EELE 250: Circuits, Devices, and Motors

Lecture 15

Assignment Reminder

- Read 5.6, 6.2 AND 10.1 – 10.6
- Practice problems:
  - P5.65, P5.67, P5.81, P5.91
  - P6.24, P6.25
  - P10.8, P10.14, P10.36

- D2L Quiz #7 by 11AM on Monday 17 Oct.

- Lab #5 this week—be sure to do the pre-lab calculations!

- Exam #2: in class on Monday 17 Oct.

Frequency Response

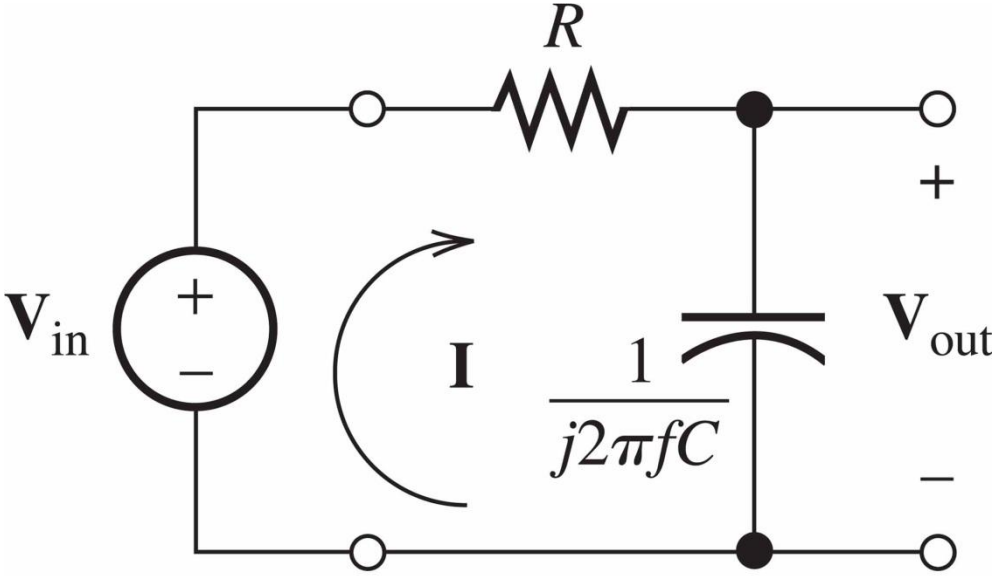
- Recall:

$$Z_L = j\omega L \qquad Z_c = 1/\, j\omega C$$

- Low frequency, $|Z_L| \rightarrow$ zero, $|Z_c| \rightarrow$ infinity
- High frequency, $|Z_L| \rightarrow$ infinity, $|Z_c| \rightarrow$ zero

“Low Pass” Filter

- A circuit that allows low frequencies to pass through and attenuates high frequencies



- $\mathbf{V_{out}} = \mathbf{V_{in}} \cdot \mathbf{Z_c}/(R+\mathbf{Z_c}) = \mathbf{V_{in}}/(1 + j2\pi fRC)$

Low Pass (cont.)

- $V_{out} = \frac{V_{in}}{(1+j2\pi fRC)}$
- As $f \rightarrow$ zero, $V_{out} \approx V_{in}$
- As $f \rightarrow$ big, $V_{out} \approx V_{in}/j2\pi fRC \approx$ zero

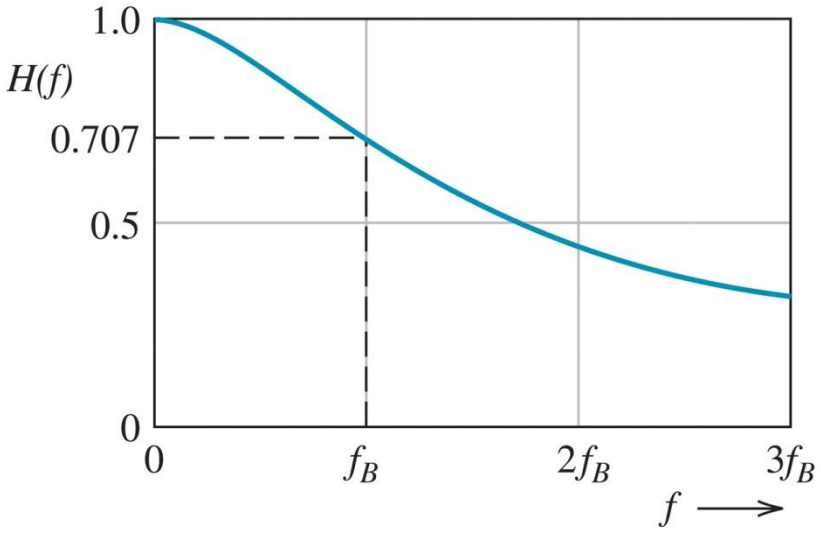
- $|V_{out}| = \frac{|V_{in}|}{\sqrt{1+(2\pi fRC)^2}}$
- $\angle V_{out}$ = -arctan($2\pi fRC$)

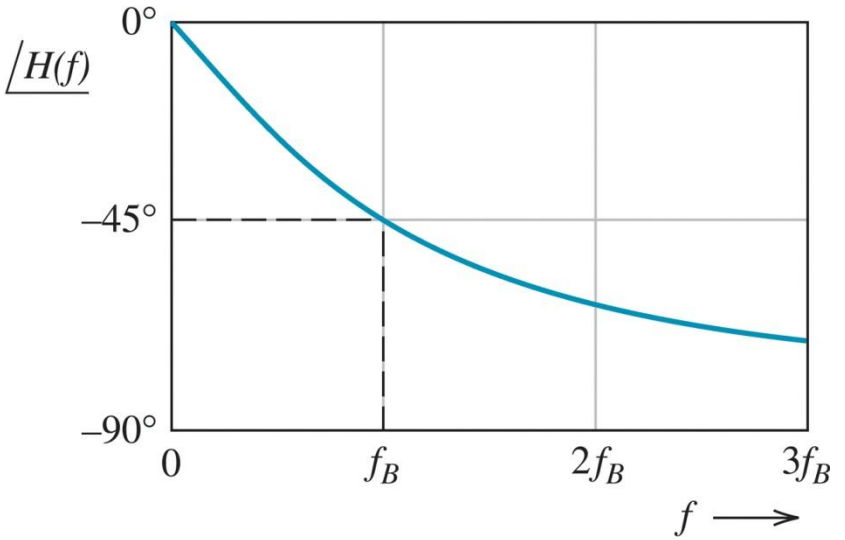
Where have we seen *R*·*C* before?

- The *time constant* came up when we looked at RC transient analysis: t_c = R·C
- If we define $\omega_b = 1/(RC)$, or $f_b = 1/(2\pi RC)$, then $RC = 1/(2\pi f_b)$
- $V_{out} = \frac{V_{in}}{(1+j2\pi fRC)} = \frac{V_{in}}{1+j(2\pi f/2\pi f_b)} = \frac{V_{in}}{1+j(f/f_b)}$
- When $f = f_b$, $V_{out} = V_{in}/(1+j1) = V_{in}/(0.707\angle 45°)$

Magnitude and Phase

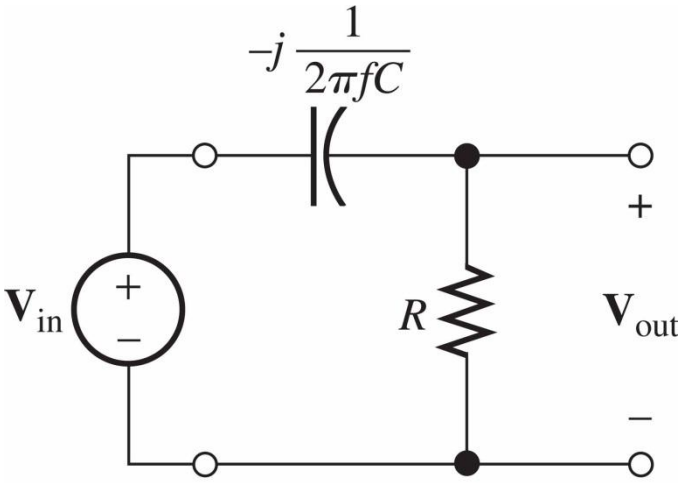
- $V_{out} = \frac{V_{in}}{(1+j2\pi fRC)} = \frac{V_{in}}{1+j(2\pi f/2\pi f_b)} = \frac{V_{in}}{1+j(f/f_b)}$
- When $f = f_b$, $V_{out} = V_{in}/(1+j1) = V_{in}/(0.707\angle 45$
- $|V_{out}| = \frac{|V_{in}|}{\sqrt{1+(f/f_b)^2}}$, $\angle V_{out}$ = -arctan(f/f_b)





High Pass Filter

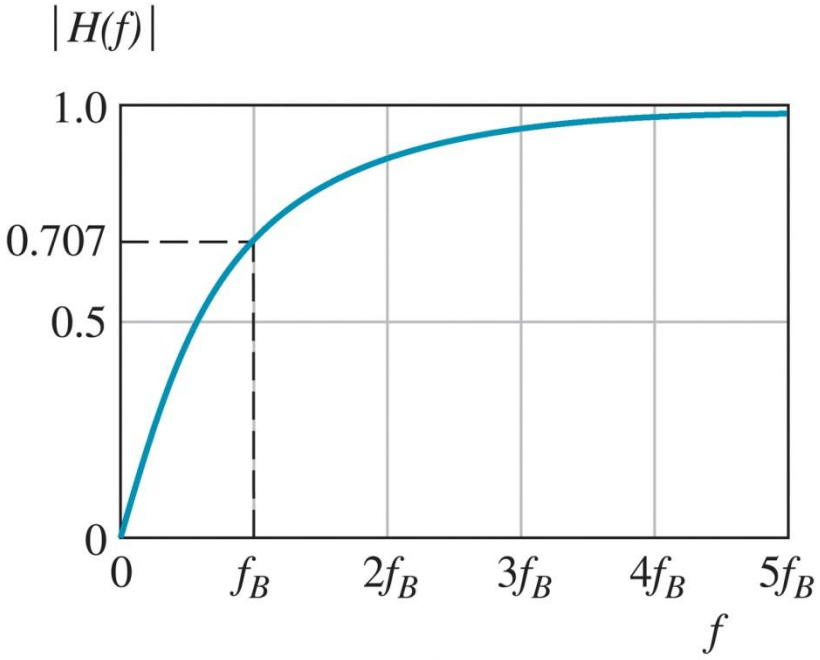
- Interchange R and C:

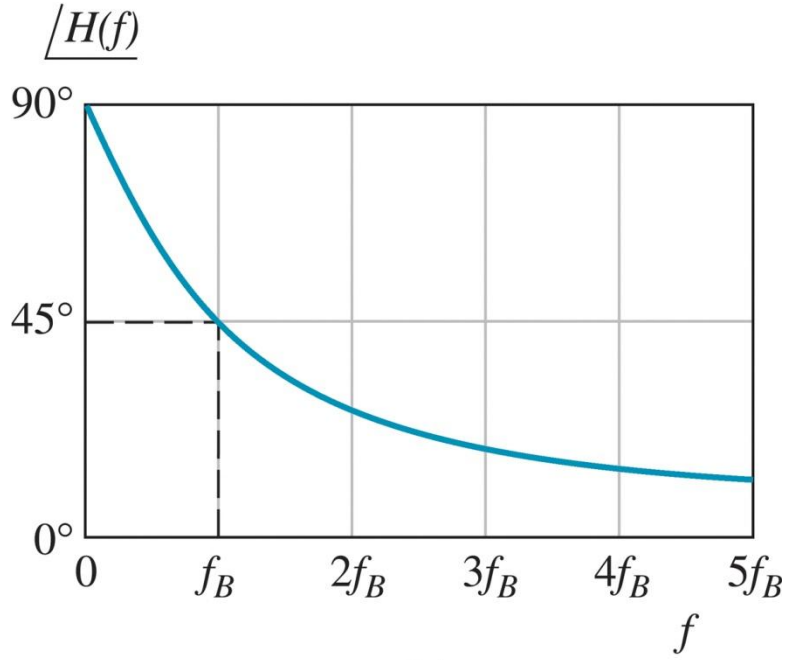


- Low frequencies are blocked, high frequencies are passed through to v_{out}

High Pass (cont.)

- As we did for Low Pass, we can define
  $f_b = 1/(2\pi RC)$





Frequency-selective Filters

- Bass/Treble control for a stereo
- Remove high frequency or low frequency noise
- Smooth out (low pass) or accentuate (high pass) variations in a signal
- Signal processing: high pass acts like a *differentiator* (*d/dt*), while low pass acts like an *integrator* ($\int dt$)