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P12 Resource Exchange – Electronics of Everyday Things

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Abstract

Electronics projects can connect concepts in engineering and measurement to other STEM topics. Use of the versatile 555 timer integrated circuit (IC) is shown for projects that produce light, sound, and motion outputs that are similar to those found in everyday devices, e.g. telephones, appliances, and toys. The resources illustrate how this low-cost IC can serve as a central element for control and switching applications with opportunities for students to explore electrical experimentation, measurement, and re-design. The activities are appropriate to supplement physical science and algebra courses at the 9th-grade level and beyond.

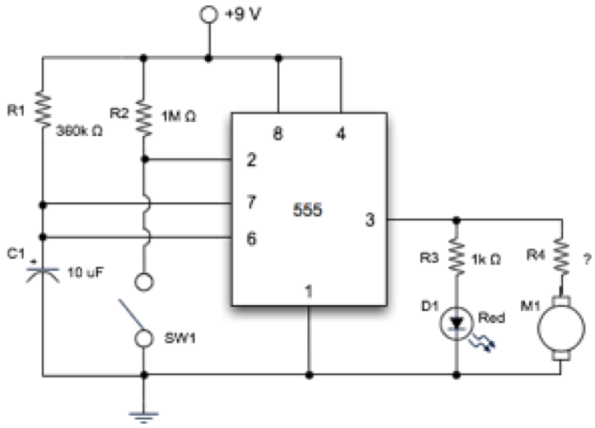
Pedagogical Context and Activities

Electronic devices are ubiquitous and deeply embedded in everyday life and students often wonder how they work. Thus, the "Electronics of Everyday things" teaching resource aims to answer students burning questions about "what makes a light blink?", "what makes a buzzer sound?", or "what happens internally when you push a button on a device?" through hands-on activities and reflection exercises. The target grade level is 9th-grade through 12th-grade.

The 555 timer IC is a highly stable device for generating accurate time delays or oscillations and is capable of operating in four different modes. The device requires the use of external resistors and capacitors to control the timing functions, which makes it ideal for exposing students to a range of circuit components. Additionally, there is little loss between the input and output voltage which allows students to control a range of components (e.g., buzzers, LEDs, motors).

Students work in groups of two to learn about basic components and circuits as well as how they are used in the design of consumer products. The students are introduced to many of the basic electronic components and are given the chance to build their own circuit to produce an output similar to devices they are familiar with. Calculations for circuit design and basic procedures for circuit prototyping using a breadboard are also covered. Then the students connect the theoretical to the practical by constructing and testing a circuit that produces a timed output. After the circuit is understood the students have the opportunity to apply reverse engineering techniques to re-design the circuit. A range of additional components is provided for the students to explore. Creativity is encouraged!

The reverse side of this sheet summarizes a selection of hands-on 555 timer IC circuit activities that demonstrate and help teach electrical concepts as well as list of necessary components. Basic circuit components and instruments are required. This presentation showcases the circuit activities and how they relate to the application of science and mathematics.



Example 555 Timer Circuit

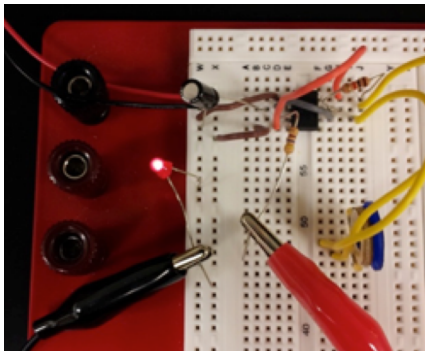
Parts:

- 555 timer IC
- Red, yellow, and green LEDs
- Potentiometers with a range of 0–50K Ω
- 9-12 V Buzzer
- Light Sensor
- Capacitors: 1 μF, 10uF
- 9V Battery (or variable power supply)
- Breadboard
- Wires, cables, battery connector
- Multi-meter
- A range of resistors from 470–1M Ω:
  - 470 Ω (Yellow, Violet, Brown, Gold)
  - 1k Ω (Brown, Black, Red, Gold)
  - 220k Ω (Red, Red, Yellow, Gold)
  - 1M Ω (Brown, Black, Green, Gold)
  - 360 kΩ (Orange, Blue, Yellow, Gold)
  - R4 – to be calculated

In the example 555 timer circuit schematic the component labeling is the following: R for resistors, C for capacitors, D for diode (LED), SW for switch, M for motor, +9 V for positive battery connection, triangle with lines for the negative battery connection, 555 box for 555 timer IC, lines for wires, and black dots for wire junctions (nodes).

Activity: Flashing LED

Light emitting diodes (LEDs) are used in several products as indicators to let the user know that something is happening, such as the device is on. The 555 timer outputs a 3-Hz square wave that causes the LED to flash at a rate of 3 flashes per minute while power is applied. Students that are more advanced can engage in challenges such as changing the flash rate using a light sensor.



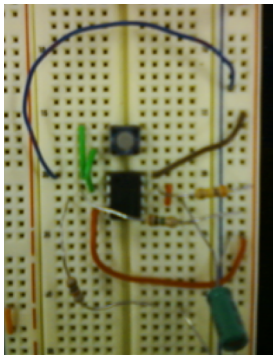
Example Circuit Measurement on Flashing LED Circuit

Activity: Circuit Measurements

Students make voltage and current multi-meter measurements on the 555 timer output resistor R3 and calculate Ohm's law values for comparison to calculations. Experience is provided with engineering equipment and experimental practice.

Activity: Switching Circuit

Light emitting diodes (LEDs) and buzzers are used in several products as indicators to let the user know that something is happening, such as a button has been pressed. In this circuit, the 555 timer generates an output pulse that causes the output to stay on for the duration of the pulse, indicated by an LED and a buzzer or motor, once the switch is activated. This activity has three parts: 1) base circuit build, 2) designing a parallel circuit for the circuit output, and 3) changing the circuit output timing all in the context of designing a circuit for a game. More advanced students can be guided in early re-design or measurement activities.



Example 555 Timer Circuit on Breadboard

Activity: Reverse Engineering

Reverse engineering is very common in consumer, industrial, and scientific designs. In this activity students are challenged to consider what else they could change (e.g. output pulse length) or for what other purposes could the circuit be used, and then prototype the design using the given set of components.