

ENVIRONMENTAL STRESS SCREENING USING THERMAL CYCLE TESTING AS AN EFFECTIVE ALTERNATIVE TO BURN-IN

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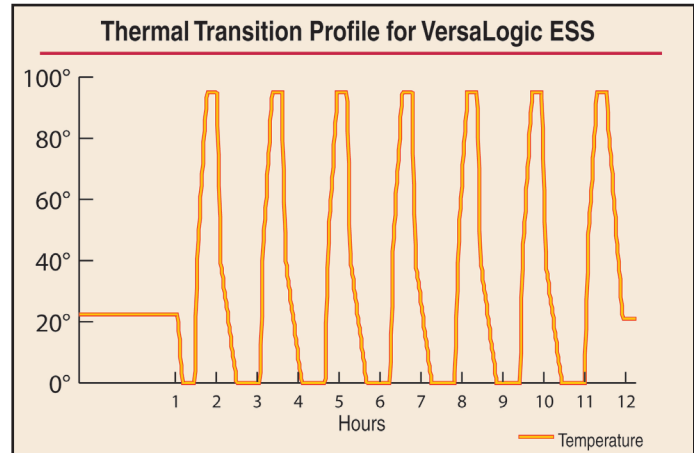
Environmental stress screening (ESS) using thermal cycle testing is primarily intended to accelerate failure of weak or inadequate solder joints. It exposes the product to an environment that causes the “weak” elements of an assembly to fail. This is achieved by exposure to a relatively high rate of repetitive thermal transitions over the operating temperature range of the product. The transitions cause stress to build up in solder joints due to the mismatch of the thermal expansion coefficients of FR4 printed circuit board material and the (primarily) plastic devices that are soldered to them. Discovery and elimination of these potential defects during testing prevents them from reaching the field. When a product has failed testing, the failed element or connection can be repaired, replaced, or discarded, depending on the severity and type of failure that has occurred.

In order to be used in a successful product screening process, ESS needs to be accomplished with negligible damage to the normal elements of the assembly. When used correctly, ESS can result in a more rugged product that demonstrates a higher Mean Time Between Failures (MTBF) rating.

This method of stress screening is presented in IPC-SM-785 “Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments,” which is based on research done by RADC (Rome Air Defense Command) involving modeling of screening parameters using the Arrhenius reaction rate for empirical screening strength.

There are several variables to be determined when ESS is specified. They are:

1. The number of cycles that are completed: which includes the transition and dwell time at each temperature extreme.
2. The temperature range that is selected for the environmental test screen: the possible span of temperature that the product will see in service. For VersaLogic boards, the operating range of 0° to +60°C is typical, with storage temperature range of -40° to +85°C. IPC-SM-785 “Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments” recommends a temperature range of 0° to +100°C for products that are in an industrial environment. The actual range of temperature employed in the stress screen is 0° to +95°C to ensure that the backup battery is not damaged.
3. The rate of change: which is dependent on how aggressive the testing is desired to be. In part, the transition may have a lot to do with the capability of most of the conventional environmental chambers available. It is also indicative of environmental exposure, such as night to day operation of equipment exposed to rising sun environmental excursions.
4. Dwell time: which allows the built up stresses in the solder to relax at the higher temperatures (recommended by IPC-SM-785 to be 15 minutes).



Thermal cycle testing which achieves high screening strength with low acceleration stress.

The number of cycles is generally low for ESS. Reliability tests of solder joints usually range into the thousands of cycles. Environmental stress screens reviewed in the literature generally range from 5 to 10 cycles. VersaLogic has chosen the number of cycles to be 7, which provides a screening strength of greater than 97% when the test length and the rate of temperature change are taken into account.

The most common reliability threat comes from stress-relaxation based fatigue damage. The stress is particularly pronounced when the solder joint is above +20°C combined with a high stress level. This causes the solder to creep faster, and the dwell at temperature then allows built-up stresses to relax. ■