EN 206 – Power Electronics and Machines

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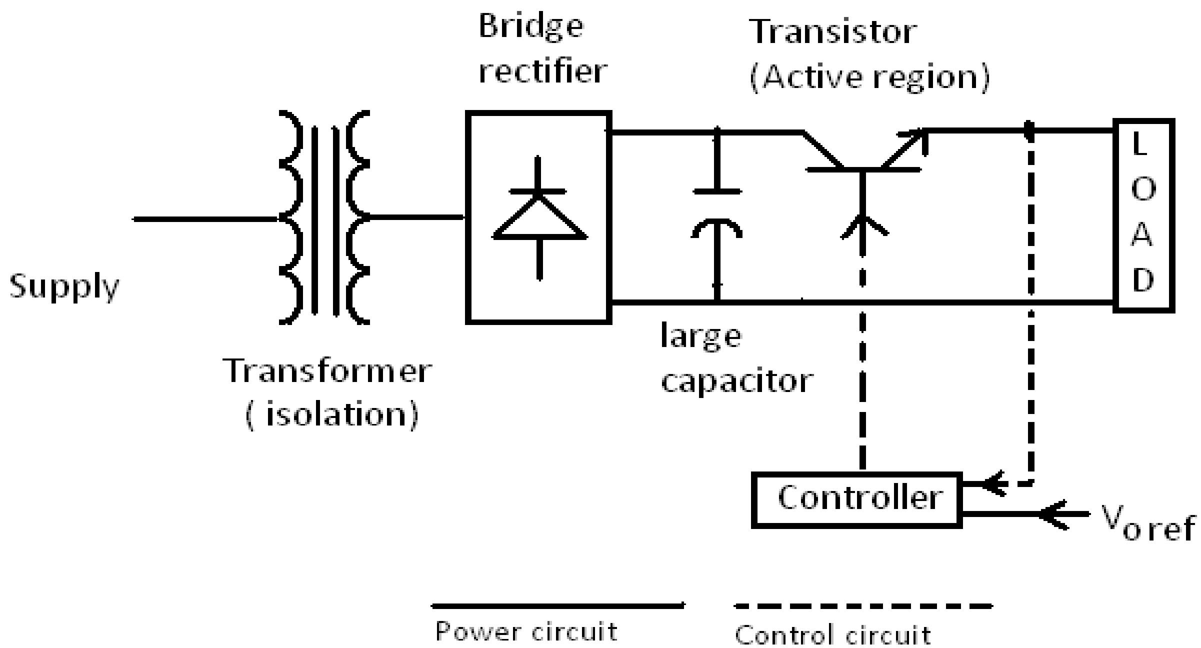
DC-DC Converters

- ❖Isolated Converters
  - ✓Flyback Converter
  - ✓Forward Converter
- ❖Bi Polar Voltage Switching
- ❖Uni Polar Voltage Switching

Power Supply

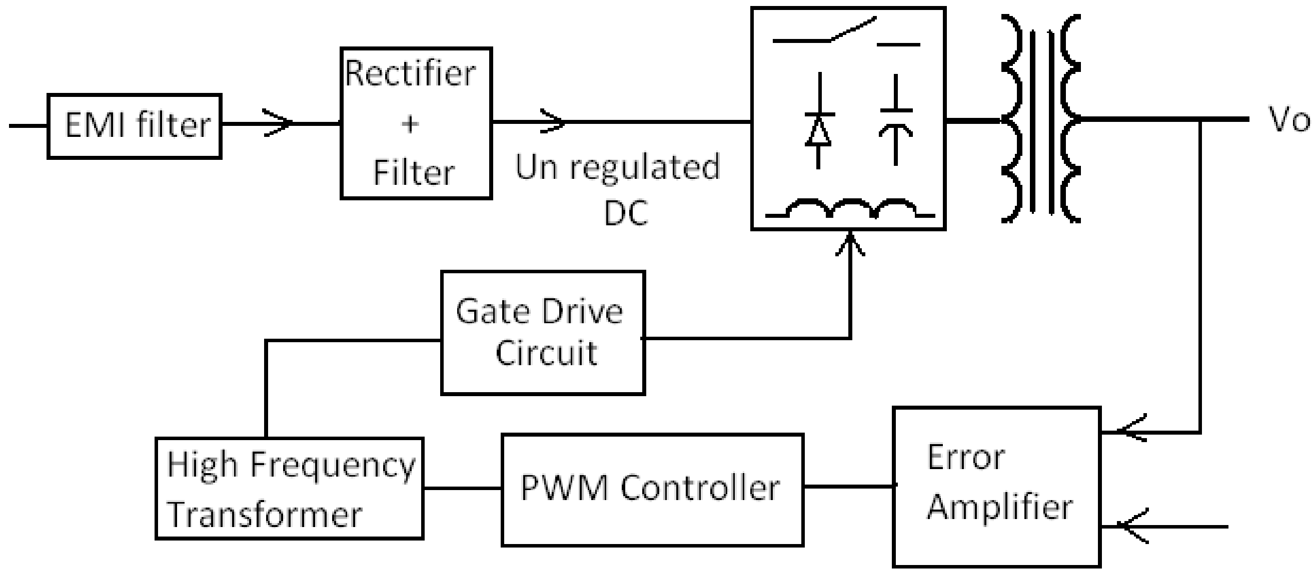
- Linear Power supply



  - Require bulky transformer
  - Efficiency is very low (30-60%), and preferred for power supply rating < 25W

POWER SUPPLY

- Switched Mode Power Supply



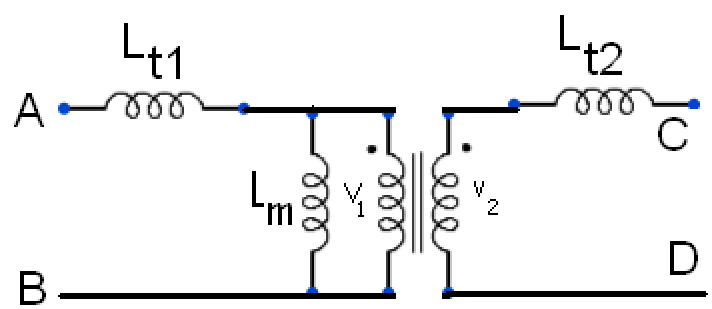
  - Reduced size of transformer
  - High efficiency (70-90%)
  - Transistor operated in on/off mode has large power handling capability compared to one in linear mode

dc-dc Converters

- Direct Converters (Non-Isolated)
  - Buck
  - Boost
- Derived Converters (Non-Isolated)
  - Buck-Boost
  - Cuk
- Full Bridge dc-dc Converters (Non-Isolated)
  - Bi Polar voltage switching
  - Uni Polar voltage switching
- Isolated
  - Unidirectional core excitation
    - Flyback
    - Forward
  - Bidirectional core excitation
    - Push-Pull
    - Half Bridge
    - Full bridge

DC-DC Converter with Isolation

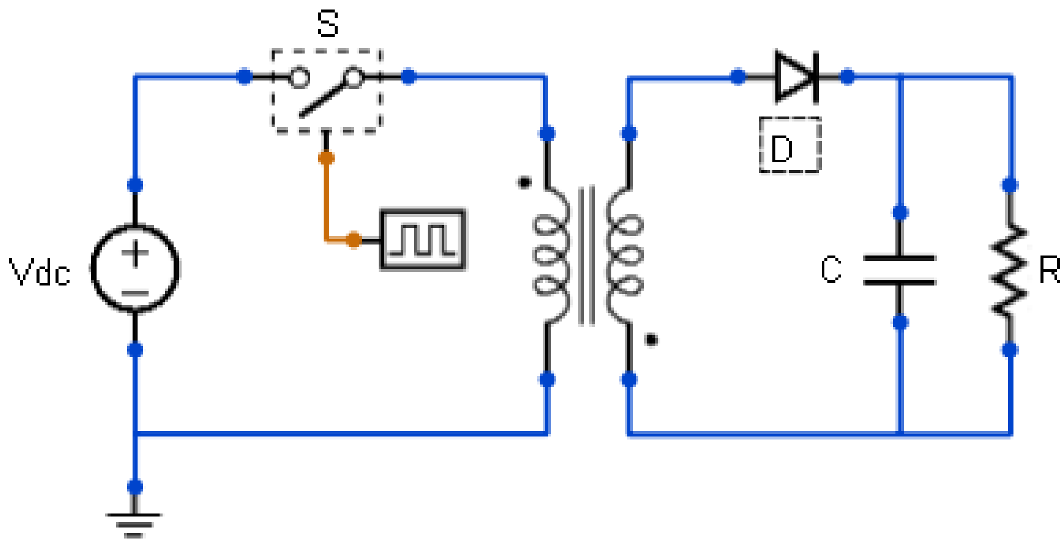
- In switched mode dc-dc converters, it is desirable to minimize the leakage inductances L_{t1} and L_{t2} by providing a tight magnetic coupling between the two windings
- It is also desirable to have high "L_m" to minimize the magnetizing current i_m that flows through the switches and thus increases their current ratings.



Flyback Converter

- If inductor core can accommodate two coils, one winding can be used to inject energy into the inductor, while the other can be used to transfer the energy to load.
- It is also possible that these two windings need not share direct electrical connection and hence can provide isolation.
- With only one winding, the current and flux are proportional, while with two or more windings, the flux is proportional to total ampere turn of all the windings.
- Flyback converter is functionally identical to buck-boost converter, but the output polarity is positive.

Flyback Converter



- Switch in ON State
  - Diode (D) is reverse biased

$$V_1 = V_d$$

$$\phi(t) = \phi(0) + \frac{V_d}{N_1} t$$

$$\phi(t_{on}) = \phi(0) + \frac{V_d}{N_1} t_{on}$$

Flyback Converter

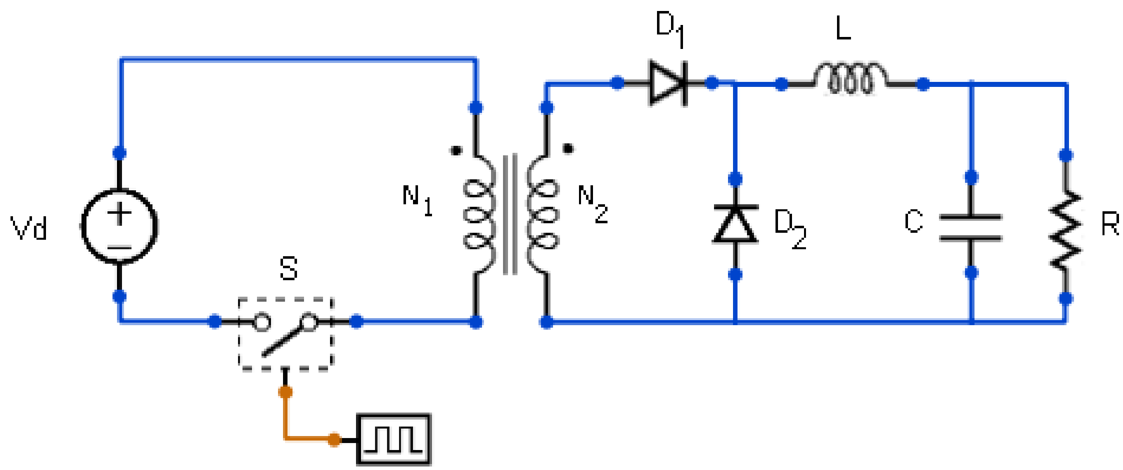
- Switch is in OFF State
  - The energy stored in the core causes the current to flow in the secondary winding through the diode "D"
  - Flux decreases linearly during t_{off}

$$\left.\begin{aligned} \phi(t) &= \hat{\phi} + \frac{V_0}{N_2}(t - t_{on}) \\ \phi(T_s) &= \hat{\phi} + \frac{V_0}{N_1}(T_s - t_{on}) \end{aligned}\right\} \quad \phi(T_s) = \phi(0) + \frac{V_d}{N_1}t_{on} - \frac{V_0}{N_2}(T_s - t_{on})$$

- At steady state: $\phi(T_s)=\phi(0)$, as net change of flux through the core over one time period must be zero

$$\frac{V_d}{N_1}ton = \frac{V_0}{N_2}(T_s - t_{on}) \Rightarrow \frac{V_0}{V_d} = \frac{N_2}{N_1} \times \frac{D}{1-D}$$

Forward Converter



- When "S" is ON, D_1 is forward biased and D_2 is reverse biased.

$$V_L = \frac{N_2}{N_1} V_d - V_0 \qquad 0 < t < t_{on}$$

- When "S" is OFF, D_1 is reverse biased and D_2 is forward.

$$V_L = -V_0 \qquad t_{on} < t < T_S$$

- Equating the integral of the inductor voltage over one time period to zero gives: $\frac{V_0}{V_d} = \frac{N_2}{N_1} D$

dc-dc Converters

- **COMPARISON OF CONVERTERS**

Converter	Output voltage	Boundary Condition
Buck	$V_O = DV_d$	$I_{LB} = \frac{T_s V_d}{2L} D(1-D)$
Boost	$V_O = \frac{1}{1-D} V_d$	$I_{OB} = \frac{T_s V_o}{2L} D(1-D)^2$
Buck-Boost	$V_O = \frac{D}{1-D} V_d$	$I_{OB} = \frac{T_s V_o}{2L} (1-D)^2$
Cuk	$V_O = \frac{D}{1-D} V_d$	
Full bridge converter	$V_O = \frac{V_d}{\hat{V}_{tri}} V_{control}$	• Uni-polar • Bi-polar