Sensors and Cables

Maslab 2005

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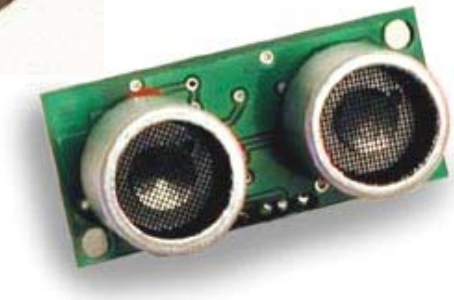
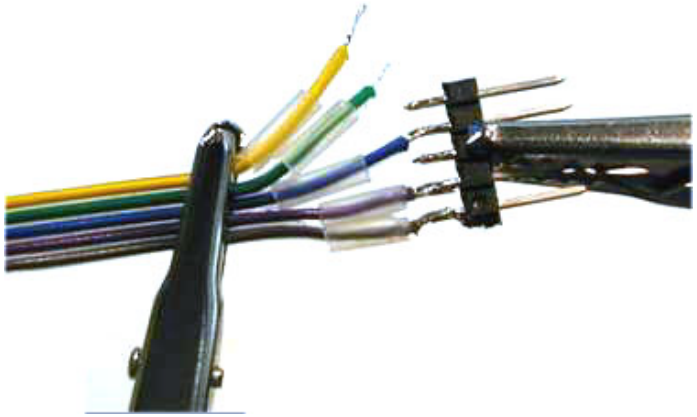


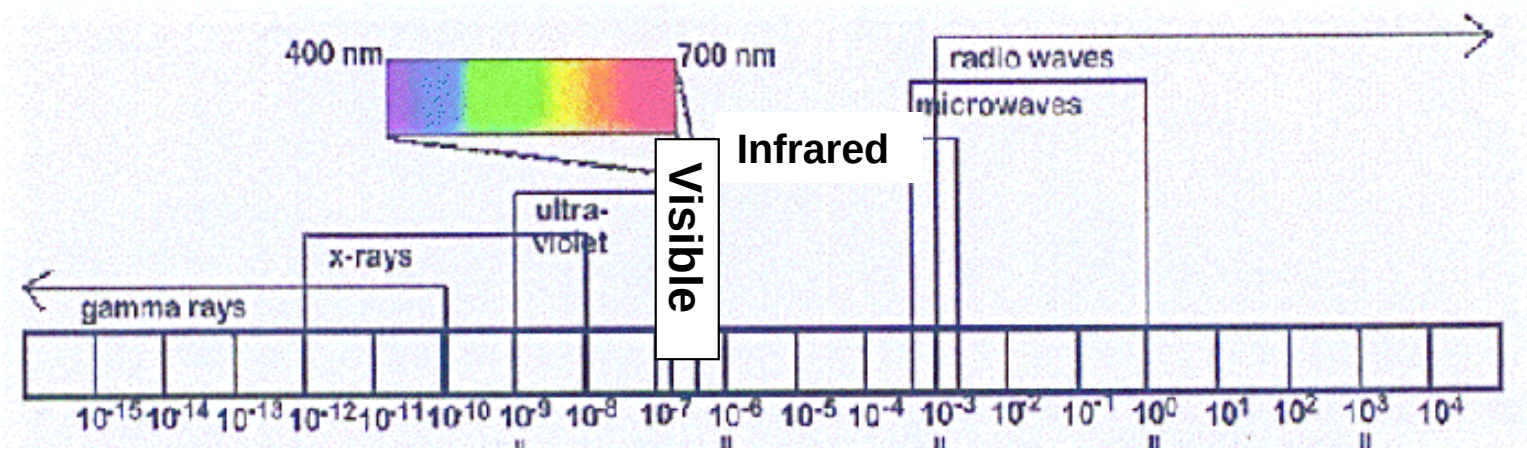


Maslab Sensor Types

- Common types:
  - Camera
  - Infra-Red (IR) range finders/reflectance
    - Auto-flush toilets
  - Ultrasound
    - Cameras
  - Physical contact
    - Roomba
  - Gyroscopes: Angular Rate Sensor
    - Automotive, GPS-assist
  - Motor current sense
  - Optical encoders
  - Timer?
- Other types:
  - Photodiodes from 6.270
  - Digital Compass
  - Reed switch
  - Mercury switch
  - Be creative!

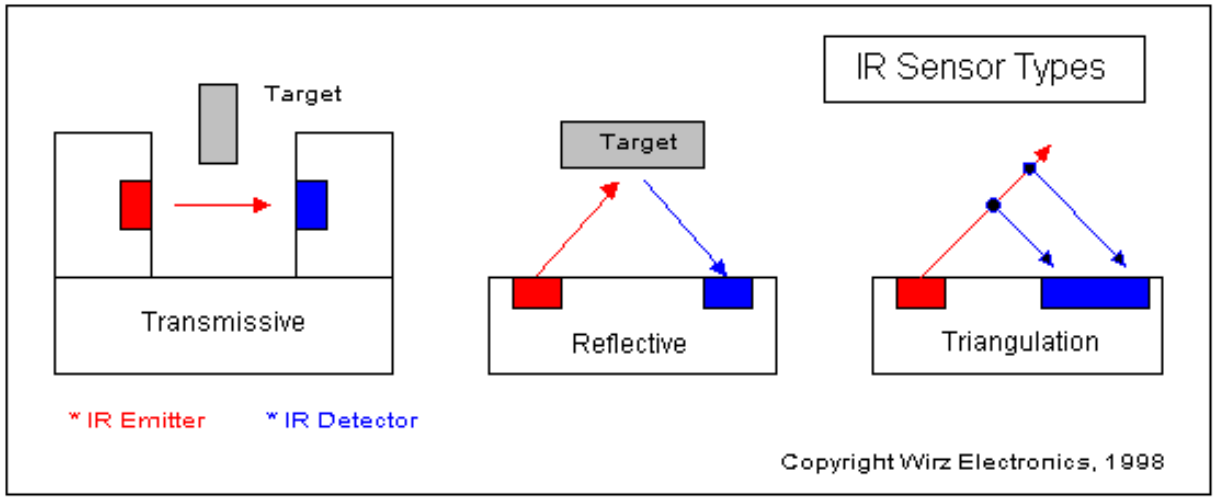
Infrared

- 750 nm to 1,000,000 nm
  - We typically use near-infrared, ~900nm. Near-infrared used on many camcorders for “night vision”
  - Far-infrared is used for body heat detection
  - Cheapest: excited silicon emits IR
  - Does not penetrate walls
- Transmitters (LEDs or thermal)
  - In our case, almost always LEDs
- Detectors (photo diodes, photo transistors)
  - Sensors use notch filter to pass *only* IR



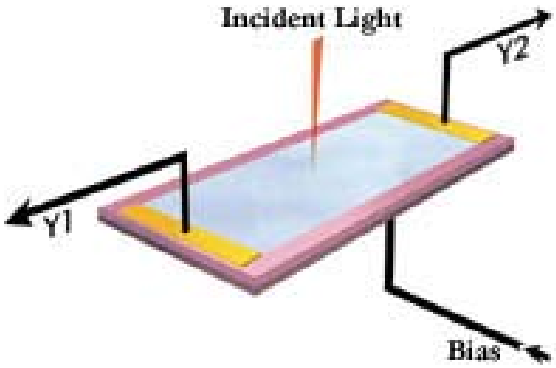
Simple IR sensors

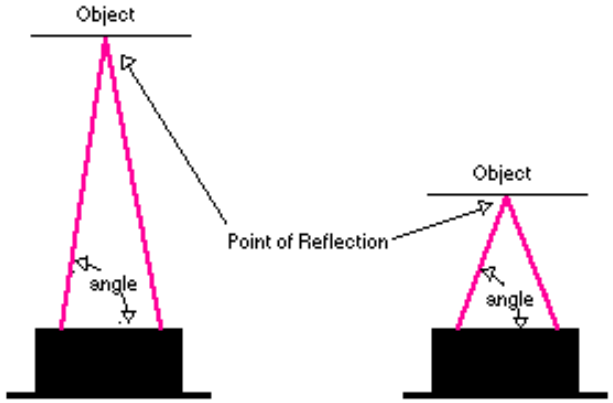
- Break-beam
  - Shine a light directly onto a detector. You can detect if something breaks the beam of light.
- Reflection
  - Shine a light and detect its reflection off a nearby object
- Triangulation
  - Shine a light at an angle, have an array of detectors



Maslab Infrared Range Detectors

- Sensor includes:
  - Infrared light emitting diode (IR LED)
  - Position sensing device (PSD) uses small lens to focus reflected pulse onto a linear CCD array (or magic, differential FET)
- To detect an object:
  - IR pulse is emitted by the IR LED
  - Pulse hopefully reflects off object and returns to the PSD
  - PSD measures the angle at which the pulse returns



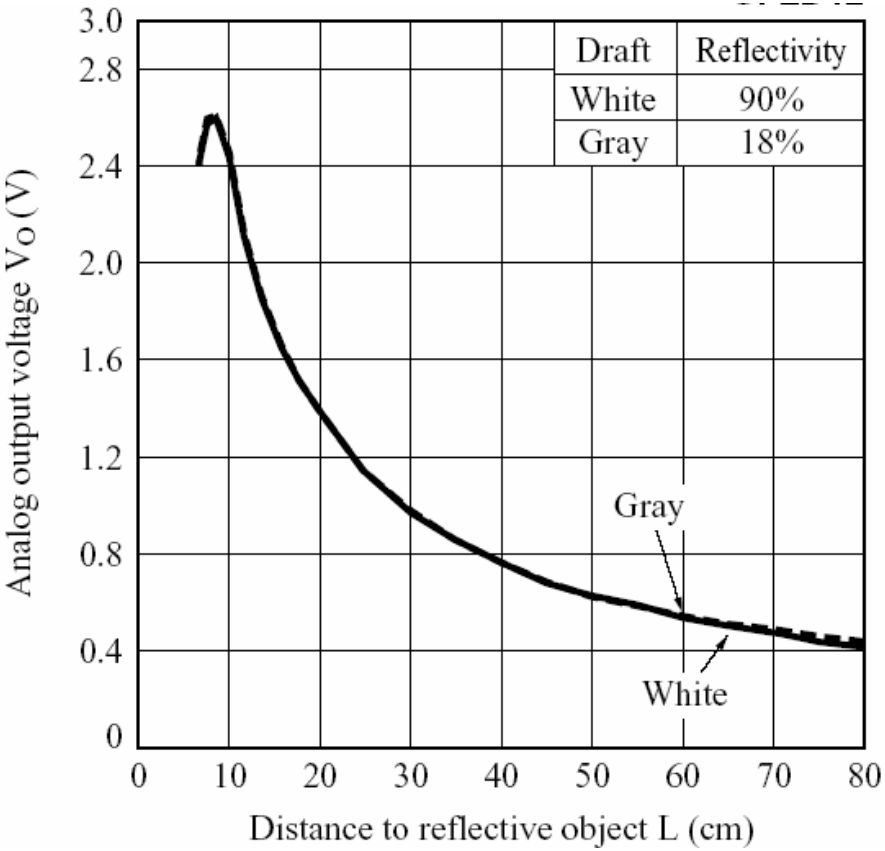


Wider angle = greater distance

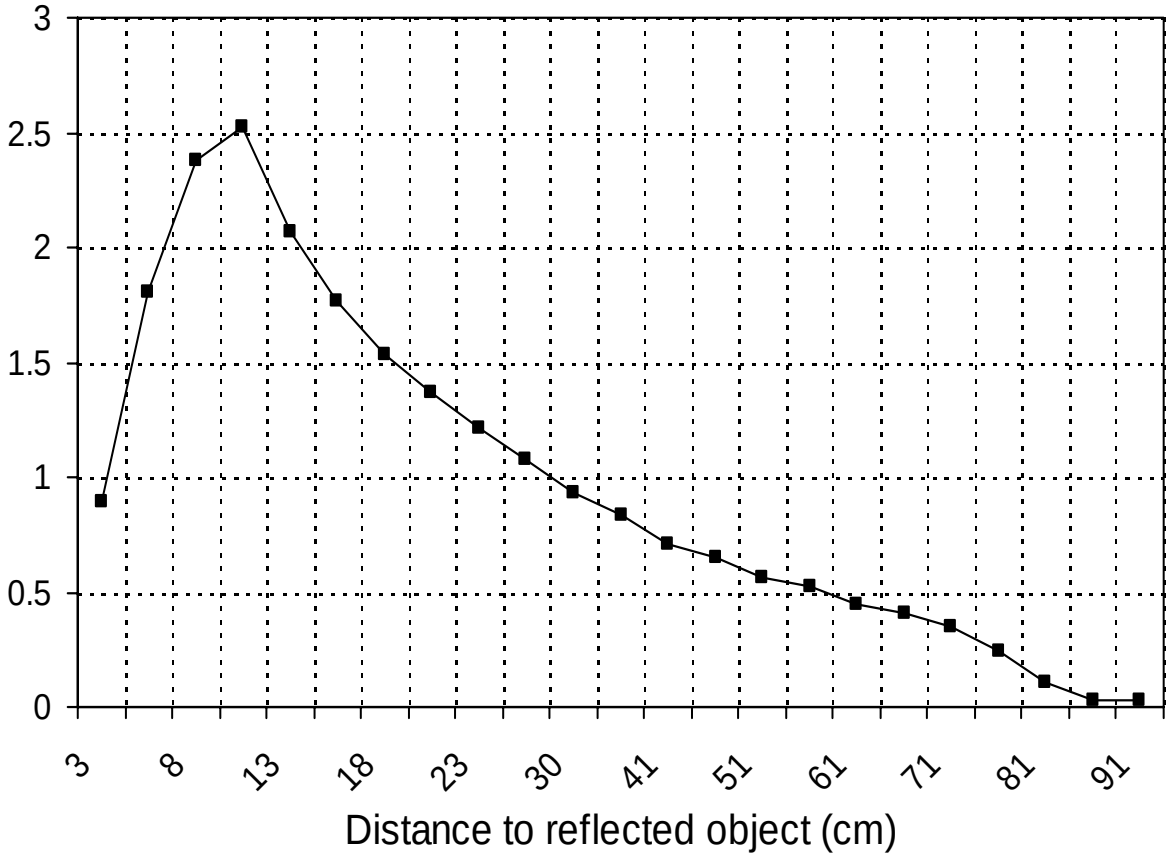
Figure: Acroname.com

Lies, damn lies, and datasheets? Characterize your sensors. Understand the default profiles.

GP2D12: Theoretical Range:
4in (10cm) to 31in (80cm)

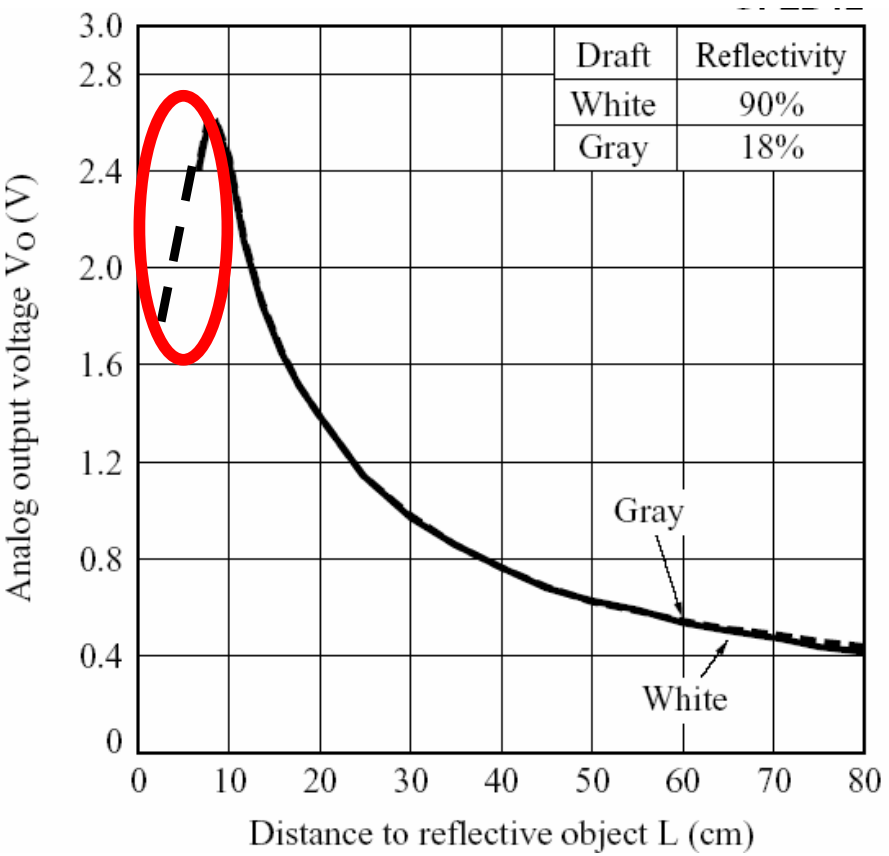


GP2D12: Measured Range:
~4in (10cm) to ~ 18in (45cm)



Non-linear response presents small problems

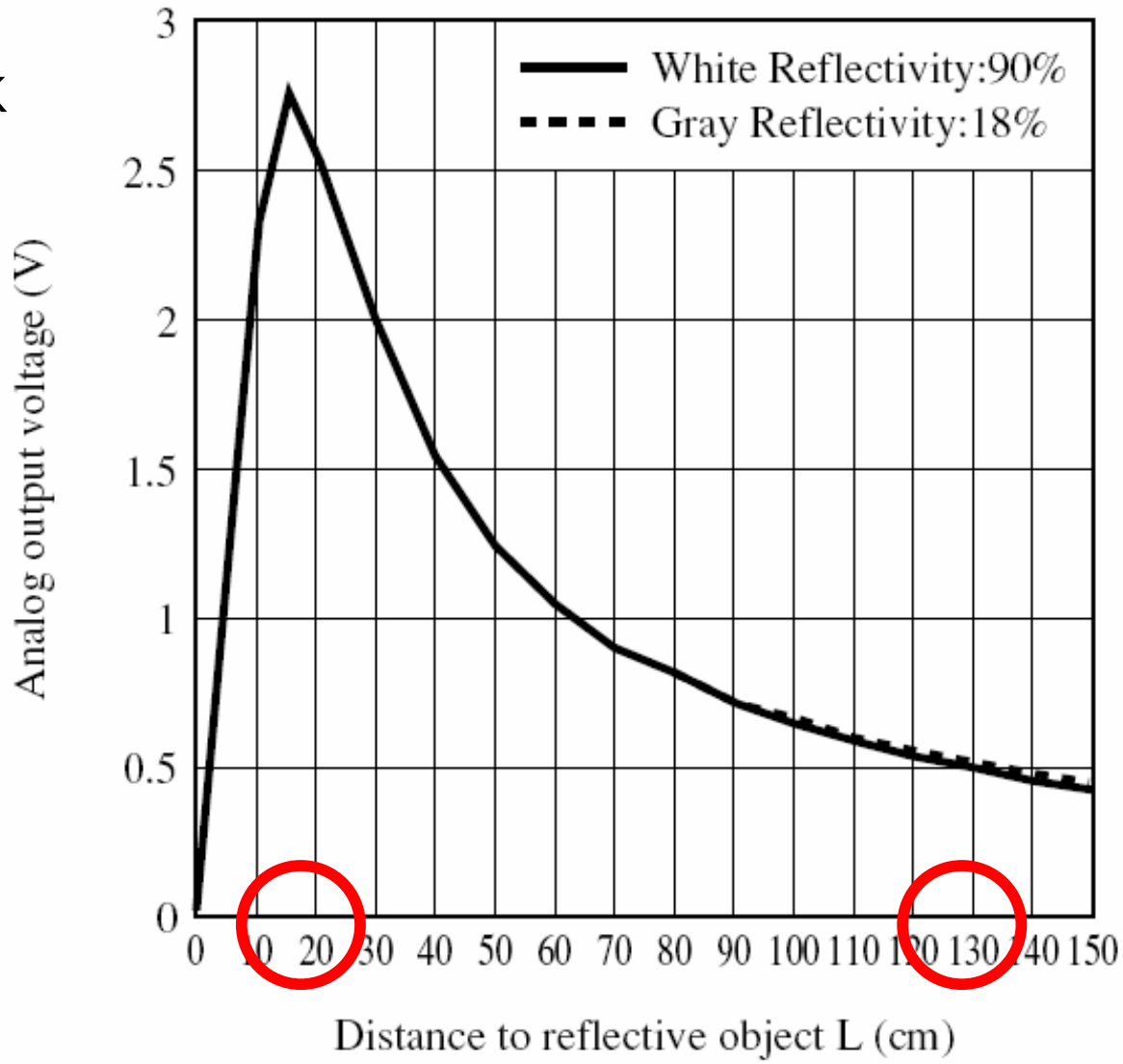
- Ultra short readings can look “far-away”
  - Mount to accommodate this
- Larger error in steep part of curve



- Orc library use inverse of curve and fits a line
  - Voltage = 1/(distance + Xd) * Xm + Xb
  - distance = (Xm/(Voltage-Xb)) - Xd

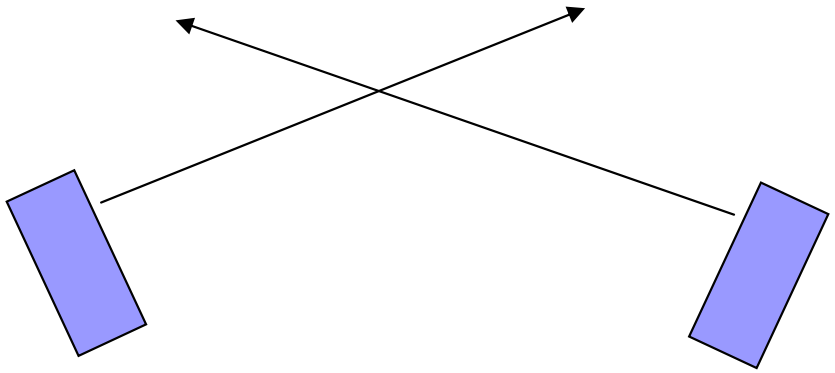
Long range IR sensor uses different lens; increases both min and max limits

GP2Y0A02YK



IR Ranger Properties

- Small, eraser-sized point beam
  - Easy to resolve details; easy to miss small objects if you're not looking right at them.
  - Set up a perimeter

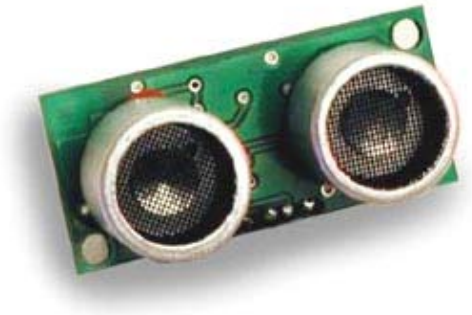


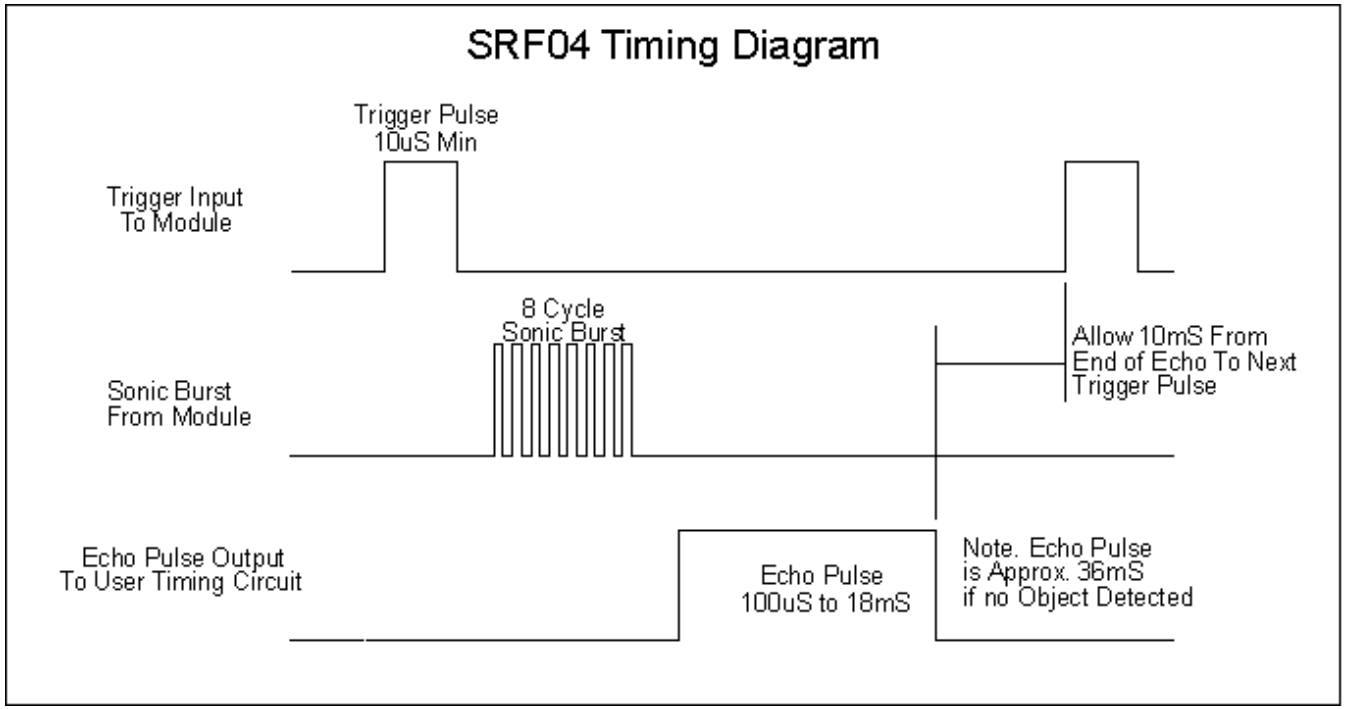
IR Rangefinders

- Can use signal strength
  - Sort of.
- Can use time-of-flight, c=299,792,458 m/s
  - How fast can you count?
    - Not fast enough!
  - Sick industrial laser scanner: $5000
    - Provides ~5cm accuracy, ¼ degree resolution, 30m range
    - (collective “ooooh!”)

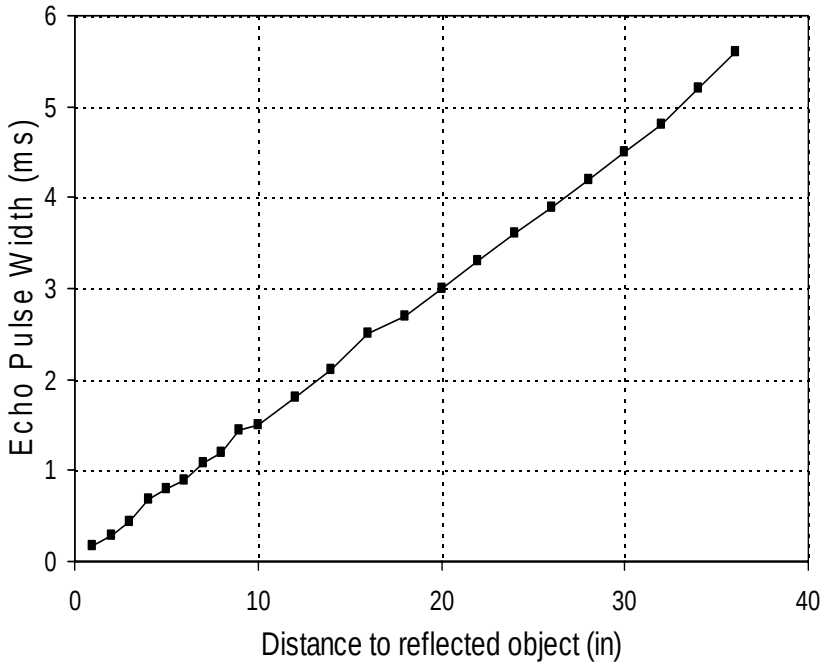
Ultrasound Rangers

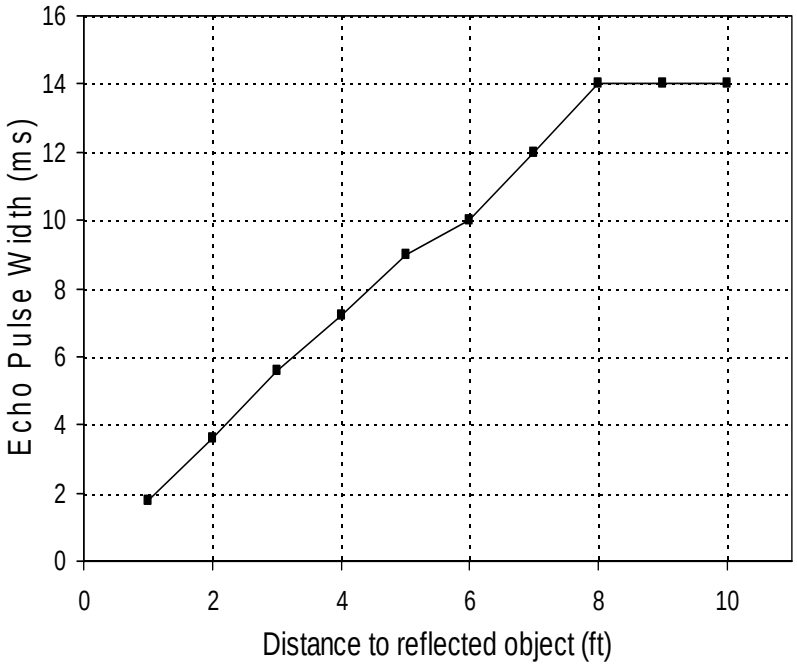
- Send an ultrasonic pulse, listen for an echo
- Time of flight. Speed of sound only ~347 m/s
- Limited supply?





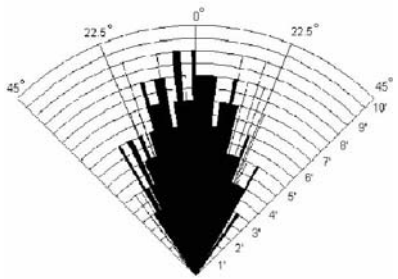
Ultrasound Ranger Properties

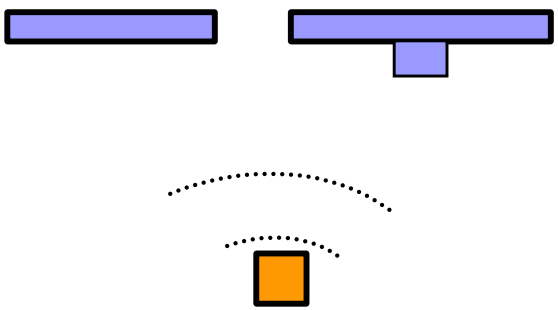




Ultrasound Ranger Properties

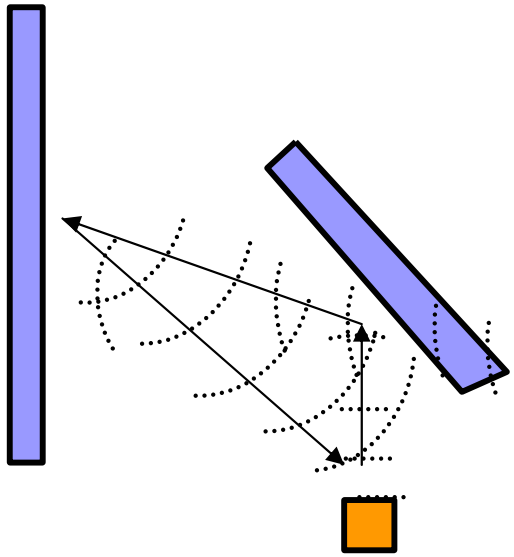
- Broad beam width “blurs” detail… but less likely to “miss” something





Small detail hard to resolve

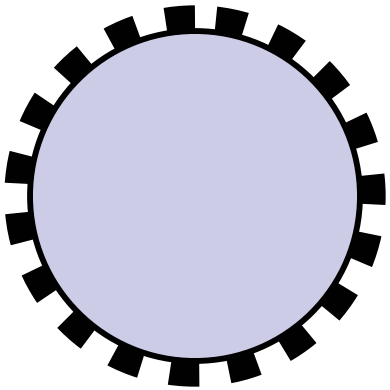
- Sound can “scatter” (shortest path) or “reflect”
  - Can dramatically overstate range.

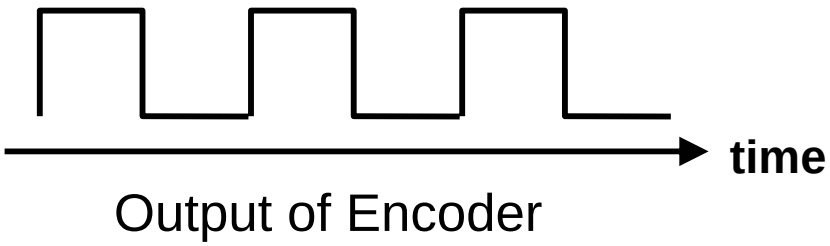


Multipath can fool you!

Optical encoders are another use for IR emitter and detector

- Attach a disk to the motor shaft and attach a break-beam sensor across the teeth.

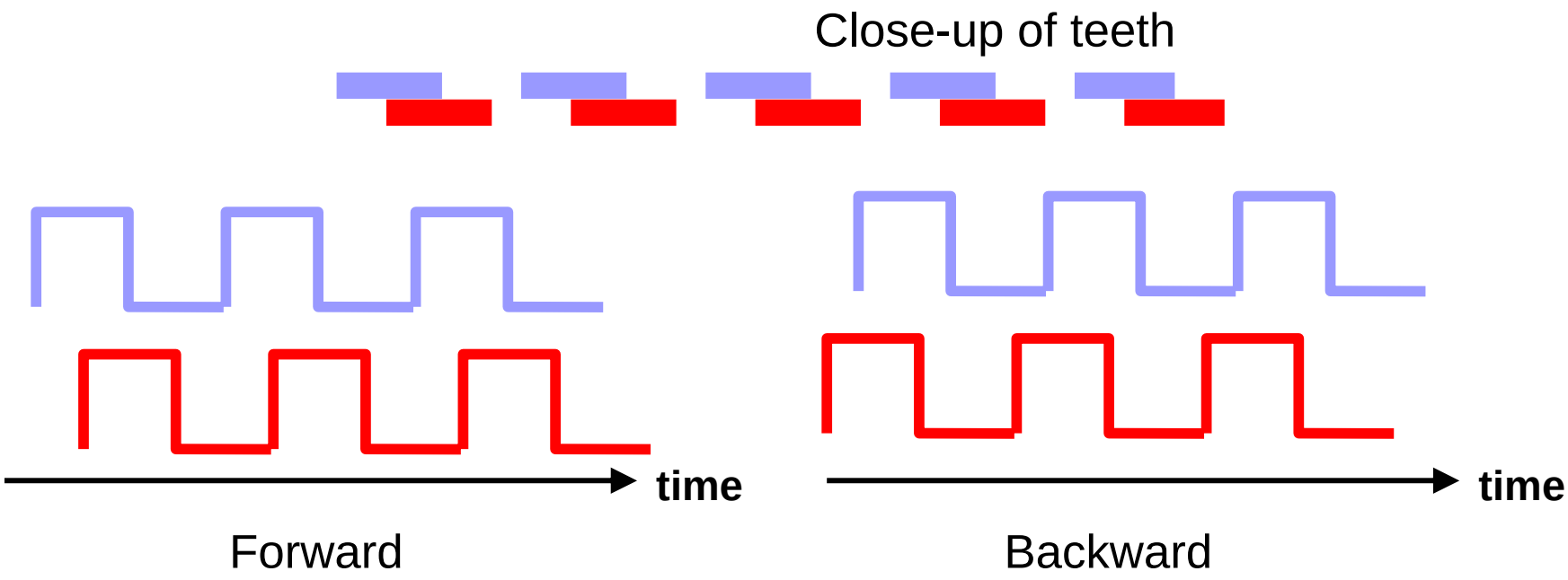




- Or, use a reflectivity sensor and a disk with black & white colored wedges.
- What if wheel stops halfway between slats?
- Are we going forwards or backwards?

Quadrature Phase Encoders allow us to distinguish direction

- Use TWO single encoders, 90 degrees out of phase.



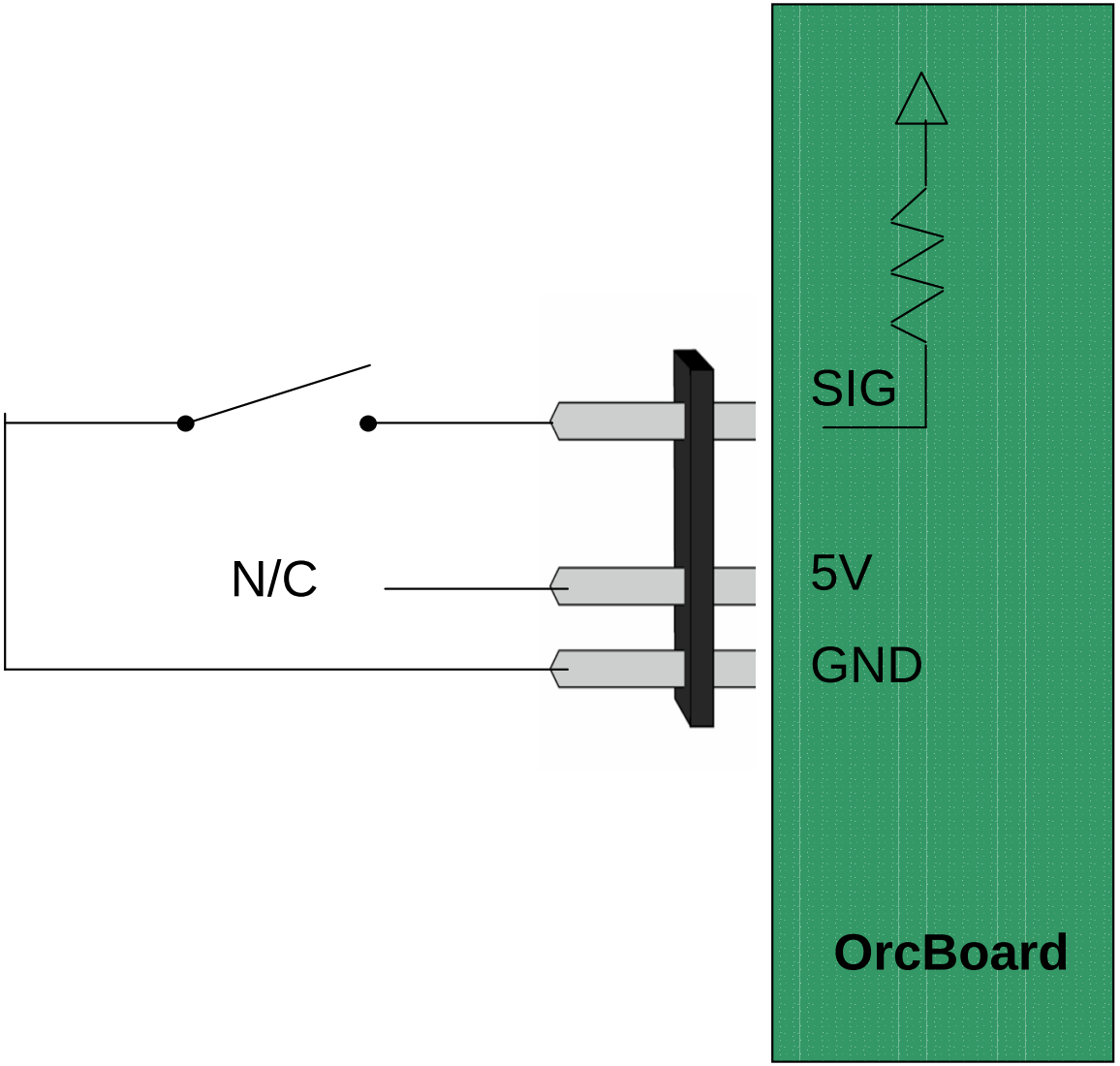
- Forward and backward are now distinguishable!
- Illegal state transitions cancel out (for each spurious forward tick, there's a spurious backward tick)

Using Quad Phase

- Quad phase can allow us to:
  - Do relative positioning– i.e., rotate 10 clicks from our present position (remember that gyro can help with this)
  - Do velocity control.
    - “driving” but not ticking? Probably stuck. Current spike may reveal this, too.
    - It’s hard to drive in a straight line. PID.
  - Compute the robot’s path using odometry.

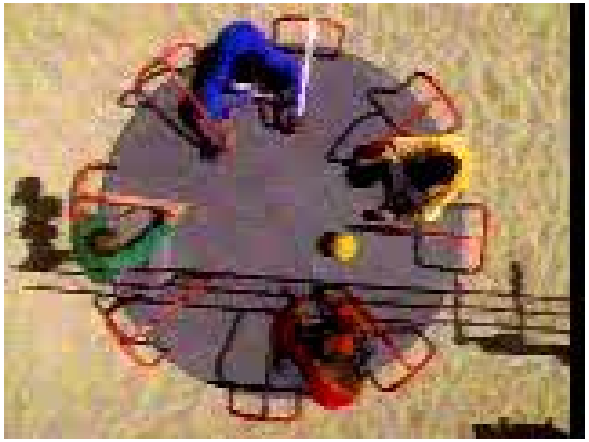
Digital Inputs

- Bump sensors
- NES, anyone?
- Uses an internal pullup resistor.

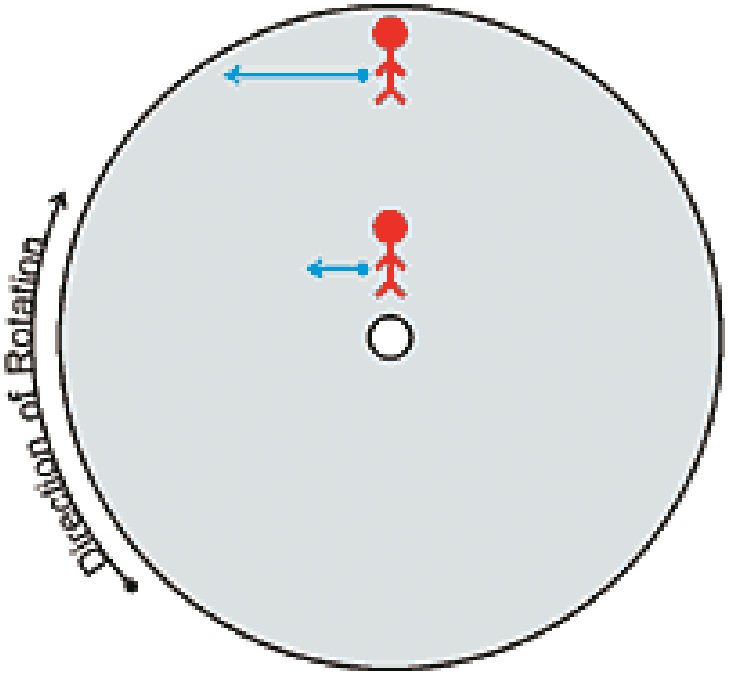


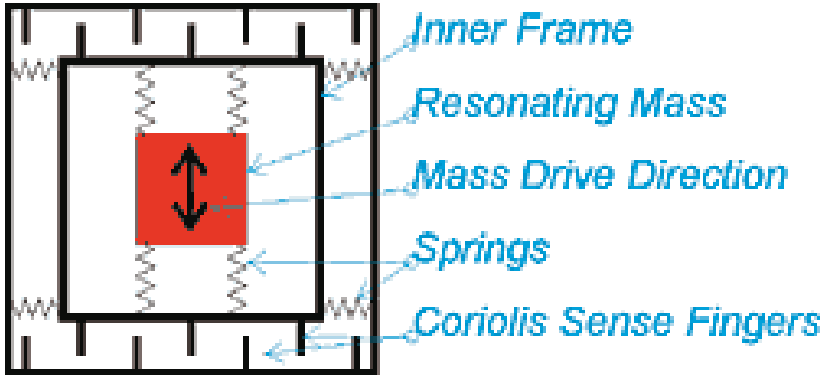
MEMS Gyroscope

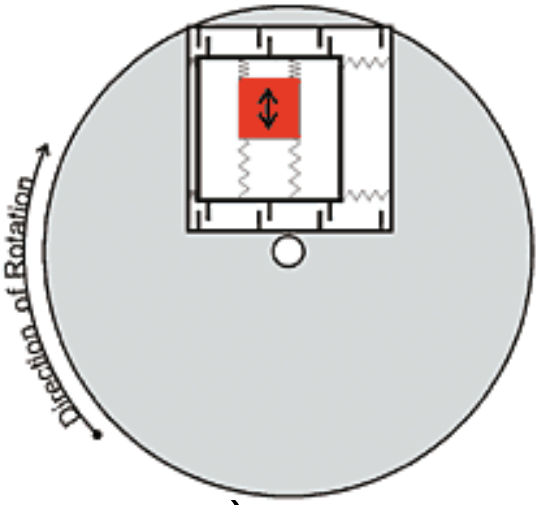
- Outputs a voltage corresponding to degrees/sec
- Note that OrcBoard integrates for you
  - Thanks, Ed!
  - But, what is effect of noise
    - Small voltages could mean the gyro thinks it's turning.
    - Lots of "slow turns" + Integration = Drift
  - Study odometry tutorial
- Uses
  - Accurate turns, straight lines
  - Combine with other sensor data (camera, encoders, etc) for dead reckoning "Columbus Style"

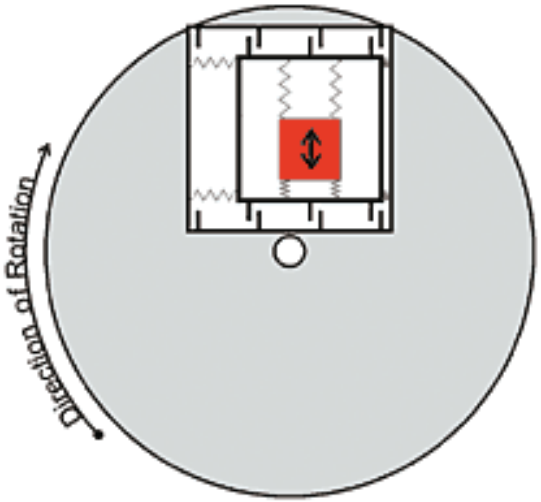


MEMS Gyroscope takes advantage of coriolis effect



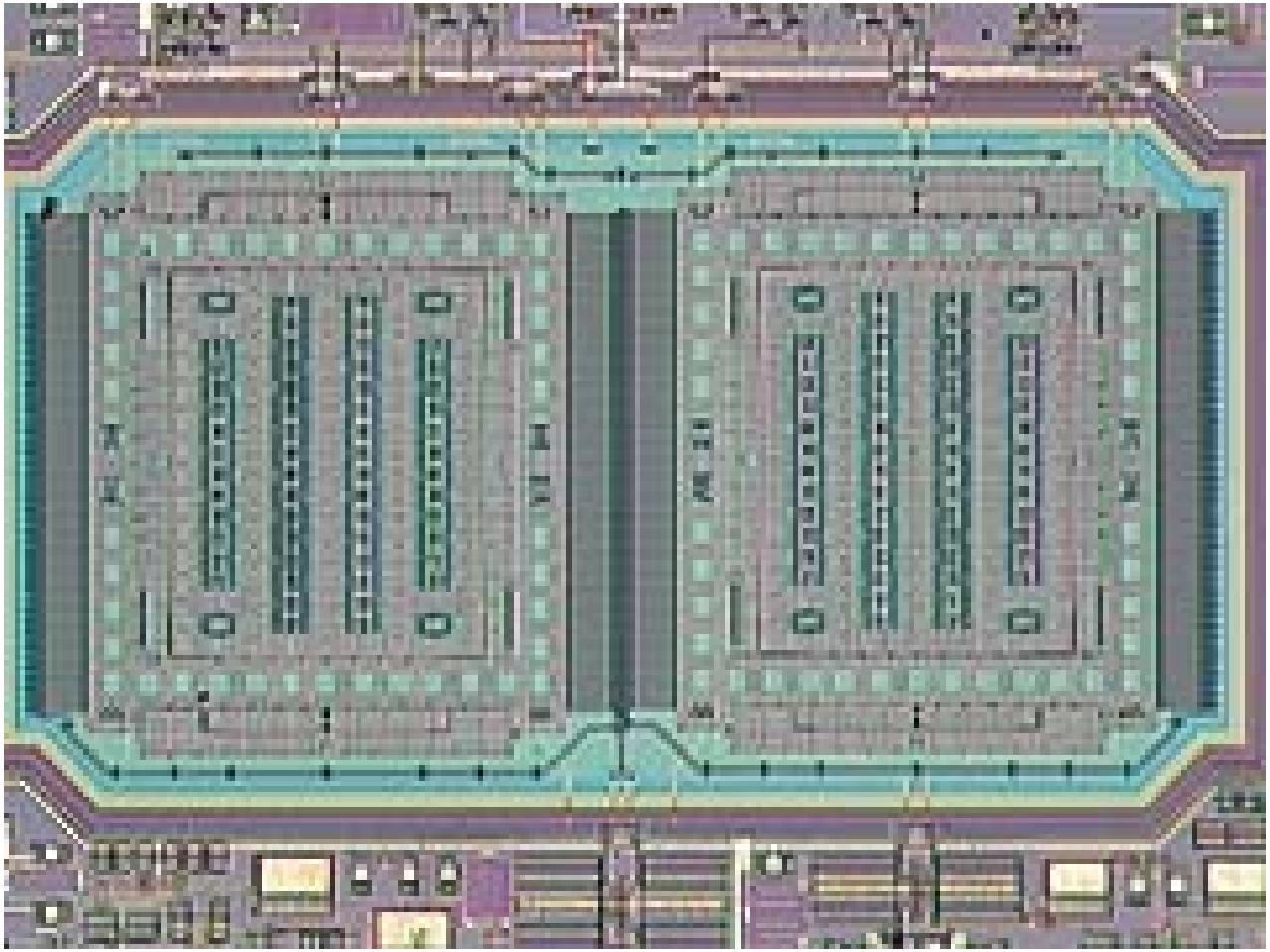






Images by
Sensors Online Magazine (sensormag.com)
David Krakauer, Analog Devices Inc.

Two sensors allow differential sensing to eliminate common-mode error (shock, vibration)



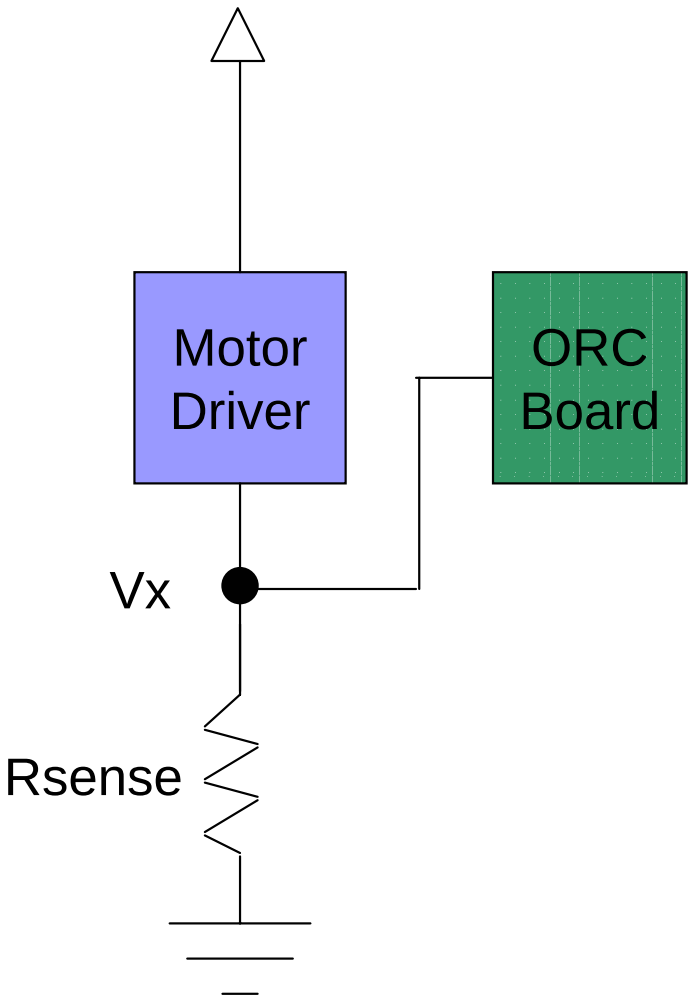
Images by
Sensors Online Magazine (sensormag.com)
David Krakauer, Analog Devices Inc.

Maslab bloopers

- Be aware of the size of your robot
- You clock is a sort of sensor, timeout!

Orc board features

- Configurable low-pass filter on analog inputs removes noise
  - Less need for a capacitor on the IR sensor
- Built-in current sense:
  - Approximate, but useful
  - All drive motors, servos 0 and 1
  - Current is proportional to torque
  - A known Rsense and measured voltage (Vx) yield current: V=IR
- Optional optical encoders
  - We'll demo, distribute today
  - Q = motor.encoder()
    Q = motor.encoderAbsolute();

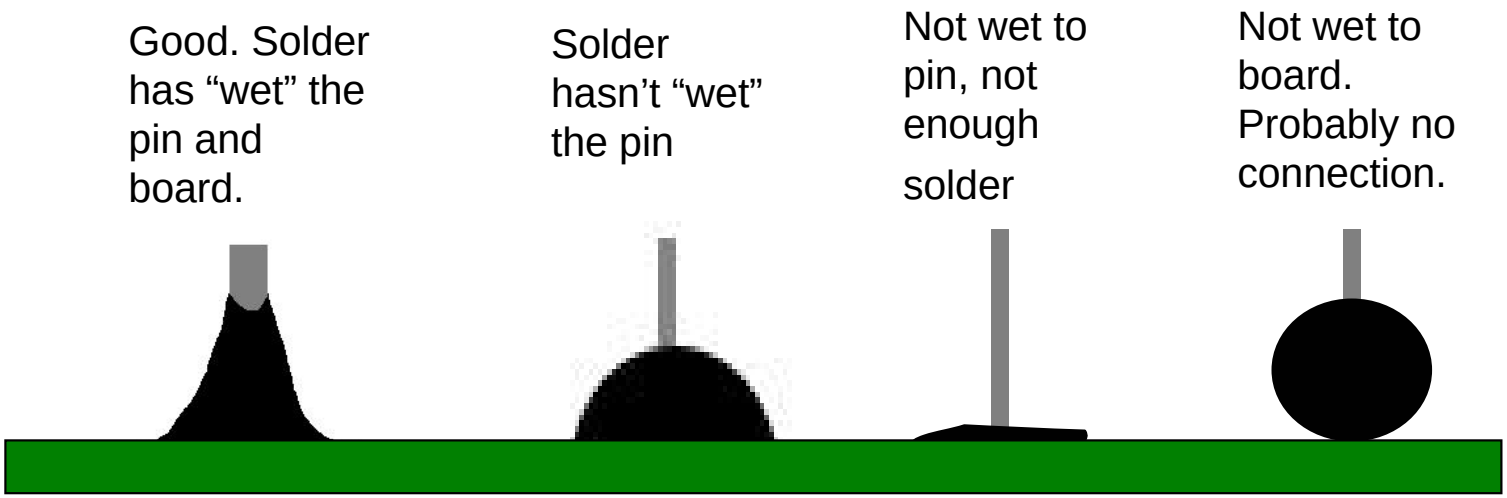


Some additional soldering points

- For MASLab-style soldering, a cheap iron probably will do.
  - Still, if you’re in the “biz”, an investment makes sense
- Some tools available for purchase through 6.270 store
  - Cheap soldering irons, helping hands, wire strippers
  - So cheap, who cares if it’s crappy?
  - Tell them you’re with MASLab.

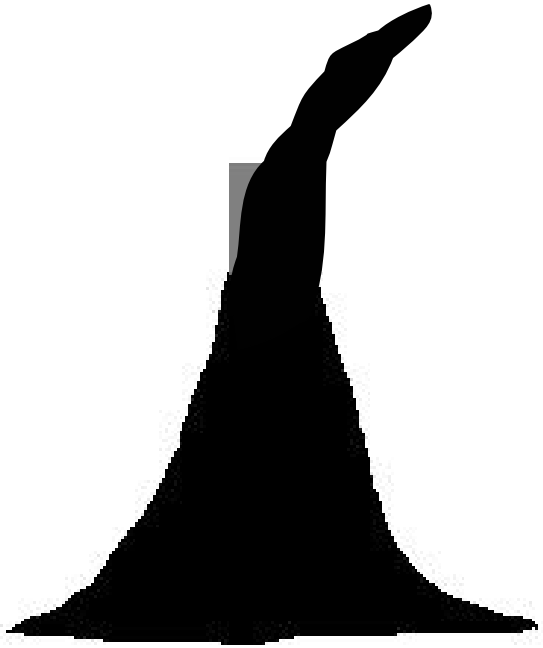
Soldering Mistakes

- Use a wet sponge to keep your iron tip clean
  - If you don't *have* a sponge, **get one**
  - Keep it *quite* damp. Don't want sponge to burn onto tip
- Make sure you apply heat to both surfaces to be joined and that solder "wets" both.



Soldering Mistakes

- Watch out for “ears”
  - Indicates a bit of oxidation, often aggravated by too much solder.
  - If the solder feels “thick”, then it’s oxidized some.
  - Connection is probably okay, but something to work on!
- On cables, can poke through insulation and heatshrinking!

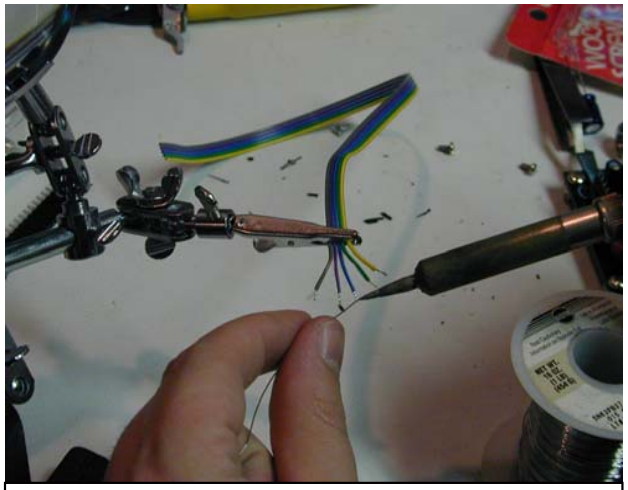


Cable making: General Tips

- Use Stranded Wire only, strip only ¼”, twist strands together
- Pre-tin all wire leads and header
- Use heatshrink on connections
- Header is plastic and will melt easily
- Use a dab of hot glue to reinforce (optional)
- Color code! Make absolutely sure pin 1 is indicated! (Use sharpie to indicate a pin if it’s not otherwise obvious to you and any random person.

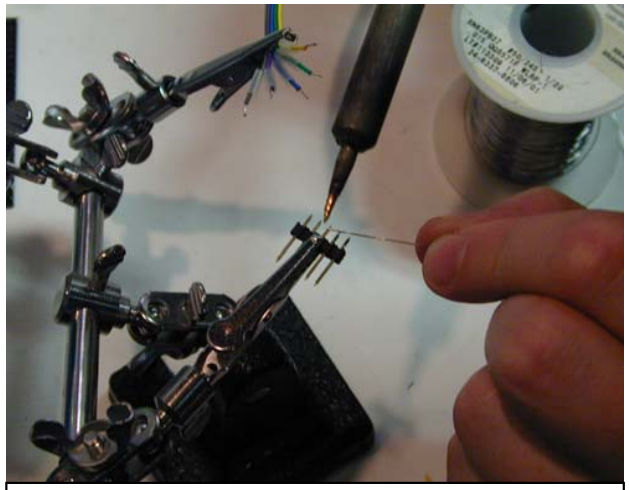
Cable making, step-by-step

Step 1



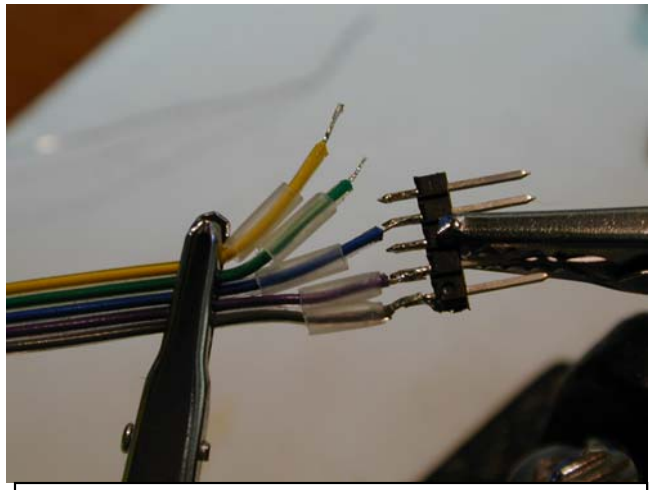
Pre-tin (add some solder) the stranded wire.

Step 2



Pre-tin the connector.

Step 3

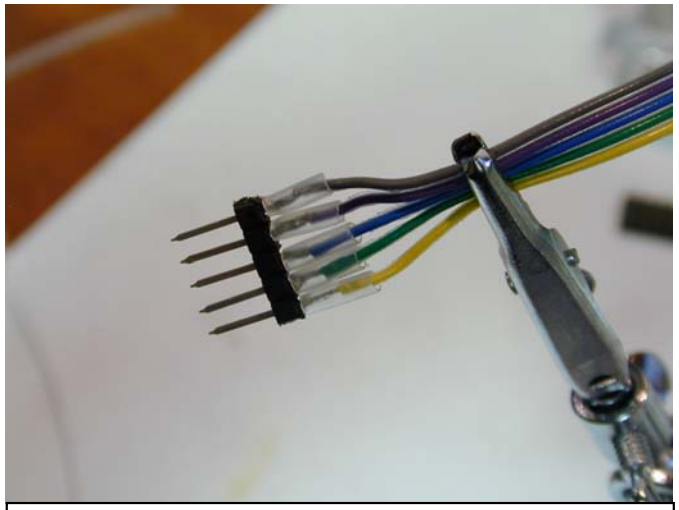


Add heat shrink tubing and solder the pins together.

Solder the wire to the header (not shown)…

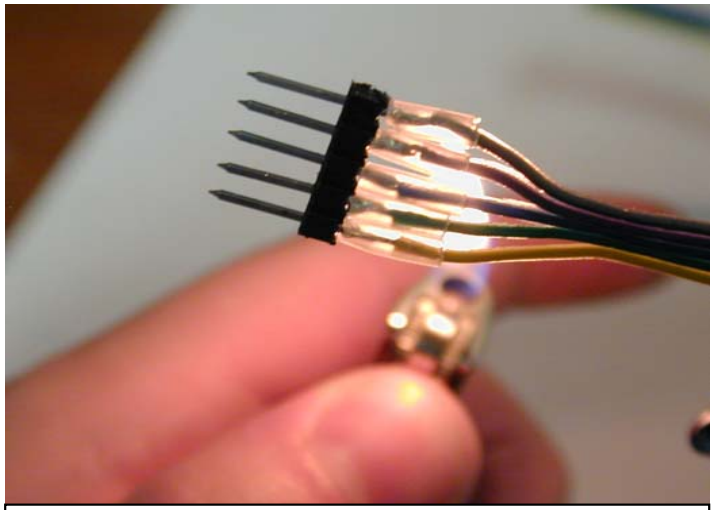
Cable making, step-by-step (cont)

Step 4



This cable is now ready for shrinking.

Step 5



Shrink the heatshrink tubing.

Cable Making: Pinouts

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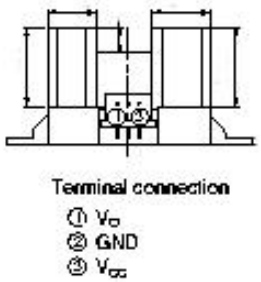

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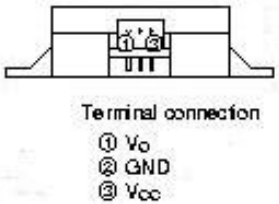

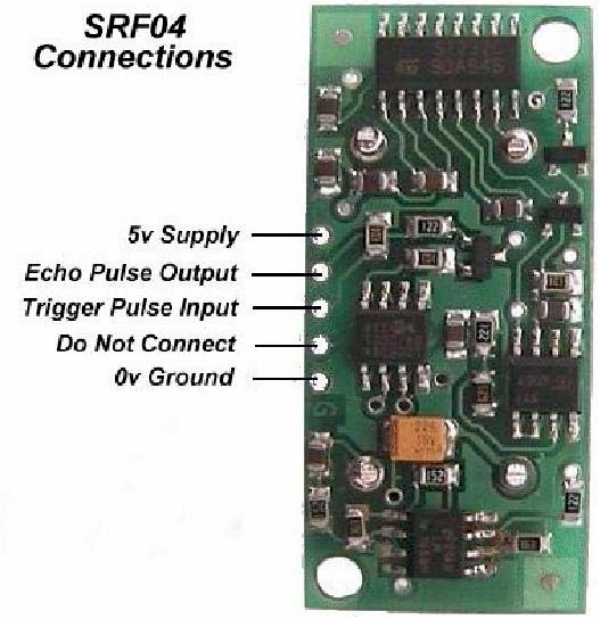

See Orc Manual for connector pinouts

Reminder

- Java for the clueless” - tonight, 7-9PM, 34-501
- Today:
  - Make sensor cables; start with short range IR
  - Characterize sensors
    - Handy worksheets
    - Build your intuition *and* start making [mental] selections
  - PegBot: IR proximity with OrcPad feedback. Choose bump/nobump or edge finder.