Meenakshi Gupta Int. Journal of Engineering Research and Application *www.ijera.com*
ISSN : 2248-9622, Vol. 8, Issue4 (Part -III) April 2018, pp01-05

RESEARCH ARTICLE OPEN ACCESS

PV And Q V Curve Analysis Of IEEE 9 Bus System

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ABSTRACT:-Voltage Stability analysis of voltage instability in electric power system is very crucial in order to maintain the equilibrium of the system.Voltage security is the ability of the system to maintain adequate and controllable voltage levels at all system load buses.The main concern is that voltage levels outside of a specifiedrange can affect the operation of the customer's loads. This paper presents the analysis of voltage instability of electric power system by using power-voltage (PV) curve and reactive power-voltage (QV) curve.

Introduction:-Voltagestability is an important aspect of any power system design as it assures the system has sufficient power to meet the load demand. Power system **voltage** instability is related to the lack of reactive power resources in the network and the **voltage** can collapse when the power limit of a system is exceeded. Voltage stability in the power system is defined as the ability of a power system to maintain acceptable voltages at all bus in the system under normal condition and after being subjected to a disturbance. In the normal operating condition the voltage of a power system is stable, but when the fault or disturbance occurs in the system, the voltage becomes unstable this result in a progressive and uncontrollable decline in voltage. Voltage stability is sometimes also called load stability.

Date of Submission: 10-04-2018 Date of acceptance: 24-04-2018

I. CLASSIFICATION OF VOLTAGESTABILITY

Voltage stability may be classified into two categories. These are

1. Large-disturbance Voltage Stability
2. Small-disturbance Voltage Stability

Large-disturbance Voltage Stability – It is concerned with a system stability to control voltages following a large disturbance such as system faults, loss of load, or loss of generation. For determination of this form of stability requires the examination of the dynamic performance of the system over a period sufficient to capture of such devices as under load tap changing transformers, generator field, and current limiters. Large disturbance voltage studies can be studied by using non-linear time domain simulations which include proper modeling.

Small-Disturbances Voltage Stability – The operating state of a power system is said to have small disturbances voltage stability if the system has small disturbances, a voltage near loads does not change or remain close to the pre-disturbance values. The concept of small disturbance stability is related to steady state and be analyzed using a small-signal model of the system.

II. VOLTAGE STABILITY LIMIT

The Voltage stability limit can be defined as the limiting stage in a power system beyond which no amount of reactive power injection will raise the system voltage to its nominal state. The system voltage can only be adjusted by reactive power injections till the system voltage stability is maintained.

Test system:-WSCC 9-bus test system (also known as P.M Anderson 9-bus) represents a simple approximation of the Western System Coordinating Council (WSCC) to an equivalent system with 9 buses and 3 generators. This particular test case also includes 3 two-winding transformers, 6 lines and 3 loads. The base kV levels are 13.8 kV, 16.5 kV, 18 kV, and 230 kV. The ***single-line diagram*** of the WSCC 9-bus case is shown below

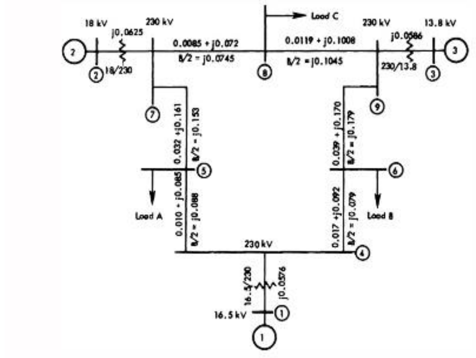

Fig 1: **WSCC 9-Bus System**

Here the modeling of IEEE 9 bus system is done in MATLAB /SIMULINK and investigate the behavior of Power system by Using PV and QV curves .

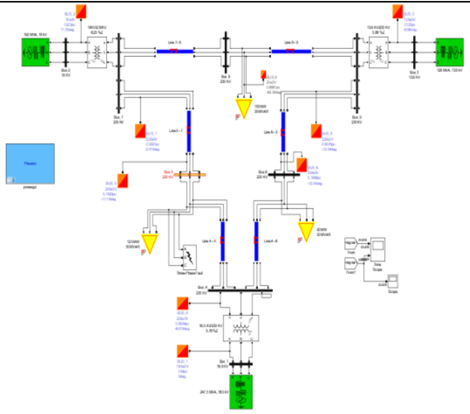

Fig 2: WSCC 9-Bus SystemMatlab Model

P-V CURVE ANALYSIS:-

P-V curve analysis is use to determine voltage stability of a radial system and also a large meshed network. For this analysis P i.e. power at a particular area is increased in steps and voltage (V) is observed at some critical load buses and then curves for those particular buses will be plotted to determine the voltage stability of a system by static analysis approach. To explain P-V curve analysis let us assume two-bus system with a single generator, single transmission line and a load, as shown in Figure.

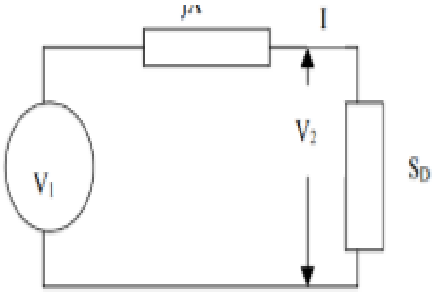

Fig 3: Two bus representation model

P-V curves are useful in deriving how much load shedding should be done to establish prefault network conditions even with the maximum increase of reactive power supply from various automatic switching of capacitors or condensers. Here, the complex load assume is with V_1 is the sending end voltage and V_2 is receiving end voltage and is load power factor.

$$P_{12} = |V_1|^2 G - |V_1||V_2| G\cos(\theta_1 - \theta_2) + |V_1||V_2| B\sin(\theta_1 - \theta_2$$

$$Q_{12} = |V_1|^2 B - |V_1||V_2| B\cos(\theta_1 - \theta_2) - |V_1||V_2| G\sin(\theta_1 - \theta_2$$

Let G=0. Then….

$$P_{12} = |V_1||V_2| B\sin(\theta_1 - \theta_2)$$

$$Q_{12} = |V_1|^2 B - |V_1||V_2| B\cos(\theta_1 - \theta_2)$$

Now we can get SD=PD+jQD=-(P21+jQ21) by

- - exchanging the 1 and 2 subscripts in the previous equations.
- - negating

$$P_D = -P_{21} = -|V_1||V_2| B\sin(\theta_2 - \theta_1)$$
$$= |V_1||V_2| B\sin(\theta_1 - \theta_2)$$

$$Q_D = -Q_{21} = -|V_2|^2 B + |V_1||V_2| B\cos(\theta_2 - \theta_1)$$
$$= -|V_2|^2 B + |V_1||V_2| B\cos(\theta_1 - \theta_2)$$

$$P_D = |V_1||V_2| B\sin\theta_{12}$$

$$Q_D = -|V_2|^2 B + |V_1||V_2| B\cos\theta_{12}$$

$$|V_2|^2 = \frac{1 - \beta P_D \pm [1 - P_D(P_D + 2\beta)]^{1/2}}{2}$$

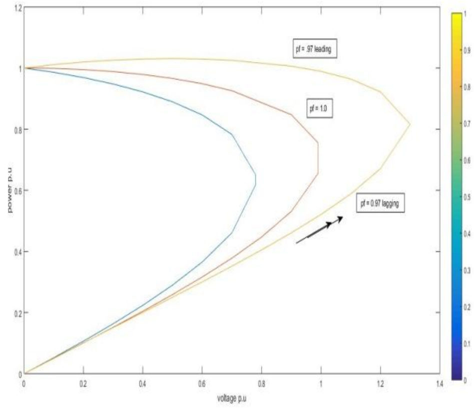

FIG 4 PV CURVE IN DIFFERENT DIFFERENTPOWER FACTOR (BUS NO 5)

QV CURVE

Q-V curve is the relationship between the reactive power support (Q) and receiving end voltage (V2) for different values of active power P [3].

$$P_D = |V_1||V_2| B\sin\theta_{12}$$

$$Q_D = -|V_2|^2 B + |V_1||V_2| B\cos\theta_{12}$$

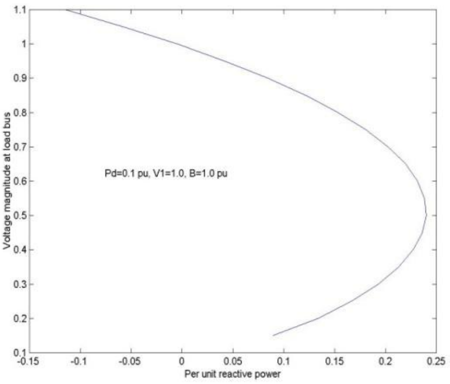

FIG 5QV CURVE(BUS NO 5)

METHODS OF IMPROVING VOLTAGE STABILITY The power system voltage instability can be improved using the following methods

1. Generator AVRs
2. Under-Load Tap Changers
3. Load shedding during contingencies
4. Reactive Power Compensation

III. CONCLUSION

Simple analytical expression for real power and reactive power at receiving end and sending end of simple two bus system has been formulated and had been used to obtain voltage V2 at load point. The same voltage expression is used to draw P-V curve Of IEEE 9 BUS system . It is observed that real power transfer increases from lagging to leading power factor. Using the Q-V curves the sensitivity of the load to the reactive power sources can be obtained. Thus basic voltage stability analysis tools i.e. P-V curve and Q-V curve are found to be effective tools to understand static voltage stability analysis.

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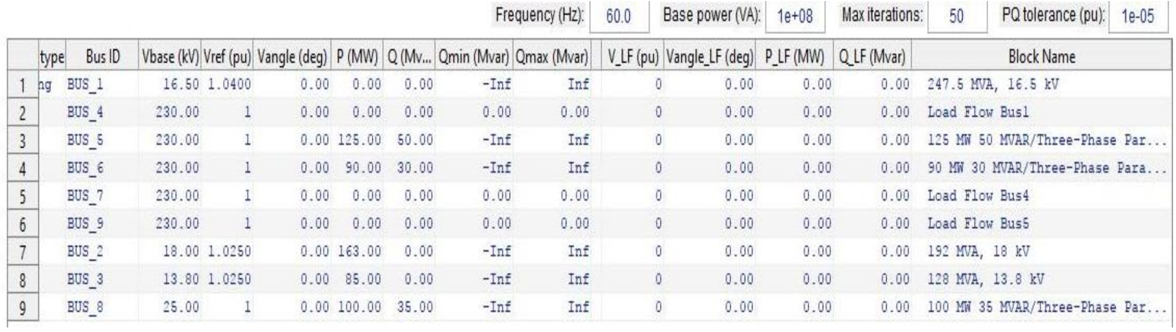
Appendix

PV AND QV CURVES ANALYSIS



Frequency (Hz): 60.0 Base power (VA): 1e+08 Max iterations: 50 PQ tolerance (pu): 1e-05

	type	Bus ID	Vbase (kV)	Vref (pu)	Vangle (deg)	P (MW)	Q (Mv...	Qmin (Mvar)	Qmax (Mvar)	V_LF (pu)	Vangle_LF (deg)	P_LF (MW)	Q_LF (Mvar)	Block Name
1	ng	BUS_1	16.50	1.0400	0.00	0.00	0.00	-Inf	Inf	0	0.00	0.00	0.00	247.5 MVA, 16.5 kV
2		BUS_4	230.00	1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	Load Flow Bus1
3		BUS_5	230.00	1	0.00	125.00	50.00	-Inf	Inf	0	0.00	0.00	0.00	125 MW 50 MVAR/Three-Phase Par...
4		BUS_6	230.00	1	0.00	90.00	30.00	-Inf	Inf	0	0.00	0.00	0.00	90 MW 30 MVAR/Three-Phase Para...
5		BUS_7	230.00	1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	Load Flow Bus4
6		BUS_9	230.00	1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.00	Load Flow Bus5
7		BUS_2	18.00	1.0250	0.00	163.00	0.00	-Inf	Inf	0	0.00	0.00	0.00	192 MVA, 18 kV
8		BUS_3	13.80	1.0250	0.00	85.00	0.00	-Inf	Inf	0	0.00	0.00	0.00	128 MVA, 13.8 kV
9		BUS_8	25.00	1	0.00	100.00	35.00	-Inf	Inf	0	0.00	0.00	0.00	100 MW 35 MVAR/Three-Phase Par...

Summary for IEEE_9bus : The load flow converged in 5 iterations
!
Subnetwork 1

	P(MW)	Q(Mvar)
Total generation	431.3758	1563.048
Total PQ load	315	115
Total Z shunt	0.636575	0.636565

```
   Total ASM          0                 0
   Total losses       115.7392          1447.411
1 : BUS_1  V= 1.040 pu/16.5kV 0.00 deg  ; Swing bus
                      P(MW)             Q(Mvar)
   Generation         183.3758          275.2691
   PQ Load            0                 0
   Z shunt            0.216324          0.216316
   BUS_4              183.1595          275.0528
2 : BUS_2  V= 1.025 pu/18kV 11.55 deg
                      P(MW)             Q(Mvar)
   Generation         163               712.3214
   PQ Load            0                 0
   Z shunt            0.210128          0.210122
   BUS_7              162.7899          712.1112
3 : BUS_3  V= 1.025 pu/13.8kV -8.56 deg
                      P(MW)             Q(Mvar)
   Generation         85                575.4573
   PQ Load            0                 0
   Z shunt            0.210129          0.210121
   BUS_9              84.78987          575.2472
4 : BUS_4  V= 0.893 pu/230kV -6.52 deg
                      P(MW)             Q(Mvar)
   Generation         0                 0
   PQ Load            2.34E-09          -3.7E-10
   Z shunt            -2.8E-06          2.77E-06
   BUS_1              -183.157          -216.898
   BUS_5              81.53728          144.6962
   BUS_6              101.6202          72.20193
5 : BUS_5  V= 0.743 pu/230kV -11.19 deg
                      P(MW)             Q(Mvar)
   Generation         0                 0
   PQ Load            125               50
   Z shunt            1.88E-12          -1E-12
   BUS_4              -77.8389          -125.089
   BUS_7              -47.1611          75.08909
6 : BUS_6  V= 0.799 pu/230kV -12.95 deg

                      P(MW)             Q(Mvar)
   Generation         0                 0
   PQ Load            90                30

   Z shunt            2.11E-12          -3.9E-12

   BUS_4              -98.125           -64.6108

   BUS_9              8.124995          34.61077

7 : BUS_7  V= 0.599 pu/230kV 2.01 deg

                      P(MW)             Q(Mvar)
   Generation         0                 0

   PQ Load            1.18E-08          -1.9E-08

   Z shunt            -1.1E-06          1.15E-06

   BUS_2              -162.78           -394.679

   BUS_5              52.41219          -62.4325

   BUS_8              110.3675          457.1119

8 : BUS_8  V= 0.686 pu/25kV -62.58 deg
                      P(MW)             Q(Mvar)
   Generation         0                 0
```

PQ Load	100	35
Z shunt	1.55E-13	-1.2E-13
BUS_7	-57.6	-12.1851
BUS_9	-42.4	-22.8149

9 : BUS_9 V= 0.698 pu/230kV -12.54 deg

	P(MW)	Q(Mvar)
Generation	0	0
PQ Load	1.2E-09	4.56E-10
Z shunt	-1.7E-06	1.66E-06
BUS_3	-84.7834	-386.668
BUS_6	-6.81295	-49.0767
BUS_8	91.59638	435.7449

Meenakshi Gupta "Pv And Q V Curve Analysis Of Ieee 9 Bus System "International Journal of Engineering Research and Applications (IJERA) , vol. 8, no. 4, 2018, pp. 01-05