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Stepper Motor Control by using Microcontroller

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Abstract: *In present the use of stepper motor is World Wide in many common and precious application various stepper motor are effectively used with lot of advantages and not any disadvantage. It is driven by giving proper square wave pulse to its winding in proper sequence. It is very much accurately controlled by any digital circuitry and AT89c51 is most easy, cheep and reprogrammable microcontroller. Which is mostly used in many industrial automatic controllers application hence , in this paper we are controlling the various parameter of the stepper motor such as speed, direction and number of rotation by using AT89c51 microcontroller*

Keywords: Stepper Motor

I. INTRODUCTION

1.1 Stepper Motor

A stepper motor is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps, for example, 200 steps. Thus the motor can be turned to a precise angle.

1.2 Fundamentals of Operation

Stepper motors operate much differently from normal DC motors, which simply spin when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple “toothed” electromagnets arranged around a central metal gear, as shown at right. To make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step." In that way, the motor can be turned a precise angle. There are two basic arrangements for the electromagnetic coils: bipolar and unipolar.

1.3 Bipolar motor

In a bipolar motor, there are only two coils, and current must be sent through a coil first in one direction and then in the other direction; thus the name bipolar. Bipolar motor need more than 4 transistors to operate them, but they are also more powerful than a unipolar motor of the same weight. To be able to send current in both directions, engineers can use an H-bridge to control each coil or a step motor driver chip.

1.4 Theory

A stepper motor can be viewed as a DC motor with the number of poles (on both rotor and stator) increased, taking care that they have no common denominator. Additionally, soft magnetic material with many teeth on the rotor and stator cheaply multiplies the number of poles (reluctance motor). Like an AC synchronous motor, itis ideally driven by sinusoidal current, allowing a stepless operation, but this puts some burden on the controller. When using an 8-bit digital controller, 256 microsteps per step are possible. As a digital-to-analog converter produces unwanted ohmic heat in the controller, pulse-width modulation is used instead to regulate the mean current. Simpler models switch voltage only for doing a step, thus needing an extra current limiter: for every step, they switch a single cable to the motor. Bipolar controllers can switch between supply voltage, ground, and unconnected. Unipolar controllers can only connect or disconnect a cable, because the voltage is already hard wired. Unipolar controllers need center-tapped windings.

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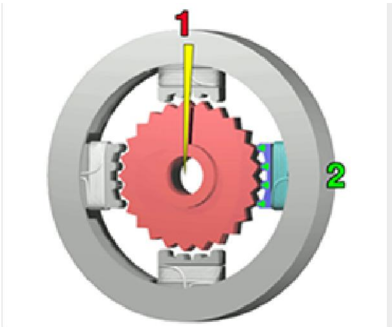
It is possible to drive unipolar stepper motors with bipolar drivers. The idea is to connect the output pins of the driver to 4 transistors. The transistor must be grounded at the emitter and the driver pin must be connected to the base. Collector is connected to the coil wire of the motor.

Stepper motors are rated by the torque they produce. Synchronous electric motors using soft magnetic materials (having a core) have the ability to provide position holding torque (called detent torque and sometimes included in the specifications) while not driven electrically. The voltage rating (if there is one) is almost meaninng less. The motors also suffer from EMF, which means that once the coil is turned off it starts to generate current because the motor is still rotating. There needs to be an explicit way to handle this extra current in a circuit otherwise it can cause damage and affect performance of the motor.

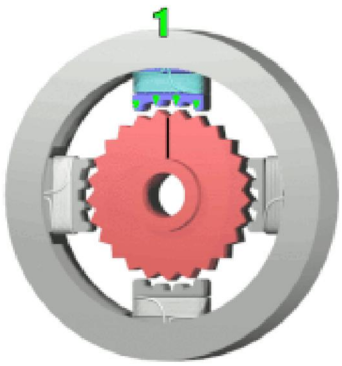
The top electromagnet (1) is charged, attracting the topmost four Teeth of a sprocket

Fig 1



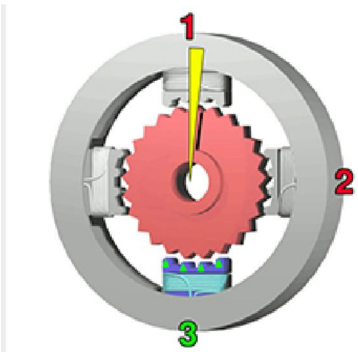
The top electromagnet (1) is turned off, and the right electromagnet (2) is charged, pulling the nearest four teeth to the right. This result in a rotation of 3.6^o .

Fig 2



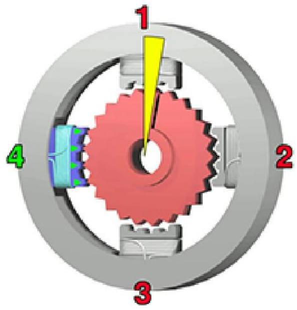
The bottom of electromagnet (3) is charged; Another 3.6^o rotation occurs.

Fig 3



The left electromagnet (4) is enabled, rotating again by 3.6° when the top electromagnet (1) is again charged, the teeth in the sprocket will have rotated by one tooth position; since there 25teeth, it will take 100steps to make a full rotation

Fig 4



AT89C51 Description

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read-only memory (PEROM). The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer that provides a highly-flexible and cost-effective solution to many embedded control applications.

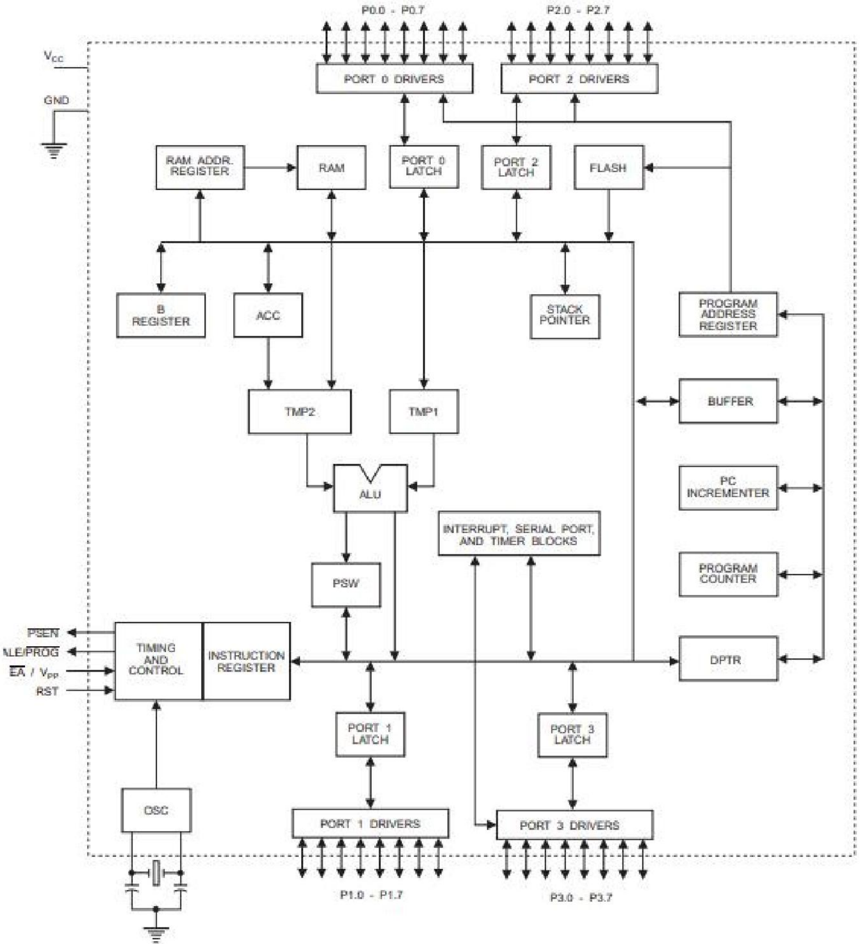


Fig 5: Block Diagram of AT89c51 microcontroller

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Port pin Description:-

Port 0

Port 0 is an 8-bit open-drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high impedance inputs.

Port 0 may also be configured to be the multiplexed loworder address/data bus during accesses to external program and data memory. In this mode PO has internal pullups.

Port 0 also receives the code bytes during Flash Programming, and outputs the code bytes during prograri verification. External pullups are required during program verification.

Port 1

Port 1 is an 8-bit bi-directional I/O port with internal pullups. The Port 1 output buffers can sink/source four TTL inputs.

When 1s are written to Port 1 pins they are pulled Highby the internal pullups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pullups.

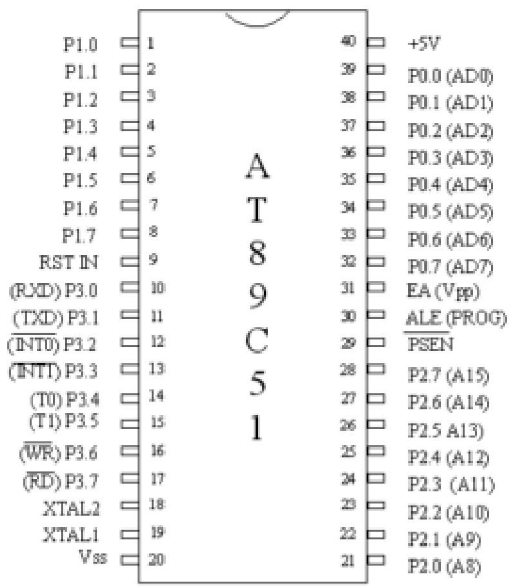

Fig 6:- Pin Diagram of AT89c51

Port 1 also receives the low-order address bytes during Flash programming and verification.

Port 2

Port 2 is an 8-bit bi-directional I/O port with internal pullups. The Port 2 output buffers can sink/source four TTL inputs. When Is are written to Port 2 pins they are pulled high by the internal pullups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pullups.

Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR). In this application, it uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @ RI), port 2 emits the contents of the p2 special function Register.

Port 2 also receives the high- order address bits and some control signals during flash programming and verification.

Port 3

Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. The port 3 output buffers can sink/source four TTL inputs. When s are written to port 3 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups.

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Port 3 also serves the functions of various special features of the AT89c51 as listed below:-

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

Fig 7:- Port pins of AT89c51

Parameter to be controlled:

Direction :-

To change the direction of the motor, you have to change the sequence of pulses applied to its coils. The pulse sequence for clockwise and anticlockwise rotation is shown in the table on the next page for better understanding. In the table, '0' and '1' indicate low logic and high logic, respectively.

Applied Pulse Sequence for Clockwise and Anticlockwise Rotation							
Clockwise Rotation				Anticlockwise Rotation			
Red	Blue	White	Yellow	Red	Blue	White	Yellow
0	1	0	1	0	1	0	1
1	0	0	1	0	1	1	0
1	0	1	0	1	0	1	0
0	1	1	0	1	0	0	1

Table 1

Speed

The speed of the motor can be change by varying the pulse repetition frequency(PRF). PRF is the frequency of pulses that are applied to the motor coils in sequence. 20 PRF means 20 pulses will be given to the stepper motor in one second. Now because step resolution of the motor is 18^o / pulse, the motor will rotate $20X18^o=360^o$(i.e., one complete revolution) in one second. So the speed of the motor is 1 RPS (60 RPM). Now if you increase PRF form 20 Hz to 40 Hz, the RPS will also double to 2 RPS (120 RPM).

Number of rotations

The step resolution is 18^o. If you apply 20 pulses in series, the motor will rotate 360^o , which means one complete revolution. So if you limit the number of pulses applied to the motor, you can restrict it to rotate desired number of rotation.

II. CONCLUSION

We can conclude that AT89c51 is a most easily and suitable microcontroller for controlling the all three parameters of stepper motor i.e. speed, direction of rotation and no.of revolution.

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