Building a low-cost Test Fixture

Guillaume Vier
Agenda

• Background
• Motivations
• Architecture
  • Bed of nails
  • Test Controller
  • Flasher
• Conclusions
Background

- **Ubidata** founded in 2003 in Brussels
- Telematics and mobile logistics solutions
- We design and build our own battery-powered tracking device
Motivations

• Functional testing at the end of the assembly line
• Run self-test on each PCB
• Program production firmware

• Small form factor:
  • PCB: 67 mm x 36 mm
  • Test points: φ 0.6 mm, spacing 1.27 mm
Motivations

Standard test fixture (€€€)

Can we build something cheaper with off-the-shelf components?
Architecture

- Bed of nails: custom PCB + soldered test probes
- Test controller: Raspberry Pi Zero
- Flasher: OpenOCD
Bed of nails

Custom PCB to:
- align the Device Under Test over the probes
- connect test points to larger header

PCB designed with KiCad
Bed of nails

Step 1: schematics

• wire test probes to a larger connector
Bed of nails

**Step 2:** create custom footprint for probe

**Constraints:**

- manufacturer’s capability:
  - pad to pad spacing
  - annular ring size
- Test points spacing
- Probe diameter

Pad size: 1.1 mm x 2 mm, \( \phi \) 0.75 mm
Bed of nails

Step 3: PCB layout

- DUT’s edges drawn on silkscreen layer
- Test points’ coordinates extracted from DUT’s gerber files
- Set origin point for the grid on new layout
- Place footprints with:
  - Position Relative To... -> Use Grid Origin
Bed of nails
Bed of nails
Bed of nails
Test Controller

• Raspberry Pi Zero running TinyCore
  • Minimal Linux system
  • Runs from RAM
• Test scripts written in Python
• Communicate with DUT via UART
Test Controller

Pimoroni Automation pHAT:
• 1 relay -> Supply power to DUT
• 3 ADCs -> Measure voltage rails
Flasher

• Connect to microcontroller via SWD
• **OpenOCD** compiled with GPIO bitbang support
  
  ```
  ./configure --enable-sysfsgpio --enable-bcm2835gpio
  ```
• Running on the Pi Zero
• Define pins for SWD in script
Conclusions

Cost comparison

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Low-cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bed of nails</td>
<td>3000 € - 6000 €</td>
<td>2 PCBs: 24 €</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 probes: 18 €</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Others: 20 €</td>
</tr>
<tr>
<td>Test controller</td>
<td>100 €</td>
<td>RPi Zero + pHAT: 25 €</td>
</tr>
<tr>
<td>Flasher</td>
<td>2 x 300 €</td>
<td>0 €</td>
</tr>
<tr>
<td>Total</td>
<td>3700 € - 6700 €</td>
<td>87 €</td>
</tr>
</tbody>
</table>
Conclusions

- Cheap
- Robust
- Easy to build/replicate

Limitations: not suited if special probes required (e.g. RF probes)
Assembly
References

• Test probes P50 series:  
  https://be.farnell.com/fr-BE/multicomp/p50-e-120-g/levier-large-point/dp/1568259

• Automation pHAT from Pimoroni:  
  https://shop.pimoroni.com/products/automation-phat