Introduction to Parallax Servos

Servo簡介

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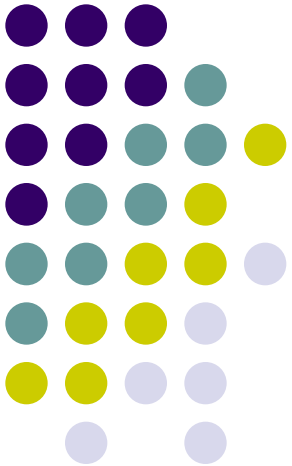
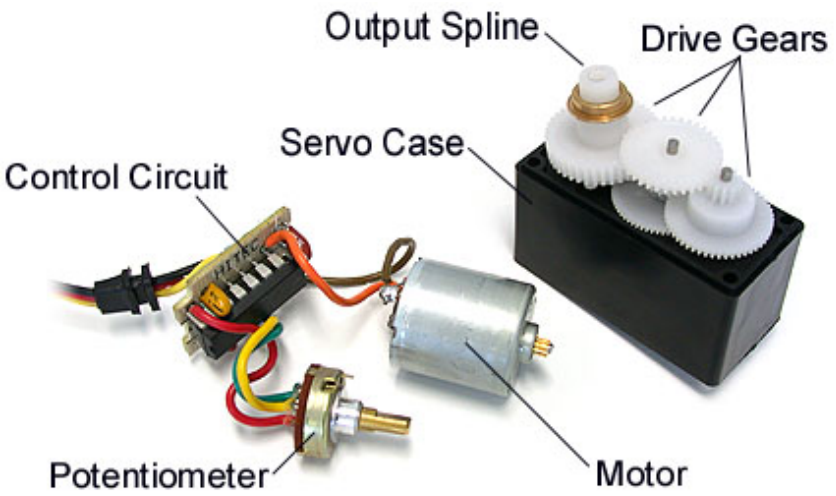
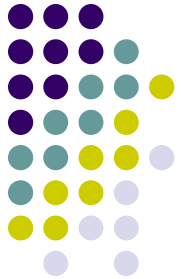


What makes a Servo

- Servo motors and are constructed out of basic DC motors, by adding:
  - some gear reduction
  - a position sensor for the motor shaft
  - an electronic circuit that controls the motor's operation

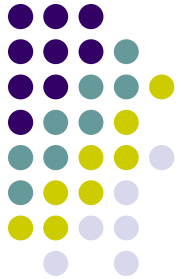


Servo Characteristics



- 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.
- Servos are extremely useful in robotics.
- The motors draws power proportional to the mechanical load.
  - The amount of power applied to the motor is proportional to the distance it needs to travel. So, if the shaft needs to turn a large distance, the motor will run at full speed. If it needs to turn only a small amount, the motor will run at a slower speed. This is called proportional control.

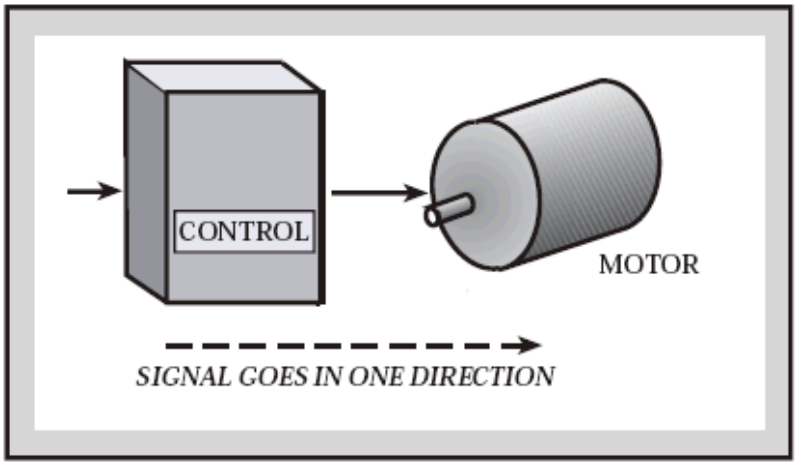
Potentiometer Feedback Control



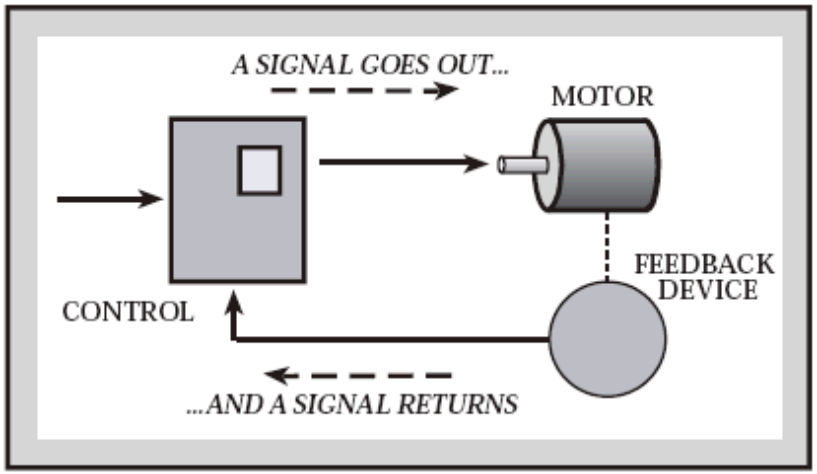
- The potentiometer allows the control circuitry to monitor the current angle of the servo motor.
  - The motor, through a series of gears, turns the output shaft and the potentiometer simultaneously.
  - The potentiometer is fed into the servo control circuit and when the control circuit detects that the position is correct, it stops the motor. If the control circuit detects that the angle is not correct, it will turn the motor the correct direction until the angle is correct.
  - Normally a servo is used to control an angular motion of between 0 and 180 degrees. It is not mechanically capable (unless modified) of turning any farther due to the mechanical stop build on to the main output gear.

Feed-back loop

open-loop



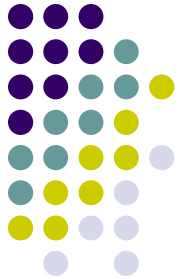
closed-loop



Hitec HS-311 Servo

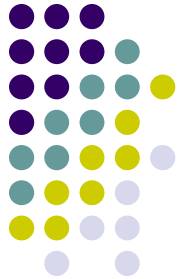
Dimensions	1.57" x 0.78" x 1.43" (39.88 x 19.81 x 36.32mm)
Product Weight	1.52oz (43g)
Output Shaft Style	24 tooth (C1) spline
Voltage Range	4.8V - 6.0V
No-Load Speed (4.8V)	0.19sec/60°
No-Load Speed (6.0V)	0.15sec/60°
Stall Torque (4.8V)	42 oz/in (3.0 kg/cm)
Stall Torque (6.0V)	51 oz/in (3.7 kg/cm)
Max PWM Signal Range (Standard)	575-2460µsec
Travel per µs (out of box)	.107°/µsec
Max Travel (out of box)	202.5°
Pulse Amplitude	3-5V
Operating Temperature	-20°C to +60°C
Current Drain - idle (4.8V)	7.4mA
Current Drain - idle (6.0V)	7.7mA
Current Drain - no-load (4.8V)	160mA
Current Drain - no-load (6V)	180mA
Continuous Rotation Modifiable	Yes

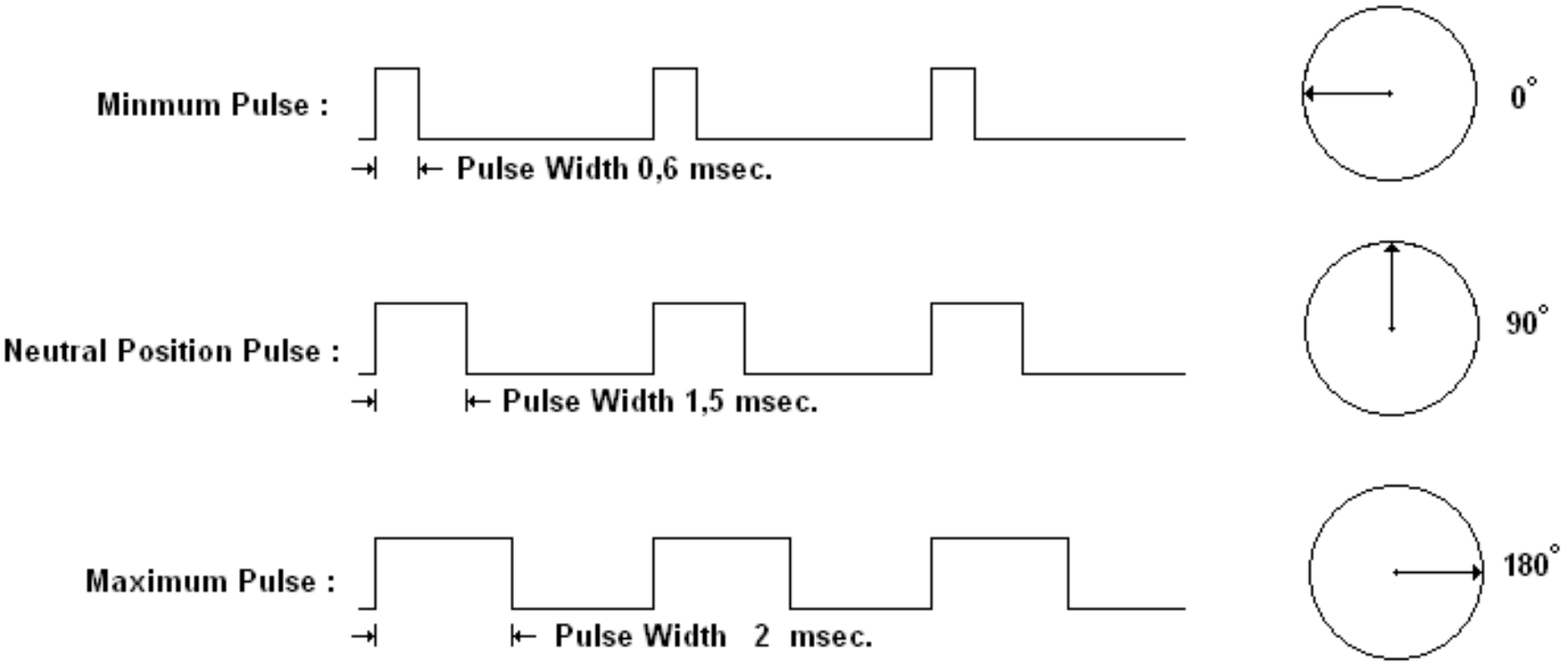
Servo Control



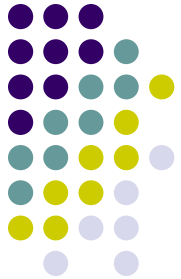
- The shaft can be positioned to specific angular positions by sending the servo a coded signal.
- As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft.
- The angular position of the shaft is determined by the duration of a pulse that is applied to the control wire.

Control Waveforms



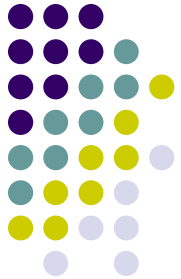


PWM



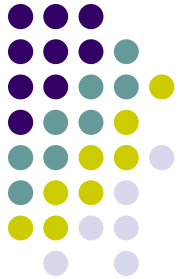
- A control wire communicates the desired angular movement. The angle is determined by the duration of the pulse applied to the control wire.
- The servo expects to see a pulse every 20 milliseconds.
- The length of the pulse will determine how far the motor turns. A 1.5 millisecond pulse will make the motor turn to the 90 degree position (often called the neutral position).
- If the pulse is shorter than 1.5 ms, then the motor will turn the shaft to closer to 0 degrees. If the pulse is longer than 1.5ms, the shaft turns closer to 180 degrees.

Modified Servos



- Servo motors can also be retrofitted to provide continuous rotation:
  - Remove mechanical limit (revert back to DC motor shaft).
  - (Optional) Remove pot position sensor (no need to tell position) and replace it with 2 equal-valued resistors with a combined resistance equivalent to that of the pot. This makes the servo "think" it is in the 90 deg position.

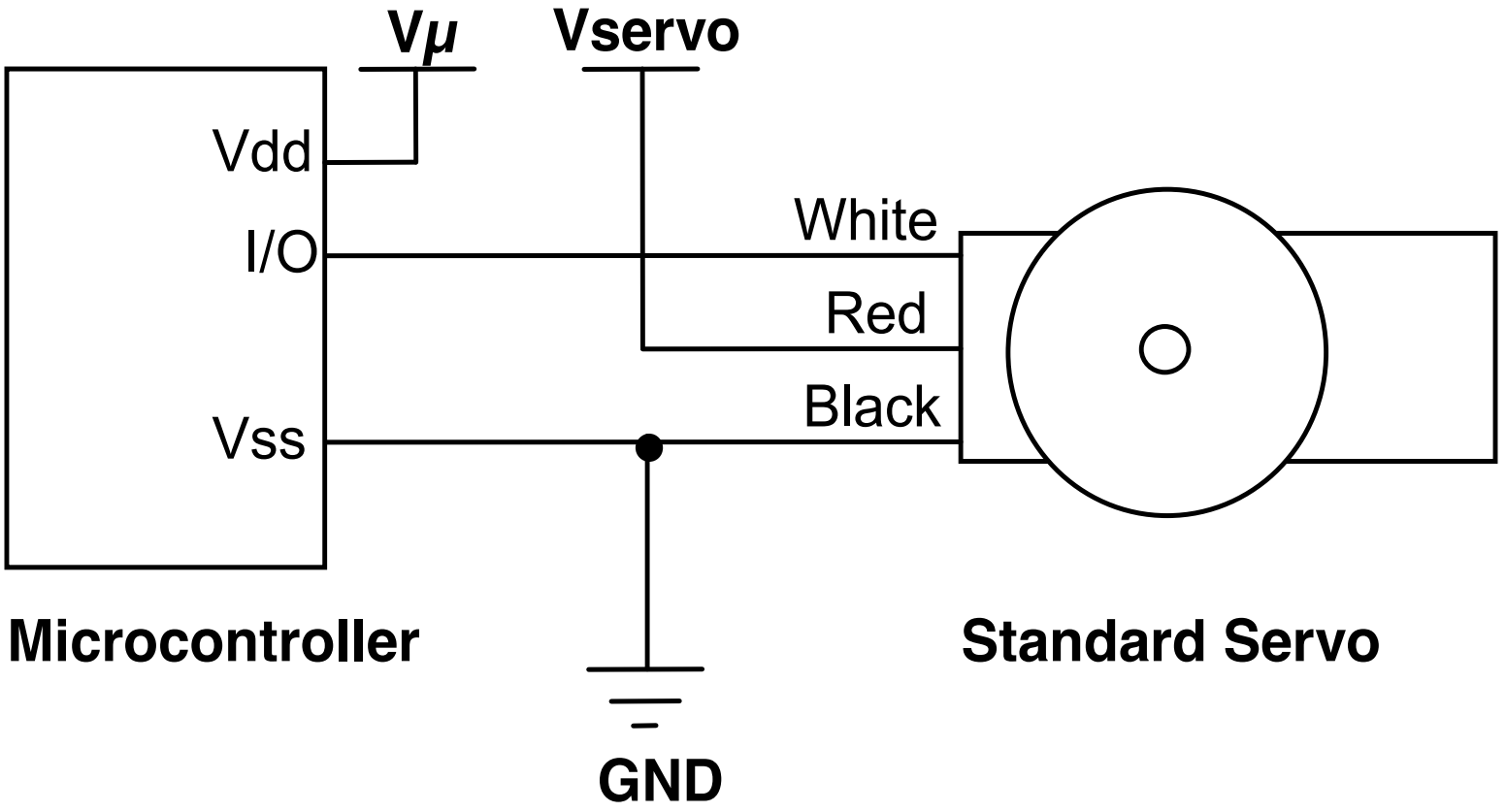
Parallax Standard Servo



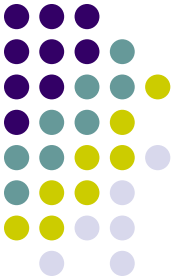
- Provides 180° range of motion and position control
- 38 oz-in torque at 6 VDC

- 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



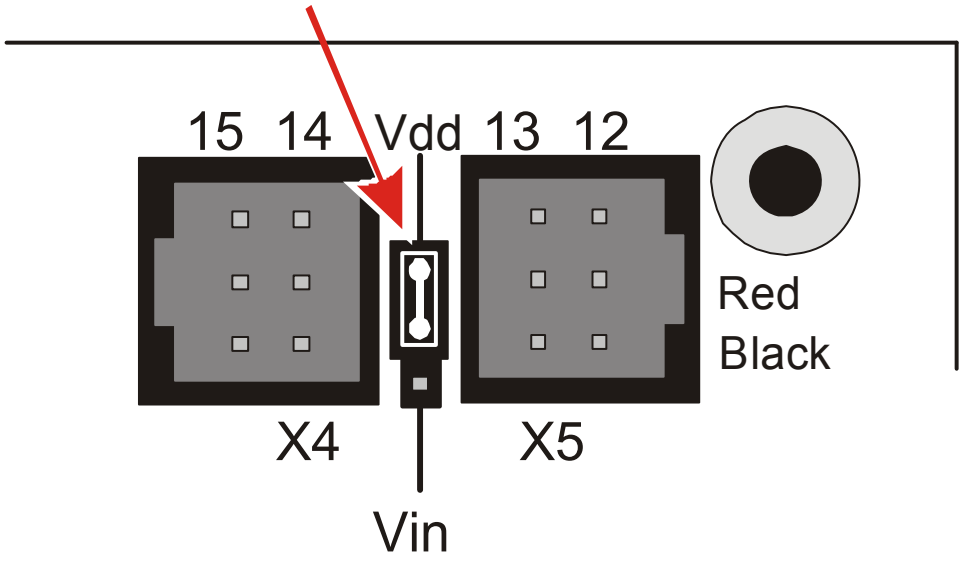
Power Precautions



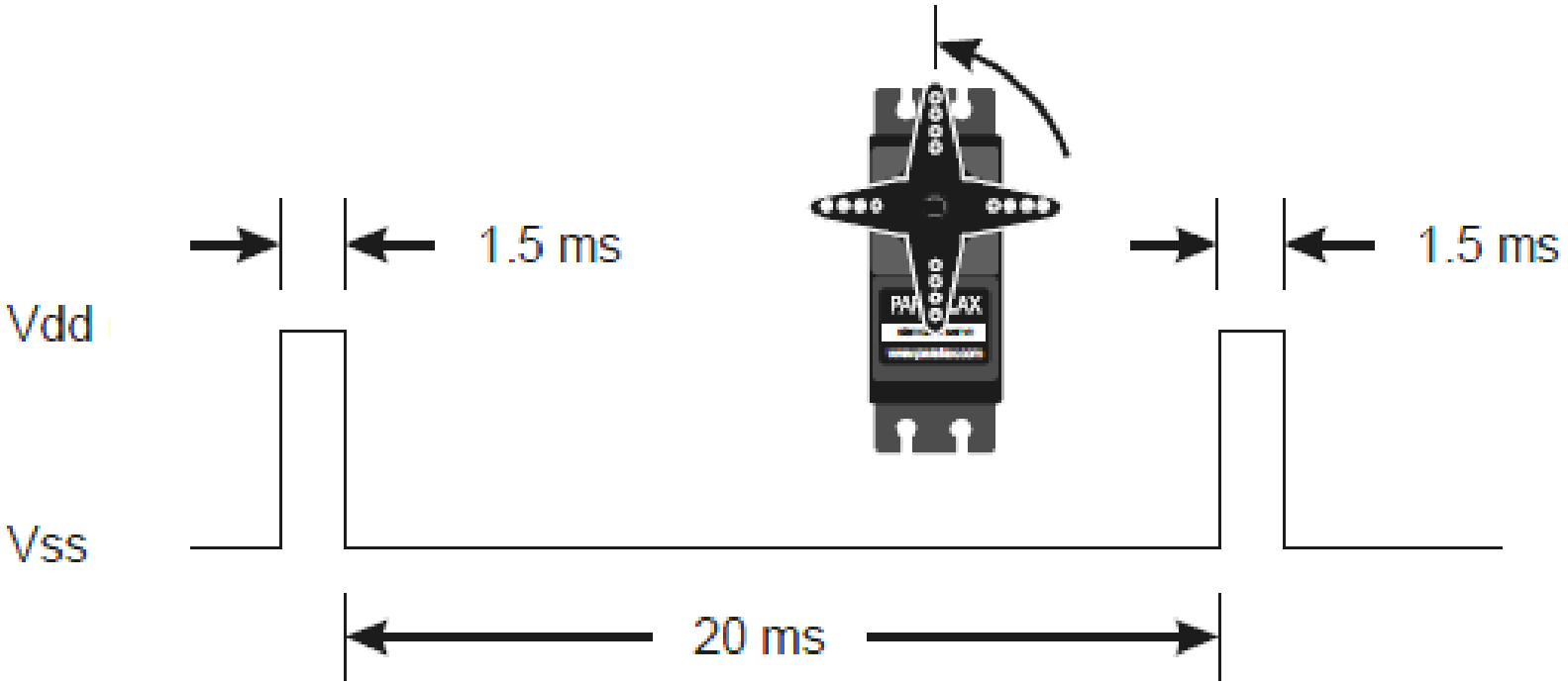
- Do not use this servo with an unregulated wall-mount supply.
- Do not power this servo through the microcontroller's Vdd pin.
- Servo current draw can spike while under peak load
  - regulator should be prepared to supply adequate current for all servos used in combination.

BOE Jumper Connection

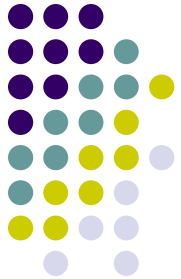
- Be sure the jumper is set to Vdd (regulated 5 VDC for this board)



Communication Protocol



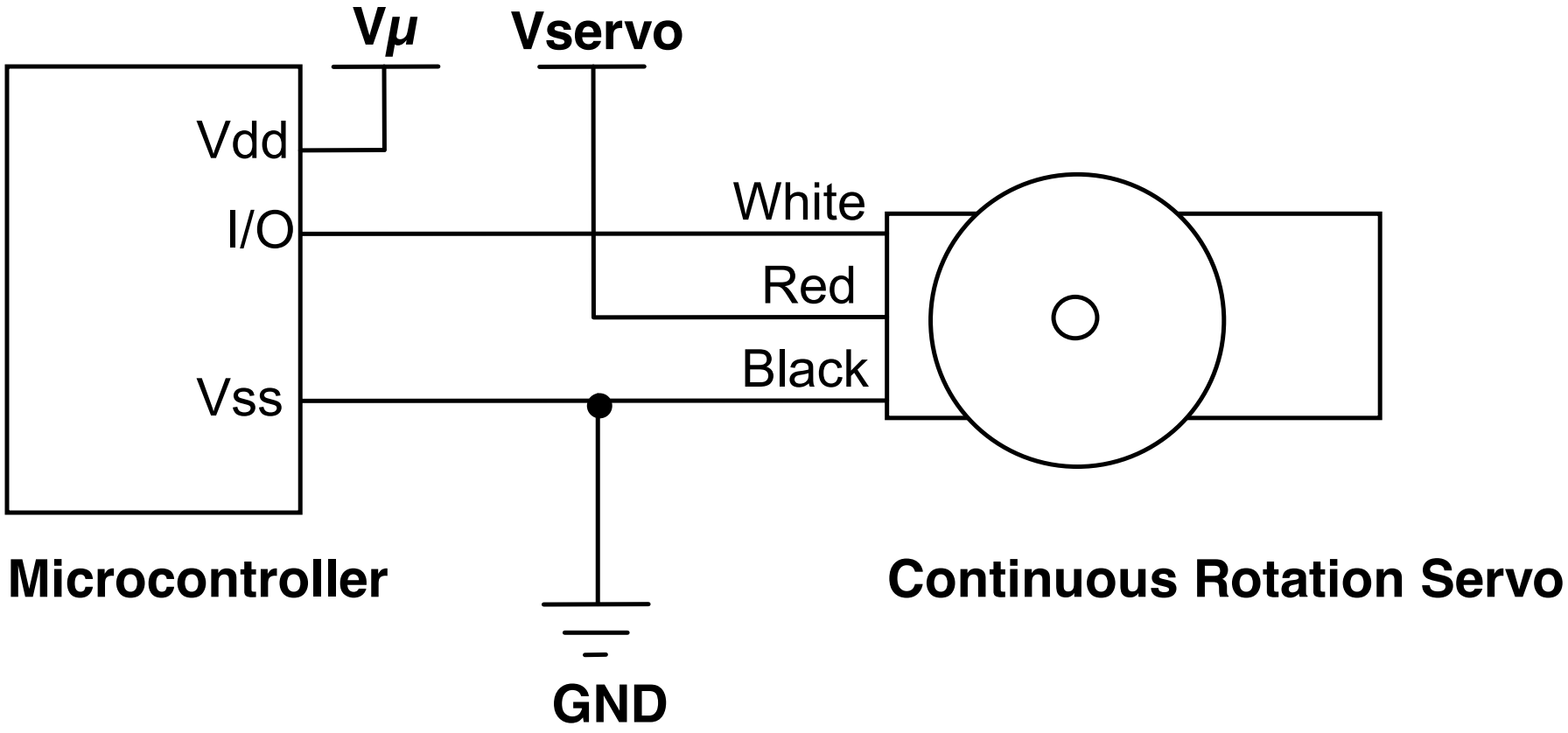
Parallax Continuous Rotation Servo



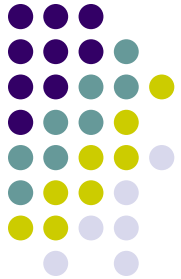
- Bidirectional continuous rotation
- 0 to 50 RPM
- a linear response to PWM for ramping

- 4 to 6 VDC
- Maximum current draw is 140 +/- 50 mA at 6 VDC when operating in no load conditions

Continuous Servo Connection



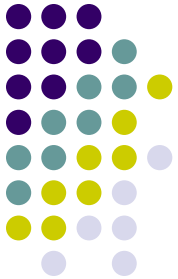
Communication Protocol



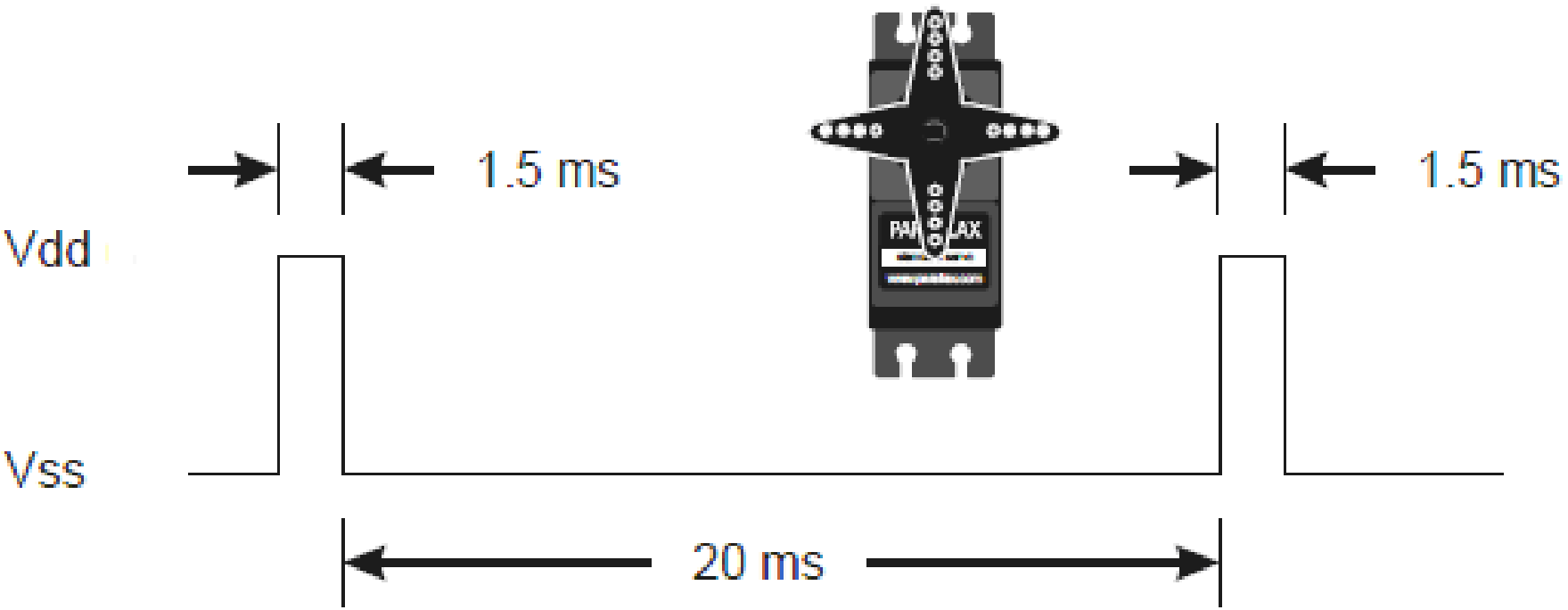
- Rotational speed and direction are determined by the duration of a high pulse, in the 1.3 -1.7 ms range.

- Maximum RPM will vary with input voltage
- 50 RPM @ 5 V is typical

Timing diagram for a centered servo

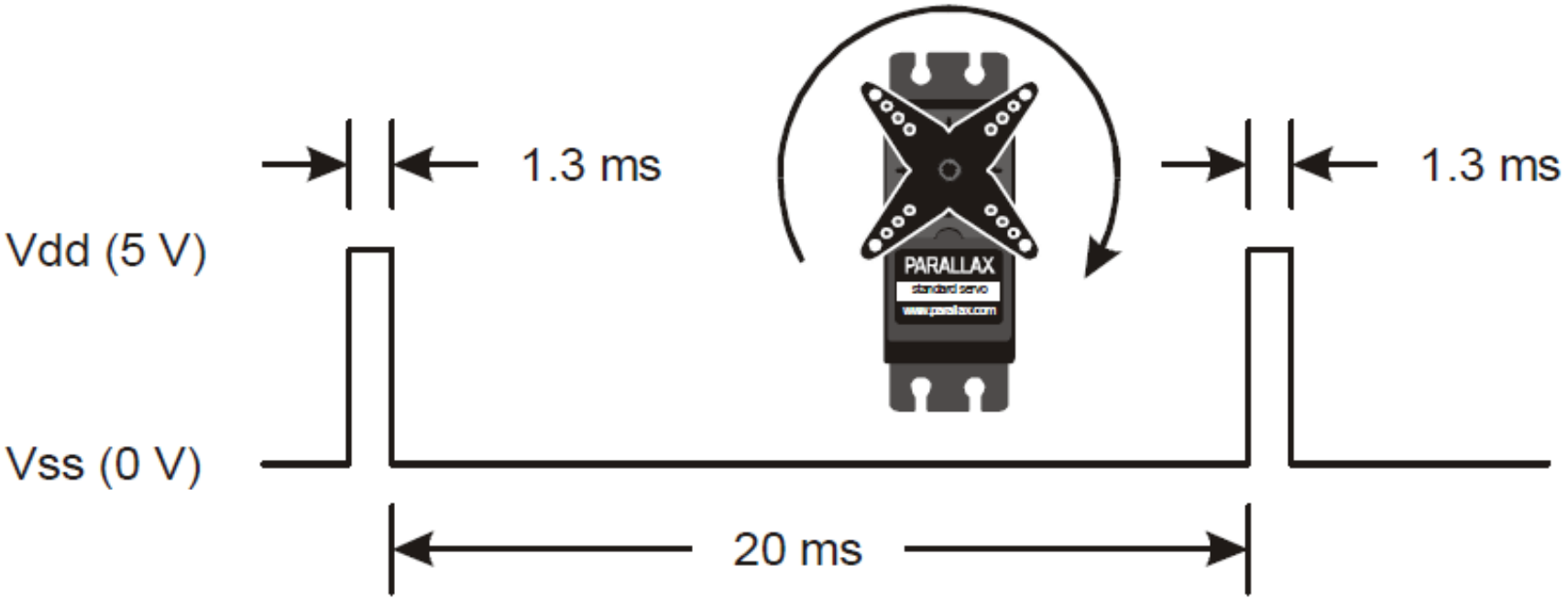


- Note that calibration is necessary



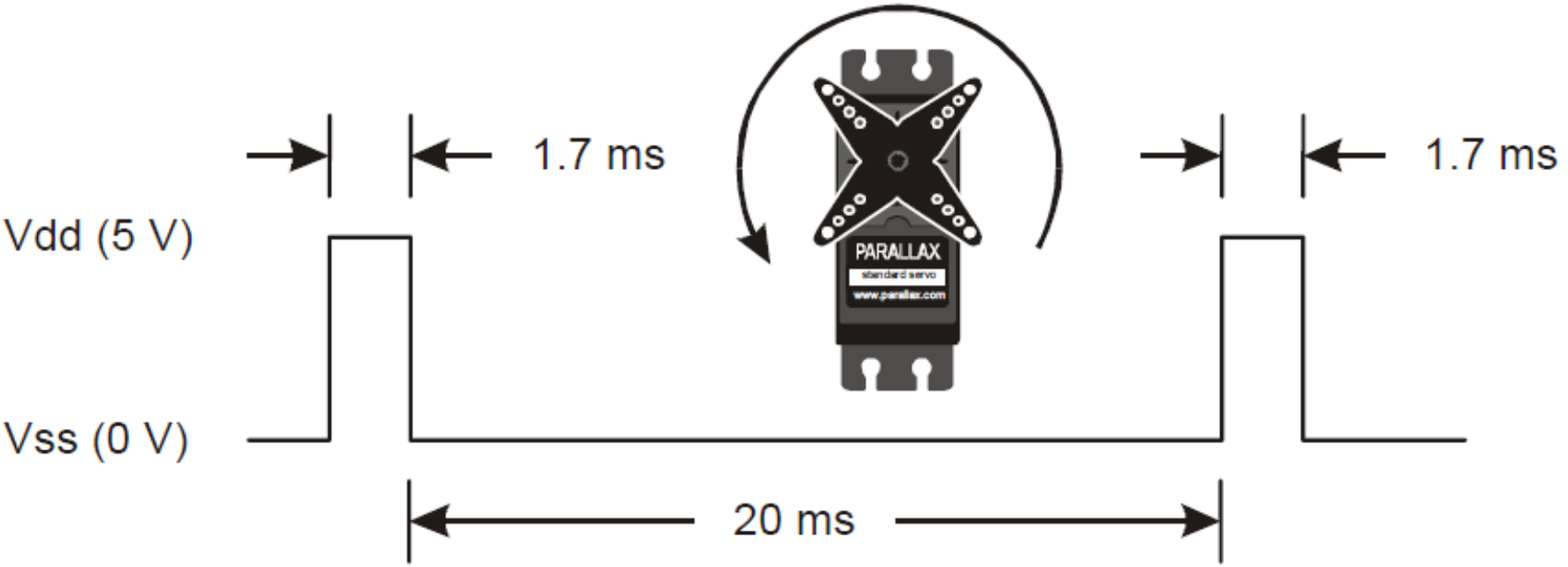
Timing diagram for a centered servo

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



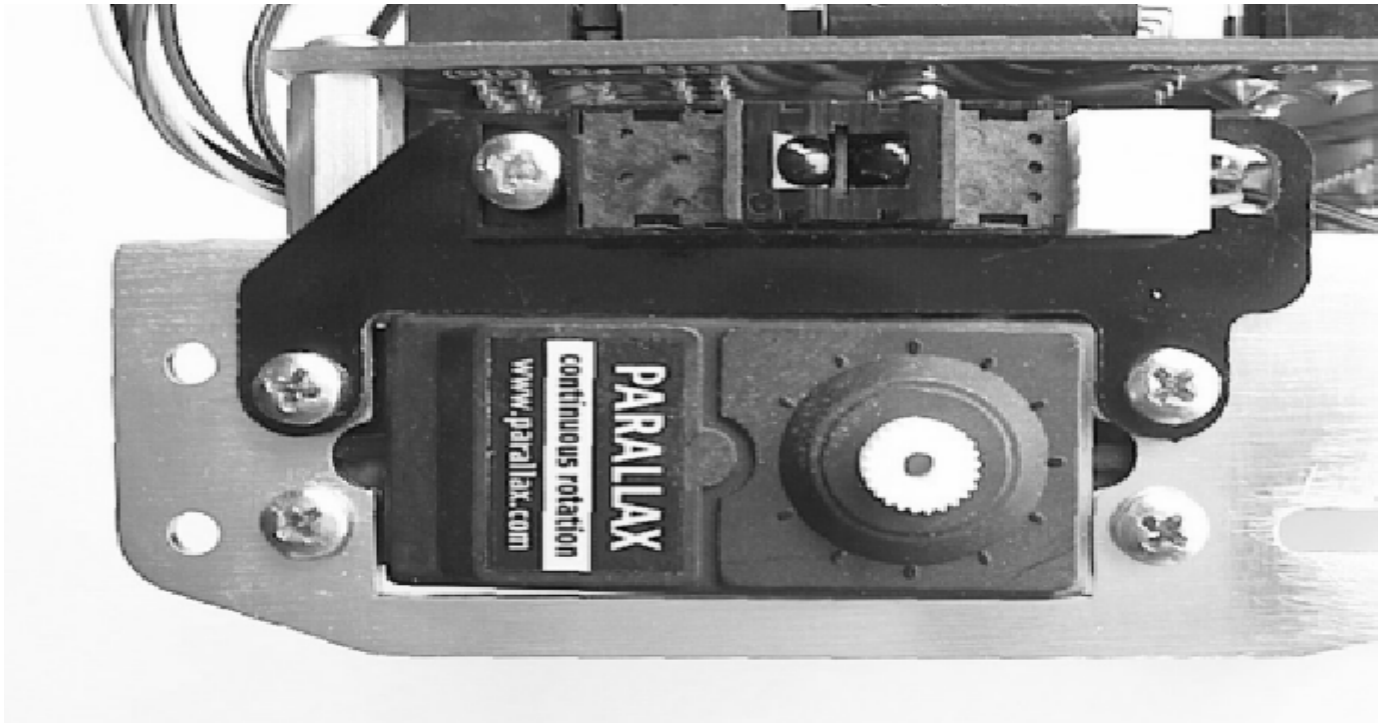
Timing diagram for Rotating Counter-clockwise

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

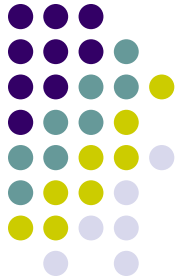


BOE-BOT Digital Encoder

- To measure the travelled distance of a wheel

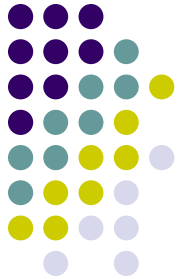


Encoder Operations



- 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

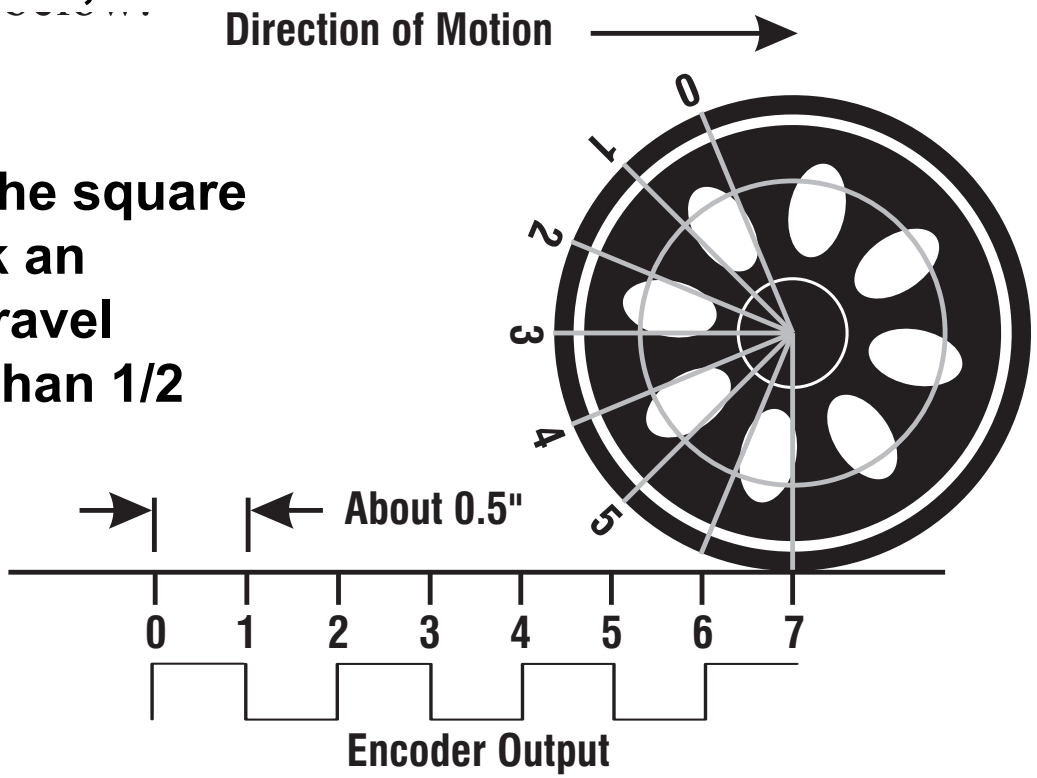


- Because the sensors emit and detect only modulated IR (at about 7.8 kHz) they are relatively insensitive to ambient light.
- Be aware, though, that some fluorescent fixtures may also emit light at this frequency and could interfere with their operation.

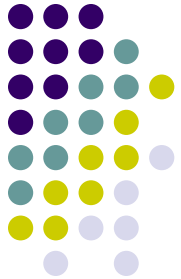
Sensor Output Signals

- 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.

Sensor Connections