ABSTRACT

Reliability has been developed within the framework of the theory of Stochastic Processes. It is concerned with the development of mathematical models to find the behavior of the system that provides service to randomly arising demands. Reliability is an important part of engineering design process and plays a vital role in life cycle analysis, cost benefit analysis, operational capability analysis, repair facility resourcing, etc. Reliability is defined as the probability that a given item or system will perform its intended function for a specified period of time under a given set of operating conditions. Repair in the system is a valuable aid because it facilitates the maximum utility of the components as desired.

A system of n components works (good) if and only if at least k of the n components work (good) is called a k-out-of-n: G system. A sensor measures some physical quantity and converts it into a signal which can be read by an observer or by an instrument. The ratio between output signal and measured property is known as the sensitivity of the sensor. Sensor nodes are the simplest devices in the network. Sensing and switching devices have got greater applications in reliability study. The purpose of introducing sensor is to detect the failure of the component in advance and hence to avoid the failure of the system for some extent. Thus, the reliability characteristics of the system can be improved. In this research work, different types of k-out-of-n: G systems with sensor are analyzed.

This research mainly deals with sensors which comprise a sensing device and switching device that convert a detected signal into an electrical signal. Whenever a component begins to fail, the sensor replaces that component with a standby component. Also, if the repair of any of the component is completed then, the sensor detects the completion of the repair and replaces the working component if necessary. Thus, the mean time to failure of the system is improved. The reliability of a repairable k-out-of-n: G system with n independently and identically distributed components and a sensor attached to the system is analyzed first. Thus, the repair and replacement of the component is through the sensor, for the perfect recovery of the system.

The cost effectiveness of the components of a system is a particular type of performance measure of the system. When the system effectiveness is analyzed, the system cost should be taken into consideration. Hence, the reliability and cost benefit analysis of a repairable k-out-of-n: G system with sensor is analyzed in the next section. When the components fail, they are sent to the repair facility and if the number of failed components exceeds the number of repairmen in the repair facility, then the failed components form a queue at the service station. Whenever the queue length of failed components exceeds a threshold value M, the additional sensor works. The additional sensor will send the failed components to the repair facility for additional repair. When this queue length is less than or equal to M, the additional repair will be dropped. A cost analysis is done in order to determine M the optimal threshold value, by considering the cost of each component.

A consecutive k-out-of-n:G system consists of a sequence of n ordered components along a line or a circle such that the system is good if and only if at least k consecutive components in the system are good. These systems are widely used in vacuum systems in accelerators, computer ring networks, systems from the field of integrated circuits etc. Each component in the system is classified as a key component or an ordinary component. When the system is in a working state, a working component is a key component if the system fails after the component fails; otherwise the working component is an ordinary component. If the system is in a failed state, then a failed component is a key component if the system will be working after completion of the repair on the component; otherwise, the failed component is an ordinary component. The system has one or more key components. If the system has failed, key components will have higher priority of repair than the ordinary components. Reliability characteristics of both linear and circular consecutive k-out-of-n: G systems with sensor are discussed in the succeeding section.

The study of sensor connected k-out-of-n: G systems with either all the failure can be repaired or the failures can lead to an absorbing state is done in the next section. The first model is the perfect fault coverage and second is imperfect fault coverage model. Each fault is repaired with a probability p in imperfect fault coverage model. The fault tolerant operations of the system, the state transition probabilities, the reliability and availability of the system both with perfect and imperfect fault coverage are obtained using transform techniques.

Standby technique is widely used to improve the reliability and availability of the system. In most of the reliability analysis, the components are assumed to be statistically identical and independent (i.i.d). In some cases the components have different failure and repair rates. Warm standby systems having two types of components and a sensor with multiple repairmen in repair facility are considered for the analysis in the next section. One category of the components is type-1 and the other category is type-2. Components of type-1 have lower failure rate than type-2 and the preference for repair is given for the type-1. A working model to illustrate the system is developed.

For all these studies the lifetimes of failure and repair of each component are exponential random variables and i.i.d. The sensing rate of each component is assumed as constant. The switchover time from one component to another is instantaneous. Numerical illustrations and graphical solutions are given for particular values of the parameters for each case to check the validity of the argument. A comparative study is given for the system with/ without repair and sensor for all the cases. The reliability, the steady state availability and the mean time to system failure using differential equation approach and Laplace transforms techniques are derived. This analysis presents a view that the reliability indices have an improvement by the introduction of sensor.