ECE581

State Plane Analysis of a Buck-Boost Converter

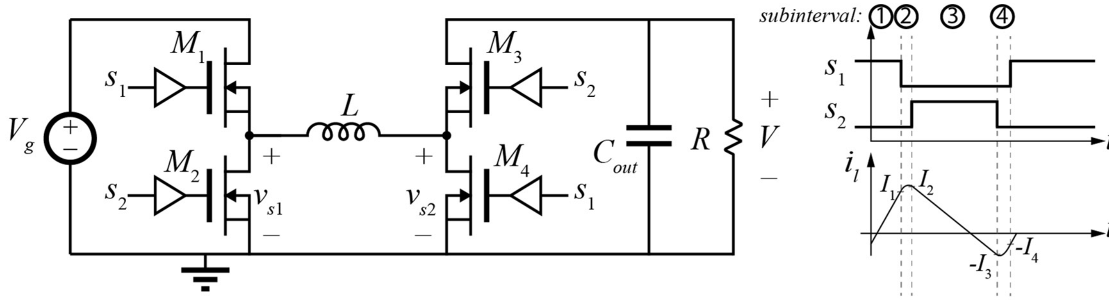

Figure 1: Noninverting Buck-Boost Converter

The noninverting buck-boost converter of Fig. 1 is switched using the given logic-level signals, s_1 and s_2. The voltages, passives, and switching durations are sized so that the inductor current takes the shape shown in Fig. 1

Devices M_1-M_4, are implemented with the same MOSFET, having corresponding capacitances C_{ds1}-C_{ds4}, respectively. C_{out} is very large. The dead times are longer than any switching transient dynamics, but you may assume that $t_{d1} + t_{d2} << T_s$. Assume V=V_g

a) During subintervals 2 and 4, when M_1-M_4 are OFF, sketch the AC-equivalent resonant circuit for state plane analysis. This circuit may have only one L, one C, and any DC voltage and current sources which participate in the resonance. Solve, analytically, the values of all elements in this circuit.

For parts (b)-(e), you may assume that C_{ds1}-C_{ds4} are equal in value.

b) Sketch the *j*-*m* state plane of the converter over an entire switching period. The voltage and current normalized should be those from the resonant elements of part (b). Use $V_{base} = V_g$ and report your I_{base}. Label all salient features.
c) Determine the conditions for Zero-Voltage Switching each of
   i) Subinterval 2
   ii) Subinterval 4

   in the normalized domain. Denormalize these conditions to obtain inequalities which relate the currents I_1 and I_3 to the passive elements and circuit voltages.
d) Solve for a system of equations which describe the geometry of the state plane. This should include four equations describing J_1-J_4, and two equations describing the conduction angles of subintervals 2 and 4.
e) Average the inductor current over one switching period and normalize to find an expression for J_L in terms of the values solved in (d)