Homework #2 (2024 Spring, EE 171)

- Deadline: May 6th 8:00 a.m.
- Please submit your homework through Gradescope (Course Entry Code: 3PV4VP)
- Handwriting is not suggested, and a poor format will lose at most 10% of your final score.
- Giving your solution in English, solution in Chinese is not allowed.
- Plagiarism is not allowed. Those plagiarized solutions will get 0 point.
- Total: 200 points

1. DCM isolated SEPIC converter. (80 points)

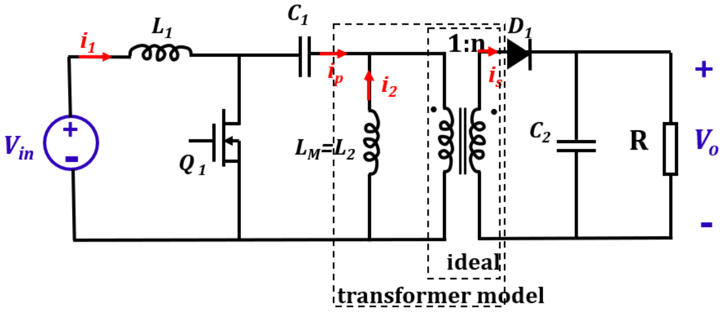

Fig. 1 Isolated SEPIC converter.

a) Derive the expression for the conditions under which the converter operates in the DCM (for i_{D1}). You may assume L_1, C_1 and C_2 are sufficiently large. Express the result in the form $K<K_{crit}(D)$ and derive the expression for K and $K_{crit}(D)$. (30 points)

b) Derive the conversion ratio M(D,K) of the converter. (10 points)

c) Under DCM mode, sketch the voltage and current waveforms of inductor L_1 and L_2, derive the expressions of their ripple magnitudes and dc components. (20 points)

d) Based on the current ripples, derive the voltage ripple for C_1. (20 points)

2. All three legs of the magnetic device illustrated in Fig. 2 are of uniform cross-sectional area *Ac*. Legs 1 and 2 each have magnetic path length *3l*, while leg 3 has magnetic path length *l*. Both windings have *n* turns. The core has permeability $\mu>>\mu_0$. (50 points)

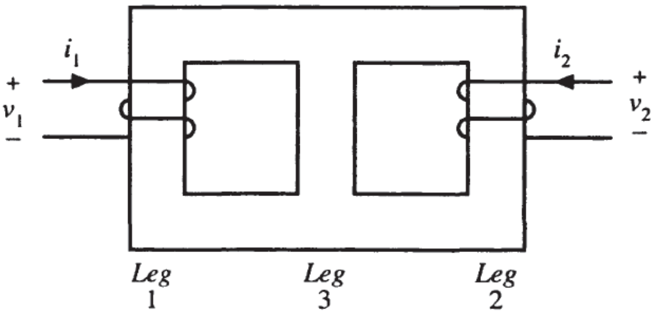

Fig. 2. Magnetic device.

a) Sketch a magnetic equivalent circuit, and give analytical expressions for all element values. A voltage source is connected to winding 1, such that $v_1(t)$ is a square wave of peak value V_{max} and period T_s. Winding 2 is open-circuited. (30 points)

b) Sketch $v_2(t)$ and label its peak value. (20 points)

3. Rotation of switching cells. A network containing switches and reactive elements has terminals a, b, and c, as illustrated in Fig.3(a). You are given that the relationship between the terminal voltages is $V_{bc}/V_{ac} = \boldsymbol{\mu}\ (D)$. (70 points)

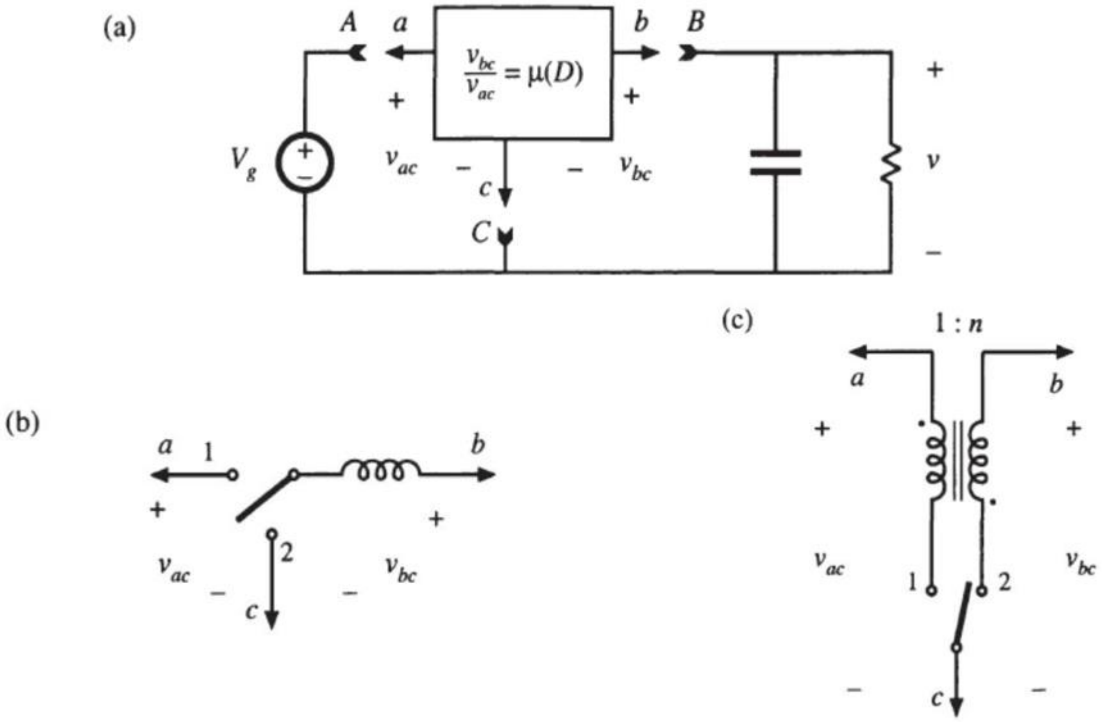

Fig. 3. Rotation of three-terminal switching cells.

(a) Derive expressions for the source-to-Ioad conversion ratio M(D) = V/Vg, in terms of $\boldsymbol{\mu}$(D), for the following three connection schemes: (30 points)

(i) a-A b-B c-C

(ii) a-B b-C c-A

(iii) a-C b-A c-B

(b) Consider the three-terminal network of Fig.3 (b). Determine $\boldsymbol{\mu}\ (D)$ for this network. Plug your answer into your results from part (a), to verify that the buck, boost, and buck-boost converters are generated. (20 points)

(c) Consider the three-terminal network of Fig. 3 (c). Determine $\boldsymbol{\mu}\ (D)$ for this network. Plug your answer into your results from part (a). What converters are generated? (20 points)