



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

Lab 7 : Wien Bridge Oscillator and Active Filters

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 analyse the circuit shown in Figure [1]. Take resistance value of R_1 , R_2 as $10k\Omega$ 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 your 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 $10k\Omega$, $R_5 = 20k\Omega$ 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]**

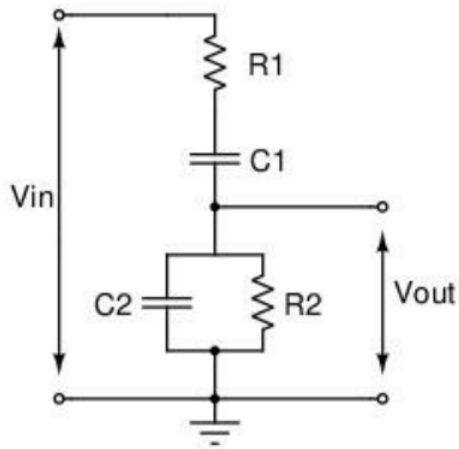


Figure 1

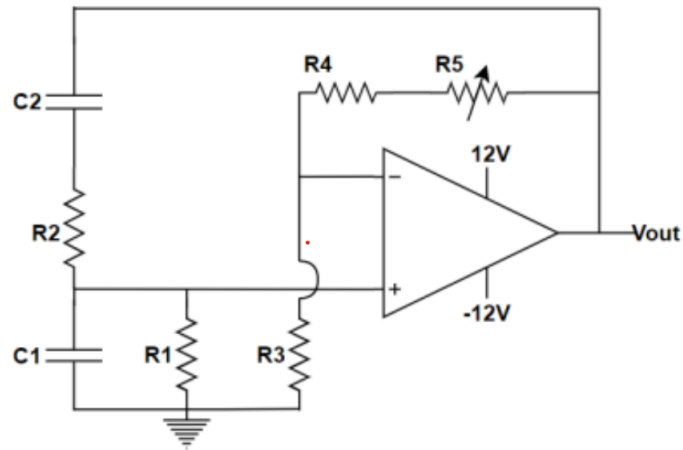


Figure 2: wien Bridge Oscillator

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 $20 \cdot \log(V_{out})$ 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.

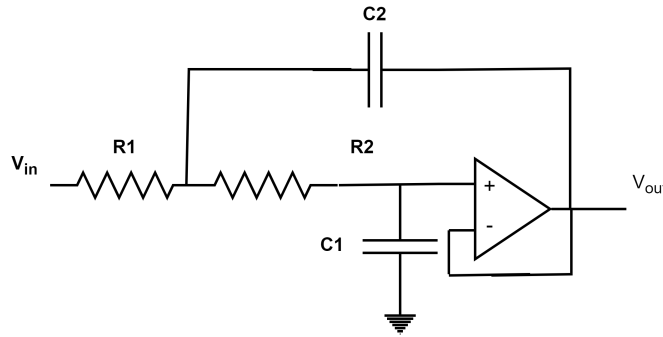


Figure 3: Sallen-Key (2-pole) active low-pass filter

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 $C = C_1 = C_2$ and Bandwidth is given by $BW = \frac{f_o}{Q}$, where $Q = \pi f_o C R_2$.
- (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]**

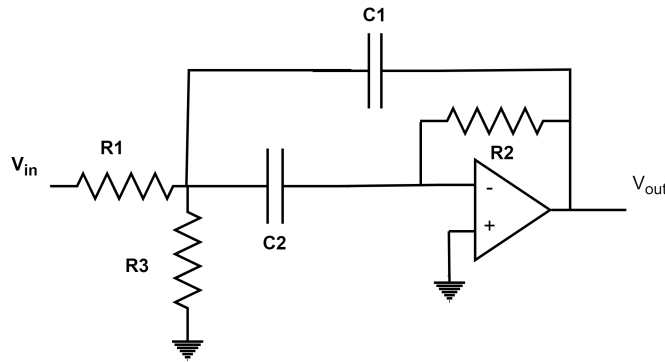


Figure 4: Multiple Feedback Active BPF