Diode reverse recovery in a boost converter

Reverse recovery of the diode D in the boost converter shown in Fig. 1 is described by the diode current waveform shown in Fig. 2. You can assume that the diode remains forward biased and that the diode voltage stays approximately zero until the end of interval t_a. During interval t_b, the diode reverse-bias voltage increases approximately as a linear function of time, reaching 400 V at the end of interval t_b. After the end of interval t_b, it can further be assumed that the diode current is approximately zero. Given I_F = 5 A, and $|di_F/dt|$ = 90 A/μs, the diode reverse-recovery parameters are as follows: t_a = 30 ns, t_b = 30 ns, reverse recovery charge Q_r = 80 nC. If the rate of diode current decay is reduced to $|di_F/dt|$ = 10 A/μs or less, no significant reverse recovery is observed, Q_r = 0.

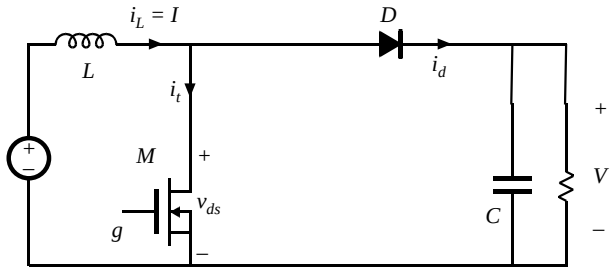

Figure 1

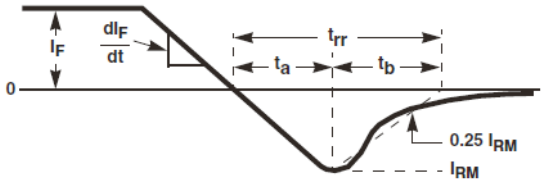

Figure 2

In the boost converter, L and C are large so that the inductor current and the output voltage ripples can be neglected. At the steady-state operating point, inductor current is I = 5 A, output voltage is V = 400 V, and output load power is P = 500 W. The switching frequency is f_s = 200 kHz. Upon turn-on, MOSFET M current i_t increases at the rate di_t/dt = 90 A/μs. Device capacitances can be neglected, and all components can be considered ideal, except as noted above.

(a) Sketch and label time-aligned waveforms $i_t(t)$, $i_d(t)$, and $v_{ds}(t)$ during MOSFET M turn on process.

(b) Find an expression for, and compute the MOSFET M, the diode D, and the total switching loss due to the diode reverse recovery. What is the converter efficiency?

(c) To reduce the switching loss, an auxiliary circuit consisting of MOSFET M_s, diode D_s, and inductor L_s has been added to the boost converter as shown in Fig. 3, together with gate-control waveforms g and g_s for M and M_s, respectively.

Choose L_s, the length of g_s pulse, and the length of the overlap between g and g_s pulses, so that reverse-recovery losses are ideally eliminated.

For the values selected, sketch and label time-aligned waveforms $i_t(t)$, $i_d(t)$, $v_{ds}(t)$, $i_{Ls}(t)$, $i_{ts}(t)$, $i_{ds}(t)$ during a switching period

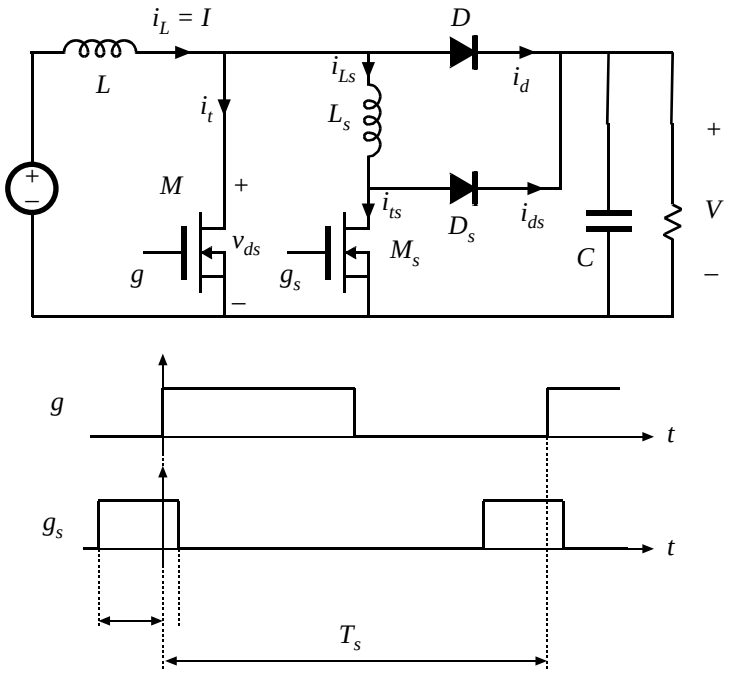

Figure 3

(d) Comment on practical advantages and disadvantages of the auxiliary circuit from part (c).