# PHYS 241 Lab 3.

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Section 22524 Thursday

Experiment performed with Guillaume Payeur

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**Question 1.**

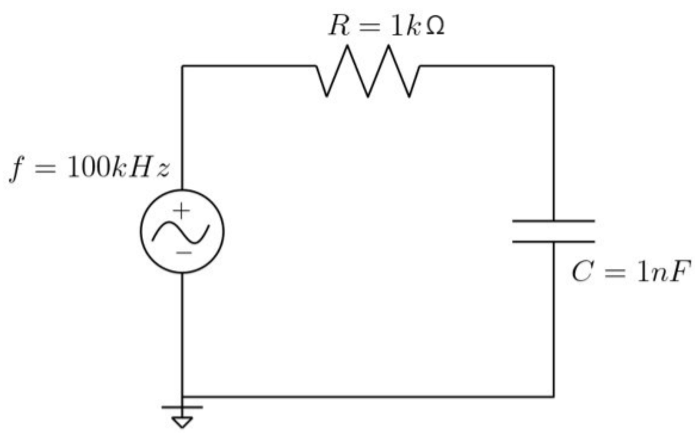


**Figure 1:** Low-Pass circuit for a 3 dB point of 100 kHz.

$$f_H = 100000 \text{ Hz} = \frac{1}{2\pi RC} = \frac{1}{2\pi 1000 \ \Omega C} \implies C = 1 \times 10^{-9} = 1nF.$$

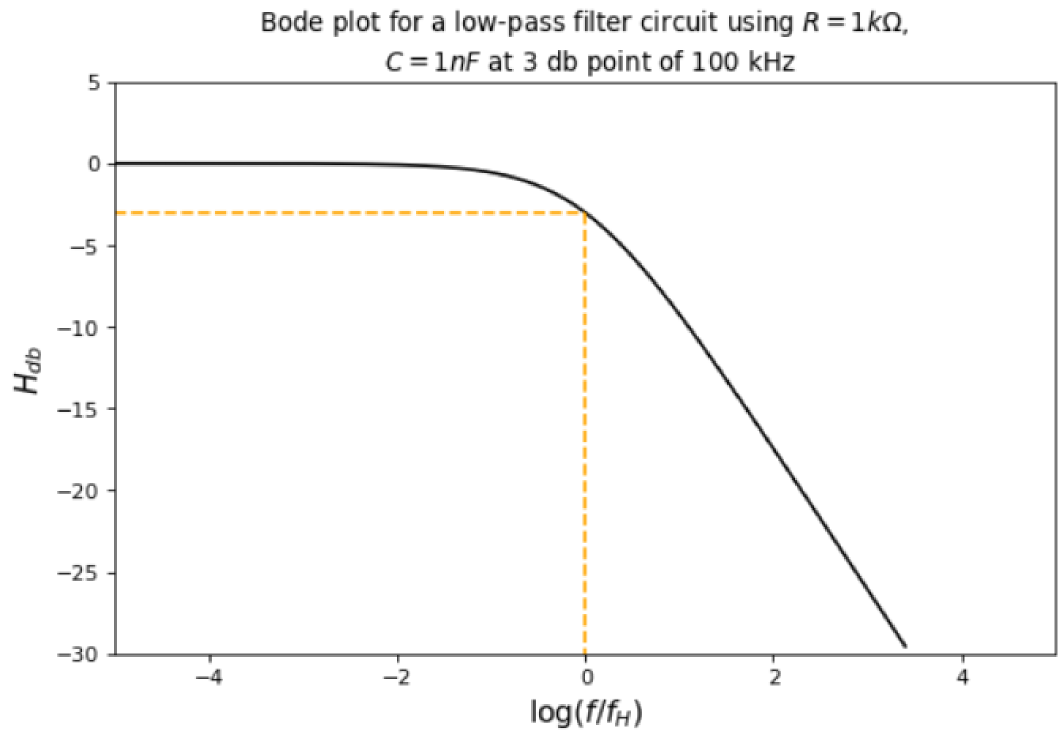


**Figure 2:** Bode plot for low-pass filter circuit.The dotted lines indicate the 3 db point.

**Question 2.**

In Experiment 1, the theoretical predicted values for $f_H$ and $\phi$ are found as follows

$$\begin{aligned} f_H &= \frac{1}{2\pi RC} = \frac{1}{2\pi 10000\ \Omega\ 0.01\ \mu\text{F}} \\ &= 1591\ \text{kHz}. \\ \phi &= \arctan(\omega CR) \qquad , \omega_C = 1/CR \\ \implies \phi &= \arctan(1) = \pi/4 = 45°. \end{aligned}$$

Experimentally it was found that $f_H = 1470$ kHz and the phase angle was evaluated graphically using the difference tool between the two channel sine-waves , $\phi = 45°$. The latter value is in excellent agreement with the theoretical value whilst the former has a considerable difference percentage. This difference is explained by the off-set present in the $V_C$ amplitude read on the scope compared to it's real amplitude. We noted that it was easier to measure the angle $\phi$ from the zero crossing compared to the peak separations since there's less visual fluctuation. Indeed, the 0-crossing horizontal line is assumed to be perfectly linear, which is advantageous with respect to measuring the distance between two wave points at equal heights.

**Question 3.**

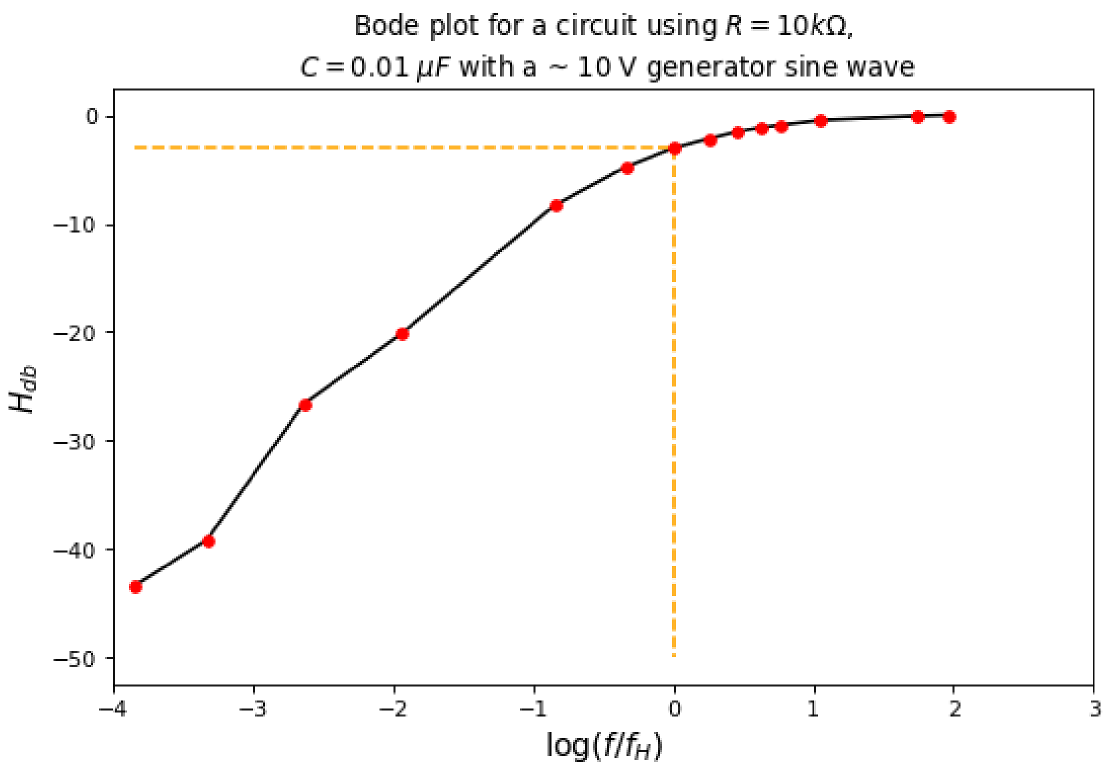


**Figure 3:** Bode plot for Experiment 2.The dotted lines indicate the 3 db point. When compared to Figure 6 in *PHYS* 241 *Signal Processing: Lab 3* manual, the plot is similar with respect to the dimensional limits, although is reflected with respect to the y-axis. It also looks less smooth in comparison. This lack of smoothness is explained by a lack of points taken in the range of $[-4, -2]$ on the x-axis. Another reason could be that some points withing that range have been miss-evaluated.

**Question 4.**

Experimentally it was found that the phase angle $\phi$ is 45°. From Figure 3, we may immediately compute the angle $\phi$,

$$\text{Using R} = 10\ \text{k}\Omega\ ,\ \text{C} = 0.01\ \mu\text{F}\ ,\ \text{we get}$$
$$\phi = \arctan\left(\frac{1}{\omega RC}\right) = \arctan(-1) = -\pi/4.$$

The found angles are both in agreement with respect to their magnitude ,although they have different signs, which is explained by a potential miss-reading on the scope.

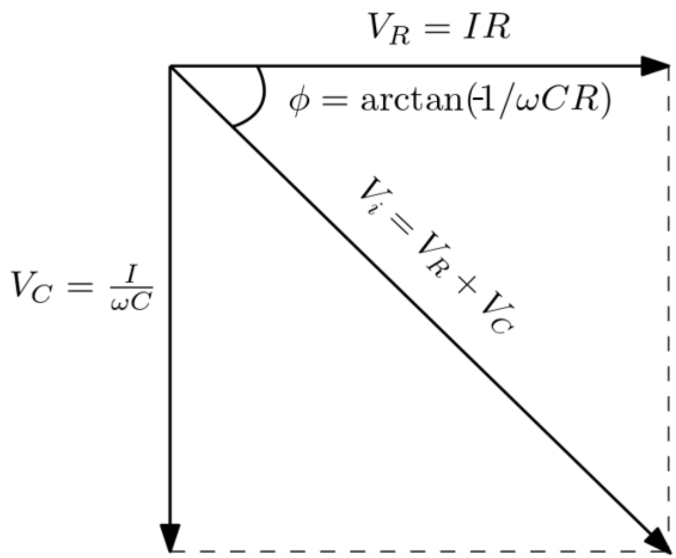


**Figure 4:** Vector diagram for Experiment 2 involving $V_R$ and $V_i$ at frequency $f_H$. The diagram presented is to scale with $V_R = V_i/\sqrt{2}$. We also note from the figure that $V_R$ lags $V_i$ since $\phi < 0$.

**Question 5.**

The channel 1 waveform increased as a result of adding a DC offset, whilst the channel 2 waveform remained unchanged. This is explained by the setup employed experimentally. All the DC voltage goes to charging the capacitor and so it is read by channel 1. The channel 2 is at position $V_R$ so nothing will change at that point for the latter reason.

**Question 6.**

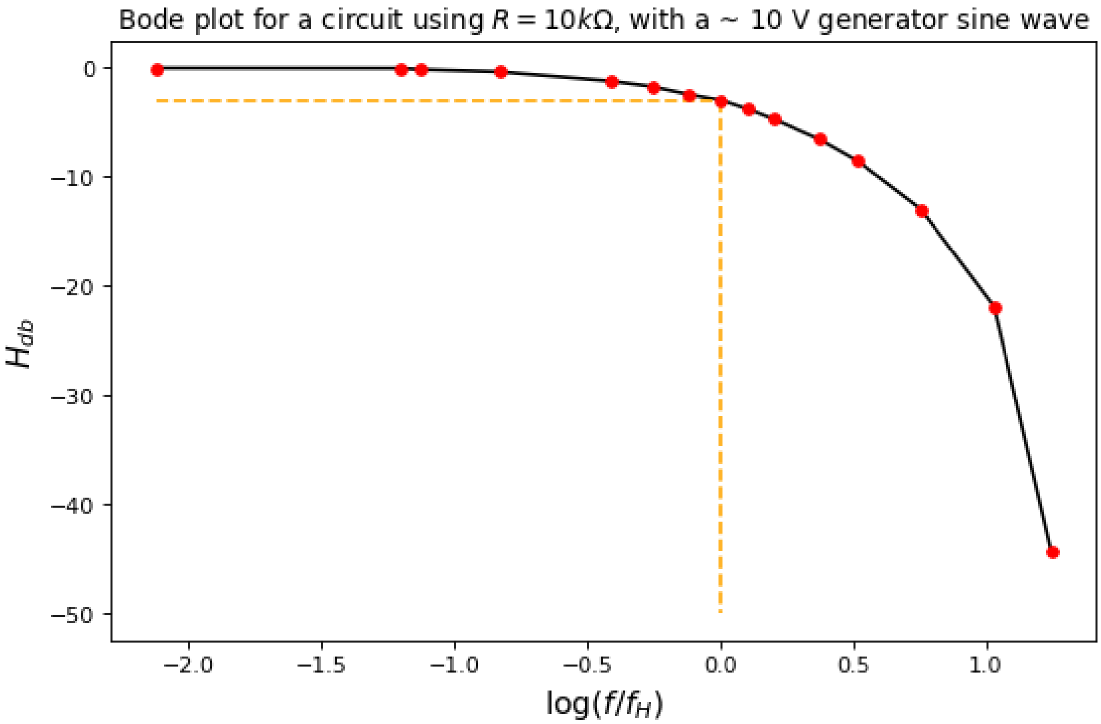


**Figure 5:** Bode plot for Experiment 4. The dotted lines indicate the 3 db point.

It was found experimentally from the difference between the waves on the scope that the phase difference is $\phi = 70°$, along with the cut-off frequency $f_h = 44300$ Hz.
From this we can immediately compute the inductance $L$ ,

$$f_h = \frac{R}{2\pi L} \implies L = \frac{R}{(f_h 2\pi)} = \frac{10000\ \Omega}{44300\ \text{Hz}2\pi} = 0.036\ H.$$

**Question 7.**

Due to the given configurations in which Experiment 1 to Experiment 4 are presented, along with their respective bode plots studied, we may conclude that

1. Experiment 1 is High-Pass
2. Experiment 2 is Low-Pass
3. Experiment 3 is Low-Pass
4. Experiment 4 is High-Pass

## Appendix

**Table 1:** Experimental data gathered for construction of the bode plots presented in Figure 2 and Figure 4.

| Raw Data | | | |
|---|---|---|---|
| Experiment 2 | | Experiment 4 | |
| Frequency($f$) [kHz] | Amplitude Ratio | Frequency($f$) [kHz] | Amplitude Ratio |
| 0.03 | 0.0068 | 5.3 | 0.990 |
| 0.05 | 0.0110 | 13.3 | 0.988 |
| 0.10 | 0.0468 | 14.3 | 0.976 |
| 0.20 | 0.0980 | 19.3 | 0.952 |
| 0.60 | 0.386 | 29.3 | 0.864 |
| 1.00 | 0.580 | 34.3 | 0.816 |
| 1.40 | 0.707 | 39.3 | 0.752 |
| 1.80 | 0.78 | 44.3 | 0.707 |
| 2.20 | 0.84 | 49.3 | 0.64 |
| 2.60 | 0.88 | 54.3 | 0.576 |
| 3.00 | 0.904 | 64.3 | 0.468 |
| 4.00 | 0.952 | 74.3 | 0.372 |
| 8.00 | 0.996 | 94.3 | 0.224 |
| 10.00 | 1.005 | 12.43 | 0.08 |
| | | 15.43 | 0.006 |