ECE581

Capacitive Switching Losses in a Buck Converter

A 12-to-5 V synchronous buck converter is shown in Figure 1. The converter operates with very large inductance and output capacitance. The output power is 50 W. Unless otherwise indicated, all elements are ideal and the converter operates in steady-state

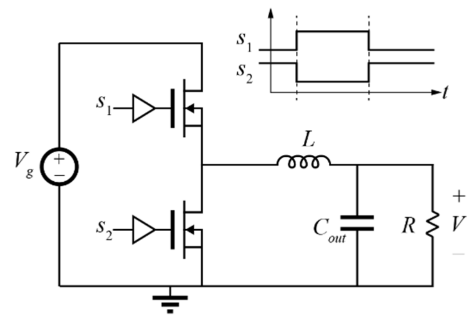

Fig. 1: Synchronous buck converter with switching logic signals shown

(a) The MOSFETs have r_{on} = 5 mΩ; Calculate the total conduction loss in the circuit.

(b) With the same MOSFETs, solve for the conduction loss if L is decreased so that the converter operates with 100% current ripple, i.e. $\Delta i_L = I_L$. Consider the real rms value of $i_L(t)$

For parts (c)-(e), again consider L to be very large. The MOSFETs are implemented with r_{on} = 5 mΩ and C_{ds} = 1 nF. Additionally, each MOSFET has an antiparallel Schottky diode with V_F = 0.5 V. To account for the capacitance, deadtimes t_{d1} and t_{d2} are inserted in the switching control signals s_1 and s_2.

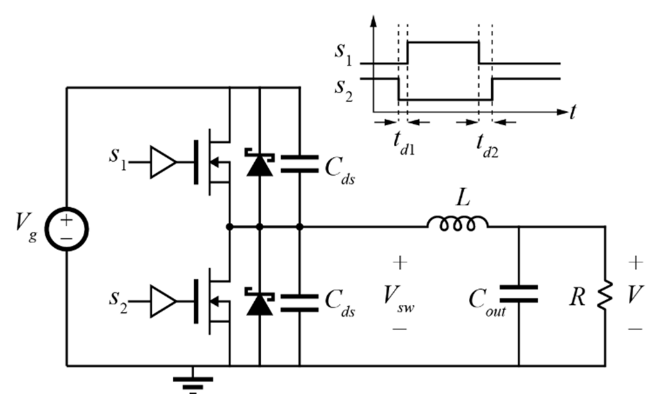

Fig. 2: Nonideal synchronous buck converter. Switching logic signals, including deadtime, are shown

(c) Assuming $t_{d1} = t_{d2}$ = 100 ns and $T_s \gg \{t_{d1}, t_{d2}\}$, sketch the waveform of V_{sw} over one full period.

(d) Select different deadtimes t_{d1} and t_{d2} so that the switching energy per period is minimized. Calculate this switching energy.

(e) Comparing your results from (a), (b), and (d), comment on the range of switching frequencies over which it may be advantageous to employ a soft-switching buck converter. If the output voltage is 1 V, with the same 50 W output power, how does this change?