A short note on Stepper motors

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Abstract

Stepper motors are used mainly to position an object to a specific position. They can be digitally controlled. After many improvements, now a days, stepper motors are used in a lot of applications.

1 Working principle

Stepper motor works on the principle of least reluctance path.

When a coil is energised, it attracts the appropriate rotor pole to minimise the path reluctance. This rotates the magnet pole through certain angle.

Consider a motor as shown in the figure 1 on page 2.

If we follow the following process, the rotor of the motor will complete a rotation. If the rotor magnet jumps from one pole to the other, it is called as full stepping.

1. A coil is energised.
2. The rotor is attracted to the coil.
3. This makes the reluctance of the magnetic path minimum.
4. We energise the coils one-after the other in sequence.
5. The rotor steps further through one step (here it is 90 degrees).

2 Full stepping using μ C

Refer to the figure 1 on page 2.

- To control stepper motor, we need to energise and de-energise the coils individually and independently.

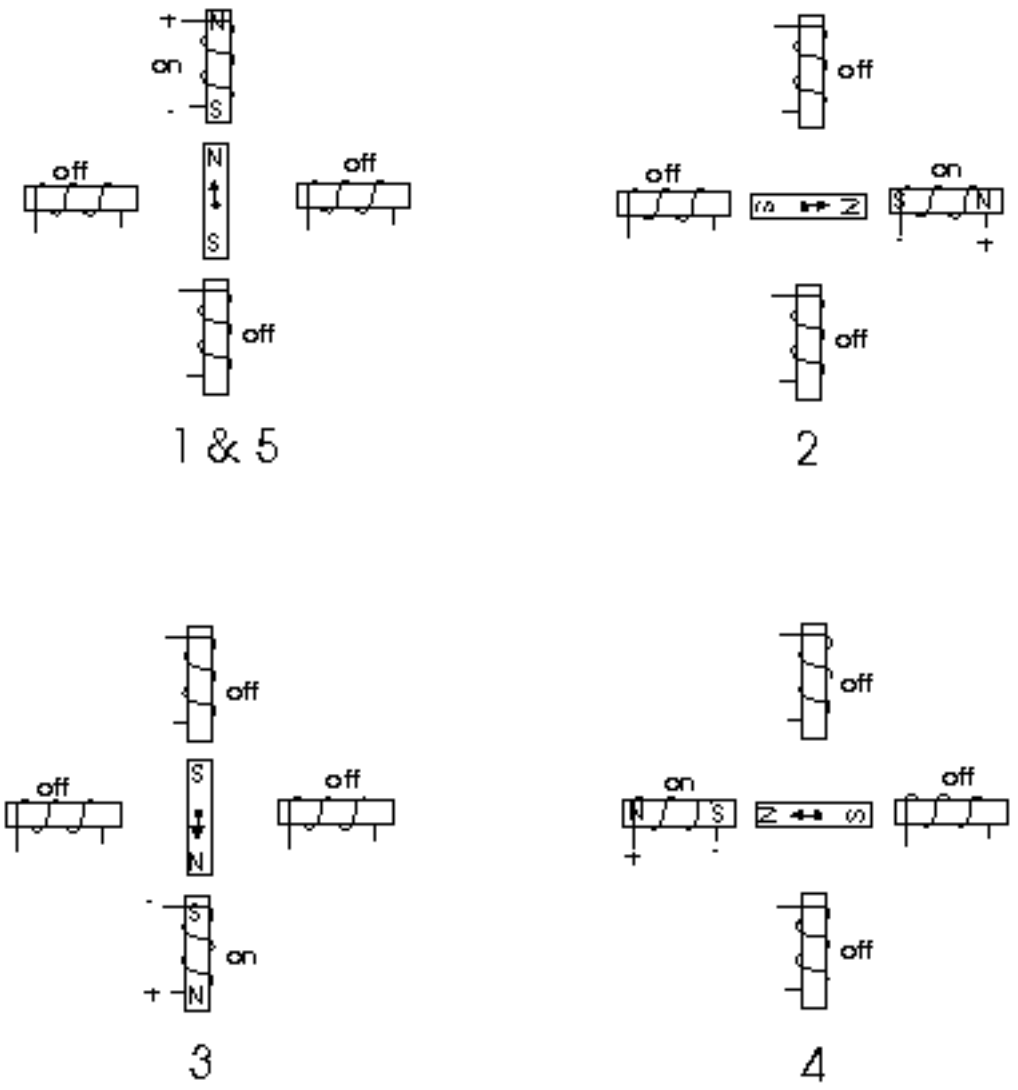

Figure 1: principle of stepper motor

- When a coil is energised, it attracts the appropriate rotor pole to minimise the path reluctance. This rotates the magnet pole through certain angle.

In the figure 1 shown,

- the rotor will rotate through 90 deg per step.
- The sequence of energizing and de-energizing the coils is as in the table 1 on page 3.
- Coils are controlled by a micro-cot roller through switching transistors.

Table 1: Full stepping sequence: 1 means energised coil

Step No.	Coil A	Coil B	Coil C	Coil D
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1

To position the rotor as we desire, we need to have the smallest step angle. We can do this by

- increasing number of stator poles
- increasing number of teeth on the rotor
- using half stepping technique

3 Half stepping

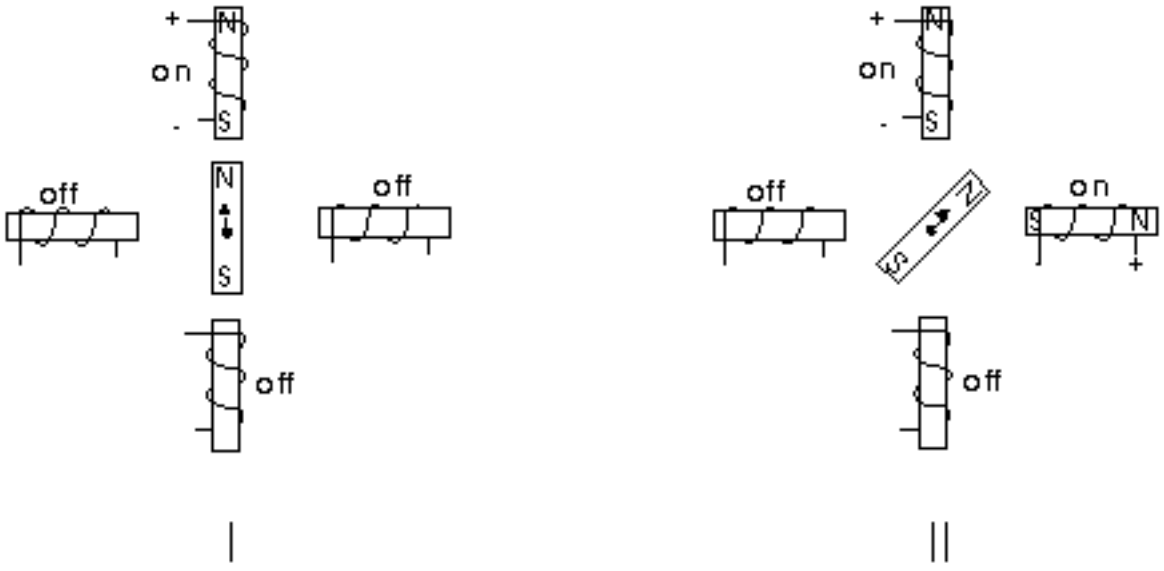

Figure 2: Half stepping of stepper motors

For the same geometry and electrical design, the step can be made half. This is called as half stepping. This is done without increasing number of stator poles. It is achieved using different energising steps through software.

Table 2: Half stepping of stepper motor: 1 means energised coils

Step No.	**Coil A**	**Coil B**	**Coil C**	**Coil D**
1	1	0	0	0
2	1	1	0	0
3	0	1	0	0
4	0	1	1	0
5	0	0	1	0
6	0	0	1	1
7	0	0	0	1
8	1	0	0	1

In this method,

1. two neighbouring coils are energised simultaneously.
2. The rotor is now attracted to both the stator coils by equal force.
3. This makes the rotor to fix its position exactly between the two stator coils thus achieving half step angle.
4. Note that 8 steps are necessary for one complete revolution of the motor.
5. If we compare this sequence with the earlier full step sequence (4 steps per revolution), we conclude that the later (8 steps per revolution) goes through half steps.

The table 2 on page 4 contains coil states for half stepping sequence.

4 Advantages and limitations

Stepper motors have following advantages:

1. Positioning of an object is possible using open loop control system. No feedback needed.
2. Micro controllers can control these motors very conveniently.
3. With small step angle, precise control is possible.
4. Power is consumed only when a coil is energised.

Stepper motor has following disadvantages:

1. Oscillations (however small) at every step are unavoidable.
2. Only digital controlling systems needed.
3. Jerky motion of rotor.

5 Applications

Stepper motors are used very widely. Some of the applications are listed below.

1. In computer printer for paper movement.
2. Robotics.
3. Plotters.
4. Control of solar mirrors.