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Voltage Instability Analysis Using Mipower

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ABSTRACT - Load Flow Analysis helps in error free operation of power system and also useful in forecasting the required equipment for expansion of the system. By forecasting the magnitude of the supply required along with effects caused by single or multiple defects in the system and calculating the magnitude of errors, it is very easy to compensate them using various techniques with minimum cost and effort. It means before installation the favorable sites and size of the infrastructure used are determined to maintain the power factor in the system. Here Power Flow Analysis is performed using Newton Raphson method. This method is used in solving power flow studies of various number of busesunder various conditions. In any network there will be undesired rise or drop or dissipation of voltage. Voltage instability decreases the efficiency of the system and also damages the equipment used. Hence voltage instability analysis is performed and magnitude of the instability is calculated and compensated using various techniques. Here we performed Load Flow Analysis on a 5bus system and Voltage Instability Analysis is also performed to the same with necessary outputs.[7]

KEYWORDS: Newton Raphson Method – Load Flow Analysis, Voltage Instability Analysis, MIPOWER version 9.

I. INTRODUCTION

The inability of a system to remain in equilibrium at all the buses whenever subjected to a disturbance called voltage instability. Now a days voltage instability is observed in the system due to lack of co-ordination between generation unit and load unit which results burden on the system. Sometimes the voltages in the system are uncontrollable and may lead to voltage collapse. In some cases the sudden changes in the voltage is undetectable and the effect cannot be stopped. These effects can be studied only after the voltage collapse in order to prevent them in future. The change in load characteristics, increased number of interconnections etc., result in the voltage instability. Use of appliances also depend upon seasons, in summer all the appliances are used more than other seasons which may not result in severe damage but can cause voltage instability and power factor problems. This clearly says that uneven demand for the load also causes voltage instability. Reactive power limit of the generators, long transmission lines also results in voltage instability.[2][8]

COUNTERMEASURES FOR VOLTAGE INSTABILITY [8]

- Under load tap changers
- Reactive compensation devices
- Automatic voltage regulators
- Load shedding etc.,

II. OBJECTIVES

First a system of buses is designed and simulated in order to forecast the size and rating of the equipment to be used for construction of a new system or extension of the existing system.All the changes in parameters are observed at different conditions. The simulation can be performed on various softwares like MIPOWER, MATLAB.

III. MIPOWER

MIPOWER is a simulation software managed by PRDC Banglore. It is designed by a power systems engineer Dr. Nagrath. The current version of Mipower is 9.0. It is a power systems network analysis package which runs on windows. It is user-friendly and convenient compared to other simulation software.

Accuracy and tolerance is high in MIPOWER. It includes a windows based graphical user interface with centralized database.[3]

Applications of MIPOWER:

Steady State Analysis, Stability Assessment, Transient Studies, Security Monitoring, Assessment and Control,Protection Co-Ordination, Planning Studies,Mipower Utilities.[3]

IV. SOLVING VIA USING MIPOWER

Open Power system network editor tab and select configure database. Give a name to the file and save it. Now draw the circuit step by step entering the details of elements required. [2]

QUESTION DESCRIPTION

Perform load flow analysis and voltage instability analysis on a 5 bus power system network with bus voltages 11kv

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with the following bus, transmission line, generator and load data.[6]

Bus no.	Bus voltage	Generator (MW)	Generation (MVAR)	Load (MW)	Load (MVAR)
1	1+j0	0	0	0	0
2	1+j0	40	30	20	10
3	1+j0	0	0	45	15
4	1+j0	0	0	40	5
5	1+j0	0	0	60	10

All the p.u values are of 100MVA impedance and line charging for the system.

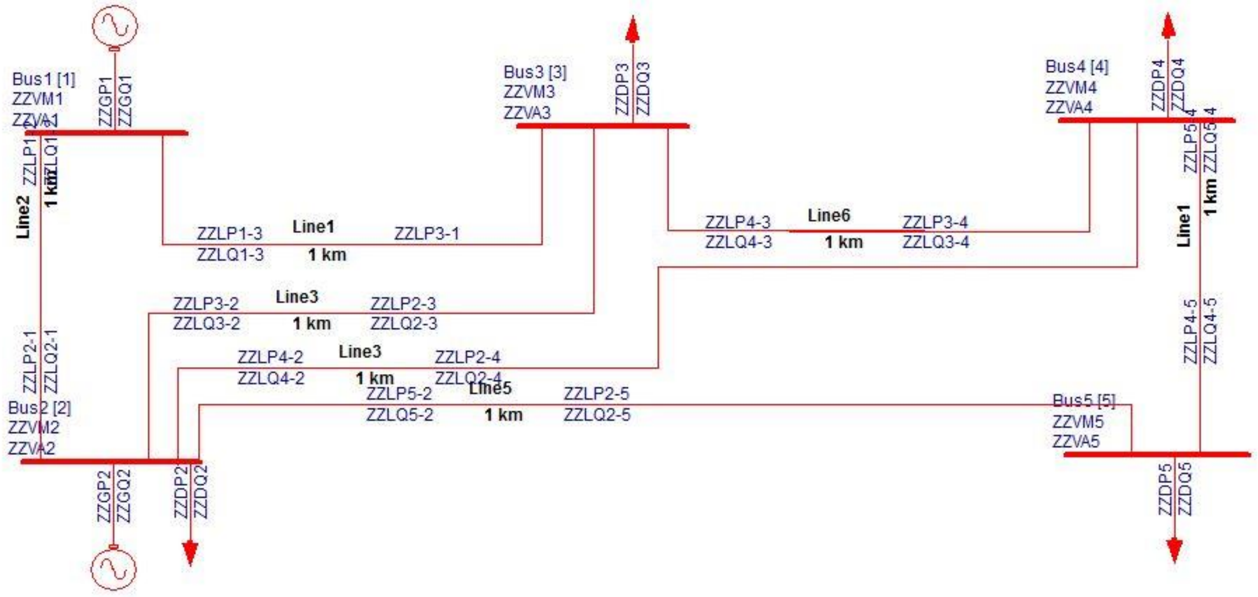
Bus	Impedance	Line Charging
1-2	0.02+j0.06	j0.030
1-3	0.08+j0.24	j0.025
2-3	0.06+j0.18	j0.020
2-4	0.06+j0.18	j0.020
2-5	0.04+j0.12	j0.015
3-4	0.01+j0.03	j0.01
4-5	0.08+j0.24	j0.025

Open Mipower software and open Power System Network Editor. First draw the buses one after one and feed the element details.

Similarly enter the details of generators and loads.

Now solve load flow analysis using any of the four methods. [4]

Then solve voltage instability analysis and save the results. [1]



V. OUTPUT

LOAD FLOW ANALYSIS USING NEWTON RAPHSON METHOD

Date and Time : Mon Mar 02 14:52:33 2020

LOAD FLOW BY NEWTON RAPHSON METHOD
CASE NO : 1 CONTINGENCY : 0 SCHEDULE NO : 0
CONTINGENCY NAME : Base Case RATING CONSIDERED : NOMINAL

VERSION NUMBER : 8.2
%% 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 : 7 Number of Series Reactors : 0
Number of Series Capacitors : 0 Number of Circuit Breakers : 0
Number of Shunt Reactors : 0 Number of Shunt Capacitors : 0
Number of Shunt Impedances : 0 Number of Generators : 2
Number of Loads : 4 Number of Load Characteristics : 0
Number of Under Frequency Relay: 0 Number of Gen.Capability Curves: 0
Number of Filters : 0 Number of Tie Line Schedules : 0
Number of Convertors : 0 Number of dc Links : 0
Number of Shunt Connected Facts: 0 Power Forced Lines : 0
Number of TCSC Connected : 0 Number of SPS Connected : 0
Number of UPFC Connected : 0 Number of Wind Generators : 0
Number of wtg Curves : 0 Number of wtg Detailed Curves : 0
Number of solar plants : 0

Load Flow With Newton Raphson Method : 6
Number of Zones : 1
Print Option : 3 - Both Data and Results Print
Plot Option : 1 - Plotting with p.u. Voltage
No Frequency Dependent Load Flow, Control Option: 0
Base MVA : 100.0

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Nominal System Frequency (Hz) : 50.0
Frequency Deviation (Hz) : 0.0
Flows in MW and MVAr, Option : 0
Slack Bus : 0 (Max. Generation Bus)
Transformer Tap Control Option : 0
Q Checking Limit (Enabled) : 4
Real Power Tolerance (p.u.) : 0.00100
Reactive Power Tolerance (p.u.) : 0.00100
Maximum Number of Iterations : 15
Bus Voltage Below Which Load Model is Changed : 0.75000
Circuit Breaker Resistance (p.u.) : 0.00000
Circuit Breaker Reactance (p.u.) : 0.00010
Transformer R/X Ratio : 0.05000

Annual Percentage Interest Charges : 15.000
Annual Percent Operation & Maintenance Charges : 4.000
Life of Equipment in Years : 20.000
Energy Unit Charge (KWH) : 2.500 Rs
Loss Load Factor : 0.300
Cost Per MVAr in Lakhs : 5.000 Rs

ZONE WISE MULTIPLICATION FACTORS

ZONE	P LOAD	Q LOAD	P GEN	Q GEN	SH REACT	SH CAP	C LOAD
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1	1.000	1.000	1.000	1.000	1.000	1.000	1.000

BUS DATA

BUS NO.	AREA	ZONE	BUS kV	VMIN(p.u.)	VMAX(p.u.)	NAME
1	1	1	11.000	0.950	1.050	Bus1
2	1	1	11.000	0.950	1.050	Bus2
3	1	1	11.000	0.950	1.050	Bus3
4	1	1	11.000	0.950	1.050	Bus4
5	1	1	11.000	0.950	1.050	Bus5

TRANSMISSION LINE DATA

STA	CKT	FROM NODE	FROM NAME*	TO NODE	TO NAME*	R(p.u.)	X(p.u.)	B/2(p.u.)	LINE PARAMETER RATING MVA	KMS
3	1	1	Bus1	3	Bus3	0.06612	0.19835	0.03025	100	1.00
3	1	1	Bus1	2	Bus2	0.01653	0.17025	0.03630	100	1.00
3	1	2	Bus2	3	Bus3	0.04959	0.14876	0.02420	100	1.00
3	1	2	Bus2	4	Bus4	0.04959	0.14876	0.02420	100	1.00
3	1	2	Bus2	5	Bus5	0.03306	0.09917	0.01815	100	1.00
3	1	3	Bus3	4	Bus4	0.00826	0.02479	0.01210	100	1.00
3	1	4	Bus4	5	Bus5	0.06612	0.19835	0.03025	100	1.00

Total Line Charging Susceptance (in p.u.) : 0.35090
Total Line Charging MVAr at 1 p.u. Voltage : 35.090
Number of Lines Opened on Both the Ends : 0
Total Line Charging susceptance of Existing Lines (in p.u.) : 0.35090
Total Line Charging MVAr at 1 p.u. Voltage of Existing Lines : 35.090

Total Capacitive Susceptance : 0.00000 p.u. - 0.000 MVAr
Total Inductive Susceptance : 0.00000 p.u. - 0.000 MVAr

GENERATOR DATA

Sl.No*	FROM NODE	FROM NAME*	REAL POWER(MW)	Q-MIN MVAr	Q-MAX MVAr	V-SPEC p.u.	CAP. CURV	MVA RATING	STAT
1	1	Bus1	80.0000	5.0000	60.0000	1.0000	0	100.00	3
2	2	Bus2	80.0000	5.0000	60.0000	1.0000	0	100.00	3

LOAD DATA

Sl.No.*	FROM NODE	FROM NAME*	REAL MW	REACTIVE MVAr	COMP MVAr	COMPENSATING MVAR VALUE MIN	MAX	STEP	CHAR NO.	F/V NO.	STAT
1	2	Bus2	20.000	10.000	0.000	0.000	0.000	0.000	0	0	3 0
2	3	Bus3	45.000	15.000	0.000	0.000	0.000	0.000	0	0	3 0
3	4	Bus4	40.000	5.000	0.000	0.000	0.000	0.000	0	0	3 0
4	5	Bus5	60.000	10.000	0.000	0.000	0.000	0.000	0	0	3 0

Total Specified MW Generation : 160.00000
Total Minimum MVAr Limit of Generator : 10.00000
TOTAL Maximum MVAr Limit of Generator : 120.00000
Total Specified MW Load : 165.00000 Changed to 165.00000
Total Specified MVAr Load : 40.00000 Changed to 40.00000
Total Specified MVAr Compensation : 0.00000 Changed to 0.00000

TOTAL (Including Out of Service Units)
Total Specified MW Generation : 160.00000
TOTAL Minimum MVAr Limit of Generator : 10.00000
Total Maximum MVAr Limit of Generator : 120.00000
Total Specified MW Load : 165.00000 Changed to 165.00000
Total Specified MVAr Load : 40.00000 Changed to 40.00000
Total Specified MVAr Compensation : 0.00000 Changed to 0.00000

GENERATOR DATA FOR FREQUENCY DEPENDENT LOAD FLOW

SLNO*	FROM NODE	FROM NAME*	P-RATE MW	P-MIN MW	P-MAX MW	%DROOP	PARTICI FACTOR	BIAS SETTING	C0	C1	C2
1	1	Bus1	80.000	20.0000	80.0000	4.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	Bus2	40.000	20.0000	80.0000	4.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Slack bus angle (degrees) : 0.00

TOTAL NUMBER OF ISLANDS IN THE GIVEN SYSTEM : 1
TOTAL NUMBER OF ISLANDS HAVING ATLEAST ONE GENERATOR : 1
SLACK BUSES CONSIDERED FOR THE STUDY

ISLAND NO.	SLACK BUS	NAME	SPECIFIED MW
1	1	Bus1	80.000

Iteration count 0 maxp 0.600000 maxq 0.083450

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Iteration count 1 maxp 0.019533 maxq 0.026128

Iteration count 2 maxp 0.000055 maxq 0.000097

Iteration count 3 maxp 0.000000 maxq 0.000000
Iteration count 4 maxp 0.000000 maxq 0.000000

BUS VOLTAGES AND POWERS

NODE NO.	FROM NAME	V-MAG p.u.	ANGLE DEGREE	MW GEN	MVAr GEN	MW LOAD	MVAr LOAD	MVAr COMP
1	Bus1	1.0000	0.00	88.455	-11.369	0.000	0.000	0.000 <
2	Bus2	1.0000	-4.00	80.000	29.489	20.000	10.000	0.000
3	Bus3	0.9775	-5.64	0.000	0.000	45.000	15.000	0.000
4	Bus4	0.9777	-6.01	0.000	0.000	40.000	5.000	0.000
5	Bus5	0.9744	-6.94	0.000	0.000	60.000	10.000	0.000

NUMBER OF BUSES EXCEEDING MINIMUM VOLTAGE LIMIT (@ mark) : 0
NUMBER OF BUSES EXCEEDING MAXIMUM VOLTAGE LIMIT (# mark) : 0
NUMBER OF GENERATORS EXCEEDING MINIMUM Q LIMIT (<mark) : 1
NUMBER OF GENERATORS EXCEEDING MAXIMUM Q LIMIT (>mark) : 0

LINE FLOWS AND LINE LOSSES

SLNO	CS	FROM NODE	FROM NAME	TO NODE	TO NAME	FORWARD MW	FORWARD MVAr	LOSS MW	LOSS MVAr	% LOADING
1	1	1	Bus1	3	Bus3	47.716	-5.215	1.5085	-1.3901	48.0^
2	1	1	Bus1	2	Bus2	40.739	-6.154	0.2754	-4.4236	41.2^
3	1	2	Bus2	3	Bus3	21.540	5.773	0.2634	-3.9424	23.9&
4	1	2	Bus2	4	Bus4	25.411	4.527	0.3441	-3.7008	27.0^
5	1	2	Bus2	5	Bus5	53.513	7.458	0.9751	-0.6130	54.0$
6	1	3	Bus3	4	Bus4	22.484	-9.110	0.0492	-2.1652	24.8&
7	1	4	Bus4	5	Bus5	7.502	-3.717	0.0394	-5.6453	8.6&

! NUMBER OF LINES LOADED BEYOND 125% : 0
@ NUMBER OF LINES LOADED BETWEEN 100% AND 125% : 0
# NUMBER OF LINES LOADED BETWEEN 75% AND 100% : 0
$ 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% : 3
* NUMBER OF LINES LOADED BETWEEN 0% AND 1% : 0

BUSES BETWEEN WHICH ANGLE DIFFERENCE IS > 30 degrees ARE: ZERO

ISLAND	FREQUENCY	SLACK-BUS	CONVERGED(1)
1	50.00000	1	1

Summary of results

TOTAL REAL POWER GENERATION (CONVENTIONAL) : 168.455 MW
TOTAL REAL POWER INJECTION (-veLOAD) : 0.000 MW
TOTAL REACT. POWER GENERATION (CONVENTIONAL) : 18.120 MVAr
GENERATION p.f. : 0.994
TOTAL REAL POWER GENERATION (WIND) : 0.000 MW
TOTAL REACT. POWER GENERATION (WIND) : 0.000 MVAr
TOTAL REAL POWER GENERATION (SOLAR) : 0.000 MW
TOTAL REACT. POWER GENERATION (SOLAR) : 0.000 MVAr
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 INJECTION : -0.000 MVAr
TOTAL SHUNT FACTS INJECTION : 0.000 MVAr
TOTAL SHUNT FACTS DRAWAL : 0.000 MVAr
TOTAL REAL POWER LOAD : 165.000 MW
TOTAL REAL POWER DRAWAL (-ve gen.) : 0.000 MW
TOTAL REACTIVE POWER LOAD : 40.000 MVAr
LOAD p.f. : 0.972
TOTAL COMPENSATION AT LOADS : 0.000 MVAr
TOTAL HVDC REACTIVE POWER : 0.000 MVAr

TOTAL REAL POWER LOSS (AC+DC) : 3.455023 MW (3.455023+ 0.000000)
PERCENTAGE REAL LOSS (AC+DC) : 2.051
TOTAL REACTIVE POWER LOSS : -21.880390 MVAr

Zone wise distribution

Description	Zone # 1
MW generation	168.4550
MVAr generation	18.1196
MW wind gen.	0.0000
MVAr wind gen.	0.0000
MW solar gen.	0.0000
MVAr solar gen.	0.0000
MW load	165.0000
MVAr load	40.0000
MVAr compensation	0.0000
MW loss	3.4550
MVAr loss	-21.8804
MVAr - inductive	0.0000
MVAr - capacitive	0.0000

Zone wise export(+ve)/import(-ve)

Zone #	1 MW	&MVAr
1	-----	

Area wise export(+ve)/import(-ve)

Area #	1 MW	&MVAr
1	-----	

Area wise distribution

Description	Area # 1
MW generation	168.4550
MVAr generation	18.1196
MW wind gen.	0.0000
MVAr wind gen.	0.0000
MW solar gen.	0.0000
MVAr solar gen.	0.0000
MW load	165.0000

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MVAr load 40.0000
MVAr compensation 0.0000
MW loss 3.4550
MVAr loss -21.8804
MVAr - inductive 0.0000
MVAr - capacitive 0.0000

Date and Time : Mon Mar 02 14:52:33 2020

VOLTAGE INSTABILITY ANALYSIS

Date and Time : Mon Mar 02 15:25:02 2020

VOLTAGE INSTABILITY ANALYSIS
CASE NO : 1 CONTINGENCY : 0 SCHEDULE NO : 0
CONTINGENCY NAME : Base Case
VERSION NUMBER : 8.1

%% 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 : 7
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 : 4
NUMBER OF FILTERS : 0
NUMBER OF HVDC CONVERTORS : 0
NUMBER OF ISLANDS : 1

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

BUS NO.	AREA	ZONE	BUS kV	VMIN(p.u.)	VMAX(p.u.)	NAME
1	1	1	11.000	0.950	1.050	Bus1
2	1	1	11.000	0.950	1.050	Bus2
3	1	1	11.000	0.950	1.050	Bus3
4	1	1	11.000	0.950	1.050	Bus4
5	1	1	11.000	0.950	1.050	Bus5

TRANSMISSION LINE DATA

STA	CKT	FROM NODE	FROM NAME*	TO NODE	TO NAME*	R(p.u.)	X(p.u.)	B/2(p.u.)	LINE PARAMETER RATING MVA	KMS
3	1	1	Bus1	3	Bus3	0.00000	0.19835	0.00000	100	1.00
3	1	1	Bus1	2	Bus2	0.00000	0.17025	0.00000	100	1.00
3	1	2	Bus2	3	Bus3	0.00000	0.14876	0.00000	100	1.00
3	1	2	Bus2	4	Bus4	0.00000	0.14876	0.00000	100	1.00
3	1	2	Bus2	5	Bus5	0.00000	0.09917	0.00000	100	1.00
3	1	3	Bus3	4	Bus4	0.00000	0.02479	0.00000	100	1.00
3	1	4	Bus4	5	Bus5	0.00000	0.19835	0.00000	100	1.00

LOAD DATA

Sl.No. *	FROM NODE	FROM NAME*	REAL MW	REACTIVE MVAr	COMP MVAr	COMPENSATING MIN	MVAR VALUE MAX	CHAR STEP	F/V NO.	NO.	STAT
1	2	Bus2	20.000	10.000	0.000	0.000	0.000	0.000	0	0	3 0
2	3	Bus3	45.000	15.000	0.000	0.000	0.000	0.000	0	0	3 0
3	4	Bus4	40.000	5.000	0.000	0.000	0.000	0.000	0	0	3 0
4	5	Bus5	60.000	10.000	0.000	0.000	0.000	0.000	0	0	3 0

GENERATOR DATA

FROM NODE	FROM NAME	STATUS 0/3
1	Bus1	3
3	Bus2	3

CENTROID VOLTAGE OF GENERATOR BUS VOLTAGES : (1.082234) + (j -0.004635)

L INDEX VALUE AND VCPI (Centroid) FOR THE SYSTEM AT GIVEN OPERATING CONDITION

SLNO	BUSNO	NAME	VOLT-MAG	L-INDEX	VCPI-centroid
1	3	Bus3	0.931822	0.102354	0.104873
2	4	Bus4	0.938109	0.105763	0.100012
3	5	Bus5	0.912197	0.190289	0.194873

VI. CONCLUSION

Load Flow Analysis is used for perfect planning and operation of a power system. This paper indicates the load flow analysis using Newton Raphson method and Voltage Instability Analysis on a 5 bus system. MIPOWER is helpful in easy and accurate solving of power flow studies and results in power and voltage enhancement. The voltage and phase is obtained at each bus along with real and reactive power flowing in each line during the normal conditions and voltage instability. The voltage instability at load bus is determined and noted. [5]

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