Experiment 06

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Abstract
In Experiment-06, we used a Op-amps to make Sallen-Key low pass filter, a Sallen-key high pass filter, and a band pass filter by cascading them. We then compared and verified them with the theoretical results.

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1 Objective

- To design and implement a bandpass filter using separate Sallen-Key Low Pass Filter (LPF) and High Pass Filter (HPF).
- To analyze and compare the frequency response of LPF, HPF, and the final bandpass filter.
- To plot the magnitude response (gain vs. frequency) of all three filter.

2 Apparatus

- Op-amp (we used the IC LM358 as it has 2 Op-amps built-in)
- Resistors $[R = 22k\Omega, R_1 = 5.6k\Omega]$
- Capacitors (2 per filter, 4 for cascade) $[C = 220nF]$
- Oscilloscope
- Function generator
- DC power supply (to power the IC)
- Connecting wires and probes, breadboard

3 Procedure

1. IC
    - Use the datasheet of your Op-amp to know the function of its pins and specifications.
    - Ensure the supply voltages V_+ and V_- being provided are within the recommended range in the datasheet, before you turn them on (We used $+15V$ and $-15V$).
2. Prepating the Circuits (same procedure for all three circuits)
    - Make the circuits as shown in the theory section using the right pins of the Op-amp, resistors, and connecting wires.
    - Connect V_{out} to ground through a resistor.
    - Apply the sine wave to V_{in} from the function generator.

3. Oscilloscope: Use the probes to measure input and output voltages, V_{in} and V_{out}. Set up the Measure function to measure the V_{pp}s of the two signals.
4. Taking Measurements
    - Start with a small frequency of the input sine wave. Note down the V_{pp} values on the oscilloscope.
    - Gradually increase the frequency of the input sine wave.
    - In intervals, note down the V_{pp}s being measured on the oscilloscope and the frequencies they occur at. The ratio of the V_{pp}s is the voltage gain, and can be used to plot this data when verifying.
    - As the frequency increases, you might need to make bigger jumps to see meaningful changes in the data.
    - In high-pass filters, at higher frequencies the V_{out} saturates to the value of V_{in}, so one may stop measuring after that.
    - Continue measuring until enough data is obtained for verification.
5. Cascading to obtain a Band Pass Filter.
    - Using the prepared low pass and high pass filter, we design a band pass filter by cascading them.
    - Connect the V_{out} of the low pass filter to the V_{in} of the high pass filter. Remove the previous input signal from the V_{int} of the highpass filter.
6. Plotting: Use a plotting software to plot the measured data with the theoretical response for the sake of verification.