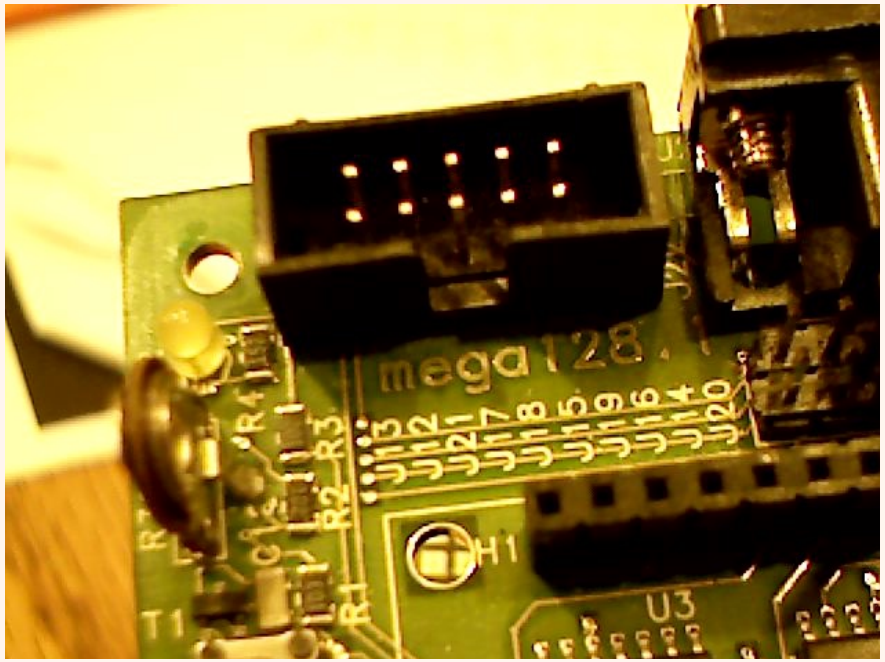
Prototyping

- Prototypes are built to see if the circuit you have in mind is worth building into something more polished. Its likely to need some tinkering before its production worthy.
- If poorly built, you get no information on your circuit's worthiness.
- A well-built prototype is rugged, easy to change, and easy to probe.
- My prototype is 17 years old. It has endured many trips to and from work. It's tested many versions of radios, temperature sensors, audio amplifiers and level shifters. It's still solid.

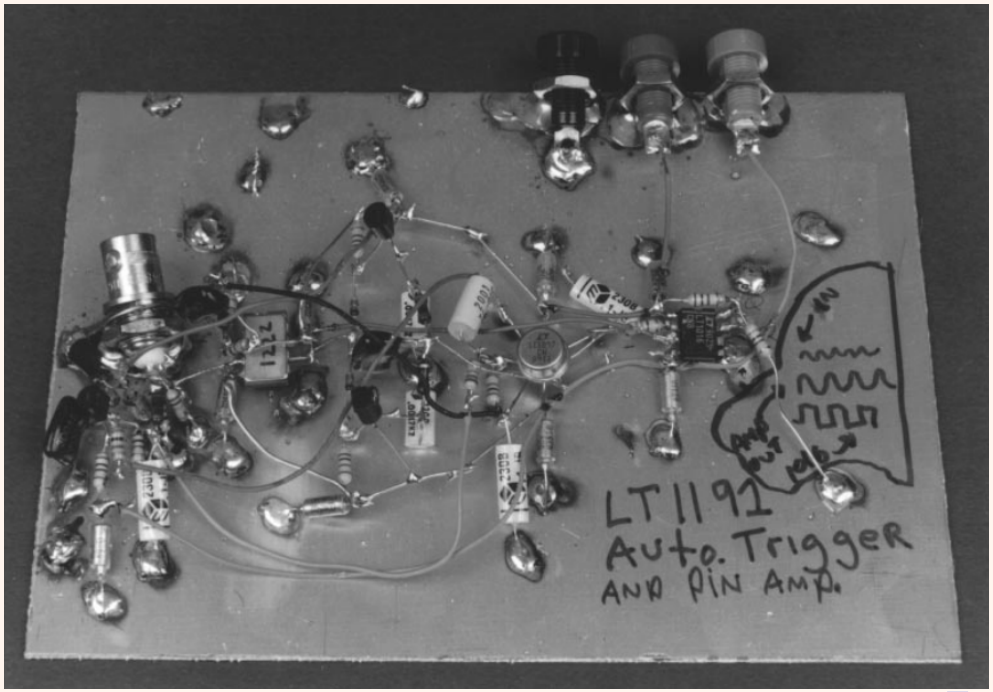


Prototyping

- Prototypes are not intended to be pretty, though they can be.
- They can be ugly, but yield vital information to the designer.
- The method of prototyping we will use is simple, robust and easily allows for changes and experimentation.
- It also utilizes some good practices for mixed analog/digital designs.
- Once you get the swing of it, its not hard.

Prototyping

- Our alarm clock radio will be built upon a solid ground plane.
- This method is common when prototyping high frequency circuits or those with low level signals. We have a circuit where 75mV and smaller signals and 5 volt signals share ground. This must be done carefully.
- Here's an example of a purely analog prototype built on a copper ground plane by the analog legend Jim Williams of Linear Technology Inc..



Prototyping

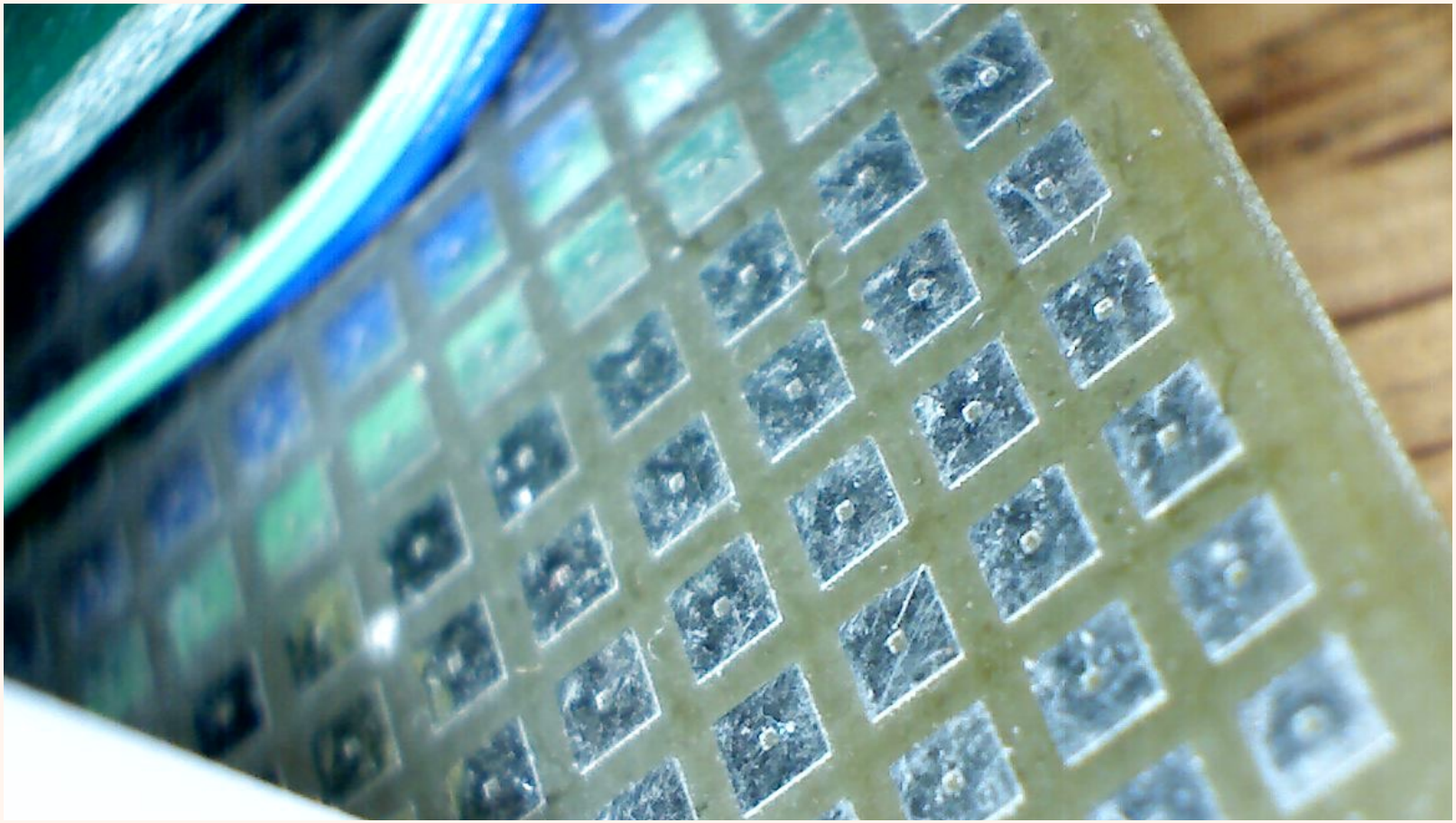
- In your lab kit, is a "pin vise" which is used to drill through the protoboard to its back side where ground connections are made.

Prototyping

- The smaller drill bit is for component leads and the bigger one (if you have one) is for connector pins or larger wire.
- The pin vise holds two different "collets" in its housing opened by unscrewing the top piece.
- The collets are changed by unscrewing the bottom of the pin vise.

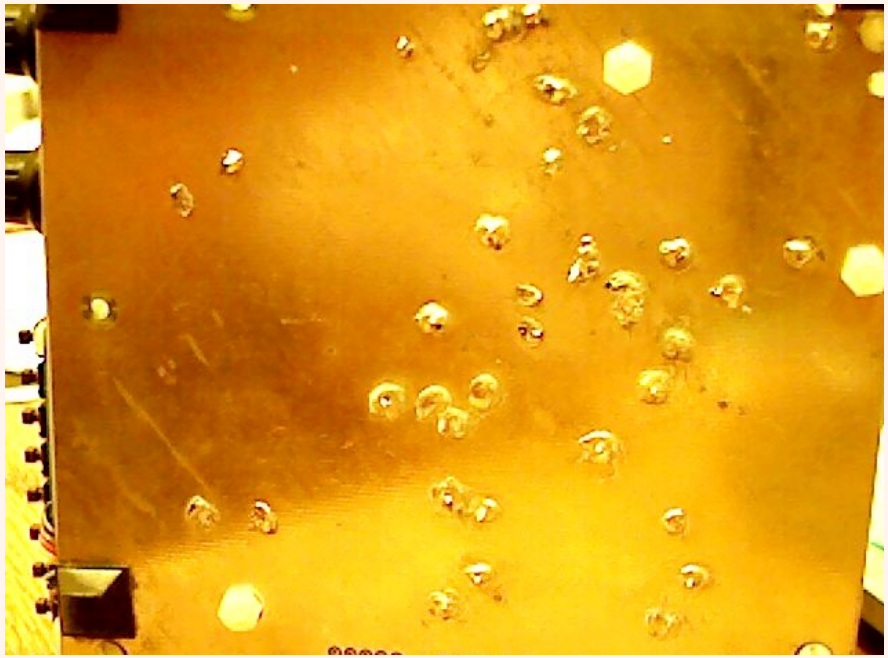
Prototyping

- The prototyping board has pads at 0.1 inch centers. In the center of the pads, there is a .010 inch divot that is used to center the drill bit.
- To make a hole through the board, put the drill bit into the divot and twist clockwise while applying light pressure. The bits are brittle, so be gentle.



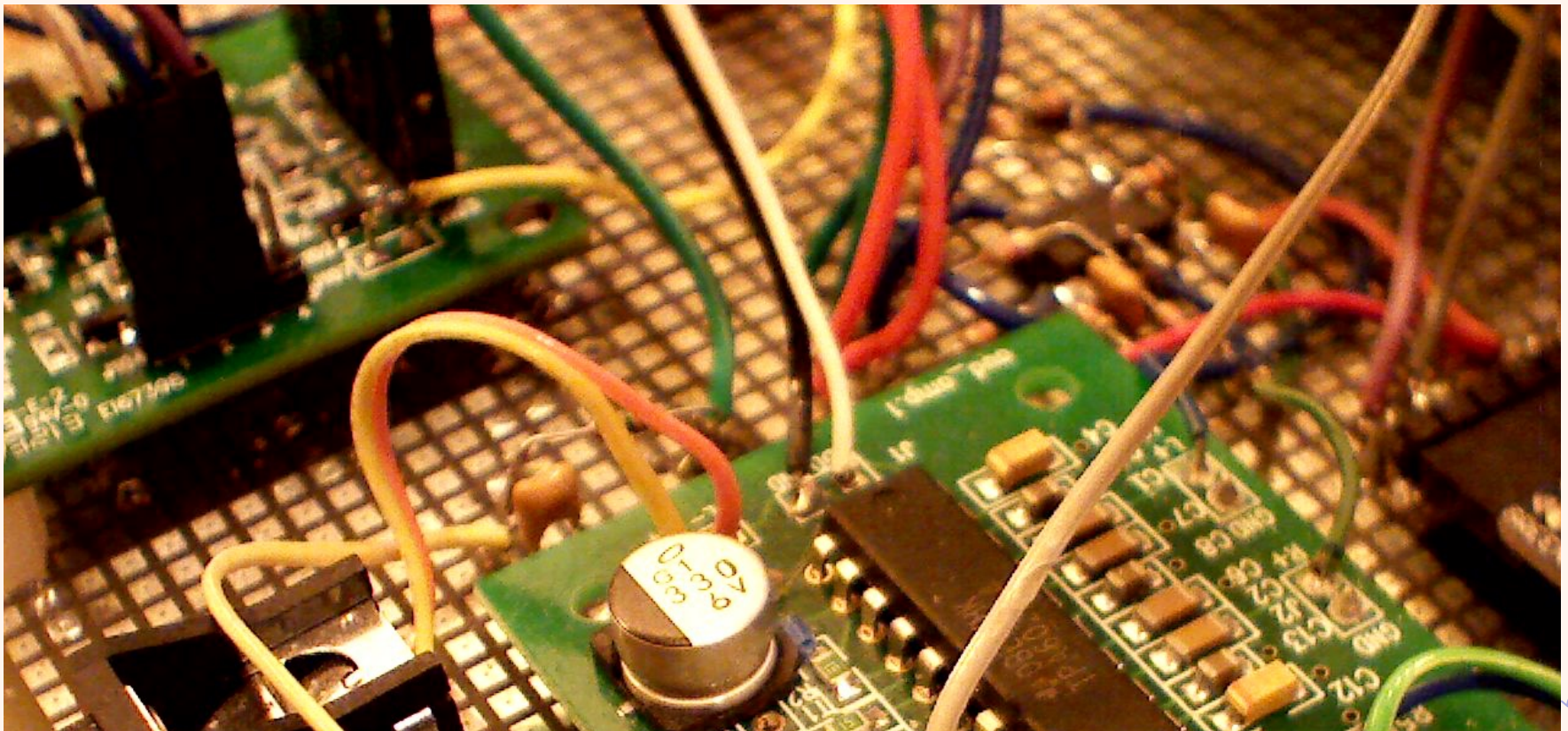
Prototyping

- Once the hole is drilled through the board, push the wire or lead through, trim it and solder directly to the back of the protoboard.
- There are no connections on the back side except for ground connections.



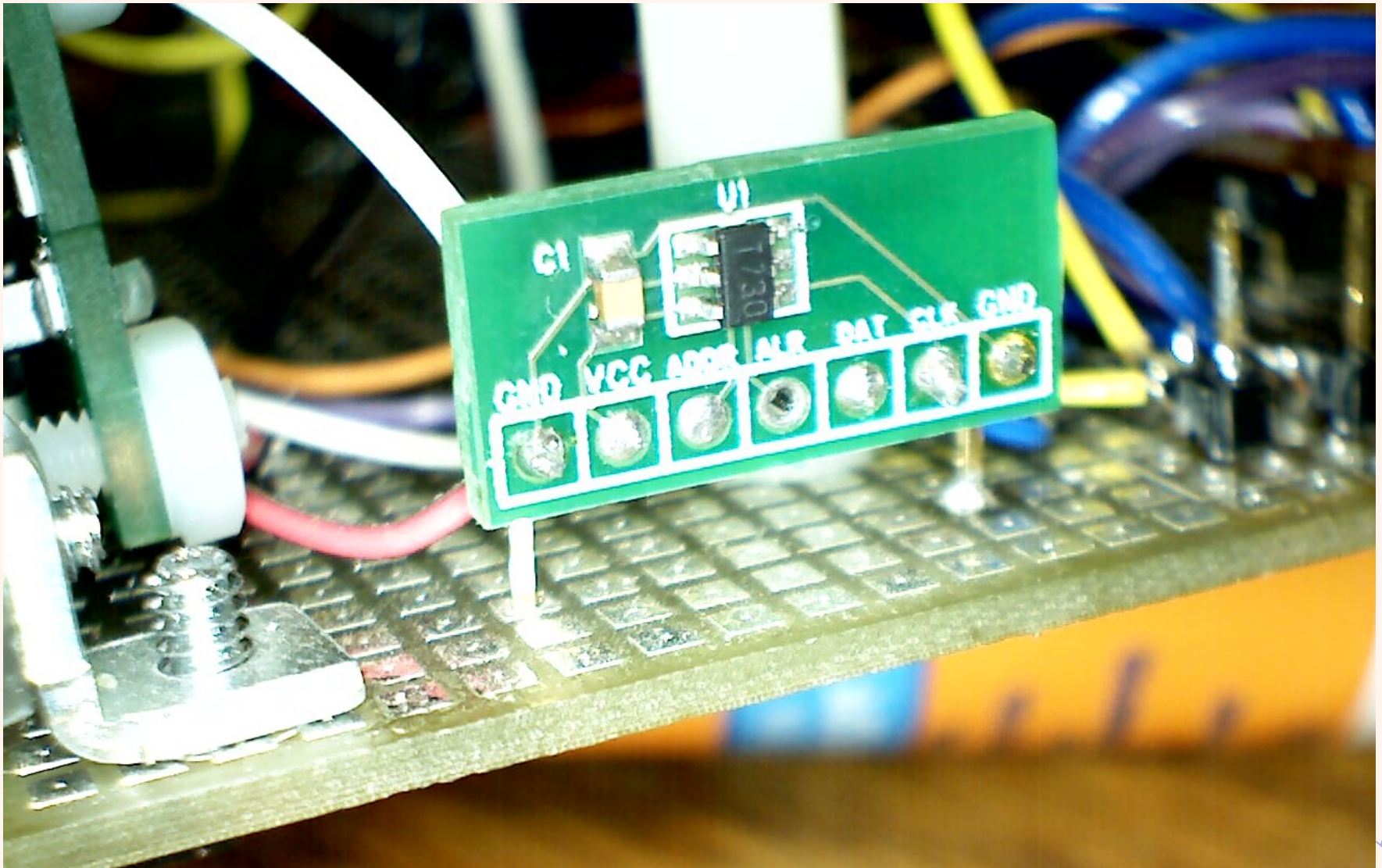
Prototyping

- Some of the subcircuits can be easily mounted directly on the protoboard without the mounting holes.
- For example, the audio amplifier is mounted by using any of its ground pins and soldering directly to the ground plane. So, a high-quality ground is obtained while physically mounting the boards. No wires are need for attaching to ground from the subcircuits.



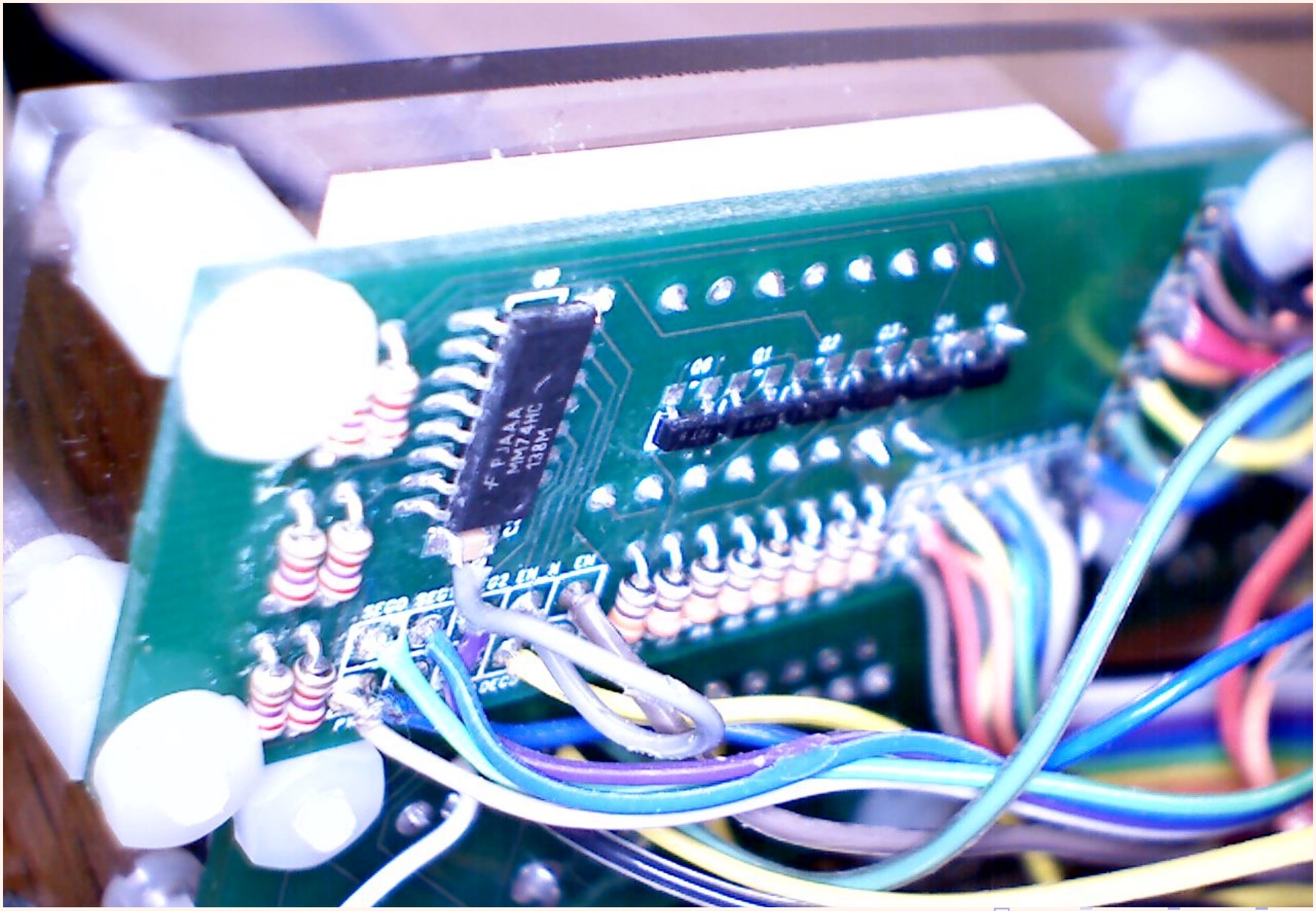
Prototyping

- Here is how I mounted my temperature sensor. I used two connector pins and soldered them to the protoboard ground. Super easy and easy to probe.



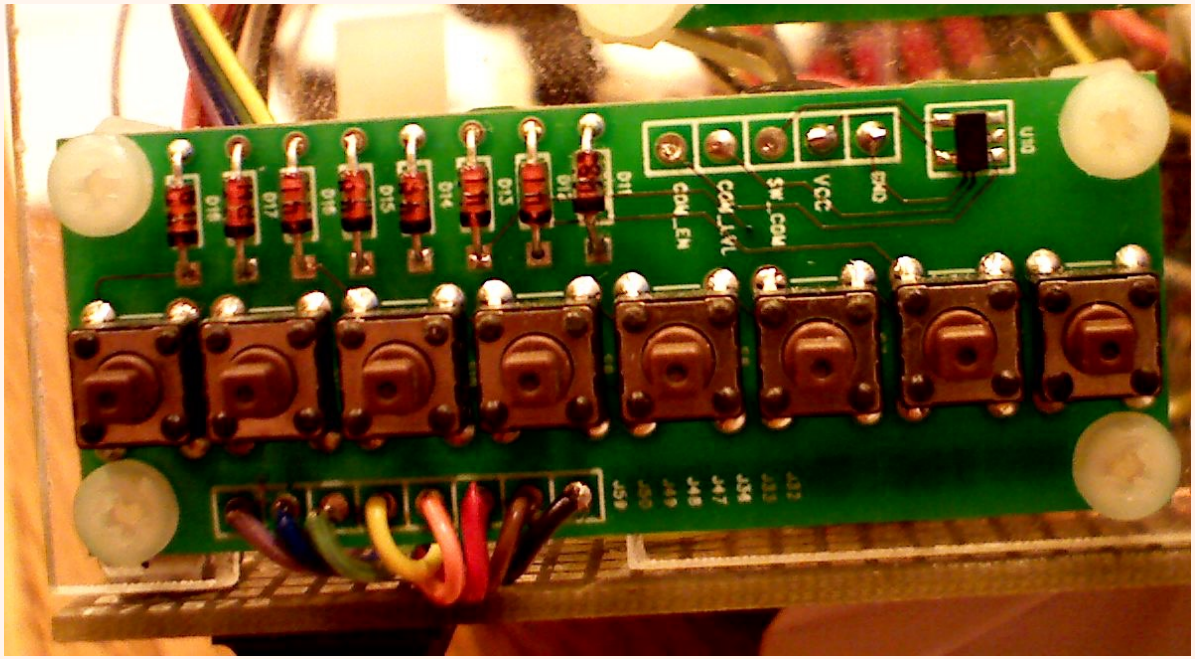
Prototyping

- Wiring on the back of the LED board.



Prototyping

- One the previous pictures, notice that no premade jumper wires were used. All the wires are soldered in directly in.
- This way, there is never a question about where a jumper goes.
- No jumpers ever become disconnected in a tangle of jumper wires or "dance" around shorting out other circuits.
- I filed a small relief on the plexiglass front to solder the wires to the button board.

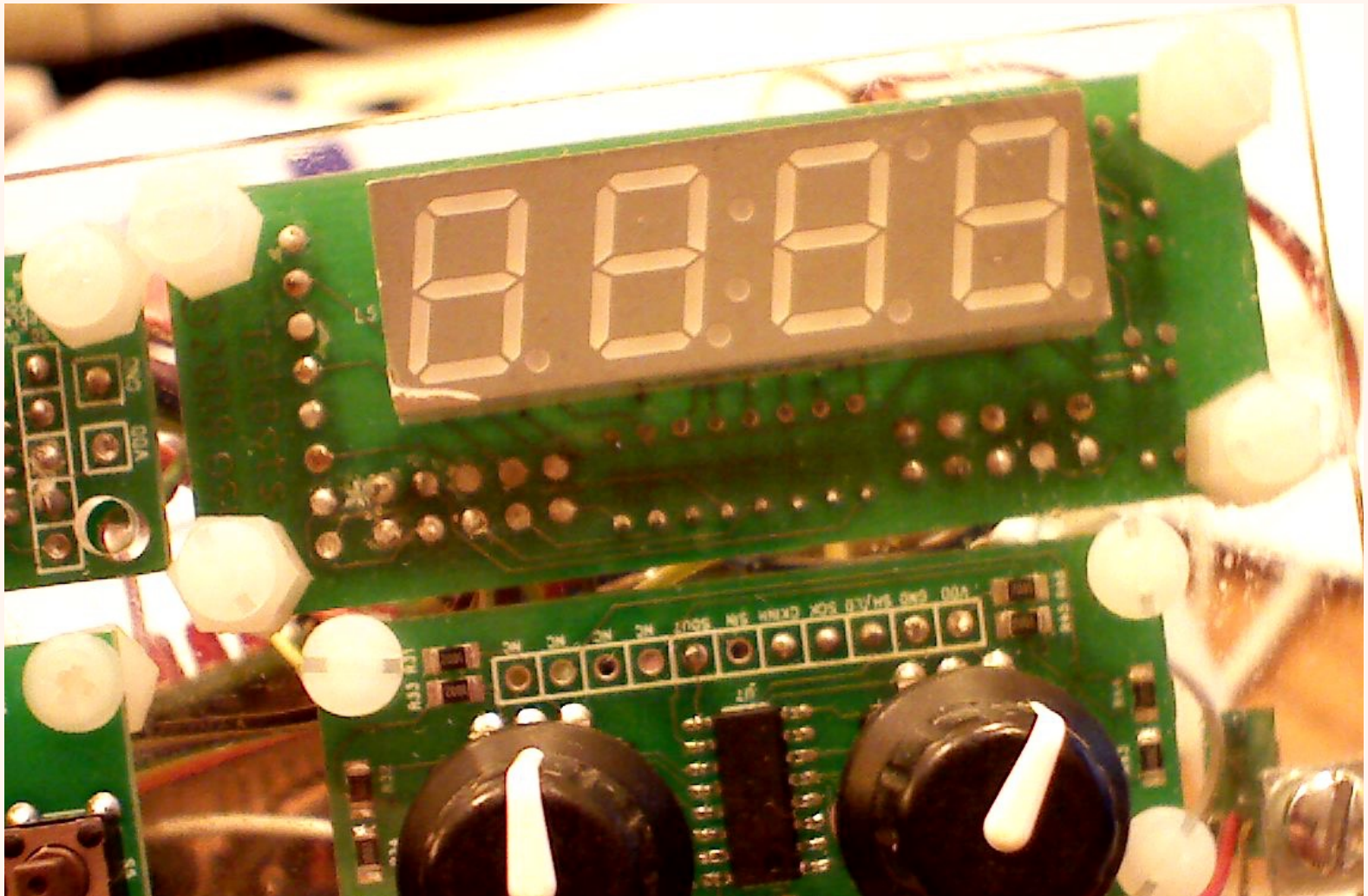


Prototyping

- When soldering the ribbon cable wires to PCB holes, there are some tricks.
  1. Strip the end of the wire to about 1mm. (a dime's thinckness) This is because the tinning process will cause the insulation to retract. Also, make sure that none of the individual wires are cut by stripping.
  2. Twist the wire to hold the strands together then tin the strands to form a solid conductor. Keep the tinned wire to 1mm or so.
  3. Fill the hole just enough solder to close the hole.
  4. Heat the hole from one side while gently but quickly pushing the wire end into the hole with molten solder till the insulation is reached.

Prototyping

- Here is how the encoders and LED display are mounted. A connector on the back of the LED display for PORTA could be used as all the 10 wires match one-to-one.
- The connections to the encoder board (bottom) are all soldered.

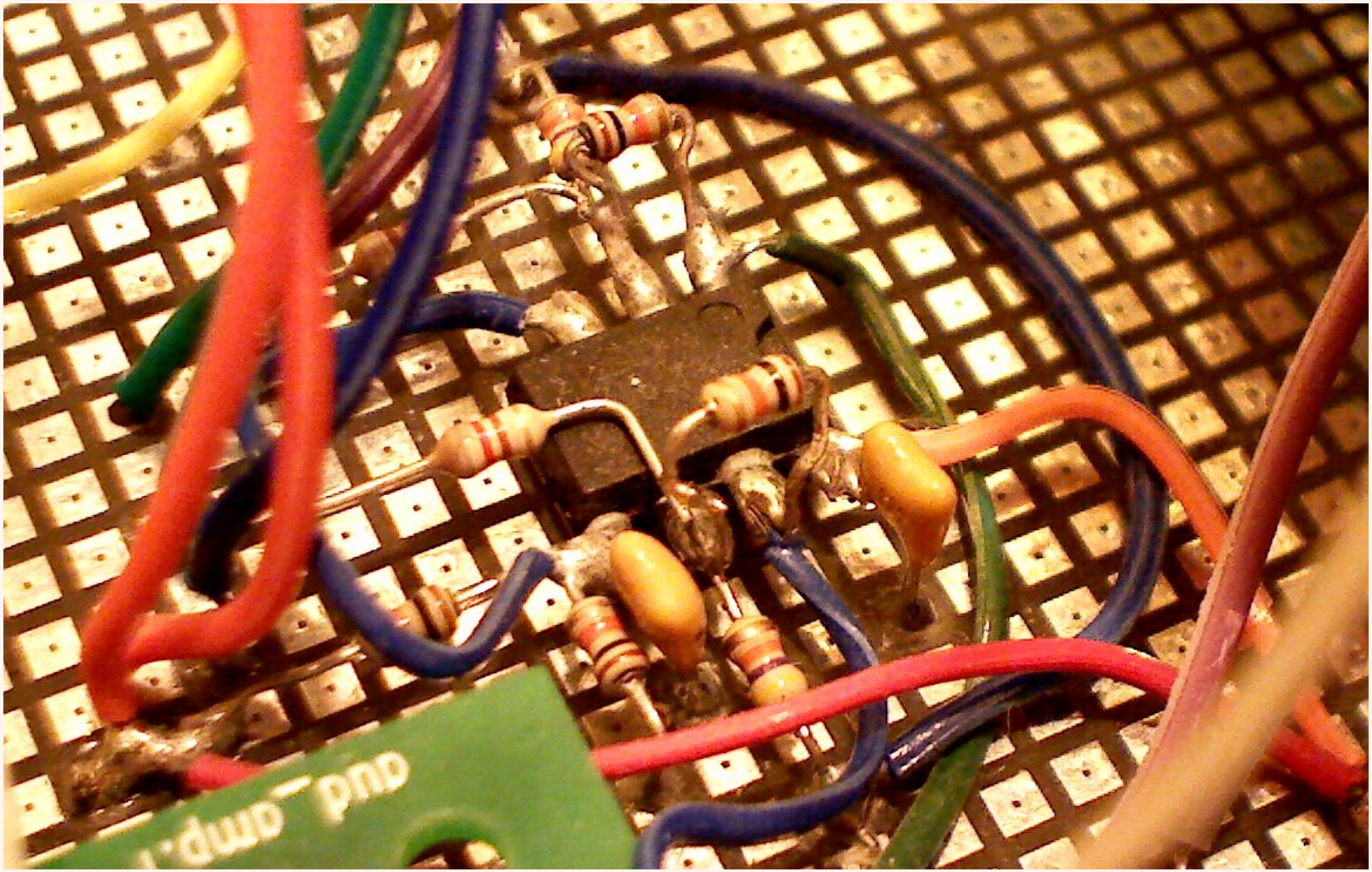


Prototyping

- It is vital for the OPAMP circuits be built on the protoboard. The opamp both sums and amplifies a low level signal. Any noise entering here will make your radio sound badly.
- The leads of the OPAMP are all bent directly outwards like wings, except for the ground pin. The skinny part of the pin is clipped off as its too narrow to solder to. The ground pin is passed through the protoboard directly to ground.
- Resistors and capacitors are soldered directly to the pins. This method of construction leaves no question as to what is connected to what. You can quickly check things.
- If this was built on a typical protoboard, you must repeatedly flip the board over to see what is hooked to what. IC pins numbers are then mirror-imaged. Mistakes are easy to make.

Prototyping

- Here is how the OPAMP is mounted and connected. Note the decoupling capacitor connected directly between pin 8 (Vdd) and ground. Pin 5 is decoupled similarly.



Prototyping

- To keep dumb errors down label port ribbon cables.

Prototyping

- Another error preventing idea, label individual wires where appropriate.

Prototyping

- Thoughts on Prototyping:
  - If you want a great education on high speed circuits, see "AN 47, High Speed Amplifier Techniques - A Designers Companion for Wide Band Circuitry", by Jim Williams.
  - There are many ways to prototype depending on the technology: SMD parts, RF, Audio, high speed digital, single-transisor circuits.
  - SMD parts: use SOIC, if smaller use "Schmartboards"
  - Quick and dirty,...maybe white protoboard. Note: these are banned from many commercial labs due to intermittent connections.
  - Copperclad boards cost about one penny per square inch.
  - Easy, small boards can be made quickly and cheaply to proto SMD circuits.
  - Ugly, AKA dead-bug construction, uses three dimensions to do wiring. These often out perform PCBs! See: dead-bug technique