Lab 3: Stepper Motor Control
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Goals

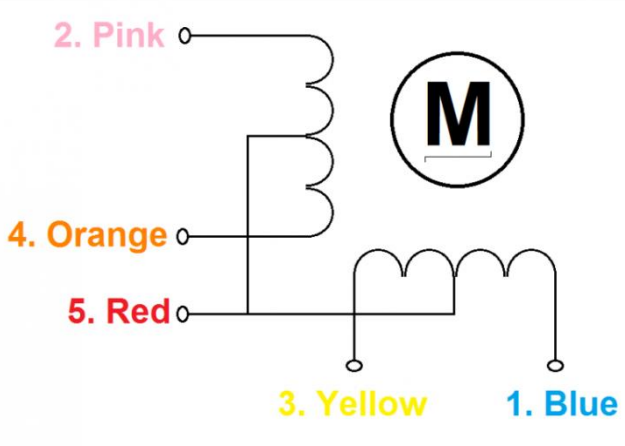
1. Understand the limitation of GPIO output current
2. Learn to use Darlington transistor arrays to perform high-current driving with extremely low input current
3. Understand the usage of full stepping and half stepping to control the speed and position of a stepper motor
4. Gain experience of generating pulse waveforms to control a stepper motor

Pre-Lab Assignment

1. Read the textbook Chapter 16 Stepper Motor
2. Watch video tutorial: How the Stepper motors are made and how they operate (Credit goes to *pcbheaven*)
    a. Part 1 (5 minutes): http://www.youtube.com/watch?v=MHdz3c6KLrg
    b. Part 2 (8 minutes): http://www.youtube.com/watch?v=t-3VnLadIbc
3. Answer the pre-lab questions

Lab Requirements

1. Basic requirement: Turn the stepper motor exactly 360 degrees clockwise by using half-stepping and full-stepping
2. Something cool. The following provide some examples.
    a. Use the keypad to set a specific degree to which the motor should rotate.
    b. The motor should smartly choose either clockwise or counter-clockwise to make a minimum amount of rotation.
    c. Display the degree and turning direction of the motor in real time.
    d. Perform micro-stepping to rotate the motor smoothly



Stepper Motors

The motor has a ULN2003 Darlington Array.

Motor model	**28BYJ-48**	Number of phases	2
Rated voltage	5V DC	Geared reduction ratio	1/64
DC resistance per phase	50Ω±7%(25℃)	Pull in torque	>300gf.cm / 5VDC 100pp

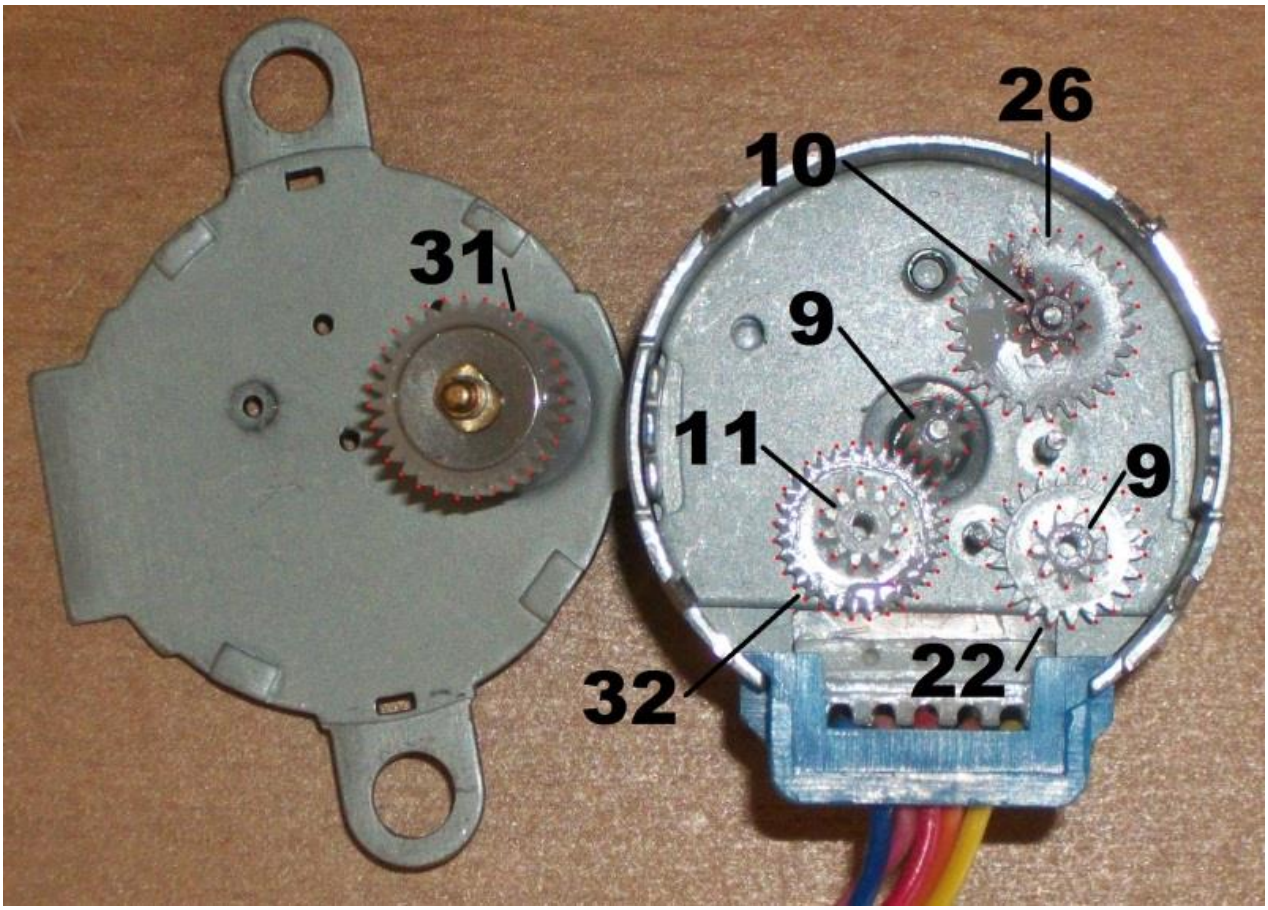


image from *forum.arduino.cc*

The gear ratio is:

$$\frac{31 \times 32 \times 26 \times 22}{11 \times 10 \times 9 \times 9} = 63.68395$$

Full-stepping

- Internal motor: 32 steps per revolution
- Great reduction ratio: 1/63.68395, approximately 1/64
- So it takes $32 \times 64 = 2048$ steps per revolution for the output shaft

Half-stepping

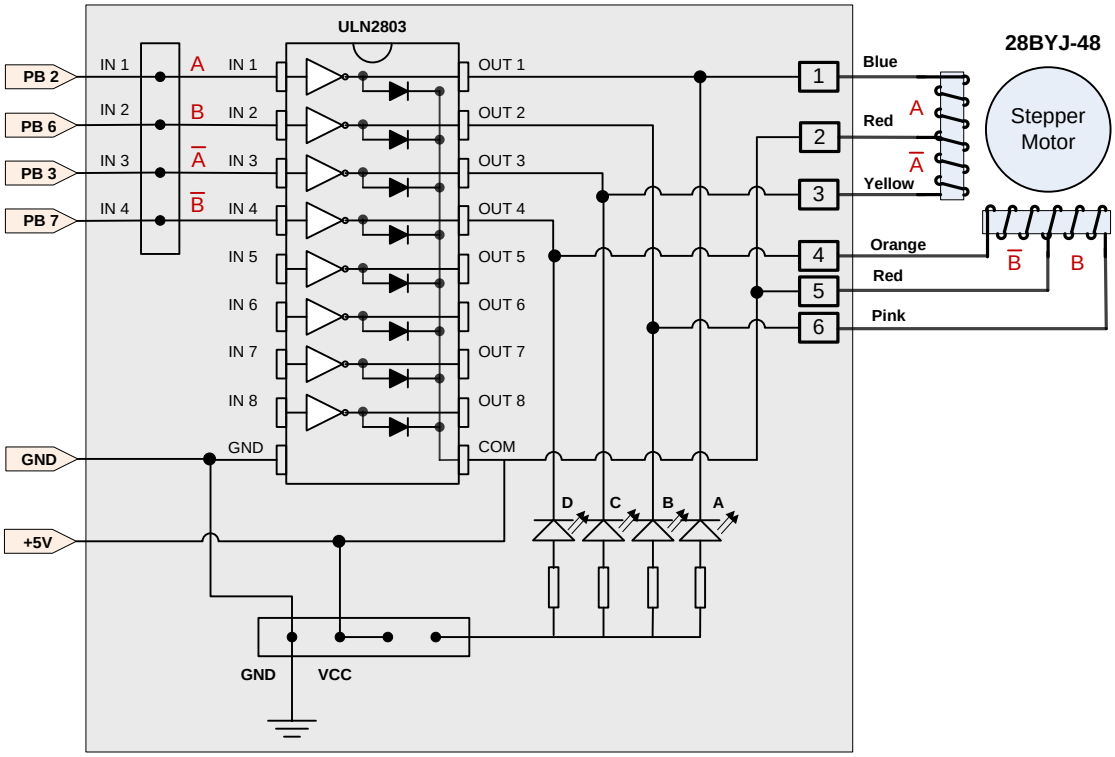
- Internal motor: 64 steps per revolution
- Great reduction ratio: $1/63.68395 \approx 1/64$
- So it takes $64 \times 64 = 4096$ steps per revolution for the output shaft

Lab 3: Stepper Motor Control

Name: _____

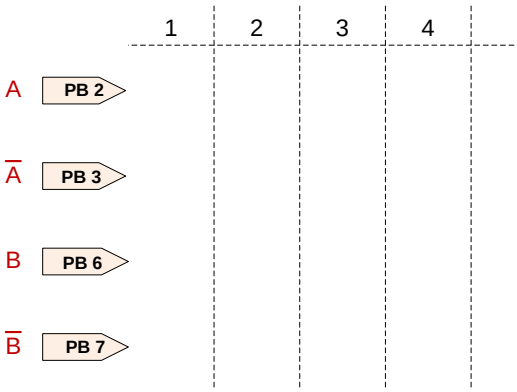
Pre-Lab Question

Interfacing the stepper motor requires four pins. We select the following four pins to control the stepper motor: **PB 2**, **PB 3**, **PB 6**, and **PB 7**. The textbook provides a connection diagram for stepper motor *Mabuchi #PF35T*, which is very similar to the diagram below.

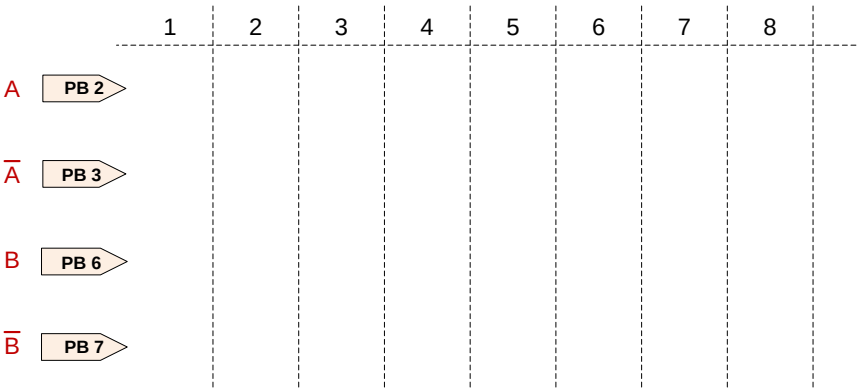


Refer to Figure 16-10 and 16-12 of textbook to complete the following two diagrams.

Full stepping sequence



Half stepping sequence



You must write your answer in *Readme.md* file and submit it to the gitlab server.

1. How to change the rotation speed of a stepper motor?

2. How to reverse the rotation direction?

Warning: Motor Overheating

The motor constantly draws electrical currents. The motor will be overheated if you leave the power on for an extended period. **Make sure to disconnect the power (Vcc) to the Darlington array if you are not debugging/testing it.**

Lab Demo Requirements

1. Rotate your stepper motor exactly 360 degrees either clockwise or counter-clockwise.

2. What is the highest update frequency of the full-stepping control signals while the motor does not drop any steps? Use an oscilloscope to find out your update frequency.

3. What is the highest update frequency of the half-stepping control signals while the motor does not drop any steps? Use an oscilloscope to find out your update frequency.

4. Is the highest update frequency of the half-stepping higher than full-stepping? Why?

Post-lab Assignments

1. The Darlington array has only 500-mA rated collector current. If you need a larger current, what option you can have to replace the Darlington array.

2. The full-stepping control sequence rotates a stepper motor a full step for each input pulse. The half-stepping rotates the motor 1/2 step for each input pulse. Is it possible to rotate the motor 1/4 or 1/8 step for each input pulse? (Hints: micro-stepping)