Press-Fit Current Carrying Capacity
Part 3: Design Considerations for Power Modules

This is the third in a series of three Tech Bulletins that focus on the current carrying capacity for Press-Fit applications. The specific three topics in this series are:

- Application requirements for higher current capabilities
- Current capability testing and results
- Special design considerations for power module applications

This Tech Bulletin addresses the third area: Design Considerations for Power Modules

As discussed in previous Tech Bulletins, the explosive growth of automotive electrical systems and other industries using inverter and converter based power modules is driving the need for press-fit technologies to provide reliable, solderless interconnect solutions that can support high current levels. Furthermore, today's press-fit interconnects have been tested and proven to support current capacities of 30 amps or more through a single press-fit eye, with reliable, predicable current carrying performance curves across a range of temperatures including 125ºC to 150ºC and above.

This Tech Bulletin provides additional information on how press-fit technology is being integrated into electronic power modules and similar devices for use in the automotive and other industries.

Design Challenges

Electronic power boards typically need to plug into a larger main board, often with complex control circuitry on it. Due to fundamental differences, these boards often use different types of substrates and therefore require interconnect methods that provide reliable performance, design flexibility, thermal compensation, strain relief and assembly efficiency.

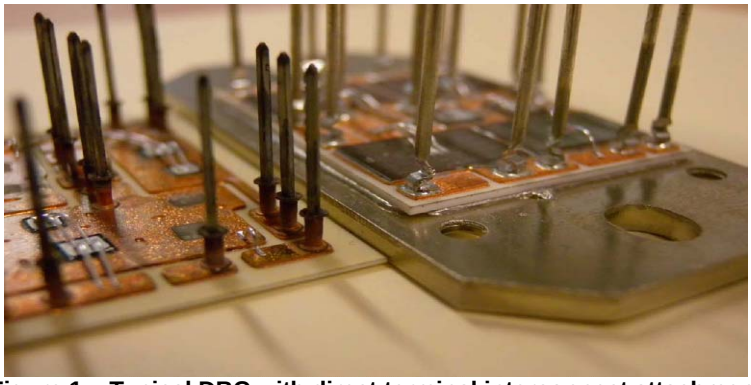

Figure 1 – Typical DBC with direct terminal interconnect attachment

In addition to connections between boards, power modules also need to incorporate reliable external interconnect methodologies that support efficient assembly of the module within higher level automotive systems.

Another significant challenge is designing for thermal dissipation and CTE mismatches because of the large power devices such as IGBTs, MOSFETs and conditioning components, which can generate significant heat that must be effectively dissipated. To get the heat out, power modules often incorporate large heat sinks that can present challenges for conventional soldering approaches. In addition, conventional solder connections add risk as a point-of-failure because the repeated stresses from CTE mismatches between the internal elements can eventually cause cracks or breakage at the solder joints, whereas press-fit's spring-like design flexes to maintain a consistent interface throughout thousands of temperature cycles.

Figure 2 – Example Heat Sinks on Power Module

A third key challenge is design flexibility, which is becoming more important because in today's interoperable automotive environments, power module designers may have to interface with fixed control board designs that are already dictated by external considerations. This means that the module's interconnect and housing strategies need the adaptability to conform to predetermined circuit board form factor requirements rather than the other way around.

Press-fit technology provides an inherently reliable, solder-free, lead-free, and automation-friendly approach that delivers both the high-current capabilities and the design flexibility needed for advanced power module assemblies.

Terminating Power Based Components Mounted on DBC Thermal Substrates

Press-fit interconnects can be used in a variety of ways within power modules to interface with power components on Direct Bond Copper or ceramic thermal substrates. One key method is using a wire bond connection from the DBC assembly circuit to a bondable surface on the press-fit terminal.

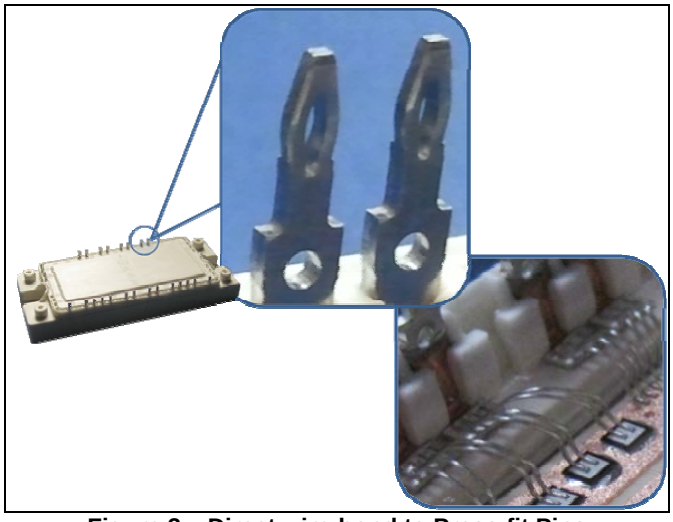

Figure 3 – Direct wire-bond to Press-fit Pins

Providing Strain-Relief between Boards

Instead of wire bonding, a second key approach is directly soldering a terminal to the DBC. While this offers advantages for certain applications, it also presents some additional challenges. As previously mentioned, CTE mismatches and repeated thermal cycling in automotive applications can put significant strain on the internal interconnects within a power module assembly. The inherent design flexibility for stamped press-fit components offers the ability to easily incorporate special configurations (such as the S-shape shown below) that provide internal strain-relief while also integrating smoothly with overall design requirements.

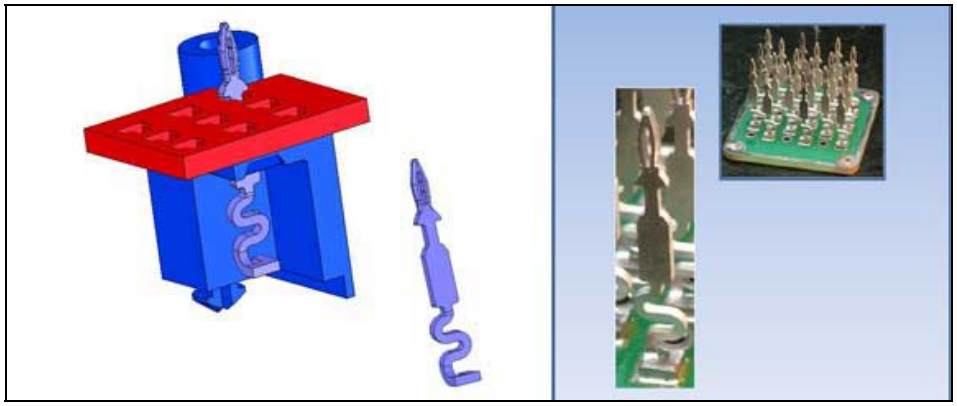

Figure 4 – S-Shaped Design Provides Strain-Relief

Integrating Through External Housings

Press-fit interconnects also offer a broad range of design options for adapting to virtually any external housing and enclosure requirements. Pin configurations can be stamped in a variety of lengths and thicknesses, with shoulders, stop-points, or other special features incorporated at specified locations. As shown below, press-fit can accommodate various external interconnect patterns, pin lengths and stand-off requirements. Also, using special two piece housings with an internal stop-comb that fits over the press-fit shoulders and locks the pins in place (image on the right), additional strength can be added to absorb insertion forces and eliminate stress on the DBC during module assembly.

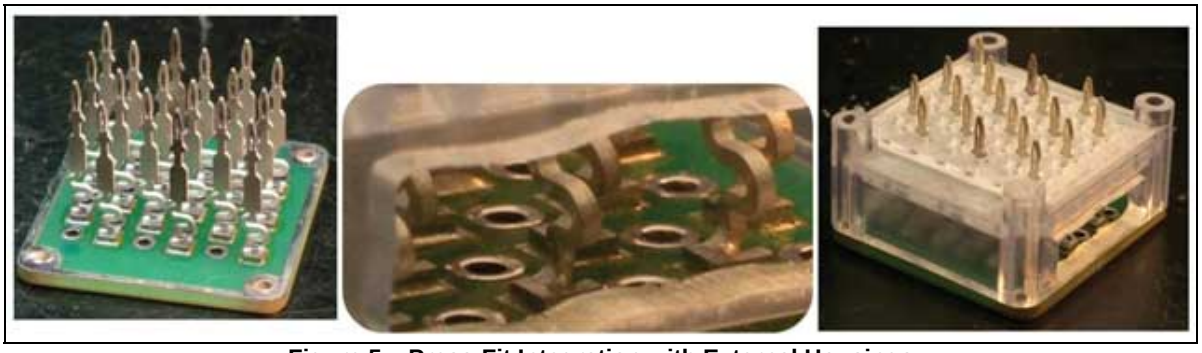

Figure 5 – Press-Fit Integration with External Housings

Custom Stamped Press-Fit Lead-frames

The inherently flexible nature of the press-fit manufacturing process also can address unique design requirements through the use of full-custom stamped lead-frames. For example, as shown below, multiple compliant press-fit interconnects can be seamlessly incorporated within a single monolithic stamped lead-frame. Depending on the overall module design requirements, the custom stamped lead-frame can support direct mounting and wire bonding of the DBC as well as providing all of the external interconnects through the housing.

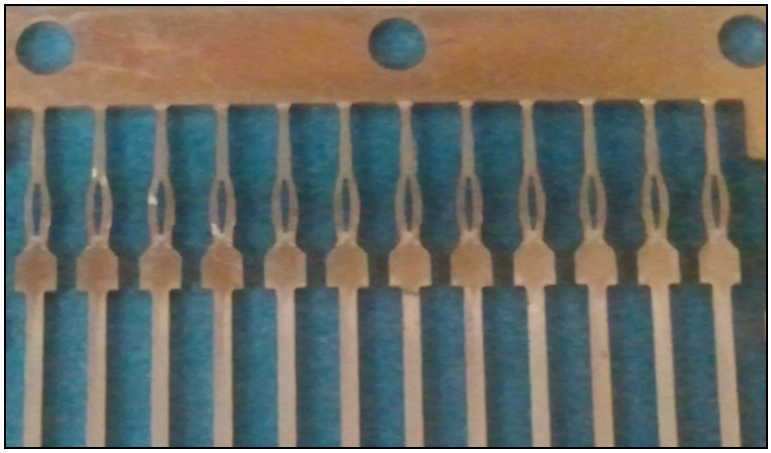

Figure 6 – Custom Stamped Press-Fit Lead-frames

Summary

As detailed in the previous two Tech Bulletins, the key to success in power module design is the combination of press-fit technology's inherent design flexibility and assembly advantages, combined with the now proven ability of press-fit interconnects to support high-current levels across a broad range of temperature conditions.

Press-fit interfaces have been proven to support current capacities of 30 amps or more through a single press-fit eye and tested to maintain reliable, predicable current carrying performance curves across a range of temperatures including 125ºC to 150ºC and above.

The choice of a variety of alloys and the solder-free nature of press-fit zone components allows engineers to optimize manufacturing processes, even if the product includes large heat sinks, multiple internal substrates, and complex control circuitry, all with different thermal coefficient of expansion (CTE) characteristics. Special material options for press-fit also exist with high thermal dissipation performance that can aid in overall thermal efficiency for the whole assembly.

The inherent adaptability of press-fit compliant technology and fabrication processes also gives product engineers much more flexibility to optimize their overall product designs for manufacturing efficiency, long-term reliability and ease of external integration within other automotive systems.

More information regarding Press-Fit technologies and products can be found on the web by visiting www.interplex.com/pressfit or by calling (718) 961-6212.