Power Electronics Education
Electronic Book

Welcome to PEEEB

Lecture 7: Isolated DC-DC Converters

Presenter: Dr. Firuz Zare

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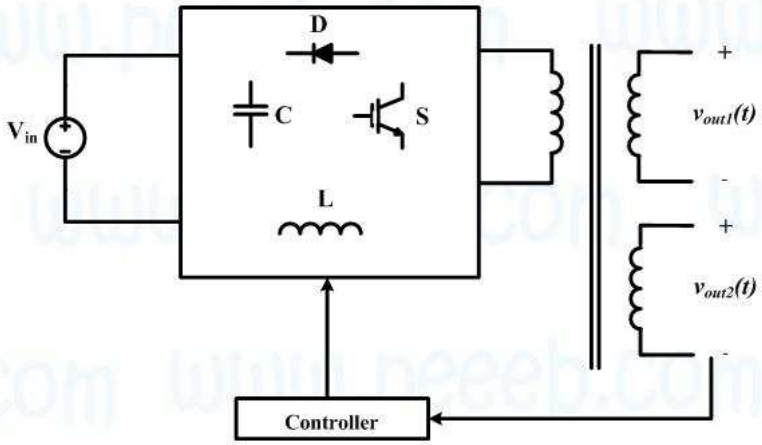
Isolated DC-DC Converters

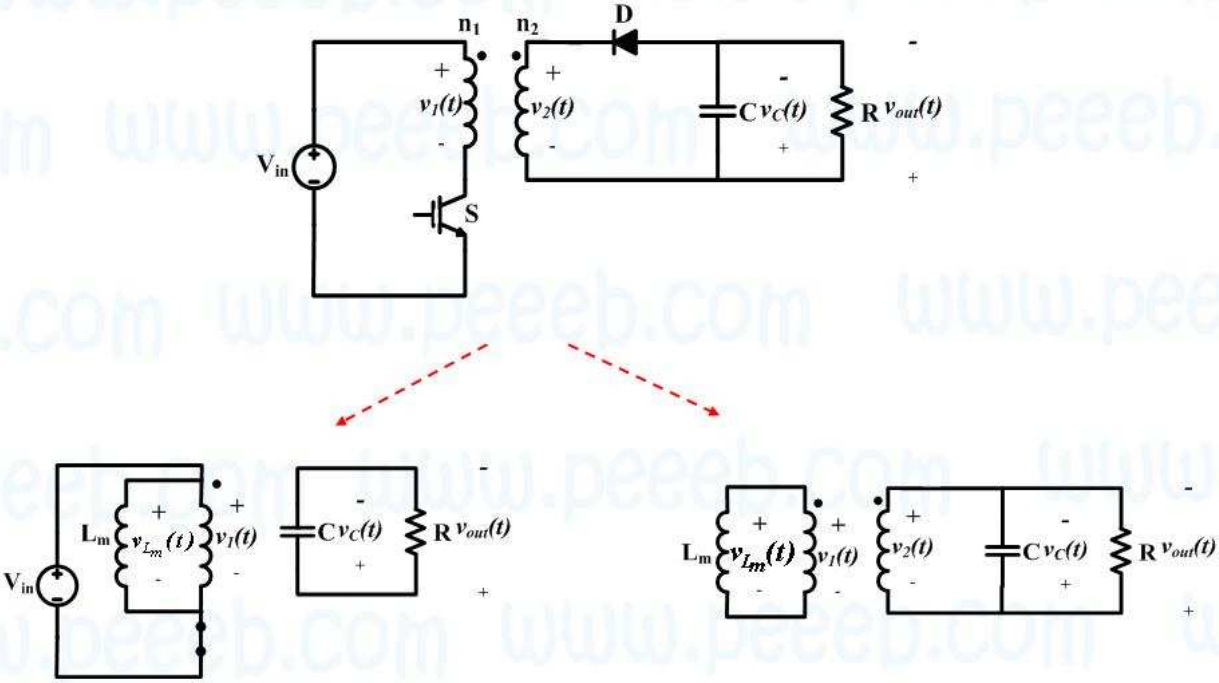


•In some applications, output voltage should be electrically isolated from input side and/or multi-output is required.
•A high frequency transformer is a better solution.

Isolated DC-DC Converters

- **Flyback Converter => Buck-Boost Converter**
  - **Are simple and low cost**
  - **Suitable for low power applications**
- **Forward Converter => Buck Converter**
  - **Used in application with output power below few hundred watts**
  - **Transformer size is smaller than the one in a flyback**

Flyback Converter



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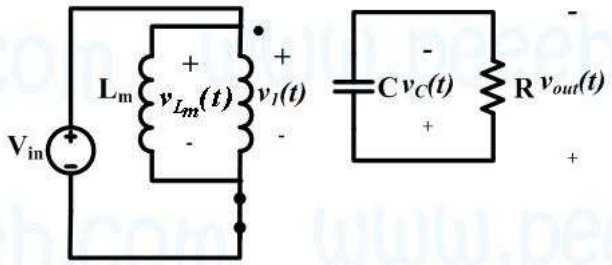
Flyback Converter

$$v_{L_m}(t) = v_1(t) = V_{in}$$

$$i_C(t) = -\frac{v_{out}(t)}{R}$$

$$v_{L_m}(t) = V_{in}$$

$$i_C(t) = -\frac{V_{out}}{R}$$



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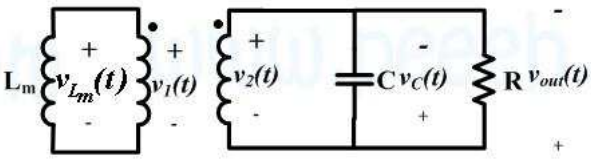
Flyback Converter



$$v_2(t) = -v_{out}(t)$$

$$\frac{n_1}{n_2} = \frac{v_1(t)}{v_2(t)}$$

$$v_1(t) = v_2(t) \times \frac{n_1}{n_2}$$

$$v_1(t) = -v_{out}(t) \times \frac{n_1}{n_2}$$

$$v_{L_m}(t) = v_1(t) = -v_{out}(t)\left(\frac{n_1}{n_2}\right)$$

$$v_{L_m}(t) = v_1(t) = -V_{out}\left(\frac{n_1}{n_2}\right)$$

$$\frac{n_1}{n_2} = \frac{i_2}{i_1} \Rightarrow i_2 = i_m \times \frac{n_1}{n_2}$$

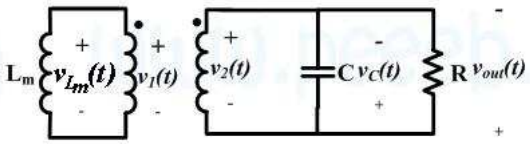
$$i_C(t) = i_m \times \frac{n_1}{n_2} - \frac{v_{out}(t)}{R}$$

$$i_C(t) = I_m \times \frac{n_1}{n_2} - \frac{V_{out}}{R}$$

Flyback Converter

$$\overline{i_C(t)} = 0$$

$$\frac{1}{T_{sw}} \int_{\theta}^{T_{sw}} i_C(t)\,dt = 0$$



$$i_C = \begin{cases} -\dfrac{V_{out}}{R} & 0 < t < DT_{sw} \\ I_m\left(\dfrac{n_1}{n_2}\right) - \dfrac{V_{out}}{R} & DT_{sw} < t < T_{sw} \end{cases}$$

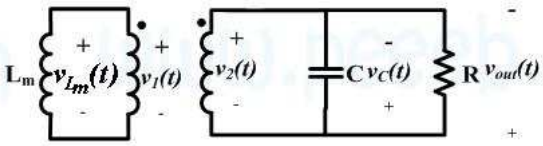
$$-D\frac{V_{out}}{R} + D' I_m \times \frac{n_1}{n_2} - D'\frac{V_{out}}{R} = 0$$

$$\frac{V_{out}}{R} = D' I_m \times \frac{n_1}{n_2} \Rightarrow I_m = \frac{V_{out}}{R} \times \frac{n_2}{n_1} \times \frac{1}{D'}$$

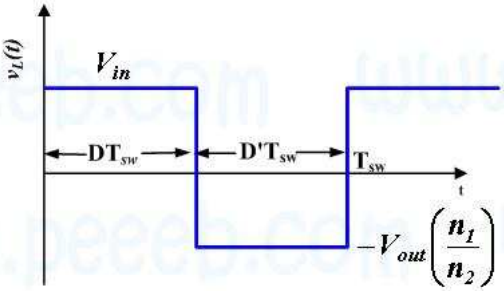
Flyback Converter

$$\overline{v_L(t)} = 0$$

$$\frac{1}{T_{sw}}\int_0^{T_{sw}} v_L(t)\,dt = 0$$



$$v_L(t) = \begin{cases} +V_{in} & 0 < t < DT_{sw} \\ -V_{out}\left(\frac{n_1}{n_2}\right) & DT_{sw} < t < T_{sw} \end{cases}$$



$$DV_{in} - D'V_{out}\left(\frac{n_1}{n_2}\right) = 0$$

$$DV_{in} = D'V_{out}\left(\frac{n_1}{n_2}\right)$$

$$\frac{V_{out}}{V_{in}} = \frac{D}{D'} \times \frac{n_2}{n_1}$$

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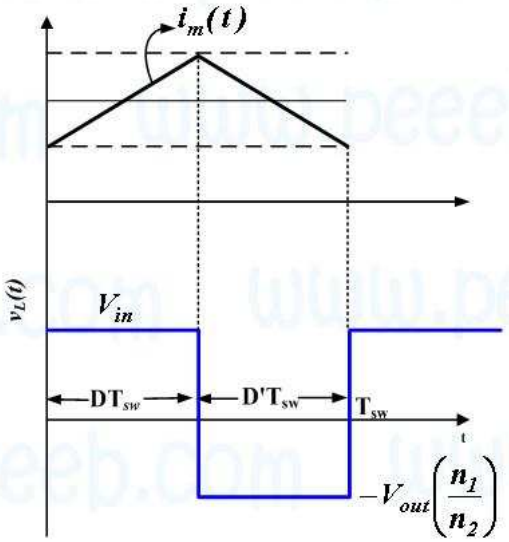
Flyback Converter

$$L_m \frac{di}{dt} = v_1(t) = v_{L_m}(t)$$

$$\frac{2\Delta i_m}{\Delta t} = \frac{V_{in}}{L_m} \Rightarrow \Delta i_m = \frac{V_{in}}{2L_m} \times DT_{sw}$$



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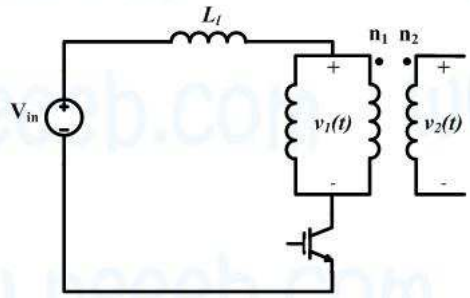
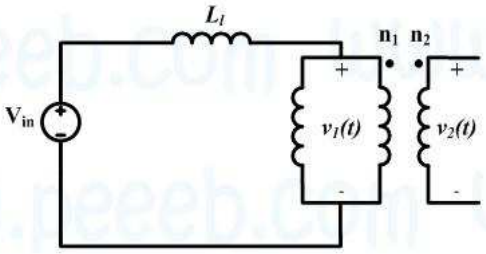
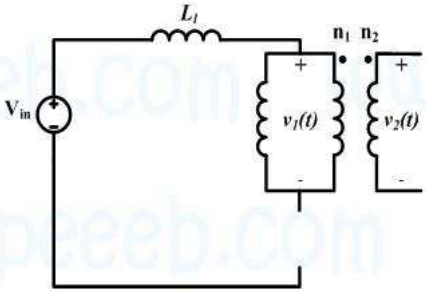
Flyback Converter







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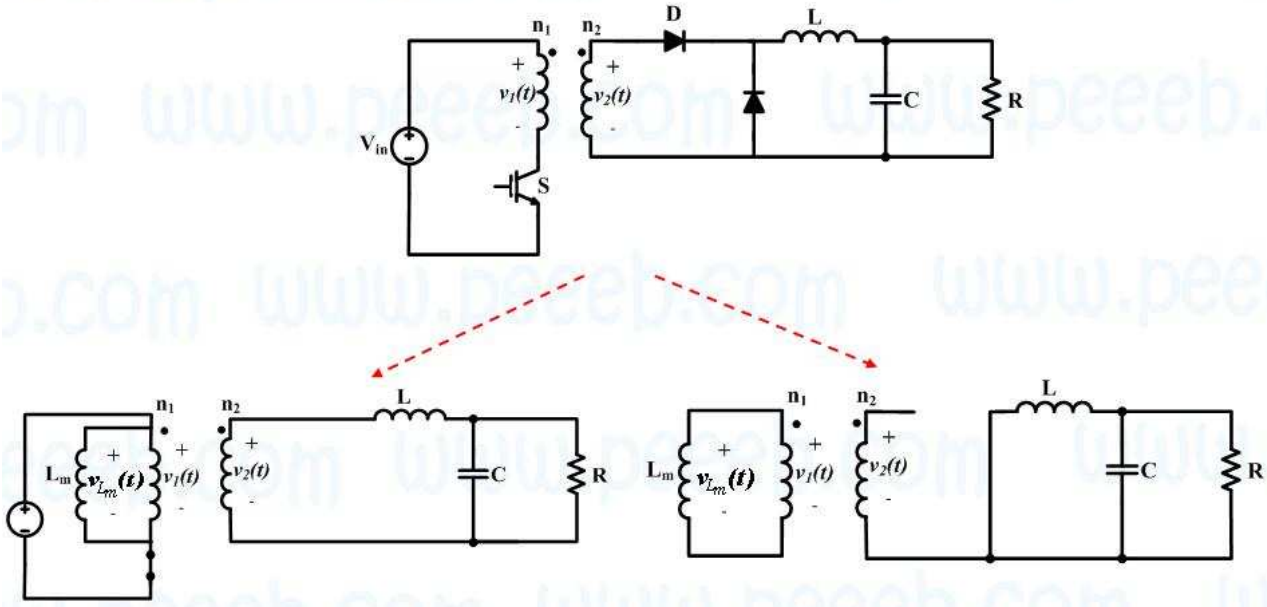
Forward Converter



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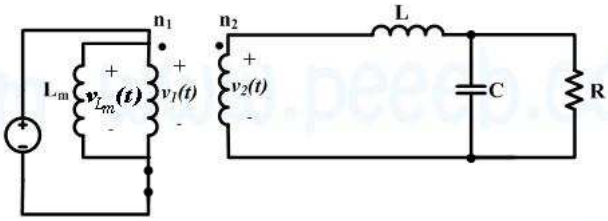
Forward Converter

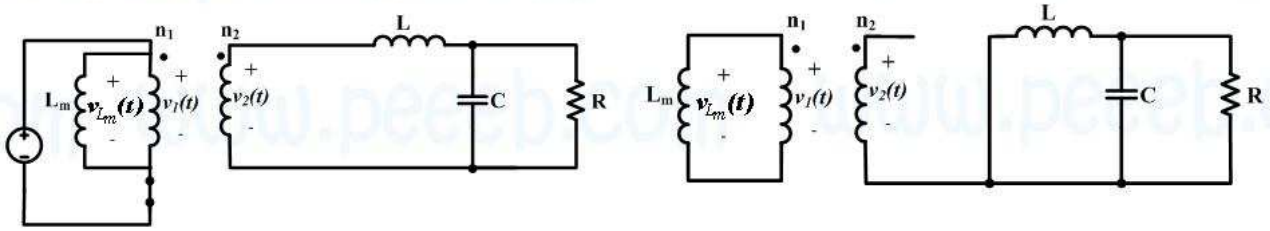


$$\begin{cases} v_1(t) = V_{in} \\ v_2(t) = v_1(t)\dfrac{n_2}{n_1} = V_{in}\dfrac{n_2}{n_1} \end{cases}$$

$$v_1(t) = v_{L_m}(t) = V_{in} = L_m \frac{di_m}{dt} \quad \Rightarrow di_m = \frac{V_{in}}{L_m}dt$$

$$i_m(DT_{sw}) = \frac{V_{in}}{L_m} \times DT_{SW}$$

Forward Converter



$$v_2(t) = 0$$

$$\begin{cases} v_1(t) = V_{in} \\ v_2(t) = v_1(t)\dfrac{n_2}{n_1} = V_{in}\dfrac{n_2}{n_1} \end{cases}$$

$$v_1(t) = v_{L_m}(t) = V_{in} = L_m \frac{di_m}{dt} \quad \Rightarrow di_m = \frac{V_{in}}{L_m}dt$$

$$i_m(DT_{sw}) = \frac{V_{in}}{L_m} \times DT_{SW}$$

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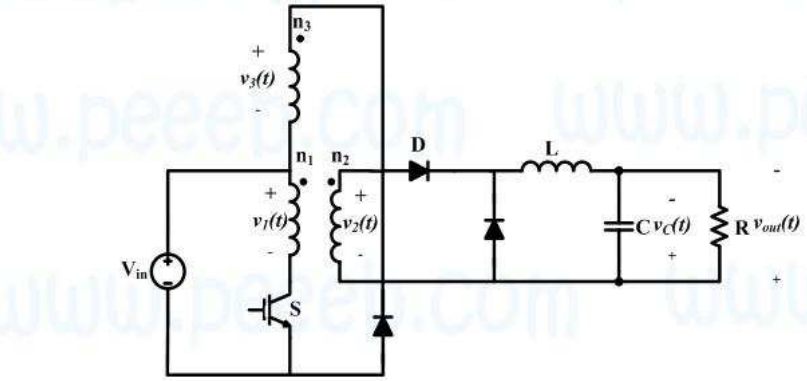
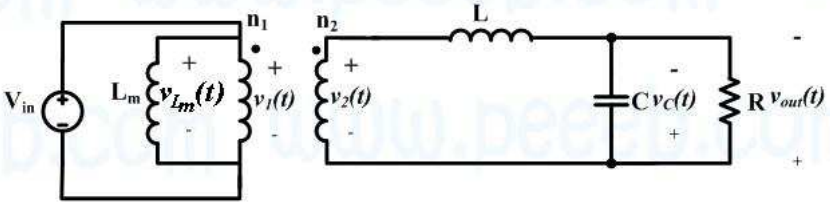
Forward Converter





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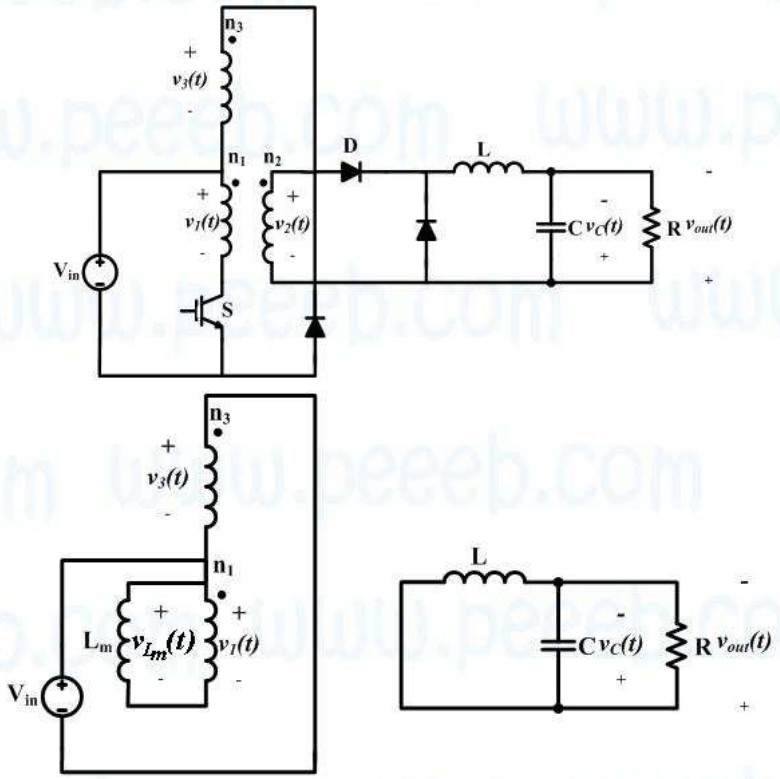
Forward Converter



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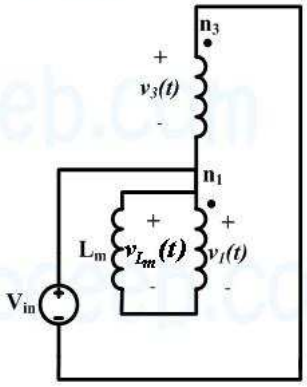
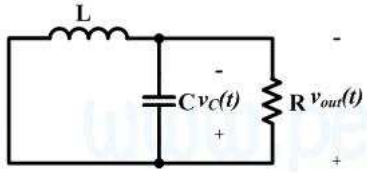
Forward Converter

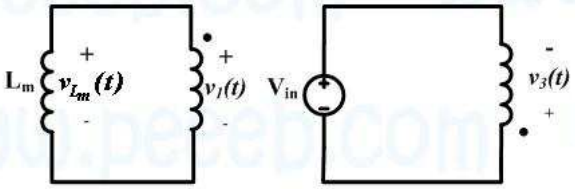
$$v_3(t) = -V_{in}$$

$$v_1(t) = v_3(t)\left(\frac{n_1}{n_3}\right) = -V_{in}\left(\frac{n_1}{n_3}\right)$$

$$v_{L_m}(t) = v_1(t) = -V_{in}\left(\frac{n_1}{n_3}\right)$$







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Forward Converter

$$\overline{v_{L_m}(t)} = 0$$

$$DT_{sw}V_{in} - D_2T_{sw}\left(V_{in}\left(\frac{n_1}{n_3}\right)\right) = 0$$

$$D = D_2\left(\frac{n_1}{n_3}\right)$$

$$D_2 = D\left(\frac{n_3}{n_1}\right)$$

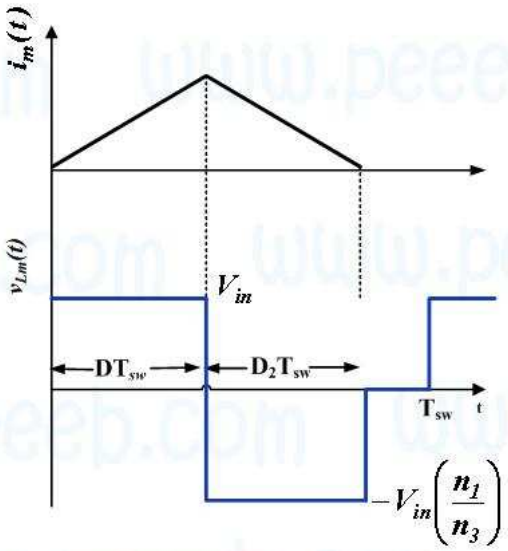
$$D_2 \le D'$$

$$D_2 \le 1 - D$$

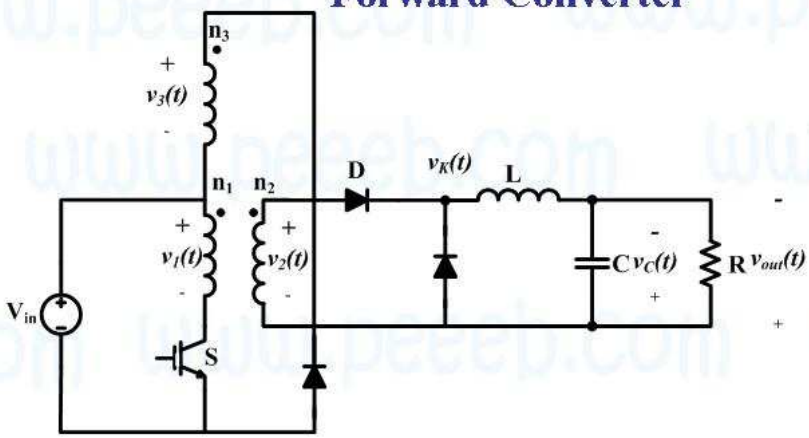
$$D\left(\frac{n_3}{n_1}\right) \le 1 - D$$

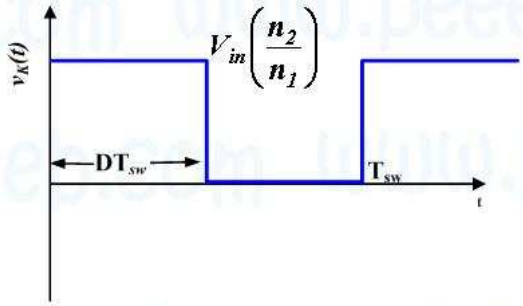
$$D\left(\frac{n_3}{n_1}\right) + D \le 1$$

$$D \le \frac{1}{1+\left(\frac{n_3}{n_1}\right)}$$



Forward Converter





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