



# PCS-985GI

## Generator Relay

PCS-985GI is a kind of high performance numerical generator protection device, which integrates main and backup protection into one device. It provides complete protection of a generator in power plant, and it also provides basic protection of a generator and an excitation transformer. PCS-985GI can be applied for turbo-dynamo generator, gas-turbine generator, hydro generator, pumped storage generator and nuclear power generator with different connection modes.

PCS-985GI provides up to 56 analog input channels including current and voltage inputs. The generator protections are configurable. Ancillary functions of fault diagnostic, disturbance records, event records and communication function are integrated in the device.

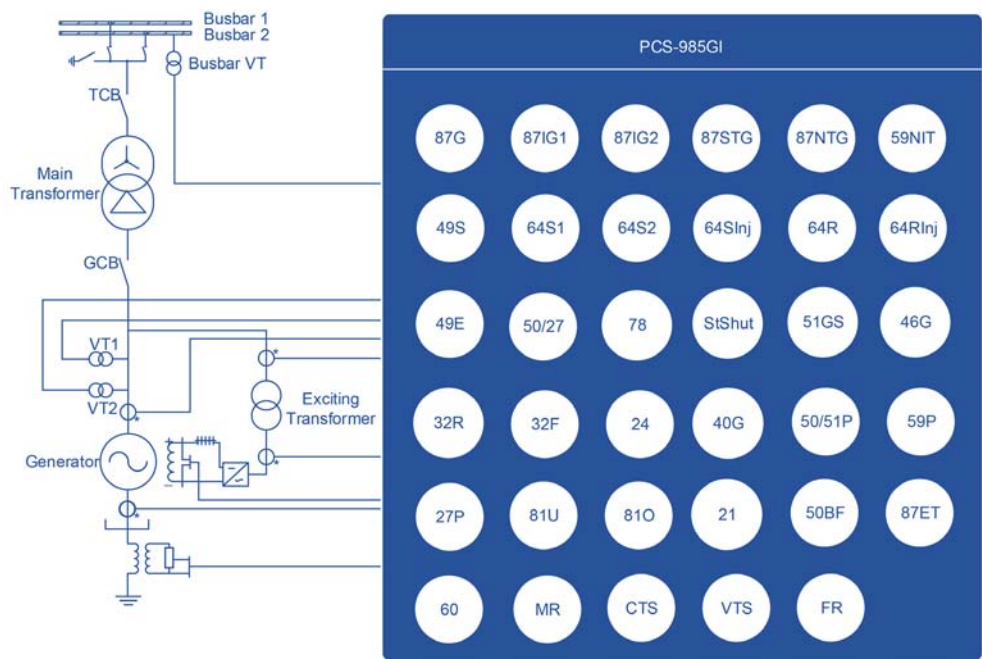


Figure 1 PCS-985GI Functional Block Diagram

## Functions

### Generator Protection

- Current differential protection (87G)

Generator current differential protection is the main protection for the internal short-circuit fault of generator stator winding. Biased current differential element consists of sensitive and conventional biased differential elements as well as independent CT saturation criterion. Unrestrained instantaneous differential element provides high speed tripping against internal serious fault. DPFC current differential element can fully reflect the change of differential current and restraint current, and it is not affected by the load current and is sensitive to small internal fault current within the generator, its performance against CT saturation is also good.

- Incomplete current differential protection (87IG)

The protection is the main protection for the internal short-circuit fault (phase-to-phase fault, short-circuit fault between different branches of one phase and inter-turn fault of the same branch) of generator stator winding. It is mostly utilized for hydro generators, and it adopts currents of the terminal and one of the branches at neutral point to detect stator inter-turn fault and phase-to-phase fault.

- Phase segregated transverse differential protection (87STG)

The protection is the main protection for the internal short-circuit fault (phase-to-phase fault, short-circuit fault between different branches of one phase and inter-turn fault of the same branch) of generator stator winding. It is mostly utilized for hydro generators, and it adopts currents of the branches at neutral point to detect stator inter-turn fault and phase-to-phase fault.

- Neutral point transverse differential protection (87NTG)

The protection is the main protection for generator stator winding internal (phase-to-phase, different branches of the same phase and inter-turn of the same branch) short-circuit fault and branches welding open fault. It is installed on a connection between two neutral points of a generator.

- Generator inter-turn protection (59NIT)

Generator inter-turn protection includes two operation elements: longitudinal zero-sequence voltage inter-turn element and negative-sequence DPFC direction inter-turn element.

For longitudinal zero-sequence voltage inter-turn element, the device adopts frequency tracking, digital filtering and full cycle Fourier algorithm, so the filtered ratio of the zero-sequence voltage relative to the 3rd harmonic is larger than 100, and the protection only reflects the fundamental component. For the increase of longitudinal unbalance zero-sequence voltage for other normal operation conditions, a floating threshold is adopted for longitudinal zero-sequence voltage inter-turn element.

Negative-sequence DPFC direction inter-turn element adopts generator terminal voltage and current directly, so

dedicated VT is not needed for it. If the negative-sequence voltage variation, the negative-sequence current variation and the negative-sequence power direction conditions are all met, negative-sequence DPFC direction inter-turn element will operate.

- Stator overload protection (49S)

Generator stator overload protection comprises definite-time overload protection and inverse-time overload protection. The low-setting stage of definite-time overload protection is used for alarm and the high-setting stage of definite-time overload protection is used for tripping. Inverse-time overload protection can simulate the heat accumulation process of the stator winding.

- Fundamental zero-sequence voltage stator ground fault protection (64S1)

Fundamental zero-sequence voltage stator ground fault protection can detect the ground fault of 85%~95% of stator winding of generator terminal side. The device adopts frequency tracking, digital filtering and full cycle Fourier algorithm, so the filtered ratio of the zero-sequence voltage relative to the 3rd harmonic is larger than 100, and the protection only reflects the fundamental component.

- Generator 3rd harmonic stator ground fault protection (64S2)

Generator 3rd harmonic stator ground fault protection includes two operation elements: 3rd harmonic ratio stator ground fault element and 3rd harmonic differential stator ground fault element. 3rd harmonic ratio stator ground fault element can detect the ground fault of approximately 25% of stator winding of generator neutral point side. Fundamental zero sequence voltage stator ground fault protection coordinate with 3rd harmonic ratio stator ground fault element can constitute 100% stator ground fault protection. 3rd harmonic differential stator ground fault element can reflect the ground fault of the whole stator winding, but it is very sensitive, so generally it is only for alarm.

- Generator stator ground fault protection with 20Hz voltage injection (64SInj)

The stator earth fault protection with external voltage injector PCS-985U can detect 100% earth faults in the stator windings of generator. The protection contains two criteria: resistance criterion and zero-sequence current criterion. Via injecting 20Hz voltage, the protection can judge whether a ground fault happens at the circuit of generator stator winding side, it can detect the single-phase ground fault of 100% of the stator winding. It will not be affected by generator operation condition, even during shutdown condition, the protection still can monitoring the insulation condition of the stator winding.

- Generator Ping-Pang type rotor ground fault protection (64R)

Generator Ping-Pang type rotor ground fault protection includes three operation elements: sensitive stage of rotor one-point ground fault element for alarm, insensitive stage of rotor one-point ground fault element for tripping or alarm, and rotor two-

point ground fault element for tripping.

Rotor one-point ground fault element reflects the decline of the insulation resistance between rotor winding and the shaft, two stages are equipped, the sensitive stage for alarm and the insensitive stage for alarm or trip. Rotor two-point ground fault element reflects the change of rotor ground position, it can operate to trip.

- Rotor ground fault protection with low-frequency square-wave voltage injection (64RInj)  
The low-frequency square-wave voltage is injected between the generator rotor winding positive/negative pole leading-out terminal and the shaft, via measuring the leakage current, the rotor one-point ground resistance is calculated, it can reflect the decline of insulation resistance that between the rotor winding (includes the directly connected excitation circuit) and the rotor shaft. If double-ends injecting wiring is adopted, it can detect the location of rotor winding ground fault. When the calculated rotor ground fault location changes, it will be considered that a two-point ground fault happens.
- Generator rotor winding overload protection (49E)  
Generator rotor winding overload protection comprises definite-time overload protection and inverse-time overload protection. The low-setting stage of definite-time overload protection is used for alarm and the high-setting stage of definite-time overload protection is used for tripping. Inverse-time overload protection can simulate the heat accumulation process of the rotor winding.
- Generator inadvertent energization protection (50/27)  
The protection according to the characteristics of voltage, frequency, circuit breaker state and current before and after the generator is closed inadvertently to detect inadvertent energization condition.
- Generator out-of-step protection (78)  
Generator out-of-step protection is used to detect the asynchronous operation due to generator out-of-step. Out-of-step protection judge whether out-of-step swing occurs via the locus of calculated impedance, and judge whether the out-of-step swing center is within the generator. Out-of-step protection can operate to trip or alarm.
- Generator startup and shutdown protection (StShut)  
The protection includes low-frequency zero-sequence overvoltage element and low-frequency overcurrent element. Low-frequency zero-sequence overvoltage element is used to reflect single-phase ground fault during startup and shutdown process of generator. Low-frequency overcurrent element is used to reflect phase-to-phase short-circuit fault during startup and shutdown process of generator.
- Generator shaft overcurrent protection (51GS)  
Generator shaft overcurrent protection detects the shaft current of generator rotor shaft, it can prevent the bearing from damage. The function is mainly used for hydropower unit.

- Negative-sequence Overload protection (46G)  
Generator negative-sequence overload protection can reflect the over-heating condition of generator rotor surface, it can also reflect the other abnormalities that caused by negative-sequence current. Generator negative-sequence overload protection comprises definite-time overload protection and inverse-time overload protection.
- Generator reverse power protection (32R)  
Generator reverse power protection includes two operation elements: conventional reverse power element and sequence tripping reverse power element. It is configured to prevent the turbine blades or gas turbine gears from damage when the generator changes into motor operating mode due to loss of its motive power.
- Generator low forward power protection (32F)  
If the detected forward active power reduces and when it is lower than the low forward power setting, low forward power protection can operate to alarm and output a contact or shutdown with a time delay. Usually it can be blocked by emergency shutdown binary input or main valve open contact.
- Overexcitation protection (24)  
Overexcitation protection is used to check the over-flux phenomenon during operation of the generator and transformer. The ratio of voltage and frequency is adopted to check overexcitation. Definite-time over-excitation protection consists of two stages: one is for alarm, the other is for tripping. Inverse-time over-excitation protection realizes inverse-time characteristic by linear processing on given inverse time operation characteristic, obtaining multiple of over excitation by calculation, and calculating corresponding operation time delay by sectional linear insertion. It reflects heat accumulation and radiation.
- Loss of excitation protection (40G)  
Three stages of loss of excitation protection with respective impedance setting and time delay are available. The offset characteristics of impedance circle of each stage can be configured as forward offset or reverse offset. Each stage of loss of excitation protection can be controlled by reverse reactive power element, stator side busbar low voltage element and rotor low voltage element.
- Generator phase overcurrent protection (50/51P)  
Three-stage generator phase overcurrent protection with independent logic, current and time delay settings are available. Stage 1 and stage 2 are definite-time characteristic, stage 3 can be selected as definite-time or inverse-time characteristic. Voltage controlled element and direction element (no direction, forward direction and reverse direction) can be selected to control each stage of generator phase overcurrent protection. Memorizing function for fault current can be enabled or disabled for each stage.
- Phase overvoltage protection (59P)

Stage 1 of phase overvoltage protection for tripping and the phase overvoltage protection for alarm are definite-time overvoltage protection fixedly, stage 2 of phase overvoltage protection for tripping can be configured as inverse-time or definite-time overvoltage protection. Phase-to-phase voltage instead of phase-to-earth voltage is selected for overvoltage protection calculation, it can prevent the overvoltage protection from mal-operation due to single phase earthing for ungrounded system.

- **Undervoltage protection (27P)**  
Stage 1 of phase undervoltage protection for tripping and the phase undervoltage protection for alarm are definite-time undervoltage protection fixedly, stage 2 of phase undervoltage protection for tripping can be configured as inverse-time or definite-time undervoltage protection. Phase-to-phase voltage instead of phase-to-earth voltage is selected for undervoltage protection calculation, it is insensitive to asymmetric voltage decline, but it is sensitive to system stability problem.
- **Overfrequency protection (81O)**  
Four stages of overfrequency protection and overfrequency band accumulate protection are available, and each stage has respective frequency setting, time setting and logic setting. Each stage can be configured to issue alarm signal or trip.
- **Underfrequency protection (81U)**  
Four stages of underfrequency protection and underfrequency band accumulate protection are available, and each stage has respective frequency setting, time setting and logic setting. Each stage can be configured to issue alarm signal or trip.
- **Impedance protection (21)**  
Impedance protection includes phase-to-phase and phase-to-earth protection. Positive polarity of CT is at generator neutral point side, and direction settings should be set according to the principle. The device adopts power swing blocking releasing to avoid mal-operation of impedance protection due to power swing.
- **Breaker failure protection (50BF)**  
When there is an internal fault of the generator, the protection operates to trip but the breaker at the generator terminal fails, it needs to initiate breaker failure protection and trip adjacent breakers in time. Breaker failure protection has following two criteria: current criterion and circuit breaker auxiliary contact criterion. The internal logic between the two criteria can be "And" or "Or".
- **Mechanical protection (MR)**  
Generator mechanical protection can repeat these binary input signals to send alarm signals, tripping directly or tripping with a time delay. By this way the output signal of some mechanical protection (such as gas protection and etc.) can be coupled to the microprocessor-based protection

device, then these signals can be repeated through high-power relays to improve the anti-inference ability of the protection.

- **Voltage balance protection (60)**  
For some generator, two groups of VT are equipped, the two groups of VT can be connected into the generator protection device simultaneously, via comparing, the VT of which abnormality is detected can be identified, if abnormality happens to one VT, all the protections that use the VT will be switched to another normal VT automatically, so the performance of the voltage related protections will not be affected.

### Excitation Transformer Protection

- **Differential protection (87ET)**  
Percentage restraint current differential element is variable slope differential element. Advanced "asynchronous method" CT saturation detection algorithms can prevent the protection from mal-operation caused by CT saturation during external fault. The fast detection of CT circuit abnormal condition can avoid mal-operation. Unrestrained instantaneous differential element provides high speed tripping against internal serious fault.
- **Overcurrent protection (50/51P)**  
Two stages overcurrent protection can be used as backup protection.

### Miscellaneous

- Fault detector (FR)
- Voltage and current drift auto adjustment.
- VT circuit supervision (VTS)
- CT circuit supervision (CTS)
- CT saturation detection
- Self diagnostic
- GPS clock synchronization
- Fault recorder
- IEC61850 MMS & GOOSE for station level
- IEC60870-5-103 protocol
- MODBUS protocol
- DNP 3.0 protocol

### Features

- **Configurable function**  
Modules of the device adopt intelligent design, amount of input and output modules and module slot position are configurable. User can increase or decrease the amount

of AC input module, binary input module and binary output module, and terminals of those modules can be defined according to actual requirement. Besides, configurability is also reflected in software design of device, which means that user can hide the protective element not used or add new protective module not in standard configuration.

- Parallel calculation of double DSP system

The hardware of the device comprises a 32-bit microprocessor and two 32-bit digital signal processors (DSP). Those processors can operate in parallel accompanied by fast A/D converter. The 32-bit microprocessor performs logic calculation and the DSP performs the protection calculation. High performance hardware ensures real time calculation of all protection relays within a sampling interval.

On the premise of 24 samples per cycle, all data measurement, calculation and logic discrimination could be done within one sampling period. The event recording and protection logic calculation are completed simultaneously.

- Independent fault detector

Independent fault detectors in fault detector DSP module for connecting power supply of output relays. The relay can drive a tripping output only when protection element on protection DSP module operates with the fault detector in the fault detector DSP module operating simultaneously. This kind of independent supervision of tripping outputs using fault detectors can avoid any mal-operation possibly caused by any hardware component failure. This highly increases the security.

- Configurable tripping output

The tripping output contacts can be configured by tripping matrix and suitable to any mode of tripping.

- Fault recording function

Event records include 1024 binary input events and 1024 alarm events. Disturbance records including 64 fault reports, and 64 disturbance waveforms, and file format of waveform is compatible with international COMTRADE91 and COMTRADE99 file. Analog inputs and binary inputs can be recorded, and three oscillography triggering mode are supported, which are protection pickup triggering, manual triggering on keypad of device, and remote triggering through PCS-Explorer software.

- Powerful PC tool software

Powerful PC tool software (PCS-Explorer) can fulfill protection function configuration, modify setting and waveform analysis.

- Integration of main and backup protection

Main and backup protection are integrated in one set of protection device. Protection information is shared by all parts. The device can record all relevant waveforms of any fault.

- Reliable CT Saturation Detection

Based on the operation sequence of DPFC restraint current element and DPFC differential current element of differential protection, external fault with CT saturation or internal fault can be distinguished correctly.