FINELINE

The Global PCB Experts

Bow and Twist of PCBs - Causes and measures for prevention

Contents

Introduction

General information

- Bow or twist in a PCB can lead to serious problems, especially during assembly of the PCB. Problems that arise as a result include issues during the soldering process, testing of the PCB and mechanical problems when mounting the finished assembly.
- This presentation details how to minimise bow and twist in a PCB.

Definition and acceptance specifications (IPC-A-600G)

Flatness of printed circuit boards is determined by two characteristics of the product; these are known as bow and twist. The bow condition is characterised by a roughly cylindrical or spherical curvature of the board while its four corners are in the same plane.

Twist is the board deformation parallel to the diagonal of the board such that one corner is not in the same plane to the other three. Circular or elliptical boards must be evaluated at the highest point of vertical displacement. Bow and twist may be influenced by the board design as different circuit configurations or layer construction of multilayer printed boards can result in different stress or stress relief conditions. Board thickness and material properties are other factors that influence the resulting board flatness.

Bow and Twist - Bow, twist, or any combination thereof, **shall** be determined by physical measurement and percentage calculation in accordance with IPC-TM-650 – 2.4.22 Bow and Twist. Panels containing multiple boards that are assembled in panel form and later separated **shall** be assessed in panel form.

Acceptance criteria

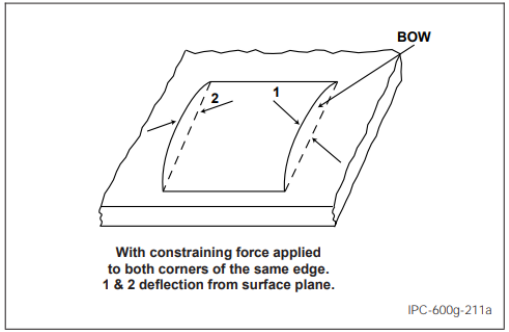
Acceptable – Class 1, 2, 3
For printed boards using surface mount components, the bow and twist **shall** be 0.75% or less.
For all other boards, bow and twist **shall** be 1.5% or less.

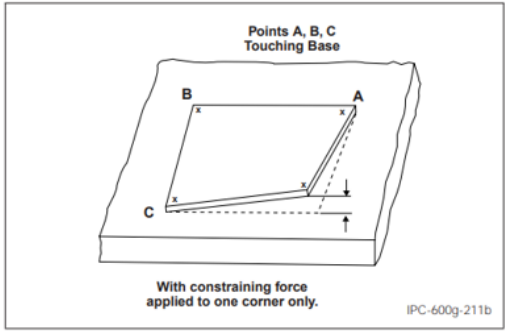
Nonconforming – Class 1,2,3
Deflects either do not meet or exceed above criteria.

Definition of Bow and Twist

- Bow is said to occur when all 4 corners of the PCB are on one plane and the PCB nevertheless exhibits bending in the longitudinal or transverse direction (also possible in both directions simultaneously).

- Twist is the condition when 3 corners of the PCB are on the same plane and the 4th corner lifts out of this plane via the diagonal.





IPC Guidelines

IPC guidelines with content on the topic

- **IPC-A-600:** Acceptability of Printed Boards
- **IPC-A-610:** Acceptability of Electronic Assemblies
- **IPC-2221:** Generic Standard on Printed Board Design
- **IPC-2222:** Sectional Design Standard for Rigid Organic Printed Boards
- **IPC -2223:** Sectional Design Standard for Flexible/Rigid-Flexible Printed Boards
- **IPC-4101:** Specification for Base Materials for Rigid and Multilayer Printed Boards
- **IPC-TM-650:** Test Methods
- **IPC-6012**: Qualification and Performance Specification for Rigid Printed Boards

Causes of Bow and Twist

Causes of Bow and Twist

- Uneven copper distribution in the layers
- Non-symmetrical layer stack up
- Thermal and mechanical stresses in the manufacturing process
- Different coefficients of expansion of the materials
- Non-symmetrical blind and buried vias
- Poor component placement
- Press-Fit components
- Incorrect storage (PCBs not laid flat)

Measures to Minimise Bow and Twist

Measures to minimise Bow and Twist

- Uniform homogeneous copper distribution
- Symmetrical layer stack up
- IPC standards already taken into account during layout creation
- Compliance with packaging regulations
- Proper storage of the boards
- Panel design

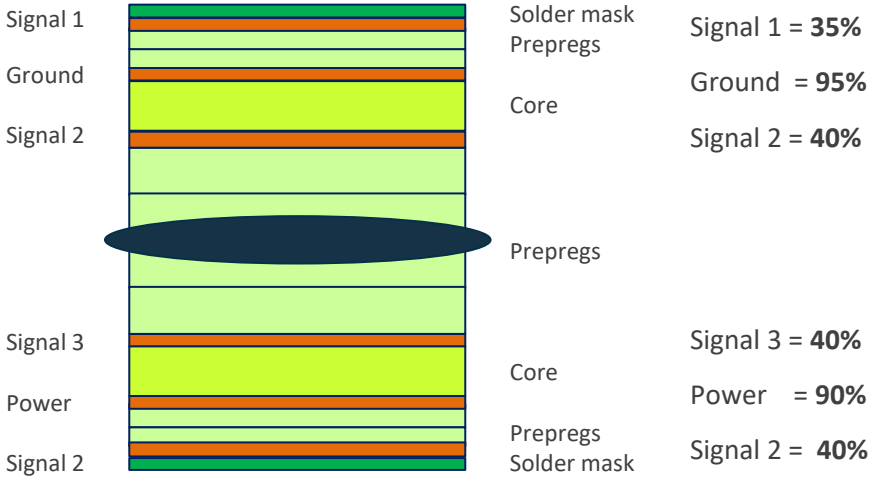
Copper Distribution

- Take care to distribute your traces as evenly as possible over the board to avoid "copper nests". This applies both within a layer and opposite an imaginary symmetrical axis (also referred to as the “neutral axis”) between two or more layers.

- If ground planes are required, these should be compensated for on the symmetrically opposite layer by filling them with copper. In this case, the free areas are filled with copper. These now form a counterweight to the copper of the opposite layer (corresponding layer inside the stack up)

Homogeneous copper distribution

Example 6 layers board:

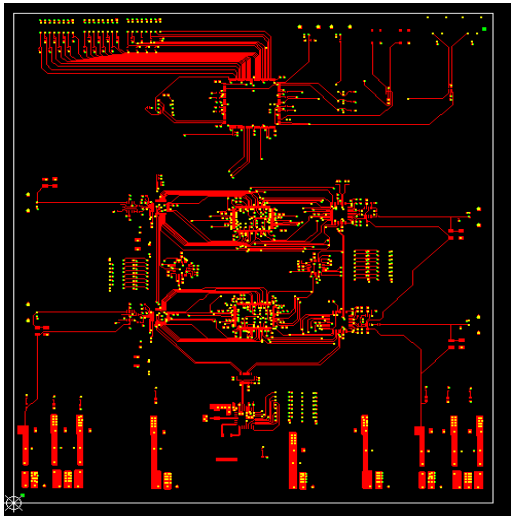


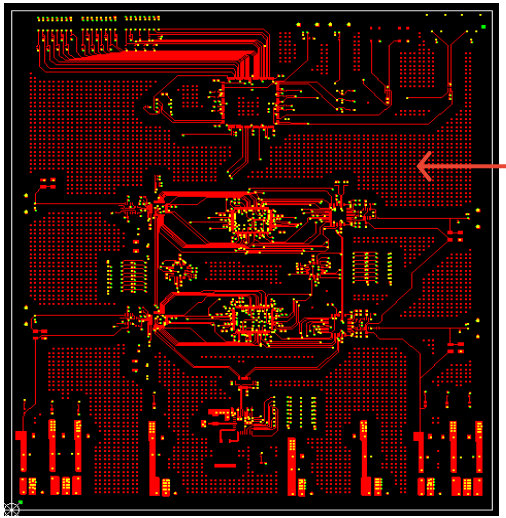
The values given here indicate the % of copper retained on the respective layers after the etching and electroplating process of the respective layers.

Copper Thieving – Plated Layers

- If the copper distribution in the layout is uneven, areas with little exposed copper will be plated thicker, while areas with large amounts of copper, such as BGA pad fields, will be thinner plated during the galvanic copper plate process.

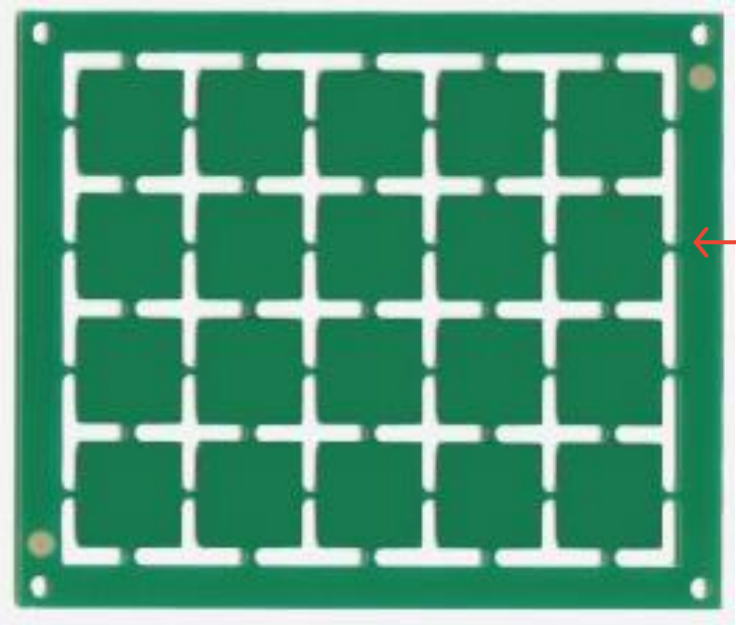
"Copper Balance" within a layer





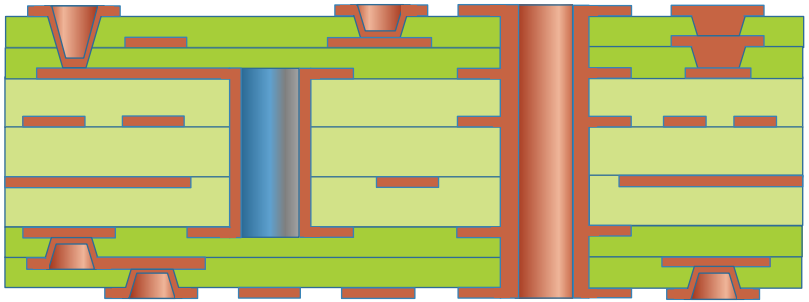
Typical Thieving Pattern
1.27mm Square
1.00mm Spacing

Panel Waste Areas



On waste areas copper should be on all layers. Generally, if it is not specified in the provided customer data, the manufacturer may adopt grid, pads or full copper depending on design and manufacturing preferences

Blind and Buried Vias



- Bow and twist can be also be caused by non-symmetrical blind and/or buried vias
- For laser stacked or staggered non-symmetrical vias (copper filled during the plating process) the effect is negligible
- For non-symmetrical buried vias over several layers this effect can be significant due to non-symmetrical lamination processes

Post-processing options

- Internal stresses of the PCB can be minimised by controlled heating/cooling of the PCB’s prior to assembly.
- This process is mantadory for flex- and rigid-flex boards

Conclusion

Conclusion

It should be noted that a 100% flat PCB / assembly cannot be guaranteed, either by the PCB manufacturer or the PCB assembler. The multitude of different influencing factors that contribute to the occurrence of stresses in the PCB / assembly cannot be completely eliminated. However as has been shown, a targeted and collaborative approach will minimize the influencing factors for torsion / warpage, improving the quality and process reliability of the PCB / PCBA through to the finished product.

Contact

Thomas Wernsdörfer

Fine Line Gesellschaft für
Leiterplattentechnik mbH

Itterpark 4

40724 Hilden

Fon: +49 2103 908540

Fax: +49 2103 9085420

Info-germany@fineline-gobal.com

www.fineline-global.com

Qta-contact:
Fon: +49 2103 908540-46
Patrick.Krohn@fineline-gobal.Com

Npi-contact:
Fon: +49 2103 908540-37
Patrick.Caruso@fineline-gobal.Com

Pcb-design-contact:
Fon: +31 (6) 4624 5007
huub.Speetjens@fineline-gobal.Com

Thank you

FINELINE

The Global PCB Experts

Thomas Wernsdörfer | Thomas.wernsdorfer@fineline-global.com