CpE 213
Digital Systems Design

Lecture 19

Thursday 10/30/2003

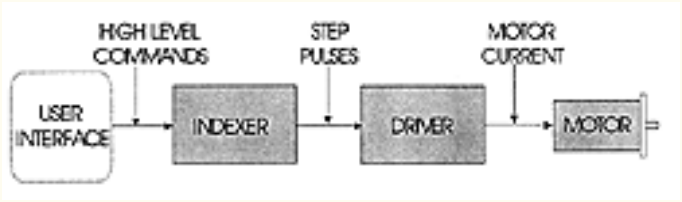
UMR UNIVERSITY OF MISSOURI-ROLLA
The Name. The Degree. The Difference.

Announcements

- Exam 2: Thursday Nov. 13th
- Review session: Tuesday Nov. 11th, from 7 to 9 pm in G31 (this room).
- See me or send me email if you have another exam on that day.
- Check your grades on blackboard and notify me of any discrepancies.
- Group exercises are for attendance check, please only write names of group members actually present.

Stepper Motors

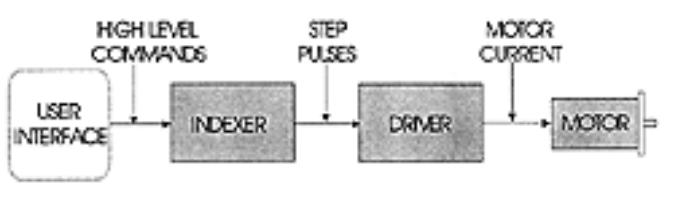
- A Stepping Motor System consists of three basic elements, often combined with some type of user interface (Host Computer, PLC or Dumb Terminal).



- The Indexer (or Controller) is a microprocessor capable of generating step pulses and direction signals for the driver.

Adapted from http://www.ams2000.com/stepping101.htm

Stepper Motors



- The Driver (or Amplifier) converts the indexer command signals into the power necessary to energize the motor windings. For 8051, can custom-design driver from power transistors or use off the shelf packages such as ULN2003.
- The stepper motor is an electromagnetic device that converts digital pulses into mechanical shaft rotation.
- Used for position control in disk drives, dot matrix printers, robotics, etc.

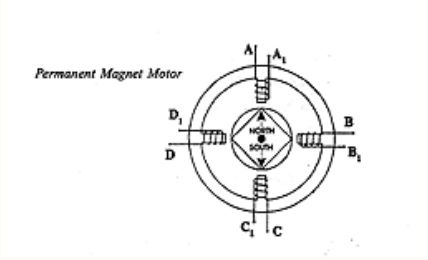
Adapted from http://www.ams2000.com/stepping101.htm

Pros and Cons

- Advantages of step motors:
  - low cost, high reliability
  - high torque at low speeds
  - simple, rugged construction that operates in almost any environment.
- Main disadvantages in using a step motor:
  - resonance effect often exhibited at low speeds
  - decreasing torque with increasing speed.

Adapted from http://www.ams2000.com/stepping101.htm

Stepper Motor

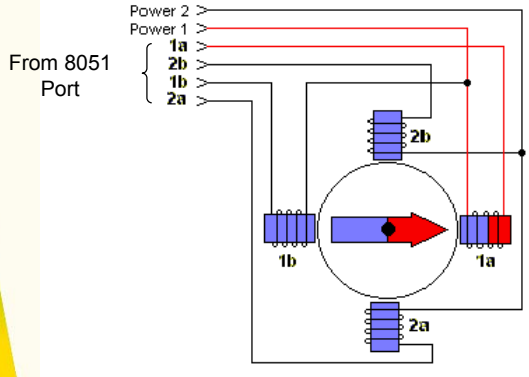


- Has a permanent magnet rotor surrounded by one or more stators with center-tapped common.
- Usually four stators (four-phase).
- Center tap allows change of current direction in each of two coils, resulting in polarity change.
- Polarity change causes movement in fixed repeatable increments (steps).

Stepper Motors

- Uses square wave for excitation
- Alternatives:
  - DC motor+PWM+feedback
  - AC motor+AC excitation+feedback
- Unipolar or Bipolar varieties
  - Unipolar: current flows in one direction through centertapped windings
  - Bipolar: current flows in both directions through windings

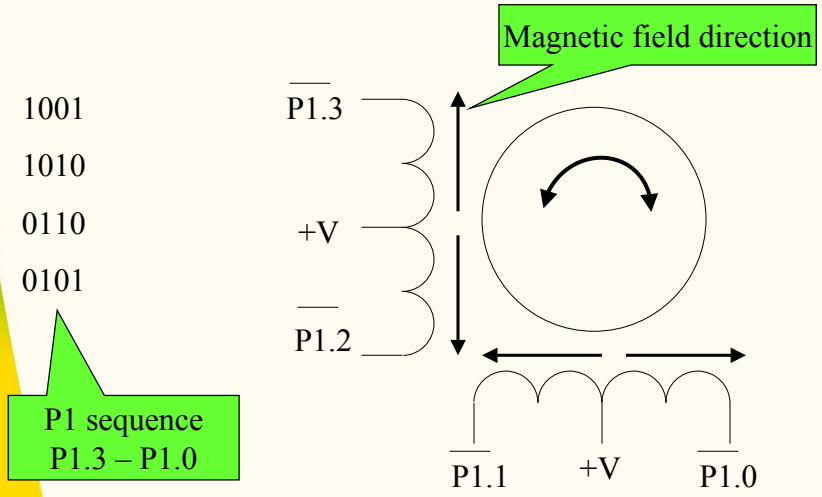
Unipolar Stepper Motor



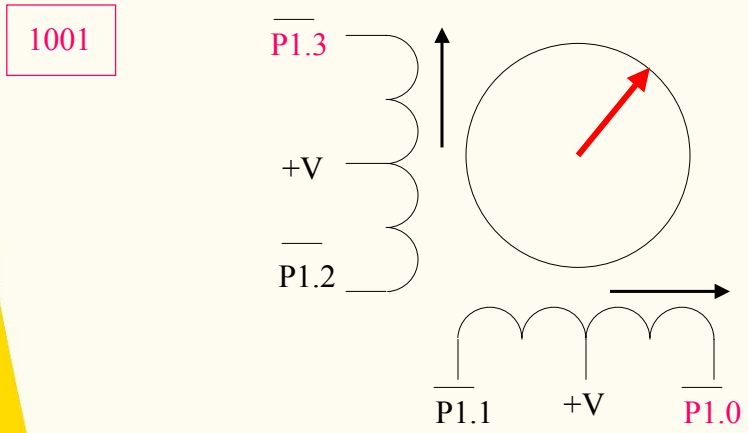
Conceptual Model of Unipolar Stepper Motor

From http://209.41.165.153/stepper/Tutorials/UniTutor.htm

Unipolar Stepper Motor Basics

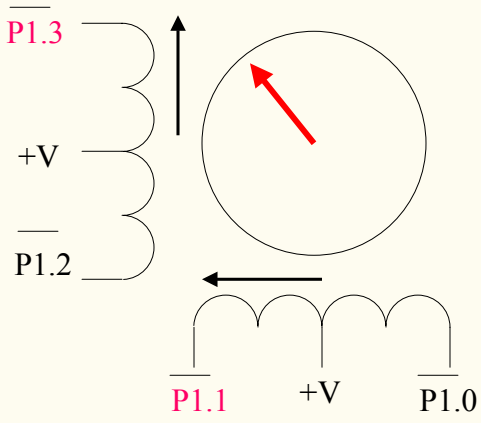


Stepper Motor Basics



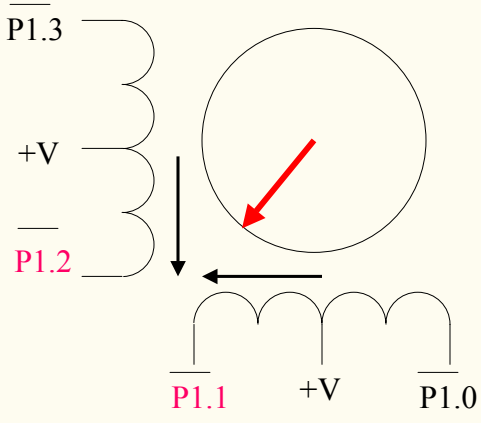
Stepper Motor Basics

1010



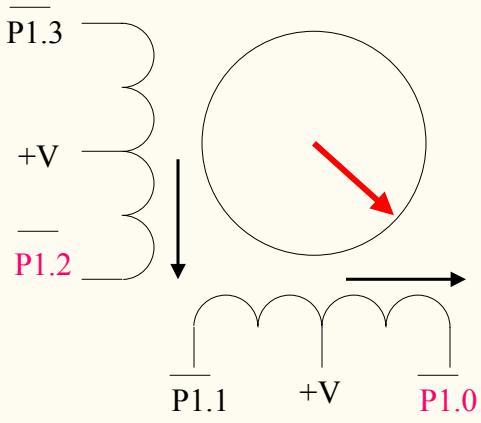
Stepper Motor Basics

0110



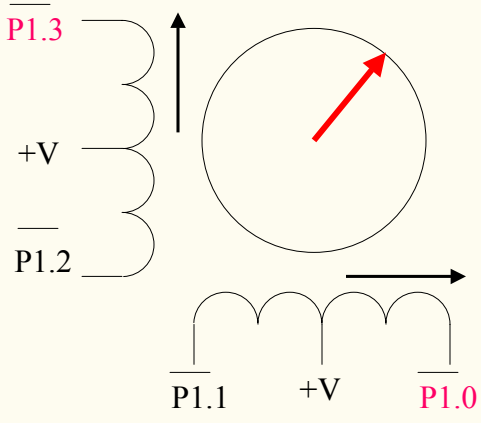
Stepper Motor Basics

0101



Stepper Motor Basics

1001



Stepper Motor Basics

- Each step may only be a few degrees
- Step rate limited by motor inertia
- Example
  - One step equals 6 degrees
  - One step per millisecond

$$\frac{6^o}{10^{-3}\,\text{sec}} \times \frac{\text{rev}}{360^o} \times \frac{60\,\text{sec}}{\text{min}} = 100\text{rpm}$$

Stepper motor driver

```
/* Try sketching a schematic diagram for this.
   Questions:
   1. How fast does the motor go? (in RPM)
   2. What changes should be made to go in reverse?
*/
#include <reg51.h>
unsigned char code pattern[]= {0x5,0x9,0xa,0x6};
void msec(int);
void step(void){
 static unsigned char i;
 P1= pattern[i=++i&3];
 msec(8);
 }
void main(void){
 while(1){step();}
}
```

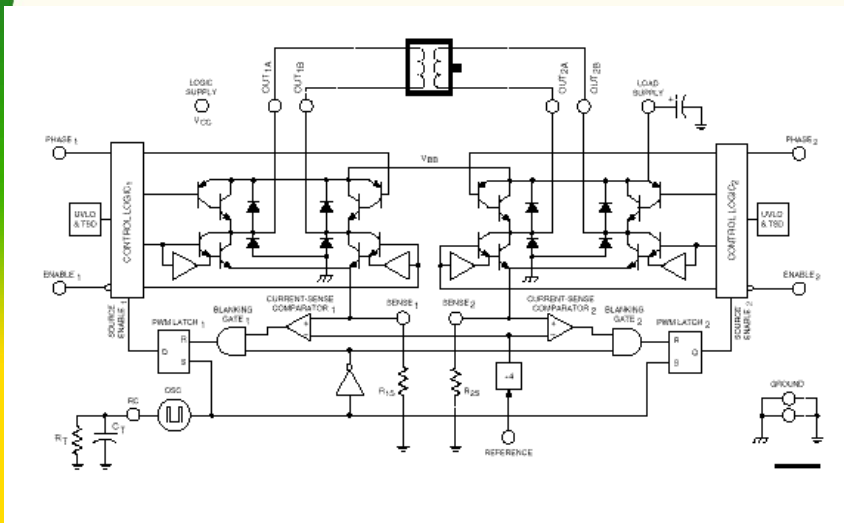
Assembly code driver

```
          STEP:
0000 0500    R      INC      i
0002 E500    R      MOV      A,i
0004 5403           ANL      A,#03H
0006 F500    R      MOV      i,A
0008 900000  R      MOV      DPTR,#pattern
000B 93             MOVC     A,@A+DPTR
000C F590           MOV      P1,A
… + call to msec and return.
```

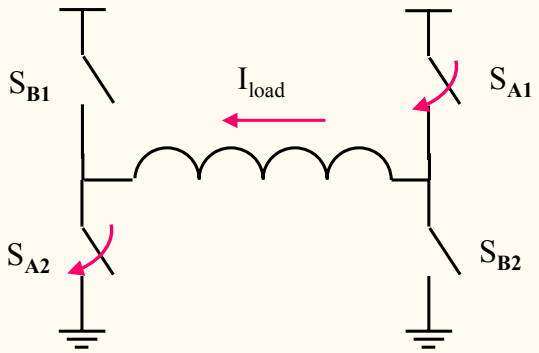
H-Bridge Example

- Required for **bipolar** stepper motors
  - current goes through windings in both directions
- Allegro UDN2998W Dual Full Bridge:
  - ± 2A Output Current, 50 v supply voltage
  - -0.3v to 15 v logic input voltage range
  - Internal protection diodes for inductive load
- See: http://www.allegromicro.com/control/motors1.htm for more details

Allegro 3996 H-bridge



Simplified H-bridge



Bipolar Stepper Pattern

- Only two bits needed instead of four
- Pattern is: 11, 10, 00, 01, … (grey code)