Electronics and Soldering Notes

The Tools You'll Need
While there are literally one hundred tools for soldering, testing, and fixing electronic circuits, you only need a few to make robot. These tools are explained below.

Safety Glasses
First and foremost, wear safety glasses. They don't have to be expensive, but they need to have some wrap-around to protect your eyes from flying wires and hot splashes of solder. While your skin will heal from nicks and burns, your eyes won't. So get some eye protection.

Figure 1. Wearing cheap safety glasses is far better than trying to make robots blind

Wire Cutters

Figure 2. A small pair of wire cutters lets you clip wires closer to the surface of the robot controller

Wire cutters cut wire to length and to trim the wires of components sticking out of the robot controller. Get a small pair as large pairs are too big to trim wires (or the leads) of components that have been soldered to the flight computer. Don't use scissors to cut wire and don't try to trim the plastic insulation from wires with a pair of wire cutters.

When wires are cut, they can often fly away in a snap. Therefore, it's important you wear safety glasses when you clip leads and aim the board away from neighbors.

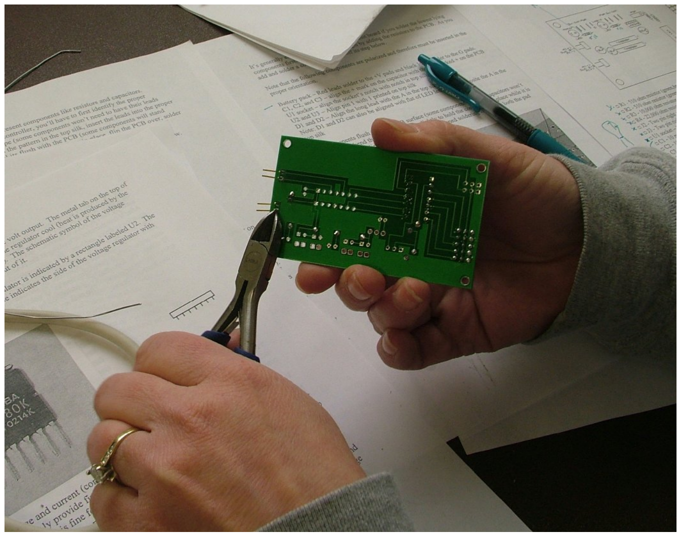


Figure 3. Be careful when you trim leads. The wires can go flying across the room.

Soldering Iron

Figure 4. The soldering iron in its stand and with its sponge. Never lay a hot soldering iron on the table, always use a stand. And always keep the sponge damp.

The traces on the PCB are 20 mils wide. If too much heat is applied to them, they along with the pads will lift off the PCB. The fastest way to overheat a PCB is to use a soldering gun. Therefore, never use a soldering gun to assemble your flight computer. Instead, use a pencil style soldering iron. A fine point or narrow chisel point is prefect. If you use a soldering iron with adjustable temperature, then set the temperature at the mid point of its range.

To transfer heat quickly to the work, the tip of the soldering iron needs to be clean and shiny. You can keep the tip clean and free of oxidation by wiping it frequently across the edge of a damp sponge. If the tip of your soldering iron is dark, then it has a coating of oxidized metal on the surface. The oxidized coating prevents heat from transferring quickly to the work and as a result, the entire work area gets hot, including the neighboring traces. Wiping the tip keeps the oxidation at bay. The flux inside your solder can remove stubborn oxide that just wiping can't remove. Apply solder to the soldering iron tip and let the flux break up some of the oxide before wiping it clean.

After wiping the tip clean, apply a thin coat of solder to the tip to block oxygen from attacking the iron tip. Keep the solder coat thin, or else a large blob of molten solder will transfer to the PCB when you tap the tip to the PCB. A thin coating of solder will help transfer heat while a thick coating will transfer excess solder.

By the way, never jab the hot soldering iron into a damp sponge. The tip should be brushed against the edge of the sponge quickly. Exposing the soldering iron to the cold damp sponge too long creates a thermal shock to the iron. It also needlessly cools the tip and you'll have to wait for the tip to get hot enough to solder again.

Apply the tip of thin solder to the soldering iron tip, pad, and lead. As the solder begins to melt, run the end of it around the pad, forming a cone of solder that wicks up the lead. Remove the solder before removing the soldering iron or else the solder will be stuck to the soldered pad.

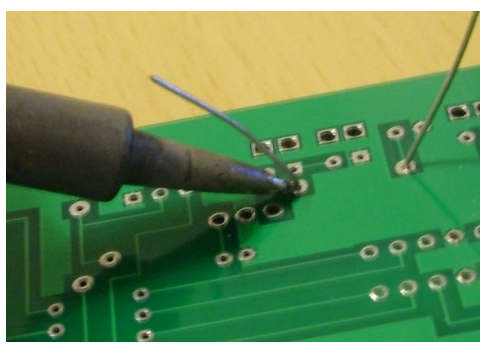


Figure 5. Apply the tip of the soldering iron to both the pad and lead before applying solder to the pad and lead

After the solder cools, clip the lead so it does not stick above the cone of solder around the pad. A well soldered lead will look similar to the image below

Figure 6. A good solder connection is a bright silvery cone

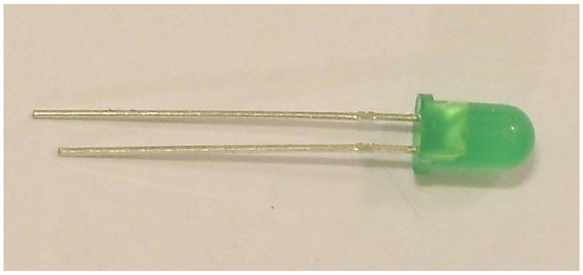
The Resistor Color Code
Rather than stamp the value (number of ohms of resistance) of a resistor on its cylindrical body, colored stripes are painted on it. The resistors in the flight computer have four stripes, but there are resistors with five stripes. Each color signifies a single digit between 0 and 9. The colors and the numbers that they are represent are shown below.

Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

So when you a green stripe, think the digit 5. Now the way the color code on a resistor works is like this. The first two colored bands are read as digits (gold is the fourth band, so read the colored bands for the end opposite the gold band). Therefore, a Red followed by a Blue is 26. The third colored band is also a digit, but it represents the number of zeros in the resistance of the resistor. Therefore, a Yellow, or 4, in the third band means there are four zeros, or 0000 at the end of the first tow numbers. So take for example, a 510 Ω resistor. Its three important colored bands are Green, Brown, Brown.

The fourth band of the resistors in your flight computer is always gold. That indicates the resistors have a tolerance of 5%, or that the actual resistance can be as much as 5% different that the indicated value.

LEDs



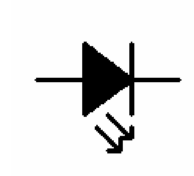


Figure 7. A light-emitting diode (LED) **Schematic of a LED**

Light-emitting diodes are a type of diode the emits light when current flows through them. In this way, they behave like light bulbs, except they will not burn out over the lifetime of the robot controller. To protect LEDs from excessive current, each one is connected to a resistor. LEDs are polarized devices, if they are soldered in backwards they will not operate (but they won't be damaged, either). The negative lead (called the cathode) is usually the shorter of the two leads. A second and surer way to identify the cathode lead is to look for the flattened side of the LED lens (plastic body). The schematic of an LED is the diode symbol (an arrow touching a bar) with one or two arrows pointing away from the diode (to indicate light is shining out of the diode). The arrow of the schematic points to the negative lead or cathode. The other lead of the LED is called the anode.

The proper placement of the LEDs on the PCB are indicated by a circle with the label D1 and D2. The upper-case A (A) next to the LED circle indicates the pad for the positive lead (anode) of the LED.

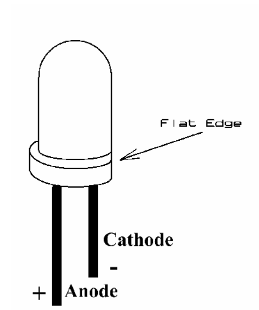


Figure 8. Identifying the two leads of the LED

Assembly Directions
Components are inserted on the printed side (top) of the PCB and their leads are soldered on the unprinted side (bottom). Bend the leads of each component to their proper spacing before inserting the leads in the PCB. Most likely, only resistors will need their leads bent, all other components will probably already have the proper lead spacing. Bend both leads at the resistor body to a 90 degree angle as illustrated below.

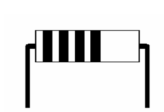


Figure 9. Bend resistor leads very close to their bodies

Insert each component into the PCB at the location reserved for that specific component. The reserved location for each one is printed on the PCB in white letters (top silk) and identified by their number, e.g. R1 for the first resistor and C2 for the second capacitor.

It's generally easier to assemble a printed circuit board if you solder the lowest lying components first. This means you'll begin by adding the resistors to the PCB. As you add and solder a component, check off its step below.

Note that the following components are polarized and therefore must be inserted in the proper orientation.

Battery pack – Red leads solder to the +V pads and black leads solder to the G pads.
C1 – align the + mark on the capacitor with the pad marked + on the PCB
U1 socket – align the socket's notch with notch in top silk
U2 – Align flat side of the voltage regulator with flat edge in top silk
D1 – Align the long lead with the A in the top silk
D2 – Align silver band of the diode with the double line in the top silk

Set components flush with the PCB surface (some components like the capacitors won't fit flush) and bend their leads apart just slightly to hold the component in place while it is being soldered. Flip the PCB over and apply a tinned soldering iron tip to both the pad and lead simultaneously.

Strain Relief for Battery Snap
In order that the wires of the 9V battery snap do not break off the flight computer, the wires first pass through large holes in the PCB before they are soldered to the PCB. The wires and their insulation pass through the large holes as shown below.

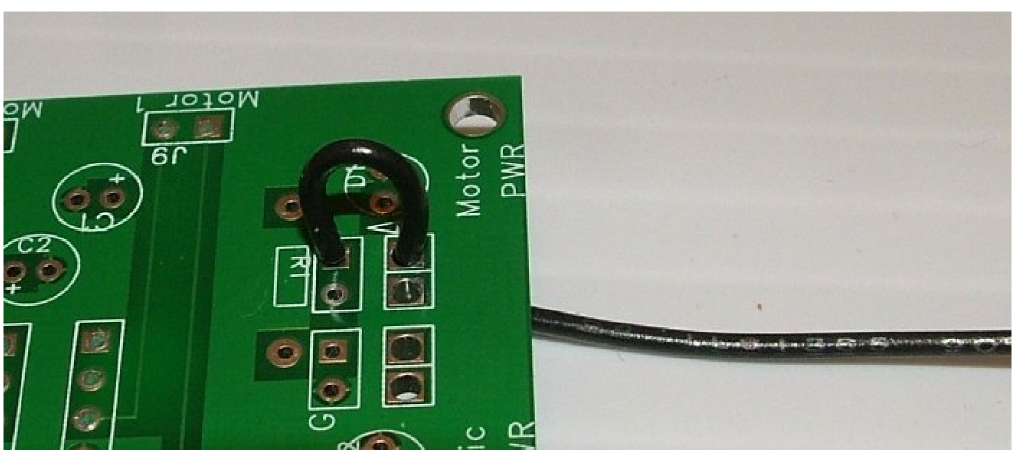


Figure 10. A strain relieved wire ready for soldering