

Article Overview

Three-stage relay protection can be effectively simulated using MATLAB/Simulink to model fault detection, zone coordination, and relay tripping logic for power system safety.

Overview of Three-Stage Relay Protection

Three-stage relay protection is a hierarchical protection scheme used in power systems to ensure reliable fault detection and isolation. It typically consists of:

- o Primary Protection (Stage 1) - Operates instantaneously for faults within the immediate zone of the relay.
- o Backup Protection (Stage 2) - Provides delayed tripping for faults in adjacent zones or when primary protection fails.
- o Remote Backup (Stage 3) - Covers faults beyond the primary and secondary zones, often with longer time delays to coordinate with downstream relays . This staged approach ensures selectivity, speed, and reliability, minimizing unnecessary outages.

Simulation Methodology

Tools and Environment

- o MATLAB/Simulink is commonly used for modeling three-stage relay protection .
- o SimPowerSystems (PSB) toolbox allows detailed modeling of transmission lines, transformers, loads, and relays.
- o RMS and mean-value blocks are used to measure voltages, currents, and calculate per-phase impedance for distance relays .

Fault Modeling

- o Faults such as single line-to-ground (SLG), phase-to-phase, and three-phase faults are simulated at various points along the transmission line .
- o Fault distances are varied to test relay response in different zones (Z_1 , Z_2 , Z_3) with corresponding time delays.

Relay Logic

- o Impedance-based distance relays compare measured impedance (Z_{measured}) with zone thresholds to determine tripping .
- o Over-current relays use full-wave Fourier algorithms to detect current exceeding preset limits and trigger staged tripping .

Relay Protection Three-Stage Simulation

o Time coordination ensures that primary relays operate first, followed by backup and remote relays if the fault persists .

Visualization and Analysis

- o Simulation outputs include voltage and current waveforms, relay operation signals, and circuit breaker tripping events .
- o Graphical user interfaces (GUIs) can be created to adjust relay settings and visualize fault responses in real time.

Example Simulation Scenarios

- o Fault within Z1: Instantaneous tripping by primary relay.
- o Fault in Z2 (adjacent line): Tripping occurs after a 1-second delay by backup relay.
- o Fault beyond Z3: Primary and backup relays remain inactive; remote relay clears the fault .

Benefits of Simulation

- o Prevents equipment damage by testing relay coordination before real-world deployment.
- o Enhances understanding of relay behavior under different fault conditions.
- o Supports training for engineers and operators in power system protection .

References for Implementation

- o GitHub projects provide ready-to-use MATLAB/Simulink models for distance relay simulations .
- o Research papers detail three-stage over-current protection algorithms and simulation results for various fault types .
- o Training models allow visualization of relay operation, auto-reclose, and backup power switching in medium-voltage networks . By using these simulation techniques, engineers can design, test, and optimize three-stage relay protection schemes to ensure safe and reliable operation of power systems.

This project simulates an impedance-type distance relay for protecting a 220 kV transmission line using MATLAB/Simulink. The relay

This paper delineates a methodology for the optimization of the settings of three-stage current protection relays within the networks,

Abstract and Figures Power system relay protection (PSRP) is a comprehensive course in electrical engineering

Relay Protection Three-Stage Simulation

The protection of machine learning algorithms in the three-phase current relay protection system has proven highly

For this purpose, the design of differential protection was utilized. In this study, the differential relay simulation has

This paper presents an in-depth investigation into the design and performance assessment of an overcurrent relay,

The publication presents training simulation models of automation for switching on backup power, relay protection and auto reclose

Free relay coordination and protection grading tool for power systems engineers. Visualize

The whole process simulation of relay protection in intelligent substation is implemented, including MU data acquisition,

Therefore it's protection against all types of faults become the point of interest of many researchers. This research

Through the simulation experimental device, the overall framework of power line relay protection simulation experimen-tal device is

RelaySimTest lets you easily analyze your protection system under transient conditions including CT saturation, power swings,

This paper proposes an overcurrent (OC) protection coordination strategy that considers both directional and non

Abstract - This project describes modeling of distance relay and zone protection scheme using Matlab/Simulink package.

The simulation results show that the simulation analysis can achieve better power line three-stage over-current protection under

Therefore, this course will tackle the modeling, simulation, and testing of protective devices such as overcurrent relays, distance, and

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