L5 - RC Filters

PHYS 301: Analog and Digital Electronics

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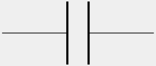
Review

Impedance

$$Z_R = R$$

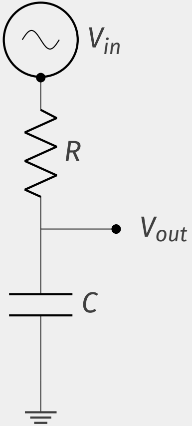


$$Z_C = \frac{1}{j\omega C}$$

$$Z_L = j\omega L$$

$$\omega = 2\pi f$$

RC Voltage Divider (AC)



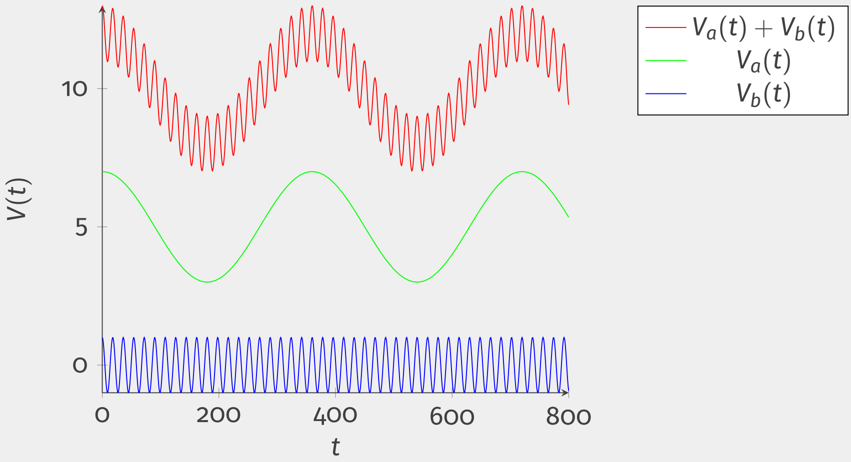
$$V_{out} = \frac{Z_C}{R + Z_C} V_{in}$$

$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + \omega^2 R^2 C^2}}$$

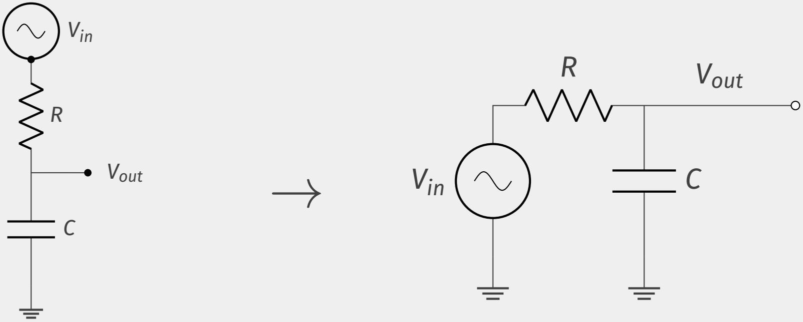
$$\Delta\phi = -\tan^{-1}(\omega RC)$$

Filters

Mixed Frequencies



Low Pass Filter



$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + (\omega RC)^2}} \qquad \Delta\phi = -\tan^{-1}(\omega RC)$$

Decibel Scale

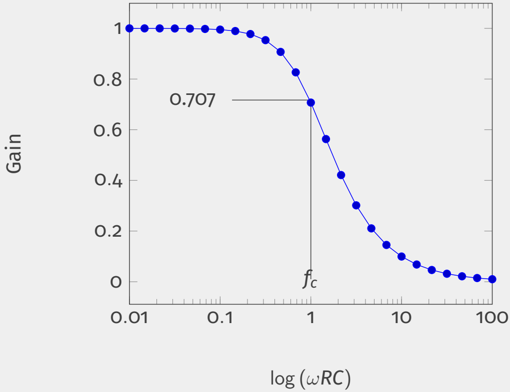
- Used as a logarithmic power scale
- Can be applied to voltage gain

$$dB = 10 \log \left| \frac{V_{out}}{V_{in}} \right|^2$$

or

$$dB = 20 \log \left| \frac{V_{out}}{V_{in}} \right|$$

Bode Magnitude Plot



$$f_c = f_{-3dB} = \frac{1}{2\pi RC}$$

$$\begin{aligned} \text{Gain} &= \frac{1}{\sqrt{2}} \\ &= \frac{1}{\sqrt{1 + (\omega RC)^2}} \\ &= \frac{1}{\sqrt{1+1}} \end{aligned}$$

Critical Point

$$f_c, \quad f_{-3dB}$$

$$\omega_c RC = 1 \rightarrow \omega_c = \frac{1}{RC} \rightarrow f_c = \frac{1}{2\pi RC}$$

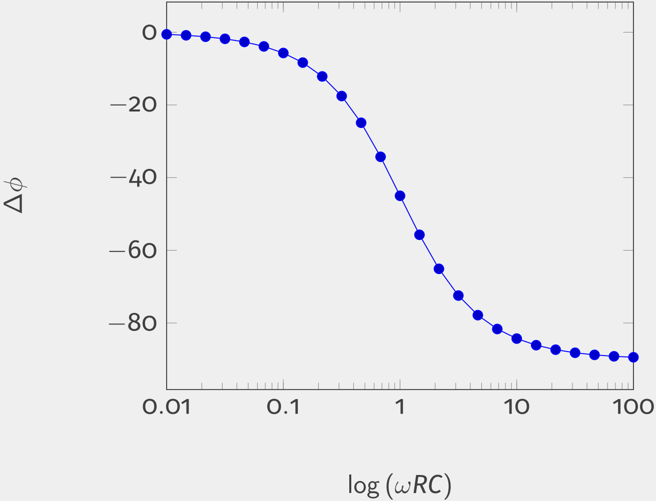
$$dB = 20 \log \left| \frac{V_{out}}{V_{in}} \right|$$

$$dB_{\frac{1}{2}} = 20 \log \left| \frac{1}{\sqrt{2}} \right| = -10 \log 2 = -3.03\ dB$$

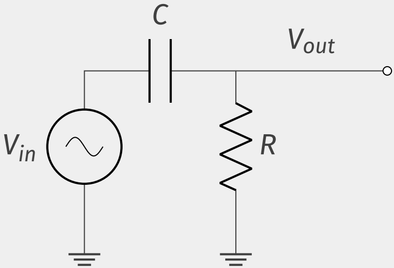
Bode Table

f	V_{in}	V_{out}	$Gain$	$\Delta\phi$
1Hz				
$\vdots$				
100kHz				

Bode Phase Plot

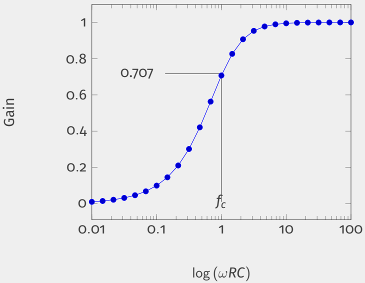


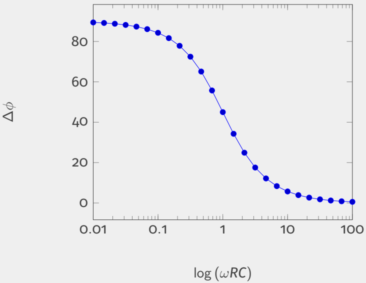
High Pass Filter



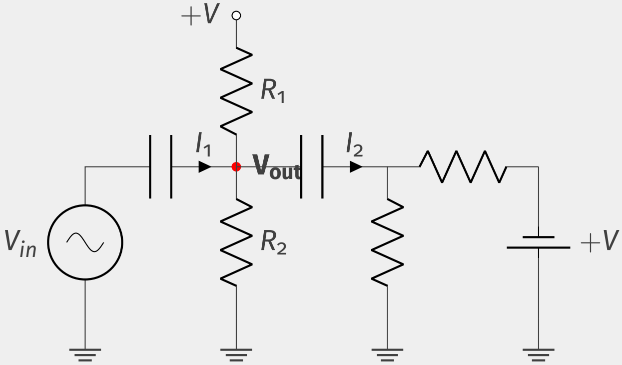
$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + (\frac{1}{\omega RC})^2}} \qquad \Delta\phi = \tan^{-1}\left(\frac{1}{\omega RC}\right)$$

High Pass Bode Plots





Blocking Capacitor



$$V_{out} = \frac{R_2}{R_1 + R_2} V + V_{in} - \frac{I_1}{j\omega C}$$