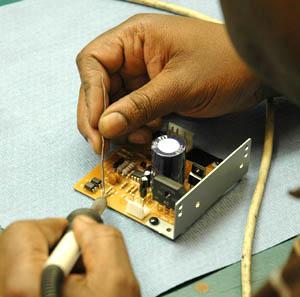
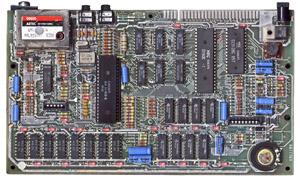
# Soldering PCBs

## Objectives

* Describe modern components used in electronics fabrication.
* Describe the parts and composition of a printed circuit board.
* List different types of electronic components.
* Describe through-hole mounting technology.
* Describe surface mounting technology.
* List different types of through-hole lead termination.
* List different types of on-board lead termination.
* Describe an integrated circuit.
* Explain how to prevent ESD when working with integrated circuits.
* List guidelines for proper handling of integrated circuits.
* Explain how to prepare for installing and soldering components on PCBs.
* Explain how to solder a through-hole component to a PCB.
* Explain how to solder a dual-inline package integrated circuit to a PCB.
* Explain how to solder a surface mount component to a PCB.
* Explain how to inspect finished soldered joints.
* Explain how to desolder through-hole and SMT components.

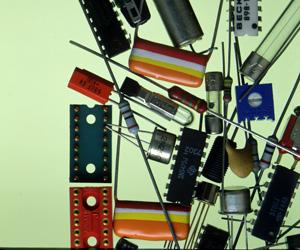
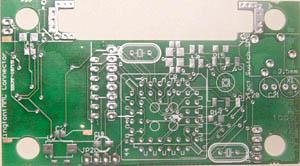
## Soldering and the Electronics Industry

The **consumer electronics** industry generates revenues of over $100 billion per year. An essential part of this industry is the **printed circuit assembly** (PCA). Figure 1 shows a PCA component. PCAs consist of **electronic components** soldered to a **printed circuit board**(PCB). They represent a dramatic shift in electronics design to circuitry that is easier and cheaper to repair than prior designs, as well as more powerful and compact.  
  
Given the enormous importance of PCAs in consumer electronics, there is a great need for skilled soldering technicians to do custom assemblies and repair work on printed circuit boards, like the one shown in Figure 2. Certification in hand soldering is available through **IPC: Association Connecting Electronic Industries**. In this class, you will learn how to create and repair PCAs by soldering and desoldering various types of electronic components on printed circuit boards.



## The Printed Circuit Board

A **printed circuit board** (PCB) is used to support and connect **electronic components**. These components may be attached by **through-hole** construction, **surface mount**construction, or a combination of both. Once the PCB has been populated with components, it is known as a printed circuit assembly, or **PCA**.  
  
A printed circuit board consists of one or more **conductive** layers, separated by a **substrate** that is usually made of **epoxy fiberglass**. The layers of the PCB are **laminated**together and connected through drilled holes, or **vias**. The substrate is then covered with a layer of copper that is etched into a conductive pattern known as the **copper trace**. This pattern provides distinct paths for the electrical current to follow, and each PCB has its own unique pattern.  
  
Figure 1 shows a printed circuit board that has not yet had any components attached to it. Note the the holes and connective patterns across the surface. Figure 2 shows a variety of electronic components. Note that components come in many different shapes and sizes.

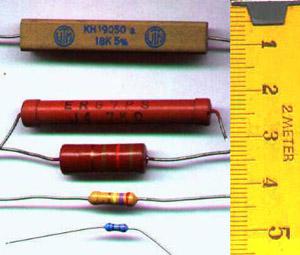


## Electronic Components

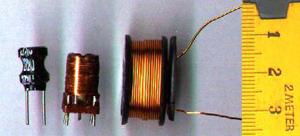
Components are very small electronic devices that are soldered to a PCB to create an **electronic circuit**. There are many different kinds of components, and each performs a specific function. Some examples of components and their functions include the following:

* **Resistors** (Figure 1) stabilize or decrease an electrical current.
* **Diodes** (Figure 2) direct the current’s flow by limiting it to one direction.
* **Inductors** (Figure 3) control magnetic fields in the current.
* **Capacitors** (Figure 4) store electrical energy.
* **Transistors** amplify the voltage.

One of the most important components of a PCB is the **integrated circuit**, or IC. Also known as a microchip or a silicon chip, an IC is a miniaturized electronic circuit that combines a variety of components like transistors, resistors, capacitors, and diodes all into one incredibly small piece.



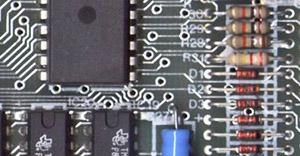


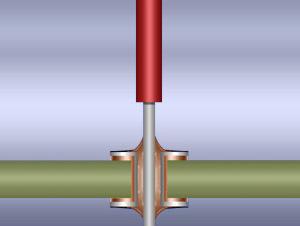


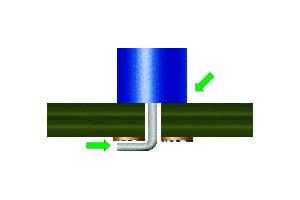


## Through-Hole Technology

A component can be attached to a PCB with either a through-hole mount or a surface mount. **Through-hole** technology (THT) refers to a method in which components are attached to a PCB by wire **leads** or **pins** that are inserted into holes in the board, as shown in Figure 1. A joint is created by soldering the protruding wires to the underside of the PCB, as shown in Figure 2.   
  
Through-hole technology provides an extremely strong and secure joint. Through-hole components tend to be larger than surface mount components, which makes them less susceptible to damage from stress. Another advantage of through-hole technology is that through-hole leads can be bent or **clinched** to provide additional mechanical support to the soldered joint, or to modify the joint. Figure 3 shows a clinched lead.





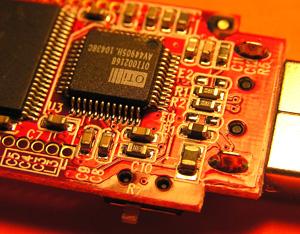


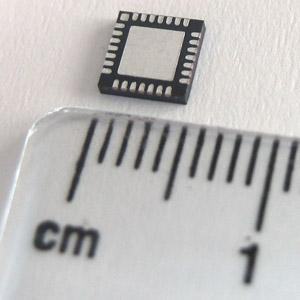
## Surface Mount Technology

**Surface mount** technology (SMT) is relatively new, but it is the preferred method of mounting components within the electronics industry today. Surface mount components are soldered directly to the surface of the PCB, as shown in Figure 1. There are several advantages to using surface mount components:

* They can be attached to both sides of a PCB, creating a more complex circuit with greater capability.
* The increasingly small size of surface mount components allows the placement of more components on a single PCB.
* Surface mount technology works very well in automated soldering processes, which increases production rates and reduces costs.

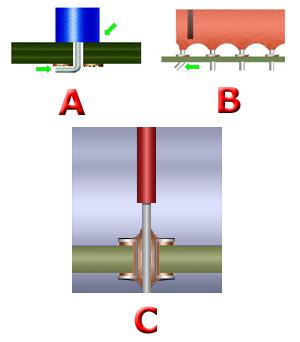
However, some SMT components are very small and can be challenging to work with by hand. You must handle them carefully to avoid damaging them, and you may need to use tweezers and a microscope to hand solder them to a PCB. Figure 2 shows a component that is so small it would easily fit on the tip of your little finger.





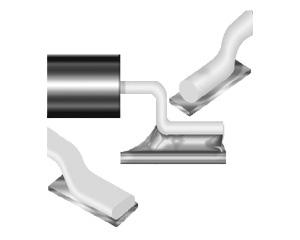
## Through-Hole Termination

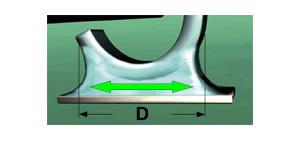
Another factor in how components are mounted and soldered to a PCB is **lead termination**. The two primary ways in which components are attached to a PCB are through-hole termination and on board termination.  
  
**Through-hole termination** means that the leads terminate through a hole in the board. As a soldering technician, you may need to **crimp** or bend component leads once you have inserted them through the board. The leads may be **fully clinched**, **semi-clinched**, or **straight-through**, as illustrated in Figure 1.   
  
A clinched through-hole joint is the strongest joint possible. However, you should take care not to damage the PCB by allowing the clinched lead to touch the edge of the through-hole or the surface of the PCB. In addition, you should avoid clinching leads in such a way that they face each other. Leads should all be crimped in the same direction, or facing away from each other in order to prevent solder **bridging**. Keep in mind that most through-hole leads must be trimmed after soldering.

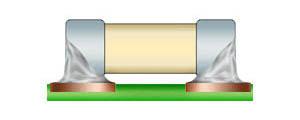


## On-Board Termination

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| |  | | --- | | **On-board termination** means that a component is mounted on top of the PCB by little "feet," or leads, protruding from the sides of a component. For integrated circuits, there are usually two types of leads:   * **Gull wing leads** (Figure 1) extend out from the sides of the component and may be round or flat. * **J-type leads** (Figure 2) curl underneath the component.   On-board termination can also take the form of caps at the end of the component, or balls or pads on the bottom of a component. Some examples of on-board SMT terminations include the following:   * **Inward-formed L** leads. The leads curl under the component similar to a J-type lead, but they are more angular and resemble the letter "L." * **Rectangular** or **square-end** leads (Figure 3). Metal caps on each end of the component are soldered to the PCB. * **Bottom-only** leads. Short leads at the bottom of the component are soldered directly onto the PCB.   When soldering an on-board mounted component, always make sure that the leads or metal parts to be soldered are set at the very center of the solder pads on the PCB. This prevents damage to the PCB, such as tearing, if the board is subjected to mechanical or thermal stress. | |





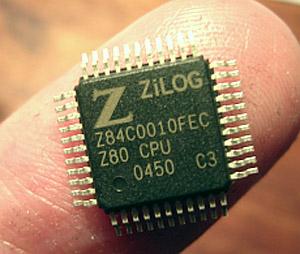
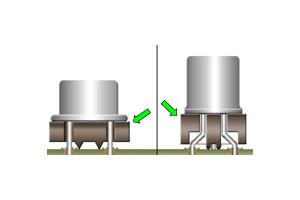


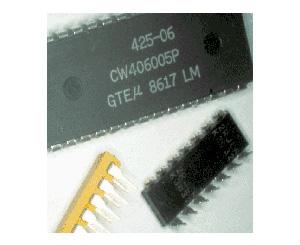
## Integrated Circuits

Integrated circuits are miniaturized circuits that have revolutionized electronics by increasing the power of electronic devices, while at the same time making them smaller and lighter. Cell phones, desktop computers, and the Internet are only some of the modern conveniences made possible by integrated circuits. The microprocessor in a computer is an example of an integrated circuit.   
  
Integrated circuits are encased in a protective cover known as the **housing** or **packaging**. The three most common types of IC housing are:

1. **Transistor-outline** or TO package (Figure 1), which is cylindrical in shape and looks like a little can.
2. **Flat pack** (Figure 2), which is named for its extremely thin (1.0mm to 1.4mm), flat shape. A quad flat pack or **QFP** has leads projecting from four sides.
3. **Dual inline package** or **DIP** (Figure 3). The DIP gets its name from the two rows of external connecting terminals or pins, which are inserted into the holes of the printed circuit board.

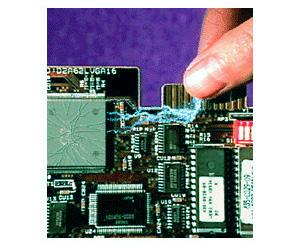
These various forms of outer packaging not only make ICs easier to handle, but also protect delicate parts from damage.





## ICs and Electrostatic Discharge

Technicians must learn how to safely handle ICs, particularly **CMOS** circuits, because of their sensitivity to static electricity, or **electrostatic discharge** (ESD). Soldering irons, testing equipment, and even human skin can generate spikes of static electricity. Static discharge of 2,000 volts or greater can cause serious damage to the IC, even though this amount of static cannot be felt by a person.  
  
Figure 1 shows static discharge traveling from a technician's hand to an electronic component. Given that a soldering technician can generate as much as 10,000 **volts** in the course of ordinary work activity, it is essential that you take precautions against ESD. You can accomplish this by adopting procedures and using devices that prevent static buildup or discharge it.   
  
A primary method of preventing ESD is **grounding**. Both you and your workstation should be grounded. Human skin easily conducts static electricity, so you should wear special wrist straps made of **Velostat** or metal. Anti-static shoes and heel straps are also available. Stand on an anti-static mat such as the one shown in Figure 2. Keep your work area free of the static-generating materials shown in Figure 3, which include Styrofoam, vinyl, and plastic. Your work area should also have an **ionized air blower**.



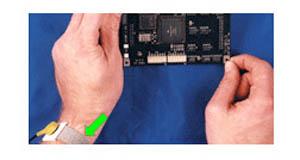


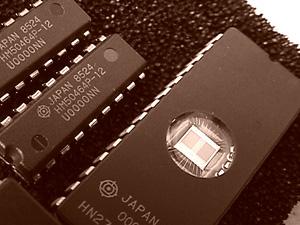


**Figure 3.**Keep your work area free of static-generating materials, like the plastic bag and Styrofoam cup on this work table. (Courtesy of NASA.)

## Guidelines for Working with ICs

|  |  |
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| |  | | --- | | When handling integrated circuits, you should follow these guidelines to prevent damage:   * Handle circuits as little as possible. * Read the warning labels on CMOS packaging and follow the instructions. * Always wear grounding wrist straps (Figure 1). * Use only grounded tools and testing equipment. * Use static-safe storage bins, racks, or other static-safe materials to store ICs (Figure 2).   As a general rule, you should hold components by the edges to prevent contaminating them with skin oil or other substances such as soaps, lotions, lint, or food particles. Even fingerprints can be harmful to integrated circuits. If possible, wear anti-static gloves, like the pair shown in Figure 3. | |





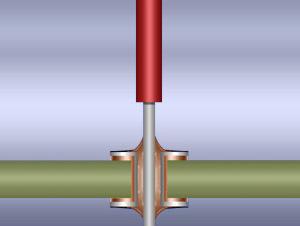
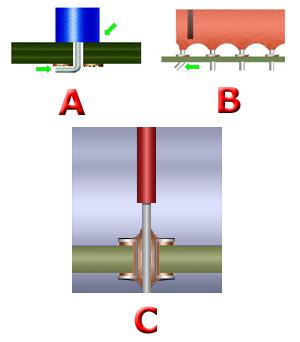


## Preparation for Installing and Soldering PCB Components

Before you solder any electronic component to a PCB, you should select the proper work materials. Always use a flux that is classified as **R** or **RMA** for electronic components. These are relatively mild fluxes that will not damage electronic parts. The type of solder you use may be determined by your employer. However, most electronic soldering is done with either **60/40** or **63/37** **SnPb** solder. Various types of lead-free solders are now being used as well. Figure 1 shows a spool of rosin-core solder.  
  
Your next step is to clean the components you will be soldering, including the leads. This usually can be done with warm water, **isopropyl alcohol**, or a flux pen like the pen shown in Figure 2. You should also clean the soldering iron tip you plan to use.  
  
Finally, inspect the printed circuit board to make sure it is free of dirt or residue and has a smooth surface. There should be no warping, bubbling, or discoloration of the substrate. Figure 3 shows a printed circuit board that is in good condition and has no defects.

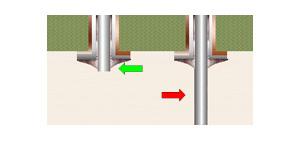
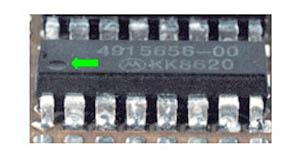
## Soldering Through-Hole Components

Before you solder any electronic component to a PCB, you should select the proper work materials. Always use a flux that is classified as **R** or **RMA** for electronic components. These are relatively mild fluxes that will not damage electronic parts. The type of solder you use may be determined by your employer. However, most electronic soldering is done with either **60/40** or **63/37** **SnPb** solder. Various types of lead-free solders are now being used as well. Figure 1 shows a spool of rosin-core solder.  
  
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Finally, inspect the printed circuit board to make sure it is free of dirt or residue and has a smooth surface. There should be no warping, bubbling, or discoloration of the substrate. Figure 3 shows a printed circuit board that is in good condition and has no defects.



## Soldering DIP ICs

When soldering dual-inline package integrated circuits (DIPs), you must find and identify the number of each through-hole pin in order to properly attach the component to the PCB. The pin reference mark is a notch or dot on top of the package near one of the pins, as shown in Figure 1. When you view the DIP from the top, pin #1 will be the first pin in the counterclockwise direction next to the reference mark. In some cases, the reference mark appears on the pin itself. That is pin #1. All the other pins are numbered consecutively in a counterclockwise direction from pin #1.   
  
DIPs typically have between 4 and 16 pins, although some manufacturers are making DIPs with up to 64 pins. After inserting the DIP into the PCB, you may partially clinch up to four leads, two on each side.   
  
Turn the PCB over and solder from the bottom. Leads should not be soldered consecutively, therefore, solder every other lead. This reduces the concentration of heat and limits possible damage to the IC or the PCB. The solder should extend no more than halfway up the lead on the component side. The solder **fillet** on the solder side should not be different from any other straight-through lead connection. Trim any long leads, as shown in Figure 2, after the DIP is soldered onto the board.

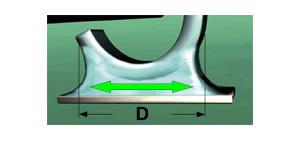
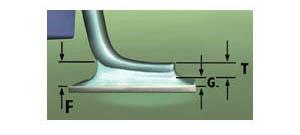


## Soldering Surface Mount Components

To solder surface mount components, clean the **pads** the components will be placed on with a small amount of flux. Next, tin the pads by applying a small amount of solder. Using tweezers, pick up the SMT component, holding it at a horizontal angle. Flow solder onto the pads and move the component into position, making sure the leads are centered in the pads. Soldering techniques will vary somewhat, depending on the shape of the component and lead type:

* For gull-wing leads (Figure 1), draw solder up the leads.
* For components with numerous leads such as **DIPs** or **QFPs** (Figure 2), solder every other lead and then go back and solder the remaining leads.
* For J-type leads (Figure 3), apply solder from the outside and work inward.

To form a proper joint, remove your iron, but continue to hold the component in place for a few seconds until the solder has solidified. The component should be sitting flat on the PCB. If it is not, you must re-melt the solder and move the component into proper position by pressing down on it gently with your tweezers.



## Joint Inspection

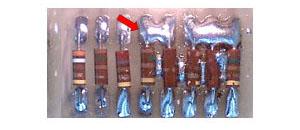
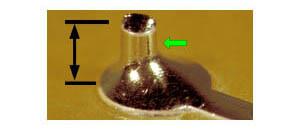
Effective fluxing and proper solder wetting are crucial to forming a good joint. Figure 1 shows how a good joint appears. In a quality joint, the solder:

* Covers the entire pad and slopes evenly down from both sides of the part at a slight angle.
* Is shiny and smooth for lead-based solder. Lead-free solder will take on a rather dull, grainy appearance.

Another important element in creating a good joint is using the right amount of solder. If you use too much, the excess solder will form an unreliable joint and make it difficult to see defects, like the joint in Figure 2. Other possible defects such as poor wetting are shown in Figure 3. In a defective joint, the solder:

* Does not completely cover the pad.
* Looks like droplets or balls.
* Slopes down from a large angle.

Ideally, a soldering technician can immediately tell from the appearance of a joint what has caused the defect and will know how to fix it.



## Desoldering PCB Components

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| |  | | --- | | To desolder a through-hole component, turn the PCB on its side and place a **power vacuum pump** on the bottom side of the joint. The desoldering tool melts the solder with a heated tip at the mouth of the vacuum, then sucks up the melted solder. When using a power vacuum tool, the diameter of the tip should be the same width as the pad. If you use too large a tip, you could damage the surface of the PCB. When you feel or see the solder melting, activate the vacuum to suction it up. This should take only a few seconds.  The best way to desolder surface mount components is with a **hot-air desoldering station**. This tool has a selection of tips with nozzles that direct hot air around the perimeter of the component. Hold the tip over, but not touching, the pins. Wait 5 to 10 seconds and lift the component free. Desoldering braids are typically not recommended for removing surface mount components because the braid might stick to the surface of the PCB and cause **lifting** of the pads or damage the component. | |

## Summary

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| |  | | --- | | Printed circuit boards (PCBs) are used to support and connect electronic components. Through-hole technology is the method by which components are attached to a PCB by wire leads inserted into hole in the board. Surface mount technology (SMT) is the method by which components are soldered onto small pads attached directly to the surface of the PCB.  Components are small electronic devices that are soldered to a PCB to create an electronic circuit. There are many different kinds of components, but one of the most important is the integrated circuit (IC). Integrated circuits are extremely sensitive to static electricity, so use a grounded workstation and wear anti-static wrist straps. You should also take care not to contaminate ICs by touching them with your bare hands.   When soldering through-hole components, first determine whether the lead termination will be straight-through, fully clinched, or semi-clinched. When soldering SMTs, your technique will be determined by the shape and location of the leads. After soldering, always inspect the joint to make sure that the pad is sufficiently covered, the surface is smooth, and the solder slopes evenly down from both sides.  When desoldering through-hole components, always turn the PCB on its side and use a power vacuum pump. The best way to desolder surface mount components is with a hot-air desoldering station. | |