

## PROTECTIVE RELAY SELECTION

Computer Based Training Module Available on NANTeL



### ABSTRACT

This CBT is a self-paced, detailed, comprehensive, nuclear industry generic overview of the design and licensing basis for protective relay selection and set point considerations. This course provides in depth coverage of the types and purpose of protective relays, the characteristics of their design, aspects of both phase and ground protection and the protection requirements for different equipment (i.e., power transformers, generators, motor protection, etc.). The module has undergone one round of revision to address ownership issues and feedback via NANTeL and other sources to make it more effective and seamless for the learners. The final exam was revised to add the open book resource documents link and reformat selected questions to improve clarity based on exam analysis and feedback.



### INTENDED AUDIENCE

1. Experienced nuclear plant electrical engineers who are developing expertise in Protective Relays
2. Site engineering Managers or Supervisors



### DURATION

- 3.5 hours
- An additional 8-12 hours for reading materials provided within the CBT

## TERMINAL LEARNING OBJECTIVES

1. Identify the different types of instrument transformers, the industry standards that apply and the design criteria associated with them.
2. Describe Current Transformer saturation and its impact on protective relay performance.
3. Classify the various types of protective relays based on their characteristics.
4. Compare the various relay technologies in use today.
5. Explain the principles of protection applied to the three types of overcurrent relays.
6. Explain the coordination principles associated with overcurrent protection.
7. Determine the applicability of directional overcurrent protection for both phase and ground protection.
8. Relate voltage and current polarization techniques to zero and negative sequence polarized directional relays.
9. Identify the various differential protection schemes used in electromechanical and numerical relays and the conditions when they are used.
10. Describe various grounding methods and their impact on the protective relays.
11. Identify the protective relay schemes used to protect against ground faults.
12. Explain the role of polarization in determining the best relay scheme.
13. Identify the protective relay schemes used to protect power transformers.
14. Explain how mechanical relays provide large power transformer protection and ground differential protection.
15. Match the generator abnormal operations with the typical configuration for protective relay settings.
16. Describe the loss-of-field protection (LOF) (relay function 40), negative phase sequence or unbalanced overcurrent protection (relay function 46), and inadvertent energization protection (relay function 50/27).
17. Identify the relay schemes used to protect against breaker failure.
18. Identify the relays that provide protection from sustained underfrequency operation and ground fault.
19. Identify the relays used for protecting generator stator multi-phase faults.
20. Describe the motor physical characteristics and their impact on protective relaying schemes.

## KEY INDUSTRY DOCUMENTS

1. EPRI – Technical Report 1009704, Protective Relays
2. EPRI – Report 1002913, Power Transformer Application and Maintenance Guide
3. IEEE Standard C57.13-2008, Requirements for Instrument Transformers
4. IEEE Std. C37.110-2007, Guide for the Application of Current Transformers Used for Protective Relaying Purposes
5. IEEE Std. C37.91-2008, Guide for Protecting Power Transformers
6. IEEE Std. 1402-2000 (R2008), Guide for Electric Power Substation Physical and Electronic Security
7. IEEE Std. C37.96-2012, Guide for AC Motor Protection
8. INPO IER L3-12-51, Automatic Reactor Scram Caused by and Incorrect Relay Setpoint
9. NRC RG 1.168 Rev 2 Software Verification Validation Review And Audits
10. NRC RG 1.169 Rev 1 Software Configuration Management Plans
11. NRC RG 1.170 Rev 1 Software Test Documentation
12. NRC RG 1.171 Rev 1 Software Testing
13. NRC RG 1.172 Rev 1 Software Requirement Specifications For Software And Complex Electronics
14. NRC RG 1.173 Rev 1 Software Life-Cycle Processes
15. IEEE Std. 666-2007, Design Guide for Electric Power Service Systems for Generating Stations (Noted Sections)
16. GE Report GER-3182A, Polarizing Sources for Directional Ground Relays
17. IEEE Std. 242-2001 (Buff book), Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
18. IEEE PSRC Working Group J9 Report to the Rotating Machinery Protection Subcommittee, May 2012, Motor Bus Transfer Applications Issues and Considerations
19. INPO OE23025, Uses of Estimated Wire Lengths Versus Actual Wire Lengths for Calculating Bus Differential Relay Settings May Cause Non Conservative Relay Settings
20. INPO ICES 176637, Loss of Startup Power Because of Improper Differential Relay Design Setpoint
21. INPO ICES 313608, Unplanned Shutdown Risk Orange Condition
22. IEEE Std. C62.92.1-2000 (R2005), Guide for the Application of Neutral Grounding in Electrical Utility Systems – Part I: Introduction
23. INPO SOER 90-1, Ground Faults on AC Electrical Distribution Systems
24. INPO ICES 288684, Inoperability of Division I and Division II Diesel Generators Due to Design Deficiency in Ground Fault Detection and Trip Circuit
25. NRC NUREG 0800 BTP 8-9, Open Phase Conditions in Electric Power System Review Responsibilities
26. INPO IER L2-14-46, Multiple Electrical Faults Result in Explosion of Unit Auxiliary Transformer and Automatic Scram
27. NERC TRD 07 30 2010, Power Plant and Transmission System Protection Coordination
28. IEEE Std. C37.102-2006, Guide for AC Generator Protection
29. EPRI Document EL-5036, Power Plant Electrical Reference Series, Vol. 8, Station Protection
30. INPO ICES 162325, Design Deficiency in Emergency Diesel Generator Protection Circuitry
31. ABB IB7.8.1.7-2, Issue D, High Speed Directional Relays
32. NRC RG 1.9 Revision 4, Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants
33. IEEE Std. 741-2007, Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations
34. NRC NUREG 0800 BTP 8-6, Adequacy of Station Electric Distribution System Voltages Review Responsibilities
35. GE Manual GEH-1816, Transformer Differential Relay with Percentage and Harmonic Restraint
36. Schweitzer Engineering Laboratories (SEL), Inc., 20061010, LWPO001, Methods for Detecting Ground Faults in Medium-Voltage Distribution Power Systems
37. IEEE C37.112-1996 (R2007) Overcurrent Relay Inverse Time Equations
38. IEEE C57.109-1993 (R2008) Transformer Fault Current Duration
39. IEEE C62.92.3-2012 Neutral Grounding Part III Gen Aux Systems
40. INPO OE 26492 Main Generator Protection Design Weakness