International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

A Survey of Software Packages in Power System Analysis

Santosh Singh Chauhan[1], Prabodh Khamparia[2]

[1]PG Student Electrical Engineering Department, SSSITS, Sehore, India

[2]Associate Professor Electrical Engineering Department, SSSITS, Sehore, India

Abstract: ***Size and complexity of power systems impose significant challenges for the power system analysis and control. As the power system becomes more complex there is a great need to develop improved and sophisticated tools for power system analysis and simulation. These tools should be able to accurately replicate real events that occur in electric power network and help to understand dynamics of changes. A number of software packages have been developed for power system research, analysis, planning, designing and teaching. Over the years, power networks have become more complex and complicated for the analysis and control. To manage such networks, simulation tools are needed due to their possibility to create accurate simulation and replicate of all the physical effects that are running in the network.***

Keywords: Power system analysis , software packages , load flow analysis , Matlab , Scilab , open source .

1. Introduction

Larger and more complex networks require advanced and powerful tools with the ability to fully optimize and refine power system in a fast and accurate way. With the use of advanced simulation software, it has become possible to study dynamic behavior and performance of network before going through a real implementation. Without the need to execute the experiments on real systems, simulation provides savings in time and costs as well as real network protection from possible unwanted consequences of experimenting. Good simulation tool should be: simple, easy-to-use, able to simulate generation, trans-mission, transformation, distribution, utilization and protection of power networks, detect errors and handle large power systems. A number of simulation tools are available today and are extensively used for power system analysis, research and education. Some of them are characterized as educational tools focused on illustrating power system control as well as introducing students to realistic, though tractable in size, design problems [1]–[7]. This provides students not only with deep theoretical knowledge but also practical skills, which are required for understanding power system functioning. In [8]– [10] advanced software and real-time power system simulation technologies are presented.

Due to powerful software and advanced real-time simulators, it is possible to simulate the dynamic behavior of very large and complex power systems and to verify their performance with the original control and protection equipment. Papers [11]–[13] summarize the information and key features of available software tools in power engineering. The comparison is based on user friend-liness, modules available, modeling of common equipment, special equipment, bus limitations and cost. Based on the study presented there, one could conclude that the advanced anal-ysis methodology combines generation, transmission, various elements, and market economics into one virtual environment to deliver location, time, user-dependent analysis results, and indicators.

2. Survey of Software in Literature

In 2014 I.Dzafic ,I.Huseinagic , M.Music&E.Halilovic in their research paper tiltled**“SOFTWARE PACKAGE FOR POWER SYSTEM ANALYSIS”** describes how to utilize an electric Power System Analyzer (PSA) as a useful instrument for power flow studies. The analyzer is designed to be user-friendly, easy-to-use, with the ability to optimize power flow and to visualize the effects of changing problem parameters. PSA can handle power system networks up to 100.000 nodes. This paper presents Power System Analyzer (PSA) software which is simple, user-friendly, easy to use and reliable. The software is designed to give the best possible performance while remaining simple to use and understand. It contains user interface which provides drawing one-line diagrams, entering data parameters and displaying simulation results. User is allowed to manipulate and modify one-line diagrams with the multiple options such as rotate, move, copy, zoom, etc. For better interpretation and visualization of the system, all network components are presented with suitable graphical symbols. This facilitates network creation and gives better demonstration of the principles of electric power flow. Thus, PSA can offer great possibilities for engineers, scientists, utilities, manufacturer, and technical or research institutions.

In 2013 AbubakarSadiqBappah in his research paper titled **“MATPOWER AS EDUCATIONAL TOOL FOR SOLVING OPTIMAL POWER FLOW PROBLEMS ON A SIMULATED NIGERIAN POWER GRID”** utilized and demonstrated the well-known MATPOWER simulation package to solve optimal power flow problem of 31-Bus Nigerian Grid system to demonstrate its application as an educational tool for solving power flow problem. The Optimal Power Flow (OPF) results of Nigerian power systems revealed that N101,548.47 is spent per hour on fueling of various generating units and that there is correlation among the load increment, cost and system losses. The importance of using MATPOWER is that being free open source package and its codes could be modified.

This is particularly important for researchers and students who are interested in developing and testing novel projects.

In 2013 Rahul Agrawal, S.K. Bharadwaj and D.P. Kothari in their research work titled **"AN EDUCATIONAL AND PROFESSIONAL SIMULATION TOOLS IN POWER SYSTEMSAND FACTS CONTROLLERS- AN OVERVIEW"** summarize and discuss the simulation tools used for analysis, design & testing of Power Systems and FACTS Controllers. FACTS devices are power electronics based components; simulation tools for power electronics circuits are also discussed. The application of simulation software and program offers a powerful tool in the technology of electrical & electronics engineering. During the last two and half decades, off-line and real-time simulation tools gained popularity to carry out of the successful operation of the power systems and FACTS controllers. This paper presents various simulation tools for teaching and research purposes. Apart from the simulation tools discussed here, there are many other simulation programs for power systems and FACTS Controller. The report also discusses a short introduction about FACTS controllers, their features, importance and their need in power systems.

In 2011 Vinayaka G Yaji, Abhishek G.S and K.N. Shubhanga in their research paper titled "**MATSIM - A TOOL TO PERFORM POWER SYSTEM STABILITY STUDIES**" presented the features and flexibilities of an analysis and visualization tool, MatSim. Using this tool they showed that they can carry out power flow, transient and small-signal stability analysis of large power systems on the widely used MATLAB environment. This tool facilitates easy visualization of complex power systems using a versatile single-line editor module which is also developed on the same platform as that of the MatSim. Such an integration not only simplifies the feeding in of enormous amounts of data required by the power system analysis software, but also permits displaying of power system analysis results in an interactive fashion on the one-line-diagram of the system using the inherent and powerful plot-handling features of the MATLAB.

In 2010 A. B. M. Nasiruzzaman in his research work titled **"A STUDENT FRIENDLY TOOLBOX FOR POWER SYSTEM ANALYSIS USING MATLAB"** a student friendly toolbox developed to assist students during their course of study in basic power system courses is presented. The toolbox takes into account the fresh students having no idea about the course and can alone be used as a textbook. The help menu in the toolbox provides details of problems solved with sufficient background materials so that each and every module can be grasped and mastered with ease. One can easily see the inner structure of the program to understand how to code a power engineering problem. The main advantage of the toolbox is that apart from using the software within MATLAB it is made version compatible and can be used without MATLAB. So it can be regarded as a standalone software package for power system analysis. The software was developed in MATLAB 6.5 and now successfully tested in the recent version of MATLAB 2010a. The toolbox is divided into different modules to focus different areas of power system as follows:

a) Fault analysis of a motor-generator set
b) Demonstration of symmetrical components
c) Fault analysis of unloaded alternator
d) Synchronous machine transients (balanced)
e) Synchronous machine transients (unbalanced)
f) Fault analysis of interconnected buses
g) Single machine stability analysis (classical)
h) Single machine stability analysis (modern)
i) Load flow

In 2009 , Inˆes M. Cec´ılio, Anne Mai Ersdaly, DavideFabozzi and Nina F. Thornhill in their research work titled **"AN OPEN-SOURCE EDUCATIONAL TOOLBOX FOR POWER SYSTEM FREQUENCY CONTROL TUNING AND OPTIMIZATION"** presents an open-source educational tool for power and control engineering students to practice frequency control and test tunings and control strategies. The disturbance scenarios are realistic and automatically generated by the tool. This feature facilitates statistical analyses of the behaviour of the system. The paper shows simulation results with a common disturbance scenario and with two more severe cases.

In 2008 , Federico Milano, Luigi Vanfretti, and Juan Carlos Morataya, in their research work titled **"AN OPEN SOURCE POWER SYSTEM VIRTUAL LABORATORY: THE PSAT CASE AND EXPERIENCE"** describes the authors' experience in the as-sessment of laboratory activities based on an open source software package for power system analysis, namely, Power System Analysis Toolbox (PSAT). PSAT is currently used in several universities for both undergraduate and graduate courses. PSAT has also its own Web forum, which provides support to students and researchers all around the world, thus resulting in an almost unique example of "virtual laboratory" over the Internet. This paper attempts to answer through a variety of real-life examples the following open questions: What are the practical and pedagogical advantages of using an open source software with respect to proprietary software for power system analysis? What happens if a power system virtual laboratory is freely available on the Web? What is the difference between a class-based and a Web-based virtual laboratory?

In 2006 ,SaffetAyasun, Chika O. Nwankpa, and Harry G. Kwatny, in their research paper titled **"VOLTAGE STABILITY TOOLBOX FOR POWER SYSTEM EDUCATION AND RESEARCH"** presents a Matlab-based voltage stability toolbox (VST) designed to analyze bifurcation and voltage stability problems in electric power systems. VST combines proven computational and analytical capabilities of bifurcation theory, and symbolic implementation and graphical representation capabilities of Matlab and its toolboxes. The motivation for developing the package is to provide a flexible simulation environment for an on-going research conducted at the Center for Electric Power Engineering (CEPE) of Drexel University, Philadelphia, PA, and to enhance undergraduate/graduate power engineering courses. VST is a very flexible tool for load flow, small-signal and transient stability, and bifurcation analysis. After a brief summary of power system model and local bifurcations, the paper illustrates the capabilities of VST using the IEEE 14-bus system as an example and describes its successful integration into power engineering courses at Nigde University, Nigde, Turkey.

In 2005 , G. Jackson, U.D. Annakkage, A. M. Gole, D. Lowe, and M.P. McShane in their research work titled **"A REAL-TIME PLATFORM FOR TEACHING POWER SYSTEM CONTROL DESIGN"** describes the development of a real-time digital simulation platform that can be used for the teaching of design principles for power system controls. In the developed approach, a rapid controller-prototyping platform (dSPACE) is interfaced to a real-time power system simulator (RTDS). The real-time platform is very successful when used in a post-graduate University course; but should also prove equally beneficial to the training of practicing engineers. The approach permits developers to physically prototype their designs and via the simulator, have them tested as if in the field. In contrast to off-line simulation, this approach extends the design to the next logical step, and exposes engineers to the important issues of implementation and real-time testing. The use of this platform is demonstrated through the design of a power system stabilizer (PSS) for a One-Machine Infinite Bus (OMIB) system.

3. Important Findings & Research Plan

This synopsis presents an overview of the user friendly and widely used simulation softwares of different types used in power systems networks with their unique features. Simulation software's discussed above can be used as a major educational tool in the teaching power systems, power electronics and electrical drive of UG and PG courses as well as in research also . The synopsis provides relevant information about simulation tools and may act as a potential source of information for simulation agencies, research scholars, manufacturers and electrical utilities working in the field of power systems research.

Based on our studies, following are the research findings:-

- There are several softwares that could be used to design and simulate power systems.
- The functionalities of the software should be such that it must be easy to understand.
- The software must have provision for code reuse and adaptability else the system would be a static system and not very useful.
- The software must be such that it should be able to run on all platforms commonly used.
- The software must have functions which can cater to a large audience, i.e. it should not be restricted to a particular problem only.

Based on the literature review , and seeing the pros and cons of various softwares , we plan to develop a software package of ouyr own which could have some functionalities and thus which could take the best of the above packages . For our purpose we have chosen MATLAB as the preffered platform and we have decided that the following functionalities need to be added in our final implementation:-

- Must have graphical user interface
- Must have an extensive help library (custom built)
- The software must be capable of solving power systems for 6 bus , 14 bus , 30 bus & 57 bus system as per IEEE standards.
- The load flow analysis should be graphical as well as in tabular format.
- Provision to add any bus system should be there in the software.
- In addition to power flow study , power stability should also be a part of the system.
- The system should be able to use different algorithms such as Newton Raphson and Gauss Siedel and should give a comparative analysis of the two algorithms for a particular bus system.
- Voltage stability analysis should be done by the software.
- There should be a provision for exporting the data from the software into any suitable format such as .txt or in MS EXCEL sheet.

4. Conclusion

This synopsis presents an overview of the user friendly and widely used simulation softwares of different types used in power systems networks with their unique features. Simulation software's discussed above can be used as a major educational tool in the teaching power systems, power electronics and electrical drive of UG and PG courses as well as in research also . The synopsis provides relevant information about simulation tools and may act as a potential source of information for simulation agencies, research scholars, manufacturers and electrical utilities working in the field of power systems research.

This synopsis presents several power system analysis softwares which are simple, user-friendly, easy to use and reliable. The softwares are designed to give the best possible performance while remaining simple to use and understand. It contains user interface which provides drawing one-line diagrams, entering data parameters and displaying simulation results. User is allowed to manipulate and modify one-line diagrams with the multiple options such as rotate, move, copy, zoom, etc. For better interpretation and visualization of the system, all network components are presented with suitable graphical symbols. This facilitates network creation and gives better demonstration of the principles of electric power flow. Thus, softwares can offer great possibilities for engineers, scientists, utilities, manufacturer, and technical or research institutions.

References

[1] N.G. Hingorani& L. Gyugyi, "Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems", IEEE Press, 2000.
[2] Y.H. Song & A.T. John, "Flexible AC Transmission Systems (FACTS)", IEE Power and Energy Series, 1999.
[3] D. P Kothari, I.JNagrath, "Modern Power System Analysis", Tata McGraw Hill, 4-e, 2012.
[4] R.M. Mathur& R.K. Varma, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", John-Wiley, 2002.

[5] M.D.Singh, K.B. Khanchandani, “Power Electronics”, Tata McGraw Hill, 2-e, 2007, pp. 1055-1059.
[6] J. Mahseredjian, V. Dinavahi, J. A. Martinez, “An Overview of Simulation Tools for Electromagnetic Transients in Power Systems”, IEEE Power Engineering Socity General Meeting, 2007, pp. 1-6
[7] R Kuffel,J.Giesbrecht, T.Maguire, R.P.Wierckx and P.G.McLaren, “RTDS A Fully Digital Power System Simulator Operating in Real-Time”, Proc. Of EMPD-95, Vol. 2, pp. 498-503.
[8] D. Paré, G. Turmel, J.-C. Soumagne, V. A. Do, S. Casoria, M. Bissonnette, B. Marcoux and D. McNabb, “Validation Tests of the Hypersim Digital Real Time Simulator with a Large AC-DC Network,” IPST 2003, International Conference on Power Systems Transients, New Orleans, USA, Sept. 28 - Oct. 2, 2003.
[9] S. Abourida, C. Dufour, J. Belanger, G. Murere, N. Lechevin and B.Yu, “ Real time PC Based Simulator of Electric System and Drives”, 17th IEEE APEC, Annual Applied Power Electronics Conference and Exposition, vol. 1, March 10-14, 2002, pp. 433-438.
[10] www.mathworks.com (accessed on date 08.12.2012)
[11] Ray Daniel Zimmerman,CarlosEdmundo Murillo-Sánchez, and Robert John Thomas, “MATPOWER: Steady- State Operations, Planning, and Analysis Tools for Power Systems Research and Education”, IEEE Transactions on Power Systems, Vol. 26, No. 1, February 2011.
[12] http://www.pserc.cornell.edu/matpower (accessed on 9.12.2012)
[13] F. Milano, “An open source power system analysis toolbox,” IEEE Trans. Power Syst., vol. 20, no. 3, pp. 1199–1206, Aug. 2005.
[14] www.uclm.edu/area/gsee/Web/Federico/psat.html/(accessed on 10.12.2012).
[15] http://simsen.epfl.ch (accessed on 11.12.2012).
[16] Kulicke, B. “NETOMAC digital program for simulating electromechanical and electromagnetic transient phenomena in a.c. Systems”, Elektrizitatwirtschaft, Heft 1, pp. 18-23.
[17] D. Povh,Retzmann D., Rittiger J.,” Benefits of simulation for operation of large power system & system interconnection,” 4th IERE General meeting & IERE central &Easterm Europe Forom, 19-21 Oct. 2004.
[18] www.etap.com (accessed on 12.12.2012).
[19] ArunSekar, BhaskarMahyavanshi, Sreedhar R. Pingili, “Power System Simulation Software for use in cyberspace” IEEE SSST,2005, pp. 230-233.
[20] R.Visnic, V. Sunde, I.Mrcela, “Matlab/GUI interface for simulation of power electronic converters”, MIPRO 2011, May 23-27, 2011, Opatija, pp. 136-140.
[21] Stijn Cole, Ronnie Belmans “MatDyn, A new Matlab based toolbox for power system dynamic simulation”, IEEE Transactions on Power Systems, Vol. 26, No. 3, August 2011, pp. 1129-1136.
[22] Rainer Krebs, Olaf Ruhle, “NETOMAC Real time simulator- A new generation of standard test modules for enhanced relay testing”, Eighth IEE International Conference on Development in Power System Protection, 2004, Vol. 2, pp. 669-674.
[23] P.Lehn, J.Rittiger, B.Kulicke, “Comparison of the ATP version of the EMTP and NETOMAC program for simulation of HVDC system”, IEEE Transactions on Power delievery, Vol. 10, No. 4, October 1995, pp.2048-2053.
[24] Keith Brown, FarrokhShokooh, HerminioAbcede, Gary Donner, “Interactive Simulation of Power System: ETAP Applications and Techniques”, IEEE Industry Application Society Annual Meeting, 1990, vol.2, pp.1930- 1941.
[25] Omar Saad, “Computation of Power System transients: Modeling portability using EMTP-RV DLL”, IEEE Power and Energy Society General Meeting, 2011, pp.1-4.
[26] Shanshan Yang, Gregory A. Franklin, “Switching transient overvoltages study simulation comparison using PSCAD/EMTDC and EMTP-RV”, Proceeding of IEEE Southeastcon, 2012, pp. 1-5.
[27] Zhang Haibo, GeDandan, “The research and implementation of experimental simulation platform based on RTDS and EMS (open-3000)”, IEEE PES ISGT Asia 2012, pp.1-4.
[28] Sameer Khader, Alan Hadad and Akram A. Abu-aisheh, “The application of PSIM and Matlab/Simulink in power electronic courses”, 2011 IEEE, April 4-6, 2010, Amman, Jordan, pp.118-121.
[29] www.emtp.com (accessed on 13.12.2012).
[30] Tao Zhao, Qunjing Wang, “Application of Matlab/Simulink and PSPICE simulation in teaching power electronics and electric drive systems”, Proceeding of IEEE- ICEMS 2005, vol.3, pp. 2037-2041.
[31] O. Apeldoorn, “Simulation in Power Electronics”, proceeding of the IEEE International Symposium on Industrial Electronics, ISIE-1996, vol.2, pp. 590-595.
[32] https://hvdc.ca/pscad/ (accessed on 23.12.2012).
[33] PSIM, User’s Guide, www.powersim.com (accessed on 12.12.2012).
[34] http://www.prdcinfotech.com (accessed on 13.12.2012).
[35] http://www.simulation-esearch.com (accessed on 13.12.2012).
[36] PSCAD User’s Guide, Manitoba HVDC Research Centre, Feb, 2010 .
[37] EMTDC User’s Guide, Manitoba HVDC Research Centre, 2005.
[38] www.rtds.com (accessed on 19.12.2012).
[39] http://simsen.epfl.ch/ (accessed on 24.12.2012).