EECS 192: Mechatronics Design Lab
Discussion 4: Project Proposal Feedback & Power Systems

GSI: Justin Yim

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- Project Proposal Feedback
- SMPS Recap
- Practical Application
- Summary
Project Proposal Feedback
Beaglebone Blue pins
Sensors
  ▶ Line scan camera(s)
  ▶ encoder/ back emf sensor
Links
  ▶ Line Scan Camera 1, Line Scan Camera 2
  ▶ Optical encoder coming soon
Motor Drive

- **G_en**
  - Needs 5V!!!!
  - Pull down resistor (6.8k good)
- **Shoot through protection**
  - Logic protection circuit
  - Inverted PWM via code
- **General**
  - Heatsinks
  - Layout

Complimentary PWM

Mosfet Package
Switching Power Supply
DC-DC Converter

- 3 Cell LiPo Battery provides 11-12V
  - Good for motor, driver chip/ op amp
- We also need 5V?
  - K64F, servo, optical encoder, camera, etc.
- How to consistently get 5V?
  - DC-DC converter!
  - **Step Down**
    - Buck Converter, Linear Regulator
  - Step Up
    - Boost Converter
Buck Converter Circuit

- DC-to-DC switching power supply generating output voltage lower than input
- Uses inductor as storage element
- Efficient, no losses in ideal case
  - Non-idealities: wire resistance, diode and transistor losses
- Capacitive filter to smooth output voltage
Buck Converter Operation

- Inductor charges when switch is closed
  - Energy stored in inductor by magnetic field, current through inductor increases
  - Diode does nothing here

Switch Closed
Buck Converter Operation

- Inductor charges when switch is closed
  - Energy stored in inductor by magnetic field, current through inductor increases
  - Diode does nothing here
- Inductor discharges when switch is open
  - Magnetic field dissipates, current through inductor decreases
  - Inductor voltage polarity reversed, generating voltage over input
  - Current flows through diode, output capacitor charged
Buck Converter Control

- If switch cycled fast enough, inductor does not fully discharge
- Can do a lot of math, but output voltage is function of duty cycle $D$
  - $V_{out} = DV_{in}$
Check your Understanding

- I’ve got a buck converter set up...
- A magic chip (LM2678) regulates the output to 5v
  - Duty cycle is adjusted to maintain voltage
  - Remember: $V_{out} = DV_{in}$
- What happens if I...

Buck Circuit
Check your Understanding

- I’ve got a buck converter set up...
- A magic chip (LM2678) regulates the output to 5v
  - Duty cycle is adjusted to maintain voltage
  - Remember: \( V_{out} = DV_{in} \)
- What happens if I...
  - Increase the input voltage?
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▶ What happens if I...
  ▶ Increase the input voltage?
    ▶ Duty cycle decreases, current decreases
  ▶ Decrease the input voltage?
I’ve got a buck converter set up...

A magic chip (LM2678) regulates the output to 5v

- Duty cycle is adjusted to maintain voltage
- Remember: $V_{out} = DV_{in}$

What happens if I...

- Increase the input voltage?
  - Duty cycle decreases, current decreases
- Decrease the input voltage?
  - Duty cycle increases, current increases
Boost Converter Circuit (for your reference)

- DC-to-DC switching power supply generating output voltage lower than input
- Similar principle to buck converter
  - $V_{out} = \frac{1}{1-D} V_{in}$
- Also exists buck-boost converters, where output can be greater than, equal to, or less than the input
Questions?

got it?

power supply pros, right?
Practical Application
So, what is the switch-controlling magic?

Feedback control: chip has logic to regulate the voltage on the feedback pin to an internal $V_{FB} = 1.21V$ reference.

$V_{out} = V_{FB}(1 + \frac{R_2}{R_1})$

$R_1 \approx 1k\Omega$ recommended
Problematic?

- What happens if the switch gets stuck in the closed position?

Boost Circuit

On-State

Boost Circuit
Layout is Important!!!

Figure 22. Basic Circuit for Adjustable Output Voltage Applications
Layout Guidelines

- Switching power supplies are layout sensitive
  - Part placement and routing matters!
- Tips from the datasheet:
  - Keep diode and filter capacitor connections as short as possible
  - Minimize high frequency current path (switch, diode, capacitor)
- Read the datasheet!

Figure 24. Top Layer Foil Pattern of Printed-Circuit Board

Recommended layout
(uses surface-mount components)
source: datasheet, Linear Technology
Supporting Components

- Capacitors
  - Ceramic, film, polarized (tantalum, aluminum, etc.)...
- Diodes
  - Shottky
- Inductor
  - Toroid
Summary

- Buck converters step down a DC voltage to a lower DC voltage
- LM2678 uses feedback control to do voltage regulation
- Follow recommended layout guidelines during PCB design
- Very difficult to make work on perfboard—just design it on the pcb.

Parts Handout Office hours for the rest of the section