SOLDERING TECHNIQUES (Part 2)

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Hand soldering

Even today, most solder joints are made by using either a soldering iron or a soldering gun. Besides being the simplest among all the techniques, this method gives the operator maximum control over the finished joints in terms of the heat applied and the amount of solder permitted to flow. Individual attention can be given to each joint without interfering or disturbing the adjacent points. Also, the application of heat is localised to a very small area.

A soldering iron consists of a high resistance heating element and a relatively massive tip. The element is slowly heated to soldering temperature and the temperature is maintained at this level. If the tip is kept clean and well tinned, it permits the maximum amount of heat to be conducted from the soldering tip to the point at which the soldered connection is being made.

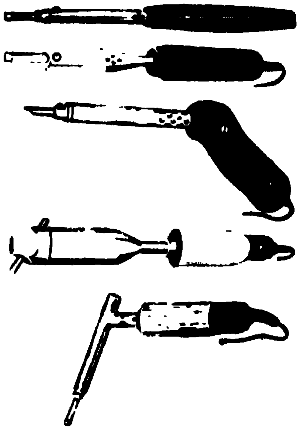

Fig. 4: Various types of soldering irons

The usual practice is to tin only that portion of the tip which is actually used during soldering. The oxidation coating on the rest of the tip then acts as a heat insulator, and reduces the risk of heat being applied to some adjacent components which the tip may touch while soldering.

A commonly-used general-purpose soldering iron tip is made of a pure copper bar which is iron clad or nickel plated to resist corrosion. The tip should not be filed, since this will destroy the plating and thus shorten the tip life. To clean such tips, use of a tip cleaner (or a fine sand paper) is recommended. After the tip has been cleaned, it should be retinned.

Fig. 4 shows soldering irons of different shapes and ratings whereas Fig. 5 shows various types of tips used for soldering.

A soldering gun (Fig. 6) comprises a step-down transformer with a thick-wire secondary winding for high current. When operated by a trigger switch, the gun's relatively low-resistance tip reaches the soldering temperature rapidly. The small tip of the soldering gun permits concentration of heat at the solder joints. This prevents damage to surrounding components from excessive heat and also saves considerable power as the gun has a very low duty cycle, i. e. 'on' time to 'off' time ratio.

Fig. 5: Various types of soldering iron bits

However, as the gun comprises a built-in transformer, it causes working fatigue if held continuously (as in line production work) because of its heavy weight. The gun is therefore best suited for those engaged in repair work.

Dip soldering

This technique is usually employed in places where soldering must be done at a rapid pace, such as in mass production work. The pre-tinned components are mounted as required on a printed circuit card, or a number of solder joints are made simultaneously and uniformly on a non-conductor base, and mechanically secured by one means or the other. The flux, normally in a liquid form, is then applied to the points to be soldered and allowed to dry. This assembly or printed circuit card is then simply dipped slowly into a solder pot to a depth just sufficient to allow solder to flow freely into all the connection points and withdrawn from the solder after a short period (Fig. 7). The advantage of this type of soldering is that gravity and temperature control the amount of extra solder adhering to the assembly. Solder with the eutectic 63:37 or 60:40 ratio is the best for dip soldering because it has either no pasty state or a very brief pasty state temperature range.

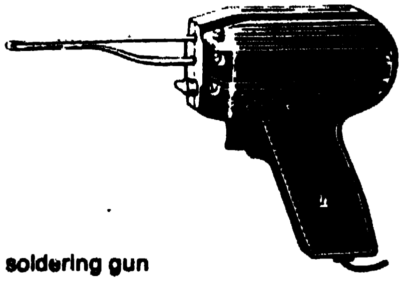

Fig. 6: A soldering gun

Wave soldering

In wave soldering (Fig. 8), a continuous molten solder is

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pumped up to the level of the printed circuit board in the form of a fountain, or a molten solder is pumped into the spout, forming a head of solder through which the work can be passed. This method has the following advantages over the dip soldering method:

1. The dynamic movement of the solder across the surface to be wetted decreases the soldering time by many orders of magnitude.

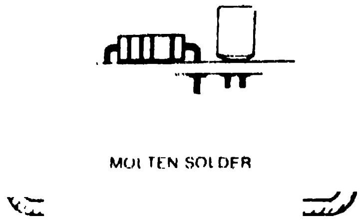


Fig. 7: Schematic of dip-soldering bath

2. The heat distortion, i. e. buckling etc, to the work is minimised to practically much within the tolerance level.
3. All flux and flux residues which are wiped off the work and would normally stay on top of the solder baths are carried down with the wave into the special reservoir where they do not come in contact with any future work.
4. The molten solder being continuously pumped, it is easy to maintain the temperature practically constant. Thus the temperature of the molten solder touching the work is always uniform and can easily be controlled and maintained.

This method is recommended for large quantities of work with a high percentage of reproducible and reliable solder joints.

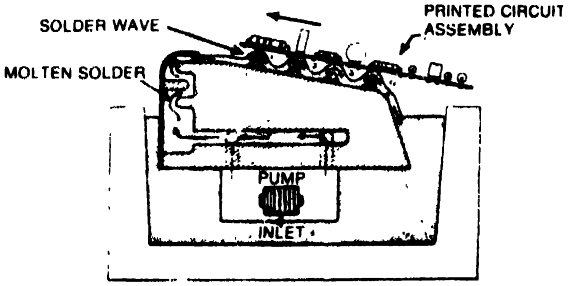


Fig. 8: Schematic showing wave soldering process. Wave nos. 2, 3 and 4 are solder waves, whereas no. 1 removes icicles—if any.

Induction soldering

In this method, the heat required to produce solder joint is generated within the workpiece by exposing the points to be soldered to the electromagnetic field produced by a high frequency current. Eddy currents induced in the metals heat them rapidly.

Resistance soldering

When a large current is passed through a high resistance material, a large amount of thermal energy is generated. This heat is instantaneous in nature and can be highly localised, which is suitable for soldering. Generally the equipment comprises a variable current source and a set of high resistance contacts. This method should not be used where current sensitive components are involved. It is also possible to get one electrode system, the job being grounded.

Properly controlled resistance soldering is a very reliable method of soldering. It can be easily automated and is also an economic way of soldering. The heat can be localised because of fast heating and rapid cooling. It is thus very useful for hermetic sealing of components' caps etc.

Ultrasonic soldering

The term 'ultrasonic' does not refer to the mode of pre-heating for soldering. Rather it refers to a technique used to facilitate soldering without any appreciable changes in the temperature of the assembly to be soldered. Once the system has been brought to the soldering temperature, high frequency (ultrasonic) waves are generated in the molten solder. These ultrasonic waves cause an erosion of the surfaces, whereby foreign particles as well as tarnish layers are physically removed and the bare metal underneath is exposed. As a result, the solder is able to wet the surfaces adequately without the need of any flux. This technique is thus very useful whenever use of flux is not feasible. The method is, however, not very common because of its prohibitive cost.

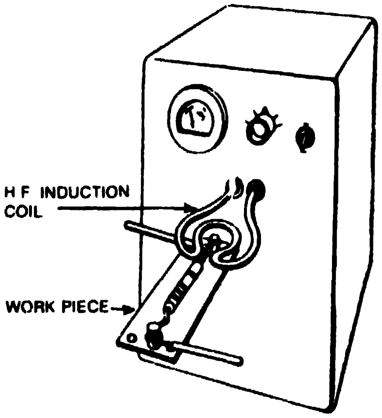


Fig. 9: Schematic representation of a high-frequency induction soldering unit

Crimped connections

This is a mechanical method of connecting the components. As can be seen, it is not suitable for printed circuit board wiring, but is useful for wire extension or connecting it with terminals, lugs etc (see Figs 10, 11 and 12).

It should be remembered that a good mechanical joint should produce good metal-to-metal contact with the surfaces free from tarnish. High pressure between the conductors is necessary to provide gastight areas capable of withstanding weather and corrosion. The area of contact must be greater than the cross-section area of the conductors involved to avoid resistance and heating.

SOLDERING SEMICONDUCTOR COMPONENTS

When soldering the lead of a semiconductor component such as a diode, transistor, thermister, LDR etc, it is desirable to use a light-duty (25W or less) soldering iron. If a larger rated iron is used, excessive heat may be conducted into the component, causing a permanent damage. The following points are worth noting at this stage:

Heat sink

When soldering or de-soldering the leads of a semiconductor component, a heat sink should always be used to absorb heat that may otherwise be conducted into the component. A very convenient heat sink can easily be made by soldering a small sheet of copper or brass to a crocodile clip, as shown in Fig. 13. In use, the clip is attached to the lead of the component at some point between the component and the terminal to which the lead is being soldered. Use of a long-nose plier to grasp a bare portion of the semiconductor's lead near the terminal to which the wire is being soldered also serves the purpose.

Copper wire tip

A medium or heavy duty soldering iron can be converted into a satisfactory soldering tool by wrapping a copper wire (14 to 16 gauge) to work as a tip, as shown in Fig. 14. To enable the maximum amount of heat conduction from the parent tip to the working tip, the parent tip should be thoroughly cleaned and the wire should be tinned before wrapping.

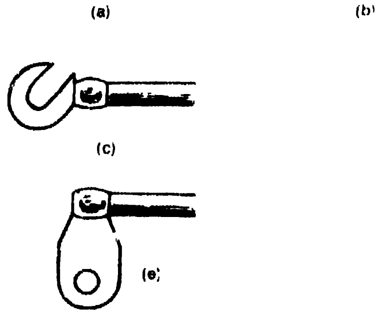
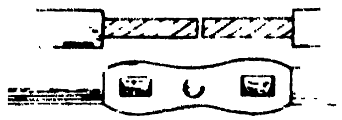


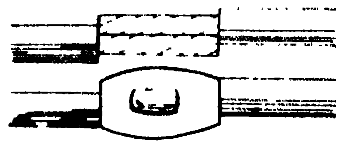
Fig. 10: Basic terminal styles or solderless crimped terminal styles: (a) ring tongue; (b) spade tongue; (c) hook tongue; (d) flanged spade tongue; and (e) flag tongue

Voltage leakage

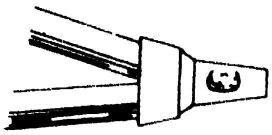
Some semiconductor components, ICs and LSIs are very sensitive to voltage, especially the MOS types. Let us consider a MOSFET, in which a very thin layer of SiO_2 forms the dielectric between gate and channel. This layer has extremely low leakage. Hence a static charge can build up and become high enough to cause a breakdown of the oxide layer. Some transistors are so sensitive in this respect that they are shipped to users with their leads wrapped in a metal foil to keep potentials between leads nil. Same is the case with MOS ICs and MOS LSIs.



A BUTT CONNECTOR (2 CRIMPS)



B PARALLEL CONNECTOR (1 CRIMP)



C PIGTAIL CONNECTOR (1 CRIMP)

Fig 11: Three methods of splicing wires with crimping tool and connectors

The possibilities of an electric charge being transferred from the soldering iron to a semiconductor cannot be ignored for the following reasons:

1. The heating element in soldering iron is a coil of wire. When AC voltages are applied to it, a varying magnetic flux may be developed which may get induced by transformer action in a nearby closed electrical circuit. Thus, if the soldering iron's coil happens to be sufficiently near a closed circuit including a low-impedance transistor, enough currents can be induced to damage the transistor.
2. Mica or ceramic normally used as an insulator between the heating coil and the metal parts of the soldering iron are good dielectrics for a capacitor. Some AC voltage can be transferred to external circuits through the capacitance effect of the insulator as a dielectric and the coil as a voltage source.
3. The insulation material, mica, is not a perfect insulator. It may have a very high leakage resistance of several hundred megohms. But the MOS components to be soldered may have an even greater impedance of several hundred or more megohms. In that case the components, if soldered without any precaution, can be exposed to nearly full voltage of the coil.

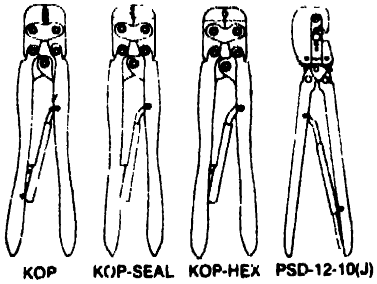


Fig. 12: Hand crimping tool/tools

The solution to these problems lies in the use of a low voltage (12V or 24V) iron using an isolating transformer with a transient suppressor. This brings the maximum potential well below the breakdown potential of the oxide layer in the MOS components.

Post-soldering treatment

To be chemically effective, every flux must be corrosive to some degree. Otherwise it will be incapable of removing tarnish from the surfaces to be cleaned. Only the residues of water-white rosin or properly treated activated rosins can be left on the assembly under special conditions. It is therefore safe to say that the best practice for good soldering includes a flux removal operation.

Many organic solvents like acetone, amyl acetate, carbon tetrachloride, toluene and xylene can be used to remove the rosin flux residues. However, while using these chemicals proper care must be taken as most of the chemicals are easily flammable and may cause serious irritation to an individual when inhaled or absorbed through the skin. Work should be carried out in a properly ventilated room and workers should be provided with gloves.

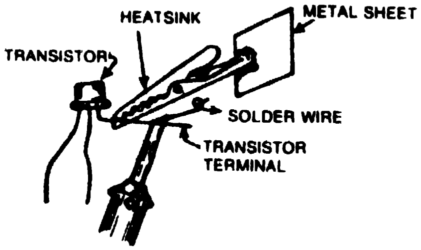


Fig. 13: Crocodile clip can work as heat sink

After treating the soldered assemblies with the flux removing chemicals, they should be further cleaned in either a vapour degreaser or in an ultrasonic cleaning equipment.

In order to prevent formation of corrosion, whatsoever, a protective layer or coating should be applied over the soldered printed circuit card. It may be applied by brushing, spraying or dipping. A layer of varnish or lacquer may very well serve the purpose and at the same time allow repair work in the future. The use of epoxies on the other hand, prohibits future repair work.

Do's and don'ts for soldering

Whether soldering a few connections or thousands, the basic requirements for good soldering remain the same. Following are a few points to be remembered:

1. Select proper soldering iron (25W or less for electronic assembly work).
2. Do not solder unclean or oxidised surfaces.
3. Use only rosin fluxes.
4. Do not depend on a soldered joint to withstand mechanical or physical stresses.
5. Do not touch component connecting leads with bare fingers.

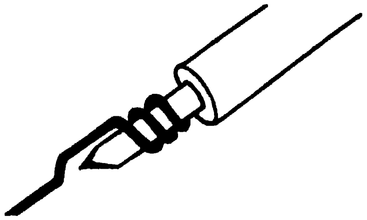


Fig. 14: Extending the tip of a soldering iron using bare copper wire

6. Use heat sinks for soldering resistors with rating up to 1W, capacitors and all semiconductor components.
7. In dip soldering, always use a solder pot or bath wide enough to accommodate work pieces comfortably and deep enough to maintain a uniform temperature throughout.
8. Avoid double dipping printed circuit assemblies.
9. Don't put terminals too close together on a printed circuit board.
10. Do not use solder to hold parts together.
11. Design equipments into easily solderable sub-units.

SOME COMMON SOLDERING DEFECTS

Defect	*Explanation*	*Main reasons*
1. Dry solder	The solder does not adhere well to either of the work-pieces; may cause 'noise' voltages in the circuit	1. Poor wetting or solderability 2. Unclean surfaces 3. Insufficient soldering temperature 4. Flux activity not proper 5. Base metal not compatible with solder
2. Intermittent or loose joint	A joint or connection which has fractured or come loose	1. Shaking of either member during soldering (after heat source is removed) 2. Soldering temperature not high enough 3. Non-eutectic solder used 4. Design does not provide sufficient joint strength 5. Excessive copper/ iron in the solder (particularly in wave soldering) leading to a brittle joint
3. Corroded joint	Corrosion on the solder on the terminal	1. Excessive flux activity and consequently flux residual becomes corrosive 2. Environment is corrosive 3. Post-soldering treatment not given
4. Lifting of PCB at the solder point		1. Too high soldering temperature 2. Soldering time too long 3. Defective laminate 4. PCB circuit too narrow in width