International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.6., 2015
(Nov.-Dec.,)

RESEARCH ARTICLE

ISSN: 2321-7758

EVALUATION OF COMPOSITE POWER SYSTEM RELIABILITY INDICES

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ABSTRACT

The reliability evaluation of the power system is gaining importance as there is a need to provide a continuous supply of electrical energy to the consumers with acceptable value of voltages. In the past, emphasis was laid on the reliability evaluation of the generating systems only. This was because of the huge investment in such systems; however, nowadays the trend is to evaluate both the generating and transmitting systems. Such a system which takes into account both the generation and transmission system is known as the composite system. In this paper, an algorithm is proposed for evaluating the indices of reliability for a composite system. Then the results are obtained by using the algorithm developed with the help of PSO.

Keywords— Power system reliability, Reliability evaluation, Reliability indices, Loss of Load Probability, Expected Load Loss.

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I. INTRODUCTION

The main task of a power system is to fulfill the demands of the customers by remaining in the economic limits for reliability as well quality [1] and for satisfying this condition, the system should remain operational [2].The most important consideration that need to be taken care of while designing a power system is to determine whether the generation is adequate to meet the requirements of customers or not. Another important consideration is to ensure a suitable transmission network for transmitting the generated electrical energy to load points [3]. The network used for transmission is further divided into two parts: the bulk transmission facilities and the distribution facilities. These two areas do not differ only in the level of voltages but also differ on the basis of their function in the system. The transmission facility or system is required to move the generated energy from the generating systems to such points through which the distribution facilities are required to provide a direct and radial path for this energy to reach the customers. The process of designing the distribution system does not depend on the transmission facilities. However, the transmission network must be carefully matched with the generation facilities in order to ensure a continuous supply to the customers.

Apart from the function of moving the energy that has been generated at the generating stations to the terminal stations, the transmission system must ensure adequate voltage level within the system and maintain the system within the limits of stability. The system which takes into account both the generation and transmission facilities is called as the composite system .The evaluation of the composite system takes into account both the static and dynamic conditions of the system. The evaluation of the static conditions of the system is mainly concerned with the ability of the system to meet the load requirements is termed as the adequacy evaluation. On the other hand, the evaluation of the dynamic conditions of the system concerns to the ability of the system to respond when subjected to a contingency is termed as the security evaluation of the system.

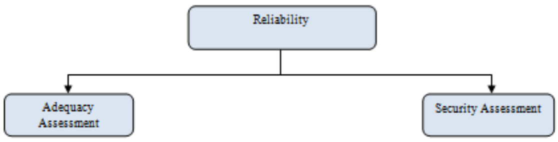

Figure 1. Classification of System Reliability

The entire problem which focuses on the assessment of the adequacy of the generating system and the transmission system so as to provide a suitable supply for the customers can be treated as the composite system reliability evaluation.

II. FUNCTIONAL ZONES OF POWER SYSTEM

The power system as a whole cannot be analyzed for the evaluation of reliability as it's a complex problem. Thus, the entire power system can be divided into three zones based on the function which they perform. These zones are generation, transmission and distribution zones. All these zones are then combined so as to form the hierarchical levels of the power system.

When the reliability is evaluated only for the generating systems, it is termed as the reliability assessment of Hierarchical Level-I (HL-I). The assessment of HL-I evaluates the generating capacity of the system in addition to the interconnected assistance. This evaluation predicts whether the system can meet the load demands or not. The evaluation performed at HL-I is called as reliability evaluation of the generating capacity. For evaluating HL-I, the transmission system as well as the distribution facilities are not taken into consideration.

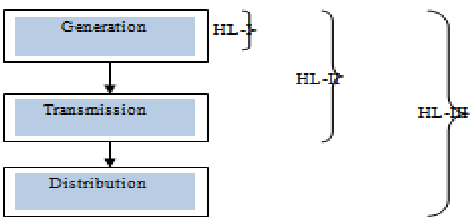

Figure 2. Division of Functional levels [4]

The adequacy evaluation at Hierarchical Level- II (HL-II) takes into account both the generation systems and the transmission facilities. This evaluation is carried out for assessing the ability of system to deliver power to the bulk load points. This evaluation is done for the assessment of adequacy of the existing power system. The evaluation at HL-II is also termed as the reliability evaluation of bulk power systems. A composite power system can be further divide into a number of operating states regarding the capacity which is available for fulfilling demands subjected to the condition that the security limits such as voltage limit and the line flows are satisfied [5].

The evaluation which is performed at Hierarchical Level-III (HL-III) relates to the overall evaluation of the system. This evaluation takes into account all the functional zones that are present in the power system. The evaluation at HL-III is the most complex problem. This evaluation is initiated at the generating stations and terminates at the load points.

III. LITERATURE SURVEY

Mohammed Benidris et.al [6] proposed a novel technique to evaluate composite system reliability indices using dynamically directed Binary Particle Swarm Optimization (BPSO). A key point in using BPSO in power system reliability evaluation lies in selecting the weighting factors associated with the objective function. . The method presented in this paper is not only easy to implement, but it does not use trial and error process, which have been traditionally adapted in PSO based reliability evaluation studies. The reliability indices used for this study have been selected as the loss of load probability LOLP and the loss of load expectation LOLE.

Mohammed Benidris et.al [7] proposed a technique to reduce the search space in evaluating the sensitivity of the well known reliability indices of power systems with respect to component parameters and system operating limits. The failure states in the unclassified subspace were discovered using binary Particle Swarm Optimization, PSO, technique. From the definite failure subspace and the failure states that are discovered by the binary PSO, the sensitivity of the reliability indices were calculated. This method was applied on the IEEE RTS and the results have proven the validity of this approach and show the significant reduction in the computational time.

Tanay Lakshman has proposed a method for carrying out the evaluation of reliability for a composite system. It takes into account both the generation and transmission facilities to meet the load demands. In this work [8], a technique has been proposed and a program, has been developed for the calculation of the system reliability indices of a power system with respect to aging failure. In this system, the reliability indices are calculated by considering a RBTS system with 6 buses. The total system capacity accounts for 240 MW. By applying the proposed technique, the reliability indices are found which have been shown to be quite reliable.

IV. PROPOSED WORK

The Particle Swarm Optimization can be regarded as an approach for solving the problems' the solution of which can be presented in the form of a point in the solution space which is n dimensional. In this technique, a large number of particles are set randomly in motion in this space. For every iteration, the fitness of the particles as well as their neighbors is observed and successful emulation of the neighbors is performed by means of moving towards them.

The steps involved in the stability calculation are:

1. Gird parameters of the load distribution
2. Load loss estimation
3. Expected output of the individual grids
4. Expected load loss probability
5. The number of observed functioning days for the grid
6. Probability of failure
7. Total load loss probability

PSO learns from the above given parameters and uses them to solve the optimization of grid stability rate calculation.

The initialization of the PSO is done with the help of some random particles and then the optima is achieved by means of updating the generations. For each iteration, every particle gets updated by the following two best values. The first value represents the best solution or fitness which has been achieved so far. PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far and is referred to as "pbest". The second value is another best value which is tracked down by the optimizer and it is obtained by a particle in the population. This value represents the global best value and is called "gbest". In a case when the particle acts as a topological neighbor in the population, the best value is the local best and is known as "lbest".

V. RESULTS

Table 1. Capacity Outage Probability Table

UNITS	CAPACITY OUT	CAPACITY IN	PROBABILITY	CUMULATIVE PROBABILITY
0	0	450	0.9412	1
1	150	300	0.0576	0.0588
2	300	150	0.0012	0.0012
3	450	0	8.0000e-06	8.0000e-06

Table 2. Expected Load Loss

UNITS	CAPACITY OUT	CAPACITY IN	LOAD LOSS	PROBABILITY	L_i X P_i
0	0	450	0	0.9412	0
1	150	300	52	0.0576	2.9964
2	300	150	202	0.0012	0.2376
3	450	0	352	8.0000e-06	0.0028

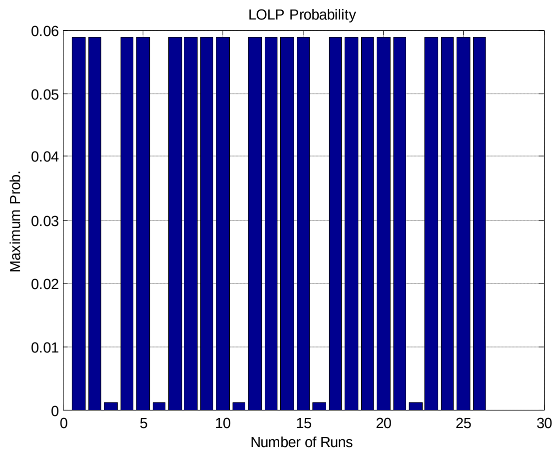

Figure 3. Calculation of LOLP

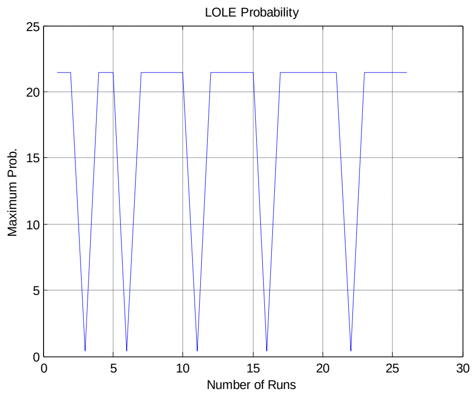

Figure 4. Calculation of LOLE

VI. CONCLUSION

The reliability evaluation for a composite system forms a very important part of the reliability study. However, this aspect of power system has not achieved much attention till date. The evaluation of such a system is a very complicated problem. But with the increasing needs of a reliable system power system, this study is getting more and more importance. The present work calculates the reliability indices including LOLP, LOLE and EDNS and then with the help of PSO the system reliability is assessed.

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