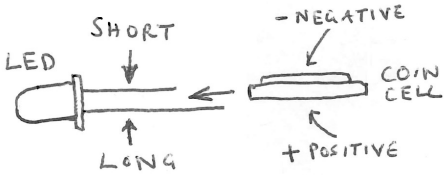
Welcome to the fifth and final instalment of A Kit A Month! It's been a busy but fun 6 months or so: approximately 800 parcels sent out and I wouldn't like to begin to guess how many components have been packed into small plastic bags!

The complexity of the kits has ramped-up over the last few parcels but this month we're back to a nice, simple circuit using just our old friends: resistors and LEDs.

But first, let's look at the 'bonus' bag. In it you'll find two "rainbow colour-changing" LEDs which, at first glance, just look like ordinary LEDs. However, when connected to a 3v battery, you'll find they're really *not* ordinary! If you've got a battery holder that takes two AA cells then you could use that to power your LEDs (each AA cell is 1.5v so, when connected in series, we get 3v). Alternatively you could connect them between the 3.3v pin and the GND pin of a Raspberry Pi. Or—and this is the most fun option because it allows you to build circuits using the LEDs into greetings cards etc.—you could place a CR2032 coin cell between the leads of the LED. Although I say to use a 'CR2032' cell, a CR2025 or CR2016 will all work equally well: they all supply a voltage of 3v. *(Potentially fascinating fact: the names of these types of cell tell you their dimensions. The first two digits give you the diameter i.e. 20mm and the last two digits are the thickness multiplied by ten i.e. 3.2mm or 2.5mm or 1.6mm).*

Apart from their colour-changing spangliness, you may have noticed one other respect in which these LEDs are different from ordinary LEDs: they don't need a resistor. Also, if you hold the illuminated LED close to a surface or piece of paper, you might be able to see three coloured dots projected: one red, one green and one blue. These dots will fade in and out to mix all the colours that you see the LED assume.

These facts might give you a hint as to how these LEDs work: they are, in fact, *three* LEDs in one package! And, as if that wasn't sufficiently complex in itself, there is also small integrated circuit in there that



adjusts the current flowing through each of the three LEDs to change the brightness and mix the colours into one.

This set-up is not dissimilar to the arrangement in the LEDs used in Pimoroni's Unicorn HAT for the Raspberry Pi or one of the "Neopixel" products from Adafruit. Like our rainbow LEDs, these have a red, blue and green LED within them and a small integrated circuit—the difference being that that i.c. receives information from a Raspberry Pi or microcontroller about what colour to display whereas our i.c. rotates through a palette of colours.

A word of warning before we leave the subject of these magical LEDs: don't be tempted to use them with this month's circuit. The rainbow LEDs are intended for 3v operation whereas this month's circuit works on 9v.

This month's circuit.

A little early, this month's circuit is a small Xmas tree featuring three LEDs, two resistors and a slide switch so you can turn the circuit off without having to disconnect the battery.

If you look at circuit you'll see that the top LED is in a circuit loop of its own with resistor R1 controlling the current flowing through it. The voltage across the LED depends on a number of factors including its colour but we can consider it to be typically around 2v (you could measure the actual voltage using a voltmeter if you wished). With our 9v battery, this leaves 7v to be 'dropped' across resistor R1 which is a 1000Ω resistor (a.k.a. 1kΩ). We can rearrange the famous $V=I \times R$ equation to work out the current flowing through resistor R1 and hence also the top LED:

$$I = V \div R$$

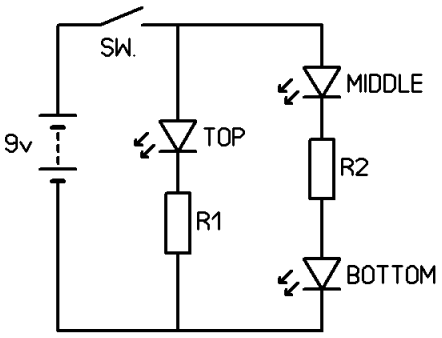
$$I = 7 \div 1000$$

$$I = 0.007A \text{ or } 7mA$$

This is a sufficient current to provide a reasonable level of brightness, irrespective of which colour of LED you choose to put at the top.

The middle and bottom LEDs are in series with each other and resistor R2 so the current through these three components will be identical. If we assume, again, that 2v is the voltage across each LED then that leaves 5v to be dropped across resistor R2 which is also 1000Ω. Using the same equation as before, we can calculate the current through the middle and bottom LED (and R2) to be 0.005A or 5mA.

You might reasonably conclude, that the middle and bottom LEDs will be less bright than the top LED due to there being a smaller current through them. This would be a valid conclusion if all of the LEDs were of the same colour and type but, in practice, different colour LEDs have different luminosities (brightnesses) for a given current. In short, each of your three LEDs is likely to be of a different brightness.



How to build the mini Xmas tree.

1) Solder both resistors in place.
2) There are three holes in one corner to hold the slide switch. You can solder this either on the front or on the back, as you prefer. The switch has a tendency to drop out of place during soldering - you can avoid this by holding it in place with a piece of tape.
3) Solder the three LEDs in whatever arrangement you desire, ensuring that the long wire goes in the hole marked with a '+' symbol (nearest the top of the tree).
4) As with our other circuit boards, solder the battery connector wires in place by pushing them up through the large hole from behind and then down into the hole where they are to be soldered. The red wire should go to the hole marked with a '+' symbol.

That's it! I hope you've enjoyed this little series of kits-by-post as much as I've enjoyed designing the circuits and getting them to you. Will there ever be another subscription in the future? It's a little early to say, but your feedback and suggestions would be very much appreciated.

-Andrew

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