

## Prototyping Methods

There's more on this in Scherz, *Practical Electronics for Inventors*.

### Solderless Breadboard or Plugboard

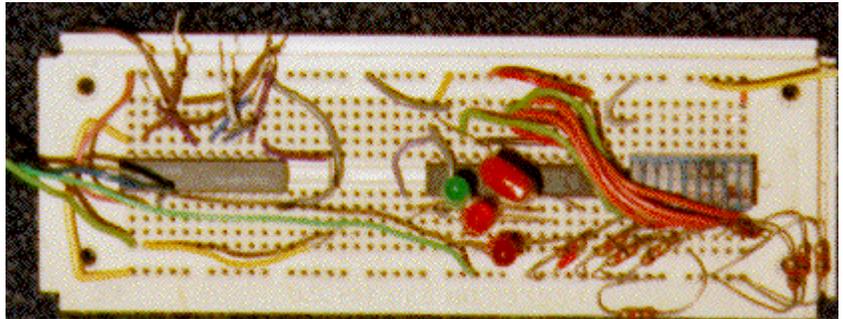
This is what we've been using in lab.

#### Advantages

- Very fast to build and make changes.
- Works well with DIP ICs

#### Disadvantages

- Limited reliability—lab testing only, for limited-size circuits.
- High capacitance between adjacent rows (~ 10 pF).
- Only for small-lead-size components (.032" or 0.82 mm max—a 1 A diode lead is just barely too big to meet the spec.)



### Springboard

Used in ENGS 22

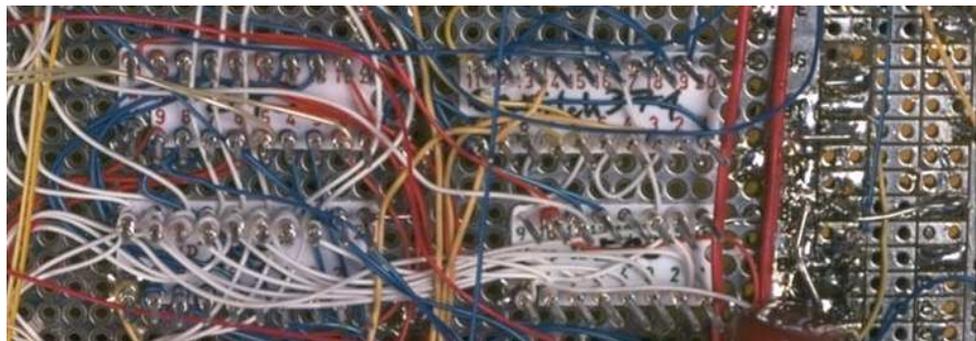
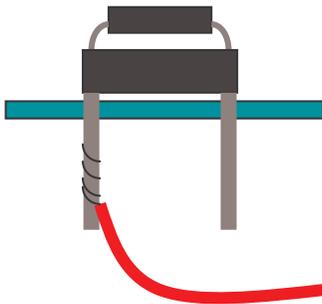
#### Advantages

- Fast to build and make changes.
- Accommodates large wire sizes.
- Secure, reliable connections.
- Can handle higher current/power.

#### Disadvantages

- Can't accommodate small lead spacings such as on ICs.
- Although it is reliable enough for long-term use, it's expensive for that purpose.

### Wirewrap



Connections made by fine wire wrapped tightly around square pins of special IC sockets. This is a great way to make a permanent version of a digital circuit almost as quickly as using a solderless breadboard. Used in ENGS 31.

#### Advantages

- Fast to build and make changes.
- Can make a complex circuit compact.
- Reliable.
- Can be used permanently.
- Inexpensive.

#### Disadvantages

- Low current—limited to under a few hundred mA.
- High inductance/resistance—on the order of 0.1 ohm, 0.25 μH per foot.
- Only makes reliable connections to square leads (as are on wire-wrap IC sockets). Discrete components (e.g., resistors, capacitors, transistors) need to be soldered to a "header" that goes in an IC socket or to individual wire-wrap pins.

## Perfboard and Solder.

Using the same perfboard as used in wire-wrap work, it is possible to simply twist and solder leads, and run wires where needed.

### Advantages

- Reliable, if done well.
- Can be used permanently.
- Inexpensive.
- Can handle any size components
- Convenient for working with discrete components.

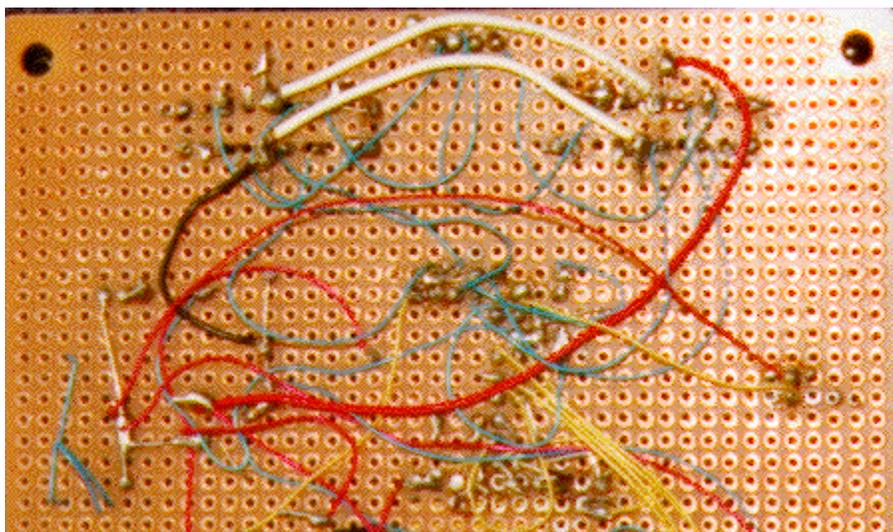
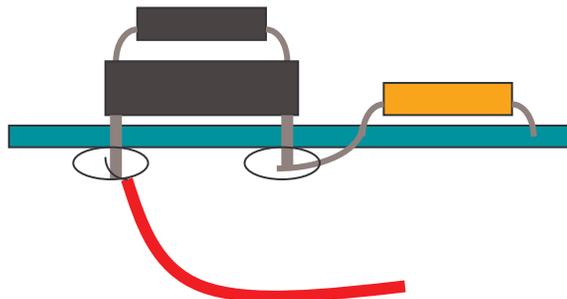
### Disadvantages

- Slow, requires skill to do well.
- Works for ICs, but not very easily.



### Variations:

- Perfboard with individual copper pads on each hole so that the solder will better hold things in place. (Photo below)
- Perfboard with a perforated ground plane. Provides the shielding and grounding benefits of a ground plane, and makes ground connections easy, but requires care to avoid shorts. Some have the ground plane etched from around the holes; others require you to cut the copper away from the holes with a special tool. This is also possible with wire-wrap, as in the photo in that section.





## “Dead Bug,” or “Ugly-board”



Start with a plain copper-clad board. Glue ICs down with the leads sticking up in the air. Then solder to them

### Advantages

- Provides an excellent ground plane. Can be a high performance way to build sensitive and/or high-frequency analog circuits
- Can make a complex circuit compact.
- Reliable.
- Can be used permanently.
- Inexpensive.

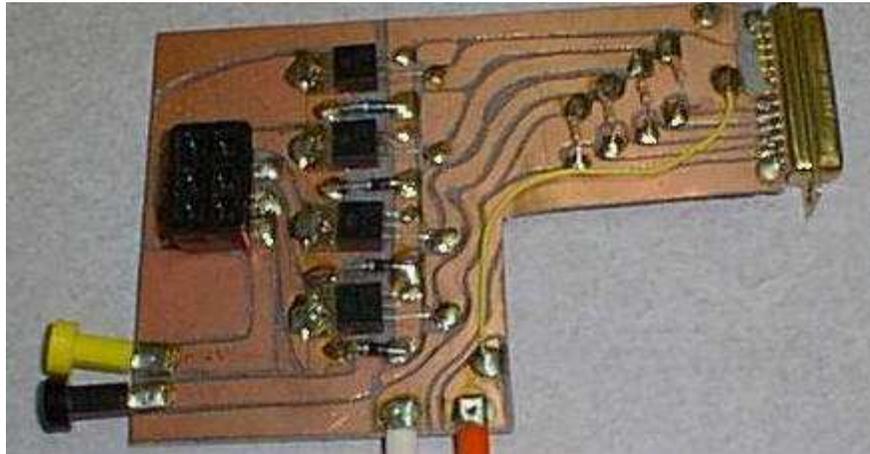
### Disadvantages

- Requires high soldering skill.
- Takes a long time to build.
- Mechanical support for components is marginal; can add glue (“RTV”) after debugging.
- Only makes reliable connections to square leads (as are on wire-wrap IC sockets). Other components (e.g., resistors, capacitors, transistors) need to be soldered to a “header” that goes in an IC socket or to individual wire-wrap pins.

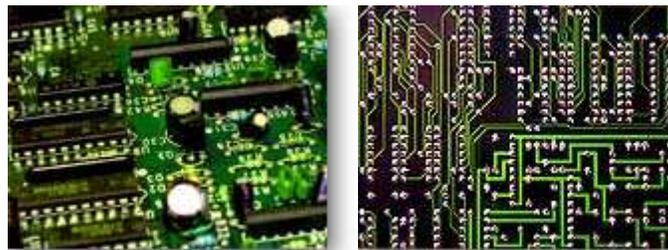


**Variations:**

- Manually cut the board with a dremel tool to isolate sections for purposes other than ground plane (use the back for ground plane). See photo below.
- Glue on little rectangles of cut-out board to add power busses, etc.



**Printed circuit board (PCB)**



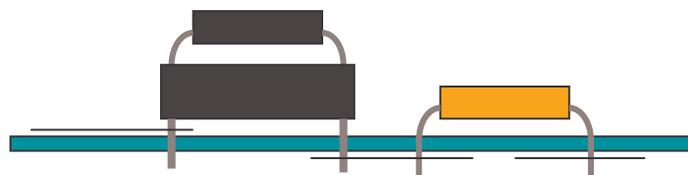
This is what is used virtually universally in production of electronics.

**Advantages**

- Easy to build in production.
- Repeatable, controllable stray L, C.
- Can handle virtually any component, power level.
- Highly reliable.
- Can make very compact.
- Design can be (somewhat) automated from a schematic you have entered.

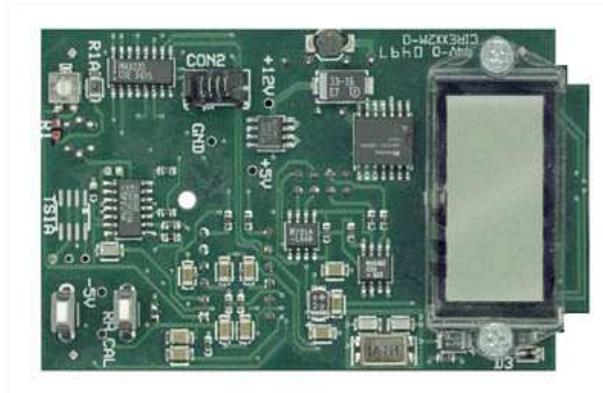
**Disadvantages**

- Laying out the board and getting it fabricated takes time, although you can pay for fabrication in a few days if you can afford it.
- Expensive, on the order of hundreds of dollars for one, but with almost no increase in cost to make many.
- Hard to make changes, but making changes may be easier than building another type of prototype.



## Notes on surface-mount components

Most modern production designs now use surface-mount components instead of “through hole” components. The circuits can be more compact, and the board layout is easier because different things can be done on each side (and in additional layers between sides) without through-holes interfering. But prototyping gets much more difficult!



### Prototyping options for surface mount

- Simulate, and then lay out a PCB. Don't ever make a breadboard.
- Order DIP ICs and leaded passives for the prototype, and then switch to surface mount for production.
- Get adaptors that have pads to solder surface-mount ICs to, and then standard-spacing (0.1") pins in DIP or SIP layout. Digikey carries “surfboards” made by Capital Advanced Technologies, and adaptors made by Aries Electronics. In addition to DIP and SIP adaptors, there are boards with solder pads for connecting larger wires; these work well for prototypes built in “dead bug” style.

