EE2016 - Microprocessor Theory + Lab
Experiment-8

In this experiment, we will interface a stepper motor to the LPC2378 microcontroller. We will begin by describing how a stepper motor works.

1 How does a stepper motor work ?

A stepper motor is a brushless electric motor that creates discrete rotation from the electrical input pulses. Such a motor is also called as a fractional horse power motor and the absence of a commutator (therefore wear and tear) adds to the robustness. While there are various types of stepper motors, the ones used in the lab experiment are called Permanent Magnet Stepper motors. These have multiple toothed electromagnets (called stator) arranged around a central gear-shaped permanent magnet (termed as rotor) as shown in Figure 1. The electromagnets are energized through the contact pins of the microcontroller. To make the motor shaft rotate, the stator is given an excitation, which attracts the rotor teeth (magnetically) to the stator electromagnet. When the rotor teeth are aligned with stator 1 (as shown in Figure 1), they are slightly offset from stator 2. When the next excitation is given, the rotor aligns with the stator 2. This process continues until the rotor makes one complete revolution. Each of these rotations is known as a "Step" with an integer number of steps making one full revolution.

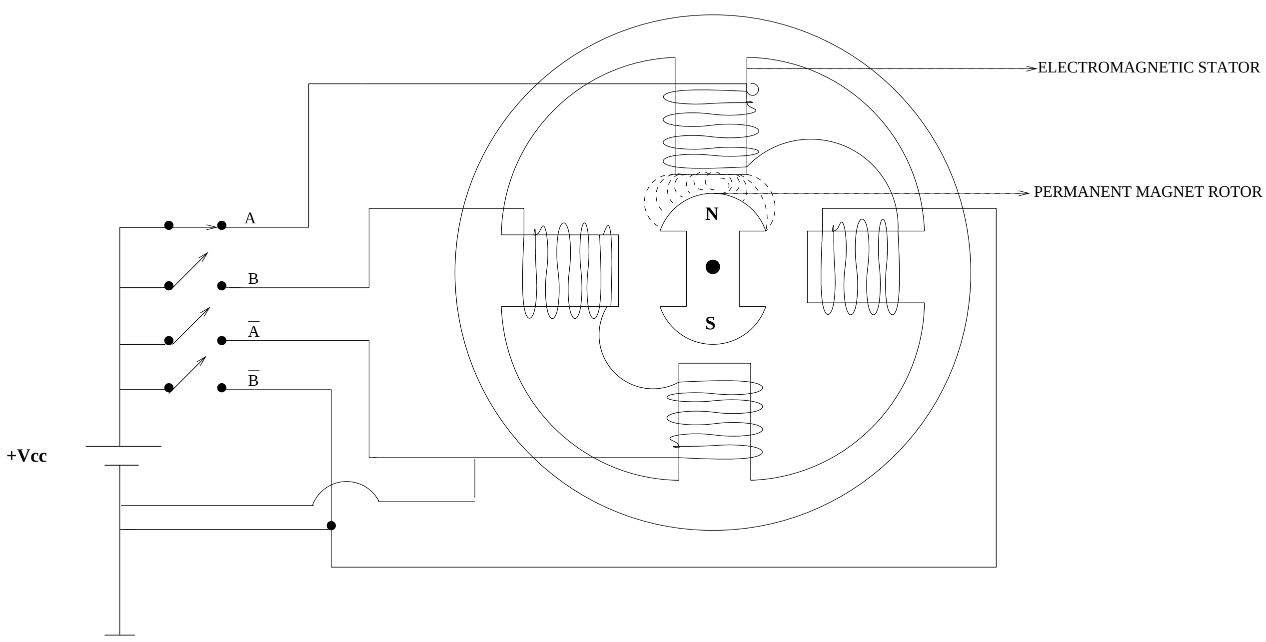

Figure 1: Permanent Magnet Stepper Motor with Phase A excited

2 Waveforms that can drive a stepper motor

The following are the possible drive control methods for a stepper motor.

- Wave Drive control
- Full Step Drive control
- Half Step Drive control

The lab experiment will be performed using the Wave Drive control of Stepper motor.

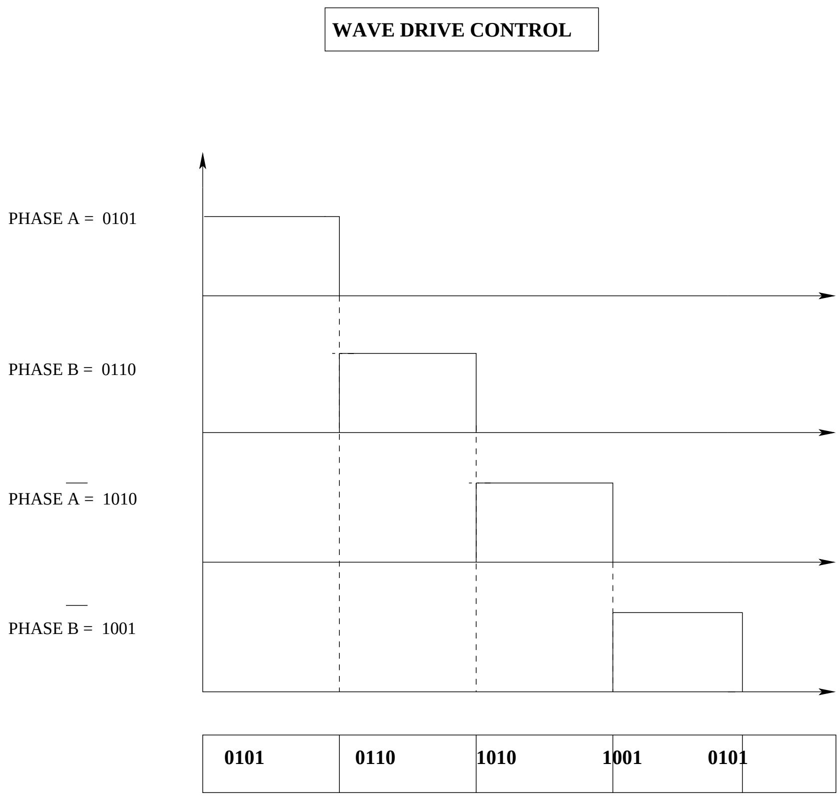

Figure 2: Wave drive control

2.1 Wave Drive Control

In Wave Drive control as shown in Figure 2, only one winding is energized per sequence (if the sequence is denoted by $AB\overline{A}\,\overline{B}$ and A is excited, the other three remain unexcited). The stepper motor has input pins termed as contact pins that allow current for excitation from the LPC2378 microcontroller of the stator coil windings. Pulsed waveforms in the correct sequence are used to create the electromagnetic fields required to drive the motor. The stepper motor driver circuit has two major tasks:

- To change the current and flux direction in the phase windings. This is achieved by taking a centre-tapped wire connection between each pair of phase windings and is termed as a Unipolar connection as shown in Figure 3 (A, B, $\overline{A}$ and $\overline{B}$ correspond respectively to Black, Orange, Red and Brown leads on the right in Figure 3).

- To drive a controllable amount of current and adjust the drive sequence according to the speed requirements.

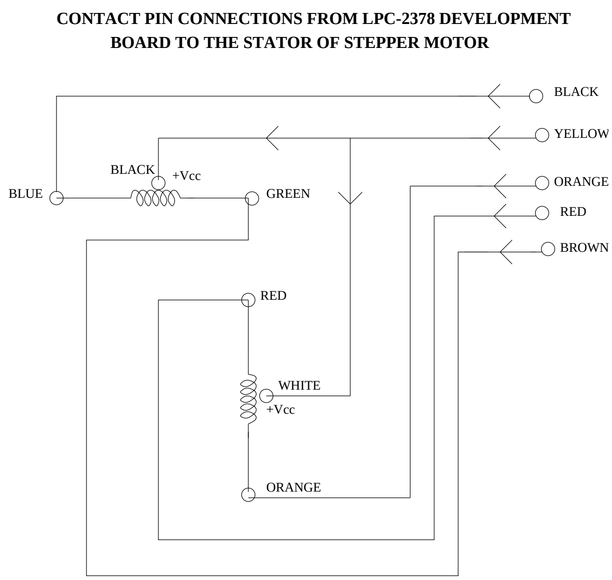

Figure 3: Unipolar connection

3 The tasks to do in this experiment

Task 1: The first task in this experiment involves completion of the program given below to make the motor rotate in a specific direction at a fixed speed.

```
//Include the header file(s)
..........................

// Complete the definition of delay function for excitation of each phase
static void delay( )
 {

 }

// Fill in the missing portions and complete the definition of main()
 int main (void)
 {







  IODIR0 = 0x00000xxx;  // Configure pins P0.6, P0.7, P0.8, P0.9 as output
 //  for exciting the four phases of the stepper motor
  // (refer pages 170-185 of user manual; can try configuring others too)

   while(1)  // execute this loop for ever (until a break is encountered
             //     or an interrupt occurs)
   {
    // Assign the phase sequence for the stator to enable the motor
```

```
    //  to rotate in a given direction. In particular, use the
    // IOPIN0 register to set the phase excitation.
    // (Refer wave drive control diagram attached).

    IOPIN0 = 0X00000xx0; // Excitation for Phase 1
            //  Select bits 6 to 9 of IOPIN0 (count from 0)
            //  to enable phase excitation
    delay();
    IOPIN0 = 0X00000xx0; // Excitation for Phase 2  (fill in  suitably)
    delay();
    IOPIN0 = 0X00000xx0; // Excitation for Phase 3 (fill in suitably)
    delay();
    IOPIN0 = 0X00000xx0; // Excitation for Phase 4 (fill in suitably)
    delay();
   } // end while

 return 0;
} // end main()
```

Task 2: Modify the program given in Task 1 to cause rotation of the stepper motor in both clockwise and anti-clockwise directions. That is, the motor should make a few rotations in clockwise direction, stop and then make a few rotations in the anti-clockwise direction.

Task 3: The program in Task 1 causes the motor to rotate at approximately 90 rpm. Write a program which will allow the motor to rotate at four different speeds. That is, it should rotate at (say) 30 rpm for one complete revolution, then at (say) 50 rpm for another revolution, then at 70 rpm and finally at 90 rpm for the last revolution.