

ECE 1750 Spring 2019 HW #6

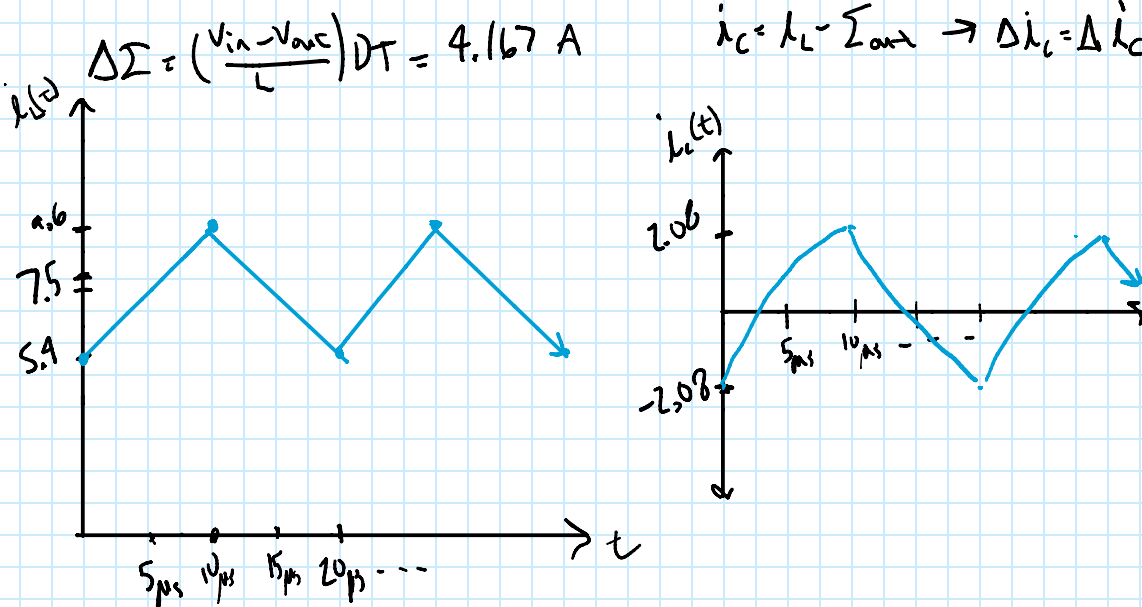
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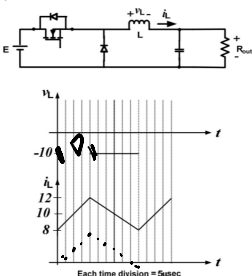
1) Consider a buck converter in which by changing the duty cycle the average output voltage may vary between 20 and 30 V. The load can also change between 5 and 10 A. What inductance value guarantees operating in continuous conduction mode? For this inductance, plot the inductor and capacitor currents for an output voltage of 25 V and load current of 7.5 A. Consider that the input voltage is 50 V and the switching frequency is 50 kHz. Also, remember that the load resistor current can be considered to be constant.

$$L > \frac{V_{out(max)}}{2 I_{out(min)} f} \quad V_{out} = 30 \quad f = 50k \quad I_{out} = 5 \quad \Rightarrow \quad L > 60 \mu H$$

$$\frac{V_{in} - V_{out}}{L} \text{ for } DT \quad \frac{-V_{out}}{L} \text{ for } (1-D)T \quad T = 20 \mu s \quad D = \frac{V_{out}}{V_{in}} = \frac{1}{2}$$



2) For the buck converter in the circuit schematic below you only know the partial waveforms that are displayed under the circuit schematic (both waveforms have missing traces, so do not assume that a missing portion of a trace means a value of zero for that particular portion of the trace). Please calculate, L, E, and R_{out} .



closed $V_L = V_{in} - V_{out}$ $V_{out} = 10V$
 open $V_L = -V_{out}$ $10V = DE$
 $D = 4/10$ $E = 25V$

$$\Delta I = 4A = \left(\frac{V_{in} - V_{out}}{L} \right) DT \quad T = 50 \mu s$$

$$\Rightarrow L = 75 mH$$

$$I_{out} = 10 = \frac{V_{out}}{R} \Rightarrow R = 1 \Omega$$

$$I_{out} = I_O = \frac{V_{out}}{R} \Rightarrow \boxed{R = 1 \Omega}$$

3) Consider that you have a buck converter with a dc output voltage of 50 V, fed by a rectifier with an input voltage of 120 V_{rms} and a 1mF capacitor. The buck converter load is a 2 ohm resistor and it has a 100 μH inductor and 500 μF capacitor. What is the buck converter peak-peak output voltage ripple caused by a switching frequency of 50 kHz? (Note: you should also see some ripple with a frequency of 120 Hz caused by the rectifier output voltage ripple but for this problem you can neglect this other ripple component).

$$\Delta V = \frac{(1-D)V_{out}}{8LCf^2} \quad V_{in} \approx \sqrt{2} V_{rms} \approx 170$$

$$\Rightarrow D = \frac{50}{170}$$

$$\boxed{\Delta V = 35 \text{ mV}}$$

4) Please indicate maximum current and voltage ratings that you need to specify when ordering a diode and a MOSFET for a buck converter with an input voltage of 120 V, an output voltage of 50 V, and load resistors that could take values between 2 and 10 Ohms.

$$\text{Voltage Rating} \rightarrow \boxed{2V_{in} = 240V}$$

$$\text{Current Rating} \rightarrow \frac{2}{\sqrt{3}} I_{out(max)}$$

$$I_{out \text{ max}} = 50/2 = 25A$$

$$\text{Current Rating} \rightarrow \boxed{I_{rms} = 29A}$$