EE 458 – Power Electronics Controls
Experiment 2 Pre-Lab Assignment: Boost Converter

Task 1: Small-signal Model Derivation

Consider the boost converter in Figure 1. The model includes the equivalent series resistance (ESR), which captures conduction losses in the capacitor material. For all the analysis below, use the value of $L = 0.2mH$, $R_L = 60m\Omega$, and $C = 2200\mu F$ from your design in EE452. **Assumptions: you can neglect the capacitor ESR, and the load resistance R is selected to be 100Ω, at a 48 V output. Assume $V_{\text{in}} = 24$ V.**

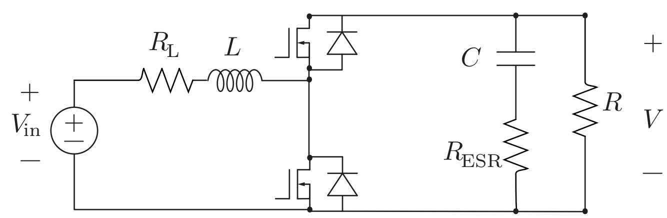

Figure 1: Boost converter from EE452 lab.

Complete the following computations below.You should do these derivations symbolically. After you have symbolic expressions, you should plug in numbers. You may use symbolic math, controls, etc. packages in MATLAB/Python.

1. Compute the steady-state inductor current, I_L, and capacitor voltage, V, given the nominal input voltage V_g and duty D.
2. Compute the transfer function that relates the small-signal duty to small-signal inductor current $G_{id}(s) = \frac{\widehat{i_L}}{\widehat{d}}$.
3. Compute the transfer function that relates the small-signal duty to small-signal capacitor voltage $G_{vd}(s) = \frac{\widehat{v}}{\widehat{d}}$.
4. Take the ratio of your results and compute $G_{vi}(s) = \frac{G_{vd}(s)}{G_{id}(s)}$.

As a side note, the following might help you,

- The MATLAB symbolic toolbox functions: simplify(), expand(), tf(), sym2poly(), numden(), bode(), etc. may be helpful. These also have analogs in Python.

EXTRA CREDIT (+5pts) Task 2: Numerical Bode Plots

For the transfer functions you have obtained in Task 1, plot the transfer functions in MATLAB. List out the poles, zeroes and dc gain of each of the three transfer functions in Task 1. Annotate on your bode plot derived from MATLAB, the poles, zeroes and the dc gain. Make sure the plots are in the following frequency range 0.1 Hz to f_{sw} Hz. If you have no experience with MATLAB bode plots before, the following commands should be helpful.

- **tf(**$[a_1 \quad a_0], [1 \quad b_0]$**)** would generate a transfer function: $\frac{a_1 s + a_0}{s + b_0}$
- bode(tf($[a_1 \quad a_0], [1 \quad b_0]$)) would do the bode plot of the transfer function $\frac{a_1 s + a_0}{s + b_0}$.
- bode(tf($[a_1 \quad a_0], [1 \quad b_0]$),[0.01, 1e6]) would do the bode plot of the transfer function $\frac{a_1 s + a_0}{s + b_0}$ from 0.01 rad/s to 10^6 rad/s