

ELECTRICAL SOFTWARE TOOLS OVERVIEW

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ABSTRACT: In this work sampling an over view about electrical power software tools, free and commercial software, software applicability, models and algorithm running and Specific COMPARISON OF THE ELEMENTS OF TWO PROGRAMS.

Keyword: Free Software, Commercial Software, electrical engineer process.

1.- INTRODUCTION:

ELECTRICAL SOFTWARE packages for system analysis can be basically divided into **two** classes of tools:

- Commercial softwares.
- Educational/research-aimed softwares.

Commercial software packages available on the market for e.g. are:

PSS/E, EuroStag, Simpow, Digsilent Power Factory, Etap, Power World, CAPE, CYME, etc. follows an *all-in-one*. Philosophy and are typically well-tested and computationally efficient. Despite their completeness, these softwares can result cumbersome for educational and research purposes. Even more important, commercial softwares are closed., i.e. do not allow changing the source code or adding new algorithms. For research purposes, the flexibility and the ability of easy prototyping are often more crucial aspects than computational efficiency. On the other hand, there is a variety of open source research tools, which are typically aimed to a specific aspect of power system analysis. An example is UWPFLOW which provides an extremely robust algorithm for continuation power flow analysis.

2.- BASIC QUESTIONS

2.1.- What is an Electrical Software?

Electrical Software it's a computer aided engineering tool for the analysis, based in mathematic, physic, logic and over electromagnetic, electromechanically lays algorithm, and by other ways, this computer tools are based on high-performance level computer language, which solutions is to apply different rules of convergence. the result of this computer tools are to facility the electrical faults solutions works of the electrical engineer.

2.2 Models and Algorithms

in focus of the more the one models and algorithms, in this papers only shown for the most popular algorithms.

- Basically, trapezoidal rule of integration is used to solve the differential equations of system components in the time domain.

- Rule of solves the differential equations of the entire power system and its controls in the time domain (both electro-magnetic and electro-mechanical systems). This class of simulation tool differs from load flow and transient stability tools, which use steady state equations to represent electrical circuits (i.e. electromagnetic), but solve the differential equations of machine mechanical dynamics (i.e. rotational inertia).
- Other package fixed-step more the one types of variable-step solvers can be used, depending on the complexity of the problem.
- Integrated, interactive single line graphic and data case handling or same
- Solutions of Modal Equations and others techniques.

2.3.- Software Applicability?

The main applications of this softwares is for any electrical problem, planning, operating, control, enterprise energy management, etc.

2.4.- Who are to be apply?

Can to be apply planner engineer, analytical engineer, operator, controller, engineer students, professor, etc. the utilizations is satisfied after strong electrical concept understand, because is very necessary take the global and punctual concept in the mind.

2.5.- Is an electrical software an virtual laboratory?

The Continuous development of appropriate software packages makes simulation of power engineering problems more and more effective, grown the more the best tools, can exactly simulate of power electrical systems, whit high validate outputs, can be applicable in electric systems design, electric device design, and others, from each other considerably from the point of view of the applicability to a special problem. This tools are very realistic, are virtual electrical systems, when the electrical engineer can

change any parameters or operations state, etc.

The software tools applications in the electric power field involving planning, design, constructions, operations, maintenance, and control of power systems. Each issue carries feature virtual experience for active engineer.

En CIEEP¹ used to simulate a wide spectrum of dynamic systems ATP-EMTP, Matlab, and PSSCAD. which are specific software to simulate power system transient problems and CIEEP research engineer obtain virtual experience.

2.6.- Which are the Virtual laboratory benefits

Engineers and scientists spend countless hours learning in the classroom and poring over academic journals, but nothing compares to the training they receive in the laboratory. Hands-on education allows them to experience the backbone of engineering and science—conducting experiments, testing hypotheses, learning from their mistakes, and reaching their own conclusions. For students with disabilities that prevent them from using their arms, the lab has been a place for observation, not action. Now, in a novel extension of the innovative computer-based tutoring technology he developed, Brian P. Butz, an electrical engineering professor at Temple is helping these students overcome their disabilities and get the most out of their learning experiences. Its necessary to do actual experience or hand-on practice, but this activity is often expensive and logically complex or dangerous. Numerical simulation software has been developed as the solution. The engineers can create a computerized simulation model for simulating the actual experience. Complexity of the concepts that has to be represented makes the utilization of the numerical simulation software.

Experiment in laboratory has been considered as natural studying method for understanding the phenomena or the concepts of technology and science. This method would be adapted in the utilization of numerical simulation system by developing environment that makes the engineers as if doing an experiment when they are exploring the system.

The virtual laboratory applications of electrical engineering safety will form the basis for experiential work in existing electrical systems such as simulation and development of new design/simulation immersive learning opportunities are also available teaching tool

3. Electrical Engineering intended software classifications

in this work are shown an intended software classifications:

A.- FREE SOFTWARE

UWPFLOW

Voltage Stability Toolbox (VST) - PC/Unix Version
SPS (SimPowerSystems)

PSAT (Power system Analysis Tool)

PSAP (Power System Analysis Program)

PST (Power System Toolbox)

PAT (Power Analysis Toolbox)

MATPOWER

MATEMTP (Matlab Electromagnetic Transient Program)

EST (Educational Simulation Tool)

ATP (Alternative Transient Program)

PCFLO and PCFLOH

Intelligent Systems in Power Systems

Powertech

PSAT - PowerFlow & Short circuit Analysis Tool

VSAT - Voltage Security Assessment Tool

TSAT - Transient Security Assessment Tool

SSAT - Small Signal Analysis Tool

CDT - Control Design ToolBox

B.- COMMERTIAL SOFTWARE

CYME (CYME INTERNATIONAL INC. USA-Canada)

PSS/E (Power Technologies, INC. Canada)

EuroStag (Tractebel, EDF Electric France Belgium - Frnace)

Simpow (STRI from ABB.)

PSCAD (Manitoba HVDC Research Centre Inc. Canada)

DigSilent PowerFactory (DigSILENT GmbH Germany)

PowerWorld (PowerWorld Corporation - Canada)

MATLAB

SIMULINK

ASPEN

EMTP-RV (TransÉnergie Technologies Hydro-Québec group)

EMTP96 (DCG/EPRI EMTP User)

NEPLAN (BCP-Suiza)

CAPE (Electrocon - USA)

SKM POWER TOOLS (SKM Systems Analysis, Inc. USA)

RTDS Simulator (RTDS Technologies Inc. Canada)

ETEP (Operation Technoloogies, Inc. USA)

EDSA (EDSA Micro Corporation USA)

SPARD Power (Energy Computer System, Inc.)

CDEGS (SES – USA)

ERACS - Power Systems Analysis Software (ERA Technology Ltd. UK)

4.- Any Electrical software Over View descriptions

A.- FREE SOFTWARE

UWPFLOW

UWPFLOW is a research tool that has been designed to calculate local bifurcations related to system limits or singularities in the system Jacobian. The program also generates a

¹ Centro de Investigaciones eléctricas electrónicas del Perú

series of output files that allow further analyses, such as tangent vectors, left and right eigenvectors at a singular bifurcation point, Jacobians, power flow solutions at different loading levels, voltage stability indices, etc.

Voltage Stability Toolbox (VST)

Voltage instability and collapse have become an increasing concern in planning, operation, and control of electric power systems. In order to understand the phenomena and mechanics of voltage instability, a powerful and user-friendly analysis tool is very helpful. Voltage Stability Toolbox (VST) developed at the Center for Electric Power Engineering, Drexel University combines proven computational and analytical capabilities of bifurcation theory and symbolic implementation and graphical representation capabilities of MATLAB and its Toolboxes. It can be used to analyze voltage stability problem and provide intuitive information for power system planning, operation, and control.

SPS (SimPowerSystems)

The `power_analyze` command computes the equivalent state-space model of the specified electrical model built with SimPowerSystems. It evaluates the A , B , C , D standard matrices of the state-space system described by the equations

$$\begin{aligned}\dot{x} &= Ax + Bu \\ y &= Cx + Du\end{aligned}$$

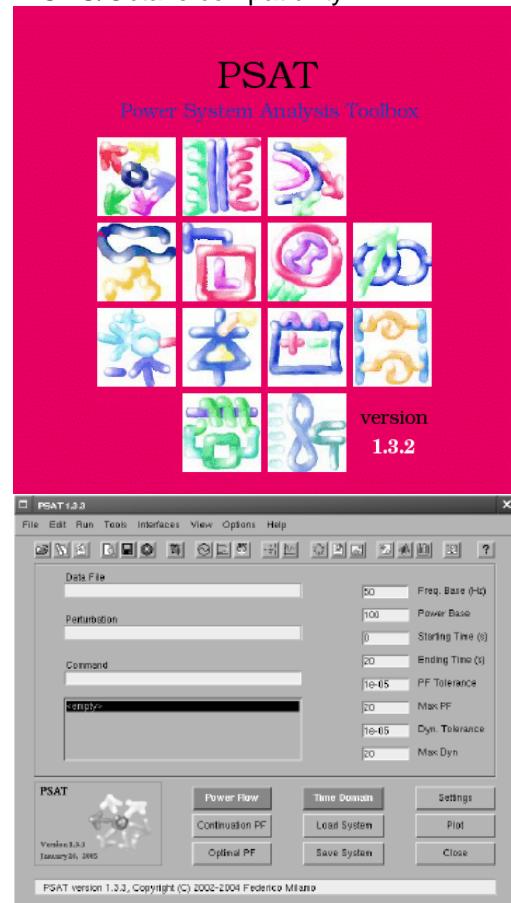
where the state variables contained in the x vector are the inductor currents and capacitor voltages. Nonlinear elements are simulated by current sources driven by the voltages across the nonlinear elements.

The inputs of the system contained in the u vector are the voltage and current sources plus the current sources simulating the nonlinear elements. The outputs of the system contained in the y vector are the voltage and current measurements plus the voltages across the nonlinear elements.

PSAT (Power system Analysis Tool)

The main features of PSAT are Power flow, Continuation power flow, Optimal power flow, Small signal stability analysis, Time domain simulation, Phasor Measurement Unit (PMU) placement, Complete graphical user interface, CAD for network design (Simulink library), User defined models, Conversion of data files from several formats, Export results to EPS, plain text, MS Excel and LaTeX files, Interfaces to GAMS and UWPFLOW programs, Command line usage, GNU/Octave compatibility.

- Power flow
- Continuation power flow
- Optimal power flow
- Small signal stability analysis
- Time domain simulation
- Phasor Measurement Unit (PMU) placement
- Complete graphical user interface
- CAD for network design (Simulink library)
- User defined models
- Conversion of data files from several formats
- Export results to EPS, plain text, MS Excel and LaTeX files
- Interfaces to GAMS and UWPFLOW programs
- Command line usage
- GNU/Octave compatibility



PSAP (Power System Analysis Program)

Power System Analysis Program (PSAP) is used to solve the power flow.

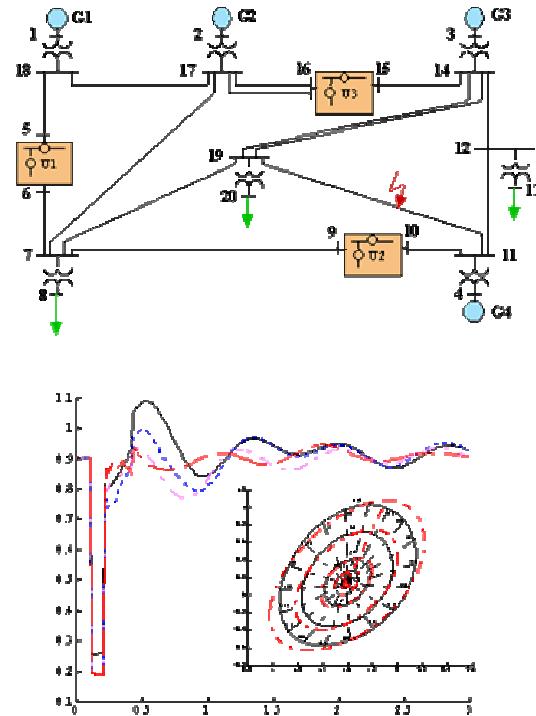
PST (Power System Toolbox)

PST was developed by Joe Chow of Rensselaer Polytechnic Inst. to enable users to perform power system analysis within MATLAB. It consists of a set of coordinated MATLAB m-files, power system application demo files, data files and a Users' Manual. A new version (2.0) is now available, which has been considerably enhanced from version 1.0. The enhancements have made the

toolbox more easy to use and it also has added models for induction motors and HVDC links. This version was developed using MATLAB Version 4.2c, but it has been converted to be fully MATLAB 5.* compatible.

PAT (Power Analysis Toolbox)

A simulation software package and design and analysis tools for complex interactive power systems: The Power Analysis Toolbox (PAT) within MATLAB/Simulink.



MATPOWER

Is a package of Matlab M-files for solving power flow and optimal power flow problems. It is intended as a simulation tool for researchers and educators that is easy to use and modify. MATPOWER is designed to give the best performance possible while keeping the code simple to understand and modify. It was initially developed as part of the PowerWeb project.

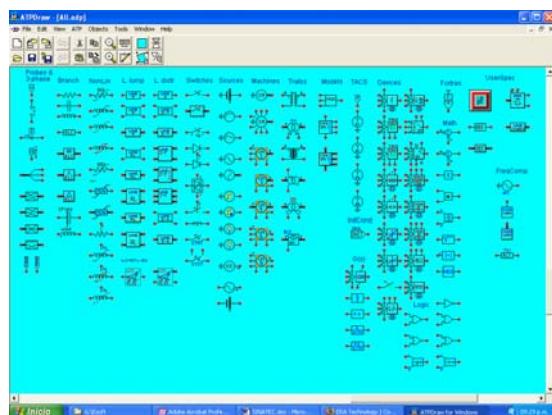
MATEMTP (Matlab Electromagnetic Transient Program)

Electromagnetic transient analysis, Power systems, Program in MATLAB: MatEMTP

EST (Educational Simulation Tool)

This case study provides an educational opportunity for electrical engineering students at the sophomore/Junior level to expand their knowledge about power systems in general, and more specifically power system blackout restoration. Besides offering explanations of concepts, this case study uses the dynamic environment of html to help create links for more detailed and often more visual representations of key concepts.

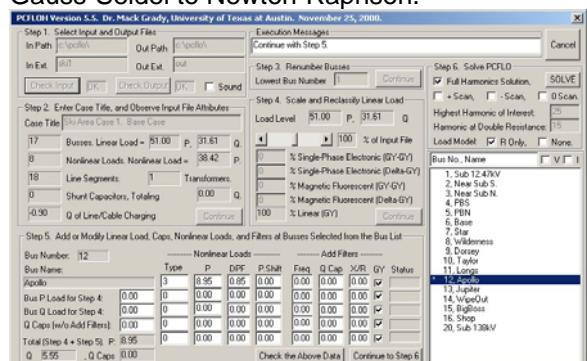
ATP (Alternative Transient Program)



Is the most widely used Electromagnetic Transients Program in the world! ATP is a universal program system for digital simulation of transient phenomena of electromagnetic as well as electromechanical nature. With this digital program, complex networks and control systems of arbitrary structure can be simulated. ATP has extensive modeling capabilities and additional important features besides the computation of transients.

PCFLO and PCFLOH

PCFLO is a load flow program which also includes short circuit and harmonics capabilities. PCFLOH is a harmonics-only version of PCFLO, with special user interface for harmonic studies. PCFLO contains some features not found in many load flow programs. For example, it lists the power loss on each line and transformer. It allows the user to control the transition point from Gauss-Seidel to Newton-Raphson.



Intelligent Systems in Power Systems

The module on intelligent systems in power systems contains three submodules: (1) security assessment, (2) fault analysis, and (3) distribution feeder protection. They have been tested on senior level power engineering classes

Powertech

PSAT - PowerFlow & Short circuit Analysis Tool
 VSAT - Voltage Security Assessment Tool
 TSAT - Transient Security Assessment Tool
 SSAT - Small Signal Analysis Tool
 CDT - Control Design ToolBox

Powertech's **DSA Tools** Suite is a leading-edge software package for Dynamic Security Assessment (DSA) of power systems. The software is suitable for both off-line (system planning) studies as well as on-line (near-real-time) power system security assessment. The **DSA Tools** include the following components,

MATLAB-BASED PACKAGES FOR POWER SYSTEM ANALYSIS

Package	PF	CPF	OPF	SSA	TD	EMT	GUI	GNE
EST	✓			✓	✓			✓
MatMTP						✓	✓	✓
MatPower	✓		✓					
PAT	✓			✓	✓			✓
PSAT	✓	✓	✓	✓	✓		✓	✓
PST	✓	✓		✓	✓			
SPS	✓			✓	✓	✓	✓	✓
VST	✓	✓		✓	✓		✓	

FUNCTIONS AVAILABLE ON MATLAB AND GNU/OCTAVE PLATFORMS

Function	Matlab	GNU/Octave
Continuation power flow	yes	yes
Optimal power flow	yes	yes
Small signal stability analysis	yes	yes
Time domain simulation	yes	yes
GUIs and Simulink library	yes	no
Data format conversion	yes	yes
User defined models	yes	no
Command line usage	yes	yes

B.- COMMERTIAL SOFTWARE

CYME (CYME INTERNATIONAL INC. USA-Canada)

Transmission & Industrial

PSAF, Power System Analysis Framework
 CYMFLOW, Power Flow Analysis
 CYM-AC, Contingency Analysis
 CYM-Motor Start, Motor Starting Analysis
 PSAF, Line Parameters Calculation
 PSAF, Cable Parameters Calculation
 CYMFAULT, Short Circuit Analysis
 CYMOPF, Optimal Power Flow Analysis
 CYMSTAB, Transient Stability Analysis
 CYMVSTAB, Voltage Stability Assessment
 WECS, Wind Energy Conversion Systems
 CYMHARMO, Harmonic Analysis
 CYMLINE, One Line Diagram
 ARC FLASH, Arc Flash Hazard Analysis
 CYMTCC, Protective Device Coordination
 CYMGRD, Substation Grounding Grid Design and Analysis
 CYMCAP, Cable Ampacity Calculations
 MDB, Multiple Duct Banks
 OPT, Duct Bank Optimizer
 CYMCAP-SCR, Short Circuit Cable Rating
 Distribution
 CYMDIST, Distribution System Analysis
 CYMDIST (MAP), Map Overlay

CYMDIST (SOM), Switching Optimization
 CYMDIST (HARMO), Harmonic Analysis
 CYMDIST (RAM), Reliability Assessment
 CYMDIST (CAM), Contingency Analysis
 CYMDIST (SUB/SUBNET), Substation and Sub-network Modeling and Analysis
 CYMDIST (SNA), Secondary Network Analysis
 CYMDIST Gateway, Creation and Maintenance of CYMDIST Distribution Network Model
 CYMTCC, Protective Device Coordination
 CYMGRD, Substation Grounding
 CYMCAP, Cable Ampacity Calculations
 CYMCAP-MDB, Multiple Duct Banks
 CYMCAP-OPT, Duct Bank Optimizer
 CYMCAP-SCR, Short Circuit Cable Rating

Solutions

CYMDIST (ASP), Advanced Switching Plan
 CYME SOLVERS, Embedded Calculation Engines
 CYMCAP/NET, Network-Wide Thermal Analysis
 MARS, Storm Assessment and Service Restoration
 CYMDIST Gateway, Creation and Maintenance of CYMDIST Distribution Network Model

PSS/E (Power Technologies, INC. Canada)

PSS/E Optimal Power Flow (PSS/E OPF) is a powerful and easy-to-use network analysis tool that goes beyond traditional load flow analysis to provide you with the ability to fully optimize and refine your transmission system. This task is made even easier with the complete integration of PSS/E OPF into the PSS/E load flow program.

PSS/E OPF improves the efficiency and throughput of your power system performance studies by adding intelligence to the load flow solution process. Whereas the conventional load flow relies on an engineer to systematically investigate a variety of solutions before arriving at a satisfactorily "good" solution, PSS/E OPF directly changes controls to quickly determine the best solution. From virtually any reasonable starting point, you are assured that a unique and globally optimal solution will be attained; one which simultaneously satisfies system limits and minimizes costs or maximizes performance.

In addition to being able to perform traditional analysis such as minimizing operating costs, PSS/E OPF is aptly suited to solving many problems more attuned to today's less regulated environment, including:

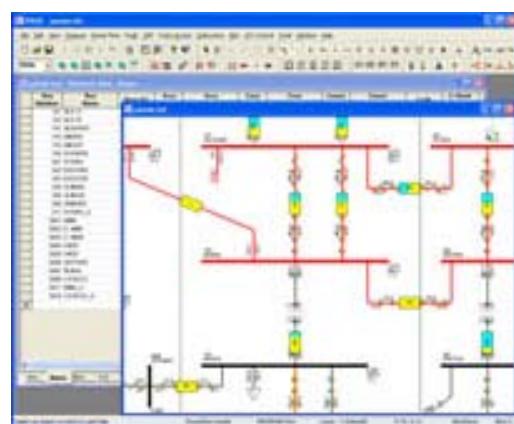
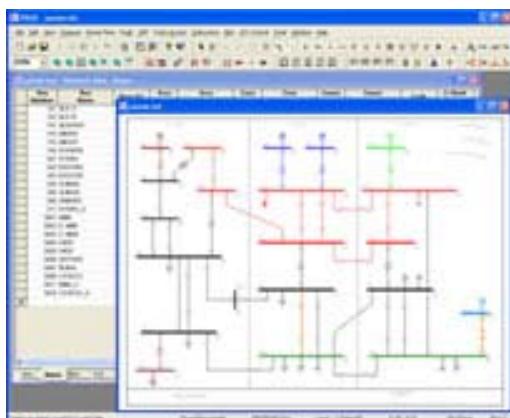
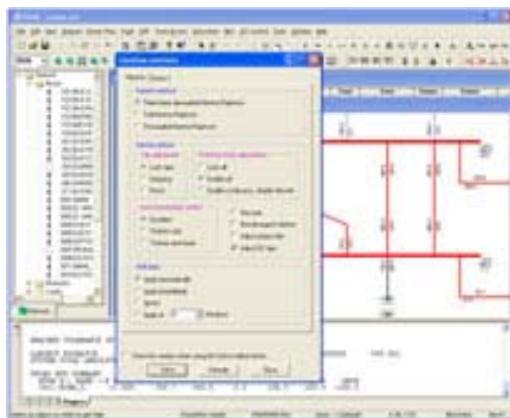
- Reactive power scheduling
- Voltage collapse analysis
- Transfer capability investigation
- Location-based marginal cost assessment
- Ancillary service opportunity cost assessment
- Impact assessment base case development

PSS/E OPF provides you with all of the most commonly desired objective functions, including:

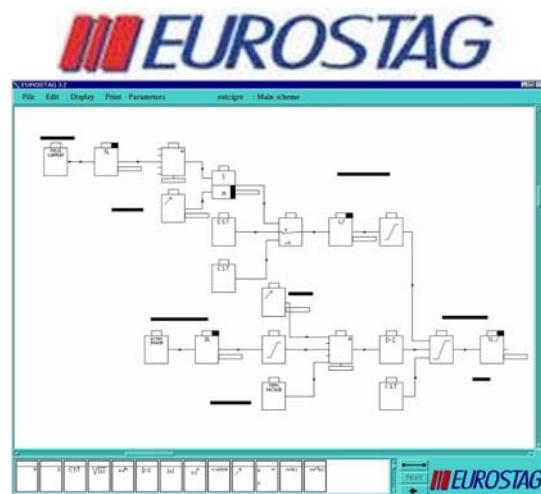
- Minimize fuel costs
- Minimize active power slack generation
- Minimize reactive power slack generation
- Minimize active power loss
- Minimize reactive power loss
- Minimize adjustable branch reactance
- Minimize adjustable bus shunts
- Minimize adjustable bus loads
- Minimize interface flows
- Maximize interface active power transfer

The optimal power flow problem statement is completed by combining the objective with any number of constraints and controls, selectable from the following:

- Bus voltage magnitude limits
- Branch flow limits (MW, Mvar, MVA, A)
- Interface flow limits (MW, Mvar)
- Generator reactive power capability limits
- Generation period reserve limits
- Generator active power limit
- Adjustable bus shunt limits
- Adjustable branch reactance limits
- Adjustable load limits



[EuroStag \(Tractebel, EDF Electric France Belgium - Fnace\)](#)



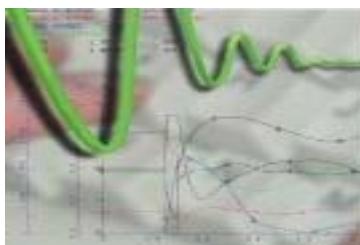
The user can create his own models, by using interactively a graphic tool (pre-processor). Each model is represented by a graphical scheme, the so called "macroblock". No FORTRAN nor C nor C++ coding is required to specify new models of turbines, boilers, controllers, SVC, load, ... The macroblocks are designed on the screen of the computer, using a large set of elementary blocks to build the block-diagram.

The macroblocks corresponding to different generating units or injectors can be coupled to represent the interactions between various power system components : hydro units on a same water column, combined cycles, HVDC lines, etc...

The first page shows an example of Automatic Voltage Regulator, modelled with the dedicated module of EUROSTAG. It includes the AVR, the excitation system and the overexcitation limiter.

You will see at the bottom of display a set of 13 elementary blocks, such as a summer, a multiplier, a constant, a square root, an exponential function, a gain, etc... More than 50 elementary blocks are available.

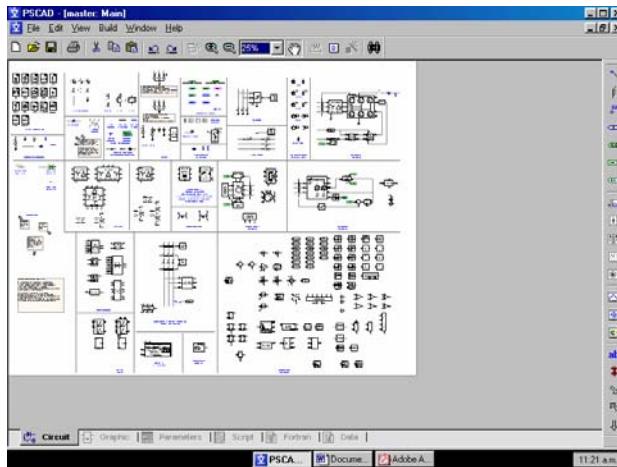
Simpow



The development of Simpow started 1977 at ASEA (ABB) since there was a need for a software for HVDC modelling. Since May 1st, 2004, the copyright, development and customer services of Simpow has been transferred to STRI from ABB.

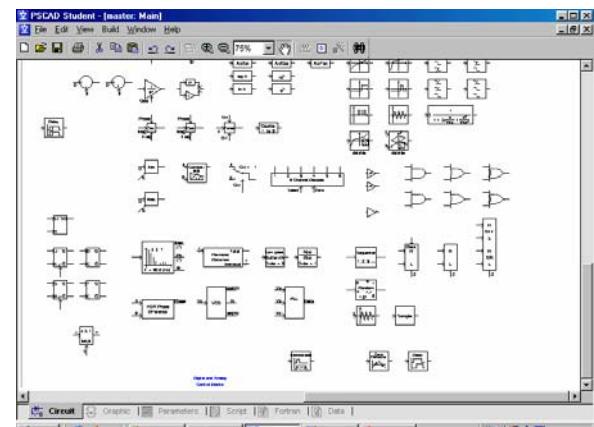
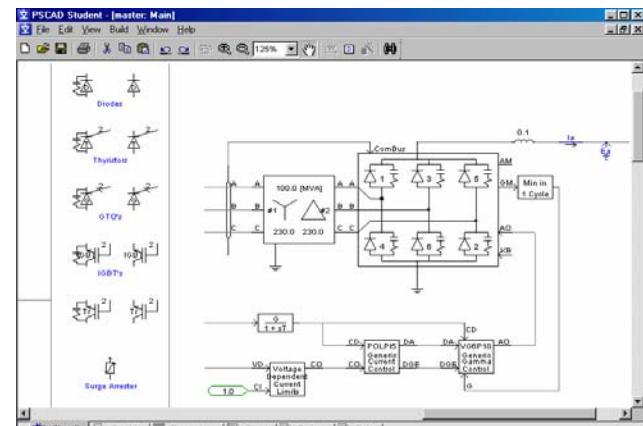
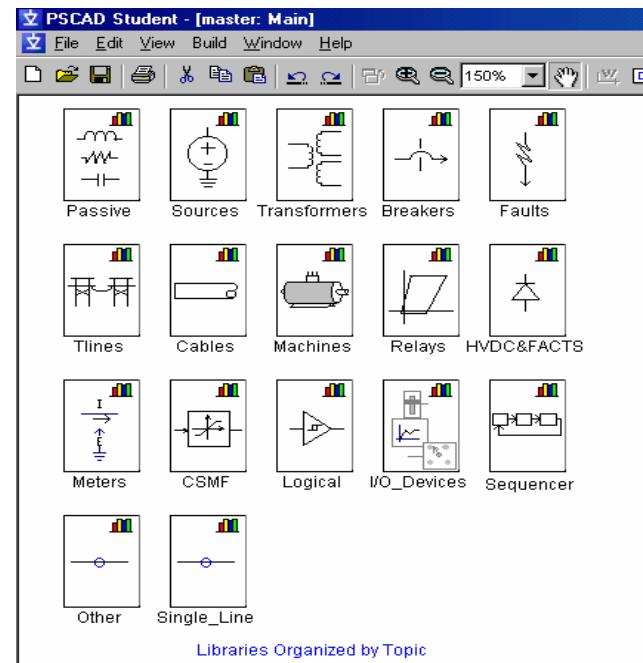
Simpow is a highly integrated software for simulation of power systems. It covers a wide field of network applications but focusing mainly on dynamic simulation in time domain and analysis in frequency domain. The unique simulation and analysis features ensure an efficient planning, upgrading and utilization of electrical power networks for power production, power transmission and distribution, steel industries, paper mills, chemical industries, oil production industries, consultant engineers EE, universities as laboratory tool for training under- and postgraduates, commercial research institutes, etc.

PSCAD (Manitoba HVDC Research Centre Inc. Canada)

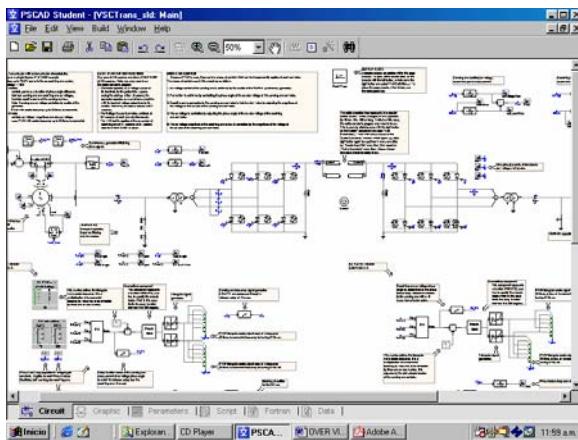


PSCAD™ is a fast, accurate, and easy-to-use power system simulator for the design and verification of all types of power systems.

For power quality studies, power electronic design, distributed generation, and transmission planning.

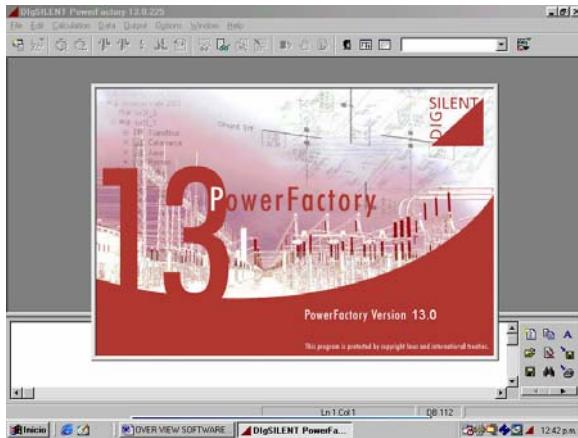


Control tools



- Frequency dependent T-lines and cables
- Multi-limb transformers with saturation
- Synchronous machines and SSR Studies
- Arrestors and insulation coordination
- Lightning and impulse studies
- HVDC, FACTS, and control coordination
- Power electronics and drives
- Control system modeling functions
- Logic functions

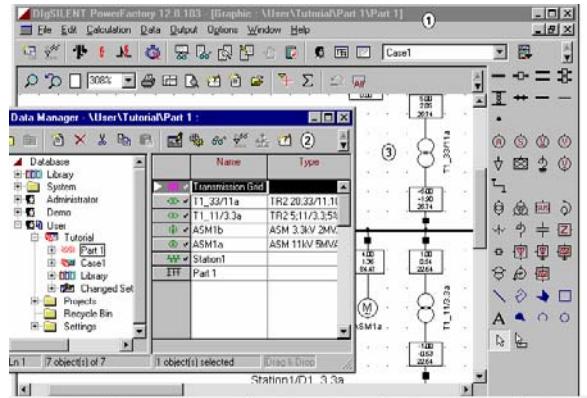
[DigSilent PowerFactory \(DigSilent GmbH Germany\)](#)



The calculation program DigSILENT PowerFactory is a computer aided engineering tool for the analysis of industrial, utility, and commercial electrical power systems. It has been designed as an advanced integrated and interactive software package dedicated to electrical power system and control analysis in order to achieve the main objectives of planning and operation optimization.

The name DigSILENT stands for "Digital SImulation andElectrical NeTwork calculation program". DigSILENT Version 7 was the world's first power system analysis software with an integrated graphical one-line interface.

That interactive one-line diagram included drawing functions, editing capabilities and all relevant static and dynamic calculation features.



DigSILENT Base Functions

- Hierarchical, object-oriented database and Object Browser
- Single-user database server for 1 simultaneous user
- Integrated Network Expansion Stage & Study Case Administration
- Multiple-Window & Multiple-Graphic Single Line
- DPL Script Language
- DOLE interface for SCADA and GIS
- Network Reduction
- Voltage stability
- Contingency Analysis

Load Flow Analysis

- Load Flow for 1-Phase AC/DC and 2-,3- Phase AC Systems
- Balanced and Unbalanced Load Flow
- Station Control, Network Control and Transformer Tap-Changer Control

Fault Analysis

- VDE, IEC, ANSI and Complete Method
- General Fault Analysis for 1-Phase AC/DC and 2-,3- Phase AC Systems

DigSILENT Stability Functions:

- Balanced / unbalanced AC/DC systems
- RMS and EMT modeling, long-term stability
- Frames and Flexible DL++ modeling
- Eigenvalue analysis

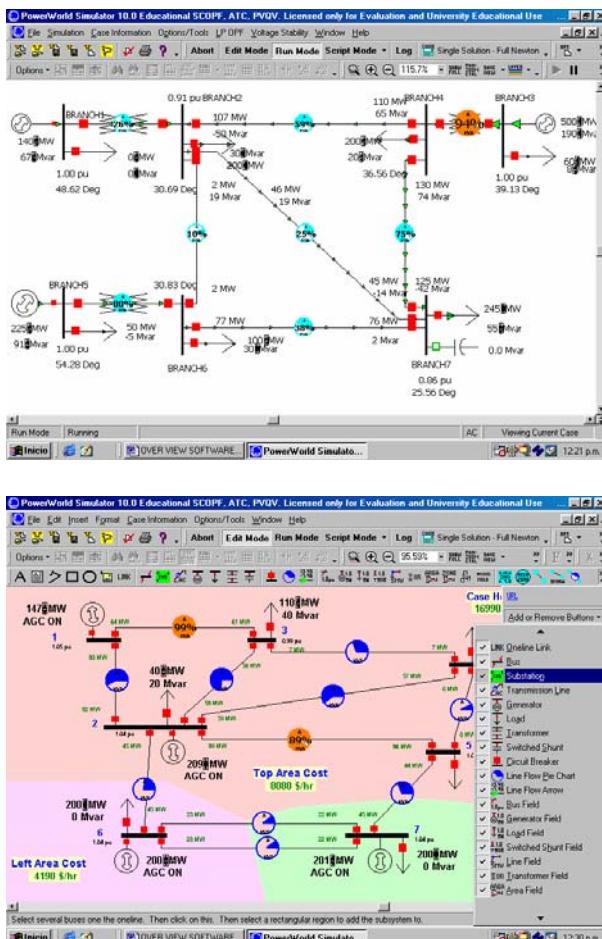
DigSILENT Harmonic Analysis:

- Balanced / unbalanced harmonics load flow
- Frequency Sweep

DigSILENT Protection Functions:

- Distance relay modeling
- Time-overcurrent relay modeling
- Device response checks

PowerWorld (PowerWorld Corporation - Canada)



PowerWorld Simulator (Simulator) is a power system simulation package designed from the ground up to be userfriendly and highly interactive. Simulator has the power for serious engineering analysis, but it is also so interactive and graphical that it can be used to explain power system operations to non-technical audiences. With Version 11.0 we've made Simulator more powerful, more visual, and easier to use. Simulator consists of a number of integrated products. At its core is a comprehensive, robust Power Flow Solution engine capable of efficiently solving systems of up to 100,000 buses. This makes Simulator quite useful as a standalone power flow analysis package. Unlike other commercially available power flow packages, however, Simulator allows the user to visualize the system through the use of full-color animated one line diagrams complete with zooming and panning capability. System models can be either modified on the fly or built from scratch using Simulator's full featured graphical case editor. Transmission lines can be switched in (or out) of service, new transmission or generation can be added, and new transactions can be established, all with a few mouse clicks. Simulator's extensive use of graphics and animation greatly increases the user's

understanding of system characteristics, problems, and constraints, as well as of how to remedy them. The base package of Simulator is capable of solving power systems comprised of up to 100,000 buses. The base package also contains all the tools necessary to perform integrated economic dispatch, area transaction economic analysis, power transfer distribution factor (PTDF) computation, short circuit analysis, and contingency analysis. All of the above features and tools are easily accessible through a consistent and colorful visual interface. These features are so well integrated that you will be up and running within minutes of installation.

MATLAB - SIMULINK

MATLAB® is a high-performance language for technical computing that includes functions for numeric computation, data analysis, algorithm prototyping, system simulation, and application development.

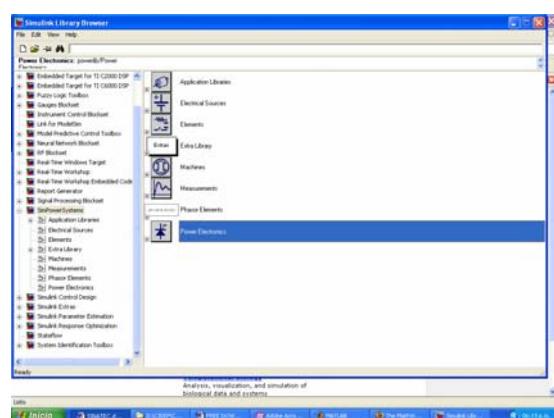
Multiplatform interoperability: MATLAB applications are fully transportable without modification across platforms.

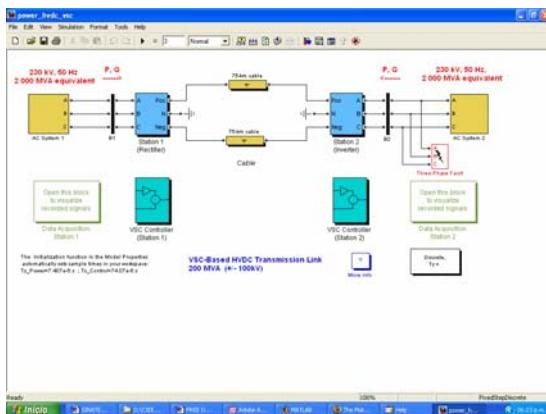
MATLAB data files (MAT-files) from different environments are converted automatically.

MATLAB offers a unique simulation and prototyping environment. The powerful technical language is both concise and descriptive, allowing you to model complex systems with small sections of easy-to-follow code.

MATLAB and companion products offer an array of tools for simulation and modeling, including:

- A large collection of high-performance functions for mathematical computation, data analysis, equation solving, and visualization, all available as part of core MATLAB.
- Additional state-of-the-art algorithms in MATLAB add-on Toolboxes.
- Simulink and Stateflow block-diagram graphical design environments.





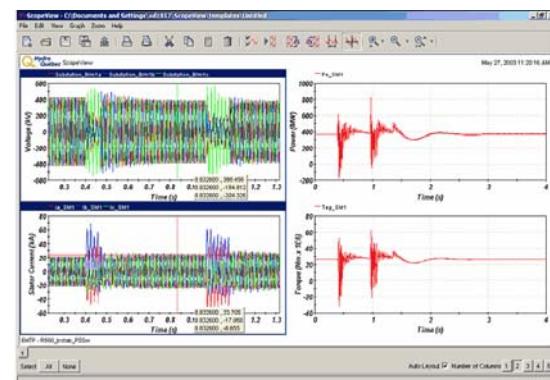
ASPEN

Advanced Systems for Power Engineering, Inc. (ASPEN) is a developer and marketer of state-of-the-art engineering software for electric utilities. *ASPEN OneLiner* is a PC-based short circuit and relay coordination program for relay engineers. *OneLiner* is a productivity tool. It relieves the engineer from the tedious and time-consuming tasks of leafing through stacks of printouts and plotting and re-plotting relay curves and one-line diagrams. *OneLiner* works very quickly under the control of the engineer. The engineer can change the relay settings and network configuration and see the results of the change immediately. The following are some highlights of *OneLiner*:

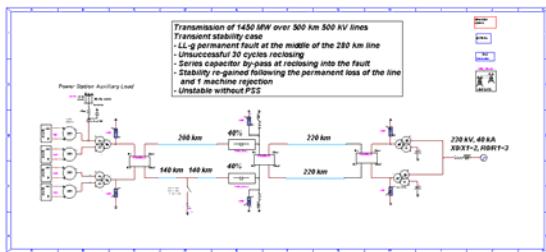
- Native Microsoft Windows program.
- Easy-to-use interactive graphics interface under Windows 95, 98, ME, NT, 2000, and XP.
- Accurate modeling of 2- and 3-winding transformers, phase shifters, lines, switch, series capacitors, generators, loads, shunts, dc lines, and zero-sequence mutual coupling.
- Detailed modeling of fuses, reclosers, and overcurrent and distance relays. Extensive relay library that can be edited by the user.
- Built-in short circuit program that simulates all classical fault types (bus faults, and line-end, line-out and intermediate faults), as well as simultaneous faults.
- Virtually unlimited system size with modest memory requirement.
- Lightning fast solution speed.
- Graphical display of post-fault solution and relay operating time on the one-line diagram and the phasor diagram.
- Automatic checking of overcurrent and distance relay coordination, plus automatic checking of overcurrent relays' pickup and instantaneous settings.
- Automatic plotting of overcurrent and distance relay characteristics on the screen.

- User-defined distance-relay methods using DLLs written in C++.
- High-quality printed outputs on a large variety of printers and plotters.
- Built-in boundary equivalence program.
- Generates relay end-to-end test files in Doble, COMTRADE, Omicron and other formats.
- Data importing facilities for short circuit data in ANAFAS, CYME, Electrocon, GE, PECO, PTI (PSS/E and PSS/U) and other formats.
- Data exporting in PTI PSS/E raw and sequence data format, GE PSLF and Short Circuit formats, and ANAFAS data format.
- Built-in PC network support.
- Built-in scripting language using the BASIC programming language.

EMTP-RV (TransÉnergie Technologies Hydro-Québec group)



EMTP-RV is the end result of the "EMTP Restructuring project" undertaken by the DCG in 1998 for modernizing the EMTP96 software. EMTP-RV is the enhanced computational engine and EMTPWorks its new graphical user interface (GUI). The package is a sophisticated computer program for the simulation of electromagnetic, electromechanical and control systems transients in multiphase electric power systems. It features a wide variety of modeling capabilities encompassing electromagnetic and electromechanical oscillations ranging in duration from microseconds to seconds. Examples of its use include switching and lightning surge analysis, insulation coordination, shaft torsional oscillations, ferroresonance and power electronics applications in power systems.

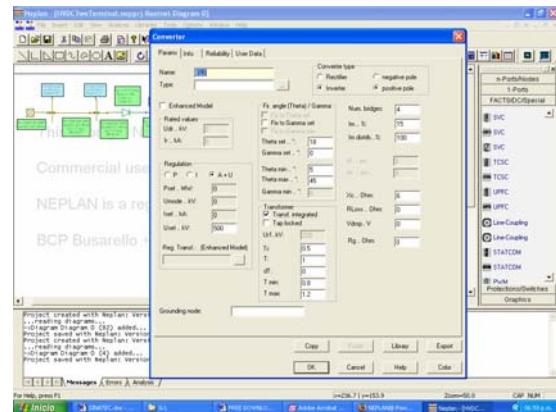
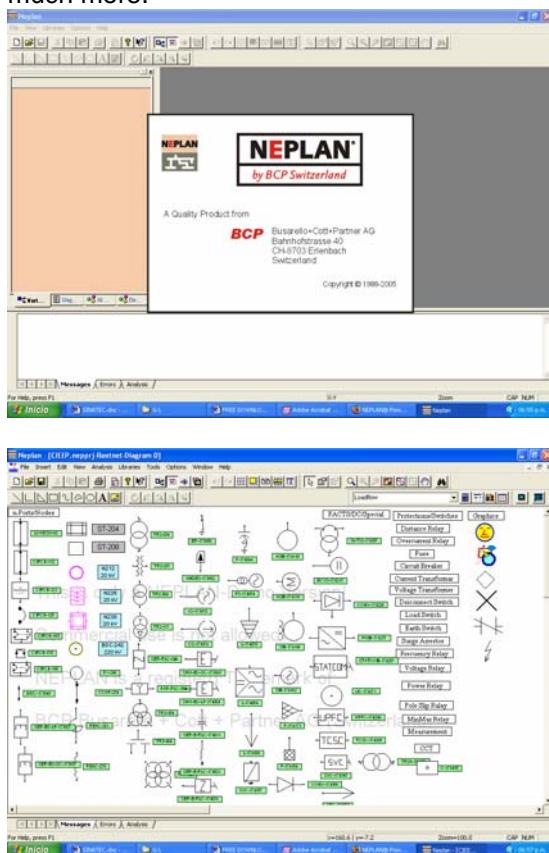


EMTP96 (DCG/EPRI EMTP User)

EMTP96 is the most technically advanced transients analysis program for the simulation of electromagnetic transients and harmonic analysis, addressing the needs of engineers in areas such as power quality, lightning protection, insulation coordination, capacitor bank switching, ferroresonance, and power electronics in electrical power systems. You can reach us, the DCG/EPRI EMTP User Support and Maintenance Centre at Hydro One Networks Inc

NEPLAN (BCP-Suiza)

The most user-friendly and fully integrated Power System Analysis software for Electrical Transmission, Distribution and Industrial Networks, including Optimal Power Flow, Transient Stability, Reliability Analysis and much more.



NEPLAN upgrades your productivity

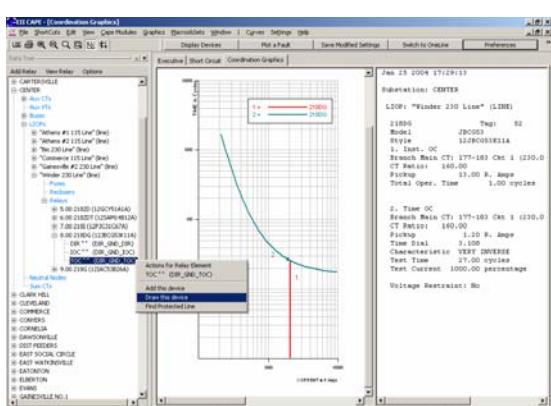
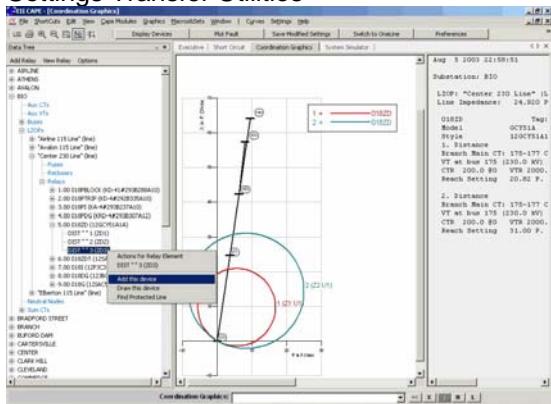
- fully-thought-out data management facility, featuring plausibility checks
- integrated connection to widely used databases
- SQL data scanning for MS-Access, Oracle
- management of different network variants
- multi-layer techniques
- flexible choices for displaying results
- extensive libraries for network elements and protection devices
- direct interfacing with geographical information systems (GIS) and SCADA systems
- option for expansion into your own network information system (NIS)

CAPE (Electrocon - USA)

The programs of the Computer-Aided Protection Engineering (CAPE) series were designed to serve you the protection engineer with the most powerful, easy-to-use software tools we could devise. CAPE is a world-class productivity tool developed by Electrocon under the initial sponsorship of ten major U.S. electric utilities. CAPE consists of a series of core and optional modules for analysis and reporting, linked by a general-purpose database. Beginning from this CAPE Home Page you will find detailed descriptions and pictures of each of the basic and optional modules of CAPE. Operating requirements, and licensing information follow immediately after the list.

- Database Editor
- Short Circuit
- One-Line Diagram
- Coordination Graphics
- Relay Setting
- System Simulator
- Relay Checking
- Line Constants
- Order Production

Short Circuit Reduction
Power Flow
Breaker Duty Analysis
Settings Transfer Utilities



Support for macros is also a standard feature. In its simplest form, a macro may be just an abbreviation you choose for a command. In more powerful macros, entering the macro name invokes a whole set of commands that run like a program within the CAPE program. In CAPE, macros have been extended to allow commands normally found in high-level computer languages, commands such as IF-THEN-ELSE, DO-WHILE, and DO loops such as DOBUSES and DOLINES that are tailored to power system problems. Taken together, these features are referred to as the CAPE User's Programming Language (CUPL).

SKM POWER TOOLS (SKM Systems Analysis, Inc. USA)

PTW Arc Flash Evaluation calculates the incident energy and arc flash boundary for each location in a power system. Arc Flash saves time by automatically determining trip times from the protective device settings and

arc fault current values. Incident energy and arc flash boundaries are calculated following the NFPA 70E and IEEE 1584 standards. Clothing requirements are specified from a user-defined clothing library. Clearing times can be automatically reduced based on current-limiting capabilities.

- Avoid fires, lost productivity, and litigation costs.
- Design safer power systems while insuring compliance with NEC 110.16, OSHA, NFPA 70E and IEEE 1584 standards. Save time with the fully integrated Short Circuit, Over-Current Coordination, Equipment Evaluation and Arc Flash Evaluation modules working together with libraries of clothing levels, protective devices and bus ratings.
- Provide a safer working environment by specifying the proper level of clothing. Wearing inadequate clothing is dangerous for obvious reasons, but wearing too much clothing is dangerous due to limited mobility and visibility.
- Evaluate alternatives quickly and easily to establish an optimal design.
- Improve safety margins with user-definable arcing fault tolerances.
- Save time by automatically generating arc flash labels and work permits.
- Avoid potential fines, lost productivity, and increased insurance and litigation costs.

ETAP (Operation Technologies, Inc. USA)



ETAP is the most comprehensive analysis tool for the design, simulation, and operation of generation, distribution, and industrial power systems.

ETAP Real-Time is a suite of software tools that offers a fully integrated enterprise solution. Through continuous monitoring, simulation, and optimization of the electrical, process, manufacturing, and management systems that are in place, ETAP optimizes the entire production process, reduce losses, and increase profits.

- System monitoring
- Cost optimizations
- Load management
- Real Time Simulator
- Alarm & Warning
- Dynamic Load Shedding, etc.

EDSA (EDSA Micro Corporation USA)



- Intelligent Electrical System Health Monitoring
- Intelligent Predictive Detection and Control
- Distributed and Embedded Secure Solutions
- Enterprise Wide View of all Key Processes
- Massively Scalable with Built-In Redundancy
- Secure Browser based solutions
- Rapidly Deployable for Mission Critical Applications
- Intelligent One-Line Diagramming, Block Diagramming and Control System Diagramming
- Robust Reporting, Plotting and Charting Built-In
- Integrated Control System Simulation (open and closed loop)
- Fault Analysis (IEEE ANSI IEC) & Arc Heat Simulation (NFPA70E 2004\ IEEE 1584)
- Power Flow Simulation (AC and DC) with Integrated Expert System
- Protection Coordination with integrated Expert System

- Best-of-Breed Dynamic Transient Stability Simulation.
- Power Quality and Reliability Analysis with integrated Expert System

5.- COMPARISON OF THE ELEMENTS OF THE PROGRAMS

Showing a abstract table Nro. 1, for the next software:

ATP-Draw

PSACAD

MatLab

Item	RESULTS OF SURVEY. COMPUTER TOOLS		
	Helpful	Some	Little
ATP-EMTP			
Number of circuit element models	65	25	5
Programming freedom and flexibility	59	31	5
PSCAD-EMTDC			
Number of circuit element models	58	33	4
Programming freedom and flexibility	53	38	4
MATLAB			
Number of circuit element models	45	44	6
Programming freedom and flexibility	70	21	4

Specific COMPARISON OF THE ELEMENTS OF TWO PROGRAMS

Source

MATLAB	ATP
<ul style="list-style-type: none"> ➤ DC voltage source, ➤ AC voltage or current source, External controlled voltage or current source (controlled by an arbitrary signal), ➤ 3-phase programmable control source (time variation of amplitude, phase and frequency by step, ramp or modulation, 2 harmonics in addition). 	<ul style="list-style-type: none"> ➤ DC source, current or voltage, ➤ AC source, current or voltage, ➤ Ungrounded AC or DC voltage source, ➤ AC source, 3 phase, current or voltage, ➤ Ramp source, current or voltage, ➤ Two-slope ramp source, current or voltage, ➤ Double exponential source, ➤ Heidler, Standler, Cigré type source, current or voltage, ➤ TACS controlled source, current or Voltage.

Switches

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Single and three-phase logical controlled (opens at next current zero-crossing) ➤ Ideal switch (parallel to an RC snubber circuit) 	<ul style="list-style-type: none"> ➤ Single phase time controlled, ➤ Three-phase time controlled, ➤ Voltage controlled, ➤ TACS (external) controlled, ➤ Statistic (random, based on predefined distribution functions), ➤ Systematic (periodic).

Machines

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Synchronous, 3 phase (Fundamental standard parameters, former ones pu), ➤ Simplified synchronous, ➤ Permanent magnet synchronous, ➤ Synchronous machine voltage regulator and exciter, ➤ Asynchronous, ➤ DC, ➤ Steam turbine and governor, ➤ Hydraulic turbine and governor. 	<ul style="list-style-type: none"> ➤ Synchronous, 3 phase, ➤ Synchronous with TACS control, 3 phase, ➤ Synchronous, set initialisation under ATP, 3 phase ➤ Induction (Asynchronous), set initialisation under ATP, 3 phase, ➤ Induction (Asynchronous), set initialisation under ATP, 1 phase, ➤ DC, set initialisation under ATP.

Lines, cables

MATLAB	ATP
<p>Lumped</p> <ul style="list-style-type: none"> ➤ _ P Section line, parameters: Number of P sections and R, L, C values. <p>Distributed (based on Bergeron's</p>	<p>Lumped</p> <ul style="list-style-type: none"> ➤ RLC equivalent 1, 2, 3 phase, ➤ RL coupled non-symmetric 2, 3, 2x3 phase, ➤ RL coupled, symmetric 3, 2x3 phase.

<p>method)</p> <ul style="list-style-type: none"> ➤ Parameters given by N*N matrices, ➤ Parameters given by sequential components. 	<p>Distributed</p> <ul style="list-style-type: none"> ➤ Transposed 1, 2, 3, 6, 2x3, 9 phase, ➤ Untransposed 2, 3 phase. <p>LCC line/cable</p> <ul style="list-style-type: none"> ➤ defined by the geometrical and material data of the line/cable 1...9 phase. Bergeron, P, J-Marti, Noda and Semlyen type of transmission line models.
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Transformers

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Linear, 1 phase (2 or 3 windings), ➤ Linear, 3 phase (YgY, YgD1, YgD11, D1Yg, D11Yg, YgYD, YgYgD), ➤ Saturable, 1 phase (2 or 3 windings), ➤ Saturable, 3 phase (YgYgD), ➤ 12 terminal linear 3 phase transformer (the connections can be set manually) <p>Three phase transformers are assembled from single-phase ones.</p>	<ul style="list-style-type: none"> ➤ Ideal, 1 phase (only the turn ratio can be given), ➤ Ideal, 3 phase (only the turn ratio can be given), ➤ Saturable, 1 phase (2 windings), ➤ Saturable, 3 phase (2 or 3 windings, the winding connection and phase shift can be chosen), ➤ Saturable, 3 phase, 3-leg core type (Y/Y only) with high homopolar reluctance ➤ BCTRAN

Linear Elements

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Series RLC branch, 1 phase, ➤ Series RLC branch, 3 phase, ➤ Parallel RLC branch, 1 phase, ➤ Parallel RLC branch, 3 phase. <p>Parameters can be defined either as R,L,C or as P and Q.</p> <ul style="list-style-type: none"> ➤ 3 phase mutual inductance. 	<ul style="list-style-type: none"> ➤ IResistor, ➤ Capacitor with damping resistor, ➤ Inductor with damping resistor, RLC in series, 1 phase, ➤ RLC in series, 3 phase, ➤ RLC branch 3 phase Y-connected, ➤ RLC branch 3 phase D-connected, ➤ Capacitor with initial voltage, ➤ Inductor with initial current.

Non-linear Elements

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Metal-oxide surge arrester. 	<ul style="list-style-type: none"> ➤ Resistor, time-dependent, ➤ Resistor, current-dependent, ➤ Resistor, TACS (external) controlled, ➤ Inductor, current dependent, ➤ Inductor, current dependent with initial flux, ➤ Hysteresis inductor, ➤ Hysteresis inductor with initial flux, ➤ Metal-oxide arrester (exponential currentdependent resistor) 1 and 3 phase.

Power electronics

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Diode, ➤ Thyristor, ➤ IGBT, ➤ GTO, ➤ Mosfet ➤ 1, 2 or 3-arm bridge of any of the former. 	<ul style="list-style-type: none"> ➤ Diode, ➤ Thyristor (Valve)controlled by TACS, ➤ Triac.

Power electronics Devices

MATLAB	ATP
<ul style="list-style-type: none"> ➤ HVDC, 6, 12, 24 Pulses ➤ SVC ➤ STATCOM ➤ UPFC ➤ TCSC ➤ DRIVES. Etc. 	<ul style="list-style-type: none"> CIEEP-ATP users devices Diode, ➤ HVDC, 6, 12, Pulses ➤ SVC ➤ STATCOM ➤ UPFC ➤ TCSC ➤ Custom Power devices ➤ Cycloconverter, and others

Power electronics control blocks

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Timer (generates a control signal as specified transition times), ➤ Synchronised 6 or 12-pulse generator (to fire the 6 or 12 electronics switches of a 6 or 12 pulse converter). 	<ul style="list-style-type: none"> ➤ Need to be constructed by the user using ➤ TACS or MODELS.

Measurement elements

MATLAB	ATP
<ul style="list-style-type: none"> ➤ Ideal voltage and current measurement, ➤ Impedance measurement, ➤ True RMS meter, ➤ Fourier coefficients, ➤ THD, ➤ Active and Reactive power ➤ 3phase sequence analyser, ➤ abc to dq0 transformation and vice versa. 	<ul style="list-style-type: none"> ➤ Probe TACS, ➤ Ideal voltage and current measurement, ➤ Branch voltage measurement ➤ Instantaneous power and energy (for most elements).

Signal processing units

MATLAB	ATP
<p>Some additional sources:</p> <ul style="list-style-type: none"> ➢ Step, ➢ Ramp, ➢ Sine wave, ➢ Random generator (gives uniformly or normally distributed random signal), ➢ Arbitrary repeating sequence, ➢ Clock, ➢ From file. <p>Sinks (simulation outputs):</p> <ul style="list-style-type: none"> ➢ Numerical display, ➢ Time scope, ➢ XY scope, ➢ Power spectral density scope (FFT), ➢ Spectrum analyser (transfer function between two points, with some restrictions) ➢ To File, ➢ Auto-correlator and cross-correlator. <p>Continuous:</p> <ul style="list-style-type: none"> ➢ Derivative, ➢ Integrator, ➢ Transfer function (user defined transfer function in the “s” domain), ➢ Variable delay (apply variable time delay to the input). <p>Discrete:</p> <ul style="list-style-type: none"> ➢ Sample/Hold (Zero/First-order sample and hold function), ➢ Transfer functions (user defined transfer function in the “z” domain), Math, logical, statistical: ➢ wide range of functions (complex, logical, trigonometric, statistical etc.). ➢ Algebraic Constraint: it solves an equation $f(x) = 0$ where x is the output of this block, and it is indirectly connected back to the block's input, which is $f(x)$. This connection realises the function f. In each simulation step an iteration of the output is performed so that the input equals to zero. Non-linear: ➢ several types of simple non-linear functions (Relay, Quantiser, Dead zone, Rate limiter, Saturation etc.). ➢ n dimensions look-up table (user define value n-tets, e.g. in 2D case a simple function given by pairs of points; linearly interpolated in between), ➢ Flip-flops (J-K, S-R, D, D Latch, 	<p>TACS sources in the signal processing network:</p> <ul style="list-style-type: none"> ➢ DC, ➢ AC, ➢ Pulse, ➢ Ramp. <p>Transfer functions:</p> <ul style="list-style-type: none"> ➢ Transfer function (user defined transfer function in the “s” domain, max. 7th order) ➢ Integral ➢ Simple derivative ➢ Filters (first order low/high pass) <p>Devices:</p> <ul style="list-style-type: none"> ➢ Frequency sensor ➢ Relay-operated switch (controlled by an external signal absolute value) ➢ Level-triggered ➢ Transport delay (give a limited delay that consists a fix and an input dependent component) ➢ Point-by point non-linearity ➢ Multiple open-close switch (Gives 18 open and close sequences at the times set) ➢ Controlled (resetable) integrator ➢ Simple derivative ➢ Input-IF component (Output is one of the three inputs depending on two reference signals) ➢ Signal selector (Gives one of the inputs or a maximum/minimum value depended on a selector signal value) ➢ Sample and track (Output follows the sum of the input or samples it or delays it by Dt) ➢ Instantaneous minimum/maximum ➢ Minimum-maximum tracking (Holds the minimum/maximum of the inputs) ➢ Accumulator and counter (Holds or integrates the sum of the inputs controlled by external signals) ➢ RMS value of the sum of input signals <p>Fortran statements:</p> <ul style="list-style-type: none"> ➢ General (determined by Fortran expression) ➢ Basic Math operations ➢ Basic Logical operators

Clock), ➤ Counters Filters (20 types): ➤ analog, ➤ digital, ➤ adaptive.	
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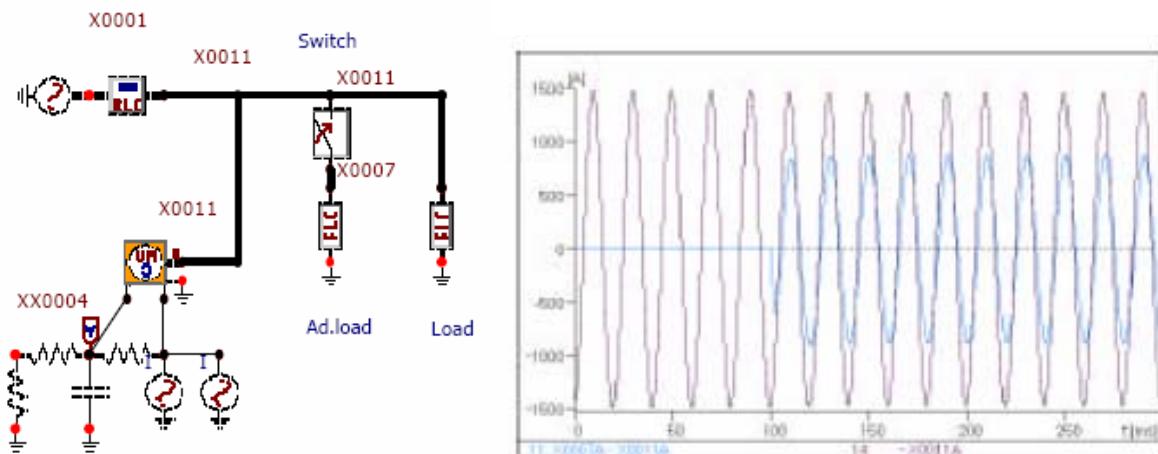
User defined

MATLAB	ATP
➤ Components that can be developed by the user either in Matlab's programming language or C or Fortran.	➤ Components that can be developed by the user programming in MODELS simulation language.

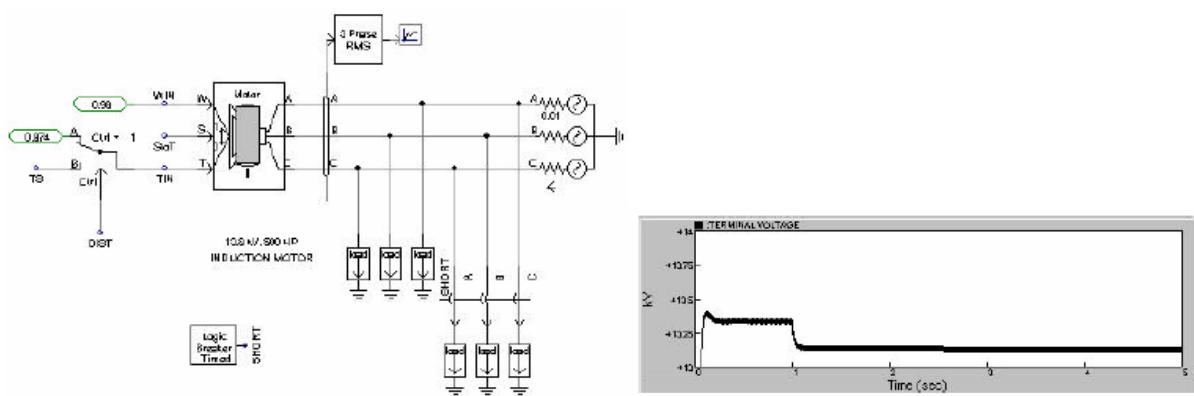
Others

MATLAB	ATP
➤ Controller blocks: PID, fuzzy, neural networks, etc. ➤ Optimal control toolbox ➤ DSP blockset ➤ Fixed point blockset ➤ Data acquisition and system identification toolboxes ➤ With certain restrictions a C code can be generated from the models and this code can be compiled to an executable file. ➤ MATLAB models can communicate with other Windows programs over DDE or ActiveX protocol.	➤ Transposition (Makes defined transposition between interconnected 3 phase elements) ➤ User specified (Some possibilities to load the user specified elements from disk) ➤ Frequency (Harmonic source and some frequency dependent elements)

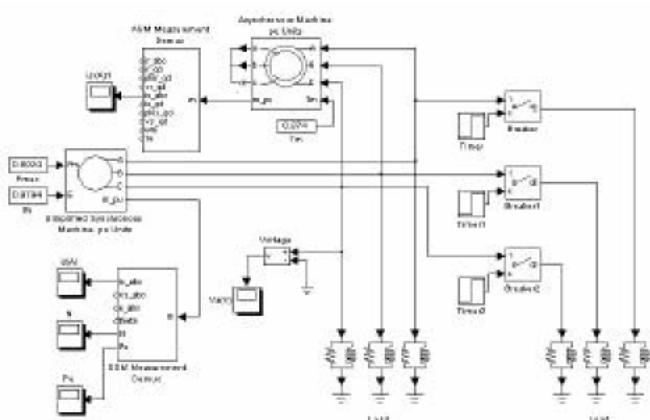
6.- AN EXAMPLE REALISED IN THIS SOFTWARES



Induction motor load
Alternative Transient Program (ATP)



INDUCTION MOTOR LOAD USING PSCAD/EMTDC.



7.- CONCLUSIONS

The widely used program packages for electric network simulation were compared. It has to be pointed out that these tools are capable of simulating the same class of Problems, though this requires experience and is time-consuming, them, the engineer using this software users may be known the power and electrical concepts.

The use of this software, enable practices experience, to day, around the world to have thousand of this. There are numerous widespread commercial software tools used by power engineers for electrical circuit simulation purposes. It is, however, a challenging and time consuming task to get acquainted with all the details and specialties of such a program, that's why the majority of the users is not inclined to keep tabs on the evolution of similar products or does not even know them.

Is very recommending, the use the free software in the teaching process, for future engineer training about de virtual laboratory.

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