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Generator Equivalent Model (GEM) in to Voltage Stability Analysis

Karthik Manyapu[1], Vijay Kumar Itham[2], Dr. T. Anil Kumar[3]
PG Scholar[1], Assistant Professor[2], Associate Professor & HOD[3]
Department of EPS[1], Department of EEE[2, 3]
Anurag Group of Institutions (Autonomous), Hyderabad, Telagana, India

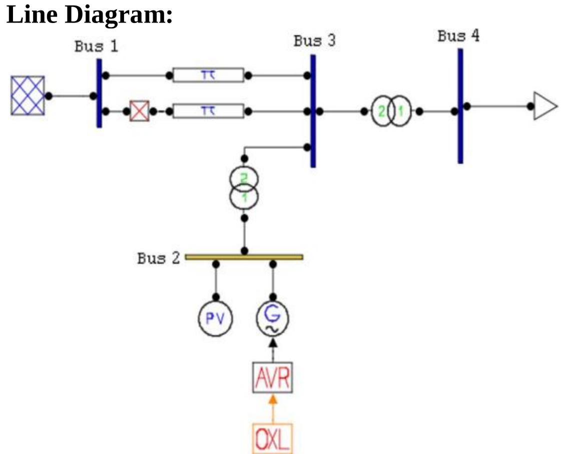
Abstract:
In most voltage stability indices, generators are normally modeled as either PV buses or ideal voltage sources. These assumptions cannot cover the entire process of systems losing voltage stability, especially when PV generators have converted to PQ nodes in case of reactive power shortage. In this paper, an alternative generator equivalent model (GEM) is proposed for voltage stability analysis. Based on their dynamic models and real-time measurements, generators are modeled by time-varying internal voltages and impedances to capture the dynamic behaviors of generators. Furthermore, the traditional L–index is extended to incorporate GEMs for system voltage stability analysis. Simulation studies have been carried out to verify the effectiveness of the proposed new index and to show the impacts of GEM on voltage stability analysis. The simulation results of four test systems show that, in certain scenarios, incorporating GEM is necessary and can significantly improve the accuracy of voltage stability analysis.

Keywords: Generator equivalent model (GEM), -index, real-time, Voltage stability.

I. INTRODUCTION:

In recent years, a considerable number of voltage-instability-related outage events have occurred around the world, which resulted in enormous economic losses and caused significant social impacts. Voltage stability has become one of the most important topics in power system security estimation. Many voltage stability indices have been proposed, and some of them have been successfully applied in real power systems for voltage stability analysis. The typical indices include the traditional P-V and Q-Curves-based indices Jacobin matrix singularity indices power-flow solution pairs and L-index for the majority of voltage stability indices, generators are often modeled as either ideal voltage sources or PV nodes for static voltage stability analysis. Such assumptions are reasonable when generators are operating within their reactive power capacity and field current limitations since the magnitudes of terminal voltages can be kept constant in varying system states. However, system voltage instability often happens in the case of a lack of reactive compensations and accompanies a transition of generators from the PV mode to the PQ mode. In these situations, the assumption of constant voltage for generators is no longer valid. Therefore, a new generator equivalent model (GEM) with time-varying internal voltage and impedance is proposed for voltage stability analysis in this paper. On the one hand, the time-varying parameters are capable of catching generator dynamic behaviors. On the other hand, the model is sufficiently simple to be embedded into some existing voltage indices, such as the L-index. The L-index was proposed by Kessel and Glavitsch in 1986 to predict voltage stability margins. In this method, a generator was modeled by an ideal voltage source and generator terminal voltages were treated as constants. Obviously, this assumption is not suitable for PQ generator nodes. The traditional L-index is extended to include GEMs in this paper. Simulations will show that this extension is particularly useful in the cases where some generators in the system are close to their excitation limits and some distributed generation (DG) sources are installed at locations closer to loads. It is worth pointing out that the L-index relies on real-time measurements in a wide area. This high measurement requirement actually limited the actual application so the L-index in the past. However, with the development of advanced smart grid technologies, such as phasor measurement units (PMUs), there is a trend of using wide-area information in power system protection and control.

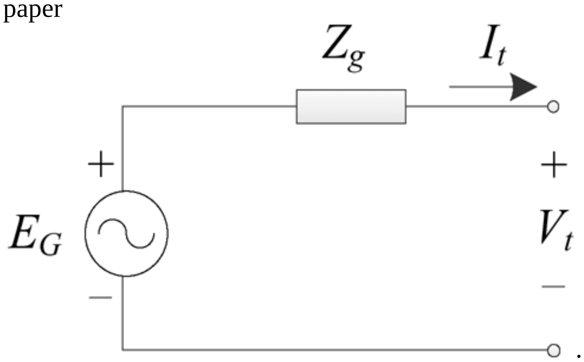
Line Diagram:



In this project, a generator equivalent model (GEM) is proposed for voltage stability analysis. Based on their dynamic models and real-time measurements, generators are modeled by time-varying internal voltages and impedances to capture the dynamic behaviors of generators. Furthermore, the traditional L–index is extended to incorporate GEMs

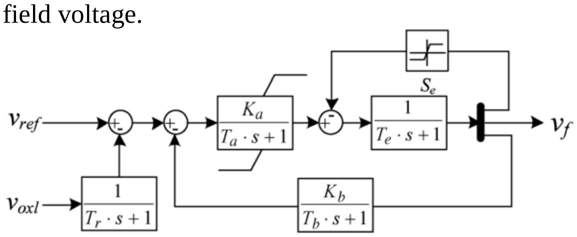
A. Generator equivalent model:

In order to describe generator dynamic behaviors, the synchronous machine model, automatic voltage regulator (AVR), as well as the over excitation limiter (OXL) are taken into account in our studies. Note that the GEM and voltage stability index proposed in this paper still belong to the framework of static voltage stability analysis though the dynamic simulations are carried out in the time domain in this paper



B.Automatic Voltage Regulator:

In the figure, $\mathbf{V_{ref}}$ is the prescribed voltage reference, $\mathbf{V_{ox1}}$ is the additional voltage signal from OXL, $\mathbf{T_r}$ denotes the measurement time constant, $\mathbf{K_a}$ and $\mathbf{T_a}$ are the amplifier gain and time constant, respectively, $\mathbf{K_b}$ and $\mathbf{T_b}$ are the stabilizer gain and time constant on the feedback circuit, $\mathbf{T_e}$ is the field circuit time constant, S_e represents the saturation curve, and $\mathbf{V_f}$ is the output field voltage.



B. Voltage stability:

Voltage stability refers to the ability of a power system to maintain steady voltages at all nodes in the system after being subjected to a disturbance from a given initial operating condition. A system is voltage unstable if, for at least one bus in the system, bus voltage magnitude decreases as the reactive power injection at the same bus is increased consequently, one of the major causes of voltage instability is the reactive power limit of the system. This problem can be solved by providing adequate reactive power support at some critical bus bar.

C. L-index:

Voltage stability is measure of whole power system quality. Voltage stability studies can do by analyzing reactive power production, transmission of power and consumption. In this paper voltage stability analysis of bus system is done by calculating L-index of the buses. Kessel developed a voltage stability index based on the solution of the power flow equations. The L -index is a Quantitative measure for the estimation of the distance of the actual state of the system to the stability limit.

Over Excitation Limiter:

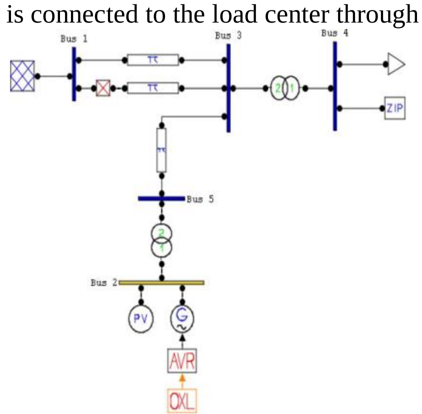
The AVR can approximately hold a constant generator terminal voltage when the OXL is inactive. However, the generator terminal voltage will lose control (normally decrease gradually) if the OXL is activated at the field current limitation.

Tap Changing in the Four-Bus System:

To explore the impact of tap changing devices, the transformer between buses 3 and 4 in the four-bus system is replaced By a load tap changer (LTC) transformer, as shown in Fig. Using this LTC transformer, 15% voltage can be changed in12 steps of 2.5% per step. Meanwhile, an ER load is installed at node 4. The results also demonstrate the effectiveness of the proposed method for the scenarios with tap changing devices.

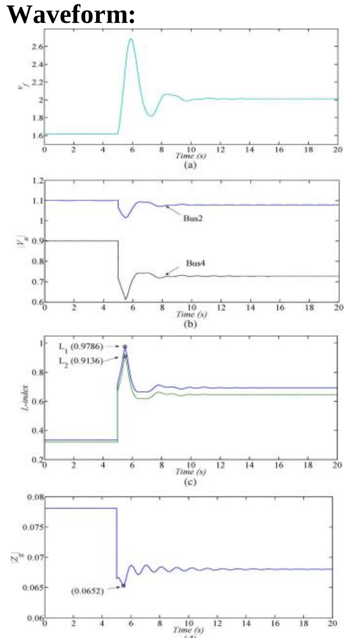
Five-bus system:

GEMs can play an important role when generators are close to loads. To further investigate the influence of GEMs for the Generators far away from loads, it is assumed that the generator is connected to the load center through an added



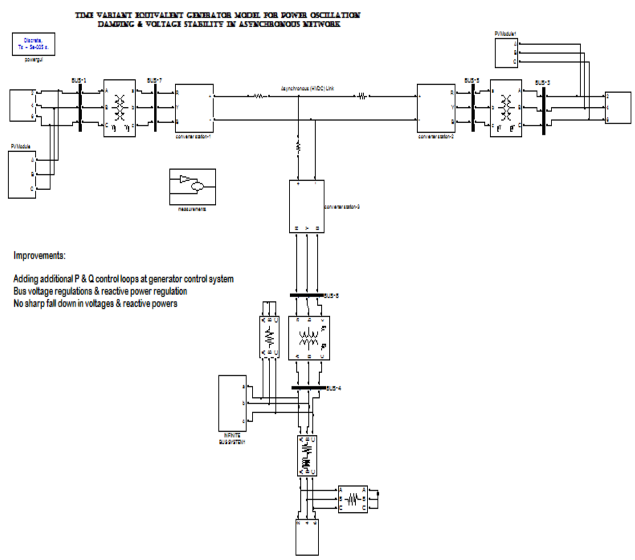
Long-distance transmission line, as shown in. The line has the same parameters as that of the lines between buses 1 and 3. Other models are kept unchanged. First of all, the load at bus 4 is increased up to the critical value 1.693 p.u. OXL is inactive and the system did not lose stability. The values of $L_1$and L_2 almost reach 1.0 at the same time. Both and can represent the point at which the system loses voltage stability immediately after the contingency. Like most voltage indices, neglecting GEMs is acceptable when generators are away from loads. It is worth pointing out that, in these two cases, the generator rotor speed only varies in a very narrow range (about 0.999 1.001 time of the fundamental frequency). Therefore, no Accompanying angle stability issue happened in the short period of voltage instability.

Waveform:



(a) Generator field voltage. (b) Voltage magnitude at buses 2 and 4. (c) -indices at bus 4. (d) Generator internal equivalent impedance.

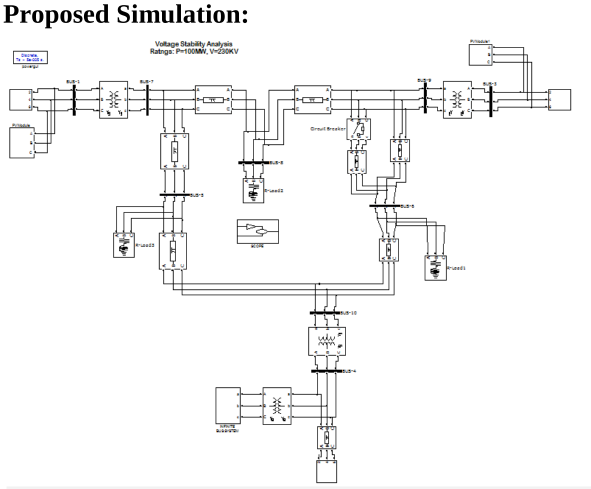
(b) Simulation result:



II. PROPOSED BUS SYSTEM:

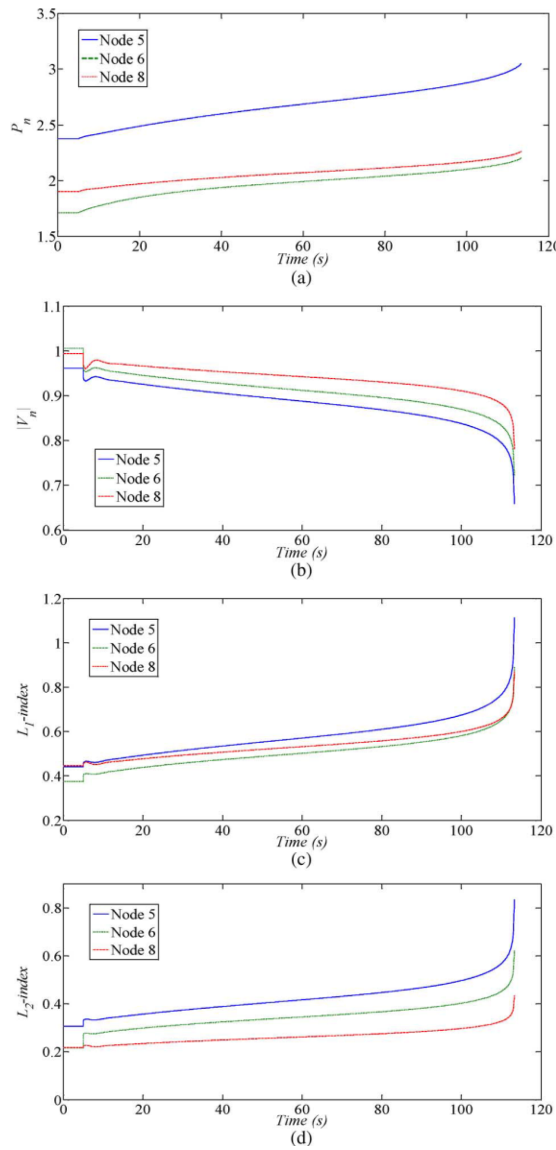
The impact of GEMs on voltage stability is investigated on a looped network system, a modified WECC nine-bus system, the system consists of three generators at buses 1, 2, and 3, respectively. In order to imitate slow load Recovery, three voltage-dependent negative ER loads, [31] are respectively installed on buses 5, 6, and 8. Meanwhile, to create a disturbance, a parallel transmission line between buses 6 and 9 is added into the system and tripped at 5 s. The real power, voltage magnitudes, and -indices at the load buses 5, 6, and 8 are plotted in respectively. Because of the load recovery, the system finally falls into voltage instability. The stability index L1 with the GEMs included can successfully catch the voltage dynamic.L_1 index has a sharp increase near the voltage collapse point and reaches 1.0 p.u. at bus 5.

Proposed Simulation:



However, index without considering the GEMs Cannot reach 1.0 and fails to do so. Again, the bus voltages can go very low because the under voltage protection and controls such as load shedding are not considered in this paper.

Proposed simulation result:



(a)Real power
(b)Voltage magnitude.
(c)L-indices.
(d)L -indices.

III. SIMULATION RESULT:

The effectiveness of the new extended -index and the importance of incorporating GEM for system voltage stability analysis. In all of the simulations, loads are modeled as either constant power or exponential recovery (ER) model. The constant load assumption is commonly used in static voltage stability analysis in industry, though this may lead to conservative conclusions on voltage stability judgment [27]. Other types of load [28]–[30] can be investigated in a similar way but are not discussed in the paper. Furthermore, in order to focus on GEMs, no under-voltage protection or load shedding will be considered in this paper.

IV. CONCLUSION:

An alternative approach has been presented in this paper to develop GEMs for voltage stability analysis based on the generator .An extended L-index has been developed to incorporate GEMs for voltage stability analysis. The dynamic simulation results on four test systems have demonstrated the effectiveness of the new extended -index and importance of GEMs on static voltage stability analysis. The results of the simulation studies suggest that, in certain scenarios, neglecting GEMs in voltage stability analysis, which is the case for the majority of existing voltage stability indices, may lead to a large error or even misjudgment on system voltage stability. Especially, in future smart grids, when more and more distributed generators are installed at locations closer to loads, GEMs can play a more vital role in system voltage stability analysis and should be given full consideration.

V. REFERENCES:

[1]. Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations U.S.-Canada Power System Outage Task Force, April 2004 [Oline]. Available:https:/ /reports.energy. gov/BlackoutFinal-Web.pdf

[2]. T. Van Cutsem and C. Vournas, *Voltage Stability of Electric Power Systems*. Boston, MA, USA: Kluwer Academic, 1998.

[3]. C.W. Taylor, "Power system voltage stability," in *EPRI Power System Engineering Series*. New York, NY, USA: McGraw-Hill, 1993, 0-07- 063164-0.

[4]. V. A. Ajjarapu and C. Christy, "The continuation power flow: A tool for steady—State voltage stability analysis," *IEEE Trans. Power Syst.*, vol. 7, no. 1, pp. 416–423, Feb. 1992.

[5]. A. Araposthatis, S. Sastry, and P. Varaiya, "Analysis of power flow equation," *Int. J. Electr. Power*, vol. 3, no. 3, pp. 115–126, 1981.

[6]. P. A. Lof, T. Smed, G. Anderson, and D. J. Hill, "Fast calculation of a voltage stability index," *IEEE Trans. Power Syst.*, vol. 7, no. 1, pp. 54–64, Feb. 1992.

[7]. B. Gao, G. K. Morison, and P. Kundur, "Voltage stability evaluation using modal analysis," *IEEE Trans. Power Syst.*, vol. 7, no. 4, pp. 1529–1542, Nov. 1992.

[8]. Y. Tamura, H. Mori, and S. Lwanoto, "Relationship between voltage instability and multiple load flow solutions in electrical system," *IEEE Trans. Power App. Syst.*, vol. PAS-102, no. 5, pp. 115–1125,May 1983.

[9]. P. Kessel and H. Glavitsch, "Estimating the voltage stability of a power system," *IEEE Trans. Power Del.*, vol. PWRD-1, no. 3, pp. 346–354, Jul. 1986.

[10]. A. G. Phadke and R. M. de Moraes, "The wide world of wide-area measurement," *IEEE Power Energy Mag.*, vol. 6, no. 5, pp. 52–65, Sep./Oct. 2008.

[11]. A. Vahidnia, G. Ledwich, E. Parmer, and A. Ghosh, "Dynamic equivalent state estimation for multi-area power systems with synchronized phasor measurement units," *Electr. Power Syst. Res.*, vol. 96, pp. 170–176, March 2013.

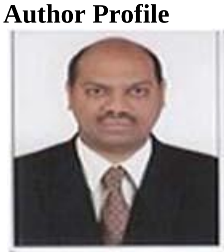
VI.AUTHOR PROFILE

Karthik Manyapu, B.Tech in Electrical & Electronics Engineering from INSTITUTE OF AERONAUTICAL ENGINEERING, Affiliated to JNTUH, Dundigal, Rangareddy and M.Tech in Electrical power systems in 2016 from Anurag group of institutions(autonomous) Ghatkeshar affiliated to JNTUH, Hyderabad. E-mail id: karthikmanyapu.. eee09 @ gmail. Com

Author Profile

Vijay Kumar Itham, B.Tech in Electrical & Electronics Engineering from QIS COLLEGE ENGG& TECH, Affiliated to JNTUK Ongole, Prakasam and M.Tech in EPE from JNTU, Hyderabad. Working as Assistant Professor in ANURAG GROUP OF INSTI TUTIONS, Ghatkesar, RR district, Telangana, India. E-mail id: vijayakumar687@gmail.com

Author Profile



Dr. T. Anil Kumar B.Tech, M.Tech, Ph.D., Dr.T. Anil kumar is Associate Professor and Head of the Department. He obtained his B.Tech from kakatiya University, M.Tech and Ph.D from JNTUH University. He is having 16 years of teaching experience. He has organized and attended various workshops and conferences at National and International levels. He published 25 papers in various National & International journals & conferences. He has guided many P.G projects. He established different Electrical Laboratories in different engineering colleges.