Power Systems Operation & Control Course Outline

IncSys Academy

23 February 2023

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About IncSys Academy

Mission Statement

IncSys Academy strives to serve the power industry by providing comprehensive training, and to serve our students by giving them the knowledge and skills they need to succeed in the power industry field.

Objective

IncSys Academy aims to address the needs of the power industry by providing relevant, quality training, and preparing candidates to become power system operators.

Qualifications

IncSys is a NERC Approved Continuing Education Provider, adhering to the NERC Continuing Education Program (http://www.nerc.com/pa/Train/CE/Pages/default.aspx).

IncSys has been developing and delivering simulation-based training to utilities since 1999.

IncSys Academy Overview

IncSys Academy is a fully online, self-paced school for students interested in careers in the electric power industry. The school's administrative office is located in Issaquah, WA. Students will take all classes online and will not be part of a traditional classroom setting. The learning environment is entirely on the student's personal computer.

Learning Management System Overview

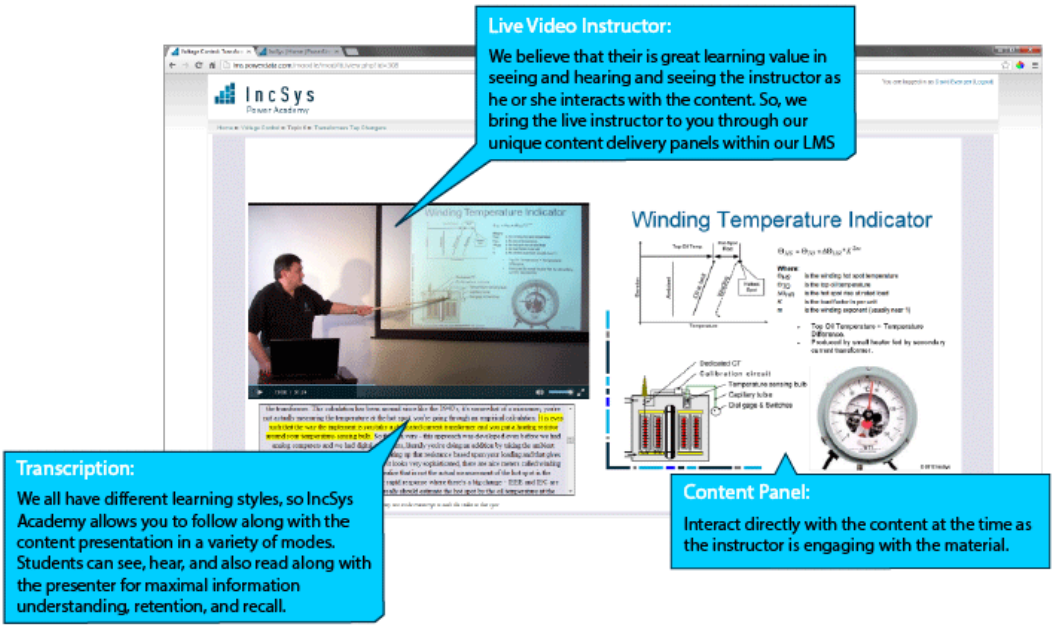
In the design and delivery of IncSys Academy courses, maximizing the student experience has always been the driving force. We believe in the value of live classroom instruction; however, this form of training is often expensive, inflexible, and lacks student control. With all IncSys Academy Courses we have recreated the benefits of the live classroom experience and then add value by using modes unique to online training.

We hope you find the student experience at the IncSys Academy to be engaging, focused, and challenging content delivered to you the student in a flexible, fun, and empowering manner. The following screenshots help to explain the what drives our LMS design.

Digital Presenter

Teaching is more than just content presented on a page or a screen. IncSys Academy course the content will be presented directly to the students by the top-notch instructors themselves. Students will be able to watch as the instructor explains, not only with his or her words, but also with gesture, inflection, props and interaction with the content itself. In addition to the live digital presenter, students will be able to follow along with the slide content in real-time, read a transcript of the content, and pause, rewind and re-watch as necessary.

These unique features of the LMS lead to more understanding, retention and recall of difficult concepts.

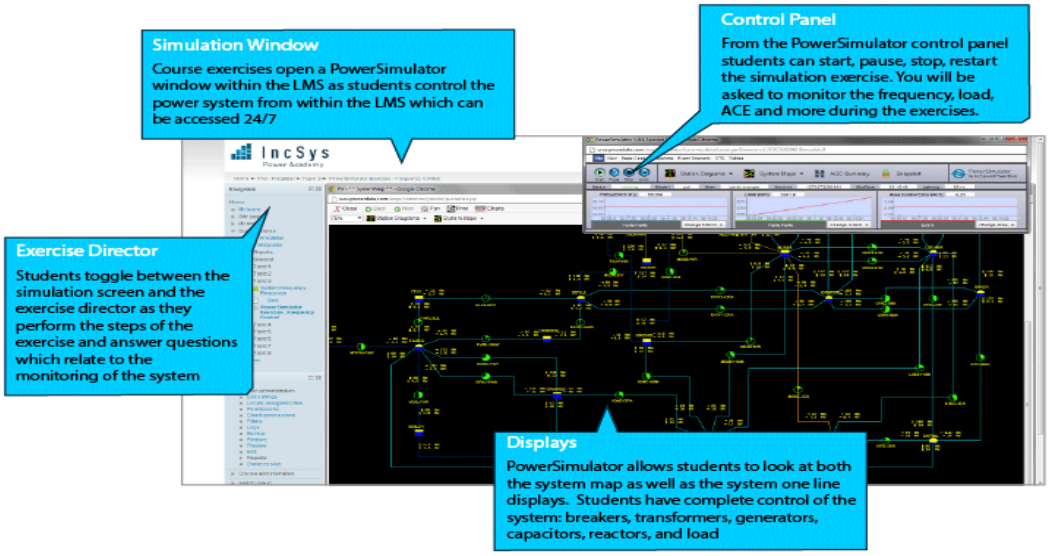


Digital Demonstrator

Through the flexible and easy to use Learning Management System, real-time power system operations will be demonstrated for students to show how experienced operators manage the power system. Our PowerSimulator® experts will show the students not only how to work with the simulation software, but also how systems experts handle difficult situations. Watching something done right is a powerful learning aid.

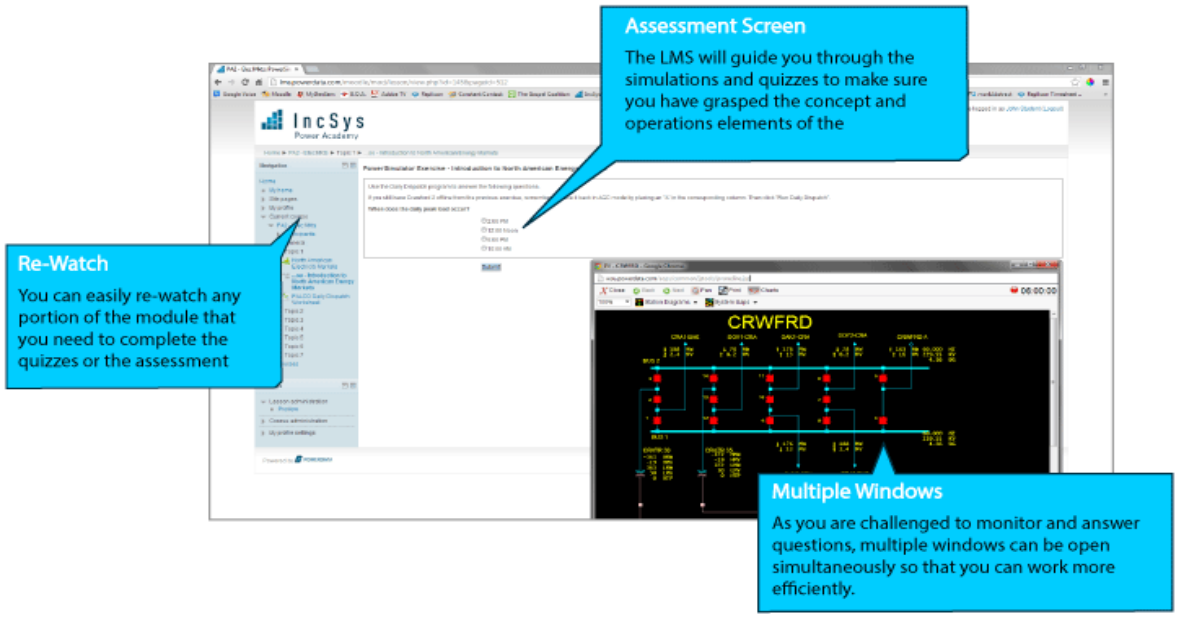
Digital Director

Another unique aspect of the IncSys Academy is that all of our training courses integrate real-life simulation exercises. Our LMS acts like a digital director prompting students to make adjustments to the system through easy to use simulator displays. As with any good direction or coaching, the hand holding get progressively less as the modules get more challenging and students get more comfortable with the simulator. With simulator and content all in one place, the student will be prompted to perform tasks in the simulator and then answer questions in the LMS. This type of one-on-one self-paced direction is hard to duplicate.



Digital Challenger

Any good class or learning experience forces the students to recall what he or she has learned and apply that knowledge. During and following each module, students are tested and assessed in both their conceptual understanding and in their operational ability. With more difficult simulations, students are challenged to control the system with almost no direction at all. This is the highest level of difficulty but also delivers the most advanced learning outcomes. This online LMS assessment process helps students and their trainers know just how well they are processing and applying the course material.



The NERC Preparation with Simulation Training Program of Study

IncSys Academy offers the Power Systems Operation & Control Course, which provides our students with theory and practical knowledge, coupled with power system simulation, to prepare students for careers in the electric utility industry. The Power Systems Operation & Control Course includes the following modules and subjects.

Each module can take several hours to complete based on the student's ability and retention. Re-attempts at coursework are encouraged, and total time to complete the course can be from 2-6 months based on the student's schedule since it is self-paced. We will provide students access to the training material for a maximum of 12 months in order to complete the course content as they work towards passing the NERC exam.

100 – Power Systems Operations Course Orientation

PSOC 101 - Introduction

- Welcome to IncSys Academy

PSOC 102 – NERC Exam Outline

- Introduction to the various NERC exam outlines and expectations for taking the NERC exam
- NERC Exam Resource Materials
- System Operator Program Manual

PSOC 103 – Student Pre-Assessments

- Pre-tests to gauge the students' knowledge on basic fundamentals of power systems
  - EPRI Fundamentals Quiz
  - Transmission Equipment Quiz
  - NERC Sample Test

PSOC 104 – NERC Roles & Responsibilities

- NERC Functional Model Lecture Video

PSOC 105 – NERC Reliability Standards

- NERC Standards Summary

PSOC 106 – NERC Glossary of Terms

- Glossary of terms manual to assist students with the industry language and terms

PSOC 107 – Simulation-based Training Approach

- Introduction to Cascadia Video
  - PALCO System Map & Guide Book for Download
  - Cascadia System Map & Guide Book for Download

- PowerSimulator® Quick Reference Guide

PSOC 108 – Technical Requirement and Troubleshooting

- Information on how to set up the student portal to utilize the PowerSimulator® and Learning Management System

PSOC 109 – Powersimulator Help-Tool Video Lectures

- A series of demonstration help vides to instruct the student on the various PowerSimulator® features for them to complete their simulation tasks

PSOC 110 – EPRI Power System Dynamics Tutorial

- Required reading material manual for the training course outline

200 – Power System Generation, Substation & Transmission, Operator Communications, Operator Decision Making, & NERC COM Reliability Standards

PSOC 201 - Types of Power Plants

- Identification and explanation of different power plants their components
- The purpose and function of power plant components
- The process of converting fuel to electricity for different types of power plants
- The roles of different power plants in relation to system operations
- Advantages and disadvantages for different unit types

PSOC 202 – Substation Equipment & Operations

- Identification and explanation of different substation equipment and their functions
- The purpose and function of substation equipment
- Sample switching procedure

PSOC 203 – Transmission Lines

- PALCO Exercise: Getting Started
- PALCO Exercise: Farlie to Homer Exercise
- PALCO Exercise: System Components Exercise
- PALCO Exercise: Switching Protocols Exercise

PSOC 204 – Communications and Grid Operations & NERC Com Reliability Standards

- NERC COM Reliability Standards
- The nature of today's power systems and future power systems
- Smart Grid technology and the requirements for future Grid Management Systems

PSOC 205 - Situational Awareness and the Expert System Operator Model

- Expert operator decision making
- Levels of expertise
- Knowledge capture and simulators
- Mental models and human considerations

300 - Frequency and Balancing Control (Important Module to Complete for the NERC Exam Content)

PSOC 301 - Introduction to Frequency Control

- Mechanical system oscillations
- Interconnection characteristics using a single shaft mental model
- The need for frequency control systems
- Components of a control system
- Energy balance concepts
- The relationship between system load and frequency
- Frequency response to generator trip
- Preparing to operate a simulated power system

PSOC 302 - Governor Components and Operation

- Describe purpose of governors
- Describe centrifugal ball-head governors
- Describe modern electronic governors
- Describe DROOP in comparison to Control System GAIN
- Describe governor droop curves
- Describe governor control in islanded systems
- Describe governor control in interconnected systems
- Detect governor response in frequency traces
- Describe how droop affects parallel unit responses

PSOC 303 - System Frequency Response

- Describe frequency responses of three major interconnections
- Describe factors that limit frequency response
- Describe impacts of different types of local plant control modes on frequency response
- Be able to operate the PowerSimulator® with all generating units in Manual or local mode

PSOC 304 - Automatic Generation Control

- Describe need for AGC systems
- Describe NERC Balancing Authorities
- Describe characteristics of a Balancing Authority
- Describe types of Interchange
- Describe functions of an AGC System
- Describe components of an AGC System
- Describe Tie-Line Bias Control
- Describe various unit control modes
- Describe Flat Frequency and Flat Tie-Line Modes

PSOC 305 - NERC Real Power Balancing Control Performance Standard BAL-001

- Describe the CPS1 criteria
- Describe compliant CPS1 regions on the Frequency vs. ACE chart
- Describe reasonability checks for CPS1
- Describe the CPS2 criteria
- Describe the BAL-001 Metering and Telemetry requirements

PSOC 306 - Time Error Correction & Reserve Monitoring and Scheduling

- Describe guidelines for Time Error correction in East, West and ERCOT interconnections
- Describe NERC BAL-002 Disturbance Control Performance Standard
- Describe operation and benefits of Reserve Sharing Groups
- Describe elements of Contingency Reserve Policies
- Describe different Operating Reserve Categories
- Describe Contingency Reserve Restoration Period

400 - Transmission Network Flows & Real-Time Assessments & Contingency Analysis (Important Module to Complete for the NERC Exam Content)

PSOC 401 – Real Time Assessment (RTA), Contingency Analysis, Network Analysis & Wide Spread Outages & System Operating Limits (SOLs)

- Identify the basic definition of a Real-time Assessment (RTA)
- Identify the Reliability Standards that are associated with the RTA.
- Identify the different tools and components that make up the RTA.
- Identify vulnerabilities that can reduce RTA capability and reliability.
- Describe internal controls used to detect problems with the RTA process.
- The sequence of events for the September 8, 2011 AZ – So. CA outage
- Normal, Alert, Emergency and Restoration States

- Definition of System Operating Limit (SOL)
- Definition of Interconnection Reliability Operating Limit (IROL)
- Normal and Emergency Ratings
- Transient Stability Limits
- Voltage Stability Limits
- Protection and RAS limits

PSOC 402 - MW Flow Basics

- Principles of MW flow in AC networks
- Kirchhoff's voltage law
- Kirchhoff's current law
- Ohm's law
- Computing series and parallel impedances
- Calculating equivalent impedance between two nodes
- Calculating bus angle differences
- Application of control flow principles in the PALCO network
- Calculating angle across a path
- Application of generator slack bus

PSOC 403 - Parallel Path Flows

- How MWs flow on parallel paths
- Power Transfer Distribution Factors (PTDFs)
- Calculating PTDFs
- Opening a lower voltage path to remove an overload situation

PSOC 404 - Generator Re-dispatch for Managing MW Flows

- Re-dispatch generation between a pair of generators
- Re-dispatch of one generator and using AGC program to control the rest
- Generator shift factors (GSF) for comparison of the effectiveness of different generator re- dispatch options
- Generation re-dispatch updates with transmission configuration changes

PSOC 405 - Line Outage Distribution Factor (LODF)

- Calculating LODFs from simulator results
- Estimating MW flows with LODFs following contingencies
- When LODFs should be updated
- Using GSFs and LODFs to estimate generation shifts needed to handle N-1 contingencies
- How GSFs and LODFs are used to comply with TOP Standards
- Guidelines for cases when real-time contingency analysis is not available

PSOC 406 - Managing a Bus Outage

- The impact of bus outages with common configurations:
  - Breaker and Half
  - Double Breaker
  - Main and Transfer
  - Ring Bus
  - Double Bus – Single Breaker
  - Single Bus – Single Breaker
- How a bus outage in a Breaker and Half configuration can cause secondary equipment outages
- The weaknesses of planning programs that do not model network topology
- Prepare for handling bus outages in PowerSimulator®

PSOC 407 - Standing Phase Angles

- How large standing phase angles be created
- How shock torque on a synchronous machine increases with:
  - Standing phase angles
- Change in path impedance between generators before and after breaker closure
- How standing phase angles can be decreased
- Possible damage from closing across large standing phase angles
- How to manually calculate standing phase angles

PSOC 408 - Phase Shifters

- How phase shifters control MW flows in AC networks
- How phase shifters can control circulating flows
- Phase shifter design
- What Transmission Operators and Reliability Coordinators should know about their system's phase shifters

500 - Voltage and Reactive Power Management (Important Module to Complete for the NERC Exam Content)

PSOC 501 - Reactive Power, Reactive Power in Simple Networks & Voltage Operating Limits

- The need for Reactive Power
- Real versus Reactive Power
- How Real and Reactive Power vary over time with AC Voltage
- Real and Reactive Power Triangle
- How current is decomposed into Real and Reactive power components
- Definition of Power Factor

- Reactive sources
- Reactive loads
- Use of shunt capacitors
- MVAR flow across a transmission line:
  - With angle difference
  - With voltage magnitude difference
- MVAR characteristics of transmission lines
- Voltage collapse in a radial system
- Causes of low voltage
- Impacts of low voltages
- Impacts of high voltages
- How voltage limits are applied for a large Reliability Coordinator

PSOC 502 - Pole and Beam Analogy & Generators

- Describing the interaction of voltage and MVAR in networks
- Apply the pole and beam analogy to:
  - Identify weak buses in a network
  - Identify strong buses in a network
  - How bus voltages vary with additional inductors, capacitors, and MW loads
  - Anticipate how voltage collapse may occur
  - Anticipate when MVARs reserves may be deficient
  - Determine best locations for dispatching MVAR resources
  - Anticipate severe over-voltages
- Anticipate the isolating effect of generators
- Generator Automatic Voltage Regulator (AVR) operation
- Limiting elements of the Steam Generator MVAR Capability Curve
- Limiting elements of the Hydro Generator MVAR Capability Curve
- How generator kV schedules are coordinated
- Role that generators play in voltage control
- NERC standards for Generator Operators in maintaining voltage schedules

PSOC 503 - Transmission Lines

- Surge Impedance Loading (SIL)
- Transmission Lines as capacitors at MW loads below SIL
- Transmission Lines as reactors at MW loads above SIL
- How MVARs increase with the MW loading
- How heavy transmission line loads cause bus voltages to drop below their minimum limits
- Ferranti Effect on open ended lines

PSOC 504 - Shunt Capacitors, Shunt Reactors & Static VAR Compensators

- Purpose of shunt capacitors
- Application of shunt capacitors
- Shunt capacitor design
    - Failure modes
- How shunt capacitor MVARs vary with the bus voltage
- Back-to-back switching of shunt capacitors
- Trapped charge in shunt capacitors
- Adding shunt capacitors onto a weak bus
- Adding shunt capacitors next to generators
- "Getting ahead of the voltage"
- Purpose of shunt reactors
- Application of shunt reactors
- Shunt reactor design
- How shunt reactor MVARs vary with bus voltage
- MVAR characteristics
- Purpose of static VAR compensators
- Static VAR compensator design
- Static VAR compensator operation
- Static VAR compensator applications:
    - Transmission
    - Wind Farm
    - Industrial

PSOC 505 – Transformers & Transformer Tap Changers

- Role of transformers in power transmission networks
- Types of transformers
- Construction and operation of transformers
- Common three phase winding configurations
- Construction and operation of tap changers
- Temperature monitoring and control
- Using transformer taps to control voltage
- Operator guides

PSOC 506 - Loads

- Understanding load response to voltage
- Historical approach to modeling power system loads
- Development of dynamic models for power system loads
- Fault Induced Delayed Voltage Recovery (FIDVR)
- Power Factors for various loads

600 – Emergency Operations (Important Module to Complete for the NERC Exam Content – Video Lectures Only)

- Understanding of NERC EOP-011-1 (Emergency Operations Standard) & (Energy Emergency Alerts)
- Understanding of NERC EOP-011-2 (Emergency Preparedness & Operations Standard)
- Addressing the effects of operating Emergencies by ensuring each Transmission Operator and Balancing Authority has developed Operating Plan(s) to mitigate operating Emergencies, and that those plans are coordinated within a Reliability Coordinator Area

PSOC 601 – Installed Reserve Capacity

- Resource Adequacy
- Summer Assessment
- Installed Capacity
- Reserve Margin
- Wind Capacity Calculation

PSOC 602 – Shoulder Months

- Demand during peak months

PSOC 603 – Polar Blast & Emergency Communications

- Identify operator responsibilities during an Energy Emergency Alert
- Identify Market solutions for mitigating capacity emergencies
- Explain the difference between Manual Load Shed and Automatic Under frequency Load Shed

PSOC 604 – Polar Blast Story

- A real-time explanation of the Artic Polar Blast of 2011 in Texas

PSOC 605 – Energy Emergency Alerts

- An explanation of the various Energy Emergency Alerts

PSOC 606 – Emergency Interruptible Load Service

- Load Resources & EISL Deployment

PSOC 607 – Wind Ramping

- Wind Ramping Behavior
- Wind Power Operations
- Wind Ramping (10 Minute Ramp, Daily Wind Ramping, Wind Ramping Capacity)

700 – System Restoration (Important Module to Complete for the NERC Exam Content – Video Lectures Only)

PSOC 701 – System Restoration Roles & Responsibilities

- System Restoration Roles and Responsibilities of the various entities (RC, TO, BA, etc.) during System Restoration.

PSOC 702 – System Restoration Applicable NERC Standards

- Applicable NERC Standards related to System Restoration (EOP 005-3, EOP-006-3, & COM-002)

PSOC 703 – Securing a Control Center

- Understanding the principles of securing a control center (EOP-008-2)

PSOC 704 – Black Start Units & Auxiliary Loads

- Black Start Characteristics
- Stabilizing Loads
- Load Pickup

PSOC 705 – Next Start Units

- Understanding the principles of next start units during restoration

PSOC 706 – Stabilizing Loads – Cold Load Pickup & Load Diversity

- Understanding the principles of cold load pickup & load diversity during System Restoration

PSOC 707 – Frequency Control

- Understanding the principles of frequency control during System Restoration

PSOC 708 – Voltage Control

- Understanding the principles of voltage control during System Restoration

PSOC 709 – Synchronizing Islands

- Understanding the principles of synchronizing islands during System Restoration

PSOC 710 – Post Synchronism

- Understanding the principles of post synchronism during System Restoration

800 – System Protection (Important Module to Complete for the NERC Exam Content – Video Lectures Only)

PSOC 801 – System Protection

- What is System Protection
- What is the Purpose of System Protection
- Attributes of System Protection
- System Protection Equipment & Components

PSOC 802 – Generator Protection

- Wat can go wrong?
- How do we protect the stator & generator?

PSOC 803 – Transformer Protection

- Understanding of Transformer Protection

PSOC 804 – Transmission Line Protection

- Understanding the principles of Transmission Line Protection

PSOC 805 – Zone Protection

- Understanding the principles of Zone Protection

900 – Severe Weather, Natural Disasters, & Geomagnetic Disturbances (Important Module to Complete for the NERC Exam Content – Slide Presentation Lecture Only)

PSOC 901 – NERC Definition of Force Outage

- NERC definition of Force Outage

PSOC 902 – Thunderstorms

- Understanding the effects of Thunderstorms and its effects on the BES

PSOC 903 – Hurricanes

- Understanding the effects of Hurricanes and its effects on the BES

PSOC 904 – High Temperatures

- Understanding the effects of High Temperatures and its effects on the BES

PSOC 905 – Freezing Temperatures

- Understanding the effects of Freezing Temperatures and its effects on the BES

PSOC 906 – Geomagnetic Disturbances

- Understanding of the NERC EOP-010-1 Standard
- NERC Webinar on Geomagnetic Disturbances & EOP-010-1
- Sample GMD Operating Plan
- Geomagnetic Disturbances Overview Slide Presentation
- Geomagnetic Disturbances Workbook (Slide Format)
- Explain the meaning of Geo Magnetic Disturbances
- Describe causes and consequences of Geo Magnetic Disturbances

1000 - Switching (Not a Required Course for the NERC Exam Content)

Switching will not be on the NERC exam, but knowing the principles and concepts of switching will give you a better understanding of switching principles will increase your level of knowledge and decision-making process as a System Operator. These re some great lecture videos from one of the best switching trainers in the industry. Topics covered are:

PSOC 1001 – Introduction to Safe Switching
PSOC 1002 – Main & Bus Transfer
PSOC 1003 – Breaker & Half Bus Switching
PSOC 1004 – Multi-Tap 115kV Switching
PSOC 1005 – 230kV Switching
PSOC 1006 – Main & Transfer Plus Breaker & Half
PSOC 1007 – Ring Bus & Double Breaker Switching
PSOC 1008 – 500kV Switching
PSOC 1009 – Switching with Equipment Out of Service
PSOC 1010 – Energizing New Equipment

1200 – Electricity Generation & Markets (Optional Course to complete - Not required for taking the NERC Exam)

PSOC 1201 - North American Electricity Markets (Parts 1 & Parts 2)

- How electricity differs from other commodities
- How the Federal Regulatory Energy Commission (FERC), through its Order 888 and 2000, created competitive markets for bulk power generators
- The development of central electricity markets such as PJM, MISO, ERCOT and CAISO
- Understanding the current split between bi-lateral and central markets

PSOC 1202 - Fuel and Energy Source Characteristics

- How energy is measured and the standard units of energy and power
- Energy characteristics of the major sources of electricity, including oil, gas, coal, uranium and renewables

- Energy content based on quantities of different energy sources
- The BTU (British Thermal Unit) requirements for set MWH requirements
- Price per BTU of fuels based on energy content and market price

PSOC 1203 - Types of Power Plants

- Identification and explanation of different power plants their components
- The purpose and function of power plant components
- The process of converting fuel to electricity for different types of power plants
- The roles of different power plants in relation to system operations
- Advantages and disadvantages for different unit types

PSOC 1204 - Economic Dispatch

- The relationship of Economic Dispatch and Unit Commitment
- Heat rate and incremental cost characteristics of generating units
- The principle of equal lambda dispatch
- The lambda iteration method of economic dispatch

PSOC 1205 - Preparing a Daily Dispatch Plan

- Anticipation of daily load forecast and sales
- Dispatch of pumped storage units
- Dispatch of hydro units to shave load peak
- Dispatch of nuclear units at base load
- Setting steam generation to minimize short-term cycling of steam units
- Calculating hourly economic dispatch for steam units
- Impact of wind and solar generation on generation dispatch
- Adjusting dispatch for loss of unit in simulations

NERC Certification Test Preparation

This portion of the program involves in depth coverage of NERC Certification test in a variety of different topics similar to the NERC Reliability Coordinator Exam Outline. It contains an extensive sample test question bank (796 total questions). The quiz banks consist of two parts and a final exam:

Practice Quizzes – Part I:

- Balancing - 5 quizzes - 100 total questions
- Emergency Preparedness & Operations – 3 quizzes, 60 total questions
- Interchange Coordination & Scheduling – 3 quizzes, 70 total questions
- Interconnection Reliability Operation & Coordination – 3 quizzes, 55 total questions

- Protection & Control – 2 quizzes, 36 total questions
- System Operations – 2 quizzes, 41 total questions
- Transmission Operations – 3 quizzes, 53 total questions
- Voltage & Reactive – 2 quizzes, 48 total questions
- Communications – 1 quiz, 20 total questions
- Other – 1 quiz, 25 total questions
- **Total questions for Part 1: 483 total questions**

Practice Quizzes Part II:

- Emergency Preparedness & Operations – Part I – 1 quiz, 35 total questions
- Emergency Preparedness & Operations – Part II – 1 quiz, 30 total questions
- Interchange Scheduling & Coordination – 1 quiz, 36 total questions
- Interconnection Reliability Operation & Coordination – 1 quiz, 8 total questions
- Protection & Control – 1 quiz, 8 total questions
- Resource & Demand Balancing – Part I – 1 quiz, 20 total questions
- Resource & Demand Balancing – Part II – 1 quiz, 24 total questions
- System Operations – 1 quiz, 36 total questions
- Transmission Operations – 1 quiz 28 total questions
- Voltage & Reactive - 1 quiz, 11 total questions
- **Total questions for Part II: 236 total questions**

Final NERC RC Exam:

- 82 Question exam which should be taken as a self-timed exam in less than 1.5 hours

Upon completion of the NERC Preparation Quizzes and Final Exam the students course grades will be reviewed and a One-on-One session will be coordinated with the student with an IncSys Trainer to ensure the student is ready for scheduling and taking the NERC Exam. Each student taking our curse material for NERC Certification is Required to send us a copy of their NERC test scores via email to david.miranda@incsys.com.

PowerSimulator® Overview

1. Introduction

PowerSimulator® uses the same EPRI OTS Power System Model used in the world's largest and most sophisticated control centers. Utility companies worldwide use PowerSimulator® to train, qualify, and certify system operators with various scenarios from restoration to emergency response. The IncSys Academy online training courses host PowerSimulator® on a cloud server to allow students access by web browser.

The Generic PowerSimulator®, a 29 station Power and Light Company (PALCO) system, and the Cascadia Model are available on the cloud for training in principles of power system operations.

2. Configuration

The Power System Model runs a real time simulation of the Generic PALCO system and the Cascadia Model that generates a new set of analog and status values every second. As the Power System Model calculates a new set of analog and status values, the system map and substation displays are updated in real-time.

A set of PowerSimulator® Control displays is used for initializing the base case, activating the simulator events, starting and stopping the simulation, and monitoring the power system conditions. Students will load base cases, monitor system conditions, and perform various operations based on prewritten scenarios that replicate real world events.

3. Instructional Functions

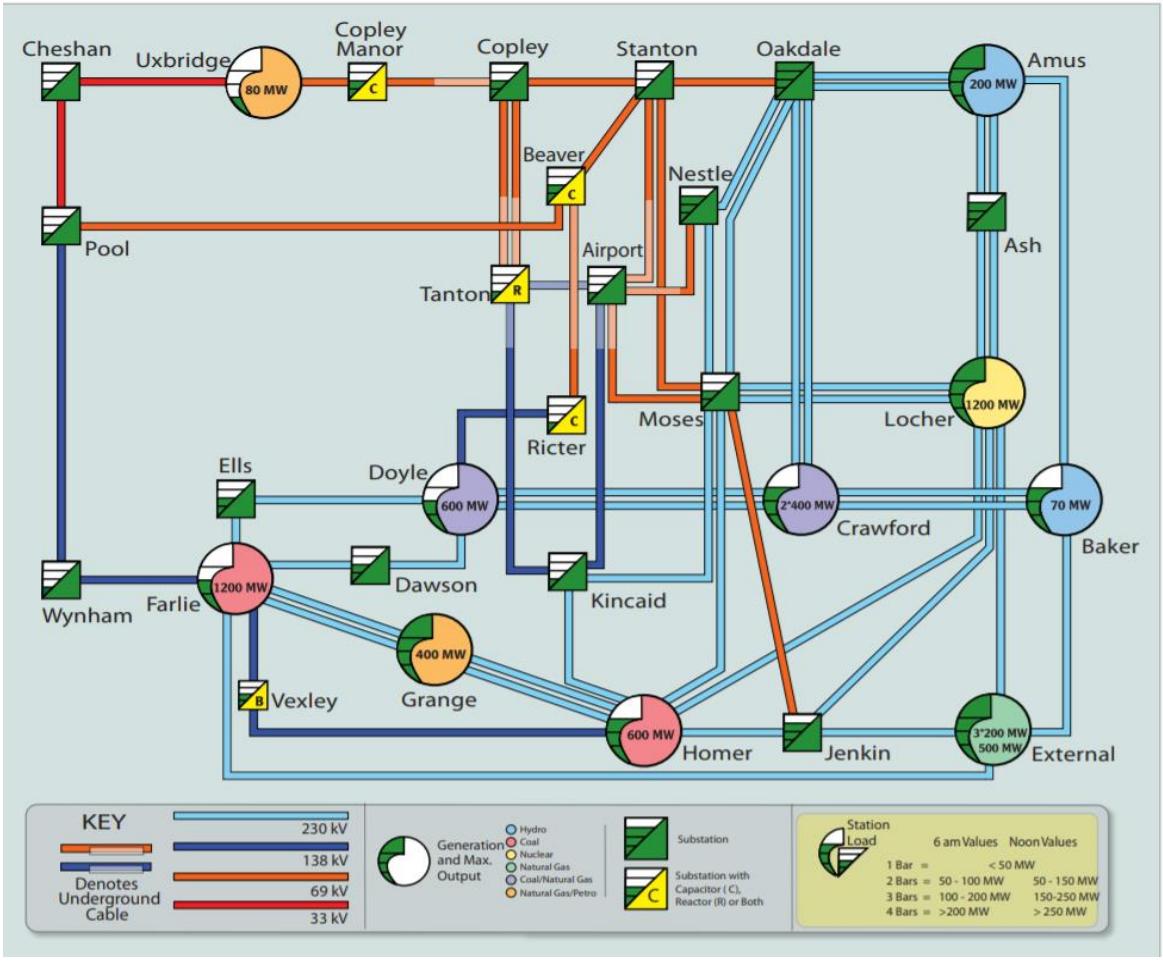
The Instructional Functions allow the user to control and monitor the overall training session.

The user can stop, pause and restart a training scenario. If the student makes a mistake the Undo button can be used to back up the system to the state just prior to the last control action. The programs and displays allow the student to quickly simulate the actions of the different operators on the power system. They can act out the roles of system operators, power plant operators, and substation operators. The student can take units on/off control, manually ramp a unit and enter interchange schedules for neighboring utility systems.

PALCO System

The Generic PowerSimulator® comes packaged with a generic power system model called the PALCO (Power and Light Company) System model.

The PALCO system map below shows the substations with generation as circles, including the MW capacity of their units.



The PALCO system is complex enough so that students can experience all the types of operating problems that occur on actual systems. The model includes details on a variety of substation breaker configurations including double breaker, breaker and half, and single bus-single breaker configurations.

The model is very flexible and can be configured to show cascading outages and system collapse under multiple contingencies.

Cascadia Model

The main tool for supporting the Generic PowerSimulator® Training Program is also the generic Cascadia System. IncSys has been developing and testing operator training materials and scenarios for the Cascadia System since 2012.

The Cascadia System includes a combination of hypothetical rural, commercial, residential, light load industrial and heavy industrial loads. The system includes different mixes of hypothetical generating plants (coal, gas, nuclear, hydro, CTs, wind farms and PV solar farms) and substations and transmission lines layered on the actual geography of Washington State. The power is delivered to customers through 52 hypothetical substations and 2700 miles of high voltage 500, 230 and 115 kV transmission lines. This system provides a much higher degree of realism in the training scenarios compared to the older PALCO system, but it does not use or compromise any actual utility Critical Energy Infrastructure Information (CEII). This allows Cascadia training to include employees who lack the clearance required to view details of your specific system.

4.