<u>The Hidden Reliability Cost of Degraded Components in Electronic Products: Overcoming the Challenges with 100% Inspection</u>

Eyal Weiss

Degraded components are a significant contributor to the higher-than-theoretical fail rate in electronic products, but they can be avoided through 100% inspection and analysis. The use of AI and big data in the inspection process can greatly enhance the detection of degradation and improve overall product reliability.

Reliability and Mean Time Between Failures (MTBF) are critical factors that determine the quality and longevity of electronic products. Electronic systems can experience a variety of degradation mechanisms over time, including corrosion, contamination, and material degradation, among others. These degradation mechanisms can reduce the MTBF of the components and, in turn, the overall MTBF of the product.

In this article, we'll discuss the impact of degraded components on the MTBF of electronic products, with a focus on the difference between ground benign (GB) and ground mobile (GM) conditions. For the purposes of this discussion, we'll assume that the server rooms are GB and the automotive environment is 80% GM and 20% GB.

We'll examine the case of a board that contains 5 Bill of Materials (BOM) lines: 100 Multi-Layer Ceramic Capacitors (MLCC), 100 chip resistors, 1 Analog to Digital Converter (ADC), 1 regulator, and 1 EEPROM. A conventional MTBF calculation under server room conditions yields a fail rate of 0.062% after one year, while in automotive conditions, it is 0.72%. However, when a single component is degraded, either by reducing its lifespan by a factor of 150 in a server room or 50 in an automotive, the fail rate increases dramatically.

For example, if a single MLCC is degraded, the fail rate after one year will increase to 0.069% under GB conditions and 0.79% under GM conditions. Similarly, a single degraded chip resistor will result in a fail rate of 0.208% in server room conditions and 1.49% in automotive conditions. And if a single ADC is degraded, the fail rate will be 0.208% under server room conditions and 1.49% under automotive conditions.

It is important to note that these degraded components will not be detected during the production stage testing as the failure rate is only observed over many years. These degraded components will have a statistical impact on the overall MTBF of the product and its fail rate in the field, depending on the environmental stress it undergoes.

The industry-standard fail rate of approximately 1.5% within a year in office environments is mostly due to degraded components that are already in the products. The theoretical fail rate of 0.06% suggests that the actual fail rate of 1.5% already includes degraded components. By controlling the quality of materials used in the production process, it is possible to reduce the occurrence of degraded components and improve the overall MTBF of the product.

The reliability of an electronic product is highly dependent on the quality of its components. Although sampling the quality of components is a common practice, it is not sufficient to guarantee the reliability of the product. In order to avoid degraded components, it is necessary to perform a 100% inspection of all components. Advanced technology, such as AI and big data, can be used to examine the bottom side and soldering leads of all components placed on the boards. This process enables the detection of evidence of degradation such as oxidation, mold, slivering, counterfeit, and more. By performing a 100% inspection, it can be ensured that only high-quality components are used in electronic products, thereby increasing their reliability and reducing the failure rate in the field.

In conclusion, the impact of degraded components on the MTBF of electronic products is significant and should not be ignored. By controlling the quality of all the materials used in the production process, it is possible to reduce the occurrence of degraded components and return to the theoretical values of MTBF.