Relion® 630 series

Load-shedding controller PML630
High performing load-shedding solution for industrial and utility power networks

Power and productivity
for a better world™

Integrated load-shedding and protection solution

The PML630 is a freely-configurable load-shedding controller device that protects industrial and utility power networks, with multiple power sources and critical loads, against disturbance-related blackouts and power outages. PML630 is a member of ABB's Relion® product family and based on its 630 product series, which is characterized by functional scalability and flexible configurability. PML630 complies with the IEC 61850 standard and offers seamless connectivity with other Relion 615, 620 and 630 series protection relays, RIO600 I/O units and COM600 series, using GOOSE and MMS communication profiles when exchanging I/O data. PML630 can easily be adapted for both new and existing installations.

Power management

Power Management Systems (PMS) are essential to ensure safe, efficient and reliable industrial power systems. The PMS functionality suite includes load-shedding, generator control, power-sharing, network synchronization and power restoration. With this functionality, the stability of industrial power systems in disturbance situations is protected and optimized by ensuring power-sharing between generators when the system is islanded from the grid. It also ensures that the generators meet the required power demand when the network is connected to the grid.

The load-shedding functionality responds to electrical disturbances and loss of generation capacity by cutting off loads in a fast, accurate and selective manner. In doing so, it ensures availability of power supply for critical loads and consequently the least possible interruption to the customer operations. and it should be considered when the industrial power system:

- Comprises captive power generation running in parallel with, or in isolation from, the grid
- Supplies substantial electrical loads, some of which are critical to the process

Application

PML630 provides system level disturbance management for small and medium-sized industrial power systems. The device supports four types of load-shedding functions:

- The device supports multiple load-shedding modes that work in a concurrent and coordinated manner. All the modes are always available and pre-loaded in the device. Based on project requirements, they can be enabled or disabled.
  - Fast load-shedding due to loss of power sources and disintegration of 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 operator based on power definition or load feeder priorities
  - Underfrequency load-shedding as backup to fast and slow load-shedding

Network configuration

PML630 performs load-shedding based on measurements and binary data received from devices associated with generator feeders (REG630, REG615), grid transformers, outgoing transformer feeders (RET630/RET620/RET615), motors (REM630/REM620/REM615), load feeders (REF630/REF620/REF615), bus coupler feeders and tie feeders (REF630/REF620/REF615). If a generator feeder, grid transformer or load feeder is protected and controlled by a non-IEC 61850 device, a RIO600 I/O unit can be deployed for sending measurement and binary data to PML630. When PML630 initiates load-shedding, it sends load-shedding commands to motor and load feeders through their respective relays or I/O units. The bi-directional data flow is accomplished using IEC 61850 GOOSE messaging.

The COM600 series products provide monitoring and operation control of load-shedding and substation processes, in addition to functioning as a station protocol gateway. The exchange of operational data between COM600 and PML630 is realized through IEC 61850 MMS communication. The COM600 series products uses web technology to display the data in a user-friendly way.

PML630 is optimally and efficiently configured to interoperate with Relion 615, 620 and 630 series transformer protection (RET), feeder protection (REF), motor protection (REM) and generator protection (REG) relays, RIO600 and COM600 series products, configuration included, to manage the overall load-shedding functionality.

This load-shedding solution cluster, consisting of PML630, Relion 615, 620 and 630 series feeder relays, RIO600 units and a COM600 series product, is referred to as compact Power Management System (cPMS), load-shedding configuration A.

Other ABB IEC 61850 devices such as Relion 670/650 series intelligent electronic devices (IEDs) and AC800M, and HMI systems like MicroSCADA, System 800xA can also be integrated into the solution cluster.

PML630 can also interoperate with non-ABB IEC 61850 intelligent devices to realize the load-shedding functionality,

provided that they meet the necessary functional requirements.

Fast load-shedding

The fast load-shedding function performs power balance calculations during power deficit conditions in the network. It arrives at the quantum of load to be shed according to priorities defined by the operator. Corrective actions are taken before the system frequency drops.

- The fast load-shedding function performs the following actions:
- Monitors up to four independent power networks (subnetworks) within its substation or power network area
- Monitors available power from generators or grid transformers, in relation to power consumption in every power network
- Considers the capability of the power sources (grid transformers and generators) – accepts operational mode and power capacity information from an external system regarding generators
- Initiates power balance calculations on activation of a critical signal (also called contingency) such as:
  - Opening of a generator or grid transformer feeder circuit breaker
  - Opening of a bus coupler feeder or tie line (network) circuit breaker
  - Lockout of any protection function of the above listed feeders
  - Lockout of a generator turbine protection function
  - Any user-configured external event, based on project-specific requirements such as the rate of frequency decay or any process event
- Uses the actual measured power from all feeders and the load feeder priorities to dynamically calculate the amount of load(s) to be shed. Loads with a priority lower than and equal to the calculated priority are issued load-shedding commands by PML630, whereas loads that are inhibited for load-shedding are discarded
- Issues load-shedding commands to trip loads to avoid blackouts and damage to electrical and process equipment
- Creates subnetwork-related dynamic load tables and power network information for display in a COM600 series product

Slow load-shedding

The slow load-shedding function is activated when an overload of a grid transformer or a generator in the power network or power demand violation at the grid tie line is detected. Overloading based on overcurrent or power demand violation is relatively slower than spontaneous events. The generated trigger can be flexibly used to either directly initiate load-shedding actions or to initiate power balance calculations. The loads are shed based on assigned load priority, resulting in reducing or eliminating the overload of the power source. By reacting before the generator or grid transformer overload protection function is activated, PML630 is able to prevent tripping of the power source. As a result, the system reliability and availability is increased.

The slow load-shedding function can be retriggered after a configurable time delay if the overcurrent condition still persists.

PML630 facilitates overload detection through:

- A dedicated overcurrent protection function (identical to the corresponding protection function in 630 series generator and transformer protection relays)
- Calculation of average power demand and detection of power demand violation (if persistent for a parameterized time interval)
- A power deficit condition (consequence of overload) in every power network (can optionally be used to trigger load-shedding)
- Using currents measured by generator and transformer protection relays and transferred over IEC 61850 GOOSE
- Measuring grid transformer currents directly

Manual load-shedding

The manual load-shedding function can be activated per subnetwork by the operator in critical situations requiring human intervention.

- The operator can enter a priority or power value via the local or Web HMI of PML630 or in a COM600 series product.
- When entered as a priority, load-shedding commands are issued to load feeders with a priority lower than and equal to the priority entered by the operator. When entered as a power value, an equivalent load-shedding priority is calculated in such a way that the actual amount of load-shedding at least equals or is just higher than the defined value.

Each subnetwork can also be automatically activated for manual load-shedding based on an external process event, such as the time of the day or the manufacturing process.

When a load-shedding priority is identified for load-shedding, all the constituent load feeders associated with that priority will receive load-shedding commands.

Underfrequency load-shedding

Every subnetwork can be set to have two stages of underfrequency.

A gradual overload in a subnetwork results in the system frequency falling in that specific subnetwork. This can be detected by the first stage and set to trigger load-shedding. Loads will only be shed in the subnetwork with the power deficit.

The second stage can be used to trigger load-shedding and to reduce the overload according to the priority or power value.

Blocking of load-shedding

Fast and slow load-shedding depend on the integrity of the data received from the power source and network feeder relays. For this reason, any anomaly related to communication or device availability will result in blocking of the functions.

The manual load-shedding and underfrequency load-shedding (second stage) functions are independent of the fast and slow load-shedding functions and can consequently still be activated, even though the fast and slow load-shedding functions have been blocked.

Blocking can also be initiated manually either via the local or Web HMI of the PML630 or a COM600 series product.

Load feeder inhibition for load-shedding

A load feeder can be disabled for load-shedding through:

- An operator action
- A system action when the load feeder protection relay loses communication with PML630
- Any external signal or event, such as trip-circuit supervision failure

Communication

PML630 fully supports the IEC 61850 standard for communication in substations. Using GOOSE communication profiles for load-shedding has the following advantages:

- Substation LAN infrastructure for binary and analog data exchange between the devices
- Reliable and proven Ethernet technology for data transfer
- Elimination of hard-wired I/Os
- Faster than hardwired-based signaling
- Less effort to introduce configuration changes
- Supervised data transfer using IEC 61850 quality definitions
- Ease of maintenance

Supported power network configurations

PML630 can support power networks with the following configurations:

- 6 generators (connected to 1 to 4 busbars)
- 2 grid transformers or grid tie lines (connected to 1 to 4 busbars)
- 6 single busbars (arranged in 1 to 3 levels)
- 15 network circuit breakers (outgoing transformer/tie feeders/bus couplers)
- 10 sheddable loads per busbar (assigned priority 1 to 19)
- 60 sheddable loads or load-shedding groups (connected to all busbars)

Only single busbar-based network configurations can be inherently managed using PML630. However, a double busbar-based network can be accommodated using adaptions in configuration and engineering involving 630 series as power source and feeder relays. PML630 can then also be used with the following configurations:

- 2 generators
- 2 grid transformers
- 3 double busbars
- 6 outgoing transformer/tie feeders/bus couplers
- 30 sheddable loads or load-shedding groups

Managing extensive power networks

In case the power network configuration exceeds the limits defined for a single PML630 device, additional PML630 devices can be configured to interoperate as peer devices and be responsible for load-shedding in their respective areas. The peer PML630 devices exchange information regarding the spinning reserve power of the respective areas and the connectivity status between their respective network areas. Coordination of load-shedding between the PML630 devices, for example, during power export from one power network area to another, is realized through parameterization.

The load-shedding behavior can be set to depend on the criticality of the process and capability of the adjacent network area:

- If the power deficit area has critical loads, load-shedding can be configured to be performed in the exporting (surplus) power network area. Consequently, the export of power can continue.
- If the power deficit area has sufficient standby power capability to support the process loads itself, the load-shedding can be configured to be performed in that specific power network area.
- Alternatively, a substantial part of the load-shedding can be activated in the surplus area and the balance executed in the deficit area, provided that it has sufficient standby power capability to support its critical loads.

This load-shedding solution is referred to as cPMS, load-shedding configuration B. A maximum number of three PML630 devices is recommended in such a configuration.

Human-machine Interface (HMI)

As a member of the Relion product family, PML630 shares the same Human Machine Interface (HMI) look and feel as the other Relion protection and control relays. The same look and feel includes the location of a push button with a certain function and the menu structure.

The 630 series relays are equipped with a large graphical display which can show customizable single-line diagrams (SLD). Also measured values can be displayed. Specifically of PML630, the key load-shedding SLD that is generated automatically from PCM600, can be further adjusted/enhanced to suit customer requirements.

The 630 series HMI is distinguished by fifteen three-color LEDs and five configurable push buttons, which can be used

as control buttons for various tasks related to load-shedding functionality. The five push buttons can also be conveniently used as menu shortcuts. Another distinguishing feature is the detached HMI, as an option to the integrated HMI, which is beneficial for specific installation requirements, such as in a switchgear.

Engineering and application configuration

The configurability of PML630 ensures easy adaptation of the load-shedding functionality to an industrial power network, thus fulfilling the project-specific requirements. PML630 has a standard Web interface for easy access to settings and device data and also features pre- and post-load-shedding analysis, using the Protection and Control IED Manager of the engineering tool PCM600.

In addition to configuring Relion 615, 620 and 630 series relays, and RIO600 I/O units, PCM600 is also used for engineering PML630. An efficient and low-effort engineering procedure ensures that the power network data is entered only once. The following steps are performed automatically:

- Instantiation of function blocks and their interconnections
- Generation of the load-shedding single line diagram for the local HMI of PML630
- PML630-specific IEC 61850 engineering and GOOSE signal mapping
- Load-shedding display configuration for a COM600 series product
- Generation of channel allocation of the RIO600 I/O modules in PDF format
- Generation of the list of relays and details involved in load-shedding in Excel format
- Generation of information of outgoing load feeder IEC 61850 GOOSE configuration for easy engineering in Excel format

In addition to supporting standard parameters, easy engineering of load feeder devices to implement the load-shedding functionality is also supported. Additional binary and arithmetic logic can be realized for tailoring the load-shedding functionality towards customer-specific requirements.

External system connectivity for cPMS load-shedding solution Configuration A

- The COM600 series products can be interfaced with any third-party system like a distributed control system (DCS)
- Any IEC 61850 client, such as MicroSCADA and 800xA Connect/Aspect Server, can be configured to display load-shedding process information in a similar way as in a COM600 series product.
- An external controller such as AC800M, running generator control functionality, can be configured to send dynamic power capability and mode information to the PML630 device using IEC 61850 GOOSE.
- For large industrial plants such as refineries, an external plant-wide load-shedding system, such as one based on AC800M, can work in a cooperation with multiple PML630 devices in downstream process plant substations (with local power generation).
- An external system can send an event based on the process situation to the PML630 device to trigger power balance calculations and subsequently activate load-shedding, if required.

Performance

In Configuration A, the end-to-end performance (from tripping of the power source to initiation of a load-shedding command to a load feeder) is achieved within 60ms.

In Configuration B, the load-shedding action in power network area 2, which is the result of a contingency in power network area 1, is achieved within 90ms.

When the load-feeder circuit is based on an ABB MV circuit breaker, the open time is approximately 50ms.

Redundancy

A communication-based redundancy solution is achieved using PRP (Parallel Redundancy Protocol). To achieve a redundancy solution (with inherent communication redundancy), two identically configured pairs consisting of one PML630 device and one COM600 series product each are connected to other Relion (615 and 620 series) relays, either in an HSR (High-availability Seamless Redundancy) or PRP configuration. In both cases, appropriate communication equipment such as redundancy boxes and Ethernet switches can be used.

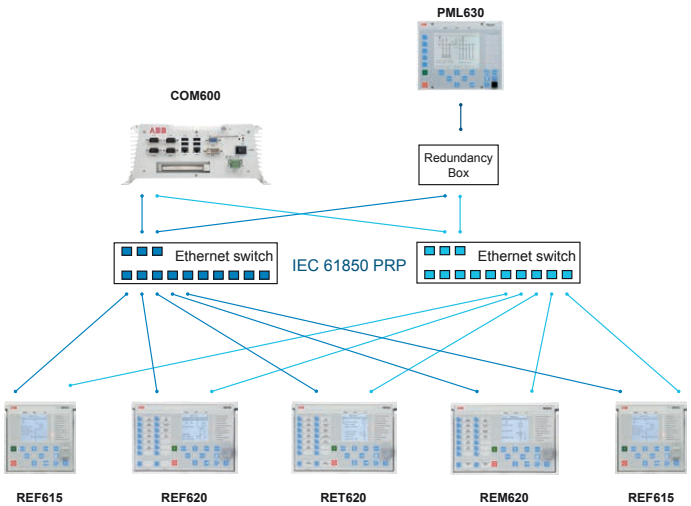


Figure 1. PML630 PRP solution

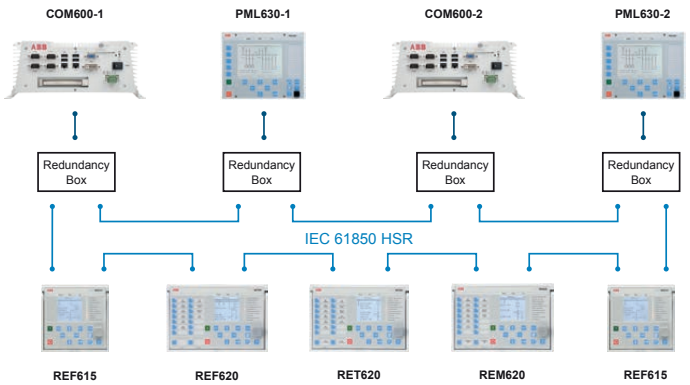
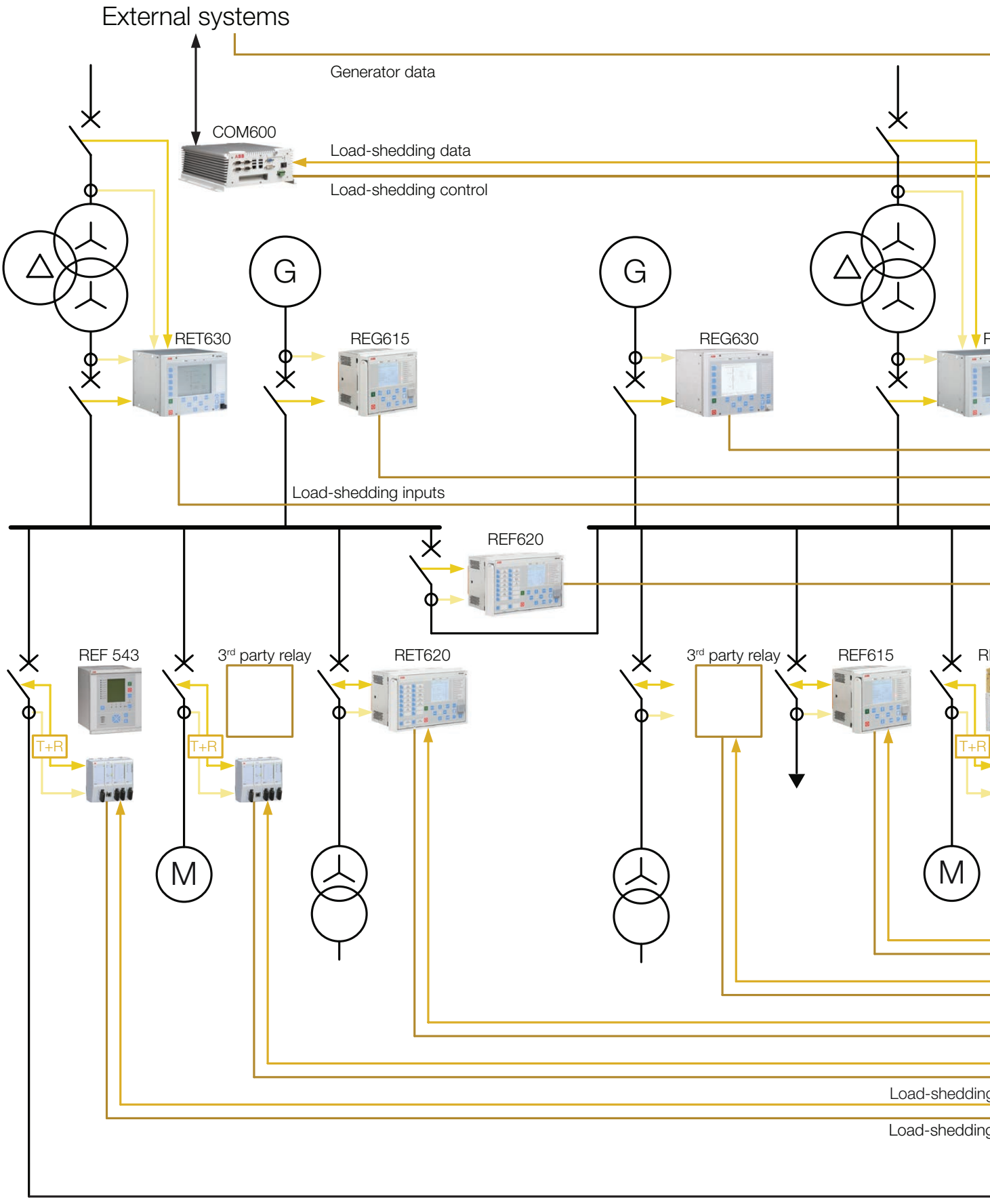


Figure 2. PML630 HSR solution

PML630 functional overview



IEC 61850 communication MMS profile
- for load-shedding display data and function control

IEC 61850 communication GOOSE profile
- for load-shedding functionality processing input data and shed commands
- data exchange with peer PML630 devices
- for load-shedding data and control information from external systems

Control functions (cPMS configuration A)
- Fast load-shedding
- Slow load-shedding
- Manual load-shedding
- Underfrequency load-shedding

(cPMS configuration B)
- Extended load-shedding

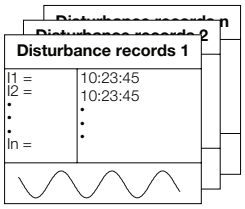
Engineering and configuration
- Optimized with Relion 630, 620 and 615 series, RIO600 and COM600S/COM600F

Web HMI

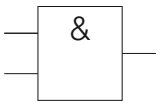
Local HMI
- load-shedding single line diagram diagram
- values, status indications
- alarms and events
- operational parameters
- 3x15 alarm multicolor indications with programmable texts
- 5 freely programmable function buttons

Supervision
- device self-supervision

Disturbance records
- analog recording
- non-volatile
- post triggering of load-shedding function



Programmable logic



I/Os
- 14 BI / 9 BO
- 4 CT + 5 VT
- 8 CT + 2 VT

RET630

EF 542plus

g command

g inputs

PML630

Contact us

For more information, see the PML630 Product Guide or contact us:

ABB Oy, Medium Voltage Products
P.O. Box 699
FI-65101 VAASA, Finland
Phone: +358 10 22 11

ABB India Ltd, Distribution Automation
Maneja Works
Vadodara-390013, India
Phone: +91 265 6724402
Fax: +91 265 6724407

ABB AG. Calor Emag Medium Voltage Products
Oberhausener Strasse 33
40472 Ratingen, Germany
Phone: +49 2102 120
Fax: +49 2102 121 777

ABB Inc, Distribution Protection and Control
4300 Coral Ridge Drive
Coral Springs, Florida 33065, USA
Phone: +1 800 523 2620
Fax: +1 954 345 5329

www.abb.com/mediumvoltage
www.abb.com/substationautomation

Power and productivity
for a better world™