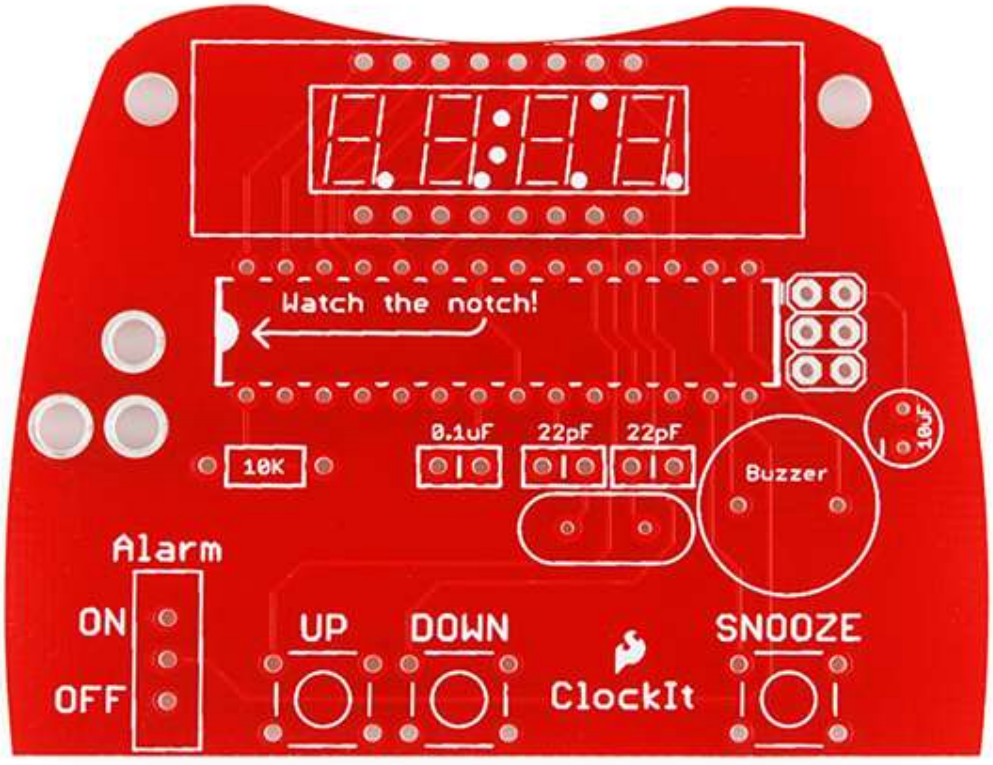
PCB Design Fundamentals: Overview

Overview

One of the key concepts in electronics is the printed circuit board or PCB. It's so fundamental that people often forget to explain what a PCB *is*. This tutorial will breakdown what makes up a PCB and some of the common terms used in the PCB world.



Over the next few pages, we'll discuss the composition of a printed circuit board, cover some terminology, a look at methods of assembly, and discuss briefly the design process behind creating a new PCB.

Suggested Reading

Before you get started you may want to read up on some concepts we build upon in this tutorial:

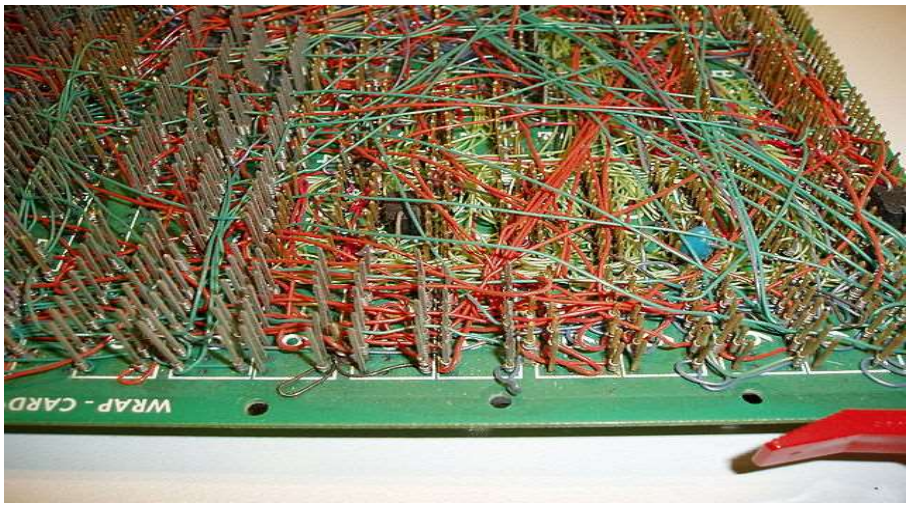
- What is Electricity?
- What is a Circuit?
- Voltage, Current, Resistance, and Ohm's Law
- Connector Basics
- Soldering 101 - PTH
- Signals

Translations

Minh Tuấn was kind enough to translate this tutorial to Vietnamese. You can view the translation here.

What's a PCB?

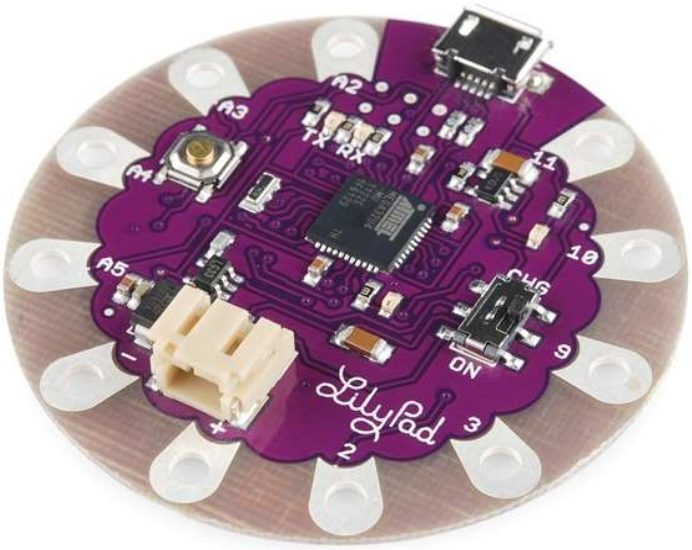
Printed circuit board is the most common name but may also be called "printed wiring boards" or "printed wiring cards". Before the advent of the PCB circuits were constructed through a laborious process of point-to-point wiring. This led to frequent failures at wire junctions and short circuits when wire insulation began to age and crack.

-> 

courtesy Wikipedia user Wikinaut <-

A significant advance was the development of wire wrapping, where a small gauge wire is literally wrapped around a post at each connection point, creating a gas-tight connection which is highly durable and easily changeable.

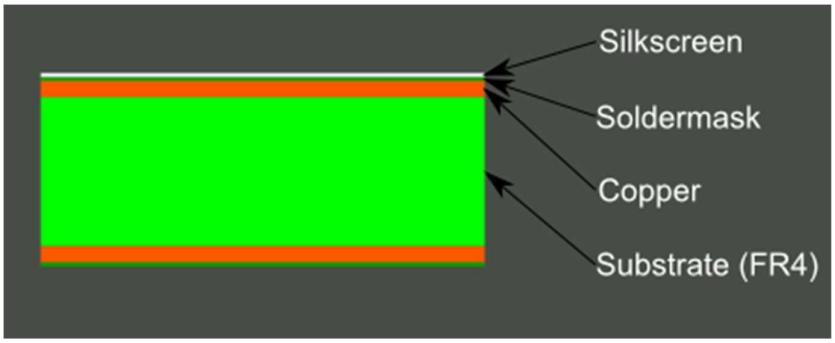
As electronics moved from vacuum tubes and relays to silicon and integrated circuits, the size and cost of electronic components began to decrease. Electronics became more prevalent in consumer goods, and the pressure to reduce the size and manufacturing costs of electronic products drove manufacturers to look for better solutions. Thus was born the PCB.



PCB is an acronym for *printed circuit board*. It is a board that has lines and pads that connect various points together. In the picture above, there are traces that electrically connect the various connectors and components to each other. A PCB allows signals and power to be routed between physical devices. Solder is the metal that makes the electrical connections between the surface of the PCB and the electronic components. Being metal, solder also serves as a strong mechanical adhesive.

Composition

A PCB is sort of like a layer cake or lasagna- there are alternating layers of different materials which are laminated together with heat and adhesive such that the result is a single object.

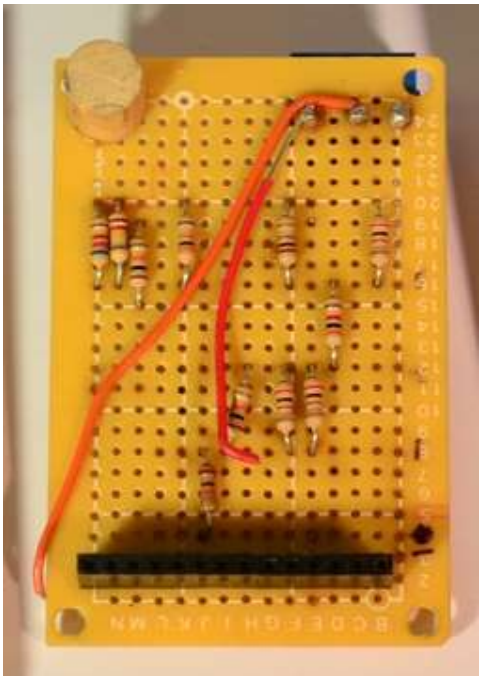


Let's start in the middle and work our way out.

FR4

The base material, or substrate, is usually fiberglass. Historically, the most common designator for this fiberglass is "FR4". This solid core gives the PCB its rigidity and thickness. There are also flexible PCBs built on flexible high-temperature plastic (Kapton or the equivalent).

You will find many different thickness PCBs; the most common thickness for SparkFun products is 1.6mm (0.063"). Some of our products- LilyPad boards and Arudino Pro Micro boards- use a 0.8mm thick board.



Cheaper PCBs and perf boards (shown above) will be made with other materials such as epoxies or phenolics which lack the durability of FR4 but are much less expensive. You will know you are working with this type of PCB when you solder to it - they have a very distictive bad smell. These types of substrates are also typically found in low-end consumer electronics. Phenolics have a low thermal decomposition temperature which causes them to delaminate, smoke and char when the soldering iron is held too long on the board.

Copper

The next layer is a thin copper foil, which is laminated to the board with heat and adhesive. On common, double sided PCBs, copper is applied to both sides of the substrate. In lower cost electronic gadgets the PCB may have copper on only one side. When we refer to a **double sided** or **2-layer board** we are referring to the number of copper layers (2) in our lasagna. This can be as few as 1 layer or as many as 16 layers or more.

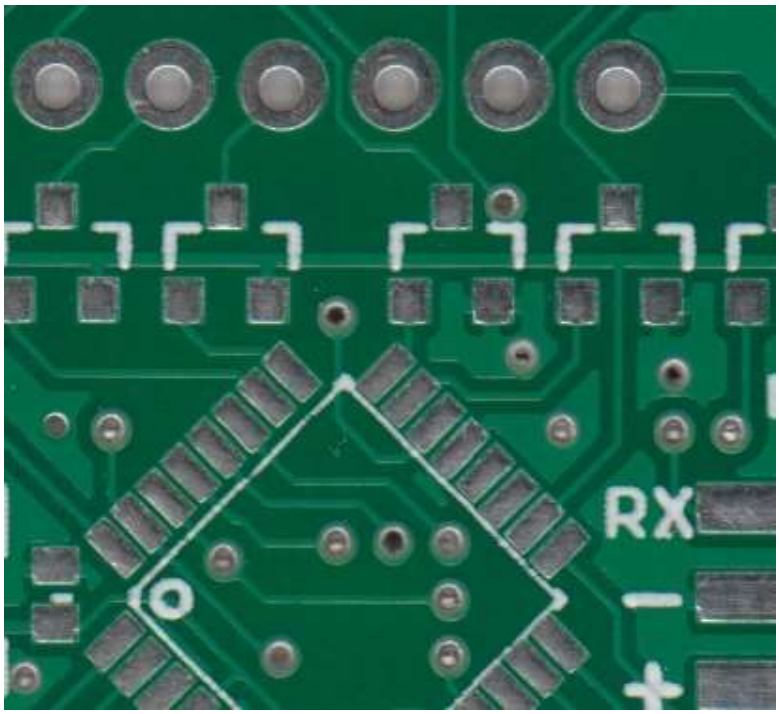
PCB with copper exposed, no solder mask or silkscreen.

The copper thickness can vary and is specified by weight, in ounces per square foot. The vast majority of PCBs have 1 ounce of copper per square foot but some PCBs that handle very high power may use 2 or 3 ounce copper. Each ounce per square translates to about 35 micrometers or 1.4 thousandths of an inch of thickness of copper.

Soldermask

The layer on top of the copper foil is called the soldermask layer. This layer gives the PCB its green (or, at SparkFun, red) color. It is overlaid onto the copper layer to insulate the copper traces from accidental contact with other metal, solder, or conductive bits. This layer helps the user to solder to the correct places and prevent solder jumpers.

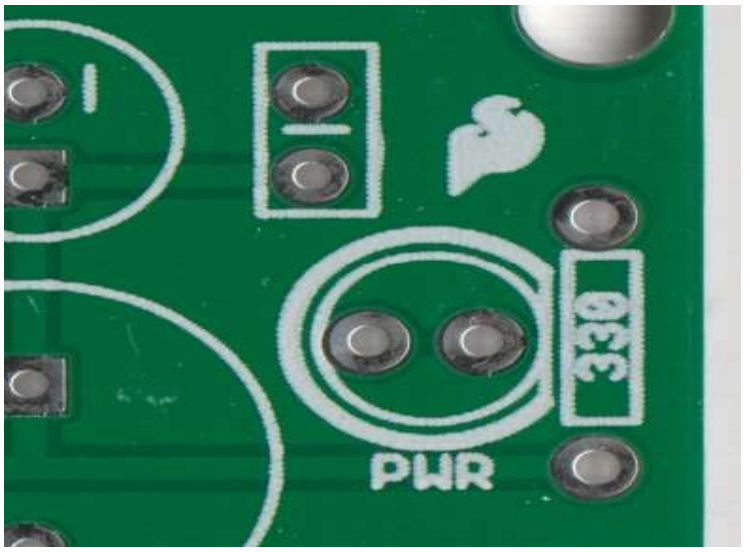
In the example below, the green solder mask is applied to the majority of the PCB, covering up the small traces but leaving the silver rings and SMD pads exposed so they can be soldered to.



Soldermask is most commonly green in color but nearly any color is possible. We use red for almost all the SparkFun boards, white for the IOIO board, and purple for the LilyPad boards.

Silkscreen

The white silkscreen layer is applied on top of the soldermask layer. The silkscreen adds letters, numbers, and symbols to the PCB that allow for easier assembly and indicators for humans to better understand the board. We often use silkscreen labels to indicate what the function of each pin or LED.

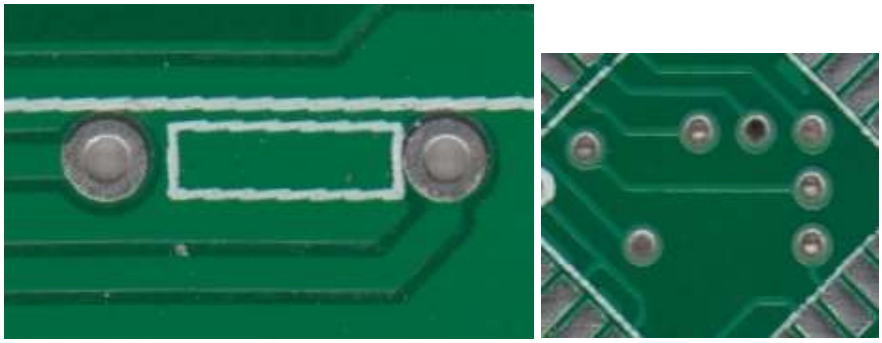


Silkscreen is most commonly white but any ink color can be used. Black, gray, red, and even yellow silkscreen colors are widely available; it is, however, uncommon to see more than one color on a single board.

Terminology

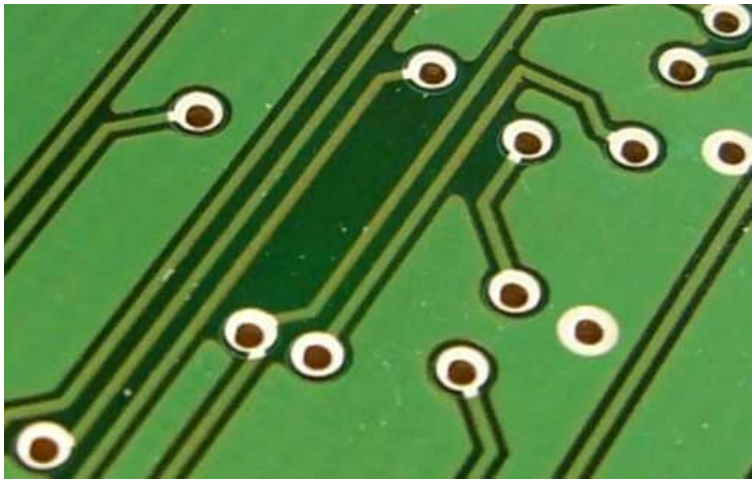
Now that you've got an idea of what a PCB structure is, let's define some terms that you may hear when dealing with PCBs:

- **Annular ring** - the ring of copper around a plated through hole in a PCB.



Examples of annular rings.

- **DRC** - design rule check. A software check of your design to make sure the design does not contain errors such as traces that incorrectly touch, traces too skinny, or drill holes that are too small.
- **Drill hit** - places on a design where a hole should be drilled, or where they actually were drilled on the board. Inaccurate drill hits caused by dull bits are a common manufacturing issue.

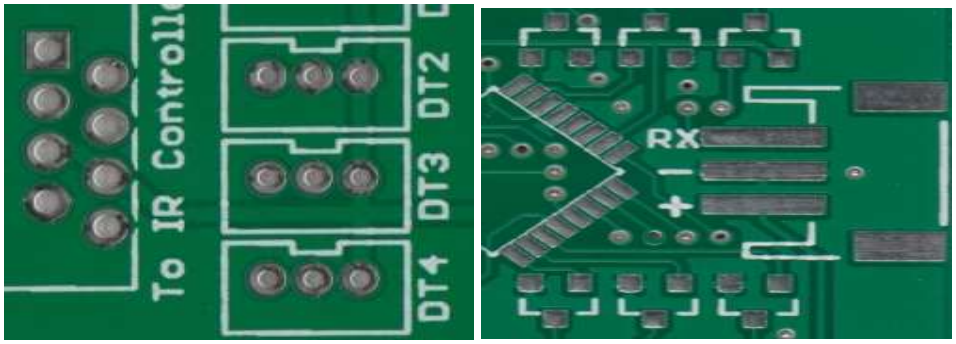


Not so accurate, but functional drill hits.

- **Finger** - exposed metal pads along the edge of a board, used to create a connection between two circuit boards. Common examples are along the edges of computer expansion or memory boards and older cartridge-based video games.
- **Mouse bites** - an alternative to v-score for separating boards from panels. A number of drill hits are clustered close together, creating a weak spot where the board can be broken easily after the fact. See the SparkFun Protosnap boards for a good example.

Mouse bites on the LilyPad ProtoSnap allow the PCB to be snapped apart easily.

- **Pad** - a portion of exposed metal on the surface of a board to which a component is soldered.

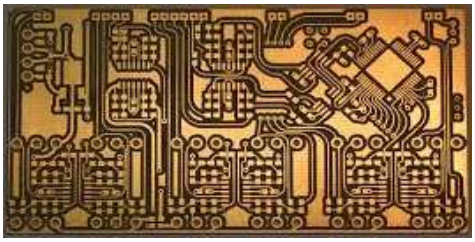


PTH (plated through-hole) pads on the left, SMD (surface mount device) pads on the right.

- **Panel** - a larger circuit board composed of many smaller boards which will be broken apart before use. Automated circuit board handling equipment frequently has trouble with smaller boards, and by aggregating several boards together at once, the process can be sped up significantly.
- **Paste stencil** - a thin, metal (or sometimes plastic) stencil which lies over the board, allowing solder paste to be deposited in specific areas during assembly.

What Are The Advantages Of Using A Printed Circuit Board (PCB)

August 29, 2017 by Tarun Agarwal 2 Comments



PCB

The printed circuit boards are very vital part of a modern electronic equipment. PCB is an acronym for printed circuit board. A basic PCB circuit consists of a very large number of passive and active components. All the components are connected from side to side with traces on the board. It is absolutely possible to develop very large circuits on small printed circuit boards with the availability of very small sized electronic components.

Printed circuit board offer varied advantages which make them the perfect choice for the manufacturers of electronic components, instruments, and equipment everywhere. The advantages of the printed circuit board are discussed below.

Compact Size and Saving of Wire

A characteristic PCB includes a large number of electronic components. On a Printed circuit board, the interconnection between the components is made through copper tracks instead of using a number of current carrying wires. It makes the interconnections less bulky.

Most of these components are very small in size. It would be close to impossible to connect these components together with wires without the aid of printed circuit boards.

A typically printed circuit board offers a simple platform to arrange the electronic components in a compressed and efficient way. This compactness allows the creation of big and complicated electronic circuits in small form factors. This, in turn, takes less space in devices.

Ease of Repair and Diagnostic

If in case of any damage, it’s very easy to check and replace the particular failure components. The electronic components and their polarities on a properly designed, printed circuit boards are clearly labeled on the board.

This allows convenience during the installation process as well as repair process. Signal paths are often traced during diagnostics.

Saving of Time

The conventional method of circuit connections takes much time to connect the components. Whereas the printed circuit board takes less time in assembling a circuit as compared to conventional method.

Immune to Movement

The most important thing to notice is that all the components on a printed circuit board held fixed to the board. This is done by solder flux which does not allow them to move irrespective of the movement of the board itself.

Tight connections and Short Circuits Avoided

As the connections are made automatically through copper tracks, there is no chance of loose connections or short circuit.

Low Electronic Noise

A printed circuit board (that has been properly laid out) gives less electronics noise. If it is not laid out properly, then the noise could significantly degrade the performance of the circuit.

The electrical components on a printed circuit board are organized in a way that the path lengths of the electrical current between them are as less as possible.

This leads to low radiation and pickup of electromagnetic waves, thus ensuring lower crosstalk in between components and in between varied traces, which usually is a major concern in electronic circuits.

The electrical noise can be released in the form of heat, radiation, or flickering sound.

Low Cost

Mass production can be achieved at lower cost.

Reliability

All the above factors bring reliability in the performance of the circuit.

Disadvantages of Printed Circuit Boards

As the copper tracks are very thin they can able to carry less current hence a PCB can not be used for heavy currents because in that case the strips will be heated up and cause problems.

Soldering needs precautions on the risk of strips being over heated and destroyed are always there.

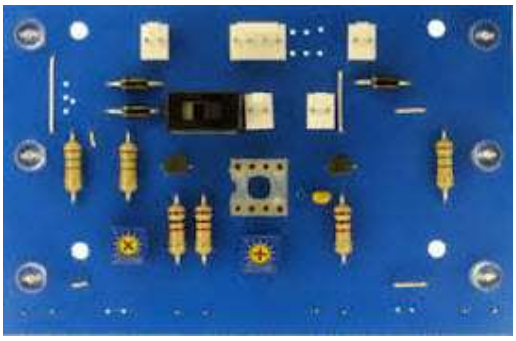
Types Of Printed Circuit Board

As we discussed above the printed circuit boards are electronic circuit boards for mounting electronic components on a non-conductive board, and for creating conductive connections between them.

The creation of circuit patterns is accomplished using both additive and subtractive methods. The conductive circuit is generally Copper, although Aluminium, Nickel, Chrome, and other metals are sometimes used.

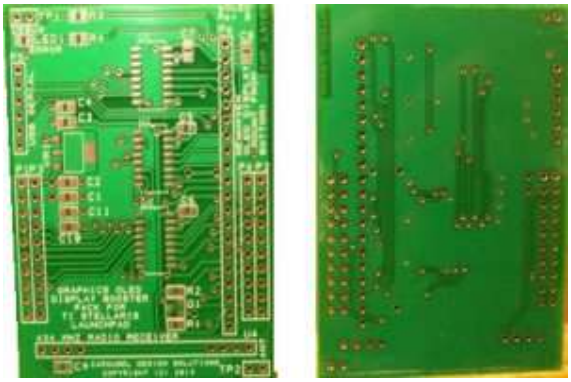
Depends upon the spatial and density requirement, and the circuitry complexity determines the type of board to be produced. There are three basic variants of printed circuit boards as below mentioned:

Single sided PCB: conductors on only one surface of the dielectric base of the printed circuit board.



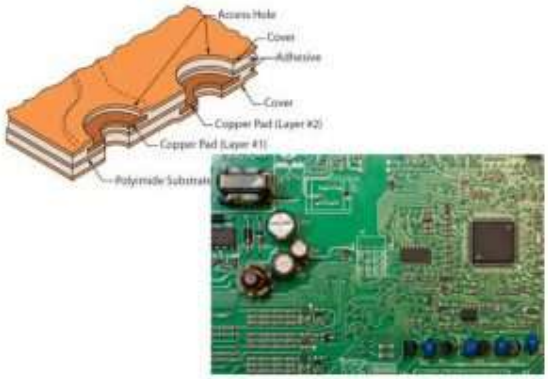
Single Sided Printed Circuit Board

Double sided PCB: conductor on both sides of a dielectric material and the layers interconnected by plated through holes (PTH).



Double Sided PCB

Multilayer PCB: conductors on three or more layers separated by dielectric material and the layers are interconnected by PTH or pads.



Multilayer PCB