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ReliabilityMeasures of a Two Unit Model in Cold Standby Mode with Expert Repairman

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Abstract: ***In this paper,the profit of a two unit cold standby system have been analysed.We have taken a two unit cold standby system having an expert repairman and his assistance.When a unit failed then standby unit becomes operating unit and his assistance repairman can repair the failed unit after getting the instruction from the expert. When the expert is busy in repairing the failed unit and also at that time standby unit failed then he leave the repair in the suspension and give instruction to his assistance.The profit rate is calculated where the failure follow exponential distributions. Graphs are plotted with the help of data given in terms of reliability parameters such as availability,MTSF,busyperiod,expected no. of repairman visits using regenerative point of graphical technique.***

Keywords: RPGT Technique,Two unit cold standby system, SemiMarkov process,Instruction time.

I. INTRODUCTION

In industry all the data related to profit along with reliability becomes central focuses. Reliability of system is very important for industries and also for satisfaction of needs of society.The system consists of operating unit O and cold standby unit CS.There may be lapse of time due to reduced capacity of system.The failure rate of system is λ, repair rate is μ and repair density function is h(t).Working and failure state is determined by fuzzy concept.The failure rates are exponentially distributed and repair rates are arbitrary.These studies are analysed by many researchers .Some of them are Kumar suresh[1] analysed the 'comparision of profit of a two unit cold standby system with instruction time', Kumar Ashok, Gupta K. Suresh and Tuteja R.k.[2]analysed the 'cost benefit analysis of a two unit cold standby system with instruction time',Goyal and Goel[3] analysed the 'behaviour with perfect and imperfect switch over of system using various techniques',Jain Madhu[4] analysed the reliability of stochastic system with two units combined hardware software failure',Bansal Ritu& Goel Pradeep[5] analysed the 'Availability analysis of poultry,cattle and fish feed plant',Goel,P. & Singh[6] analysed the 'Availability analysis of a standby system having imperfect switch',Malik,S.C. & Rathee, R.[7]analysed the 'Reliability modelling of a parallel system with maximum operation and repair times'.

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II. ASSUMPTIONS OF MODEL

- All the random variables are independent.
- As soon as unit fails, it repaired by expert repairman.
- The model consists of two units.
- Priority for repairing is given to expert repairman.
- System is repaired by his assistant in case of temporary suspension.
- System is failed when both the unit fails.

III. SYMBOLS AND NOTATION

λ Failure rate of the operative unit.
μ Constant repair rate of assistant repairman.
h(t), H(t) p.d.f and c.d.f of time to repair by expert.
O Operative unit.
CS Cold standby unit.
Fre Failed and under repair by expert repairman.
Fra Failed and under repair of assistant repairman.
Fwre Failed and waiting for repair of experts.
Fwri Failed and waiting for repair while expert gives instruction to his assistant.

IV. TRANSITION DIAGRAM OF THE SYSTEM

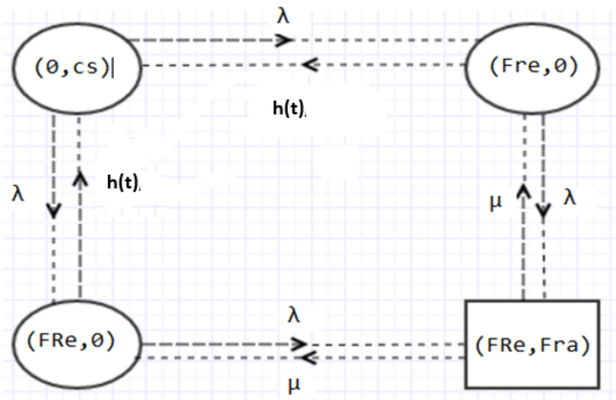

Fig.1

V. EVALUATION OF PARAMETER OF THE SYSTEM

The key parameter of system is calculated by applying RPGT with the help of base state. The MTSF and other parameter is determined with respect to initial state "0".

Vertex(i)	Primary circuit	Secondary circuit	Tertiary circuit
0	(0 1 0) (0 3 0)	(1 2 1) (3 2 3)	(2 3 2) (2 1 2)
1	(1 2 1) (1 0 1)	(2 3 2) (030)	(3 0 3) (3 2 3)
2	(2 3 2) (2 1 2)	(3 0 3) (1 0 1)	(0 1 0) (0 3 0)
3	(3 0 3) (3 2 3)	(0 1 0) (2 1 2)	(1 2 1) (1 0 1)

VI. TRANSITION PROBABILITIES

$q_{ij}(t)$ = Probability density function from regenerative state i to a regenerative state or failed state j without visiting any additional regenerative state.

p_{ij} = probability for steady state transition for regenerative state i to a regenerative state j without visiting any additional regenerative state.

$p_{ij} = q_{ij\,*}(0)$, where * denote Laplace operator.

$p_{01}= 1/2$
$p_{03}= 1/2$
$p_{10}= g^*(\lambda)$
$p_{12}=1- g^*(\lambda)$
$p_{30} = g^*(\lambda)$
$p_{32}=1-g^*(\lambda)$
$p_{21} = 1/2$
$p_{23} = 1/2$
$p_{01}+ p_{03}=1$
$P_{10}+ p_{12}=1$
$p_{30}+ p_{32}=1$
$P_{21}+ p_{23}=1$

Mean Sojourn Times

$R_i(t)$ Reliability of the system at time t given that system is in state i.

μ_i Mean time spent in state I before visiting any other states.

$\mu_i=R_i^*(0)$
$\mu_0 = 1 / 2\lambda$
$\mu_1 = 1\text{-}g^*(\lambda)/ \lambda$
$\mu_2 = 1/2\mu$
$\mu_3 = 1\text{-}g^*(\lambda)/ \lambda$
where " * " denotes Laplace operator

VII. EVALUATION OF PARAMETERS

The mean time to software system failure and all the parameters of the system are calculated by using Regenerative Point Graphical Technique(RPGT) and using '0' as the base state of the system as under:

The transition probability factors for all the states reachable from the base state '0' are:

$V0,0$=[(0,1,0) + (0,3,0) /1-{(0,1,0)(0,3,0)}]=[$p_{01}p_{10+}\, p_{03}p_{30/\{1-}$ $(p_{01}p_{10+}\, p_{03}p_{30})$}]
$V0,1$ = (0,1) = $p_{0,1}$
$V0,2$ = [(0,1,2)/{1-(1,2,1)}]=[$p_{01}p_{12}$/{1-$p_{12}p_{21}$}]
$V0,3$ = (0,3) = p_{03}

(a) MTSF(T_0)

The time before entering any failed state to which system can travel from the base state or It represents the regenerative un-failed states to which the system can travel from the base state before entering any failed state. As per given fig. 1, these states are: x = 0 to 3. For 'θ' = '0', MTSF is calculated by:

MTSF= [$\sum$ { $\{pr(\theta sr(sff) \to x)\}.\mu_x/\prod m$ $\{1-\overline{Vm1,m1}\}$ $1\neq\theta$ } x,sr] ÷ [$1-\sum$ { $\{pr(\theta sr(sff) \to \theta)\}$ /$\prod m$ $\{1-\overline{Vm2,m2}\}$ $2\neq\theta$ } sr]

T_0=[(0, 0) μ_0+(0, 1) μ_1 + (0,3)μ_3]÷ ([1–($L1$+$L2$)])= N/D

Where, $L1=(0, 1, 0)=p_{0,1}p_{1,0}L2=(0, 3, 0)= p_{0,3}p_{3,0}$,

$N=(0, 0)\,\mu_0+(0, 1)\,\mu_1 + (0,3)\mu_3$

$D = [1-(L1+L2)]$

(b)Availability of the software system(A_0)

It represents the regenerative states, at which the system is available. As per given fig. 1 these states are: y = 0, 1 and the regenerative states are x = 0 to 3. For 'θ' = '0', the total duration for which the system is available is given by:

$A_0= [\sum \{ \{pr(\theta sr \rightarrow y)\} f_y.\mu_y / \prod \{1-Vm1,m1\ m \}\ 1\neq\theta y,s \}\ r\ ] \div [\sum \{ \{pr(\theta sr \rightarrow x)\}.\mu_x{}^1 / \prod \{1-Vm2,m2\ m \}\ 2\neq\theta x,s \}\ r\ ]$

$A_0 = [\sum y V\theta,.\ f_y.\ \mu_y] \div [\sum V\theta,xx\ .\ \mu_x{}^1]$

$=[V0,0\ .\ f_0\ .\mu_0 + V0,1\ .f_1\ .\mu_1 + V0,3\ .f_3.\ \mu_3] \div [V0,0\mu_0{}^1 + V0,1\mu_1{}^1 + V0,2\mu_2{}^1 + V0,3\mu^{3\ 1}]$

(c)Busy period of the Repairman(B_0)

It represents the regenerative states where repairman is busy while doing repairs. As per given fig. 1 these states are: y =1,3; the regenerative states are: x = 0 to 3. For '□' = '0', the total duration for which the repairman is busy is given by:

$B_0= [\sum \{\{pr\ (\theta sr \rightarrow y)\}.\ \eta_y / \prod \{1-Vm1,m1\ m \}\ 1\neq\theta y,s \}\ r\ ] \div [\sum \{ \{pr(\theta sr \rightarrow x)\}.\mu_x{}^1 / \prod \{1-Vm2,m2\ m \}\ 2\neq\theta x,s \}\ r\ ]$

$B_0 = [\sum y V\theta,.\ \eta_y] \div [\sum V\theta,xx\ .\ \mu_x{}^1]$

$B_0= [V0,1\ .\eta_1 + V0,3.\ \eta_3] \div [V0,0\mu_0{}^1 + V0,1\mu_1{}^1 + V0,2\mu_2{}^1 + V0,3\mu_3{}^1]$

(d)Expected number of Repairman's visits(V_o)

It represents the regenerative states where the repairman visits for repairs of the system. As per given fig. 1 these states are: y = 1, 2, 3. The regenerative states are: x = 0 to 3. For 'θ' = '0', the expected number of server's visits per unit time is:

$V_0= [\sum \{\{pr\ (\theta sr \rightarrow y)\} / \prod \{1-Vm1,\ m1\ m\}\ 1\neq\{y,\ s\}\ ] \div [\sum \{ \{pr(\theta sr \rightarrow x)\}.\mu_x{}^1 / \prod \{1-Vm2,m2\ m \}\ 2\neq\theta x,s \}\ r\ ]$

$V_0 = [\sum y V\theta,\ y] \div [\sum V\theta,\ xx.\mu_x{}^1]$

$=(V0,1 + V0,3) \div [V0,0\mu_0{}^1 + V0,1\mu_1{}^1 + V0,2\mu_2{}^1 + V0,3\mu_3{}^1]$

Profit Analysis of the System

$P=K1A_0-K2B_0-K3V_0$

Where

K1= revenue per unit of time the system is available

K2 = cost per unit time the server remains busy for the repairs

K3 = cost per visits of the server

Particular Cases

Let us take h(t) = αexp(-αt)

a = 2,μ = 0.6

K0 = 500,K1= 50, K2 = 20

VIII. COMPARITIVE STUDY AND GRAPHICAL DISCUSSION

Failure Rate(λ)	Availability(A_0)
0.1	0.99980
0.2	0.99844
0.3	0.99499
0.4	0.9896
0.5	0.97930
0.6	0.967
0.7	0.95103
0.8	0.93252
0.9	0.91171
1	0.8887

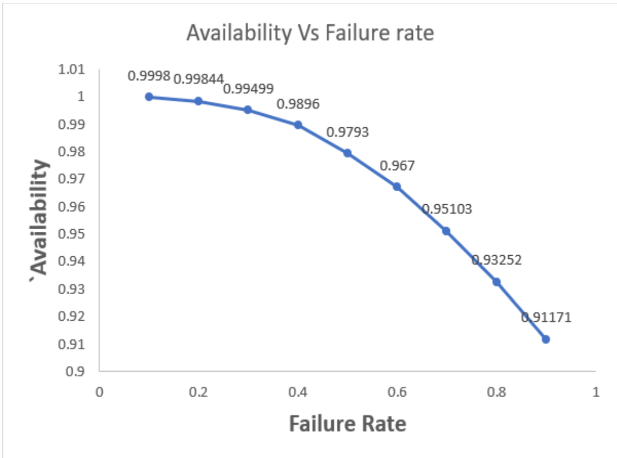

Fig.-2

Failure Rate(λ)	MTSF(T_0)
0.1	2110
0.2	280
0.3	88.52
0.4	40
0.5	22
0.6	13.70
0.7	9.30
0.8	6.72
0.9	5.09
1	4

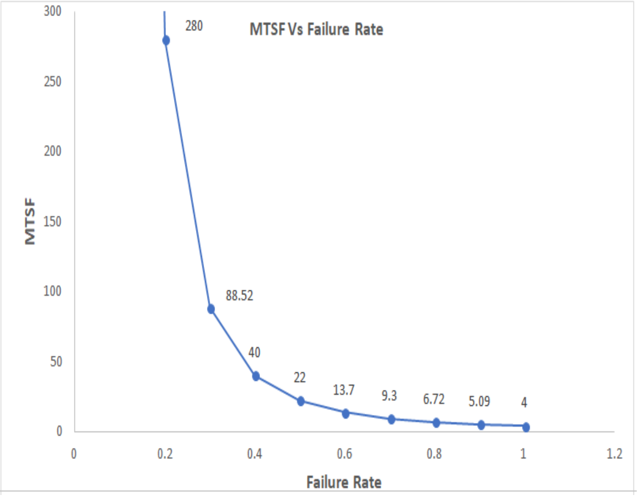

Fig.-3

Failure Rate(λ)	Profit(P_0)
0.1	499.46
0.2	497.55
0.3	493.901
0.4	488.7431
0.5	480.75
0.6	471.51
0.7	460.325
0.8	447.867
0.9	434.33
1	419.906

Fig.-4

IX. CONCLUSION

From the Tables and graphs, we see that, Availability and profit of the System is increasing, as the Repair Rate increases and decrease with increase in failure rate. In future,variation between various parameters can be evaluated when Repair rate and Failure rate are varied. Results obtained can be used for cost and benefit analysis. Any state can be taken as the Base-state to evaluate the various parameters.Other Graphs can be plotted and then various conclusions can be drawn which will be very useful in taking various decisions for the beneficial to the company.

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