International Journal of Scientific Research and Engineering Development-– Volume 2 Issue 5, Sep – Oct 2019

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Application of Graphical User Interface (GUI) for Analysing Voltage Instability of Electrical Power System Teaching and Learning

AnasSyafiq Ahmad Wizan, Ahmad Fateh Mohamad Nor

Green and Sustainable Energy (GSEnergy) Focus Group, Faculty of Electrical and Electronic Engineering,UniversitiTun Hussein Onn Malaysia, 86400 Parit Raja,BatuPahat, Johor, Malaysia
Email: afateh@uthm.edu.my

----------**********----------

Abstract:

The research presented in this paper focuses on the development of a Graphical User Interface (GUI) platform that can be used to perform the voltage instability analysis of electrical power system using Modal Analysis Technique for teaching and learning application. The designed GUI platformhas the ability to produce the Participation Factor (PF) of every load buses in the power system. PF shows the tendency of a certain load bus towards experiencing voltage instability. The higher the PF of the load bus, the higher the chance of the system towards experiencing voltage instability and vice versa. A three bus system from HadiSaadat reference book and IEEE 14 bus system have been chosen as the test systems for this research. The results have shown that for the 3-bus power system, Load Bus 2 has the highest PF value. Meanwhile for the IEEE-14 bus system, Load Bus-14 has the highest PF value. The developed GUI platform has the ability to produce all of these PF values. The GUI is done by using MATLAB Software. The GUI platform is targeted for teaching and learning purposes especially for undergraduate engineering students,postgraduate research students as well as junior engineers.

Keywords **—Voltage Stability Analysis; Modal Analysis Technique; IEEE-14 Bus; MATLAB; GUI.**

----------**********----------

I. INTRODUCTION

Since the beginning of electrical power system discovery, power systems blackoutshas been acknowledged as one of the most serious problem in the field of electrical power engineering. This is due to the fact that power system blackouts can lead to huge economic losses on top of disturbing the electrical power distribution. According to [1]–[3],common blackouts that occurred around the world were caused by voltage instability in the power system. A power system in considered experiencing voltage instability when the power system is not able to maintain the voltage values of buses after the system is being exposed to a disturbance [3], [4]. One of the disturbance that force the power system to enter voltage instability condition is usually the increasing of load demand [5]. The modal analysis technique has the ability to directly show which load buses that has the highest tendency towards experiencing voltage instability [6], [7]. However, the method to perform the modal analysis technique consists of very detail and intensive procedures and calculations. In order to make the modal analysis technique smoother, a graphical user interface (GUI) platform has been

developed. This GUI has the ability to show the result of the modal analysis. Previous research work such as [8] has successfully developed a GUI platform for analyzing voltage instability for a two bus radial system. The GUI platform developed in this project has the ability to analyze voltage instability for a larger power system which is the IEEE-14 bus system. The GUI platform package is targeted for undergraduate engineering students, postgraduate research students as well as junior practicing engineers.In addition, GUI is a very popular method that has been used by previous researchers such as [9]–[12] for teaching and learning application especially in the field of engineering, science and mathematics.

II. METHODOLOGY

A. Menu

The first part of the GUI platform is the main menu as depicted in Fig. 1. From the main menu the user can choose to perform the voltage instability Modal Analysis Technique for 3-bus system or for IEEE-14 bus system.

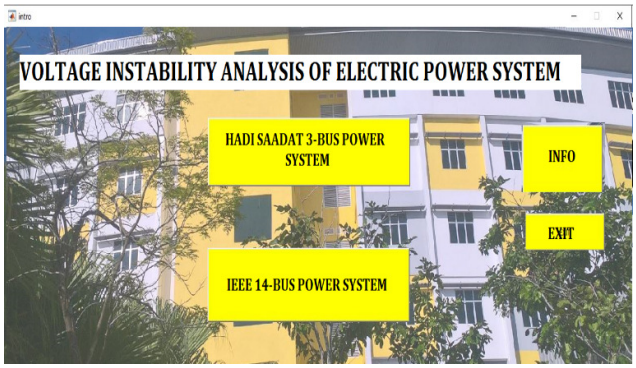

Fig. 1 The main menu of the GUI platform

B. HadiSaadat 3-bus Power System

This 3-bus power system has been taken from [13]. This power system consists of one slack bus (Bus 1) and two load buses (Bus 2 and Bus 3). The diagram of this power system that has been integrated in the developed GUI platform is illustrated Fig. 2.

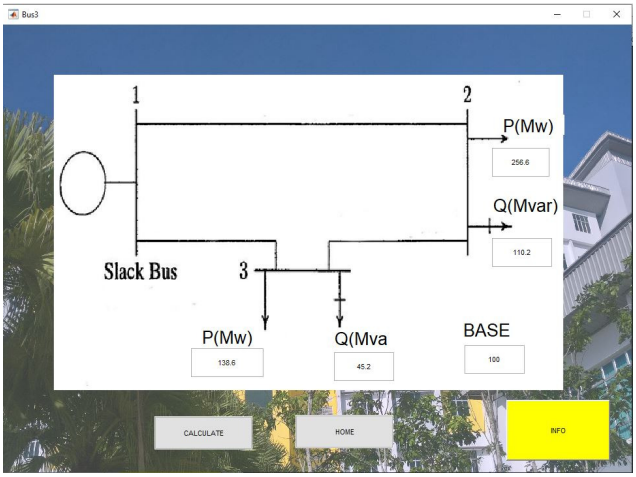

Fig. 2Three-bus power system GUI window

C. IEEE 14-bus Power System

IEEE 14-bus test power system consists of one slack bus (Bus 1), four voltage controlled buses (Bus 2, Bus 3, Bus 6 and Bus 8) and nine load buses (Bus 4, Bus 5, Bus 7 and Bus 9 until Bus 14) [14]. Load buses is very important in voltage stability analysis because the Participation Factor (PF) values are on the load buses.Fig.3 shows the GUI window that illustrates the IEEE-14 bus system.

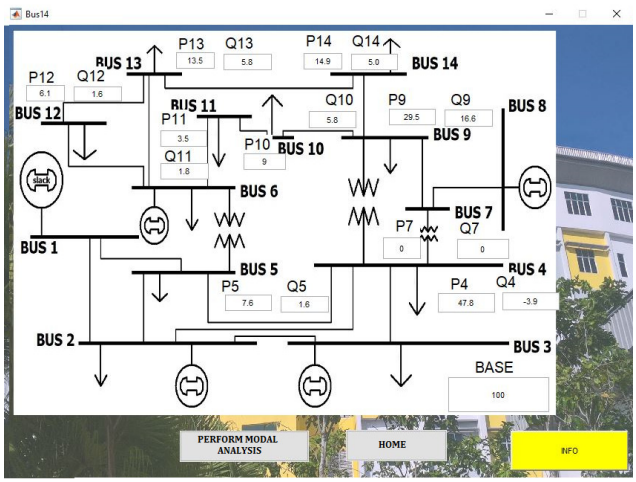

Fig. 3IEEE 14-bus power system GUI window

D. Modal Analysis Technique

The modal analysis technique was discovered by [7]. This technique'sobjective is to calculate the values of eigenvalue and eigenvector of the reduced Jacobian matrix (Jr). Jacobian matrix from the Newton Raphson

power flow analysis method can be found during the load flow analysisthat represents the injected real power (P) and reactive power (Q) in buses as shown in Equation (1)[2], [7], [13], [15].The Jr values for the modal analysis technique can be obtained by letting the value of ΔP in Eqn. 1 equals to 0. From here, the participation factor (PF) can be obtained. The higher the PF value, the higher the tendency of that particular load bus to experiencing voltage instability. The details of modal analysis technique can be found in[2], [6], [15].

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}J_{P\delta} & J_{PV}\\ J_{Q\delta} & J_{QV}\end{bmatrix}\begin{bmatrix}\Delta\delta\\ \Delta V\end{bmatrix} \qquad \text{Eq. 1}$$

where
ΔP is the incremental change in bus real power
ΔQ is the incremental change in bus reactive power
$\Delta\delta$ is the incremental change in bus voltage angle
ΔV is the incremental change in bus voltage magnitude

III. RESULTS AND DISCUSSION

Modal Analysis Technique has been applied to both 3 and 14 bus systems. The results are presented in the following sections.

A. PF for HadiSaadat 3-bus Power System

The modal analysis technique was performed upon the HadiSaadat 3 bus system. The PF obtained from this technique from the developed GUI platform is depicted in Fig. 4.

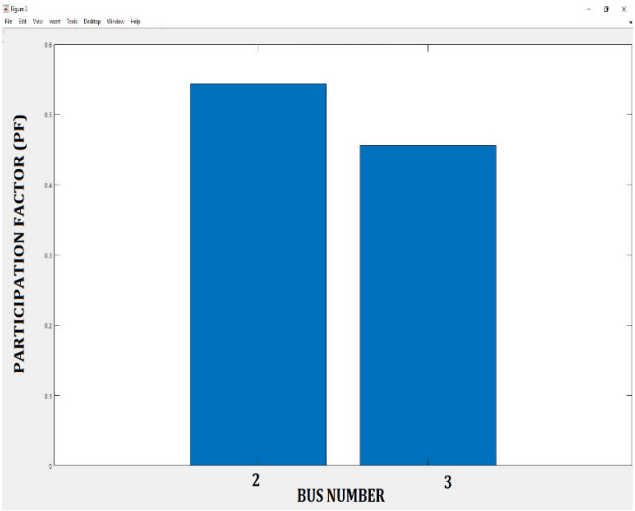

Fig. 4PF of the 3 Bus System

Fig. 4 depicts that Bus 2 has the PF value of 0.55 and Bus 3 has PF value of 0.45. This shows that between these two load buses, Bus 2 has higher chance of experiencing voltage instability.

B. PF for IEEE 14-bus Power System

The modal analysis technique was performed upon the IEEE-14 bus system. The PF obtained from this technique from the developed GUI platform is depicted in Fig. 5.

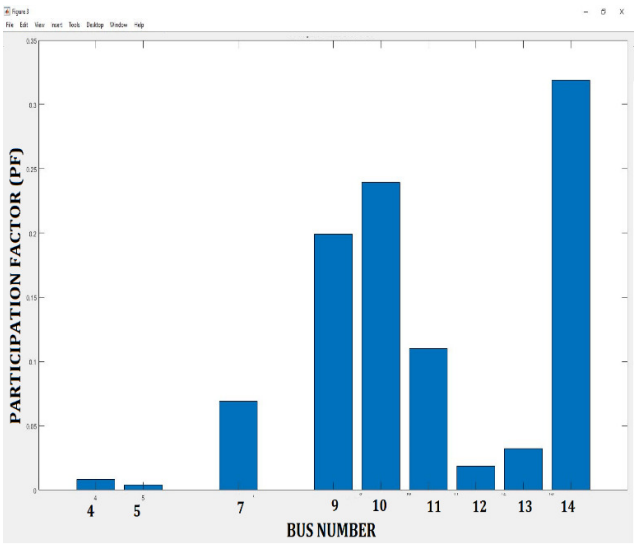

Fig. 5PF of the IEEE 14- Bus System

Fig. 5 depicts that Bus 14, Bus 10 and Bus 9 have high participation factor with Bus 14 is the highest which is 0.3190. This means that Bus 14 has the highest tendency towards voltage instability. One more important information that can be learned from Figure 4 is that Bus 5 and Bus 4 are the two most stable load buses in this power system.

IV. CONCLUSIONS

This project has shown that the developed GUI has successfully shows the PF obtained from the voltage instability modal analysis technique. For future research works, this GUI can be expended to perform voltage instability analysis for larger power system as well as real power system data.

ACKNOWLEDGMENT

The authors are grateful to the Green and Sustainable Energy (GSEnergy) Focus Group, Faculty of Electrical and Electronic Engineering, UniversitiTun Hussein Onn Malaysia (UTHM) for providing conducive research platform.

REFERENCES

[1] A. F. M. Nor, M. Sulaiman, A. F. A. Kadir, and R. Omar, "Voltage Instability Analysis for Electrical Power System Using Voltage Stabilty Margin and Modal Analysis," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 3, no. 3, pp. 655–662, 2016.

[2] Y. A. Mobarak, "Voltage Collapse Prediction for Egyptian Interconnected Electrical Grid EIEG," *International Journal on Electrical Engineering and Informatics*, vol. 7, no. 1, pp. 79–88, Mar. 2015.

[3] B. Poornazaryan, P. Karimyan, G. B. Gharehpetian, and M. Abedi, "Optimal Allocation and Sizing of DG Units Considering Voltage Stability, Losses and Load Variations," *International Journal of Electrical Power and Energy Systems*, vol. 79, pp. 42–52, 2016.

[4] A. F. M. Nor, M. Sulaiman, A. F. A. Kadir, and R. Omar, "Classifications of Voltage Stability Margin (VSM) And Load Power Margin (LPM) Using Probabilistic Neural Network (PNN)," *ARPN Journal of Engineering and Applied Sciences*, vol. 12, no. 19, pp. 5591–5596, 2017.

[5] S. M. Perez-Londono, G. Olivar-Tost, and J. J. Mora-Florez, "Online Determination of Voltage Stability Weak Areas for Situational Awareness Improvement," *Electric Power Systems Research*, vol. 145, pp. 112–121, 2017.

[6] A. F. M. Nor and M. Sulaiman, "Voltage Stability Assessment of Power System Network using QV and PV Modal Analysis," *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, vol. 8, no. 7, pp. 7–11, 2016.

[7] B. Gao, G. K. Morison, and P. Kundur, "Voltage Stability Evaluation using Modal Analysis," *IEEE Transactions on Power Systems*, vol. 7, no. 4, pp. 1529–1542, 1992.

[8] Noor Ropidah Bujal, Marizan Sulaiman, and Rosli Omar, "A Graphical User Interface (GUI) for Voltage Stability Analysis," in *Conference In Education - Technical Vocational Education and Training*, 2014, pp. 1441–1461.

[9] I. Burhan, R. Othman, and A. A. Azman, "Development of Electro Pneumatic Trainer Embedded with Programmable Integrated Circuit (PIC) and Graphical User Interface (GUI) for Educational Applications," in *IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS)*, 2016, pp. 1–6.

[10] N. F. Naim *et al.*, "Interactive Learning Software for Engineering Subjects Based on MATLAB-GUI," *Journal of Telecommunication, Electronic and Computer Engineering*, vol. 8, no. 6, pp. 77–81, 2016.

[11] H. Ratu, P. Negara, V. Mandailina, and L. Sucipto, "Calculus Problem Solution And Simulation Using GUI Of Matlab," *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH*, vol. 6, no. 9, pp. 275–279, 2017.

[12] R. Moharil, P. Yeole, S. Gupta, and A. Kumar, "CSIT: An Open Source and interactive GUI based tool for learning and analyzing Control Systems," in *11th International Conference on Intelligent Systems and Control (ISCO)*, 2017, pp. 55–58.

[13] H. Saadat, *Power System Analysis*. Singapore: McGraw-Hill Inc., 2004.

[14] M. A. Pai, *Computer Techniques in Power System Analysis*, Second Edi. New Delhi: Tata McGraw-Hill, 2006.

[15] B. Telang and P. Khampariya, "Voltage Stability Evaluation Using Modal Analysis," *International Journal of Scientific Research Engineering & Technology (IJSRET)*, vol. 4, no. 4, pp. 408–411, 2015.

