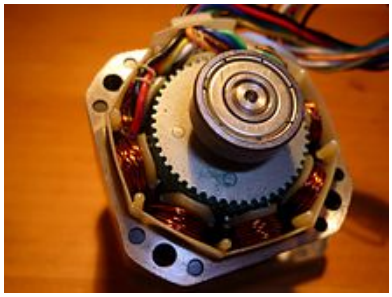
ECGR 4101/5101, Fall 2015: Graduate Lab 1

Stepper Motor Driver

Objective:

In this lab, you will be creating a stepper motor driver using the YRDKRX63N. The board contains a circle of LED lights which can be used to simulate the coils in a stepper motor. A stepper motor is a motor which is easily controlled by powering coils surrounding a magnetized rotor to control steps.

Background:



A stepper motor or step motor or stepping motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

DC brushed motors rotate continuously when DC voltage is applied to their terminals. The stepper motor is known by its property to convert a train of input pulses (typically square wave pulses) into a precisely defined increment in the shaft position. Each pulse moves the shaft through a fixed angle.

Stepper motors effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a microcontroller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

There are a few different methods by which stepper motors activate and deactivate the coils to generate steps. The method by which the motor activates the coils can result in varying levels of step resolution.

- Wave drive (one phase on)

  In this drive method only a single phase is activated at a time. It has the same number of steps as the full step drive, but the motor will have significantly less than rated torque. It is rarely used.

- Full step drive (two phases on)

This is the usual method for full step driving the motor. Two phases are always on so the motor will provide its maximum rated torque. As soon as one phase is turned off, another one is turned on. Wave drive and single phase full step are both one and the same, with same number of steps but difference in torque.

- Half stepping

  When half stepping, the drive alternates between two phases on and a single phase on. This increases the angular resolution. The motor also has less torque (approx 70%) at the full step position (where only a single phase is on). This may be mitigated by increasing the current in the active winding to compensate. The advantage of half stepping is that the drive electronics need not change to support it.

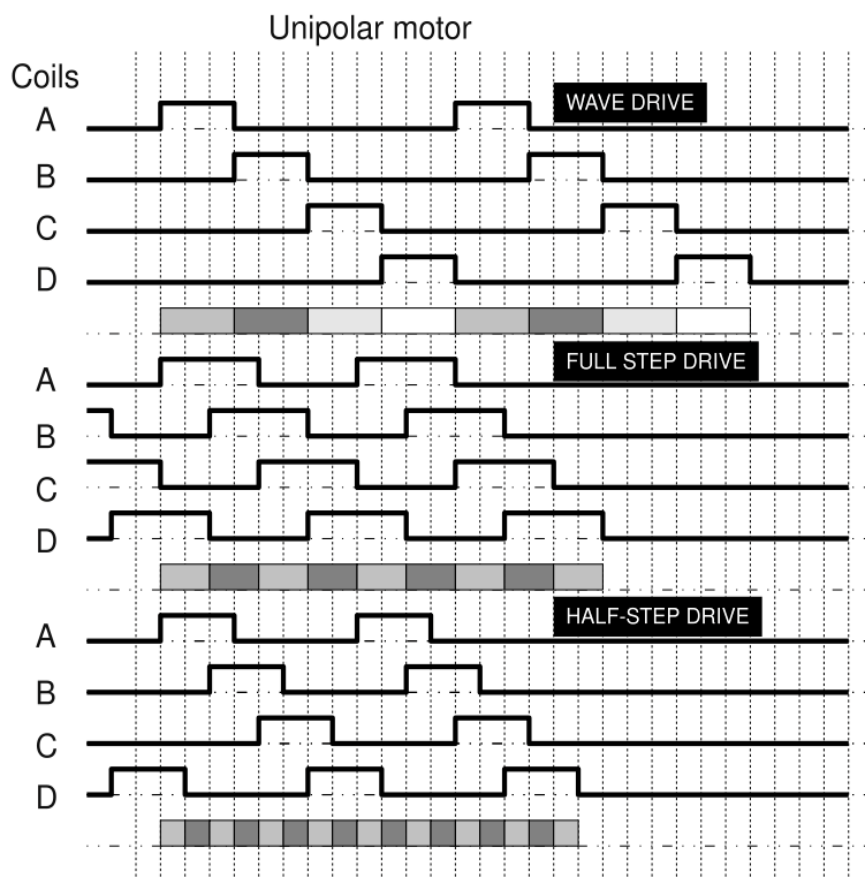


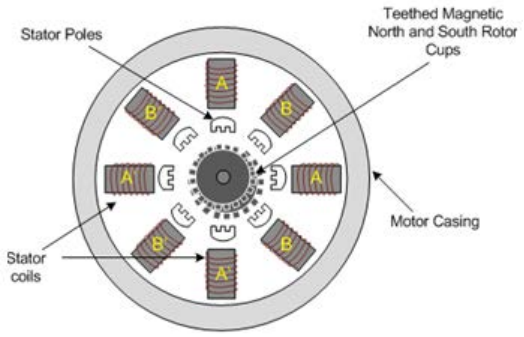
Figure 1: Waveforms for stepper motor control

Source: https://en.wikipedia.org/wiki/Stepper_motor

Assignment:

For this assignment, you are tasked with creating a stepper motor driver using the LED ring on the YRDKRX63N to simulate activating the coils of a stepper motor. Since we are only activating the "coils" of the stepper motor and we have no real rotor, we won't be concerned with step size or anything, only the sequence in which the coils are activated. Treat the red and green

LEDs as two separate coils in a bipolar stepper motor. The stepper motor driver should be able to operate in the step mode described in the background section: Wave Drive, Full-Step, and Half-Step. Do some research to learn more about these modes and stepper motors in general.



For this lab assignment, you will need to create a stepper motor driver with the following reqirements:

1. The LEDs on the YRDKRX63N light up as coils would be energized in a stepper motor.
2. The 3 buttons on the board change the stepping mode of the driver. One button should set the mode to wave drive, one to full step, and one to half step.
3. The current stepping mode of the driver should be displayed on the LCD at all times.
4. When in wave drive mode, the LEDs should represent the steps taken in that mode.
5. When in full step mode, the LEDs should represent the steps taken in that mode.
6. When in half step mode, the LEDs should represent the steps taken in that mode.
7. An external pin should be selected as the drive pin, and another pin should be selected as the direction pin.
8. The direction pin will change the direction the stepper motor rotates, reversing the LED sequence when changed from a 1 to a 0.
9. The drive pin is used to control the speed of the motor. At each rising edge of a square wave or PWM input to the drive pin, the stepper motor should take a step.
10. Use the YRDKRX63N's on-board temperature sensor to detect motor overheating. Set an arbitrary sensor value as a threshold to check for overheating. If the threshold value is exceeded, the controller should deem the motor as overheated, and shut down the motor until it has cooled off.

To Submit:

- A zip file containing the workspace of your project
- Your lab check-off sheet at the demonstration
- At the demonstration, your board will be connected to a function generator to drive your motor. A square wave will be emitted at various frequencies into the drive pin of your driver to test the functionality of your stepping modes.
- A datasheet document describing the operation of your stepper motor driver. The documentation will require a brief background on the stepper motor, how your LEDs represent the coils in your motor, a brief outline of wave drive, full step, and half step operation, a pinout diagram indicating how to interface with your board to drive the motor, and any other information necessary for a user to use your driver. Don't be afraid to get creative!
- Grading will be weighted as 60% demonstration, 40% documentation

Embedded Systems Lab Demonstration Validation Sheet

This sheet should be modified by the student to reflect the current lab assignment being demonstrated

Lab Number:	Graduate Lab 1 – Stepper Motor Driver
Team Members	Team Member 1: Team Member 2:
Date:	

Lab Requirements

Obtain a list of the Lab requirements from the end of the lab handout and type them here, perform a self-review and indicate with an X if you met each requirement or not.

REQ Number	Objective	Self-Review	TA Review
1	The LEDs on the YRDKRX63N light up as coils would be energized in a stepper motor.		
2	The 3 buttons on the board change the stepping mode of the driver. One button should set the mode to wave drive, one to full step, and one to half step.		
3	The current stepping mode of the driver should be displayed on the LCD at all times.		
4	When in wave drive mode, the LEDs should represent the steps taken in that mode.		
5	When in full step mode, the LEDs should represent the steps taken in that mode.		
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7	An external pin should be selected as the drive pin, and another pin should be selected as the direction pin.		
8	The direction pin will change the direction the stepper motor rotates, reversing the LED sequence when changed from a 1 to a 0.		
9	The drive pin is used to control the speed of the motor. At each rising edge of a square wave or PWM input to the drive pin, the stepper motor should take a step.		
10	Temperature sensor can trigger a temporary shutdown until the driver has “cooled off”		