Mens et Manus

Last Week’s Project: Build an Electric Motor
Six permanent magnets in rotor and four electromagnets in stator.

Principles of Operation
Switch currents to electromagnets to rotate permanent magnets.

We implemented this strategy synchronously: each coil was energized for a fixed amount of time (controlled by the delay function).

Position-Based Switching
In a brushed motor, electromagnets in the rotor are attached to a voltage supply through electrical contacts called brushes.

As the rotor turns, the brushes contact different electromagnets.

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Switching between electromagnets is based on position, not time.
Position-Based Switching

Position-based switching (commutation) is more tolerant of changes in mechanical loads than synchronous switching. This commutator (in electric drill) has two brushes that contact 12 electrical contacts (plates) to distribute power to six electromagnets.

Disadvantages: sparks, excess heat, and power loss.

We will use a solid-state (Hall-effect) device to sense rotor position.

Physics:
Current through device → electrons flowing in opposite direction.

Magnetic field \( B_y \) in orthogonal direction generates (Lorentz) force

\[ f = qv \times B \]

in \( z \) direction, where \( q \) is charge on electron and \( v \) is its velocity. Lorentz force pushes electrons upward, making top more negative than bottom. This Hall-effect voltage is proportional to \( B_y \).

Today’s Project: Add Hall-Effect Sensors

Use two Hall-effect sensors to measure rotor angle.
Brushless Motor Control
Use two Hall-effect sensors to measure rotor angle.

If Hall B senses South, set B coils so North points left. 
→ rotor will turn clockwise.

If Hall A senses North, set A coils so North points down.
If Hall B senses North, set B coils so North points right.
**Brushless Motor Control**

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If Hall A senses North, set A coils so North points down.
If Hall B senses North, set B coils so North points right.
→ rotor will turn clockwise.

**Breakout Groups**

We will divide up now to work in small groups on this week’s project.