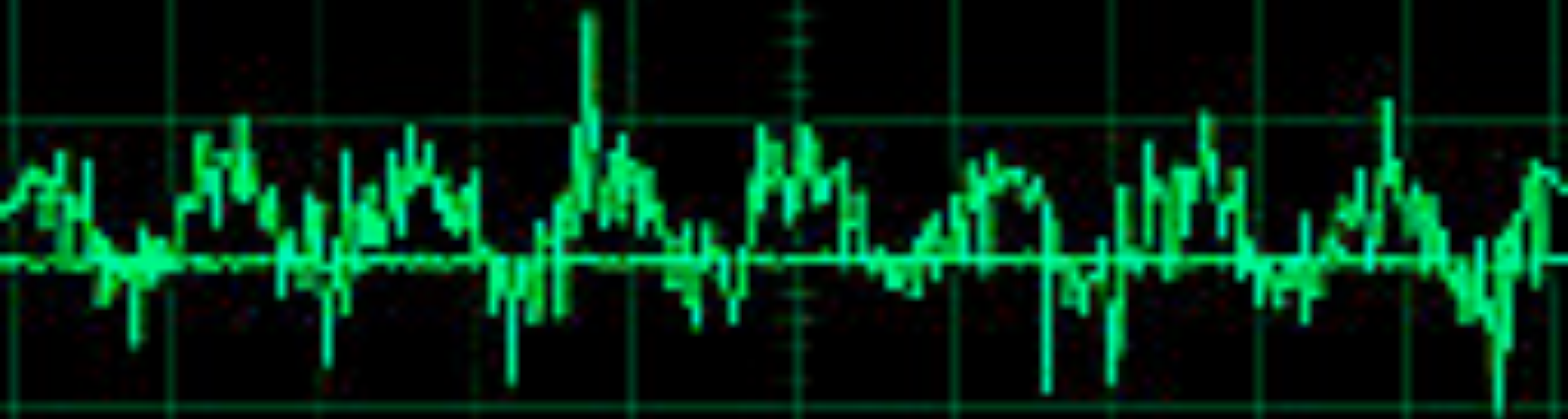
ECE 203 Circuits I



Lecture 2

Introduction and the Basics

Suggestions for Success

- *Keep current with the work; it's difficult to catch-up when you fall behind*
- *Work problems from the book, even ones I don't assign*
- *Read the Text- I won't cover everything in the lectures that is in the text, but will expect you to know everything; and, I try to discuss things a bit differently than the way it's done in the text*

Text book- Nilsson and Riedel: Electric Circuits

- 10^{th} edition

- **Basic Concepts**
- **Resistive Circuits**
- **Nodal & Loop Analysis Techniques**
- **Operational Amplifiers**
- **Additional Analysis Techniques**
- **Capacitance and Inductance**
- **First- and Second-Order Transient Circuits**
- **AC Steady-State Analysis**
- **Steady-State Power Analysis**

Course Objectives

- This course is intended to be an introduction to circuit theory.
- The main topics include: basic elements and sources, energy and power, Ohm's and Kirchhoff's laws, resistive networks, node and loop analysis, network theorems, first-order and second-order circuits, impedance, Phasors, three-phase circuits, and complex power.
- The main objective of this course is to provide you with the ability to analyze basic circuits; *i.e.,* find voltage and current as a function of time anywhere in a circuit.

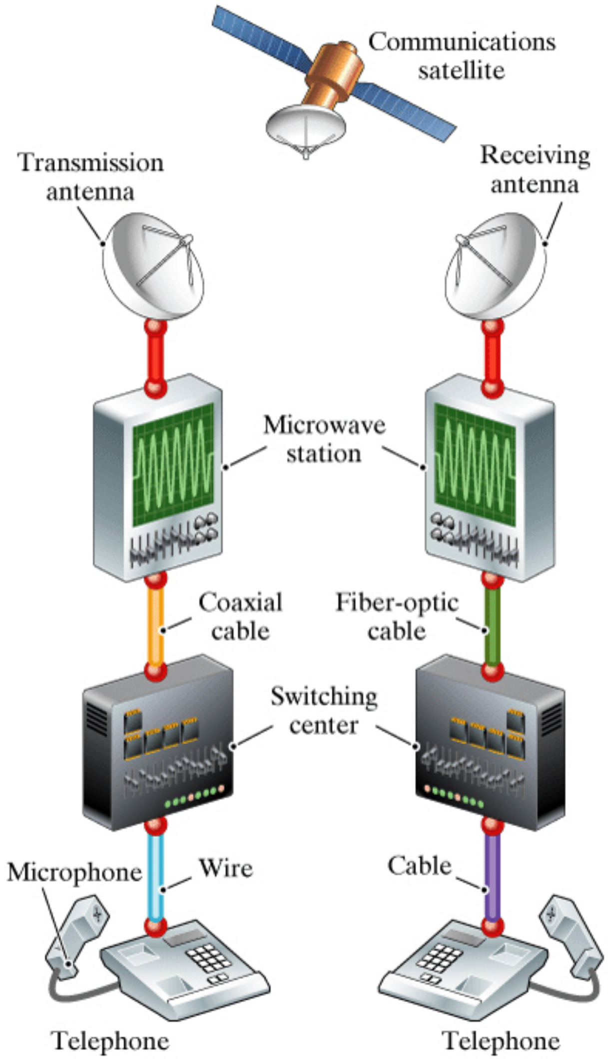
Basic Electrical Elements and Sources We Will Cover

- **<u>Elements</u>**
  - Resistors
  - Capacitors
  - Inductors
  - Transformers
- **<u>Sources</u>**
  - DC, AC, transient
  - Independent [Voltage or Current]
  - Dependent [Voltage or Current]

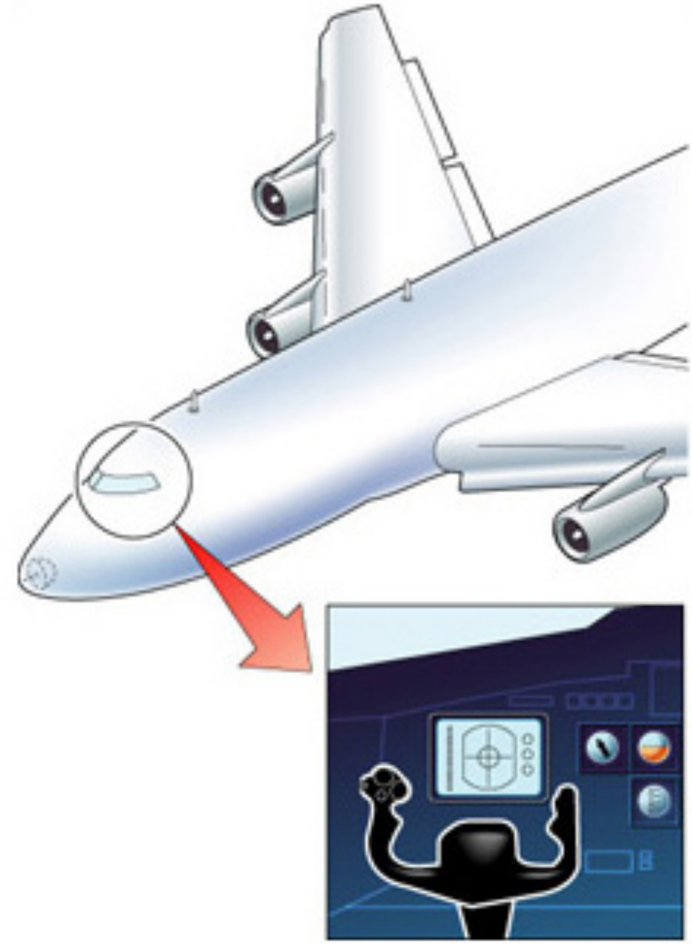
Electrical Engineering - Overview

Major classifications of electrical systems

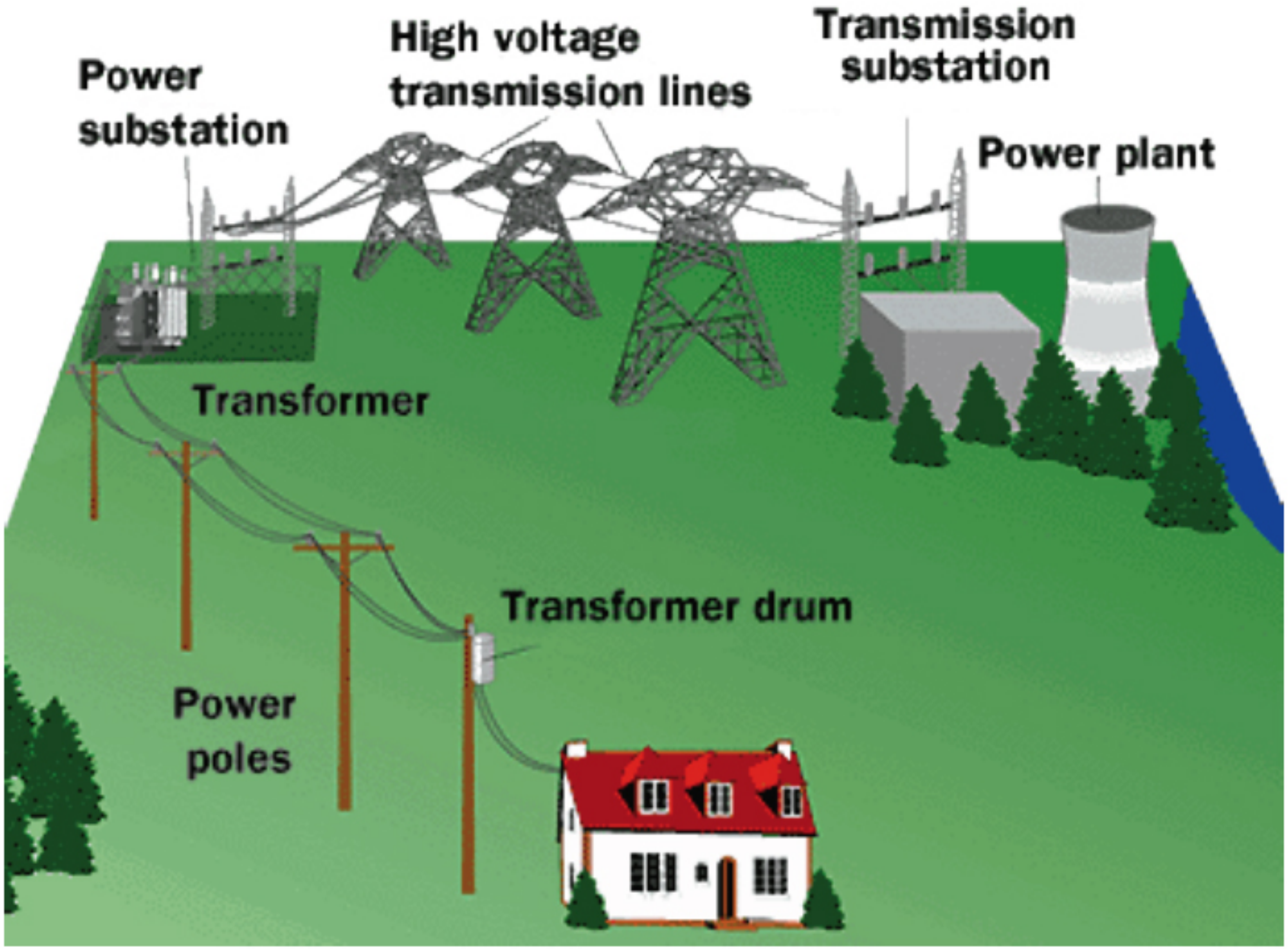
- communication systems (distribute information)
- computer systems (process information)
- control systems (regulate processes)
- power systems (generate and distribute power)
- signal-processing systems (transform information)



Communication systems.
generate and distribute information



Control systems
regulate processes

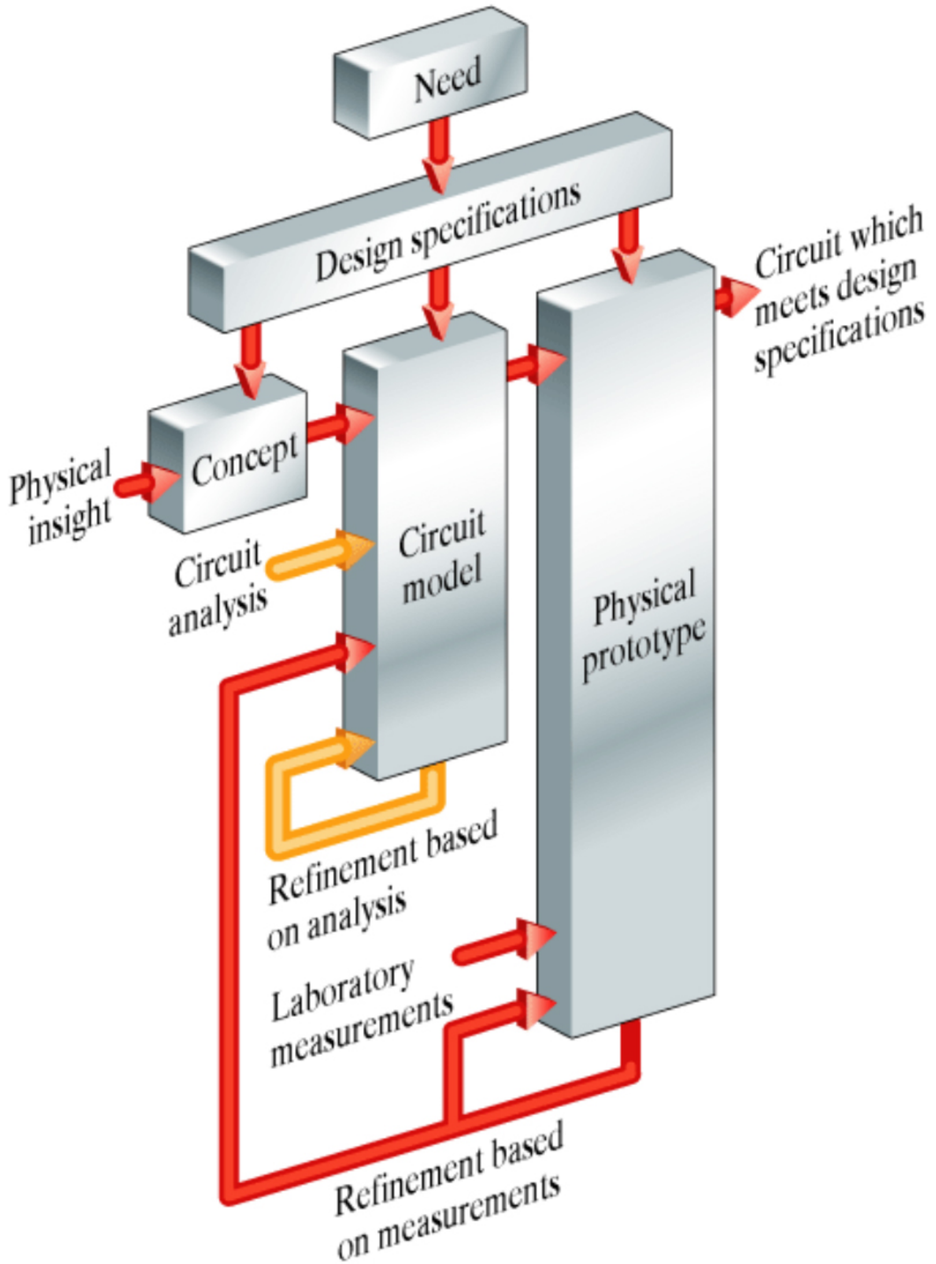


Power systems generate and distribute power

Circuit Design: An Overview

This is the basic idea of what electrical and computer engineers do.

We will learn the basics of the circuit model and analyze parts of this.



Circuit Theory

The term Electric Circuit can refer to a **real circuit** or a **model**.

In this class we typically mean **a model**

Basic Assumptions

1. **Electrical effects happen instantaneously throughout a system.** Electric signals travel at or near the speed of light. Thus, if the system is physically small, electric signals move through it so quickly that we can consider them to affect every point in the system simultaneously. A system that is small enough so that we can make this assumption is called a **lumped parameter system**

2. **The net charge on every component in the system is always zero.** Thus no component can collect a net excess of charge, although some components, as you will learn later, can hold equal but opposite separated charges.

3. **There is no magnetic coupling between the components in a system.** As we demonstrate later, magnetic coupling can occur within a component.

Definition of a Circuit

1) An interconnection of electrical components; and,

2) “Circuit” implies circulation; in other words, there must be a circular connected path in order for there to be an electrical circuit

Circuit Examples

Diagrams showing circuits and arrangements that are not circuits

Go to example 2-1

Charge Definition

Electric charge is the basis for all electrical phenomena.

Charge is bipolar. There are positive and negative charges.

Electric charge exists in discrete quantities, which are integral multiples of the charge of an electron, **1.6022×10^{-19} C** (Coulombs)

Electrical effects occur when **charges are separated** or **charges are in motion**.

Separation of charge creates an electric potential (VOLTAGE)

Motion of charge creates an electric fluid (CURRENT).

Charles Augustin de Coulomb
(1736 – 1806)

French physicist, pioneer in electrical theory, born in Angouleme. He served as a military engineer for France in the West Indies, but retired to Blois, France, at the time of the French Revolution to continue research in magnetism, friction, and electricity. In 1777 he invented the torsion balance for measuring the force of magnetic and electrical attraction. With this invention, Coulomb was able to formulate the principle, now known as Coulomb's law, governing the interaction between electric charges. In 1779 Coulomb published the treatise Theorie des machines simples (Theory of Simple Machines), an analysis of friction in machinery. After the war Coulomb came out of retirement and assisted the new government in devising a metric system of weights and measures. The unit of quantity used to measure electrical charges, the coulomb, was named for him.

Voltage

Voltage is the energy per unit charge created by the separation of charge. We express this ratio in differential form as:

DEFINITION OF VOLTAGE

$$v = \frac{dw}{dq}$$

Where:
v = the voltage in volts,
w = the energy in joules,
q = the charge in coulombs.

This equation is the definition for the **magnitude** of **voltage**.

The bipolar nature of electric charge requires that we also assign **polarity** to voltage.

Alessandro Volta
(1745-1827)

Alessandro Volta, Italian physicist, known for his pioneering work in electricity. Volta was born in Como and educated in the public schools there. By 1800 he had developed the so-called voltaic pile, a forerunner of the electric battery, which produced a steady stream of electricity. In honor of his work in the field of electricity, the electrical unit known as the volt was named in his honor.

Example: Voltage and Potential

If I have a 1 C charge located at a position where there is a potential of 1 V, and move it to a place where there is a potential of 5 V, how much energy must I expend to accomplish this?

Go to example 2-2

Current

When charges move they cause a CURRENT to flow. The size of the current depends on the rate of charge flow.

DEFINITION OF CURRENT

$$i = \frac{dq}{dt}$$

where
$\boldsymbol{i}$ = the current in amperes,
$\boldsymbol{q}$ = the charge in coulombs,
$\boldsymbol{t}$ = the time in seconds.

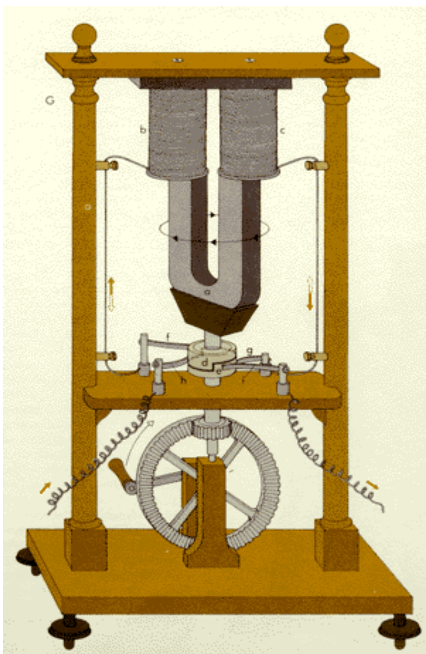
This equation is the definition for the **magnitude** of **current**.

The bipolar nature of electric charge requires that we also assign a **polarity to current**. In other words, we must specify in which direction it is going.

André-Marie Ampère

(1775-1836)

French mathematician and physicist who extended Oersted's results by showing that the deflection of a compass relative to an electrical current obeyed the right hand rule. Ampère argued that magnetism could be explained by electric currents in molecules, and invented the solenoid, which behaved as a bar magnet. Ampère also showed that parallel wires with current in the same direction attract, those with current in opposite directions repel. He dubbed the study of currents electrodynamics, and also developed a wave theory of heat. Ampère maintained that magnetic forces were linear, but this proposition was questioned and disproved by Faraday.



Ampere's Generator

Example: Current and Charge

How many electrons must pass a given point to make a current of 1 A?

Go to Example 2-3

Example: Current and charge Go to Example 2-4

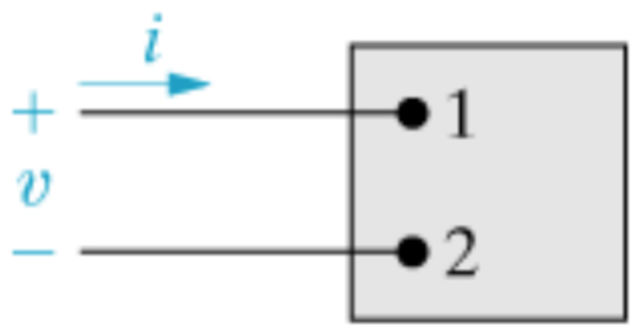
The current at the terminals of the circuit element in Fig. 1.5 is

$$i = 0, \qquad t < 0;$$

$$i = 20e^{-5000t}\,\text{A}, \quad t \geq 0.$$

Calculate the total charge (in micro-coulombs) entering the element at its upper terminal.

Figure 1.5. An ideal basic circuit element



Current Flow

Current is the motion of electrons (or possibly positive charge carriers)

Two ways used to describe current flow:

1) Conventional current flow- in a metallic conductor, current is in opposite direction to flow of electrons

   electrons $\longrightarrow$ current $\longleftarrow$

2) Electron current flow- in a metallic conductor, current is in the same direction as the flow of electrons

   electrons $\longrightarrow$ current $\longrightarrow$

Current flow continued

We will exclusively use conventional current flow, even though it’s not intuitive.

When describing a current, you must include a magnitude and the direction of the current flow.