Directional Protection Applied to Wind Systems: Challenges and Solutions

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Outline

- Introduction

- Features of the Directional Element

- Case Studies
  - Windfarm Application
  - Series Capacitor Application

- Recommendations

- Conclusions
Introduction

• Directional protection plays a major role in power system protection.
  • Provides the selectivity and security

• Key Applications
  • Distance protection schemes
  • Over current protection
Introduction cont..

• Application issues
  • Passive sources (inverter connected wind sources)
    • Lower fault currents
    • Low frequency oscillations

• Series compensated systems
  • Voltage and current inversions
  • Low frequency oscillations
Directional Element

- Flexibility in selecting sequence components

![Diagram showing directional element logic]
Directional Element

- Compensation for series capacitors

![Line Parameters Graph](image)

- Line
  - Line to Line Voltage: 230.00 kV (Pri)
  - Line Length: 80.00 km

- Sequence Impedance
  - Positive Sequence Impedance (Z1): 20.35 ohm
  - Positive Sequence Angle (Z1): 86.0 deg
  - Zero Sequence Impedance (Z0): 54.97 ohm
  - Zero Sequence Angle (Z0): 74.7 deg

- Series Compensation
  - Enabled
  - % Compensation: 20.0%

- K0
  - K0 Override Enabled
  - $K_0 = \frac{Z_0 - Z_1}{3Z_1}$
  - K0 Magnitude: 0.58
  - K0 Angle: -17.8 deg

$V_s$ (estimated)
Directional Element

- Low frequency removal
Case Study-1
Case Study-1

- Forward fault – no correction
Case Study-1

- Forward fault – with correction
Case Study-2
Case Study-2

- Reverse fault – no correction
Case Study-2

- Reverse fault – with correction
Summary

- Applicability of a flexible directional element was investigated.
  - Series compensated line protection
  - Inverter connected windfarm

- Simulation based testing has been carried out using simplified networks models.

- Results demonstrated secured operation for the proposed directional element for investigated applications.
Thank you!