

## Circuit Bending Part 3: Bending the Circuit to Create a Monster

### Objective: Modifying the “clock”

- (1) Learn to solder
- (2) Explore Resistor/Capacitor (R/C) circuits
- (3) Make your own “alien” toy

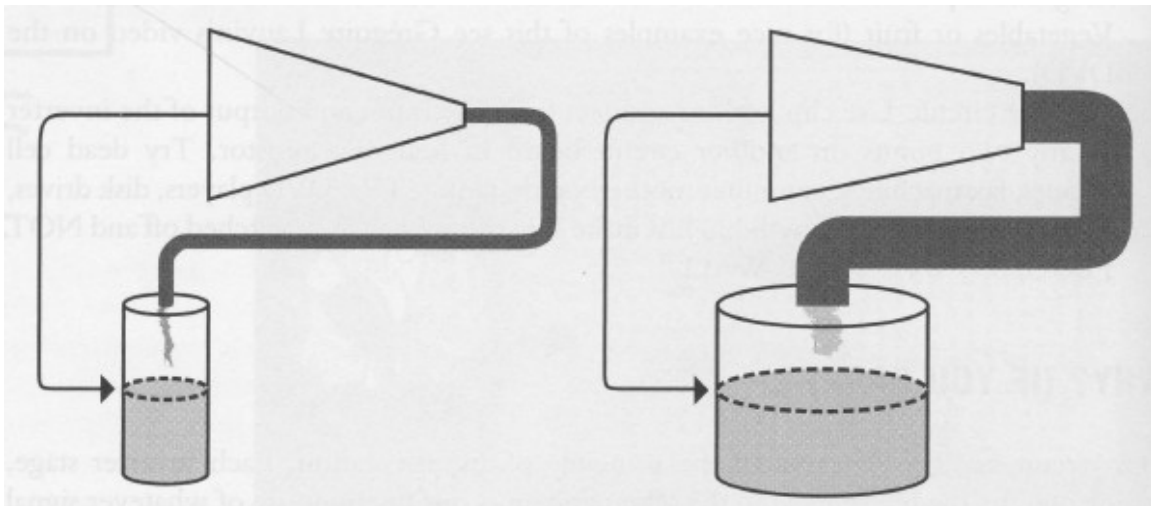
### Dr. Frankenstein, I Presume

The quest to understand is almost always coupled with the quest to create. Let us now create our own monster or alien toy. If the IC is the brain of our toy, the unit that sends the signals to the speaker, then the Resistor/Capacitor, or R/C, circuit is the heart of the toy. It is the internal “clock” that controls the speed at which the system operates. Each time the clock ticks, the brain performs another operation (e.g., sends another signal to the speaker), and remember from our previous exercise, the clock ticks when the capacitor discharges. We will now give our monster a new heart.

### The Heart

Locate the resistor and capacitor on your schematic and on the circuit-board of the toy. If there is more than one resistor on your circuit, you will have to experiment to determine which resistor is interacting with the capacitor. Keep in mind that the resistor and capacitor need not be directly connected, they can be indirectly connected through the IC, and the details of that connection will be obscured by the “blob.” Use your alligator-clip leads to “short” each resistor in turn. *Shorting* the resistor that you are looking for will dramatically change the sound produced by your toy.

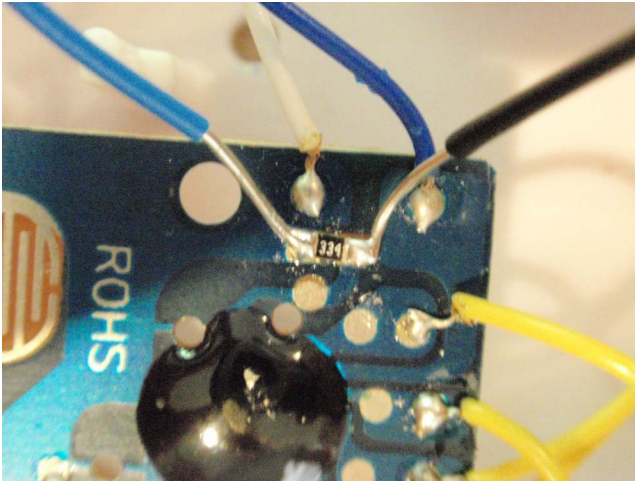
Think of the resistor-capacitor-IC interaction as being described by the picture below, where the resistor is the pipe, the capacitor is the glass, and the triangle (or funnel) is the IC (Yes, it’s another fluid-flow analogy.).



The capacitor discharges and sends its liquid contents to the funnel when the liquid reaches the dotted line. The discharge is the clock tick. Once the glass is empty, it is refilled by the pipe. Together the size of the glass and the size of the pipe determine the rate at which the clock ticks. The slowest clock has the biggest glass and the smallest pipe.

## Heart Surgery

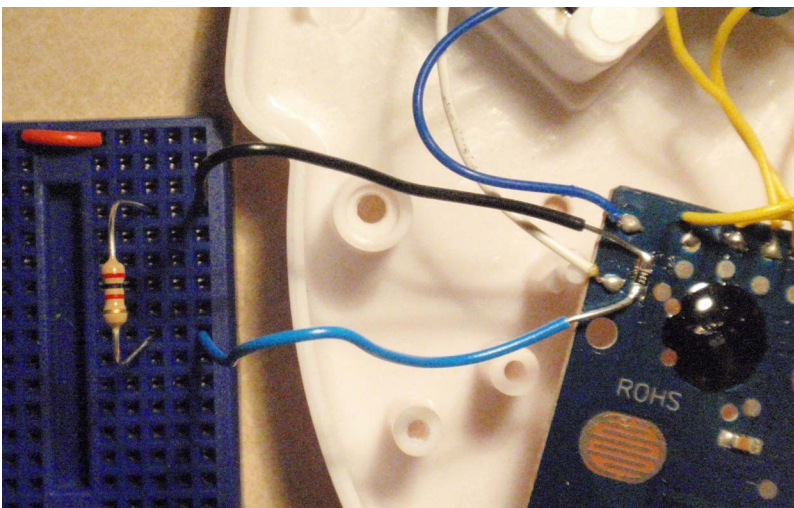
For us, heart surgery involves soldering. We will enter the R/C circuit at the resistor because that is probably the safest and easiest place to intercede. Our objective is to create a modified circuit as shown below. In this circuit, a single-strand wire has been connected to each “leg” of the resistor at the solder points joining the resistor to the circuit-board. These new wires will allow us to add-to the R/C circuit---our own form of “by-pass” surgery.



Please read the following [discussion](#) and watch the following [video](#) before attempting this yourself. This is the part of the operation that requires a surgeon's skills----ask your instructor for help if you are feeling uncertain.

## Dr. Frankstein, May I Proceed

Now for some fun. Connect the wires running from the resistor to a *breadboard* as shown in the figure below (you may have a different size/color breadboard).



A breadboard allows you to make electrical connections without soldering which is something you can now appreciate. Breadboards are used for prototype development---they are “clunky” but very easy to change. Electrical connections (pathways for current to travel) are built into a bread-board as described [here](#).

First, use the breadboard to insert a new resistor *in parallel* with the resistor on the circuit-board, configure you breadboard as shown in the picture above---note the resistor.

The connection you have just made allows current (moving charged particles) to flow through either of the resistors in their path back to the capacitor. When resistors are connected in *parallel* like this, the *effective resistance* (the total resistive effect of the 2 resistors) is slightly more than that of the smallest resistance. So, if a 1,000 Ohms resistor and a 10,000 Ohms resistor are connected in parallel, the effective resistance would be slightly more than 1,000 Ohms.

As alluded to above, all resistors have a specified *resistance* which is encoded in the resistor’s colored stripes as described [here](#). Determine the resistance of the resistor on your breadboard. If it is not less than the resistor on the circuit-board (e.g., 330,000 Ohms), replace it with one that is less. What effect did the parallel resistor have on the sound made by the toy? Can you explain this effect using the fluid-flow analogy introduced earlier?

Now, pick a resistor whose resistance exceeds that of the resistor on the circuit-board (e.g., 330,000 Ohms) and place it in the parallel connection on your breadboard (remove and replace the first resistor). What effect did that have on the sound made by the toy? Can you explain your observation?

## Your Own Alien Creation

You’ve heard the expression, “necessity is the mother of invention,” well how about, “invention is the mother of understanding.” Don’t be afraid to try things---you don’t have to understand something to try it. Here is a list of things you can try in making your own creation:

- Add any (or all?) of the following to the parallel circuit on your breadboard:
  - Multiple resistors in series
  - A [potentiometer](#)
  - A [photoresistor](#) both covered and/or uncovered
  - A switch in series with a [resistor](#) (or photoresistor or potentiometer)
  - A [capacitor](#) in series with a resistor (or photoresistor or potentiometer)
  - Use your body as a resistor
  - Use multiple bodies as a resistor (i.e. holding hands)
  - Use a fruit or vegetable as a resistor
  - Pencil lead
  - Corroded metal

- Another circuit (NOT PLUGGED INTO THE WALL)
  - A new [speaker](#)
  - Different batteries (be careful here---you could “blow” your circuit)

Experiment until you have found your optimal configuration. Be prepared to describe and demonstrate your alien toy in class.