

Capacitor Bank Protection and Control REV615

Capacitor bank protection and control in medium voltage networks

The relay is intended for protection, control, measurement and supervision of single Y, double Y and H-bridge connected capacitor banks used for compensation of reactive power in utility and industrial power distribution systems. The relay is also intended for protection of harmonic filter circuits when the highest significant harmonic component is below or equal to the 11th harmonic.

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. 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 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) and inverse definite minimum time (IDMT) characteristics. The function shall have two stages of operation, one operation and one alarm stage. 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 shall have three-phase current unbalance protection (51NC-2) for shunt capacitor banks to protect H-bridge capacitor banks against internal faults. The function shall suit internally fused, externally fused and fuseless applications and include settable definite time (DT) and inverse definite minimum time (IDMT) characteristics. The function shall have two stages of operation, one operation and one alarm stage. The operation of the alarm stage shall be based based on the DT characteristic.

- 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.
- The relay shall have non-directional phase overcurrent and earth-fault protection (50/51, 50/51N) 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.
- If specified, the relay shall have three-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 two-stage negative-sequence overcurrent protection (46) with definite time (DT) and inverse definite minimum time (IDMT) characteristics.
- In compensated, unearthed and high-resistance earthed networks, the relay shall be able to detect transient, intermittent and continuous earth faults.
- If specified, 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 protection (59G). The protection functions shall operate in one, two, or three-phase mode according to application requirements, and the operation mode shall be individually settable for each stage. Functions (59) and (27) shall measure either the phase-to-phase or phase-to-earth voltages. The selection shall be software-based and individually selectable for each stage.

Inputs and outputs

- The relay shall have five voltage inputs, three for phase voltage measurement supporting both phase-to-phase and phase-to-earth VT connections, one for open delta voltage measurement, and one for capacitor bank residual voltage measurement from the neutral.
- The relay shall have seven current inputs, three phase current inputs, three unbalance current inputs and one residual current input for earth-fault protection.
- The relay shall have 8 binary inputs and 9 binary outputs and all of them freely configurable. Optionally, it must be possible to add up to 6 more binary inputs and 3 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 ≥ 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 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.

Measurements, alarms and reporting

- The relay shall have three-phase voltage measurement (fundamental or RMS-based as selectable options) with an accuracy of $\pm 0.5\%$ and zero, negative and positive-sequence voltage measurement with an accuracy of $\pm 1\%$ within the range of ± 2 Hz of the nominal frequency.
- The relay shall have frequency measurement with an accuracy of ± 10 mHz within the range of 35...75 Hz.
- 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.
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- 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 voltages and frequency; zero, negative and positive-sequence 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 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 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 support subscribing analog values 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 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
 - Phaser 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