PCS-931

Line Differential Relay

The PCS-931 relay provides full-scheme current differential and distance protection solutions for transmission lines with high-speed sub-cycle distance element. As well, the pilot scheme of distance protection and earth fault protection are integrated to provide a complete protection solution for the transmission line. The PCS-931 is intended for application on overhead lines and underground cables with diverse voltage levels, including series compensated, double-circuit, heavily loaded, weak infeed (WI), short and long lines. The relay provides dual pilot channels used for redundant tele-communication or three-terminal line application. It can meet the requirements of single-pole or three-pole tripping, it also provides single- and/or three-pole auto-reclosing functions. The PCS-931 is suitable for single- and dual-breaker applications, providing optional dual CT inputs, dual breaker failure protections, dual breaker auto-reclosing and dual synchro-checks. Additionally, the relay provides the remote/local control of circuit breaker, disconnector and earth switch.

The PCS-931 employs a wide range of innovative patented technologies, such as adaptive restraint threshold, dynamic capacitive current compensation, DPFC (Deviation Power Frequency Component) differential protection and unique power swing blocking releasing logic, guaranteeing accurate and reliable operations.

The PCS-931 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. The front panel RJ-45 port is provided for testing and setting, allowing for easier commissioning and maintenance.

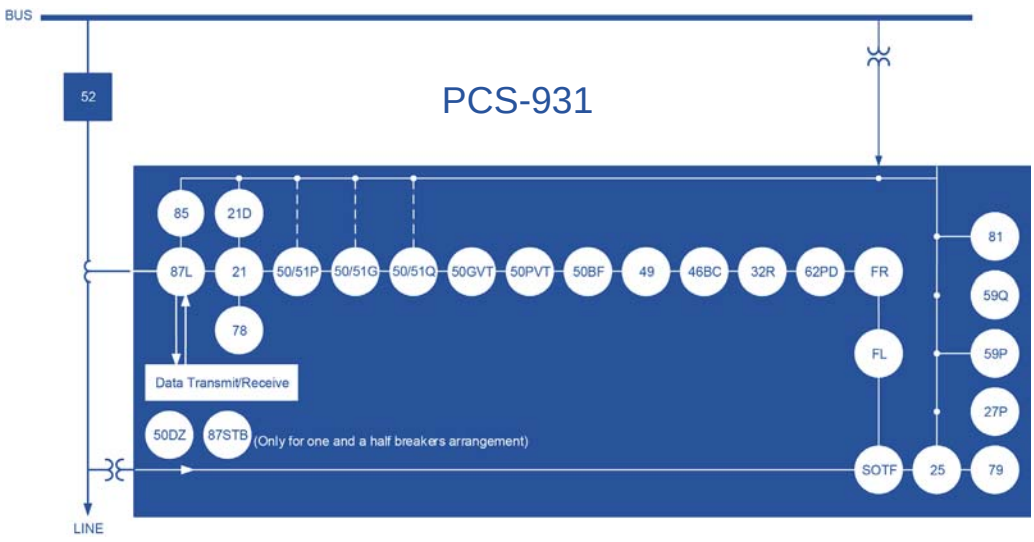

Figure 1 PCS-931 Functional Block Diagram

Functions

Protection and Control

- Phase-segregated DPFC differential protection (87L)
  DPFC (Deviation of Power Frequency Component) percentage differential protection reflects superimposed quantities which can recognize the sensitive protection for high impedance faults. The relay provides dynamic charging current compensation, adaptive restraint threshold and CT saturation detection to improve the reliability of DPFC differential protection.

- Phase-segregated current differential protection (87L)
  Dynamic charging current compensation, adaptive restraint threshold and CT saturation detection are integrated to achieve a combination of both dependability and security.

- Neutral current differential protection (87L)
  Neutral current differential protection is integrated to improve the sensitivity to the earth faults during heavy load state. Dynamic charging current compensation, adaptive restraint threshold and CT saturation detection are integrated for neutral current differential protection.

- Five zone phase-to-phase distance protection (21P)
  Directional, load encroachment, power swing blocking and unique low-voltage elements are provided for phase-to-phase distance protection.

- Phase-to-phase distance protection for pilot scheme (85)
  The relay provides an independent zone for pilot scheme of PUTT, POTT, Blocking, Unblocking, DTT & Zone Extension. The scheme intergrates current reversal logic, weak-infeed echo and open breaker echo.

- Five zone phase-to-ground distance protection (21G)
  The reactance characteristic, directional, load encroachment, power swing blocking and unique low-voltage elements are provided for phase-to-ground distance protection.

- Phase-to-ground distance protection for pilot scheme (85)
  The relay provides an independent zone for pilot scheme of PUTT, POTT, Blocking, Unblocking, DTT & Zone Extension. The scheme integrates current reversal logic, weak-infeed echo and open breaker echo.

- High-speed DPFC distance protection (21D)
  Innovative Deviation of Power Frequency Component (DPFC) distance protection quickly clears faults in a sub-cycle. DPFC is immune to the load fluctuation, weak-infeed and power swing.

- Pilot directional earth-fault protection (85)
  The relay includes directional zero sequence comparison element for earth faults. The pilot scheme integrates current reversal logic, weak-infeed echo and open breaker echo.

- Four stage phase overcurrent protection (50/51P)
  Selectable time characteristics (definite-time or inverse-time) and directional elements (forward, reverse or non-directional) are provided. A harmonic blocking function is integrated to restrain each stage independently.

- Four stage earth fault protection (50/51G)
  Selectable time characteristics (definite-time or inverse-time) and directional elements (forward, reverse or non-directional) are provided. A harmonic blocking function is integrated to restrain each stage independently.

- Four stages negative-sequence overcurrent protection (50/51Q)
  Selectable time characteristics (definite-time or inverse-time) and directional elements (forward, reverse or non-directional) are provided. Stage 4 can be set to alarm.

- Breaker failure protection for one or two breakers (50BF)
  Breaker failure protection can be applied to single-breaker and dual-breaker applications.

- Stub differential protection (87STB)
  Stub differential protection is introduced to protect the T-zone in one-and-a-half breaker and ring breaker arrangements.

- Three stages undervoltage protection (27P)
  Time characteristics is selectable between definite-time and inverse-time. Phase voltage or phase-to-phase voltage can be selected for protection calculation. “1-out-of-3” or “3-out-of-3” logic can be selected for protection criterion.

- Three stages overvoltage protection (59P)
  Time characteristics is selectable between definite-time and inverse-time. Phase voltage or phase-to-phase voltage can be selected for protection calculation. “1-out-of-3” or “3-out-of-3” logic can be selected for protection criterion.

- One stage negative-sequence overvoltage protection (59Q)

- Three stages residual overvoltage protection (59G)
  Stage 1 is definite-time characteristic, stage 2 and 3 can be selected as definite-time or inverse-time characteristic, only stage 3 can be defined for trip purpose or alarm purpose.

- Four stage overfrequency protection (81O)
  Frequency is calculated by using the positive sequence voltage.

- Four stage underfrequency protection (81U)
  Frequency is calculated by using the positive sequence voltage. The df/dt element is provided for the supervision of underfrequency protection.

- Phase overcurrent protection during VT failure (50PVT)
  Independent phase overcurrent protection is automatically enabled to substitute the phase-to-phase distance protection which is blocked during VT failure.

- Ground overcurrent protection during VT failure (50GVT)
  Independent neutral overcurrent protection is automatically

enabled to substitute the phase-to-ground distance protection which is blocked during VT failure.

- Switch-onto-fault (SOTF) logic
  Switch-onto-fault logic is used to clear the faults during manual closing and auto-reclosing
- Unique power swing blocking releasing logic (PSBR)
  The power swing blocking releasing logic prevents mal-operations during external faults in power swing and quickly clears the internal faults in power swing.
- Out-of-step protection (78)
- Broken conductor protection (46BC)
  The ratio of negative to positive phase sequence current (I2/I1) is adopted to detect the broken conductor.
- Dead zone protection (50DZ)
  It is provided to clear the dead zone faults between CT and breaker.
- Thermal overload protection (49)
  Thermal accumulation using thermal models is implemented for overload protection. Two stages for alarm and two stages for tripping are provided.
- Pole discrepancy protection (62PD)
  It can be initiated by three auxiliary contacts of phase-segregate circuit breaker, and it can select zero-sequence current or negative-sequence current as auxiliary criterion
- Reverse power protection (32R)
  The reverse power protection monitors the direction of active power flow and picks up when the mechanical energy fails. This function can be used for operational shutdown (sequential tripping) of the generator but also prevents damage to the steam turbines.
- Single and/or three-pole auto-reclosing (single-breaker or dual-breaker) (79)
  Single/three pole auto-reclosing is provided for single- and dual-breaker applications. Priority logic is integrated for the applications of one-and-a-half breaker and ring breaker arrangements.
- Remote/local control
  The control of circuit breaker, disconnector and earth switch can be implemented via communication, LCD menu and binary inputs. User programmable interlocking logics are available by PCS-Explorer.
- Synchronism check (25)
  Synchro-check can be used for auto-reclosing and manual closing of single-breaker and dual-breaker.
- Voltage and current drift auto adjustment.
  The relay continually and automatically traces the voltage and current drifts and adjusts the zero point to acquire accurate measurements.
- Frequency tracking.
  Frequency tracking is provided to accommodate the frequency shift in power system.

Monitoring and Measurement

- Energy measurement (active and reactive energies for import and export)
- CT circuit failure supervision
- VT circuit failure supervision
- Fault phase selection
- Fault Locator with parallel-line compensation
- Self-diagnostic
- Event recorder including 1024 change-of-binary-input events, 1024 supervision events, 256 control logs and 1024 device logs
- Disturbance recorder including 32 disturbance records with waveforms (The format is compatible with COMTRADE.)
- Pilot communication channel supervision
- System frequency supervision
- Clock synchronization using IRIG-B, SNTP, PPS (Pulse-Per-Second) and PPM (Pulse-Per-Minute) , IEEE 1588

Communication

- Optional single or dual pilot channels (fiber optic), complying
- with G.703 and C37.94
- Up to four 10Base-T/100Base-TX copper Ethernet ports using IEC 61850, DNP3.0 or IEC 60870-5-103 over TCP/IP
- Up to two 100Base-FX optical Ethernet ports using IEC 61850, DNP3.0 or IEC 60870-5-103 over TCP/IP (Sharing two copper Ethernet ports)
- 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

- Innovative dynamic capacitive current compensation is introduced to the relay, in order to compensate both steady-state capacitive current and transient capacitive current, which can increases the sensitivity to high-impedance faults in long distance transmission lines.
- Adaptive restraint threshold continuously adjust the restraint current according to the current measurement fluctuation, which improves the security during CT saturation and keeps sensitivity to internal faults.
- CT saturation detection is provided to improve the security of current differential protection. It measures the time difference between change-of-differential-current and change-of-restraint-current.
- CT ratio compensation is integrated in the relay to deal with the mismatched CT ratios located on different terminals of the transmission line. It allows the selection flexibility of CT equipment and eliminates additional interposing CTs.
- The unique DPFC protection principle, firstly introduced by NR Electric, employs superimposed increscent quantities as protection criteria, which provides high speed fault clearance and is immune to power swing and load fluctuation.
- A unique two-out-two logic is adopted in hardware design to improve security. Coordinating with the redundant scheme, this 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.
- Self-adaptive floating threshold which only reflects deviation of power frequency components improves the sensitivity and reliability during load fluctuation and system disturbance.
- The unique power swing blocking releasing logic can properly supervise the distance protection during power swing, which ensures the distance protection will operate correctly for internal faults during power swing, and prevents distance protection from mal-operation during power swing.
- Fast clearance of faults within the protected zone is achieved by this relay. The typical operating time is less than 10 ms for close-up faults, less than 15ms for medium-zone faults and less than 25ms for remote-end faults.
- Comprehensive flexibility is achieved via modular hardware design, scalable function library, programmable logics, configurable I/Os and definable LEDs. It allows users to create customized schemes for the specific projects. 2 fixed LEDs and 18 definable 3-color LEDs (Green/Yellow/Red) are provided.
- 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 Sampled Value and IEC 61850-8-1 GOOSE, as well as up to 4 Ethernet ports for station bus with IEC 61850-8-1 MMS.
- 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 500-cycle waveform records with settable pre-fault waveform.