Electronics for Model Railways

Chapter 25

Soldering

By Davy Dick

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In memory of Margaret

Contents

Soldering

Soldering is defined as the joining of two metals using a low melting temperature alloy (solder) as the filler metal.
Solder serves three functions:

- It wets the metal surfaces that make up the joint.
- It flows to fill the spaces between the two parts.
- It metallurgically bonds the surfaces when it solidifies.

Although solder is a poorer conductor than the metals it connects, its very short conducting path means that it has little impact on the overall resistance of the joint.

Soldering requires three resources:

- A soldering iron (sometimes called a soldering bolt) to generate the heat required.
- Solder to bond the joint.
- A selection of tools and accessories to aid the soldering process.

Soldering Irons

Types of soldering iron

A range of soldering irons are available, with differing characteristics and advantages/ disadvantages.

Wired

Most soldering irons work at mains voltage (e.g. 240v in the UK) and plug directly into a mains supply socket.
This ensures a constant supply current and allows for high-wattage irons to be constructed.

Another mains-powered bolt is the hot air station. The gun blows out a clean source of heat and is very useful for other tasks such as drying glue, fault-finding, working with SM (surface mount) components, heat-shrinking and desoldering. It can be a very expensive option (see later).

Another type of wired iron use a 12v supply. This is useful when working under a baseboard, attaching the iron's cable to any 12v connection that runs along under the baseboard. Also handy for working on car repairs. They are fixed wattage irons, with no facility to vary temperature. This image shows the Antex S4144H8 CS 18W 12V soldering iron.

Portable

There are two types of portable (i.e. non-wired) irons. These have the advantage that they can be used anywhere without needing to find a source of power.
The illustration shows a typical low wattage battery-powered iron. It produces 6W and runs off three AAA batteries.
The Weller BP860CEU is an 8W model that can carry out 180 solder joints on a set of four AA batteries.
They are often described as *'cold soldering'* as the tip heats to working temperature in only a few seconds and, when switched off, the tip is safe to touch within only a few seconds.

For higher wattage portable irons you have to use external battery packs.
The image shows a TS100 iron.
It is temperature controlled and can be powered by a DC input voltage between 12V-24V, via its 5.5mm barrel connector.

The temperature can be set anywhere between 100°C and 400°C and the temperature is displayed on a digital readout.
When powered with 12V, it produces 17W and 65W when powered

A *'Cold Heat'* type of iron has a tip made up of two prods that are shorted by the joint/solder and the high resulting current produces an almost instant heat. When removed from the joint, the tip cools very quickly. This iron is NOT suitable for kit building as the voltage it produces may damage electronic components.

The other form of portable iron is gas powered, as shown in the illustration, and uses normal cigarette lighter fuel. A typical gas iron will run for about 20 minutes on a butane fill.
With portable irons, you gain convenience of use at the cost of regular replacement of batteries/gas and less control over temperature.

Wattage and temperature

These are different characteristics but they are closely linked.
The temperature specifies how hot the iron's tip can become, while the wattage determines how long this temperature can be maintained when applied to a joint (i.e. the heat capacity).

> Soldering is all about applying heat at the correct temperature and for the correct amount of time, for any given job.

So, using a higher wattage iron does not necessarily providing greater heat; it means it may provide heat for a longer period.
In some situations, a sustained heat is necessary - e.g. when soldering brass items together or when soldering an earth wire to a metal chassis. A low wattage iron would not be capable of maintaining a constant high temperature, as the heat would be shunted away by the large area of the job being soldered.

On the other hand, high sustained heat applied to small joints could easily result in burnt/lifted PCB tracks and burnt components.

Modellers may, therefore, have two soldering irons - a lowish wattage iron for working on circuit boards and a higher wattage iron for soldering track droppers, brass kits, etc.

Soldering irons rated at 12W / 15W /17W / 18w are generally used for assembling kits, with 25W irons used for general layout work (e.g. brass kits, track droppers, baseboard wiring).

Higher wattage irons range from 40W / 50W / 80W / 100W and are used for larger soldering jobs, such as connections to metal chassis, large terminals, earthing tags, stained glass windows.

Variable temperature irons

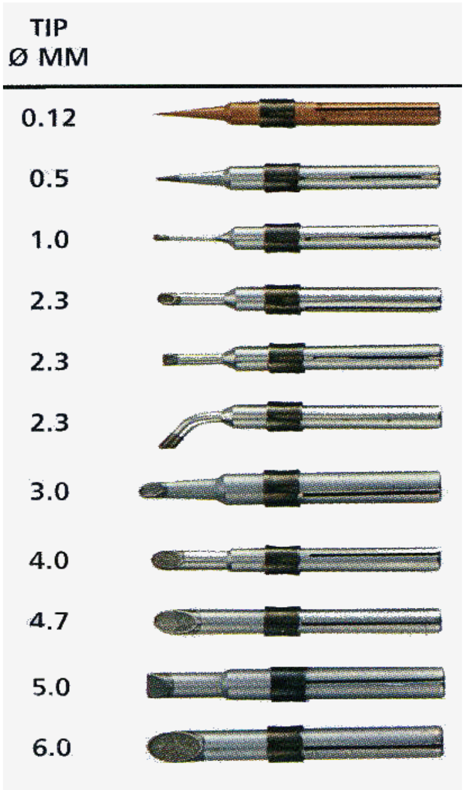
Different types of solder melt at different temperatures (see later). Also, desoldering 60/40 solder is normally carried out at a higher temperature than soldering.
To provide this flexibility, you can buy a *'soldering station'*.
This is a soldering iron that can have its bit temperature set by a rotatory knob or by push-buttons (as in the illustration).
A cheaper alternative is the soldering iron whose temperature is controlled via a miniature setting dial, set into the handle which is continuously variable from 200 to 450°C .

Typical operating temperatures are:

60/40 (leaded) solder - 280°C to 320°C
Lead-free solder - 350°C to 400°C
Solder for white metal - 80°C
Desoldering - 320°C to 360°C
Sleep - 220°C

Bits

The tip of the soldering iron's bit is usually made from copper or copper alloy, to achieve the best heat transfer to the joint being soldered.
As the illustration shows, a wide range of bit sizes is available, even for average soldering irons.
The size of the tip determines the heat transference capability, while the shape of the tip determines how well the heat is transferred to the joint.
The trick is to match the tip size/shape to the nature of the work.
The smallest bit shown is ideal for working with tiny components, or in awkward places to reach.
The largest, chisel-shaped, bit is best used to transfer large amounts of heat to large surface areas.



Solder

For many years, solder was made from an alloy of tin and lead, usually in the proportions of 60% tin and 40% lead (therefore known as '60/40 solder').
However, on July 1, 2006 the European Union Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction of Hazardous Substances Directive (RoHS) banned using lead in most consumer electronics products manufactured in the EU.

60/40 solder is still OK for home/hobby use and is still manufactured. It is widely regarded as easier to work with than lead-free solder.

The melting points of different solders are:

60/40 solder – 188°C
LMP (Low Melting Point) for SM – 179°C/188°C
Low Melt (for white castings) – 70°C
Lead-free solder - 217°C to 227ºC

Lead-free can have a matt finish, whereas leaded solder is shiny.
Solder is available in different thickness.

- 18swg is used for for larger joints
- 22swg is used for kit building.

Low melt solder, for use in constructing white metal loco kits, is supplied in sticks or as solid blocks.

Flux

A successful soldered joint requires that the surfaces to be soldered be perfectly clean, both before and during the soldering process.
Unfortunately, metals such as copper and tin oxidise rapidly when exposed to air, moisture or heat. It forms a non-conductive, therefore non-solderable, surface on the metal. For example, copper's normally bright shiny colour turns to a dull, orange colour.

Flux is a chemical cleaner with three jobs;

- It removes any existing oxide layer from the joint's surfaces.
- It prevents the joint's surface from oxidizing under the extreme heat of the bolt – until the solder makes the joint.
- It encourages the flow of solder into the recesses of the joint.

Most solder has several cores of flux embedded in the solder (maybe 3 or 5 cores). When heat is applied, the flux flows out over the surfaces to be soldered, thus removing any oxides and preventing re-oxidation during the soldering process.

It is possible to buy a flux pen, shown in the illustration. It has a 'felt' tip, similar to that used in marker pens. When pressed, it dispenses flux and the pen can be used to apply addition flux to a particular spot. This is sometimes used when soldering thin lead-free solder, where the joint may not be getting sufficient flux.
Its use has been controversial, mainly due to constructors using water soluble flux pens which can cause long-term damage to the joint and its surrounding metal. The *'No Clean'* flux pen is not water soluble and is commonly used as a safe aid for soldering with thin lead-free solder.

Note

Soldering brass kits and white metal kits use different materials and different techniques from assembling electronic modules.
A Google search will result in websites that explain theses processes.
In both cases, cored solder is not used. Instead joining surfaces have flux applied to them and the solder is applied before the flux is burnt away.
For example, ROX150 Liquid flux is used for white metal soldering and Rox145 solder is used for brass and nickel silver joints.

Soldering

Successful soldering is about how heat is transferred to the joint and how solder is applied to the joint.

Below is a suggested guide to the steps.

Clean the joint

The surfaces to be soldered must be free from oxidation, grease, dirt, etc.
While flux is great at removing oxides from the surfaces, it will not clean dirt, oil, grease, etch resist, etc. For that you must use one of a number of cleaning methods.
The PCB connecting pads can be cleaned using either steel wool , fine grit sandpaper, a cleaning block, a fibreglass pen (supplied with refills) or an ultra fine abrasive pad.

Prepare wire/components

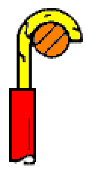
When you purchase a kit it is likely that the components have been purchased relatively recently and will only show minor amounts of surface deterioration. Nevertheless, the leads of the components should be cleaned before insertion into the PCB.
Strip off a little of the insulation on any wires that are to connect to the PCB and tin their ends (especially with multi-stranded wire) before soldering on to board.

Support the work

Holding components in place and rotating the board to the best angle for soldering, while holding the soldering iron and applying solder can be a frustrating experience. Ever wished you had three hands?

A number of devices can be used to support the board and hold it at the correct angle, freeing your two hands for the iron and the solder. For professional work an expensive PCB holding frame is available. , Hobbyists usually employ a small vice or a *' helping hand'* as shown in the illustration. This model has a clamps to hold the work, as well as a magnifying glass, a soldering iron holder and a pad for cleaning the iron's tip.

Best mechanical joint



Where possible, it is best to obtain a good mechanical connection between components. The illustration shows a wire being wrapped round a pin or a tag. This provides improved mechanical strength as well as improved electrical conductivity.
This is not always possible e.g. poking a resistor's leads through holes in a PCB. In such cases, it is best to insert the component's leads through their holes and then bend the wires to an angle. This has the double benefit of allowing the lead to touch the side of the copper pad on the PCB, as well as preventing the component from dropping out when the board is turned over for soldering.

Wet/tin the iron's tip

The first step in soldering is to heat the joint to be soldered. The iron's job is to transfer heat to the joint.   To promote the the transference of heat, the iron's bit is 'tinned' or 'wetted' – a small amount of solder is applied to the tip. This allows the tip to have a greater contact with the surfaces of the joint and prevents oxidisation of the tip.

Apply heat to joint

Use the iron's tip to apply heat to <u>both</u> surfaces of the job. Try not to rely on heat applied to one surface being transferred to the other surface. This could result in a 'dry joint' (see later).

The process is – the iron heats the surfaces
– the surfaces melt the solder that is placed on them.

Apply solder to heated joint

With the joint at working temperature, apply the solder to the joint. The heat from the joint melts the solder and its flux cores. Capillary action ensures that the molten flux covers the surfaces to be joined and also penetrates between the surfaces.

Apart from keeping the joint clean, the flux encourages the flow of the molten solder into every part of the joint. As soon as the joint is covered by the solder, the soldering iron should be removed from the joint.

The act of soldering a joint should only take about two seconds to complete. If it takes a lot longer, the iron may not be up to the job, the joint may be dirty, or you may be doing it wrong.

Enough is enough - applying heat for longer than necessary risks heat damage to sensitive components or copper tracks lifting away from the PCB. It may also change the physical properties (strength and hardness) of the metals being soldered in a process known as 'annealing' leading to failed joints at a later time.

Some dont's

Don't apply extra heat or extend the soldering time in an attempt to 'force' the solder to adhere to a dirty surface.

Don't drip solder on to to joint, or create a large blob of solder on the end of the tip, to carry over to the joint. That way, the flux that was designed to protect the joint from oxidisation during soldering is burnt off prior to the solder touching the joint. Let the joint melt the solder.

Don't use 60/40 on lead-free joints. The lead will degrade the lead-free material.

Support joint until it cools

When the soldering iron is removed from the job, the solder on the joint takes time to solidify. If the connection is disturbed during this time, it can lead to dry joints. Resist the temptation to immediately move the board and wait until the solder has cooled before snipping off the excess wires on component leads.

Some other soldering issues

<u>Soldering track droppers</u>

Soldering wires to track can be difficult, as the large amount of metal in the track can quickly shunt away the heat from the area to be soldered. Contrary to possible expectations, a high wattage iron should be used. Although this may be thought to melt the plastic, the shorter time required to make the soldered connection results in a lesser risk of melting the track. A large amount of heat for a short time is the preferred way to solder track droppers.

<u>Tack soldering</u>

Here, a small temporary solder joint is used to hold component in position (e.g. one pin of an IC socket) with the joint being remade later.

<u>Seam soldering</u>

Used in the building of brass kits, a continuous bond is made along a seam or joint, by slowly moving the iron along the seam, heating up the soldered area as it progresses.

Health and Safety

A hot soldering iron is a dangerous implement when not given sufficient respect. It is not unknown for hobbyists to burn tables, lamps – and themselves – while carelessly holding an iron (usually while engrossed in examining a joint, etc.).
Switch the iron off when not being used for a period, keep the iron in its holder when not in use, and keep the iron away from any flammables.
Remember too that the joint remains very hot for some time after the soldering is removed.
Try to avoid inhaling the fumes that are produced during soldering. Professional workshops have extractor fans, but you can use a small desk fan to push the fumes away from you. If possible, work in a well-ventilated area.
Phosphoric acid fumes can be highly irritating to the nose and lungs, while inhaling Cadmium fumes (silver soldering) can cause serious lung conditions.

Tip maintenance

Although the soldering iron tip may be clean and wetted at the start of a session, it can soon end up with a tip that is dry and is dirty.
Eventually, flux residue and oxidized lead from the solder coat the tip. This gunge is often referred to as 'clag' and can contaminate joints. A black oxide scale results from using 60/40 solder.
Since only a tip that is clean, shiny and wetted successfully transfers heat, it follows that the tip needs periodic cleaning during soldering. Different methods are compared next.

Tip cleaner

The illustration shows an example of a tip cleaner that is supplied in a small tin. The tin contains a solid disc of solder powder and some chemicals.
For badly affected irons, the tip of the iron is pushed into the cleaner and results in large quantities of smoke being produced (use in a well-ventilated room). For general use, a single wipe of the bit across the block is sufficient to clean an re-wet the tip.

Moist sponge

A very popular method is to clean the tip with a moist (not wet) sponge. The tip is wiped across the sponge to remove any oxide layer.
Most soldering iron stands and soldering stations have a built-in area for storing the sponge.
This is the cheapest method but it has its drawbacks.

It is often suggested that the sponge should be used after every soldered joint but this can lead to early tip failure.
Repeated frequent wiping during a session creates large swings in tip temperature and the metal layers that make up the tip expand and contract at different rates, leading to metal fatigue.
The sponge is also often used to remove excess solder from the tip. The tip of the iron is drawn across the damp sponge and this cools the solder at a different rate from the irons' tip, helping to remove debris. However, this dumps the excess solder, burned flux residue, and other contaminants onto the sponge. Eventually, the next time you clean the tip, you may pick up as much gunge as you deposit. To overcome this, some sponges have a circle or an arc cut out of them so that the gunge can be wiped on their

edges. This depositing the gunge in the hole rather than on the sponge.

Brass wool

A very useful option is the brass wool pad into which the tip is inserted and withdrawn, or wiped across a few times.
Brass is abrasive enough to remove the gunge without damaging the tip's coating, as brass is a softer metal than that of the tip.
Unlike the sponge, it does not cool down the iron's tip significantly, so soldering can carry on without waiting for the tip's temperature returning to its operating point.   Great for 60/40 solder, or a badly coated lead-free tip.

Abrasives

It is possible, although not advisable, to scrape the gunge off using a file, sandpaper or steel wire brush.   While they may be used in cases of extreme contamination, they should generally be avoided.
An iron's tip is generally made from a copper core with an outer iron cladding and a nickel or chrome plating.   If the protective outer plating is breached, flux is able to penetrate into the copper area. Combined with the heat, this will rapidly eat away the copper core, leading to pitting and holes in the bit's surface. If you really must use extreme measures, use extra fine grade sandpaper (between 220 and 600 grit) and be careful not to rub excessively.
You may find that a fine-bristle, brass grill-brush will be sufficient and safer.

Keep tip tinned

The tip should be kept clean and shiny during the soldering session, for the reasons already explained.
It helps if you match the diameter of the solder to the tip. Using small diameter solders may not keep the tip flooded with solder while in use and cause the tip oxidise and wear faster.
If, on the other hand, there is excess solder on the tip, remove the iron from the job, take it to an used section of the workbench (one with a protective cover) and give the iron a gentle tap or whip-like shake to remove the excess solder.
At the end of a soldering session, the iron should be left in a tinned state, to protect it from oxidation and corrosion when lying unused.

Other issues

- Do not use the iron's tip to push a component or use it as a lever (e.g. to prise out a component lead).
- Do not push solder against the tip, to force it to melt; wait until the tip is sufficiently hot to melt the solder naturally.
- Do not use pressure or rubbing of the bit on the joint, in an attempt to improve heat transfer.

Excessive force on the tip will cause the iron plating to crack, with reduced tip life as previously explained.

Use only the temperature that you need. Higher tip temperatures result in faster oxidation.
Soldering at temperatures over 470º C will make the tip to oxidise twice as fast as soldering at 370ºC.

Desoldering

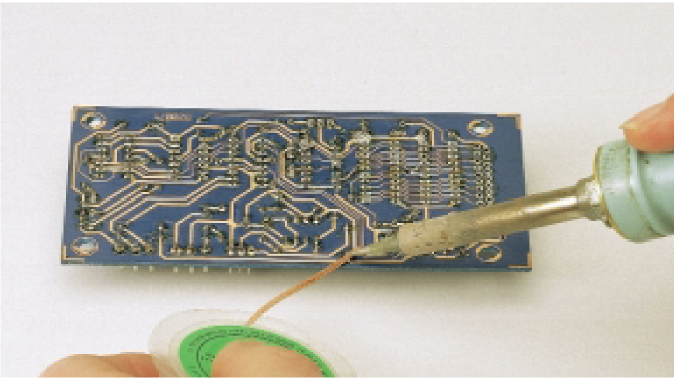
There are many occasions when you might want to desolder a wire or a component.

- A component has become faulty.
- You have wired a component in the wrong place.
- To remake a joint that you think may be suspect.
- You want to lift one lead off a component to aid in fault-finding.
- You want to recover components from a module that you no longer use.

Trying to remove the solder with only the use of the iron is often not successful, with the remaining solder running back into the joint whenever the iron is removed.

To remove large solder blobs, a desoldering pump, often called a 'solder sucker' can be used. It is a spring-loaded device that puts the spring into tension when the knob is pushed down. The iron is placed on the soldered joint to melt the solder before being quickly withdrawn and replaced by the sucker. A quick press on the button releases the spring and the solder is sucked into the body of the pump.

A very effective method for most joints is the use of a 'solder wick' or 'desoldering braid'.



The wick is made from a ribbon of braided copper wire that is impregnated with flux. The braid is placed over the soldered joint and the soldering iron's tip is then held against the braid.
The heated braid melts the solder which wicks (seeps) into the braid.
Removing the braid lifts away the excess solder.
The impregnated section of the braid is then cut off and discarded.
A typical desoldering may use up less than 1” of the braid and, since the braid comes in 5' rolls, it will last for some.

Shopping List

If you are just about to start experimenting with soldering, the following is a list of the tools and accessories you might find useful.

Must haves

- Soldering Iron
- Soldering Iron Stand (if not supplied with the soldering iron)
- Solder
- Cutters (to trim off component leads, cut wires and wire links to length)
- Pliers
- Magnifying glass / eyeglass

- Good lighting
- Protective surface (to avoid burning the dining room table!)
- Brass wool tip cleaner

Useful accessories

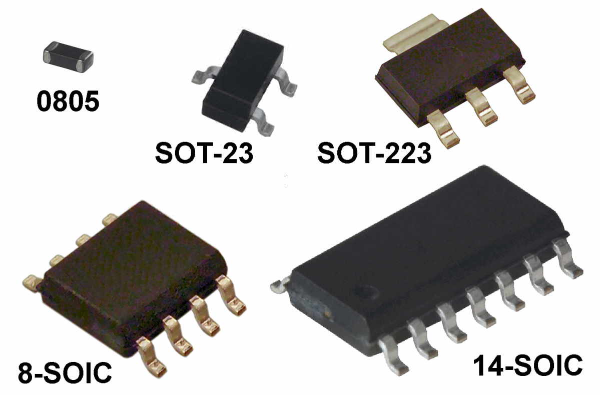
- Third 'Hand' / small vice
- Wire strippers (strips insulation from wires without risking damaging the wire)
- Solder wick / desoldering braid
- Solder sucker
- Earthing strap / anti-static wrist strap with cord (if handling static-sensitive devices)
- Brass wire brush
- Tweezers
- Tip cleaner
- Flux pen
- Heat sink (to clip on to a lead if it is being soldered close to a heat-sensitive component)

Further information on some of these tools can be found in the chapter on *"Assembling a Toolkit"*

Surface Mount components

For a long time, electronic components were of the *'through-hole'* type. They have wire leads that poke through holes in circuit boards and are soldered to the copper pads underneath. These are still in widespread use but have been joined by *'surface mount'* equivalents. These are tiny devices that allow the miniaturisation of mobile phones, etc. They also make the production of commercial boards quicker and simpler to produce, being designed for robotic pick-and-place assembly of boards, rather than the manual assembly. All the common electronic components, such as ICs, resistors, capacitors, regulators, LEDs, etc. available in both through-hole and SMD types.
Surface mount devices are so small that they are measured in thousands of an inch.
The most common size is the 0805, which means that it is 8 thou long by 5 thou wide (i.e. 2mm x 1.3mm). Most resistors and capacitors are supplied in this size. Other sizes are larger (1206 – 3mm x 1.5mm, 1210, 2010 and 2512) or smaller (0603 and even smaller).

The image shows some of the most common shapes for SMD components.
Passive components (i.e. resistors and capacitors) are found in the 0805 or 1206 outlines. General-purpose transistors use the SOT-23, with power transistors using the SOT-223 outline.
The 8-SOIC and 14-SOIC are the *'Small Outline Integrated Circuit'* outlines for many integrated circuits.



SMD components are so small that it is difficult to print conventional markings on them.
Often, they will have no markings and have to be kept in separate plastic bags with labels.

They are usually supplied on a bandolier (a 'film strip' with many sealed pockets) and should be kept there until they are ready to be mounted on your modules.
If any components have markings, they will not be ones you are accustomed to but you can look up their details at:

www.marsport.org.uk/smd/codeintro.htm

For example, a resistor marked as 273 is a value of 27k, while one marked as 2702 is a 27k resistor with a 1% tolerance.

Soldering methods

As SMD components are intended for industrial and professional use, it poses extra challenges to hobbyists who have to work with much smaller components and increased risks of shorts, dry joints, burnt-out components, etc. Having said that, many hobbyists have adapted to working with surface mount technology.
They have different (sometimes contradictory) experiences, use slightly different methods and offer differing advice.
There are three main methods, depending on what you are prepared to spend.

- Hand soldering
- Hot air
- Reflow oven

Hand soldering

Like conventional soldering, it uses a soldering iron and solder, with the possible addition of other aids and materials.

Soldering iron

You might think that you would use a soldering bit with a fine point but it will not transfer heat as effectively as a bit with a flat edge. A flat or chisel tip of at least 1mm should be used, with some users reporting great results with a tip as large as 3mm.
While a 15W iron will handle a few components, it may struggle to maintain its temperature when soldering many components, or working with large surface areas.
If you have a temperature controlled station, you will benefit from the constant heat output it provides. The temperature can be set to 315ºC to 370ºC for tin-lead solder, and 370ºC to 426ºC for lead-free solder.

A different tip is better for handling ICs and this is covered later.

Solder/Flux/Solder paste

Efficient solder flow is even more important when soldering SMD components, as prolonged application of heat from the soldering iron can damage components. Solder that contains a small amount of silver aids the flow and shortens the time needed for soldering.

From earlier, we know that flux prevents oxides from forming on surfaces, aids the distribution of heat and makes the solder flow more easily.
Normal solder has flux cores embedded in it and the flux flows when the soldering iron melts the solder. We can use this method to solder SMD components but normal solder is far too thick for the job. Instead, we use a fine gauge solder (26 SWG) that still manages to have cores of flux. Since the solder is so fine, there is not a lot of flux in the cores. If necessary, the user can apply extra flux to a solder pad using a flux pen or brushing on from a jar of liquid flux.

There are three types of flux in common use - water soluble flux, rosin-based flux and no-clean flux.

- Water-based flux is more 'active' (better at combatting oxides) but is mildly corrosive and also conductive, so excess flux has to be cleaned off with water.
- Rosin-based flux is less active, less corrosive and the residue is cleaned off using a cleaning solvent.
- No-clean flux has a low activation level, making it harder to achieve good results. However, its residue is non-corrosive and non-conductive, so does not require to cleaned away except to improve appearance.

Solder paste is something completely different and should not be confused with solder flux. Flux can be used along with your solder, as in normal soldering.
Solder paste is used *instead* of separate solder and flux. It has tiny particles of solder suspended in a flux gel. The paste is grey in colour and sticky to help hold components in place during soldering.

The two hand soldering techniques are looked at next.

Getting started

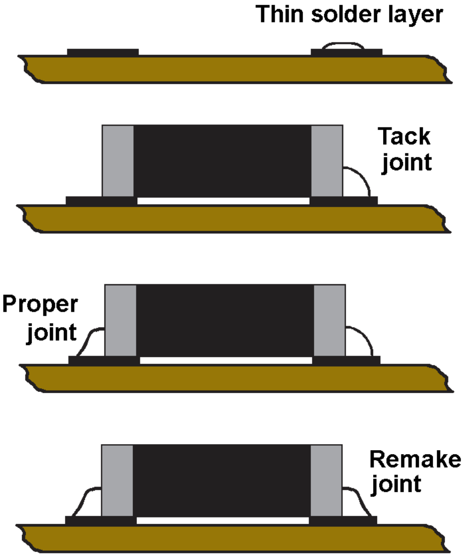
The components you are working with are tiny and the board on which they will be soldered is likely to be small too. These pose extra challenges for us.
SMD components can easily slide off the board, or even *'ping'* off in any direction and get lost forever.
It helps, therefore, to work on a flat surface that has plenty of visibility.
If you place the board on a flat work area that is covered by a large sheet of white paper (A3 or even lining paper) you improve your chances of successful construction.
Professionals use precision board holders that clamp the board to prevent movement during soldering. A budget equivalent is to stick your small board on to a larger piece of board using double-side tape or even Blu-Tack. This larger board provides stability and can be easily rotated to provide optimum access when soldering.
Other items to gather together include:

- A source of adequate light
- A magnifier (or combined lamp plus magnifier)
- A soldering iron
- The appropriate soldering bit for the method being adopted.
- Brass wool or other cleaner to maintain a clean bit.
- Tweezers
- Desolder braid
- Solder, flux or solder paste and a cocktail stick
- IPA, to clean the board before starting, during the construction where required and after completion of soldering where required.

As a rule, it is best to work with a single SMD component at a time to minimise the risks of lost components. The protective film strip should only be peeled back as far as required to uncover each component. The component can then be removed by tipping it on to the board, where it can be moved into place.

Using cored solder

The pads on the printed circuit board may or may not be pre-tinned. If the pads are tinned, ensure that they are only a thin film; any blobs should be removed with desolder braid.
If the pads are not tinned, tin one pad only.



- Pick up the component using tweezers.
- Place the component across the pads.
- Hold the component in place.
- Quickly tack one side of the component to its pad, with as little solder as possible.
- Check that the component has not moved; melt the solder and adjust if necessary.
- Maintaining light pressure on the component, solder the other end properly.
- Return to the first end of the component and solder it properly.

Solder as quickly as possible with as little solder as possible, consistent with making a good joint.
You can watch this video on YouTube:
www.youtube.com/watch?v=Jpj3tilIaik

You do not need a lot of solder to make a good joint. If a pad is pre-tinned, you may only need apply a little solder to the iron's tip and apply it to the joint, specially if you apply flux to the pads.
This is the opposite of conventional soldering where you heat the joint and then apply the solder to the heated joint. You can still manage this with fine gauge solder. Alternatively, you can melt the solder on the iron and apply it to the joint. This way, the flux will boil off before the iron reaches the joint, hence the need for additional liquid flux.
When all the components are soldered, clean off the flux residue.

Using solder paste

This method is a little simpler.

- Ensure that *both* pads are tinned with a thin layer; use desolder braid to remove any excess solder.
- Apply solder paste to each pad, using a cocktail stick or similar thin pointed object.
- Pick up the component using tweezers.
- Place the component across the pads.
- Hold the component in place.
- Place the iron's tip on one end of the component, until the paste melts and flows.
- Check that the component has not moved; melt the solder and adjust if necessary.
- After a few seconds, the joint will be cool enough to solder the other end of the component.

If your iron is too hot, the paste will sputter and minute solder balls will be sprayed out from the paste. That, and any unfused paste must be cleaned from the board.

This method can also be seen on the above YouTube video.

Soldering ICs

This can appear a very task as you have to solder multiple tags that are spaced very close to each other, with all the possible shorts that could be caused.
A number of techniques are used and they all share some basic rules:

- Before starting, make sure that all pads are tinned with a thin layer of solder. Check that there are no solder bridges between adjacent pads.
- When placing the IC on the pads; make sure the pins are centred on the pads and it is fitted the correct way round!
- Solder two pins on diagonally opposite sides of the IC. This holds the IC securely in place while soldering the remaining pins. Check and reposition if necessary before proceeding.

Some hobbyists apply flux to the pads. This method is:

- Apply flux to the pads. There is no need to dab each pad individually, just apply to the local area.
- Place the IC on the pads, soldering diagonally opposite pins.
- Solder each remaining IC pin, one at a time, using a fine gauge solder and a very fine tipped soldering iron. Pause from time to time to prevent the IC from overheating.

  OR
- Using a soldering iron with a flat tip, rub the flat tip along the pins whilst feeding solder. Pause between each row to prevent the IC from overheating.

Some hobbyists use the 'drag soldering' method. It is similar to the above method but uses a soldering iron with a special tip with a concave cup at the end. These are available as gull wing tips, bucket tips, spoon tips, or NTGW conical tips.
This acts as a reservoir or bowl for some molten solder.
This method is:

- Apply flux to the pads. There is no need to dab each pad individually, just apply to the local area.
- Place the IC on the pads, soldering diagonally opposite pins.
- Load up the reservoir pool with solder.
- Slowly run the tip across a row of pins with its solder pool facing the pins. The solder will be drawn to the joints and, with practice, there will be little or no shorts between pins.

This method can also be seen on this YouTube video;
www.youtube.com/watch?v=t06maIVew40

Some hobbyists apply solder paste to each pad.
This method is:

- Apply solder paste to the pads. There is no need to dab each pad individually, just run a strip of the paste along each row of pins.
- Place the IC on the pads, soldering diagonally opposite pins..
- Solder each remaining IC pin, one at a time, using a very fine tipped soldering iron.

  OR
- Using a soldering iron with a flat tip, rub the flat tip along the pins.

Hot air rework station

This method does not use a soldering iron to melt the solder. Instead it directs a stream of very hot air at the joint. The temperature can be set between 100° and 480° Celsius by turning a setting knob. The current air temperature from the nozzle is displayed on a LED screen.

This method is:

- Before starting, make sure that all pads are tinned with a layer of solder. Check that there are no solder bridges between adjacent pads.
- Apply solder paste to the pads.
- Place the component on, or close to, the pads.
- Heat the air gun to its working temperature and set the air flow to a constant gentle stream (you don't want to blow the component off the board!).
- Hold the gun over the work until the solder melts.
- Move the component into its final position.

Some users replace the solder paste with flux and rely on having sufficient solder on the pad to melt and complete the joint.

As the image shows, you can fit specially-shaped nozzles on the end of the hot air gun. A range of shapes and sizes is available, covering round shapes, DIP 8-pin upwards and QFP (Quad Flat Package) outlines. These nozzles direct the heat more efficiently at the work area, allowing an IC to be soldered in a single operation. They also prevent any unintended unsoldering of nearby components. Unlike soldering iron tips, the nozzles have a very long working life.
You can see this method near the end of this video on YouTube:
www.youtube.com/watch?v=Jpj3tillaik

Note

You cannot use a normal hot air gun (the kind used for stripping paint, thawing pipes, etc.). for soldering as you cannot sufficiently control its temperature.

Reflow oven

All the above methods solder one component at a time.
This method solders all the components at the same time, in a single operation.
It uses an oven with infrared heating elements.
Large versions are used industrially and the one shown in the image is smaller and used by developers and hobbyists who are willing to pay out around £200.

This method is:

- Before starting, make sure that all pads are tinned with a layer of solder. Check that there are no solder bridges between adjacent pads.
- Degrease the board, using a cleaner such as IPA.
- Apply solder paste to the pads .
- Place the components on the pads.
- Check that all components are seated correctly.
- Place the board in the oven.
- Set the timer.
- Sit back and relax while the heat melts the solder.

This is a much simpler and less stressful process than soldering one component at a time.
The drawback is the price for someone who only builds boards occasionally.
If you are really adventurous and are confident in your abilities, you can always consider building your own reflow oven, usually from a toaster oven.
Just do a Google search for 'DIY reflow oven'.

In all cases ...

Whichever method you use to solder components to boards, you should make the same final steps.

- Examine board with magnifier, looking for any problems with joints, solder bridges, components that have moved, etc.
- Remake any bad joints.
- Remove any solder bridges with desolder braid or a solder sucker.
- Remove any flux or other residue, using a cleaner such as IPA.

You may not always spot a dry joint during a visual inspection.
You can make a confirmation check with your multimeter.
You touch one prod to the lead of the resistor, capacitor or IC socket pin.
You touch the other prod on the solder blob on the other side of the board.
If you get a high resistance reading or an open circuit reading, you have detected a problem joint.