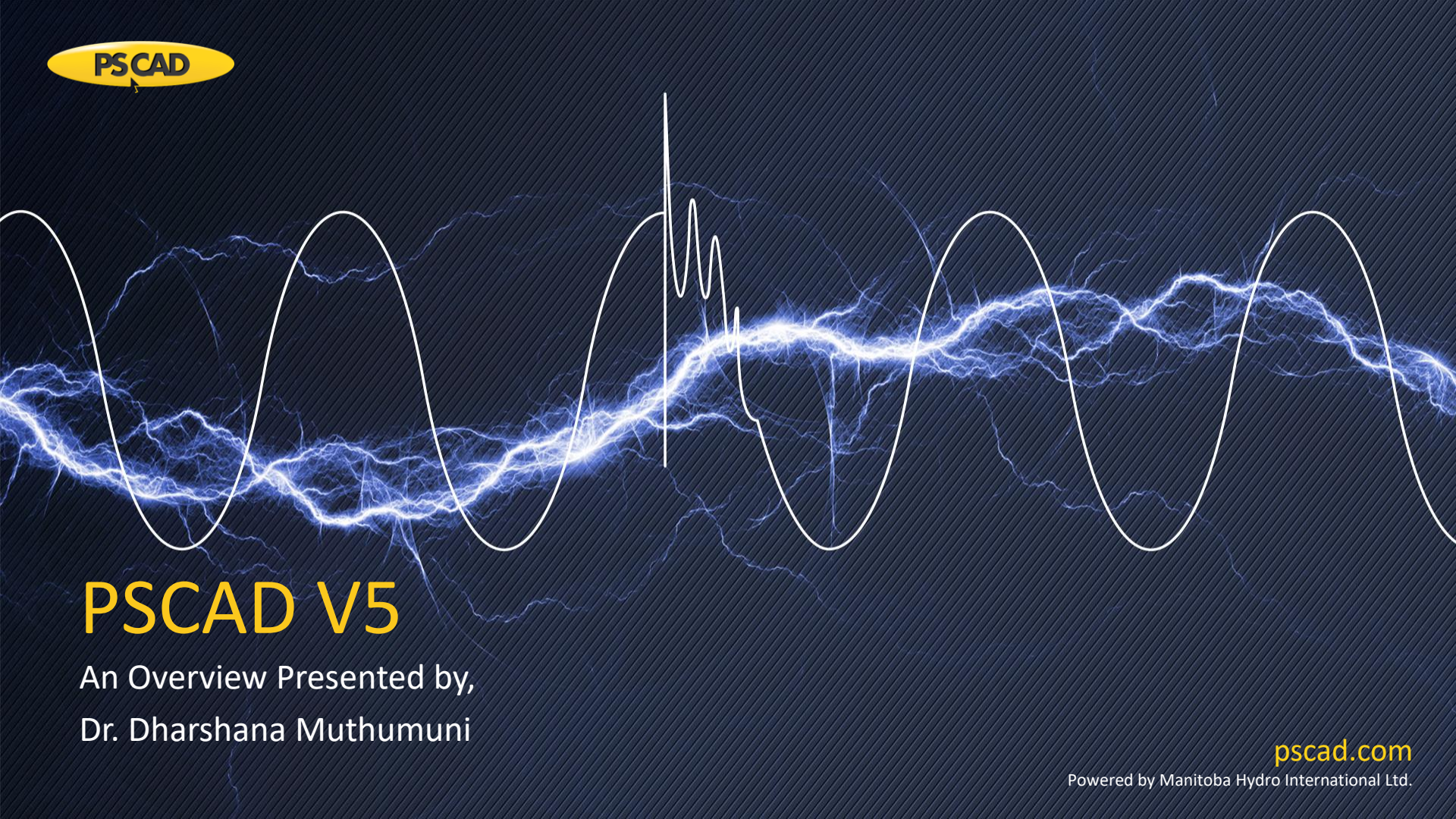

PSCAD V5

An Overview Presented by,

Dr. Dharshana Muthumuni

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PSCAD V5

Introduction

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PSCAD V5

We are very excited to release this update, likely in the first quarter of 2021.

PSCAD V5 presents major upgrades, new tools and features.

Some new tools and features have been the result of over 3 years of effort from our experts.

PSCAD V5 development plan was outlined based on currant and future industry needs.

Specifically, the requirements of power systems with large penetration of power electronic interfaced renewable generation.

PSCAD V5 Enhanced

Includes additional modules:

- PRSIM™
- PSCAD Initializer
- Enerplot™

PSCAD V5

Includes new functionalities and can be fully automated through the embedded Python scripting language interface. With most of our existing and familiar features refactored to function more efficiently, PSCAD V5 enhances the user's overall experience.

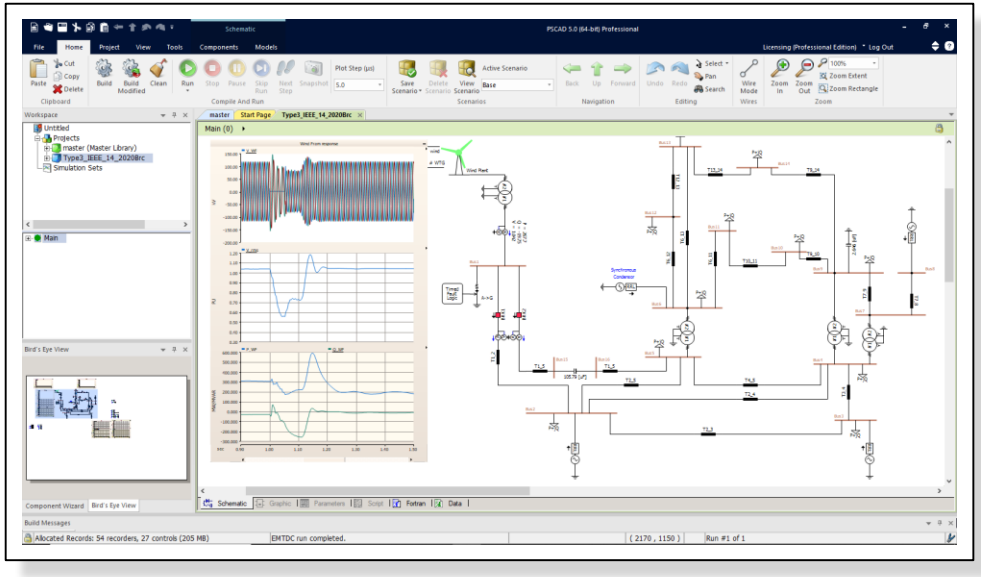
PSCAD V5 Enhanced

Includes additional modules:

- PRSIM™
- PSCAD Initializer
- Enerplot™

PSCAD™ V5

- **W**ith the advent of renewables and their complex controllers, Electromagnetic Transients (EMT) simulators have advanced beyond a design and problem solving tool for small, localized systems.
- **E**MT simulations are now a necessity in the design of large electric grids.
- **I**n this new era, PSCAD V5
    - Will enable user to develop large network models
    - Fast simulations
    - Automation of simulations and data (results) gathering



PSCAD V5

EMT Simulation to Support Renewable Integration

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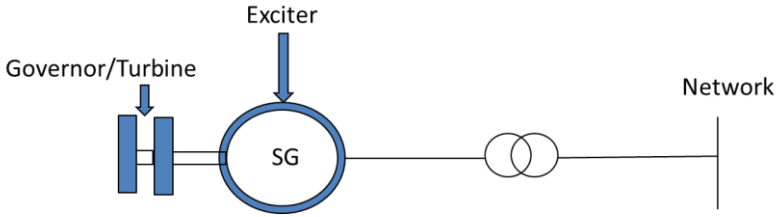
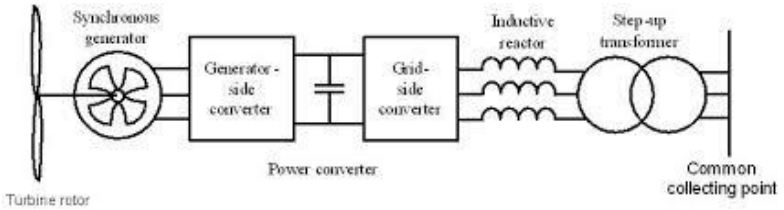
Wind and Solar PV Technology

Power Electronic based generation has changed the characteristics of power systems

The characteristics of wind generators (or PV) are much different from traditional synchronous machine based generation.

Nature of AC or HVDC transmission used to connect wind to the transmission grid (long ac cables, filters, weak grids, series compensation) impact the dynamic response of wind and solar PV systems.





Wind and Solar PV Technology

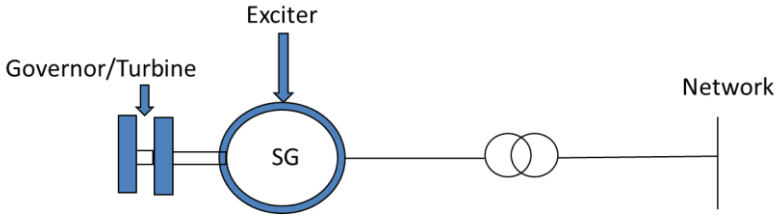
Power Electronic based generation has changed the characteristics of power systems

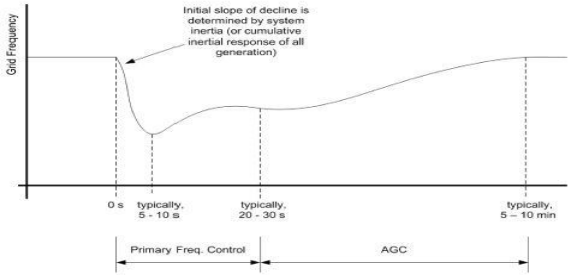
The Synchronous generator response is determined by

- Machine electrical characteristics
- Exciter characteristics
- Governor / turbine
- Inertia of the rotating masses

The inertial response immediately follows the event

- The inertial response is due to the inertia of large synchronous generators
- Primary control - 20 -30 Sec
- Power electronic based generation does not provide the same style of ‘inertia’

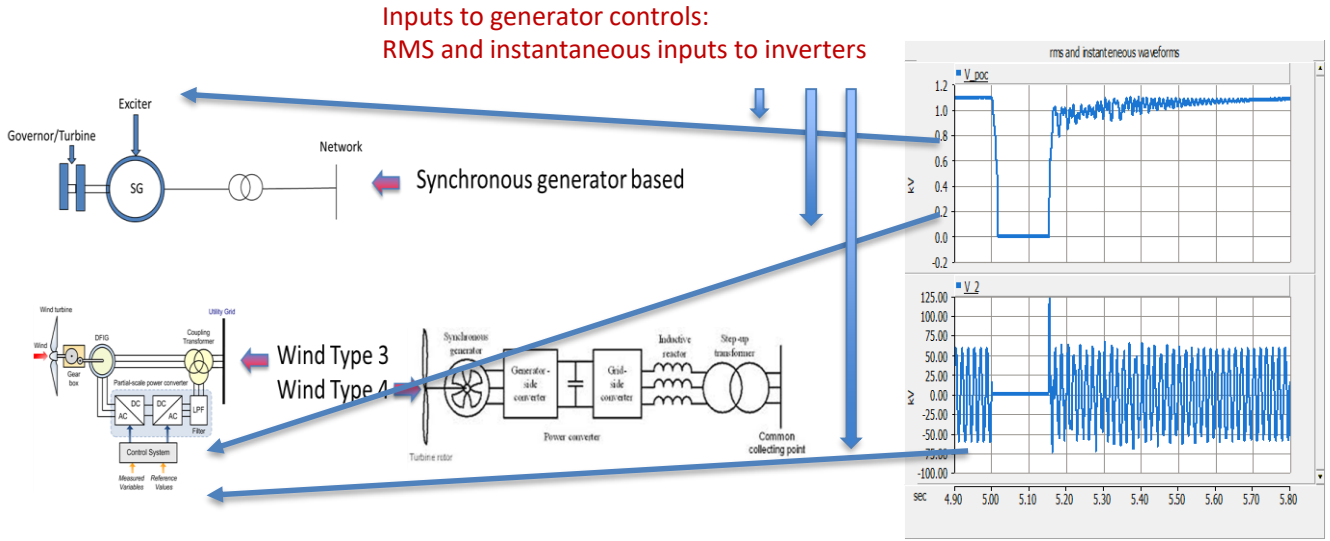




Wind and Solar PV Technology

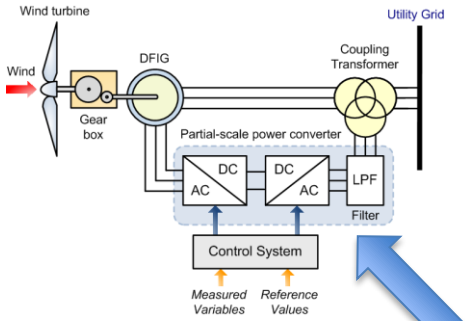
Wind Generators and Transmission Characteristics

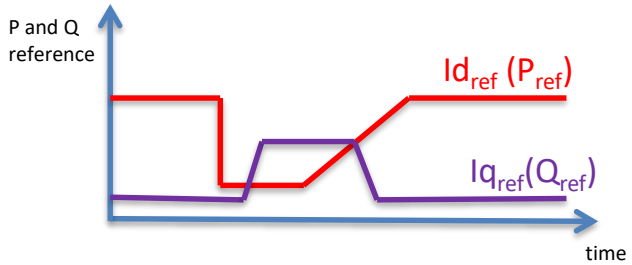
Nature of AC (or HVDC transmission) used to connect wind to the transmission grid (weak grids, series compensation, long ac cables, filters) has a significant impact on wind/solar PV response following system events

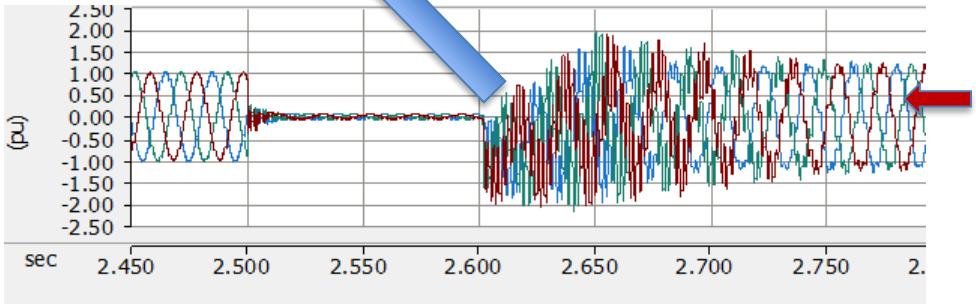


Wind and Solar PV Technology

Integration of Wind Power to Weak Grids – Example





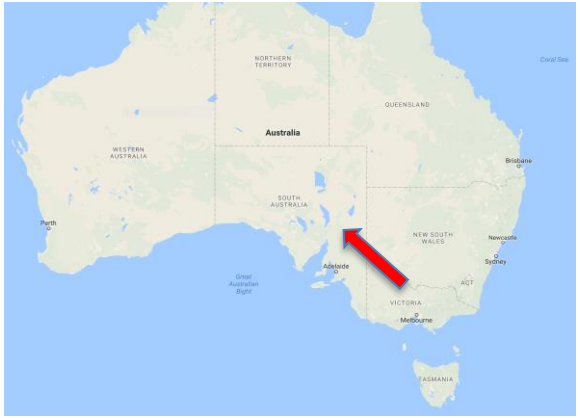


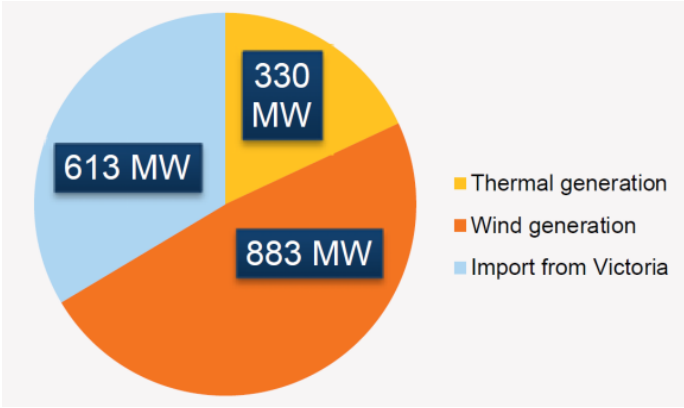
Bus voltage following a fault

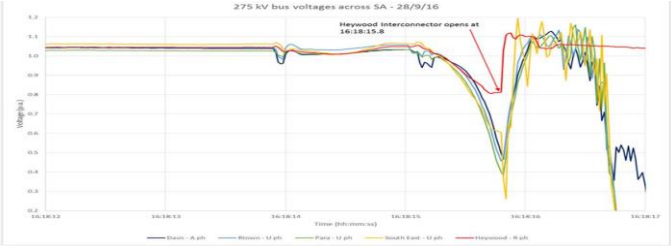
This voltage must be tracked and phase angle shifts estimated accurately and fast to ensure stable operation

Need for System Wide Modeling

Black System South Australia – September 28, 2016

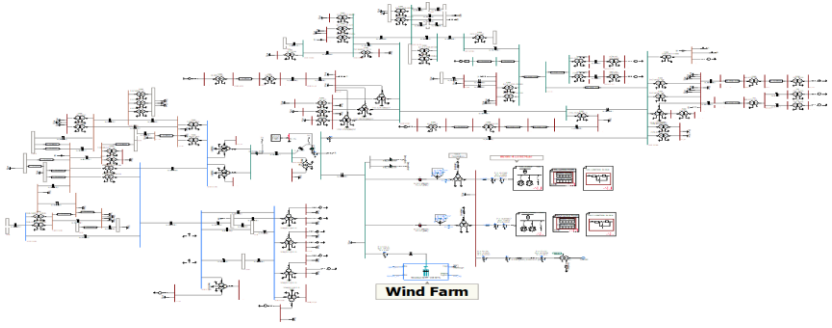


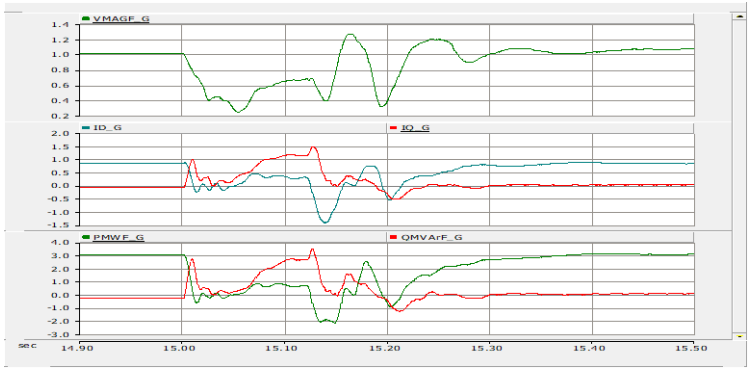




Need for Detailed Modeling

Control Interaction - 200 MW Windfarm Connection

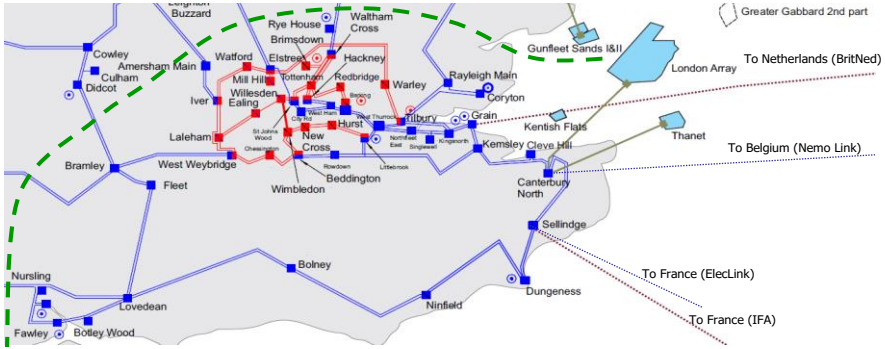




- Fault is applied at 15s for 120ms
- First 10ms duration fault: large rotation in Vd and Vq frame leads to high Iq injection and Low Id injection
- Next 50ms, inverter bring down Id and Iq to allow the PLL to relock to the phase.
- Last 60ms during the fault: inject Iq to support the system
- After fault release, PLL goes unstable and causes large voltage fluctuation

Need for Detailed Modeling Capturing a Large System Extent

Potential Control Interaction and SSTI issues - South East England



- South East England is where several HVDC interconnectors land and is a region that has little synchronous plants and even that is being displaced by offshore wind farms.
- Three STATCOMs commissioned to provide voltage support.
- The short circuit ratio is low and reactive current during a fault is sought.
- Control interactions and sub synchronous oscillations concerns given the ‘weak grid’

PSCAD V5

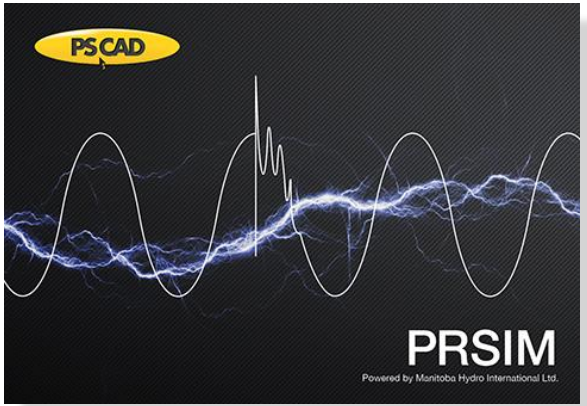
New or Improved Tools

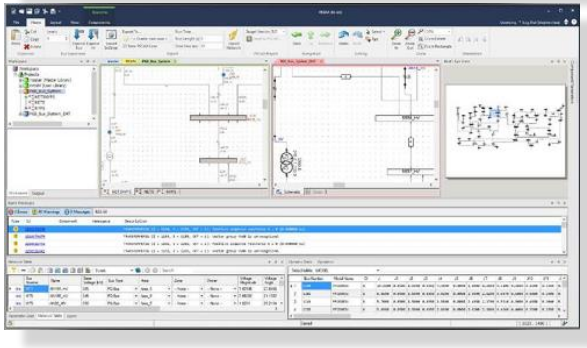
PRSIM™

Power System Importer

The PRSIM application allows users to convert standard PSSE or PowerFactory network data to PSCAD with minimal time and effort:

- Convert PSS/E and PowerFactory data files to PSCAD V5.0 and V4.6
- Import detailed dynamic data
- Import sequence data
- Import location data for automatic schematic expansion
- Form network equivalents for unexpanded segments of the network
- Re-initialize previously generated PSCAD projects



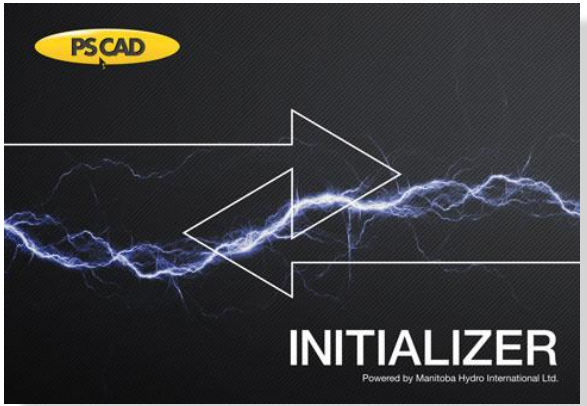


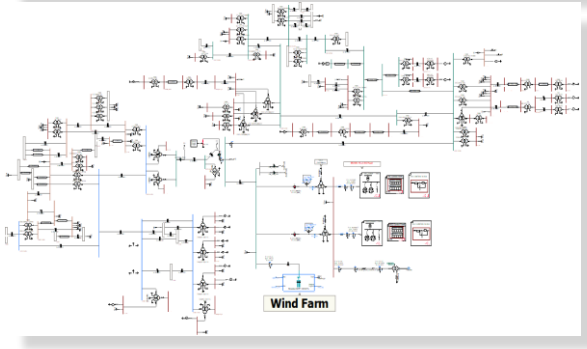
PSCAD Initializer

Initialization of EMTDC from a Power Flow Result

An Electro Magnetic Transient (EMT) program such as PSCAD simulates the behaviour of a power system network after a disturbance, such as a fault or a circuit breaker operation. During this short period, the system gradually changes from one steady-state behaviour to another.

- The purpose of the PSCAD Initializer is to set up the proper power flow conditions (e.g. correct voltage and angles at buses, active, reactive power flows between buses, etc.) prior to the disturbance. This involves a solution to the power flow equations and setting up the correct parameters of generators, sources in PSCAD, etc.



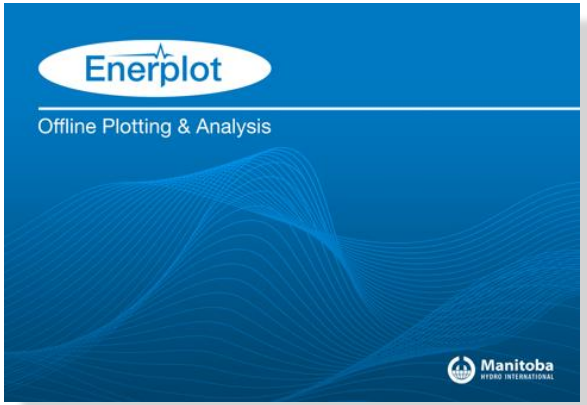


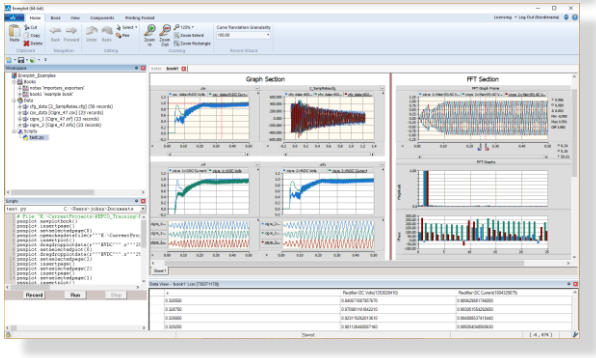
ENERPLOT™

Process Data Quickly and Efficiently

Enerplot™ is a fully automatable application that allows you to perform highly repetitive tasks at lightning speed. You can write scripts using the embedded Python interface or record your actions to create custom script macros.

- Automated scripting with embedded Python interface
- The ability to create custom scripts by recording user actions
- Powerful, embedded math parser for creating and modifying new and pre-existing curves;
- Fast-Fourier Transform (FFT) analysis tools;
- Ability to template projects when performing similar studies;
- Quickly switching between curves by toggling references and loaded datasets;
- Loading huge data files in seconds with the lazy-loading feature;





PSCAD V5

New Features

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EMTDC

Modified, Augmented Nodal Analysis (MANA) in EMTDC

- Modified Augmented Nodal Analysis is an extension of nodal analysis which not only determines the circuit's node voltages but some branch currents. This helps to mitigate some of the problems in classical nodal analysis, such as the difficulty of representing dependent sources.
- Dependent source models are now included as a part of the master library. The solution automatically uses the MANA algorithm if dependent source models are included in the simulation.

EMTDC

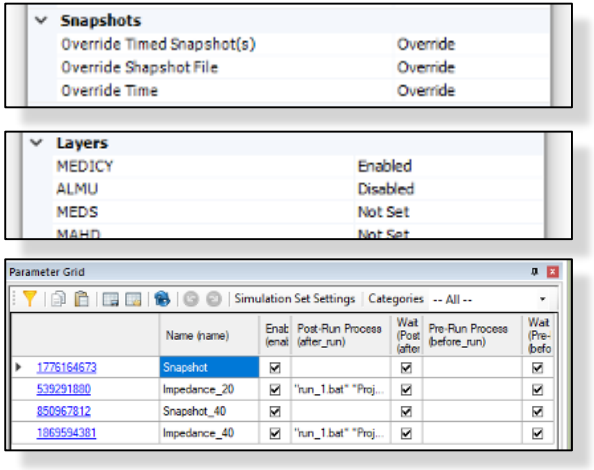
KLU Sparsity Algorithm in EMTDC

- KLU is a software package for solving sparse linear systems of equations that arise in circuit simulation applications. It relies on a permutation to Block Triangular Form (BTF), several methods for finding a fill-reducing ordering (variants of approximate minimum degree and nested dissection), and a sparse left-looking LU factorization algorithm to factorize each block.
- EMTDC now uses KLU algorithm for larger subsystems. The default matrix size where KLU comes into solving the equations can be set by the user.

Simulation Set – Parallel Simulations

Functionality Improvements

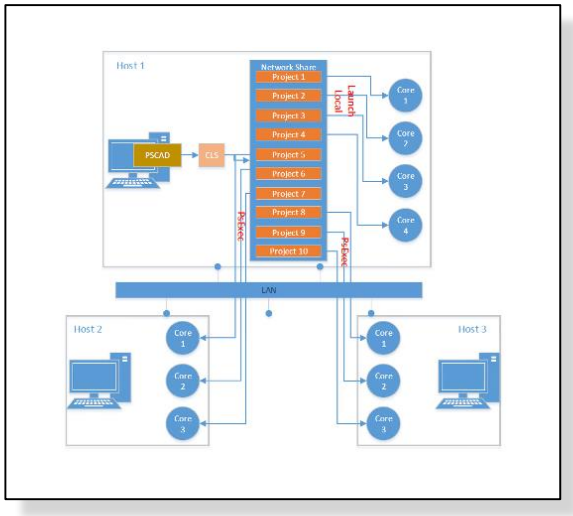
- Simulation sets were introduced in PSCAD v4.5 in order to facilitate the launching of parallel simulations. They have been continuously enhanced in each version since, and V5 is no exception:
  - Project Settings Override
  - Layer Settings Override
  - Global Substitutions Set Select
  - Enable/Disable Set
  - Parameter Grid Support
  - Force Re-Build
  - New Parallel Run Options



Parallel Processing Functionalities

Cluster Launch System (CLS)

- The utilization of high-performance and parallel processing functionalities requires multiple processor cores – the number of which may exceed those available locally on a typical workstation.
- In such situations, users may either purchase a large and expensive, high-performance computer (ex. 64-core) or connect a collection of multi-core computers across a Local Area Network (LAN). The latter option is referred to as a computational cluster.
- Running processes across multiple computers requires additional software to manage the simulation processes. Enter the Cluster Launch System (CLS), a utility that can both launch and manage simulations on a computational cluster.

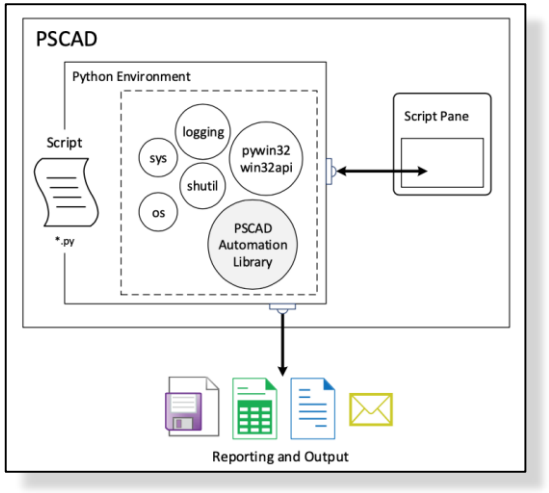


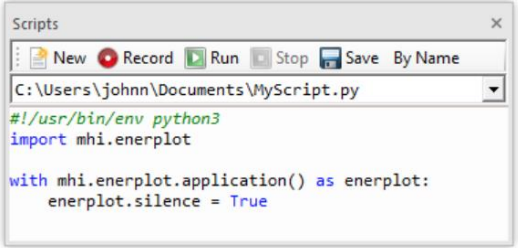
Automation

Embedded Python Scripting with Recording

Automation of the PSCAD application, utilizing custom-made Python language scripts, was first introduced in v4.6.1. It included commands to launch the software, load and run simulations, change parameters, and analyze data, among many others. Installed as standalone software, an automation controller library was bound to other Python scripting libraries, to achieve control over application-level features through an automation interface (part of PSCAD).

- In V5, automation utilizing the Python script language is embedded directly into the software and is included with the installation of PSCAD.
- Now users can maintain their scripts from within PSCAD, using a new Script pane, from which custom scripts may be recorded, edited or launched.





Master Library

New Master Library Models

- MMC Model Library
- Phase-Domain Synchronous Machine
- Single-Phase Induction Machine
- Z-Domain (Discretized) Controls
- 1-Phase, Multi-Winding (5-12), Transformer
- 3/5-Limb, Duality-Based Transformer
- Hysteresis Reactor
- TRV Envelope Generator
- Harmonic Signal Generator
- Pick-Up, Drop-Out Timer
- Clark/Inverse Clark Transform
- Change Detector
- Dead-Band Controller
- Scale Changer
- Discretizer
- Complex Conjugate
- Electrical Phase Tap

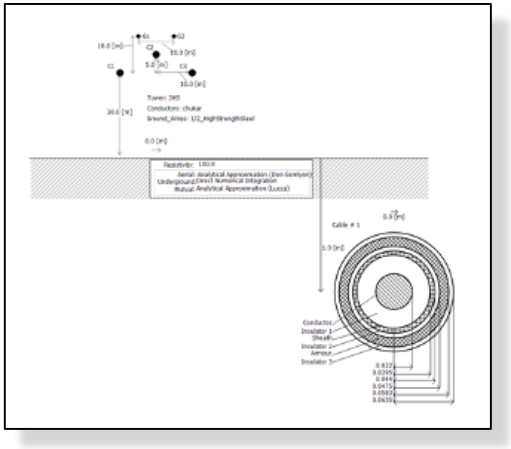
Master Library

General Master Library Model Enhancements

- Complex Signal Support
- Array Signal Support
- Multiple Run Additional Recording Statistical Summary
- FFT Enhancements
- B-H Core Characteristic for Saturable Reactor
- Permanent Magnet Machine Neutral Connection
- Mutually Coupled Three Wires – Zero Impedance

Mixing of Overhead and Underground Transmission Systems

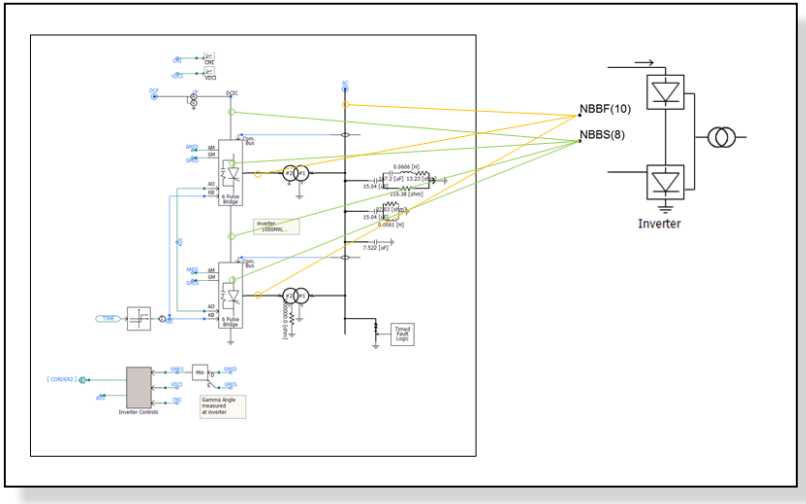
- The underground cable transmission segment editor and line constants program (LCP) have been modified to allow the combination of overhead transmission tower and underground cable cross-sections, within the same right-of-way.
- The additional formula in the LCP takes care of the mutual impedance between aerial and underground lines.



Blackbox Upgrades

Electric Networks Support

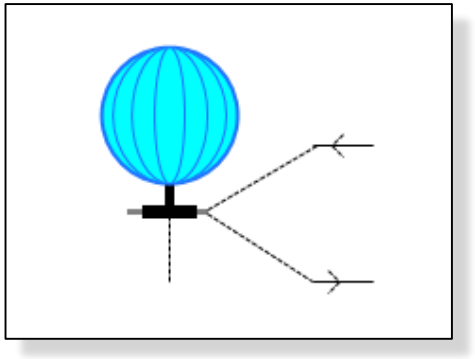
- Starting from the top-level page module, an entire electric network, which may span across several module levels, can be collapsed into a single component, complete with multi-instance compatible, Fortran source code.
- The new component definition includes prefabricated graphical port arrays to represent the network, as well as pre-scripted Branch, Transformers and Matrix-Fill segments.



Co-Simulation

Application Programming Interface

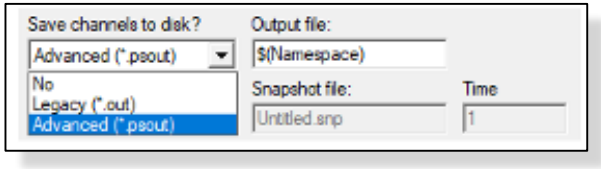
- A general Application Programming Interface (API) is provided with PSCAD V5, enabling EMTDC to link to, and co-simulate with, just about any external application.
- Referred to as the Co-Simulation API, it is in its basic form, a C-language structure called EmtdcCosimulation_Channel, which houses a collection c-functions.
- These functions can be used to customize an interface on the external application-side. At the same time, a new master library component called *Cosimulation*, may be utilized in a case project to quickly provide the PSCAD/EMTDC side of the interface.
- **Note that the onus remains on the user to program the interface from the external application side, as all external applications differ in complexity and purpose.** A complete description of the Co-Simulation API can be found in the PSCAD Application Help.

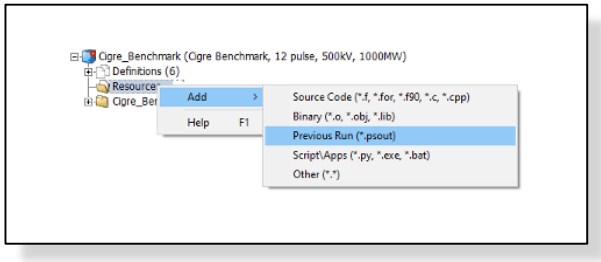


New Binary EMTDC Output File Format

*.psout

- A brand new EMTDC output file format (*.psout) is included with the PSCAD V5 release. A proprietary design, this new format is binary, which ensures a much smaller storage footprint, as well as faster data access.
- Not only does it store all simulation curve and trace data, but it can also store all sequential or parallel multiple run data, as well as animated graphics information, all in a single file.
- For example, if you were to launch a volley of 100, parallel simulations, all EMTDC output data is stored in a single file named <project_name>.psout.

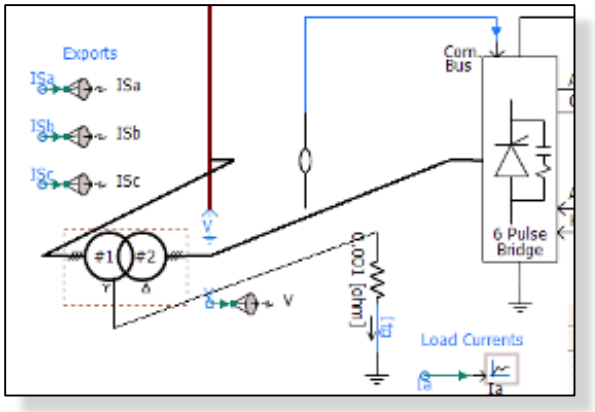




Rubber Banding (Sticky Wires)

New, tri-segment, sticky wire component

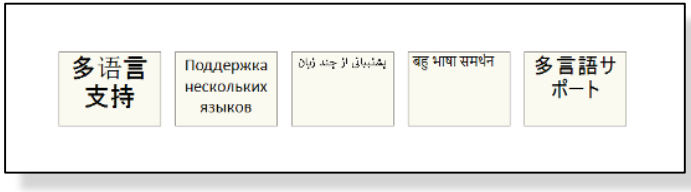
- When either endpoint of this wire is attached to another object (component, bus or another wire), the wire's endpoint will 'stick' to the object.
- If the object is moved, the wire endpoint will remain stuck, and the sticky wire will stretch (like a rubber band), as the object to which it is attached is moved around.



Unicode

Multiple Language Support in Sticky Notes

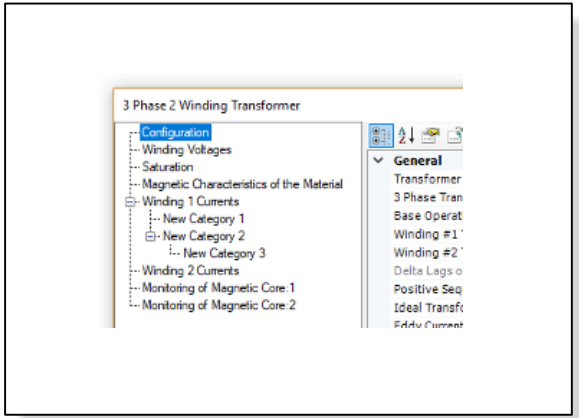
- The PSCAD V5 codebase has been updated to fully support Unicode, which enables users to use all known writing systems within sticky notes.
- This of course includes the Cyrillic alphabet and Chinese characters.
- This is a very important new feature, which has been passionately requested by many of our Asian users.



Component Parameter Dialog

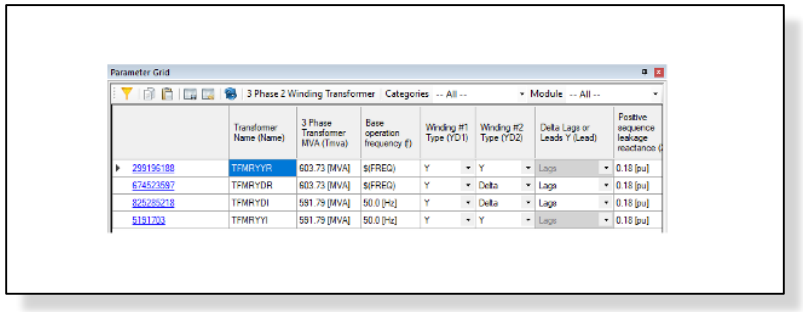
Enhanced

- In an effort to provide a more efficient means of organizing very large amounts of component input and output parameter data, the component parameter dialog has been greatly improved for the V5 release. Two huge improvements were made: The manner in which parameter category pages are organized, as well as the inclusion of a Java-based, dynamic display and feedback window, called the Dynamic Help Pane.
- The flat, drop-list category page format, which has been a part of PSCAD since the V2 days of the 1990s, has been replaced by a multi-level, tree-based category window. The new tree style can be extended to provide multiple branch levels (branches within branches), to provide a second dimension to the organization of categories.



New and Improved Parameter Grid

The immensely popular parameter grid feature has been completely re-architected in PSCAD V5, specifically to address the user-identified shortcomings of its predecessor in v4.6. For the most part, the new parameter grid looks and feels like the old one. However, under the hood, we have made many changes that will facilitate functionality that was missing previously.



Significant enhancements:

- Support for buses, transmission lines, simulation sets, file reference components and sticky notes - virtually all schematic objects.
- Results may be filtered by parameter category page, in addition to page module.
- Disabled parameters (instance-based) are now displayed as such in the parameter grid results.
- Store, append and replace parameter grid results to/from file in *.cvs format.
- Parameter grid results may be transferred directly to a spreadsheet, modified and then transferred back via copy/paste.
- Full undo/redo support.

Project Navigation

Enhanced

- Multiple enhancements have been included with PSCAD V5, to help users navigate projects quicker and more efficiently, as well as minimizing the risk of getting lost in larger projects. Prior to V5, project navigation was performed by drilling down through multiple module layers manually.
- Navigating upwards was accomplished in the same way. PSCAD V3 and V4 provided a sub-tree under each project, containing a clickable representation of the existing module hierarchy, allowing users to jump to specific modules. In X4 (v4.3 to v4.6), this navigation tree was brought out into its own area, referred to as the workspace secondary window.

V5 now boasts a handful of other navigation-related niceties, in addition to the navigation tree:

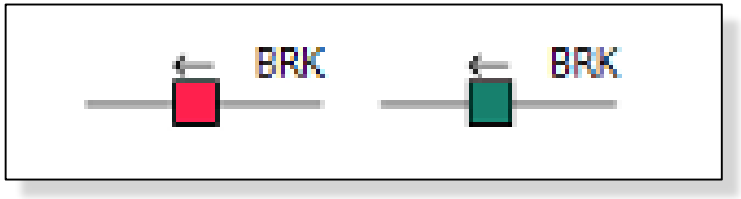
- Navigation Bar
- Bookmark Component
- Bookmarks pane
- Case Link Component
- Hyperlink Component

Animated Graphics Patch

The animated graphics feature has been in use since PSCAD V3, and has remained mostly unchanged, until now. Prior to V5, the animated graphics display (ex. breaker state colour, multi-meter PQ text, etc.) would only update if the corresponding component was currently in view, during a simulation.

This means that if the user was to navigate to another page module schematic after the run had finished, the graphical state of any components in that schematic may not be up to date. For example, if a breaker went from open to closed while not in view, it may still appear green if the user navigates into its page module following the end of run.

- This issue has been rectified in V5, so that all animated graphics will show their last state in the simulation, regardless of whether they were viewed or not.



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