DIY Easy Magnetic Levitation Project! Deadline Saturday night

1. Intro
   1. Video of completed project
      1. Voice over saying something like “Hey everyone! In this project I will be showing you guys how to build this simple levitation device. Lets get started.”
2. Basic operation (whiteboard)
   1. As you all know when you bring opposite poles of a magnet together they attract eachother. This property suggests it should be extremely easy to find an equilibrium which resists gravity, but in fact it is extremely difficult. A system like this is known as a point of unstable equilibrium where a deviation in either direction creates a net force in that direction. Even the slightest perturbation builds exponentially until
   2. In this project we will instead be using an electromagnet and a magnetic field sensor which allows us to vary the magnetic field strength and stablely maintain levitation.
   3. The main components of this system are an electromagnet, a hall effect sensor, a NPN transitor, and a microcontroller (which in this case is an Arduino).
   4. Hall effect sensor(which I explain here) has the ability to detect magnetic field intensity and modify its output voltage which the Arduino can read as an analog signal.
   5. The Arduio then uses this information to approximate the distane between the sensor and the permanent magnet. It then uses a PID algorithim then uses the NPN transitor as a switch to pulse the electromagnet on and off in order to resist disturbances from the determined setpoint. If you want to know more about how the PID algorithm works I made a video explaining it here.
   6. Other than these components you will also need a 12 volt power supply and panel jack to power the electromagnet, a DCDC buck converter to power the arduino at 5V, and a set of 3D printed components or traditionally manufactured analogs.
   7. If you feel so inclined you can also include a Neopixel strip and 10k potentiometer which are complexly optional but aid in tuning the system.

“Hey everyone! In this project

[graphs]

So as you all know its extremely difficult to levitate a magnet by just dangeling it below another magent. In fact its mathematically impossible. This is because while there is a point where the weight of the magnet and the magnetic force perfectly cancel out, if you deviated even slightly in either direction from this point you’d gain a net force pushing even farther from that point. This system is known as unstable equilibrium.

What we want to do is using some clever engineering develop a situation where the bottom magnet is in stable equilibrium, or where the force on both sides of the equilibrium point pushes the magnet back towards the equilibrium point. For example if we were able to turn the top magnet off when it gets too close and back on when it gets to far away this technically creates a situation of stable equilibrium. This is not exactly what we will be doing in this project as that scenario would be prone to oscillations and quickly far apart, but the actual description is outside the scope of this video. If you want to learn more about how this and PID algorithms work in general click on my video of the topic here.

The first step to building such a device it to determine the distance between the magnets and the electromagent. The obvious choice is a Hall Effect sensor. [multimeter reading voltage]. This sensor works by varying the output voltage based on the amount of magnetic force it is experiencing. This voltage can easily be read by the analog port of an Arduino nano’s analog pin and gives us a good idea of the distance between the magnets.

The Arduino then uses a PID algorithm (Which I explain more here) to control when and for how long the electromagnet is on, and therefore its average strength . [schematic]. Obviously the Arduino doesn’t have the voltage or current potential to drive an electromagnet of this size so you’ll need a simple driver circuit which is just composed of a [ part number] transistor, [value] resistor and fly back diode to protect from inductive spikes. I’ll have links to where we buy these components in the description.

To get started I first soldered the necessary extension wires to both the electromagnet and the hall effect sensor.

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