EE270: Homework 3

Due: Nov. 9th, 2023 before class

Problem 1

Consider the nonideal buck converter of Fig. 1. The input voltage source $v_g(t)$ has internal resistance R_g. Other component nonidealities may be neglected.

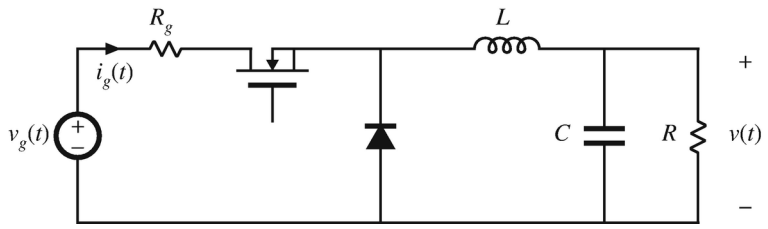

Figure 1: Nonideal buck converter.

(a) Using the state-space averaging method, determine the small-signal ac equations that describe variations in i, v, and $i_{;}g$, which occur owing to variations in the transistor duty cycle d and input voltage v_g.

(b) Construct an ac equivalent circuit model corresponding to your equations of part (a).

(c) Solve your model to determine an expression for the small-signal control-to-output transfer function.

Problem 2

In Cuk converter in Fig. 2, the MOSFET has on-resistance R_{on} and the diode has constant forward voltage drop V_D. Loss of other components can be neglected.

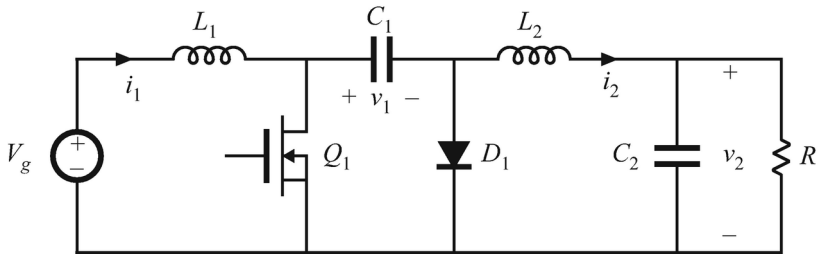

Figure 2: Cuk converter.

(a) Using the state-space averaging method, derive the steady-state averaged equation in matrix form.

(b) Perturb and linearize, to determine the small-signal ac equations in matrix form and construct the small-signal ac equivalent circuit model for this circuit.

Problem 3

Given a buck converter, as shown in Fig. 3. $f_s = 100\text{kHz}$, $R = 2\Omega$, $C = 300\mu\text{F}$, $L = 2\text{mH}$. Time range is [0; 0:04] seconds.

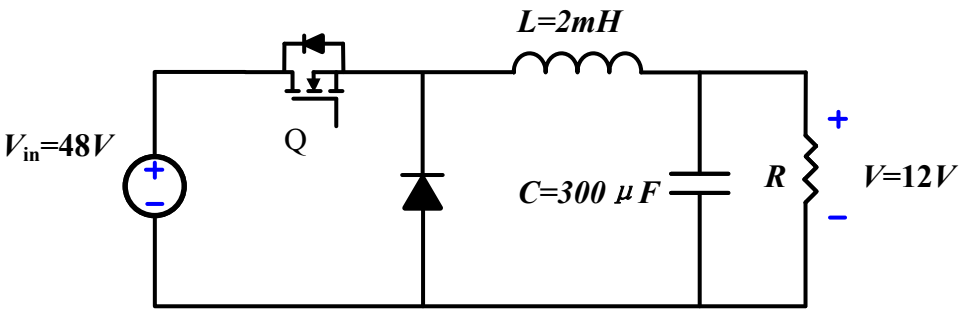

Figure 3: Buck converter.

(a) Express the circuit operation in matrix form utilizing GSSA technique.

(b) Assume the initial condition of the state vector is

$$X_{initial} = [x_1, x_2, x_3, x_4, x_5, x_6]^T = [1, 1, 1, 1, 1, 1]^T$$

Write a program in Matlab to solve $v_o(t)$ and $i_L(t)$.

(c) Plot $v_o(t)$ and $i_L(t)$ in Matlab.