Bandpass and bandstop responses using first-order circuits we can construct more complicated frequency responses by cascading filters.

\[ T(j\omega) = T_1(j\omega) \times T_2(j\omega) \]

\[ = \left( \frac{j\omega K_1}{j\omega + \alpha_1} \right) \left( \frac{K_2}{j\omega + \alpha_2} \right) \]

[Diagram showing frequency response with passband and stopband]

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

\[ \alpha_2 > \alpha_1 \]
We can also connect filters in parallel.

\[ T(j\omega) = T_1(j\omega) + T_2(j\omega) \]

high-pass  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 \( T(j\omega) = \frac{V_2(j\omega)}{V_1(j\omega)} \) of the circuit shown below.

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

This can be written as a product of the transfer functions:

\[
T(j\omega) = \frac{V_2(j\omega)}{V_1(j\omega)} = \left( \frac{R_L}{R_L + j\omega L} \right) \left( \frac{R_1 + R_2}{R_1} \right) \left( \frac{R_c}{R_c + \frac{1}{j\omega C}} \right)
\]

\[
T(j\omega) = \frac{1}{1 + j\omega \frac{L}{R_L}} \frac{R_1 + R_2}{R_1} \frac{j\omega R_c}{1 + j\omega R_c}
\]

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

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

Use:
\[ R_c = \frac{1}{40\pi} \quad R_c = 100,000 \]
\[ R_{L/L} = 40,000 \pi \]
\[ R_1 = 200k \quad R_2 = 90k \quad \Rightarrow \frac{R_1 + R_2}{R_1} = 10 \]
\[ T(j\omega) = 20 \log_{10} |10| + 20 \log \left| \frac{\omega}{40\pi} \right| - 20 \log \left| 1 + j \frac{\omega}{40000 \pi} \right| - 20 \log \left| 1 + j \frac{\omega}{40 \pi} \right| \]

\[ 40\pi = 125.7 \quad 40000\pi = 125663 \quad 40 \pi = 125.7 \]

+20 db from first term

slope reduced to zero by

-20 log \left| 1 + j \frac{\omega}{40 \pi} \right|

+20 db/decade from 20 log \left| \frac{\omega}{40 \pi} \right|

-20 db/decade from

-20 log \left| 1 + j \frac{\omega}{40000 \pi} \right|