Lab 7
The 555 Timer

Prelab Exercises

This prelab exercise will be completed as a class the day of the lab

You should bring your class notebook and take good notes, the intro to this lab is complex and you will need to know the information for your formal report.

Using the general layout in Figure 1, design a circuit, which will produce a TTL compatible signal. A TTL signal is a DC voltage that turns on and off at a regular rate like the pulse source we used in Lab 4. You are to design a circuit so that the TTL signal output will have a frequency range from 1Hz to 10Hz. This signal will drive two LED's which will alternately flash to indicate the high and low (on and off) states of the output (at Pin 3 on the 555 timer component "LM555CN").

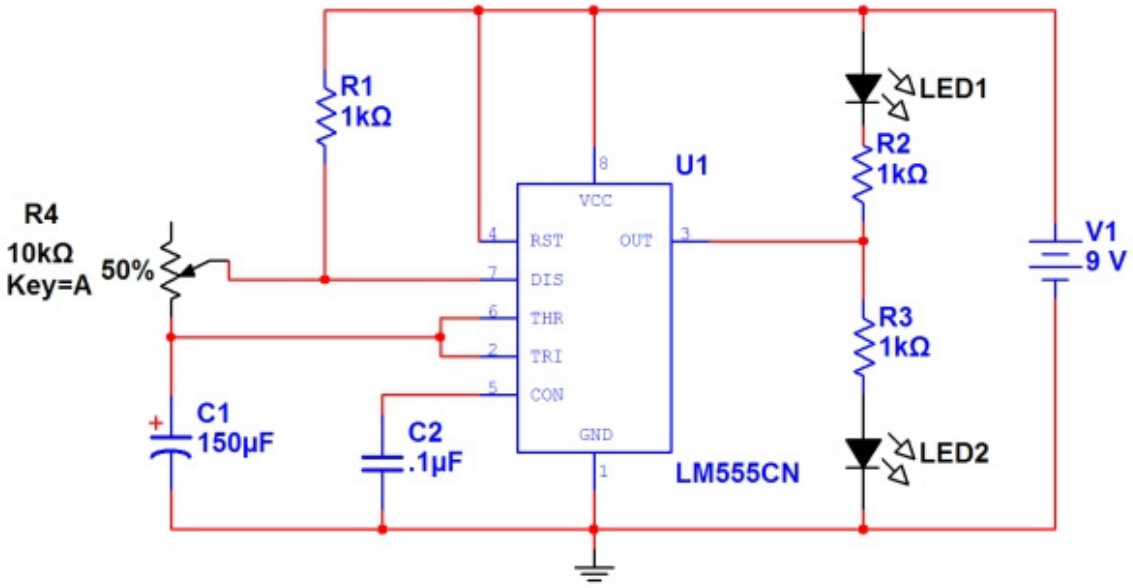

Figure 1: 555 timer circuit

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Design Parameters:

1. Your business manager has told you that your company has a surplus of 10 kΩ potentiometers and 150µF capacitors. Therefore, select R_4 and C_1 so that you can make use of these parts.
2. When designing your circuit for R_1, R_2, R_3, $LED1$, and $LED2$, take note that:
   - The LED's have a nominal current rating of 20mA, but we would like to be significantly under that. You must choose R_2 and R_3 values such that the LED current does not exceed the recommended maximum, in this case we will aim for 9mA.
   - An acceptable design is one in which the lower and upper frequency limits are within 10% of the specified values.
   - Specific resistor values between 1kΩ and 1MΩ are available.
   - The TTL output signal has a frequency equal to

$$f = \frac{1.44}{(R_1 + 2R_4)C_1}\text{Hz} \tag{1}$$

Once we have designed your circuit together in the lab introduction, on your own you need to perform some calculations. Determine the output frequency for each case where $R_4 = 0\Omega$, 3kΩ, 6kΩ, and 10kΩ. The max and min values for R_4 should correspond to your low and high values for the frequency range, respectively.

Your pre-lab should include a completed schematic with all circuit element values along with the math you used to design all aspects of your circuit.

Extra Credit

In the prelab we discuss how the frequency range could be implemented more exactly by using a parallel resistor to limit the maximum value of the potentiometer. Calculate the resistor needed, add it to your circuit, and test one of the frequency ranges to see if it helped. Calculate your prelab values using this data and the resistor when you build your schematic. Next week we'll use the extra resistor to get experimental data for the same circuit.

Lab Exercises

In this lab exercise you will complete the first stage of your EE101 semester project. Later in the semester you will need the schematic and results from today's lab. Therefore, it is important that you keep all of this today's work in a safe, easy to find location. It is highly recommended that you create a separate subdirectory in the network drive for this lab. You may also wish to backup this work on a USB drive when you have the chance.

For this lab, you will use Multisim to simulate your design, and to verify that your design is valid. It is absolutely critical that you get a working design today, because this schematic will be used later to generate a printed circuit board for your final project. Settling for a non-working design today will result in constructing a non-functional final project!

Here is a great animation of the 555 timer operation. Definitely check this out and see if you can correlate the annimated behavior with the material we covered in the prelab lecture. [Complements of Rensselaer Polytechnic Institute www.rpi.edu]

1. Using the Multisim schematic capture program, enter the circuit that you designed in the pre-lab. Refer to Figure 1 to help you with parts placement and attributes. Below are some items to help you define certain elements of your circuit.

   - The 555 timer chip is in the Mixed group, *TIMER family*. Choose LM555CN (be sure you get the exact match).
   - Use *CAP_ELECTROLYT* for the 150µF cap (C_1).
   - For the potentiometer (R_4) use the *Potentiometer family* and pick the proper value from the list.
   - LED's are in the *Diodes group*, *LED family*. Use *LED_red* to indicate an OFF output and *LED_green* to indicate an ON ouput. Yes, you will have to think about this to get it right.

2. Simulating Your Design:

   - We will want to see how the capacitor voltage controls the output voltage, so we will plot both of these voltages in the simulation.
   - Set R_4 to the minimum value and perform the transient analysis. You will have to set the end time to something reasonable. If you have set R_4 to 0Ω then your frequency will be 10Hz; so what should the end time be to get 3 cycles.? In the *Output* tab add the voltages you need.
   - Run the simulation and measure one full period then calculate the frequency. Be sure you do not inculde the first pulse in the measurement since it has a longer charge time (it has to charge all the way up from 0v instead of 1/3 of V_{cc}, making first cycle is longer).
   - Compare the measured frequency to what you calculated in the pre-lab. Calculate a percent difference (but you already knew that's what was meant by "compare," right?)
   - Repeate the above steps with $R_4 = 3\text{k}\Omega$, $R_4 = 6\text{k}\Omega$ and $R_4 = 10\text{k}\Omega$.