Novel 3-D Vision System Inspects SMD Pin-Out Coplanarity

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Until relatively recently, DC-DC converter modules have been one of the few remaining leaded parts on a PCB assembly. Now, however, by employing rugged lead frames and transfer moulding encapsulation traditionally associated with ICs, manufacturers can produce true, surface-mount DC-DC converters with high power densities and miniature footprints. For SMD DC-DC converters to become standard items for high-volume manufacture, it’s vital for today’s processes to handle them in the same way as ICs. Consequently, the DC-DC converters need to be rugged enough to withstand high-temperature reflow soldering processes while offering the accurate lead alignment and size that OEMs now routinely expect from ICs.

The positioning and size of an SMD DC-DC converter’s leads are critical for today’s high-volume manufacturing processes. In particular, a slightly mis-aligned or slightly raised leg can result in inaccurate placement on the board, poor soldering performance, and part rejection. To avoid these failures, manufacturers have to test and verify devices before they leave the plant. There are nine key test criteria:

- **lead coplanarity** — less than 0.1 mm to suit an SMD manufacturing environment,
- **lead offset** — lateral distance between measured position of the lead and its ideal position,
- **lead skew** — lateral distance between the shoulder (where the lead touches the component body) and the tip of a lead,
- **lead pitch** — lateral distance between the tip centres of two adjacent leads,
- **lead width** — width at the tip of the lead,
- **lead span/half span** — distance between the lead tip and the local axis parallel to its row,
- **lead length deviation** — deviation of the length with respect to the average length of the leads of the same row,
- **terminal dimension** — tip-to-tip distance between two opposite leads, and
- **body standoff** — distance between a reference point and the body plane.

### Customised Vision System

In order to address these issues, Newport engineers set about designing a customised, automated test system for its UK facility. The biggest issue for the new system was the measurement of coplanarity — how well the lead tips of a device lie in a 3-dimensional plane. For an ideal device the tips lie in a perfect 3-dimensional plane, but in practice, deviations from the plane always exist.

Measuring coplanarity is not a trivial task. In order to perform accurate measurements, you need to define a reference plane that closely approximates to the ideal plane containing the lead tips. You can then define the coplanarity of each lead as the distance from its tip to this reference plane. You can define a reference plane in two ways known as Least Mean Square (LMS), and seating plane. By convention, the coplanarity of a lead is positive when its tip is above the reference plane and negative when the lead tip is under the reference plane. The LMS plane (see Figure 1a) is the “best fit” plane through all lead tips. The three lowest leads (see Figure 1b) define the seating plane.

**Figure 1.** Two methods of defining SMD pin-out coplanarity are: (a) the Least Mean Square, and (b) the seating plane.

Because using a 2-D image to measure coplanarity is a complex task, Newport engineers decided that a key feature of the new automated test system would be the ability to build a 3-D model of a device and then use this to generate coplanarity figures. As a result, the final design criteria for the automated system were:

- **accurate measurement of all key criteria,**
- **rapid measurement of all criteria to ensure 100% testing of high-volume production runs,** and
- **minimum operator handling and manual intervention.**

Having considered various options, Newport engineers decided to combine a 3-D lead-inspection vision system from a specialist manufacturer with a custom-built automated handling system that would remove all manual handling from the tests.

### Generating a 3-D Model

Conventional vision systems use two or three CCD cameras with different viewing angles, but to improve accuracy the newer 3-D vision system combines a single camera with four separate LED sources. A fixture holds the component under test on a pedestal above a frosted glass plate. Four light sources then cast shadows onto the plate. In this way the first light source generates the first shadow of a lead on the plate, the second light source a second shadow and so on (see Figure 2).

**Figure 2.** The inspection system calculates pin-out positioning to 10 µm from shadows using different light sources.

The camera then views these shadows from below the plate. The system then calculates the exact x, y, and z coordinates of the lead within 10 µm using triangulation techniques based on the light source and shadow positions. This technique, coupled with the fact that the system is entirely static during measurements, ensures very high levels of test accuracy. You can configure the system so that the four LED light sources turn on either consecutively or two at a time (to give combined illumination). With combined illumination, the total test time per component can be as little as 500 ms.

Newport engineers have integrated the 3-D vision system with an automatic handling system to completely eliminate the need for operators to handle the components during the test process. The system is a gravity-fed, tube-to-tube system that tests more than 100 components per minute. The system automatically steps through all the tubes, testing all individual devices and segregating passes from failures.

By constantly replenishing the component tubes, the system will work twenty-four hours a day, seven days a week, therefore providing 100% testing of DC-DC converters from even the highest volume production runs. Newport engineers developed and commissioned all the software and electronics needed to integrate the vision and handling capabilities in less than eight months.

As well as ensuring that the company provides high levels of repeatable component quality to its customers, the ability of the system to store data for SPC analysis is making it a key element in the monitoring and constant improvement of manufacturing. Newport plans to install similar systems in all of its manufacturing facilities in Europe and China. T&ME

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