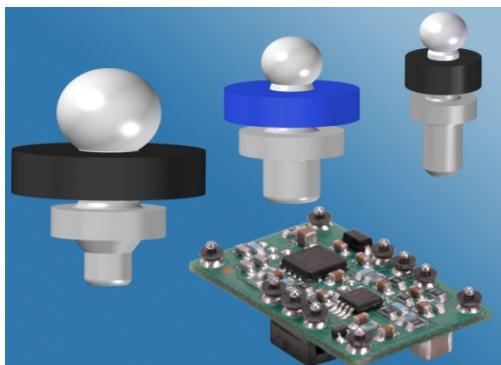


Using Solderball PinTM Technology to Streamline Production and Conserve PCB Space While Increasing Interconnect Reliability For Multi-Board Product Designs

Automation-Ready, Discrete Components Offer Design Flexibility and Facilitate SMT Reflow while Eliminating Coplanarity Issues

New Connector Designs Leverage Solderball Pin Technology to Optimize Board-to-Board and Specialized Interconnect Arrays

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Executive Summary

The growing use of multi-board modular product designs across a widening range of electronics applications is driving the need for advanced interconnect technologies that can deliver a high degree of design flexibility and soldering efficiency, while also leveraging high-speed automated production processes.

The use of daughter-board modules offers numerous advantages such as:

- Enhanced configuration flexibility with module-based options
- Improved thermal management by segregating heat-generating components
- Production and logistics efficiency by building/stocking at sub-assembly levels
- Opportunities for sub-contractor production of many module-level assemblies
- Length and width dimensional reduction of main/mother board

In order to maximize these advantages, designers and manufacturers need interconnect solutions that conform with industry-standard SMT processes while simultaneously overcoming the challenging coplanarity issues that can be roadblocks to consistently achieving reliable inter-board surface mount connections.

Originally pioneered by Autosplice, discrete Solderball Pin™ Technology incorporates precisely-formed spheres of RoHS-compliant solder on high-current carrying copper terminals packaged in continuous tape-and-reel automation-ready formats. Available in a variety of different configurations, pin-lengths and materials, Solderball Pins can be integrated into virtually any daughter module, with the solderballs then providing a standards-based SMT interface for subsequent parallel assembly of the daughter-board to the mother-board.

During final assembly and reflow, the Solderball Pins also provide auto-compensation for coplanarity differences between the PCBs, enabling the daughter module to settle onto the main board and assuring consistent formation of solder fillets for all pins. With non-coplanar boards some solderballs will compress while others will columnize, in each case ensuring a robust solder joint.

As discrete auto-placeable components, Solderball Pins also give PCB designers the freedom to determine the optimal pattern and positioning of individual interconnects based on specific application requirements. Discrete Solderball Pins also allow for designers to optimize PCB trace layout and shorten electrical path lengths. In addition, for products being migrated to high-speed SMT processes, using Solderball Pins allows for layout consistency between new SMT versions and through-hole legacy versions to provide a smooth transition.

Over recent years, Solderball Pin Technology has continued to evolve in response to both industry-wide needs and specific design requirements. As product designs have become more compact and densely populated, Solderball Pin Technology is playing a key role in both conserving board space by enabling greater layout flexibility and also reducing the space between PCBs by minimizing connector sizes.

This whitepaper provides a brief overview of the challenges, followed by a description of Solderball Pin Technology and an update on the growing range of standard product configurations and applications; as well as a look at new board-to-board interconnect solutions that are being made possible using Solderball Pin arrays.

Trends and Challenges with Multi-PCB Designs

Multi-board, modular PCB assemblies, such as small switching power supplies, have become key elements used in electronic products across a wide spectrum of industries, including telecom, networking, computing, industrial controls, medical, and avionics. The need for more compact multi-board solutions is also being driven by the proliferation of ever smaller and feature rich mobile devices.

Some of the key challenges that manufacturers have to overcome are:

- Wasting board space by having to route circuitry to the connectors
- Requiring extra board layers for circuit routing to connectors
- Using longer electrical path lengths than is desirable
- Having to stock several connector sizes for different applications
- Needing special connectors to accommodate power and signal connections
- Using separable connectors when the application doesn't require separation
- Transitioning through-hole designs to SMT can require extensive redesign
- Wasting space between boards by using large off-the-shelf connectors
- Soldering problems due to connector coplanarity and/or board flatness issues
- Reliability of separable connectors
- Providing optimum spacing between parallel boards – smaller than connectors and larger than just solderballs.
- Providing accurate board standoff capability without extra hardware

To address all of these challenges, designers need interconnect solutions that give them flexibility to optimize PCB layout, densities, pin locations and board spacing for specific application requirements.

At the same time, manufacturers need discretely placeable interconnects that allow them to optimize high-speed automated assembly with standard equipment, maximize solder joint integrity, overcome coplanarity issues and minimize secondary operations.

Overview of Solderball Pin Technology

Basic Design

The original breakthrough innovation from Autosplice developers was to incorporate a precisely formed sphere of solder on to a high-conductivity copper pin and to optimize the parts for high-speed automated pick-and-place assembly. As shown in Figure 1, this basic solderball design approach provides a “compensation zone” that is the key to overcoming coplanarity differences during the reflow process.

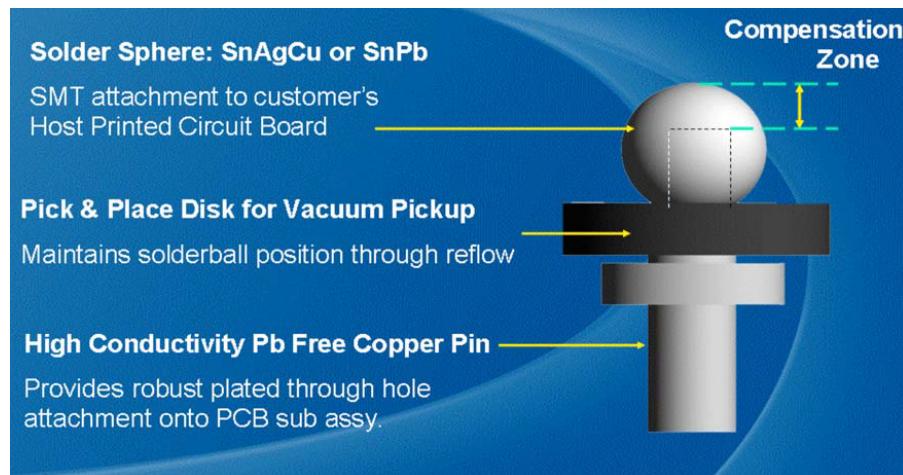


Figure 1 – Solderball Pin Design Features

Other key characteristics that make Solderball Pin Technology unique are:

- Pin terminal: High Conductivity Copper alloy
- Solder sphere: RoHs Compliant SAC alloy or Tin/Lead
- Packaging: STD 16mm Tape and Reel per Spec EIA-481
- Pick and Place: Pin through paste via standard high-speed SMT equipment

The internal pin provides a rigid, high conductivity foundation while the solderball enables a physical adjustment within the compensation zone as each solder joint is formed. The integrated pick-and-place disk, which also serves as a solder dam, supports vacuum nozzle pick-up by standard high-speed automated placement systems while the lower ring on the pin itself assures correct through-hole seating and standoff height and adequate solder fillet to pad formation. The pick-up disk also maintains proper solderball positioning during reflow.

The ability to place these discrete interconnects anywhere in PCB layout addresses the first three challenges listed on the previous page by eliminating unnecessary circuitry, wasted board space and longer than desirable electrical traces. Solderball Pins also address the next two challenges by eliminating the need to stock a variety of different connector sizes or sub-optimize designs to accommodate the connectors.

SMT and Through-Hole Versions

As the basic technology evolved after inception, one of the first key advances was to create SMT versions to complement the original through-hole interconnects. This now gives designers and manufacturers a wider choice of solder methodologies for assembling daughter-boards, while still incorporating all of the Solderball Pin advantages for final assembly to the mother-boards.

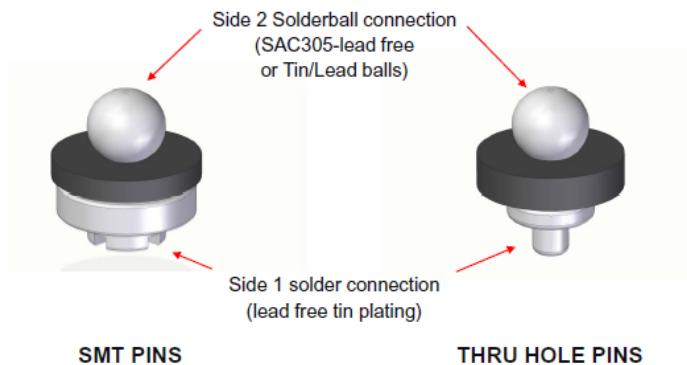


Figure 2 – SMT and Through-Hole Versions

Range of Configurations and Standoff Heights

Controlling the amount of inter-PCB spacing is another critical issue in multi-board product designs. There is a constant push for smaller overall form factors, meaning that many product designs cannot afford the wasted space between PCBs that typically results from using conventional connectors. At the same time, with increasingly dense circuitry, smaller dimensions, and varied power requirements, the need for airflow between boards can be a vitally important design criterion.

In response to these changing requirements, the Solderball Pin family has undergone a steady evolution of both pin styles and standoff heights. Currently available standard products include through-hole, SMT and SMT High Power pin styles, with stack heights ranging from .100 to .170 inches and pin diameters from .033 to .070 inches.



Figure 3 – Pin Styles and Standoff Heights

The standard solderball sphere diameters are .071 inches (Midi Solderball Pin™) and .041 inches (Mini Solderball Pin™), which are stocked by distributors. In addition, Micro versions and custom diameters are also available depending on the specific application requirements.

Standard Solderball Pin products are available with different pin tail configurations, including straight, tapered or double-tiered for a variety of PCB layouts, process choices and dimension parameters. The chart in Figure 4 details the currently available standard Solderball Pin Midi, Mini, Power, SMT and through-hole product configurations.

Part Number Description	Qty Per Reel	Tail Configuration	Pin Size Dia Inches/mm	Stack Height Inches/mm	Tail length Inches/mm	Solderball Diameter	RoHS Compliant
Midi Solderball 0.033" [0.84] Diameter Tapered Pin. 0.071" [1.8] Diameter Ball							
9-B13341AATTA	1,600	Tapered	.033" [0.84]	.100" [2.54]	.034" [0.86]	.071" [1.80]	Tin Lead
9-B13341AATT	1,600	Tapered	.033" [0.84]	.100" [2.54]	.034" [0.86]	.071" [1.80]	Yes
9-B13341BBTTA	1,500	Tapered	.033" [0.84]	.130" [3.30]	.040" [1.02]	.071" [1.80]	Tin Lead
9-B13341BBTT	1,500	Tapered	.033" [0.84]	.130" [3.30]	.040" [1.02]	.071" [1.80]	Yes
Midi Solderball 0.059" [1.50] Diameter Tapered Pin. 0.071" [1.8] Diameter Ball							
9-B15941AATTA	1,500	Tapered	.059" [1.50]	.100" [2.54]	.034" [0.86]	.071" [1.80]	Tin Lead
9-B15941AATT	1,800	Tapered	.059" [1.50]	.100" [2.54]	.034" [0.86]	.071" [1.80]	Yes
9-B15941BCTTT	1,500	Tapered	.059" [1.50]	.130" [3.30]	.045" [1.14]	.071" [1.80]	Yes
Midi Solderball 0.033" [0.84] Diameter Straight Pin. 0.071" [1.8] Diameter Ball							
9-B23341ADTTA	1,800	Straight	.033" [0.84]	.100" [2.54]	.055" [1.40]	.071" [1.80]	Tin Lead
* 9-B23341ADTT	1,800	Straight	.033" [0.84]	.100" [2.54]	.055" [1.40]	.071" [1.80]	Yes
9-B23341BGTTA	1,300	Straight	.033" [0.84]	.130" [3.30]	.065" [1.65]	.071" [1.80]	Tin Lead
* 9-B23341BGTT	1,300	Straight	.033" [0.84]	.130" [3.30]	.065" [1.65]	.071" [1.80]	Yes
9-B23341CDTTA	1,300	Straight	.033" [0.84]	.150" [3.81]	.055" [1.40]	.071" [1.80]	Tin Lead
9-B23341CDTT	1,300	Straight	.033" [0.84]	.150" [3.81]	.055" [1.40]	.071" [1.80]	Yes
9-B23341DETTA	1,100	Straight	.033" [0.84]	.170" [4.32]	.083" [2.11]	.071" [1.80]	Tin Lead
* 9-B23341DETT	1,100	Straight	.033" [0.84]	.170" [4.32]	.083" [2.11]	.071" [1.80]	Yes
Midi Solderball 0.064" [1.62] Diameter Straight Pin. 0.071" [1.8] Diameter Ball							
9-B26441DETTA	1,100	Straight	.064" [1.62]	.170" [4.32]	.083" [2.11]	.071" [1.80]	Tin Lead
9-B26441DETT	1,100	Straight	.064" [1.62]	.170" [4.32]	.083" [2.11]	.071" [1.80]	Yes
Power Midi SMT to SMT Solderball 0.070" [1.78] Tiertd Pin. 0.041" [1.04] Diameter Ball							
9-00-0050-1TT	1,700	Double Tier	.070" [1.78]	.125" [3.18]	SMT	.071" [1.80]	Yes
Mini Solderball 0.038" [0.96] Diameter Straight Pin. 0.041" [1.04] Diameter Ball							
9-B43841FHTTA	2,000	Straight	.038" [0.96]	.065" [1.65]	.032" [.081]	.041" [1.04]	Tin Lead
* 9-B43841FHTT	2,000	Straight	.038" [0.96]	.065" [1.65]	.032" [.081]	.041" [1.04]	Yes
9-B43841HHTTA	1,700	Straight	.038" [0.96]	.120" [3.05]	.032" [.081]	.041" [1.04]	Tin Lead
9-B43841HHTAA	1,700	Straight	.038" [0.96]	.120" [3.05]	.032" [.081]	.041" [1.04]	Tin Lead
9-B43841HHTT	1,700	Straight	.038" [0.96]	.120" [3.05]	.032" [.081]	.041" [1.04]	Yes
Power Mini SMT to SMT Solderball 0.070" [1.78] Tiertd Pin. 0.041" [1.04] Diameter Ball							
9-B97041H0TT	1,700	Double Tier	.070" [1.78]	.125" [3.18]	SMT	.041" [1.04]	Yes

Figure 4 – Solderball Pin Standard Configurations

Testing and Qualification Results

Solderball Pin interconnects have been qualified for a wide range of demanding application environments, including industrial, communications, automotive and rugged military applications. Below are a few of the specific test results and certifications:

- Mini-Solderball pin was tested to handle 11 amps with only 20° C heat rise from ambient
- Midi-Solderball pin is designed to carry 30 to 40 amps depending on application
- Midi-Solderball pin testing includes:
 - Mechanical Shock and Vibration testing to Mil-STD-202F Method 213B (50g's peak)
 - Thermal Cycling to Mil-STD-202F Method 107G; (-55C – +125C)
 - Solder joint integrity:
 - Pull testing strength; 16 pounds/pin ave
 - Shear testing strength; 15 pounds/pin ave

One of the reasons that Solderball Pin technology is able to deliver superior reliability compared to conventional connectors is the fact that they provide a direct PCB-to-PCB connection, either through PCB barrel to PCB pad or pad-to-pad through the solid copper pin. In comparison, conventional connectors are soldered to each PCB but the electrical path also must pass through the male-to-female mating between the connectors, thereby creating a zone of potential failure.

Because the basic Solderball Pin Technology is highly adaptable to meet specific needs, Autossplice engineers have already amassed extensive experience in tailoring special configurations using the core solderball concept in a variety of different situations. Some of these application scenarios are addressed in subsequent sections of this paper, after a more detailed discussion of the technology's unique coplanarity compensation features.

Eliminating Coplanarity Issues

Overcoming coplanarity mismatch is one of the more challenges issues for achieving high yields and consistent solder joint integrity for SMT assembly processes. The term coplanarity is used to define the maximum distance between the physical contact points of a surface mount device (SMD) and the seating plane. When placed on a perfectly flat surface, the SMD will rest on the three lowest points, which defines the seating plane. The acceptable coplanarity specification defines the maximum gap that can exist between the seating plane and all other contacts on the device.

Achieving consistent coplanarity can be especially problematic with daughter-board modules because of the typically larger surface area involved, as well as the difficulty associated with tightly controlling flatness in substrates such as FR4.

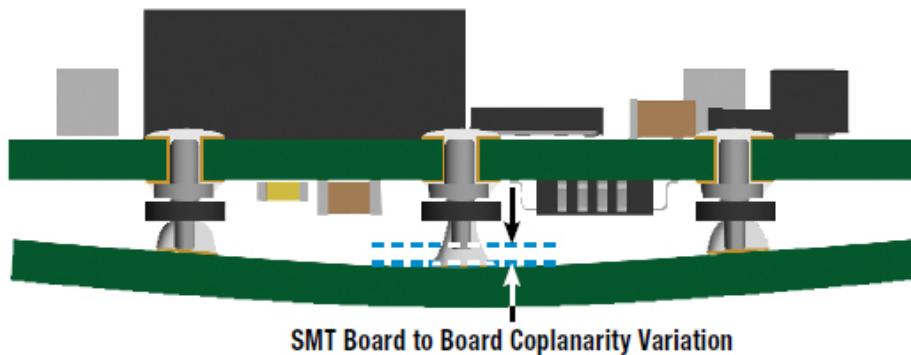


Figure 5 – SMT Coplanarity Variations

A more cost-effective and higher-yield solution is to incorporate an interconnect strategy that can automatically compensate for these coplanarity variations. Solderball Pin Technology addresses this issue through the previously mentioned feature called the “compensation zone”. The solderball adds two important attributes that enable higher coplanarity variance to exist between modules and host PCBs. It provides an additional amount of solder and also allows the module to drop slightly when the solder becomes liquid and the weight of the module overcomes the buoyancy of the molten solder.

Each solderball pin provides board-to-board adjustment flexibility that is equal to the distance by which the diameter of the solderball extends beyond the end of the pin inside the ball. The internal copper pin provides a rigid and high conductivity foundation and the reflow of the solderball allows a physical adjustment as each solder joint is formed and the module settles on to the mother-board. As shown in Figure 5, some solderballs will compress while others will columnize depending on coplanarity.

Solderball Pins can provide automatic compensation of up to 0.020 inches, depending on the diameter of the sphere and the amount of solder paste applied to the board prior to reflow. Figure 6 shows completed solder joints after reflow and how the compensation zone enables consistent solder fillet formation and overcomes the coplanarity mismatch.

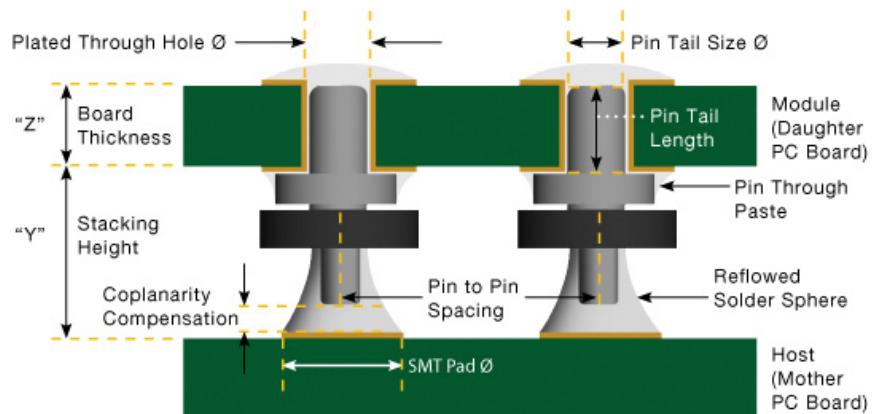


Figure 6 – Solderball Pin Compensation Results After Reflow

Leveraging Standards-based Automation Processes

Solderball Pins are packaged in standard Tape and Reel formats to enable automated placement to the module PCBs using existing standard high-speed pick and place equipment.



Figure 7 – Solderball Pins in Tape and Reel Packaging

For designs that are being migrated from through-hole to SMT, this allows manufacturers to seamlessly adapt existing PCB layouts to full SMT processes, eliminating the need for pin insertion, special equipment and multiple reflow-flip-reflow steps. This process simplification is a key productivity advantage whereby Solderball Pin Technology enables efficient single-pass assembly of modules that are then ready for SMT assembly to the mother-board.

Mother-board design and assembly are also simplified. The plated through holes on the host PCB layout need only be replaced with SMT pads and vias. Converting to SMT also has the advantage of freeing up the host PCB underside for additional SMT devices.

Solderball Pins are designed to undergo multiple reflow passes of up to 4 to 5 times for most standard reflow processes. This provides seamless process compatibility for using Solderball Pins with double-sided reflow assembly at the module manufacturing level and then again at the final assembly manufacturing level.

Application Examples and Specialized Configurations

Solderball Pin Technology's compact configurations, coplanarity compensation and flexibility as a discrete SMT component have spurred adoption into a broad scope of applications, including power modules, electronic lighting controls, remote telemetry monitoring, Ethernet, Fibre Channel, storage area networks, automotive, and many other daughter-to-motherboard module-based subassemblies.

Parallel Board Mating

As previously discussed, parallel PCB interfacing is the first major arena in which Solderball Pin Technology has made a significant impact. Not only does the technology improve production efficiency; it has opened up key opportunities for enabling design enhancements.

For example, the ability to randomly position discrete inter-board connections anywhere in the circuit path has allowed engineers to optimize their designs for performance and simplicity, rather than having to route everything to rigid connector locations. As a result, excess trace lengths are eliminated, signal integrity is improved and potentially board layer counts can be reduced.

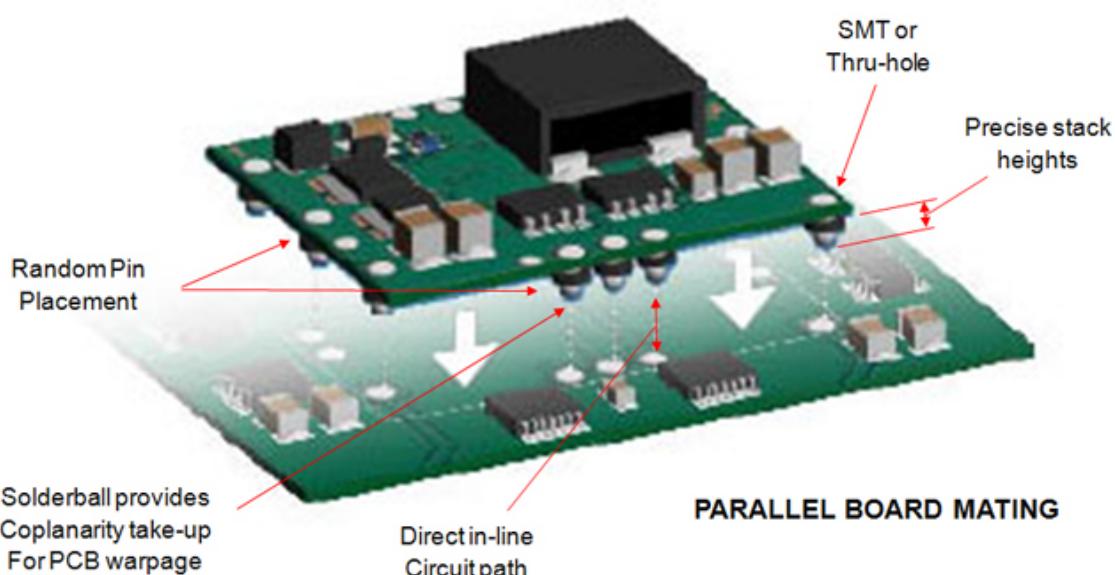


Figure 8 – Parallel Board Mating

Designers are also able to minimize inter-PCB spacing to enable more compact overall product configurations by selecting an optimal standoff height for each application. The ability to control pin placements and standoffs also allows designers to optimize both airflow and space at the same time. Precisely controlling these factors helps to solve many of the thermal challenges in demanding parallel-board applications.

In addition, standardizing on a single-part-number solderball interconnect for use across multiple designs can greatly simplify logistics, inventory and BOM management for both designers and production staff.

Specialized Solderball Pin Arrays

The inherent flexibility of underlying Solderball Pin Technology has made possible a growing range of “application engineered solutions” in which the Solderball Pin concepts are being adapted to specialized requirements.

For instance, pre-set configurations of solderball pins can be supplied in tape and reel formats for use as board-to-board interface strips to address virtually any set of application requirements. Continuous-reeled strips can include either solderball to through-hole or solderball to solderball interconnects, with various ball diameters and either staggered or in-line spacing with custom-defined pitch between pins.

If more specialized pin arrays are required, the basic Solderball Pin Technology can be adapted to virtually any form factor, such as the SMT-to-SMT circular ring headers shown in Figure 9. Such an approach can provide a highly effective method for assembling multi-module products with unique form factors.



Figure 9 – Specialized Solderball Pin Arrays

Conclusions and Future Directions

Solderball Pin Technology already has significantly expanded the ability of designers and manufacturers to streamline production of multi-board assemblies while overcoming coplanarity issues and improving solder joint reliability. It has also created a very cost effective path for transitioning legacy through-hole product designs into SMT production with virtually no changes to PCB layout or circuitry.

For new product designs, Solderball Pin Technology enables designers to further optimize board real estate, circuitry layout, PCB layer-count and inter-board spacing for results that are more compact, reliable and easier to manufacture.

Going forward, the fundamental Solderball Pin Technology is being expanded and enhanced in multiple directions. In response to application-engineered projects, new solderball diameters, standoffs, power capacities and configurations continue to be developed, tested and qualified, thereby fueling an ongoing expansion of the standard product portfolio. In addition, specialized application needs are driving the adaptation of Solderball Pin Technology into a widening range of value-added sub-assemblies such as pre-configured solderball headers, multi-solderball arrays, high-power bus bars, heat sinks, etc.

In effect, Solderball Pin Technology has fundamentally changed the way that designers approach any module-to-module soldering and assembly challenges by expanding the available options, improving the quality of soldering results and driving down the production costs.