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Revelation For New User To Select Power System Simulation Software

Author

P.Selvan
Associate Professor, Department of Electrical and Electronics Engineering, M.P.N.M.J. Engineering College, Erode – 638 112
E-mail: selvan_14@rediffmail.com

R.Anita
Professor, Department of Electrical and Electronics Engineering, Institute of Road and Transport Technology, Erode – 638 316.
E-mail: anita_irtt@yahoo.co.in

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Abstract

As power system become increasingly complex, there is a critical need to make available improved tools for analyzing the power system. In addition, it gives guidance to the entry of new working professional into the power system with at least a basic understanding of power system operation. Number of available power system simulation software increases the complication to select the right software for new users. This paper aims at the comparison between different software and gives guidance to new user. The comparison is based on user friendliness, modules available, modeling of common equipment, special equipment, bus limitations and cost. In this paper, software like MiPower, ETAP, EasyPower and PowerWorld has taken and their performances are evaluated. In that, real time data has taken for analyzing the performance of the MiPower & ETAP software. Guidelines and comparison provided in this paper will be a revelation for new user to select the right software.

Introduction

Over the years computer simulation programs have played an important role in providing power system engineers with a better understanding of power system operation. Because of the rapid advances in computer hardware and software, computer based power system educational tools have grown from very simple implementations, providing the user with little more than a stream of numerical output, very detailed representations of the power system with an extensive graphical user interface[7]. A Power System Simulator (PSS) that allows engineers, technicians and control room operators to gain knowledge-based learning and skills-based training in all aspects of electrical power systems. The Power System Simulator contains everything needed to teach students, how electrical power systems work. It is a self-contained unit (only needs electrical power) with full safety features. It includes all the main parts of an electrical power system, from supply (generation) to demand (utilization). Each part includes dedicated industrial-standard protection relays that do specific jobs, from generator protection to distance protection on transmission lines and distribution transformer protection.

Features of Power System Simulator

1. Completely self-contained teaching module for class and project work.
2. Simulates generation, transmission, transformation, distribution, utilisation and protection.
3. Fully controllable generator and prime mover mounted inside the cabinet for safety.
4. Twin distribution transformers with variable tapping for parallel transformer and load flow tests.
5. Simulated power transmission lines and distance protection relay for realistic experiments.
6. ‘Double bus’ switched bus bar with protection relays to connect the main systems together.
7. Includes supplies, circuit protection, internal load banks, instruments and controls.

Power System Simulation Models
Models are a class of computer simulation programs that focus on the operation of electrical power systems. These computer programs are used in a wide range of planning and operation including:

- Long-term generation and transmission expansion planning
- Short-term operational simulations
- Market analysis (e.g. price forecasting)

These programs typically make use of mathematical optimization techniques such linear programming, quadratic programming, and mixed integer programming.

Key elements of power systems that are modeled include:

1. Load flow (power flow study)
2. Short circuit
3. Transient stability
4. Optimal dispatch of generating units (unit commitment)
5. Transmission (optimal power flow)
6. Harmonic Study
7. Voltage Instability Analysis
8. Relay Coordination
9. Sub-synchronous Resonance
10. Load forecasting
11. Load shedding studies
12. Online monitoring

Load flow calculation: The load-flow calculation is the most common network analysis tool for examining the undisturbed and disturbed network within the scope of operational and strategically planning.

Based on the network topology with the impedances of all devices as well as with the in feeds and the consumers, the load-flow calculation can provide voltage profiles for all nodes and loading of network components, such as cables and transformers. With this information, compliance to operating limitations such as those stipulated by voltage ranges and maximum loads, can be examined. This is, for example, important for determining the transmission capacity of underground cables, where the influence of cable bundling on the load capability of each cable also has to be taken into account. The ability to determine losses and reactive-power allocation, load-flow calculation also supports the planning engineer in the investigation of the most economical operation mode of the network.

When changing over from single and/or multi-phase in feed low-voltage meshed networks to isolated networks, load-flow calculation is essential for operational and economical reasons. Load-flow calculation is also the basis of all further network studies, such as motor start-up or investigation of scheduled or unscheduled outages of equipment within the outage simulation. Especially when investigating motor start-up, the load-flow calculation results give helpful hints, for example, of whether the motor can be started in spite of the voltage drop caused by the start-up current.

Short circuit analysis: Short circuit analysis analyzes the power flow after a fault occurs in a power network. The faults may be three-phase short circuit, one-phase grounded, two-phase short circuit, two-phase grounded, one-phase break, two-phase break or complex faults.

Transient stability: The goal of transient stability simulation of power systems is to analyze the stability of a power system in a time window of a few seconds to several tens of seconds. Stability in this aspect is the ability of the system to make a quick return to a stable operating condition after being exposed to a disturbance such as for example a tree falling over an overhead line resulting in the automatic disconnection of that line by its protection systems. In engineering terms, a power system is stable if the rotational speeds of motors and generators, and substation voltage levels must return to their normal values in a quick and stable manner.

Unit commitment: The problem of unit commitment involves finding the least-cost dispatch of available generation resources to meet the electrical load. Generating resources includes a wide range of types, such as

1. Nuclear
2. Thermal
3. Renewables (including hydro, wind, wave-power, and solar)

The key decision variables that are decided by the computer program are:

1. Generation level (in megawatts)
2. Number of generating units ON

The latter decisions are binary (0s,1s), which means the mathematical problem is not continuous. In addition, generating plant is subjected to a number of complex technical constraints, including:

1. Minimum stable operating level
2. Maximum rate of ramping up or down

3. Minimum time the unit is up and/or down

These constraints are amenable to mathematical programming as linear or mixed-integer constraints.

Optimal power flow: Electricity flows through an AC network according to Kirchhoff's Law. Transmission lines are subjected to thermal limits (simple megawatt limits on flow), as well as voltage and electrical stability constraints. The simulator must calculate the flows in the AC network that result from any given combination of unit commitment and generator megawatt dispatch, and ensure that AC line flows are within both the thermal limits and the voltage and stability constraints. This may include contingencies such as the loss of any one transmission or generation element, so called security-constrained optimal power flow (SCOPF) and if the unit commitment is optimized inside this framework, have a security-constrained unit commitment (SCUC).

Power System Simulation Challenge

Today's Power System Simulation Challenges are High-performance, Scalable, Upgradable, Affordable COTS-Based Real-Time Digital Simulators. The secure operation of power systems has become more and more dependent on complex control systems and power electronic devices. Furthermore, the proliferation of distributed generation plants, often based on the use of renewable energy resources, presents significant challenges to the design and stable operation of today's power systems. Examples include the integration of wind farms, photovoltaic cells or other power electronic based distributed energy generation systems, domestic loads and future plug-in electric vehicles into the existing power grid. Power system simulation software was introduced mainly for time consumption and accuracy of power flow calculations. There are so many software hits in the Indian market based on different aims. A new user gets confused in making a choice of the right software among the alternatives. This paper gives a solution for such problems. Different software has been taken and their performances are compared based on different methodologies like equipment model, user friendliness, cost of the software, graphical user interface and modules available and tabulated. Because software purchase is a one time activity but it is used for a long time, suitable selection of power system simulation software is a challenging one. In this paper, MiPower, ETAP, EasyPower and PowerWorld software have been taken because of their popularity in Indian economy. MiPower and ETAP has 40% market share in India and that of PowerWorld is 5%. EasyPower is considered due to their user friendliness.

Role of computers in power system

The first method for solving various power system problems were AC and DC network analyzers developed in early 1930s. AC network analyzers were used for load flow and stability studies whereas DC network analyzers were preferred for short-circuit studies. Analog computers were developed in 1940s and were used in conjunction with AC network analyser to solve various problems for off-line studies. In 1950s, many analogue devices were developed to control the on-line functions such as generation control, frequency and tie-line control. The 1950s also saw the advent of digital computers, which were first used to solve a load flow problem in 1956. Power system studies by computers gave greater flexibility, accuracy, speed and economy. Till 1970s, there was a wide spread use of computers in system analysis. Off-line applications include research, routine evaluation of system performance, data assimilation and retrieval. It is mainly used for planning and analysing some new aspects of the system. On-line and real time applications include data-logging and monitoring of the system state. A large central computer is used in central load despatch centres for economic and secure control of large integrated systems.

Selection of Software

Software available: The following table shows the list of companies that developed the power system simulation software with their websites [1].

Sl. No	Company	Software	Website
1	DIgSILENT	Power Factory	http://www.digsilent.de/
2	Manitoba HVDCResearch Centre	PSCAD	http://pscad.com/
3	NREL	HOMER, HYBRID2	http://www.nrel.gov/homer/ http://www.ecs.umass.edu/
4	CYME International T&D	PSAF, CYMDIST	http://www.cyme.com/
5	STRI AB	SIMPOW	http://www.stri.se/
6	PowerWorld Corporation	PowerWorld	http://www.powerworld.com/
7	DMS Group	DMS Software	http://www.dmsgroup.co.yu/
8	Optimal Technologies	AEMPFAST	http://www.otii.com/
9	SAMsixED	DEW	http://www.samsix.com/
10	EDSA Micro Corporation	EDSA Micro	http://www.edsa.com/
11	IPSA Power	IPSA	http://www.ipsa-power.com/
12	Etta	Etap	http://www.etap.com/
13	ASPEN	OneLiner, Breaker Rating Module, Relay Database, Power Flow, DistriView	http://www.aspeninc.com/
14	Modelica	ObjectStab	http://www.modelica.org/
15	CESI	SPIRA	http://www.cesi.it/
16	BCP	NEPLAN	http://www.neplan.ch/
17	Siemens PTI	PSS/E	http://www.pti-us.com/m
18	ECI	Quickstab	http://www.scscc-us.com/
19	Electrocon	CAPE	http://www.electrocon.com/
20	SKM	Power* Tools	http://www.skm.com/
21	Fujitsu	DINIS	http://www.dinis.com/
22	Energy Computer System	SPARD	http://www.energyco.com/
23	ESA	Easy Power	http://www.easypower.com/
24	Powertech	DSATools	http://www.dsapowertools.com/
25	Advantica	SynerGEE	http://www.advantica.biz/ http://www.advantica.biz/
25	Nexant	Modelex, Gen-se, Topaz, Flash	http://www.nexant.com/ http://www.nexant.com/
26	SES	CDEGS	http://www.sestech.com/
27	DCG	EMTP-RV	http://www.emtp.com/
28	Personnal	ATP	http://www.emtp.org/
29	Tractebel EDF-RTE	Eurostag	http://www.eurostag.be/ http://www.rte-france.com/
30	V&R Energy System	POM, OPM, BOR	http://www.vrenergy.com/
31	CAI	TRANSMISSION 2000	http://www.cai-engr.com/
32	CEPEL	Anacoge, Anafas, Anafin, Anaquali, Anatem, Asloss,	http://www.cepel.br/
33	Milsoft	WindMil	http://www.milsoft.com/
34	GE Energy	PSLF	http://www.gepower.com/
35	PRDC	MiPower	http://www.mipowersoftware.com/
36	University of British Columbia	Microtran	http://www.microtran.com/
37	Siemens	PSS/NETOMAC	http://www.netomac.com/
38	The MathWorks	SimPowerSystem	http://www.mathworks.com/
39	CherryTree	PST	http://www.eagle.ca/

	Scientific Software		
40	Electrotek Concepts	PQView, PQWeb, SuperHarm, …	http://www.electrotek.com/ http://www.pqsoft.com/
41	Sumatron	Power Engineering EE Helper	http://www.sumatron.com/
42	Intellicon	VCCS, CVA, VCPP, THERM,PLSC, PVR,	http://www.intellicon.biz
43	Psap	Psap	http://www.psasp.com.cn/
44	EleQuant	AGORA	http://www.elequant.com/
45	Fractal	WINdis, PowerCAD	http://www.fractal.hr/
46	NexGen	EL-PSoft	http://nexgenconsultancy.com/
47	PSI	Visual PSA, Visual DSA, Visual CON, Visual EMF	http://www.visualpes.com/
48	PSerc	MATPOWER	http://www.pserc.cornell.edu/
49	Personnal	FENDI	http://www.martinole.org/

Free programs			
Sl. no	**Company**	**Software**	**Website**
1	InterPSS	InterPSS project	http://www.interpss.org/
2	Personnal	Power Designer	http://www.baghli.com/
3	University of Waterloo	UWPFLOW	http://www.power.uwaterloo.ca/
4	University of Texas	PCFLO, PCFLOH	http://www.ece.utexas.edu/
5	Universidad de Castilla-La Mancha	PSAT	http://thunderbox.uwaterloo.ca/
6	PSerc	MATPOWER	http://www.pserc.cornell.edu/
7	Personnal	FENDI	http://www.martinole.org/

Software compared

The following software has been taken for comparison because of their popularity in Indian economy.

- MiPower
- ETAP
- EasyPower
- PowerWorld

MiPower: MiPower is the state-of-the-art Windows based power system software. MiPower is highly interactive, user-friendly software for all analysis, planning, design and simulation of any given power system irrespective of the geographical and environmental constraints. MiPower is widely used by consultants, power utilities, state electricity authorities and academic and research institutes for more than a decade. MiPower is aimed with robust power system engine in the backend and a lucid top-notch windows GUI in the front-end. Approach, technique and methodology employed are field proven and time-tested. These conform to standard ANSI, IEEE, IEC and other worldwide accepted standards. All power system data are centrally maintained with an industry standard relational database. MiPower helps in dealing with a wide range of power system problems. Highly intuitive Graphical User Interface smoothens the learning curve largely. With MiPower, power system engineers can become productive with minimum effort / time and results are emphatically visible. MiPower is an interactive, user-friendly Window based power system analysis software package to perform a wide range of power system analysis design and study. The software was indigenously developed to meet the utilities requirement and Auto Reclosure for SLG Fault, Series capacitor are modeled which is not available in any other power system software [5]. Also to meet the utility requirements, topographical drawing is also available in MiPOWER which will be very handy to layman who is collecting the information at site. MiPOWER 6.0 is the latest version available in the market.

ETAP: ETAP is the most comprehensive analysis platform for the design, simulation, operation, control, optimization, automation of generation, transmission, distribution and industrial power systems. Release 7.5 of the ETAP enterprise solution brings design and analysis innovation to a new level of advancement and provides the platform upon which future ETAP innovation will follow. ETAP 11 is expected well within this year to meet all the requirements of industries in all aspects. This release adds new powerful analysis modules and time-saving capabilities to the ETAP suite. ETAP offers a suite of fully integrated software solutions including arc flash, load flow, short circuit, relay coordination, cable capacity, transient stability, optimal power flow, and more. Its modular functionality can be tailored to fit the needs of any company from small to large power systems. Typical information for all equipment (Generator, Transformer, Shunt equipment) are readily available which reduces the considerable time of the user. ETAP provided error report and highlight the mistake to the user in brief report. [4]

Easy Power : Easy Power is a computer aided engineering tool for the analysis of industrial, utility and commercial electrical power systems. Easy Power is unique in that it completely integrates the short circuit, power flow, protective device coordination and database functions under control of the interactive graphical one-line diagram. Easy Power lets normally do directly from the one-line diagram. Easy Power has the most interactive and user friendly interface ever developed for power system analysis software. Easy Power uses the latest network analysis techniques developed by world leaders in sparsity solution algorithms and innovative computer techniques. Many of the algorithms used in Easy Power are not available in any other program. This gives Easy Power a tremendous advantage over other programs in execution time, modeling capabilities and accuracy. Each focus has its own menu bar and toolbar, showing only the commands that are appropriate for that focus. This feature keeps the user interface for each focus simple. For example, one does not have to wade through a bunch of Short Circuit menus, when all that is really wanted to do is power flow. In addition, as major new analysis capabilities are added to Easy Power in the future, they can each have their own focus. This helps to avoid the problem plaguing many programs today - a cluttered, complicated user interface. [3]

Power World Simulator: Power World Simulator is a power system simulation package designed from the ground up to be user-friendly 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. 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 1,00,000 buses. This makes simulator quite useful as a stand-alone power flow analysis package. Unlike other commercially available power flow packages, however, simulator allows the user to visualize the system with 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. [6]

Test system

Real time system is taken for analyzing the various performances (like Load flow, Short circuit and Transient study) of ETAP & MiPOWERsoftware.

Simulation Results

To compare the performance of ETAP and MiPOWER, load flow study and transient study of real time system is performed and their graphical results are given.

Simulation results in ETAP

Load flow study of real time system

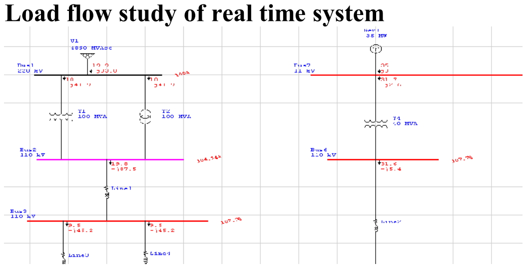

Fig.1. Load flow analysis

Fig.1 shows the load flow result of real time system. In this, real power(P) and the reactive power(Q) are shown in the form of P+ jQ. The bus voltage is indicated as % value.

Short circuit study of real time system

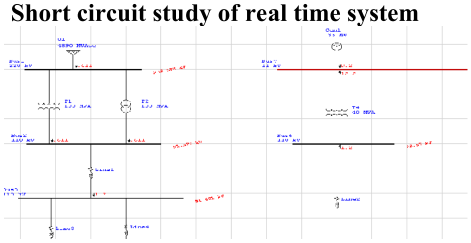

Fig.2. Short circuit analysis

The short circuit current is represented as kA and the voltage as kV as shown in figure 2. In addition, the current flow direction is indicated.

Transient study of real time system

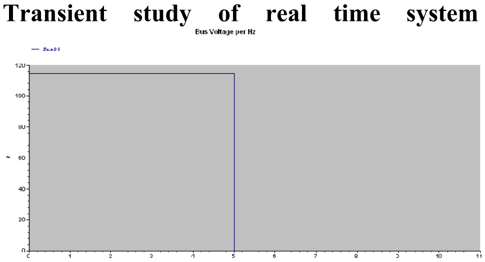

Fig.3. Transient output for bus voltage per Hertz

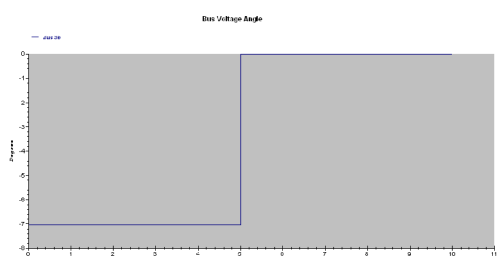

Fig.4. Transient output for bus voltage angle

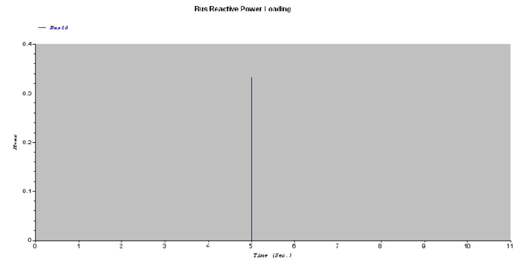

Fig.5. Transient output for bus reactive power loading

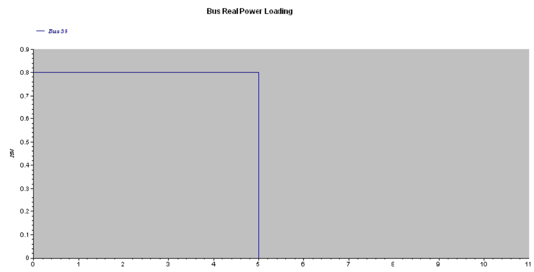

Fig.6. Transient output for bus real power loading

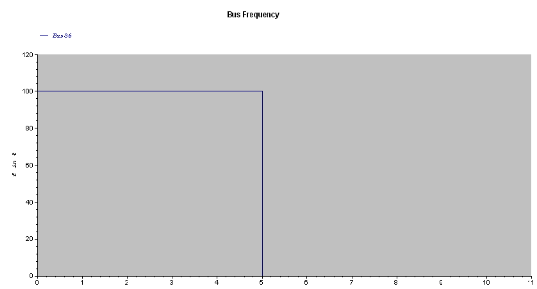

Fig.7. Transient output for bus frequency

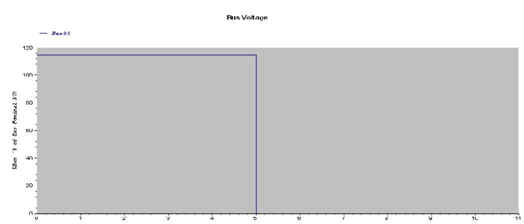

Fig.8. Transient output for bus voltage

When transient occurs, the bus voltage per Hertz, reactive power, real power, frequency, voltage are dropped to zero from its normal value as shown in figures 3, 5, 6, 7 and 8 respectively. Figure 4 shows that, the voltage angle of bus reaches to zero from its negative value.

Simulation results in MiPower

Load flow study of real time system

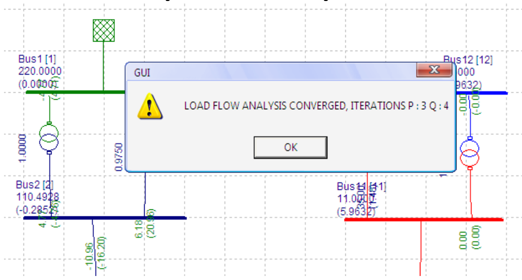

Fig.9. Load Flow Analysis

Figure 9 shows the load flow result of real time system. From this, it is clear that, the load flow converged for real power in three iterations and for reactive power in four iterations.

Transient study of real time system

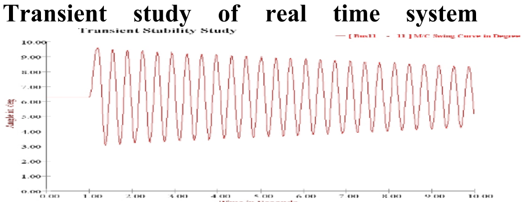

Fig10. Swing curve of bus 11

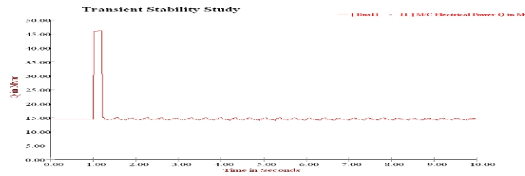

Fig.11. Reactive power of bus 11

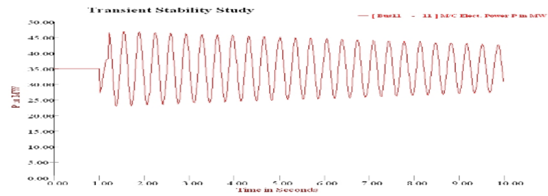

Fig.12. Real power of bus 11

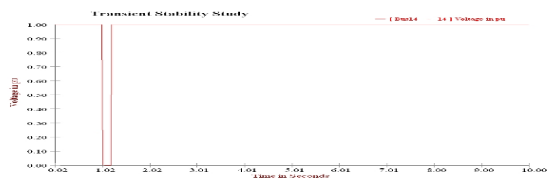

Fig.13. Bus voltage in per unit for bus 14

When transient occurs, the effect on swing curve (angle), reactive power, real power and bus voltage are shown in figures 10, 11, 12 and 13 respectively.

TABULATION OF PERFORMANCE OF SOFTWARE

The result of this paper after analyzing the performances of all the software is shown below.

Features	Mi Power	ETAP	EasyPower	PowerWorld
1. Equipment				
1.1 Generator				
a) Multi swing bus option	Not available	Available	Not available	Not available
b) AVR Modeling	Available (To be modeled by user in Free Programmable Block)	Available (Interface with Matlab for modeling)	Available	Not available
c) Governor Modeling	Available	Available	Available	Not available
1.2 Two Winding Transformer				
a) ON Load Tap Changer	Not available	Available	Available	Not available
b) Phase displacement	Not available directly	Available	Not available	Not available
1.3 Transmission Line				
a) Notation of Resistance value	Ω/Km only available. p.u is also available	Ω/Km,Ω/m, Ω/mile or Ω	Ω/Km,Ω/m, Ω/mile or Ω	Not available
1.4 Load				

a) Static Load	Available	Available	Available	Available
b) Lumped Load	Not available	Available	Not available	Not available
c) Constant current, power, Impedance Load	Available	Static load / Lumped load shall be modified with user data	Not available	Not available
1.5 Series Reactor, Capacitor				
Modeling	Available	Not available	Not available	Available
1.6 Shunt Reactor, Capacitor				
Modeling	Available	Available	Available	Available
1.7 Static Var compensator				
Modeling	Available for Load flow analysis	Available	Not available	Not available
1.8 Current transformer				
Modeling	Not available	Available	Not available	Not available
1.9 Relay & Releases				
Modeling	Not available	Available	Not available	Not available
2.Graphical User Interface				
a) Animation	Not available	Not available	Not available	Available
b) Bus Coloring	Available	Available	No	Not available
c) Display of Cable Length	Not available	Available	Not available	Not available
d) Symbol	IEEE only	Both IEC and IEEE	IEEE only	IEEE only
3.Modules available				
3.1 Load Flow				
a) Types of load flow	Available(Frequency Dependent, Slack Bus, Optimal Load Flow, Contingency Analysis, B co-efficient& Economic Dispatch)	Slack bus option only	Slack bus option only	Slack bus option only
3.2 Short circuit analysis				
3.2.1 Modeling standards				
a) IEEE	Partially available	Available	Available	Not available
b) IEC	Not available	Available	Available	Not available
3.2.2 Topographical representation	Available	Not available	Not available	Not available
3.3 Transient analysis				
a) Simulation of multiple events	Available	Available	Not available	Not available
b) Auto recloser	Available (only for L - G fault)	Not available	Not available	Not available

Conclusion

In this paper, the various performance of all software are compared and tabulated. The table given, contains all the relevant information about the power system simulation software. It gives an ultimate solution for the long time unresolved problem in a specialized area. It will be a revelation for selecting power system simulation software especially for new users.

References

1. www.martinole.org
2. www.google.com
3. www.easypower.com
4. www.etapsoftware.com
5. www.mipowersoftware.com

6. www.powerworld.com

7. Thomas J.Overbye(1995), Peter W.Sauer, Caroline M.Marzinzik, George Gross "A User-Friendly Simulation Program For Teaching Power System Operation" IEEE Transactions on Power Systems, Vol 10, No 4, November 1995

Aims and Scope

The Journal of Asian Scientific Research is a monthly, peer-reviewed international research journal which deals with empirical as well as theoretical issues. The editors welcome papers in all the major issues including:

- Research Articles and Reviews Article
- Scientific Commentaries in the Fields of Applied and Theoretical Sciences
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- Chemistry
- Physics
- Zoology
- Medical Studies
- Environmental Sciences
- Geology
- Engineering
- Short Communications
- Computer Science
- Social Sciences
- Natural Sciences
- Technological Sciences
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- Mathematics
- Statistics
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Authors are requested to prepare their articles by following the guidelines given below:

Author(s) introduction: Should be on a separate page consisting of full name, position, affiliation, and e-mail address
Font Size: 12 points with double spacing

1. Heading 16 point font sizes
2. Sub Heading 14 point font sizes
3. Text 12 point font sizes

Format: Times New Roman
Length: Maximum 7,000 words
Title: Should be impressive and not lengthier
Abstract: Should be 200 to 400 words
Keywords and JEL code: Most appropriate keywords and code should be used. JEL Code
Equations, Tables and Diagrams: Should be clear & accurate and on the right place
Reference: Should be completed according to the following guidelines

Arrow, K. (1970) "The Organization of Economic Activity: Issues Pertinent to the Choice of Market Versus Non-market Allocations" in Public Expenditure and Policy Analysis by R.H. Havenman and J. Margolis, Eds., Markham: Chicago, pp. 67-81

Benabou, Roland (1994) "Education, Income Distribution, and Growth: The Local Connection". NBER working paper number 4798

Berglas, E. (1976) "Distribution of tastes and skills and the provision of local public goods". Journal of Public Economics Vol. 6, No.2, pp.409-423.

Edgeworth, F.Y. (1881) Mathematical Psychics, Kegan Paul: London.

Mas-Colell, A and J. Silvestre (1991) "A Note on Cost-Share Equilibrium and Owner- Consumers" Journal of Economic Theory Vol.54, No.1,pp. 204-14.

Appendix: At the end of the paper

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