ARPN Journal of Engineering and Applied Sciences

DEVELOPMENT OF AN ALTERNATIVE SOURCE OF POWER IN AN OCTOPUS RIDE USING KINETIC ENERGY

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ABSTRACT

This paper is about the development and implementation of an electromagnetic transducer in harvesting kinetic energy from an octopus ride. The kinetic energy harnessed from the octopus ride by the electromagnetic transducer is stored in a 1F, 5.5V supercapacitor. The voltage is stored in the supercapacitor is regulated to approximately 4V by a conditioning circuit which uses an LM393 comparator. This research aims to utilize an alternative source of energy to reduce the cost and expenses in maintaing an octopus ride system.

Keywords: electromagnetic transducer, kinetic energy, octopus ride, supercapacitor.

1. INTRODUCTION

In many countries today, numerous ways of utilizing alternative energy are being studied. Some of these include heat energy, wind energy, solar energy, and kinetic energy. Harnessing these alternative energies can reduce costs to save money. Anything in motion, whether it be vertical, horizontal, rotational, or translational, has kinetic energy [1,2]. A few sources of which the walking and the running of persons, a moving car or amusement park rides such as the Octopus.

Common amusement park rides consume high electricity during its operation. With the increasing demand for alternative energy, the study of converting kinetic energy into electric energy can be a solution for these rides. The trend today is not just to think of a way to lessen electricity cost, but also to utilize alternative energy (also known as power harvesting) instead of always being dependent on electricity [3]. Storing the kinetic energy of an octopus ride and converting it to electrical energy to power its lights is an example of power harvesting [4,5]. With the evolving improvements in the technology of power harvesting, especially in harnessing the kinetic energy of movements, the next logical step is to expand and explore the usage of alternative energy [6,7].

In this paper, we used electromagnetic transducer as the kinetic energy harvesting device that will produce DC voltage to light up various load types. The harvested voltage will then be regulated by a conditioning circuit using an LM393 comparator.

2. SYSTEM CONSIDERATIONS

2.1 Octopus Ride

An octopus ride is a rotational type of ride usually seen in amusement parks, carnivals and fairs. It has four to eight legs, sometimes referred here as arms, each having one up to four free moving seats on its ends. These legs move in a circular motion while moving up and down. The rotational and vertical movement of the octopus ride is caused by two different motors. Some of the modern octopus rides feature another motor that controls the rotation of the seats at the end of each leg. Connecting the transducer and circuits for testing and data gathering on a miniature octopus ride is safer and convenient [8,9]. Refer to Figure-1 for the connection of the gears from the main pole to the transducer.

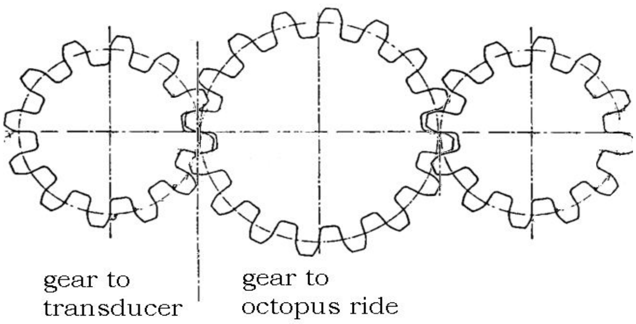

Figure-1. Illustration of Gear Connection from the Main Pole to the Gear Connected to the Transducer.

The main pole will be attached with several gears. The electromagnetic transducer is attached to a horizontal pole, in which at the other end, a gear is attached. This horizontal pole is being held in place by another vertical pole which is a few centimeters away from the main pole.

Once the octopus ride starts to operate, the rotational motion of the main pole will cause the gears attached to it to rotate. These gears will cause the transducer to shake.

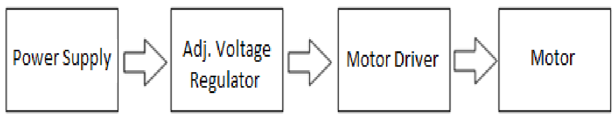

Figure-2. Block Diagram of the Miniature Octopus Ride Prototype.

VOL. 14, NO. 22, NOVEMBER 2019 ISSN 1819-6608
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The power supply of the octopus ride is composed of the transformer, full bridge rectifier, smoothing and filtering capacitors.

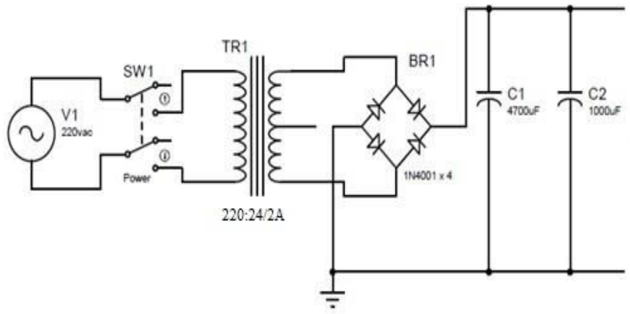

Figure-3. Schematic Symbol of the Power Supply.

The variable voltage regulator circuit is for the controlling of the speed of the Octopus ride. The two capacitors serve as the filter for the motor driver. The 1kΩ-resistor serves as the component that makes the output of the regulator clean. The potentiometer serves as the control for the speed of the motor driver [10,11].

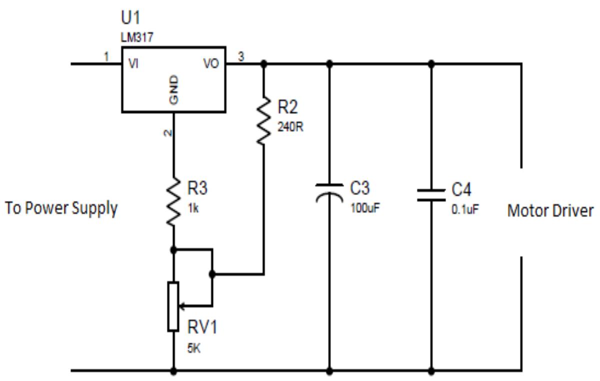

Figure-4. Schematic Diagram of the Adjustable Voltage Regulator.

The LM317 adjustable voltage regulator is an integrated circuit wherein it regulates a voltage to a level desired which is typically around 1.25V. The resistor between the output and the adjust serves to make the output cleaner and more fixed.

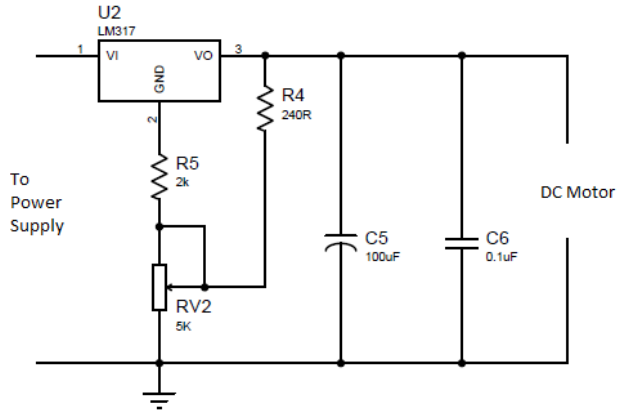

Figure-5. Schematic Diagram of the Motor Driver.

The main motor that will be used in this project will be the Maxon DC Stepper Motor. This motor will be responsible for the rotational movement of the arms of the miniature octopus ride. Its voltage operation ranges from 12V to 24V.

A second DC motor will be used to control the vertical movement of the arms while the octopus ride is rotating. It requires about 5V to 9V DC in order to ensure that the speed of the movement of the arms is enough for the safety of the riders. This is also connected to the same power supply as the motor driver.

2.2 Electromagnetic Transducer

An electromagnetic generator or transducer is a device that converts kinetic energy to electricity. The concept of electromagnetic generators is based on Faraday's Law of Induction [12]. Electromagnetic generators are classified into three: resonant, rotational and hybrid. Resonant electromagnetic generators are dependent on the moving body relative to the coil of wire [13]. Rotational electromagnetic generators are dependent on sources providing rotational motion like a dynamo. Hybrid electromagnetic generators are imbalanced rotors capable of converting linear motion to rotational [14,15].

The energy harvesting device used in this paper is a basic electromagnetic transducer made out of a neodymium magnet and a coil of wire. The kind of electromagnetic transducer used is resonant, that only needs two external forces to move the magnet. Neodymium magnets are strong magnets that even half-inch diameter of a magnet is able to lift ferromagnetic objects of several pounds.

2.3 Full Bridge Diode Rectifier

Rectification is the process of converting AC (alternating current) voltages and currents to DC (direct current) voltages and currents. Diodes are commonly used in the process of rectification due to its unidirectional current characteristics. This is the reason why diodes are also called rectifiers [16].

The schematic diagram of the full bridge diode rectifier used in the circuit is shown in Figure-6. The voltage output of the transducer is fed to the diode rectifier

VOL. 14, NO. 22, NOVEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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to convert the signal into a DC signal. The bridge type rectifier optimized the voltage produced by the transducer [17].

2.4 Supercapacitor

Supercapacitors, also known as ultracapacitor, is an electrochemical double-layer capacitor (EDLC) with high capacitance. In contrast with the structure of traditional capacitors, supercapacitors do not use dielectric [18]. Instead, it has layers of “plates” in which, when a voltage is applied, a double electric field acts as the dielectric of a traditional capacitor. Supercapacitors use carbon technology which enables it to use high-surface-area electrodes and nanometers thin physical separation. EDLC has an exceptionally large surface area which enables the huge amount of ion absorption and, in effect, can charge and discharge fast [19,20].

Supercapacitors are suitable for unstable voltage sources for it is not susceptible to error from fluctuation. It is used as a storage bank of the voltage produced by the transducer after passing through conditioning circuits. The connection of the supercapacitor, labeled C7, can be seen in Figure-6.

2.5 LED as a Load

The storage bank, supercapacitor, is connected in parallel with the load, refer to Figure-6. The main load used for testing is LED but other loads were tested as well, such as super bright LED and lamps.

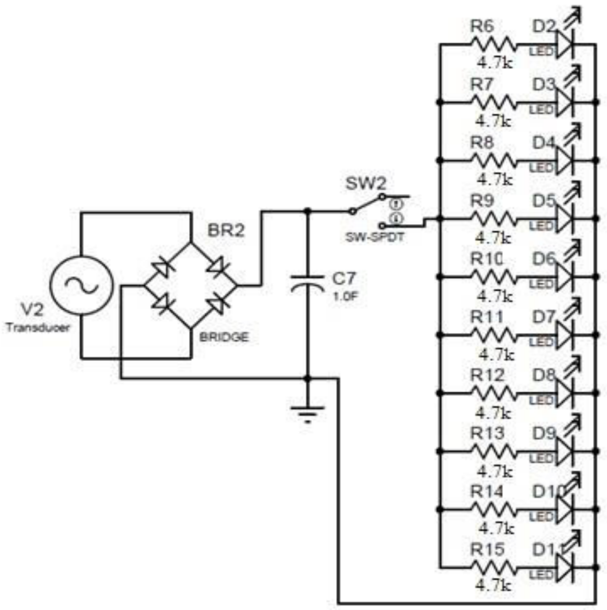

Figure-6. Schematic Diagram of Electromagnetic Transducer Connected to the LEDs in Parallel.

2.6 Conditioning Circuit Using LM393 Comparator

Comparator is an application of an op-amp integrated circuit that compares two voltage signals with respect to its magnitude. There are three terminals in a comparator: non-inverting input (+), inverting input (-) and the output.

Refer to the Figure-7 for the schematic symbol and terminals. If the positive terminal, pin2, is greater than the negative input, pin3, then the output at pin 6 would be driven to the positive voltage supply, +V pin 7, and if the negative input is greater than the positive terminal, then the output would be driven to the negative supply voltage, -V pin 4.

The voltage output equation based on Operational Amplifier:

$$V_{out} = A_V(Input_{(+)} - Input_{(-)}) \quad (1)$$

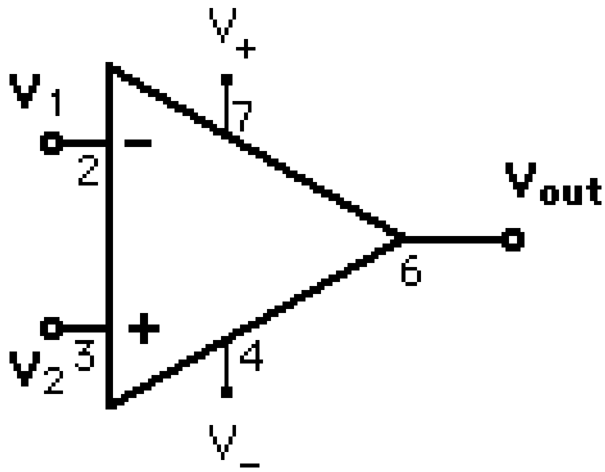

Figure-7. Comparator Schematic Symbol.

DC voltage supplied by the electromagnetic transducer is replaced by a variable power supply as a simulation. In the circuit, the positive input (V+) of the LM393 comparator will always be approximately equal to 5.1V since the zener diode 1N4733 acts as a 5.1V battery in reversed biased operation. Since the voltage across the capacitor (which is connected to the negative input (V-) of the comparator) is initially equal to zero, we can assume that V+>V- which will lead the output of the comparator to be equal to the supply voltage (Vs) since the Vcc of the comparator is pulled to the supply voltage. As long as the output of the comparator is pulled up to Vs, the supercapacitor will charge continuously up to a point where in its voltage is now greater than 5.1V. When that happens, V- will now be greater than V+ causing the output of the comparator to be pulled to the ground since the Vss of the comparator is connected to ground. The supercapacitor will now be fed with the ground signal and will not charge anymore. However, when the output of the comparator becomes ground the supercapacitor will discharge and V+ will eventually be greater than V- once again causing the supercapacitor to charge. This means that the voltage across the supercapacitor will be maintained to approximately 5V at all times.

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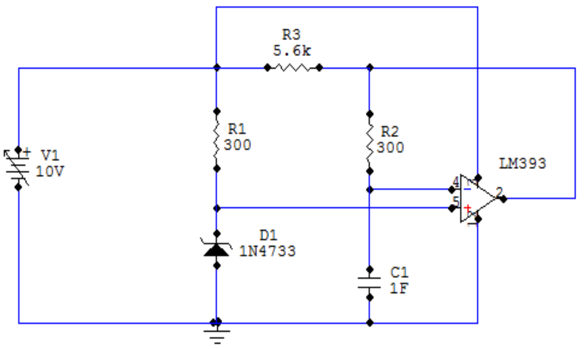

Figure-8. Schematic Diagram of Conditioning Circuit.

3. DATA AND RESULTS

3.1 Methods of Testing and Data Gathering

The prototype is a scaled-down version of the real octopus ride that can be seen in an amusement park. In exception to those tests that would be needing a longer test time, most of the testing and simulation of the ride will be conducted at intervals of three minutes (3) as this is the average time for one round of ride. Test simulations will be done according to the different possible scenarios happening in an amusement park. For all tests, the group will be gathering data for ten trials. Data to be considered are the voltage acquired during charging, the voltage dissipated during discharging, the increase in voltage during in between charging, the time it takes for the capacitor to charge and to discharge and the time it takes for the capacitor to fully drain. All the data that will be gathered will be recorded in table form and will be plotted as a line graph to easier see the trend of the data gathered. The analysis will be done for every set of data gathered.

3.2 Voltage Tests

Table-1. Capacitor charge and discharge rate without load.

Trial	V at the 3rd min.	V at the 6th min.	V at the 9rd min.	V at the 12th min.	V at the 15th min.	V at the 18th minute
1	1.139	1.124	1.893	1.866	2.499	2.468
2	1.285	1.264	1.957	1.93	2.429	2.399
3	1.22	1.205	1.92	1.898	2.439	2.41
4	1.236	1.217	2.031	2.004	2.574	2.539
5	1.293	1.277	2.031	2.007	2.522	2.494
6	1.191	1.172	1.84	1.817	2.378	2.338
7	1.479	1.442	2.4	2.355	3.004	2.95
8	1.563	1.54	2.451	2.412	3.039	2.996
9	1.534	1.515	2.375	2.343	2.95	2.907
10	1.561	1.534	2.483	2.44	3.091	3.045

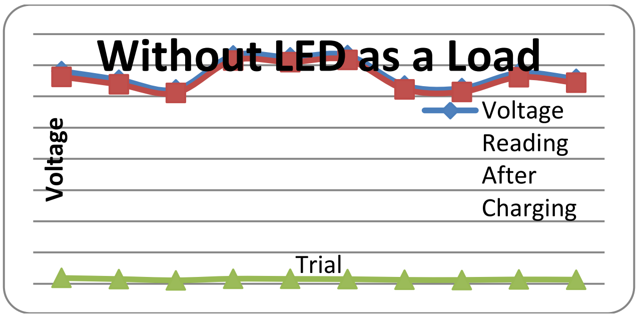

Figure-9. Capacitor Charge and Discharge without LED as load.

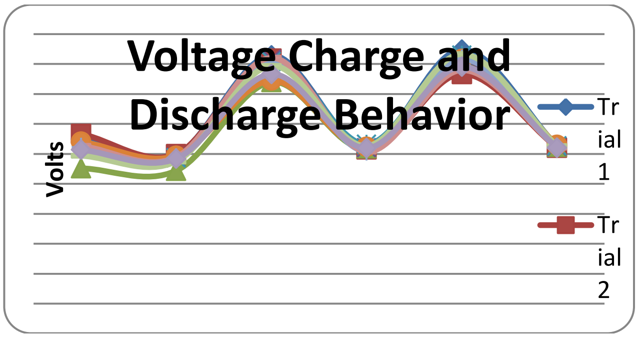

Figure-10. Capacitor Charge and Discharge without LED during charging and with LED load during discharging.

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Table-2. Capacitor charge and discharge rate with load.

Trial	V at the 3rd min.	V at the 6th min.	V at the 9rd min.	V at the 12th min.	V at the 15th min.	V at the 18th minute
1	1.648	1.49	2.486	1.575	2.544	1.578
2	1.701	1.498	2.453	1.546	2.301	1.563
3	1.356	1.332	2.219	1.555	2.43	1.572
4	1.566	1.465	2.446	1.561	2.439	1.573
5	1.551	1.46	2.425	1.598	2.49	1.581
6	1.623	1.482	2.235	1.571	2.449	1.59
7	1.567	1.463	2.409	1.527	2.449	1.555
8	1.58	1.468	2.462	1.523	2.338	1.563
9	1.482	1.425	2.381	1.579	2.499	1.578
10	1.541	1.453	2.298	1.558	2.372	1.563
Table 2 has load only during discharge						

Table-1 shows that for each succeeding interval of three-minute charge, the voltage is stored in the capacitor is increasing. Also, the discharge is also increased at a rate consistent with the charging period. Without a load connected to the capacitor, it reaches 1.2 volts to 1.5 volts after three minutes. The supercapacitor will store the accumulated voltage but will slowly dissipate a range of 9 to 37 millivolts. However, as it charges up again, the voltage in the capacitor increases by 0.6 volts after three minutes based from the consistent voltage increase of the first (between 3rd to a 6th minute) and second (between 9th to 12th minute) interval.

Table-2 and Figure-10 shows the data and illustration, respectively, the charge and discharge rate of the capacitor with the load. For the first three-minute intervals, the voltage was not enough to light up the LED. The voltage decreased at a range of 0.057 to 0.203V during discharging. As it charges up in the 2nd interval, the LED lights up beyond 1.5V. Based on the 10 trials, the voltage reaches a maximum of 2.5V. Once the LED was able to light up, it will pull down the voltage stored in the capacitor to 1.5V which is the turn-on voltage of the ten parallel LEDs.

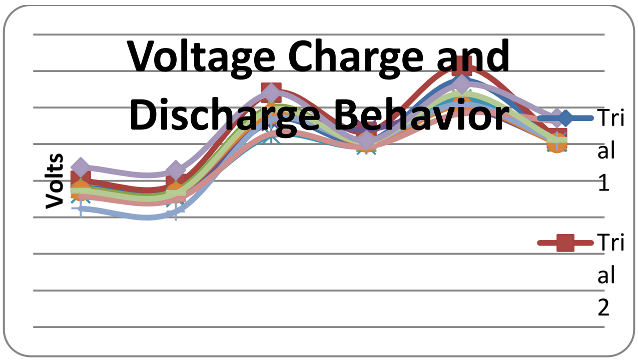

Figure-11. 3min. Charge and Discharge Voltage behaviour with LED as load all through-out.

It can be seen from Figure-11 that there is, again, a consistent charge and discharge rate within the ten trials. After three minutes of operation, the voltage across the supercapacitor was around 1.2V and was not sufficient to power the LEDs. Because of this, there was a minimal voltage drop after the 6th minute. In contrast, the charge across the capacitor by the 9th minute was around 1.8V and was enough to power the LEDs. The voltage across the capacitor in the 12th and 18th minute were similar because, as stated earlier, it was observed that the voltage will drop to around 1.5V regardless of the initial voltage across the capacitor when the LEDs are used as a load.

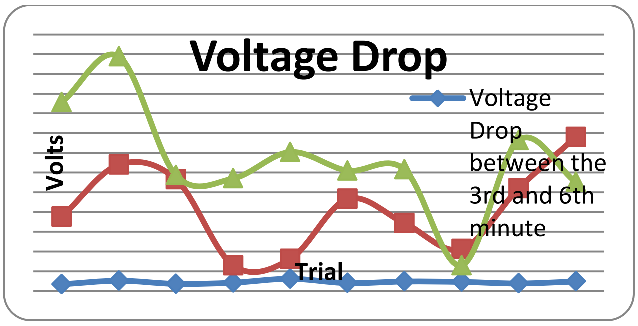

Figure-12. Voltage drop with LED as load.

3.3Voltage drop

The graph in Figure-12 shows that the voltage drop in the discharging period of each trial. The plots show that most of the discharge rate of the 15th and the 18th minute is higher compared to the discharge rate of the 9th and 12th minute. This shows that the stored energy in the capacitor is already being utilized fully once the charging period reaches the 12th to the 15th minute.

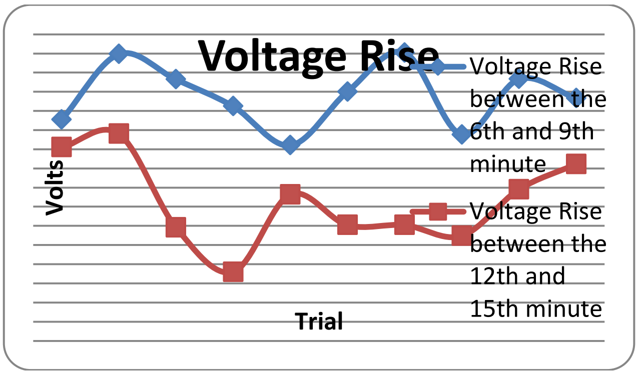

Figure-13. Voltage Rise with LED as loa from table.

3.4 Voltage rise

This graph in Figure-13 shows the voltage rise in each succeeding charging period. The plots show that in each succeeding charging period the voltage rise is also getting higher. This shows that the longer the transducer is being shaken the stored energy will be higher compared to the stored energy of its previous charging period.

It can be seen that the voltage rise in the 1st intervals is slightly higher than the voltage rise in the 2nd interval. There is a lower initial voltage in the 1st interval that resulted in a higher rise in voltage. In contrast to the 1st interval, there is a higher initial voltage in the 2nd interval that resulted in a lower rise in the voltage across the supercapacitor.

3.5 Current Tests

According to Ohm's Law, voltage is directly proportional to the current. In Figures 9 and 10, it can be seen that the voltage produced by the capacitor is proportional to the current supplied to the LED. At the first two minutes of the test, that current was zero despite the capacitor having an output voltage. This is because the voltage supplied by the capacitor to the LED is not enough to turn it on.

3.6 Tests with Different Load Types

In this set of tests, the group will assess and check if the harnessed energy stored in the supercapacitor would be enough to light up the different loads that will be used. The loads considered in this set of tests are the super bright LED, the DC lamp with 2.3V and 0.27A rating and the DC with 2.5V and 0.3A rating.

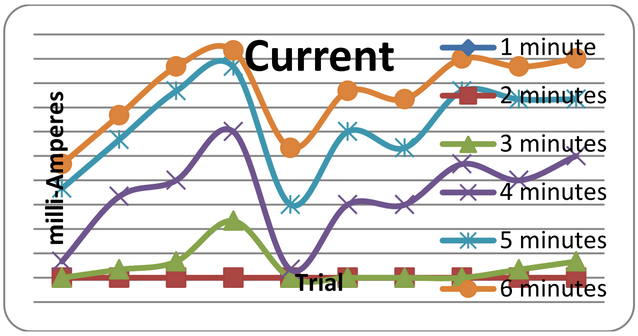

Figure-14. Current test.

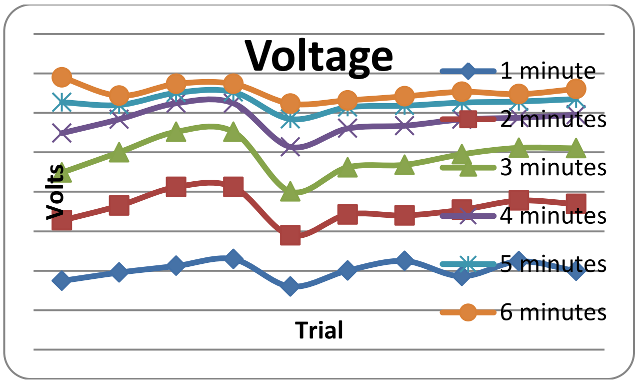

Figure-15. Voltages during Current Test.

3.7 Super-bright LED

The same test procedures were done for super bright LED as for LED.

The graph in Figure-16 based on Table-3 shows the voltage across the supercapacitor with the super bright LEDs as load after three minutes of charging. The consistency of the electromagnetic transducer to charge the supercapacitor is clearly seen after the 10 trials. During the test, it was observed that the super-bright LEDs lights up at around 2.5V as compared to the ordinary LEDs which light up at around 1.5Vonly. This resulted in a minimal voltage drop in the 1st and 2nd interval and a higher voltage drop in the 3rd interval.

However, it can be seen that the voltage drop in the 3rd interval of this testing is slightly lower than the voltage drop of having the load during discharging. In comparison, the voltage rise of this testing is also slightly lower than the voltage rise of having the load during discharging.

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Table-3. Capacitor voltage as a load during charging and discharging.

Trial	The voltage at the 3rd minute	The voltage at the 6th minute	The voltage at the 9th minute	The voltage at the 12th minute	The voltage at the 15th minute	The voltage at the 18th minute
1	1.397	1.375	2.307	2.255	2.82	2.62
2	1.395	1.366	2.274	2.236	2.815	2.621
3	1.429	1.404	2.331	2.289	2.966	2.751
4	1.496	1.473	2.478	2.427	2.948	2.681
5	1.566	1.524	2.479	2.419	2.983	2.717
6	1.536	1.511	2.426	2.377	2.838	2.636
7	1.42	1.4	2.26	2.227	2.847	2.645
8	1.41	1.391	2.289	2.257	2.844	2.638
9	1.504	1.482	2.42	2.375	2.903	2.661
10	1.573	1.555	2.517	2.45	2.971	2.696

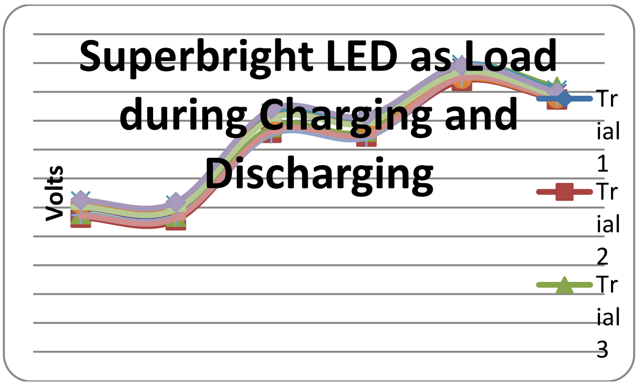

Figure-16. 3min. charging and discharging with Superbright as load.

3.8 DC lamp

In this set of tests, the group first determined the turn-on voltage of the lamp using DC supply. Having determined the turn-on voltage of the lamp, the group recorded the time it took for the electromagnetic transducer to reach the turn-on voltage. The group also set a voltage higher than the turn-on voltage of the lamp and recorded the time it took for the electromagnetic transducer to reach the said voltage. Lastly, the group recorded the time it took for the stored energy to drop to zero when the load was applied.

3.9 LAMP with 2.3V and 0.27A

The turn-on voltage of this DC lamp as the group have tested and measured is 2.3V. The group set 2.5V as the value to stop charging and start applying the lamp as a load for discharging.

In Table-4, it can be seen that there is a consistency in the time required to charge the supercapacitor. The lamp had a resistance of 0.9Ω that made the supercapacitor discharge at a high rate. The lamp was only lit up for about two seconds, and it took about 1.5 to 2.5 minutes to completely discharge the capacitor.

The group tried to place the capacitor in series with the lamp so that the discharge time of the capacitor will be minimized. However, placing a resistor will make the current that will flow through the lamp not reach the current requirement of the lamp thus not allowing it to light up.

Table-4. DC Lamp with 2.3V and 0.27A.

Trial	Time to Reach 2.3V	Time to Reach 2.5V	Time to Drop to 0V
1	6:02	1:47	5:13
2	6:06	2:19	5:16
3	6:52	2:42	5:55
4	6:22	2:04	5:33
5	6:02	1:55	5:17
6	6:33	2:43	5:39
7	5:55	2:29	5:27
8	5:45	1:48	4:58
9	5:49	1:47	5:05
10	5:34	1:54	4:50

3.10 Lamp with 2.5V and 0.3A

The turn-on voltage of this DC lamp as the group have tested and measured is 1.5V. The group set 2V as the value to stop charging and start applying the lamp as a load for discharging.

ARPN Journal of Engineering and Applied Sciences

Table-5. DC Lamp with 2.5V and 0.3A.

Trial	Time to Reach 2.3V	Time to Reach 2.5V	Time to Drop to 0V
1	2:37	3:50	1:23
2	2:36	3:54	1:20
3	2:35	3:50	1:21
4	2:31	3:44	1:23
5	2:27	3:36	1:33
6	2:25	3:30	1:23
7	2:24	3:29	1:26
8	2:24	3:31	1:30
9	2:20	3:38	1:30
10	2:33	3:49	1:22

In Table-5, it can be seen that there is a consistency in the time required to charge the supercapacitor. The lamp had a resistance of 0.9Ω that made the supercapacitor discharge at a high rate. The lamp was only lit up for about two seconds, and it took about 60 to 90 seconds to completely discharge the capacitor. The group tried to place the capacitor in series with the lamp so that the discharge time of the capacitor will be minimized. However, placing a resistor will make the current that will flow through the lamp not reach the current requirement of the lamp thus not allowing it to light up.

3.11 Stress Test

For the stress test of the prototype, the group operated the octopus ride for five hours non-stop, recording data at intervals. The stress test was conducted to make sure that the octopus ride, the electromagnetic transducer, and the supercapacitor will properly function despite the long hours of operation.

3.12 Without LED load

Analysis of without LED as the load is based on table-5 and Figure-17. At the first thirty minutes of charging, there is a significant rise in voltage from 0 to approximately 3V. The data gathered by the group shows that within two hours, the supercapacitor has reached its 5V peak. It continued to charge for the next three hours but since it has already reached its 5V peak, the rate of charging has already slowed down.

Table-6. DC Lamp with 2.5V and 0.3A.

Trial	Time to Reach 2.3V	Time to Reach 2.5V	Time to Drop to 0V
1	2:37	3:50	1:23
2	2:36	3:54	1:20
3	2:35	3:50	1:21
4	2:31	3:44	1:23
5	2:27	3:36	1:33
6	2:25	3:30	1:23
7	2:24	3:29	1:26
8	2:24	3:31	1:30
9	2:20	3:38	1:30
10	2:33	3:49	1:22

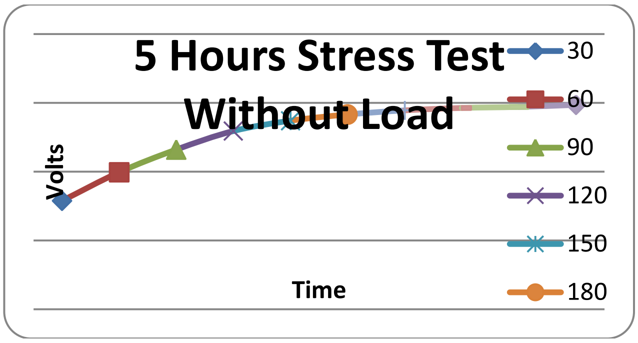

Figure-17. Stress Test Graph.

3.13 With LED load

The graph in Figure-13 shows that the charge and discharge rate of the supercapacitor has a certain pattern that it follows. As can be seen in Figure-18, the capacitor reaches a peak every 45 minutes. After reaching the said peak, it discharges for another 45 minutes. In other words, after one and a half hour, the capacitor discharges to a minimum value and then starts to charge up again until it reaches a certain peak voltage which will cause the capacitor to start to discharge.

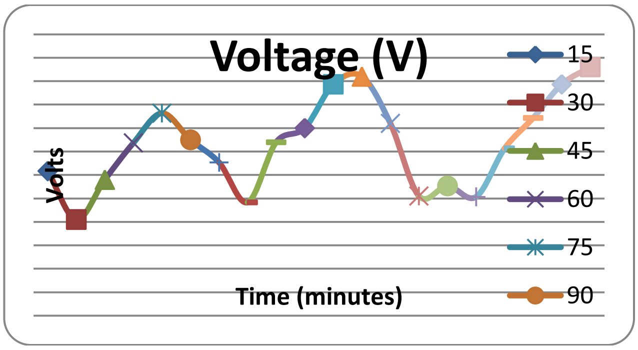

Figure-18. Voltages of the stress test.

3.14 Dynamo

As seen in the graph of Figure-19, the voltage that is generated by the motor is increasing rapidly up 2V.

VOL. 14, NO. 22, NOVEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

However, around approximately 2.1V the increase in voltage per minute decreases and peaks to 2.19V.

Table-7. Dynamo Voltage.

Time (mins)	Voltage (v)	Time (mins)	Voltage (v)
3	1.901	33	2.151
6	2.013	36	2.156
9	2.058	39	2.159
12	2.084	42	2.163
15	2.1	45	2.166
18	2.113	48	2.17
21	2.123	51	2.173
24	2.132	54	2.178
27	2.14	57	2.184
30	2.146	60	2.19

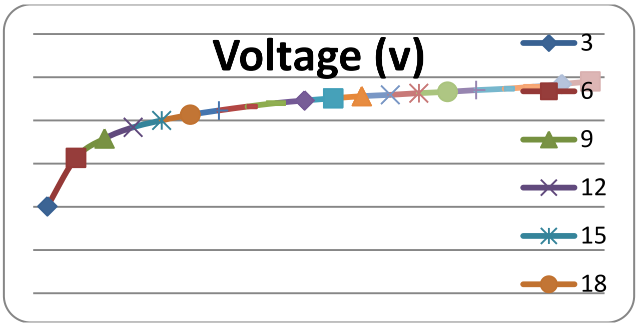

Figure-19. Dynamo Voltages.

3.15 Conditioning Circuit

Using Circuit Maker Student Edition v6.0 (a circuit testing and simulation program) we can get the DC analysis of the supercapacitor voltage.

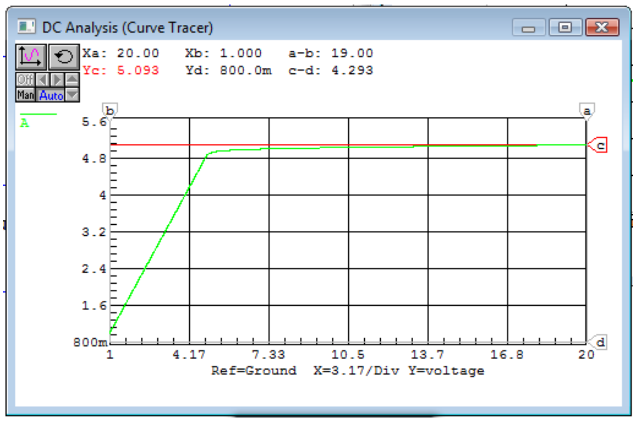

Figure-20. Conditioning circuit DC analysis.

As seen in the waveform of the DC analysis, the voltage across the capacitor will charge up to approximately 5V and will be maintained at that value regardless of the supply voltage. Using a 20V voltage supply, the charge across the supercapacitor will reach only up to 5.093V which is still safe considering that the supercapacitor has a 5.5V rating. In addition, the peak voltage that the transducer produces peaks and saturates to about 6V so the supercapacitor will definitely not overcharge using this conditioning circuit.

The maximum forward bias current than a standard LED can handle is 30mA. Given that the voltage across the supercapacitor peaks to about 5V and the load resistance is 470Ω (ten 4700Ω in parallel), we can assume that:

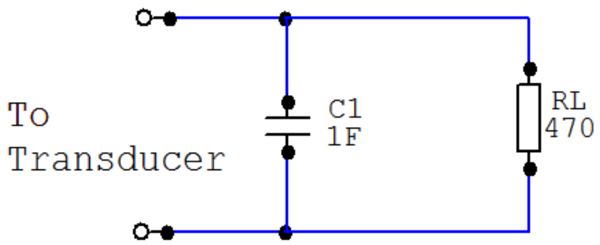

Figure-21. Assumed connection of supercapacitor to the load.

$$Vc = (Imax)(RL) \tag{2}$$

Where the values in equation 2 are:

Vc = Capacitor Voltage
The imax = maximum forward bias current of the LED
RL = Load resistance

Which gives us:

$$5V = 30mA\ (RL)$$
$$RL = 166.67\Omega$$

Therefore, to reach the maximum current the load resistance must be equal to 166.67Ω. Given that the group used 4700Ω resistors in parallel we can compute for how many resistors in parallel are needed to achieve 166.67Ω load resistance.

$$\frac{4700\Omega}{x} = 166.67\Omega$$

Where is the number of 4700Ω resistors in parallel to achieve 166.67Ω load resistance? Therefore,

$$x = 28.20\ \approx 28$$

Given that the is not exact, we use 28 resistors instead of 29 because using 29 resistors would result in a load resistance less than 166.67Ω which will exceed the maximum forward bias current.

Meanwhile, the minimum voltage that could turn on an LED is 0.7V.

Rx will provide the voltage drop that would result in RL having only 0.7V to compute for its minimum current.

ARPN Journal of Engineering and Applied Sciences

By voltage divider;

$$V_{RL} = \frac{(Vc)(RL)}{RL+Rx} \tag{3}$$

Where values of equation 3 are:
VRL = voltage across RL
RL = load resistance
Vc = voltage across the capacitor
Rx = Resistance to be added to produce a voltage drop of 0.7V across RL

Therefore;

$$0.7V = \frac{(5V)(470\Omega)}{470\Omega + Rx}$$
$$Rx = 2887.14\Omega$$

Having the value for Rx, we can now compute for the current that passes through RL which will be the minimum current.

$$Vc = (Imin)(Rx + RL)$$
$$5V = Imin\ (2887.14\Omega + 470\Omega)$$
$$Imin = 1.49mA$$

Table-8. Summary of Computed Data.

	@ Imin	@Imax
Current	1.49mA	30mA
Load Resistance	3357.14Ω	166.67Ω
Number of LEDs	0	28

4. CONCLUSIONS

After working on different tests, the group has proven that it is possible to harness rotational kinetic energy by means of an electromagnetic transducer with the supercapacitor as its bank.

The prototype was able to light up different lighting devices such as LEDs and lamps. With the data gathered, it can be concluded that the charge stored in the supercapacitor that was harnessed by the electromagnetic transducer charges at a consistent rate peaking up to approximately 6V and 4mA. The charge in the capacitor discharges at a consistent rate depending on the load that is applied. Therefore, the electromagnetic transducer can be considered as an alternative power solution for low powered devices.

The miniature octopus ride operates at approximately 123rpm to 236rpm. In considering the manner of design in which the electromagnetic transducer is applied, it must at least provide around 3 to 4 shakes per second to produce a usable dc output for LED devices.

Given the results of the group's testing, we, therefore, conclude that kinetic energy can be harnessed and converted to electrical power by using an electromagnetic transducer better than a dynamo. With this, the project can now be further studied and implemented onto an actual octopus ride or other mechanical equipment to harness kinetic energy.

5. RECOMMENDATION

In doing this research, the group has experienced situations that may be further improved. This includes using a dynamo to power the load as compared to the electromagnetic transducer (EMT) as an additional source. Also, the group recommends scaling the electromagnetic transducer and testing its characteristics on an actual octopus ride, and also the testing of the EMT to other applications. Furthermore, the group thinks that introducing a new storage bank like rechargeable batteries will be beneficial to future researchers that would want to continue or improve this study.

First is doing tests using a dynamo and comparing the results to the electromagnetic transducer, since dynamos are already known devices that are efficient for converting mechanical energy to electrical energy. If ever the data gathered using the dynamo is much more efficient compared to the EMT, it would help in the future research regarding kinetic energy harnessing.

Second is the application of the concept in an actual octopus ride. Since the concept is for an actual octopus ride, it would be more practical to apply the concept in real-rides. Furthermore, the group recommends to others who want to improve this research to apply the electromagnetic transducer to other applications, since there are a lot more of practical applications that the electromagnetic transducer can be incorporated in.

The third is that the group recommends the usage of other storage devices like the lead-acid, sodium-sulfur or lithium-ion batteries. Lithium-ion batteries are commonly used on cell phones and laptops. We recommend using these kinds of batteries since they provide longer outputs compared to supercapacitors.

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