Multi-Disciplinary Education Using Curriculum Re-engineering, Industry Partnership and Simulation Technology MERIT 2000

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Outline

- Background
- Unbalanced Conditions and Short-Circuit Analysis
- Digital Relay Elements and Design Principles
- Modeling and Testing Digital Relays
- Library of Digital Relays and Protection Systems
- Digital Simulator Based Relay Test System

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Background

- Enhance teaching of protective relaying
- Utilize modeling and simulation
- Develop low cost tools, mostly in-house
- Allow strong hands-on experience
- Gain experience that may continue at workplace
- Make a sustainable tool development
- Seek industry donations
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Teaching Goals:

- Convert phase signals into symmetrical components using numerical and graphical techniques.
- Represent three-phase unbalance systems by three-symmetrical-component systems.
- Develop short-circuit program using admittance and impedance methods.

\[
\begin{align*}
\dot{F}_a &= \dot{F}_a^0 + \dot{F}_a^+ + \dot{F}_a^- \\
\dot{F}_b &= \dot{F}_b^0 + \dot{F}_b^+ + \dot{F}_b^- \\
\dot{F}_c &= \dot{F}_c^0 + \dot{F}_c^+ + \dot{F}_c^-
\end{align*}
\]
Unbalanced Conditions
Short-Circuit Analysis

Analysis Using Sequence Networks

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Digital Relay Elements and Design Principles

**Teaching Goals:**

- Learn digital relay elements (data acquisition, measurement, decision making, etc.) by performing simulations.
- Design digital relay models for implementing various protection algorithm. (overcurrent, impedance, differential etc.)
Library of Relay Elements
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Modeling and Testing Digital Relays

Teaching Goals:

• Perform power system simulations of faults and observe how a given protection (overcurrent, impedance, differential etc.) works.
• Determine correct settings, verify relays operations in a given power system by simulation.
• Model relay malfunctioning and verify the back-up protection functions.
Differential Relaying Principle

Continuous
powergui

Fault
Bus1
Load1
K CT L
CT1
CB1
Line1
Fault
Load2
Bus2
Fault
CB2
CT2
Line2
 Fault
Load3
Bus3
System A1
A
Fault
CB3
CT3
Line2
Differential
Relay1
Differential
Relay
TRIP1
V1
V2
TRIP2
V3

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Library of Digital Relays and Protection Systems

POTT+WEI+TB tripping logic of ABB's distance relay LZ96a
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Digital Simulator Based Relay Test System

**Teaching Goals:**

- Perform on-line and off-line protective relay tests with various power system disturbances including fault types, locations etc.
- Learn how to correctly set up relay functions, verify relay settings through testing.
- Analyze test results, characterize relay operation performance.
Low Voltage Laboratory Simulator

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Off-Line Relay Testing Model

Off-Line Distance Relay Testing Using 230 kV Transmission Line Model
Lab Facilities
Discussion!