UTA PhD Diagnosis Exam (Fall 2012)

Power Electronics

Instructions:

• Verify that your exam contains 7 pages (including the cover sheet).
• Please be sure to use blank paper to write your answers. If more space is needed, please ask the instructor for extra paper. DO NOT WRITE ON THE BACK OF A SHEET!
• The point values listed on this exam serve only as a guideline. The Dept reserves the right to make modifications to the weighting of the problems.
• Calculator is okay.

I choose to work on Problems _____ and ______ (Choose only 2 from the 3 problems).

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1. Find the steady-state voltage conversion ratio (output voltage/input voltage), as the function of the duty cycle, for the both circuits shown (25 points each). Both converters are in continues conduction mode, and the duty cycle is applied to the switch number 1:

Converter 1:

\[ M = \frac{V_{out}}{V_{in}} = \frac{D}{1-D} \]

Converter 2:

\[ M = \frac{V_{out}}{V_{in}} = D^2 \]
1- A buck converter is designed with a 5 V input, 0.25 ohm load, and 100 kHz switching frequency. The input voltage varies between 30 V and 60 V. The load power ranges between 10 and 200 W. What would be the minimum inductance that ensures operation in the continuous conduction mode, $L_{\text{min}}$ (25 points)? What would be the maximum inductance that ensures operation in the discontinuous conduction mode, $L_{\text{max}}$ (25 points)?

**Solution:**

$L_{\text{min}} = 11.46 \ \mu\text{H}$

$L_{\text{max}} = 0.521 \ \mu\text{H}$
2. The following ideal boost converter is in discontinuous conduction mode, with the inductor current waveform shown on the right. The switching frequency is \( f_{sw} \).

a) Find the duty ratio constraint, \( d_2 \), as the function of \( \frac{i_L}{v_{in}} \) (25 points).

b) Find the full-order state-space averaged model of the converter in discontinuous conduction mode (25 points).

![Diagram of Boost Converter](image)

**Solution:**

a) \( d_2 = \frac{2Ls_w}{d_1v_{in}} - d_1 \)

b) \[
\begin{align*}
\frac{di_L}{dt} &= 2f_{sw}i_C \left(1 - \frac{v_C}{v_{in}}\right) + \frac{d_1v_C}{L} \\
\frac{dv_C}{dt} &= \frac{i_C - d_1v_{in} - v_C}{C} - \frac{v_C}{2Lsf_{sw}} - \frac{v_C}{RC}
\end{align*}
\]