Investigation of Static Voltage Stability and Power Losses of ZIP Load Modeling in Power Systems

M. Kenan DÖŞOĞLU*, Mustafa DURSUN*, Gökhan POYRAZ+, Bayram KÜÇÜK*

*Düzce University
Faculty of Technology, 81620 Konuralp, Düzce, Turkey
{ kenandosoglu, mustafadursun, bayramkucuk }@duzce.edu.tr

+Bilecik Seyh Edebali University
Faculty of Engineering, 11210 Gülümbe, Bilecik, Turkey
gokhan.poyraz @bilecik.edu.tr

Abstract*— One of the most important problems with energy consumer is effect of static load modeling in power systems. In this study, Effects on static voltage stability and active-reactive power losses of static load modeling in 5 bus power system were investigated. As static load modeling; constant impedances, constant current, and constant active power (ZIP) load model has been used. The impacts of ZIP load modelling on different parameter values were evaluated in terms of voltage-maximum loading parameters and active-reactive power losses. It was found that static voltage stability and active-reactive power losses increased while maximum loading parameter values decreased as the ZIP load modelling constant current value changed.

***Keywords*— Static Voltage Stability, Power Losses, ZIP, Power System, Static Load Modeling**

I. INTRODUCTION

Owing to increasing demand for the consumers' power systems, the operation conditions of the power systems became problems. Problems might lead to system instability in operation conditions. Voltage stability is a one of the most visible in power systems. There are various literature studies about voltage stability. Static and dynamic load modeling are studied on different parameter for voltage stability. Different parameters are examined to find the relationship between bus active power-bus voltage [1-2]. Line voltage, power factor, line length, serial compensation, shunt compensation effects in power systems are investigated. The relationship between active power and maximum loading parameter of these parameters has been analyzed [3-4]. Jacobean matrix for active power-voltage curve in voltage stability is enhanced. With enhancement of the Jacobean matrix and voltage index, the improvement of the maximum loading parameter and the decrease in losses were observed [5-6]. The effects on the voltage stability both of the phase shifter transformers at different angle values and of the 3-winding transformer are investigated. In terms of voltage stability, phase shifter transformer and 3-winding transformer have given effective results [7-8]. FACTS devices are used for improving operation conditions in voltage stability. Static Synchronous Compensator (STATCOM), Static Var Compensator (SVC), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Control (UPFC) provide to voltage control and active-reactive power control for voltage stability in power systems [9-12]. Therefore, FACTS devices are widely used for power system analysis. In this study, the effects on static voltage stability of the ZIP load model are emphasized. The different constant impedance, constant current and constant power analysis of the ZIP load model have been investigated in the 5-bus power system. The voltage-maximum load parameter values and voltage profiles at different parameter values were compared.

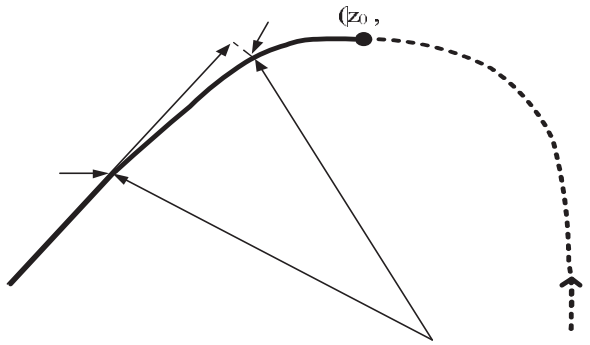
II. STATIC VOLTAGE STABILITY

Static voltage stability depends on reactive power change. The operating conditions of the load bus can be improved by providing reactive power. If the reactive power support decrease below the specified limits and the voltage drop, the system break-out arises. To prevent this problem, different operation modes is enhanced for static voltage stability. The relation between the system maximum-load parameter and the active power-reactive power of the bus are shown in Equation 1 and Equation 2.

$$P_L = P_{L0}(1+\lambda) \tag{1}$$

$$Q_L = Q_{L0}(1+\lambda) \tag{2}$$

P_{L0} and Q_{L0}, are initial active and reactive power values, P_L and Q_L are active and reactive power of the load λ maximum loading parameter value, respectively. In the continuous load flow, the relationship between the voltage and the maximum load parameter is used. Continuous load flow method is used for the analysis of voltage and MLP. Continuous load flow is very effective in analyzing certain difficulties without the support of certain system models. The voltage has the ability to automatically change against the adverse situation that may be caused by single analysis of the system equations. The use of strategy in continuous load flow is shown in Fig. 1.


(z0 ,

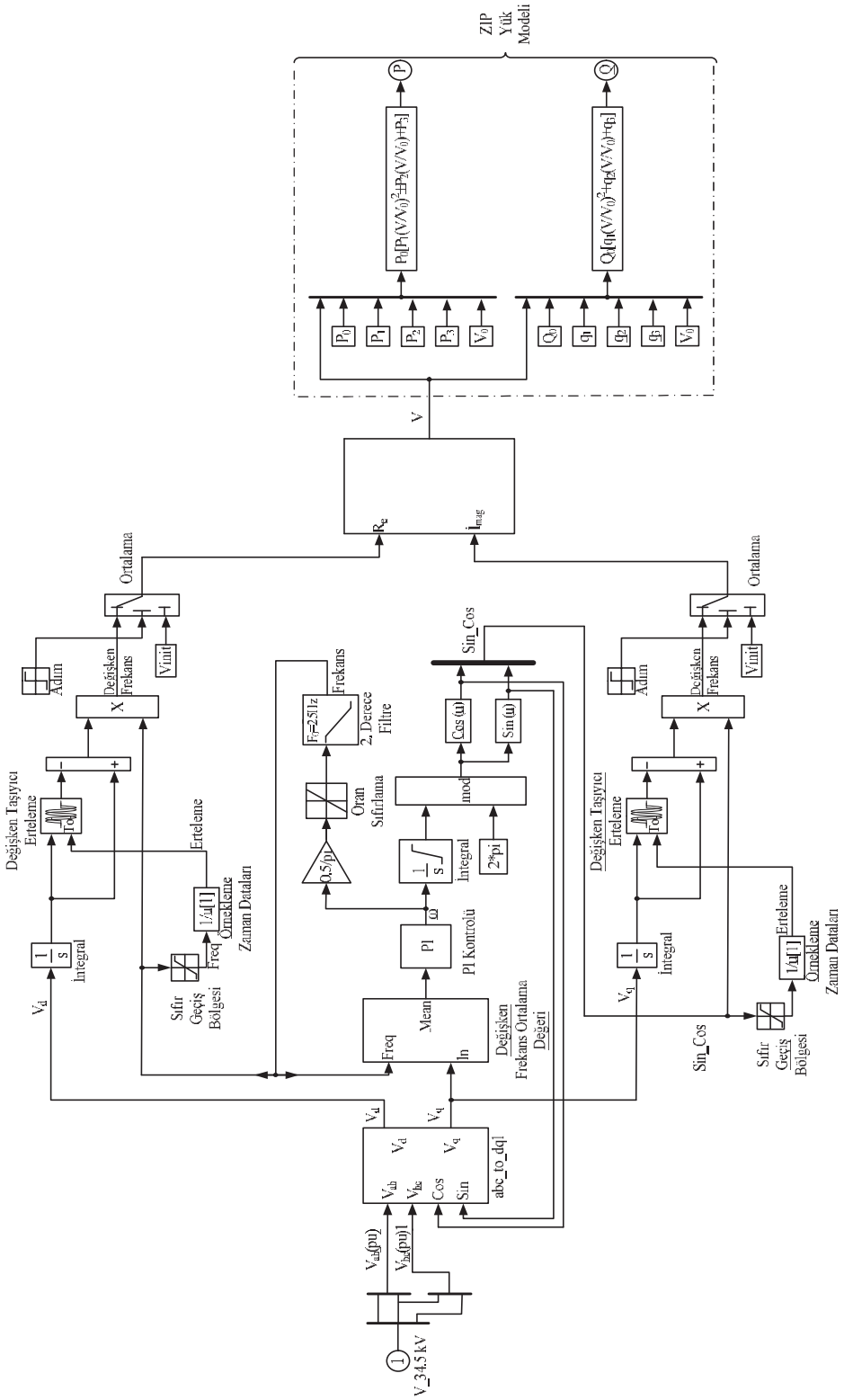


Fig. 2. ZIP Load Model

V. SIMULATION RESULTS

ZIP load model is used connected to instead of the PQ bus load model with the lowest voltage profile. With ZIP load input parameters are regulated to different values, Static voltage stability is determined by continuous load flow. When the bus voltage is used as input ZIP load model. Active and reactive power is obtained in the output. When both zip load active power and zip load reactive power input parameters are used as 0.15 - 0.15 - 0.70, the maximum load parameter of the system is 3.54. ZIP load model 0.1 - 0.1 - 0.8 parameter values in 5 buses power system, system total the active power losses and the reactive power losses are 2.04 p.u and 5.91 p.u, respectively. The relationship between the obtained voltage profiles and the voltage-maximum loading parameter is shown in Fig. 4 and Fig 5.

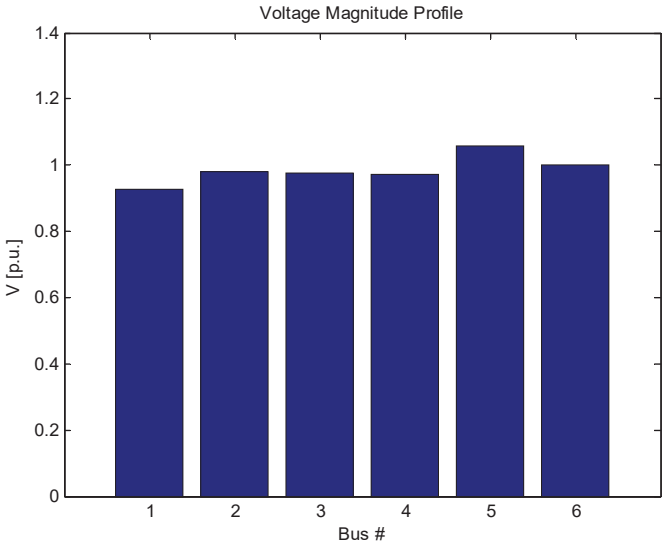


Fig. 4. Voltage profile of the buses in 0.15-0.15-0.7 values

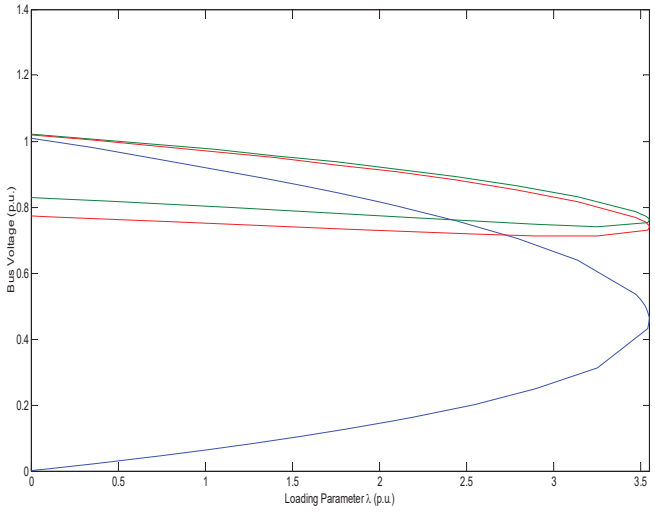


Fig. 5. Voltage-MLP curves in 0.15-0.15-0.7 values

When both zip load active power and zip load reactive power input parameters are used as 0.1 - 0.1 - 0.8, the maximum load parameter of the system is 3.49. ZIP load model 0.1 - 0.1 - 0.8 parameter values in 5 buses power system, system total the active power losses and the reactive power losses are 1.91 p.u and 5.53 p.u, respectively.

The relationship between the obtained voltage profiles and the voltage-maximum loading parameter is shown in Fig. 6 and Fig 7.

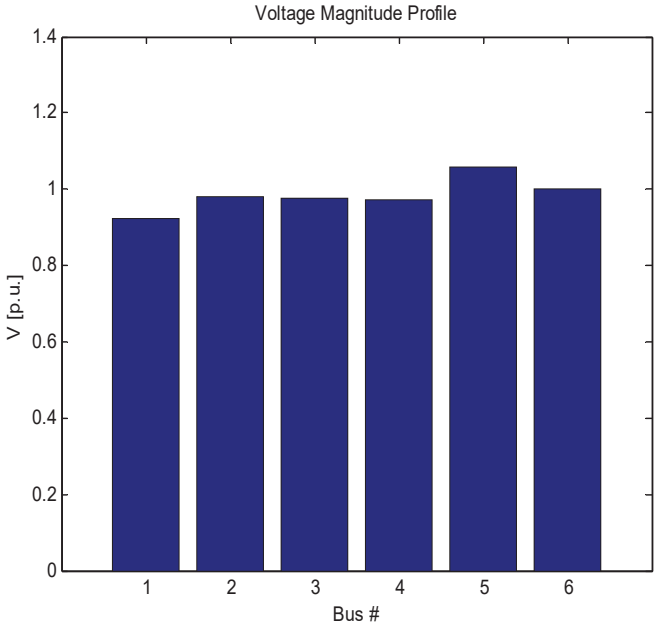


Fig. 6. Voltage profile of the buses in 0.1-0.1-0.8 values

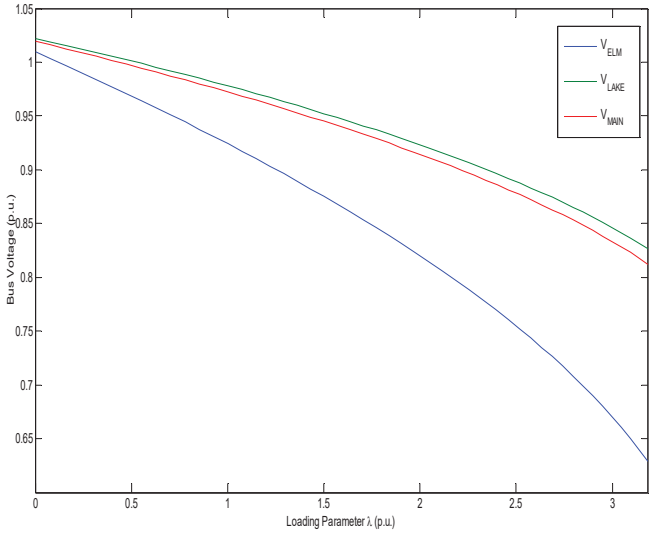


Fig. 7. Voltage-MLP curves in 0.1-0.1-0.8 values

When both zip load active power and zip load reactive power input parameters are used as 0.05 - 0.05 - 0.9, the maximum load parameter of the system is 3.16. ZIP load

model 0.05-0.05-0.9 parameter values in 5 buses power system, system total the active power losses and the reactive power losses are 1.28 p.u and 3.63 p.u, respectively.

The relationship between the obtained voltage profiles and the voltage-maximum loading parameter is shown in Fig. 8 and Fig 9.

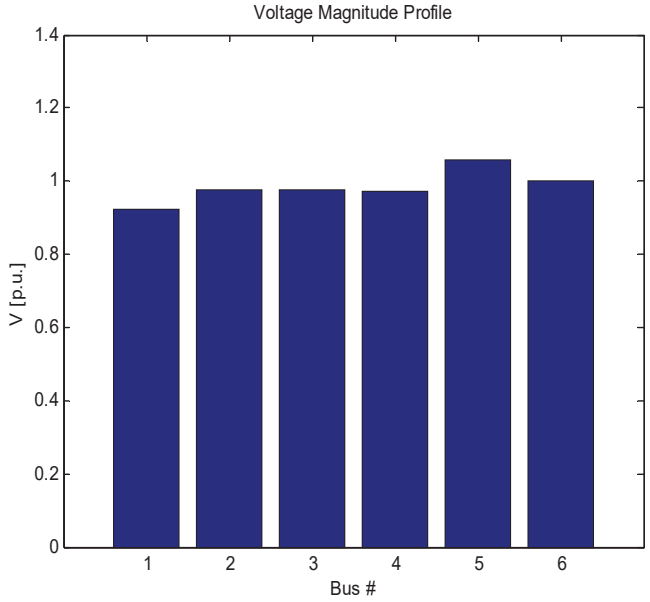


Fig. 8. Voltage profile of the buses in 0.05-0.05-0.9 values

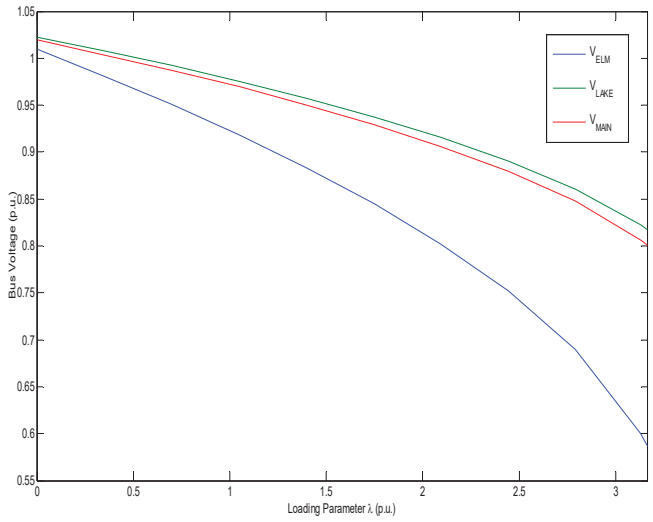


Fig. 9. Voltage-MLP curves in 0.05-0.05-0.9 values

VI. Conclusion

In this study, the effect of the voltage stability on the ZIP load model with the continuous load flow in the 5 buses power system is investigated. Used as nonlinear load modelling, ZIP load model, constant impedance, constant current and constant active power variations are examined with different scenario. There is a decrease in constant impedance (Z) and constant current (I) of ZIP load model values, an increase in constant active power (P) of ZIP load model values and a decrease in voltage-MLP value. Besides, bus voltage profiles during continuous load flow analysis decrease depending on ZIP load model parameters. When ZIP load modeling parameter values decrease, total active-reactive power losses of the 5 buses power system decrease.

References

[1] Y. Zhu and J.V. Milanović, "Efficient identification of critical load model parameters affecting power system voltage stability," *In PowerTech 2017 IEEE Manchester*, pp. 1-6.

[2] W. Xu and Y. Mansour, "Voltage stability analysis using generic dynamic load models," *IEEE Transactions on Power Systems*, vol. 9(1), pp. 479-493, 1994.

[3] A. J. Conejo, F. Milano and R. García-Bertrand, "Congestion management ensuring voltage stability," *In Power and Energy Society General Meeting-Conversion and Delivery of Electrical Energy in the 21st Century 2008 IEEE*, pp. 1-8.

[4] R. Bayındır, M. Yeşilbudak and Ü. Çetinkaya, "Güç Sistemlerinde Gerilim Kararlılığını Etkileyen Faktörler," *Gazi Üniversitesi Fen Bilimleri Dergisi Part C: Tasarım ve Teknoloji*, vol. 3(4), pp. 595-602, 2015.

[5] P. W. Sauer and M. A. Pai, "Power system steady-state stability and the load-flow Jacobian," *IEEE Transactions on power systems*, vol. 5(4), pp. 1374-1383, 1990.

[6] I. Musirin and T. A. Rahman, "Novel fast voltage stability index (FVSI) for voltage stability analysis in power transmission system," *In Research and Development SCOReD 2002. Student Conference on*, pp. 265-268, 2002.

[7] M. K. Döşoğlu, S. Tosun, A. Öztürk and G. Poyraz, "Faz Kaydırıcı Transformatörlerin Statik Gerilim Kararlılığı Üzerindeki Etkilerinin İncelenmesi," *İleri Teknoloji Bilimleri Dergisi*, vol. 2(3), pp. 43-52, 2013.

[8] M. K. Döşoğlu, U. Güvenç, S. Duman and M. Dursun, "3 Sargılı Transformatörün Gerilim Kararlılığı Üzerindeki Etkilerinin İncelenmesi," *3. Anadolu Enerji Sempozyumu*, pp.292-298, 2015.

[9] A. Sode-Yome, N. Mithulananthan and K. Y. Lee, "Static voltage stability margin enhancement using STATCOM, TCSC and SSSC," *In Transmission and Distribution Conference and Exhibition: Asia and Pacific 2005 IEEE/PES*, pp. 1-6, 2005.

[10] N. Boonpirom and K. Paitoonwattanakij, "Static voltage stability enhancement using FACTS," *In Power Engineering Conference, 2005. IPEC 2005*, pp. 711-715, 2005.

[11] A. Sode-Yome and N. Mithulananthan, "Comparison of shunt capacitor, SVC and STATCOM in static voltage stability margin enhancement," *International Journal of Electrical Engineering Education*, vol. 41(2), 158-171, 2004.

[12] A. Kazemi, V. Vahidinasab and A. Mosallanejad, "Study of STATCOM and UPFC controllers for voltage stability evaluated by Saddle-Node bifurcation analysis," *In Power and Energy Conference, 2006 PECon'06*, pp. 191-195, 2006.

[13] A. Kazemi and B. Badrzadeh, "Modeling and Simulation of SVC and TCSC to Study Their Limit on Maximum Loadability Point," *International journal of Electrical Power Energy Systems*, vol. 26(5), pp. 619-626, 2004.

[14] M. K. Döşoğlu and A. B. Arsoy, "Modeling and simulation of static loads for wind power applications," *Neural Computing and Applications*, vol. 25(5), pp. 997-1006, 2014.

[15] F. Milano, "Power System Analysis Toolbox," *Version 1.3.4, Software and Documentation*, 2005.

[16] K. Kaya, "Esnek Alternatif Akım İletim Sistemleri Kontrolörlerinin İncelenmesi Ve Şebeke Üzerindeki Etkileri," *İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi*, 2015.