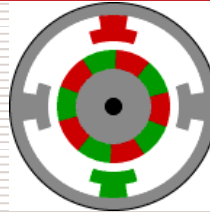


ECGR-6185
Advanced Embedded Systems

**INTRODUCTION TO DIGITAL ACTUATORS
(Stepper and Servo Motors)**



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Classification: -

- Variable Reluctance
- Permanent Magnet
- Hybrid



Construction

- Unifilar
- Bifilar



Winding Configurations

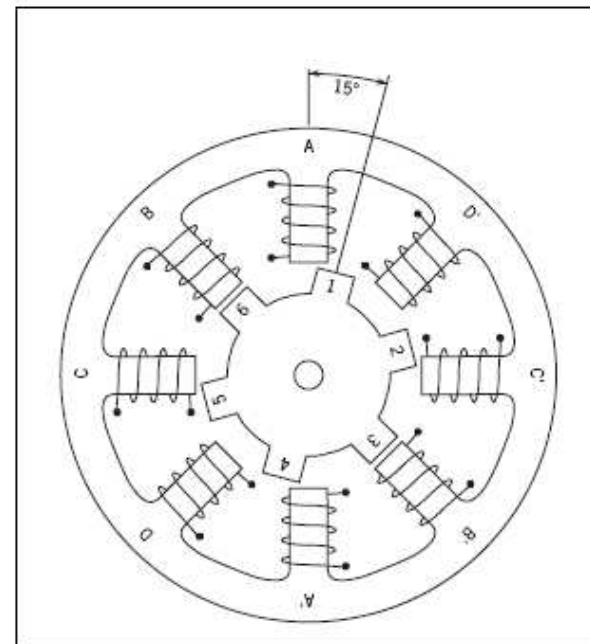
- Full Step
- Half Step
- Micro Step



Drive Mode

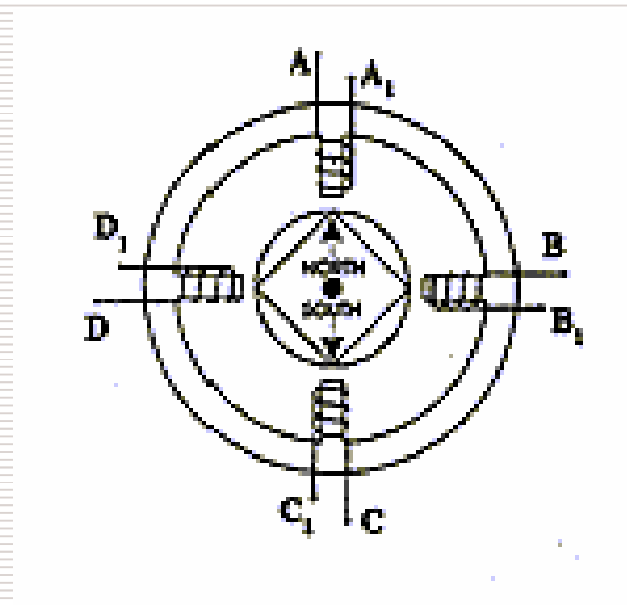
Variable Reluctance:

- Salient pole stator
- No windings on the rotor
- Stator and rotor pole numbers are different
- Torque is developed by the tendency for the magnetic circuit to adopt the configuration of minimum reluctance



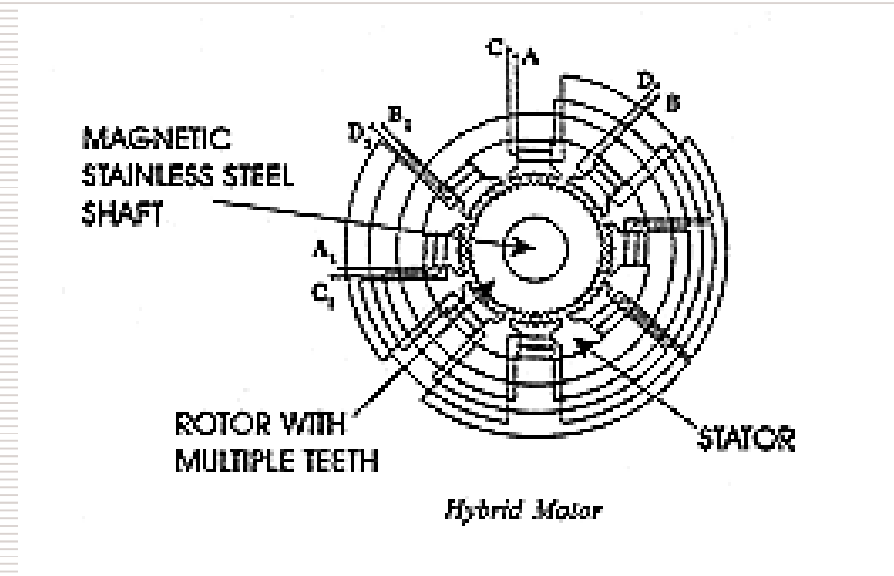
Permanent Magnet:-

- Permanent magnet in the rotor
- Stator is similar to single stack variable reluctance
- High inertia and lower torque to inertia ratio
- Restricted to large step size



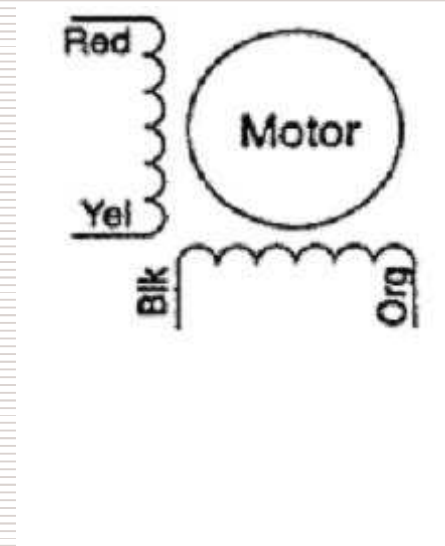
Hybrid Motor:-

- Operated with the combined principles of the PM and VR motors
- Small step angle and a high torque from a small size



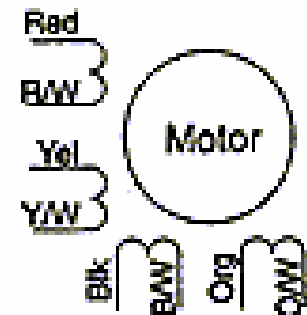
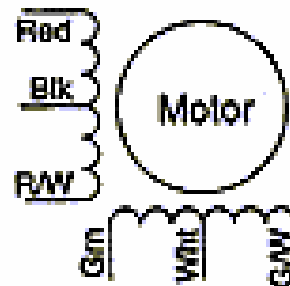
Unifilar Motor:-

- Only one winding per stator pole
- To change direction requires reversing the current in the same winding.



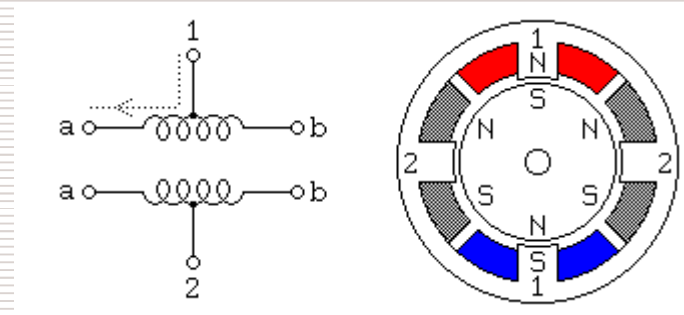
Bifilar Winding:-

- Two identical sets of windings on each stator pole
- Winding configuration simplifies the drive circuitry



Unipolar Motor:-

- Current flow is limited in one direction
- To rotate the motor, just apply power to the two windings in sequence

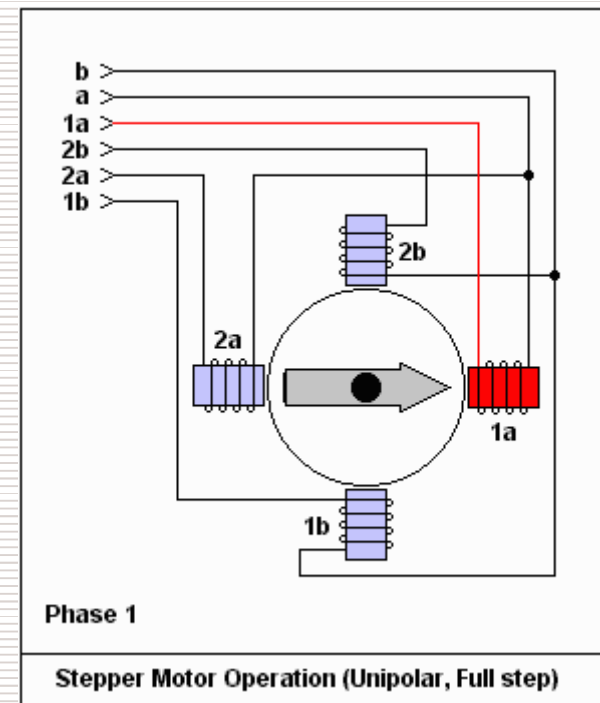


Modes of Stepper Motor:

- Full Step
- Half Step
- Micro Step

Conceptual Model of Unipolar Stepper Motor: Full Step

- The center taps of the windings are wired to the positive supply
- The two ends of each winding are alternately grounded to reverse the direction of the field provided by that winding

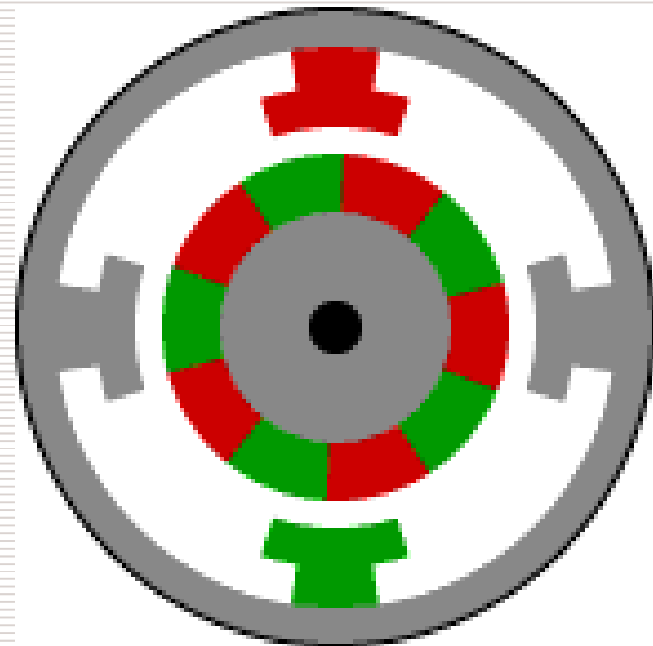


Full Step Mode:-

- Full step sequence showing how binary numbers can control the motor

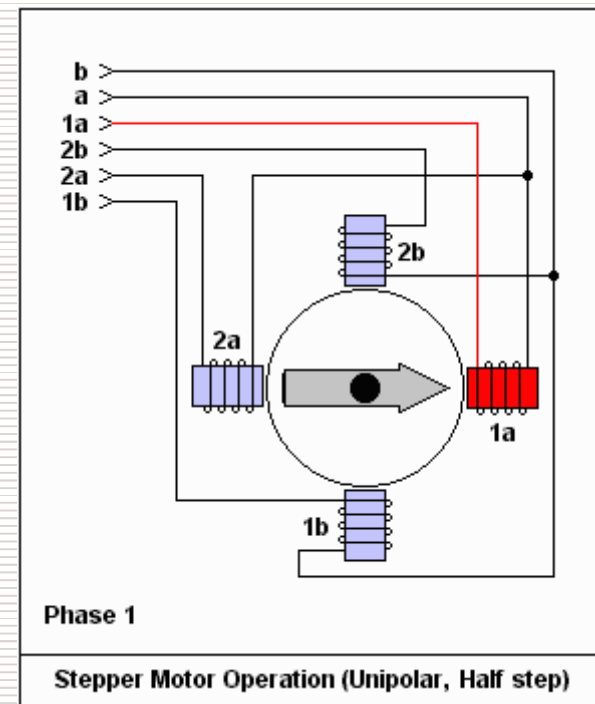
Clockwise Rotation ↓

Index	1a	1b	2a	2b
1	1	0	0	0
2	0	1	0	0
3	0	0	1	0
4	0	0	0	1
5	1	0	0	0
6	0	1	0	0
7	0	0	1	0
8	0	0	0	1



Conceptual Model of Unipolar Stepper Motor: Half Step

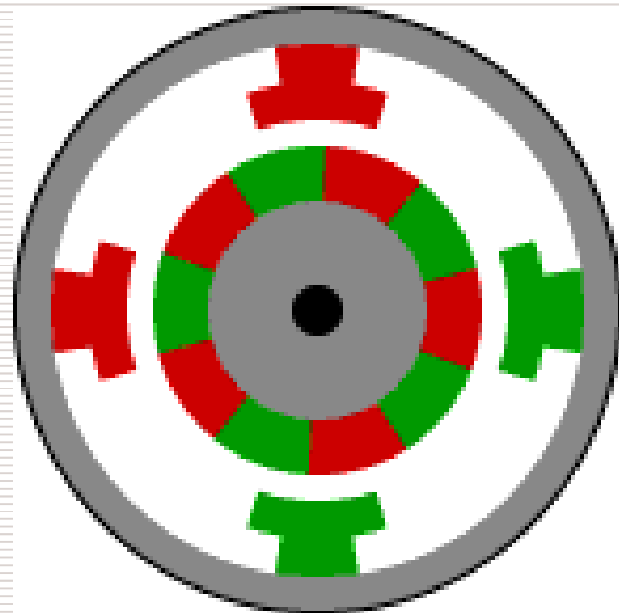
- Same circuitry with different winding sequence
- Two windings are energized at the same instance



Half Step Mode:-

Clockwise Rotation ↻

Index	1a	1b	2a	2b
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
9	1	0	0	0
10	1	1	0	0
11	0	1	0	0
12	0	1	1	0
13	0	0	1	0
14	0	0	1	1
15	0	0	0	1
16	1	0	0	1

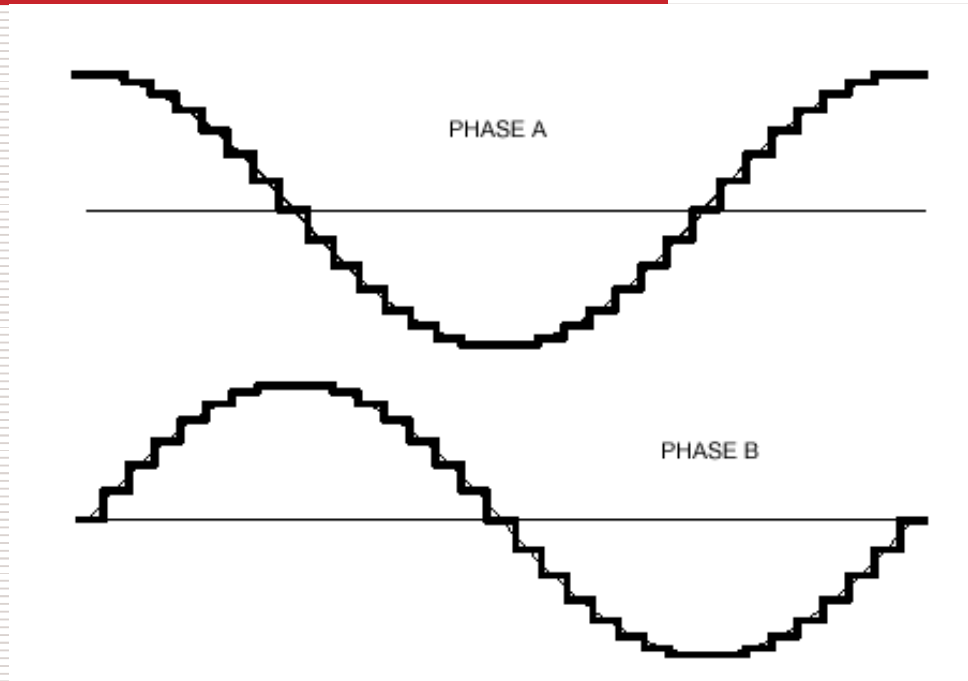


- Half step sequence showing how binary numbers can control the motor

Micro Stepping Mode:-

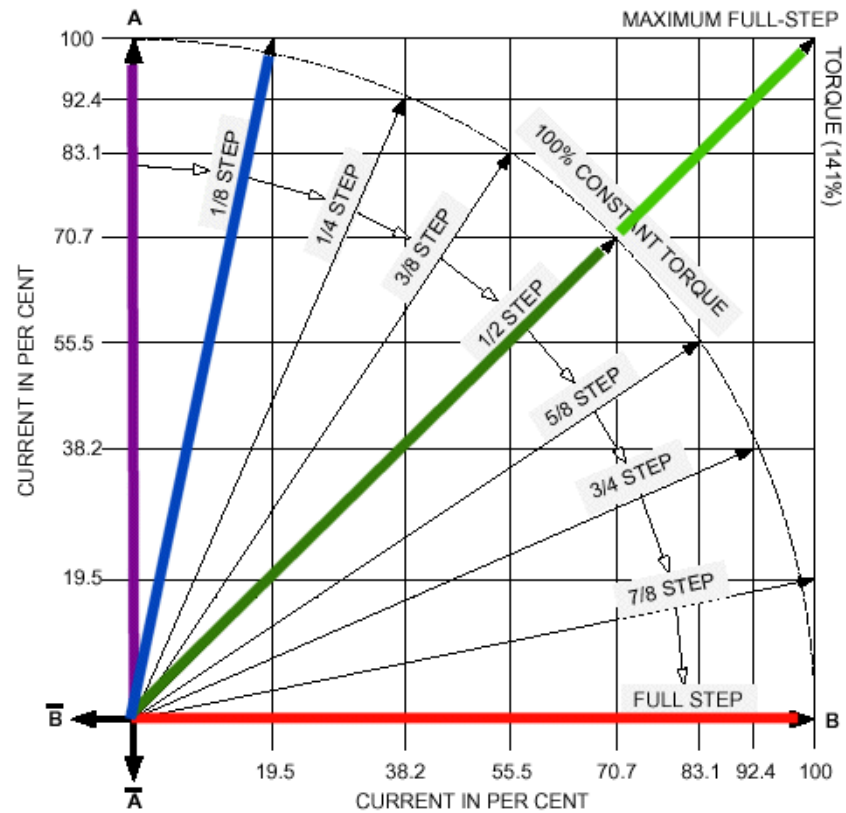
- Positional resolution is limited because of the mechanical design of the unit
- It allows a stepping motor to stop and hold a position between the full or half-step positions
- The jerky character of low speed stepping motor operation and the noise at intermediate speeds

Principle of Micro Stepping (contd)

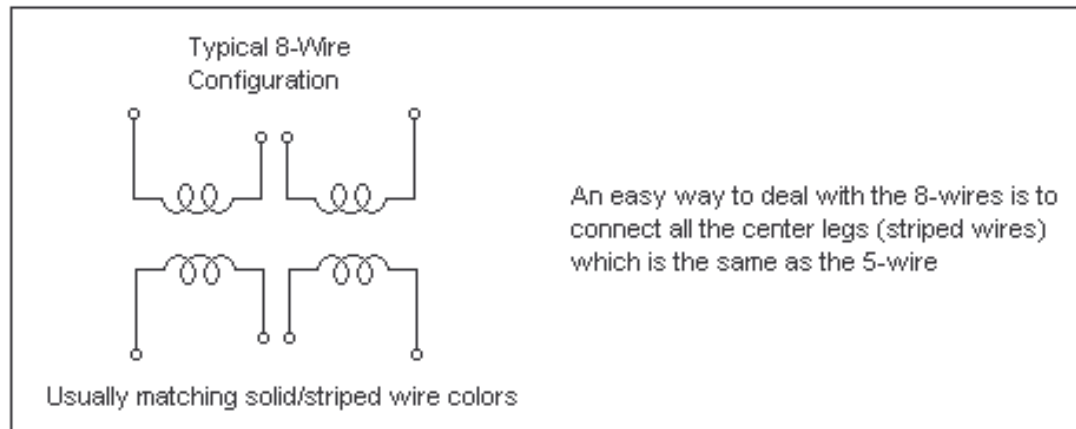
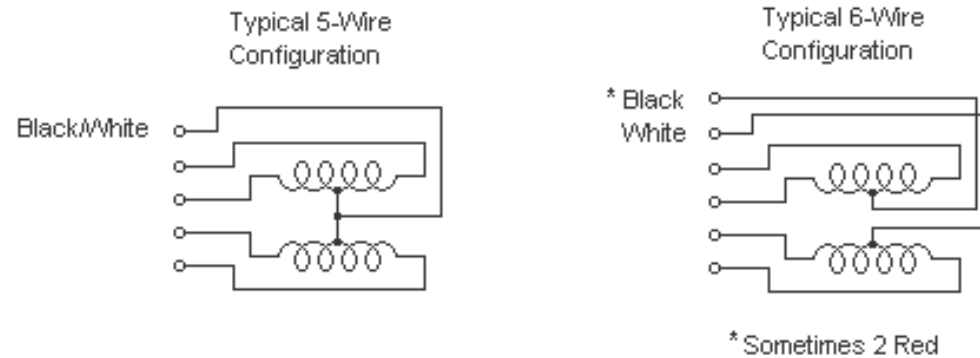


- Two sine waves in 'quadrature' (90 degrees out of phase) form the ideal current drive.

Principle of Micro Stepping: Phasor



Identifying a stepper motor:-



Identifying a stepper motor:-

- Stepper motors have numerous wires, 4, 5, 6, or 8. When you turn the shaft you will usually feel a "notched" movement. Motors with 4 wires are probably Bipolar motors and will not work with a Unipolar control circuit. The most common configurations are pictured above. You can use an ohm-meter to find the center tap - the resistance between the center and a leg is 1/2 that from leg to leg. Measuring from one coil to the other will show an open circuit, since the 2 coils are not connected. (Notice that if you touch all the wires together, with power off, the shaft is difficult to turn!)

Shortcut for finding the proper wiring sequence

Connect the center tap(s) to the power source (or current-limiting resistor.)
Connect the remaining 4 wires in any pattern. If it doesn't work, you only need try these 2 swaps...

1	2	4	8	-	(arbitrary first wiring order)
1	2	8	4	-	switch end pair
1	8	2	4	-	switch middle pair

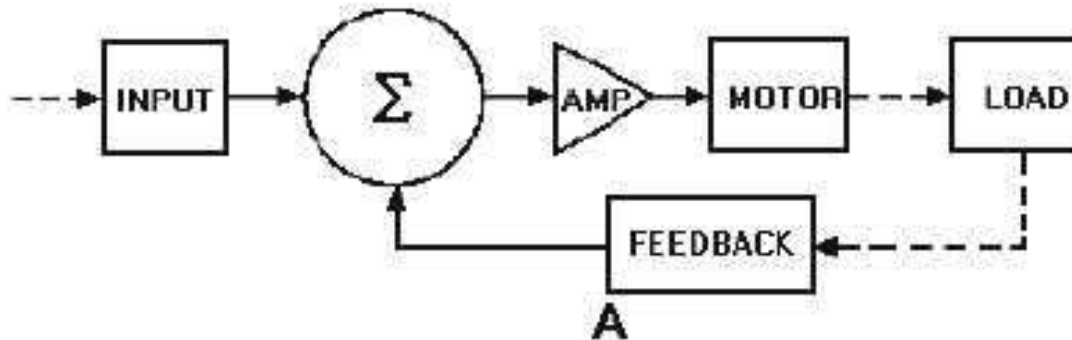
You're finished when the motor turns smoothly in either direction. If the motor turns in the opposite direction from desired, reverse the wires so that ABCD would become DCBA.

Servo Motors:

- Servo motors has an output shaft which can be positioned to specific angular positions by sending the servo a coded signal
- As long as the coded signal exists on the input line, the servo will maintain the angular position of the shaft.
- As the coded signal changes, the angular position of the shaft changes

FUNCTIONAL SERVO LOOPS

- Feedback causes the amplitude of the error signal to decrease, slowing the speed at which the load is moving
- Servo systems are also classified according to their functions: POSITION, VELOCITY, and ACCELERATION.



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