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REVIEW ARTICLE

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A REVIEW OF COMPOSITE SYSTEM RELIABILTY EVALUATION

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ABSTRACT

Reliability deals with the capability of a system to survive. The evolution of new technologies has led to an increase in the expectations of customers in the last few years. As a result of these technological evolutions, the customers are expecting alot from their suppliers. Some of the expectations include products with lower costs and higher quality and improved customer support. In order to survive under such conditions, the supplier should meet these requirements. A supplier should constantly improve the quality of products; try to minimize the cost of the product and be responsive to the changing demands of the customers.

Reliability is the most important issue in the design and operation of electric power system. Thus, the reliability evaluation of combined generation and transmission system known as the composite system reliability evaluation has to be carried out.

Keywords— Power system reliability, Reliability evaluation, Reliability indices.

I. INTRODUCTION

The basic function of an electric power system is to meet the requirements of its customers and to provide acceptable levels of quality and continuity of supply[1]. The generation and transmission systems receive considerably more attention in terms of reliability planning as compared to the distribution systems. The main reason behind this is that the generation and transmission systems are very capital intensive and outages in these systems can have widespread catastrophic economic consequences[2].

An electric power system comprises generation, transmission and distribution. It is also necessary to ensure a reasonable balance in the reliability of these various constituent parts [3].

In the past the criteria and techniques which were used for reliability assessment were deterministic in nature. The drawback of those techniques was that they did not take into account the probabilistic or stochastic nature of system behavior and component failure. However, the probabaility theory alone cannot predict the reliability of the system.It acta as a tool in the hands of an engineer to transform his knowledge of the system for the prediction of future behavior of the system[4].

The composite system reliability evaluation involves the determination of reliability indices of a power system giving consideration not only to changes in generation levels but also to the transmission line capacities and outages[5].

The reliability of a system is further categorized into adequacy assessment and security assessment as shown in figure 1[6]. Adequacy assessment deals with the existence of sufficient facilities to meet the customer demands. These facilities include those required to generate the required amount of electrical energy and those which are used to transmit this power to the consumers. Adequacy deals with the static conditions of the system; it does not take into account the effect of system disturbances. Security assessment on the other hand deals with the response of a system under disturbances. It takes into account the response of a system under disturbance. Adequacy evaluation of a system is a mid or long term problem, whereas security assessment is a short term problem. In the adequacy assessment of a system, the dynamic behavior of system components is not considered and thus, static models are applied in the system studies [7].

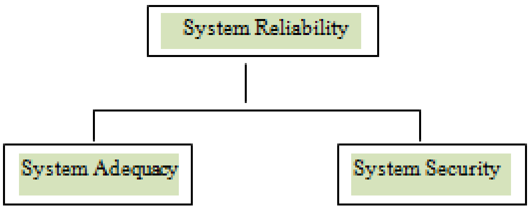

Figure 1. Classification of System Reliability

II. RELIABILITY

Reliability is generally defined as" The probability with which a specific function is performed without failure under a given set of conditions for a period of time". This definition of reliability highlights the five main elements on which it depends:

1) Probability: Reliability is a probability i.e a probability of performing a function without any failure, thus, it is a number between 0 & 1.
2) Failure: The function to be performed must be clearly specified in advance. It should be clear before testing the system under observation. For example: if a pump is supposed to deliver 100 gallons of fluid per minute but now it is delivering only 20 gallons of fluid per minute, the pump is said to be failed.
3) Function: the system whose reliability is to be evaluated must perform a specific function.
4) Conditions: The conditions under which the device should operate must be specified in advance. For example: if we are building a cylinder that is designed to be used in temp of 0-100 ^{0}F and such a cylinder is brought to Alaska and it fails to operate in the winter, it could not be charged as a failure.
5) Time: T he system is supposed to operate for a specified time. If the time of observation is not specified we cannot cite a reliability figure to the system.

III. FUNCTIONAL ZONES AND HIERARCHICAL LEVELS

The power system as a whole cannot be analysed as a single entity because it is very difficult to do so. Thus, power system reliability can be divided into three functional ones namely: generation, transmission and distribution. These ones are then combined to create three hierarchical levels as shown in figure2 [8].

Reliability assessment at Hierarchical level-I (HL-I) is concerned with the generation facilities only. In HL-I assessment, the total generation of the system including interconnected assistance is evaluated. This is done in order to determine the ability of the system to meet the total load demand of system. The assessment at HL-I is referred to sa the generating capacity reliability evaluation. In the HL-I assessment, the transmission and the distribution facilities are not included.

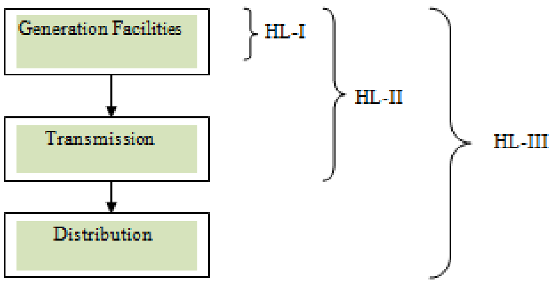

Figure 2. Division of Functinal levels [8]

Adequacy assessment at Hierarchical level –II (HL-II) comprises of both the generation and transmission facilities in order to assess the ability of a composite system which will deliver energy to bulk loads. The HL-II studies are carried out to assess the adequacy of a proposed or existing system. This study at HL-II is generally termed as composite system reliability evaluation. It is also known as bulk power system reliability evaluation. This is done in order to assess a system's ability to meet the real and reactive power requirements at each and every major load point to be within acceptable voltage levels. In this level of evaluation, the reliability of both the generating sources and transmission facilities is evaluated and is sometimes called as bulk system analysis.

The evaluation at Hierarchical level-III (HL-III) is the overall assessment of the system which includes all the three functional ones. The evaluation at HL-III is very complex as it initiates at the generating points and ends at the individual load points.

IV. COMPOSITE SYSTEM RELIABILITY EVALUATION

Figure 3 shows a simple network configuration of the system. However in a more practical case, there exists a number of load points; each of these points possessing a different set of reliability indices. The probability of failure and its frequency at individual load points are the basic parameters; however additional indices can also be evaluated.

The system indices can be obtained by aggregating the individual load point indices. These system indices include the considerations to be taken in generation adequacy as well as the need of moving the energy generated by means of transmission network to the load points. Table 1 shows a list of load point indices that can be used.

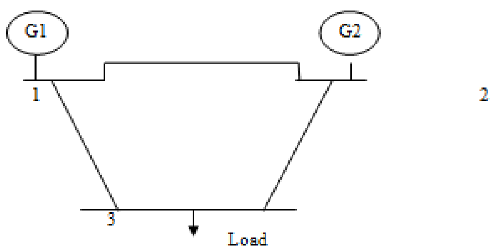

Figure 3. Simple network configuration

V. RELIABILITY INDICES

Table 1. Reliability Indices

Basic values:
Probability of failure
Expected frequency of failure
Expected number of voltage violations
Expected number of load curtailments
Expected load curtailed
Expected energy not supplied
Expected duration of load curtailment
Maximum values:
Maximum load curtailed
Maximum energy curtailed
Maximum energy curtailed
Maximum duration of load curtailment
Average values:
Average load curtailed
Average energy not supplied
Average duration of curtailment
Bus isolation values:
Expected number of curtailments
Expected load curtailed
Expected energy not supplied
Expected duration of load curtailment

It should be noted that if these indices are evaluated for a single load level and expressed on a one year base, they are designated as the annualized values. The annualized indices that are calculated at system peak level are usually higher than the actual annualized indices.

VI. DATA REQUIREMENTS FOR COMPOSITE SYSTEM RELIABILITY EVALUATION

The composite system reliability evaluation comprising of both the generation and bulk transmission system is a complex problem. The data required to analyse the problem of evaluating the composite system reliability can be divided as: deterministic and the stochastic data as shown in figure 4.

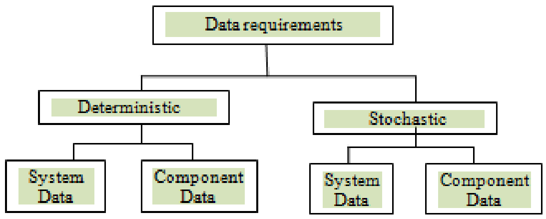

Figure 4. Data requirements for reliability evaluation

Deterministic data

The deterministic data is required to be included at both the system and the component level. The system data requirements are difficult to include as it takes into account system response when the system is working under outage conditions. The data at the actual component level comprises of the parameters as impedances and susceptances of the line, current carrying capacity of components, and some other factors as are required to carry out the conventional load flow studies.

The deterministic data is very important in the reliability study of a composite system. The proposed model must behave in a similar manner as the actual system; otherwise the results would not be the same or appropriate.

Stochastic data

The stochastic data required for carrying out the composite system reliability evaluation comprises of the system and component data. The component data required includes parameters like failure and repair rates of each and every element in the system. This data is easy to obtain and is available all the time. In the stochastic data requirements, there is a need to include events which are supposed to involve two or more components at the same time. This type of data is specific for a system. System data comprises of multiple failures that result from the common transmission line configurations as well as station-induced effects.

VII. CONCLUSION

The composite system reliability evaluation is a part of power system reliability studies which is not much developed till date. It also forms the most complicated part of the power system based reliability studies. But because of the ecological and economical constraints existing in the power utilities, the composite system reliability evaluation is getting more and more importance day by day.

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