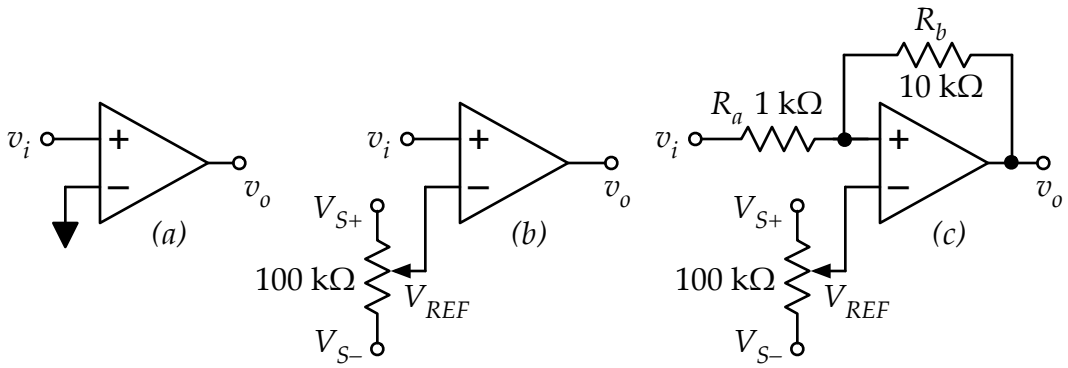
Comparators & a non-linear oscillator

This time, we look at some non-linear op amp circuits.

Prior to Lab

1. Review the theory for the comparators and non-linear oscillators (book or class notes).
2. Calculate the V_{TL} and V_{TH} of the two comparator circuit.
3. If you can, calculate the expected oscillation frequency for the inverting-type oscillator of part c.

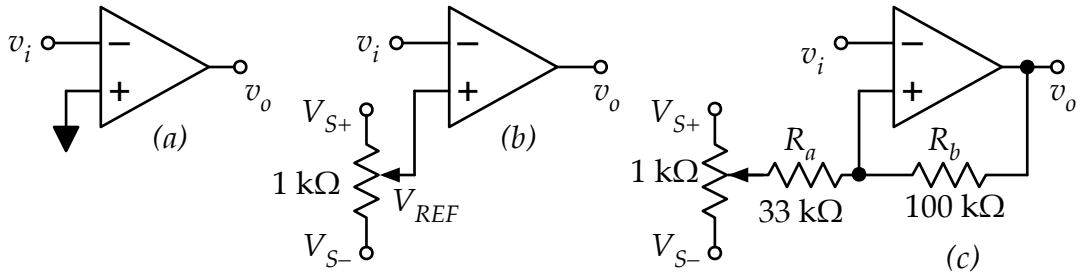
A. Non-inverting comparator



- Build the simple non-inverting comparator shown in part (a) of the figure above. Use a 660 op amp with ±8-V power supplies. The comparator has no feedback loop (i.e. no hysteresis) and the reference voltage is a ground ($V_{REF} = 0$). For the input, use a 100-Hz sinusoid with amplitude of 5 V. (10 V peak-peak or 3.54 V_{RMS}.) Observe the input and output together on the oscilloscope. Save a clear set of traces for your report. Then switch the display into x-y mode so that you can see the transfer characteristic. Save a copy of that for the report.
- Now add a potentiometer to serve as an adjustable reference as shown in part (b) of the figure. Observe the input and output together on the oscilloscope. Adjust the potentiometer and see the effect on the output waveform. Note that if you adjust the potentiometer too far in either direction, the output no longer switches – V_{REF} has been moved to a voltage that the input never reaches. Also, put the oscilloscope into x-y mode and adjust the potentiometer to see how the transfer characteristic changes as V_{REF} is adjusted.
- Finally, add a positive feedback network as shown in Fig. 3(c) to create some hysteresis. Calculate the expected switching points and the amount of hysteresis that would result for the given resistors and assuming $V_{REF} = 2$ V. Adjust the potentiometer so that $V_{REF} = 2$ V in the circuit. (Measure it with the voltmeter.) Using the same input sinusoid, observe the input and output waveforms together on the oscilloscope. Record a copy for your report. Use the oscilloscope cursors to measure the switching points. Put the oscilloscope into x-y mode and record a copy of the transfer characteristic for the report. Adjust the potentiometer to see the effect on the transfer characteristic.

B. Inverting comparator

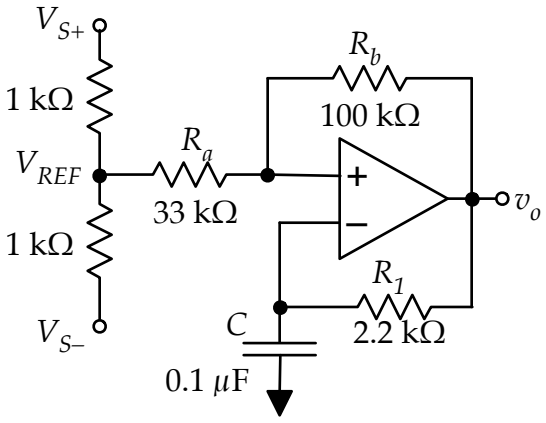
For the inverting comparator circuits shown in the figure below repeat all of the steps and measurements done for the non-inverting comparator in part A above. Again, use a 660 op amp with ± 8 V supplies. Note the different size of potentiometer.



Subtle detail: In the feedback network of part (c), R_a actually consists of the 33 kΩ fixed resistor plus the Thevenin equivalent resistance of the 1-kΩ potentiometer (parallel combination of the two arms of the potentiometer). However, the Thevenin resistance is small – no bigger than 500 Ω – and so you can reasonably ignore it in comparison to the 33-kΩ resistor.)

C. non-linear oscillator

Starting with the inverting comparator with positive feedback shown in the figure below, build the non-linear oscillator shown below. Use a 660 op amp with ±8-V power supplies. Replace the V_{REF} potentiometer with two 1-kΩ resistor as shown. This will fix V_{REF} at 0 V. No input voltage is required!



- Calculate the expected T_H, T_L, and the oscillation frequency for the circuit.

- Observe the v_i and v_o waveforms together on the oscilloscope. Confirm T_H, T_L, and the oscillation frequency from the measurements. Save a copy of the trace of the waveforms together for your report.

- Lastly, Replace R_1 with a series combination of a 1.5 kΩ fixed resistor and a 1-kΩ potentiometer. Observe the two waveforms as you adjust the adjust potentiometer, showing that this is a tunable-frequency oscillator.

Reporting

Prepare and submit a report after you have finished the lab — one report per group. Be sure to include all the calculations and the various oscilloscope screen shots. The report is due in one week at the regular lab time.