

# Unitary State Failure Mode Sets

R.P.Clark

April 2, 2010

## Abstract

This chapter defines what is meant by the terms components, component fault modes and ‘unitary state’ component fault modes. Mathematical constraints and definitions are made using set theory.

## 1 Introduction

When building a system from components, we should be able to find all known failure modes for each component. For most common electrical and mechanical components, the failure modes for a given type of part can be obtained from standard literature[?] [?].

An important factor in defining a set of failure modes is that they should be as clearly defined as possible. It should not be possible for instance for a component to have two or more failure modes active at once.

Having a set of failure modes where  $N$  modes could be active simultaneously would mean having to consider  $2^N$  failure mode scenarios. Should a component be analysed and simultaneous failure mode cases exit, the combinations could be represented by a new failure modes, or the component should be considered from a fresh perspective, perhaps considering it as several smaller components within one package.

**Definition: 1.** *A set of failure modes where only one fault mode can be active at a time is termed a ‘unitary state’ failure mode set. This is termed the  $U$  set throughout this study. This corresponds to the ‘mutually exclusive’ definition in probability theory[?].*

We can define a function  $FM()$  to take a given component  $K$  and return its set of failure modes  $F$ .

$$FM : K \mapsto F$$

We can further define a set  $U$  which is a set of sets of failure modes, where the component failure modes in each of its members are unitary state. Thus if the failure modes of  $F$  are unitary state, we can say  $F \in U$ .

### 1.1 Component failure modes : Unitary State example

A component with simple “unitary state” failure modes is the electrical resistor.

Electrical resistors can fail by going OPEN or SHORTED. However they cannot fail with both conditions active. The conditions OPEN and SHORT are mutually exclusive. Because of this the failure mode set  $F = FM(R)$  is ‘unitary state’.

Thus

$$R_{SHORTED} \cap R_{OPEN} = \emptyset$$

We can make this a general case by taking a set  $C$  representing a collection of component failure modes, We can now state that

$$c1 \cap c2 \neq \emptyset | c1 \neq c2 \wedge c1, c2 \in C \wedge C \notin U$$

That is to say that if it is impossible that any pair of failure modes can be active at the same time the failure mode set is not unitary state and does not exist in the family of sets  $U$

Note where that are more than two failure modes, by banning pairs from happening at the same time we have banned larger combinations as well

April 2, 2010