EEE201
Circuit Analysis II

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

Introduction to Frequency Selective Circuits

EEE201 Circuit Analysis II

Lecture 13

Agenda

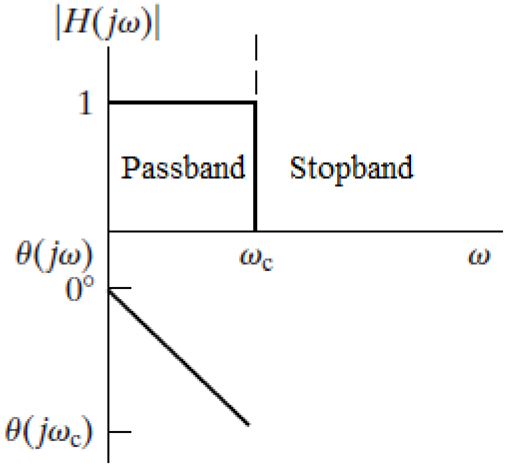
- Concept of Frequency-Selective Circuits
- Low-Pass Filters (LPFs)
- High-Pass Filters (HPFs)

Concept of Frequency-Selective Circuits

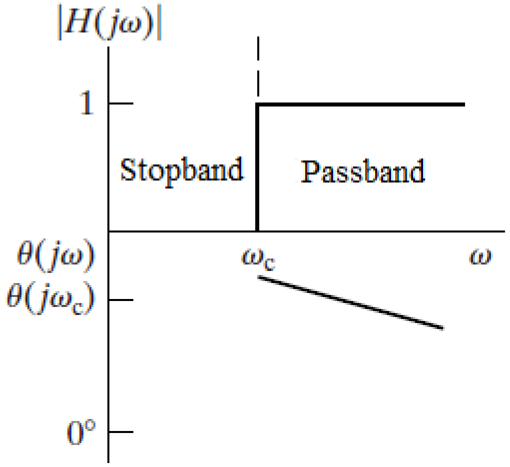
Frequency-selective circuits are also called **filters**. Their ability is to filter out certain input signals on the basis of frequency:

- Passband
- Stopband
- Frequency response plot: Magnitude plot and phase angle plot
- Cut-off frequency

Concept of Frequency-Selective Circuits

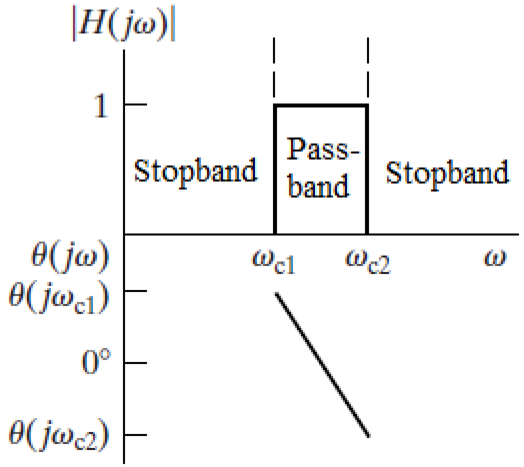


Ideal low-pass filter

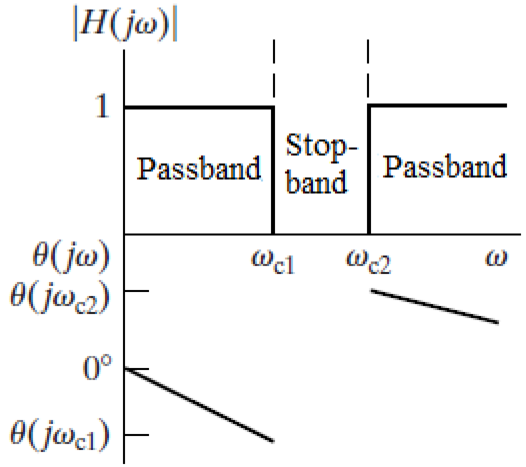


Ideal high-pass filter

Concept of Frequency-Selective Circuits



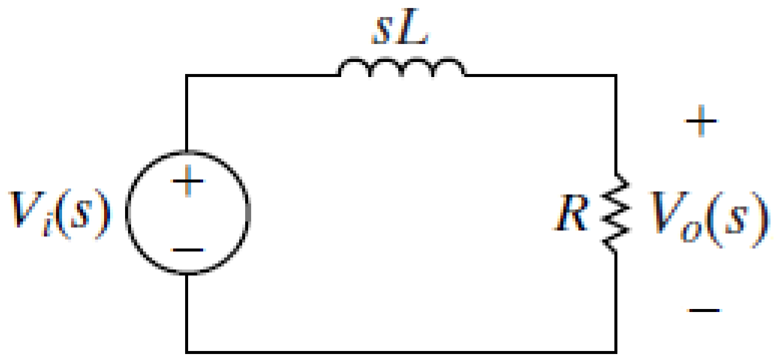
Ideal bandpass filter



Ideal bandreject filter

Low-Pass Filters: The Series RL Circuit

Voltage transfer function:



$$H(s) = \frac{R/L}{s+R/L}$$

Let's make the substitution $s = jw$,

$$H(jw) = \frac{R/L}{jw+R/L}$$

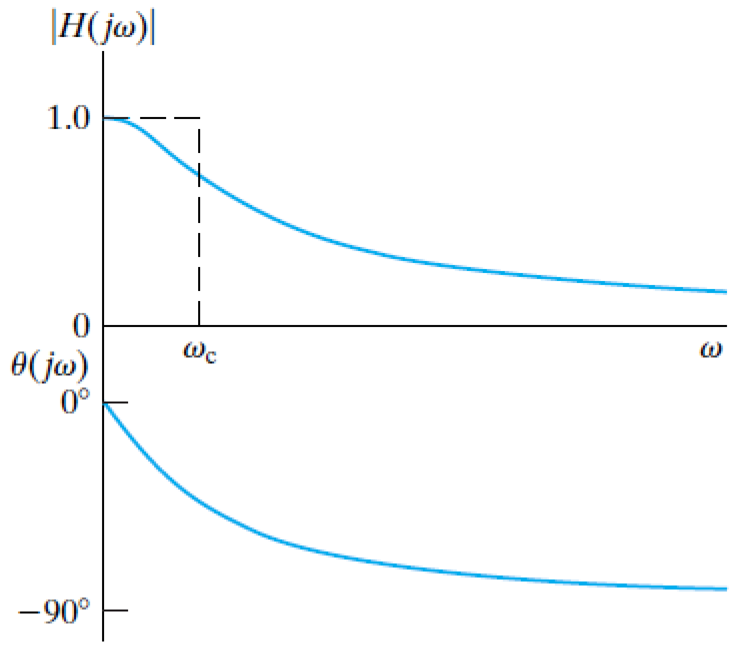
Low-Pass Filters: The Series RL Circuit

Transfer function magnitude:

$$|H(jw)| = \frac{R/L}{\sqrt{w^2+(R/L)^2}}$$

Transfer function phase angle:

$$\theta(jw) = -\tan^{-1}\left(\frac{wL}{R}\right)$$



Low-Pass Filters: The Series RL Circuit

Let's define the cut-off frequency,

$$|H(jw_c)| = \frac{1}{\sqrt{2}} H_{max}$$

w_c is also called the half-power frequency,

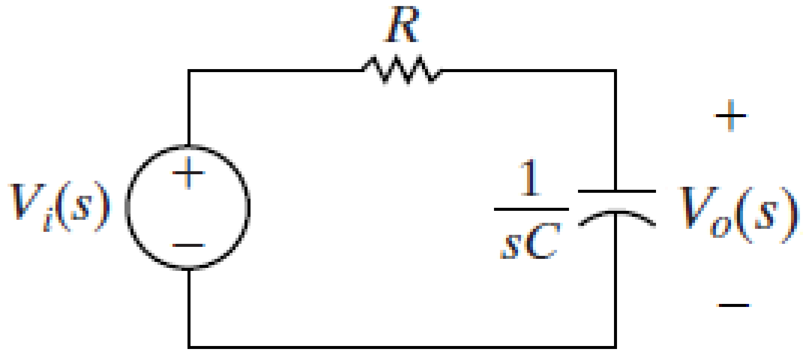
$$P(jw_c) = \frac{P_{max}}{2}$$

For RL filters,

$$|H(jw_c)| = \frac{1}{\sqrt{2}}|1| = \frac{R/L}{\sqrt{w_c^2 + (R/L)^2}} \rightarrow \; w_c = \frac{R}{L}$$

Low-Pass Filters: The Series RC Circuit

Voltage transfer function:



$$H(s) = \frac{\frac{1}{RC}}{s+\frac{1}{RC}}$$

Let's make the substitution $s = jw$,

$$H(jw) = \frac{\frac{1}{RC}}{jw+\frac{1}{RC}}$$

Low-Pass Filters: The Series RC Circuit

Transfer function magnitude:

$$|H(jw)| = \frac{\frac{1}{RC}}{\sqrt{w^2+\left(\frac{1}{RC}\right)^2}}$$

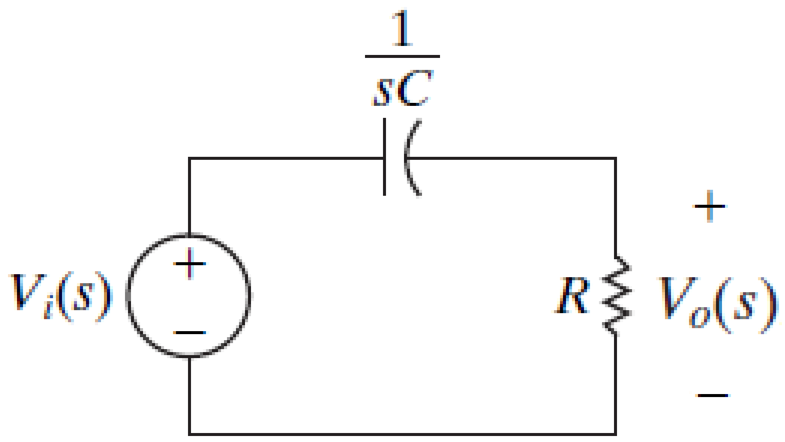
Cut-off frequency:

$$|H(jw_c)| = \frac{1}{\sqrt{2}}|1| = \frac{\frac{1}{RC}}{\sqrt{w_c^2+\left(\frac{1}{RC}\right)^2}} \rightarrow \; w_c = \frac{1}{RC}$$

High-Pass Filters: The Series RC Circuit

Voltage transfer function:

$$H(s) = \frac{s}{s+\frac{1}{RC}}$$



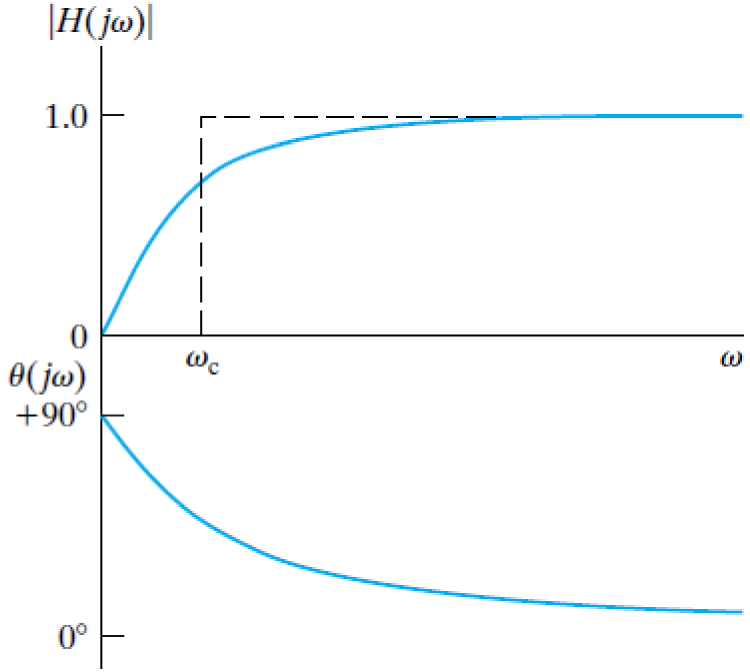
Let's make the substitution $s = jw$,

$$H(jw) = \frac{jw}{jw+\frac{1}{RC}}$$

High-Pass Filters: The Series RC Circuit

Transfer function magnitude:

$$|H(jw)| = \frac{w}{\sqrt{w^2+\left(\frac{1}{RC}\right)^2}}$$



Transfer function phase angle:

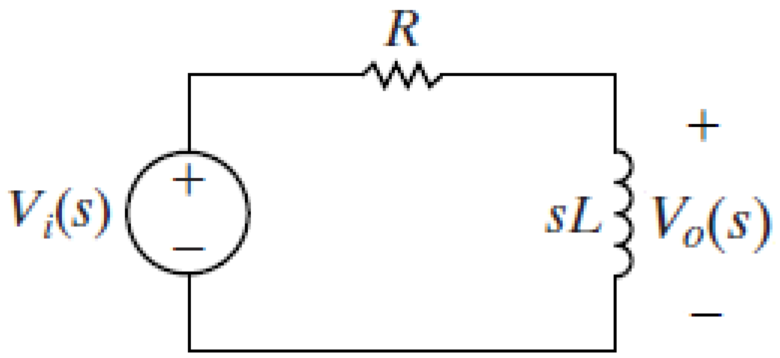
$$\theta(jw) = 90° - \tan^{-1}(wRC)$$

Cut-off frequency:

$$|H(jw_c)| = \frac{1}{\sqrt{2}}|1| = \frac{w_c}{\sqrt{w_c^2+\left(\frac{1}{RC}\right)^2}} \rightarrow \; w_c = \frac{1}{RC}$$

High-Pass Filters: The Series RL Circuit

Voltage transfer function:



$$H(s) = \frac{s}{s + R/L}$$

Let's make the substitution $s = jw$,

$$H(jw) = \frac{jw}{jw + R/L}$$

High-Pass Filters: The Series RL Circuit

Transfer function magnitude:

$$|H(jw)| = \frac{w}{\sqrt{w^2+(R/L)^2}}$$

Cut-off frequency:

$$|H(jw_c)| = \frac{1}{\sqrt{2}}|1| = \frac{w_c}{\sqrt{w_c^2+(R/L)^2}} \rightarrow \; w_c = \frac{R}{L}$$

Reference

- Electric Circuits, Tenth Edition, James W. Nilsson, Susan A. Riedel Pearson, 2015