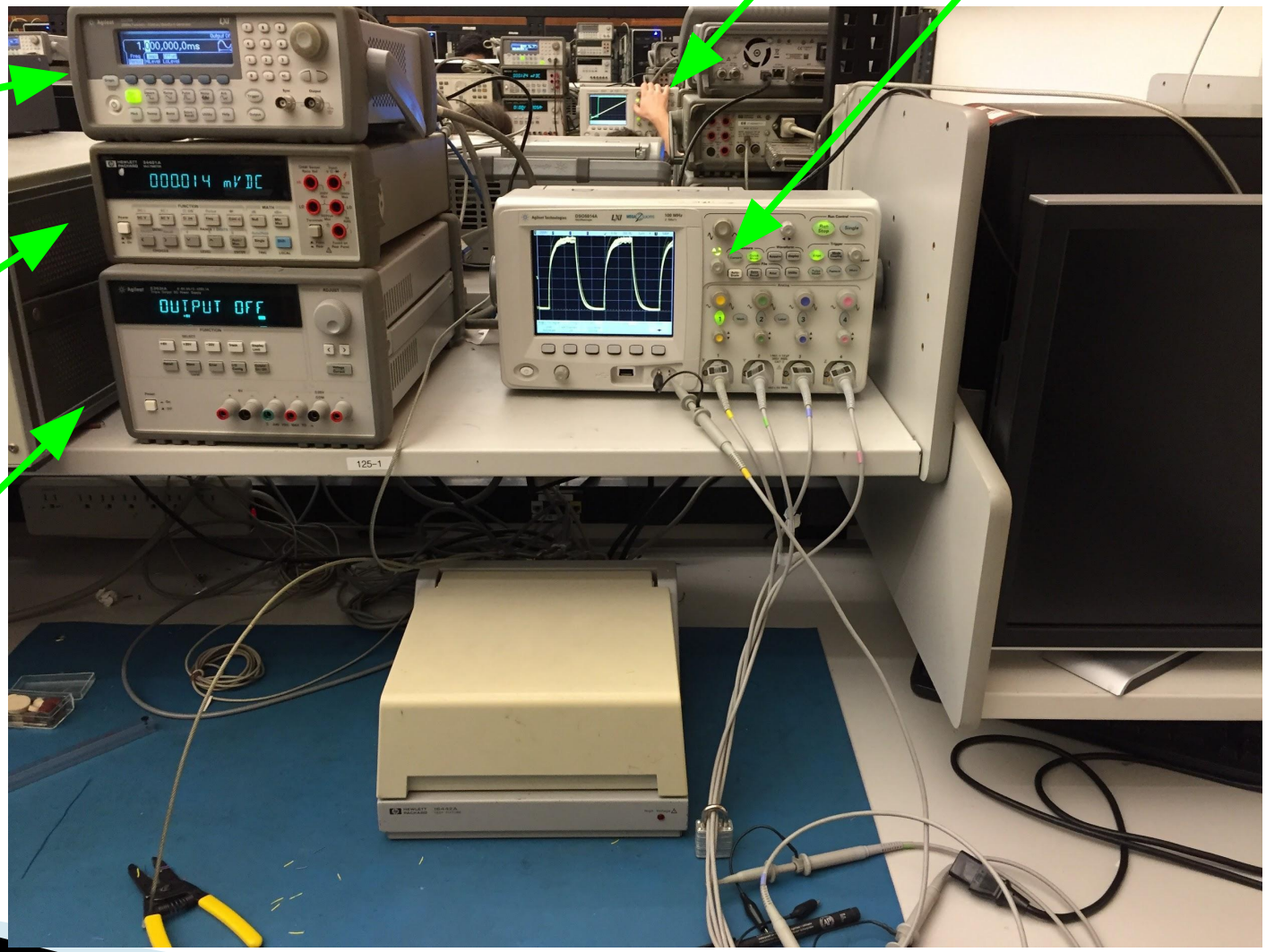
Guide to Debugging

EE 16B

Spring 2018

Your Lab Bench Setup



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

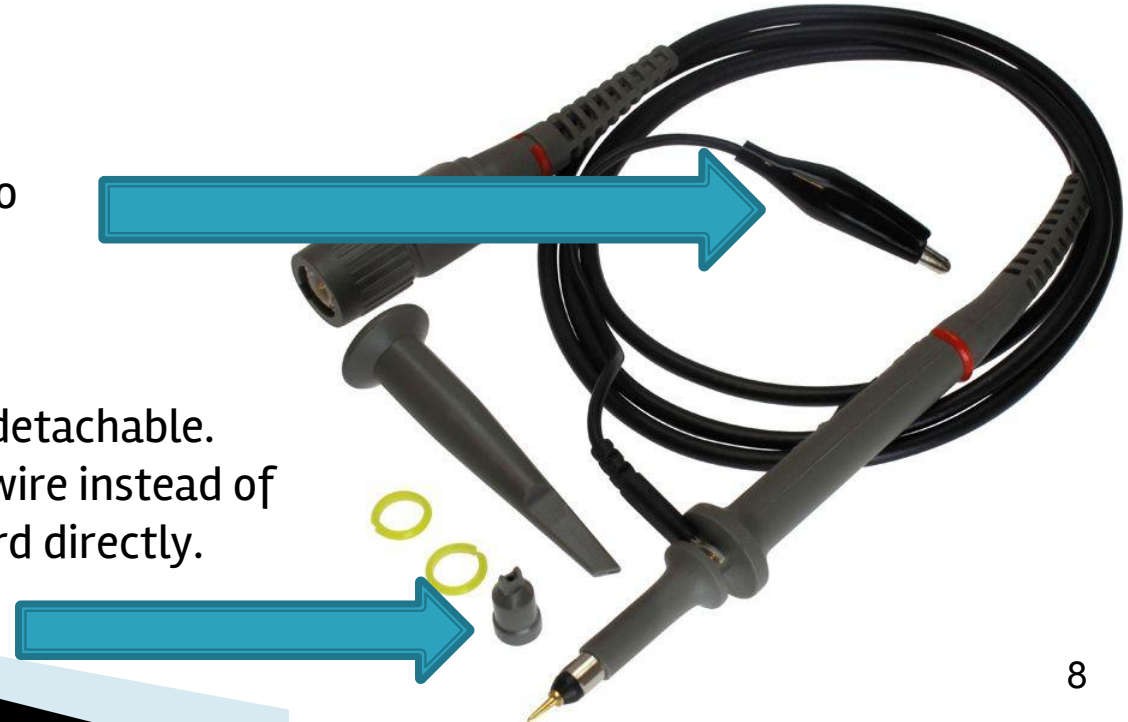
Becoming Better Friends With Your Scope

Oscilloscope

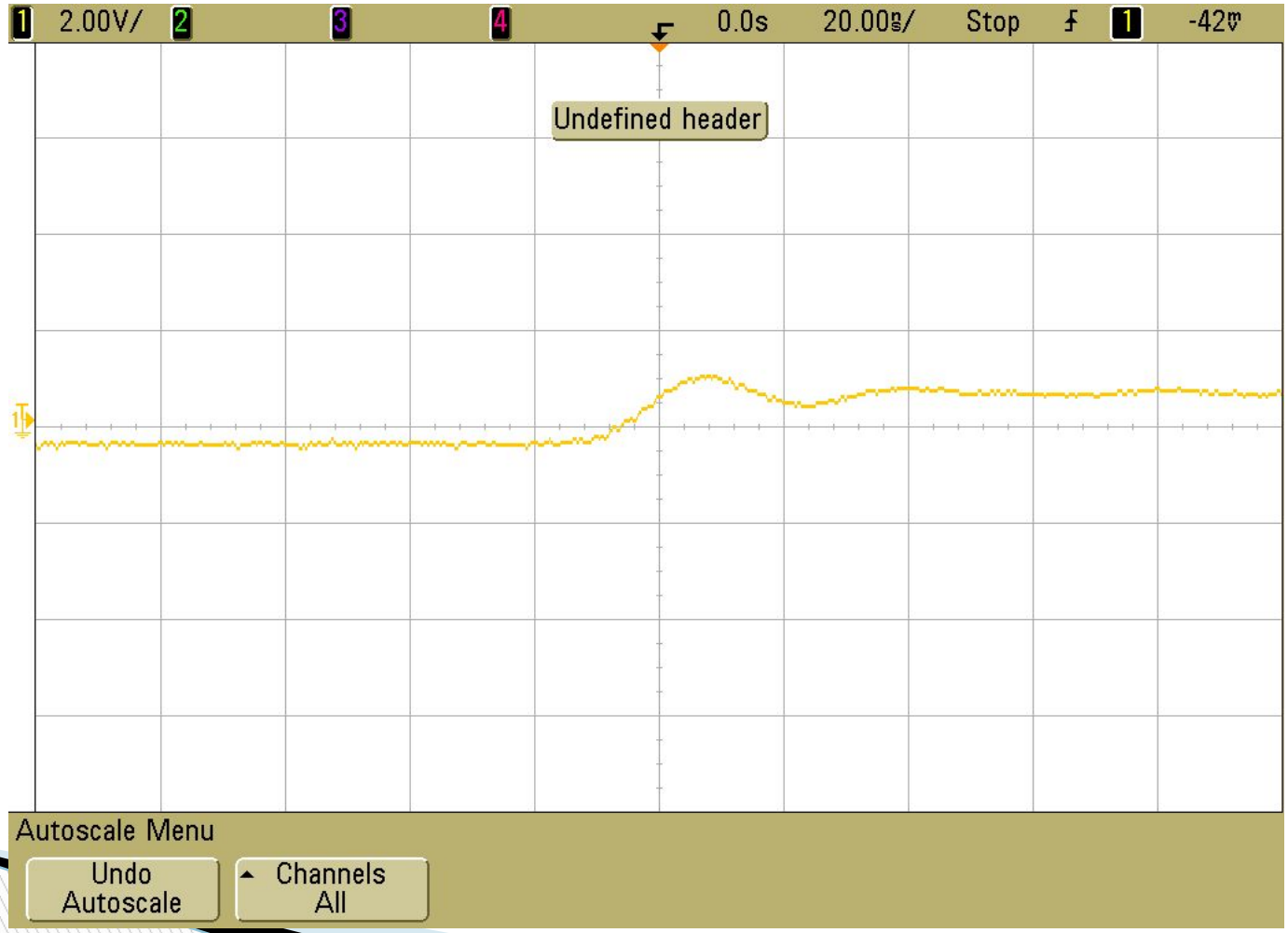
- Knowing how to use your scope will help you track down clues.
- Collecting clues only matters if you know what you are looking at

Goes to ground. No excuses.

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

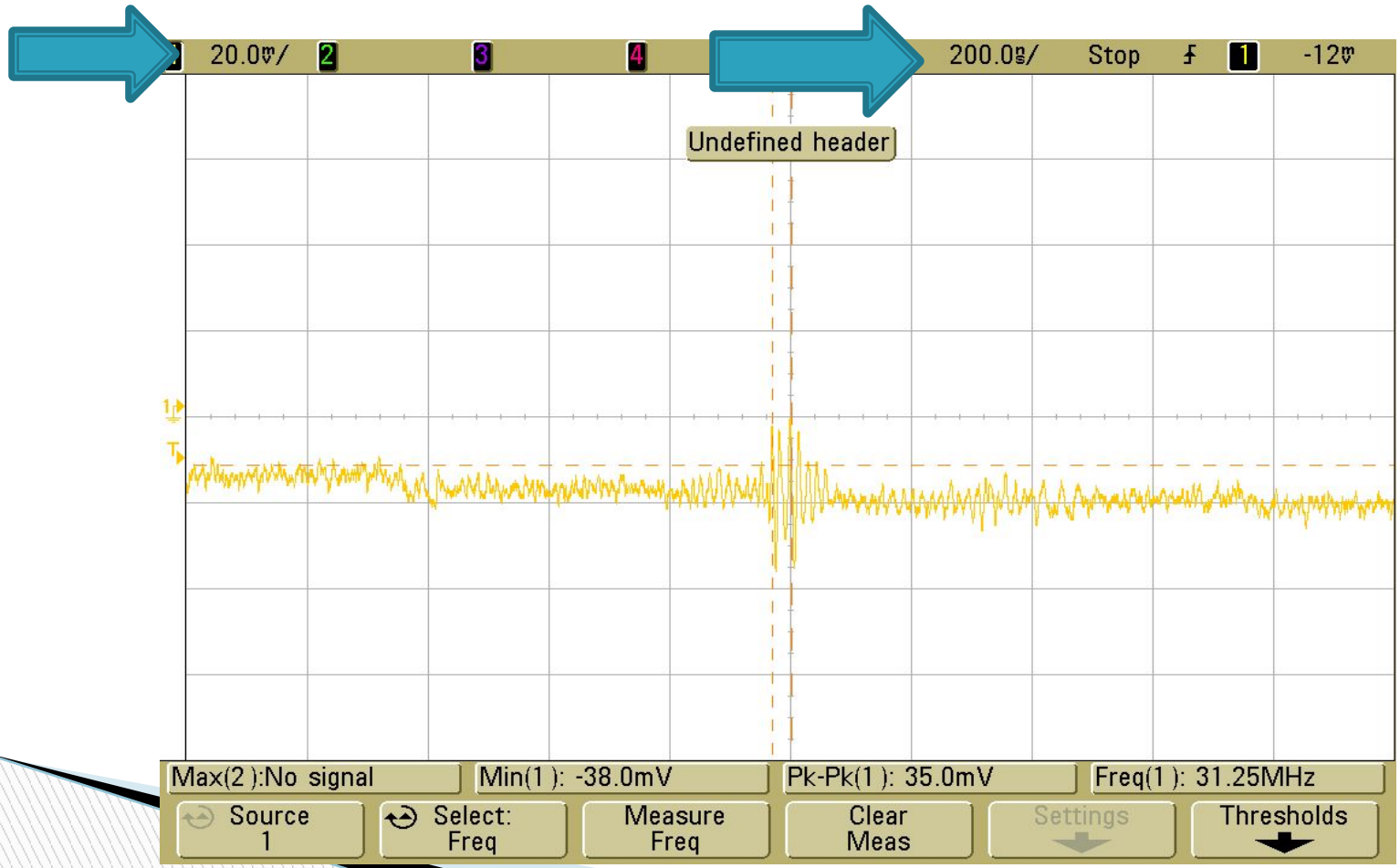


Auto Scale can be Dumb

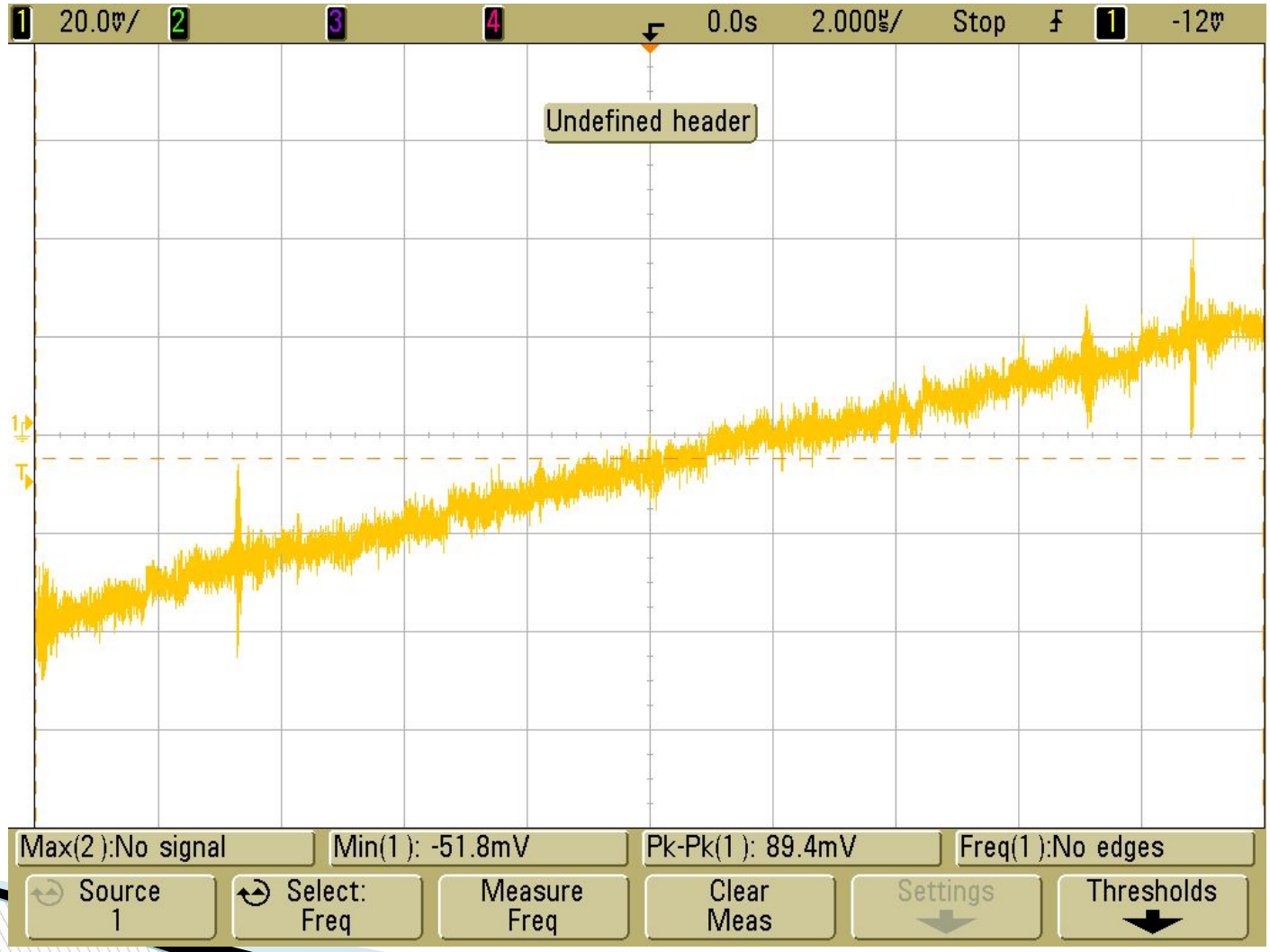


Note the Division Scale

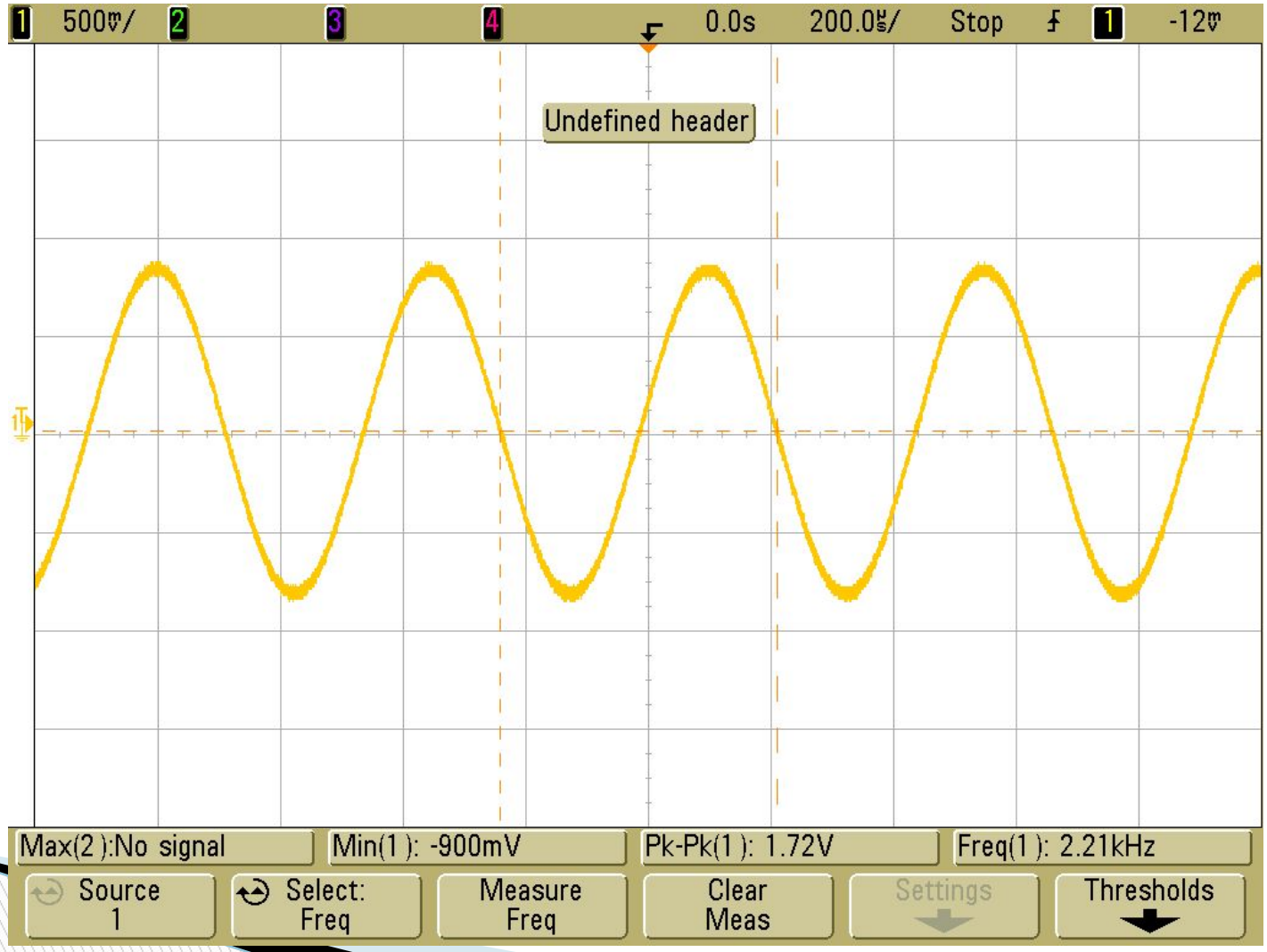
- Time and Voltage are too small



Zoom Out

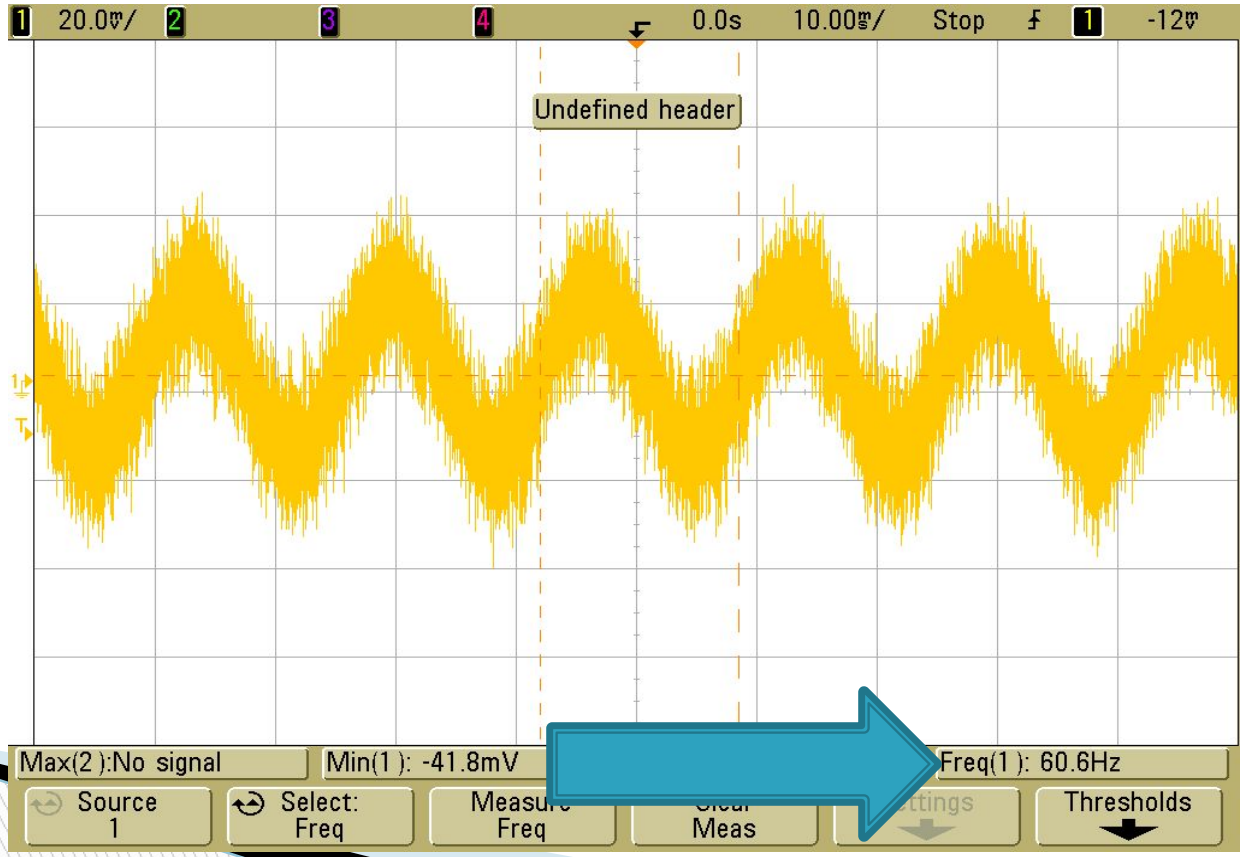

1 20.0mV/ 2 3 4 0.0s 2.000ms/ Stop 1 -12mV
Undefined header
Max(2):No signal
Min(1): -51.8mV
Pk-Pk(1): 89.4mV
Freq(1):No edges
Source 1
Select: Freq
Measure Freq
Clear Meas
Settings
Thresholds

Zoom Out More



60 Hz Noise from building power

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



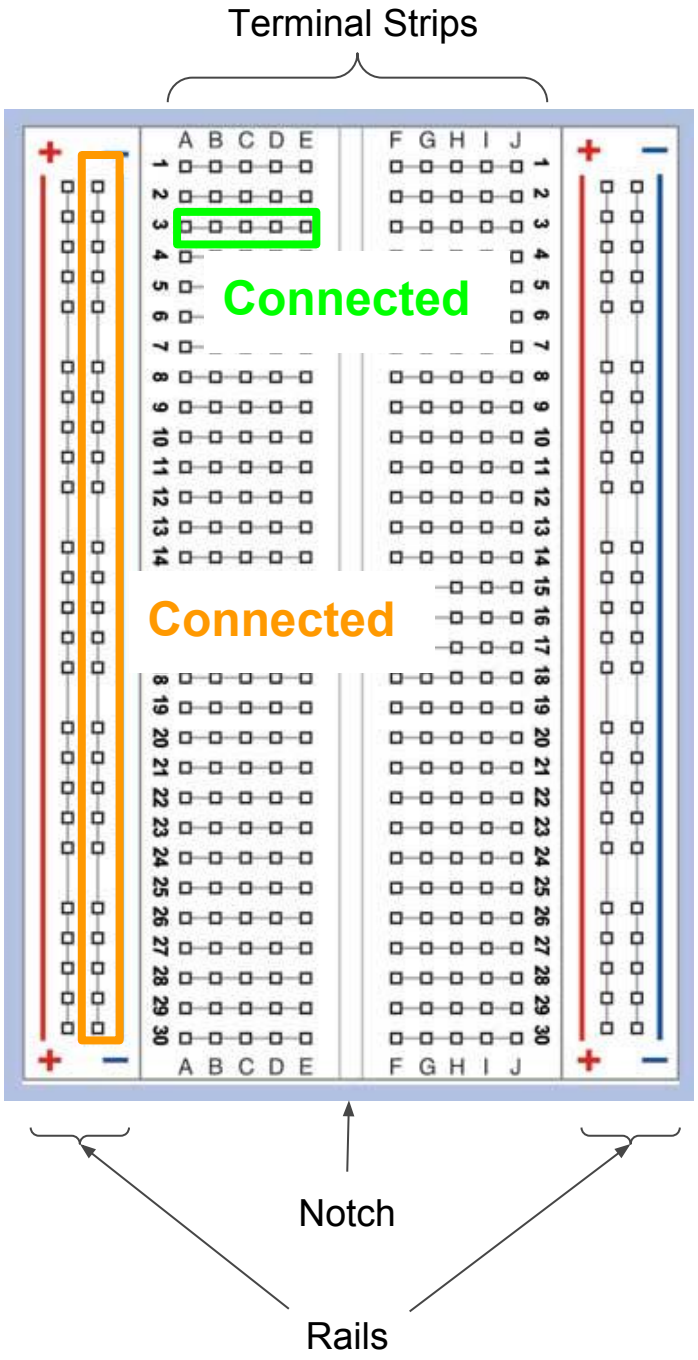
Most Important

- 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

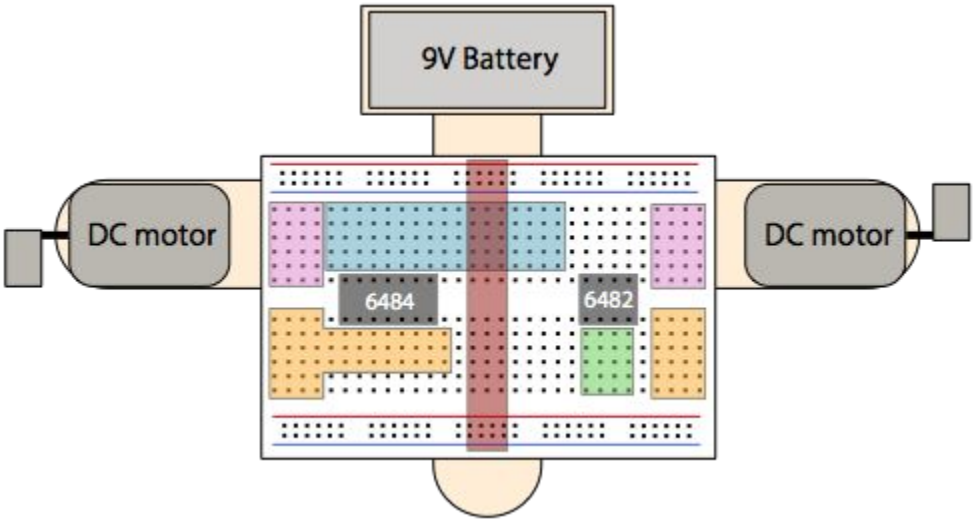


Breadboard Layout Guidelines

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

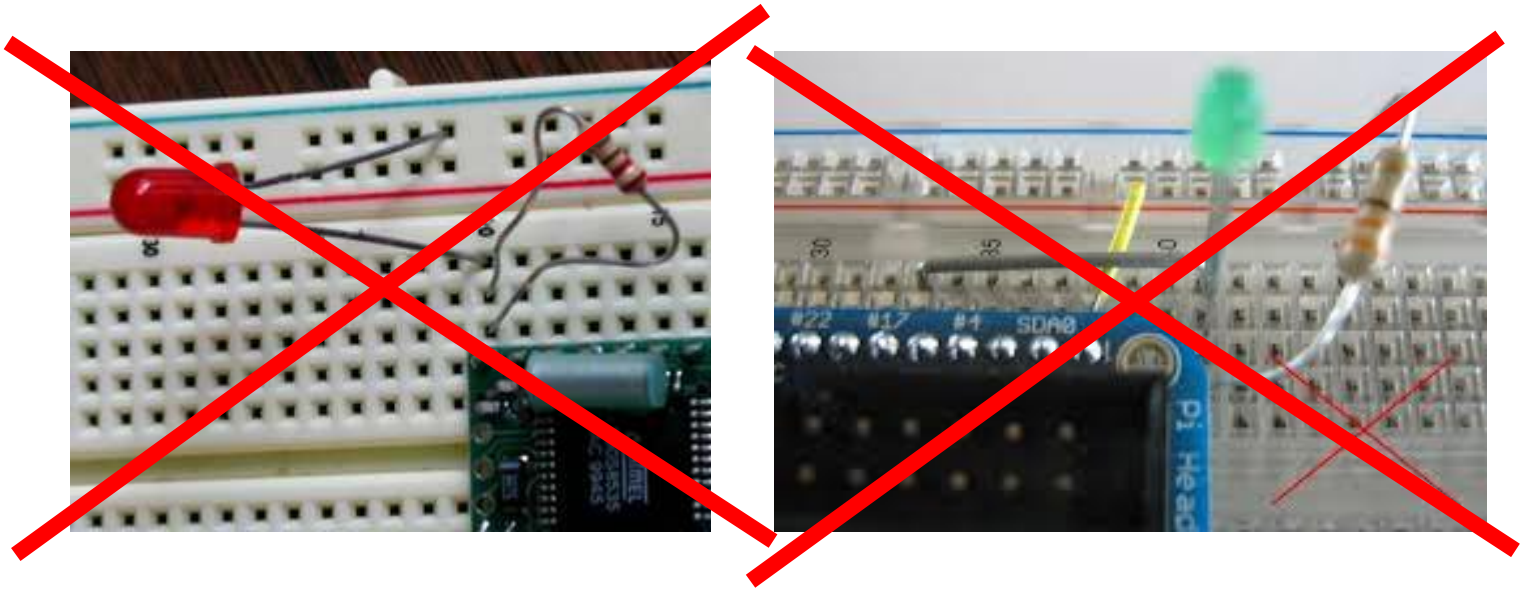
If you wish to receive help, you must first check that your breadboard follows these guidelines.
Otherwise, you will not receive help debugging.

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

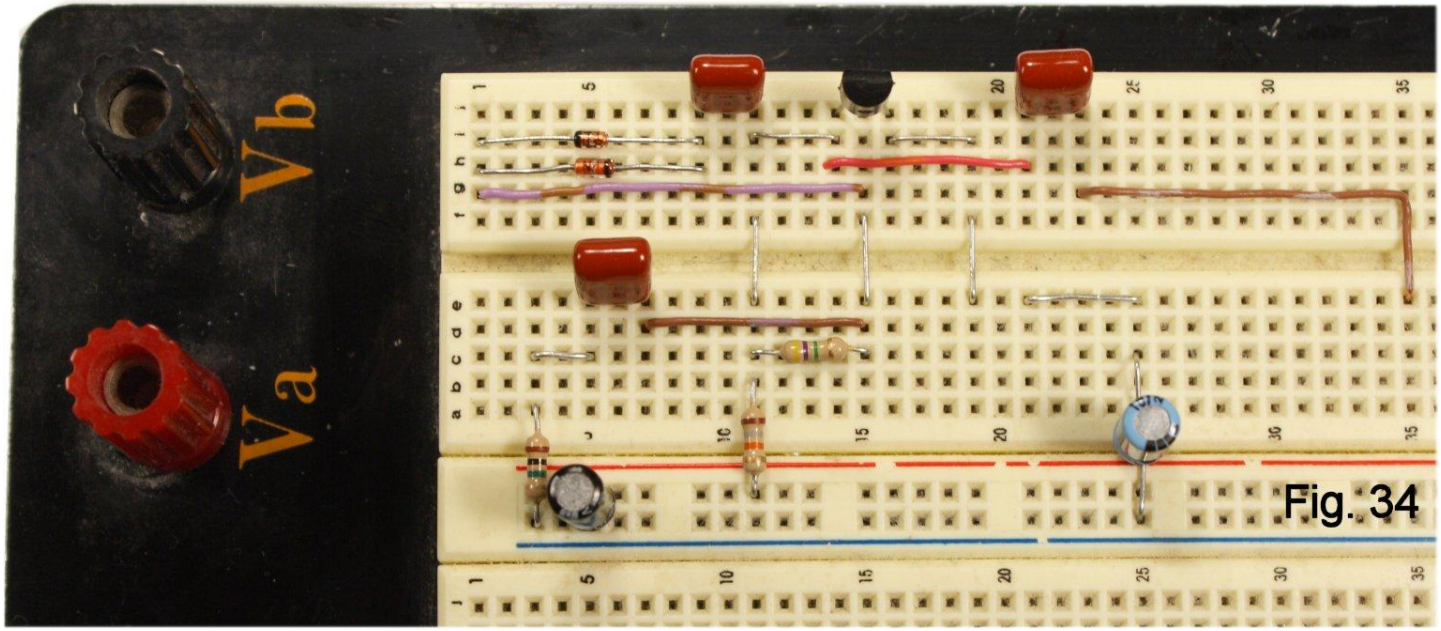
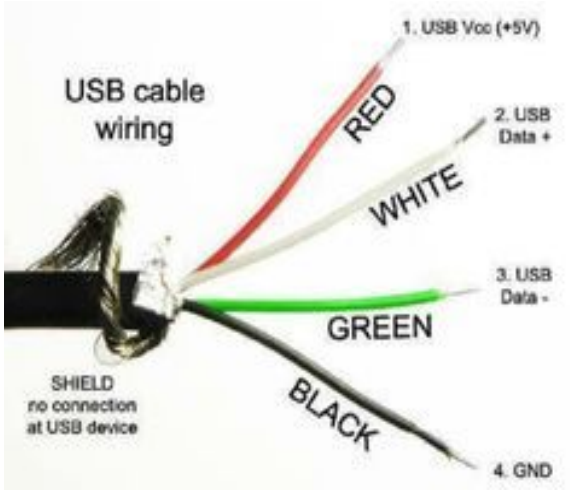


Fig. 34

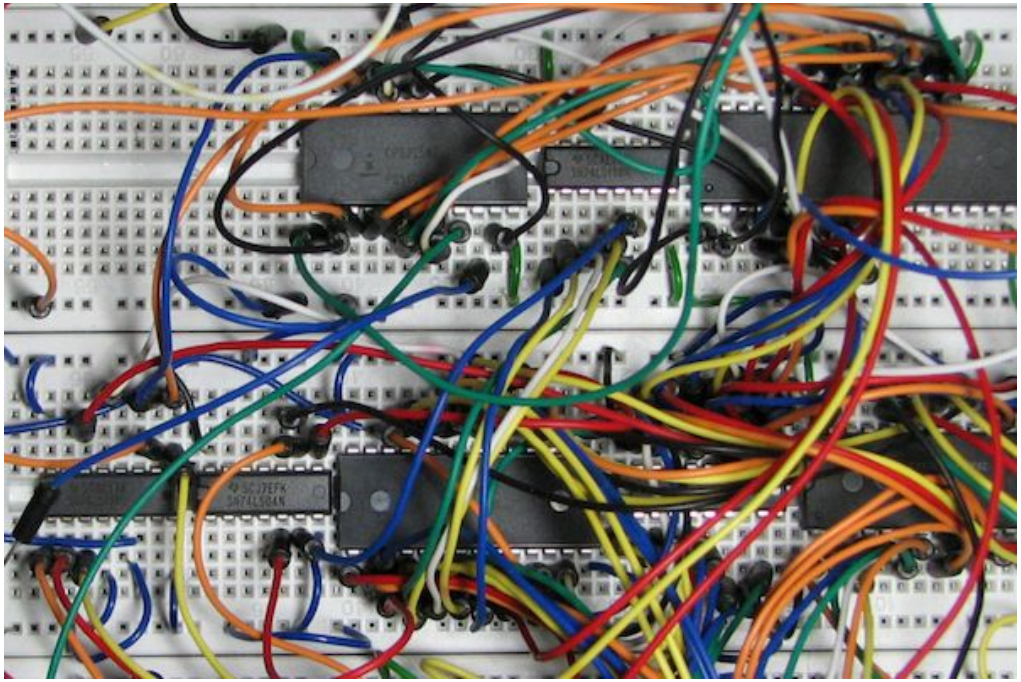
Cut leads and wires to be only as long as necessary. (Planning ahead is important before you cut the wires)

Color code your wires



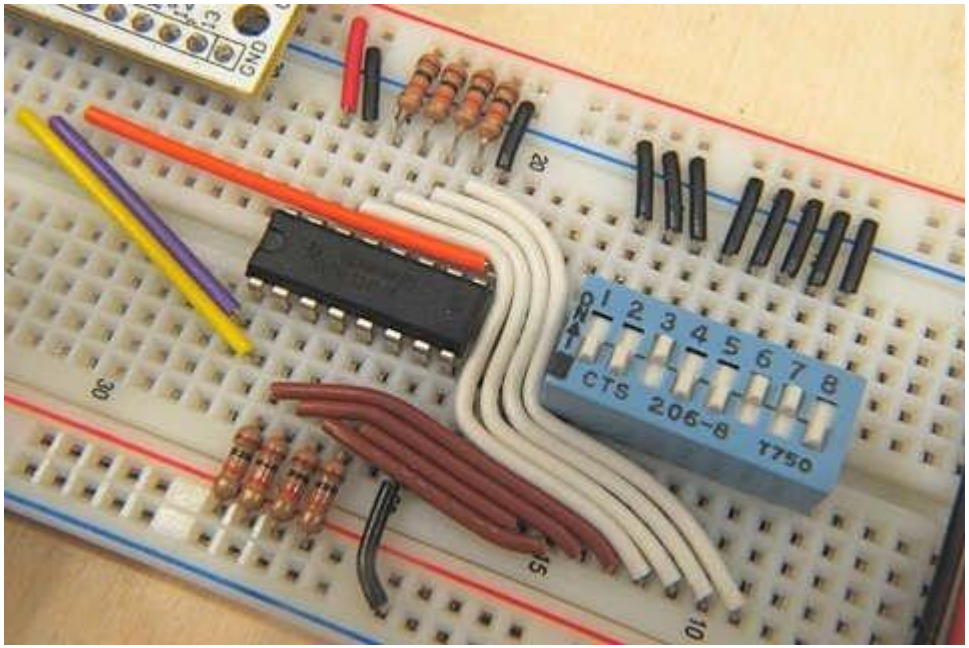
- Mandatory color convention
  - Red = power
  - Black = ground
  - **If you don't follow this convention, we will not help you debug**
- Other colors used for all other connections, but should organized, clear, and methodical

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



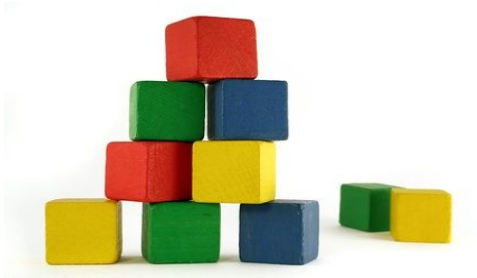
You should use as few wires as possible and make them as short as possible

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

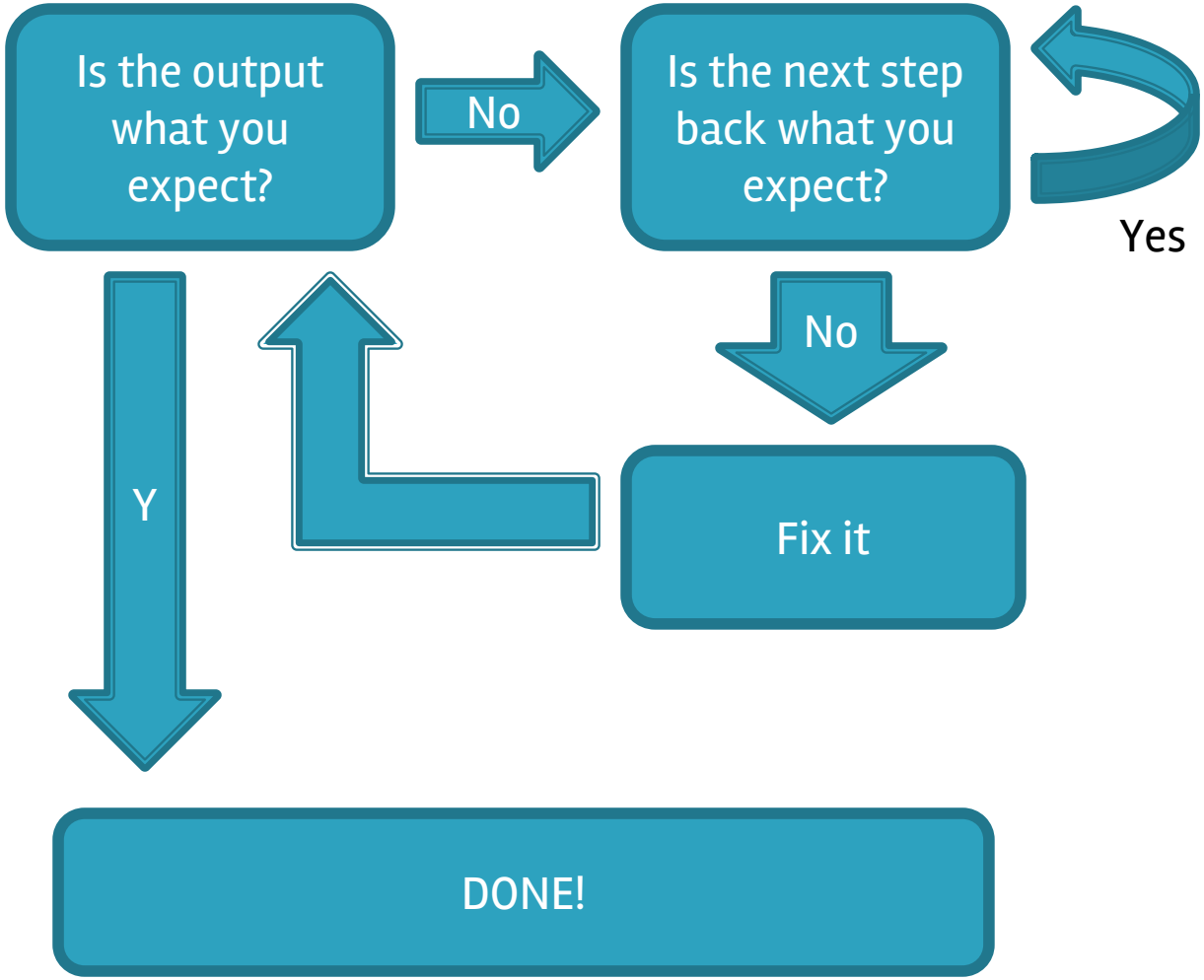


- Circuits are building blocks
  - Start with the smallest part of the circuit (e.g., connect power rails)
  - Build up once the first blocks work
- Take your time, check your work over and over as you go
  - It might seem slow, but you save time later

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!


Is the output what you expect?
No
Is the next step back what you expect?
Yes
No
Y
Fix it
DONE!

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!