The Definitive PCB Design Guide

Everything You Need To Know

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Most electronics require a **printed circuit board (PCB)** to operate, both as the wiring area for socketed and surface-mounted components as well as a physical support structure. PCBs typically consist of epoxy fiberglass, and other composite materials. For basic electronics, such as your garage door opener, most PCBs have a single layer, but more sophisticated devices like motherboards or computer graphics cards can have as many as 50 or even more layers.

While most commonly associated with computers, PCBs are also present in radios, televisions, cell phones, digital cameras, and other electronic devices. There are several styles of PCBs available to fit a broad range of applications and industries.

This eBook will discuss how to make a circuit board, the materials commonly used, and how to design PCBs to meet the demands of varying applications.

PCB Types

PCBs are classified by type based on the design specifications, manufacturing processes, and application requirements. Complex designs may require more space, electrical and mechanical stability, and the ability to handle stress. The three main styles of PCBs include the following:

Single-sided boards:

All of the necessary components get placed on one side of the board. The PCB consists of a single layer of substrate or base material with one side coated with a thin metal layer (usually copper) that acts as an electrical conductor.

Double-sided boards:

Both sides of the board contain the necessary components. There are conductive metal layers on both sides of the board, and holes are drilled and plated with copper to allow circuits to connect to either side of the board.

Multi-layered boards:

A series of three or more layers are, with copper coating, imaged and then have the copper etched away, leaving the necessary circuits. The layers are then laminated together using fiberglass bonding material called prepreg. Multi-layered boards are made up of multiple double-sided layers, laminated together, increasing the circuitry routing through these layers. They come in a variety of sizes, ranging from three to 50 or more layers, and are beneficial in GPS technology, file servers, medical equipment, consumer electronics, and data storage applications.

PCBs can also be classified by their degree of flexibility:

Rigid PCBs:
Constructed of a solid substrate material, which prevents the board from twisting or bending

Flexible PCBs:
Constructed of flexible materials, such as Kapton® polyimide, polyester, or PEN that can easily move and flex

Rigid-Flex PCBs:
Constructed of multiple layers of rigid PCBs built around layers of flexible PCBs

PCB Materials

Each sublayer of a PCB consists of different materials to meet the board's operating requirements. Starting from the core to the outside edges for double-sided boards (or from the bottom up), the layers are:

Layer 1
A thin fiberglass board with copper on both sides, called laminate or innerlayer

Layer 2
Prepreg, a resin coated glass fabric which is used to bond the layers together

Layer 3
Electronic pathways usually constructed from copper, called circuits and vias

Layer 4

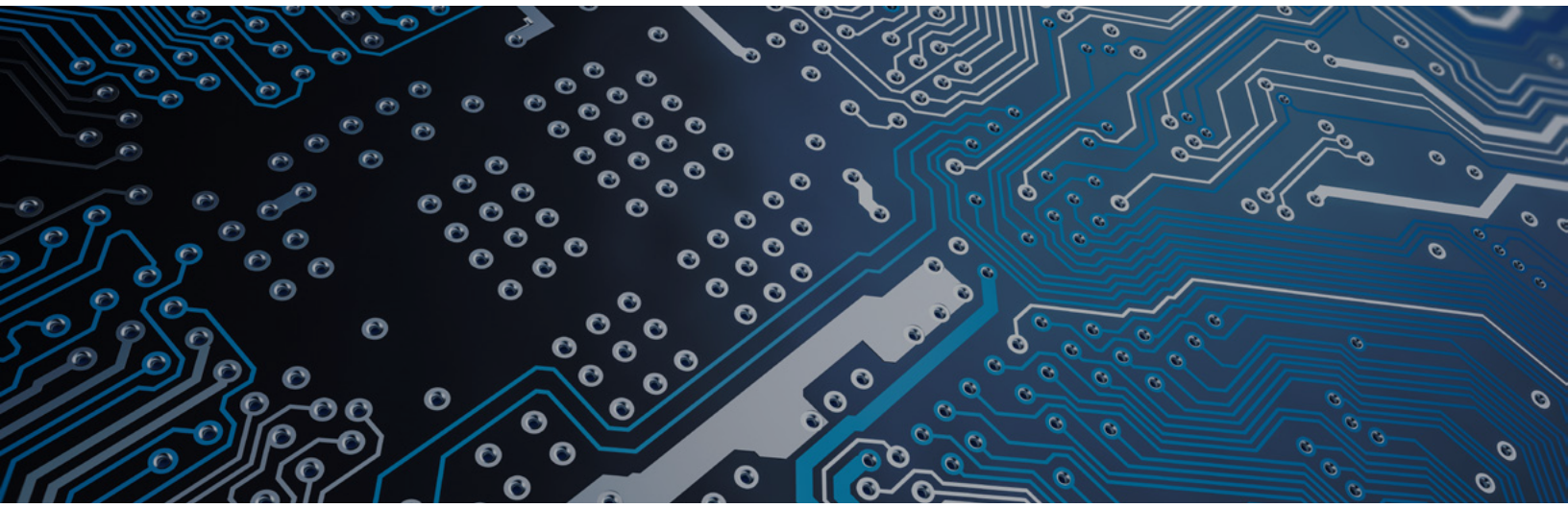
Solder mask which covers and protects the outerlayer circuits from shorting and oxidation

Layer 5

Nomenclature which is the white lettering on top of the soldermask, indicating where components are to be placed

Layer 6

A final finish to the copper surfaces of the external layers, protecting the copper from oxidation and promoting solder assembly of the components



PCB Construction

Circuit board materials must be chosen based on the application's environmental and electrical requirements and the schematic, which determines the circuits and routing required to connect all of the required components.

There are several important considerations for choosing materials for a PCB, since each type of material has distinct advantages and disadvantages. Some commonly used materials for fabrication include:

FR4:

This flame retardant laminate contains an underlying woven-glass fabric layer with an epoxy resin binder. The NEMA-grade material has been utilized for 50+ years and can withstand continuous operating temperatures of up to 180 °C. However, it is not always the highest performance choice of materials, due to relatively slow(er) signal speeds in the circuits and a relatively high(er) coefficient of thermal expansion (CTE).

Polyimide:

Polyimides are synthetically mass-produced polymers used for PCB bases that are fire retardant, very temperature resistant, and thermally stable.

Flexible polyimide:

This material is extremely flexible and commonly used for constructing flexible and rigid-flex printed circuit boards. It is thermally stable and offers excellent tensile strength, durability, and warp resistance.

MEGTRON, and other high-speed, low-loss materials:

Designed for use in digital products with higher signal integrity and higher speed requirements, MEGTRON and similar materials also can withstand extreme temperature ranges.

PTFE (Teflon) and PTFE composites:

This material often gets used for radar applications, satellite dishes, or other very high-speed communication applications. It can withstand environmental conditions better than other resin materials, such as FR4.

PCB Applications

All electronic devices require PCBs to function according to the desired specifications. These essential components are found in computers, tools, automobiles, mobile phones, televisions, video games, satellites, and more.

The following industries rely heavily on the use of PCBs:

Aerospace:

The aerospace industry often utilizes flexible PCBs that can withstand the continual high-vibration environments commonly found in aerospace applications. The PCB must be lightweight and capable of fitting into tight spaces, such as behind gauges on a dashboard or inside an instrument panel.

Military:

Most military instruments require a wide variety of PCB types, with applications including temperature sensors, power supplies, control tower systems, power converters, monitoring equipment, and more.

Medical:

Most medical devices require a high-density PCB for creating small, dense designs for use in pacemakers and other small medical equipment. Larger applications such as X-ray or CAT scan machines require significantly larger PCB designs.

Industrial & Commercial:

High-powered industrial machinery commonly requires a PCB for proper operation. Thick copper PCB construction often is utilized for equipment involving high-current battery chargers, motor controllers, and industrial load testers.

Robotics:

PCBs power the control system for robotics, working in tandem with actuators, sensors, power supplies, and feedback for proper operation.

Contact your PCB fabricator to Get the Best PCB for Your Application

It is always imperative to consider the demands of an application before selecting a PCB. **Contact us** or request a quote to learn how we can help you find the PCB that best meets the needs of your application.