Low-voltage power supply buying guide (portable mains-powered)

This guide does not cover specialised power supplies such as High Tension (HT) and Extra High Tension (EHT) supplies, or stabilised power supplies specifically designed for advanced work with electronics.

For use by students up to GCSE

Feature	Essential	Desirable	Points to consider
AC/DC outputs	DC	Both	Some practical work needs AC, eg transformers.
Output connections	4-mm plug sockets		
Voltage range	0-12 V		Max safe voltage 40 V DC, 28 V AC.
Varying the voltage	Yes – fixed voltage steps sufficient	Continuously variable	Continuously variable supplies are generally more expensive – a few are useful for demos.
Digital voltage display		Can be useful	Can be used instead of an external voltmeter in some experiments.
Lock maximum voltage	Yes		See Explanatory notes below.
Overload protection	Yes		Various designs: see Explanatory notes below. Do you need a power supply at all? Using zinc-carbon batteries for work with circuits will limit the current available and reduce the risk of burns.
Smoothed		Yes	Unsmoothed power supplies are unsuitable for electronics circuits and general-purpose DC voltmeters and ammeters will give incorrect readings.
Regulated (or stabilised)		Yes	Poorly regulated power supplies can be a nuisance.
Linear or switch mode	Either	Either	Switch mode power supplies are usually cheaper and lighter than comparable output linear power supplies.

For use by teachers and students at A-level

Feature	Essential	Desirable	Points to consider
AC/DC outputs	Both		
Output connections	4-mm plug sockets		
Voltage range	0-12 V	0-40 V DC	Max safe voltage 40 V DC, 28 V AC.
Varying the voltage	Yes – continuously variable		
Digital voltage display		Yes	Can be used instead of an external voltmeter in some experiments
Lock maximum voltage	No	No	
Overload protection	Yes		Various designs: see Explanatory notes.
Smoothed	Yes		
Regulated (or stabilised)	Yes		Poorly regulated power supplies can be a nuisance.
Linear or switch mode	Either	Either	Switch mode power supplies are usually cheaper and lighter than comparable output linear power supplies.

Feature	Explanatory notes
For further guidance and information about training refer to the CLEAPSS website: www.cleapss.org.uk	
AC and DC	AC outputs are essential for work on transformers, and to teach pupils about the difference between AC and DC using an oscilloscope.
Output connections	Output connections should be 4-mm sockets, most common for bench circuits.
Voltage Range	Most general low-voltage supplies give 0-12 V.
Varying the voltage	Power supplies where the voltage is varied in discrete steps eg 2 V, 4 V, 6 V etc are usually suitable for most practical activities. For finer control of voltage (and corresponding current), a variable resistor can be included in the circuit. Continuously variable supplies are more expensive but provide infinitely variable output voltages (up to the maximum for the supply), with no need for additional variable resistors in the circuit.
Digital voltage display	More expensive supplies may display the voltage output so a separate voltmeter is not needed. The displays can be vandalised and are expensive to replace.
Output voltage and current	For circuit activities (eg low power electric motors and filament lamp ray boxes), 15 volts or even 12 volts may be adequate. A maximum output of 5 amps should also be enough. Higher output current risks circuit wires overheating and insulation burning, eg with a short circuit.
Locked max voltage	The output voltage can be locked to a maximum set by the teacher. Without this function students may adjust the output voltage to a lot higher than the required rating. Components may be damaged. This can be dangerous and components may be expensive to replace.
Overload protection	The power supply output must tolerate indefinite short circuits. The output can be protected by fuses, circuit breakers (cutouts or trips), or electronic circuits to limit the current. **Fuses** are best avoided because replacement is a nuisance. **Circuit breakers (cut-outs or trips):** Thermal circuit breakers do not trip with brief overloads, but may take time before they can be reset. Circuit-breaker switches flip when the breaker is activated, and are restored by resetting the switch. **Current limiting output protection** is convenient. The circuit reduces the output voltage and current when the output is overloaded, keeping the power supply within safe working limits. You may not notice the output is overloaded if there is no indicator. Some advanced power supplies have adjustable output current limit.
Smoothed	When AC is converted to DC using just diodes, the output voltage isn't constant – it is a pulsed waveform. Smoothing capacitors reduce pulsing to a negligible level. Inductors reduce electrical 'noise' from switching circuits. Capacitors and inductors in a switch mode power supply are smaller than in a comparable output linear power supply.
Regulated (or stabilised)	Output voltage is reasonably constant no matter what the output current, up to the maximum current output. Some power supplies have circuits to maintain good regulation. Not essential for low-voltage work, but a poorly-regulated power supply can be a nuisance.
Linear or switch mode	**Linear** (Traditional low-voltage power supply): Mains voltage is stepped down by a transformer and rectified for DC output. The output may or may not be smoothed. These supplies tend to be heavier, bulkier, and run warmer than switch-mode designs, but are easier to repair.
	Switch mode: Typically the mains voltage is changed to a much higher frequency; this is applied to the step-down transformer and rectified to produce a DC output. Output voltage is regulated by feedback to the input frequency changing circuit. If the feedback circuit fails, the supply can fail with the output voltage going high. The input may be protected by a fuse rather than the output. This fuse must be replaced with the correct value. If the fuse repeatedly blows, the supply has failed.

Other considerations

Repair	Technicians considering repair should check their employer's policy. Most linear low-voltage supply repairs involve electrical connections eg soldering, crimping, etc. Replacement of components and other repairs need a technician with expertise, tools and time. If mains cables are replaced, take care to put back hoods over connections and to clamp the cable. After any repair, earth bonding and insulation must be tested using a portable-appliance tester. Switch mode power supplies are more difficult to repair, particularly if an electronic component has failed and there is no circuit diagram.
Weight	Avoid moving heavy/bulky low-voltage supplies between laboratories. Mass and dimensions are reported for each supply. Have enough sets to avoid continual movement. Store low-voltage supplies on dedicated trolleys, one trolley for each floor. There may be little bench space per pupil pair. Small low-voltage supplies help.
Use of batteries instead of power supplies	Zinc carbon or alkaline batteries are better than rechargeable batteries for circuit work. Short circuits produce lower currents, and less risk of burns, with non-rechargeable batteries. Batteries limit maximum voltage, preferable for delicate components such as thermistors, LDRs and analogue meters. Replacing batteries is cheaper than replacing these delicate components.

See Technical Notes on following page.

Technical notes

AC and DC

AC and DC stand for Alternating Current and Direct Current (direct in this context meaning one-way).

An AC voltage is where the polarity of the output alternates periodically. A DC voltage is where the polarity of the output doesn't change. With a DC power supply, the current from the supply flows in one direction; in an AC power supply, the current reverses periodically.

A battery is an example of a DC power supply. Household mains is an example of an AC power supply.

In an AC power supply, the number of times the polarity of the output reverses in one second is called the frequency and is measured in Hertz (Hz).

In the most common AC power supplies, the output voltage varies like a sine wave (called sinusoidal). Mains electricity in the UK is sinusoidal with a frequency of 50 Hz.

Sinusoidal AC 

Constant DC from a battery 

Rectification

Rectification is the process of converting AC into DC. In a power supply circuit this is done with diodes. After rectification the current flows in one direction, but not steadily. Voltage varies over time as a series of pulses; this can be shown on an oscilloscope.

Rectified DC 

Smoothing

Pulsing DC voltage from a rectified supply can be evened out or 'smoothed' by capacitors.

Smoothed DC 

Regulated

A regulated power supply output voltage is not affected greatly by the range of current it is designed to supply.

With the power supply at 6 volts output up to 5 amps, output will stay at 6 volts whatever current flows, up to 5 amps.

With an unregulated supply, the voltage tends to drop as the current increases. See Internal resistance below. Regulated power supplies have little internal resistance up until the maximum output current.

Internal resistance

This is the resistance of the power supply itself. The output voltage from a power supply will drop as more current flows in the circuit. This can be a nuisance if the teacher is demonstrating that when more bulbs are added to a parallel circuit the brightness stay the same (with an unregulated supply it doesn't!).

However internal resistance is a property of many power supplies, and it is often part of post-16 physics courses.

Safe voltages for bench circuit work

Effects of an electric current on the human body depend on the path taken, but 5 mA is normally below the harm threshold. The size of the current depends on the resistance of the path, including the skin, so it is impossible to specify a definitive maximum safe voltage. Lower voltages can be hazardous in exceptional circumstances; CLEAPSS (and the ASE) have adopted the safe limits of 28 V AC / 40 V DC for bench circuit work by pupils in school laboratories. This is based on practical experience and likely worst-case scenarios.

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