SOLDERING AND DESOLDERING

Sept 1999

Notes

Section 1: Hand Soldering

The Egyptians are believed to have made hand soldering joints as early as 5000 BC, and the Hanging Gardens of Babylon, built about 600 BC, are said to have had a floor covered with sheets of lead soldered together. So, by now quite a great deal is known about the art of hand soldering.

When soldering, a filler metal is used that has a lower melting point than the other metals being joined. This filler metal is commonly called solder.

Pure lead was used in the early days, but lead by itself results in a mechanically weak joint. In the electronics industry, solder containing tin is used, which not only increases the strength of the alloy but also decreases the solder melting point. The liquidus point decreases from that of 327 °C for lead to 188 °C for 60% tin and 40% lead type solder.

Most metals when heated will react with the atmosphere causing the metal to oxidize. Oxidisation is detrimental to the properties of a soldered joint. This problem of oxidisation of the heated surfaces has lead to the use of a substance called 'flux'.

Flux is a substance that is capable of preventing oxides, it also promotes 'wetting' and therefore spreading the solder over the surfaces to be joined. Flux also aids the transfer of heat from the soldering iron tip to the joint. The type of flux used widely in the electronics industry is non-corrosive, based on rosin, using alcohol as a carrier.

The basic operational steps of soldering are as follows:

1) Thorough cleaning of the surfaces to be joined.
2) Tinning surfaces.
3) Application of heat.
4) Cooling of joint.
5) Removing flux residue
6) Testing the joint

1) Material Preparation

The success of a soldered joint depends on the condition of the surfaces to be fitted or joined. Although flux has a certain cleaning capacity, it is rendered useless when films of oil, wax, grease, perspiration or heavy oxides are present on the surface. Any contaminant on the surfaces should carefully be removed in order to achieve repeatedly reliable solder joints.

There are two basic methods of removing contaminants from the surfaces to be soldered.

a) Chemical Cleaning

In chemical cleaning, contaminants are removed by the action of an acid, alkali, or solvent. Solvents are used for printed circuit board and component cleaning because they are reasonably safe and effective.

The solvent used must have effective cleaning properties, but also be one that will not damage the surfaces being cleaned, i.e. components or printed circuit boards.

Precaution:

Solvents are quite safe if used with care and discretion.

Have only a small quantity at the workplace in a capped container, so that it does not evaporate in use.

Most solvents are flammable, so do not smoke or use naked flames. Always use solvents in a well ventilated area.

Avoid spilling solvents as this could cause damage to components.

Use a clean brush for application and cleaning and avoid contact with the skin as many solvents can cause inflammation of the skin.

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b) Abrasive Cleaning

Various methods of abrasive cleaning can be used i.e. blasting, scouring, wire brushing or surface erasing. Most of these methods are usually carried out by machine, but to clean small areas i.e. when assembling small quantity components or local area cleaning of printed circuit boards, it is far simpler to use abrasive rubber or fibre glass brush.

Abrasive cleaning should only be carried out where oxides are such that a solvent is ineffective.

It is essential when using abrasive cleaning, to avoid damage to component and printed circuit board surface finish. Also it should be noted that some abrasives can become embedded in the material surface. After abrasive cleaning it is better to follow up by solvent cleaning to remove any abrasive that may have embedded in the surface being cleaned.

2) Tinning Materials

The purpose of tinning the surfaces to be joined is to improve on their solderability. To be 'tinned' is for the material surfaces to be covered with a thin layer of tin or tin-lead solder. Before tinning the surfaces, they first must be cleaned either chemically or abrasively.

The solder may be applied by means of a heated soldering iron bit, after the surfaces of the materials have been treated with a suitable flux. The material should be held so that the excess solder drains back into the solder iron bit, leaving a thin, flat film that will not interfere with the assembly of the parts.

Another method of tinning, suitable for small parts or component leads is to immerse them in liquid solder contained in an electrically heated iron pot (solder pot). Solder pot temperature should ideally be at 250°C.

3) Application Of Heat

When using a soldering iron, it is important to remember that the iron should act only as a source of heat and no pressure should be applied, as this could result in the printed circuit board damage i.e. lifted lands or conductors.

If excessive force is necessary to obtain good heat transfer, then it is due to the soldering iron bit being either too small or too low a temperature for the area being soldered.

The solder should not be applied to the soldering iron and carried to the joint, but should be applied at the junction between the soldering iron bit and the component lead.

This method of applying heat and solder will cause the minimum amount of heat to travel inside the component and because of the quick 'wetting' of the joint, will cause the least danger of delamination of the printed board land area.

4) Cooling The Joint

In the case of tin solders, it is best to allow the joint to cool unaided, ensuring that the materials being joined do not move. Any movement during the joint cooling stage could result in a mechanically weak joint which may also be of high electrical resistance (dry joint).

Do not be tempted to hasten cooling by 'blowing' on the joint, as this causes the solder to contract too rapidly and is sometimes sufficient to cause cracking of the solder joint (hot tearing).

5) Flux Residue Removal

The flux residue should be removed after completing the joint to prevent possible corrosion and/or attraction of foreign matter. This can be carried out using a bristle brush and a safe solvent.

6) Testing The Joint

Testing the joint usually relies upon visual examination preferably using an X5 to X10 magnifier. The following points should be noted:

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a) Both surfaces are 'wetted' (no de-wetting).
b) No surface holes or cracks.
c) Surface of the solder should have a bright metallic finish.
d) Must be electrically and mechanically sound.

7) Common Soldering Faults

a) Good Wetting

A good indication of an acceptable soldered joint, is one where the solder 'wets' the surface of the board and component lead, giving none or little indication of where the solder meets both surfaces. The solder should be feathered out, indicating a small dihedral angle. The surface should be bright and smooth, with few or no pinholes.

b) Poor Wetting

Solder makes a large contact angle. Solder surfaces are not continuous, irregular and non-wet areas are exposed.

c) Dewetting

Solder does not completely cover the surface, having a large contact angle. Solder appears as droplets or balls, either having withdrawn from the previously wet adjacent area or never wetting at all.

d) Cold Joint

Joint appears frosty and granulated because of movement during solidification. In its worst form it will result in a fractured joint. Can also be caused by gold contamination of solder.

Most soldering defects can be put down to poor solderability of the two materials being joined and is often the result of insufficient preparation.

8) Gold Contamination

Metals that are often assumed to have a good solderability can present a problem after a period of time. One of these metals is gold, used in component terminations. Research has shown that when gold surfaces are soldered, depending upon the amount of gold present, an amalgam of solder, gold and base metal is formed at the surface of the termination (gold is dispersed through the tin content of the solder), this causes embrittlement of the solder joint which will be weak and will not withstand vibration.

The best practice is to remove the gold deposit by dissolving it in molten solder contained in a solder pot at 250oC. A soldering iron can be used but gold contaminated solder must be removed from the iron bit before further use. After the degolding operation, the surface should be re-tinned and is then ready for normal soldering.

9) Revision Of Soldering Techniques

a) Reliable soldering of connections is not difficult, provided that the solder is capable of, and is permitted to, react with the metal surfaces of the printed circuit board and component terminations. This process is called 'wetting'. Contaminants will impede wetting, therefore freedom from tarnishes such as oxides or residues and even perspiration from handling is essential for good soldering.

b) Sometimes one is tempted to overcome surface problems by burning off the contaminants with a hot soldering iron and expecting the solder still to run. When solder does not initially run properly, more is applied until a fat blob covers all of the metalwork and looks like a joint. What usually happens is that the component lead is in a sheath of dirt or corrosion and has no bond and a high electrical resistance joint can result. The hot iron may also have damaged the adhesion of the copper foil to the board.

c) The application of the soldering iron should be for the minimum time compatable with the melting of the solder and wetting the joint, particularly where transistor, integrated circuit, heat sensitive and static sensitive components are involved.

d) A person carrying out hand soldering should remember that when heat is applied to a printed circuit board, the bond between the copper foil and the laminate is soft and weak. If the soldering and/or desoldering is not accomplished within 5 seconds, a wait of approximately 5 minutes is necessary to allow the strength of

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the bond to return, before a second application of heat. Also excessive pressure with the soldering iron must be avoided.

e) Generally fluxes will not overcome poor solderability of boards or components, which therefore will require attention beforehand.

f) Visual examination of the soldered joint should reveal a smooth even flow of solder. A failure would be indicated by signs of non-wetting or excessive de-wetting.

A joint which has de-wetted will not be rectified by applying more flux or solder if the failure is due to poor solderability. The solder should first be removed, the solderability of the surfaces improved and resoldered.

10. Printed Circuit Board Enemies

The peel force of the copper foil from the base laminate are quite adequate for normal purposes, but when we solder and/or desolder components from a printed circuit board, it is then subjected to three enemies: HEAT, DIRT AND YOURSELVES. The third enemy, with training and experience can be eliminated. Bear in mind, that the other two enemies are mostly within your control.

a) Heat

Excessive heat during soldering, is by far the greatest enemy to components and printed circuit boards. It will destroy the adhesive bond between the copper foil and base laminate. Although in most cases this type of damage can be repaired, it will result in delay in manufacturing or servicing your equipment, shortening the life of components or incurring expense in replacing damaged items.

b) Thermal Energy

Here we have a graph plotting temperatures against time. We can safely assume that to make a perfect soldering joint, ideally all material surfaces must reach the same temperature.

If for example, we use a soldering iron 370°C to make a perfect soldering joint, the printed circuit board will also theoretically rise to this temperature, given good thermal contact. Assuming the average soldering joint will take between two and three seconds, we can see how much thermal energy is used in making that joint.

If we increase the soldering time and/or temperature we will increase the amount of thermal energy, therefore, increasing the risk of damage by excessive heat.

We can safely say that to prevent damage by excessive heat we must control the soldering iron bit temperature and limit the time heat is applied to the board.

N.B.

If the task of soldering or desoldering is not completed in five seconds, we must remove the heat source and allow five minutes to elapse. This will allow the epoxy resin bond between the copper foil and the base laminate to reform.

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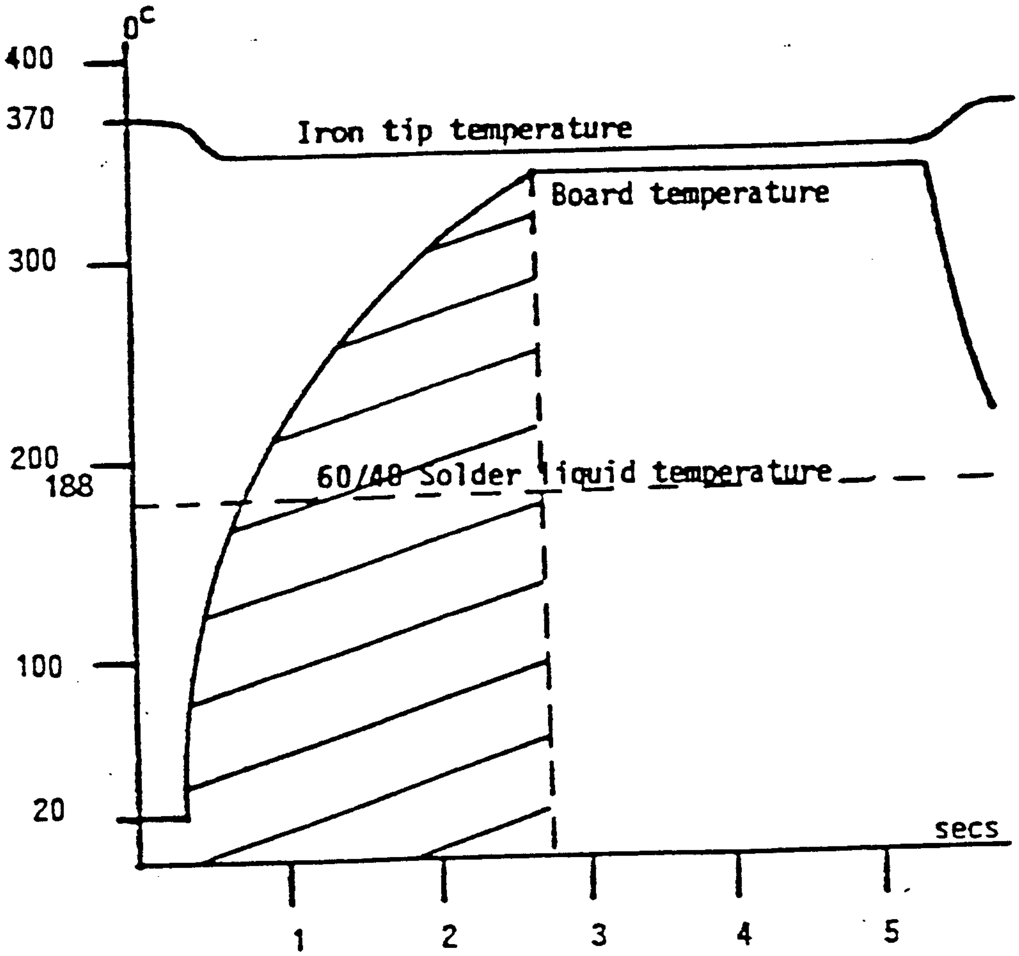


11) Dirt

When heat is applied to the copper foil of a printed circuit board, the epoxy resin bond between the copper foil and base laminate will soften. While the epoxy resin is in this softened state, any grease or dirt around the area can mix with the epoxy resin and prevent if from reforming. This will result in the copper foil lifting away from the base laminate. The same result as that of excessive heat.

In the preparation of any type of soldered joint, the need for cleanliness can never by overstated, and in the end, this results in the easiest, quickest and best quality joint.

12. Soldering Iron Care

Basic care of the soldering iron and its bit will result in longer bit and soldering iron life, therefore in more reliable solder joint quality.

USEFUL HINTS

(i) When not in use, always place the soldering iron in the stowage provided.

(ii) Do not allow the soldering iron bit to contact any metal part when idling, as the heat sinking effect could result in short soldering iron life.

(iii) Regularly check the soldering iron for signs of damage, especially the supply cable and bit for indications of wear.

(iv) Daily removal of the bit prevents possibility of tip seizure caused by ingress of flux and other contaminants around the body.

*(a) **Copper Bits***

If using copper bits, always maintain the bit profile, holed or pitted bits are poor means of heat transfer, so keep the bit working surface flat.

*(b) **Iron Plated Bits***

Never use a file or abrasive on this type of bit or very short bit life will result. To clean the bit, a wipe on a damp sponge is only required. The bit should only be wiped prior to soldering (when a clean bit is essential). Do not wipe the bit before stowing the iron, as the solder remaining on the bit will prevent oxidisation by excluding air and moisture.

TIP SELECTION

Always select the largest bit profile possible, but not larger than the area being soldered.

Select the correct bit temperature:

315 °C for single sided boards.

371 °C for plated through boards.

430 °C for hard wiring.

Remember, the higher the bit temperature the shorter its life.

The larger the bit dimension the longer its life.

Always use the lowest temperature and dimensionally largest tip possible to give you the longest life.

Notes

Section 2: Desoldering

When replacing a component on a printed circuit board, the operation will entail the step of removing the solder from around the component leads, this operation is called 'desoldering'.

The purpose of the desoldering operation is to remove solder from around the component leads to facilitate the removal of the component. Care should be carried out when desoldering to prevent damage to the printed circuit board, this will prevent the need for expensive and time consuming repair.

There are several methods of solder removal, some good and some which can create more problems than just a component removal.

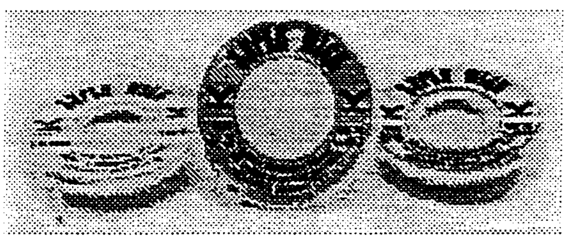
Some of the methods of desoldering are as follows:

(a) Melt, Wipe, Brush or Shake

This method involves melting the solder and then wiping, brushing or shaking the molten solder from the component termination. This is a very unsuccessful method, leading to solder traces across the board surface causing short circuits. Damage could also result due to the excessive rough handling of the printed circuit board. Also in the act of wiping, brushing or shaking the molten solder, personal injury could occur.

(b) Solderwicking

A flux impregnated copper braid which when heated will remove solder by capillary action.



To use this method, first select the correct size wick to suit the joint to be desoldered and place the end of the wick over the joint. Place a soldering iron tip on top of the wick and when the solder is molten it will be drawn into the wick by capillary action.

Wick is available in sizes 1.5, 2.0, 2.5 and 3.0 mm.

This method is not recommended for desoldering component leads on plated through hole boards as it will not break the solder 'sweat' joint where the component lead is in contact with the hold plating.

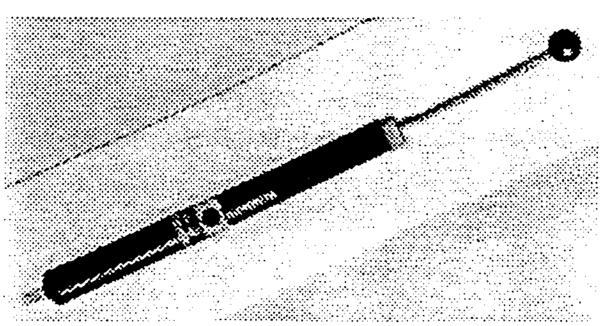
Can also cause lifted lands as it often means exceeding the safe heat application time for 5 seconds.

This method is suitable for the removal of solder from surface mount boards after the component has been removed via some other method.

(c) Single Shot

(i) Spring Loaded Suction Pump

Solder removal is achieved by a spring loaded suction pump operating like a bicycle pump in reverse.



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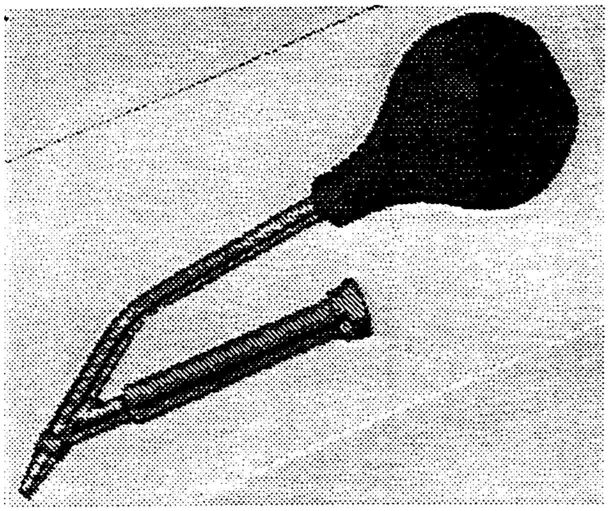
This type of desoldering tool is used by placing the nozzle as close to the joint to be desoldered as possible, after having first 'cocked' the tool by depressing the plunger.

Place a heated soldering iron tip onto the solder joint and when the solder is fully molten, release the plunger of the desoldering tool. The plunger will then rapidly return and in doing so will cause suction at the desoldering tool nozzle.

Damage can be caused to printed circuit board lands due to the excessive recoil action of some of these types of tool. Also not a reliable method to break the 'sweat' joint on plated through hole boards.

(ii) Rubber Bulb



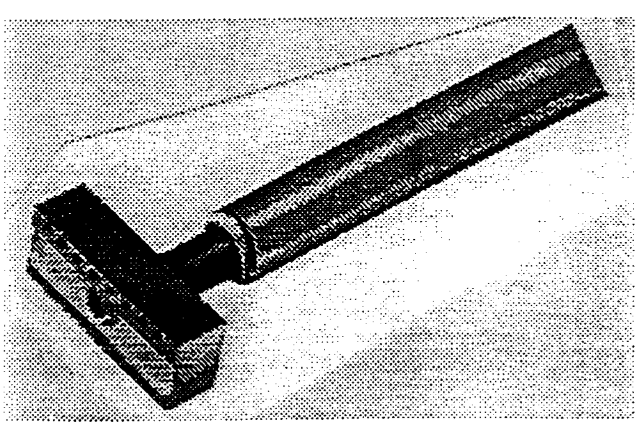
Suction is achieved by means of a bellows action. Adapted for use with the Weller TCP and W60 temperature controlled soldering irons.

The tool is used by first attaching it to a suitable Weller soldering iron and waiting approximately 5 minutes to allow for the tool nozzle to reach the correct temperature. Depress the bellow and place the heated nozzle on the joint to be desoldered. When the solder is fully molten release the pressure on the bellow which will cause suction at the nozzle, thereby removing the solder from the joint.

This method is suitable on single and double sided boards but is not always successful on plated through hole boards due to insufficient thermal mass.

(d) Heated Blocks

Simultaneously melts the solder surrounding the component leads of Dual-In-Line components. Adapted for use with Weller TCP and W60 temperature controlled soldering irons.



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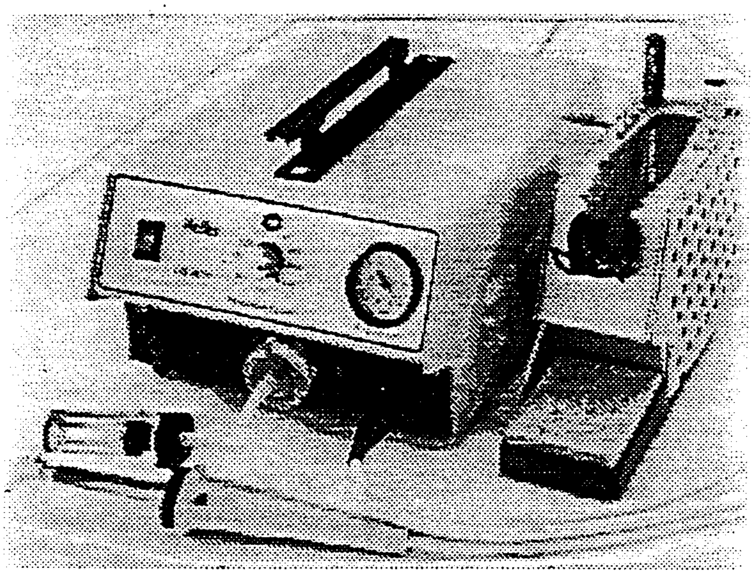
An ideal method of component removal on single, double and plated through hole boards. This method is limited to fourteen and sixteen pin D.I.L components as the increase copper area needed to desolder larger multipin components would subject the printed circuit board to too great a thermal mass which could lead to damaged conductors and lands.

When employing this method of removing components an appropriate means of extraction should be used to aid component removal.

(e) Vacuum

The solder is heated and when molten, it is removed by air movement through the terminal hole created by a venturi or vacuum pump.



The desoldering tool nozzle is placed over the terminal to be desoldered. When the solder is fully molten it is sucked away by use of a vacuum.

By far the best method of desoldering, as the air being drawn through the hole surrounding the component lead prevents the lead from 're-sweating' and also keeps the land area to an acceptable temperature due to the airflow.

This method is especially recommended for desoldering multipin components.

Fig. 1.

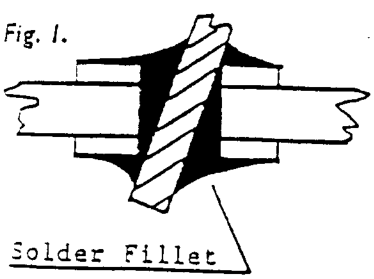


Fig. 2.

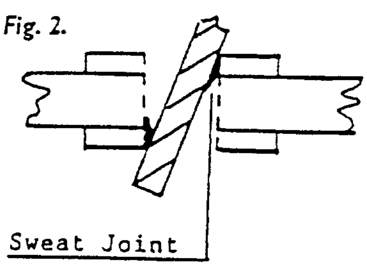
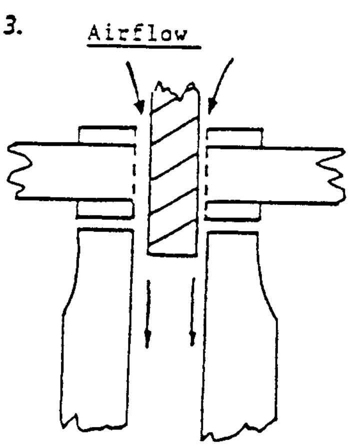


Fig. 3.



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Section 3: Component Replacement

When removing a component prior to replacement, always remember that the easy way is not always the best. Prevention of damage to the printed circuit board should always be uppermost in ones mind.

1. Avoiding Mechanical and Electrical Damage During Rework

Careless handling of printed circuit boards and hand tools during rework or repair can cause further damage. The following precautions are worth noting.

(a) Remove the board from the main equipment during the repair/rework process.

(b) Take care to avoid damage to the board when removing components, especially if the component has been adhered to the board surface.

(c) Cleansing solvents when used carelessly, can damage components.

(d) Damage to conductors and lands is most likely to occur when stress is applied to component leads in a direction that would force the copper foil from the board. Avoid applying such a force.

(e) During the soldering process, when the joint is at soldering temperature, the strength of the bond between the copper foil and the laminate is weak. Thus unnecessary disturbance of the joint should be avoided at this temperature. When the soldering process has been carried out correctly and the joint has cooled, the strength of the bond returns.

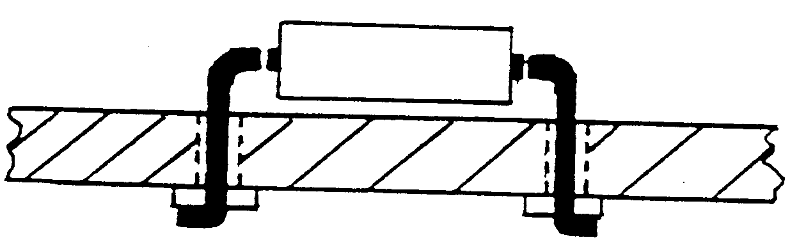
(f) Excessive heating of the board should be avoided. In repair and rework it is generally found that the use of a hot soldering iron applied for a short time reduces the possibility of damage. Most repair/rework methods described in these notes recommend an iron temperature controlled at 600 °F (315 °C) for single and double sided boards and 700 °F (371 °C) for plated through hole boards.

(g) Some repair/rework techniques can be applied to multi-layer boards but care must be taken not to damage the plated through holes as these often interconnect the internal layers.

(h) Check when replacing components whether special handling methods are required. If so, these instructions must be strictly adhered to. Static sensitive components fall into this category.

(i) Components can be damaged very easily by bending the leads to close to the body, thus damaging the seal. Avoid this type of damage.

2. Removal Of Axial Lead Component By Cutting (Clinched Lead)



Procedure

(a) Using a pair of small side cutters, cut the component leads and remove the component body.

(b) Straighten the remaining stub end of the component lead. Apply a temperature controlled soldering iron to the joint, when the solder is fully molten apply pressure to the stub end of the component lead from the component side of the board.

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(c) Using a pair of tweezers remove the stub end from the hole. Check that the hole is clear. If any solder remains it should be removed using a temperature controlled solder removal iron.

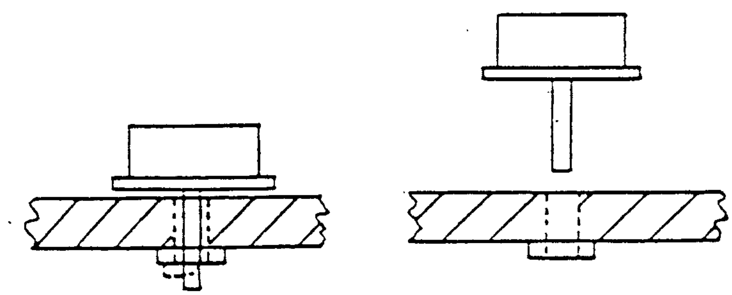
(d) Inspect the land for any signs of damage i.e. lifting.

(e) Assemble a new component in the normal way. Care should be taken to ensure that excessive heat is not applied to replacement components that are known to be heat sensitive.

(f) Remove excess flux with a solvent cleaner.

(g) Inspect to ensure that the task has been carried out in a neat and workmanlike manner.

3. Replacement Of Components Where Leads Are Inaccessible From Component Side (i.e.Transistors)



Component Lead Straightened.   Component Withdrawn after Solder Removal.

Procedure

(a) Hold the board firmly in a vice or by other mechanical means that will give free access to either side of the faulty component.

(b) Using a temperature controlled soldering iron melt the solder around a lead and bend vertical to the board with a dental probe or scalpel while the solder is still liquid.

(c) Repeat (b) for all other leads.

(d) Using a temperature controlled solder removal tool, remove solder from the component lead and holes.

(e) Ensure that all leads are free before removing the component from the board.

(f) Insert the replacement component and re-solder ensuring that each terminal is heated for only the minimum time required to effect a successful joint.

(g) Remove excess flux with a solvent cleaner.

(h) Inspect to ensure that the task has been carried out in a neat and workmanlike manner.

4. Replacement Of Through Mounted D.I.L. Integrated Circuits When Special Tools Are Not Available

Procedure

(a) With a small pair of side cutters, cut gently through each of the leads of the component flush with the board surface and remove the body.

(b) Using a temperature controlled soldering iron melt the solder around the first remaining lead and lift the lead from the hole using a pair of tweezers or snipe nosed pliers. Care should be taken to apply the soldering iron for sufficient time only to enable the lead to be freed.

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(c) Repeat (b) until all leads are free of the board.

(d) Insert replacement component using an insertion tool and re- solder ensuring that each terminal is heated for only the minimum time required to effect a successful joint.

(e) Remove excess flux using a solvent cleaner.

(f) Inspect to ensure that the task has been carried out in a neat and workmanlike manner.

5. Replacement Of Through Mounted D.I.L. Integrated Circuits Using Vacuum Desoldering Tool

This method requires the use of a temperature controlled solder removal tool, i.e. Weller DS-TCP, Weller DS 701, DS 801 or DS-900 Desoldering Station.

Procedure

(a) Using a temperature controlled solder removal tool, melt the solder around the joint. When the solder is fully molten remove with the solder removal tool.

(b) Repeat (a) for all remaining leads.

(c) Ensure that all leads are free, then carefully remove the package using fingers only or an approved removal tool.

(d) Examine board and lands for signs of damage.

(e) Insert the replacement package and re-solder ensuring that each terminal is heated only for the minimum time required to effect a successful joint.

(f) Remove the excess flux using a solvent cleaner.

(g) Inspect to ensure that the task has been carried out in a neat and workmanlike manner.

6. Replacement Of Through Mounted D.I.L. Integrated Circuits Using A Desoldering Block

Removal of fourteen and sixteen lead through mounted D.I.L. packages using special tools, i.e. Weller SK126-6-TCP or Weller SK137-6-TCP.

Note:

When removing D.I.L. packages by this method it is essential to melt the solder retaining both rows of terminals simultaneously and to remove the package quickly the moment the solder melts, this is best effected with special tools.

(i) Temperature controlled soldering iron Weller TCP.

(ii) Weller SK126-6-TCP (16 lead package) or Weller SK137-6-TCP (14 lead package).

(iii) Spring loaded removal tool.

Procedure

(a) Fit the spring loaded removal tool over the D.I.L. package and apply the multiple pin desoldering block simultaneously to both rows of terminals; the instant the solder retaining every terminal is sufficiently molten the package will be withdrawn from the board by the removal tool.

(b) Using a temperature controlled solder removal tool, remove excess solder from the holes.

(c) Insert the replacement component and re-solder ensuring that each terminal is heated only for the minimum time required to effect a successful joint.