Mathematical and ANN Approach Outcomes in Hydro-Thermal Generation System

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ABSTRACT

Both Mathematical Model and ANN model for assessment of reliability of Generation System have been developed. The outcomes of one model supported the outcomes of another model. Illustration gave a satisfactory support and thus it could be possible to assess the reliability of generation system by both the approaches. The outcome of threshold value of reliability of generation system is an appreciable outcome of the work. The results of reliability of constituent parts of generation system have been plotted against time. Also, the threshold reliability of generation system could be determined by graphical solution.

This paper presents the mathematical model of reliability of individual components and equivalent reliability of entire generation system.

Keywords: Hydrothermal system, mathematical, ANN, networks, power, system.

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INTRODUCTION

The failure of Generation System leads to prolonged interruption period besides being uneconomical. Thus the reliable operation of Generation System needs a thorough care and periodic servicing of its constituent parts such as boiler, turbine, generator and circuit breaker. Our industries, agriculture and software companies require consistant and uninterrupted power supply for toing the needs of continuous customer demand.

It therefore drew the attention of researcher to determine the condition when reliability of generation system would be at stake. Further due to complexity of generation system, the determination of its reliability is filled with risk of skipping of some important factors which are responsible for loss of reliability. Thus, it needed a trusted and full proof model to deal with the reliability of Generation System.

In order to validate the result a model of ANN has been developed to obtain the reliability of Generation System. It could be found that the results obtained by two methods agree with each other. It is therefore possible to estimate the threshold value R_{Th} of equivalent reliability upto which the Generation System can be taken to be reliable. It however loses reliability beyond threshold value of equivalent reliability.

Proposed Problem

It is aimed to asses the reliability of consider a Generation System consisting of :

(a) Mechanical Unit which again consists of boiler and turbine.
(b) Electrical Unit which again consists of Generator and Circuit Beaker as shown in Fig.1.

(c) Obtain Mathematical model of equivalent reliability, Req of Mechanical and Electrical Units.
(d) Obtain validation of reliability assessment made by mathematical model by way of ANN model.

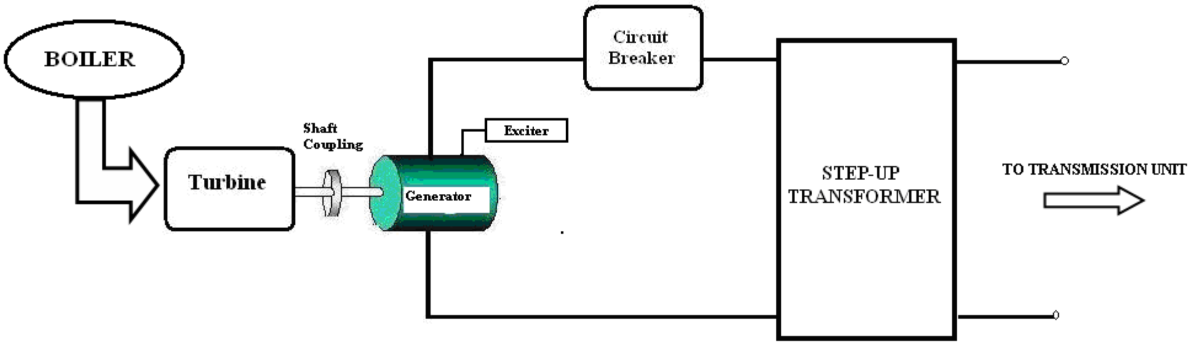

Fig. 1: Proposed Generation System Model

IMPORTANCE OF RELIABILITY

Reliability is, in a general sense, a measure of the ability of any system to perform its intended function without failure under certain conditions for a stated period of time. In the case of a generation system, reliability is usually defined in a quite different way. A Generation system is designed to perform its function for a relatively longer period of time. A Generation system can have failures at different points in the system at certain time, but these failures can always be repaired, and the system can be constantly developed to satisfy the changing demands and for improved the performance of its functionaries. It is therefore important for a power system to recognize and control the various possible system failures and to minimize the failure rate to provide uninterrupted power supply to the customers. Time of repair can be shortned by use of stand by systems.

The measurement of Generation system reliability includes the unavailability, the expected failure frequency and duration, and the expected magnitude of adverse effects on consumer service. System reliability evaluation is based on the data which make up the system. The collection of subsystem reliability data is therefore a fundamental task in system reliability evaluation.

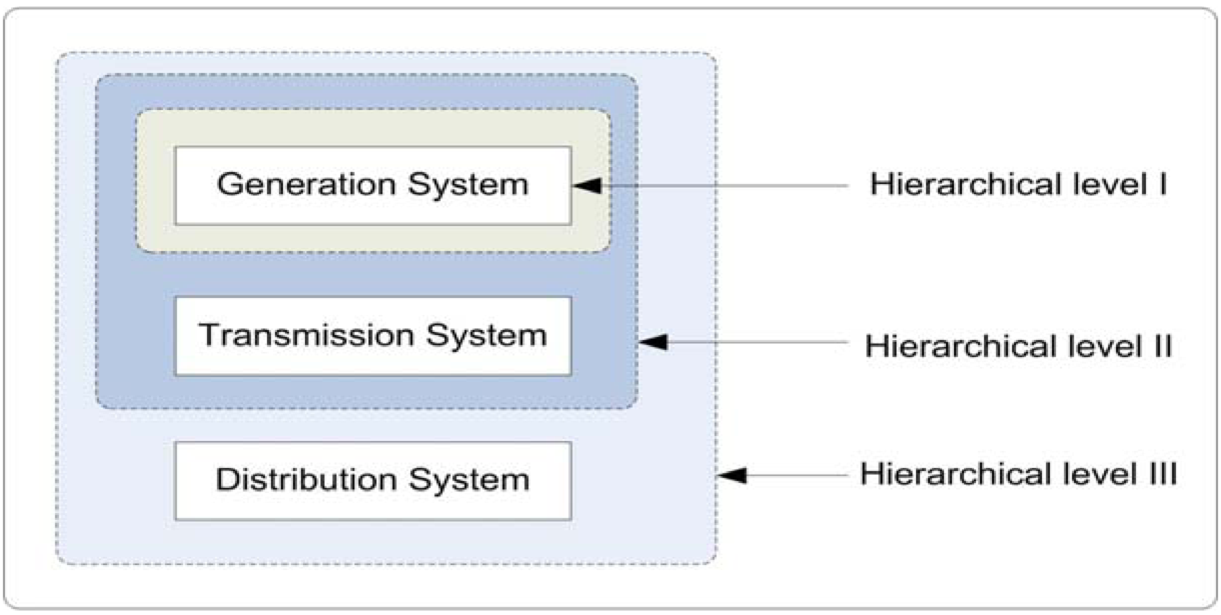

Fig. 2: Hierarchical levels of Power System for Reliability Analysis

METHODS OF RELIABILITY ASSESSMENTS

The methods used in reliability assessments of power systems determine the accuracy of the results. Analytical and simulation approaches are the two types of techniques used in power system reliability analysis. Each approach has its merits and limitations. In this section, the concepts, assumptions, and typical applications of the commonly used methods in both techniques are reviewed. The limitations of analytical approaches are summarized as the reason to select the Artificial Neural Network simulation to perform the reliability analysis in this study.

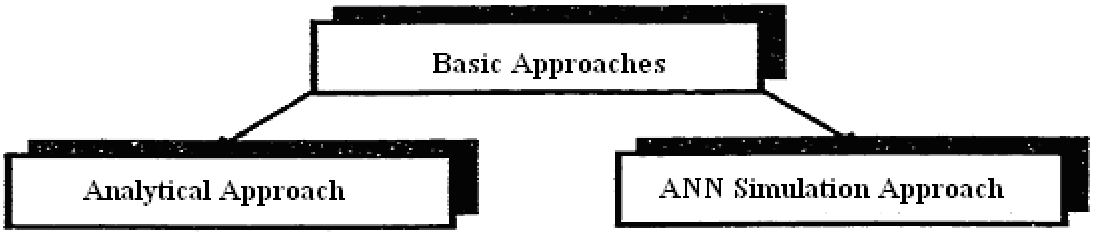

Fig.3: Two Fundamentally different Approaches

Analytical Approaches

The analytical analysis methods use mathematical models to provide solutions to a reliability problem. Specific calculation results are obtained for a given set of system topology and input values. Some widely used methods are block diagram, event tree, cut sets, fault tree, state enumeration, and Markov modeling. Using reliability sets in calculation is also proposed in recent years. The common problem is the frequent need to make simplifying assumptions and approximations.

Artificial Intelligence Approach

The above review demonstrates that present analytical reliability techniques are not capable of modeling a large number of real system characteristics. For those analytical methods utilizing parallel and series network calculating principles, there are many realistic systems not easily separated into small independent subsystems. All of the analytical methods that model detailed system states and/or enumerate among them have the common problem of system model size for large systems. Stiffness in calculation is also a problem when using traditional matrix methods. Additionally, using the Markov chains implies the events are memoryless, which often is not the case. Compared with analytical approaches, the simulation or Artificial Intelligence approach is more universal. A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships. Neural Networks are an information processing technique based on the way biological nervous systems, such as the brain, process information. They resemble the human brain in the following two ways:

1. A neural network acquires knowledge through learning.
2. A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights.

Neural networks are being applied to an increasing large number of real world problems. Their primary advantage is that they can solve problems that are too complex for conventional technologies; problems that do not have an algorithmic solution or for which an algorithmic solution is too complex to be defined. In general, neural networks are well suited to problems that people are good at solving, but for which computers generally are not. These problems include pattern recognition and forecasting, which requires the recognition of trends in data. The true power and advantage of neural networks lies in their ability to represent both linear and non-linear relationships and in their ability to learn these relationships directly from the data being modeled. Traditional linear models are simply inadequate when it comes to modeling data that contains non-linear characteristics.

RESULTS AND DISCUSSIONS

The mathematical model for determining the equivalent reliability, R_{eq} of Generation System, has been developed by eqn. reproduced as below:

$$R_{eq} = 1 - [\{1 + \exp(-\lambda_1 t) - \exp(-\lambda_2 t) + \exp(-\lambda_1 t).\exp(-\lambda_2 t)\} \times \{1 - \exp(-\lambda_3 t) + R_{SC} - \exp(-\lambda_3 t).R_{SC}\}] \times$$
$$\times [\{\exp(-\lambda_4 t) - R_E + \exp(-\lambda_4 t).R_E)\} \times \{1 - R_{CB}\}]$$

The reliability is basically a function of time and is dependent on rate of fall of water level , rate of failure of heating element, rate of failure of blade angle, rate of failure of generator winding as well as on different states of Exciter, Shaft Coupling and Circuit Breaker. When this mathematical model is tested for the reliability of individual parameters as well equivalent reliability R_{eq} , the results are as follows:

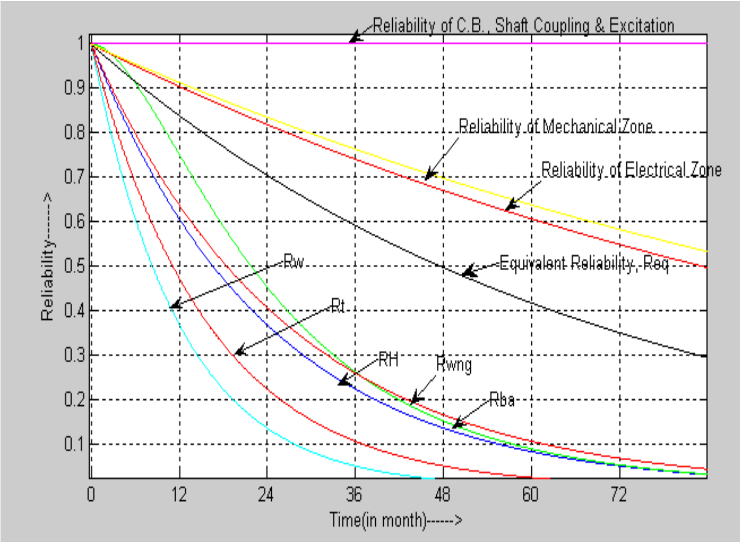

Fig.-4: Reliability of individual units as well as equivalent reliability, Req of Generation System

Testing Method of Artificial Neural Network

In order to test the reliability of Generation System on Artificial Neural Network (ANN) a proposed model has been developed, which has been trained as well as tested on MATLAB. The ANN developed model has been trained for seven inputs (i.e. Rw, RH, RSC, RBA, RWng, RE, RCB) and one output (i.e. Req). In order to obtain ANN model to test the reliability of Generation System, which is mainly affected by seven parameters. A proposed ANN model is required to be simulated. Thus, the ANN model which represents the dynamics of generation system its failure has been derived by trial and error method on the platform of MATLAB.

The data for equivalent reliability are given in Appendix A. Also , the data for ANN Model are given in Appendix B. Both the Mathematical and ANN models were tested for reliability and the results are shown in Fig.5.

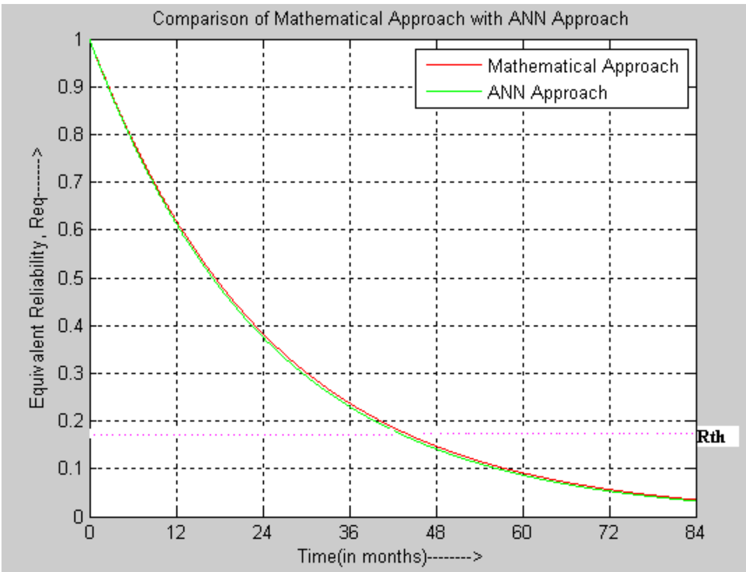

Fig. 5: Comparison of Mathematical Approach with ANN Approach

Note: For test results please refer Appendix A, B and C.

CONCLUSION

The reliability study was carried and it was found that it depends upon so many factors, individually and collectively. It is a function of time. The factors were also tested on Artificial Neural Network. After a through training about 300*7 data, the Artificial Neural Network also gave similar and Agreeable results for 50*7 testing data. The results of both the studies provided a good validation of reliability model.

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