

# Innovative Insights

AUTOMOTIVE

## Eliminating Inefficient and Costly Soldering When Manufacturing Automotive Electronic Systems >

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### The Benefits and Design Considerations of Press-Fit Compliant Pin Technology

When manufacturing automotive electronic and power systems, mistakes delay time-to-market and can cost thousands in rework, especially if discovered late in the production process. If mistakes are not discovered until after vehicles have reached the consumer market, manufacturers may face substantial damage claims and even lawsuits. That's why it's critical to consider the benefits and follow recommended design guidelines of automation-ready, solder-free compliant pin technology.

Prevalent throughout the automotive industry, compliant pin terminals and connectors have performed well in both power and signal contacts for nearly four decades. As pins that store elastic energy to form reliable, solder-less and press-fit electrical connections with substrates, compliant pin terminals and connectors are also commonly deployed in commercial products, transportation, and other industries.



*CMC 154-circuit header in compliant pin mount offers robust, sealed, wire-to-board connection for high-conductivity, high vibration powertrain applications.*

Within the automotive industry, press-fit technologies have become mainstays for designing economical, durable and demanding electronic and power applications:

- Body Electronics
- Engine compartments
- Powertrain
- Transmissions
- Automotive telematics
- Anti-Lock Braking Systems
- Infotainment
- Passenger occupancy detection sensors
- Airbag control modules
- Crash and rollover sensors

From a quality perspective, critical faults in pins from leading manufacturers are rarely reported, which is a testament to the durability of the technology.

### The Popular and Reliable Eye of the Needle Interface

A popular and highly-reliable compliant pin configuration is the economical "Eye of the Needle" (EON) interface, which has been used successfully for almost 10 years in the automotive industry. A compliant pin interface (CPI) with vertical and right angle headers can utilize an EON design, handle up to 8.0A current for signal contacts, and is ideal in blind-mate and press-fit applications when soldering boards is inconvenient or costly.

The headers also can be pressed into boards with thicknesses of 1.57mm (.062"), which is key because pressing CPI terminals into the board makes reliable connections. Headers from leading manufacturers also feature flanges for blind-mating applications. For higher current applications, other proven press-fit interconnects are available with higher amperage capacity.

Press-fit pins and terminals also offer superior current capacity in PCB applications, where bulkier power interconnects result in a less-than-secure mating. On fine-pitch SMT boards, compliant pins simplify design challenges and eliminate expenses inherent in soldering small connections.



*Mini-Fit® Compliant Pin Interface (CPI) vertical headers utilize a highly reliable "eye-of-the-needle" contact design, handle up to 8.0A current and are ideal in blind-mate and press-fit networking applications.*

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In some cases, compliant pins can be inserted directly into PCBs to eliminate the need for molded connectors. As with standard connectors, compliant pin technology can achieve the right balance between pin insertion/retention force and low electrical resistance.

### Understanding the Press-Fit Connector Interface

Numerous application categories fall under the umbrella of press-fit technology. Advanced compliant pin technology is integrated into many device connectors and modules to achieve solder-less electrical contacts onto printed circuit board (PCB) assemblies. Press-fit terminals include rigid and compliant types in addition to rigid solid type and compliant subcategories, such as beam-type and deformable cross-section press-fit terminals. Compliant pins, also referred to as a press-fit connection, are basically pins that store elastic energy to form a reliable press-fit connection with PCB substrates.

The mechanical and electrical interfaces to the PCB are created using oversized, spring-like compliant pins inserted into a plated through-hole (PTH), also referred to as a via. Compliant pins come in a range of sizes, shapes, patterns and pitches, and may comprise a single pin or any number of pins. A PCB can be used for the via to connect the pins in addition to serving as a substrate for other circuitry.

The pin deforms on insertion, thus the classification of compliant as it conforms to the PTH. Compliant pins also preserve the integrity of the plated via. Conversely, a standard or non-compliant pin could deform or damage the through-hole.

### Advantages of Compliant Pin Technologies

Compliant pins offer multiple benefits over non-compliant pins, also referred to as solid pins:

- The spring-like response of flexible pins protects the PTH, and when designing for compliant pins, there is a smaller hole-tolerance of the plated drill holes on the PCB. The resulting connection is permanent, highly reliable, and provides a shock-resistant, gas-tight interface that minimizes corrosion.
- Compliant pin connections can also be used on either the solder side or the component side of the PCB, enabling more flexible, double-sided, through-hole, SMT PCB assemblies. Multiple stacked PCBs may require compliant tail sockets or a solder tail. Headers with compliant pins are typically constructed of economical, standard plastic material, which make them readily adaptable for lead-free ROHS environmental compliance.

- Press-fit pins ensure a lower insertion force during assembly and cannot be reused, but the hard plated via, which retains structural integrity, enables multiple insertions into the same hole for PCB reworks or future modifications.
- Normal pin connectors differ from those designed for compliant pins. For example, a via on a PCB for normal pins will not accept a compliant pin. However, a via for a compliant pin can accept a normal pin.
- Press-fit pins eliminate stress and wear that occur with other connector styles. Because it is a well-protected permanent connection, the connector interface-surface plating quality remains consistent throughout the product life cycle.
- Eliminating selective soldering required for other connectors, compliant pin connectors also reduce assembly and cost. Additionally, these designs eliminate common problems resulting from solder slugs, flux residue, bridging and cold solder joints. The populated PCB can also be thoroughly tested prior to adding compliant pin connectors.
- From a thermal design standpoint, compliant pins produce less thermal heat than alternative connectors; they provide a reliable interface that naturally dissipates thermal heat and maintains a consistent mating interface—even in harsh conditions and temperature cycles.
- Press-fit connectors provide a similar insertion force as separable contacts. The entry angle remains an important parameter affecting insertion force and preventing damage of the PTH. The contour of the outer surface of the compliant zone is also a significant contributor to determining insertion force and mitigating the potential of wall damage.

### Compliant Pin Design Guidelines

As an alternative to solid pins and soldered connections, compliant pin interfaces provide a more durable and cost-effective PCB connection. In addition to reducing the electronic components on the PCB, press-fit technology provides consistent high-quality results. When designing compliant pins, the following guidelines will help ensure these performance levels and durability:

- The selection of compliant pins is contingent on the specific application requirements. To adhere to IEC and OEM standards, compliant pins should undergo extensive electrical and mechanical testing,

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including termination resistance, insertion/retention force and vibration as well as thermal soak and shock. The pins should also be visually inspected for plowed plating, tin slivers and whiskers.

- The through-hole design mitigates thermal stress and heat that can negatively impact other PCB components. The plating thickness of copper, tin and tin-lead must be controlled to optimize the plating to allow proper insertion without creating slivers. Although plating thickness compared to the normal force is secondary, its effect on insertion force through associated friction forces can be significant.
- Through-holes enable automated installation of the compliant pins onto the PCB. While it's important that the via be sized and drilled properly to avoid thermal stress due to expansion and contracting, there is less tolerance because compliant pins are by definition intended to deform.
- PCB engineering for Eye of the Needle compliance requires that the pin diameter or cross-section be initially wider than the through-hole. In a spring-like fashion, the inserted pin conforms to the PTH diameter, which remains intact by virtue of the plating material. Easy-to-install in final assembly, the EON-compliant pin configuration requires only simple tooling and is suitable for a wide range of applications.
- In sensor modules, the EON terminals can be pre- or final-stitched into plastic. Before pressing onto the compliant pins, the fully-populated PCB should be tested. In a transmission or power train control module, the EON terminals should be stitched into a straight-molded module housing and installed into die cast before the populated PCB is mated.

- In specifying compliant pin connectors, it's important to consider retention force. The radius of the outer surface determines the contact area with the PTH and the distribution of the contact force against the through-hole. A sharp radius can have a negative effect on compliant pin performance, and the total area of contact will affect contact resistance.
- Retention force is determined by the residual elastic recovery forces following the deformation of the compliant zone as it is inserted into the PTH. These forces depend on the compliant zone geometry, which determines the effective spring rate and the relative amounts of elastic and plastic deformation that may occur as well as the amount of deflection experienced.

### Efficient Soldering Facilitates Lead-Free Compliance

For the automotive industry, compliant pins clearly offer an automation-ready interconnect ideal for integration into high-volume, through-hole manufacturing processes without the requirement of soldering. In addition, the insertion of compliant pins can be achieved in a single-step process with tools or using machine-automated insertion.

A well-designed compliant pin and plated via will be robust enough to withstand harsh environmental conditions, which may include high temperatures, moisture, vibration, or other ambient conditions typical in automotive applications. Ultimately, press-fit compliant pin technology eliminates inefficient and costly soldering processes, which also streamlines the transition to lead-free compliance.