TAIWAN SEMICONDUCTOR

AN-1005

Mounting and lead forming instructions for TO220 package

Content

1. Introduction

1.1 Purpose

The objective in this document is to discuss the mounting and lead forming for TO-220 package, and provide user the guideline for appropriate handling.

1.2 Scope

The document describes the mounting considerations that contain screw torque mounting methods, lead forming process and soldering recommendation value in the application.

2. The influence on mounting of To-220

2.1 Thermal resistance

The $R_{\theta JA}$ is junction to ambient thermal resistance and it consists of many thermal resistances. The relationship between them is shown as following:

$R_{\theta JA} = R_{\theta JC} + R_{\theta CH} + R_{\theta H} + R_{\theta HA}$

$R_{\theta JC}$: Junction-Case thermal resistance

$R_{\theta CH}$: Case-Heatsink thermal resistance

$R_{\theta H}$: Heatsink thermal resistance

$R_{\theta HA}$: Heatsink-Ambient resistance

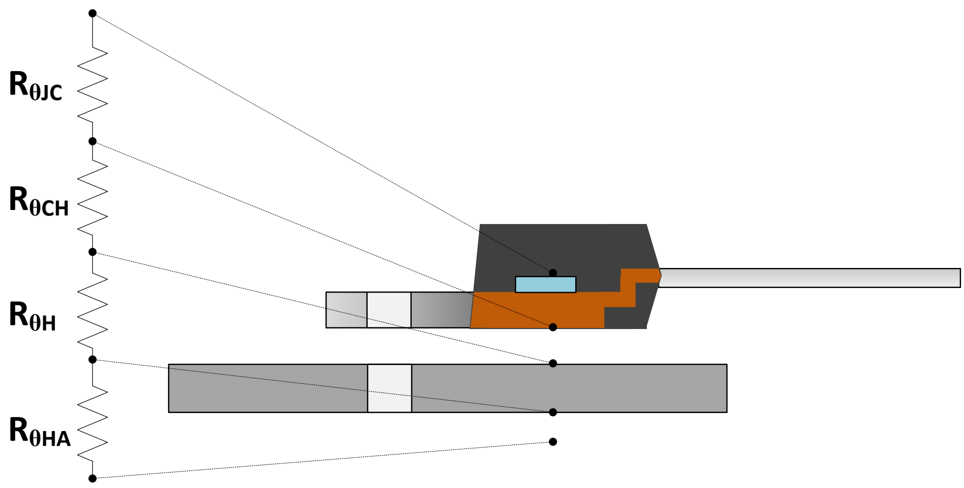


Fig 1. Thermal resistance structure

The contact surface between device and heatsink significantly affect thermal performance. The bad contact can cause air gap between them and thermal resistance can be increased. When the device's heat cannot be effectively transferred to heatsink, it might cause excessive heat to damage the device.

Hence, the mounting torque is importance in application. If the torque is too low, the thermal resistance can be increased due to it doesn't provide enough contact pressure. If the torque is too high, the pressure may cause product deformation and it is not helpful to reduce thermal resistance.

Furthermore, the heatsink flatness should be considered. The bumpy or unclear heatsink can result in uneven contact surface and the air gap between them that can increase the thermal resistance.

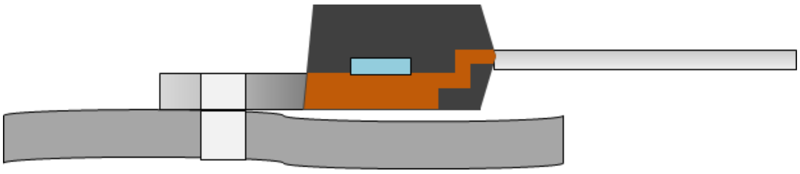
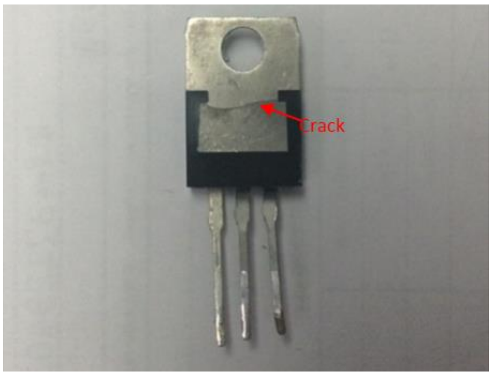


Fig 2. Uneven contact surface

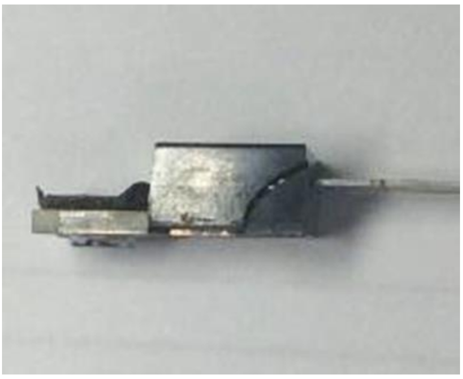
2.2 Mechanical stress failure

The improper mounting process or uneven contact surface can cause external mechanical stress on device. The high mechanical stress may cause some issue on the device, such as die crack, package crack and inner delamination. The following examples are failure samples for unsuitable mounting process.

For this case, the serious crack can be observed on package by visual inspection. The failure is due to the excessive stress on device.



(a) Back side of lead frame crack



(b) Mold compound crack

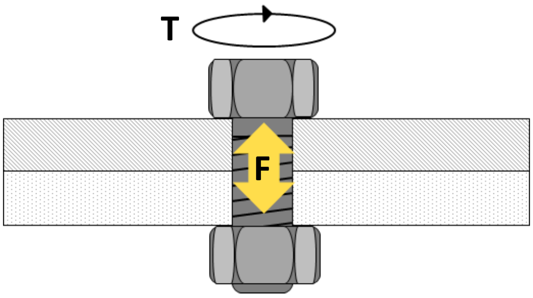
Fig 3. Package crack

The other case, the device's electrical characters test data are abnormal. After de-cap it, the finding indicate that the die has some cracks. According to die crack direction analysis, the failure is the result of improper screw mounting process.

Fig 4. Die crack

3. Screw Mounting

When two objects are fastened together using a nut and a screw, it can create the axial tension. The axial tension is also called tightening force that is difficult to measure. In general, the torque control is applied for screw fastening and can be carried out easily. The relationship between torque and axial tension is given by following formula. The different thread or size of screw can influence the tightening force. It needs to refer to the screw datasheet to estimate the clamp force.



T : Torque
K : Torque coefficient
d : Normal size of screw
F : Axial tension

$$T = \mathrm{K} \cdot \mathrm{d} \cdot \mathrm{F}$$

Fig 5. The relationship between torque and axial tension

Screw mounting is a traditional assembly method accomplished with fastening a screw, nut and washer. As mentioned in the previous section, it needs to provide appropriate torque to minimize thermal resistance and avoid excessive mounting torque to damage the device.

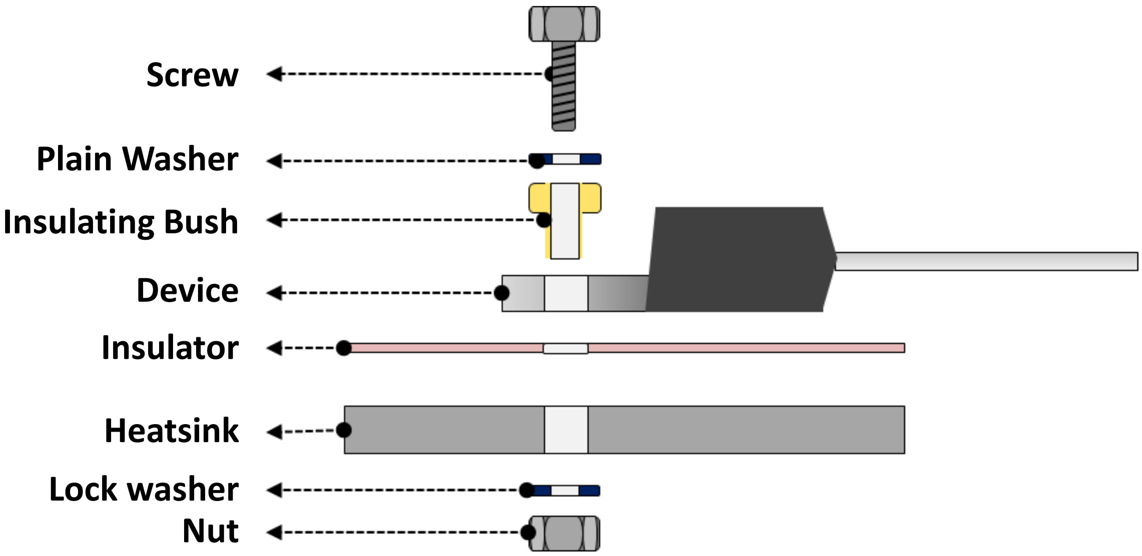


Fig 6. Screw mounting of TO-220

The following lists are recommendations for mounting process:

- The mounting torque is recommended to be 0.9Nm (for M3 pitch 0.5mm)
- Self-tapping screws should not be used.
- The metallic washer between the screw head and the device tab is recommended to reduce the stress.
- Device attach to the heatsink before soldering in order to avoid shearing stress to damage the die during fastening

4. Lead processes

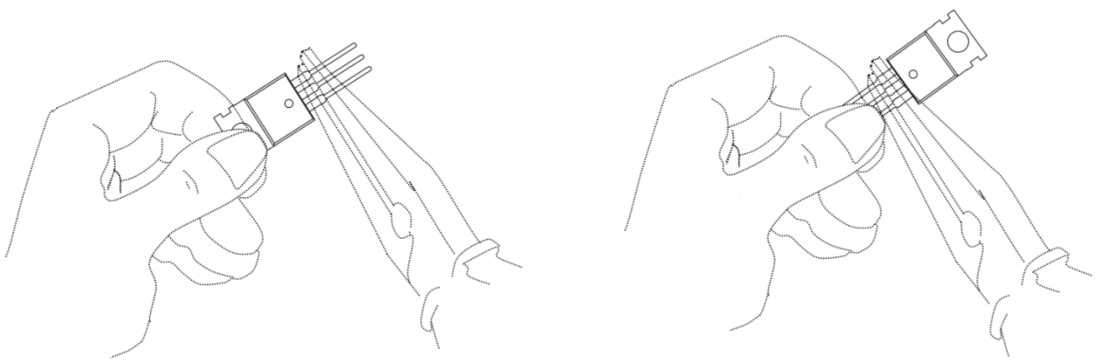
4.1 Lead cutting

The TO-220 lead can be cut before mounting or after mounting and soldering. When cutting after soldering, the harsh mechanical mishandling during cutting that could cause external stress to damage solder joint, but generally does not harm component body. When cutting before mounting, the leads have to be fixed firmly by a clamp (see Fig 8).

4.2 Lead bending

Improper bending or lead forming can cause many problem, such as the die damage , the internal connection delamination or micro cracking on the solder plating of leads to expose the copper. In order to prevent those problems, the lead forming guideline is provided as following:

- Leads must be formed before mounting on a PCB or a heatsink.
- For manual lead bending, an un-tapered snipe-nose plier is recommended for fixture; see Fig 7.
- Clamp the leads firmly between the package body and the bend point. This way can relieve tensile stress during bending process and prevent component body damage; see Fig 8.
- TO-220 package show a wider leads near the package body. Only narrow section of the leads can be bent; see Fig 8.
- Bend radius should not less than the thickness of the lead; see Fig 8.
- The leads should not be bent at an angle of more than 90°; see Fig 8.
- Do not bend the leads laterally; see Fig 9(a).
- Do not bend directly at the edge of the package; see Fig 9(b).



(a) Correct method (b) wrong method

Fig 7. Manual lead bending

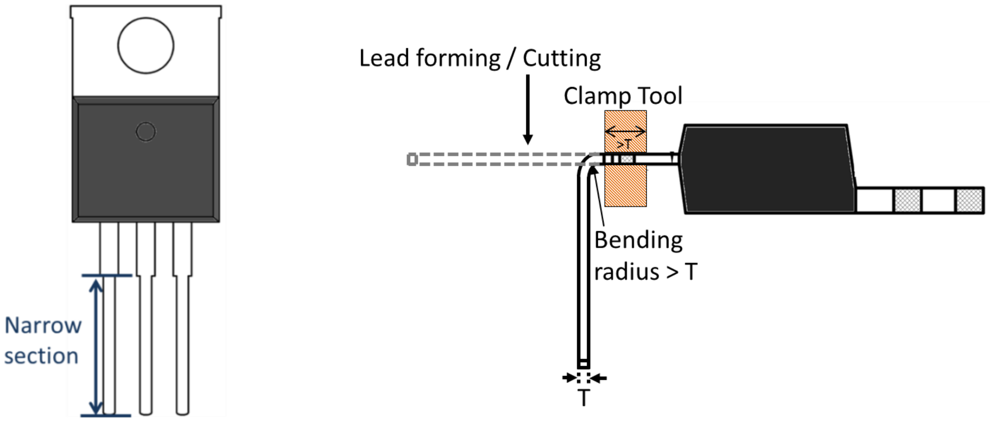
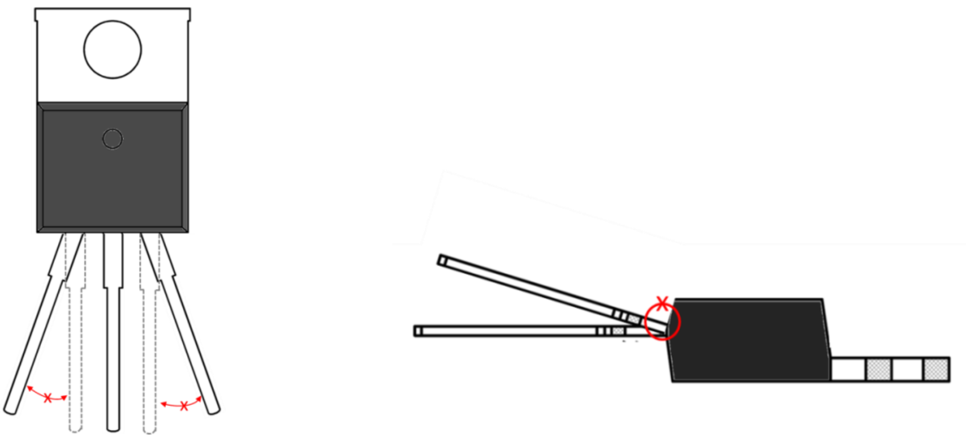


Fig 8. Lead forming and cutting



(a) Bend the leads laterally. (b) Bend directly at the edge of the package.

Fig 9. Incorrect lead bending methods

5. Soldering

Wave soldering is reliable method for assembly that is typically used for soldering through-hole component. Dual wave soldering is common method for wave-soldering (see Fig. 10). The durations, ramp rates and max temperature are depended on the materials and the soldering equipment. According to JESD22-B106 definition for the heat resistance of solder wave. The recommended max value is 260°C, the sum of first and second wave should be less than 10s [1].

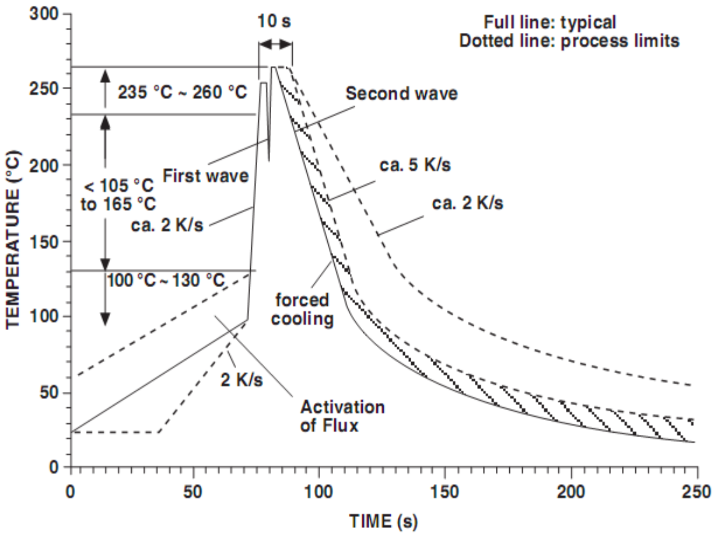


Fig.10 Dual wave Solder profile

Reference

[1] JEDEC Solid State Technology Association: JESD22-B106. "Resistance to Solder Shock for Through-Hole Mounted Devices.", 2005.

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