EN 313 - Power Electronics

Assignment-5

Date: 30-10-2018 Due: 05-11-2018

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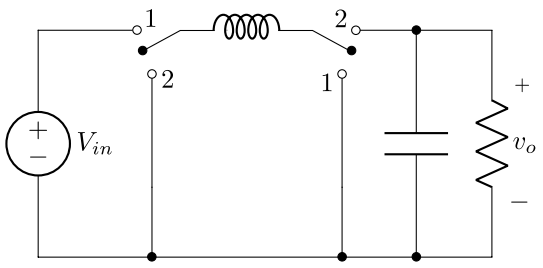
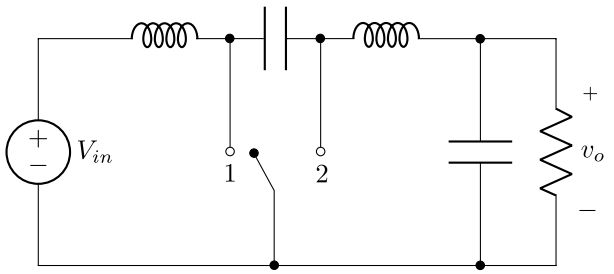
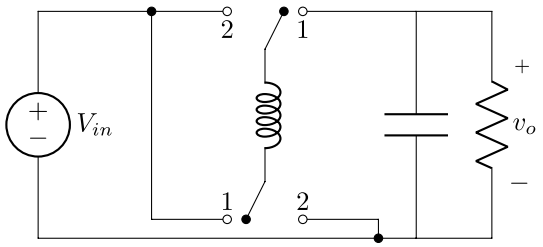
1. Derive expressions for the voltage gain (average output voltage/input voltage) of the DC-DC converters shown in Fig. 1. The switch(es) is(are) in position 1 for a duration of DT_s and in position 2 for a duration of $(1-D)T_s$. Assume that the current through the inductor(s) is continuous (CCM operation). Make any other suitable assumptions if necessary.



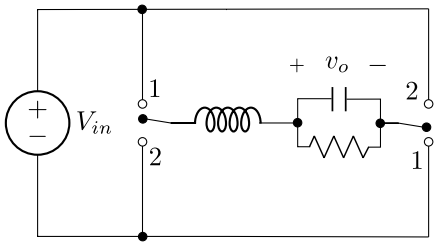
(a) Non-inverting buck-boost converter



(b) Ćuk converter



(c) Watkins-Johnson converter



(d) Bridge converter

Figure 1: DC-DC converters

2. A boost converter switching at 100kHz is supplied with an input voltage that varies between 5V and 10V. The output needs to be regulated at 15V.

   (a) The value of inductance used in the converter is 100μH. What is the worst-case peak-to-peak ripple current in the inductor?

   (b) A 10Ω load is connected at the output of the boost converter. Determine the minimum value of capacitance required to limit the peak-to-peak output voltage ripple to 1% of the average output voltage.

3. It is desired to interface a 9V DC source to a 5V, 2.5Ω load using a DC-DC converter. Two possible approaches, using buck and buck-boost converters are being considered (Terminals of the 9V source can be connected appropriately to get a positive voltage output from the buck-boost converter).

   (a) Draw the two converter circuits.

   (b) The diode used in both the converters has a constant forward voltage drop of 0.8V when it conducts. Ignore all other non-idealities. Determine the duty ratio of each converter for the specified operating conditions, considering the voltage drop across the diode.

(c) Determine the conduction loss in diode for each converter. Which converter is better?

4. A boost converter delivers 48W of power at 12V. Input voltage to the converter is 5V. The converter switches at 200kHz and the value of inductance is 146μH. Draw the circuit and sketch the waveforms of currents through (i) inductor (ii) MOSFET and (iii) diode. Make suitable assumptions. It is required to estimate the approximate power loss in MOSFET and diode, based on the idealised waveforms. ON-state resistance of the MOSFET is 40mΩ. Sum of the turn-ON and turn-OFF transition times of the MOSFET is 150ns. Forward voltage drop across the diode is 0.8V. A Schottky diode is used here, which has negligible switching loss. Based on the loss calculated and the output power, comment on the efficiency of the DC-DC converter.