

# EECS 192: Mechatronics Design Lab

## Discussion 2: Lab Equipment, Project Proposals

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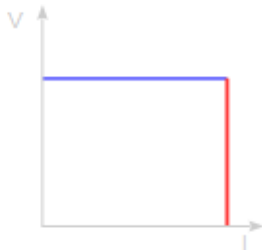
25 & 26 Jan 2017 (Week 2)

- Lab Equipment
- Project Proposals
- Car Critiques

# 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  $V_{set}=5\text{v}$ ,  $I_{set}=500\text{mA}$   
and some  $\frac{1}{4}$ -watt resistors...

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

100  $\Omega$  resistor

1  $\Omega$  resistor

10  $\Omega$  resistor

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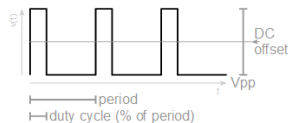
100  $\Omega$  resistor

1  $\Omega$  resistor

10  $\Omega$  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?!”



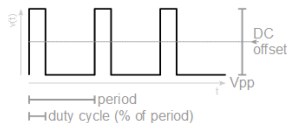
## Square Wave



## 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



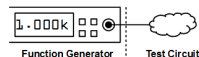
## Square Wave



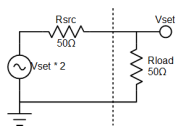
## Sine Wave

# 50-ohm mode

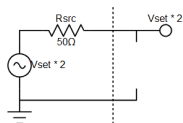
- ▶ Function generators internally have a  $50\Omega$  impedance and expect a  $50\Omega$  load
- ▶ Double the voltage is generated internally
  - ▶ If you have a high impedance (Hi-Z) load, you see double the voltage
- ▶ You can either:
  - ▶ Manually halve the voltage
  - or -
  - ▶ Set the generator into Hi-Z mode



Function generator  
at setpoint  $V_{set}$



with a  $50\Omega$  load

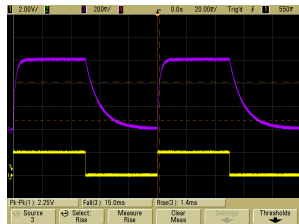


with a Hi-Z load



# Oscilloscope Intro

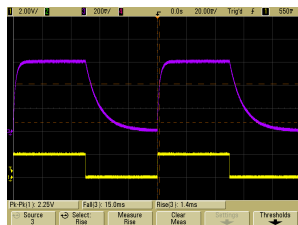
- ▶ Displays graph of voltage over time
  - ▶ Well, no - - - -, Sherlock



Scope traces

# Oscilloscope Intro

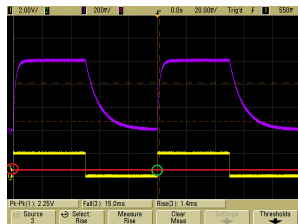
- ▶ Displays graph of voltage over time
  - ▶ Well, no - - - -, Sherlock
- ▶ Provides visibility into your system
- ▶ Verify signals are what you expect:
  - ▶ Is your motor turning on?
  - ▶ Is your speed sensor outputting counts?
- ▶ Provide insights into subsystems:
  - ▶ See how line camera output 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



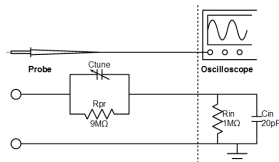
## Triggering mode

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  $9\text{M}\Omega$  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!

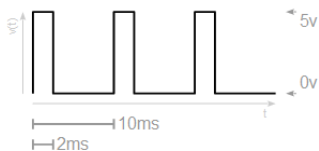
Generate a square wave with these characteristics  
and show it on your scope:

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



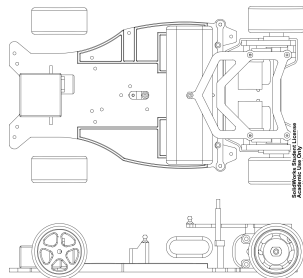
One weird trick  
to flunk ee192!

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

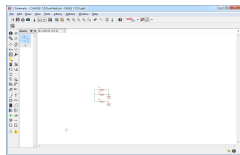


Use the provided diagrams!

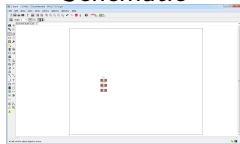
Links: (top) (side) (CAD)

# 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



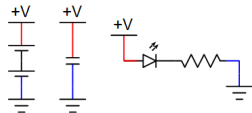
Board

Library links: (lib 1) (lib 2)

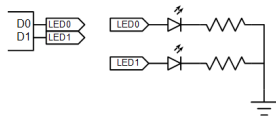
EAGLE only (for now!)

# 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!)

©Fox

# 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...

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

**Maintainability**

how can you make fixing a blown board easy?

**Design for Test**

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

# 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?