Electronics Thermal Testing – Improving Accuracy and Throughput

Controlling thermal test by directly monitoring environment or device temperature

Testing the performance of electronics during power and temperature cycling or testing hi-tech materials at temperature extremes is standard industry practice. The method for creating an environment will vary - convection, conduction or force air. The speed and accuracy to arrive at set temperatures depends on control feedback from temperature sensors, regardless of the heating and cooling method.

This application note compares two methods of reaching a desired temperature for a Device-Under-Test (DUT):

1. Environment Control, where temperature is controlled from a sensor in the air surrounding the DUT, and;
2. DUT Control, where temperature is controlled directly from the DUT sensor.

Sensor location is critical to achieving testing objectives whether they are simply to create a thermal environment or increase test speed and accuracy.

Environment Control

There are two major considerations affecting DUT temperature when using the environment (air) sensor for temperature feedback. Firstly, the sensor is typically installed near the enclosure's wall or at the outlet of the heat source. In either configuration the sensor is located away from the working DUT area, creating an air space between the sensor and the DUT. For this reason, DUT temperature will lag behind air temperature until the enclosure circulates air long enough to stabilize the area around the DUT. Figure 1, for example, shows an environment set point of 25°C is reached in 5 minutes while the DUT stabilizes in 9 minutes.

Secondly, all environments experience thermal loss to ambient due to inefficiencies in the enclosure's walls. Moreover, thermal loss will increase as the enclosure's temperature moves away from ambient. This is important when attempting to establish precise DUT temperatures. Figure 2 shows what happens to DUT temperature as environment temperature rises: a 1°C difference at a 25°C set point becomes 2°C at 75°C. Without compensation, the DUT may never reach the set point temperature.

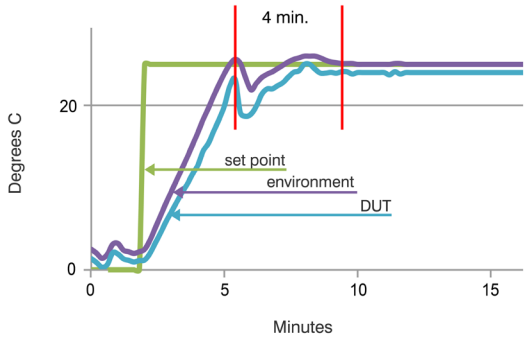

Fig. 1. Time needed for DUT temperature to stabilize after set point is reached using an environment sensor.

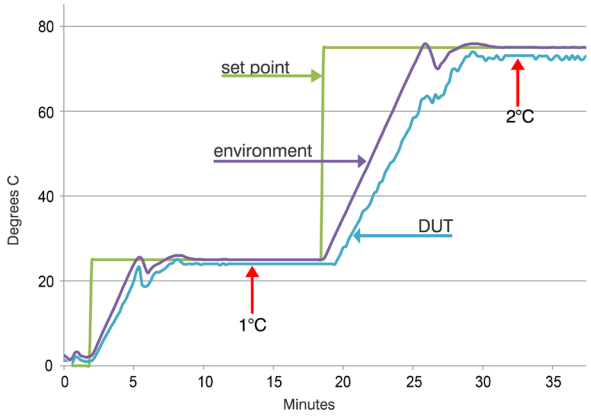

Fig. 2. Environment-control mode results in a 1°C and 2°C DUT temperature offset from set point temperatures at 25°C and at 75°C, respectively.

Environment-control mode is ideal when the objective is to simulate an operating environment that the device needs to experience.

This mode can also be used for DUT-specific temperature testing, however, DUT temperature must be calculated or estimated. This calculation is based on the performance of the system (temperature resolution, gradients, stability, and ramp rate) and DUT characteristics (mass, size, material, and power dissipation).

DUT Control

In DUT-control mode a sensor is attached to the DUT, providing the feedback for system control. The system's controller responds only to the temperature experienced at the DUT. Here, the controller can drive the environment past the DUT set point until the DUT temperature is reached.

Using the same test enclosure as the earlier examples, Figure 3 shows the environment driven to 50°C before the DUT sensor measures 25°C. The effect of this environment overshoot is to get the DUT to a precise temperature and do so more quickly than the environment-control method. Four minutes faster in this comparative test example (Fig.1).

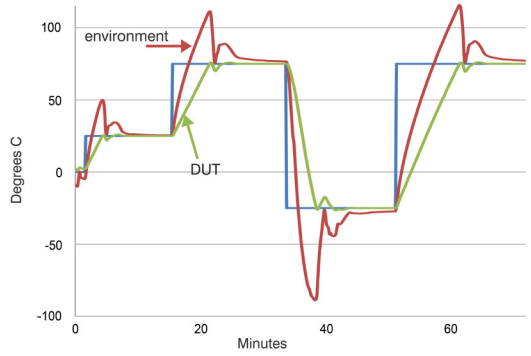

Fig. 3. DUT control results in a significant over or undershoot of environment temperature to bring the device to set point.

There are also times when the core temperature of a device must be known, which can vary as much as 10°C from the outside of the DUT. In this case, a sensor is embedded in the DUT and the system is controlled in the same way.

DUT control is an important tool to minimize test time when cycling through multiple temperatures at various loads. It's also effective when the DUT needs to be tested at precise temperatures, which can be controlled within 0.1°C.

DUT Time to Reach Set Point		
Set Point (°C)	Environment mode (Min.)	DUT mode (Min.)
0-25	7.6	4.3
25-75	13	8

Table 1. Comparison of control modes for DUT transition time.

DUT Temperature at Set Point		
Set Point (°C)	Environment mode (°C)	DUT mode (°C)
25	24	25
75	73	75

Table 2. Comparison of control modes for DUT temperature.

Environment- or DUT-Control Mode What's Best?

The answer is: It depends on the application. If the test plan calls for the DUT to experience a particular thermal environment, then using Environment Mode with its built-in sensor will satisfy the requirements with minimal test setup.

On the other hand, if the test plan specifies precise DUT temperatures, then DUT-control mode is a preferred method. Here, you need to mount a sensor (Thermocouple, RTD, Diode), and ensure that it is consistently and securely mounted from DUT to DUT*. However, once the sensor is mounted, it will allow you to drive the DUT to a specific temperature and do so faster with DUT mode's ability to overdrive the environment for faster DUT transition times.

In some cases, you may be able to save setup time by using a hybrid version of both modes. If the test plan allows, you can use DUT mode to perform a one-time characterization of the DUT. This characterization can be used to establish temperature offsets that can be applied in Environment mode. It would eliminate the need to mount a sensor for each DUT.

Conclusion

Your thermal specifications and business requirements will determine which method of temperature control best fits the application. By understanding these control modes you have the flexibility to apply the appropriate method for your design, development, and production testing needs.

Of course, test performance relies not only on sensor placement but also on robust enclosure design and dynamic control algorithms. Both Environment- and DUT-control modes are available on all Sigma chambers and platforms and Temptronic air forcing systems.

* To learn more about proper techniques for mounting DUT sensors, contact the factory.

The inTEST Thermal family includes three temperature-related corporations: Temptronic, Sigma Systems, and Thermonics.

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