

# Guide to Debugging

EE 16B  
Fall 2018

# Your Lab Bench Setup

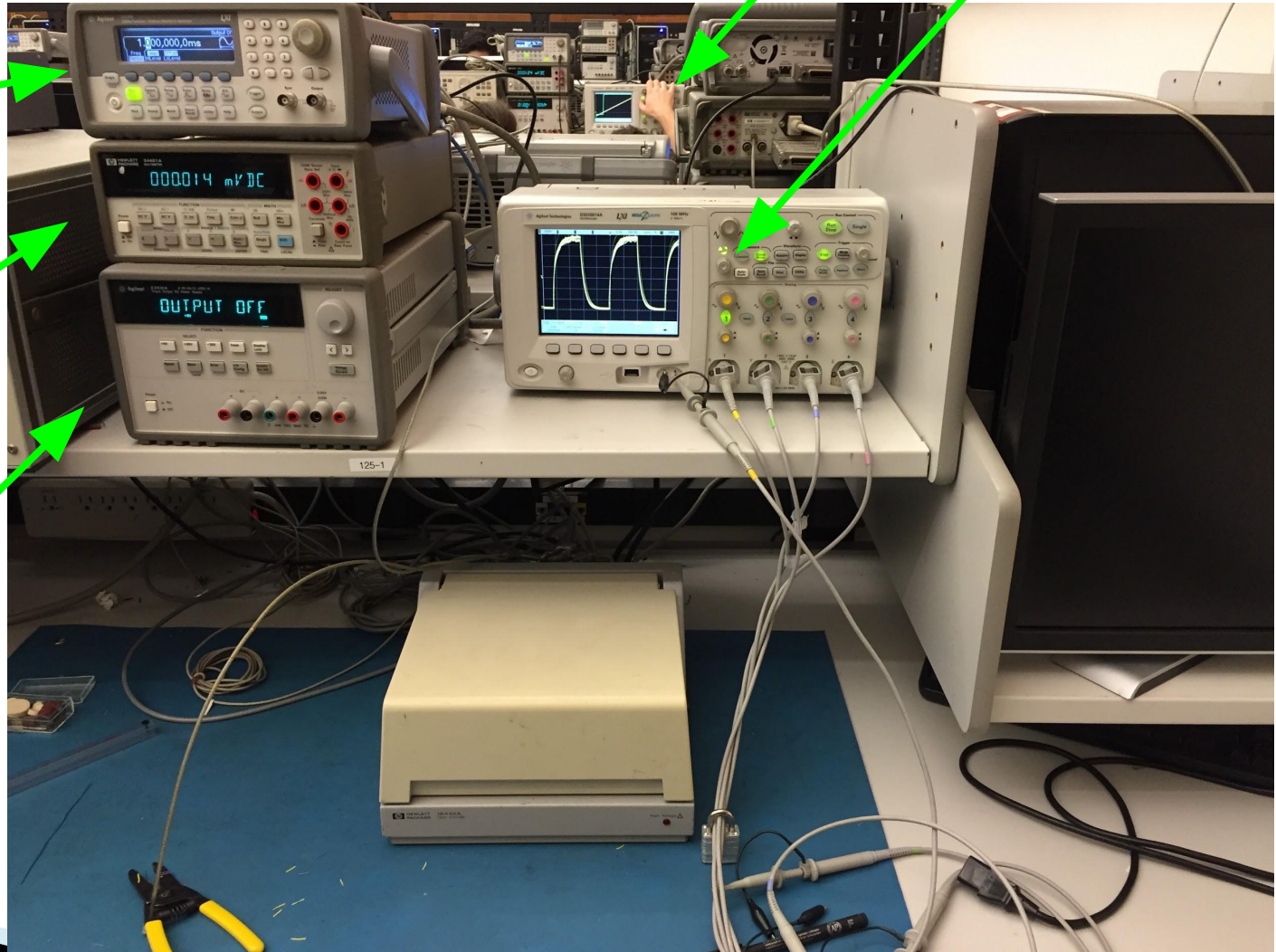
Somebody's Hand

Oscilloscope

Function  
Generator

Digital  
Multimeter

Power  
Supply



# Power Supply Checklist

- Power supply is turned on
- Output is on
- Set your voltages appropriately
- Current limit is set appropriately (0.1A)
- Positive terminal connected to the appropriate breadboard power rails
- Negative terminal connected to all breadboard ground rails

Video: [Power Supply Video](#)

# Digital Multimeter (DMM) Checklist

- DMM is set to measure correct unit (i.e. V, A, R, etc.)
- Probes are connected to the correct plugs
- Probes placed in parallel to measure voltage, series to measure current

Video: [DMM Video](#)

# Function Generator Checklist

- Turned on
- Positive terminal connected to designated input
- Negative terminal connected to all breadboard ground rails
- **Port impedance is set to High-Z**
- Output is on
- Output waveform is as expected

Video: [Function Generator Video](#)

# Oscilloscope Checklist

- Probe ground clips are connected to a breadboard ground rail
- Voltage and time scales are appropriate and reasonable
- The green “Run” button is lit up
- Trigger level is appropriately set

Guide:

[Oscilloscope Cheatsheet](#)

[Oscilloscope Video](#)

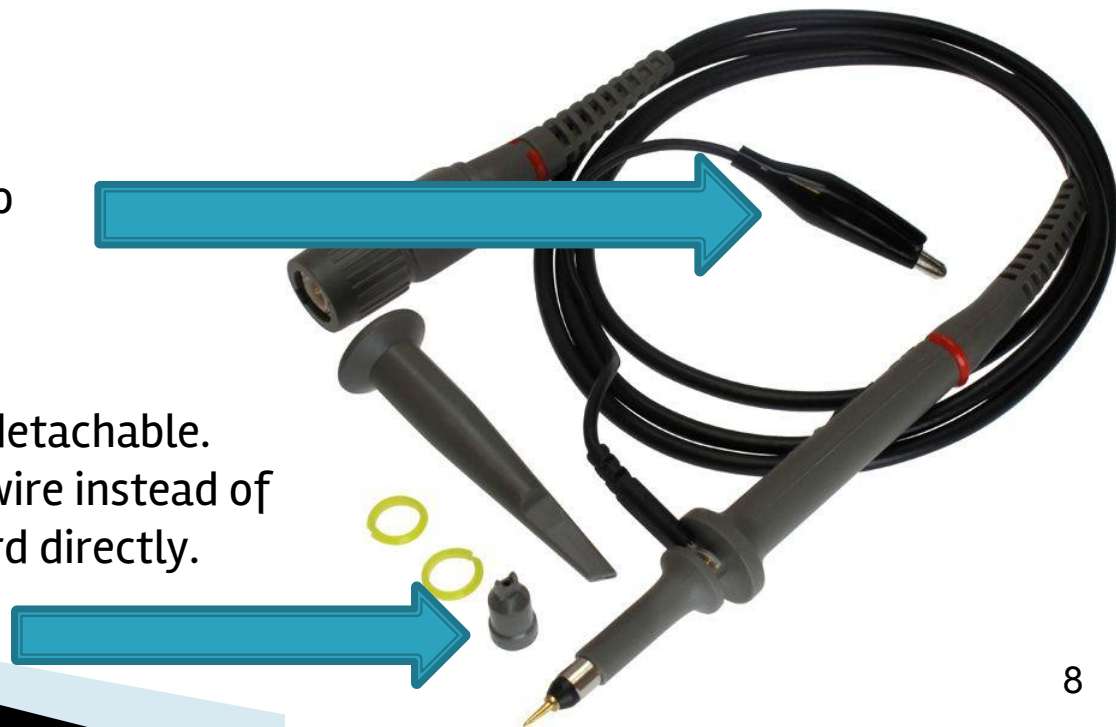
# Becoming Better Friends With Your Scope

# Oscilloscope

- Knowing how to use your scope will help you track down clues.
- Collecting clues only matters if you know what you are looking at

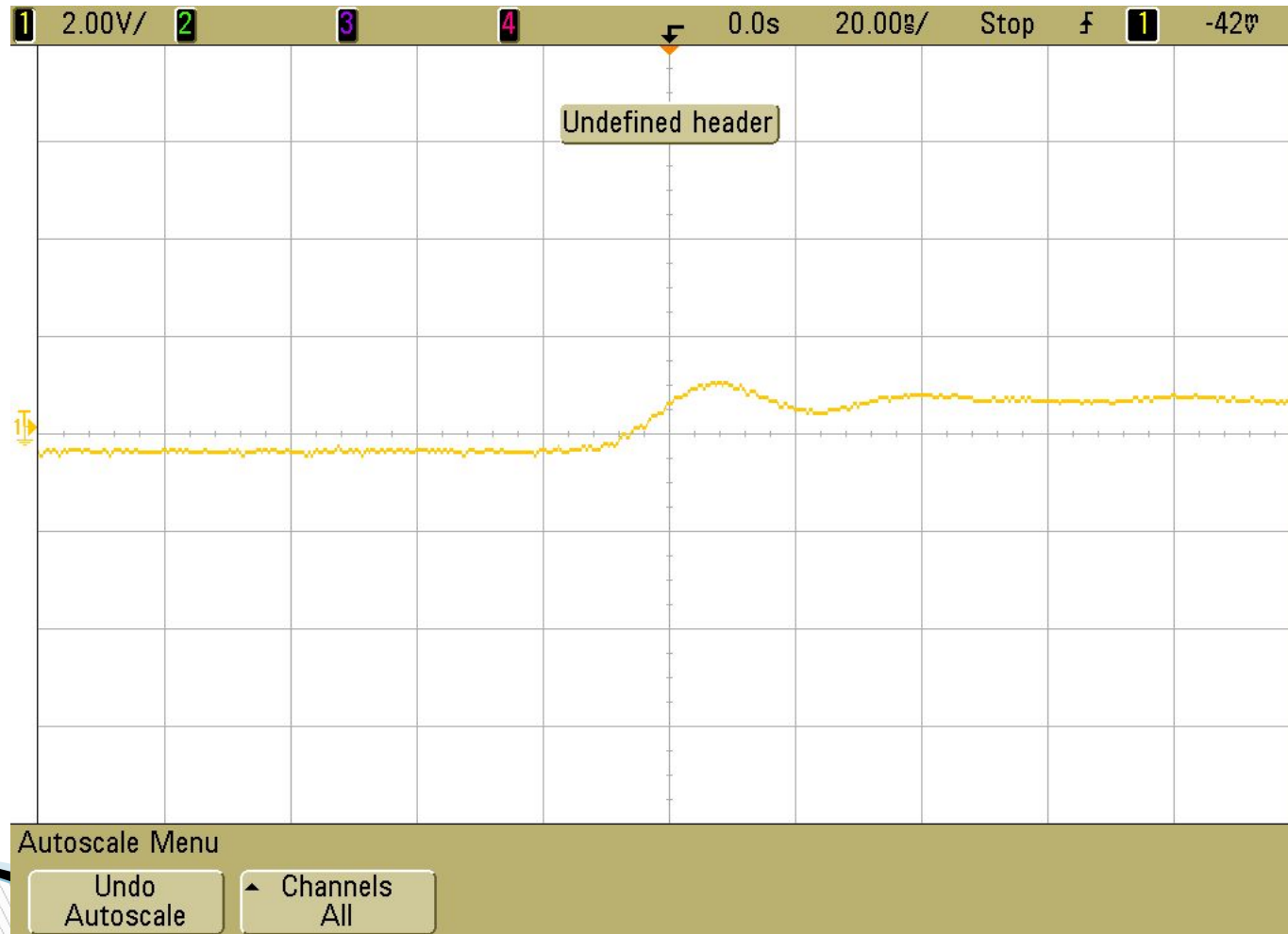
Goes to ground. No excuses.

Hook-shaped tip detachable. Connect this to a wire instead of probing breadboard directly.



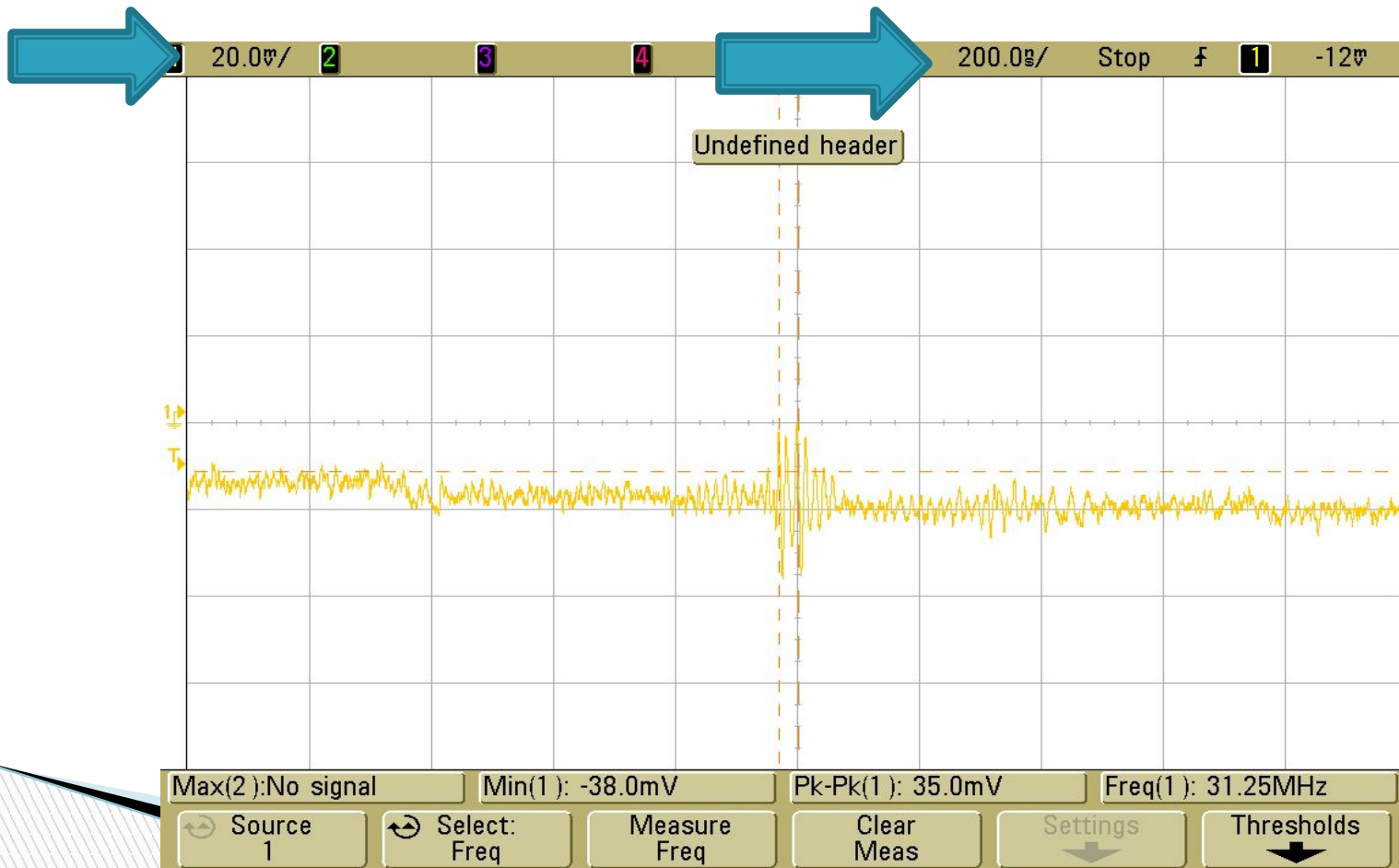


# Auto Scale can be Dumb

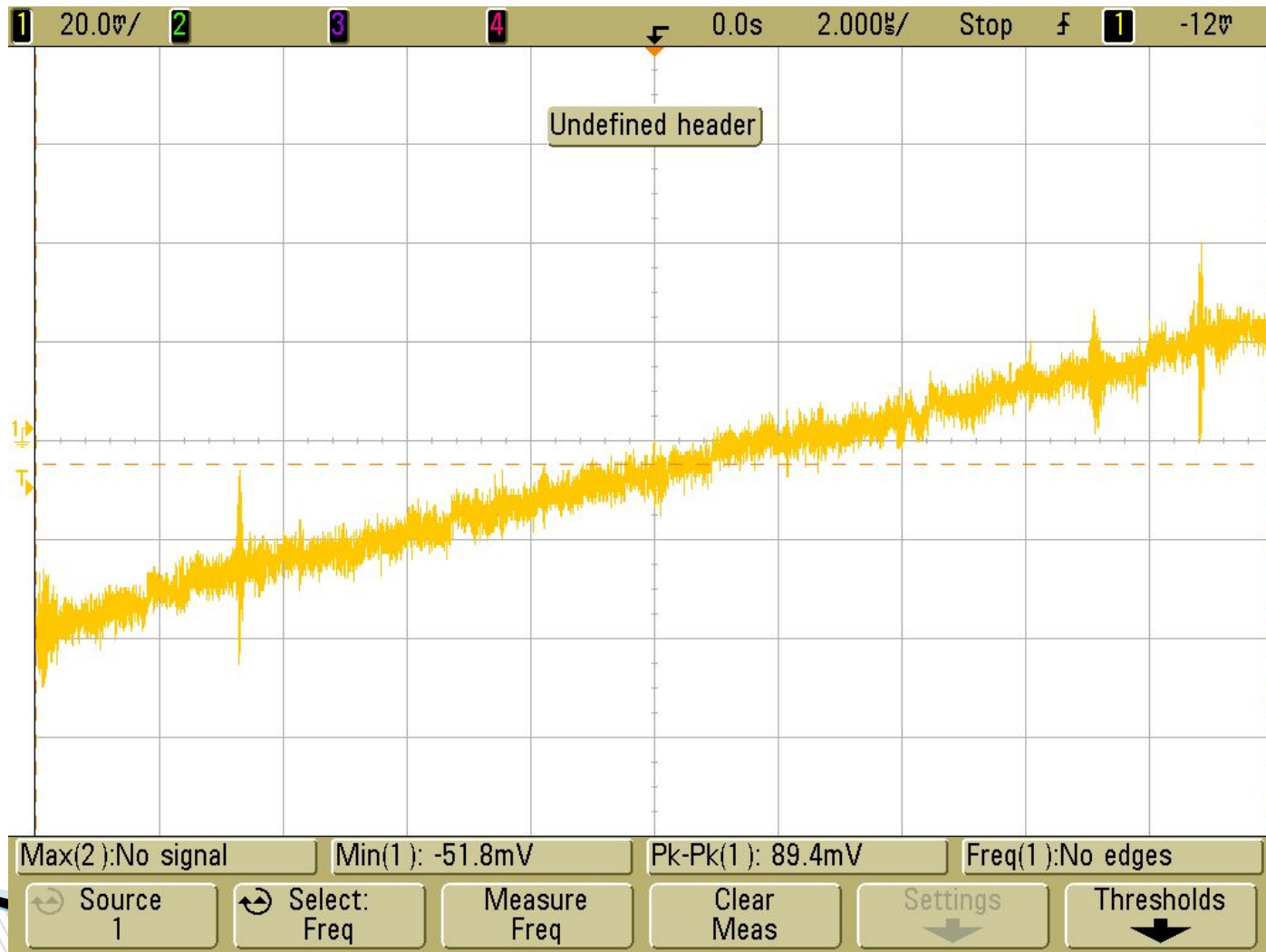


# Note the Division Scale

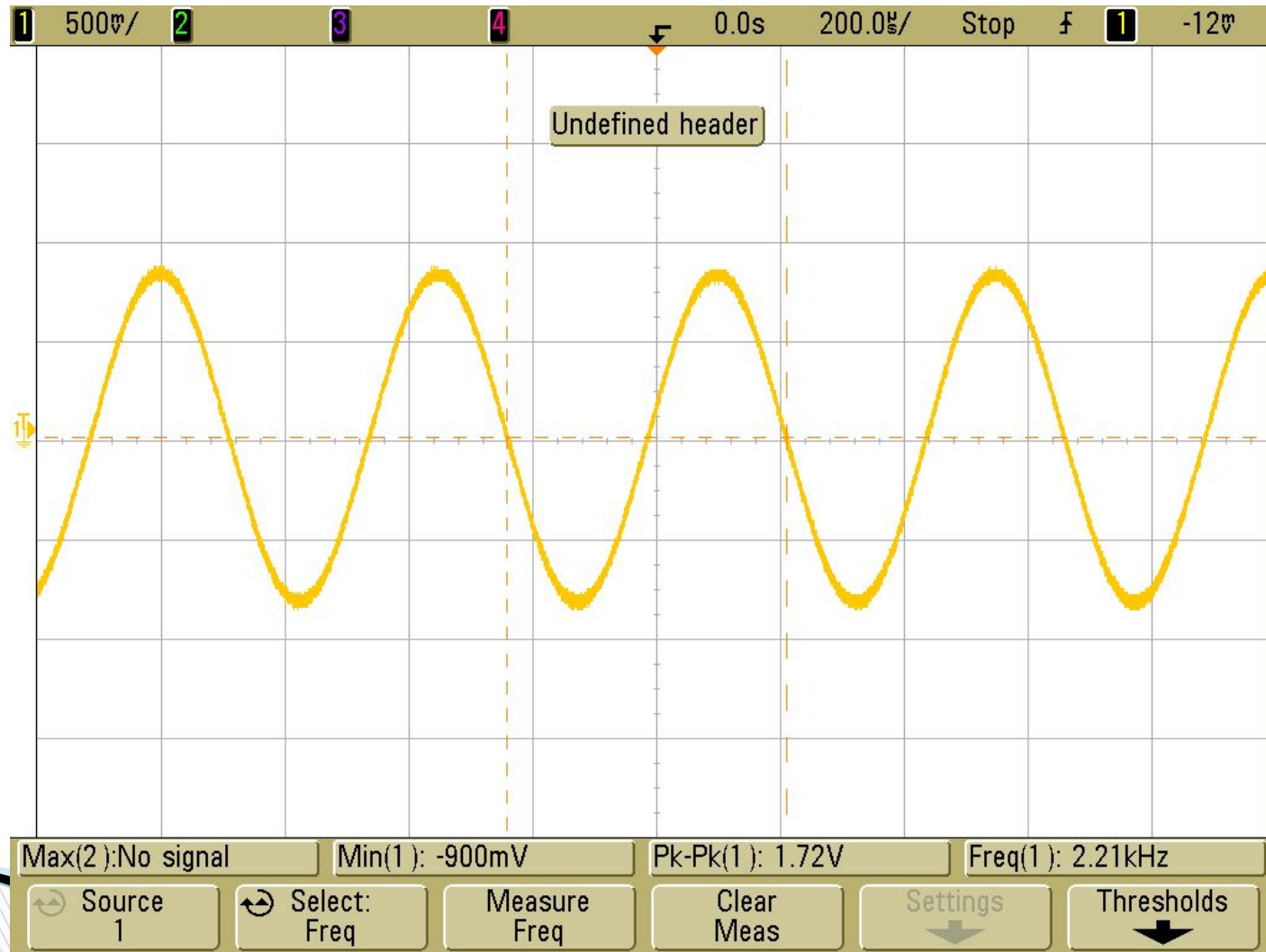
- Time and Voltage are too small



# Zoom Out

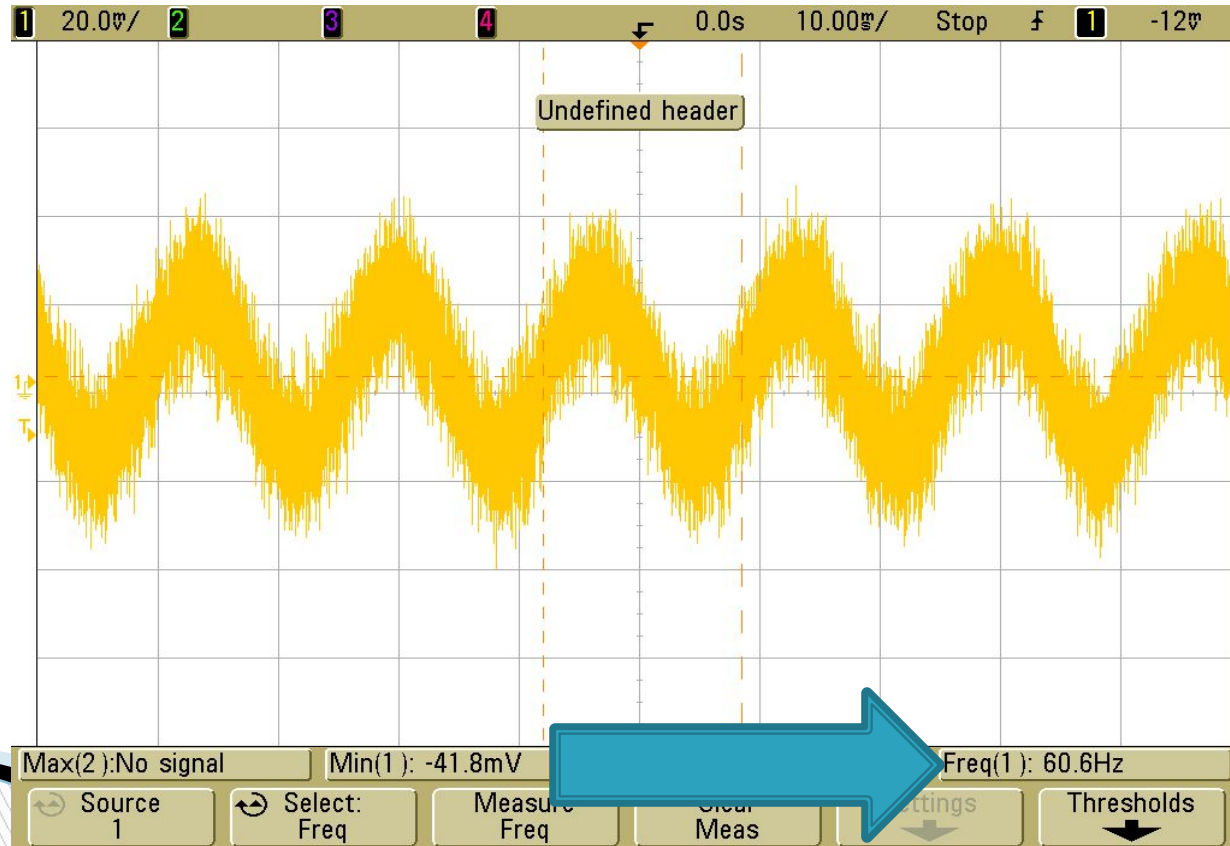


# Zoom Out More



# 60 Hz Noise from building power

- If you see this, something is not grounded and is picking up noise.



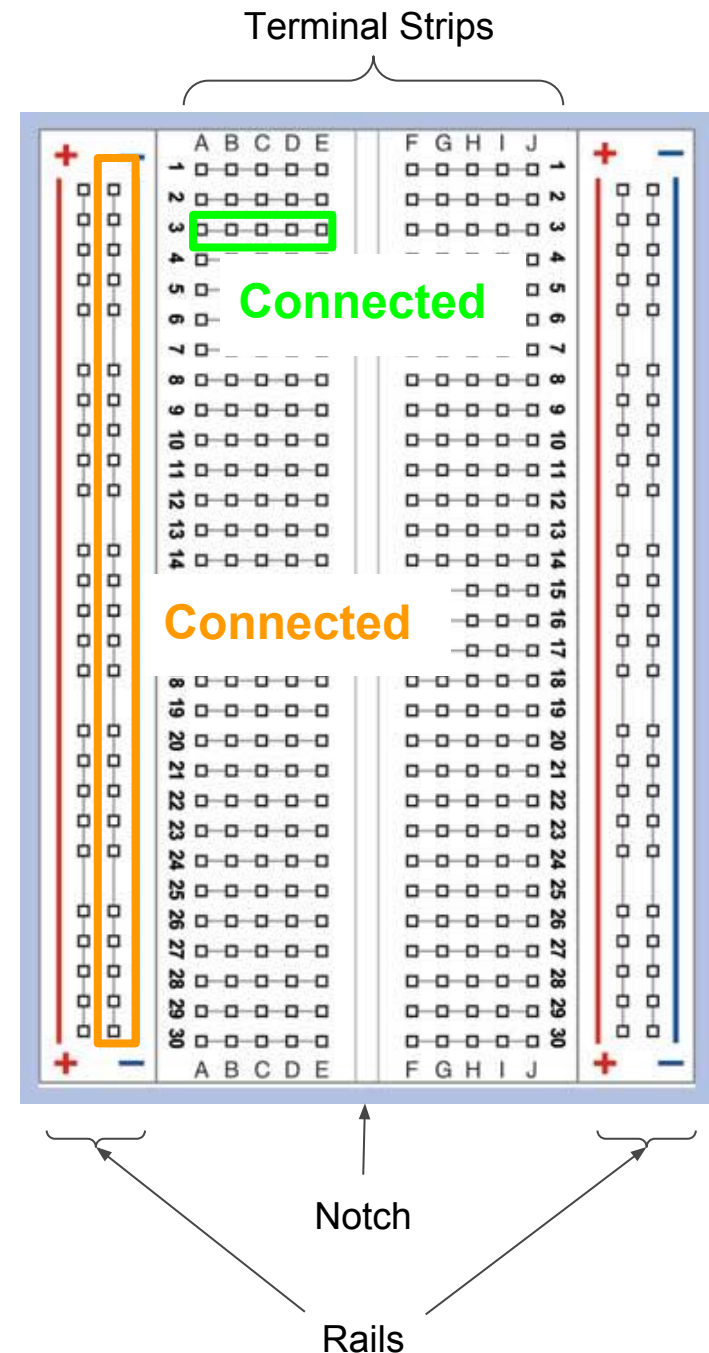
# Most Important

- Stupid Happens. But, it happens less with two brains.
  - Let your partner rebuild the circuit. Step back and check each other's thinking. Don't get stuck in a rut.
- Don't give up!
  - Engineering requires *Truck Loads of Stubborn* and *The Belief That it Will Work Eventually*. Because it will work. You just have to keep looking for clues until you get there.

# Breadboard Layout

# Breadboards

- Terminal strips (rows) are connected in groups of 5
- Rails (side columns) are for power/ground
  - Use **red wire** for power
  - Use **black wire** for ground. All grounds should be connected together
- Chips should straddle the notch





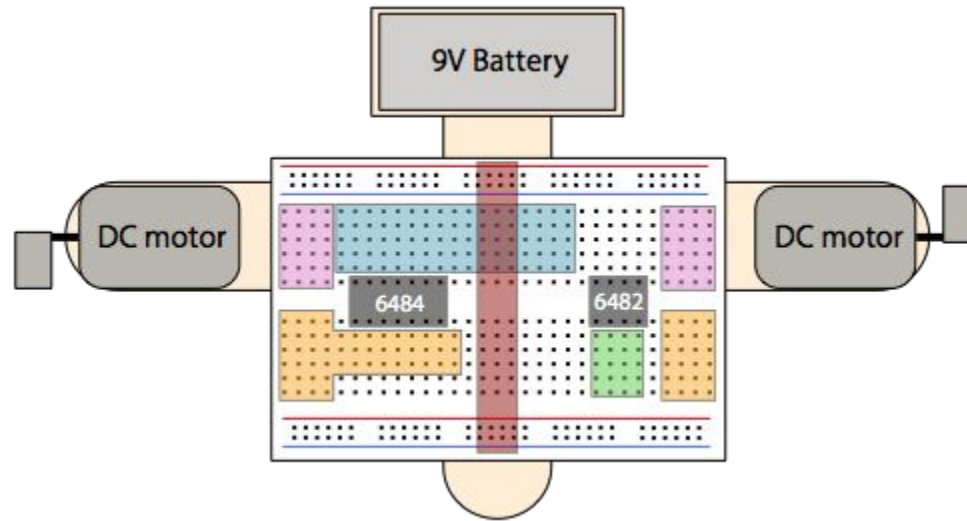
# Breadboard Layout Guidelines

- Plan ahead
- Shorten leads
- Color code your wires
- Reduce length and number of wires

If you wish to receive help, you must first check that your breadboard follows these guidelines.

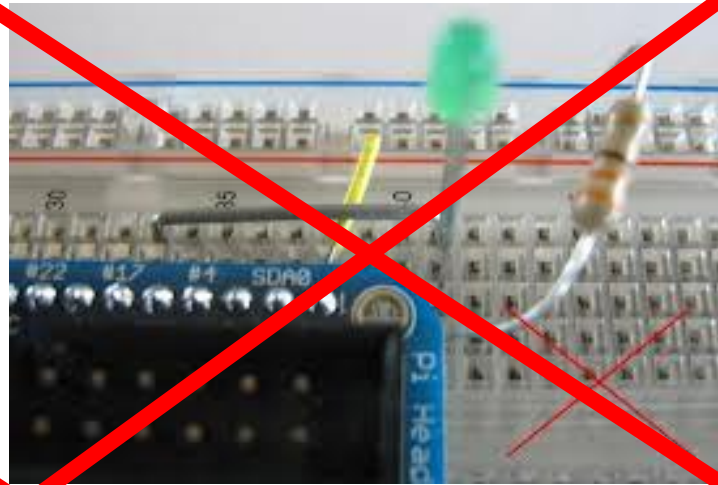
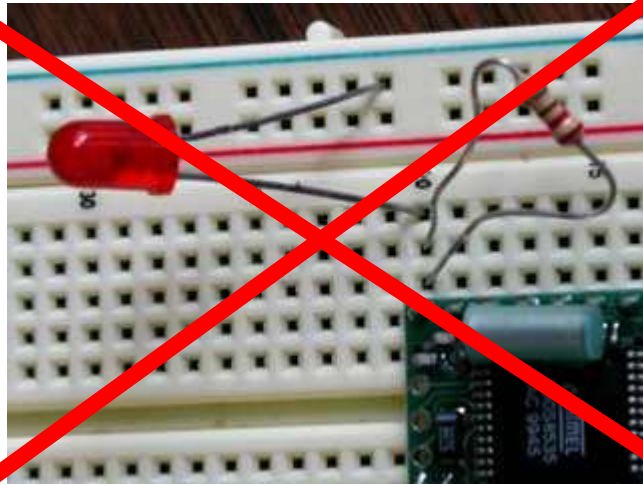
**Otherwise, you will not receive help debugging.**

# Plan Ahead



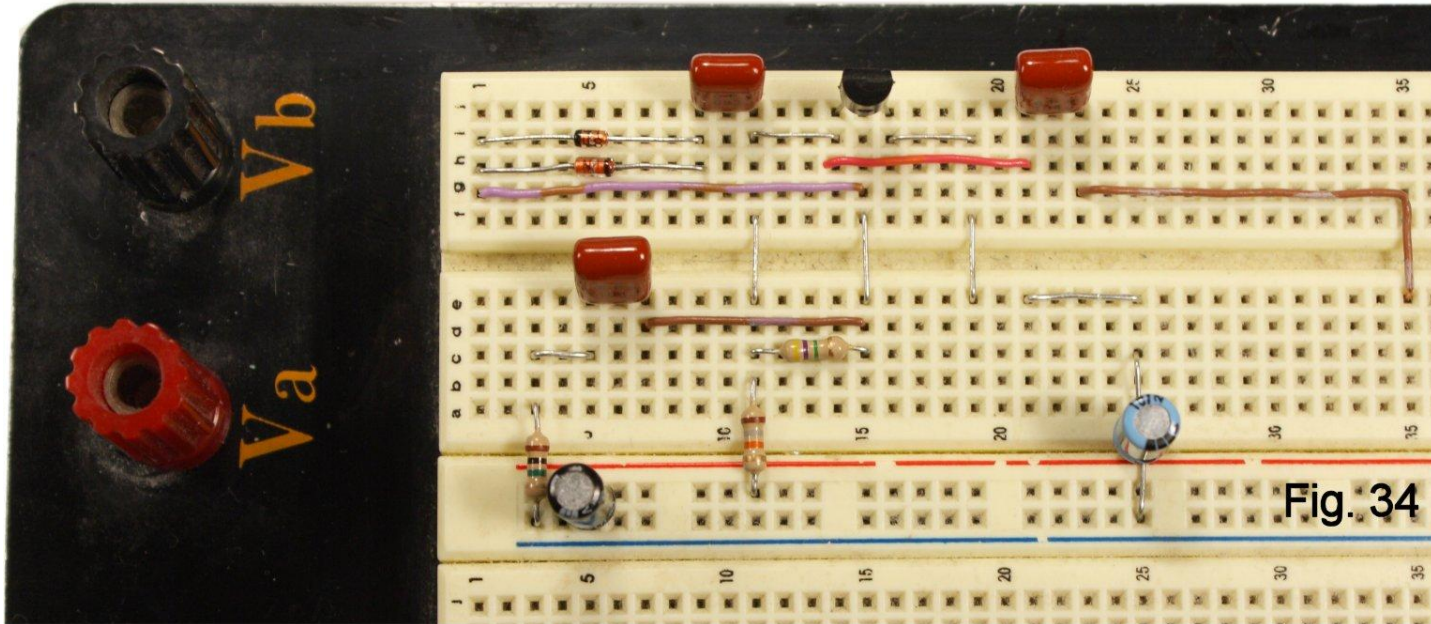
Before you begin, take a few minutes to get a good idea of how to fit your project onto the breadboard. This will avoid space management problems in the future.

# Shorten uninsulated leads



Long uninsulated leads can easily contact each other. This causes undesired short circuits and may even burn out your components.

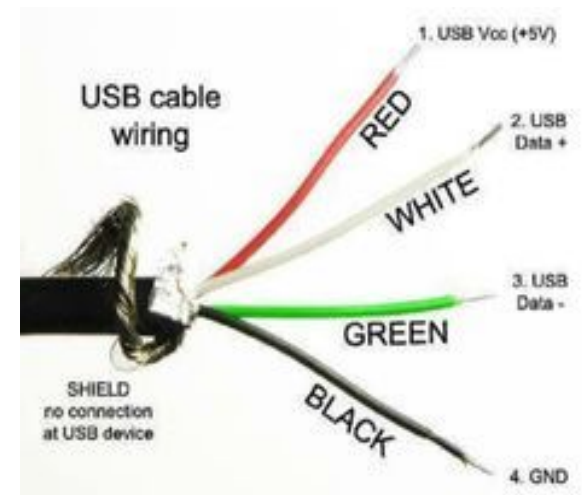
# Shorten uninsulated leads



Cut leads and wires to be only as long as necessary.  
(Planning ahead is important before you cut the wires)

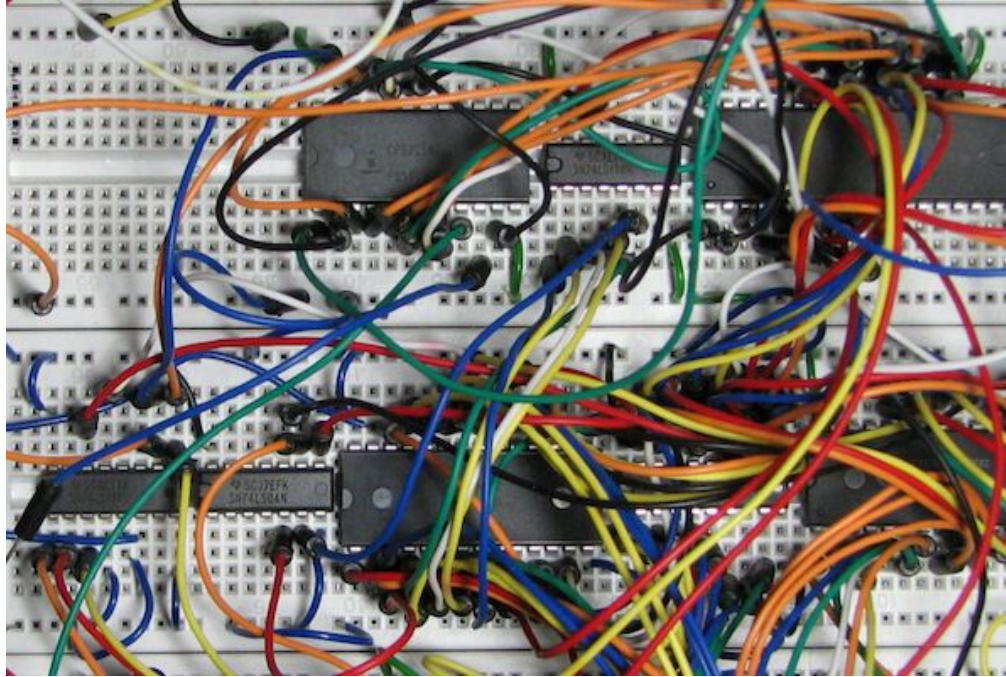
# Color code your wires

- Mandatory color convention
  - Red = power
  - Black = ground
  - **If you don't follow this convention, we will not help you debug**
- Other colors used for all other connections, but should be organized, clear, and methodical



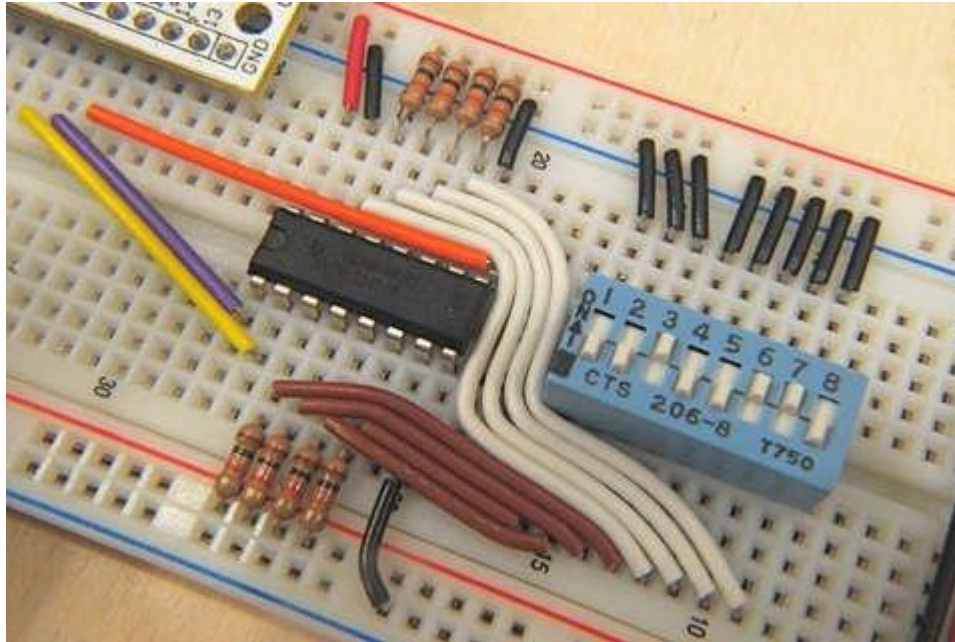


# Reduce length/number of wires



Nobody can figure out what's going on here. A messy breadboard will give you a headache.

# Reduce length/number of wires



You should use as few wires as possible and make them as short as possible

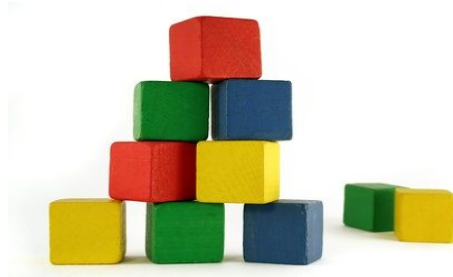
# Debugging Circuits



# Debugging is Detective Work

- How do we track down mistakes?
- You can't debug what you don't understand
- Always know what you expect to happen

# First Step: Build the Circuit

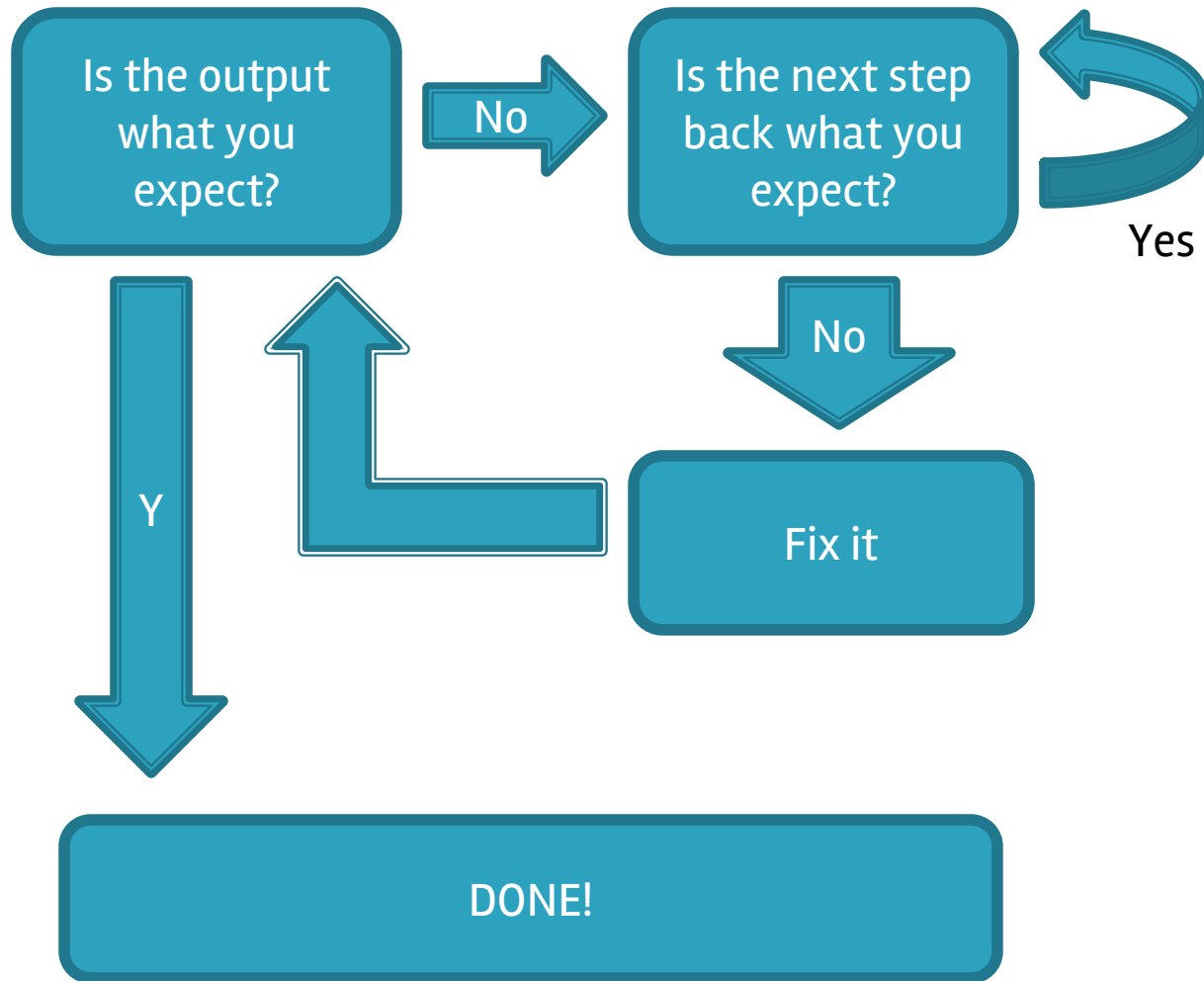


- Circuits are building blocks
  - Start with the smallest part of the circuit (e.g., connect power rails)
  - Build up once the first blocks work
- Take your time, check your work over and over as you go
  - It might seem slow, but you save time later

# The Inevitable Bug

- You were careful building your circuit, but your scope isn't showing the right output. What now?
  - The wrong answer is not necessarily useless.
  - Think about what in your circuit might cause the output you are getting.
  - Collect clues!

# Flow Chart!



# Back it Up

- The scope is your best friend!
- Power
  - Check that each chip is actually getting power
  - Check that your source is **not current limited**
- Previous signals
  - If an earlier signal is what you expect, then something after that point in your circuit is the problem

# Back Back it Up

- Are the wires in the right row?
  - Check that each wire is actually connected
- Are your wire connections in securely?
  - Press and wiggle wires
  - Check connectivity using DMM
- Worst case: use the multimeter or replace the wires

# Back Back Back it Up

- Back all the way up to the function generator
  - Use the scope to make sure the input signal is correct.
- Are the wires really REALLY correct?
  - Try tearing up a messy circuit and just trying again.
- Back all the way up to your schematic
  - Check the datasheet
  - Is your wiring diagram correct?

# Last Resort

- Is the hardware broken?
  - Change components
  - Change wires
  - Change pins on launchpad
  - Check probe is not broken by connecting to the test signal on the scope
- Rebuild the circuit
  - Tear everything up and retry. There is a very good chance that this will fix everything.



# Quiz

- Take the lab quiz linked in IPython notebook
- You must get 100% to be checked off!