Mens et Manus: Building on the GIRs

Making with Technology

September 18, 2017

Brushless Motor Project

Why use a brushless motor?
- Electronic control to optimize performance.
  - we will use a Raspberry Pi microprocessor.
- Parts contructed using modern fabrication techniques.
  - we will use laser cutting and 3D printing.

Today’s goals:
- understand brushless motor operation
- use a Raspberry Pi microprocessor to sense and control magnets

How do electric motors work?

Electric motors rotate due to the interaction of magnetic fields that are fixed to a rotor that rotates and a stator that is stationary.

Electromagnets to electronically steer magnetic field

Use electromagnets in the stator, so they can be controlled.

Controlling Electromagnets with an H-Bridge

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.

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

Synchronous Operation

Switch electromagnets at regular intervals of time.

Hard to start (inertia). Stalls if mechanical load changes.
**Asynchronous Operation**

Use magnetic field sensor to detect rotor position.

![Magnetic Field Sensor Diagram]

More resilient to changing mechanical loads.

**Hall Effect Sensor**

Magnetic fields divert the motion of charged particles.

![Hall Effect Sensor Diagram]

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,

$$f = qv \times B$$

where $q$ is charge on electron and $v$ is its velocity. Lorentz force pushes electrons upward, making conductor more negative at top than bottom.

**Brushless Motor Project**

Homework: design your motor.

You can use
- up to twelve permanent magnets,
- as many electromagnets as you are willing to wind,
- up to four Hall effect devices (hardware limitation), and
- up to four H-bridges (hardware limitation).

You should make
- a sketch the layout of rotor, stator, and Hall effect sensors, and
- a timing diagram for how to switch of the H-bridges.

Work thorough the SOLIDWORKS tutorial.
- available for Windows from IST (http://ist.mit.edu), or
- run through a virtual machine on your Mac or Linux system, or
- use one of our laptops.

We will set up office hours to help you with the installation.