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An Investigation of Redundant System with Common Cause Failures

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Abstract

In this paper, we discussed a redundant system and the behavior of with common cause failure condition follows. Reliability prediction is an essential function in evaluation a system design from its conceptual stage through development and manufacture and also in assisting in controlling changes during the production. In the discussion of this accurate prediction of the reliability of a new product before it is manufactured or marked, is highly desirable, since with the advance knowledge of its reliability accurate forecasts of support costs, and space etc., could be made with reasonable certainty.

Key Words: *Redundant System, Failure Mode Effects, Maintainability Analysis, PC Method, Environment Item.*

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1. INTRODUCTION

When the design of an electronic system to perform a complex [4] and demanding job is proposed, it is assumed that the required investment will be justified when the system fails to perform the job upon demand or fails to perform repeatedly.

Almost the various evolving technologies, electronics evolution is particularly rapid it is sometimes referred to as an exploding technology [6]. As there is very little time for an orderly evolution of systems, applications suffer most from unreliability. The ratio of new to tried portions of electronic systems is relatively high and till the new becomes proven and true, its reliability [2] must be suspected.

Reliability investigation has many purpose as under:

- [i] Basis for selection among competing designs.
- [ii] Disclose critical or reliability limiting items in the design.
- [iii] Sensitivity of design to electrical stress, thermal stress and part quality.
- [iv] Basis of reliability tradeoffs among system components.
- [v] Describe numerically the inherent reliability [8-10] of the design**.**
- [vi] Provide input to design review, Failure Mode Effects [1,3] and Criticality Analysis (FMECA) maintainability analysis, safety analysis, logistic support and thermal design.

2. INVESTIGATION METHODOLOGY OF COMMON CAUSE FAILURE BY PARTS COUNT METHOD

The part count method is a predication method used in the preliminary design stage [12] when the number of parts in each generic type class such as capacitors, resistors etc., are reasonably fixed and the overall design complexity is not expected to change appreciably during later stages of development and production. The parts count method assumes the time to failure of the parts as exponentially distributed [14].

The item failure rate can be determined directly by the summation of part failure rates if all elements of the item reliability model are in series or can be assumed in series for purposes of an approximation. In the event the item reliability model consists of non-series element item reliability can be determined by summing part failure rates [5] for the individuals elements and calculating an equivalent series failure rate for the non-series elements of the model.

The information needed to support the parts count method includes.

- [i] Generic part types [7]
- [ii] Part quantity
- [iii] Part quality levels
- [iv] Item environment

The general expression for item failure rate with this method is

$$\lambda_{item} = \sum_{i=1}^{n} N_i \lambda_G \{\prod Q_i\},$$ for a given item environment [9] where,

$\boldsymbol{\lambda_{item}}$	Total failure rate
$\boldsymbol{\lambda_G}$	Generic failure rate for the i^{th} generic part.
$\prod \mathbf{Q}_i$	Quality factor for the i^{th} generic part.
$\mathbf{N}_i$	Quality of the i^{th} generic part.
n	Number of different generic part categories.

The above equation applies to an entire item being used in one environment.
If the item comprises several units operating in different environment (such as avionics with units in airborne, inhabited fighter (**A_{IF}**) and uninhabited fighter (**A_{UF}**) environment. These 'environment item' failure rates should be added to determine total item failure rate [11].

3. Redundancy System in Common Cause Failure at Component Level

Consider the first configuration as given in Fig. 3a

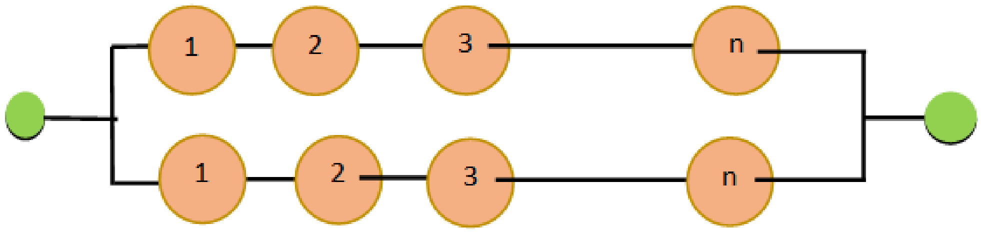


Figure: 3a

In this configuration Fig. 3a, there are n components connected series, and the set of this n components is placed in parallel [13] with another set.

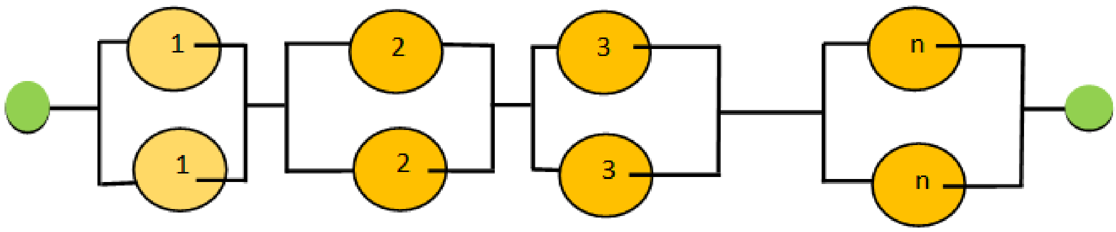


Figure: 3b

In this configuration Fig. 3b, there components have been first placed in parallel, and in terms connected in series.

Let the reliability of each component be ***r***. The reliability of the system (***R_S***) in the case of configuration Fig. 3a, can be expressed as

$$R_S = 1 - (1 - r^n)^2 = r^n (2 - r^n)$$

The reliability of the system **R'_S** in the case of configuration Fig. 3b, is expressed as

$$R'_S = [1 - (1 - r^n)^2]^n = r^n (2 - r)^n$$

The ratio of ***R'_S*** and ***R_S*** gives

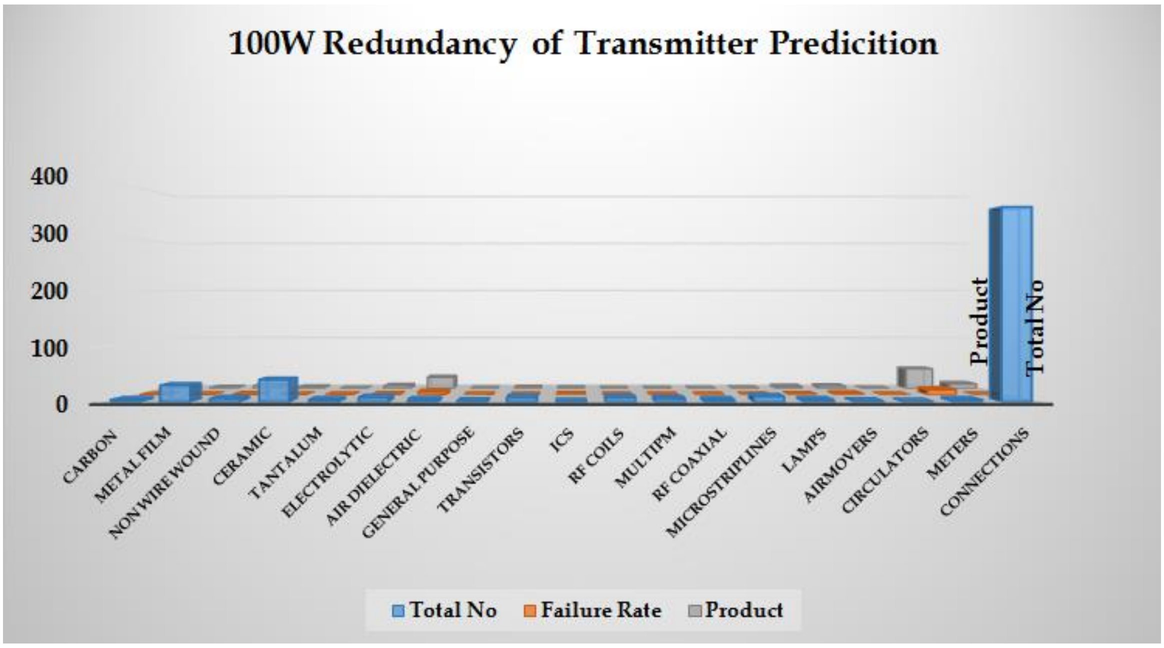
$$\frac{R'_S}{R_S} = \frac{(2-r)^n}{(2-r^n)}$$

Observation: We observed that $R'_S : R_S$ is greater than unity for r < 1. Hence the configuration Fig., would always provide higher reliability of Redundancy components [15].

Construct a Table as given below:

Component	**Total No.**	**Failure Rate λ_G x 10^6**	**Product x 10^6**
Resistors (fixed)			
Carbon	4	0.033	0.132
Metal Film	30	0.046	1.380
Resistors (variable)			
Non Wire Wound	6	0.900	5.400
Capacitors (fixed)			
Ceramic	40	0.054	2.160
Tantalum	4	0.042	0.168
Electrolytic	8	0.660	5.280
Capacitors (fixed)			
Air Dielectric	4	5.70	22.800
Diodes			
General Purpose	2	0.031	0.062
Transistors (NPN)	8	0.160	1.280
ICs	1	1.085	1.085
RF Coils	8	0.011	0.088
Connectors			
Multi-pin	6	0.051	0.306
RF Coaxial	4	0.051	0.204
Micro-strip lines	10	0.072	0.720
Miscellaneous			
Lamps	4	1.000	4.000
Air movers	2	2.400	4.800
Circulators	1	0.240	0.240
Meters	4	10.000	40.000
Connections	350	0.027	9.450
Total		99.56	

Graphical Diagram Representation between Failure Rate and Product:



4. Conclusion and Future Work

In typical parts count method prediction transmitter unit, the quality failure are to be applied to each part type where quality level data exists or can be reasonably assumed multi-quality levels and data exists for parts such as microelectronics, discrete semiconductors, and capacitors.

For other parts such as non-electronics ∏ **Qi = 1**, provided that parts are procured in accordance with applicable parts specifications.

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