International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 6 Ver III || June 2018 || PP 49-55

Load Flow and Voltage Instability Analysis Using MI Power Software

Vibha Parmar[1], Margi Shah[2]
[1]*(Assistant Professor, Electrical department, Charusat University, India)*
[2]*(Junior research fellow, Electrical department, Charusat University, India)*
Corresponding Auther: Vibha Parmar

Abstract: *The load flow study or power flow analysis is very important for planning, control and operations of existing systems as well as planning its future expansion. The satisfactory operation of the system depends upon knowing the effects of interconnections, new loads, new generating stations or new transmission lines etc., before they are installed. It also helps to determine the best size and favorable locations for the power capacitors both for the improvement of the power factor and also raising the bus voltage of the electrical network. They help us to determine the best locality as well as optimal capacity of the proposed generating stations, substations or new lines. For this work the Fast Decoupled method is used for numerical analysis. This type of analysis is useful for solving the power flow problem in different power systems. voltage instability takes on the form of a dramatic drop of transmission system voltages, which may lead to system disruption it is a factor leading to limit power transfer. The objective of this paper is to describe load flow studies using Fast Decoupled Method and voltage instability analysis using MI Power software.*

Keywords: *Power flow analysis, Fast Decoupled Method,voltage instability, MI Power software.*

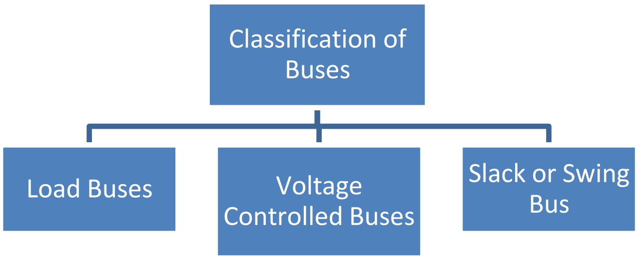
Date of Submission: 30-05-2018 Date of acceptance: 15-06-2018

I. INTRODUCTION

The Load flow problem consists of calculation of voltage magnitude and its phase angle at the buses. And also the active and reactive lines flow for the specified terminal or bus conditions. Load flow studies are used to ensure that electrical power transfer from generators to consumers through the grid system is stable, reliable and economic. Conventional techniques for solving the load flow problem are iterative, using the Newton-Raphson or the Gauss-Seidel methods. Depending upon the quantities specified for the buses, they are classified into three types namely load bus, generator bus or voltage controlled bus and slack bus or swing bus or reference bus.

II. BUS CLASSIFICATION

Buses are classified according to which two out of the four variables are specified Load bus: No generator is connected to the bus. At this bus the real and reactive power are specified and it is desired to find out the voltage magnitude and phase angle through load flow solutions. It is required to specify only Pd and Qd at such bus as at a load bus voltage can be allowed to vary within the permissible values.



Load Bus : In these buses no generators are connected and hence the generated real power P_{Gi} and reactive power Q_{Gi} are taken as zero. The load drawn by these buses are defined by real power $-P_{Li}$ and reactive power $-Q_{Li}$ in which the negative sign accommodates for the power flowing out of the bus. This is why these buses are sometimes referred to as P-Q bus. The objective of the load flow is to find the bus voltage magnitude $|V_i|$ and its angle δ_i

Generator bus or voltage controlled bus: Here the voltage magnitude corresponding to the generator voltage and real power Pg corresponds to its rating are specified. It is required to find out the reactive power generation Qg and phase angle of the bus voltage. Slack (swing) bus: For the Slack Bus, it is assumed that the voltage magnitude |V| and voltage phase are known, whereas real and reactive powers Pg and Qg are obtained through the load flow solution

Slack or Swing Bus : Usually this bus is numbered 1 for the load flow studies. This bus sets the angular reference for all the other buses. Since it is the angle difference between two voltage sources that dictates the real and reactive power flow between them, the particular angle of the slack bus is not important. However it sets the reference against which angles of all the other bus voltages are measured. For this reason the angle of this bus is usually chosen as 0° . Furthermore it is assumed that the magnitude of the voltage of this bus is known.

Now consider a typical load flow problem in which all the load demands are known. Even if the generation matches the sum total of these demands exactly, the mismatch between generation and load will persist because of the line I^2R losses. Since the I^2R loss of a line depends on the line current which, in turn, depends on the magnitudes and angles of voltages of the two buses connected to the line, it is rather difficult to estimate the loss without calculating the voltages and angles. For this reason a generator bus is usually chosen as the slack bus without specifying its real power. It is assumed that the generator connected to this bus will supply the balance of the real power required and the line losses.[7]

III. Fast Decoupled Method

The Fast Decoupled Power Flow Method is one of the improved methods, which is based on a simplification of the Newton-Raphson method and reported by Stott and Alsac in 1974. This method, like the Newton- Raphson method, offers calculation simplifications, fast convergence and reliable results and became a widely used method in load flow analysis. Generally the power system have very high X/R ratio[1]. Hence the real power changes are less sensitive to change in voltage magnitude $|V|$ but it is more sensitive for changes in phase angle δ. Whereas the reactive power are more sensitive to changes in voltage magnitude and less sensitive for change in phase angle δ. Therefore it is reasonable to set J2 and J3 of Jacobian matrix to zero. Hence the equation for ΔP and ΔQ becomes:

$$\boxed{\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix}=\begin{bmatrix}J_1 & 0\\ 0 & J_4\end{bmatrix}\begin{bmatrix}\Delta\theta\\ \Delta V\end{bmatrix}} \text{--------- (1)}$$

By solving this we get two decoupled equations which require less time to solve as compared with N-R method. Hence finally after solving the above equations we get,

$$\boxed{\frac{\Delta P}{V}=[B']\,\Delta\theta} \text{----------(2)}$$

$$\boxed{\frac{\Delta Q}{V}=[B'']\,\Delta V} \text{---------(3)}$$

Here B′ and B″ are the bus susceptance matrixes *i.e.* it is imaginary part of admittance matrix Ybus. The bussusceptance matrix is constant and required to evaluate onlyonce at beginning of the iterations. B′ is the order of (n-1).For voltage regulated buses the Qi are not specified and hencethe corresponding rows and columns of the Ybus matrix areeliminated, hence we get B″ matrix of the order of (n-1-m)where ‘n’ is the total number of buses and ‘m’ is the numberof voltage controlled buses. The fast decoupled method requires more iteration than N-R method, but the time required is considerably less and we get rapidly the power flow solutions.[8]

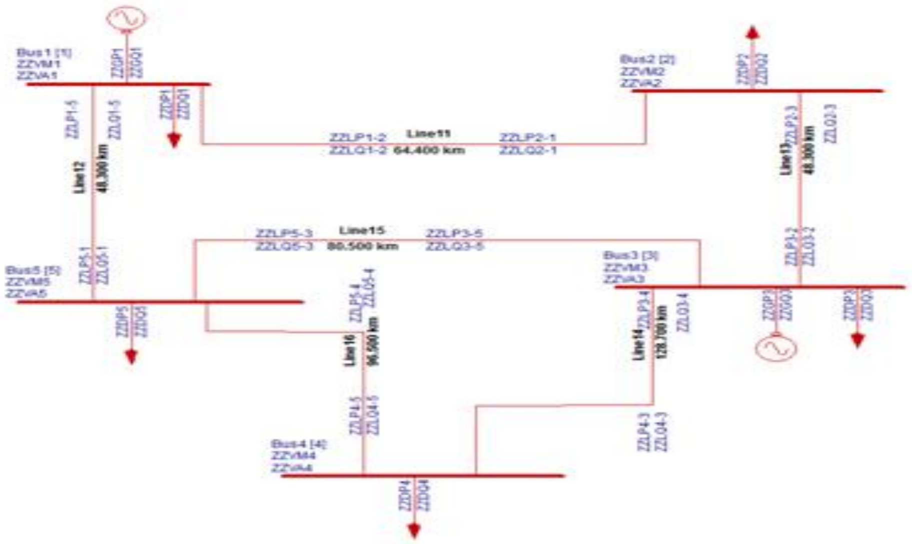
IV. Mi Power Software

Mi Power is a highly interactive, user friendly windows based Power System Analysis package. It includes a set of modules for performing a wide range of power system design and analysis study. Mi Power features include a top notch Windows GUI with centralized database. Steady state, transient and electro-magnetic transient analysis can be performed with utmost accuracy and tolerance. Designed to assess the risk of Voltage instability and margin of stability during sudden disturbances, under steady state conditions. It ranks the load busses based on the L-index value and the highest L-index indicates the system collapse point. The value of

L-index is zero at no load and 1 at the verge of collapsing point. Performs three-phase harmonic load flow to compute harmonic distortion factors. Calculates harmonic transfer and driving point impedances for both transmission and distribution power systems.

V. SYSTEM UNDER STUDY

Figure 1 shows the single line diagram of the system under study in MI Power software. The Transmission line data for the system is given in table 1.generator data in table 2. Load data in Table 3.



[Figure.1: 5 bus system]

Table.1: Transmission line data

Line, Bus to Bus	Length km	Nominal voltage	R in p.u.	X in p.u.	Charging MVAR	Positive sequence Susceptance (B/2)	Thermal rating
1-2	64.4	138	0.042	0.168	4.1	0.0205	100
1-5	48.3	138	0.031	0.126	3.1	0.0155	100
2-3	48.3	138	0.031	0.126	3.1	0.0155	100
3-4	128.7	138	0.084	0.336	8.2	0.041	100
3-5	80.5	138	0.053	0.210	5.1	0.0255	100
4-5	96.5	138	0.063	0.252	6.1	0.0305	100

Susceptance B/2= (Charging MVAR / Base MVA) / 2

Table.2: Generator data

NAME	Generator 1	Generator 2
Manufacture reference number	111	222
Type of modeling	Infinite	Infinite
De- rated MVA	500	225
Specific voltage	143.52	140.76
Scheduled power	300	180
Reactive power minimum	0	0
Reactive power maximum	200	110.3
Breaker rating	2500	2500

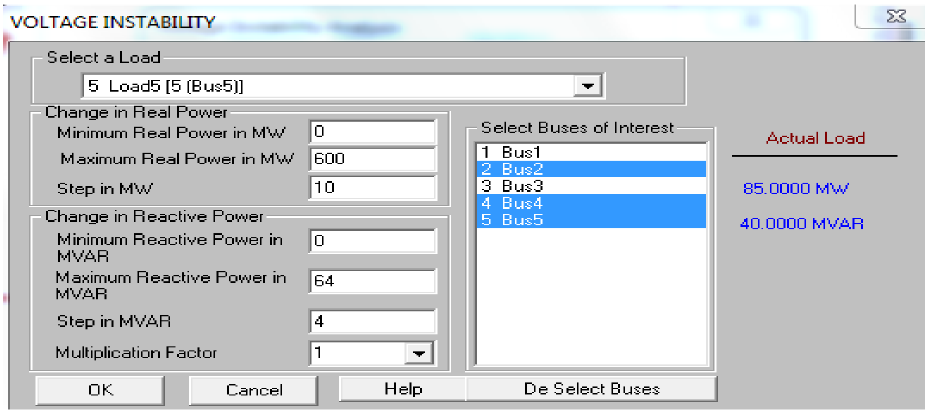
Table.3: load data

Load number	Load-1	Load-2	Load-3	Load-4	Load-5
Bus number	1	2	3	4	5
Real power in MW	65	115	70	70	85
Reactive power in MVAR	30	60	40	30	40

VI. Voltage Instability

The state of an electric power system may be classified as either stable or unstable. The borderline of stability is at any condition for which a slight change in an unfavorable direction of any pertinent quantity will cause instability. The nature of the unstable response will depend upon the characteristics of the system and the operating condition. Voltage instability analysis in electric power system is one of the most important factors in order to maintain the equilibrium of the power system. A power system is said to be unstable if the system is not able to maintain the voltage at all buses in the system remain unchanged after the system is being subjected to a disturbance.in this paper to perform voltage instability consider bus no 2, 4 and 5 of five bus system and plot the instability curve. In this paper to perform load flow analysis and voltage instability analysis Consider load variation at bus 5 for the voltage instability analysis with following data.

Power	Minimum	Maximum	Step
Real power (MW)	0	600	10
Reactive power (MVAR)	0	64	4



VOLTAGE INSTABILITY

Select a Load: 5 Load5 [5 (Bus5)]

Change in Real Power
Minimum Real Power in MW: 0
Maximum Real Power in MW: 600
Step in MW: 10

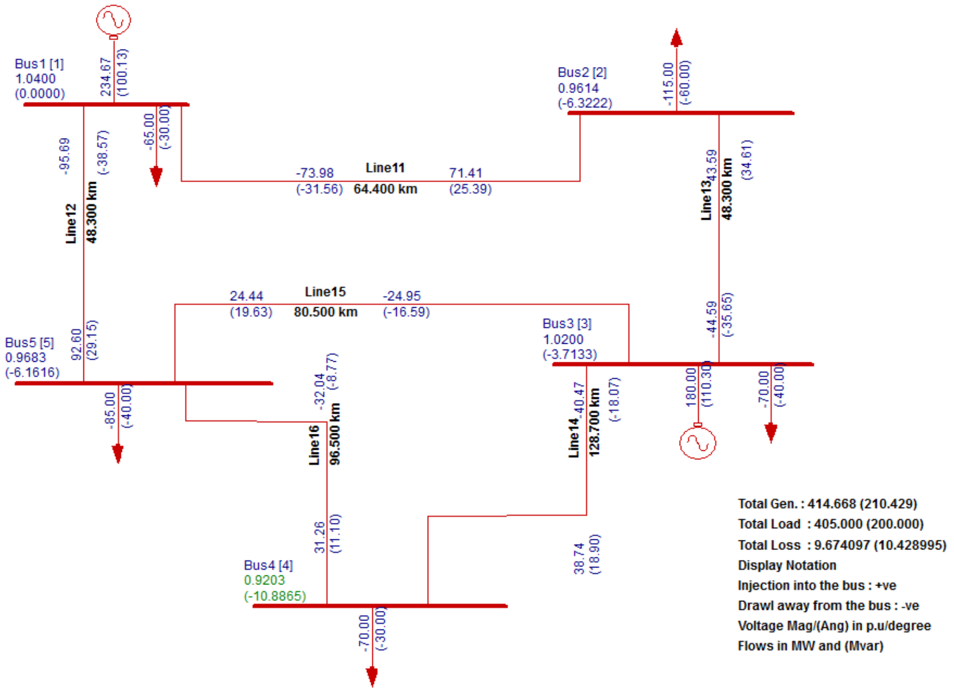
Change in Reactive Power
Minimum Reactive Power in MVAR: 0
Maximum Reactive Power in MVAR: 64
Step in MVAR: 4
Multiplication Factor: 1

Select Buses of Interest
1 Bus1
2 Bus2 (selected)
3 Bus3
4 Bus4 (selected)
5 Bus5 (selected)

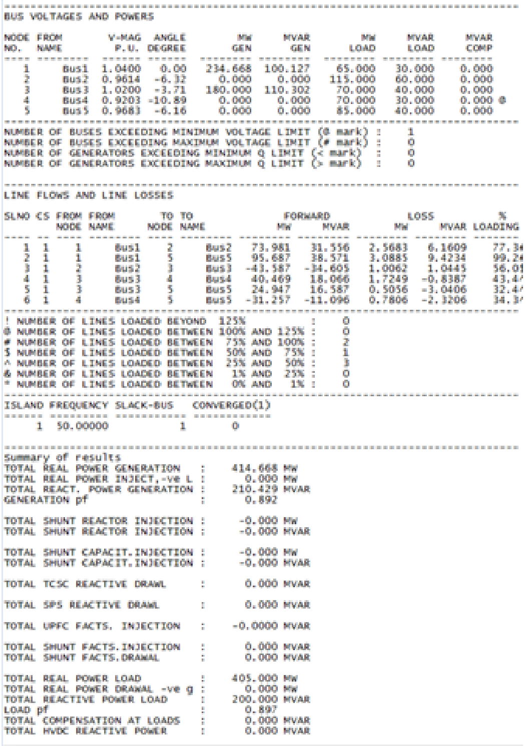
Actual Load
85.0000 MW
40.0000 MVAR

VII. Summary Of Result

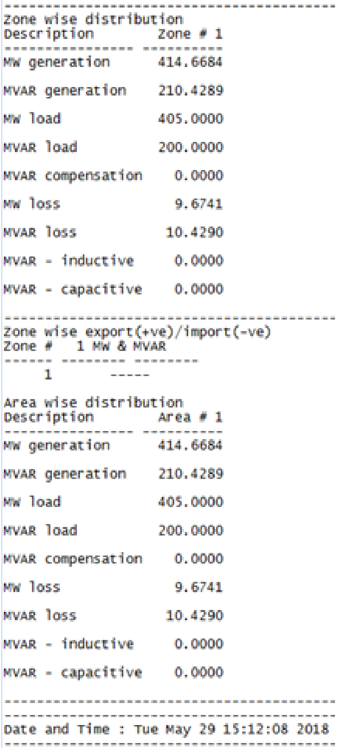
Load flow analysis result (Fast Decoupled method): When perform load flow studies on 5 bus system using fast decoupled method using Mi Power software the following result we got.



[**Figure2:** 5 bus system result with load flow analysis]

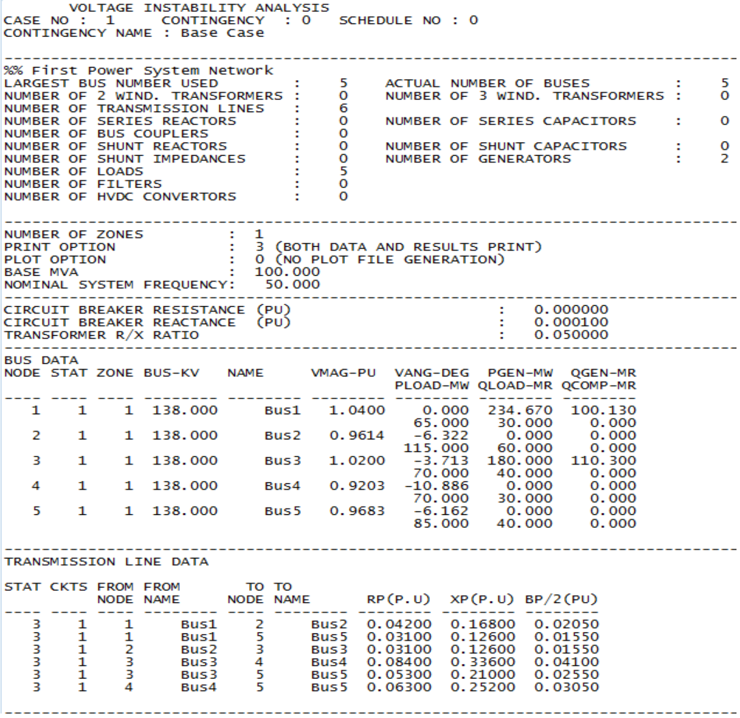


```
---------------------------------------------------------------------------------
BUS VOLTAGES AND POWERS

NODE FROM        V-MAG  ANGLE       MW      MVAR        MW      MVAR      MVAR
NO.  NAME         P.U.  DEGREE      GEN      GEN       LOAD     LOAD      COMP
---- --------  ------ ------   -------- --------   -------- --------  --------
   1     Bus1  1.0400   0.00   234.668  100.127     65.000   30.000     0.000
   2     Bus2  0.9614  -6.32     0.000    0.000    115.000   60.000     0.000
   3     Bus3  1.0200  -3.71   180.000  110.302     70.000   40.000     0.000
   4     Bus4  0.9203 -10.89     0.000    0.000     70.000   30.000     0.000 @
   5     Bus5  0.9683  -6.16     0.000    0.000     85.000   40.000     0.000
---------------------------------------------------------------------------------
NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) :    1
NUMBER OF BUSES EXCEEDING MAXIMUM VOLTAGE LIMIT (# mark) :    0
NUMBER OF GENERATORS EXCEEDING MINIMUM Q LIMIT (< mark)  :    0
NUMBER OF GENERATORS EXCEEDING MAXIMUM Q LIMIT (> mark)  :    0

---------------------------------------------------------------------------------
LINE FLOWS AND LINE LOSSES

SLNO CS FROM FROM        TO TO              FORWARD            LOSS          %
        NODE NAME      NODE NAME          MW      MVAR       MW     MVAR LOADING
---- -- ---- --------  ---- -------- -------- -------- -------- -------- -------
   1  1    1     Bus1     2     Bus2   73.981   31.556   2.5683   6.1609    77.3
   2  1    1     Bus1     5     Bus5   95.687   38.571   3.0885   9.4234    99.2
   3  1    2     Bus2     3     Bus3  -43.587  -34.605   1.0062   1.0445    56.0
   4  1    3     Bus3     4     Bus4   40.469   18.066   1.7249  -0.8387    43.4
   5  1    3     Bus3     5     Bus5   24.947   16.587   0.5056  -3.0406    32.4
   6  1    4     Bus4     5     Bus5  -31.257  -11.096   0.7806  -2.3206    34.3
---------------------------------------------------------------------------------
! NUMBER OF LINES LOADED BEYOND  125%          :    0
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% :    0
# NUMBER OF LINES LOADED BETWEEN  75% AND 100% :    2
$ NUMBER OF LINES LOADED BETWEEN  50% AND  75% :    1
^ NUMBER OF LINES LOADED BETWEEN  25% AND  50% :    3
& NUMBER OF LINES LOADED BETWEEN   1% AND  25% :    0
* NUMBER OF LINES LOADED BETWEEN   0% AND   1% :    0
---------------------------------------------------------------------------------
ISLAND FREQUENCY SLACK-BUS   CONVERGED(1)
------ --------- ----------- ------------
     1  50.00000           1        0

---------------------------------------------------------------------------------
Summary of results
TOTAL REAL POWER GENERATION   :    414.668 MW
TOTAL REAL POWER INJECT,-ve L :      0.000 MW
TOTAL REACT. POWER GENERATION :    210.429 MVAR
GENERATION pf                 :      0.892

TOTAL SHUNT REACTOR INJECTION :     -0.000 MW
TOTAL SHUNT REACTOR INJECTION :     -0.000 MVAR

TOTAL SHUNT CAPACIT.INJECTION :     -0.000 MW
TOTAL SHUNT CAPACIT.INJECTION :     -0.000 MVAR

TOTAL TCSC REACTIVE DRAWL     :      0.000 MVAR

TOTAL SPS REACTIVE DRAWL      :      0.000 MVAR

TOTAL UPFC FACTS. INJECTION   :    -0.0000 MVAR

TOTAL SHUNT FACTS.INJECTION   :      0.000 MVAR
TOTAL SHUNT FACTS.DRAWAL      :      0.000 MVAR

TOTAL REAL POWER LOAD         :    405.000 MW
TOTAL REAL POWER DRAWAL -ve g :      0.000 MW
TOTAL REACTIVE POWER LOAD     :    200.000 MVAR
LOAD pf                       :      0.897
TOTAL COMPENSATION AT LOADS   :      0.000 MVAR
TOTAL HVDC REACTIVE POWER     :      0.000 MVAR
```

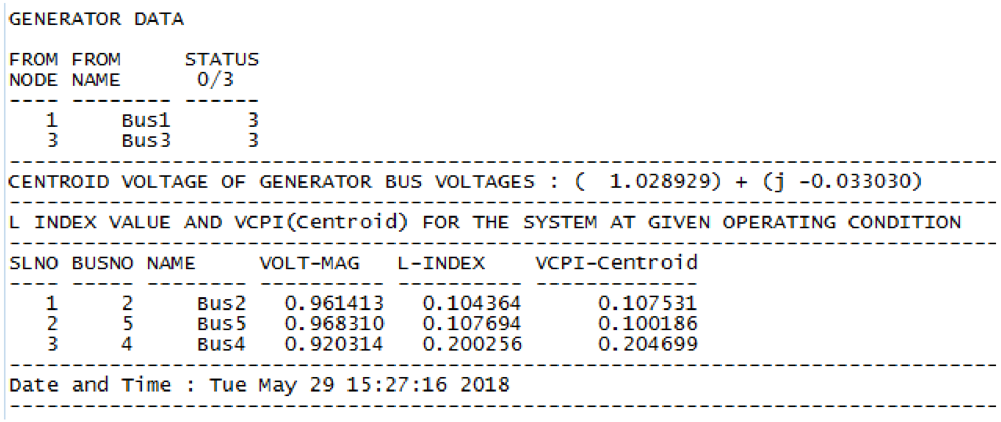


```
-------------------------------------------
Zone wise distribution
Description           Zone # 1
----------------- ----------
MW generation        414.6684

MVAR generation      210.4289

MW load              405.0000

MVAR load            200.0000

MVAR compensation      0.0000

MW loss                9.6741

MVAR loss             10.4290

MVAR - inductive       0.0000

MVAR - capacitive      0.0000

-------------------------------------------
Zone wise export(+ve)/import(-ve)
Zone #    1 MW & MVAR
------ -------- --------
     1      -----

Area wise distribution
Description           Area # 1
----------------- ----------
MW generation        414.6684

MVAR generation      210.4289

MW load              405.0000

MVAR load            200.0000

MVAR compensation      0.0000

MW loss                9.6741

MVAR loss             10.4290

MVAR - inductive       0.0000

MVAR - capacitive      0.0000

-------------------------------------------
-------------------------------------------
Date and Time : Tue May 29 15:12:08 2018
-------------------------------------------
```

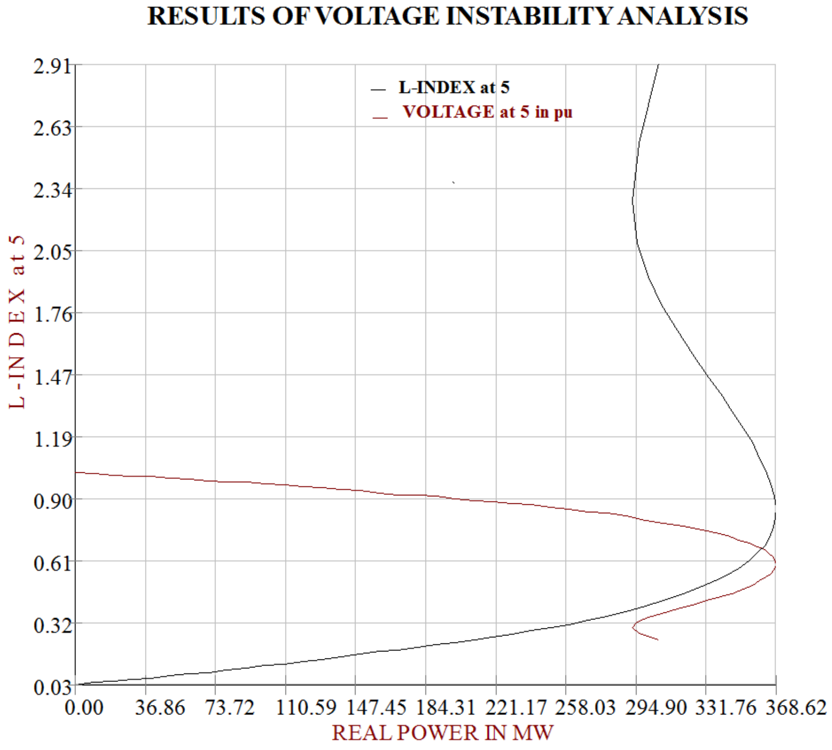
Voltage instability result report:



```
         VOLTAGE INSTABILITY ANALYSIS
CASE NO :  1     CONTINGENCY  : 0   SCHEDULE NO : 0
CONTINGENCY NAME : Base Case

--------------------------------------------------------------------------------
%% First Power System Network
LARGEST BUS NUMBER USED        :    5     ACTUAL NUMBER OF BUSES         :    5
NUMBER OF 2 WIND. TRANSFORMERS :    0     NUMBER OF 3 WIND. TRANSFORMERS :    0
NUMBER OF TRANSMISSION LINES   :    6
NUMBER OF SERIES REACTORS      :    0     NUMBER OF SERIES CAPACITORS    :    0
NUMBER OF BUS COUPLERS         :    0
NUMBER OF SHUNT REACTORS       :    0     NUMBER OF SHUNT CAPACITORS     :    0
NUMBER OF SHUNT IMPEDANCES     :    0     NUMBER OF GENERATORS           :    2
NUMBER OF LOADS                :    5
NUMBER OF FILTERS              :    0
NUMBER OF HVDC CONVERTORS      :    0

--------------------------------------------------------------------------------
NUMBER OF ZONES          :  1
PRINT OPTION             :  3 (BOTH DATA AND RESULTS PRINT)
PLOT OPTION              :  0 (NO PLOT FILE GENERATION)
BASE MVA                 :  100.000
NOMINAL SYSTEM FREQUENCY:    50.000
--------------------------------------------------------------------------------
CIRCUIT BREAKER RESISTANCE (PU)                      :   0.000000
CIRCUIT BREAKER REACTANCE  (PU)                      :   0.000100
TRANSFORMER R/X RATIO                                :   0.050000
--------------------------------------------------------------------------------
BUS DATA
NODE STAT ZONE BUS-KV    NAME     VMAG-PU  VANG-DEG  PGEN-MW  QGEN-MR
                                           PLOAD-MW QLOAD-MR QCOMP-MR
---- ---- ---- -------- -------- -------- -------- -------- --------
   1    1    1 138.000      Bus1   1.0400    0.000  234.670  100.130
                                            65.000   30.000    0.000
   2    1    1 138.000      Bus2   0.9614   -6.322    0.000    0.000
                                           115.000   60.000    0.000
   3    1    1 138.000      Bus3   1.0200   -3.713  180.000  110.300
                                            70.000   40.000    0.000
   4    1    1 138.000      Bus4   0.9203  -10.886    0.000    0.000
                                            70.000   30.000    0.000
   5    1    1 138.000      Bus5   0.9683   -6.162    0.000    0.000
                                            85.000   40.000    0.000

--------------------------------------------------------------------------------
TRANSMISSION LINE DATA

STAT CKTS FROM FROM       TO  TO
          NODE NAME      NODE NAME      RP(P.U)  XP(P.U)  BP/2(PU)
---- ---- ---- --------  ---- -------- -------- -------- --------
   3    1    1     Bus1     2     Bus2  0.04200  0.16800  0.02050
   3    1    1     Bus1     5     Bus5  0.03100  0.12600  0.01550
   3    1    2     Bus2     3     Bus3  0.03100  0.12600  0.01550
   3    1    3     Bus3     4     Bus4  0.08400  0.33600  0.04100
   3    1    3     Bus3     5     Bus5  0.05300  0.21000  0.02550
   3    1    4     Bus4     5     Bus5  0.06300  0.25200  0.03050

--------------------------------------------------------------------------------
```



```
GENERATOR DATA

FROM FROM      STATUS
NODE NAME       0/3
---- --------- ------
   1     Bus1       3
   3     Bus3       3
-------------------------------------------------------------------------------
CENTROID VOLTAGE OF GENERATOR BUS VOLTAGES : (  1.028929) + (j -0.033030)
-------------------------------------------------------------------------------
L INDEX VALUE AND VCPI(Centroid) FOR THE SYSTEM AT GIVEN OPERATING CONDITION
-------------------------------------------------------------------------------
SLNO BUSNO NAME      VOLT-MAG   L-INDEX    VCPI-Centroid
---- ----- -------- ---------- ---------- -------------
   1     2     Bus2   0.961413   0.104364      0.107531
   2     5     Bus5   0.968310   0.107694      0.100186
   3     4     Bus4   0.920314   0.200256      0.204699
-------------------------------------------------------------------------------
Date and Time : Tue May 29 15:27:16 2018
-------------------------------------------------------------------------------
```



VIII. CONCLUSION

Power flow or load flow studies exhibit significant importance for power system planning and operation. This paper represents the load flow and Voltage instability analysis of 5 bus system using Fast decoupled method by MiPower software. This software helps to solve the load flow technique in an efficient manner andleads the system to effective utilization of power and voltage. The principal information obtained from the power flow study is the magnitude and phase angle of the voltage at each bus, and the real and reactive power flowing in each line.L(line) index is proposed as a good voltage stability indicator with its value change between zero (no load) and one (voltage collapse) In voltage instability analysis we get L Index value at Bus number 2,4 and 5 which is shown in voltage instability result report. Graphical analysis between real power and L Index with voltage at bus number 5 has also been depicted.

REFERENCES

[1]. .SreemoyeeChatterjee&SuprovabMandal, "A novel comparison of Gauss-Seidel and Newton Raphson methods for load flow analysis",*IEEE Trans. Power Syst.*, vol.10, no.1109, ICIEECT.2017. 17289904, 16-18 March 2017.

[2]. .Dharamjit and D.K.Tanti “Load Flow Analysis on IEEE 30 bus System “ International Journal of Scientific and Research Publications,Vol.2,Issue 11, Nov. 201 2.

[3]. SandeepKaur, Amarbir Singh, Dr. Raja Singh Khela, Jasdev Singh Sandhu, “Load Flow Analysis of IEEE-3 bus system by using Mipower Software”, International Journal of Engineering Research and Technology, Vol. 4 Issue 03, March-2015.

[4]. M.J.Katira, Student, M. Tech. Final (I.P.S.), K.B.Porate, Assistant Professor, “Load Flow Analysis of 132 / 11 kV Distribution Sub Station using Static Var Compensator for Voltage Enhancement – A Case Study”,TENCON 2009-2009 IEEE Region 10 Conference.
[5]. M. Javad, G. Eskandar, K. Amin, "A comprehensive review of the voltage stability indices", *Renewable and Sustainable Energy Reviews*, vol. 63, pp. 1-12, 2016.
[6]. Ray D. Zimmerman and Hsiao-Dong Chiang.” Fast Decoupled Power Flow for Unbalanced Radial Distributi on System s” 1995,IEEE.pp241-25 0.
[7]. Power System Analysis by HadiSaadat, 1999, TheMc-Graw Hill Componies, Inc., pp. 208,240-242.
[8]. AbhijitChakrabarti, SunitaHalder, "Power System Analysis: Operation and Control", *PHI Learning Pvt. Ltd.*, 2010.
[9]. P. S. Bhowmik, D. V. Rajan,and S. P. Bose “Load Flow Analysis: An Overview” World Academy of Science, Engineering and Technology 63 [201 2].
[10]. Brian Scott, "Review of Load-Flow Calculation Methods", *Proceedings of the IEEE*, vol. 62, no. 7,1974.

Vibha Parmar. " Load Flow And Voltage Instability Analysis Using MI Power Software"International Journal of Engineering Science Invention (IJESI), vol. 07, no. 06, 2018, pp 49-55