



System Protection Technology Series (100 NERC CE Hours)

Overview

This program will train personnel on the principles of protection systems, including different schemes used in the protection of: generators, buses, transmission & distribution lines, transformers, motors, etc.

Program Segments

2101 Elements of System Protection (4 CE Hours)

Philosophy and objectives of system protection; zones of protection; faults; tolerable and intolerable faults; reading electrical diagrams; relay performance; analysis of incidents; correct and incorrect operation; reliability, selectivity, and speed.

2102 Types of Protective Relays (4 CE Hours)

The differential principle; instantaneous and time overcurrent relays; directional relays; distance relays; MHO relays; reactance relays; backup protection.

2103 Monitoring System Conditions (4 CE Hours)

Current transformers; effect of burden; saturation effects; voltage transformers; VT connections; polarity; voltage polarization; current polarization; directional sensing; circuit and phasor diagrams; phase rotation; per unit calculations; MVA fault capacity.

2104 Fault Characteristics (4 CE Hours)

Types; symmetrical components; fault phasors; system grounding; high and low impedance; solid grounding; ferroresonance; safety grounding.

2105 Generator Protection (4 CE Hours)

"Mechanical" protection; faults; tripping arrangements; primary protection; backup protection; negative sequence protection; generator capability curve; loss of field protection; system disturbances; under frequency, overcurrent, reverse power, under voltage; off-line protection; over voltage; synchronizing.

2106 Transformer Protection (4 CE Hours)

Types of faults; overcurrent protection; backup; primary fuses; differential protection; in-rush current; phasing of CTs; calculation of mismatch; connection of multiple restraint coils; zero-sequence protection; directional protection; remote transfer tripping; thermal relays; reactor protection.

2107 Bus Protection (4 CE Hours)

Typical bus arrangements; single breaker - single bus; single buses connected with bus tie; main and transfer buses with single breaker; single breaker double bus; double breaker double bus; ring bus; breaker-and-a-half bus; transformer-bus combination; differential protection for buses; ground-fault bus.

2108 Motor Protection (4 CE Hours)

Potential hazards; motor characteristics; general protection; phase fault protection; differential protection; ground fault protection; thermal limits; locked rotor protection; system unbalance; under voltage; bus transfer and reclosing; repetitive starts and jogging protection; synchronous motors; unbalanced conditions; current time curves; motor applications, voltage levels; torque curves-speed, slip stall.

2109 Line Protection (4 CE Hours)

Classification; techniques; protection coordination; setting and coordination; instantaneous overcurrent; instantaneous trip application for a loop system; short-line applications; network and spot network systems; distance protection; ground fault protection; distance vs. overcurrent; directional sensing; polarizing problems with auto transformers; dual polarization; ground directional sensing with negative sequence; mutual coupling; mutual induction; fault resistance; long EHV series compensated; backup - remote, local and breaker failure.

2110 Pilot Protection (4 CE Hours)

Classification; communication channels; transfer trip pilot-wire; directional comparison blocking and unblocking pilot systems; overreaching and underreaching transfer trip pilot systems; phase comparison systems; single pole-selective pilot systems.

2111 Protection for System Stability (4 CE Hours)



Power transmission; steady-state and transient operation and stability; system swings; out-of-step detection; automatic line reclosing; distribution feeder reclosing; reclosing with transformers or reactors; automatic synchronizing; load shedding.

2112 Testing and Commissioning of Protective Schemes (4 CE Hours)

Construction diagram review and installation check; preparation of relays, review setting instructions; CT and VT tests; VT and CT secondary wiring checks; relay calibration; functional testing; primary and secondary injection tests; bus equipment visual check; coordination with dispatcher; primary phasing test, phase angle checks; in-service readings on protection circuits, on-load and at zero load; revise drawings and operating instructions.

2113 Power Line Carrier (4 CE Hours)

L-C line traps, parallel resonance; high Q and low Q traps; wide band traps; coupling capacitor grounding equipment; line tuning equipment; impedance matching; reflectivity; signal loss attenuation; examples of dB loss; hybrid units; transmitter and receiver tests and adjustments; special test equipment; audio signals, frequency band; SSB carrier equipment and features.

2114 Fault Investigation and Analysis (4 CE Hours)

Need for investigation; reporting; capturing information; relay targets; oscillograms; digital transient recorders; selection of data to be monitored; dispatcher's log, operating instructions; sequence of event recorders; case studies - faults and subsequent analysis; interpretation of data.

2115 Introduction to Static Relaying (4 CE Hours)

Solid-state devices; solid-state circuitry; advantages, relay applications; calibration; comparison; solid-state protective schemes; digital protection schemes.

2116 Coordination of Protective Devices (4 CE Hours)

The theory and procedures used to coordinate various protective devices in power systems; fuses - function and operation; fuse ratings; melting time and damage curves; fuse coordination; reclosers and sectionalizers; coordination with overcurrent relays; overall system coordination; protection coordination in industrial installations; co-generation coordination.

2117 Power Supply for Protection and Control Systems (4 CE Hours)

Need for un-interruptible power supply, batteries - types, characteristics, construction; battery care and maintenance; DC distribution - security, redundancy; battery chargers; AC/DC rectification; inverters; un-interruptible AC.

2118 Energy Center Operations (4 CE Hours)

Elements of the power system; generation, transmission, distribution; system control, frequency control; the load curve, economic dispatching; spinning reserve, load shedding; automatic generation control; interconnections; planned outages; system response to interruptions; cascade tripping.

2119 Telecommunications Protection I (HVSP Devices) (4 CE Hours)

Usage of wire lines; routing; effect of power system faults on telephone lines; longitudinal common mode induction; GPR-ground potential rise; remote ground and local ground; high voltage hazards; location of demarcation interface; standard protection; air gap arresters; carbon block, gas tube, solid-state protectors and limitations; voltage clamping; mutual drainage reactor; high voltage special protection; neutralizing transformer and reactor; isolation transformers; relay for DC signals; safety precautions; optical isolators: tucon fiber optic link; fiber optic cable.

2120 Telecommunications Protection II Configuration & Installation (4 CE Hours)

Types of service; SPO classification; voltage rise; protection requirements for different SPO classifications and voltage rise; HVSP configurations for different circuits; location of protection devices; selection and limitations of protectors; grounding arrangements at TELCO, RDL, HVI; grounding or isolating dedicated cable shield; PVC conduit; cable to network interface; surge arrester connections; isolation transformers as MDR; location and mounting of HVI cabinet; grounding at conductors, protection of unassigned pairs, connection of secondary windings; installation of isolating transformer, HVI layout, terminal strips, ground bus, remote side wiring, station side wiring, cable connections; connection of protectors and MDR's; circuit identification and documentation; modular HVI; installation pitfalls; maintenance and inspection; safety considerations.

2121 Supervisory Control System (SCADA) (4 CE Hours)

Basic features; remote data collection, transmission, processing, display; remote control; polling; RTU inputs, outputs, reporting and data collection; analog points, transducers, analog digital conversion; control commands - select - check - operate sequence; modems, signal transmission; FSK, PSK, A.M.; rate of signal transmission; communication line arrangements; master assembly and peripherals; memory; clock; communications controller; display computer, stations, operator input; standby station;



CPU priority tasking; on-line diagnostics; operator interface and input; alarm system - logging and reports; troubleshooting; preventive maintenance; functional tests.

2122 Inadvertant Trips - Cause and Prevention (4 CE Hours)

National guidelines and strategies; types of tests, calibration, functional, in-service; why test, when to test, confirming performance; impact of testing, specifications, tolerance; inadvertent trips; station awareness and attention to detail; pre-test checklists, work permits, performing tasks; safety, system reliability and security; cause of false trips; different relay and breaker failure relays.

2123 Fault Calculations and Relay Settings (4 CE Hours)

Fault characteristics; voltage source; impedance to fault; per unit impedance; conversion of ohmic to per cent Z; balanced fault MVA & fault current; impedance addition - operator 'J'; substitution of complex circuits by equivalent circuits; unbalanced fault components; characteristics of symmetrical components; positive negative & zero sequence; addition of sequence components-operator 'A'; sequence impedances; unbalanced fault calculations; factors affecting relay settings (60 minutes)

2124 Testing Techniques (4 CE Hours)

Effective measurement of voltage and current; analog and digital meters; current peaks; conductor resistance; insulation resistance; frequency measurements; bandwidth; dB signal strength; timers; phase angle measurement; using the oscilloscope; sources of test signals; digital test sets; safety precautions for test personnel.

2125 Programmable Logic Controllers (4 CE Hours)

Process logic, logic diagrams; compact industrial PLC's; rack mounted PLC's; types of memory, RAM, ROM, EPROM; CPU operation, scanning time; input and output signals, input and output interfaces; external programming modules; coding instructions, programming functions; extended PLC networks; distributed control systems.