MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.622 Power Electronics — Issued: April 10, 2023
Problem Set 8 — Due: April 19, 2023

Reading: KPVS Chapter 12 through 12.4; KPVS Chapter 13 through 13.1, 13.3

Problem 8.1

Fig. 1 shows a dc/dc converter. Assume that the converter operates in continuous conduction mode (CCM).

a. Assuming that the converter is operating in periodic steady state (PSS), find an expression for the dc capacitor voltage V_C in terms of dc input voltage V_1 and fixed switch duty ratio D.

b. Derive the average state-space equations for this converter under duty ratio control. You can use either state space averaging or direct circuit averaging, but express your results as a pair of state-space equations in terms of the local averages of state variables i_L and v_C and local averages of inputs v_1 and q. (The local average of q is denoted as d.) You may assume that i_L and v_C have small ripple and are slowly varying.

c. Draw an averaged circuit model for this system. (i.e., draw a circuit that has the same state-space equations as the averaged model of the original system.)

d. Is the averaged system linear (with respect to the state variables and inputs V_1 and d)? Justify your answer in three sentences or less.

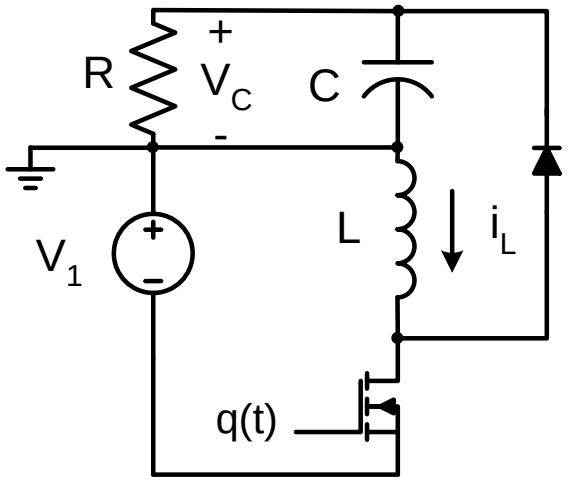

Figure 1 A dc/dc converter.

Problem 8.2

Following the approach of KPVS example 12.5, derive the averaged model for a boost converter operating in *discontinuous* conduction mode. Another reference for this approach is P.R.K. Chetty, "Current Injected Equivalent Circuit Approach to Modeling of DC-DC Converters in Discontinuous Inductor Conduction Mode," *IEEE Transactions on Industrial Electronics* **29:230-234,** August, 1982.

Problem 8.3

Derive the averaged, linearized model for a buck converter in continuous conduction mode. Do this both by direct circuit averaging and state-space averaging. (You must show both the averaged circuit and the averaged state-space description of the system.) Show that the state-space averaged model and the averaged circuit model are equivalent descriptions of the system.

Linearize the state-space averaged model about an operating point (if it is not already linear) and derive the transfer function from perturbation in duty ratio to perturbation in output voltage.

Find the *audio susceptibility* for the buck converter. The audio susceptibility is defined as the transfer function from perturbation of the input voltage to perturbation of the output voltage with duty ratio held constant.

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