New approach for production line Environmental Stress Screening

By DR. HONG-SUN LIU
President
Quanta Laboratories
Santa Clara, California

It is well known that environmental stress screening (ESS) is a very effective tool to find mechanical/electrical weaknesses in a product. When the weaknesses are corrected by design/manufacturing process changes, the reliability of the product is significantly increased. However, because of the long process time currently required for ESS, and its high cost, most companies still choose not to include this very beneficial procedure in the manufacturing process. Here, a new approach that will reduce the ESS process time from days to minutes is proposed to alleviate this problem.

Background

Manufacturers have observed that electronic devices experience a bathtub curve failure rate over the life of the product (see Figure 1). This curve describes a high failure rate immediately after products are placed in service—often referred to as "infant mortality"—and as they near the end of their service life—often referred to as "wear out." During a device's "useful life" between infant mortality and wear out, failure occurrences usually drop precipitously to a much lower level.

If, before shipping a product, a manufacturer can reliably and economically identify and eliminate defective components or parts, it can significantly improve the reliability of its product, while also significantly reducing warranty expenses. Studies of electronic products have shown that most components fail because of latent defects introduced into the unit during the manufacturing process, usually at the board level. However, only after the product experiences stress in its normal operating environment does the latent defect reveal itself.

> **"Large, complex, systems such as telecommunications devices are cumbersome to handle for ESS. Fast temperature ramp rates and controlled vibration stresses are difficult, time-consuming, expensive —if not impossible—to achieve."**

In order to eliminate these defects, Environmental Stress Screening (ESS) is applied to devices or components before they enter service. Old techniques employed for ESS involve subjecting the operating device or component to a single stress such as temperature cycling, vibration, power cycling, or burn-in, and evaluating its performance while being stressed. Burn-in is by far the most prevalent approach.

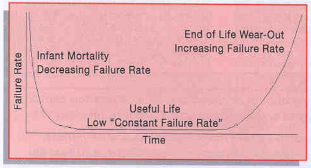

FIG. 1—Bathtub failure rate curve.

More recently, advanced ESS techniques involve continuous monitoring of a device or component during operation while exposing it to multiple stresses, such as vibration, ultra-high rate temperature cycling, humidity, power off/on, electrical voltage variation, etc. Currently, typical ESS practice employs ramping the temperature of the product at a fast rate (10°~30°C/minute) between extreme low/high temperatures and adding vibration stress during these temperature extremes (see Figure 2).

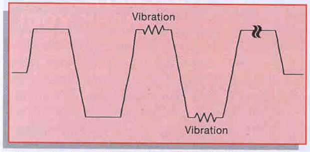

FIG. 2—Typical advanced combined ESS production screen—temperature cycline 10~30°C/minute ramp rate on the product.

Problems with current ESS approach

There are two difficulties when applying ESS to typical large systems such as telecommunication switches, routers, storage devices, etc. First, these systems are cumbersome to handle and require a large ESS system to perform the necessary process; second, it is very difficult, time-consuming, and expensive—if not impossible—to achieve the required fast temperature ramp rates and controlled vibration stresses required for an effective ESS process.

Because of these inherent drawbacks in the current ESS approach, most manufacturers do not include it in the manufacturing process. To eliminate this problem, a new ESS approach is proposed that will integrate the process directly into the production line, drastically reducing product handling and ESS processing time, thereby increasing the production-line throughput and significantly reducing ESS cost.

The new ESS approach

In a complex electronic system, most defects occur principally in structures, connectors and in printed circuit boards with attached components. With the new ESS approach, a highly accelerated life test (HALT) process is performed on one or two entire units to identify potential structural and interconnecting problems. The equipment to do this requires a fast-ramping large chamber and shaker combination, such as the system shown in Figures 3-A and 3-B.

FIG. 3-A—A large network device set up for ESS in a fast-ramping, chamber/shaker combination.

FIG. 3-B—Another view of the large, fast-ramping, chamber/shaker combination used for ESS of large and complex systems.

Because most of these structural and interconnection problems are mechanical, once the design is modified or the manufacturing process is corrected, it will prevent them from occurring again. Therefore, the majority of the remaining defects will be associated with the PC boards. Applying a focused ESS process directly to the PC boards will eliminate most of the remaining defects, resulting in high reliability.

Since the size and weight of PC boards is much less than the large chassis, handling of these units will be considerably easier, and the ESS equipment needed will be smaller and less expensive. Also, since the boards are screened outside the chassis, their exposure to ultra-high temperature ramp rates and uniform vibration will be much easier to achieve.

To further reduce the screening time, we propose that the PC boards be vibrated at a skewed angle as outlined in this author's patent, titled "Skewed, multi-axis vibration fixture" (U.S. Patent No. 5,650,569, see Figure 4). This approach will yield more uniform results and will reduce the vibration time by more than two thirds, since only one vibration direction will be required to impose the vibration on all three axes of the PCBs under test.

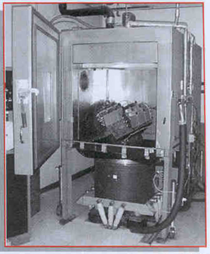

FIG. 4-A—Chamber/shaker for ESS using a skewed table on an electromagnetic shaker.

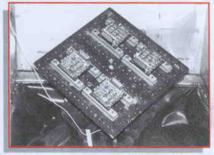

FIG. 4-B—The skewed fixture itself, Quanta Patent #05,650,569.

Summary

In summary, this new screening process is performed on the entire system for one or two units to detect the structural and interconnecting problems, and then all or a portion of the PC boards are screened to identify and remove flawed units before they are assembled into the system. This approach will significantly increase the reliability of the system but with drastically reduced cost and screening time. With these advantages, most companies can economically employ this ESS approach in the manufacturing process to improve their reliability in the future.

Dr. Hong-sun Liu is president of Quanta Laboratories, Santa Clara, CA, a test lab he founded in 1985. He has extensive experience in research, development, and testing of mechanical and electronic devices, theoretical and experimental stress analysis, shock, and vibration. Dr. Liu has consulted and taught in universities and in the test community, and has published in the industry, including in TEST Engineering & Management. Over his career, Dr. Liu has developed three patents in environmental testing; currently his production ESS technology is patent-pending. He regularly conducts seminars in the U.S. and Asia and his current focus is the opening of seven test labs in China. He holds an MS degree from the University of Washington and a Ph.D. in Mechanical Engineering from UC Berkeley.

For more information about Quanta Laboratories' ESS systems and testing capabilities, CIRCLE #166 or go to www.testmagazine.biz/info.php/5as166

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