



SOLDERING TECHNIQUES

I. Soldering Concepts

- A. Solder is used to hold two (or more) conductors in electrical contact with each other.
- B. Solder is not used to make the electrical contact.
- C. Solder is not used to provide the main mechanical support for a joint.
- D. Solder is used to encapsulate a joint, prevent oxidation of the joint, and provide minor mechanical support for a connection.

II. Soldering Irons and Accessories

A. Soldering Iron Types

1. Temperature-controlled iron. A soldering iron with electronic temperature control is highly recommended. Irons without temperature control can reach temperatures that are high enough to irreversibly damage the tips. Since temperature is not proportional to wattage with this type of iron, the wattage rating is relatively unimportant. A higher wattage iron results in a faster temperature recovery time between soldering operations (40 W to 60 W units seem to work well). See Figure 1.
 2. Non-temperature-controlled iron. A low wattage (10 W to 25 W) pencil-type (not gun-type) can be used but is not recommended. This type of iron must be unplugged when not in use to save the tips. The temperature is proportional to wattage and most of these types of soldering irons will reach temperatures that can destroy tips quickly.
 3. Modified, non-temperature-controlled iron. A 10 W to 40 W pencil-type iron can be operated from a variac to limit the wattage (and therefore the temperature) and is a reasonable substitute for a temperature-controlled iron. However, a variac can cost more than a temperature controlled station and will yield less satisfactory results!
- B. Sponge. A sponge is required for keeping tips clean for best heat transfer. A clean soldering iron tip is one of the most important steps towards producing good solder joints. Most soldering stations come with sponges and sponge holders.
- C. Tips. Currently, most tips sold for electronics work are iron-clad copper and have long life spans. Iron-clad tips cannot be filed or sanded when they become oxidized; they must be replaced. Many tip shapes are available, but miniature needle or chisel point tips are best for most work. The tip shape should be chosen to provide the highest contact surface area for best heat conduction. Minimizing the shank length can increase the heat transfer from the iron (heater) to the tip. Copper tips can still be purchased but are not recommended because of their short life span and poor wetting properties.



Figure 1. A temperature-controlled soldering iron.

III. Solder and Flux

A. Flux

1. Flux is used to prepare the surfaces of the conductors prior to soldering. Flux removes oxidation from the conductors and maintains oxide-free surfaces at elevated temperature during the soldering process. This allows all surfaces to “wet” properly.
2. The most common flux used in hand soldering of electronic components is rosin, a combination of mild organic acids extracted from pine trees (some manufacturers use synthetic compounds).
3. Although fluxes can be obtained in liquid or paste form, they are typically contained in solders (rosin core) used for hand assembly of electronics. Fluxes labeled as “Acid” are strong acids (as opposed to the mild rosins) and should never be used for electronics assembly.

B. Solder

1. Rosin core. 60/40 Sn/Pb (M.P. 361-376°F) and 63/37 Sn/Pb (M.P. 361°F) solders are the most common types used for electronics assembly. These solders are available in various diameters and small diameters are most appropriate for small electronics work (0.02” - 0.05” dia. is recommended). See Figure 2.



Figure 2. Acceptable solder types (60/40 and 63/37).

2. Lead-free. Lead-free solders are used as more environmental-friendly substitutes for leaded solder, but they are typically not as easy to use mainly because of their higher melting point and poorer wetting properties.
3. Silver. Silver solders are typically used for low resistance connections but they have a higher melting point and are more expensive than Sn/Pb solders.
4. Acid-core. NEVER USE ACID CORE SOLDERS FOR ELECTRONICS! They are intended for plumbing or non-electronics assembly work. The acid-core flux will cause corrosion of circuitry and can damage components. See Figure 3.



Figure 3. Never use acid core solder for electronics assembly.

5. Other Specialty Solders:

- a. Various melting point eutectics. These specialty solders are typically used for non-electronics assembly of difficult to construct mechanical items that must be assembled in a particular sequence.
- b. Paste solders. These solders are used in field applications or in specialized manufacturing applications

IV. Necessary Tools (See Figure 4)

This is the recommended minimum complement of tools for soldering:

- A. Miniature needle-nose pliers
- B. Miniature side cutters
- C. Wire strippers
- D. Solder removal tool ("Solder Sucker")
- E. Water bottle
- F. Safety glasses



Figure 4. Tools necessary for proper soldering.

V. Helpful Tools

- A. Lamp with magnifying glass
- B. Vise or circuit board holder
- C. “Third hand” device
- D. Heat sink clips
- E. Desoldering station
- F. Fume absorber

VI. Preparation for Soldering

- A. Warm-up. Allow the soldering iron to reach adequate temperature. The recommended temperature setting is between 600 and 750° F. Some tips may have recommended operating temperatures that should be observed.
- B. **Clean Tip.** A clean tip promotes heat transfer and helps to prevent unwanted “solder bridges” from forming. A heavily oxidized tip will make it impossible to solder properly. The steps to maintain clean tips are as follows:
 - 1. Moisten sponge.
 - 2. Wipe tip on sponge.
 - 3. “Wet” tip with solder – just enough for a very thin coating.
 - 4. Repeat if necessary to obtain a clean, shiny tip surface. Also, repeat between each solder operation to maintain a clean tip (See Figure 5).



Figure 5. A properly cleaned and “wetted” soldering iron tip.

C. Prepare surfaces to be soldered

1. If soldering to a bare copper (non-pretinned) printed circuit board (PCB), the copper should be cleaned using fine steel wool or other fine abrasive. All oils and remaining abrasives should be removed with light soap and water followed by an alcohol rinse. The copper should have a bright, shiny appearance prior to soldering.
2. If soldering to magnet wire or other wire with a varnish insulation or with oxidized surfaces, fine grit sandpaper can be used to prepare the surfaces to be soldered.

VII. Wire Types

A. Stranded Wire

1. Stranded wire should be used for connections from PCB to panel-mounted components, or where wires will be flexed.
2. Strip, twist, and lightly “tin” the wire prior to soldering it in place this prevents fraying of the conductors. Apply solder sparingly since too much solder may increase the wire diameter so that it becomes too large or too stiff. A wire prepared in this way may now be hooked around a terminal or soldered into place on a PCB without fraying. See Figure 6.

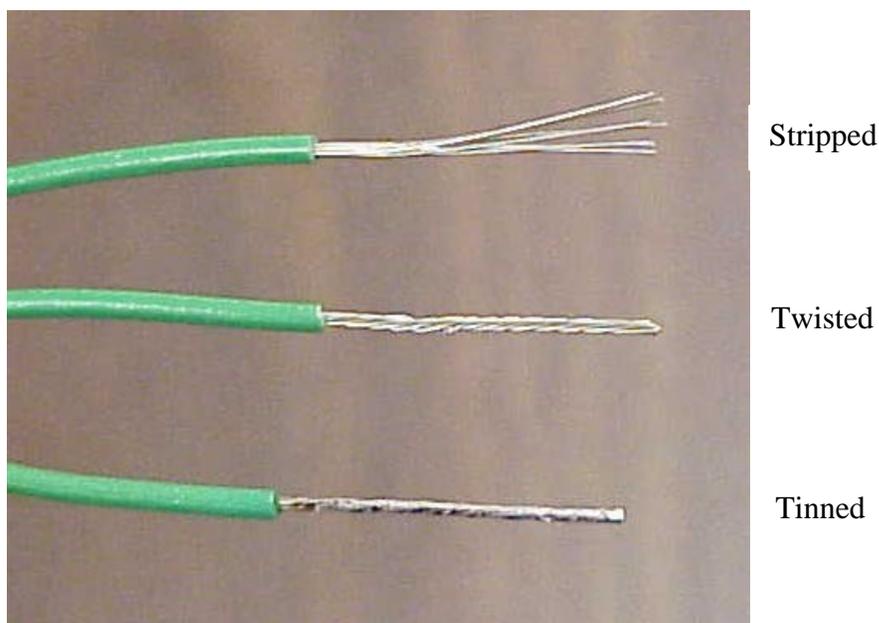


Figure 6. Stranded wire preparation.

3. 22 – 26 ga. stranded copper wire is recommended and 22 or 24 ga. is most common.
4. For power connections, refer to wire tables (e.g., CRC Handbook) to determine the proper gauge to carry the required current.

B. Solid Wire

1. Solid wire should be used for jumpers on pc boards or for any point-to-point wiring.
2. Use pre-tinned wire for best results.
3. 22 – 28 ga. solid copper wire is recommended and 22 or 24 ga. is most common
4. For power connections, refer to wire tables (e.g., CRC Handbook) to determine the proper gauge to carry the required current.

C. Coaxial Cable

1. Coax should be used when shielding from noise sources is desired.
2. Preparation Methods: (See Figure 7)
 - a. Strip the outer insulating sleeve using a sharp knife (e.g., X-Acto knife).
 - b. Bend the wire over, split the shield braid and pull the center conductor through the opening.
 - c. Strip the center conductor using a knife or wire strippers.
 - d. Twist and tin the center conductor (if stranded type).
 - e. Twist and tin the braid.

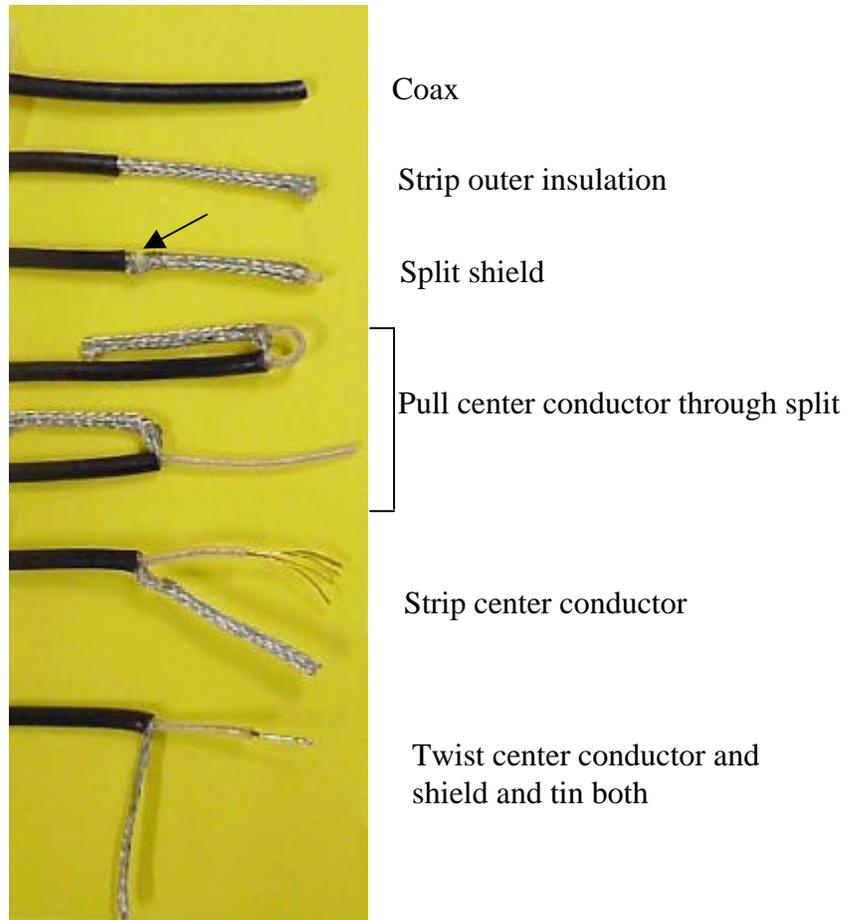


Figure 7. Coaxial cable preparation

VIII. Construction and Soldering Techniques

A. Printed Circuit Board (PCB) Soldering and Construction.

1. Component mounting. Components are pushed through from the top side of the board and the leads are bent slightly to hold the component while soldering. See Figure 8.



Figure 8. Component mounting on PCBs.

2. Components are then soldered to the board as shown in Figures 9 and 10.
 - a. The soldering iron tip should be placed in contact with both the trace (foil) and the lead. The two should be heated only enough to melt solder in order to avoid damaging sensitive components and to avoid delamination of the PCB traces.
 - b. Solder is then touched to the area and allowed to flow freely around the lead and to cover the solder pad. A minimal amount of solder should be applied. Only enough solder to cover the joint and to form a smooth fillet should be used.
 - c. The iron should be removed after the solder has flowed properly and wetted all surfaces. The component and the board should not be moved until the solder has hardened (up to several seconds, depending on the lead and trace size).

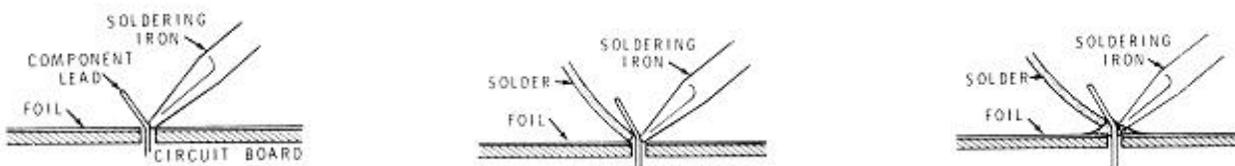


Figure 9. Steps for soldering components to a PCB.

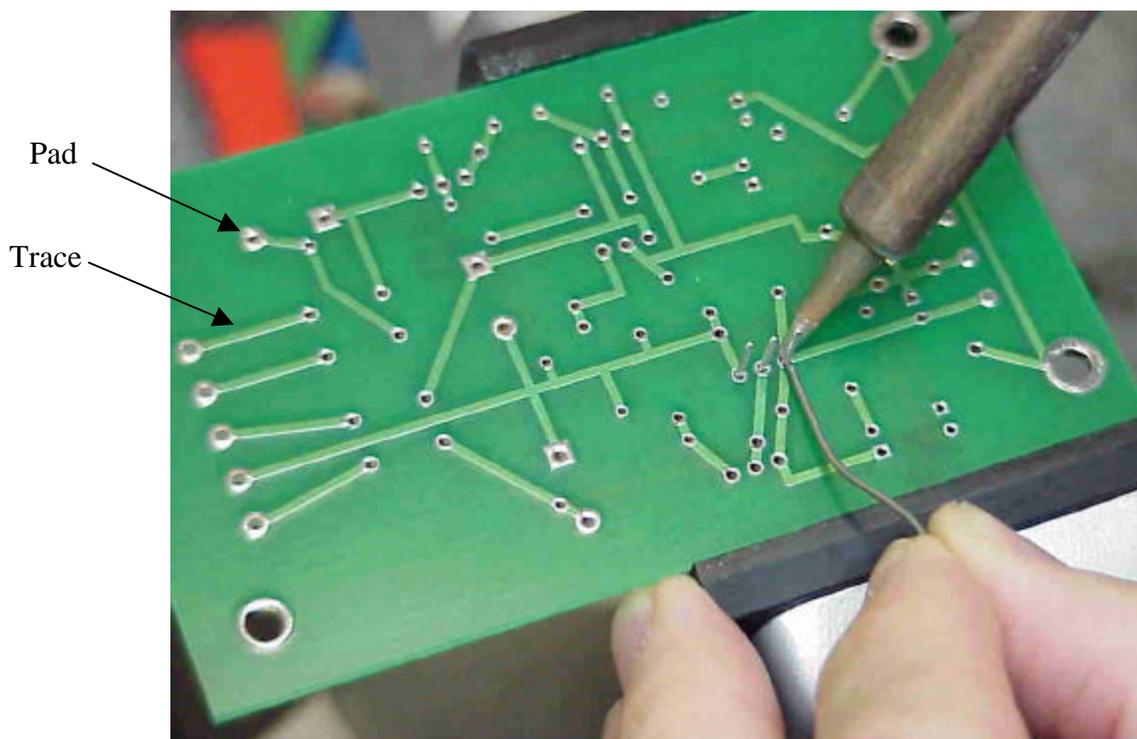


Figure 10. Soldering a component to a PCB.

3. Solder joints should be inspected when completed to determine if they have been properly made:
 - a. Qualities of good solder joints (See Figure 11):
 1. Shiny surface.
 2. Good, smooth fillet.

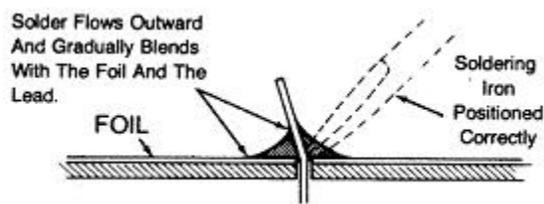


Figure 11. A good solder joint.

- b. Qualities of poor solder joints (See Figure 12):

1. Dull or crystallized surfaces. This is an indicator of a cold solder joint. Cold solder joints result from moving the components after the soldering iron has been removed but before the solder has hardened. Cold solder joints may work at first but will eventually fail.
2. Air pockets. Air pockets (voids) result from incomplete wetting of surfaces, allowing air to be in contact with the connecting metals. This will cause oxidation of the joint and eventual failure. Blowholes can occur due to vaporization of moisture on the surface of the board and exiting through the molten solder. Boards should be clean and dry prior to soldering. Ethanol (100%) can be used as a moisture chaser if boards are wet prior to soldering.
3. Dimples. Dimples in the surface do not always indicate a serious problem, but they should be avoided since they are precursors to voids.
4. Floaters. Black spots “floating” in the solder fillet should be avoided because they indicate contamination and a potential for failure as in the case of voids. These black spots usually result from overheated (burnt) rosin or other contaminants such as burnt wire insulation. Maintaining a clean tip will help to avoid these problems.
5. Balls. A solder ball, instead of a fillet, can occur if the trace was heated but the lead was not (or vice-versa). This prevents proper wetting of both surfaces and results in solder being attached to only one surface (component or trace).
6. Excess Solder. Excess solder usage can cover up other potential problems and should be avoided. It can also lead to solder bridges as seen in Figure 12. In addition, spherical solder joints can result from the application of too much solder.

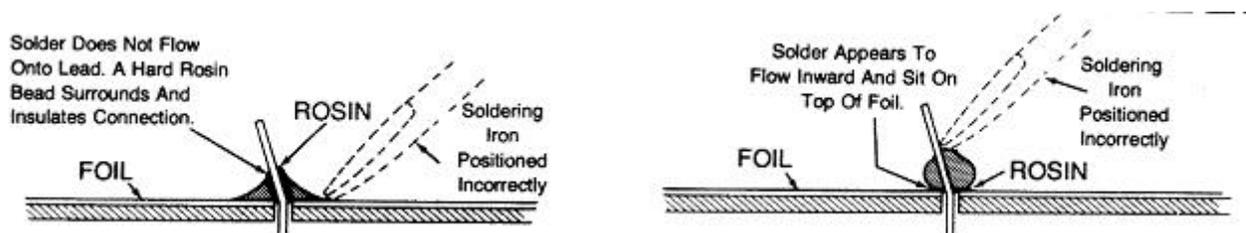


Figure 11. Examples of poor solder joints.

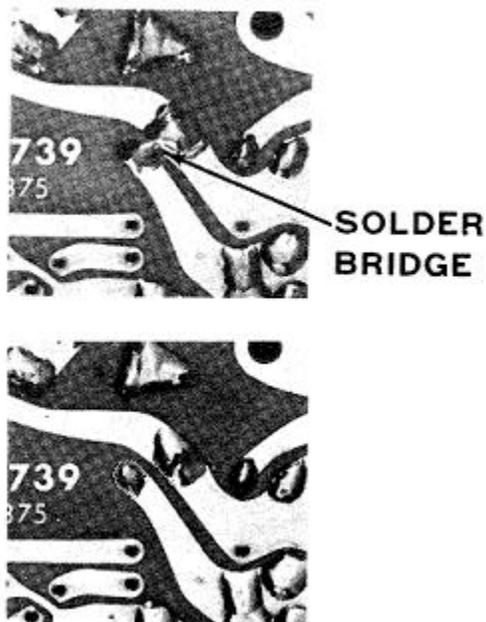


Figure 12. Example of a solder bridge.

B. Point-to-Point Prototyping Techniques

1. Point-to-point techniques are used when the expense of designing a PCB is prohibitive or as the prelude to the design of a PCB.
2. Point-to-point wiring typically uses either plain perforated board (“perf-board”) or “pad per hole” perf -board. Pad per hole boards have a plated-through eyelet, or pad, at each hole. Pad per hole boards are more expensive, but are highly recommended because the eyelets ensure that components are physically held to the board. In either case, wires must be wrapped around each other or around the pins of components to make connections. Soldering methods are approximately the same as for PCBs. Examples of each are shown in Figures 13 and 14.

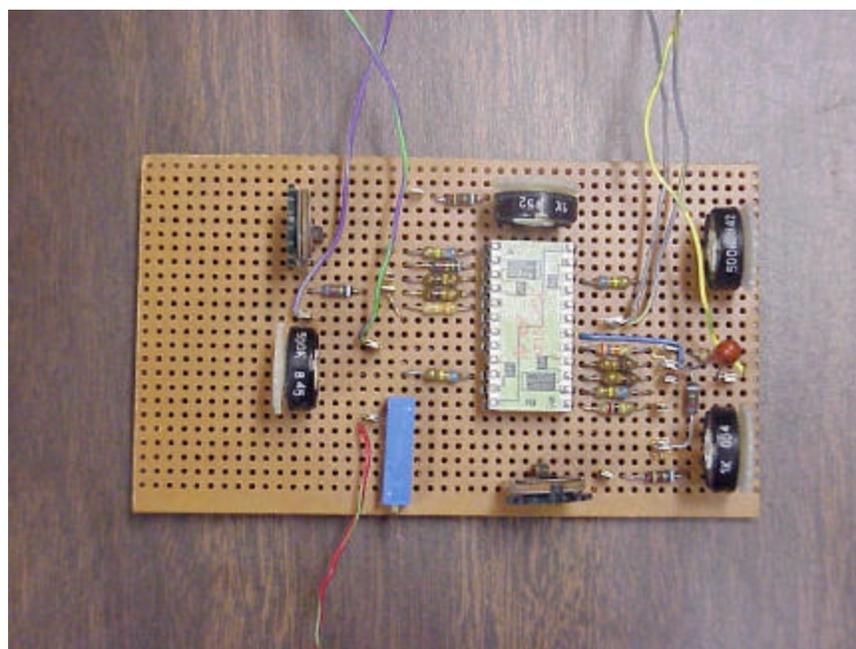
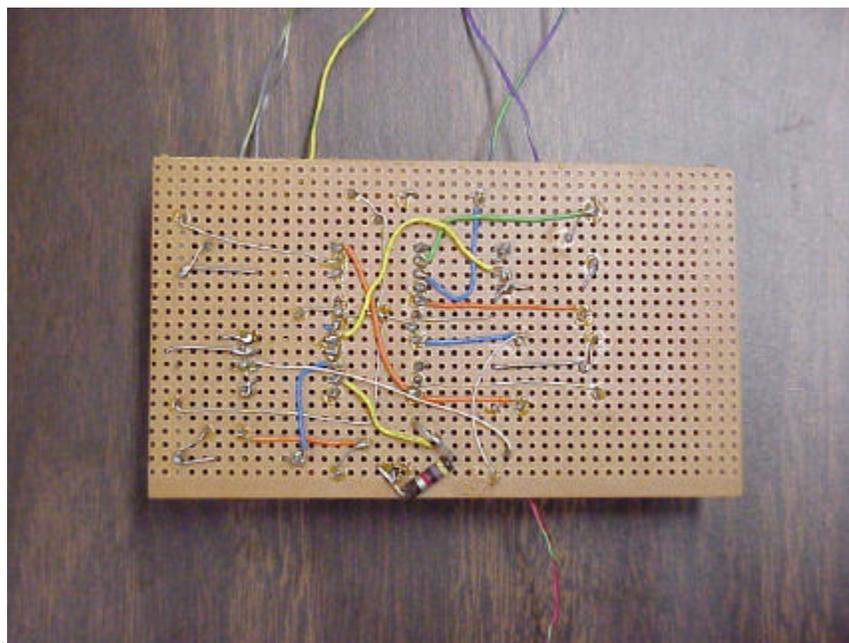


Figure 13. Point-to-point wiring using perf-board.

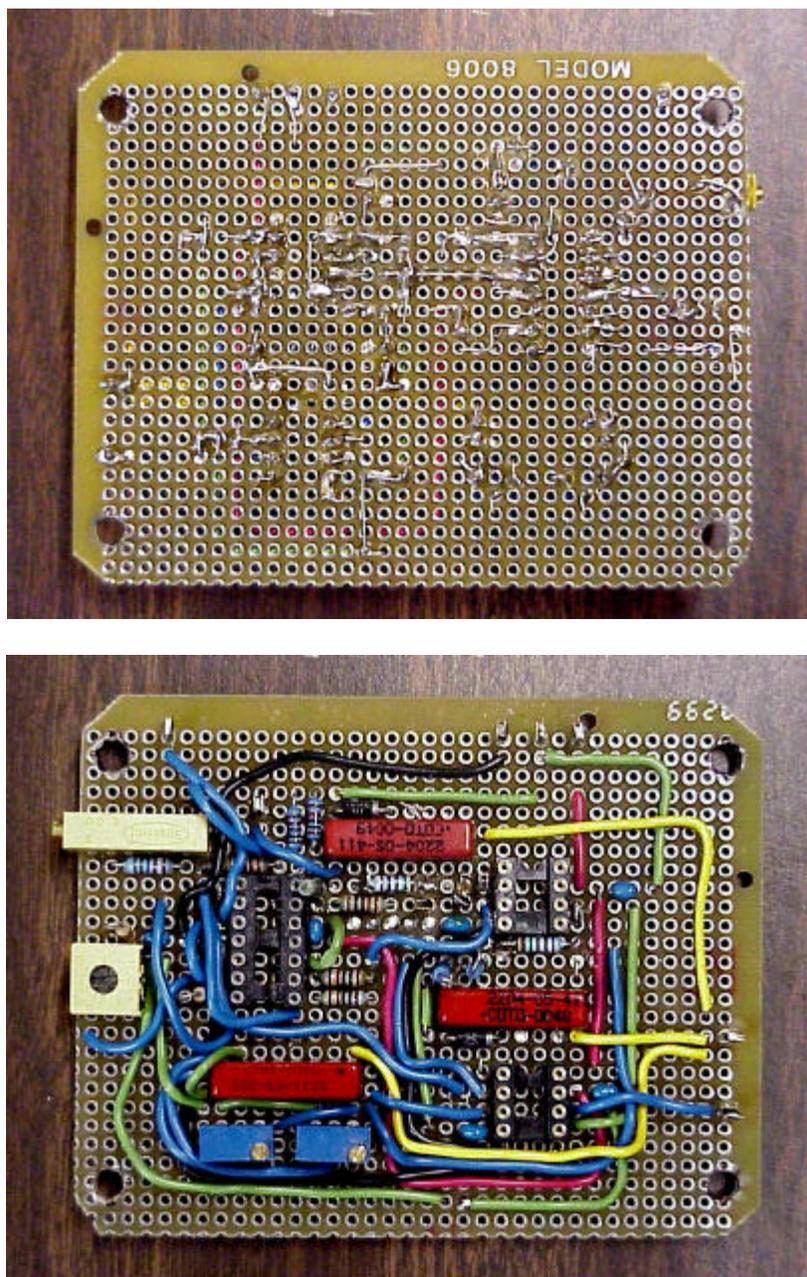


Figure 14. Point-to-point wiring using a pad per hole board.

C. Miscellaneous construction techniques.

1. Commercially available prototyping boards. Several types of prototyping PCBs are available for special applications. Figure 15 shows a board intended for use with a single DIP IC and Figure 16 shows a board with many small prototyping boards (“cracker board”) for surface mount components.

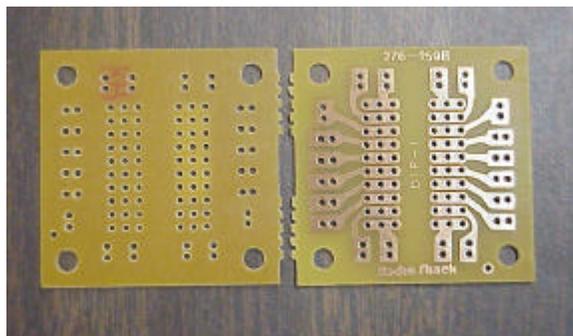


Figure 15. Single DIP prototyping board.

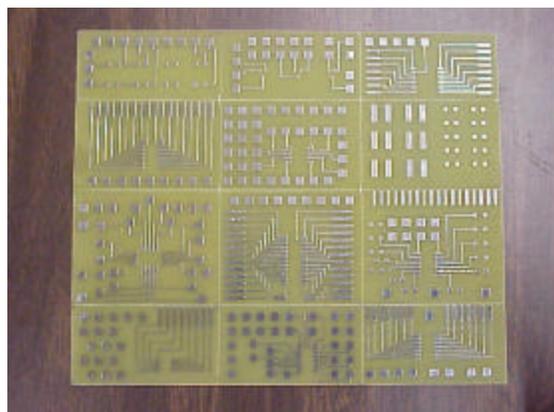


Figure 16. Prototyping board for surface mount components

2. Flea Clips. “Flea clips” can be used for mounting components that may be changed frequently during the prototyping stage. They can also be used for terminals for connecting stranded wires between the board and panel-mounted components. Flea clips can be seen in each of the point-to-point examples above and are shown with an insertion tool in Figure 17.



Figure 17. Flea clip terminals and insertion tool.

3. Spacers and Chassis. Spacers are usually used to mount circuit boards to a chassis. Spacers are available in many lengths and materials, and may have internal or external threads. Figure 18 shows two sizes of aluminum hexagonal threaded spacers and shows how they are used for mounting a PCB into a chassis.

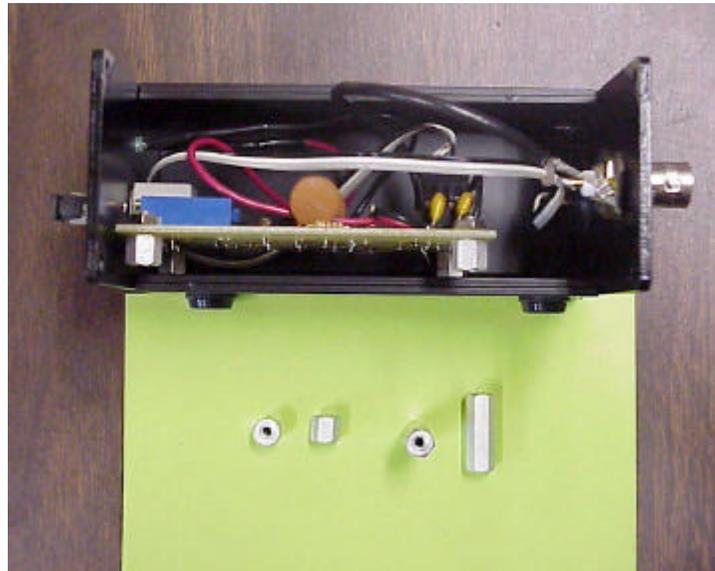


Figure 18. Use of spacers in construction.

REFERENCES:

Clyde F. Coombs, ed. *Printed Circuits Handbook*, Second Edition, 1979, McGraw-Hill, New York, NY. ISBN 0-07-012608-9