



Design for Manufacturing, Assembly, and Reliability

Module 3F Manufacturing Electronic Components

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



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

Manufacturing Electronics

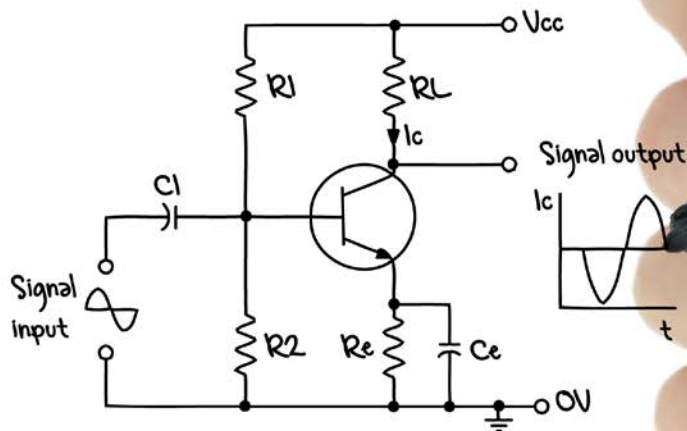
Process flow



Block Diagram

Basics

- A basic figure indicating all the components included and their connections



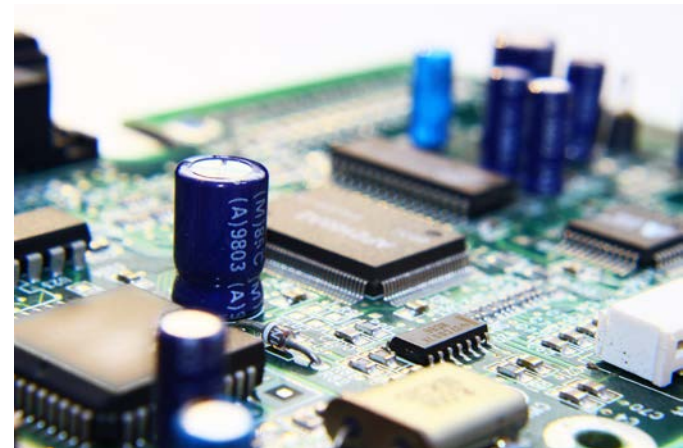
Circuit Boards

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 ² |
|----------|----------------------------|
| 1–9 | \$5.95 |
| 10–99 | \$5.36 |
| 100+ | \$4.76 |



Manufacturing Electronic Components

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Circuit Boards

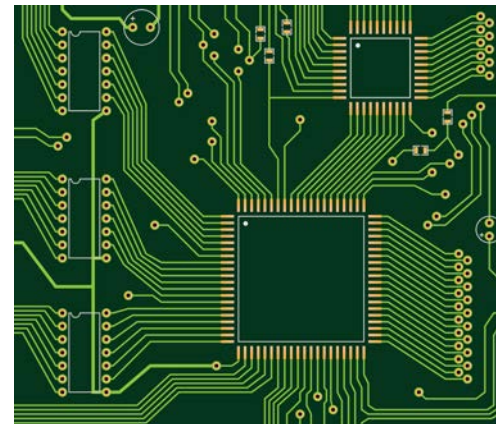
Types (cont.)

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 ² |
|----------|----------------------------|
| 1–9 | \$8.95 |
| 10–99 | \$8.06 |
| 100+ | \$7.16 |

Printed Circuit Board



Bill Of Materials

Basics

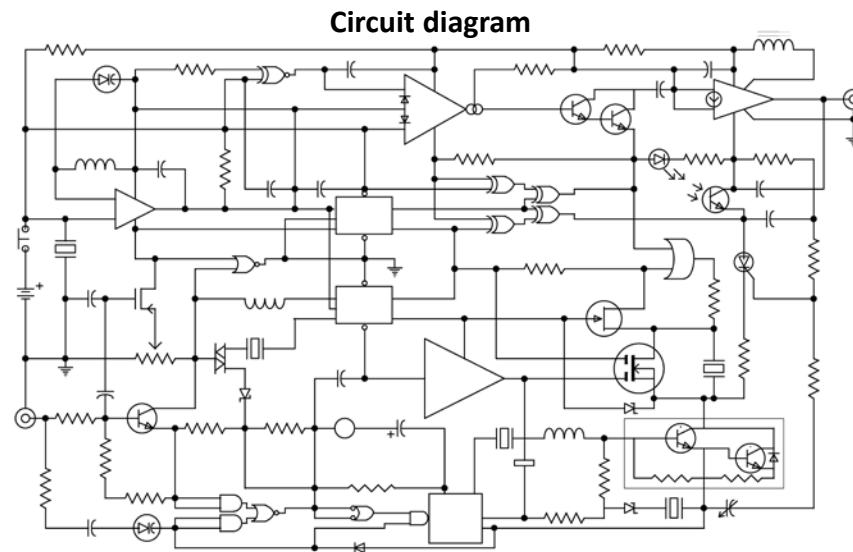


- Similar to their mechanical analogs, electronic boards have a BOM as well
- It is a list of all the parts required to make the end product
 - Boards
 - Semi-conductors (diodes, resistors etc.)
 - Passives
 - Microcontrollers

Schematic Diagram

Basics

- 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



Design For X

Design for excellence



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 X

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 X

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

Design For X

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

Design For X

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

Design For X

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 requirements go beyond these numbers, cooling systems can be used

Design For X

Operating conditions and effects (cont.)



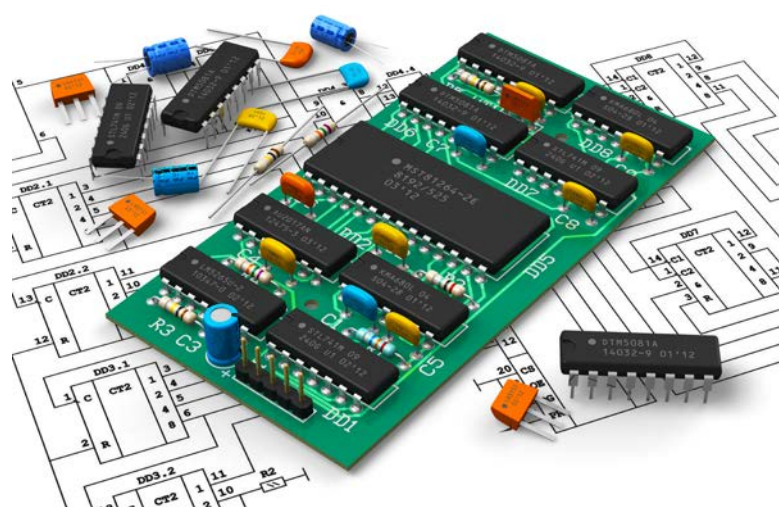
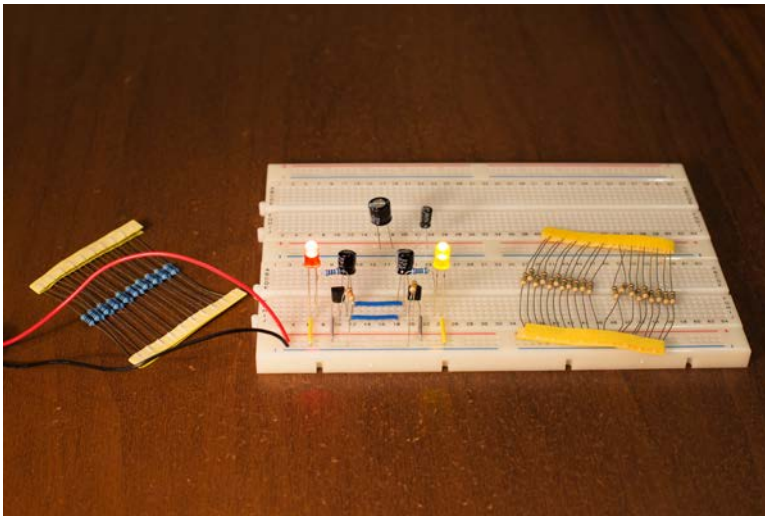
A variety of thermal management options are available such as:

- **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

- 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



Soldering/Connecting

Considerations (cont.)



- 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 |

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-boards-professionally-printed>

Glossary

Module 3F

Block Diagram is a diagram of a system in which the principal parts or functions are represented by blocks connected by lines that show the relationships of the blocks

Schematic Diagram is a representation of the elements of a system using abstract, graphic symbols rather than realistic pictures.

Soldering is a process in which two or more items (usually metal) are joined together by melting and putting a filler metal (solder) into the joint, the filler metal having a lower melting point than the adjoining metal.

Gerber Files is an open ASCII vector format for 2D binary images. It is the de facto standard used by printed circuit board (PCB) industry software to describe the printed circuit board images: copper layers, solder mask, legend, etc.

Active Cooling is a design approach that uses fans and other auxiliary assistance to cool a component, such as a processor.

Passive Cooling is a design approach that uses natural cooling through slowing the speed at which a component, such as a processor is operating and through ventilation without auxiliary assistance.