SKEE4643 **TEST1** **1 hour 15 minutes**

Question 1

In the buck-boost converter of Figure Q1, the averaged model of the switch network is desired. The terminals voltage and current of the switch network are given as v_1, v_2, i_1 and i_2. The input voltage is a constant, v_d. The capacitor, C, is sufficiently large so that the output voltage, v_o, is considerably constant. The converter operates in CCM with inductor current repeatedly changes between i_{Lmin} and i_{Lmax} in steady state.

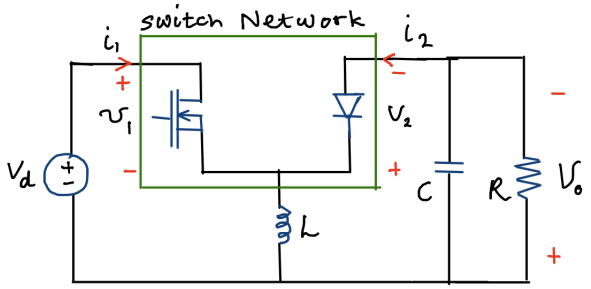

Figure Q1

(i) Draw terminal switch network waveforms: v_1, v_2, i_1 and i_2. Label key quantities. [3 marks]

(ii) Find the average voltage conversion ratio, $<v_2>/<v_1>$ and the average current conversion ratio, $<i_2>/<i_1>$, of the switch network. [2 marks]

(iii) Construct averaged circuit model of the complete buck converter by replacement of the switch network by the averaged switch model (dependent sources) based on the equations found in (ii). [2 marks]

(iv) Show that the efficiency of the averaged circuit is 100 % under steady-state condition. [2 marks]

Question 2

In a buck converter, the MOSFET has on resistance, R_Q = 50 mΩ, the diode forward voltage drop can be modeled by constant voltage V_D = 0.9 V, with resistor R_D = 60 mΩ, and the inductor has an internal resistance r_L = 70 mΩ.

(i) Draw an equivalent circuit which models the DC properties of this converter. The averaged switch model can be represented by dependent sources or a DC transformer. [3 marks]

(ii) Determine the efficiency of the buck converter. [3 marks]

(iii) Determine the required duty cycle, D. [2 marks]

Question 3

Show that the conversion ratio for the boost converter including just MOSFET on resistance, RQ, is given as:

$$\frac{V_o}{V_d} = \frac{1}{1 - D + \left(\frac{D}{1-D}\right)\frac{R_Q}{R}}$$

[3 marks]