

Taking the Lead on Lead Forming

Whether it's a costly fine-pitch flat pack or an inexpensive axial-leaded resistor, lead forming can be a tricky business.

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This pneumatic press enables operators to adjust all the key dimensions for lead forming, including tip-to-tip length, foot length, offset height, and bend radii.
Photo courtesy Fancort Industries Inc.

High-reliability, fine-pitch microelectronic packages for military and aerospace applications typically cost \$2,000 to \$4,000 each. Some components cost as much as \$50,000.

"I've had engineers visit my plant with chips locked in briefcases handcuffed to their wrists," marvels Robert G. Antonelli, vice president of sales for Fancort Industries Inc. (West Caldwell, NJ).

Unlike the leads on ordinary components, the leads on high-reliability devices are made of Kovar, Alloy 42 and other tough materials that can handle stress. As a result, these devices usually arrive at the assembly line with unformed leads. Trimming and shaping those leads—without damaging the component, skewing the leads or altering coplanarity—requires careful engineering and precision equipment.

Both manual and pneumatic presses can be used to form leads on flat packs, multichip modules and other packages. Tooling can be dedicated or adjustable, depending on the component and the production volume. For example, a one- or two-sided flexible tool might be more economical than a dedicated one for high-mix, low-volume production. On other hand, dedicated tooling might be more appropriate for medium volume production with very expensive parts.

Before specifying presses or dies for lead forming, engineers should first determine the values and tolerances of five key component dimensions:

- the length of the component from lead tip to lead tip.
- the package offset, or the distance from the top of the board to the bottom of the component.
- the length of the lead foot.
- the thickness of the leads.
- the shoulder length, or the length of the lead from the component body to the first bend in the lead.

Other important dimensions are the lead pitch, shoulder radius, heel radius, and the length, width and thickness of the component body.

Of all these specifications, the most important is lead thickness, says Antonelli. This dimension must include

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Tim Hoffman, Hepco Inc.

accurate measurements of platings and tolerances. Even the grain of the metal can be important. If the lead thickness is not correctly specified, the die could have trouble maintaining coplanarity and foot angle, and lead problems such

as spring-back, burnishing and scoring could occur.

“The more accurate the lead frame is before you bend it, the better the odds of meeting the requirements for coplanarity and standoff height,” says Antonelli.

When setting component specifications, engineers are well-advised to seek assistance early from the component manufacturer as well as the supplier of the lead forming equipment. “We’ll work with engineers to recommend a component footprint that makes sense for the package *and* conserves real estate on the board,” says Antonelli. “If the standard gull-wing shape doesn’t work, there are alternate bends that can provide more flexibility.”

To get an idea of how these specifications affect lead forming, consider a fine-pitch ceramic component with top-brazed leads. This type of component is popular, because its leads

are compliant. However, because the lead legs are longer than those of side-brazed and bottom-brazed components, the leads are more prone to spring-back.

By itself, this issue is not critical. However, “when compounded with lead thickness variations and standoff

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—Av Shiloh, President, Automated Production Systems

height tolerances, it compels engineers to assign realistic tip-to-tip tolerances and to provide adequate real estate for pad contact during soldering,” explains Antonelli.

Another example of how component dimensions and tolerances affect lead forming is related to width variations from one package to another. For example, if the body width of a quad flat

pack varies by 0.025 inch, then the tip-to-tip length, after lead forming, will vary by 0.0125 inch, says Antonelli.

One way around the problem is to locate the component in the die by the corners of the lead frame instead of the body. Another solution is to use an adjustable tool. “The tool allows you to adjust shoulder length and foot length to compensate for differences in component dimensions,” says Antonelli.

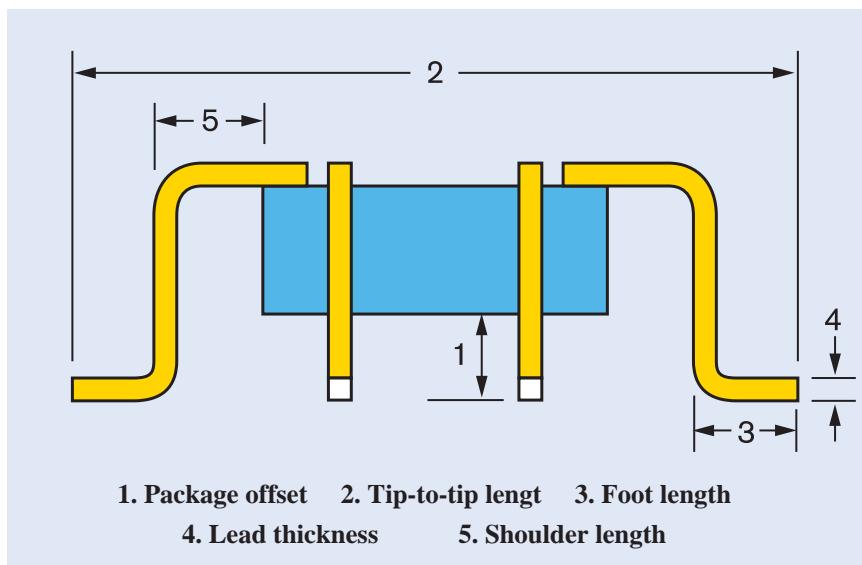
Just as packages can vary in width, so too can they vary in thickness, which can cause difficulty maintaining coplanarity and offset height. To solve that problem, Fancort developed a press with a floating anvil. “Before each forming operation, the anvil measures the distance from the seating plane to the bottom of the package,” says Antonelli. A precision stepper motor then automatically adjusts the forming tools to ensure consistent offset height.

The floating anvil tool is also useful for handling the most difficult of high-reliability components: metal-encased packages. Glass seals insulate the metal leads from the metal body of the package. “Forming the leads without cracking those glass seals is difficult,” says Antonelli.

Moreover, the leads on metal-encased packages are usually round rather than flat. “It’s easy to clamp something that’s flat. You don’t have to worry about crushing it,” says Antonelli. “If the leads are round, you have to hold the leads firmly without flattening them by more than 10 percent, which can be tricky.”

The floating anvil allows the forming pressure to be finely adjusted for each package.

Important Lead Forming Dimensions for High-Reliability Packages

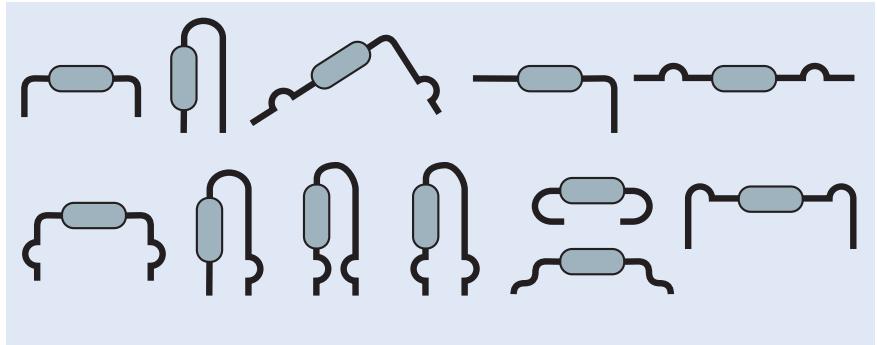


Before specifying lead forming equipment for high-reliability microelectronic packages, engineers should determine the values and tolerances of the dimensions shown here. Other important dimensions are the lead pitch, shoulder radius, heel radius, and the length, width and thickness of the component body. *Source: Fancort Industries Inc.*

From the Sublime...

Not every component with unformed leads is a high-reliability device worth thousands of dollars. Radial-leaded components, axial-leaded components, power transistors and DIP components still find their way into printed circuit

Lead Forms for Axial Components



Axial components can be formed for horizontal or vertical insertion. Forming a tiny outside bend in the lead will produce a standoff; a tiny inside bend in the lead will produce a snap-in. No bend at all will enable the component to be mounted flush with the board. *Source: Automated Production Systems*

boards, and a surprising number of suppliers still offer equipment to form leads on these parts.

Depending on the part and the production volume, lead forming equipment for these components can be semiautomatic or fully automatic. Parts can be fed manually or from tapes, tubes and vibratory bowls.

“You always want to use taped components when you can,” says Av Shiloh, president of Automated Production Systems (Huntingdon Valley, PA). “You only want to use loose components when you have no other choice. A machine processing taped components will operate 10 to 20 times faster than one processing loose components.”

Some dies are fixed; others are adjustable. Depending on the range of applications, a single die can accommodate a variety of lead lengths, lead diameters, lead forms and component sizes, says Tim Hoffman, president of Hepco Inc. (Sunnyvale, CA).

Leads can be bent into many forms. For example, the leads on axial components can be formed for horizontal or vertical insertion. Forming a tiny outside bend in the lead will produce a standoff; a tiny inside bend in the lead will produce a snap-in. No bend at all will enable the component to be mounted flush with the board. Forming an upward bend, or camel hump, in each lead will help relieve stress on the component.

“In general, you want to use the simplest shape possible to accomplish the goal,” says Shiloh.

As with forming leads on high-end packages, engineers can facilitate the lead forming process for axial and radial components through good design work. For example, with axial components, the shoulder length should be no less than 0.05 inch.

In an attempt to save board space, engineers may be tempted to cheat on this distance. Shiloh advises against it. Bending the leads too close to the body could damage both the body and the leads.

“Many engineers try to squeeze a 5-pound load into a 3-pound bag,” he says. “I’ve seen part drawings with bends that were physically impossible to make no matter how you did them. The most important specification is to allow enough space for the machine to bend the lead.”

Lead length is another critical parameter, says Hoffman. If the component will be inserted manually, the leads should be long enough to enable the operator to insert it easily, but not so long as to impair wave soldering.

“It’s best if engineers can work with us as they are designing the board, so we can make sure that the component can be bent in the form they want,” Hoffman says. “A lot of problems can be avoided simply by changing the position of the component on the board.” A