

# Feeder Protection and Control REF620

## Numerical feeder protection in medium voltage networks

The configurable relay is intended for protection, control, measurement and supervision of the outgoing or incoming feeder in complex applications with a high number of switching devices in medium voltage networks. With extended protection functionality, it can also be applied to interconnection, capacitor bank, basic motor protection and busbar protection applications.

### Mechanical and construction details

- The relay shall have compact dimensions not exceeding 4U in height. The depth of the relay shall, without any additional raising frame, not exceed 160 mm when flush mounted so as not to foul with other equipment mounted inside the cabinet. The weight of the relay must not exceed 6 kgs to permit use of optimized sheet metal thickness in construction of panels.
- The relay shall support flush, semi-flush, rack and wall mounting options.
- As flush mounted, the relay shall meet the IP54 ingress protection requirements on the front side and IP20 on the rear side and connection terminals.
- To facilitate quick unit replacement, the relay design shall be of draw-out type with secure current transformer (CT) shorting. It shall be possible to quickly replace a faulty unit with a spare without disturbing the majority of the wiring. The mean time to repair (MTTR) shall be less than 30 minutes.
- To prevent unauthorized detachment of the relay plug-in unit, the relay shall be provided with an integrated seal.
- The relay shall have a graphical display with at least 7 rows of characters and up to 20 characters per row.
- The HMI shall include at least 16 freely configurable push buttons with integrated status LEDs.

### Protection functions

- The relay shall have non-directional phase overcurrent and earth-fault protection (50/51) with four stages (low-set, high-set and non-directional instantaneous stage), definite time (DT) and inverse definite minimum time (IDMT) characteristics, and IEC and ANSI/IEEE operating curves.
- The relay must have four-stage directional phase overcurrent protection (67) with voltage memory and positive and negative-sequence polarization.
- The relay must have four-stage directional earth-fault protection (67N) with selectable negative and zero-sequence polarization.  $I_0$  and  $U_0$  shall be derived either from the phase voltages and currents or from the measured neutral current and residual voltage.
- In compensated, unearthed and high-resistance earthed networks, the relay shall be able to detect transient, intermittent and continuous earth faults. The fault direction determination criterion of the protection function must include multiple harmonics.
- In compensated, unearthed and high-resistance earthed networks, the relay shall have admittance (21YN/67YN) and wattmetric-based (32N) earth-fault protection.
- The relay shall have arc protection based on simultaneous detection of current and light. During maintenance work at the substation, it shall be possible to change the operation criteria to light only via a binary input.

- The relay shall have two-stage negative-sequence overcurrent protection (46) settable between 0.01 and 5 times  $I_n$ , definite time (DT) and inverse definite minimum time (IDMT), and IEC and ANSI/IEEE operating curves.
- To detect phase unbalance caused by a broken conductor, the relay shall have phase discontinuity protection (46PD). For optimum sensitivity and stability, the operation must be based on the ratio between the positive and negative-sequence current.
- The relay shall have phase unbalance, voltage and frequency protection.
- The relay shall include a six-stage frequency-based load-shedding and restoration function for automatic disconnection and reconnection of less important loads in network overload situations.
- The relay shall include a fault-locating algorithm to calculate the fault location with  $\pm 2.5\%$  accuracy for phase-to-phase and phase-to-earth faults in effectively and low-resistance earthed networks.
- For overhead line applications, the relay shall have a multishot auto-reclose function.
- The relay shall have circuit breaker failure protection (51BF/51NBF) including independent timers for repeated tripping of the same breaker and backup tripping of the upstream breaker. The function shall allow higher selectivity by avoiding tripping of the upstream breaker if the repeated tripping of the breaker closest to the fault is successful.

### Inputs and outputs

- The relay shall have 8 binary inputs and 9 binary outputs and all of them freely configurable. Optionally, it must be possible to add 8 more binary inputs and 1 more binary output.
- To enable direct tripping of the circuit breaker, the relay must have 2 double-pole power output relays with integrated trip-circuit supervision (TCS). The two power output relays shall be rated to make and carry 30 A for 0.5 s with a breaking capacity of  $\geq 1$  A ( $L/R < 40$  ms).
- To enable fast direct tripping of the circuit breaker, the relay must have 3 optional high-speed binary outputs with an operate time of  $\leq 1$  ms. The binary output contacts shall be rated to make and carry 30 A for 0.5 s with a breaking capacity of  $\geq 1$  A ( $L/R < 40$  ms).
- The threshold voltage of the relay's binary inputs shall be settable to 16...176 V DC.
- The binary inputs of the relay shall, when energized, utilize a higher inrush current to facilitate the breaking of possible dirt or sulfide from the surface of the activating contact.
- The relay shall offer two optional RTD inputs and one mA input.
- The phase current inputs and the residual current input of the relay shall be rated 1/5 A. The selection of 1 A or 5 A shall be software-based.
- For applications requiring sensitive earth-fault protection, the relay shall offer an optional 0.2/1 A residual current input. The selection of 0.2 A or 1 A shall be software-based.
- The relay must offer optional current and voltage sensor inputs and support the use of combined current and voltage sensors connected with one connector per phase. The current sensor inputs must facilitate the usage of sensors within the nominal range of 40...1250 A without any external adaptors.

#### **Interconnection protection**

- To determine whether and when to disconnect a distributed generation unit from the grid during network disturbances, the relay shall have three-stage low-voltage ride-through protection (27RT) with a user-definable Low-Voltage Ride-Through (LVRT) curve, to comply with local or national grid code requirements.
- To ensure power system stability, the relay shall have directional reactive power and undervoltage protection (32Q,27) and monitor the reactive power flow to prevent a power system voltage collapse in the event of a network fault. The function shall include two independently settable stages enabling the disconnection of the generator circuit breaker, or the common coupling breaker if several power generating units are operated in parallel and feeding the network.
- To detect islanding or loss-of-mains conditions of distributed generation units, the relay shall have vector shift protection (78V). The function shall continuously measure the voltage cycle shift in terms of the phase angle, which shall be settable between 2 and 30 degrees with 1 degree resolution.

#### **Capacitor bank protection**

- The relay shall have single, two and three-phase capacitor bank overload protection (51C) against overloads caused by harmonic currents and overvoltages in shunt capacitor banks. The operation of the overload protection shall be based on the peak value of the integrated current that is proportional to the voltage across the capacitor.
- The relay shall have undercurrent protection for detecting disconnection of the capacitor bank. To avoid an undercurrent trip when the capacitor bank is disconnected from the power system, the undercurrent protection shall be blocked using the capacitor bank circuit breaker open status signal.
- To provide protection against reconnection of a charged capacitor to a live network and ensure complete capacitor discharging before breaker reclosing, the relay shall include breaker reclosing inhibit functionality. The capacitor bank discharge time shall be settable between 1 and 6000 seconds.

- The relay shall have current unbalance protection (51NC-1) for shunt capacitor banks to protect double Y-connected capacitor banks against internal faults. The function shall suit internally fused, externally fused and fuseless applications and include settable definite time (DT) or inverse definite minimum time (IDMT) characteristics. The operation of the alarm stage shall either be based on the DT characteristic or the faulty element counter of the capacitor bank.
- The relay must have current-based shunt capacitor bank switching resonance protection (55TD) for detecting three-phase resonance caused by capacitor switching or topology changes in the network. The operation of the switching resonance protection shall be based on the definite time (DT) characteristic. In harmonic filter applications, it shall be possible to exclude the designed harmonic filter frequency. Detection and disconnection of the harmonic resonance situation shall avoid the need for a detailed system study for each installation to determine the right size and operating range of the capacitor bank.

#### **Motor protection**

- The relay shall have directional active and reactive overpower protection (32O) preventing motors from consuming excessive power. It shall be possible to select the operating direction with the combination of the settings directional mode and power angle, where directional mode can be either forward or reverse and power angle set between reactive or active power. The power setting shall be settable between 1...200 % of the machine's apparent power in steps of 1% and the operate time to 0,04...300 seconds.
- The relay shall include two-stage underpower protection (32U) for detecting loss of load, which is considered a fault condition. The function shall calculate the apparent power based on the selected voltage and current measurements. It shall be possible to use the positive-sequence components for calculating the apparent power, which makes the determination of power insensitive to the possible asymmetry in currents or voltages.

### Busbar protection

- The relay shall include phase segregated busbar protection (87A/B/C) based on the high impedance principle.

### Other functions

- The relay shall have undercurrent protection (37) for detecting feeder disconnection, low-load and loss-of-phase conditions.
- The relay shall include Switch-On-To-Fault (SOTF) logic ensuring a fast trip when the breaker is closed onto a faulted feeder or bus. The function shall complement the non-directional or directional overcurrent protection functions and accelerate the operation of the protection.
- The relay shall include a synchro-check (25) function for circuit breaker closing. The function shall ensure that the voltage, phase angle and frequency on either side of an open circuit breaker meet the requirements for safe interconnection of two networks. The function shall include energizing check functionality and support the operation modes dead-line/live-line and dead-bus/live-bus. To enable circuit breaker closing when reconnecting two asynchronous networks, the function shall consider the circuit breaker closing delay and the measured slip frequency to ensure that the closing command is given at the right moment. The function shall include phase-shift compensation for cases where the reference voltage is measured across a power transformer.
- To permit the circuit to operate close to thermal limits, at the same time providing adequate protection, the relay shall have three-phase thermal protection (49F) for feeders, cables and distribution transformers. The thermal model shall be compliant with the IEC 60255-149 standard.

### Inputs and outputs

- The relay shall have at least 24 binary inputs and 14 binary outputs and all of them freely configurable. Optionally, it must be possible to add another 8 binary inputs and 4 binary outputs.
- To enable direct tripping of the circuit breaker, the relay must have 2 double-pole power output relays with integrated trip-circuit supervision (TCS). The two power output relays shall be rated to make and carry 30 A for 0.5 s with a breaking capacity of  $\geq 1$  A ( $L/R < 40$  ms).
- To enable fast direct tripping of the circuit breaker, the relay must have 3 optional high-speed binary outputs with an operate time of  $\leq 1$  ms. The binary output contacts shall be rated to make and carry 30 A for 0.5 s with a breaking capacity of  $\geq 1$  A ( $L/R < 40$  ms).
- The threshold voltage of the relay's binary inputs shall be settable to 16...176 V DC.
- The binary inputs of the relay shall, when energized, utilize a higher inrush current to facilitate the breaking of possible dirt or sulfide from the surface of the activating contact.
- The relay shall offer six optional RTD inputs and two mA inputs.
- The phase current inputs and the residual current input of the relay shall be rated 1/5 A. The selection of 1 A or 5 A shall be software-based.
- For applications requiring sensitive earth-fault protection, the relay shall offer an optional 0.2/1 A residual current input. The selection of 0.2 A or 1 A shall be software-based.
- The relay must offer optional current and voltage sensor inputs and support the use of combined current and voltage sensors connected with one connector per phase. The current sensor inputs must facilitate the usage of sensors within the nominal range of 40...4000 A without any external adaptors.

### Measurements, alarms and reporting

- The relay shall have three-phase current and voltage measurement (fundamental or RMS-based as selectable options) with an accuracy of  $\pm 0.5\%$  and zero, negative and positive-sequence current and voltage measurement with an accuracy of  $\pm 1\%$  within the range of  $\pm 2\text{Hz}$  of the nominal frequency. Power measurement (P, Q & S) with an accuracy of  $\pm 1.5\%$  and power factor measurement with an accuracy of  $\pm 0.015$  shall also be included.
- To collect sequence-of-events (SoE) information, the relay must include a non-volatile memory with a capacity of storing at least 1024 event codes with associated time stamps.
- The relay must support the storage of at least 128 fault records in the relay's non-volatile memory.
- The fault record values must at least include phase currents, phase voltages, zero, negative and positive-sequence currents and voltages, and the active setting group.
- The relay shall have a disturbance recorder supporting a sampling frequency of 32 samples per cycle and featuring up to 12 analog and 64 binary signal channels.
- The relay's disturbance recorder shall support not less than 6 three-second recordings at 32 samples per cycle for 12 analog channels and 64 binary channels.
- The relays shall support up to 100 disturbance recordings.
- The relay must have a load profile recorder for phase currents and voltages supporting up to 12 selectable load quantities and more than 1 year of recording length. The load profile recorder output shall be in COMTRADE format.

### Communication

- The relay must support IEC 61850 Edition 1 and Edition 2.
- The relay must support, besides IEC 61850, simultaneous communication using one of the following communication protocols: Modbus® (RTU-ASCII/TCP), IEC 60870-5-103 or DNP3 (serial/TCP). With external adapter it shall support Profibus where needed.
- The relay must have an Ethernet port (RJ45) on the front for local parametrization and data retrieval.

- The relay shall support up to five IEC 61850 (MMS) clients simultaneously.
- For redundant Ethernet communication, the relay shall have either two optical or two galvanic Ethernet network interfaces with HSR and PRP-1.
- The relay shall have a third Ethernet port for providing connectivity of any other Ethernet device to an IEC 61850 station bus inside a switchgear bay.
- The relay must support IEC 61850 GOOSE messaging and meet the performance requirements for tripping applications ( $< 10\text{ms}$ ) as defined by the IEC 61850 standard.
- The relay shall support sharing analog values, such as temperature, resistance and tap positions using IEC 61850 GOOSE messaging.
- The relay must support IEEE 1588 v2 for high-accuracy time synchronization ( $< 4\ \mu\text{s}$ ) in Ethernet-based applications. The relay shall also support the SNTP (Simple Network Time Protocol) and IRIG-B (Inter-Range Instrumentation Group - Time Code Format B) time synchronization methods.
- The relay must support IEC 61850-9-2LE process bus for sending sampled values of currents and voltages.

### Engineering and configurability

- The relay must have 6 independent settings groups for the relevant protection settings (start value and operate time). It must be possible to change protection setting values from one setting group to another in less than 20 ms from the binary input activation.
- The relay must have a web browser-based human-machine interface (WHMI) with secured communication (TLS) and shall provide the following functions:
  - Programmable LEDs and event lists
  - System supervision
  - Parameter settings
  - Measurement display
  - Disturbance records
  - Phasor diagram
  - Single-line diagram (SLD)
  - Importing and exporting of parameters, sequence-of-event (SoE) information and disturbance records

- When a protection function is disabled or removed from the configuration, neither the relay nor the configuration tool shall show the function-related settings.
- The relay HMI and configuration tool shall have multilingual support.
- The relay HMI and configuration tool shall support both IEC and ANSI protection function codes.
- The relay shall have at least 11 freely configurable and programmable two-color LEDs.
- The relay must have at least 10 user-configurable local HMI views including measurements and SLDs.
- The relay shall have a graphical configuration tool for the complete relay application including multi-level logic programming support, timers and flip-flops.
- The relay configuration tool must include online visualization of the relay application state.
- It must be possible to keep the relay configuration tool up-to-date using an online update functionality.
- The relay configuration tool shall support viewing of relay events, fault records and visualization of disturbance recordings.
- The relay configuration tool must include the complete relay documentation including operation and technical details.
- The relay configuration tool must include functionality for comparing the archived configuration to the configuration in the relay.
- The relay configuration tool must allow configuration of IEC 61850 vertical and horizontal communication including GOOSE and sampled values.
- The relay configuration tool must support importing and exporting of valid IEC 61850 files (ICD, CID, SCD, IID).
- The relay configuration tool must be compatible with earlier relay versions.

#### **Type tests and other compliance requirements**

- The relay shall have a continuous operating temperature range of -25 ... +55°C and transport/storage temperature range of -40...+85°C.
- The relay must fulfill the mechanical test requirements according to IEC 60255-21-1, -2 and -3, Class 2 for vibration, shock, bump and seismic compliance.
- The relay's maximum DC auxiliary power consumption shall be less than 20 W (all inputs activated and over the full supply range).
- The relay must have an IEC 61850 Edition 1 certificate from an accredited Level A testing laboratory.
- The relay must have an IEC 61850 Edition 2 certificate from an accredited Level A testing laboratory.
- The relay must fulfill the electromagnetic compatibility (EMC) test requirements according to IEC 60255-26.
- The relay must be tested according to the requirements of the IEC or an equivalent standard.
- The relay must be certified by independent test laboratories for marine applications.

#### **Additional information**

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

**[www.abb.com/substationautomation](http://www.abb.com/substationautomation)**

**[www.abb.com/mediumvoltage](http://www.abb.com/mediumvoltage)**