Physics 4L Lab 6 (2026)

6.1 One-pole filter circuit designs.

We pick up from last week, where you solved the first (L.5; Q.10) of 4 circuits. Use available components in the laboratory to build circuits:

- C = 2000 pF, 0.01 μF, 0.033 μF, and 0.1 μF.
- L = 1 mH (r_L ~ 30 Ω), 10 mH (r_L ~ 300 Ω), and 15 mH (r_L ~ 30 Ω), ; remember to measure the internal resistance of the inductor.
- Keeping the load resistance on the waveform generator large, R > 2 kΩ.

Use this procedure to design the additional circuits below:

- Attempt to hit the desired "break frequency" at 5 % (and no worse than 10 %).
- Acquire data first with the oscilloscope to target the range of the design parameter(s).
- Then measure carefully by acquiring with the DAC-interface (no scope-probe).
- Use a slow, logarithmic sweep, i.e., 2 or more sweeps of 30 s of increasing frequency and 30 s of decreasing.
- Apply a short-time Fourier transform, coded in Matlab, to the acquired data. This analysis calculates the local frequency content within a short duration of a longer signal.

Q.1 Design a RC low-pass filter with f_{3dB} = 8.0 kHz (Figure 6.1). Include a SCREENSHOT from the oscilloscope of the rough performance that shows that the 3dB point is within design criteria. A nice way to accomplish this is with an image of the frequency sweep.

Q.2 Show the full Bode plot of only the magnitude to demonstrate that your measurements confirm that you hit the desired 3dB break frequency.

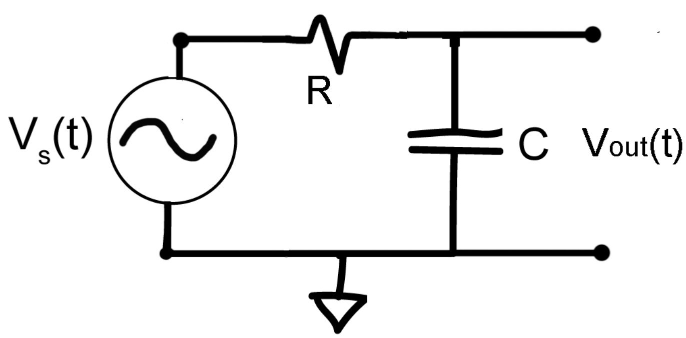

Figure 6.1.

Q.3 Design a LR high-pass filter with f_{3dB} = 8.0 kHz (Figure 6.2). Include a SCREENSHOT from the oscilloscope of the rough performance that shows that the 3dB point is within design criteria. A nice way to accomplish this is with an image of the frequency sweep.

Q.4 Show the full Bode plot of only the magnitude to demonstrate that your measurements confirm that you hit the desired 3dB break frequency.

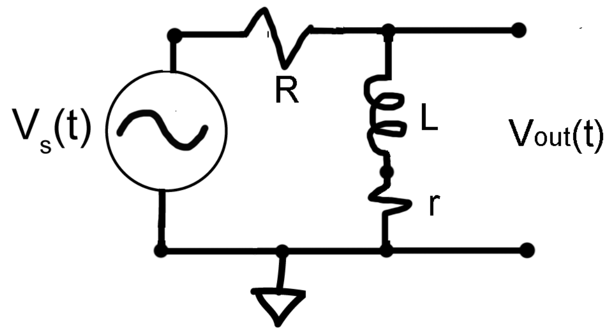

Figure 6.2.

Q.5 Design a LR low-pass filter with f_{3dB} = 8.0 kHz (Figure 6.3). Include a SCREENSHOT from the oscilloscope of the rough performance that shows that the 3dB point is within design criteria. A nice way to accomplish this is with an image of the frequency sweep.

Q.6 Show the full Bode plot of only the magnitude to demonstrate that your measurements confirm that you hit the desired 3dB break frequency.

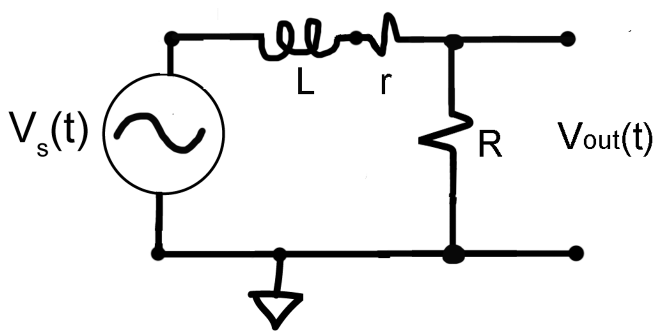

Figure 6.3

6.2 The transfer function for a 2-pole bandpass filter.

Build the circuit in Figure 6.4. The central frequency for this circuit is ω = 1/RC radians/s (Figure 6.5). Choose a combination of R and C to make the central frequency equal to *roughly* 1000 Hz.

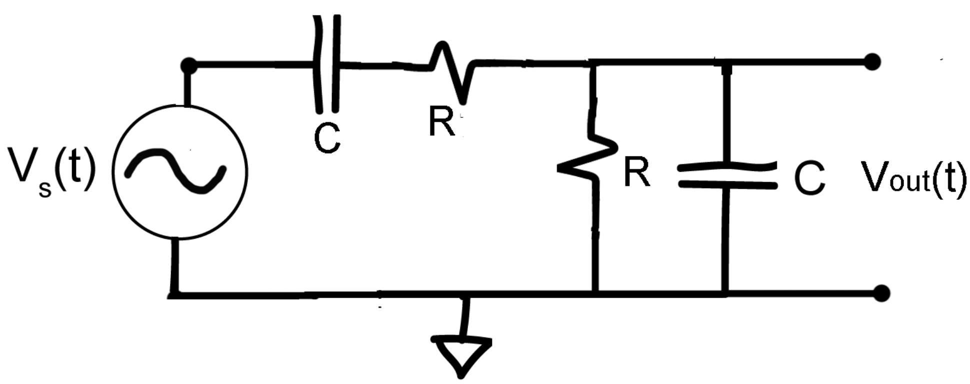

Figure 6.4

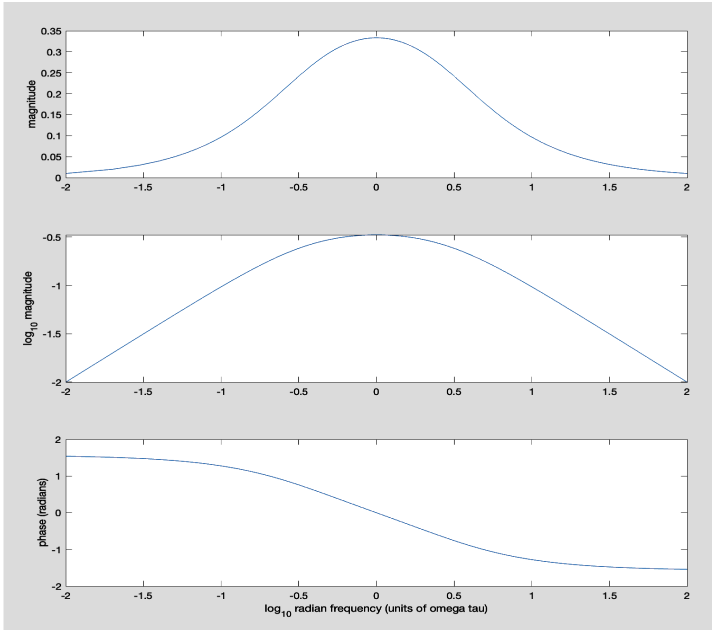

Figure 6.5

Q.7 & 8. Measure the magnitude response (Q.7) and the phase shift (Q.8) of the two-pole bandpass over a range of two orders of magnitude above and two orders of magnitude below the central frequency. Choose 10 points for each order of magnitude.

Q.9. Calculate the expected response as predicted by the transfer function; refer to figure 6.5 as a normalized example. Recall that the output can be expressed in terms of voltage divider of complex impedance.

Q.r10 Plot theory (as a solid line) and experiment (as data points) for both magnitude and phase on the same Bode plots. Explain where and why any mismatch occurs.