Journal of Energy and Power Engineering 10 (2016) 497-503
doi: 10.17265/1934-8975/2016.08.006

DAVID PUBLISHING

Virtual State Estimation Calculator Model for Three Phase Power System Network

Samson Raja Simson[1], Sundar Ravichandran[1], Amudha Alagarsamy[2] and Nithiyananthan Kannan[1]

1. Karpagam College of Engineering, Coimbatore-641032, Tamilnadu, India

2. Karpagam University, Coimbatore-641021, Tamilnadu, India

Received: April 11, 2016 / Accepted: April 25, 2016 / Published: August 31, 2016.

Abstract: The main objective of this research work is to develop a simple state estimation calculator in LabView for three phase power system network. LabView based state estimation calculator has been chosen as the main platform because it is a user friendly and easy to apply in power systems. This research work is intended to simultaneously acclimate the power system engineers with the utilization of LabView with electrical power systems. This proposed work will discuss about the configuration and the improvement of the intelligent instructional VI (virtual instrument) modules in power systems for state estimation solutions. In the proposed model state estimation has been carried out and model has been developed such that it can accommodate the latest versions of state estimation algorithm.

Key words: State estimation, LabView, three phase power system network.

1. Introduction

In light of the latest advances in PCs and advances, the multifaceted nature of each part of the electrical power industry (period, transmission, distribution, control and so on) has extended and the graduates of engineering must be all around prepared to address the necessities of the business. To address this need, most of the engineering programs and a rate of the outlining advancement programs have introduced courses, projects, and research offices in power systems to give the graduates for theoretical and sensitive data, and also experience. The examination of electrical power systems requires a decent establishment on cutting edge science, and since an expansive bit of the building development programs engineering innovation programs do not require pushing number juggling, it is difficult to indicate electrical power systems in these projects. To deal this subject, numerous content driven software programs are as of now utilized as a part of college to outline and break down diverse systems. A decent illustration of such programs is a Matlab software. With the coming of object -oriented software, now programs are intelligent and easy to use. Utilizing such PC programs permits understudies to invest less energy written work the code to take care of an issue and invest additional time comprehension the ideas. LabView software is a graphical software environment and depends on the idea of data flow software. Initially intended for test and estimation applications, the system has been altered in the course of the most recent 15 years to plan and break down different complex systems.

Energy management is the process of monitoring, coordinating and controlling the generation, transmission and distribution of electrical energy. An energy control centre utilizes the computer aided tools to monitor, control and optimize the generation, transmission and distribution of electrical energy. The functions of a typical control centre can be categorized into three subsystems as shown in Fig. 1 namely the data

Corresponding author: Nithiyananthan Kannan, Ph.D., professor, research fields: computer applications for power systems engineering, renewable energy, and embedded systems.

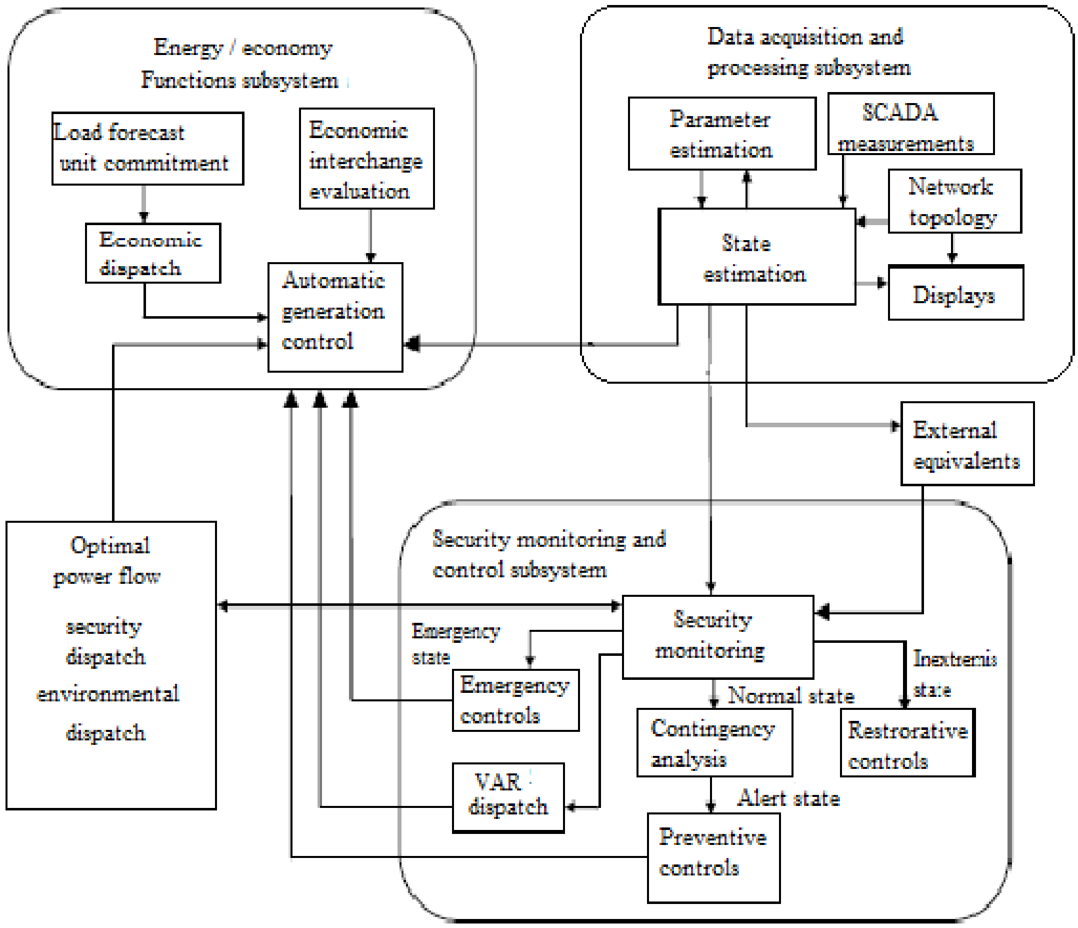

Fig. 1 Functional diagram of modern energy management system.

acquisition and processing subsystem, the energy management/automatic generation control subsystem and the security monitoring and control subsystem. SCADA (supervisory control and data acquisition system) forms the front end of EMS (energy management systems). A simple SCADA provides the raw data of the operating condition of the system to the control centre operators. State estimation forms the backbone for energy management system. Although reliability remains a central issue, the need for the real time network models becomes more important than before due to new energy market related functions are to be added to the existing EMS. These models are based on the results yielded by state estimation and are used in network applications such as security monitoring, contingency analysis, optimal power flow, economic dispatch, unit commitment, automatic generation control and economic interchange evaluation.

It is generally acknowledged by the industry, college, and examination, research centers far and wide as a standard for DAQ (data acquisition) and instrument control software [1]. Users of LabView can construct instrumentation called VIs (virtual instruments) utilizing software items. With legitimate equipment, these VIs can be utilized for remote data acquisition, analysis, design, and distributed control.

The implicit library of LabView has different VIs that can be used to arrange and add to any system. LabView can be used to address the necessities of various courses in an innovation and science program [2, 3]. The objective of this paper is to talk about the use of develop VIs in LabView to create VI modules for use in electrical power system state estimation arrangements.

2. Application of LabView in Electrical Engineering

LabView is an extraordinary degree versatile and a bit of the application zones of LabView are simulation, data acquisition, and data processing [4]. The data processing library fuses signal era, computerized signal handling (DSP (digital signal processor)), estimation, channels, windows, bend fitting, likelihood and insights, straight variable based math, numerical techniques, instrument control, program advancement, control systems, and fuzzy logic [5]. These segments of LabView will give an interdisciplinary, coordinated educating and learning background that joins a group situated, hands-on learning encounters all through the building innovation and sciences program, associating with understudies in the layout and examination method. LabView can order DAQ sheets as appeared in Fig. 1 to peruse simple information flags (A/D conversion), produce simple yield signals (D/A conversion), read and compose computerized flags, and control the on-board counters for frequency measurement, pulse generation and so forth. The voltage information goes into the module DAQ board in the computer, which sends information into the computer memory for storage, processing, or other manipulation [6].

3. State Estimation

State estimation is a digital processing scheme, which provides a real time data for many of the central control and dispatch functions in a power system. Its purpose is to improve the dispatch of energy, system reliability and planning capabilities by understanding the operating state of the power system. In general the state variables in the power system are the voltage magnitudes and phase angles at all the buses except the slack bus. In order to ensure secure and economical operation of the power systems, the operator must be aware of the exact state of the power system at regular intervals.

Today’s complex, large scale power systems require highly sophisticated techniques for monitoring and control to maintain the system in a secure and reliable state. There is a constant need to update information about the system to be used for security assessment, load frequency control and a host of other purposes. In this context, two aspects of the problem stand out prominently. Firstly, it is uneconomical and in many cases not feasible to monitor all possible information about the power system. Secondly, the measuring and equipments that are used, subjected to random errors, which make the data highly suspicious from the point of view of reliability. The main objective of state estimation in power systems is therefore to build a complete and reliable database. Such a database is obtained by feeding the measured data to a central real time computer, which on the basis of a pre written mathematical program, filters the data and extends it to cover all information regarding the system. In short, state estimation guarantees reliable information even if some of the measurements are inaccurate. Thus, the central task of the state estimator is to validate the information supplied to the system operator.

The major ingredients of state estimation are: measurement devices located at strategic points on the system, high speed data transfer system to convey the measured information to the control centre, a real time computer with interfacing equipment to accept and display information and efficient estimation algorithm. The state of a system may be defined as the minimal amount of information that one has to know about the system in order to predict its future evaluation. From this view point, the complex voltages in all buses in a power system are qualified to be assigned as state variables. Specifically, for an N bus system, taking a particular bus (preferably the swing bus) as reference, we may assign N voltage magnitudes and (N – 1) phase angles of n voltages, which are to be called as state variables. Thus, for an N bus system, the dimension of the state vector is (2N – 1). The rationale behind this choice is that, knowing these variables along with the active and reactive power injections at the N buses (real P_i and reactive Q_i at all buses except P_i at the swing bus) and system parameters it is possible to compute all measurements pertaining to the system. When observation errors are present the success of state estimation depends on the redundancy of observed data. Thus, if the state variables are n (equal $2N - 1$) in number and if n load injections at the buses are given then the problem reduces to a load flow calculation.

A state estimator is capable of filtering the information to provide a more accurate picture of the status of the system. The state estimation can be defined as a process which determines the operating state of the power system to allow the system operator to make decisions aimed at maintaining the security of the power system. WLS (weighted least square) algorithm is normally used for estimating the state of the system. The traditional objective of the state estimation is to reduce measurement errors by utilizing the redundancy available in the most measurement systems. In particular, the objectives are to reduce the variance of the estimate and to improve the overall efficiency [10].

The solution of state estimation gives the optimal generators needed to be committed with all the constraints satisfied. This information about number of generators to be committed is very much essential for real time operations in power systems control. This indicates the need for automating the state estimation calculations and developing a state estimation calculator in a good platform is essential. LabView is a powerful tool to create a calculator model for state estimation analysis [11].

4. LabView Based State Estimation Calculator Model

In this proposed LabView based state estimation calculator model, initially the FCi (fuel cost function) data were obtained from the coordination equations. After collecting the data, the block diagram panel will be used to design the state estimation calculator model [7] as shown in Fig. 2. The exceptional estimation of Lambda has been mapped with individual generators committed for a specific load demand. Numerous constraints can be forced on the power system’s target capacity for optimization purposes. Every individual power system might indicate its own particular arrangement of limitations relying upon specific elements as system topology, reliability and security requirements. The constraints in state estimation can be classified as spinning reserve, hydro constraints, fuel constraints, thermal unit constraints, including minimum uptime, minimum downtime, crew constraints, startup cost, shunt down cost and must run constraints [8].

The various algorithms such as a priority list method, dynamic programming method, evolutionary algorithms, Lagrangian-relaxation methods can be implemented in the proposed calculator model and any new algorithms can be implemented in a LabView environment without much difficulty. Since the problem of state estimation is to determine the most economical combination of the units of a power plant that should operate in a particular load on the power plant. Since the electrical load is highly dynamic and variable the input data for the proposed model has been designed with a high variable range as shown in Fig. 3.

4.1 Step by Step Developmental Procedure for State Estimation Calculator

Implementation of state estimation of the LabView platform is needed to the following steps to follow while implementing the model in a stand alone system [12].

- The measurement input data are given as a input to the state estimation calculator design to calculate the measurement vector.
- A boolean push button tool used here to calculate θ. Then the calculated value is taken for further calculations.

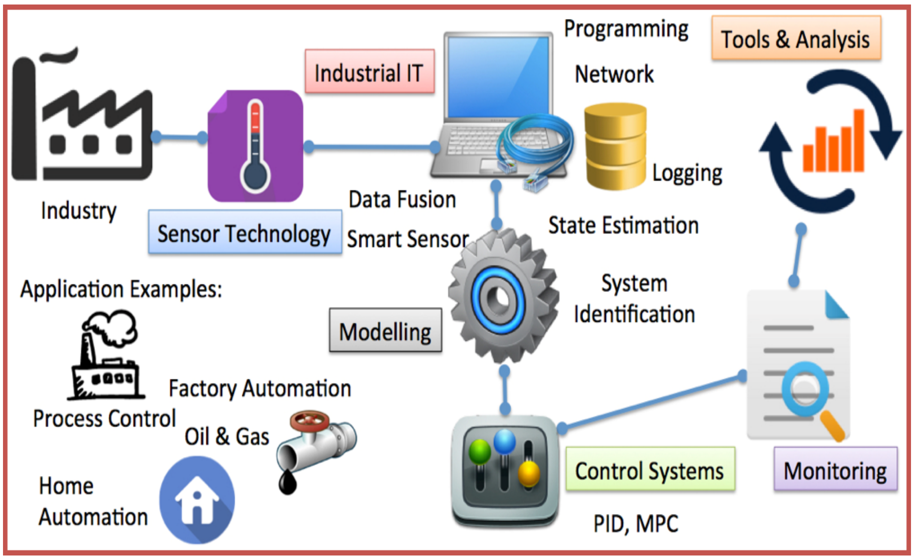

Fig. 2 LabView based data communications network.

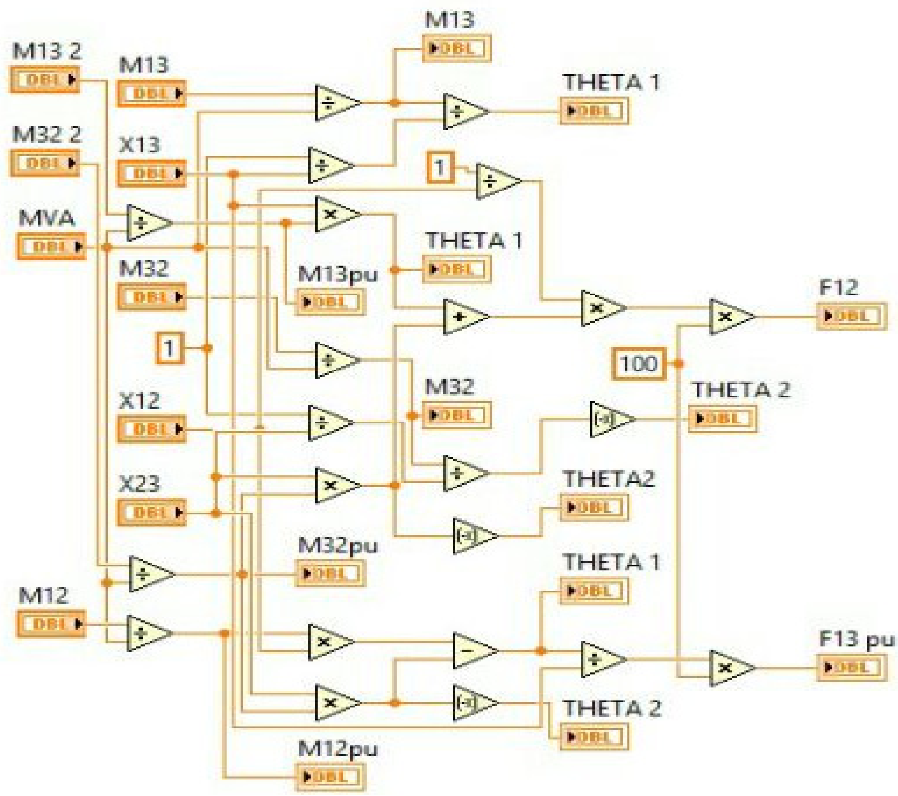

Fig. 3 State estimation calculator LabView model.

• For the calculated θ value, and the given measurement data for without error case, the new state measurement vector fuction was found.

• Based on the measurement data, new θ values were found for without error case. For error considering case, similarly the measurement data are converted to P.U values and the measurement vector function was formed.

• Similarly the different measurement vector functions are found for different values in the next and then the power flow values were also found and it has been shown in Figs. 3 and 4.

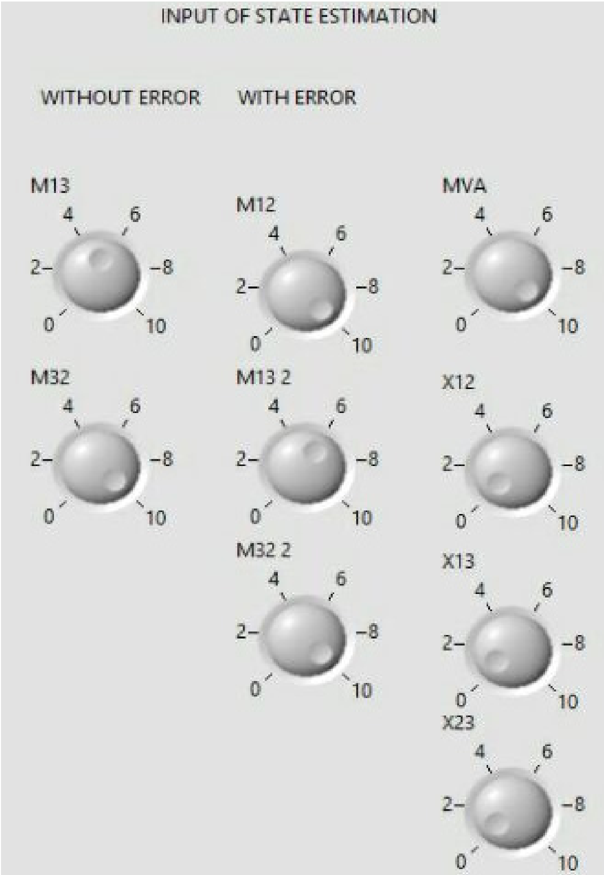

Fig. 4 State estimation solution calculator input.

5. Results

A simple state estimation calculator model has been implemented by using LabView. The result was shown in Fig. 4.

The Fig. 4 gives the state estimation solution for the power system network in the LabView window. The inputs are fed in the front panel of LabView and the state estimation runs automatically. Finally the state estimation solution displays the output [9] on the front panel as shown in Fig. 5. Using these approach different methods of state estimation analysis can be done for different numbers of bus system for three phase power system. This innovative model is very useful and handy for power engineers for calculating state estimation calculation. Proposed work has been developed such that different versions of state estimation algorithms can be implemented for state estimation calculations.

6. Conclusions

An effective LabView based state estimation calculator model has been developed for a power system network. In this model, the state estimation solutions were obtained for the system in Lambda iteration method. This model has been developed such that any recent algorithms of state estimation can be implemented without any reservations. The virtual state estimation model has been implemented model in LabView will be useful to the engineers and educators. Accordingly the proposed model can be implemented in multi-area power system network. A viable execution of this methodology proposed in this paper was surveyed in view of 6, 8, 9, 10, 13 and 15 transport test systems. In like manner the proposed model can be executed for extensive power system network spread over geologically separated. As future scope the entire power system analysis, such as contingency analysis, transient stability, fault analysis etc., can be implemented in a LabView based environment.

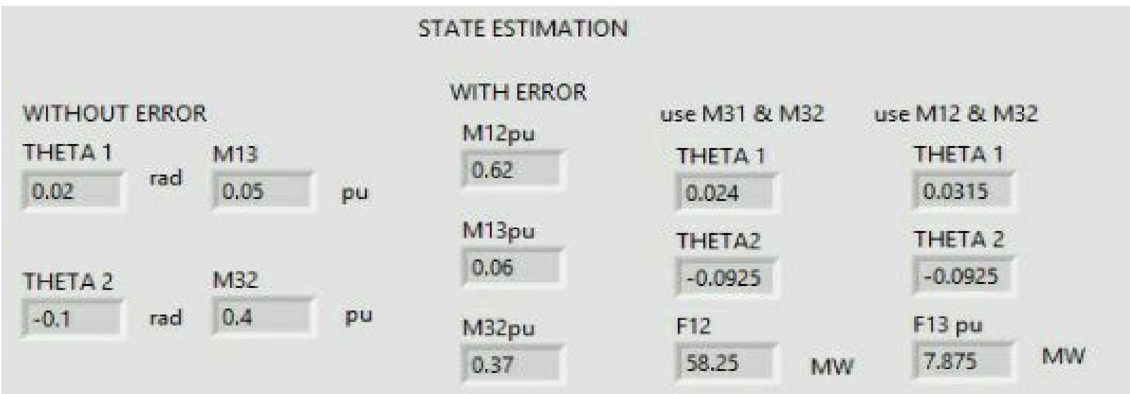

Fig. 5 State estimation solution calculator output.

References

[1] Chugani, M. L., Samant, A. R., and Cerna, M. 1998. *LabView Signal Processing.* NJ: Prentice Hall.

[2] Anderson, J. A., Korrapati, R. B., and Swain, N. K. 2000. "Digital Signal Processing Using Virtual Instrumentation." In *Proceedings of the SPIE,* 285-91.

[3] Korrapati, R. B., and Swain, N. K. 2000. "Study of Modulation Using Virtual Instruments." In *Proceedings of Academy of Information and Management Sciences,* 78-83.

[4] Benhamida, F., AYAD, A., Bendaoued, A., and Bentaallah, A. 2011. "A Basic Power System Analysis by Using LabView." *Acta Electrotehnica* 52 (1): 38-44. http://ie.utcluj.ro/files/acta/2011/Number1/Paper07_Benhamida.pdf.

[5] Swain, N. K., Anderson, J. A., and Korrapati, R. B. 2000. "Computer-based Virtual Engineering Laboratory (CBVEL) and Engineering Technology Education." In *Proceedings of the ASEE Annual Conference*, 5.162.1-5.162.7.

[6] Wells, L., and Travis, J. 1997. *LabView for Everyone, Graphical Programming Even Made Easier.* NJ: Prentice Hall.

[7] Yang, P., Tan, Z., Wiesel, A. I., and Nehorai, A. 2013. "Power System State Estimation Using PMUs with Imperfect Synchronization." *IEEE Transactions On Power Systems* 28 (4): 4162-72.

[8] Samson, S., Sundar, R., Ranganathan, T., and Nithiyananthan, K. 2015. "LabView Based Simple Load Flow Calculator Model for Three Phase Power System Network." *International Journal of Computer Applications* 132 (2): 9-12.

[9] Nithiyananthan, K., and Ramachandran, V. 2013. "Distributed Mobile Agent Model for Multi Area Power Systems Automated Online State Estimation." *International Journal of Computer Aided Engineering and Technology* 5 (4): 41-4.

[10] Gayathri, S., and Meenakumari, R. 2013. "Hybrid State Estimation Approach for the Optimal Placement of Phasor Measurement Units." *International Journal of Soft Computing and Engineering* 3 (2): 199-203.

[11] Mahaei, S. M., and Navayi, M. R. 2014. "Power System State Estimation with Weighted Linear Least Square." *International Journal of Electrical and Computer Engineering* 4 (2): 169-78.

[12] Nithiyananthan, K., and Ramachandran, V. 2004. "RMI Based Multi-Area Power System Load Flow Monitoring." *Iranian Journal of Electrical and Computer Engineering* 3 (1): 28-31.