Op Amps II

Op-amp relaxation oscillator

Build the relaxation oscillator shown in Figure 1 above. The output should be a square wave with a frequency about $1/(2RC)$. Resistor $R_1$ can be any value between 1K and 1 M. Resistor $R$ is one side of a potentiometer. Examine the voltages at (+) and (-) inputs and at the output and follow the action of the switching. It is useful to display $v_+$ and $v_-$ simultaneously on the same scale to illustrate that the switching occurs at the crossover of $v_+$ and $v_-$. Note that the small triangular symbols indicate connections to ground.

Low-pass resonant filter

Show that the transfer function for the low pass resonant filter, shown in Figure 2, is given by:

$$H(j\omega) = \frac{1}{1 \bar{\square} x + x(1 + j\omega \bar{\square})^3}$$

where $\bar{\square} = RC$ and $x$ is the ratio of $R_1$ to the total pot resistance $R_1 + R_2$. 
[Hint: Begin by naming the output voltages of each op amp, from left to right, as \( v_1 \) through \( v_4 \). Then use the infinite gain assumption to show that:

\[
\frac{(v_4 - v_{in})}{R_1} = \frac{(v_{in} - v_1)}{R_2}
\]

Next, use what you know about RC filters to find \( v_4 \) in terms of \( v_1 \).

When you understand the equation for the transfer function, build the circuit. It is convenient to use a TL084 with four op amps in a package.

Choose \( RC \) so that the resonant frequency is 2 to 5 kHz. Tune the pot until the circuit nearly oscillates. See how close you can get. Notice how oscillations grow and die exponentially. Find the resonant frequency by feeding in a sine signal from a function generator. (You may need to decrease the input voltage considerably to avoid saturating the filter near resonance.) Check the high frequency roll off. It should be proportional to \( 1/\omega^3 \). Estimate the gain at resonance. Observe how the phase shift changes at resonance. Observe that the phase shift is not zero at the frequency where the gain is maximum. Make a Bode plot of the transfer function. (Spend your time wisely here by starting with a survey to find the frequencies where important features occur. Important features include resonance, high-frequency roll off and low-frequency constant region.)