PCB Cost Overview 101

What Reduces/Increases PCB Costs?
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Agenda

1. What affects PCB cost?
   a. PCBs are mechanical/chemical components
   b. Mechanical methods still employed
   c. Time to produce and yield = cost

2. How BGA pitch, etc. affects PCB cost
   a. TI BGAs are often smallest pitch devices
   b. Smallest pitch devices drive PCB rules
   c. PCB rules drive PCB prices

3. Summary
What Affects PCB Cost?

What are PCBs?

- Laminated layers of fiberglass (FR-4) with copper coatings etched into traces.
- Multilayer boards have vias to go between the layers.

[Diagram of PCB layers with FR4 Laminate, Through hole via, and Copper traces]
What Affects PCB Cost?

How are they produced?

Start with Fiberglass material (core or prepreg) with copper laminated on one or two sides.

1. Inside layers are coated with photoresist and etched to make traces and bare FR-4.
2. Layers are then pressed together with the outside layers unetched.
3. The whole PCB is drilled and vias are electrically plated through.
4. Then outside layers are etched.
What Affects PCB Cost?

How are they produced?
It’s a mechanical and chemical process.

1. Mechanical process seems to be weak point.
2. Drilling is done in groups (gang drilling) by special drills on granite air tables going 150K-250K RPM.
3. Often boards are stacked 2-3 thick (4-12 boards at once).
4. Drills are exponentially weaker as they get thinner.
5. Thinner drills wander as they’re drilled.
6. There is a limiting drill size/thickness ratio because of this.
What Affects PCB Cost?

For this reason, via hole size (which dictates diameter) and PCB layer count have the most major PCB price impact.

1. Via size; makes HDI/non-HDI decision
2. Layer count; adds to cost of materials + yield loss
3. Trace/clearance size; impacts yield loss
4. Special vias (blind/buried/etc.) impact time and yield, so adds cost.
What Affects PCB Cost?

If small (16 mil diameter/8 mil hole size or smaller) via sizes are required, HDI is often the only answer.

HDI generally raises the cost of a PCB by 2x, unless the PCB is:
1. Very small (like a cell phone)
2. Extremely complex and dense (many large pin count devices like an aircraft A/V distribution system board)

HDI- High Density Interconnect
- Laser drilled blind vias (<13 mils diameter) on 1 or more layers, often with a thru-hole board sandwiched in between.
- Can have stacked vias (laser or mechanical)
- Adds significant cost because of the additional steps (time) required and equipment cost.
BGAs Affect PCB Cost!

• Fry’s motherboard- example of cheap PCB:

• MSI K9N SLI-F v2 Motherboard (older)

Special Features
• 11.96 in. (L) x 8.25 in. (W); ATX
• 4 DIMMs w/ DDR2 800+ up to 8GB
• 2 PCI-E 16X (with SLI technology, both slots operate at 8X speed); 2 PCI-E X1; 2 PCI; 10 USB
• 7.1 CH HD audio; Gb LAN; RAID (0, 1, 0+1 & 5); SATA2; ATA133
• Gb LAN; IEEE 1394, RAID(0, 1, 0+1, & 5); SATA2; SAS; ATA133
Price: $79.99!
BGAs Affect PCB Cost!

- Products like that don’t just happen, they are planned before the chips are even built.
- Cheap consumer electronics are result of heavy competition where price is #1 or #2 concern.

- For semiconductor companies to compete in this market they’ve been focusing on lowering system cost. Historically this means:
  - More integration (less component cost)
  - Shrinking die (less component cost and lower power)
  - Shrinking package (thought to be cheaper due to less board space, but now is actually increasing costs)

- What they haven’t done is understand PCB cost implications of BGA packages.

- This is often now the #1 topic of customer concern when considering new silicon.
BGA Ball Pitch = PCB Cost?

- All of the PCB feature sizes are primarily driven by the most complicated part on the board, the processor.
- The processor pitch often determines
  - Layers
  - Design rules:
    - Laser drilled vias
    - Via size
    - Blind/Stacked vias
    - Trace/space sizes
- This means the BGA ball pitch most often determines PCB cost.
Asian PCB Shop Capability/Regular Ball Pitch

Cheap and common (1.0mm pitch and some 0.8mm pitch parts):
- 20-18 mil via ring
- 10 mil finished hole size
- 4 mil traces/spaces

More expensive/not commonly produced without HDI (0.65mm pitch):
- 16 mil via ring
- 8 mil finished hole size
- 4 mil traces/spaces

Most expensive (HDI, often 50%-100% premium) avoid this! (<=0.65mm pitch):
- 10 mil via ring
- 3 mil finished hole size
- 3 mil traces/spaces
Summary

• Making PCBs is a mechanical and chemical process, not subject to Moore’s law.

• Cheap PCBs don’t just happen, they are planned from the beginning by intelligent BGA selection and routing.

• The most important consideration (for a given schematic) for PCB cost reduction is choosing BGA parts that are compatible with reduced layers and larger vias.
Conversion between mm and mils

- 0.075mm = 3 mils (0.003”) (actually 0.076mm)
- 0.1mm = 4 mils (0.004”) (0.102mm)
- 0.125mm = 5 mils (0.005”) (0.127mm)
- 0.2mm = 8 mils (0.008”) (0.203mm)
- 0.4mm = 16 mils (0.016”) (0.406mm)
- 0.45mm = 18 mils (0.018”) (0.457mm)
- 0.5mm = 20 mils (0.020”) (0.508mm)