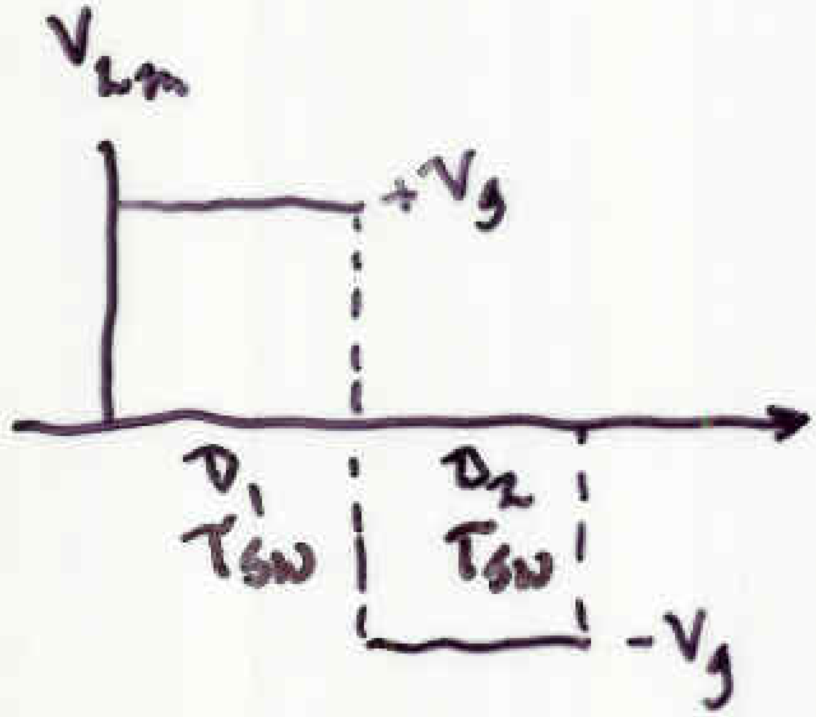
2Q Forward

CCM
DCM ← CAN guarantee?



$+V_g$ on primary for $D_1 T_{sw}$ $\Rightarrow$ both diodes D_1, D_2 off

$-V_g$ on primary $\Rightarrow$ diodes D_1, D_2 on

$V_Q(max) = V_g +$ diode drop

$+V_g$ on primary $\Rightarrow$ primary $i(trf) = \underbrace{\dfrac{I_{Load}}{n}}_{\text{lower } i_{drain} \text{ than } I_2}$

$n>1$

$n<1$?

$$i_g = \underbrace{i_{prim}}_{\text{big } \square\text{-wave}} + \underbrace{i_{L_m}}_{\text{small } \Delta\text{-wave}}$$

due to big L_m

How to Guarantee L_m reset: DCM

Q_1 and Q_2 ON

$$I_{Lm} = \frac{V_g}{L_m}\left(D_1 T_{sw}\right) \nearrow$$

D_1 and D_2 ON [Q's off]

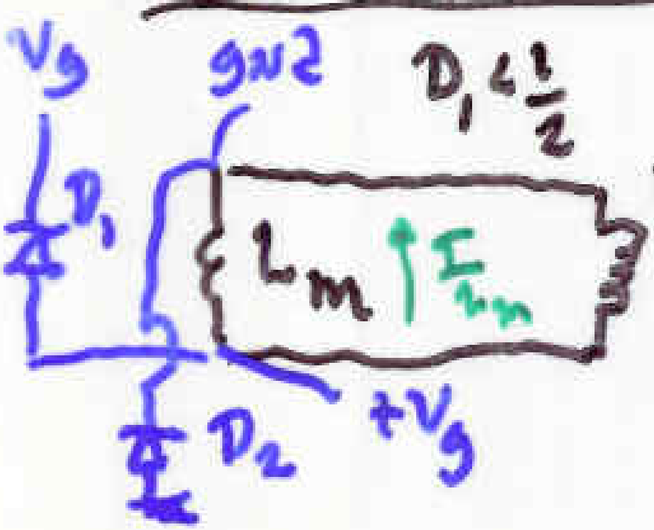
$$I_{Lm} = \frac{-V_g}{L_m}\left(D_2 T_{sw}\right) \searrow$$

Reset insured if $i_{L_m} = 0$ over T_{sw}

$D_1 \leq \frac{1}{2}$ insures this

$D_1 < \frac{1}{2}$

$I_{L_m} = 0$ interval



I_{Lm} cannot go $-$

D_2 opens if

$I_{Lm} < 0 \Rightarrow I_{L_m} = 0$

Secondary for CCM conditions

L_{sec} big $I_L^{AV}(sec) > \Delta i$

$\frac{V_{L(sec)}}{L_{sec}} = ?$

$\frac{V_L}{L_{sec}} = ?$

$\frac{N_2}{N_1} V_g$ + − V_0 L_{sec}

≈ gnd − + V_0 L_{sec}

$\frac{\Delta V}{L}$ $\frac{\Delta V}{L}$

i_{sec} conditions $\Delta i < I_L^{AV}(sec)$

i (in buck inductor)

$$V_3 \; \underset{L_B}{—\!\!\text{mm}\!\!—} \; V_{out} \text{ (fixed)}$$

interval 1

$V_3 = \frac{n_3}{n_1} V_g$ Q_{on} $V_{out} < V_g$ goal

interval 2

$V_3 = 0$ Q_{off} diode 2 off

interval 3

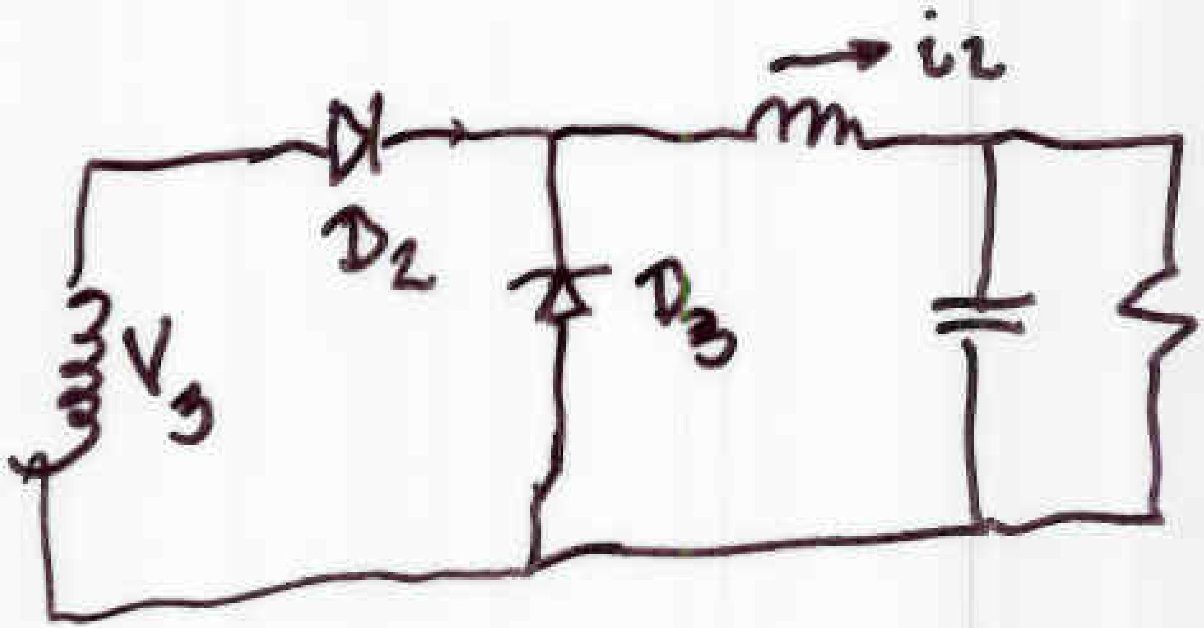
$V_3 = 0$ Q_{off} diode 1 off, diode 3 on

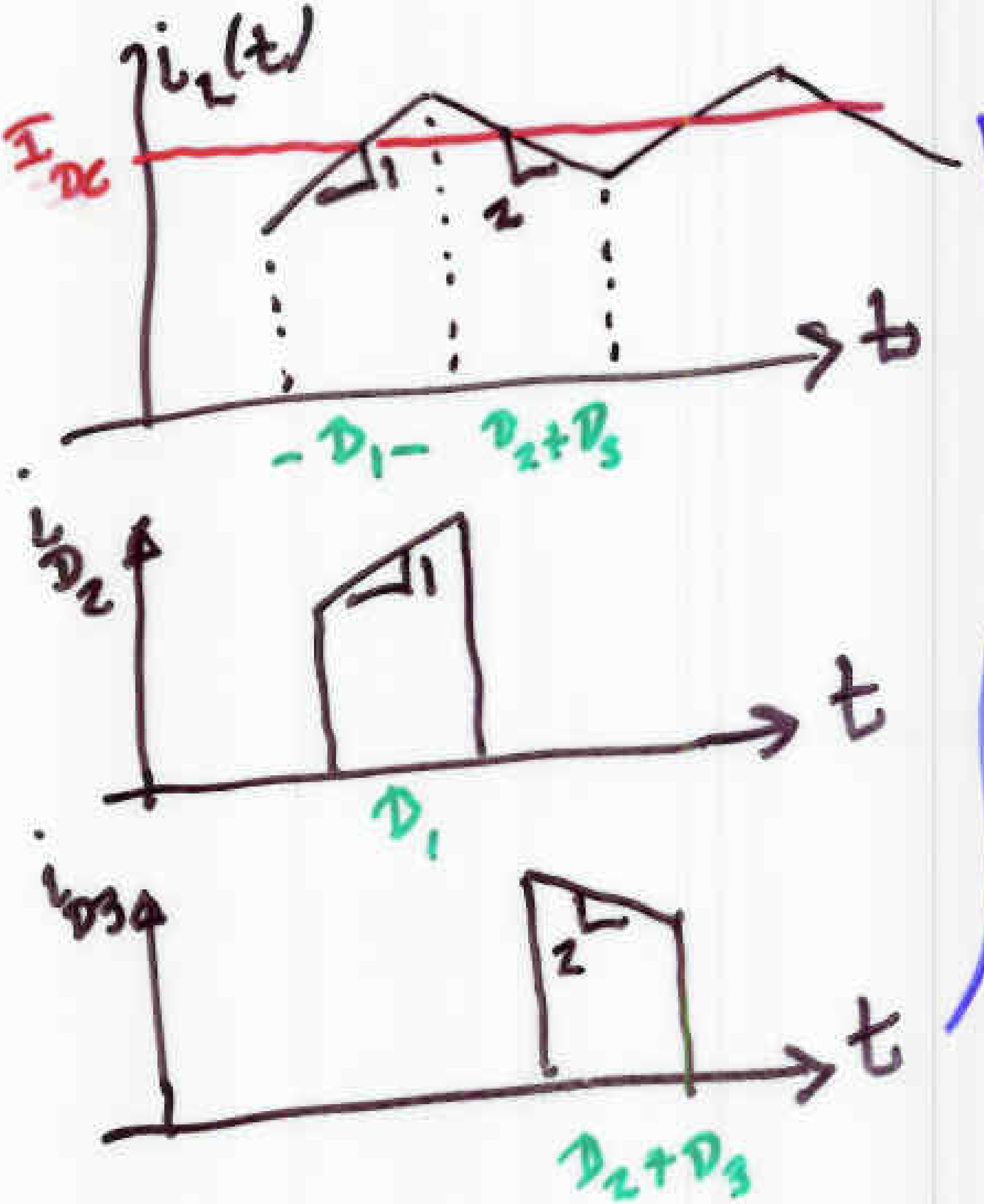
slope 1:

$$\frac{\frac{n_3}{n_1} V_g - V_0}{L_B}$$

slope 2:

$$\frac{-V_0}{L_B}$$



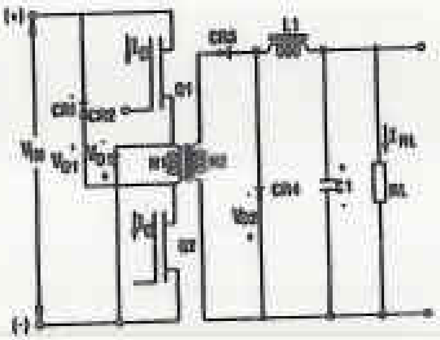


Std CCM Buck waveforms

TYPE OF CONVERTER

Two-Switch Forward

CIRCUIT CONFIGURATION



IDEAL TRANSFER FUNCTION

$$\frac{V_O}{V_{IN}} = \frac{N_2}{N_1}\left(\frac{t_{on}}{T_S}\right) = \frac{N_2}{N_1}(D)$$

$i_D(max)\downarrow$ $N_2 < N_1$

PEAK DRAIN CURRENT

- $I_{DMAX} = \underbrace{\frac{N_2}{N_1}\left(I_{RL} + \frac{\Delta I_{L1}}{2}\right)}_{load} + \underbrace{\hat{I}_{MAG}}_{core}$

  ($\hat{I}_{MAG}$ = peak magnetizing current.)

PEAK DRAIN VOLTAGE

- (Q_1 or Q_2) $V_{DS} = V_{IN} + V_{D1}$

lower P.I.V. each Q

AVERAGE DIODE CURRENTS

- $I_{CR1,AVE} = I_{CR2,AVE} = \frac{\hat{I}_{MAG}}{2} D$

  $I_{CR3,AVE} = I_{RL} D$

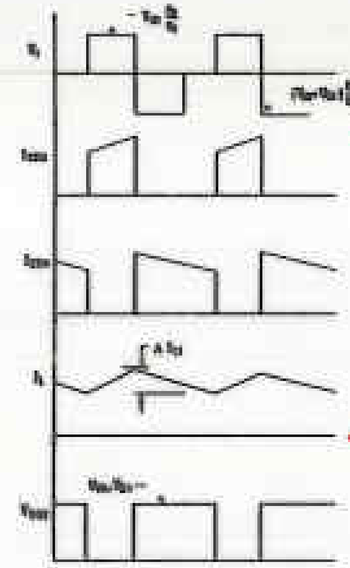
  $I_{CR4,AVE} = I_{RL}(1-D)$

DIODE VOLTAGES (VRM)

- $V_{CR1,PK} = V_{CR2,PK} = V_{IN}$

  $V_{CR3} = V_{CR4} = \left(\frac{N_2}{N_1}\right)V_{IN}$

VOLTAGE AND CURRENT WAVEFORMS



CCM

ADVANTAGES

Drain currents reduced by turns ratio. Lossless snubber recovers energy. Drain voltage 1/2 that of conventional forward converter. Low output ripple.

DISADVANTAGES

Poor transformer utilization, high parts count, high-side switch drive required. Transformer reset limits duty ratio. High input current ripple.

TYPICAL APPLICATIONS

High input voltage, moderate power. Supports multiple outputs.

APPLICABLE HARRIS PRODUCTS

HIP2500, HV400

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Two-Switch Forward

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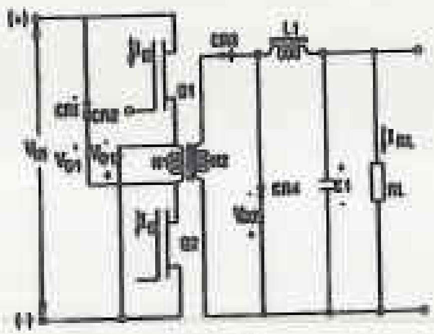

$I_d \downarrow$ if $N_2 < N_1$

IDEAL TRANSFER FUNCTION

$$\frac{V_O}{V_{IN}} = \frac{N_2}{N_1}\left(\frac{t_{on}}{T_S}\right) = \frac{N_2}{N_1}(D)$$

PEAK DRAIN CURRENT

- $I_{DMAX} = \frac{N_2}{N_1}\left(I_{RL} + \frac{\Delta I_{L1}}{2}\right) + \hat{I}_{MAG}$

  ($\hat{I}_{MAG}$ = Peak magnetizing current.)

PEAK DRAIN VOLTAGE

- (Q_1 or Q_2) $V_{DS} = V_{IN} + V_{D1}$

No turns ratio penalty

AVERAGE DIODE CURRENTS

- $I_{CR1,AVE} = I_{CR2,AVE} = \frac{\hat{I}_{MAG}}{2} D$

  $I_{CR3,AVE} = I_{RL} D$

  $I_{CR4,AVE} = I_{RL}(1-D)$

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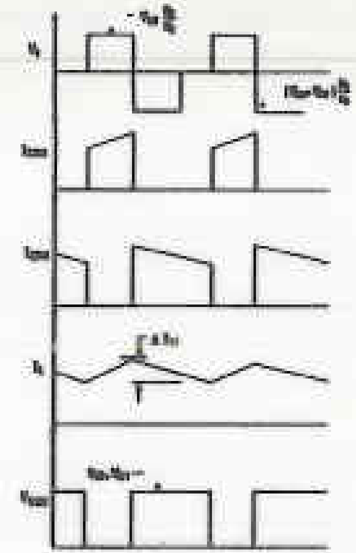

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