Advantages of Stamped and Formed Technologies in Power Connectors

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Just as designers of new electronic systems are striving to design systems that deliver more functions and performance, connector manufacturers must keep up with this trend in order to maintain a competitive advantage. Tyco Electronics has developed and produced power connectors using alternative manufacturing technologies while other connector manufacturers continue to produce products with traditional screw machined contacts. This paper will present some of the benefits offered from a stamped & formed power contact design. The specific power connector evaluated is the "Zone 1" connector specified in the Advanced Telecommunications Computer Architecture (ATCA) Standard.

Why Stamped & Formed?

Connector performance, intermatability and interchange-ability (related to printed circuit board footprints) are well defined by the AdvancedTCA PICMIG 3.0 standard. A connector manufacturer has the liberty, even obligation, to optimize a connector design to best meet the specified performance standards and market requirements. Careful study of these performance requirements led Tyco Electronics' designers to consider existing, well proven stamping & forming design and manufacturing technologies. While requiring considerably more investment to develop than a screw-machined contact, the stamped & formed contact had the potential to offer a breakthrough in performance. With the relatively high contact-to-pcb retention forces required as well as the high shock & vibration and current carrying requirements, a stamped & formed contact geometry proven in both Industrial and Military applications was selected.

While meeting specific industry performance goals is always part of the design process, the ability to offer future product performance improvements as well as cost reductions also weighs heavily in the selection of the best design. With the volatility of precious metal costs, the ability to plate just the critical separable interface proved paramount in controlling the cost contribution of the precious metal platings. The stamped & formed contact design along with a strip-line plating process allows use of heavier plating thicknesses of the precious metals applied specifically in the separable interface, without the waste associated with putting gold where it is not needed. **Figure 1** shows an example of one stamped and one machined contact where the stamped contact has a specified plating zone for the precious metal platings. This "selective" plating controls the overall costs without implementing thinner platings over the entire surface to meet market cost requirements. In addition, modern strip-line plating processes provide improved process control as compared to loose-piece barrel plating operations typically used with screw-machined contacts. The selective plating approach and stamped &

formed process combine to provide both the long-term reliability and market cost requirements of modern telecommunications equipment.

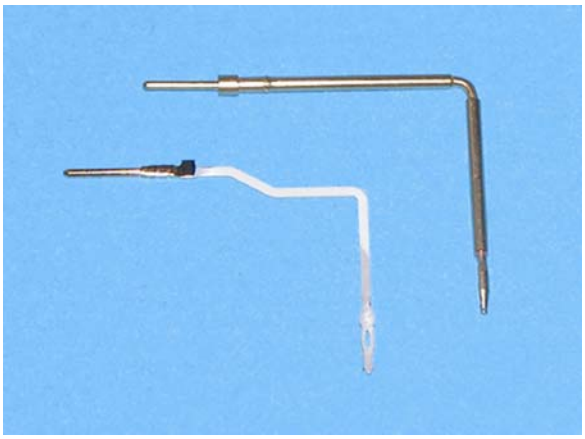


Figure 1

An additional performance requirement critical to the connector was the retention of the press-fit (solder-less) contact to the circuit board's plated through hole, after insertion to the pcb. An advantage of a stamped & formed contact is that the contact geometry can be optimized to provide a high retention to the pcb. **Figure 2** shows a cross-section of the solder-less compliant section inside the plated through hole in the circuit board. The compliant section maintains high internal (gas-tight) forces over a large area to the inside of the hole for high strength, low resistance and long-term reliability. Additional selection criteria considers the robustness of the contact and the resistance to damage during either initial assembly to the pcb and/or actual mating with Tyco Electronics or alternate brands of the Zone 1 AdvancedTCA connector. With these factors in mind, selection of rugged time-proven contact designs used in Tyco Electronics' Type III+ and Twin Beam products provides long-term reliability of the interface in the Advanced TCA applications.

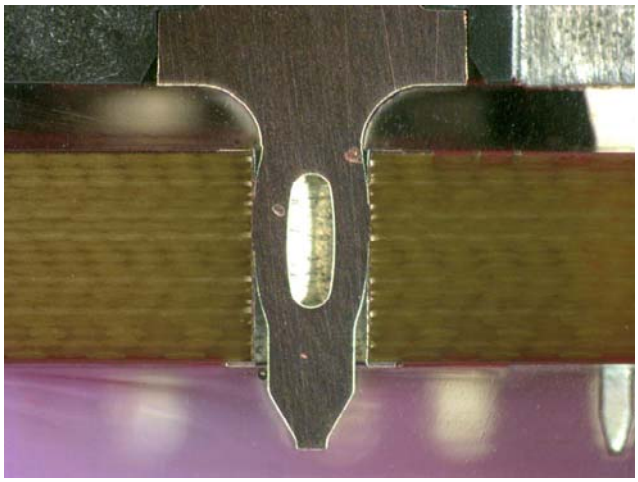


Figure 2

Manufacturing advantages of stamped & formed contacts

While screw machined contacts are manufactured by turning and machining round bar stock of metal, stamped and formed contacts are created using flat coils of copper alloy stock that has been fabricated to a specific conductivity, strength and temper. In a progressive stamping die, the contact profile is stamped from the flat stock and then formed into the desired final geometry. In many cases the contact exiting the die is a completely formed contact, without secondary bending operations required. This results in excellent true-position of the pcb solder or press-fit tails which allows easier assembly to the circuit board. This process also enables highly consistent manufacturing repeatability as well as greater efficiencies in use of base metal and precious metal plating. Material handling for subsequent assembly processes is greatly improved as contacts are handled on strip to the point of installation into the housing. In comparison, bulk packaged machined contacts are typically handled individually and often manually. The stamped and formed manufacturing advantages lead to higher manufacturing consistency, higher quality PPM yields and the ability to realize lower manufacturing costs as volumes increase.

Why is flat better than round?

It's been proven for many years that a flat conductor can deliver more current at the same temperature rise than a round conductor of the same cross sectional area. The permissible current density for a conductor is determined primarily by its heat-dissipation characteristics. A comprehensive evaluation of the electrical relationships between flat conductor cables can be found in 3.2 FCC Applications in the NASA TM X-53975, Flat Conductor Cable Design, Manufacture and Installation, Jan. 9, 1970.

In this report tests show that fully loaded flat conductors can carry up to 155 percent higher current loads than round wire of the same size. Considering discrete "hook-up" wire as an example, from a manufacturing viewpoint a flat wire would be far more difficult to form and more costly to produce than round wires. However, when it comes to forming precision electrical contacts with both mechanical and electrical properties, in equivalent volumes, then costs are far more comparable. In fact many flat contacts used in industry standard connectors (or round contacts with flat sectional areas) are produced today at a lower cost than solid round contacts. Therefore, the benefit appears to be a potentially lower cost contact, with a potentially higher current carrying capacity. **Figure 3** shows the individual power contacts used in the Z1 Power connector. The flat section provides the greater heat dissipation while the round section provides the intermating interface to the specified industry-standard dimensions.

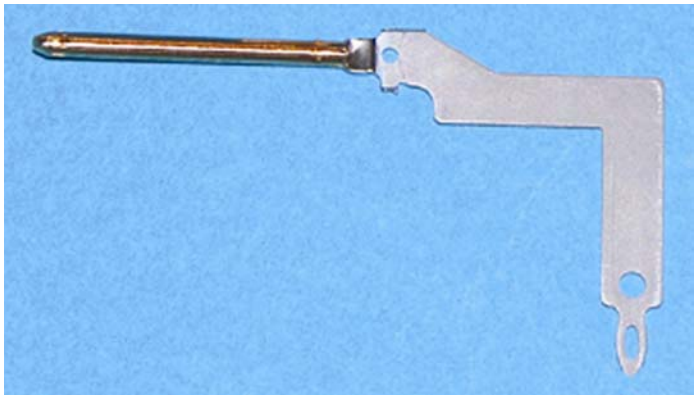
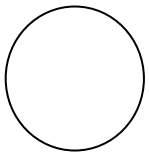


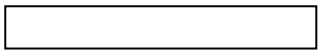
Figure 3

Cross Sectional Area vs. Surface Area

The strongest characteristic of flat conductors is the large surface area for heat transfer in comparison to a round conductor of equivalent cross section. This translates immediately into better heat dissipation, and therefore a higher current rating. **Figure 4** shows two geometric shapes representing contact cross-sections of round and flat contacts. While both contacts have the same cross sectional area, the flat contact has over 50% more surface area, which leads to better heat dissipation. Simply stated, it is a more effective use of the available material. While additional current carrying capacity may not be needed, long-term reliability is a high concern and excessive heat is a major contributor to failure in electronic systems. Therefore, a contact design which allows for lower temperature operation, while carrying the same current, is a preferred design.



Cross section of traditional screw-machined Size 16 contact
Area = A1
Circumference = C1



Cross section of stamped & formed Z1 power contact
Area = A2
External Surface Area = C2

Summary
A1 = A2 (Cross sectional areas are identical)
C2 = 1.5 X C1 (Surface area of flat contact is far greater)

Figure 4

With the contact geometry optimized for improved heat dissipation, initial prototype contacts confirmed the stamped & formed contact to be equivalent or better as a power contact than the traditional screw-machined construction. Further optimization continued in the final design utilized in the Z1 power connector. **Figures 5 and 6** show a comparison test set-up and current vs. temperature rise results between a traditional connector utilizing screw-machined contacts and Tyco Electronics' Z1 Power connector. Tested under the same conditions, the Z1 Power connector shows well over 40% improvement in current carrying capacity at the same temperature rise.

Figure 5

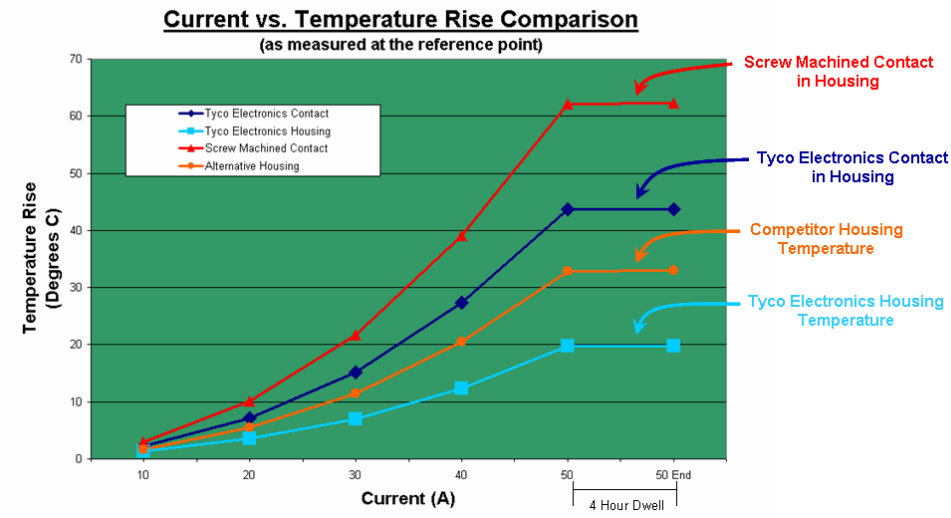


Figure 6

Flat contacts in the Zone 1 Connector

The Tyco Electronics Z1 Power free-board plug (right angle) connector was designed using a round separable interface with a flat inner section to improve heat dissipation (**see Figure 7**). The contacts are assembled into a module (also referred to as a "chicklet" approach), similar to that used in the popular Z-Pack 2mmHM-Zd product line. This means that contacts are stamped in a columnar configuration and are sandwiched between two plastic housings, which both insulate the contacts from one another as well as control the contact tail positions. The chicklets are then inserted into a main housing body that holds the contact mating interface positions per the AdvancedTCA standard. Additionally, the chicklet approach allows air space between contacts resulting in a thermally relieved housing that helps to dissipate the heat (**see Figure 8**).

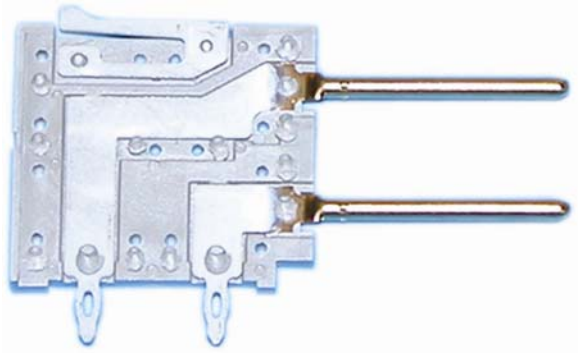


Figure 7

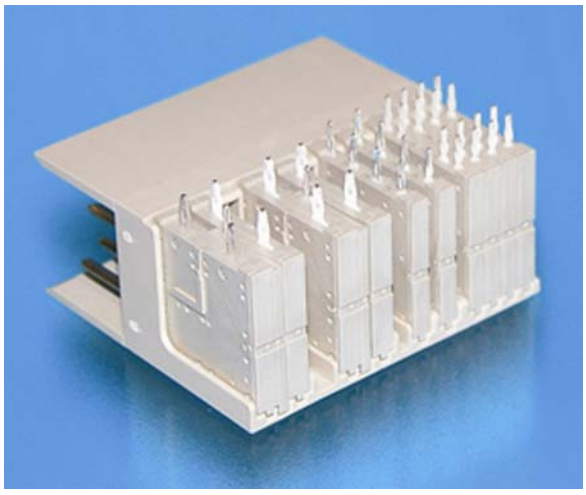


Figure 8

The Tyco Electronics Z1 Power receptacle (vertical) connector was designed based on the popular Multimate high-current, Size 16 Type III+ contacts, which utilize a stainless steel contact spring with excellent stress relaxation properties to provide long-term reliability. The receptacle connector housing utilizes void coring for optimized heat dissipation and structural/dimensional integrity (**see Figure 9**).

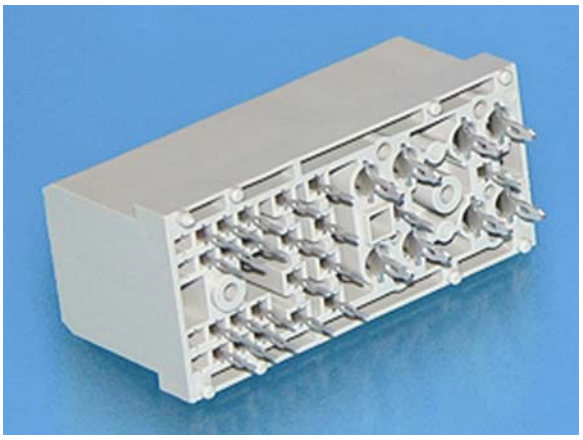


Figure 9

Summary

Power connectors have been continuously improved to deliver more current without increasing the total installed costs. Use of new copper alloys has helped, however, a more significant factor is how well the contact/connector dissipates the heat generated as current passes through each contact. Designs specifically geared towards eliminating this heat have shown remarkable improvements in current carrying capacity. Use of flat material stock instead of round has resulted in improved contact consistency, improved mechanical strength of compliant pin designs and improved current carrying capacity, without adding cost to the system.