# Why choosing the right spring-loaded connector saves long-term cost – *and reputations*

Reliable machined pin contacts reduce total cost of ownership in key applications

By: James Peluso,
Global Sales Manager, Mill-Max Mfg. Corp.

In today's cost-sensitive world, designers are often driven to specify the lowest cost solution for every aspect of their designs to ensure that their solution is competitively priced and their company remains profitable. However, specifying a low-cost, low-quality connector solution can result in premature failure, considerable re-work costs and damage to reputations.

In this whitepaper, MILL-MAX looks at the technology, materials and testing behind machined pin spring-loaded connectors. They will then consider numerous ways that these precision-made interconnects can ultimately provide better solutions, improved efficiency and lower overall costs versus other connector types.

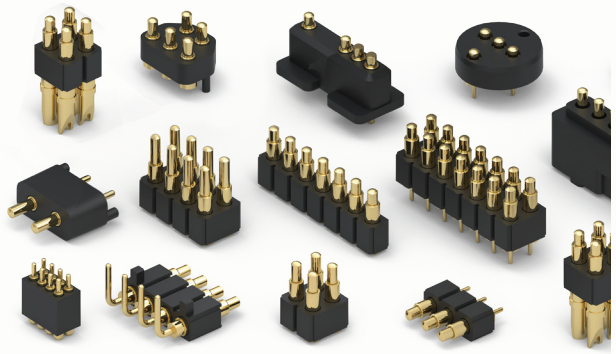
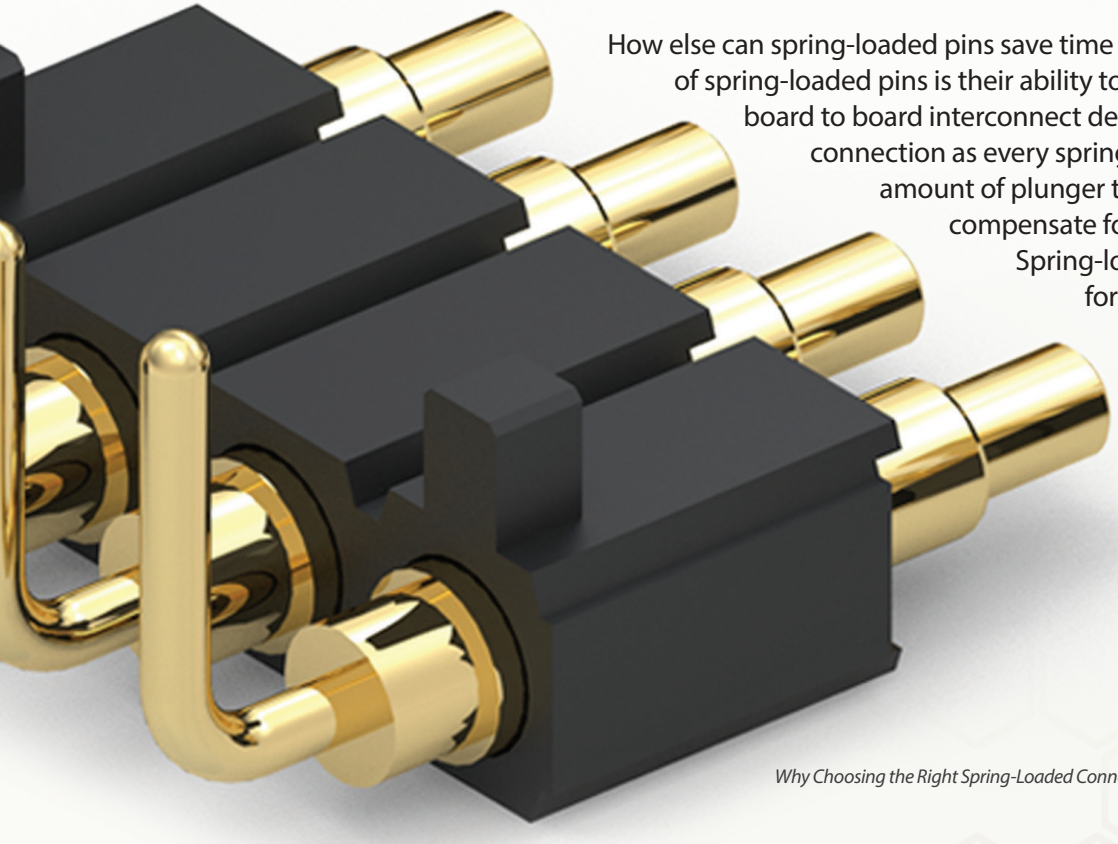


***Figure 1:*** *Various Spring-loaded Connectors for multiple mounting applications.*

# The Big Picture

As stated, cost can be the primary driving force behind connector selection. But to focus solely on component cost without consideration of other factors can be a regrettable venture. For instance, connector quality and reliability are of utmost importance. Spring-loaded pins that are precision-machined are among the highest quality interconnects available in the world. On the more critical end, applications which are potentially life-saving, such as products manufactured for the medical industry, cannot afford to specify connectors that are of inferior quality as failure can mean the difference between life and death. The same can be said of a number of other industries such as equipment for military, aerospace, law enforcement, fire protection, security and industrial safety.

But what about cost? One of the chief benefits of spring-loaded pins is that a connection can be made with one component instead of two as required by most connector systems. A spring-loaded pin can simply mate with a pad on a mating PCB. That translates to fewer parts on the BOM, fewer parts to purchase, fewer parts to assemble and fewer parts to be concerned about availability and delivery in the supply chain.



How else can spring-loaded pins save time and money? A primary benefit of spring-loaded pins is their ability to absorb stack-up tolerances in board to board interconnect designs. This assures a quality connection as every spring-loaded pin has a defined amount of plunger travel which allows it to compensate for tolerances in any given design. Spring-loaded pins are also more forgiving in terms of positional tolerance as perfect alignment is not as critical as it is in most connector systems. The cost benefits here are obvious; fewer field failures and faster assembly times.

***Figure 2:*** *Right-Angle Surface Mount Spring-loaded Connector*

# What are Spring-Loaded Connectors?

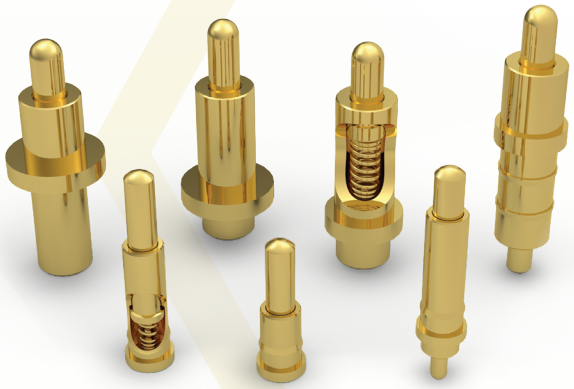


***Figure 3:*** *Mill-Max Offers over 100 styles of Machined Spring-Loaded Pins*

The main components in a spring-loaded connector are the spring-loaded pins - sometimes called spring pins, spring probes, or pogo pins - that provide a highly reliable interconnect solution ideal for a wide variety of demanding applications. In the spring-loaded connectors discussed here, the contacts are precision-machined to ensure a high quality, low resistance and compliant connector.

Spring-loaded contacts are typically comprised of three or more separate machined components that are assembled with an internal spring. Components are precision-machined from brass and are electroplated with gold to ensure excellent electrical conductivity, durability and corrosion resistance. The inner spring, made from either beryllium copper or stainless steel, is also plated with gold. The contacts are then assembled into high temperature insulators, producing spring-loaded connectors in a variety of configurations. They are available in SMT, through-hole and wire termination styles with options for vertical or horizontal orientation.

Contact resistance at working travel is less than 20 mΩ and current carrying capacity ranges from 2A continuous (3A peak) up to 9A. They are rated for 100,000 to one million cycles and can operate in a temperature range between -55°C and +125°C depending on the exposure time and other application variables.

# About Precision Machining

Precision machining is the most flexible and reliable method for making the pins used in connectors. It is a process that delivers high-quality and repeatability, as well as significant design and material flexibility. The resulting high-precision pins typically have a cylindrical geometry and are sometimes called 'turned' pins. This highly accurate and extremely consistent process can hold critical feature tolerances to +/-.0005" (0,0127 mm) or better.

***Figure 4:*** *Components of Spring-Loaded pins are machined to extremely tight tolerances*

# How Intelligent Application of Spring-loaded Pins Reduces Cost

Often designers incorrectly perceive precision machined spring-loaded pins as a high-cost, outside-the-budget solution. This is primarily due to the high-quality materials and processes employed in their manufacture. While the connector piece-part cost can be justifiably higher because of this level of quality, often the overall cost of the connection is lower due to the many features and benefits associated with spring-loaded pins.

In modern designs, space is at a premium and it might be appropriate for a design engineer to use multiple PCBs to best utilize the volume available in the application. But in this type of vertical board stacking design, stack-up tolerances must be accounted for. This is one of the primary benefits derived from using a spring-loaded pin. An engineer may decide to use a 'traditional' connector system but as connector heights are basically fixed, there is no ability to compensate for these tolerances. Yet as each spring-loaded pin offers a level of "stroke" (the amount of height variation that a spring-loaded pin can provide while maintaining a reliable connection) stack-up tolerance issues are virtually eliminated. Also, traditional connector systems require precise alignment on each mating board pair to ensure a quality connection as misalignment can result in a faulty connection or a damaged connector. This can also add to design and assembly time, and increases costs.

As spring-loaded pins are simply contacting a pad on a mating PCB, the full length and width or diameter of the mating pad provide the amount of acceptable "off-center" positioning (positional tolerance) the spring-loaded connector can tolerate. Consequently, a spring-loaded pin solution inherently offers forgiveness in the x, y and z directions, ensuring improved assembly time and better overall functionality. Again, only one part number is added to the BOM instead of two.

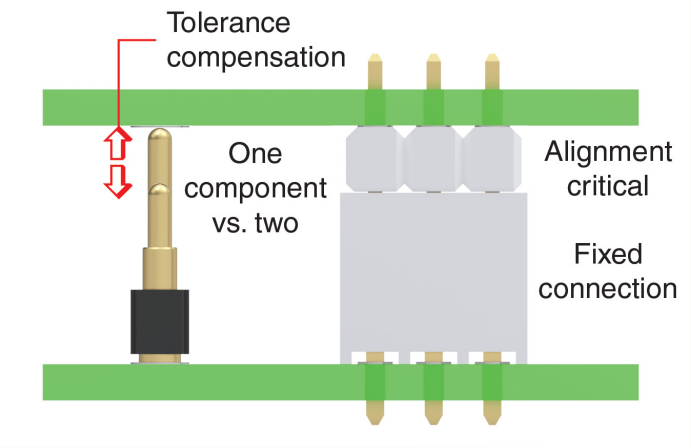



***Figure 5:*** *By using a spring-loaded connector the design engineer can use one component instead of two*

Another common occurrence in many of today's designs is lack of visibility to the connection area. Often due to the size or nature of the design, an assembler must make a connection without actually being able to see the connectors as they are being mated. This is referred to as 'blind-mating'. Again, the same concerns we saw in the previous example, such as critical alignment issues, etc., apply once more. And again, the positional tolerance advantages spring-loaded pins offer will virtually eliminate concerns associated with blind-mating. This will also reduce assembly time and costs while adding only one component to the BOM.

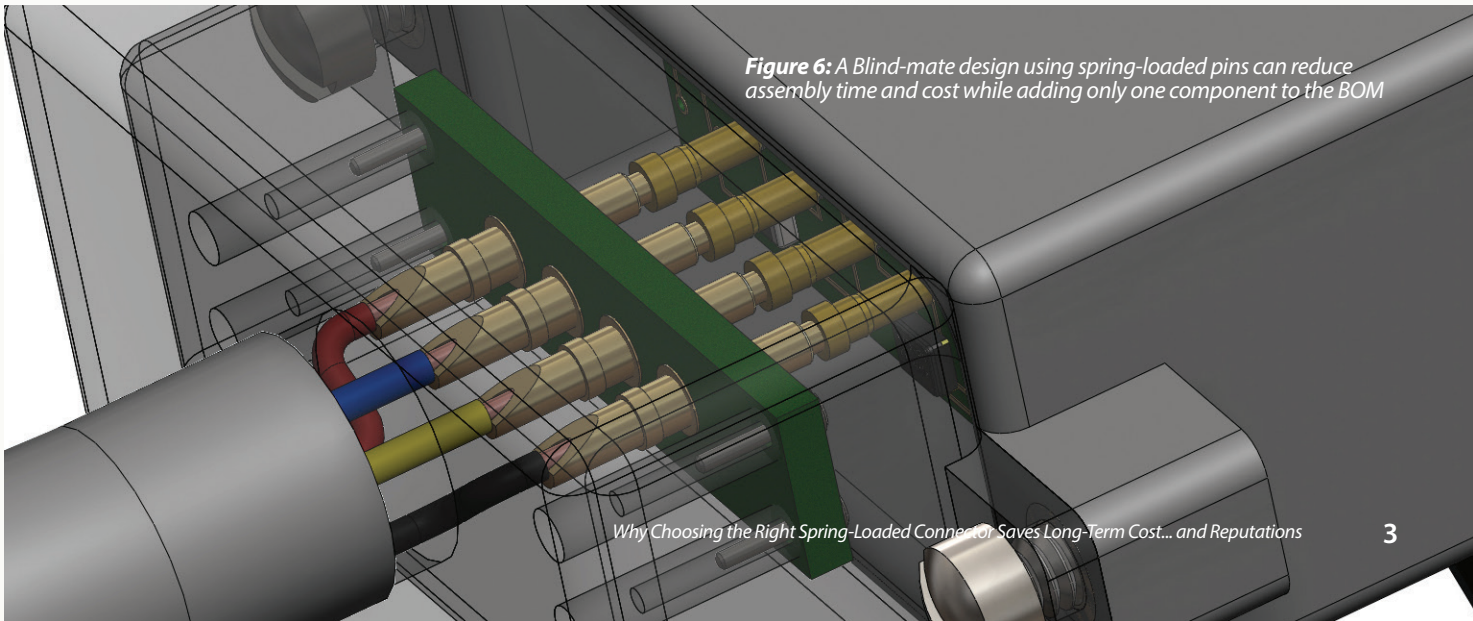


***Figure 6:*** *A Blind-mate design using spring-loaded pins can reduce assembly time and cost while adding only one component to the BOM*

# General Applications

As products continue to decrease in size, engineers continue to be challenged to design products with more features and capabilities in smaller and smaller packages. Subsequently, the available area for connectors shrinks accordingly. Often the vertical spacing for a board to board connection is just too small for a traditional connector system to accommodate, especially if the design requires an SMT connection. In these types of applications, spring-loaded pins may not only be the best solution, but the only solution. Mill-Max offers an SMT spring-loaded pin solution which reduces the vertical space between two boards to as little as .082" (2,08 mm) with their 0965-0 spring-loaded pin - also available in standard SIP and dual-row configurations (815/ 817 series).

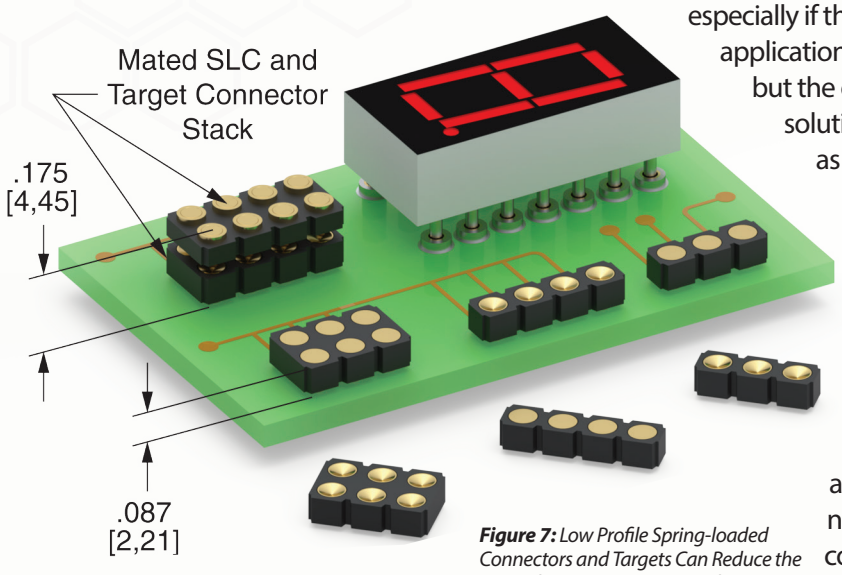



***Figure 7:*** *Low Profile Spring-loaded Connectors and Targets Can Reduce the Vertical Space Between Boards*

Mill-Max also offers "target" mating connectors, made using the same hi-precision machining technology. The Mill-Max targets are readily available with flat or concave mating surfaces, offered loose or in SIP or dual-row insulator packages. These are especially helpful in applications where wide expanses between two boards need to be accommodated or to maintain a gold-gold connection on a tin-plated PCB.

While vertical mounting is the most common arrangement, the form-factor of certain applications means that horizontal mating of two or more boards is sometimes necessary or appropriate. Right-angled and horizontal surface mount pins and targets can offer a low profile and reliable solution to this challenge.

For applications where conserving space horizontally is critical, Mill-Max offers spring-loaded connectors in .050" (1,27 mm) pitch packages. These are available in SIP, dual-row, SMT and through-hole as well as horizontal SMT.

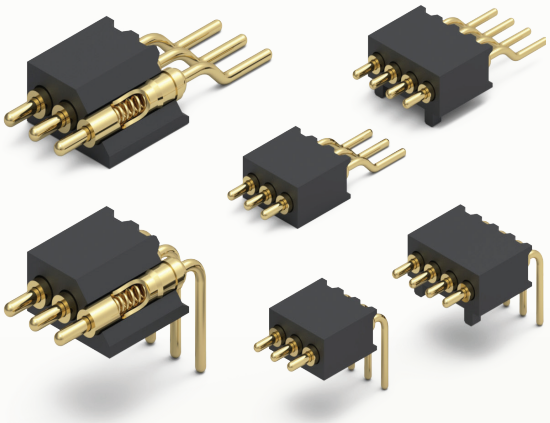


***Figure 8:*** *.050" (1,27 mm) Pitch Right-Angled and Horizontal Surface Mount Spring-loaded Connectors*

Depending upon the mechanical configuration of the application, different travel distances and/or custom spring forces may be required. Most spring-loaded pins offer 60 grams (g) of force at mid-stroke, although alternate springs are readily available which provide for lower or higher forces. Plunger stroke travel up to 3mm is also a standard offering.

Spring-loaded pins are not limited to PCB-oriented applications. This versatile technology extends to providing connectivity for wire termination through the availability of pins with solder cups or crimp barrels. Various sizes are available offering the ability to accommodate wires up to 16 AWG, with 9 Amp (A) current handling capability.

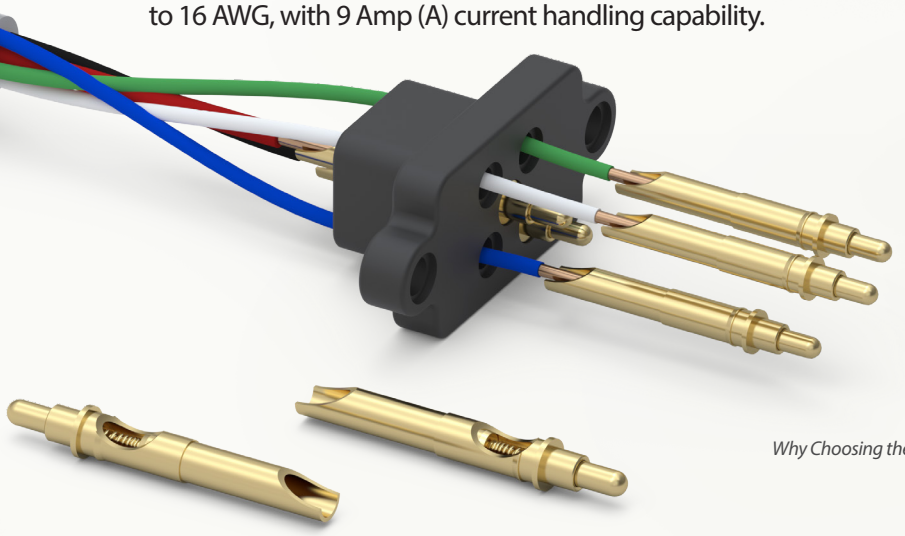


***Figure 9:*** *Mill-Max offers specific spring-loaded pin designs with solder cups or crimp barrels*

# Charging Applications

As portable, battery powered products become more popular, the need for regular charging is increasingly commonplace. Smaller end products such as smart phones, tablets, fitness bands and hearing aids are often charged as a single device, whereas larger products such as cordless power tools, typically have detachable battery packs that are charged independent of the main unit. In both cases, the challenge is similar - designers must develop a charging cradle that is simple to use, robust and reliable. Early failure of a charger can be damaging to the reputation of the equipment manufacturer.

This type of application also bears similarities to the board stack challenge. In charging applications the same issues of alignment exist, yet the challenge is compounded as the manufacturer has no control over how forceful or indelicate the consumer is when mating to the charger. Unlike the board stack however, there could be many thousands of mating cycles over the useful life of the charger. While traditional connector solutions have been used in charging applications, any type of blind mating insertion type connection requires additional keying or mechanical alignment features on the connector to ensure accurate mating. Given the inherent wiping action and associated plating wear of most connector systems, coupled with requirements for a large number of mating cycles, thicker gold plating is often applied on the terminals. This increases costs for that type of solution. Spring-loaded connectors can offer a number of advantages here.

***Figure 10:*** *Spring-loaded pins provide the optimum solution in a variety of charging applications.*

The greater alignment flexibility means that features to facilitate accurate mating are not required. Again, a single spring-loaded connector makes contact with a pad or target on the device or battery to be charged, thereby reducing cost and avoiding the wear associated with other connector solutions. One of the key advantages of spring-loaded connectors in charging cradle applications is the ability to choose a spring with the proper force to ensure that the device is held in the cradle correctly and also provide sufficient contact pressure to ensure constant power delivery.

# Automatic Test Equipment (ATE) Applications

Not only do spring-loaded connectors excel in product-based applications, they are also used successfully in Automatic Test Equipment (ATE) applications due to the benefits they exhibit versus traditional connectors. Spring-loaded connectors form the 'bed of nails' that is the all-important electrical connection to the assembly being tested. Here, a single sided solution is almost mandatory, especially for SMT devices as adding test sockets to an assembly would increase cost to unacceptable levels and unduly slow down the testing process. The connection to the device being tested is critical as wear or degradation in the connection could be misinterpreted as a problem with the device, leading to many hours of unnecessary debugging. Moreover, only spring-loaded contacts are able to accommodate the warping often associated with larger boards. The spring travel can easily be specified to accommodate the maximum amount of warping which again, reduces the expense associated with potential erroneous test results.

# Rapid and Cost-Effective Custom Solutions

Applications often require custom connector solutions. The costs associated with custom stampings are usually high - and often prohibitively so. There is a risk placed on the manufacturer with upfront NRE costs having been committed to. As the design evolves, any changes to the connector could potentially require expensive rework of the stamping tool(s), or completely new tooling may be required altogether. Not only are the tooling costs high with stamped contacts, timescales to get tooling made are also relatively long.

By their very nature, spring-loaded connectors do not require expensive tooling as they are manufactured using either precision high-speed turning or deep drawn/cold forming processes. Minimal NRE costs may apply for a custom spring-loaded pin, but they compare very favorably to those associated with stamped leaf-spring contacts. By employing precision machining processes, spring-loaded connectors offer a unique ability to be rapidly customized to exactly match specific application requirements. And almost any component of any spring-loaded pin can be modified in order to create a fully customized solution.

For custom multi-pin connectors, spring-loaded pins can be assembled into any non-standard spacing configuration or circular array using machined FR-4 material as an insulator. This eliminates tooling costs associated with custom-molded housings. Not only does this make custom-configured spring-loaded connectors lower overall cost than alternative approaches, it also reduces time to market. This approach removes much of the risk as there is little early-stage investment and design updates require minimal work and investment as well. Only when the design is finalized and production volumes warrant may it be practical to move forward with a custom-molded housing, at which point significant reductions in per-piece costs will be realized.

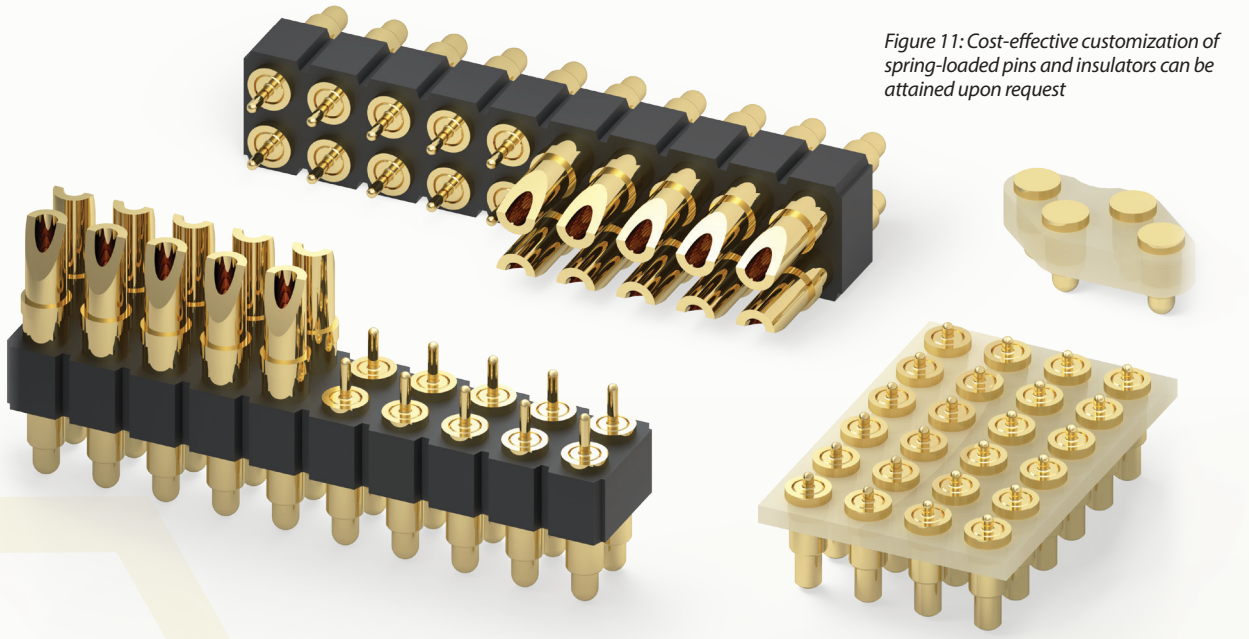


*Figure 11: Cost-effective customization of spring-loaded pins and insulators can be attained upon request*

# Simple Customization Options

The breadth of the Mill-Max product range offers the ability to choose from many different standard internal spring and component options to create a customized spring-loaded connector that provides a tailored solution for a specific application. This "mix & match" approach, using existing components eliminates tooling charges and reduces lead times, providing an extremely rapid, optimized solution.

# Summary

Spring-loaded pins possess unique features and properties that often contribute significantly to overall cost savings in a variety of design situations. They facilitate single-sided connections, require less space and reduce BOM cost. They also compensate for mechanical variances while reducing the need for precision alignment.

When considering all the benefits that spring-loaded contacts provide it is obvious that they can be a significant cost and time saver in any electronic design. For questions on how you can utilize a spring-loaded connector in a design, contact the Mill-Max applications engineering team to assist with your specific application.

***Figure 12:*** *Offering unique features and properties often contribute to overall cost savings*