Resistors

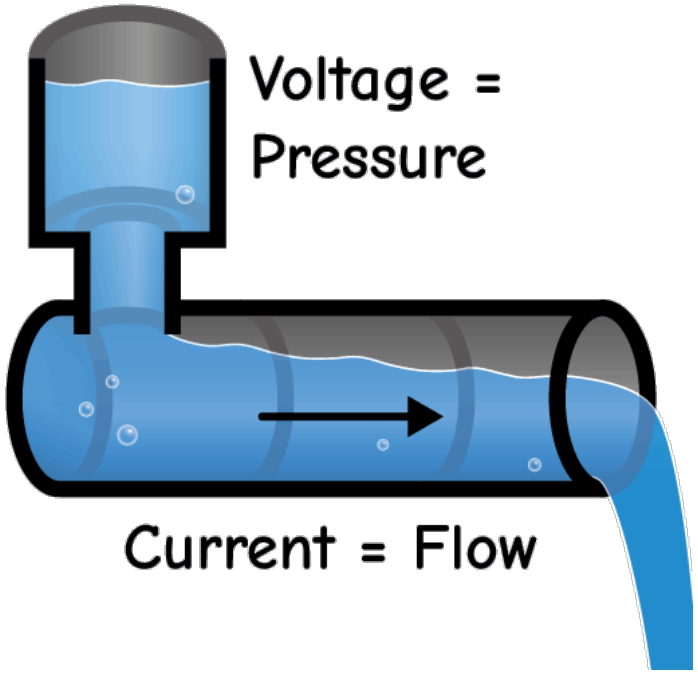
Resistance

- Resistance is the opposition to current flow
- It has the symbol R with the unit Ohm (Ω)

Analogy

- Like a **narrow pipe** restricting water flow.

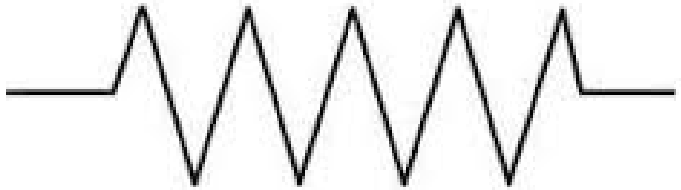
- Factors affecting resistance:
  - Material (copper vs rubber)
  - Length (longer wire = more resistance)
  - Thickness (thicker wire = less resistance)
  - Temperature (hotter wire = more resistance)



What is a resistor

- A resistor is an electrical component that opposes the flow of electric current.
- It creates a voltage drop when current passes through it.
- Resistance is measured in ohms (Ω).
- Purpose: to control current, divide voltages, and protect components.

As per IEC standard



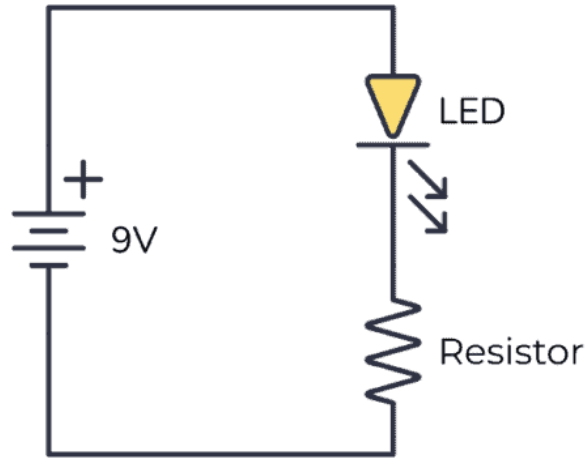
As per American Standard

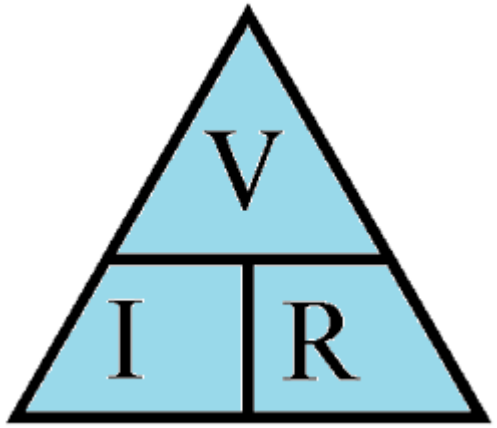
Function of a Resistor

- **Current Limiting**
- **Voltage Division**
- **Signal Conditioning**
- **Heat Dissipation**

Current Limiting

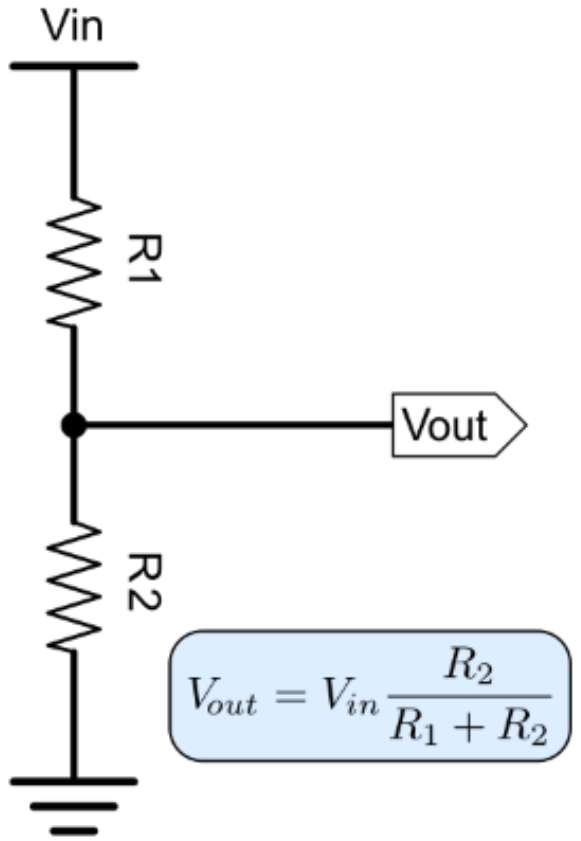
- **Purpose:** Protect components from excessive current.
- **Example:** LEDs need current limiting to prevent burning out.
- **How it Works:** The resistor restricts current according to Ohm's Law
- **Typical Application:** Resistor in series with an LED.
- **Key Point:** Without a resistor, sensitive components can be damaged.





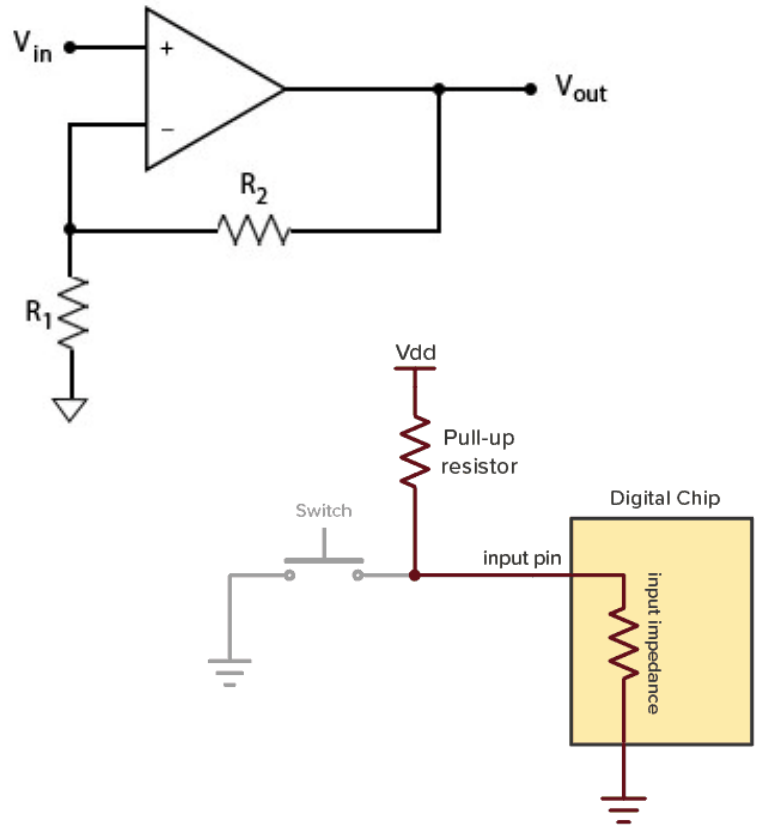
Voltage Divider

- **Purpose:** To split an input voltage into a smaller output voltage.
- **Circuit:** Two resistors in series across a supply.
- **Applications:**
  - Sensor circuits (e.g. LDRs, thermistors)
  - Reference voltages
  - Scaling signals for measurement



Signal Processing

- **Biasing:** Set operating points in amplifiers (e.g. transistor base bias).
- **Pull-up/Pull-down:** Ensure logic inputs default to a known state (0 or 1).
- **Filtering (with capacitors):** Form RC low-pass or high-pass filters. Control which frequencies are allowed through.
- **Impedance Control:** Match circuit stages to prevent signal loss or distortion.



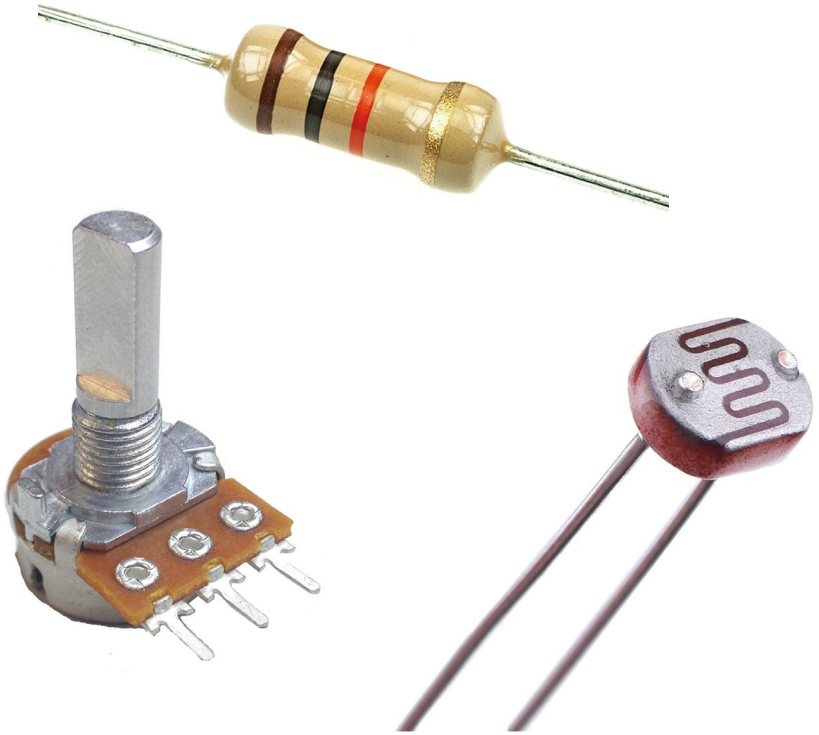
Heat Dissipation

- **Why it matters:** Resistors convert unwanted electrical energy into heat.
- **Power Rating:**
  - Small resistors: ¼ W – 1 W
  - Wirewound resistors: up to 100 W+
- **Applications:**
  - Used as heaters (to burn off excess power)
  - Protection in high-current circuits
- **Key Point:** Always choose a resistor with a power rating higher than expected dissipation.

$$P = VI = I^2R = \frac{V^2}{R}$$

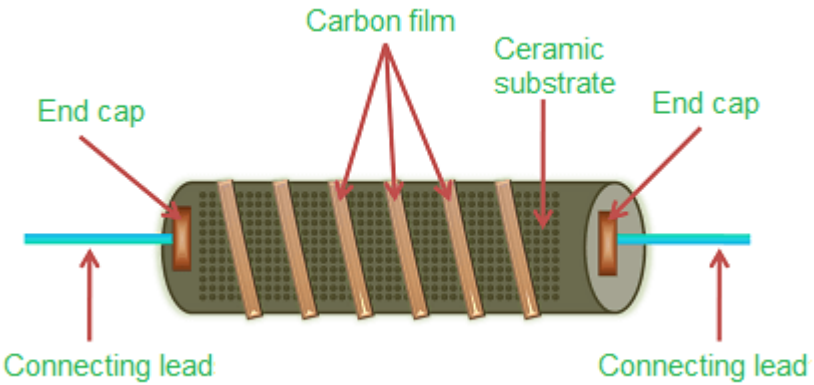
Types of Resistors

- We can divide resistors 3 main ways:
  - **Fixed**
    - Carbon Film
    - Metal Film
    - Wire Wound
  - **Variable**
    - Potentiometer
    - Rheostats
  - **Special variable resistors**
    - LDR
    - Thermistor
    - Varistor



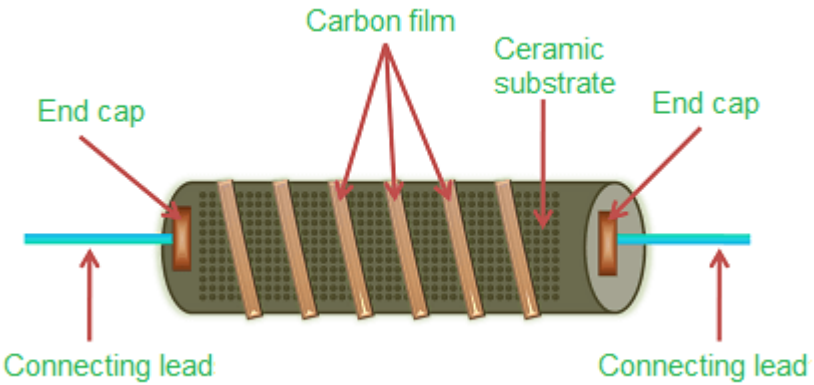
Carbon Film Resistors

- **Construction**: A thin film of carbon deposited on an insulating substrate.
- **Resistance Value**: Controlled by the thickness and length of the carbon film.
- **Power Rating**: Typically, low to medium (¼ W to 2 W).
- **Tolerance**: Around ±5% (standard), but can be tighter.



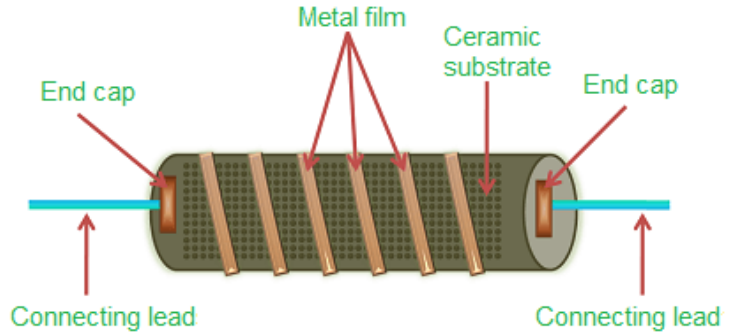
Carbon Film Resistors

- **Advantages:**
  - Cheap and widely available
  - Good stability for general use
- **Limitations:**
  - Higher noise than metal film resistors
  - Not suitable for high precision applications



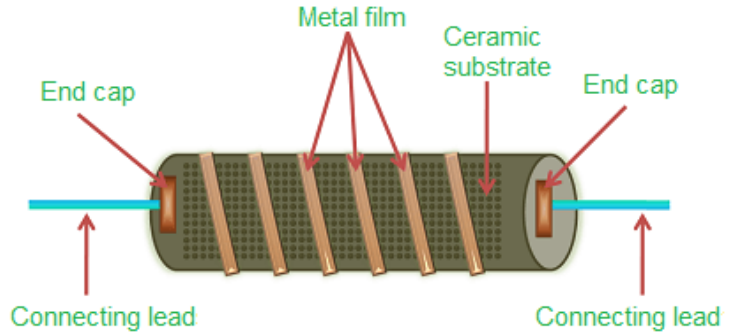
Metal Film Resistors

- **Construction**: Thin layer of metal (often nickel-chromium) deposited on a ceramic rod.
- **Resistance Value**: Adjusted by cutting a helical groove in the film.
- **Power Rating**: Typically low (⅛ W to 1 W).
- **Tolerance**: Very precise, often ±1% or better.



Metal Film Resistors

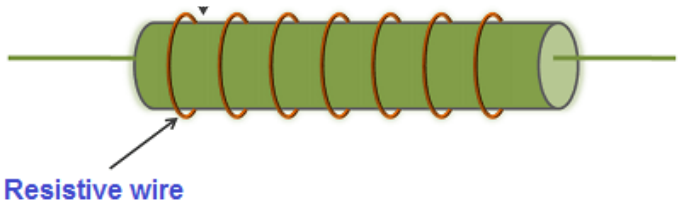
- **Advantages**:
  - High accuracy and stability
  - Low noise compared to carbon film
  - Good temperature performance



- **Limitations**:
  - Slightly more expensive than carbon film
  - Limited to low–medium power applications

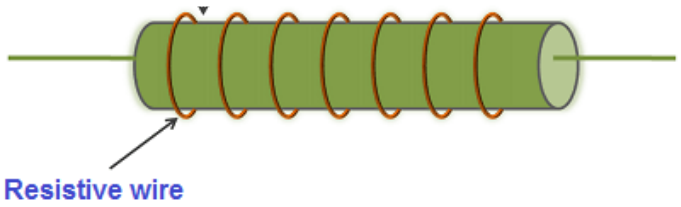
Wire wound Resistors

- **Construction:** Resistive wire (usually nichrome) wound around a ceramic or fiberglass core.
- **Resistance Value:** Determined by the length and thickness of the wire.
- **Power Rating:** High – can handle several watts to hundreds of watts.
- **Tolerance:** Precise, typically ±1% or better.

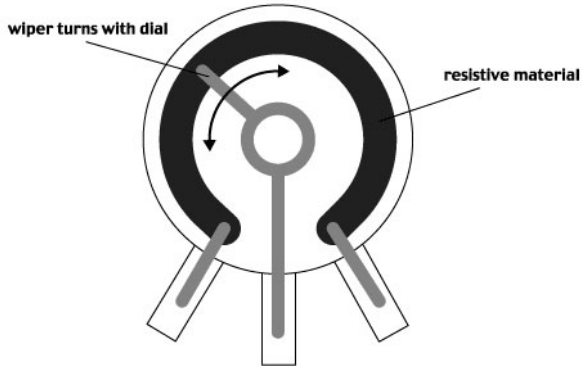


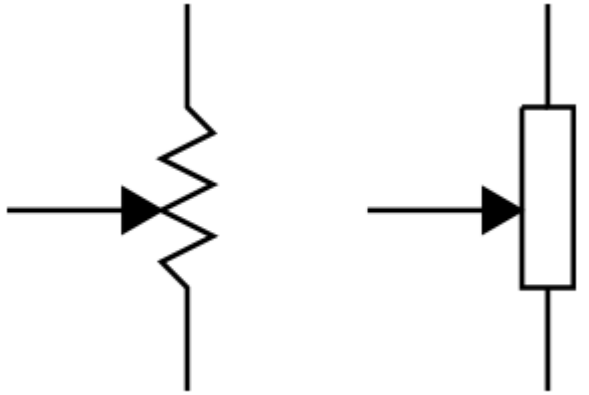
Wire wound Resistors

- **Advantages:**
  - Excellent stability and accuracy
  - Can dissipate large amounts of power
  - Low temperature coefficient
- **Limitations:**
  - Larger physical size
  - Inductive properties (not ideal for high-frequency circuits)
  - More expensive than film resistors



Potentiometers





- **Potentiometer (3 terminals):**
  - Adjustable resistor with a wiper.
  - Used as a voltage divider (all 3 terminals).
  - Common in volume knobs, sensor calibration, etc.

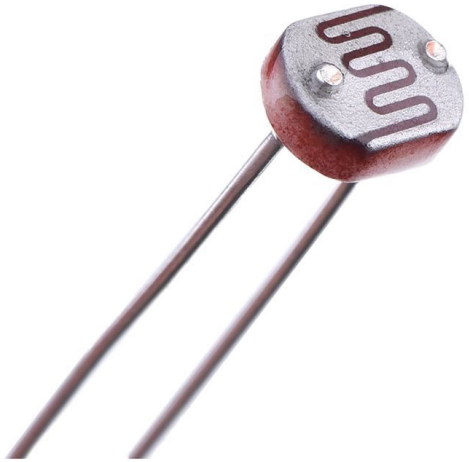
- **Rheostat (2 terminals):**
  - Potentiometer used as a variable resistor.
  - Controls current directly.
  - Common in lamp dimmers, motor speed control.

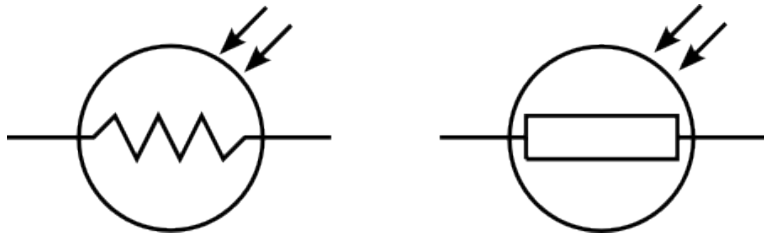
- **Types:**
  - Rotary (knob style)
  - Linear (slider style)

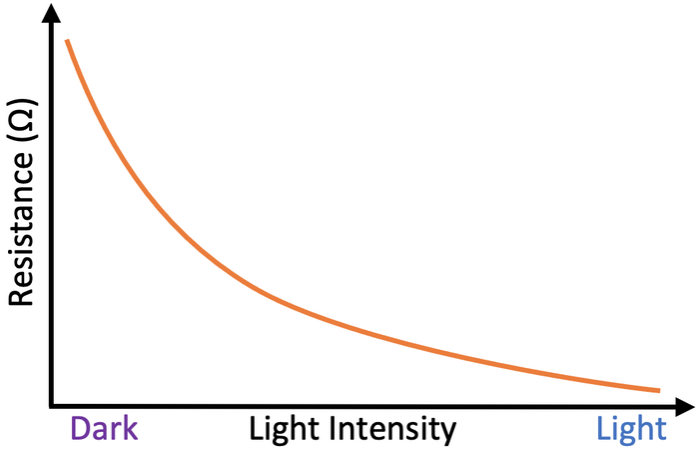
Light Dependent Resistors (LDRs)

- **Definition:** A special type of variable resistor whose resistance changes with light intensity.

- **Behaviour:**
  - Bright light → low resistance
  - Darkness → high resistance







- **Applications:**
  - Automatic street lights
  - Light meters (cameras)
  - Solar garden lights

- **Key Point:** Often used in a voltage divider to convert light levels into a voltage signal.

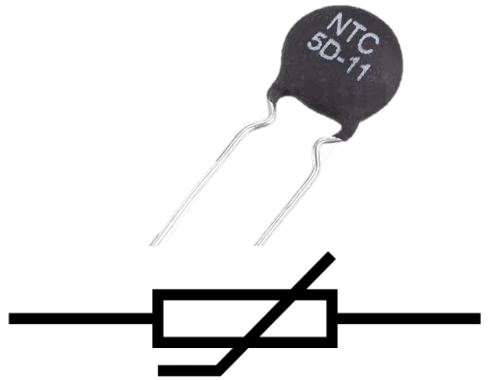
Thermistor

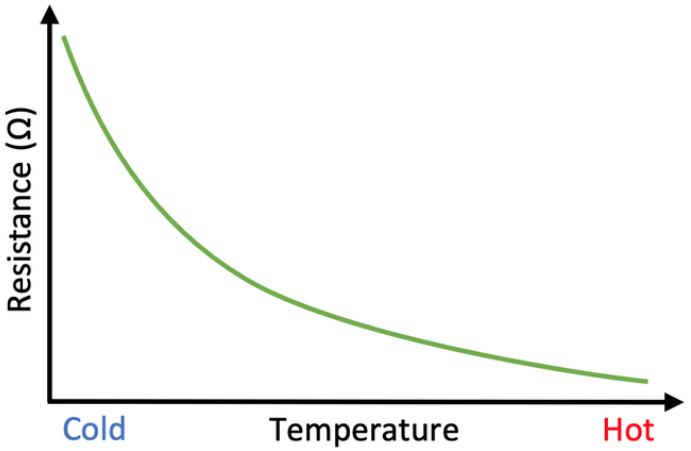
- **Definition:** A type of resistor whose resistance changes with temperature.

- **Types:**
  - NTC (Negative Temperature Coefficient): Resistance decreases as temperature increases. Common in temperature sensors.
  - PTC (Positive Temperature Coefficient):Resistance increases as temperature increases. Used in resettable fuses and overcurrent protection.

- **Applications:**
  - Digital thermometers
  - Temperature compensation in circuits
  - Overheat protection in power supplies

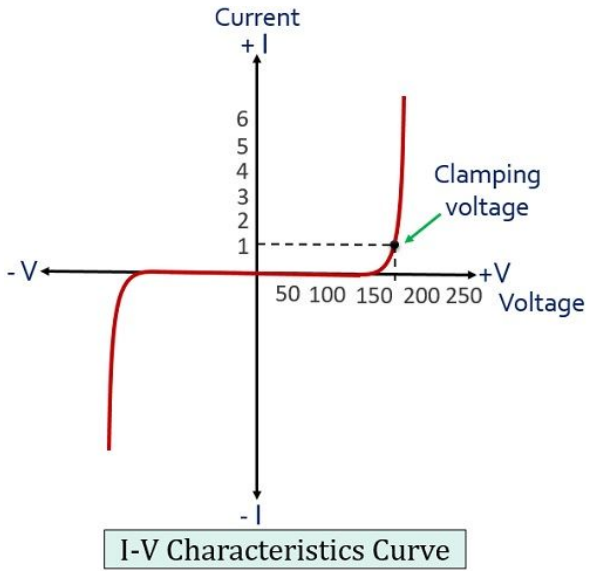
- **Key Point:** Often used in a voltage divider like an LDR but responds to heat instead of light.





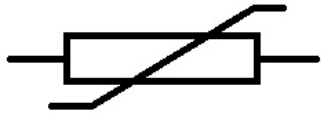
Varistor

- **Definition:** A resistor whose resistance changes with applied voltage.
- **Common Type:** MOV (Metal Oxide Varistor).
- **Behaviour:**
  - At normal voltages → very high resistance (almost open circuit).
  - At high voltages → resistance drops sharply, clamping the voltage.
- **Applications:**
  - Surge protection (e.g. in power strips, appliances).
  - Protecting circuits from voltage spikes (lightning, switching surges).
- **Key Point:** Acts like a safety valve – only conducts when voltage exceeds a set threshold.



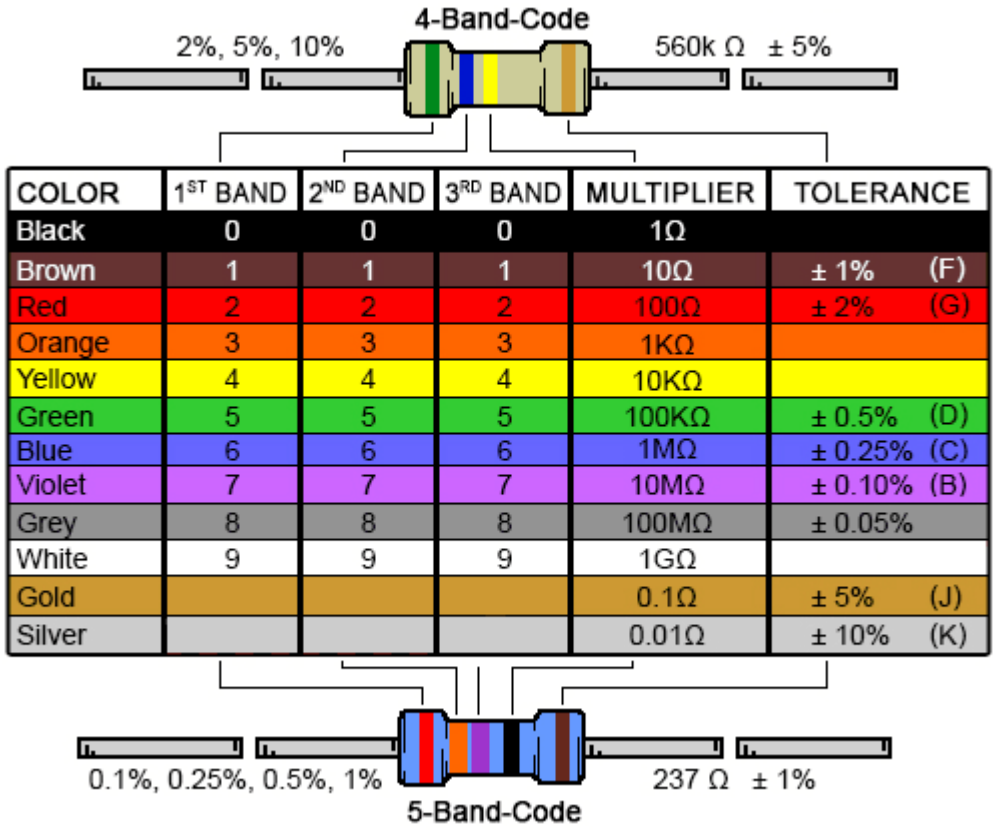
I-V Characteristics Curve


IEEE Standard Symbol for Varistor


IEC Standard Symbol for Varistor

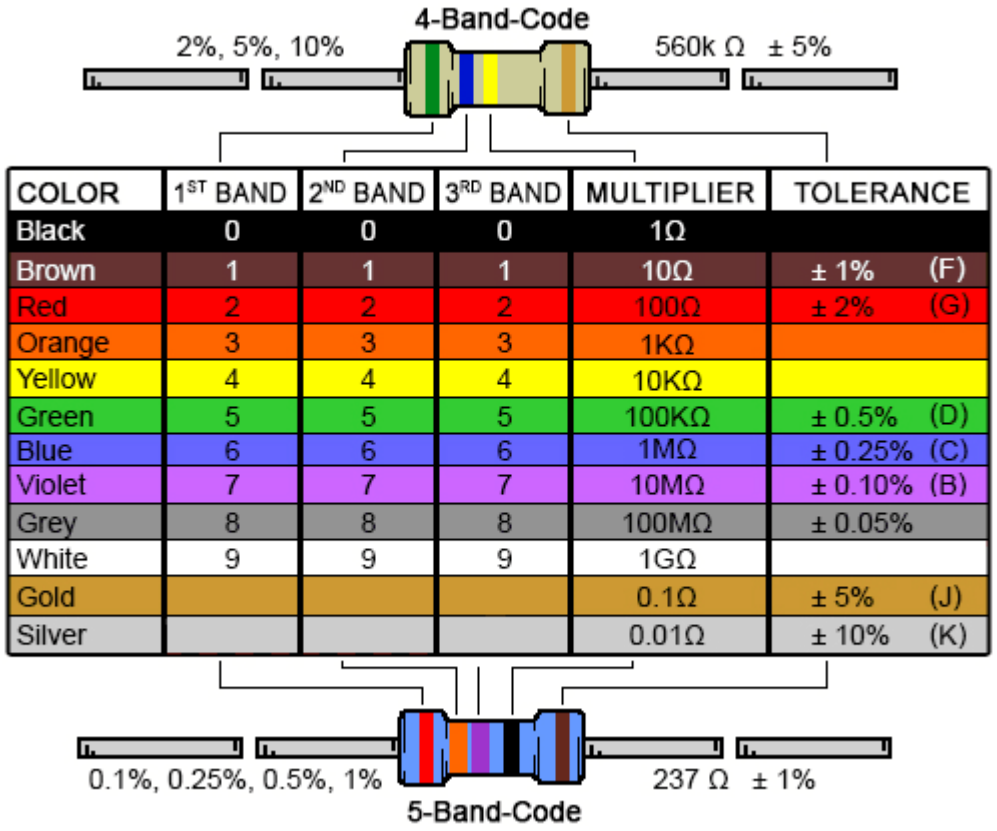
Identifying Resistors

- **Resistor Colour Code:**
  - Each band represents a number or multiplier.
  - Final band = tolerance (gold = ±5%, silver = ±10%).
- **Other Identifiers:**
  - Marked values (printed on some precision resistors).
  - Case size indicates power rating (¼ W, ½ W, etc.).



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Identifying Resistors - Example



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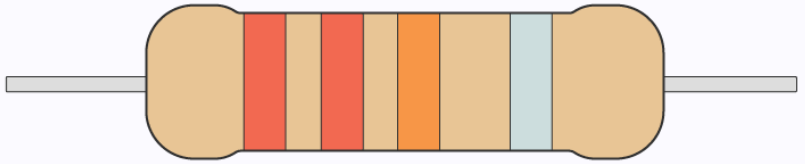

Red	Red	Orange	Silver
2	2	10^3	±10%

22000 Ω ±10%