Guidelines for lead forming of Hall sensors in SIP package (v1.0)

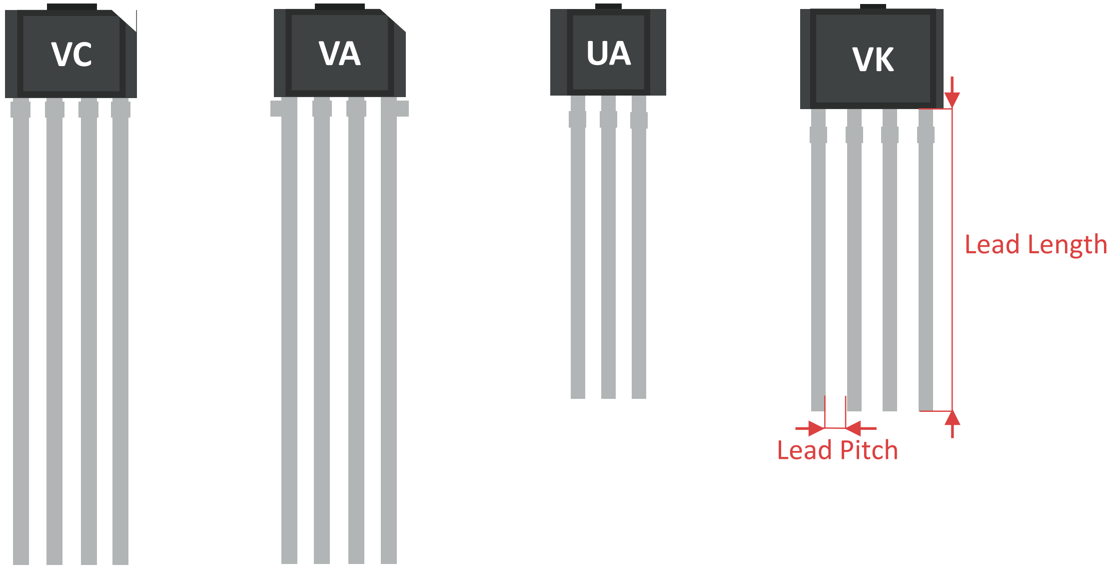
January 2020

Advanced Customer Solutions

Lead forming of Hall sensors in SIP package

1. Introduction to lead forming

Melexis SIP packages



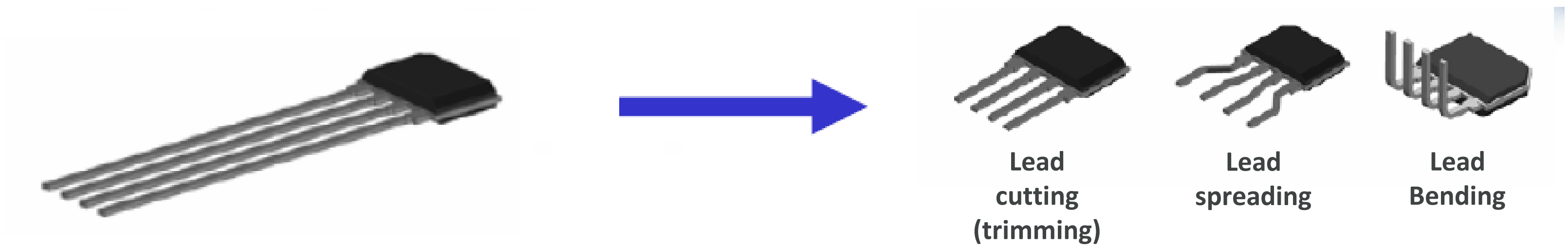
Melexis Hall sensors in SIP (*Single-in-Line Plastic*) packages are intended for PCB and PCB-less applications. Melexis SIP packages are of 4 types – VA, VC, UA and VK, with 3 and 4 leads. The lead length vary from 10.5 to 18mm depending on package type and the lead pitch is originally 1.27mm for all types. UA and VA are the most popular: UA because of its small form factor and VA because of its higher positional accuracy.

SIP packages are compatible and qualified for standard system manufacturing processes according to AEC-Q100. This document underlines the most important guidelines as well as some restrictions for lead pre-forming process at customer side, in order to favour high product performance and reliability. For other process steps (soldering, welding…), please contact Melexis to obtain the relevant documentation.

Refer to product datasheet for detailed package drawings and dimensions. Contact Melexis for 3D models or specific questions.

1. Introduction to lead forming

Introduction to lead forming



Example of lead forming that can be done at customer

The long leads of the four packages are typically not used with straight leads in the final application. Instead, the user forms them as needed and cut them to their desired shape.

The lead-forming process and tolerances depend on several points:

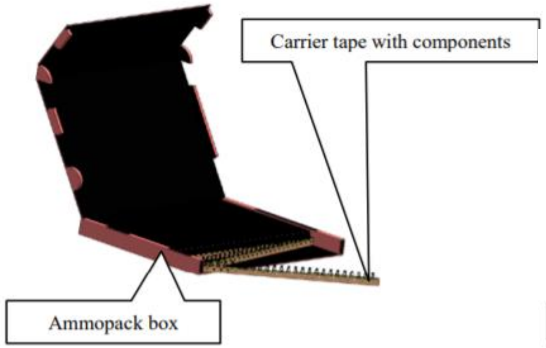
- Intended application and PCB or housing (for PCB-less) design
- Tooling quality used for lead-forming
- Delivery form from Melexis (radial tape or bulk)

Melexis might review the customer forming process and prepare a risk assessment on request.

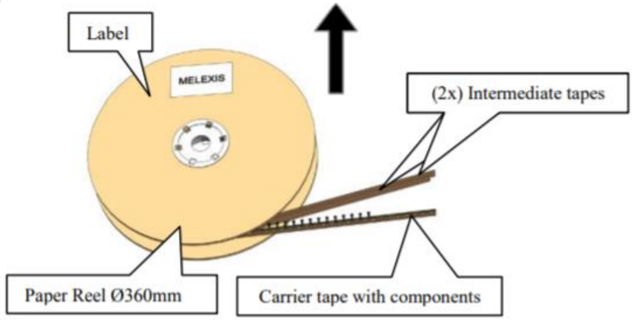
The design and manufacturing of tooling and forming quality is customer responsibility.

1. Introduction to lead forming

Delivery form



Ammopack Box
(Automatic processing)



Reel
(Automatic processing)

Bulk in ESD-safe bag
(Manual or automatic processing)

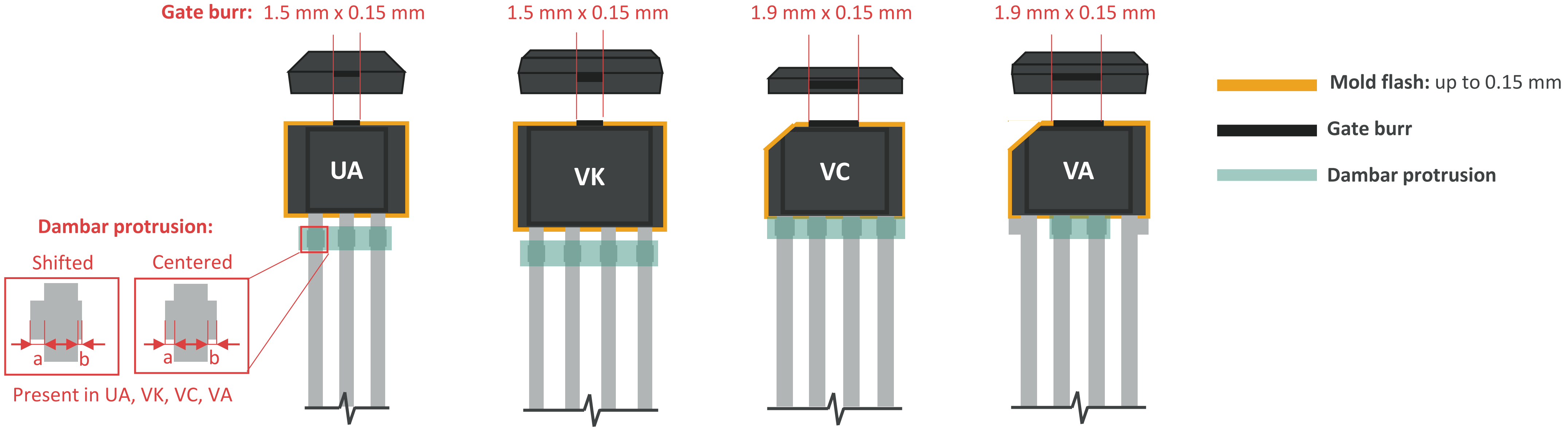
There are three delivery forms. Contact Melexis (https://www.melexis.com/en/contact) for the specifications for each one:

- **Radial tape on reel:** According to standard IEC 60286-2 and intended for automatic handling in a radial tape feeder because of the indexing sprockets. It is aimed at protecting the leads from bending during shipping. Typically, there are 3500 parts per reel.
- **Radial tape on ammopack:** Also following standard IEC 60286-2 and intended for automatic handling in a radial tape feeder because of the indexing sprockets. It is aimed at protecting the leads from bending during shipping. Typically, there are 7500 parts per ammopack box.
- **Bulk:** Intended for manual processing or automatic handling with the use of a vibrating bowl feeder. Typically, there are 1000 parts per bag. The leads might be slightly deformed during shipping due to mechanical overstresses during transport. If such lead deformation is critical for the lead forming process, it is recommended to order on radial tape (reel or ammopack), even if manual loading into the tool is foreseen.

Lead forming of Hall sensors in SIP package

2. SIP package specifics

SIP package details to take into account

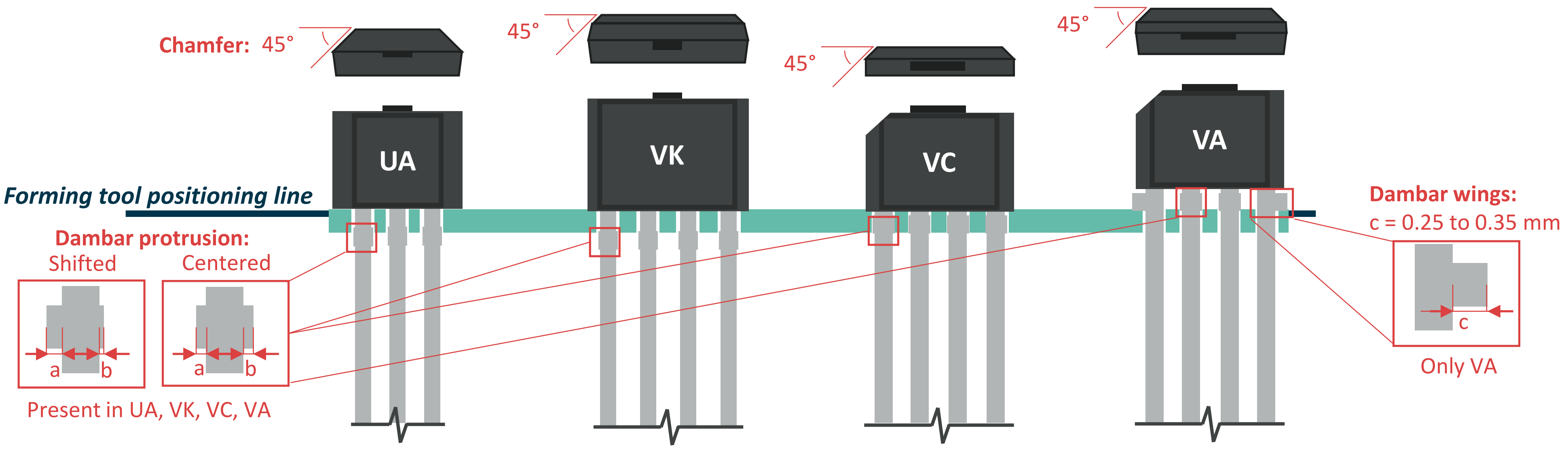


The dambar protrusion is a remnant from tie bar cutting: it can be centered on the pin or shifted to one side. If opening or channels are designed for the pins in the tooling or housing, they should incorporate the dambar protrusion maximum size. Refer to the POD (*package outline drawing*) in the datasheet for the dimensions.

Mold flash and mold gate burr are inherent results of the molding process. They are mostly removed during mechanical de-flash process, but a minor leftover might still exist because of the clearance between the de-flash punch and the mold package. Therefore, lead forming tooling and housing should be designed with enough clearance allocated for them.

2. SIP package specifics

SIP package positioning features



Melexis SIP packages have designed features to achieve proper alignment of the parts with the positioning line in both the lead forming tooling and the housing:

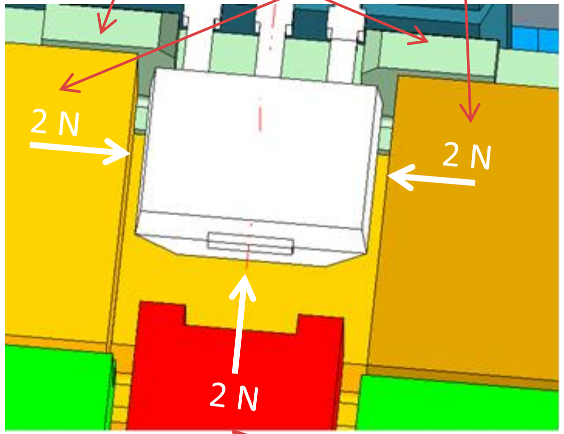
- **VA**: The dambar wings are designed as stoppers. The 45° chamfer is a feature for self-alignment. Dambar wings on pin 1 and 4 are dimensionally controlled, whereas dambar protrusions on pin 2 and 3 are not guaranteed dimensionally. Hence, it is not recommended to use the dambar protrusion as a positioning feature.
- **UA, VK, VC**: Positioning should be done using the mold body. The 45° chamfer feature is also present for self-alignment. Dambar protrusions on all pins are not guaranteed dimensionally. Hence, it is not recommended to use the dambar protrusion as a positioning feature.

2. SIP package specifics

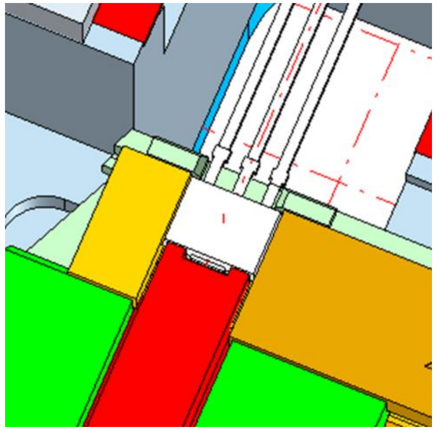
Examples of part positioning in the tooling

Fixed body stoppers

Optional side positioners



UA top positioning pusher (shape adopting mold gate burr)

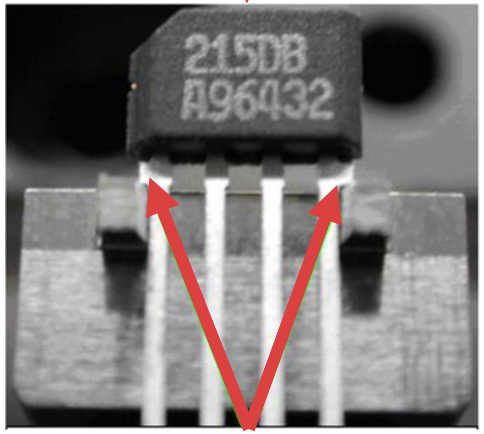


UA positioned by body

UA positioning by mold body

(also applies to VC and VK)

Positioning force: 2N



Clamp block part: component centered on dambar

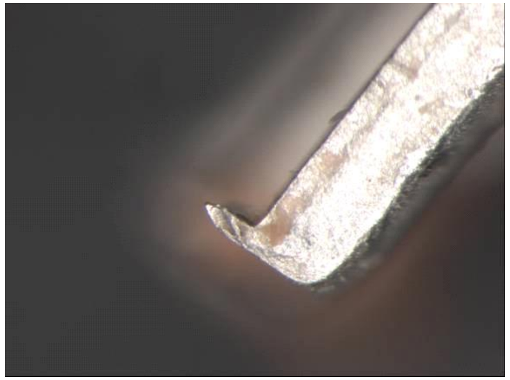
VA positioning by dambar wings

(only applies to VA)

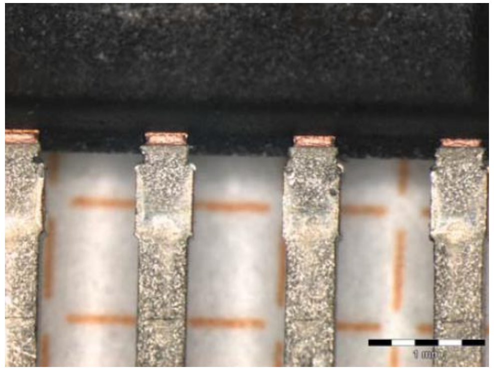
Lead forming of Hall sensors in SIP package

3. Lead forming principles

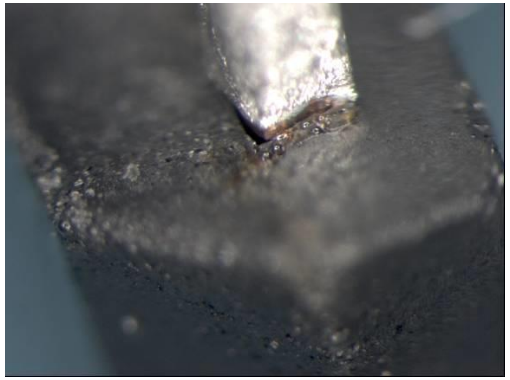
SIP forming risks and mitigations



Lead 'beak' due to increased cutting gap during lead cutting



Exposed lead core copper from excessive pull force on the pin during lead bending



Mold crack and delamination around lead as a result of a high side force during lead spreading

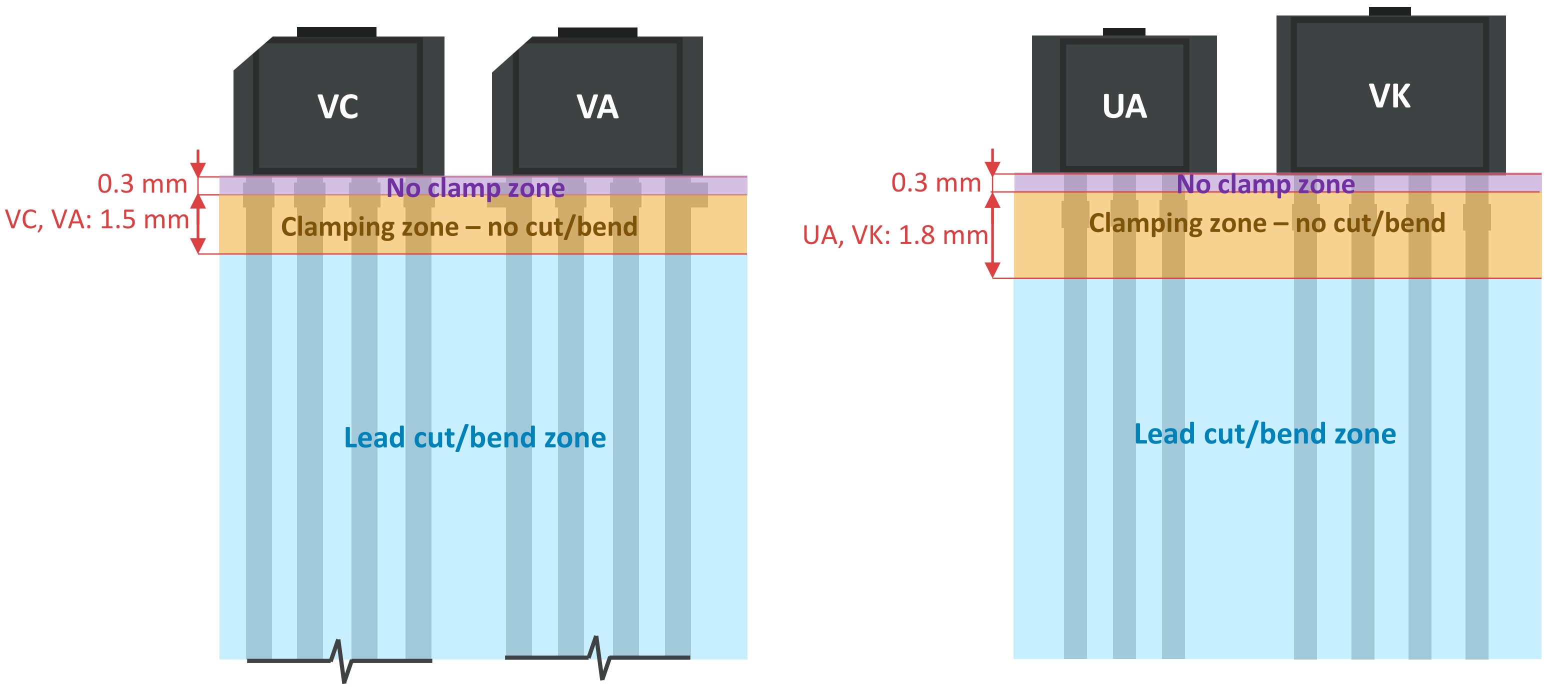
SIP lead forming (lead cutting, lead bending and lead spreading) might apply significant forces on the leads versus the mold body which represent a risk for structural integrity and long-term reliability.

Care shall be taken to guarantee that the design of the forming tool and the process do not overstress the devices beyond their robustness limits.

To enable safe lead forming process, lead resistance to push, pull and bending forces from the mold package is defined by IEC-60068-2-21. Melexis SIP packages are tested to comply the aforementioned standard.

3. Lead forming principles

SIP package guidelines on clamping



No clamp zone: Mold flash width up to 0.15 mm

Clamping zone – no cut/bend: Dambar cut area, mold flash and cutting burr width. Clamping is allowed in this zone

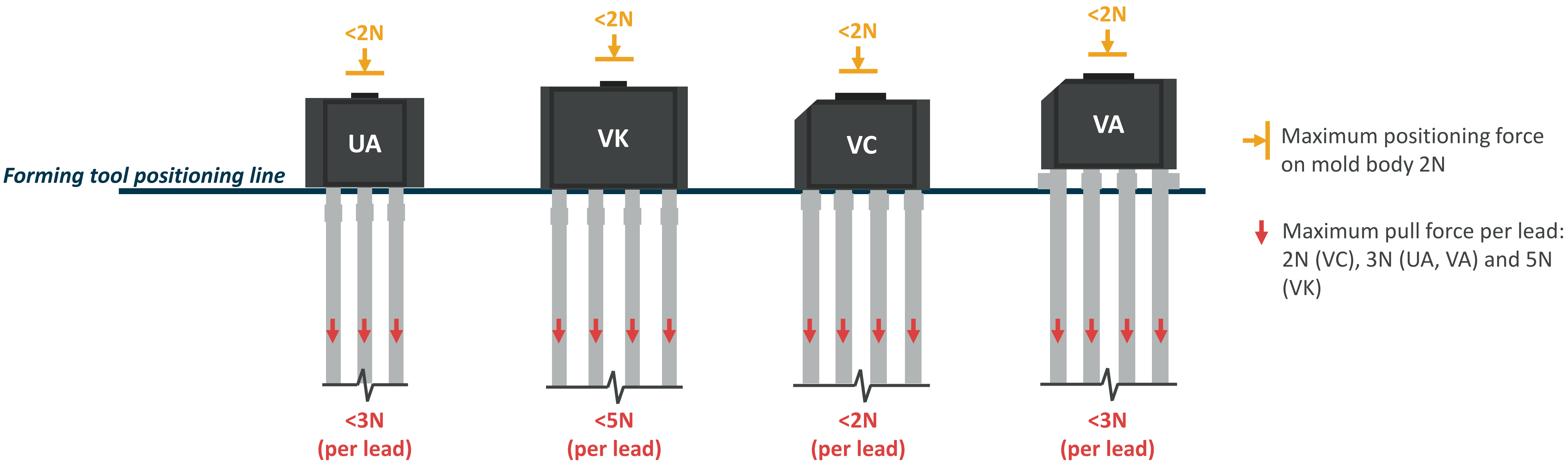
Lead cut/bend zone: The bending or cutting line can be safely positioned in this zone

Clamping on leads between the mold body and the bending/cutting line is a must to prevent lead versus mold body push/pull overstress.

The zones highlighted in the diagram shall be respected in any lead forming operation. UA and VK have thicker leads, so the clamping area should be wider. VC and VA, on the other hand, have thinner leads requiring less clamping area. **Contact Melexis in case your design requirements do not meet above guidelines and dimensions**.

3. Lead forming principles

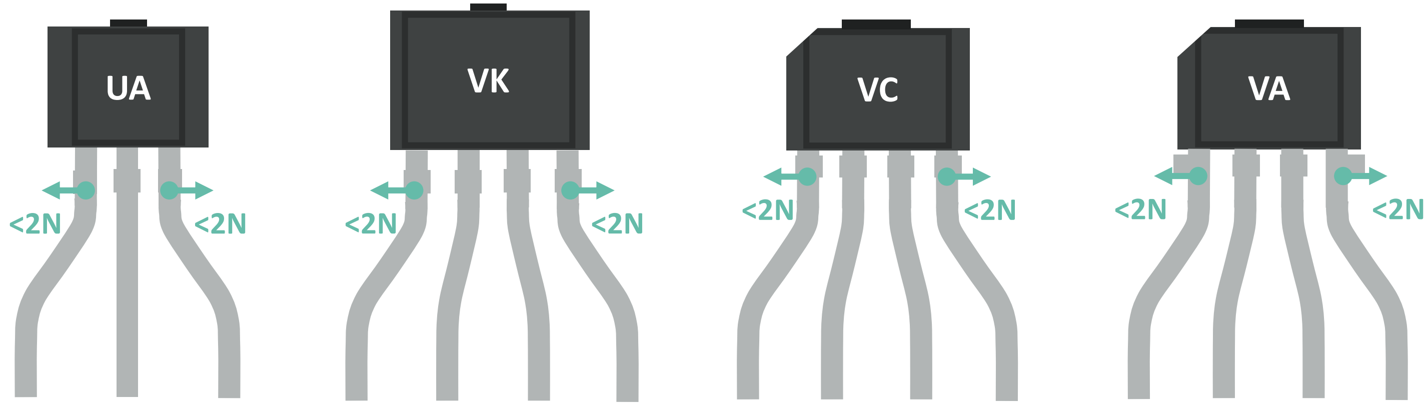
Maximum pull forces allowed on leads versus mold body during lead bending/cutting



Maximum allowed applied forces on pin versus the mold body **after clamping** are shown in the diagram for each pin/package. Exceeding these values may cause parameter drift or introduce structural degradation and failure. Therefore they should be taken into account during the design of the lead forming tool.

3. Lead forming principles

Maximum side force allowed on lead versus mold during lead spreading



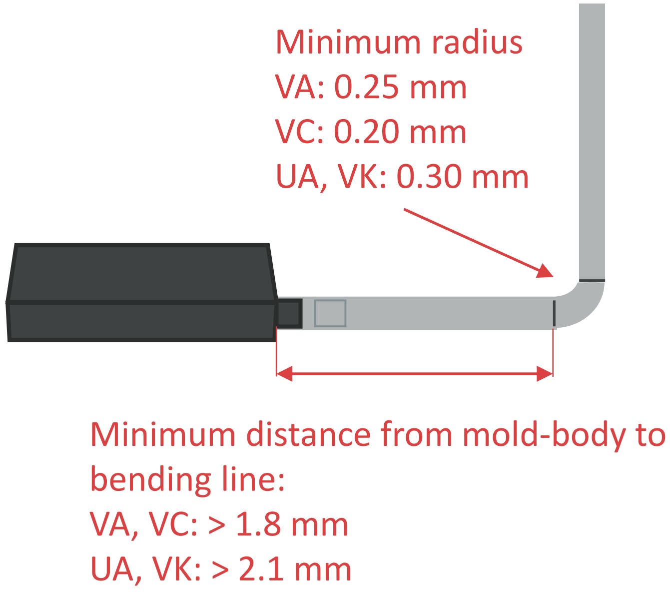
Maximum side pull force on lead versus mold: 2N

Maximum allowed side forces applied on pin versus the mold body **after clamping** are shown in the diagram for each pin/package. Clamping for lead spreading is applied on the side of the leads and it is less effective than in lead bending.

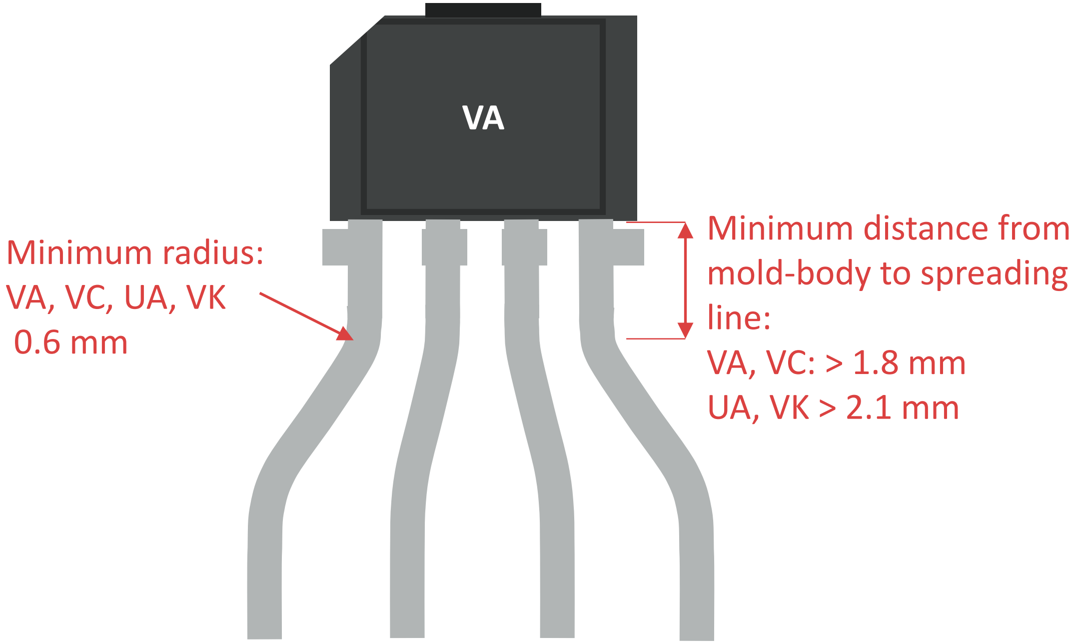
Exceeding these values may cause parameter drift or introduce structural degradation and failure. Therefore they should be taken into account during forming tool design. It might also lead to mold crack and delamination, which will allow moisture to ingress and corrode the structure inside.

3. Lead forming principles

Lead bending/cutting and lead spreading recommended dimensions



VA, VK, UA, VA:
Up/down lead bending may be applied for easier integration

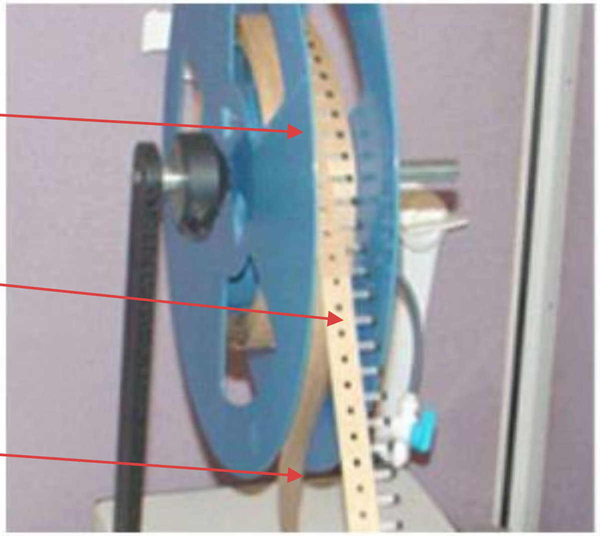


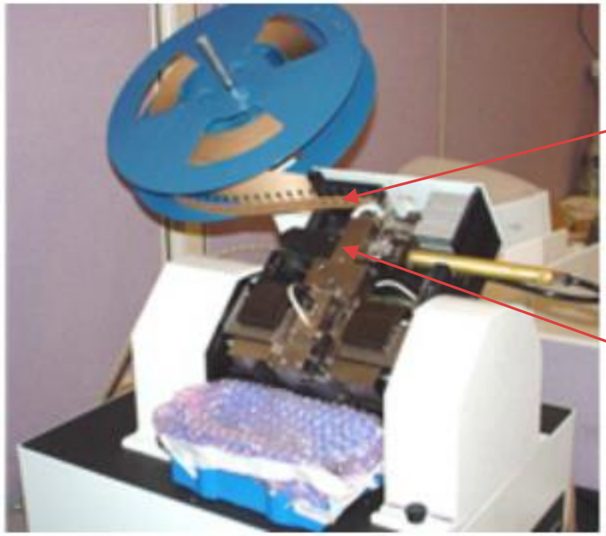
VA, VK, UA, VA:
Side lead bending may be applied to expand lead pitch value above original 1.27mm

Lead forming of Hall sensors in SIP package

4. Customer lead forming of radial taped parts

Radial tape unwinding and feeding in





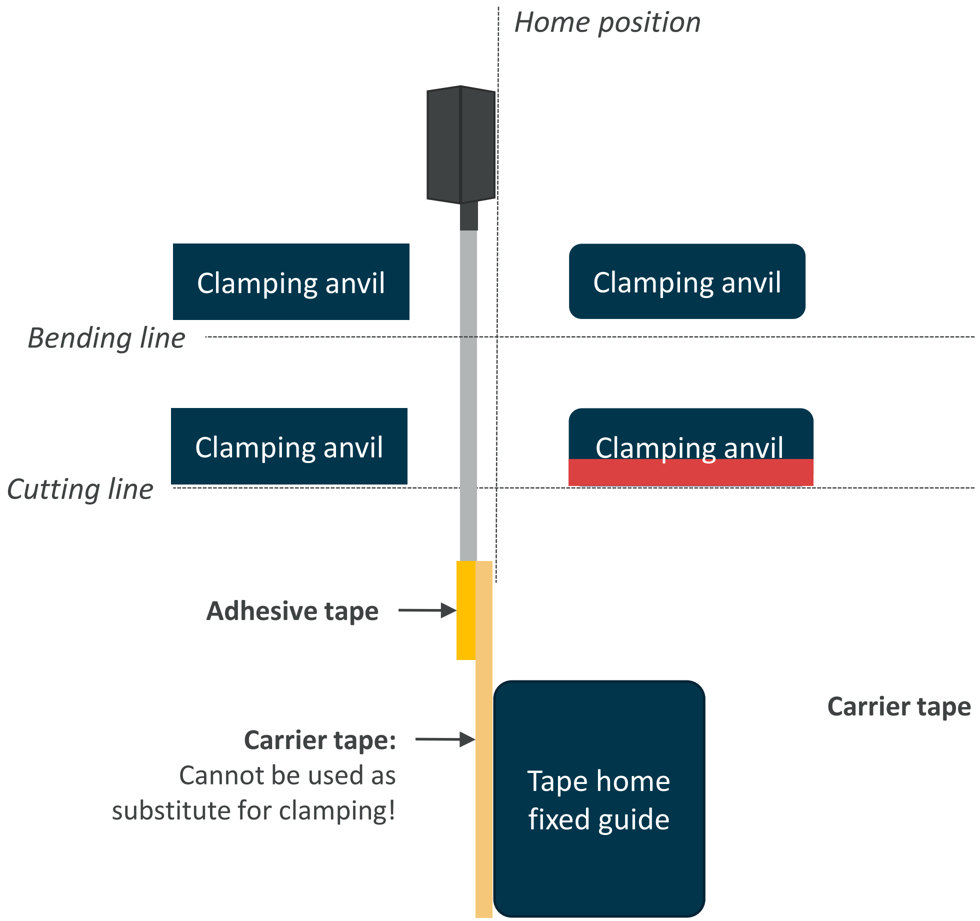
Pictures: Courtesy of America Tape and Reel, Inc.

The tape unwinding and the separation of the intermediate tape from the carrier tape might lead to charge build-up by triboelectric effect. **An overheard ionizer is a must** to remove the excess charge safely from the tape before any metal tool contacts the leads of the IC, which will lead to an ESD event.

If manual processing is foreseen, the devices might be cut from tape, gathered in loose form in an ESD-safe plastic tray, and then processed with manual loading.

4. Customer lead forming of radial taped parts

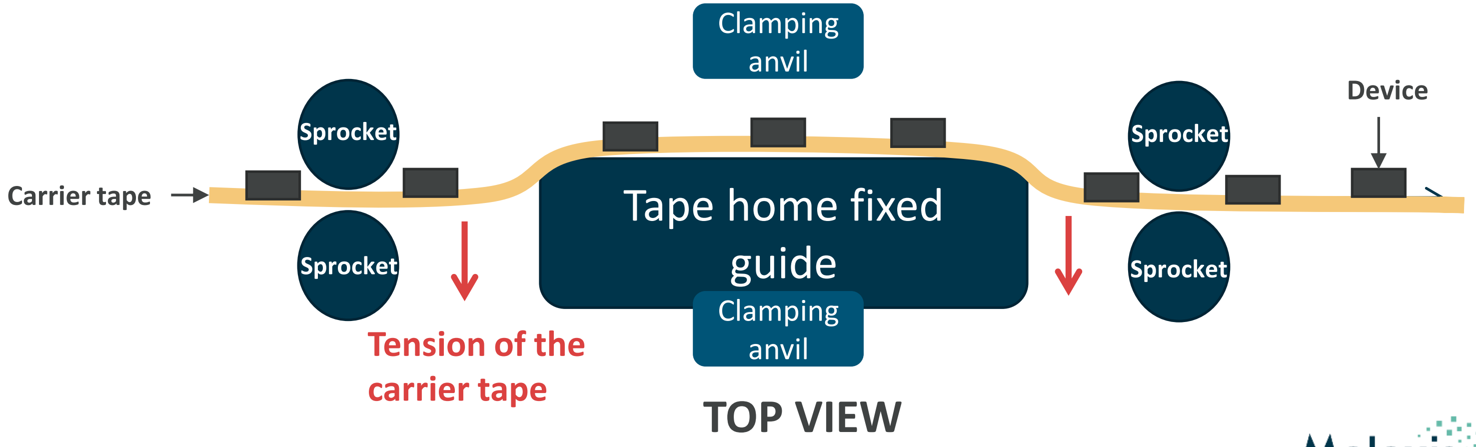
Positioning



A fixed guide to define the home position of the carrier tape is needed, otherwise the verticality of the device might be compromised leading to wrong cutting and bending of the device. Using a fixed clamping anvil is also recommended.

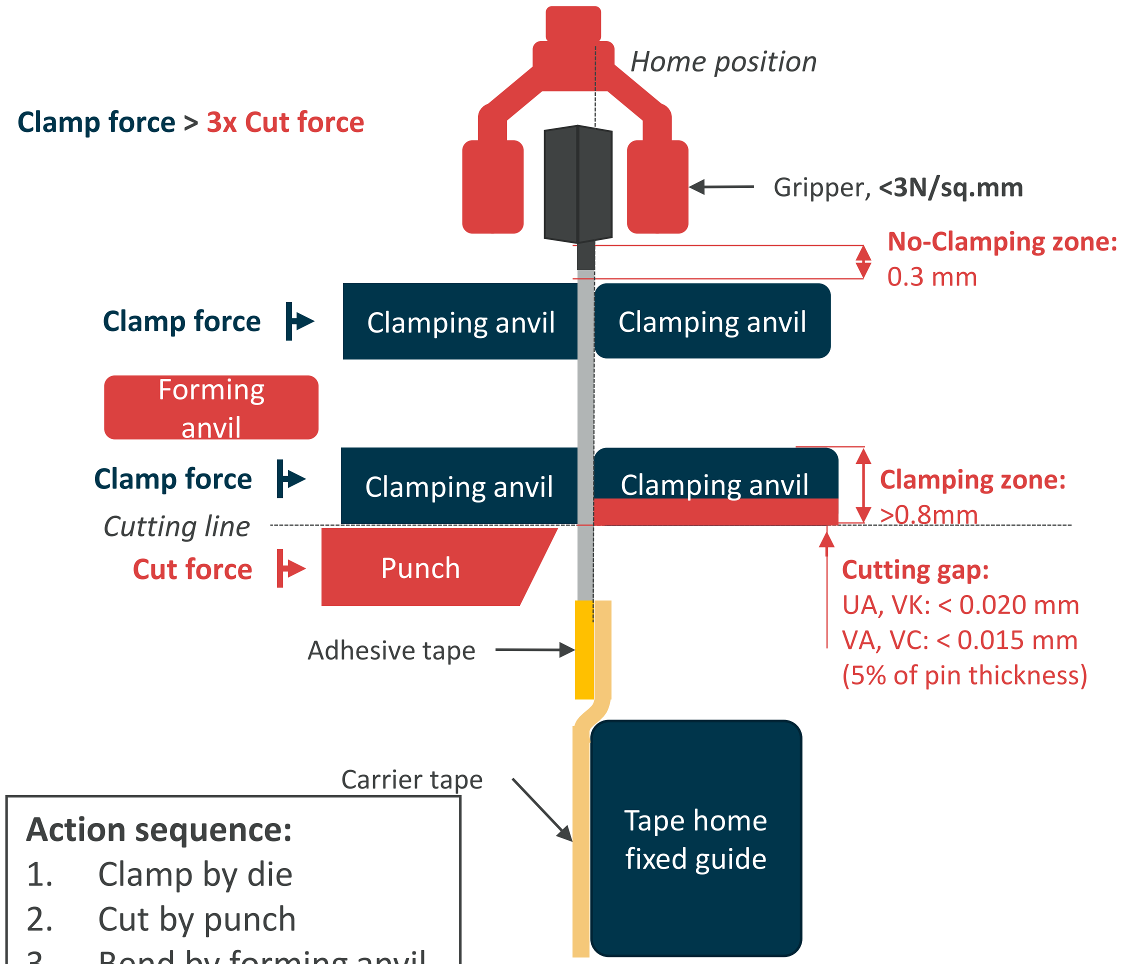
The carrier tape does not offer strong enough support, so clamping should be always performed between the bending/cutting line and the package body to avoid twisting of the leads.

The tolerances for the sprocket holes position (as defined in standard IEC 60286-2) and the device height needs to be taken into account for proper alignment of the tooling and the device.



4. Customer lead forming of radial taped parts

Lead cutting



Action sequence:

1. Clamp by die
2. Cut by punch
3. Bend by forming anvil

Cutting must always be performed to singulate the devices from the carrier tape.

A flat gripper holding the mold body might be used for picking up the parts after cutting. If a gripper is not used, the box for collecting them after free falling should be of a conductive material for ESD safety.

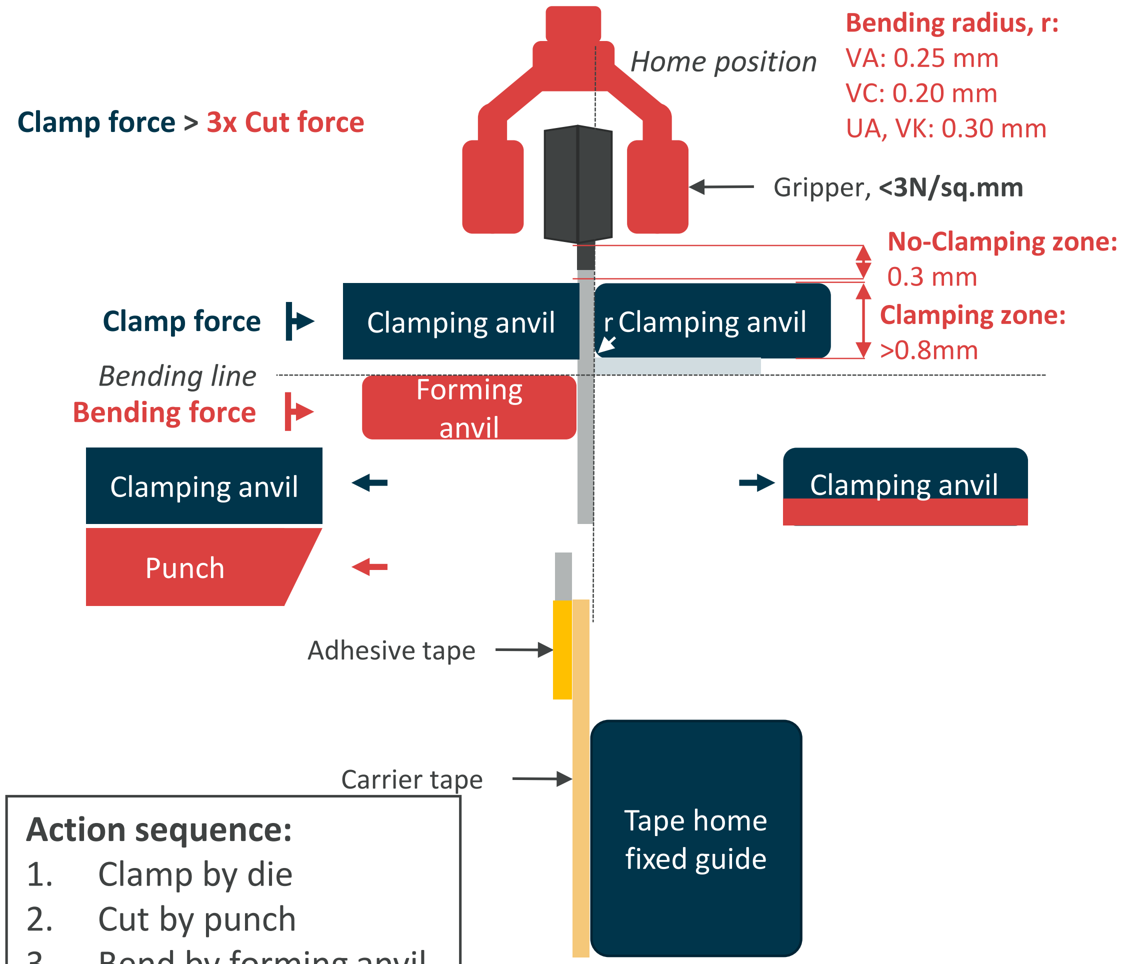
The clamping must be fully closed before the cutting operation begins. Otherwise, the excessive pull force on the leads will lead to wirebond damage, mold crack and delamination.

The cutting gap size needs to be maintaned and periodically sharpened to avoid wear-out of the punch: otherwise a tip burr might appear that will compromise the positioning of the device in the PCB or housing, as well as the electrical connection after soldering and welding.

Maximum gripper holding pressure on mold body (on package flat surface, branded (top) and bottom) is 3N/sq.mm.

4. Customer lead forming of radial taped parts

Lead bending



Action sequence:

1. Clamp by die
2. Cut by punch
3. Bend by forming anvil

Lead bending is done on the same position of the tool but after cutting leads from tape. The clamping anvils of the cutting tool stay closed to hold the part for bending action.

For a 90 degrees bend, a single forming anvil is enough. For more complicated shapes, a set of forming anvils acting sequentially might be needed to achieve the desired final shape.

Apart from a fully closed clamping, the clamping pressure must be enough to avoid slippage leading to the same failures described for cutting.

The anvils must have round corners to avoid lead finish peel-off. The exposed copper might lead to problems with corrosion and the burr and tin flakes might create unwanted conductive paths

The radius of the lead cannot be below the minimum, otherwise crack might develop on the leads

Deformation of the lead should be avoided since a reduced thickness of the lead is a reliability concern.

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Lead forming of Hall sensors in SIP package

1. Introduction to lead forming
2. SIP package specifics
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4. Customer lead forming of radial taped parts
5. Customer lead forming of bulk packed parts
6. Melexis lead pre-forming options

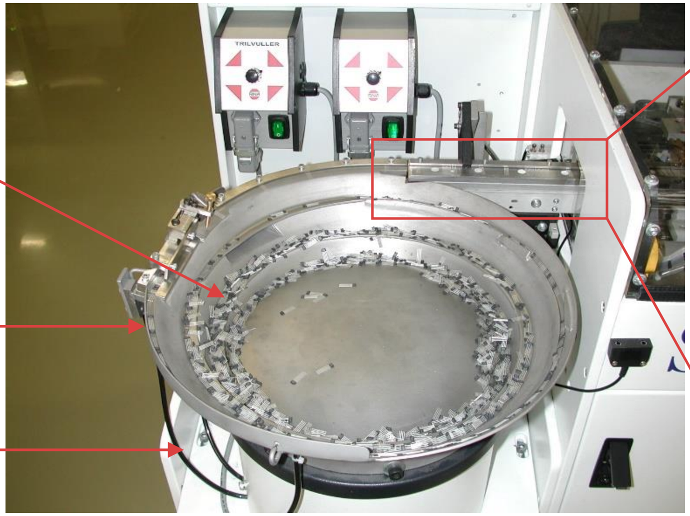
5. Customer lead forming of bulk packed parts

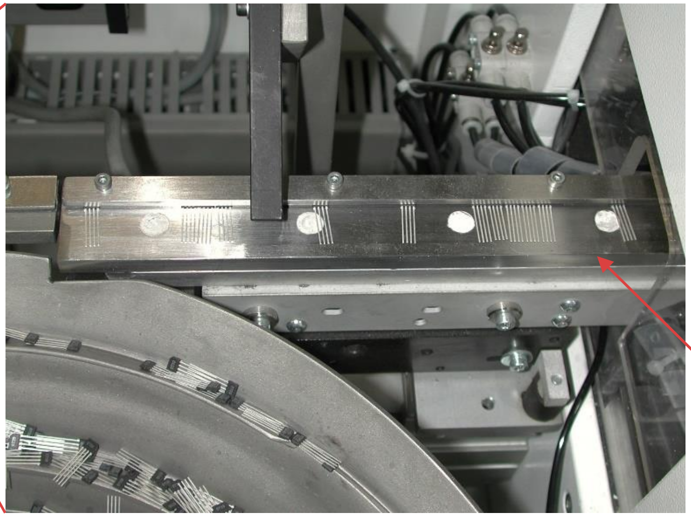
Bulk delivery and vibrational feeder

Devices inside feeder

Feeder

Base





To tooling:
Nozzle, flipper, gripper…

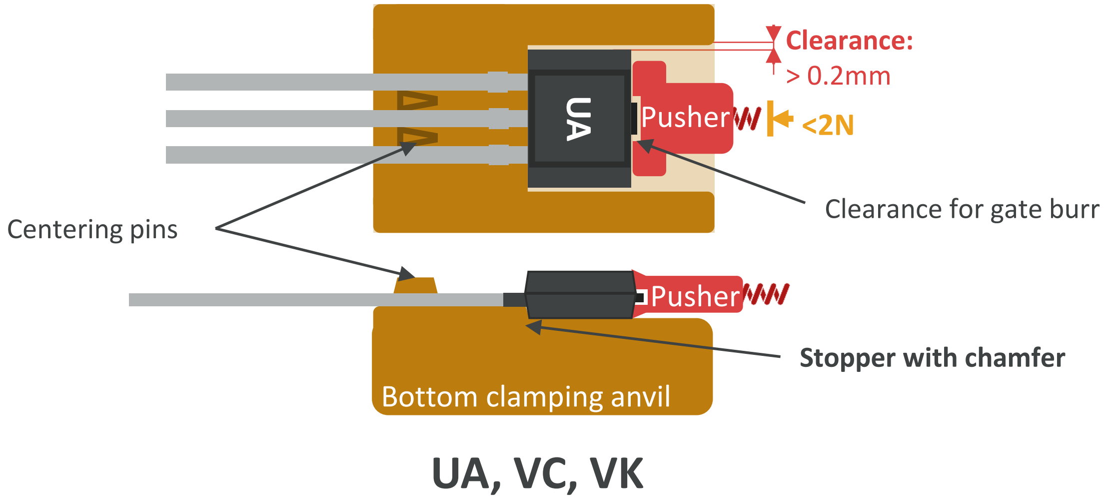
Rail with parts oriented horizontally (vertical is also possible)

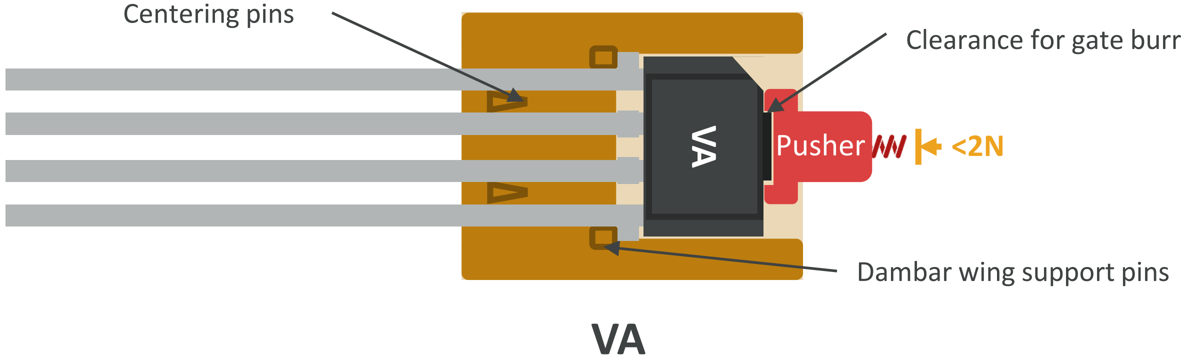
Parts delivered in bulk format need a vibrating bowl feeder for automatic processing. The rails might be designed to orient parts in vertical or horizontal position. The tooling might have nozzles, flippers or grippers for positioning of the devices in the tooling as needed. Some yield loss might be expected since leads might be deformed during shipping in bulk. **<u>An overhead Ionizer over the vibrating bowl feeder is a must</u>** because the bowl surface is often hard coated with a non-conductive material to reduce weariness, and this might lead to charge build-up by triboelectric effect.

If manual loading into the tool is foreseen, an ionizer must be located on the manual pick station and a conductive tray used for storage of the parts after processing. Operators shall follow the ANSI S20.20 for proper ESD safety.

5. Customer lead forming of bulk packed parts

Horizontal bottom positioning





Horizontal processing of the parts is recommended because the gravity helps with the proper positioning. Also the flat mold surface helps to keep and move the part without tilting.

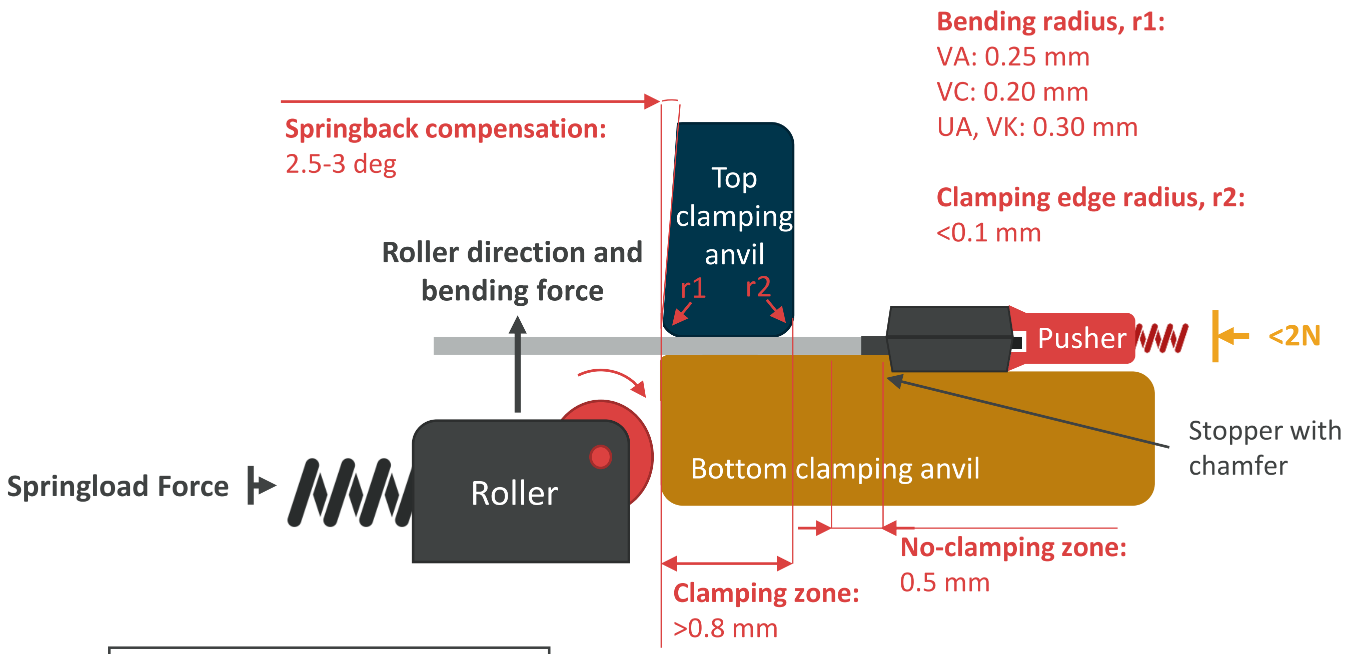
The positioning force by the pusher should not be exceeded to avoid damage in the silicon structure.

For UA, VC and VK the mold body is used as a positioning feature. To avoid tilting of the part when the push force is applied, the stopper should be designed with a chamfer angle matching the chamfer angle of the package. For VA, the dambar wings can be used for precise positioning.

Clearances or the mold flash and the mold gate burr shall be taken into account during tooling design.

5. Customer lead forming of bulk packed parts

Clamping and lead bending



Action sequence:
1. Positioning by pusher
2. Clamp by top anvil
3. Bend by roller

After positioning of the part on the bottom clamping anvil, the clamping action shall be completed before bending of the leads. Insufficient clamping will lead to different failures modes as described in radial tape bending.

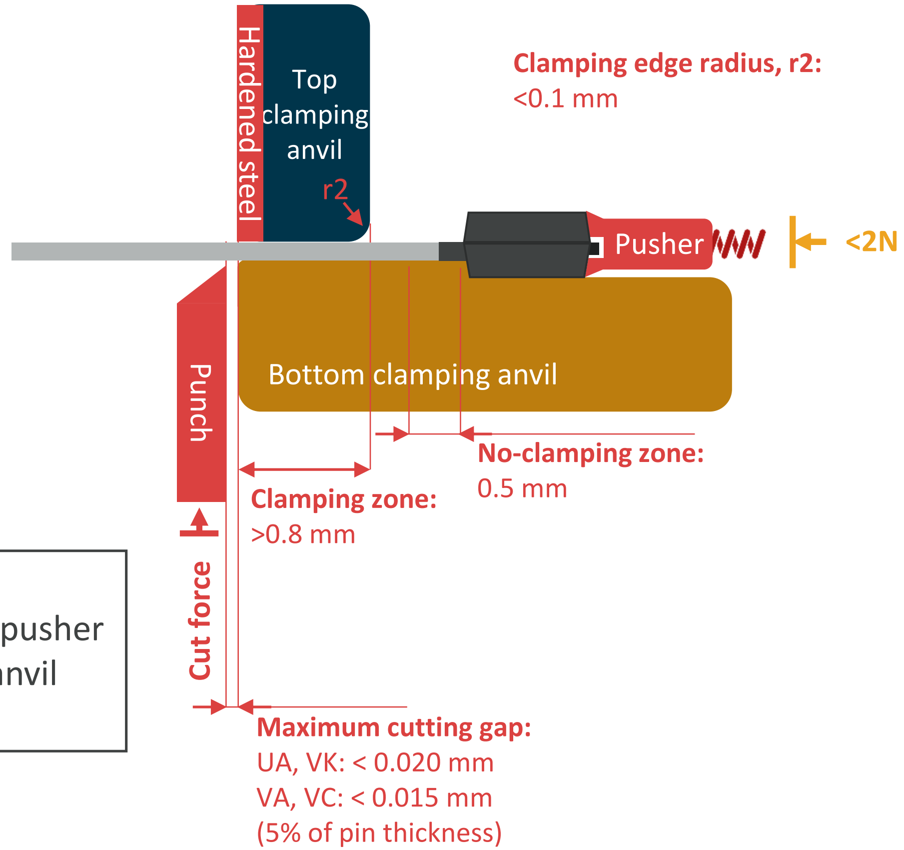
A roller on the bending anvil is recommended to reduce the deformation in the bending line. A spring load force will help overcoming the tensile strength of the pin. The minimum radius shall be respected and sharp edges in the tooling avoided to reduce the risk of lead finish peel-off and exposed core copper.

The top anvil design shall foresee the presence of positioning pins on the bottom anvil, which might also help with the alignment of the top and bottom anvil.

A spring-back compensation angle shall be foreseen to overcome the elastic reaction of the leads after bending.

5. Customer lead forming of bulk packed parts

Clamping and lead cutting



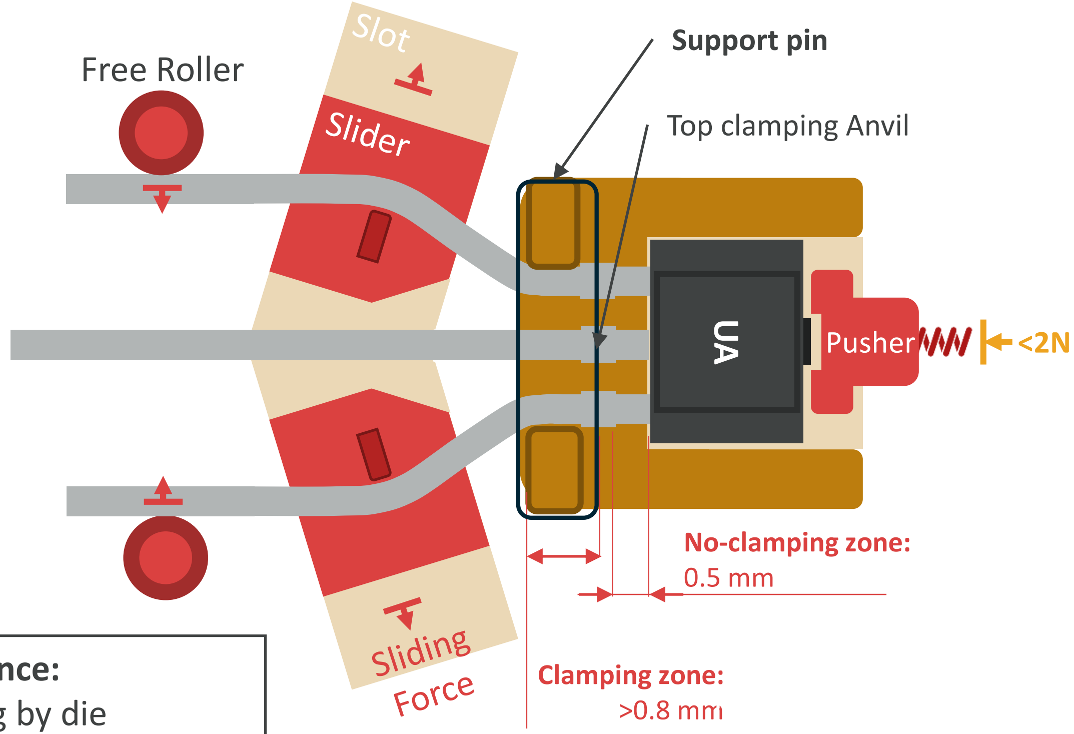
Action sequence:
1. Positioning by pusher
2. Clamp by top anvil
3. Cut by punch

The top clamping anvil and the punch shall be treated for extra hardness to reduce the weariness of the cutting edges.

It is important to maintain the cutting gap below the maximum recommended value to avoid an excessive burr on the lead tip (as explained in radial taped parts).

5. Customer lead forming for bulk delivery

Lead spreading



Action sequence:
1. Clamping by die
2. Side bending by slider
3. Second bending by roller

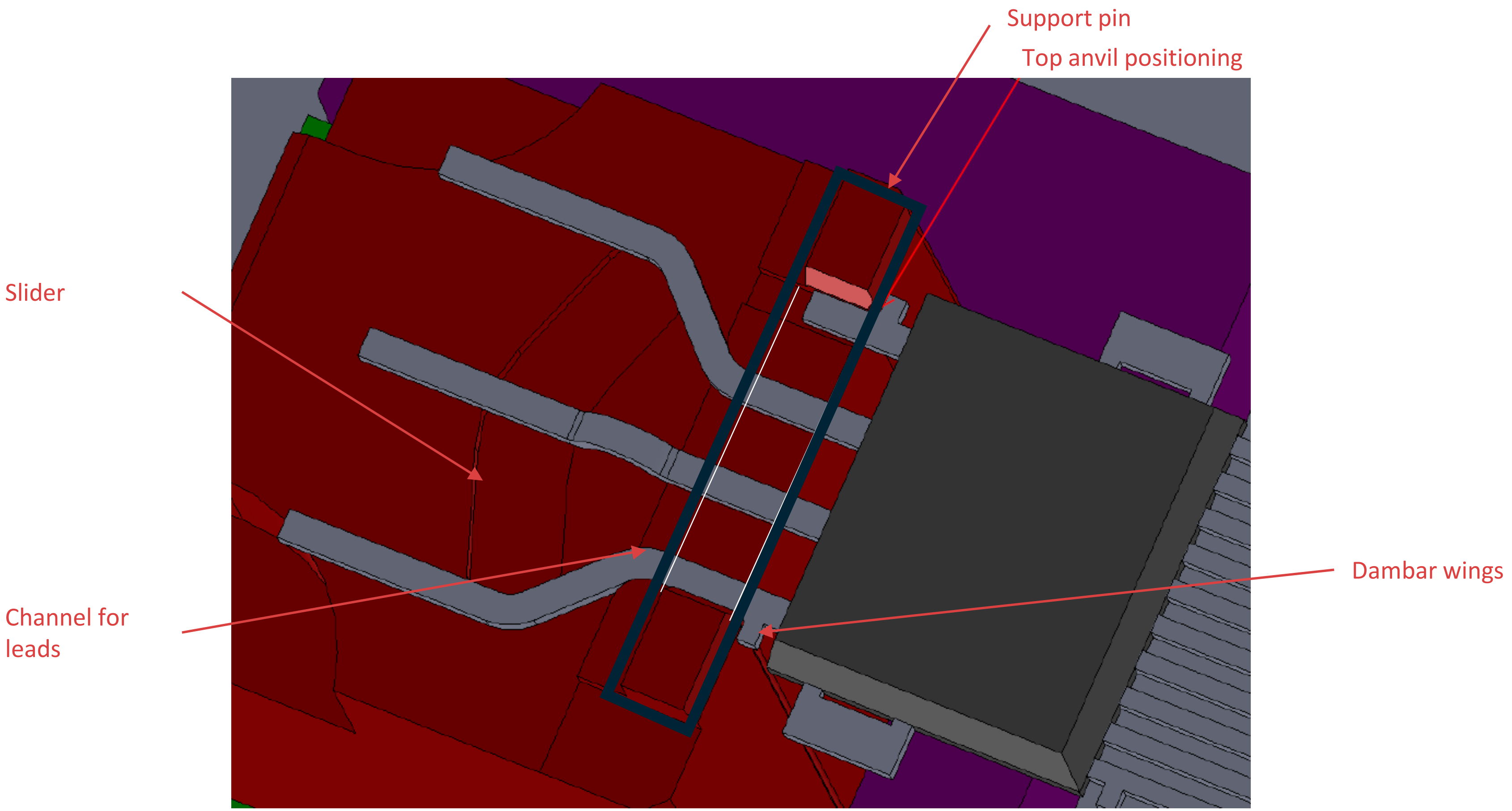
The top clamping anvil has mating holes to align with the support pins on the bottom clamping anvil.

Lead spreading is performed by a slide which will increase the pitch of the leads, assisted by a free support roller to keep them straight. This defines the first bending line. The second bending line is achieved by a support pin which will limit the side movement of the pin.

Since the clamping is not as effective during lead spreading, sliding marks might appear on the pin if the lateral movement is not limited by the support pin.

5. Customer lead forming of bulk packed parts

Example of side bending tool



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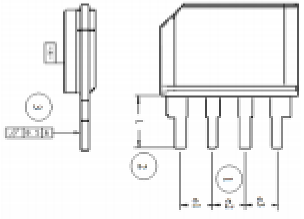
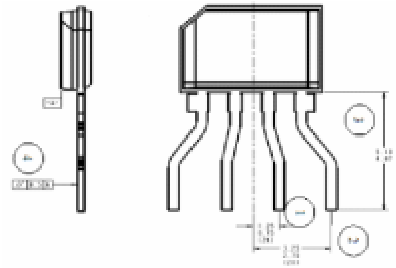
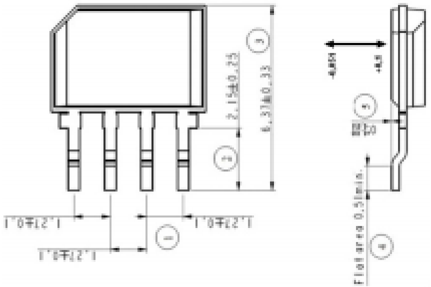
6. Melexis lead pre-forming options

Examples of lead pre-forming at Melexis







Melexis offers popular lead forming options as a back-end process delivering the parts formed in embossed tape.

Please contact Melexis for more details about the shapes available for a particular application

Appendix I: Standards addressed in the document

IEC 60286-2:

Packaging Of Components For Automatic Handling -
Part 2:
Tape Packaging Of Components With Unidirectional Leads On Continuous Tapes

IEC-60068-2-21:

Environmental Testing –
Part 2-21:
Tests - Test U: Robustness of terminations and integral mounting devices

ANSI/ESD S20.20:

For the Development of an Electrostatic Discharge Control Program for –
Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

AEC-Q100:

Failure Mechanism Based Stress Test Qualification for Integrated Circuits

Appendix II: Acronyms used in the document

SIP: Single-in-Line Plastic

PCB: Printed Circuit Board

ESD: Electrostatic Discharge

IC: Integrated Circuit

POD: Package Outline Drawing

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