Traffic lights

Cutlery cabinets and traffic lights in the Design Museum

David Mellor is an award-winning cutlery designer.

He also designs traffic lights. His designs have been used in the UK for more than 40 years.

However, he doesn't design the electronic control systems that make traffic lights work. That's down to engineers.

your task

Investigate how you can use electronics to:

- turn lights on and off automatically in the correct sequence (the right order)
- adjust the timing of the sequence
- build a circuit that operates a set of model traffic lights correctly.

some things to think about

Which component(s) can you use, instead of mechanical switches, to turn lights on and off?

What sequence of red, green and amber lights do you need?

How can you turn the lights on and off at the right times to get this sequence?

Can you adjust the length of time the lights stay on?

Must all three stay on for equal lengths of time? Or can you make the green light stay on longer than the amber, and the red stay on longer still?

To control traffic, several sets of lights have to work together. When you can control one set, you could try something more complicated, such as:

- pedestrian crossing, with lights for people as well as traffic
- road works, allowing traffic in one direction at a time
- T-junction
- crossroads
- T-junction or cross roads with left filter.

what you need to do

1. Make sure you are familiar with the electronics kit. Find out:
   - ~ what electronic components you've got
   - ~ what each component does
   - ~ how to connect components together to build a circuit.

   In particular, you need to know how to use a timer and decade counter to turn LEDs on and off in sequence.

2. You will be given a timer-counter circuit. Add the necessary components so that the circuit lights up ten LEDs in sequence.

3. Work out how to use OR gates to make one LED light up for several counts, instead of several LEDs for one count each.

   Test your idea by changing the connections appropriately. You should now be able to make a red LED (traffic light) stay on for the first five counts.

4. In a similar way, make a green LED stay on for the next four counts (counts six to nine).

5. For the tenth count you need an amber LED, before the sequence starts again with red.

6. Finally, work out how to get red and amber together. You need this for a single count at the correct point in the sequence.

7. Check that your lights follow the whole sequence correctly.

8. Red (without amber) and green should stay on for equal times. Investigate how to make red stay on longer than green, or vice versa.

9. Also investigate the timer section of the circuit. Find out how to make the counts quicker or slower, so that the complete sequence takes less time, or more.

10. Adjust the circuit so that the lights follow the time sequence that your teacher gives you. Show your teacher that you have succeeded.

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Curriculum links

key stage three programme of study: design and technology	
key concepts	1.1a, 1.3c, 1.4b
key processes	2a, b, e, g
range and content	3b, c and n-q
curriculum opportunities	4a-d
SQA technology outcomes	
third level	TCH 302A,
fourth level	TCH 406C, 408D, 411D

Introducing the activity

The Enginuity *What is engineering?* poster shows traffic lights as an example of computer systems designed by engineers. Road and rail systems both rely on these 'stop' and 'go' signals, and also use lights to display a range of other information and warnings.

The activity focuses on the use of electronic components to control the operational sequence of traffic lights. To tackle the activity, pupils require a basic knowledge of electronics – the function of components, rather than how they actually work. This includes timer and decade counter ICs (such as 555 and 4017) to generate and count pulses.

You could start by considering the simple communication system underlying the principle of traffic lights – how a universally-understood code (red=stop, green=go) is used to control traffic movements, on road and rail networks worldwide. Discuss the consequences of controlling flow, including economics and safety.

Move on to considering improvements to the simple alternating red-green system: use of amber; timing of the sequence; controlling multiple flows at junctions; ability to alter timings according to traffic flows. Discussion of how these are achieved leads to electronic timing.

The practical activity

Pupils may work individually or in small groups, depending on equipment availability. Suitable kits are available for a few pounds each.

Assuming limited time and knowledge of electronics, pupils should be given a ready-made timer-counter circuit with ten outputs, which go high in sequence. The circuit should include a variable resistor to control the frequency of the timer pulses. Suitable examples are given in the information sources listed below.

Pupils need a circuit diagram (omitting the LEDs) showing which pin relates to each output (0 to 9) from the counter. By attaching a resistor and LED to each output they can produce ten LEDs flashing in sequence.

Using OR gates, they then investigate how to replace several flashing LEDs with a single LED lighting up for several counts. This provides the basis for longer red and green traffic lights. They are then challenged to add amber, making it light up for one count only, both alone and combined with red at the correct points in the counting sequence.

Having discovered how to make an LED stay lit for multiple counts, they should be able to deduce how to alter the number of counts, to illuminate red and green for different intervals.

They should also investigate how to alter the time taken for one complete 10-count cycle (using the variable resistor in the timer section of the circuit).

Challenge pupils to adjust their sequence to give specified proportions of red and green, and a specified time for one complete cycle. Give each pupil or group a different target sequence.

Differentiation

As a minimum, pupils should appreciate that the timer generates regular pulses, the frequency of which is regulated by the variable resistor. These pulses are fed to the counter where they turn on each output (0 to 9) in turn. The ouputs 'go high' one at a time in sequence.

Discussion of the other components on the circuit board, and functions such as resetting the counter, will depend on pupils' understanding of electronics.

They should also be able to relate components and connections on their circuit board to a circuit diagram (which initially should omit the LEDs).

If pupils have a good grasp of electronics, you could discuss truth tables and logic diagrams for operating the three LEDs, and the function of OR gates.

Possible extensions

1. Extend the traffic lights system for one of the following (increasingly complex) situations:
   - ~ pedestrian crossing: two sets of lights operating in tandem, plus stop-go lights for the pedestrians
   - ~ road works: two sets controlling alternate traffic flows, with a 'both red' safety period in between
   - ~ T-junction: three sets, with two for 'straight across' operating in tandem, and alternating with the side road
   - ~ crossroads: four sets, with each pair operating in tandem, but alternating with the other pair
   - ~ T-junction or crossroads as above, plus one or more 'left filter' lights.
2. Add a vehicle detection system, so that the 'go' sequence triggers as a 'vehicle' approaches.
3. Research how LEDs are used for real traffic lights, and why these are increasingly being used in place of normal bulbs.
4. Draw up a new design and specification for 3-light traffic lights. Explain why it is an improvement on David Mellor's 1960s design.
5. Write a computer program to display short traffic messages on a dot-matrix screen, as found on motorways.

Information sources

- http://www.doctronics.co.uk/beastie_zone.htm (Descriptions of components and applications)
- http://www.doctronics.co.uk/555.htm (Timer IC)
- http://www.doctronics.co.uk/4017.htm (Decade counter IC)
- http://www.kpsec.freeuk.com/projects/trafficlight.htm (Traffic light project)
- http://www.freeinfosociety.com/electronics/schemview.php?id=1535 (Circuit diagram)
- http://www.rapidonline.com/Educational-Products/Projects-Robotics/Project-Kits/Traffic-light-kit/73849/kw/ (4-way traffic lights kit)
- http://ourworld.compuserve.com/homepages/Bill_Bowden/page10.htm#traffic.gif (4-way lights circuit diagram)
- http://auto.howstuffworks.com/question234.htm (Inductive loop vehicle detector)