Module 2

Lecture: Voltage, Current and Power

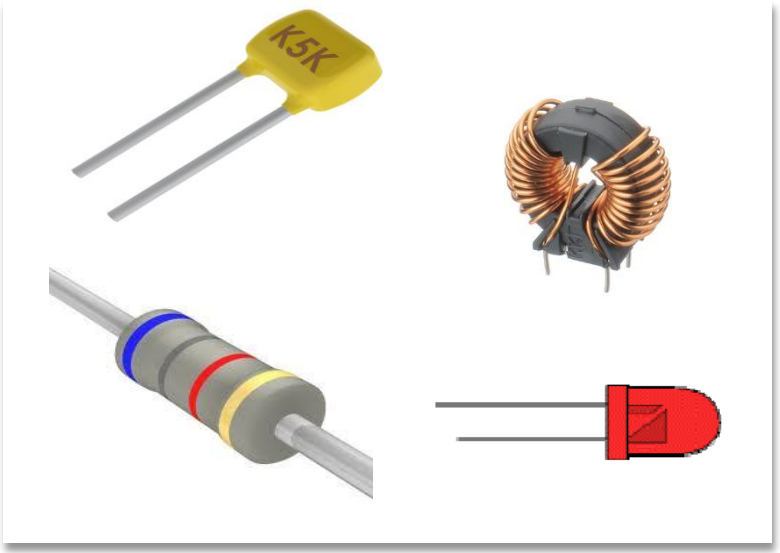
Voltage, Current and Power

You will learn in this module

- Electrical Engineering Terms
  - Voltage, V (volts)
  - Current, I (amps)
  - Energy, E (joules)
  - Power, P (watts)

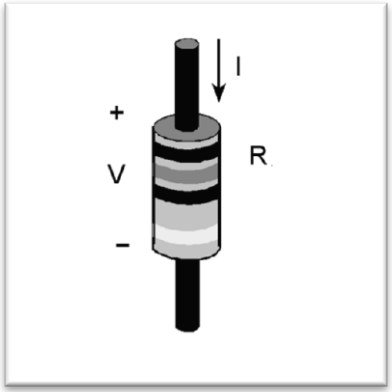
- Electrical Engineering Devices
  - Resistors
  - Capacitors
  - Inductors
  - LEDs

- Test Equipment
  - Voltmeter, ohmmeter, current meter
  - Oscilloscope



Current

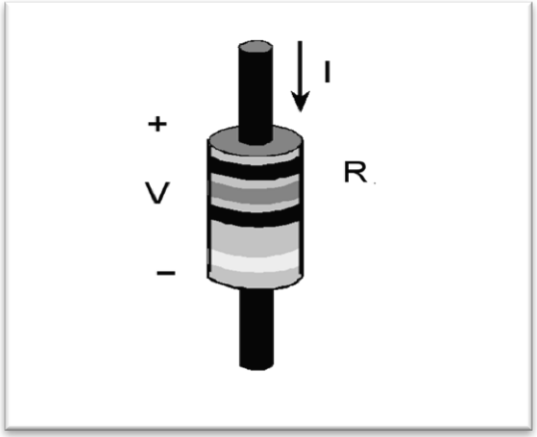
- Definition of Current
  - Current is caused by motion of electrons
  - Symbol is **I, measurement unit is Ampere or Amps**
  - 1 ampere (A) is 6.241×10^{18} electrons per second
  - Current of 1A = one coulomb of charge per second
- Properties
  - Directional, along a path or wire
  - Stimulates muscles and nerves
  - Drive motors of your robot
  - Follows Ohm's Law (V= IR)
- Measurements
  - Current inside a circuit can be measured with a meter
  - Voltage across a know resistor V = I*R



MSP432 can source/sink up to 6 mA

Voltage

- Definition of voltage
  - Voltage is caused by potential difference between two points
  - Symbol is V and is measured in Volts
  - Electromotive force or potential to produce current
- Properties
  - Always measured as a difference
  - Signed, directional causes current to flow
  - Battery used to drive motors of your robot
  - Follows Ohm’s Law
- Measurements
  - Voltmeter measures DC and AC voltage
  - Oscilloscope measures voltage changes as function of time (V v/s t)



MSP432 can output 0V or 3.3V

Energy and Power

- Definition of energy
  - Amount of storage, for battery specification
  - Units of energy are joules(J=volts*amps*time)
  - E=1J delivers 1V at 1A for 1 second

- Batteries
  - Constant voltage
  - Rated in amp-hour

- Power
  - Rate of change of energy
  - P = V*I
  - Units of power are watts=J/sec = volts*amps
  - Conversions: electrical, optical, mechanical, thermal, acoustic

MSP432 requires 5mA at 3.3 V

AA alkaline battery has 2 A-h at 1.5V

Power budget:

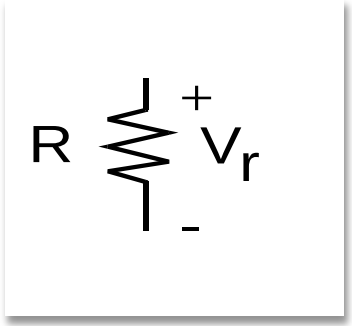
Two AA alkaline batteries will power an MSP432 for 16 days, 2000 mA-h = 5mA*400h

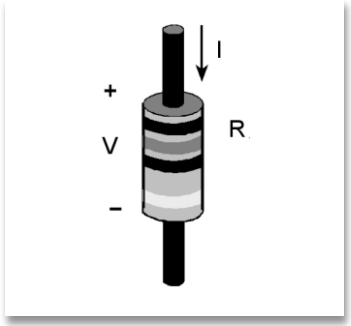
Resistor

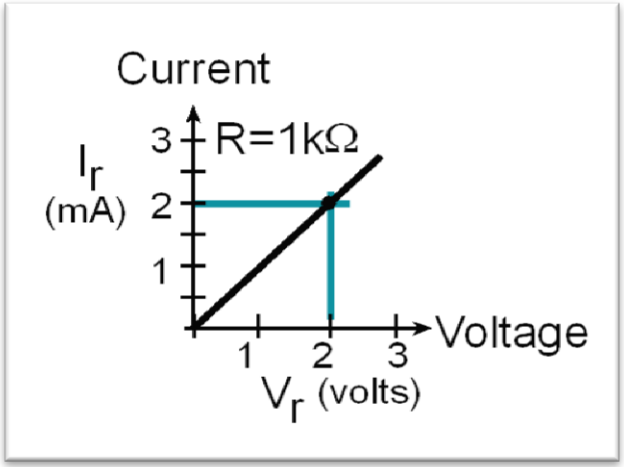
- Definition of resistor
  - Passive device with a linear V-I relationship
  - Resistance is measured in R, in Ohms (Ω)
  - Follow's Ohm's Law

- Parameters
  - Tolerance, e.g**., 5% (1000 Ω ± 5%)**
  - Maximum power, wattage (¼ watt = 250 mW)
  - For a V= 2 V, I = 2 mA, P = 2 * 2 mA = 4 mW

- Applications
  - Used to limit or control current
  - Used in circuits to effect gain, offset, frequency response

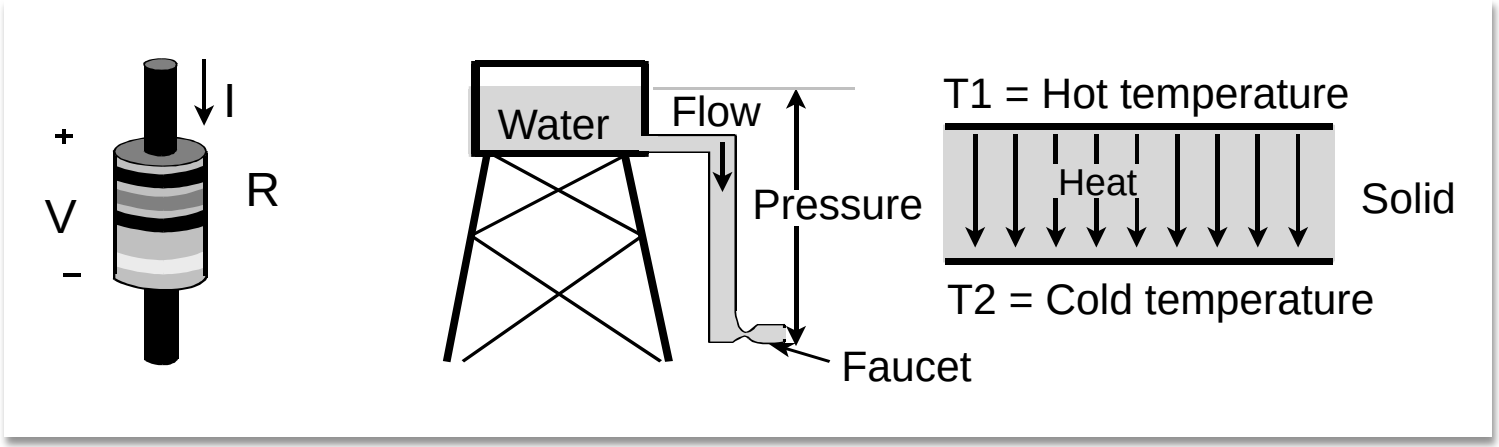






Analogy

- Current = Voltage/Resistance
- Fluid Flow = Pressure/Resistance
- Heat Flow = Temperature/Resistance

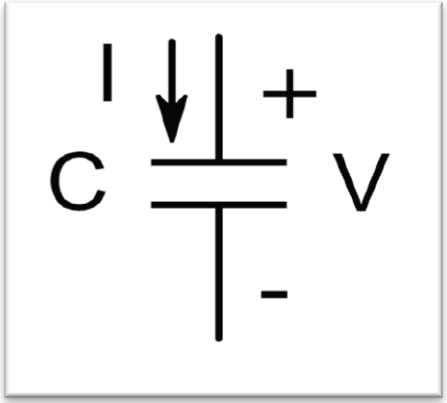


Capacitor

- Definition of capacitor
  - Passive device that can store charge
  - Complex impedance, Z = 1/(j2πfC)
  - Open circuit at DC
  - Allows current at AC
  - Reactance, |V|/|I| ≡ X = 1/(2πfC)

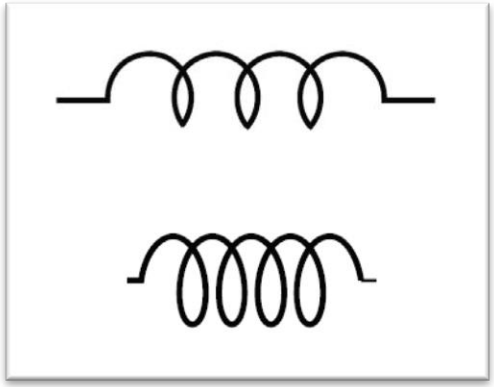
- Parameters
  - Capacitance, C, in farads (F)
  - Tolerance, e.g., 5%
  - Maximum voltage
  - Type, e.g., ceramic, tantalum

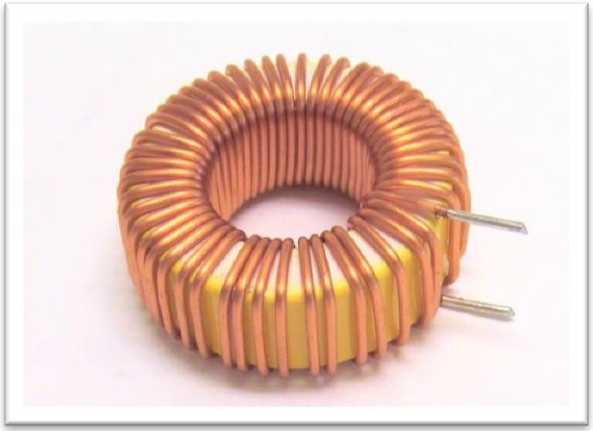
- Applications
  - Used as temporary storage of energy
  - Used in circuits to effect frequency response
  - Used to reduce noise in circuits



Inductor

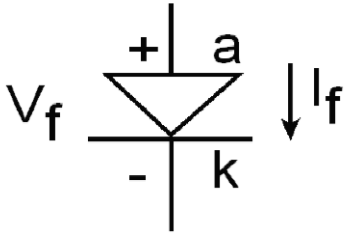
- Definition of inductor
  - Passive device build with coiled wire
  - Complex impedance V/I ≡ Z = j2πfL
  - Closed circuit at DC
  - Resists current at AC
- Parameters
  - Inductance, L, in Henries (H)
- Applications
  - Used as to build DC motors

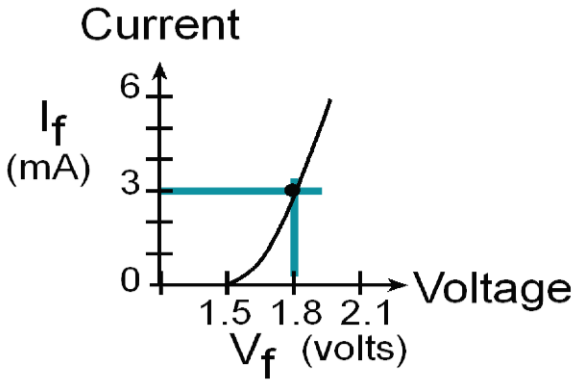




Light Emitting Diode

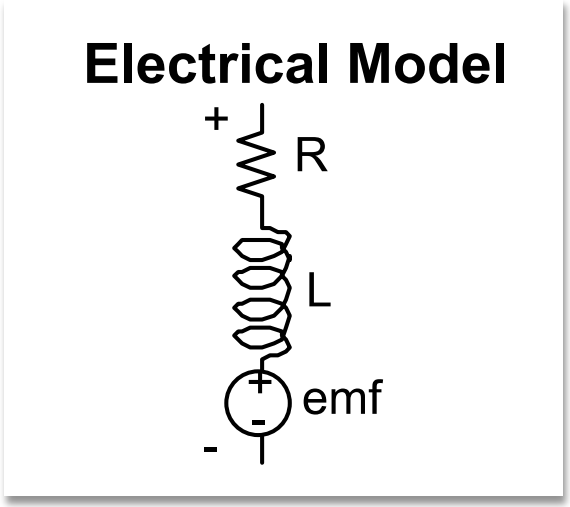
- Definition of LED
  - Semiconducting device that can emit light
  - Electrical power => optical power
  - Conducts in one direction only
- Parameters
  - Voltage, current
  - Efficiency, brightness
  - Size
- Applications
  - Lights, displays, sensors
  - Isolation circuits, fiber optics





DC motor

- Definition of DC Motor
  - Electromechanical device
  - Electrical power => mechanical power
  - Spins in both directions
- Parameters
  - Voltage, current
  - Efficiency, torque
  - Size, weight
- Applications
  - Robot actuator

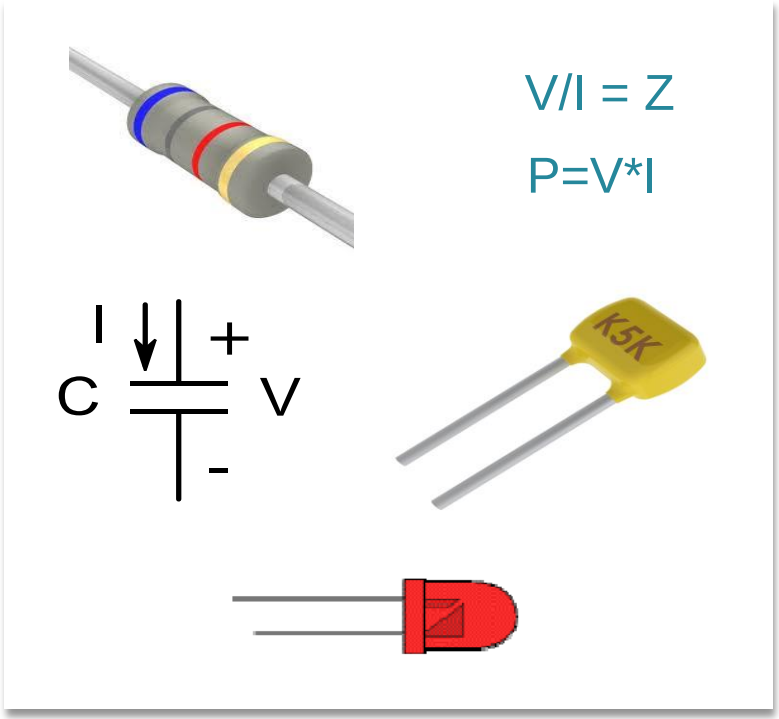


- Resistance, R
- Inductance, L
- emf, V

Voltage, Current, Power

Summary

- Resistors
  - Voltage, current, power
  - Ohm's Law, V=I*R
- Capacitors
  - Voltage, current
  - Reactance, X =1/(2πfC)
  - Impedance, Z =1/(j2πfC)
- Inductors
  - Voltage, current
  - Impedance, Z =j2πfL
- LEDs
  - Voltage, current, power
  - Unidirectional
  - Nonlinear



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