C & S Group

Electric Power Software

PSAS™ *For Windows*

The world's leader in affordable & innovative power system design software

www.electricpowersoftware.com

C & S Group Introduces PSAS …

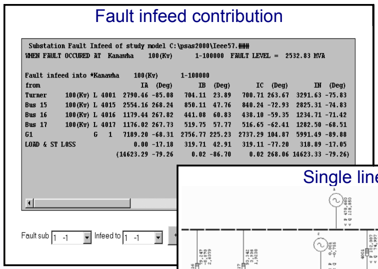
Power **S**ystem **A**nalysis **S**oftware (PSAS) is the integrated power system simulation software package from C & S Group, Australia. PSAS is packed with a wide range of study modules capable of performing complex electrical studies in AC interconnected power systems and open market power systems. All simulation modules are designed using well proven state-of-the-art technology and the latest industrial and software standards. The PSAS program consists of conventional modules for network and stability analysis such as power flow, short circuit, fast contingency assessment, harmonic analysis, transient stability and small signal dynamic stability. In addition, special modules are applicable to open market power system such as impact of power transactions, transmission loss allocations and calculation of nodal prices. The PSAS program also includes modules dedicated to the distributed and renewable generators, in particular, wind generators.

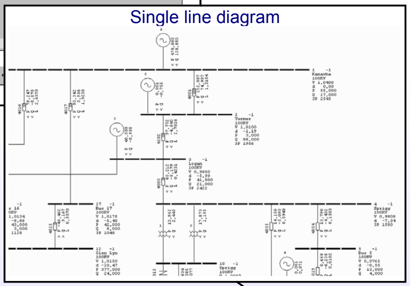
Network adequacy studies

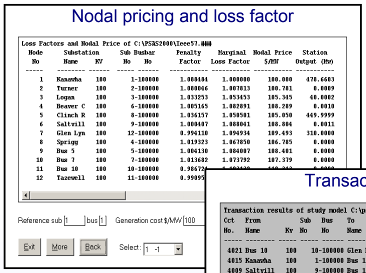
Load flow and single line diagram
Balanced and unbalanced fault
Harmonic impedance and harmonic power flow
Fast contingency assessment

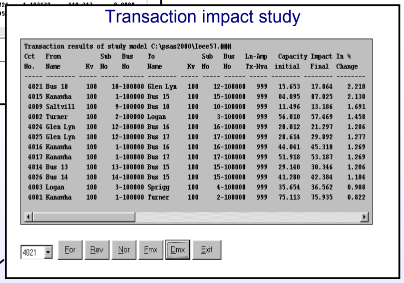
Electricity trading and pricing studies

Impact of bilateral transactions
Transmission loss allocation
Nodal pricing and loss factors
Penalty factors for economic dispatch







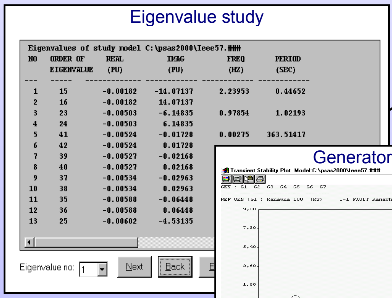


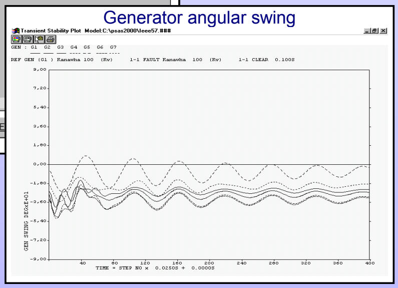
Generator stability studies

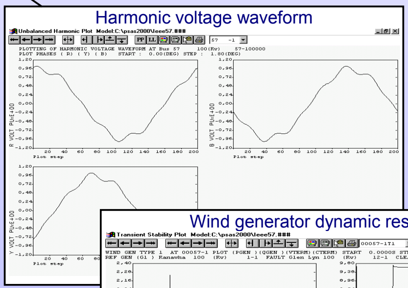
Transient stability under disturbance
Motor starting and protection simulation
Generalised model for AVR, governor & SVC
Critical fault clearance time assessment
Dynamic stability and eigenvalues
Eigenvector sensitivity and step AVR response

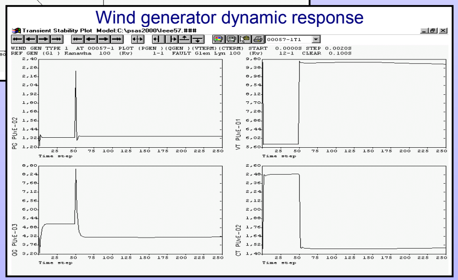
Distributed and renewable generator studies

Harmonic distortion and voltage fluctuation
Steady state stability and transfer limit
Dynamic performance of wind generators
Impact of wind farms on power system









Power System Network Analysis

LOAD FLOW

The power flow module assesses the overall power flow and voltages of interconnected power systems and networks for specific system loading and generation conditions. Overall system operating performance can be visualised by plotting the circuit loadings and voltage profile for the entire system.

Key Features

- Model up to 18000 buses, 6000 generators, 9990 transformers and 22000 lines
- Full Newton-Rapson solution using sparse matrix method
- Generator with MVAR limit or remote voltage control ability
- Voltage control by auto tapping transformer
- Representation of two terminal DC lines
- Simultaneous solution for split systems
- Global scaling of system loading, generation and reactive facilities
- Importing data directly from standard industrial format including IEEE and PSS/E*

SINGLE LINE DIAGRAM

The single line diagram provides an user friendly interface for the display of load flow and short circuit study results. The network database can be directly updated via the diagram.

Key Features

- Navigation map showing co-ordinates and current map position
- Highlight overloaded equipment and the loading level of transmission line in a gauge
- Colour coding of different bus voltages
- Automatic checking of network connectivity
- Powerful zoom and screen manipulation facilities

SECURITY ASSESSMENT

The security assessment module allows rapid assessment of whether any circuit in the system suffers the risk of overloading under first order contingency condition. By the use of matrix modification method, the module examines the circuit flow in the system after every single circuit outage event without the need of repeating the load flow study. A summary of the overloaded circuits under contingencies will be reported.

THREE PHASE & UNBALANCED FAULT

The three phase fault and unbalanced fault modules assess the fault current flow and voltage in a power system during short circuit conditions. The information is required to design an adequate protection system and to determine the interrupting capability of the circuit breakers at switching locations.

Key Features

- Model three phase, single-phase-to-earth, phase-to-phase or double-phase-to-earth faults
- Arcing faults between phases with user specified fault arc impedance
- Model common earthing resistor at a substation
- Model phase shift in delta-star winding transformers
- Compute peak DC current at half cycle

HARMONIC IMPEDANCE & UNBALANCED HARMONICS

The harmonic impedance module provides frequency scan of the positive sequence harmonic impedance at any bus up to the 50th harmonics. The results can highlight the possibility of harmonic resonance. The unbalanced harmonics module studies the harmonic current flow and voltage distortion in the system due to harmonic injections from abnormal loads such as the converter equipment of renewable generator, traction loads and arc furnaces. Multiple harmonic injection sources can be modelled simultaneously. Typical harmonic filters with user specified ratings and parameters can be added to the system to suppress harmonic resonance.

Key Features

- Advanced modelling technique using sparse matrix and sequence network components
- Different harmonic models for loads, lines and transformers
- Single tuned, double tuned and high pass harmonic filter models
- Automatic modelling of the positive, negative and zero sequence networks
- Suppress the flow of balanced zero sequence current in transformer delta windings

*PSS/E is trademark of Power Technologies Inc.

Power System Stability Analysis

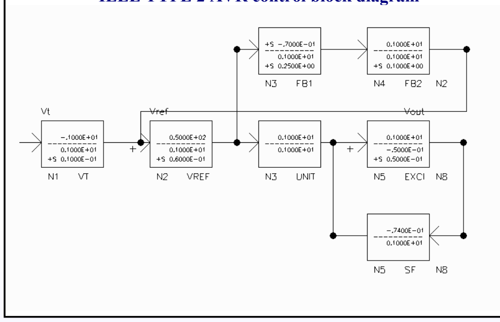
TRANSIENT STABILITY

The transient stability module assesses the capability of the generators to operate in synchronism during large disturbances such as system fault, load change, loss of generation and transmission network outages. Generators can be modelled using transient or subtransient equations with the effect of saturation included. Control systems of exciter, power system stabiliser, governor and static var compensator are modelled by a generalised connection of control blocks. DC transmission lines are modelled as constant power load or a quasi-steady-state model with fixed transformer tapping.

Key Features

- Simultaneous solution for network, generators and control equations using trapezoidal integration
- Disturbances include fault inception, fault clearance, generator trip, load shed or connection, circuit tripping and reclosing
- Dynamic starting of induction motors with different load characteristics
- Capability to test step response of excitation system (AVR)
- Automatic determination of critical fault clearance time
- Standard IEEE models for AVRs and Governors
- Model distance relays, overcurrent relays and underfrequency relays
- Frequency and voltage dependent load models
- Possibility to interrupt the study and save the results
- Plotting of all monitor variables in time axis
- Plotting of impedance locus changes in R-X impedance axis
- Plotting of controllers in automatically generated block diagrams
- Option to build simplified generator model based on load flow data

IEEE TYPE 2 AVR control block diagram



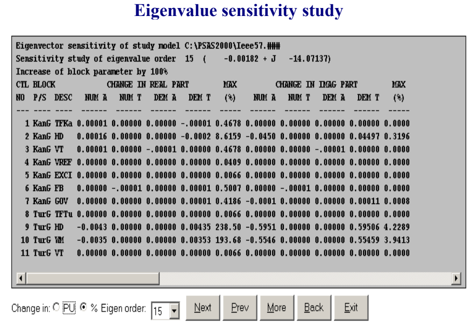
DYNAMIC STABILITY

The dynamic stability module assesses the damping of the generators under small disturbance conditions. The generator transient equations and other control equipment are represented by first order differential equations which are solved to produce the eigenvalues. The oscillating frequencies and their respective damping factors are reported for the whole system. The module also conducts sensitivity analysis of the eigenvalues relative to the generator and control parameters. The module also studies the time response of the generators when the excitation system is subject to a step input. To reduce matrix size, generators with similar characteristics can be grouped into an equivalent machine.

Key Features

- Detailed representation of automatic voltage regulators and power system stabilisers
- Governor simplified as a proportional controller with a time delay constant
- Eigenvalues in ranking order for the whole system
- Eigenvalue sensitivity in percentage or unit change of control parameters
- Report oscillation frequency, period and damping factor
- User selection of eigenvalue for sensitivity study
- Accept similar data as the transient stabilty module
- Grouping of generators to reduce system matrix requirement
- Monitor state output variables during step input response test
- Maximum 500 system state variables

Eigenvalue sensitivity study



Electricity Market Trading and Costing

TRANSACTION IMPACT

The transaction impact module examines the effects of bilateral transactions on the power flow and circuit loading across the system. A bilateral transaction injects power to a sending bus and takes power from a receiving bus. Both single or multiple transactions can be specified. A pseudo load flow study is conducted to assess the effects of the transactions on the system flow. The program assesses the impact of the transactions by sorting the study results in order of final circuit loading percentages and percentage changes in circuit loading caused by the transactions. For the case of a single transaction, its distribution factor can be determined from the change in circuit loading as a percentage of the transaction power. Repeated assessments can be conducted using different transactions trading scenarios. Circuits with high risk of overloading which require capacity rights trading or re-enforcements can be identified.

PENALTY FACTOR

The penalty factor is used to adjust the cost of generation to compensate for losses in the transmission networks. The product of marginal generator cost and the penalty factor is commonly called the equivalent marginal generating cost of a generator bus. Under optimal economical dispatch, system operators always schedule generators with the lowest equivalent marginal generating cost on bar to meet load demand. Traditionally, the penalty factors are determined from so called "*B loss coefficients*" which express the total transmission loss as a quadratic function of the power output of generators. PSAS offers a special module to calculate penalty factors using the Newton's method. The Newton's method assumes that the load has a frequency sensitive component and any incremental power injection is distributed amongst existing loads. This method allows the penalty factors to be calculated for all buses including the slack bus. A paper entitled "*Transmission loss evaluation in an open electricity market using an incremental method* " which illustrates this technique for fair allocation of transmission losses has been accepted for publishing in the research journal IET - Generation, Transmission and Distribution, volume 1, issue 1, Jan 2007. The penalty factors are automatically calculated after power flow study. As the Newton's algorithm is unique for a specific system load flow condition, PSAS can provide an accurate and unbiased set of penalty factors for economic dispatch and for pricing of transactions in an open electricity market.

LOSS FACTOR & NODAL PRICE

Loss factors are used in some open electricity markets to determine the nodal price for market settlement of electricity trading and costing of bilateral transactions within a supply region. A reference bus is defined which supplies the incremental generation when there is incremental power change in other buses in the region. The nodal price of other buses are obtained by multiplying the generating cost of the reference bus with the loss factors. As the reference bus is assumed to supply all incremental generation, the marginal loss at the reference bus is zero and its loss factor is unity. PSAS can be used to calculate the loss factors using the penalty factors derived from Newton's method. Users can choose the reference bus and define the cost of marginal generation at this bus. The loss factor at other buses are obtained by dividing the penalty factor at the reference bus by that of the other buses. PSAS also determines the nodal price of all other buses by multiplying their loss factors with the marginal generator cost of the reference bus. The results are unaffected by the choice of slack bus in the load flow system. The nodal prices calculated using this method fully reflect the marginal cost of generation and marginal losses when there are no circuit constraints. It also offers a simple measure to set the cost of electricity and bilateral transactions in an open market system.

Key Features

- Instant calculation of penalty factors, loss factors and nodal prices from user defined reference bus and generating cost
- Rapid assessment of different generating cost scenarios without re-run of power flow
- Nodal pricing independent on the choice of slack bus in the power flow model
- Difference in nodal price can be used for costing electricity and bilateral transactions

Distributed and Renewable Generators

STEADY STATE STABILITY

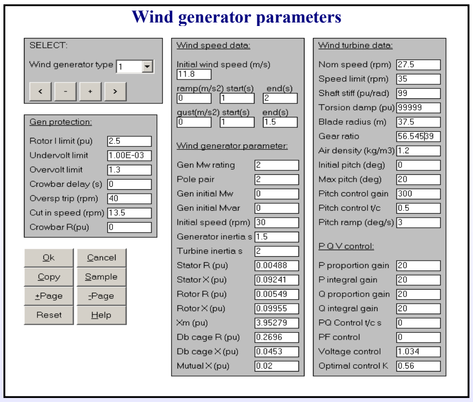
The steady state stability module assesses the maximum power transfer in interconnectors or generator outlet circuits under steady state conditions. Each individual generator is modelled as constant voltage behind transient impedance. Selected generator groups of the same bus increase their generation by increasing the generator angle. The total system load is assumed unchanged. Some generators can be specfied as constant load. As the generator angle increases automatically, the power transfer in the interconnectors or outlet circuits should increase to a maximum which is the steady state stability limit. As the module can be performed immediately after power flow without further system data, this module is useful for assessing the transfer limit of small hydro synchronous generators at remote locations.

WIND GENERATOR

PSAS incorporates the latest technique to model variable speed doubly fed induction wind generators which are commonly used in wind farms. The complete model includes wind speed dynamics, wind turbine drive train mechanics, induction generator with back to back converter to control rotor voltage, pitch control, protection and power control systems. Dynamic simulation of the wind generator is fully integrated in the transient stability module. The impact of wind farms on power system dynamic stability can be assessed for a wide range of system operating and disturbance conditions.

Key Features

- Model double cage induction generator with back-back voltage converter control
- Model two masses drive train with shaft torque effects or single mass drive train
- Separate integral proportional controllers for real and reactive power control
- Controller response can be instantaneous or time delay
- Maximum power tracking for the power controller
- Constant power factor or reactive power control
- Simulation of wind gust and ramp change
- Rotor overcurrent, overspeed, overvoltage protection
- Crowbar protection with automatic insertion of damping resistor after time delay
- System wide representation of wind generators as percentage of system load
- Automatically determine wind generator initial operating conditions



Program Options

The PSAS software package is offered in four different versions:

- PSAS v2000.x8 - capacity 18000 buses
- PSAS v2000.9k - capacity 9000 buses
- PSAS v2000.3k - capacity 3000 buses
- PSAS v2000.30 - capacity 300 buses

Hardware and Software Requirements

PSAS softwares run on IBM P/C or compatible computers using Windows 98, NT, 2000 or XP. The recommended minimum hardware requirements are:

- A Pentium based computer
- 512 Mbytes of memory
- 200 Mbytes of free hard disk space

For further information contact:
C & S Group – Electric Power Software
P.O. Box 1322, Glen Waverley, Victoria 3150, Australia
Tel: +613 9561 8205
Fax: +613 9561 8308
Email: csgroup@electricpowersofware.com
web: www.electricpowersoftware.com