Homework 10

1. *Comparator basic concepts*
2. A zero-crossing detector is a comparator with its output voltages ideally switches from low to high or vice versa whenever the input voltage crosses zero. Draw a zero-crossing detector and describe its theory of operation. Add any necessary components for your sketch. (5)
3. How does a Schmitt trigger differ from a zero-crossing detector? (5)
4. How can I prevent a noisy input from triggering a comparator? Draw a schematic diagram and some waveforms to support your discussion. (5)
5. *Comparators*
6. Design an **inverting** comparator with output swings between $\pm 5V$ and with a reference voltage 1.5V. You have:
	* + *an ac source (sine wave peak voltage 5V, peak-to-peak 10V at 10kHz),*
		+ *a dc source of* $5V$*and a dc source of* $-5V$*,*
		+ *various resistors and capacitors,*
		+ *and ground of course.*
	* Draw your schematic diagram below. Label all the components and values. Explain how your circuit works. Sketch two periods of the input and output waveforms in one graph. (8)
	* What resistors values did you pick? Why an engineer probably will not use a $100Ω$ or a $10Ω$ resistor? (2)
7. It’s a luxury to have two dc supplies with opposite polarity. Most likely you have a 5V dc charger such as the ones you use to charge your phone, iPad, router hub, Bluetooth speaker, Christmas LED light strip… etc.

Modify this inverting comparator circuit you designed above so the output swings between 0 and $5V$ at a reference voltage of $2.5V$. You have all the available components as in part II-a except the $-5V$ dc source. Draw your schematic diagram below. Label all the components and values. Sketch two periods of the input and output waveforms in one graph. (5)

1. *Schmitt Trigger*

The ac source you used in II-bis noisy. You used a scope to measure the input ac source **noise’s** maximum peak-to-peak value being about 200mV. Modify your previous design of II-b to an **inverting** comparator with hysteresis to reduce the input signal noise sensitivity. The new comparator’s output now swings from 0 to $5V$ without any chatters.

*Note: the reference voltage is still 2.5V as in* II-b*, so the hysteresis is based on* $V\_{ref}=2.5V.$

1. Draw your schematic diagram below. Label all the components and add all the resistor values after you finish step III-c. (10)
2. What are the UTP and the LTP voltages (mV)? And what’s the hysteresis H (mV) (2)
3. What’s the value of the added feedback resistor $R\_{f}$ to achieve the hysteresis H above? Show your work below. (8)
4. *Relaxation oscillator*

This noisy ac source is annoying, so we threw it away. Build an integrator circuit\* and add it to the inverting Schmitt trigger from part III. Now you have a relaxation oscillator.

1. Draw the schematic below, label all the components. (5)
2. Sketch two periods of the input and output waveforms in one graph and explain how this oscillator works. *No need to worry about the frequency for this step. (5)*

\*Note: Pick your own resistor and capacitor values of the integrator. We will simulate this circuit in our lab 10 and find the frequency.