Portable Electronics Require Smaller, More Modular SMT Battery Connectors

Next-generation battery connectors face many new market demands, although the common ingredients remain the same: high life cycle, stability, simple design, and SMT compatibility.

By Tom Anderson

For years, traditional battery pack connectors have been found in applications such as cellular telephones and portable industrial electronic devices. Available in various sizes and shapes, traditional batteries feature two distinct contact configurations (see Fig. 1). Stamped cantilever contacts provide the more economical interconnect for volume consumer electronic level products, whereas spring-loaded "pogo pins" are chosen for industrial applications to provide extended cycle life. In both cases, the same performance requirements found in a compression-style interconnect apply to a majority of the application parameters.

Figure 1. Battery pack connectors come in various sizes and shapes featuring two distinct contact configurations: stamped cantilever contacts for consumer electronic products, and spring-loaded "pogo pins" for industrial applications.

Of primary concern to most design engineers is durability. The contact geometry must provide stub-free operation for a specified number of cycles. The average connector is rated at a minimum of 5,000 insertion and withdrawal cycles. In addition to the contact shape, the finished plating on the contact and adjacent pad is a major contributor to the life cycle of the device. Gold plating has become the defacto standard for its durability and lower contact resistance properties, both of which maximize the length of charge.

Another criterion to consider is current capacity and voltage rating of the interconnect. This will dictate the physical size of the individual contacts, the number of contacts within the specific connector, and the centerline spacing of the contacts. The printed circuit board (PCB)-to-case tolerance is important to the connector's performance because it joins two different mechanical components together. The connector must absorb the allowable mated tolerance difference within the operating range of the contact's beam deflection.

For example, a standard battery connector provides a beam deflection or mating compression range of 0.7 mm, while maintaining an allowable contact normal force. This is normally charted in a contact deflection curve, which compares deflection range with the applied contact force (see Fig. 2).

Figure 2. A contact deflection curve compares deflection range with the applied contact force.

Now that we have looked at the basics, let's turn to two primary forces driving the development trends of next-generation battery connectors. The first of these forces focuses on significant size reduction to meet the continued miniaturization of handheld electronic devices.

Volume reduction

Two recently released surface-mount technology (SMT) connectors address overall connector size and z-axis height. The first of these two products offers almost 50% savings in connector size—the actual volume of the connector—compared to existing commercial connectors (see Fig. 3). This significant reduction in size, however, does not diminish any of the key contact/connector performance requirements.

Figure 3. Demonstration of 50% savings in connector volume (right) as compared to existing commercial connectors (left).

For example, using an "S"-shaped stamped-and-formed contact configuration maintains the necessary contact deflection and normal force, and allows the containment of the solder tail attachment area within the envelope dimensions of the insulator body. Additionally, this contact geometry provides superior mechanical PCB retention strength due to the long front-end-positioned solder tail for positive board attachment and maximum peel resistance. Several standard features are packed into this next-generation connector, including availability of multiple case sizes and 3-A current ratings. These connectors are also designed for automatic placement and feature redundant beryllium-copper base material and a high-temperature insulator for compatibility with either convection or the infrared reflow soldering processes.

Height reduction

The second product addresses the z-axis height requirements for extremely thin applications. Until now, we have discussed connectors with heights between 2.5 and 3.0 mm. New ultralow-profile connectors support heights below 2.0 mm (see Fig. 4). The stamping technology developed to achieve a reliable yet robust low-profile contact system comes from many years of compression contact experience. A variety of low-profile board-to-board and card-to-board connectors have been available since the early 1990s. While each of these products and their predecessors had to meet certain market requirements as they were downsized, the common ingredients have remained the same: high life cycle, stable contact deflection, simplicity (cost), and SMT compatibility.

Figure 4.
The simple design of ultralow-profile connectors can reduce z-axis height by 50%, or as low as 2.0 mm.

The first connector to be released in the new ultralow-profile family starts with a contact beam static height of 2.45 mm. Once fully deflected, the compressed height reduces to 1.3 mm above the board, or about a 50% reduction in z-axis height from the battery connectors discussed previously. Remarkably, even at this profile, the primary and secondary performance features of the connector have not been sacrificed. This is still a 3-A contact system providing high durability and high-tolerance absorption features that are derived from proven beryllium-copper base material and a stable contact beam design. The long sweeping design of this contact provides positive mechanical solder attachment to the PCB with a full-length tail that extends from both ends of the insulator. The high-temperature insulator has an integral end stop to aid in either radial (angular) or slide-in (horizontal) battery engagement.

The second force driving the development of these next-generation battery connectors is not actually tied to battery packs themselves. It comes from everyday applications looking for a more creative interconnect scheme to replace low-pin-count board-to-board and wire-to-board interfaces. Taking a slightly different view of the traditional battery pack application, it is basically a module (battery pack) to a PCB interface. The input/output of the module in this case is simply plated pads on a PCB that interface with the compression contacts in the connector. A module could also be an internal PCB assembly that simply needs to mate up to an adjacent board. It can be a fixed device or assembly that gets attached to a housing or cabinet. Or, it could be a small removable device that gets plugged and unplugged on a regular basis. The following are some example real-world applications for each of these definitions.

Real-world applications

For the internal board-to-board application, the challenge was creating a small industrial handheld device that could carry 6 to 8 A of power, a ground, and some signal lines between two PCBs. Because of the different features between devices, each product required a different number of contacts. In discussing the options with the development engineer, the standard battery connectors appealed to the customer because of the off-the-shelf availability and end-to-end stackability of the connectors. With the introduction of the new lower-profile battery connector, the design engineer was able to offer a slightly smaller board separation height for next-generation products.

For the fixed device-to-cabinet application, we worked on a project that mounted an electromechanical module to the side of a cabinet. This module contained solenoids connected with external discrete 24 AWG wires. While this approach worked, the customer found that the most field failure and repair time involved module replacement and re-wiring. By changing the interface to compression-style battery connectors, the components were modularized, simplifying initial assembly and field repair. The key features of this application were the current capabilities and robustness of the standard connectors.

For the removable device application, the project called for integrating a small external programming or access module slot to the customer's device. Because this was a custom product, they wanted to find a standard connector that could provide the necessary interface, without the worry of a commercially available product being plugged into the same slot. For this application, size, durability, and availability were key factors.

The current and next-generation battery connectors continue to support their traditional market applications and migrate to new ones. Their success to date has been due to the ability to solve reliable and robust interconnect needs with simple and industry-proven off-the-shelf connectors.

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