

Upgrading Product Designs From Solderjoints to Press-Fit Why, When and How?

Compliant press-fit interconnects have already become a key enabling technology that is widely used in the automobile industry, power module designs and other applications. The ability to eliminate soldering hassles while providing high-reliability interconnects with excellent thermal characteristics and high-current carrying capacity has already made press-fit technology a preferred solution for the design of many new products. In addition, we are experiencing a growing number of design upgrades of products being migrated from solder-based connections to press-fit technology.

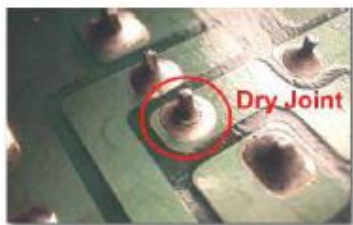
This Press-Fit Tech Bulletin provides an overview of the reasons why press-fit technology is gaining usage as a solderjoint alternative for new and existing designs and also looks at when it is most appropriate as well as the key considerations for a successful transition.

Some specific areas covered are:

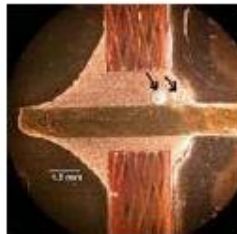
- What is driving the trend of conversions from soldering to press-fit?
- What types of designs can most benefit from converting to press-fit during upgrades?
- What issues should be addressed to assure a successful conversion to press-fit?

Driving Factors for Upgrading to Press-Fit Technology

Deployments of press-fit “eye-of-the-needle” compliant interconnects have shown a consistent pattern of better reliability than similar designs using conventional solderjoint connections. This confirms the extensive testing data that has also been amassed in the laboratory and production environments, which demonstrates the overall higher quality and reliability of press-fit technology as compared with solder-based approaches.



Solder Joint Connection



Press-fit Connection

Because there is no metal filler, there are no risks of voids or other flaws, thereby providing a much higher yield of good interconnections. The solder-free nature of press-fit also helps to eliminate any unnecessary heating of assemblies that have been partially or fully populated, thereby avoiding the risk of damage to components and/or the unintended partial reflow of other solderjoints that could be weakened by multiple heating cycles

Some key driving factors for the growing movement toward press-fit include:

- Eliminating the risk of dry joints, cracking, and other solder formation problems
- Strong, solder-free, repeatable and highly reliable interfaces
- Verifiable assembly techniques with integrated force-monitoring
- Automated press-fit assembly processes for consistent results
- Direct-contact interfaces with high normal force
- Excellent electrical and thermal transfer characteristics
- Ability to withstand CTE mismatch forces during thermal cycling
- High current carrying capacity for power-oriented applications

The following sections provide a closer exploration on some of these key issues.

Reliability During Repetitive Thermal Cycling

The excellent thermal profile of press-fit interconnects is an especially important factor for long-term life-cycle reliability, particularly for with a wide temperature range and harsh environmental conditions, such as automotive electronics and many power-module designs. For example, on a cold winter day, going from engine start-up to standard running temperatures could potentially require an under-hood engine-mounted electrical sub-system to go from 0° C to 150° C in less than ten minutes. The most common press-fit applications are for passenger compartment and underhood locations, with on engine and transmission applications becoming more popular.

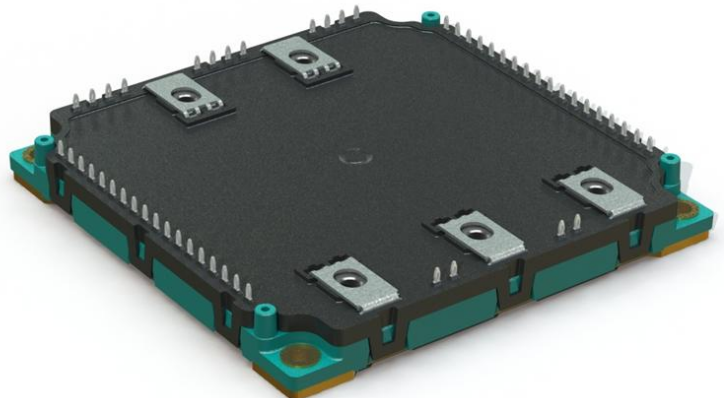
A complex automotive or power-module electrical sub-system consists of diverse components, FR4 PCBs, metal or plastic mounting frames, heat-sinks, and enclosures that typically have a wide range of thermal coefficient of expansion (CTE) characteristics. This can be problematic when these systems must endure hundreds or even thousands of repeated thermal cycling during normal usage..

Conventional solder connections add risk as a primary point-of-failure because the repeated stresses from CTE mismatches eventually cause cracks or breakage at the solder joint. Press-fit technology with its residual spring solderless connection provides an inherently reliable interface that flexes during thermal cycling without degrading the current carrying capability or incurring long-term damage.

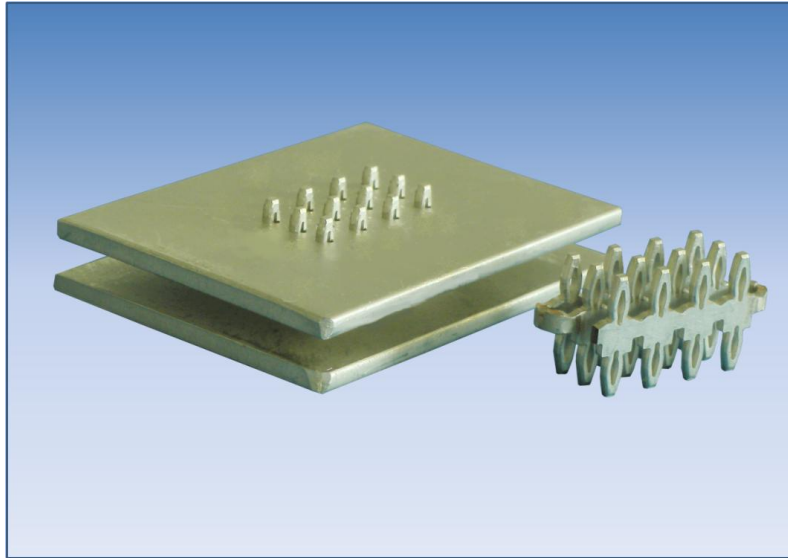
High Current-carrying Capacity for Power Connections

The explosive growth of automotive, power-industry and other markets 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. 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 125°C to 150°C and above.

The combination of high-current capacity, high reliability and a wide range of configuration alternatives is making press-fit a predominant interconnect design choice for power-oriented applications. The elimination of solder-related hassles while at the same time improving reliability, performance and reducing production costs offer compelling reasons for using press-fit technology.



For example, shown below is a bus-bar interconnect that leverages a custom-stamped press-fit configuration to provide a solder-free, high-current, multi-point interface that greatly streamlines the assembly process, while improving performance.



Power-oriented designs can be particularly challenging 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 difficulties for conventional soldering approaches.

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.

Streamlining Assembly Processes

With long-term life-cycle quality performance now confirmed, some of the other major reasons that many manufacturers are converting existing designs to press-fit are the significant benefits from improved efficiency and simplified production processes; both for module assembly and higher-level system integration.



From a production standpoint, the major advantage of press-fit technology is the elimination of soldering problems and hassles, especially for complex and hard to control secondary soldering steps. In addition, the automation-friendly aspects and design-flexibility of press-fit make it a straightforward solution for either converting existing designs or creating new ones, with the inherent capability to rapidly prototype and to quickly ramp up to full high-volume production.

Stamped press-fit interconnects can be provided in a range of automation-ready formats for smooth integration into virtually any existing production environment. Press-fit pins are available in standard gauge (thickness) such as 0.64mm and 0.80mm as well as new 0.40mm and 1.2mm sizes. In addition, a range of different plating options and current-carrying capacities are available to accommodate specific application requirements.



These configurability and automation advantages are particularly important for converting existing multi-board and/or molded assemblies where press-fit interconnects between the modules can be easily created to accommodate existing pin patterns, diameters, pitch requirements, standoff distances, and other form factors.

Also, by using press-fit solderless interconnects for the external connections, the completed modules are also automation-ready and can be picked and assembled along with other odd-form components without requiring a subsequent soldering step. This avoids exposing any of the components on the populated assembly to an additional heating step and also eliminates the challenges of secondary soldering of power modules often include a large heat sink.

Identifying Candidate Designs for Upgrading to Press-Fit

Press-Fit interconnects have already proven to be very effective for implementing a wide range of applications that benefit from the ability to provide robust solderless interconnects while streamlining assembly processes.

Also the configurability of press-fit technology makes it a straightforward process to upgrade from solder-based interconnects as part of most routine product update processes. By incorporating a change to press-fit during product updates, manufacturers can boost reliability and reduce costs for the remainder of the product lifecycle.

As more manufacturers look at converting existing designs to press-fit during update or retrofit change cycles, some of the key factors that come into play include:

- Are changes or updates planned that could open opportunities for retrofit?
- Are secondary solder processes hurting product yields.
- What has been the field quality and reliability experience?
- Is the product exposed to temperature cycling and other environmental stress?
- Are solderjoint failures a cause of field quality problems?
- Can the product benefit from cost-reduction over the remaining life-cycle?

Key Considerations for a Successful Conversion

Once a decision is made to upgrade a design to press-fit, it is a relatively straightforward process, given the maturity of the press-fit technology and inherent design flexibility. The benefits of conversion almost always outweigh the challenges because press-fit rarely necessitates any changes to the core design of the product. However it is important to point out a few key considerations that should be taken into account to assure a successful conversion. These factors include:

- PCB hole size and plating control
- Press-fit pin lengths
- Press-fit assembly forces

Because the compliant pin exerts a constant normal force on the surrounding hole to create the electrical and mechanical interface, correct PCB hole size is the first critical factor that must be controlled for optimal press-fit success. PCB construction requirements and application drawings need to specify the required parameters in order to maintain consistent control over the plated-through-hole size. If the raw hole is drilled too large and back filled with copper, over time the copper will push away and contact resistance will grow. Conversely, if the drill hole is too small or the copper is too thin, the copper in the hole can be pushed out and/or delaminate from the internal layers during press-fit pin assembly.

PTH Size	Drill Hole Contour Deformation "a" (µm)		Remaining Plating Thickness "b" (µm)		Vertical Trace Deformation "c" (µm)	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Maximum Value	28.6	27.8	45.7	43.5	44.5	26.0
Mean Value	20.3	14.9	33.4	31.9	30.9	17.4
Minimum Value	11.8	7.0	21.5	26.0	13.5	12.0
Requirement	50.8 Maximum		8.0 Minimum		50.0 Maximum	

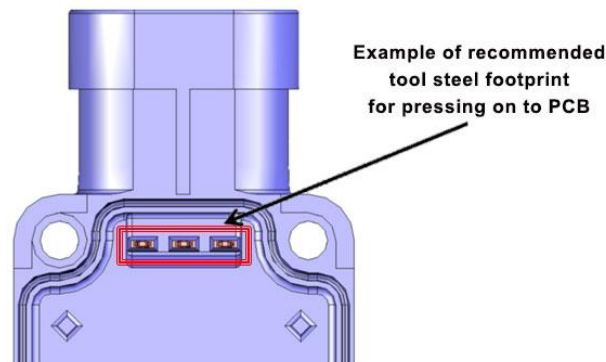
It is important to note that the PCBs can still be made with standard PCB manufacturing processes. There is just a need meet construction requirements for press-fit that are different than for solder joint PCBs. No extra costs are required in the PCB manufacturing process.

One simple procedure that can be helpful to ensure proper hole size is to include additional test drill holes on the PCB that are not filled with copper. By measuring the non-plated holes, and comparing them to measurements of the same hole but plated through, the hole construction can be verified. In addition, when PCB manufacturers know why you've included the verification holes, they are likely to pay more attention to hole size and the quality goes up.

The second key factor to consider when converting existing designs is providing sufficient pin length to accommodate the press-fit compliant interface. To ensure the proper normal force in the hole and sufficient direct-contact interface, the press-fit pin might need to be longer than a typical tail, however the difference is rarely large enough to require any changes to board-to-board spacing or other form factors.

The third factor is compensating for the insertion force that is exerted on to the circuit board, plastic module or other receiving component during the press-fit assembly process. Press-fit insertion force is typically 30-50 Newtons but in some cases can be more than 150 Newtons per pin. Therefore it is important that both the pins and the receiving part be sufficiently supported around the insertion area to avoid any bowing or damage during the process.

Best practices recommend that the distance from the press-fit hole to the PCB edge be at a minimum equal to the press-fit hole diameter. It is also recommended that the tooling for pressing the PCB include tool steel around each row or column of pins as well as between the last press-fit hole and the edge of the PCB.



Summary

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 a wide range of applications.

As press-fit has gained momentum for enabling new designs that exhibit very consistent performance and higher reliability than traditional solderjoints, manufacturers have also now increasingly turned to conversion projects that incorporate press-fit into existing designs during product update and retrofit change cycles.

The bottom line is that press-fit technology has now moved beyond just a focus on compliant pins and has become an important enabling technology for fueling innovation and an expanding range of new product opportunities as well as cost-savings and quality improvements for existing designs.

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.