Introduction to Failure Mechanisms

What is a failure?

We start by asking the question 'what is a failure?', because this is not always a straightforward issue. Take the high mileage car which you traded in. Was this because it totally failed to function? More likely it was because it had started to exhibit increased fuel consumption, occasionally didn't start too well, or didn't look as smart as in its youth. All these represent failures, but at different levels.

Other kinds of equipment may still function as intended, but no longer be compatible with other requirements, standards or legislation – someone, somewhere must still have a working BetaMax VCR! Other kinds of failure in the consumer market relate to a product not being state-of-the-art, or reflecting the most modern styling, considerations which fuel the mobile communications and games industries.

In the same way, at the system level, electronic failures will vary very considerably from total failure to function, through to purely cosmetic issues. Whilst creating a product that looks the part, and is made to an acceptable cosmetic standard, is of major interest to the marketers and manufacturers of equipment, in most of our reliability material we are looking primarily at the failure of individual components, rather than systems, and only at those types of failure that result in system malfunction.

Types of electronic failure

At the component level, electronic failures fall into four categories:

- ‘Catastrophic failures’, where the failure of function is total, as with diodes that conduct in both directions, transistors without gain, or capacitors which become short-circuit.

- ‘Parametric failures’, where the component functions in the intended manner, but outside normal operating limits. Examples of this are passive components which have drifted outside tolerance, perhaps altering the response curve of filters.

- ‘Intermittent failures’, where the function is correct for the majority of the time, but occasionally becomes for a short time either a catastrophic or parametric failure. Such faults are commonly caused by poor connections.

- Related to the parametric failure is the failure of the component to work correctly over the intended range of environments – circuits may malfunction at low or high temperature, or under conditions of vibration.

The effect that component failures will have on the system depends on the fault tolerance of the system, and the degree and type of failure. With high-reliability requirements, it is not uncommon for designs to be deliberately made to tolerate degrees of failure, particularly at a system level. An example of this might be a critical server application, where the operation of one system is mirrored by a second fully-functioning machine which takes over automatically if the main system fails.

In considering failure, we also have to bear in mind the possibility that there will be some knock on consequences, particularly of catastrophic failures. For example, failure in protection components can result in the failure of associated circuitry – service personnel will be familiar with cases where a cheap component fails and 'takes out' an expensive module elsewhere in the circuit. Sometimes this knock-on failure can be quite dramatic. The writer recalls a very expensive complex assembly becoming a total write-off because of the short-circuit failure of a ceramic capacitor placed across a high current supply, when it literally burnt a hole in the board!

What causes electronic failure?

A range of conditions cause electronic failures. Sometimes the mechanism is simple overload, but often misuse, misapplication, lack of full testing, or defects in manufacture can play a part. At the*system* level, failures can be caused by:

- drift in component parameters
- short or open circuits due to solder defects
- connectors, switches or relays going high resistance
- mismatches in component tolerances
- electromagnetic interference disturbing circuit function.

In considering the potential for failure, it is important to keep in mind that the majority of components used in electronic assemblies do not have mechanisms that would cause the part to degrade sufficiently to fail during storage or normal use, *provided* that they:

- have been selected correctly for the application as regards performance, protection against the environment, and the level of thermal, electrical and mechanical stress applied
- were not defective when manufactured, and have not been damaged during assembly and test.

These are important provisos, but remember that the quality of manufacture of modern electronic components is high, with typically fewer than 10 defective parts per million for complex components such as integrated circuits, and even less for simpler components.

Source : http://www.ami.ac.uk/courses/topics/0180_ifm/index.html