

Line Differential Protection and Control RED615

Numerical line differential protection in medium voltage networks

The relay is intended for protection, control, measurement and supervision of outgoing or incoming overhead line and cable feeders in medium voltage networks.

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 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.

Protection functions

- The relay must have phase-segregated line differential protection with two stages, one biased (low-set) and the other (high-set) non-biased.
- The line differential protection algorithm shall be independently executed in the local and remote end relay according to the so called Master-Master principle. In order to maximize protection co-ordination and simultaneous tripping of the circuit breakers at both ends, the relays shall additionally send an intertrip command to the remote end as a dedicated binary signal over the protection communication channel.

- The line differential protection shall be able to accommodate a power transformer within the protection zone. The relay shall match both the power transformer connection group and different current transformer ratios.
- In order to ensure selective operation of the protection functions on the LV-side of a small tapped power transformer within the protection zone, the biased stage of the line differential protection must be able to operate based on definite time (DT) and inverse definite minimum time (IDMT) characteristics.
- It shall be possible to block the biased stage of the line differential protection based on the detected inrush condition. The detection shall be based on the content of the second harmonic component of the measured phase currents. The detected inrush condition shall be transferred to the remote end as dedicated phase segregated binary signals over the protection communication channel to block the remote end line differential protection.
- Interferences in the protection communication link between the local and remote end units shall be detected. The supervision shall cover missing, delayed or corrupted messages.
- Detected interference in the protection communication link, which may lead to delayed tripping or maltripping of the line differential protection, shall block the line differential protection and release the selected backup protection.
- When the protection communication recovers, the line differential protection scheme shall automatically return to normal status.
- The relay shall have selectable directional or non-directional phase-overcurrent and earth-fault protection (50/51/67) with three 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 three-stage directional phase overcurrent protection (67) shall have voltage memory and positive and negative-sequence polarization.
 - The relay must have selectable three-stage non-directional (50/51N) or directional earth-fault protection (67N).
 - The directional earth-fault protection shall have selectable negative or 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
 - In compensated, unearthed and high-resistance earthed networks, the relay shall have admittance (21YN) and wattmetric-based (32N) earth-fault protection.
 - The relay shall include phase unbalance, voltage and frequency protection.
 - The relay shall include a fault-locating algorithm to calculate the fault location with +/- 2.5 % accuracy for phase-to-phase and phase-to-earth faults in effectively and low-resistance earthed radial networks.
 - For overhead line applications, the relay shall have an optional multishot auto-reclose function. The auto-reclose function shall be capable of performing coordinated local and remote end circuit breaker closing based on the Master-Follower scheme.
 - For closed loop and ring-type distribution networks, the relay has to be able to provide synchro-check for circuit breaker closing.
 - The relay shall include current circuit supervision which is capable of preventing maltripping by blocking the affected protection functions. The operation speed of this supervision function is critical, especially for line differential protection. The supervision method shall be based on comparing the reference current, originating either from different CT cores or from different CTs, with the currents that the line differential protection is using.
- 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.
 - In addition to the physical inputs and outputs, the local relay has to be able to simultaneously send and receive eight binary signals to and from the remote end relay. The signals shall be freely usable within the relay logics and/or relay's physical inputs and outputs. The data transfer shall be of full-duplex type with a signalling delay less than 10 ms.

Measurements, alarms and reporting

Inputs and outputs

- The relay shall have 8 binary inputs and 10 binary outputs and all of them freely configurable. Optionally, it must be possible to add 8 more binary inputs.
- 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).
- 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 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 ± 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 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).
- 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 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 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 μs) 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.
- It shall be possible to send a station-time synchronization message to the remote end unit over the protection communication link in case there is no synchronizing source available at the remote end.
- The relay shall have a dedicated fiber-optic port for protection communication between local and remote end units. The port shall support either multimode or single-mode 1300 nm optical media with LC connectors. The maximum distance to be covered shall be no less than 20 km between the local and remote end units. The optical communication link interface shall be integrated in the relay and thus available without any additional converters.
- Protection communication, including related time synchronization, shall be delivered by the supplier ready to use without any parameterization.
- Protection communication time synchronization between the local and remote end relays shall be independent of the station bus time synchronization and shall not require any external time synchronization source.
- The relay shall optionally support the usage of a galvanic pilot wire connection. It shall be possible to later change from galvanic to optical media without modifying the relay's hardware or software. The use of galvanic media shall not impact the relay's performance or features.

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
- 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 an 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 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