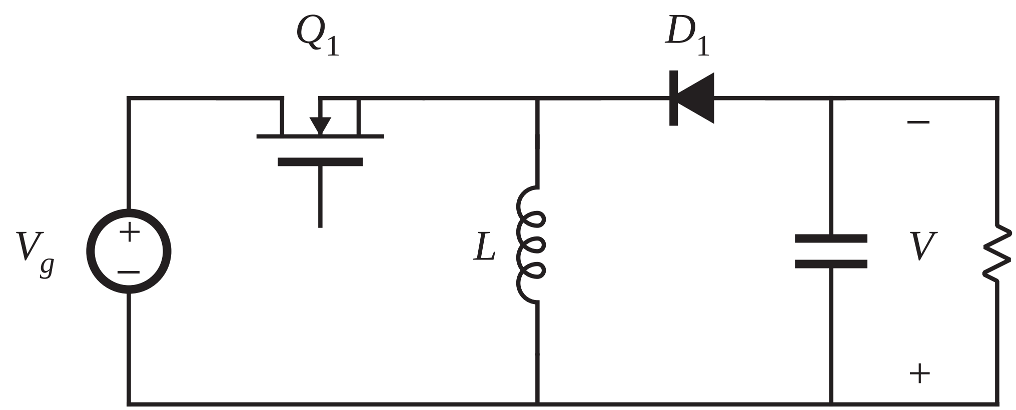
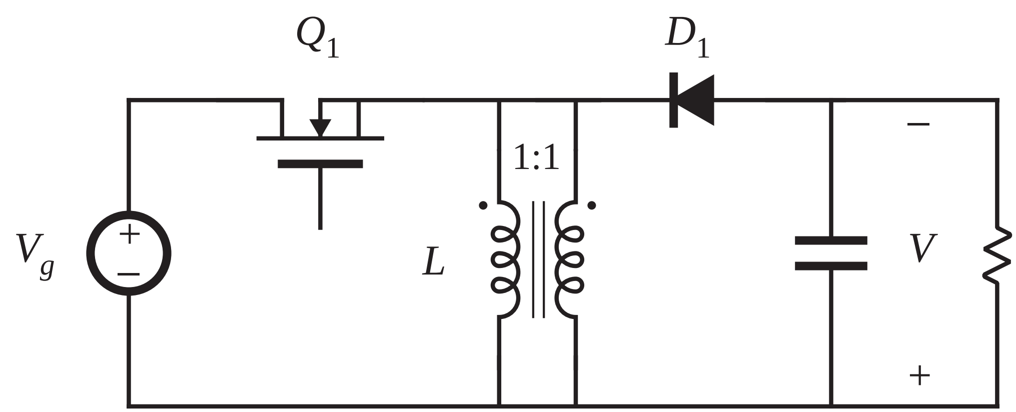
6.3.4. Flyback converter

buck-boost converter:

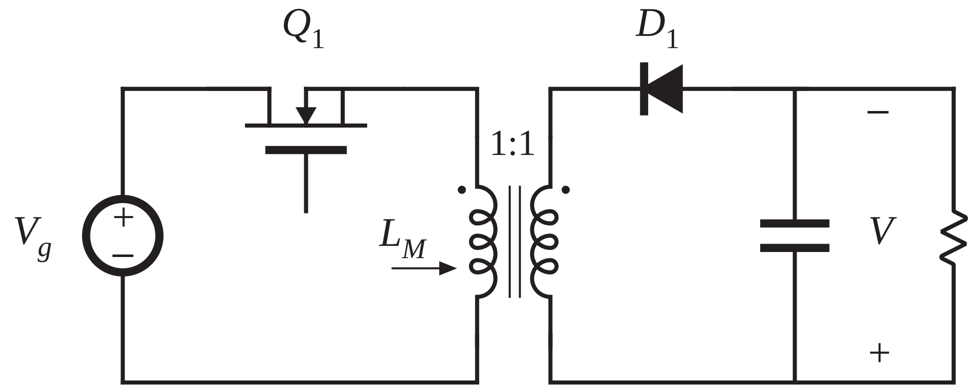


construct inductor winding using two parallel wires:

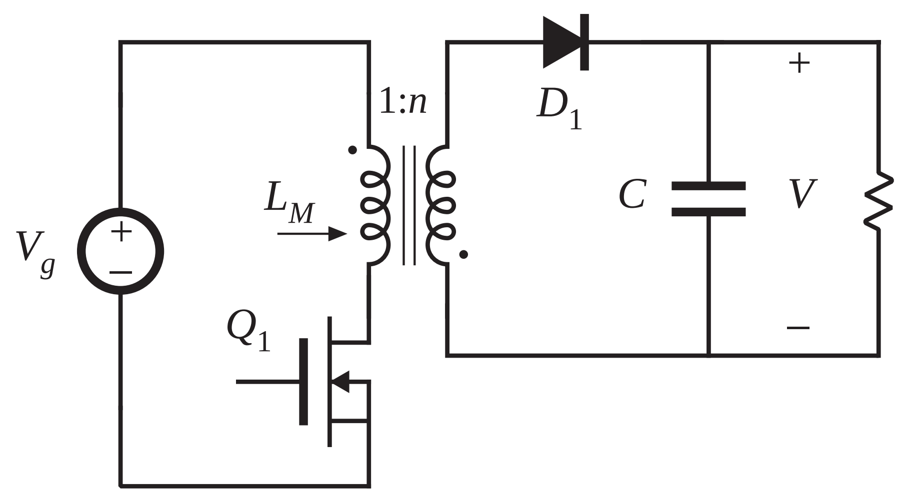


Derivation of flyback converter, cont.

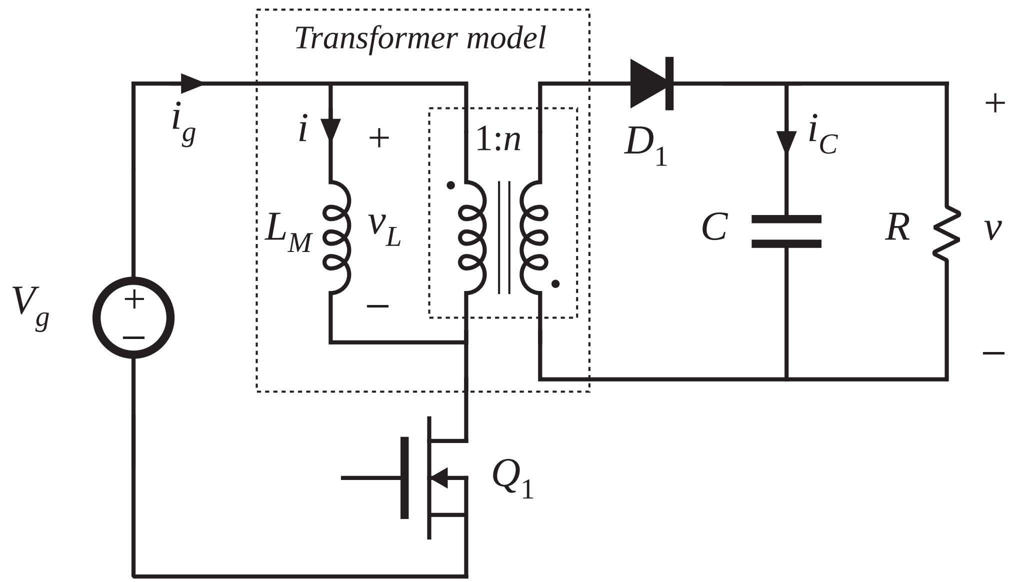
Isolate inductor windings: the flyback converter



Flyback converter having a $1{:}n$ *turns ratio and positive output:*



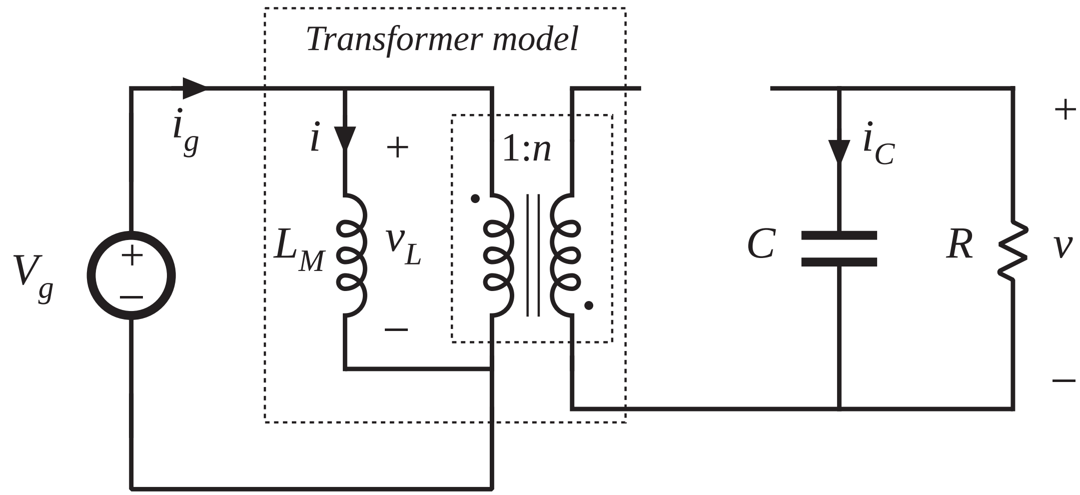
The "flyback transformer"



- A two-winding inductor
- Symbol is same as transformer, but function differs significantly from ideal transformer
- Energy is stored in magnetizing inductance
- Magnetizing inductance is relatively small

- Current does not simultaneously flow in primary and secondary windings
- Instantaneous winding voltages follow turns ratio
- Instantaneous (and rms) winding currents do not follow turns ratio
- Model as (small) magnetizing inductance in parallel with ideal transformer

Subinterval 1



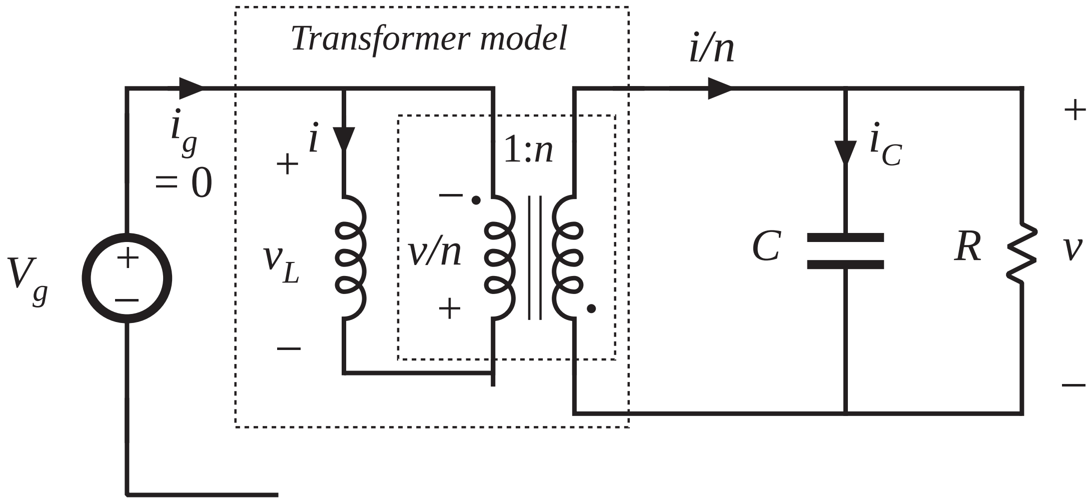
Q_1 on, D_1 off

$$v_L = V_g$$
$$i_C = -\frac{v}{R}$$
$$i_g = i$$

CCM: small ripple approximation leads to

$$v_L = V_g$$
$$i_C = -\frac{V}{R}$$
$$i_g = I$$

Subinterval 2



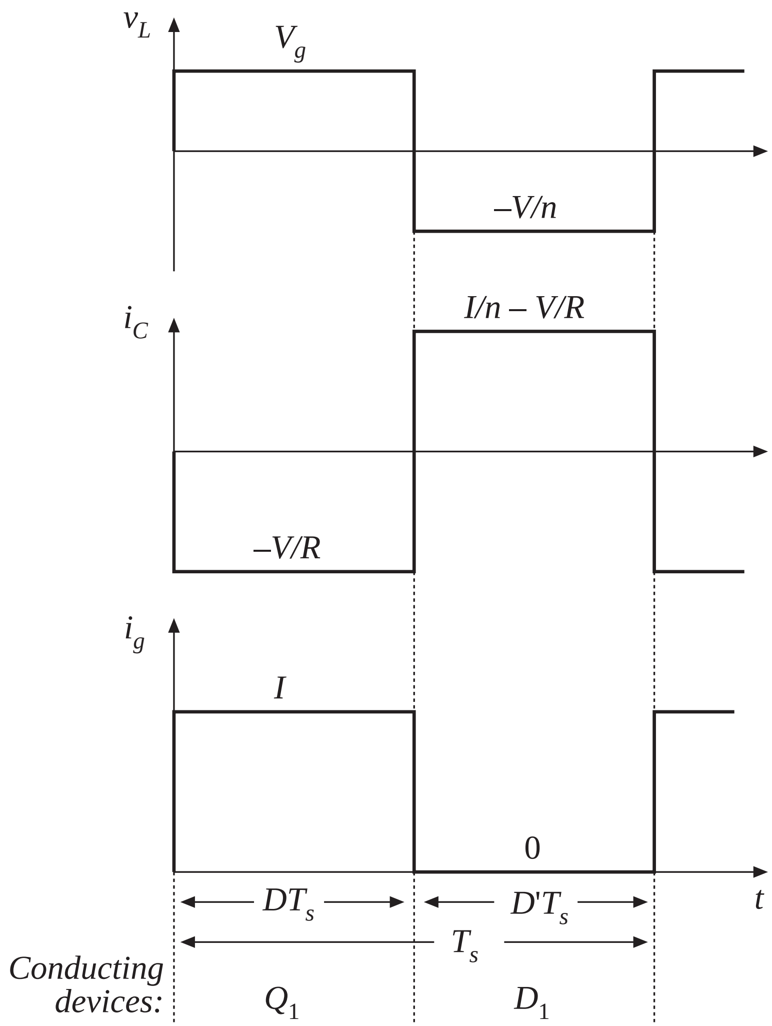
$$v_L = -\frac{v}{n}$$
$$i_C = \frac{i}{n} - \frac{v}{R}$$
$$i_g = 0$$

CCM: small ripple approximation leads to

Q_1 off, D_1 on

$$v_L = -\frac{V}{n}$$
$$i_C = \frac{I}{n} - \frac{V}{R}$$
$$i_g = 0$$

CCM Flyback waveforms and solution



Volt-second balance:

$$\left\langle v_L \right\rangle = D\left(V_g\right) + D'\left(-\frac{V}{n}\right) = 0$$

Conversion ratio is

$$M(D) = \frac{V}{V_g} = n\,\frac{D}{D'}$$

Charge balance:

$$\left\langle i_C \right\rangle = D\left(-\frac{V}{R}\right) + D'\left(\frac{I}{n} - \frac{V}{R}\right) = 0$$

Dc component of magnetizing current is

$$I = \frac{nV}{D'R}$$

Dc component of source current is

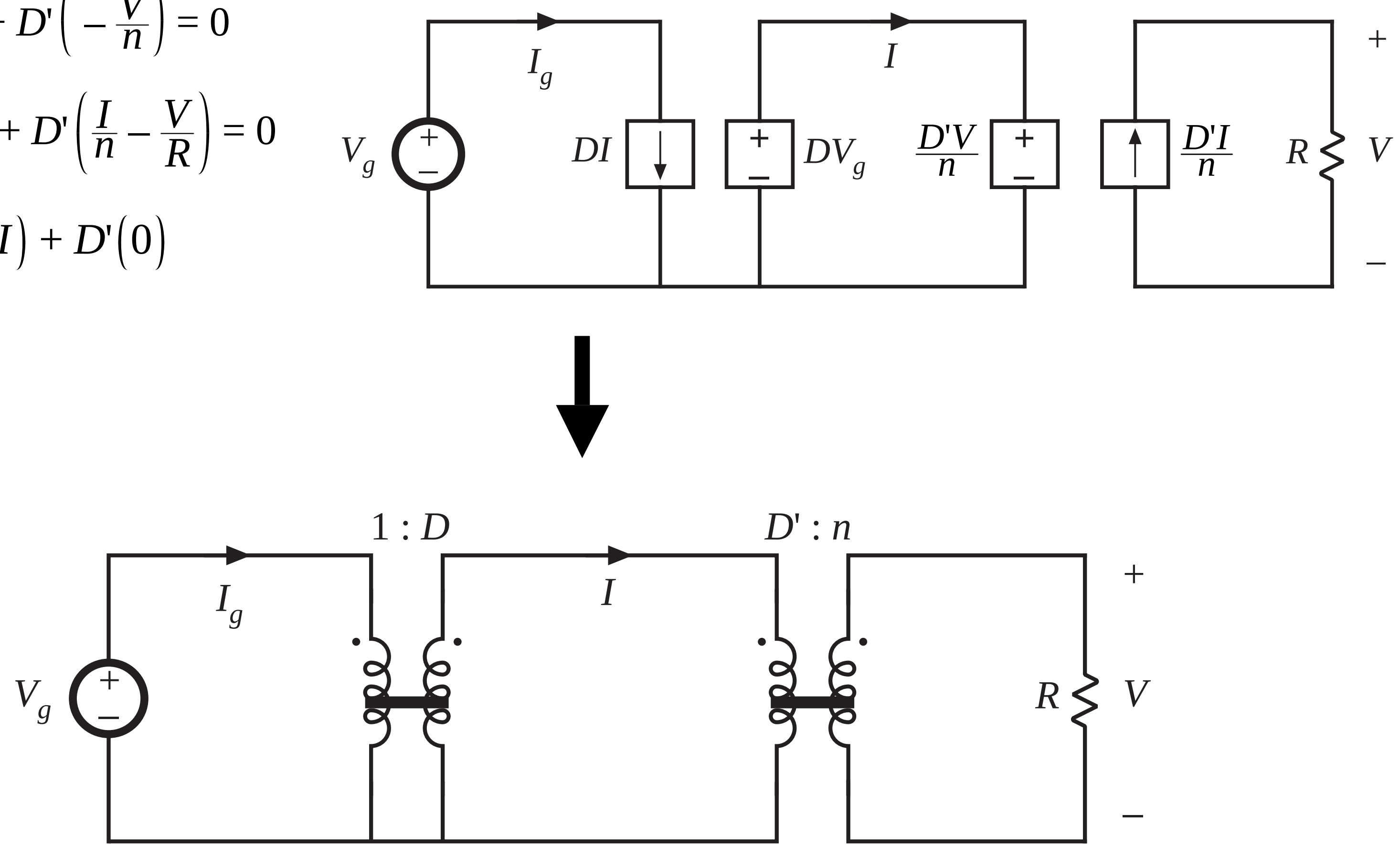
$$I_g = \left\langle i_g \right\rangle = D\left(I\right) + D'\left(0\right)$$

Equivalent circuit model: CCM Flyback

$$\left\langle v_L \right\rangle = D\left(V_g\right) + D'\left(-\frac{V}{n}\right) = 0$$

$$\left\langle i_C \right\rangle = D\left(-\frac{V}{R}\right) + D'\left(\frac{I}{n} - \frac{V}{R}\right) = 0$$

$$I_g = \left\langle i_g \right\rangle = D\left(I\right) + D'\left(0\right)$$



Discussion: Flyback converter

- Widely used in low power and/or high voltage applications
- Low parts count
- Multiple outputs are easily obtained, with minimum additional parts
- Cross regulation is inferior to buck-derived isolated converters
- Often operated in discontinuous conduction mode
- DCM analysis: DCM buck-boost with turns ratio