CYME INTERNATIONAL T&D

"Serving the Electrical Industry Worldwide"

Transmission & Industrial System Analysis - PSAF

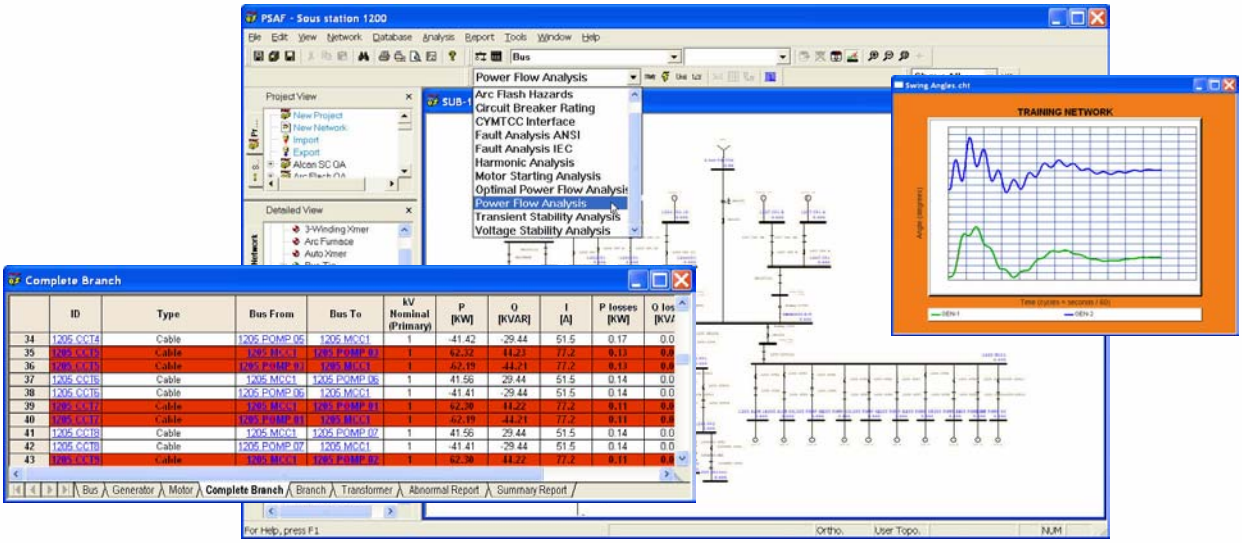
CYME's **Power Systems Analysis Framework** (PSAF) is a comprehensive suite of integrated software programs that perform the simulations and analyses of transmission or industrial electrical systems as needed by the electrical engineers.

A wide selection of network equipment and controllers is supported by a built-in database that contains industry standard equipment characteristics. Every type of equipment features more than one modeling possibility depending on the purpose and extent of the simulation to be conducted.

PSAF offers both graphical and tabular data entry modes, user-preferred single-line diagram drawing options and sophisticated facilities for reporting, plotting and customizing the simulation reports.

Deploying PSAF brings significant advantages in performing the planning, design and problem-solving activities related to the assessment, improvement and maintenance of electrical power systems.

PSAF is directly applicable to both utility-type and industrial three-phase electric power systems.



Features and Capabilities

- *Power flow for normal operating conditions and "what-if' scenarios.*
- *Short circuit calculations and protection settings.*
- *Breaker ratings.*
- *Arc flash hazard calculations.*
- *Optimal power flow.*
- *Voltage stability/Modal analysis.*
- *Harmonic analysis.*
- *Transient stability under normal operating conditions such as transient motor starting and load transfer.*
- *System dynamics under abnormal operating conditions such as bus fault and line tripping.*
- *Transmission lines parameters calculations in sequence or phase domain, with modal analysis and frequency-dependence modeling capability.*
- *Underground cable parameters calculations.*

CYMFLOW - *Power Flow Analysis*

Dedicated to power flow analysis in three-phase electric power networks, it is equipped with powerful analytical options and alternative solution techniques.

CYMFLOW utilizes state of the art sparse matrix/vector methods and multiple solution algorithms: full Newton-Raphson, fast Decoupled (with or without constraints), and Gauss-Seidel.

Some of the CYMFLOW capabilities are:

- Analyze networks with thousands of buses and branches.
- Multiple swing buses allowed.
- Automatic swing bus selection for isolated subsystems.
- Simultaneous solution for islanded networks.
- Switchable shunt element.
- Generalized load modeling, including constant power, impedance and current.
- Representation and control of DC lines.
- Wind Energy Conversion Systems (WECS).
- Modeling and representation of FACTS devices (UPFC and STACOM).
- Transformer inrush currents.
- Color coding on the network one-line diagram of overloaded equipment and buses with voltage violations.

CYM-AC Contingency

The AC CONTINGENCY operates in conjunction with CYMFLOW, for power flow related contingency analysis. The analytical approach used is the same as CYMFLOW; i.e. the contingency analysis is performed using full AC power flow solutions (no DC approximations). The module features the sequential solution of all contingencies in a single run.

The contingency module is structured so that an unlimited number of "what-if" scenarios can be included in a given contingency study. All contingency-related system modifications refer to the base case network single outages and/or multiple outages/modifications can be concurrently defined at will to represent an adverse contingency analysis scenario such as:

- Modify loads globally, individually or by zone.
- Modify generation globally, individually or by zone.
- Connection and disconnection of branches.
- Shunt modification.
- Addition and removal of induction and synchronous motors.
- Connection and disconnection of buses.

CYM-Motor Start

The CYM-Motor Start Analysis Module operates in conjunction with CYMFLOW and is dedicated to simulating the effects of induction and synchronous motor starting in three-phase electric power systems. This module is a reliable and easy to use tool for assessing system voltage dips and acceleration times of induction motors, using a variety of starting methods.

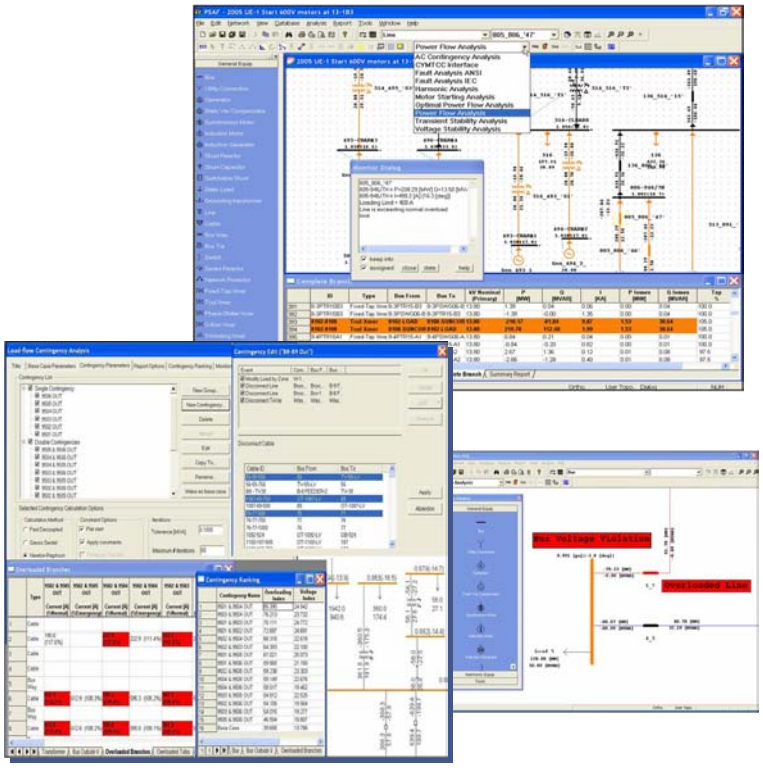
- Induction motor starting.
- Synchronous motor starting.
- Ten starting methods supported, including soft motor start, VFD, auto transformer, etc.
- Detailed mechanical load model based on manufacturer data curves or with the equation of load torque versus speed.
- In the absence of detailed information, the module includes support functions for deducing the induction motor equivalent circuit for single rotor, double rotor or deep bar rotor induction motors.

Electrical Equipment Parameter Estimation

PSAF is capable of suggesting typical data for the system equipment. These estimating functions account for a wide array of industry manufacturing practices, and respect the recommendations outlined in both North American and International calculating guidelines. This capability is very useful when detailed information about lines or cables is not available.

***Transmission line models** are defined by their geometrical line configurations. Transposed and/or full three-phase un-transposed models including frequency dependency are supported for single or double circuit lines, with solid or tubular conductors, multiple conductors per phase and multiple neutral wires (segmented or not).*

***Underground cable** constants are calculated single and/or three-core cables with either sheath or ground return.*



CYMFAULT - *Fault Analysis (ANSI & IEC)*

To simulate fault conditions in three-phase electric power systems. User-friendly data entry, a multitude of reports and flexibility in applying all industry-accepted standards are features that make CYMFAULT an indispensable tool for these very common and important system studies.

CYMFAULT adheres to North American ANSI C37.5, ANSI C37.010, ANSI C37.13 and International IEC-60909 guidelines. It also supports conventional short-circuit studies without reference to any particular standards.

- Series faults (one-phase open, two-phase open and three-phase series unbalance).
- Separate network reduction for ANSI X/R ratios.
- Arcing faults through user-defined fault impedance.
- Mutual coupling in zero sequence.
- Interrupting device adequacy evaluation.
- Automated sliding fault option on a transmission line and/or cable.
- System-wide voltage, current and machine contribution reports (phase and sequence values).

ANSI Short-Circuit Studies

CYMFAULT adheres to North American ANSI C37.5, ANSI C37.010, ANSI C37.13 for all duty types that are of interest to industrial fault studies. Duty types supported include: time delayed, contact parting, closing / latching, low voltage circuit breaker.

IEC Short-Circuit Studies

CYMFAULT adheres to the international IEC-60909 guidelines and supports all four types of fault currents that are of interest to industrial fault studies. Duty types supported include: initial short-circuit current (I"k), maximum asymmetrical fault or peak current (Ip), breaking fault current (Ib), steady state fault current (Ik).

CYMFAULT/CYMTCC Interface

CYMFAULT includes an interface module to our Protective Device Coordination Program CYMTCC. This interface provides CYMFAULT users with full access to the complete library of over 5000 protective devices available in the CYMTCC program.

The user simply has to define the coordination path of the feeder on the one-line diagram of PSAF and export to CYMTCC.

CYMTCC will automatically generate the Device Time / Current curves for any device setting adjustments along with the selected feeder one-line diagram.

CYMBREAK - *Breaker Ratings*

CYMBREAK checks the validity of the current breaker size, and is designed to execute the appropriate simulation for high, medium or low voltage circuit breaker according to either ANSI or IEC standards.

The CYMBREAK engine allows the user to specify the breaker with information such as rated voltage, short circuit currents, temperature, etc. It is also possible to specify the breaker configuration arrangement such as 2, 1½, ring, etc. Then it determines if it is correctly sized in a steady state context or during a short circuit. Based on the breaker configuration, simulations are automatically performed on the worst system arrangement for each performed check.

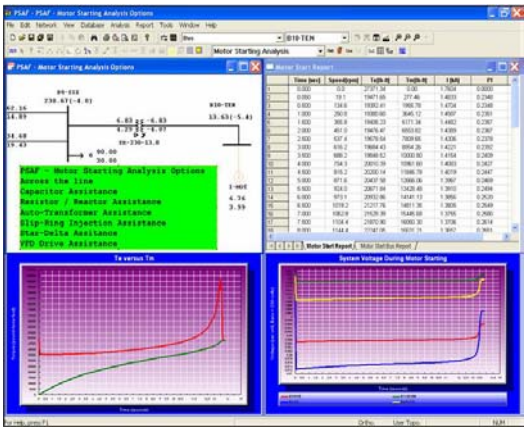
Arc Flash Hazard

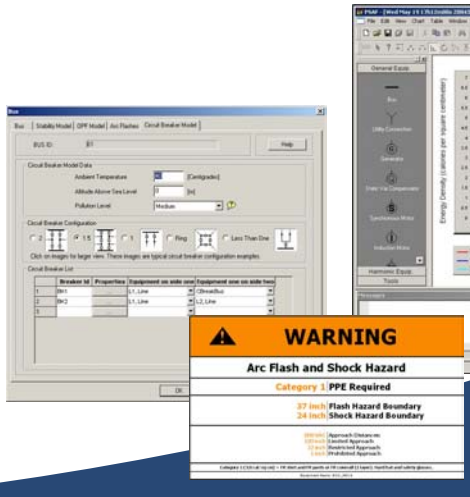
This module is primarily designed to analyze and promote the electrical safety for employees working on or near electrical equipment.

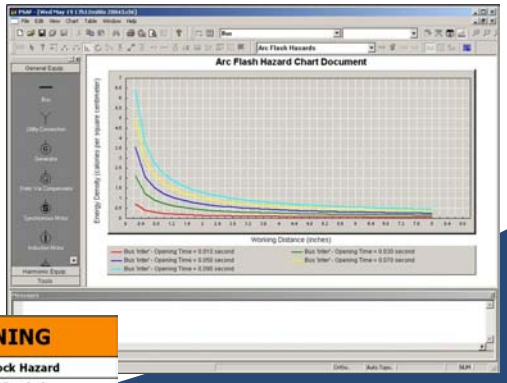
It computes the necessary parameters required to assess the risk level and adopt the adequate safety procedures, and complies with industry recognized standards and methods for performing ARC Flash Hazard calculations namely: the Electrical Safety Requirements for Employee Workplaces (NFPA-70E-2004) and the Institute of Electrical and Electronic Engineers (IEEE-1584-2002).

The module facilitates the calculation of arc flash hazards in different types of equipment in various power systems.

The program generates reports a variety of reports including labels that can be printed directly on ARC Flash Hazard weatherproof warning stickers.







CYMSTAB - *Transient Stability Analysis*

CYMSTAB is the PSAF simulation module used to simulate electromechanical transients in three-phase electric power systems. It features an extensive library of equipment and controller models, the capability to include user-defined controls, a very flexible user-interface and powerful graphics.

CYMSTAB utilizes the simultaneous implicit trapezoidal integration solution technique for network, machine and controller equations. The program supports the capability to test the step response of controllers and User Defined Modeling (UDM) for system equipment and controllers.

CYMSTAB features a large library of pre-defined models for network equipment and control systems that includes:

- Turbo and salient pole generators.
- IEEE Excitation Systems including saturation modeling.
- Power System Stabilizers.
- Governor models comprising hydraulic, thermal, diesel, and gas turbines.
- Static Var compensators.
- Under-voltage, under-frequency and frequency droop relays.
- Power swing and impedance relays.
- Induction motor models with frequency dependent modeling.

Some of the analytical capabilities of CYMSTAB are:

- LLL, L-G, LL and LL-G fault application and removal.
- Line switching and line re-closing.
- Single pole re-closing including line charging effects.
- Load shedding and load increase; generation shedding.
- Disconnection of lines, cables and transformers.
- Direct on-line or assisted induction motor starting and stopping; synchronous motor starting.
- Possibility to vary the integration step during the simulation.
- Frequency-dependent modeling.
- Networks with multiple frequencies.
- HVDC modeling.
- Generalized load modeling at individual bus bars or throughout the system.
- Series capacitors and controls.

Robust User Defined Modeling

In addition to its built-in library, the program includes a comprehensive Library of User-Defined excitation systems, governors and stabilizers.

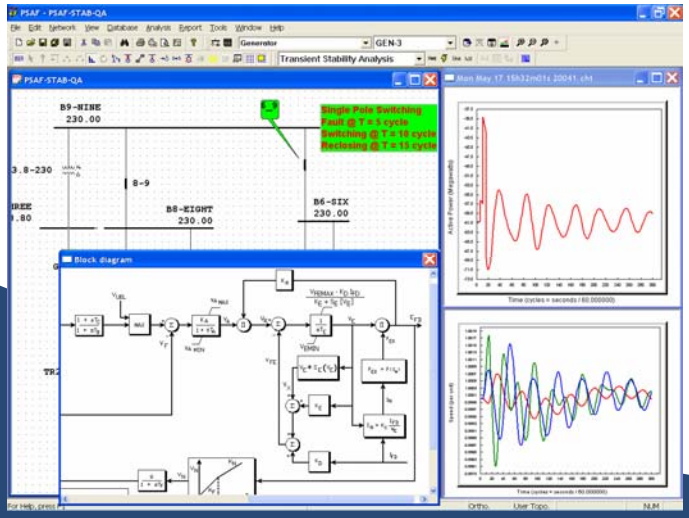
Virtually any schematic diagram *of Laplace-domain transfer functions can be created using our User-Defined Modeling functionality. With UDM it is also possible to perform manoeuvres (like stopping a motor) based on network conditions, rather than at fixed times.*

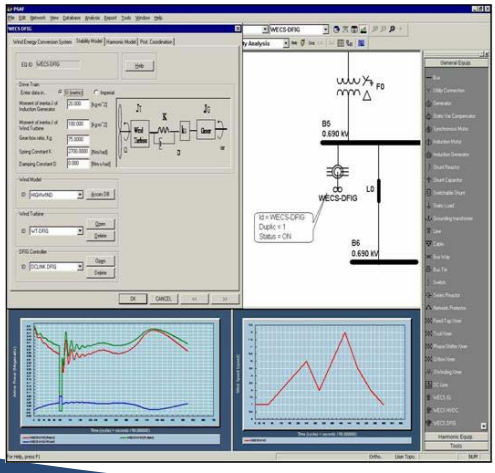
The PSAF User Defined Modeling functionality is a robust, field-proven capability with which the engineer can define the components of the network and their functions with the optimum precision that yields to more accurate simulation results.

Wind Energy Conversion Systems (WECS)

CYMSTAB now includes extensive modeling capability of Wind Energy Conversion Systems (WECS) dynamics. The advanced solution algorithms provide the user with the necessary tools to carry out power system studies comprising wind farm installations. Wind-turbine generation systems supported include:

- WECS-IG, for induction generators directly coupled with the AC grid.
- WECS-HVDC, for induction generators connected to the AC grid through a Voltage-Source Converter (VSC) DC link.
- WECS-DFIG, for doubly fed induction generators, featuring not only a direct stator connection to the AC grid but, also, a VSC-based DC link rotor energy recovery system, for variable turbine speed operation.
- Wind modeling, accounting for "cut-in" and "cut-off" capability.
- Two-mass drive train turbine-generator shaft model.
- Blade pitch control.





CYMVSTAB - *Voltage Stability Analysis*

CYMVSTAB performs the voltage security assessment of power systems. In planning and operating today's stressed power systems, the ability to maintain voltage stability has become a growing concern. CYMVSTAB is designed to meet this challenge by assessing the ability of the power system to maintain stable voltages under different contingencies and loading conditions.

Power system voltage instability is related to the lack of reactive power resources in the network. This is very similar to frequency instability in transient stability studies for systems that do not have sufficient spinning reserve.

Many aspects of voltage stability problems can be effectively analyzed with the Steady state or Static Power Flow based domain for a specified operating condition of the power system.

CYMVSTAB offers the user the same common format as our Power Flow Program CYMFLOW for entering the network data, defining the study parameters, report options and solving the network.

The program assesses the voltage stability of a network by means of the two most common static voltage stability analysis techniques.

- P-V Analysis (P-V Curves)
- V-Q Analysis (V-Q Curves)

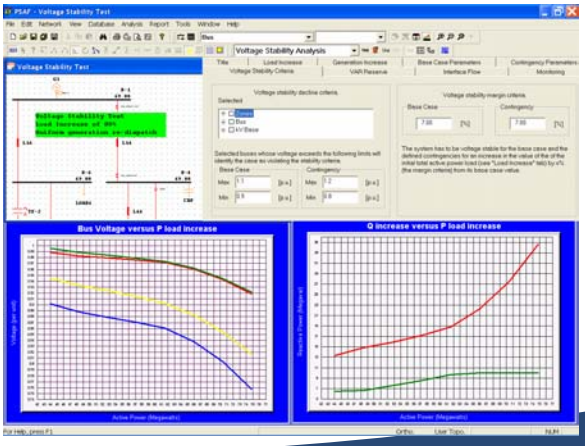
All curves of monitored variables can be exported to CYMVIEW, which is capable of managing the outputs of different modules and storing the results for any number of simulations generated by CYMVSTAB.

Modal Analysis

In addition to the voltage stability analysis techniques, there is a need for analytical tools capable of predicting voltage collapse in complex networks, accurately quantifying stability margins, power transfer limits, identifying voltage-weak points and areas susceptible to voltage instability.

The voltage stability module CYMVSTAB can identify the contributing factors and sensitivities which in turn provide insight into system characteristics that are key elements for the development of remedial actions in the network.

CYMVSTAB has the unique feature that for both PV and VQ approaches, the modal analysis is applied at each operating point to determine the voltage stability critical areas by identifying the ten buses contributing most to each identified mode of operation.



CYMHARMO - *Harmonic Analysis*

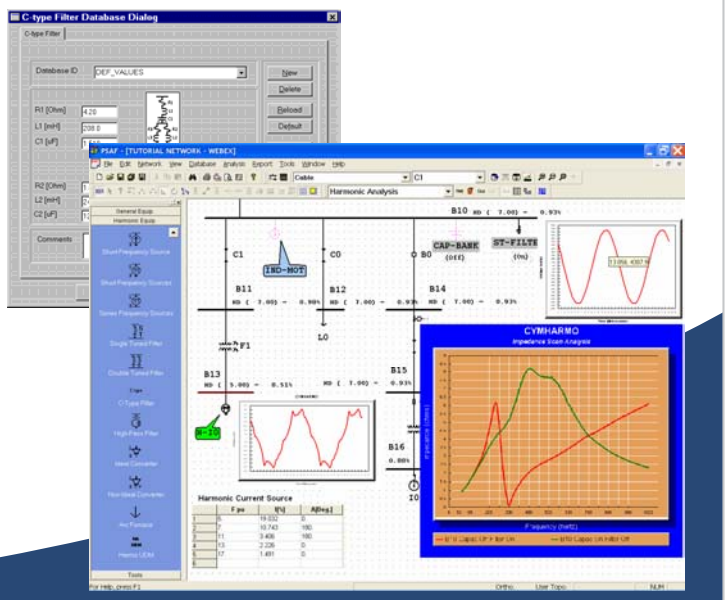
CYMHARMO is designed to perform harmonic penetration analysis in electric power systems. It features both single phase and full three-phase modeling capabilities. It can flexibly and easily be applied to utility-type grids, industrial power systems and distribution feeders of any configuration.

CYMHARMO utilizes state of the art sparse matrix/vector methods with a three-phase nodal admittance network matrix representation.

The program obtains from CYMFLOW the fundamental frequency current and voltage system profile for harmonic distortion calculations and waveform display.

- Phase or sequence analysis.
- Driving point and transfer point frequency scanning analysis.
- Voltage and current harmonic distortion.
- Calculation of telephonic indices (TIF, IT, etc.).
- Sensitivity analysis.
- System equivalence.
- Noise-to-ground analysis.
- Inductive coordination analysis.
- Communication interference analysis with slanted-exposure power circuits.
- Harmonic cancellation analysis.
- System detuning analysis.
- Capacitor stress analysis.
- Skin effect modeling.

CYMHARMO includes a **capacitor rating** module to perform the stress analysis of all power capacitors installed in the network, including those incorporated in filters. The analysis reports the harmonic currents and voltages of each capacitor as well as the total reactive power, RMS current, RMS voltage and peak voltage. These quantities will be compared to user-defined limits and any capacitor that violates any of those limits will be reported and highlighted on the network one-line diagram.



CYMOPF - *Optimal Power Flow Analysis*

CYMOPF allows the user to engage in advanced system planning studies to optimize system performance, examine cost-efficient operational planning alternatives, articulate system control strategies and rationalize equipment utilization, resulting in better overall system asset management.

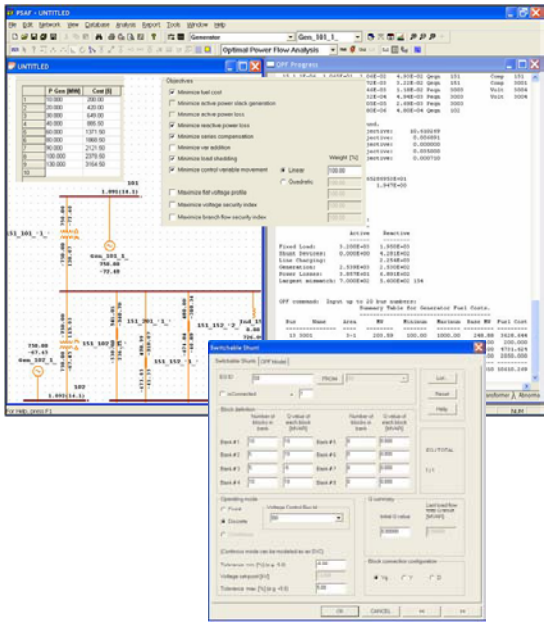
CYMOPF calculates the "best possible" values for "higher level set points" considering a set of user-specified objective functions and a number of constraints. In this way, it adds intelligence and, consequently, improves efficiency and throughput of power system studies significantly.

CYMOPF relies on robust barrier-method based nonlinear optimization techniques that permit fully coupled optimization, with the entire set of system control variables, including generation schedules, transformer taps, phase shifter settings, etc. System equipment constraints are observed, in particular bus voltages and line flows.

CYMOPF includes infeasibility handling through automatic relaxation of immediate binding constraints and comprehensive constraint ranking severity indicators for cases that exhibit convergence difficulty.

CYMOPF is aptly suited in solving many problems typically found in today's less-regulated power markets :

- Scheduling of ancillary services for reactive power and active power.
- Development of system reference scenarios.
- Voltage collapse analysis.
- Transfer capability investigation.
- Location based marginal cost assessment.
- Implicit penalty function consideration.



PSAF for Industrial Power Systems

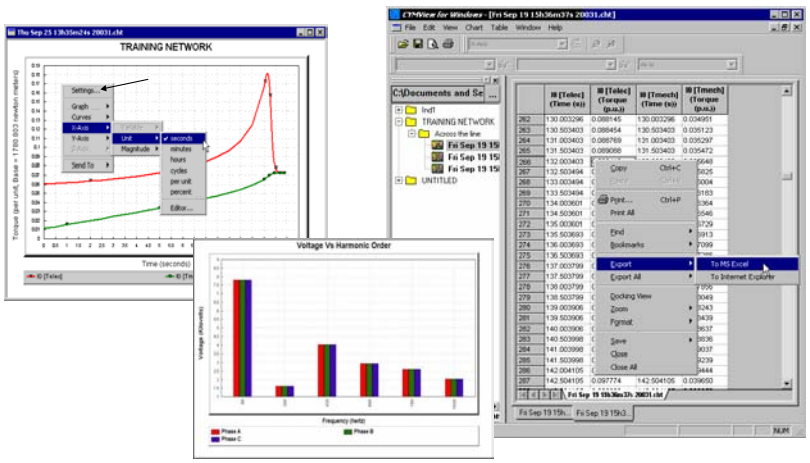
CYME offers a comprehensive suite of power engineering applications well adapted for industrial power systems with 250 buses or less.

PSAF features applications for the most common studies and assessments involved in the design and maintenance of power systems in industries. Includes load flow, short-circuit, motor starting analysis, and protective device coordination. With more specialized tools you can perform harmonic analysis (with full 3-phase modeling capacity) and transient stability studies. The latter comprises user-defined modeling capabilities allowing for the creation of your own models for equipment, controls, relays or special functions.

CYMVIEW - *Simulation Results*

CYMVIEW, common to all CYME simulation modules, generates any kind of charts. CYMVIEW is capable of managing the outputs of the various CYME software modules:

- Real-time plotting of variables specified in user-defined models (bar charts, curves, time waveform).
- Complete system-wide tabular reports generated with complete echo of the data used for the simulation.
- R-X plots, sensitivity analysis plots.
- Equipotential contours in 2D and 3D.
- Capability to compare results from different simulations.
- Algebraic manipulation of plots and variables during plotting.
- Possibility to plot multiple results on the same graph.
- Unlimited number of graphs.
- Capability to customize units, labels and plots appearances.
- Can be exported to MS Excel or to HTML format.



CYMTCC - *Protective Device Coordination*

CYMTCC addresses Time Over-Current protection for Industrial, Commercial and Distribution Power systems. The program comes with an extensive database of over 5000 protective devices that are easily called to produce Time-Current curve plots and device settings reports. It also features a unique Coordination wizard to suggest protective device settings/ adjustments and ratings. CYMTCC features a direct interface to PSAF to verify the coordination of protective devices. It can also be used to provide the device opening times that are used in the Arc Flash Hazard simulation module of PSAF.

CYMGRD - *Substation Grounding*

CYMGRD is CYME's substation grounding grid design and analysis module specially designed to help engineers optimize the design of new grids and reinforce existing grids, of any shape, by virtue of easy to use, built-in danger point evaluation facilities . The program conforms to IEEE Std. 80-2000, Std. 81-1983 and Std. 837-2002. The use of CYMGRD allows for the rapid analysis of various design alternatives to choose an economical solution for any particular installation. User-friendly data entry, efficient analysis algorithms and powerful graphical facilities render CYMGRD an efficient tool that helps the engineer arrive at technically sound and economical designs.

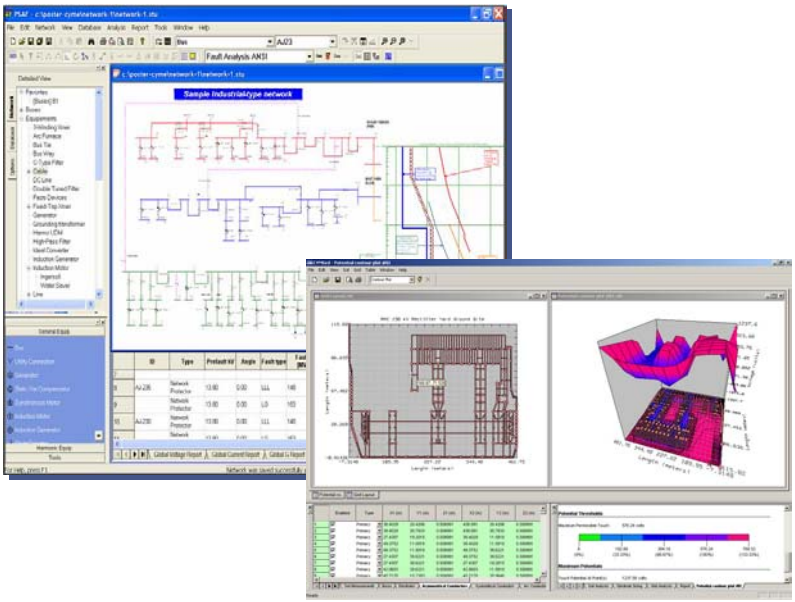
Graphical and Reporting Facilities

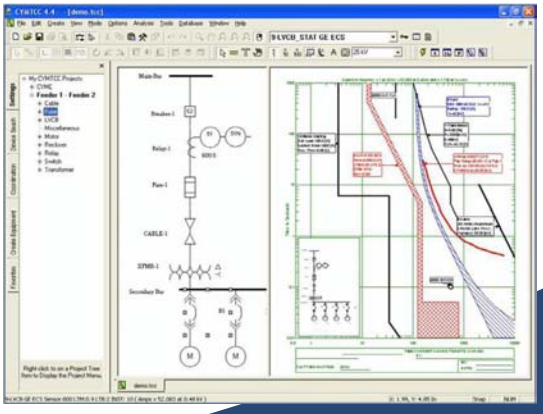
The PSAF simulation modules are easy to use, reliable and powerful with the most advanced industry-proven modeling and algorithmic solution techniques for the most demanding engineering analyses.

PSAF offers a highly interactive graphical interface that makes it easy to draw the network one-line diagram on the screen and define the parameters of its components. At any time, you may display and edit the data pertinent to any component. You may even have the one-line diagram drawn automatically for you as you connect components together.

PSAF also comprises cable and equipment estimation programs to further enhance the process of building a consistent network diagram upon which realistic and reliable system studies can be performed.

With the PSAF sophisticated facilities for reporting and plotting, you can easily select the variables you need and customize your simulation reports as required. You may design custom reports by selecting items from a menu. Undesirable load flow conditions such as overloads and under/over-voltages may be reported.





Power System Studies

CYME's Electrical Analysis Software Solutions are readily available for customers' immediate use in planning and engineering applications.

CYME engineers can also assist you in the resolution of emerging, specialized and non-routine problems, and provide more specialized assistance and study services.

Our engineering staff is at a high degree of skill and their knowledge covers almost every area of power system analysis. Backed by extensive experience in systems' planning, design and operation, they provide a range of options in terms of specialization, experience and know-how.

Specialized and sophisticated system studies to deal with new and emerging problems in the energy sector.

- Minimizing cost and maximizing profit by operating equipment near, at, or beyond their design limits.
- Dealing with modern customer equipment sensitive to system disturbances.
- Rationalization of cost by system planning and operation optimization.
- Assessment of system performance, its ability to meet regulation requirements, and measures for its enhancement.
- Conduction of technical studies for system expansion and/or refurbishment purposes and prepare equipment specifications for these purposes.
- Conduction of postmortem analyses to establish failure causes and provision of remedial actions.
- Preparation of technical specifications for tendering purposes and reviewing tenders.
- Provision of third party opinions in disputed matters.

System problems with increasing importance need special analytical studies in the following areas:

- Voltage sags and swells.
- Harmonics levels and their control.
- Flicker problems and their mitigation.
- Integration of distributed generation in power systems.
- Insulation coordination.
- Arc flash regulations.
- Grounding systems and ground potential rise.
- Voltage control and VAR flow optimization.
- System reliability and outage analysis.
- Design of protection systems and coordination of relay settings for optimum selectivity and prompt isolation of faulty sections.

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