EE 254

Electronic Instrumentation

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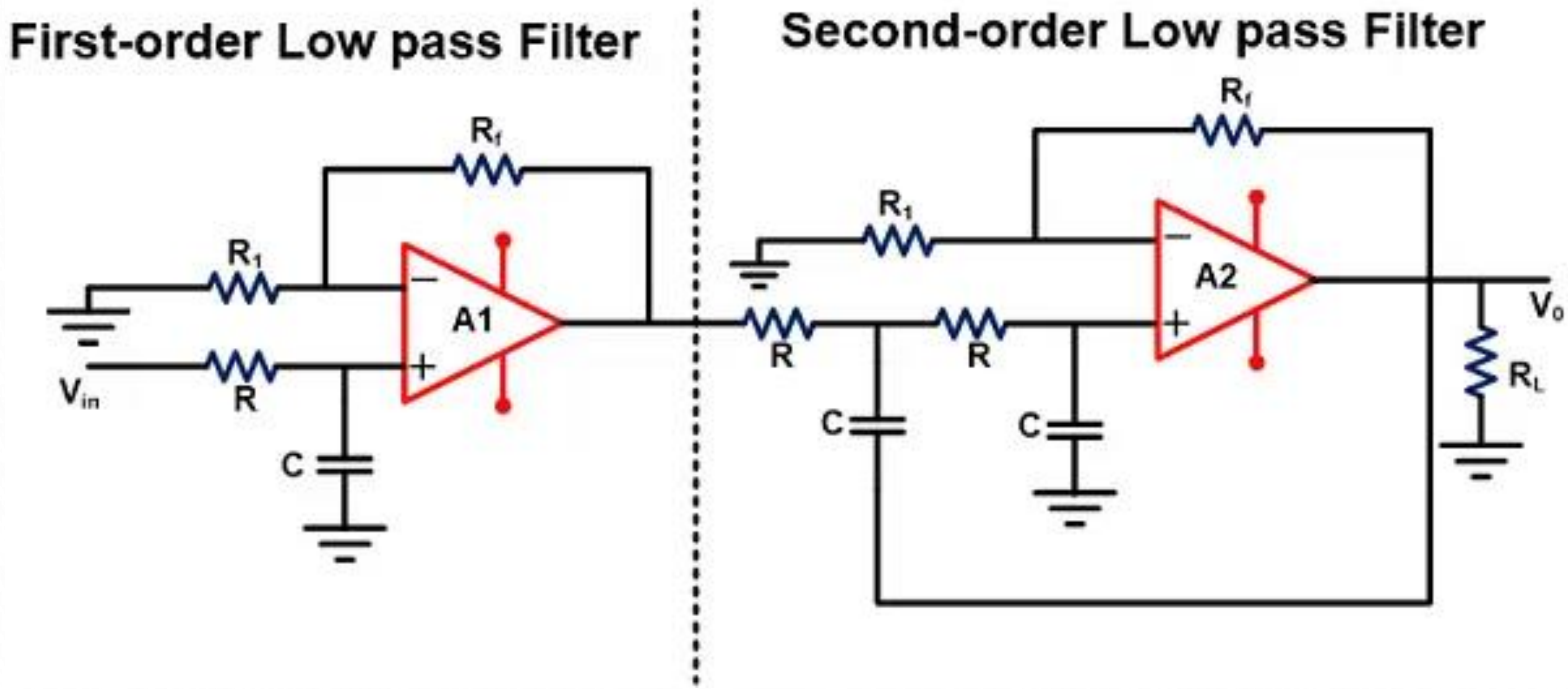
Lecture Note #08

Low-pass and High-Pass Filters

- More Examples -

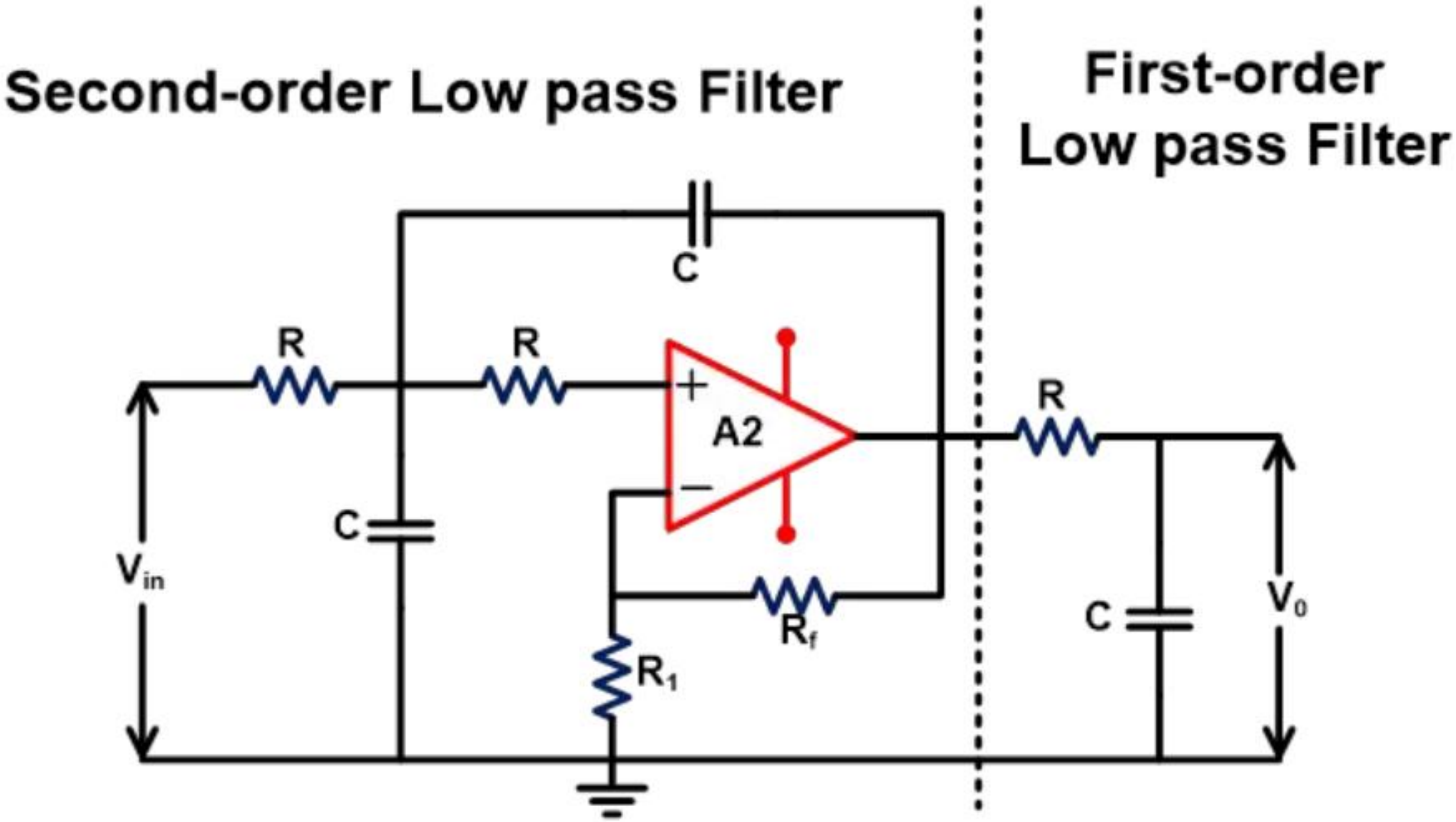
Third-Order Lowpass Butterworth Filter

- Third-order lowpass Butterworth filter can design by cascading the first-order and second-order Butterworth filter.
- The voltage gain of the first part is optional, and it can be set at any value.
- Then the third-order low pass filter can be expressed in different way.



Third-Order Lowpass Butterworth Filter

- Third-order Low Pass Butterworth Filter (with one OP-AMP)

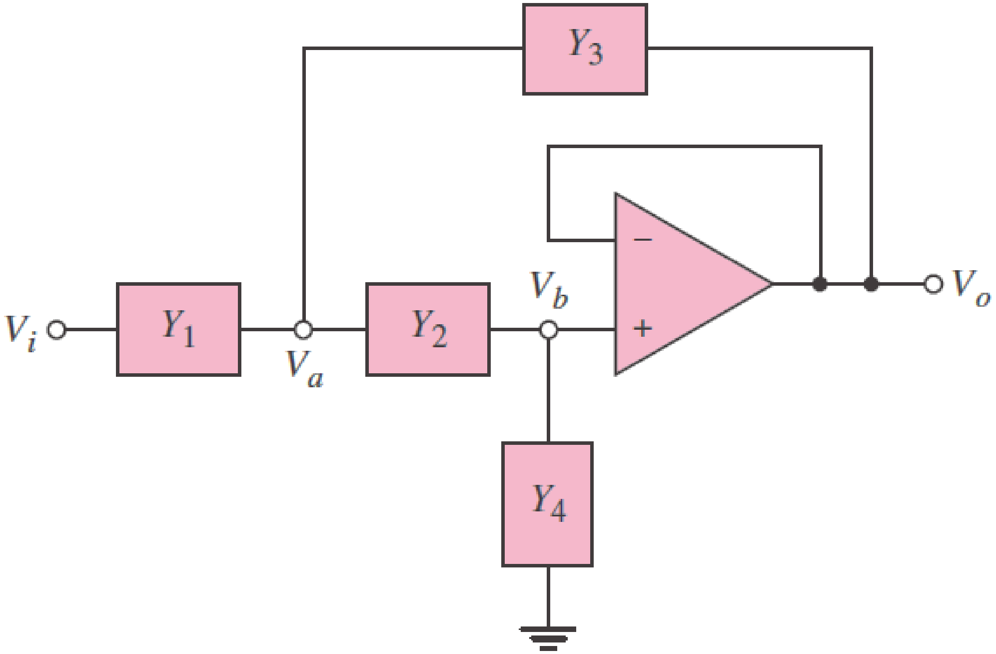


HW

What are the applications of Butterworth filter?

Example 05: Two-Pole High-Pass Butterworth Filter

Starting with the general transfer function given below, derive the relationship between R_1 and R_2 in the two-pole high-pass Butterworth active filter.



$$T(s) = \frac{V_o(s)}{V_i(s)} = \frac{Y_1 Y_2}{Y_1 Y_2 + Y_4(Y_1 + Y_2 + Y_3)}$$

Example 06: Low-Pass Butterworth Filter

A low-pass Butterworth filter is to be designed such that the magnitude of the voltage transfer function at $f = 1.2\, f_{3dB}$ is $14\, dB$ below the maximum gain value. Determine the required order of filter.

Example 07: High-Pass Butterworth Filter

A high-pass Butterworth filter is to be designed with a cutoff frequency of $f_{3dB} = 4\ kHz$. The gain magnitude is to be reduced by $12\ dB$ at $f = 3\ kHz$ from the maximum gain value. Determine the required order of filter.

Example 08: Low-Pass Butterworth Filter Design

A low-pass filter is to be designed to pass frequencies in the 0 to 12 kHz range. The gain of the amplifier is to be $+10$ at the low frequency and change by no more than 10 percent over the frequency range. In addition, the gain of the amplifier for frequencies greater than 14 kHz is to be no greater than 0.1. Determine f_{3dB} and the number of poles required in a Butterworth filter.