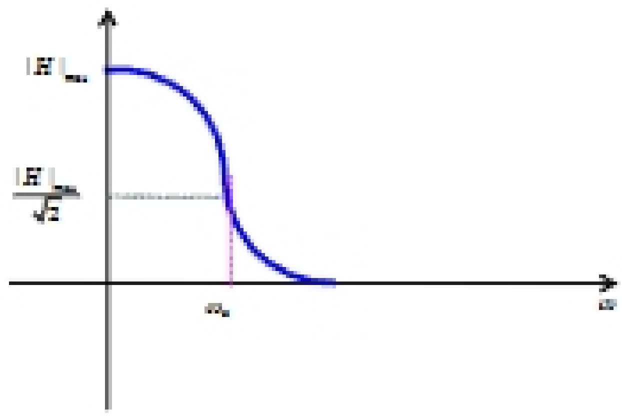
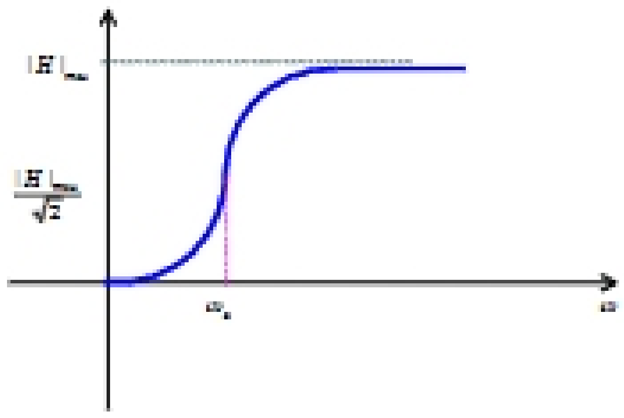
Low pass filters:

$$H(j\omega) = \frac{(k)\omega_o}{\omega_o + j\omega}$$



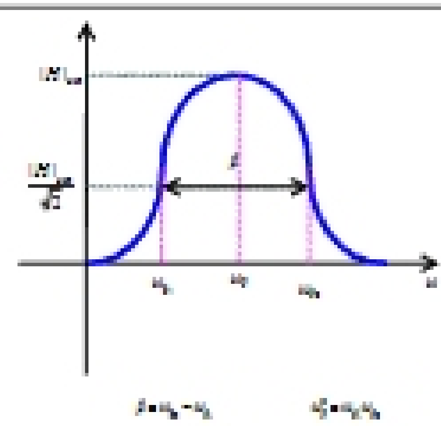
High pass filters:

$$H(j\omega) = \frac{j\omega(k)}{\omega_o + j\omega}$$



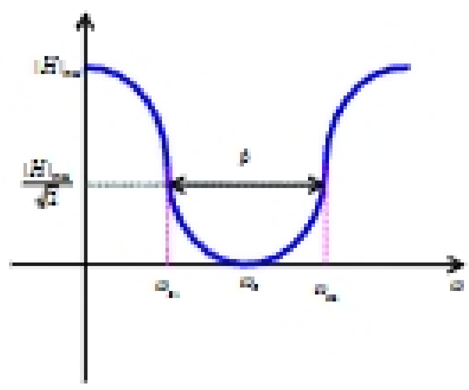
Band-Pass filter:

$$H(j\omega_o) = \frac{j\omega_o\beta(k)}{\left(\omega_o^2 - \omega_c^2\right) + j\omega_o\beta}$$



Band-reject filter:

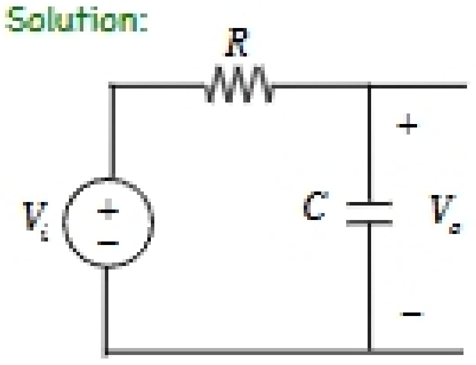
$$H(j\omega) = \frac{\left[\omega_o^2 - \omega^2\right](k)}{\left[\omega_o^2 - \omega^2\right] + j\left[\omega\beta\right]}$$

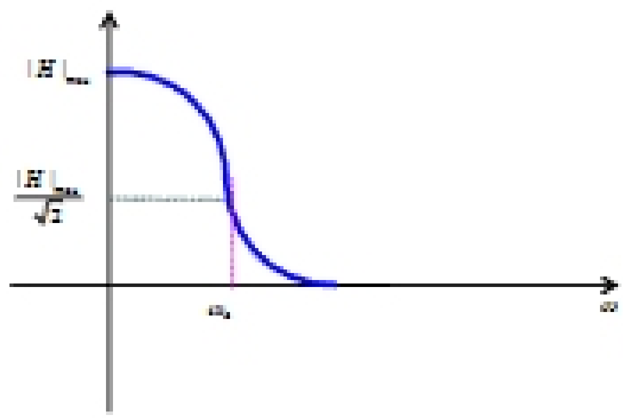


Design a low pass filter using a capacitor $C = 0.4\mu F$

With a cutoff frequency $\omega_c = 5k\ rad/s$

Solution:



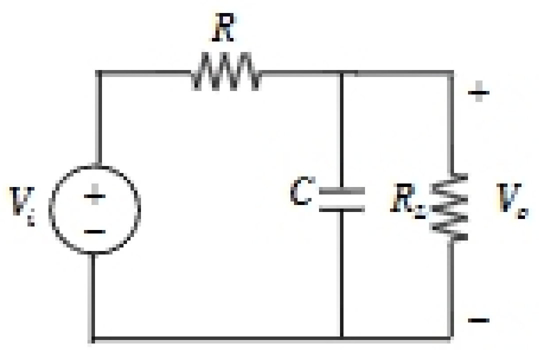


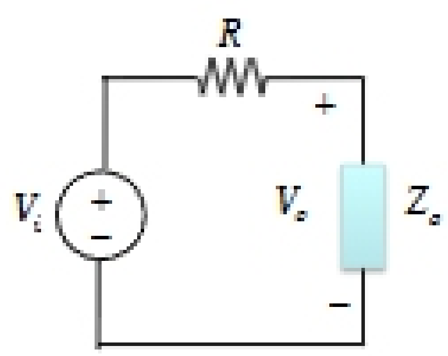
$$H = \frac{\frac{1}{j\omega C}}{R + \frac{1}{j\omega C}} \qquad H = \frac{1}{1 + j\omega RC} \qquad H = \frac{1/RC}{1/RC + j\omega} \qquad H = \frac{\omega_c}{\omega_c + j\omega}$$

$$\omega_c = \frac{1}{RC} \qquad 5k = \frac{1}{R(0.4\mu)} \qquad R = \frac{1}{(5k)(0.4\mu)} \qquad R = 500\Omega$$

Connect a resistive load to the filter $R_L = 100k\Omega$

Find the transfere function of the loaded filter.





$$Z_o = \frac{R_L\left(\frac{1}{j\omega C}\right)}{R_L + \left(\frac{1}{j\omega C}\right)}$$

$$Z_o = \frac{R_L}{1 + j\omega C R_L}$$

$$H = \frac{\frac{R_L}{1 + j\omega CR_L}}{R + \frac{R_L}{1 + j\omega CR_L}} \qquad H = \frac{R_L}{R(1 + j\omega CR_L) + R_L} \qquad H = \frac{R_L}{(R + R_L) + j\omega CRR_L}$$

$$H = \frac{R_L / CRR_L}{(R + R_L)/CRR_L + j\omega} \qquad H = \frac{1/CR}{(R + R_L)/CRR_L + j\omega} \qquad H = \frac{k}{\omega_c + j\omega}$$

$$\omega_c = \frac{R + R_L}{RR_L C} \qquad \omega_c = \frac{500 + 100}{(500)(100)(0.4\mu)} \qquad \omega_c = 30k\ r/s$$

Filter Circuits

* Passive Filters:

Using passive elements (Resistors, Inductors and Capacitors)

* Active Filters:

Using OP. AMPS

Advantages of active filters:

- Size
- Weight
- Gain control
- Loading effect is negligible

First order Low-Pass filter

Test:

$\omega = 0$ $\quad V_o = ?$

$\omega = \infty$ $\quad V_o = ?$