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

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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

TSL1401CL

Optical Encoder
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
Switching Power Supply
Buck Converter Theory

SMPS Recap

3 Cell LiPo Battery provides 11-12V
- Good for motor, driver chip/ op amp
- We also need 5V?
  - 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

On-State

Diode

Inductor
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
- Output voltage is function of duty cycle $D$ and efficiency $\eta$ (link)
  - $V_{out} = \eta D V_{in}$
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: $V_{out} = \eta D V_{in}$

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: $V_{out} = \eta D V_{in}$
- What happens if I...
  - Increase the input voltage?
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: $V_{out} = \eta D V_{in}$
▶ What happens if I...
  ▶ Increase the input voltage?
    ▶ Duty cycle decreases, current decreases
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: \( V_{out} = \eta D V_{in} \)

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: $V_{out} = \eta DV_{in}$

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

Boost Circuit
Figure 22. Basic Circuit for Adjustable Output Voltage Applications

Circuit

Locate the Programming Resistors near the Feedback Pin Using Short Leads

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Practical Application

Issues

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!

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

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