Example Midterm Problem
Loss Analysis and Compensator Design
ECE 482

1) Boost Converter Loss Analysis

Fig. 1 shows the power stage of the drivetrain boost converter to be assembled in experiment 2. For all parts of this prelab, consider operation of the converter at an operating point around which:

- $V_{bat} = 20$ V
- $V_{bus} = 50$ V

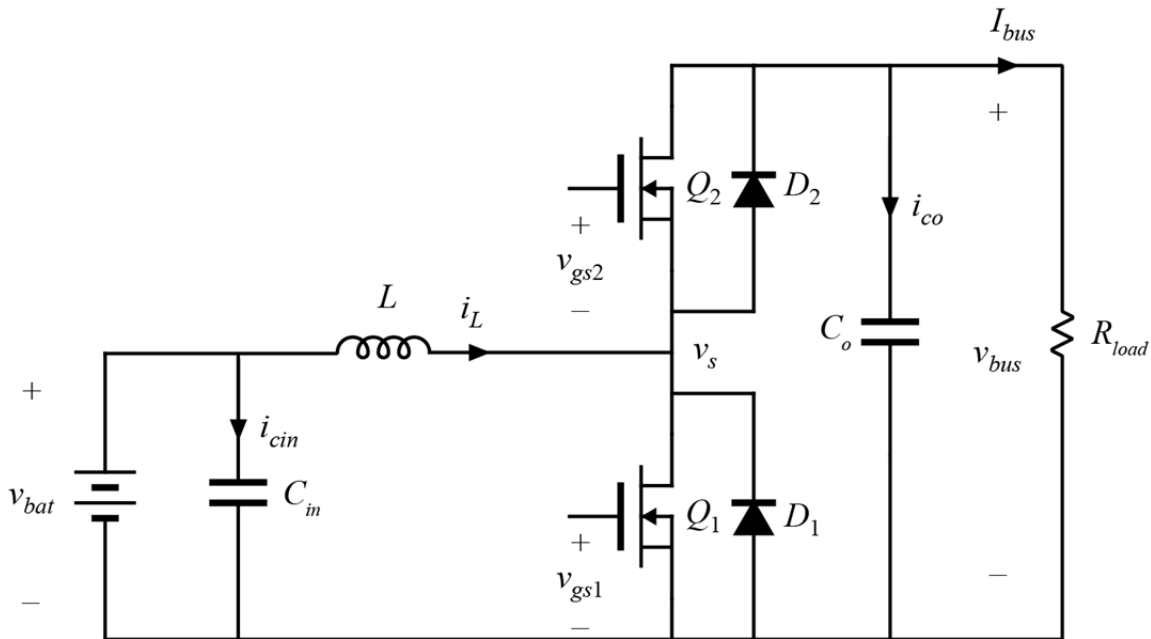- $P_{out} = V_{bus}I_{bus} = 100$ W
- $f_s = 200$ kHz

Figure 1: Open Loop Boost Converter

Dead times of the MOSFETs are very small but result in zero shoot-through current. Assume that the output capacitance of the MOSFETs and diodes are given by constant values:

- $C_{oss} = 5$ nF
- $C_d = 1$ nF

You may assume that the converter is ideal (i.e. lossless) other than these capacitances. Solve for the following losses associated with these output capacitances:

a) E_{on1}: The loss during the turn-on transition of Q_1 (and turn off of Q_2)
b) E_{off1}: The loss during the turn-off transition of Q_1 (and turn on of Q_2)
c) $P_{sw,c}$: The power loss of the converter associated with these two losses

Extra Credit:

C_{oss} for the MOSFET is instead given by the expression

$$C_{oss}(v_{ds}) \approx \frac{C_0}{\sqrt{v_{ds}}},$$

with $C_0 = 3.5\text{e-}8$. The diode capacitance remains the same. Recalculate a) and b) for this nonlinear capacitance.

2) Boost Compensator Realization

A compensator for the boost converter must be designed which has the following characteristics:

- Infinite DC Gain
- One zero at $w_z = 1$ krad/sec
- A pole at $w_p = 100$ krad/sec
- Gain near unity at frequencies close to 10 krad/sec

Draw a diagram of a circuit which realizes this transfer function using only a single op-amp, and any necessary resistors and capacitors. (Do not worry about how this compensator works in-system, just realize the transfer function). Label values of all resistors and capacitors.

3) Circuit Design and Operation
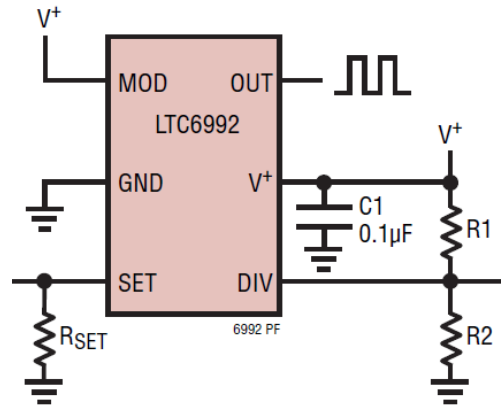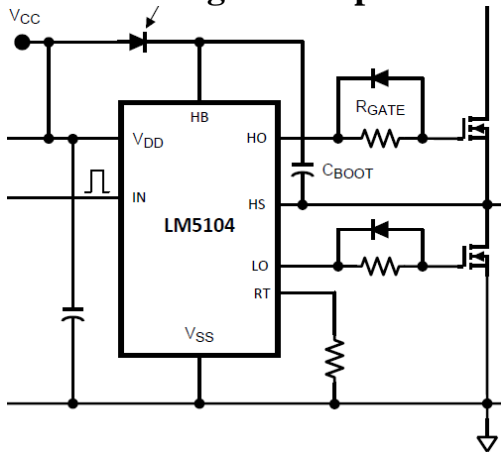
Application diagrams of two ICs are shown above. Describe the purpose of each. Also, describe the purpose of the resistors R_T, R_{SET}, R_1, and R_2 in the above diagrams. Be brief; limit responses to once sentence at most for each.