Smaller and smaller: Connectors shrink to meet the demands of miniature electronics

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To meet the needs of today's ever-smaller electronics, the individual electromechanical elements on printed circuit boards (PCBs) have become miniaturized. While this creates higher density, the small size can present challenges when manufacturing.

Plug connectors with centerlines of 2.5 mm or smaller can be especially challenging. When selecting components, manufacturers need to find balance between operability, manufacturability and size.

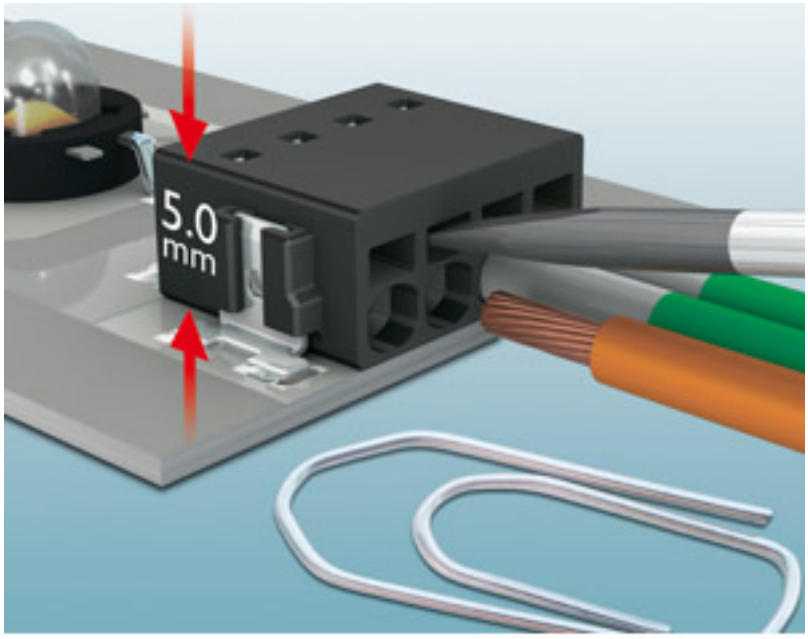

Figure 1. Easy connection of wires for SMD boards: LEDs and PCBs are soldered in the same process, thus eliminating the need for additional connection steps.

Wiring the board

Before deciding which type of plug connector to use, the installer must understand the three steps of the wiring process. Those steps are:

1. Determine functionality of terminal actuation
2. Prepare conductor and position it at wire entry
3. Actuate terminal

A clearly designed terminal will make installation easy, safe and intuitive. Note: always check the terminal's data sheets to verify critical information, such as the length of wire lead you need to strip.

Determine functionality of terminal actuation

There are three main types of connections: spring-cage, insulation displacement connection (IDC, also known as pierce contact) and screw cage. No matter what connection technology is used, a well-designed connector makes it easy to identify each terminal's wire connection and actuating areas. Skilled technicians can usually rely on experience to identify the type of conductor and necessary steps to connect it. Today, however, non-experienced IT personnel often install building equipment. This reinforces the need for intuitive connections.

In screw connectors, the act of tightening or loosening the screw is visible from outside. It is imperative that the installer clearly understands where the wires must be entered, and where to tighten the screw to ensure the required connection.

For spring-cage and IDC connections, however, wire termination action takes place inside the terminal, so it is not always visible. These connection methods are not the most clear for installers, and they need a way to show how to properly actuate from the outside. One method is an easily identifiable color latch (usually orange) that can only be actuated in one direction. Another way is to use actuating slots where a screwdriver can be inserted to terminate the wire, open the cage or remove the wire.

Preparing the conductor and making the connection

Preparing the conductor depends on the type of connection technology used. The wire may need to be stripped of insulation, fitted with a ferrule or simply trimmed to ensure there is a flat end with the insulation still surrounding the conductor.

Figure 2. SMT processes generate new requirements for PCB connection technology, with additional approval measures agreed upon with electronic manufacturers.

In screw-type terminals, the wire is stripped (and could be fitted with a ferrule). Then the user positions the conductor by pushing it against the back of the cage inside the terminal. The installer screws down to the appropriate torque specification. This screw termination will secure the wire against the contact, ensuring proper connection and allowing the flow of electrical transmission.

IDC technology has guide grooves or special guide mechanisms to help the user position the non-stripped wire into the terminal. Confirming the wire is properly seated into the wire entry shaft is critical for the actuation. Using a tool or finger, the actuation occurs with the contact forks displacing the insulation and making connection to the conductor inside.

Spring-cage technology starts with the same prepared wire as screw terminals. The installer uses a tool to open the contact, so the conductor may be pushed into the wire entry shaft. Once the wire is bottomed out, the tool may be removed. The wire will now be securely terminated with the connector. The spring-cage will maintain the required force on the wire to meet the stated electrical requirements.

Push-in spring technology can be actuated with one hand. The user actuates the terminal directly by pushing the stripped solid or ferruled wire against the spring resistance from its position in front of the spring until the wire is clamped into place.

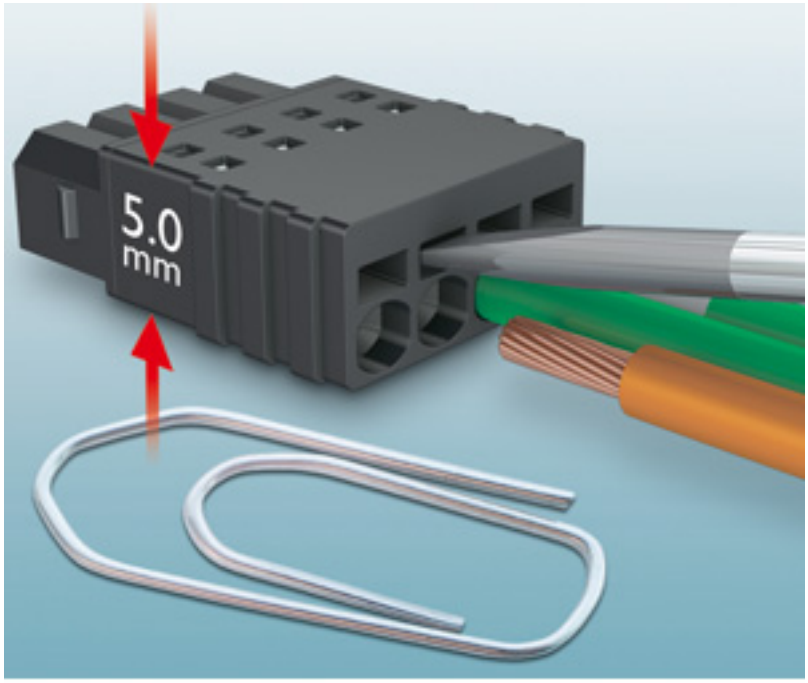

Figure 3. Spring-cage connectors like the PTSM from Phoenix Contact are easy to use despite small height. Rigid wires are first stripped and then inserted directly. They can be released using a screwdriver.

Screw-type and spring-cage technology require two-handed actuation. The user must open or close the actuating mechanism with one hand, while holding the wire in position with the other hand. Depending on the design of the clamping mechanism, the cage may be able to hold the screwdriver in place, allowing for a two-handed operation of inserting the wire. Some lever-actuated products can be used to terminate the wire without tools.

In a well-designed terminal block, users can actually feel the connection taking place (for example, the spring closing or the latch stopping). This tactile feel gives the users assurance that the connection is secure.

IDC and spring-cage technologies are the best choices for miniature connectors (2.5 mm centerline and smaller). Screw connection is generally not recommended because the screwhead size would need to be extremely small, making process of screwing down difficult. The vertical size of the screw itself could also increase the vertical height of the connector.

According to DIN 47726, the maximum diameter of a wire with a nominal cross section of 0.5 mm² (including insulation) must not exceed 2.6 mm. This means if the centerline is 2.5 mm, it is not possible to have lateral actuating elements or guides at the height of the wire. To accommodate the requirements of this specification, height (top to bottom of the connector) and length (front to back of the connector) dimensions are used to house the contact and termination method. With this shrinking of centerline between pins, connector manufacturers are now miniaturizing the height and depth of the connectors.

Balancing the size and usability of connectors is a challenge. For example, in a

spring-cage connector with a centerline of 2.5 mm, the actuating elements are so close together, they cannot be terminated with just the fingers. A screwdriver or other tool is necessary to effectively actuate the individual poles. (Consult your datasheet to find out what screwdrivers are compatible with your connector.)

SMT processes mean higher requirements

Surface-mount technology (SMT) processes have become extremely common in PCB manufacturing today. SMT processes can automatically feed components along a belt to the pick-and-place machine.

The pick-and-place machine relies on a large, smooth suction surface to pick the components from the belt. A standard vacuum pipette picks the components and then places them onto the PCB. Next, the PCB goes through the reflow soldering process. Here, temperatures reach up to 260°C, as specified in standard IPC/JEDEC J-STD-020D.

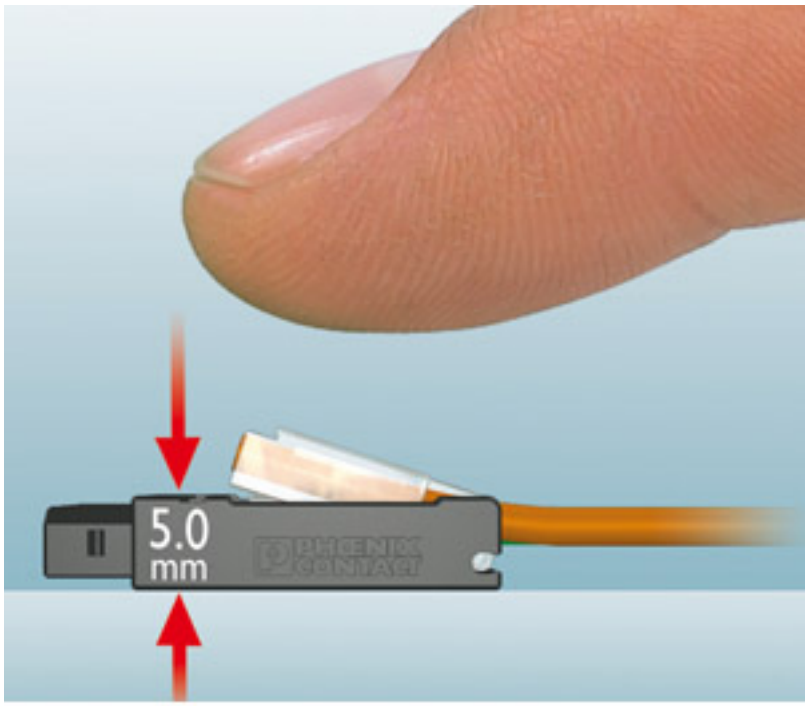

Figure 4. With miniature IDC connectors (such as Phoenix Contact's PTPM), flexible wires are inserted into the guide with thumb pressure to establish the contact. There is no need to first strip the wires.

All surface-mount components have additional requirements for the solder contact surfaces. Most specifications stipulate a solder surface coplanarity of 100–200 µm. This applies to the solder surfaces of any anchor metals in use as well as to the contact solder pin, since the component is bonded to the printed circuit board through these surfaces. Plug connectors and PCB terminals are subject to mechanical forces in the field, so a stable soldered connection is absolutely critical.

Finding the right miniature connector for SMT processes

For miniature spring-cage connectors, new technology enables a push-in spiral spring as the clamping element. This type of contact is extremely compact and

allows quick connection of stripped, rigid and flexible wires. The terminal actuating elements provide additional potential for miniaturization. If release buttons are no longer included, then they no longer require any space. By eliminating the release buttons, the components can use a flatter and shorter design. Instead of an additional release button, the user can insert a 2.0-mm screwdriver into the actuator slot.

Miniature IDC terminals are also available for flexible wires. They feature piercing contacts designed so that the contacts just enter into the insulation, making connection inside with the wire. Hinged guides encourage proper positioning of the wire. After positioning the wires, the user depresses the lever with thumb pressure, and the piercing element will contact the wire. This method is up to 80 percent faster than screw-connection technology.

Both of these plug connectors demonstrate potential for even further miniaturization of common wire connector elements. With some connectors measuring just 5 mm high, valuable space is available for other PCB components. These true SMD connectors can carry voltages of 150-V UL and currents of 5 A UL across each pole.