

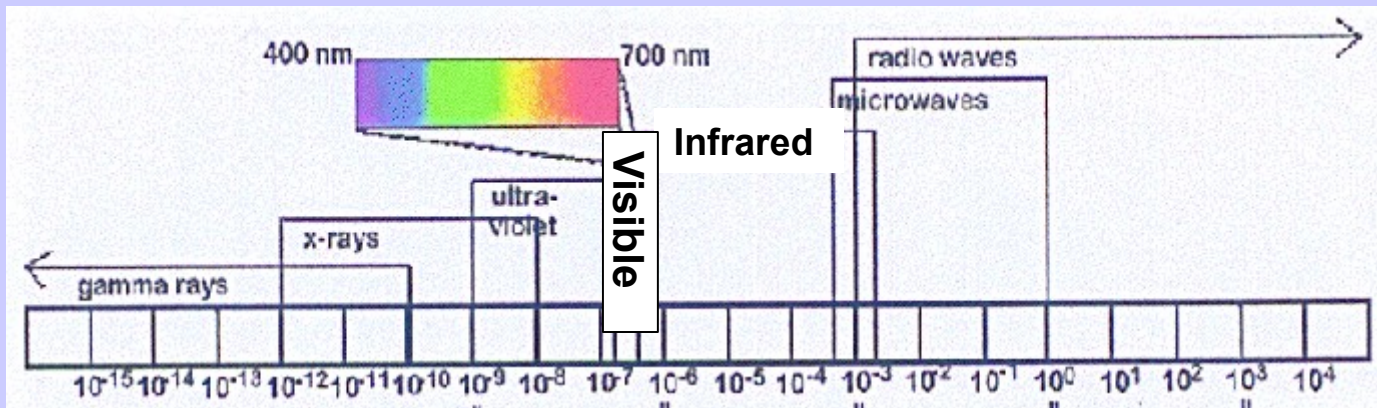
.: maslab 2006 :: dheera venkatraman

# Maslab Sensor Types

- Common types:
  - Camera
  - Infra-Red (IR) range finders/reflectance
  - Ultrasound
  - Bump sensors
  - Gyroscopes: Angular Rate Sensor
  - Motor current sensing
  - Optical encoders
  - Timer
- Other types:
  - Photodiodes from 6.270
  - Digital Compass
  - Reed switch
  - Mercury switch
  - Be creative!

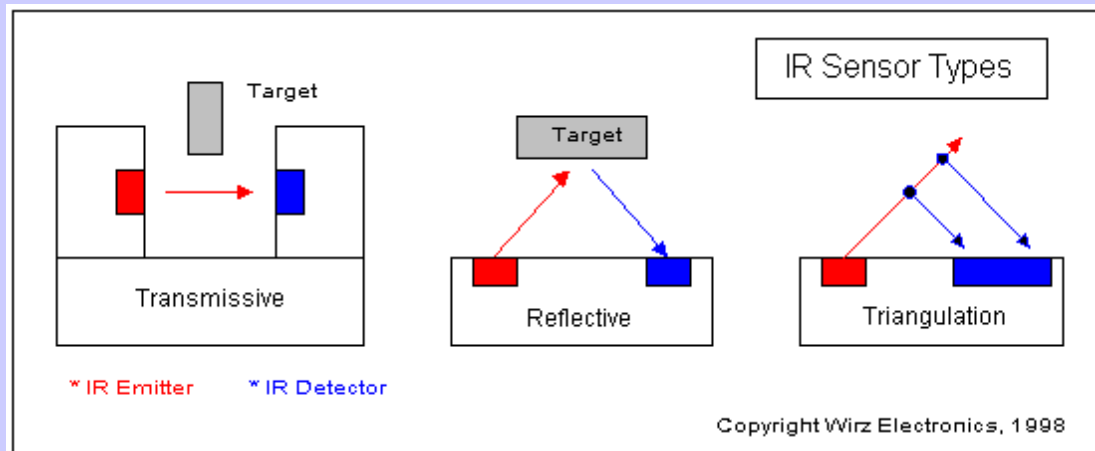
# 1. Infrared

- 750 nm to 1,000,000 nm
  - We use near-infrared, ~900nm. Used often 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



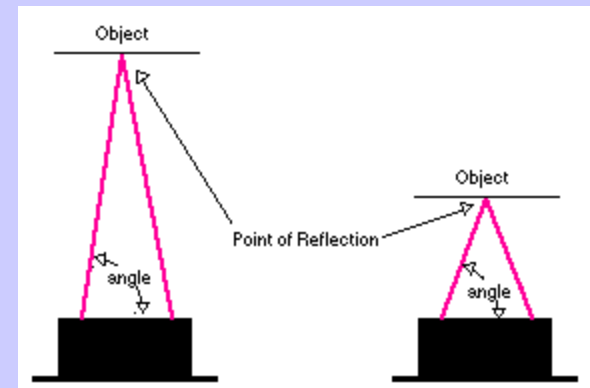
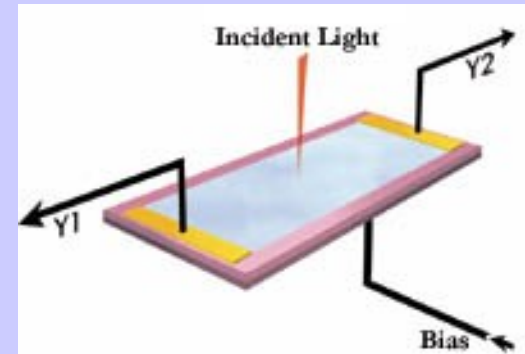
# 1. Infrared: Simple IR sensors

- 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



# 1. Infrared: Maslab 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



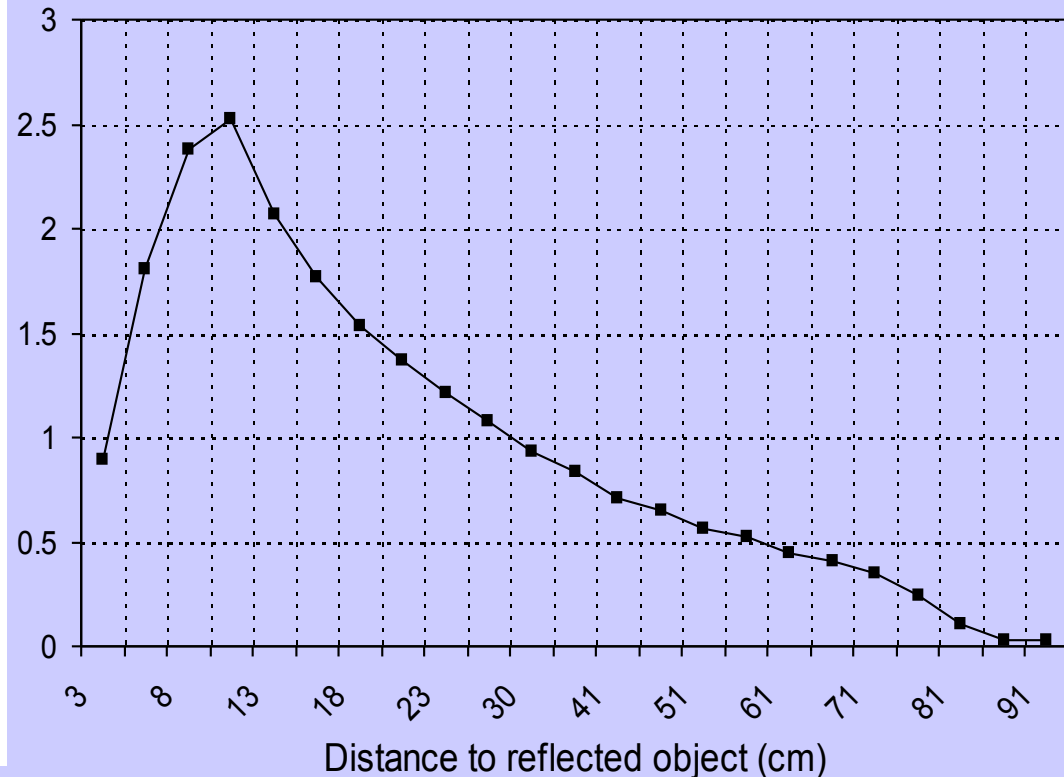
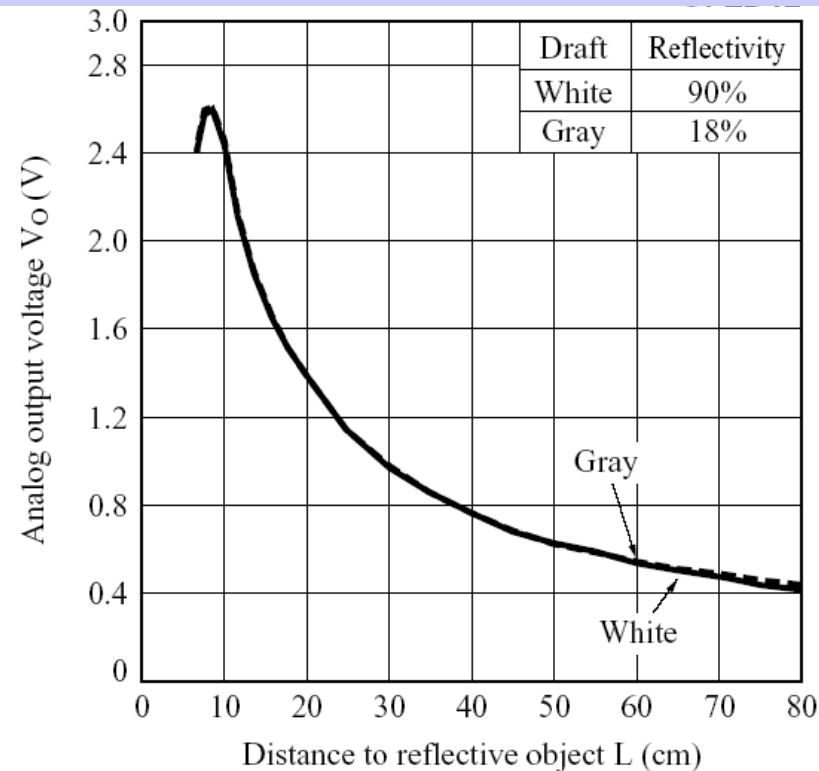
Wider angle = greater distance

Figure: Acroname.com

# 1. Infrared: Lies, damn lies, and datasheets?

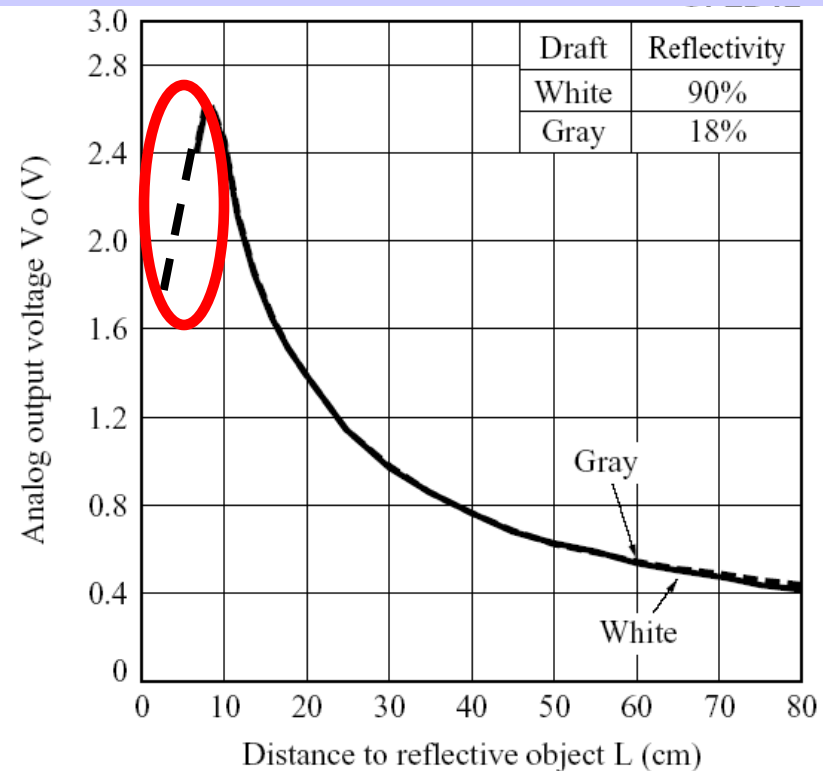
GP2D12: Theoretical Range:  
4in (10cm) to 31in (80cm)

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



# 1. Infrared: Non-linear response

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

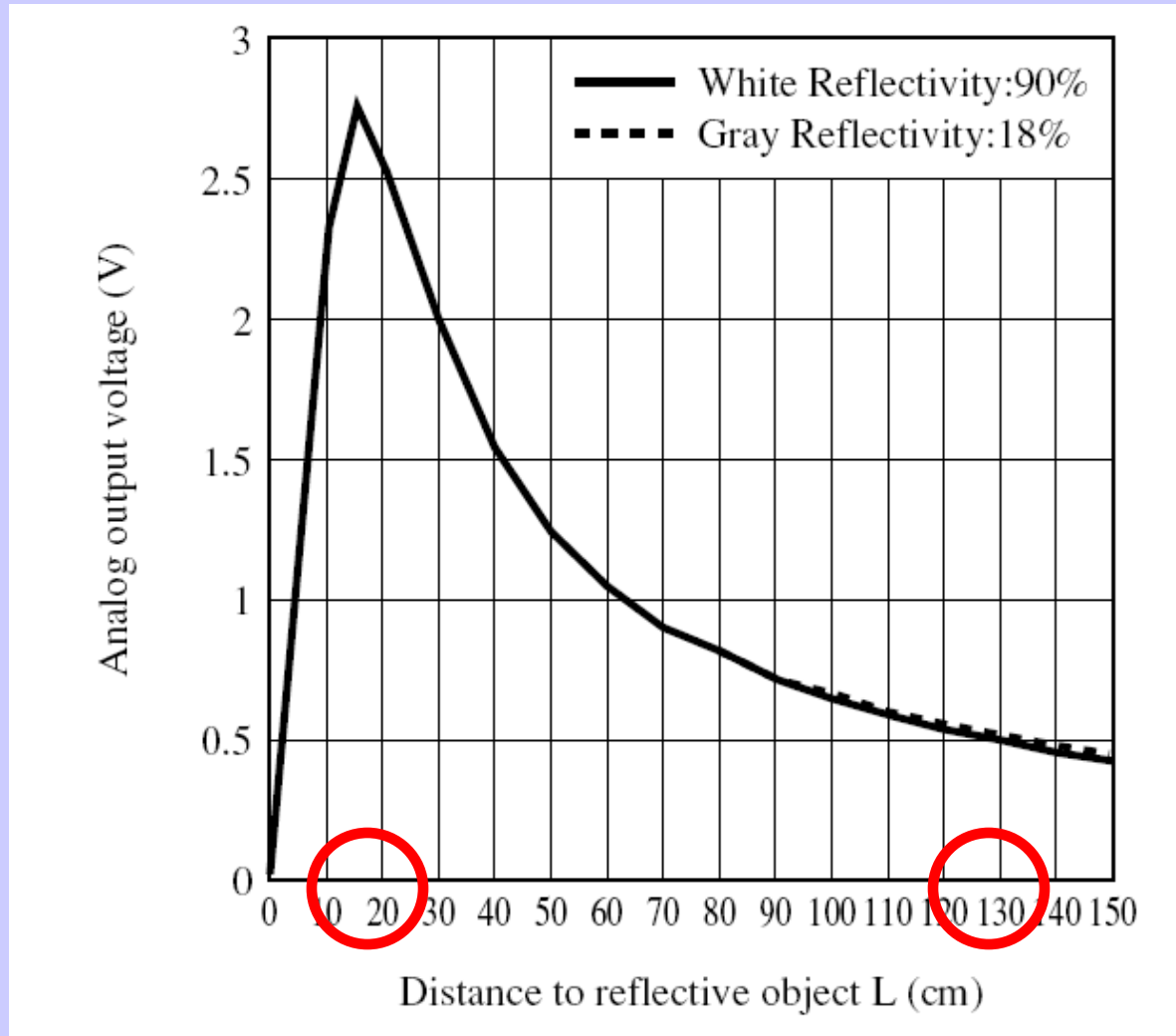


- Orc library use inverse of curve and fits a line

- Voltage =  $1/(\text{distance} + X_d) * X_m + X_b$
- distance =  $(X_m/(\text{Voltage} - X_b)) - X_d$

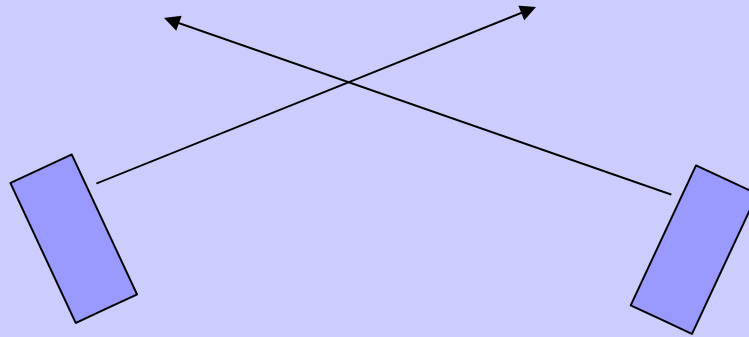
# 1. Infrared: Long range IR sensor

Model: GP2Y0A02YK



# 1. Infrared: 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



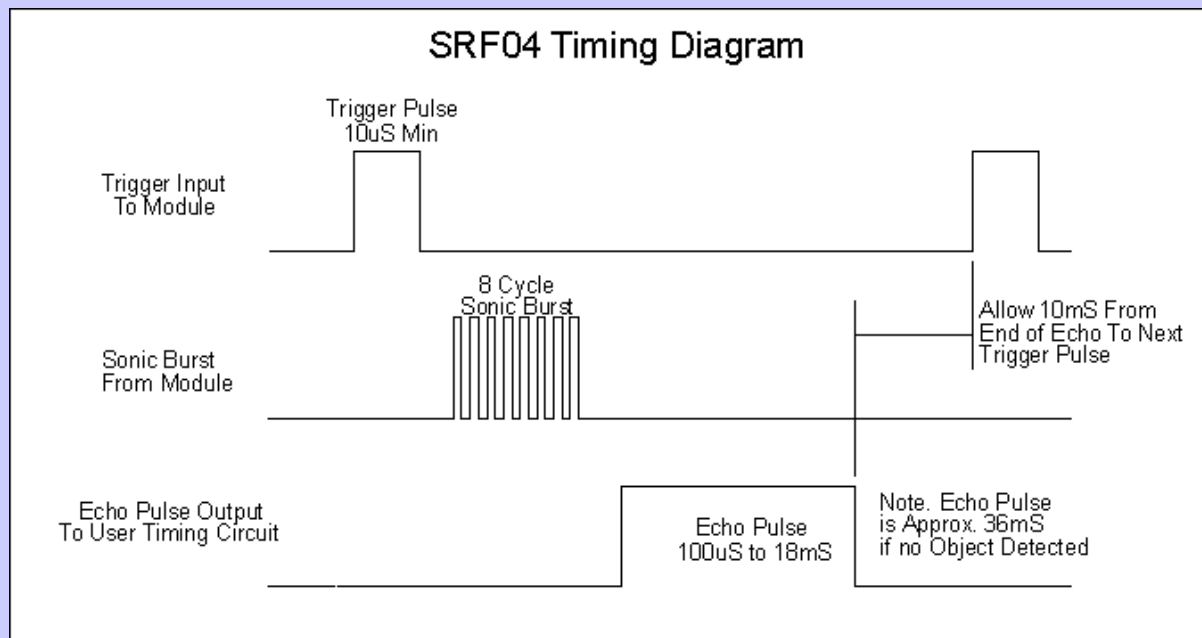
# 1. Infrared: IR Rangefinders

- Can use signal strength
  - Sort of, but materials reflect differently
- Can use time-of-flight,  $c=299792458$  m/s
  - How fast can you count?
    - Not fast enough!
  - Sick industrial laser scanner: \$5000
    - Provides ~5cm accuracy,  $\frac{1}{4}$  degree resolution, 30m range
    - (collective “ooooh!”)

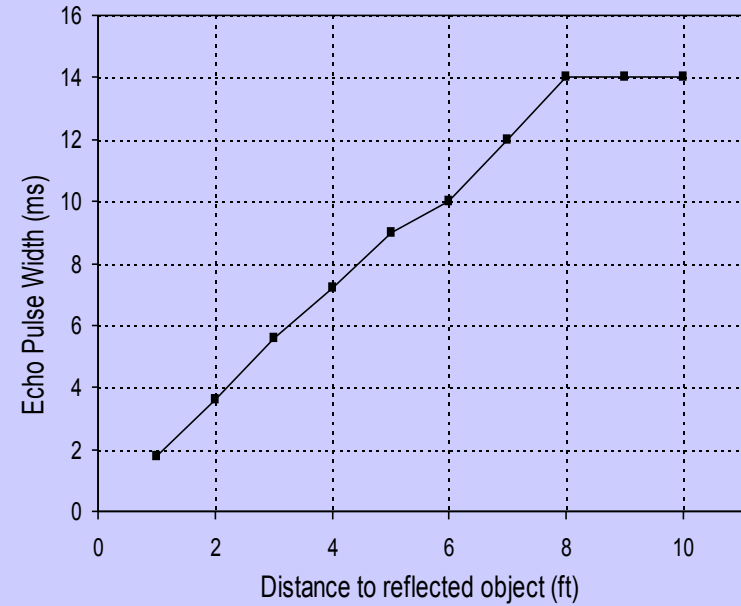
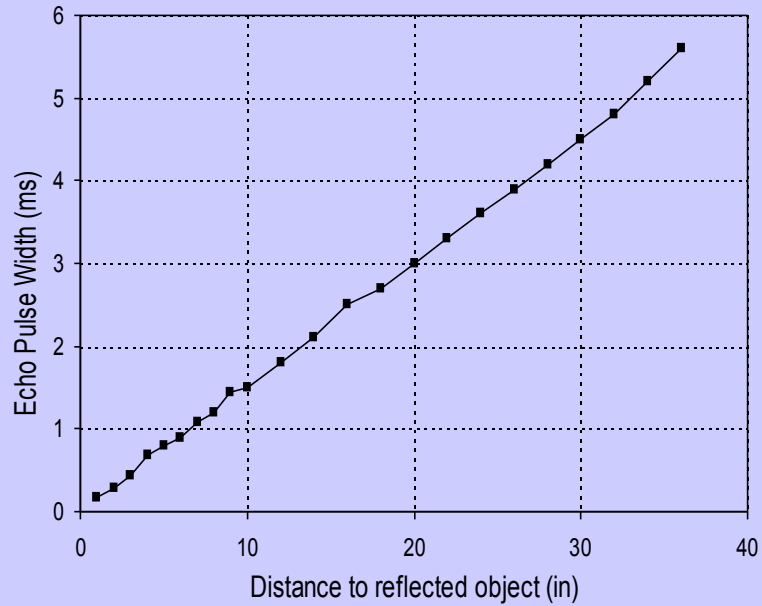


## 2. Ultrasound Rangers

- Send an ultrasonic pulse, listen for an echo
- Time of flight. Speed of sound only  $\sim 347$  m/s

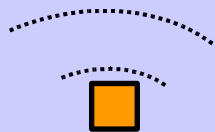
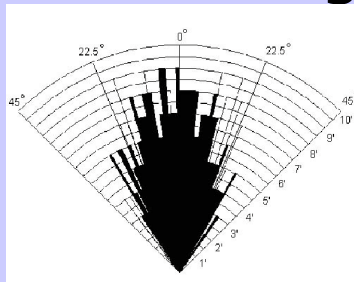


## 2. Ultrasound Rangers: Properties

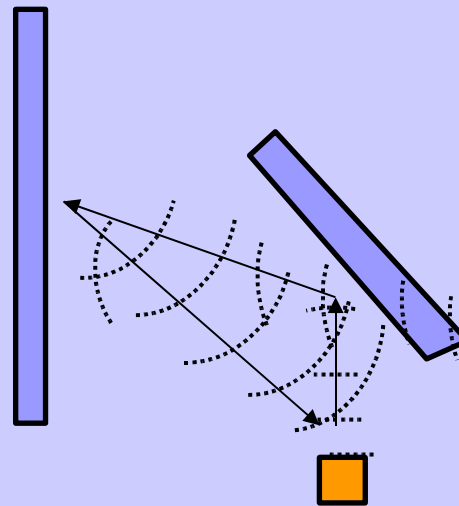


## 2. Ultrasound Rangers: Properties

- Broad beam width “blurs” detail... but less likely to “miss” something
- **Caveat:** Sound can “scatter” or “reflect” off other objects.



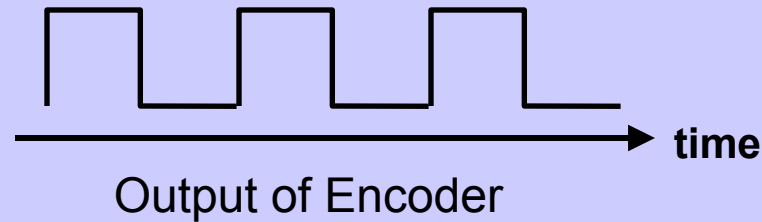
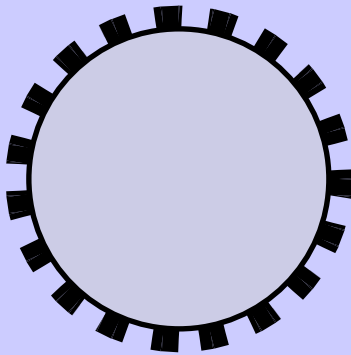
Small detail hard to resolve



Multipath can fool you!

### 3. Optical encoders

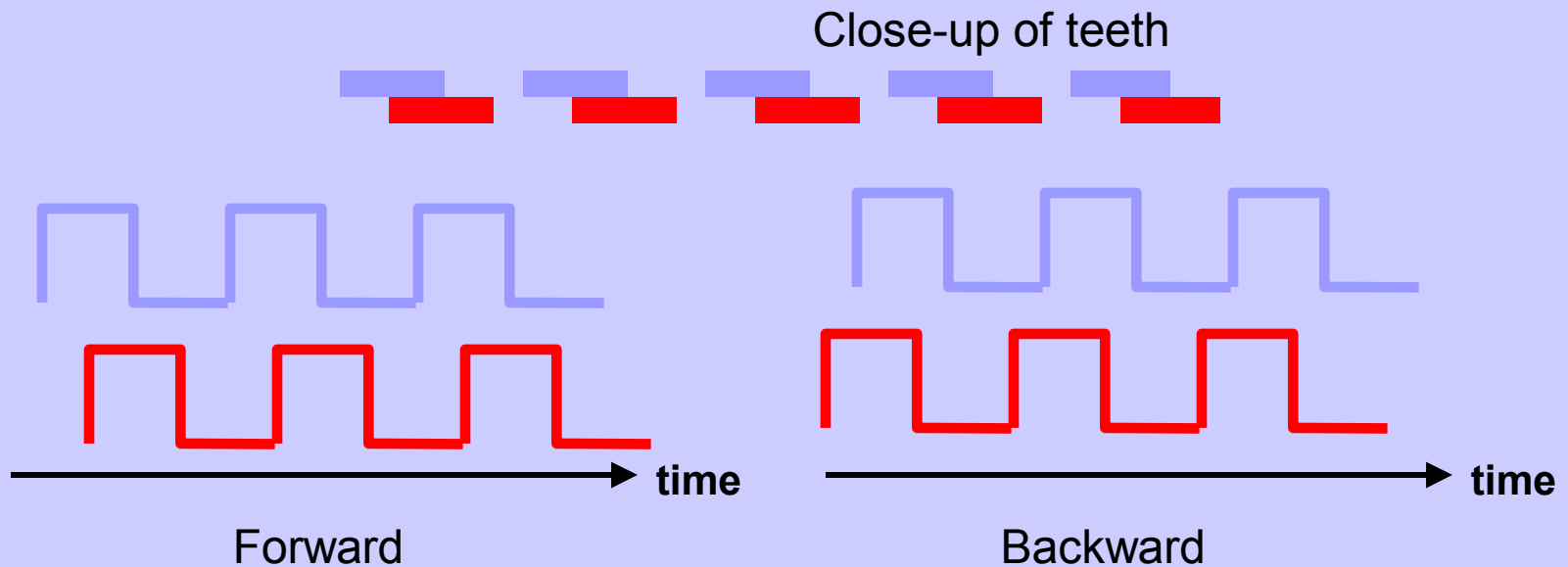
- Attach a disk to the motor shaft and attach a break-beam sensor across the teeth.



- 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?

### 3. Optical encoders: Quadrature Encoders

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



Forward and backward are now distinguishable!

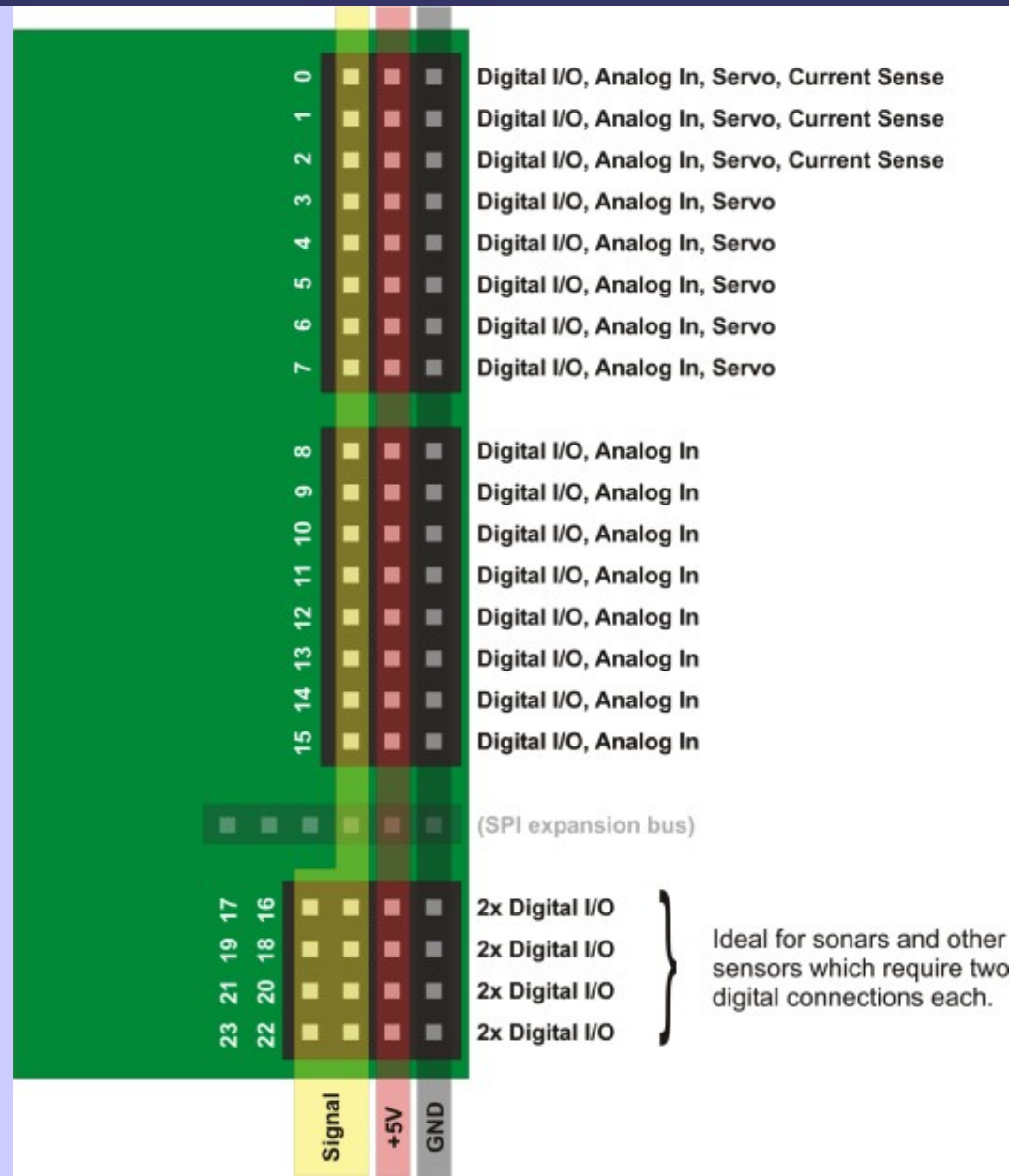
Illegal state transitions cancel out (for each spurious forward tick, there's a spurious backward tick)

### 3. Optical encoders: Applications

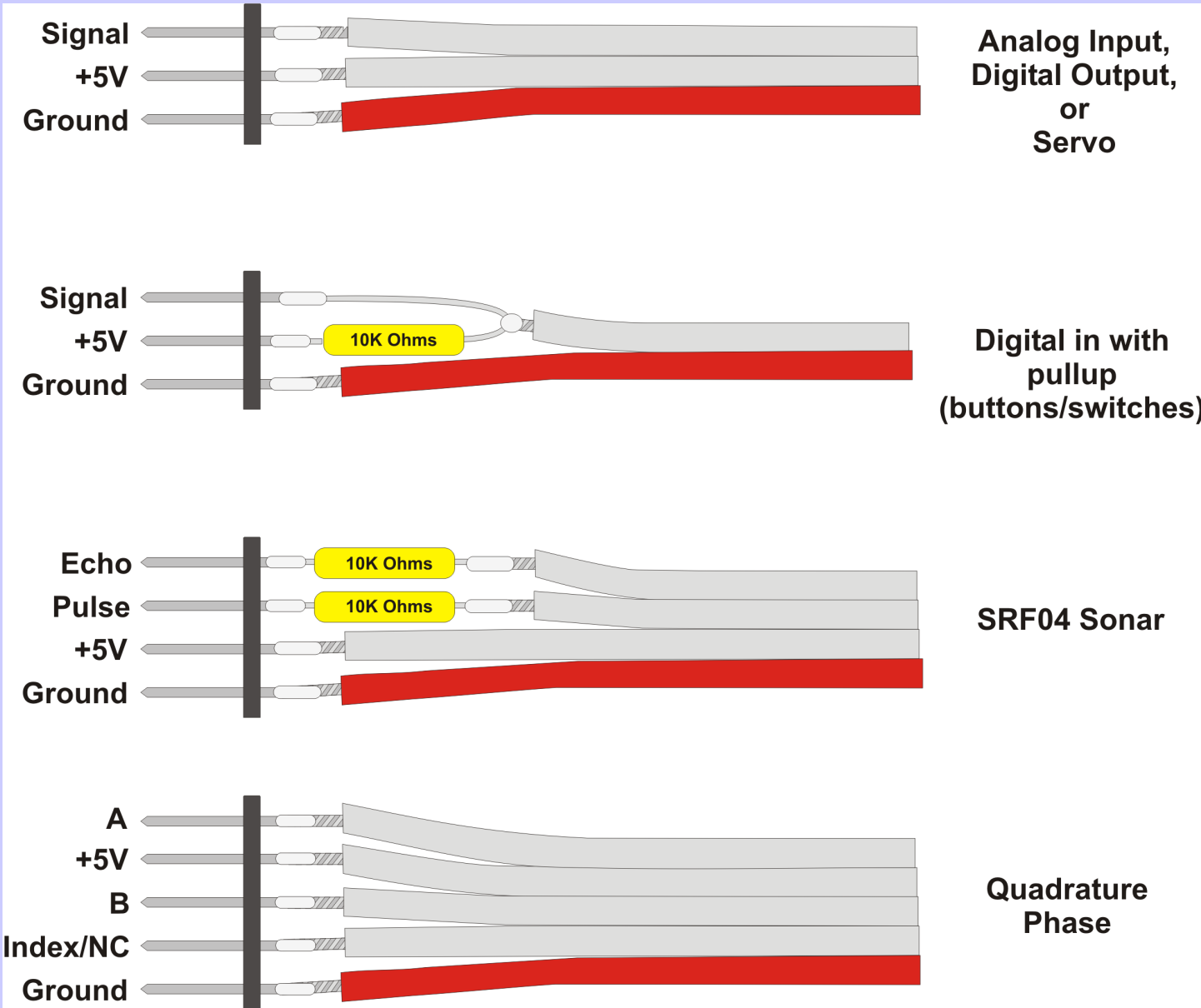
- Quad phase can allow us to:
  - Do relative positioning– i.e., rotate 10 clicks from our present position (remember that gyro can help with this)
  - Do velocity control.
    - “driving” but not ticking? Probably stuck. Current spike may reveal this, too.
    - It’s hard to drive in a straight line.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

# 4. Digital Inputs

- Bump sensors
- Hall magnetic sensors
- Reed switches
- Mercury switches
- Uses a pull-up resistor that you need to include when making a sensor cable.



# 4. Digital Inputs: Cable assembly

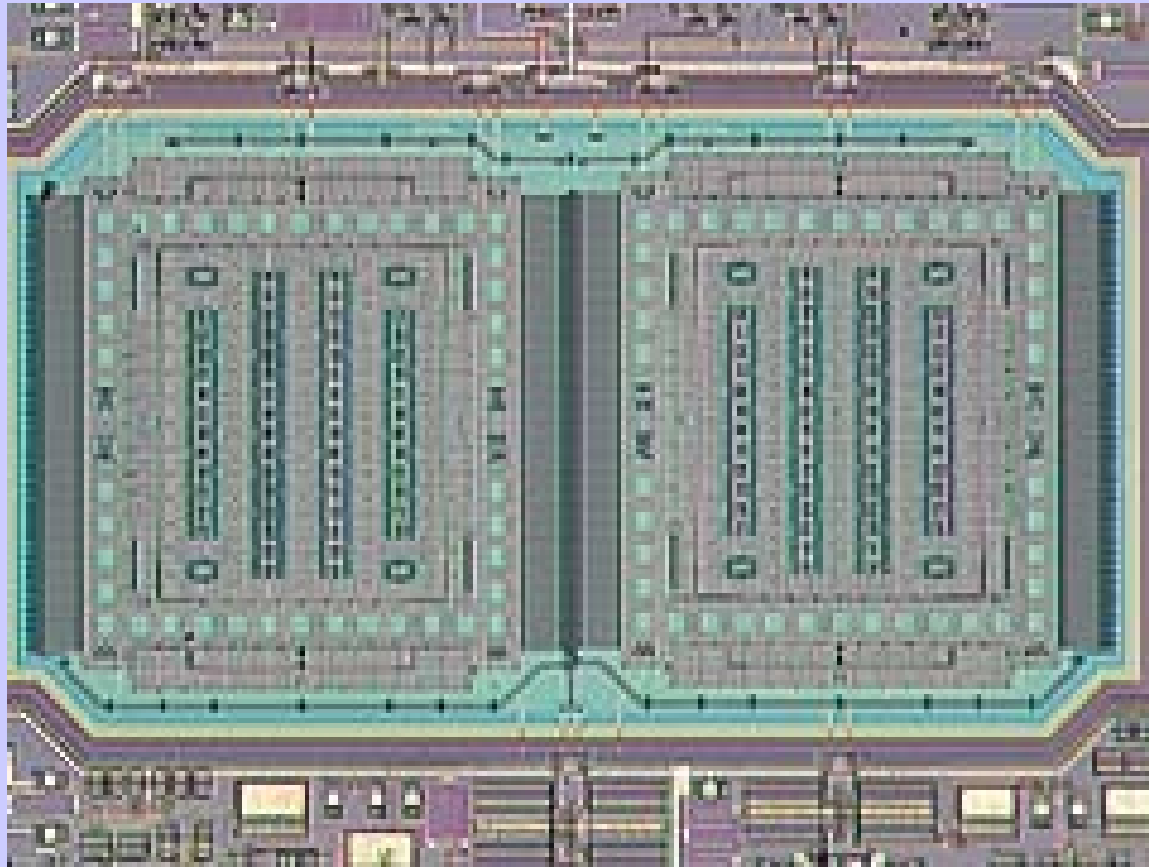


# 5. MEMS Gyroscope

- Outputs a voltage corresponding to degrees/sec
- Note that OrcBoard integrates for you
  - Thanks, Ed!
  - **Caveat:** 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)



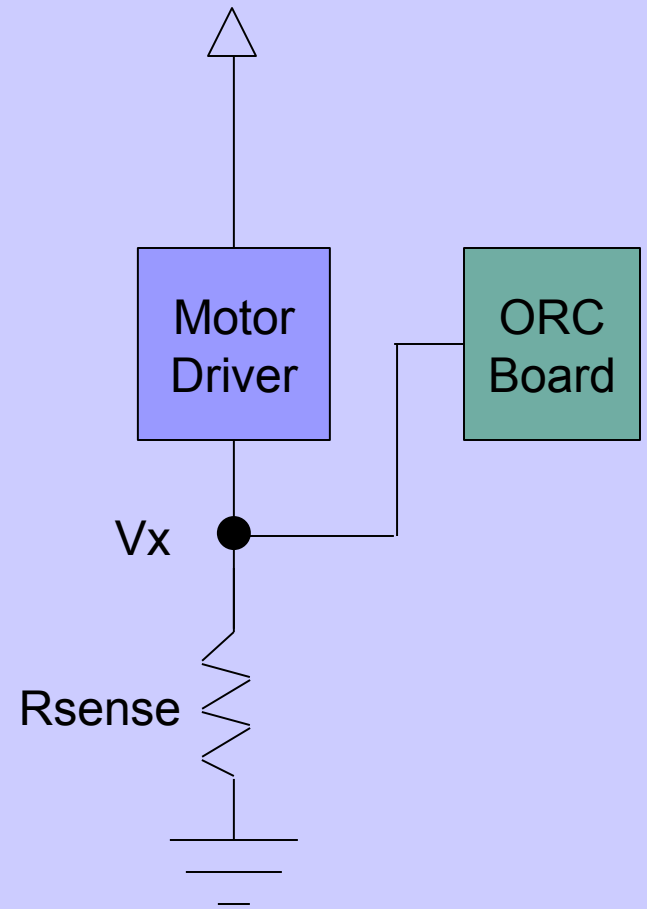
## 5. MEMS Gyroscope: How it works



Images by  
Sensors Online Magazine ([sensormag.com](http://sensormag.com))  
David Krakauer, Analog Devices Inc.

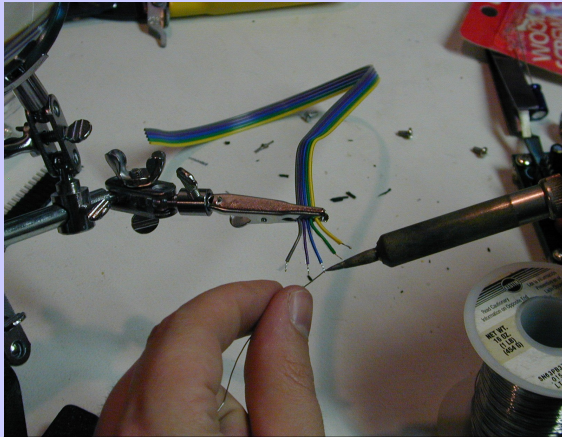
## 6. Other sensors

- Built-in motor current sense
- Timer
- Last but not least: **Camera!**



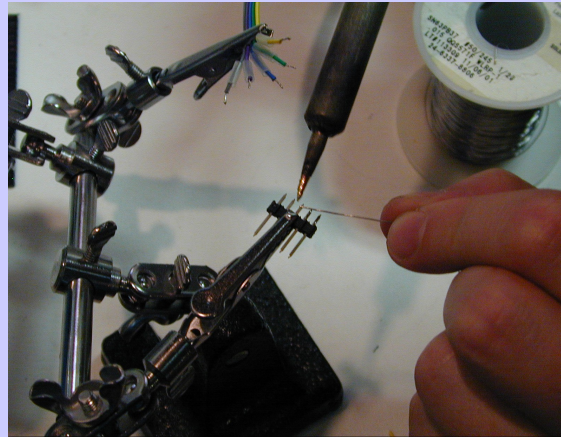
# Cable making, step-by-step

## Step 1



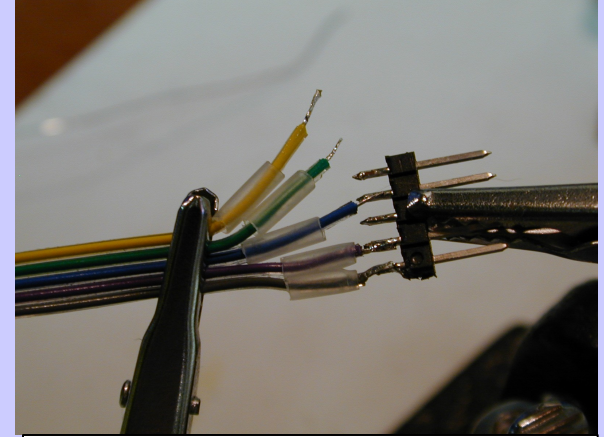
**Pre-tin (add some solder) the stranded wire.**

## Step 2



**Pre-tin the connector.**

## Step 3

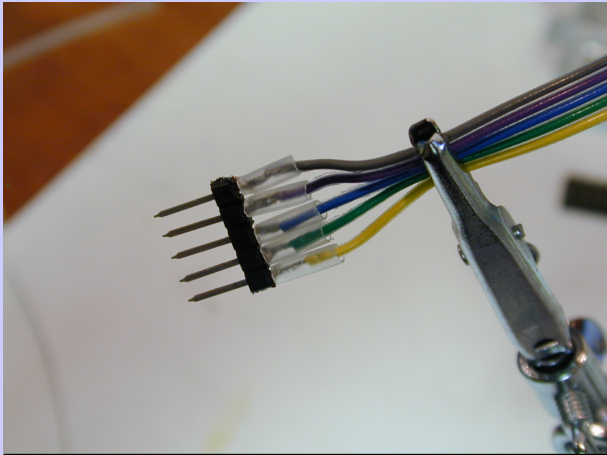


**Add heat shrink tubing and solder the pins together.**

Solder the wire to the header (not shown)...

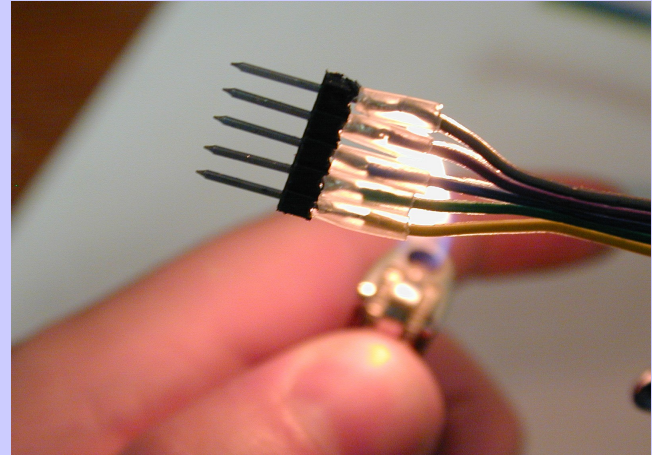
# Cable making, step-by-step

## Step 4



**This cable is now ready for shrinking.**

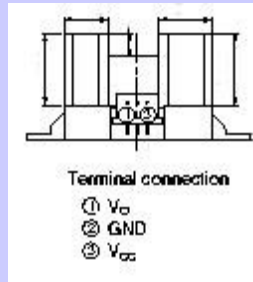
## Step 5



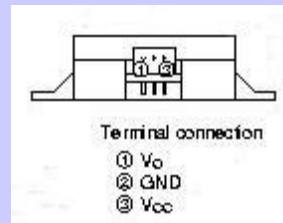
**Shrink the heatshrink tubing.**

# Cable Making: Pinouts

GP2Y0A02YK

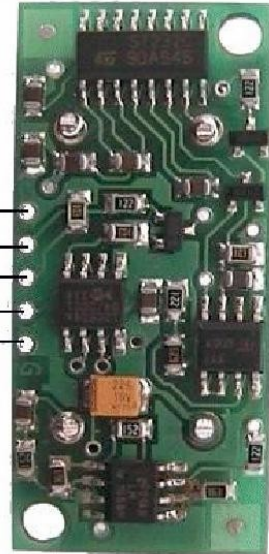


GP2D12



**SRF04  
Connections**

5v Supply  
Echo Pulse Output  
Trigger Pulse Input  
Do Not Connect  
0v Ground



See Orc Manual for connector pinouts

# Maslab bloopers: things to think about

- Camera calibration (different in 26-100!)
- Vision algorithms
- IR too close to edge of robot
- Noise and sensor failure
- Timer as a sensor: stop motors
- Robot size
- Backups! + repositories

**Start thinking now.**