Toward the Zero-defect Production Line

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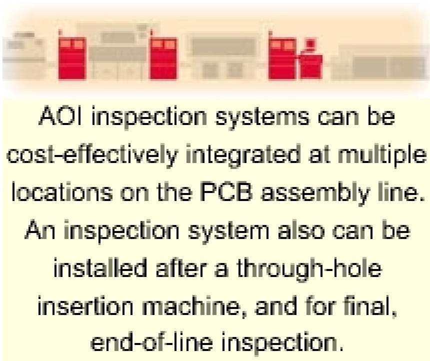
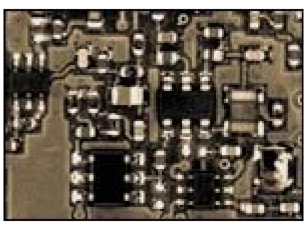


AOI inspection systems can be cost-effectively integrated at multiple locations on the PCB assembly line. An inspection system also can be installed after a through-hole insertion machine, and for final, end-of-line inspection.

Automated optical inspection (AOI) has long been a key part of PCB production. New trends, however, are changing AOI and the role it plays in processing.

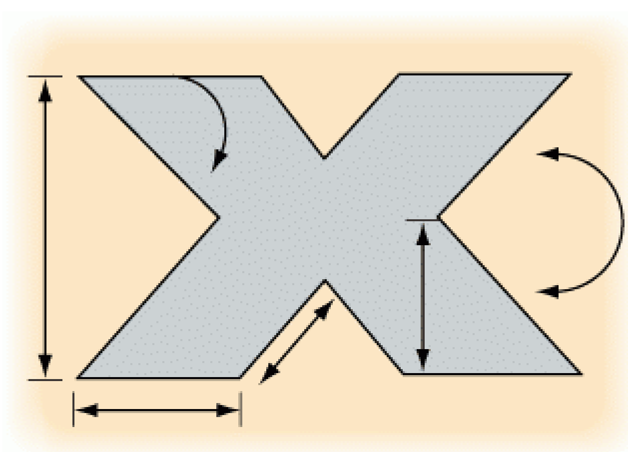
By Mark J. Norris

With conventional AOI, grayscale correlation techniques store an image considered as an acceptable representation of the component to be checked. Pixel by pixel, the image is compared to those acquired during production and is "recognized" if enough pixels match those of the stored image (Figure 1). Often, however, grayscale correlation cannot be used to inspect a number of components of the same type because while similar in function, such components can be radically different in appearance, e.g., design, color and shape. Grayscale correlation also can be "fooled" when a number of identical components are attached to the same board. Because of background color or image occlusions, these components can appear different, resulting in high false-failure rates.



Recently, a new technology, called vectoral imaging*, has been gaining acceptance as an alternative approach. These systems produce myriad lighting combinations that can verify component presence, confirm polarity and ensure placement accuracy at speeds up to 200,000 components per hour in any situation or application. In comparison, grayscale correlation technology generally lacks the speed, robustness, repeatability and ease of use of vectoral imaging for in-process component inspection.

Figure 1. Run-time image of a PCB. Using grayscale correlation, it is recognized as a "good enough" match to the stored image of the board, though problems may arise when the board is rotated.



A Different Approach

Vectoral imaging solves inspection problems with a different approach to grid-based pattern analysis in that it converts the pixel grids provided by the image sensor into geometric features (Figure 2). Because it uses such features rather than gray-scale pixel values, vectoral imaging is unaffected by color changes or changes in nonlinear size caused by manufacturing variations. Feature contours represent the bound-aries between dissimilar regions in an image and can be line segments, arcs, angles, or open or closed geometric shapes. By analyzing a board's geometric information and spatial relationships, the technology can locate components regardless of size, orientation or background appearance, resulting in lower false-failure rates.

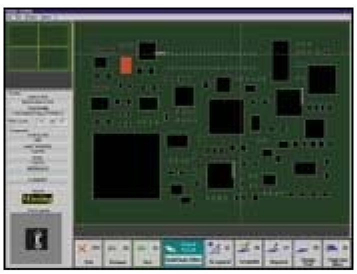
Figure 2. Vectoral analysis of an object showing interfeature relationships, which remain regardless of scale or object position.

Since vectoral imaging relies on geometric feature extraction rather than pixel counting to represent an actual image model, users can generate purely mathematical or synthetic models of the pattern to be located. The models are generated using component images or data from IPC or JEDEC component specification sheets, and comprise an extensive synthetic library supplied with the new inspection systems. Because they are unrelated to the assembly environment, synthetic models are said to eliminate adverse lighting effects and background variations for accurate representations. Also, manufacturers with several networked machines are able to use the same component library for all systems. Additionally, users can access a synthetic-component library via the Internet.

Data on Display — The First Step to Zero Defects
Production systems collect inspection data for immediate process intervention and repair and defect analysis. With inspection data available at all times on the graphical user interface (GUI), the operator knows the exact state of the process and can decide quickly if corrective action is necessary.

Screen displays also show defects, such as missing components, bad placement or polarity errors on the last 10 production boards. A green "go" bar on the screen means there are no defects on a board; a yellow bar denotes an acceptable board but one nearing tolerance limits; a red bar signals that a defect has been detected (together with component type, part number, reference designator and feeder location); and a flashing red bar indicates that an identical error has been detected on two consecutive boards.

Also displayed is the average and standard deviation of placements in the X, Y and q directions. More positional information appears on a scatter chart, which shows the placement accuracy of all components. This data can be sorted as required to show the results of a particular JEDEC type, a machine, or a specific nozzle or feeder. Nozzle or feeder information can be pre-programmed into the AOI system or imported from the pick-and-place machine.



Viewing Information at the Repair Station
At the repair station, data displayed on the GUI help the operator decide what repairs are necessary. The screen shown in Figure 3 illustrates a graphical representation of the printed circuit board (PCB) panel, with a red mark indicating the defective board. Below the image is the barcode reference as well as the program name, component reference and topology. Also on the screen is a graphical representation of the defective PCB with cross-hairs marking the exact location of the defect. The defect itself appears in the bottom-right corner.

Figure 3. Repair station defect-location detail screen. Along the bottom, action buttons permit the recording and logging of all actions for future reference.

Additional supervisor software allows a process engineer to call up a record of all defects on a particular machine or line for a particular time period. Defect records for the past hour, day, week or month thus can be organized by defect type or component.

Statistical Process Control (SPC)
While representing a major advance in process control, data collection methods only provide information on actual defects after the fact. With real-time SPC data collection, however, manufacturers can catch problems before adversely affecting product quality. Equipped with an integrated SPC package, the vectoral imaging AOI system permits the tracking of solder paste deposition and component placement accuracy in real-time. The engineer decides on the layout of SPC data, the criteria for collection, the methodology, and the upper and lower control limits. When there is a trend — according to standard SPC practice, an occurrence shown in seven measurements — the SPC software logs it and sends the data to the proper engineer, who views it in real-time on a computer screen.

If the system detects a problem that is still within control limits and still producing good products, it signals a warning before production is affected. The engineer then can trace the source of the trend and take corrective action. But what if the engineer is absent or does not see the warning signals, or worse, the process is out of control? The SPC tool can be programmed to spot a trend and automatically notify specific personnel via e-mail, phone, pager or Palm Pilot. Finally, in a "worst-case scenario," the system can stop production.

A Look Ahead to Zero-defect Production

Eventually, all AOI devices will communicate in real-time with production machines, and corrective actions will occur automatically before defective products are made. For example, a printer will be informed that the stencil must be cleaned; a pick-and-place machine will automatically calibrate its pick-up head or its camera-to-nozzle offset; in mobile phone production, a machine will be directed not to place a shield on a board with a placement or solder paste defect.

While this technology exists, whether or not it enters the mainstream will depend on the overall agreement of a single protocol that will enable all AOI systems to communicate with other equipment. Using AOI only at the end of the line already is history. By moving it to a pre-reflow position and implementing SPC for spotting and correcting manufacturing trends, however, it truly can be used to control surface mount device production and permit the zero-defect line to become reality.

- Vectoral Imaging is a trademark of ViTechnology LLC.

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