Electronics Club

# Roadmap to
# **Printed Circuit Board Designing**

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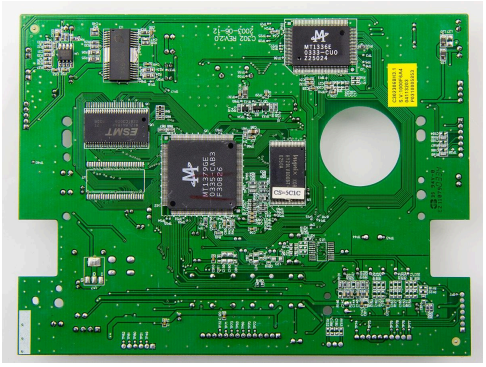
## INTRODUCTION:

### What is a PCB?

Breadboards are great for prototyping circuits, but they aren't so good for actually using the thing you're building. At some point, you'll probably want to make a project more permanent. The best way to do that is to put it on a PCB.

A Printed Circuit Board (PCB) is a flat, rigid board that mechanically supports and electrically connects electronic components using conductive tracks, pads, and other features etched from copper sheets laminated onto a non-conductive substrate. PCBs are used in virtually all electronic devices, providing the foundation for assembling complex circuits. They can be single-sided (one copper layer), double-sided (two copper layers on both sides of the substrate), or multi-layer (several copper layers separated by insulating layers). The design and manufacturing of PCBs involve precise layout planning, material selection, and adherence to industry standards to ensure reliability and performance.



## What is PCB Designing?

Printed Circuit Board (PCB) designing is the process of creating a layout for electronic circuits. This layout integrates all the necessary components such as resistors, capacitors, and integrated circuits, ensuring that they work together seamlessly. The design process involves several steps, including schematic capture, component placement, routing, and generating manufacturing files.

PCB design involves multiple disciplines including electrical engineering, mechanical engineering, and computer-aided design. It requires a good understanding of electronics, circuit theory, and the physical properties of materials. The field is constantly evolving with advancements in technology, such as higher density interconnect (HDI) PCBs, flexible PCBs, and multi-layered PCBs.

## Why Learn PCB Designing?

1. **Foundation of Modern Electronics**: PCBs are the backbone of virtually all modern electronic devices, from smartphones to industrial machinery.
2. **In-Demand Skill**: With the rise of IoT, wearable tech, and other advancements, the demand for skilled PCB designers is on the rise.
3. **Innovation and Creativity**: PCB designing allows for innovation, enabling the creation of new and improved electronic devices.
4. **Career Opportunities**: Knowledge in PCB design opens doors to various roles in electronics engineering, manufacturing, and research and development.
5. **Project Realization** (Most important): For hobbyists and makers, learning PCB design is crucial for bringing electronic project ideas to life.

## Prerequisites for Learning PCB Design?

Before diving into PCB design, it’s beneficial to have a foundational understanding of:

1. **Basic Electronics**: Understanding components like resistors, capacitors, diodes, transistors, and their functions in a circuit.
2. **Circuit Theory**: Knowledge of how electrical circuits work, including Ohm's Law, Kirchhoff's laws, and basic circuit analysis techniques.
3. **Schematic Reading**: Ability to read and interpret electronic schematics.
4. **Computer Skills**: Familiarity with basic computer operations and software use.
5. **Mathematics**: Basic algebra and geometry skills are helpful for understanding and calculating circuit parameters.

## Softwares for PCB Designing

1. **Eagle**: A popular PCB design software known for its ease of use and extensive library of components.
2. **KiCad**: An open-source PCB design tool that provides powerful features and flexibility.
3. **Altium Designer**: A professional-grade PCB design software that offers advanced features for complex designs.
4. **OrCAD**: Another industry-standard tool that provides comprehensive solutions for PCB design and simulation.
5. **DipTrace**: User-friendly PCB design software suitable for beginners and advanced users alike.
6. **EasyEDA**: A web-based PCB design tool that is accessible and easy to use, ideal for both beginners and experienced designers

## Steps to Design a PCB

Designing a PCB involves several methodical steps to ensure a functional and manufacturable electronic circuit. Here is a step-by-step guide:

1. **Define the Requirements**:
   - Determine the purpose and functionality of the PCB.
   - List all components and their specifications.
   - Establish design constraints such as size, shape, and power requirements.

2. **Create the Schemati**c:
   - Use PCB design software to draw the schematic diagram.
   - Place all the electronic components and connect them according to the circuit design.
   - Check for any schematic errors and ensure all connections are correct.

3. **Select the PCB Layout Software**:
   - Choose a suitable PCB design software (e.g., Eagle, KiCad, Altium Designer, OrCAD, DipTrace, EasyEDA).

4. **Component Placement**:
   - Import the schematic into the PCB layout tool.
   - Place the components on the board, considering factors like thermal management, signal integrity, and ease of routing.
   - Follow guidelines for component spacing and orientation.

5. **Routing the PCB**:
   - Connect the components using copper traces according to the schematic.
   - Use different layers if designing a multi-layer PCB.
   - Ensure minimal trace length for high-speed signals and adequate trace width for power traces.

6. **Design Rules Check (DRC)**:
   - Run a design rules check to identify and fix any layout issues.
   - Ensure that all design constraints and manufacturing tolerances are met.

7. **Simulation and Validation**:
   - Simulate the PCB design to verify the functionality of the circuit.

- Make necessary adjustments based on the simulation results.

8. **Generate Manufacturing Files**:
   - Export the Gerber files, which are used by PCB manufacturers to create the physical board.
   - Include the drill files, pick and place files, and any other necessary documentation.

9. **Prototype and Testing**:
   - Send the design to a PCB manufacturer for prototyping.
   - Assemble the prototype board and perform testing to ensure it works as intended.
   - Identify and correct any issues found during testing.

10. **Final Adjustments and Production**:
    - Make final adjustments based on the prototype testing results.
    - Prepare the design for mass production, ensuring all design files and documentation are up to date.

By following these steps, you can systematically design a PCB that meets your project requirements and is ready for manufacturing.

# Week I -

✧ Intro to PCB Design ( Use Cases and Stuff). General Components in Electronic Circuits ( Cap, Ind, Transistor, Diode, Nmos,Pmos,Cmos).
Introduction to Microcap
BM ka Lectures
Yashwi

✧ **BREAKDOWN -**

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| **Day I** | On Day I, we will first cover the basics of PCB Designing, including its various **Use Cases and types.**<br><br>**Introduction to PCBs -**<br>- What are PCBs?<br>- Places of Application of PCBs<br>- Typical PCB Manufacturing Process<br>- Additional resource about the manufacturing process of PCBs- Here<br><br>**Various Types of PCBs -**<br>- Types of PCBs Intro<br>- PCB Types in Detail |
| **Day II** | Moving on from Day-II we would now be covering various components involved in such PCBs. Here we will cover basic ones in detail.<br><br>**Capacitors -** Capacitors store electrical charge by accumulating it on two closely spaced plates separated by a dielectric, air, or vacuum. In detail.<br>**Inductors -** Inductors store magnetic energy when electric current flows through it. It comprises an insulated wire wound around an iron or ferrite core.<br>**Transistor -** Transistors are miniature semiconductor building blocks for most modern electronics. They can form logic gates and play either switching or amplification roles in digital circuits. Detail<br>**Diode -** Diodes are also semiconductors. However, they are two-terminal devices that allow AC to flow in only one direction because they have low resistance in forward bias and high resistance in negative bias connections. Diode Model<br>**MOSFETs -** A Metal Oxide Semiconductor Field-effect Transistor (MOSFET, MOS-FET, orMOS FET) is a field-effect transistor (FET with an insulated gate) where the voltage determines the conductivity of the device. It is used for switching or amplifying signals.<br>- Working |

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| | - MOS Circuits<br>- Types :<br>  ☐ The PMOS turns on whenever the voltage is low and goes off as the voltage goes high. Detail<br>  ☐ The NMOS turns on when the voltage is high and off when the voltage is low. Detail<br>  ☐ CMOS (Complementary MOS): They are called complementary because NMOS and PMOS work in a complementary fashion. When the NMOS switch turns on, the PMOS gets off, and vice-versa. Detail |
| **Day III** | Moving on to Day-III we would be brushing up our knowledge of circuit analysis and RLC Circuits. Then we will familiarize ourselves with MicroCap for circuit simulations.<br><br>**Circuit Analysis -**<br>- ESC201T L8 : Circuit analysis - summary<br><br>**RLC Circuits -**<br>- RLC Transients: ESC201T- L11<br><br>**Introduction to MicroCap -**<br>- Circuit simulation using Micro-Cap (EE21...<br><br>**Practice Time !!**<br>- ESC201P : Simulation Lab 1 Introduction ...<br>- ESC201P Simulation Lab2: Thevenin and ... |
| **Day IV** | Moving on to Day-IV we would learn about sinusoidal steady states and phasor analysis. We will also practice a simulation for RLC circuits.<br><br>**Sinusoidal Steady States -**<br>- Sinusoidal Steady State : Phasors: ESC20...<br>- Phasor analysis: ESc201T- L14<br>- Frequency Response : ESC201T L15 |

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| | **Practice Time !!**<br>- ESC201P Simulation Lab 3: RLC Circuits a... |
| **Day V** | Next we move on to Bode plots and filters. We will also introduce diode models and circuits.<br><br>**Bode Plots and filters -**<br>- Bode plots and filters : ESC201T-L16<br>- LCR filters: ESC201T - L17<br><br>**Diodes -**<br>- Diode Models<br>- Diode circuits : ESC201T: L22<br><br>**Practice Time !!**<br>- Oscillator Design |
| **Day VI** | On Day-VI, we will continue with diode concepts like half and full wave rectification and zener diodes. Then we start with the concept of amplifiers.<br><br>**Diodes -**<br>- Diode power supply part-2: ESC201T- L24<br><br>**Amplifiers -**<br>- Amplifiers: part -1 : ESC201T: L25<br>- Amplifiers-2: ESC201T : L26<br><br>**Practice Time !!**<br>- ESC201P Simulation Lab 5 : Power suppl...<br>- ESC201P Simulation LAB 6: Voltage Dou... |
| **Day VII** | Finally we will cover the theory of opamp circuits and then move on to practice all the concepts we have covered in the week.<br><br>**Opamp Circuits -**<br>- Opamp circuits 1 : ESC201T L29<br>- opamp circuits 2 : ESC201T L30<br><br>**Practice Time !!**<br>- ESC201P Simulation Lab 7 : BJT amplifier ...<br>- ESC201P Simulation lab 9 : opamp circuits<br>- ESC201P Simulation Lab 8 : MOSFET Circ... |

✧ **Some Extra Topics for Week I -** *(Depends on your interest :)*

- LED Display - Capacitors and Displays : ESC201T L12
- Sequential Circuits -
    - Sequential circuit 1: ESC201T L37
    - ESC201P Lab10 : Digital Circuits 1
    - ESC201P Lab 11 sequential circuits

# ➡️ Week II -

General Circuits in Analog Electronics ( MOSFET as Amplifier, Switch and Temperature Invariance ) (EE210 Course Lectures)
Intro to PCB Design Softwares ( KiCAD ) ( Very BASIC TUTORIAL)

### ✧ BREAKDOWN -

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| **Day I** | **Common emitter, collector and base amplifier-**<br>Common Emitter amplifier (part-1) (EE210 ...<br>https://www.youtube.com/watch?v=urlfKFJjdLk&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=16<br>Common collector amplifier (part 1) (EE210... |
| **Day II-III** | **MOSFET-**<br>https://www.youtube.com/watch?v=GgPefhL53Ok&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=24<br>EE210 L28 MOSFET (part 2)<br>https://www.youtube.com/watch?v=Y4HXLj5342s&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=26<br>https://www.youtube.com/watch?v=wyKFeaKHak8&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=27<br><br>MOSFET as a switch:<br>https://www.electronics-tutorials.ws/transistor/tran_7.html<br>MOSFET as an amplifier:<br>(will be elaborated in the next day) |

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| | https://www.electronics-tutorials.ws/amplifier/mosfet-amplifier.html |
| **Day IV** | **MOSFET Amplifiers-**<br><br>https://www.youtube.com/watch?v=ad9DYK0FSXQ&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=28<br><br>https://www.youtube.com/watch?v=C2q5tPkDXNU&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=29<br><br>https://www.youtube.com/watch?v=RswZAEPcefg&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=30<br><br>https://www.youtube.com/watch?v=0Z670Vz_Too&list=PLTFMW-rP7fupbNruuK3hKTIR4zeX637W3&index=31 |
| **Day V** | **Differential Amplifiers:**<br>differential amplifier (part -1) (EE210 L35)<br>Differential Amplifier (part 2) (EE210 L36)<br>Differential amplifier (part 3)(EE210 L37)<br>Differential amplifier (part-4) :EE210 L38 |
| **Day VI** | **Extra reading on MOSFET:**<br>Explanation:<br>https://www.geeksforgeeks.org/mosfet/<br><br>Practice:<br>https://www.ee.iitb.ac.in/course/~dghosh/mosfetSlides.pdf |
| **Day VII** | **Installation of KiCAD:**<br>How To Install KiCad on Windows Step By ...<br>**Intro to KiCAD:**<br>Quickstart Intro to Kicad - Design a board i... |

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| | **Tutorial:**<br>KiCAD 7 PCB Layout in 5 steps |

Recommended reading:
KiCAD documentation (refer for doubts)
https://docs.kicad.org/7.0/en/pcbnew/pcbnew.html

# ➡️ Week III -

BMS Design thing and Self Project - Hariharan
Resources on Resistor Sizes and Stuff
**Kicad basics**-https://youtu.be/KgmsvopC9Qk?si=HiwvE-y_KAclEb2W
Refer to this for adding components and footprints from online sources -
How To Design A PCB on KiCad from Start to Finish (Easy Guide)

EXTRA THINGS IF YOU ARE INTERESTED AFTER COMPLETING WEEK 3=
Full Kicad basics video
Try to understand the full circuits and its components in last week link
How to Solder properly || Through-hole (THT) & Surface-mount (SMD)
Playlist -
https://www.youtube.com/playlist?list=PLEGpdOSaimetNKObw5PWqjsKtdNDYG8rd
Interesting components-
https://www.youtube.com/playlist?list=PLsR1AO4QH1Ax5ysDjKkPHP7e0WciExmnA
Interesting projects -
https://www.youtube.com/playlist?list=PLsR1AO4QH1Ax6f4WnQ76739KWHPkPbeUm
A long and complete series on BMS -
https://www.youtube.com/playlist?list=PLJJ-NKzzRQygLr5ta54anSxbbq5CFP0W2

## ✧ BREAKDOWN -

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| **Day I** | (kicad basics video around 25 min) +(task) you and your friend are trapped in an argument between seniors on who's hall can shout more, so they ask you both to make a pcb hardware to resolve the problem.you have to design a schematic in which you use an arduino nano with sound sensor(microphone condenser) , output light and buzzer if you sense sound and take turns and shout from different distance |

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| | Solution<br>REMEMBER - writing the code is your friends headache, you only have to draw the schematic for now |
| **Day II -III** | (kicad basics video till around 1hr 30min) + resistor-<br>Understand resistors better than EVERYONE, ...<br>Capacitor-<br>Types of Capacitor and their applications Expl...<br>diodes- What are the Types of Diodes?<br>transistors- What are the Types of Transistors? |
| **Day IV** | Kicad basics video full + Complete the other steps of pcb design and generate a gerber file( make sure to pass all the tests)<br>Solution |
| **Day V** | BATTERY MANAGEMENT SYSTEM(BMS) basics-<br>1)<br>What is a Battery Management System? \| Topologies of the …<br>2)<br>How does a BMS (Battery Management System) work? \| Pa…<br>3)<br>https://www.monolithicpower.com/en/learning/resources/how-to-design-a-battery-management-system-bms#:~:text=The%20MCU%20is%20the%20central,the%20rest%20of%20the%20system.&text=The%20AFE%20provides%20the%20MCU,current%20readings%20from%20the%20battery<br>AFE(cell balancing,protection)-<br>Battery Protection BMS Module (4S 40A) Teardown - Schem…<br>(learn schematic and working if you are interested)<br>Fuel gauge(measure battery percentage)-<br>Interfacing MAX17043 Lithium Battery Fuel Gauge IC with Ar…<br>MCU(connects AFE and fuel gauge and interfacing with rest of the system)- can be any programmable board like arduino,esp32,attiny etc |
| **Day VI-VII** | https://simple-ee.com/2019/07/20/arduino-4s-bms-version-7/<br>+ TASK- you need to modify the circuit in above link such that u use an ESP32 board as MCU and usecase of 3-5 battery. |

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| | SOLUTION |