Robotic FAIL

~

How To Avoid It

Ed Nisley • KE4ZNU
softsolder.wordpress.com
~
Trinity College Fire Fighting Home Robot Contest
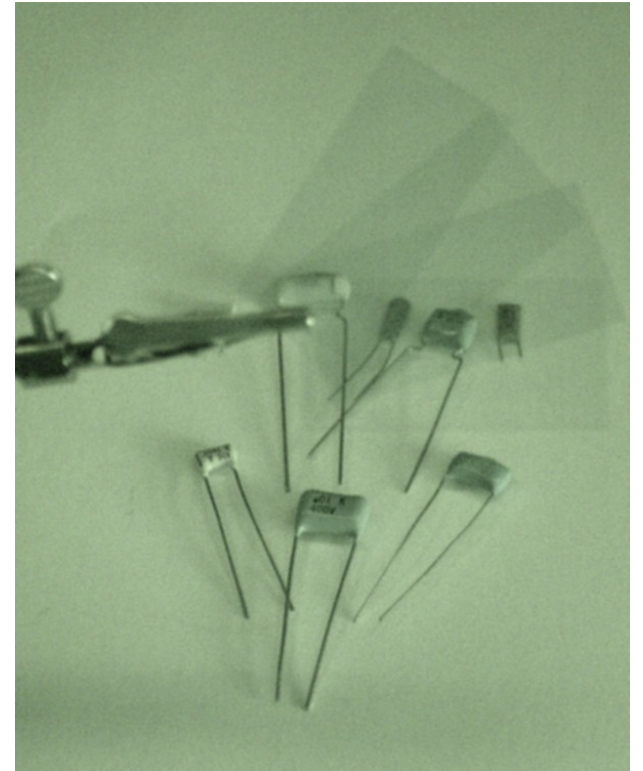April 2010

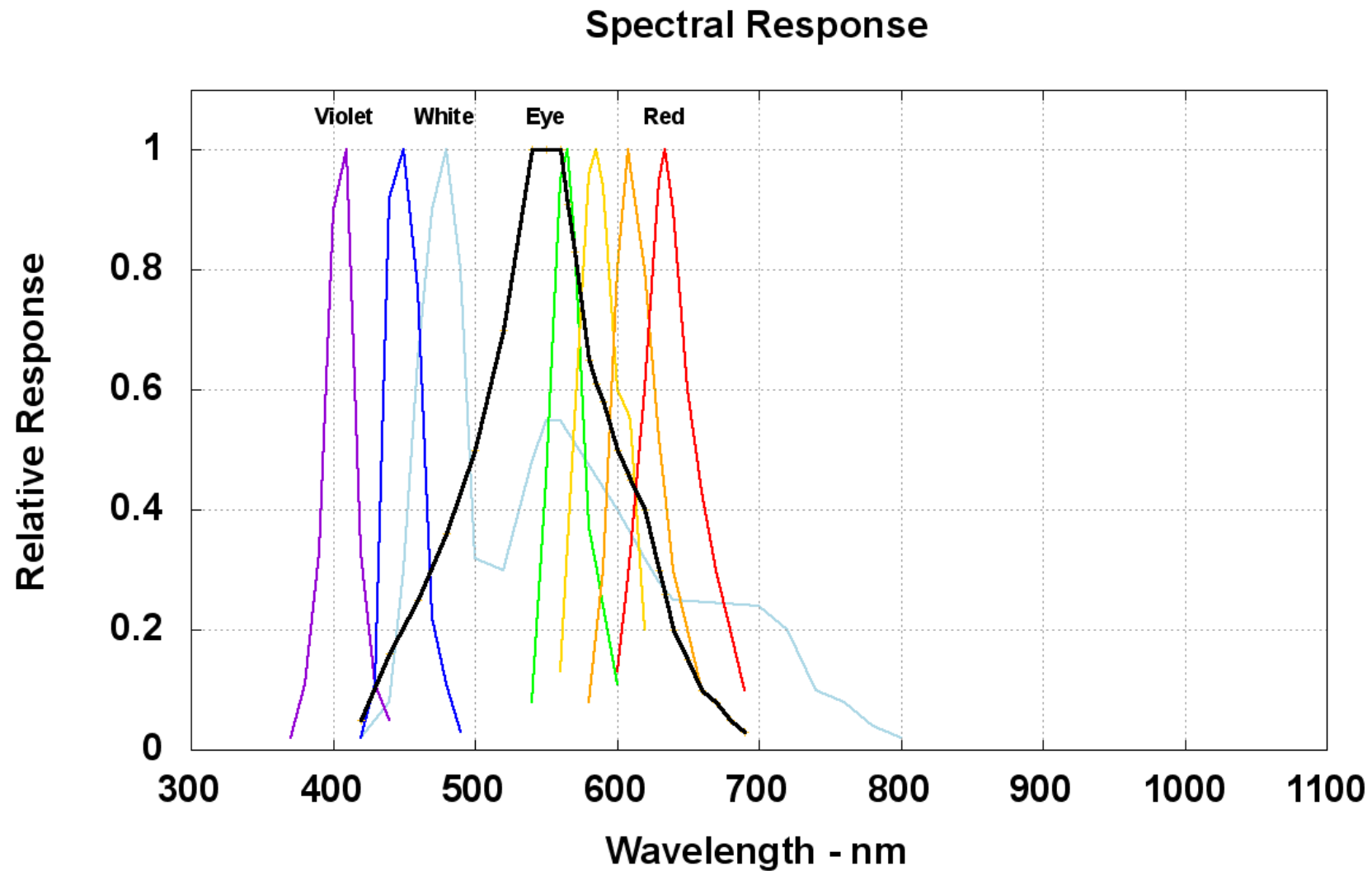# Upcoming Events

IR Sensing for the Bewildered

Power Corrupts
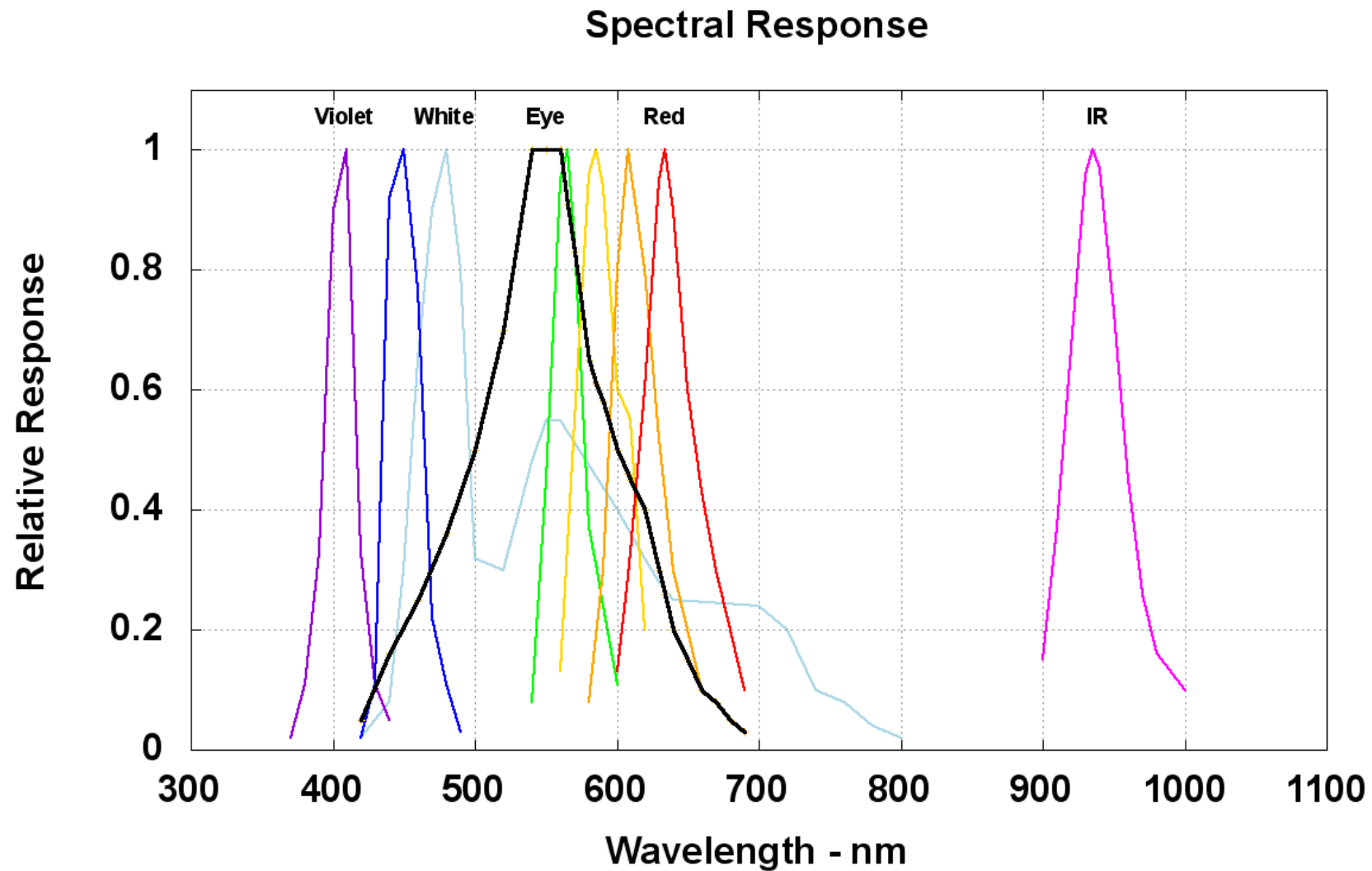
Neatness Counts

Frequently Heard Comments

IR Sensing for the Bewildered

Now You See It

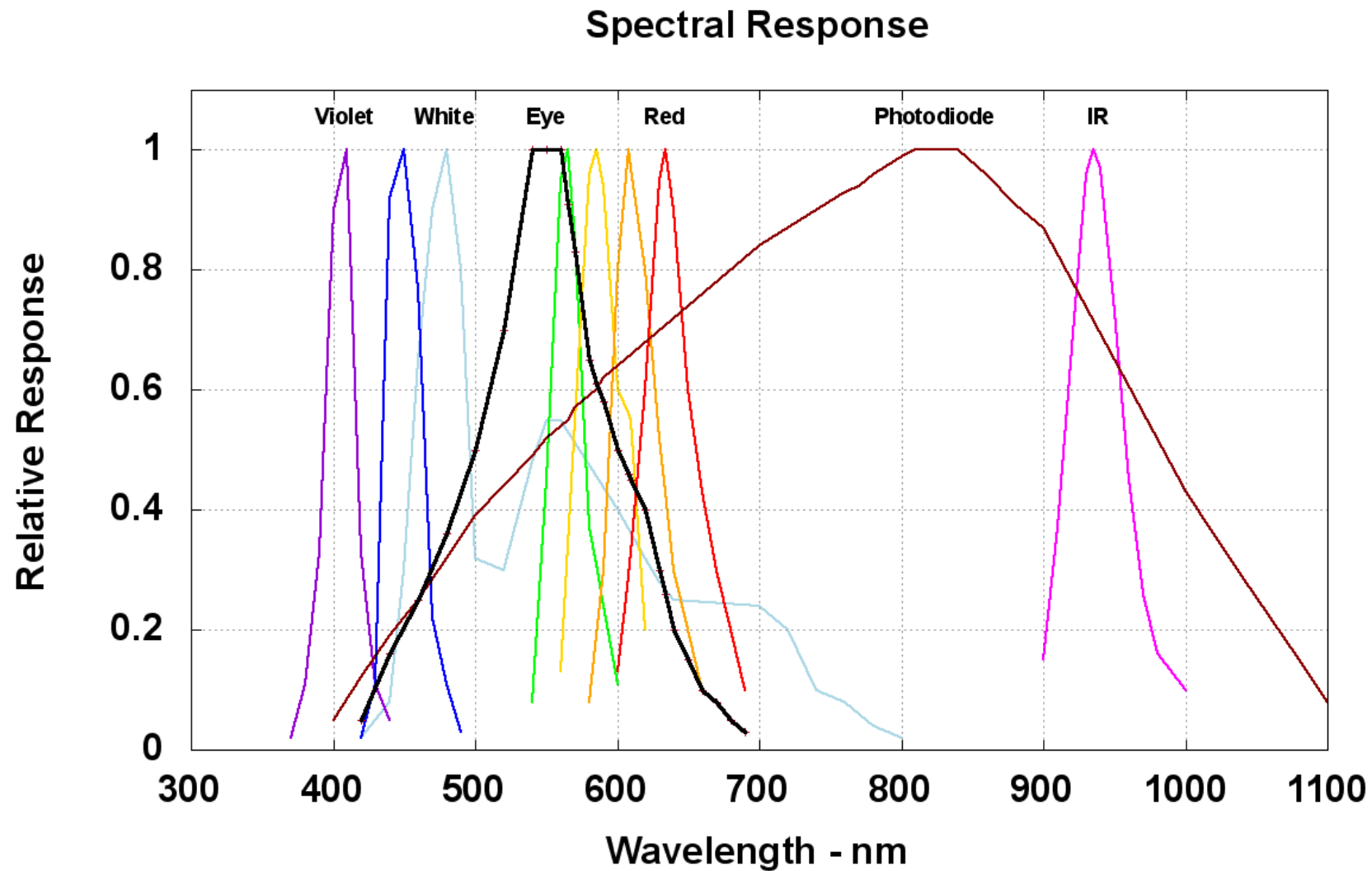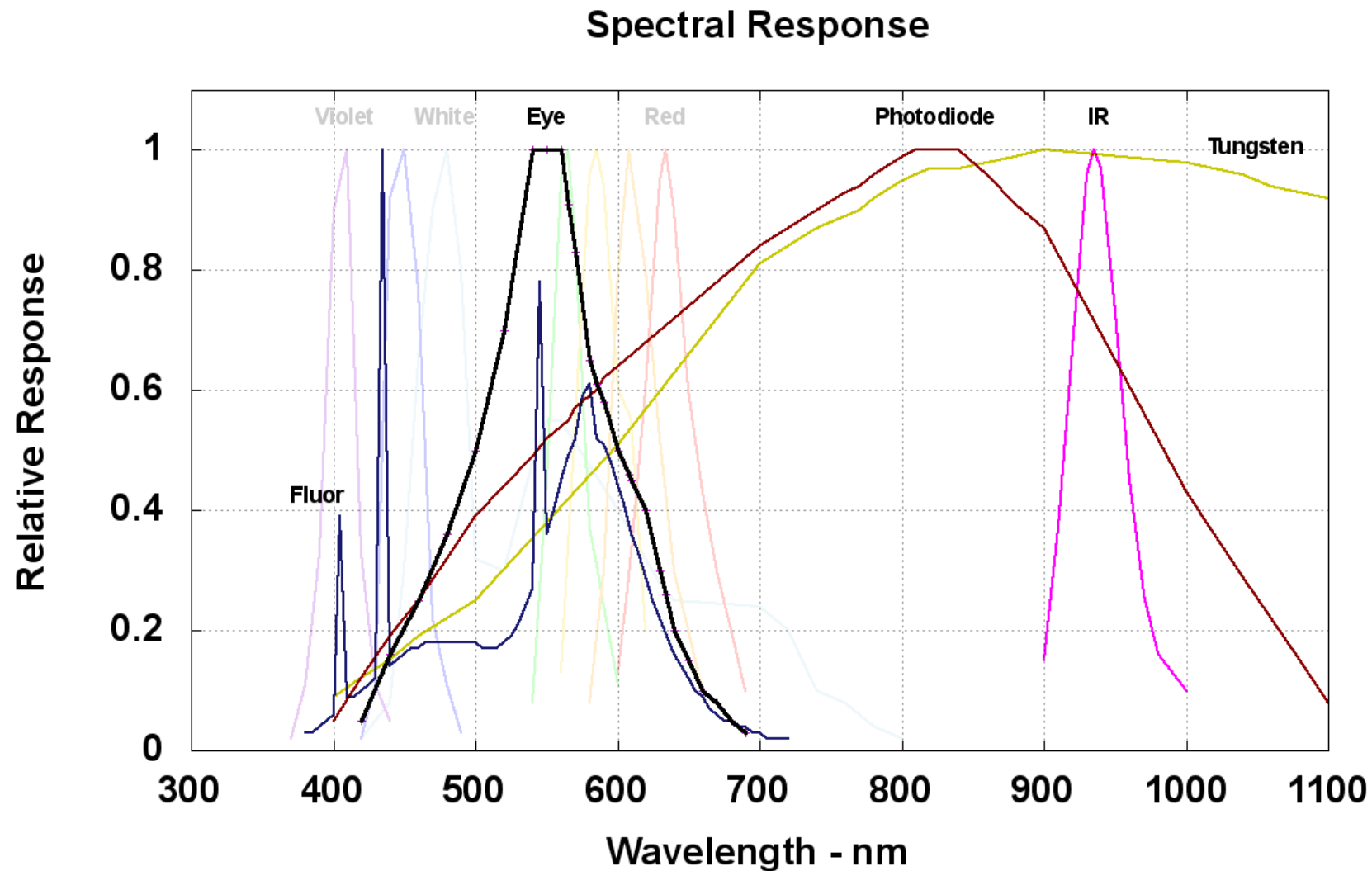

Spectral Response
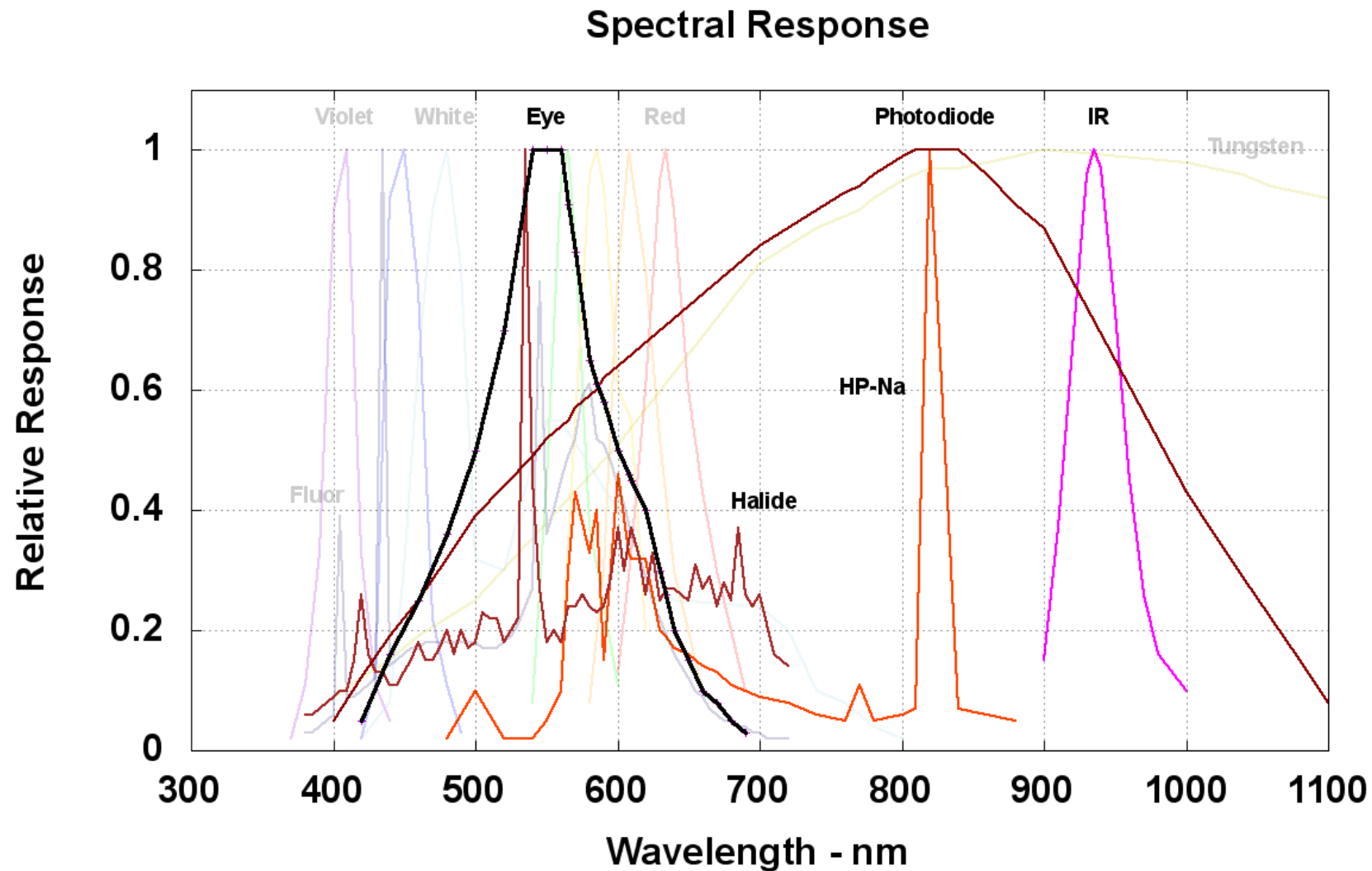
Now You Don't

Spectral Response

Photodiodes See It

Spectral Response

Photodiodes See Everything

Spectral Response

Even When You Can't

Spectral Response
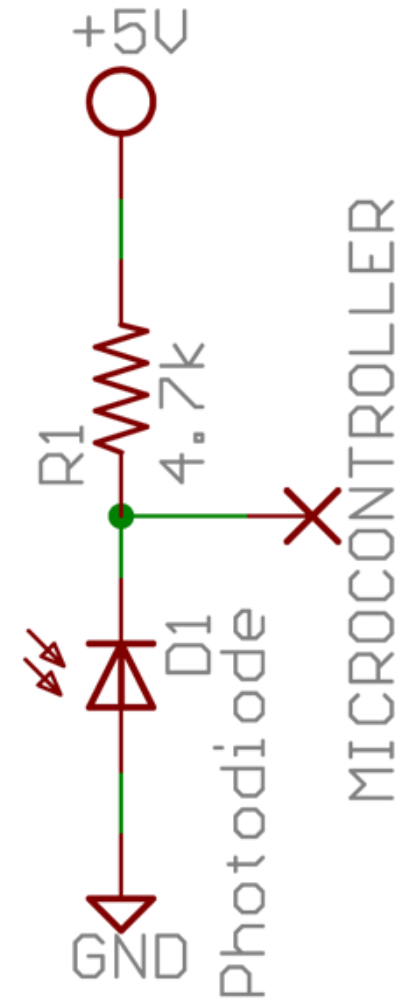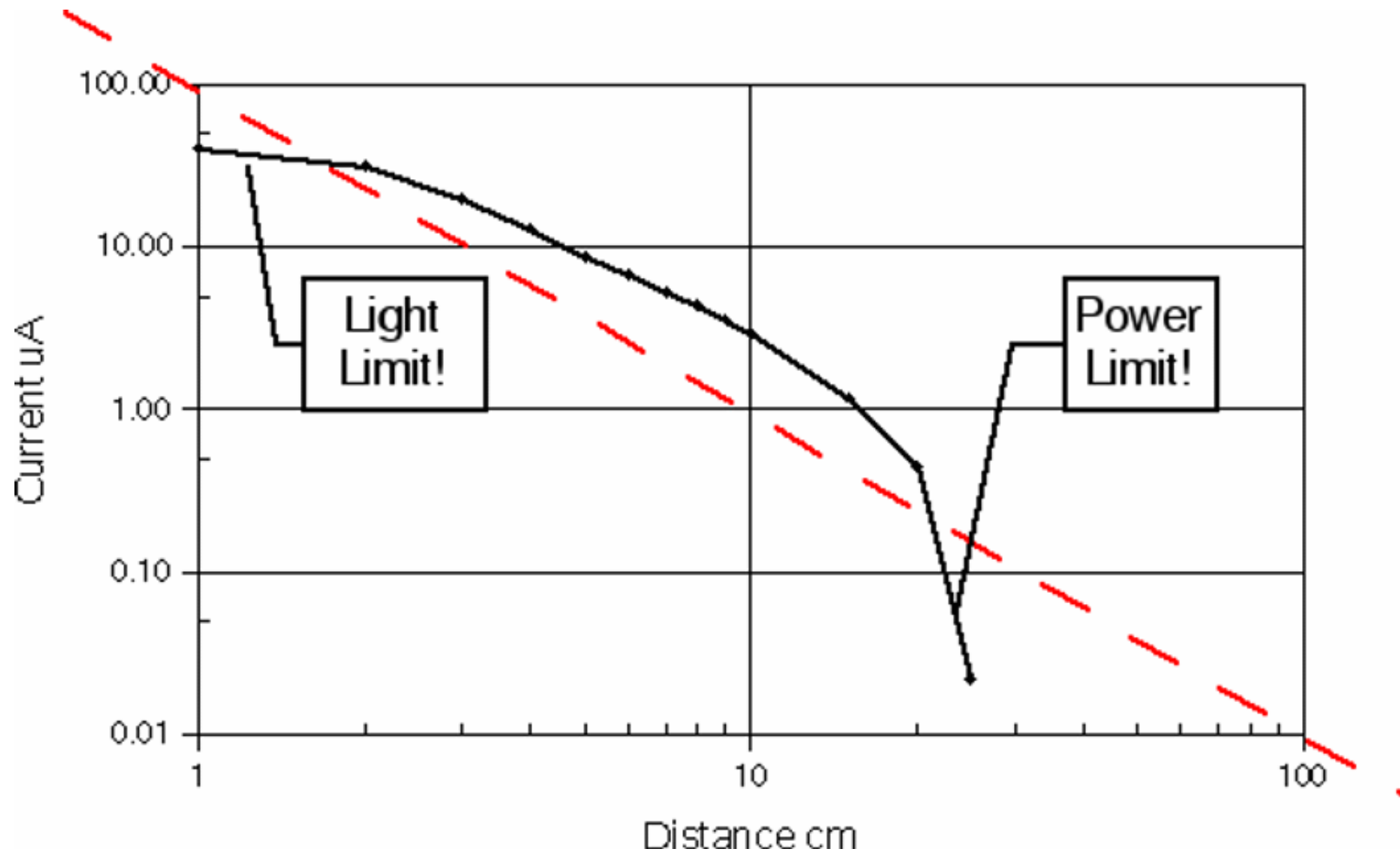
Simple Optical Sensor

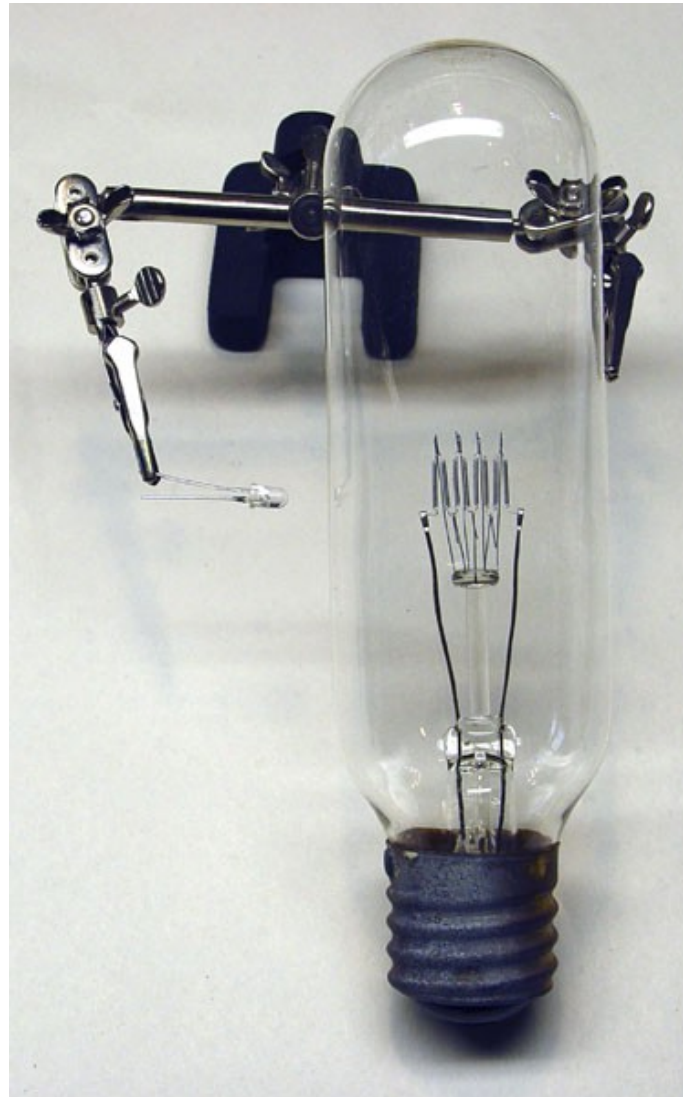- Just add an LED
  - An IR LED, right?
- A spectrally matched IR LED!
  - Peak closer to photodiode peak
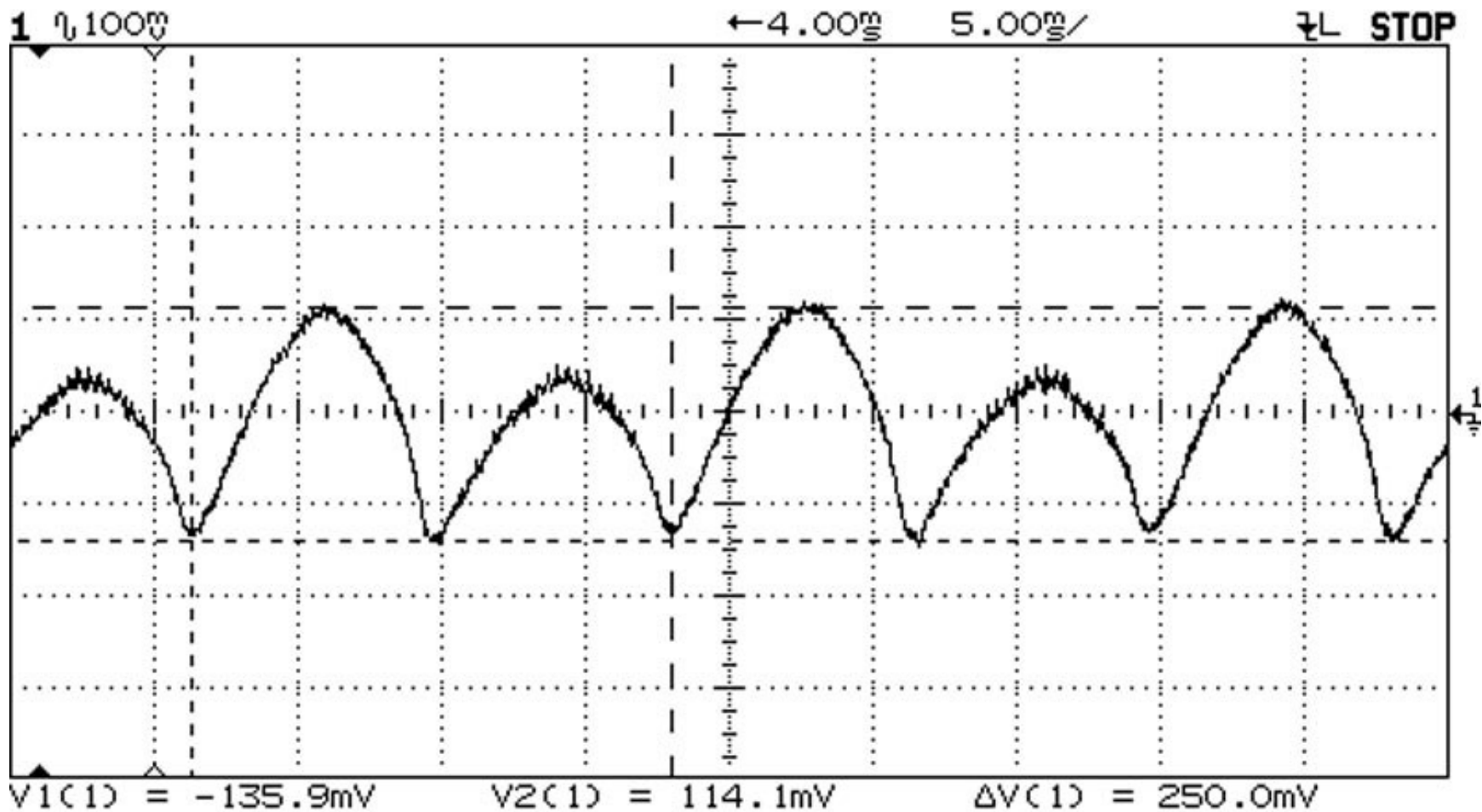- **What could possibly go wrong?**

+5V

R1 4.7k

D1 Photodiode

MICROCONTROLLER

GND

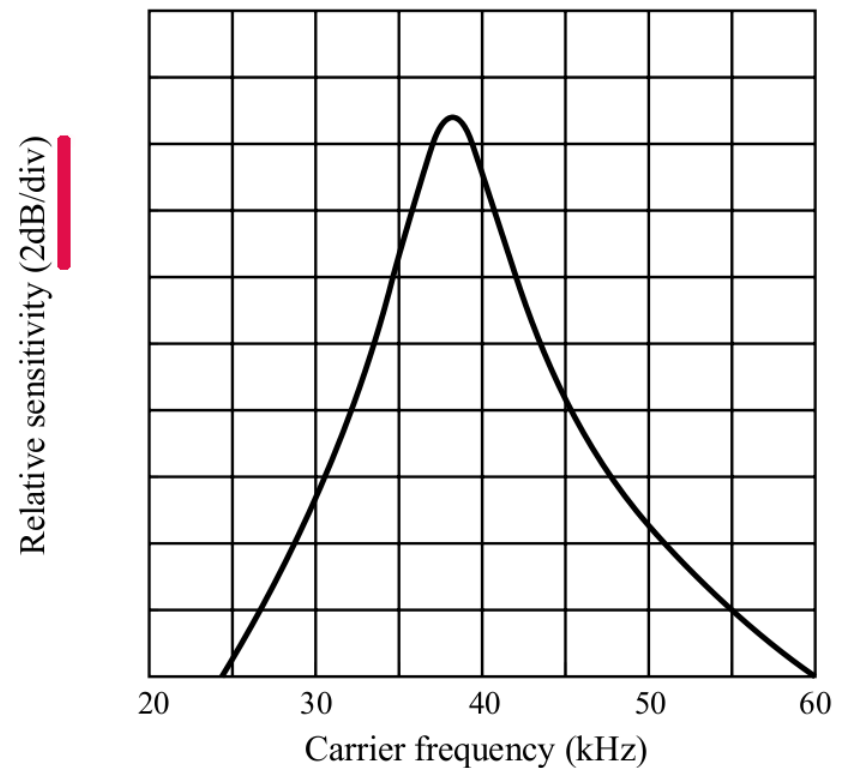# Intensity ≈ 1 / Distance²

Your Pathetic LED Can't Win

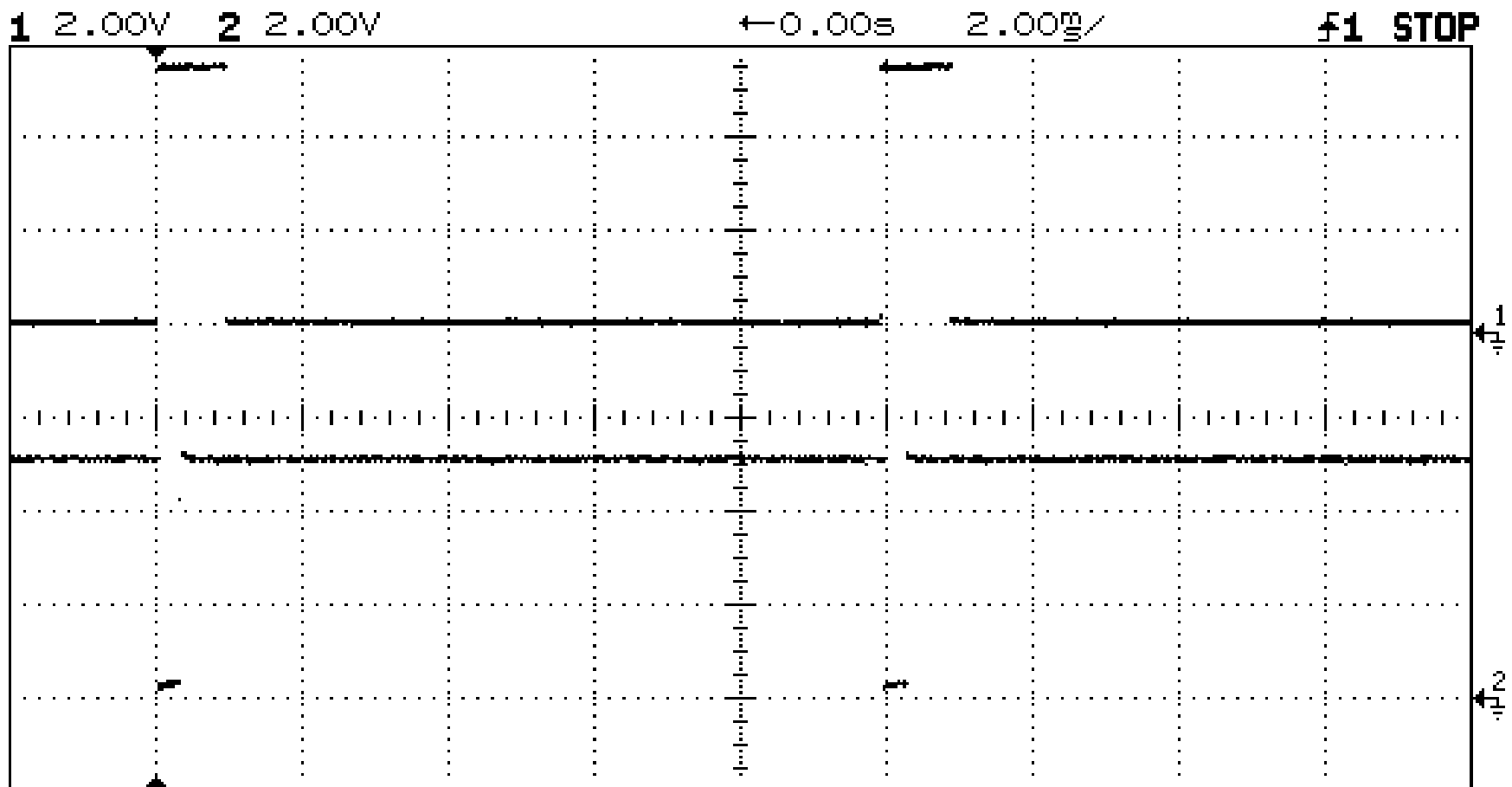# Visible Power-line Hum

Frequency Selectivity

- IS1U60 IR Receiver
  - **38 kHz** carrier
  - Narrow bandpass
  - Binary output
- Data transmission
  - Not a rangefinder
- Pop Quiz
  - Response @ **100 Hz**?

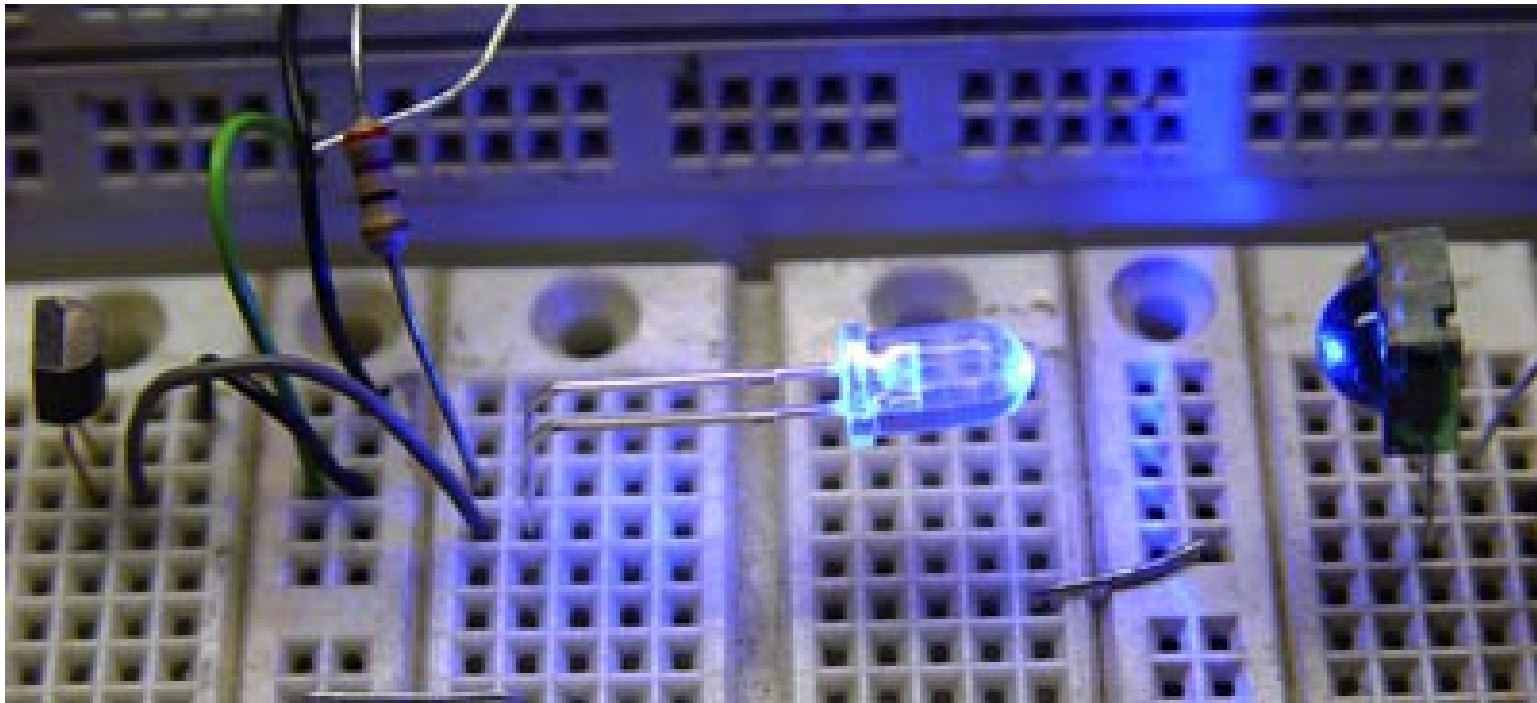Fig. 1 B.P.F. Frequency Characteristics (TYP.)

Frequency Selectivity?
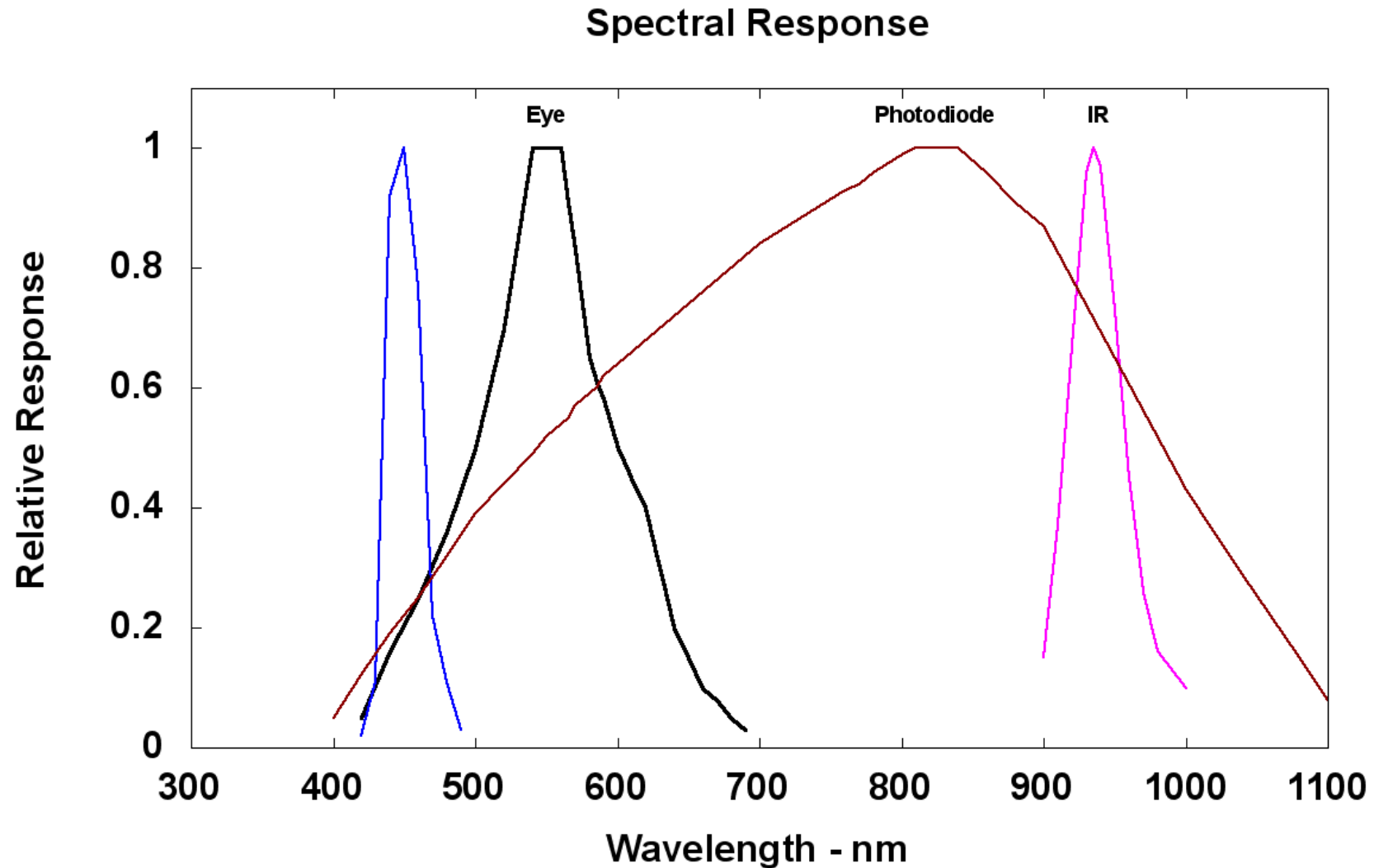

Any output pulse looks like data!
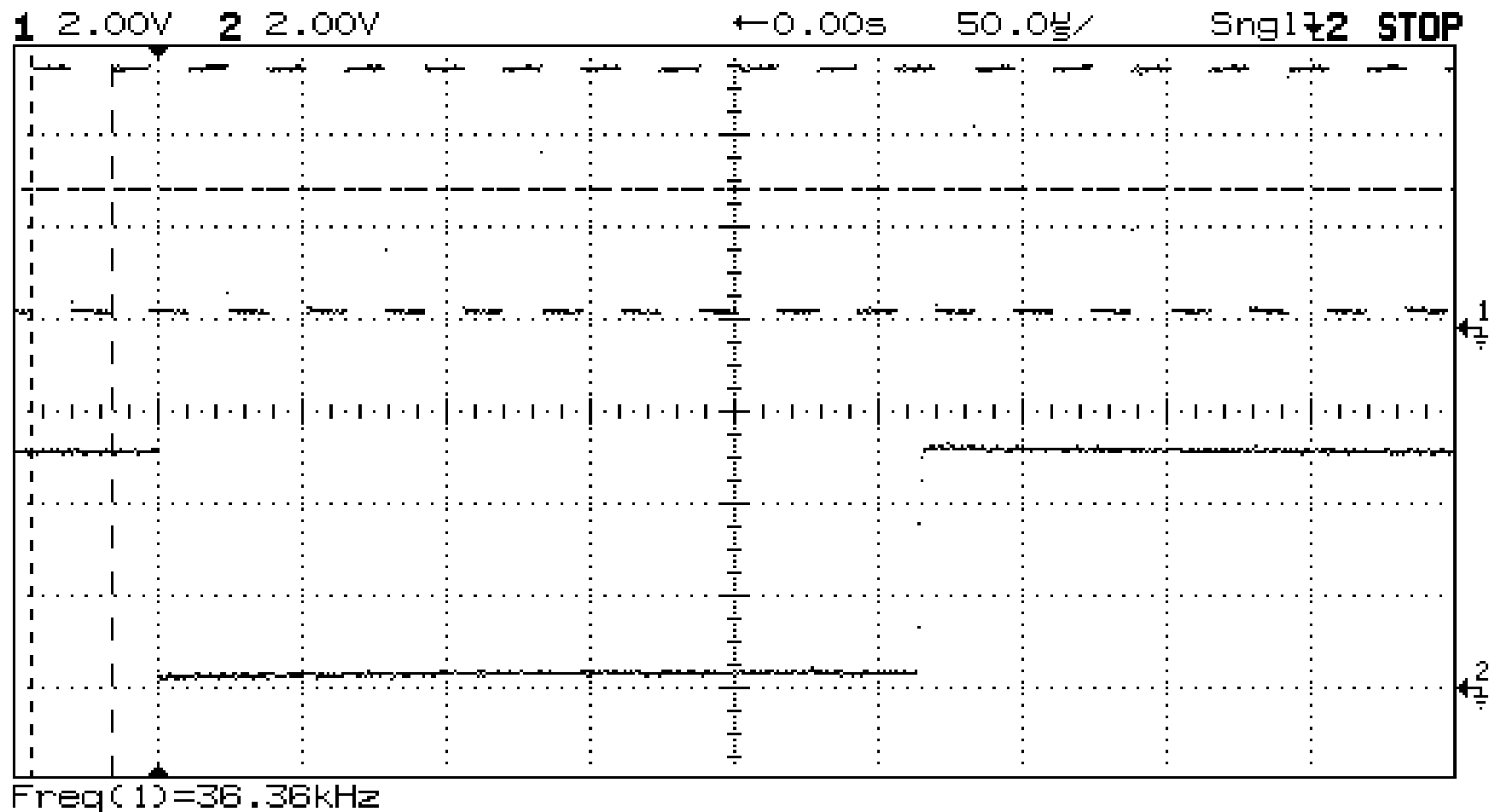
Optical Filtering Might Help

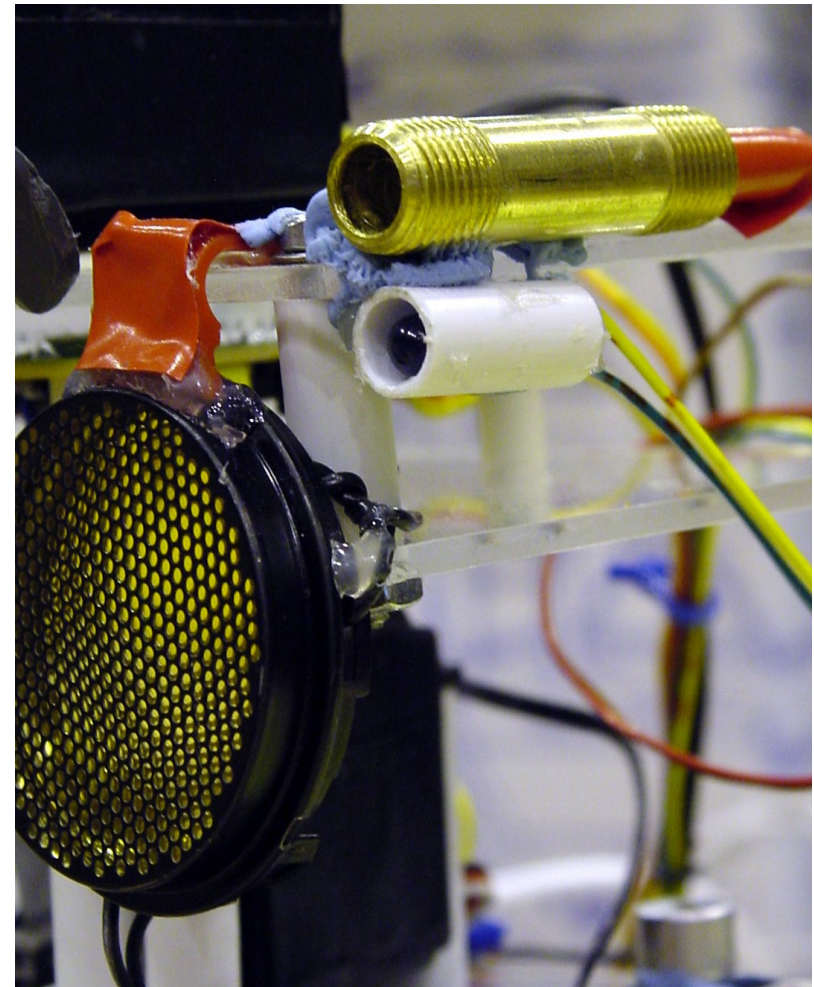IR sensors have visible-reject filters!

What Could Go Wrong?

Your Firmware Will Know

Blue LED @ 38 kHz → **IR** IS1U60

Conclusions: Optics

- Avoid DC sensors!
- Collimation
  - Tunnel vision helps
- Optical filters
  - **Not** on LEDs!
- Frequency filters
- Glitch rejection
- Sanity checking

Power Corrupts
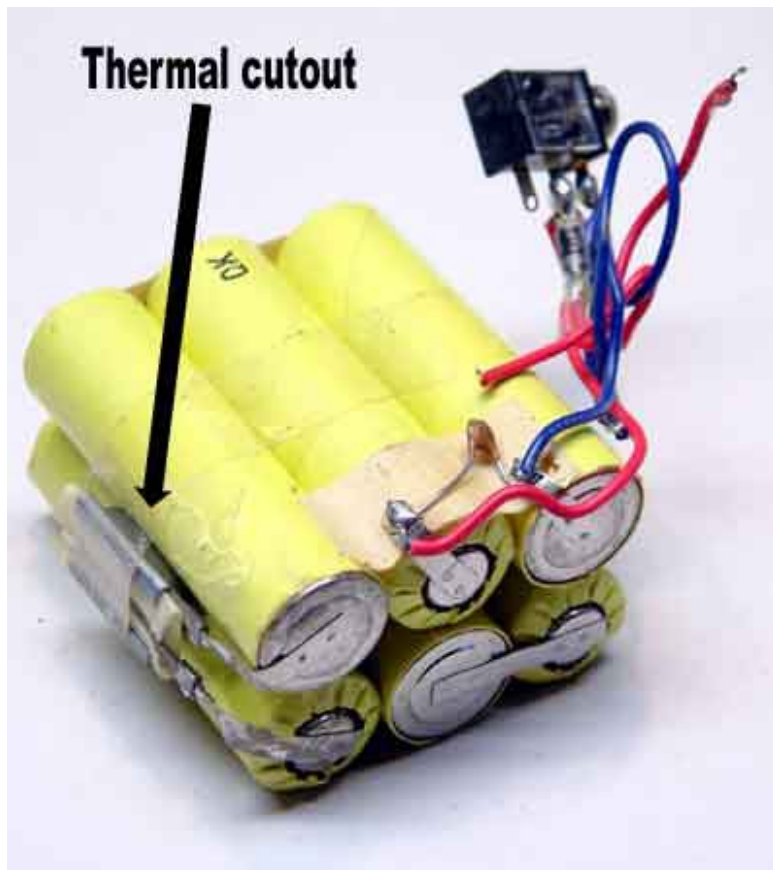
Check Your Batteries
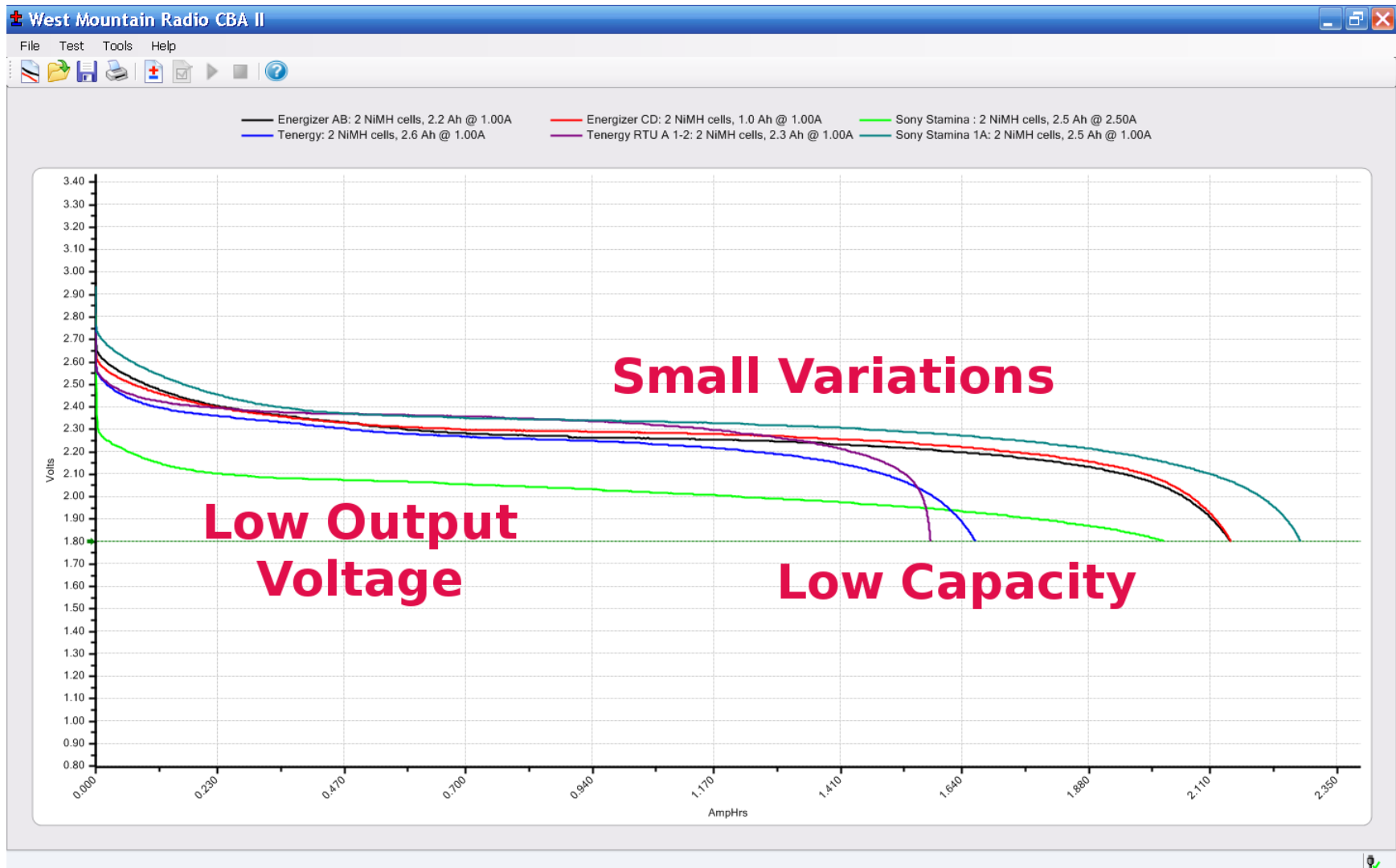
Ohm's Law

- **E=IR**
  - Remember this!
- It **never** sleeps
- You can't see it
  - Digital logic can
- Help kill your 'bot
  - Skinny wires
  - Poor connections
  - Shared power

430 mA   5.950 V   105 mV

0.43

120 mV   13 mV   25 mV   5.730 V
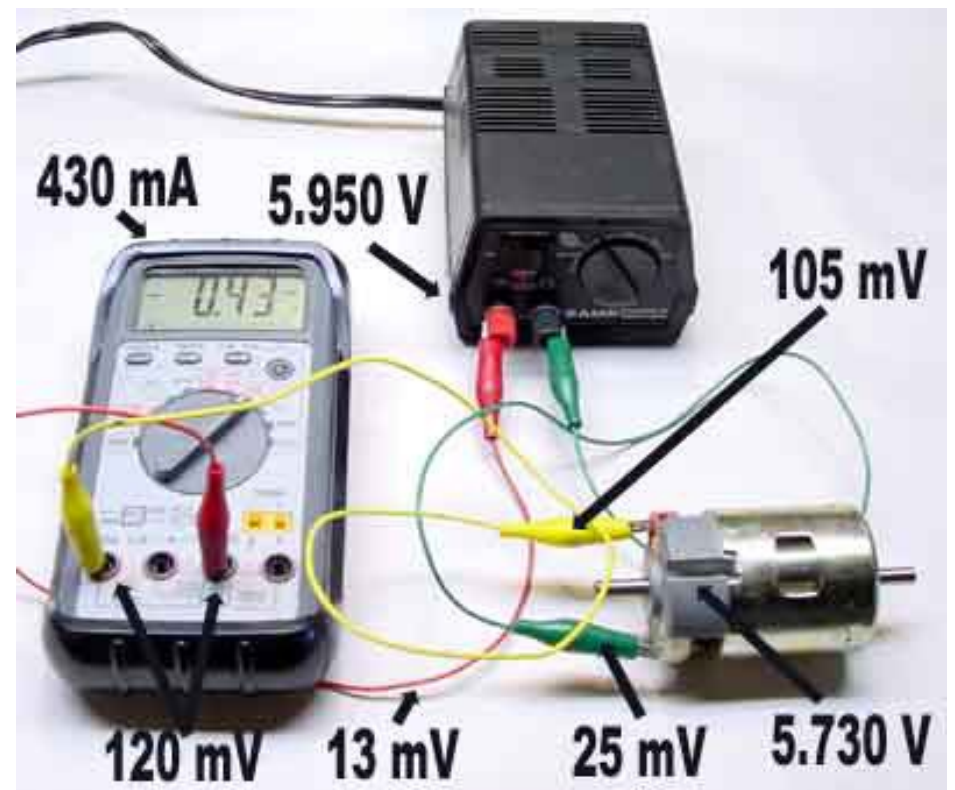
DC Motor Startup

- **DC** is misleading
- 0.1 Ω Sense Resistor
    - 10 A/V = 1 A/100mV
- Oscilloscope
    - DMM is *sooo* **DC**
- Trigger from µC pin?
    - Add a line of code!
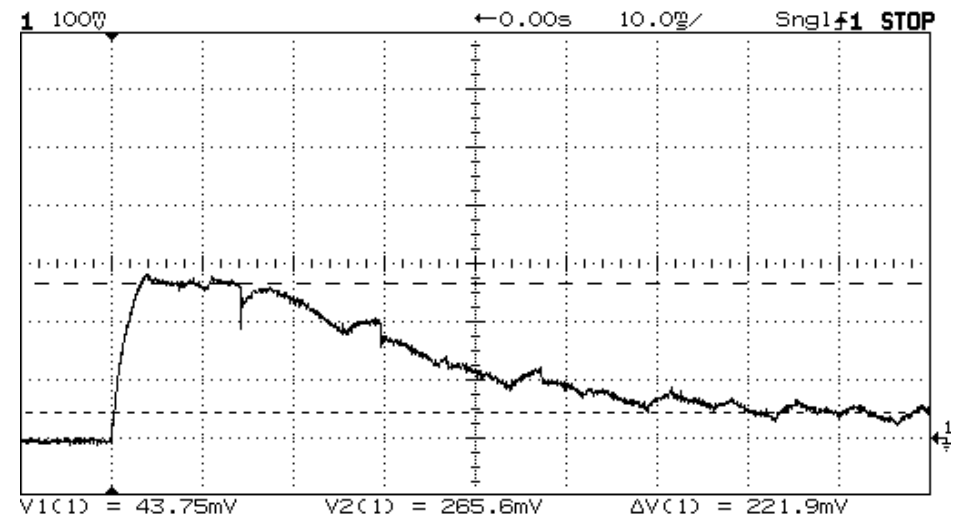
DC Motor Startup
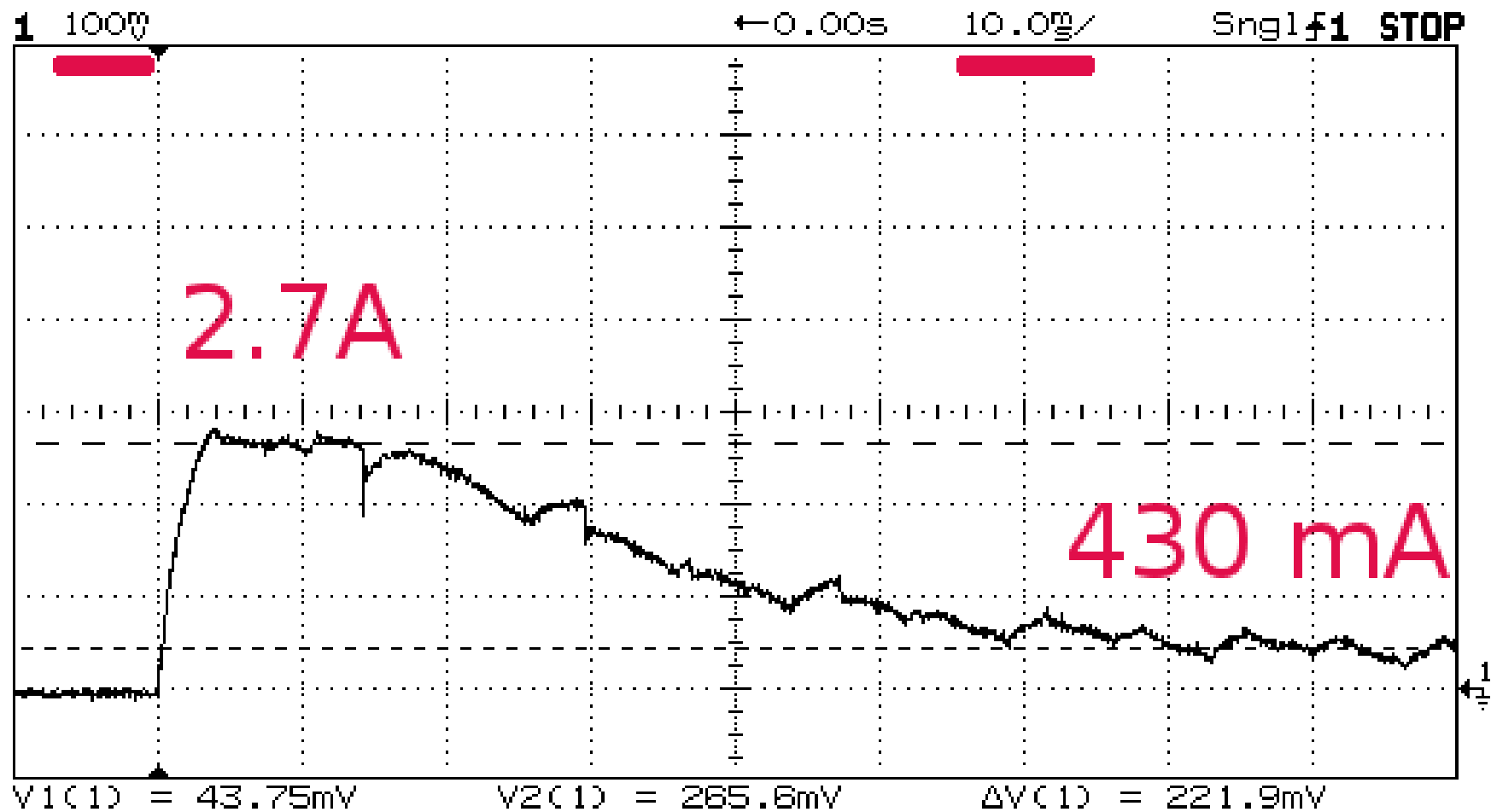
DC Motor Startup

- Ohm's Law **E=IR**

- Same resistances

  - **0.5 Ω** = 0.22 V / 0.43 A

- Peak current = **2.7 A**

  - Ratio: 6.2 = 2.7 / 0.43

- Bigger voltage drop

  - **1.35 V** = 2.7 x 0.5

430 mA   5.950 V   105 mV

120 mV   13 mV   25 mV   5.730 V

DC Motor Startup

Only 1.35 V?

So what?

Check Your Vcc

SHARP

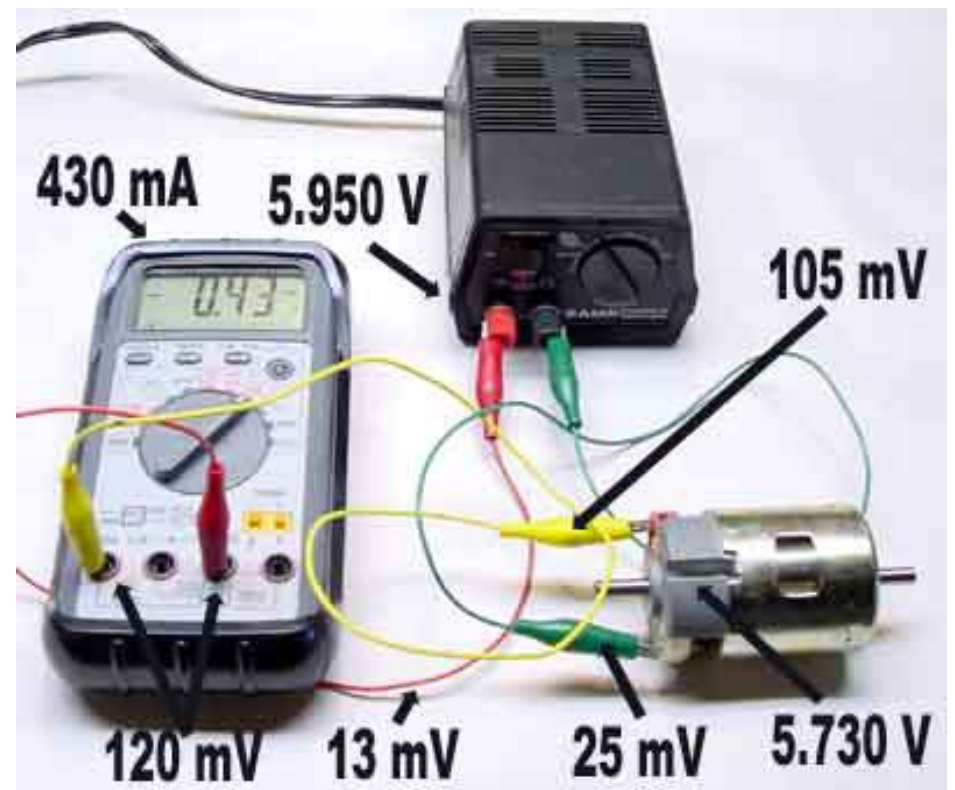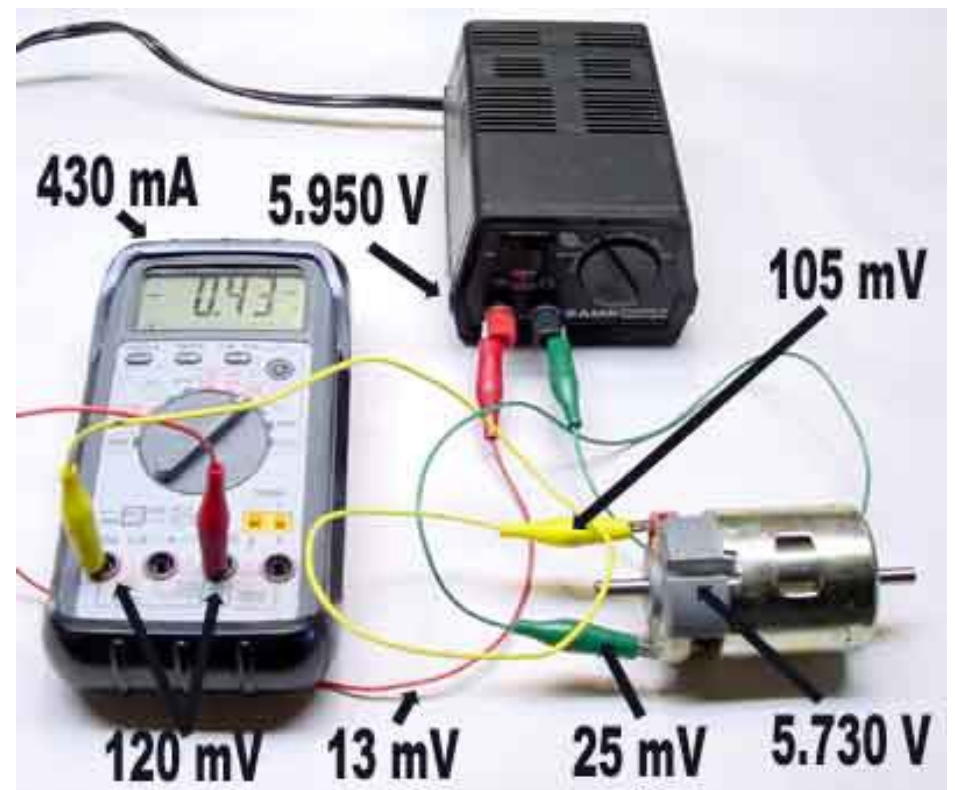# GP2Y0A02YK

■ Recommended Operating Conditions

Parameter	Symbol	Rating	Unit
Operating Supply voltage	V_{CC}	4.5 to 5.5	V

More datasheets at http://www.acroname.com/robotics/info/articles/sharp/sharp.html

Check Your Timing

V_CC (Power supply)

38.3ms±9.6ms

Distance measuring operation

| First measurment | Second measurment | | nth measurment | |

V_O (Output)

| Unstable output | First output | Second output | | nth output |

5.0ms MAX.
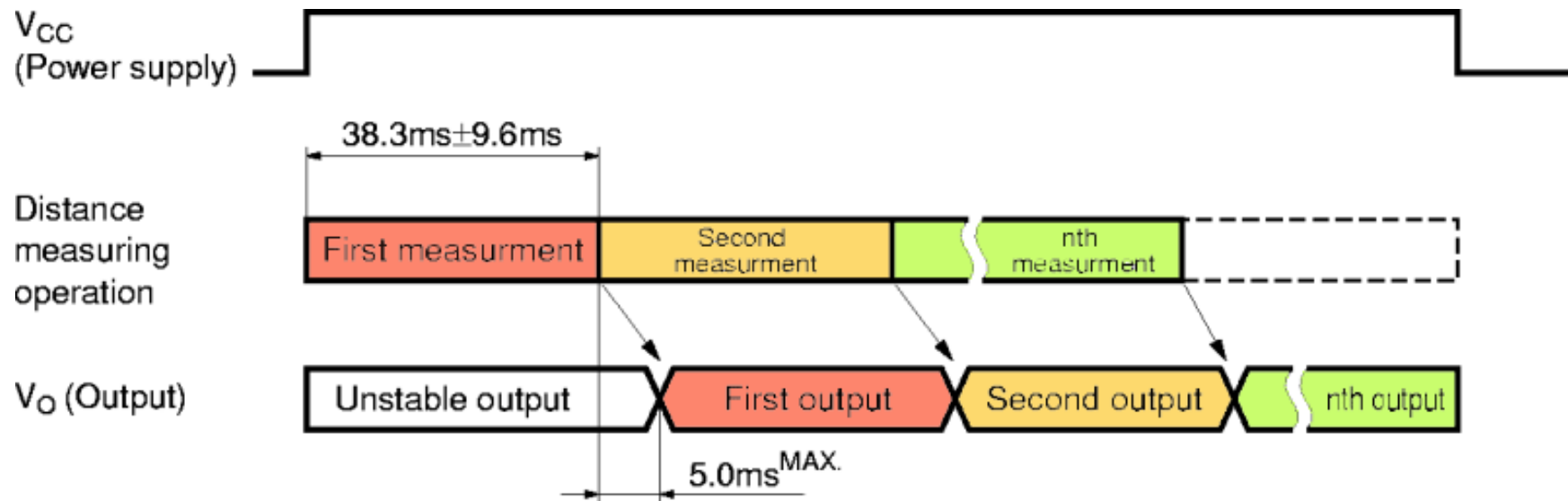
Timing starts **after** the final Vcc glitch...

More datasheets at http://www.acroname.com/robotics/info/articles/sharp/sharp.html

More Vcc Transients

- ## Ultrasonic Rangefinder

  - 5 V "logic" Vcc supply

  - 1 ms ranging pulses

  - **2.5 A** Icc during pulse

- ## Use a **local** bulk cap!

  - Wiring inductance

  - Don't share Vcc!

  - Why not? Work it out…
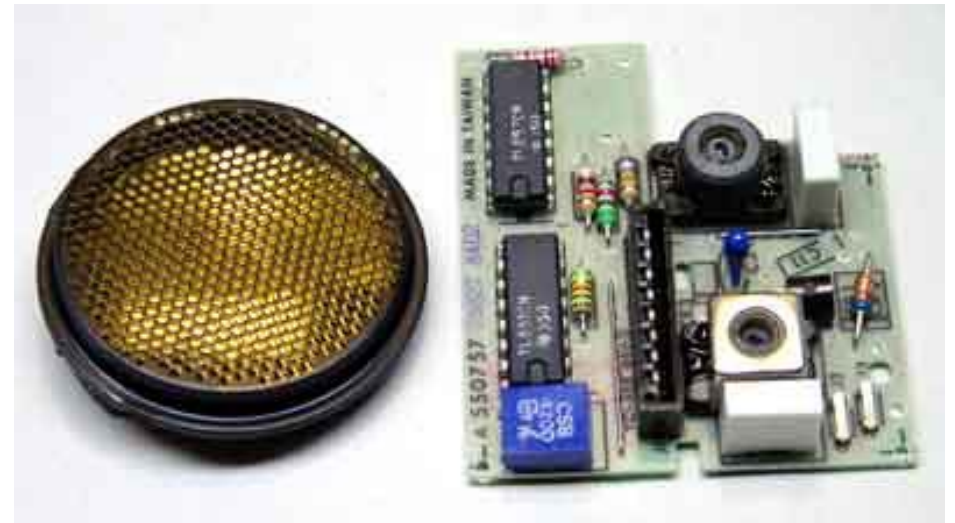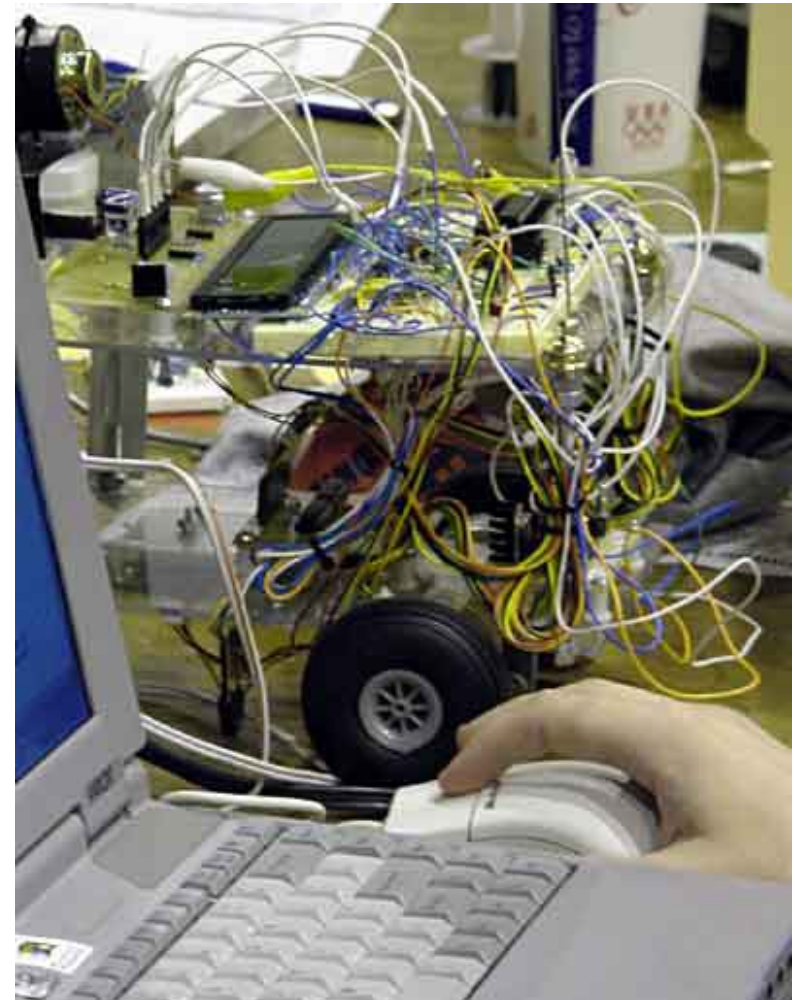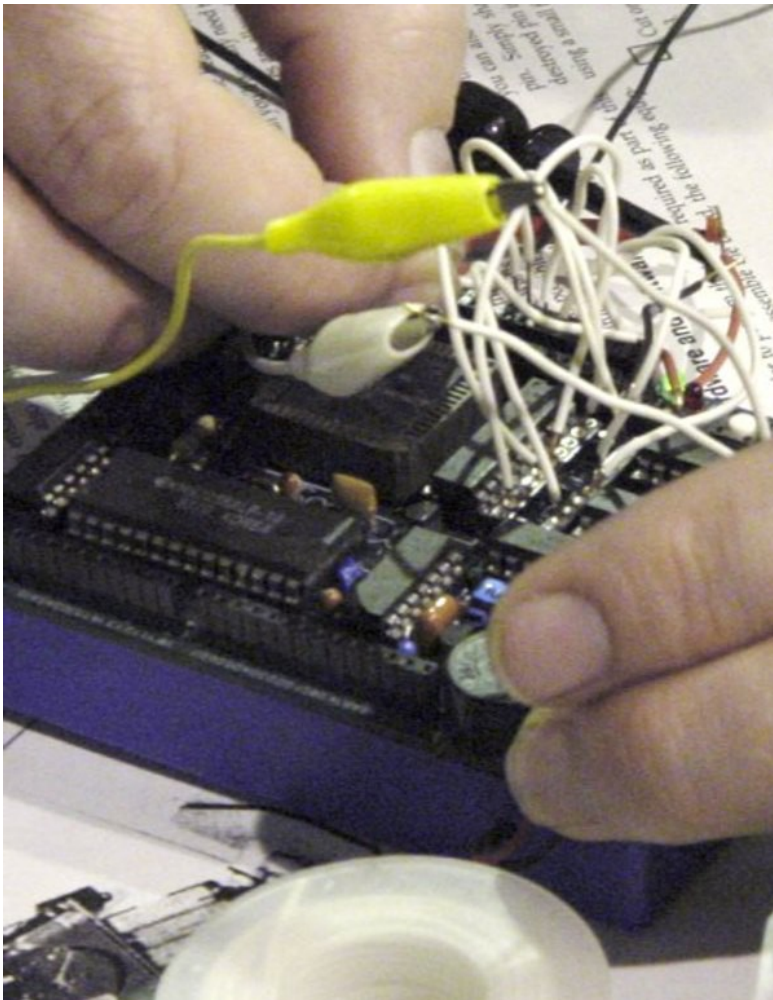
Conclusions: Power

- Charge your batteries!
- Separate your power
  - Motors don't share well
- Bulk local caps
  - Wiring inductance!
  - Shared grounds?
- Local regulators
  - Verify **peak** current
  - Verify dropout
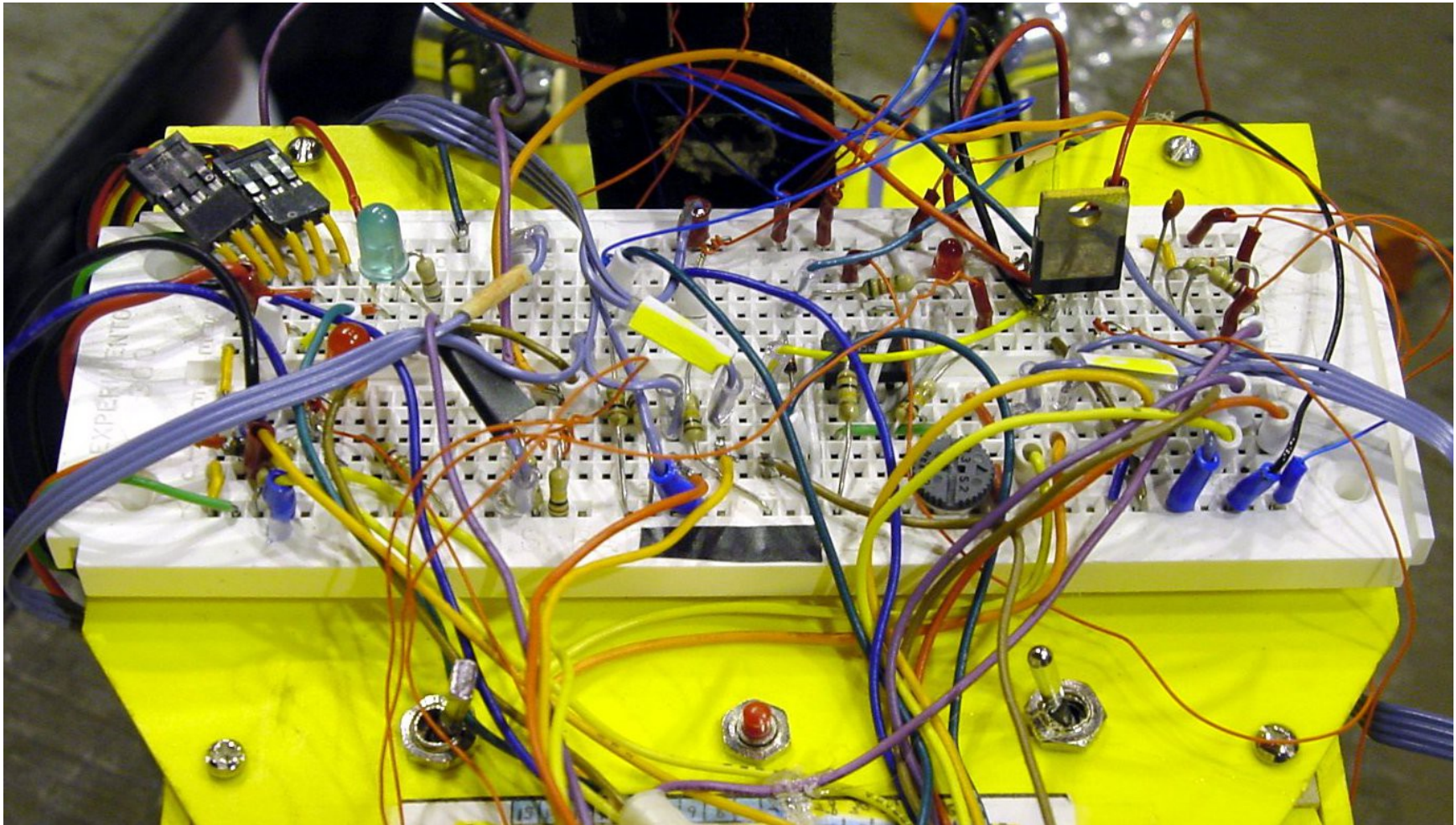

24 A (?)   10 ms/div
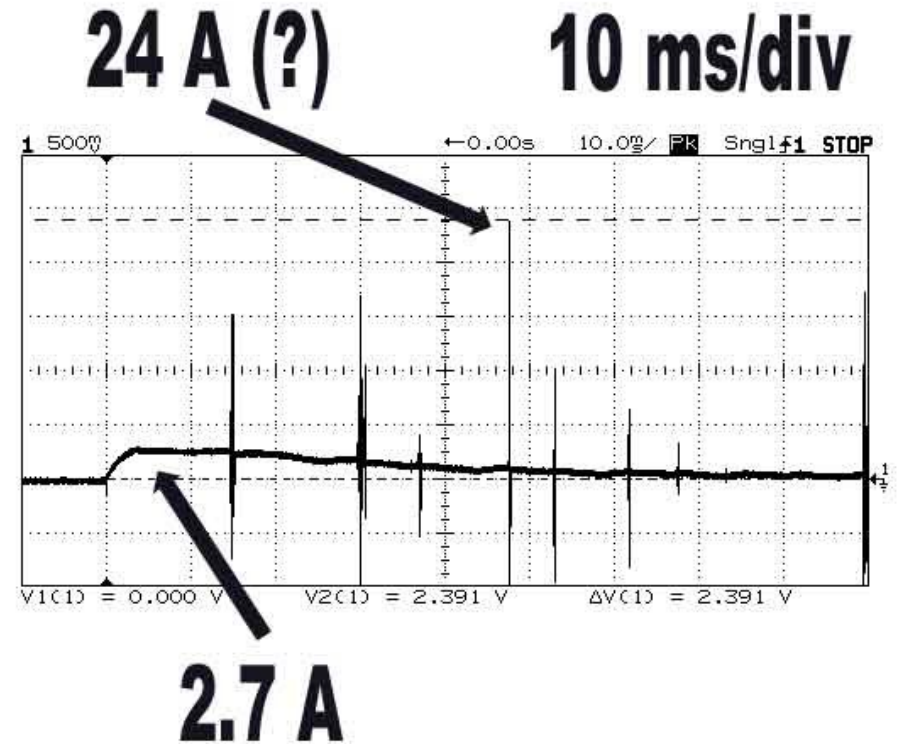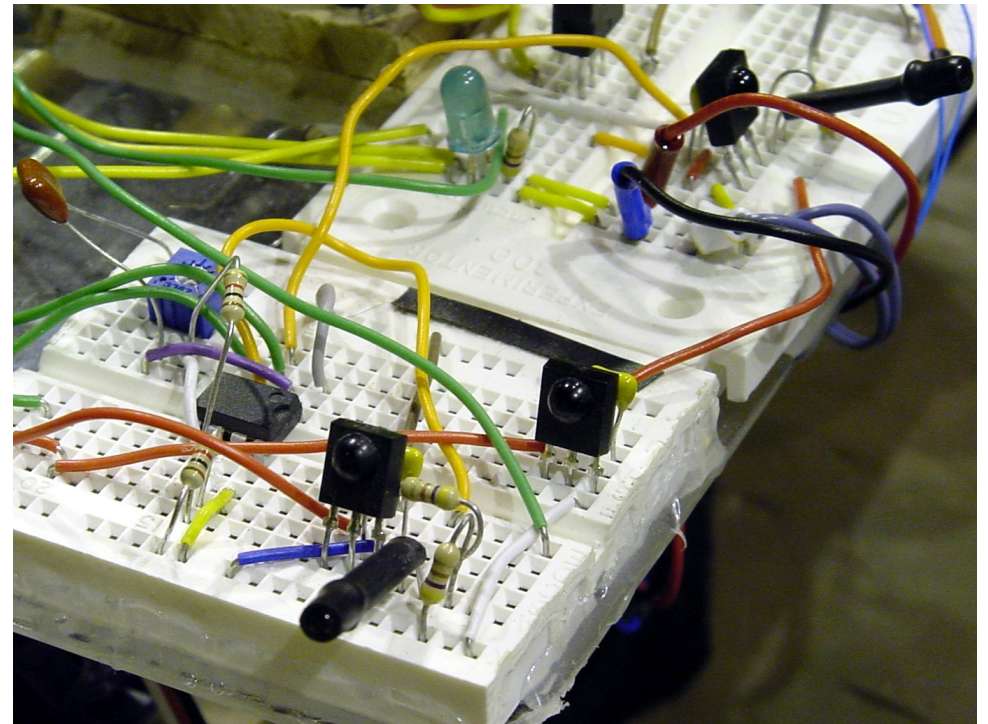
DC Motor Commutation

Neatness Counts

What Could Go Wrong?

Solderless Breadboards

- Unreliable contacts
- Low retention force
- Intermittent errors
- High inductance
- Bad documentation
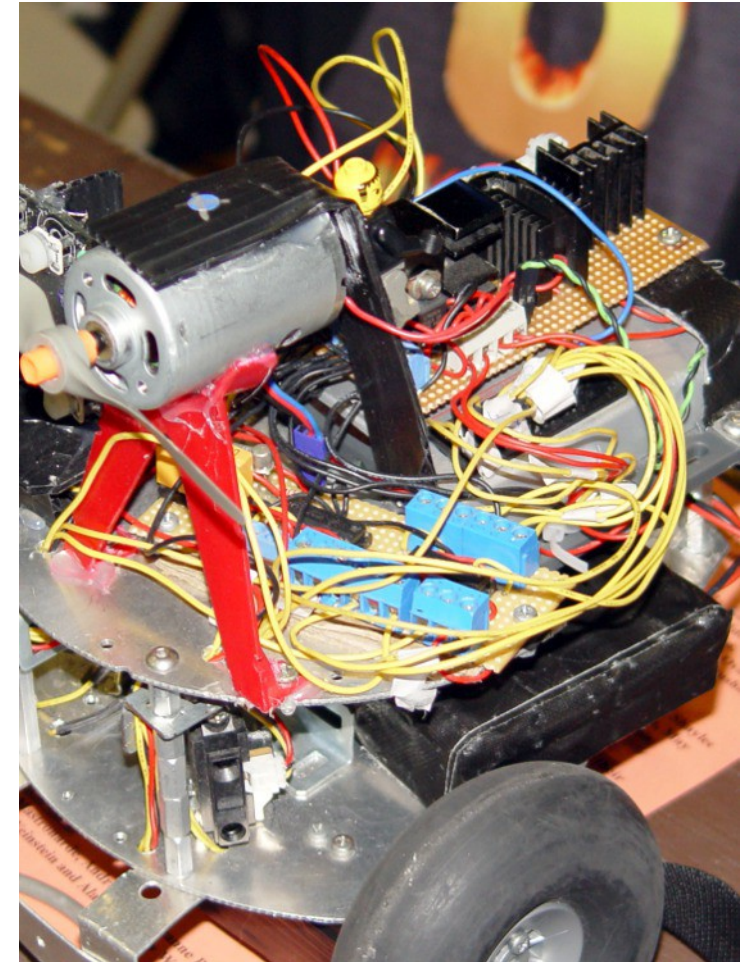- Terrible repairability
- **Don't do this!**

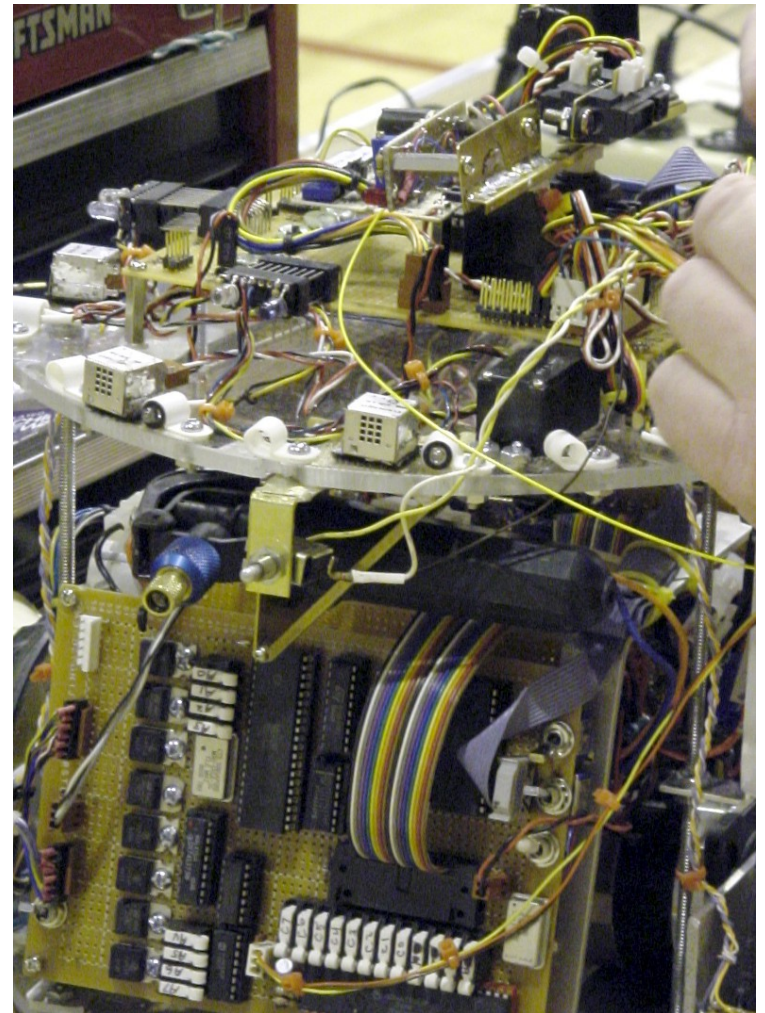

Where *did* this wire go?

Perforated Proto Boards

- Need good soldering skills

- Use screw terminals!

- Moderately good doc

- Easy to build

- Quick to repair

- Can swap in PC boards

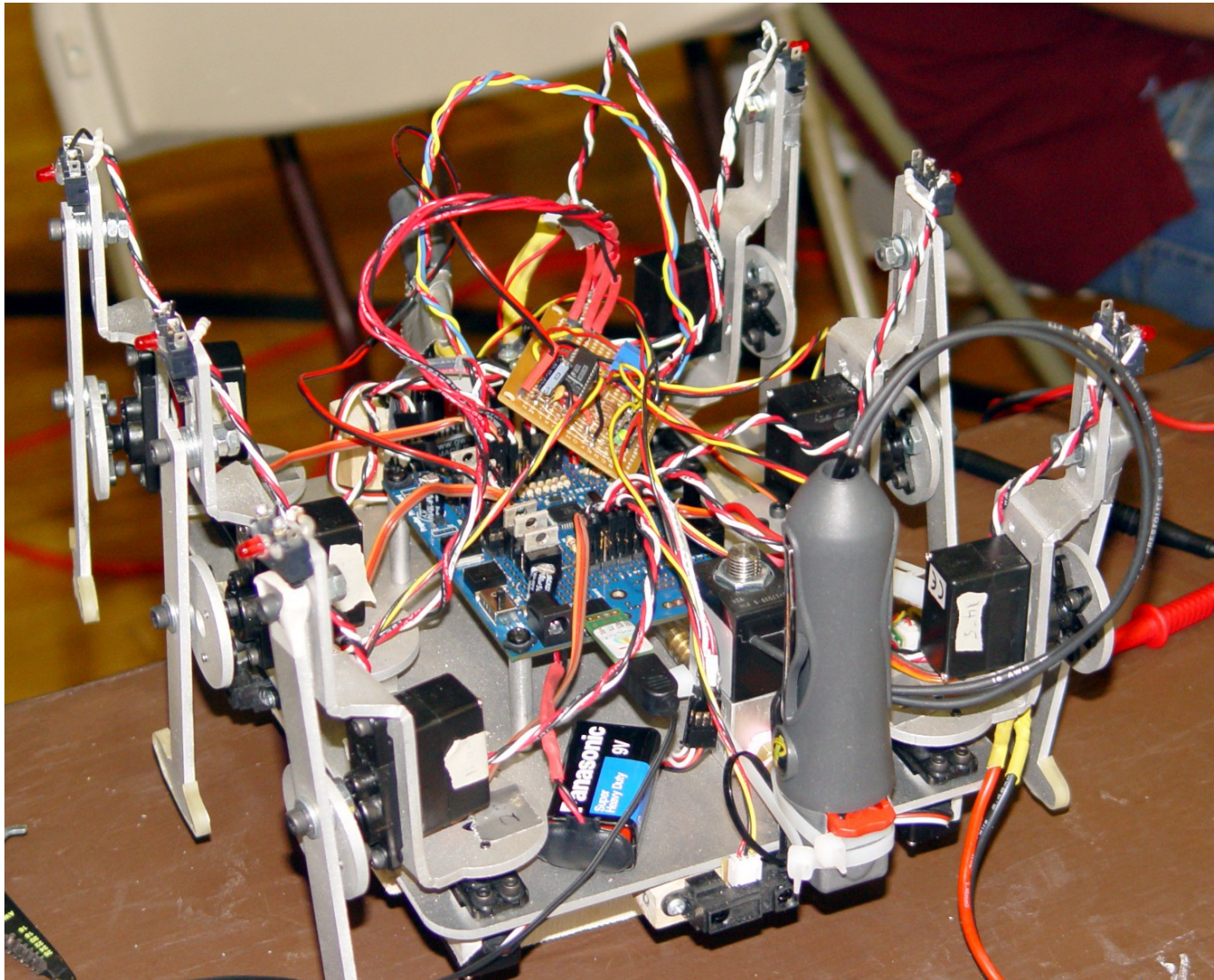- You could do worse...

Secure Hardware Mounting

- Tradeoffs
  - Rigid brackets
  - Easy access
  - Reliable connections
  - Quick modification
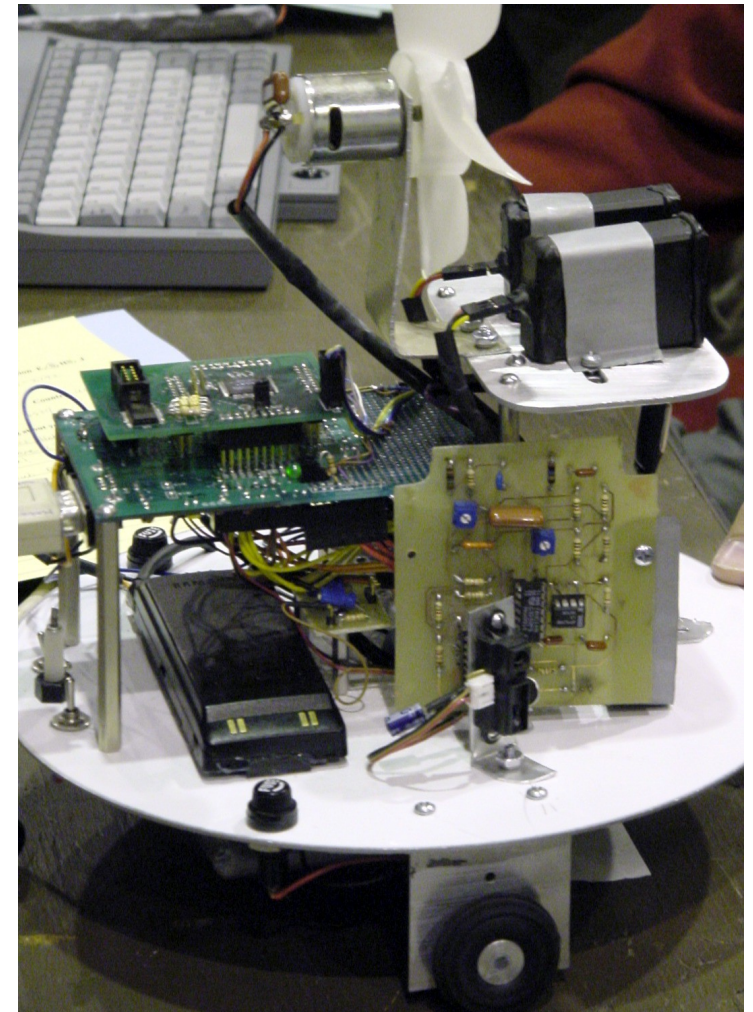   - Why aren't you finished?
- Choose any three...

Or Just Pile It On

Conclusions: Neatness

- Can you connect it?
  - Will it vibrate loose?
- Can you find it?
  - With everybody watching?
- Can you fix it?
  - In the arena in 5 seconds?
- Does it still work?
  - After dropping it?

Frequently Heard Comments

- *It worked perfectly in the lab!*

  - Under different lighting conditions
  - With freshly charged batteries

- *The hardware / sensor must be broken!*

  - Because your diagnostics show, what, exactly?

- *I didn't touch that subroutine / function!*

  - All parts of a program are deeply intertwingled
  - Do you have regression tests?

Go Forth and Make It Work!

Copyright-ish Stuff

Some images & doc copyrighted, but
shown & attributed here under "fair use"
[whatever that is]

The rest is my own work

●

Ed Nisley

It's "NISS-lee", even if we're the half-essed branch of the family tree

Engineer (ex PE), Hardware Hacker, Programmer, Author

The Embedded PC's ISA Bus: Firmware, Gadgets, Practical Tricks

Circuit Cellar www.circuitcellar.com
  Firmware Furnace (1988-1996) - Nasty, grubby hardware bashing
  Above the Ground Plane (2001 ...) - Analog and RF electronics

Dr. Dobb's Journal www.ddj.com
  Embedded Space (2001-2006) - All things embedded
  Nisley's Notebook (2006-2007) - Hardware & software collisions

Digital Machinist www.homeshopmachinist.net
  Along the G-Code Way (2008 ...) - G-Code and mathematics

If you
can't read this
~ then ~
make a new friend
'way up front!