

# CS122A: Intermediate Embedded and Real Time Operating Systems

Jeffrey McDaniel

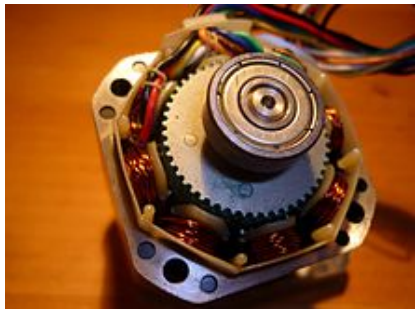
University of California, Riverside

# Stepper Motor - Introduction

- Brushless DC electric motor

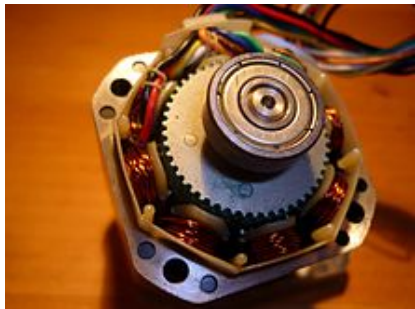


# Stepper Motor - Introduction



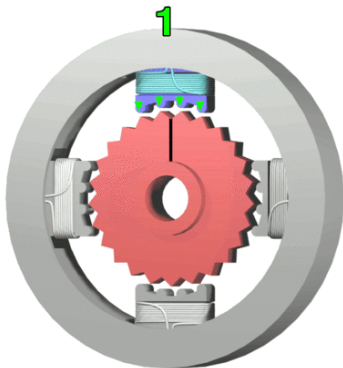
- ▶ Brushless DC electric motor
- ▶ Divides full rotation into discrete steps using a gear

# Stepper Motor - Introduction



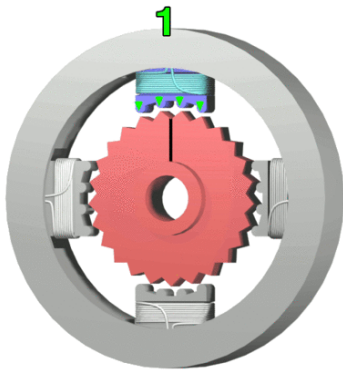
- ▶ Brushless DC electric motor
- ▶ Divides full rotation into discrete steps using a gear
- ▶ No feedback required

# Stepper Motor - Introduction



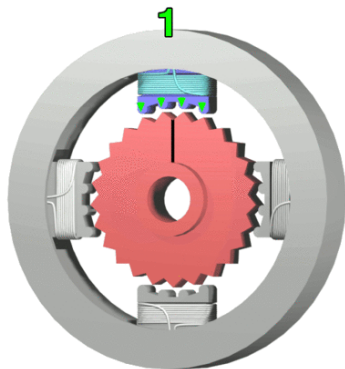
- ▶ Brushless DC electric motor
- ▶ Divides full rotation into discrete steps using a gear
- ▶ No feedback required
- ▶ A rotor with 25 teeth and 4 steps to rotate by one teeth

# Stepper Motor - Introduction



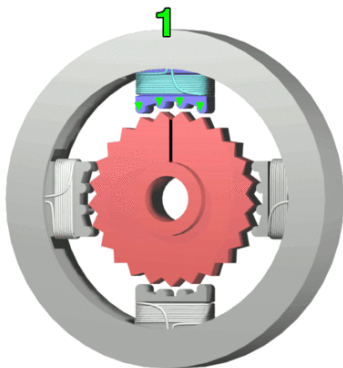
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- ▶  $25 * 4 = 100$  steps per full rotation

# Stepper Motor - Introduction



- ▶ Brushless DC electric motor
- ▶ Divides full rotation into discrete steps using a gear
- ▶ No feedback required
- ▶ A rotor with 25 teeth and 4 steps to rotate by one teeth
- ▶  $25 * 4 = 100$  steps per full rotation
- ▶  $360/100 = 3.6$  degrees per step

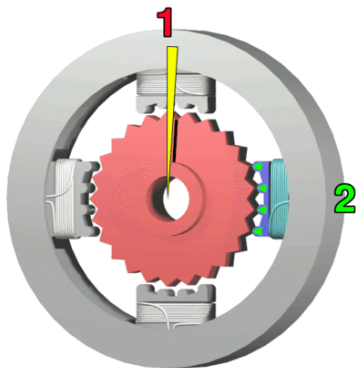
# Stepper Motor - Operation



1. Electromagnet 1 is turned on, attracting nearest teeth, offsetting teeth from electromagnet 2

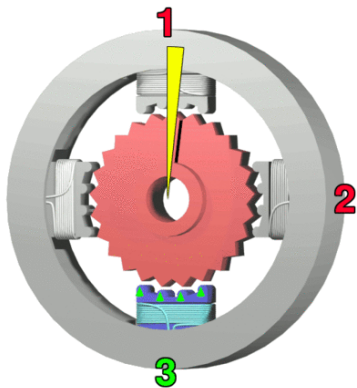


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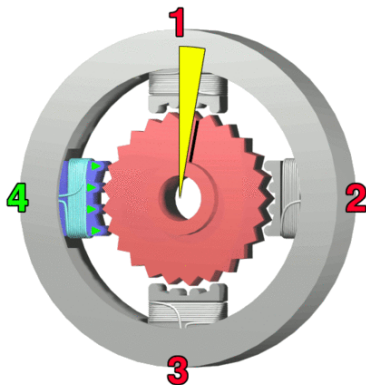
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2. Electromagnet 1 is turned off, electromagnet 2 is turned on, rotating teeth

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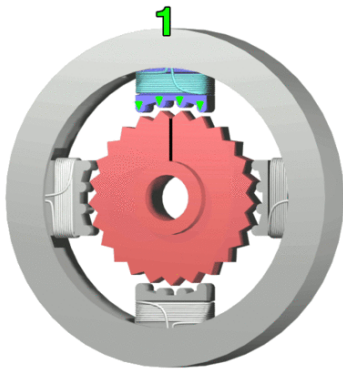
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3. Electromagnet 2 is turned off, electromagnet 3 is turned on
4. Electromagnet 3 is turned off, electromagnet 4 is turned on

# Stepper Motor - Operation

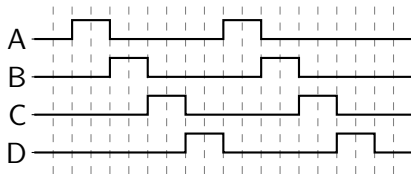


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3. Electromagnet 2 is turned off, electromagnet 3 is turned on
4. Electromagnet 3 is turned off, electromagnet 4 is turned on
5. Electromagnet 4 is turned off, electromagnet 1 is turned on

# Stepper Motor - Operating Modes

## Wave Drive

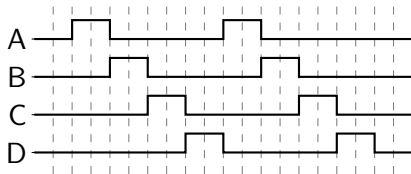
- ▶ A single phase is activated at a time



# Stepper Motor - Operating Modes

## Wave Drive

- ▶ A single phase is activated at a time
- ▶ Motor has significantly less torque

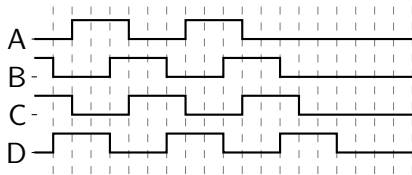




# Stepper Motor - Operating Modes

## Full Step Drive

- ▶ Two phases are always on

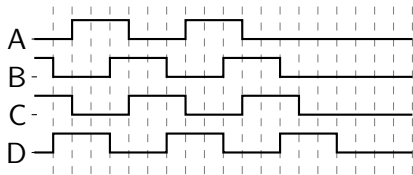




# Stepper Motor - Operating Modes

## Full Step Drive

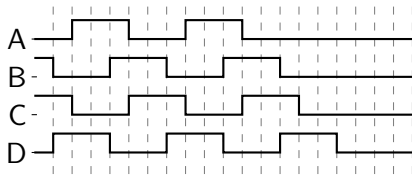
- ▶ Two phases are always on
- ▶ Provides maximum torque



# Stepper Motor - Operating Modes

## Full Step Drive

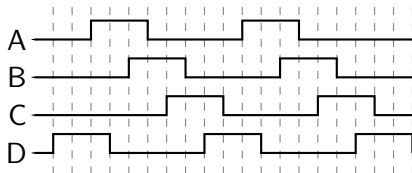
- ▶ Two phases are always on
- ▶ Provides maximum torque
- ▶ One phase turned off, another turns on



# Stepper Motor - Operating Modes

## Half-Step Drive

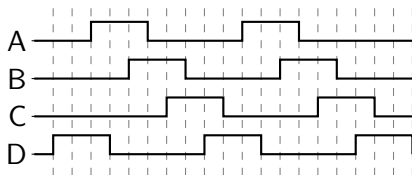
- ▶ Alternates between two phases on and single phase on



# Stepper Motor - Operating Modes

## Half-Step Drive

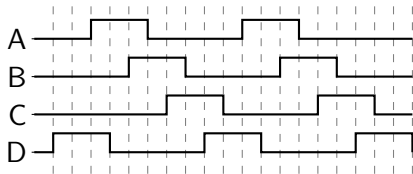
- ▶ Alternates between two phases on and single phase on
- ▶ Motor has less torque



# Stepper Motor - Operating Modes

## Half-Step Drive

- ▶ Alternates between two phases on and single phase on
- ▶ Motor has less torque
- ▶ Angle per step is half of the full step



# DC Motor



- ▶ Runs from a direct current power source

# DC Motor



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- ▶ Changing the operating voltage varies the speed

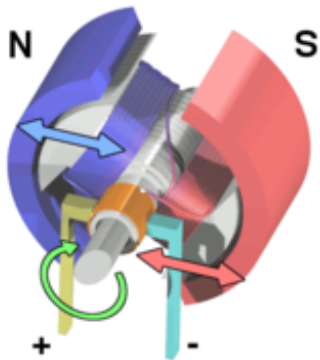
# DC Motor



- ▶ Runs from a direct current power source
- ▶ Changing the operating voltage varies the speed
- ▶ Operating voltage is changed on the microcontroller using PWM

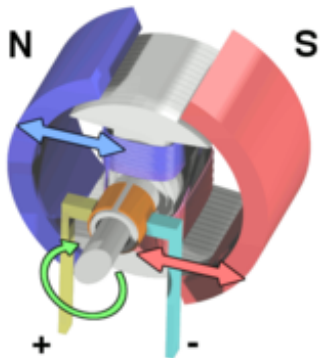


# DC Motor



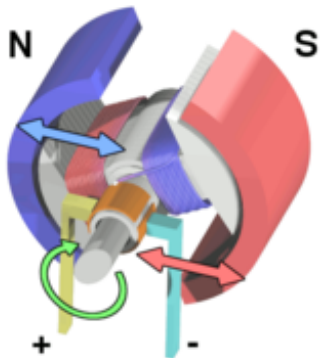
1. Left side of armature is pushed away from left magnet and pulled towards right

# DC Motor



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2. Armature continues rotating until horizontally aligned

# DC Motor



1. Left side of armature is pushed away from left magnet and pulled towards right
2. Armature continues rotating until horizontally aligned
3. Torque becomes zero, commutator reverses the direction of the current

# Pulse Width Modulation (PWM)

- ▶ Motor spins when input is a 1

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- ▶ PWM with 40% duty cycle achieves 400 rpm