Backplane Assembly and Test Challenges

Dennis Willie

OCT 2012

AEG - WW Assembly & Test Technology
Backplane Assembly and Test Challenges

• Abstract
• Introduction and Background
• Backplane Complexity
  • PCB (LFF, Layers, Copper Thickness)
  • Backplane Types
• Assembly Process
  • Handling
  • SMT
  • Press Fit
  • PTH Soldering
• Testing Requirements
  • Equipment Method and Selection
• Challenges Summary
Abstract: Backplane Assembly and Test Challenges

While Backplane Assemblies remain simple in complexity, their large form factor PCB’s drive unique challenges for assembly and test processes.

Backplane assembly technologies incorporate mixed component forms ranging from surface mount devices, press fit connectors to through hole soldered devices. Backplane PCB’s have high PTH and layer counts using thick copper planes and have typically very large length and widths.

Equipment available to assemble and test these large form factor Backplane PCB’s becomes limited when exceeding 20” wide by 24” long and .240” thick. Ability to inspect and test the large form factor backplanes using AOI, X-Ray and Electrical test drive unique test equipment and high capital costs.

This presentation will highlight process, equipment and unique challenges experienced when building Backplane Assemblies.
Backplane Introduction and Background

• The Backplane is the main PCB of an Electronics Enclosure System
• Backplanes are critical to system functionality and have a non-zero risk of malfunction
• Used as a backbone to interconnect several PCBA’s together to make the system.
• Drives Fans, PCBA’s and Accessories
• Connects several connectors in parallel to each other
• Power Supplies plug into Backplane
• The Backplane distributes Power and Ground throughout Chassis
• PCA’s are typically hot swappable for continuous operation
• System redundancy critical to prevent system down time
• Backplanes are often described as being either active or passive
• Backplane PCB MFG and Assembly drives unique process and equipment needs.
Backplane Complexity Challenges

Applications:
• Telecom, Networking, Storage, Communications, Power Distribution

Attributes:
• PCB Size: 24” wide x 36” long (609x914mm)
• High layer Counts: 10-50+ Layers
• Thickness: .093”-.425” (~2– 11mm)
• Weight: 10lbs+ (5Kg+)
• High Speed PCB Laminate & Connectors
• Conductor Etched Features: 4mil lines / spaces
• Finish: ImAg, ImSn, ENIG, SnPb, OSP
• PF Drill Size: down to .012” (.3mm)
• PF FHS: down to .008” (.2mm)
• Back Drilling: 3 – levels
• Aspect Ratio: ~ 15:1+
• Press Fit Connectors
• SMD’s (Surface Mounted Devices)
• PTH Solder (Through Hole Devices)
• Mechanicals (Buss Bars, Guide Pins, Nuts, Bolts….)
• Optical Connectors and Waveguides
Backplane Types

Backplanes
- Backplane or Midplane
- Active or Passive
  - Active BPA’s: SMD’s (0201, QFN, BGA, CNN’s....)
- High Speed PCB Laminate
- High Speed Press Fit Connectors
- Mechanical Hardware
Handling Equipment and Methods

Challenges

• Backplanes are large heavy PCB’s
• Employee Ergonomics due to size and weights
• Custom Oversized Conveyers, Racks & Totes
• Unique Support Fixtures, Pallets, Jigs
• Large Trays and Vertical Carts

Custom Fixture and Vertical Jig

Custom Carts with Vertical Racks
SMT Process Challenges – Equipment Capability

Paste Print, SMD Placement and Reflow Equipment Challenges:

- **Print and Place**
  - PCB length, width, thickness and weight capable
    - 24” wide x 36” long x .5” thick x 15kg
  - PCB to Stencil Alignment: PCB shrinkage (variable by lot)
  - Component Heights (SMD height limits, other parts….)

- **Thermal Reflow Convection**
  - Thermal Profiling – PCB/PKG Thermal Density & Long PCB
  - 10 Heat Zone with Cooling Section
Press Fit Connector Density Challenges

Key Connector Density Roadmap & Challenges:

- Smaller - Shorter Compliant Press Fit Pins
- Lower Pin insertion / retention forces
- Smaller pitch spacing
- Smaller PTH FHS
- Higher Pins qty. per inch/cm
- Higher speeds
- Higher Power Options

---

<table>
<thead>
<tr>
<th>Press Fit Connector Roadmap</th>
<th>2013</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electrical - Mechanical Features</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Differential pairs / inch (Backplane Press Fit Connectors)</td>
<td>&gt;50 dpin</td>
<td>&gt;70 dpin</td>
</tr>
<tr>
<td># of Differential pairs / inch (Mezzanine Press Fit Connectors)</td>
<td>&gt;60 dpin</td>
<td>&gt;80 dpin</td>
</tr>
<tr>
<td>Press Fit Connector Data Rates</td>
<td>&gt;10 Gbps</td>
<td>10-25 Gbps</td>
</tr>
<tr>
<td># Compliant Pins (max. # of pins per one piece connector)</td>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>PTH Diameter (Min. Finished Hole Size)</td>
<td>.012” (.3mm)</td>
<td>.008” (.2mm)</td>
</tr>
<tr>
<td>PTH Tolerance Diameter (Min. Finished Hole Size Tolerance)</td>
<td>+.002” (.05mm)</td>
<td>+.0015” (.038mm)</td>
</tr>
<tr>
<td>Pin to Pin Pitch (Min.)</td>
<td>.043” (.11mm)</td>
<td>.040” (.1mm)</td>
</tr>
<tr>
<td>Column to Column Spacing (Min.)</td>
<td>.071” (.18mm)</td>
<td>.060” (.1mm)</td>
</tr>
<tr>
<td>Compliant Pin Tail Length (Min.)</td>
<td>.060” (.152mm)</td>
<td>&gt;.060” (.15mm) - .040” (.1mm)</td>
</tr>
<tr>
<td>Compliant Pin Max Power Rating (Amps / Contact)</td>
<td>110 amps</td>
<td>125</td>
</tr>
<tr>
<td>Compliant Pin Max Power Rating (Amps / Inch)</td>
<td>390 amps</td>
<td>400</td>
</tr>
<tr>
<td>RoHS Compliant Press Fit Sections Coating</td>
<td>SnPb, Sn with Ni underplate</td>
<td>SnPb, Sn, Ni Plate, Ni Undercoat, Nano Coating,…</td>
</tr>
<tr>
<td>Press Fit Pin Coating Types</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Press Fit Compliant Pins in Same Hole (Front and Back Load)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interconnect with Embedded Capacitance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Press Fit Equipment

Press Equipment Selection

- Arbor, Electric, Hydraulic or Pneumatic
- Manual or Automated Control
- Computer Controlled
- SPC Data Collection

Challenge

- PCB Form Factor
- Press Head Location Control & Precision
- Force Application Control
- Maintenance

Pneumatic Press

Hydraulic Press

Arbor Press

Electric Press Types
Press Fit Connector Installation Process

Condition:
• Backplanes have large quantity of press fit connectors. ~200+ locations
• Long cycle times to manually pick, place and press each connector

Challenge:
• How to Reduce Cycle Time and optimize connector press process.

Solution:
• Design Tools/Process to press multiple connectors with single tool and stroke

Before
Pressing was done one by one. Total 38 press causing long cycle time 13mins.

After
Gang press which 3 connectors can be pressed at the same time. Reduced CT to 6.7mins. Saved Cycle Time by 48.5%
Press Fit Connector Tooling

**Condition:**
- Press Fit Seating Tools
  - OEM or CM Local Tool?
    - Precision and durability

**Challenge:**
- High Cost
- Availability
- Lead Time
- Precision
Press Fit - Bent Connector Pins

**Condition:**
- Bent Connector Pin
  - Above & Below Base

**Challenge:**
- Difficult to Detect
- Best Detection Method?
Press Fit CNN Pin Tip True Position Measurements

- **Objective:**
  - Verify Pin Alignment (Pin Post and Tail)
  - Bent Pin Detection Prior to Connector Insertion

- **Challenges:**
  - Pin Tip True Position Definition, Measurement Methodology & Acceptance Criteria
  - Different Datum Points based on MFR:
    - 1). Off A1 pin location
    - 2). off Housing Key
    - 3). Off Connector Body centroid?
  - Optical Measurement System or Mechanical Go-No Go gages

- **Goal:**
  - Common True Position Criteria defined specifically for Connector grids
  - State of the art and standardization of measurement methods.

Example of AOI Scan Result
Bent Connector Pin Detection Method

• **Condition:**
  • Connector Bent Pin Inspection & Detection Methodology

• **Challenge:**
  • Which is the Best method for Bent Pin Detection?
    • Visual Inspection
    • AOI (Automated Optical Inspection)
    • X-Ray
    • 3D Scan
Bent Connector Pin Detection Method

- **Condition:**
  - Visual Inspection

- **Challenge:**
  - Best Detection Method…?
  - Human Dependent
    - Experience
    - Fatigue
  - Pin features are smaller / finite
Bent Connector Pin Detection Method

**Condition:**
- AOI (Automated Optical Inspection)

**Challenge:**
- Best Detection Method…?
- Unable to see bent pin under connector housing base
- Pin Tip True Position Requirements
- Acceptability Criteria
- Ability to see Pin Tail from bottom side
- Platform Size
- Equipment Availability - Large Form Factors
Bent Connector Pin Detection Method

- **Method:**
  - X-Ray

- **Challenges:**
  - Best Detection Method?
  - Mating Post Inspection
  - Excess metal within Connector body
  - Bent Pin Inspection Algorithm
  - High Cost Platform
Bent Connector Pin Detection Method

- **Method:**
  - 3D Optical Scan

- **Challenges:**
  - Best Detection Method?
  - New Emerging Method
  - Platform and Scanner Cost
**PTH Soldering Challenge**

**PTH Soldering – Vertical Hole Fill**

- Condition: Inability to achieve 100% vertical PTH solder fill

**Challenge:**
- Vertical Solder Flow in thick PCB
- Thermal interconnect density
- Copper Layer Count & Thickness
- Rework

**Actions:**
- Update Interconnect Design
- Equipment / Pre-Heat
Test / Inspection: Equipment Selection

- Electrical Test
  - Bed of Nails
  - High Node Count RQD
  - Expensive Fixturing

- Optical AOI
  - True Position Datum

- X-Ray
  - Programming
  - Need Detection Automation
Test / Inspection: Equipment Selection & Challenge

- Flying Probe / Test Head
  - Acceptance Criteria

- Impedance Testing

- 3D Scanning
  - New Method

3D Scanning

Model 603d

Confocal chromatic line sensor

Scan

Results: missing pin

Backplane assembly

Difference between measured and reference traces – falls within blue boundary so passes test

Measured trace – falls within boundaries so passes test

Reference trace from known good board
Challenges Summary

• Backplane is critical to system interconnection, performance and reliability
• PCB MFG Difficult
• Assembly of Large Form Factors
  • Unique Equipment needs
  • Equipment Solutions Limited
• SMT, Press Fit and Assembly Issues
• Test and Inspection Solutions
  • Electrical, AOI, X-Ray, Impedance, 3D
Thank you