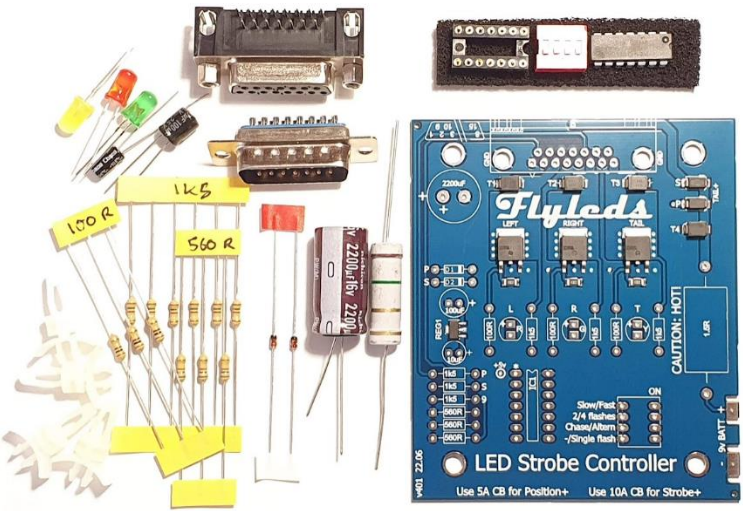
Part 2: Building the Controller Board



Congratulations for making it this far!
The controller printed circuit board (PCB) uses smaller components than the wing boards, which means that everything is actually easier to solder, although those of us with more experienced eyes may disagree with that last statement!

Surface mount components

We supply the controller board with some components already reflow soldered onto the PCB. For your reference the components are:

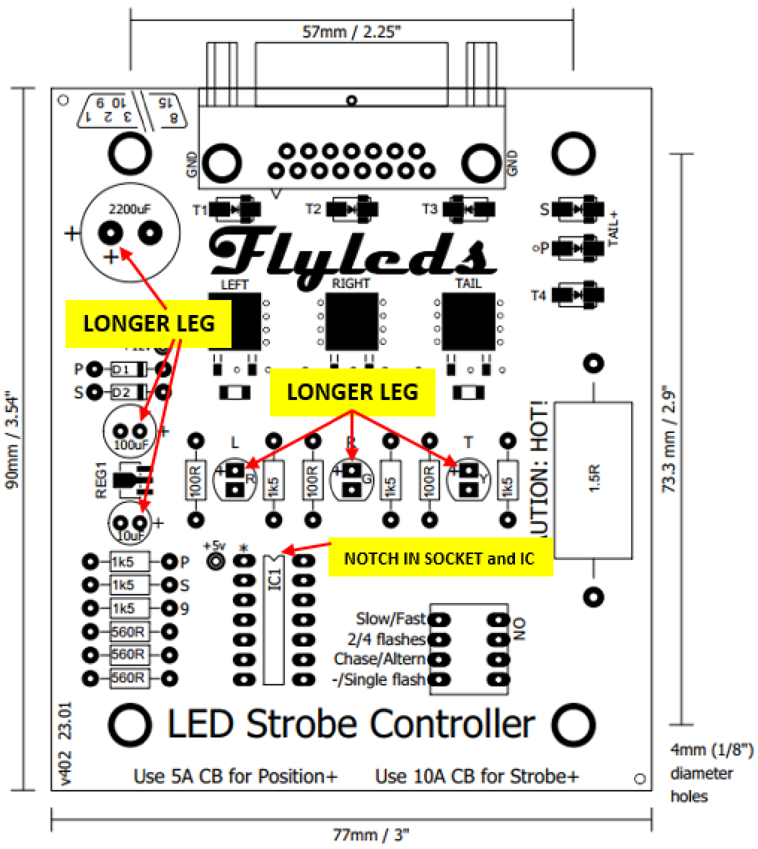
Voltage regulator: Converts the incoming 12 volt power down to 5 volts to supply the microcontroller IC.

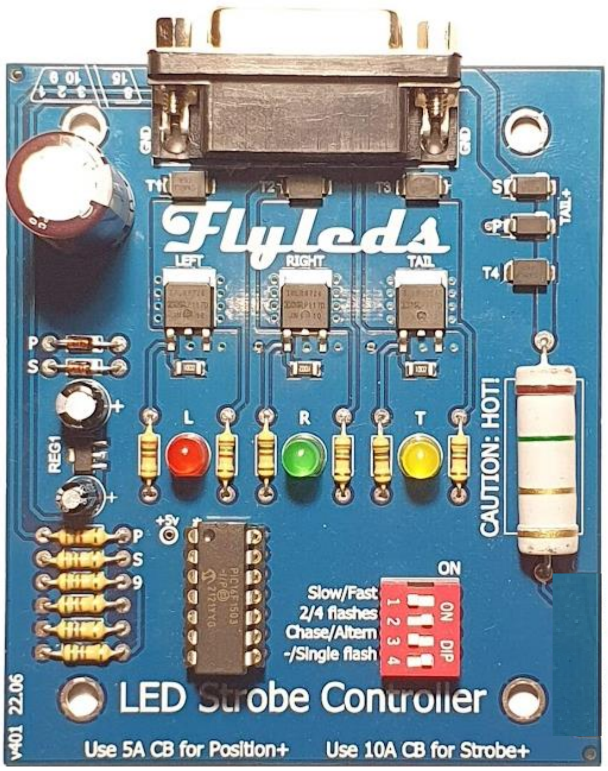
Diodes: These are part of the circuit that allows the tail LED to act as both a strobe and a position light.

N-channel power MOSFETs: These little miracles will switch 45 amps of current all day long and have an 'on' resistance of only 0.006 ohms. In this circuit, they only switch ~5-6 amps for the strobe flash duration, so they generate very little heat. In years gone by, this control circuit would have required large switching transistors that came in steel bodies, all mounted on a large and heavy heatsink.

Transient Voltage Suppressors marked T1-T4, prevent stray voltage spikes from causing damage to the components.

Final component layout





Loading components

With circuit board construction it is easiest to fit the lowest profile components to the board first and work your way up in physical size.

1: The **resistors** are supplied banded together in their resistance value groups. Resistors can be inserted either way around, but the convention is to be able to read the colour code bands from left to right, or top to bottom.

(There's another +1 knot in speed gained.)

Electronics drafting convention uses the multiplier letter in place of a decimal point, as a decimal point is easily lost in print. A 1.5kΩ resistor is a very different value to a 15kΩ resistor, so the convention is to write them as 1k5 and 15k, for example. R is also often used to replace the Ω symbol.

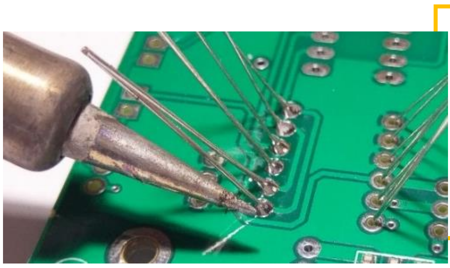
* Begin by removing the yellow tape from the **three 100Ω** (ohm) resistors (Brown/Black/Brown/ Gold).
Bend their legs over and insert them in the vertical positions marked 100R in the middle of the board.
Splay their legs apart slightly as shown so that the resistor stays in place tight to the board, as pictured below left.

* Next insert the **six 1.5kΩ** resistors (Brown/Green/Red/ Gold) in the positions marked 1k5 on the board.

* The last group to insert is the **three 560Ω** resistors (Green/Blue/Brown/ Gold) in the positions marked 560R.

2: Insert the **two 1N4148 diodes** in the positions marked D1 and D2 on the board.
Note that the diode has a **black band** around one end. Diodes are polarised, so they must be mounted as indicated on the PCB with the band **to the right**, otherwise there will be no blinking lights! (P stands for Position, S for Strobes.)

3: At this point you can **turn the board over and solder all of these components.**
Let the tip of the iron touch **both** the circuit board and the component leg, and after a few seconds introduce some solder. Leave the iron there for a few seconds more to allow the solder to **flow** and then you should have a nice smooth looking volcano-shaped joint around each leg.



If the solder acts like it is 'allergic' to either the board or the resistor leg and does not want to flow smoothly around the component leg and the PCB pad, it is telling you that one part is not hot enough. You may need to adjust the 'angle of attack' of your soldering iron to ensure *both* the component and the PCB are getting the heat from the iron.

4: You can now mount the **socket** for the microcontroller.
One end of the socket has a notch taken out of it, which aligns with the asterisk (*) on the PCB. Solder one leg first, then check that the socket is still mounted flush to the board. Reheat the solder joint if necessary to let the socket sit properly.

Continue to solder the rest of the legs in place, perhaps alternating pins as you would tighten up a cylinder head on an engine. That way if you're still a bit slow with your soldering the heat build-up won't melt the plastic socket.

5: Mount and solder the four-way **DIP switch**, checking that it is oriented as pictured above. Again, solder one leg first and check that the switch is still mounted flush to the circuit board.

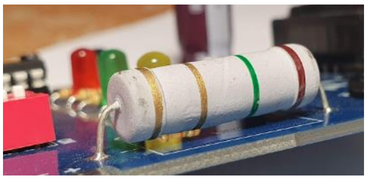
Loading components, continued.

6: Insert the red, green and yellow **LEDs**. The *longer* leg of each LED mounts in the upper hole marked with a +, closest to the switching FETs.

7: Mount the two **smaller capacitors**, 100µF closest to the two diodes, 10µF closest to the resistors. Note the orientation as per the diagram, and the + on the silkscreen on the PCB. The ***longer*** leg of the capacitors is the **+** terminal. (And the white stripe on the body printing highlights the **–** terminal, just to keep you on your toes!)

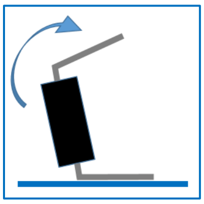
8: You can now fit the **15 pin D connector**. It might be a tight fit, but they do push in! If one pin is a little bent it's going to do all it can to frustrate you. We start by anchoring one of the mounts at one end and then try to insert the plug one pin at a time, with a little persuasion for the one pin that's occasionally out of line.
…either that or it just falls straight in!
Solder the pins in along one row, then rotate the board to suit your angle of attack and solder the other row of pins. Feel free to solder the mounting pins at each end as well, but it's not absolutely required.

9: Mount the **1.5Ω ceramic power resistor** for the tail strobe. Leave a millimetre or so of air gap under it to allow for heat dissipation.

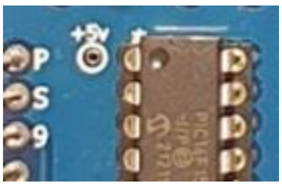


10: Mount the **2200uF** capacitor, observing the + sign on the silkscreen and inserting the longer leg of the capacitor in that hole first. Double check the orientation of this one before soldering it in!

11: The **microcontroller chip** can now be inserted into the socket, however the legs of the chip may be spread too wide to fit straight into the socket.
Hold the body of the chip so that one side of legs is against your workbench, and gently "roll" the chip forward so that the legs are *almost* 90^{o} to the body. Turn the chip over and again straighten the other row of legs.



If you've just realised you've soldered the microcontroller chip to the board instead of the socket in step 4 above, don't panic! All is good, leave it there. You will very likely damage the PCB trying to remove the chip.



You can now carefully insert the controller IC into the socket. Note the small detent and/or notch in the chip, which marks pin 1, and corresponds with the (*) on the PCB.

The IC is held in by a friction fit and does not need to be soldered to the socket.

12: Finally, apply a few dabs of silicon/RTV to the base of the large 2200uF capacitor to anchor it to the PCB.

That's it! You're done!

The Blink Test

* Using your square 9 volt battery and some scraps of wire, connect the battery+ to **STROBE+ (pin 10)** and battery– to **GROUND (pin 1)**. See the diagram below.
Configure the switches and you will see the different flash patterns in action with the on-board LEDs. Hours of fun!
* To enable the WigWag mode, you need to connect *both* **WIGWAG+ (pin 9)** *and* **STROBE+ (pin 10)** to the positive + terminal of the 9v battery. You might start running out of hands trying to test this!
* Applying battery+ power to **POSITION+ (pin 5)**, the yellow Tail LED will light dimly at 10% power.

> With this version 4 blue controller board, the red, green and yellow LEDs on the circuit board are directly driven by the switching FETs, so if the LEDs blink in the tests above you can be confident that everything is working as it should. Well done! **If the behaviour of the on board LEDs changes when you connect the wiring harness then that indicates that you have some wiring issues!**

The Beep Test

The strobe LEDs on the wings and tail flash when the switching MOSFETs connect the ***negative*** side of each LED circuit to ground. This is why the STROBE- wires from the wings and tail must come back to the controller board. If you decide to add an extra ground connection (please don't!) the strobe LEDs will stay stuck on rather than flash.
This test is optional to do, but it is a great way to show you how to use the beeper function on your meter.
1: Set your multimeter to the *continuity/beeper* function.
2: Check that your meter *beeps* when you touch the test leads together.
3: Check for periodic beeps in time with the flashing LEDs with your black test lead on any ground connection, eg **pin 1 or 2** or the metal body of the DB15 socket, and the red test lead on **pin 3** (Left-), **pin 6** (Right-), or **pin 8** (Tail-).

(Power needs to be applied for this test to work!)

If everything beeps as expected here, that's it, you're good to go!
* When you are later testing or troubleshooting your installation, the Beep Test can also be performed out at the wingtips with the black meter lead on the airframe as ground and the red test lead on the STROBE- (minus) wire.
* Just to annoy us both, some meters can be slow to respond to the short strobe pulses. If you're having troubles here perform these tests with **Switch 4 Single Flash** turned on.

Connector pinout

The label colours shown at right describe the wire groups and functions.
The diagram represents the mating face of the socket on the board, and/or the wire terminals on the back of the harness plug.

- The red labels are the four connections to the left wing.
- The green labels are the four connections to the right wing.
- The blue labels are the + and - connections, plus shield, to the tail light.
- Airframe Ground is connected to Pin 1, which then connects to pin 7 for tail light wire shielding, and to pins 2 and 14 for the wing strobe wire shield. The shield is also used as the ground return for the position LEDs.
- **Position** light power is applied to pin 5 POSITION +12v IN, which then feeds +12v *out* to the red and green position LEDs on pins 4 &13.
- **Strobe** power is applied to pin 10 STROBE +12v IN, which then feeds +12v *out* directly to the strobe LEDs on pins 11 & 12.