LAB #1 CCM BUCK CONVERTER (IDEAL & NON-IDEAL)

Introduction

In this lab you will introduced to power electronics design and analysis. You will observe the behavior of the continuous conduction mode (CCM) Buck converter.

The basic operation of the buck converter in CCM consists of two modes. The first mode is when the high-side mosfet is conducting, and the inductor current linearly increases. When the high-side mosfet is turned off, and the low-side mosfet begins conducting, the inductor will have negative voltage across it, causing the current to linearly decrease. The behavior is known as continuous conduction mode since the inductor current is always either increasing or decreasing.

Basic Design Equations (for derivation see Appendix A)

(Ideal)

$$\frac{\mathrm{V_o}}{\mathrm{V_{in}}} = \frac{I_{in}}{I_o} = D$$

$$\Delta I_L = \frac{V_o}{L}(1-D)\cdot T_s$$

$$\frac{\Delta V_c}{V_o} = \frac{(1-D)}{8\cdot L\cdot C\cdot f_s^2}$$

(Non - Ideal)

$$\frac{\mathrm{V_o}}{\mathrm{V_{in}}} = \frac{1}{(1+\frac{R_{ds}\cdot D}{R_o}+\frac{R_{Lesr}}{R_o})}[D-\frac{V_d}{V_{in}}(1-D)]$$

PreLab

- Calculate the Duty Cycle for a Buck converter that has an input voltage of 30 volts (V_{in} = 30V) and a output voltage of 15 volts (V_o = 15V).

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- Calculate the Voltage and Current ripple of the above converter for switching frequency of 50 kHz, 100 kHz and 200 kHz, with a load of 10Ω, and inductance of 30 μH and an output capacitance of 660 μF.

Optional PreLab

- Repeat PreLab for Boost converter

Experiment

Take the following measurements, (Make sure that the synchronous switching is enabled to ensure you are in CCM mode)

Vary the Duty cycle:

- Set V_{in}=30V, F_s=100kHz and R_L=10 Ω
- Vary the Duty ratio in the following steps: 25%, 50%, 75%
- Measure the output voltage, output voltage ripple and inductor current ripple to the corresponding duty ratio (hint: to measure the ripple easier use AC coupling on the oscilloscope)
- Calculate the theoretical output voltage, output voltage ripple and inductor current ripple to the corresponding duty ratio

Vary the Switching Frequency:

- Set V_{in}=30V, D=50% and R_L=10 Ω
- Vary the Switching Frequency between 50 kHz, 100 kHz, and 200 kHz
- Measure the output voltage, output voltage ripple, and inductor current ripple
- Calculate the theoretical output voltage, output voltage ripple and current ripple to the corresponding switching frequency

Vary the Load:

- Set V_{in}=30V, D=50% and F_s=100kHz
- Vary the Load resistance from 5 Ω to 15 Ω (in steps of 5 Ω)
- Measure the output voltage, output voltage ripple and current ripple to the corresponding switching frequency

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- Calculate the theoretical output voltage, output voltage ripple and current ripple to the corresponding switching frequency

Lab Report

- Create a table of the measured data and the theoretical data versus each part that was varied (example table below)

Varying Load

		Measured			Theoretical	
R_o	V_o	ΔV_o	ΔI_L	V_o	ΔV_o	ΔI_L
5						
10						
15						

- What is the relationship between output voltage and duty cycle and explain why?
- What is the relationship between output voltage ripple and switching frequency and explain why?
- What is the relationship between inductor current ripple and switching frequency and explain why?
- What is the relationship between inductor current ripple and output voltage ripple and explain why?
- With constant duty cycle, what is the relationship between output voltage and load resistance and explain why?
- What is the relationship between output voltage ripple and load resistance and explain why?

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