PCS-978

Transformer Relay

PCS-978 provides full scheme protection and control solution for varies type power transformers including multiple-winding transformers and auto-transformers, as well as shunt reactors. It integrates up to 36 current/voltage inputs in order to be suitable for applications like one-and-a-half breaker or ring breaker arrangements. Up to 6 group CT inputs are included in current differential protection. In addition, 288 vector groups are available for 3-winding transformers, as well as 24 vector groups, which available for 2-winding transformer.

The unique current differential protection includes conventional phase current differential elements and innovative DPFC differential elements, in effort to provide reliable and secure protection and to ensure the safety of vital assets. To improve

the reliability of mechanical protection, dedicated high-threshold binary inputs are designed for mechanical protection. In addition, automatic CT ratio compensation and vector group compensation are provided to eliminate the external interposing CTs.

The PCS-978 is compatible with IEC 61850 station bus and process bus applications. It supports IEC 61850-8-1 MMS, GOOSE and IEC 61850-9-2 Sampled Value. Additionally, a RJ-45 faceplate port is provided for testing and setting in order to make commissioning and maintenance easier.

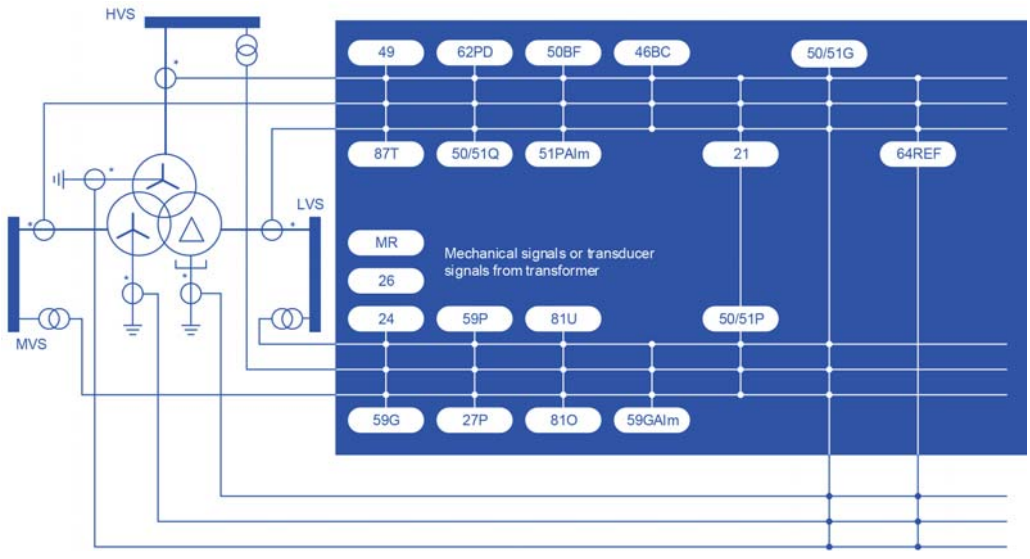

Figure 1 PCS-978 Functional Block Diagram

Functions

Protection and Control

- Transformer biased current differential protection (87T)
  Conventional and sensitive biased differential elements are available for fast and sensitive fault clearance. The conventional biased differential element can be with inrush current blocking, while the sensitive biased differential element can be further blocked by CT saturation, over excitation and CT failure.

- Transformer unrestrained instantaneous current differential protection (87T)
  The unrestrained instantaneous current differential protection instantaneously responds and clears serious internal faults without any restraining characteristics and blocking elements.

- Transformer biased DPFC current differential protection (87T)
  The Deviation of Power Frequency Component (DPFC) differential protection element is immune to load fluctuations and provides high sensitivity for turn-to-turn faults and high impedance faults.

- Reactor biased current differential protection (87R)
  The conventional and sensitive stages are provided in order to ensure operating speed and sensitivity. The conventional stage can be supervised by inrush blocking. Furthermore, the sensitive stage can be supervised by inrush blocking, CT saturation blocking and CT failure blocking.

- Reactor unrestrained instantaneous current differential protection (87R)
  Reactor unrestrained instantaneous current differential protection is implemented in order to instantaneously clear potential internal faults without restraining characteristics and blocking elements.

- Inrush blocking
  Two methods are provided for inrush blocking: waveform distortion method and harmonic method. In the waveform distortion method, the symmetry principle is utilized to detect interrupted and unsymmetrical inrush currents. The harmonics method relies on the 2nd and 3rd harmonics in order to determine the inrush current. The self-adaptive blocking mode and phase-to-phase cross-blocking mode are both provided for inrush blocking.

- CT saturation blocking
  The 2nd and 3rd harmonics are both employed to detect both steady-state CT saturation and transient CT saturation. In addition, the time intervals between difference current and restraint current are utilized to distinguish internal faults and external faults.

- Overexcitation blocking
  The 3rd and 5th harmonics are utilized in the V/Hz calculation to detect the overexcitation conditions and prevent mal-operation due to overexcitation.

- CT circuit failure blocking
  The percentage current differential protection can be blocked to prevent mal-operation due to CT circuit failure. Combined current and voltage detection are employed to accurately discriminate CT circuit failure conditions.

- Amplitude compensation
  The current amplitudes can be internally corrected to compensate the amplitude difference due to mismatched CT ratios and transformer ratios.

- Phase angle compensation
  The current phase angles can be internally corrected to compensate phase shifts due to Δ-Y connections. Y→Δ and Δ→Y compensation methods are provided to meet different protection requirements.

- Restricted Earth Fault Protection (64REF)
  Zero sequence differential protection is used as REF for each Y-connection winding to detect sensitive ground faults. Up to 3 REF protections are provided for different sides of the transformer. Furthermore, up to four 3-phase CTs and one neutral CT are integrated in each REF protection.

- Winding differential protection (87W)
  Winding differential protection can be applied where winding CTs exist. In comparison to REF, it provides high sensitivity for both earth faults and phase-to-phase faults. Up to three winding differential protections are provided for the different sides of a transformer, and up to five 3-phase CTs can be integrated in each differential protection. It can also be used as T-zone current differential protection when the transformer is connected to a one-and-a-half breaker arrangement or ring breaker arrangement.

- Inter-turn fault protection for reactor (21IT)
  Reactor inter-turn faults may not be detected by current differential protection, thus dedicated inter-turn protection is provided in the relay. Inter-turn protection consists of zero-sequence power directional element, zero-sequence impedance element and a DPFC inter-turn fault detector element. It provides sensitivity for inter-turn faults while still maintaining security for external faults.

- Overexcitation protection (24)
  Overexcitation protection is based on the ratio of voltage to frequency (V/Hz). The overexcitation protection can be configured into any side of the transformer using PCS-Explorer software.

- Underfrequency and overfrequency protection (81U/81O)
  Four-stage underfrequency protection and four-stage overfrequency protection are provided in each relay. The change-of-rate (df/dt) element is integrated for underfrequency protection. Zero-sequence voltage and out-of-limit frequency are detected in order to block under-/over-

frequency protection.

- Mechanical protection (MR)
  The relay provides eight high-power-pickup binary inputs for mechanical relays in order to realize mechanical tripping/ alarm. Four of these inputs are provided with time delay. The high-power-pickup design reduces the risk of Electro-Magnetic Interference (EMI) to improve reliability. Generally, the mechanical relays include winding temperature relays, oil temperature relays and buchholz relays.

- Temperature protection (26)
  The relay provides six analog inputs (0-20mA/0-5V) for temperature transducers in effort to detect possible over temperature states.

- Two-stage phase-to-phase impedance protection (21P)
  They are selectable to forward direction or reverse direction by logic setting. The power swing blocking logic is integrated to improve reliability.

- Two-stage phase-to-ground impedance protection (21G)
  They are selectable to forward direction or reverse direction by logic setting. The power swing blocking logic is integrated to improve reliability.

- Power swing blocking releasing (PSBR)
  The unique power swing blocking releasing logic is integrated to prevent the mal-operation of impendence protection due to power swings.

- Four-stage phase overcurrent protection (50/51P)
  Overcurrent protection is supervised by the voltage element, harmonic element and directional element. .Inverse-time curves take into account both IEC/IEEE curves and a self-definable curve.

- Four-stage neutral overcurrent protection for each side (50/51G)
  Overcurrent protection is supervised by the voltage element, harmonic element and directional element. Inverse-time curves take into account both IEC/IEEE curves and a self-definable curve.

- Two-stage negative-sequence overcurrent protection (50/51Q)
  Inverse-time curves take into account both IEC/IEEE curves and a self-definable curve.

- Two-stage phase overvoltage protection (59P)
  Phase voltage and phase-to-phase voltage can be selected as calculation values. The '1-out-of-3' and '3-out-of-3' criterions are provided for flexible protection logic. Inverse-time curves take into account both IEC/IEEE curves and a self-definable curve.

- Two-stage residual overvoltage protection (59G)
  Inverse-time curves take into account both IEC/IEEE curves and a self-definable curve.

- Four-stage undervoltage protection (27P)
  Generally, undervoltage protection is employed for load-shedding in order to keep the system's voltage in normal operation range. The positive-sequence voltage is used as the calculation value. To differentiate between the low-voltage due to short-circuit faults and the low-voltage due to the lack of reactive power, the voltage rate-of-change (du/dt) element, the negative sequence voltage element and the low positive sequence voltage elements are integrated .

- Thermal overload protection (49)
  A thermal model is adopted to continuously calculate the heat capacity of a transformer. Two stages are integrated for alarm and tripping. Up to three thermal protections are provided for the different sides of transformer.

- Breaker failure protection (50BF)
  Breaker failure protection for each breaker is supplied to initiate re-tripping and adjacent breaker tripping.

- Pole disagreement protection (62PD)
  External binary input and zero-sequence/negative-sequence current are used to detect a pole disagreement state of the circuit breaker.

- Phase overcurrent alarm (51PAlm)
  A dedicated overcurrent element is employed to detect the load current of the transformer. If an overload condition is detected, the relay can initiate the cooling system and block the tap changer. The phase overcurrent alarm element is not supervised by Fault Detector elements.

- Residual overvoltage alarm (59GAlm)
  The element is generally used in ungrounded systems to detect ground voltage and to issue potential alarm signals.

- Voltage and current drift auto adjustment
  The relay continually and automatically traces the voltage and current drifts, then it adjusts the zero point to the normal value.

- Frequency tracking
  Frequency tracking is provided to accommodate the frequency shifts in the power system.

Monitoring and Measurement

- CT failure supervision
- VT failure supervision
- Self diagnostic
- Event recorder including 1024 change-of-binary-input events, 1024 supervision events and 1024 device logs
- Disturbance recorder including 32 disturbance records with waveforms (The format is compatible with COMTRADE.)
- Clock synchronization using IRIG-B, SNTP, PPS (Pulse-Per-Second), PPM (Pulse-Per-Minute) and IEEE 1588
- Support DST

Communication

- Optional two or four 10Base-T/100Base-TX copper Ethernet ports using IEC 61850, DNP3.0 or IEC 60870-5-103 over TCP/IP
- Optional two 100Base-FX optical Ethernet ports using IEC 61850, DNP3.0 or IEC 60870-5-103 over TCP/IP (Sharing two copper Ethernet ports)
- Optional two RS-485 serial ports using IEC 60870-5-103
- One RS-485 serial port for clock synchronization
- Optional Sampling value and GOOSE communication module with six optical Ethernet ports using IEC 61850-9-2 and IEC 61850-8-1 GOOSE
- Support of IEC 61850 Edition 2
- Support of IEC 62439-3 PRP and HSR protocols
- Cyber security in accordance with NERC CIP

User Interface

- HMI interface with large-size LCD and 9-button keypad on the front panel
- Support setup up to 40 users and allow each user to own different password and access authority
- Provide some function shortcuts key, which can be configured by PCS-Explorer and be fulfilled by combination key of devices' keypad, to execute some operation quickly.
- One front RJ-45 port for testing and setting
- One RS-232 or RS-485 rear port for printer
- Language selection – English + selected language
- Assistant software - PCS-Explorer

Features

- A CT transient detection element is provided for REF in order to eliminate the influence of CT transient characteristic difference. The element is based on the ratio of zero-sequence current to positive-sequence current.
- The waveform distortion and harmonics methods are both integrated in the current differential protection to improve reliability. Either method can be selected in order to cover applications in different types of transformers.
- Self-adaptive blocking and phase-to-phase cross-blocking modes are both provided for inrush blocking. The self-adaptive mode enhances the dependability on internal faults and ensures security during inrush conditions.
- To enhance the judgment accuracy of overexcitation condition, both the 5th and 3rd harmonics are employed for continuous overexcitation supervision.
- Both Δ→Y and Y→Δ phase angle compensation are provided in the relay for selection. The Δ→Y method is preferred due to the inrush characteristic remaining in each corresponding phase, so as to realize phase-segregated inrush blocking.
- The unique DPFC protection principle, pioneered by NR Electric, employs superimposed increscent quantities as protection criteria. This principle provides high sensitivity for slight internal faults.
- A unique two-out-two logic is adopted in hardware design to improve security. Coordinating with redundant scheme, the solution improves both security and dependability of protection system. The two independent data acquisition paths are provided to prevent mal-operation caused by component failure. One works as a fault detector and the other is designed for protection logic. Tripping outputs are supervised by both data acquisition paths.
- Comprehensive flexibility is provided via modular hardware design scalable function library, programmable logics, configurable I/Os and definable LEDs. This allows users to create customized schemes for specific projects. Two fixed LEDs and 18 definable 3-color LEDs (Green/Yellow/Red) are employed.
- The relay is fully compatible with IEC 61850, including station bus communication and process bus communication. It provides up to 6 Ethernet ports for process bus with IEC 61850-9-2 Sampling Value and IEC 61850-8-1 GOOSE, as well as up to 4 Ethernet ports for station bus with IEC 61850- 8-1 MMS.
- A powerful disturbance recording function is integrated in the relay for post-fault analysis. Up to 32 disturbance records can be stored in non-volatile memory. Each report includes 250-cycle to 400-cycle waveform records with settable pre-fault waveform.