Mens et Manus

Making with Technology

September 17, 2018
Brushless Motor Project

Advances in semiconductor technology has made brushless motors the leading motor technology in a wide range of applications:

• computer peripherals (such as printers),
• hand-held power tools, and
• vehicles from model aircraft to automobiles.

Electronic control allows designers to optimize performance.

  – we will use a modern microcontroller

Parts constructed using modern rapid-prototyping techniques.

  – we will use laser cutting and 3D printing.

Today’s goals:

• understand brushless motor operation
• become familiar with the parts
How do electric motors work?

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![Diagram of electric motor with magnetic fields and rotor/stator labels]
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Controlling the Electromagnets

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The commutator determines how to activate the coils based on rotor angle, and then steers currents through the coils accordingly.

Mechanical switching generates sparks, excess heat, and power loss.
Controlling the Electromagnets

Sensing rotor position and controlling current flow are separated in a brushless motor.

**Sensing** is accomplished with a solid-state magnetic field sensor. Currents are **switched electronically**.
Hall Effect Sensor

Magnetic fields divert the motion of charged particles.

Current in $x$ direction results from flow of electrons in $-x$ direction. Magnetic field $B$ in $y$ direction generates (Lorentz) force $f$ in $z$ direction,

$$f =qv \times B$$

were $q$ is charge on electron and $v$ is it’s velocity.

Lorentz force pushes electrons upward, making conductor more negative at top than bottom.
Controlling the Electromagnets

We will use electronic switches to activate the electromagnets.

This configuration is called an **H-bridge**. It consists of two **half-bridges** that each control the voltage on one side of the coil.

![Diagram of an H-bridge](image)

By opening and closing four switches, one can set the voltage across a coil to be $+V$, $-V$, or zero.
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Circuit diagram:

![Circuit Diagram](image)

Closing $X_{1H}$ and $X_{2L}$ causes currents to flow left-to-right through the coil.
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This configuration is called an **H-bridge**. It consists of two **half-bridges** that each control the voltage on one side of the coil.

Closing \(X2H\) and \(X1L\) causes currents to flow right-to-left through the coil – reversing the magnetic polarity of the coil.
Brushless Motor Project

Make a brushless motor:

• using laser-cut or 3D printed parts,
• with electronic sensors and actuators, and
• controlled with a microcontroller.

You can choose

• the configuration of the rotor and stator,
• the number and configuration of coils and magnets,
• the placement of sensors, and
• timing and choreography via a microcontroller.

No previous experience is assumed.
Lab Today

Use **Hall effect devices** to measure magnetic fields.

Maximize the **magnetic force** between a magnet and coil.

Use insights to start designing your motor: **sketch your layout**.

**Next time:** CAD to implement your layout; start making parts.