

Major Exam: ELL 302 Power Electronics

Date: 6th January 2021, Time: 9:00 AM to 11:00 AM

Answer all questions, total marks – 50

Please write your name and entry number at the top of the answer sheet

1. For a buck-boost converter

(a) show that the converter operates in discontinuous conduction mode when $K < K_{crit}$, and derive expressions for K and K_{crit} . (2+2+2=6)

(b) Derive an expression for the dc conversion ratio V/V_{in} of the buck-boost converter operating in discontinuous conduction mode. 4

(c) For $K = 0.25$, plot V/V_{in} over the entire range $0 \leq D \leq 1$. 2

(d) Sketch the voltage across the inductor and inductor current waveforms for $K = 0.25$ and $D = 0.5$. Label salient features. 2+2=4

(e) A buck boost converter is operated with the following parameters- V_{in} varies from 20 V to 80 V, $V_{out} = 40$ V, load resistance $R = 10$ ohm, switching frequency = 50 kHz, all switches are ideal. Find the minimum inductance value for which the converter always operates in CCM. 4

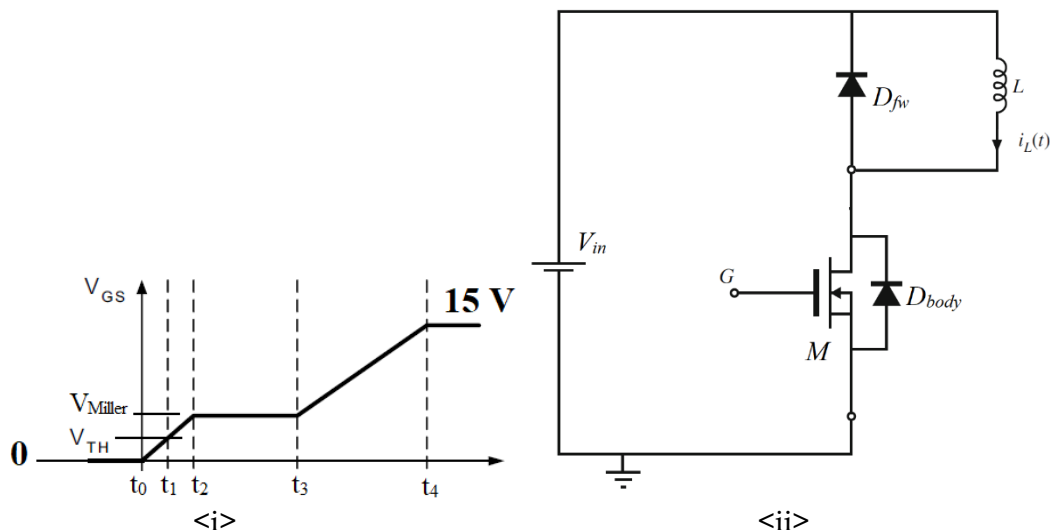
2. For synchronous boost converter, answer the following

(a) Does this converter operate in the discontinuous conduction mode at light load condition? Draw the converter circuit diagram and explain your answer.

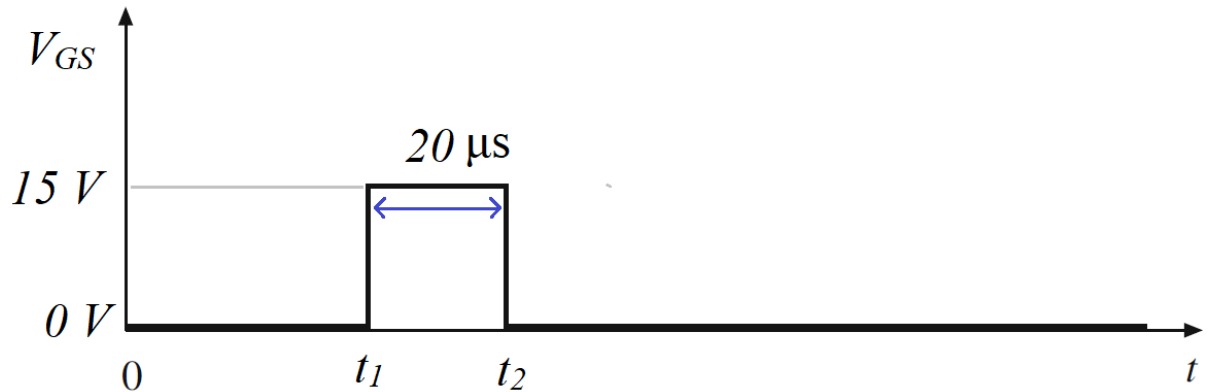
(b) The load resistance is disconnected ($R \rightarrow \infty$), and the converter is operated with duty cycle 0.5. Sketch the inductor current and inductor voltage waveform. (1+ 1+ 4 + 2+ 2 = 10)

3. (a) Describe the MOSFET turn on process when a V_{GS} voltage shown in Fig. <i> is applied. Assume that the steady-state MOSFET current is I_D and MOSFET was blocking a voltage V_{DS} prior to turning on. Properly show the current and voltage transition of the MOSFET according to the time instant $t_0 \sim t_4$. 3

(b) For the circuit shown below in Fig. <ii>, the circuit was at relaxed condition with the MOSFET turned off with $V_{GS} = 0$ V. At this condition, find the voltage across the diode and the MOSFET drain-to-source terminal, V_{DS} . Find the current through the inductor, i_L . Given $V_{in} = 500$ V, $L = 100$ μ H. MOSFET breakdown voltage rating is 250 V, continuous drain current rating is 100 A at 25 degree Celsius, diode forward voltage drop $V_F = 1.5$ V. 1+1+1=3



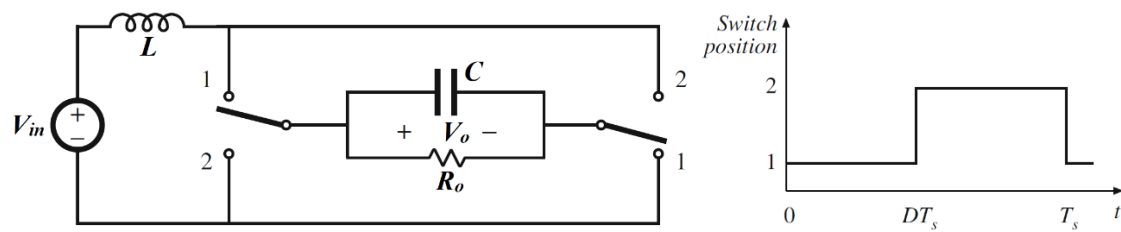
(c) The MOSFET is turned on after some time t_1 with a single pulse of $20 \mu\text{s}$ pulse-width as shown in figure below.



Draw the inductor current for the applied V_{GS} . Draw the MOSFET and Diode current with proper values. At what time, the inductor current reaches zero? (1 + 1 + 1 + 1)

4. (a) For the following converter, find the expression for the average output capacitor voltage and the inductor current. Plot the voltage gain versus duty ratio.

(2+2+6=10)



- (b) For the following converter, switch S_1 and S_3 are switched with the following duties.
 $d_{S1} = 0.5 + 0.4 \sin \omega t$ and $d_{S3} = 0.5 - 0.4 \sin \omega t$

Switches S_4 and S_2 are switched with complementary duties of S_1 and S_3 , respectively, in order to produce a 50 Hz AC at the output. Find the switch realisation for switches S_1, S_2, S_3, S_4 .

