**Names** ______________________________________________________________________

## Introduction

This is the first lab not based on the book *Getting Started with MicroPython*. In this lab you are going to explore some of the common usages of capacitors in circuits. One use is to use an RC circuit to time events or set the oscillation time of a circuit. A second usage is to filter signals in frequency, and a third usage is to *decouple* DC, AC, and noise signals from each other. This covers a lot of territory, so let's get started!

## Capacitors for Timing

Capacitors store charge and the basic formula is

$$V = \frac{Q}{C} \qquad \text{Eq. 1}$$

where *V* is the voltage across a capacitor in Volts (abbreviated *V*), *Q* is the charge on the capacitor in Coulombs (abbreviated *C*), and *C* is the capacitance value in Farads (abbreviated *F*.) It turns out 1 F is a very large capacitor. The capacitors we will use are in the ranges of µF, nF, or pF. When a current runs into a capacitor, charge accumulates in it and the voltage across it increases. Consider the following circuit

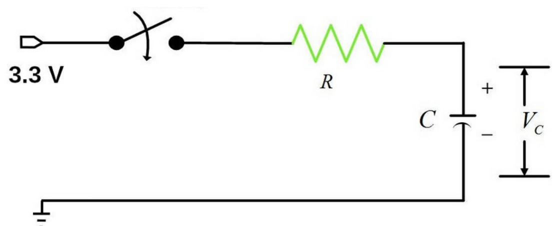


*Figure 1: A charging RC circuit. If Vc starts at zero when the switch is closed, the capacitor will charge and Vc will increase.* ***Note*** *3.3V is also called Vcc.*

**Challenge**:

- If *R* = 100 kΩ and *C* = 100 µF, what will the initial current be?

- What do you think the maximum *Vc* will be when the capacitor is fully charged?

### *The Charge – Discharge Function*

You should have seen the formula for a capacitor charging of discharging through a resistor

$$V(t) = V_0 \pm V_1 e^{-t/\tau} \qquad \text{Eq. 2}$$

where $\tau = RC$ .

**Challenge**:

- Find the value of *τ* in seconds for the Challenges above.

- Find the values for $V_0$ and $V_1$ for the circuit in Figure 1 when the switch is closed.

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You are going to make an oscillator. Consider the circuit in Figure 2 (but don't build it yet.) You will drive the circuit with a digital output, and read $V_C$ with an ADC input. You need to write a program that:

- Turns on the digital output.to 1
- When $V_C$ = ⅔$V_{CC}$, set the digital output to 0
- When $V_C$ = ⅓$V_{CC}$, turn the digital output back 1.
- Repeat infinitely

Figure 3 shows what the waveform should look like, but t_on and t_off will be equal.

**Super Challenge**:

- How long will it take the RC circuit to charge from ⅓$V_{CC}$ to ⅔$V_{CC}$?
- What will $T$ be in terms of $R$, $C$, and $V_{CC}$?
- For $R$ = 100 kΩ and $C$ = 100 µF, what will $T$ be?

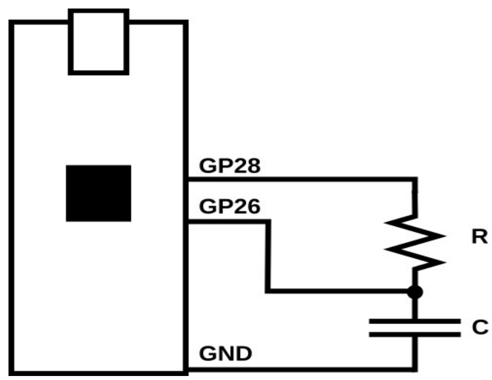

*Figure 2: The oscillator circuit. GP28 is a digital output and GP26 is an ADC input.*

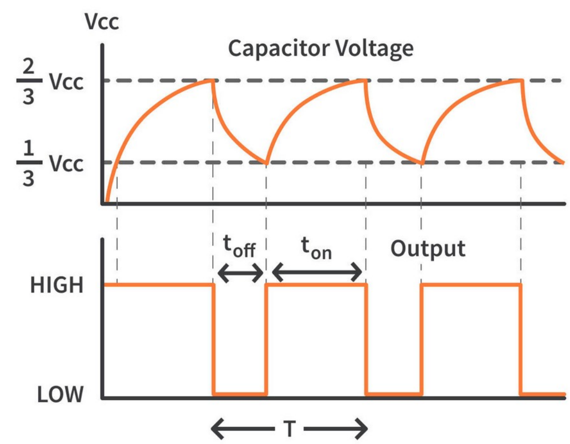

*Figure 3: The charge-discharge curve for the ocillator. You must make t_on and t_off equal.*

## *Building Your Oscillator*

1) Build the oscillator circuit with the components above, program the PicoW, and measure its frequency using an oscilloscope. In the space below, analyze your data and compare it to your calculated $T$. What is the percentage difference?

**Names** ______________________________________________________________________

2) Change the components to make a 1 kHz oscillator. Is the result within the tolerance of the components? Show your work below.

## TO CONTINUE …

The next lab is about using capacitors to filter signals in frequency. However, first you need to take a diversion to build a Function Generator. You will use it to make sine waves at different frequencies and measure how an RC filter affects that signal.

So now you will change gears to do Function Generator project.

**Names** ______________________________________________

## Materials

- Pico W on a breadboard.
- A  100 kΩ resistor
- A 100 μF capacitor
- Variety of resistors and capacitor for students to try to make a 1 kHz oscillator.
- An oscilliscope.