Which connector termination method is right for your PC/104 application?

By Ronald M. Weber

*Since the release of the PC/104 Specification in 1992, there have been numerous component developments and improvements to support this popular architecture. One of the many components found on PC/104 and PC/104-*Plus *modules is the mezzanine, or stacking connector, that is an integral part of the PC/104 system. Like many of its active and passive component counterparts, these connectors have seen continuous product developments and improvements since the inception of PC/104. As these components continue to evolve, it is important to consider how application efficiency and costs will be affected.*

To fully analyze application efficiency and costs, one must first answer the question, "What must a mezzanine connector do?" Mezzanine connectors are used to bridge the gap and connect printed circuit boards or modules that are used in a vertical stacking arrangement. Normally, the bottom board in the stack employs a standard, non-stacking connector. With a non-stacking connector, the contact tails are short and are designed only to provide adequate length for wave soldering. Boards designed to be stacked on top of the bottom board incorporate connectors with longer contact tails. These tails mate with the connector on the board or module below it. In other words, the stacking connector tails pass through the board at a specified length per the PC/104 spec (see Figure 1).

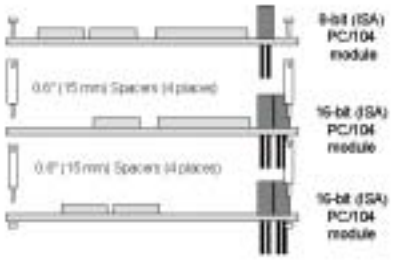

Figure 1. PC/104 modules in a stacking arrangement. Courtesy of PC/104 Consortium.

In the early days of applying PC/104 mezzanine connectors to boards, or modules, OEMs used a dual row, 64-position connector "stick." This generation of embedded systems supported the familiar 8-bit XT bus. With the onset of the 16-bit AT bus, more connector positions were necessary, so developers issued a spec for an additional 40-position connector. This new spec placed the 40-position connector parallel with the 64-position connector. Thus, this configuration accommodates 104 positions in four rows on .100-inch centerlines.

When developers first designed PC/104 and for some time afterward, there was only one option for installing the connector to the board – hand soldering. Wave soldering was not an option because of the long tails of the mezzanine connectors. Consequently, on a typical application, a technician would hand place the 64-pin and 40-pin connectors and meticulously hand solder each of the 104 pins. The proximity of the contacts and their tight spacing make this task difficult and time consuming. The two-connector orientation provided the technician some relief in that it allowed the technician to install the first stick and solder it, then install the second stick and solder it. Nonetheless, this was and still is a time consuming process. In fact, hand soldering is still in widespread use in PC/104 applications.

To install the PC/104 connectors with the manual process, a good soldering technician may take up to five minutes for each connector. Since many PC/104 modules also incorporate a 120-position PC/104-*Plus* connector, the connector installation cycle time can easily be doubled per board assembly. The entire assembly process, the repeatability, reliability, and quality implications of a hand-soldered connection, and the need to stock multiple connector configurations, clearly warranted a better solution.

The next generation of PC/104 connectors attempted to address the manufacturing concerns that PC/104 module designers brought to light. The new generation of connectors eliminated the need for hand soldering of each pin. Connector designers employed solder pre-forms, or doughnuts, in various configurations to eliminate the hand soldering (see Figure 2). Typically, manufacturers installed a solder doughnut around each pin of the connector. By doing this, they could then place the mezzanine connector on the board and use hot air to reflow the solder to the through-hole on the board.

Figure 2. Cross-sectional view of an EOTN contact pressed into a plated through-hole. The "eye" of the needle provides the mechanical force to hold the connection in place and the normal force to make a viable electrical contact.

To assemble a complete PC/104 module with this new mezzanine connector termination method, manufacturers would first populate the board with all the active and

passive components. Then, the module would pass through a reflow oven for the SMT components. Next, it would go through a wave soldering process to connect the through-hole components to the board. Lastly, manufacturers would place the PC/104 connector(s) with the solder pre-forms on the board to undergo a selective hot-air reflow process. In other words, hot air jets would aim at the underside of the module where the connector tails exit. The heat reflows the solder and completes the electrical connection. Compared to the manual soldering process, the selective reflow offers assembly efficiency improvements. Selective reflow takes between two and two-and-a-half minutes.

While labor is reduced and cycle times improve, there are some shortcomings with this method. First, since a number of variables affect how the solder reflows, it is sometimes difficult to predict where the molten solder pre-form will reflow. If the solder pre-form fails to reflow to the intended location, contacts on the connector may not make a good electrical connection with the board or, worse yet, the reflowing solder can form bridges between adjacent pins creating an electrical short. Another phenomenon observed during reflow is solder wicking along the connector tail, which results in a non-noble interface on a gold interconnect system. Problems like electrical shorts and wicking are un-repairable and may render a fully populated module unsalvageable. Further, since the pre-form reflow step is usually the last assembly step in a circuit board assembly, these problems go undetected until final testing of the module.

Another more recent termination method for PC/104 connectors is a press-fit approach. With the press-fit approach, soldering is eliminated. Instead, manufacturers use eye-of-the-needle (EOTN) contacts. EOTN dramatically enhances assembly efficiencies. Press-fitting the connector onto the printed circuit board is simple. Manufacturers prepare the module the same way they would for hand soldering or for use with solder pre-forms. Following the normal reflow and/or wave soldering, the manufacturer positions the connector and presses it into the circuit board with an appropriate applicator. It's as simple as that.

The evolution to the EOTN product addresses the problems associated with soldered connections. First and most significantly, this process reduces labor and handling compared to hand soldering or solder pre-form processes. Application cycle times are significantly reduced since the press-fit process typically takes less than thirty seconds from positioning the connector on the module to completing the press cycle. Inventory issues with separate 64- and 40-position connectors are solved since this process allows a unitized, or one-piece, connector to be used for PC/104 applications.

What is press-fit and eye-of-the-needle all about?

Eye-of-the-needle is sometimes called compliant-pin technology. It is a proven technology and has been used to attach connectors to printed circuit boards and high-speed backplanes in the telecom industry for many years. The technology is well established and has been put through its paces in communications applications as well as ruggedized military applications.

The EOTN concept is relatively basic. Each pin has a small hole in it that provides a compliant section on the pin (Figure 2). The hole, or "eye" of the needle, provides spring properties to the circumference of the pin such that when the pin is inserted into a through-hole, an appropriate normal force is exerted on the inside of a plated through-hole by the compression of the eye. This normal force not only provides mechanical retention, but also provides a high reliability, gas-tight electrical connection.

From an engineering perspective, press fit connections are desirable since the connection is compliant. In other words, the mating interface between the pin and the board has some "spring" to it. Thus, press fit connections not only provide a gas-tight connection, but they also stand up to vibration and mechanical shock much better than rigid solder joints. Naturally, a rigid connection may be more susceptible to cracking when exposed to vibration or mechanical shock.

Press-fit connections using EOTN are considered permanent connections, yet if a manufacturer needs to remove an EOTN connector, it is possible. Not only does a press-fit connection improve the quality of the interconnect, but also it allows for factory rework if necessary. With appropriate support fixturing, a press-fit connector can be readily pressed out of a printed circuit board. Once the connector is removed, the manufacturer can reinstall a new one in its place. Compare this process to the extremely tedious process of de-soldering a multi-pin/multi-row connector, and the benefits of EOTN are readily evident.

Collateral benefits

In addition to reducing labor, improving cycle times, simplifying inventory, and improving connection quality and reliability, some press-fit PC/104 connector variants offer additional benefits. Each PC/104 module has four holes (one at each corner) to accept screws and area allocated for the spacers. Regardless of the connector termination method, the stacks between modules must be properly spaced per the PC/104 specification. In the past, four loose-piece spacers and associated hardware provided the space. Spacers are sandwiched between modules (at the modules' four corners) and held in place by mounting screws. This assembly process alone presents its own challenges as a result of the number of components needed to perform the simple task of spacing two boards a set distance apart. The press-fit connector can address this spacing requirement in a unique way. Optional integral spacers and hardware are incorporated into the connector housing in such a way that the spacers become part of the connector.

The integral hardware approach helps reduce inventory requirements. Before there was integral hardware, manufacturers had to order, maintain inventory, and install the spacers and hardware. With the integral hardware, the inventory issue is simplified and, as an added bonus, spacer installation is simplified. Since the spacers are attached to the connector and remain stationary, assembly workers need not fumble around holding the spacers in place while stacking modules and tightening hardware.

Tyco Electronics offers integral spacers as an option on their press-fit PC/104 connector line. For a PC/104 application, the Tyco Electronics version, for example, has four integral spacers on the connector. Two of the spacers are designed to be broken off for use on one side of the board while the two other spacers remain attached to the connector and match the board holes at the other side of the board. (See Figure 3.)

Integrating assembly automation

While the press-fit connectors add cycle time efficiency and labor reduction benefits, some manufacturers may require complete assembly integration. Unlike solder termination of PC/104 connectors, the press-fit alternative lends itself toward another level of assembly automation. In high volume applications, press-fit PC/104 connectors can be accommodated in an automated pick and press operation and can eliminate manual assembly and improve efficiency. As demand for PC/104 modules continues to grow, press-fit PC/104 connectors afford manufacturers the ability to migrate from manual insertion to high-rate automated equipment and processes (Figure 4).

It is critical that connectors for PC/104 applications are designed to ensure intermateability between PC modules from various manufacturers. The challenge to

connector manufacturers has been to significantly improve upon the first generation products while maintaining this intermateability. As embedded modules gain popularity, it will be important for manufacturers to use the most efficient, cost-effective components in their module designs. Press-fit connectors hold tremendous promise for manufacturers who need to reduce production costs and improve throughput. Moreover, since press-fit connectors offer inventory benefits too, manufacturers could see reductions in part count and part numbers, which directly affect manufacturing costs. In addition to obvious productivity and cost improvements, it is also important to maintain a keen eye on the level of quality each termination method yields. Certainly, less scrap is desirable, but more important is that consistent, high quality modules are delivered to the end customer.

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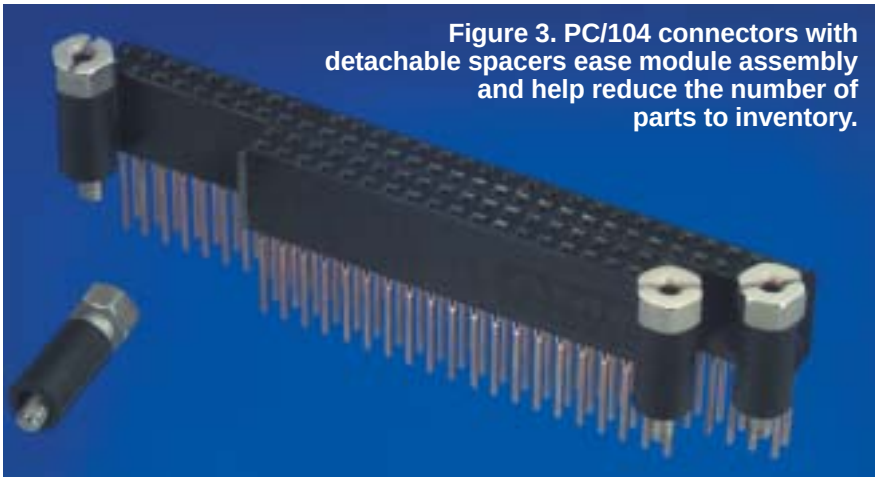

Figure 3. PC/104 connectors with detachable spacers ease module assembly and help reduce the number of parts to inventory.

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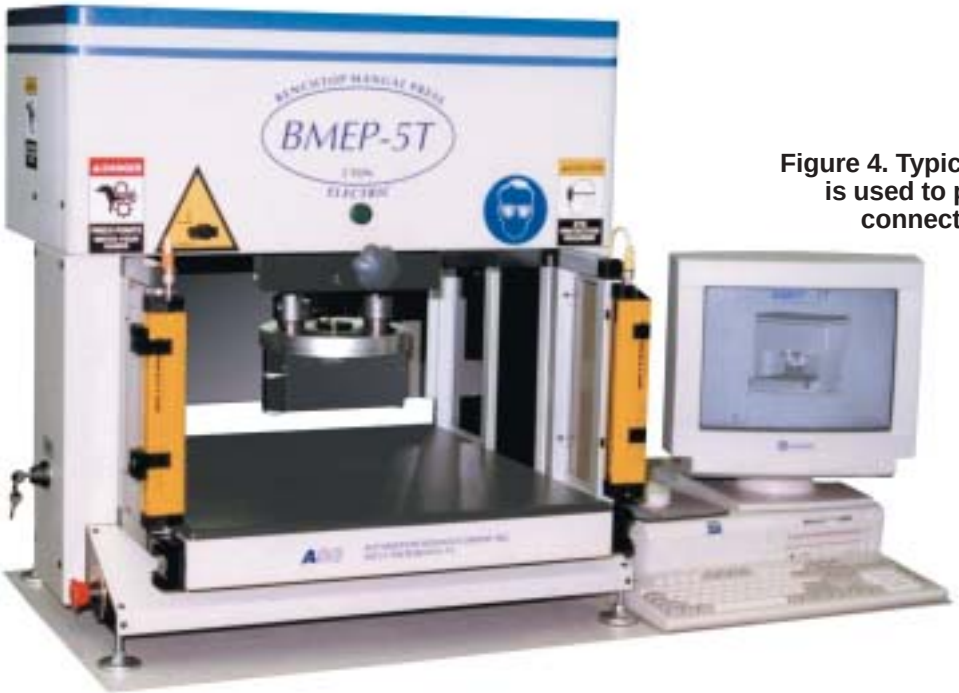

Figure 4. Typically, a flat rock style press is used to press an eye-of-the-needle connector into a board or module.