

Load-shedding controller PML630

Integrated load-shedding and protection solution for industrial and utility power networks

The freely configurable load-shedding controller is intended to protect industrial and utility power networks with multiple power sources and critical loads against disturbance-related blackouts and power outages. In disturbance situations, the load-shedding device shall ensure the availability of power supply for critical process loads by dropping less critical ones in a fast, accurate and selective way. As a result, the duration and frequency of production downtime in the industry and power outages in the distribution network can be minimized, and damage to electrical and process equipment avoided.

Mechanical and construction details

- The device shall have compact dimensions not exceeding 4U in height for panel door mounting installations.
- The device shall support flush, semi-flush, rack and wall mounting options.
- As flush mounted, the device shall meet the IP40 (IP42 with detached HMI) ingress protection requirements on the front side and IP20 on the rear side and connection terminals.
- To facilitate quick replacement, the device shall have detachable connectors with secure current transformer (CT) shorting.
It shall be possible to quickly replace the faulty unit with a spare without disturbing any of the wiring.
- The device shall have either an integrated human-machine interface (HMI) or alternatively be offered with a detached HMI.
The integrated or detached HMI shall be referred to as LHMI (local HMI). The detached LHMI shall enable flexible installation for reduced wiring and weight impact on the panel door of the low voltage (LV) compartment.
- The power supply to the detached LHMI shall be provided using Power over Ethernet (PoE) to avoid additional wiring for the auxiliary voltage.
- The LHMI of the shall have a large graphical display with dimensions no less than 70 mm x 100 mm and 320 x 240 pixel resolution, allowing the display of at least 10 switching objects. The HMI shall also include 5 freely configurable push buttons.

Load-shedding functions

- The device shall support multiple, preloaded load-shedding functions. It shall be possible to enable or disable the functions and to use one or several functions simultaneously. The device shall support the following load-shedding functions:
 - Fast load-shedding due to loss of power sources and disconnection of the power network
 - Slow load-shedding based on overload of power sources or maximum demand violation at the power grid tie-line or generator
 - Manual load-shedding initiated by the operator based on power definition or load feeder priorities
 - Underfrequency load-shedding as backup to fast and slow load-shedding
- The device shall support simultaneous use of all load-shedding functions in the supported number of power islands or subnetworks.

Fast load-shedding

- The device shall generate network topology information based on the status of the tie feeder and the bus coupler circuit breaker.
- Taking network topology into consideration, the device shall perform power balance calculations based on a comparison between active power capability or capacity (of the power sources) and power consumption (of consumers or loads).
- The trigger to initiate the power balance calculation shall be based on a power source outage in a subnetwork or disintegration in the power network topology, caused by a protection event and/or a circuit breaker opening.
- The device shall activate fast load-shedding when the connected load exceeds the available power in the subnetwork.
- The fast load-shedding function shall take corrective action before the system frequency drops and ensure fast restoration of the frequency profile in the subnetwork.
- In the absence of any trigger, the device shall also activate fast load-shedding only on detection of a power deficit condition in a subnetwork.

Slow load-shedding

- The slow (or overload) load-shedding function shall prevent tripping of a power source due to overcurrent or power throughput exceeding threshold limits for a defined time period. It shall be possible to enable detection of either of these conditions or both at the same time.
- The overcurrent protection function shall detect (pick up) overload simultaneously with the overcurrent protection function of the grid transformer or generator protection relay. However, the device shall react faster than the protection relay and trigger load-shedding to reduce the overload on the grid transformer or generator so that it drops below the threshold levels.
- The device shall detect violation of the contractual power demand over a specific time period at the grid tie-line point. When a violation event is registered, the device shall activate load-shedding to reduce the power drawn from the grid.

- The number of loads to be shed due to a power source overload or maximum demand violation shall be in accordance with the power balance during the overload. Alternatively, the number of loads to be shed shall be operator-settable based on the permitted overload on the power source.

Manually or operator-initiated load-shedding

- The device shall support operator actions to initiate load-shedding based on operator-defined priorities or power definition in different subnetworks.
- The manual load-shedding function shall be totally independent of the fast and slow load-shedding functions.

Underfrequency load-shedding

- The device shall include a local underfrequency detection function based on bus bar frequency values. Alternatively, the device shall trigger load-shedding based on the rate of change of frequency or an underfrequency stage event.
- On detection of underfrequency, the device shall trigger load-shedding to disconnect loads according to calculated priorities or based on fixed load priorities in a subnetwork.
- The device shall include at least two stages of frequency-based load-shedding for each subnetwork.

Network handling capability

- The device shall support networks comprising at least:
 - 6 generators
 - 2 power grid transformers or grid tie lines
 - 6 single busbars
 - 4 subnetworks or power islands with power sources
 - 23 critical circuit breakers associated with power sources and bus coupler/bus tie circuit breakers
 - 60 sheddable loads with individual load-shedding priorities
 - 10 sheddable loads or load-shedding groups in a single busbar
 - 19 user-assignable load priorities common to all load-shedding modes

Failsafe operation mechanism

- The device shall include a safety mechanism to automatically block and prevent fast and slow load-shedding in a particular subnetwork in case of a communication failure between the device and a protection relay or I/O device associated with a power source.
- The device shall automatically block fast and slow load-shedding in all subnetworks in case of a communication failure between the device and a protection relay or I/O device, associated with a feeder affecting network topology.
- The device shall include a load feeder inhibition mechanism for automatically ignoring the load feeder in load-shedding priority calculations and preventing the issuing of load-shedding trip commands to trip the circuit breaker when the following conditions apply :
 - Communication failure between the load feeder's protection relay or I/O device and the LS device
 - Circuit breaker trip circuit supervision mechanism of the device has reported an unhealthy status
 - Load feeder's protection relay or I/O device is in the test mode
- It shall be possible to manually block fast and slow load-shedding and inhibit load feeders.
- It shall be possible to manually enable the load-shedding functions separately for each subnetwork and simultaneously disable all enabled functions in all subnetworks.
- The device shall ensure that the manual and underfrequency load-shedding functions are activated when the fast or slow load-shedding functions are blocked.
- The device shall permit blocking overrides through parameterization, especially when the causal conditions are known.

Extended network considerations

- The device shall operate as a peer device together with one or two other load-shedding devices when a power network configuration exceeds the capability of a single device. In such an extended configuration, every device shall be responsible for fast load-shedding in its designated power network area, considering the available power or capacity from the adjacent power network area(s).
- The device of a power network area shall also initiate fast load-shedding in adjacent power network area(s) through their respective load-shedding devices.

Integration to an external load-shedding system

- The device shall support triggering of power balance calculation based on an external process event.
- The device shall accept load-shedding activation and load-shedding priority instructions from an external load-shedding system.

Application input and output interface

- The load-shedding system shall include the load-shedding device, protection relays and/or I/O devices, and a dedicated IEC 61850-compliant load-shedding or substation automation HMI, using IEC 61850 GOOSE (Generic Object-Oriented Substation Event) communication.
- The device shall interface with the dedicated load-shedding or substation automation HMI in accordance with the IEC 61850 MMS (Manufacturing Message Specification) profile.
- All devices or units participating in load-shedding shall exchange I/O data required for activating and performing load-shedding.

- Every protection relay or I/O device associated with a generator power source shall be configured to provide the load-shedding device with at least the following input:
 - 3-phase active power value
 - Line current values, if required for overload detection
 - Master trip and/or turbine trip status
 - Circuit breaker and/or disconnecter status
 - Circuit breaker service position status
 - Protection relay test mode status
- Every protection relay or I/O device associated with a grid transformer power source shall be configured to provide the load-shedding device with at least the following input:
 - 3-phase active power value
 - Line currents value
 - Master trip status
 - Circuit breaker and/or disconnecter status
 - Circuit breaker service position status
 - Protection relay test mode status
- Every protection or I/O device associated with load or power consumer shall be configured to provide the load-shedding device with at least the following input:
 - 3-phase active power value
 - Circuit breaker status
 - Trip circuit supervision status
 - Protection relay test mode status
- Bus-section protection relay or I/O device shall be configured to provide the load-shedding device with at least the following input:
 - 3-phase active power value
 - Frequency value
 - Circuit breaker and/or disconnecter status
 - Circuit breaker service position status
 - Protection and control relay test mode status
 - Rate of change of Frequency or Underfrequency stage(s) activation
- The load-shedding system or substation automation system HMI shall be configured to provide the load-shedding device with at least the following input:
 - Slow load-shedding reset for all power sources
 - Manual load-shedding priority or power value in every subnetwork
 - Manual load-shedding command activation in every subnetwork
 - General load-shedding trip command reset for individual or all subnetworks
- Every protection or I/O device associated with loads or power consumers participating in load-shedding shall be configured to accept the following output from the load-shedding device:
 - Trip command
 - Auto-changeover inhibit command (to prevent bus-coupler closing)
- The generator unit control systems shall be configured to provide the load-shedding device with the following input:
 - The operational mode of the governor
 - Generator capability (includes spinning reserve information)
- The load-shedding device operating as a peer device together with other load-shedding devices shall be configured to exchange at least the following information:
 - Available power in the network of each device depending on power source capabilities
 - Connectivity status for the network of each device and the adjacent power network
- A higher-level load-shedding system that is integrated with the load-shedding device shall be configured to accept comprehensive load-shedding information per subnetwork from the device.
- When the load-shedding device is integrated with an external load-shedding system it shall be configured to receive the following inputs:
 - Load-shedding activation command
 - Load-shedding priority information
- The load-shedding device shall accept a binary signal, which is based on a customer operational event, from an external system such as DCS to trigger power balance calculation.

System and device inputs and outputs

- The load-shedding system shall support the exchange of both analog and binary GOOSE messages between the protection or I/O devices and the load-shedding device.
- The binary GOOSE messaging between the protection relays or I/O devices and the load-shedding device shall be according to Type 1A (tripping), Class P1 (<10ms).
- The device shall include a test mode to facilitate testing the entire application chain until the load feeder receives a load-shedding command.
- The device shall include up to 14 binary inputs and 9 binary outputs.
- The threshold voltage for the binary inputs of the device shall be independently settable between 15...221 V DC.
- The binary inputs of the device shall, when energized, utilize a higher inrush current to facilitate the breaking of possible dirt or sulphide on the surface of the activating contact.
- The device shall optionally include analog inputs configured to receive 3-phase line currents directly from CT secondaries of two power sources.
- The device shall be considered as a substation-level unit, including an HMI with push buttons, supervision, indication and monitoring functionality.

Load-shedding operation

- The device shall operate and issue load-shedding commands to identified load feeders within 20 ms (or faster) of receiving information on loss of a power source or a deficiency of available power in a subnetwork.
- The overall load-shedding system operation time shall be 60 ms or faster.
- The end-to end performance time of the load-shedding system, shall be 110 ms or faster, including the operation time of the load feeder circuit breaker (approximately 50 ms).
- The device shall respond to a cascade tripping condition triggered by multiple power sources.

Information and reporting on LHMI

- The device shall support the following HMI functions: setting, monitoring and manual load-shedding.
- The device shall support viewing load-shedding key single line diagrams (SLD), input data such as power flows, circuit breaker status, set parameters and operational data for fast, slow, manual and frequency-based load-shedding via the LHMI.
- To collect sequence-of-events (SoE) information, the device must incorporate a non-volatile memory with a capacity of storing at least 1000 event codes with associated time stamps and user-definable event texts with a minimum resolution of 1 ms.
- The device shall include a disturbance recorder supporting a sampling frequency of 20 samples per cycle and featuring up to 40 analog and 64 binary signal channels.
- The device must trigger the creation of a numerical disturbance report on occurrence of a load-shedding activation event, which shall be stored in a non-volatile memory and accessible via the local HMI. Such a report shall be configurable and include at least the following information:
 - Power balance for every subnetwork
 - Load-shedding priority for every subnetwork
 - General load-shedding start and operate information
 - Fast and slow load-shedding start and operate information
 - Load-shedding blocking information for every subnetwork on a occurrence of a load-shedding operation event
 - Manual load-shed activation trigger for every subnetwork
 - Load-shedding reset command for every subnetwork
 - Load-shedding activation for every subnetwork
- The device shall support not less than 100 disturbance reports.
- Unused buttons on the LHMI of the device shall be permanently disabled.

Reporting load-shedding information via the substation HMI

- It shall be possible to interface the load-shedding device with a substation HMI to visualize the load-shedding operations.
- The substation HMI shall supplement the load-shedding device and present the overall system aspects related to load-shedding .
- The substation HMI and the load-shedding device shall be interfaced using the IEC 61850 MMS communication profile, where the substation HMI is the client and the load-shedding device is the server.
- The substation HMI shall display the following load-shedding information for every subnetwork:
 - Busbar or network configuration
 - Power availability
 - Power consumption
 - Power balance in the network of each device
 - System-inhibited load power
 - Operator-inhibited load power
 - Inaccuracies of measurement causing a load mismatch
 - Net load available for load-shedding
 - Load table
 - Load-shedding status information (e.g., enable, block)
 - Substation and load-shedding single line diagram views
 - Calculated and actual loads shed
 - Power balance in each subnetwork where a load-shedding device is operating as a peer device
 - Connectivity between adjacent network area(s)
 - Communication status between peer devices
 - Load-shedding status and information from connected adjacent network area(s)
 - Load-shedding activated by a load-shedding device in an adjacent network area
- The substation HMI shall facilitate incorporation of any process-level application logic to supplement the load-shedding application running in the device. The applications running in the substation HMI and the load-shedding device shall exchange information based on GOOSE to facilitate faster load-shedding.

- The substation HMI shall monitor and analyze GOOSE messages exchanged between the protection relays, I/O devices, the load-shedding device and the substation HMI itself.

Communication

- The device shall support IEC 61850.
- The device shall have an Ethernet port with a galvanic (RJ45) or an optical (LC) interface.
- The device shall have an Ethernet port (RJ45) on the front for local parametrization and data retrieval.
- The device shall support up to five IEC 61850 (MMS) clients simultaneously.
- The device shall support the SNTP (Simple Network Time Protocol) and IRIG-B (Inter-Range Instrumentation Group - Time Code Format B) time synchronization methods.
- The device shall support supervision of binary and analog GOOSE messaging to ensure data integrity, system reliability and secure operation of the load-shedding function.

Engineering and configurability

- The device shall have a web browser-based human-machine interface (WHMI) that shall provide access to:
 - Sequence-of-events (SoE)
 - Device status
 - Parameter settings
 - Measurements
 - Disturbance records
 - Programmable LED status
- The device shall have at least 15 freely configurable programmable three-color LEDs.
- The device shall have at least 4 user-configurable local HMI pages, including measurements and single line diagram (SLD).
- The device shall have a graphical configuration tool for the complete load-shedding application, including multi-level logic programming support, arithmetic and binary functions, timers, flip-flops etc.
- The device configuration tool shall be identical to that used for protection relays and I/O devices.

- The device configuration tool shall include online visualization of the load-shedding device application status.
- The device configuration tool shall facilitate easy and user-friendly load-shedding application engineering.
- It shall be possible to keep the device configuration tool up to date using an online update functionality.
- The device configuration tool shall support viewing events, disturbance reports and visualization of disturbance recordings.
- The device configuration tool shall include complete device documentation, including operation and technical details.
- The device configuration tool shall include functionality for comparing the archived configuration to the configuration of the device.
- The device configuration tool shall allow configuration of IEC 61850 vertical and horizontal communication, including GOOSE.
- The device configuration tool shall support import and export of valid IEC 61850 files (ICD, CID, SCD, IID).
- It shall be possible to freely assign current inputs to load-shedding measurement functions.
- The device shall facilitate building of additional programmable logics to supplement the main load-shedding functions and also customize the LED indications and LHMI buttons.

Type tests and other compliance requirements

- The device shall have a continuous operational temperature range of -25 ... +55°C and a transport and storage temperature range of -40...+85°C.
- The device shall fulfill the following mechanical tests: IEC 60255-21-1, -2 and -3 according to Class 1 for vibrations, shock, bump and seismic compliance.
- The device shall fulfill the electromagnetic compatibility (EMC) tests according to IEC 60255-26.
- The device shall be tested according to the requirements of the IEC or an equivalent standard.

Additional information

For more information, please contact your local ABB representative or visit our website at:

www.abb.com/substationautomation

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