EXPERIMENT NO.-4

Title: Interfacing of Stepper Motor to 8051 – Software delay using timer

AIM: Write An Alp To Stepper Motor In Clock/Anticlock Wise Directions

OBJECTIVE:

1. To understand the concept of stepper motor interface
2. Able to write programs for rotating stepper motor at different angles

THEORY:

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Every revolution of the stepper motor is divided into a discrete number of steps, in many cases 200 steps, and the motor must be sent a separate pulse for each step. The stepper motor can only take one step at a time and each step is the same size. Since each pulse causes the motor to rotate a precise angle, typically 1.8°, the motor's position can be controlled without any feedback mechanism. As the digital pulses increase in frequency, the step movement changes into continuous rotation, with the speed of rotation directly proportional to the frequency of the pulses. Step motors are used every day in both industrial and commercial applications because of their low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment.

Stepper Motor Advantages

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at standstill (if the windings are energized).
3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3 to 5% of a step and this error is non-cumulative from one step to the next.
4. Excellent response to starting/stopping/reversing.
5. Very reliable since there are no contact brushes in the motor. Therefore the life of the step motor is simply dependant on the life of the bearing.
6. The stepper motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.
7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.

8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

Types of Step Motors

There are three basic types of step motors: variable reluctance, permanent magnet, and hybrid. This discussion will concentrate on the hybrid motor, since these step motors combine the best characteristics of the variable reluctance and permanent magnet motors. They are constructed with multi-toothed stator poles and a permanent magnet rotor. Standard hybrid motors have 200 rotor teeth and rotate at 1.8° step angles. Because they exhibit high static and dynamic torque and run at very high step rates, hybrid step motors are used in a wide variety of commercial applications including computer disk drives, printers/plotters, and CD players. Some industrial and scientific applications of stepper motors include robotics, machine tools, pick and place machines, automated wire cutting and wire bonding machines, and even precise fluid control devices.

Step Modes

Stepper motor "step modes" include Full, Half and Micro step. The type of step mode output of any stepper motor is dependent on the design of the driver. stepper motor drives with switch selectable full and half step modes, as well as micro stepping drives with either switch-selectable or software-selectable resolutions.

FULL STEP
Standard hybrid stepping motors have 200 rotor teeth, or 200 full steps per revolution of the motor shaft. Dividing the 200 steps into the 360° of rotation equals a 1.8° full step angle. Normally, full step mode is achieved by energizing both windings while reversing the current alternately. Essentially one digital pulse from the driver is equivalent to one step.

HALF STEP
Half step simply means that the step motor is rotating at 400 steps per revolution. In this mode, one winding is energized and then two windings are energized alternately, causing the rotor to rotate at half the distance, or 0.9°. Although it provides approximately 30% less torque, half-step mode produces a smoother motion than full-step mode.

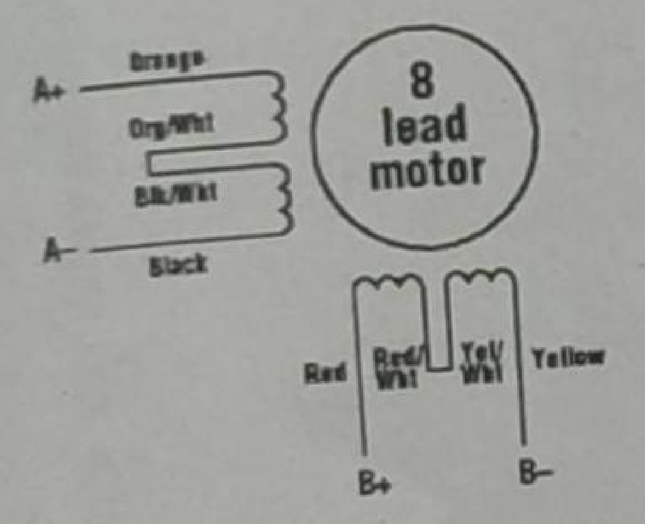
MICROSTEP
Micro stepping is a relatively new stepper motor technology that controls the current in the motor winding to a degree that further subdivides the number of positions between poles. Omegamation micro stepping drives are capable of dividing a full step (1.8°) into 256 microsteps, resulting in 51,200 steps per revolution (.007°/step). Microstepping is typically used in applications that require accurate positioning and smoother motion over a wide range of speeds. Like the half-step mode, microstepping provides approximately 30% less torque than full-step mode.

Linear Motion Control

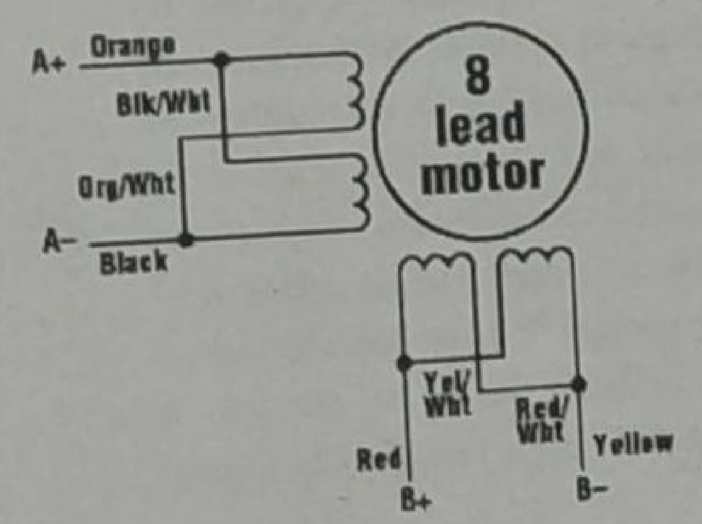
The rotary motion of a stepper motor can be converted to linear motion using a lead screw/worm gear drive system *(See figure B)*. The lead, or pitch, of the lead screw is the linear distance traveled for one revolution of the screw. If the lead is equal to one inch per revolution, and there are 200 full steps per revolution, then the resolution of the lead screw system is 0.005 inches per step. Even finer resolution is possible by using the step motor/drive system in microstepping mode.

Series vs. Parallel Connection

There are two ways to connect a stepper motor, in series or in parallel. A series connection provides a high inductance and therefore greater torque at low speeds. A parallel connection will lower the inductance which results in increased torque at faster speeds.



Series connection



Parallel connection

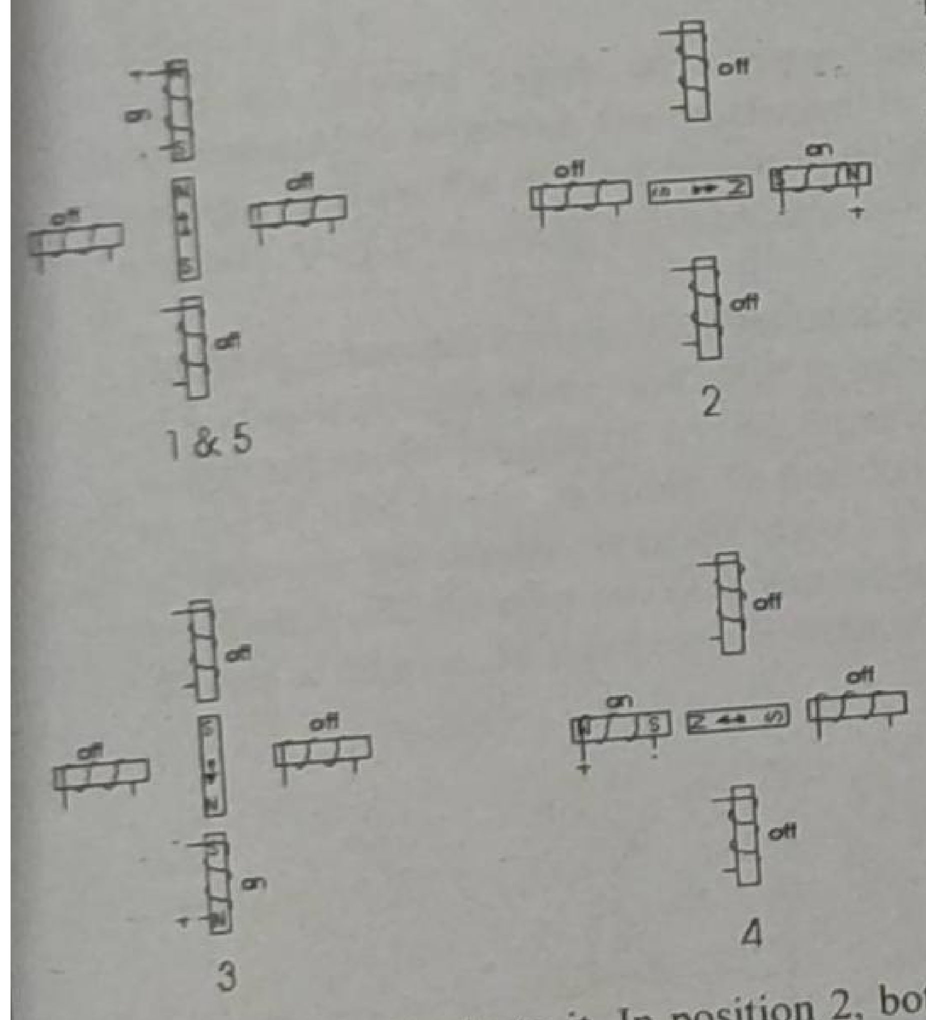
Driver Technology

The stepper motor driver receives step and direction signals from the indexer or control system and converts them into electrical signals to run the step motor. One pulse is required for every step of the motor shaft. In full step mode, with a standard 200-step motor, 200 step pulses are required to complete one revolution. The speed of rotation is directly proportional to the pulse frequency. Some drivers have an on-board oscillator which allows the use of an external analog signal or joystick to set the motor speed.

Speed and torque performance of the step motor is based on the flow of current from the driver to the motor winding. The factor that inhibits the flow, or limits the time it takes for the current to energize the winding, is known as inductance. The effects of inductance, most types of driver circuits are designed to supply a greater amount of voltage than the motor's rated voltage. The higher the output voltage from the driver, the higher the level of torque vs. speed. Generally, the driver output voltage (bus voltage) should be rated at 5 to 20 times higher than the motor voltage rating. In order to protect the motor from being damaged, the step motor drive should be current-limited to the step motor current rating.

1. How Stepper Motors Work

Stepper motors consist of a permanent magnet rotating shaft, called the rotor, and electromagnets on the stationary portion that surrounds the motor, called the stator. Figure 1 illustrates one complete rotation of a stepper motor. At position 1, we can see that the rotor is beginning at the upper electromagnet, which is currently active (has voltage applied to it). To move the rotor clockwise (CW), the upper electromagnet is deactivated and the right electromagnet is activated, causing the rotor to move 90 degrees CW, aligning itself with the active magnet. This process is repeated in the same manner at the south and west electromagnets until we once again reach the starting position.



In the above example, we used a motor with a resolution of 90 degrees or demonstration purposes. In reality, this would not be a very practical motor for most applications. The average stepper motor's resolution -- the amount of degrees rotated per pulse -- is much higher than this. For example, a motor with a resolution of 5 degrees would move its rotor 5 degrees per step, thereby requiring 72 pulses (steps) to complete a full 360 degree rotation.

You may double the resolution of some motors by a process known as "half-stepping". Instead of switching the next electromagnet in the rotation on one at a time, with half stepping you turn on both electromagnets, causing an equal attraction between, thereby doubling the resolution. As you can see in Figure 2, in the first position only the upper electromagnet is active, and the rotor is drawn completely to it. In position 2, both the top and right electromagnets are active, causing the rotor to position itself between the two active poles. Finally, in position 3, the top magnet is deactivated and the rotor is drawn all the way right. This process can then be repeated for the entire rotation.

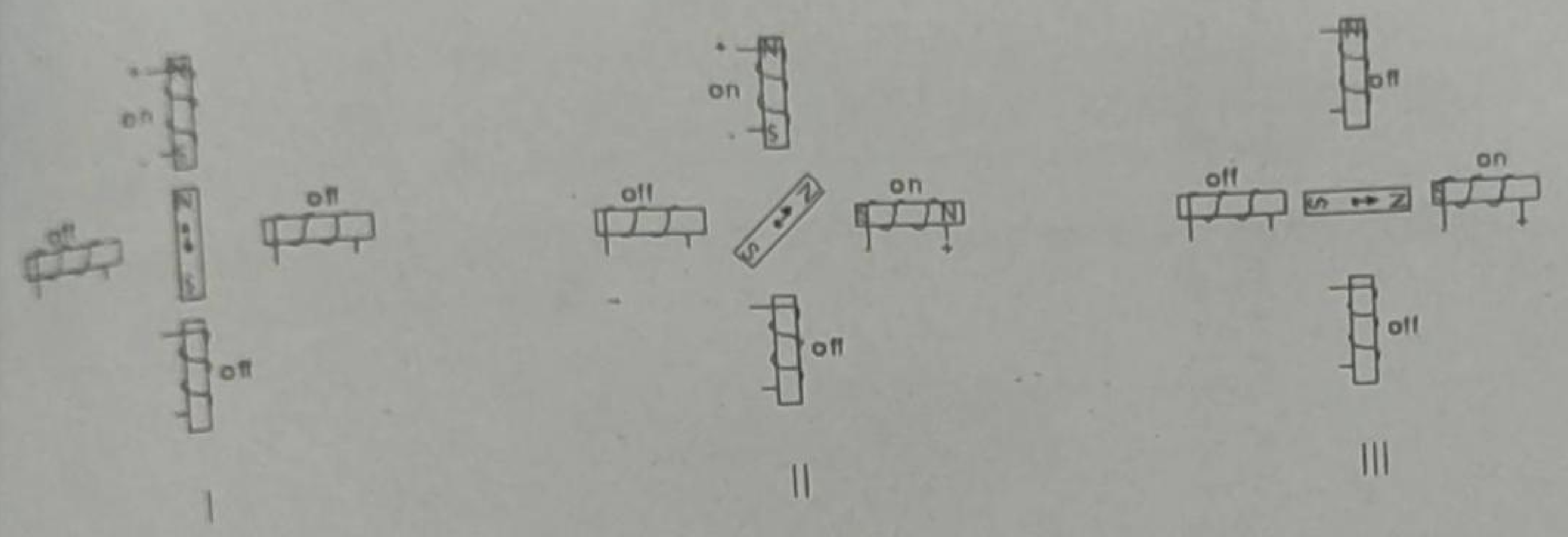


Figure 2 Working of stepper motor

There are several types of stepper motors. 4-wire stepper motors contain only two electromagnets, however the operation is more complicated than those with three or four magnets, because the driving circuit must be able to reverse the current after each step. For our purposes, we will be using a 6-wire motor.

Unlike our example motors which rotated 90 degrees per step, real-world motors employ a series of mini-poles on the stator and rotor to increase resolution. Although this may seem to add more complexity to the process of driving the motors, the operation is identical to the simple 90 degree motor we used in our example. In position 1, the north pole of the rotor's permanent magnet is aligned with the south pole of the stator's electromagnet. In position 2, the upper electromagnet is deactivated and the next one to its immediate left is activated, causing the rotor to rotate a precise amount of degrees. In this example, after eight steps the sequence repeats.

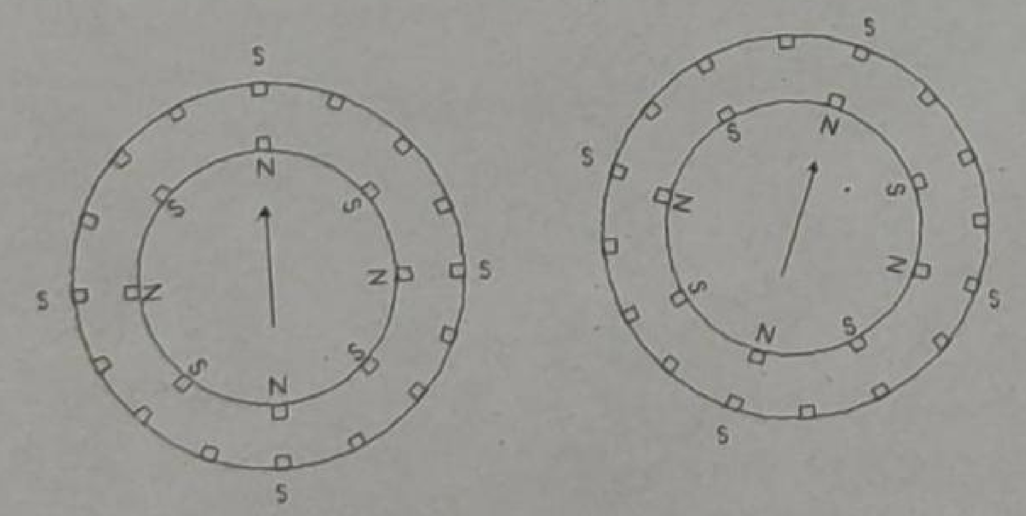


Figure 3. Step angle movement

STEP angle

It is angle through which motor shaft rotates in one step.

"It is the minimum degree of rotations associated with step angle"

step angle is different for different motor and depends on the internal construction of motor. In Particular no of teeth on stator and rotor selection of motor according to step angle depends on the application , No of steps required for one rotation = 360 deg. / step angle in deg.

- Minimum step angle is always a function of no. of teeth on rotor. *i.e smaller the step angle ,the more teeth rotor passes*

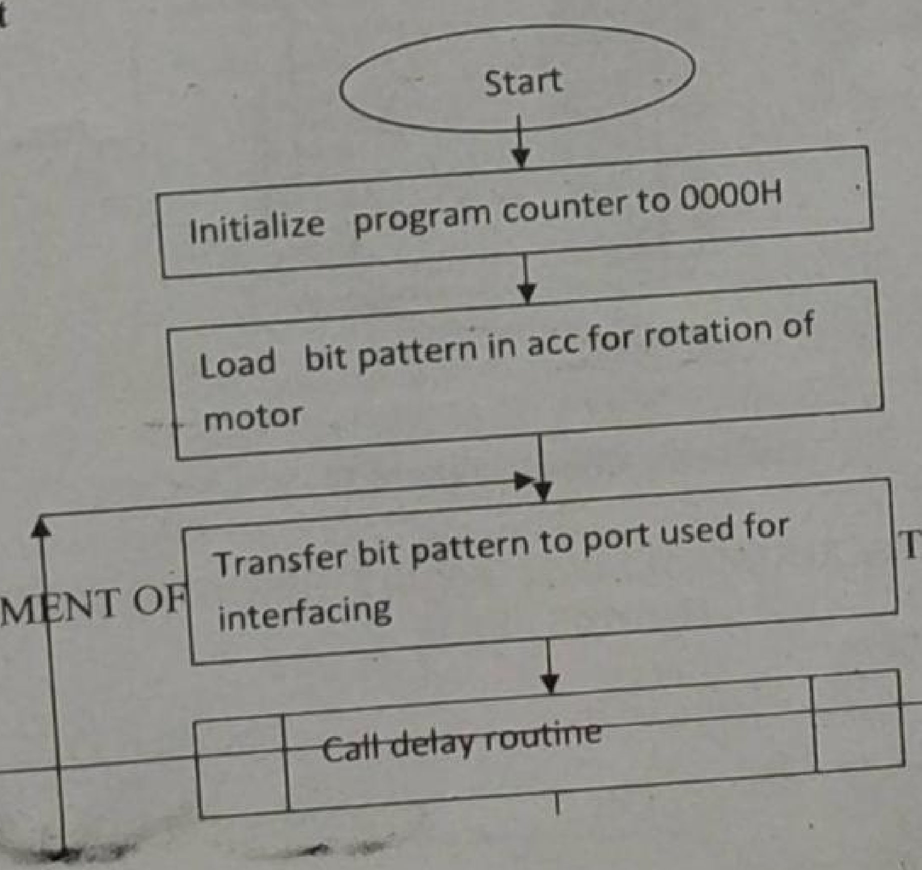
Step angle	Steps per revolution
0.75	500
1.8	200
2	180
2.5	144
5.0	72
7.5	48
15	24

➢ **ALGORITHM :**

Depending on type of waveform generated algorithm changes

7. Load bit pattern into accumulator
8. Transfer it to port
9. Delay :Wait for some time depending on duty cycle
10. Rotate the bit pattern
11. Transfer to port
12. Repeat Steps 1-5

➢ **Flow chart**



Interfacing diagram: The complete interface of stepper motor with 8051 is shown in fig (4)

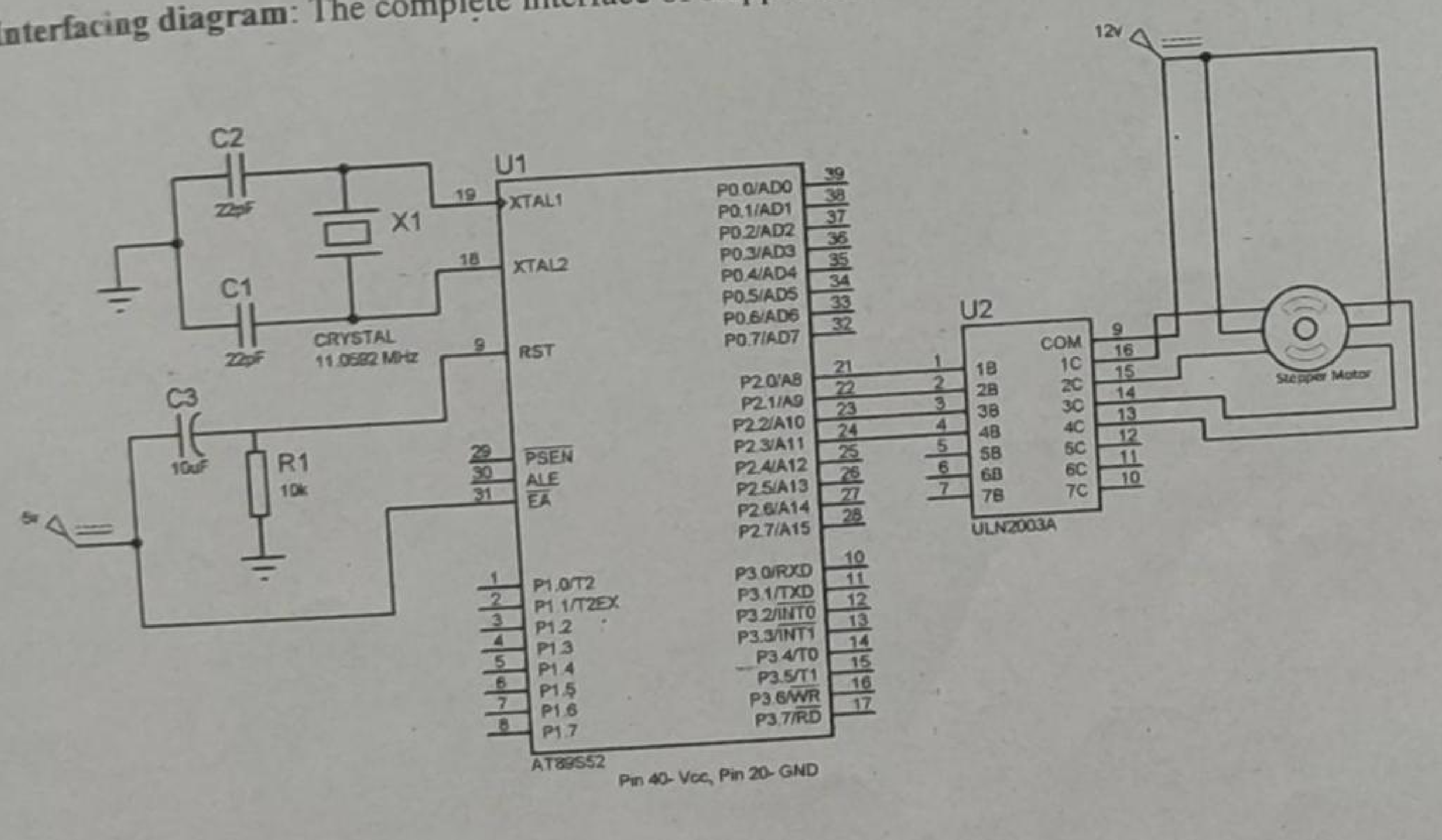


Fig (4) Stepper motor interface

Scanned by TapScanner

Experiment NO:-04

```
//stepper clockwise

#include <reg51.h>
void delay()
{
    int i,j;
    for(i=0; i<200 ;i++)
        for(j=0; j<200 ;j++);
}

void main()
{
  while(1)
  {
      P2=0x03;
      delay();
      P2=0x06;
      delay();
      P2=0x0C;
      delay();
      P2=0x09;
      delay()
  }
}
```

Scanned by TapScanner