International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 2, Issue 2 (March-April 2014)), PP.81-84

TWO UNIT REDUNDANT SYSTEM WITH n-FAILURE MODES, n- FAULT DETECTION AND INSPECTION

Dr Sushant Pandey
Department Of Mansgement,
Ishan Insititute Of Management & Tecchnology
Gr. Noida

***Abstract*— The present paper gives the analysis of a two unit cold standby system with n failure modes of the online unit. The failed online unit is first sent for fault detection to decide its failure mode. After repair the unit is sent for inspection to decide whether the repaired unit is perfect or not. If it is found to be imperfect, them it is sent for post repair. Using regenerative points technique in Markov renewal process several effective measures of reliability are obtained.**

***Keywords*— Laws - legislations - quality of life - sustainability.**

I. INTERODUCTION

Many researchers working in the field of system reliability have analyzed two unit standby reduficiant system without considering the mode of failure of an online unit (operative unit). But in our daily life, we come across with engineering systems in which the online unit has more than one failure modes. Incorporating the idea of failure mode, we in,, this paper analysed a two unit gystem with n-failure modes of the on line unit. The failed unit is repaired, in the respective mode and after each repair it is inspected to decide whether the repaired unit is perfect or not If the repaired unit is found to be imperfect than it is sent. for post repair.

II. MODEL DESCRIPTION AND ASSUMPTIONS

(1) Consider a two unit system with one unit operative and the other as cold standby.
(2) Upon failure of an operative unit, the cold standby unit becomes operative instantaneously
(3) Before starting the repair, a failed unit is taken for its fault detection t decide the mode of failure. (4) After repair, the unit is inspected to decide whether the repair is perfect or not. If the repair of a unit is found to be perfect then the repaired unit becomes operative or cold standby otherwise it is again sent for post repair. The probability of having perfect repair is fixed.
(5) Failure rate of an operative unit is constant, while the distributions of time for fault detection, repair, inspection and post-repair are general .
(6) A single repair facility is available for fault detection, repair, inspection and post-repair.
(7) Service discipline is FCFS.
Identifying the suitable regenerative points several measures of system effectiveness are discussed.

III. NOTATIONS AND STATES OF THE SYSTEM

N0 : Normal unit when it is operative

Ns : Normal unit when it is cold standby

Fwf : Failed unit waiting for fault detection

Ff : Failed unit under fault detection

FF : Fault detection is continued from earlier state

Frc : Failed unit in the Cth failure mode is under repair

Fic : Failed unit in the Cth failure mode is under inspection

Fpc: Failed unit in the Cth failure mode is under post repair

Note : C takes value from 1 to n.

α : Constant failure rate of an operative unit.

F(.),F(.) : pdf and cdf of time to detect the mode of failure

Gc(.),Gc(.) : pdf and cdf of time for repair in the Cth failure mode.

Kc(.),Kc(.) : pdf and cdf of time for inspection in the Cth failure mode.

Hc(.),Hc(.) : pdf and cdf of time for post repair in the Cth failure mode

Two Unit Redundent System With n-Failure Modes

P = (1-q) : Probability that the repair is perfect.

ml, m2c, m3c, m4c : Mean time for fault detection, repair inspection and post repair in the Cth failure mode.

Using the above notations, the possible states of the system are :

Up States :

So : (No, Ns) ; S1 : (No, Fr) ; S3c (No, Frc)

S5c : (No, Fic) ; S7c : (No, Fpc)

Down States:

Se : (Fwf, FF) ; S4c : (Fwf, Frc) ; S6e : (Fwf, Fie)

Sec : (Fwf, Fpc)

The possible transitions between the states are shown in Fig-I.

IV. TRANSITION AND STEADY STATE PROBABILITIES

Using the definition of Qij(t) the transition probability matrix of the embedded Markov chain is
P = (Pij = [Qii (∞)i

with the non zero elements :

with the non zero elements :

$$P_{01} = 1 \quad ; \quad P_{12} = 1 - f^*(\alpha)$$

$$P_{1,3c} = f^*(\alpha) \quad ; \quad P_{3c,4c} = 1 - g^*_0(\alpha)$$

$$P_{3c,5c} = g_c^*(\alpha) \quad ; \quad P_{4c,6c} = 1$$

$$P_{5c,0} = PK_c^*(\alpha) \quad ; \quad P_{5c,6c} = 1 - K_c^*(\alpha)$$

$$P_{5c,7c} = qK_c^*(\alpha) \quad ; \quad P_{6c,1} = P$$

$$P_{6c,8c} = q \quad ; \quad P_{7c,0} = h^*_c(\alpha)$$

$$P_{7c,8c} = 1 - h_c^*(\alpha) \quad ; \quad P_{8c,1} = 1$$

$$P^{(2)}_{1,4c} = 1 - f^*(\alpha) \quad ; \quad P^{(4c)}_{3c,6c} = 1 - g^*_c(\alpha)$$

.

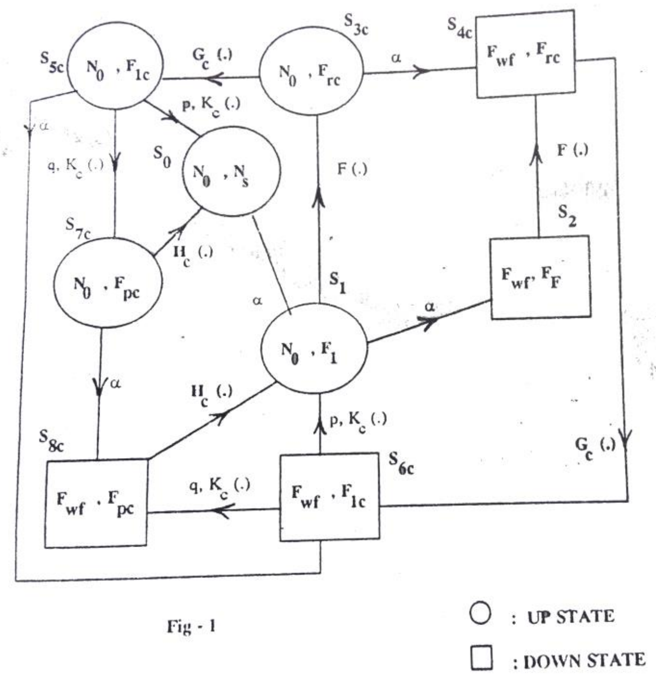

Fig - 1

Two Unit Redundent System With n-Failure Modes

$$P_{5c,1} = P[1-K^*_c(\alpha)] \quad ; \quad P^{(6c)}_{5c,8c} = q[1 - K^*_c(\alpha)]$$

$$P^{(8c)}_{7c,1} = 1 - h_c^*(\alpha) \qquad \ldots (2\text{-}20)$$

V. MAN SOJOURN TIMES

As defined earlier, the mean sojourn time in state S1ε E is

$$\mu_1 = E(T) = \int P[T > t]\, dt$$

Thus we have

$$\mu_0 = 1/\alpha \quad : \quad \mu_1 = [1 - f^*(\alpha)]/\alpha$$

$$\mu_{3c} = [1 - g_c^*(\alpha)]/\alpha \quad ; \quad \mu_{4c} = \int t\, g_c(t)\, dt$$

$$\mu_{5c} = [1 - k_c^*(\alpha)]/\alpha \quad ; \quad \mu_{6c} = \int t\, k_c(t)\, dt$$

$$\mu_{7c} = [1 - h^*_c(\alpha)]/\alpha \quad ; \quad \mu_{8c} = \int t\, h_c(t)\, dt$$

... (2-20)

VI. MEAN TIME TO SYSTEM FAILURE

To obtain the distribution function 11 (t) of TSF with starting state Si, we regard the failed states S2, S4c, S6c and S8c as absorbing.

Using the probabilistic arguments, the recursive relations among II_1 (t)

Are:

$$\Pi_0(t) = Q_{01}(t) \ \$ \ \Pi_1(t)$$

$$\Pi_1(t) = Q_{12}(t) \ \$ \ \Sigma\, Q_{1,3c}(t) \ \$ \ \Pi_{3c}(t)$$

$$\Pi_{3c}(t) = Q_{3c,4c}(t) + \Sigma\, Q_{3c,5c}(t) \ \$ \ \Pi_{5c}(t)$$

$$\Pi_{5c}(t) = Q_{5c,6c}(t) + Q_{5c,0}(t) \ \$ \ \Pi_0(t) + \Sigma\, Q_{5c,7c}(t) \ \$ \ \Pi_{7c}(t)$$

$$\Pi_{7c}(t) = Q_{7c,8c}(t) + Q_{7c,0}(t) \ \$ \ \Pi_0(t) \qquad \ldots (30\text{-}34)$$

{ Σ extends from c = 1 to c = n}

Taking Laplace-Stieltjes transform of these relations and solving for no by omitting the argument "S" for brevity, therefore we get MTSF of the system when it starts operation from. So, as

$$E(T) = \left. \frac{-d\,\tilde{\Pi}_0(s)}{ds} \right|_{s=0} = \frac{D'_1(0) - N'_1(0)}{D_1(0)} = N_1/D_1 \qquad \ldots (35)$$

where

$$N_1 = \mu_0 + \mu_1 + \Sigma\, P_{1,3c}\,(\mu_{3c} + P_{3c,5c}(\mu_{5c} + \mu_{7c} P_{5c,7c})) \qquad \ldots (36)$$

and

$$D_1 = 1 - \Sigma\, P_{1,3c}\, P_{3c,5c}\,(P_{5c,0} + P_{5c,7c}\; P_{7c,0}) \qquad \ldots (37)$$

VII. AVAILABILITY ANALYSIS

As define& the expression for Mi(t) are

$$M_0(t) = e^{-(\alpha+\beta)t} \quad ; \quad M_1(t) = e^{-\alpha t}\bar{F}(t)$$

$$M_{3c}(t) = e^{-\alpha t}\bar{G}_c(t) \quad ; \quad M_{5c}(t) = e^{-\alpha t}\bar{K}_c(t)$$

$$M_{7c}(t) = e^{-\alpha t}\bar{H}_c(t) \quad \ldots (41\text{-}45)$$

From the argument used in the theory of regenerative process, the pointwise yAO) are seen to satisfy the following recursive relations:

$$A_0(t) = M_0(t) + q_{01}(t) ©A_1(t)$$

$$A_1(t) = M_1(t) + q_{1,3c}(t) © A_{3c}(t) + \Sigma\, q^{(2)}_{1,4c}(t) © A_{4c}(t)$$

$$A_{3c}(t) = M_{3c}(t) + \Sigma q^{(4c)}_{3c,6c}(t) © A_{6c}(t) + \Sigma\, q_{3c,5c}(t) © A_{5c}(t)$$

$$A_{4c}(t) = \Sigma\, q_{4c,6c}(t) © A_{6c}(t)$$

$$A_{5c}(t) = M_{5c}(t) + q_{5c,0}(t) © A_0(t) + q^{(60)}_{5c,1}(t) © A_1(t)$$

$$+ \Sigma\, q_{5c,7c}(t) © A_{7c}(t) + \Sigma\, q^{(6c)}_{5c,8c}(t) © A_{8c}(t)$$

$$A_{6c}(t) = q_{6c,1}(t) © A_1(t) + \Sigma\, q_{6c,8c}(t) © A_{8c}(t)$$

$$A_{7c}(t) = M_{7c}(t) + q_{7c,c}(t) © A_0(t) + q^{(8c)}_{7c,1}(t) © A_1(t)$$

$$A_{8c}(t) = q_{8c,1}(t) © A_1(t) \quad \ldots (43\text{-}50)$$

Taking Laplace-transform of the above equations and solving for Mo(s) by omitting the argument "s" for brevity, therefore we (Jet the steady state availability when the system initially starts operation from So is

$$A_0(\infty) = \lim_{s\to 0} s.A^*_0(s) = N_2(O) / D'_2(O) = N_2/D_2 \quad \ldots (51)$$

where

$$N_2 = \mu_0(1 - \Sigma\, P_{1,3c}\, P_{3c,5c}\, (P^{(6c)}_{5c,1} + P^{(6c)}_{5c,8c} + P^{(8c)}_{5c,7c} P_{7c,1})$$

$$- \Sigma\, (P_{1,3c}\, P_{3c,6c} + P^{(2)}_{1,4c})) + \mu_1 + \Sigma\, P_{1,3c}\, \mu_{3c}$$

$$+ \Sigma\, P_{1,3c}\, P_{3c,5c}\, (\mu_{5c} + P_{5c,7c}\, \mu_{7c}) \quad \ldots (52)$$

and

$$D_2 = m_1 + \Sigma\, P_{1,3c}\, (m_{2c} + P_{3c,5c}\, \{(P_{5c,0} + P_{5c,7c}\, P_{7c,0})\, \mu_0$$

$$- m_{3c} + P_{5c,7c}\, m_{4c} \}] + \Sigma\, P^{(2)}_{1,4c}\, \mu_{4c} + \Sigma\, (P_{1,3c}\, P^{(4c)}_{3c,6c}$$

$$+ P^{(2)}_{1,4c})\, \mu_{6c} + P_{6c,8c}\, \Sigma\, (P_{1,3c}\, (P_{3c,5c}\, P^{(6c)}_{5c,8c} + P^{(4c)}_{3c,6c})$$

$$+ P^{(2)}_{1,4c} \}\, \mu_{8c} \quad \ldots (53)$$

VIII. BUSY PERIOD ANALYSIS

According to the definition of Wi(t), we have

$$W_1 = \bar{F}(t) \quad ; \quad W_{3c}(t) = \bar{G}_c(t) = W_{4c}(t)$$

$$W_{5c} = R_c(t) = W_{6c}(t) \quad ; \quad W_{7c}(t) = A_c(t) = W_{8c}(t) \quad \ldots (54\text{-}57)$$

Defining Bi(t) =P[system initial?' from regenerative state S1 is under repair at epoch t}

the following relations among 131(t) hold good

$$B_0(t) = q_{01}(t) © B_1(t)$$

$$B_1(t) = W_1(t) + \Sigma q_{1,3c}(t) © B_{3c}(t) + \Sigma\, q^{(2)}_{1,4c}(t) © B_{4c}(t)$$

$$B_{3c}(t) = W_{3c}(t) + \Sigma q_{3c,5c}(t) © B_{5c} + \Sigma\, q^{(4c)}_{3c,6c}(t) © B_{6c}(t)$$

$$B_{4c}(t) = W_{4c}(t) + \Sigma\, q_{4c,6c}(t) © B_{6c}(t)$$

$$B_{5c}(t) = W_{5c}(t) + q_{5c.0}(t) © B_0(t) + q^{(6c)}_{5c,1}(t) © B_1(t)]$$

$$+ \Sigma q_{5c,7c}(t) © B_{7c}(t) + \Sigma q^{(6c)}_{5c,8c}(t) © B_{8c}(t)$$

$$B_{6c}(t) = W_{6c}(t) + q_{6c,1}(t) © B_1(t) + \Sigma\, q_{6c,8c}(t) © B_{8c}(t)$$

$$B_{7c}(t) = W_{7c}(t) + q_{7c,0}(t) © B_0(t) + q^{(8c)}_{7c,1}(t) © B_1(t)$$

$$B_{8c}(t) = W_{8c}(t) + q_{8c,1}(t) © B_1(t) \quad \ldots (58\text{-}65)$$

Taking Laplace transform of the above equations and solving for B*0(s) by omitting the argument "s" for brevity, one gets the fraction of time for which the system is under repair is given by

$$B_0 = \lim_{t\to\infty} B_0(t) = \lim_{s\to 0} s.B^*_0(s) = N_3 / D_2 \quad \ldots (66)$$

where D_2 is same as in (53) and

$$N_3 = m_1 + \Sigma (m_{2c} + m_{3c}) + \Sigma m_{4c} (P_{1,3c} P_{3c,5c} (P_{5c,7c} + P^{(6c)}_{5c,8c}) + (P_{1,3c} P^{(4c)}_{3c,6c} + P^{(2)}_{1,4c}) P_{6c,8c}\} \quad \ldots (67)$$

IX. . EXPECTED NUMBER VISITS BY THE REPAIRMAN

Using the definition of Vi(t) the following recursive relations among Vi(t) can be obtained :

$$V_0(t) = Q_{01}(t) \$ [1 + V_1(t)]$$

$$V_1(t) = \Sigma Q_{1,3c}(t) \$ V_{3c}(t) + Q^{(2)}_{1,4c}(t) \$ V_{4c}(t)$$

$$V_{3c}(t) = \Sigma Q_{3c,5c}(t) \$ V_{5c}(t) + \Sigma Q^{(4c)}_{3c,6c}(t) \$ V_{6c}(t)$$

$$V_{4c}(t) = \Sigma Q_{4c,6c}(t) \$ V_{6c}(t)$$

$$V_{5c}(t) = Q_{5c,0}(t) \$ V_0(t) + Q_{6c,1}(t) \$ V_1(t) + \Sigma Q_{5c,7c}(t) \$ V_{7c}(t) + \Sigma Q^{(6c)}_{5c,8c}(t) \$ V_{8c}(t)$$

$$V_{7c}(t) = Q_{7c,0}(t) \$ V_0(t) + Q^{(8c)}_{7c,1}(t) \$ V_1(t)$$

$$V_{8c}(t) = Q_{8c,1}(t) \$ V_1(t) \quad \ldots (68-$$

Taking Laplace-Stieltjes transform of the above equations and solving for Vo(s) by omitting the argument "s" for brevity, we get the expected number of visits per unit of time in steady state as-

$$V_0 = \lim_{t\to\infty} [V_0(t) / t] = \lim_{s\to 0} \tilde{V}_0(s) = N_4 / D_2$$

where D_2 is same as in (53) and

$$N_4 = \Sigma P_{1,3c} P_{3c,5c} (P_{5c,0} + P_{5c,7c} P_{7c,0})$$

REFERENCES

[1] L.R. Goel, R.K. Agnihotri and Rakesh Gupta (1990) Stochastic analysis of a two unit warm standby system with fault detection and inspection. Micro electron Reliab. Vol. 30. No. 1, PP. 61-65.

[2] L.R. Gocl,S.C. Sharma (1989) : Stochastic analysis of a two unit standby system with two factor modes and slow switch. Micro electron Reliab. 29, 493-498.