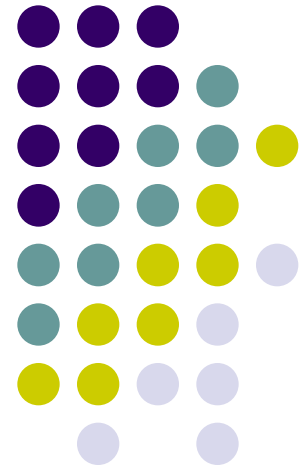


Chapter 13: Servo

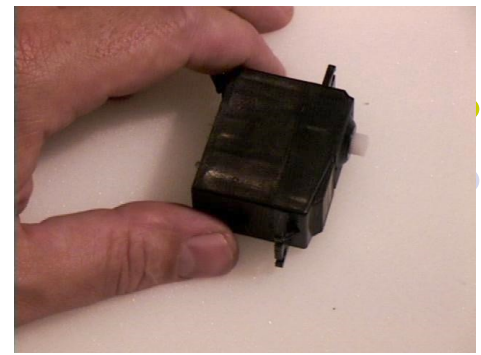
EE2405

嵌入式系統與實驗

Embedded System Lab



Overview



- Servo motors are used for angular positioning, such as in radio control airplanes.
 - They typically have a movement range of 180 deg but can go up to 210 deg.
 - The output shaft of a servo does not rotate freely, but rather is made to seek a particular angular position under electronic control.
- They are typically rated by torque and speed.
 - A servo rated 40 ounce-in/.21 means that at 1 inch from the hub, the servo can exert 40 ounces of force and move 60 deg in 0.21 sec.



Components of a Servo

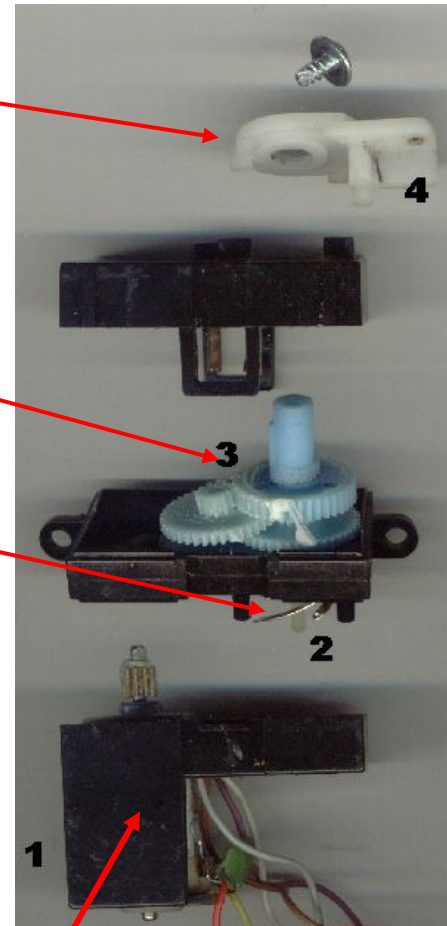
A potentiometer (variable resistor) measures the position of the output shaft at all times so the controller can accurately place and maintain it's setting.

Actuator

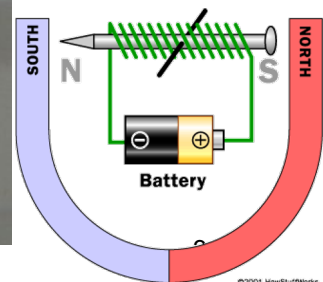
Reduction gear

Position feedback

Potentiometer
(closed loop system)



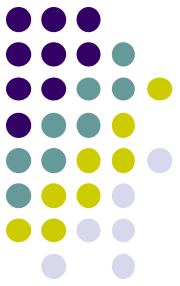
Small electric DC motor



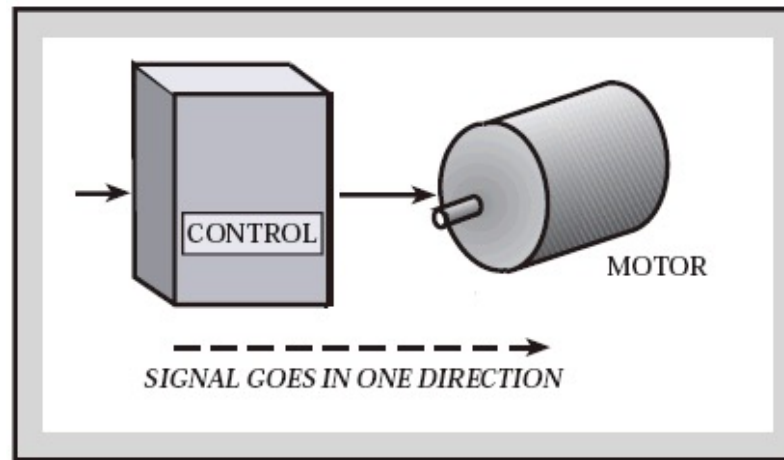
How DC motor works

<https://www.youtube.com/watch?v=GQatiB-JHdI>

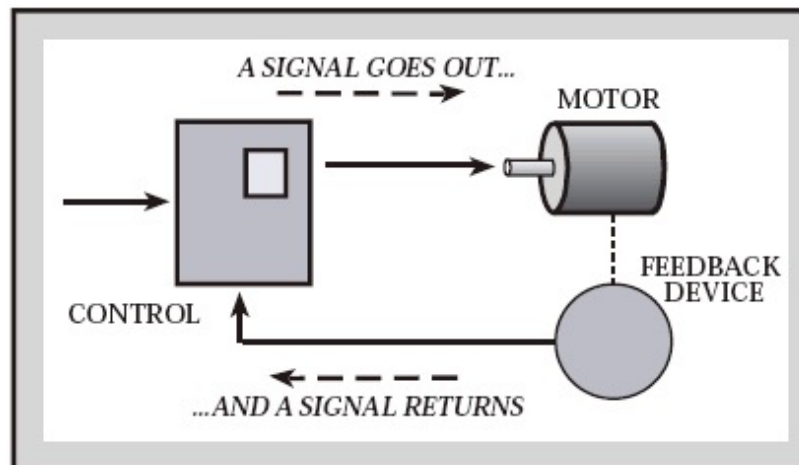
Feed-back loop



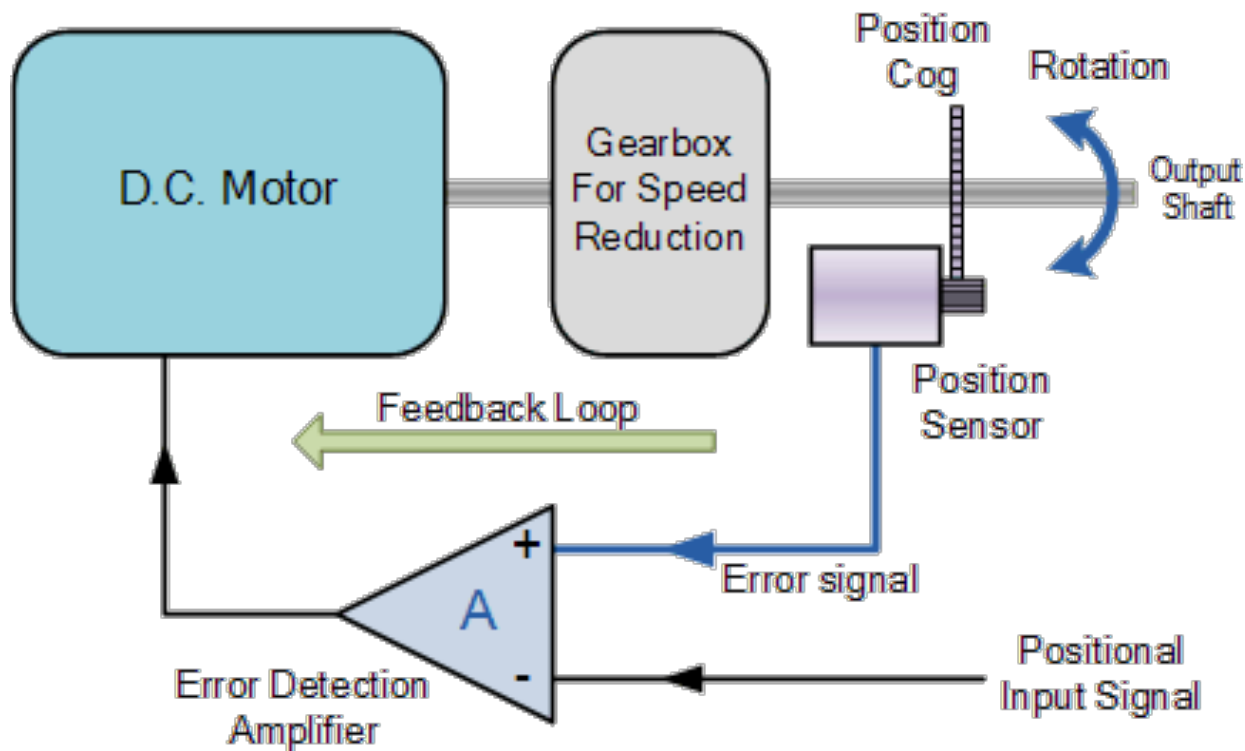
open-loop



closed-loop



DC Servo Motor Block Diagram

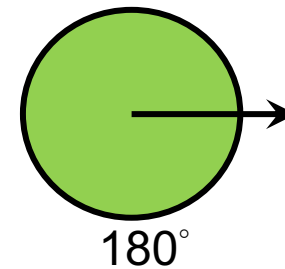
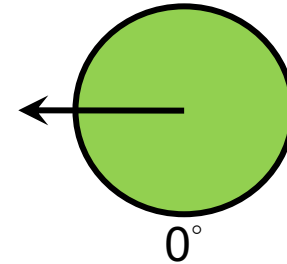
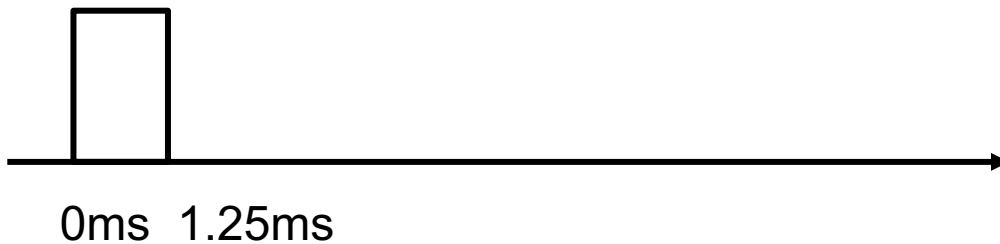
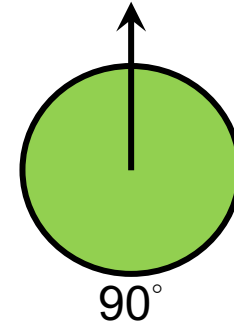
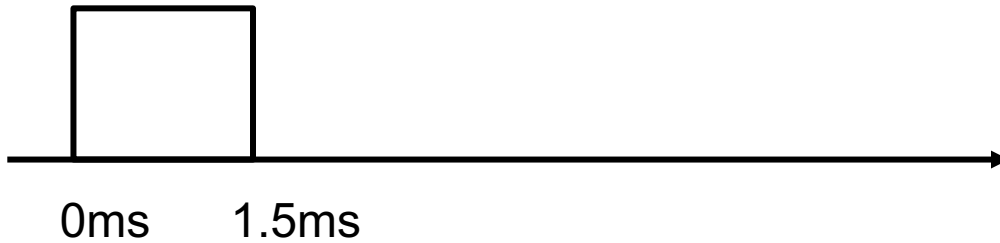
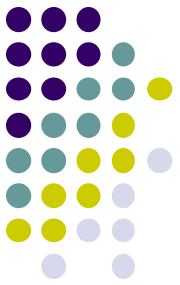


Servo Control with PWM Signals

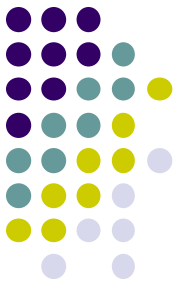


- PWM uses ~ 1 to 2ms out of a 20ms time period to encode its information.
 - The servo expects to see a pulse every 20 milliseconds.
 - The angle is determined by the duration of the pulse applied to the control wire.
 - As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft.

PWM Control Illustration

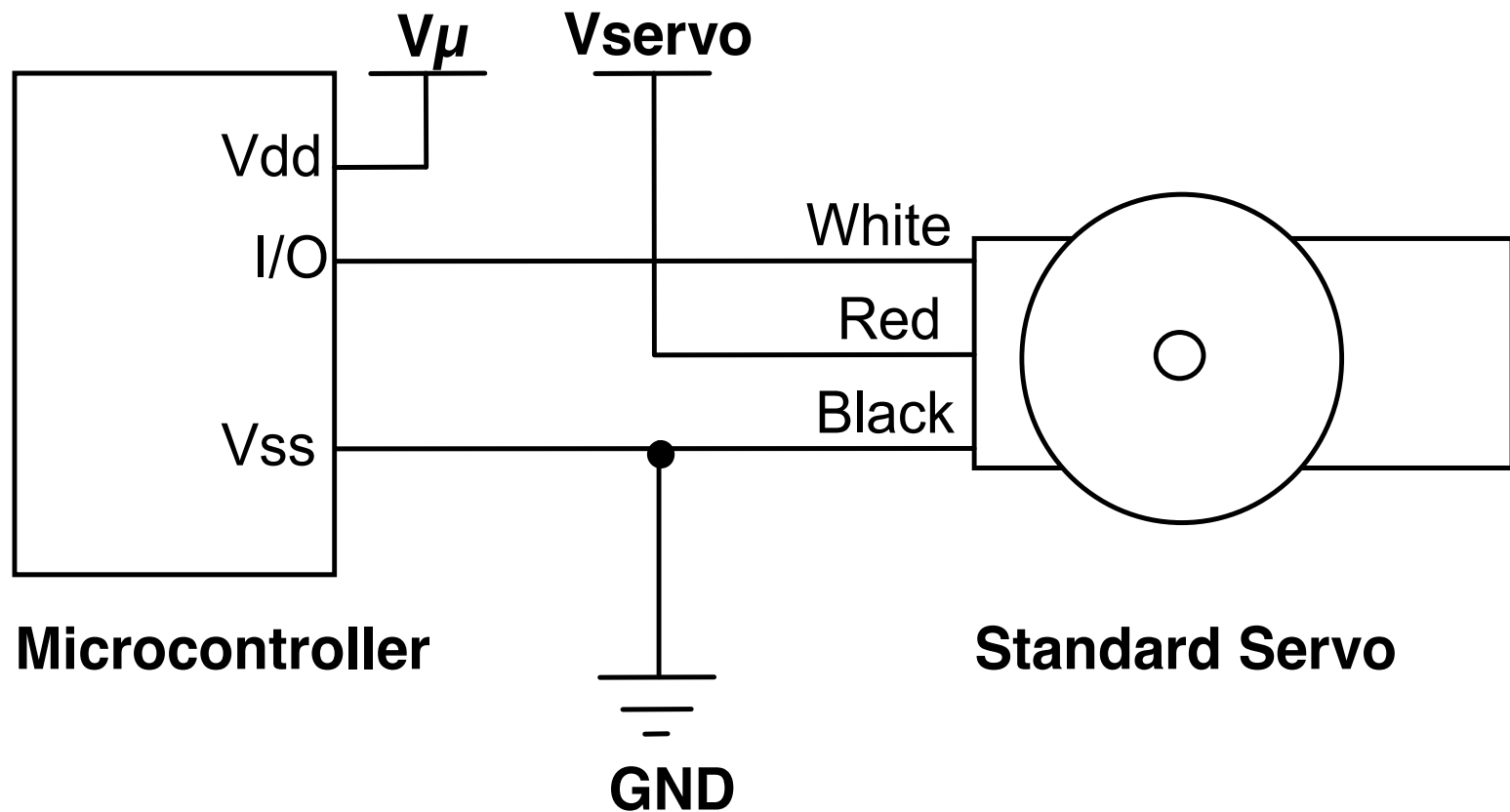
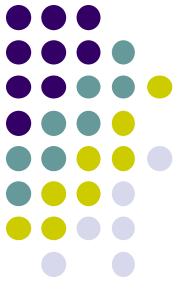


Parallax Standard Servo

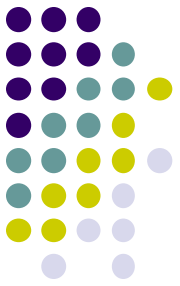


- Provides 180° range of motion and position control
- 38 oz-in torque at 6 VDC
- 4 to 6 VDC
- Maximum current draw is 140 +/- 50 mA at 6 VDC when operating in no load conditions
- Pulse-width modulation, 0.75–2.25 ms high pulse, 20 ms intervals

Parallax Servo Connection

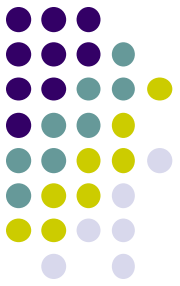


Power Precautions

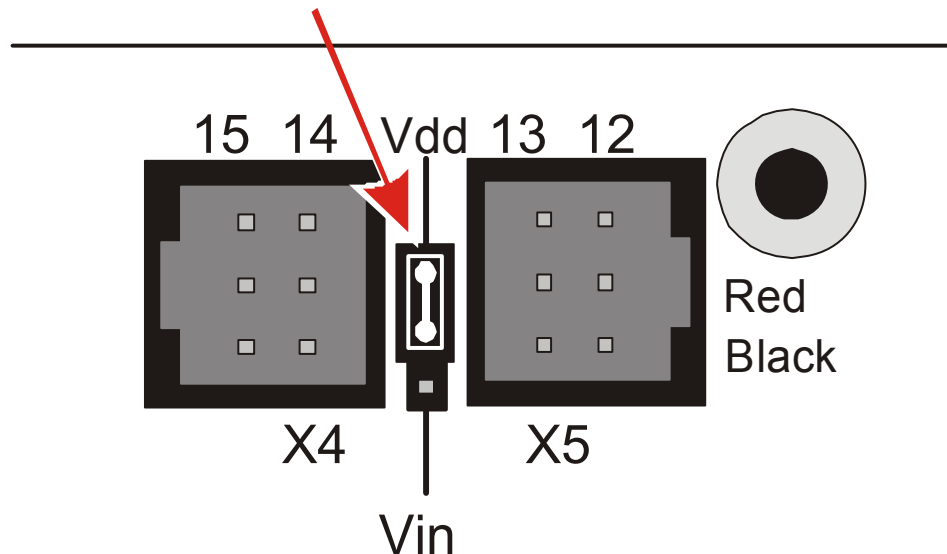


- Do not use this servo with an unregulated wall-mount supply.
- Do not power this servo through the microcontroller's Vdd pin.
- Servo current draw can spike while under peak load
 - Regulator should be prepared to supply adequate current for all servos used in combination.

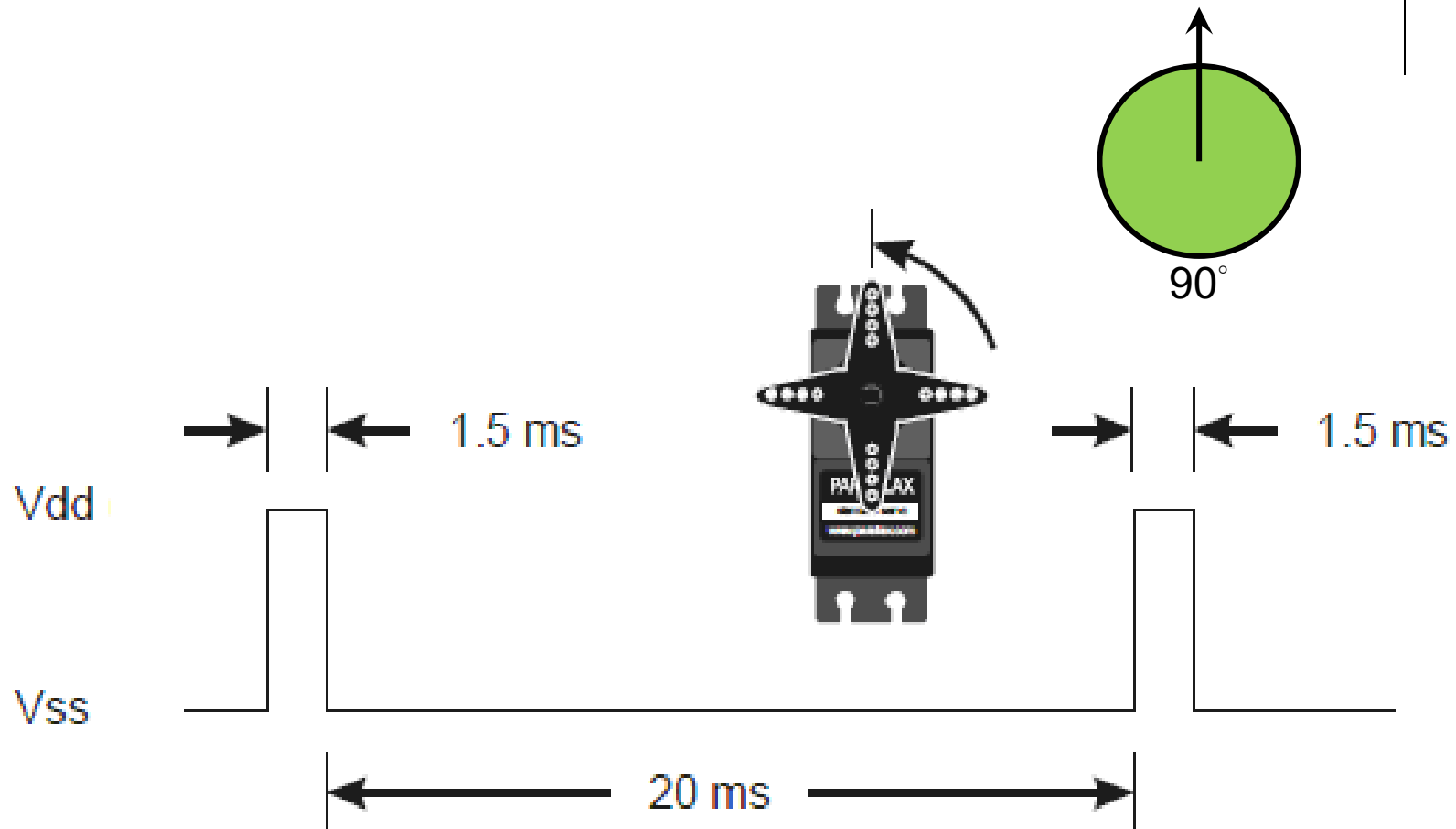
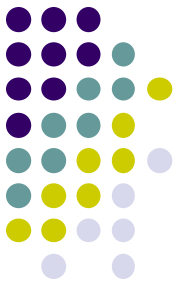
BOE Jumper Connection



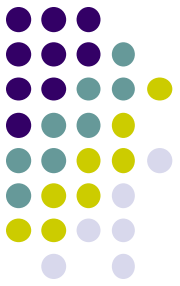
- Be sure the jumper is set to Vdd (regulated 5 VDC for this board)



Communication Protocol

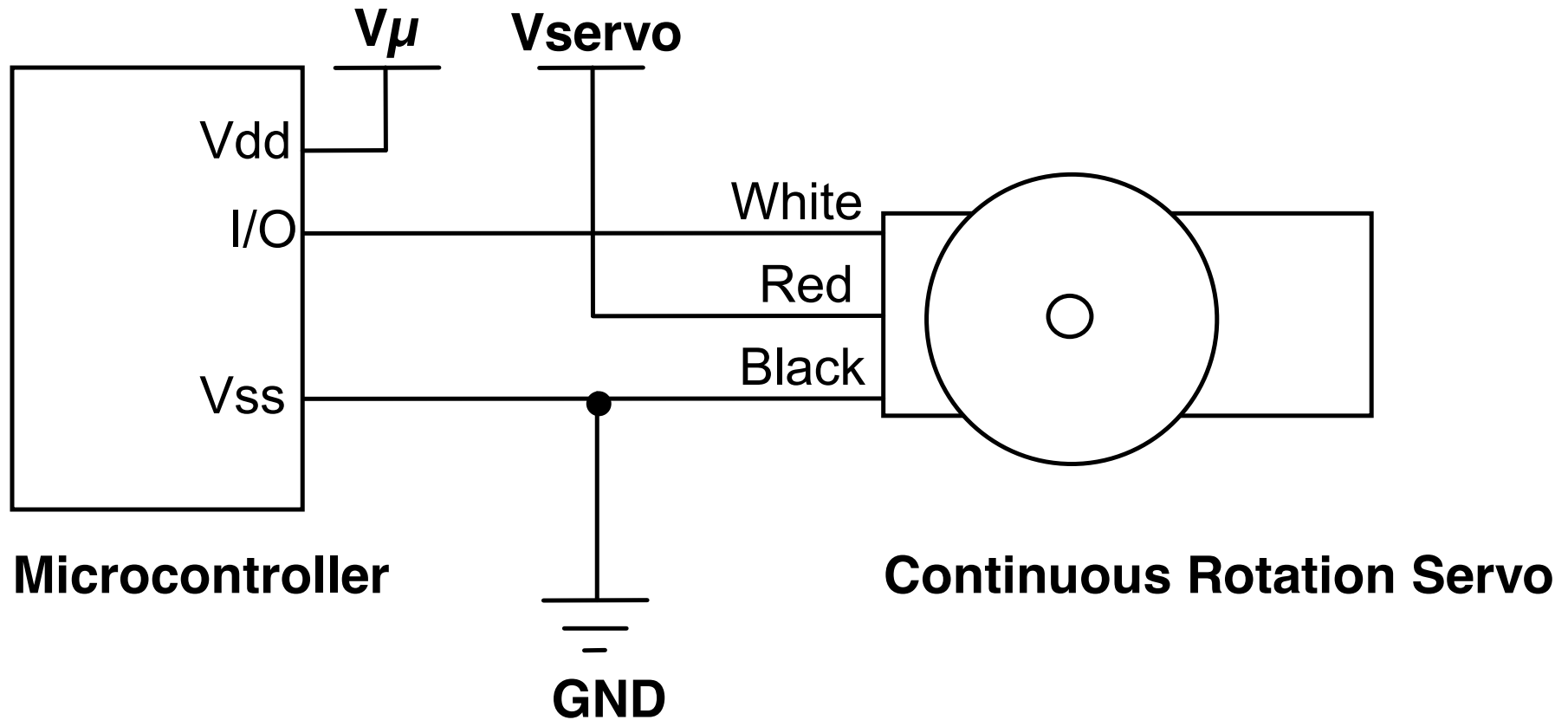
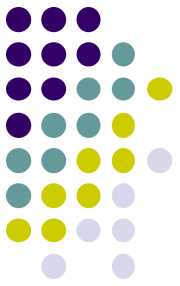


Parallax Continuous Rotation Servo

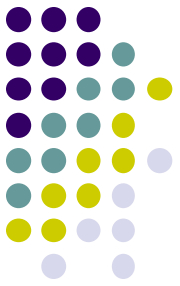


- Bidirectional **continuous** rotation
- **0 to 50 RPM**
- A linear response to PWM for ramping
 - Under no load condition
- 4 to 6 VDC
- Maximum current draw is 140 +/- 50 mA at 6 VDC when operating in no load conditions

Continuous Servo Connection

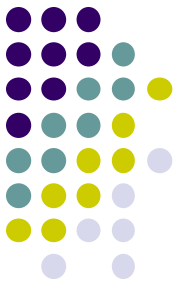


Communication Protocol

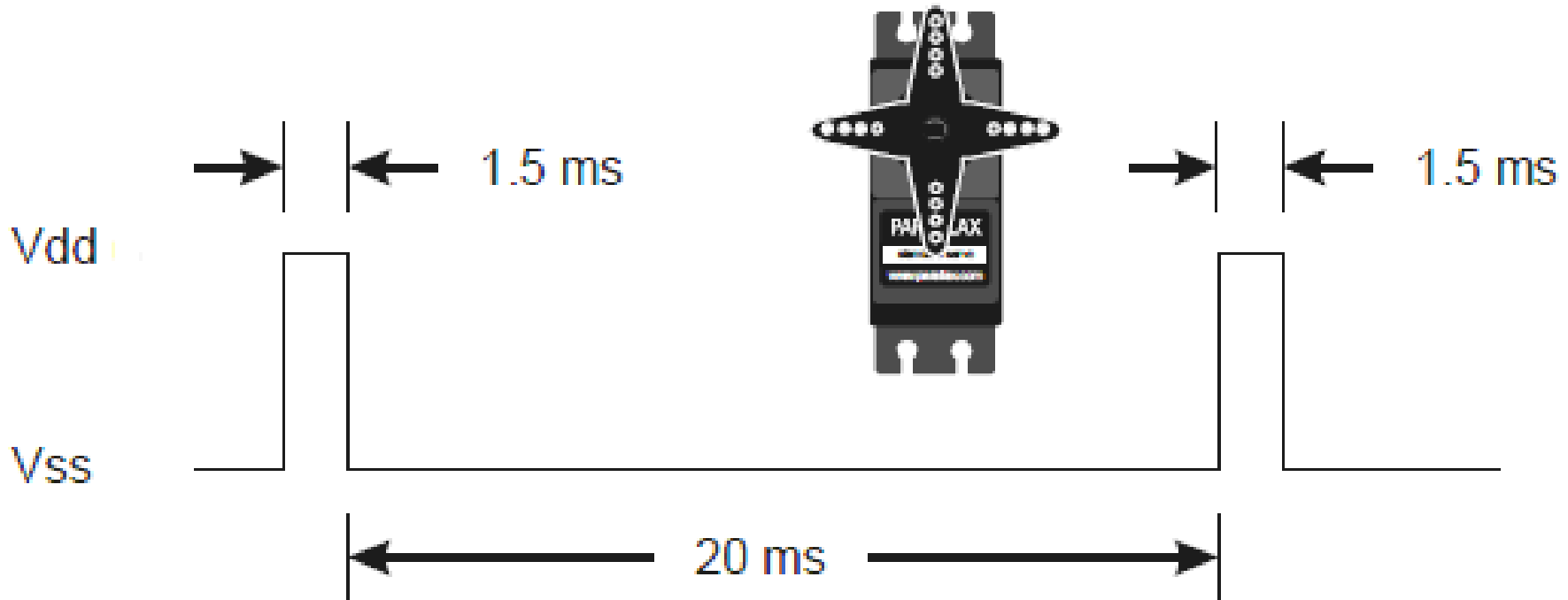


- Rotational speed and direction are determined by the duration of a high pulse, in the 1.3 -1.7 ms range.
- Maximum RPM will vary with input voltage
- 50 RPM @ 5 V is typical

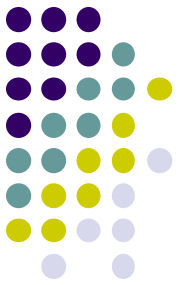
Timing diagram for a centered servo



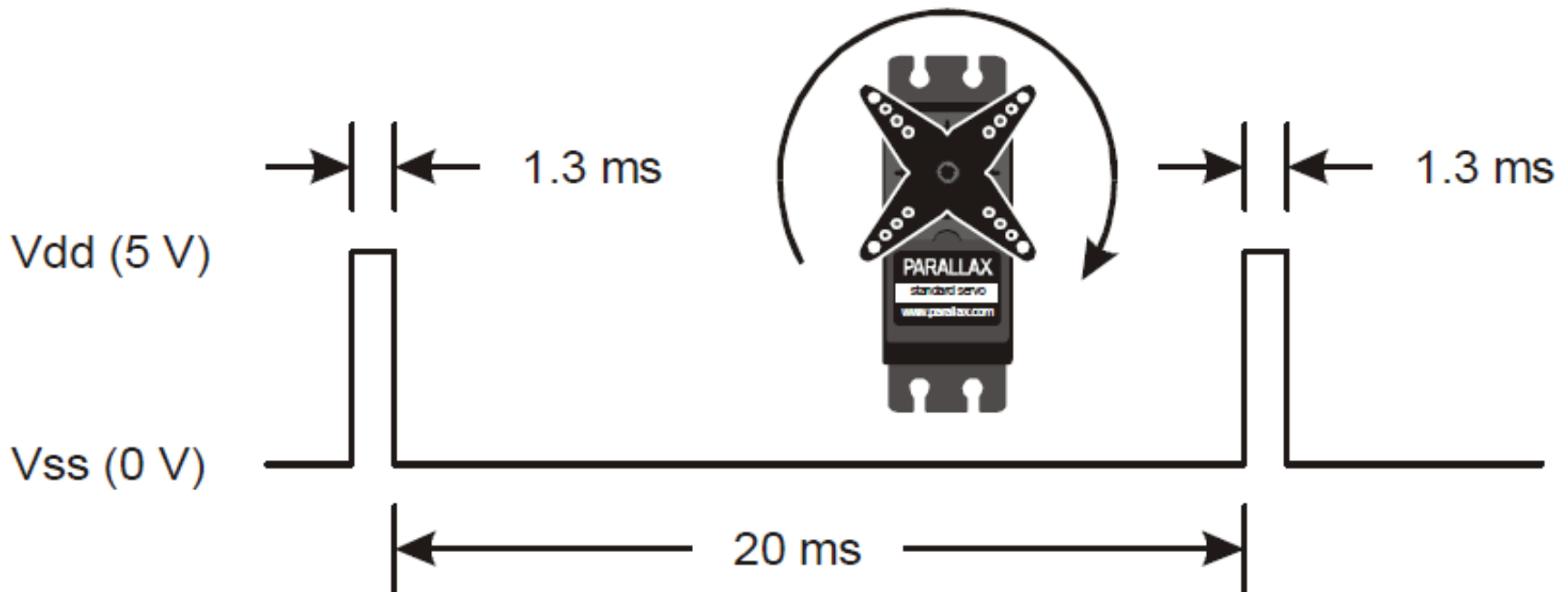
- Note that calibration is necessary



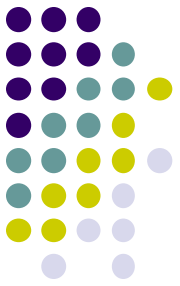
Timing diagram for Rotating Clockwise



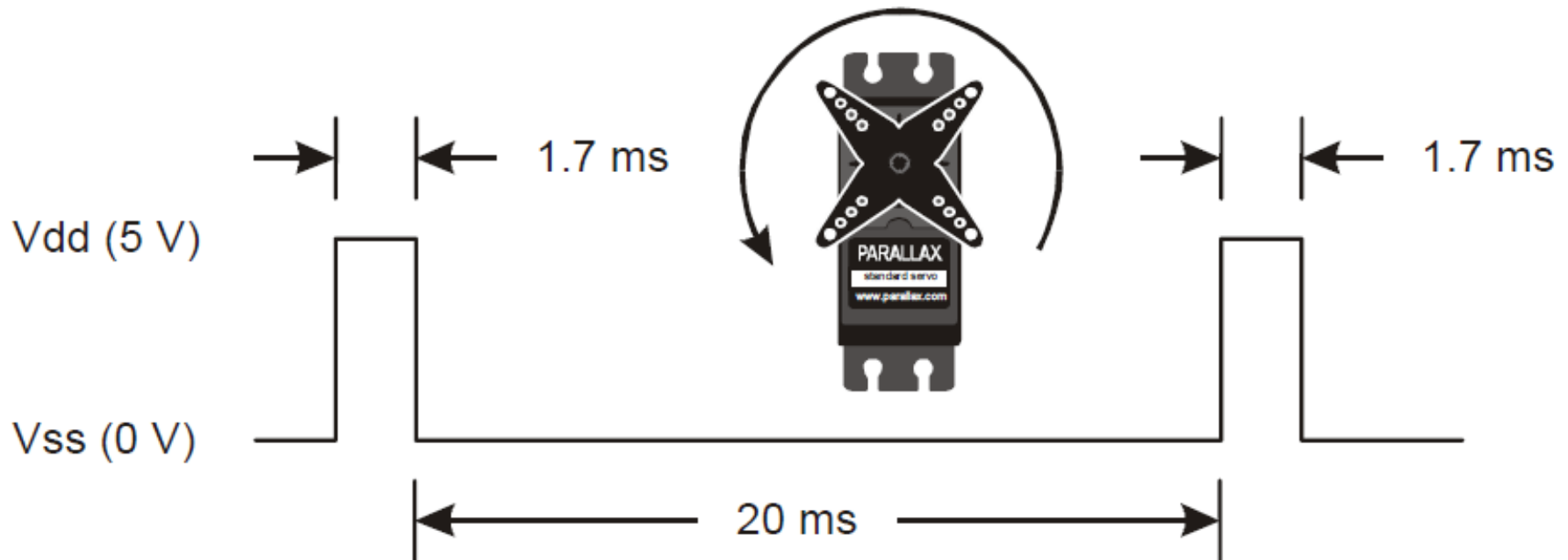
- As the length of the pulse decreases from 1.5 ms, the servo will gradually rotate faster in the clockwise direction



Timing diagram for Rotating Counter-clockwise



- As the length of the pulse increases from 1.5 ms, the servo will gradually rotate faster in the counter-clockwise direction





BOE-BOT Digital Encoder

- To measure the travelled distance of a wheel





Encoder Operations

- The sensors emit infrared light and look for its return from a reflective surface.
 - They are calibrated for optimal sensing of surfaces a few millimeters away.
- The Boe-Bot's wheels, even though they are black, reflect sufficient IR to cause the sensors to respond.
 - When a sensor "sees" part of a wheel, it pulls its output low.
 - When it's looking through a hole, its output floats, and the pullup resistor pulls it high.



IR Sensor in Encoder

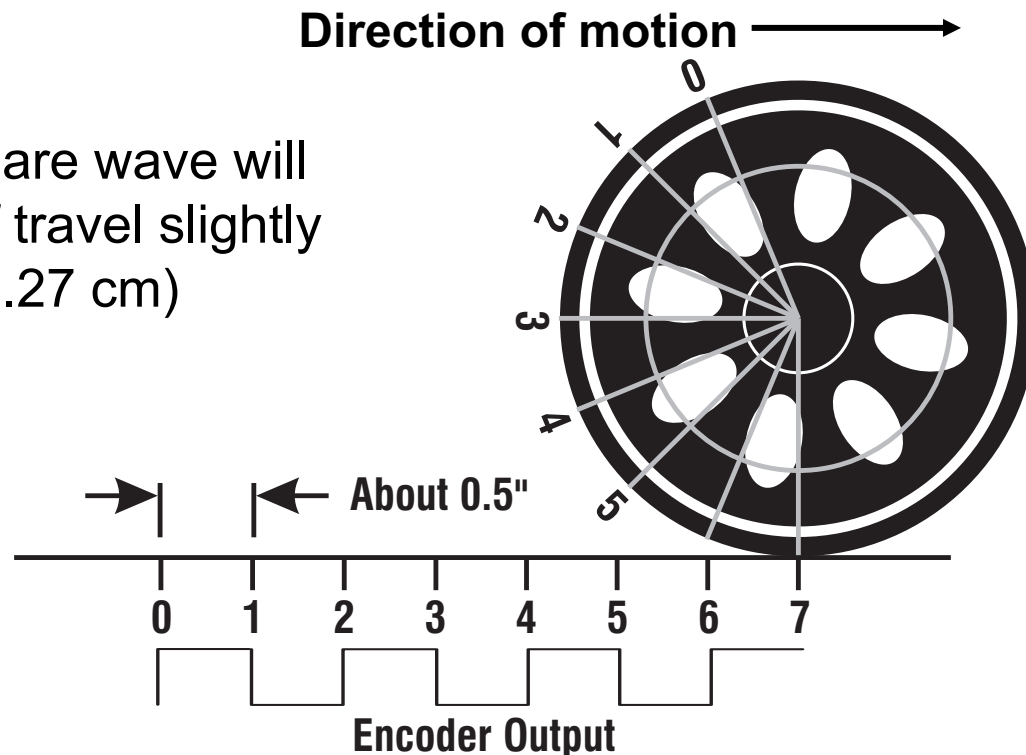
- Because the sensors emit and detect only modulated IR (at about 7.8 kHz) they are relatively insensitive to ambient light.
- Be aware, though, that some fluorescent fixtures may also emit light at this frequency and could interfere with their operation.



Encoder Output Signals

- As a Boe-Bot wheel turns, the sensor will see an alternating pattern of hole - no hole - hole - no hole, etc.

Each edge of the square wave will mark an increment of travel slightly more than 1/2 inch (1.27 cm)

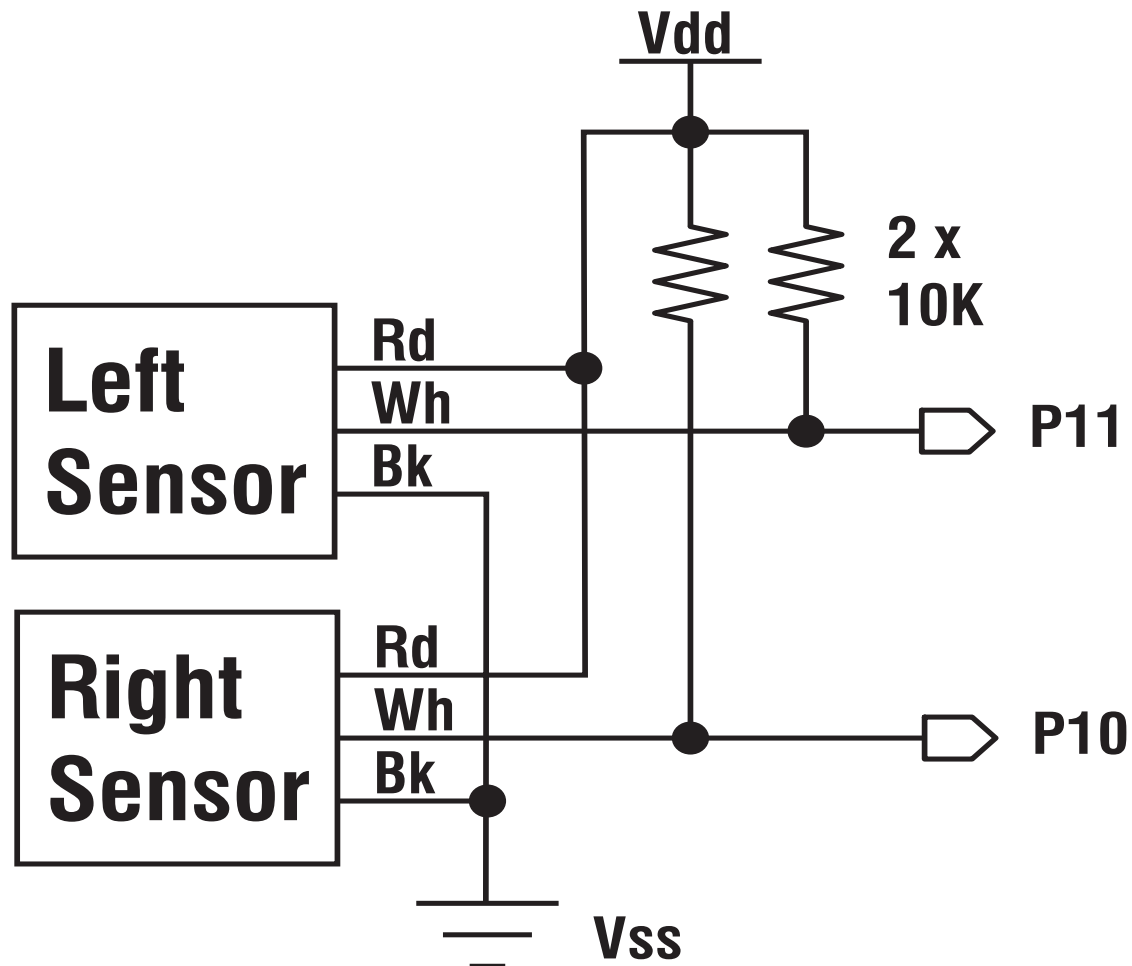
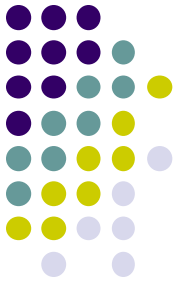




Uncertainty and Errors

- Wheel encoders are never perfect
- Uncertainties in the effective wheel diameters can lead to position errors.
- Further uncertainties in effective wheel spacing during turns can result in direction errors.
- Small position and direction errors have a way of accumulating quickly
- May need calibration periodically.

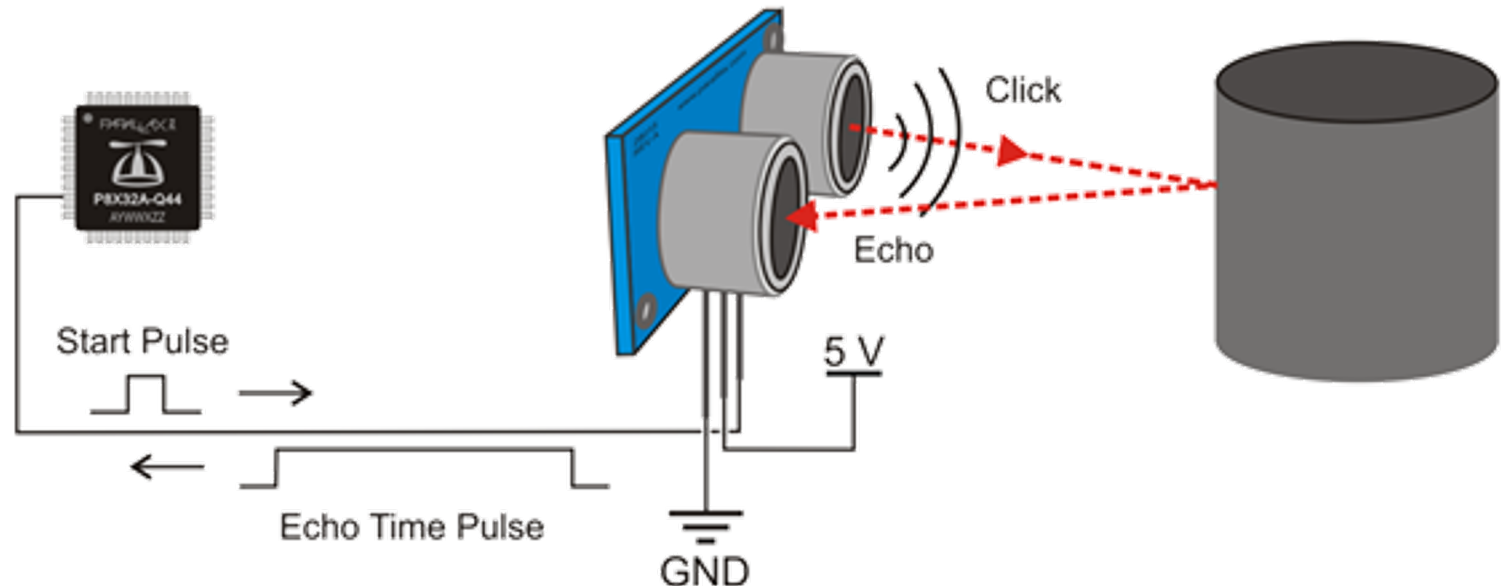
Encoder Connections





Parallax PING Sensor

- Send a Start pulse from mbed
- PING will send an ultrasound signal out, and PING pulls up signal output
- PING pulls down signal output when return echo is detected.





Calculate PING Distance

- Assume
 - s =distance between PING and object
 - c =speed of sound
 - t =measured pulse duration (time for sound to travel from PING to object and back to PING).
 - $2s = ct$
 - $s = \frac{ct}{2} = 0.03448 \frac{cm}{s} * \frac{t}{2} \sim \frac{t}{58} cm$ (at 22.2°C)
 - $c_{air} = 331.5 + (0.6 * T_c) m/s$

Conditions when PING will Not Detect

