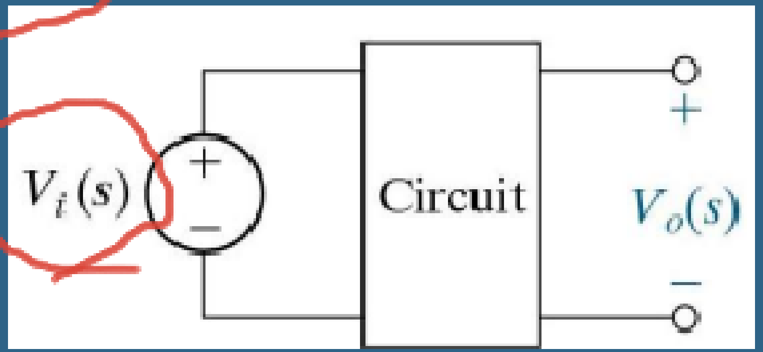
Filters

==> To study the frequency response of a circuit, we replace a fixed frequency sinusoidal source with a varying-frequency sinusoidal source.

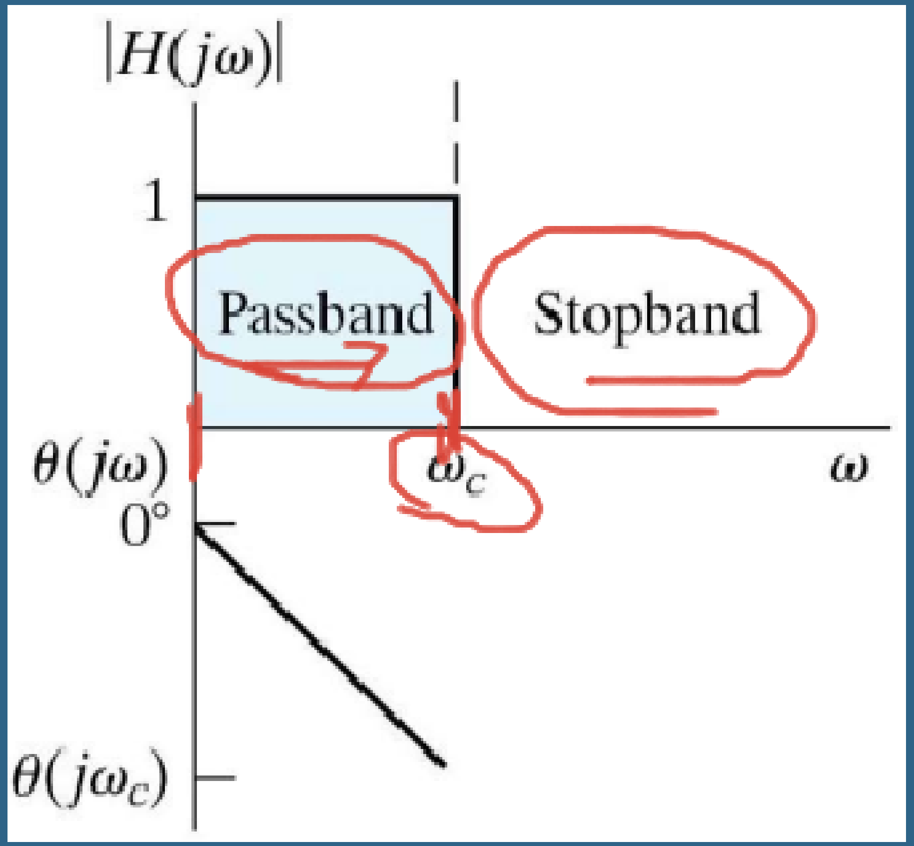


==> The transfer function is still an immensely useful tool because the output signal's magnitude and phase depend only on the transfer function H(jω), which varies as a function of the source frequency v (input).

$TF = \frac{V_o}{V_i}$

==> The circuit's transfer function will be the ratio of the Laplace transform of the output voltage t.

==> The signals passed from the input to the output fall within a band of frequencies called the passband.



==> Input voltages outside this band have their magnitudes attenuated by the circuit and are thus effectively prevented from reaching the circuit's output.

==> Frequencies not in a circuit's passband are in its stopband.

==> Frequency-selective circuits are categorized by the location of the passband

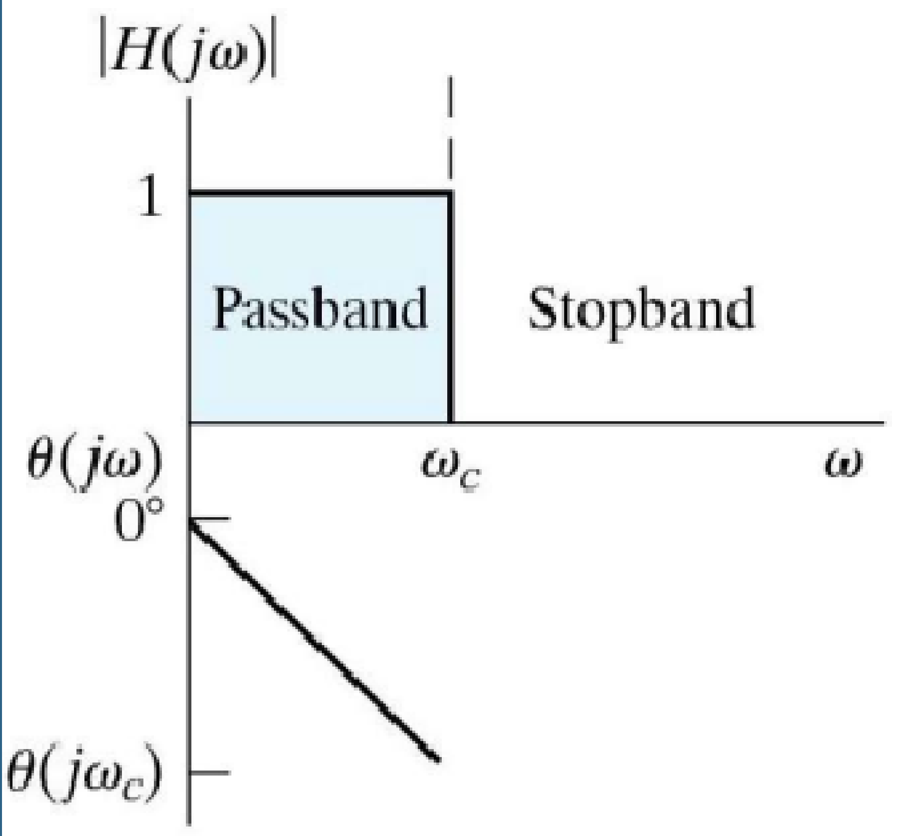
==> We can identify the type of frequency-selective circuit by examining its frequency response plot.

==> A frequency response plot shows how a circuit's transfer function (both amplitude and phase) changes as the source frequency changes.

A frequency response plot has two parts:

1- A graph of $|H(j\omega)|$ versus frequency ω, called the magnitude plot.

2- A graph of $\theta(j\omega)$ versus frequency ω, called the phase angle plot



==> Cutoff frequency (widely used by electrical engineers): is the frequency for which the transfer function magnitude is decreased by the factor from its maximum v.

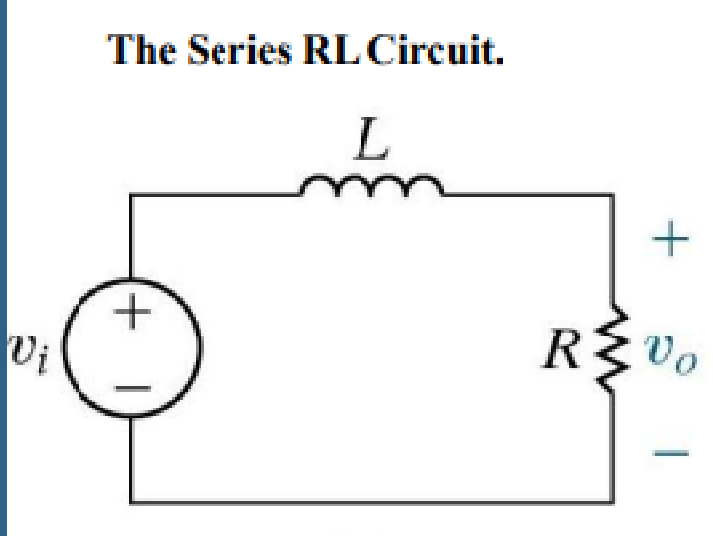
Low-pass filters

passes signals at frequencies lower than the cutoff frequency from the input to the output.

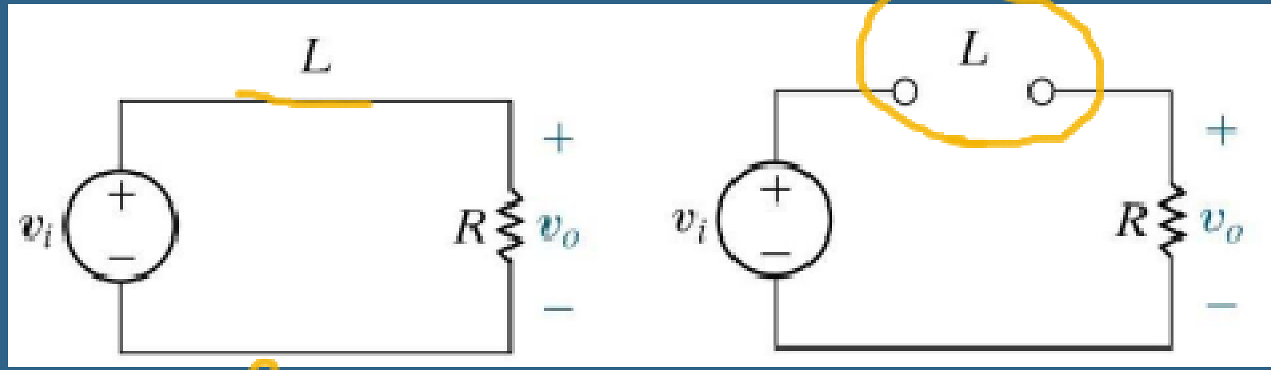
$Z_L = SL = j\omega L$

RL Low-pass filters

==> At low frequencies, the inductor's impedance is very small compared with the resistor's impedance, and the inductor effectively functions as a short circuit ($\omega L \ll R$)



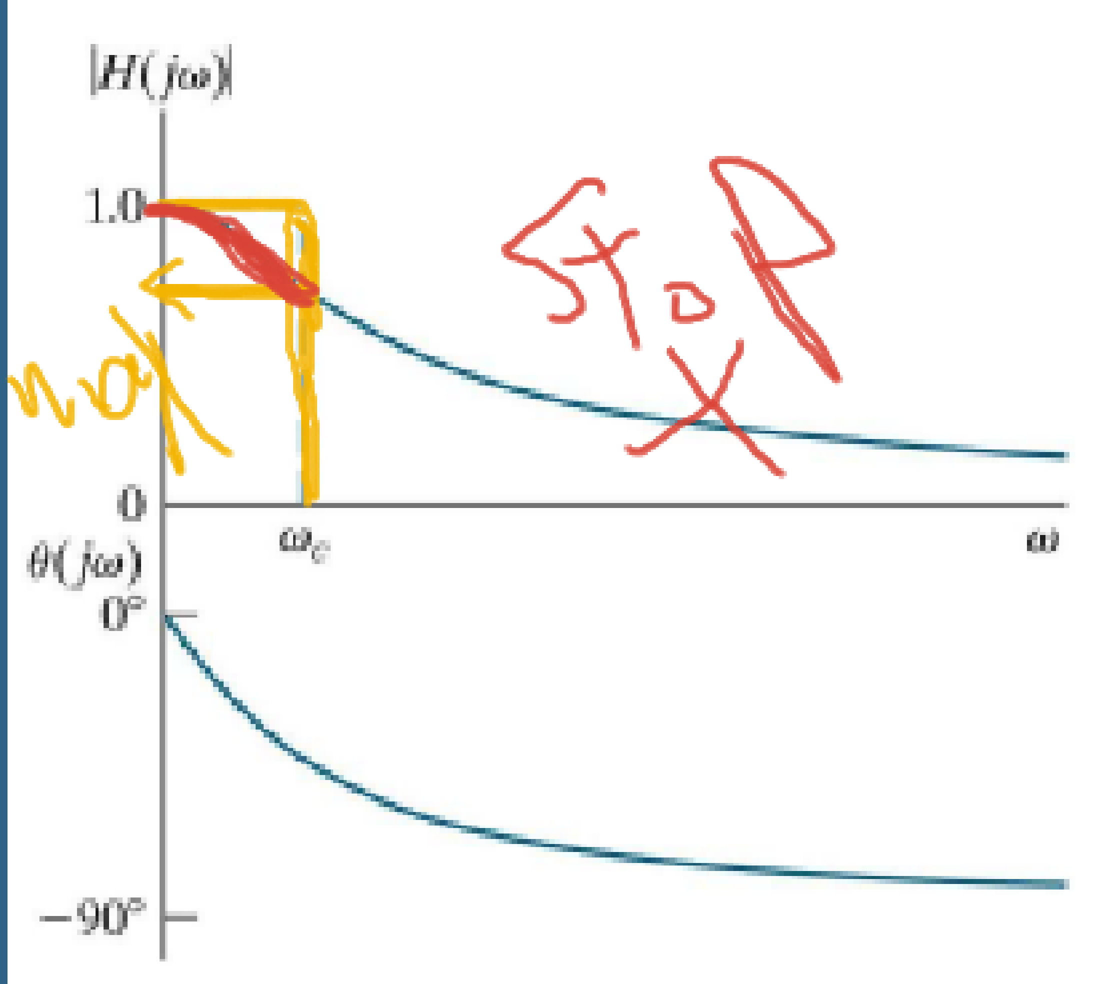
==> At high frequencies, the inductor's impedance is very large compared with the resistor's impedance, and the inductor



low freq

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

$\sqrt{2}$ H max

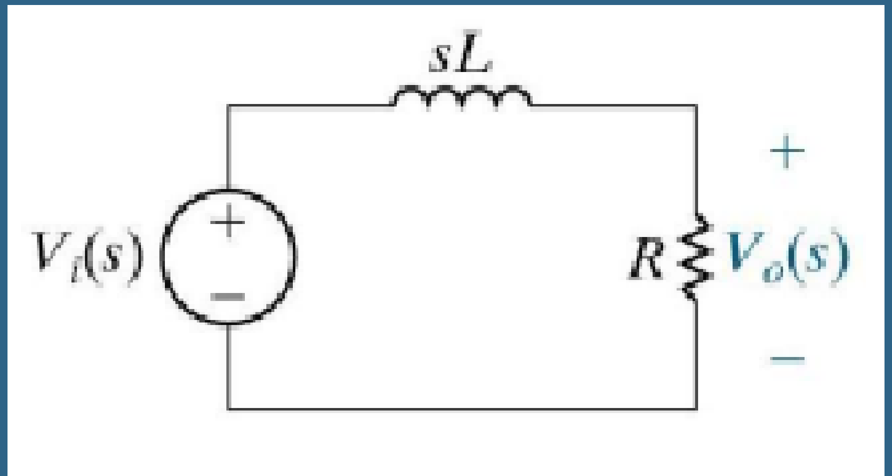


H(s)=?

$$s = j\omega$$

$$H(s) = \frac{V_o(s)}{V_i(s)} =$$

$$H(j\omega)$$



$$V_o(s) = \frac{R}{R+sL} V_i(s)$$

$$|H(j\omega)| = \frac{R/L}{\sqrt{\omega^2 + (R/L)^2}},$$

$$\theta(j\omega) = -\tan^{-1}\left(\frac{\omega L}{R}\right).$$

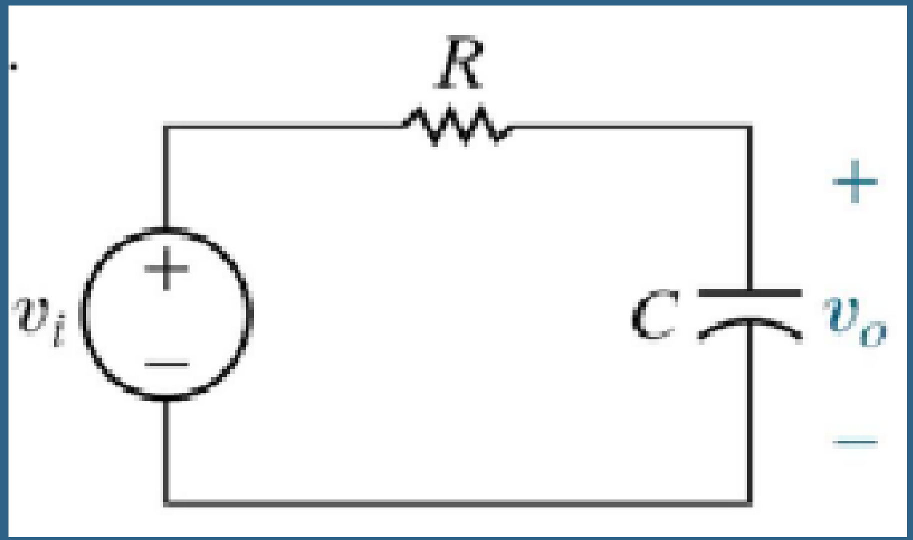
$$|H(j\omega_c)| = \frac{1}{\sqrt{2}}|1| = \frac{R/L}{\sqrt{\omega_c^2 + (R/L)^2}}.$$

$$\frac{V_o(s)}{V_i(s)} = \frac{R}{R+sL} = \frac{R/L}{s+R/L}$$

$$\omega_c = \frac{R}{L}.$$

RC Low Pass Filter

$Z_c = \frac{1}{j\omega C}$



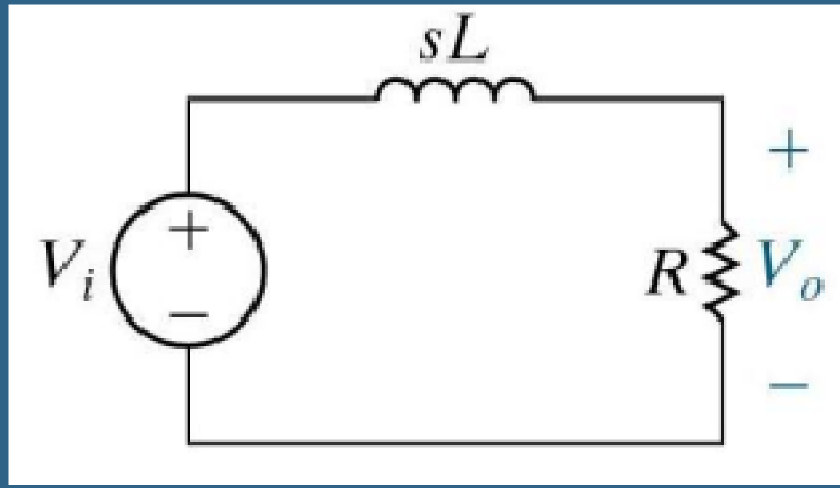
==> @ low freq: The impedance of the capacitor is large, and the capacitor acts as an o.c
So ==>(Vi = Vo).

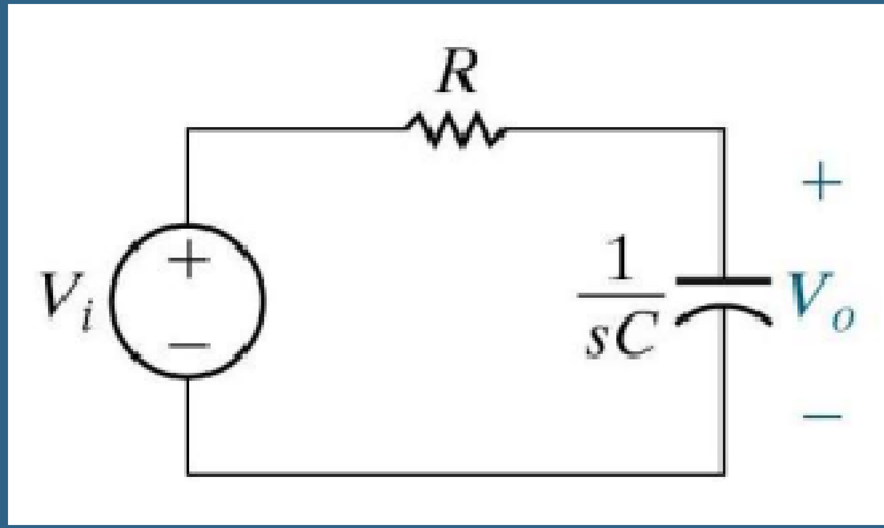
==> @ high freq: The impedance of the capacitor small relative to the impedance of R, and the source voltage divides between Zc and ZR (Vo < Vs).

S.C

==> So @ ω = 0: Zc = ∞ & Cap is o.c (Vo = Vi)
==> So @ ω = ∞: Zc = 0 & Cap is s.c (Vo = 0)

$Z_c = 1/j\omega C \ \Omega$





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

$$\omega_c = R/L$$

$$H(s) = \frac{\omega_c}{s + \omega_c}.$$

$$H(s) = \frac{1/RC}{s + 1/RC} \qquad \tau = 1/\omega_c.$$

$$\omega_c = 1/RC$$