Properties of magnetic generators

By: Alex Jackson

A rotating magnet inside a coil of wire will create a current. The question to cover in this experiment is "how do various geometries of the magnet and loops and changing number of turns of wire around the magnet affect the output?"

If a loop of wires is moved across a magnetic field, the equation that relates the potential difference to the properties of the loop is

$$EMF=NvBL$$

Where N is number of turns, v is velocity B is magnetic field and L is the length of wire in the field. From this it can be assumed the number of wraps around the magnet will be directly proportional to the voltage output of the generator.

Electromotive force is also equal to negative the rate of change of the magnetic flux. This means that the faster a magnetic field is changing around a loop of wires, the higher the potential difference will be at the end of the wires.

$$EMF=-d\varphi m/dt$$

According to the principles of Lorenz Forces, the direction of the cross product of the current and the magnetic field of a wire will be the same direction as the resulting force vector.

$$F=IL \times B$$

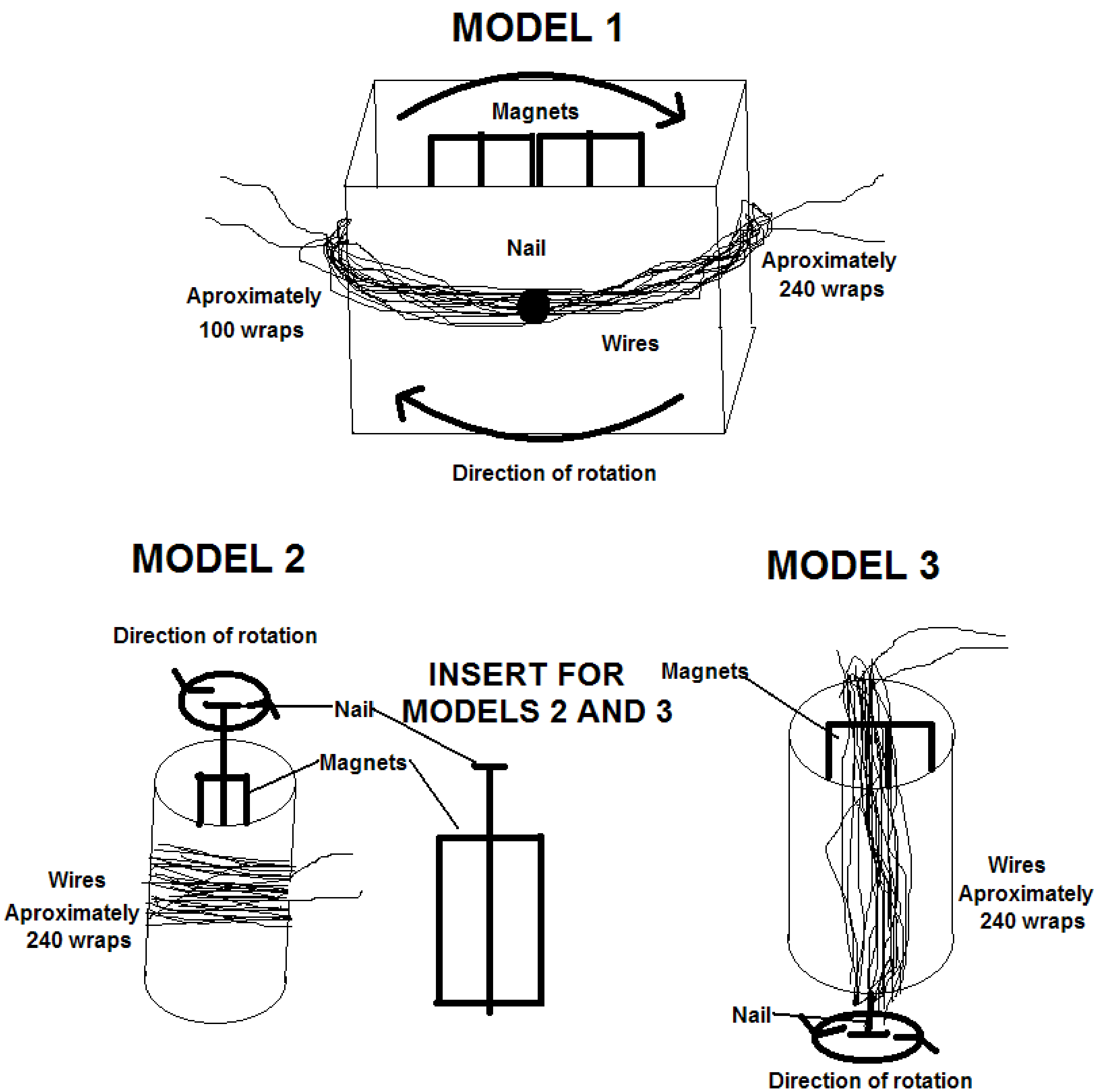
Where F is the force, I is the current, L is the direction of the current and B is the Magnetic field.

By the rules of cross products and geometry, it also must be true that

$$B \times F=IL$$

So if current is allowed to flow through the wire then there will be resistance of the magnet turning by the Lorenz forces of the current and the magnetic field.

Three different geometric generator designs were tested in this experiment.



Results:

MODEL	APROXIMATE NUMBER OF TURNS	MAXIMUM VOLTAGE OUTPUT	Felt resistance to turning magnet
1	240	1.8	Yes
1	100	.8	Yes
2	240	0	No
3	240	.8	Yes

Explanation:

The maximum voltage output between the 240 and 100 turn wires on model 1 is almost exactly proportional to the number of loops of wire, consistent with the equation EMF=NvBL.

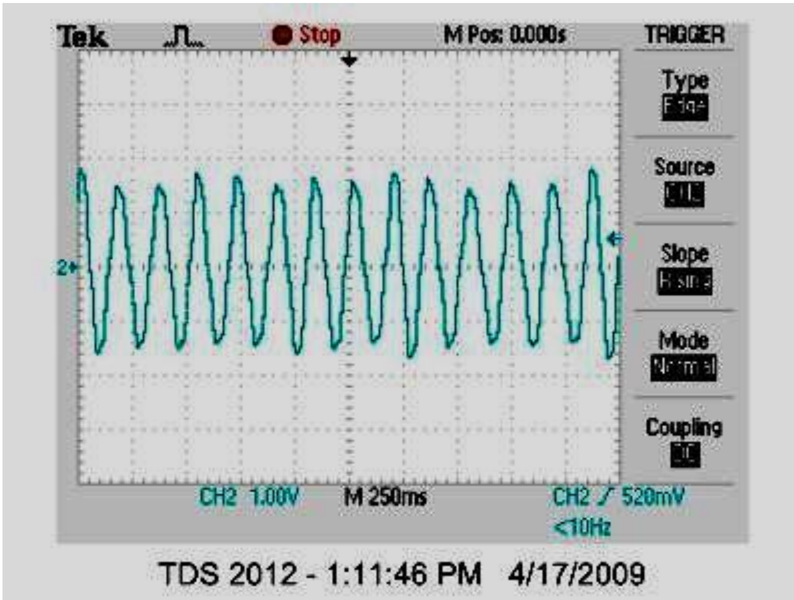
The design of model three only permits it to have 2 magnets, as opposed to 4, this also cut the output down by very close to half.

The wires in model 2 were wrapped in the same direction as the change of the magnetic field; it therefore had no magnetic flux through the loop. Obviously this would create no current.

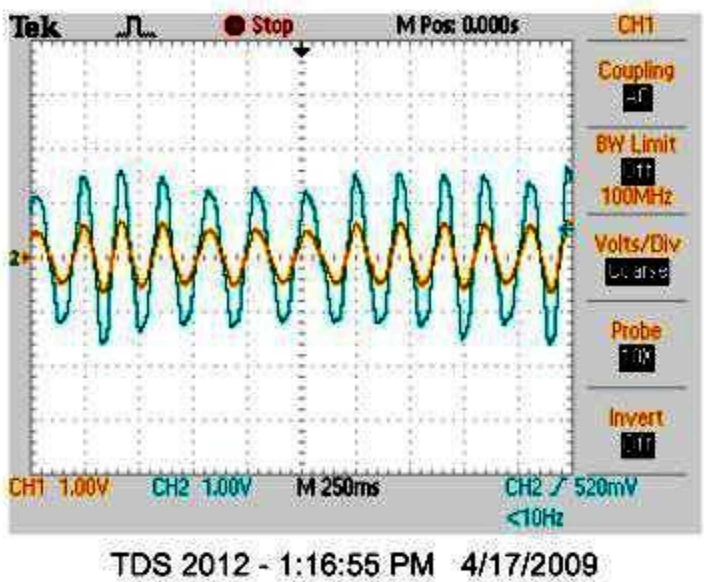
The readings of the different models are outputted on an oscilloscope. The scale measurement of each box on the graph is recorded on the bottom

The resistance to the magnet turning was observed only in the models that created current. This is because the currents created the Lorenz forces.

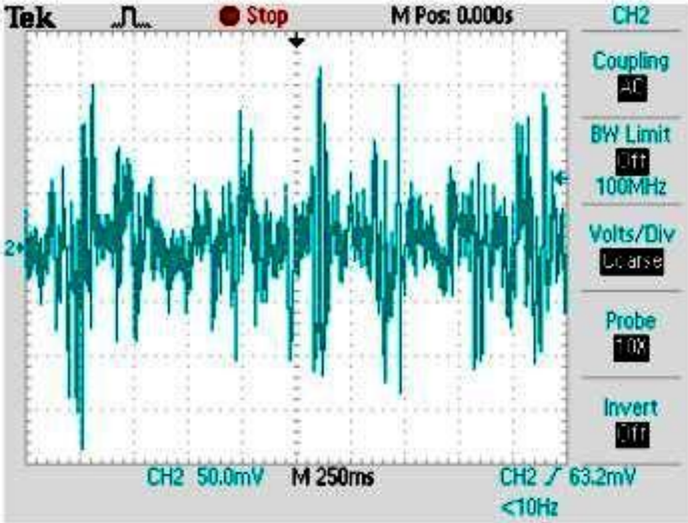
This is the reading of model 1 with 240 turns:



This is a reading of both the 100 loop section and the 240 loop section of model 1. As you will notice the yellow(100 loop) is almost exactally 100/240 the magnitude of the blue line(240 loop).:



This is model number 2, if you will notice, the scale is 50 MV, meaning that these recordings are basically electronic junk(picking up other signals):



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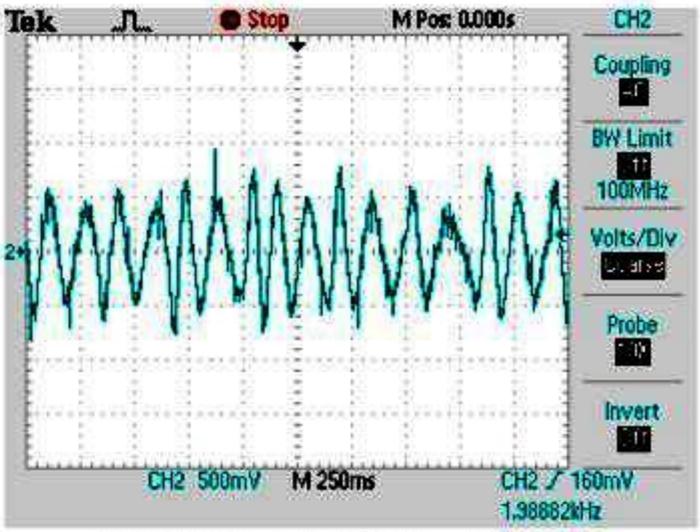
This is model number 3



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As a reverse part of the experiment, design 1 was converted into a motor.

By running current through the wire, a Lorenz force would then be created on the magnets. For half of the positions of the magnets, the force would spin it clockwise and for the other of the rotation, the force would push it counter clockwise.

This was solved by the following implementation:

1) One of the wires was attached to the positive end of a battery

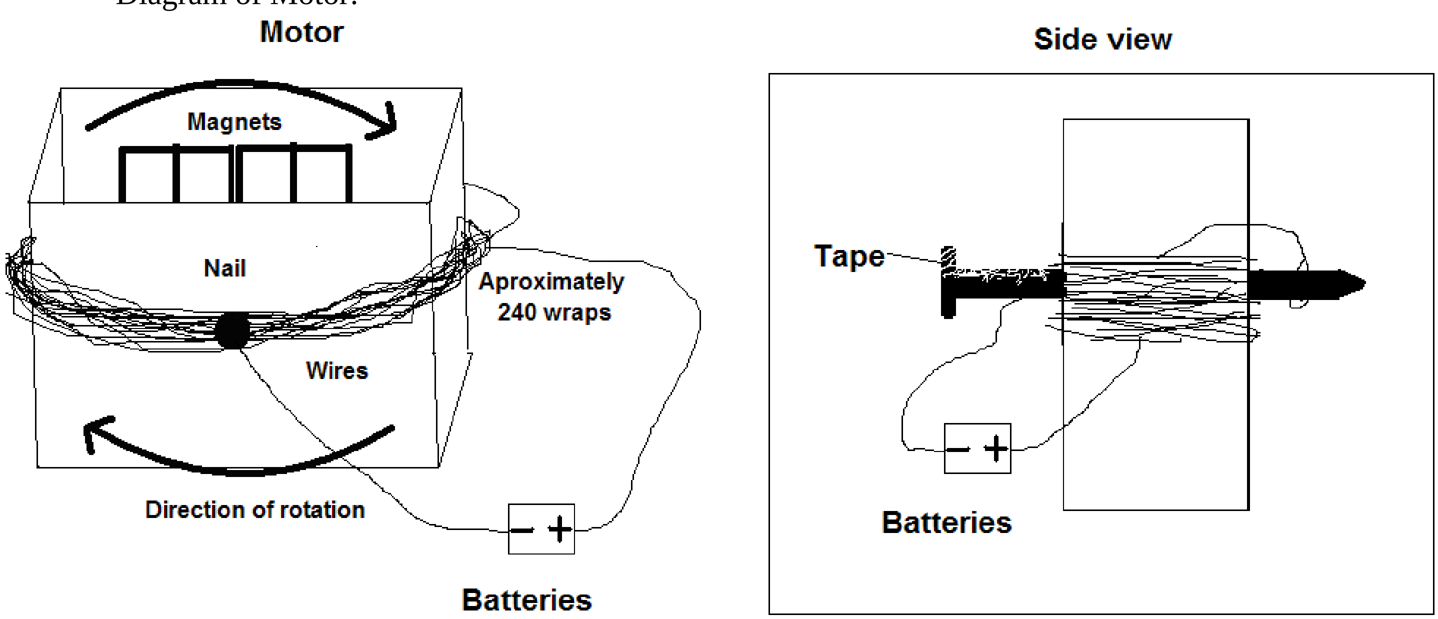
2) A new wire was run off the negative end and rested on the nail next to the head.

3) The side of the nail with the head was covered in duct tape so that the wire was touching the nail only half of the time during the nails rotation.

4) The other wire was looped around the other end of the nail so that it was always in contact with the nail, but would not get wrapped up as the nail spun.

5) The current then traveled through the nail and wire, but only when the tape was not blocking the electrical connection. The tape was placed on in a way that blocked the current only when the Lorenz force was pushing the magnet counterclockwise.

Diagram of Motor:



Result:
The Lorenz force was clearly identified and caused movement of the magnet when current was run through the wire. The switch mechanism did not work very well due to minimal conductivity and poor electrical contact with the nail. With manually touching each end of the two wires together at the proper times, several rotations could be accomplished.

Sources:

UPII Spring 2009 Course Guide Part 2: Magnetism and Optics By: Dr. John and Gay Stewart

Chen, J.; Nayar, C.V.; Xu, L., "Design and finite-element analysis of an outer-rotor permanent-magnet generator for directly coupled wind turbines," *Magnetics, IEEE Transactions on* , vol.36, no.5, pp.3802-3809, Sep 2000

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Eurosensors XVI Prague, Czech Republic

http://www.eskimo.com/~billb/amateur/coilgen.html