A TECHNITROL COMPANY

RELIABLE INTERNAL INTERCONNECTS

for Magnetic SMT Components

Pulse's InterLock Base Technology Improves Density, Consistency, and Resistance to Physical Stresses

EXECUTIVE SUMMARY

The Situation

As electronics manufacturing has steadily moved toward SMT processes and increased densities, the issue of creating effective and reliable internal component interconnections has become a major challenge. Such internal interconnections form the vital electrical pathway between the internal component and the lead-frame, providing the external pins required for creating SMT solder connections. Not only must these internal interconnections be extremely small to allow for ever-increasing densities, they also must be designed to resist the physical stresses involved in the component encapsulation process and the high temperatures involved in subsequent SMT solder processes.

The semiconductor industry has addressed the internal interconnect challenge through the adoption of highly automated micro-miniaturized bonding processes, such as welding and brazing. Because of the essentially two dimensional nature of IC wafers, the automated micro-bonding machines are able to precisely place and bond micro-thin wiring to both the IC die contact points and the corresponding contact points on the lead-frame. The die is firmly locked into position in the lead-frame and the consistently low profile of the wiring connection reduces any stress damage from occurring during the component encapsulation process. Because the micro-wiring process uses a non-solder process such as welding or brazing, the internal connection is also much less susceptible to damage from the high temperatures that occur when the component is later subjected to reflow solder processes.

The Challenge

With larger three-dimensional components such as magnetic coils, the challenge of creating effective, reliable internal connections is not quite so straightforward. Traditionally, magnetic coils have been formed into SMT components in one of several ways. The first way is to mount the coils onto a miniature PC board, solder their leads into place, solder the PC board to the lead-frame pins, and then encapsulate the entire PC board into the SMT component. This method uses a significant amount of hand labor operations, adding cost and time to the process and runs the risk of creating solder joints with poor workmanship that can incur damage during the reflow process. Another historic method consists of wire-wrapping the coils' leads directly to the lead-frame pins, hand soldering, and then encapsulating the entire part with the coils "floating" in place. Because the flow of plastic encapsulation material can move the "floating coil," there is the potential for undue physical stress and/or damage to the wire-wrapped connection during the encapsulation process. Like the PC board mounting method, the individual wire-wrapping method is also subject to the costs, time delays, and inconsistencies inherent to any hand labor process. Dip soldering has also been used. However, the coils have to be moved away from the termination area and then moved back into position for encapsulation. Broken wire connectors and insulation damage can result.

The Solution: "InterLock Base"

As a leader in magnetics component technology, Pulse has developed a patented method for ensuring the quality, consistency, and connection integrity of encapsulated coils and other three-dimensional electronic SMT components. This solution, the InterLock Base, consists of an internal plastic carrier that holds the coil firmly in place and provides precisely engineered "lead-channels" to lock together the lead wires and the lead-frame pins. All of the InterLock Base interconnections are then simultaneously dip soldered, providing for both efficiency and uniformity.

The Benefits

The benefits of using InterLock Base technology for the manufacture of SMT magnetic components are multi-faceted. In general, the benefits can be grouped into three major categories:

Quality and Reliability Improvements

- Improved solder joint reliability through parallel routing of coil lead wires and lead frame pins
- Protected interconnects for less physical stress
- Protected coil assemblies during encapsulation process
- Control of lead insulation "burn back" to improve Hi-Pot resistance

Manufacturing Process Efficiencies

- Increased levels of mechanization in the component assembly process
- Repeatable and consistent location of coils, coil leads, and lead lengths
- Reduced use of manual placement and soldering operations
- More uniform internal structure for more consistent encapsulation process, eliminating voids and pin holes

Design Flexibility and Extensibility

- Create components with multiple coils, chokes, etc. without using fragile wire-wrapped "flying lead" interconnections or cumbersome "daisy-chain winding" of multiple components
- Changing coil/pin connections does not require a PC board change
- Improved ability to efficiently position multiple components within a single encapsulated package

Taken together, the accrued benefits of InterLock Base technology allow for the delivery of higher density, higher quality, and higher functionality products to Pulse's customers. The following sections of this paper will discuss in detail the InterLock Base technology and how it contributes to each of the above benefit areas.

How the InterLock Base Works

The primary objective of the InterLock Base is to facilitate miniaturization and to mechanically and electrically join the magnetic component and the lead frame in such a way as to maximize consistency and to minimize the risk of decoupling.

The InterLock Base is a preformed plastic component carrier that contains recessed “pockets” designed for holding magnetic coils of various sizes and “channels” created to position the coils’ lead wires in firm contact with the lead frame pins. See **Figure 1** for an example of how cores are inserted into a three-pocket InterLock Base. See **Figure 2** for an example of how the lead frame is fitted to the InterLock Base. **Figure 3** illustrates the completed transfer molded module.

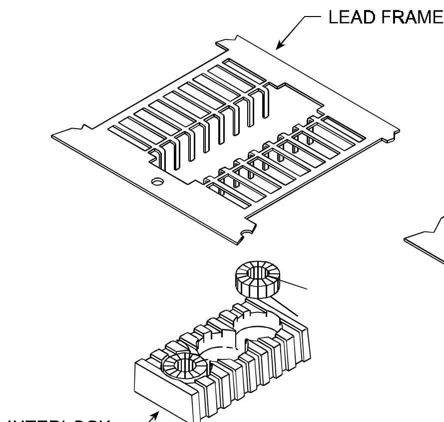


Figure 1

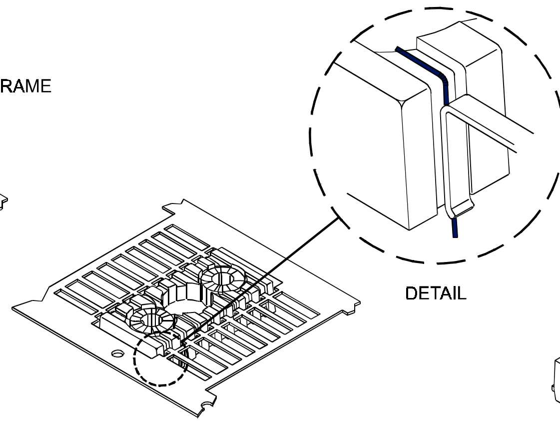


Figure 2

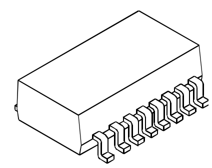


Figure 3

The InterLock Base allows for physical isolation of the coils from the encapsulation, while at the same time providing a mechanism for high density integration of multiple magnetic components within a single SMT package. See **Figure 4** below.

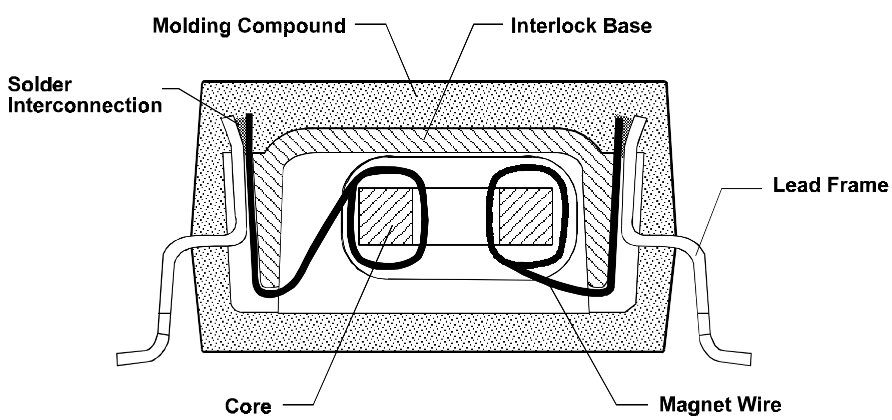


Figure 4

The steps involved in using the InterLock Base are as follows:

Step 1 **Placement:** The magnetic coils are placed into the InterLock Base pockets and held into place using a silicon compound.

Step 2 **Routing:** The wire leads are routed into the appropriate channels, where they are held into place by double-sided tape on the sides of the fixture below the InterLock Base. The bottoms of the coil lead wires are then trimmed to the appropriate length to match the length of the lead frame pins.

Step 3 **Forming:** The lead frame is preformed with right angle pins that fit the InterLock Base channel grooves.

Step 4 **Assembly:** The lead frame is then fitted snugly into the InterLock Base channels and is designed to exert spring tension to hold the lead wires firmly in place.

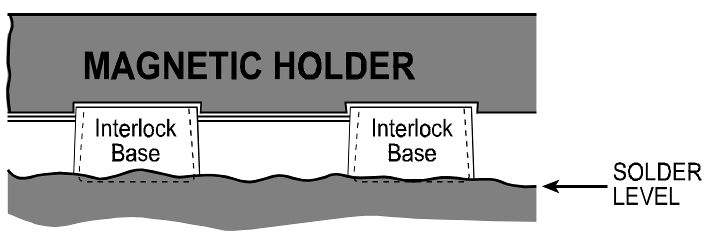
Step 5 **Automated Soldering:** The protruding leads of the assembled InterLock Base are then subjected to a mass dip solder process that precisely wicks solder into the channels, creating uniform solder joints between all coil leads and the lead frame.

QUALITY AND RELIABILITY BENEFITS

Improved Solder Joint Reliability

The InterLock Base routes the coil lead wires and the lead frame pins in a uniformly parallel configuration for soldering, creating solder joints that are significantly more consistent and reliable than hand soldered connections. The natural capillary action of the molten solder wicks the solder joint into the InterLock Base's lead wire channel, just as solder is wicked into a plated via hole on a printed circuit board. The completed solder joints are electrically sound, consistently uniform, and highly resistant to physical stresses. **Figure 5** illustrates the InterLock Base soldering process where multiple assemblies are dip soldered in a mass production process.

Figure 5



Protected Interconnects for Less Physical Stress

Because the final solder joints are mechanically captured in the InterLock Base lead channels, they are much more protected from physical stresses than traditional hand-soldered joints which are either exposed on the surface of the internal PC mounting board or are merely wire-wrapped to the lead frame pin. In both of these cases, the stresses associated with the flow of encapsulant materials and the subsequent temperature spikes of the SMT reflow solder process will "pull" on the lead wires and can damage or break the solder connection. In contrast, the InterLock Base and its captured solder joints will react to such physical stresses as a single unit, thereby eliminating any "pull" effect on the joints themselves.

Protected Coil Assemblies During Encapsulation Process

In addition to protecting the solder joints, the InterLock Base's structure also protects the coils themselves from damage during the encapsulation process. Held firmly in place within the InterLock Base's recessed pockets, the magnetic coils are not subjected to any unplanned movements caused by the encapsulant flow. This reduces physical stresses on the coil and its lead wires which can otherwise cause component damage and/or failure.

Isolation of Lead "Burn Back" to Improve Hi-Pot Resistance

With traditional encapsulated coils, the tapered "neck-down" area at the end of the insulation burn-back is typically the weakest electrical point of the assembly. If the insulation has been burnt back too close to the coil during the hand soldering/assembly process, there is a high likelihood for arcing directly to the coil during Hi-Pot testing, creating a failure. Because the InterLock Base process isolates the burn-back so that it is always within the wiring channel, the risk of shorting to the coil is completely eliminated.

Manufacturing Process Efficiencies

The use of InterLock Base technology allows for significantly increased levels of efficiency and effectiveness in the component assembly process. The elimination of manual soldering results in a more repeatable and consistent end product. Because the InterLock Base provides a uniform mechanical structure that precisely positions the magnetic coils, lead wires, and lead frame pins in a consistent relationship to each other, subsequent processes such as soldering can be conducted on a mass production basis. This highly controlled physical configuration also allows for a more uniform and consistent encapsulation process.

Another benefit of such a mechanized and highly structured production process is that higher quality output levels are easier to maintain. By improving the consistency and uniformity of the overall production process, resources can be refocused from inspecting variations in the output of individuals and used for high-level process control activities, such as Statistical Process Control.

The benefits of process improvements in both efficiency and quality accrue directly to Pulse's customers in the form of industry-leading cost competitiveness and product reliability. As pin count, package size, and the number of internal coils increase, the advantage in reliability and costs of the InterLock Base becomes more significant.

Design Flexibility and Extensibility

In addition to improving the quality, reliability and consistency of Pulse's SMT magnetic components and the manufacturing processes used to produce them, the InterLock Base technology also allows Pulse to better serve its customers and markets by streamlining the process for introducing and refining new higher integration product designs.

While today's miniaturized telecommunications applications can greatly benefit from the single package integration of multiple magnetics (e.g. transformers, chokes, etc.), traditional packaging methods have not been conducive to such integration. Without the use of InterLock Base technology, multiple devices must be connected either by wire-wrapping their leads together in a series of "flying lead" connections, or using a single length of coil wire to wind multiple components in a continuous “daisy chain.” The “flying lead” method is highly unreliable because of the stresses that are placed on these multiple unprotected connections during encapsulation and/or SMT reflow. On the other hand, the “daisy chain” method significantly increases production costs because subsequent coils using the same strand of continuous wiring must be individually hand-wound, thereby sacrificing all the benefits of modern machine winding methods.

The InterLock Base offers a proven, straightforward alternative method for efficiently positioning and connecting multiple components within a single encapsulated package. Because the InterLock Base is a pre-formed plastic carrier, it can be designed in many different physical configurations. Standardized bases with pockets for various sizes of coils can be used for quickly prototyping new component combinations or specially structured packages can be developed for non-standard component sizes.

Just as the InterLock Base wiring channels can be used to match coil wiring to lead frames, they can also be used effectively to interconnect the leads between multiple devices within the same SMT package. The leads from different internal components are simply routed into a common channel on the InterLock Base and are then dip soldered together in the same pass with the lead frame pins.

The InterLock Base enables Pulse to quickly respond to customers’ requirements for increasingly higher levels of integration and flexibility. It is especially beneficial to customers in the networking and telecommunications arenas who must match their products to constantly evolving standards, frequency spectrums, and market demands. Pulse continues to develop the InterLock Base technology to support non-magnetic components and more complex electrical circuits.

Summary

The increasing use of SMT production technology and the market demands for even smaller miniaturized products is constantly driving the need for higher component densities. An inherent challenge in achieving these densities involves the development of effective internal interconnection methods that provide the pathway between the encapsulated component and the “outside world.” The SMT magnetics industry has had to deal with the additional challenges of positioning large, three-dimensional components and their lead wires and then holding them in place during the soldering and encapsulation processes.

Pulse has responded to this challenge with the development of a patented InterLock Base technology that provides for an efficient, uniform, mechanized method of achieving consistent high quality interconnection results. In addition, InterLock Base technology provides a flexible and extensible design foundation for responding to the higher level integration needs of Pulse’s customers.

Bibliography:

U.S. Patent for “Electronic Micro-Miniature Packaging and Method,” granted May 14, 1991.

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