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# Maximum Watt Margin (MWM) of Different Buses of a Multi-bus System

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***ABSTRACT:*** *The purpose of this paper is to examine the Maximum Watt Margin (MWM) of different buses of a multi-bus system. Load Flow analysis is carried out by using Newton Raphson iterative method and the weakest and the strongest buses are determined by using $\partial Q_i/\partial V_i$ index. A study is also performed to observe the variation of Maximum Watt Margin (MWM) with the degree of weakness of the bus. P-V and Q-V profiles are observed and reported. The whole method is tested on the IEEE-57 bus system and the observations are revealed in this paper.*
***Keywords:*** *Loadability, Maximum Watt Margin (MWM), $\partial Q_i/\partial V_i$ index, Strongest Bus, Weakest Bus.*

## I. INTRODUCTION

The electricity demand is increasing day by day but the source is limited. Hence stability is a main concern now a day. Voltage instability is caused mainly due to reactive power imbalance. The maximum power transfer capability or loadability of a bus in the interconnected grid system depends on the amount of reactive power which the bus can receive from the system. Otherwise the system will approach towards Voltage collapse phenomenon. Voltage collapse phenomena in power systems have become one of the important concerns in the power industry over the last two decades, as this has been the major reason for several major blackouts that have occurred throughout the world [1]. Hence, the ability to determine voltage stability before voltage collapse has received a great attention [1].

**'Voltage stability'** is concerned with the ability of power system to maintain the steady acceptable voltages at all system buses under normal conditions as well as when the system is being subjected to a disturbance [14]. Voltage stability is maintained if voltages after a disturbance are close to the base voltage. A power system becomes unstable when voltage decreases below the limit known as voltage collapse point.

All the buses have some maximum limit of delivering active power to its connected load without affecting the voltage stability. This Maximum limit is known as Maximum Watt Margin (MWM). It is also known as the loadability of the bus which indicates the robustness of the system.

Load Flow analysis has been done using Newton-Raphson iterative method on an IEEE 57 bus system and the weakest and strongest bus of the system are determined with the help of $\partial Q_i/\partial V_i$ index which are found from the Jacobian matrix. Also the Maximum Watt Margins of the various load buses are determined and the variation of Maximum Watt Margin with the degree of weakness of the buses is observed.

## II. DETERMINATION OF THE WEAKEST LOAD BUS ,STRONGEST BUS, AND MAXIMUM WATT MARGINS (MWMS)

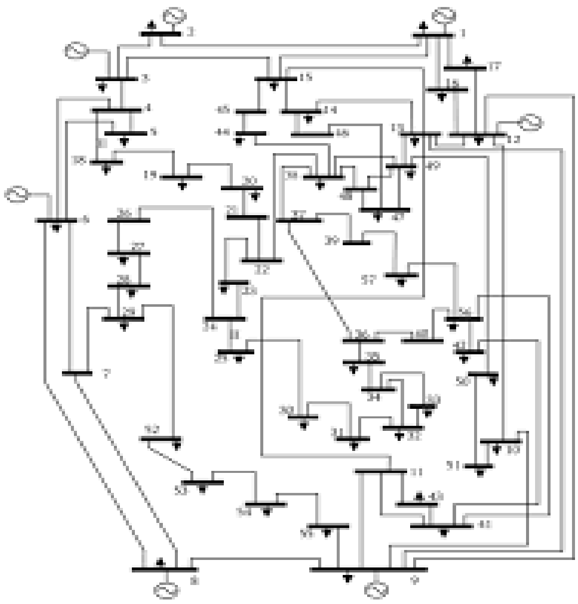
Newton-Raphson Load Flow analysis is carried out on the IEEE-57 bus system. The variation of active power (P) and reactive power (Q) is determined with the following equation-

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta |V| \end{bmatrix} \qquad \text{.............................. (1)}$$

The matrix J= [J1 J2; J3 J4] of equation (1) is known as Jacobian Matrix. The degree of weakness of the i-th bus or the reactive power sensitivity of the corresponding bus is determined by using the value of diagonal elements of J4 matrix. The maximum value of $\partial Qi/\partial|Vi|$ corresponds to the strongest bus and the minimum value corresponds to the weakest bus [1].

If there is change in the active or reactive power of any bus the voltage level of the corresponding bus decreases. This event can be observed from the plot of power transferred versus the voltage level (per unit) of that bus. The plots are popularly referred to as P-V curve or "Nose" curve [1]. The decrease in voltage level with the increase in active power transfer is reflected in the P-V profile. It is plotted by keeping the value of reactive power (Q) constant. Similarly, Q-V curve can also be plotted by keeping the active power (P) constant and gradually increasing the reactive power (Q) level of the bus. Now the voltage collapse point is determined from this P-V and Q-V profiles. Voltage Collapse point is the critical point beyond which the Newton-Raphson load flow Method fails to converge. Such a load point represents the "knee" point of the P-V and Q-V curve [1]. This is the point at which the voltage stability of the system is lost. From the P-V profile of the bus the Maximum Watt Margin (MWM) can be determined.

## III. FIGURES AND DATA TABLES



[16]

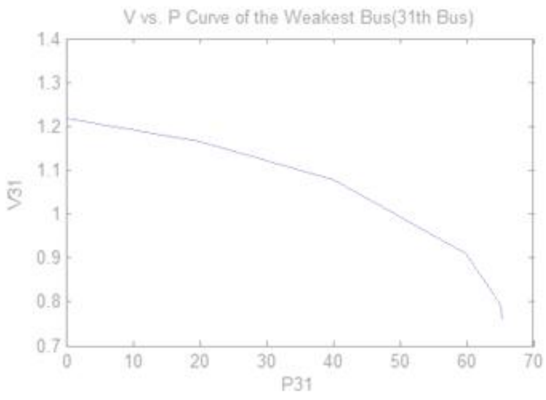
**Fig-1:** IEEE 57 Bus System[16]

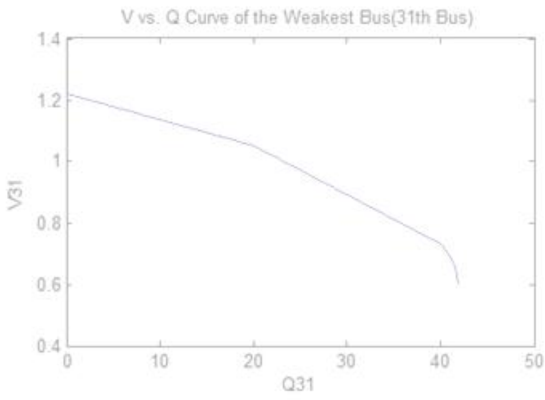
The IEEE-57 bus system is shown in figure-1. There are three type of buses-

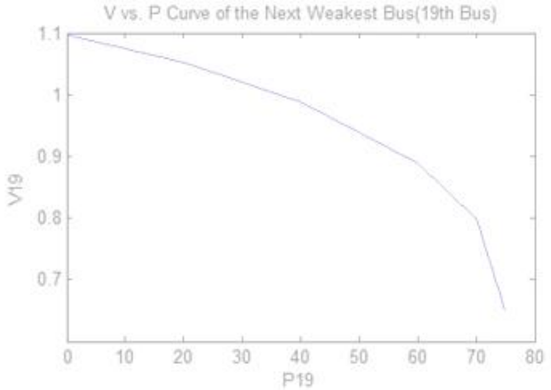
1 - Slack Bus
2 - PV Bus
3 - PQ Bus

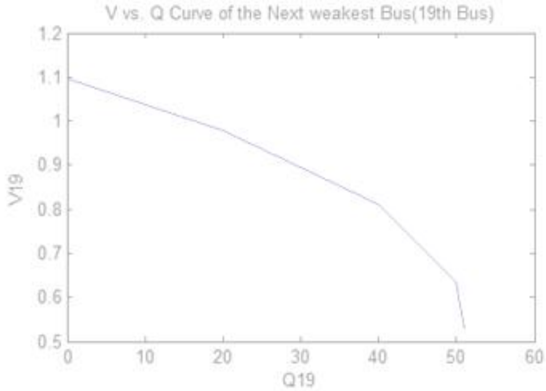
The minimum value of (∂qi/∂vi) corresponds to the weakest bus and the maximum value corresponds to the strongest bus. Hence for this system 31st bus is the weakest, 19th is the next weakest and 22nd is the strongest bus.

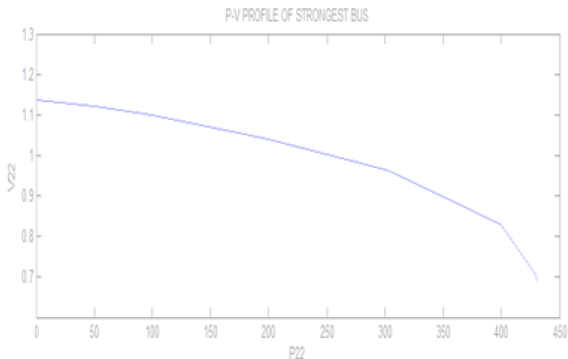
The P-V and Q-V profile of the weakest, next weakest and strongest bus are shown in the figure below-

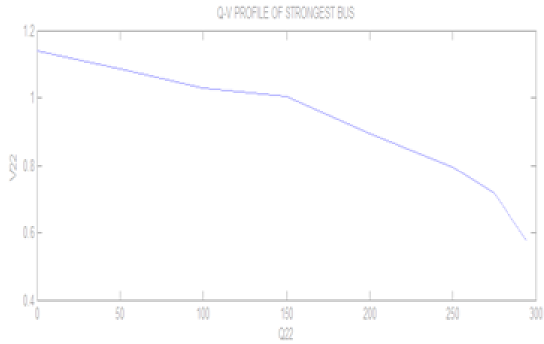




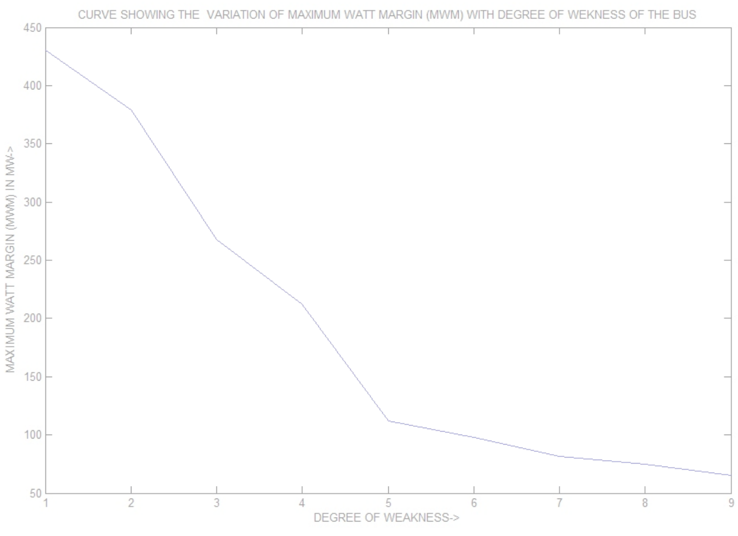

The Maximum Watt Margin (MWM) as obtained from the analysis for the weakest, next weakest and strongest bus are tabulated below-

**Table-1:-**

| Load Bus No. | System Bus No. | Maximum Watt Margin (MWM) in MW |
|---|---|---|
| 24 | 31 | 65.5 |
| 12 | 19 | 75 |
| 15 | 22 | 430.7 |

## IV. CONCLUSION

The variation of Maximum Watt Margin (MWM) with the degree of weakness of the bus is also plotted and shown in the figure below-




Therefore it is seen from the curve that Maximum Watt Margin (MWM) decreases as the degree of weakness is increased i.e. the weakest bus ($31^{st}$ bus) has minimum MWM whereas the strongest bus ($22^{nd}$ bus) has maximum value of MWM without effecting the voltage stability of the system. This maximum value of power transfer capability of a bus may be increased with reactive power compensation as the magnitude of the voltage of a bus depends on the reactive power level.

## REFERENCES


[1] Sourav Basu, Chandramouli Gupta, Sumana Chowdhuri- "Voltage Stability Margin (VSM) and Maximum Loading Point (MLP) Of A Multi-Bus System Before and After Compensation", International Journal of Engineering Research and Development, Vol-5, Issue-7, pp-30-35, January 2013.

[2] Kabir Chakraborty and Sangita Das Biswas "An Offline Simulation Method to Identify the Weakest Bus and Its Voltage Stability Margin in a Multi-bus Power Network", Proceeding of International Conference MS'07, India, December 3-5,2007, pp. 1-5.

[3] An Analytical Investigation of Voltage Stability of an EHV Transmission Network based on Load Flow-A. Chakrabarti and P. Sen, Journal of Electrical Engg., Institution of Engg. (I, Vol.-76, May 1995].

[4] P. Kessel and H. Glavitsch "Estimating the Voltage Stability of Power System" IEEE Trans. On Power delivery, Vol. PWRD-1, No.3 July/1986, pp. 346-354.

[5] H.K. Clark "New Challenges: Voltage Stability" IEEE Power ENG. Rev., April 1990, pp. 33-37.

[6] Y. Tamura, H. Mori and S. Lwanoto "Relationship between voltage instability and multiple load flow solution in electrical system" IEEE Trans. Vol. PAS-102, pp. 115-125.

[7] Crisan and M. Liu "Voltage collapse prediction using an improved sensitivity approach", Electrical power system research, 1984, pp. 181-190.

[8] C.K. Chanda, S. Dey, A. Chakrabarti and A.K. Mukhopadhyay; Determination of Bus Security Governed by Sensitivity Indicator in a Reactive Power Constrained LPS System. Journal of Engg. and Material Science, India, Vol. IX August 2002.

[9] S. Dey, C.K. Chanda and A. Chakrabarti; Development of a Global Voltage Security Indicator and Role of SVC on it in LPS System. Journal of Electric Power System Research, USA, Vol.68 2004.

[10] C.W Taylor, Power System Voltage Stability, McGraw-Hill, 1994.

[11] R.J Koessler, Voltage instability/ Collapse-An overview, IEE Colloquium on voltage collapse, Digest No. 1997/101, 1997, pp. 1/6-6/6.

[12] Abhijit Chakraborty, Sunita Halder, "Power System Analysis Operation and Control", Prentice-Hall India, 2006.

[13] Hadi Saadat, Power System Analysis, TATA McGRAW-HILL, 2004.

[14] Abhijit Chakrabarti, D.P. Kothari, A.K. Mukhopadhyay, Abhinandan De "An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems, PHI Learning Private Limited, 2010.

[15] Padiyar K.R., Facts Controllers in Power Transmission and Distribution, New Age International Publishers, 2009.

[16] Satyajit Bhuyan, Sanjib Hazarika, Aroop Bardalai-"Power Flow Analysis on IEEE 57 bus System using MATLAB", International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 8, August – 2014.