

Interconnection Protection REG615 std configuration D

Numerical generator protection in low and medium-voltage networks

The relay is intended for protection, control, measurement and supervision of small and medium-sized synchronous power generators (typically 0.5 MW – 8 MW requiring differential protection) in diesel and gas-based power plants and micro/mini hydel power plants.

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 5 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 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.

Protection functions

Protection and control during start-up and shutdown

- To ensure sensitive and selective protection during generator start-up and shutdown in low-frequency and low-voltage amplitude conditions, it shall be possible to enable frequency adaptivity for the below-mentioned start-up protection functions. The relay shall provide protection in the operating

frequency range of 10...75 Hz (12...90 Hz for 60 Hz networks). By using the selectable wide peak-to-peak measuring principle, the overcurrent protection shall, if required, operate from as low as 2 Hz during start-up or shutdown.

- The relay shall have non-directional overcurrent (50/51) and earth-fault (50/51N) protection with multiple stages and settable definite time (DT) and inverse definite minimum time (IDMT) characteristics, supporting both IEC and ANSI/IEEE operating curves.
- The relay shall have three-stage directional earth-fault protection (67N) with selectable negative and zero-sequence voltage 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.
- The relay shall have comprehensive voltage protection functionality, including at least overvoltage (59), undervoltage (27), positive-sequence undervoltage (47U+), negative-sequence overvoltage (47O-) and residual overvoltage (59G) protection.
- The relay shall have overexcitation (V/Hz) protection (24) to protect generators and transformers against an excessive flux density and saturation of the magnetic core. The function shall include settable definite time (DT) and inverse definite minimum time (IDMT) characteristics, and a settable alarm.

Protection and control during normal run:

- The relay shall have stabilized and instantaneous differential protection (87M/G) for machines, to provide stator winding short-circuit and earth-fault protection.
- The relay shall have two-stage directional overcurrent protection (67) with voltage memory and positive and negative-sequence voltage polarization.
- The relay shall have three-phase voltage-dependent overcurrent protection (51V) against short circuits close to the generator terminals. The function shall include settable definite time (DT) and inverse definite minimum time (IDMT) characteristics. The function shall operate when the current exceeds a set value dynamically calculated based on the measured terminal voltage. It shall also be possible to select either a voltage restrained /voltage slope or voltage controlled/voltage step characteristic.
- The relay shall have two-stage negative-sequence overcurrent protection (46M) against single-phasing, unbalanced load or unsymmetrical voltage, with DT or IDMT characteristics and settable between 0.01 and 5 times pu. The negative-sequence overcurrent protection must be blocked if the current circuit supervision detects a fault in the current measuring circuit.
- The relay shall have four-stage frequency protection (81), including at least overfrequency (81O), underfrequency (81U) and frequency rate-of-change protection (81R) with rate-of-rise or rate-of-fall freely selectable for each stage.
- The relay shall have three-phase thermal overload protection (49T/G) and protect the transformer/generator mainly from short-time overloads. The protection shall be able to utilize either one or two time constants, which shall be selectable. It shall be possible to include the ambient temperature measured from an external temperature sensor in thermal modeling for better accuracy.
- The relay shall have a three-phase inrush detection function (68) to avoid tripping in magnetizing inrush conditions in the generator transformer. It shall be possible to selectively block the overcurrent and earth-fault stages when the ratio of the second harmonic component over the fundamental component exceeds the set value.
- The relay shall have two-stage underpower protection (32U) for protecting the generator and prime mover against the effects of very low power output or reverse power conditions.
- To protect the generator and turbine from the harmful effect of excessive power/motoring, the relay shall have two stage reverse power/directional overpower protection (32R/32O). It shall be possible to use positive-sequence components for calculating power, which makes the determination of power insensitive to the possible asymmetry in currents or voltages and corresponds to the real load of the generator's prime mover. The protection function shall have a power angle settable between -90 and +90 degrees and an adjustable power setting range of 1...200%.
- The relay shall have underexcitation protection (40) to protect synchronous machines against underexcitation or loss of field/excitation conditions, which may cause excessive heating in the end region of the stator winding, damaging the insulation of the stator winding and the iron core. The function shall prevent the machine from operating in the asynchronous mode, which increases the rotor speed, causing heating in the rotor iron and damper windings. The protection shall be based on the offset-mho circle characteristic on the impedance plane, defined by setting the Offset, Diameter and Displacement values. For impedance calculation, the voltage selection options shall be 1Phase-earth, 1Phase-phase, 3Phase-earth, 3Phase-phase and Pos Seqn.
- The relay must have impedance monitoring-based out-of-step protection (78). An out-of-step condition (pole slip) is characterized by periodic changes in the rotor angle. The main purpose of the function is to detect, evaluate and, if required, operate during pole slip conditions. The out-of-step protection function shall detect stable power swings and out-of-step conditions based on the measured impedance travel time through the settable impedance blinders (inner and outer blinders).
- For selective relay operation during power swing conditions (near or far), it shall be possible to divide the impedance characteristic into two zones. The number of pole slips shall be independently settable for each zone. To avoid breaker stress, it shall be possible to include the breaker opening time to optimize the tripping
- 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.
- 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.

- 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..

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 4 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 ≥ 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 ≤ 1 ms. The binary output contacts shall be rated to make and carry 30 A for 0.5 s with a breaking capacity of ≥ 1 A (L/R<40 ms).
- The threshold voltage of the relay's binary inputs shall be set table to 16...176 V DC.
- The relay shall be equipped with inputs for detecting temperature using resistance temperature detector (RTD) sensors. At least 2 inputs shall be required to measure stator winding, bearing or ambient temperatures of a three-phase generator.
- The relay shall support the commonly used sensor types Pt100, Pt250, Ni100, Ni120, Ni250 and Cu10 with 2-wire or 3-wire connection with common ground.
- 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.

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 functionality with an accuracy of $\pm 1\%$ within the range of ± 2 Hz of the nominal frequency.
- 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 relay 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.
- The relay shall include a motor runtime counter for calculating and presenting the accumulated operation time of a machine. The function shall alert the operator via a warning and an alarm when the accumulated operation time exceeds the set limit.

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).
- 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.
- The relay must have two fiber-optic Ethernet ports 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 ms) as defined by the IEC 61850 standard.
- The relay shall have support for sharing analog values like temperature, resistance, tap positions using IEC 61850 GOOSE messaging.
- The relay must support IEEE 1588 v2 for high-accuracy time synchronization (< 4 μ 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 with IEEE 1588 v2 for accurate time synchronization.

Engineering and configurability

- The relay must have 6 independent settings groups for the relevant protection settings (start value, 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

- When a protection function is disabled or removed from the configuration, neither the relay nor the programming tool shall show the function-related settings.
- The relay HMI and engineering tool shall have multilingual support.
- The relay HMI and engineering tool shall support 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 an operational 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 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.

Additional information

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

www.abb.com/substationautomation

www.abb.com/mediumvoltage