Generator Switchgear Products
Automatic Transfer Switches

Cat® Paralleling Switchgear Applications Guide

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General Description

Introduction

Cat® Generator Paralleling Switchgear is designed to integrate the control requirements and electrical generation capabilities of Caterpillar generator sets with the electrical distribution and protection functions of conventional distribution switchgear. Operating seamlessly with Caterpillar on-package microprocessor-based engine control and electrically operated circuit breakers, Cat® Switchgear provides for smooth, reliable and efficient operation of the user's emergency power system. The system acts as the central data hub for the emergency power system and can be tied into the users overall building management system.

Applications

- Emergency/legally required standby systems
- Optional Backup/Storm Avoidance systems
- Distributed Generation
- Cogeneration
- Peak Shaving
- Prime Power
- Combined Heat and Power (CHP)

Industries

Cat Paralleling Switchgear is engineered for use in industries with the most critical power demands:

- Data Centers
- Healthcare
- Government
- Critical Industrial/Chemical Processing
- Water/Wastewater Treatment
- Commercial Standby
- Resorts
- Infrastructure
- Landfill gas to energy

Features

- Full color touchscreen interface with industry leading graphics
- Scalable redundancy
- Advanced engine communications
- Intuitive Operation
- Detailed alarm and parameter reporting
- Industry leading support network
- Best in Class footprint
- Flexible Sequence of Operations
- Factory integration and testing

Low Voltage

Medium Voltage

Standards

Factory Standard Low-Voltage (<600V) Switchgear conforms to the following applicable standards:

- NEMA® Standard SG-5
- CSA®
- ANSI C37.20.1
- ANSI C37.5.1
- UL® Standard 1558
- NFPA 110, 99, and 70

UL 1558 designs utilize circuit breakers built to NEMA Standard SG-3; ANSI Standards C37.13, C37.16, C37.17 and UL 1066. Optional switchboard construction is available that is built to UL 891.

Factory Standard Medium-Voltage (>600V through 27KV) Switchgear conforms to the following applicable standards:

- NEMA Standard SG-5
- ANSI/IEEE C37.20.2
- CSA-C22.2 No. 31-M89
- EEMAC G8-3.2
- NFPA 110, 99, and 70
- IBC/CBC

Medium voltage designs utilize vacuum circuit interrupters that are designed to meet or exceed all applicable IEEE/ANSI standards including C37.06.

Cat Paralleling Switchgear is built utilizing market leading switchgear in both low and medium-voltage applications. This allows for the use of common components on both the normal and emergency power systems, providing for simplified coordination, common spares, and ease of use.

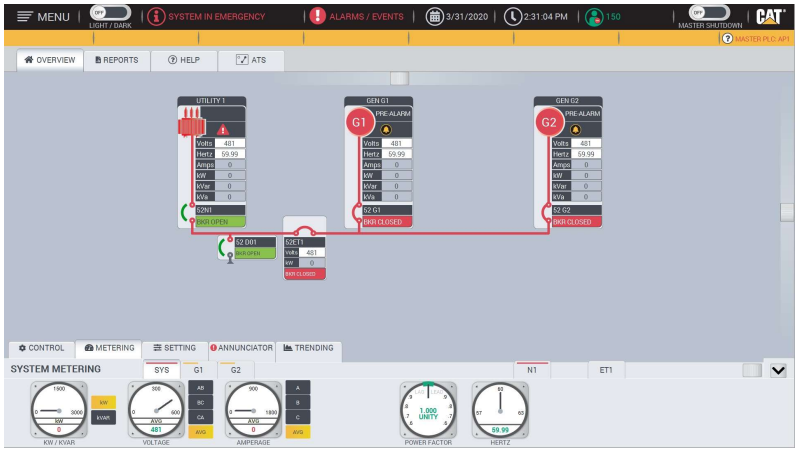


Figure 1.1: Sample System Metering Screen

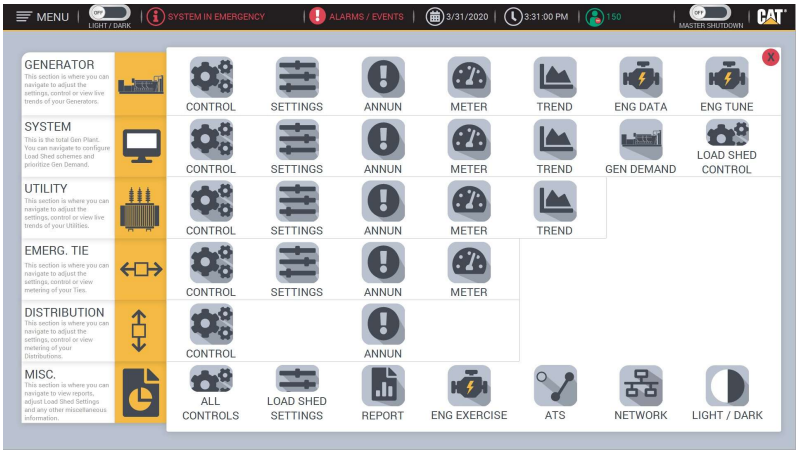


Figure 1.2: Sample System Menu Screen

Figure 1.3: Login prompt

Definitions

The terms and acronyms below are referenced throughout this document.

Alternator: A device for converting mechanical energy into alternating current electrical energy. It may also be called an AC or synchronous generator.

ATS: See Automatic Transfer Switch

Automatic Transfer Switch: A switch designed to sense the loss of one power source and automatically transfer the load to another source of power.

Closed-Transition Transfer: A transfer between sources that provides a momentary paralleling of both power sources during a transfer in either direction. This results in no interruption of power to the loads during the transfer. The closed transition transfer is only possible when the sources are properly synchronized.

DGPS Distributed Generation Power System: Typically a local engine genset and automation connected to the utility system to peak shave and/or export power.

EGP Switchgear: Parallels multiple engine/gensets to serve loads transferred via downstream ATS units (no utility paralleling).

EGPT Switchgear: Same as EGP except with a controlled emergency bus tie breaker between sets of generators to segregate loads or areas of the bus.

EMCP Electronic Modular Control Panel: A Caterpillar microprocessor module for engine/genset control.

Emergency Generator Bus Tie: A bus tie breaker used in EGP systems to segregate groups of generators and/or loads. Typically used where critical loads are required to be powered in 10 seconds and exceed the capacity of a single generator.

EPS Emergency Power System: The emergency power sources and emergency power distribution to downstream loads.

Emergency Standby Power Application: Typical usage of 50 hours per year with a maximum of 200 hours per year. Generators can be applied at their Standby rating with a typical variable load factor of 70%.

Emergency Tie Breaker: A feeder breaker that is used to connect an EGP system to a separate piece of normal (utility) switchgear.

Feeder Breaker Controls: Automation to allow control of the distribution feeder devices for load shed/load add functions.

Generator: A machine for converting mechanical energy into electrical energy. The electrical energy may be AC or DC.

Genset: A combination of an engine prime mover and an electrical generator for converting fuel to electrical energy.

Generator Bus Tie: A bus tie used in XLM systems for separating the generator bus and/or loads from the normal utility fed bus and/or loads.

Generator Demand Priority: Controls that automatically match the online generator capacity to the load to avoid unnecessary generator operation with low load. (Alternatively called load sense/load demand.)

Generator Tie Breaker: A feeder breaker that is used to connect an XLM system to a separate piece of normal (utility) switchgear.

Governor: A device that regulates prime mover speed by adjusting the fuel input to maintain constant speed at varying load.

HMI Human Machine Interface: Typically a touchscreen used by the operator for interfacing with the paralleling generator system.

Load Shed/Load Add: Automation that controls distribution devices (turn off and restore on) when only partial emergency engine gensets are available for duty. Typically accomplished by assigning priority levels to each controlled distribution device.

Master Controls: All Processors, HMI and programming to implement the desired modes and sequences of emergency power system operation.

NFPA 110—Standard for Emergency and Standby Power Systems: Standard for the assembly, installation and performance of electrical power systems to supply critical and essential needs during outages of the primary power source.

NPS Normal Power System: The utility service entrance equipment and distribution circuits to downstream loads.

NPSS Normal Power System Supplier: Supplier of all components of the NPS, such as the distribution equipment vendor's authorized distributor.

Paralleling: The procedure of electrically connecting two or more power sources to a common load through matching phase, voltage, and frequency characteristics.

Peak Shaving: Process by which utility customers minimize peak demand utility charges through the utilization of his alternative power sources to maintain utility import below a given threshold.

Prime Power Application: Applications in which the generator(s) is the only power source.

Processor: A specially configured logic controller with appropriate input/output capability and programming.

SAW (Surface Acoustic Wave): A premium touchscreen sensing technology that offers maximum protection from wear or contaminants.

Station Battery: A power supply used for control of switchgear and/or controls.

Synchronizer: A device that will actively match phase, voltage and frequency of an on-coming generator set with the bus or another generator set to allow paralleling.

Synchroscope: An instrument that measures phase angle differences and provides a visual indication of proper time for closing of the breaker when attempting to parallel sources.

TFT: (Thin Film Transistor): A type of touchscreen display technology that offers high levels of brightness and clarity.

Utility Protection: A collection of protective relays or a multifunction relayed required by the utility to detect abnormal conditions and open the utility breaker.

XLM Switchgear: Parallels multiple generator sets and the utility to serve downstream loads. Typically does not include downstream ATS units.

XLMT Switchgear: Same as XLM except with a controlled generator bus tie breaker between the utility bus and the genset bus.

Standard Configurable Products

Cat Switchgear is available in two standard product configurations:

- **XLM** (Emergency Transfer (**X**fer) and **L**oad **M**anagement)
- **EGP** (**E**mergency **G**enerator **P**aralleling)

These configurations are available for both low-voltage and medium voltage applications and represent the most typical paralleling switchgear configurations seen in the industry. Additionally, custom configurations are available to meet the demands of even the most unique and complicated systems.

EGP

EGP (Emergency Generator Paralleling) switchgear is used for paralleling multiple generators that are not directly connected to a utility source. EGP switchgear is primarily used in applications where downstream automatic transfer switches provide the switching between normal and emergency sources. This is what is typically required in medical facilities, hospitals, and water/wastewater treatment facilities when multiple generator sets are paralleled.
For detailed EGP product description, specifications, layouts, and so on, refer to Section 3 and 7.

XLM

XLM switchgear is used when the Generators are paralleled with a normal utility (or multiple utility) power source(s). XLM switchgear allows closed transition, soft-loading and unloading from utility and peak shaving capability where generators operate continuously in parallel with the utility. Typically, XLM switchgear eliminates the need for automatic transfer switches. Data centers, industrial process, and other critical process loads are prime candidates for XLM switchgear. For detailed XLM product description, sequence of operations and sample layouts, refer to Section 4 and 7.

Medium-Voltage Switchgear

Medium-voltage switchgear is available in custom configurations, as well as standard configurations listed in this section. Medium-voltage Cat Switchgear uses the same control technology and operator interface, and has all of the same features and functions as the low-voltage systems.
At the heart of all medium-voltage Cat Switchgear systems is metal-clad switchgear with vacuum circuit breakers.
For detailed medium-voltage (5 and 15 kV class) product descriptions, specifications, layouts, and so on, refer to sections 5 and 7.

Custom Products

Custom switchgear is available to meet the needs of the most demanding, unique or complicated system configurations. Custom engineered systems are available for special system requirements such as: custom sequences of operation, special load control requirements, multiple utility and tie combinations, unique switchgear locations or layouts, and so on. No matter how complicated or unique the system, Cat Switchgear has the power and flexibility to handle it. For detailed examples of product customization, refer to Section 6.

Cat Switchgear Applications

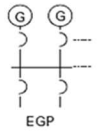
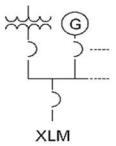
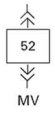
Application Guide Tab Section	Voltage Range		Parallel Multiple Gensets	Paralell withUtility	Standby Applications	Transfer Switches	Modes of Operation: Emergency Standby	Modes of Operation: Closed Transition/ Soft Load	Modes of Operation: Peak Shaving	Modes of Operation: Load Shed/Add Control	Modes of Operation: Utility Export	Application Considerations
Emergency Generator Paralleling Switchgear (EGP)												
3 	208-600V	UL 1558 Ul 891 CSA Arc Res 2B	✓		✓	✓	✓			✓		EGP product is used to parallel multiple gensets to a common bus where interconnect with the uiltiy is not required. EGP systems are commonly used where there are downstream transfer switches.
	2.4-27kV	ANSI C37.20.2 ANSI C37.20.3 UL MV, CSA Arc Res 2B, 2C, 2BC	✓		✓	✓	✓			✓		
Transfer and Load Management Paralelling Switchgear (XLM)												
4 	208-600V	UL 1558 Ul 891 CSA Arc Res 2B	✓	✓	✓		✓	✓	✓	✓	✓	XLM Product is used when generators will be paralleled with a utility (Utility Breaker may be local or remote). Allows closed transition transfer to/from utility as well as continuous paralleling.
	2.4-27kV	ANSI C37.20.2 ANSI C37.20.3 UL MV,CSA Arc Res 2B, 2C, 2BC	✓	✓	✓		✓	✓	✓	✓	✓	
Additonal Medium Voltage Features												
5 	2.4-27kV	ANSI C37.20.2 ANSI C37.20.3 UL MV , CSA Arc Res 2B, 2C, 2BC	✓	✓	✓	✓	✓	✓	✓	✓	✓	Medium Voltage product utilize vaccum circuit breakers. This section covers equipment specific to applications >600V.
Custom Paralleling Switchgear Features												
6 	208V-27kV	UL 1558 Ul 891 CSA Arc Res 2B ANSI C37.20.2 ANSI C37.20.3 UL MV, CSA Arc Res 2B, 2C, 2BC	✓	✓	✓	✓	✓	✓	✓	✓	✓	Customize products are available to meet the most demanding or unique requirements including multiple utilities, multiple ties, custom sequence of operations, etc.

Table 1-1 Cat Switchgear Selector

Control Architecture

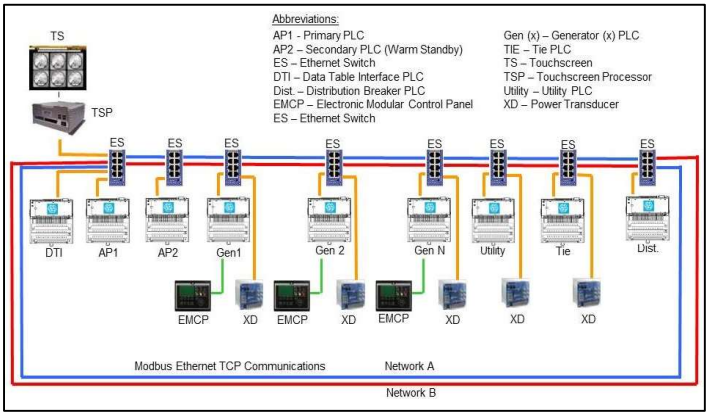


Figure 2.1: Distributed Processing—Ethernet Network—Dual Redundant Ring Option, standard controllers

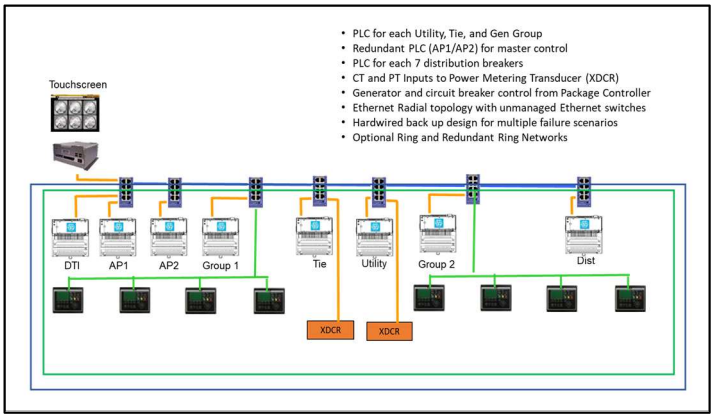


Figure 2.2: Distributed Processing—Ethernet Network—Dual Redundant Ring Option, Paralleling controllers

Features are common to all low- and medium-voltage configurations.

Cat Switchgear uses industry-leading, microprocessor-based control architecture designed to work exclusively with Cat engine generator sets.

Redundancy and Fault Tolerance

Cat Switchgear Control Technology provides maximum efficiency and reliability. With Cat Switchgear, single points of failure are eliminated because of the multiple levels of redundancy and fault tolerance that are built into the system:

- **Standard Distributed Processing.** A separate automation controller for each power source ensures the system continues to operate even if a single controller fails.
- **Available Redundant System Masters (warm standby).** Master functionality maintained through primary and secondary automation controller.
- **Available Redundant System Masters (hot standby).** Master functionality maintained through synchronized primary and secondary controllers, providing seamless and bumpless transfer in the event of a master controller failure.
- **Distributed Manual Control.** In the highly unlikely case of a complete loss of system automation, distributed manual control is available
- **Available Redundant Ethernet Supervisory Networks.** Available ring and dual ring topologies.
- **Instant Auto Switch.** If the touchscreen fails, an “Instant Auto” switch is provided to place all digital controls in the Auto position, protecting your facility from power outages. A functional touchscreen is not required for complete automatic operation of Cat Switchgear
- **Remote Operator Stations.** The remote operator station functions completely independent of the local operator interface touchscreen. If the local operator interface touchscreen fails, it will not affect the operation of the remote station connected to the system.

- **Hardwired Emergency Start Backup.**
  Each system is designed with a hardwired emergency start backup system installed in the event of a catastrophic network communications failure. The hardwired emergency start backup system will initiate a generator start signal to ALL of the generator controllers based on any ATS start signal or a "Utility Failure" signal. This ensures that the system is always alerted of a utility outage or ATS Run Request so generators can be started and power can be restored.

- **Hardwired "First Up" Dead Bus Backup.**
  Each system is designed with a hardwired hot bus backup system installed in the event of a catastrophic network communications failure. This feature prevents multiple units from closing to a "Dead Bus" at the same time. Once the first generator breaker closes to the bus, a hardwired "Hot Bus" signal is passed to all controllers.

- **Best Source DC System.**
  Control power is protected against single point of failure by the use of a 24 Vdc Best Source DC system. Each engine battery and an optional station battery are connected to a common DC bus. Each engine battery and the station battery are furnished with their own battery charger. The entire system is protected so that no individual battery/charger fault will affect the rest of the system.

- **ATS Start Signal Integrity**
  Allows for compliance with Article 700.10 of the 2017 National Electrical Code using three wire verification and alarm logic.

Touchscreen Interface

Cat Switchgear technology uses a touchscreen for operator interface, monitoring and control of the paralleling switchgear. The screens give the operator an instantaneous, easily understandable view of the entire system status. This feature is standard in all Cat Switchgear.
The easy-to-use touchscreen interface makes it possible to view, monitor and perform multiple functions including:

- Metering
- Engine data
- Protective relay settings
- Annunciators
- Adjust load shed controls and generator demand priority
- Synchronize and parallel
- Set modes of operation
- Voltage and frequency adjustments

Graphics emulate conventional meters and gauges on switchgear. At a glance, users can easily see how the system is performing and, based on real-time information, optimize system performance.

Logins and Passwords

Cat Switchgear comes with a login feature designed to prevent unauthorized use. Once activated, three levels of user access are provided:

- **Observer** (default): When all users are logged out, the HMI is in the lowest level of access. Most screens can be accessed to provide any desired information to the user, but no controls, settings or tuning settings can be changed.

- **User**: When a user is logged in, the operator has access to all controls, but cannot change settings or tuning settings.

- **Admin**: When an administrator is logged in, the operator has full access to all controls and settings. This should be limited to site administrators.

- **Engineer**: An additional password is provided for factory access by Caterpillar Switchgear and Cat dealer personnel to operate the switchgear. The Engineer access is the same as the Admin access.

Graphics Package Options

Feature Description	Factory Standard Package
Redundancy and Fault Tolerance Features	
True distributed processing	Standard
Redundant master controller	Optional
Engine 24 Vdc best source system	Standard
Station 24 Vdc battery system	Optional
Automation Network Capabilities	
Ethernet Radial	Standard
Ethernet Ring	Optional
Ethernet Redundant Ring	Optional
HMI Touchscreen Displays	
19" high-resolution SAW Touchscreen (widescreen)	Standard
22" high-resolution SAW Touchscreen (widescreen)	Optional
27" high-resolution SAW Touchscreen (widescreen)	Optional
Custom sized displays	Optional
Individual genset touchscreen display	Optional
Redundant/Remote displays	Optional
Display Features	
Intuitive menu navigation system	Standard
Dynamic system overview one-line	Standard
Pop-up notifications, control & metering screens	Standard
Password entry system (minimum 2 levels)	Standard
Logging and Reporting Features	
Alarm "light box" type annunciation screens	Optional
Alarm and event summary (1 second time and date stamp)	Standard
Tuning and setting reports	Standard
Joint Commission Test reports	Optional
Custom reports	Optional
Real-time trending	Optional
Historical trending	Optional
Save/export alarm logs	Standard
Messenger (SMS, voicemail)	Optional
Remote Montoring and System Access	
Remote monitoring and control	Optional
Factory support connectivity	Optional
Gateways to BMS/SCADA	Optional
Ancillary Monitoring and/or Control	
Balance of system (NGR, SCR, CHP, etc)	Optional
Cat ATS via communications	Optional
Other ATS via hardwire	Optional
Applications	
Emergency Standby	Standard
Utility Paralleling	Standard
Prime Power	Standard
Landfill	Standard
Alternative fuels	Optional
Multisource management (Microgrid)	Optional

Cat Switchgear System Advantages

Cat Switchgear performs generator protective functions internal to the automation controller. With Cat technology, operators can monitor, process, compare, display and transmit data with a high degree of precision and control—and that control translates into high reliability and functionality.

Cat Switchgear has enhanced features that set the standards for the industry.

- Unequaled fault tolerance
- World-leading operator interface
- Sophisticated communications abilities
- Superior connectivity
- Less installation wiring
- Smaller footprint provides better
- utilization of available space
- Available detailed engine and
- electrical reports
- Low cost redundancy
- Enhanced performance
- UL, NFPA, CSA and IEEE compliant
- Higher mean time between failure
- Lower mean time to repair

Advanced Communications Capabilities (optional)

Cat Switchgear technology is equipped with secure password protected remote communications technologies, enabling you to control and monitor your engine generator sets from anywhere at any time. Whether at home, in the office, or on the road, operators can access controls and information on a real-time basis and respond immediately...even control multiple facilities from a single centralized site. Whether on-site or off-site, the available remote communications package gives you the identical interface and same capabilities as standing in front of the generator or Cat Switchgear. The remote communications run completely independent of the paralleling switchgear automation. This ensures remote communication devices or systems will not affect the reliability of your Cat Switchgear.

Cat Switchgear can also easily communicate data to third party Building Management, SCADA or other monitoring systems. For these applications, a Data Table Interface acts as a “firewall” between your Cat Switchgear system and the Building Management or SCADA System. The Data Table Interface serves up the requested data to the third-party monitoring system, but stays completely independent of all critical generator control automation. This ensures remote communication devices or systems will not affect the reliability of your Cat Switchgear. Other systems of communication interfaces with either Modbus or Bacnet would be specific to the third party building management—listed typically as Building Automation Systems (BAS).

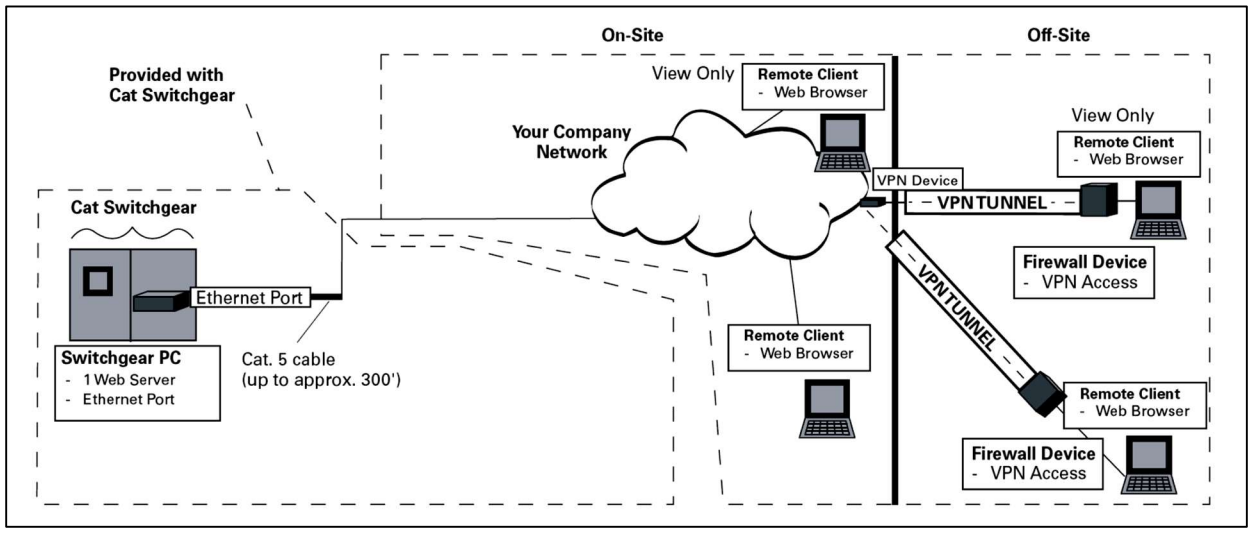


Figure 2.3 Off Site Remote—TCP-IP) Web Based Connection with Multiple Users (View Only)

EGP

Overview

Cat Emergency Generator Paralleling (EGP) Switchgear for multiple engine generator sets provide the following functionality:

- Automatic start, synchronize, parallel and load/var share on a common bus
- Main lugs output to feed downstream emergency distribution
- Optional emergency distribution circuit breakers
- Load shed/load add
- Generator demand priority
- For use with multiple downstream Automatic Transfer Switches
- Cat Switchgear is designed to integrate seamlessly with Cat Automatic Transfer Switches. EGP Switchgear is optionally available with direct communication to Cat ATSs to provide “fingertip” control and monitoring of all your facility ATSs from one convenient central location
- Cat Switchgear brings the power and reliability of microprocessor technology to your generator switchgear application. Through the use of the operator interface touchscreen display with clear graphical representation; Cat Switchgear merges the features of:
- Power monitoring
- Switchgear automation
- Generator set control
- Optional remote communications

EGP3 Switchgear

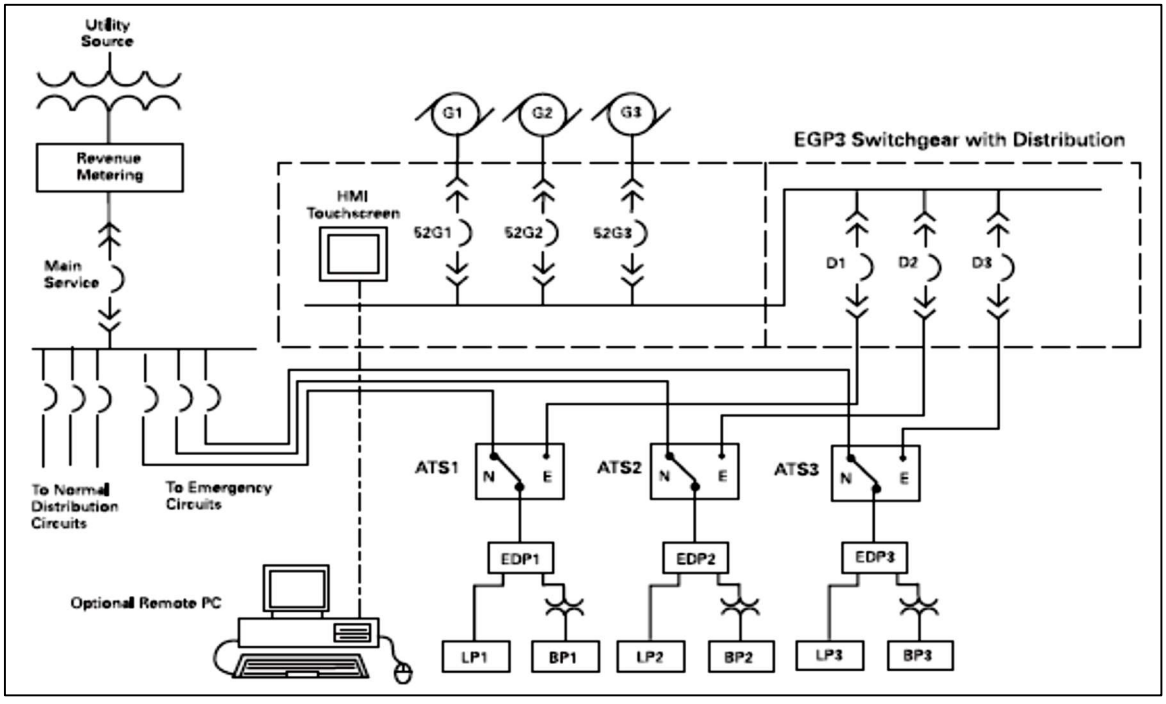


Figure 3.1 EGP3 Low-Voltage Switchgear (3 Generator Sources)

EGP Equipment

Standard Equipment—EGP

- EGP controls can be implemented in LV or MV switchgear lineups.
- Operator Interface Touchscreen—surface acoustic wave color touchscreen with key switch (choose one of the following):
  - 19.00-inch
  - 22.00-inch
  - 27.00-inch
- Direct data communication to Cat microprocessor-based engine generator set control network (EMCP)
- System overview screen with one line mimic diagram that depicts real-time metering, status and control
- Full function 0.5% accuracy analog and digital AC metering for generators: voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar
- Full function engine gauges: RPM, DC battery voltage, oil pressure, engine coolant temperature, engine hours, number of starts
- Full function synchronizing and paralleling controls with selection for automatic or manual synchronizing
- Full function 0.5% accuracy analog and digital AC metering for system: voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar
- System control functions for auto (standby for emergency), test without load and test with load
- Automatic load shed control with on-screen operator adjustments for essential (Life/Safety), critical and non-essential loads. Manual load shed/load add control
- Automatic generator demand priority with on-screen operator adjustments for automatic addition and removal of generator to the load bus
- System status and alarm annunciation with color display and 85 dbA alarm horn with silence button
- Password secured settings and adjustments for generator and system setups and protective relaying
- Alarm summary reports
- Settings reports
- Engine and generator load charts
- Engine trend data

Optional Equipment—EGP

- Distribution sections with electrically operated drawout UL 1066 circuit breakers
- NFPA 110 engine/generator status, pre-alarm, lamp test button, shutdown fault annunciation and 85 dBA alarm horn with silence button
- Remote monitoring and control
- Building Automation System or SCADA communications—Modbus or Ethernet
- Remote notification
- Historical data trending
- Communication to Cat ATS units
- Automated Joint Commission report

EGPT: Tie Breaker Application

Many systems require the use of tie breakers to meet Code or system performance requirements. Tie breakers can be used anywhere throughout the line-up to segment or isolate desired sources, loads or sections of bus.

Emergency Generator Bus Tie

Certain NFPA Codes require all life safety and critical loads (Priority 1 loads) to be restored in a maximum of 10 seconds. If the total Priority 1 load that must be restored in ten seconds exceeds the capacity of a single generator, an emergency generator bus tie breaker should be used. This allows one generator on each side of the tie to restore power to Priority 1 loads in under 10 seconds.

The system can then parallel all generators across the emergency generator bus tie breaker so the full generator plant capacity is available.

Note: Priority 1 loads must be split to either side of the generator tie breaker. See **Page 38** for an example of a system with an emergency generator bus tie breaker.

EGP Controls

Generator Metering
- 0.5% accuracy
- Analog and digital voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar; synchroscope

Generator Protective Relaying
- 27/59—under/overvoltage
- 81 O/U—under/overfrequency
- 32—reverse power
- 40—loss of excitation (reverse var)
- 25—synch check

Note: Medium-voltage applications utilize multi-function relays to provide above protectives plus 50/51 as a minimum (optional 51G, 87).

Engine Gauges
- RPM meter
- Engine battery volt meter
- Oil pressure gauge
- Engine coolant temperature gauge

Engine Monitoring and Alarms
- Low coolant temperature pre-alarm
- High coolant temperature pre-alarm and shutdown
- Low oil pressure pre-alarm and shutdown
- Low fuel alarm (diesel only)
- Low and high engine battery alarm
- Battery charger alarm
- Overcrank shutdown
- Overspeed shutdown

Engine/Generator Control
- Automatic engine start
- Adjustable engine cool-down timer
- 15—automatic synchronizer
- 65—microprocessor engine governor load sharing and soft loading control
- 90—Var/PF and cross current compensation controller

System Metering
- 0.5% accuracy
- Analog and digital voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar

System Protective Relaying
- 27/59—bus under/overvoltage
- 81 O/U—bus under/overfrequency

System Control
- Automatic standby mode
- Emergency mode
- Test without load
- Test with load
- Automatic load shed control with bus underfrequency protection
- Automatic generator demand priority control
- Master shutdown

Power Supply
- Power from 24 Vdc engine cranking batteries
- Automatic best DC source selector
- Optional 24 Vdc station battery, sealed jar, 4-hour, external 120 Vac emergency power required for charger

Communications
- Automation network—high speed, high reliability, industrially hardened
- Optional remote communications
- Optional communication to building automation or SCADA systems or general monitoring—Modbus RTU or Ethernet

EGP Functional Sequence of Operations

A. the EPS automation shall be provided with the following modes of operation:

1. **Automatic/Standby Mode**
   a. The automatic transfer switches are in the normal position serving utility power to the loads.
   b. The generator set main breakers are open.
   c. The automation is standing by to act in response to a run request from associated automatic transfer switches.
2. **Emergency Mode**
   a. Automatic Transfer Switch Run Request.
   b. Where applicable, load shed sequence is executed.
   c. All available generators are started.
   d. The first generator up to voltage and frequency is closed to the bus.
   e. Critical loads and load shed priority 1 loads are powered in less than 10 seconds.
   f. The remaining generator sets are synchronized and paralleled to the bus as they come up to voltage and frequency.
   g. As additional generators are paralleled to the emergency bus, Load Shed Priority levels are added
   h. The system is now in Emergency Mode.
3. **Exit from Emergency Mode**
   a. Automatic transfer switches sense the utility source is within acceptable operational tolerances for a time duration set at the automatic transfer switch.
   b. As each automatic transfer switch transfers back to utility power, it removes it's run request from the generator plant.
   c. When all run requests have been removed from the generator plant, all generator set main circuit breakers shall be opened.
   d. The generator sets are allowed to run for their programmed cool down period and shut down.
   e. The system is returned to Automatic/Standby Mode.
4. **No Load Test Mode**
   a. Entrance into No Load Test Mode.
      I. The no load test switch is placed in the "on" position.
      II. All available generators are started.
      III. The first generator up to voltage and frequency is closed to the bus.
      IV. The remaining generators are synchronized and paralleled to the bus as they come up to voltage and frequency.
      V. The system is now in No Load Test Mode.
   b. Exit from No Load Test Mode.
      I. The no load test switch is placed in the "off" position.
      II. All generator breakers are opened.
      III. The generators are allowed to run for their programmed cool down period and shut down.
      IV. The system is returned to automatic/standby mode.
5. **Utility Fail Test Mode**
   a. Entrance into Utility Fail Test Mode
      I. The utility fail test switch is placed in the "on" position.
      II. A contact output signals downstream automatic transfer switches to enter utility failure test mode.
      III. The system enters into emergency mode as described in the "Emergency Mode" sequence above.
   b. Exit from Utility Fail Test Mode
      I. The utility fail test switch is placed in the "off" position.
      II. A contact output signals downstream automatic transfer switches to exit utility failure test mode.
      III. The system exits emergency mode as described in the "Exit from Emergency Mode" sequence above.

B. The EPS Automation shall support two (2) sub-modes: Load Shed/Load Add, and Generator Demand Priority.

1. Load Shed

a. Conditional Load Shed:

I. Upon entrance into emergency mode of operation, the load shed control shall open all sheddable circuit breakers.

II. As generator sets come to the bus, essential priority level loads shall be added conditionally based on the number of generator sets on line. When the first generator set comes to the bus, priority level 1 loads shall be added; second generator set, priority 2, etc.

III. After a time delay that allows all operational generator sets to come to the bus, the system shall shift to load sensitive mode.

b. Load Sensitive Load Shed:

I. The system shall compare generator on-line capacity (in kW) to system load. If surplus generator capacity exists, load shed priority level(s) are added. If system load exceeds generator on-line capacity, load shed priority level(s) are shed.

II. The load shed control, in its automatic shedding and adding of loads, shall not override any manual load shed/add operation.

c. Bus Underfrequency:

I. Should the load bus frequency fall below the bus underfrequency setpoint, all priority level loads shall be shed. Load addition shall not resume until manually reset.

II. The bus underfrequency protection shall override any manual load add operation.

2. Generator Demand Priority Control

a. Upon entrance into emergency mode, all generator sets shall be started and paralleled to the bus. After a load stabilization delay, generator sets are automatically added to or removed from the bus according to system load demand.

b. Generator Demand Priority Control shall have two modes of operation.

I. Engine Hour base Generator Demand—Engines are automatically reassigned priority levels each time the generators are started in order to maintain them within a user settable amount of hours.

II. Operator manual selection of Generator Demand—An operator can disable Engine Hour based Generator Demand and manually set the priority level for each generator.

XLM

Overview

Cat XLM Controls—Generator Paralleling Controls for Emergency Transfer (**X**fer) and **L**oad **M**anagement control of multiple engine generator sets with one utility source. XLM systems provide the following functionality:

- Automatic transfer to emergency upon utility failure
- Automatic start, synchronize, parallel, and load share on a common bus for emergency operation
- Closed transition transfer back to utility upon stable return of power, with soft generator unloading
- Closed transition Load Management Mode with soft loading and unloading of generator system
- Closed transition transfer to Emergency Mode to facilitate maintenance, or for storm threat avoidance with soft loading and unloading of generator system
- Load shed/load add
- Generator demand priority
- Cost-effective, technically superior alternative to conventional ATS arrangement

Cat Switchgear brings the power and reliability of microprocessor technology to your generator switchgear application. Through the use of the operator interface touchscreen display with easy-to-follow graphical representations, Cat Switchgear merges the features of:

- Power monitoring
- Switchgear automation
- Generator set control
- Optional remote communications

XLM2 Switchgear

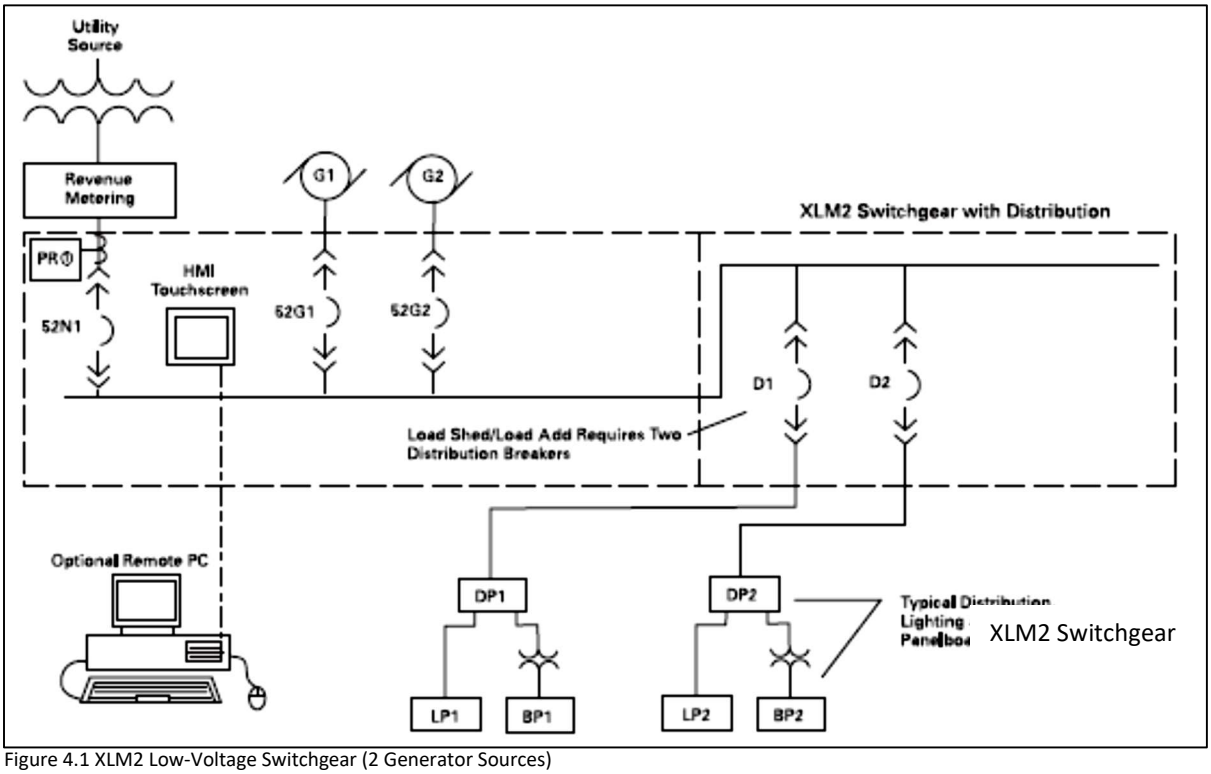


Figure 4.1 XLM2 Low-Voltage Switchgear (2 Generator Sources)

XLM Equipment

Standard Equipment—XLM Controls

- XLM controls can be implemented in LV or MV switchgear lineups.
- Operator Interface Touchscreen—surface acoustic wave color touchscreen with key switch (choose one of the following):
  - 19.00-inch
  - 22.00-inch
  - 27.00-inch
- Direct data communication to Cat microprocessor-based engine generator set control network
- Full function 0.5% accuracy analog and digital AC metering for utility: voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar
- Full function 0.5% accuracy analog and digital AC metering for generators: voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar
- Full function engine gauges; RPM, DC battery voltage, oil pressure, engine coolant temperature, engine hours, number of starts
- Full function synchronizing and paralleling controls with selection for automatic or manual synchronizing
- Full function 0.5% accuracy analog and digital AC metering for utility: voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar
- System control functions for auto (standby for emergency), closed transition to emergency and load management
- Automatic load shed control with on-screen operator adjustments for essential, critical, and non-essential loads.
- Manual load shed/load add control
- Automatic generator demand priority with on-screen operator adjustments for automatic addition and removal of generator to the load bus
- System status and alarm annunciation with color display and 85 dbA alarm horn with silence button
- Password secured settings and adjustments for generator and system setups and protective relaying Alarm summary reports
- Settings reports
- Engine and generator load charts
- Engine data (available with ADEM 3 or ADEM 4 Governor)
- Plug together control connections across shipping split

Optional Equipment—XLM

- Distribution control of electrically operated circuit breakers
- NFPA 110 engine/generator status. pre-alarm, lamp test button, shutdown fault annunciation and 85 dBA alarm horn with silence button
- Trip unit metering and communications (LV only, e.g. with Eaton Digitrip 520M, 520MC and 1150+ electronic trip units or similar)
- Remote monitoring and control
- Building Automation System or SCADA communications— Modbus or Ethernet
- Remote notification
- Historical data trending

XLMT: Tie Breaker Application

Many systems require the use of tie breakers to meet Code or system performance requirements. Tie breakers can be used anywhere throughout the line-up to segment or isolate desired sources, loads or sections of bus.

Generator Bus Tie

Generator Bus Ties can isolate the normal electric service sources from the generator sources.
This can also isolate load breakers for such as load banks or dedicated emergency loads. This separation also may be required by NFPA or local codes.

Generator bus tie breakers can be applied to serve several purposes.

1. Starting of large loads—the generator bus tie can be opened to allow multiple generators to be paralleled before being connected to large load(s). Once multiple generators are paralleled, the generator bus tie can be closed to power the large loads.
2. Load banks—the generator bus tie can allow the generators to be isolated from the normal utility fed bus. Having a distribution breaker or set of load take-off lugs on the generator side of the bus allows the generators to be load bank tested without affecting any normal utility fed loads.
3. Emergency standby systems with automatic transfer switches— the generator bus tie provides isolation between the normal and emergency buses. During a loss of utility power, the generator bus tie can be opened to isolate all normal loads and allow restoration of power to emergency loads. Once emergency loads are restored, the emergency bus tie can be reclosed to restore power to normal loads. **Note:** See **Page 34** for an example of an XLM system with generator bus tie breaker.

XLM Controls

- Automatic standby mode
- Emergency mode with closed transition to normal
- Closed transition to emergency mode
- Load management mode
- Automatic load shed control with bus underfrequency protection and one four-pole, 10 A, 120 Vac, Form C, dry contact output for each load shed level (1 level for each generator in the system)
- Automatic generator demand priority control
- Master shutdown button

Utility Metering

- 0.5% accuracy
- Voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar; synchroscope

Utility Protective Relaying

- 15—automatic synchronizer
- 86—reverse power lockout relay, manual reset
- Multi-function utility grade, drawout with:
  - 81 O/U—under/overfrequency
  - 47—phase sequence/phase failure
  - 32—reverse direction, 32/51—reverse direction overcurrent relay, 32/62—reverse direction timing relay,
  - 27/59—under/overvoltage relay
  - 25—sync check relay

Generator Metering

- 0.5% accuracy
- Voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar; synchroscope

Generator Protective Relaying

- 27/59—under/overvoltage
- 81 O/U—under/overfrequency
- 32—reverse power
- 40—loss of excitation(reverse var)
- 25—sync check
- **Note:** Medium-voltage applications utilize multi-function relays to provide above protectives plus 50/51 as a minimum (optional 51G, 87).

Engine Data

- RPM meter
- Engine battery volt meter
- Oil pressure meter
- Engine coolant temperature meter

Engine Monitoring and Alarms

- Low coolant temperature pre-alarm
- High coolant temperature pre-alarm and shutdown
- Low oil pressure pre-alarm and shutdown
- Low fuel alarm (diesel only)
- Low engine battery alarm
- Overcrank shutdown
- Overspeed shutdown

Engine/Generator Control

- Automatic engine start
- Adjustable engine cool-down timer
- 15—automatic synchronizer
- 65—microprocessor engine governor load sharing and soft loading control
- 90—Var/PF and cross current compensation controller

System Metering

- 0.5% accuracy
- Voltage 1-2, 2-3, 3-1; current 1, 2, 3; frequency; power factor; kW; kvar

System Protective Relaying

- 27/59—bus under/overvoltage
- 81O/U—bus under/overfrequency

Power Supply

- Power from 24 Vdc engine cranking batteries
- Automatic best DC source selector
- Optional 24 Vdc station battery, sealed jar, 4-hour, external 120 Vac emergency power required for charger

Communications

- Automation network—high speed, high reliability, industrially hardened
- Optional remote communications network—Ethernet, modem
- Optional communication to building automation or SCADA systems for general monitoring—Modbus® RTU or Ethernet

XLM Functional Sequence of Operations

A. The EPS automation shall be provided with the following modes of operation:

1. Automatic/Standby Mode

a. The utility main breaker is closed serving utility power to the generator/load bus.
b. The generator set main breakers are open.
c. The automation is standing by to act in response to a utility failure.

2. Emergency Mode

a. Utility Failure
b. Utility protective relaying senses utility voltage or frequency out of tolerance.
c. The utility main breaker is opened.
d. Load shed sequence is executed.
e. A run request is sent to the generator plant.
f. The first generator set up to voltage and frequency is closed to the bus.
g. [With Generator Bus Tie Breaker] The generator bus tie breaker is closed after the minimum # of gensets required to perform transfer (user adjustable) are synchronized and paralleled to the bus, or the maximum time to transfer expires. (User adjustable) The remaining generator sets are synchronized and paralleled to the bus as they come up to voltage and frequency.
h. The system is now in Emergency Mode.
i. Utility Restoration and Exit from Emergency Mode.
j. Utility protective relaying senses utility voltage and frequency within tolerance.
k. Following an adjustable time delay to assure that the utility power source is stable, the generator plant is synchronized and paralleled to the utility source by closing the utility main breaker.
l. The generator plant is soft ramp unloaded until the utility source is nominally serving the entire system load.
m. [With Generator Bus Tie Breaker] The generator bus tie breaker is opened once kW is below the disconnect kW value.
n. The generator set breakers are opened.
o. The generator sets are allowed to run for their programmed cool down period and shut down.
p. The system is returned to Automatic/Standby Mode.

3. Transfer to Emergency Mode

a. Entry
   I. The operator places the system into the closed transfer to emergency mode.
   II. A run request is sent to the generator plant.
   III. The generator sets are paralleled to the bus at no load and allowed to warm up.
   IV. [Without Generator Bus Tie Breaker] When all generator sets are on the bus they are soft ramp loaded until the generator plant assumes the entire load on the bus and the utility main breaker is opened.
   V. [With Generator Bus Tie Breaker] When all generator sets are on the bus, they are paralleled across the generator bus tie breaker. They are then soft ramp loaded until the generator plant assumes the entire load on the bus and the utility main breaker is opened.
   VI. The system is now running in emergency mode.
b. Exit
   I. The operator returns the system to the Automatic Mode.
   II. Following an adjustable time delay, the generator plant is synchronized and paralleled to the utility source by closing the utility main breaker.
   III. The generator plant is soft ramp unloaded until the utility source assumes the entire system load.
   IV. [With Generator Bus Tie Breaker] The generator bus tie breaker is opened.
   V. The generator set breakers are opened.
   VI. The generators are allowed to run for their programmed cool down period and shut down.
   VII. The system is returned to the Automatic/Standby Mode.

4. Load Management Mode

a. Entry

I. The operator selects one of the following modes of operation:

(a) Import Limit—The system maintains utility kW import level at an operator defined minimum utility import limit.

(b) Export Limit—The system maintains utility kW export level at an operator defined utility export setpoint.

(c) Base Load Import—The system maintains an operator defined base load kW setpoint, subject to a minimum utility kW import limit.

(d) Base Load Export—The system maintains an operator defined base load setpoint, regardless of whether power is being imported or exported.

II. The operator places the system in the load management mode.

III. A run request is sent to the generator plant.

IV. The generator sets are allowed to run for an adjustable warm-up time.

V. The generator sets are synchronized and paralleled to the bus at no load after completion of the warm-up time.

VI. [With Generator Bus Tie Breaker]When all generator sets are on the bus, they are paralleled across the generator bus tie breaker.

VII. When all generators are on the bus, they are soft ramp loaded until the generator plant assumes the required amount of the load on the bus to meet the mode of operation selected.

VIII. Should the utility fail at any time during load management operation, the utility protective relays shall cause the utility main to open and be locked out, thus placing the system in Emergency Mode until the utility is restored (as described in Emergency Mode exit).

b. Exit

I. The operator returns the system to the Automatic Mode.

II. The generator plant is soft ramp unloaded until the utility source assumes the system load.

III. [With Generator Bus Tie Breaker] The generator bus tie breaker is opened.

IV. The generator set breakers are opened.

V. The generator sets are allowed to run for their programmed cool down period and shut down.

VI. The system is returned to the Automatic/Standby Mode.

5. No Load Test Mode

a. Entry

I. No load test is initiated by the operator.

II. All available generator sets are started and come up to voltage and frequency.

III. [With Generator Bus Tie Breaker] The generator sets are synchronized and paralleled to the bus at no load.

IV. The system is now in no load test mode.

b. Exit

I. No load test is terminated by the operator

II. [With Generator Bus Tie Breaker] The generator main breakers are opened.

III. The generator sets are allowed to run for their programmed cool down period and shut down.

IV. The system is returned to the Automatic/Standby mode.

6. Utility Fail Test Mode

a. Entry

I. Utility fail test is initiated by the operator.

II. Voltage sensing at the utility protective relay is opened, which simulates a loss of utility.

III. The system enters into emergency mode as described in the emergency mode sequence above.

b. Exit

I. Utility fail test is terminated by the operator.

II. Voltage sensing at the utility protective relay is restored, which simulates the return of utility power.

III. The system exits from emergency mode as described in the emergency mode sequence above.

B. The EPS Automation shall support two (2) sub-modes: Load Shed/Load Add, and Generator Demand Priority.

1. Load Shed

a. Conditional Load Shed:

I. Upon entrance into emergency mode of operation, the load shed control shall open all sheddable circuit breakers.

II. As generator sets come to the bus, essential priority level loads shall be added conditionally based on the number of generator sets on line.

III. When the first generator set comes to the bus, priority level 1 loads shall be added; second generator set, priority 2, etc.

IV. After a time delay that allows all operational generator sets to come to the bus, the system shall shift to load sensitive mode.

b. Load Sensitive Load Shed:

I. The system shall compare generator on-line capacity (in kW) to system load. If surplus generator capacity exists, load shed priority level(s) are added. If system load exceeds generator on-line capacity, load shed priority level(s) are shed.

II. The load shed control, in its automatic shedding and adding of loads, shall not override any manual load shed/add operation.

c. Bus Underfrequency:

I. Should the load bus frequency fall below the bus underfrequency setpoint, all priority level loads shall be shed.

II. Load addition shall not resume until manually reset.

III. The bus underfrequency protection shall override any manual load add operation.

2. Generator Demand Priority Control

a. Upon entrance into emergency or load management modes, all generator sets shall be started and paralleled to the bus.

b. After a load stabilization delay, generator sets are automatically added to or removed from the bus according to system load demand.

c. Generator Demand Priority Control shall have two modes of operation.

I. Engine Hour base Generator Demand—Engines are automatically reassigned priority levels each time the generators are started in order to maintain them within a user settable amount of hours.

II. Operator manual selection of Generator Demand—An operator can disable Engine Hour based Generator Demand and manually set the priority level for each generator.

Additional Features for Medium Voltage

the following functions are typically applied in medium voltage applications and are available in EGP and XLM configurations:

A. (**87B) Switchgear Bus Differential**
   1. Bus differential relays are high speed protective devices that are used to limit damage from faults within the switchgear by quickly isolating the faulted "zone." Differential relays measure the difference between the current flowing into and the current flowing out of a given "zone." Systems with multiple utilities and/or tie breakers will typically have more than one bus differential zone. In this configuration, during a differential fault, only breakers feeding in and out of the faulted zone are tripped and locked out. The other zone(s) are unaffected and can continue to operate.

B. **Generator Neutral Grounding Resistors**
   1. NGRs provide added protection for generator windings by limiting the fault current during line to ground faults.
   2. Cat Switchgear recommends a Low Resistance Grounding system with a Neutral Grounding Resistor tied to the Generator Neutral rated at 10 seconds and the Line to Neutral voltage.
   3. NGRs protect the alternator windings on MV and HV gensets with 87G schemes.

C. **Surge Arresters**
   1. A surge arrester is used to prevent large surges from power inconsistencies, lightning, switching, etc., from reaching electronic instruments and ensure the safety of individuals nearby by limiting the crest of impending voltage surges to safe values.
   2. Surge arrestors are connected between each electrical conductor in a power system and the ground, which provides a short-circuit to the ground.
   3. Surge arrestors are typically installed on utility feeders, and feeders exiting the building to other loads.
   4. Recommended minimum protection: surge arrester for protection from high overvoltage peaks, or surge capacitor for protection from fast-rising transient. Please note that the surge arresters or surge capacitor alone may not provide adequate surge protection from escalating voltages caused by circuit resonance.

D. **Surge capacitors**
   1. Recommended to protect the alternator on 5 kV or 15 kV Gensets. Surge capacitors should be used to protect AC alternators.
   2. Surge capacitors are used to prevent regular electric flow from being grounded.
   3. Protective Surge Capacitor systems should be designed to operate in conjunction with lightning arresters to provide surge protection for generator alternators.
   4. The capacitor should reduce the steepness of the wave front of the voltage surge, thereby reducing the stress on the turn and line-to ground insulation.
   5. Surge capacitors function best when located as close as possible to the generator alternator output leads.
   6. Surge capacitors should be connected line-to-ground, and be on the load side of the breaker to eliminate the chance of a bus short-circuit in the event of capacitor failure.
   7. Maximum effectiveness is achieved in limiting impulse voltages, if a low-resistance and low-inductance ground connection is established. All ground connections need to be tied together with a minimum #6 AWG copper conductor.
   8. Although surge capacitors are installed line-ground, they should be rated for line-to-line voltage in the event they are installed on an ungrounded or poorly grounded system.
   9. Cat Switchgear recommends the following values based on system voltage: 0.5 ?f on 5 and 7.5 kV, 0.25 mf on 15 kV, and 0.13 'f on systems operating at 24 kV and higher. Where applicable, the surge capacitor shall conform to NEMA CP-1 standards

Custom Systems

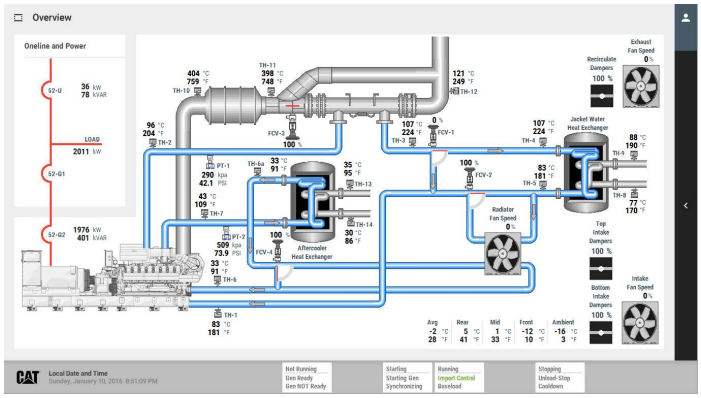
Overview

Cat Generator Paralleling Switchgear has the power and flexibility to handle even the most unique or demanding configurations and project requirements. If the standard **XLM** and **EGP**) configurations do not fit the needs of your specific project, Cat Switchgear offers fully customized solutions.

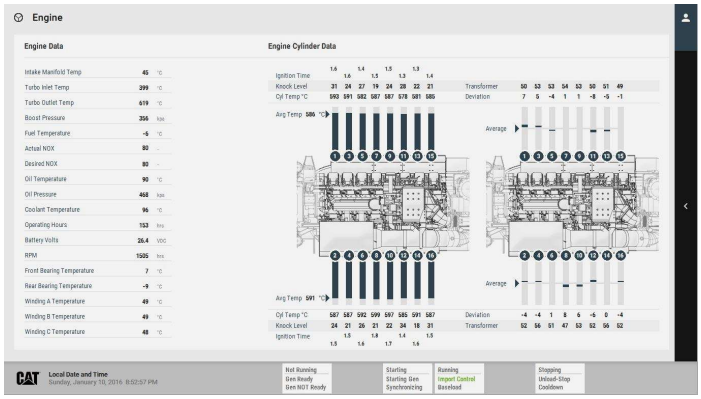
In many cases, custom configurable systems are based on standard XLM or EGP configurations with additional requirements such as:

- Multiple utility connections
- Additional power sources
- Multiple tie breakers
- Additional System Components (e.g. CHP)
- Unique sequence of operations
- Special switchgear layout requirements, and so forth

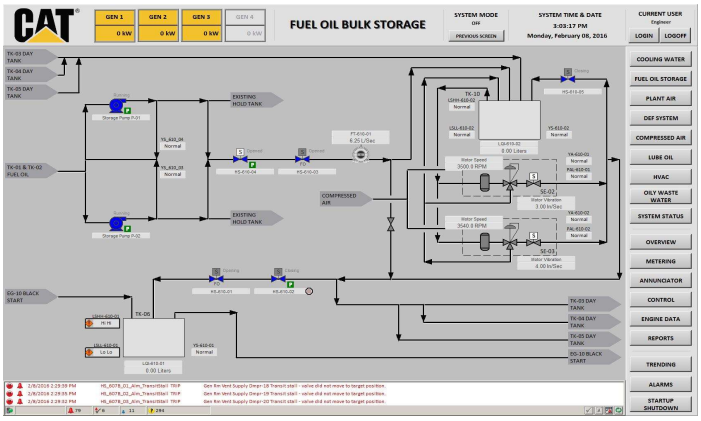
Regardless of what the project requires, Cat Switchgear can meet your needs. Some examples of Custom System one-line diagrams and layouts are on the following pages.



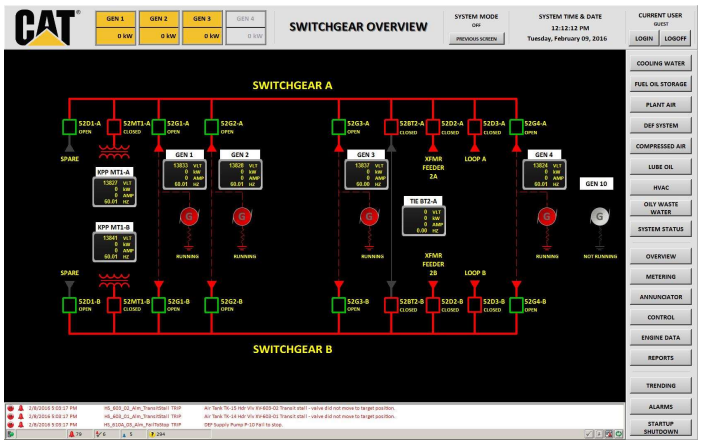
Example Custom CHP System Overview Screen



Example Custom Engine Data Screen



Example Custom Fuel Oil Screen



Example Custom Plant Overview Screen

Example Custom Applications

Examples of Custom One-Line Diagrams

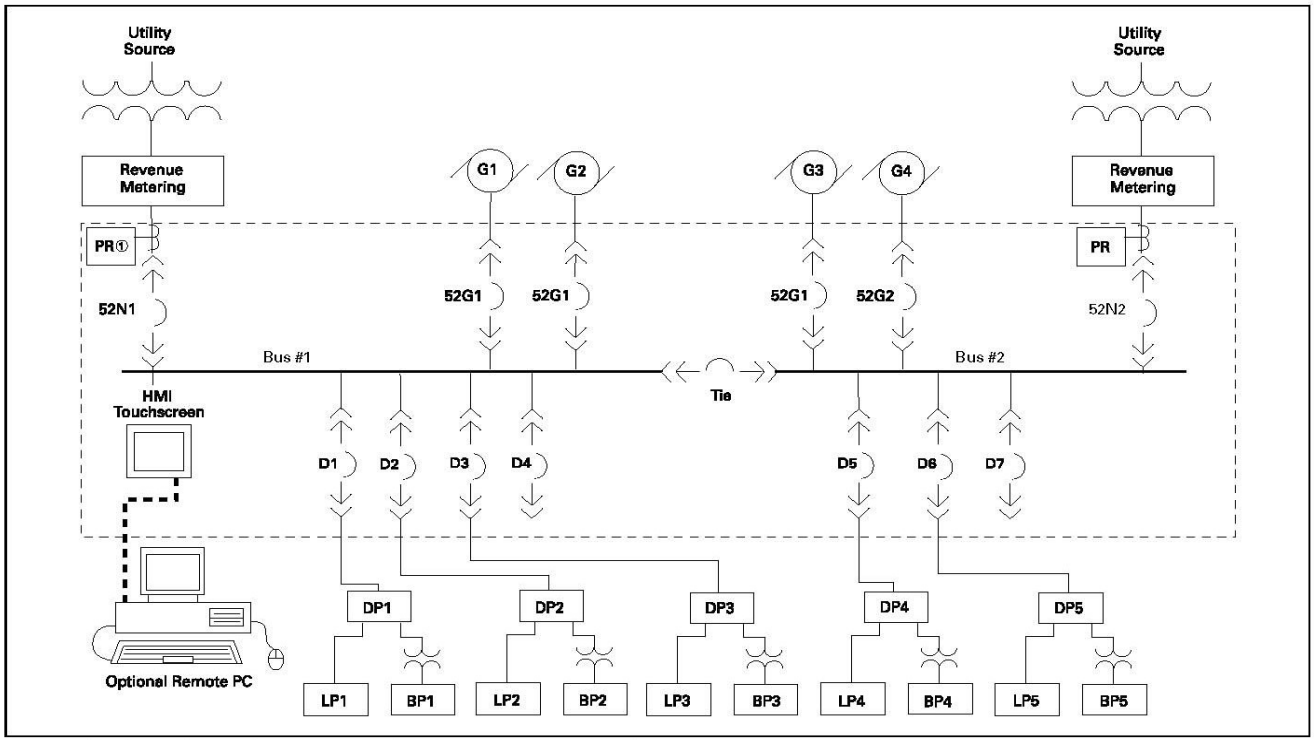


Figure 6.1 Low-Voltage Main-Generator-Tie-Generator-Main Switchgear with two Utility, Four Generators, and Two Generator bus ties

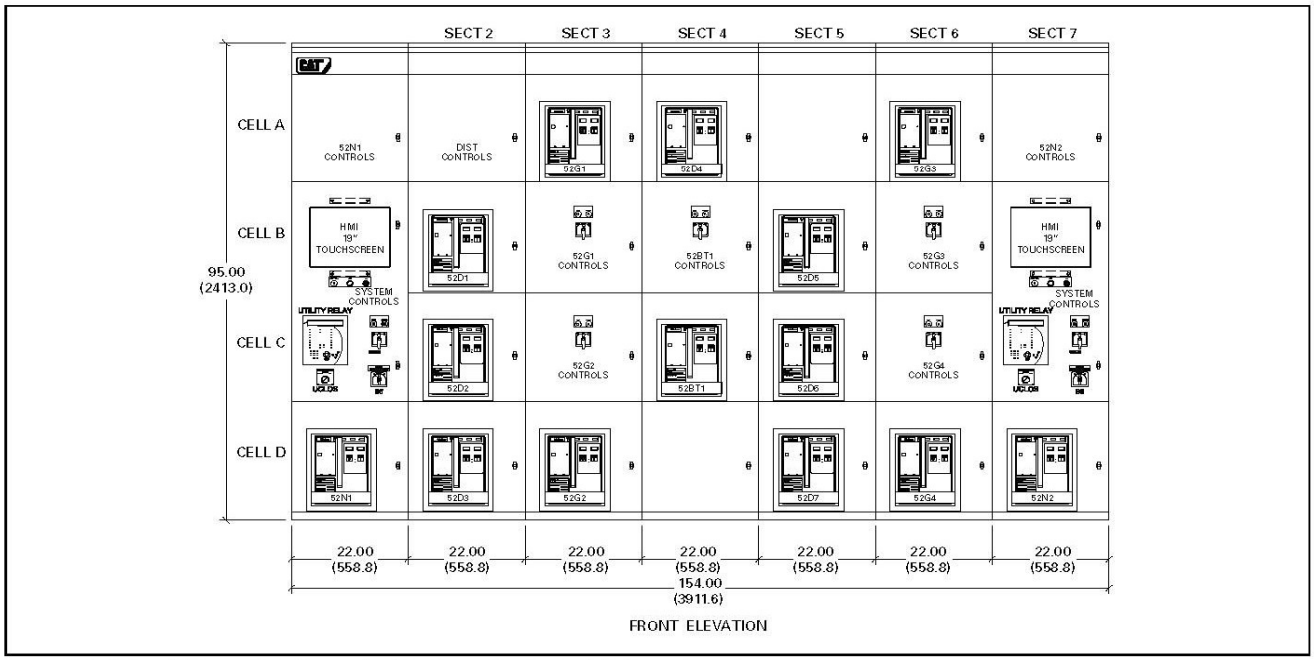


Figure 6.2 Low-Voltage Main-Generator-Tie-Generator-Main Switchgear Arrangement

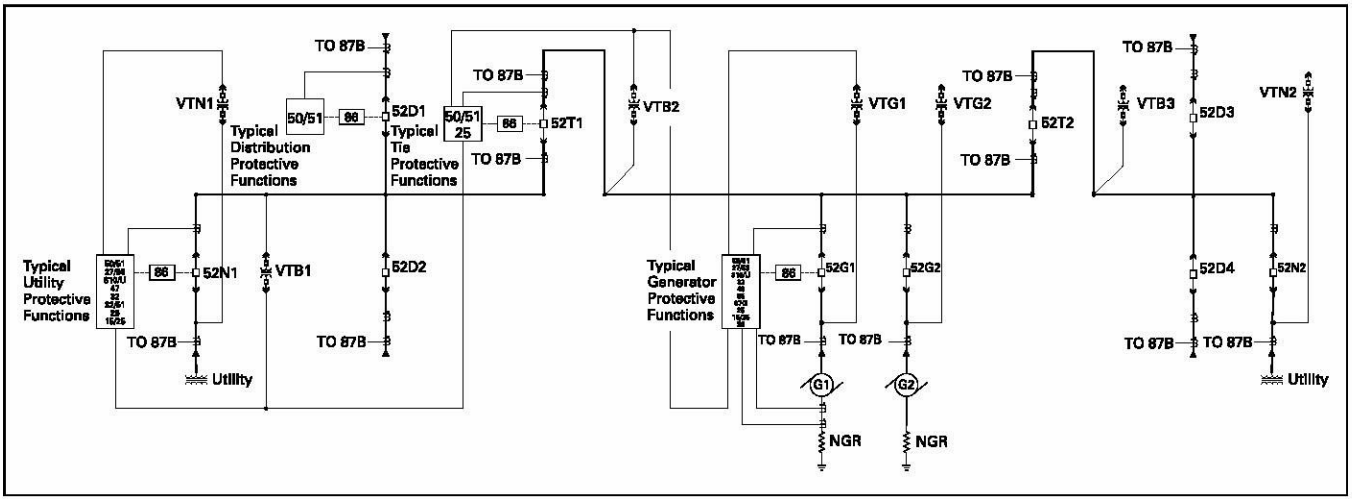


Figure 6.3 Medium-Voltage Main-Tie-Generator-Tie-Main Switchgear Switchgear (87B = Bus Differential Protection)

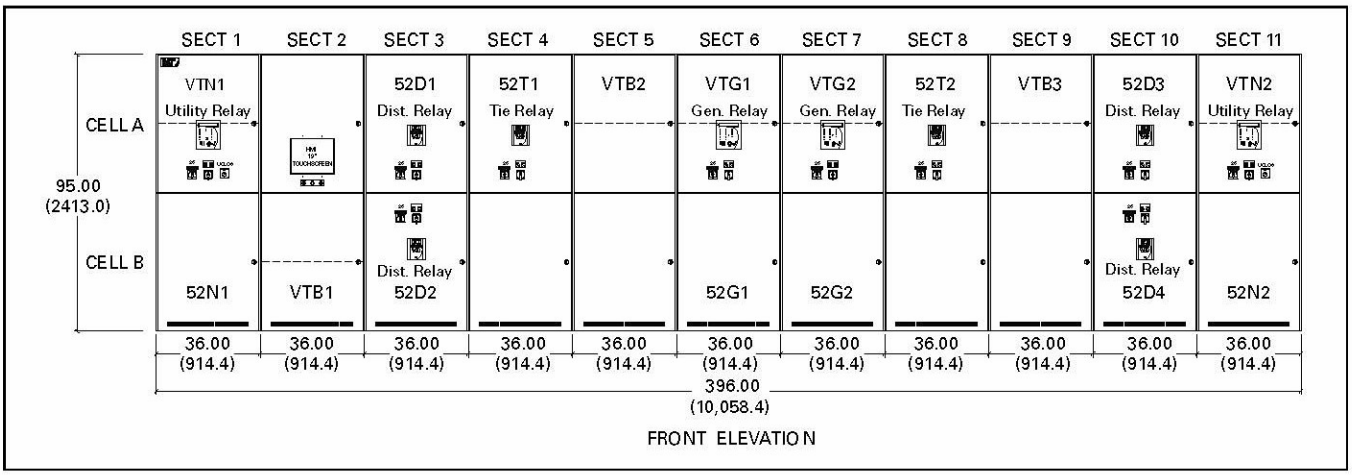


Figure 6.4 Medium-Voltage Main-Tie-Generator-Tie-Main Switchgear Arrangement

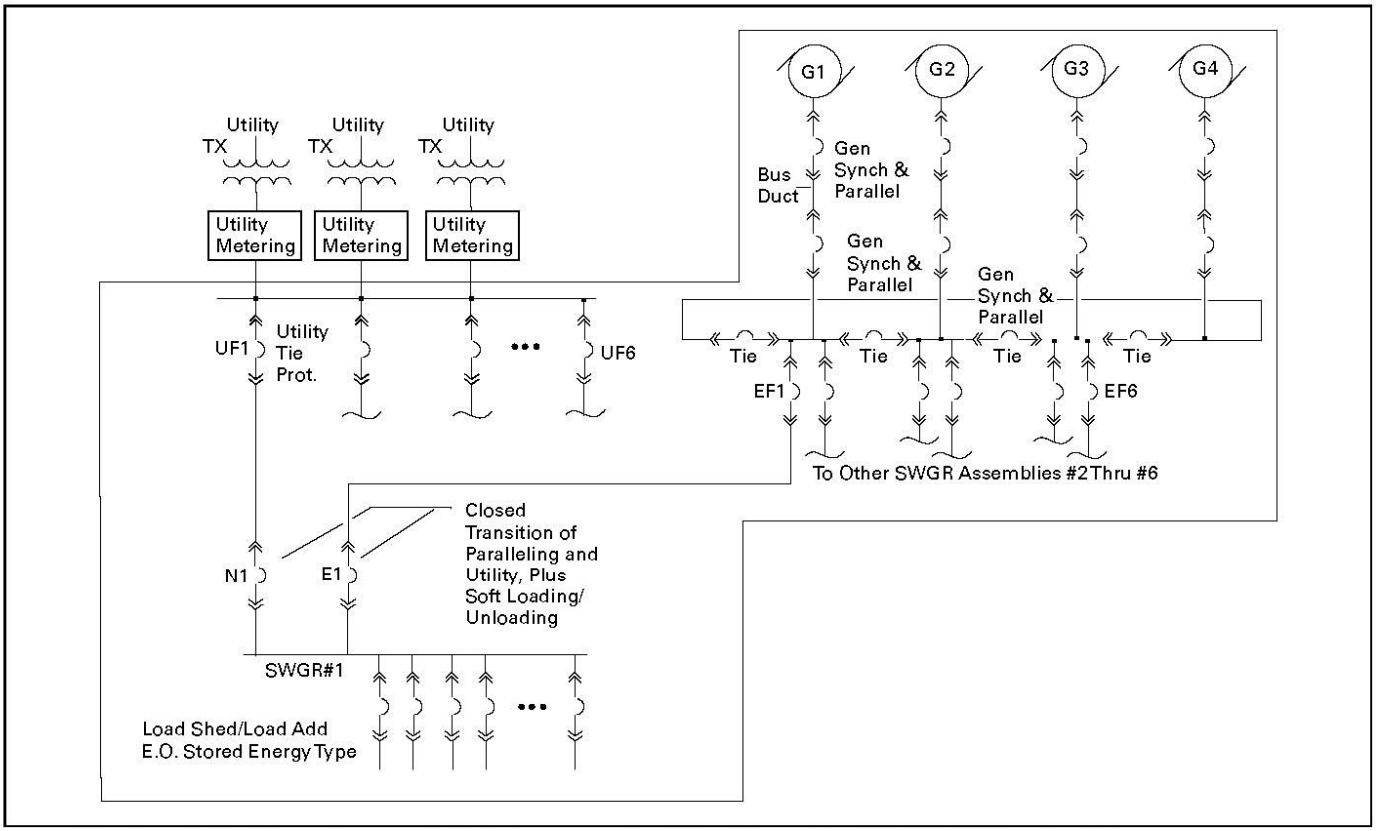


Figure 6.5 Large Critical Power System—Multiple Generators Closed Transition and Load Shed/Add (complex scheme)

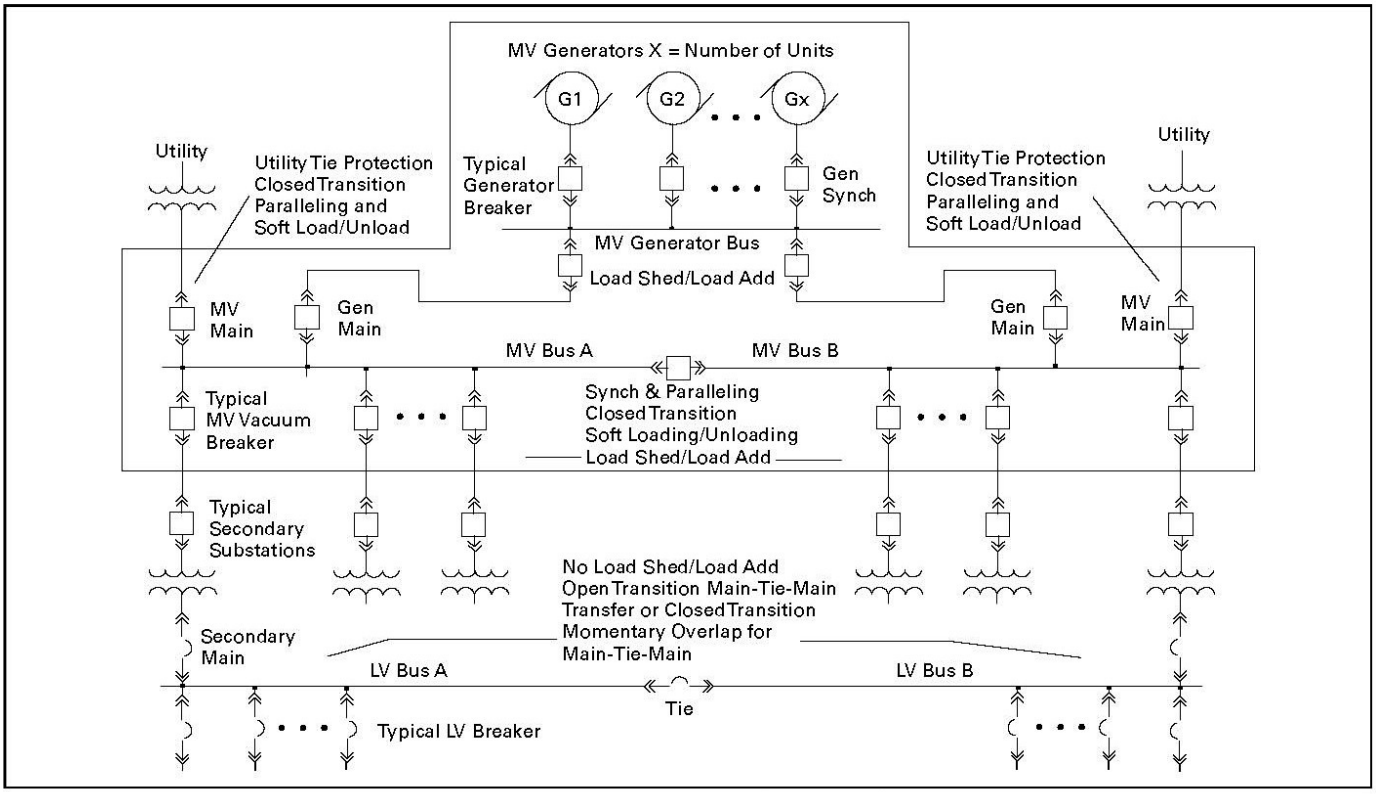


Figure 6.6 Large Critical Power System—Multiple Generators Closed Transition (Active Sync) and Load Shed/Add MVComplex Utility and Generator Paralleling System

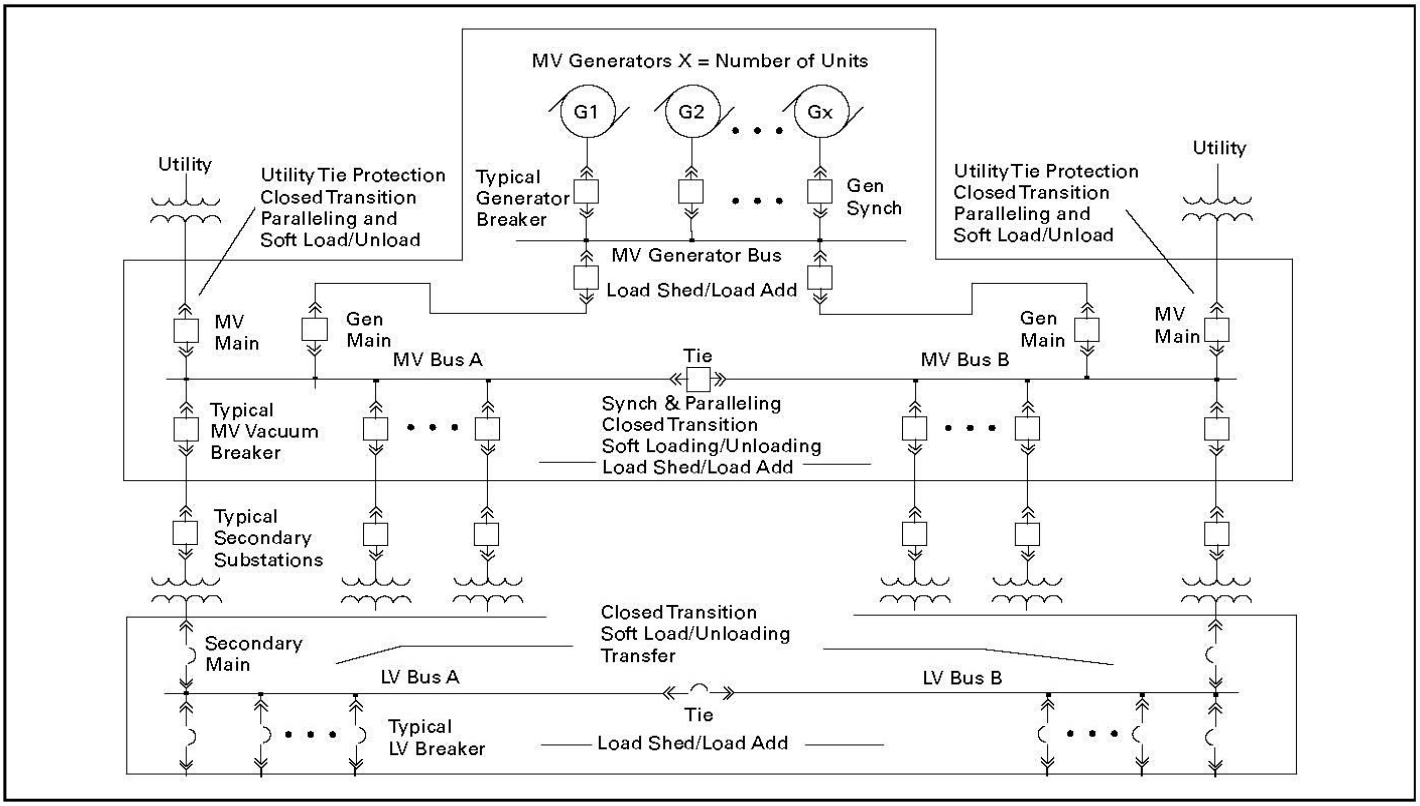


Figure 6.7 Large Critical Power System—Multiple Generators MV/LV Closed Transition and MV/LV Load Shed/Add MV Complex Utility and Generator Paralleling System

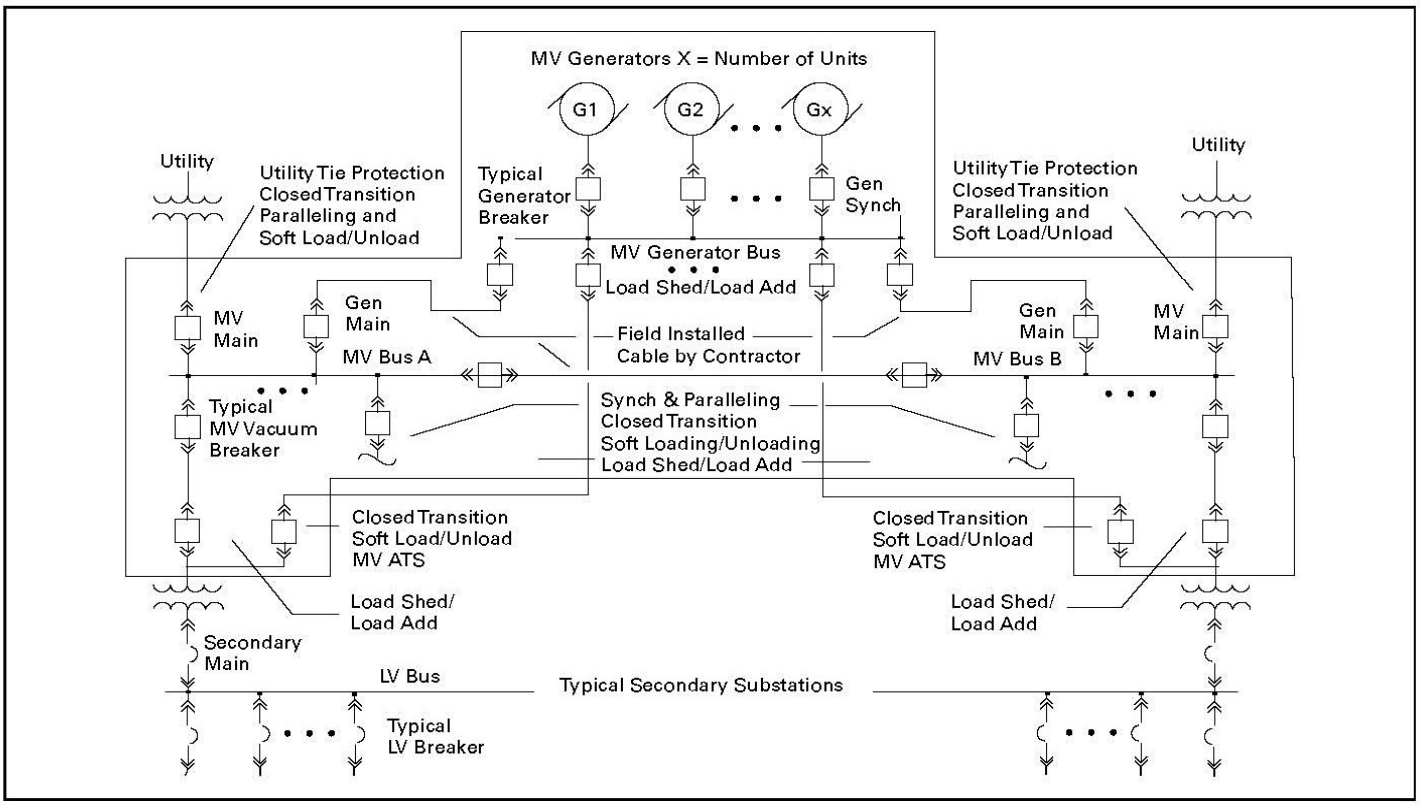


Figure 6.8 Large Critical Power System—Multiple Generators MV Only Closed Transition and MV/LV Load Shed/Add MV Complex Utility and Generator Paralleling System

Sample Arrangements

Low-Voltage Examples

Switchgear—One-Line Diagrams

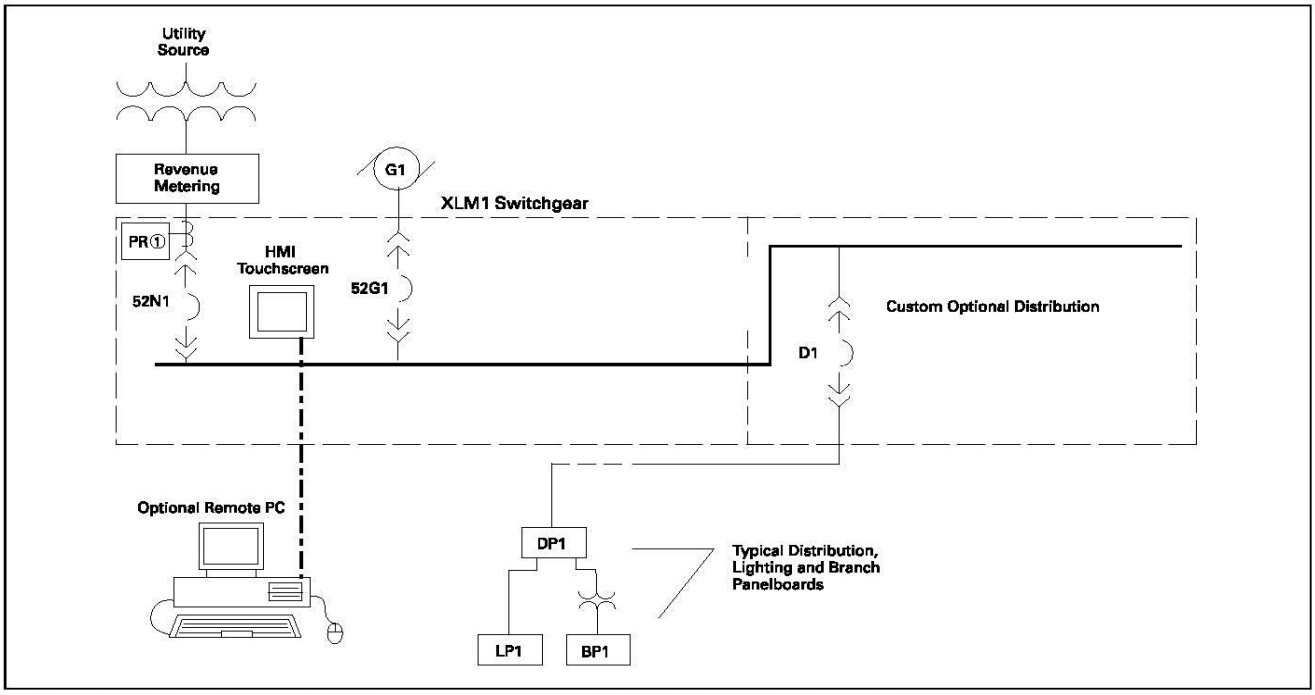
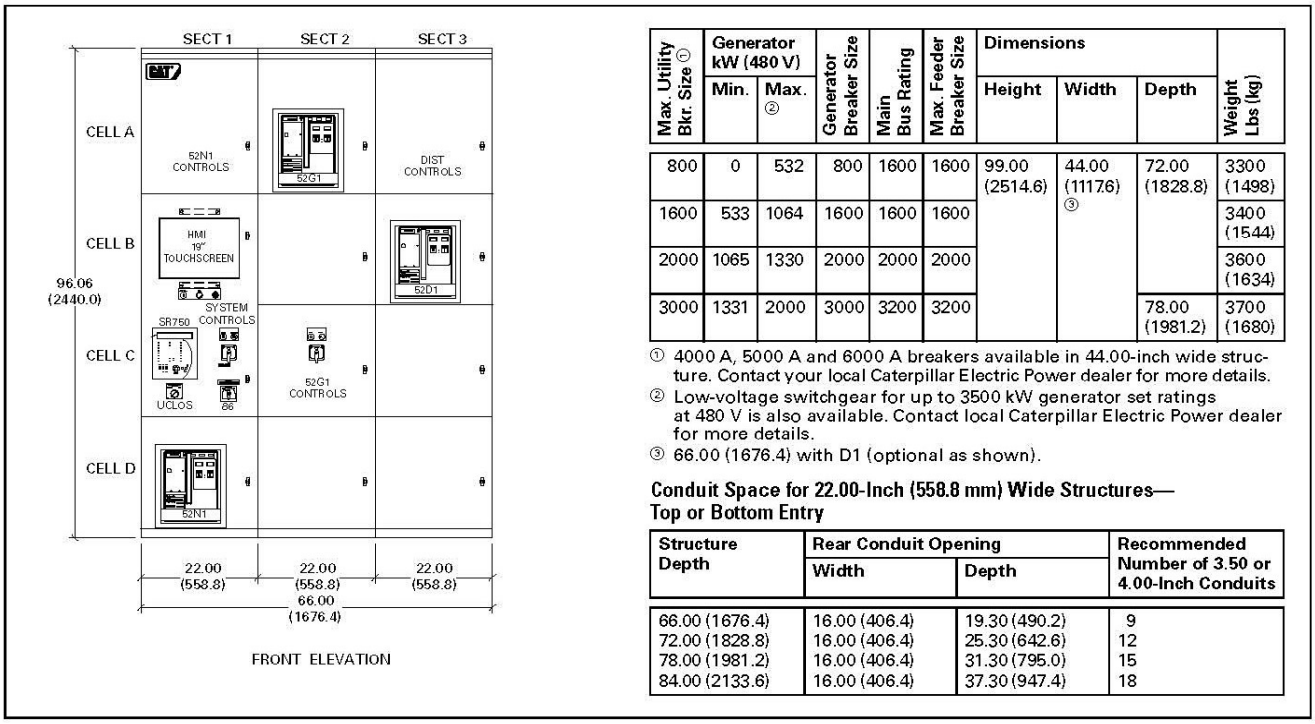


Figure 7.1 Typical Electrical System with XLM1 Switchgear (One Generator, One Utility)
PR = Protective Relay



Max. Utility Bkr. Size ①	Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Breaker Size	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)
800	0	532	800	1600	1600	99.00 (2514.6)	44.00 (1117.6) ③	72.00 (1828.8)	3300 (1498)
1600	533	1064	1600	1600	1600				3400 (1544)
2000	1065	1330	2000	2000	2000				3600 (1634)
3000	1331	2000	3000	3200	3200			78.00 (1981.2)	3700 (1680)

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.
② Low-voltage switchgear for up to 3500 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.
③ 66.00 (1676.4) with D1 (optional as shown).

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.2 XLM1 Low-Voltage Switchgear Layout (UL1558)

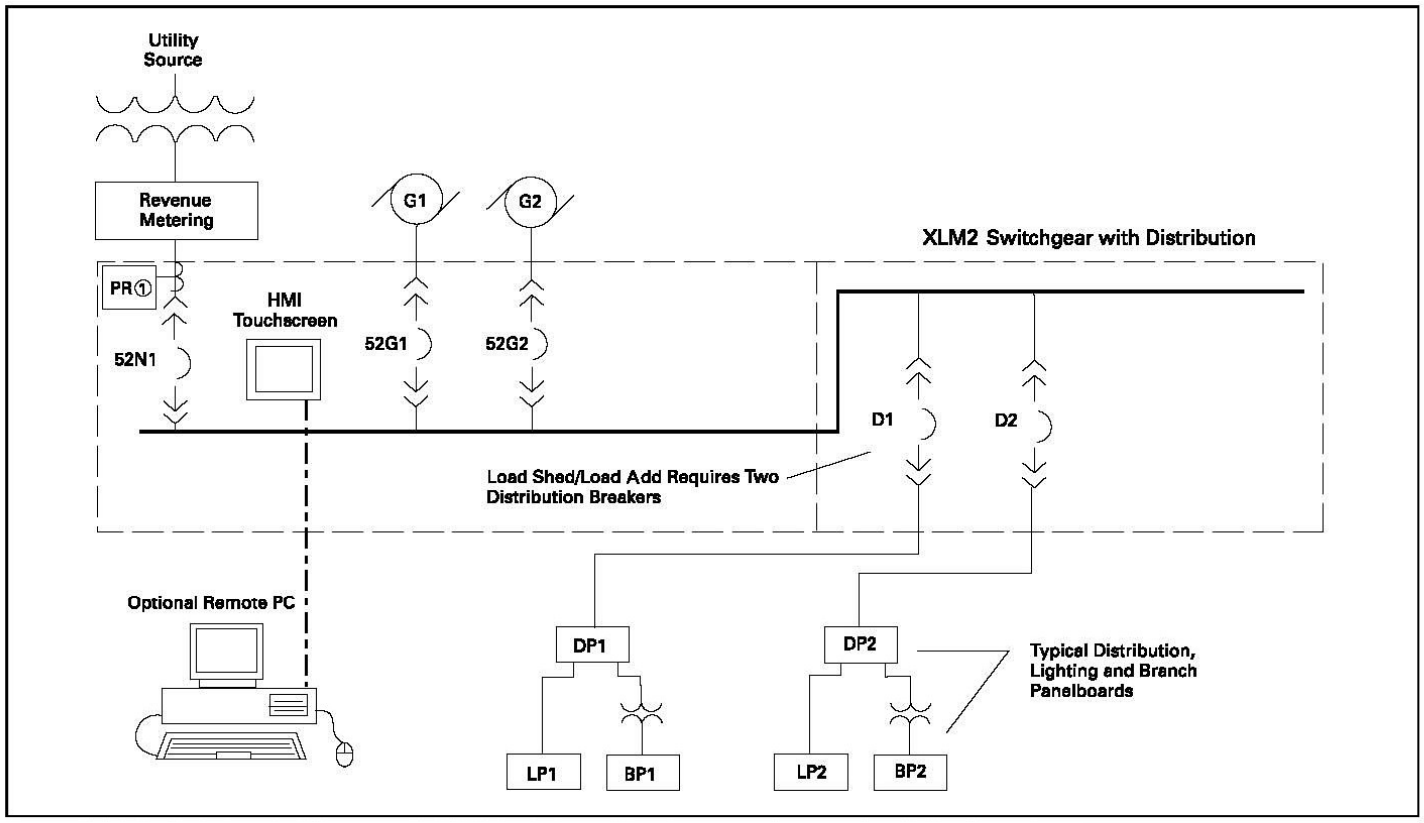
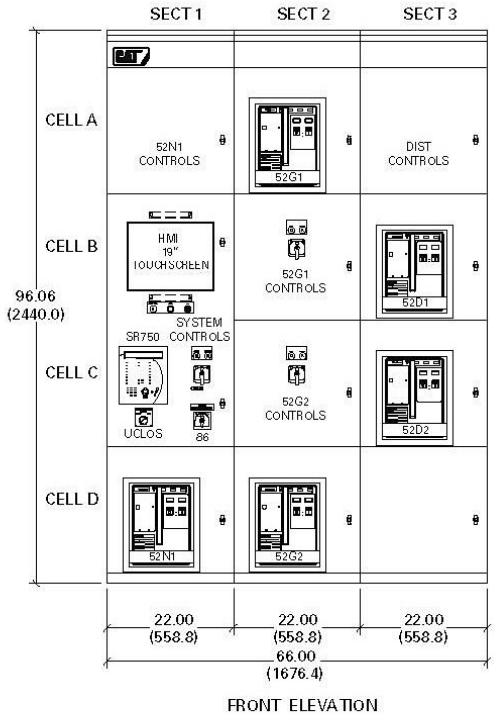


Figure 7.3 Typical Electrical System with XLM2 Switchgear (Two Generators, One Utility)
PR = Protective Relay



Max. Utility Bkr. Size ①	Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Breaker Size	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)
800	0	532	800	1600	1600	99.00 (2514.6)	66.00 (1676.4)	72.00 (1828.8)	5000 (2270)
1600	533	1064	1600	1600	1600				5200 (2361)
2000	1065	1330	2000	2000	2000				5600 (2542)
3000	1331	2000	3000	3200	3200			84.00 (2133.6)	5800 (2633)

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.
② Low-voltage switchgear for up to 3500 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.4 XLM2 Low-Voltage Switchgear Arrangement

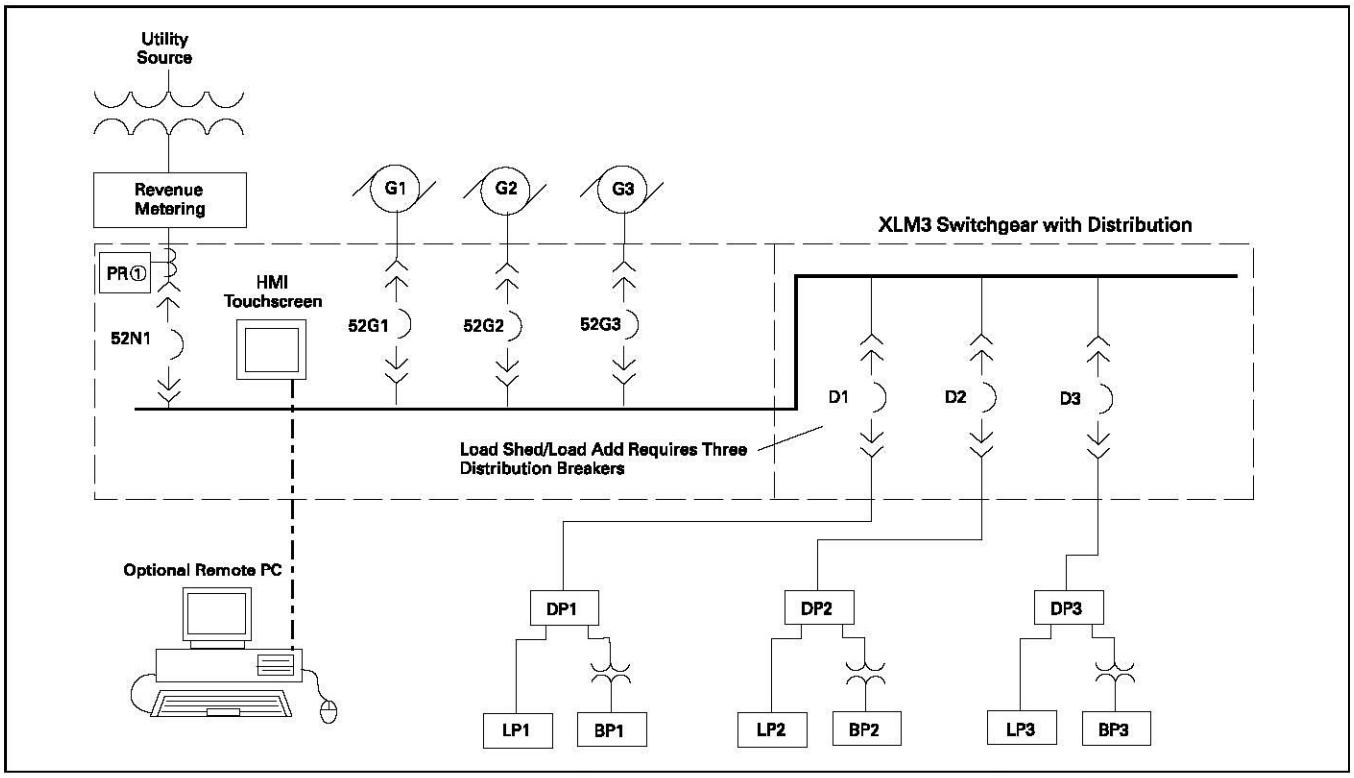
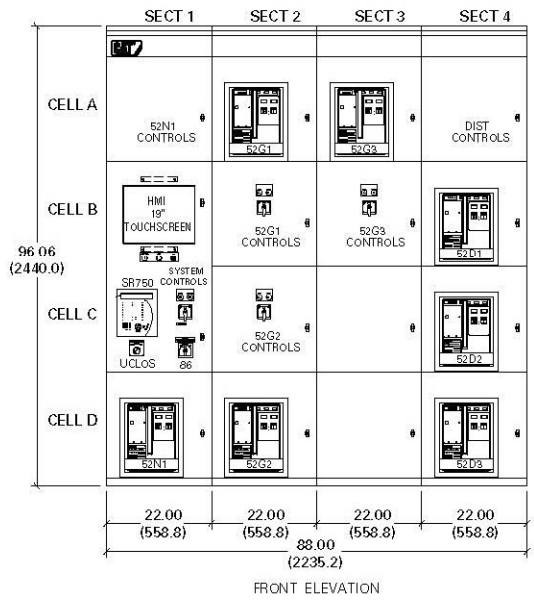


Figure 7.5 Typical Electrical System with XLM3 Switchgear (Three Generators, One Utility)
PR = Protective Relay



Max. Utility Bkr. Size ①	Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Breaker Size	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)
800	0	532	800	1600	1600	99.00 (2514.6)	88.00 (2235.2)	72.00 (1828.8)	7100 (3223)
1600	533	1064	1600	1600	1600				7300 (3314)
2000	1065	1330	2000	2000	2000				7700 (3496)
3000	1331	2000	3000	3200	3200			84.00 (2133.6)	7800 (3541)

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.
② Low-voltage switchgear for up to 3500 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.6 Typical XLM3 Low-Voltage Switchgear Layout (UL1558)

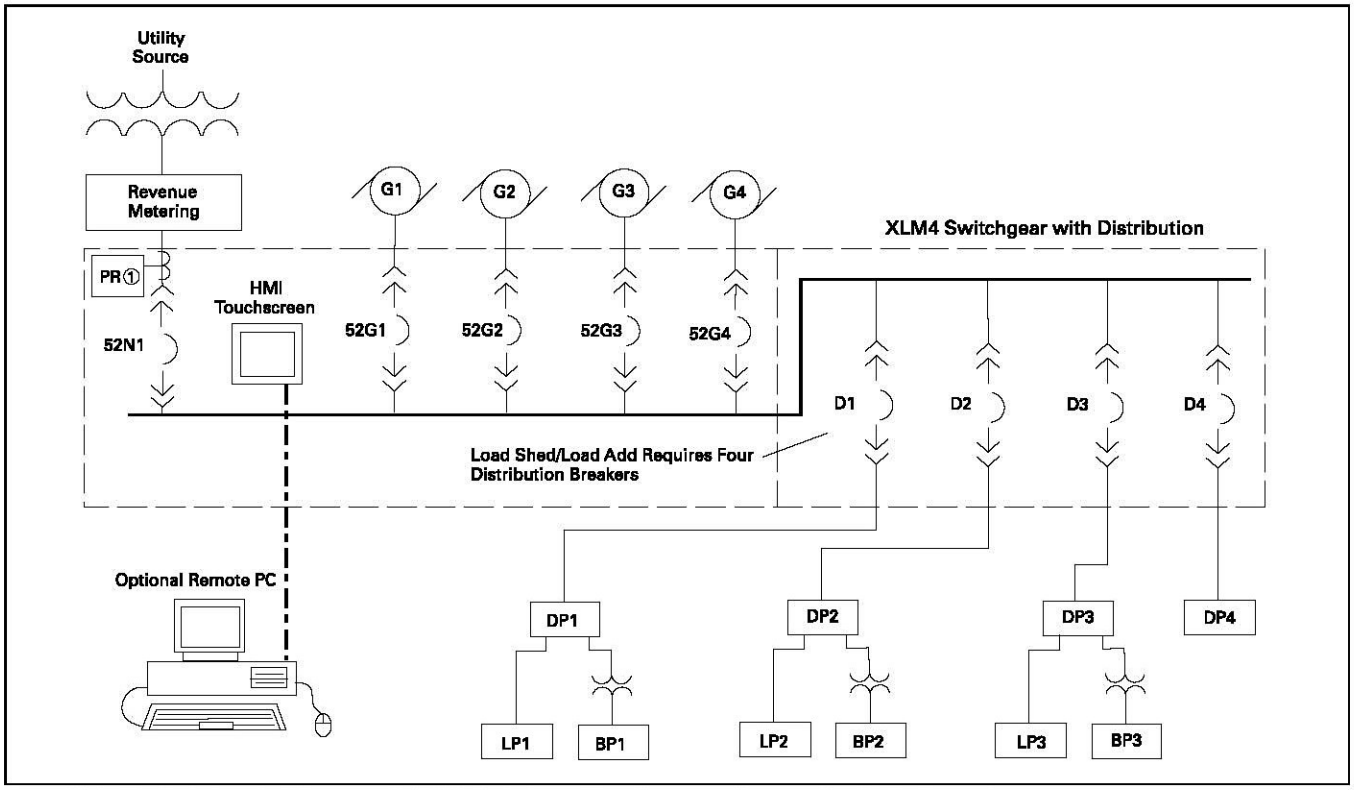
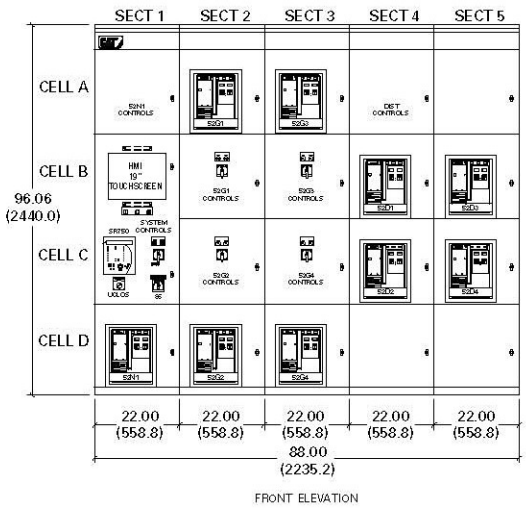


Figure 7.7 Typical Electrical System with XLM4 Switchgear (Four Generators, One Utility)
PR = Protective Relay



Max. Utility Bkr. Size ①	Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Breaker Size	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)
800	0	532	800	1600	1600	99.00 (2514.6)	110.00 (2794.0)	72.00 (1828.8)	9100 (4131)
1600	533	1064	1600	1600	1600				9300 (4222)
2000	1065	1330	2000	2000	2000				9500 (4313)
3000	1331	2000	3000	3200	3200			84.00 (2133.6)	9800 (4449)

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.
② Low-voltage switchgear for up to 3500 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.8 XLM4 Low-Voltage Switchgear Arrangement

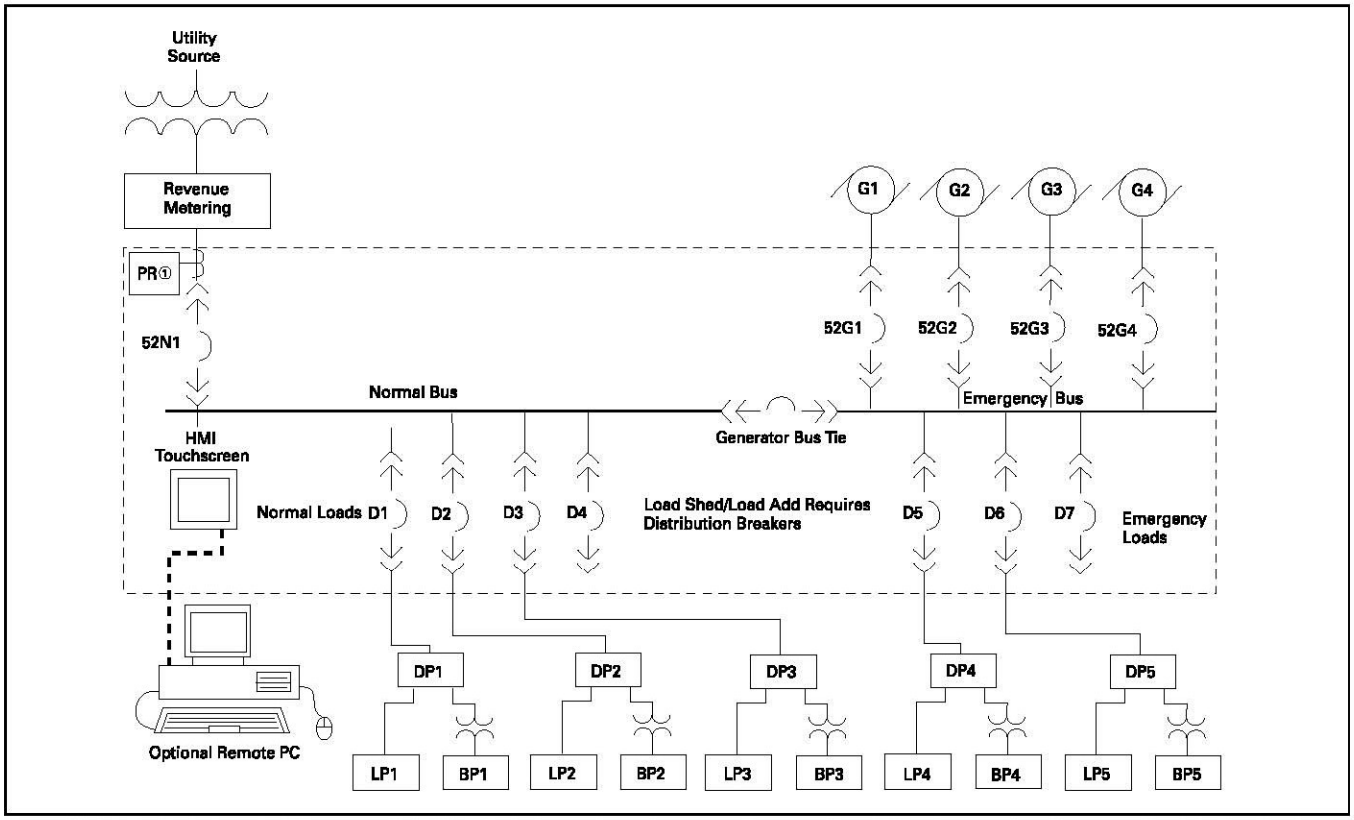
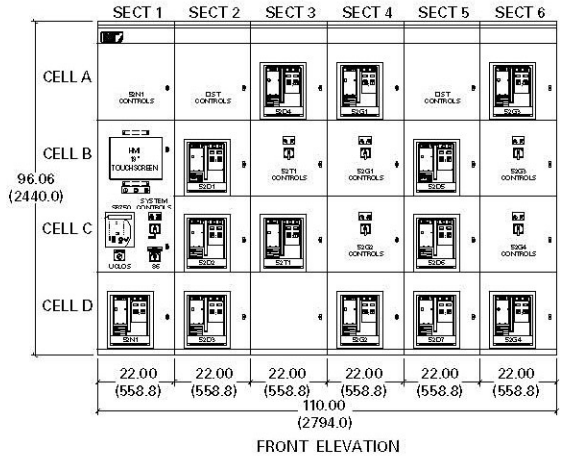


Figure 7.9 Typical Electrical System with XLMT4 Switchgear (Four Generators, One Utility, One Generator Bus Tie)

① PR = Protective Relay.



Max. Utility Bkr. Size ①	Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Breaker Size	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)
800	—	532	800	1600	800	99.00 (2514.6)	132.00 (3352.8)	72.00 (1828.8)	9100 (4131)
1600	—	1064	1600	1600	1600			78.00 (1981.2)	9300 (4222)
2000	—	1330	2000	2000	2000			84.00 (2133.6)	9500 (4313)
3000	—	2000	3000	3200	3200				9800 (4449)

① 4000 A, 5000 A, and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.
② Low-voltage switchgear for up to 3500 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.10 XLMT4 Low-Voltage Switchgear Arrangement

EGP2 Switchgear—One-Line Diagrams

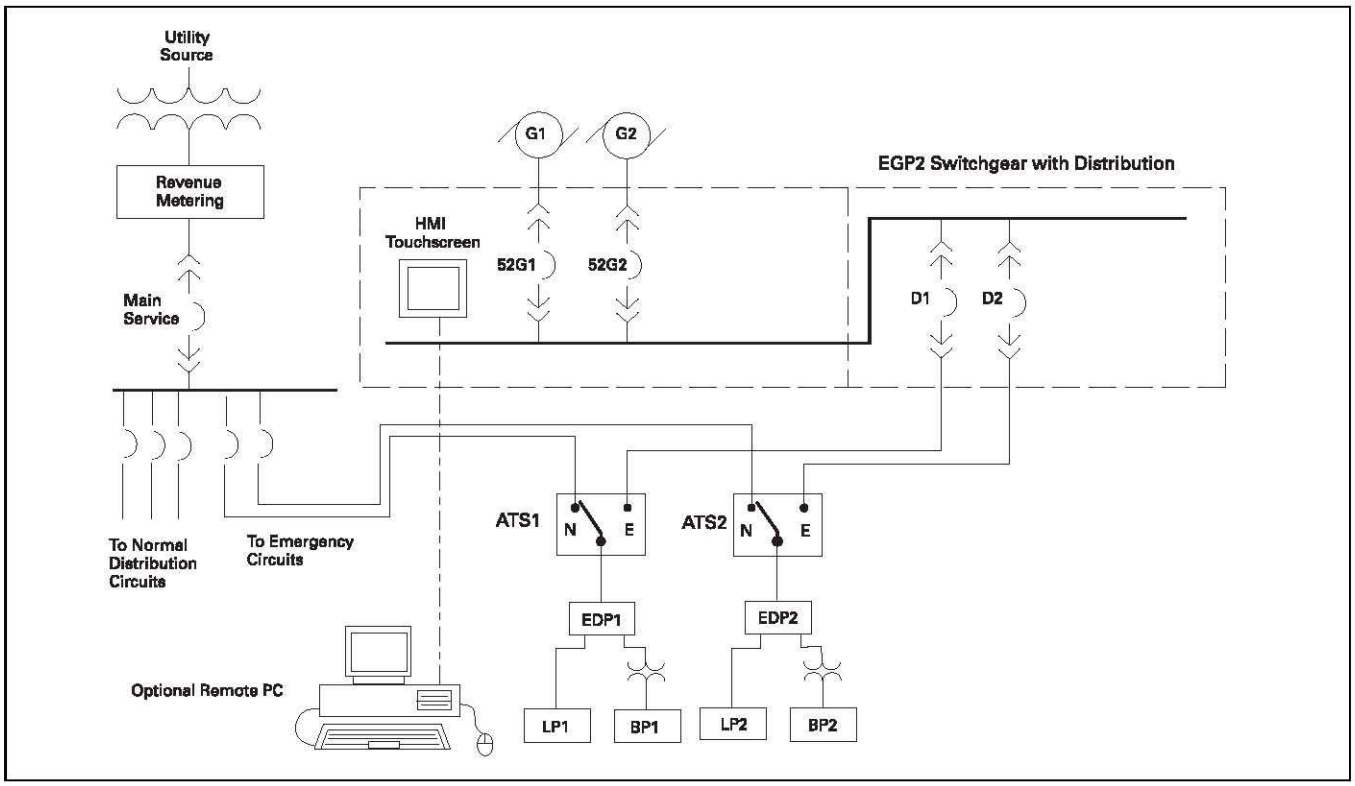
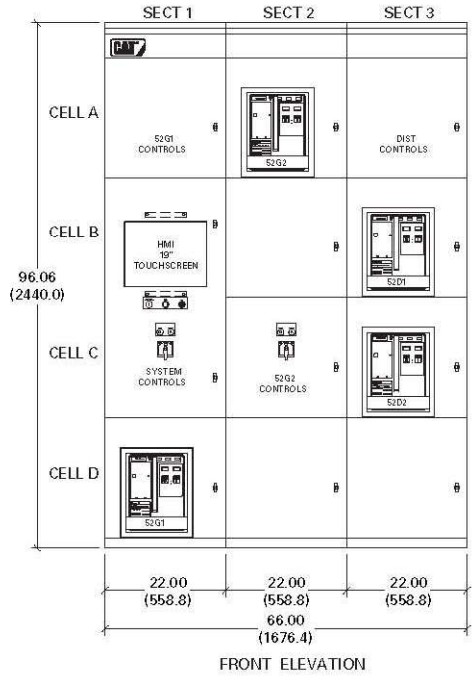


Figure 7.11 Typical Electrical System with EGP2 (Two Generators)



Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Breaker Size ①	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)
0	532	800	1600	1600	99.00 (2514.6)	66.00 (1676.4)	72.00 (1828.8)	5000 (2270)
533	1064	1600	3200	3200				5100 (2315)
1065	1330	2000	4000	3200				5300 (2406)
1331	2000	3000	6000	3200			84.00 (2133.6)	5500 (2497)

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.

② Low-voltage switchgear for up to 4000 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.12 EGP2 Low-Voltage Switchgear Arrangement

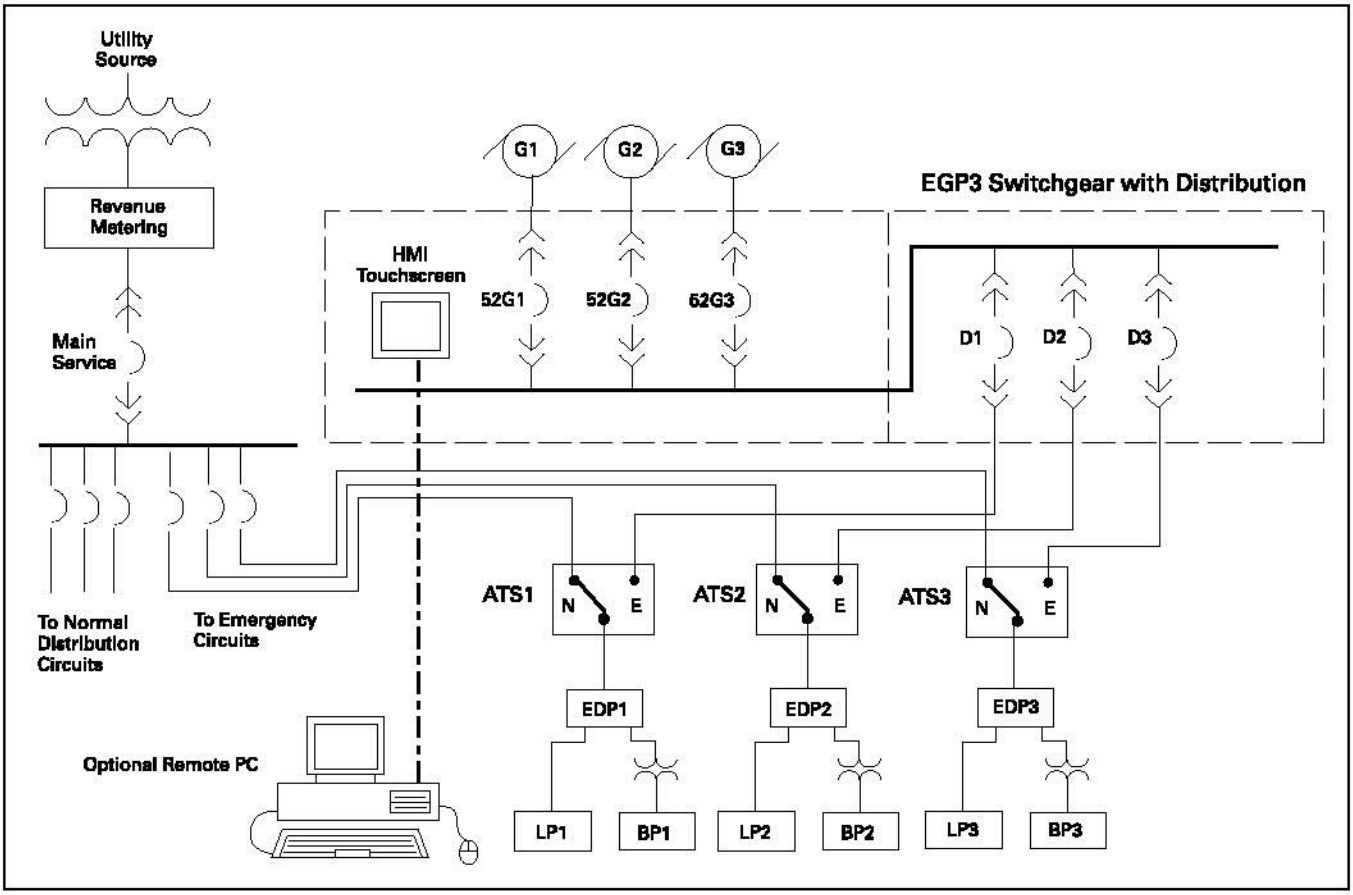
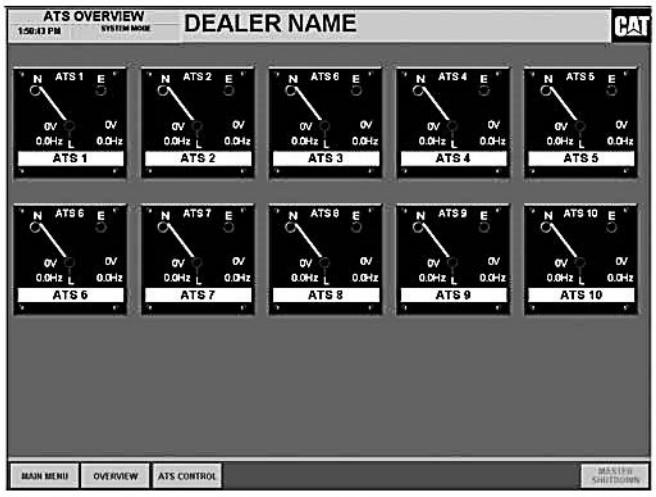
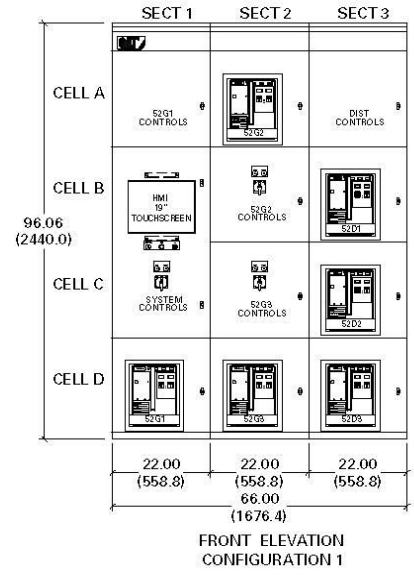


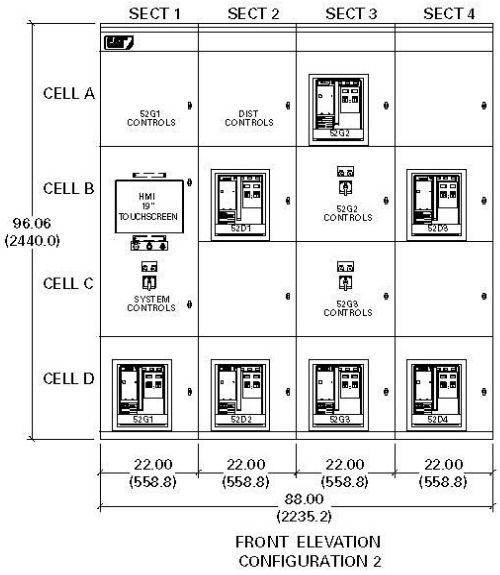
Figure 7.13 Typical Electrical System with EGP3 and multiple ATS (Three Generators)



ATS Overview Screen



FRONT ELEVATION
CONFIGURATION 1



FRONT ELEVATION
CONFIGURATION 2

Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Bkr. Size ①	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)	Configuration Number
0	532	800	3200	1600	99.00 (2514.6)	66.00 (1676.4)	84.00 (2133.6)	7000 (3178)	1
533	1064	1600	5000	2000				7050 (3201)	1
533	1064	1600	4000	3200		88.00 (2235.2)		7500 (3405)	2
1065	1330	2000	6000	2000		66.00 (1676.4)		7100 (3223)	1
1065	1330	2000	4000	3200		88.00 (2235.2)		7600 (3450)	2
1331	2000	3000	6000	2000		66.00 (1676.4)		7200 (3269)	1
1331	2000	3000	6000	3200		88.00 (2235.2)		7800 (3541)	2

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.

② Low-voltage switchgear for up to 4000 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.14 EGP3 Low-Voltage Switchgear Arrangement

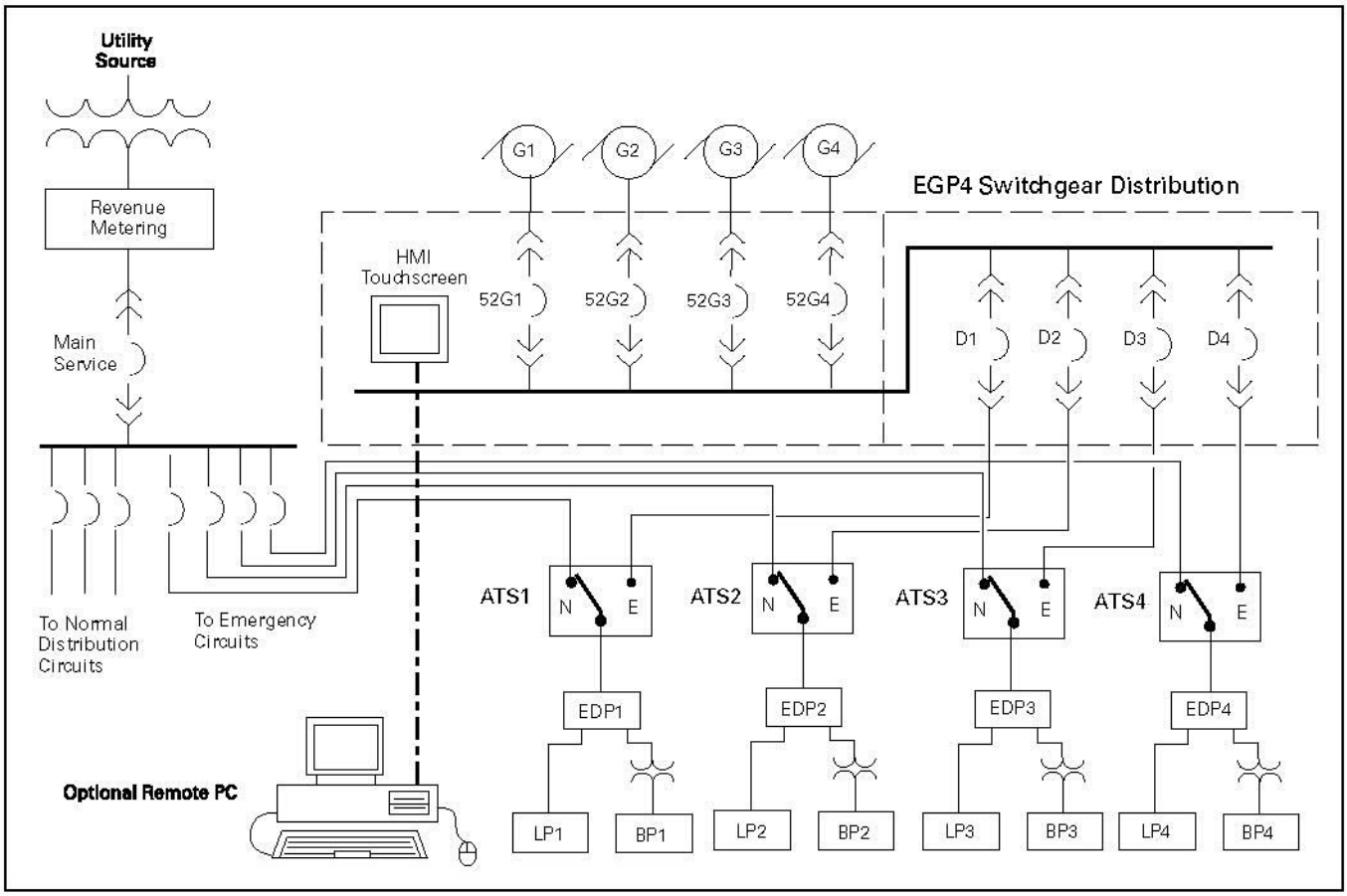
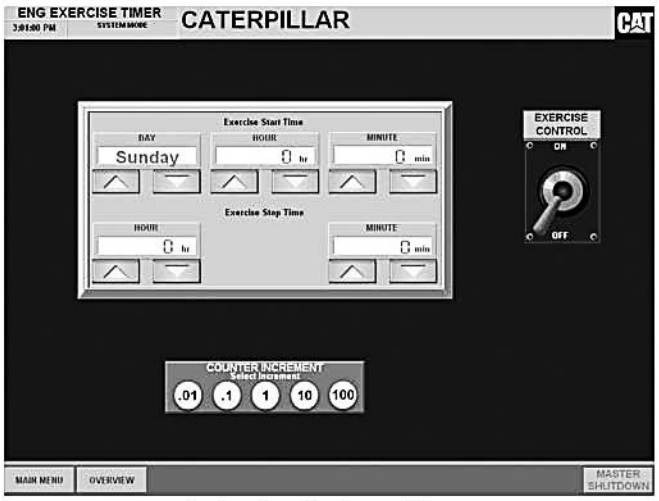
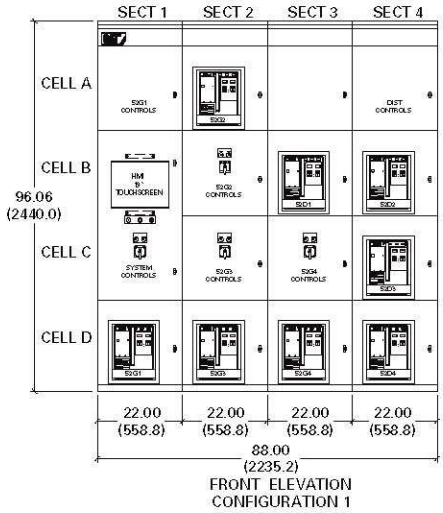


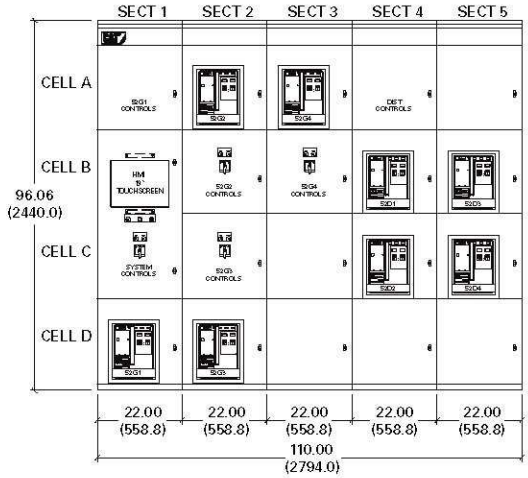
Figure 7.15 Typical Electrical System with EGP4 and multiple ATS (Four Generators)



Engine Exercise Control Screen



FRONT ELEVATION
CONFIGURATION 1



FRONT ELEVATION
CONFIGURATION 2

Generator kW (480 V) Min.	Generator kW (480 V) Max. ②	Generator Bkr. Size ①	Main Bus Rating	Max. Feeder Breaker Size	Dimensions Height	Dimensions Width	Dimensions Depth	Weight Lbs (kg)	Configuration Number
0	532	800	3200	1600	99.00 (2514.6)	88.00 (2235.2)	78.00 (1981.2)	7800 (3541)	1
533	1064	1600	5000	2000				7950 (3609)	1
533	1064	1600	4000	3200		110.0 (279.4)	84.00 (2133.6)	9500 (4313)	2
1065	1330	2000	6000	2000		88.00 (2235.2)		8000 (3632)	1
1065	1330	2000	4000	3200		110.0 (279.4)		9600 (4358)	2
1331	2000	3000	6000	2000		88.00 (2235.2)		8200 (3723)	1
1331	2000	3000	6000	3200		110.0 (279.4)		9800 (4449)	2

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.

② Low-voltage switchgear for up to 4000 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening Width	Rear Conduit Opening Depth	Recommended Number of 3.50 or 4.00-Inch Conduits
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.16 EGP4 Low-Voltage Switchgear Arrangement

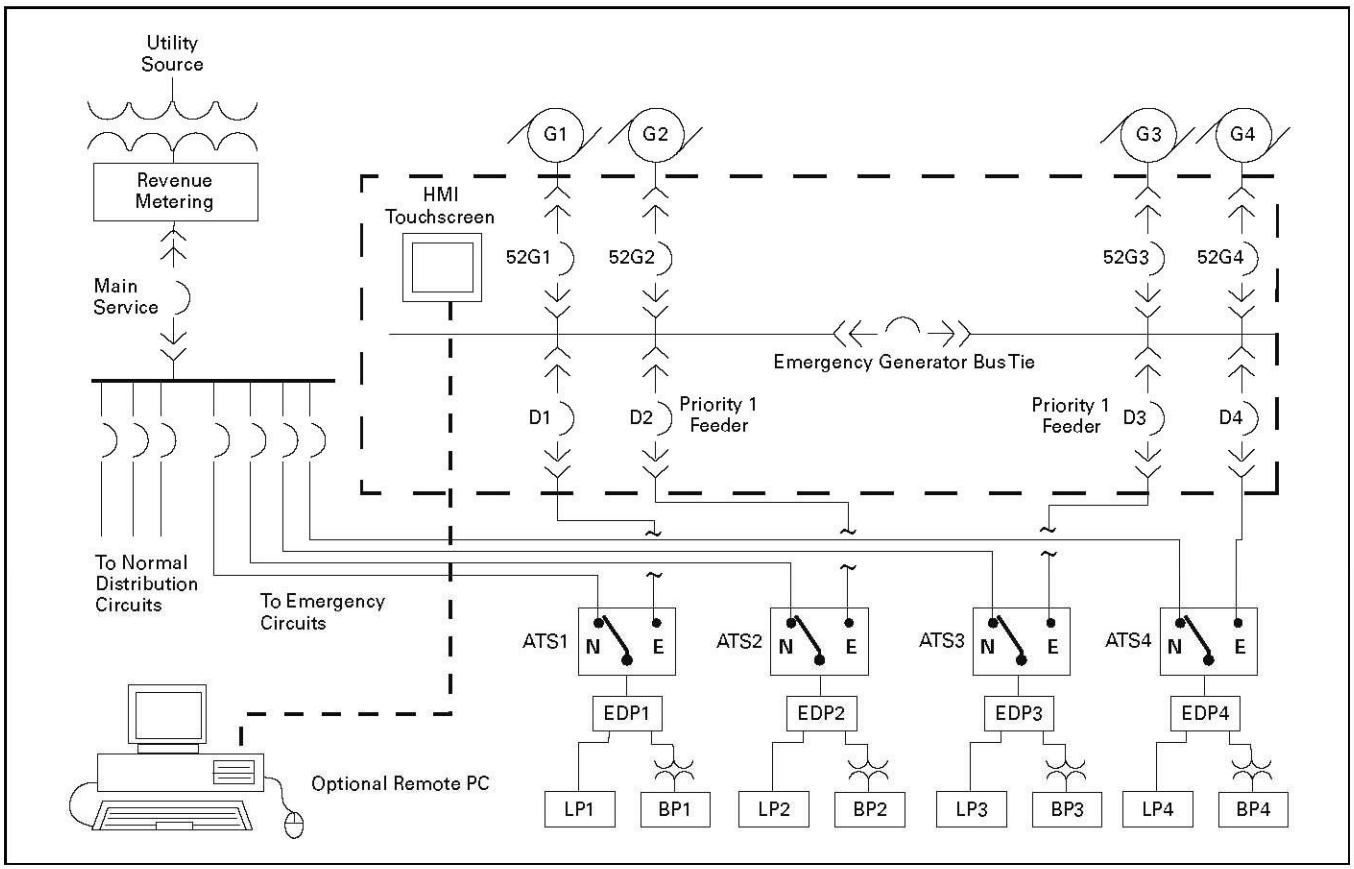
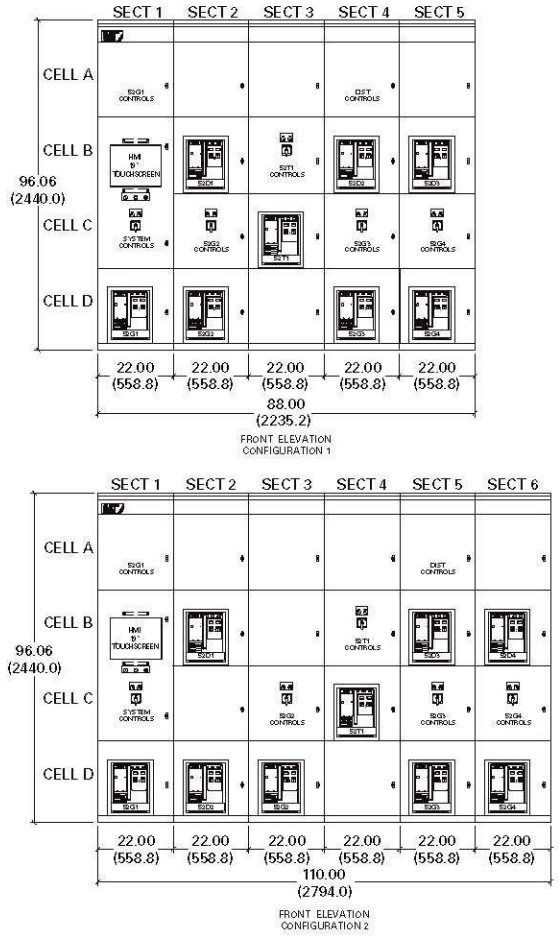


Figure 7.17 Typical Electrical System with EGPT4 and ATS Units (Four Generators, One Emergency Bus Tie)



Generator kW (480 V)		Generator Bkr. Size ①	Main Bus Rating	Max. Feeder Breaker Size	Dimensions			Weight Lbs (kg)	Configuration Number
Min.	Max. ②				Height	Width	Depth		
0	532	800	3200	1600	99.00 (2514.6)	110.00 (2794.0)	78.00 (1981.2)	7800 (3541)	1
533	1064	1600	5000	2000		132.00 (3352.8)		7950 (3609)	1
533	1064	1600	4000	3200			84.00 (2133.6)	9500 (4313)	2
1065	1330	2000	6000	2000		110.00 (2794.0)		8000 (3632)	1
1065	1330	2000	4000	3200		132.00 (3352.8)		9600 (4358)	2
1331	2000	3000	6000	2000		110.00 (2794.0)		8200 (3722)	1
1331	2000	3000	6000	3200		132.00 (3352.8)		9800 (4449)	2

① 4000 A, 5000 A and 6000 A breakers available in 44.00-inch wide structure. Contact your local Caterpillar Electric Power dealer for more details.

② Low-voltage switchgear for up to 4000 kW generator set ratings at 480 V is also available. Contact local Caterpillar Electric Power dealer for more details.

Conduit Space for 22.00-Inch (558.8 mm) Wide Structures—Top or Bottom Entry

Structure Depth	Rear Conduit Opening		Recommended Number of 3.50 or 4.00-Inch Conduits
	Width	Depth	
66.00 (1676.4)	16.00 (406.4)	19.30 (490.2)	9
72.00 (1828.8)	16.00 (406.4)	25.30 (642.6)	12
78.00 (1981.2)	16.00 (406.4)	31.30 (795.0)	15
84.00 (2133.6)	16.00 (406.4)	37.30 (947.4)	18

Figure 7.18 EGPT4 Low-Voltage Switchgear Arrangement

Medium-Voltage Examples

Cat XLM Switchgear—One-Line Diagrams

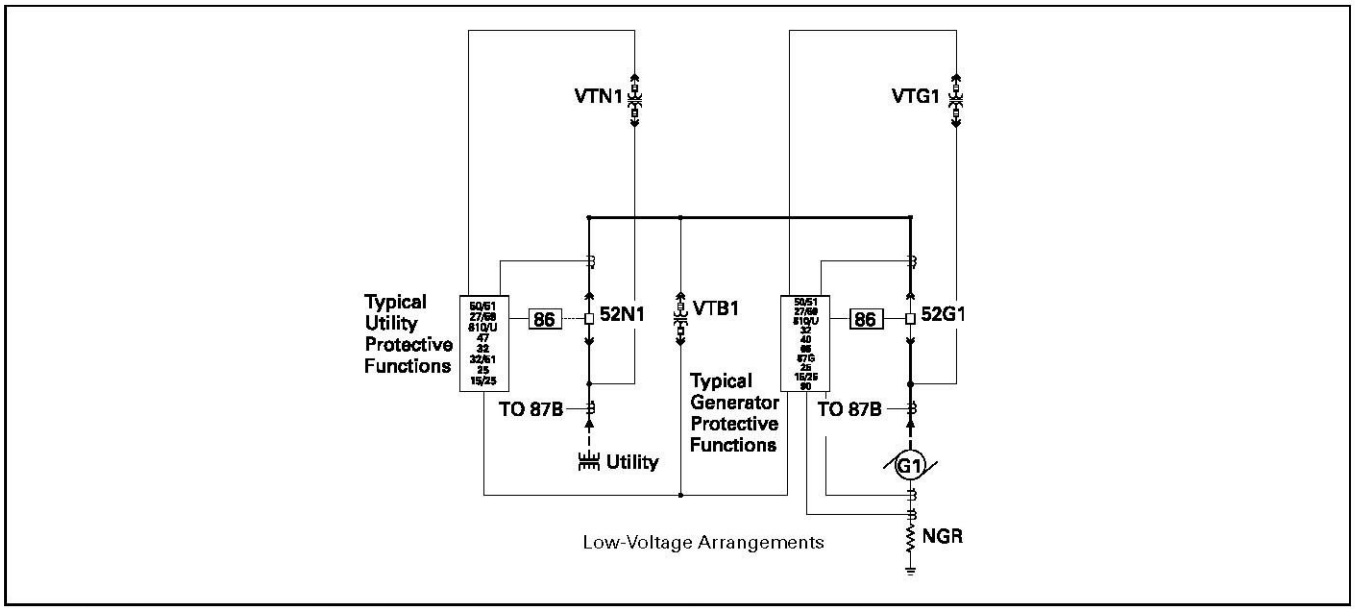


Figure 7.19 Medium-Voltage XLM1 (One Generator, One Utility Source)
Notes: For Multiple Utility Sources, see Custom Systems Section 6) (87B = Bus Differential Protection if applicable)

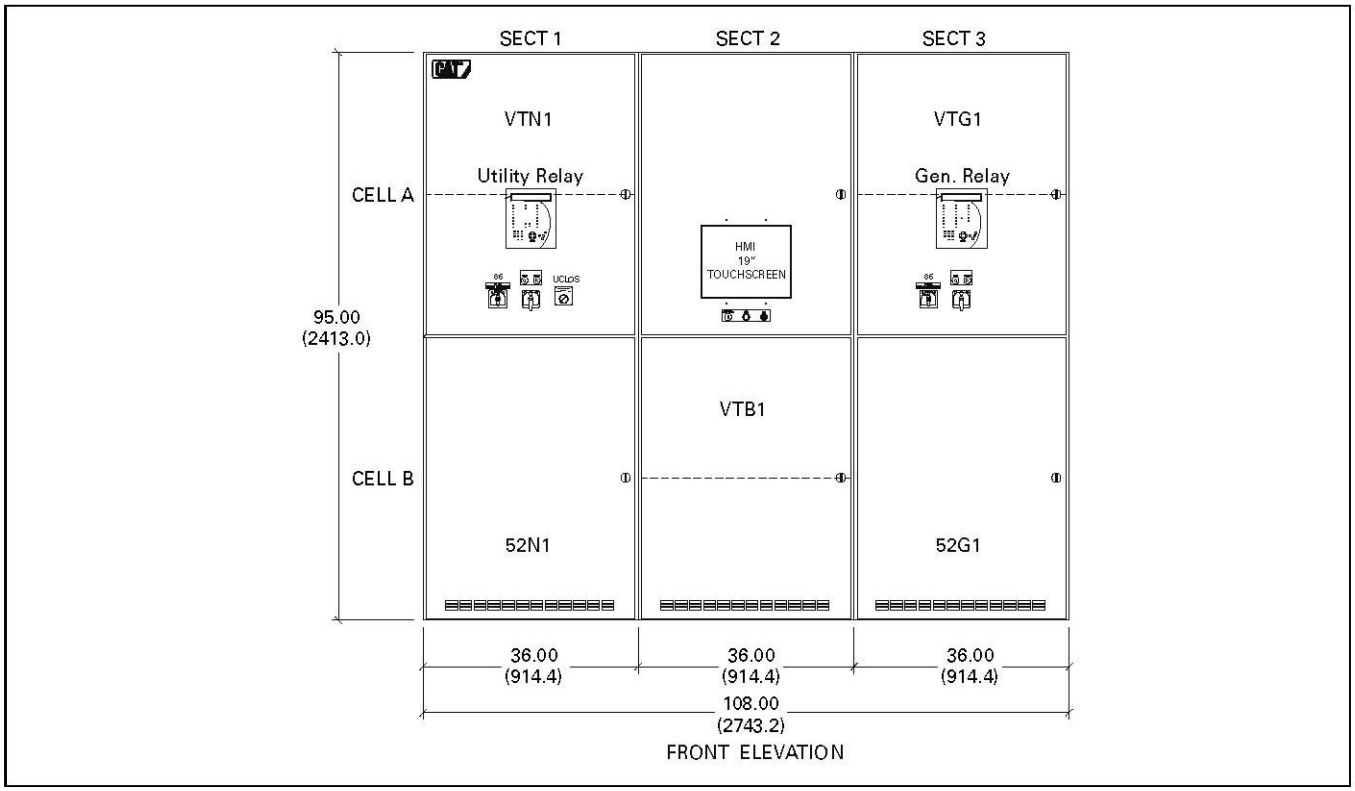


Figure 7.20 5/15 kV XLM1 Switchgear Arrangement
Note: All Structures are 96.25 inches (2445mm) deep
Note: See Figure 7.27 and 7.28 for typical distribution structure layouts

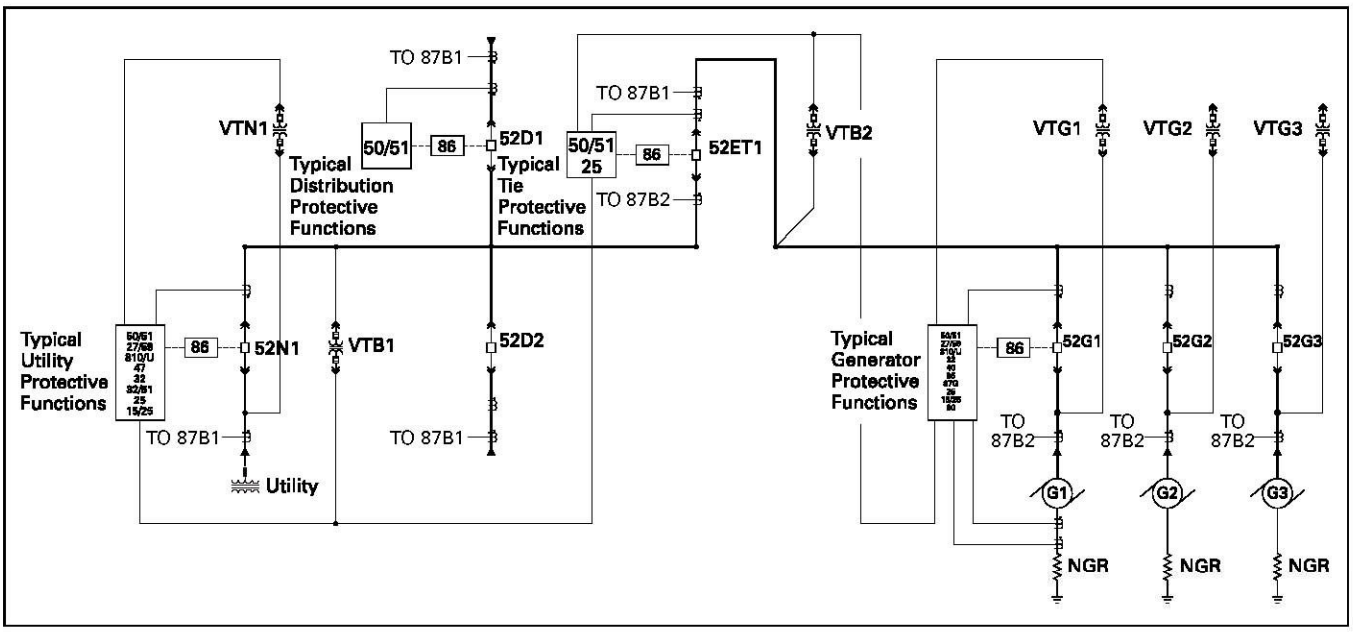


Figure 7.21 Medium-Voltage XLMT3 (Three Generator, One Utility, One Generator Tie Breaker)
Notes: For Multiple Utility Sources, see Custom Systems Section 6) (87B = Bus Differential Protection if applicable)

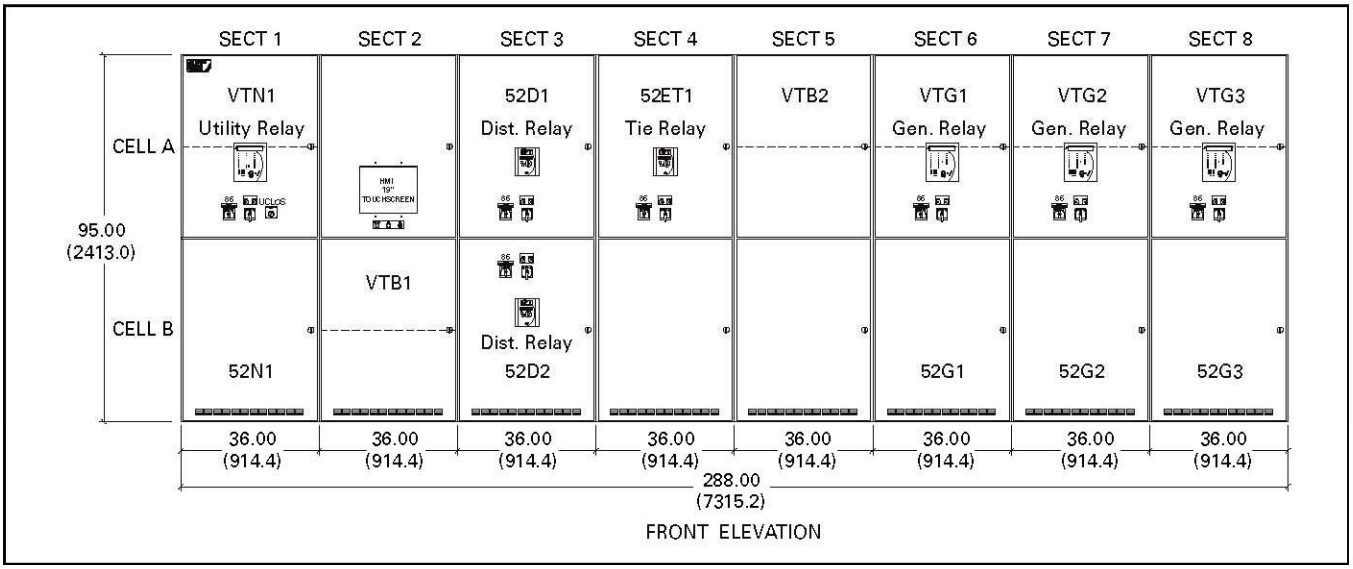


Figure 7.22 5/15 kV XLMT3 Switchgear Arrangement
Note: All Structures are 96.25 inches (2445mm) deep
Note: See Figure 7.27 and 7.28 for typical distribution structure layouts

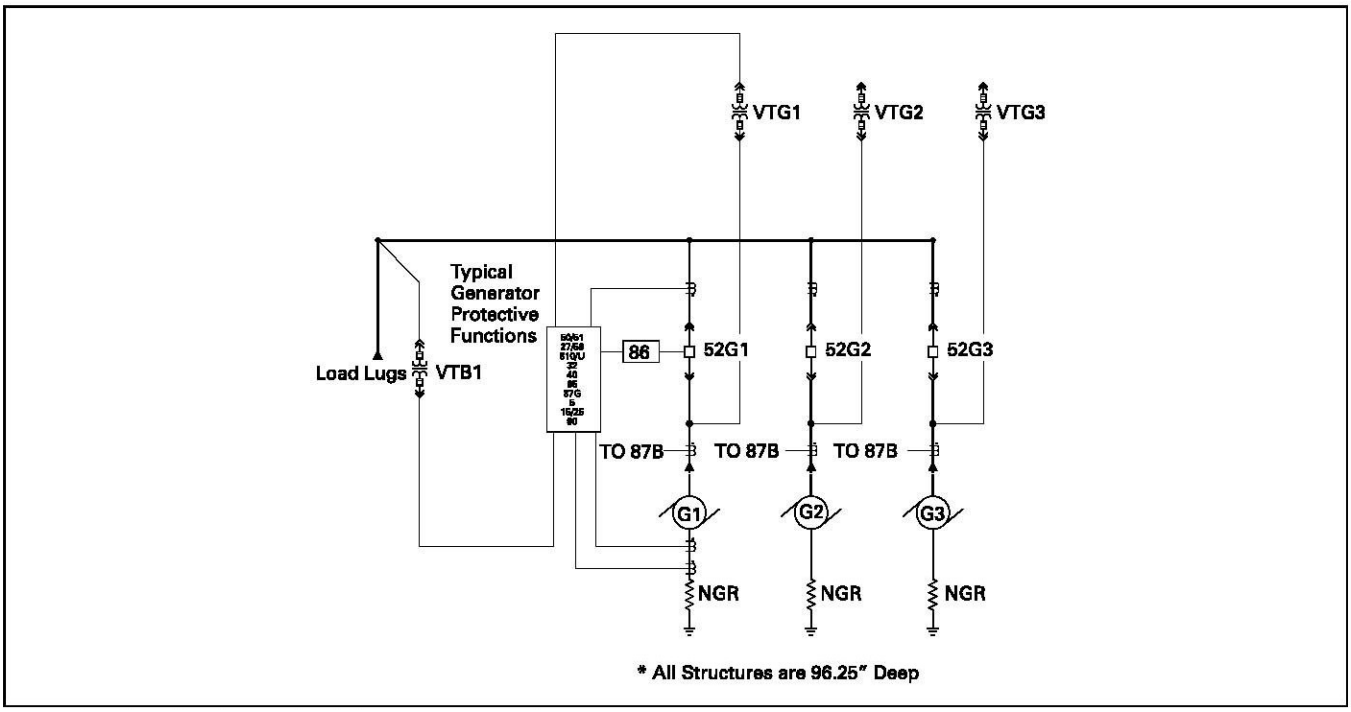


Figure 7.23 Medium-Voltage EGP3 (Three Generator)
Notes: (87B = Bus Differential Protection if applicable)

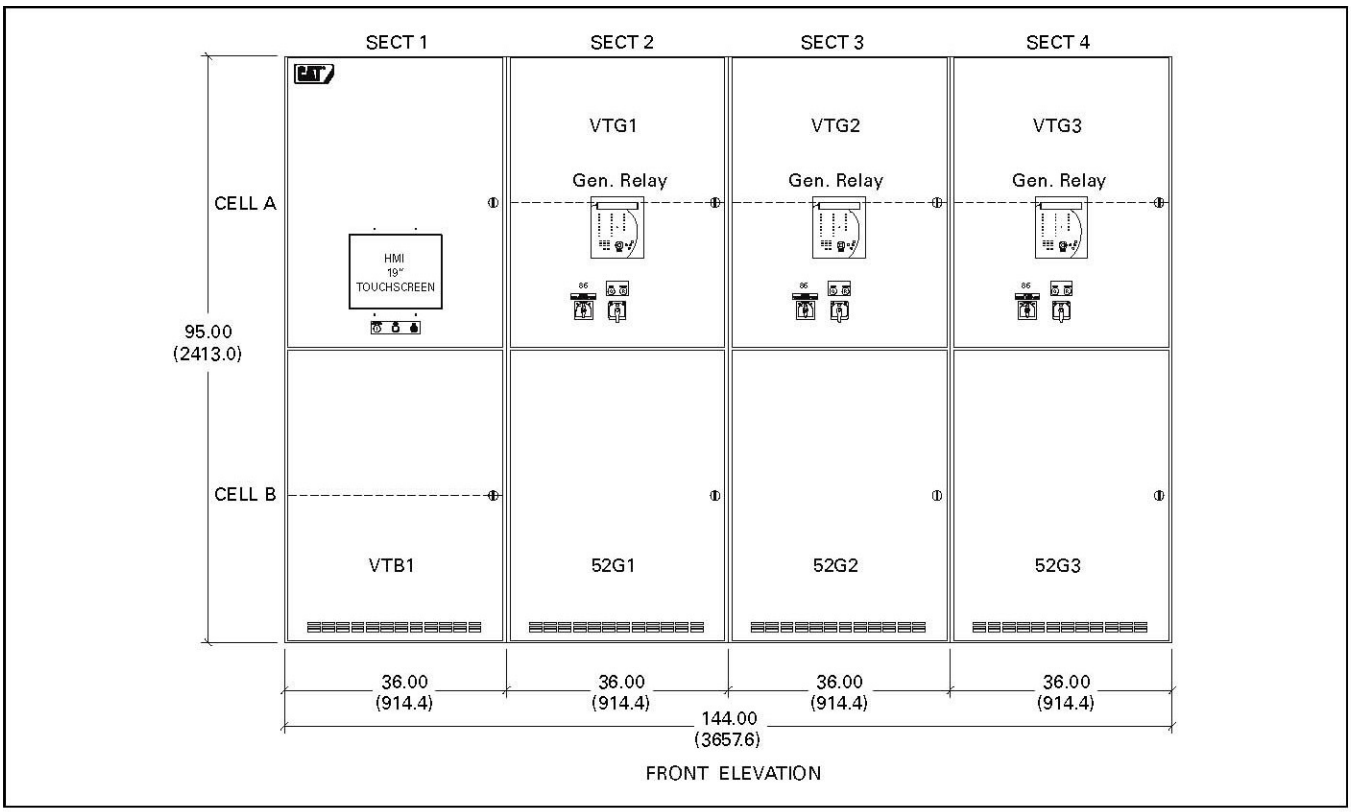


Figure 7.24 5/15 kV EPG3 Switchgear Arrangement
Note: All Structures are 96.25 inches (2445mm) deep
Note: See Figure 7.27 and 7.28 for typical distribution structure layouts

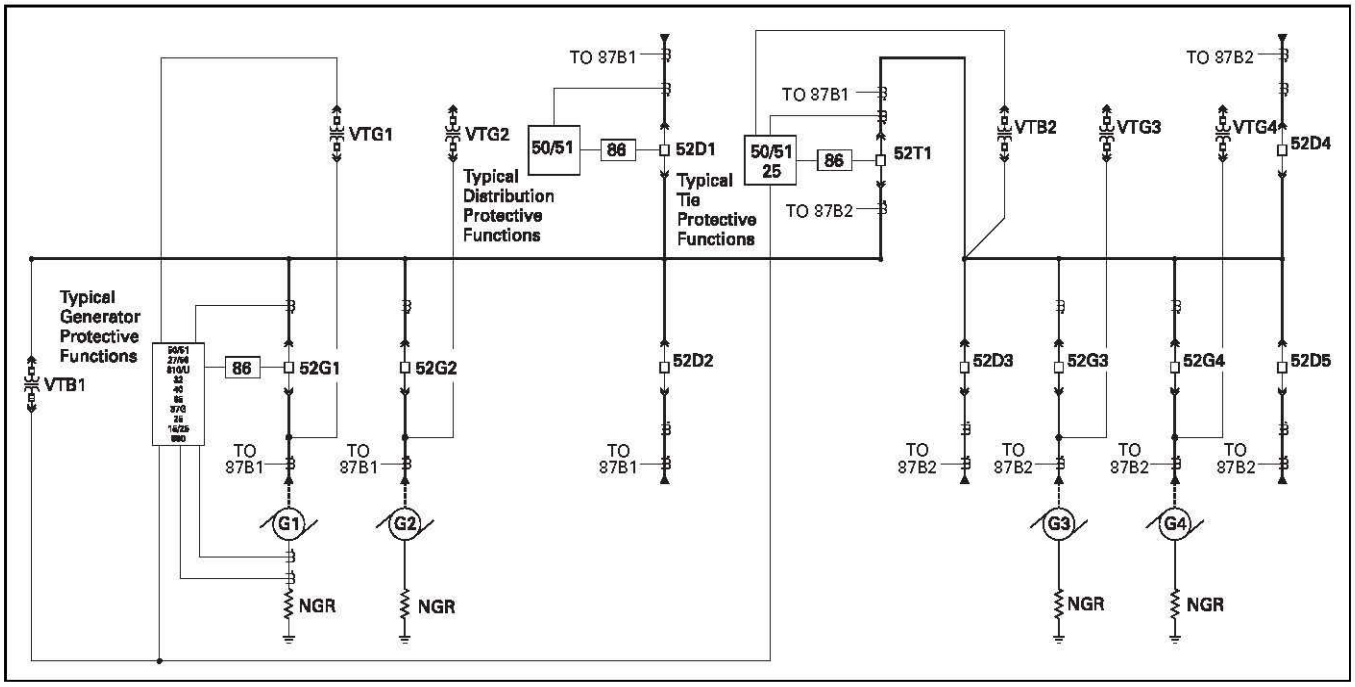


Figure 7.25 Medium-Voltage EGPT4 (Four Generators, One Emergency Generator Bus Tie)
(87B1, 87B2 = Zone Specific Bus Differential Protection if applicable)

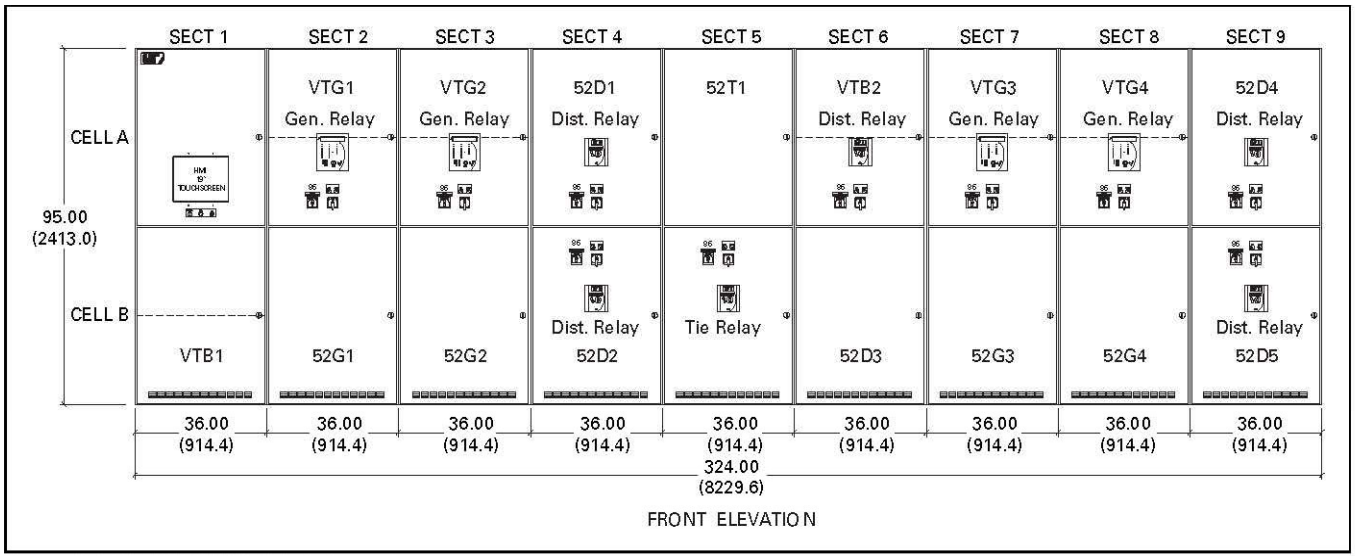


Figure 7.26 5/15 kV EGPT4 Switchgear Arrangement
Note: All Structures are 96.25 inches (2445mm) deep
Note: See Figure 7.27 and 7.28 for typical distribution structure layouts

Typical Medium-Voltage Distribution Section

Note: Single or double (as shown) distribution breaker sections can be added to XLM and EGP layouts as needed.

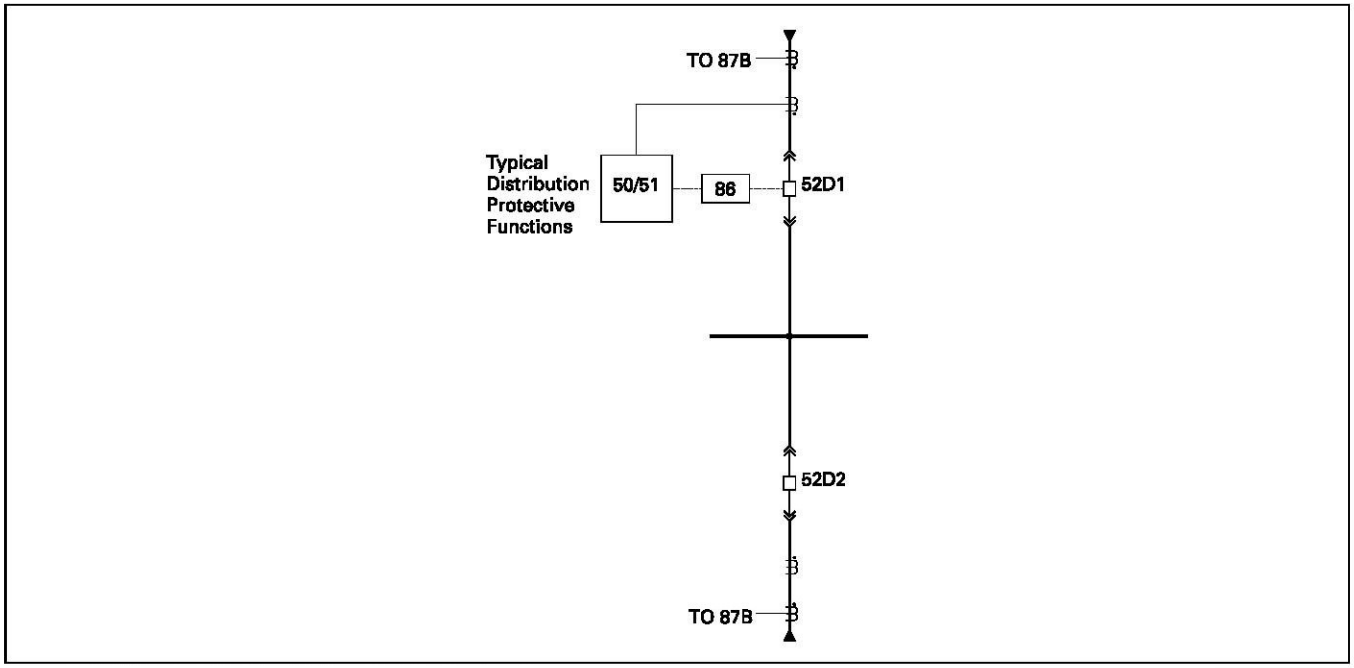


Figure 7.27 Typical Medium-Voltage Distribution Section

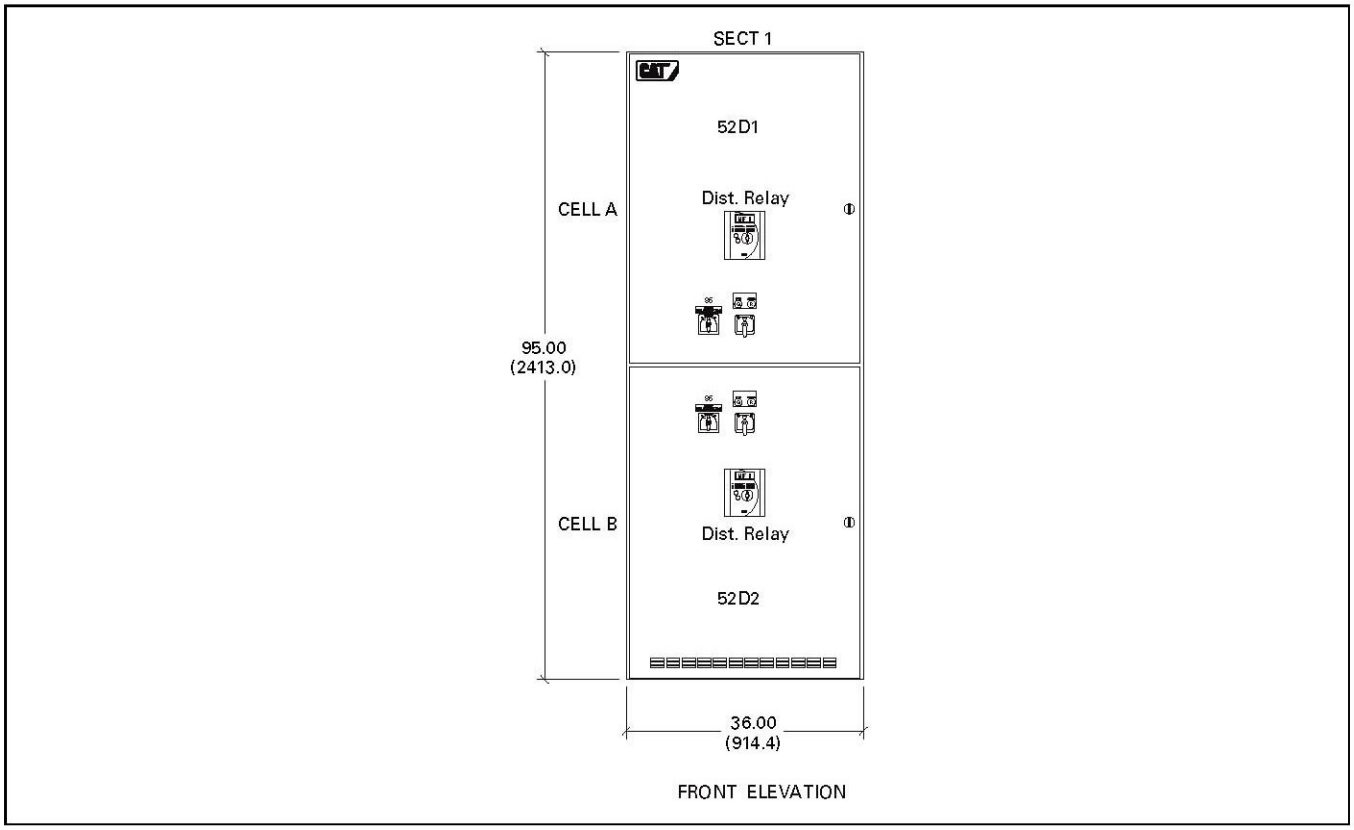


Figure 7.28 5/15 kV Distribution Section Arrangement
Note: All Structures are 96.25 inches (2445mm) deep
Note: See Figure 7.27 and 7.28 for typical distribution structure layouts

Dimensions in Inches (mm) (Continued)

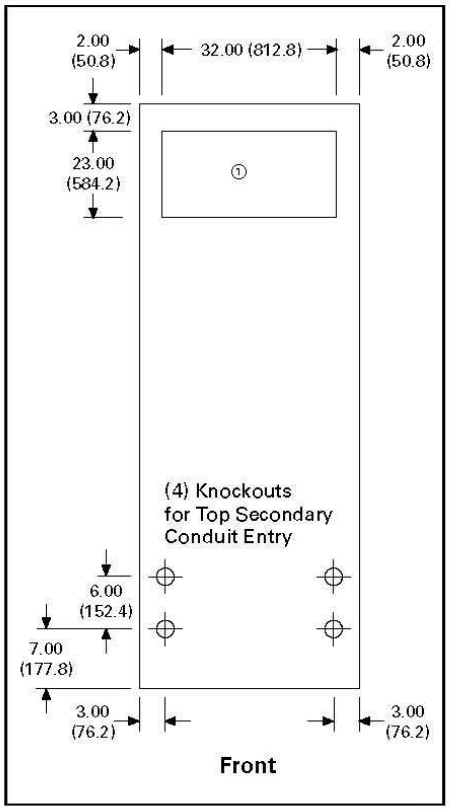


Figure 7.29 Top View of Typ. Indoor Breaker & Aux Structures

① Power cable entrance area. Refer to **Figure 5.5-12** for typical conduit locations. Refer to shop drawings for order specific locations.

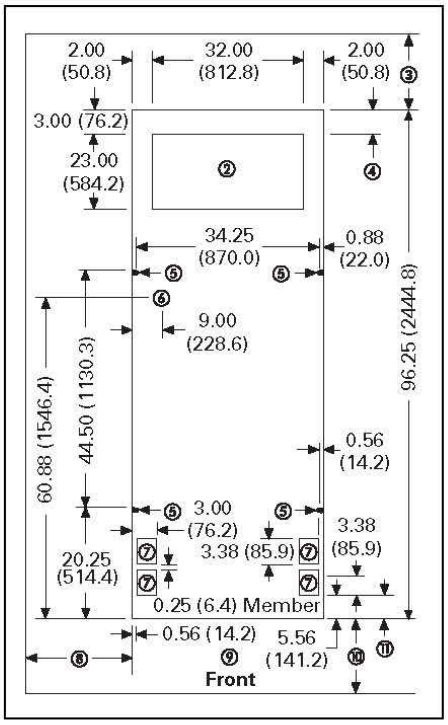


Figure 7.31 Base Plan of Typ. Indoor Breake & Aux Structures

② Power cable entrance area. Refer to **Figure 5.5-12** for typical conduit locations. Refer to shop drawings for order specific locations.

③ Recommended minimum clearance to rear of VacClad-W: 36.00 inches (914.4 mm).

④ Floor steel, if used, must not exceed 3.25 inches (82.6 mm) under VacClad-W.

⑤ Anchor locations: indoor—0.50-inch (12.7 mm) bolts or weld, outdoor—0.50-inch (12.7 mm) bolts.

⑥ Station ground connection provision.

⑦ Secondary conduit space: All—maximum of 1.00-inch (25.4 mm) projection.

⑧ Minimum clearance to LH side of VacClad-W: 32.00 inches (812.8 mm). Minimum clearance to RH side of the switchgear: 6.00 inches (152.4 mm).

⑨ Finished foundation surface shall be level within 0.06-inch (1.5 mm) in 36.00 inches (914.4 mm) left-to-right, front-to-back, and diagonally, as measured by a laser level.

⑩ Minimum clearance to front of VacClad-W: 70.00 inches (1778.0 mm).

⑪ Floor steel if used, must not exceed this dimension under VacClad-W.

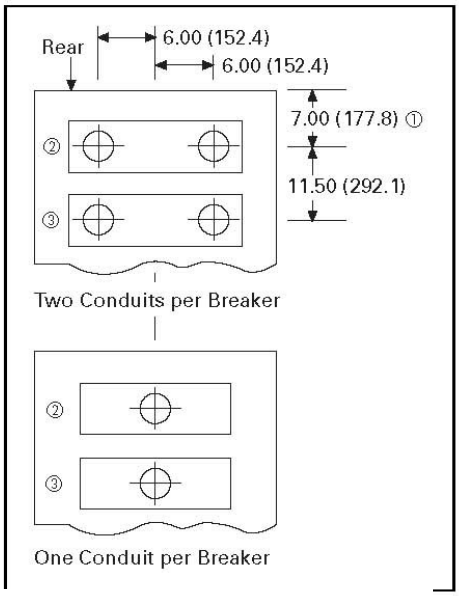


Figure 7.31 Primary Conduit Locations for Stacked Breakers

① Changes to 8.25 (209.6 mm) if optional hinged rear doors are required.

② When cables enter from top, they connect to the breaker located in the bottom compartment. When cables enter from bottom, they connect to the breaker in the upper compartment.

③ When cables enter from top, they connect to the breaker located in the upper compartment. When cables enter from bottom, they connect to the breaker in the bottom compartment.

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Additional Technical Data

Typical Control Circuit Interconnect Wiring

Table 40.7-1. Typical Control Circuit Interconnect Wiring

Function	(Quantity)/Size/ Type of Cable ①②	Signal Type ③	Description
Generator Control			
Cat engine generator set communications	Diesel—(1) x #16 AWG shielded twisted pair (Belden 8719)	Signal level	Network communications for monitoring and display of engine data from EMCP to switchgear
	Gas—(1) x #16 AWG shielded twisted quad	Signal level	
Control panel discrete control interface	(16) x 1/c #14 AWG (includes spares)	DC control ≤ 30 Vdc	Discrete control (start/stop, emergency stop and crank terminate, includes spares, etc.)
Best source 24 Vdc	(4) x 1/c #10 AWG (2 x + 24 Vdc and 2 x–24 Vdc)	DC control ≤ 30 Vdc	±24 Vdc from generator battery system to supplement switchgear 24 Vdc control voltage
Voltage regulation (VR) control	(1) x #16 AWG twisted pair (Belden 8719)	Signal level	Bipolar DC bias signal for voltage control
	(3) x 1/c #14 AWG (additional for CDVR only)	DC control ≤ 30 Vdc	
Speed control (governor)	Type 2301A speed controller— (2) x #16 AWG shielded twisted pair (2301A)	DC control ≤ 30 Vdc	Bipolar DC bias signal for speed control
	ADEMIII speed controller— (1) x #16 AWG shielded twisted triplet (Belden 8618)	Signal level	
	(Additional for Pro Act gov. only) (3) x #14 AWG XHHW Cu	DC control ≤ 0 Vdc	
Air fuel ratio (AFR) controller	Gas only—(1) x #16 AWG shielded twisted pair	Signal level	For gas engines equipped with AFR controller only
Battery Systems			
Power for 24 Vdc station battery charger	(3) x 1/c #12 AWG (in master section)	AC control	120 Vac/20 A emergency circuit for 24 Vdc battery charger power
24 Vdc station batteries	(4) x 1/c #10 AWG (2 x + 24 Vdc and 2 x–24 Vdc) (next to switchgear)	DC control ≤ 30 Vdc	24 Vdc supply to switchgear controls from 24 Vdc battery system
24 Vdc station battery charger malfunction	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Power for 125 Vdc battery charger (breaker/relay control power) ④	(3) x 1/c #10 AWG	AC control	120 Vac/40 A emergency circuit for 125 Vdc battery charger power (circuit size varies with charger ampacity requirements).
125 Vdc batteries (breaker/relay control power) ④	(4) x 1/c #10 AWG (2 x + 24 Vdc and 2 x–24 Vdc) (next to switchgear)	DC control ≤ 30 Vdc	125 Vdc supply to from 125 Vdc batteries to MV breaker controls (5 kV and 15 kV only)
125 Vdc battery charger malfunction ④	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Generator(s) battery charger malfunction	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Fuel Systems			
Low fuel tank level (master fuel tank)	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Fuel tank rupture basin (master fuel tank)	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
High fuel tank level (master fuel tank)	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Other fuel tank alarms (master fuel tank)	(2) x 1/c #14 AWG (each)	DC control ≤ 30 Vdc	Alarms
Low fuel tank level (day tank)	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Fuel tank rupture basin (day tank)	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
High fuel tank level (day tank)	(2) x 1/c #14 AWG	DC control ≤ 30 Vdc	Alarms
Other fuel tank alarms (day tank)	(2) x 1/c #14 AWG (each)	DC control ≤ 30 Vdc	Alarms
Generator Protection Systems			
Genset mounted CB status ⑤	(2) x 1/c #14 AWG	DC control ≤30 Vdc	Alarms
Generator differential CTs	(6) x 1/c #10 AWG (at generator)	AC control	87G relay alarm/shutdown
Generator RTD leads	(1) x #14 AWG shielded twisted quad per reading (at generator)	DC control ≤ 30 Vdc	Indication/alarms/shutdown
Engine thermo-couples	(2) x 1/c #14 AWG thermo-couple wire per reading (at generator)	DC control ≤ 30 Vdc	Indication/alarms/shutdown
VT and CT wires ④	(4) x 1/c #10 AWG per AWG and (6) x 1/c #10 AWG (at generator panel)	AC control	Metering input
Neutral grounding resister (NGR) CT ④	(2) x 1/c #10 AWG per NGR (at neutral resistors)	AC control	51G relay alarm/shutdown

① All control wiring to be stranded copper unless specified otherwise. Conductor size may have to be increased for Voltage Drop over long distances.
② Recommend 20% spares of each size single conductor and one of each multi-conductor cable.
③ Separate metallic conduits should be used for each Signal Type. "Signal Level" and "DC Control Signal ≤ 30 Vdc" wires may be combined in the same conduit.
④ Medium-voltage applications only.
⑤ Not applicable for medium-voltage applications.

Note: Specific project and equipment requirements will determine exact number and type of control wiring required.

Table 40.7-1. Typical Control Circuit Interconnect Wiring (Continued)

Function	(Quantity)/Size/ Type of Cable ①②	Signal Type ③	Description
Automatic Transfer Switch Interface (Per ATS)			
Cat ATS monitoring and control	(1) x #16 AWG shielded twisted pair (Belden 8471)	Signal level	Monitoring and control of ATS functions
Engine start discrete ATS position ATS load shed	(2) x 1/c #14 AWG (4) x 1/c #14 AWG (2) x 1/c #14 AWG	DC control ≤ 30 Vdc DC control ≤ 30 Vdc DC control ≤ 30 Vdc	Engine start request Normal and emergency ATS status Load shed/load add
Miscellaneous (Optional)			
Miscellaneous enclosure alarms Miscellaneous aux. equipment alarms Switchgear 120 Vac space heaters	(2) x 1/c #14 AWG per required alarm (2) x 1/c #14 AWG per required alarm (3) x 1/c #10 AWG per 10 structures	DC control ≤ 30 Vdc DC control ≤ 30 Vdc AC control	Alarms/shutdown Alarms/shutdowns 120 Vac for space heaters (single-phase/30 A)
Remote monitoring/control PC	(1) x 4 pair #24 AWG UTP CAT 5 (Ethernet)— or—(1) 4 conductor fiber optic cable (Belden I100466—varies based on installation requirements)	Signal level	Communication signal to remote Monitoring/control PC workstation or LAN
Building management/SCADA interface	(1) x #18 AWG shielded twisted pair (Belden 3073)	Signal level	Communication signal to building Management or SCADA system

① All control wiring to be stranded copper unless specified otherwise. Conductor size may have to be increased for Voltage Drop over long distances.
② Recommend 20% spares of each size single conductor and one of each multi-conductor cable.
③ Separate metallic conduits should be used for each Signal Type. "Signal Level" and "DC Control Signal ≤ 30 Vdc" wires may be combined in the same conduit.

Note: Specific project and equipment requirements will determine exact number and type of control wiring required.

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