

SIMULATION AND ANALYSIS OF 400KV 11 BUS SYSTEMS

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ABSTRACT

The paper reviews the use of pie charts in modeling and analysis of a 400KV power system. The proposed model gives an accurate representation of connectivity of 11 buses in a power system. The buses are so connected that it fulfills the needs of each other's demands of power taking all the factors like losses, blackout, generation, and loads into consideration. The simulation of the connected power system is done with the help of PWS 8.0 tool and this simulation of multi machine power system is subjected to a wide variety of disturbances like line to line fault, line to ground fault, double line to ground fault on the buses and transmission lines.

Keywords: *Automatic Generation Control (AGC), Power Transfer Distribution Factor (PTDF), Automatic Control Error (ACE).*

I. INTRODUCTION

Load Flow analysis is an important aspect of Transient Stability analysis. Load flow study is to know current, voltage, active and reactive power at different buses in power system. Also to know the total capacity of power to control power flow, to maintain stability in condition of addition or removal of load or generator. It gives us the information about the effect of new load on generating stations, new lines and new interconnection before they are installed. The prior information serves to minimize the system losses and to provide check on the system stability.

As far as fault analysis is concerned it is to know the impact of various faults on the running power system. Fault may be in the form of line to line, line to ground, double line to ground, three phase fault. Faults are introduced deliberately and then we calculate the values of fault voltage, fault current rotor angle of generators, losses of the system. Effect of the faults are also seen on the simulator in terms of change in speed, direction and color of arrows that are being used to show the flow of power from one bus to another bus. Contingencies are also covered in this part of analysis. It has also a provision of keeping the bus views for each and every bus. Technology having advanced so much in the recent years has taken man to places never seen or experienced before. The main aim of advancement is to make life easier with simple programs going tedious jobs. To do the cumbersome calculations a speedy results we have used the software PWS which stands for POWER WORLD SIMULATOR.

The program operation resembles real electric system operation as closely as possible. After feeding proper data of any practical power system, PWS will provide us with the performance of each and every machine in power system, no matter how large and complicated the power system is in load flow study, load and voltage at each machine will be obtained in seconds. PWS is preferred because of the following advantage:

- i. This is a user friendly package.
- ii. Single line diagram gives extra idea of power system and provides graphical study which becomes quite easier.
- iii. Can run under window XP.

The power system considered for load fault and fault analysis is 400KV grid system of Uttar Pradesh. This transmission network consists of 11 buses connected by 15 lines. There are 7 generators out of these Agra is swing bus.

II. SYSTEM MODEL

A 9 machine 11 bus interconnected power system is simulated in this paper. There is slack bus (voltage magnitude $[V_i]$ & phase angle δ are specified for this bus .This bus is first bus to respond to a changing load condition). Moving arrows in direction of power flows with different direction of power flow with different speeds depending upon the power being transferred, pie charts showing % share of use of capacity of transmission lines, area wise segregation and cost of power in segregated areas are some of the prominent features of the system model. Circuit breakers are also used to connect or disconnect the transmission lines, generators and loads connected with the buses. The diagram of power system model is shown in fig.1. Whole system model is comprised of three zones fragmented by dotted lines in the model.

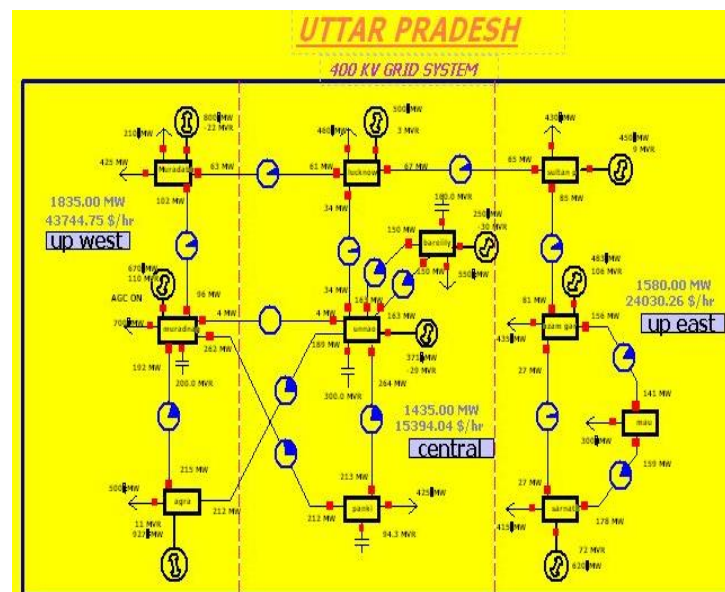


Fig. 1

III. CONTROL SCHEME

Area control: One of the important aspects of interconnected power system operation is the requirement that each operating area changes its total generation to match changes in the sum of its load plus losses plus power transactions with other areas. Normally, this requirement is met by Automatic Generation Control (AGC). The AGC system accomplishes this by first calculating the Area Control Error (ACE), which is defined as

$$ACE = P_{\text{actual}} - P_{\text{scheduled}} + (a \text{ term dependent upon system frequency})$$

Where P_{actual} is the actual amount of MW flowing out of an area. If power is actually flowing into the area, P_{actual} is negative. $P_{\text{scheduled}}$ is the amount of power scheduled to flow out of the area and thus equals the areas total sales minus its total purchases, both expressed in MW.

Area Slack Bus Control: Only the output of the area's slack bus changes automatically to drive the area control error (ACE) to zero.

In Participation Factor Control, the ACE is allocated to each generator in the area in proportion to that generator's participation factor divided by the total of the participation factors for all AGC generators in the area. With Economic Dispatch (ED) Control, simulator tries to change the output of the area's generators economically so that the area's operating cost is minimized. ED control recognizes that some generators are less expensive than others and tries to least generators to the largest extent possible.

To do economic dispatch, we need to know how much it would cost to generate one more MW at a particular generator. This is known as the incremental or marginal cost. The incremental cost for each generator is modeled using the formula

$$\lambda_i = ICI(P_{gi}) = (b_i + 2c_i P_{gi} + 3d_i (P_{gi})^2) * \text{fuel cost } \$/\text{MWH}$$

IV. LOAD FLOW

Load flow is a traditional power engineering calculation that is performed to determine the flows on all lines and the voltages at all buses in the system given the power injections at all buses and voltage magnitudes at some of them. When simulator performs a timed simulation, it actually performs a sequence of power flow calculations, each based on data that present a snapshot of system conditions at a particular instant. Since it is based on power flow, simulator models the system as being of constant frequency. This assumption is only an approximation, but frequency deviations are generally very small in everyday operation.

The load flow problem entails solving a system of nonlinear equations. Here we use Newton-Raphson polar coordinate method to solve the load flow problem.

$$S_i = P_i + jQ_i = V_i \sum_k Y_{ik} V_k^*$$

$$= \sum_k (V_i V_k Y_{ik}) / (\delta_i - \delta_k - \theta_{ik})$$

$$P_i = \sum_k (V_i V_k Y_{ik}) \cos(\delta_i - \delta_k - \theta_{ik})$$

$$Q_i = \sum (V_i V_k Y_{ik}) \sin(\delta_i - \delta_k - \theta_{ik})$$

$$\Delta f = J \Delta X$$

$$\Delta P_i = P_i(sp) - P_i(cal), \quad i = 1, 2, \dots, n,$$

$$\Delta Q_i = Q_i(sp) - Q_i(cal) \quad i = 1, 2, \dots, n.$$

The off diagonal and diagonal elements of the sub matrices H, N, M, L are determined by

$$H_{ik} = \frac{d P_i}{d \delta_k} = (V_i V_k Y_{ik}) \sin(\delta_i - \delta_k - \theta_{ik})$$

$$H_{ii} = \frac{d P_i}{d \delta_i} = -V_i \sum V_k Y_{ik} \sin(\delta_i - \delta_k - \theta_{ik})$$

$$N_{ik} = \frac{d P_i}{d V_k} = (V_i Y_{ik}) \cos(\delta_i - \delta_k - \theta_{ik})$$

$$N_{ii} = \frac{d P_i}{d V_i} = 2 V_i Y_{ii} \cos \theta_{ii} + \sum V_k Y_{ik} \sin(\delta_i - \delta_k - \theta_{ik})$$

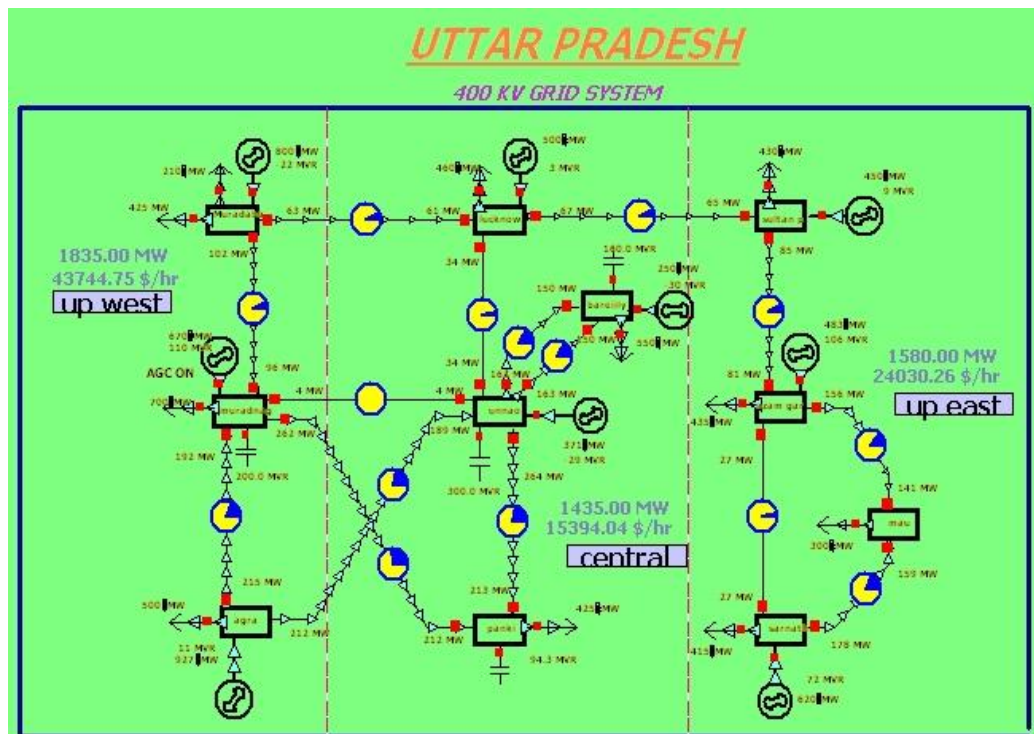
$$M_{ik} = \frac{d Q_i}{d \delta_k} = -(V_i V_k Y_{ik}) \cos(\delta_i - \delta_k - \theta_{ik})$$

$$M_{ii} = \frac{d Q_i}{d \delta_i} = \sum V_i V_k Y_{ik} \cos(\delta_i - \delta_k - \theta_{ik})$$

$$L_{ik} = \frac{d Q_i}{d V_k} = (V_i Y_{ik}) \sin(\delta_i - \delta_k - \theta_{ik})$$

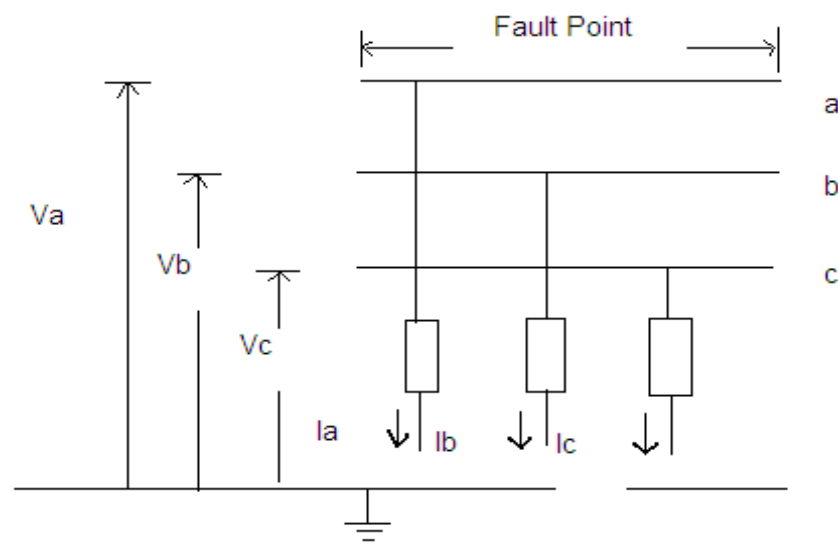
$$L_{ii} = \frac{d Q_i}{d V_i} = -2 V_i Y_{ii} \sin \theta_{ii} + \sum V_k Y_{ik} \cos(\delta_i - \delta_k - \theta_{ik})$$

From these equations we find the values of Jacobian matrix which is used for further calculations.



V. FAULT ANALYSIS

For doing fault analysis, we create faults either by disconnecting generators on different stations in terms of lack of power generation or by infusing some faults like LG, LLG, LL using additional resistances and reactance in the system. By fault analysis we calculate the values of fault current, fault voltage, bus voltage, bus angle, ac line MW flow, ac line MVAR flow, generator MW output and generator MVAR output.



1. Line to Ground Fault

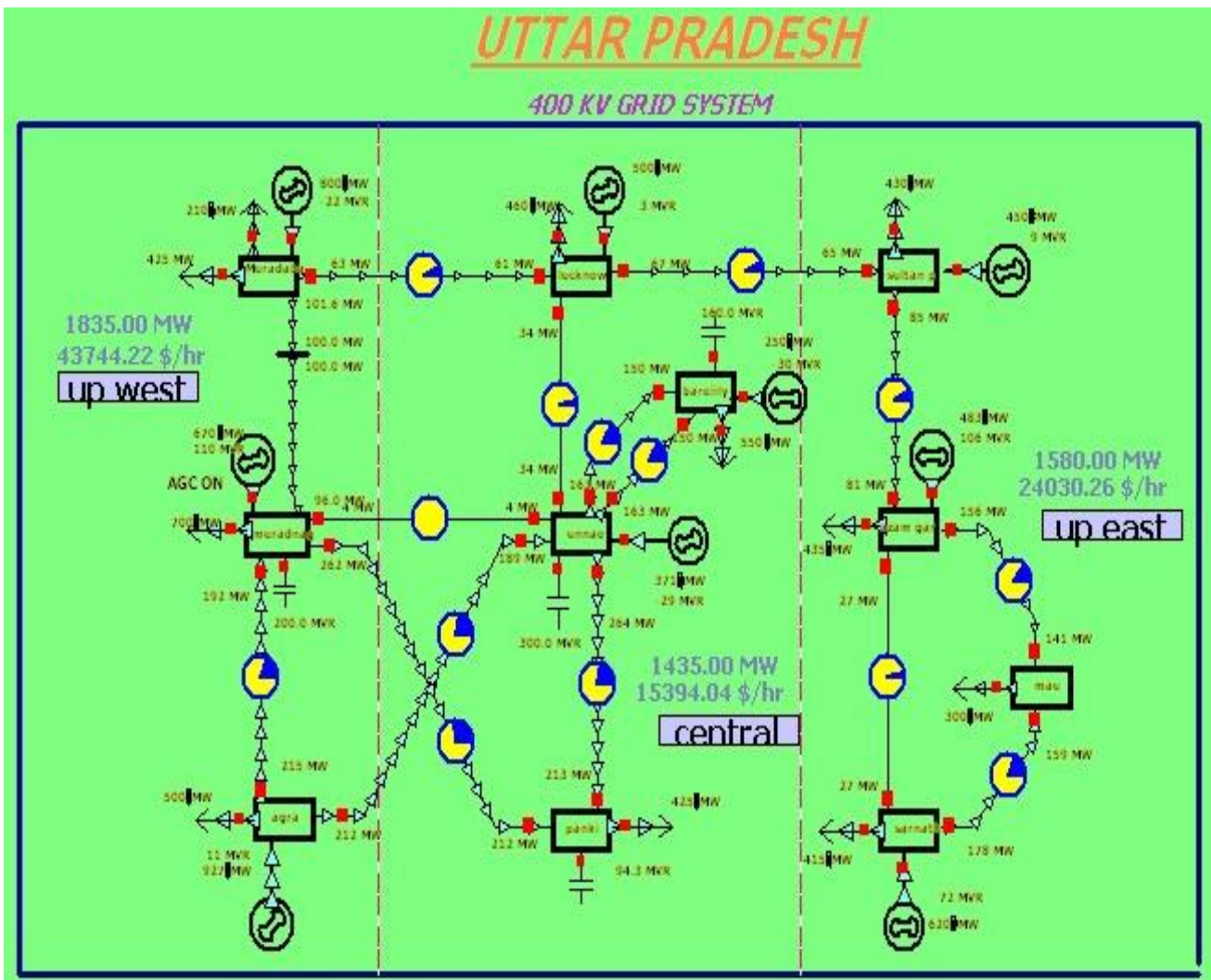
$$I = V_f / \{Z_f + 1/3(Z_{a0} + Z_{a1} + Z_{a2})\}$$

$$I = -j\sqrt{3} V_f / (Z_{a1} + Z_{a2} + Z_f)$$

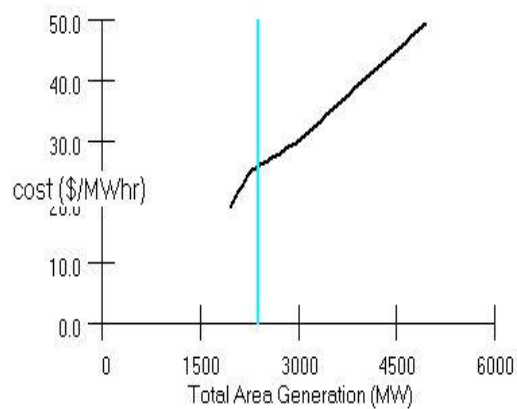
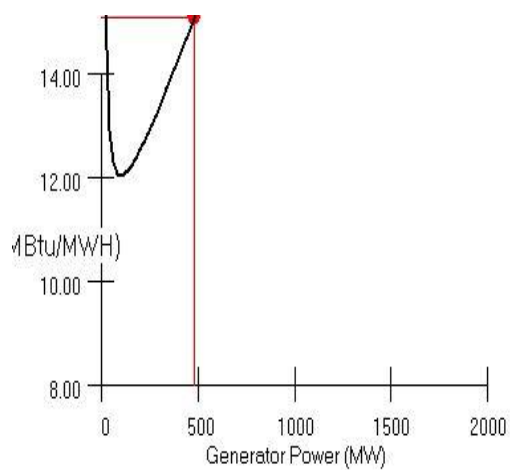
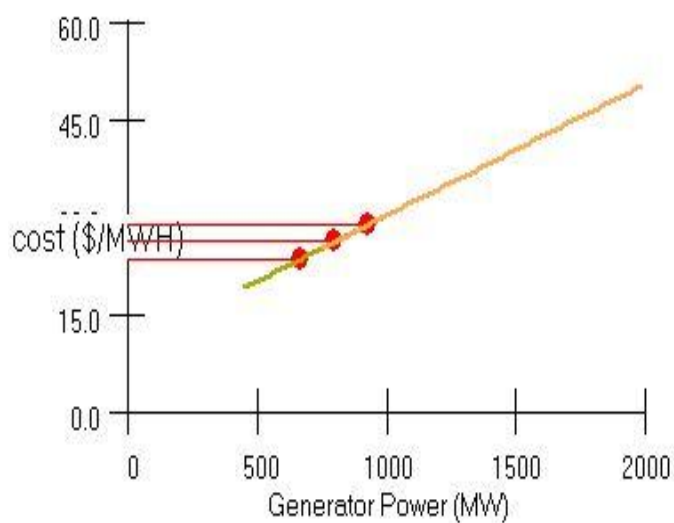
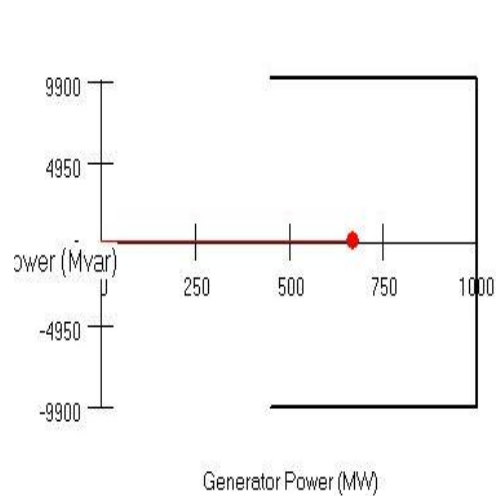
3. Double Line to Ground Fault

$$I = V_f / Z_{eq}$$

$$Z_{eq} = Z_{a1} + Z_f + \{(Z_{a2} + Z_f)(Z_{a0} + Z_f + 3Z_g) / (Z_{a2} + Z_{a0} + 2Z_f + 3Z_g)\}$$



VI. SIMULATION RESULTS



Fault Data - Buses							
Number	Name	Phase Volt A	Phase Volt B	Phase Volt C	Phase Ang A	Phase Ang B	Phase Ang C
1	Muradabad	1	0.41087	0.78238	-157.09	70.27	0.19
2	Muradnagar	1	0.7205	0.89358	-170.58	69.41	-34.87
3	agra	1	0.94145	1.10023	-142.05	106.92	-15.05
4	lucknow	1	0.79106	0.9678	-165.5	78.68	-32.87
5	Bareilly	1	0.90016	1.0395	168.35	54.44	-63.99
6	unnao	1	0.85846	1.02567	-170.08	76.4	-40.21
7	panki	0.68662	0.54108	0.65819	143.14	26.68	-84.25
8	sultan pur	1	0.9259	1.00946	-174.38	68.7	-49.25
9	azam gar	1	0.98313	1.01392	174.41	55.9	-64.03
10	mau	0.82102	0.81473	0.83376	152.12	33.41	-86.87
11	sarnath	1	1.00133	1.01661	178.03	59.09	-61.51
12	Fault Pt	0.99443	0.49721	0.49721	-160.86	19.14	19.14

Fault Data - Lines									
From Number	From Name	To Number	To Name	Phase Cur A From	Phase Cur B From	Phase Cur C From	Phase Cur A To	Phase Cur B To	Phase Cur C To
1	Muradabad	2	muradnagar	0	0	0	0	0	0
1	Muradabad	4	lucknow	92.47	245.44	333.36	92.47	245.44	333.36
1	Muradabad	12	FaultPt	147.74	897.34	789.48	147.74	897.34	789.48
2	muradnagar	3	agra	310.71	361.75	251.48	310.71	361.75	251.48
2	muradnagar	6	unnao	5.46	105.93	100.53	5.46	105.93	100.53
2	muradnagar	7	panki	455.73	308.33	430.4	455.73	308.33	430.4
12	Fault Pt	2	muradnagar	147.75	485.11	632.06	147.75	485.11	632.06

3	agra	6	unnao	305.4 2	302.8 5	295.5 1	305.42	302.8 5	295.51
4	lucknow	6	unnao	50.42	47.23	88.31	50.42	47.23	88.31
4	lucknow	8	sultan p	97.64	126.6 2	179.5	97.64	126.6 2	179.5
6	unnao	5	bareilly	235.9 1	212.8	268.3 4	235.91	212.8	268.34
6	unnao	5	bareilly	235.9 1	212.8	268.3 4	235.91	212.8	268.34
7	panki	6	unnao	459.4 4	413.0 1	452.3	459.44	413.0 1	452.3
8	sultan pur	9	azam gar	123.1 4	138.8 9	164.0 2	123.14	138.8 9	164.02
9	azam gar	10	mau	248.0 2	244.3 8	256.1 2	248.02	244.3 8	256.12
9	azam gar	11	sarnath	39.84	36.64	28.21	39.84	36.64	28.21
11	sarnath	10	mau	279.9 3	279.1 2	279.7	279.93	279.1 2	279.7

Fault Data - Generators							
Number	Name	Phase Cur A	Phase Cur B	Phase Cur C	Phase Ang A	Phase Ang B	Phase Ang C
1	Muradabad	1155.13	1169	1086.56	-155.54	80.2	-38.32
11	sarnath	900.92	898.25	899.47	171.4	51.39	-68.46
2	Muradnagar	980.12	987.49	949.28	-179.94	57.75	-61.48
3	agra	1337.7	1316.69	1318.26	-142.75	96.8	-22.19
4	lucknow	721.7	714.19	691.25	-165.81	71.75	-46.48
5	bareilly	363.47	348.23	344.19	175.24	53.03	-63.64
6	unnao	537.63	522.39	512.46	-165.57	72.23	-45.18
8	sultan p	649.66	642.8	636.62	-175.58	63.43	-55.54
9	azam gar	713.71	710.65	709.39	162	41.74	-77.92

Fault Data - Loads					
Number	Name	ID	Phase Cur A	Phase Cur B	Phase Cur C
1	Muradabad	1	303.11	124.54	237.15
1	Muradabad	2	613.43	252.04	479.94
2	Muradnagar	1	1010.36	727.96	902.84
3	agra	1	721.69	679.44	794.02
4	lucknow	1	663.95	525.23	642.57
5	Bareilly	1	793.86	714.6	825.21
7	panki	1	893.41	704.03	856.41
8	sultanpur	1	620.65	574.66	626.53
9	azamgarh	1	627.87	617.28	636.61
10	mau	1	527.41	523.37	535.6
11	sarnath	1	599	599.8	608.95

VII. CONCLUSION

In this paper simulation of a power system which is suitable for fault studies has been presented. The performance of the system depends upon the generation, loads, type of faults, and connectivity among the buses. The result shows different values of voltages, currents, angles of different elements.

REFERENCE

- [1]. Nasser, D. Tleis, "Power Systems Modelling and Fault Analysis Theory and Practice", 1st ed, Elsevier Ltd., a. Burlington, USA, 2008.
- [2]. Mathworks Inc., "The Language of Technical Computing MATLAB User Guide Version 6.5", Release 13 of Matlab 6.5, The MathWorks, Inc, Copyright 2002.
- [3]. O.I. Elgerd, "Electrical Energy System Theory", Tata Mc. Graw Hill.
- [4]. Leon K. Kirchmayer, "Economic Operation Of Power Systems", Wiley Eastern Ltd.
- [5]. Rakosh Das Bagmudre, "Extra High Voltage AC Transmission Engineering", Wiley Eastern Ltd.
- [6]. G. W. Stagg and A.H. El-Abiad, "Computer Methods in Power System Analysis", Mc Graw Hill.

