ACCELERATE Interconnect Reliability Tests

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Accelerated environmental tests help you verify the reliability of your designs before you begin production.

Electronics packaging technology is changing rapidly. In the past 10 years, we've gone from through-hole technology to surface-mount, and ball-grid arrays and multichip modules will soon be in widespread use. Before these packaging techniques can become widely used, companies have to verify the reliability of both the design and of the manufacturing process. One way to do this is with accelerated environmental tests.

Accelerated environmental tests let you validate new interconnect designs and manufacturing processes more quickly than traditional test methods. The stress levels used in accelerated environmental tests are higher than those used in traditional test methods, and they also may be many times greater than the operating specification.

By using these high stress levels, you can shorten test times and can bring reliable products to market sooner. Furthermore, you don't need to rely on production testing and inspection to assess product quality. If you perform accelerated tests on prototypes during the design phase, you can verify the reliability of your designs before you begin production.

The types of tests you perform can include temperature cycling, temperature shock, vibration, and mechanical stress. The conditions you use will depend on the operational environment for your product. For example, a test for an automotive-electronics device might include temperature cycling, vibration, and mechanical shock, but for a consumer-electronics device you might run only a temperature cycling test.

While performing accelerated environmental tests, you must monitor the connections for intermittent operation to verify the long-term reliability of your design. The IPC standard IPC-SM-785[1] specifies criteria for failures. The standard states that an interconnect is a failure if it is intermittent 10 times within a 10% period of the total test duration. A connection is defined as being intermittent when the resistance of the connection exceeds the specified resistance threshold for a period longer than the specified time.

Equipment exists that can monitor up to 1,024 individual connections for intermittent operation. This equipment can detect resistance changes as low as 10 Ω for periods as short as 10 ns. Once the test is complete, you can analyze the data to project the life and reliability of the design under test.

The number of interconnects you select to test will determine the significance of the result. The larger your sample size, the more statistically significant your test results will be.

The number of interconnects you choose will also affect the cost of testing. One way to increase the number of interconnects under test and keep the cost of test low is to daisy-chain connections. By doing this, you will lose the ability to pinpoint failures, but you'll reduce test costs.

Once you decide how many interconnects to test, you can choose the type of monitoring equipment you will use: an oscilloscope, a custom glitch-detection circuit, or a sophisticated event-detection system. MIL-STD-202F Method 310[2] contains a circuit diagram for a simple glitch-detection circuit. To automate the test, however, you should use a multiple-channel, event-detection system.

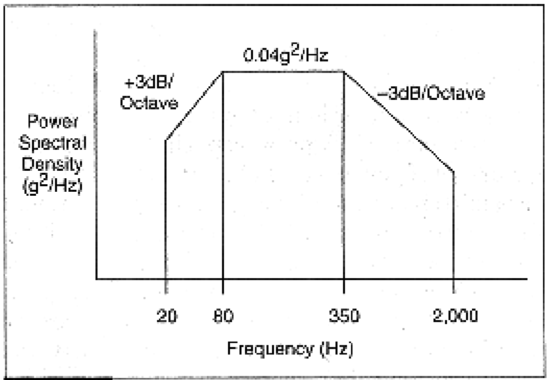

FIGURE 1. This profile from NAVMAT P-9492 provides a good starting point for vibration tests.

Selecting an Event-Detection System

When selecting an event-detection system, look for these three features:

- The event-detection system must be able to trigger when the resistance of an interconnect exceeds the resistance threshold for a given time, called the time domain. Both the resistance threshold and the time domain need to be programmable because they will vary from test to test.
- The system must be able to record at least two test conditions when a

failure occurs. For interconnect tests, these two variables are time of day and chamber temperature.

- The harness that connects test samples to the event-detection system must have the proper electrical shielding and be easy to connect.

Pay close attention to the triggering specification when selecting an event-detection system. Ideally, the triggering system will be programmable over a wide range and be able to trigger on very short time domains. For example, if you are testing the electronic interconnects of a high-speed, data-communications system, the event-detection system may have to trigger when the interconnect is intermittent for only 10 ns. On the other hand, interconnects in less-demanding applications, such as automotive switch applications, may be interrupted for up to 1 µs without being considered intermittent.

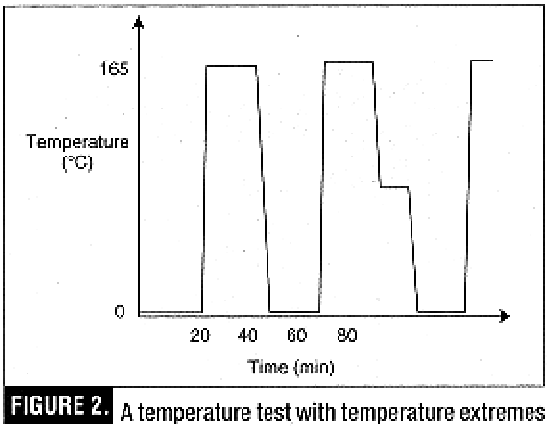

FIGURE 2. A temperature test with temperature extremes of 0°C and +165°C is used for testing electronics assemblies that go onto the head of an oil drill rig.

Pay Attention to Wiring and Grounding

In addition to selecting the right event-detection system, you must pay attention to wiring and grounding. Poor grounding and shielding can make test signals noisy and cause false indications of intermittent connections. This is especially important if you are trying to detect intermittent connections with very short duration, say 10 ns, because noise spikes are often very short. Poor wiring and grounding are less of a problem when the resistance thresholds are high or intermittent times are long, but there's still no need to be careless.

During the test, the test system will gather data continuously and display the status of the interconnections under test as they begin to develop intermittent behavior. When the test is complete, you can use available software to plot the failures versus the test cycles. (The cycles could be temperature cycles, mechanical cycles, vibration cycles, or any other environmental cycles.) From the plotted information, you can calculate statistical life distributions (such as exponential, Weibull, and log normal) and life-stress relationships to determine the long-term reliability of the interconnects.

FOR MORE INFORMATION

1. *Accelerated Testing: Statistical Models, Test Plans, and Data Analysis*, by Wayne Nelson, 1990. ISBN 0-471-522-775. John Wiley and Sons, New York, NY. *800-255-5945.*

2. *How to Plan an Accelerated Life Test*, by William Q. Meeker and Gerald Hahn, 1985. ISBN 0-87389-007-8. American Society for Quality Control (ASQC), Milwaukee, WI. *800-952-6587.*

A Combined Test Example

When designing a test to evaluate the reliability of electronic interconnects, make sure the test environment matches the application environment of the product. In some cases, this means using a temperature-cycling test, in other cases a vibration test, and in still other cases you may want a combined test.

At Trace Laboratories, one of our customers wanted a combined test to assess the reliability of different methods of attaching ball-grid array (BGAs) to PCBs. The BGAs come in two different packages—a 169-pin package and a 225-pin package—and the procedure calls for each package to be tested with a tin/lead solder and a lead-free solder.

We ran an accelerated vibration test, because the BGAs are part of a handheld, portable device and can experience a fair amount of vibration in the field. To test the attachment reliability, we used the NAVMAT P-9492[3] profile (**Fig. 1**). The test procedure calls for vibration levels that are three times the published levels, or about 18 g's rms.

The test runs at room temperature. The shaker applies vibration in a direction perpendicular to the plane of the board, and the test fixture supports the board only along the perimeter, simulating mounting. The test time is between four and eight hours, which is assumed to be equivalent to one year of field operation, and an event-detection system constantly monitors the connections.

The resistance threshold for this test is 100 Ω and the time domain is 1 µs. Once the test is complete, a technician plots the failures versus the test cycle. Boards pass the test if none of the interconnects fail during the test.

While this test procedure calls for only random vibration, you could develop a similar test that combines vibration with temperature cycling. A combined test would precipitate defects more rapidly and further accelerate life tests.

Another way to improve the effectiveness of this test would be to use vibration data collected from an actual application environment. The NAVMAT profile is a good starting point and is useful when actual field data is not available. Vibration data acquired from the actual operating environment, however, gives you the most useful information.

A Temperature Cycling Example

A second customer asked us to develop a test for a PCB assembly used in oil exploration. The board goes into the head of a drill rig that bores deep into the earth. The board assembly contains both surface-mount components and through-hole components.

The test procedure calls for a temperature-cycling test. The temperature cycles between 0°C and +165°C (**Fig. 2**). The temperature ramps up and down at a rate of 40°C/min, and the dwell time is 20 min at each temperature extreme. This environment simulates the temperatures experienced by the electronics as the drill head drills an oil well.

(continued)

The test runs until the unit under test fails; this often takes more than 1,000 cycles. While the test is in progress, an event-detection system monitors the interconnects continuously. The resistance threshold for the test is 250 Ω and the time domain 1 μs.

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An alternative to the temperature cycling test is a mechanical stress test. Some companies, including IBM, are now experimenting with mechanical tests and may use them to replace temperature-cycling tests. Instead of using a temperature chamber, IBM uses a device that mechanically deforms the board under test. This test works as well as temperature cycling, yet it only takes a fraction of the time to complete testing. *T&MW*

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REFERENCES

1. IPC-SM-785, "Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments," November 1992. Institute for Interconnecting and Packaging Electronic Circuits (IPC), Lincolnwood, IL. *708-677-2850.*
2. MIL-STD-202F "Test Methods for Electronic and Electrical Component Parts," Notice 11, June 1992.
3. NAVMAT P-9492, "Navy Manufacturing Screening Program," May 1979.

Copies of MIL-STD-202F and NAVMAT P-9492 may be obtained from Global Engineering Documents, Washington, DC (800-854-7179) or from the Document Center, Belmont, CA (415-591-7600).

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