Chapter 10
Reliability Analysis of Two Dissimilar–Cold Standby Redundant Systems Subject to Inspection with Preventive Maintenance Using Copula

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ABSTRACT
The objective of this chapter is to study the system reliability through redundant component and additional preventive maintenance of operative and standby units. The considered system consists of two units in cold-standby, one is main unit and other is standby. The configuration of main unit is of 1-out-of-2: G whereas standby unit is of (n-1)-out-of-n: F and (n-2)-out-of-n: D nature. Main unit of the system has two modes viz. operable and failed and standby unit of the system has three modes viz. operable, degraded and failed. Both units after failure go for inspection where the type of the failure is detected and accordingly repairing action is decided. The failure and repair times follow exponential and general time distributions respectively. The system is studied by using the supplementary variable technique, Laplace transformation and Gumbel-Hougaard family of copula to obtain reliability, availability, downtime, busy period, M.T.T.F. and cost effectiveness of the system. At last some special cases of the system have been discussed.

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INTRODUCTION

Reliability is an important concept at the planning, designing, manufacturing and operation stages of product and systems ranging from simple to complex. Users expect that the product and system they purchase should be reliable. In practice, we come across with a number of systems consisting of one or more parts where failure of any of the parts results into the complete / partial failure of the system and as a result, the reliability of the system reduces. The better maintenance of such parts originate better reliability which helps in achieving the markets demands of reliability, functionality, price and performance of the system. A unit or system is composed of a number of components or elements and to make the system highly reliable we have to use reliable components. Sometimes either it is not possible to produce highly reliable components or the cost of producing such components is very high, thus introducing redundant parts, providing maintenance and repair at the time of need may achieve better degree of reliability. Also redundancy plays an important role in enhancing system reliability. One of the commonly used forms of the redundancy is the standby redundancy. Standby system often finds applications in various industrial and other setups. In a redundant system, some additional paths are created for the proper functioning of the system. If all the redundant parts start working together at the time of operation, then it is called parallel redundancy. A standby redundant system is the one in which one unit is followed by spare units called standbys. In general there are 3-types of standby i.e. hot, warm and cold. Hot standbys are those which are loaded in exactly the same way as the operating unit. Warm standbys have a diminished load and cold standbys are completely unloaded.

Several researchers like Lasanovsky (1982), Mokaddis and Tawfek (1996), Hatogama (1997), Agarwal et al. (2010), and Kumar and Singh (2016) have studied the reliability behavior of a two/three state system. Many other researchers: Gopalan and Nagarwalia (1985), and Said and EL-Sherbeny (2005) and Haggag (2009) have studied cost analysis of two-unit redundant systems with preventive maintenance assuming two/three states of operation. The purpose of the present chapter is to discuss the reliability characteristics of a two-dissimilar unit cold standby system with preventive maintenance subject to inspection after failure. In this chapter we consider a system which comprises of two unit cold standby system, one is main unit and other is standby unit. The main unit is of 1-out-of-2: G and standby unit is of (n-1)-out-of-n: F and (n-2)-out-of-n: D configurations. The main unit of the system has two modes viz. operable and failed and standby unit of the system has three modes viz. operable, degraded and failed. Two repairmen are involved in repairing of the system. The first repairman repairs the main unit and the second repairman repairs the standby unit. Here we consider two types of failures namely minor and major in main unit. A minor failure is that failure which can be repaired by first repairman and a major failure is that failure which cannot be repaired by first repairman. Thus if the major failure occurs in main unit then second repairman repairs the main unit. After failure, units go for inspection, where the type of the failure is detected and accordingly corrective action is decided. After repair, system becomes as good as new. Preventive maintenance is provided to the system at $S_0$. At $S_6$ and $S_{10}$ both the units are completely failed and being repaired with two different repair rates. The repairs from state $S_6$ to $S_0$ and $S_{10}$ to $S_0$ have two types namely exponential and general. Joint probability distribution of repair rate from $S_6$ to $S_0$ and $S_{10}$ to $S_0$ is computed by Gumbel-Hougaard family of copula. The system is studied by using the supplementary variable technique, Laplace transformation and Gumbel-Hougaard family of copula to obtain reliability, availability, downtime, busy period, M.T.T.F. and cost effectiveness of the system as done by Nelson (2006) and Ram and Singh (2010). At last some particular case pertaining to the system have been computed. System state description of the transition diagram is shown in Table.1.