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Accuracy in 3D AOI Enables M2M Communications

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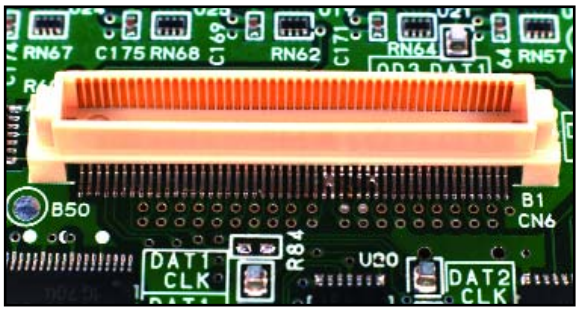
There have been many obstacles to overcome in the process of developing machine-to-machine (M2M) communications. But, with more diversity in electronics, increased global competition, and demand for shorter lead times, M2M communications are becoming a necessity.

Factors such as mass customization and the Internet of Things (IoT) are driving the need for increased production, and greater interconnection of production equipment. It is falling to equipment manufacturers to collaborate and come up with a smart factory approach to manufacturing and assembly. Saki Corporation has partnered with Panasonic to research methods of interfacing Saki's 3D AOI systems with Panasonic's placement machines.

Inspection and M2M Communication

Despite leaps in progress in tackling the challenges posed by small components and pad sizes, denser boards, a wide variety of substrates, and an emphasis on eliminating failure rates, AOI equipment manufacturers now have to adapt to greater changes brought on by the smart factory ideal and IoT.

Factory operation ratios are being improved and productivity maximized. SPI and AOI systems are now being designed to communicate with peripheral equipment through feedback and feed-forward connections.



PCB image captured by a side-angle camera.

Inspection equipment is used to carry out three main M2M functions: feedback from the SPI system to the printer, feed-forward from the SPI system to the placement machine, and feedback from the AOI system to the placement machine.

The equipment must meet the inspection configurations for many different applications, so AOI equipment, in particular, should accommodate both large and extra-large boards, and be equipped with dual lanes for increased throughput. Today's systems have angled side cameras that, along with top cameras, capture simultaneous images to inspect solder and the leads of complex packages, such as QFNs, J leads and connectors. 3D extra component detection (ECD) is used to detect extra components on the board.

Adding cameras and ECD capabilities reduces the need for manual visual inspection, improving the process and productivity.

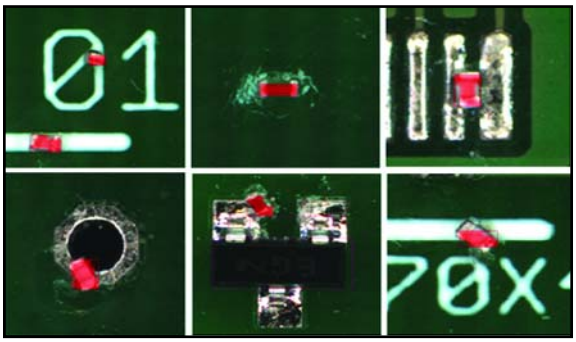
More advanced, high-precision, high-speed inspection systems are now available to inspect micro-components. This has become a necessity due to the increased use of these components in smartphones and wearables and for inspecting the components used in modularization. Very detailed images of component shapes can be captured. These high-resolution inspection systems are not only an integral part of SMT lines, but also have applications in other process lines.

The Need for Accuracy

With all the lighting, cameras, positioning systems, and other factors that are essential to inspection machines, accuracy is by far the most important element for M2M communi-

cation. For machines to function optimally, the data that is fed to them must be extremely accurate or they will fail.

It is similar to the game "telephone" where one person whispers into another's ear and the message is passed on through a line of people until the last person blurts out the message. It is rarely the same message that was first introduced. With M2M communications, it is critical that the data and detailed information that goes into one machine is relayed accurately to the next.



Stray components detected by Saki's ECD system.

When inspection machine conditions change, or there is a change in the condition of the PCB, absolute accuracy of the data, and its communication, will be affected. Generally, the offset between component coordinate information from CAD data and component measurements coordinated from the AOI system is caused by a change of AOI machine or PCB conditions.

It is important to distinguish whether the change is from the PCB or the inspection machine itself, so only the changed PCB conditions are relayed to the previous piece of equipment. The more accurate the machine, the better the feedback or feed-forward to peripheral equipment.

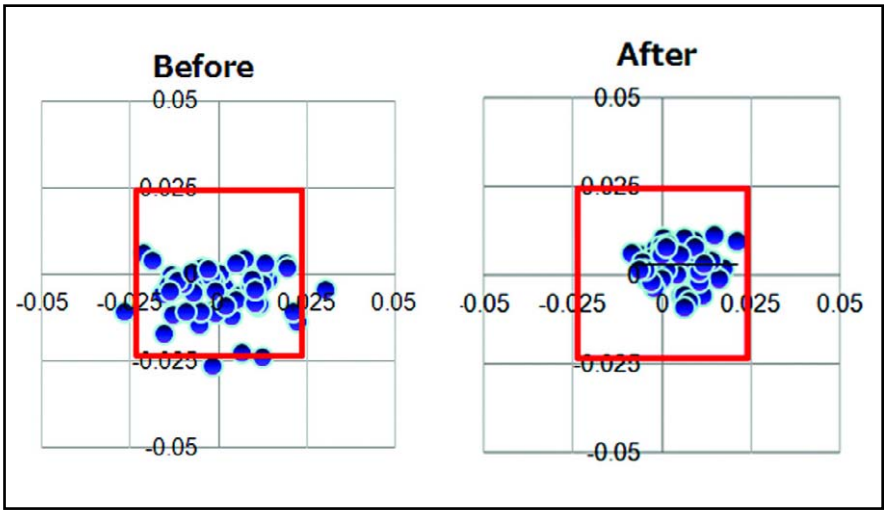
For example, if there isn't PCB expansion and contraction, but the AOI equipment causes a coordinate offset, the wrong feedback will be given to the peripheral equipment and productivity will be affected.

As a prerequisite to M2M communication, factors that could change the machine configuration or the PCB should be eliminated. If the inspection machine has a sturdy configuration, it can deliver more precise results during the assembly process, which is necessary for absolute accuracy, as is fine-tuning and machine calibration.

By using equipment that can produce highly-accurate data, and by measuring the offset amount of each component, changes in the PCB can be deduced, enabling the inspection equipment to communicate accurate feedback to the other equipment in the line.

Testing for Accuracy

Factory tests were conducted using Panasonic's NPM placement equipment and Saki's BF-3Di 3D AOI system, to assess the role that inspection accuracy plays in good M2M communication. Saki's system is based on a sturdy gantry structure, which is the foundation for its accuracy. It contains a rigid frame to ensure that the vertical axes are parallel, a twin motor drive system for y-axis positioning and a high-precision linear scale. Its sturdy base maintains the coordinates and positioning and keeps the system running smoothly, even at high speeds. It also prevents movement and shaking that can result in friction, causing thermal expansion.



The result of feedback from Saki's 3D AOI system to Panasonic's placement equipment during testing (unit = mm).

The success of M2M communication relies on the amount, type, degree, quality, and accuracy of the data that is recorded. The software, capabilities and operation of the equipment also play a significant role in the type of data that can be collected and communicated. Since PCB conditions can affect accuracy, AOI systems with pixel-based board warpage measurement and compensation contribute to the accuracy of data transmission.

The assembly line under test ran continuously for five hours. A position was marked at the start of the run and again at completion. When comparing the two marks, Saki's 3D AOI inspection system achieved an accuracy greater than 1.0 Cpk, indicating that a ±10 µm accuracy was maintained. The coordinates remained constant and the process was not influenced by thermal expansion.

Using the feedback from the inspection results collected by the AOI system, the placement accuracy of the components was brought to within 25 µm, with Cpk also showing improvement.

The success of the smart factory and Industry 4.0 will be based on the functional level of each piece of equipment on the line, the amount, type and quality of data collected, and the ability to communicate that data to each part of the assembly line. The accuracy of inspection equipment has been demonstrated to directly affect the quality and optimization of the production process for all other equipment involved.

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