International Journal of Science and Engineering Science Research
Volume 1 | Issue 2 | April-June 2025 | ISSN 3049-2793
Peer Reviewed (Referred Journal)

Analytic Behaviour of a Parallel Redundant Complex System Involving Environmental Failure Under Pre-Emptive-Resume Repair Discipline

Dr. Tripti Dixit
Department of Mathematics
Govt. Post Graduate College Kotdwar Uttarakhand
drtdixit22@gmail.com

Abstract

In these days reliability requirement is more important. The present paper describes the analytic behaviour of a parallel redundant complex system involving environmental failure under pre emptive resume repair discipline. In this analysis laplace transform and supplementary variable techniques have been used to find the probabilities of the system being in various states.

Keywords

Reliability, MTTF, Parallel Redundant, Environmental Failure, Complex System, MTSF, Pre-Emptive, Resume Repair.

1. Introduction

In this paper we initiated the study of analytic behaviour of a parallel redundant complex system involving environmental failure under pre-emptive resume repair discipline. This techniques shows a failed component of subsystem L_1 goes to repair immediately on its failure. This means, components of subsystem L_1 pre-emptive repair facilities even when these facilities are engaged in the repair of the failed component of subsystem L_2 .However when the components of subsystem A are taken back in repair facilities, the repair starts from the point where it was left earlier.

2. Notations

To formulate the mathematical model, we define the following in additions to the definition of $P_{0.M}(t), P_{0.M-j}(y,t), P_{F_1.M}(x,t), P_{F_1.M-r}(x,t), P_F(u,t)$. $Q_{F_1.M-r}(x,y,t)\Delta$- The probability that at time't'. the system is in the failed state due to the failure of the ith component of subsystem L_1 and the elapsed repair times lies in the interval (x. x +Δ) and at the instant when it pre-empted in the repair facilities, the elapsed time of class L_2 was in the interval (y, y +Δ)

2.1 Mathematical Model of the Problem

$$[\delta/\delta t+\lambda+v+M\lambda']P_{0M}(t) = \int_0^\infty P_{0,M-j}(y,t)\phi_j(y)dy + \sum_{i=t}^{N}\int_0^\infty P_{F_1M}(x,t)\eta_1(x)dx + \int_0^\infty \delta(u).\bar{P}(u,t)\,du \quad \text{.........(1)}$$

$$\left[\frac{\delta}{\delta t} + \lambda + (M-r)\lambda' + v\right] P_{0M-r}(t) = (M-r+1)\lambda' P_{0,M-r+1}(t) + \sum_{i=1}^{N}\int_0^\infty P_{F_iM-r}(x,t)\eta_1(x)dx \quad \text{.......(2)}$$

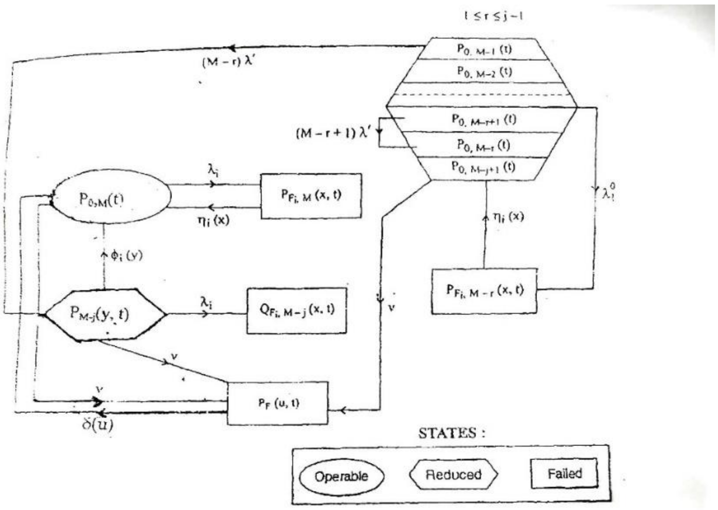
$$\left[\frac{\delta}{\delta t} + \frac{\delta}{\delta t} + \lambda + v + \phi_j(y)\right] P_{0,M-j\,(y,t)=}\sum_{i=1}^{N}\int_0^\infty Q_{F_iM-j}(x,y,t)\eta_1(x)dx \quad \text{........(3)}$$

$$\left[\frac{\delta}{\delta t} + \frac{\delta}{\delta t} + \eta_1(x)\right] P_{F.M}(x,t) = 0 \quad \text{.........(4)}$$

$$\left[\frac{\delta}{\delta x} + \frac{\delta}{\delta t} + \eta_1(x)\right] P_{F.M-r}(x,t) = 0 \quad \text{.........(5)}$$

$$\left[\frac{\delta}{\delta x} + \frac{\delta}{\delta t} + \phi(y)\right] Q_{F.M-j} \quad \text{.........(6)}$$

$$\left[\frac{\delta}{\delta u} + \frac{\delta}{\delta t} + \delta(u)\right] P_F(u,t \quad \text{.........(7)}$$



Initial Conditions

$$P_{0,M}(0) = 1 \quad \text{........(8)}$$

and other states of various probabilities are zero.

Boundary Conditions

$$P_{F_1M}(0,t) = \lambda_i P_{0,M}(t) \quad \text{........(9)}$$

$$P_{FM-r}(0,t) = \lambda P_{0,M-t}(t)\,. \quad \text{.........(10)}$$

$$P_{0M-j}(0,t) = (M-j+1)\,\lambda' P_{0,M-j+1}(t) \quad \text{.........(11)}$$

$Q_{F,M-j}(0,y,t) = \lambda_i . P_{0,M-j}(y,t)$ ....(12)

$\bar{P}_f(0,t) = v\,[\int P_{0M-j}(y,t)dy + P_{0,M-r}(t) + P_{0,M}(t)]$ ....(13)

2.2 Solution for the Model

Taking Laplace transform of equation (1) through (13) w.r.t 't' one may obtain, $(s + \lambda + v + M\lambda')\,\bar{P}_{0.M}(s) = 1 + \int_0^\infty \bar{P}_{0.M-j}(y,s)\,\phi_j(y)dy$

$+ \sum_{i=1}^{N} \int_0^\infty \bar{P}_{F_i.M}(x,s)\eta_1(x)dx + \int_0^\infty \delta(u).\bar{P}_f(u,s).du$ ....(14)

$(s + \lambda + \overline{M - r\lambda'} + v)\bar{P}_{0.M-r}(s)$

$+ \sum_{i=1}^{N} \int_0^\infty \bar{P}_{F_i.M}(x,s)\eta_1(x)dx$ ....(15)

$\left[\frac{\partial}{\partial y} + s + \lambda + v + \phi_j(y)\right]\bar{P}_{0.M-r}(y,s) = \sum_{i=1}^{N} \bar{Q}_{F_iM-j}(x,y,s)\,\eta_1(x)dx$ ....(16)

$\left[\frac{\partial}{\partial x} + s + \eta_1 + (x)\right]\bar{P}_{0.M-r}(y,s) = 0$ ....(17)

$\left[\frac{\partial}{\partial x} + s + \eta_1 + (x)\right]\bar{P}_{F\,M-j}(x,s) = 0$ ....(18)

$\left[\frac{\partial}{\partial x} + s + \eta_1 + (x)\right]\bar{Q}_{F\,M-j}(x,y,s) = 0$ ....(19)

$\left[\frac{\partial}{\partial x} + s + \delta(u)\right]\bar{P}_F(u,s) = 0$ ....(20)

$\bar{P}_{F\,M-j}(0,s) = \lambda_1 \bar{P}_{0M}(s)$ ....(21)

$\bar{P}_{F\,M-r}(0,s) = \lambda_1 \bar{P}_{0\,M-r}(s)$ ....(22)

$\bar{P}_{0\,M-j}(0.s) = (M - j + 1)\lambda'\bar{P}_{0.M-j+1}(s)$ ....(23)

$Q_{F.M-j}(0,y,s) = \lambda_1.\bar{P}_{0.M-1}(y,s)$ ....(24)

$\bar{P}_0(0.s) = v\,[\int P_{0M-j}(y,s)dy + P_{0M-j}(s) + P_{0M}(s)$ ....(25)

$\bar{P}_{F_iM}(x.s) = \lambda_i\bar{P}_{0M}(s)e^{-sx-\int_0^x \eta_1(x)dx}$
.........(26)

$\bar{P}_{F_iM}(x.s) = \lambda_i\bar{P}_{0M}(s)e^{-sx-\int_0^x \eta_1(x)dx}$
.........(27)

$\bar{Q}_{F_1M-j}(x,y,s) = \lambda' \bar{P}_{0M-j}(y,s)e^{-sx-\int_0^x \eta_1(x)dx}$
.........(28)

$\bar{P}_{0M-r}(s) = \frac{(M-r+1)\lambda'\bar{P}_{0M-r+1}(s)}{[s+\lambda+v+(M-r)\lambda' - \sum \lambda_i\bar{S}_i(s)}$
.........(29)

$\bar{P}_{0M-j}(y-s) = (M-r+1)\lambda' \bar{P}_{0M-j+1}(s)e^{-[s+\lambda+v-\sum\lambda_i\bar{S}_i(s)]\, y \times e^{\int_0^x \phi_j(y)dy}}$
.........(30)

$\bar{P}_F(u.s) = v\left[\int_0^\infty P_{0\,M-j}(y,s)dy + \bar{P}_{0\,M-r}(s) + \bar{P}_{0.M}(s)\right]e^{-su-\int_0^u \delta(u)du}$
.........(31)

$\bar{P}_{0.M}(s) = \frac{1}{L(s)}$
.........(32)

Where, L(s) $= s+\lambda+v+ M\lambda' - \sum_{i=1}^N \lambda_i\bar{S}_i(s) - (M-j+1)(\lambda')^j$

$$\times S_j\left\{s+\lambda+v-\sum_{i=1}^N \lambda_i\bar{S}_i(s)\right\} \times \prod_{r=1}^{j-1}\left(\frac{M-r+1}{s+\lambda+v+\overline{M-r\lambda'} - \sum\lambda_i\bar{S}_i(s)}\right)$$

$$-v\bar{S}_\delta(s)\left[(M-j+1)(\lambda')^j.\bar{S}_j(s+\lambda+v-\textstyle\sum_{i=1}^N \lambda_i\bar{S}_j(s))\right.$$

$$\times \prod_{r=1}^{j-1}\left(\frac{M-r+1}{s+\lambda+v+\overline{M-r\lambda'} - \sum\lambda_i\bar{S}_i(s)}\right)$$

$$\times \prod_{P=0}^{j-1}\left(\frac{(\lambda')^t(M-P)}{s+\lambda+v+(M-P-1)\lambda' - \sum\lambda_i\bar{S}_i(s)}+1\right)$$

$\bar{P}_{0M-r}(s) = \frac{(\lambda')^r}{L(s)}.\prod_{P=0}^{j-1}\left(\frac{M-P}{s+\lambda+v+\overline{M-P-1}\lambda' - \sum\lambda_i\bar{S}_i(s)}\right)$
.........(33)

$\bar{P}_R(s) = \bar{P}_{0.M-j}(s)$, can be written as

$$\bar{P}_R(s) = \int_0^\infty \bar{P}_{0.M-j}(s)\,dy$$

$$\bar{P}_R(s) = \frac{1-\bar{S}_i\{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)\}}{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)}.\frac{(M-j+1)(\lambda')^j}{L(s)}$$

$$\times \prod_{r=1}^{j-1}\left(\frac{(M-r+1)}{s+\lambda+v+\overline{M-r\lambda'}-\sum\lambda_i\bar{S}_i(s)}\right)$$
.........(34)

$$\bar{P}_F(s) = \frac{\lambda_i}{L(s)}.\frac{1-\bar{S}_i(s)}{s} \quad ....(35)$$

$$\bar{P}_{F_{i\,M-r}}(s) = \frac{\lambda_i}{L(s)}.\frac{1-\bar{S}_i(s)}{s} + (\lambda')^r \times \prod_{P=0}^{r-1}\left(\frac{M-P}{s+\lambda+v+\overline{M-P-1\lambda'}-\sum\lambda_i\bar{S}_i(s)}\right) \quad ....(36)$$

$$\bar{Q}_{F_{i\,M-j}}(s) = \frac{\lambda_i}{L(s)}.\frac{1-\bar{S}_i(s)}{s} + \frac{1-\bar{S}_i\{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)\}}{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)}.(M-j+1)(\lambda')^j$$

$$\times \prod_{r=1}^{j-1}\left(\frac{M-r+1}{s+\lambda+v+\overline{M-r\lambda'}-\sum\lambda_i\bar{S}_i(s)}\right)$$
.........(37)

$$\bar{P}_F(s) = \frac{v\{1-\bar{S}_\delta(s)\}}{L(s).s}\left[\frac{1-\bar{S}_i\{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)\}}{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)}(M-j+1)(\lambda')^j\right.$$

$$\times \prod_{r=1}^{j-1}\left(\frac{M-r+1}{s+\lambda+v+\overline{M-r}\lambda'-\sum_{i=1}^{N}\lambda_i\bar{S}_i(s)}\right)$$

$$\left.+ (\lambda')^r \times \prod_{P=0}^{r-1}\left[\left(\frac{M-P}{s+\lambda+v+(M-P)\lambda'-\sum_{i=1}^{N}\lambda_i\bar{S}_i(s)}\right)+1\right]\right] \quad ....(38)$$

2.3 Evaluation of Up and Down State Probabilities

$$\bar{P}_{up}(s) = \bar{P}_{0.M}(s) + \sum_{r=1}^{j-1}\bar{P}_{0.M-r}(s) + \bar{P}_r(s)$$

$$= \frac{1}{L(s)}\left[1 + \sum_{r=1}^{j-1}\{(\lambda')^r \prod_{r=1}^{r-1}\left(\frac{M-P}{s+\lambda+v+\overline{M-P-1\lambda'}-\sum\lambda_i\bar{S}_i(s)}\right)\right]\mathrm{p}$$

$$+ \frac{1-\bar{S}_i\{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)\}}{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)} \times (M-j+1)(\lambda')^j$$

$$\times \prod_{r=0}^{j-1}\left(\frac{(M-r+1)}{s+\lambda+v+(M-P)\lambda'-\sum_{i=1}^{N}\lambda_i\bar{S}_i(s)}\right)$$
.........(39)

$$\bar{P}_{down}(s) = \sum_{i=1}^{N}\left[\int_0^\infty \bar{P}_{F_1 M}(x,s)dx + \sum_{r=1}^{j-1}\bar{P}_{F_1 M-r}(x,s)dx\right.$$

$$\left.+\int_0^\infty Q_{F_{1M-j}(y,s)dy}\right] + \int_0^\infty \bar{P}_F(u,s)du$$

$$= \sum_{i=1}^{N}\left\{\frac{\lambda_1}{L(s)}.\frac{1-\bar{S}_1(s)}{s}\right\}\left[1+(\lambda')^r \times \prod_{P=0}^{r-1}\left(\frac{M-P}{s+\lambda+v+\overline{M-P-1}\lambda'-\sum\lambda_i\bar{S}_i(s)}\right)\right]+$$

$$(M-j+1)(\lambda')^j.\frac{1-\bar{S}_i\{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)\}}{s+\lambda+v-\sum\lambda_i\bar{S}_i(s)}$$

$$\times \prod_{r=1}^{j-1} \left(\frac{M-r+1}{s+\lambda+v+(M-r)\lambda'\bar{S}_1(s)} \right)$$

$$+ \frac{v.1-\bar{S}_\delta(s)}{L(s).s} \left[\frac{1-\bar{S}_\delta\{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)\}}{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)} (M-j+1)(\lambda')^j \right]$$

$$\times \prod_{r=1}^{j-1} \left(\frac{M-r+1}{s+\lambda+v+(M-r)\lambda'-\sum \lambda_i \bar{S}_i(s)} \right)$$

$$+(\lambda') \prod_{P=0}^{r-1} \left(\frac{M-P}{s+\lambda+v+\overline{M-P-1}\lambda'-\sum_{i=1}^{N} \lambda_i \bar{S}_i(s)} \right) + 1 \Big]$$

……….(40)

It may be seen that

$$\bar{P}_{up}(s) + \bar{P}_{down}(s) = \frac{1}{s}$$

……….(41)

2.4 Ergodic Behaviour of the System

Using Abel's Lemma,

$$\lim_{S \to 0} S\bar{F}(s) = \lim_{t \to \infty} F(t) = F\ (say),$$

provided the limit on right exist, the system's steady state probabilities are obtained as under :

$$P_{0.M} = \frac{1}{L'(0)}$$

……….(42)

$$P_{0.M-r} = \frac{M}{(M-r)L'(0)}$$

……….(43)

$$P_R = \frac{M\lambda' M_j}{L'(0)}$$

……….(44)

$$P_{F_i.M} = \frac{\lambda_i M_i}{L'(0)}$$

……….(45)

$$P_{F_i.M-r} = \frac{\lambda_i M_i}{L'(0)} \cdot \frac{M}{M-r}$$

……….(46)

$$Q_{F_i.M-j} = \frac{\lambda_i M_i . M\lambda' . M_j}{L'(0)}$$

……….(47)

and $P_f = \frac{v M_\delta}{L'(0)} \cdot \left[M\lambda' M_j + \frac{M}{M-r} \right]$

……….(48)

where $L'(0) = \left[\frac{d}{dx} L(s)\right]_{s=0}$

2.5 Particular Cases

(A) Class L_1 consists of N components in series and Class L_2 consists of M components in Parallel Redundancy, assuming that the failure of any two components out of M causes the system to work in reduce efficiency state.

Substituion of j = 2 in relation (32) through (38), one gets

$$\bar{P}_{0.M}(s) = \frac{1}{A(s)}\{s + \lambda + v + \overline{M-1}\lambda' - \sum_{i=1}^{N} \lambda_i S_i(s)\} \quad \text{.........(49)}$$

$$\bar{P}_{0.M}(s) = \frac{M\lambda'}{A(s)} \quad \text{.........(50)}$$

$$\bar{P}_{R}(s) = \frac{M(M-1)(\lambda')^2}{A(s)} . \frac{1-\bar{S}_2\{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)}{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)} \quad \text{.........(51)}$$

$$\bar{P}_{F.M}(s) = \frac{\lambda'}{A(s)} . \frac{1-\bar{S}_i(s)}{s}\{s + \lambda + v + \overline{M-1}\lambda' - \sum_{i=1}^{N} \lambda_i S_i(s)\} \quad \text{.........(52)}$$

$$\bar{P}_{F.M}(s) = \frac{\lambda'}{A(s)} . \frac{1-\bar{S}_i(s)}{s} M\lambda' \quad \text{.........(53)}$$

$$\bar{Q}_{F.M-2}(s) = \frac{\lambda_i}{A(s)} . \frac{1-\bar{S}_{(s)}}{s} . M(M-1)(\lambda')^2 \frac{1-S_2\{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)\}}{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)} \quad \text{.........(54)}$$

$$\bar{P}_{F}(s) = \frac{v}{A(s)} . \frac{1-\bar{S}_\delta(s)}{s}\left[\frac{1-S_2\{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)\}}{s+\lambda+v-\sum \lambda_i \bar{S}_i(s)} \text{ M(M} - 1) (\lambda')^2\right.$$

$$\left. + M\lambda' + \{s + \lambda + v + \overline{M-1\lambda'} - \sum_{i=1}^{N} \lambda_i \bar{S}_i(s)\right] \quad \text{.........(55)}$$

Where,

$$A(s) = \left\{ s + \lambda + v + M\lambda' - \sum_{i=1}^{N} \lambda_i \bar{S}_i(s) \right\} \left\{ s + \lambda + v + \overline{M-1\lambda'} - \sum_{i=1}^{N} \lambda_i \bar{S}_i(s) \right\}$$

$$- M(M-1)(\lambda')^2 \times \bar{S}_2\{s + s + \lambda + v + M\lambda' - \sum_{i=1}^{N} \bar{S}_i(s).\lambda_i\} \text{-} v.\bar{S}_\delta(s)[M(M-1)(\lambda')^2$$

$$\bar{S}_2[s + \lambda + v - \sum_{i=1}^{N} \bar{S}_i(s).\lambda_i] + M\lambda + \{s + \lambda + \overline{M-1\lambda'} \text{-} \sum \lambda_i \bar{S}_i(s)\}$$

(B) Repair Follows Exponential Time Distribution

Setting $\bar{S}_i(s) = \frac{\eta_i}{s+\eta_i}$ and $\bar{S}_i(s) = \frac{\phi_i}{s+\phi_i}$ and $\bar{S}_i(s) = \frac{\delta}{s+\delta}$ in relations (32) through (38), one may get

$$\bar{P}_{0.M}(s) = \frac{1}{B(s)} \quad \text{.........(56)}$$

$$\bar{P}_{0.M-r}(s) = \frac{(\lambda)^r}{B(s)} \prod_{P=0}^{r=1} \left(\frac{M-P}{s+\lambda+v+\overline{M-P-1\lambda'} - \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \right) \qquad \text{.........(57)}$$

$$\bar{P}_R(s) = \frac{(\lambda')^j (M-j+1}{\left\{ s+\lambda+v+\phi_j - \frac{\lambda_i \eta_i}{S+\eta_i} \right\} . \mathrm{B(s)}}$$

$$\times \prod_{r=}^{j-1} \left[\frac{M-r+1}{s+\lambda+v+\overline{M-r\lambda'} - \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \right] \qquad \text{.........(58)}$$

$$\bar{P}_{F.M}(\mathrm{s}) = \frac{\lambda_i}{(S+n_i).B(s)} \qquad \text{.........(59)}$$

$$\bar{P}_{F.M-r}(\mathrm{s}) = \frac{\lambda_i (\lambda')^r}{(S+n_i).B(s)} \prod_{P=0}^{r-1} \left[\frac{M-P}{s+\lambda+v+\overline{M-P-1\lambda'} \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \right] \qquad \text{.........(60)}$$

$$\bar{Q}_{F.M-j}(\mathrm{s}) = \frac{\lambda_i}{(S+n_i).B(s)} \cdot \frac{(\lambda')^j (M-j+1)}{\left\{ s+\lambda+v+\phi_{j-} \sum \frac{\lambda_i \eta_i}{S+\eta_i} \right\}}$$

$$\times \prod_{r=1}^{j-1} \left(\frac{M-r+1}{s+\lambda+v+M-r\lambda' - \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \right) \qquad \text{.........(61)}$$

$$\bar{P}_F(\mathrm{s}) = \frac{v}{B(s)} \cdot \frac{1}{s+\delta} \left[\frac{M(M-1)(\lambda')^2}{s+\lambda+v+\phi_{j-} \sum \frac{\lambda_i \eta_i}{S+\eta_i}} + M\lambda' \right.$$

$$\left\{ s+\lambda+v+\overline{M-1\lambda'} \sum \frac{\lambda_i \eta_i}{S+\eta_i} \right. \qquad \text{........(62)}$$

Where, $\mathrm{B(s)} = s+\lambda+v+M\lambda' - \sum \frac{\lambda_i \eta_i}{S+\eta_i} - \frac{(M-j+1)(\lambda')^j . \phi_j}{s+\lambda+v+\phi_{j-} \sum \frac{\lambda_i \eta_i}{S+\eta_i}}$

$$\times \prod_{r=1}^{j-1} \left(\frac{M-r+1}{s+\lambda+v+\overline{M-r}\lambda' - \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \right) - \frac{v\delta}{S+\delta}$$

$$\left[\frac{(M-j+1)(\lambda')^j . \phi_j}{s+\lambda+v+\phi_{j-} \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \times \prod_{r=1}^{j-1} \left(\frac{M-r+1}{s+\lambda+v+\overline{M-r}\lambda' - \sum \frac{\lambda_i \eta_i}{S+\eta_i}} \right) \right.$$

$$\left. + \prod_{P=0}^{j-1} \frac{(\lambda')^r (M-P)}{s+\lambda+v\ \overline{M-P-1}\lambda' - \sum \frac{\lambda_i \eta_i}{S+\eta_i}} + 1 \right]$$

2.6 Numerical Computation

To depict the result numerically and graphically, $P_{up}^{Res.}(t)$obtained from (39) has been plotted against t in the steady state for N = 1, λ = 0.03, $\lambda' = 0.02$, v = 0.01, M = 10, $\delta = \eta = \phi = 1, \mathrm{i} = 1, \mathrm{j} = 2$ for any complex system, we have $P_{up}^{Res.}(t) = 0.431162287 + 0.005188786 \times$

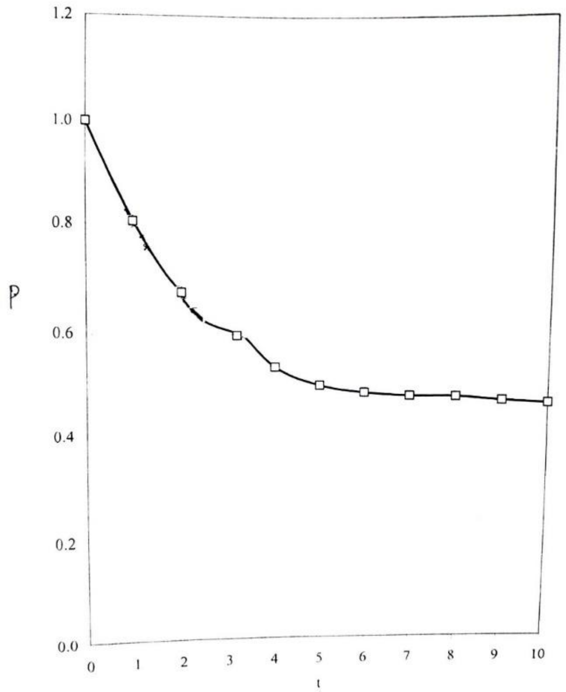
$e^{1-033690t} + 0.087040988 \times e^{1-033690t} - 0.05758925 \times e^{-1.160167\,t} + 0.586153689 \times e^{-0.42864t}$

$$-0.051956792 \times e^{-0.81451t} \quad \text{.........(63)}$$

Effect of time on $P_{Up}^{Res.}(t)$

From equation (2.1)

t	P
0	1
1	0.80383269
2	0.675071482
3	0.622997268
4	0.535463433
5	0.499304304
6	0.485653321
7	0.480195324
8	0.480099485
9	0.473523056
10	0.469211126



Conclusion

From the Table 2.1 and Graph 2.1 We concludes that $P_{Up}^{Res.}(t)$ of the system decreases with respect of time.

References

1. A.P Basu.; Rigdow, E Steven, Statistical Method for the reliability of repairable systems, MC Graw Hill (2000).
2. B.L. Amstader.; Reliability Mathematics; Mc Grow Hill Book Company; Newyork (1971).
3. Blischke, R.Wallace and Murthy, N.D. Prabhaker: Reliability Modelling Prediction and optimization. John Wiley and sons (2000)
4. B.S. Dhillon and N. Yang; Reliability and Availability of warm stand by system with common cause failure and human errors. Micro electrons and Reliability 32 PP.561-575 (1992).
5. E.E.Lewis; 'Introduction to reliability engineering John willey and sons; Newyork (1987).
6. J.C. Hwan and J.K.Jae ; on the existence of the steady availability of imperfect repair model the Indian Journal of statistics Vol-64 Series B. Pt-1, PP-76-81 (2002).
7. K.S. Trivedi Probability and statistics with reliability, Queuing and Computer Science Applications; John Willey and Sons (2002).
8. M.Alka and S.B.Singh; Reliability Analysis of a complex repairable system composed of two 2 out of 3; G subsystem connected in parallel" Journal of Reliability and statistical studies Vol-7 No. 1PP 89-111 (2014).
9. R.Sharma and G.Kumar "Availability improvement for the successive K-out of n machining system using stand by with multiple working vacations, International Journal of Reliability and safety Vol. 11 No. 3/4 PP 256-267 (2017).
10. R. Patil .M. Arenzki Mellal et al; "Reliability Maintainability and Availability Analysis of a using Markov Chains" Acta Polytechnica Hungarica Vol- 18 No.-6 PP. 45-70 (2021).
11. A. Sirohi, P.K. Pooniya D. Raghav: Reliability analysis of a complex repairable system in a series configuration with switch and catastrophic failure using copula repair: J Math Comput, Sci 11(2) 24-03-2425 (2021)