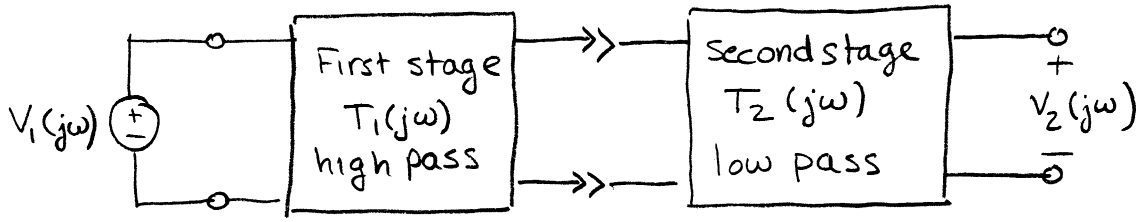
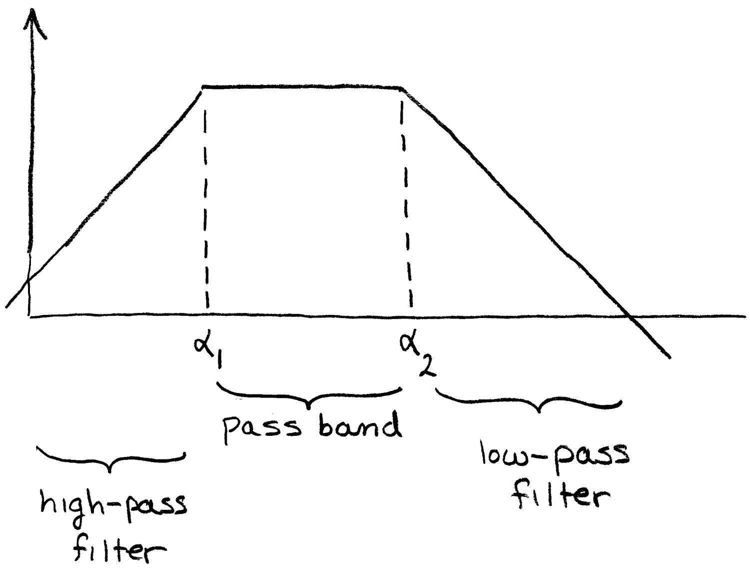
Bandpass and bandstop responses using first-order circuits

We can construct more complicated frequency responses by cascading filters.



$$T(j\omega) = T_1(j\omega) \times T_2(j\omega)$$

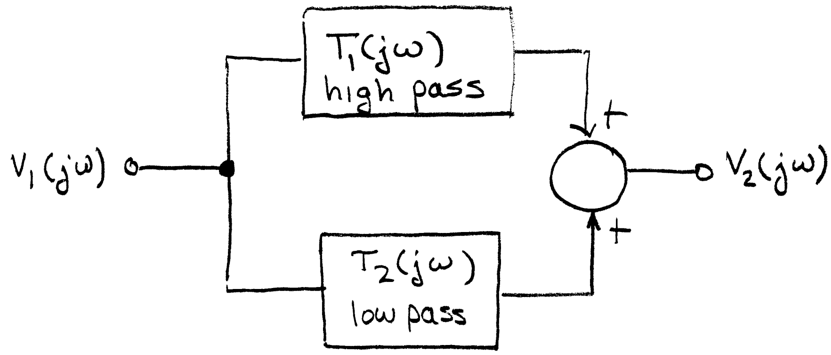
$$= \underbrace{\left(\frac{j\omega K_1}{j\omega + \alpha_1}\right)}_{\text{high pass}} \underbrace{\left(\frac{K_2}{j\omega + \alpha_2}\right)}_{\text{low pass}}$$



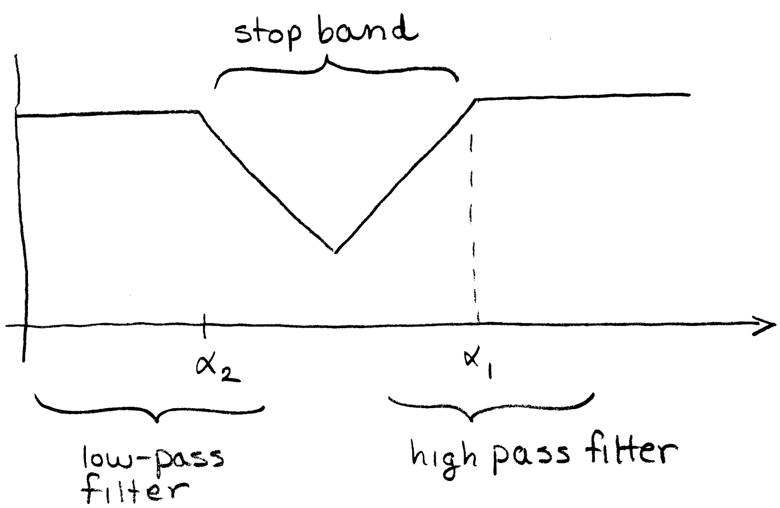
The secret is that the cutoff for the low pass filter must be larger that that for the high-pass filter

$$\alpha_2 > \alpha_1$$

We can also connect filters in parallel.



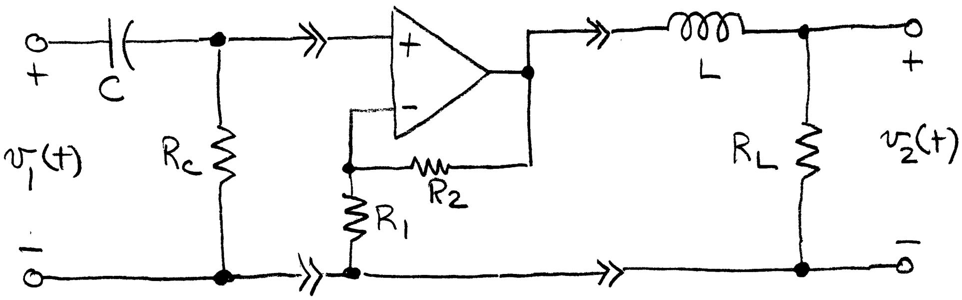
$$T(j\omega) = \underbrace{T_1(j\omega)}_{\text{high-pass}} + \underbrace{T_2(j\omega)}_{\text{low-pass}}$$



The secret here is that $\alpha_1 > \alpha_2$ so that both filters reject a range of frequencies — the stop band.

Design Example 12-7

Determine the transfer function $T(j\omega) = \dfrac{V_2(j\omega)}{V_1(j\omega)}$ of the circuit shown below.



This is a cascade collection of (a) a high-pass filter
(b) an amplifier (a gain section)
(c) a low-pass filter

This can be written as a product of the transfer functions

$$T(j\omega) = \frac{V_2(j\omega)}{V_1(j\omega)} = \underbrace{\left(\frac{R_L}{R_L + j\omega L}\right)}_{\text{low-pass}} \underbrace{\left(\frac{R_1 + R_2}{R_1}\right)}_{\text{gain}} \underbrace{\left(\frac{R_c}{R_c + \frac{1}{j\omega C}}\right)}_{\text{high-pass}}$$

$$T(j\omega) = \frac{1}{1 + j\omega L/R_L} \quad \frac{R_1 + R_2}{R_1} \quad \frac{j\omega R_c C}{1 + j\omega R_c C}$$

$$20\log|T(j\omega)| = 20\log\left|\frac{(R_1+R_2)}{R_1}\right| + 20\log|\omega R_c C| - 20\log\left|1 + j\omega\frac{L}{R_L}\right| - 20\log|1 + \omega R_c C|$$

You really can't plot this without knowing circuit values.

Use

$R_c C = \frac{1}{40\pi}$ $\qquad R_c = 100\,000$

$R_L/L = 40000\,\pi$

$R_1 = 200k \qquad R_2 = 90k \quad \Rightarrow \quad \frac{R_1 + R_2}{R_1} = 10$

$$T(j\omega) = 20\log_{10}|10| + 20\log\left|\frac{\omega}{40\pi}\right| - 20\log\left|1+j\frac{\omega}{40000\pi}\right| - 20\log\left|1+j\frac{\omega}{40\pi}\right|$$

$40\pi = 125.7$ $\quad$ $40000\pi = 125663$ $\quad$ $40\pi = 125.7$