Opportunities for HALT in designing robust electronic systems

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Reliability Prediction Analysis

Manufacturers usually make reliability predictions based on failure models described in reliability standards like **MIL-HDBK-217, Telcordia, IEC62380** or some other model before products are manufactured or marketed. But when a product is delivered to customers, the preliminary reliability prediction sometimes is not validated by real-world failure reports. These standards typically consist of two basic methods:

- **Parts Count Analysis** during design phase
- **Parts-Stress Prediction** near the end of the design cycle

General failure model: $\lambda_p = \lambda_b \cdot \pi_Q \cdot \pi_E \cdot \pi_A \cdot \ldots$

The EUT is an **electronic circuit**, intended to measure the electricity consumption sending its data by the GSM-network to a central datacenter .

Table 1. Results of EUT according to MIL-HDBK-217

Part type	*Failure rate by part type (10^{-6} failures/hour)*	*Relative percentage*
Resistors	1,18	15,12
Capacitors	0,63	8,05
Inductors	2,93	37,48
Diodes	1,24	15,82
Quartz crystals	0,07	0,83
Transformers	0,16	2,07
Pushbutton	0,00	0,01
Fuses	0,02	0,26
Connectors	0,53	6,75
Optocouplers	0,06	0,81
Transistors	0,55	6,98
IC's	0,46	5,83
System	**7,82**	

Table 2. Results of EUT according to Telcordia

Part type	*Failure rate by part type (10^{-6} failures/hour)*	*Relative percentage*
Resistors	0,39	7,64
Capacitors	0,36	6,95
Inductors	0,38	7,41
Diodes	0,25	4,99
Quartz crystals	0,04	0,74
Transformers	0,02	0,47
Pushbutton	0,01	0,09
Fuses	0,01	0,22
Connectors	0,45	8,80
Optocouplers	0,09	1,78
Transistors	0,19	3,74
IC's	2,95	57,16
System	**5,16**	

MIL-HDBK-217 is targeted for military applications, which might explain the more pessimistic numbers. The Telcordia models were originally developed for commercial applications. Tests comparing both standards indicate that **Telcordia results** are usually better (25%-450%).

HALT: Highly Accelerated Life Testing

HALT exposes the system to a **step-by-step cycling** in environmental variables such as temperature, shock and vibration and finally can include the **simultaneous cycling of multiple environmental variables**, e.g. temperature cycling and vibration testing.

Unlike conventional testing, the goal of HALT testing is to **break** the product. After a product has failed, the weak component(s) are upgraded or reinforced. By going through **several iterations** like this, the product can be made quite robust.

HALT is very different from qualification testing in that it is **not a pass/fail test**.

Figure 1. Equipment under test in HALT chamber

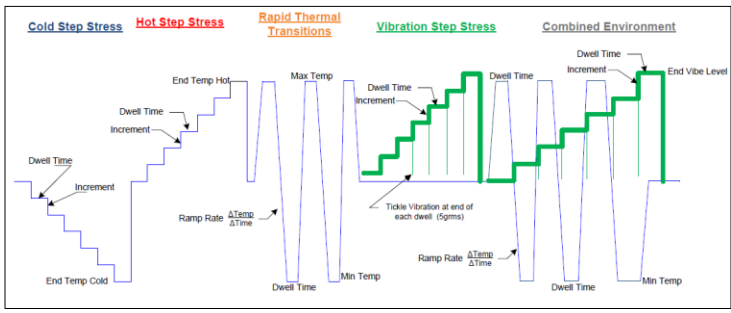

Figure 2. Typical HALT test profile consisting of 4 tests

To summarize the HALT test cycle brought out next **weak points**: not glued electrolytic capacitors, loose resistors, poly switch, varistors and connector.

Comparing the results of the reliability analysis with the results of HALT, it is clear that the detected weak points in HALT are **not necessarily corresponding** to a high failure rate. In case of electrolytic capacitors for example, both methods prove that these are weak spots. On the other hand, a lot of varistors failed during HALT, while the failure rate of them was negligible in the total failure rate of the module.

Both techniques have the intention to give an idea about the reliability of an electronic circuit, but their focus is different.

Research domain: reliability of electronics, standards, ALT , HALT and correlation between them.