Advanced Power Electronics

Problem 1:

Consider the waveform of some quantity *x(t)* vs. time shown in Fig. 1 in the context of a **switch mode dc-dc power converter**. You may assume the components of the converter to be ideal.

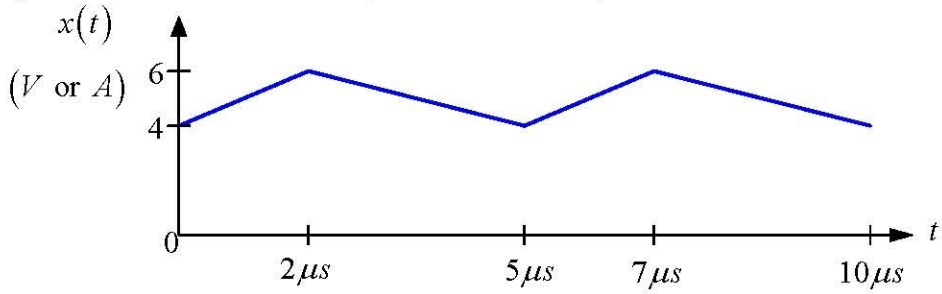


Fig. 1

(a) Can the waveform of Fig. 1 be that of the ***voltage across a 100 μH inductor*** in steady state?
If Yes, calculate and plot the corresponding **current** through the same inductor.
If No, give a specific reason why it is not a valid waveform.

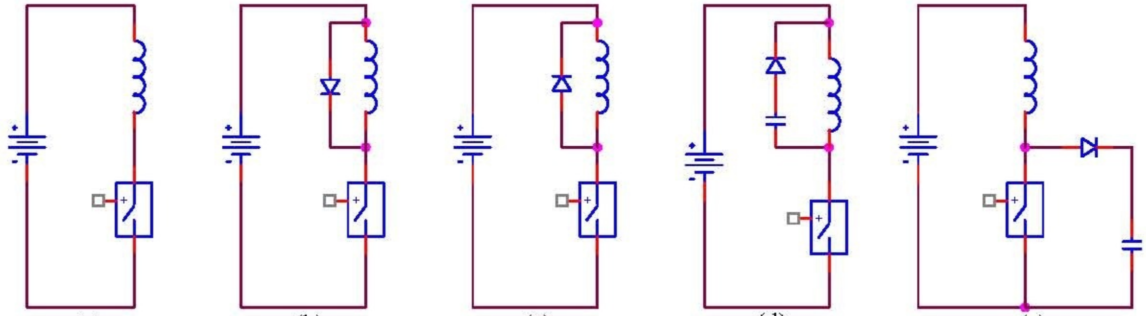
(b) Can the waveform of Fig. 1 be that of the ***current through a 100μH inductor*** in steady state?
If Yes, calculate and plot the corresponding **voltage** across the same inductor.
If No, give a specific reason why it is not a valid waveform.

(c) Can the waveform of Fig. 1 be that of the ***voltage across a 100 μF capacitor*** in steady state?
If Yes, calculate and plot the corresponding **current** through the same capacitor.
If No, give a specific reason why it is not a valid waveform.

(d) Can the waveform of Fig. 1 be that of ***current through a 100μF capacitor*** in steady state?
If Yes, calculate and plot the corresponding **voltage** through the same capacitor.
If No, give a specific reason why it is not a valid waveform.

(e) Can the waveform of Fig. 1 be that of the ***voltage across a MOSFET*** in steady state?
If Yes, calculate and plot the corresponding **current** through the same MOSFET.
If No, give a specific reason why it is not a valid waveform.

Problem 2



(a) (b) (c) (d) (e)

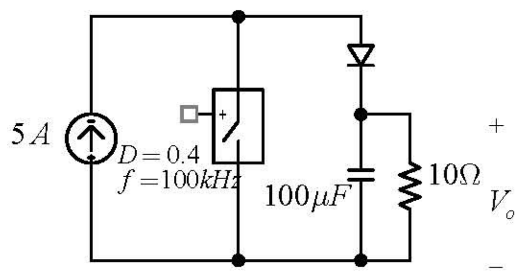
(a) In the above circuits all the components are assumed ideal. The value of inductance is 25 μH and the capacitance is 10 μF. The switching frequency is 100 kHz and the duty ratio is 0.5. Which of the above circuit(s) result in valid *steady-state* operation? Justify your answers.

(b) If the inductor is assumed to have a series resistance of 50 Ω (all other components still ideal), which of the above circuits will result in valid steady-state operation?

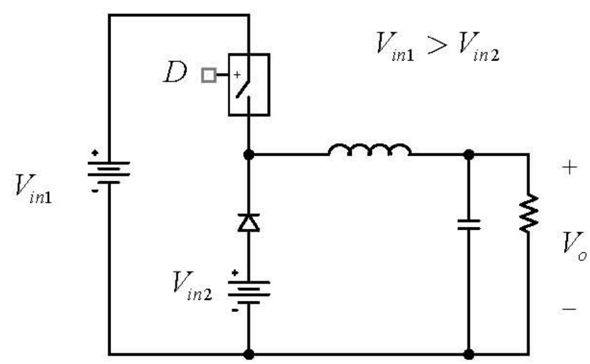
Problem 3

For each of the four circuits shown below, determine if steady state operation is possible. If yes, calculate V_o in steady-state (for each). If not, explain why steady state operation is not possible.

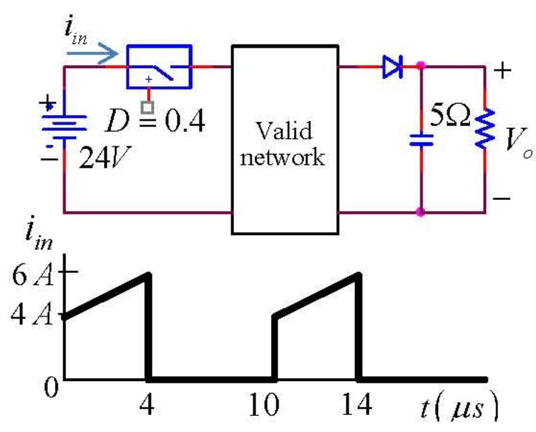
(a)



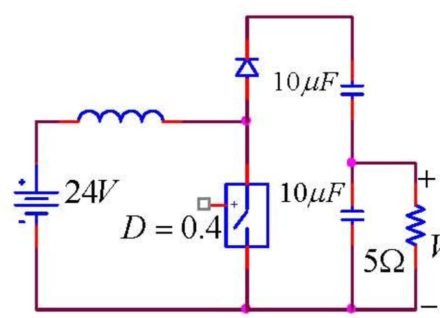
(b)



(c)



(d)



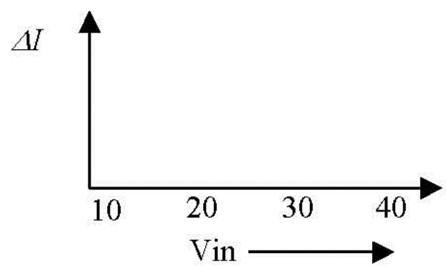
Problem 4

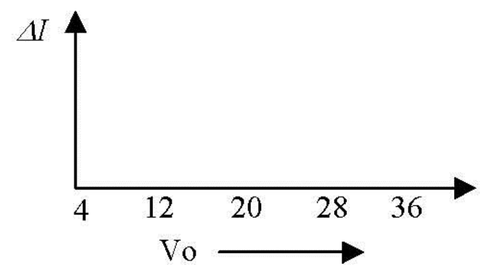
A buck converter has the following parameters.

$L = 100\mu H$, $C = 100\mu F$ (neglect ESR), $f_s = 100kHz$

(a) If the above converter is used in an application where the input voltage, V_{in} can vary in the range of 10V to 40V dc and the output voltage is regulated at 8V, plot the peak-to-peak inductor ripple current ΔI_L as a function of V_{in}.

(b) If the above converter is used in an application where the input voltage remains constant at 40 V dc, and the output voltage, V_o needs to be controlled in the range of 4 V to 36 V dc, plot the peak-to-peak inductor ripple current ΔI_L as a function of V_o.





Problem 5 (25 points)

Design a power electronic converter to meet the following specifications. Neglect ESR.

$$V_{in} = 36V - 72Vdc;\ V_o = 28Vdc;\ I_{o_{max}} = 10A;\ I_{o_{min}} = 1A$$

$$f_s = 200kHz;\ \Delta I_L \le 2A\ (pk-pk);\quad \Delta V_o \le 200mV\ (pk-pk)$$