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US ARMY RDECOM

U.S. Army Research, Development and Engineering Command

Malcolm Baldrige National Quality Award 2007 Award Recipient

Prototyping Fuze Electronics With Rigid-Flex Technology

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Fuze Development Center

US Army RDECOM ARDEC Fuze Division
Picatinny Arsenal, NJ

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NDIA 2012 Fuze Conference – Baltimore, MD

- 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

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The Fuze Development Center
Picatinny NJ, Building 1530

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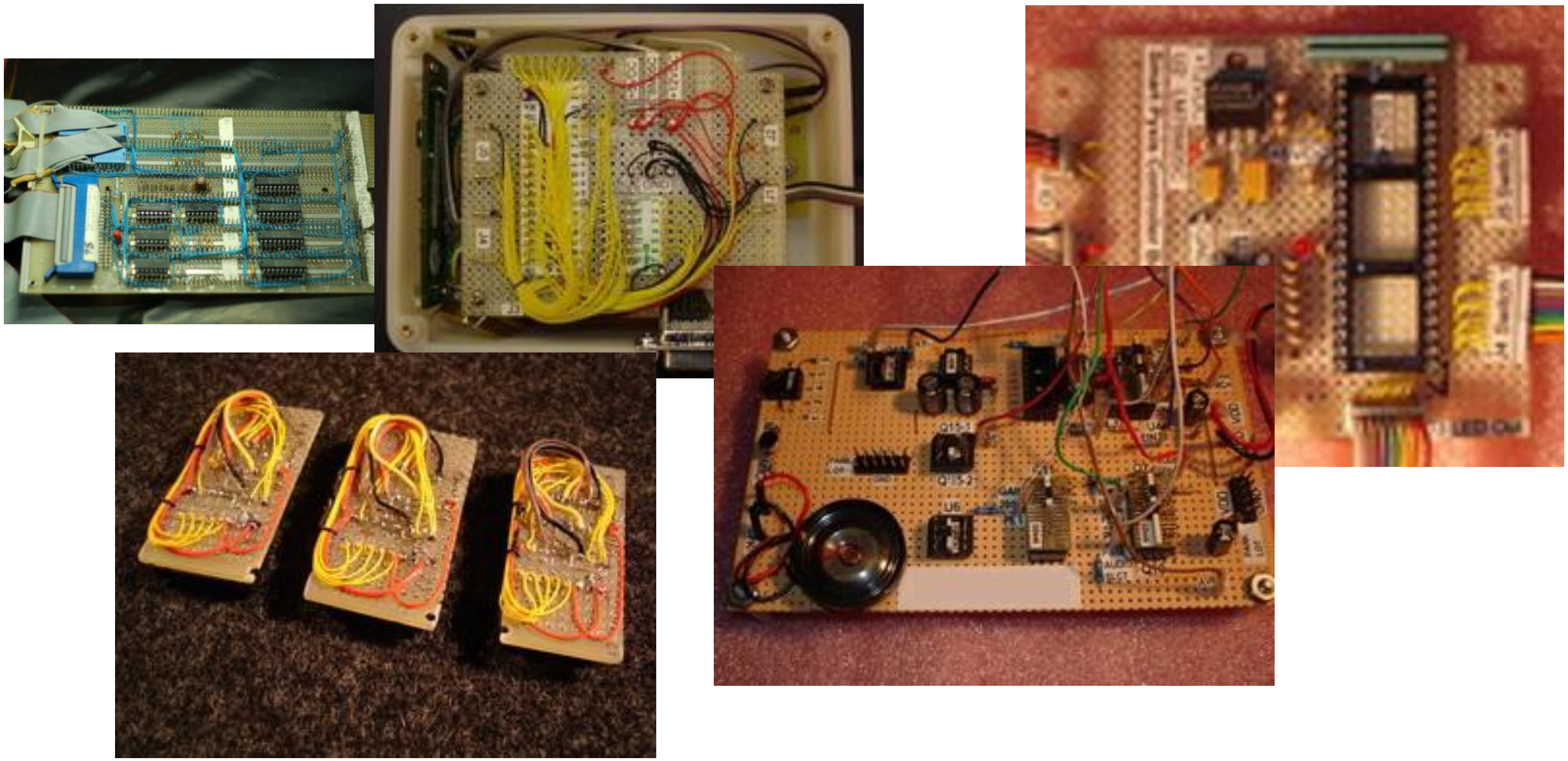
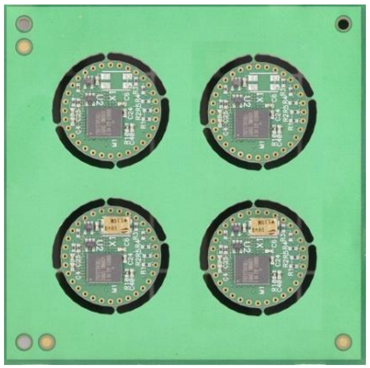
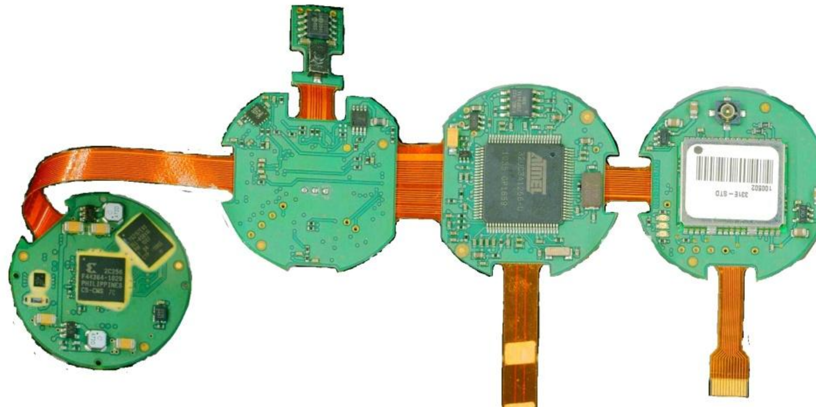
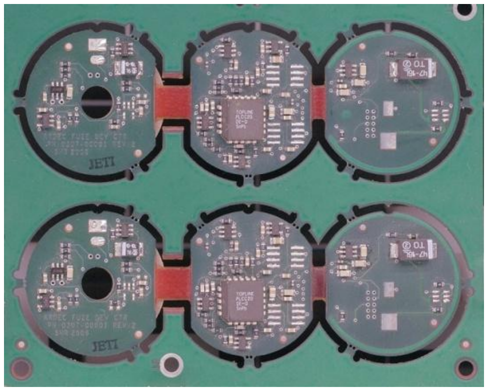


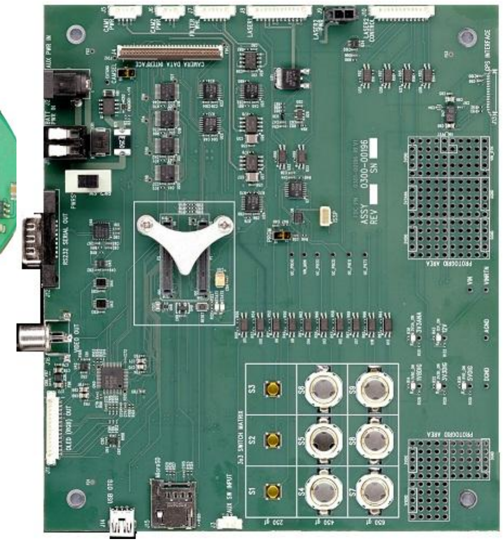
These Days of Prototyping Are Gone!

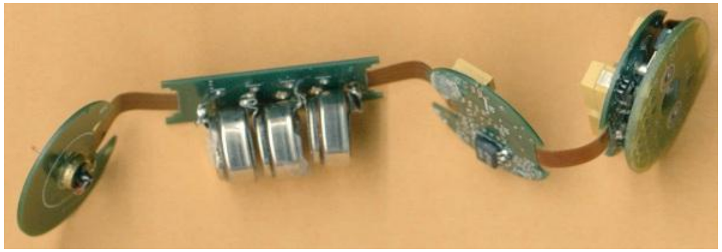
Prototyping Fuze Electronics with Rigid-Flex Technology











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

Manufacturable

  – Design Point of View
    - I built something to see if or how it works

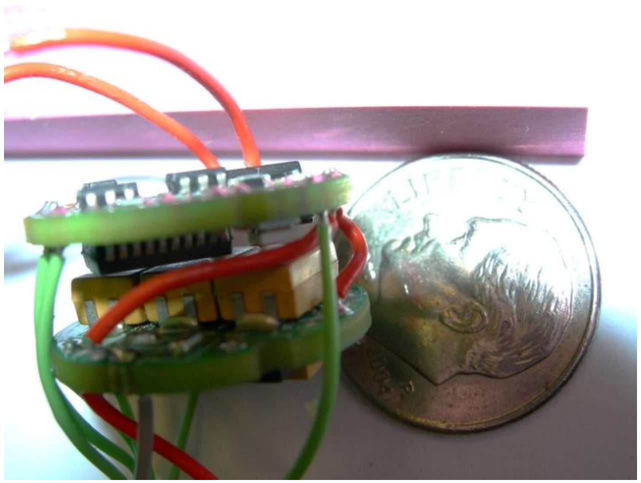
Experimental

- 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

Prototyping Fuze Electronics with Rigid-Flex Technology

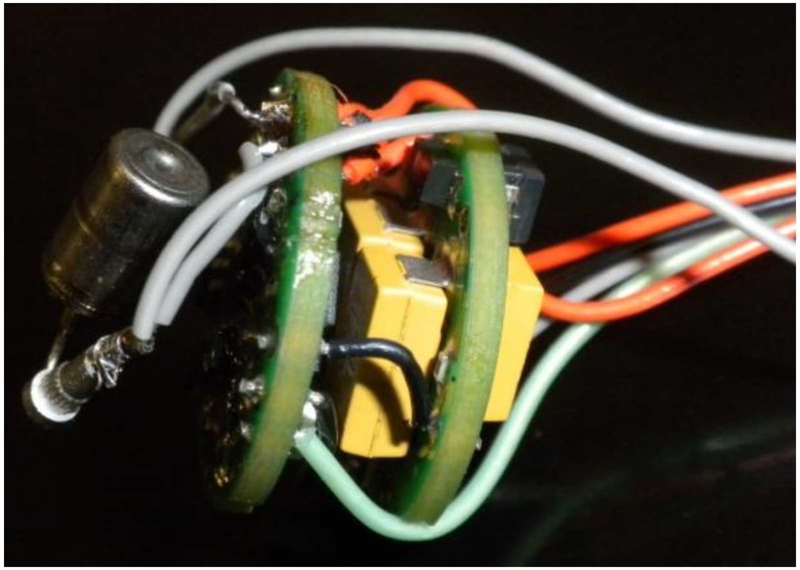
- What are the trade offs?
  - A rigid Flex design will cost about 2X to 10X its multi-layer version depending on quantities
    - NRE / Turnaround time / Minimum lot charges
  - How much labor is being saved? Cost of connectors and wiring?
  - Reliability in high-G environments
    - Minimal touch labor = better reproducibility/reliability

Hand wired assembly

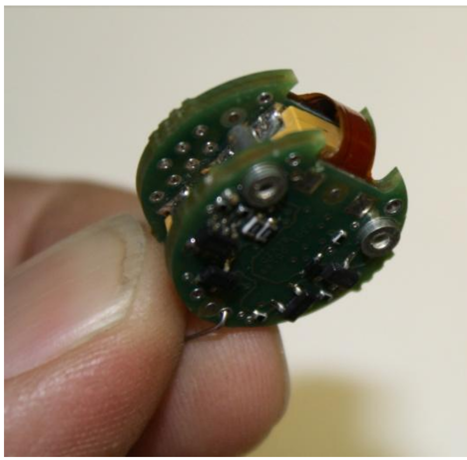


Schedule: About 8 weeks ARO – Problems due to poor documentation and questions about wiring

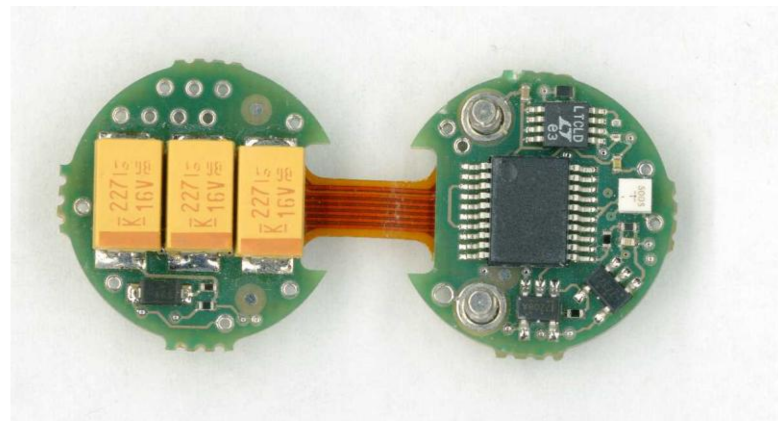
Cost: $1,650 Assembly Labor & Profit
$ 500 Rigid Boards
$ 135 Components
Total $2.55K for 5 units ($510 Ea)



Rigid-Flex Assembly



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

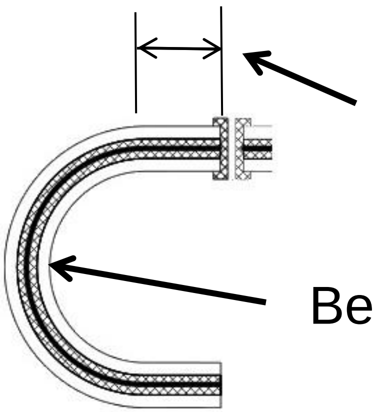


Cost: $2,250 Assembly Labor & Profit (Overhead)
$5,000 Rigid-Flex Boards
$1,350 Components
Total $8.6K for 50 units ($172 Ea) a 65% cost reduction

- 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

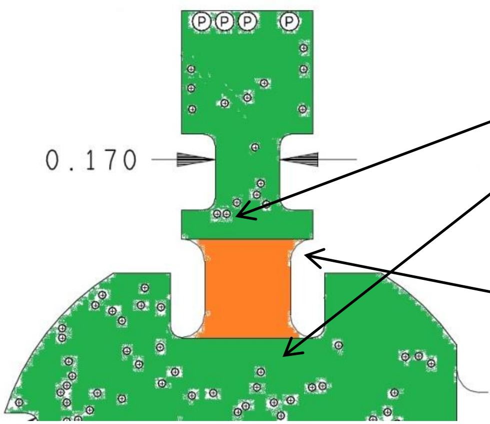


Allow 0.050” min distance from holes to bend areas

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.



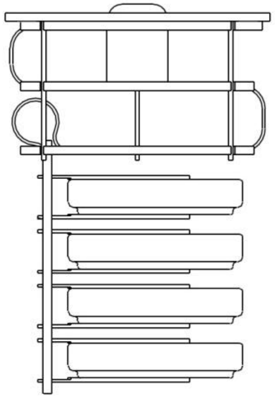
0.075” (min) hole to edge to avoid delamination problems between cover material and rigid adhesive materials

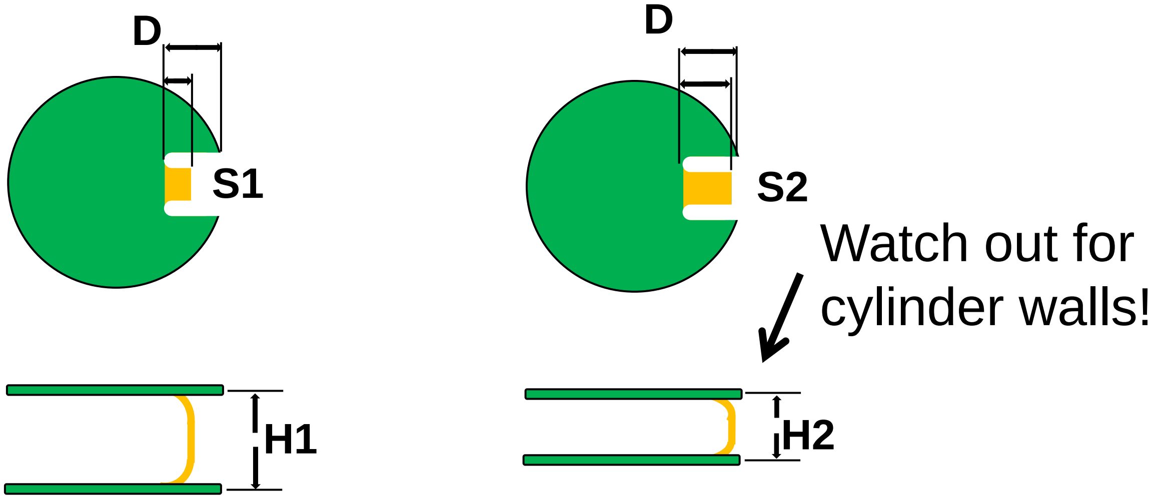
0.060” (min) radius in flexible material to relieve tear stress

- 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

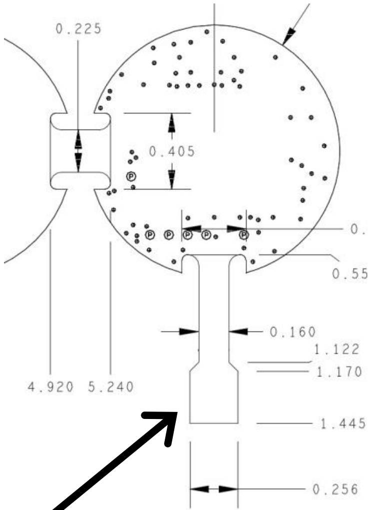
- Design Tips
  - Plan your backbone for interconnecting paddles first
    - Eliminate all PCB interconnecting connectors
    - Determine # of traces and tape width up front. Add a spare
  - Design in the appropriate ‘slack factor’ or margin of error
    - Bends and routing channels need space
      - 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)

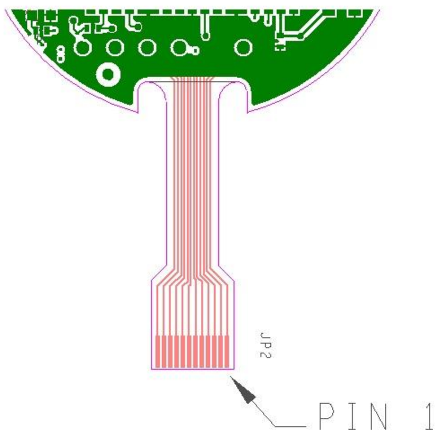
- Design Tips
  - Board Stacking for Variable Height
    - Trade channel depth for stack height. As board gap decreases, channel slack increases
    - Slack Factor : (S2-S1)*2 = Height Margin of Error. Use tape edge for wall clearance measurements





- Design Tips
  - Free test connectors





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

Test connector using FFC

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

- Design Tips
  - Study Origami, Be creative

Questions

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