THE UNI-POLAR PROGRAMMED SUPERCAPACITOR

Technovators

By

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ACKNOWLEDGMENT

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SUMMARY

The reliance of humanity on fossil fuels has resulted in severe repercussions such as global climate change and air pollution. The transition to renewable energy and electrical electronics has made battery technology critical. Although lithium-ion batteries are efficient, they have downsides such as the need for rare earth metals and harmful electrolyte chemicals. Supercapacitors have been considered as an alternative, although their energy density and discharge voltage are lower. The Uni-Polar Programmed Supercapacitors is innovative energy storage device that replaces electrolytes and dielectric substances with smooth-surfaced electrodes, a programmed circuit to regulate voltage and insulators. The Uni-Polar Programmed Supercapacitor provides various advantages over typical energy storage devices, including higher power and energy density, faster charging times, longer lifespan, increased safety, and stable power supply. They have the potential to replace standard battery systems in many areas as research progresses.

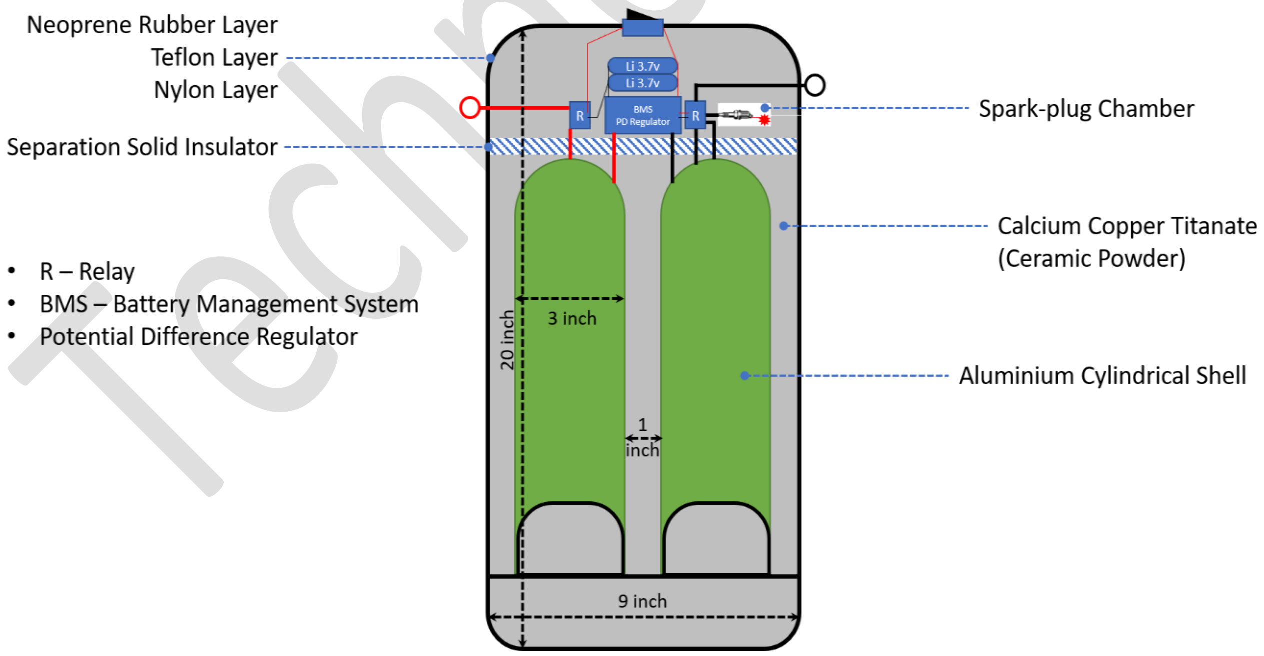


TABLE OF CONTENT

TABLE OF CONTENTS

I. Introduction

Over many decades, humanity has relied largely on the combustion of fossil fuels, which played an important role in propelling technological, social, economic, and developmental growth during the Industrial Revolution. This reliance, however, has had several detrimental repercussions. The combustion of fossil fuels emits CO2, which contributes to global climate change, and they also substantially damage local air quality, resulting in millions of premature deaths each year. We are currently at a critical juncture in history where it is critical to lessen our reliance on fossil fuels and transition towards renewable energy sources to prevent further environmental devastation. One critical component o3af this transformation is the move towards powering as many items as possible and producing electricity from renewable sources. This energy, however, must be efficiently stored, which brings us to the question of battery technology. Due to their efficiency, lithium-ion batteries have become the go-to solution for storing electrical energy, but they have many downsides, including the need for rare earth metals and non-recyclable hazardous electrolyte compounds. Furthermore, the batteries are temperature sensitive, making them unreliable in certain conditions, such as catching fire or exploding in mobiles and EVs.

The supercapacitor is another alternative that has been investigated, but they have a poor energy density, linear discharge voltage, and faster self-discharge rate. Batteries have become an essential part of almost every system in our world, including cars, where they are employed for automation, control maneuvering, and self-start. The transition away from fossil fuels has resulted in a progressive movement towards electric vehicles, emphasizing the need for a more environmentally friendly method of storing energy. To that purpose, a new storage technology with enhanced efficiency and zero-carbon emissions has been designed. This method tries to lessen our dependency on fossil fuels and battery systems such as lithium-ion technology, which require rare earth metals and harmful electrolytic chemicals that are not renewable. We can pave the road for a cleaner and greener future by shifting towards more sustainable and environmentally friendly energy storage options. Because of its better efficiency rate than currently employed grid storage, this technology can also replace grid storage energy devices.

The Uni-Polar Programmed Supercapacitors are cutting-edge energy storage device that differs significantly from regular supercapacitors. One of its distinguishing aspects is the use of smooth-surfaced electrodes with few corners and edges, which reduces internal leakage and improves energy efficiency. Furthermore, the Uni-Polar Programmed Supercapacitor use a programmed circuit to regulate the potential difference between the electrodes, ensuring stable performance and preventing overcharging or over-discharging, which could damage the device or shorten its lifespan.

Introduction (Cont.)

The system uses just insulating materials to isolate the charges and is free of electrolyte chemicals and dielectric separation medium. Insulators such as CCTO, Mylar, and ceramic are often employed to prevent coronal discharge and keep all charges on the electrodes in place. The Uni-Polar Programmed Supercapacitors outperform standard energy storage technologies such as batteries in various ways. They offer increased power and energy density, allowing them to deliver significant power outputs fast and effectively. The Uni-Polar Programmed Supercapacitors have an energy density of at least 376Whr/kg, which is nearly double that of a Li-ion battery. This high energy density enables more compact and lightweight energy storage devices, which is especially useful for weight and space-constrained applications. The Uni-Polar Programmed Supercapacitors can also charge up to 3.3 kWh in less than three minutes, which is substantially faster than standard batteries. This capability is especially significant in situations where rapid charging and extended power supply are required, such as electric vehicles and renewable energy storage systems such as grid storage and power backup systems. Another advantage of the Uni-Polar Programmed Supercapacitors is their extended lifespan, which can endure an immense number of charge-discharge cycles, which is significantly more than that of a standard lithium-ion battery and nearly as much as that of a supercapacitor or more. This feature lessens the need for regular replacements, which can be costly and time-consuming. Finally, the lack of electrolyte and dielectric components in the system lowers the risk of leakage, explosion, or fire, making the Uni-Polar Programmed Supercapacitors a safer and more environmentally friendly alternative to typical batteries. In the end, the Uni-Polar Programmed Supercapacitors are a revolutionary energy storage technology that has various advantages over standard battery systems, such as high power and energy densities, short charging times, longer lifespan, greater safety, and consistent power delivery. It is believed that as research into the supercapacitors continues, they will become even more efficient, inexpensive, and adaptable, potentially replacing standard battery systems in many sectors.

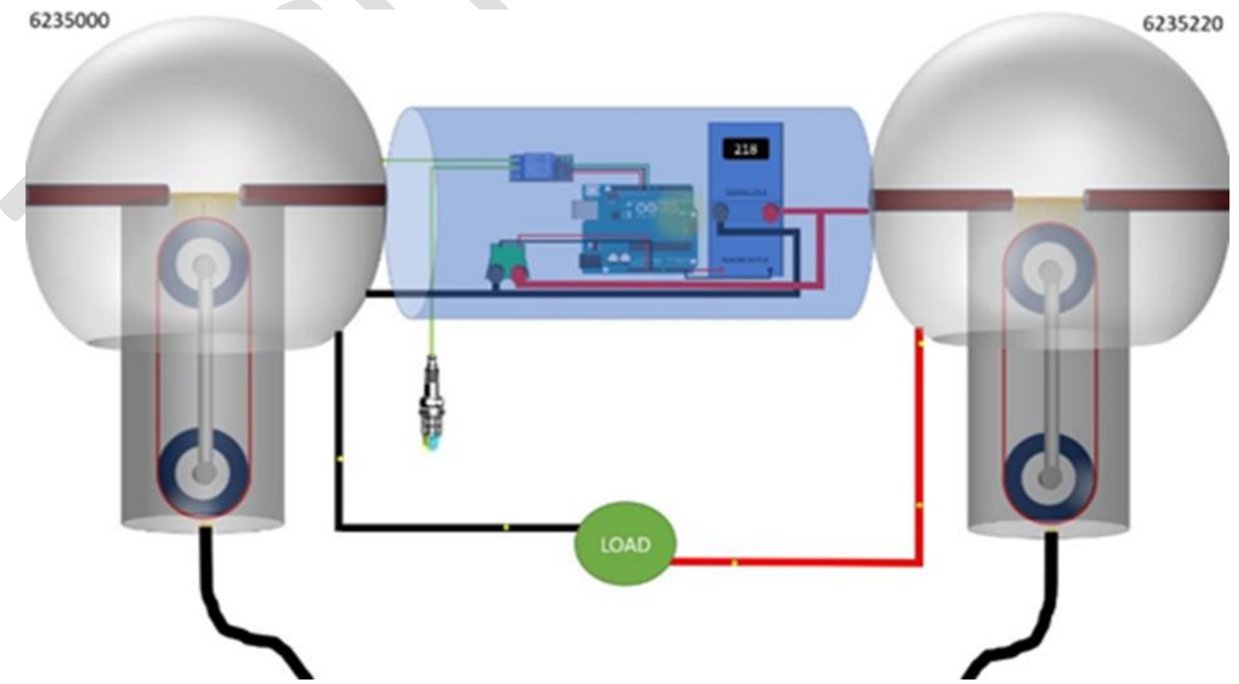
I. Background

Many industries, including renewable energy systems and electric automobiles, rely on energy storage. While lithium-ion batteries have dominated the market for many years, they have some drawbacks, including sluggish charging times, limited lifespan, and safety concerns. As a result, scientists have been investigating alternate energy storage methods that can provide improved efficiency, cost, and sustainability.

Uni-Polar Programmed Supercapacitors (UPPSC) is a viable alternative to traditional battery storage methods. UPPSCs have the ability to swiftly store and release enormous amounts of energy, making them excellent for high-power applications such as electric cars. Furthermore, UPPSCs outlast regular batteries, are safer to use, and provide a steadier power supply.

UPPSCs are a significant candidate for the future of energy storage due to their advantages over standard battery storage technologies. They are less expensive to produce, emit less pollution, and charge faster. As a result, UPPSCs have the potential to revolutionize numerous industries, particularly those that require lightweight and space-efficient energy storage solutions.

Ongoing research into UPPSCs is likely to provide even greater improvements in efficiency, cost, and versatility, making them a viable alternative to standard battery systems in a wide range of applications. UPPSCs are a potential advance in the quest for a more sustainable and environmentally friendly future.



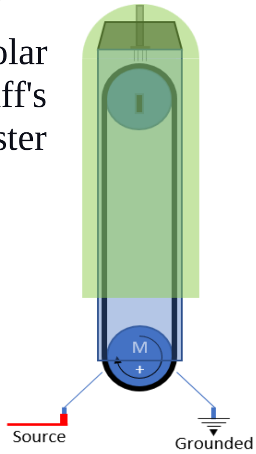
II.Proposed Work

The Uni-Polar Programmed Supercapacitor can be charged using a variety of high voltage charging methods. Thus, Uni-Polar Programmed Supercapacitor possesses remarkable scalability, given its ability to be seamlessly integrated into a diverse array of devices depending upon the charging method. Some of the charging methods are as follows:

1. Charging using Electro-Static Generators – Mechanical method
2. Voltage Multiplier Circuit

1) Charge using Electro-Static Generator – Mechanical method:

With some modifications, the mechanical method of the Uni-Polar Programmed Supercapacitor employs the principles of Van de Graaff's generator and Pelletron. This system incorporates 3 input sources for faster charging rates and higher charging efficiency:



a. Electrostatic energy generated by the system
b. Reverse earthing method
c. Grid power supply using renewable electrical energy sources

a) Electrostatic energy generated by the system

The mechanical method employed in the system draws inspiration from the Van de Graaff generator and Pelletron. It is composed of two rollers, positioned at the top and bottom, and a motor-driven belt running between them that serves to connect the two rollers. The belt is fabricated using materials such as Rubber, Teflon, or a sequential rubber-metal coated belt. Additionally, the upper roller is made of Silicone, whereas the lower roller is fashioned from Nylon. All the components' combinations are according to the triboelectric series.

The lower roller is connected to an electric motor that, upon receiving an electrical input, sets the roller in motion. The resulting frictional force between the belt and the roller generates electrostatic energy, which is then transmitted to the upper roller via the motor-driven belt. The entire charge generated by this process is subsequently transferred to the belt through metal combs, before being collected within the metal hollow shell located atop the upper roller.

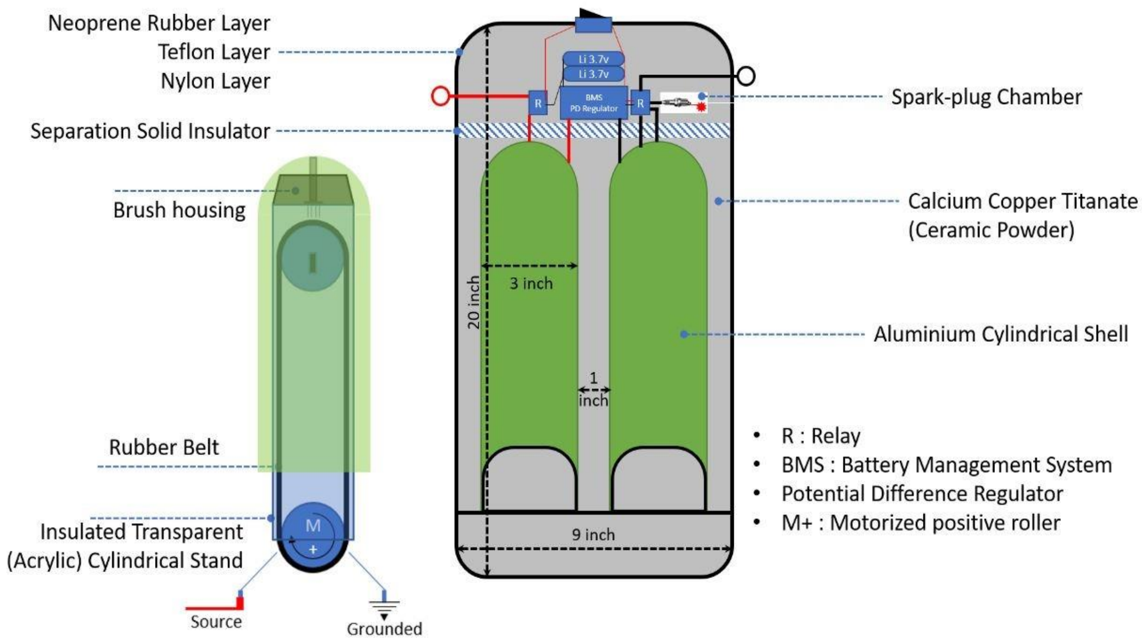
Proposed Work (Cont.)

b) Reverse earthing method

The transfer of electrical charge directly from the Earth through a low-resistance wire is known as Reverse Earthing. The Earth's surface, owing to factors such as the Earth's high temperature and pressure, is believed to be negatively charged, while the inner part of the Earth is positively charged due to the ionization of surface atoms.
By employing this technique, the Earth can serve as a provider of charges to a given system, which can then be utilized to supply electric current to the hollow shell by spraying electrons on the motor-driven belt, which are subsequently transferred to the shell. The hollow metallic shell in the Uni-Polar Programmed Supercapacitor works as the electrode in the mechanical method, which stores all the charge and is completely insulated and isolated to retain charges for a longer duration

c) Grid power supply using renewable electrical energy sources

By incorporating a grid wire in the lower part of the system and linking it with the metal comb, the Uni-Polar Programmed Supercapacitor can amass a greater charge as the energy generated by renewable sources can boost the electrical energy supplied to the system. This method can also help reduce the charging time required to charge the supercapacitor, which makes it a more efficient energy storage option.



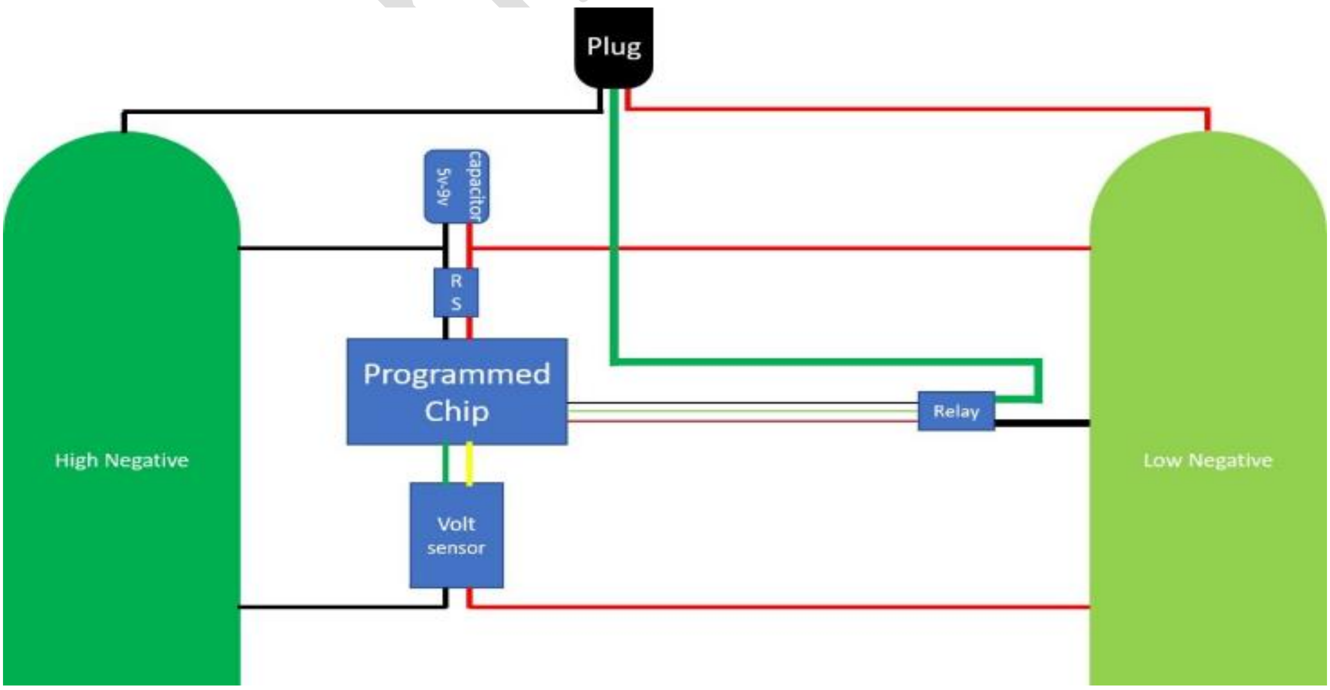
Proposed Work (Cont.)

By promoting the use of renewable energy sources such as solar, wind, and tidal, this method can contribute to a cleaner and more sustainable energy ecosystem, which is crucial for the long-term well-being of society. Furthermore, this approach aligns with the global effort to decrease reliance on non-renewable energy sources that contribute to environmental degradation and climate change.

Once the primary and secondary electrodes are charged to a similar potential with respect to the ground, the potential difference between the electrodes becomes almost zero. To allow energy or charges to flow between these electrodes, a potential difference is required. This is where the circuit comes into play, which measures the potential difference between the two electrodes.

If the potential difference is less than the set value of 12V, the circuit discharges the secondary electrode by connecting it to the ground via a relay. This connection lasts for a few microseconds and does not cause any significant voltage loss on the second electrode as it goes through the regulator.

As a result of this discharge, the potential of the second electrode with respect to the ground decreases, causing an increase in the potential difference between the primary and secondary electrodes. Charges flow when a load is attached, resulting in the consumption of energy. Meanwhile, the circuit also gets continuous power from the electrodes via the voltage regulator unit comprising a capacitor and a flip-flop.



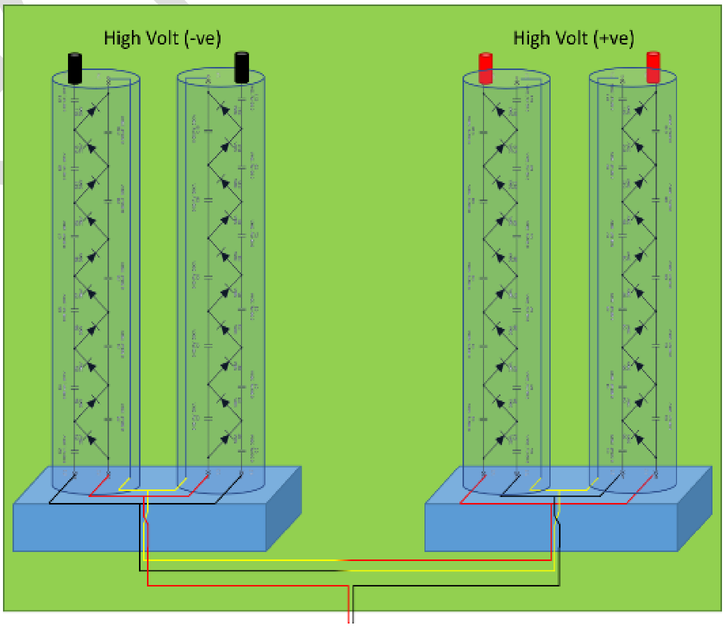
Proposed Work (Cont.)

As charges flow from the primary electrode to the second electrode, the potential difference between them decreases again, which is detected by the voltage sensor or battery management system. The circuit then again connects the second electrode to the ground for a fraction of a second, and the second cycle continues. And such millions of cycles take place to fully discharge the system.
Overall, the circuit maintains a potential difference between the electrodes by discharging the second electrode to the ground and continuously monitoring the potential difference between the electrodes through sensors.

2) Voltage Multiplier Circuit:

The voltage multiplier circuit is composed up of capacitors and diodes arranged in a specific sequence. When connected to an AC source, it is designed to convert the input energy from an average AC input to a very high-voltage DC output. This high-voltage DC output has two electrodes with opposite charges, one positive and the other negative.

Unlike the mechanical method, which relies on the concentration of negative charges on the surface of conductors, the voltage multiplier circuit requires modification in the output sockets so that it only collects negative charges on one of the socket combinations and positive ones on the other. Two such circuits are used simultaneously for one socket. The negative socket has two charging stands/charging rods that transfer negative high voltage to two of the shells.

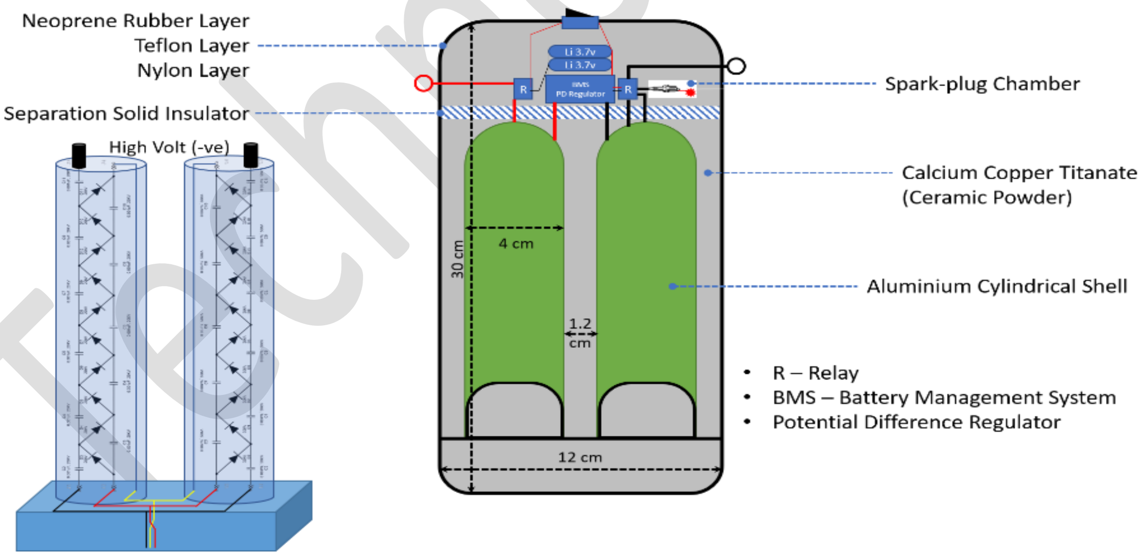


Proposed Work (Cont.)

The system charged using voltage multiplier circuits has a minimum of four shells or four electrodes, two negative electrodes, and two positive electrodes. The two negative electrodes first transfer charges among themselves while discharging and supply energy to the load.

After this, the shells are discharged, and the internal circuit redirects the load's connection to the two high positive voltage rods/positive high voltage socket. These two high-voltage positive rods then transfer charges between them while discharging and powering the attached load.

The reason for transferring power between negative-negative and then afterward between positive-positive is to avoid a sudden discharge and a sudden flow of energy through the load, which could burn the load and cause it to fail. If the circuit were only to use the negative porting, the positive charges would have to be grounded, which would reduce the charging efficiency of the device, as half of the energy while charging the device is never stored/utilized and is instead grounded.



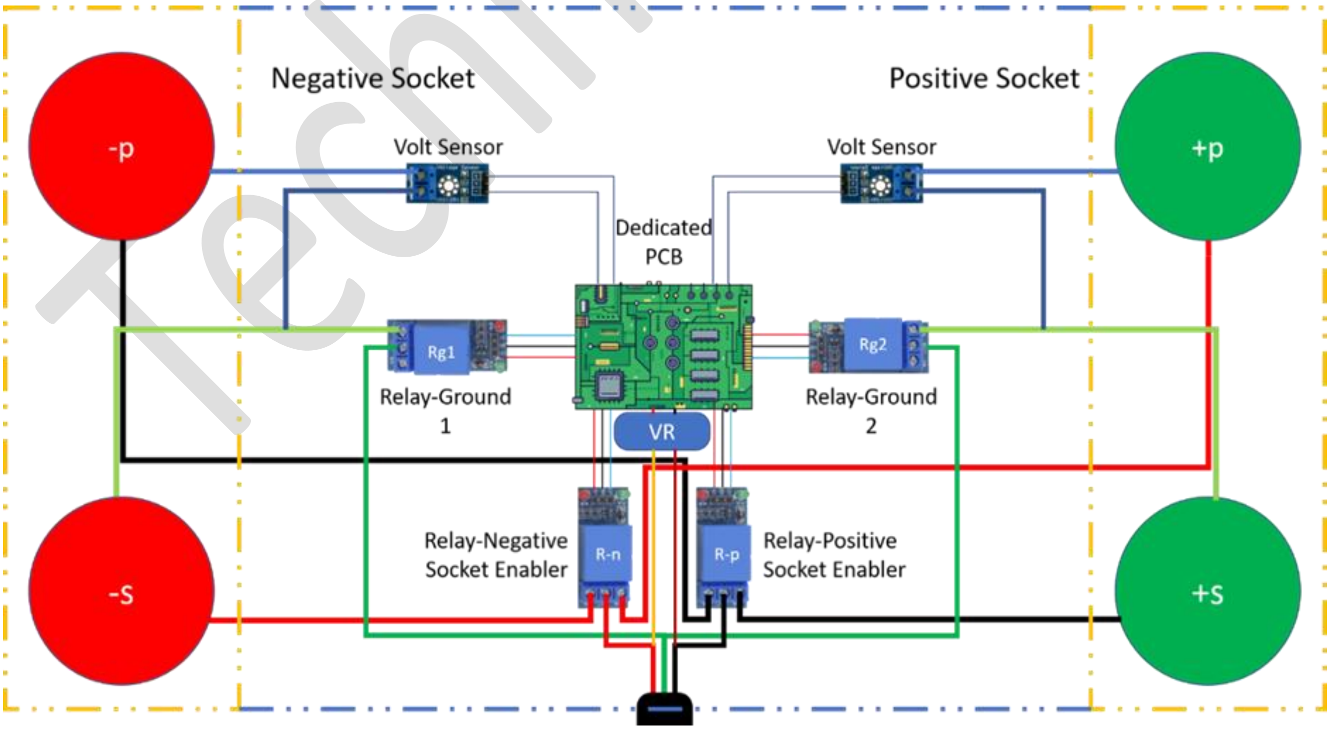
Hence, the voltage multiplier circuit can be seen as two separate charging methods, one which is in the higher concentration of electrons and the other on the deficiency of the prUPPSCnce of electrons. The insulation and isolation between the negative-negative electrode can be normal, but the insulation between a subsequent positive and negative high-voltage electrode needs to be at least 2.5 times the normal insulation.

Proposed Work (Cont.)

Apart from the change in the charging method, the discharging and power output circuit is also different than the prior major in the connections. However, the program remains almost the same except for the segment that changes the connection nodes of the attached loads after the first discharging of the negative portions.

Energy extraction via method 2 utilizes the voltage multiplier circuit, which requires at least four shells. The first energy extraction cycle takes place at the negative socket, which has two negative electrodes. The principle of energy extraction between these two electrodes is similar to the mechanical method, where there is a primary electrode and a second electrode. The primary electrode has a potential almost identical to the second shell, and the potential difference is picked up by the dedicated PCB, which regulates and discharges the secondary shell by grounding it momentarily, creating a potential difference. This process continues until both shells are completely discharged.

Whenever the potential difference is measured to be less than 12V or close to 0V for more than 1 second, the PCB activates relays to shift the connection from the negative socket to the positive socket. This process repeats at the positive socket, allowing the load to extract energy from both sockets in turn.



3) Calculations:

Formula for the closed-body static charge storage capacity (Spherical shell) is,

$$\text{Capacitance}(C) = 4\pi\varepsilon_m r$$

Here, ε_m is the permittivity of the medium surrounding the shell, and r is the radius of the spherical shell.

The material that will be used for layering the shell is Calcium Copper Titanate with a relative permittivity (ε_r) of more than 250,000.

We can calculate permittivity of the medium (ε_m) by calculating product of relative permittivity (ε_r) and permittivity of free space (ε_o).

$$\varepsilon_m = \varepsilon_o \times \varepsilon_r$$
$$= 8.85 \text{ x } 10^{-12} \text{ x } 250000$$
$$= 2.2125 \text{ x } 10^{-6}$$

Now, Capacitance for the insulated shells of radius 10.24 cm we have used would,

$$\text{Capacitance}(C) = 4\pi\varepsilon_m r$$
$$= 4 \text{ x } 3.14 \text{ x } 2.2125 \text{ x } 10^{-6} \text{ x } 0.1024$$
$$= 2.845 \text{ x } 10^{-6} \text{ F}$$

Energy Stored in the shell (U) = $\frac{CV^2}{2}$

From online data available as well as experimental observations with Van De Graff's Generators, the attainable charge density without insulation or in air is between 7.8 to 29.29 kV/cm (approx.) in open air.

Similarly, observations with Van De Graff's Generators with insulated shells (ceramic, CCTO and Mylar composite), the attainable charge density is 590 to 1968 kV/cm (approx.) in isolation.

Substituting the values of C and V in the energy equation for (minimum 1 inch insulation) composite we have,

$$U = \tfrac{1}{2} (2.845 \text{ x } 10^{-6}) \text{ x } (5{,}90{,}000 \text{ x } 2.56)^2$$
$$= 3.2 \text{ x } 10^{6} \text{ joules}$$

Converting joules to kwh,

If, 1 Joule = 2.77×10^{-7} kwh

Then, $3.2 \text{ x } 10^{6}$ Joule is equal is,

$$= 2.77 \times 10^{-7} \times 3.2 \text{ x } 10^{6}$$
$$= 889 \text{ Wh (approx.) per shell}$$

Proposed Work (Cont.)

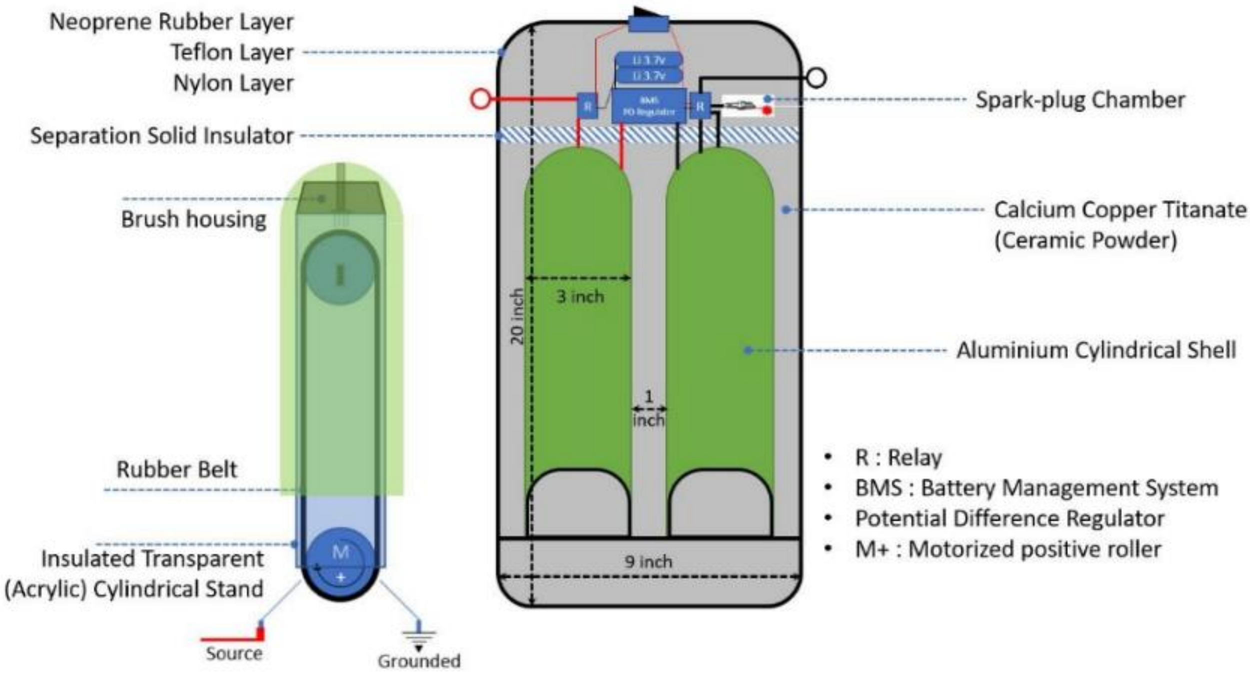
Now, substituting the values of C and V in the energy equation for (maximum 1 inch insulation) composite we have,

$$U = \frac{1}{2}(2.845 \times 10^{-6}) \times (19{,}68{,}000 \times 2.56)^2$$
$$= 3.5 \times 10^{7} \text{ joules}$$

Converting joules to kwh,
If, 1 Joule = 2.77×10^{-7} kwh
Then, 3.5×10^{7} Joule is equal is,

$$= 2.77 \times 10^{-7} \times 3.5 \times 10^{7}$$
$$= 9.88 \text{ kWh (approx.) per shell}$$

The aforementioned calculations are based on the proof of concept (POC) that has been developed thus far. The POC is not as compact as the planned prototype since it utilizes readily available materials with multiple applications and use cases, including in the electronics components.



Consequently, no dedicated circuits, components, or materials were utilized in this POC. The POC costs approximately ₹ 80,000, which includes several tested equipment, materials, belts, etc., that have been subjected to a high degree of stress, resulting in many fried circuits.

Proposed Work (Cont.)

Alternatively, a single prototype or all the components present in the POC at a particular time cost around ₹ 30,000, and it can hold up to 3.3 kWh of energy. Despite its bulky appearance, as mentioned earlier, the components in the wooden box are critical parts of the charging station, and not the storage unit itself. The overall weight of the POC is relatively low, consisting of only two aluminum shells, some insulation, and a small circuit. The storage unit weighs approximately 5kgs, resulting in an energy density of 660 Wh/Kg. The achieved energy density ratio is sufficient, even for the aviation sector.

Additionally, to develop much more lightweight designs for electronic-powered aviation sectors, the system can be installed using an integrated body design approach, which is better suited for vacuum-based vessels such as satellites, but it can also be incorporated into aerial vehicles to some extent.

III.Proposed Practical Work

The Uni-Polar Programmed Supercapacitor (UPPSC) technology exhibits immense potential for diverse applications, beyond its current use in grid storage and residential backup power systems. Its applications span various types of electric vehicles, including cars, trucks, trains, bikes, ships, and even aviation and aquatic vehicles. UPPSC technology boasts of significantly higher energy density and lightweight features, making it a potential game-changer in the aviation industry, enabling intercontinental flights to become feasible on a larger commercial scale. Its charging mechanism is highly influenced by the presence of a vacuum, making it even more efficient, thus opening up opportunities for space sector applications. Additionally, the integration of solar panels with UPPSC technology could create lightweight and entirely renewable satellites with electrical shielding capabilities, protecting against EMF or EMR.

Another promising application of UPPSC technology is its integration with hypothetical Dyson sphere structures, where it can be used to harness electricity by connecting solar panels or any photoelectric effect layer to its negative end. However, the presence of a strong electric field resulting from unnaturalized fields must also be considered. Furthermore, high-voltage usage devices such as rail guns and drone defense systems can benefit from the technology's ability to generate high electrical fields, rendering drones unusable.

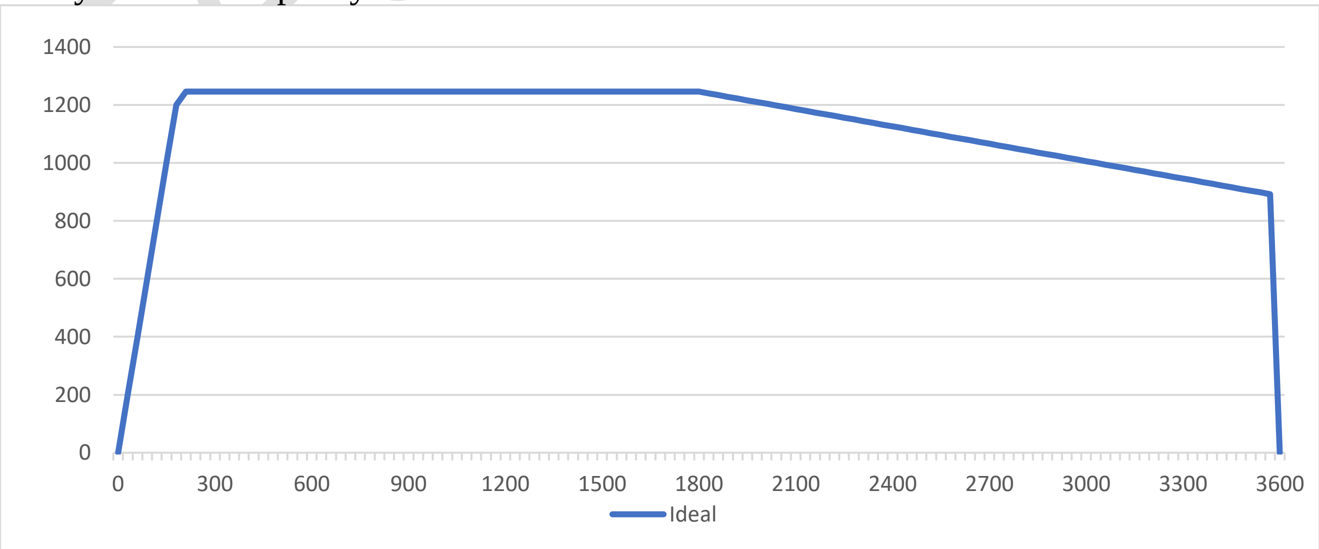
The development of this technology represents a significant step towards achieving our sustainable and environmentally friendly goals, enabling us to lead a more sustainable life with minimal pollution and a high recyclability rate. UPPSC technology's high recyclability ratio ensures that most of its components can be reused, as it uses few rare earth elements and no toxic electrolytic chemicals or permeating mediums. It can also power high energy demand devices that cannot be powered by Li-ion cells, ultimately replacing generators and facilitating a shift towards 100% renewable energy resources. Utilizing such technologies ensures greater reliability and implications in our renewable energy shift.

IV. Results and Analysis

This portion of the article discusses the technique used for data gathering and analysis, which is critical for the report's findings. The accuracy of the test reports given below is particular to the respective primary shell, although it should be noted that the energy density for the second shell can be doubled, resulting in double the stated energy density. A quantitative analysis was used to acquire insight into the performance of the Uni-Polar Programmed Supercapacitor (UPPSC).
To collect data, a graphical depiction of energy (in watt-hours) and time (in seconds) for the UPPSC running for an hour was created. The generated graph depicts four separate stages. The charging duration is represented by phase one, the retention capacity by phase two, the degradation of the graph when linked to an external source by phase three, and the grounding of all charges on the shell by phase four.
This methodology allowed the researchers to examine the UPPSC's performance at various stages and acquire a full grasp of its energy storage and release capabilities. This data provides significant insights into the potential applications of UPPSC in a variety of sectors and professions.

a) <u>Ideal Graph</u>

For the first three minutes of the ideal phase, the Uni-Polar Programmed Supercapacitor (UPPSC) was charged until it reached its full storage capacity of 1200 watt-hours. The effects of frictional and static energy, on the other hand, resulted in an additional 46 watt-hours, for a total energy storage of 1246 watt-hours, the required maximum for the UPPSC. The UPPSC was then turned off for 27 minutes (minutes 4-30), during which time the graphical representation of the stored energy remained constant, indicating a steady retention capacity.



Results and Analysis (Cont.)

This step was conducted to assess the device's retention capability. When an external source was connected for 29.5 minutes, the graph began to drop, and the unit's energy began to discharge until it was completely discharged/grounded, reaching 0wh within 0.5 minutes.

Time (Mins)	Time (Sec)	Ideal	Input/Output	Time (Mins)	Time (Sec)	Ideal	Input/Output	Time (Mins)	Time (Sec)	Ideal	Input/Output	Time (Mins)	Time (Sec)	Ideal	Input/Output
0	0	0	Charging	15	900	1246	Hold	30	1800	1246	Hold	45	2700	1066	Load Att.
0.5		200	Charging	15.5		1246	Hold	30.5		1240	Load Att.	45.5		1060	Load Att.
1		400	Charging	16		1246	Hold	31		1234	Load Att.	46		1054	Load Att.
1.5		600	Charging	16.5		1246	Hold	31.5		1228	Load Att.	46.5		1048	Load Att.
2		800	Charging	17		1246	Hold	32		1222	Load Att.	47		1042	Load Att.
2.5		1000	Charging	17.5		1246	Hold	32.5		1216	Load Att.	47.5		1036	Load Att.
3		1200	Charging	18		1246	Hold	33		1210	Load Att.	48		1030	Load Att.
3.5		1246	cutoff	18.5		1246	Hold	33.5		1204	Load Att.	48.5		1024	Load Att.
4		1246	Hold	19		1246	Hold	34		1198	Load Att.	49		1018	Load Att.
4.5		1246	Hold	19.5		1246	Hold	34.5		1192	Load Att.	49.5		1012	Load Att.
5	300	1246	Hold	20	1200	1246	Hold	35	2100	1186	Load Att.	50	3000	1006	Load Att.
5.5		1246	Hold	20.5		1246	Hold	35.5		1180	Load Att.	50.5		1000	Load Att.
6		1246	Hold	21		1246	Hold	36		1174	Load Att.	51		994	Load Att.
6.5		1246	Hold	21.5		1246	Hold	36.5		1168	Load Att.	51.5		988	Load Att.
7		1246	Hold	22		1246	Hold	37		1162	Load Att.	52		982	Load Att.
7.5		1246	Hold	22.5		1246	Hold	37.5		1156	Load Att.	52.5		976	Load Att.
8		1246	Hold	23		1246	Hold	38		1150	Load Att.	53		970	Load Att.
8.5		1246	Hold	23.5		1246	Hold	38.5		1144	Load Att.	53.5		964	Load Att.
9		1246	Hold	24		1246	Hold	39		1138	Load Att.	54		958	Load Att.
9.5		1246	Hold	24.5		1246	Hold	39.5		1132	Load Att.	54.5		952	Load Att.
10	600	1246	Hold	25	1500	1246	Hold	40	2400	1126	Load Att.	55	3300	946	Load Att.
10.5		1246	Hold	25.5		1246	Hold	40.5		1120	Load Att.	55.5		940	Load Att.
11		1246	Hold	26		1246	Hold	41		1114	Load Att.	56		934	Load Att.
11.5		1246	Hold	26.5		1246	Hold	41.5		1108	Load Att.	56.5		928	Load Att.
12		1246	Hold	27		1246	Hold	42		1102	Load Att.	57		922	Load Att.
12.5		1246	Hold	27.5		1246	Hold	42.5		1096	Load Att.	57.5		916	Load Att.
13		1246	Hold	28		1246	Hold	43		1090	Load Att.	58		910	Load Att.
13.5		1246	Hold	28.5		1246	Hold	43.5		1084	Load Att.	58.5		904	Load Att.
14		1246	Hold	29		1246	Hold	44		1078	Load Att.	59		898	Load Att.
14.5		1246	Hold	29.5		1246	Hold	44.5		1072	Load Att.	59.5		892	Load Dtch

The study made use of an ideal graph, as seen in the image. However, achieving similar outcomes on the earth's surface is extremely difficult. As a result, we ran three independent charging cycles to get the most precise readings possible.

b) Test Values for three different cycles

The system operates on the principle of Van de Graaff's Generator, which is based on static electricity, resulting in the transfer of charges to the unit's surface. To prevent any leakage and potential hazards, the unit is insulated using Calcium Copper Titanate (CCTO) and Mylar. CCTO possesses a relative permittivity (ε_r) of up to 250,000, while Mylar is highly durable, making their combination effective in alleviating issues.

However, environmental conditions such as dampness, freezing temperatures, and humidity hampered the operation of the Uni-Polar Programmed Supercapacitor (UPPSC) during testing. Due to moisture buildup and the UPPSC being cold, the first cycle of testing produced findings that differed slightly from cycles 2 and 3. This resulted in longer charge storage durations, which influenced the cycle 1 graph.

Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output	Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output
0	0	0	0	0	Charging	15	900	1200	1210	1220	Hold
0.5		0	110	290	Charging	15.5		1230	1210	1220	Hold
1		80	320	640	Charging	16		1200	1210	1220	Hold
1.5		240	560	870	Charging	16.5		1200	1210	1220	Hold
2		490	890	1210	Charging	17		1200	1200	1220	Hold
2.5		830	1420	1490	Charging	17.5		1200	1210	1220	Hold
3		1320	1430	1470	Charging	18		1200	1220	1220	Hold
3.5		1460	1260	1310	cutoff	18.5		1200	1210	1210	Hold
4		1250	1240	1230	Hold	19		1200	1210	1210	Hold
4.5		1230	1240	1230	Hold	19.5		1190	1210	1210	Hold
5	300	1220	1240	1230	Hold	20	1200	1190	1210	1210	Hold
5.5		1210	1240	1230	Hold	20.5		1190	1210	1210	Hold
6		1210	1240	1230	Hold	21		1190	1210	1210	Hold
6.5		1210	1240	1230	Hold	21.5		1190	1210	1210	Hold
7		1210	1240	1230	Hold	22		1190	1210	1210	Hold
7.5		1210	1220	1230	Hold	22.5		1190	1210	1210	Hold
8		1210	1220	1230	Hold	23		1190	1210	1210	Hold
8.5		1210	1220	1240	Hold	23.5		1190	1210	1210	Hold
9		1210	1220	1230	Hold	24		1190	1210	1210	Hold
9.5		1210	1220	1230	Hold	24.5		1180	1210	1210	Hold
10	600	1210	1230	1230	Hold	25	1500	1190	1210	1210	Hold
10.5		1205	1220	1230	Hold	25.5		1190	1200	1210	Hold
11		1205	1220	1230	Hold	26		1190	1210	1190	Hold
11.5		1205	1220	1230	Hold	26.5		1180	1210	1200	Hold
12		1205	1220	1220	Hold	27		1180	1210	1200	Hold
12.5		1205	1220	1220	Hold	27.5		1180	1200	1200	Hold
13		1205	1220	1220	Hold	28		1180	1210	1200	Hold
13.5		1205	1220	1220	Hold	28.5		1180	1200	1200	Hold
14		1200	1210	1200	Hold	29		1180	1200	1200	Hold
14.5		1200	1210	1220	Hold	29.5		1180	1200	1190	Hold

The testing process consisted of three cycles, each with its own set of observations and results:

- Cycle 1

The Uni-Polar Programmed Supercapacitor was charged in cycle 1 for 3 minutes, reaching a peak value of roughly 1320wh. The silica belt's static electricity allowed for the quick extraction of 140wh more within 30 seconds due to static electricity. A loss of 210wh of energy occurred as a result of sparking because the system had already reached its saturation limit. Cycle 1 took longer to charge due to the environment and the shell's surface's chilly and wet conditions. At 1200wh, the unit was left inactive for 27 minutes during phase 2 of cycle 1 after the energy was turned off after 4 minutes. 830wh of energy were still in the unit when the energy discharge began at 59.5 minutes. The system was discharged or grounded completely using the ground pin, completing phase 4 and cycle 1.

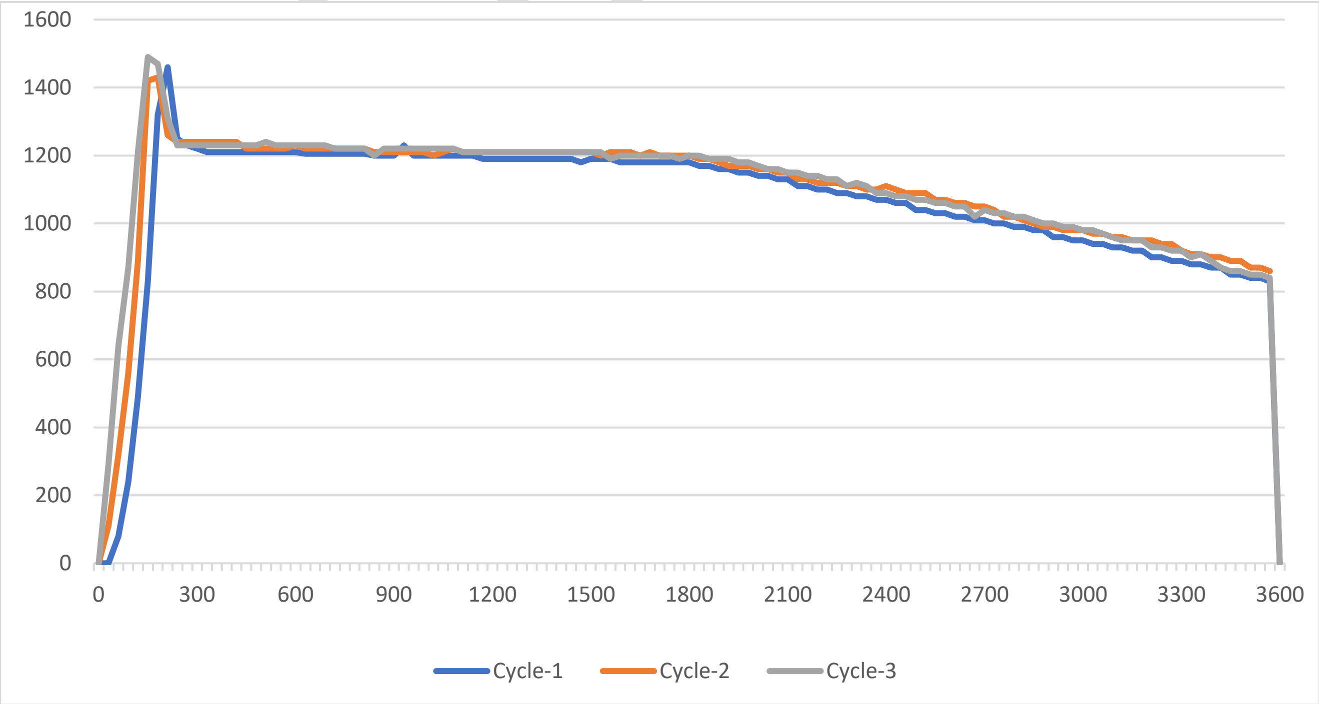
Results and Analysis (Cont.)

- Cycle 2

Due to more static electricity input in cycle 2, the UPPSC rose to 1460wh in phase 1, its highest energy value. Due to its early start time, the UPPSC produced findings that were superior to those of cycle 1. As it only loses 40wh of energy and proceeds from 1240wh to 1200wh till 1800 seconds, the graph depicts a straight line. When the UPPSC was linked to an external power source, it began to lose energy after 30 minutes. The energy-time graph continued to decline until 59.5 minutes, when 860wh were still in the unit. When it was grounded, cycle 2 came to an end, and the energy-time graph fell to 0wh.

- Cycle 3

In cycle 3, the storage unit charged to its maximum capacity of 1490 wh after 2.5 minutes, but lost 260 wh after the power was cut-off after one minute to keep the saturation limit of the shells in order. The UPPSC lost only 20wh of energy during phase 2 of the final cycle, going from 1230wh to 1210wh. Phase 3 started with the external load being connected to the unit after 30 minutes. The energy-time graph decreased consistently from 1200 wh to 840 wh until 3570 seconds into the graph. At the 59.5-minute point, the energy was grounded once more, and cycle 3 came to a close when the graph fell to 0 watts.



Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output	Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output
30	1800	1180	1200	1200	Hold	45	2700	1010	1050	1040	Load Att.
30.5		1170	1190	1200	Load Att.	45.5		1000	1040	1030	Load Att.
31		1170	1190	1190	Load Att.	46		1000	1020	1030	Load Att.
31.5		1160	1180	1190	Load Att.	46.5		990	1020	1020	Load Att.
32		1160	1170	1190	Load Att.	47		990	1010	1020	Load Att.
32.5		1150	1170	1180	Load Att.	47.5		980	1000	1010	Load Att.
33		1150	1170	1180	Load Att.	48		980	990	1000	Load Att.
33.5		1140	1160	1170	Load Att.	48.5		960	990	1000	Load Att.
34		1140	1160	1160	Load Att.	49		960	980	990	Load Att.
34.5		1130	1150	1160	Load Att.	49.5		950	980	990	Load Att.
35	2100	1130	1150	1150	Load Att.	50	3000	950	980	980	Load Att.
35.5		1110	1130	1150	Load Att.	50.5		940	970	980	Load Att.
36		1110	1130	1140	Load Att.	51		940	970	970	Load Att.
36.5		1100	1120	1140	Load Att.	51.5		930	960	960	Load Att.
37		1100	1120	1130	Load Att.	52		930	960	950	Load Att.
37.5		1090	1120	1130	Load Att.	52.5		920	950	950	Load Att.
38		1090	1110	1110	Load Att.	53		920	950	950	Load Att.
38.5		1080	1110	1120	Load Att.	53.5		900	950	930	Load Att.
39		1080	1100	1110	Load Att.	54		900	940	930	Load Att.
39.5		1070	1100	1090	Load Att.	54.5		890	940	920	Load Att.
40	2400	1070	1110	1090	Load Att.	55	3300	890	920	920	Load Att.
40.5		1060	1100	1080	Load Att.	55.5		880	910	900	Load Att.
41		1060	1090	1080	Load Att.	56		880	910	910	Load Att.
41.5		1040	1090	1070	Load Att.	56.5		870	900	890	Load Att.
42		1040	1090	1070	Load Att.	57		870	900	870	Load Att.
42.5		1030	1070	1060	Load Att.	57.5		850	890	860	Load Att.
43		1030	1070	1060	Load Att.	58		850	890	860	Load Att.
43.5		1020	1060	1050	Load Att.	58.5		840	870	850	Load Att.
44		1020	1060	1050	Load Att.	59		840	870	850	Load Att.
44.5		1010	1050	1020	Load Att.	59.5		830	860	840	Load Dtch

c) Ideal graph for 3.5 minutes of charging

The goal of this testing phase was to assess the Uni-Polar Programmed Supercapacitor's (UPPSC) capacity to store energy during the course of a 3- to 4-minute charging session. The ideal energy-time graph for the UPPSC charging phase is shown above, based on the assumption that the system is completely dry and insulated. The graph demonstrates an increase in energy accumulation that is gradual and steady, reaching its theoretical saturation limit of 1320wh in 3 minutes and then remaining constant during the remainder of the testing.

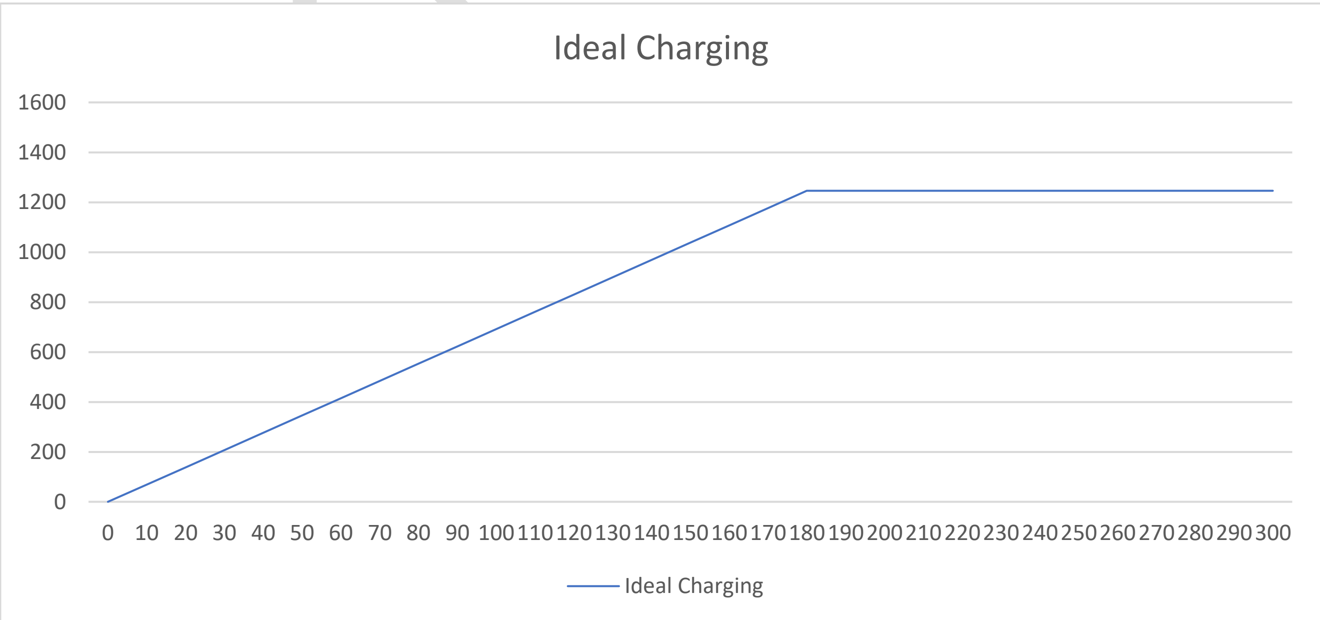
The constant interactions with the surrounding atmosphere make creating such a perfect charging environment for the UPPSC difficult on the surface. However, since coronal discharges and interactions with the environment are negligible in a vacuum or free space, the UPPSC's efficiency would rise. In fact, the UPPSC's efficiency can exceed 100% in space because static electricity and the reverse earthing technique allow it to produce more energy than the system receives.

The UPPSC must be completely insulated with a layer of Mylar and CCTO in order to get the best charging conditions on the surface. This will lessen the impact of the environment on the system.

Results and Analysis (Cont.)

Time (Mins)	Ideal Charging	Time (Mins)	Ideal Charging
0	0	300	1246
10	69.22	160	1107.52
20	138.44	170	1176.74
30	207.66	180	1246
40	276.88	190	1246
50	346.1	200	1246
60	415.32	210	1246
70	484.54	220	1246
80	553.76	230	1246
90	622.98	240	1246
100	692.2	250	1246
110	761.42	260	1246
120	830.64	270	1246
130	899.86	280	1246
140	969.08	290	1246

The test was carried out three times in order to obtain the true value of charging. Multiple cycles are performed during a test for a number of reasons, such as to improve the validity and reliability of the results. Multiple cycles can be performed to guarantee that the results are consistent across tests and that they are not the result of chance or a fluke, as determined by the metrics obtained via the test. It is feasible to limit the amount of test error and the influence of outside elements, which in the case of UPPSC include moisture, cold temperature, and external atmospheric interactions.



Results and Analysis (Cont.)

d) Observed reading for 3 round tests

Time (Sec)	Charging 1	Charging 2	Charging 3	Time (Sec)	Charging 1	Charging 2	Charging 3
150	830	1420	1490	0	0	0	0
160	1040	1210	1170	10	0	20	80
170	1200	1340	1290	20	0	60	160
180	1320	1430	1470	30	0	110	290
190	1240	1150	1210	40	10	160	410
200	1290	1180	1280	50	30	230	540
210	1460	1260	1310	60	80	320	640
220	1320	1380	1420	70	110	390	720
230	1280	1270	1290	80	180	430	790
240	1250	1240	1230	90	240	560	870
250	1240	1240	1230	100	300	640	980
260	1240	1240	1230	110	380	760	1150
270	1230	1240	1230	120	490	890	1210
280	1230	1230	1240	130	610	1030	1390
290	1240	1240	1230	140	740	1260	1220
300	1220	1240	1230	150	830	1420	1490

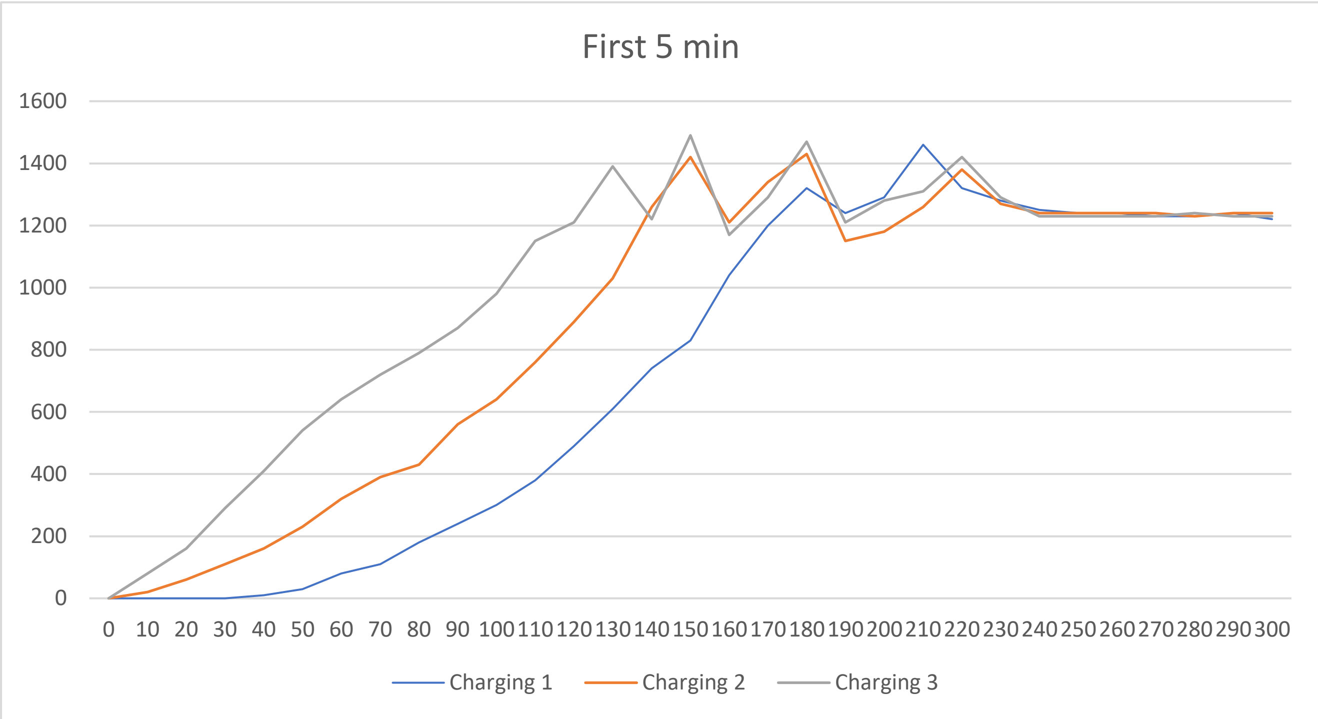
To find out how well the Uni-Polar Programmed Supercapacitor (UPPSC) charged when it was insulated and free of external loads, three tests were run.

- Cycle 1

Due to the moisture and low temperature in the atmosphere during the first cycle, it took the UPPSC 30 seconds to begin building up charges. However, instant discharge was the outcome.

After the 30-second point, the device started storing charge, and at 180 seconds, it reached a secondary high value of 1320wh. The graph then began to decline because of the system's 1240wh saturation limit. The graph's highest value of 1460wh was obtained in the following 30 seconds.

The graph, however, began to decline when the UPPSC began sparking and loosing charges after reaching its saturation limit. After 210 seconds of charging, the system's power source was disconnected. Due to the surplus charges on the shells, the UPPSC continued to spark, although it soon stabilized once the system reached its saturation limit.



- Cycle 2

Since both shells had already warmed up during cycle 2, the Uni-Polar Programmed Supercapacitor started generating energy as soon as it was connected to the power source. Within the first two and a half minutes, the energy-time graph indicated an exponential rise that reached 1420 Wh, but it then started sparking and losing charge, producing a zig-zag pattern in the graphical representation.

When the power supply was turned off after the 3-minute test, the system had attained its max value of 1460 Wh but was still sparking. The UPPSC hit its 1240 Wh energy storage saturation limit about 230 seconds into cycle 2, and it stayed essentially steady throughout the test.

- Cycle 3

The last cycle showed the most encouraging results since the Uni-Polar Programmed Supercapacitor (UPPSC) started storing energy more quickly than it did in the first two cycles. The UPPSC performed much better when the moisture level was lower and the temperature was higher. It gathered 1390wh of energy in the first 130 seconds, but as it approached its saturation limit, it ignited and discharged. A secondary high of 1470wh was reached at 180 seconds after the UPPSC's initial peak of 1490wh in 150 seconds.

Results and Analysis (Cont.)

Due to the system's higher temperature and lower humidity, cycle 3's graphical representation showed more zigzag lines than the cycles before it because faster charge accumulation and discharge occurred. At 240 seconds, the Uni-Polar Programmed Supercapacitor reached its energy storage saturation limit and stayed steady for the rest of the test.

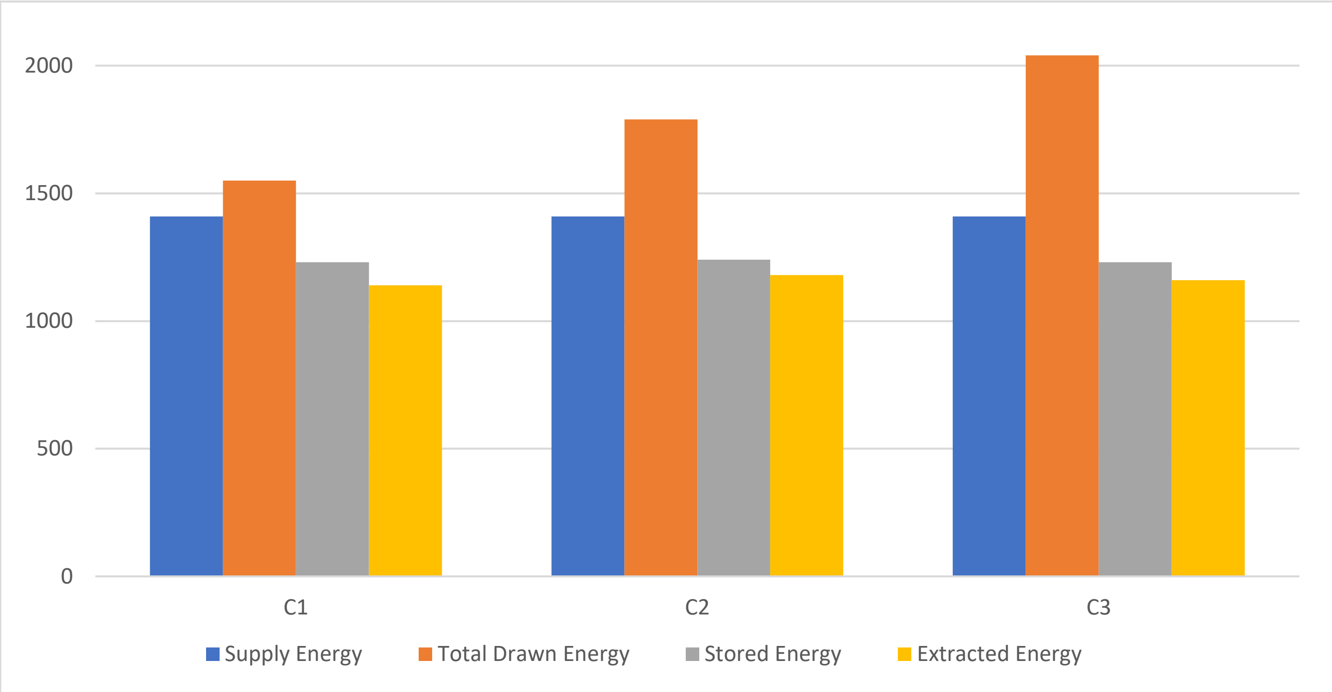
e) Bar graph representation of energy

To represent the amount of charge supplied to the UPPSC, a bar graph representation has to be used to measure the values of energy in watt hour for each cycle. With the use of computer programming that was linked to the appropriate meters and measurement equipment in the system, all readings are generated.
This test was conducted three time and each time, the total drawn energy was higher than the previous cycle with cycle 3 reaching till 2040wh of energy, whereas the stored energy and extracted energy were almost the same. This graph shows the relationship between supply energy, total energy pulled throughout each cycle, stored energy, and extracted energy.
The UPPSC was charged uniformly with 1410wh across all three cycles, or alternatively, a renewable energy source could be utilized. The total drawn energy reflects the charge accumulated on the device. In each cycle, the total energy drawn surpasses the supplied energy, as the engine generates an excess charge via static electricity. The supplied energy is allocated to power the motor and socket spray, whereas the additional energy from indirect sources, which is not supplied due to the device's configuration, is channeled to reverse earthing. The stored energy is the energy accumulated by the unit, while the extracted energy is the energy that is drawn out.

There are three methods of supplying power to the Uni-Polar Programmed Supercapacitor.

1. The first method through which power is supplied is reverse earthing. The basic setup of this method is by using a metal plate that is attached close to the roller but does not touch it and is connected to the ground pin. With the help of the reverse earthing principle, the system is supplied with energy.
2. The second approach is through static electricity or friction. The same setup is taken with an added metal plate parallel and opposite to the original metal plate; However, this plate is touching the belt creating friction or static electricity.
3. The third method includes socket spraying electrons onto the belt.

Results and Analysis (Cont.)



- Cycle 1

The first cycle received 1410wh of energy for 3-3.5 minutes, the same as the others. However, due to the additional charge taken, UPPSC's total energy consumption is 1550wh, which is higher than the amount of energy delivered.
The energy drawn in the first cycle is, in comparison to the other two, smaller because the shells were cooler at the start of the experiment. The energy storage device held 1230wh of power. Theoretical calculations determined the saturation value to be 1246.8wh. And 1140wh of output energy has been recorded.

- Cycle 2

The most successful cycle was cycle 2. It also obtained 1410wh of electricity after being charged for 3-3.5 minutes. It is evident that more energy is brought in overall than in the first cycle, which turns out to be 1790wh; this is because the shells are already hot and have little to no moisture on their surface.
The Uni-Polar Programmed Supercapacitor had previously been charged and warmed up earlier, therefore the system does not encounter the issue of the shells being cold throughout this process. The cycle's observed stored energy is 1240wh, which is nearly at the predicted saturation point for the system theoretically. The energy extracted is listed as 1180wh. Due to the already heated shells, this cycle's price is also higher than the first.

Results and Analysis (Cont.)

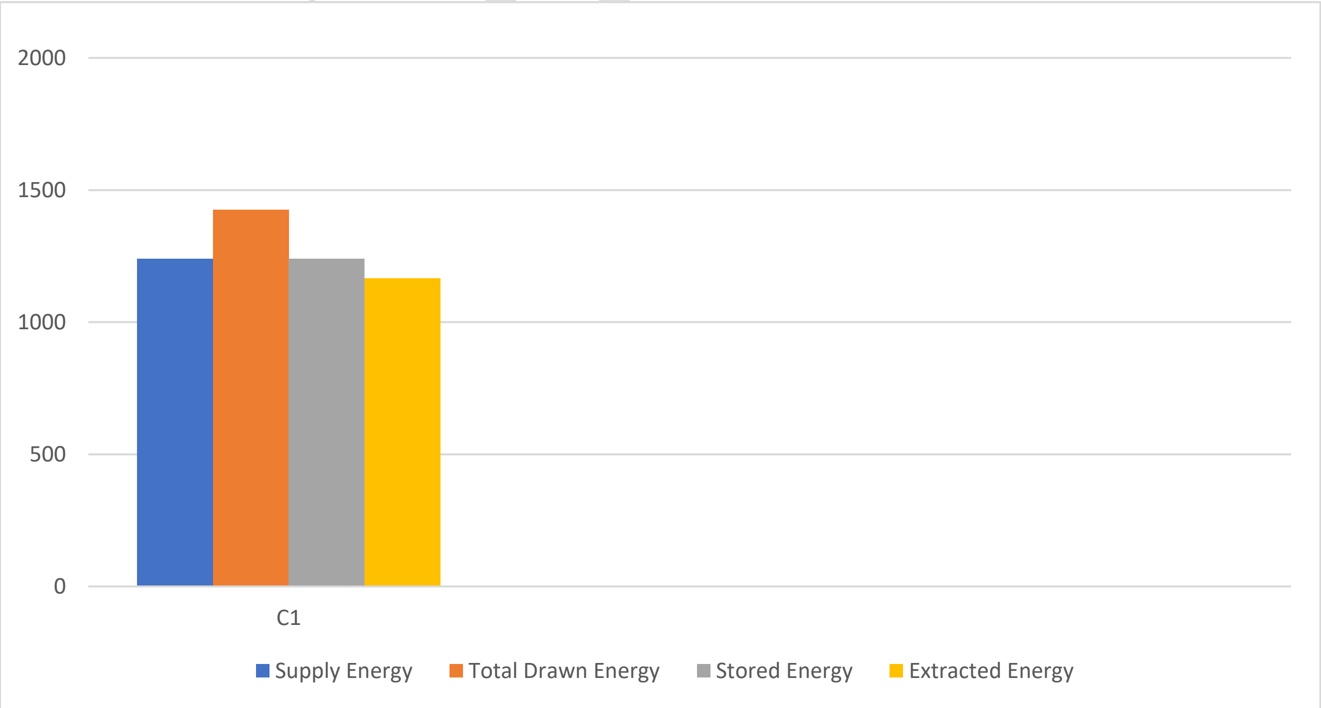
- Cycle 3

According to protocol, the final cycle received 1410wh after being charged for 3-3.5 minutes. A total of 2040wh of energy were extracted. It is implied that the total energy drawn rises by 240wh every cycle since the shells are heated more frequently, and any moisture that may have formed on them is also diminished.

Bar Graph	Supply Energy	Total Drawn Energy	Stored Energy	Extracted Energy
C1	1410	1550	1230	1140
C2	1410	1790	1240	1180
C3	1410	2040	1230	1160

It can be observed that during this cycle, the amount of stored energy and the amount of extracted energy are significantly lower than they are during the other two cycles. Testing revealed that the production is 1160wh, and the stored energy is worth 1230wh. There may be outside barriers causing this. One of the reasons could be small sparking in the unit, which was unnoticeable, or because of objects near the shells while testing.

f) Theoretical readings of energy



To understand the energy input and output of the system, it was necessary to have theoretical calculations ready to estimate the amount of energy the UPPSC would be supplying. The ideal outcomes needed in terms of charging cycle and energy are shown in this bar graph. In relation to the three charging cycles carried out throughout the testing, it displays the amount of energy given, total energy pulled, stored energy, and extracted energy.

The storage container should ideally be tested and operated without any obstructions. Without obstacles like wetness, cold, or humidity getting in the way, the values should be attained.

As shown, in this instance, the graphical depiction only considers one cycle. The battery charges for 3 minutes and delivers 1240wh of energy to the device. 1426wh of energy were extracted, according to the record.

As the engine produces more charge and there is additional energy from indirect sources, which is not much, but enough to observe a shift in the graph's pattern, the total amount of energy drawn exceeds the total energy supplied.

The unit's saturation point, 1240wh, represents the amount of energy that can be stored in this perfect scenario. Additionally, it is clear that the energy supplied and the energy stored are equal.

This implies that there is no energy waste and that there is no charge leakage because the insulation is optimal. Our total energy production is 1165.6wh, which is the quantity of energy that was to be extracted.

Bar Graph	Supply Energy	Total Drawn Energy	Stored Energy	Extracted Energy
C1	1240	1426	1240	1165.6

g) <u>1 hour retention graph</u>

At the end of the test, to measure the retention capacity of the Uni-Polar Programmed Supercapacitor, another test was conducted to obtain its retention capacity for an entire hour, and this test is also divided into three cycles.

In this part of the testing, a graphical reprUPPSCntation is made to show the correlation between energy in watt hours and time in seconds. It mainly depicts the retention power of the Uni-Polar Programmed Supercapacitor.

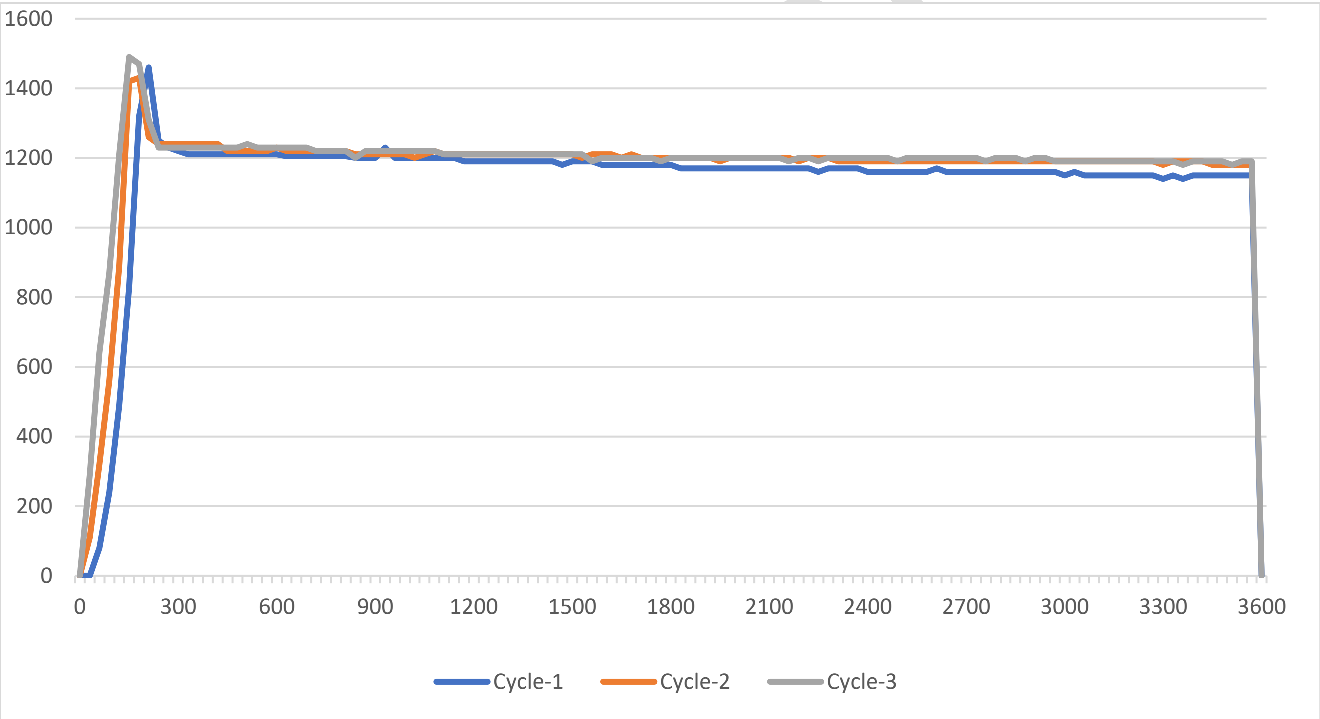
During all three, the storage unit is run for an hour and charged for the 3 minutes when they reach their peak values.

Results and Analysis (Cont.)

- Cycle 1

During cycle 1, the unit was charged for 3 minutes after which it reached its peak value of 1460wh. A slight gap is shown between cycle 1 and the y-axis. This is because the storage units took more time heating up as compared to the other cycles, the reason being, the shells were cold and had accumulated moisture on their surfaces which hindered their performance.

The graph of this cycle is seen to dip to maintain the saturation limit and then project a straight line at 1200wh from 300 seconds to 3600 seconds when the unit is left idle. This portion shows its retention power. Since no load is added during this part of the testing, the graph immediately falls to zero when the unit is grounded.



- Cycle 2

During cycle 2, the unit was charged for 3 minutes after which it reached its peak value of about 1430wh. By this time the shells are heated so there is not much gap between the graph of this cycle and the y-axis. After reaching its peak value and maintaining the saturation limit by sparking, it is seen that the energy is retained at around 1210wh until grounding. No load is connected and so therefore the graph is not seen to depreciate, it directly falls to zero. Some small peaks and dips are seen during the retention period, this may be due to some unnoticeable sparking that occurred during the testing.

Results and Analysis (Cont.)

- Cycle 3

Cycle 3 yields the most favorable outcome since the shells have been heated for an extended period, effectively removing any impediments in that regard. Similar to the other cycles, the unit operated for an hour, charged for 3 minutes, and attained its maximum value of approximately 1490wh.

During the retention period from 250 seconds to 3600 seconds, a steady straight line is observed, albeit with slight peaks resulting from sparking, which are comparatively smaller than those observed in the other two cycles. Eventually, the graph descends to zero at 3600 seconds upon being grounded.

Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output	Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output
0	0	0	0	0	Charging	15	900	1200	1210	1220	Hold
0.5		0	110	290	Charging	15.5		1230	1210	1220	Hold
1		80	320	640	Charging	16		1200	1210	1220	Hold
1.5		240	560	870	Charging	16.5		1200	1210	1220	Hold
2		490	890	1210	Charging	17		1200	1200	1220	Hold
2.5		830	1420	1490	Charging	17.5		1200	1210	1220	Hold
3		1320	1430	1470	Charging	18		1200	1220	1220	Hold
3.5		1460	1260	1310	cutoff	18.5		1200	1210	1210	Hold
4		1250	1240	1230	Hold	19		1200	1210	1210	Hold
4.5		1230	1240	1230	Hold	19.5		1190	1210	1210	Hold
5	300	1220	1240	1230	Hold	20	1200	1190	1210	1210	Hold
5.5		1210	1240	1230	Hold	20.5		1190	1210	1210	Hold
6		1210	1240	1230	Hold	21		1190	1210	1210	Hold
6.5		1210	1240	1230	Hold	21.5		1190	1210	1210	Hold
7		1210	1240	1230	Hold	22		1190	1210	1210	Hold
7.5		1210	1220	1230	Hold	22.5		1190	1210	1210	Hold
8		1210	1220	1230	Hold	23		1190	1210	1210	Hold
8.5		1210	1220	1240	Hold	23.5		1190	1210	1210	Hold
9		1210	1220	1230	Hold	24		1190	1210	1210	Hold
9.5		1210	1220	1230	Hold	24.5		1180	1210	1210	Hold
10	600	1210	1230	1230	Hold	25	1500	1190	1210	1210	Hold
10.5		1205	1220	1230	Hold	25.5		1190	1200	1210	Hold
11		1205	1220	1230	Hold	26		1190	1210	1190	Hold
11.5		1205	1220	1230	Hold	26.5		1180	1210	1200	Hold
12		1205	1220	1220	Hold	27		1180	1210	1200	Hold
12.5		1205	1220	1220	Hold	27.5		1180	1200	1200	Hold
13		1205	1220	1220	Hold	28		1180	1210	1200	Hold
13.5		1205	1220	1220	Hold	28.5		1180	1200	1200	Hold
14		1200	1210	1200	Hold	29		1180	1200	1200	Hold
14.5		1200	1210	1220	Hold	29.5		1180	1200	1190	Hold

Results and Analysis (Cont.)

Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output	Time (Mins)	Time (Sec)	Cycle-1	Cycle-2	Cycle-3	Input/Output
30	1800	1180	1200	1200	Hold	45	2700	1160	1190	1200	Hold
30.5		1170	1200	1200	Hold	45.5		1160	1190	1200	Hold
31		1170	1200	1200	Hold	46		1160	1190	1190	Hold
31.5		1170	1200	1200	Hold	46.5		1160	1190	1200	Hold
32		1170	1200	1200	Hold	47		1160	1190	1200	Hold
32.5		1170	1190	1200	Hold	47.5		1160	1190	1200	Hold
33		1170	1200	1200	Hold	48		1160	1190	1190	Hold
33.5		1170	1200	1200	Hold	48.5		1160	1190	1200	Hold
34		1170	1200	1200	Hold	49		1160	1190	1200	Hold
34.5		1170	1200	1200	Hold	49.5		1160	1190	1190	Hold
35	2100	1170	1200	1200	Hold	50	3000	1150	1190	1190	Hold
35.5		1170	1200	1200	Hold	50.5		1160	1190	1190	Hold
36		1170	1200	1190	Hold	51		1150	1190	1190	Hold
36.5		1170	1190	1200	Hold	51.5		1150	1190	1190	Hold
37		1170	1200	1200	Hold	52		1150	1190	1190	Hold
37.5		1160	1200	1190	Hold	52.5		1150	1190	1190	Hold
38		1170	1200	1200	Hold	53		1150	1190	1190	Hold
38.5		1170	1190	1200	Hold	53.5		1150	1190	1190	Hold
39		1170	1190	1200	Hold	54		1150	1190	1190	Hold
39.5		1170	1190	1200	Hold	54.5		1150	1190	1190	Hold
40	2400	1160	1190	1200	Hold	55	3300	1140	1180	1190	Hold
40.5		1160	1190	1200	Hold	55.5		1150	1190	1190	Hold
41		1160	1190	1200	Hold	56		1140	1190	1180	Hold
41.5		1160	1190	1190	Hold	56.5		1150	1190	1190	Hold
42		1160	1190	1200	Hold	57		1150	1190	1190	Hold
42.5		1160	1190	1200	Hold	57.5		1150	1180	1190	Hold
43		1160	1190	1200	Hold	58		1150	1180	1190	Hold
43.5		1170	1190	1200	Hold	58.5		1150	1180	1180	Hold
44		1160	1190	1200	Hold	59		1150	1180	1190	Hold
44.5		1160	1190	1200	Hold	59.5		1150	1180	1190	Hold

V. Conclusions and Recommendations

In conclusion, energy storage is a crucial aspect of modern life, with numerous industries relying on it for power backup and portable energy sources. While standard lithium-ion batteries have been the go-to choose for energy storage for many years, their limitations, including safety issues, limited lifespan, and sluggish charging times, have led researchers to explore alternative energy storage methods.

One of these alternatives is the Uni-Polar Programmed Supercapacitor (UPPSC), a supercapacitor that provides improved efficiency, cost-effectiveness, and sustainability over traditional battery storage methods. UPPSCs have smooth-surfaced electrodes with few corners and edges, which reduces internal leakage and improves energy efficiency. Additionally, they use a programmed circuit to regulate the potential difference between the electrodes, ensuring stable performance and preventing overcharging or over-discharging, which could damage the device or shorten its lifespan.

UPPSCs are also different from standard batteries because they use insulating materials such as CCTO, Mylar, and ceramic to prevent coronal discharge and keep all charges on the electrodes in place. This feature allows UPPSCs to outperform standard energy storage technologies such as batteries in various ways, offering increased power and energy density, and allowing them to deliver significant power outputs quickly and effectively. UPPSCs have an energy density of at least 376Whr/kg, which is nearly double that of a Li-ion battery. This high energy density enables more compact and lightweight energy storage devices, which is especially useful for weight and space-constrained applications. Additionally, UPPSCs can charge up to 3.3 kWh in less than three minutes, which is substantially faster than standard batteries. This capability is especially significant in situations where rapid charging and extended power supply are required, such as electric vehicles and renewable energy storage systems such as grid storage and power backup systems.

Another advantage of the UPPSCs is their extended lifespan, which can endure an immense number of charge-discharge cycles, which is significantly more than that of a standard lithium-ion battery and nearly as much as that of a supercapacitor or more. This feature lessens the need for regular replacements, which can be costly and time-consuming. Finally, the lack of electrolyte and dielectric components in the system lowers the risk of leakage, explosion, or fire, making the UPPSCs a safer and more environmentally friendly alternative to typical batteries.

Conclusions and Recommendations (Cont.)

The Uni-Polar Programmed Supercapacitor is a revolutionary energy storage technology that has various advantages over standard battery systems, such as high power and energy densities, short charging times, longer lifespan, greater safety, and consistent power delivery. It is believed that as research into these supercapacitors continues, they will become even more efficient, inexpensive, and adaptable, potentially replacing standard battery systems in many sectors.

The potential applications for UPPSCs are broad, including electric vehicles, aerospace, grid storage, portable electronics, and military applications, among others. As the demand for clean energy and high-performance energy storage systems increases, UPPSCs have the potential to play a significant role in the energy transition. Additionally, UPPSCs are less expensive to produce, emit less pollution, and charge faster, making them an attractive option for numerous industries, particularly those that require lightweight and space-efficient energy storage solutions.

However, there are still some challenges that need to be overcome before UPPSCs can be fully commercialized. One of the primary challenges is to develop high-performance insulating materials that can withstand high voltage and current loads. Additionally, optimizing the electrode and electrolyte materials can lead to increased energy densities and performance. Furthermore, UPPSCs may face some competition from emerging energy storage technologies such as hydrogen fuel cells, which offer high energy density and zero emissions.

In conclusion, the Uni-Polar Programmed Supercapacitor is a promising alternative to traditional battery storage technologies, offering significant advantages over lithium-ion batteries. As research

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APPENDIX I
Project Programs / Codes / Flowcharts

```
#include <ESP8266WiFi.h>
#include <ESPAsyncTCP.h>
#include <ESPAsyncWebServer.h>
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

double percentage;
double voltage;

bool Display = false;

// Set the LCD address to 0x27 for a 16 chars and 2 line display
LiquidCrystal_I2C lcd(0x27, 16, 2);

int offsetValue = 20; // set the correction offset value

unsigned long buttonPressedTime = 0;
unsigned long previousMillis = 0;  // variable to store the previous time
const long interval = 10000;       // interval at which to blink (milliseconds)


// Replace with your network credentials
const char* ssid = "FuturisticIOX IoT";
const char* password = "12345678";

AsyncWebServer server(80);

void setup() {
  Serial.begin(115200);
  lcd.begin();
  lcd.backlight();
  lcd.print("Welcome!!");
  delay(3000);
  lcd.clear();
  lcd.noBacklight();

  pinMode(A0, INPUT); // analog input pin
  pinMode(D5, OUTPUT); // relay control pin
  pinMode(D6, OUTPUT);
  pinMode(D7, OUTPUT);
  pinMode(D8, OUTPUT);
```

```
digitalWrite(D5, HIGH);
 digitalWrite(D6, HIGH);
 digitalWrite(D7, HIGH);
 digitalWrite(D8, HIGH);

 WiFi.softAP(ssid, password); // Set WiFi AP mode

 IPAddress IP = WiFi.softAPIP();
 Serial.print("AP IP address: ");
 Serial.println(IP);

 server.on("/", HTTP_GET, [](AsyncWebServerRequest * request) {
   int sensorValue = analogRead(A0); // read the analog input value
   voltage = map(sensorValue, 0, 1023, 0, 1565) + offsetValue; // map 0-1023 to 0-
2500 and add correction offset
   voltage /= 100; // divide by 100 to get the decimal values
   percentage = ((voltage - 9.75) / (12.6 - 9.75)) * 100; // convert to percentage

   String html = "<html><head><style>";
   html += "body { font-size: 50px; text-align:center; }";
   html += "h1 { font-size: 36px; }";
   html += "p { font-size: 60px; }";
   html += "input[type='submit'] { font-size: 100px; padding: 40px; }";
   html += "</style></head><body>";
   html += "<h1>Battery Monitoring</h1>";
   html += "<p>Sensor Value: " + String(sensorValue) + "</p>";
   html += "<p>Battery Voltage: " + String(voltage) + "V</p>";
   html += "<p>Percentage: " + String(percentage) + "%</p>";
   html += "<h1>Control Buttons</h1>";
   html += "<form method='get' action='/relay'>";
   html += "<p><input type='submit' name='Display' value='Display'></p>";
   html += "<input type='submit' name='relay1' value='Relay 1'>";
   html += "<input type='submit' name='relay2' value='Relay 2'>";
   html += "<input type='submit' name='relay3' value='Relay 3'>";
   html += "<input type='submit' name='relay4' value='Relay 4'>";
   html += "</form>";
   html += "</body></html>";
   request->send(200, "text/html", html);



 });
```

```
  server.on("/relay", HTTP_GET, [](AsyncWebServerRequest * request) {
    if (request->hasParam("Display")) {
      Display = true;
    }
    if (request->hasParam("relay1")) {
      digitalWrite(D5, !digitalRead(D5)); // toggle relay state
    }
    if (request->hasParam("relay2")) {
      digitalWrite(D6, !digitalRead(D6));
    }
    if (request->hasParam("relay3")) {
      digitalWrite(D7, !digitalRead(D7));
    }
    if (request->hasParam("relay4")) {
      digitalWrite(D8, !digitalRead(D8));
    }
    request->redirect("/");
  });

  server.begin();
}

void loop() {
  if (Display) {
    int sensorValue = analogRead(A0); // read the analog input value
    voltage = map(sensorValue, 0, 1023, 0, 1565) + offsetValue; // map 0-1023 to 0-
2500 and add correction offset
    voltage /= 100; // divide by 100 to get the decimal values
    percentage = ((voltage - 9.75) / (12.6 - 9.75)) * 100; // convert to percentage

    lcd.begin();
    lcd.backlight();
    lcd.setCursor(0, 0);
    lcd.print("Voltage: ");
    lcd.print(voltage);
    lcd.print("V");
    lcd.setCursor(0, 1);
    lcd.print("Percent: ");
    lcd.print(percentage);
    lcd.print("%");
    //      lcd.print("Volt: "+voltage+"V    ");
    //      lcd.print("percent: "+percentage+"%");
```

```
    previousMillis = millis();
    Display = false;

  }

  // check if it's time to turn off the LED
  unsigned long currentMillis = millis();
  if (Display == false && currentMillis - previousMillis >= interval) {
    lcd.clear();
    lcd.noBacklight();
  }

}
```

- **Test**

```
float offset =20;// set the correction offset value
float energy=0;
//#include <Servo.h>
//Servo servo01;      // variable to store the servo position
//int servo1Pos;
//int servo1PPos;

unsigned long lastMillis = 0;
#define Relay1 8
void setup()
{

  Serial.begin(9600);
  //servo01.attach(9);  // attaches the servo on pin 9 to the servo object
  pinMode(Relay1, OUTPUT);
  digitalWrite(Relay1, 1);
  while(Serial.available()==0){}
  //int t=Serial.parseInt();
}
```

APPENDIX I (Cont.)
Project Programs / Codes / Flowcharts

```
void loop()
{
  float x=random(10,100);
  delay(x);
  float  dec_volt = random(00,99)/100.0;
  float voltage = random(10.00,13.00)+dec_volt;
  energy+=(voltage*x*random(0.00,2.00))/3600000;

  Serial.print("Voltage: ");
  Serial.print(voltage);//print the voltge
  Serial.println("V");

  Serial.print("Energy consumed: ");
  Serial.print(energy);//print the voltge
  Serial.println("wh");

  if(voltage<12)
  {
    digitalWrite(Relay1, 0);
    //servo01.write(0);
  }
  else
  {
    digitalWrite(Relay1, 1);
    //servo01.write(180);
  }

}
```