Thermal Load Boards Improve Product Development Process

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TEA

Contents

- Common Electronic System Industry Problems
- TLB Definition
- TLB Requirements
- TLB Design Considerations
- X, Y, Z Dimensions
- Simulation Heat Source Alternatives
- Directing Heat Flow
- Copper Content
- Electrical Connection
- Measurement Issues
- TLB Examples
- Summary

Major Electronic System Industry Issues

- How can electronic system development costs be reduced?
- How can electronic system operational and reliability performance be improved?
- How can the time-to-market be reduced?

Major Electronic System Industry Issues

The usual answer to these questions is –

USE SIMULATION SOFTWARE.

However, use of simulation software without validation usually leads to problems.

This leads to the need for a new thermal management design tool –

The **Thermal Load Board**

What is a Thermal Load Board?

- A “form and fit” replacement that thermally simulates the application printed circuit assembly (PCA)
- It can be inserted into the system enclosure and be powered up to simulate actual heat source loading.
- Its circuitry is relatively simple and does not require complex power sources
- It can be used for steady state and transient investigations
- It can be developed long before the final chip(s) are available and/or the electronic circuitry design is done

TLB Requirements

- It must match the application PCA in X, Y, & Z dimensions
- Heat source placement and size should closely match that of actual heat sources
- It must have the same mounting holes, component cutouts, etc.
- TLB pcb should have the same equivalent copper content
- Complexity determined by the thermal management design objective

TLB Design Considerations

1. The X-Y dimensions
2. The Z dimension
3. The component heat generation
4. Heat transfer into the printed circuit board
5. Heat transfer into the potential thermal management solution
6. Heat simulation dynamic range

TLB Design Considerations

X, Y, Z Dimensions

- TLB pcb must match dimensions and be capable of same system mounting configuration as application PCA
- Heat Sources must match X & Y dimensions of PCA heat generation sources to approximate the same heat flux density
- Heat Source must match Z dimension if mating to a thermal management solution
- Heat Sources must be in the same spatial location as the PCA heat generators

TLB Design Considerations

Heat Source Simulation Alternatives

- **Metal Film Chip Resistors**
  - Available in multiple sizes
  - Relatively inexpensive
  - Limited power dissipation capability
  - Most of power goes into the board if mounted directly to board
- **Metal foil heaters**
  - Useful alternatives but are more difficult to implement
  - X-Y dimensions are limited
  - Z dimensions are usually very small
  - Power density issues
  - Purchase availability
- **Rectifier Diodes**
  - PN or Schottky junction type in a surface mount package
  - Best driven by a current source
  - Heat transfer & dynamic range issues are similar to those for the chip resistors

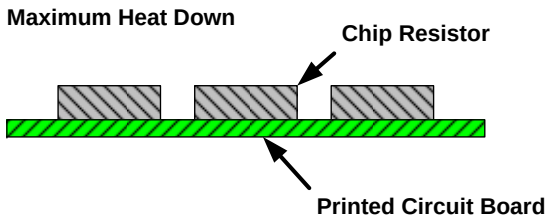
TLB Design Considerations

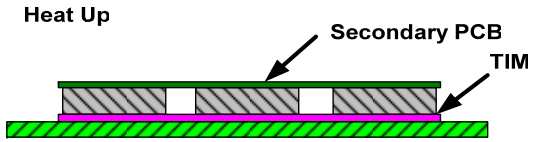
Heat Source Simulation Alternatives continued

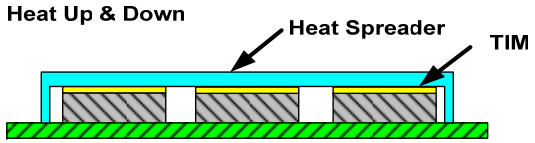
- **MOSFET and Bipolar Transistors**
  - Can generate large amounts heat in a small package and
  - Can be attached to a pcb copper pad to maximize power into the board
  - Can be mounted upside down on pcb to minimize power into the board
  - Electrical circuitry for driving these 3-terminal devices is complex
- **TTVs (Thermal Test Vehicles)**
  - Thermal test chips (TTCs) mounted in packages.
  - TTVs do not always exist and are usually difficult to get.
  - Usually supplied by chip manufacturers but now available from third-party sources

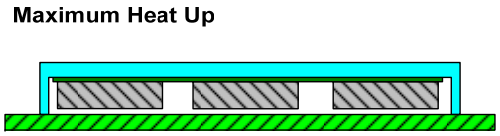
TLB Design Considerations

Directing Heat Flow

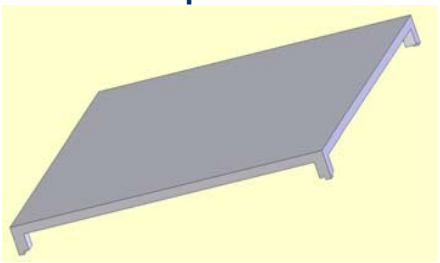




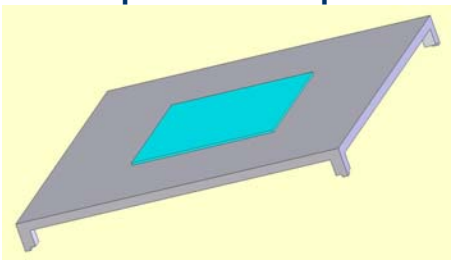




Heat Spreader



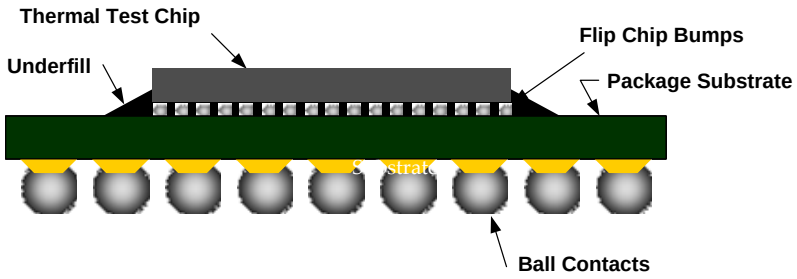
Heat Spreader with pedestal

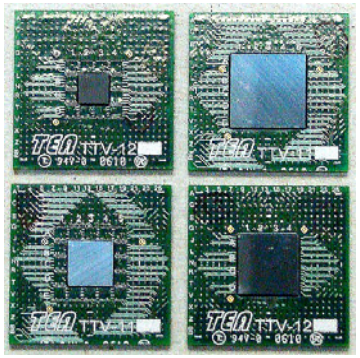


TLB Design Considerations

Directing Heat Flow (continued)

Packaged Thermal Test Chip ➔ TTV





TLB Design Considerations

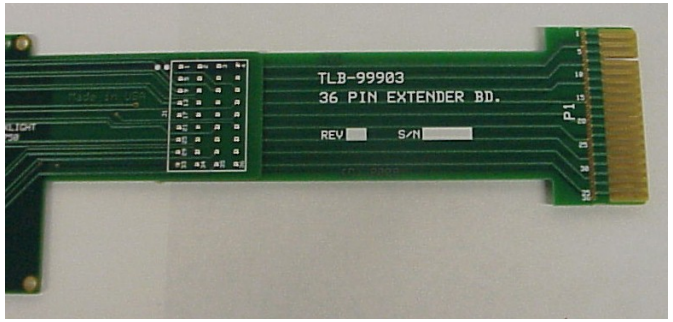
Copper Content

- Most system-level PCAs have multi-layer (4 to >16) internal copper planes
- TLBs with large number of internal copper planes are expensive and not usually necessary
- Construct a TLB top, bottom and 2 internal plane copper equivalent to PCA's layer coverage and copper thickness
- Include specific thermal vias as required

TLB Design Considerations

Electrical Connection

- **Flying Leads**
  - Soldered to the TLB on one end and bare or connector on other end
  - High Power
- **Edge Finger**
  - Double sided, multi-finger to mate with connector
  - Medium Power
- **Socket**
  - Boxed Header with ribbon cable
  - Low Power



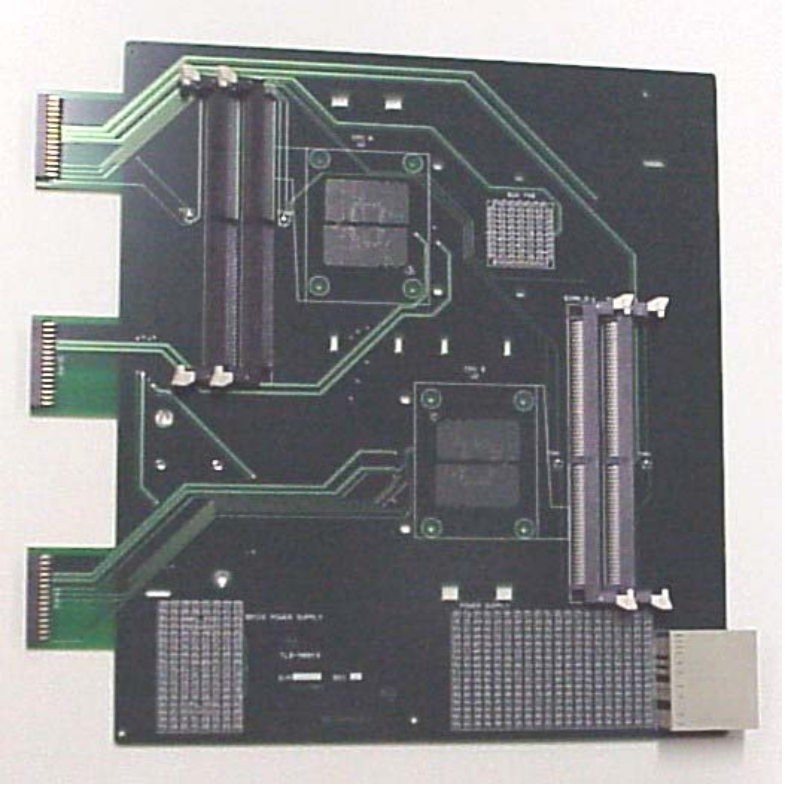
TLB Design Considerations

Measurement Issues

- **Kelvin connection for power measurement**
  - **Important for hi-power dissipations**
- **Junction Temperature Measurement**
  - **Possible with TTVs or application ICs**
- **Board Temperature Measurement**
  - **Usually thermistor in SMT chip form for pcb mounting**
  - **Thermocouple for IC or component measurement**
- **Air Flow Measurement**
  - **Possible for low-lying flow measurement**

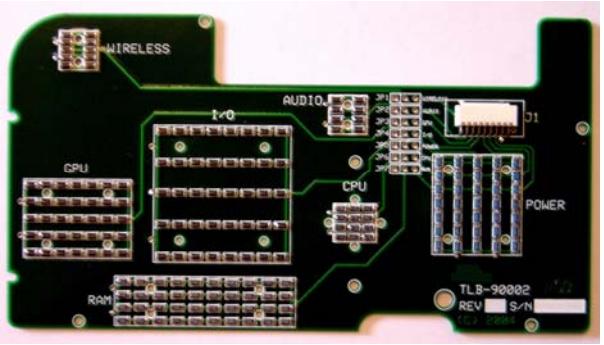
TLB Design Examples

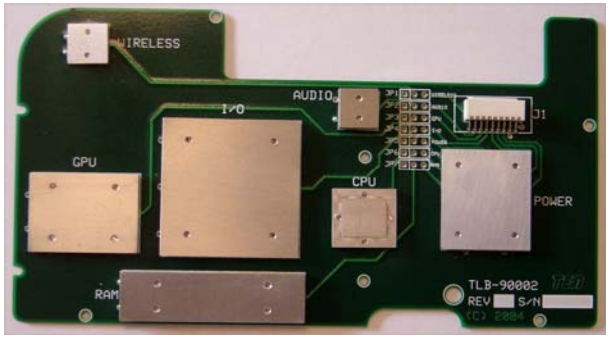
Blade Sever



TLB Design Examples

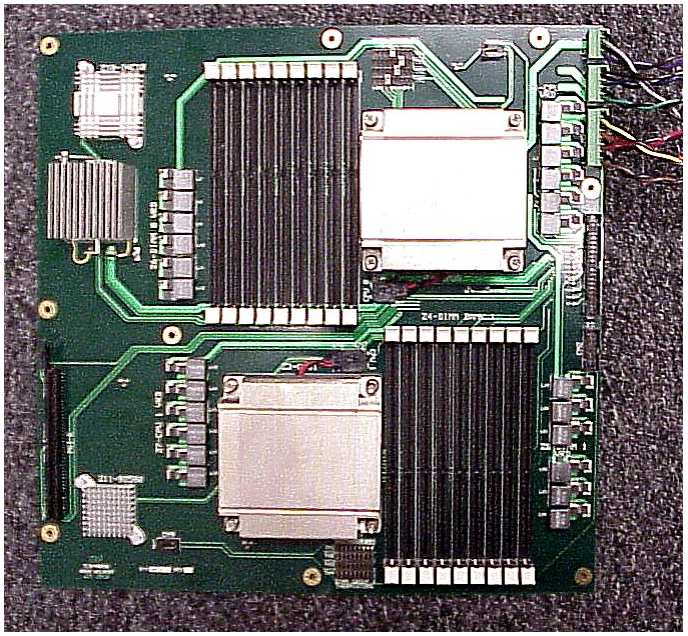
Heat Spreaders





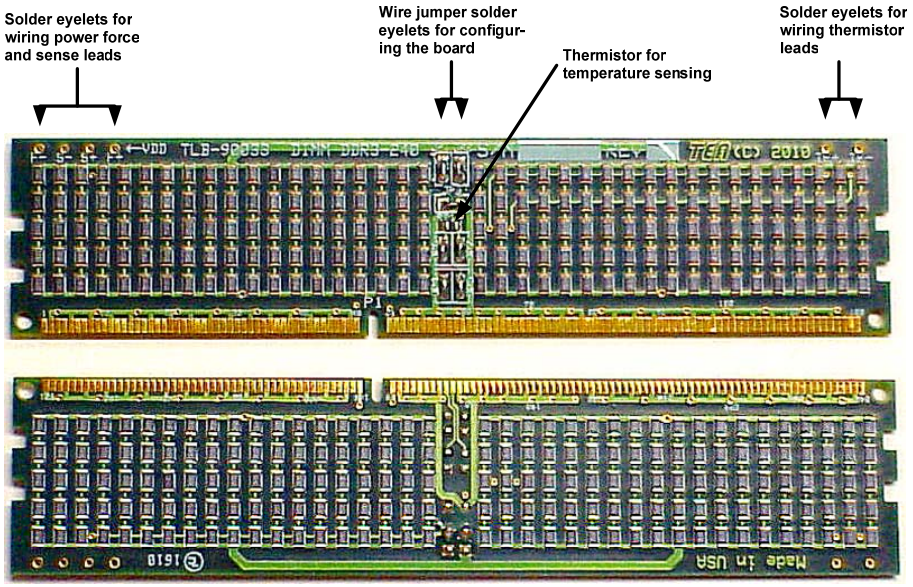
TLB Design Examples

HiPwr Dual CPU Server



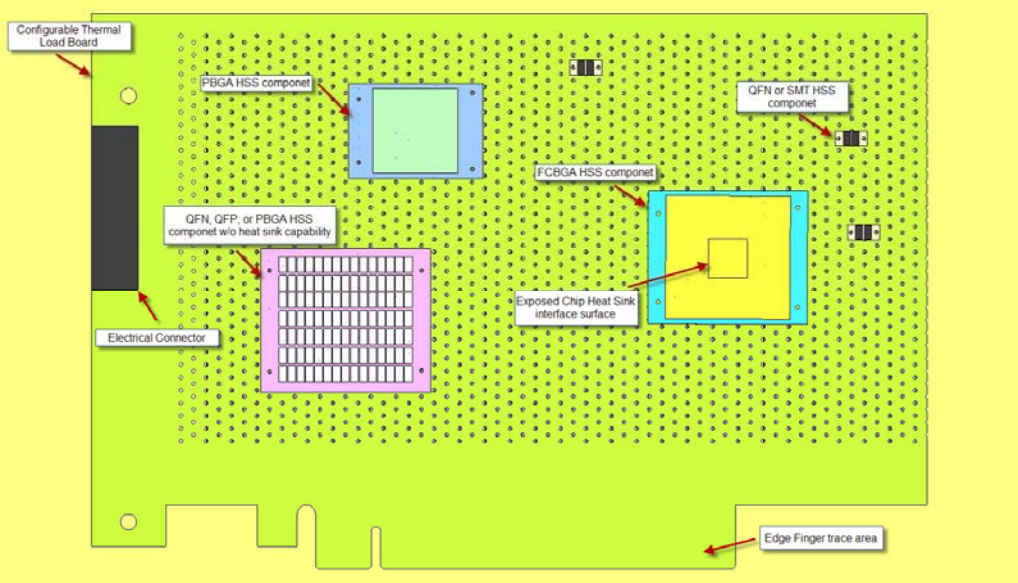
TLB Design Examples

DDR3 DIMM Heat Source Simulator



TLB Design Examples

User-Configurable TLB (Short PCI-e)



Summary

- Electronic system development cost, operational and reliability performance, “green” considerations, and time-to-market requirements require greater thermal management design efficiencies.
- Increased use of simulation software for electronic system thermal modeling is a “must” for time-efficient and cost-efficient product development.
- Reliance on un-validated software models can be dangerous as thermal issues continue to grow in importance.
- TLB is a tool for confirming model predication and reducing design uncertainty.
- TLB can be designed, fabricated & put into use quickly & at moderate expense.
- The TLB’s low turnaround time and fabrication cost offers the potential of modeling and validating several different mechanical configurations while the electronic circuit and chip design is under development.