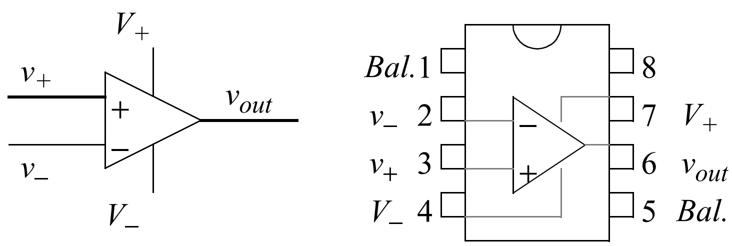
Physics 475, Laboratory 18
Clocks

Overview

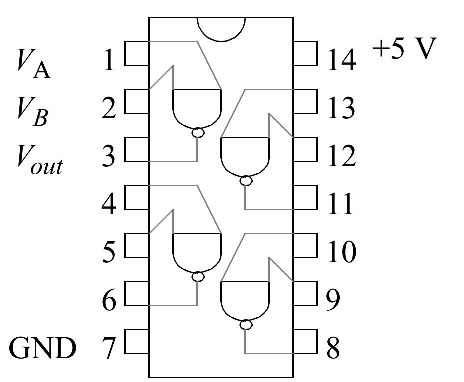
The purpose of these experiments is to study the properties of clocks and square-wave oscillators, both as discrete-component circuits and in integrated circuits (555).

Components

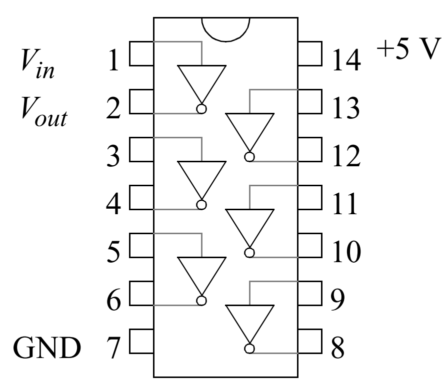
The CA3140 op-amp is an integrated circuit based with MOSFET inputs to provide a low input bias current. The chip comes in an 8-pin dual in-line package (DIP). The connections for the chip looking down with the notch facing up is:



The 74LS00 is an integrated circuit based on low-power schottky technology that includes 4 NAND gates. The 74HC04 is an integrated circuit based on CMOS technology that includes 6 inverters. The pinouts for the 74LS00 and 74C04 are shown below.



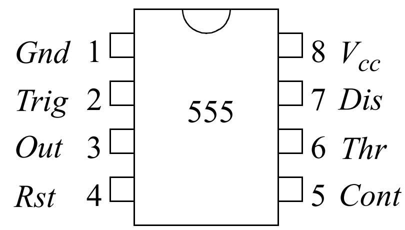
74LS00



74HC04

To use any of the gates in the chip, it must be attached to both power (+5 V) and ground.

The 555 timer is an integrated circuit designed to produce square waves and squave pulses between *Gnd* = 0 V and $+V_{cc}$. The chip comes in an 8-pin dual in-line package (DIP). The connections for the chip looking down with the notch facing up is:



The *Rst*, pin 4, is an asynchronous reset that operates when it is at ground, and it should be tied to $+V_{cc}$ for normal operation. The *Cont*, pin 5, is an external control of the internal thresholds, and is normally connected to a 0.01 μF capacitor to ground. The *Thr*, *Trig*, and *Dis* (pins 2,6, and 7) are connected to an RC network to establish the clock period, and if necessary to an external trigger for monostable operation.

1. Schmitt Trigger

Connect an op-amp without negative feedback to form the circuit in figure 1. Use resistors in the range from 1-10 kΩ, and use $V_+ = +5$ V and $V_- = 0$ V.

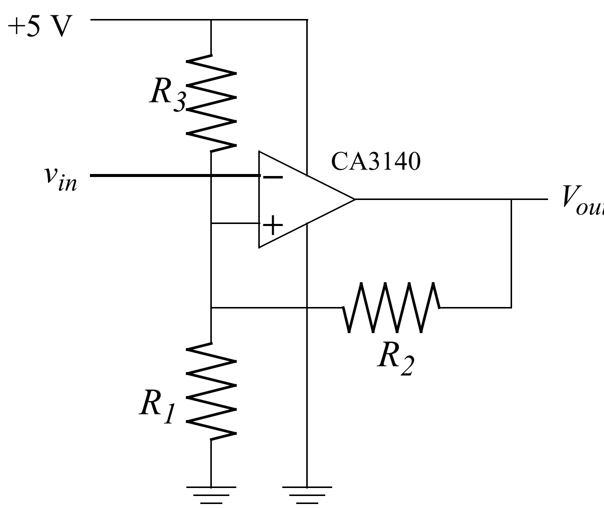


Figure 1: Schmitt Trigger

Set the function generator to provide v_{in} with a sine wave of 1 kHz and 2.5 V amplitude, and then adjust the DC offset so that the voltage varies from 0 to 5 V. Measure V_{out} and v_{in} with the oscilloscope and make a graph of V_{out} as a function of v_{in}. Use the X-Y setting of the oscilloscope to view the hysteresis directly. How do the two thresholds compare to the expected value based on the resistors?

2. Relaxation Oscillator

Modify the circuit in figure 1 by adding the negative feedback shown in figure 2.

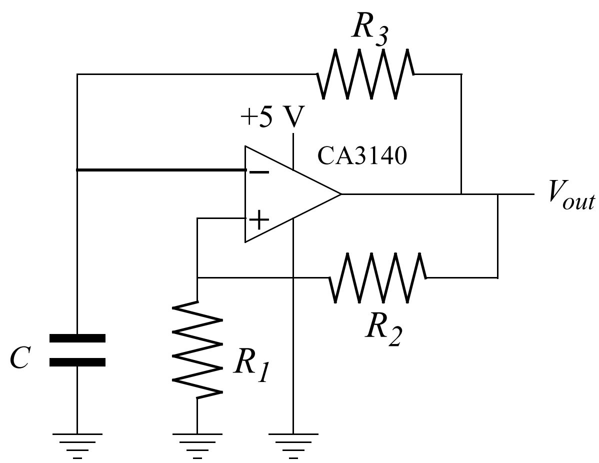


Figure 2: Relaxation Oscillator

Measure the period of oscillation and compare to the time constant R_3C. Compare the waveform at the output with the waveform at the negative input. How does the threshold voltage at the input compare to the hysteresis limit from part 1?

3. Inverter Oscillator

One of the simplest oscillator circuits can be made from two CMOS digital inverters and an RC network as in figure 3.

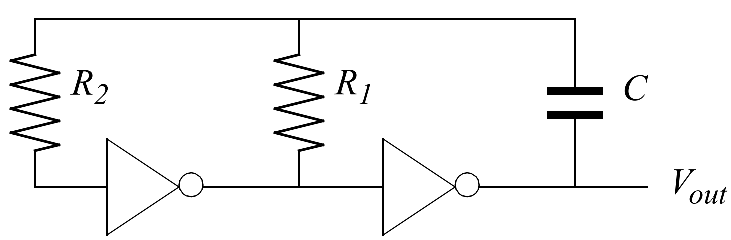


Figure 3: Inverter Oscillator

Set $R_2 = 0$ and measure the period of oscillation and compare to the time constant R_1C. Set $R_2 = 10R_1$ and observe the effect on the oscillation.

4. 555 Monostable Multivibrator

Use a 555 timer and 74HC04 inverter to construct the circuit in Fig. 4. Use V_{CC} = +5V and use the pulse generator with a 10 KHz square wave as input to the trigger. Start with R = 10 KΩ and C = 0.01 µF. Vary the input frequency from 100 Hz to 1 MHz and observe any changes to the output pulse width. Change C to 0.001 µF, 120 pF and 26 pF to see how short the output pulse can be made. Does the pulse width stay linear with RC?

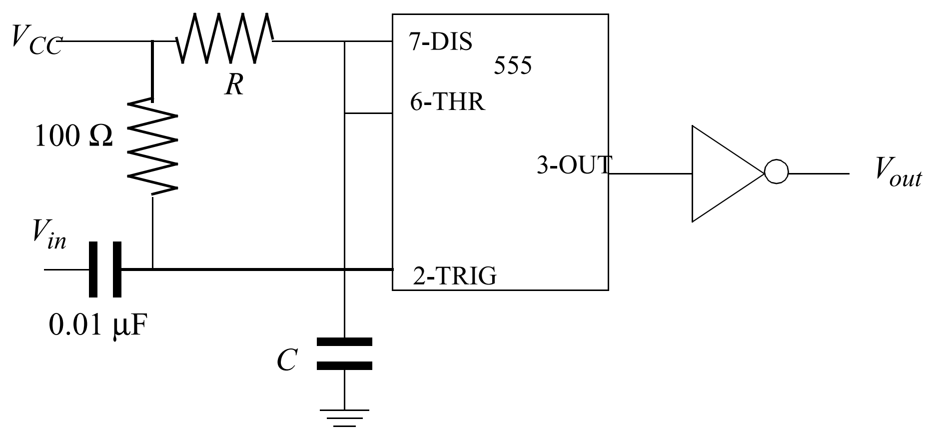


Figure 4: 555 Monostable Multivibrator