Micro Generator

Goal and Objective:

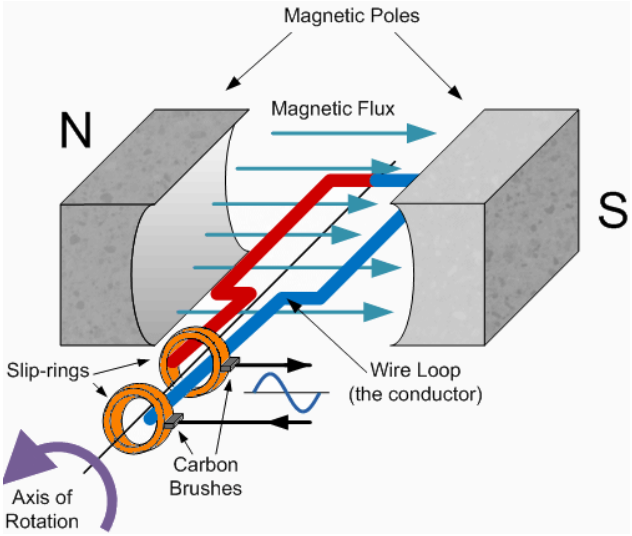
The purpose of this research is to develop a micro generator which is at most 0.5cm in diameter and 5cm in length. Such micro electric generator will offer a promising power source for small size electronic devices, like phones, watches, and so on. Different from batteries, micro generators work without chargers and have much longer operating time.

Current micro generators on the market usually have a motor size of 15mm or even more. There is no commercial unit of the size that we require. Maximum size with 5mm in diameter and 5cm in length is impressively smaller than those on sale, which means that it can occupy a smaller space, have lighter weight, and be more competitive.

After making a satisfactory micro generator, we want to evaluate its efficiency. Efficiency is the ratio of output power and input power. It is much more significant for a micro generator to have a high efficiency because its output power has small value and any change in efficiency will make a huge difference.

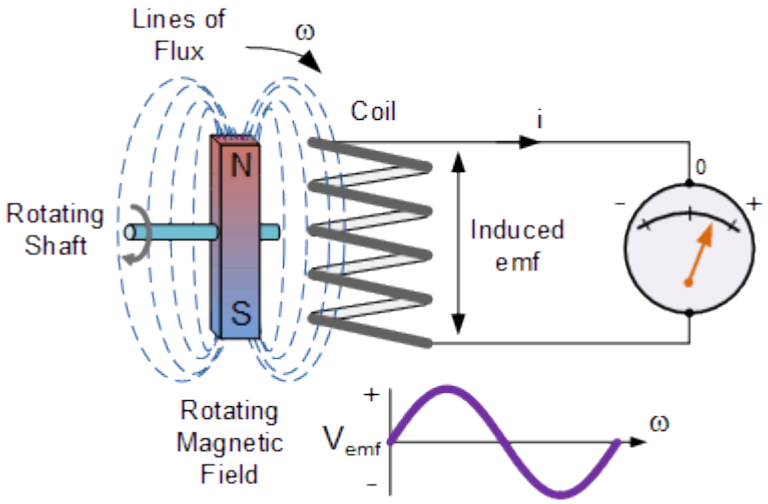
Introduction:

We determine that wind is the power source of our micro generator. By using wind, we don't need to consider about fuel addition. Furthermore, wind energy is a clean and renewable, discharging zero greenhouse gas and producing zero traditional pollutants. Wind industry is a promising field right now and the United States wind industry has attracted more than $100 billion from investors since 2008.



To build a generator, the principal is to convert mechanical power to electrical power. Due to the Faraday Law of Electromagnetic Induction, when a conductor such as an electrical wire in a close loop is cutting magnetic lines in a magnetic field, the current will be induced. For example, in the left figure, the rectangular conductor can rotate in the magnetic field with cutting the magnetic flux. Therefore, there will be currents flowing from red to blue during the first half circular rotation and from blue to red during the second half circular rotation. It is a typical instance to show how to make electrical power and it has the same principal as the wind power generator does.

For a wind power generator, wind will drag the fan to rotate, spinning a shaft which is connected to the fan. During the rotation of the shaft, as the figure below shown, the magnet which is drilled through at the center by the shaft moves at the same time, so the fixed coil is



cutting lines of flux. Higher speed of the wind will make the fan and shaft spin faster, angular velocity of the flux lines will be higher, so the coil cuts more lines and generates larger induced emf.

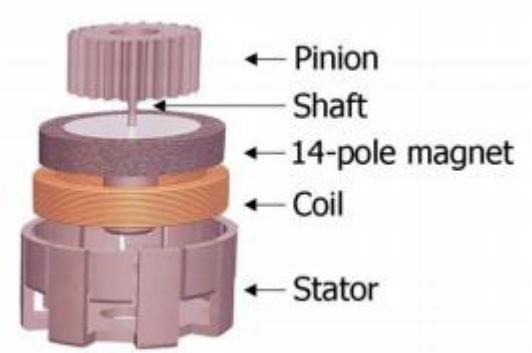
Considering the size restraint of our micro generator, we did the research about current micro generators on the market. The size of what we can find is apparently greater than the requirement, especially all products have diameter larger than 0.5cm. We decide to buy a product whose size is closest to the restraint, and we will shrink the size of it by ourselves.

Method:

The right figure shows a micro generator using water turbine as the power. It basically has same principal as the wind power generator. It also has perfect size that is consistent to our requirement. But unfortunately, KINETRON, the company owning this patent, is in the Netherlands. It seems that this company only sells this product to other companies.

Therefore, we decide to buy parts and make a similar one by ourselves by referring to the information in the right figure. The pinion is not needed, and we will replace it by a fan (the size of fan is not taken into size consideration). The 14-pole magnet is made of Sm_2Co_{17} and the coil is required to providing a resistance of 320ohm with 1140 windings. These two parts as well as the stator are what we need to buy and fabricate. There are such kinds of materials on the market but the size is much bigger than designed.

To calculate the wind power efficiency, we need to calculate the output power and input power.



Specifications:

Housing:
- Material:
- Dimensions: Diameter = 4.6 mm, Height = 3.4 mm

Stator:
- Material: Soft magnetic iron with 40% Nickel, Thickness = 0.2 mm
- Dimensions: Diameter = 4.0 mm, Height = 2.2 mm

Magnet:
- Material: resin bonded Sm_2Co_{17}
- Dimensions: Diameter = 3.4 mm, Height = 0.5 mm

Coil:
- Windings: N = 1140
- Resistance: R = 320 Ω
- Wire: Diameter = 0.026 mm

Generator:
- Pole pairs: p = 7
- Total flux: Ψ = 0.7 mVs
- Power: P = 10mW

The input power is power generated by wind, by following calculation:

$$E = \frac{1}{2}mv^2 \Rightarrow P = \frac{dE}{dt} = \frac{1}{2}v^2\frac{dm}{dt} \Rightarrow \frac{dm}{dt} = \rho Av \Rightarrow P = \frac{1}{2}\rho Av^3$$

Due to the Betz Limit, $C_{p_{max}} = 0.59$
We have

$$P_{avail} = \frac{1}{2}\rho Av^3 C_p \quad ,$$

where $A = \pi r^2$ and r is the radius of fan.

The output power is easier to get, as long as we connect a smaller resistor R to the power generator and use voltmeter to test the voltage of R, use $P = V^2 / R$ to find P.
Then we can have efficiency $\eta = P / P_{avail}$.

Annotation

E	=	Kinetic Energy (J)	ρ	=	Density (kg/m^3)
m	=	Mass (kg)	A	=	Swept Area (m^2)
v	=	Wind Speed (m/s)	C_p	=	Power Coefficient
P	=	Power (W)	r	=	Radius (m)
$\frac{dm}{dt}$	=	Mass flow rate (kg/s)	x	=	distance (m)
$\frac{dE}{dt}$	=	Energy Flow Rate (J/s)	t	=	time (s)

Student's Responsibility:
We are responsible to design and fabricate this micro generator. We will buy one similar but bigger generator online and disassemble it, then study how the generator works. We will make every smaller parts and fabricate a micro generator which meets the requirements.

Timeline:

April – June	Doing research and buy a bigger generator online.
September – November	Fabricating every parts we need.
December – March	Assembling the micro generator and test it.

Itemized Budget:

Materials	Bigger generator for researching, materials for fabricate new micro generator.	$500
Lab fees	50/Month	$500

Reference:

"Wind 101: The Basics of Wind Energy." *Wind 101: The Basics of Wind Energy*. N.p., n.d. Web. 01 May 2016.

"Principle of DC Generator." *Electrical Engineering and Technology*. N.p., n.d. Web. 01 May 2016.

"The 14-pole Micro Generator with Sm2Co17 Magnet with Housing (MG4.0H)." *Sci Am Scientific American* 12.24 (1865): 371. KINETRON. Web. 30 Apr. 2016.

"Wind Turbine Power Calculations." *Npower*. The Royal Academy of Engineering, n.d. Web. 30 Apr. 2016.