



Fundamentals of Power Supplies

Key Terminology

AC (Alternating Current)	The type of electrical current supplied by wall outlets. Power supplies convert AC to DC.
DC (Direct Current)	The type of electrical current required by computer components. Power supplies provide DC voltage.
Watt (W)	Unit of power, calculated as Volts x Amps. Indicates the amount of power a component requires or a PSU can deliver.
Volt (V)	Unit of electrical potential difference. Common voltages in PCs are 3.3V, 5V, and 12V.
Ampere (A)	Unit of electrical current. Indicates the amount of current flowing through a circuit.
Efficiency	The ratio of output power to input power, expressed as a percentage. Higher efficiency means less wasted energy.

Power Supply Form Factors

ATX (Advanced Technology Extended)	The most common form factor for desktop PCs. Standard size and mounting configuration.
SFX (Small Form Factor)	Smaller form factor used in compact PCs. Often found in Mini-ITX builds.
TFX (Thin Form Factor)	Slim form factor designed for low-profile cases and small systems.
EPS (Entry-Level Power Supply Specification)	Primarily used in servers and high-end workstations. Provides more power and additional connectors.

Key Voltages and Rails

+12V Rail	Supplies power to the CPU, GPU, and some storage devices. Critical for modern PCs.
+5V Rail	Powers USB ports, older components, and some SSDs.
+3.3V Rail	Supplies power to RAM, motherboard chipset, and some SSDs.
-12V Rail	Used by older serial ports and some legacy components. Less critical in modern systems.
+5Vsb (Standby)	Provides power to the motherboard for standby functions, such as wake-on-LAN and USB charging when the system is off.

Selecting the Right Power Supply

Wattage Calculation

- Determine Component Power Requirements:**
 - CPU:** Check the TDP (Thermal Design Power) in the CPU specifications.
 - GPU:** Consult the GPU manufacturer's website for power requirements.
 - Motherboard:** Estimate around 25-50W.
 - RAM:** Typically 5-10W per module.
 - Storage:** SSDs use 5-10W, HDDs use 10-20W.
 - Peripherals:** USB devices can draw up to 2.5W each.
- Sum Up Total Power:** Add all individual component power requirements to get the total system power draw.
- Add Headroom:** It's recommended to add 20-30% headroom for future upgrades and to ensure stable operation.

$$\text{Total Wattage} = (\text{Component Power Sum}) * 1.2 \text{ or } 1.3$$

Efficiency Certifications (80 Plus)

80 Plus certifications guarantee a certain level of efficiency at different load percentages (20%, 50%, and 100%). Higher certifications indicate better efficiency and less wasted energy.

- 80 Plus:** 80% efficiency at 20%, 50%, and 100% load.
- 80 Plus Bronze:** 82% efficiency at 20% and 100% load, 85% at 50% load.
- 80 Plus Silver:** 85% efficiency at 20% and 100% load, 88% at 50% load.
- 80 Plus Gold:** 87% efficiency at 20% and 100% load, 90% at 50% load.
- 80 Plus Platinum:** 90% efficiency at 20% and 100% load, 92% at 50% load.
- 80 Plus Titanium:** 92% efficiency at 20% and 100% load, 94% at 50% load.

Modular vs. Non-Modular

Non-Modular	Cables are permanently attached to the PSU. More affordable but can lead to cable clutter.
Semi-Modular	Some cables are fixed, while others can be detached. Offers a balance between cost and cable management.
Fully-Modular	All cables can be detached, allowing for maximum customization and clean cable management. Generally more expensive.

Connectors and Pinouts

Common Connectors

24-pin ATX Connector	Main connector for the motherboard, supplying power to most components.
4/8-pin CPU Power Connector (EPS 12V)	Supplies dedicated power to the CPU. High-end motherboards often use an 8-pin connector or an 8+4 pin combination.
6/8-pin PCIe Connector	Provides power to the graphics card. Higher-end GPUs may require two 8-pin connectors.
SATA Power Connector	Powers SATA-based storage devices (SSDs, HDDs) and some optical drives.
Molex Connector	Older connector type used for some fans, peripherals, and older hard drives. Less common in modern systems.
Floppy Connector (Berg Connector)	Used to power floppy drives. Rarely used in modern systems.

Pinout Basics (ATX 24-pin)

Understanding the ATX 24-pin connector pinout helps in troubleshooting and custom builds. Here are some key pins:

- **+3.3V:** Orange wires
- **+5V:** Red wires
- **+12V:** Yellow wires
- **Ground (GND):** Black wires
- **-12V:** Blue wire
- **+5VSB (Standby):** Purple wire
- **Power Good (PS_ON):** Green wire (connect to ground to turn on the PSU manually for testing)

Troubleshooting and Maintenance

Common Issues

- **System won't turn on:** Could be a dead PSU, a faulty power switch, or a motherboard issue. Check the power cord and connections first.
- **System shuts down randomly:** Overheating, insufficient wattage, or a failing PSU can cause this. Monitor temperatures and check PSU load.
- **Blue screen errors (BSOD):** Can be caused by unstable power delivery. Check PSU voltages and replace if necessary.
- **Strange noises (clicking, buzzing):** Indicates a failing fan or internal component. Replace the PSU immediately.
- **Overheating:** Dust accumulation or a failing fan can cause the PSU to overheat. Clean the PSU regularly and ensure proper ventilation.

Testing a Power Supply

1. Paperclip Test (Basic Functionality):

- Disconnect the PSU from all components.
- Use a paperclip to short the green wire (PS_ON) to a black wire (ground) on the 24-pin ATX connector.
- If the fan spins, the PSU is likely functioning, but this doesn't guarantee stable voltage output under load.

2. Multimeter Testing (Voltage Levels):

- Connect the PSU to a load tester or a spare motherboard.
- Use a multimeter to measure the voltages on the +3.3V, +5V, and +12V rails.
- Voltages should be within $\pm 5\%$ of their nominal values.
 - +3.3V: 3.14V - 3.47V
 - +5V: 4.75V - 5.25V
 - +12V: 11.4V - 12.6V

3. PSU Tester:

- Use a dedicated PSU tester to check all voltage rails and detect any potential issues. These testers often have LCD displays for easy reading.

Maintenance Tips

- **Regular Cleaning:** Use compressed air to remove dust from the PSU fan and vents every 3-6 months.
- **Check Cables:** Ensure all power cables are securely connected to the PSU and components.
- **Monitor Temperatures:** Keep an eye on PSU temperatures, especially during heavy usage.
- **Surge Protection:** Use a surge protector or UPS (Uninterruptible Power Supply) to protect the PSU from voltage spikes and power outages.
- **Avoid Overloading:** Do not exceed the PSU's rated wattage. Leave sufficient headroom for future upgrades.