Lab 8
Multi-Range 555 Frequency Source

Now that you have a TTL compatible square wave source operating between about 1Hz and 10Hz (last week's lab) the folks in marketing want an enhanced model with selectable frequency ranges up to 100kHz. (Marketers rarely know how hard it is to bang this stuff out). Using the existing 555 based signal source you designed in lab 7, calculate new values for capacitor C_1 (do not change any other components) to provide the following output frequency ranges:

10Hz	-	100Hz
100Hz	-	1000Hz
1000Hz	-	10kHz
10kHz	-	100kHz

The general layout of the timer chip is shown in Figure 1 for convinience.

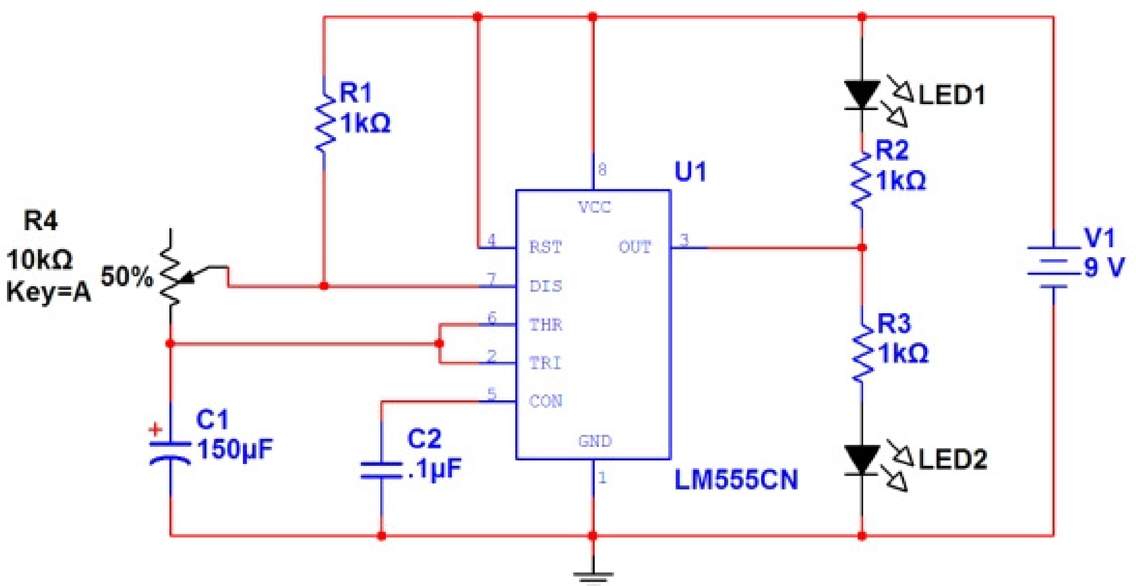

Figure 1: 555 timer circuit

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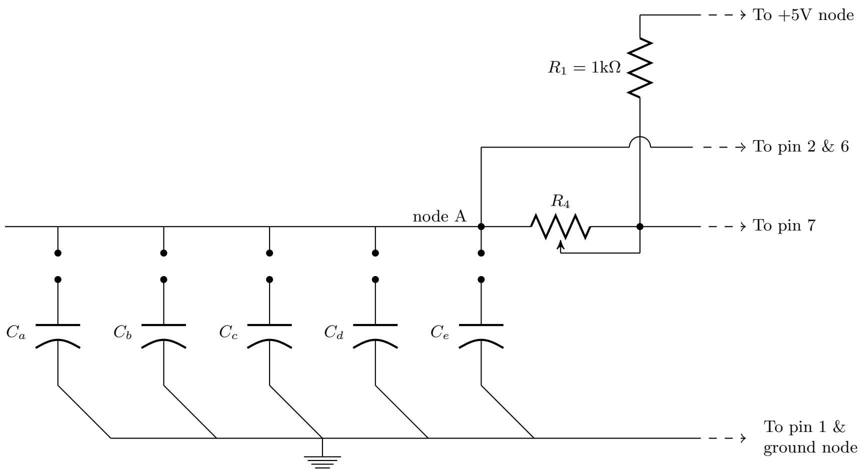

Figure 2: Capacitor bank for multi-range 555 frequency source

Recall that your 555 output frequency is determined by the formula:

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

Prelab Exercises

Assume you are using the same 1kΩ resistor for R_1 and the same 10kΩ potentiometer for R_4 that you designed for last week. Also assume that you are still using the 150µF capacitor for the 1Hz to 10Hz. range.

1. Look at Equation 1 and determine how to scale it to implement 10 times the original frequency range by changing just the capacitor (this new circuit will be just like the old one but will implement a range of 10 to 100Hz instead of 1 to 10Hz). Then repeat the process for 100×, 1000×, etc. to choose capacitors for each specified frequency range. Show all calculations to determine the capacitor values for each of the five frequency ranges (including the original 1Hz to 10Hz range from last week) in your pre-lab.

2. Now that you have chosen the capacitor values, plug them back into the Equation 1 (for both extremes of R_4) to find the actual frequency ranges it will be able to implement. These will become the theoretical values for this lab, where we'll actually build the circuit with each capacitor and determine the experimental values for each frequency range.

3. Draw an updated schematic, adding a capacitor bank to your lab 7 schematic in place of the original C_1. An example capacitor bank schematic is shown in Figure 1 below, with the upper frequency for each capacitor noted. In this application, a jumper wire is used to select which capacitor will be used by connecting node A to the desired capacitor. When you build the circuit you will not use a bank, you'll simply replace the capacitor with another one.

Lab Exercises

In this lab exercise you will complete the second stage of your EE101 semester project. Be sure to write up this lab thoroughly because you will need it to write your formal report.

1. Build the circuit. Start with the 150µF capacitor so we can test the 1 to 10Hz range first, then switch to each of the other capacitors for the remaining ranges. Use as few wires as possible, make them as short as possible, and take advantage of the red and blue Vcc and Ground bus lines provided on the breadboard. **Before proceding, have a TA check to see that your circuit is safely wired BEFORE turning on the power supply.**

2. Test the functionality of your circuit with an oscilloscope.

   (a) For the frequency range of 1 to 10Hz (using the 150µF capacitor), we will measure the actual frequency range the circuit is capable of implementing. This becomes our experimental data set. Use a table to Compare this data set to the two data sets from lab 7 (theoretical values from the prelab and simulation values from P-spice). Calculate percent errors, and write a brief conclusion about how they compare. What method does a better job of predicting the 555 behavior–the equation from the manufacturer's spec sheet or the software simulation?

   (b) Attach the positive oscilloscope test lead clip to the out-put pin of the 555 (pin 3), and attach the negative (ground) test lead clip to your ground.

   (c) After you have a stable waveform on the screen (ask the TA for help if needed) measure the period of your circuits waveform and then calculate frequency.

   (d) Record your systems functionality (does it work as expected) and a brief note on quality of function (note what the wave looks like, is it a good, clean squarewave? if not what does it look like?).

   (e) Plot a sample waveform for at least one of your frequencies.

   (f) If your system doesn't work fully as expected, record what it is doing and where (at what frequency) it stops behaving nicely.

3. Repeat the testing process for the other frequency ranges by switching out the capacitor for each range. Compare this data to your prelab data from this week (you do not have simulation data because we did not simulate the other frequency ranges in last week's lab).

4. Demonstrate functionality of at least one range to the TA and tell them how your design behaved, the TA will initial your lab book after you show them how it went.

Extra Credit

Last week we discussed how the frequency range could be implemented more exactly by using a parallel resistor to limit the maximum value of the potentiometer. If you didn't already do it last week, it's not too late. Calculate the resistor needed, add it to your circuit, and test one of the frequency ranges to see if it helped. Calculate new percent errors compared to theoretical values and summarize your results and their meaning.