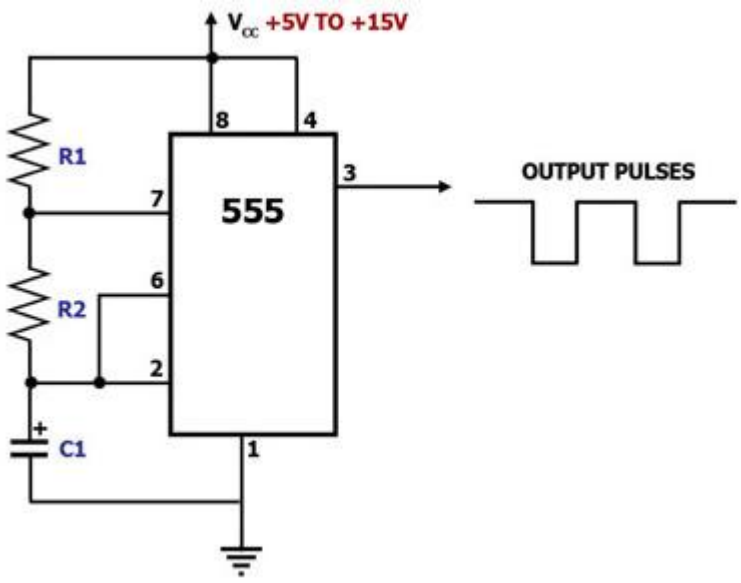
15-348 Embedded Systems
Fall 2019
Hardware Lab 4: **Shift Register (75 points)**

This is a hardware homework. You should demo the circuit on October 31st, during the lab session. This hardware lab consist in understanding the 595 shift register.

First, you will use the 555 timer (recall hardware lab 2) to make a free running astable oscillator that continuously produces square wave pulses. The circuit is the following:



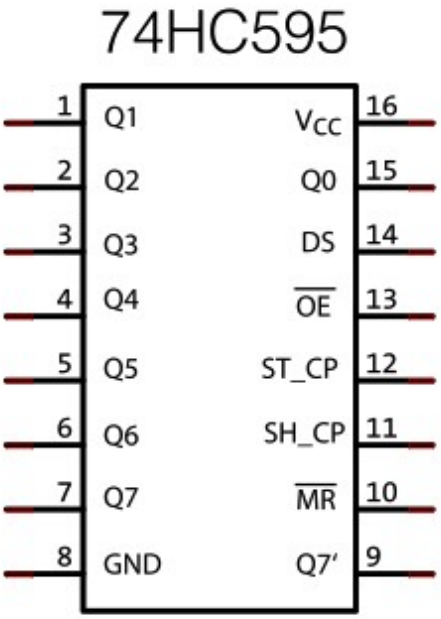
Use a ceramic capacitor of 2.2μF as C1. Given C1, find suitable values for R1, and R2 in order to produce pulses with frequency ~1Hz and ~50% duty cycle. Note that achieving an exact 50% duty cycle is impossible with this circuit. Check the formulas for C1, R1, and R2 in the following links. You will have to decide how to approximate the values of R1 and R2 to the closest valid resistor value. Use a resistance of at least 1KΩ.

https://www.allaboutcircuits.com/tools/555-timer-astable-circuit/
http://www.ohmslawcalculator.com/555-astable-calculator

Once you find out the resistor values, build the 555 astable circuit and connect the output pin to an LED to verify that it is producing the desired output.

TIP: You can also use the oscilloscope to verify the output wave.

Once you are done with the 555 astable circuit, proceed to build a second circuit with the 595 shift register IC. The pinout of the IC is described below and its functionality was explained during class.



Q0 to Q7 (pin 1 to 7 and 15) are the eight output pins. This is the 8-bit pattern that is “stored” by the IC. Q7' (pin 9) is the overflow bit, and won’t be used in this lab.
DS (pin 14) is the “data” pin that when HIGH a bit 1 gets shifted into the pattern,. 0 otherwise.
MR (pin 10) is the "Master Reclear". It clears all bits if LOW. In this lab, it won’t be used and connect this pin to Vcc to not clear any bits.
SH_CP (pin 11) is the "SHift register Clock Pin". When this pin is pulled HIGH, it will shift the register. It must be pulled LOW before pulled HIGH in order to shift again. In other words, it works with pulses.
ST_CP (pin 12) is the "STorage register Clock Pin". It needs to be pulled to HIGH to move the bit pattern to the output pins and after each pulse given to SH_CP. You could shift multiple times by giving multiple pulses to the SH_CP but only display the ending pattern. However, in this lab, we will connect SH_CP and ST_CP to the same pulse generator. In this way we display each pattern after we perform a shift.

OE (pin 13) is the "Output Enable" pin. It enables the output when LOW and disables output when HIGH. You will connect it to ground.
The datasheet of the 595 can be found here: http://www.ti.com/lit/gpn/sn74hc595

Connect one LED to each output pin of the shift register IC. Remember to use a resistor (220 Ohm) when connecting each LED. Connect a push button (active high) to pin 14 (DS) of the shift register. Finally, connect pins SH_CP and ST_CP to the output pin of the 555 IC.

You can find a reference diagram of the 595 circuit and a picture of the final circuit (555 and 595). Note that you can use a single 5v power supply for both ICs.