PowerCommand® Paralleling System Digital MasterControl™

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Cummins Power Generation

Description

The PowerCommand Digital MasterControl™ is a system-level controller designed to interface directly with Cummins Power Generation PowerCommand paralleling generator sets. The DMC is a complete distributed logic control system for complex and demanding on-site power systems where reliability, performance, and flexibility are paramount.

In PowerCommand paralleling systems, the generator set-mounted controls provide all the paralleling functions including genset control, generator set protection, synchronizing, first-to-bus logic, load sharing (for isolated bus operation with other generator sets) and load governing (for grid-interconnected operation). The DMC provides system-level functions, including load add and shed sequencing, load demand, and system operator interface. The DMC also provides power transfer control functions in some applications.

The DMC can either be installed separately at a convenient location or integrated into the system power sections when required. It is suitable for both low and medium voltage applications.

Features

The Digital MasterControl offers a wide range of standard control and digital display features so custom control configurations can be achieved with minimal design work.

Major control features include:

- **Full function master control for any paralleling system.** System master control provides for use of the on-site power system for both emergency/stand-by (isolated bus) operation and operation in parallel with a utility (mains) service for applications ranging from short-term soft power transfer to continuous paralleling situations.
- **High resolution color touchscreen** graphically displays comprehensive system and generator data, AC metering, trending, and other information.
- **Automatic load adding and shedding.** System includes load sequencing to automatically add load and remove load as system capacity changes due to generator set availability and changes in system load level.
- **PowerCommand Network** links the Digital MasterControl with generator sets, transfer switches (when used) and remote monitoring equipment (when used). The DMC provides detailed operational data on all components in the system and allows direct operator control.
- **Remote user interface** (optional). The DMC is configured to allow use of a remote PC-based operator panel running the same HMI software as the master control panel.
- **Warranty**. PowerCommand systems are supported by a worldwide network of independent distributors who provide local parts, service and warranty support.

Operator panel

The easy-to-see operator panel provides the user with a complete range of easy-to-use information.

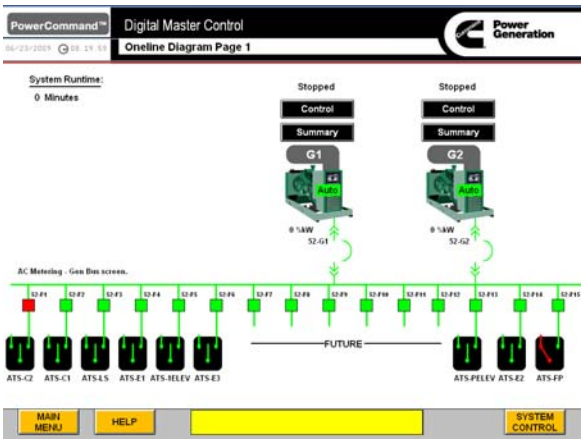
Touchscreen operator panel

A full color high-resolution 15 inch (diagonal) touchscreen operator interface panel (HMI) allows the operator to monitor and control the on-site power system.

All data is configurable for display in either U.S. standard or metric indications. Screens are configured in a typical Windows® format. Each screen includes navigation buttons to allow quick access to other screens that are logically connected with the screen being displayed. Access to screens that impact on system settings or sequence of operation are controlled by a multi-level password system.

The HMI typically includes the following screens and/or functions:

One line diagram

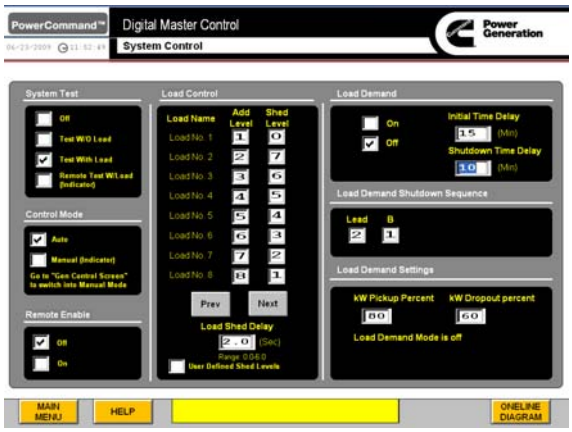


The one-line diagram screen displays system status by a combination of animation, changing screen color, text messages, and pop-up indicators. Conditions visible on the screen include:

- Generator set(s) and bus configuration with generator set, parallel breaker and bus energized/de-energized indication (red indicating energized, green indicating de-energized).
- Generator set designation, with control data, and performance summary screens accessible through hot keys (links) located on or adjacent to the genset icon.
- Generator set mode (run/off/auto).
- Generator set status (normal/warning/shutdown/load demand stop).
- Paralleling breaker status (open/closed/tripped/racked out). Optional status and condition displays of other breakers and devices can be supplied where required.
- Bus condition (energized or de-energized) Clicking on the bus icon provides access to a bus AC data screen.

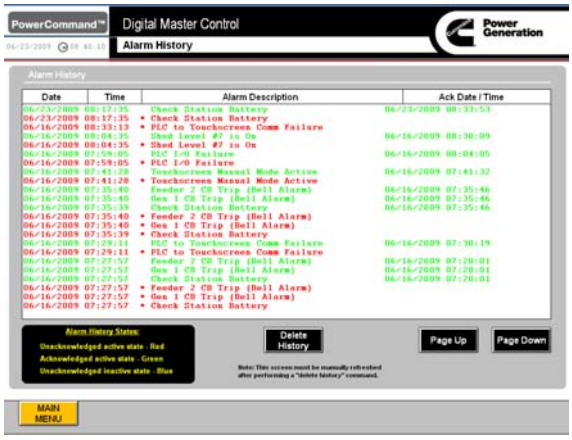
For applications which include automatic transfer switches (ATS), the Digital MasterControl provides a depiction of the ATS in the one line, indicating source availability and switch position. It also is available with detailed information access to each ATS in the system.

System control



The system control screen provides the operator with the ability to enable or disable load demand operation, view timer values and the load demand sequence; initiate test (with or without load); control the shutdown sequence for the generator sets in the load demand mode; set the load demand time delays; set the load demand operation set points; and display and modify the automatic load add and shed sequence. The screen also allows setting of the source availability settings and sequence timing for power transfer. This screen is password-protected to prevent access to the configuration functions by unauthorized users.

System alarm history



The master control touchscreen records the date, time and nature of all alarm and shutdown conditions reported on the system. This log includes all alarms reported on the generator set and all master control and network connected functions.

Generator set and transfer switches retain a detailed independent log of their perspective operating histories, allowing the user to not only understand system level operation conditions, but also view details of operation of any component in the system.

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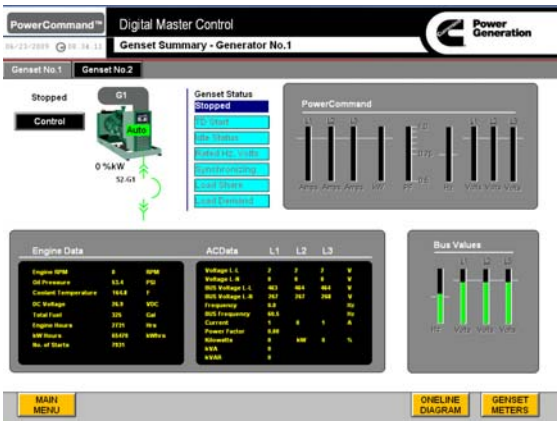
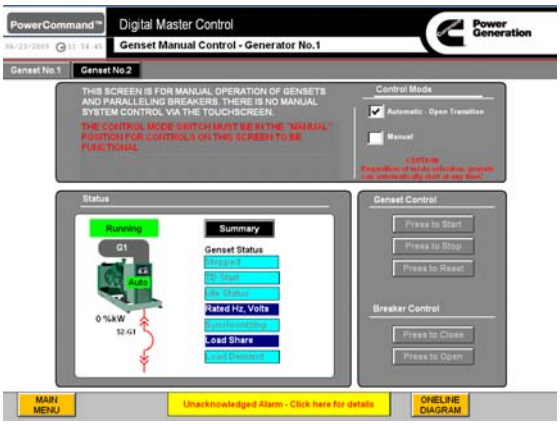
Generator set status and control



The genset status summary provides an analog and graphical display of critical generator set operating parameters for each generator set in the system. The screen includes generator set state display (stopped, time delay start, idle speed state, rated volts/hertz, synchronizing, load share or load govern); analog AC metering for generator set (3-phase, AC volts and current, frequency, kW and power factor); and three-phase AC bus voltage and frequency. The screen provides a complete display of engine and alternator data present in the generator set control. The screen also shows status of the generator set breaker. Hot buttons are provided for this data on all generator sets in the system, including system equipment provided by third parties.

Generator set manual control



Manual control of the generator set paralleling function and resetting of warning condition faults is available to users via a password-protected access.

Trending

The touchscreen provides real-time trend charts for AC output parameters and continuously monitors average voltage, frequency, total kilowatts, and average amperage. Scales of values displayed are field-configurable.

Alarms

Any alarm on any generator set or in the system will cause an alarm bar and warning condition display to appear on the touchscreen. A click on the bar displays a pop-up screen describing the equipment where the fault has occurred, and the name of the fault. The screen allows the operator to attempt to reset warning conditions from the HMI.

Service information

System information and service information, including the name, address and phone number for the local service point for the equipment, is provided on the main menu screen for the system.

Internal components

System PLC

Paralleling control functions (synchronizing, load sharing, etc.) are provided by the PowerCommand Generator set paralleling controls. System control logic such as load add and shed sequence is performed by a programmable logic controller (PLC). The PLC is a rack-mounted system of components with swappable cards to allow easy servicing of components. Other features of the PLC include:

- On-line changes. The PLC may be interconnected to a personal computer and control sequences may be modified without shutting down the system.
- EEPROM program storage. The PLC program is stored in non-volatile EEPROM memory with additional battery backup of the PLC RAM for storing system configuration settings.
- LED status indicators. The PLC and input/output (I/O) blocks include LED status indicators for use in viewing system status and diagnosis of failures.
- I/O block surge suppressors. Inputs and outputs to the PLC are connected via integral surge suppressors to provide reliable protection against over-voltage damage.

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Protective functions

Protective functions are provided by separate protective relays (optional) and/or the PowerCommand generator set controls. Generator set protective functions include over and under bus voltage, under frequency, over load and phase sequence protection. Since these functions are resident in the generator set controls, they are effectively redundant, so that whenever a generator set is closed to the bus the protective functions for over/under voltage and frequency (bus overload) are available.

The InPower service tool software allows fast, consistent settings for all system protective functions, or they can be adjusted through the generator set operator panels. On a warning condition the control system indicates a fault by displaying the fault name and service code. The nature of the fault and time of occurrence is logged in the generator set control (based on engine operating hours) and in the master control based on a system real-time clock. The service manual and InPower service tool provide service keys and procedures for the service code specified.

System level protection and utility paralleling protection is provided by independent utility grade protective relaying as specified by the local utility service provider or the system designer.

Control power system

Control power for the system is derived from the generator set 24 VDC starting batteries. A solid state no- break "best battery" selector system is provided so control voltage is available as long as any battery bank in the system is operational. All battery banks are isolated to prevent the failure of one battery from disabling the entire system. A station battery and charger backs multiple generator set control power sources so that the master control has multiple redundant control power provisions. The PowerCommand control (on each generator set in the system) continually monitors the battery charging system for low and high DC voltage and runs a battery load test every time the engine is started. Functions and messages on the generator paralleling control include:

- Low DC voltage (battery voltage less than 24 VDC, except during engine cranking).
- High DC voltage (battery voltage greater than 32 VDC).
- Weak battery (battery voltage less than 14.4 VDC for more than 2 seconds during engine cranking).

The master control integral station battery also includes battery failure testing and alarm indication.

Typical sequence of operation

PowerCommand digital paralleling systems can be configured for nearly any logical sequence. The following description provides details of typical operation for the system components.

Synchronizing and Paralleling

Normal Starting Sequence

System level controller or transfer switches signal each generator set to start in an emergency or test/exercise mode. When signaled, each generator set control automatically and independently starts each generator, accelerates to rated frequency and builds up to rated voltage. The integrated First Start Sensor System in each control monitors this process, and on finding a generator set at 90% of rated voltage and frequency, automatically disables all other units from closing to the bus and closes the ready unit to the generator bus.

After the first unit is closed to the bus, the remaining generators sense availability of bus voltage and the synchronizer in each generator set control automatically switches on. Simultaneously, the synchronizer(s) cause each generator set to synchronize with the system bus and then close it at the proper time. As each unit closes to the bus, the unit assumes its proportional share of the total load on the bus.

Normal Stopping Sequence

When system start commands are removed from the generator sets, each generator set opens its paralleling breaker and the generator set performs its time delay stop and/or cool-down sequence. As each generator set completes its cool-down sequence, it is automatically switched off.

If a system start signal is received at the generator sets during the cool-down period, one generator set will immediately close to the system bus and all other units will synchronize to it, as described in “Loss of normal power” below.

Failure of a unit to start or synchronize

If a generator set fails to start, after the fail-to-start time delay (in the generator set control) has expired, the unit will be shut down and an alarm will sound.

If a generator set fails to synchronize, after a preset time delay an alarm will sound but the unit will continue to attempt to synchronize until signaled to stop by manual operation of the control switches on the generator set.

Power Transfer Control

The Digital MasterControl or automatic transfer switches commonly provide system power transfer control functions.

Loss of Normal Power

The power transfer control system continuously monitors the availability of each power source (utility service or generator bus) and automatically connects the system loads to the best available source based on settings programmable by the operator.

Power Generation

On loss of normal power, each power transfer control executes a short time delay, then initiates generator system starting by issuing start commands to each generator set.

When the first generator set has closed to the bus, the power transfer control system will sense the availability of generator capacity and begin transfer of loads to the generator bus by disconnecting the utility source and connecting the generator bus to system loads.

The Digital MasterControl may inhibit operation of some power transfer devices until adequate capacity is available to serve the connected loads. A manual control system is available to the operator to control sequence of operation of the power transfer controls. For further information see “Load and Capacity Management”.

Return of Normal Power

When the power transfer control system has sensed that normal source power has returned and is within programmed limits and a time delay re-transfer period is completed, each power transfer control will begin a re-transfer process in either an open or closed transition mode, as selected by the operator.

If running in the closed transition mode, the system synchronizes the generator bus to the first utility source, and closes to the utility source. If the system is designed for “soft” transfer between live sources, it ramps down load on the generator bus to a minimum value, and then opens the connection to the generator source. If the system is operating in a “fast” transfer mode, the ramping function is not used and the system will operate from source to source as quickly as possible, typically in 100 milliseconds or less. The transfer process is repeated sequentially across each power transfer point.

If running in the open transition mode, the system sequentially transfers back to the utility by opening the connection to the generator bus at each transfer pair, then closing its associated utility connection at an operator-programmed time period later. This process is completed at each power transfer point in the system, by each power transfer control.

When all loads have been transferred back to the utility, power transfer control system removes the start commands from generator sets.

System Test or Exercise

Generator set exercise (test) without load

The system allows testing of the generator sets at no load. In this operation mode the generator sets will start, build up to rated speed and voltage, synchronize and close to the generator bus, but system loads will not automatically transfer to the generator system. If a power failure occurs during a test period, loads will immediately close into the system on a priority basis. When the system is operating in the closed transition mode, it will always transfer between “good” sources without a power interruption to the load.

Exercise (test) with load mode

The system will allow the generator sets to be tested by transfer of the system loads to the generator sets. Sequence of operation in this mode shall be similar to that described for a power failure condition, except that if the system is configured to perform closed transition transfer operations it will transfer the loads without interruption of power to the loads.

Load and Capacity Management

The load control system in the Digital MasterControl automatically controls the addition of system loads to the generator bus and the number of generator sets operating on the system. The sequence may utilize automatic transfer switches, feeder breakers, or a facility management system (usually provided by others) to control the load adding and shedding in the system. When all the generator sets are closed to the bus the system will sequence remaining loads on to the system in a timed sequence that is configurable by the operator. Loads may also be manually controlled (added or shed from the system) via the system touchscreen.

Bus overload

If a bus overload occurs for any reason, a signal will be generated to initiate load shedding in the system. If the bus does not return to proper frequency within a predetermined period of time (adjustable via the HMI), additional load shed signals will be generated until the generator set bus returns to normal frequency. Loads that are shed due to overload require manual reset via the HMI.

Load demand mode

When the system is running in the emergency mode with the "load demand" switch in the HMI in the "on" position, controls continuously monitor the total load on the bus. If the total load on the bus falls below preset limits for a period of 15 minutes, the controller will automatically shut down generator sets in an operator predetermined order until the minimum number of generators required to operate the load remain on the bus. The purpose of this function is to allow the generator sets to operate closer to their rated capacity, thereby decreasing fuel consumption and reducing wear on the system. On sensing that the available bus capacity is being approached, the standby units will automatically be restarted (in the reverse order of which they were shut down) and paralleled with the bus to assume their proportional share of system load. As each load parallels to the bus, load ramps to load share level. The system automatically compensates for generator sets of different sizes.

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Control interface

All control interconnections in the MasterControl are provided on standardized terminal block assemblies. Interconnections to external equipment may include:

- Load add and load shed relays. Each relay includes “form C” contacts (a normally open and a normally closed contact with common return) rated 10 A @ 600 VAC.
- Paralleling breaker control relays. Relays are directly driven by the PowerCommand generator set control and mounted in the master control for interconnection convenience.
- Bus voltage connection. Control includes fused 3-phase 4-wire connections up to 600 VAC. It provides a bus voltage reference signal to the PowerCommand generator set control, if desired.
- System remote start command. Provided to allow for remote (with load) system test.

Construction

The control system is housed in a rigid, freestanding, NEMA1/IP40, metal enclosed structure designed to require front access only. Framework is constructed of minimum 2.5 mm (12 ga) steel sheet metal. The framework and all other sheet metal components of the system are primed with a rust-inhibiting primer and finished with satin finish ANSI 61 gray enamel.

Control components are completely isolated from power-carrying components by metal or insulating barriers. All components and surfaces operating at more than 50 volts are shielded to prevent inadvertent contact. All control wiring is 105 °C (221 °F), 600 volt rated and sized as required for safe, reliable operation. Each wire, device and functional component is identified by silk-screen or similar permanent identification. Fuses are installed in DIN-rail mounted safety-type fuse holders. Terminal blocks are provided for all field connections on DIN-rail mounted devices.

The Digital MasterControl may be integrated into the paralleling switchgear or provided in a separate, freestanding panel. Free-standing panels should be located within 100 meters (350 feet) of the switchgear. (Consult factory if longer distance is required.)

Certifications

Digital Master Controls meet or exceeds the requirements of the following codes and standards:

AS/NZS 3000 Wiring Rules
AS 3009 Emergency Electrical Power Supply for Buildings
AS/NZS 3947 Low-voltage Switchgear and Control gear
AS/NZS 3947 Part 6.1 Multiple function equipment – Automatic transfer switching equipment
AS 60529 degrees of protection provided by enclosures (IP Code)
AS/NZS 3439.1 Low-voltage switchgear and control gear assemblies, Part 1 Type-tested and partially tested assemblies
CSA C282-M1999 Emergency Electrical Power Supply for Buildings
CSA 22.2 No. 14 M91 Industrial Controls
BS/EN 60439-1:1999 Low Voltage Switchgear and Control Gear
BS/EN 60204-1:1993 Safety of Machinery (electrical)
BS/ISO 8528-4:2005 Control Systems for Reciprocating Generator Sets
IEC 60439.1 Low Voltage Switchgear and Control Gear.
ISO 8528-4: 2005 Control Systems for Reciprocating Engine-driven Generator Sets
ISO 12100-2: Safety of Machinery
NFPA 70: U.S. National Electrical Code.
PowerCommand controls are suitable for use in emergency, critical and standby applications, as defined in articles 700, 701, and 702.
NFPA 99: Standard for Health Care Facilities
NFPA 110 for level 1 systems
UL 891 Listed, Category NIWT7 for U.S. and Canada.

PowerCommand control systems and generator sets are designed and manufactured in ISO9001 certified facilities.

Environment

The control is designed for proper operation without recalibration in ambient temperatures from 0 °C to +46 °C (32 °F to 115 °F) and for storage from -20 °C to +70 °C (-4 °F to 158 °F). Control will operate with humidity up to 95%, non-condensing, and at altitudes up to 10,000 feet (5000 meters).

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Network

The MasterControl includes network communications over an Echelon® Lonworks™ Network. The network is suitable for local or (optional) remote control and monitoring functions. The control system is available with Modbus RTU interface via either RS485 or TCP/IP interface.

Optional features

Paralleling systems are designed around facility requirements which can vary considerably from site to site, so there are many features that can be applied to digital Master Controls. These may include:

- Remote and multiple user interfaces
- Web interfaces to allow monitoring and controls via the internet
- Reporting tools, such as automatic report generation, for health care applications
- PLC redundancy
- Third party communication protocols, primarily for building management interfaces

Contact your local Cummins Power Generation representative for more information on features needed in your application.

Warranty

PowerCommand systems are part of a complete power system provided by Cummins Power Generation and are covered by a limited warranty as a standard feature. Extended warranty options are available. Contact your Cummins Power Generation distributor for more information.

See your distributor for more information

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