Lab 1.2: 555 Timer and Nano Every

Introduction

The Arduino Nano Every allows you to emulate some lab equipment functionality, specifically for this lab, an oscilloscope. The Arduino Nano Every is a microcontroller with a built-in power regulator and supports the standard Arduino software by installing the Arduino megaAVR Boards library. To start, install the recommended version of the Arduino IDE according to the instructions and the additional board library. Then, make sure you can correctly run the basic LED blink test. Note that the red LED next to the USB port is the LED connected to pin 13. We will use this in lab 2.2 to demonstrate some aspects of the compiler. In this lab, we will be using the Arduino Nano Every as a simple oscilloscope to plot the discharge curve of a 555 timer.

One of the oldest integrated circuits which remains popular today (40+ years after it was introduced) is the "555" timer. Try searching on "555" in Google Images, and you will get an idea of how popular this device is.

The specific part number of the 555 chip in our Kit is the NE555, and we have both Texas Instruments (NE/LM555) and STMicroelectronics (NE555) datasheets on our Resources page on the course website.

Prelab Deliverables:

- There is no prelab for Lab 1.
- Make sure you have a working install of Arduino IDE

Circuit Operation

The 555 timer integrates the following components. First, an internal transistor allows an external capacitor (denoted C_1) to charge and discharge. Second, there is an input called threshold to discharge the capacitor. When the voltage on the threshold surpasses $\frac{2}{3}V_{cc}$ (where V_{cc} is the Arduino Nano Every's 5V output), the transistor is put into discharge mode. Finally, there is an input called the trigger to charge the capacitor. When the voltage on the trigger is below $\frac{V_{cc}}{3}$, the transistor is put into charge mode.

The NE555, when operating in astable multivibrator mode it works as follows:

1. Initially, the capacitor voltage is 0 V.
2. Because the threshold is below the trigger voltage ($\frac{1}{3}V_{cc}$), the internal transistor in the 555 will start charging the capacitor through the resistors. The discrete components form an R-C circuit where $R_{eq} = R_1 + R_2$ and C_1 acting as the R and C, respectively.
3. The capacitor continues to charge until it hits the threshold voltage ($\frac{2}{3}V_{cc}$) upon which time the 555 will start discharging.
4. To discharge C_1 a switch connected to pin 7 is closed (specifically, an open collector transistor is turned on). C_1 then discharges through $R_{eq} = R_2$ to ground, resulting in a separate R-C time constant (τ).
5. When the C_1 has discharged to below the trigger voltage ($\frac{1}{3}V_{cc}$), the cycle repeats from step 2.

It is important to note that C (which you will use to be 10uF in this lab) is a polarized electrolytic capacitor. You must be sure the longer terminal (the + terminal) is connected to pin 6, while the shorter terminal (the stripe with '–' signs within it) is connected to ground. An electrolytic capacitor connected backward may explode due to the electrolyte boiling off.

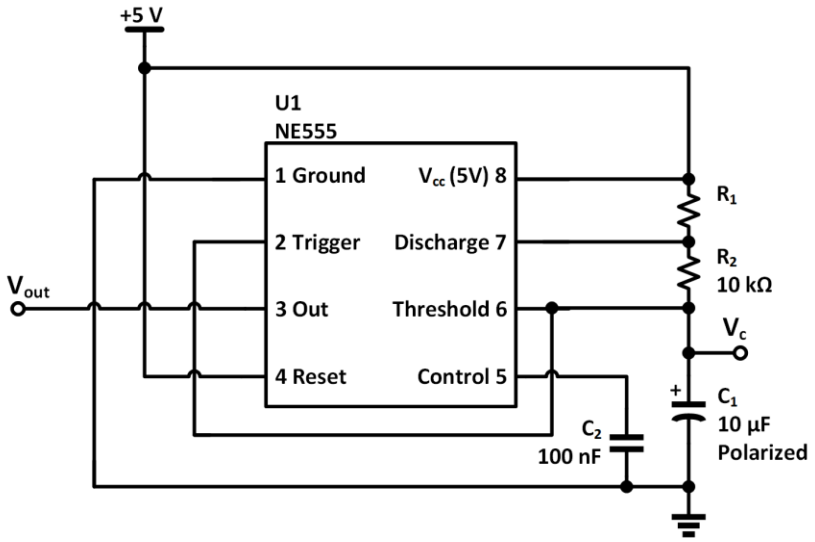

Figure 1. NE555 circuit to be constructed in Lab 1.2. Pin 1 is typically denoted by the beveled edge running along the 1-4 side, a printed or physical dot, or slot in the end between pins 1 and 8. The pins countup counter clockwise around the chip from pin one.

Challenge

Construct an astable multivibrator (oscillator) circuit and use the Arduino Nano Every to confirm/deny that R_2 determines the discharge time, but $R_1 + R_2$ determines the charge time.

- use fixed values for R_2 (10 kΩ), and C_1 (10µF, within 20%)
- use **at least two** different values for R_1 by connecting the resistors in series. 10 kΩ and 20 kΩ are suggested values forR_1 but other combinations are allowable (it may be hard to measure if R_1 is below 10 kΩ).
- Record the waveform(s): $V_C(t)$ (from Pin 6), and $V_{out}(t)$ (Pin 3) for each value of R_1
    - Use the Arduino Nano Every analog inputs (i.e., A6 & A7) to measure $V_C(t)$ and $V_{out}(t)$. **Why do we need to use analog inputs? What would be different if we used digital inputs?**

Required Lab Resources

- Arduino Nano Every board
- Breadboard
- Components required to create the astable multivibrator circuit
    - LM555 or NE555 timer chip
    - 3x 10 kΩ resistors (R_1, R_2)
    - 100 nF capacitor (non-polarized, Ceramic)
    - 10 µF capacitor (polarized, electrolytic)

Required Report Deliverables

- Obtain sufficient data from the Arduino Nano Every plot to confirm that the discharge time depends only on R_2, while the charge time depends on both R_1 and R_2.
    - Make measurements for **at least two** different values of R_1.

- TA signoff – Demonstrate your graph(s) for each value of R_1. The graphs should include measurements of:
    - The capacitor charge/discharge, $V_C(t)$
    - The 555's output, $V_{out}(t)$
- Answer questions posed in the document above.
