Prototyping Fuze Electronics With Rigid-Flex Technology

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INTRODUCTION
- The Fuze Development Center

Prototyping Methodology
- Then and Now
- Modern Problems with Prototyping

Rigid-Flex Technology Up Front
- Factors for consideration
- Does it Pay? / A Case Study

Design Rules for Fuzing
- Basic Design Rules / Guidance
- Design tips for fuzing
Fuze Development Center Mission: Accelerate New technology to the Field
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These Days of Prototyping Are Gone!
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Modern Prototypes Look Like Products
• What we call a prototype means different things to different people

  – Product Point of View
    • I have something I can put in the field

  – Design Point of View
    • I built something to see if or how it works
Factors to consider in early development

- How many units do I need to build?
  - When does labor and/or schedule become significant?

- Where is the assembly labor coming from?
  - If not under direct supervision good documentation is needed

- Is reliability a factor?
  - Yes: Focus on reducing touch labor. Eliminate/minimize hand wiring

- Is this a dead end design or a foundation for the future?
  - Dead End: Minimize cost
  - Foundation: Invest more time & $$ up front
• What are the trade offs?
  – A rigid Flex design will cost about 2X to 10X its multi-layer version depending on quantities
    – NRE / Turnaround time / Minimum lot charges
  – How much labor is being saved? Cost of connectors and wiring?
  – Reliability in high-G environments
    – Minimal touch labor = better reproducibility/reliability
Hand wired assembly

Schedule: About 8 weeks ARO – Problems due to poor documentation and questions about wiring

Cost: $1,650 Assembly Labor & Profit
   $ 500 Rigid Boards
   $ 135 Components
Total $2.55K for 5 units ( $510 Ea)
Rigid-Flex Assembly

Schedule: About 3 weeks ARO – Includes Rigid-Flex Fab (2 weeks)

Cost: $2,250 Assembly Labor & Profit (Overhead)
$5,000 Rigid-Flex Boards
$1,350 Components
Total $8.6K for 50 units ( $172 Ea) a 65% cost reduction
• Flexible Technologies (IPC 6013)
  – Flex (with or without stiffener)
    ▪ Single sided – Type 1
    ▪ Double sided – Type 2
    ▪ Multilayer – Type 3
  – Rigid and Flex (Rigid-Flex)
    ▪ Multilayer with rigid and flexible sections – Type 4
  – Rigid-Flex or Flex
    ▪ 2 or more layers without plated holes – Type 5
• Basic Design Guidance
  – Flex portions of Rigid-Flex
    ▪ Uses a cover layer in place of solder mask
    ▪ Solder pads and exposed copper should use ‘tie downs’ that extend under the cover layer
    ▪ Avoid corners 90 degrees or less to minimize stress from flexing (use fillets)
    ▪ The material can only flex in one plane in one direction at one time to avoid wrinkles.
• Guidance (continued)
  • Keep conductors 0.050” from edge.
  • Always follow the bend without changing direction
  • Allow adequate space for bending

Allow 0.050” min distance from holes to bend areas

Bend Radius = 10 x Material Thickness (in general)

Can go lower for applications that do not need to flex (i.e. folding and potting)
• Guidance for Rigid Portions of Rigid-Flex
  • Similar rules as for rigid designs but special consideration needed for transition regions and flexible sections.

- 0.060” (min) radius in flexible material to relieve tear stress
- 0.075” (min) hole to edge to avoid delamination problems between cover material and rigid adhesive materials
- 0.060” (min) radius in flexible material to relieve tear stress
• Design Tips for Fuzing and Dense Packaging
  – Use paper models to determine flex behavior !!!!!!!!
  – Spend pennies vs thousands of dollars per board spin
  – Any complex geometry can be built and tested.
    – Print outlines 1:1 on paper and cut out.
    – Use 20 lb paper and packing tape to mimic flex
    – Use 110 lb or heavy paper to mimic rigid sections
    – Glue layers together to obtain thickness
  – Look for wrinkle formation, bend, stretch and fit issues that would cause failures
• Design Tips
  – Plan your backbone for interconnecting paddles first
    – Eliminate all PCB interconnecting connectors
    – Determine # of traces and tape width up front. Add a spare
  – Design in the appropriate ‘slack factor’ or margin of error
    – Bends and routing channels need space
      – Too much slack: no place to put it (wrinkles)
      – Too little slack: cannot fold without over stressing bends.
  – Trade channel depth for gap height to accommodate slack (see following slide)
• Design Tips
  – Board Stacking for Variable Height
    – Trade channel depth for stack height. As board gap decreases, channel slack increases
    – Slack Factor : \((S2 - S1) \times 2 = \text{Height Margin of Error}\). Use tape edge for wall clearance measurements

\[ S1 \quad \text{H1} \quad D \quad S2 \quad \text{H2} \]

Watch out for cylinder walls!
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• Design Tips
  – Free test connectors

You are already paying a premium, take full advantage of it

– Minimize Panel Waste
  – Small shapes with large protrusions can cost more than large shapes with small protrusions

Test connector using FFC
• Design Tips
  – Study Origami, Be creative