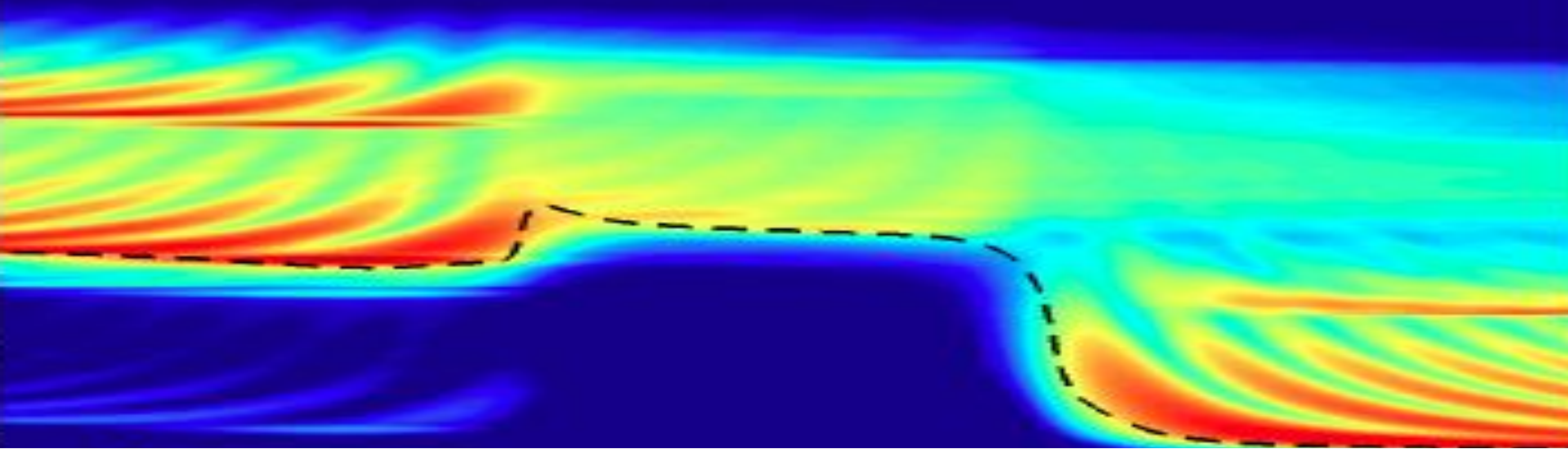

# EECS 16B
# Designing Information Devices and Systems II
# Lecture 8

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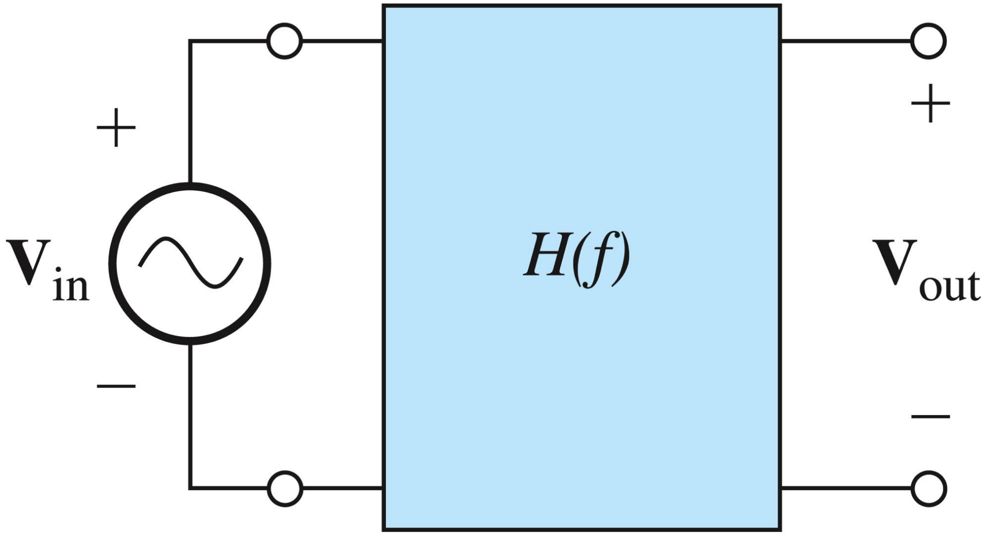
# Transient Response

- Outline
  - High Pass Filters
  - Series and Parallel Resonance
  - Amplifiers and Devices

- Reading- Hambley text sections 6.4, 6.5, 6.6, 6.7,slides

# Recap: Concept of Transfer Function

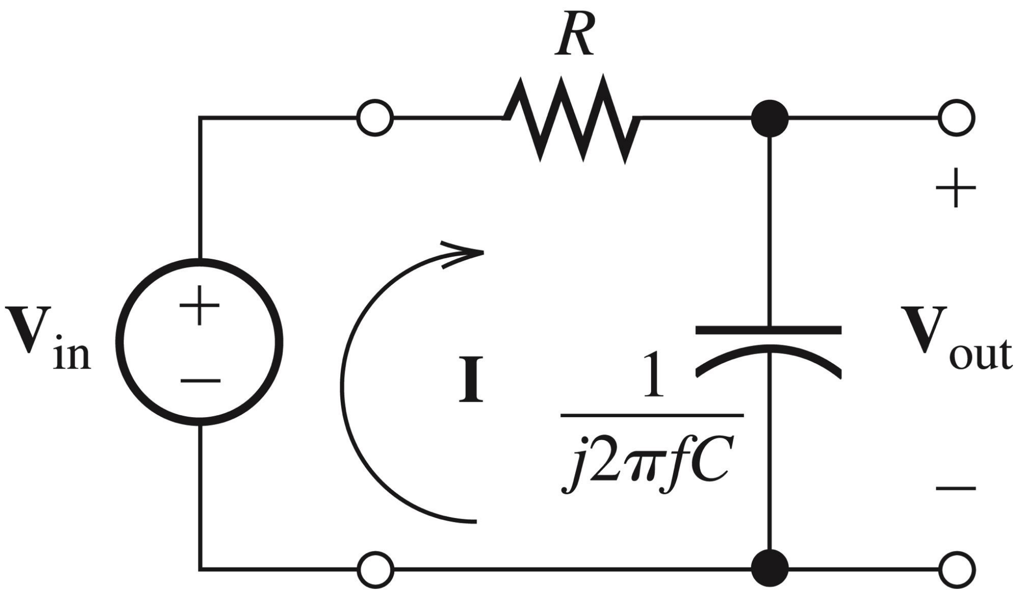




$$H(f) = \frac{V_{out}}{V_{in}}$$

$H(f)$ is a complex number

# Recap:First order low pass filter

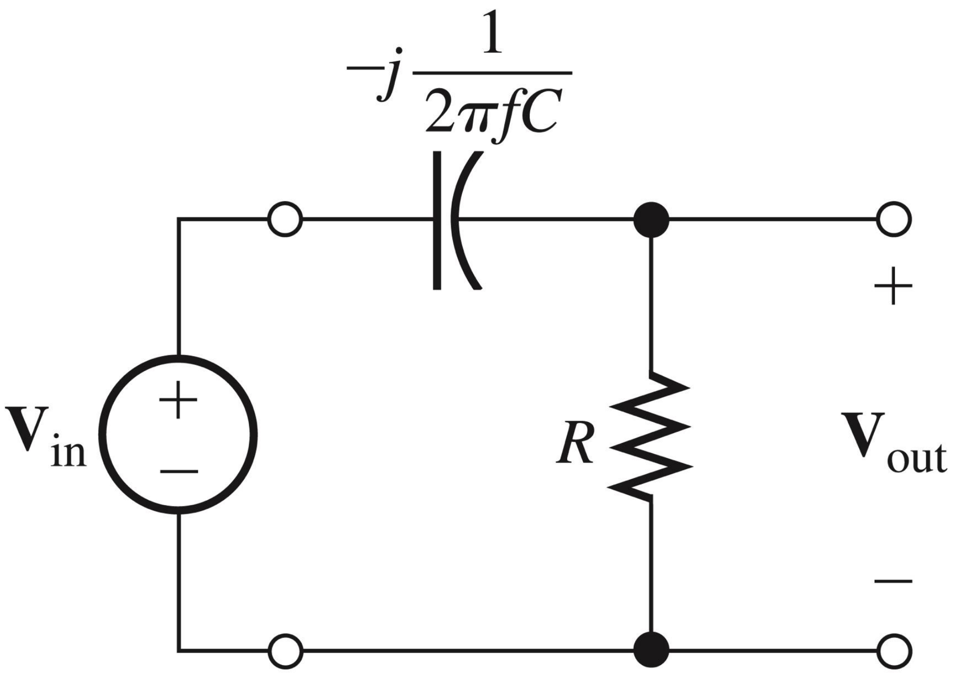





$$H(f) = \frac{1}{\sqrt{\left(1 + \frac{f^2}{f_B^2}\right)}} \angle - \tan^{-1}\left(\frac{f}{f_B}\right)$$

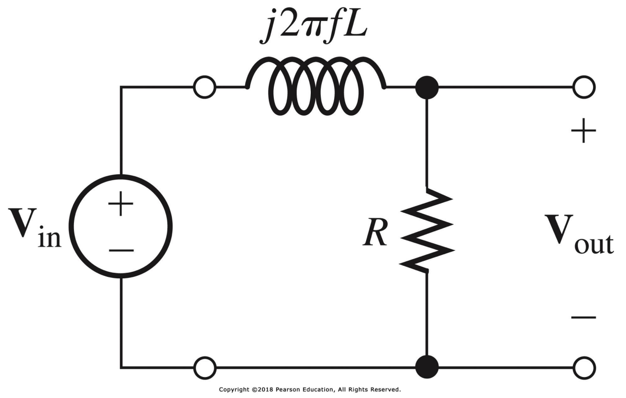
$$f_B = \frac{1}{2\pi RC}$$

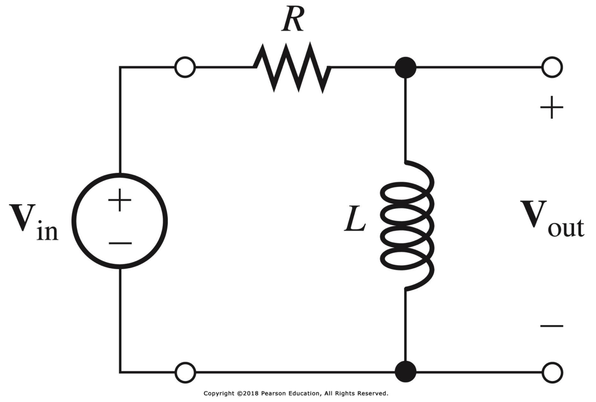
# First order High Pass Filter



# First order High Pass Filter

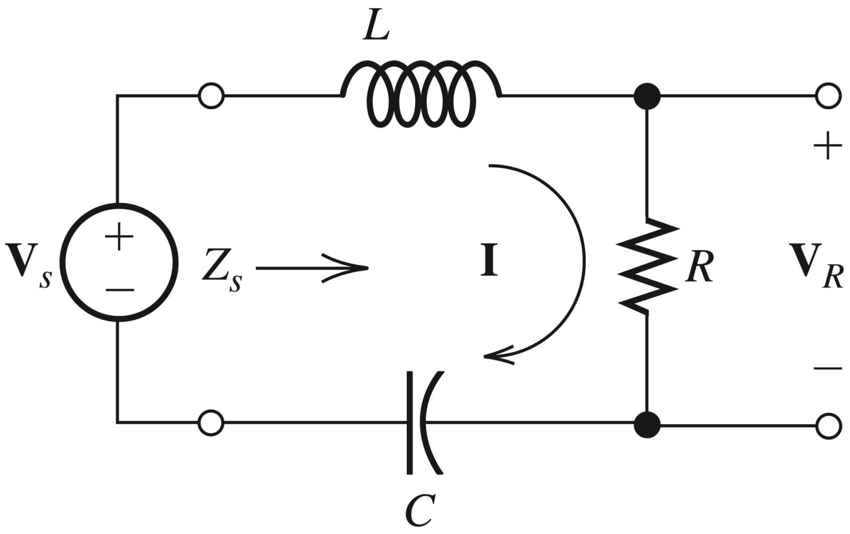
# Low Pass and High Pass Filters with Inductors



# Resonant Circuits

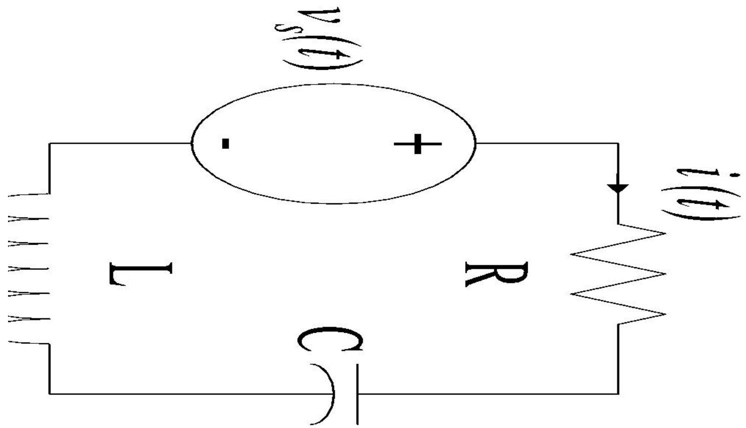
Series Resonance



# Recap: R-L-C circuits: Response in time

$$\frac{d^2v_c}{dt^2} + \frac{1}{(L/R)}\frac{dv_c}{dt} + \frac{1}{LC}v_c = v_s$$

$$\frac{d^2v_c}{dt^2} + 2\alpha\frac{dv_c}{dt} + \omega_0^2 v_c = v_s$$



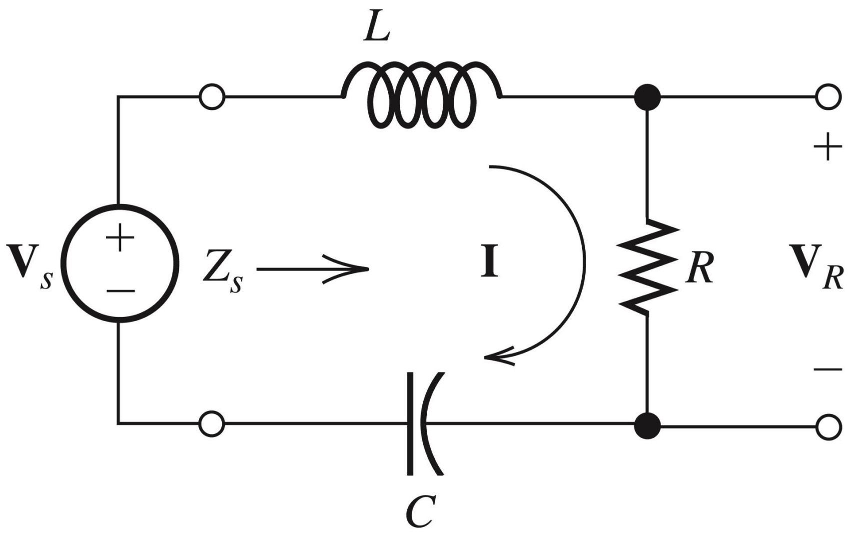

Homogeneous solution

$$\frac{d^2v_c}{dt^2} + 2\alpha\frac{dv_c}{dt} + \omega_0^2 v_c = 0$$

From previous discussions we have seen that an exponential solution works

Lets try: $v_c(t) = Ae^{st}$

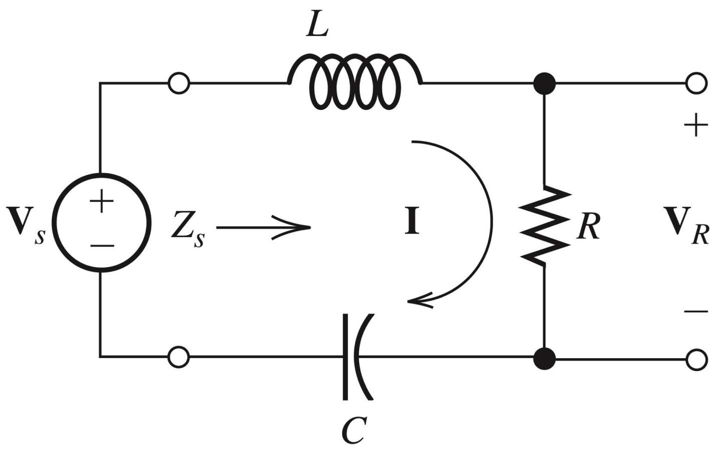
# Series Resonance





$$Z = R + j\omega L - \frac{j}{\omega C}$$

# Series Resonance

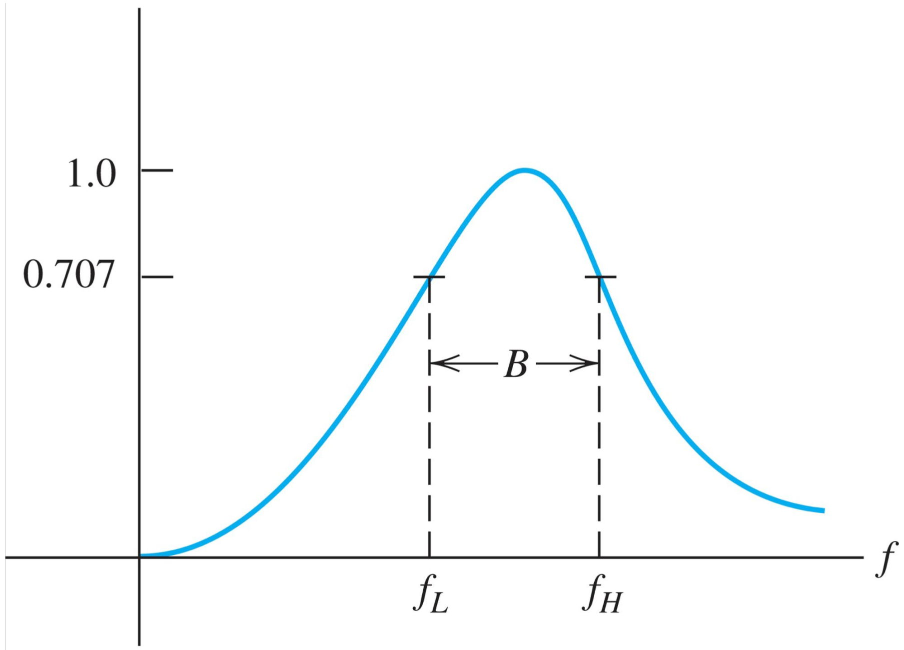


# Series Resonance

# Series Resonance

# Series Resonance

# Series Resonance Bandpass Filter

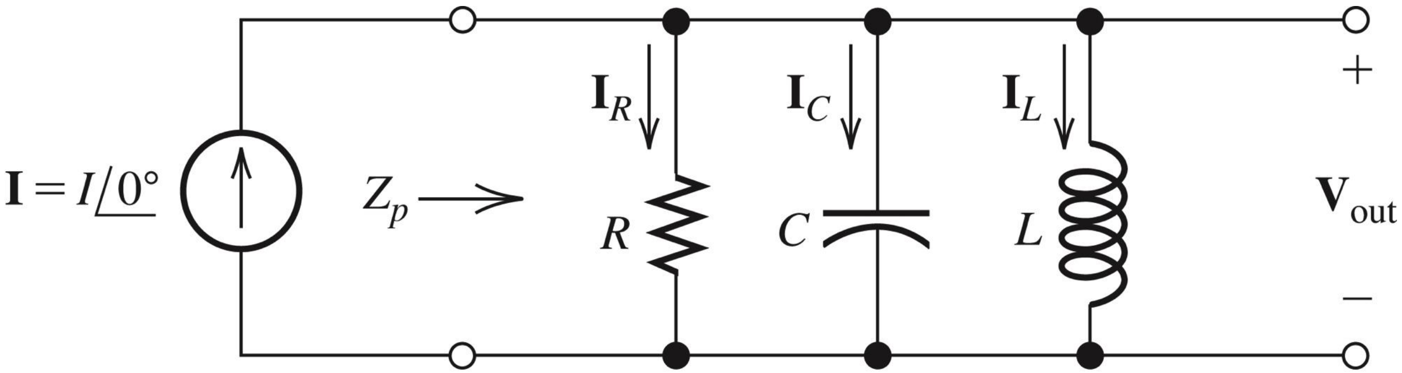




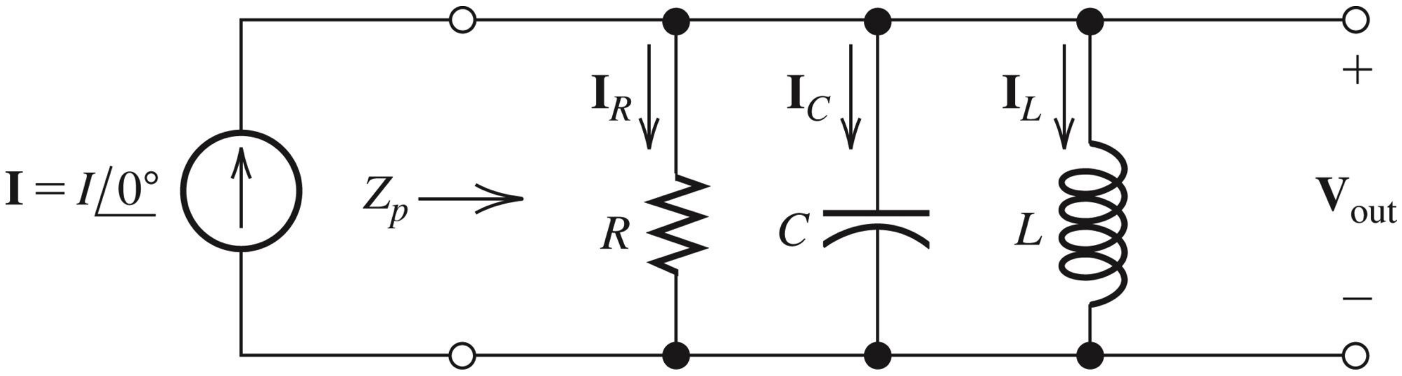
**Half-power** frequencies are defined as the frequencies where the magnitude of the transfer function has fallen by a factor of $\frac{1}{\sqrt{2}} = 0.707$

It can be shown that $$B = f_H - f_L = \frac{f_0}{Q_s}$$

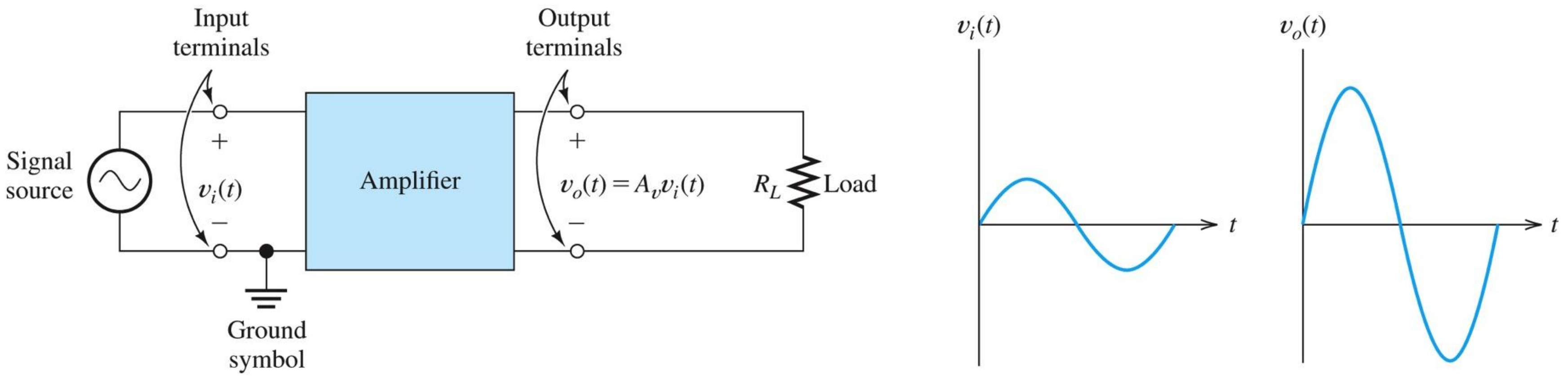
# Parallel Resonance



# Parallel Resonance



# Active Devices





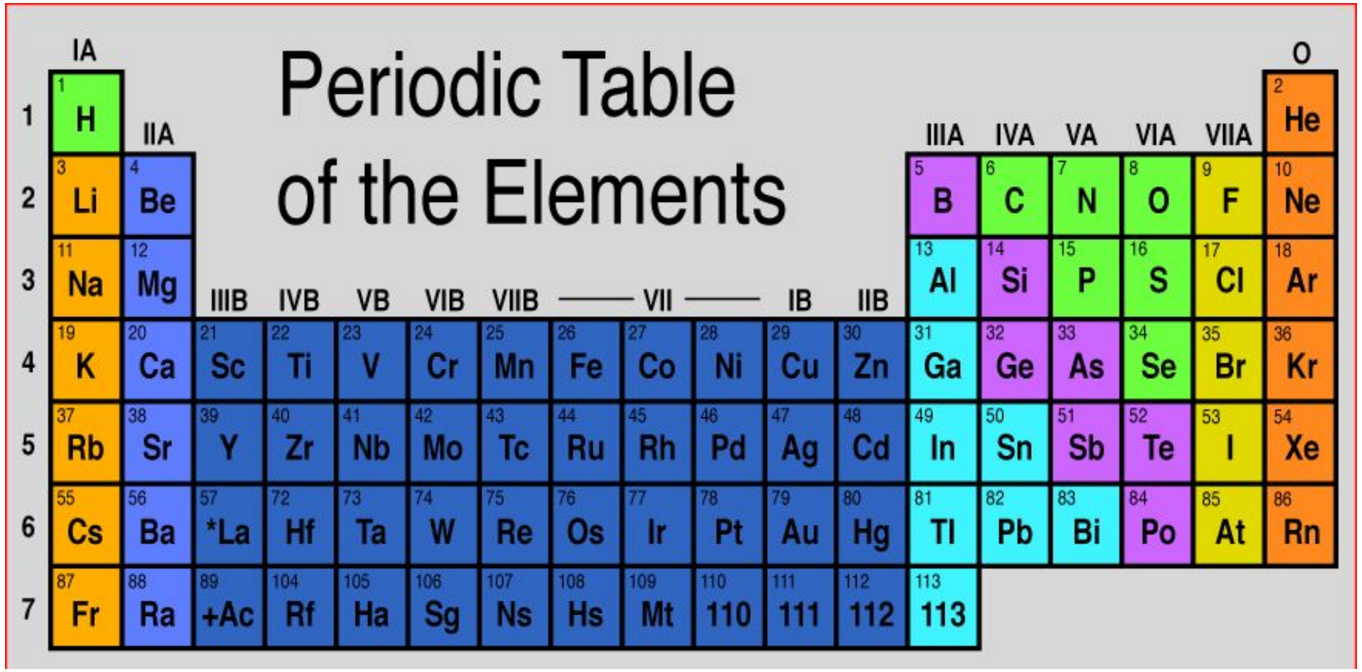

- Active devices are made of semiconductors
- Semi-conductors are materials whose resistance is in between a metal and insulator

Half

- More interestingly, one is able to change the resistance of the semiconductor materials by using external control such as voltage or current

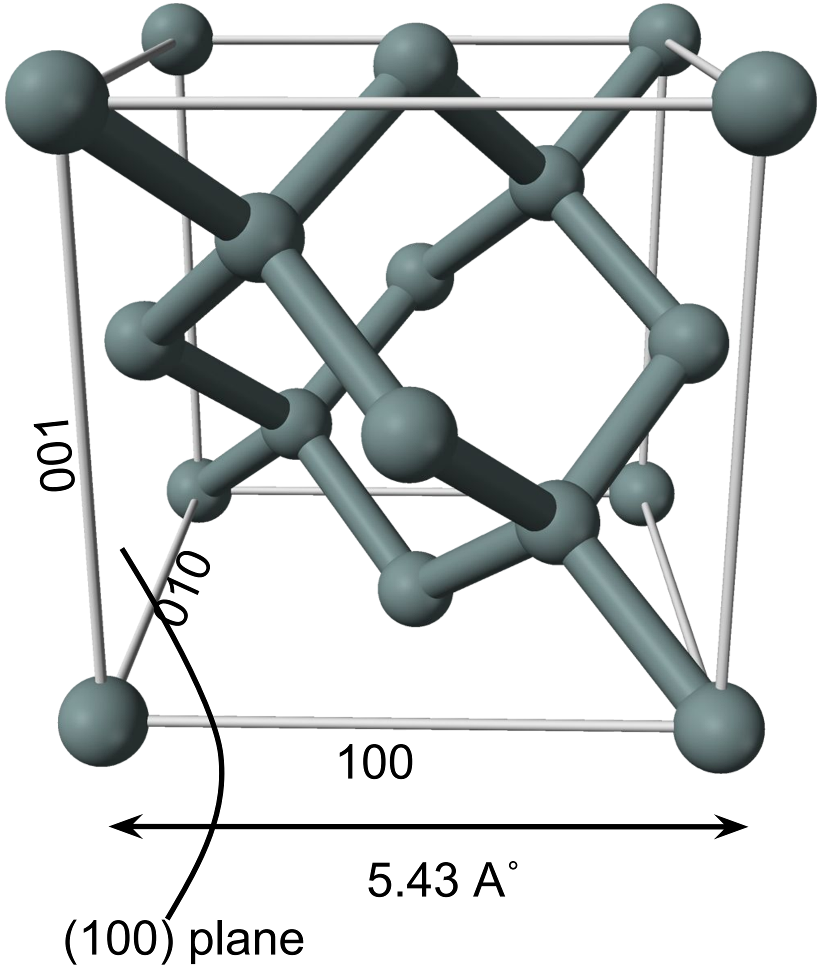
# Semiconductors

- Semiconductors are **usually** made of group IV elements- atoms that contain, on average, four valence electrons
- Most Common semiconductor used in electronic devices is **Silicon**

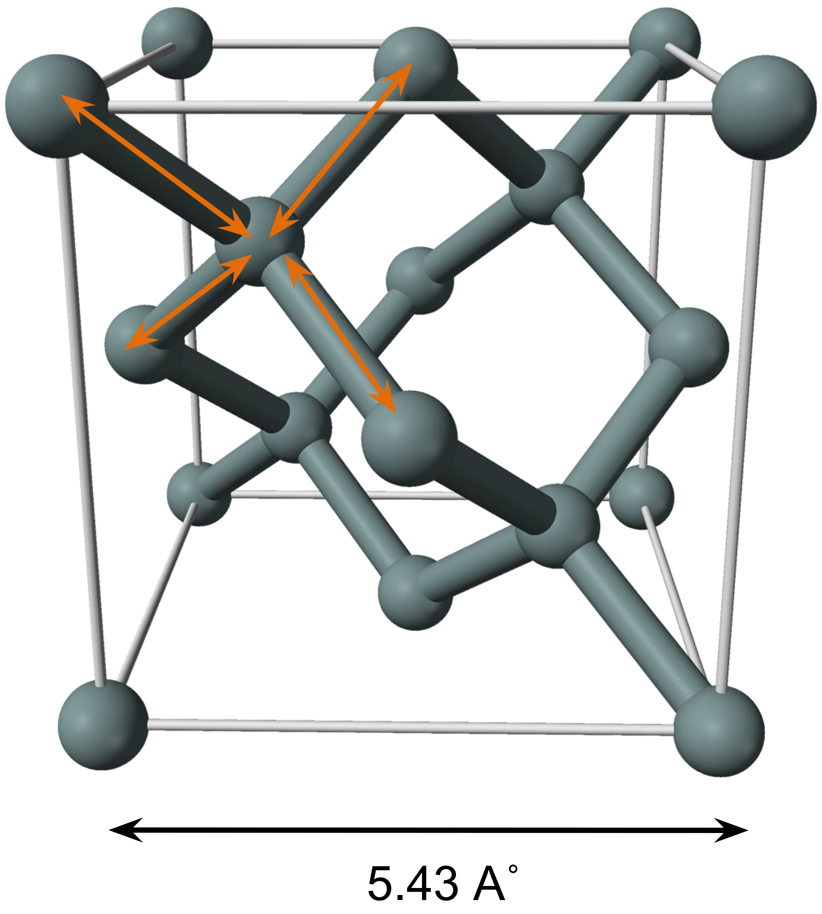


# Crystal Structure of Si

Often known as the diamond lattice



# Crystal Structure of Si




Each atom has 4 nearest neighbors

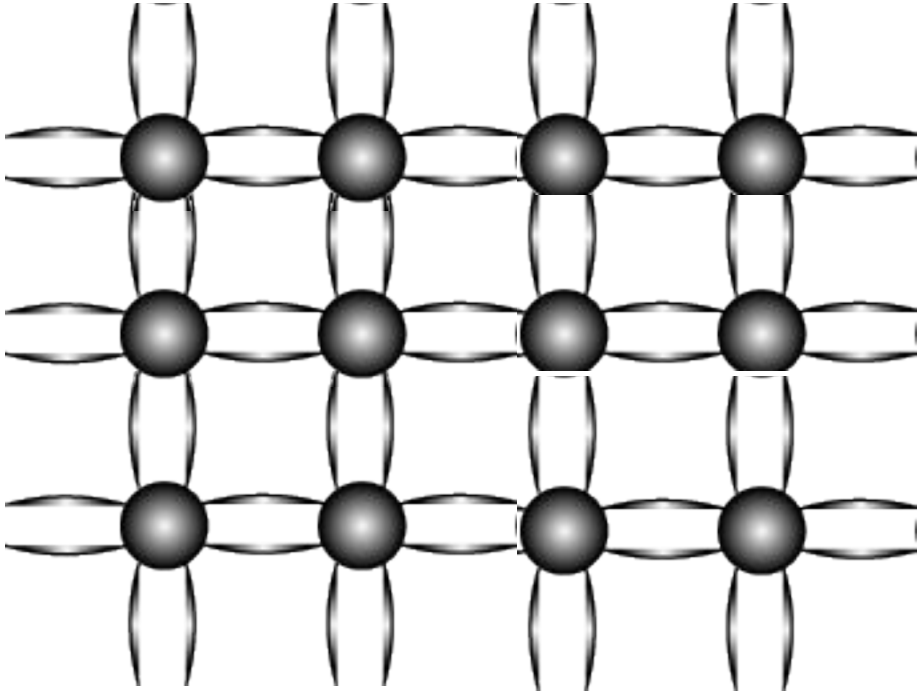
$Si(14)=1S^2 2S^2 2P^6 3S^2 3P^2$

4 valence electrons

Each atom shares 2 electrons with 4 nearest neighbors to form a covalent bond

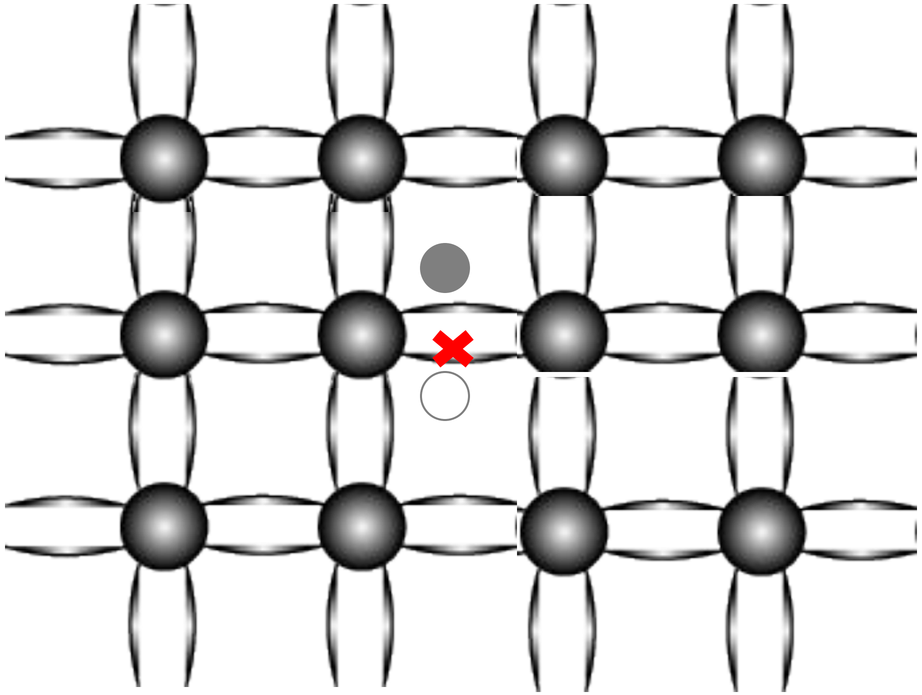
# The Bond Model

Each atom shares 2 electrons with 4 nearest neighbors to form a covalent bond



At T=0K, all bonds are satisfied, there are no free carriers, no current flows, looks like an insulator

# Intrinsic Si: The Bond Model: Electrons



At finite temperature, an electron may gain enough energy to break the covalent bond, become free and move around.