# Engineering Level 2– Printed Circuit Boards

# 1 of 16 - Welcome

Welcome to this session on printed circuit boards.

By the end of this session, you will be able to:

* Understand and identify the printed circuit board (PCB) manufacture process
* Understand the surface mount technology (SMT) process

# 2 of 16 - What is a printed circuit board? A printed circuit board (PCB) is a type of printed electronics which connects electronic components by using conductive pathways, tracks or other features, which are etched into sheets of copper laminated between layers of a non-conductive substrate such as fibreglass or epoxy.

# If a PCB only has copper tracks and elements such as capacitors or resistors, it is commonly referred to as a printed wiring board (PWB) but can also be referred to as an etched wiring board, or a simple PCB.

# 3 of 16 – Uses of PCB’s

Printed circuit boards are an essential part of almost all types of electronic equipment, both consumer and in industry. Below are just a few examples of items which use PCB’s:

* Game consoles
* Smartphones
* Microwaves
* Kettles
* LED lights
* Pacemakers
* Aerospace communication equipment

# 4 of 16 – Manufacturing a PCB

There are several steps taken to manufacture printed circuit boards. Click on the tabs below to view these steps.

1. Design and produce PCB artwork (the pattern which will be used on the board)
2. Etch the PCB (removal of copper to produce the pattern)
3. Drill the board
4. Populate and solder additional parts

# 5 of 16 – Designing and producing a PCB layout

This first process can begin with sketching out some simple designs. Ideas for these designs need to include space on the board for additional components such as heat sinks. In modern day manufacturing size is incredibly important, so you should try to make your circuit board as compact as possible.

Once you have decided on a layout, you should produce a schematic to aid you in the computer aided manufacturing (CAM) process. Programs such as Autodesk Eagle or KiCAD include both a schematic editor, as well as a PCB editor which includes the ability to manage multiple PCB layers for more complex circuit boards.

You can then use your schematic to either print off the pattern, or you can upload the pattern directly to a PCB milling machine which will then use your layout to etch copper directly off printed circuit board material.

# 6 of 16 - Etching a PCB Typically, the PCB etching process can be divided into two types: chemical and laser.

# Both of these types require a similar ‘end’ process which involves putting the board inside an etching solution to remove the copper from the pattern on the board. Their differences are in how the pattern is transferred onto the board.

# Most industries use laser etching, photoengraving and silk screen printing as a way of etching their PCBs. The main benefits for these types of engraving is that they are done by machine, which significantly reduces the chances of human error or accidental defects during the process of applying the artwork to the circuit board.

# Chemical etching is the process of coating PCB artwork in a solution which is then transferred on to the PCB itself. The designed circuit is printed out, then the board and circuit image are cut to the appropriate size. The components are then exposed to UV light for a small amount of time. Once this is done, the transfer will be complete but not visible on the PCB, as it needs to be developed to make the circuit visible. Finally, the board is placed inside an etching solution which removes copper from the pattern.

# [Watch this video to view an example of simple chemical etching.](https://www.youtube.com/watch?v=ILRdnfEM7YI)

# 7 of 16 – Drilling a PCB

Printed circuit board drilling is a very important step in the process of PCB manufacturing. There are two main reasons holes are drilled; either to allow electrical connection between the layers of a PCB, or for non-conductive component holes for mounting the PCB. As surface mount technology increases in prevalence, the majority of holes on modern PCBs are frequently vias.

Vias are made conductive by electroplating or are sometimes lined with a tube or rivet. There are three main types of via. These are:

* Through holes – Drilled entirely through the board
* Blind via – Only exposed on one side of the board
* Buried via – Connecting internal layers without being exposed

# 8 of 16 – Soldiering components onto a PCB

A printed circuit board can have many components which need to be soldered onto it. Before beginning, you should make sure the solder areas are thoroughly cleaned using a surface preparation pad, then rinsed off with a solvent such as acetone to remove any chemical contamination. Let the board dry and gather your components.

It is generally a good idea to start with your smallest and flattest components, then work up to the larger ones. This will help keep the board stable while soldering, and provide you with more space to work in. If you have sensitive components such as laser diodes or CMOS chips (which make up computer graphics cards) you should put these aside until you have finished soldering the other components. This is to decrease the chance of damaging them while assembling the rest of the circuit.

Once you have soldered a component you should inspect the join, then clean any excess residue from the board. This is important as soldering chemicals such as flux can build up and potentially become conductive, which could lead to damaging the PCB.

# 9 of 16 – Surface mount technology

Surface mount technology (SMT) is a method of producing electronic circuits in which components are mounted directly onto the printed circuit board. This removes the complicated and expensive drilling of through holes and means the process can be automated.

Surface-mount devices (SMDs) are small electronic devices that can only be placed on a PCB by using an SMT machine. This type of component is soldered onto the PCB using soldering paste and has become integral in modern production.

Virtually all of today’s mass-produced electronic products are manufactured this way. The SMT process can be applied to a single person, but it is more commonly used at an industrial scale as a way of speeding up the production process.

# 10 of 16 – Surface mount technology – the process

Let’s look at the steps involved in the SMT process on an industrial scale.

1. Apply solder paste to copper pads
2. Place components using pick and place robots
3. Conveyor belts are used to transport boards to the reflow soldering oven
4. The board is heated to a temperature that melts the solder paste
5. Components are soldered to the surface of the board
6. The finished board is then inspected for imperfections

[Click on the link below to learn about a fully automated SMT production line.](https://www.youtube.com/watch?v=u0chrqzf8Hg)

# 11 of 16 – Question 1

Put the steps of manufacturing printed circuit boards into the correct order.

* Etch the PCB (removal of copper to produce the pattern)
* Populate and solder additional parts
* Design and produce PCB artwork (the pattern which will be used on the board)
* Drill the board

The correct order is:

1. Design and produce PCB artwork (the pattern which will be used on the board)
2. Etch the PCB (removal of copper to produce the pattern)
3. Drill the board
4. Populate and solder additional parts

# 12 of 16 – Question 2

Select the two types of etching process commonly used in PCB production.

1. Hand etching
2. Chemical etching
3. Laser etching
4. Magnetic etching

The correct answers are b and c.

# 13 of 16 – Question 3

Match the types of drilled holes to their definition.

***Blind via, through holes, buried via***

1. Drilled entirely through the board
2. Only exposed on one side of the board
3. Connecting internal layers without being exposed

The correct answers are:

1. Through holes – Drilled entirely through the board
2. Blind via – Only exposed on one side of the board
3. Buried via – Connecting internal layers without being exposed

# 14 of 16 – Question 4

What is a surface mount device?

1. Large electronic devices placed by an SMT machine
2. Small non-conductive materials placed by an SMT machine
3. The name given to a fully assembled PCB
4. Small electronic devices placed by an SMT machine

The correct answer is d.

# 15 of 16 – Question 5

Put the steps involved in SMT production into the correct order.

* The board is heated to a temperature that melts the solder paste
* Apply solder paste to copper pads
* The finished board is then inspected for imperfections
* Place components using pick and place robots
* Components are soldered to the surface of the board
* Conveyor belts are used to transport boards to the reflow soldering oven

The correct order is:

1. Apply solder paste to copper pads
2. Place components using pick and place robots
3. Conveyor belts are used to transport boards to the reflow soldering oven
4. The board is heated to a temperature that melts the solder paste
5. Components are soldered to the surface of the board
6. The finished board is then inspected for imperfections

# 16 of 16 – End

Well done. You have completed this session on printed circuit boards.

You should now:

* Understand and identify the printed circuit board (PCB) manufacture process
* Understand the surface mount technology (SMT) process

If you are unsure or have any questions about any of these topics, make a note and speak to your tutor for more help.