4. Passive Filters（无源滤波器）

A filter is a circuit that is designed to pass signals with desired frequencies and reject or attenuate others.

Passive filter：consists of only passive elements R, L and C.

Active filter：consists of active elements such as transistors and op amps in addition to passive elements.

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There are four types of filters whether passive or active:

1. A lowpass filter passes low frequencies and stops high frequencies.

2. A highpass filter passes high frequencies and rejects low frequencies.

3. A bandpass filter passes frequencies within a frequency band and blocks or attenuates frequencies outside the band.

4. A bandstop filter passes frequencies outside a frequency band and blocks or attenuates frequencies within the band.

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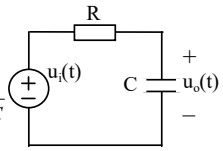
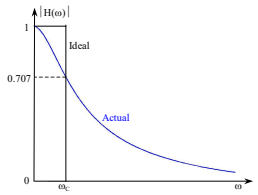
Lowpass filter (低通滤波器)

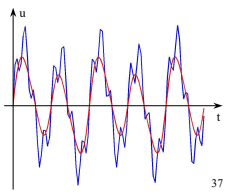
A lowpass filter is designed to pass only frequencies from dc up to the cutoff frequency ω_C.

ω_C: cutoff frequency $\omega_c = \dfrac{1}{RC}$

$$H(\omega) = \frac{U_o}{U_i} = \frac{1/j\omega C}{R + 1/j\omega C} = \frac{1}{1 + j\omega RC}$$







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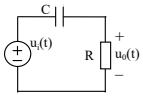
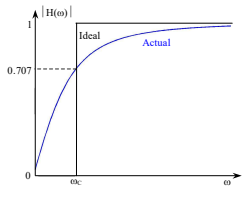
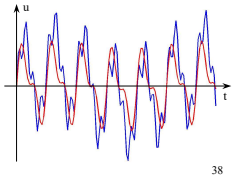
Highpass filter (高通滤波器)

A highpass filter is designed to pass all frequencies above its cutoff frequency ω_C.

$$H(\omega) = \frac{U_o}{U_i} = \frac{R}{R + 1/j\omega C} = \frac{j\omega RC}{1 + j\omega RC}$$







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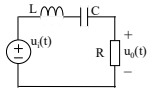
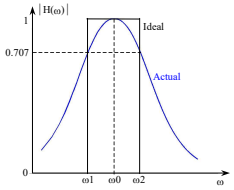
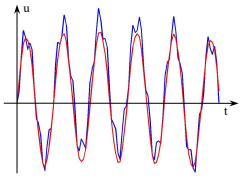
Bandpass filter (带通滤波器)

A bandpass filter is designed to pass all frequecncies within a band of frequencies, $\omega_1<\omega<\omega_2$.

$$H(\omega)=\frac{U_o}{U_i}=\frac{R}{R+j(\omega L-1/\omega C)} \qquad \omega_0=\frac{1}{\sqrt{RC}}$$







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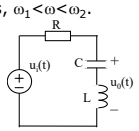
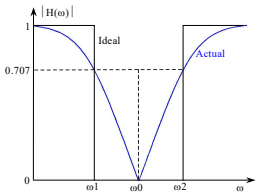
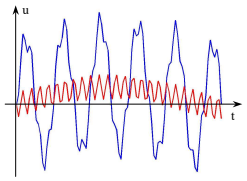
Bandstop filter (带阻滤波器)

A bandstop filter is designed to stop or eliminate all frequencies within a band of frequencies, $\omega_1<\omega<\omega_2$.

$$H(\omega)=\frac{U_o}{U_i}=\frac{j(\omega L-1/\omega C)}{R+j(\omega L-1/\omega C)}$$







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5 Active Filters（有源滤波器）

Three major limits to the passive filters:

1. **They cannot generate gain greater than 1;**
2. **They may require bulky and expensive inductors;**
3. **They perform poorly at frequencies below the audio frequency range(300Hz<f<3000Hz).**

Passive filters are useful at high frequencies.

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Three major advantages over the passive filters:

1. **They are often smaller and less expensive;**
2. **They can provide amplifier gain in addition to providing the same frequency response as RLC filters;**
3. **Active filters can be combined with voltage followers to isolate each stage of filters from source and load impedance effects. This isolation allows designing the stage independently and then cascading them to realize the desired transfer function.**

Active filters are less reliable and less stable. The practical limits of most active filters is about 100kHz.

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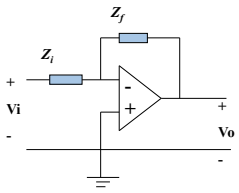

A general first-order active filters

Transfer function:

$$H(\omega)=\frac{V_o}{V_i}=-\frac{Z_f}{Z_i}$$

If $Z_i=R_i$, and

$$Z_f=R_f\left\|\frac{1}{j\omega C_f}\right.=\frac{R_f}{1+j\omega C_f R_f}$$

Therefore,

$$H(\omega)=-\frac{R_f}{R_i}\frac{1}{1+j\omega C_f R_f}$$

If $Z_i=R_i+1/j\omega C_i$, and $Z_f=R_f$,

$$H(\omega)=\frac{R_f}{R_i+1/j\omega C_i}=-\frac{j\omega C_i R_f}{1+j\omega C_i R_i}$$

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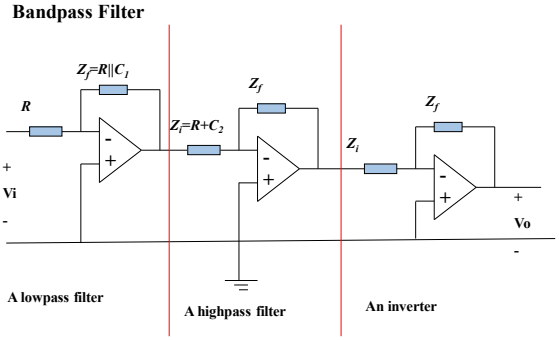
Bandpass Filter



$$H(\omega)=(-\frac{1}{1+j\omega C_1 R})(-\frac{j\omega C_2 R}{1+j\omega C_2 R})(-\frac{R_f}{R_i})$$

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Summary

（1）Definition of Resonance;

（2）Characteristics at Resonance;

（3）Calculation of Resonant frequency;

（4）Calculation of Resonant circuits;

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