Shed Relay and lights a Priority ( ) Load-Shed light indicating the ISAS switchgear response to frequency outside acceptable limits.

Shut down the generator set as described in Section 5.1.4. Determine and correct the cause of the frequency failure and restore the generator set to service. Position the Priority ( ) Load Control RESET/BYPASS Switch to RESET to return shed loads to service. The Priority ( ) Load-Add Light indicates the restoration of priority ( ) loads to service.

If the cause of the frequency failure cannot be reset and the shed loads must be restored to service, position the Priority ( ) Load Control RESET/BYPASS Switch to BYPASS. The Priority ( ) Load Bypass Light indicates the manual restoration of priority ( ) loads to service.

5.5 Option Group 3 Generator Management

NOTE

Option Group 3 includes standard ISAS and Option Group 2 features.

To ensure even generator set wear, ISASs. Lead unit selection prevents one generator set from always being the first started and the last shut down. Set up a rotation of lead units in which a different generator starts first each time the system operates.

A system test disables Generator Management.

Select a lead unit.

1. Position the ECS on each generator cubicle to AUTO.
2. Position the CBAM switch on each generator cubicle to AUTO.
3. Position the generator management switch (GMS) on the control panel to RESTART.
4. Press the RESET pushbuttons on the generator control panel and the option group 3 control panel to reset any faults. The lead unit light goes on.
5. Press the SELECT LEAD UNIT pushbutton to select a generator set for the lead unit. Generator sets not selected as lead unit are standby generator sets. Standby unit lights light.
6. Position the GMS to AUTO. The select lead unit light goes out.

6.1 Hand-held Programmer

Use the hand-held programmer to create user programs for the programmable logic controller (PLC.)

6.2 Powering Up the HHP

Connect the HHP before or during the PLC power-up sequence. The display following power up depends on the operating mode and screen displayed just prior to powering down or disconnecting the HHP.

6.3 HHP Setup and Installation

The HHP connects to the PLC via a supplied six-foot cable with latching connectors on each end. See Figure 6-1. The cable serves the dual purpose of transmitting power and data.

NOTE

Disconnecting the cable from the PLC with power applied automatically cancels the operation being performed.

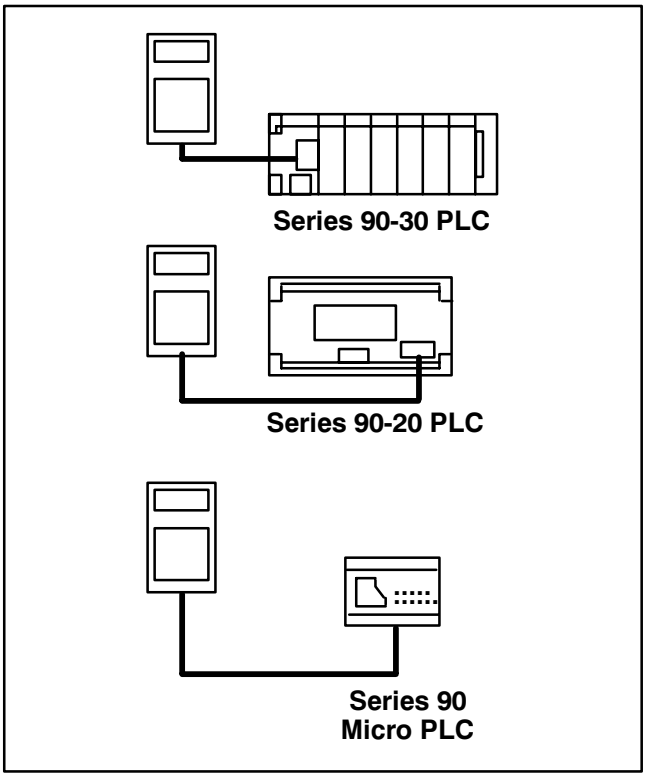


Figure 6-1. HHP Connections

6.4 Using the HHP

At power up, the PLC runs diagnostic tests on the hardware. Following diagnostic tests, the PLC gives the operator the option to select one of the four operating modes. Do not select Config. Mode, as system configuration and programming are done at the factory. To change system register (%R) values, select Data Mode.

6.5 Hand-held Programmer Keypad

The hand-held programmer (HHP) keypad has 42 keys arranged six keys across by seven keys down. Several keys on the keypad serve more than one function depending on the operating mode. See Figure 6-2. Press the key twice to access the function on the lower half of the key.

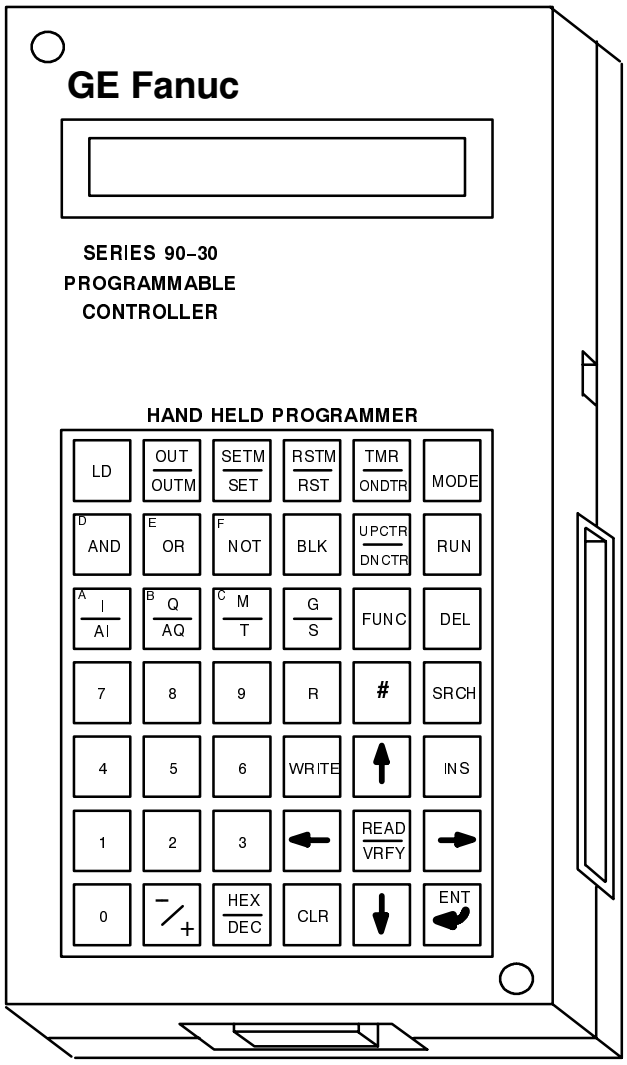


Figure 6-2. HHP Keypad

6.6 Operating Modes

Most functions are available in only one operating mode. It may be necessary to shift modes in order to accomplish all required tasks.

The HHP can operate in four major modes:

Program Mode allows the operator to create and/or edit programs.
Data Mode allows the operator to view and alter reference values.
Protection Mode allows the operator to restrict access to program logic.
Configuration Mode is used to configure the PLC at the factory.

Perform the following steps to select an operating mode.

1. Press the MODE key. The following screen appears.

2. Use the up and down arrow keys to scroll through the menu with the following options. PROGRAM, DATA, PROTECT, and CONFIG.
3. Enter the number corresponding to the desired mode and press ENT to start the new mode.

6.7 Edit and Display Control Keys

The following table lists the most commonly used keys and a brief description of each key's function.

Key	Description
MODE	Selects an HHP operating mode
RUN	Starts or stops the PLC
DEL	Deletes instructions in Program Mode
SRCH	Search for target or start program check in Program Mode
INS	Begin insert operation in Program Mode
↑	Move between steps in Program Mode
↓	Move view window in Data Mode
← →	Move between function parameters in Program Mode
ENT	Complete operation or user input
CLR	Cancel current operation

Figure 6-3. Control Keys

NOTE

Do not press any keys without knowing the result. Program and configuration data may be lost.

6.8 Changing PLC Register Values

Use the following procedure to change the register values within the PLC:

1. Connect the Hand-Held Programmer (HHP) cable to the PLC port at the power supply module.
2. After the power-up sequence the two-line HHP screen displays the following:

NOTE

The underscore is a menu selection navigator, and the <R symbol indicates that the PLC is in the run mode.

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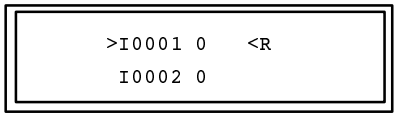
3. Press the **2** key or use the **Down arrow** key to scroll the menu down one position to select the Data mode of operation.
4. Press the **ENT** key to invoke the new mode.
5. The screen displays the following:



NOTE

Display the register's reference data to change its value.

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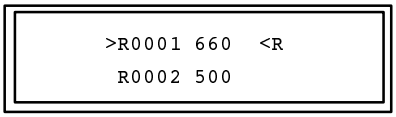
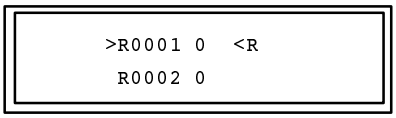
6. Enter the key sequence **R**, (Register to be displayed/ change number), **ENT** key. For example, to change register 1 press **R,1, ENT**.



7. Press the right cursor key to change the value of the register (the value in register number 1 in this example).



NOTE

Enter a new data value when the underscore (_) character flashes.

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8. Enter the desired new data value for register address 1. For example, 800.

6.9 Starting and Stopping the PLC

Start or stop the PLC while in the Mode selection screen or in any of the Operating Modes.

Use the +/– key to toggle between RUN and STOP modes. When the HHP screen indicates the desired mode, press ENT.

Notes

Appendix A. Glossary of Abbreviations

Abbreviations are used throughout this manual. Normally in the text they will appear in complete form with the abbreviation following in parenthesis the first time they are used. After that they will appear in the abbreviated form. The commonly used abbreviations are shown below.

AC	alternating current
AISI	American Iron and Steel Institute
Amp	ampere
Amps	amperes
ANSI	American National Standard Institute
API	American Petroleum Institute
approx.	approximate, approximately
A/R	as required, as requested
A/S	as supplied, as stated, as suggested
ASA	American Standards Association
ASME	American Society of Mechanical Engineers
assy.	assembly
ASTM	American Society for Testing Materials
ATDC	after top dead center
aux.	auxiliary
AWG	American Wire Gauge
AWM	appliance wiring material
BBDC	before bottom dead center
BDC	before dead center
BHP	brake horsepower
bmep	brake mean effective pressure
Btu	British thermal unit
°C	Celsius degree
cc	cubic centimeter
CCA	cold cranking Amps.
CEC	Canadian Electrical Code
cfh	cubic feet per hour
cfm	cubic feet per minute
CID	cubic inch displacement
cm	centimeter, centimeters
cmm	cubic meters per minute
co.	company
cont'd.	continued
CSA	Canadian Standards Association
CT	current transformer
cu. in.	cubic inch, cubic inches
cyl.	cylinder
dB	decibel
dBA	decibels (A weighted)
DC	direct current
DCR	direct current resistance
deg.	degree
dept.	department
dia.	diameter
e.g.	example given
EIA	Electronic Industries Association
EMI	electromagnetic interference
EPA	Environmental Protection Agency
etc.	et cetera (and so forth)
ext.	external
°F	Fahrenheit degree
fl. oz.	fluid ounce, fluid ounces
FM	frequency modulation
ft.	foot, feet
ft. lbs.	foot pound, foot pounds
ga.	gauge–
gal./ gals.	gallon, gallons
gph	gallons per hour
gpm	gallons per minute
gr.	grade
grd.	ground
HCHT	high cylinder head temperature
HET	high exhaust (or engine) temperature
Hg	mercury (element)
H_2O	water
HP	horsepower
hr, hrs	hour
Hz	hertz (cycles per second)
ID	inside diameter
IEEE	Institute of Electrical and Electronic Engineers
in.	inch(es)
inc.	incorporated
in. lbs.	inch pounds
int.	internal
int.-ext.	internal-external
ISO	International Standards Organization
J	joule, joules
JIS	Japanese Industry Standard
kg	kilogram, kilograms
kg/cm^2	kilograms per square centimeter
kgm	kilogram meter(s)
kJ	kilojoules (btu cal)
km	kilometer, kilometers
kPa	kiloPascal, kiloPascals
kph	kilometers per hour
kV	kilovolt
kVA	kilovolt amperes
kW	kilowatt, kilowatts
kWH	kilowatt hour
L	liter, liters
LxWxH	length x width x height
LED(s)	light emitting diode
lb., lbs.	pound, pounds
L/hr.	liter per hour, liters per hour
L/min.	liter(s) per minutes
LOP	low oil pressure
LP	liquefied petroleum
m	meter, meters
m^3	cubic meter, cubic meters
max.	maximum
MCM	one thousand circular mils.
megger	megohmmeter
MHz	megahertz
mi.	mile, miles
mil	one one-thousandth of an inch
min.	minimum
mJ	millijoule, millijoules
MJ	mega joule, mega joules
mm	millimeter, millimeters
m^3/min	cubic meters per minute
MPa	megaPascal
mW	milliwatt, milliwatts
MW	megawatt, megawatts
N/A	not available or not applicable
NBS	National Bureau of Standards
N.C.	normally closed
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
Nm	Newton meter, Newton meters
no., nos	number, numbers
NPT	National Standard taper pipe thread per general use
N/R	not required
OC	overcrank
OD	outside diameter
OEM	original equipment manufacturer
OS	overspeed, oversize
O/S	oversize
OSHA	Occupational Safety and Health Act
OV	overvoltage
oz.	ounce, ounces
PF	power factor
PMG	permanent magnet generator
pot.	potentiometer
ppm	parts per million
psi	pounds per square inch
pt., pts.	pint, pints
PVC	polyvinyl chloride
qt., qts.	quart, quarts
qty.	quantity
ref.	reference
RFI	radio frequency interference
r.h.m.	round-head machine (screw)
rms	root mean square
RPM	revolutions per inch
RTV	room temperature vulcanization
SAE	Society of Automotive Engineers
SCR	silicon-controlled rectifier
sec.	second, seconds
spec.	specs, specification
sq.	square
sq. cm	square centimeters
sq. in.	square inch, square inches
tach	tachometer
TDC	top dead center
tech. pub.	technical publications
temp.	temperature
TIF	telephone influence factor
TP, TPs	technical publications
turbo	turbocharger
UHF	ultrahigh frequency
UNC	Unified coarse thread (was NC)
UNF	Unified fine thread (was NF)
UL	Underwriter's Laboratories, Inc.
U/S	undersize
U.S.A.	United States of America
V	volt, volts
vac	volts alternating current
vdc	volts direct current
VHF	very high frequency
W	watt, watts

Notes

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DETROIT DIESEL

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