INTRODUCTION OF PCBs

Printed Circuit Boards (PCBs) are essential components in electronic devices, providing the physical platform for mounting and interconnecting electronic components.
A printed circuit board (PCB) mechanically supports and electrically connects components with conductive tracks, pads, and other features etched from sheet layers of copper laminates. These layers define the overall functioning of the PCB.
A PCB layer is made up of signal transmitting levels that stacked are vertical to the board's plane. For instance, a 2-layer board has top and bottom layers while a 4-layered PCB has a top, inner 1, inner 2, and bottom layer.
There is an insulating substrate in the middle of every PCB layer – the ***FR4 (Fire Retardant Version4)***. This substrate is an epoxy saturated fiberglass with Teflon-based material.

Generally, standard PCBs contain solder masks on the surface copper layers. Sometimes, the mask is present in both the upper and lower layers. These masks get applied as a liquid or sheet onto the board layers.

DIFFERENT LAYERS OF A PCB

PCBs can have multiple layers, each serving specific functions. Here's an in-depth look at the different layers typically found in a PCB:

1. Substrate/Core Layer

- **Material:** Typically made of fiberglass-reinforced epoxy resin (FR4), though other materials like polyimide or PTFE (Teflon) can be used.
- **Function:** Provides mechanical support and electrical insulation for the entire PCB.

2. Copper Layer

- **Material:** Copper
- **Function:** Conductive pathways or traces that carry electrical signals between components. PCBs can have multiple copper layers:
  - **Single-layer PCBs:** One copper layer.
  - **Double-layer PCBs:** Copper layers on both sides.
  - **Multilayer PCBs:** Multiple alternating layers of copper and insulating material, allowing for more complex and denser circuit designs.

3. Solder Mask Layer

- **Material:** Liquid photo-imageable (LPI) solder mask ink, typically green, though other colors are available.
- **Function:** Protects the copper traces from oxidation and prevents solder bridges during soldering. It also helps with the application of solder to the correct locations.

4. Silkscreen Layer

- **Material:** Non-conductive ink, often white.
- **Function:** Provides labels and markings for components, test points, part numbers, logos, and other identifying information. This aids in assembly and troubleshooting.

5. Dielectric Layer

- **Material:** Various insulating materials, often the same as the substrate.
- **Function:** Separates conductive layers in multilayer PCBs to prevent electrical shorts and provides insulation.

6. Ground and Power Planes

- **Material:** Copper
- **Function:** Dedicated layers for ground and power distribution. These planes help reduce electrical noise and provide a stable reference voltage for components.

7. Prepreg Layer

- **Material:** Fiberglass impregnated with resin.
- **Function:** Acts as an adhesive to bond layers together in multilayer PCBs and provides insulation between the layers.

8. Vias

What are Vias?

The term "vias layer" can be a bit misleading because vias themselves are not a separate layer but rather structures that connect different layers within a printed circuit board (PCB).Vias are small plated holes drilled through a PCB that establish electrical connections between different layers of the board. They can be classified into two main types:

1. **Through-Hole Vias:**

    - These vias extend completely through the entire thickness of the PCB, connecting traces and layers from one side of the board to the other.
2. **Blind and Buried Vias:**
    - **Blind Vias:** Connect an outer layer to one or more inner layers of the PCB but do not go through the entire board thickness.
    - **Buried Vias:** Connect two or more inner layers of the PCB but do not extend to the outer layers.

- **Material:** Copper-plated holes.
- **Function:** Electrical connections between different layers in a multilayer PCB.

9. Surface Finish

- **Material:** Various types of finishes like HASL (Hot Air Solder Leveling), ENIG (Electroless Nickel Immersion Gold), OSP (Organic Solderability Preservative), etc.
- **Function:** Protects the exposed copper pads and ensures good solderability during assembly. Different finishes offer various benefits, such as improved shelf life, flat surfaces for surface-mount components, and good electrical performance.

Material:

- **Types of Surface Finishes:**
    - **HASL (Hot Air Solder Leveling):** Tin/lead or lead-free solder.
    - **ENIG (Electroless Nickel Immersion Gold):** Nickel layer covered with a thin layer of gold.
    - **OSP (Organic Solderability Preservative):** Organic compound coating.

Application Process:

- **HASL:** The PCB is dipped in molten solder, and excess solder is removed using hot air knives.
- **ENIG:** Involves a chemical process where nickel and then gold are deposited onto the copper pads.
- **OSP:** Applied by immersing the PCB in an organic solution.

Functionality:

- **Long-Term Protection:** Provides long-term protection to the copper pads until assembly.
- **High Reliability:** Some finishes like ENIG and ENEPIG offer high reliability for sensitive applications.

- **Consistent Performance:** Ensures consistent solderability and electrical performance across all pads.

10. Adhesive Layer

- **Material:** Various types of epoxy or resin.
- **Function:** Bonds different layers together, especially in flexible PCBs or in layers that require additional mechanical strength.

11. Controlled Impedance Layers

- **Material:** Combination of copper and dielectric materials.
- **Function:** Used in high-frequency applications to maintain the integrity of signal transmission by controlling the impedance of specific traces.

Layer Configuration in PCBs

Single-layer PCBs:

- Consist of a single substrate layer with one copper layer on top, solder mask, and silkscreen.

Double-layer PCBs:

- Have a substrate with copper layers on both sides, along with corresponding solder masks and silkscreens.

Multilayer PCBs:

- Include multiple layers of copper and dielectric material stacked together, with internal layers for power and ground planes, signal layers, and interconnections made through vias.

Specialized Layers

User Defined Layers

- A user-defined layer refers to a custom layer that the designer can create and define for specific purposes that are not typically covered by the standard layers (such as signal layers, ground planes, power planes, solder mask, and silkscreen). These layers can be used for a variety of custom tasks depending on the needs of the design.

Flexible PCBs (Flex PCBs):

- Use a flexible substrate like polyimide, allowing the PCB to bend and fit into tight or complex spaces.

Rigid-Flex PCBs:

- Combine rigid and flexible substrates within the same PCB, providing both structural integrity and flexibility where needed.

High-Frequency PCBs:

- Use specialized materials like PTFE to maintain signal integrity at high frequencies, with controlled impedance layers being critical.

Understanding these layers and their functions helps in designing PCBs that meet specific electrical, mechanical, and environmental requirements, ensuring the reliability and performance of the final electronic product.