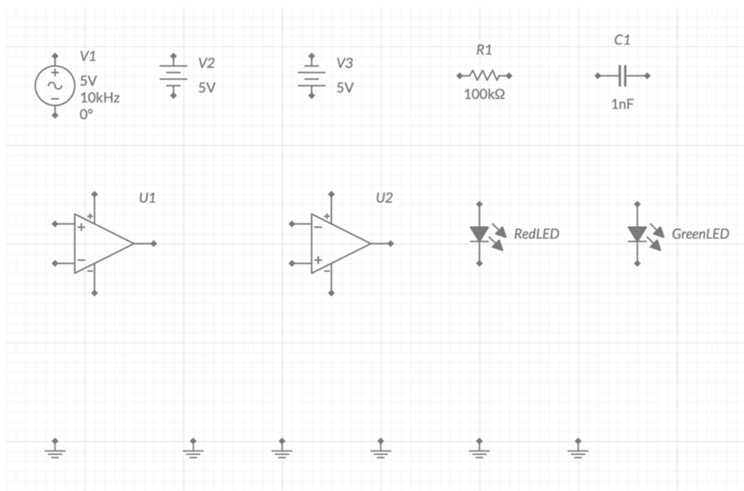
Lab 10 Comparators, Schmitt trigger & Oscillators

Zero-crossing detector

A comparator is a circuit that can indicate when the input voltage exceeds a specific limit. With a zero-crossing detector, the trip point is zero. With a limit detector, the trip point is either a positive or negative voltage.

In this simulation lab, we only have the following components available here:

- An ac source (sine wave peak voltage 5V with variable frequencies.)
- Two dc sources of $5V$;
- A green LED and a red LED;
- The Multisim 5 terminal op-amp;
- Various resistors and capacitors (more than shown, unlimited);
- Ground & wires.



a. Build a zero-crossing detector. Show the schematic and the graph of two periods of the input and output below. Is your detector inverting or non-inverting?

b. Connect the two LEDs to the output so that the when the input is positive, green LED is on, when the input is negative the red LED is on. Set the frequency low enough (such as 0.01Hz) so our eyes can see which light is on which light is off. Be careful if your detector is an inverting one. Put a V-meter at the LED, take two screenshots – red light on and green light on with voltages displaying on the voltage meter.

c. Most LEDs cannot handle more than $50mA$. How much current are you sending into the LEDs? In real life will your LED burn off or not turn on at all? Did you include a current limiting resistor to each LED? Should you? If you use a 741 op-amp, do you still need a current limiting resistor?

Limit Detector

a. Modify your zero-crossing detector into a limit detector, that is, when input is greater than a certain limit voltage: $V_{ref} = 1.0V$, the output switches sign. Show the schematic and the graph of two periods of the input and output below. The two LED lights should still work as expected: when $v_{in} > 1.0V$, green LED is on, when $v_{in} < 1.0V$ the red LED is on. Take two screenshots – red light on and green light on with the voltages displaying on the voltage meter.

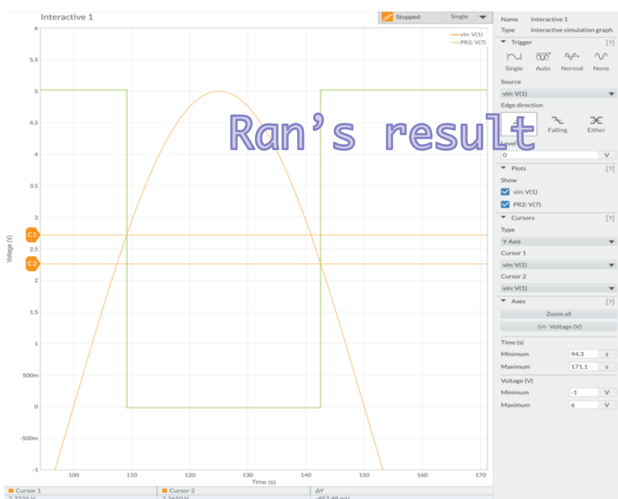
b. As discussed in homework 10, dual power supply is a luxury, so I take away one of your 5V dc source. Modify your circuit so the output swings between 0V and 5V as the input crossing 1.0V. The two LED lights should still work as expected: when $v_{in} > 1.0V$, green LED is on, when $v_{in} < 1.0V$ the red LED is on. Well, you may discover that now the red LED stays off, only the green LED flashes. You will need to modify your red LED circuit so that **when the output is 0V it turns on** – an OFF indicator. Take two screenshots – red light on and green light on with voltages displaying on the voltage meter. Also show the schematic and the graph of two periods of the input and output below.

c. ***Duty cycle*** is defined as the ratio of the ***ON*** time (or ***pulse width***, the time between the rising edge and the falling edge) and the period. For example, the duty cycle of the zero-crossing detector is 50%. What's the duty cycle of your limit detector with $V_{ref} = 1.0V$? Switch the two resistors you used to determine the reference voltage. What's the new reference voltage? What's the new duty cycle? What do you observe with the two LEDs before and after switching the two resistors? Is your observation as expected?

Schmitt Trigger

a. Adjust the two resistors you used to set the reference voltage so now $V_{ref} = 2.5V$. What's the duty cycle? Build the inverting Schmitt Trigger you designed in ***Homework 10-III***. *If your current comparator is already an inverting one, you will only need to add the feedback resistor to set the hysteresis. If your current comparator is a non-inverting one, you will need to modify it to the one you designed in the homework.* Your LED circuits at the output stages should still work as expected: when $v_{in} > UTP$, green LED is on, when $v_{in} < LTP$ the red LED is on. Take two screenshots – red light on and green light on with voltages displaying on the voltage meter. Also show the schematic.

b. Now double click the graph, set the y axis display -1V ~ 6V, set the trigger to Single, set the x axis time to about half a period so you can clearly see the input sine wave and the output square pulse crossing each other. Choose cursors – Y axis and set the two cursors at the UTP and LTP. Take a screenshot. Do the UTP and the LTP voltages agree with your calculations in the homework? Is this inverting Schmitt trigger indeed working as inverted? Here is my example of what it should look like.



Relaxation Oscillator

Now I also take your ac source away because it is too noisy. Build the oscillator you designed in ***homework 10-iv***. Is the red and green LED still flashing alternately? Are you able to see which one is on which one is off with your eyes? Adjust the integrator's R and C value so you can distinguish the on and off of the two lights. Take two screenshots – green light on and red light on with voltages displaying on the voltage meter. Also show the schematic and the graph of two periods of the input and output below. Measure the frequency of your oscillator.