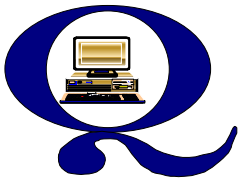


ELECTRONIC SYSTEM DESIGN

PART 1: POWER SUPPLY DESIGN

Prof. Yasser Mostafa Kadah

Power Conversion Circuit Basics

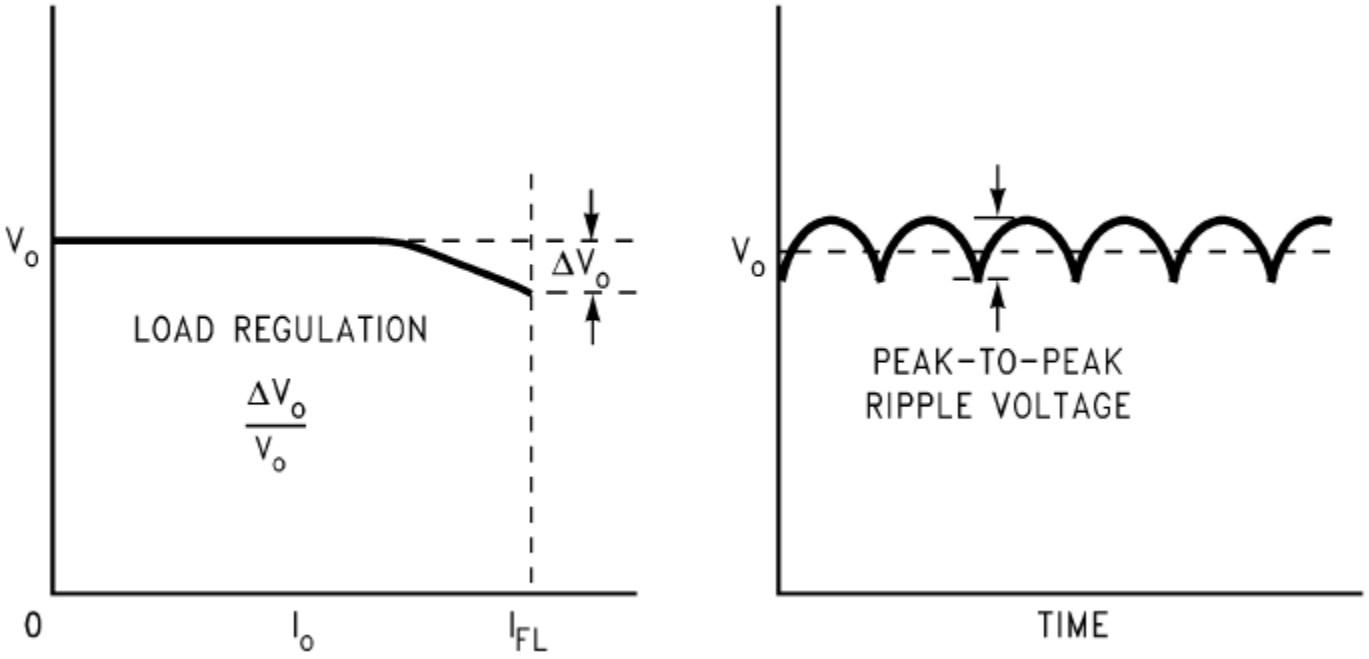
- There are three types of electronic power conversion devices in use today which are classified as follows according to their input and output voltages
  - DC/DC converter
  - AC/DC power supply
  - DC/AC inverter.
- We will focus in this lecture on first two types

AC/DC Power Supply

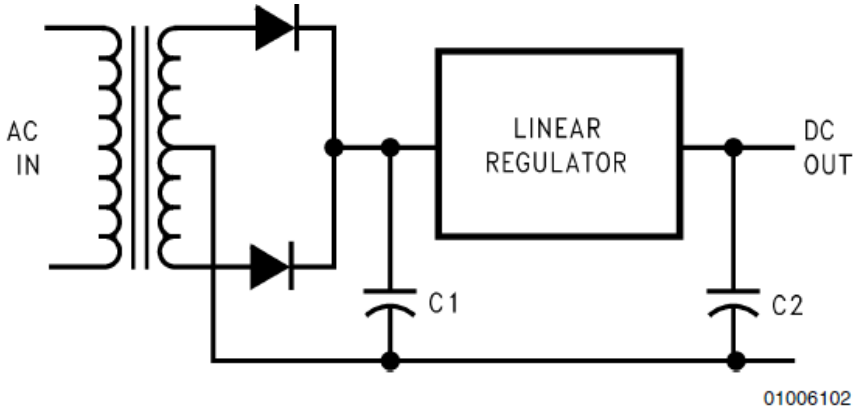
- Rectification
  - Convert the incoming AC line voltage to DC voltage
- Voltage transformation
  - Supply the correct DC voltage level(s)
- Filtering
  - Smooth the ripple of the rectified voltage
- Regulation
  - Control the output voltage level to a constant value irrespective of line, load and temperature changes
- Isolation
  - Separate electrically the output from the input voltage source
- Protection
  - Prevent damaging voltage surges from reaching the output; provide back-up power or shut down during a brown-out

AC/DC Power Supply

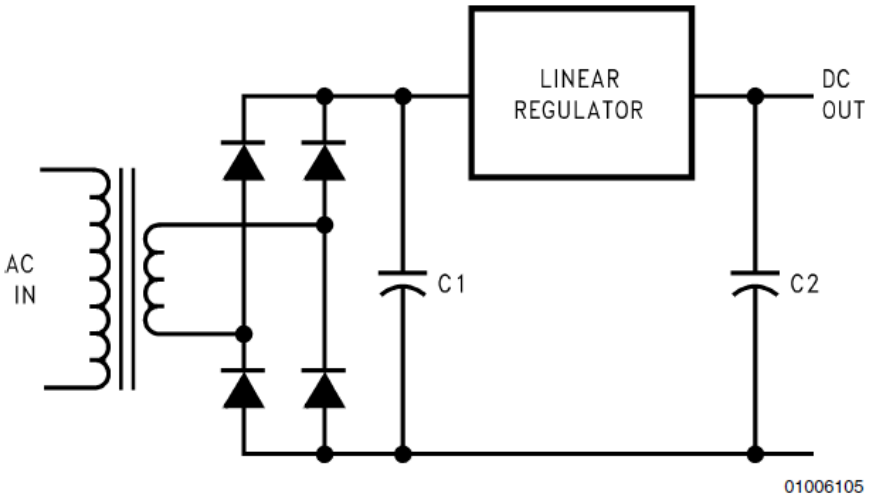
- An ideal power supply would be characterized by supplying a smooth and constant output voltage regardless of variations in the voltage, load current or ambient temperature at 100% conversion efficiency



Linear AC/DC Power Supplies



a. Center Tap Transformer Input



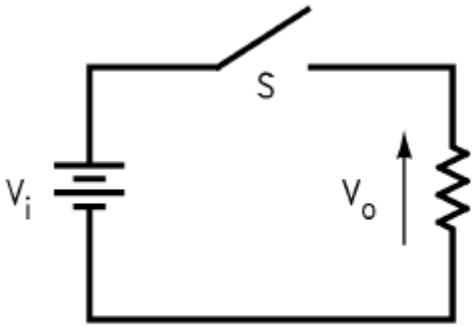
b. Full-Wave Bridge Input

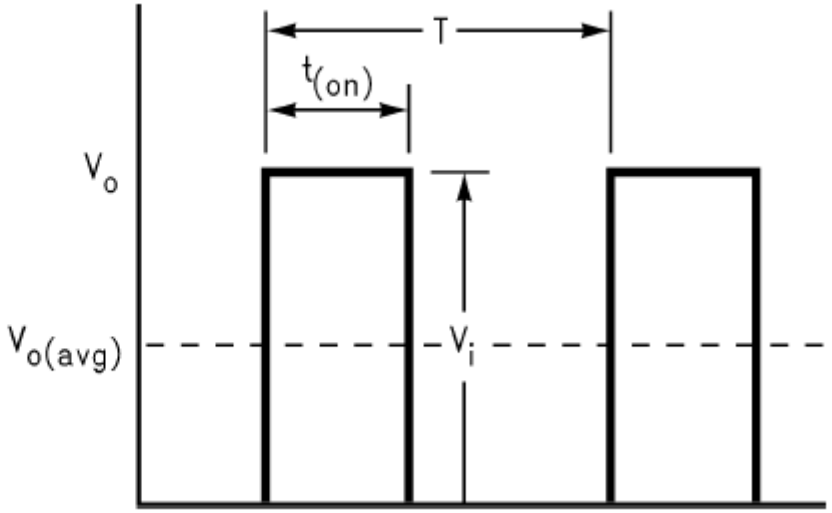
- Linear voltage regulator behaves as a variable resistance between the input and the output as it provides the precise output voltage.
- Limitations: low efficiency, large in size

Linear vs. Switching Power Supplies

Specification	Linear	Switcher
Line Regulation	0.02%–0.05%	0.05%–0.1%
Load Regulation	0.02%–0.1%	0.1%–1.0%
Output Ripple	0.5 mV–2 mV RMS	10 mV–100 mV_{P-P}
Input Voltage Range	±10%	±20%
Efficiency	40%–55%	60%–95%
Power Density	0.5 W/cu. in.	2W–10W/cu. in.
Transient Recovery	50 µs	300 µs
Hold-Up Time	2 ms	34 ms

Switching Power Supply: Pulse Width Modulation



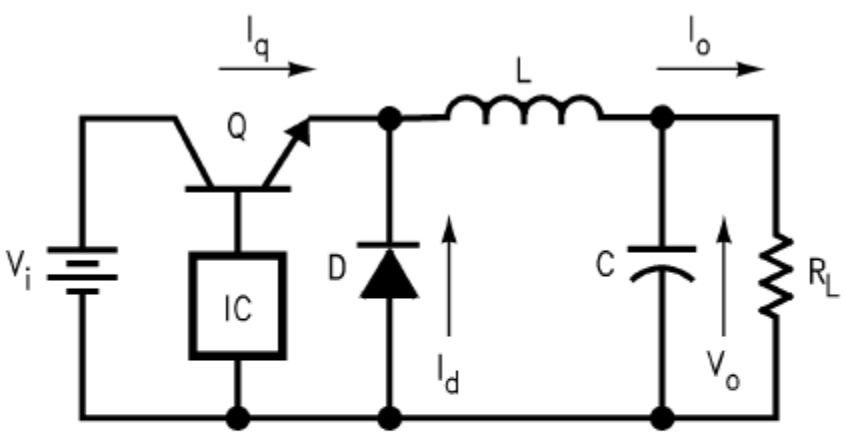


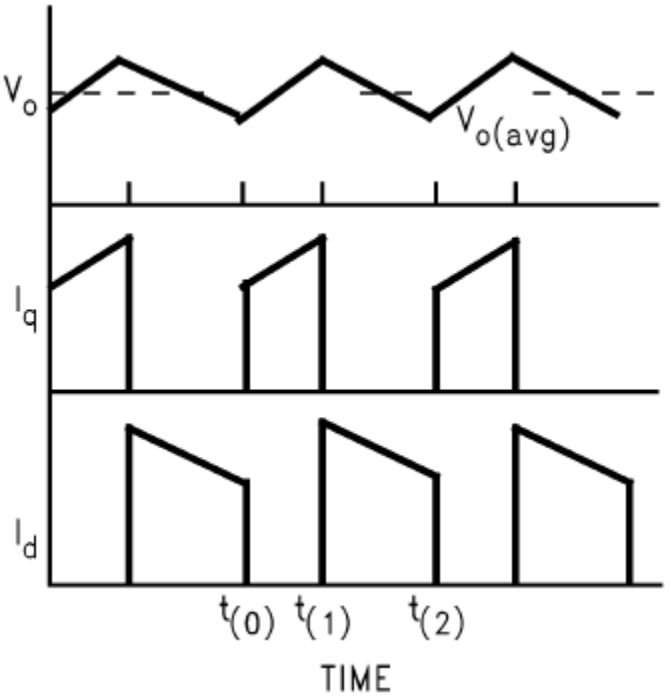
- The average voltage seen by the load resistor R is equal to:

$$V_{o(avg)} = (t_{(on)}/T) \times V_i$$

  - Reducing $t_{(on)}$ reduces $V_{o(avg)}$
  - This method of control is called *pulse width modulation* (PWM)

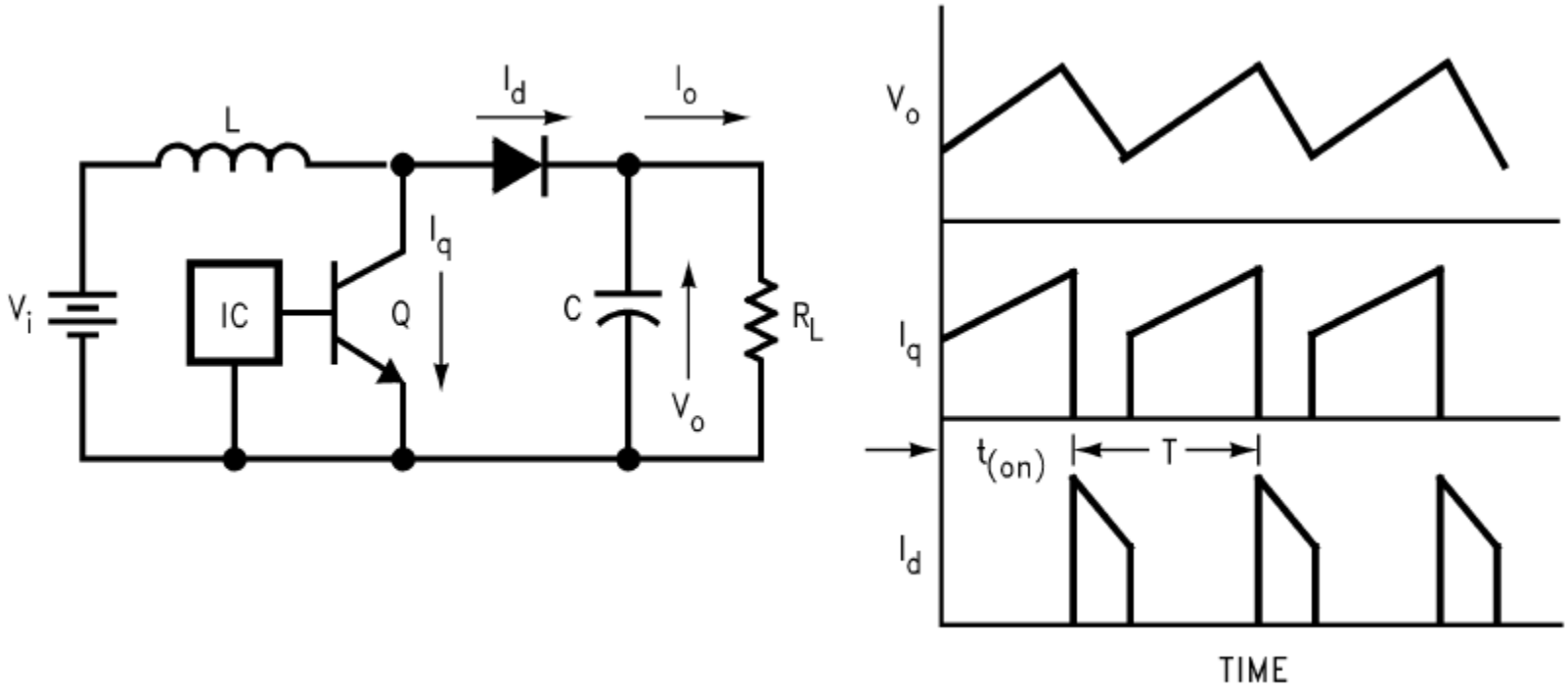
Buck Regulator





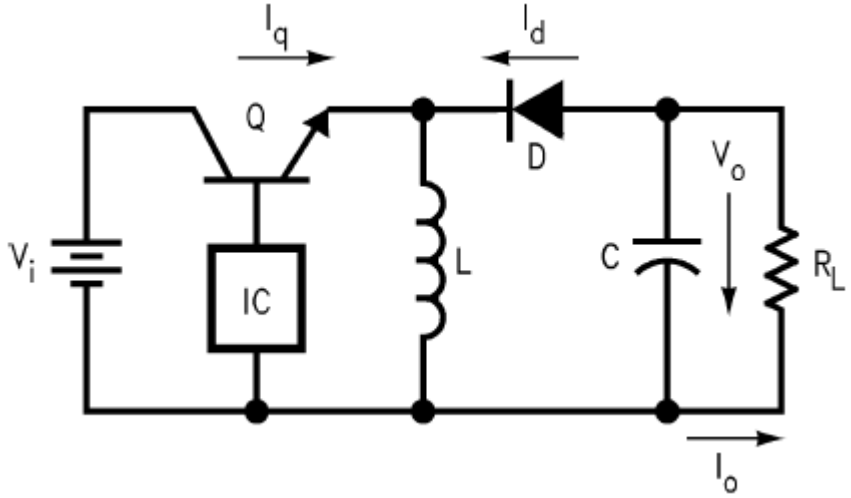
- Simple step-down regulator
- IC senses output voltage and switches Q on/off

Boost Regulator



- Step-up regulator $V_o = V_{IN}\,(T/(T - t_{(on)}))$
- IC senses output voltage and switches Q on/off

Inverting Regulator

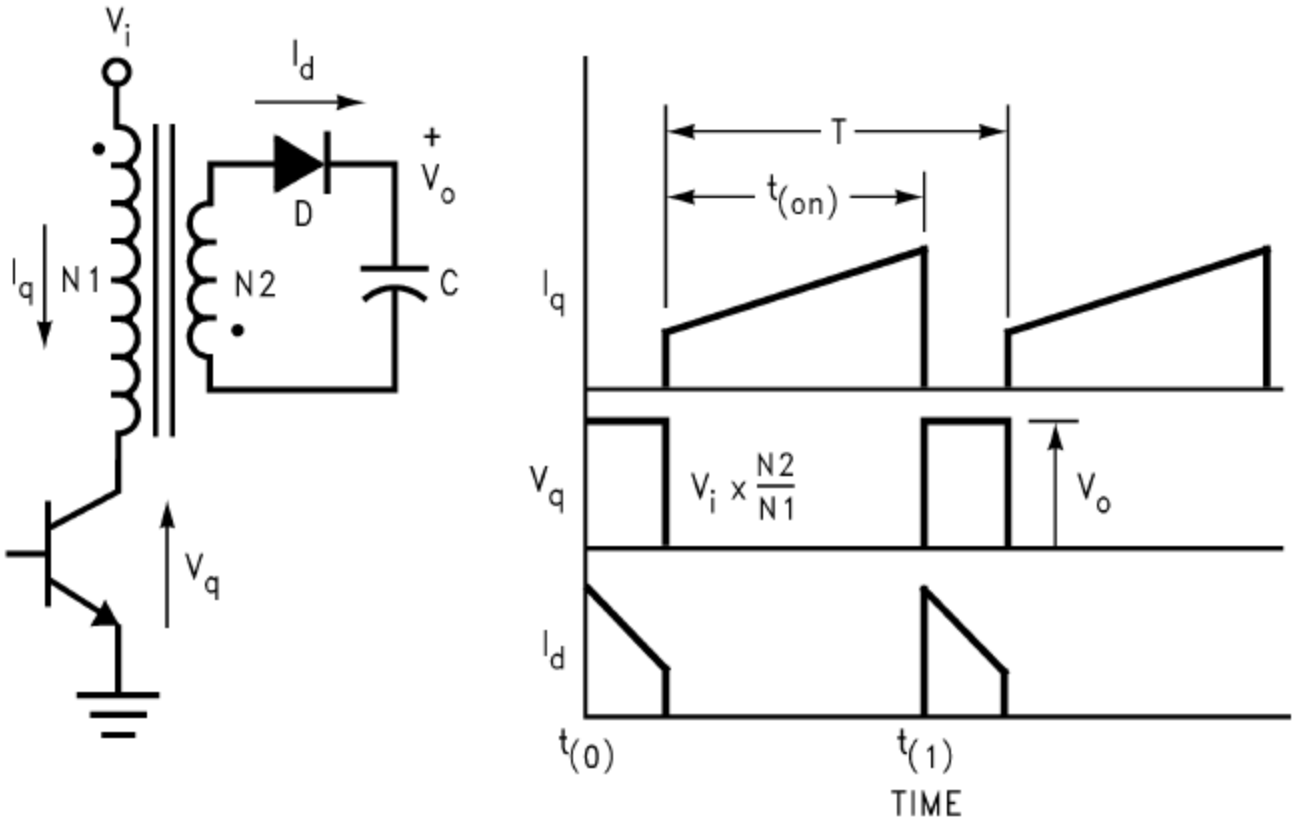


- Output voltage with opposite polarity of input voltage
  - Works in the same fashion as the boost converter but with exchanging positions of transistor and inductor
  - also known as a buck-boost regulator since the absolute magnitude of output voltage can be higher or lower than input voltage depending upon the ratio of on-time to off-time

Flyback Converter

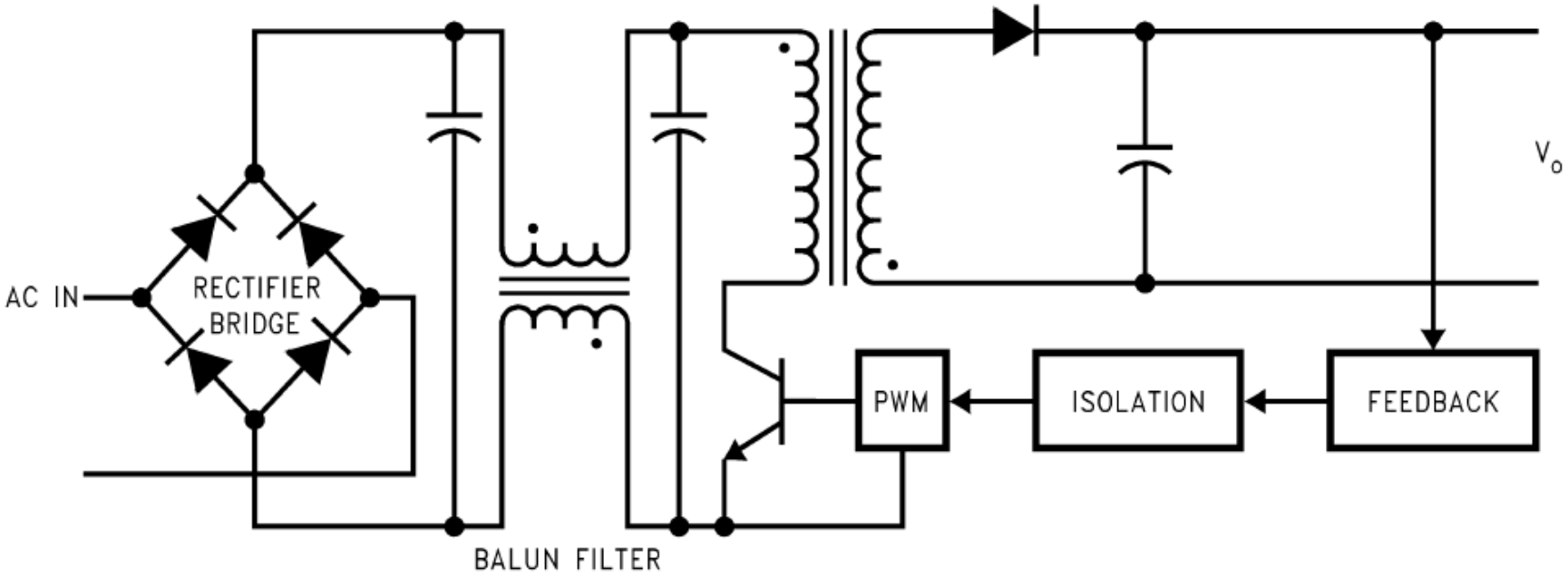
- The three previous regulators are suitable for low voltage control when no electrical isolation is required.
- However in off-line switchers operating from 110V/220V mains, electrical isolation is an absolute must.
- This is achieved by using a transformer in place of the inductor.

Flyback Converter



$$V_o = V_{IN} \times (t_{(on)})/(T - t_{(on)}) \times (N2/N1)$$

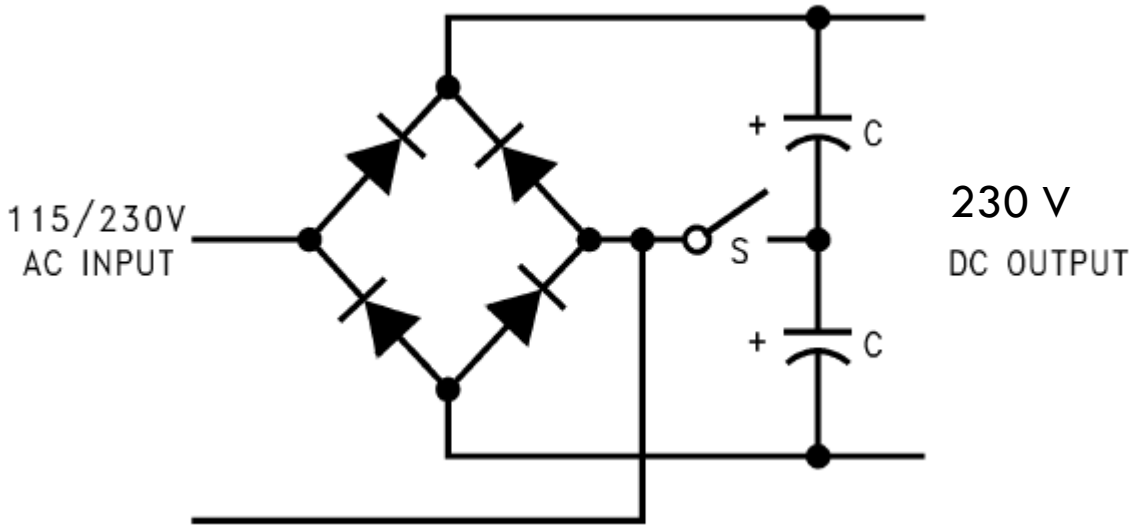
Off-Line Flyback Switching Supply



- Called “off-line” because the DC voltage to the switch is developed right from the AC line
- Feedback is usually opto-isolated

Selector Switch for 115/230V

- 230 V: Switch S OPEN
- 115 V: Switch S CLOSED
- Output: 230V DC in BOTH cases



Assignments

- Design an AC to 5V linear power supply
- Design a 12V to 5V switching power supply
- Design a 5V to 12V switching power supply
- Design a 5V to -5V switching power supply
- Design an AC to 5V switching power supply

- Lab: Inspect ripples from a PC power supply
- Lab: Implement a power supply of your choice