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| |  | | --- | |  |   **🧠 Crowbar vs Clamp**   * **Crowbar**: Once triggered, it pulls voltage down to near zero and stays latched until power is removed. * **Clamp**: Limits voltage to a preset level but doesn’t shut down the circuit entirely.   **🔄 Active Crowbar Variant**  Some advanced designs use **transistors or GTO thyristors** that can **automatically reset** after the transient is gone. These are common in high-reliability systems like **wind turbines** or **industrial converters** |

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AI 產生的內容可能不正確。

Circuit protection is essential for keeping electrical systems safe and reliable. Besides the **crowbar circuit**, there are several other types of protection methods, each designed to guard against specific faults like overcurrent, overvoltage, short circuits, and ground faults.

**🔌 Common Circuit Protection Methods**

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| **Protection Method** | **Function** | **Typical Use Cases** |
| **Fuses** | Melt when current exceeds a safe level, breaking the circuit | Household appliances, automotive systems |
| **Circuit Breakers** | Mechanically trip to interrupt current flow during overload or short | Residential panels, industrial equipment |
| **Surge Protection Devices (SPDs)** | Clamp high-voltage spikes to safe levels | Power strips, telecom systems |
| **Metal Oxide Varistors (MOVs)** | Absorb voltage spikes by changing resistance | AC mains protection, lightning arrestors |
| **Thermal Circuit Breakers** | Use heat to trip the breaker during overload | Motor control, HVAC systems |
| **Ground Fault Circuit Interrupters (GFCIs)** | Detect imbalance in current flow and shut off power | Bathrooms, kitchens, outdoor outlets |
| **Residual Current Devices (RCDs)** | Similar to GFCIs, used in European systems | Residential and commercial buildings |
| **Electronic Current Limiters** | Actively monitor and limit current flow | Power supplies, battery chargers |
| **Reverse Polarity Protection** | Prevent damage from incorrect power connections | DC circuits, battery-powered devices |
| **TVS Diodes (Transient Voltage Suppressors)** | Clamp fast voltage transients to protect sensitive components | Data lines, microcontrollers |

**🧠 Bonus Insight**

Each method has its own strengths:

* **Fuses** are simple and cheap but need replacement.
* **Circuit breakers** are reusable and more versatile.
* **MOVs and TVS diodes** are great for fast, transient protection.
* **GFCIs/RCDs** are lifesavers—literally—when it comes to preventing electric shock.