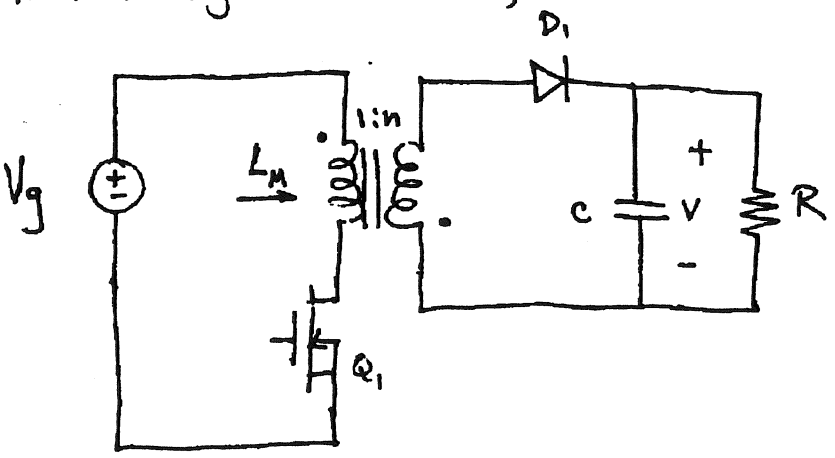
C L15
U L14

Solution to Problem 6.5

Nonideal flyback converter, CCM

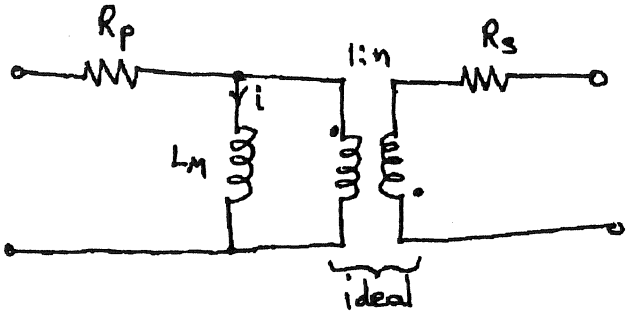


Model MOSFET on-resistance R_{on}

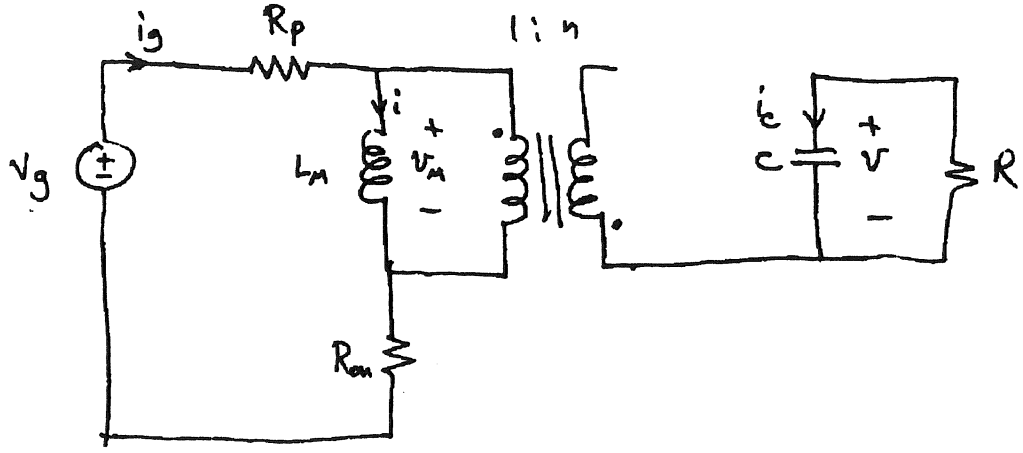
Diode forward voltage drop V_D

Flyback transformer winding resistances R_p and R_s

Equivalent circuit model used for flyback transformer:



Switch in position 1 : Q_1 on, D_1 off

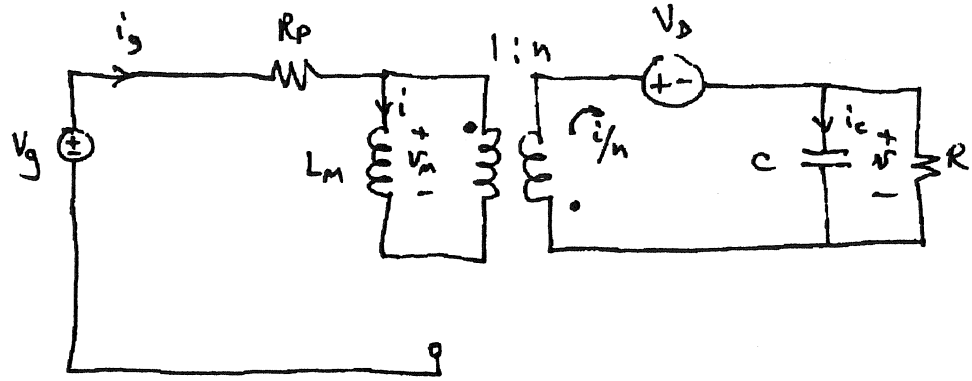


$$v_M = L_M \frac{di}{dt} = V_g - iR_p - iR_{on} \approx V_g - IR_p - IR_{on}$$

$$i_c = C\frac{dv}{dt} = -\frac{v}{R} \approx -\frac{V}{R}$$

$$i_g = i \approx I$$

Switch in position 2 : Q_1 off, D_1 on



$$v_M = -\frac{v}{n} \approx -\frac{V+V_D}{n} \qquad i_g = 0$$

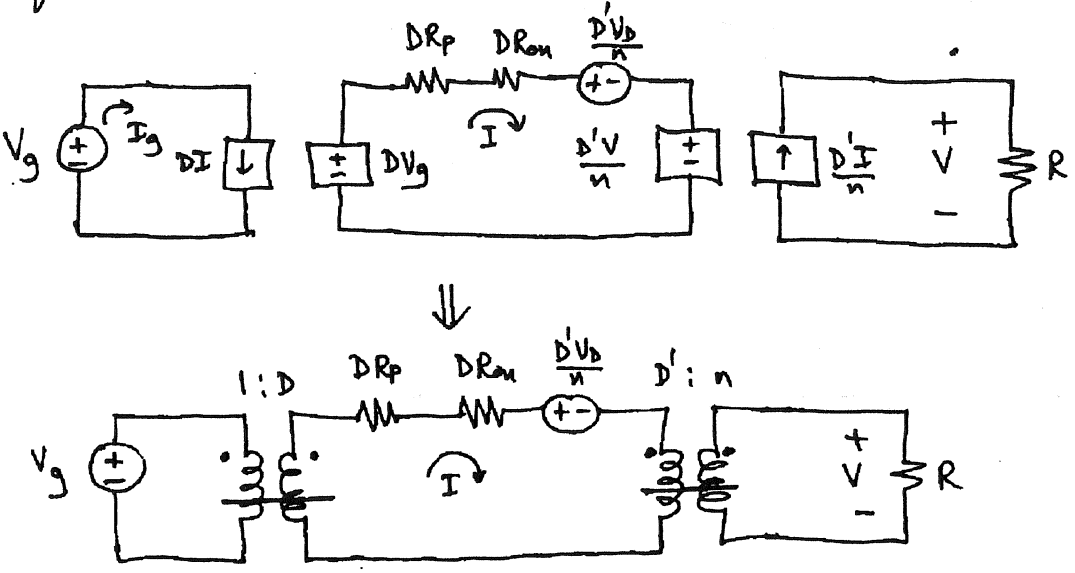
$$i_c = \frac{i}{n} - \frac{v}{R} \approx \frac{I}{n} - \frac{V}{R}$$

$$\langle v_m \rangle = 0 = D\left(V_g - IR_p - IR_{on}\right) + D'\left(-\frac{V+V_D}{n}\right)$$

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

$$\langle i_g \rangle = I_g = DI$$

Equivalent circuit model



b) Find converter efficiency

$$P_{in} = (V_g)(DI)$$

$$P_{out} = (V)\left(\frac{D'I}{n}\right)$$

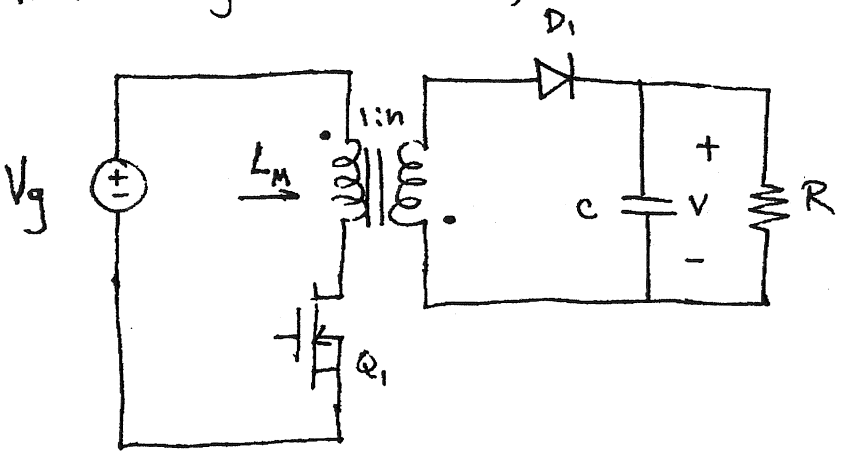
$$\eta = \frac{P_{out}}{P_{in}} = \frac{V}{V_g}\,\frac{D'I}{nDI} = \frac{V}{V_g}\,\frac{D'}{nD}$$

Also,
$$V = \left(DV_g - \frac{D'V_D}{n}\right)\left(\frac{n}{D'}\right)\frac{R}{R + \frac{n^2 DR_p}{D'^2} + \frac{n^2 DR_{on}}{D'^2}}$$

$$\frac{V}{V_g} = \frac{nD}{D'}\,\underbrace{\frac{\left(1 - \frac{D'V_D}{nDV_g}\right)}{\left(1 + \frac{n^2 D(R_p + R_{on})}{D'^2 R}\right)}}_{\eta}$$

Solution to Problem 6.5

Nonideal flyback converter, CCM

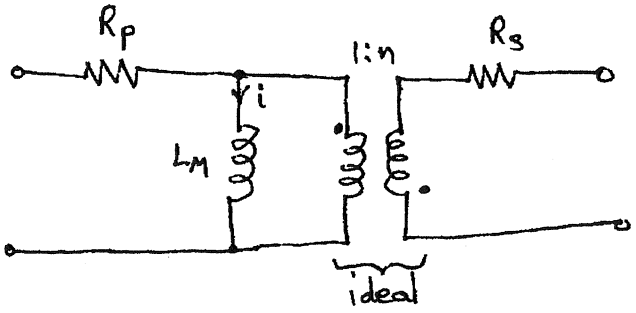


Model MOSFET on-resistance R_{on}

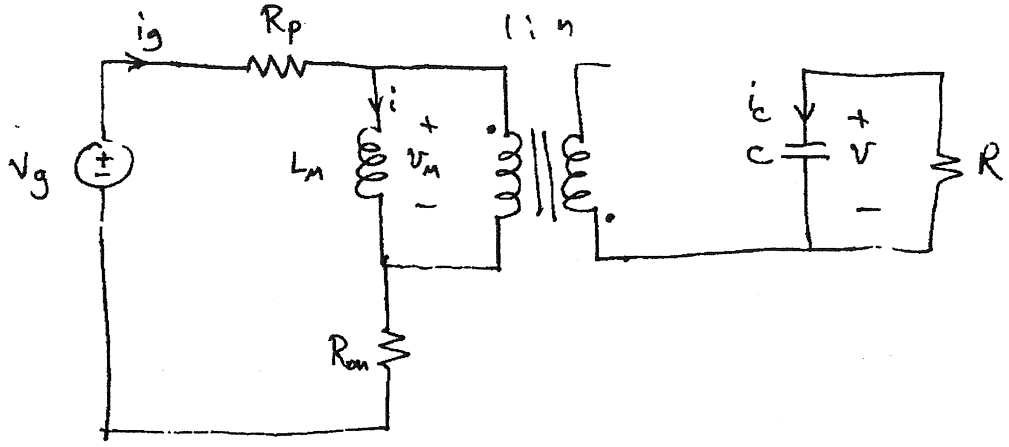
Diode forward voltage drop V_D

Flyback transformer winding resistances R_p and R_s

Equivalent circuit model used for flyback transformer:



Switch in position 1 : Q_1 on, D_1 off

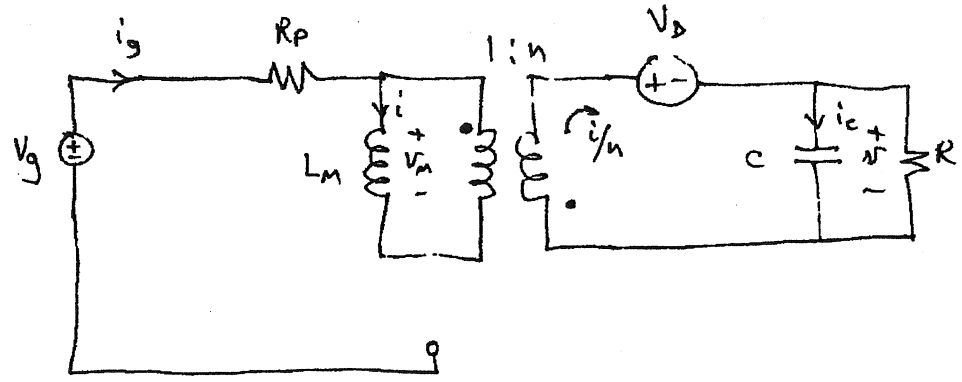


$$v_M = L_M \frac{di}{dt} = V_g - iR_p - iR_{on} \approx V_g - IR_p - IR_{on}$$

$$i_c = C\frac{dv}{dt} = -\frac{v}{R} \approx -\frac{V}{R}$$

$$i_g = i \approx I$$

Switch in position 2 : Q_1 off, D_1 on



$$v_M = -\frac{v}{n} \approx -\frac{V+V_D}{n} \qquad i_g = 0$$

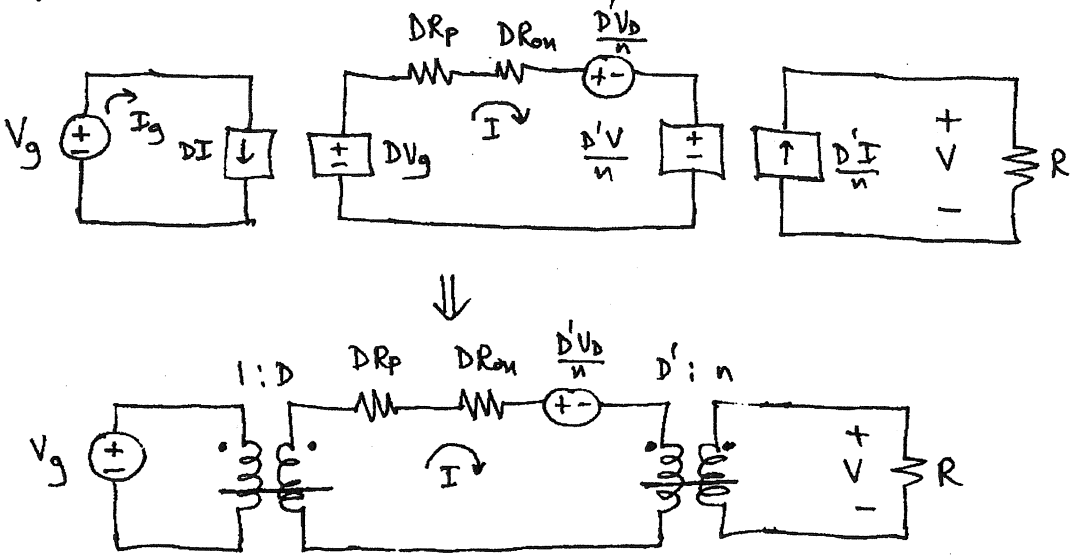
$$i_c = \frac{i}{n} - \frac{v}{R} \approx \frac{I}{n} - \frac{V}{R}$$

$$\langle v_m \rangle = 0 = D\left(V_g - I R_p - I R_{on}\right) + D'\left(-\frac{V+V_D}{n}\right)$$

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

$$\langle i_g \rangle = I_g = DI$$

Equivalent circuit model



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Also,

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$$\frac{V}{V_g} = \frac{nD}{D'}\,\underbrace{\frac{\left(1 - \frac{D'V_D}{nDV_g}\right)}{\left(1 + \frac{n^2 D(R_p + R_{on})}{D'^2 R}\right)}}_{\eta}$$