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Published by
Siemens AG 2017
Energy Management Division
Freyeslebenstrasse 1
91058 Erlangen, Germany

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Article Number: EMDG-B10125-00-7600--PSSE Brochure

Online brochure not subject to EAR.
Printed version: AL:N; ECCN:EAR99

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PSS[®]E

**High-performance Transmission
Planning and Operations
Software for the Power Industry**

siemens.com/pss-e

PSS®E has achieved “industry standard” status, and offers the distinct advantage of being one of the leading power transmission simulation and analysis tools in the world.



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PSS®E – Overview

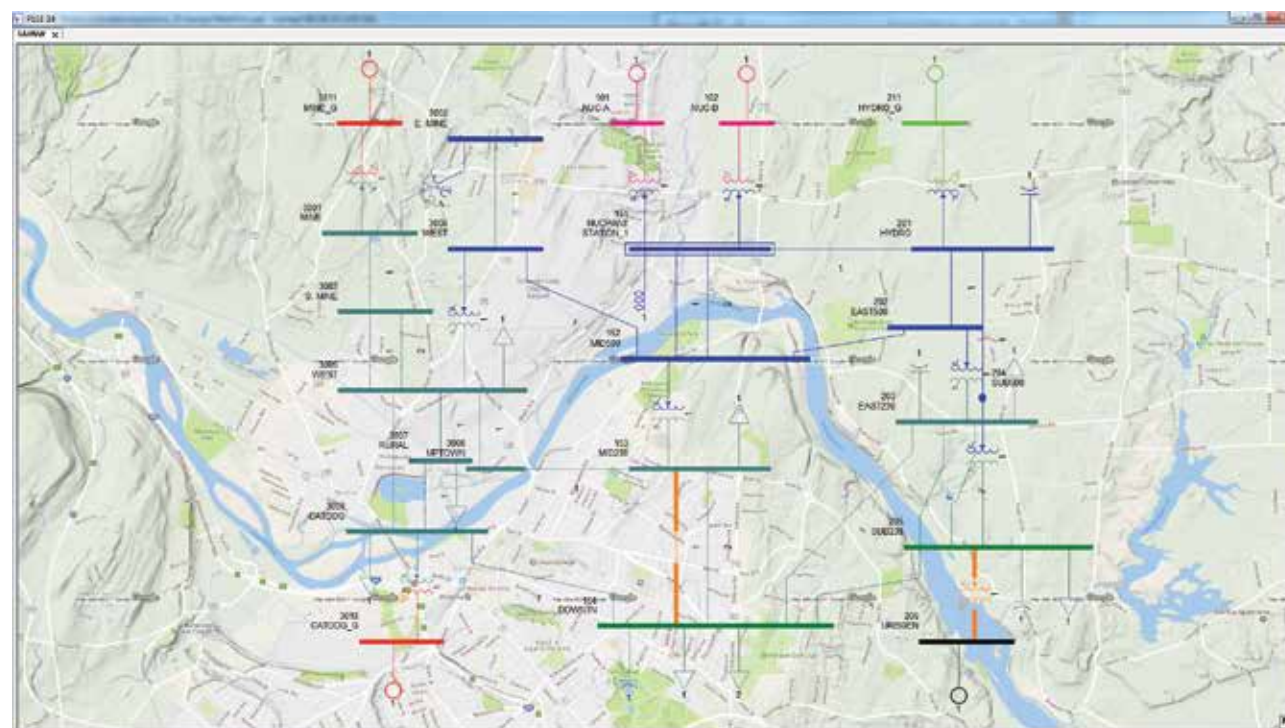
High-performance Transmission Planning and Operations Software for the Power Industry

PSS®E is a power system simulation and analysis tool for Power Transmission Operations and Planning. It is used in over 145 countries around the world by utility transmission Planning and Operations engineers, consultants, universities, and research labs. PSS®E allows users to perform a wide variety of analysis functions, including: power flow, dynamics, short circuit, contingency analysis, optimal power flow, voltage stability, transient stability simulation, and much more. Since its inception in 1972 as the first commercially available software for transmission system simulation, PSS®E has achieved “industry standard” status, and offers the distinct advantage of being one of the leading power transmission system simulation and analysis tools in the world.

Unique Advantages

In most regions around the world, PSS®E is the standard model/data format, and provides the benchmark for simulation results. Due to its longevity and widespread industry adoption, PSS®E offers a number of advantages:

- Trusted results, which are used as the “benchmark” in the industry and academic literature
- Data and models which are easily exchangeable with other entities across the industry
- Access to resources: enjoy a rich ecosystem of documentation, online forums, script libraries, model libraries, and other fellow PSS®E users around the world
- Interoperability with a vast landscape of other industry tools
- PSS®E also offers vast automation and customization through its APIs, which are among the most flexible in the industry, and based on open Python™ technology.



PSS®E slider diagrams now support geographical map backgrounds

Where Does PSS®E Fit?



Generation

Available in the PSS®E Core

Utilities, ISOs, and Independent Power Producers (IPPs) need to run a variety of different studies to plan for secure, reliable, and economically feasible investments in the power generation infrastructure. These “generation interconnection” studies include multiple types of analysis e.g. power flow, dynamics, contingency analysis, load deliverability, generation deliverability, etc.

PSS®E provides the core analysis and automation functions that are needed for the most accurate generation planning outcomes:

- IPPs can improve the accuracy with which they can assess their generation interconnection proposals before submitting to the ISO/RTO.
- ISOs/RTOs benefit from an automatable, trusted tool for assessing generation interconnection requests

Use Cases:

- Generation Planning for IPPs
- Generation Interconnection Studies for ISOs / RTOs



Transmission

Available in the PSS®E Core

In order to ensure grid reliability, security, compliance with regulations, and sound capital investment decisions, transmission companies need to perform a wide variety of studies around their grid infrastructure. These studies can be fairly complex, and typically require software that can perform highly accurate simulations and analysis of the power grid.

PSS®E supports a full spectrum of analysis functions across power transmission Planning and Operations workflows, including: power flow, advanced contingency analysis, steady-state voltage stability, short-circuit analysis, dynamics / transient stability simulation, optimal power flow, and geomagnetically induced currents (GIC).

Use Cases:

- Transmission Planning
- Transmission Operations Planning





Renewables and Integrated T&D Planning

Available by Expanding PSS®E with PSS®SINCAL

The proliferation of distributed energy resources (DER) such as small-scale solar, wind, storage, and demand-side management programs are disrupting the traditional “trickle-down” model of the power grid, where power flows from generation to transmission to distribution to end customers. The flow of power is now increasingly bi-directional, and concentrations of demand and generation are distributed across the power grid in new ways. This gives rise to a new generation of Planning questions and needs e.g. “How much renewable penetration can my system handle – overall and on a per-feeder basis?”, “What is the transmission effect of distributed energy resources connected at the distribution level?”

With PSS®E plus PSS®SINCAL, you can boldly meet tomorrow’s planning challenges by building on the proven PSS®E foundation that you already have today:

- Extend transmission modeling and simulation into the distribution realm
- Perform integrated transmission and distribution studies
- Model the impact of DERs simultaneously at both the transmission and distribution level
- Determine how much renewable penetration a system can accommodate
- Understand the effect of DERs at the distribution level and its impact to the transmission system

Use Cases:

- Integrated Transmission and Distribution (T&D) Planning
- Renewable Analysis
- Distributed Energy Resource (DER) Penetration Planning and Studies



Photo credit: www.siemens.com/press



Grid Data Management

Available by Expanding PSS®E with the Model Management Add-On Module, PSS®ODMS, and / or PSS®MOD

A simulation is only as good as the data / model it runs on.

A lack of sound data management and exchange can result in simulation accuracy problems, wasted time, duplicated effort, poor organizational efficiency, and financial damages.

Data management problems can exist at various levels, each with a unique solution consisting of PSS®E combined with other elements of the PSS® Suite:

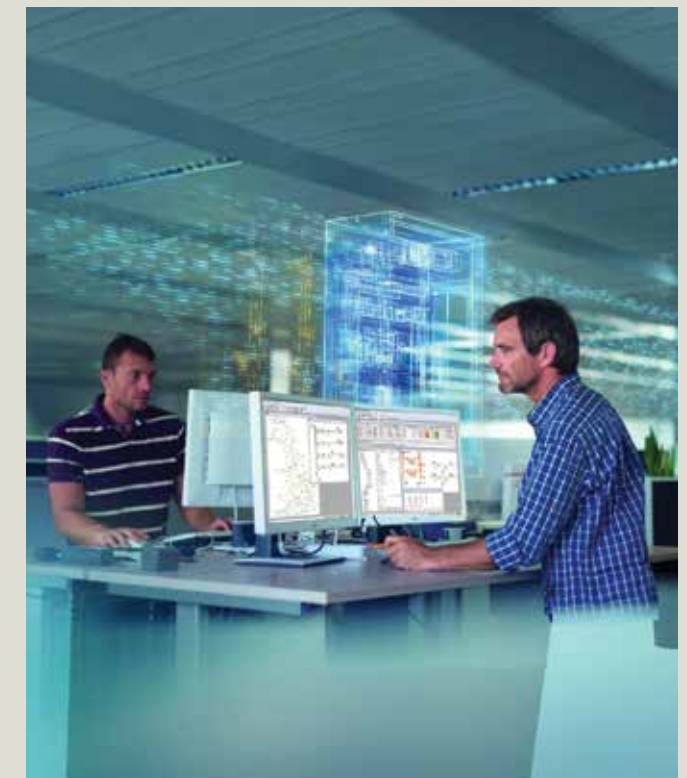
- The Model Management Add-On Module for PSS®E solves the problem of maintaining an organized database (as opposed to numerous flat files) for all of your projects / scenarios, model data, seasonal ratings, and cases.
- PSS®ODMS can be combined with PSS®E (and PSS®MOD) to bridge the gap between multiple utility domains – including Operations and Planning. It maintains a single “source of truth” for all of your modeling data across multiple enterprise systems (e.g. EMS, GIS, etc.) and time horizons.
- PSS®MOD provides PSS®E users with a solution for large scale online data/model exchange and change management across multiple companies and interconnections / power pools.

Extending PSS®E with these various other PSS® portfolio elements provides you with the benefits of reduced data maintenance costs, increased organizational efficiency around the modeling process, eliminated duplicate modeling effort, reduced modeling errors, and facilitates automation.

For more information please see the PSS®ODMS and PSS®MOD brochures.

Use Cases:

- Data management within PSS®E
- Large scale data / model exchange and change management across multiple companies and interconnections
- Consolidated “single source of truth” data model across multiple utility domains (including Operations and Planning) and time horizons



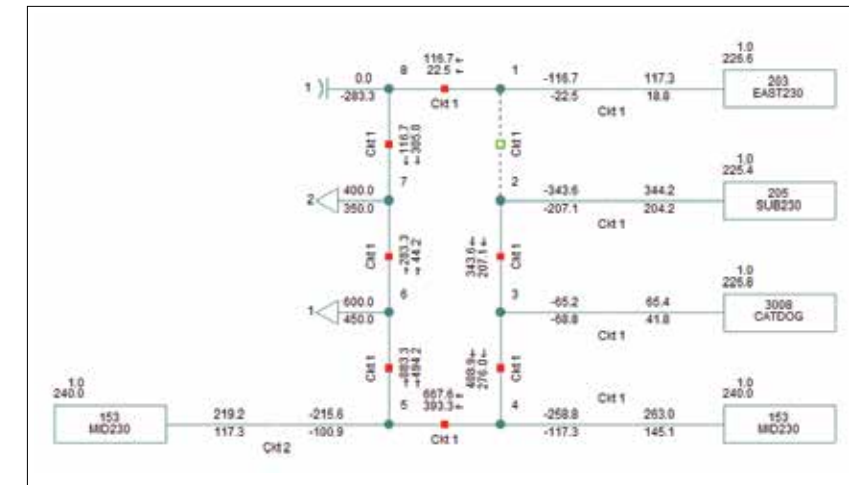
Standard Features

Load Flow Analysis

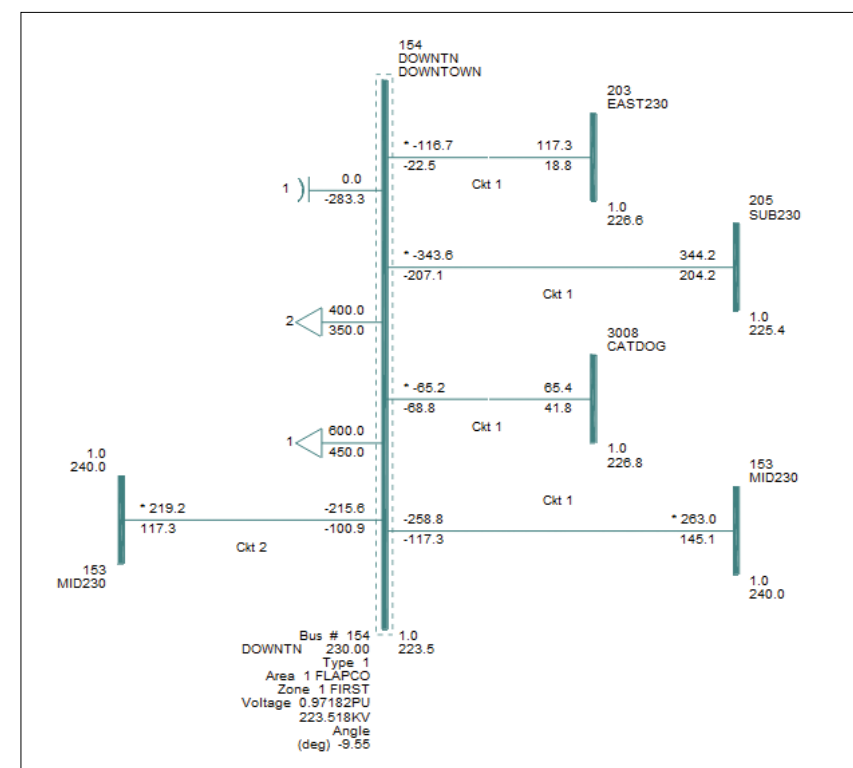
- Robust load flow solutions for AC and DC equivalent networks
- Tap changer, phase shifter, switched shunt capacitor / reactor and SVC control
- Local and remote distributed voltage control options
- DC tap adjustment
- Non-divergent solution option
- Switching device oscillation prevention
- Support for generator capability curves (D curves)
- Inertial load flow
- Area interchange control (local area slack)
- Advanced modeling of induction machines
- ZIP load models
- Multiple Gauss-Seidel and Newton solution options
- Corrective action solution for automatic adjustment of controls (generator dispatch, tap adjustment, etc.) to mitigate violations
- Simple load and generation scaling
- Triangular Y-bus solution for switching and motor start studies
- Pre-solution node-breaker topology processing
- Powerful network data and solution result comparison tools
- Economic dispatch (generator heat-rate curves)

Integrated Node-breaker Network Representation

- Automatic substation topology generation for common substation topologies (breaker-and-a-half, ring bus, double bus double breaker, etc)
- Novel approach for linking bus-branch and node-breaker worlds
- Ability to reference elements and navigate the network via bus numbers / names
- Automated node-breaker contingency analysis for common node-breaker contingencies
- Full integration into SAV and RAW formats
- Bus-branch data can be used with node-breaker data extensions
- Creation and management of topology buses is fully automated
- Topology buses referenced and reported as bus sections



Node breaker ring-bus substation diagram with a breaker outage



Traditional bus-branch single-line diagram with no breaker outages

Network Reduction

- Calculation of load flow and short-circuit electrical equivalent
- Support for load, generation, and full Thevenin equivalents
- Full-topology retention of subsystems based on generator size, phase-shifting and tap-changing transformers, etc.

Linear Analysis

- DC equivalent load flow and DC equivalent contingency analysis
- Calculation and reporting of common linear factors (PTDF, OTDF, etc.)
- Analysis of the impact of a power exchange between two regions
- Various load and generation scaling options
- Available transfer capacity analysis
- Simultaneous transfer sensitivity calculation

Advanced Contingency Analysis

- AC or DC load flow automated contingency analysis
- Automated node-breaker contingency generation and simulation for breaker-to-breaker, stuck breaker and open terminal contingencies
- Tools for generation of contingencies, monitored element lists, and subsystem definitions
- Ability to save and recreate any contingency individually for detailed study
- Contingency result comparison reports for up to nine cases
- Built-in single-machine parallelization of contingency analysis for multiprocessor hardware with up to 24 cores
- N-1-1 solution with automated corrective actions (generator dispatch, tap adjustments, etc.)
- Multi-level contingency analysis with contingency pruning using ranking wind chime algorithm for up to N-3 combinations

Results and Reporting

- Interactive spreadsheet reports supporting filtering and sorting with export to Excel and CSV formats
- Network results spreadsheets for all load flow output quantities
- Comprehensive reporting as annotations in single-line diagrams for most analysis results (load flow, short circuit, dynamics, contingency analysis, GIC, etc.)
- Integrated dynamics plotter featuring drag-and-drop dynamics channel plotting
- Comprehensive results retrieval Python™ API for data-intensive results from contingency and PV / QV results

Interactive Single-line Diagrams

- Interactive single-line diagrams for bus-branch and node-breaker substation views
- Automatic bus view diagrams for quick navigation of network
- Overlay diagrams on geographical map backgrounds by linking to various mapping sources
- Annotation layers and drawing tools (including shapes, texts, images, etc.)
- Automated, intelligent drawing of substation diagrams
- Robust auto-draw mode with intelligent layout algorithm
- Comprehensive reporting as annotations in single-line diagrams for most analysis results (load flow, short circuit, dynamics, contingency analysis, GIC, etc.)
- Heat-map contouring for several network quantities (bus voltage, line flows)
- Embedded single-line diagram mini-map for full diagram view and navigation
- High-resolution diagram export and printing functionality
- Python-powered report node for custom on-diagram text derived from network quantities
- Animated power flow indicators (arrows) and loading gauges

Steady-state Stability (PV-QV)

- Fully automated PV curves calculation
- Determination of critical point of voltage instability

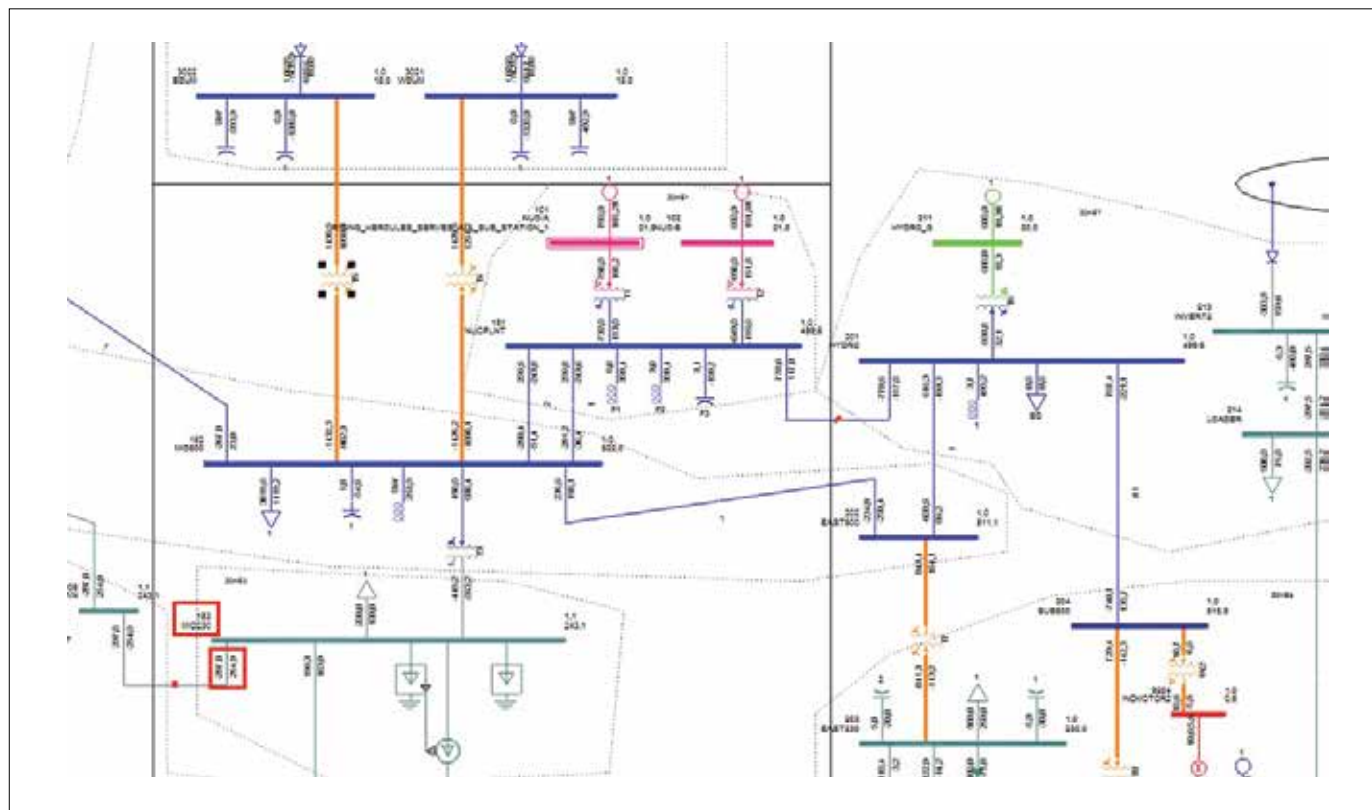
- Detection of limiting contingency
- QV curves calculation
- Determination of maximum power transfer capacity between two regions
- Various load and generation scaling options for exporting and importing region
- Thermal, voltage and contingency constraints options

Scripting and Automation

- Full Fortran, batch command, and Python API for all program functions and features
- Imbedded Python interpreter
- PSS®E engine mode driven by any external interpreter
- Comprehensive results retrieval Python API for data-intensive results (contingency, PV/QV results, etc.)
- Command line interface for legacy PSS®E response language, IDEV batch commands and Python API calls
- User-defined custom Python-powered GUI buttons
- High-level Python Excel and Word interface for simple reading / writing to / from Excel and Word

Inductor Machine Parameter Modeling (IMD)

- Calculate motor characteristics for given estimated machine impedances
- Graphical plotting of torque, current, and power factor curves resulting from provided motor parameters
- Generate DYRE record for use in PSS®E Dynamics Simulation



Example of Diagrams in PSS®E

Optional Add-On Modules

Analytical Modules

Dynamic Simulation

- Analyze the dynamic system response and stability of the grid to disturbances
- Includes a vast library of built-in dynamics models for modeling many types of equipment
- Users can define custom models of any complexity using the modeling interface
- An integrated dynamic simulation plotting package allows for quick generation and export of plots from the dynamic simulations

Short-circuit Analysis

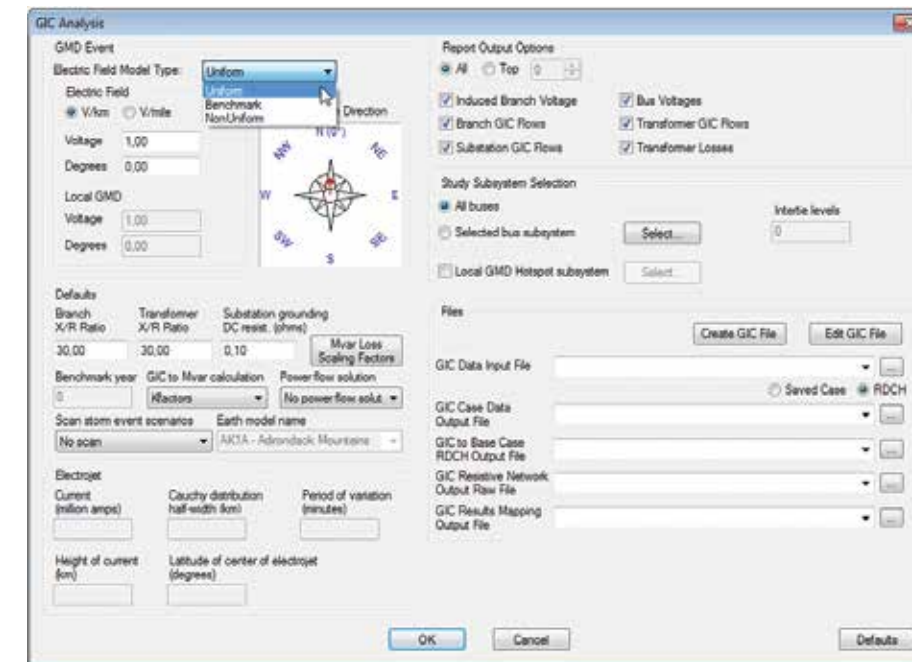
- Perform balanced and unbalanced short circuit analysis
- Automatic sequencing of short circuit calculations for large models
- Circuit breaker duty calculations based on ANSI and I or IEC standards
- Circuit breaker detailed fault analysis

Optimal Power Flow (OPF)

- Go beyond traditional load flow analysis to provide the ability to fully optimize and refine your transmission system plans
- Includes functions to minimize fuel costs, transmission losses, interface flows, and many more objectives
- Accurately models the many controls and constraints on the network
- Includes soft and hard limit penalties to allow more robust solutions

Transmission Line Parameter Calculation (LINEPROP)

- Graphically design corridor cross sections and calculate positive- and zero-sequence branch impedances from line geometry models
- Can handle complex corridors with multiple lines, arbitrary conductor placement / bundling and mutual impedances



Geomagnetic Induced Currents (GIC)

PSS®E-PSCAD™ Co-simulation (E-TRAN PLUS)

- Hybrid simulation interface between PSCAD™ electromagnetics transients program and PSS®E transient stability
- Allows complex PSCAD™ models to communicate with a PSS®E transient stability time-domain simulation
- This hybrid simulation allows dynamic system equivalents in PSCAD™, more accurate model behavior in PSS®E, and different versions of PSS®E running simultaneously
- Powerful PSS®E contingency results APIs for loading contingency results into a relational database

Geomagnetic Induced Currents (GIC)

- Accurately model the effects of a geomagnetic disturbance (GMD) on your system
- Uses the methods of calculation recommended by the latest research and NERC

- Includes tools for streamlining the process of gathering the required data
- Use the model with the effects of the GMD in other PSS®E analyses, such as dynamics or steady-state contingency analysis

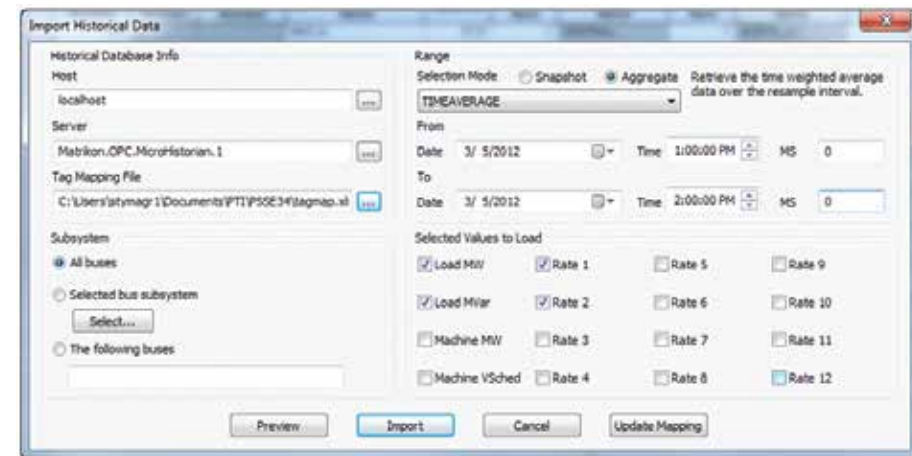
Small Signal Stability Analysis

- Provides an extension of analytical methods to examine wide-area system oscillations
- Includes methods to investigate long-term stability
- Allows a deeper view into eigenvectors, determines the best damping locations, and allows evaluation of damping strategies

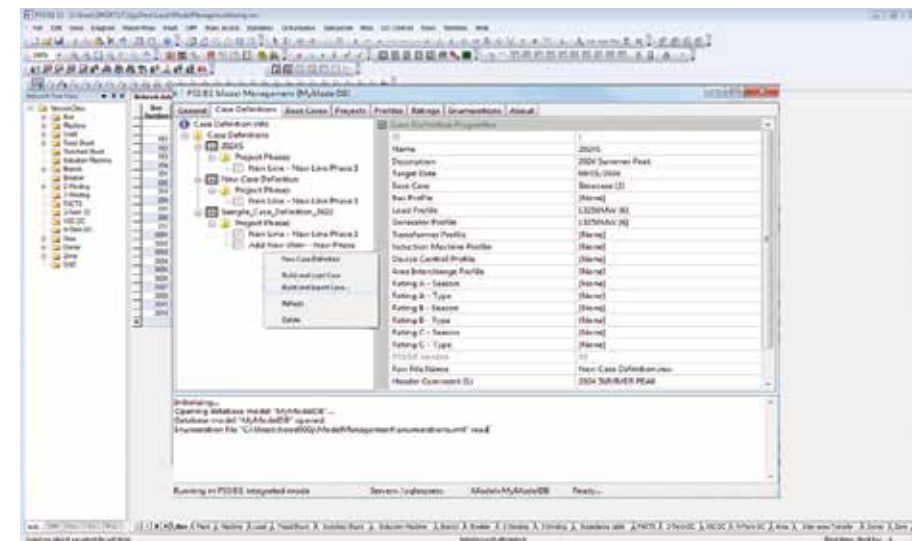
Advanced Contingency and RAS Tools

- Tools for allowing PSS®E users to perform power flow and contingency analysis customizations
- Includes an interface for modeling Remedial Action Schemes (RAS) and Special Protection Systems (SPS)

Modeling and Data Exchange/Interface Modules



Measurement Interface Module



Model Management Module

CIM Importer

- Import CIM models from other systems (e.g. EMS) directly into PSS®E
- Allows model comparison and validation between operations and planning
- Assists in model maintenance, data interoperability and exchange, and NERC-MOD-33 compliance

PSS®E-PSCAD™ Data Conversion (E-TRAN)

- Directly translate PSS®E network models into high-fidelity PSCAD™ electromagnetic transient models
- Includes translation support for the full standard library of PSS®E dynamics models
- The generated PSCAD™ model is fully flat-line initialized
- More complex / detailed PSCAD™ machine and HVDC models can then be integrated into this network model for sophisticated analysis

Measurement Interface

- Interface for importing real-time and historic telemetry data from measurement data sources (e.g. PI Historian) into PSS®E
- Example use cases are to calculate and set ambient-adjusted and dynamic ratings in PSS®E for off-line analysis, and to obtain more accurate generation and load profiles

Model Management

- Centrally manage all your PSS®E data, files, projects, changes, etc. across multiple users and time horizons directly in PSS®E
- Lightweight, easy to use, and barely any IT burden to deploy
- Includes a batch mode for streamlining model series development for regional model development efforts and automatic next-day model building for operations studies
- Scalable and suitable for any size modeling team

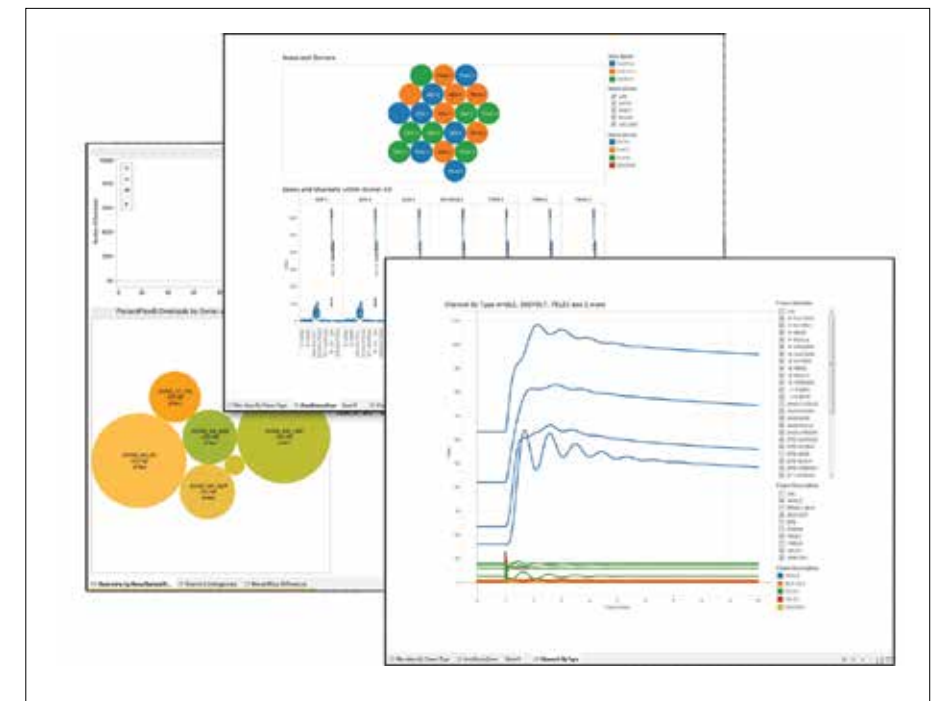
Graphical Module Builder (GMB)

- A powerful and easy to use dynamics model development tool based on graphic representation of control block diagrams
- Allows specialized modeling by supporting both standard and non-standard dynamic models

Visualization Modules

Data Visualization and Reporting (DVRM)

- Provides PSS®E users with new ways of interacting with their power flow and dynamics output data
- Simplifies the analysis and visualization of these results by converting numbers and metrics into plots, graphs, and diagrams

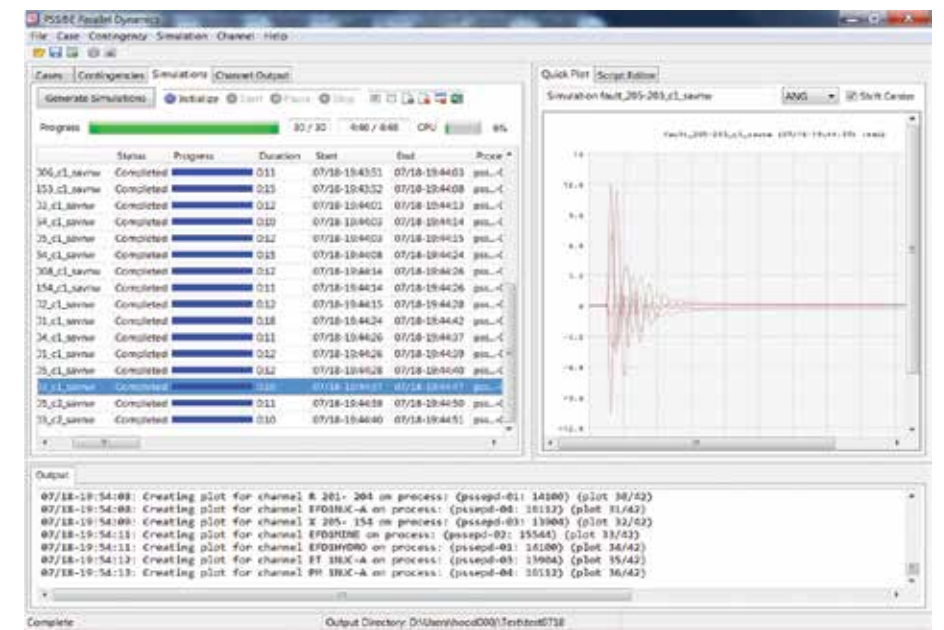


Data Visualization and Reporting Module

Enhanced Performance / Workflow Speedup Modules

PSS®E Parallel Dynamics

- Provides up to 24x speedup of dynamics simulations on a single workstation
- Includes tools to monitor and analyze your dynamics simulations from a dashboard view



PSS®E Parallel Dynamics Module

Product Support

Support

- Application support offered by dedicated in-house Siemens PTI Customer Care team with direct access to subject matter experts
- Premium access to product updates, enhancements and improvements as well as new functionality
- Interactive online forums to facilitate knowledge sharing among the community of professionals
- Extensive knowledge database
- Power packed technical user conferences with regional focus to increase product roadmap awareness, providing opportunities to meet with Siemens PTI experts and fellow users

PSS® Ideas Portal

- Platform for PSS® Product Suite users to submit, track, and vote on product ideas
- To request access to the PSS® Ideas Portal, contact pti-support-energy@siemens.com

Siemens Power Academy

- Beginner to advanced level certified PSS®E training
- PSS®E module training:
 - Power Flow
 - Optimal Power Flow
 - Fault Analysis
 - Dynamics
 - Model writing
 - Automation
 - GIC
- How to use PSS®E for grid studies training:
 - Voltage control and reactive power
 - Assessing reliability standards
 - Power electronics
- Flexible delivery options including e-learning or at a customer site
- Standard and customized training
- For more information on Siemens Power Academy visit www.siemens.com/poweracademy

Licensing and Installation Options

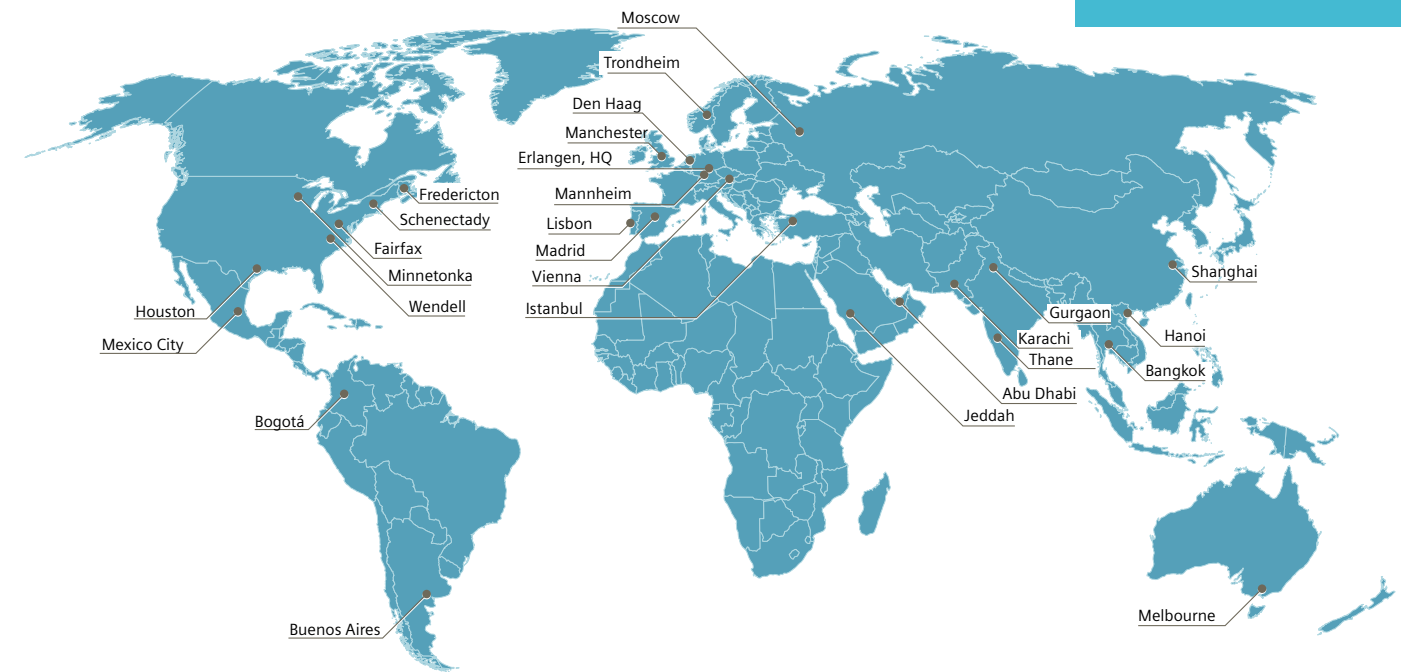
- Single-machine or network licensing
- Software and hardware (dongle) licensing options
- Compatible with 32/64 bit Windows 7, 8, and 10, and Windows Server 2008 and 2012

Sales Contact

- Email: pti-software-sales.ptd@siemens.com

Did you know?

- Siemens PTI founded in 1956
- Headquarter in Erlangen, Germany
- ~30 offices worldwide
- 2,000+ customers
- 3,000+ projects p.a.
- 200+ consultants
- Renowned experts
- Profound experience
- Global leader in power systems planning



Software Solutions

Siemens PTI offers a powerful suite of software applications and solutions to efficiently support system planning and operations with their daily simulation and analysis work. The Power System Simulator (PSS®) Product Suite provides a full set of integrated and specialized applications for the simulation, analysis, and modeling of transmission, distribution, and industrial power networks, as well as gas, water, heating, and cooling infrastructures. Easily integrated into any existing IT environment, these powerful and user-friendly tools feature an intuitive graphical user interface, customizable visualization options, automation capabilities, and efficient data management. Data exchange with other systems (e.g. EMS, DMS, AMS, GIS, other planning tools, etc.) is provided through industry standards (i.e. CIM) and native interfaces. Siemens PTI also provides custom software solutions based on its blend of engineering and software architecture expertise, custom software development capabilities, award-winning project management, and existing product functionality.

Energy Business Advisory

Energy business advisory guides enterprises to maximize their value in an increasingly complex, global, and evolving energy marketplace. Siemens' consulting service combines technology and market expertise and decades of industry experience in a flexible methodology toolbox covering all

project stages from strategy development to implementation. Our expertise in strategic planning is enhanced by Pace Global's long-standing experience in the fields of risk management, market advisory, infrastructure development and transaction advisory. With our collective resources we bring a complete best practice perspective to power, natural gas, renewable generation and environmental markets.

Power System Consulting

Ever changing industry challenges and opportunities along with the rising complexity of modern power systems call for comprehensive, systematic grid planning. Siemens PTI's renowned Power System Consulting experts leverage experiences gained in numerous and diverse projects to derive grid concepts which follow the overall business strategies of utilities and end-customers. Profound power system analysis, both technically and economically, together with leading planning competence provide insight that enable our clients to take well-informed decisions influencing the structure, performance and operation of their systems. Our services address utility as well as industrial or commercial grids and cover the complete range of studies: from steady-state, dynamic and transient analyses to protection and control concepts or power quality aspects. In studies, continuous partnerships, long-term planning or research projects, we tailor our services to individual demands.

Company Profile

Siemens Power Technologies International

From strategic advisory to technical consulting and state-of the art software solutions: Siemens PTI offers a holistic approach to mastering the technical and economic challenges of today's and future energy systems. Drawing upon more than 60 years of experience and continuous innovations in power system planning, Siemens PTI's renowned experts address the full scope of power system analysis, design and optimization studies. Experiences gained in international studies and the dynamic changes to the industry, directly flows into Siemens PTI's comprehensive suite of power system planning and software tools which reliably support the power and energy industry around the world. Our strategic consultants help optimize business value by providing valuable advice in the fields of business transformation, infrastructure development, as well as market and transaction advisory. Siemens' financial strength and regional competence centers around the world make Siemens PTI an ideal partner to develop individual, innovative solutions which create sustainable value for our customers and turn change into opportunities.