COST-FUNCTION OF TWO-DISSIMILAR COLD STANDBY UNITS UNDER THE INFLUENCE OF ELECTRICAL FLUCTUATIONS AND HUMAN ERRORS

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Abstract- Studies on reliability systems are currently ever on the increase, not only dominating but undoubtedly accounting for a major part of the research out-put in the areas of stochastic processes and their applications, applied probability and operation research. A large number of papers on a two unit standby redundant systems have appeared because of the large number of parameters governing system behavior and the complex environment with uncertainties. In this paper we have taken CCFM (common cause failure mode) which is caused due to some human errors. When the main unit fails due to Electrical fluctuations then cold standby system becomes operative. Voltage fluctuations cannot occur simultaneously in both the units and after failure the unit undergoes very costly repair facility immediately. Applying the regenerative point technique with renewal process theory the various reliability parameters of interest and profit analysis have been evaluated.

Keywords- Cold Standby, Common Cause Failure, Electrical Fluctuations, First Come First Serve, MTSF, Availability, Busy Period, Cost-Benefit Analysis.

I. INTRODUCTION

The change in operating conditions viz fluctuations of voltage, corrosive atmosphere etc may make a system completely inoperative. Severe environmental conditions can make the actual mission duration longer than the ideal mission duration. In this paper we have taken CCFM (common cause failure mode) which is caused due to human error, and other failure due to electrical fluctuations such as voltage fluctuations. When the main operative unit fails due to electrical fluctuations then cold standby system becomes operative. Electrical fluctuations cannot occur simultaneously in both the units and after failure the unit undergoes repair facility of very high cost in case of failure due to electrical fluctuations immediately. Failure due to human error may be destructive. It may be due to repairman’s carelessness or he may be unskilled. The repair is done on the basis of first fail first repaired.

Assumptions

1. \(F_1(t)\) and \(F_2(t)\) are the failure time distributions due to human error and electrical fluctuations and repair is of two types -Type-I,Type-II with repair time distributions as \(G_1(t)\) and \(G_2(t)\) respectively.
2. The electrical fluctuations are non-instantaneous and it cannot come simultaneously in both the units.
3. Whenever the electrical fluctuations occur within specified limit of the unit, it works as normal as before. But as soon as there occur electrical fluctuations of magnitude beyond specified limit of the unit the operation of the unit stops automatically.
4. The repair starts immediately after the electrical fluctuations of beyond specified limit of the unit are over and works on the principle of first come first served basis.
5. The repair facility does no damage to the units and after repair units are as good as new.
6. The switches are perfect and instantaneous.
7. All random variables are mutually independent.
8. When both the units fail, we give priority to operative unit for repair.
9. The CCFM(common cause failure mode) Is due to some human errors.
10. Repairs are perfect and failure of a unit is detected immediately and perfectly.
11. The system is down when both the units are non-operative.

Symbols for states of the System

\(F_1(t)\) and \(F_2(t)\) are the failure rates due to electrical fluctuations and human errors respectively \(G_1(t), G_2(t)\) – repair time distribution due to Type-I, Type-II respectively Superscripts O, CS, ELF, CCFM Operative, Cold Standby, Electrical fluctuations, common cause failure mode due to human error respectively Subscripts nelf, elf, he, ur, wr, uR No electrical fluctuations, electrical fluctuations, human error, under repair, waiting for repair, under repair continued from previous state respectively

Up states – \(0, 1, 2\);
Down states – \(3, 4\);
regeneration point – \(0,1,2\)

Notations

\(M_i(t)\) System having started from state I is up at time t without visiting any other regenerative state
\(A_i(t)\) state is up state as instant t
\(R_i(t)\) System having started from state I is busy for repair at time t without visiting any other regenerative state.

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Let $M_i(t)$ be the probability of the system having started from state $i$ at time $t$ without making any other regenerative state belonging to $E$. By probabilistic arguments, we have

The value of $M_0(t), M_{-1}(t), M_{-2}(t)$ can be found easily. The point wise availability $A_i(t)$ have the following recursive relations

$$A_0(t) = M_0(t) + q_{01}(t) [c]A_1(t) + q_{02}(t) [c]A_2(t)$$
$$A_1(t) = M_1(t) + q_{10}(t) [c]A_0(t) + q_{11}(t) [c]A_1(t) + q_{12}(t) [c]A_2(t)$$
$$A_2(t) = M_2(t) + q_{20}(t) [c]A_0(t) + [q_{22}(t) (c) + q_{26}(t)] [c]A_2(t)$$

Taking Laplace Transform of eq. (7-9) and solving for $A_0(s)$ and $D_2(s)$ and $D_3(s)$.

$$A_0(s) = N_2(s)/D_2(s)$$

$$D_2(s) = \left(1 - \frac{q_{11}(s)}{q_{11}(s)} \right) \left(1 - \frac{q_{22}(s)}{q_{22}(s)} \right) \left(1 - \frac{q_{26}(s)}{q_{26}(s)} \right) - \left[1 - \frac{q_{22}(s)}{q_{22}(s)} \right] \left[1 - \frac{q_{26}(s)}{q_{26}(s)} \right]$$

Taking Laplace Transform of eq. (7-9) and solving for $A_0(s)$ and $D_2(s)$ and $D_3(s)$.

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Solving $H(t) = \frac{N(t)}{D(t)}$ for $H(t)$.

The expected period of the system under human error is

$H(t) = \frac{N(t)}{D(t)}$  

In the long run, $H(t)$ is already defined.

Cost Benefit Analysis

The cost-benefit function of the system considering mean up-time, expected busy period of the system under electrical fluctuations when the units stop automatically, expected busy period of the server for repair of unit under human error, expected number of visits by the repairman for unit failure.

The expected total cost-benefit incurred in $(0,t]$ is $C(t) = \text{Expected total revenue} - \text{expected total repair cost in (0,t]} + \text{due to electrical fluctuations failure}$

- expected total repair cost due to CCFM resulting from human error for repairing the units in $(0,t]$ - expected busy period of the system under electrical fluctuations when the units automatically stop in $(0,t]$ - expected number of visits by the repairman for repairing of the units in $(0,t]$ - expected cost per unit time for which the system is under repair of type-I - cost per unit time for which the system is under repair of type-II

CONCLUSION

After studying the system, we have analysed graphically that when the failure rate due to human error and failure rate due to electrical fluctuations increases, the MTSF and steady state availability decreases and the cost function decreased as the failure increases.

REFERENCES

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