Operation Manual

Team 9

Development of Power Converting Sub-System of Kite Power Generator

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1. Functional Analysis

The project is meant to produce electricity by means of a pogo solenoid. The driver of this pogo solenoid is a kite. A line from the kite is brought down and tied off to a magnet. The kite is flown in a figure-8 pattern which drives the oscillation of the magnet. It is important to note that a figure-8 pattern may not be the optimal kite path to drive the oscillation of the magnet. When the kite is at the top of its figure-8 pattern, compression springs that are attached to the magnet are compressed and force the magnet down, back through the solenoid via Hook's Law. In order to operate in variable wind speeds, three concentric springs are used in series. Only the first spring is compressed in low wind speeds, and the second spring is compressed in mid to high wind speeds. The third spring is meant to be a safety mechanism for strong wind gusts, and very high wind speeds. During these types of conditions, it is important to not plastically deform the first two springs, which the third spring is meant to prevent.

Figure 1 shows a diagram and flow chart of how the system will operate. Around the spring and magnet is a copper coil. Each time the magnet is forced through the coil, a voltage is induced via Faraday's Law. The power generated is AC and is delivered at the frequency of the oscillation which is estimated to be 1Hz-3Hz. Because this device is meant to deliver power to the grid, this power must be supplied at 60Hz. To do this with minimal losses, it is best to convert this power to DC such as charging batteries, and then draw AC power at 60Hz from these charged batteries.

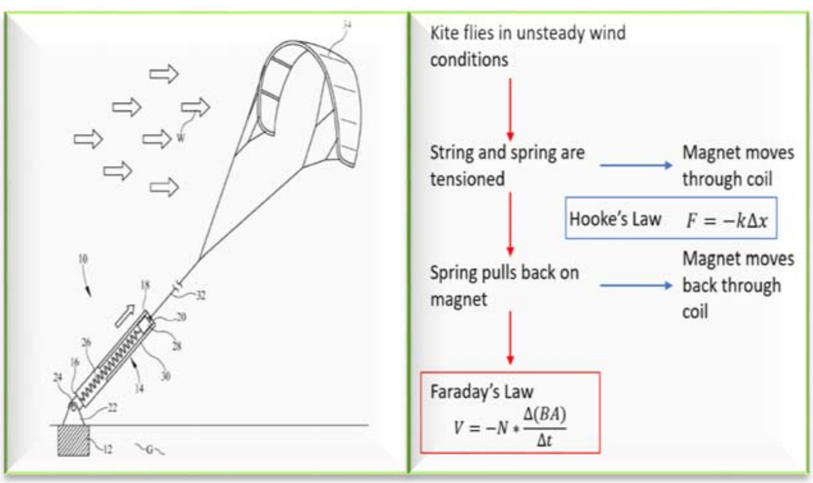

Figure 1. Functional Diagram of kite powered generator

A motor can also be used to simulate the kite motion. The motor is programmed to simulate the kite motion at different wind speeds, and for different frequencies of oscillation. A string connected to the magnet will be wrapped around the shaft of the motor. To simulate higher wind speeds, the motor will spool the kite string around the shaft, compressing the springs. For lower wind speeds, the motor will only compress the springs slightly. Motor will then spin counter clockwise and clockwise, to simulate the oscillation of the kite and drive the magnet through the coil. The ends of the copper coil will be connected to whatever device is going to be powered or a voltmeter.

2. Product/ Project Specifications

The assembly of the demo model consists of three concentric compression springs of different lengths and stiffness coefficients. These are connected to the top of the housing with a strong adhesive. The solenoid is a 3D printed piece of plastic that surrounds the three compression springs and is connected to the top of the housing with the same strong adhesive. Copper wire is then wrapped meticulously around the solenoid as to not come into direct contact with any of the moving parts. A string is tied to the bottom of the magnet and fed through the solenoid and springs then attached to the kite.

The specs for the kite that is used can be found in Table 1. Table 2 desicribes the specifications of the magnet that was selected for this model. Table 3 shows the specifications for the springs that were used in the model thoughout testing. The old spring configuration was selected based on the notion of hand cranking the magnet though the coil. Since it was later decided that the device would in fact be driven by a kite, new springs needed to be used based on lower forces provided by the kite. Figure 2 shows the specifcation of the motor that will be used for simulating the kites motion when desired.

Table 1. Kite specification that is flown in figure-8 pattern

Tantrum 220 Prism	
Weight (lbs)	1.5
Wing Span (in)	86.5 x 98.5
Wind Range (mph)	5 to 25
Kite String Length (ft)	85

Table 2. Selected magnet specifications

Neodymium Magnet	
Diameter (in)	3
Thickness (in)	1/2
Hole (in)	1/4
Strength (tesla)	1.32

Table 3. Specifications for new and old springs that are used in model

	Springs	Length (in)	Stiffness (lbs/in)	Outer D (in)	Inner D (in)	Solid Height (in)
Old	1	9.00	13.00	3.00	2.62	1.54
	2	6.88	9.00	1.50	1.25	1.88
	3	3.50	153	1.00	0.68	2.11
New	1	9.25	2.20	2.25	2.01	1.68
	2	7.00	1.70	1.55	1.37	1.61
	3	3.50	153	1.00	0.68	2.11

rpm @ Continuous Operating Torque	3,000 rpm @ 21 in.-oz.
Starting Torque	159 in.-oz.
Maximum rpm	3,456
hp	0.06
DC Voltage [Nom]	12 Volts DC
Amps @ Full Load	4.9
Electrical Connection	Lug Terminals
Lug Terminals	
Width	0.187"
Thickness	0.02"
Motor Type	Brushed Permanent Magnet
Service Factor	1
Efficiency	68%
Enclosure Type	TENV
Enclosure Material	Steel
Bearing Type	Ball

Overall	
Length	4 3/4"
Width	2 1/4"
Height	2 3/4"
Shaft	
Diameter	0.250"
Length	1"
Center to Base (A)	1.06"
Mounting Orientation	Any Angle
Mounting Holes	
Thread Size	6-32
Quantity	4
Bolt Circle Diameter	1.53"
Insulation	
Class	F
Maximum Temperature	311° F

Figure 2. Specifications for motor used to simulate kite motion

3. Project Assembly

Figure 3 shows the dimensioned drawing of the model that is being used. Figure 4 shows how the parts of the model are assembled and shows each component in more detail.

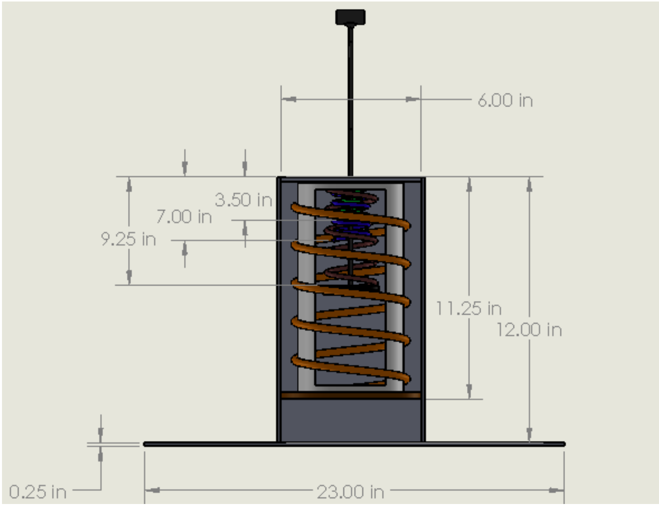

Figure 3. Dimensioned drawing of demo model

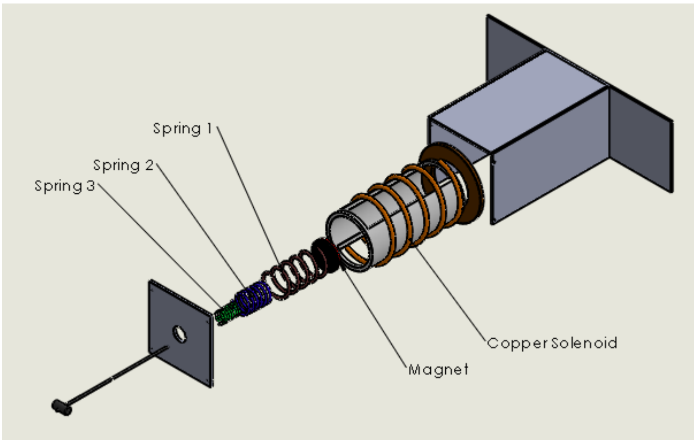

Figure 4. Exploded view of demo model

4. Operational Instruction

1. Check that the springs are properly attached to the housing with a strong adhesive

    - If the springs are not attached, use strong metal adhesive to attach the springs is concentric order to the roof of the housing

2. Check that the magnet is attached to the largest spring, and that the kite line is secured to the magnet

-If the magnet is not attached to the springs, use a strong metal adhesive to attach the magnet to the longest spring

-Feed the center kite string though the cut out on the top of the housing and through the center of the springs, down through the center of the magnet

-Tie kite string to the support bar on the bottom the magnet securely

3. Make sure that the ends of the copper coil are either tied to a voltmeter or connected to whichever device you would like to power

4. Secure the housing to the ground by standing on it, or adding weights to the side panels of the housing

5. Unravel the kite and kite strings, being careful not to tangle the lines

6. Once the kite strings are unraveled, grab hold of the kite control bar

-If you do not have experience flying the kite, familiarize yourself with basic kites before flying the generator kite

7. Have a friend grab hold of the kite while kite strings are tensioned and untangled

8. When suitable wind is present, throw the kite into the wind, and fly the kite using the control bar

9. Watch as power is generated when the magnet moves through the coil

10. *****If the motor is used to simulate the kite motion follow direction below

11. Repeat steps 1-3 using a line that is tied off on the shaft of the motor

12. Have at least two feet of slack to wrap around motor shaft

13. Select motor speed and simulated wind speed using the microcontroller

14. Repeat step 8

5. Troubleshooting

Potential problems with this kite may involve but are not limited to; 1) Kite string tangling 2) adhesive failing between the springs and the housing 3) Kite tearing 4) Magnet coming lose 5) Copper coil coming unraveled 6) Kite string breaking.

If the kite strings become tangled, the user should use care in untangling the lines to not further tangle them or damage the lines. If the adhesive fails between the springs and the housing, or the springs and the magnet, the user should use a strong metal adhesive and reattach the components until a more reliable mount is created. If the kite is torn, that kite should be decommissioned and a new kite will need to be purchased for the system to work as designed. If the copper coil comes unraveled, the user should rewrap the coil making tight loops, and secure both ends of the coil. If the kite string shows signs of tearing or wear, new strings should be used to prevent tearing. It is important to fly the kite in a safe area, away from people and powerlines. If the kite strings do break, retrieve the kite where it lands and determine the cause of the tear. Prevent this from happening at all costs.

6. Regular Maintenance

Maintenance should be performed on the kite weekly if it is being flown continuously. The kite strings and kite itself should be inspected carefully for signs of wear. If there are signs of wear and tear, the kite strings and kite should be replaced immediately to prevent the kite from breaking lose and flying away. The adhesive holding the springs to the housing should also be inspected weekly to make sure that there is no breaking where they are connected. If there is cracking seal, apply more adhesive or redo the seal. If the springs show any sign of deformation, replace them at the earliest convenience.

7. Spare Parts

Spare parts needed for extended run time of this power generating device can be found in Table 4 below. The springs are needed in case of plastic deformation from increased and continuous loading on them. The kite is needed in case any damage is done to the kite that is in operation, and the kite strings are needed in case the lines sustain any damage during operation.

Table 4. Summary of spare parts

Spare Parts List	
1	Replacement initial spring
2	Replacement second spring
3	Spare kite string to replace kite lines
4	Extra kites