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Monte Carlo Simulation of Load Flow Analysis of Power System

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Abstract—.Monte Carlo simulation is a computerized practice of mathematics that enables individuals to consider the threat in quantitative study and decision building. This technique is used by specialists in such various areas like finance, project supervision, energy, manufacturing, engineering, research and development, insurance, oil and gas, transport and the environment. In power system, existing systems are always required to be modified in order to meet the growing load densities. Power flow studies are required. Power flow study has great importance in planning during the expansion of power system as well as for determining the best operational conditions. This study involves information related to real power, reactive power, angle and voltage on each bus. Monte Carlo simulation provides a conclusion with a range of possible results and the probability of happening for choice of anything that could happen. This shows the extreme options and the most conventional solutions at the same time with all the possible significances for focus solutions. In this research, probability of the states of the generators are calculated for IEEE – 30 bus system for load transferring and forecasting based on reserve capacity of generators. Simulation environment is created in Matlab. Different characteristics curves are plotted for decision building and understanding relationships between key parameters of power systems.

Index Terms— Monte Carlo simulation, load flow analysis, IEEE-30 bus system, Matlab

1 Introduction

Monte Carlo simulation is a computerized practice of mathematics that enables individuals to consider the threat in quantitative study and decision building. This technique used by specialists in such various areas like finance, project supervision, energy, manufacturing, engineering, research and development, insurance, oil and gas, transport and the environment [3] [4] [5] [6].

In power system, existing systems are always required to be modified in order to meet the growing load densities. Power flow studies are required. Power flow studies have great importance in planning during the expansion of power system as well as for determining the best operational conditions. It includes information related to real power, reactive power, voltage and angle on each bus. These four parameters are the key parameters required for the analysis of power system [1] [2].

In this research, states of the generators are generated. Capacity of generator is each state, possible load according to generation and then reserve capacity of generator are calculated in each state of the generator. All these calculation are utilized to turn on/ off new generator for growing load demands. Characteristics curves are drawn to evaluate the performance of Monte Carlo's simulation on load flow analysis of power system.

In this research paper, Section I consists of introduction of Monte Carlo simulation and load flow analysis. Section II consists of model development and analysis. Simulation results and their explanation are presented in Section IV. Section V consists of conclusion.

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2 Model Development and Analysis

Model development and analysis consists of following steps.

- Generation of random states of generators
- Explanation of states

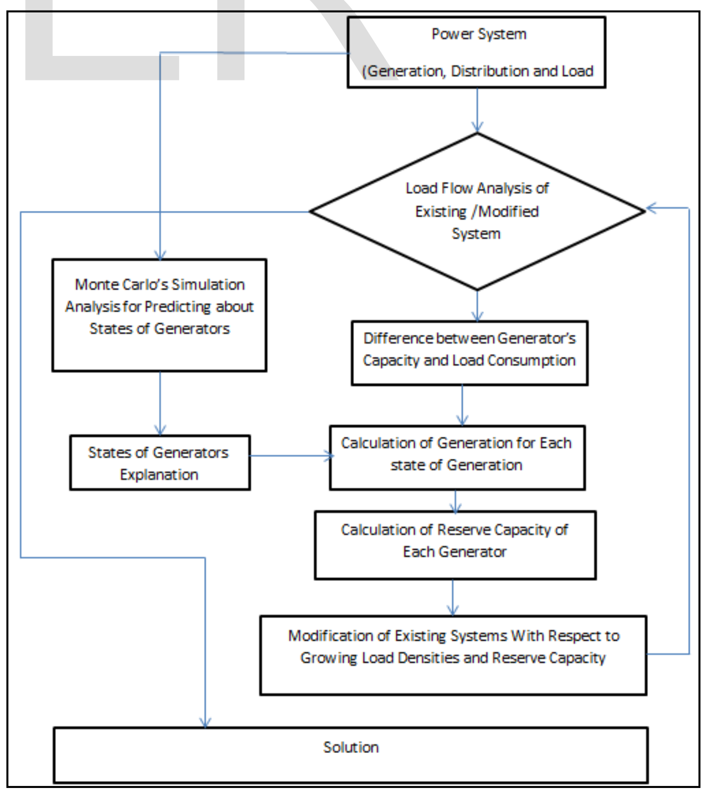

Fig. 1. Flow chart of proposed algorithm for Monte Carlo simulation of load flow in power systems

- Evaluation of States

- Evaluation of Generation Capacity
- Evaluation of Reserve Capacity of Generators
- Load Transferring and Increasing Algorithm
- Load flow analysis

Proposed model algorithm is given in figure number 1.

2.1 Generation of Random States of Generators

A lot of probabilistic techniques were developed previously. In this research, Monte Carlo's simulation technique is used for quantitative analysis of generators and decision building. Monte Carlo technique uses recursive function to generate random number. This technique is used because of following objectives.

- It should be fast enough
- It is portable to other computer
- It should have enough long cycle
- It should be replicable
- It should close enough to the ideal statistical properties of uniformity and independence.

On line condition and state monitoring can be achieved by fulfilling these objectives.

TABLE 1
States of the Power System with respect to the Loaded and No Loaded Generators

States	Generator 1	Generator 2	Generator 3	Generator 4	Generator 5	Generator 6
0	0	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	0	0	1	1
4	0	0	0	1	0	0
. . . .						
62	1	1	1	1	1	0
63	1	1	1	1	1	1

2.2 Explanation of States

In this research, six generators are added to feed the load of power systems. All the possible states of the generators are generated. In this system, there are sixty four possible states of the system. The generator with state 0 is assumed to be on with no load condition. The generator with state1 is assumed to be on with loaded conditions. For example in state two, there are two loaded generators that are generator 4 and generator 5. In state sixty three, there are five loaded generators that are generator 1, generator 2, generator 3, generator 4 and generator 5. State one means that there is no load in the system. State 64 means that there is no no-load generator. These explanations help us to make an effective and rapid load management plan so that loads could be met with in the acceptable criteria set by a supply company.

2.3 Evaluation of Generation Capacity

In this step, generation capacity/ consumption are calculated. This information is utilized for load management and load transferring. Load can only be transferred to a particular generator, if it is loaded with in acceptable limits and if it is running at no load.

2.4 Evaluation of Reserve Capacity of Generation

In this step, reserve capacity of generator is calculated. Reserve capacity is actually the difference between maximum capacity of generator and rated load on a generator over a specific period of time. This is actually required for load increasing and load transferring possibilities. This is also required for shut down of generator if its reserve capacity is very large that generation cost is exceeding the acceptable limits prescribed by Generation Company. This step is required for evaluation of efficiency of the existing power system.

2.5 Load Transferring and Increasing Algorithm

In this step, load is transferred or increased with respect to reserve capacity and generation capacity of generators. A generator with less reserve capacity is preferred for load adding instead of adding load on a no load generator.

2.6 Load Flow Analysis

In this step, load flow analysis of existing and modified power system is done so that condition and state of power system could be addressed. This is done on the basis of probabilistic states of generators so that load management could be done efficiently, load transferring and growing loads could be meet effectively. Load management, load transferring and meeting growing load demands are evaluated on the basis of values of voltage and power losses.

3 Simulation Analysis

Simulation Analysis is carried out in Matlab Environment. Proposed algorithm is carried out on IEEE – 30 bus system. Voltage graphs with respect to number of buses of the system are plotted for different states of power systems. It is evident from the figure 2 and table 2 that voltages are stable or nearly stable throughout the system which depicts that irrespective of the states of power systems, this Monte Carlo's based algorithm makes us possible to efficiently manage the load so that voltages could be maintained. Load is efficiently transferred to the generator having reserve capacity so that high load growth demands are meeting successfully with the minimum generators on load.

TABLE 2
This table shows per unit voltage values at different buses in different states of power systems.

Bus Number	State 1	State 2	State 3	State 4	State 5	State 6
1	1.06	1.06	1.06	1.06	1.06	1.06
2	1.043	1.043	1.043	1.043	1.043	1.043
3	1.0333	1.0333	1.0333	1.0333	1.0333	1.0333

4	1.0268	1.0269	1.0269	1.0269	1.0269	1.0269
5	1.01	1.01	1.01	1.01	1.01	1.01
6	1.0221	1.0221	1.0221	1.0221	1.0221	1.0221
7	1.0128	1.0128	1.0128	1.0128	1.0128	1.0128
8	1.01	1.01	1.01	1.01	1.01	1.01
9	1.06	1.06	1.06	1.06	1.06	1.0601
10	1.0563	1.0563	1.0563	1.0563	1.0563	1.0563
11	1.082	1.082	1.082	1.082	1.082	1.082
12	1.0641	1.0642	1.0641	1.0641	1.0641	1.0642
13	1.071	1.071	1.071	1.071	1.071	1.071
14	1.0576	1.0576	1.0576	1.0576	1.0576	1.0577
15	1.0553	1.0554	1.0553	1.0554	1.0554	1.0554
16	1.0569	1.0569	1.0569	1.0569	1.0569	1.0569
17	1.0532	1.0532	1.0532	1.0532	1.0532	1.0533
18	1.0507	1.0508	1.0507	1.0508	1.0508	1.0508
19	1.0491	1.0492	1.0491	1.0492	1.0492	1.0492
20	1.0505	1.0506	1.0505	1.0506	1.0506	1.0506
21	1.0487	1.0488	1.0487	1.0488	1.0488	1.0488
22	1.0517	1.0517	1.0517	1.0517	1.0517	1.0518
23	1.0489	1.0489	1.0489	1.0489	1.0489	1.0489
24	1.0461	1.0462	1.0462	1.0462	1.0462	1.0462
25	1.0402	1.0404	1.0404	1.0404	1.0404	1.0404
26	1.0314	1.0317	1.0318	1.0317	1.0317	1.0318
27	1.0415	1.0416	1.0416	1.0416	1.0416	1.0416
28	1.0217	1.0217	1.0217	1.0217	1.0217	1.0218
29	1.0355	1.0356	1.0357	1.0357	1.0357	1.0357
30	1.0332	1.0332	1.0334	1.0334	1.0334	1.0334

In figure number 1, state 1 of the power system is plotted. Only generator 6 is required to meet the load demand. Per unit values of voltages are plotted against the number of buses of power system.

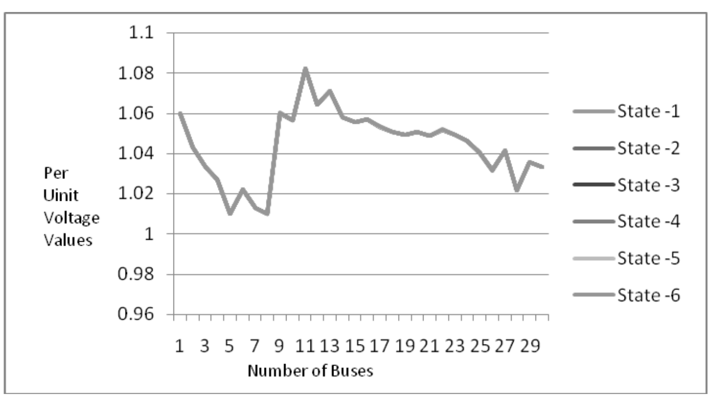

Fig.2. This graph shows the relationship between per unit voltage values and buses. It seems from the graph that voltage remains constant to ensure stability at different states of power systems.

Table 3 and figure 3 clearly depicts that efficiently transmission and distribution is achieved by effective load management with Monte Carlo's proposed algorithm. Losses are very much under controlled with small variations.

TABLE 3
This table shows the power losses at different branches and at different states of power systems.

Number of Branches	State - 1	State - 2	State - 3	State - 4	State - 5	State - 6
1	0.4584	0.4671	0.4657	0.4723	0.4666	0.4711
2	0.1529	0.1555	0.1551	0.1571	0.1553	0.1568
3	0.0458	0.0452	0.0453	0.0449	0.0453	0.0449
4	0.0514	0.0523	0.052	0.0527	0.0522	0.0525
5	0.1275	0.1279	0.1279	0.1281	0.1279	0.128
6	0.0738	0.0735	0.0736	0.0734	0.0735	0.0734
7	0.0189	0.0192	0.0192	0.0195	0.0193	0.0194
8	0.0037	0.0036	0.0036	0.0036	0.0036	0.0036
9	0.0359	0.0359	0.0359	0.0358	0.0359	0.0358
10	0.0992	0.1	0.0998	0.1005	0.1	0.1004
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0.0074	0.0073	0.0073	0.0073	0.0073	0.0073
18	0.0286	0.0286	0.0286	0.0286	0.0286	0.0286
19	0.0121	0.0121	0.0121	0.0121	0.0121	0.0121
20	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
21	0.0029	0.0029	0.0029	0.0029	0.0029	0.0029
22	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045
23	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
24	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
25	0.007	0.007	0.007	0.007	0.007	0.007
26	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043
27	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349
28	0.006	0.006	0.006	0.0059	0.006	0.006
29	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
30	0.0095	0.0095	0.0095	0.0096	0.0095	0.0095
31	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
32	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
33	0.0046	0.0045	0.0044	0.0044	0.0044	0.0045
34	0.0127	0.0127	0.0127	0.0126	0.0127	0.0126

35	0.0009	0.001	0.0009	0.001	0.0009	0.001
36	0	0	0	0	0	0
37	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042
38	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057
39	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
40	0.0214	0.0215	0.0215	0.0217	0.0216	0.0216
41	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

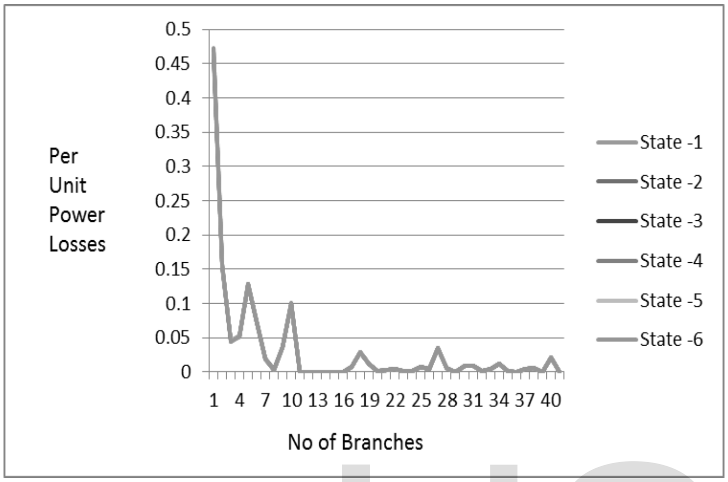

Fig.3. This figure shows the values of power losses at different branches. It seems from the graph that in majority of the branches, losses are almost negligible and it ensures the efficient transmission of power at different states of the power system.

4 Conclusion

In this research, Monte Carlo's simulation based power or load flow analysis of power system is carried out. It is quite obvious from the graphs that random states of the power system are effectively run by successful load management with the consideration of reserve capacity of generators installed to meet the power demands. Not only the power losses are under-controlled but also voltage values are maintained. This technique will definitely helpful for load management during critical load periods with in the acceptable criteria for supply companies and consumers and within allowable cost/benefit ratio.

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References

[1] John J. Grainger and William D. Stevenson, "Power System Analysis", New York: Mc- Graw Hill, 1994

[2] Hadi Saadat, "Power System Analysis", New York: Mc- Graw Hill, 2011

[3] H. Haroonabadi and M.R. Haghifam. "Generation Reliability Assessment in Power Markets Using Monte Carlo Simulation and Intelligent Systems", World Applied Sciences Journal, 302-310, 2008

[4] Mini Thomas, Rakeshranjan, Roma Raina. "Load Flow Solution for Unbalanced Radial Power Distribution using Monte-Carlo Simulation" , WSEAS Transaction on Power Systems, 24-30, 2014

[5] I.Rose, D.R. Bones, M. Pimentel. "Monte Carlo simulation and its application in modelling electricity market behaviour", Australian Journal of Electrical and Electronics Engineering, 199-208, 2005

[6] C. Prasanna Kumari, A. Hema Sekhar. "Calculation of Available Transmission Capability Based on Monte Carlo Simulation", International Journal of Engineering Research and Applications (IJERA), 1254-1260, July - August 2012