

# Debugging Analog Circuitry

- Common issues
- Sanity checks
- Unit testing
- System testing

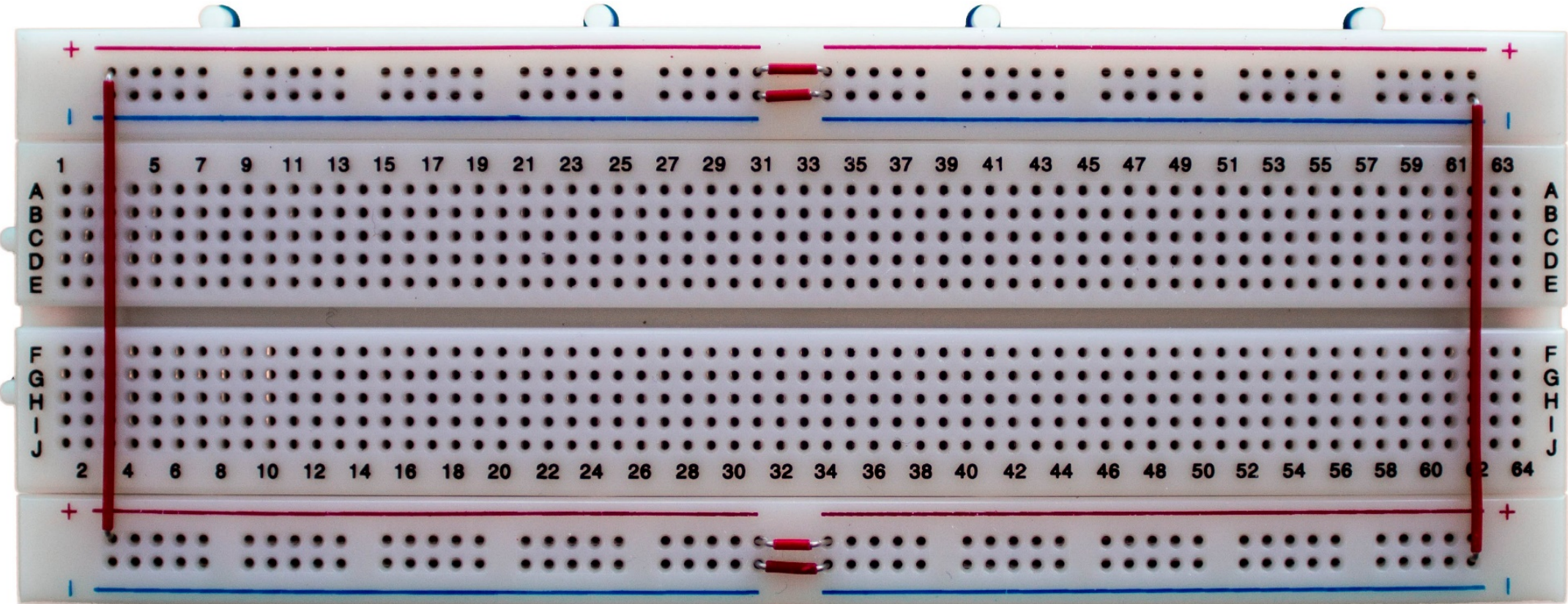
# Crazy Wires!

- Red/Black: VCC/GND
- Purple/Grey: Battery/return
- Other colors are signal wires (decide on a color scheme!)
- Shorten wires
- Twist out/return wires
- Plugs are removable, but soldered joints are smaller.
- Use soft over rigid wires

# How to solder wires like a Pro!

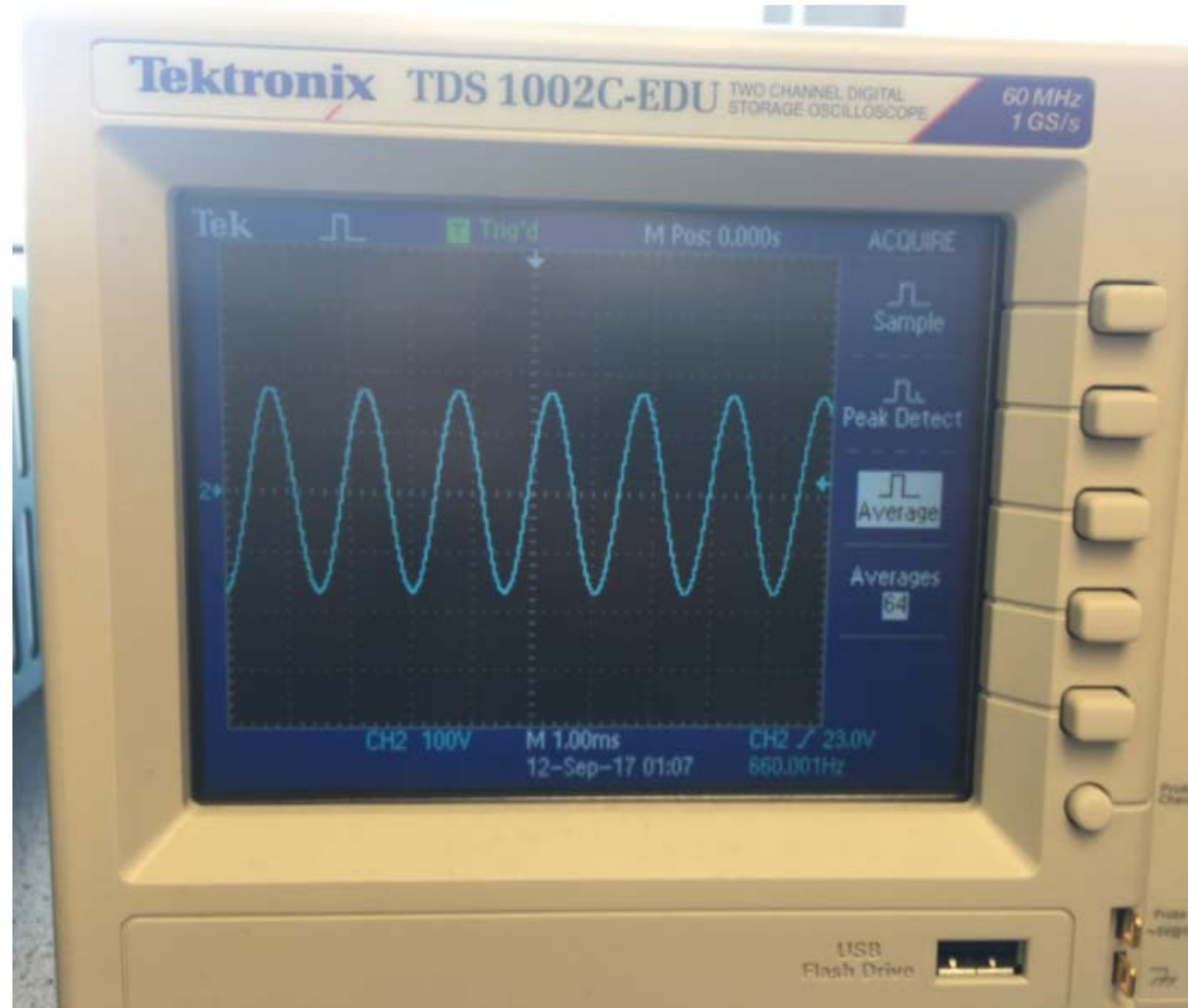


# Common Reference



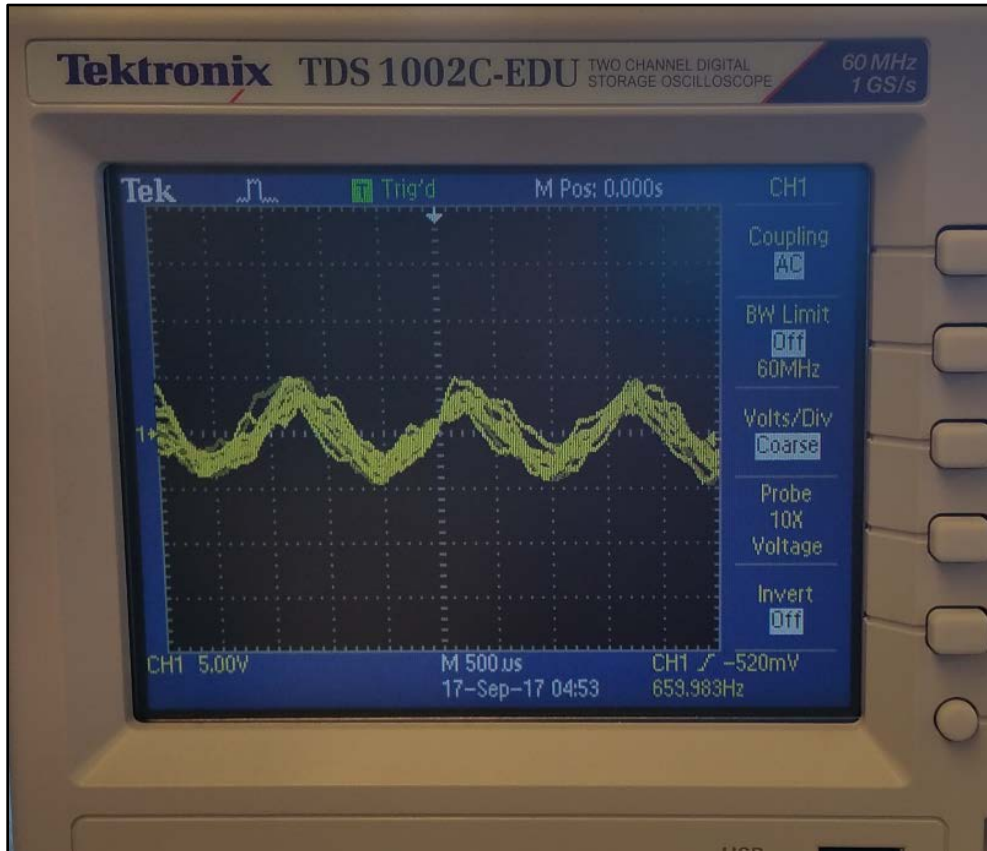
# Microphone - Sanity Check

- Play 660Hz tone to a speaker, what do I expect the signal to look like?



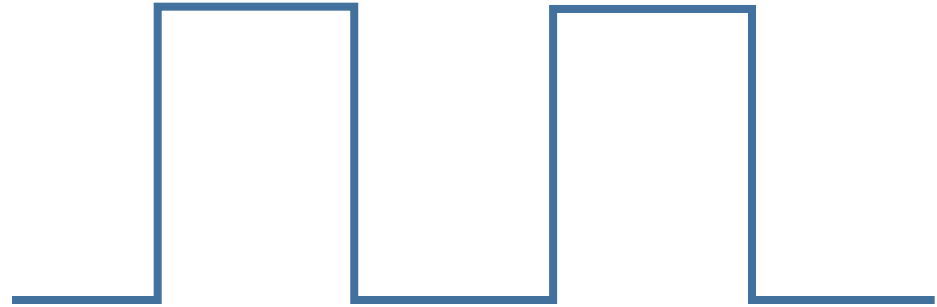
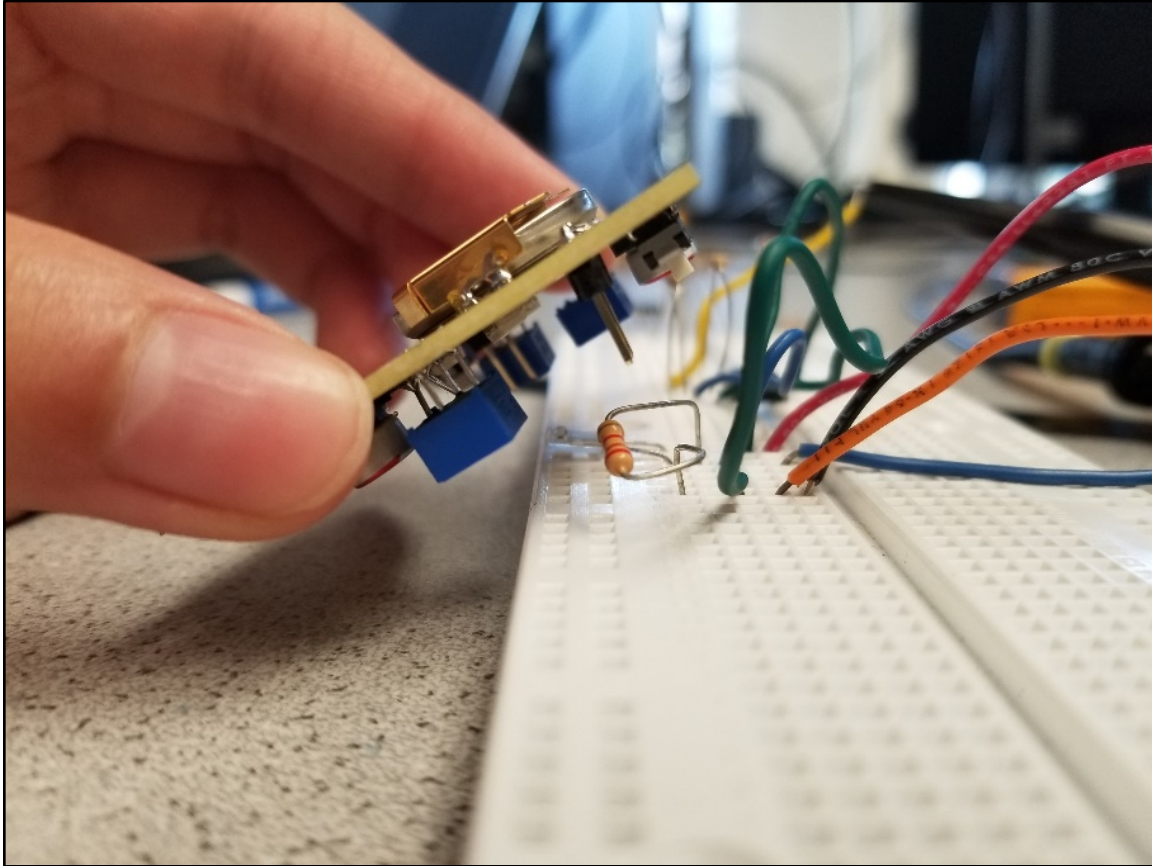
# Microphone - Sanity Check

- Play 660Hz tone to a speaker, what do I expect the signal to look like?



# Treasure - Sanity Check

- Emit a treasure signal - what do I expect my sensor output to look like?



# Treasure – Sanity Check

- What if the output looks like a saw tooth wave?

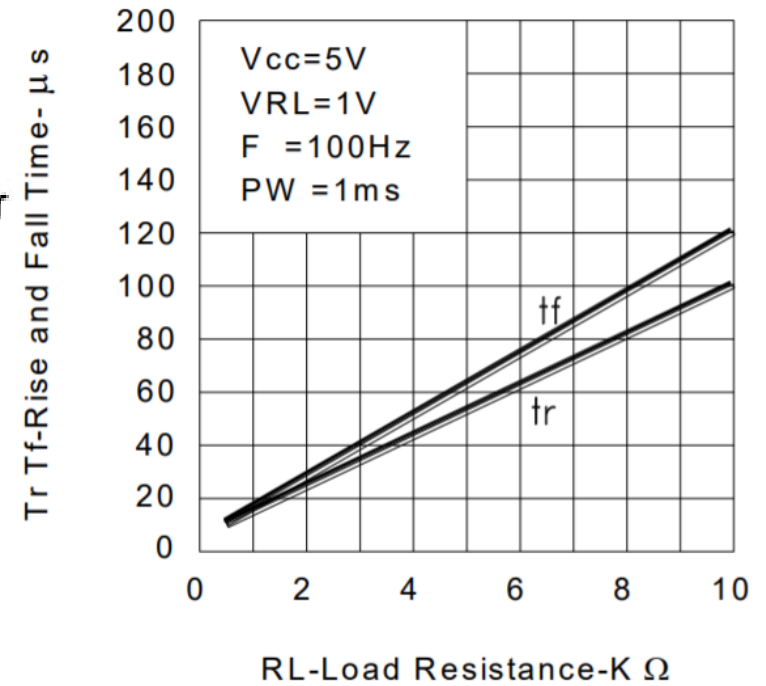
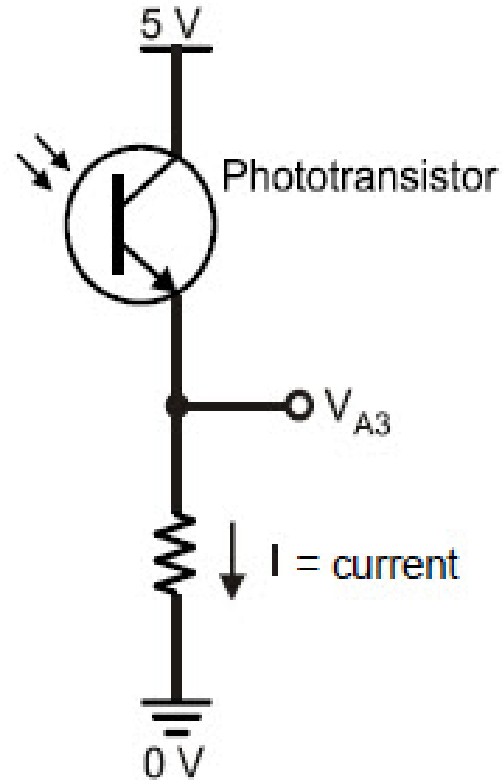
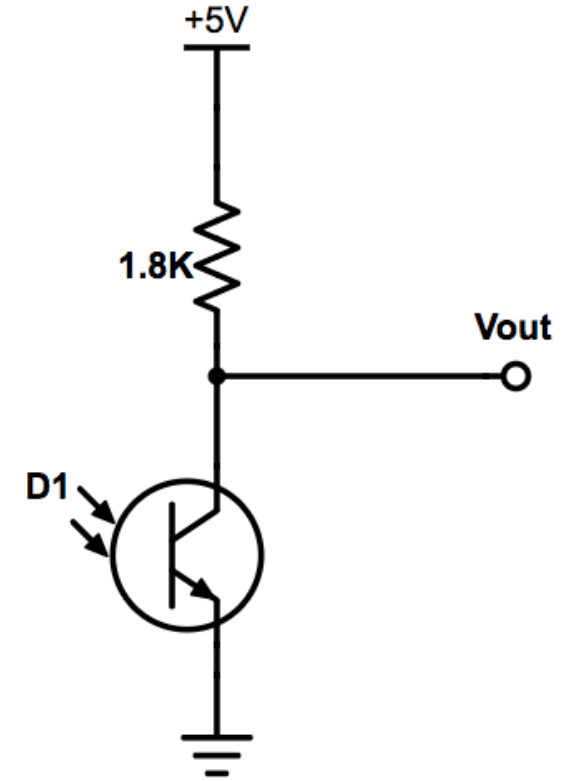
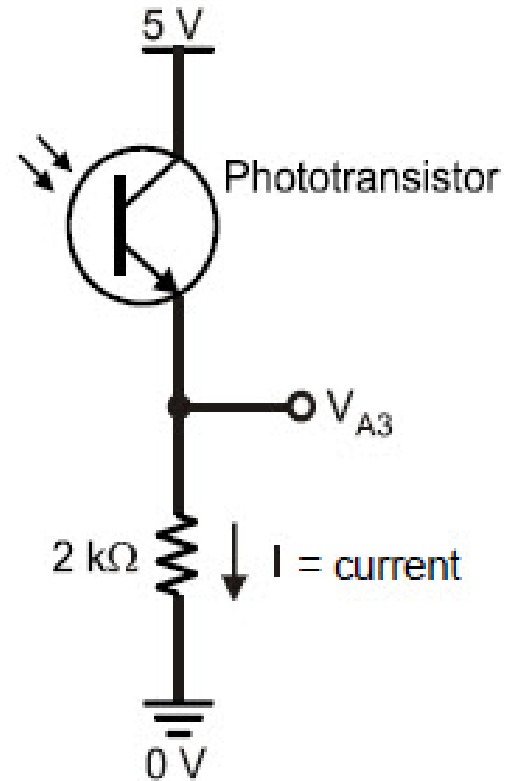


FIG.3 RISE AND FALL TIME VS LOAD RESISTANCE



# Treasure - Sanity Check

- What if the output looks like a saw tooth wave?

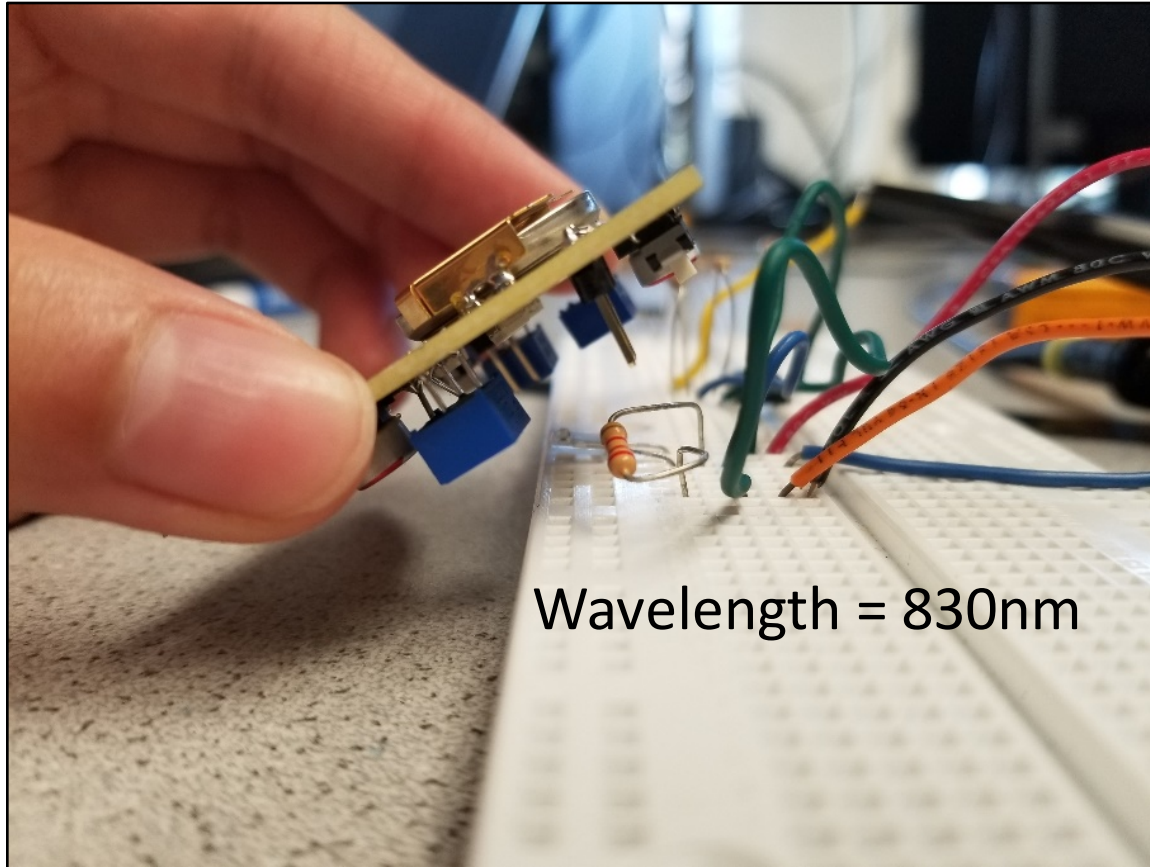


# Treasure - Sanity Check

- What if it is dampened?



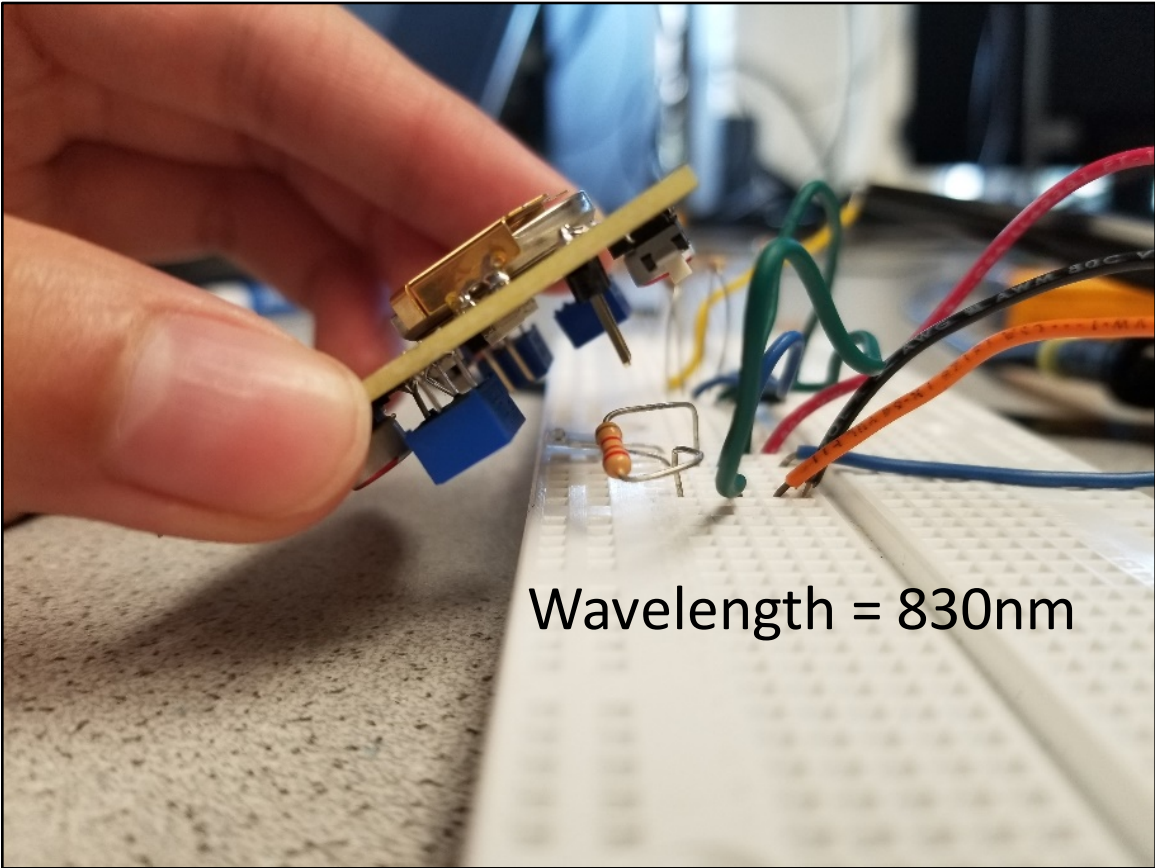
Wavelength = 830nm



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# Treasure - Sanity Check

- Know Thy Sensor!



Wavelength = 830nm

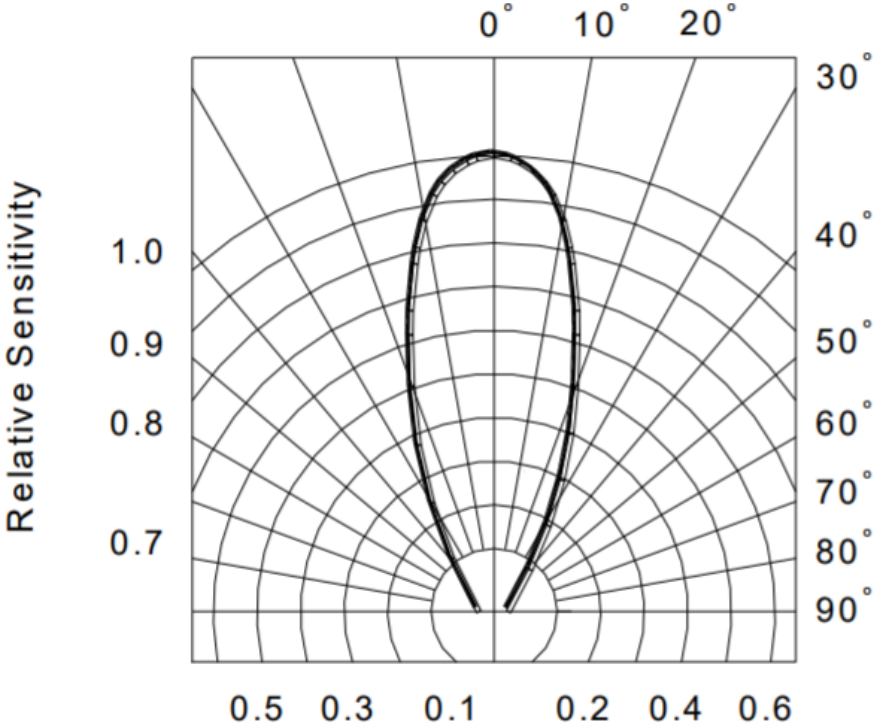
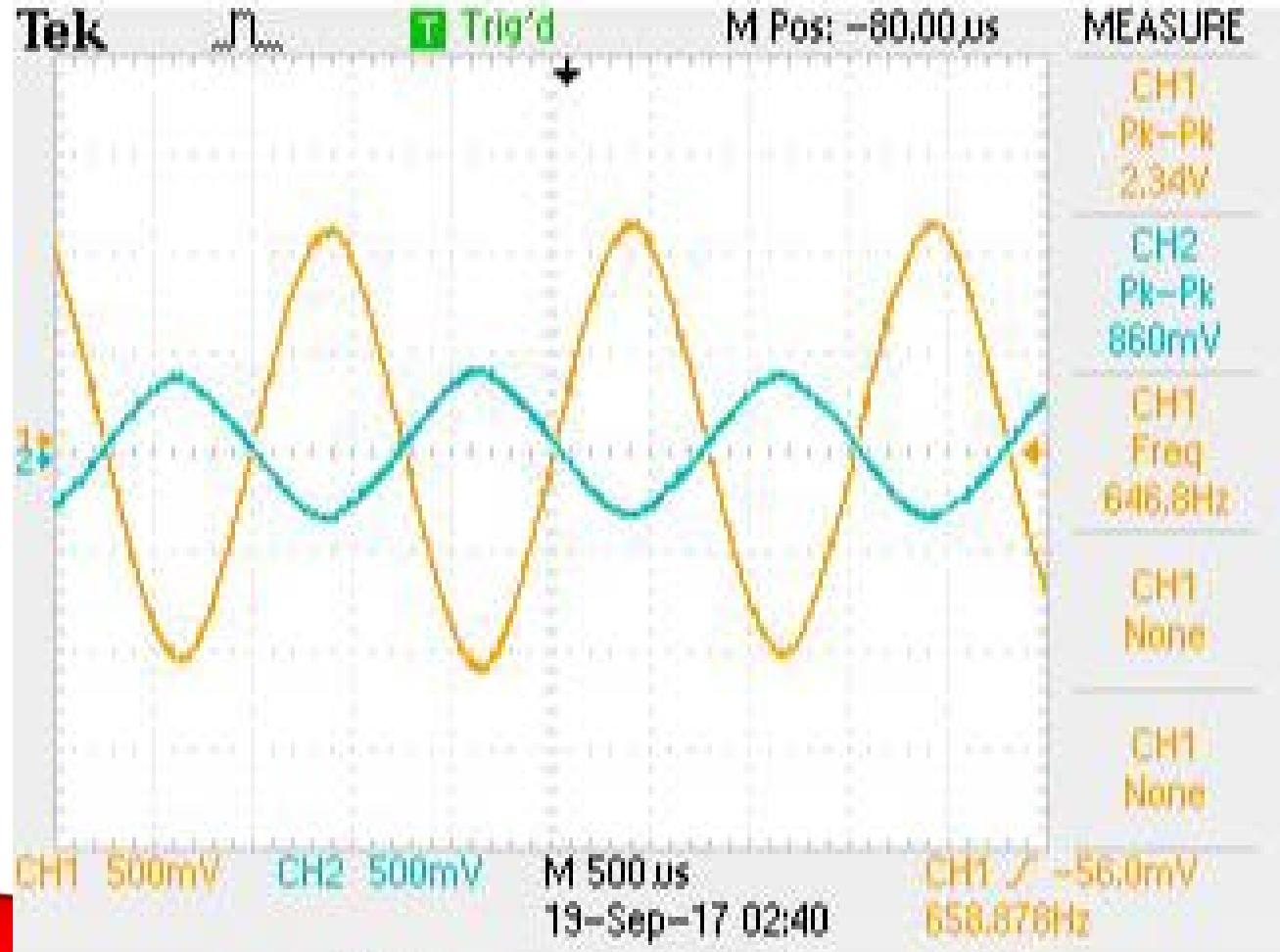
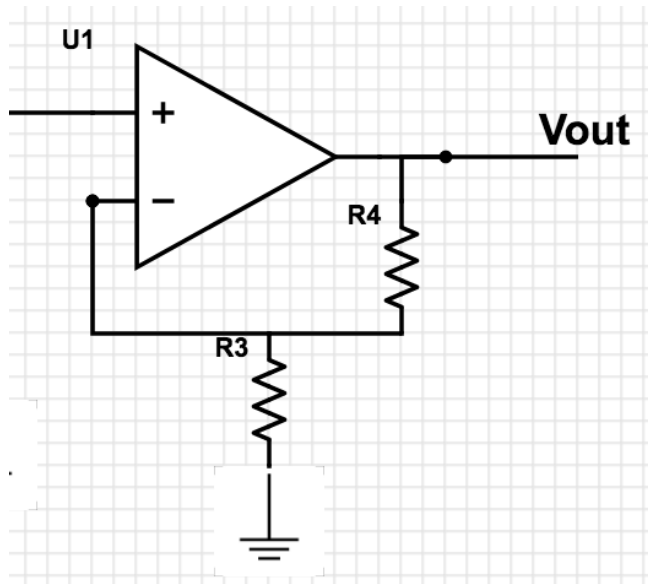


FIG.5 SENSITIVITY DIAGRAM

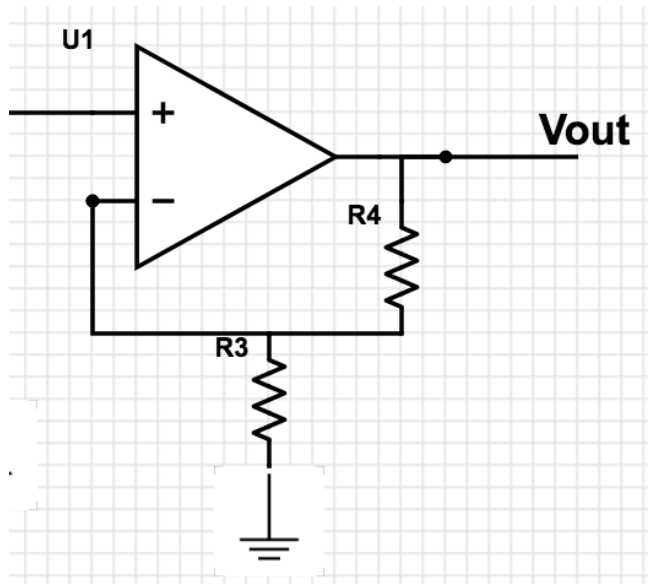
# Amplifiers - Sanity Check

- What does a sine wave look like after an amplifier?
  - A bigger sine wave!

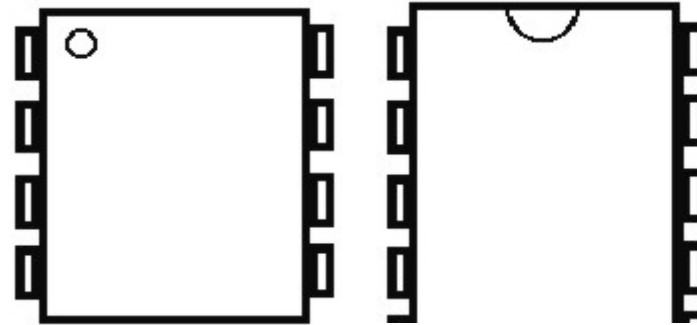


# Amplifiers - Sanity Check

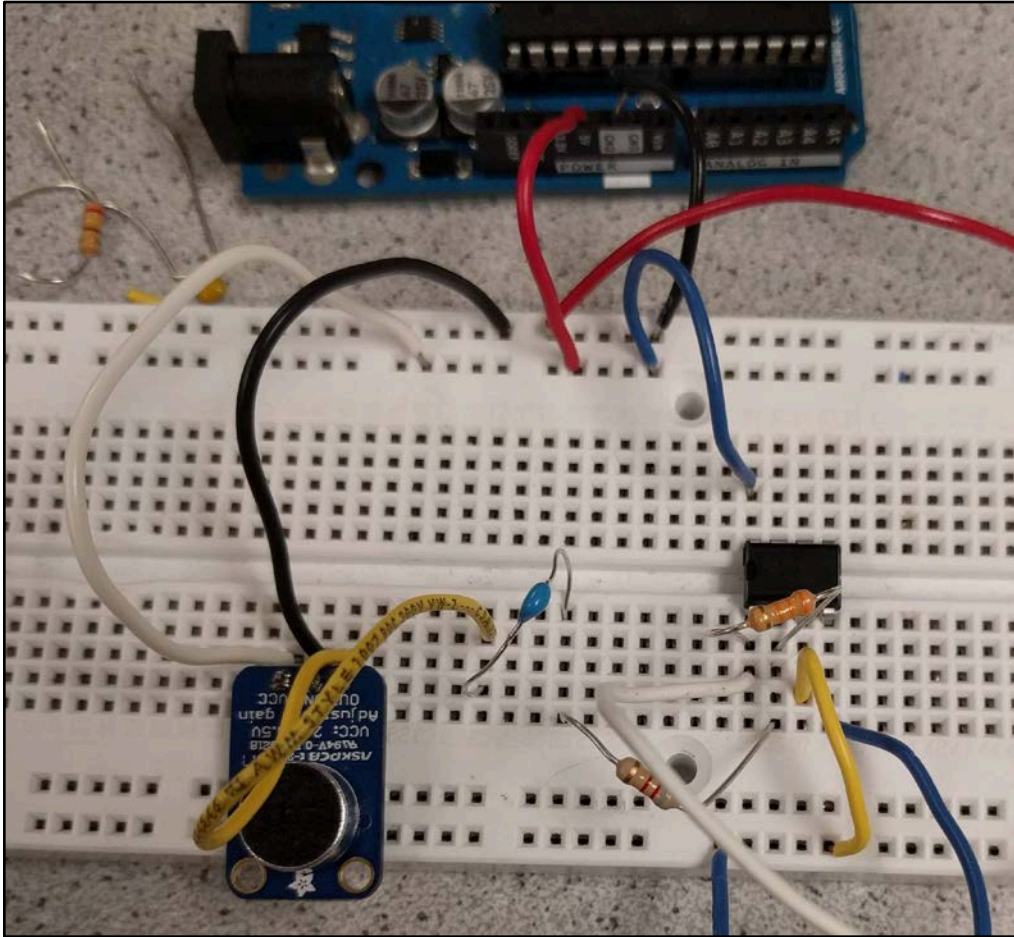
- What if there is no output?



- Is it powered / hooked up right?
- Is it saturated?
- Check the DC value of your input signal
- Recalculate the amplification
- Check if the scope is set to AC

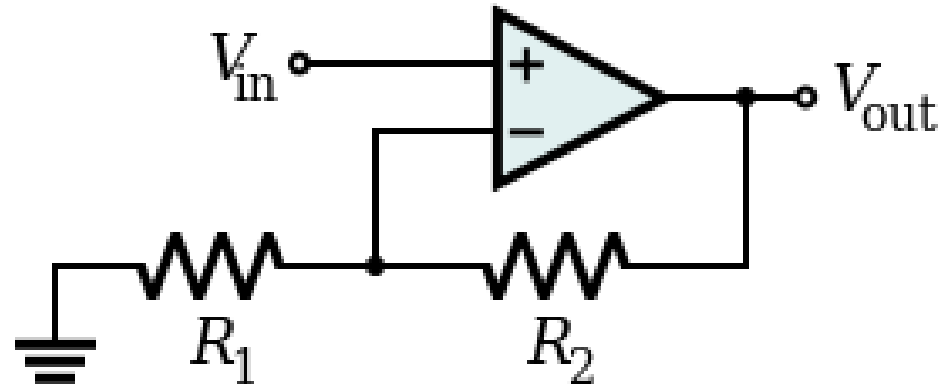


# Case Study

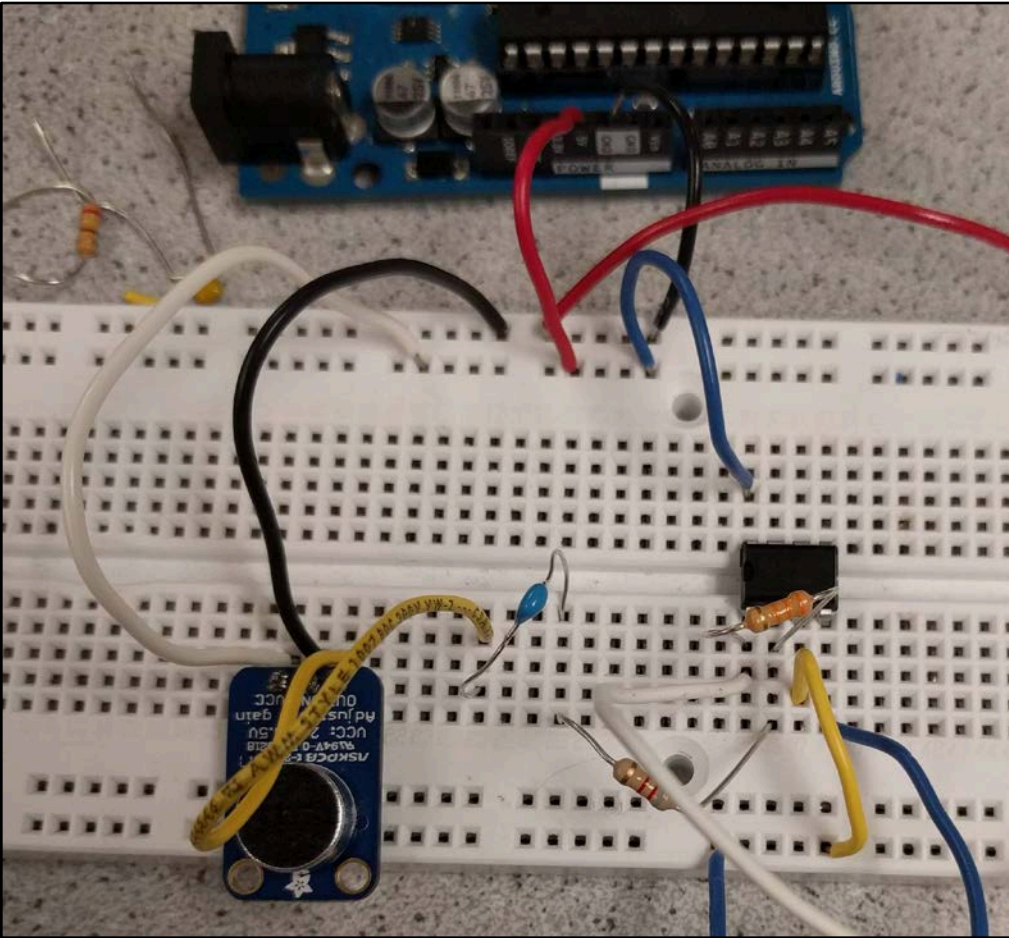


*No output from the amplifier!*

- At first, we were using smaller resistors, 300  $\Omega$  and 100  $\Omega$ .
- Can you choose values that are too big?
  - Input bias current
  - Input offset current



# Case Study

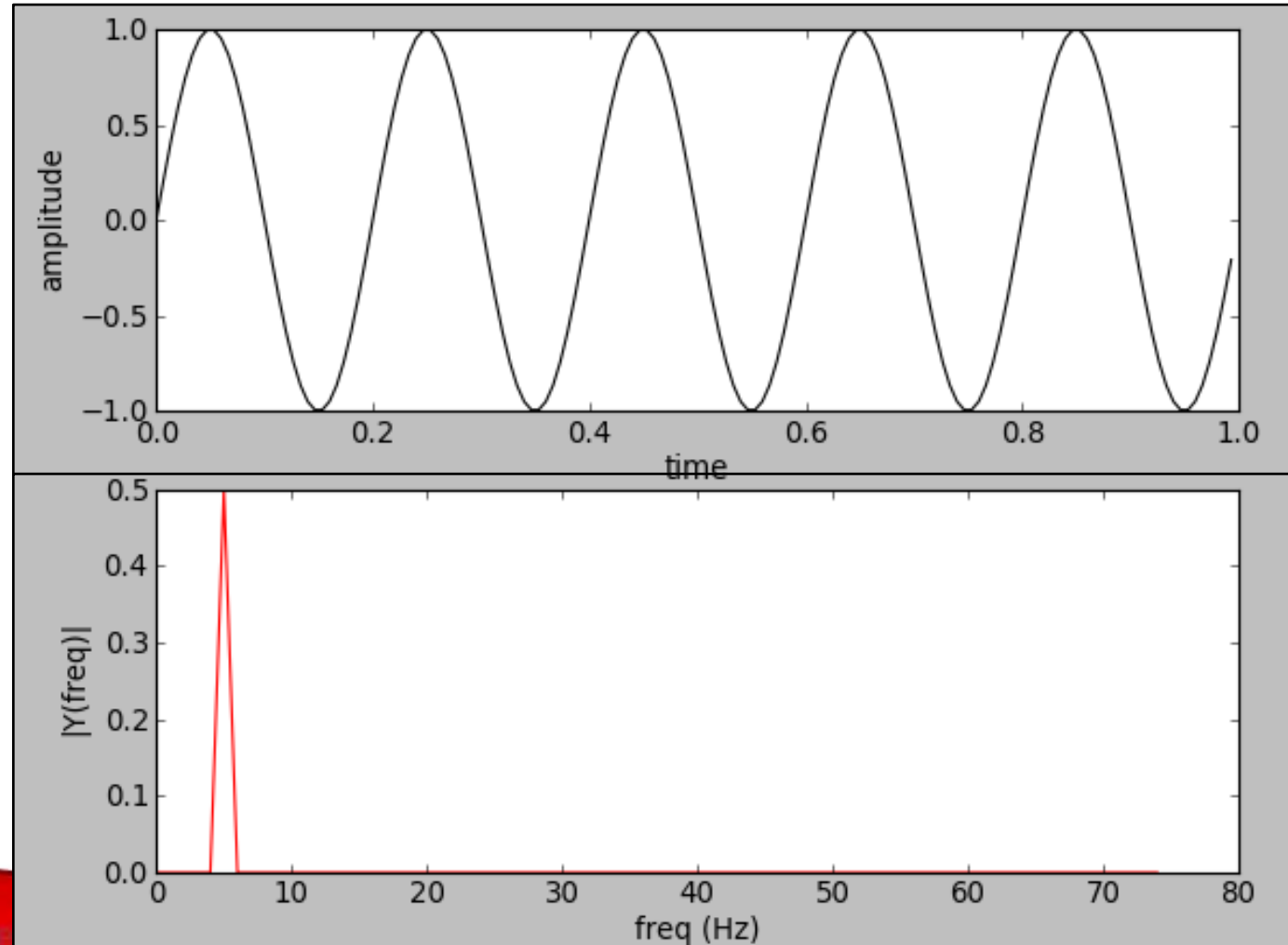


## *No output from the amplifier!*

- At first, we were using smaller resistors,  $300\ \Omega$  and  $100\ \Omega$ .
- Changing to larger resistors such as  $3\ \text{k}\Omega$  and  $1\ \text{k}\Omega$  gave us a cleaner signal, but still no gain.
- In fact, even with the resistors in the correct orientation, we sometimes got fractional gain.
- We also tried to feed  $V+$  of our op-amp with a smaller voltage, such as  $2.5\ \text{V}$ , but this did not help with our signal.
- We also tried putting a low pass filter at the input, but this did not help with our signal either.

# FFT - Sanity Check

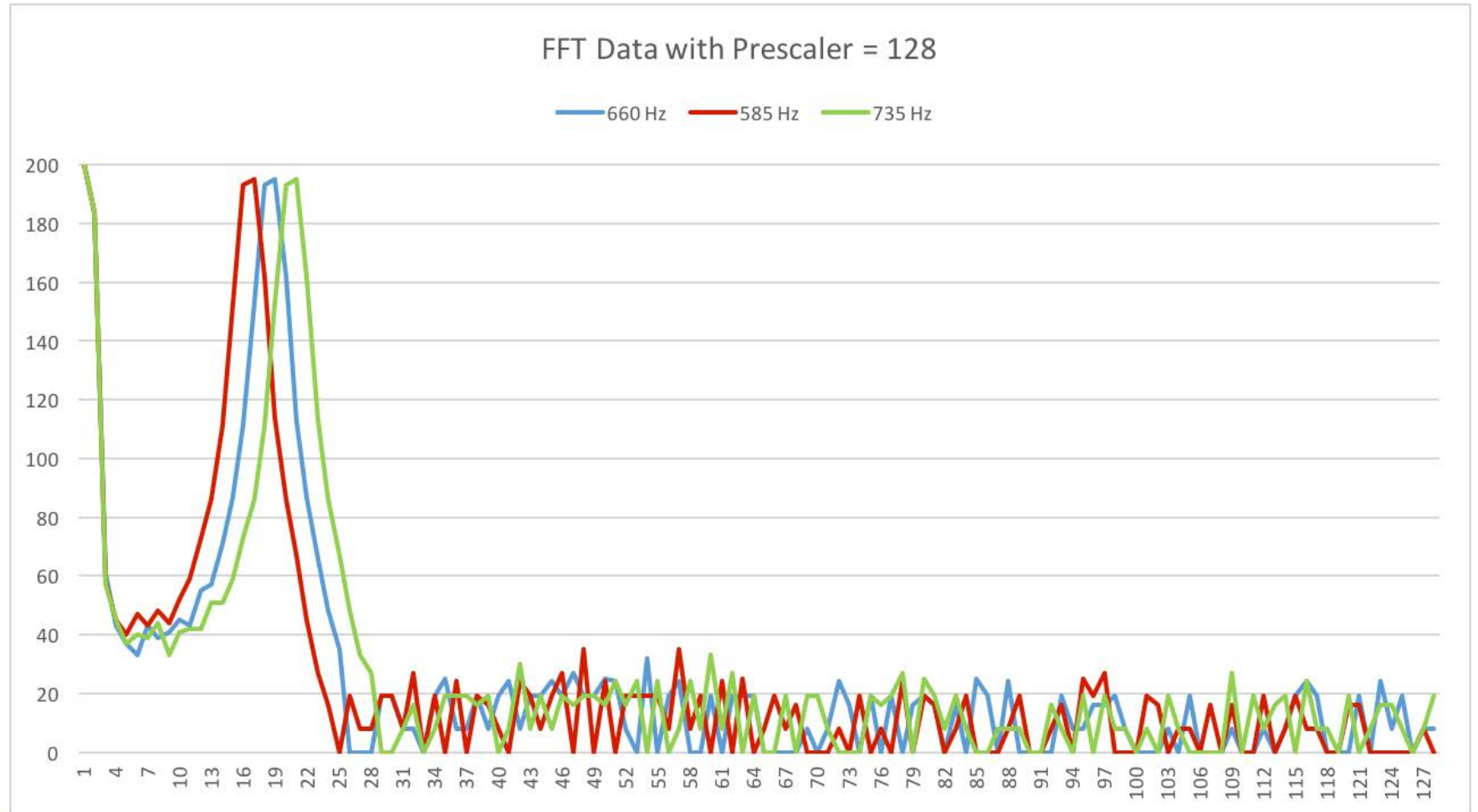
- What does a sine wave look like in an FFT?





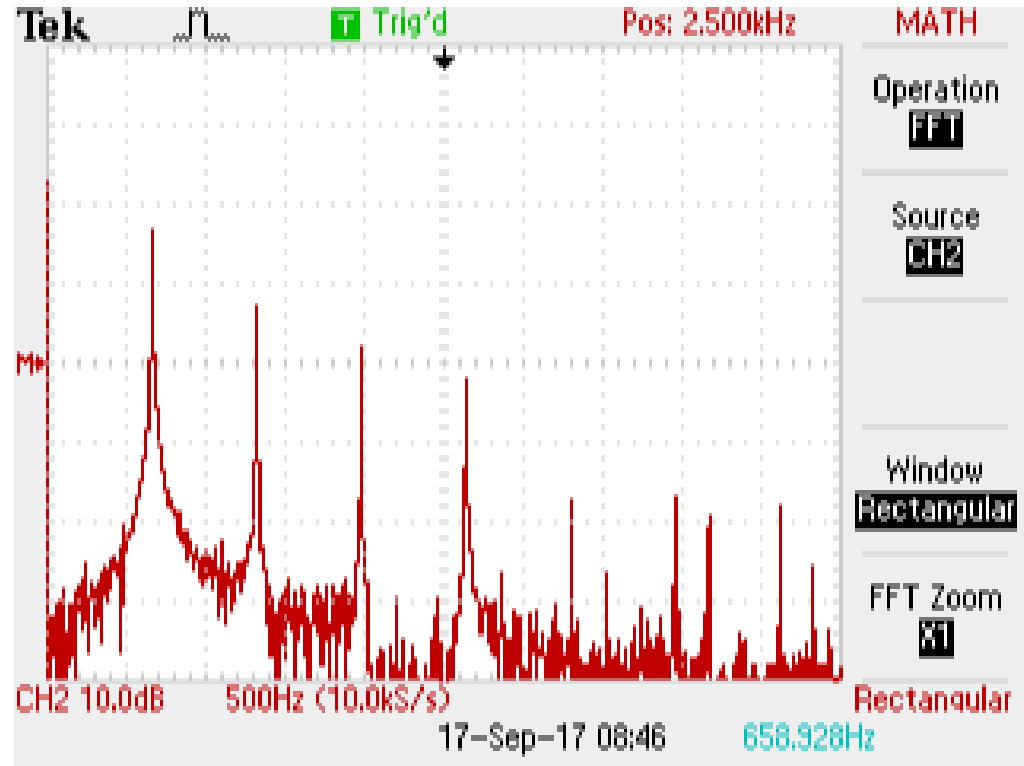
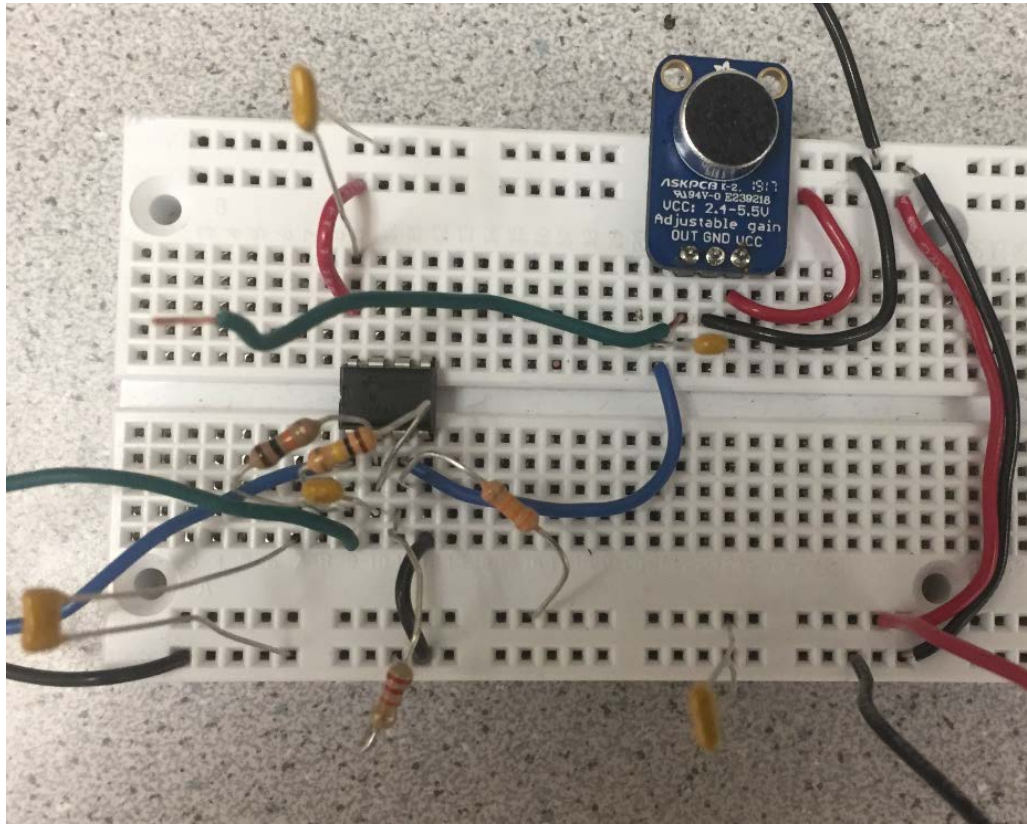
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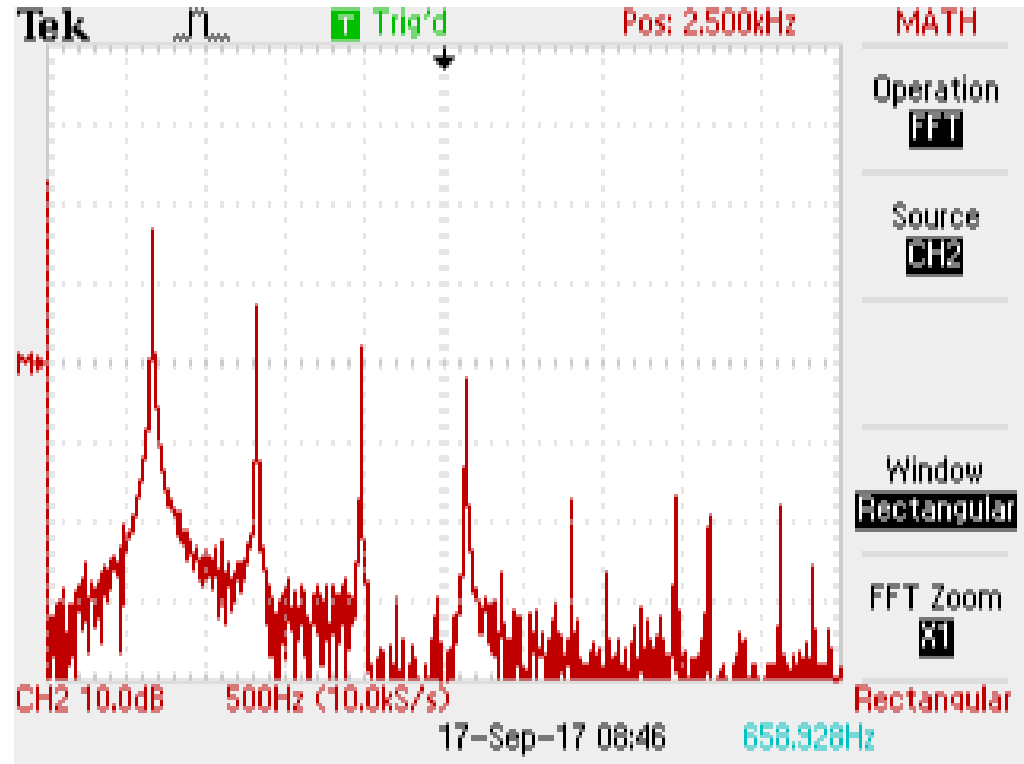
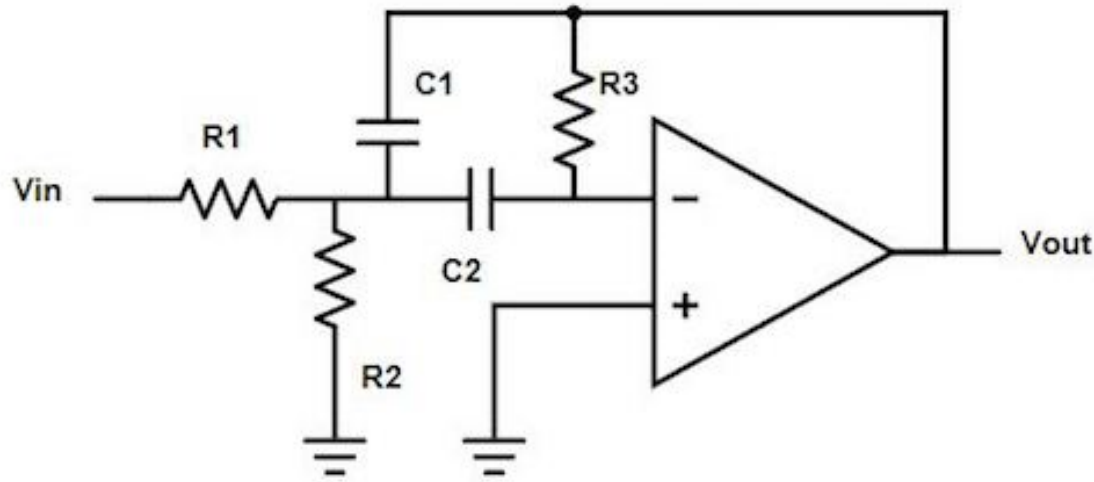
# FFT - Sanity Check

- What does a sine wave look like in an FFT?



# FFT - Sanity Check

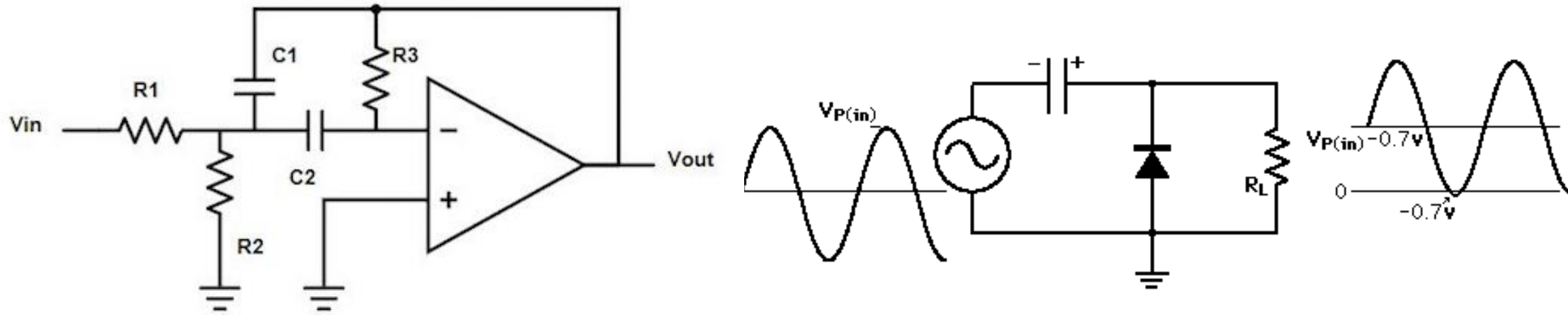
- What does a sine wave look like in an FFT?
  - Stuff grabbed off the internet, probably expects a negative rail



TDS 1002C-EDU - 8:50:40 PM 9/16/2017

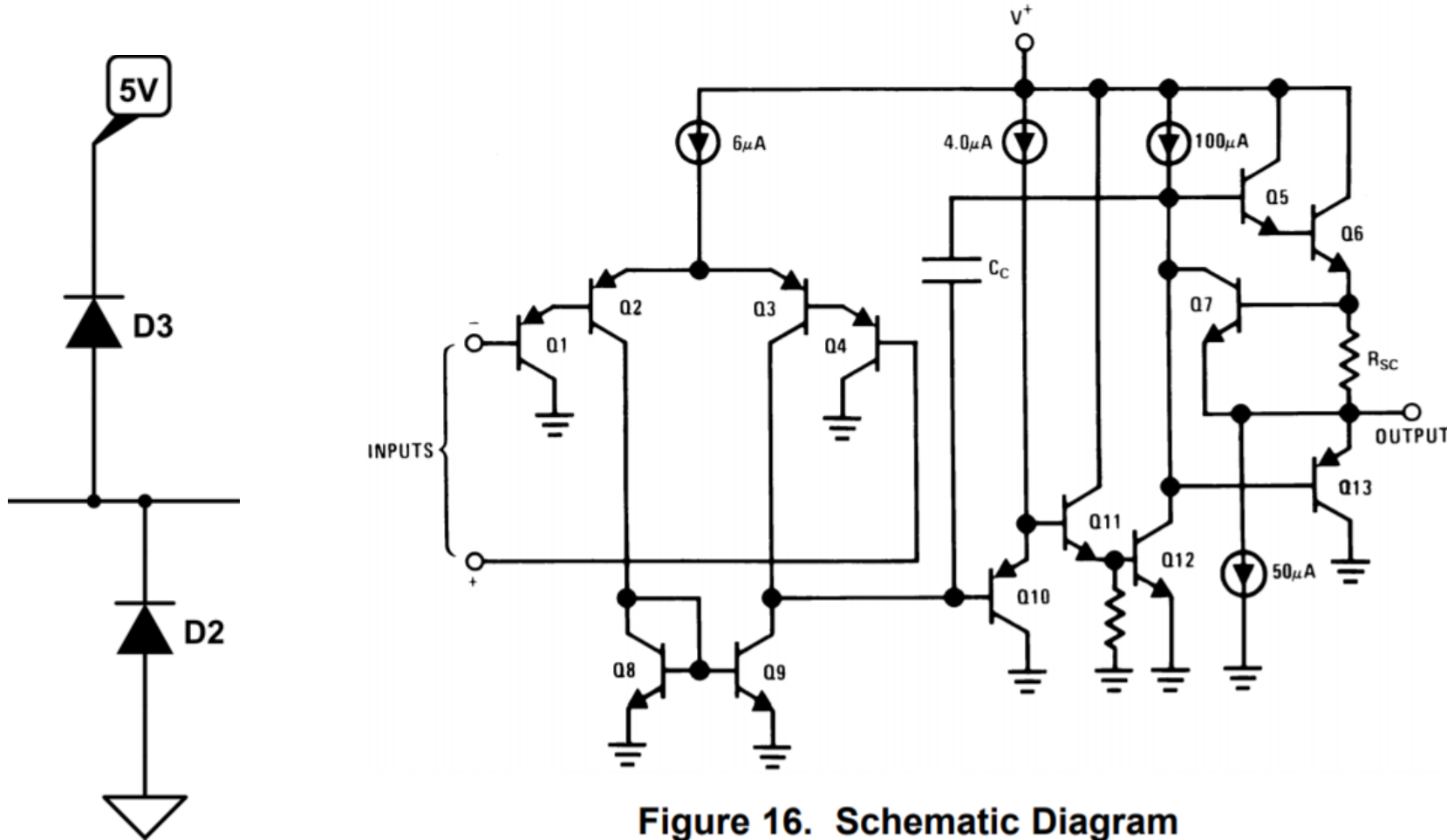
# FFT - Sanity Check

- What can I do if I really want to use *this* filter?
  - Make a negative supply and use an op-amp that can handle that!
  - Bias your signal around 2.5V and send in 2.5V on the reference



# Supply Rail

- What happens when you send in voltage outside of the supply rail?
  - Best case: it survives, or completely fails
  - Worst case: it sort-a keeps working!

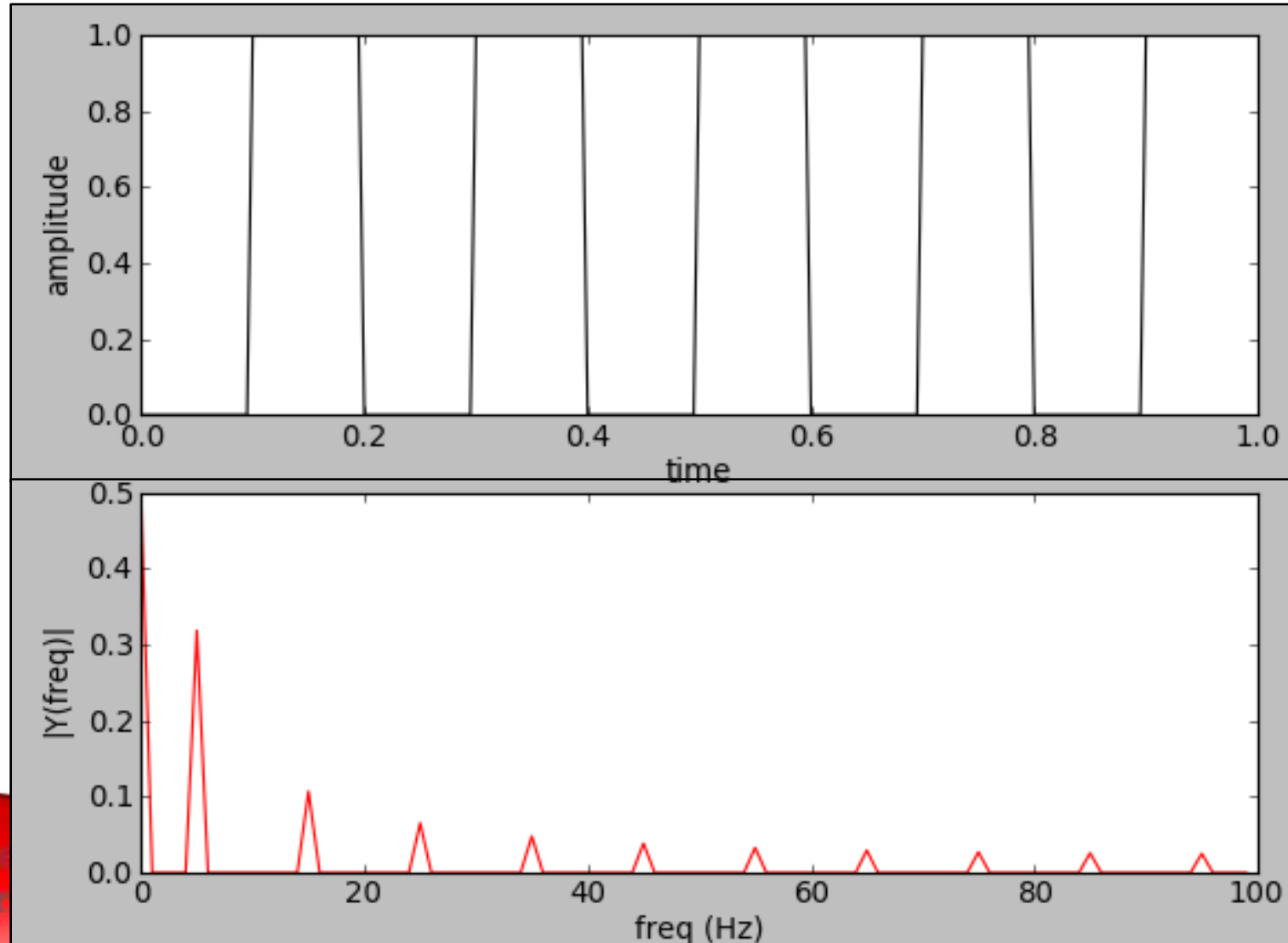


\*MAX: GND-0.3V

**NEVER GO BEYOND THE SUPPLY RAIL!**

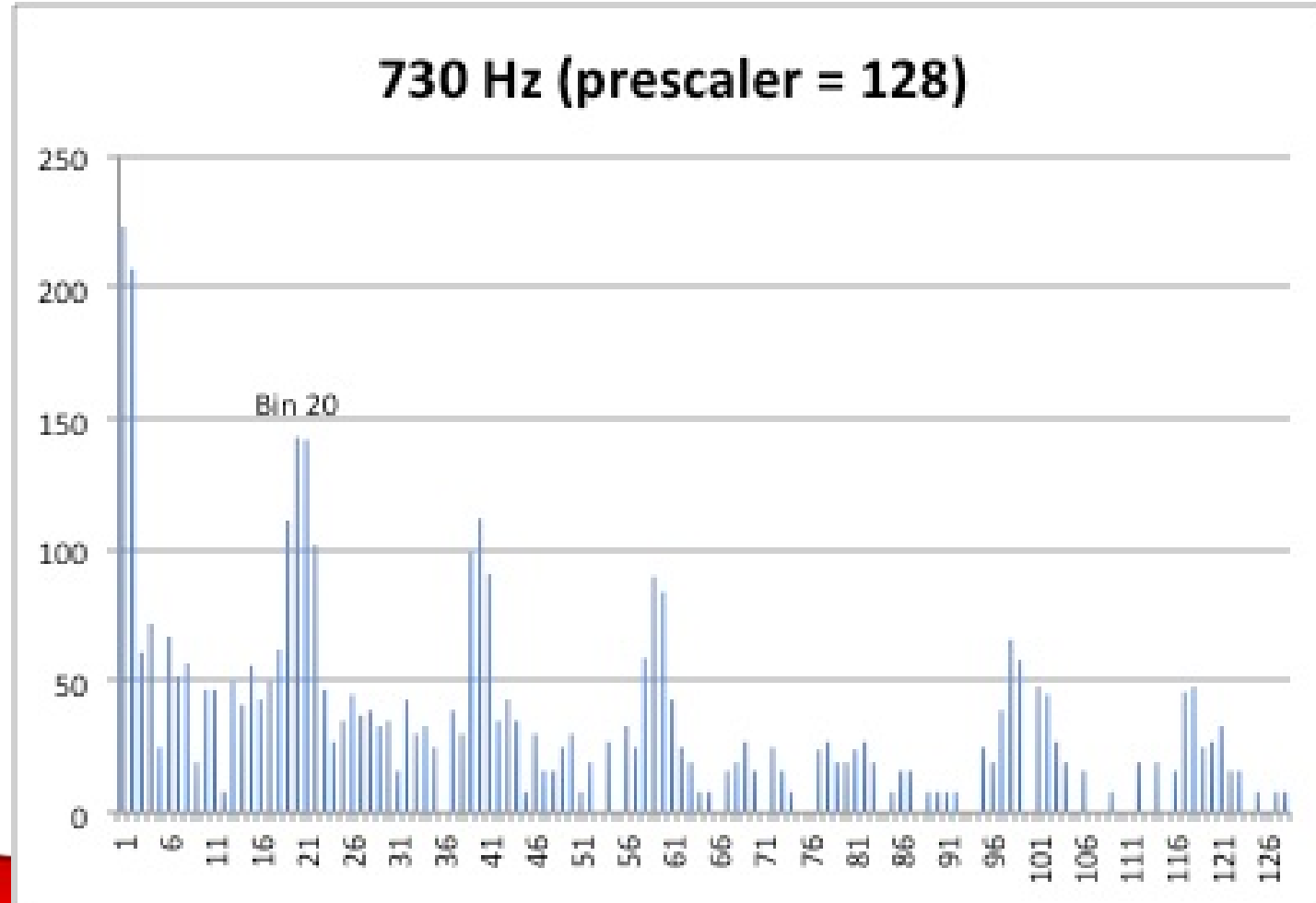
# FFT - Sanity Check

- What does a square wave look like in an FFT?



# FFT - Sanity Check

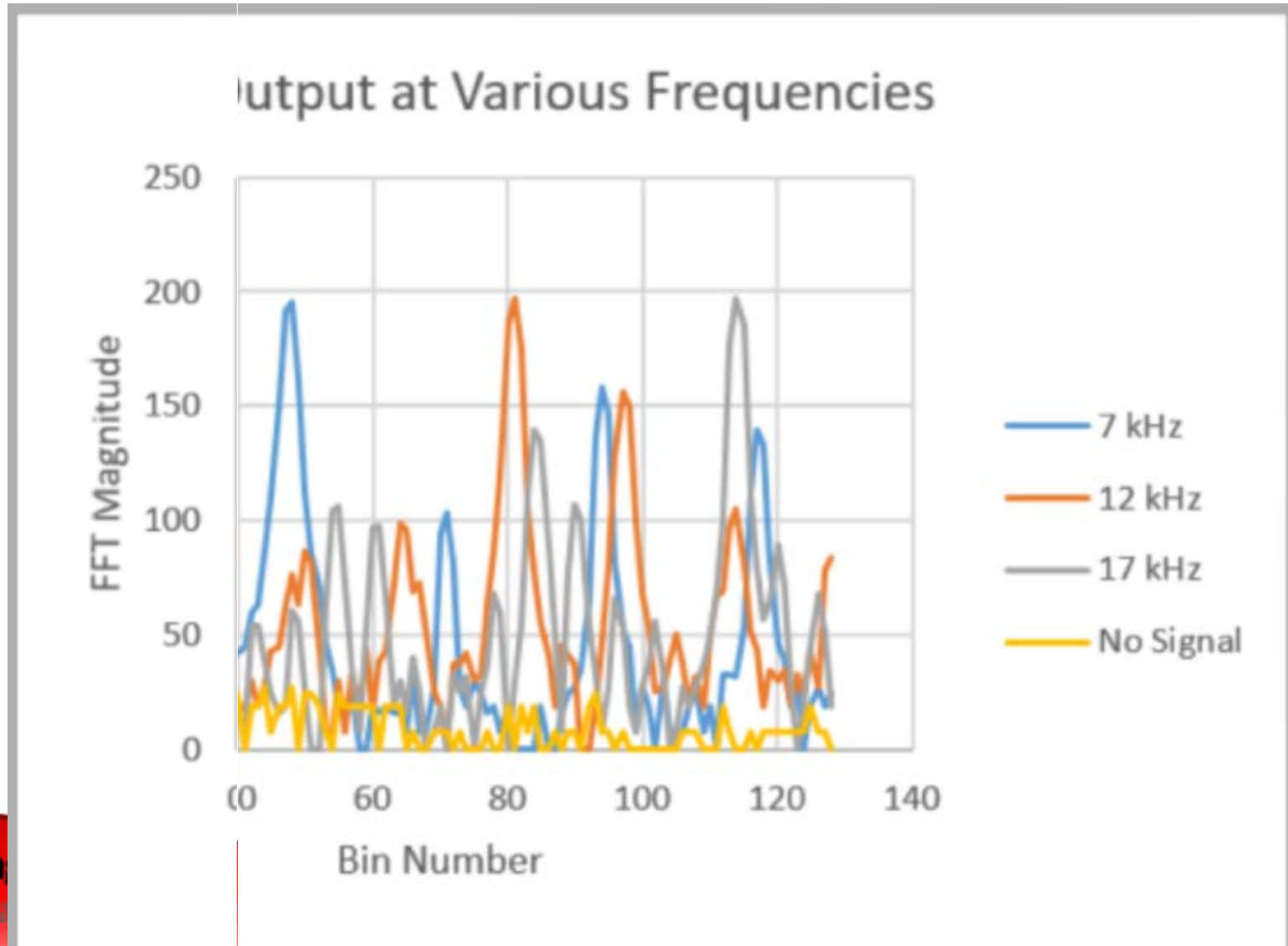
- What does a square wave look like in an FFT?





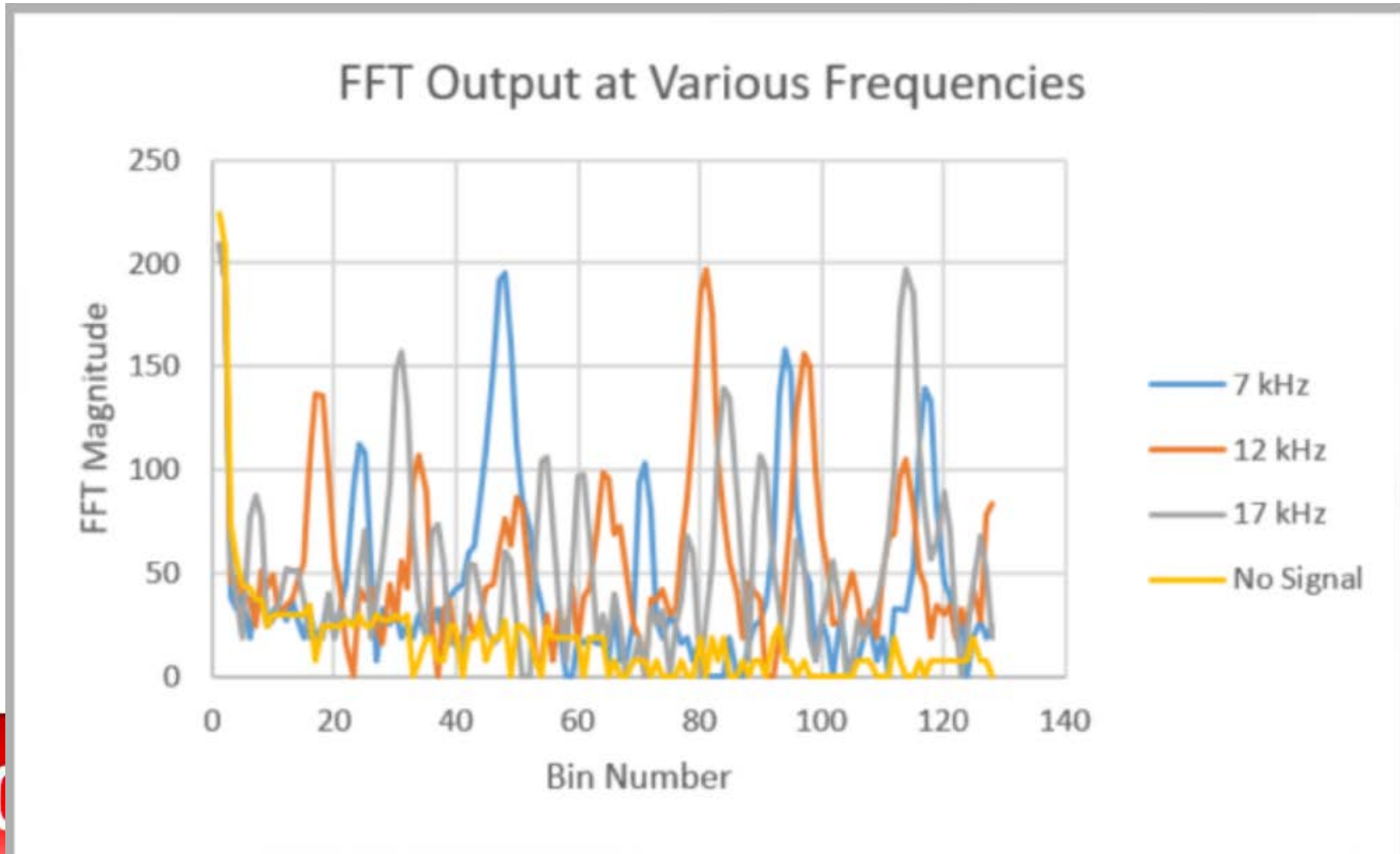
# FFT - Sanity Check

- What does a square wave look like in an FFT?



# FFT - Sanity Check

- What does a square wave look like in an FFT? • WHY??



# Conclusion

- Perform sanity checks!
- If things aren't working, reach out before the deadline!

*Go Build Robots!*

