

# Transformer Protection and Control RET620

## Numerical transformer protection in medium voltage networks

The configurable transformer management relay is intended for protection, control, measurement and supervision of two-winding power and step-up transformers, including power generator-transformer blocks, in medium voltage utility and industrial power distribution systems.

### 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

#### Differential protection for two-winding transformers

- The relay shall have stabilized (biased) differential protection (87T) with two independently settable stages. The stabilized low-set stage shall provide fast fault clearance while remaining stable when high currents are passing through the protected zone, which increases current measurement errors. The instantaneous high-set stage shall provide very fast clearance of severe internal power transformer faults with a high differential current regardless of their harmonics content. The operate time of the instantaneous stage shall be less than 25 ms.
- The necessary adaptation to the current ratios and vector groups shall be made using software (with internally settable adaptation for CT ratio matching and vector group) and all current inputs (1A and 5A) shall allow direct connection to the main CT, i.e. no interposing current transformers for matching transformer group and main CTs ratio shall be required.
- The differential protection functions shall be provided with a 2nd harmonic blocking to avoid tripping at magnetizing inrush when the transformer is energized either from the HV or LV-side and with a 5th harmonic restraint to avoid tripping at overexcitation. It shall be possible to set the blocking and unblocking levels for the 5th harmonic restraint to manage excessive overvoltage situations.
- The relay shall detect CT saturation conditions and prevent the differential protection from malfunctioning during external faults.
- The biased stage of the differential protection shall have a fully adjustable three-section restraint characteristic to manage measuring errors due to CT errors and tap changer position.

- The relay shall be able to eliminate the zero-sequence current from the measured current. Elimination of the zero-sequence current shall be possible for either the HV or LV winding or both.
- Tap changer position compensation shall be included to enable more sensitive settings to be used. The correction of the transformation ratio due to changing tap changer positions shall be done automatically based on the tap changer position information.

#### **Restricted earth-fault protection**

- The relay shall have both high-impedance (87NH) and low-impedance (87NL) restricted earth-fault protection, freely selectable for both the HV and LV-side.
- The stabilized restricted low-impedance earth-fault protection (87NL) shall be based on the numerically stabilized differential current principle and the neutral-current second harmonic shall be used for blocking the function in a transformer inrush situation. No external stabilizing resistors or non-linear resistors shall be required. The operating characteristics shall be according to the definite time mode.

#### **Backup protection**

- The relay shall have three separate non-directional overcurrent (50/51) stages settable between 0.05 and 40 times pu. The operation characteristic of the low and high-set stages shall be settable to either definite time (DT) or inverse definite minimum time (IDMT), supporting various types of inverse curves, including a user-definable one. The instantaneous stage shall support the peak-to-peak measurement mode and include a possibility to introduce a dedicated two-times setting value peak detection for fast operation in conditions when the current transformers have saturated.

- The relay shall have two separate non-directional earth-fault (50N/51N) stages for remote earth-faults and internal transformer earth-faults. The operation characteristic of the low and high-set stages shall be settable to either definite time (DT) or inverse definite minimum time (IDMT), supporting various types of inverse curves, including a user-definable one.
- The number of overcurrent and earth-fault elements shall be available for the LV and HV-side respectively. It shall be possible to select the number of started phases for overcurrent operation, either one, two or all three phases.
- The relay shall include two negative-sequence overcurrent protection (46) stages settable between 0.01 and 5 times pu.

#### **Overload protection**

- The relay shall include three-phase thermal overload protection (49T) and shall protect the transformer mainly from short-time overloads. The protection shall be able to utilize either one or two time constants, which shall be selectable.
- To protect the generator and turbine from the harmful effect of excessive power/motoring, the relay shall have reverse power/directional overpower protection (32R/32O).
- The relay shall have overexcitation (V/Hz) protection (24) to protect the generators and power transformers against an excessive flux density and saturation of the magnetic core.
- The relay shall have temperature supervision to monitor the thermal behavior of the transformer windings and cooling oil.

### Other protections

- The relay shall have comprehensive voltage protection, including at least overvoltage (59), undervoltage (27), positive-sequence undervoltage (47U+), negative-sequence overvoltage (47O-) and residual overvoltage (59G) protection.
- The relay shall have six-stage frequency (81) protection. The frequency shall be measured using the positive-sequence voltage. It shall be possible to set each stage individually to operate based on underfrequency, overfrequency or rate-of-change of frequency.
- The relay shall have two-stage directional phase overcurrent protection (67) with voltage memory and positive and negative-sequence polarization.
- The relay must have two-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.
- 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 support local and remote control of circuit breakers and motor operated disconnectors/earthing switches. The relay shall provide status indication for manually operated disconnectors/earthing switches.
- The relay shall have circuit breaker failure protection (51BF/51NBF) including independent timers for repeated tripping of the same breaker and back-up 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 must have an option include manual and automatic voltage regulation (90V) of power transformers with a motor-driven on-load tap-changer. The voltage regulator function shall have the following features:
  - Parallel operation of up to four power transformers
  - Parallel operation modes according to master-follower, minimizing circulating current and negative reactance principles
  - Support for necessary data exchange between relays using IEC 61850-8-1 GOOSE messaging when power transformers are running in parallel
  - Line drop compensation for both single power transformers and transformers running in parallel
  - Out-of-step supervision for followers in the master-follower mode
  - Possibility to apply reduced set-point voltage setting in case of a temporary power shortage within the supplying network
  - Both definite time (DT) and inverse definite minimum time (IDMT)-based time delay modes for the tap-changer steptimer. This allows either a fixed time delay or an inverse time delay, based on the difference between the measured and the target voltage level, to be applied for the step-timer.
  - Fast lowering feature that is activated when a specific set voltage value is exceeded due to large load rejection. In this case, the voltage regulator drives the on-load tap-changer to reach the desired LV-side voltage as fast as possible.
  - Blocking of the operation in an overcurrent situation
  - Blocking of the operation in case the measured voltage is too low to be regulated by the tap-changer
  - Supervision of the tap-changer response to the given control command and issuing of an alarm if the performance is not within the set performance limits

### Inputs and outputs

- The relay shall have at least 8 binary inputs and at least 13 binary outputs and all of them freely configurable. Optionally, it must be possible to add 8 more binary inputs and 4 more 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 at least two RTD inputs and one mA input. Additionally, the relay shall also 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.

### Measurements, alarms and reporting

- The relay shall provide comprehensive measurement of three-phase currents and voltages (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  $\pm 2$  Hz of the nominal frequency. Power measurement (P, Q & S) shall be provided with in the accuracy of  $\pm 1.5\%$  and Power Factor measurement shall have an accuracy of  $\pm 0.015$ .
- 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 offer 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 (<10ms) 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  $\mu$ 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 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 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)**

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