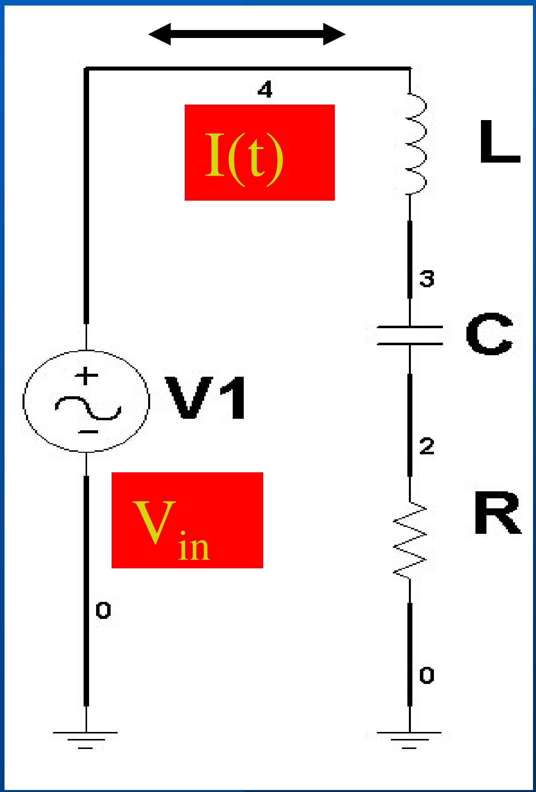
# Passive Filters

# Review: RLC in Series

(1) $V_l = L\, dI/dt$

(2) $V_c = 1/C \int I dt$




Suppose that: $I(t) = I_{ph}\, e^{i\omega t}$ ;

$V_{in} = V(t)$ such that $Z = V_{in}/I(t)$

$I Z = I R + 1/c \int I dt + L\, dI/dt \Rightarrow$

$I Z = I R + 1/(i\, \omega\, c)\, I + (i\, \omega\, L)\, I \Rightarrow$

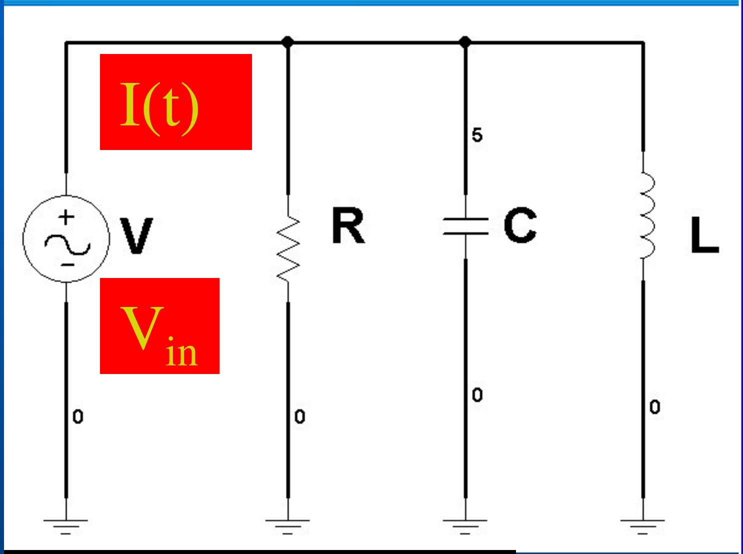
$$\boxed{Z = R - i/(\omega\, c) + (i\, \omega\, L)}$$

$Z_R = R$

$Z_C = - i/(\omega\, c)$

$Z_L = i\,(\omega\, L)$

# Review: RLC in Parallel




(1) $I_c = c\, dV/dt$

(2) $I_L = 1/L \int Vdt$

Suppose that: $V(t) = V_{ph}\, e^{i\omega t}$ ;

$I = I(t)$ such that $Z = V_{in}/I(t)$

$I = V_{in}/Z = V_{in}/R +$

$+ 1/L \int Vdt + C\, dV/dt \Rightarrow$

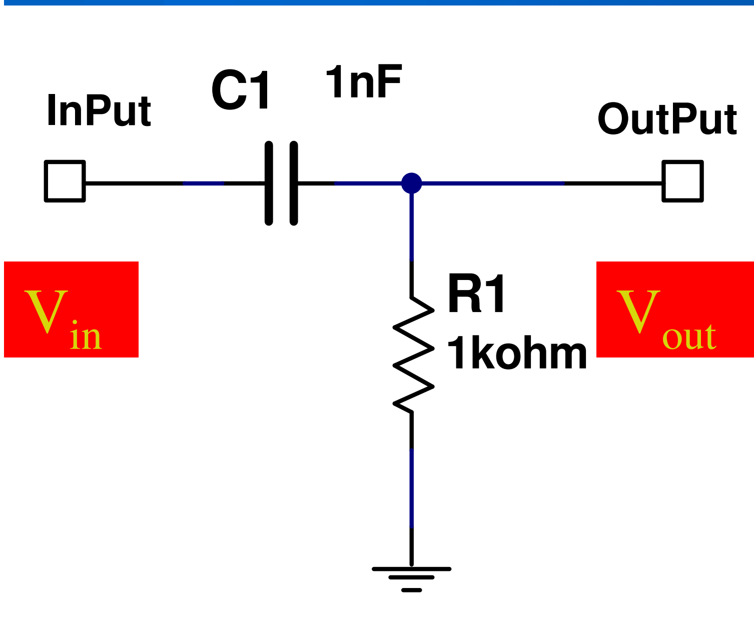
$V_{in}/Z = V_{in}/R +$

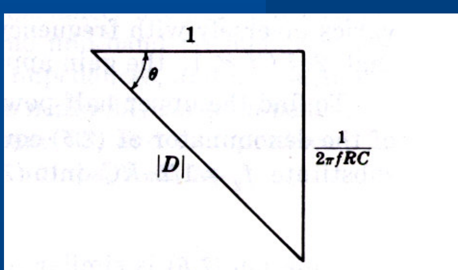
$1/(i\,\omega\, L)\, V_{in} + (i\,\omega\, C)\, V_{in} \Rightarrow$

$$\boxed{1/Z = 1/R + 1/(-\,i/\omega\, c) + 1/(i\,\omega\, L)}$$

$Z_R = R \quad Z_C = -\,i/(\omega\, c) \quad Z_L = i\,(\omega\, L)$

# High Pass Filter I




$I = V_{in}/Z \quad Z = R - i/(\omega C)$

$I = V_{in} /(R - i/(\omega C)) \Rightarrow$

$V_{out} = V_{in} R / ( R - i/(\omega C)) \Rightarrow$

$A = V_{out} / V_{in} = R/( R - i/(\omega C)) \Rightarrow$

$A = 1 / ( 1 - i/(2\pi fRC)) \Rightarrow$

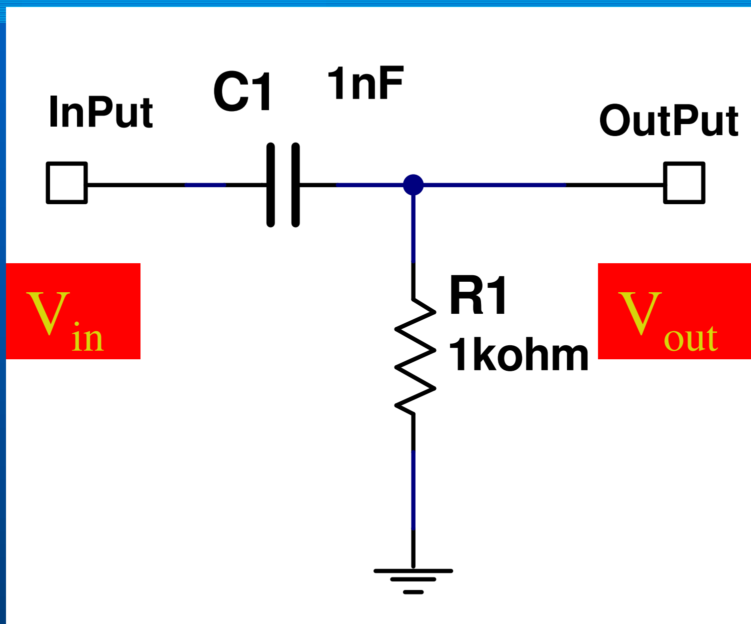
$A = 1 / ( 1 - if_0/f )$

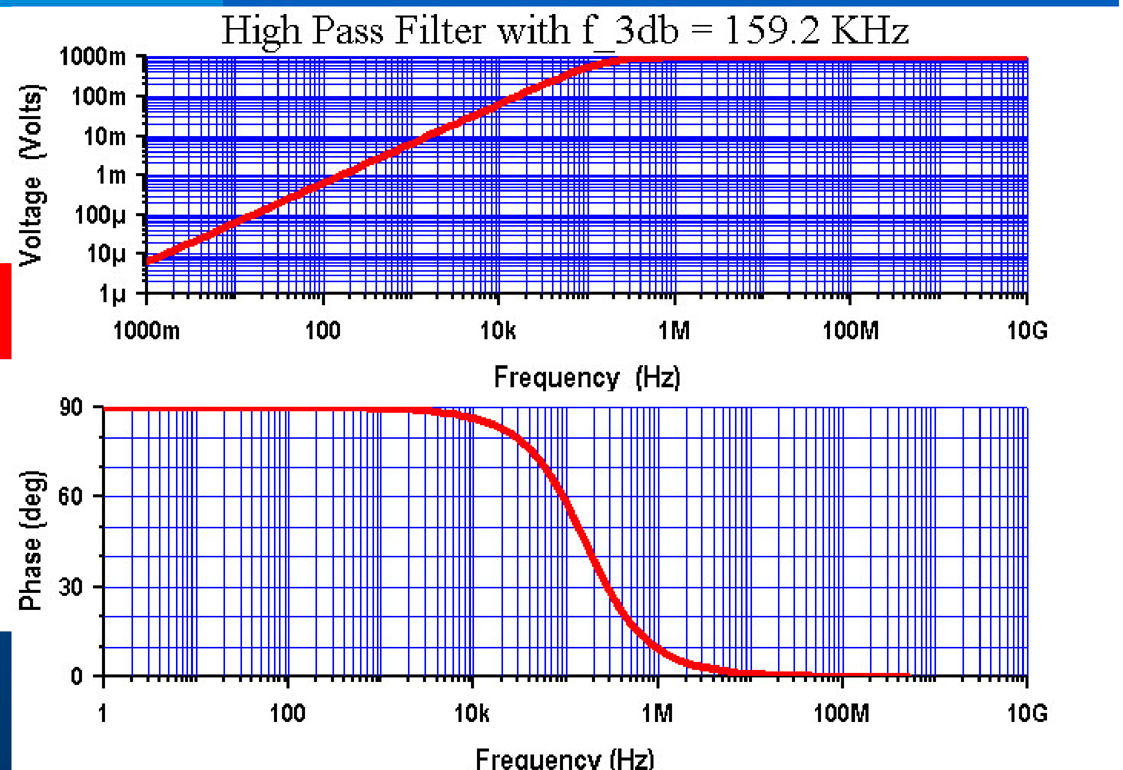
$A = | A | e^{i\varphi}$ and

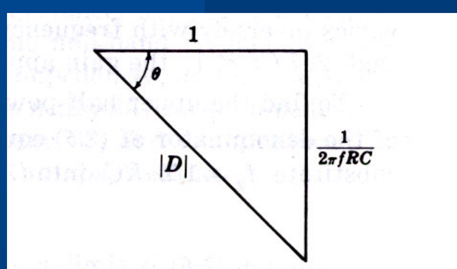
$|A| = 1/\sqrt{(1+ (f_0/f)^2)}$

$\tan\varphi = f_0/f$

# High Pass Filter II



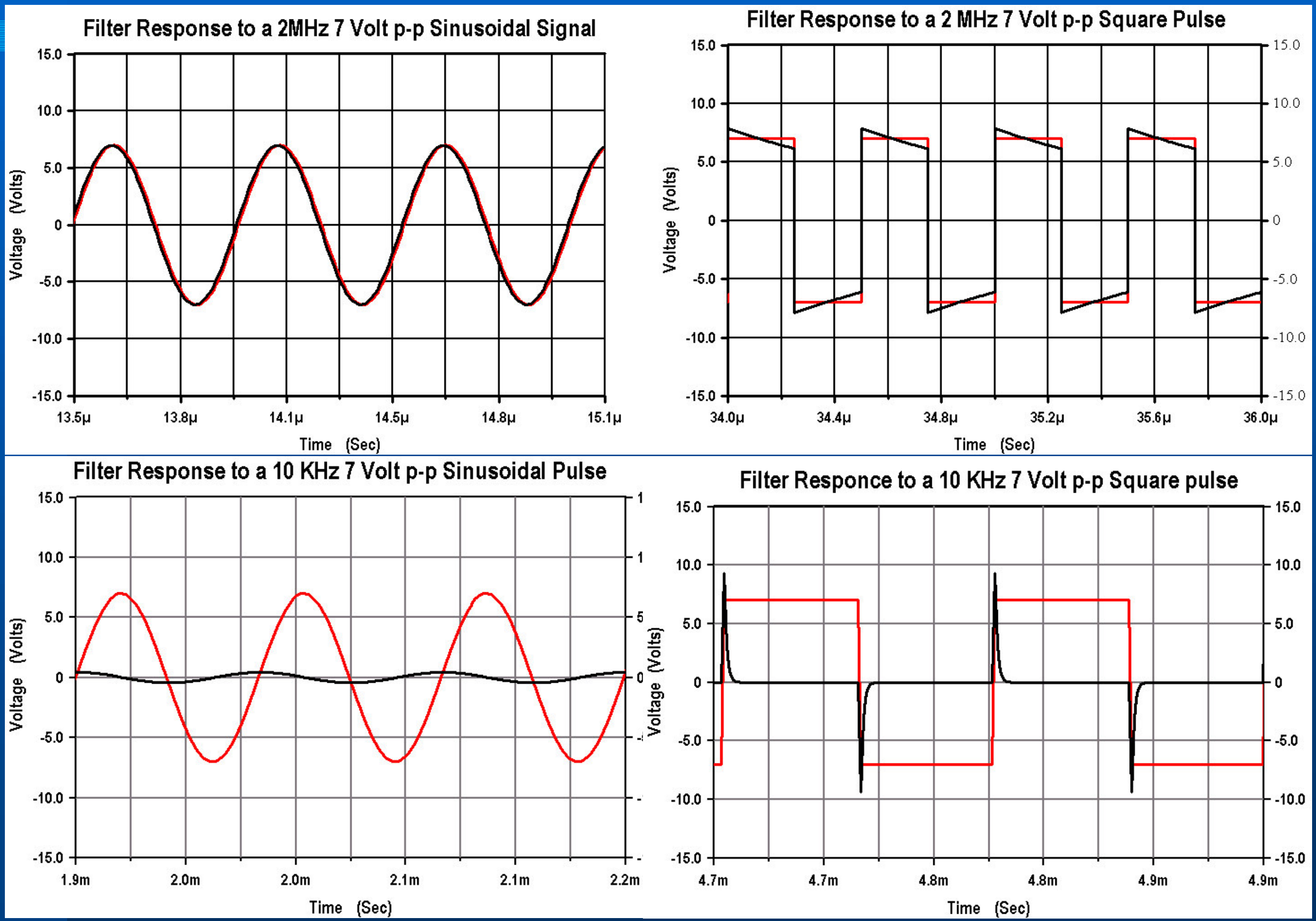




$A = |A|\ e^{i\varphi}$ and

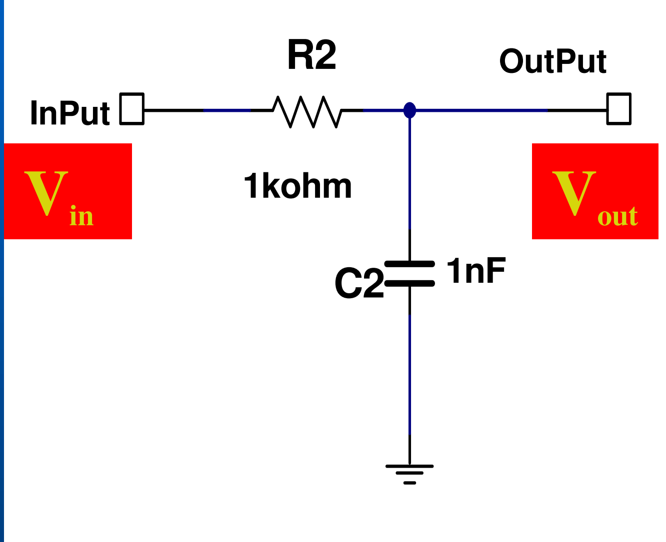
$|A| = 1/\sqrt{(1+(f_0/f)^2)}$

$\tan\varphi = f_0/f$

# High Pass Filter Response III



# Low Pass Filter I




$V_{in}$

$V_{out}$

$I = V_{in}/Z \quad Z = R - i/(\omega C)$

$I = V_{in} /(R - i/(\omega C)) \Rightarrow$

$V_{out} = V_{in} (-i/(\omega C))/( R - i/(\omega C)) \Rightarrow$

$A = V_{out} / V_{in} =$

$- i/(\omega C)/(R-i/(\omega C)) \Rightarrow$

$A = 1 / ( 1 + 2i\pi fRC) \Rightarrow$

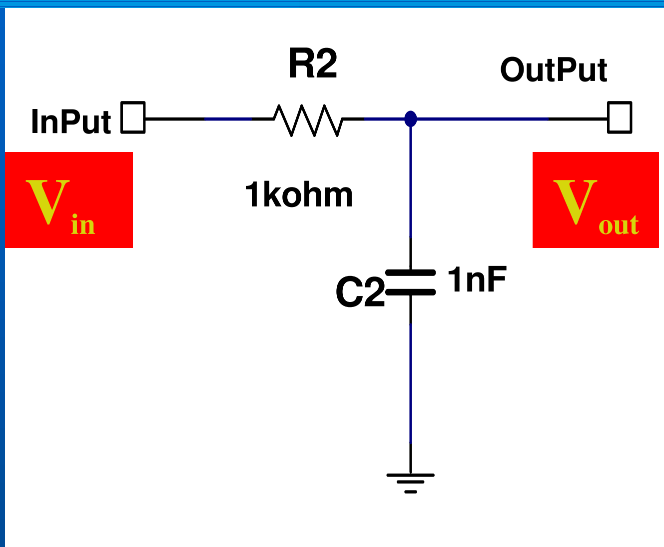
$A = 1 / ( 1 + if/f_0)$

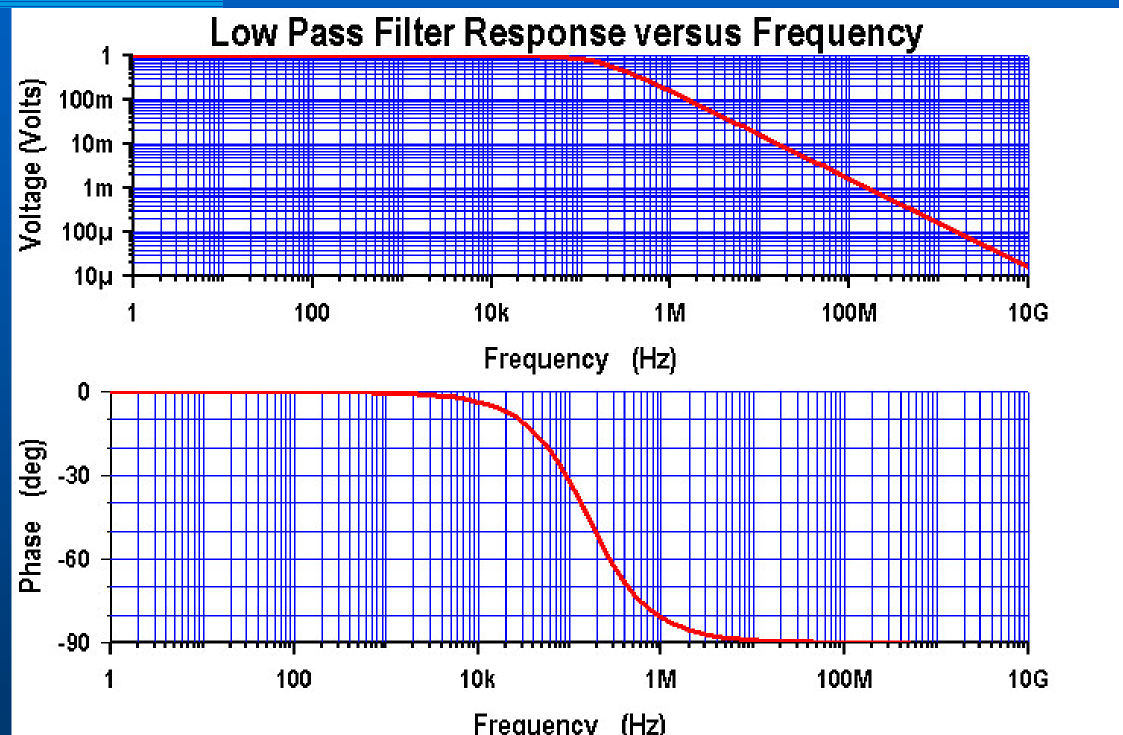
$A = | A | e^{i\varphi}$ **and**

$|A| = 1/\sqrt{(1+ (f/f_0)^2)}$

$\tan\varphi = -f/f_0$

# Low Pass Filter II



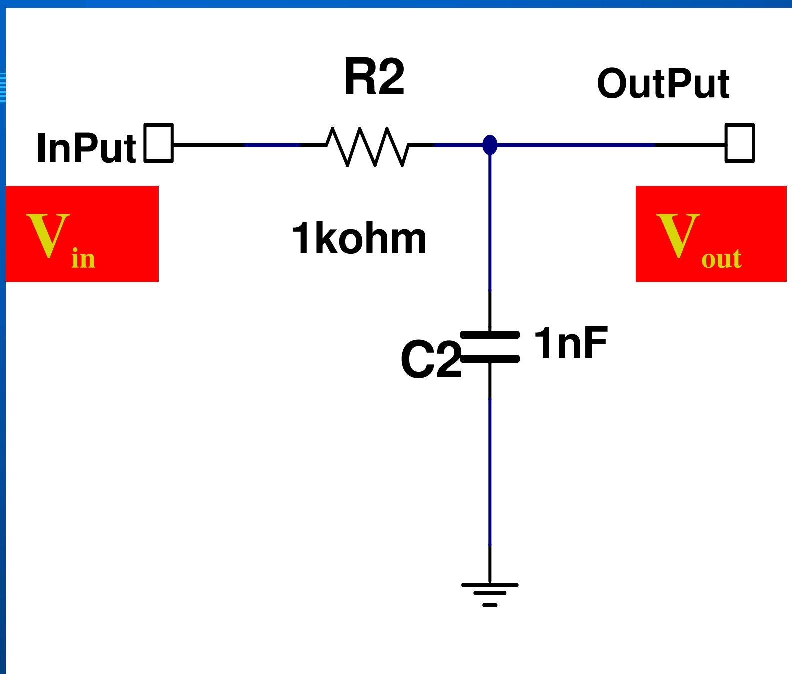



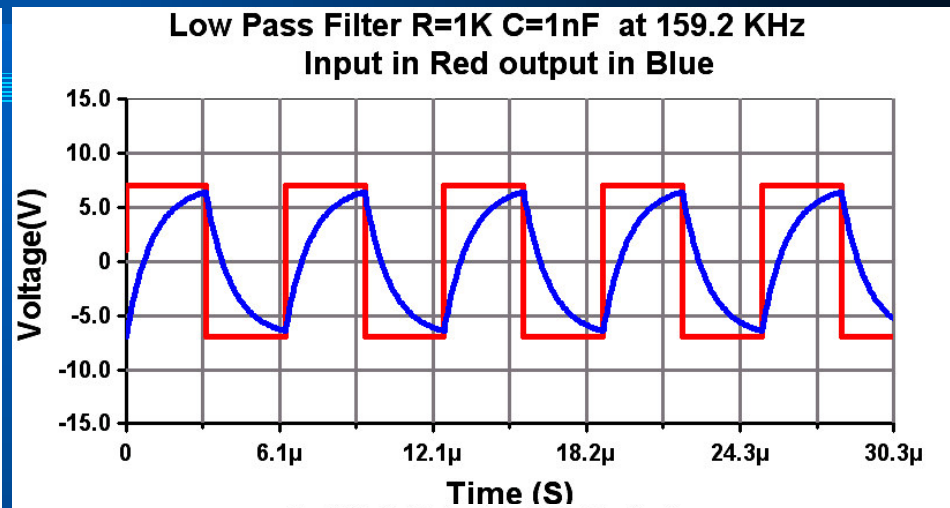

$A = |A|\, e^{i\varphi}$ and

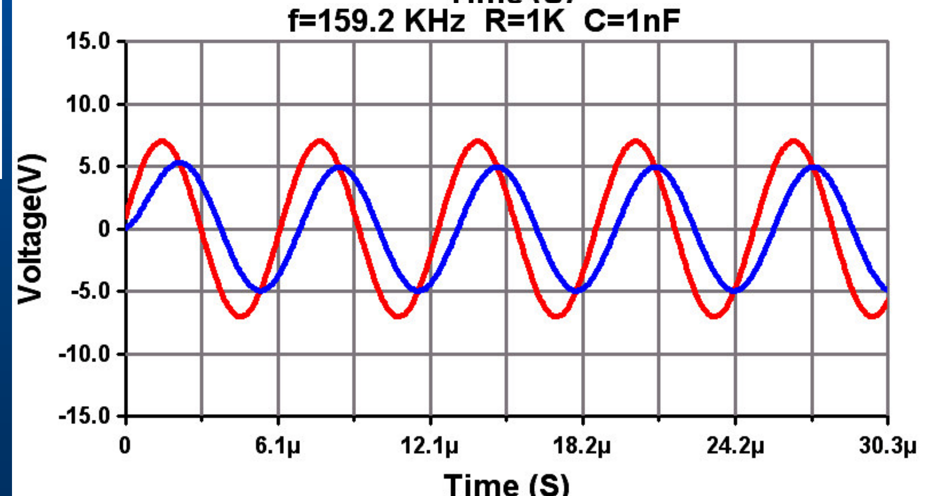
$|A| = 1/\sqrt{(1 + (f/f_0)^2)}$

$\tan\varphi = -f/f_0$

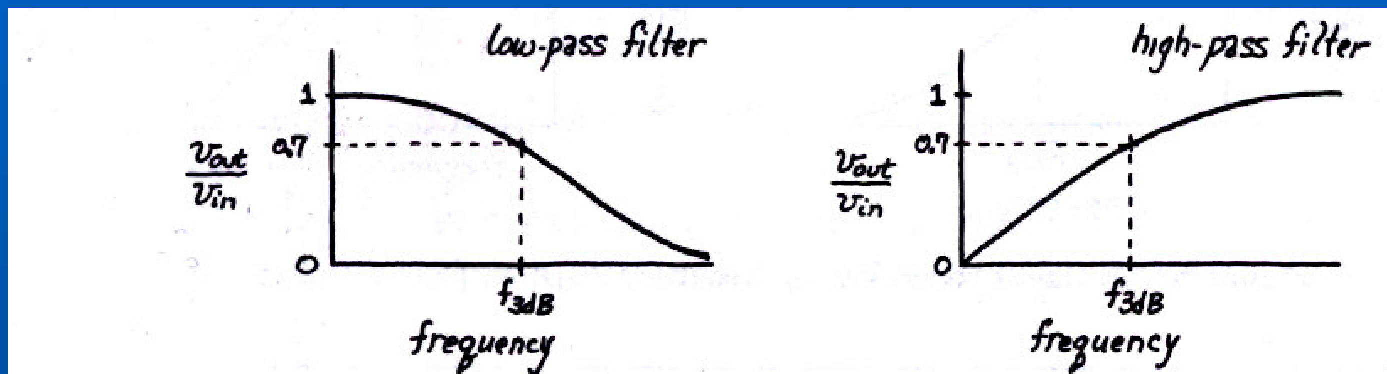
# Low Pass Filter Response III



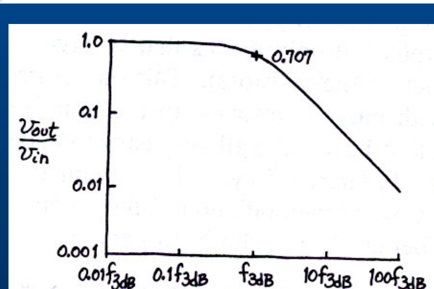



# $f_{3db}$ of a Filter




$$\boxed{f_{3dB} = 1/(2\pi RC)}$$



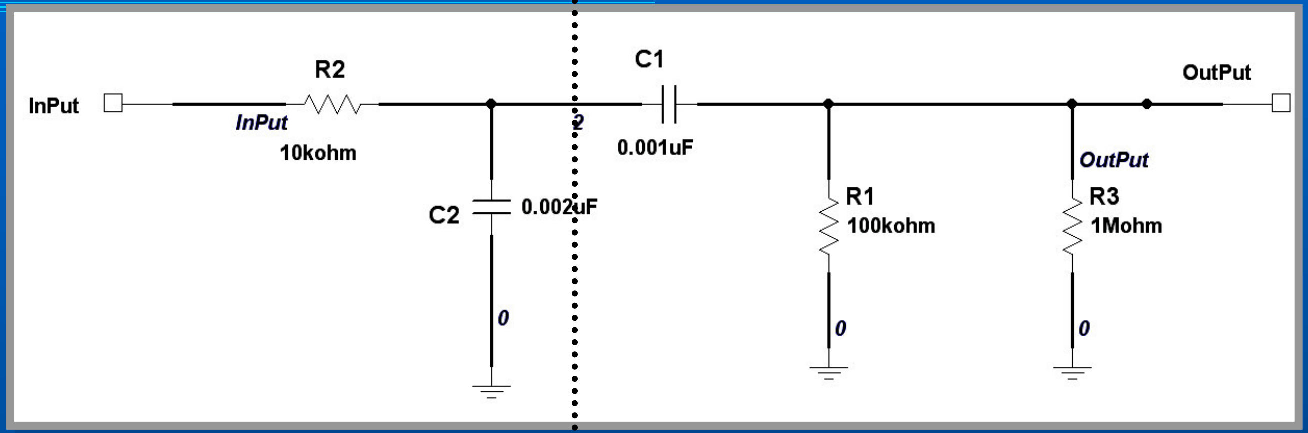

**$A = |A|\, e^{i\varphi}$ and**

**$|A| = 1/\sqrt{(1 + (f_0/f)^2)}$**

**$\tan\varphi = f_0/f$**

**If $f_0 = f$ then $|A| = 1/\sqrt{2} = 0.707$**

# Design a Band-Pass Filter for 1.6-8 KHz ; 1M Ω




Low Pass High Pass

Pick $R_1 = (1/10)\ 1\ M\Omega = 100\ K\Omega$
and $R_2 = (1/10)\ R_1 = 10\ K\Omega$

$$f_{3dB} = 1/(2\pi RC) \Rightarrow$$

C2=0.002 μ F
C1=0.001 μ F

# Band Pass Filter Response

- It cuts both high and low frequencies whilst it keep a predetermined range of frequencies: