AN NEW ALGORITHIM FOR IMPROVING RELIABILITY OF A SERIES BASED DESIGNED SYSTEM BY INCREASING ELECTRONIC COMPONENTS RELIABILITY

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ABSTRACT

Reliability engineers are very often called upon to make decisions as to whether to improve a certain electronic component or components in order to achieve minimum required system reliability in small scale industry (SSI). (Note: This minimum required system reliability is for a specified time.) There are two approaches to improving the reliability of a system: fault avoidance and fault tolerance. Fault avoidance is achieved by using high-quality and high-reliability electronic components and is usually less expensive than fault tolerance. Fault tolerance, on the other hand, is achieved by redundancy. Redundancy can result in increased design complexity and increased costs through additional weight, space, etc. Before deciding whether to improve the reliability of a system by fault tolerance or fault avoidance, a reliability assessment for each electronic component in the system should be made. In this paper series designed based system reliability is discussed where reliability of system is increased by increasing electronic components reliability in small scale industry.

Keywords: System Reliability, Fault Tolerance, Fault Avoidance, Redundancy & Design Complexity.

I. INTRODUCTION

Modern systems and devices (electronic systems, electronic devices and components, electrical and mechanical systems) are made to operate under a number of extreme environmental and operating conditions. The resulting stresses can affect the working-life of the electronic components and test their endurance to the limit. Failure of systems and devices can be categorized in a number of ways such that major failures, minor failures, parametric failures, catastrophic failures etc. System which we dealt in this work will be followed by boundary condition. Output of these systems depends upon the output of Electronic Components used in the system. There are small and simple systems or big and complex systems. Small systems may be like electronic toys, weighing machines, calculators etc. and big systems may be like complicated Aircraft monitoring systems, Missile detection and shooting system, Banking system, Mobile system etc. System will do production or it will be directly related to the revenue generation. In both the cases operation has to be done successfully. System may be any but analysis of it should be thoroughly. Otherwise there may fault occur at later stage. Cost factor play important role if the electronic component is to be changed or not. If cheap and easily available electronic component is changed before it expected life than the reliability of the system will remain as required. Otherwise if we change after the failure than complete system will come at stand still and it will effect the production as well as revenue generation. Electronic components whose chances of failure are more than they should be connected in parallel. In summery electronic components should be replaced before their expected life. It is better to avoid group replacement. It depends on the cost factor of electronic component whether it has to be replaced individually or in group.

II. DESIGN ANALYSIS

Once the reliability values for the components have been quantified, an analysis can be performed in order to determine if that system's reliability goal will be met. If it becomes apparent that the system's reliability will not be adequate to meet the desired goal at the specified mission duration, steps can be taken to determine the best way to improve the system's reliability so that it will reach the desired target. In a system with three electronic components connected reliability-wise in series. The reliabilities for each component for a given time are:

R_1 = 70%, R_2 = 80% and R_3 = 90%.

A reliability goal, R_G = 85%, is required for this system.

The current reliability of the system is:

$$R_s = R_1 \cdot R_2 \cdot R_3 = 50.4\% \qquad \text{------------ (1)}$$

Obviously, this is far short of the system's required reliability performance. It is apparent that the reliability of the system's constituent electronic components will need to be increased in order for the system to meet its goal. First, it will be tried to increase the reliability of one electronic component at a time to see whether the reliability goal can be achieved. Figure 1.2 shows that even by raising the individual component reliability to a hypothetical value of 1 (100% reliability, which implies that the component will never fail), the overall system reliability goal will not be met by improving the reliability of just one component. The next logical step would be to try to increase the reliability of two components. The question now becomes: which two? One might also suggest increasing the reliability of all three components. A basis for making such decisions needs to be found in order to avoid the "trial and error" aspect of altering the system's components randomly in an attempt to achieve the system reliability goal. As the reliability goal for the preceding example could not be achieved by increasing the reliability of just one component. There are cases, however, where increasing the reliability of one component results in achieving the system reliability goal. Consider, for example, a system with three components connected reliability-wise in parallel. Three electronic components connected parallel wise will make the system to work in better way as if one system fails then other system are there to cover up. Thus for better production parallel system is preferred than series system.

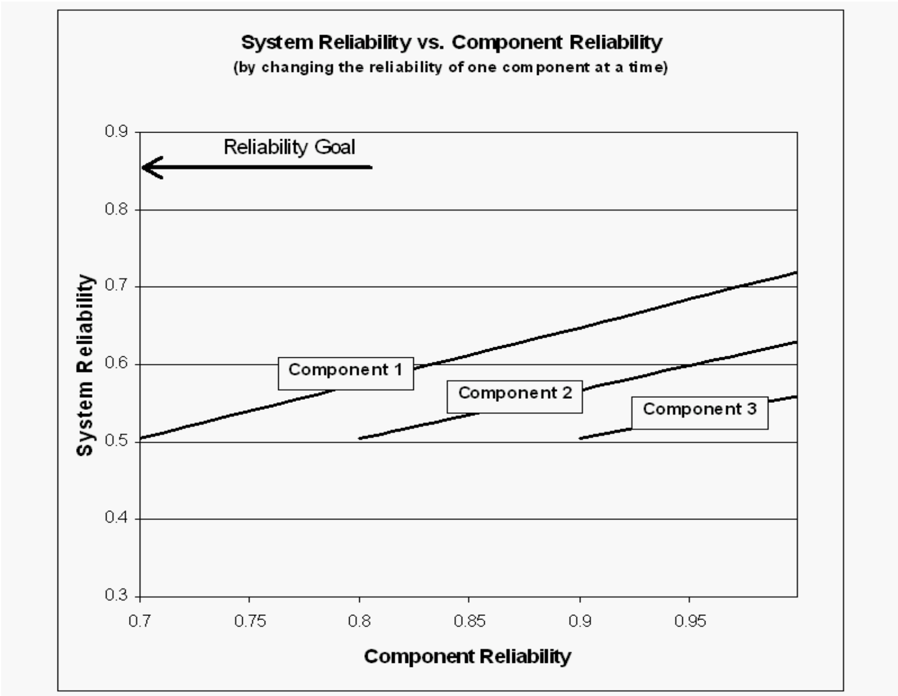

Figure 1.2: Change in System Reliability if A Three-Unit Series System Due to Increasing The Reliability of Just one Component.

The reliabilities for each component for a given time are:

R_1 = 60%, R_2 = 70% and R_3 = 80%.

A reliability goal, R_G = 99%, is required for this system. The initial system reliability is:

$$R_S = 1 - (1 - 0.6) \cdot (1 - 0.7) \cdot (1 - 0.8) = 0.976 \qquad \text{---------- (2)}$$

The current system reliability is inadequate to meet the goal. Once again, we can try to meet the system reliability goal by raising the reliability of just one of the three components in the system.

III. RELIABILITY GOAL OF SYSTEM CAN BE IMPROVED BY CHANGING RELIABILITY OF ELECTRONIC COMPONENTS

As reliability for the system is fixed for specific problem in system, thus it can be improved by improving reliability of individual electronic components. From Figure 1.3, it can be seen that the reliability goal can be reached by improving Component 1, Component 2 or Component 3. The reliability engineer is now faced with another dilemma: which component's reliability should be improved? This presents a new aspect to the problem of allocating the reliability of the system.

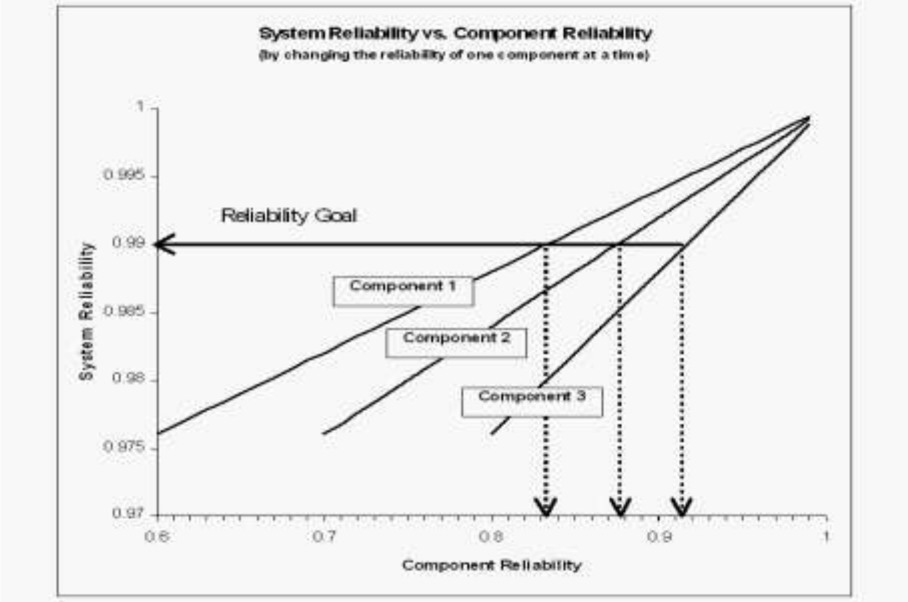

Figure 1.3: Meeting a Reliability Goal Requirement by Increasing a Component's Reliability.

Since we know that the system reliability goal can be achieved by increasing at least one unit, the question becomes one of how to do this most efficiently and cost effectively. We will need more information to make an informed decision as to how to go about improving the system's reliability.

IV. COST VALUES TO THE RELIABILITIES OF THE SYSTEM'S COMPONENTS

How much does each component need to be improved for the system to meet its goal? How feasible is it to improve the reliability of each component? Would it actually be more efficient to slightly raise the reliability of two or three components rather than radically improving only one? In order to answer these questions, we must introduce another variable into the problem: cost. Cost does not necessarily have to be in rupees. It could be described in terms of non-monetary resources, such as time. By associating cost values to the reliabilities of the system's components, we can find an optimum design that will provide the required reliability at a minimum cost. There is always a cost associated with changing a design due to change of vendors, use of higher-quality materials, retooling costs, administrative fees, etc. The cost as a function of the reliability for each component must be quantified before attempting to improve the reliability. Otherwise, the design changes may result in a system that is needlessly expensive or over designed. Developing the "cost of reliability" relationship will give the engineer an understanding of which components to improve and how to best concentrate the effort and allocate resources in doing so. The first step will be to obtain a relationship between the cost of improvement and reliability. The preferred approach would be to formulate the cost function from actual cost data. This can be done from past experience. However, there are many cases where no such information is available. For this reason, a general (default) behavior model of the cost versus the component's reliability was developed for performing reliability optimization. One needs to quantify a cost function for each component, C_i, in terms of the reliability, R_i, of each component, or:

$$C_i = f(R_i) \qquad \text{----------------- (3)}$$

This function should:

1. Look at the current reliability of the component, $R_{Current}$.

2. Look at the maximum possible reliability of the component, R_{Max}.
3. Allow for different levels of difficulty (or cost) in increasing the reliability of each component. It can take into account:

- Design issues.
- Supplier issues.
- State of technology.
- Time-to-market issues, etc.

V. CONDITIONS ADHERED TO COST FUNCTION

Thus, for the cost function to comply with these needs, the following conditions should be adhered to:

1. The function should be constrained by the minimum and maximum reliabilities of each component (*i.e.* reliability must be less than one and greater than the current reliability of the component or at least greater than zero).
2. The function should not be linear, but rather quantify the fact that it is incrementally harder to improve reliability. For example, it is considerably easier to increase the reliability from 90% to 91% than to increase it from 99.99% to 99.999%, even though the increase is larger in the first case.
3. The function should be asymptotic to the maximum achievable reliability.

VI. CONCLUSIONS

In this work following conclusions are made:

- Each electronic components reliability cannot be improved after certain parameters.
- It is practically not feasible to improve the reliability of every electronic component in every case.
- It is actually be more efficient to slightly raise the reliability of two or three components rather than radically improving only one.

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