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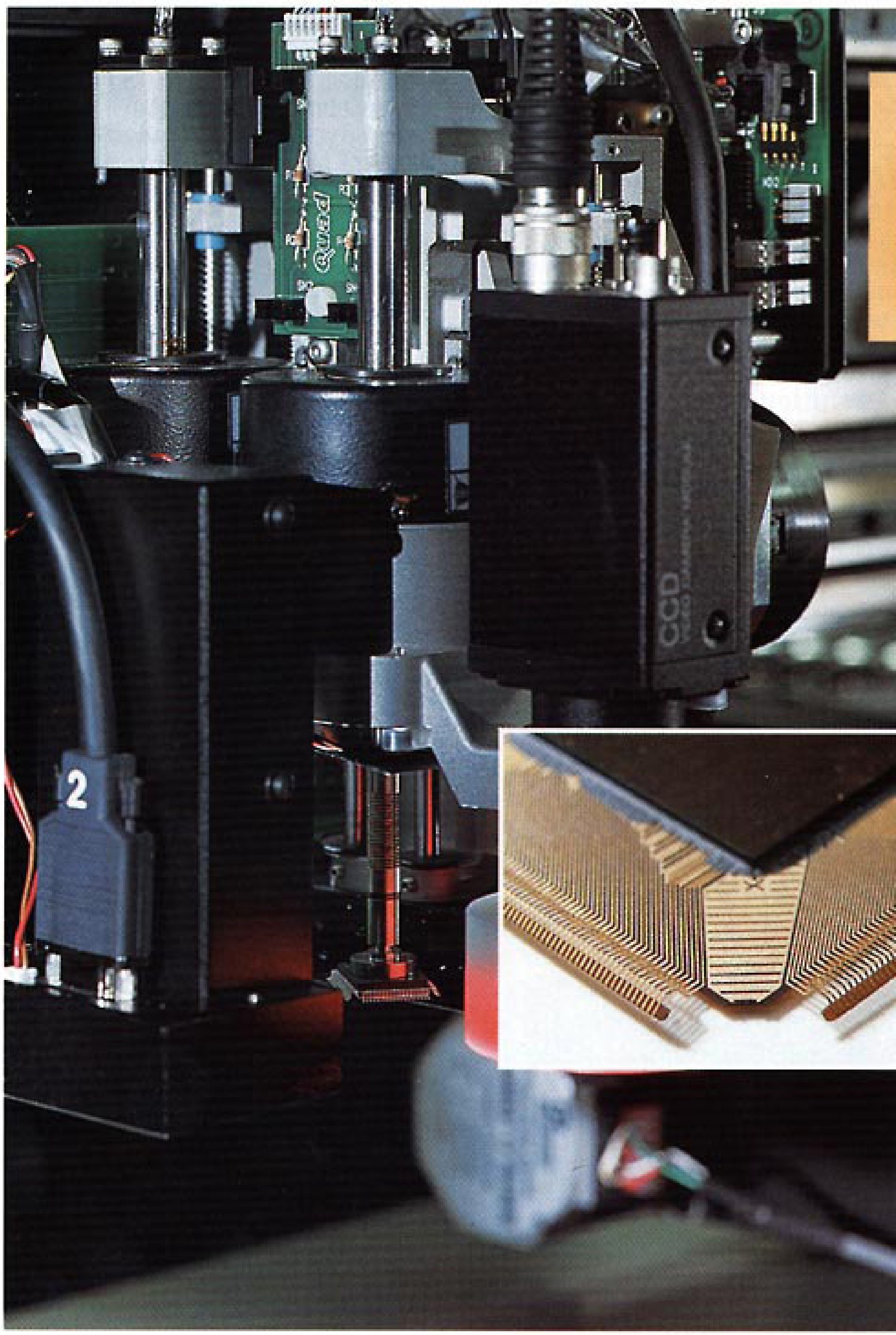


## ASSEMBLY



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## SPECIAL

# Integrated Terminal/Feeder Design Delivers Continuous SMT Solution

## *Taking the "odd form" pin, jumper or terminal and placing it with high-speed assembly equipment, in-line.*

*Janos Legrady, Zierick Manufacturing, Mount Kisco, N.Y.*

In surface mounting unique or unusual shaped connecting devices, finding the right terminal design, feeding system and placement method can significantly reduce assembly process constraints and costs. The increasingly specialized nature of board connection requirements has driven the development of SMT terminals with new and often very complex shapes, mounting parameters and manufacturing process implications. Manufacturers often face the need to create innovative new interconnection solutions, while at the same time substantially reducing both per-unit terminal cost and overall production expenses.

### Evolution in terminals

Many single-type terminals are typically available only for through-hole technology. If a printed circuit board calls for test points, IDCs, tabs or other types of single terminal interconnections, the board and the related manufacturing process must combine both SMT and through-hole technology. This dual-design, dual-production requirement can add substantial time and cost to the entire manufacturing process, and in many advanced board applications can be entirely impractical.

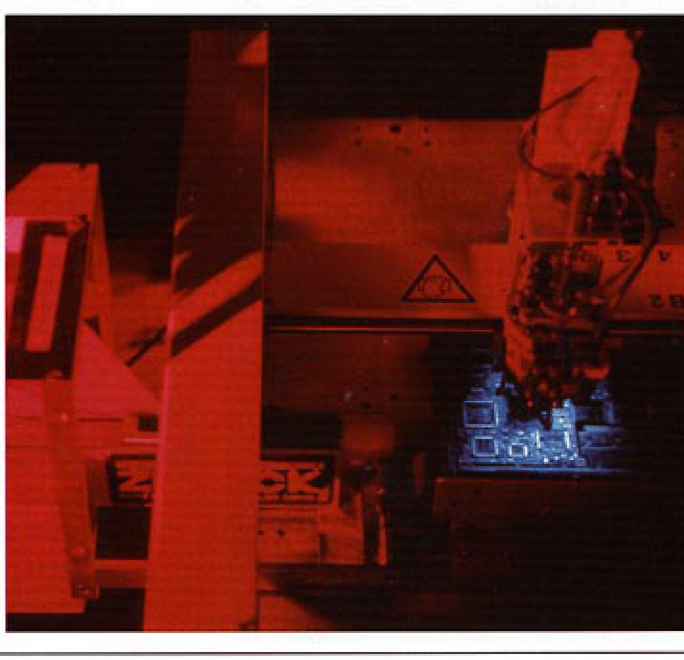
As competitive pressures have driven electronics manufacturers to seek lower per-board production costs — while at the same time responding to product requirements for smaller, more complex and more versatile PCBs — the need for more efficient terminal design and placement technology has become apparent.

By seeking a solution that integrates connector design with the high-speed capabilities of an automated terminal placement system, electronic manufacturers can achieve improvements in interconnection productivity. This approach can promote increased product reliability, repeatability and PCB building efficiency. It also can be a lot less expensive on a per-connection basis.

There are two traditional methods of moving connectors into position for assembly. Parts can be tube-fed via standard feeders into the pick-and-place system, but this form of packaging is costly and requires repeated and expensive manual tube replacement.

A second method, often used in SMT applications, calls for connectors to be prepackaged in a tape-and-reel format. Using this well-known method, individual loose parts are taped into plastic bucket-like holders, then advanced and placed on the PCB by a pick-and-place machine. The cost of this plastic packaging can, in some instances, be two to three times the cost of the terminal itself.

More importantly, because parts are loose in an oversized carrier pocket of this tape-and-reel format, locational accuracy at the point of pickup cannot be guaranteed. If the part is not presented with precise accuracy, particularly in the case of very small or oddly shaped parts, pickup is impossible. As shown in Figure 1, which depicts a 0.025 in. pin

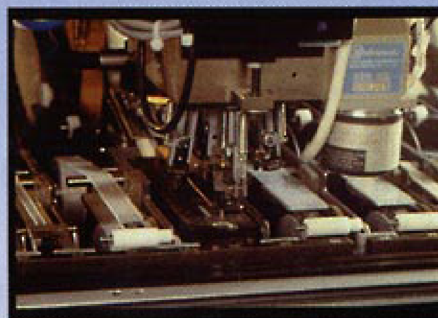


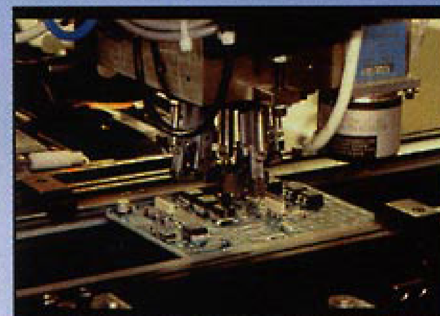
*Surface mounting pins, posts, IDCs, quick disconnects and receptacles along with active and passive components.*

## Proving the Placement of Surface Mount Jumpers

When a newly developed micro-inverter product line called for the high-speed placement of a uniquely shaped PCB jumper terminal, TB Woods Co. needed both a cost-effective connector and an efficient way to deliver that part accurately and in volume to the pick-and-place machine.

The Chambersburg, Pa., manufacturer of AC/DC motor controls and inverters introduced surface mount technology to an inverter production line several years ago. The company's newest product line is a micro-inverter that required six to eight jumper connections. "Our specific goals were to reduce board cycle times and control per-board costs," reported Tony Cassella, manager of PCB assembly and process engineering.





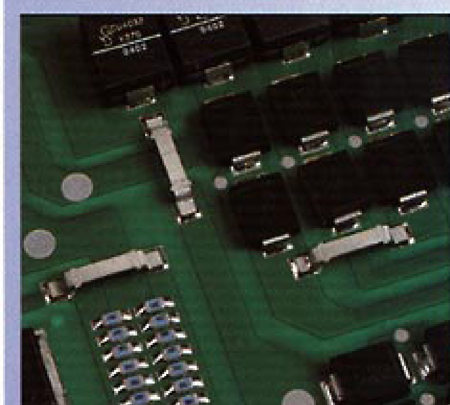
***Automatic placement of the jumper*** *onto the IMS surface mount pads. The terminal strip is advanced into the shear station (left) where the jumper is singulated and positioned for pickup by the placement head. It is then placed (right) onto the paste-coated solder pad.*

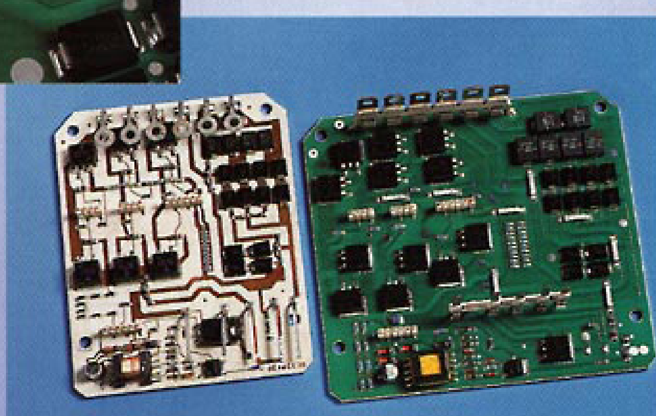
Because of the unit's small dimensions, a compact surface mount design employing aluminum substrate was seen as the optimal process. IMS (insulated metal substrate) aluminum surface-mounted boards, on which the board traces cannot be allowed to overlap one another, are increasingly popular in the power supply and industrial control industries due to their superior heat dissipation properties.

For the particular board under development, the need to jump several traces on the single-sided IMS board precluded the use of traditional through-board jump solutions. At the prototype stage, TB Woods employed a handcrafted, manually applied staple-shaped wire to jump the traces. But this was not acceptable for full production volumes. A new jumper was designed that would meet the connectivity requirements of the board, and could be stamped onto a continuous reel and be properly oriented for pickup by the placement machine. Cassella noted, "the combination of a custom jumper and feeding system solved the positioning problem associated with a very unique terminal."

The integrated jumper/feeder solution reduced the micro-inverter board cycle time to minutes as opposed to the extended time required when the jumpers were hand-placed. The compact feeder integrated easily with in-place surface mount equipment and complemented the company's overall automated manufacturing philosophy.

TB Woods is currently consulting with the Zierick design team on integrating surface mount pins into their process. Once the design of that terminal is complete, a continuous-reel feeder will be customized to move the pin in-volume to a surface mount pick-and-place machine.





***The prototype inverter board*** *(left) with the final production board (right). Inset (above) illustrates the surface mount jumper configuration.*

being picked up by a vacuum nozzle with an inside diameter of 0.035 in., smaller parts often must be positioned for pickup with a margin of error of 0.005 in. or less. In this and many other part placement applications, locational accuracy at the point of pickup is vital to the success of a high-volume circuit board assembly operation.

### An integrated solution

The solution to the problem of pickup and orientation is surface-mountable terminals stamped from flat stock into a continuous chain format and then wound onto reels. This allows the terminals to be fed through a component feeding system that automatically singulates the part and presents it to a standard pick-and-place machine.

The feeder (Fig. 2) offers an outside envelope dimension similar to standard tape feeders used with many placement machines. The feeder, which is individually engineered with the particular part to be placed, consists of a feeding mechanism that advances the part, a shear station that singulates the part,

# The need for more efficient terminal design and placement technology has become apparent

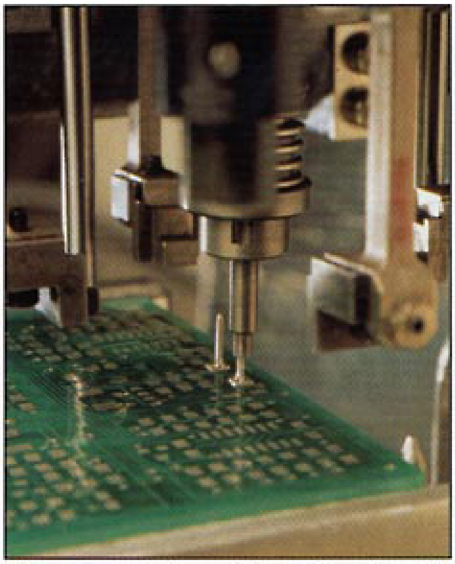


*Figure 1. Pickup of the singulated terminal by the vacuum nozzle.*

and a clamping mechanism that holds the part during and after shearing.

Once the shearing mechanism has separated the part from the wound strip, the pickup nozzle approaches the part. As the pickup nozzle descends to the part, the clamping mechanism releases the part and the component is picked up via suction from the nozzle. The nozzle then lifts the part and places it in the proper position on the PCB.

## Experimental analysis

An experiment was conducted to examine two key qualities of SMT terminal placement when using this integrated component/placement technology:

- Locational accuracy of part placement after reflow, and
- Pull-off force of the soldered part.

The test analyzed the effect of design and manufacturing variables on the most complex of these connectors: a surface mount post. The post tested is 0.025 in. sq, 0.250 in. long and is supported by a square base perpendicular to the body (Fig. 3). The test examined a number of variables, including pad size, solder mask and stencil geometry, stencil alignment, placement depth and alignment, reflow parameters, stencil print quality, solder fillet quality, terminal location tolerances, and adhesion forces.

The PCB used was a 3 x 3 in., 1/16 in. thick FR-4 board with 1 oz copper pads. Thirty boards were tested using a total of 3,000 components placed with a vacuum system. Two solder pastes were used in thicknesses (before reflow) from 0.006 to 0.010 in. In some tests, both paste and solder base were aligned precisely. In other tests, both paste and parts were offset up to 0.015 in. in both X and Y directions. The terminals were reflowed using a convection conveyor oven.

## Analysis

The results of these tests revealed that the design of the part itself, as well as the relationship between terminal base size and pad size, are the key variables affecting the accuracy of post-reflow positioning and joint strength.

The parts being examined have internal holes or slots in their base. These small openings serve to promote an important capillary wicking action during reflow. This critical capillary action prevents the part from floating on the solder during reflow, and draws the part down onto its pre-reflow position with a high degree of accuracy.

Unlike headers, these surface mount pins are placed on the PCB one at a time and require accurate locational tolerances after solder reflow to ensure proper mating of the terminals. Precise terminal location can be ensured in two ways:

- The solder pad should be sized slightly larger (about 0.015 in.) than the size of the terminal base to prevent terminal movement during reflow. This guarantees that the post-reflow positional accuracy will be equal to the accuracy of the placement machine.
- A solder pad that is significantly larger than the terminal base allows the centering of the terminal on the solder pad during reflow. The terminal's locational accuracy, therefore, depends on the accurate location of the solder pad.

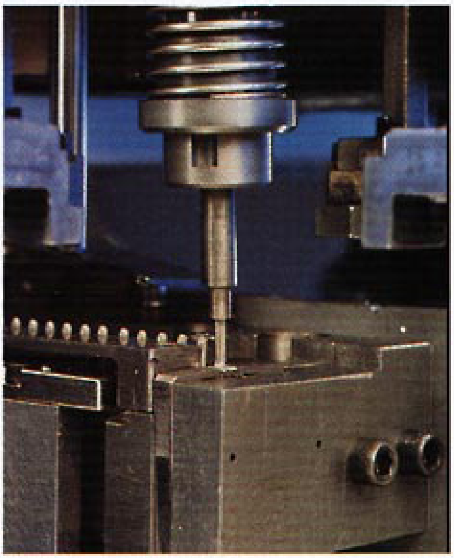


*Figure 2. Terminal feeder fits the same envelope as standard tape feeders.*

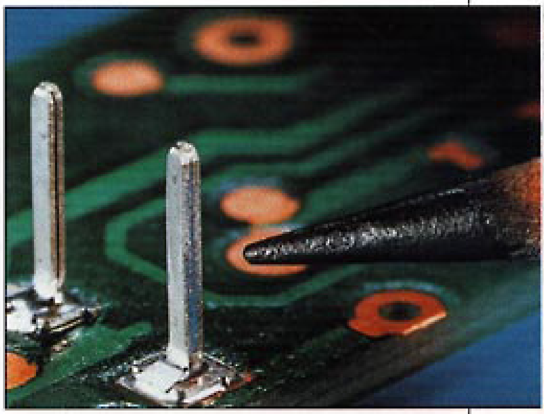


*Figure 3. The slotted base of the test post promoted capillary wicking of solder to draw the base down to the PCB pad.*

The test also revealed that a tall tower-like component with a small base would exhibit poor perpendicularity if the terminal did not provide capillary action. In all tests, joint integrity was well-maintained.

A key advantage to the continuous-reel feeder used to present these connectors is that it is similar in size and shape to conventional surface mount feeders.

The integrated part/feeder technology can be installed on most existing production lines, and can be conveniently moved from one location to another within most manufacturing layouts. Both the various terminals and the associated feeder mechanism can be custom-tailored to meet specific PCB and manufacturing process requirements.

## Conclusion

The integrated part/feeder solution offers a broad range of benefits to printed circuit board builders:

- Reduced material and labor costs,
- Improved post-reflow positional accuracy,
- Superior solder joint integrity,
- Elimination of combined SMT and through-hole assembly methods, and
- High-speed automation of part feeding and placement. **EP&P**

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