ME 3210 Mechatronics II Laboratory

Lab 1: Stepper Motors

In this laboratory exercise, you will look at several properties of stepper motors. The motor used is a two-phase motor. You will look at the pulse pattern of the motor, the holding torque and the stall frequency of the motor. There is no lab report required for this exercise, but you are expected to come to your scheduled lab and answer all the questions to your T.A.

Brief Background

The term "stepper motor" is a short descriptive name for a wound synchronous motor. These motors operate on the principle of a rotating magnetic field. A permanently magnetized rotor sits within an envelope of stator windings, as seen in Figure 1. When current is introduced to the windings, a magnetic field in the windings results because of Faraday's law. The poles of the rotor line up with the induced magnetic field (the equilibrium point or position of lowest potential energy), resulting in a net torque on the rotor. It would not be very interesting or useful to have the rotor go to one position and stay there when the current is switched on. To gain usefulness, current is switched between the windings in a circular pattern, thus causing a rotating magnetic field. The rotor chases the magnetic field resulting in a net speed. Most stepper motors have two windings, but some have three. The stepper motor of Figure 1 does not have a very desirable resolution since it has only one pole pair on the rotor. In reality, the rotors of stepper motors contain many pole pairs, thus improving the resolution (step size) according to the following relation:

$\Delta q = \frac{360\,°}{m \cdot N}$, where Δq is the resolution, m is the number of stator phases, and N is the number of rotor teeth. This formula works for full-step configuration. The half-step configuration doubles the resolution. Note that each pole pair has two teeth. Thus, for the figure below, m=2 and N=2. The class web page has a link to an animated tutorial of these principles in the "Lab Handouts" section.

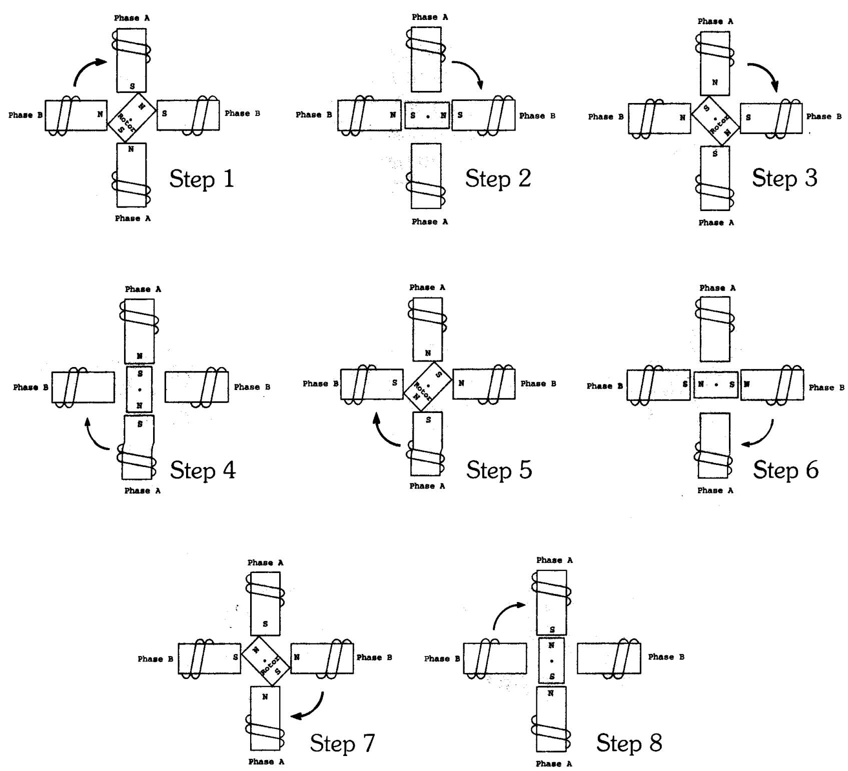

Figure 1: Schematic of a simple wound synchronous motor taking half steps.

Procedures

1. Build the following stepper motor control circuit shown in Figure 2. The circuit is built around the Motorola MC3479P stepper motor driver chip. The chip takes an input clock signal (i.e. square wave) and produces control signals that excite individual coils within a stepper motor, hence causing the motor to rotate. Rotation direction is controlled through PIN 10 on the chip and half or full stepping is controlled through PIN 9. The individual stepper motor coils are connected to PIN 2, 3 and PIN 14, 15, respectively. You must find a way to determine which output plug on the motor belongs to the appropriate coil pins on the chip (hint: measure the resistance). The "Lab Handouts" section on the class web page contains the Motorola technical document for more detailed information.

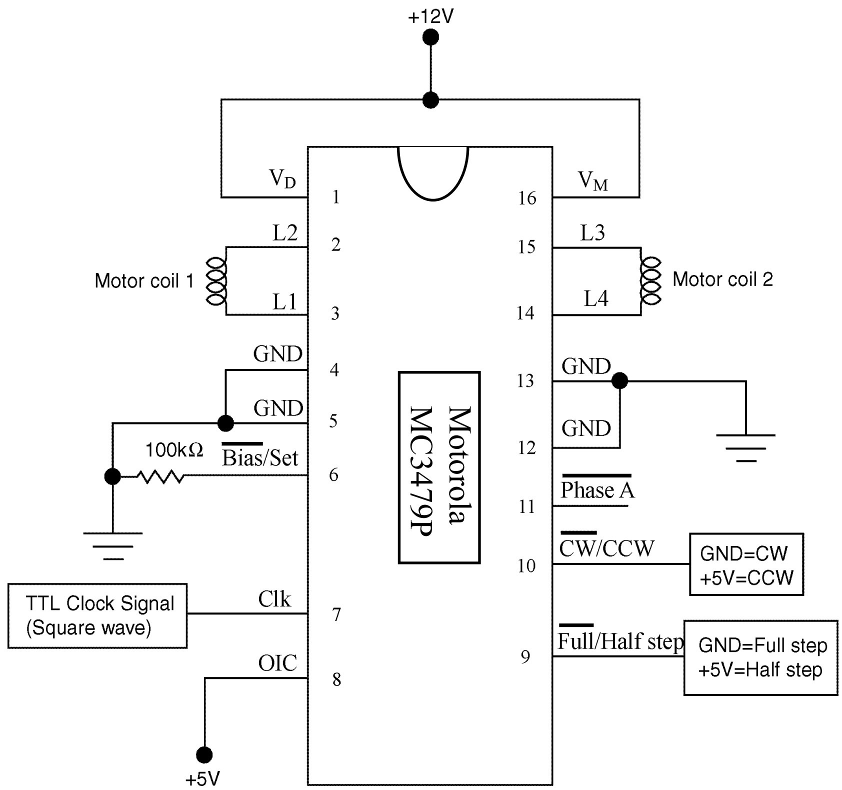

Figure 2: Pin out schematic for the driver chip.

2. Look at the pattern of the phases of the motor as the motor is stepped clockwise and counter-clockwise. Unplug the inputs to the stator windings and route them to the input channels of the oscilloscope. Describe the pattern and the operation of the motor in each direction.

3. Measure the stepping torque of the motor as the motor is operated slowly (start-stop mode) with your finger. What happens as the motor stepping speed increased?

4. Find the number of rotor pole pairs for the given stepper motor. Count how many steps it takes to complete one revolution in full-step mode, and then use the given equation.

5. Slowly increase the stepping rate. Find the stepping rate where the motor stalls. You may note that the motor misses steps at slower rates before it completely stalls. Why? Observe the motion of the shaft and feel the shaft motion with your finger.

6. Do not remove the driver chip from the breadboard, but put the rest of the circuit away so the next group will have the opportunity to build the circuit. Answer the following additional questions.

Additional Questions

What are some possible applications of stepper motors?

How can you find the absolute position of the motor shaft?

What are some potential disadvantages of having more stator windings?

Compare stepper motors to DC motors.

Servo Exercise

This exercise is intended to make sure that everyone has some experience using the HandyBoard to control a servo. If you have programmed the HB for servo operation already, then these steps will be simple to complete.

1. Locate the c-code to run the servo on the lab computers
   C:\IC\libs\RCservo
2. Save a copy of servoExample.c that you can use to make changes to the code.
3. Unload any previous files on the HB and load the three files
   servoExample.c (a copied version)
   servo_a5.icb
   servo_a7.icb
4. Put the white (signal) lead into the digital 9 port (the top slot)
5. Put the red and black leads into the +5 and gnd buses respectively

The file servoExample.c gives digital 9 and timer-out 3 a value based on the position of the knob. When used for your skiing robot, the knob value will be replaced with a value based on the sensor readings. In this exercise, you will determine the min and max values that can be given to your servo.

6. The default min and max values are 650 and 4700. Use your imagination and creativity to determine if a different range is needed.
7. Show your friendly TA <u>how</u> you found the limits and use the knob to <u>prove</u> that your software limits correspond to the hardware limits.