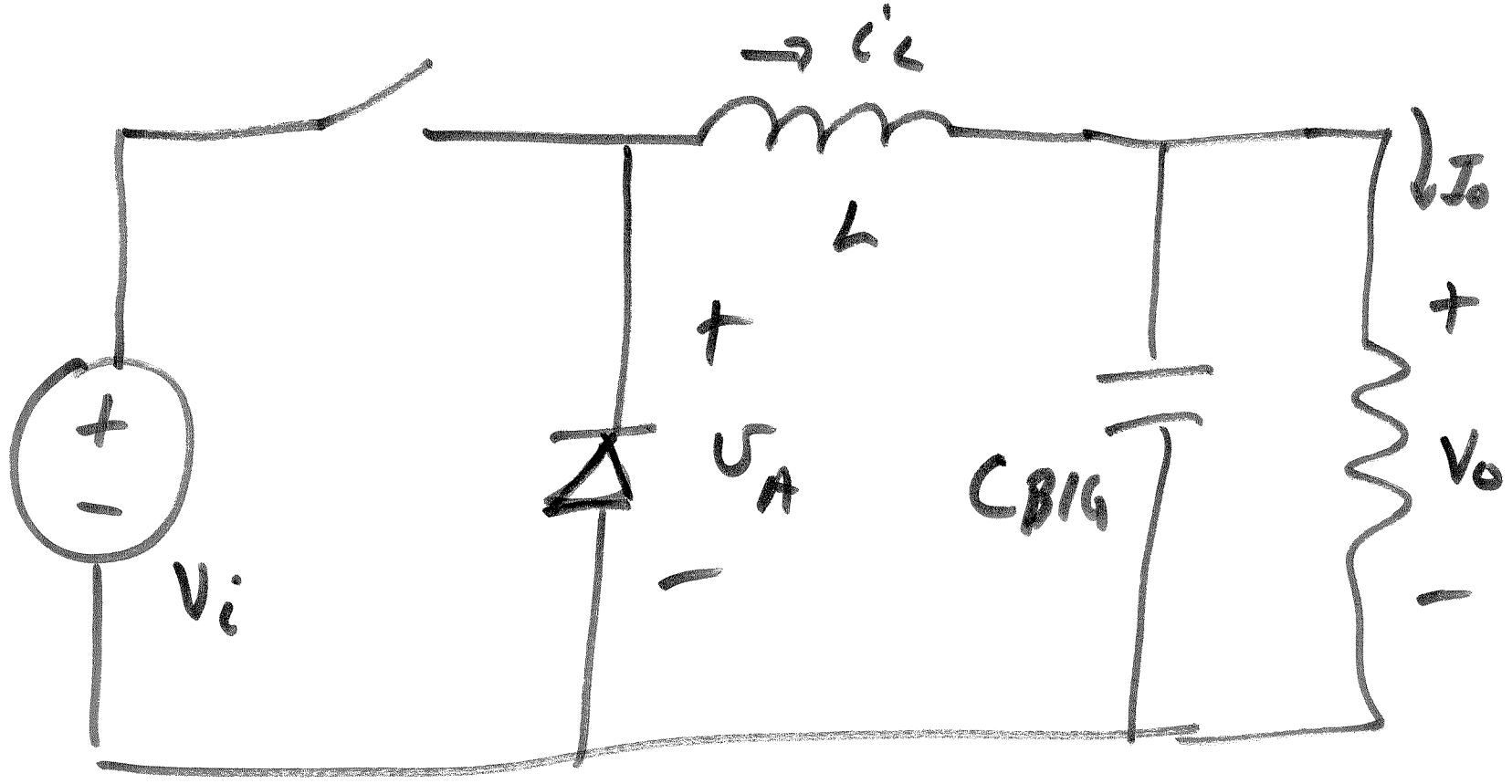
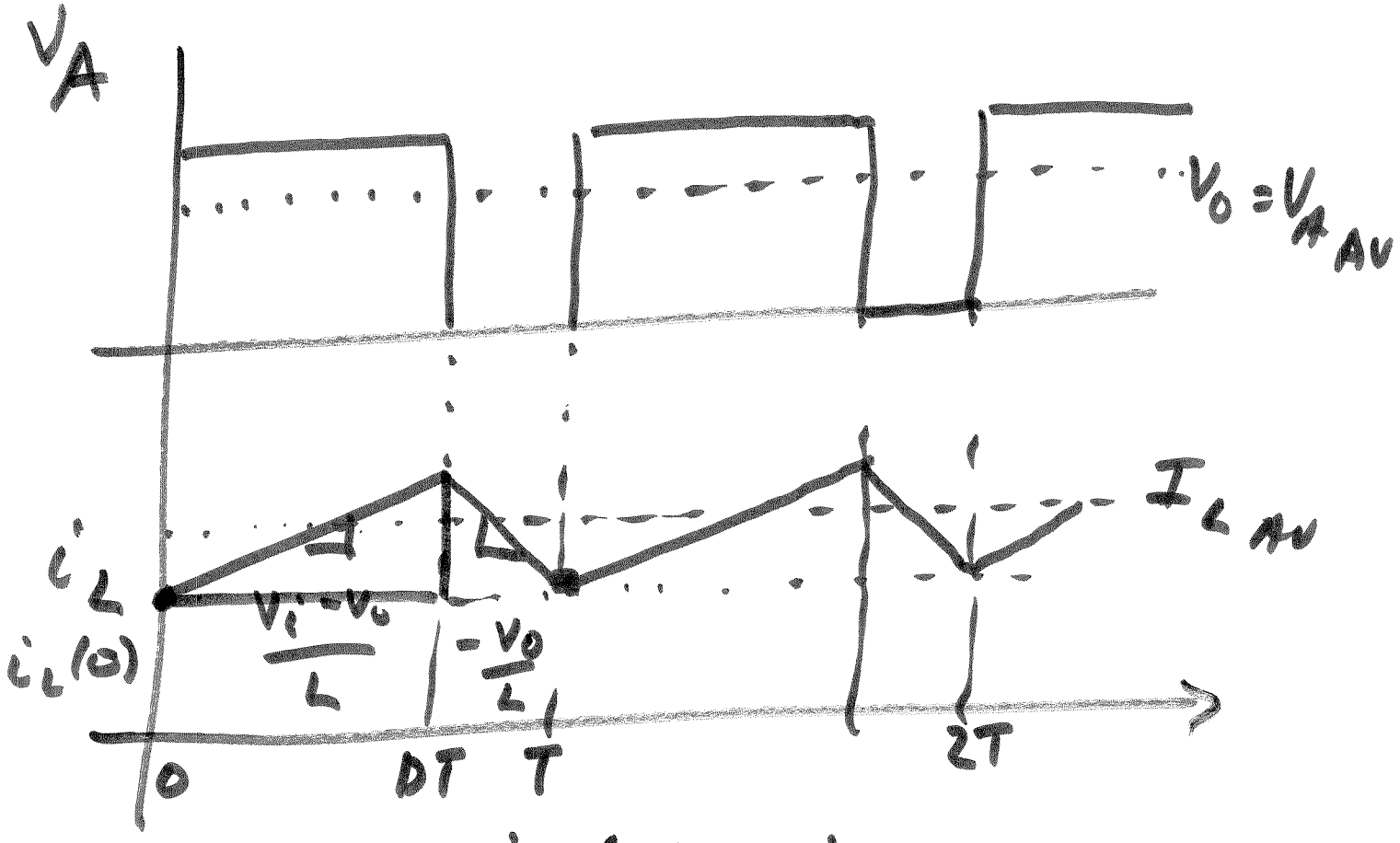
ECE 320 & ECE 329

ENERGY SYSTEMS I
BACKGROUND STUDY IN ENERGY SYSTEMS

SESSION no. 32



$V_i > V_o$



$$i_L(T) = i_L(0)$$

EXAMPLE

BUCK CONVERTER

$V_o = 5V$ $\quad V_{in} = 12.5V$

$L = 100\mu H$ $\quad R = 2\Omega$ $\quad f_s = 40\,KHz$

FIND D, i_L { PEAK, MIN, ~~PEAK~~ AVERAGE, RMS }

DUTY CYCLE = $D = \frac{5V}{12.5V} = 0.40$

Duty cycle

$$D = \frac{t_{on}}{\text{period}}$$

$$\text{period} = t_{on} + t_{off}$$

$$I_o = \frac{V_o}{R} = \frac{5V}{2\Omega} = 2.5A$$

$$I_{C\ AVERAGE} = 0$$

$$I_{L\ AVERAGE} = I_o + I_C = 2.5 + 0$$

$$I_{L\ AVERAGE} = 2.5\ A$$

$$\Delta i_L = \frac{1}{L}\int_{DT}^{T} V_o\, dt$$

40kHz

$$\Delta i_L = \frac{V_o}{L}(kt) = \frac{5V}{100\mu H}\cdot\left(0.6\,\frac{1}{f_s}\right)$$

$$\Delta i_L = 5\times10^{4}\,\frac{(0.6)}{40kHz} = 0.75A$$

$$i_L\,Min = (2.5A) - \left(\frac{0.75}{2}\right) = 2.125A$$

$$i_L\,max = 2.5 + \left(\frac{0.75}{2}\right) = 2.875A$$

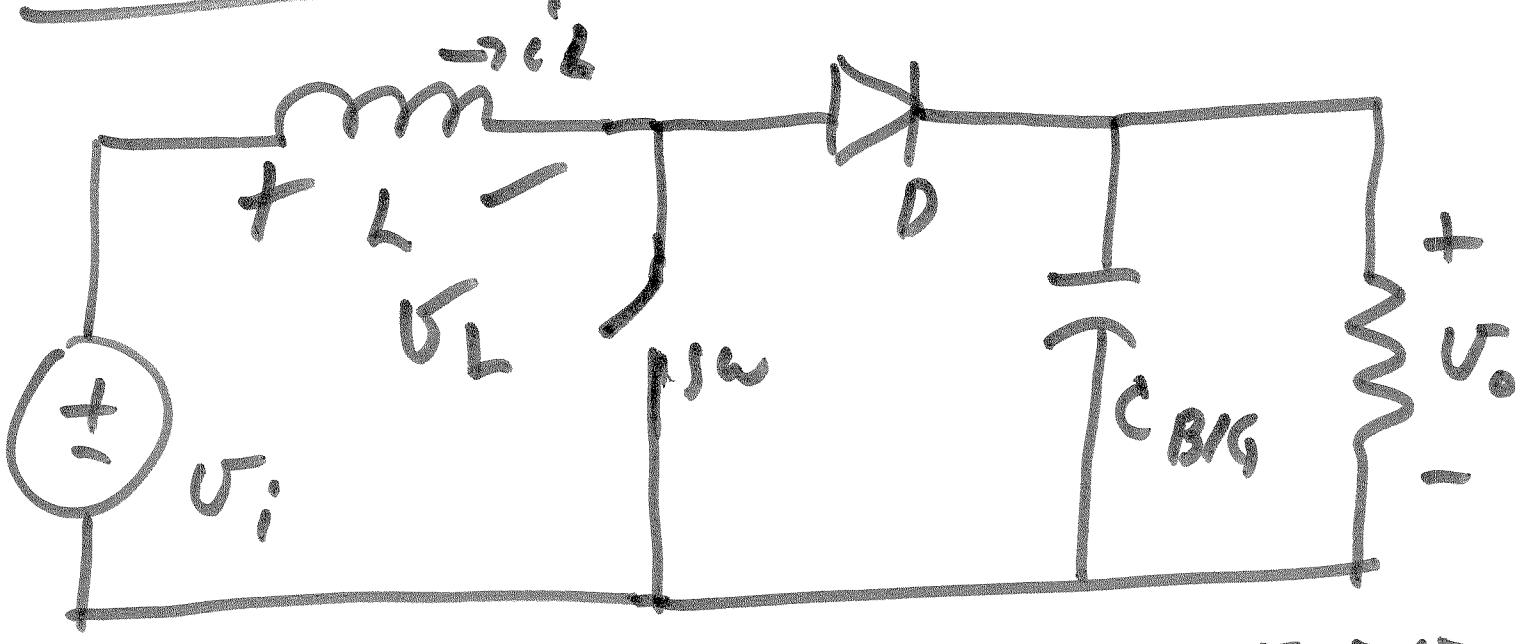
$$i_{L\,RMS} = \sqrt{\frac{1}{T}\int_0^T i_L^2\, dt}$$

$$i_{L\,RMS} = \sqrt{\frac{1}{(0.4)(25\,ms)}\int_0^{(0.4)(25\,ms)}\left(\frac{0.75\,A}{(0.4)(25\,ms)}\cdot t + 2.125\,A\right)^2 dt}$$

RISE TIME

$$i_{L\ RMS} = \underline{2.509\,A}$$

BOOST



- INITIAL $i_L > 0$ $v_o > 0$ $v_o > v_i$ BOOST
- CLOSE THE SWITCH

$$i_L = \frac{1}{L}\int_0^{DT} v_i \, dt$$ I_L RAMPS UP!

$$W_L = \frac{1}{2} L i_L^2$$

STORE ENERGY!

⇒ OPEN THE SWITCH

- DIODE CONDUCTS
- INDUCTOR DISCHARGES ENERGY

BUCK → FORWARD

(SWITCH ON → ENERGY TO LOAD)

BOOST → STORAGE

(STORES WHILE SWITCH

→ ENERGY TO LOAD WHEN

SWITCH OFF

CURRENT i_L DECREASES

... $i_L(T) = i_L(0)$

CYCLE COMPLETE

... CLOSE THE SWITCH

...

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On: $V_L = V_i$

OFF: $V_L = V_i - V_o$

$i_L(0) = i_L(T)$

$$\frac{1}{L}\int_0^{DT} V_i \,\text{~~dt~~} + \frac{1}{L}\int_{DT}^{T} (V_i - V_o)\, dt = 0$$

$$\frac{V_i}{L}(DT - 0) + \frac{V_i - V_o}{L}(T - DT) = 0$$

$\times \frac{L}{T}$

$$V_i D + (V_i - V_o)(1 - D) = 0$$

$$V_i D + V_i - V_o - V_i D + V_o D = 0$$

$$V_i - V_o + V_o D = 0$$

$$V_o - V_o D = V_i$$

$$V_o (1-D) = V_i$$

$$\frac{V_o}{V_i} = \frac{1}{1-D}$$

ECE 320

Energy Systems I

Lesson 32

Power Electronics

Password = BoostConverter