EEE201
Circuit Analysis II

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

Introduction to Frequency Selective Circuits

EEE201 Circuit Analysis II

Lecture 14

Agenda

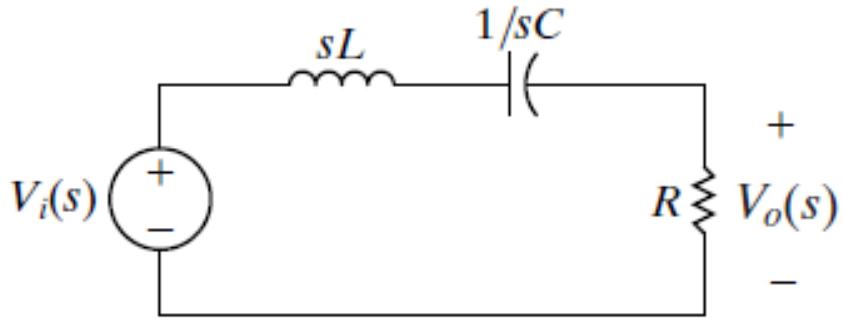
- Bandpass Filters (BPFs)
- Bandreject Filters (BRFs)

Bandpass Filters and Bandreject Filters

- Center frequency, w_o
- Bandwidth, β
- Quality factor, Q

Bandpass Filters: The Series RLC Circuit

Voltage transfer function:



$$H(s) = \frac{(R/L)s}{s^2+(R/L)s+\left(\frac{1}{LC}\right)}$$

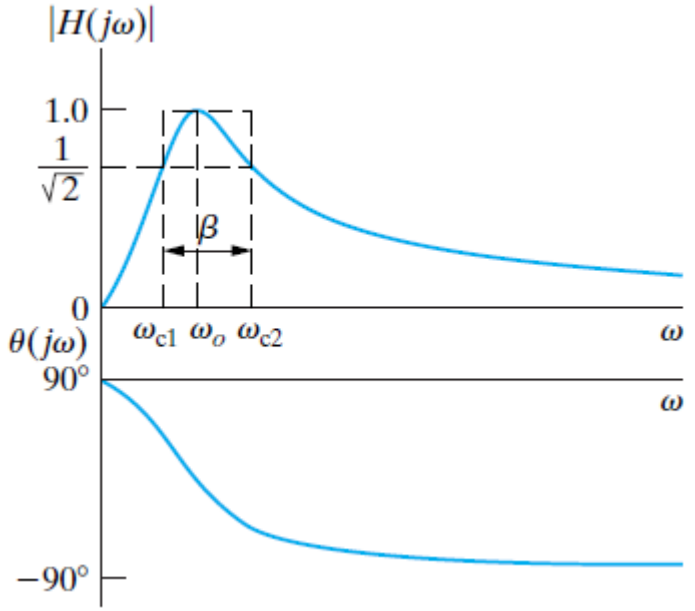
Let's make the substitution $s = jw$,

$$H(jw) = \frac{(R/L)(jw)}{(jw)^2+(R/L)(jw)+\left(\frac{1}{LC}\right)}$$

Bandpass Filters: The Series RLC Circuit

Transfer function magnitude:

$$|H(jw)| = \frac{w(R/L)}{\sqrt{\left[\left(\frac{1}{LC}\right) - w^2\right]^2 + [w(R/L)]^2}}$$



Transfer function phase angle:

$$\theta(jw) = 90° - \tan^{-1}\left[\frac{w(R/L)}{\left(\frac{1}{LC}\right) - w^2}\right]$$

Bandpass Filters: The Series RLC Circuit

$$jw_oL + \frac{1}{jw_oC} = 0 \rightarrow \; w_o = \sqrt{\frac{1}{LC}} = \sqrt{\boldsymbol{w_{c1} \cdot w_{c2}}}$$

$$|H(jw_c)| = \frac{1}{\sqrt{2}}|1| = \frac{w_c(R/L)}{\sqrt{\left[\left(\frac{1}{LC}\right) - w_c^2\right]^2 + [w_c(R/L)]^2}} \rightarrow$$

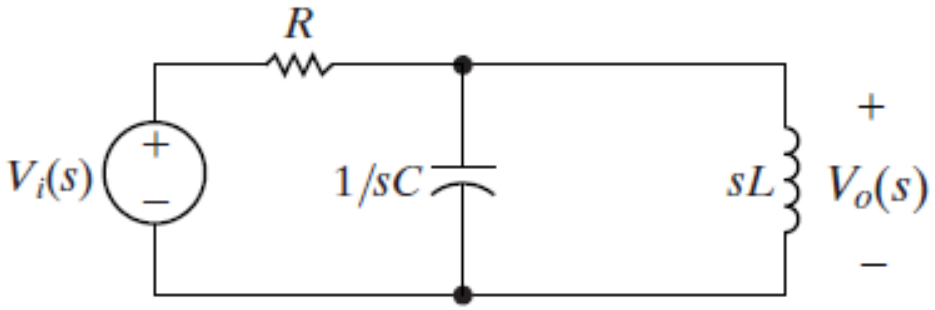
$$w_{c1} = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \left(\frac{1}{LC}\right)} \qquad w_{c2} = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \left(\frac{1}{LC}\right)}$$

Bandpass Filters: The Series RLC Circuit

$$\beta = \boldsymbol{w_{c2}} - \boldsymbol{w_{c1}} = \frac{R}{L}$$

$$Q = \frac{\boldsymbol{w_o}}{\boldsymbol{\beta}} = \sqrt{\frac{L}{CR^2}}$$

Bandpass Filters: The Parallel RLC Circuit



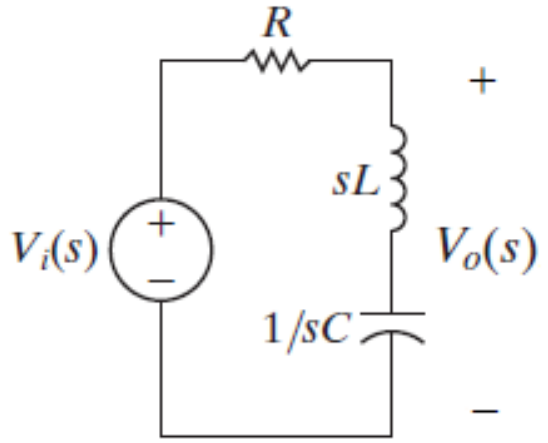
Voltage transfer function:

$$H(s) = \frac{\frac{s}{RC}}{s^2 + \frac{s}{RC} + \frac{1}{LC}}$$

Bandreject Filters: The Series RLC Circuit

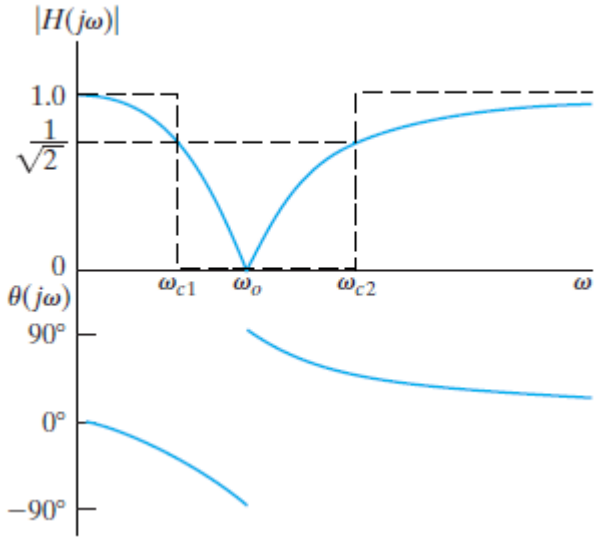
Voltage transfer function:

$$H(s) = \frac{s^2 + \frac{1}{LC}}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$



Transfer function magnitude:

$$|H(jw)| = \frac{\left|\frac{1}{LC} - w^2\right|}{\sqrt{\left[\left(\frac{1}{LC}\right) - w^2\right]^2 + [w(R/L)]^2}}$$



Transfer function phase angle:

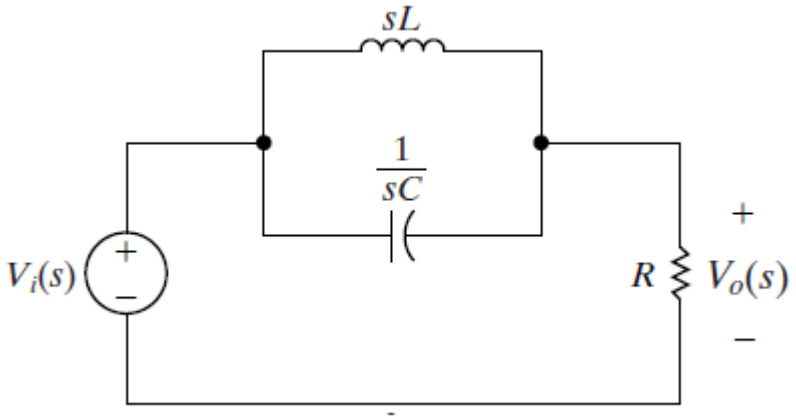
$$\theta(jw) = -\tan^{-1}\left[\frac{w(R/L)}{\frac{1}{LC} - w^2}\right]$$

Bandreject Filters: The Series RLC Circuit

$$w_{c1,c2} = \mp\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

$$w_o = \sqrt{\frac{1}{LC}} \qquad \beta = R/L \qquad Q = \sqrt{\frac{L}{R^2C}}$$

Bandreject Filters: The Parallel RLC Circuit



Voltage transfer function:

$$H(s) = \frac{s^2 + \frac{1}{LC}}{s^2 + \frac{s}{RC} + \frac{1}{LC}}$$

Reference

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