Lab 5: Oscillators

Important Note:
An individual, oral report to one of the teaching assistants at the completion of this lab will take the place of the formal, written report for this lab. You are still expected to do and to show appropriate written theoretical and design calculations, measurements, observations and explanations.

Purpose:
The purpose of this exercise is to study two oscillator circuits: the Wien-bridge oscillator and the phase-shift quadrature oscillator.

Introduction:
Before beginning this exercise, read Sedra and Smith, "Micro-Electronic Circuits", SS4 pp. 973-979 (SS5 1165-1171) on sinusoidal oscillators, SS4 pp. 980-983 (SS5 1171-1174) on the Wienbridge oscillator, and SS4 pp. 983-984 (SS5 1174-1177) on the phase-shift oscillator.

Part 1: The Wien-Bridge Oscillator

Part l(a)
Figure 5.1 shows the Wien-Bridge oscillator, with no amplitude control.

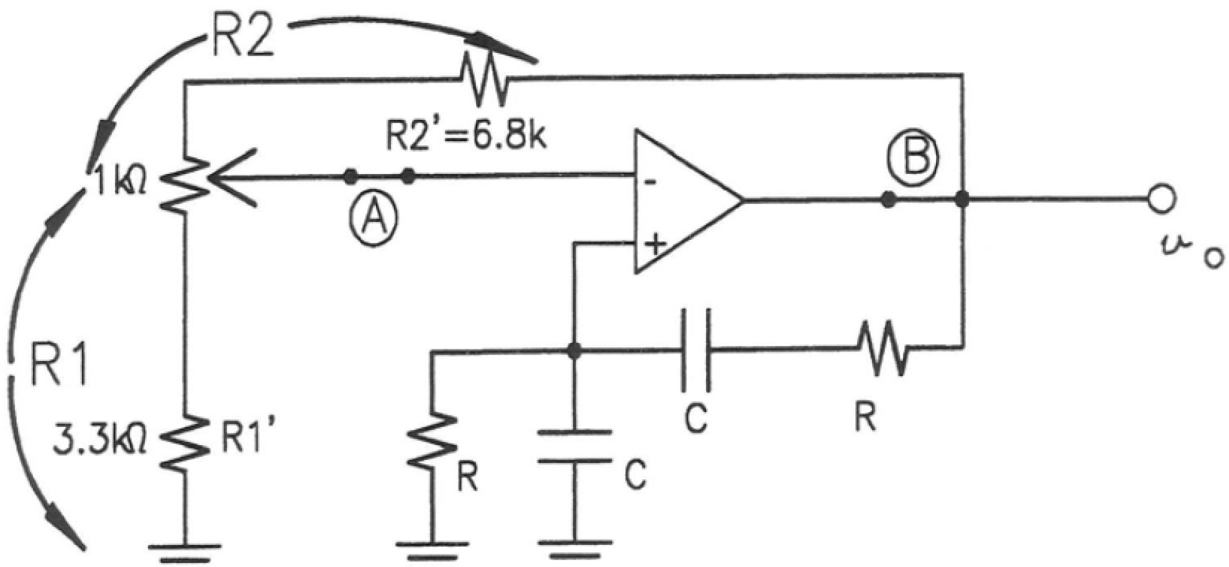

Fig. 5.1

The values for R & C are to be chosen so that the oscillator oscillates at a frequency ***f_0* =250 exp(xx/30)** Hz, where xx are the last two digits of your student number (same frequency as in as in Lab 4).

Initial calculations should be done to give the exact value of *f_0*. (Suggestion: choose C based on what capacitor you already have and calculate the required value for R). After doing these calculations, choose the closest standard value for R (and/or C) and recalculate the expected frequency of oscillation using these values.

Connect the circuit of Figure 5.1, using the chosen values for R and C. In order to achieve sustained oscillation, the ratio R_2/R_1 must be at or above the critical value of 2. Using the oscilloscope to monitor the output, adjust the potentiometer (i.e. the ratio R_2/R_1) until sustained oscillation is achieved.

Measure the amplitude and frequency of the output waveform, v_o, and compare with the expected frequency from calculations. Adjust the potentiometer to the point where oscillation is just maintained and, using the DVM, measure the critical value of R_2/R_1. (Note that power should be disconnected when making the resistance measurements in order to get accurate results). **Note what happens to the output waveform when R_2/R_1 is above and below the critical value. Explain briefly.**

Part 1(b)

In order to obtain a stable output (i.e. a waveform that will not vary with time or temperature) with little or no distortion, it is necessary to connect some type of amplitude control to the circuit. Figure 5.2 shows one possible control circuit which uses zener diodes to limit the amplitude of the output waveform.

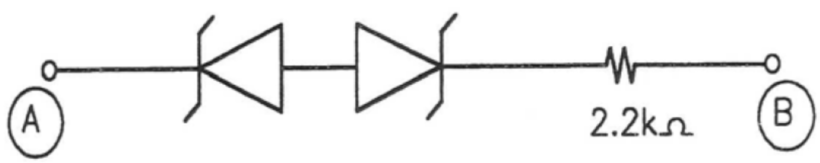

Fig 5.2: 2 x IN5233B (6.0V ± 5%), or 2 x IN5234B (6.2V ± 5%) or 2 x IN5235B (6.8V ± 5%)

Construct the circuit of Figure 5.2 and connect it to the Wien-bridge oscillator (Figure 5.1) as indicated (points A & B). Once again adjust the potentiometer to obtain sustained oscillation. Measure the amplitude and frequency of vo and note what happens to vo as R2/R1 is varied.

Give a brief qualitative description of how the circuit of Figure 5.2 works as a gain control

Part 2: The Active-RC Phase-Shift Quadrature Oscillator

Figure 5.3 shows the active-RC phase-shift oscillator, with no amplitude control.

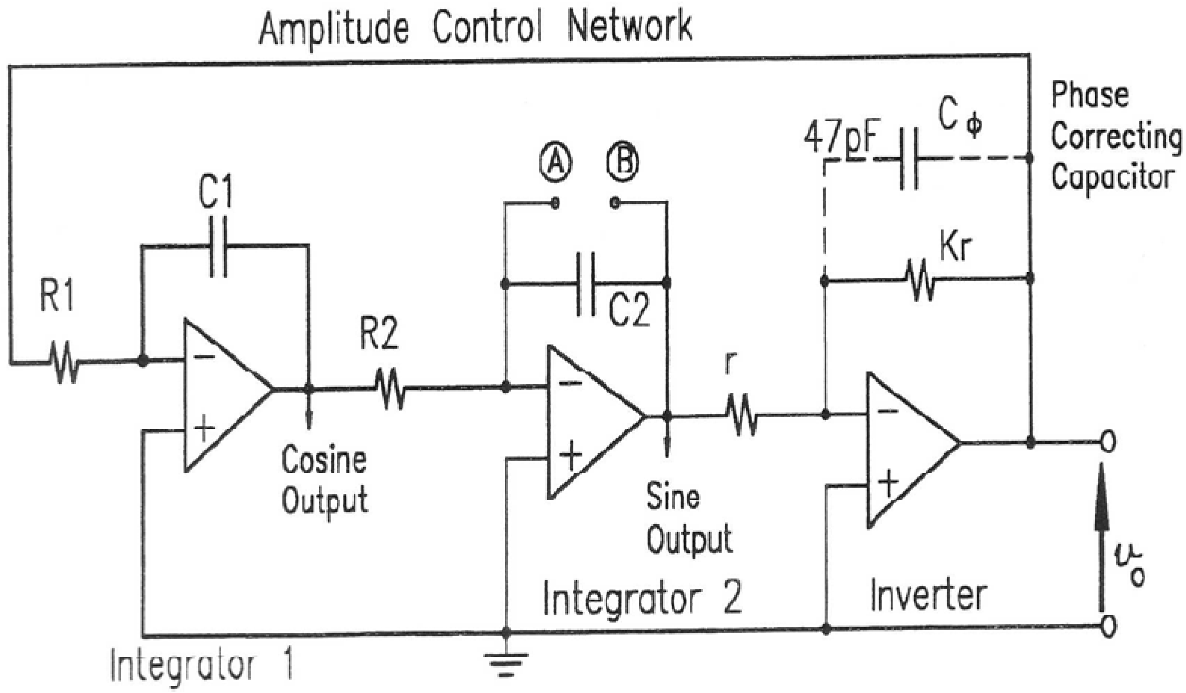

Fig 5.3

It is similar to the classical phase-shift oscillator that Sedra and Smith describe, but it is based on active RC integrators, instead of a passive RC circuit, to provide the necessary phase shift for oscillation. In the circuit, the two pure integrators each provide approximately 90 degrees of phase shift, while the inverting amplifier makes the loop's response up to 360 degrees at all frequencies. The oscillating frequency is then determined by the loop gain being equal to 1, which occurs at a frequency given by the formula:

$$\omega_\circ = \frac{K}{\sqrt{R_1 \cdot R_2 \cdot C_1 \cdot C_2}} = \frac{\sqrt{K}}{RC}, \text{ if } R_1 = R_2 = R \text{ and } C_1 = C_2 = C$$

Real op amps have finite gain, and capacitors are slightly lossy, therefore the actual phase shift of each integrator is very slightly less than 90 degrees. For these reasons the circuit will not normally oscillate unless a small phase-correcting capacitor shunts the feedback resistor of the inverter to make up the phase difference; this capacitor is $C\varphi$ in Figure 5.3. For simple amplitude control use K=1 and choose r=33k to 100k. (If the circuit does not oscillate increase $C\varphi$ to 100pF}

Modify the Tow-Thomas Biquad circuit in your previous lab to the circuit shown in Figure 5.3.
By (1) removing R_q and R_g, (2) replacing R_3, R_4, C_3 and C_4 with the set of R's and C's as were used in the Wien-Bridge Oscillator and (3) adding the phase correcting capacitor.

The amplitude control circuit of Figure 5.2 can also be used with the phase-shift oscillator (although it should be noted that it will not limit v_o to the same value as it did with the Wien-bridge oscillator).

Connect the amplitude control circuit to the phase-shift oscillator as indicated (points A and B). Measure the frequency and amplitude of the output waveform v_o. Try removing or adjusting C_φ and note its effect on the circuit.