EXPERIMENT 4: Passive Low Pass Filter and High Pass Filter (LTspice and Experiment)

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Objective

To study and analyze the characteristics of passive Low Pass Filter (LPF) and High Pass Filter (HPF) using both experimental setup and LTspice simulation. To compare experimental, simulated, and theoretical results.

Components and Circuit Details

- **Resistor (R):** 1 kΩ
- **Capacitor (C):** 1 μF
- **Cutoff Frequency (f_c):** $f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 1000 \times 1 \times 10^{-6}} \approx 159.15$ Hz

Plots

Upload all 8 plots as per instructions:

- LPF Experimental: Frequency vs Output Voltage, Frequency vs Gain
- LPF LTspice: Frequency vs Output Voltage, Frequency vs Gain
- HPF Experimental: Frequency vs Output Voltage, Frequency vs Gain
- HPF LTspice: Frequency vs Output Voltage, Frequency vs Gain

Validation and Comparison

Compare the experimental results with LTspice simulation and theoretical calculations. Discuss any differences observed and provide reasoning (e.g., component tolerances, measurement errors, simulation assumptions).

Theoretical Calculations

-3dB Point Explanation: The -3dB point is the frequency at which the output power drops to half its maximum value, corresponding to a gain of $\frac{1}{\sqrt{2}}$ of the maximum. For RC filters, this is the cutoff frequency.

Q1: A resistance of 10Ω and a capacitance value of 100μF are connected in series to a supply voltage given as $V(t) = 100\sin(314t)$.

- **Capacitive Reactance:** $X_C = \frac{1}{2\pi fC}$, where $f = \frac{314}{2\pi} = 50$ Hz. $X_C = \frac{1}{2\pi\times50\times100\times10^{-6}} \approx 31.83\,\Omega$
- **Total Impedance:** $Z = \sqrt{R^2 + X_C^2} = \sqrt{10^2 + 31.83^2} \approx 33.36\,\Omega$
- **Phase Angle:** $\theta = -\arctan\left(\frac{X_C}{R}\right) = -\arctan\left(\frac{31.83}{10}\right) \approx -72.5^\circ$

Q2: A non-inductive resistor of 20Ω, a capacitor of 200μF, and an inductor of 0.30H are connected in series to a 240V, 50Hz supply.

- **Inductive Reactance:** $X_L = 2\pi fL = 2\pi \times 50 \times 0.3 = 94.25\,\Omega$
- **Capacitive Reactance:** $X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi\times50\times200\times10^{-6}} \approx 15.92\,\Omega$
- **Complex Impedance:** $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{20^2 + (94.25 - 15.92)^2} = \sqrt{20^2 + 78.33^2} \approx 80.83\,\Omega$

Conclusion

Summarize the findings, validate the experimental results against simulation and theory, and discuss any discrepancies. Mention the importance of the -3dB point and the practical implications of filter design.