

Introduction to Circuits & Signals

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- Electrical engineering deals with systems that produce, transmit, and measure electrical signals
 - Electrical signals: Mostly voltages and currents
 - Electrical components: Resistors, capacitors, inductors, etc.
 - * Resistor — Opposes the flow of current
 - * Capacitor — Stores the energy in electrical fields by storing charge to generate voltage
 - * Inductor — Stores energy in magnetic fields when current flows through it
- Communication systems deal with the generation, transmission, and distribution of information (Cable-TV, cellphone networks, old dial-up networks, radio telescopes, radar systems)
- What is an electric circuit?
 - A complete or partial path over which current may flow
 - Electric circuits consist of elements (voltage sources, current sources, resistors, capacitors, inductors, etc.)
 - Electrons move in the conductors (wires, elements) in a circuit, giving current flow
 - Can have moving electrons (-) or moving holes (+); protons and neutrons are immobile
- Measurements
 - Voltmeter — Measure voltage without drawing current
 - Ammeter — Measures current without dropping voltage
- The unit of charge is Coulomb (C)

- Charge can either be positive or negative
 - The fundamental (smallest) quantity of charge is that of a single electron or proton. Its magnitude usually is denoted by the letter e (1.6×10^{-19} C)
 - According to the law of conservation of charge, the (net) charge in a closed region can neither be created nor destroyed
 - Two like charges repel one another, whereas two charges of opposite polarity attract
- Current flows in the direction opposite of electron flow
 - $I = JA$, where A is the cross-sectional area of a conductor, J is the current density, and I is the current
 - $J = neu$, where n is the density of charges, e is the smallest magnitude of charge, and u is the velocity of the electrons
 - Voltage and Current
 - Voltage (V) is the electric potential difference of a point (in a circuit) relative to some other point (in the circuit)
 - In a resistor: V, I, and R are related by Ohm's Law, where Resistance (R) is the electrical resistance to current flow

$$V = IR$$

- Resistance
 - To calculate the resistance, we can use the formula $R = \frac{l}{\sigma A} = \rho \frac{l}{A}$, in ohms Ω