EE 230 - Analog Lab
Wadhwani Electronics Laboratory
Electrical Engineering IIT Bombay

Lab 6 : Wien Bridge Oscillator and Active Filters — Date: Feb 15, 2024

Instructions:

- Write down all your observations in notebook.
- Verify your calculations with your respective RA.

Objectives:

- Designing of Positive Feedback OP-Amp based circuitry.
- Designing of Active Filters.

Wien Bridge Oscillator:

1. **Wien Bridge Oscillator**

   (a) Before designing the Oscillator first anlayse the circuit shown in Figure [1]. Take resistance value of R_1, R_2 as 10kΩ and capacitance value of C_1, C_2 as 10nF. Measure the magnitude as well as phase of the output waveform V_{out} for frequency of range 100Hz to 30kHz (with suitable steps) for $10V_{pp}$ sine wave input. Explain you observations. Note the phase relation between the V_{in} and V_{out} when the gain is maximum. **[2 Marks]**

   (b) Explain the working of the Wien Bridge circuit shown in Figure[2]. **[2 Marks]**

   (c) Connect the circuit shown in Figure[2] and take resistance value of R_1, R_2,R_3, R_4 equal to 10kΩ, $R_5 = 20k\Omega$ pot(connect two 10K pots in series) and capacitance value of C_1, C_2 equal to 10nF.Use dual supply of $\pm 12V$ for the Op-amp TL084, and derive the frequency at which bridge oscillator oscillates. **[2 Marks]**

   (d) You may need to adjust R_5 pot for getting sustained oscillation . Measure the frequency and peak to peak of V_{out} and compare it with your theoretical results. **[2 Marks]**

   (e) You can change the values of R_1, R_2, C_1, and C_2 and observe the impact of these values on oscillator frequency. Take $R_1 = R_2 = 5K$ and note down the output frequency and peak-to-peak amplitude. Ensure R_1=R_2 and C_1=C_2. What would be the frequency of oscillation if R_1 and R_2 are not equal? **[2 Marks]**

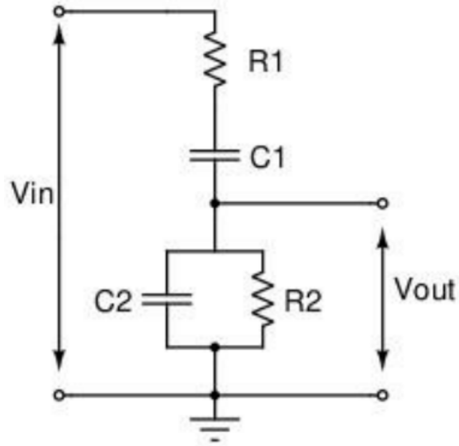

Figure 1

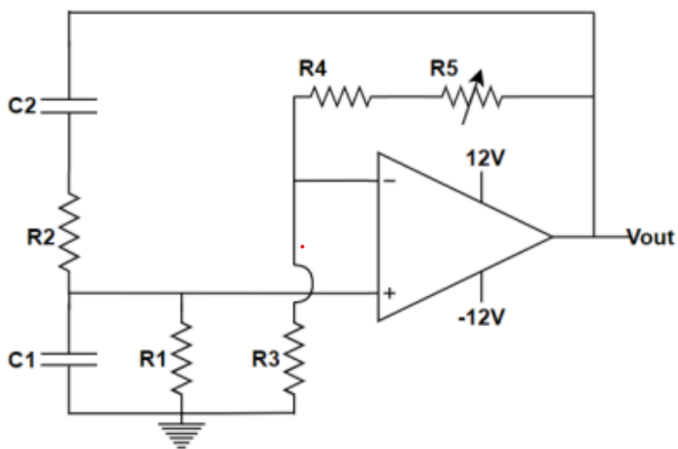

Figure 2: wien Bridge Oscillator

2. **Sallen-Key (2-pole) Active Low-pass Filter**
   The filter's cut-off frequency can be determined using the formula (Fig [3]), $f_c * FSF = \frac{1}{2\pi RC\sqrt{mn}}$, where $R_1 = mR, R_2 = R, C_1 = C, C_2 = nC$, and FSF represents the Frequency Scaling Factor. The circuit's quality factor (Q) is given by, $Q = \frac{\sqrt{mn}}{m+1}$. Using these expressions, design a filter with a cut-off frequency of 1 kHz below (Butterworth and Chebyshev). Apply 1 V_{pp} input.

   (a) **Butterworth** Circuit values: $R_2 = 18.4k\Omega, C_1 = 0.01\mu F$

For the design of a 2nd order Butterworth filter, with FSF = 1 and a quality factor of $\frac{1}{\sqrt{2}}$ (Refer to the filter table in the supporting document, Page 11), determine the values of m and n to set R_1 and C_2. Then, calculate the frequency response ranging from 10 Hz to 10 kHz (in steps of 50 Hz up to 3 kHz, and in steps of 100 Hz from 3 kHz to 10 kHz). Finally, plot 20*log(V_{out}) against log($frequency$). **[5 Marks]**

(b) **Chebyshev** Circuit values: $R_2 = 7.32k\Omega, C_1 = 0.01\mu F$
For the design of a 2nd order Butterworth filter, with FSF = 0.8414 and a quality factor of 1.3049 (Refer to the filter table in the supporting document, Page 11), determine the values of m and n to set R_1 and C_2. Then, calculate the frequency response ranging from 10 Hz to 10 kHz (in steps of 50 Hz up to 3 kHz, and in steps of 100 Hz from 3 kHz to 10 kHz). Finally, plot log(V_{out}) against log($frequency$). **[5 Marks]**

Plot the frequency responses of both Chebyshev and Butterworth filters on a single plot and list their differences.

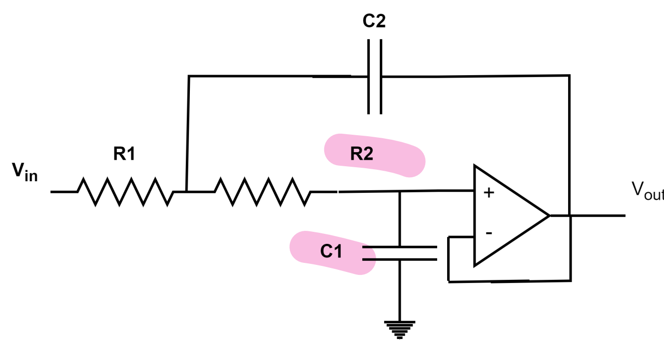

Figure 3: Sallen-Key (2-pole) active low-pass filter

3. **Multiple-feedback Active Band-Pass Filter**

(a) Circuit values: $R_1 = 68k\Omega, R_2 = 180k\Omega, R_3 = 2.7k\Omega, C_1 = C_2 = 0.01\mu F$

(b) The center frequency of the filter is given by, $f_o = \frac{1}{2\pi C}\sqrt{\frac{R_1+R_3}{R_1 R_2 R_3}}$, where $\mathrm{C} = C_1 = C_2$ and Bandwidth is given by $\mathrm{BW} = \frac{f_o}{Q}$, where $\mathrm{Q} = \pi f_o C R_2$.

(c) Experimentally find the filter response of the circuit in Figure [4]. Plot the filter response, find the center frequency and bandwidth and compare the theoretical and ideal results (bandwidth and center frequency). **[5 Marks]**

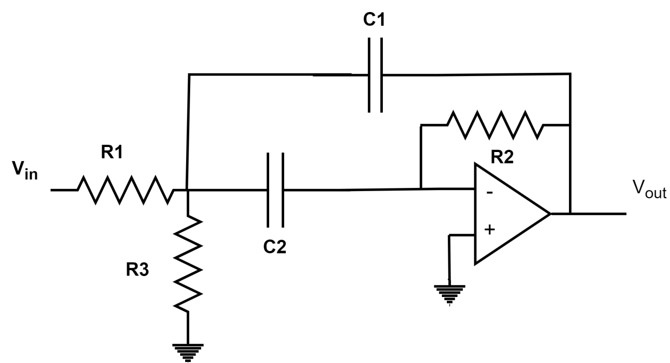

Figure 4: Multiple Feedback Active BPF