

Introduction to Electronics



An introduction to electronic components and a study of circuits containing such devices.

Week 1: Review





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Review of Circuit Elements

Review linear circuit components and properties

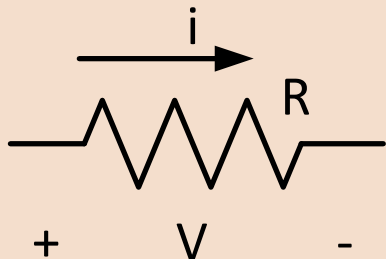


Lesson Objectives

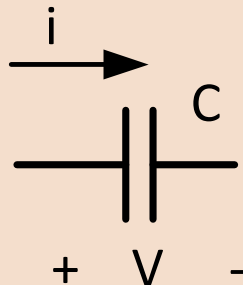
⦿ Review

- Resistors, capacitors, inductors
 - i-v characteristics of these elements
- Sources, nodes

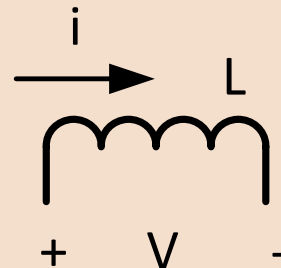
Passive Elements

Resistor

$$V = iR$$


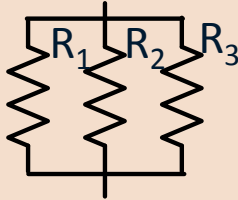

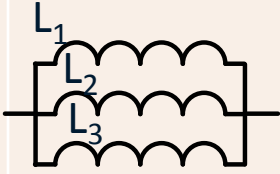
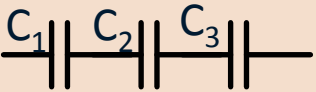
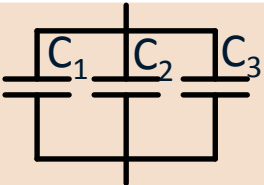
Capacitor

$$i = C \frac{dV}{dt}$$







Inductor

$$V = L \frac{di}{dt}$$

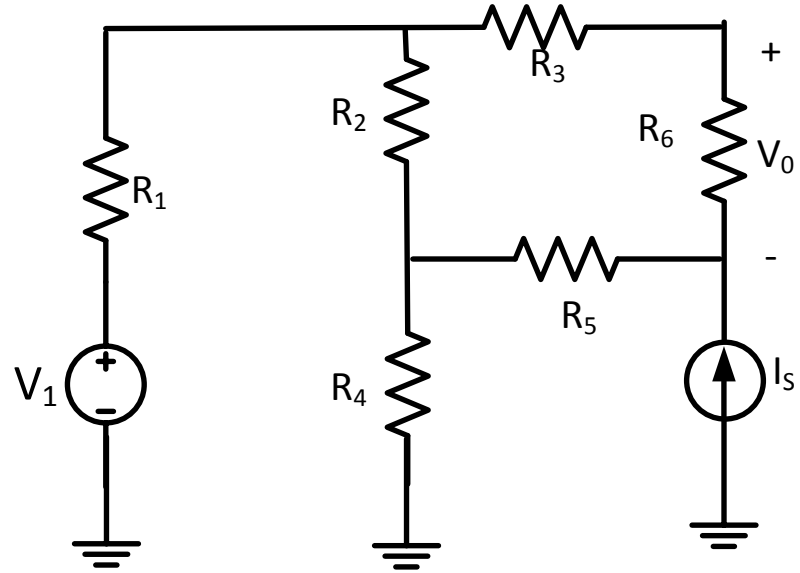
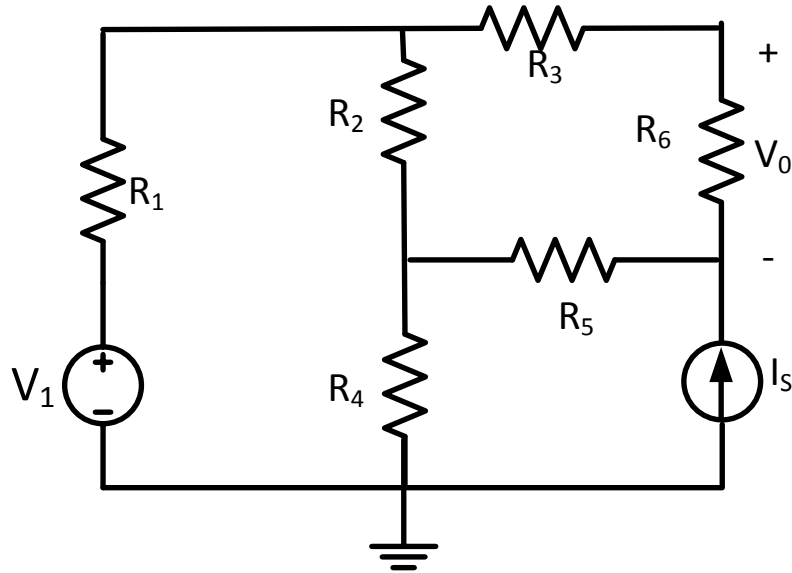
Series and Parallel Connections

	Series	Parallel
Resistors	 $R = R_1 + R_2$	 $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$
Inductors	 $L = L_1 + L_2$	 $L = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}}$
Capacitors	 $C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$	 $C = C_1 + C_2 + C_3$

Connections and Sources

Ground		Reference for 0 volts
Node		Voltage level the same everywhere on the node
Voltage Source	Independent 	Dependent 
Current Source	Independent 	Dependent 

Circuit Connections





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Review of Kirchoff's Laws

Review of KVL and KCL

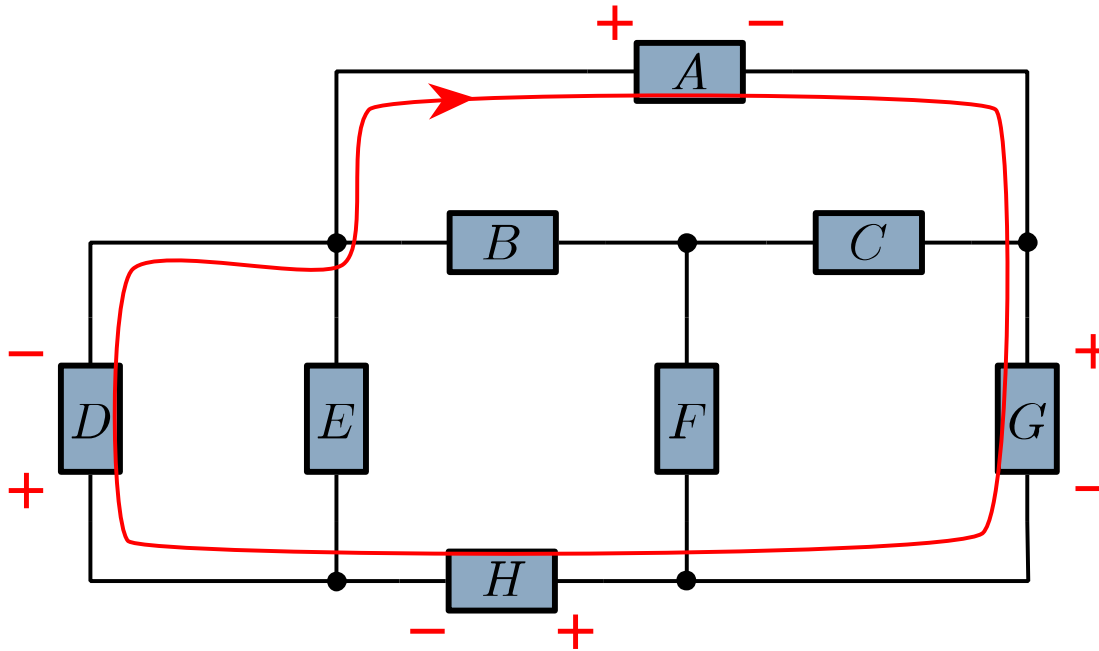


Lesson Objectives

◉ Review

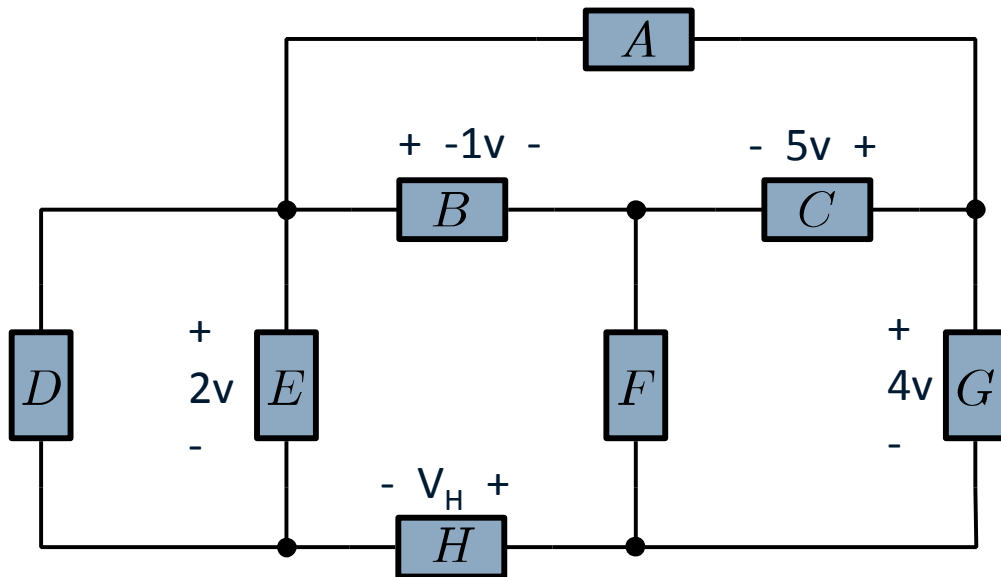
- Kirchhoff's Current Law (KCL)
- Kirchhoff's Voltage Law (KVL)

Kirchhoff's Voltage Law (KVL)

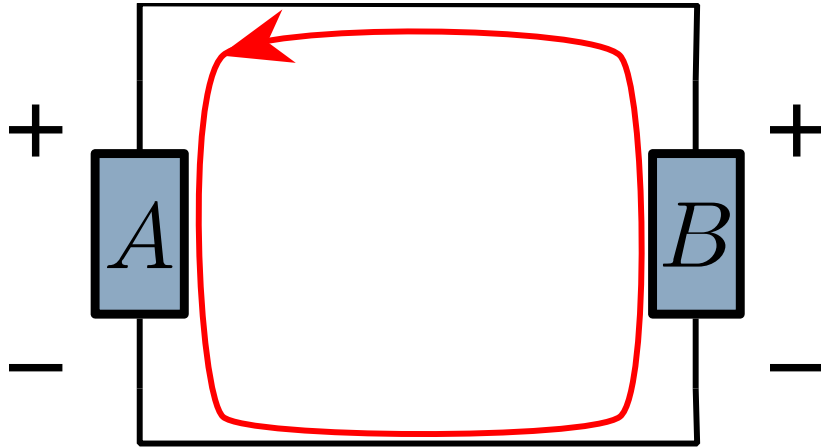


The sum of voltages around any closed loop is zero.

KVL Quiz



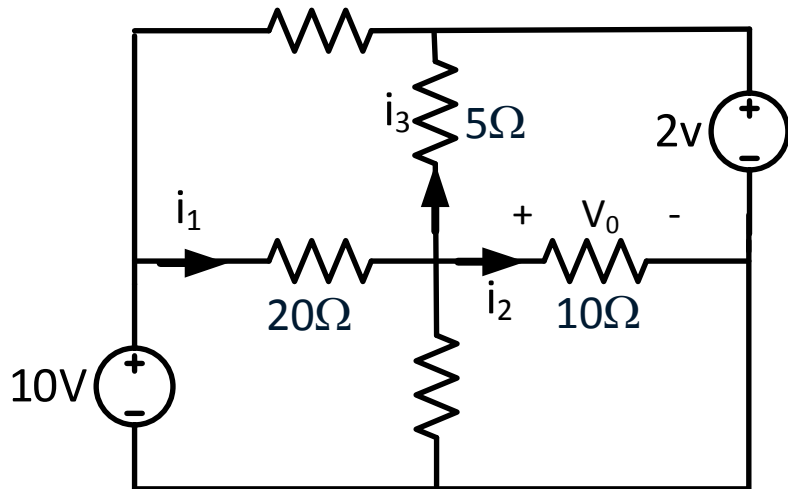
KVL and Parallel Circuits



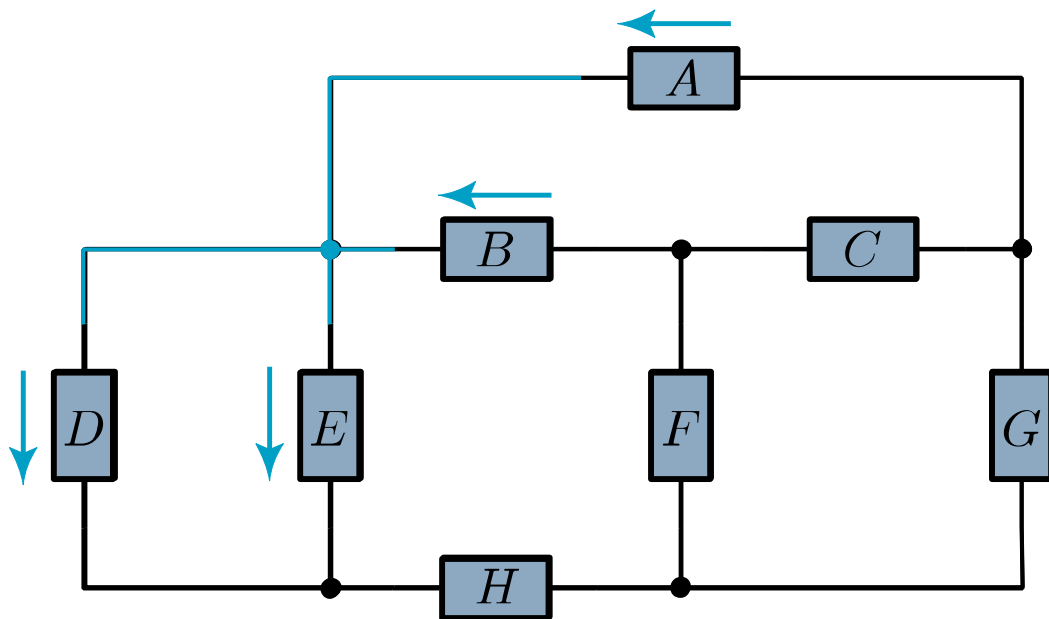
$$v_A - v_B = 0$$

$$v_A = v_B$$

KVL Example

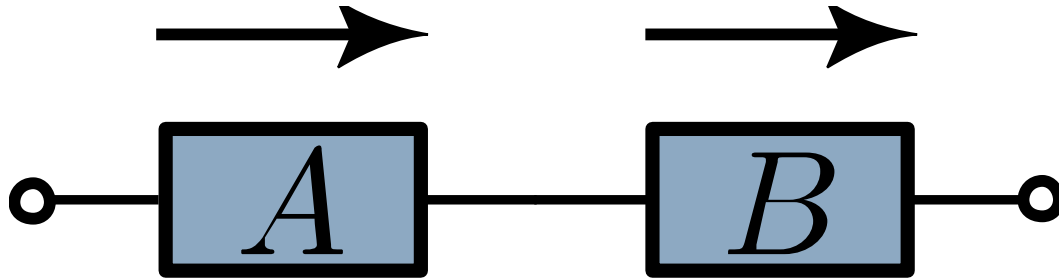


Kirchhoff's Current Law (KCL)



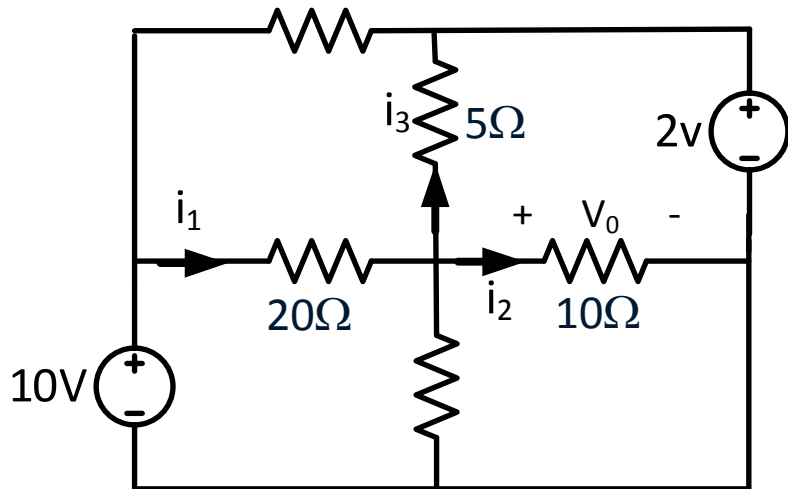
$$\sum i_{\text{entering}} = \sum i_{\text{leaving}}$$

KCL and Series Circuits



$$i_A = i_B$$

KCL Example



Summary

- Introduced KVL and KCL
- Applied KVL to parallel elements
- Applied KCL to series elements
- Solved a simple circuit using
Kirchhoff's Laws



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Review of Impedance

Review of Impedance for Analyzing AC Circuits



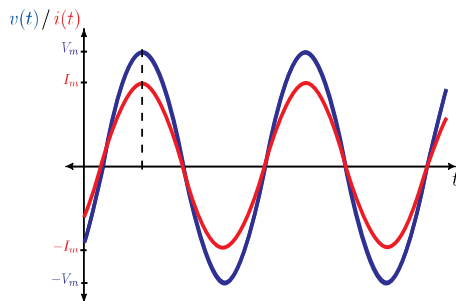
Lesson Objectives

- Review
 - Impedances for steady-state sinusoidal inputs (AC)

Impedances

 R 

$$Z_R = R$$

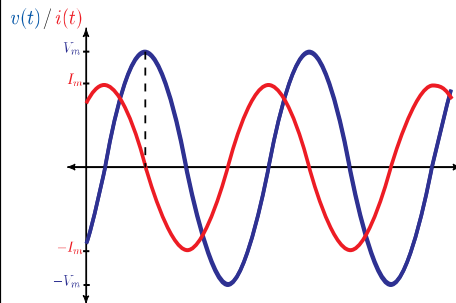


In-phase

Frequency invariant



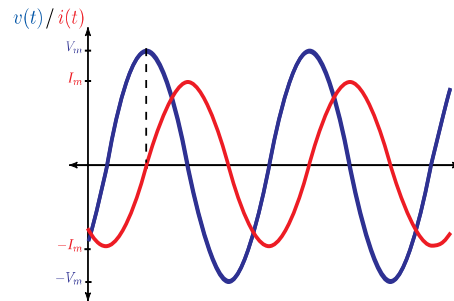
$$Z_C = \frac{1}{j\omega C}$$



Current leads voltage

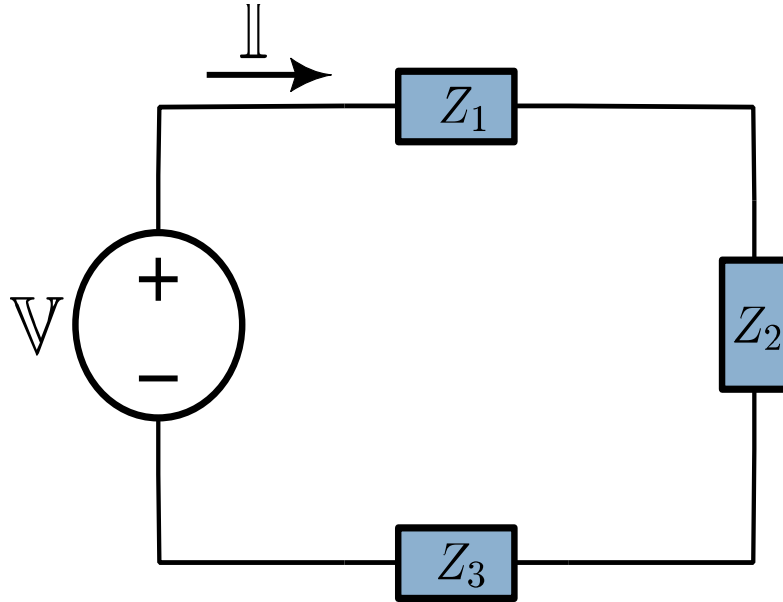


$$Z_L = j\omega L$$



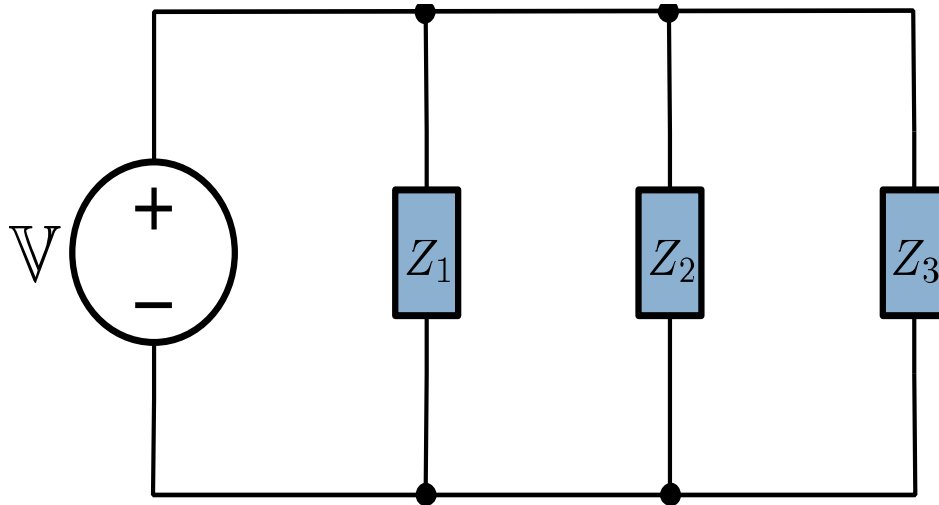
Current lags voltage

Impedances in Series



$$Z_{cq} = \sum_i Z_i$$

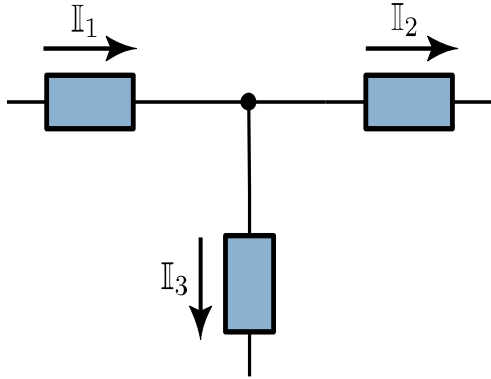
Impedances in Parallel



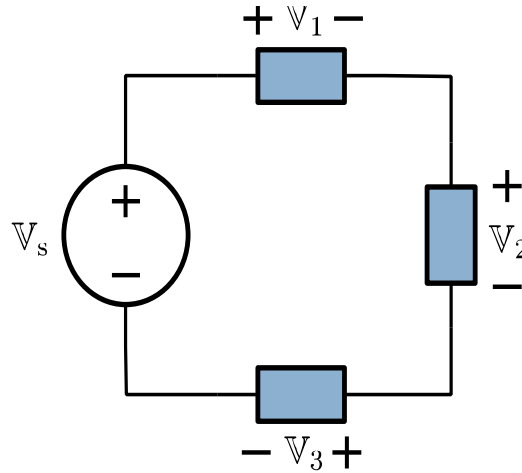
$$Z_{\text{eq}} = \left[\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} \right]^{-1}$$

$$Z_{\text{eq}} = \left[\sum_i \frac{1}{Z_i} \right]^{-1}$$

Kirchhoff's Laws

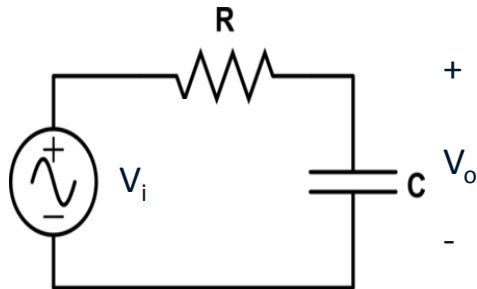


$$I_1 = I_2 + I_3$$

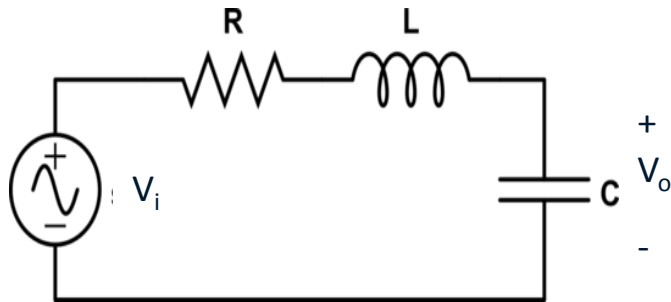


$$V_s = V_1 + V_2 + V_3$$

Series RC



Series RLC



Summary

- Introduced KVL and KCL
- Applied KVL to parallel elements
- Applied KCL to series elements
- Solved a simple circuit using
Kirchhoff's Laws



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Review of Transfer Functions

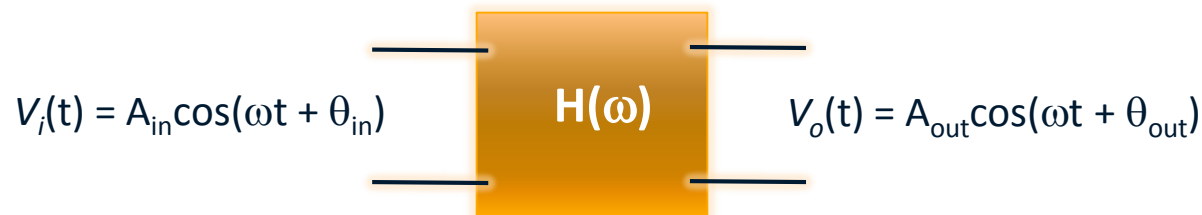
Review of transfer functions for characterizing circuits



Lesson Objectives

- Review transfer functions
 - To characterize a circuit
 - To find frequency response curves

Transfer Function Two-Port Networks

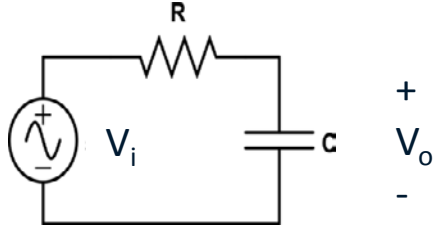
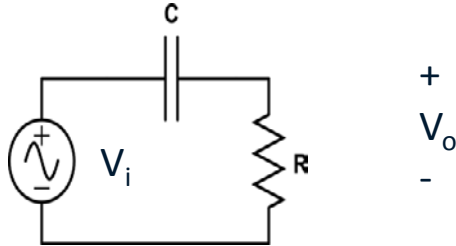
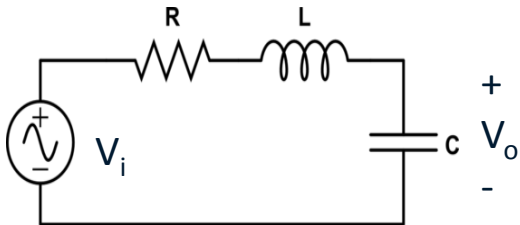


$$H(\omega)V_i = V_o$$

$$H(\omega)A_{in} \angle \theta_{in} = A_{out} \angle \theta_{out}$$

$$A_{out} = |H(\omega)|A_{in} \quad \theta_{out} = \angle H(\omega) + \theta_{in}$$

Summary of Simple Circuits

	$H(\omega) = \frac{1}{1 + RC\omega j}$
	$H(\omega) = \frac{RC\omega j}{1 + RC\omega j}$
	$H(\omega) = \frac{1}{1 - \omega^2 LC + RC\omega j}$

Summary

- Defined transfer function for Two-Port Networks
 - Showed transfer functions of simple circuits



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Review of Frequency Response Plots (Bode)

*Review of linear plots and Bode plots to show the frequency
characteristics of signals and circuits*



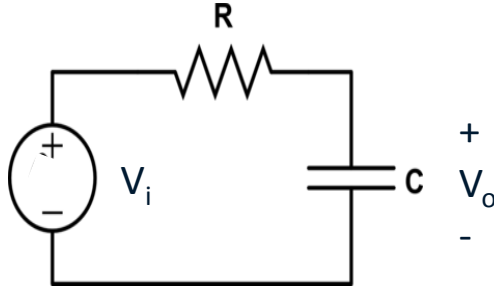
Lesson Objectives

- Define the frequency response for a transfer function $H(\omega)$

Magnitude Plot: $|H(\omega)|$ vs ω
Angle Plot: $\angle H(\omega)$ vs ω

- Show linear plots and Bode plots

Frequency Response

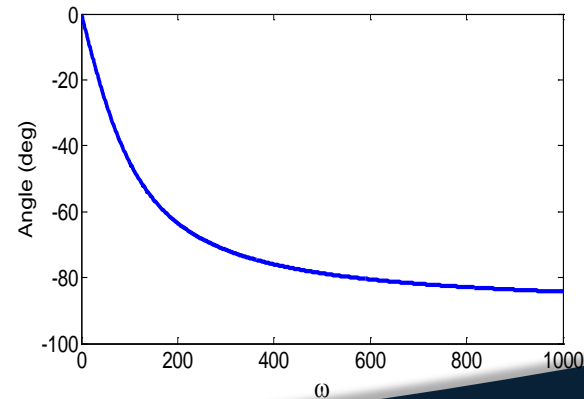
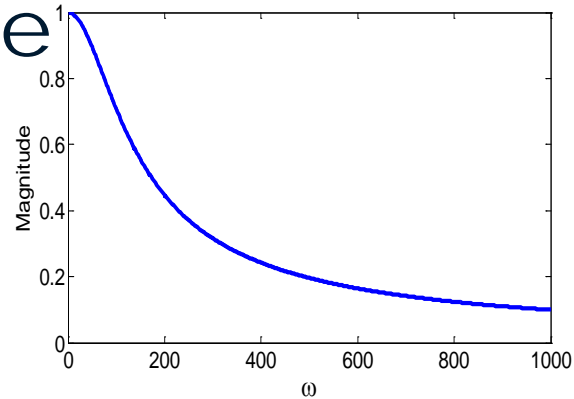


Transfer Function

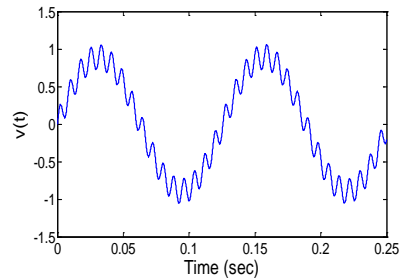
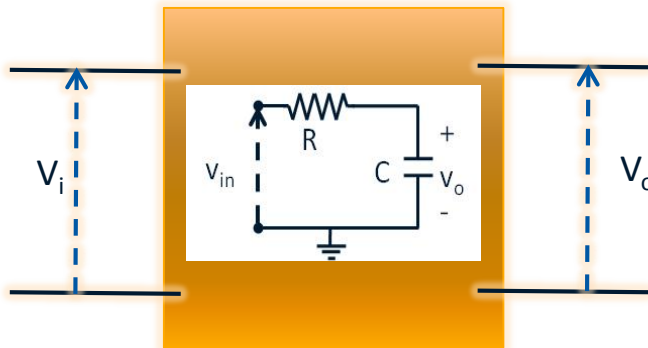
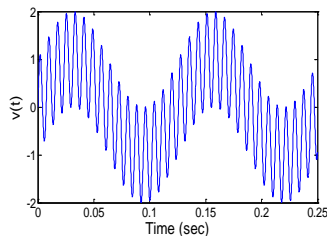
$$H(\omega) = \frac{1}{1 + RC\omega j}$$

$$|H(\omega)| = \frac{1}{\sqrt{1 + (RC\omega)^2}}$$

$$\angle H(\omega) = -\tan^{-1}(RC\omega)$$

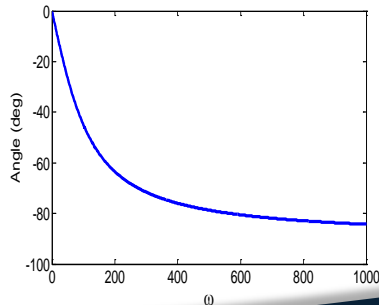
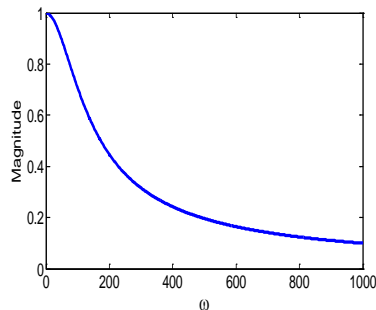


Circuit Response

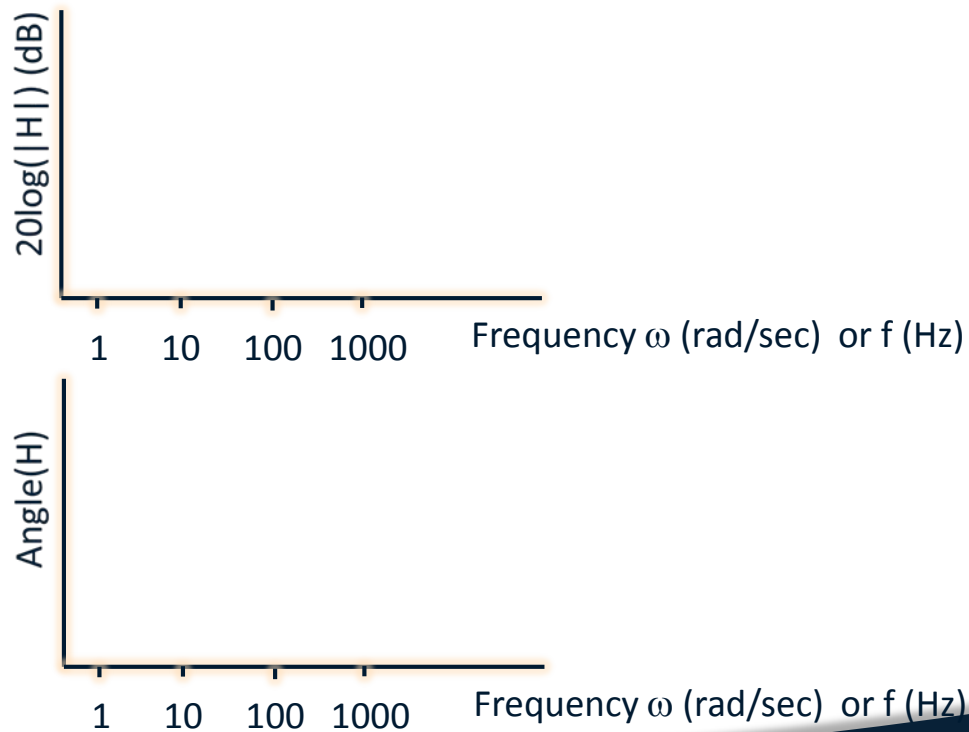


$$V_i = \cos(50t) + \cos(800t)$$

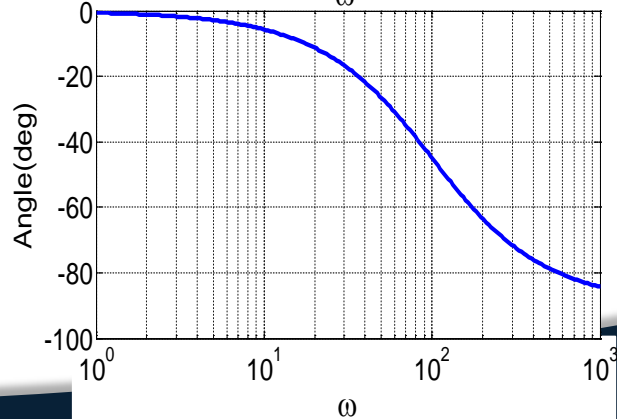
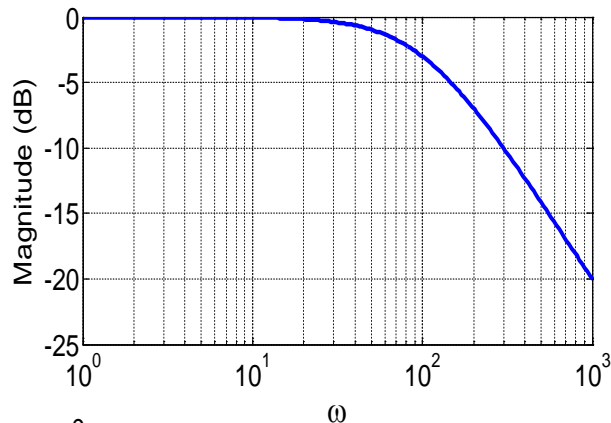
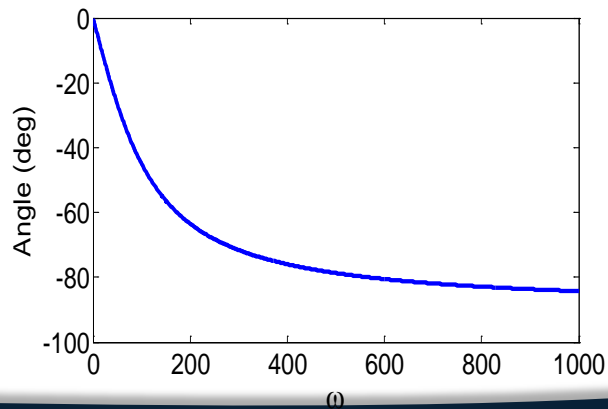
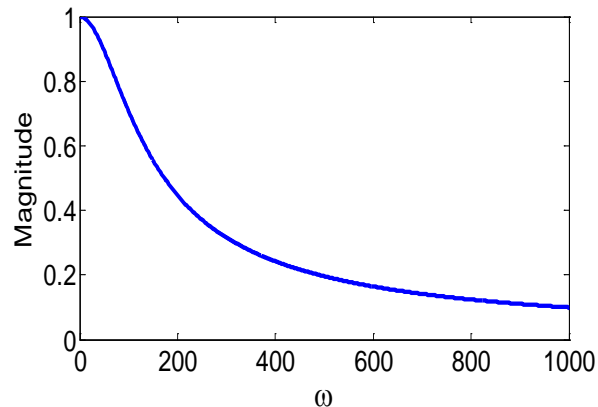
$$V_o = 0.95\cos(50t-20^\circ) + 0.13\cos(800t-85^\circ)$$



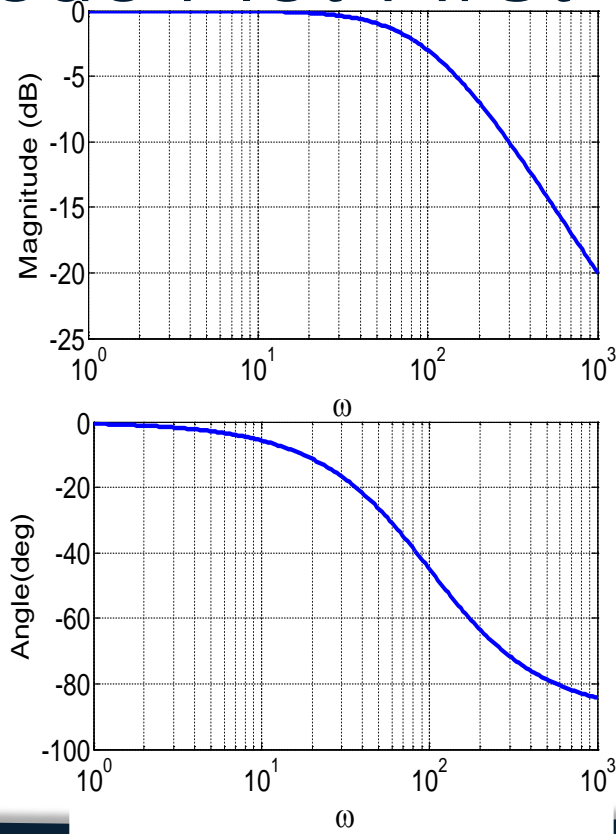
Bode Plots



Linear Plot and Bode Plot



Bode Plot First-Order Characteristics

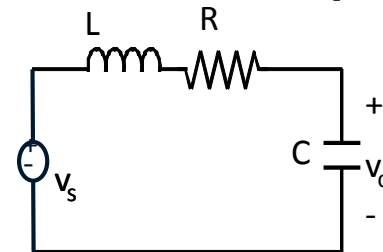
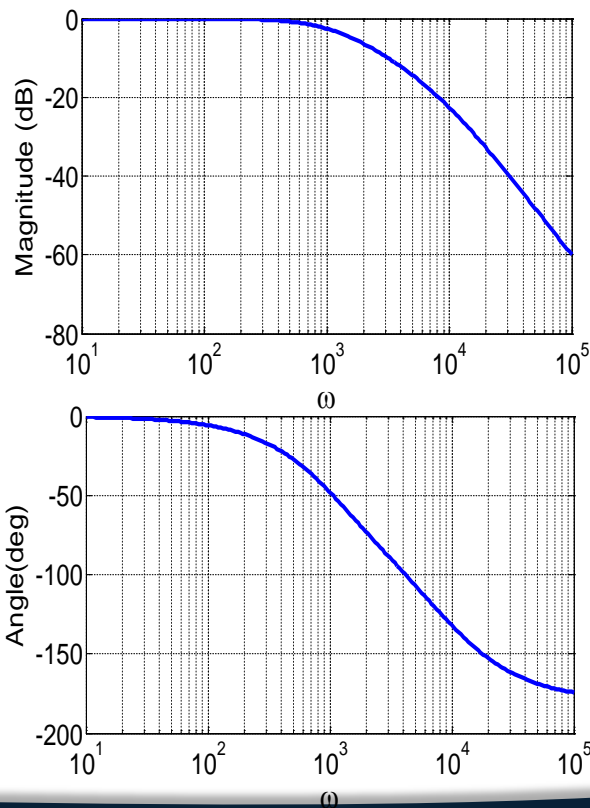


$$H(\omega) = \frac{1}{1 + j\omega RC}$$

$$|H(\omega)| = \frac{1}{\sqrt{1 + (\omega RC)^2}}$$

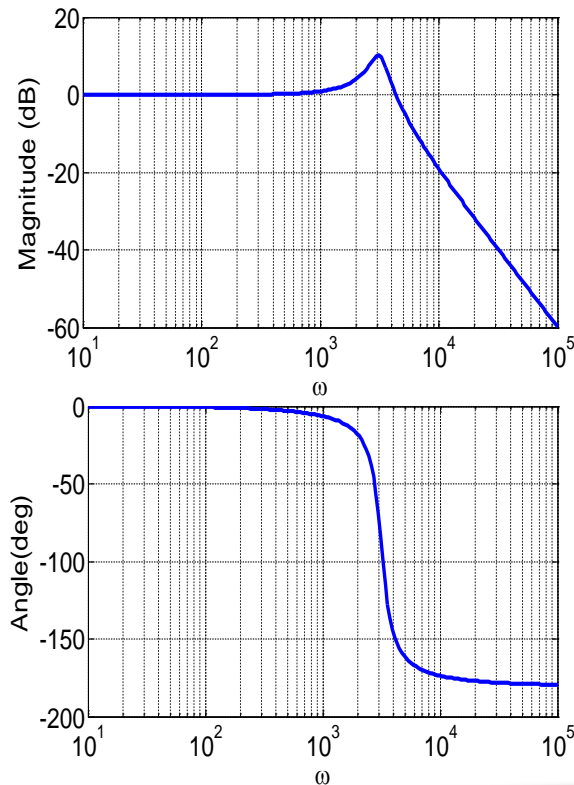
$$\angle H(\omega) = -\tan^{-1}(\omega RC)$$

Bode Plot of RLC Circuit, Overdamped



$$H(\omega) = \frac{1}{(1 - LC\omega^2) + RCj\omega}$$

Bode Plot of RLC Circuit, Underdamped



Summary

- A **frequency response** is a plot of the transfer function versus frequency
- The frequency response can be used to determine the steady-state sinusoidal response of a circuit at different frequencies