Designing a flyback DC/DC converter

Video 2
Fundamentals of flyback converters

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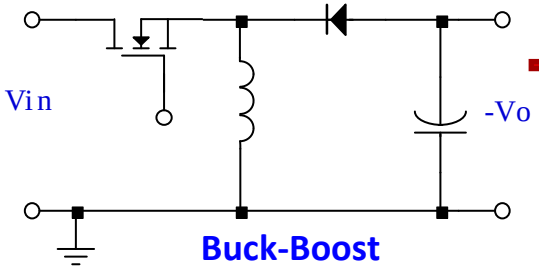
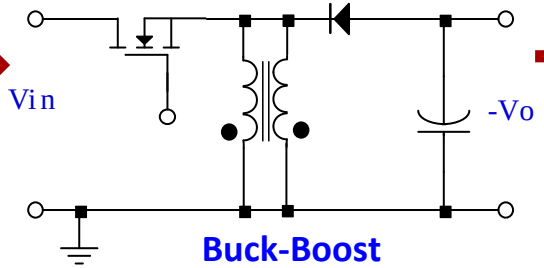
Outline of video series

1. Guidelines for topology selection
2. Fundamentals of flyback converters
3. Flyback converter design procedure I
4. Flyback converter design procedure II
5. Flyback transformer basics
6. Practical issues experienced with flyback converters

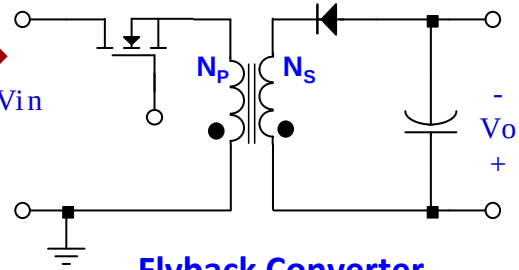
Flyback topology derivation



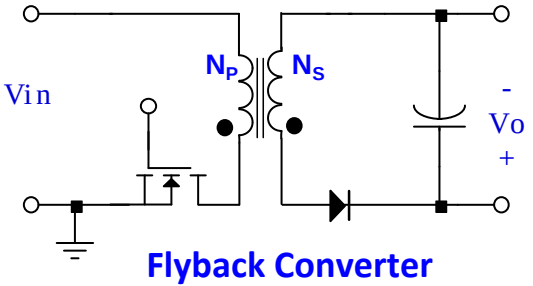
Buck-Boost Converter



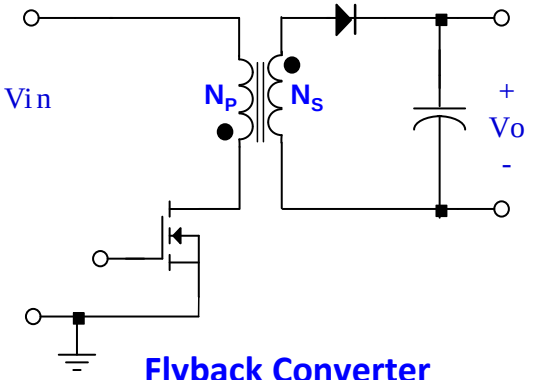
Buck-Boost Converter



Flyback Converter



Flyback Converter



Flyback Converter

$$V_{OUT} = V_{IN} \times \frac{D}{1-D} \times \frac{Ns}{Np}$$

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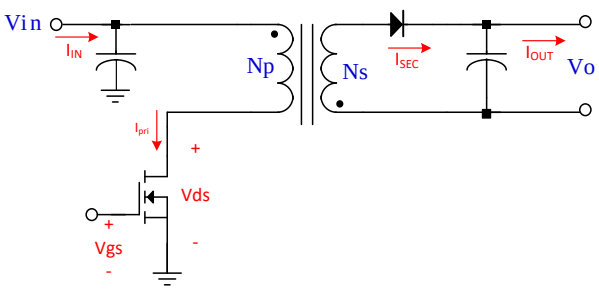
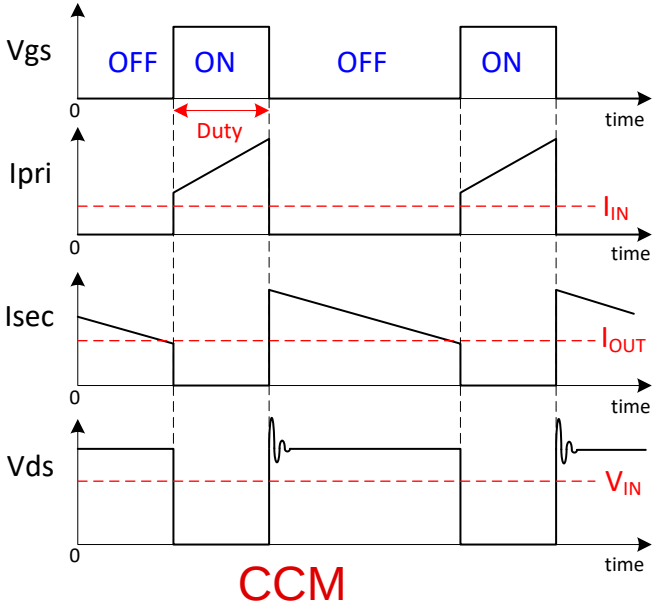
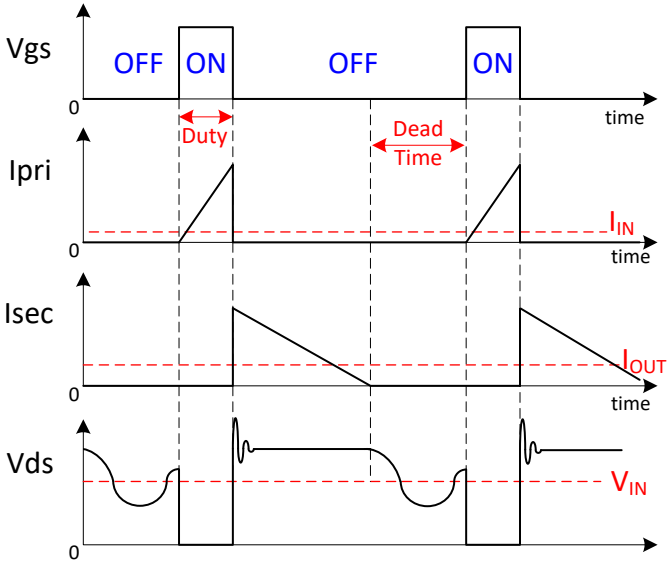
Operating principle

- Key Waveforms



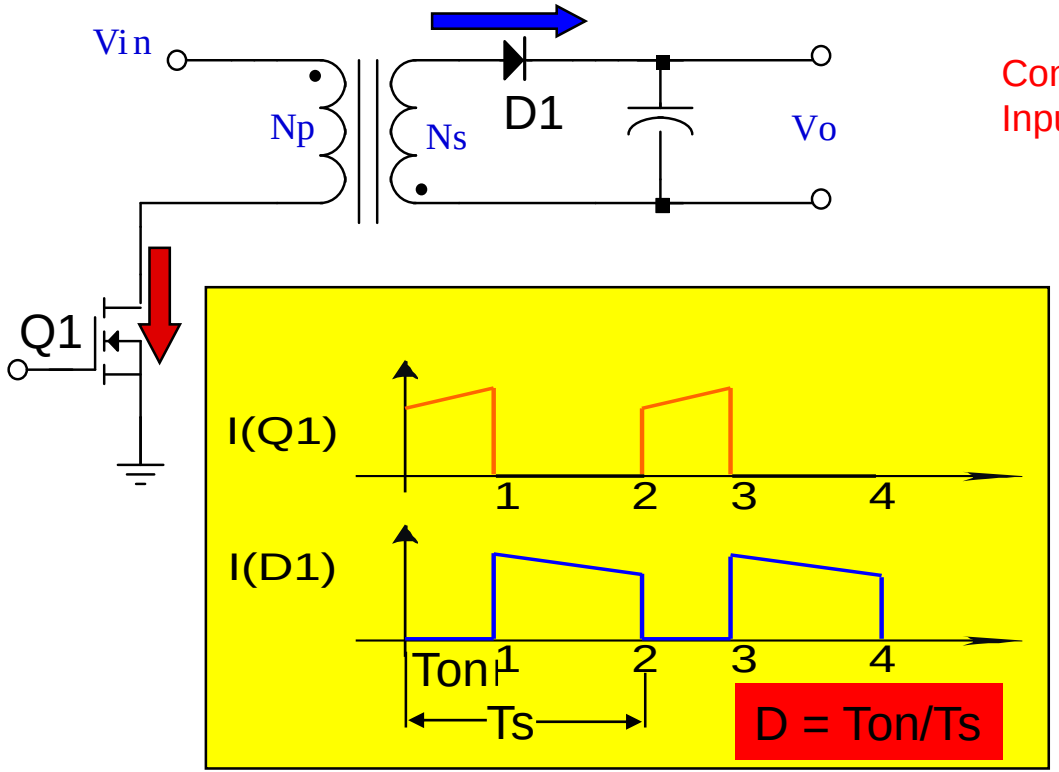


CCM



DCM

Operating principle



Continuous Conduction Mode
Input/Output relationship:

$$V_{OUT} = V_{IN} \times \frac{D}{1-D} \times \frac{Ns}{Np}$$

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Steady state analysis

Duty Cycle: $$D = \frac{V_{OUT} + V_F}{V_{OUT} + V_F + \frac{Ns}{Np} \cdot V_{IN}}$$

Primary Circuit:

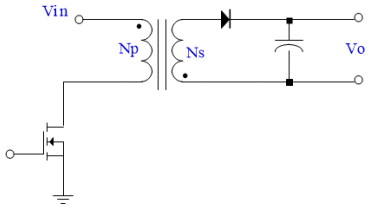
Average: $$I_{avg} = \frac{P_{OUT}}{V_{IN} \cdot \eta}$$

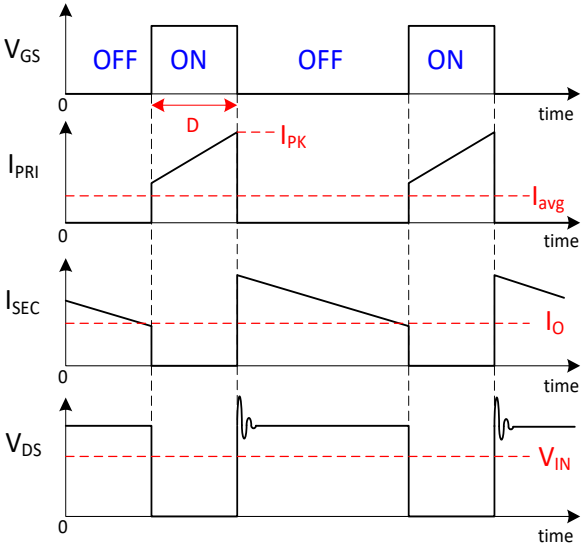
Peak: $$I_{pk} = \frac{1}{2} \cdot \frac{V_{IN}}{L_m} \cdot \frac{D}{f_{SW}} + \frac{I_{avg}}{D}$$

RMS: $$I_{rms} = \frac{I_{avg}}{\sqrt{D}}$$

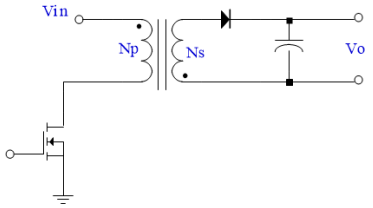
Ripple: $$I_{AC} = \sqrt{I_{rms}^2 - I_{avg}^2} = I_{avg} \cdot \sqrt{\frac{1-D}{D}}$$

V_{DS} : $$V_{DS} = V_{IN} + \frac{Np}{Ns} \cdot (V_{OUT} + V_F)$$





Steady state analysis

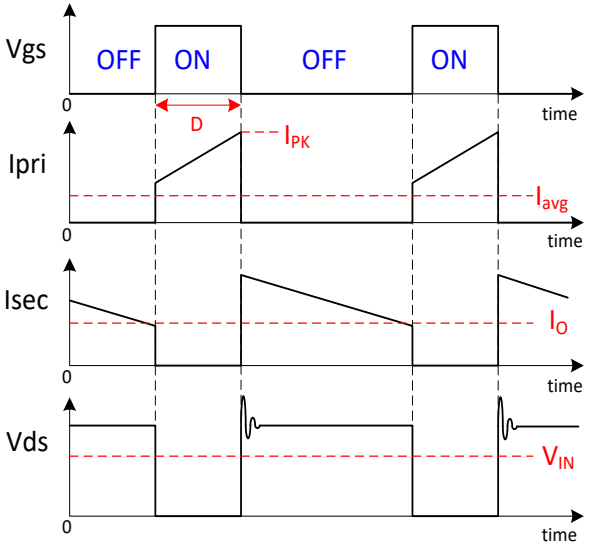


Secondary Circuit:

Avg: I_{OUT}

Ripple: $I_{ac\_sec} = I_{OUT} \cdot \sqrt{\frac{D}{1-D}}$

PIV: $V_r = V_{OUT} + \frac{Ns}{Np} V_{IN}$



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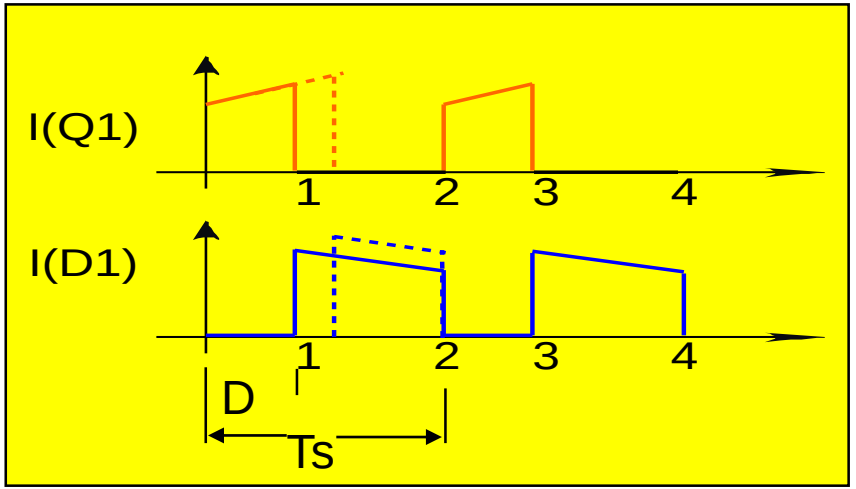
Flyback RHPZ

- The Right Half Plan Zero (RHPZ) affects the speed of dynamic response

$$F_{RHPZ} = \frac{V_{out} \cdot (1-D)^2}{2 \cdot \pi \cdot D \cdot L_s \cdot I_{out}}$$



Details on RHPZ: https://www.ti.com/seclit/ml/slup084/slup084.pdf

Video 1 and 2 Summary – Video 3 to 6 Outlook

- **We discussed**
  - **Topology selection guidelines** based on power level
    - Flyback and sepic topologies comparison and their suitable applications
  - **Fundamentals of flyback:** operating modes and key parameters

- **We will discuss**
  - **Design procedure** demonstrated with LM5155 example**, for non-isolated, PSR and isolated applications**
  - **Flyback transformer basics**, and the need of air gap
  - **Frequently asked questions** including multi rails, light load regulation, and high input voltage solutions, and **commonly seen mistakes**

Tools and application collaterals

Most important: E2E Forum https://e2e.ti.com/support/

All the following are available in the product folders on https://www.ti.com/

1. **Flyback EVMs and user's guides**
2. **Excel design calculators**
3. **WEBENCH™ Power Designer support**
4. **PSpice® models**
   - **Transient model supports flyback**
   - **We are adding more average models for flyback loop simulation**
5. **Application notes**
6. **Reference designs**
   - **You can find many flyback reference designs at: https://www.ti.com/reference-designs/index.html**

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