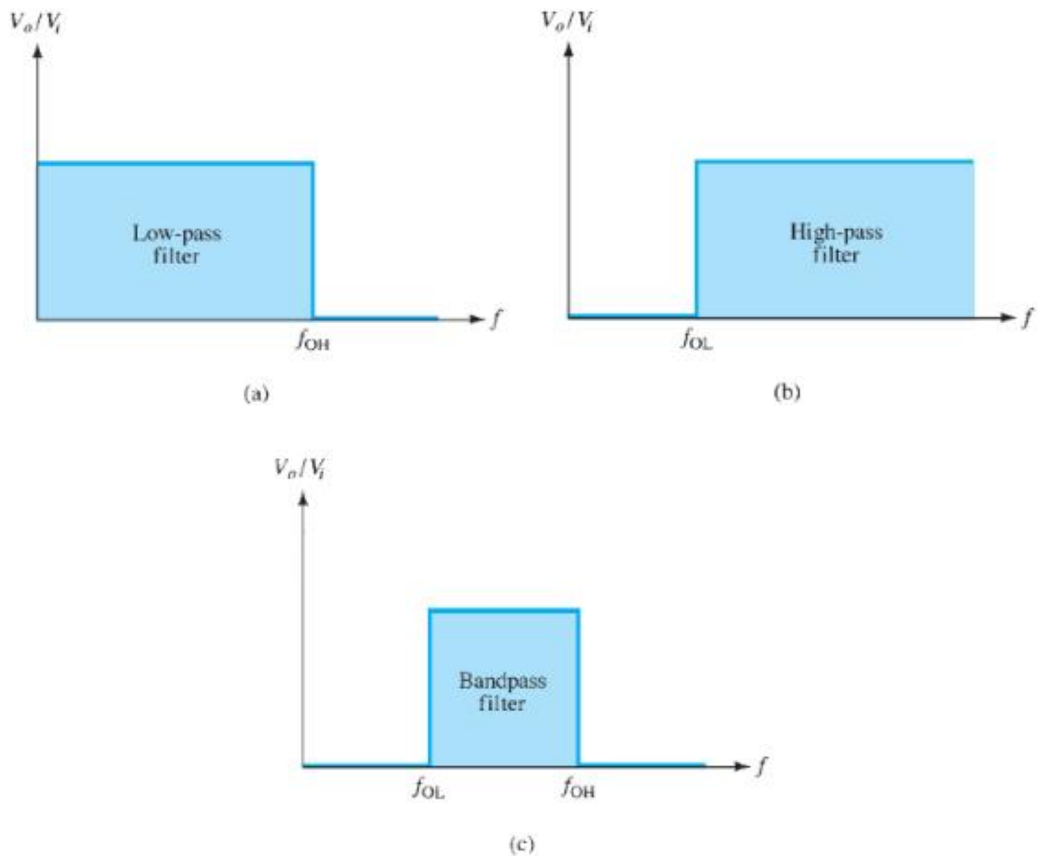
Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class: Three
Subject: Medical electronic system
Lecturer: Dr. zahraa hashim kareem
Lecture-6: active fillter

ACTIVE FILTERS

A popular application uses op-amps to build active filter circuits. A filter circuit can be constructed using passive components: resistors and capacitors. An active filter additionally uses an amplifier to provide voltage amplification and signal isolation or buffering.

A filter that provides a constant output from dc up to a cutoff frequency f_{OH} and then passes no signal above that frequency is called an ideal low-pass filter. The ideal response of a low-pass filter is shown in Fig. A filter that provides or passes signals above a cutoff frequency f_{OL} is a high-pass filter, as idealized in Fig. b. When the filter circuit passes signals that are above one ideal cutoff frequency and below a second cutoff frequency, it is called a bandpass filter, as idealized in Fig. c.



Email: zahraa.hashim@uomus.edu.iq

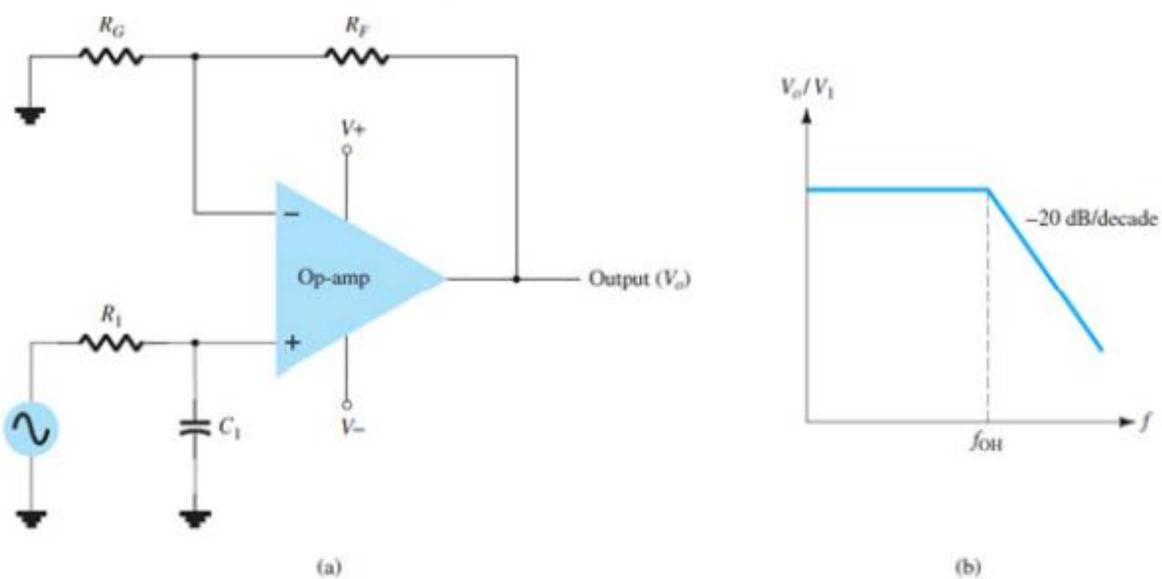
Low-Pass Filter

A first-order, low-pass filter using a single resistor and capacitor as in Fig. a has a practical slope of −20 dB per decade, as shown in Fig. b (rather than the ideal response of Fig. a). The voltage gain below the cutoff frequency is constant at

$$A_v = 1 + \frac{R_F}{R_G}$$

at a cutoff frequency of

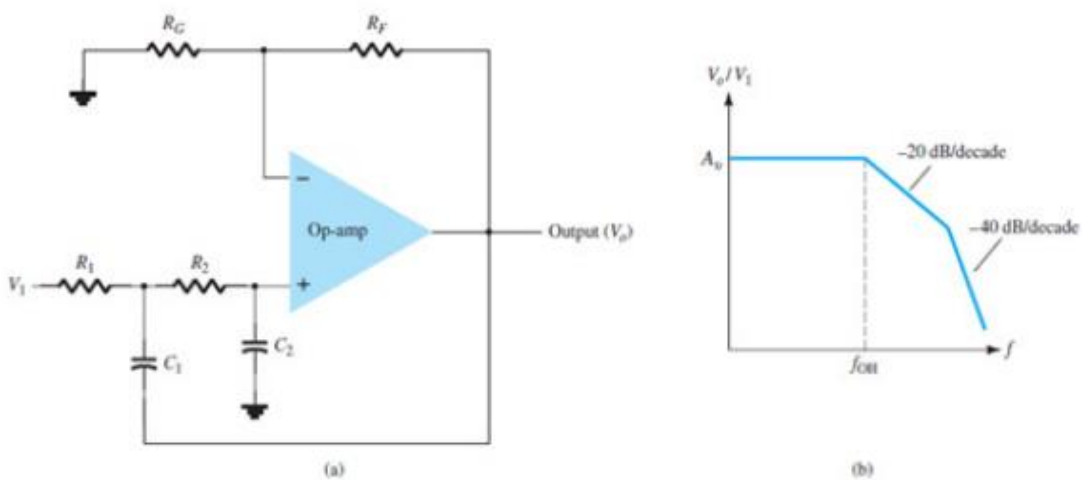
$$f_{OH} = \frac{1}{2\pi R_1 C_1}$$



First-order low-pass active filter.

Email: zahraa.hashim@uomus.edu.iq

Connecting two sections of filter as in Fig. results in a second-order low-pass filter with cutoff at −40 dB per decade—closer to the ideal characteristic of Fig. . The circuit voltage gain and the cutoff frequency are the same for the second-order circuit as for the first-order filter circuit, except that the filter response drops at a faster rate for a second-order filter circuit.



Second-order low-pass active filter.

EXAMPLE Calculate the cutoff frequency of a first-order low-pass filter for $R_1 = 1.2\,k\Omega$ and $C_1 = 0.02\,\mu F$.

Solution:

$$f_{OH} = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(1.2 \times 10^3)(0.02 \times 10^{-6})} = \mathbf{6.63\,kHz}$$

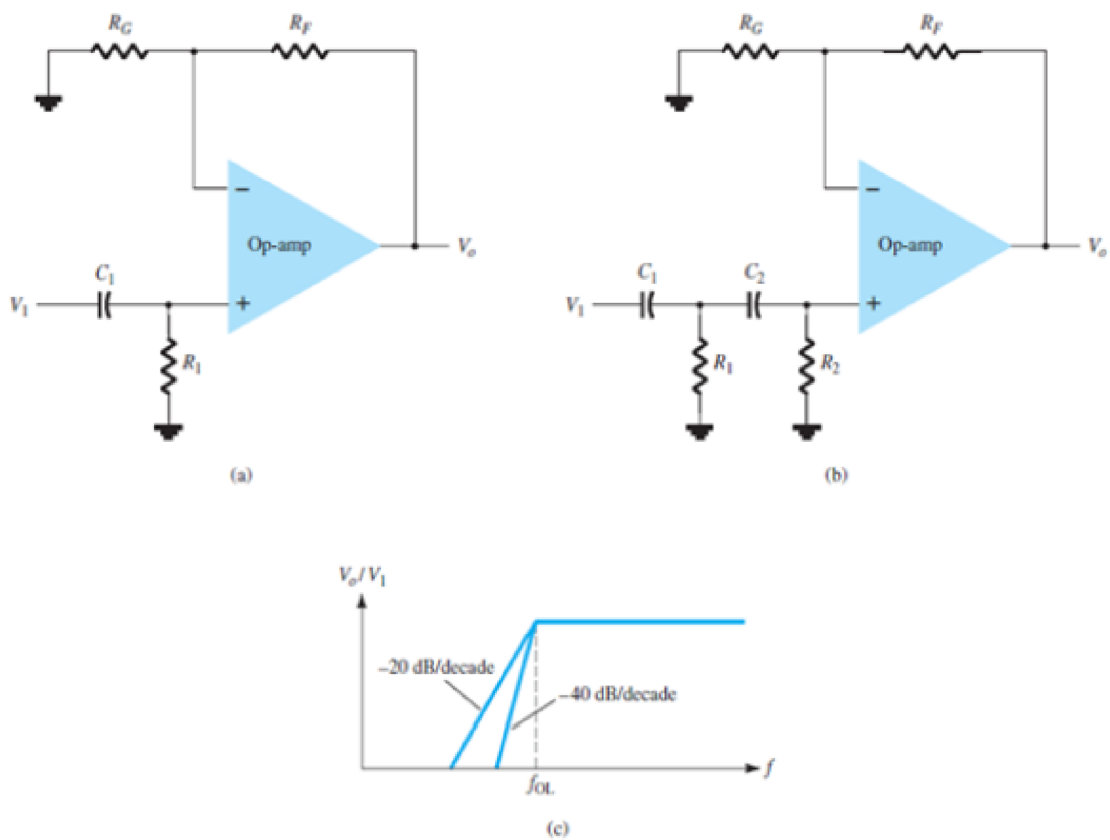
Email: zahraa.hashim@uomus.edu.iq

High-Pass Active Filter

First- and second-order high-pass active filters can be built as shown in Fig. . The amplifier gain is calculated using Eq. ( ). The amplifier cutoff frequency is

$$f_{OL} = \frac{1}{2\pi R_1 C_1}$$

with a second-order filter $R_1 = R_2$, and $C_1 = C_2$ results in the same cutoff frequency as in Eq. ( ).



High-pass filter: (a) first order; (b) second order; (c) response plot.

EXAMPLE Calculate the cutoff frequency of a second-order high-pass filter as in Fig. for $R_1 = R_2 = 2.1\ \text{k}\Omega$, $C_1 = C_2 = 0.05\ \mu\text{F}$, and $R_G = 10\ \text{k}\Omega$, $R_F = 50\ \text{k}\Omega$.

Solution:

$$A_v = 1 + \frac{R_F}{R_G} = 1 + \frac{50\ \text{k}\Omega}{10\ \text{k}\Omega} = 6$$

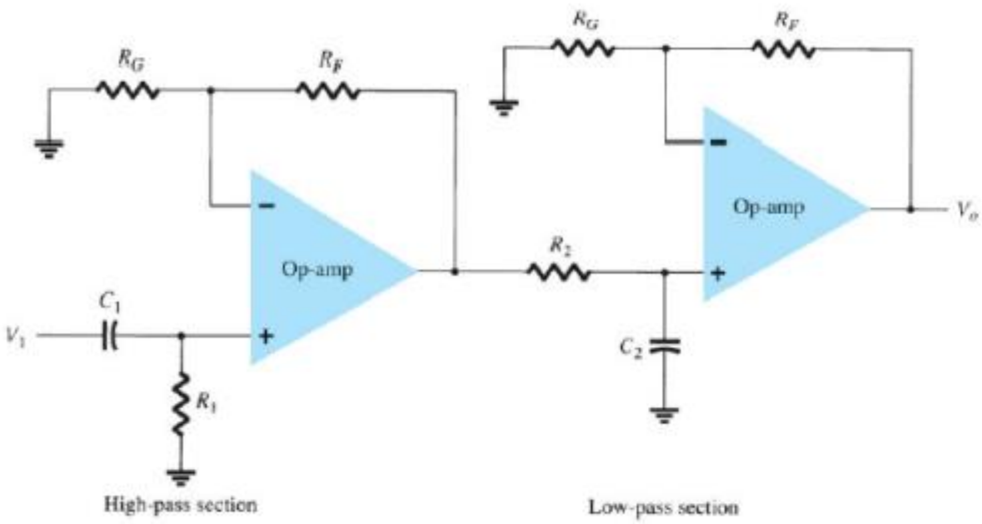
The cutoff frequency is then

$$f_{OL} = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(2.1 \times 10^3)(0.05 \times 10^{-6})} \approx \mathbf{1.5\ kHz}$$

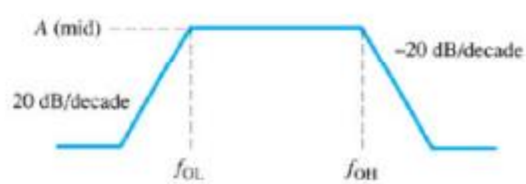
Email: zahraa.hashim@uomus.edu.iq

Bandpass Filter

Figure 11.34 shows a bandpass filter using two stages, the first a high-pass filter and the second a low-pass filter, the combined operation being the desired bandpass response.



(a)



(b)

EXAMPLE Calculate the cutoff frequencies of the bandpass filter circuit of Fig. with $R_1 = R_2 = 10\ \text{k}\Omega$, $C_1 = 0.1\ \mu\text{F}$, and $C_2 = 0.002\ \mu\text{F}$.

Solution:

$$f_{OL} = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi(10 \times 10^3)(0.1 \times 10^{-6})} = \mathbf{159.15\ Hz}$$

$$f_{OH} = \frac{1}{2\pi R_2 C_2} = \frac{1}{2\pi(10 \times 10^3)(0.002 \times 10^{-6})} = \mathbf{7.96\ kHz}$$