CE-370 Safety and Reliability of Engineering Systems

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SUMMARY OF LECTURE 9 - RELIABILITY OF COMPONENTS IN PARALLEL

Many engineering systems are arranged such that if any single component survives the complete system will survive. Consider as examples a multi-lane highway or an electric grid with multiple power sources. These systems are referred to as parallel systems. Mathematically we can express the probability of failure of such systems as

$$F_s(t) = \prod_{i=1}^{n} F_i(t) \tag{1}$$

and their reliability as

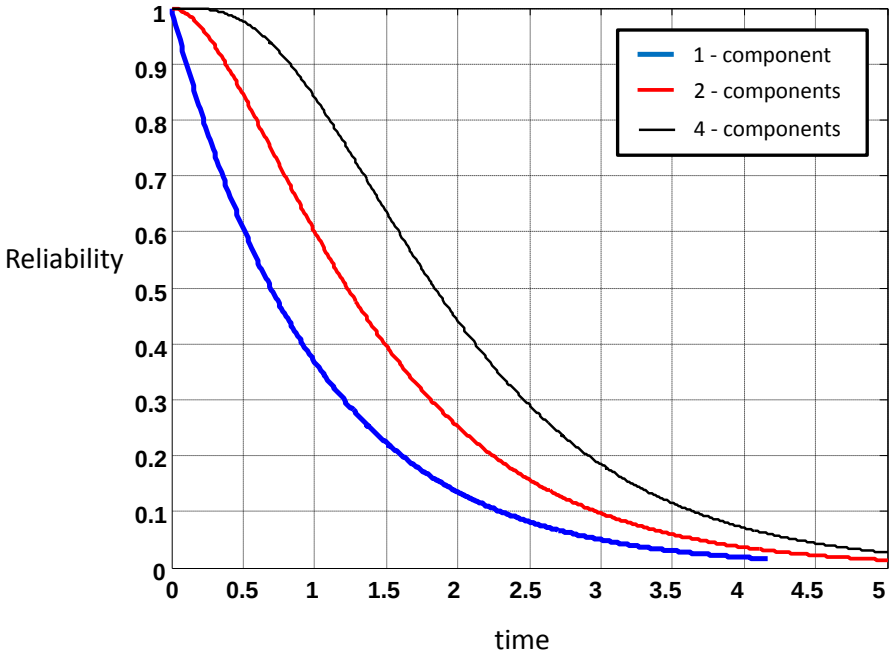
$$R_s(t) = 1 - \prod_{i=1}^{n} F_i(t) = 1 - \prod_{i=1}^{n} (1 - R_i(t)) \tag{2}$$

where n is the number of components in the system and $R_i(t)$ is the reliability function of component i.
In the case of a parallel system with n components with uniform failure rate λ, the reliability function is given by

$$R_s(t) = 1 - \left(1 - R_o e^{-\lambda t}\right)^n \tag{3}$$

Example - Parallel System

Consider parallel systems with 1,2, and 4 components respectively. Each component is exponential with failure rate $\lambda = 1$. In the figure below (see next page) we show the reliability function for each respective case. As can be seen, as time elapses the reliability of the parallel system with multiple components increases with respect to the reliability of the single unit system.


Reliability
time
1 - component
2 - components
4 - components
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5