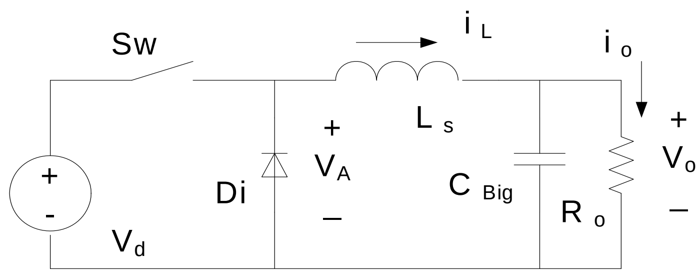
ECE 320

1. (8 points) A buck converter operates at 500kHz at a duty cycle of 0.35. It provides an output voltage of 2.5 Volts DC to a 20 Ohm load. The inductor is 10µH. Assume an ideal transistor switch and diode; Assume negligible voltage ripple on the output voltage.

   a. (2 points) Draw a circuit diagram for this buck converter. Label currents and voltages that you use in this problem.



b. (3 points) Find and sketch the diode voltage waveform. Label its maximum voltage, its minimum voltage, and the times that switching occurs during at least one switching cycle.

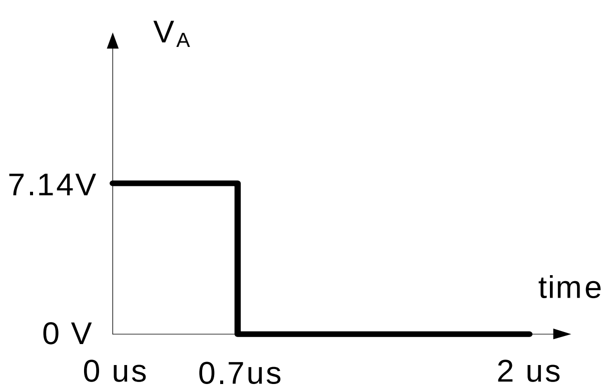
Restate the given.

$f_s := 500\cdot kHz \quad D := 0.35 \quad V_o := 2.5\cdot V \quad R_o := 20\cdot\Omega \quad L_s := 100\cdot\mu H$

Rearrange the voltage formula to find the input voltage. The time period is the reciprocal of the switching frequency.

$V_d := \frac{V_o}{D} = 7.143\,V \qquad T_s := \frac{1}{f_s} = 2\cdot\mu s \quad D\cdot T_s = 0.7\cdot\mu s$

Graph the waveform.



c. (3 points) Find and sketch the inductor current and label its maximum current value.

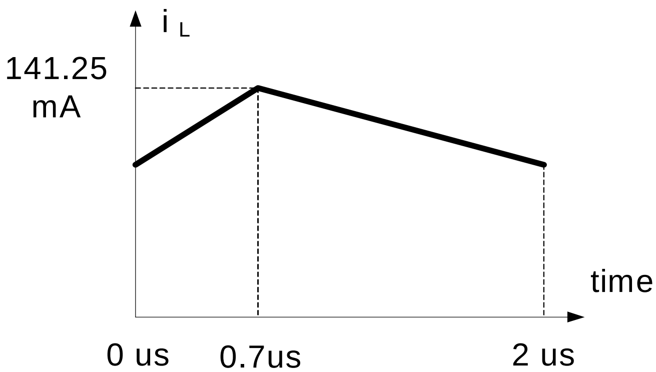
The average or DC output current is the same as the average or DC inductor current because the capacitor has zero average current.

$$I_{oDC} := \frac{V_o}{R_o} = 125 \cdot mA$$

Take the slope of one of the sections of the inductor current and integrate it over the time allotted.

$$\Delta i_L := \frac{V_o \cdot (1 - D) \cdot T_s}{L_s} = 32.5 \cdot mA$$

The maximum is the average plus half of the ripple.



$$I_{Lmax} := I_{oDC} + \frac{\Delta i_L}{2} = 141.25 \cdot mA$$

2. (2 points) For our buck converter, we find that our transistor switch has a forward voltage of 0.2V and our diode has a forward voltage of 0.6V. For an input voltage of 8.0V, estimate the output voltage for the same 20 Ohm load. Assume continuous conduction.

I lose 0.2V during D due to the transistor voltage drop; I lose 0.6V during (1-D) due to the diode voltage drop. I would expect

$$V_o := D \cdot (8.0 \cdot V) = 2.8\,V$$

I lose

$$\Delta V_o := (0.2 \cdot V) \cdot (D) + (0.6 \cdot V) \cdot (1 - D) = 0.46\,V$$

Therefore, I would more reasonably expect

$$V_o - \Delta V_o = 2.34\,V$$