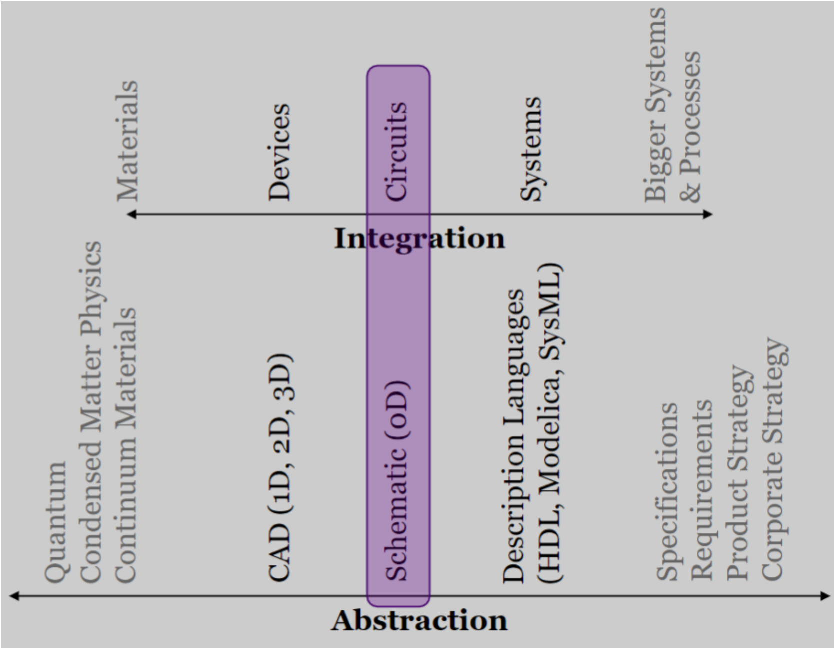
## Lecture 1: Intro & Context




## C1 Summary

- The International System of Units (SI) enables engineers to communicate in a meaningful way about quantitative results. Table 1.1 summarizes the base SI units; Table 1.2 presents some useful derived SI units. (See pages 30 and 31.)
- Circuit analysis is based on the variables of voltage and current. (See page 33.)
- **Voltage** is the energy per unit charge created by charge separation and has the SI unit of volt ($v = dw/dq$). (See page 34.)
- **Current** is the rate of charge flow and has the SI unit of ampere ($i = dq/dt$). (See page 34.)
- The **ideal basic circuit element** is a two-terminal component that cannot be subdivided; it can be described mathematically in terms of its terminal voltage and current. (See page 34.)
- The **passive sign convention** uses a positive sign in the expression that relates the voltage and current at the terminals of an element when the reference direction for the current through the element is in the direction of the reference voltage drop across the element. (See page 35.)
- **Power** is energy per unit of time and is equal to the product of the terminal voltage and current; it has the SI unit of watt ($p = dw/dt = vi$). (See page 37.)
- The algebraic sign of power is interpreted as follows:
  - If $p > 0$, power is being delivered to the circuit or circuit component.
  - If $p < 0$, power is being extracted from the circuit or circuit component. (See page 38.)

## CHAPTER 1: CIRCUIT VARIABLES

- linear circuits have no net power
- **power balances**: total power in circuit == 0

### 1.1 Electrical Engineering: Overview

- systems that produce/transmit/measure signals
- 5 major classifications
  - **communication** systems: generate/transmit/distribute information
  - **computer** systems: uses electric signals to process information
  - **control** systems: uses electric signals to regulate processes
  - **power** systems: generate & distribute electric power
  - **signal-processing** systems: acts on electric signals that represent information

**Circuit Theory**

special case of electromagnetic theory; study of static & moving electric charges

1. electrical effects are instantaneous throughout a system (near speed of light)

   **lumped-parameter system**: systems small enough that electrical effects can be assumed simultaneous

   - 1/10 of wavelength; $\lambda = \frac{c}{f} = \frac{3\times108(m/s)}{frequency(Hz)}$
2. net charge on every component in system is zero
3. no magnetic coupling between system components

**electric circuit**: math model that approximates behavior of an actual electric system

## 1.2 SI Units

| Prefix | Symbol | Power |
|---|---|---|
| atto | a | $10^{-18}$ |
| femto | f | $10^{-15}$ |
| pico | p | $10^{-12}$ |
| nano | n | $10^{-9}$ |
| micro | µ | $10^{-6}$ |
| milli | m | $10^{-3}$ |
| centi | c | $10^{-2}$ |
| deci | d | $10^{-1}$ |
| deka | da | $10^{1}$ |
| hecto | h | $10^{2}$ |
| kilo | k | $10^{3}$ |
| mega | M | $10^{6}$ |
| giga | G | $10^{9}$ |
| tera | T | $10^{12}$ |

| Quantity | Basic Unit | Symbol |
|---|---|---|
| Length | meter | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Thermodynamic temperature | degree kelvin | K |
| Amount of substance | mole | mol |
| Luminous intensity | candela | cd |

Derived Units

| Quantity | Unit Name (Symbol) | Formula |
|---|---|---|
| Frequency | hertz (Hz) | $s^{-1}$ |
| Force | newton (N) | $kg \cdot m/s^2$ |
| Energy or work | joule (J) | $N \cdot m$ |
| Power | watt (W) | $J/s$ |
| Electric charge | coulomb (C) | $A \cdot s$ |
| Electric potential | volt (V) | $J/C$ |
| Electric resistance | ohm (Ω) | $V/A$ |
| Electric conductance | siemens (S) | $A/V$ |
| Electric capacitance | farad (F) | $C/V$ |
| Magnetic flux | weber (Wb) | $V \cdot s$ |
| Inductance | henry (H) | $Wb/A$ |

## 1.3 Circuit Analysis: Overview

**ideal circuit component**: mathematical model of an actual electrical component

**circuit analysis**: uses math techniques to predict behavior of circuit model & its ideal circuit components

**physical prototype**: actual electric system

## 1.4 Voltage & Current

Important Characteristics of Electric Charge

- bipolar
- exists in discrete quantities (integer multiples of electronic charge, 1.6 x 10^19)
- attributed to both separation of charge & charges in motion

**Voltage**: energy per unit charge created by separation

$$V = \frac{dw}{dq} \tag{1.4.1}$$

V: voltage (V), w: energy (J), q: charge (C)

$1C = 6.242 \times 10^{18} charges$

$1V = 1\frac{J}{C}$

**electric current**: rate of charge flow

$$I = \frac{dq}{dt} \tag{1.4.2}$$

I: current (A), t: time (s)

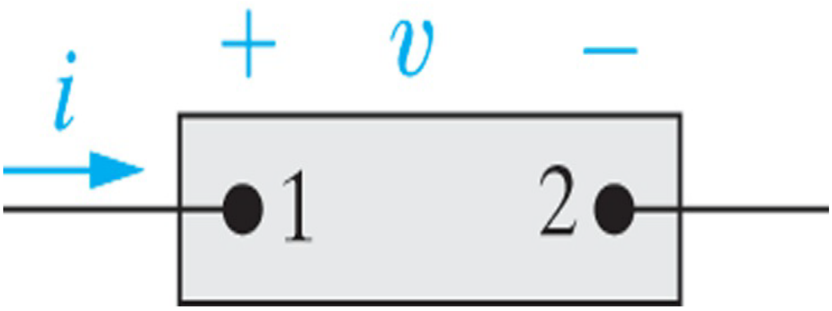
$1A = 1\frac{C}{s}$

- made up of discrete moving electrons; considered as one smooth flowing entity (continuous variable)

## 1.5 Ideal Basic Circuit Element

**ideal basic circuit element**:

1. only two terminals: point of connection to other circuit components
2. described mathematically in terms of current/voltage
3. cannot be subdivided




***passive sign convention**:

Whenever the reference direction for the current in an element is in the direction of the reference voltage drop across the element (as in Fig. 1.5), use a positive sign in any expression that relates the voltage to the current. Otherwise, use a negative sign.

- V @ terminal 1 minus V @ terminal 2
- i: charge from terminal 1 to terminal 2

*I-V characteristics (graph) for any unknown device

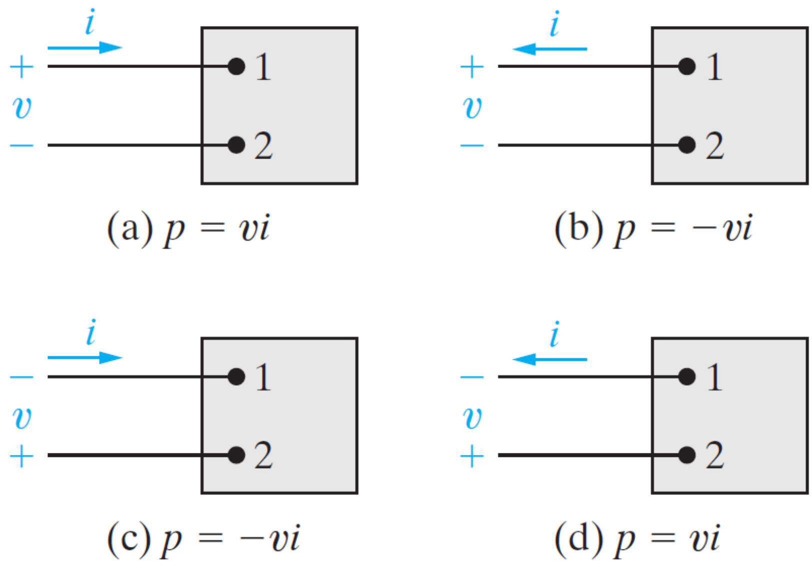
## 1.6 Power & Energy

**net**: lines with same voltage

$$P = \frac{dw}{dt} = (\frac{dw}{dq})(\frac{dq}{dt}) = V \times I$$

P: power (W), v: voltage (V), i: current(A)

1W = 1J/s




Interpreting **algebraic sign of power**: If the power is positive (that is, if p > 0), power is being delivered to the circuit inside the box. If the power is negative (that is, if p < 0), power is being extracted from the circuit inside the box.