Computer Control #2

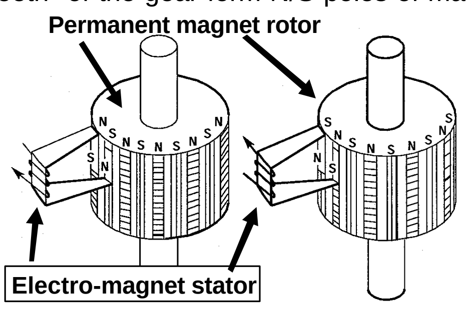
Friday, Nov. 9

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, and
  - hybrid

Permanent Magnet (or PM) Stepping Motors

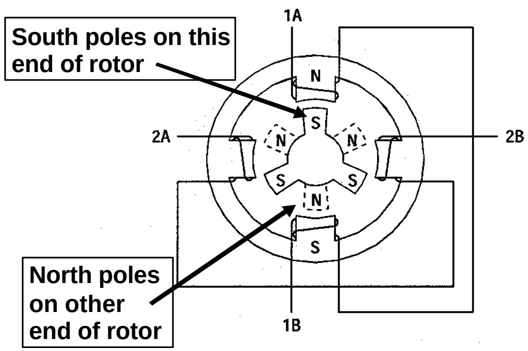
- rotor cross-section is gear shaped
- "teeth" of the gear form N/S poles of magnet



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

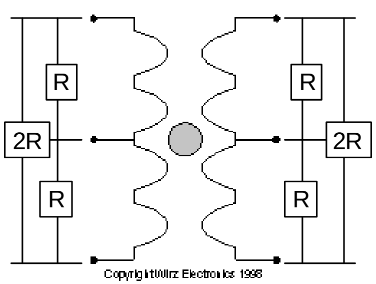
Figure 1.4 - Simple 12 step/rev hybrid motor



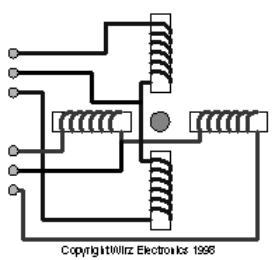
Selection of Stepper Motors

- 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

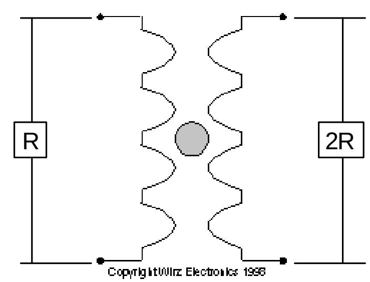


6 leads

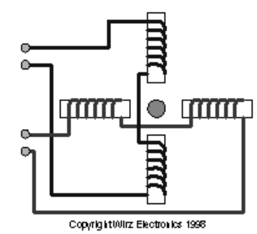


5 leads if two center “taps” are connected

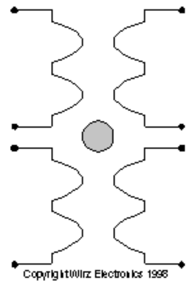
Bipolar Windings



4 leads

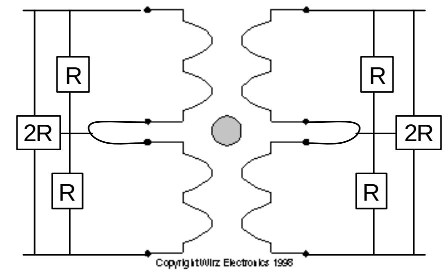


“Universal” Windings



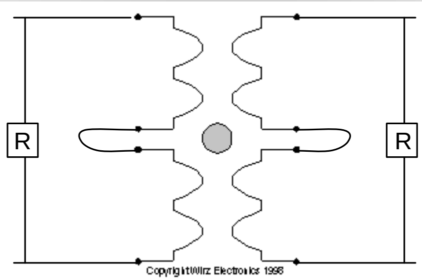
8 leads

“Universal” – Wired Unipolar



“6” leads

“Universal” – Wired Bipolar



“4” leads

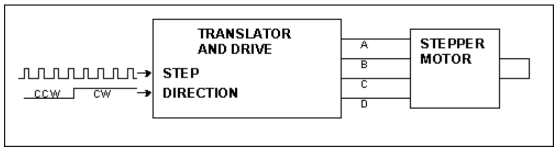
Indexer/Translator/Driver #1

- All step motor systems must consist of an indexer, translator-driver and motor.
- The <u>indexer</u> portion of the system controls timing and direction for each step of motion.
- Under control of the indexer, the <u>translator-driver</u> powers the motor windings so that each step of motion is accomplished

http://www.abilitysystems.com/indexlpt.htm

Indexer/Translator/Driver #2

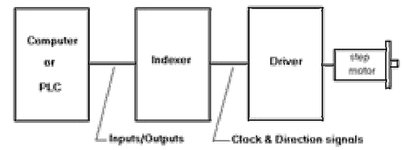
- Stepper motor translator and drive circuits typically require STEP and DIRECTION input signals to operate.
- These signal can be provided by PLC's, stepper indexers or stand-alone digital circuitry.



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

Indexer/Translator/Driver #3

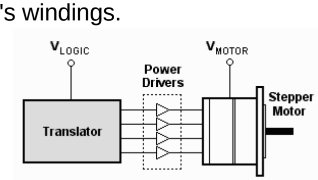
- The computer or PLC (programmable logic controller) sends commands to the indexer.
- The Indexer creates the clock pulses and direction signals.
- The Driver accepts clock pulses and direction signals and translates these signals into appropriate phase currents in the motor.



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

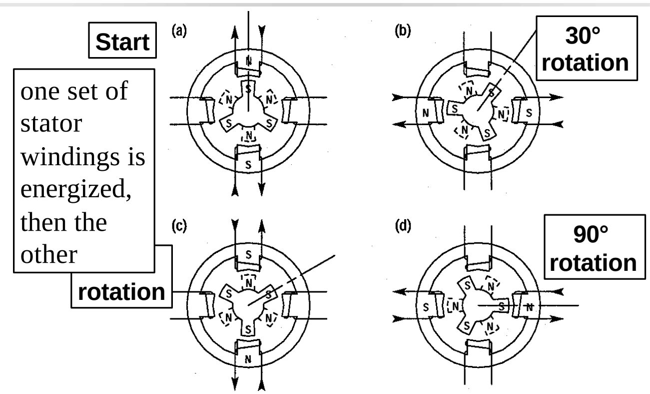
Indexer/Translator/Driver #4

- 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.

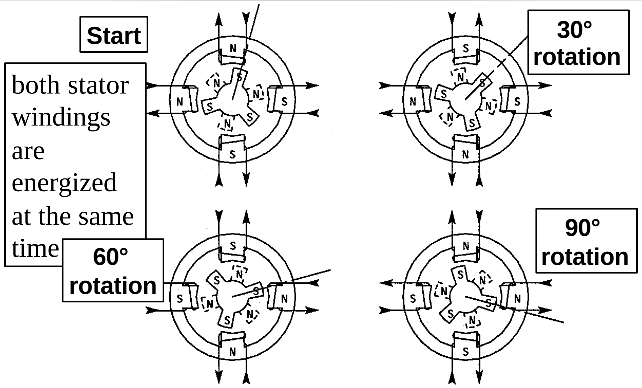


http://www.eio.com/jasstep.htm

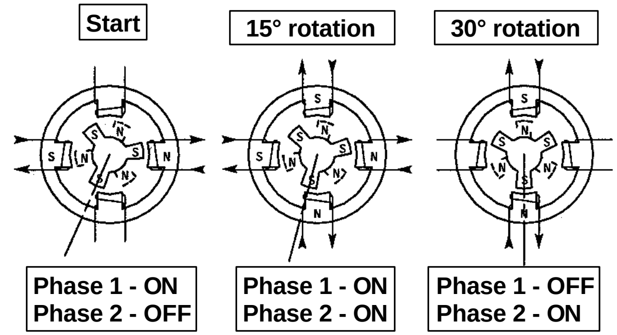
Wave Drive (full steps)



Two Phase Drive (full step)



Half Stepping



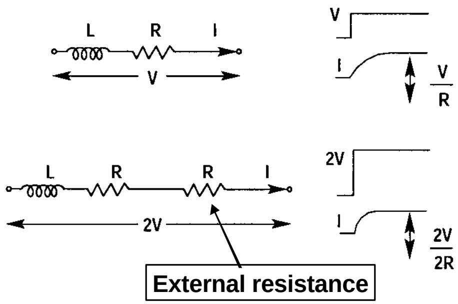
Half Step Mode

- 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

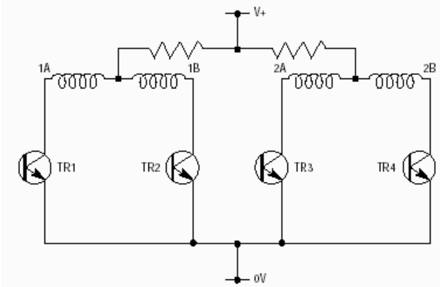


$$t = \frac{L}{R}$$

$$t = \frac{L}{2R}$$

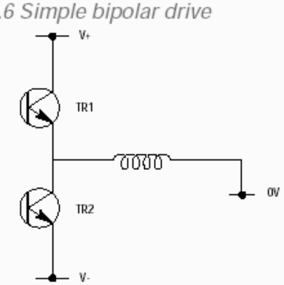
Stepper Motor Drives #1

Fig. 2.5 Basic unipolar drive



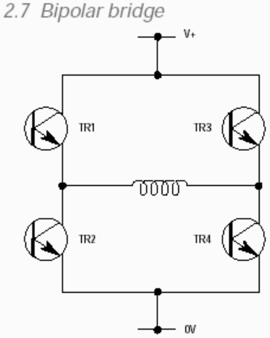
Stepper Motor Drives #2

Fig. 2.6 Simple bipolar drive

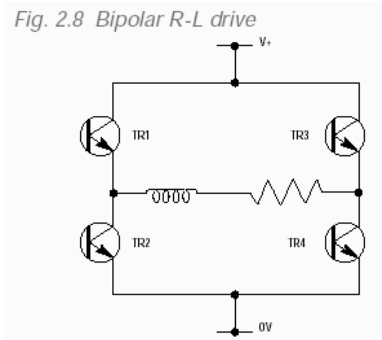


Stepper Motor Drives #3

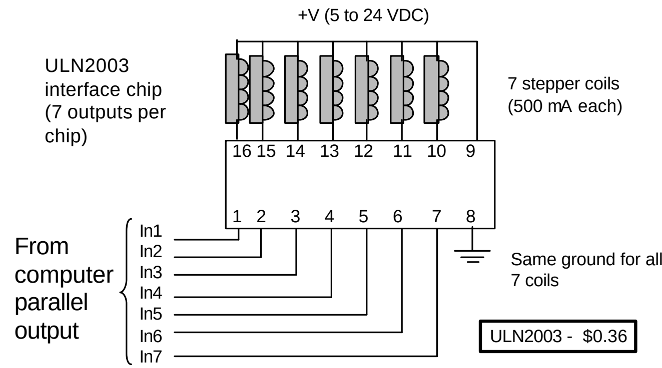
Fig. 2.7 Bipolar bridge



Stepper Motor Drives #4

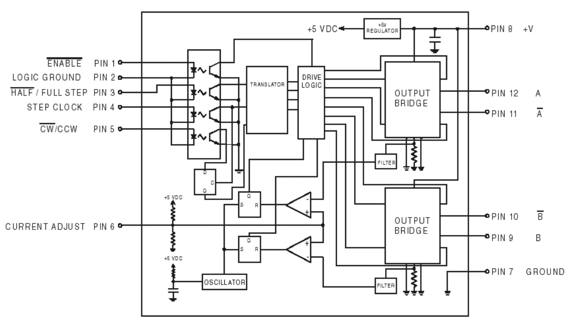


Output Interfacing



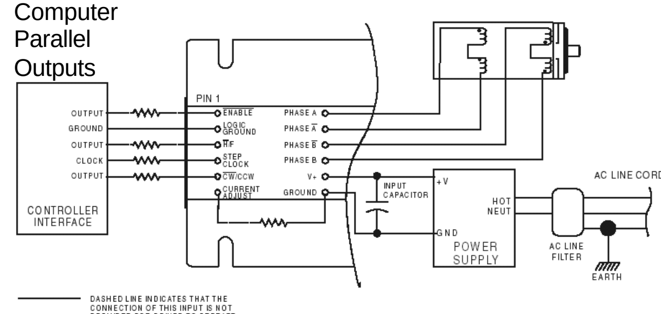
IMS #IB462

2 amp bipolar chopper driver



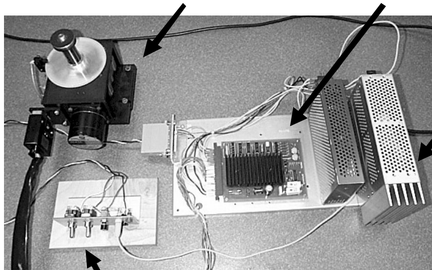
IMS #IB462, #IB104, #IB483

Computer Parallel Outputs



Oriental Motor/Vexta

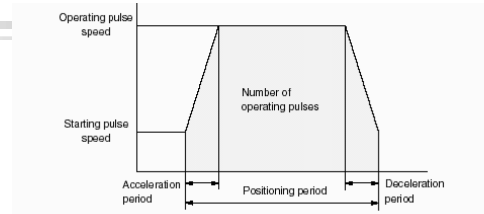
Stepper motor driven rotary table – with indexer/drive



24 VDC power supply

Inputs (similar to IMS drive)

Stepper Motor Acceleration



$$\text{Operating pulse speed } f_2 = \frac{\text{Number of operating pulses [pulses]} - \text{Starting pulse speed [Hz]} \times \text{Acceleration (deceleration) period [sec]}}{\text{Positioning period [sec]} - \text{Acceleration (deceleration) period [sec]}} = \frac{A - f_1 \cdot t_1}{t_0 - t_1}$$

Accel-Vel-Position