Adapting Press-Fit Connection Technology for Electronic Modules in Harsh Environments.

By

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& Business Development - Interplex Engineered Products

HiTEN 2009 - Oxford
Introduction

- Interplex
- Press-fit basics
- Connections in HE
- Testing
- Approvals
- Module development
- Applications
Press fit basics ...

- Function of Press-Fit Technology
- Telecom to Automotive Adoption
- Core design types
  - 0.25mm, 0.64mm, 0.80mm
- Plating Types, & options
- Applications
Press fit technology ...

Solder Less Interconnect System to Printed Circuit Cards

Typical Male/Female Interconnect

Male Blade
Female Contact (Compliant)

Normal Force Applied by Female

Interconnection Force
*Grams*

Typical Press-Fit Male/Female Interconnect

Male Blade (Compliant)
Female PCB Hole

Normal Force Applied by Male

Interconnection Force
*Kilograms*
Press fit connections ........

Require:

- Complex Plastics
- Press fit Terminals
  - IDC
  - Eyelet
  - Tuning Fork
  - Clamp
- PCB Hole Construction Controls-------
- Application Knowledge
**Telecom**

Temp to 85 °C

Vibration – None

Retention Force- 8N

Rework – Yes

Plating- 2 to 3 Microns

Contact Resistance- 4.0mΩ Max

**Automotive**

Temp to 150 °C

Vibration- 12G-three Axis (In Temp)

Retention -20N to 40N

Rework - no

Plating- 0.4 to 1.2 Microns

Contact Resistance- 0.5mΩ Max
Press fit connections ...

Complex Press fit Stampings

Complex Plastic holders
Harsh Environment interconnections ...

- **Mechanical Requirements** - Kilograms
- **Temperature Requirements vs. Material Selections**
  - (125°C, 150°C, @ 175°C)
- **Electrical requirements**
  - Milliohm resistance (0.5MΩ)
  - Typical current requirements
    - per eye & thickness
    - Per Application Size
- **Application requirements**
  - Energy
  - Transport
- **Testing requirements**
  - resulting example data will shown in the Testing
- **PCB Constructions and Types**
  - Hole size, plating PCB copper
- **Applications Failure Modes** - (Printed Circuit Card)
Solderless Technology design to meet the Automotive/Transportation Requirements

Qualified to 125°C and 150°C Operational temperatures and moving to 175°C

Requirements defined by IEC, EIA and SAE.

Designs validated for both 0.64mm and 0.80mm thick press-fit sections - Other sizes being Introduced (.4mm, 1.0mm, 1.5mm)

High conductive material options - Power Applications 30%, 40% & 80% IACS

Compatible with Various PCB Plating Types
• **PCB hole sizes:**
  • 0.64mm & 0.80mm press-fit to fit into (Nominal) 1.016mm and 1.486mm respectively.

<table>
<thead>
<tr>
<th>REQUIRED PCB HOLE CONSTRUCTION</th>
<th>mm</th>
<th>in</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRILL</td>
<td>Ø1.151±.0.025</td>
<td>Ø.0453±.0010</td>
</tr>
<tr>
<td>COPPER THICKNESS</td>
<td>0.025 MIN</td>
<td>.0010 MIN</td>
</tr>
<tr>
<td>FINAL IMMERSION PLATED HOLE DIAMETER</td>
<td>Ø1.020±.0.076</td>
<td>Ø.0400±.0030</td>
</tr>
</tbody>
</table>

- PIN INSERTION FORCE: 100 N (22.5 lbf) MAXIMUM
- PIN RETENTION FORCE: 20 N (4.5 lbf) MINIMUM
- SEE 0.64 PRESS-FIT TEST REPORT SUMMARY FOR TYPICAL VALUES

• **PCB Types:**
  • Tg > 150 ° C
  • Plated Through Holes (PTH)- Single & Multilayer
  • PCB Platings: Tin, Silver, Gold, OSP
  • PCB Construction FR-4 1.57mm thick & up

• **Terminal Plating:** 1 Micron-Tin plating in Press-Fit Zone
Primary Drivers for Materials & Options:

Temperature • Conductivity • Bend Radius

.64mm Thick:
• 125 °C Primary Alloy: CuSn5 15% IACS
• 150 °C alloy: 7025 CuNiSi- 40% IACS
• Conductive Alloy: Special Brass:(CuZnSnNiFeP) 30% IACS

.80mm Thick:
• 125 °C Primary Alloy: Special Brass:(CuZnSnNiFeP) 30% IACS
• 150 °C alloy: 7025 CuNiSi – 40% IACS
• Conductive Alloy:(CuCrAgFeTiSi) 80% IACS
Tests criteria

Test sequence & requirements

Data and results
Test Criteria

- Insertion force and retention force
- Vibration in Temperature
- Thermal shock
- High temperature exposure
- Temperature and humidity cycling
- Mixed flowing 4 Gas test
- Current carrying capacity
- Plated through hole integrity

![Graph showing force and distance relationship](image)
- Contact Resistance: 5mΩ Max
- 20N retention for .64mm
- 60N retention for .80mm
- IEC–60352-5 Plated Through Hole Integrity
- No Visual Damage
Thermal requirements

• Materials and testing up to 150 °C
• Testing Continuing to 175 °C
• Random Vibration in Temperature - For Chassis mount

Cabin • Underhood • Near Engine • On Engine

<table>
<thead>
<tr>
<th>Temperature class</th>
<th>Temperature range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$T_{lo}$</td>
</tr>
<tr>
<td>1</td>
<td>-40 °C</td>
</tr>
<tr>
<td>2</td>
<td>-40 °C</td>
</tr>
<tr>
<td>3</td>
<td>-40 °C</td>
</tr>
<tr>
<td>4</td>
<td>-40 °C</td>
</tr>
</tbody>
</table>

SAE Temperature Classifications

<table>
<thead>
<tr>
<th>Class</th>
<th>Ambient Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-40° C to +85° C</td>
</tr>
<tr>
<td>2</td>
<td>-40° C to +100° C</td>
</tr>
<tr>
<td>3</td>
<td>-40° C to +125° C</td>
</tr>
<tr>
<td>4</td>
<td>-40° C to +150° C</td>
</tr>
<tr>
<td>5</td>
<td>-40° C to +175° C</td>
</tr>
</tbody>
</table>
Summary of Interplex 0.64mm Press-Fit IF/RF Testing –Sn PCB’s

0.64 PRESS-FIT
15% IACS PHOS-BRONZE
Sn PCB
Min PTH

N=174
N=72
N=72

Cpk=3.06

Cpk=3.13

Cpk=4.27

Cpk=3.85

Cpk=2.19

Cpk=1.96

0.64 PRESS-FIT
15% IACS PHOS-BRONZE
Sn PCB
Max PTH

N=174
N=72
N=72

Mean+3*SD
Mean-3*SD
Mean

Test Sequence
1) IF
2) RF 7-DAY
3) RF POST-ENVIRO

Newton's

Newton's

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Interplex Industries, Inc.
Global Solutions for Complex Parts and Assemblies
Summary of Interplex 0.64mm Press-Fit IF/RF Testing – Ag PCB’s

0.64 PRESS-FIT
15% IACS PHOS-BRONZE
Ag PCB
Min PTH
N=444 N=144 N=144

0.64 PRESS-FIT
15% IACS PHOS-BRONZE
Ag PCB
Max PTH
N=444 N=144 N=144

NEWTONS

Cpk=2.06
Cpk=1.83
Cpk=1.78

Cpk=2.29
Cpk=1.95
Cpk=1.35

1) IF 2) RF 7-DAY 3) RF POST-ENVIRO
TEST SEQUENCE

Mean+3’S.D
Mean-3’S.D

Mean
Summary of Interplex 0.80mm Press-Fit IF/RF Testing –Sn PCB’s
Summary of Interplex 0.80mm Press-Fit IF/RF Testing –Sn PCB’s

[Graph showing force (N) vs. distance (mm) for different scenarios: Press-in and Push-out for Ø1.35 PTH and Ø1.45 PTH.]
Summary of Interplex 0.80mm Press-Fit IF/RF Testing –Ag PCB’s

0.8 PRESS-FIT
30% IACS TIN-BRASS
Ag PCB
Min PTH
N=444

Cpk=0.32

Mean+3'SD
Mean-3'SD
Mean

N=144

Cpk=1.52

0.8 PRESS-FIT
30% IACS TIN-BRASS
Ag PCB
Max PTH
N=444

Cpk=2.86

Mean+3'SD
Mean-3'SD
Mean

N=144

Cpk=1.03

Cpk=0.70

NEWTONS

1) IF
2) RF 7-DAY
3) RF POST-ENVIRO

TEST SEQUENCE

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Testing Results Plated Through Hole Integrity
IEC-60352-5 Requirements

IF Verified

Contact Resistance Verified

X-Sections
Plated Through Hole Integrity
IEC-60352-5
Testing Results Plated Through Hole Integrity
IEC -60352-5 Requirements

Figure 8: Transverse and Longitudinal Cross-sectioning Measurement Locations

Horizontal

Vertical Single Layer

Vertical Four Layer

b= Plating Thickness

a= Drill Hole Contour Deformation

c= Trace Deformation

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0.64 mm Plated Through Hole Integrity

<table>
<thead>
<tr>
<th></th>
<th>Drill Hole Contour Deformation &quot;a&quot; [µm]</th>
<th>Remaining Plating Thickness &quot;b&quot; [µm]</th>
<th>Vertical Trace Deformation &quot;c&quot; [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PTH size</strong></td>
<td>Lower Limit</td>
<td>Upper Limit</td>
<td>Lower Limit</td>
</tr>
<tr>
<td>Maximum value</td>
<td>19.3</td>
<td>14.7</td>
<td>34.0</td>
</tr>
<tr>
<td>Mean value</td>
<td>9.9</td>
<td>7.1</td>
<td>37.6</td>
</tr>
<tr>
<td>Minimum value</td>
<td>3.3</td>
<td>1.5</td>
<td>21.5</td>
</tr>
<tr>
<td>Requirement</td>
<td>50.8 maximum</td>
<td>8.0 minimum</td>
<td>50.0 maximum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Drill Hole Contour Deformation &quot;a&quot; [µm]</th>
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<th>Vertical Trace Deformation &quot;c&quot; [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PTH size</strong></td>
<td>Lower Limit</td>
<td>Upper Limit</td>
<td>Lower Limit</td>
</tr>
<tr>
<td>Maximum value</td>
<td>31.8</td>
<td>30.2</td>
<td>58.4</td>
</tr>
<tr>
<td>Mean value</td>
<td>22.5</td>
<td>26.8</td>
<td>51.0</td>
</tr>
<tr>
<td>Minimum value</td>
<td>14.6</td>
<td>22.9</td>
<td>44.5</td>
</tr>
<tr>
<td>Requirement</td>
<td>50.8 maximum</td>
<td>8.0 minimum</td>
<td>50.0 maximum</td>
</tr>
</tbody>
</table>
## 0.80 mm Plated Through Hole Integrity

### Cross Section Dimensional Data in Immersion Silver

<table>
<thead>
<tr>
<th>PTH Size</th>
<th>Drill Hole Contour Deformation “a” (µm)</th>
<th>Remaining Plating Thickness “b” (µm)</th>
<th>Vertical Trace Deformation “c” (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower Limit</td>
<td>Upper Limit</td>
<td>Lower Limit</td>
</tr>
<tr>
<td>Maximum Value</td>
<td>28.6</td>
<td>27.8</td>
<td>45.7</td>
</tr>
<tr>
<td>Mean Value</td>
<td>20.3</td>
<td>14.9</td>
<td>33.4</td>
</tr>
<tr>
<td>Minimum Value</td>
<td>11.8</td>
<td>7.0</td>
<td>21.5</td>
</tr>
<tr>
<td>Requirement</td>
<td>50.8 Maximum</td>
<td>8.0 Minimum</td>
<td>50.0 Maximum</td>
</tr>
</tbody>
</table>

### Cross Section Dimensional Data in Immersion Tin

<table>
<thead>
<tr>
<th>PTH Size</th>
<th>Drill Hole Contour Deformation “a” (µm)</th>
<th>Remaining Plating Thickness “b” (µm)</th>
<th>Vertical Trace Deformation “c” (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower Limit</td>
<td>Upper Limit</td>
<td>Lower Limit</td>
</tr>
<tr>
<td>Maximum Value</td>
<td>26.7</td>
<td>25.4</td>
<td>40.6</td>
</tr>
<tr>
<td>Mean Value</td>
<td>22.0</td>
<td>23.3</td>
<td>30.0</td>
</tr>
<tr>
<td>Minimum Value</td>
<td>17.1</td>
<td>20.3</td>
<td>20.3</td>
</tr>
<tr>
<td>Requirement</td>
<td>50.8 Maximum</td>
<td>8.0 Minimum</td>
<td>50.0 Maximum</td>
</tr>
</tbody>
</table>
Standards applicable

IEC, EIA, SAE

Tier 1 Automotive OEM,

OEM Qualifications

Hella, Conti, Bosch, TRW, Volkswagen, GM & Omron etc.
Module development

Design Drivers

1.) Operational Temperature & Mounting Location
2.) Sealed or unsealed requirements
3.) PCB Plating and PCB Thickness
4.) Power Requirements and Lead Interface
5.) Operational frequency

Options & features Effected by Design Drivers

1.) Raw Material- 4 core options +
2.) Plating Lead Interface- Various interconnect and wire bondable options
3.) Press-Fit Gauge Thickness
4.) Plastic material- Multiple options
5.) Bend Radius
Integrated Connector Package Modules

- Plug & Play philosophy ....
- Complex Engineering:
  - Stamp
  - Plate
  - Mold
Customer Specific Application Testing

Report Summary for Interplex 0.8mm Thick Press-Fit Pins in Bosch supplied PCBs

Interplex PF Pin material: CuNiSn1Mg, Nickel K55 (C7025) R050 temper

Performance Summary

Table 1: Mechanical Forces Summary

<table>
<thead>
<tr>
<th>Press-in Force [N]</th>
<th>Pull-out Force [N]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX value</td>
<td>112.7</td>
</tr>
<tr>
<td>AVE value</td>
<td>101.3</td>
</tr>
<tr>
<td>MIN value</td>
<td>99.7</td>
</tr>
<tr>
<td>Sample Size</td>
<td>33 Pins</td>
</tr>
</tbody>
</table>

Table 2: Contact Resistance Summary

<table>
<thead>
<tr>
<th>Contact Resistance [µΩ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX value</td>
</tr>
<tr>
<td>AVE value</td>
</tr>
<tr>
<td>MIN value</td>
</tr>
<tr>
<td>Sample Size</td>
</tr>
</tbody>
</table>

Figure 1: Representative Force Curves

Table 4: Microsection Measurements

<table>
<thead>
<tr>
<th>PTH #</th>
<th>Drill Hole Ø [mm]</th>
<th>Plated Hole Ø [mm]</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.658</td>
<td>1.541</td>
<td>35</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>2</td>
<td>1.647</td>
<td>1.529</td>
<td>46</td>
<td>43</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>1.650</td>
<td>1.534</td>
<td>30</td>
<td>41</td>
<td>25</td>
</tr>
</tbody>
</table>

Microsection Notes:
- "a" = Radial plating hole (PTH) deformation; maximum value recorded per sample
- "b" = Remaining plating stackness; minimum value recorded per sample
- "c" = Plated-through hole vertical deformation; maximum value recorded per sample
Automotive Applications ...

- Motor & Flapper Controls
- Tire Pressure Monitors
- Component Holders
- Molded Sensor & Control Modules
- Solder Less Circuit Stacking Applications
- Bus Bar Interconnects & Fuse Receptacles
- Junction Boxes
- Engine & Transmission Controllers
Other Applications...

Telecomms
- Telecom- Backplane

Automotive
- MAP, Pressure & Position Sensors
- Inverters & Power Module

Transport
- IGBT Power modules

Energy
- Solar Interconnects

Future ....
- DC to DC power Conversions
- Transportation, Energy-Oil & Gas, Wind energy
- IDC to press-fit applications
Direct Insert Press-fit Applications…
Conclusions

- Automotive Electronics is a primary "Harsh Environment" for electronic connectors...

- Motor and Power control equipment will be the next major development area for electronic interconnection issues

- Press-Fit interconnects are an enabler for more reliable and robust connections in Harsh Environments

- Adaption to Integrated Connector Package Modules (ICPM) will contribute to greener, more sustainable electronics
The Authors would like to Acknowledge the help and assistance of:

- Interplex Engineered Products- East Providence RI
- Interplex Soprec, Besancon
- France
- Test Authorities
  - Conotech Research, Attleboro, MA
  - SGS Germany GmbH, München
  - Intertek Labs, Livonia, MI

For their assistance and permission to publish this information.