# PSCAD Advanced Application Modules

Our list of prearranged application modules are listed below.  You can select the modules based on your interest. If an application area you are looking for is not listed below, contact us @ training@nayakcorp.com. We will be happy to work with you to arrange a course that is best suited for your requirements.

**Note: The objectives of our courses are to teach the attendees how to use PSCAD for a particular application. Even though we may discuss some theoretical background behind each application, we will not discuss detailed theory or any standards involved unless specified. It is assumed that the attendees are familiarized with these applications.**

**These courses are for users who are familiarized with PSCAD. If you are a novice user, we recommend you to take our "Introduction to PSCAD" course before attending these advanced courses.**

**Minimum attendees for a course: 4**
**We can host the course at our facility in Skillman, NJ or we can arrange it at the customer location based on interest.**

## Module 1: Transmission line & Cables (1/2 a day)

- Transmission line modelling in details
  - Introduction to frequency dependent lines
  - Modelling transmission lines in PSCAD
  - Transmission lines tower configurations
  - Conductor Transposition
  - Conductor Data
  - Conductor Bundling
  - Mutual Coupling
  - Ground wire data & ground wire elimination
  - Solving line constant data and output files
  - Example of a real line and how to enter the parameters in the PSCAD model
- Cables
  - Modelling cables in PSCAD
  - Cable parameters
  - Practical cable modelling
  - Cable cross-bonding of underground cables
  - Conducting layer elimination
  - Semi Conducting layers
  - Example of a real cable and how to enter the parameters in the PSCAD model
- Line model features
  - Tandem lines

- o Subsystem splitting and parallel computing (PNI)
- o Multirate simulation

## Module 2: Transient Recovery Voltage (1/2 a day)

- General theory of TRV
  - o TRV Peak
  - o RRRV
  - o Objective of a TRV study
- Modelling consideration for performing an EMT study
  - o Stray Capacitance values
  - o Simulation Time-step
- Modelling TRV capability envelope
  - o Duty
  - o TRV violation
- TRV Mitigation methods
- TRV Types
- Practical Example of a TRV

## Module 3: Capacitor Bank Switching Transients (1/2 a day)

- Introduction to Cap bank switching
  - o Inrush Current
  - o Outrush Current
  - o Isolated Switching
  - o Back-to-Back Switching
  - o Capacitor breaker ratings
- Energizing the first leg of the capacitor
- Back to back capacitor bank switching
- Capacitor bank discharge and Transients Outrush Currents Study
- Voltage Magnification due to Capacitor Switching Transients Study
- Breaker Pole Restrike Phenomena Within a Capacitor Bank Study
- Transformer Phase-to-Phase Overvoltage Study
- Capacitor Bank TRV

## Module 4: Surge Arrester Modelling in PSCAD (2 hours)

- Overvoltage surge Protection
- PSCAD Surge Arrester  Model
  - o Arrester Data
- Arrester non-linear characteristics and TOV capability curve
- Example case

## Module 5: Network Impedance and Resonance (1/2 a day)

- Frequency analysis of the network
- PSCAD Harmonic Impedance Scan
  - How to perform in PSCAD
  - Limitations and assumption of the static impedance scan component in PSCAD
- System Impedance vs Frequency plots
  - Series Resonance Points
  - Parallel Resonance Points
- Network Resonance Due to harmonic from power electronic converters
- Harmonic Resonance Example cases
  - Transformer Energization
  - Resonance Due to a solar inverter


## Module 6: Renewable Modelling & SSO Studies (2 days)

- Wind Power Modelling
  - Generic & Detailed vendor models
  - Switching & average models
    - Type 1
    - Type 2
    - Type 3
    - Type 4
- Renewable Power Integration
  - Solar PV examples
    - Essential components in a plant model
    - Inverter control
    - Inverter aggregation
    - Power plant controller
    - Typical Tests
  - Collector system aggregation
- Grid Integration of Power Electronic Based Generation
  - Fault Ride Through
- Wind Farm Integration
- Wind Farm Studies
  - How to Model WTGs in PSCAD for studies?
  - TOV
  - Wind farm responses during faults
  - Harmonic Performance
  - Harmonic Interaction Issues
  - SSCI
  - PSCAD illustrative examples
- Sub-Synchronous resonance and control instability
  - Introduction
    - Types of SSO
    - Study Methods
  - Generator Torotional Interactions

- o Sub-synchronous Control Interactions (SSCI)
- o Perform Simulation studies for SSCI and SSR
  - ▪ Identify study scenarios
  - ▪ Frequency scans
    - • Dynamic Frequency Scans
  - ▪ Detailed EMT simulations

## Module 7: HVDC & FACTS (5 Days)

- Introduction to HVDC
  - o What is HVDC?
  - o Advantages and Disadvantages of DC Transmission
  - o For which Applications is HVDC recommended?
    - ▪ Typical Examples of HVDC Transmission around the world
- Basics of HVDC-LCC converters
  - o Understanding of Converter Operation
    - ▪ Delay angle, overlap angle and extinction angle
    - ▪ Rectifier and Inverter Operation
  - o Converter current and voltage waveforms
  - o Converter Equations and their use
  - o ***Hands-on tutorial ( Rectifier and Inverter Operation)***
- The HVDC Converter Connected into the Ac Network
  - o HVDC  Converter Arrangements
    - ▪ Pole, Bipole, Back-back etc.
  - o The Impact of AC System Strength on Converter Operation
    - ▪ Load rejection Over voltages
    - ▪ Commutation Failure
    - ▪ Harmonic Instability
- HVDC Control Principles
  - o Pole and Valve-group  level Controls
    - ▪ Current Control
    - ▪ Extinction angle Control
    - ▪ Current-error control
  - o Bipole Level Controls
    - ▪ Power Control
    - ▪ Auxiliary Controls
  - o ***Hands-on tutorial (Control of a point-to-point HVDC Transmission Scheme)***

- HVDC System Measurements and Protection
  - o HVDC System Measurements:
    - ▪ Measurement of firing and extinction angles
    - ▪ Detection of Commutation Failure
  - o HVDC-specific  Protection  Aspects (Does not include aspects of ac system protection common to ac systems)
    - ▪  HVDC line faults
    - ▪ Response to commutation failures and recovery

- o ***Hands-on tutorial (Recovery from HVDC Line fault)***
- Reactive Power and AC Filters
  - o Reactive Power requirements at HVDC stations.
  - o Reactive Power Supply Options,
  - o Harmonics of HVDC Converters
  - o Filter Design,
  - o Filter Switching Coordination
  - o ***Hands-on tutorial (Filter Current Waveforms, Filter Switching Coordination with Dc loading)***
- Static Var Compensators (SVC), TCR, TSC
  - o Operation and design considerations
  - o Control
    - ▪ Generating a reference signal (PLL,VCO…)
    - ▪ Voltage regulation, higher level controls
  - o ***Hands-on tutorial (TCR and TSC operation)***
  - o ***Hands-on tutorial (on 3 phase SVC controls and load voltage regulation)***
- Voltage Sourced Converter (VSC) Based Reactive Power and Filtering
  - o VSC arrangements
    - ▪ Multi pulse converters with Pulse-width modulation
    - ▪ Multi-level Converters (Modular Multi-level Converters MMC)
  - o Static Synchronous Compensator (STATCOM) and its role as a voltage control device
  - o ***Hands-on tutorial (Switching methods for VSC, i.e., phase control, SPWM, Selective Harmonic Elimination (SHE) and Current reference PWM***)
  - o Theory of operation and operating Limits
  - o ***Hands-on tutorial (STATCOM for voltage Control)***
  - o Active Filters
    - ▪ Operating Principles
    - ▪ ***Hands-on Tutorial: Active filter for harmonics and load balancing***

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- Limits to Operation: Steady-state Stability Limits
  - o Maximum Power Curves and Maximum Available Power (MAP)
  - o Control Sensitivity Indices for Stability Analysis
- New HVDC Topologies
  - o HVDC with Capacitor Commutated Converters
  - o The Capacitor Commutated Converter (CCC)The Controlled Series Capacitor Commutated Converter (CSCC)
- Voltage Sourced Converters (VSC)
  - o Advantages and Disadvantages of VSC Transmission
  - o Control of VSC-HVDC Systems
  - o Applications of VSC
  - o Hands-on tutorial (VSC HVDC transmission scheme) time permitting
- Multi-infeed and multi-terminal Dc systems
  - o Multi infeed systems
    - ▪ Impact on Maximum available power
    - ▪ Impact on Commutation Failure

- - Impact on Transient Overvoltages
  - LCC versus VSC Converters in multi-infeed systems
- General Discussion