What is a Power Supply?

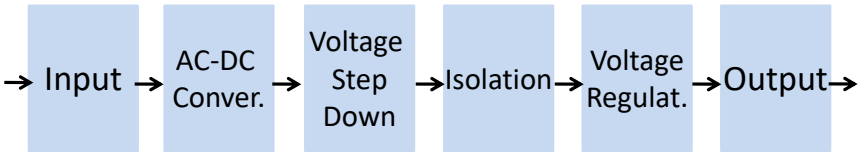
- Power converters – change electrical quantity from one form to another:
  - AC-DC (rectifier)
  - DC-DC (chopper)
  - DC-AC (inverter)
  - AC-AC (ac voltage controller, cyclo-converter)
- A power supply may consist of a combination of power converters to provide a power source for a load. Almost all electronic equipment need a power supply
- In addition to the need for a certain power rating of a voltage level, there could be other requirements, such as regulated output, and isolation
- Attributes (features) of the power supply you are to design: safe (to use); efficient; reliable; and economical. And other attributes if you would like to add

Various Power Supplies

- Isolated (electrical separation between input and output) v.s. non-isolated
- Open frame v.s. closed frame (closed box)

Functional Structure of a Power Supply

- Input: 120V, ac (60Hz)
- Output: 15V, 30W, dc, regulated (constant volt), isolated
- Functions: ac-dc conversion; isolation; voltage step down; voltage regulation; input; output.



- The structure of the design may be different

Power Supply Specifications

- Input voltage range (the maximum voltage and minimum voltage limits that the power supply can accept while still has rated output)
- Output voltage – nominal voltage (fixed, or variable in a range, or multiple values)
- Efficiency: $\eta=P_{out}/P_{in}$ X 100%; $P_{out}=P_{in}-P_{loss}$
- Line regulation: $VR_{Line}=(V_{out@Vinmax}-V_{out@Vinmin})/V_{out@rated}$ X 100%
- Load regulation: $VR_{Load}=(V_{out@maxLoad}-V_{out@minLoad})/V_{out@rated}$ X 100%
- Other features: remote sensing (voltage regulate at the load site instead of the output terminals)
- Cooling and thermal management: natural, force air (fan), conduction
- Protection functions: over-current, over-temperature, auto-restart
- Standards and certification

Types of Power Supply

- Unregulated
  transformer + rectifier + filter
- Linear regulated
  Zener diode
  Linear regulator ICs
- Switching regulated
  Switched-mode power supply
- Others

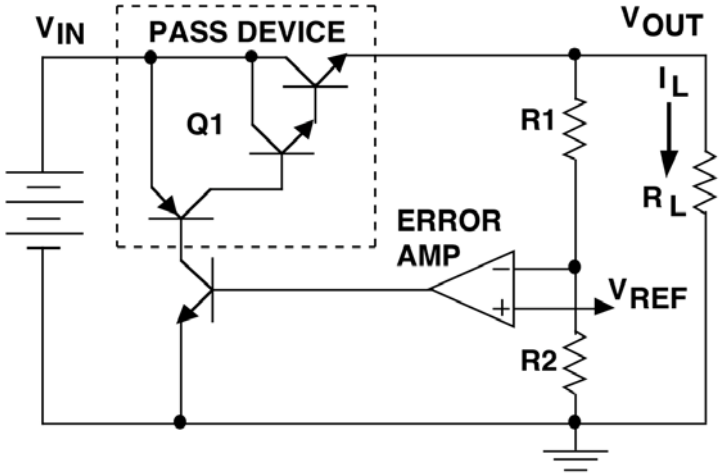
Unregulated Power Supply

- Unregulated AC-DC
  transformer + rectifier + filter
  – Simple
  – Flexible
  – Isolated
- Unregulated DC-DC
  think of a voltage divider

Linear Regulated

- Zener diode (shunt regulator)
- Zener diode + Emitter follower (series regulator)
- Linear regulator ICs
  – Fixed voltage
  – Variable voltage

Linear Regulator



Switching Regulated (Switched-mode power supply)

- Non-isolated:
  - Buck converter
  - Boost converter
  - Buck-boost converter
  - …
- Isolated:
  - Flyback converter
  - Forward converter
  - …

Switched-mode power supply

- PWM – Pulse Width Modulation
- Switching Frequency
- Duty Cycle Ratio
- CCM – Continuous Conduction Mode
- DCM – Discontinuous Conduction Mode
- Freewheeling Diode
- MOSFET
  - metal-oxide-semiconductor field-effect transistor

Switched-mode power supply

Principles of steady-state analysis:

✓Inductor volt-second balance

integral/average voltage = 0

✓Capacitor charge (amp-second) balance

integral/average current = 0

Buck converter: $V_o = V_s D$

Boost converter: $V_o = \frac{V_s}{1-D}$ CCM Mode

Buck-boost and Ćuk converters: $V_o = -V_s\left(\frac{D}{1-D}\right)$

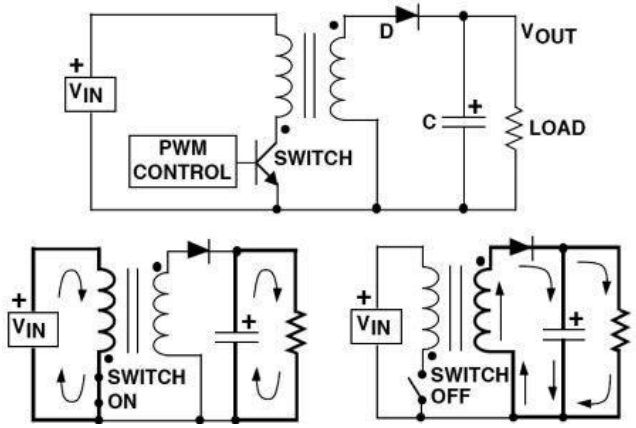
SEPIC: $V_o = V_s\left(\frac{D}{1-D}\right)$

Flyback converter: $V_o = V_s\left(\frac{D}{1-D}\right)\left(\frac{N_2}{N_1}\right)$

Forward converter: $V_o = V_s D\left(\frac{N_2}{N_1}\right)$

Switched-mode power supply

Example: Single-output Flyback Circuit Diagram



Switched-mode power supply

A Typical Application from Datasheet:

https://ac-dc.power.com/sites/default/files/product-docs/topswitch-jx_family_datasheet.pdf?download=1