# Build4 Scale U.S. Department of Energy

# Design for Manufacturing, Assembly, and Reliability

Module 3F Manufacturing Electronic Components

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### Motivation

Why is this module important?



Module 3D outlines general Design for Manufacturing and Assembly Processes (DFMA). This module focuses on insights relating specifically to electronics assembly.

#### Key points, mentioned in 3D, that are relevant here:

DFMA can determine how much you pay for production tooling and how much it costs to assemble your product

DFMA can affect:

- -Manufacturing cost and quality
- -Production cycle time-and-fixture costs
- —Production and supply-chain complexity
- -Production personnel morale

### **Module Outline**

Learning objectives

- Design for manufacturing (DFM) and assembly process for electronics
  - -Process Flow
  - —Type of Circuit Boards
  - —Bill of Material (BOM): List of parts
  - —Schematic Diagram: Placement of parts
  - —Design for X, unique to electronics
    - Assembly
    - Excellence
    - Operating conditions

### **Learning Objectives**



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- □ LO1. Understand fundamentals of electronics assembly
- LO2. Understand reliability aspects that must be taken into consideration when manufacturing electronics

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### **Manufacturing Electronics**

Process flow





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### **Block Diagram**

**Basics** 

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□ A basic figure indicating all the components included and their connections AMPLIFIER



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### **Circuit Boards**

### Types

### Solderless:

- Uses Breadboards as base to connect circuits
- Becomes very messy for more complicated circuit
- Less cost
- Mainly used in prototyping and testing

Quantity	Cost per unit <sup>2</sup>
1–9	\$5.95
10–99	\$5.36
100+	\$4.76



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## **Circuit Boards**

Types (cont.)

### Soldering:

- □ Uses Printed Circuit Boards (PCB) as base
- Widely used replacing breadboards in all applications
- Costlier
- Sturdier and more reliable design

Quantity	Cost per unit <sup>2</sup>
1–9	\$8.95
10–99	\$8.06
100+	\$7.16

#### **Printed Circuit Board**



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### **Bill Of Materials**

**Basics** 



- Similar to their mechanical analogs, electronic boards have a BOM as well
- It is a list of all the parts required to make the end product
  - -Boards
  - —Semi-conductors (diodes, resistors etc.)
  - -Passives
  - -Microcontrollers

### **Schematic Diagram**

**Basics** 



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Explains the placement of each part on the board

- Has all the information about board dimensions, parts, and their positions as well as the assembly methods
- □ Called **Gerber files**, in the market, are used as communication between the customers and manufacturers



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Design for excellence



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While designing the layout, many things have to be considered for successful conversion of an idea into a marketable product

#### **Design for manufacturability**:

- DFM are guidelines to make the manufacturing process of the product as easy, cost and time efficient in the design process
- This allows the designer to be aware of manufacturing tolerances and technological challenges in production while designing

Design for excellence (cont.)

#### **Design for assembly:**

- DFA ensures that the system design facilitates the process of system assembly
- This focuses on designing a system that allocates the minimum required rotations for assembly and minimum possibility of incorrect assembly
- □ These systems are best for easier, quicker, and error-free parts insertion
  - —The feature of early detection of errors makes the DFA approach valuable for time and cost saving

Design for excellence (cont.)

#### **Design for performance**:

- For a product to perform to its best, operating conditions play a key role
- It is best to consider the environment of its operation early in the design stage

Operating conditions and effects

#### Moisture:

- Humidity interrupts with flow of current in form of condensation, decreases resistance of capacitors, increases losses in transistor and often results in short circuits
- Can be avoided by use of packaging with material of low water vapor transmission rate (polypropylene) and Desiccant (Silica Gel)

#### Vibration:

Electronic products are subject to a range of vibrations based on the applications—

One example of heavy vibration and shock are in racing cars

To overcome the physical wear and defects isolators, enclosure frames, stiffeners and braces can be used Manufacturing Electronic Components

Operating conditions and effects (cont.)



#### Dust:

- Small particles mixed with water vapor can get accumulated on the circuit board
- □ Main consequences are short circuits and dust combustion
- Can be avoided with enclosures and clean environment

Operating conditions and effects (cont.)

#### Temperature:

- Many times a high temperature tolerance is expected of the electronics in fields like automotive
- By adopting temperature tolerant fabricating technology of Silicon on Insulator (SOI) the values can be increased up to 380°C from 150°C
- But when system requirement go beyond these numbers, cooling systems can be used

Operating conditions and effects (cont.)



- A variety of thermal management options are available such as:
- □ Active Cooling: Achieved by introduction of external force such as a fan or coolant to bring the temperature to operational range
- Passive Cooling: The processors are slowed down in order to match the temperature standards

## Soldering/Connecting

Considerations

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□ All the appropriate connections have to be made in chosen way

This can be done in-house, but requires skilled labor and technology (machines) especially for the soldering type





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## **Soldering/Connecting**

Considerations (cont.)

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Lot of vendors available in market for fabrication given the Gerber files

*Examples*: Bittele, Barebones PCB, etc.

- Cost mostly depends on the quantity to be produced and technology required
- Getting quotes from multiple vendors helps in determining cost efficient way for a certain application

Quantity	Cost per Unit
1–25 (Prototype)	\$15–\$22
100+(Small scale)	\$7–\$12

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### References



Hobbyprojects [n.d.] Blog post

http://www.hobbyprojects.com/block\_diagrams/block\_diagrams.html

Adafruit Products Retail https://www.adafruit.com/product/239

#### Cost estimate as given by bittele

http://www.7pcb.com/PCB-Assembly-Quote.php?d3=0&d5=1&c6=100&c8=2&c11=0&c13=1&c18=1&c20=1&c23=2& c25=0&send=Calculate&x=0&y=0#

#### Popular Science [n.d.] Blogpost

http://www.popsci.com/diy/article/2009-09/getting-your-circuit-boardsprofessionally-printed

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