

Transformer Protection and Control RET630

Numerical transformer protection in medium voltage networks

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

Mechanical and construction details

- The relay shall have compact dimensions not exceeding 4U in height for panel door mounting installations.
- The relay shall support flush, semi-flush, rack and wall mounting options.
- As flush mounted, the relay shall meet the IP40 (with detached HMI IP42) ingress protection requirements on the front side and IP20 on the rear side and connection terminals.
- To facilitate quick replacement, the relay shall have detachable connectors with secure current transformer (CT) shorting. It shall be possible to quickly replace the faulty unit with a spare without disturbing any of the wiring.
- The relay shall have an integrated human-machine interface (HMI) or alternatively be offered with a detached HMI. The detached HMI shall enable flexible installation for reduced wiring and weight impact on the panel door of the low voltage (LV) compartment.
- The power supply to the detached HMI shall be provided using Power over Ethernet (PoE) to avoid additional wiring for the auxiliary voltage.
- The HMI of the relay shall have a large graphical display with dimensions no less than 70 mm x 100 mm and 320 x 240 pixel resolution, allowing the display of at least 10 switching objects. The HMI shall also include 5 freely configurable push buttons.

Protection and control functions

Differential protection for two-winding transformers

- The relay shall have stabilized (biased) differential protection (87T) with two independently settable stages. The stabilized (biased) 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 20 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 stabilized (biased) stage of the differential protection shall have an adjustable three-section restraint characteristic to manage measurement errors caused by CT errors and the tap changer position.
- The stabilized (biased) low-set of the differential protection 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 second harmonic restraint, together with the waveform-based algorithms, shall ensure that the low-set stage does not operate due to transformer inrush currents, including inrush currents with low harmonic content. When switching the power transformer on to a fault within the protected zone, the 2nd harmonic restraint shall not delay the operation. In such a situation, the blocking, based on the 2nd harmonic of the differential current, shall be prevented by the waveform-based algorithm.
- The relay shall detect CT saturation conditions and prevent the differential protection from malfunctioning during external faults.
- 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 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 resistor or non-linear resistors shall be required. The operating characteristics shall be according to the definite time.

Backup protection

- The relay shall have three separate non-directional overcurrent (50/51) stages, freely 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-time setting value peak detection for fast operation in conditions when the current transformers have saturated.
- The number of overcurrent stages shall be available for the LV and HV-side respectively. It shall be possible to select the number of started phases for operation, either one, two or all three phases.
- The relay shall include two negative-sequence overcurrent protection (46) stages for both the HV and LV side, settable between 0.01 and 5 times pu.
- 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.
- The relay shall have two-stage underimpedance protection (21GT) as backup protection against short circuits at the generator terminals or on the HV-side of a step-up transformer when used for generator–transformer block differential protection. Underimpedance protection shall be applied instead of definite time voltage-dependent overcurrent protection to obtain a limited protection zone and an optimum operating time.
- The relay shall have non directional earth-fault protection (51N) as backup protection for remote earth-faults and internal transformer earth faults.

Other protection

- 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 comprehensive voltage protection, including at least overvoltage (59), undervoltage (27), positive-sequence overvoltage(47O+), positive-sequence undervoltage (47U+), negative-sequence overvoltage (47O-) and residual overvoltage (59G) protection. It shall be possible to apply the protection on the HV or the LV side of the transformer.
- The relay shall have circuit breaker failure protection (51BF/51NBF) for both the HV and LV-side of the transformer. The function shall have independent timers for repeated tripping of the same breaker and backup tripping of the upstream breaker. The function shall facilitate enhanced protection 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 three-stage frequency protection, including at least overfrequency (81O), underfrequency (81U) and frequency rate-of-change (81R) protection with rate-of-rise or rate-of-fall freely selectable for each stage.

Control functionality

- The relay shall 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 step-timer. 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
- The relay shall include a synchrocheck (25) function for circuit breaker closing. The function shall check voltage, frequency and angle conditions between two network parts before allowing the circuit breaker to close.
 - To enable circuit breaker closing in case of two asynchronous networks, the function shall compensate for the measured slip frequency and the circuit breaker closing delay.
 - The synchrocheck function shall perform an energizing check prior to connecting a dead section of the network to an energized one, to ensure safe reconnection of disconnected lines.
 - In case of a fuse failure, it shall be possible to block the synchrocheck function.
- The relay shall support the control of at least 10 objects, including at least 2 circuit breakers and 8 disconnectors/earthing switches freely selectable for control or indication only.

Transformer monitoring

- The relay shall include online monitoring (26/49HS) for calculating the hot spot temperature of the transformer winding, the momentary aging rate of the insulation and the resultant loss of life caused by thermal stress. The hot spot temperature and the momentary aging rate shall be calculated based on the IEC 60076-7 or the IEEE C57.91-2011 standard, according to a user-defined setting. The calculation of the transformer's overall loss of life is measured in years. It shall be possible to apply this function both to new transformers and transformers already in use.

Inputs and outputs

- The relay shall have a scalable amount of binary inputs and outputs. The number of binary inputs shall be scalable up to 50 and the number of binary outputs to 45.
- The relay shall have at least 3 trip output relays with integrated trip circuit supervision (TCS). The trip output relays shall be rated to make and carry 30 A for 0.5 s
- The threshold voltage of the relay's binary inputs shall be independently settable between 15...221 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 optionally include 8 RTD/analog inputs and 4 mA outputs settable between -20 mA and +20 mA. The RTD/analog input shall support various options, e.g. RTDs, mA signals, voltages and resistance arrays.
- The RTD inputs shall support both 2-wire and 3-wire measurements for RTD and resistance modes.
- 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 0.1/0.5 A residual current input. The selection of 0.1 A or 0.5 A shall be software-based.

Measurements, alarms and reporting

- The relay shall have three-phase current, residual current and voltage measurement with an accuracy of $\pm 0.5\%$, and positive and negative sequence current and voltage measurement with an accuracy of $\pm 1\%$.
- The relay shall support current and voltage phase-angle measurement viewing via the local HMI.
- To collect sequence-of-events (SoE) information, the relay must incorporate a non-volatile memory with a capacity of storing at least 1000 event codes with associated time stamps and user-definable event texts with a minimum resolution of 1 ms.
- The relay shall include a numerical disturbance report containing information on the fault. The report shall incorporate the recording time, pre-fault and post-fault time, pre-fault amplitude, pre-fault angle, fault amplitude and fault angle trip values. The report shall be stored in a non-volatile memory and be accessible via the local HMI.
- The relay shall have a disturbance recorder supporting a sampling frequency of 20 samples per cycle and featuring up to 40 analog and 64 binary signal channels.
- The relay shall support not less than 100 recordings with a sampling frequency of 20 samples per cycle, each recording 3.4 seconds in length, 10 analog channels and 64 binary channels.

Communication

- The relay must support IEC 61850 Edition 1.
- The relay must support, besides IEC 61850, simultaneous communication using one of the following communication protocols: IEC 60870-5-103 or DNP3 (TCP).
- The relay shall have an Ethernet port with a galvanic (RJ-45) or an optical (LC) interface.
- 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 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 the SNTP (Simple Network Time Protocol) and IRIG-B (Inter-Range Instrumentation Group - Time Code Format B) time synchronization methods.

Engineering and configurability

- The relay must have 4 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 values to another via the local HMI, using a binary input signal, and remotely through the communication link.
- The relay must have a web browser-based human-machine interface (WHMI) that shall provide access to:
 - Sequence-of-events (SoE)
 - Device status
 - Parameter settings
 - Measurements
 - Disturbance records
 - Phasor diagram
 - Programmable LED status

- 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 15 freely configurable programmable three-color LEDs.
- The relay must have at least 4 user-configurable local HMI pages including measurements and single line diagram (SLD).
- 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, disturbance reports 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.
- 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.
- It shall be possible to freely assign current and voltage inputs to protection and measurement functions.

Type tests and other compliance requirements

- The relay shall have a continuous operational temperature range of -25 ... +55°C and transport and storage temperature range of -40...+85°C.
- The relay must fulfill mechanical tests IEC 60255-21-1, -2 and -3 according to Class 1 for vibrations, shock, bump and seismic compliance.
- The relay must fulfill the electromagnetic compatibility (EMC) tests 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