Availability analysis of two parallel unit system under the provision of maintenance

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Abstract:

Objectives: This paper illustrates the availability investigation of a two unlike parallel unit stand-in system under the provision of preventive or protective maintenance (PM) as well as on the spot substitute of low cost unit. Only one repair man availability in the system has been considered for both repair work and maintenance work.

Methods/Statistical Analysis: We had analyzed the system/framework under the assistance of regenerative point techniques.

Findings: Many graphs have been plotted for discussing/examine the Graphical trends of MTSF and availability which are very useful for the manufacturer, Reliability engineers, managers etc. Novelty/Improvements: This study can be used or applicable to optimize the reliability of the electronics framework/system in the industry.

Keyword: MTSF, Availability of the system, Analysis of Busy time of server.

I. INTRODUCTION

Number of researchers/engineers are involved in the field of investigation of unwavering quality and accessibility of the electronics components/frameworks. A two unit cold stand-in arrangement discussed with the presupposition of the breakdown rate of a unit is steady and the renovate time dispersion is a two-phase Erlang distribution. For the framework execution examination they determined mean time before failure, system availability, and relentless state accessibility¹. The unwavering quality examined, of more than one component standby framework with alone repair facility. For acquiring desired reliability, they interchanged the active and the standby components at randomly and they also used the concept of preventive maintenance (PM) of functioning in addition to the stand-in component. After the completion of the work of repair, they sent the particular unit for examine whether the repair was satisfactory or not². A paper presented on a framework wherein both PLC’s were working in master-slave pattern. They had assumed that main component is Functioning, and the secondary component was in stand in phase. The secondary component had more reliability as compared to the main one³. A newly genetic algorithm concept discussed, to get the solution of reliability optimization problem in a k unrelated-component non-repairable surplus system. There they discussed that each component is linked with a number of self-sufficient components with Erlang distributions set in a series-parallel pattern. The main role of their work was to get the idea about the best component⁴.

A work explained on the study of a computer database framework having Primary database and backup database component⁵. Reliability analysis done by two researchers on two unit stand by system under the concept of Poisson shock⁶. Reliability analysis explained under the perfect environment as far as repair work is concerned⁷. The purpose of our work is to investigate a real life model existing in a cable manufacturing plant located at Baddi, Himachal Pradesh, India. Single repairman was available there for both repair and maintenance work as well. So here we worked on such a system with two different parallel components, one and only of them is adequate for working the framework/system, framework comes up short totally if both the components fail flat simultaneously. And here preference of repair has been given to unit A over the unit B if both get failed and it is a choice of management or engineer that they can also go for replacement of unit B if both components get failed.

II. SYSTEM DESCRIPTION AND ASSUMPTIONS

1) System composed of two unlike components A and B, Component A is functioning in the starting for operation but the unit B is in rest mode.

2) There is only one server/repairman facility available. He/she may appear and disappears from the system randomly. It has been assumed
that if the repairman starts the repair or PM he cannot go for the vacation.

3) If both components are in failure mode then preference has been given to unit A for repairing first

Notations
For getting the MTSF and other reliability characteristics we are having the state transition table and symbols as follows:

\( A_0 \): Component A is in active state
\( B_0 \): Component B is in active state
\( A_{Fr} \): Component A under failure state
\( A_{pm} \): Component A under PM state
\( B_{Fr} \): Component B under failure state
\( A_w \): Component A is in Waiting state
\( B_w \): Component B is in Waiting state

\[
P_{01} = \frac{\alpha_1 (1-r_1)}{\alpha_1 (1-r_1) + \lambda_1 + \theta_1}
\]
\[
P_{02} = \frac{\lambda_1}{\alpha_1 (1-r_1) + \lambda_1 + \theta_1}
\]
\[
P_{03} = \frac{\alpha_3 (1-r_3)}{\beta_3 (1-r_3) + \alpha_3 (1-r_3)}
\]
\[
P_{04} = \frac{\beta_3 (1-r_3)}{\beta_3 (1-r_3) + \alpha_3 (1-r_3)}
\]

After calculation we are getting

\[ P_{01} + P_{02} + P_{03} = 1 \]
\[ P_{13} + P_{10} = 1 \]
\[ P_{35} = 1 \]

Mean sojourn Time
The mean (interim) time consumed by the framework to passage from state “i” when it is counted from epoch of passage into state “i” mathematically or scientifically expressed as:

\[
m_{ij} = \int_{0}^{\infty} t q_{ij} (t) dt = -q_{ij}^{-1} (0) \quad (21)
\]

III. ANALYSIS OF CHARACTERISTICS OF RELIABILITY

MTSF (Mean Time to System Failure)
To decide the MTSF of the framework, we assumed the fizzled condition of the framework as engrossing state, by applying some mathematical concepts like probability and Laplace Stieltjes transforms and solving for \( \phi_0^{**} (s) \), we get

\[
\phi_0^{**} (s) = \frac{N(s)}{D(s)}.
\]

After taking the limit with the help of L-Hospital’s rule we have

\[ N = \frac{\mu_0 + \mu_1 (p_{01} + p_{02}P_{08}P_{24}P_{41}) + \mu_2 P_{02}P_{08} + \mu_3 P_{02}P_{20}}{D} \]

\[ D = 1 - p_{01}p_{10} - p_{10}P_{02}P_{24}P_{41} - p_{02}P_{20} \]

**Availability Analysis**

Utilizing numerical approach availability (accessibility) \( A_i(t) \) can be described by the following expressions,

\[ A_0^* (s) = \frac{N_1}{D_1 (s)} \]

The steady state availability is

\[ A_0 = \lim_{s \to 0} \frac{N_2}{D_1 (s)} \]

\[ N_1 = \mu_0 (1 - p_{46}P_{64})(\mu_0 + \mu_1 P_{01} + \mu_2 P_{02}P_{08}) - p_{51.3}P_{15.3}P_{15.3} \]

\[ + (1 - p_{46}P_{64})P_{01}P_{15.3} + \mu_2 P_{02}P_{08} \]

\[ D_1 = (1 - p_{46}P_{64})(1 - p_{51.3}P_{15.3} + p_{24}P_{08}P_{01}) + (1 - p_{46}P_{64})P_{01}P_{15.3} \]

**Analysis of Busy time of server**

Let \( B(t) \) be the probability that the only server given by the company’s organization is engaged at instant \( t \), provided the framework is entered to regenerative state “i” initially. By probability theory, we have the following equations for busy period,

\[ B_0 (s) = \frac{N_1}{D_1 (s)} \]

\[ B_0 = \lim_{s \to 0} \frac{N_2}{D_1 (s)} \]

\[ N_2 = \mu_0 (1 - p_{46}P_{64}) + \mu_1 P_{15.3} + \mu_2 P_{02}P_{24} \]

\[ + p_{02}P_{08}P_{24}[\mu_4 (1 - p_{15.3}P_{51.3})] \]

**V. REFERENCES**


Table 1
(State Transition Table)

<table>
<thead>
<tr>
<th>States</th>
<th>$S_0$</th>
<th>$S_1$</th>
<th>$S_2$</th>
<th>$S_3$</th>
<th>$S_4$</th>
<th>$S_5$</th>
<th>$S_6$</th>
<th>$S_7$</th>
<th>$S_8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td>$A_{c1}, B_o$</td>
<td>$A_{f1}, B_o$</td>
<td>$A_{f2}, B_w$</td>
<td>$A_{c1}, B_o$</td>
<td>$A_{w1}, B_o$</td>
<td>$A_{c1}, B_f$</td>
<td>$A_{w1}, B_w$</td>
<td>$A_{w1}, B_f$</td>
<td>$A_{w1}, B_o$</td>
</tr>
<tr>
<td>Status of the state</td>
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<td>operative</td>
<td>Operative</td>
<td>failed</td>
<td>operative</td>
<td>Operative</td>
<td>failed</td>
<td>failed</td>
<td>Operative</td>
</tr>
<tr>
<td>Repairman Availability</td>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Figure 1 (MTSF vs Failure Rate)

- $r_{11}=0.25$
- $r_{12}=0.50$
- $r_{13}=0.75$
Figure 2. (Availability vs Failure Rate)

Figure 3. (Profit vs Failure Rate)
Figure 4. (Profit vs Failure Rate)

Figure 5. (Busy Period vs Failure Rate)