Control Chip Temperature During VLSI Device Burn-in

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Burn-in Strategies

Burn-in strategies include static, dynamic, and burn-in with test. Static burns in systems apply extremes of voltage and temperature to each device but do not exercise the device. Thus, static burn-in—the least expensive of the burn-in strategies—does not stress the potential failure mechanisms.

Dynamic burn-in systems exercise the device inputs and outputs to determine the outputs in addition to applying extremes of voltage and temperature. With dynamic systems, electronic charge transfers occurring in the exercised device’s circuit nodes initiate failure mechanisms that would escape static burn-in.

Burn-in-with-test test devices while stressing them. They provide test vectors to a device and compare actual device outputs with expected outputs while the device under test (DUT) operates at its voltage and temperature limits. Burn-in-with-test systems can identify devices that fail to meet open-circuit conditions but that would pass a test burn-in in more-temperature test.

Burn-in-with-test systems also verify that a device under test meets expected that, if the device is powered up and test vectors are applied. Keep in mind that burn-in — fragile high-pin-count components subjected to the repeated insertion/extraction cycles of production burn-in—are themselves prone to failure. Just a few bad socket pins can prevent test vectors or supply voltages from reaching the device undergoing burn-in, resulting in your shipping or using parts that haven’t been electrically stressed.

Burn-in-with-test systems provide the information about each DUT on a burn-in board. Here, green indicates satisfactory temperature performance; red indicates a temperature anomaly; and blue indicates a disabled part.

Many combinations of air temperature and velocity will remove a given amount of heat. Each of the three lines here represents the various combinations of air temperature and velocity that will provide the required heat flow from a heat-sink assembly.

Air temperature and velocity are generally set so that the heater runs at half power (50% duty cycle) when the device is operating at maximum power. This choice centers the heater output relative to the device power range. As the heat given off by the device increases, the control circuitry senses the temperature increase and reduces the heater power, allowing the package temperature to settle back to the setpoint temperature. Similarly, as the device dissipation less heat, the heater will dissipate more.

The total heat dissipation of the heat-sink assembly is exactly equal to the power dissipation of the device versus under test. Thus, the air temperature and velocity, once appropriately set, need not be changed during testing. Figures 4 and 5 show graphs of the rate of heat transfer in the air stream as a function of temperature and velocity. One particular device in the test chamber. For example, slightly warmer air at one device location would result in slightly less power to the heater for the corresponding device.

The display also shows global temperature settings for the burn-in board as well as actual minimum, maximum, and average temperatures and heater duty cycles. T&MW Control Software gives you the power to the heater for the corresponding device.

A high-power burn-in-system’s software can provide individual device temperature control and monitoring. In the Figure 5 example, the display provides color-coded information about each device; test codes provide details. The display also shows global temperature settings for the burn-in board as well as actual minimum, maximum, and average temperatures and heater duty cycles. T&MW Control Software gives you the power to the heater for the corresponding device.

Figure 1. The traditional burn-in curve describes silicon device failure rates with respect to time. Devices that survive the first few hours will likely last years.

The burn-in process uses power and temperature extremes to compress the infant-mortality period, forcing failures to occur quickly, thus saving time and money. The more extreme the power and temperature, the sooner failures occur and the faster burn-in proceeds. Adding the required burn-in time. Ultimately, increasing voltage and temperature will not only compress the infant-mortality period but also weaken good devices that will survive the burn-in at yet full well before their anticipated end-of-life.

Burn-in-with-test systems allow you to determine the dissipation characteristics of the devices undergoing simultaneous burns as well as for variations in each device’s dissipation in response to varying electrical inputs during the burn-in and subsequent use.

Figure 2. The burn-in board accommodates 24 DUTs. A burn-in-with-test strategy ensures that supply voltages and test vectors pass through the fragile burn-in board sockets to the DUT.

The heat-sink assembly contains a spring, temperature sensor, and heater. The spring holds the temperature sensor tightly against the device package to ensure good thermal contact. The control circuitry monitors the device temperature and supplies the proper heater power to maintain the device at the required temperature.

Figure 3. A heat-sink assembly attaches to each DUT on a burn-in board. A sensor provides temperature information to a control subsystem, which regulates device temperature by controlling heater duty cycle. Thermal foam ensures good thermal contact between DUT and heat-sink assembly.

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Material Temperature

The die inside the DUT is the active component whose temperature is most important. The high-power burn-in system monitors and controls the package temperature, which in turn controls the die temperature in accordance with the thermal impedance between die and package. The thermal impedance is typically less than 0.5°C/W, depending on package, die, and die mounting method. Although this thermal impedance varies by device type, it’s usually uniform for a given part.

You can calculate the package temperature (TP) required to maintain a specific die temperature (TD) from the thermal impedance (q) and the DUT heat dissipation (P):