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Failure mechanism dependence and reliability evaluation of non-repairable system

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Abstract: Reliability study of electronic system with physics-of-failure method has been promoted due to the increase knowledge of electronic failure mechanisms. System failure initiates from independent failure mechanisms, have effect on or affect by other failure mechanisms and finally result in system failure. Failure mechanisms in a non-repairable system have many kinds of correlation. One failure mechanism developing to a certain degree will trigger, accelerate or inhibit another or many other failure mechanisms, some kind of failure mechanisms may have the same effect on the failure site, component or system. The destructive effect will be accumulated and result in early failure. This paper presents a reliability evaluation method considering correlativity among failure mechanisms, which includes trigger, acceleration, inhibition, accumulation, and competition. Based on fundamental rule of physics of failure, decoupling methods of these correlations are discussed. With a case, reliability of electronic system is evaluated considering failure mechanism dependence.

Keywords: failure mechanism dependence; trigger; acceleration; reliability evaluation; non-repairable system

Nomenclature

M_i	the i_{th} mechanism	ΔX	accumulated damage in unit time
t_i	the failure time of M_i	$F(t)$	failure probability function of system
F	system failure	$F_i(t)$	failure probability function of M_i
ς	system lifetime	$f_i(t)$	failure density function of M_i
X_{th}	the threshold of system due to damage	T_{tr}	trigger time
X_{Mith}	the threshold of damage caused by M_i	$F_{tr}(t)$	failure probability function of T_{tr}
$X_{Mi}(t)$	damage that M_i brings to the system and varies with time t	$f_{tr}(t)$	failure density function of T_{tr}
ΔX_i	damage in unit time due to M_i		

1 Introduction

Failure dependence has been extensively treated in reliability modeling for complicated system in aerospace, aviation, naval and nuclear power plants system. For example, a two-component parallel system, when one of the components fails, the stress places on the surviving component will change. Dependent failure will increase joint-failure probabilities, and then reduce system reliability [1]. Thus, for many complicated system, a modeling approach incorporating dependent failure resembles the true system reliability behavior in a more realistic manner.

Failure dependence exists in different levels of real-life system, these levels includes system level, component level and failure process or failure mechanism level. On system or component level, considerable research efforts have been devoted to modeling common cause failure (CCF), which is defined as a subset of dependent failures in which two or more component functional fault states exist at the same time, or within a short interval, as a result of a shared cause. For example, Jose and Coit [2]proposed three different reliability optimization models for redundancy system subject to CCF and results show that the consideration of common cause failures will lead to different optimal design strategies.

Levitin [1] believes that CCFs of a system may cause by external cause as well as internal cause. Failures caused by common internal cause are called propagated failures. And for a component, the failure can be classified