Chapter 14

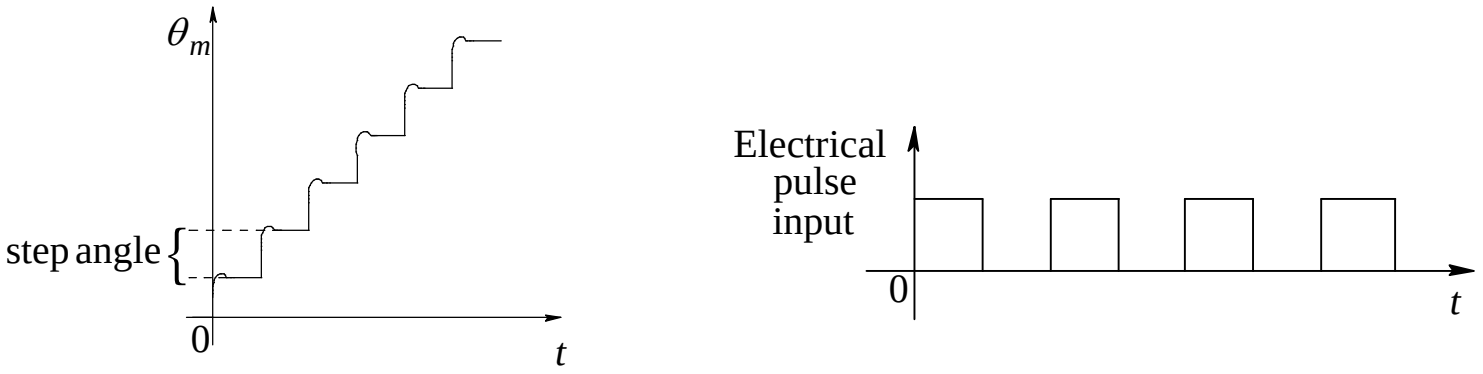
Reluctance Drives: Stepper-Motor and Switched-Reluctance Drives

Reluctance Drives
Stepper – Motor and Switched – Reluctance Drives

- Reluctance Drives
  - Stepper – Motor drives
    - Accurate position control without feedback
    - Electrical pulse input gives discrete angle change
    - Types: Variable Reluctance
      Permanent Magnet
      Hybrid

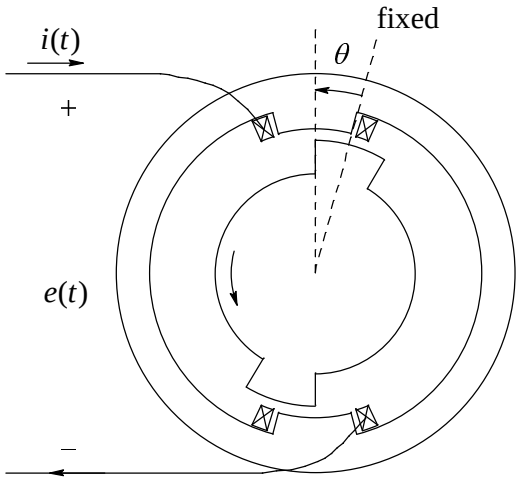
  - Switched – Reluctance drives
    - Variable-reluctance stepper-motor designed to go into saturation
    - Feedback necessary

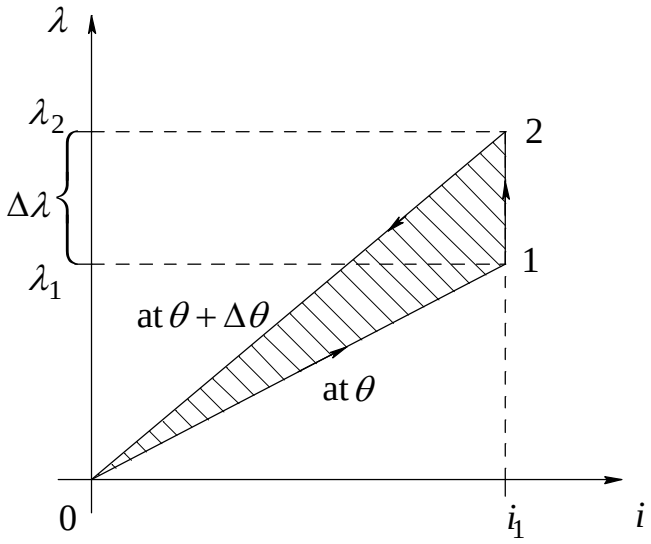
Stepper-Motor Positioning



- Each pulse moves motor a discrete angle – step angle
- Counting pulses tells how far motor has turned without actually measuring (no feedback)

Reluctance Motors – Operating Principles



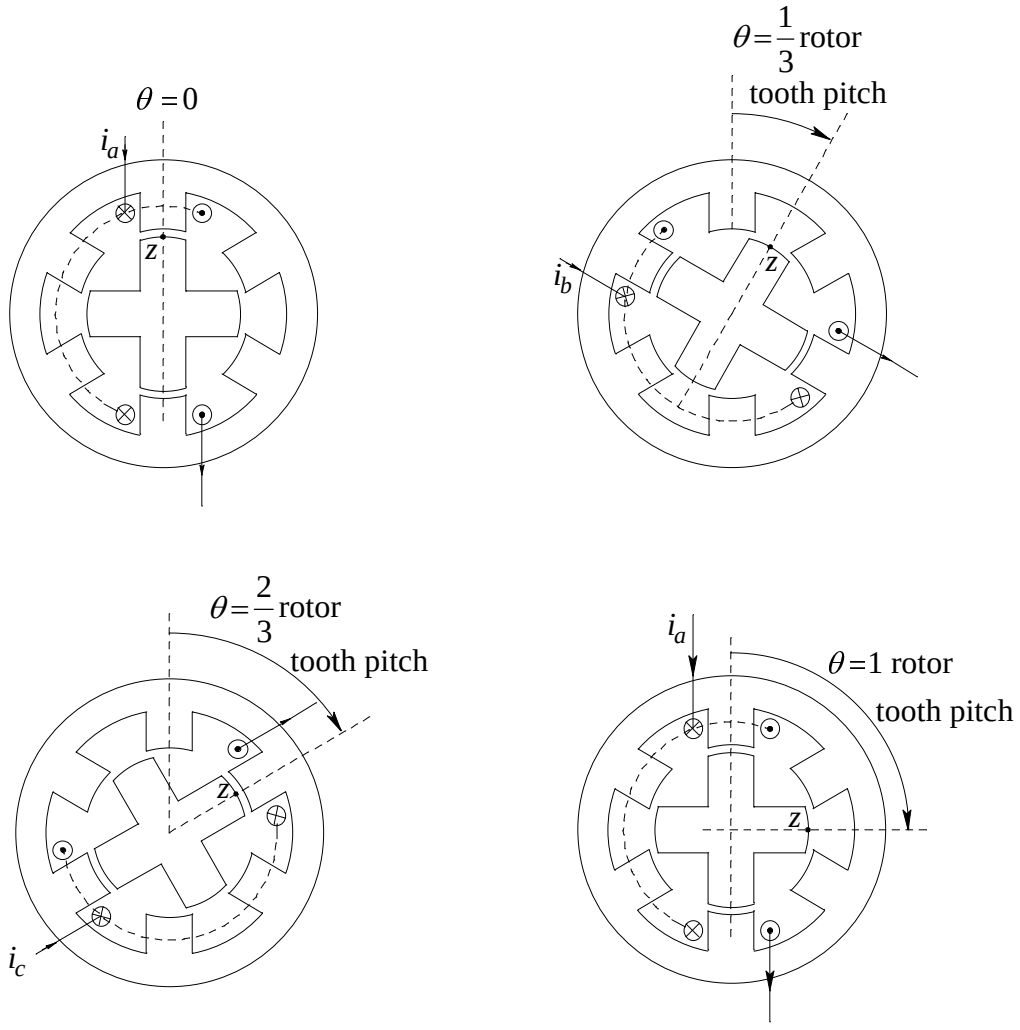


- Salient rotor aligns to salient stator

Stepper - Motors

- Variable – reluctance motors
  - relies on rotor saliency
- Permanent magnet motors
  - relies on rotor magnets
- Hybrid motors
  - relies on both saliency and rotor magnets

Variable – Reluctance Stepper Motors



Variable - Reluctance Stepper Motors (cont…)

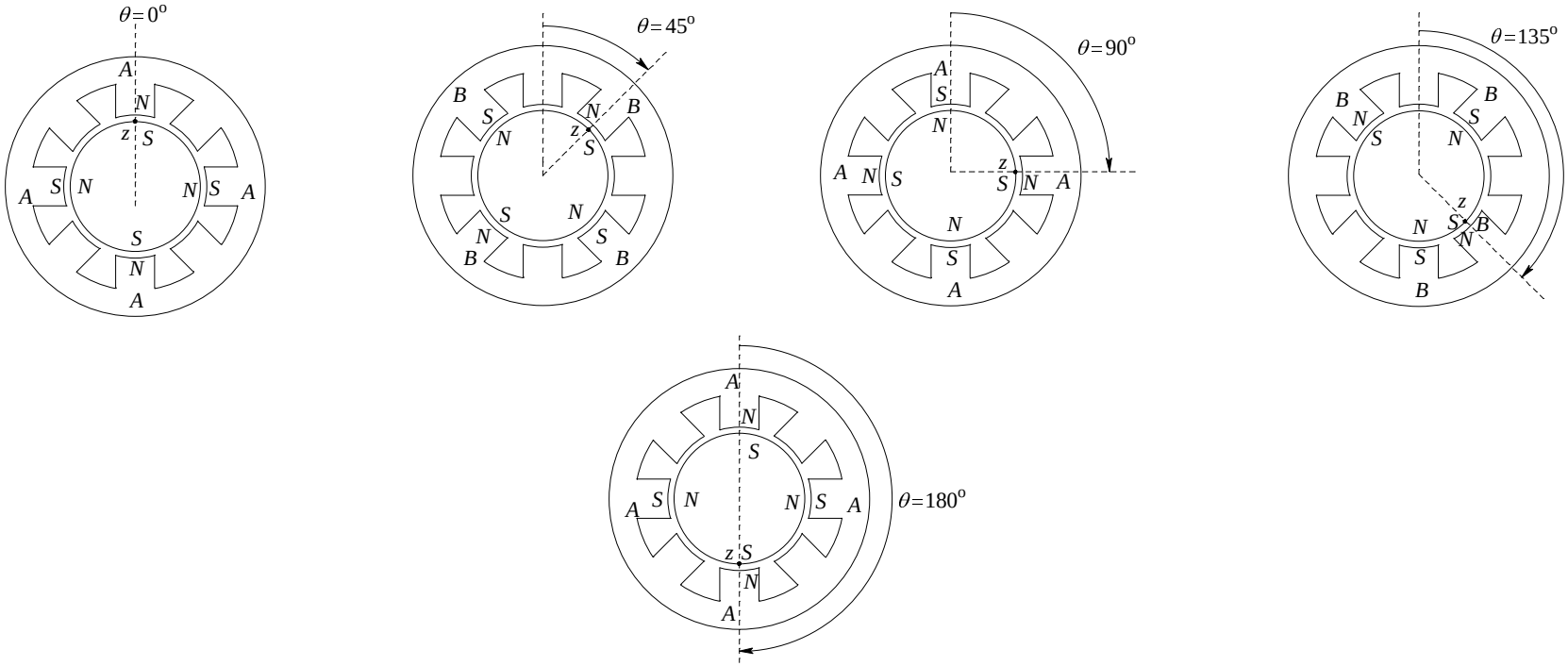
- Rotor and stator saliency
- Unequal number of poles
- Stator current effectively pulls rotor pole in line with stator pole

$$\text{step-angle} = \frac{360^0}{qN_r}$$

q = number of phases

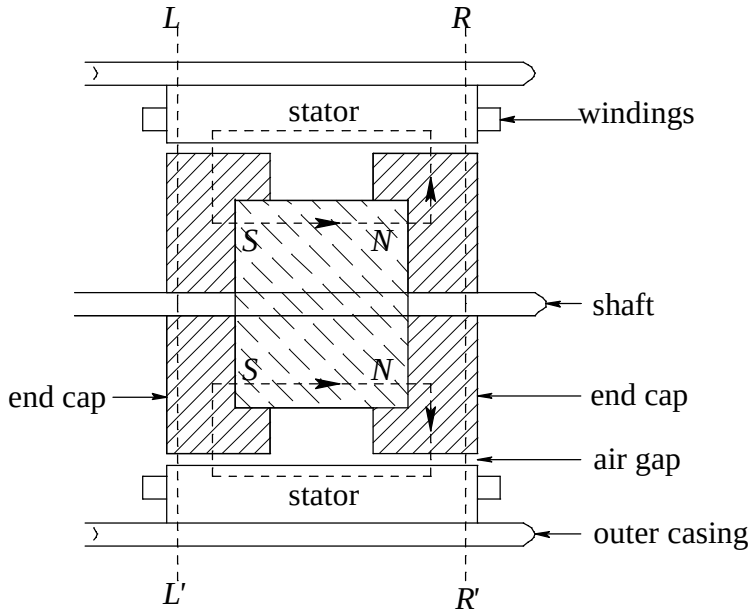
N_r = number of rotor poles

Permanent Magnet Stepper Motor



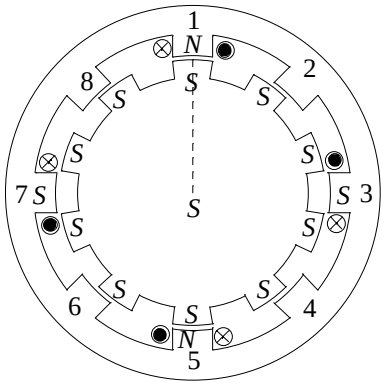
- Permanent magnets replace salient poles of variable-reluctance motor

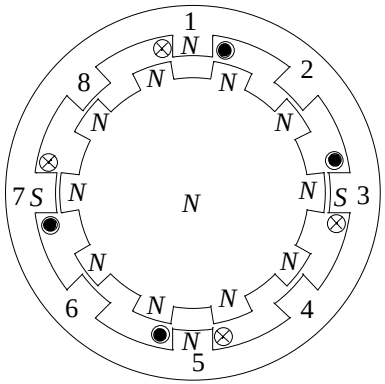
Hybrid Stepper Motor

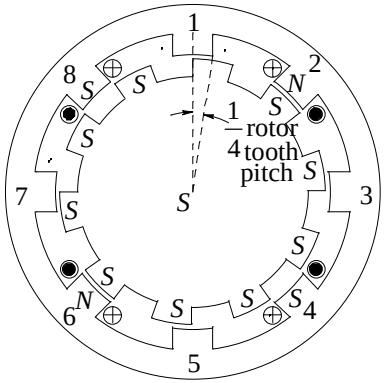


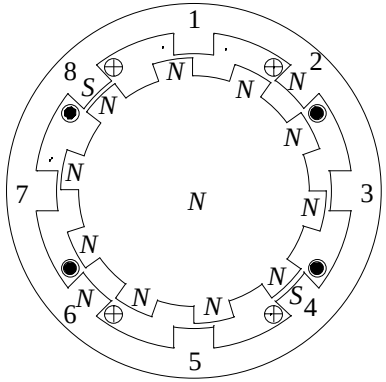
- Uses both rotor saliency and permanent magnets on rotor
- Saliency on ends of rotor – ends not lined up
- Permanent magnet makes one of the rotor ends a south pole and the other a north pole

Hybrid Stepper Motor (cont…)

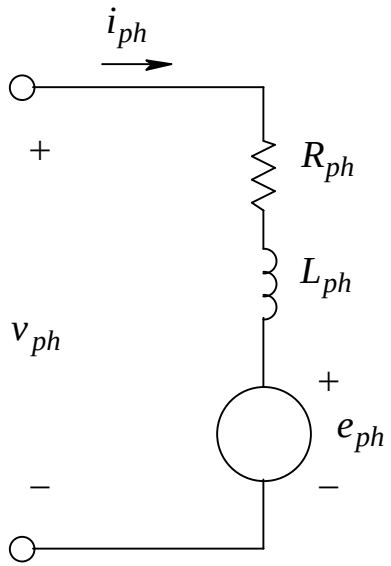




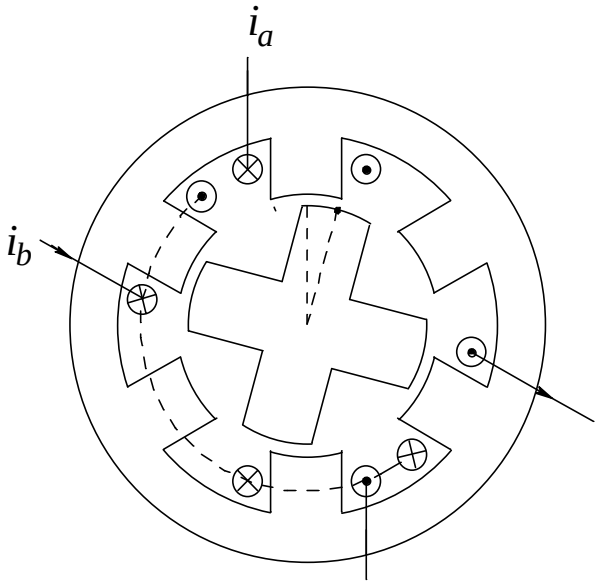




Stepper-Motor Equivalent Circuit

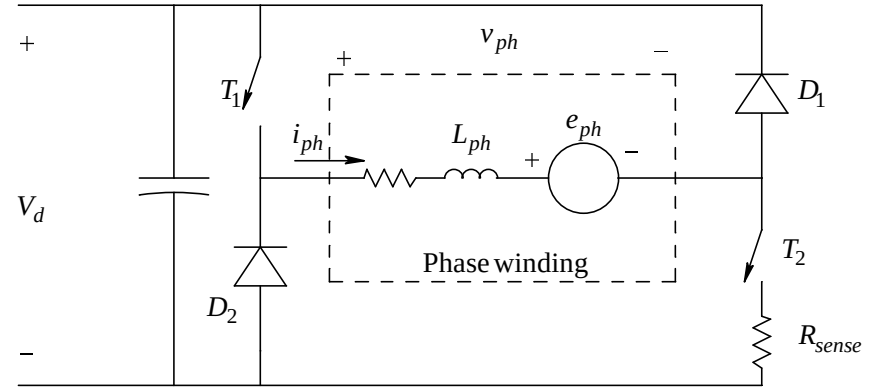


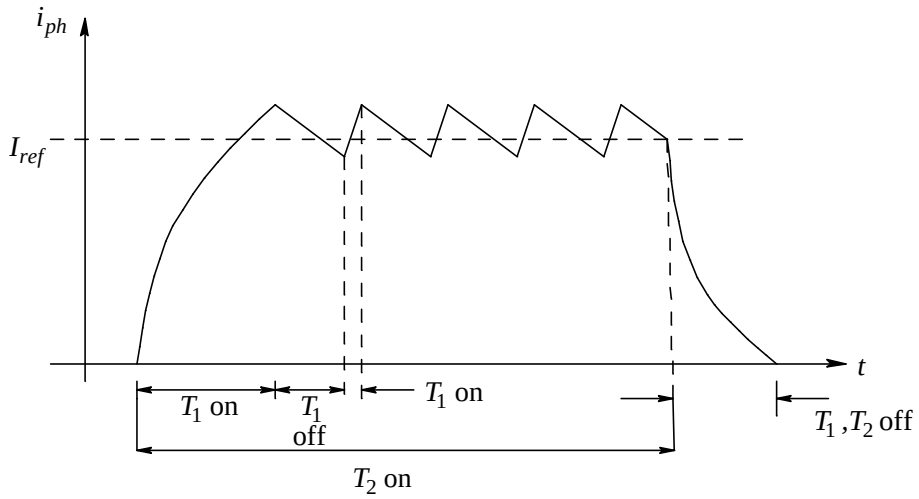
Half–Stepping and Micro-Stepping



- Possible to move rotor by half steps by exciting two stator windings equally
- Finer steps possible by exciting two windings unequally

PPU for Variable-Reluctance Stepper-Motor

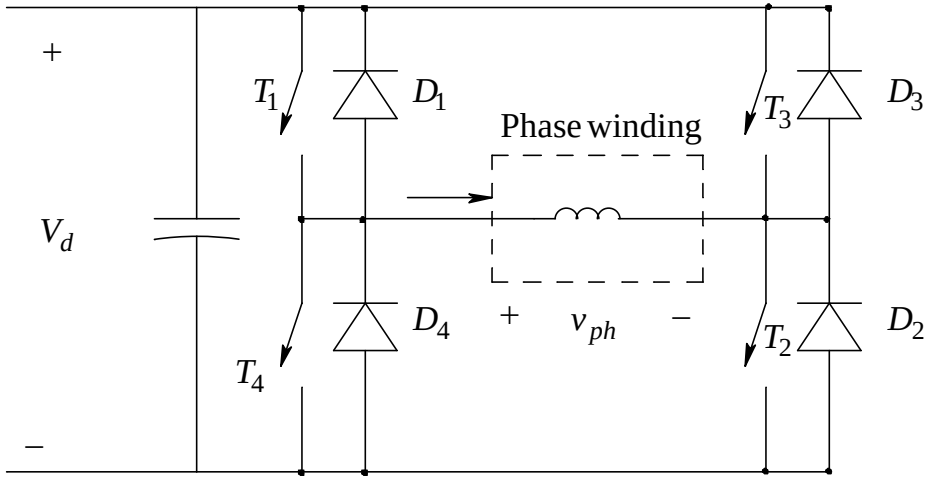




PPU for Variable-Reluctance Stepper-Motor (cont…)

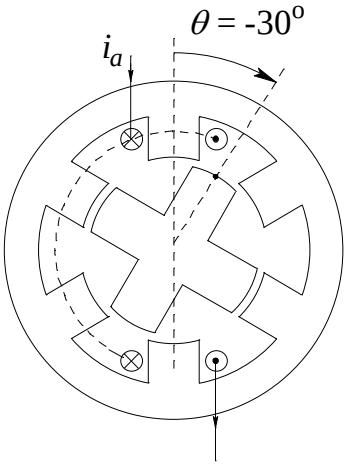
- Currents do not need to reverse
- Circuit uses “incomplete” switch poles that can pass current only one direction through the motor phase

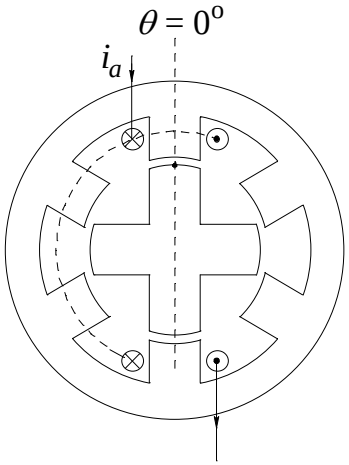
PPU for PM and Hybrid Stepper-Motor

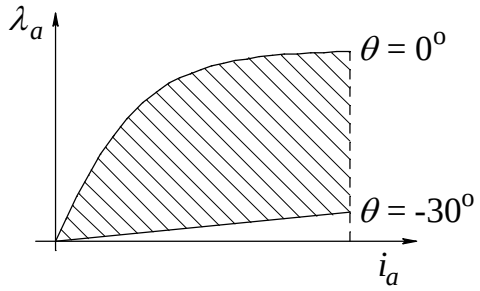


- Phase currents must be reversible
- Complete switch poles used

Switched-Reluctance Motor Drives







- Variable-reluctance stepper-motor
- Closed-loop, uses feedback
- Motor goes into saturation
- Rugged, inexpensive

Summary/Review

- What are the three broad categories of reluctance drives?
- How is the principle on which reluctance drives operate different than that seen earlier with other drives?
- Write down the reluctance torque expression. What does the direction of torque depend on?
- Describe the operating principle of a variable-reluctance stepper-motor.
- Describe the operating principle of a permanent-magnet stepper-motor.
- Describe the operating principle of a hybrid stepper-motor.
- What is the equivalent-circuit representation of a stepper-motor?
- How is half-stepping and micro-stepping achieved in stepper-motors?

Summary/Review

- What is the nature of power-processing units in stepper-motor drives?
- Describe the operating principles of switched-reluctance drives.
- What are the application areas of switched-reluctance drives?