EECS 192: Mechatronics Design Lab

Discussion 2: Lab Equipment, Project Proposals

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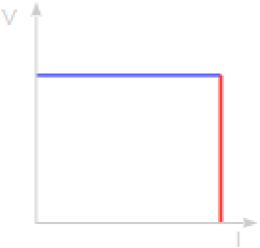
Lab Equipment

Benchtop Power Supply Intro

- Provides a regulated power source
- Limits to the more restrictive of the voltage setpoint or current setpoint
- Or, a more helpful way to think about it:
  - Acts as a constant voltage supply
  - Until it hit the current setpoint (or “current limit”), then it regulates the voltage not to exceed the current limit
  - Set current limit to a known “shouldn’t exceed” point to act as a fuse
- Caveat: source has internal capacitance and limiting has response time
  - May instantaneously exceed current limit



IV Curve

constant-voltage mode

current-limiting mode

Check your Understanding

So I've got a power supply set at V_{set}=5v, I_{set}=500mA and some $\frac{1}{4}$-watt resistors...

What will be the voltage across, current through, and power supply operating regime when loaded with:

100 Ω resistor

1 Ω resistor

10 Ω resistor

Check your Understanding

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What will be the voltage across, current through, and power supply operating regime when loaded with:

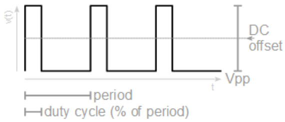
100 Ω resistor

1 Ω resistor

10 Ω resistor
why might this be a bad idea?

Function Generator Intro

- Generates an arbitrary waveform with configurable parameters
- Useful for generating test inputs
  - ... like motor driver PWM inputs
  - ... and servo control signal
- “but wait, why not use my MCU?!”

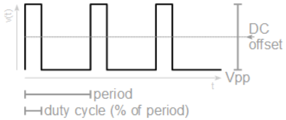


Square Wave

Sine Wave

Function Generator Intro

- Generates an arbitrary waveform with configurable parameters
- Useful for generating test inputs
  - ... like motor driver PWM inputs
  - ... and servo control signal
- “but wait, why not use my MCU?!”
  - Debugging protip: test things in isolation!
  - Function generator output is known good
  - You are much less sure your software works the first time, every time



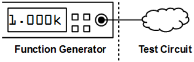
Square Wave

Sine Wave

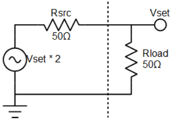
50-ohm mode

- Function generators internally have a 50Ω impedance and expect a 50Ω load
- Double the voltage is generated internally
  - If you have a high impedance (Hi-Z) load, you see double the voltage
- You can either:
  - Manually halve the voltage

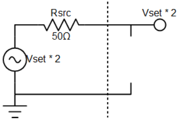
    \- or -
  - Set the generator into Hi-Z mode



Function generator at setpoint V_{set}



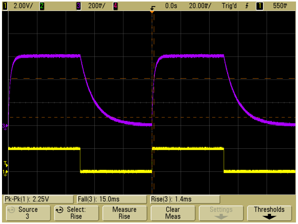
with a 50Ω load



with a Hi-Z load

Oscilloscope Intro

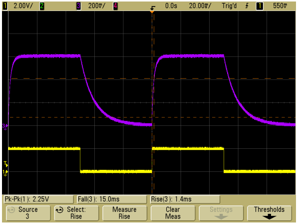
- Displays graph of voltage over time
  - Well, no - - - -, Sherlock



Scope traces

Oscilloscope Intro

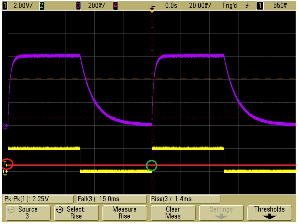
- Displays graph of voltage over time
  - Well, no - - - -, Sherlock
- Provides visibility into your system
- Verify signals are what you expect:
  - Is your motor turning on?
  - Is your speed sensor outputting counts?
- Provide insights into subsystems:
  - See how line camera output works
- If you ever get stuck...
  - Don't debug by brute force
  - Turn on the scope and figure out the root of the problem



Scope traces

Viewing Window

- There is an auto-scale function
  - but garbage-in, garbage-out...
  - and Prof. Pister will die a little inside...
- Know how to manually set the scope
  - You should have an idea of what to expect
    you DO understand your circuit, right? RIGHT?!
  - Set the per-channel vertical scale based on the expected voltage range
  - Set the global horizontal scale based on expected timescale
- Capture modes
  - Trigger: aligns start time to a signal edge
  - Auto: continuous sampling



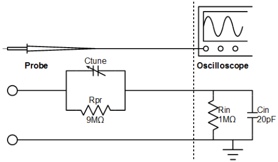
Triggering mode

trigger level setpoint in red

triggered rising edge in green

Probe Compensation

- Scope has an internal input resistance and capacitance
- A 10:1 probe presents a higher input resistance by attenuation
  - Most scopes can compensate for this
  - Internally, a 9MΩ resistor forming a resistive divider with scope input
- But need capacitive divider for AC signals
  - Input capacitance varies with each scope
  - Tunable capacitor on probe
- Compensation procedure
  - Connect probe to reference square wave
  - Tune probe until wave is square



Probe schematic

note divider circuit and tunable capacitor

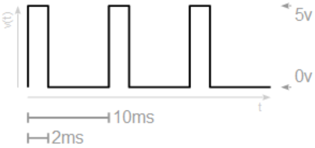
Adapted from `http://www.syscompdesign.com/assets/Images/AppNotes/probes.pdf`

Check your Understanding

Show me you know what you're doing!

Generate a square wave with these characteristics
and show it on your scope:

low voltage = 0v
high voltage = 5v
period = 10ms
high time = 2ms



Questions?

solid?

we're all testing pros now, right?

Project Proposals

Focus: Planning & Reliability

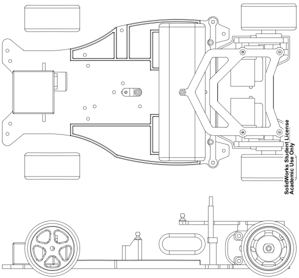
- ~~Measure once, cut twice, then hammer~~
- Measure twice, cut once
- Start thinking about high-level project plan
  - Plan ahead and examine feasibility
  - Get feedback on design ideas
- Reliability first, THEN performance
  - "Better is the enemy of the good"
  - Fast car going into a wall gets you a F minus minus

One weird trick
to flunk ee192!

image from LOLCaption.com

Mechanical: Tips n' Tricks

- Goal: show us that you have a solid plan for mounting boards / other mechanisms
  - Level of detail: screw holes, dimensions
- Paper and pencil is acceptable
  - Possibly even the most expedient solution
- Cameraphone to take and annotate photos
- Draw over picture in Paint or PowerPoint
  - Can even be physically accurate
- SolidWorks only if you know how
  - Parametric CAD is really, really nice, but not worth learning for this

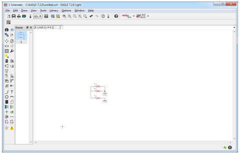


Use the provided diagrams!

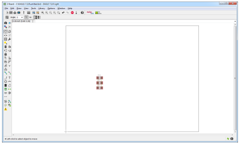
Links: (top) (side) (CAD)

Electrical: Tips n' Tricks

- Goal: show us that you know motor driver design and have a board layout plan
  - Please NO ROUTED BOARDS!
- Quick demo: EAGLE schematic and layout
  - Big idea: EDA tools are easy to use!
  - Feel free to use better design software, like DipTrace or even KiCAD
- And you can get them for free!
  - ... as in beer: (DipTrace) (EAGLE)
  - ... as in speech: (KiCAD)
- Tutorials for each can easily be found on the intertubes



Schematic



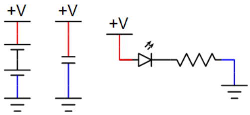
Board

Library links: (lib 1) (lib 2)

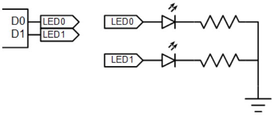
EAGLE only (for now!)

Schematic Style

- Style? Why do I care?!
  - Confusing designs hide errors
  - Helps reviewers understand your circuit
- Component placement
  - Dataflow ordering: left-to-right
  - Voltages: high-to-low on top-to-bottom
- Modularizing your schematic
  - Use tunnels to minimize intersections and decouple schematic blocks
  - Use global voltage rails
- Perfect is impossible
  - ... but you CAN minimize stylistic badness



Global power rails



Decoupling using tunnels

Questions?

got it?

we can all write awesome project proposals now, right?

Car Critiques

Car Critiques

- Goal: don't reinvent the wheel
  - Take design cues from those who came before you - recognize and use good ideas
  - Conversely, learn from other's mistakes, so you don't have to repeat them
- Some design points to consider:
  - Idiot-proofing
  - Robustness
  - Maintainability
  - Design for Test
  - Anything else you want to add?

It's been done before (don't repeat it!)

Group Car Critiques

Break into your teams and critique your cars

if your team doesn't have an assembled car, pair with one that does

Take 10 minutes to discuss amongst yourselves

(I'll walk around to help out and offer suggestions!)

then you'll present your findings to the class

(aim for about 3 minutes, then we'll give others a chance to chime in)

Stuck? Consider these desirable features:

Idiot-proofing

we're not idiots, but not everyone has had their coffee

Robustness

because, well, crash happens...

Maintainability

how can you make fixing a blown board easy?

Design for Test

things WILL go wrong; how do you make debug easy?

... and anything else you can think of ...

Car Critique Presentations

Start by introducing yourselves

both as a team and as individuals

Then, talk about your car:

What did you like about your car? Why?

What did not not like about your car? Why?

Did you see any good design philosophies?

Is there anything you would have done differently?