Stepper Motors

- Stepping motors move in response to a series of electrical pulses, one output "step" per input pulse
- Open-loop control (without output position monitoring) is common
- Three types of stepping motors are widely available
  - Permanent magnet,
  - Variable reluctance,
  - Hybrid

Permanent Magnet (or PM) Stepping Motors

- Rotor cross-section is gear shaped
- "Teeth" of the gear form N/S poles of magnet

Permanent Magnet (or PM) Stepping Motors

- An electrical circuit alternately switches the polarity of the stator poles
- As the polarity of a stator pole changes, the rotor will move to approach an equilibrium position
- Equilibrium positions where N/S rotor poles align with the S/N stator poles
Figure 1.4 - Simple 12 step/rev hybrid motor

South poles on this end of rotor

North poles on other end of rotor

Selection of Stepper Motors

- steps per revolution (or degrees/step)
  - actual output position depends greatly on the static friction in the system
- maximum stepping torque
  - cannot be exceeded or the motor will slip
- Unipolar or Bipolar windings

Unipolar Windings

6 leads

5 leads if two center “taps” are connected

Bipolar Windings

4 leads
All step motor systems must consist of an indexer, translator-driver and motor.

The indexer portion of the system controls timing and direction for each step of motion.

Under control of the indexer, the translator-driver powers the motor windings so that each step of motion is accomplished.

http://www.abilitysystems.com/indexlpt.htm
Indexer/Translator/Driver #2

- Stepper motor translator and drive circuits typically require STEP and DIRECTION input signals to operate.
- These signals can be provided by PLC's, stepper indexers or stand-alone digital circuitry.

http://www.ontrak.net/step.htm

Indexer/Translator/Driver #3

- The computer or PLC (programmable logic controller) sends commands to the indexer.
- The Indexer creates the clock pulses and direction signals.
- The Driver accepts clock pulses and direction signals and translates these signals into appropriate phase currents in the motor.

http://www.anaheimautomation.com/intro.htm

Indexer/Translator/Driver #4

- A circuit which is responsible for converting step and direction signals into winding energization patterns is called a translator.
- Most stepper motor control systems include a driver in addition to the translator, to handle the current drawn by the motor's windings.

http://www.eio.com/jasstep.htm

Wave Drive (full steps)

- Start
- One set of stator windings is energized, then the other
- 30° rotation
- 90° rotation
Two Phase Drive (full step)

- Both stator windings are energized at the same time.
- 60° rotation
- 90° rotation

Half Stepping

- Start
- 15° rotation
- 30° rotation
- Phase 1 - ON
- Phase 2 - OFF
- Phase 1 - ON
- Phase 2 - ON
- Phase 1 - OFF
- Phase 2 - ON

Half Step Mode

- Twice the resolution (steps/rev) from the same motor
- Much better smoothness at low speeds
- Less overshoot and ringing at end of each step
- Slight loss of torque
  - can be improved with the "profiled current" method of Figure 1.10

"Micro" Step Mode

- Ratio the current in each of the two phases
  - Rotor will be proportionally attracted to the stator pole with the most current
- 100 to 500 times the resolution (steps/rev) from the same motor
- Very smooth at low speeds
- Much more complicated electronics
**Principle of R-L drive**

\[ \tau = \frac{L}{R} \]

**Stepper Motor Drives #1**

*Fig. 2.5 Basic unipolar drive*

**Stepper Motor Drives #2**

*Fig. 2.6 Simple bipolar drive*

**Stepper Motor Drives #3**

*Fig. 2.7 Bipolar bridge*
Stepper Motor Drives #4

Fig. 2.8 Bipolar R-L drive

ULN2003 interface chip (7 outputs per chip)

+V (5 to 24 VDC)

7 stepper coils (500 mA each)

Same ground for all 7 coils

ULN2003 - $0.36

From computer parallel output

IMS #IB462

2 amp bipolar chopper driver

IMS #IB462, #IB104, #IB483

Computer Parallel Outputs
Oriental Motor/Vexta

Stepper motor driven rotary table – with indexer/drive

24 VDC power supply

Inputs (similar to IMS drive)

Stepper Motor Acceleration

Operating pulse speed

Starting pulse speed

Acceleration period

Deceleration period

Stepper Motor Acceleration

Operating pulse speed

Starting pulse speed

Positioning period [sec]

Acceleration (deceleration) period [sec]

Vmax

A

Time, sec

V

T

S

S1

S2

S3

S4

S5

S6

T