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By Implementing Supercapacitors Converting an Electric Vehicles into Hybrid Vehicles

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Abstract*— As the world is facing a big need for greener transportation since, the fossil fuel we use in our vehicles are big contributor to greenhouse emissions. Luckily, electric vehicles (EVs) are making waves of hope, as well as we are moving away from fossil fuel and embracing more eco-friendly options such as Hybrid vehicle, Hydrogen fuel cell vehicle and Electric vehicle which are way cleaner compared to fossil fuel. But the traditional electric vehicles are facing some challenges, especially when it comes to their batteries such as slow charging speed, limited lifespan, low range. Such similar challenges were also evident in Internal Combustion vehicles (e.g. petrol/diesel /compressed natural gas) which were mostly resolved by converting them to hybrid system. Similarly, in electric vehicles we can resolve problems like limited battery life (charging cycles) and low range of vehicle by converting it into a hybrid electric vehicle. So, to tackle this problem we have proposed a smart Hybrid system for an electric vehicle using supercapacitors secondary source of fuel along with traditional Lithium-ion battery as primary source of fuel. We will use the regenerative braking to charge the supercapacitor bank (i.e. multiple supercapacitors and connected in serial parallel combination) by using bridge rectifier to charge the supercapacitor bank that will eventually provide additional required current to the motors while rapid acceleration.

***Keywords:** SUPERCAPACITOR, regenerative braking, Hybrid system, EV's, charging and discharging.*

I. INTRODUCTION

As we are using petrol and diesel vehicles primary for now but it affects environment and produced greenhouse effect. So now peoples and government moving towards Electric Vehicles and Hybrid Vehicles. Following this we have identify that the range of electric vehicles is comparatively very small than the petrol and diesel vehicles. The "Smart Hybrid Electric Vehicle Using Supercapacitor " system is an innovative project designed to enhance the efficiency and performance of hybrid vehicles through the integration of advanced energy storage solutions. Supercapacitors, also known as ultracapacitors are electric storage device which can be recharged very quickly and release a large amount of power. Unlike traditional batteries, which store energy through chemical reactions, supercapacitors store energy electrostatically, giving them a much higher power density and longer cycle life. Then this make them perfect energy storage and regenerative braking system in hybrid vehicles. "In smart Hybrid Electric Vehicles, supercapacitors are integrated with traditional batteries to form a hybrid energy storage system (HESS). This system optimizes energy management by using supercapacitors for short-term, high-power demands and batteries for long-term energy storage. The result is Increased Performance, Extended component lifespan and Enhanced Energy Efficiency. This system incorporates a range of components, including a Battery, voltage regulator, Arduino Nano, Two voltage sensors, a current sensor, MOSFET drive, motors, Bridge rectifiers, a supercapacitor bank, an LCD display, a buzzer, and a button. By leveraging the high-power density and rapid charge-discharge capabilities of supercapacitors alongside traditional batteries, the system aims to provide a more robust and reliable energy management solution. The inclusion of sensors and a microcontroller ensures precise monitoring and control of the vehicle's power dynamics, while the user interface components facilitate easy interaction and real-time feedback.

- In this system, The Arduino Nano (shown in figure-1) is the main microcontroller of the system. It collects data from the sensors, controls the MOSFETs for power management, and show in LCD display. It ensures optimal power distribution between the supercapacitor bank and the battery to improve efficiency.

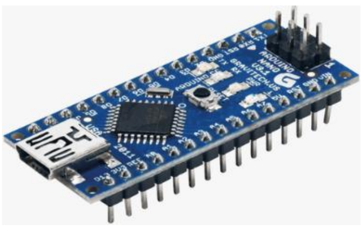

Figure 1. Arduino Nano

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- 20 supercapacitors (shown in figure-2) are connected in series to form a supercapacitor bank that provides the necessary voltage for high-power operations. Supercapacitors offer rapid charging and discharging.

Figure 2. Super-Capacitor

- The 12V lithium-ion battery serves as the main energy storage for sustained power delivery. It supplies power when the demand is stable and supports the motors in conjunction with the supercapacitor bank.
- The current sensor (INA219) (shown in figure-3) is used to monitor the current flowing through the system, it provides feedback to the Arduino Nano.

Figure 3. Current Sensor (INA219)

- The voltage sensor (shown in figure-4) measures the voltage levels across the supercapacitor bank and the lithium-ion battery. The Arduino Nano uses this data from voltage sensor and to manage charging and discharging effectively, ensuring systemstability.

Figure 4. Voltage Sensor

- The voltage regulator (7805) provides stable power to the components, thus it gives 5v DC output.
- The MOSFET drive (IRFZ44N) (shown in figure-5) is controlled by Arduino Nano and manage power flow between the supercapacitor bank, battery, and motors. The MOSFET acts as an electronic switch, it's allowing control of current flow.

Figure 5. MOSFET drive (IREZ44N)

- The Bridge rectifier converts the alternating current (AC) generated during regenerative braking into direct current (DC), which is then stored in the supercapacitor bank.
- The system uses Two Motors (shown in figure-6) that work as the primary units. They are powered by either the supercapacitor bank or the lithium-ion battery, depending on the power requirements.

Figure 6. Motor (12V/ 100 rpm)

- The buzzer is used as an alert mechanism. It indicates that the supercapacitor and battery overvoltage, overcurrent means it will give warning to the user.
- The 20x4(alpha-numeric) LCD display (shown in figure-7) shows real-time information such as the voltage levels of the battery and supercapacitor bank, the current supplied to the motors, and system alerts. This helps the user monitor the status and performance of the hybrid system.

Figure 7. 20x4 LCD Display

A. Block Diagram:

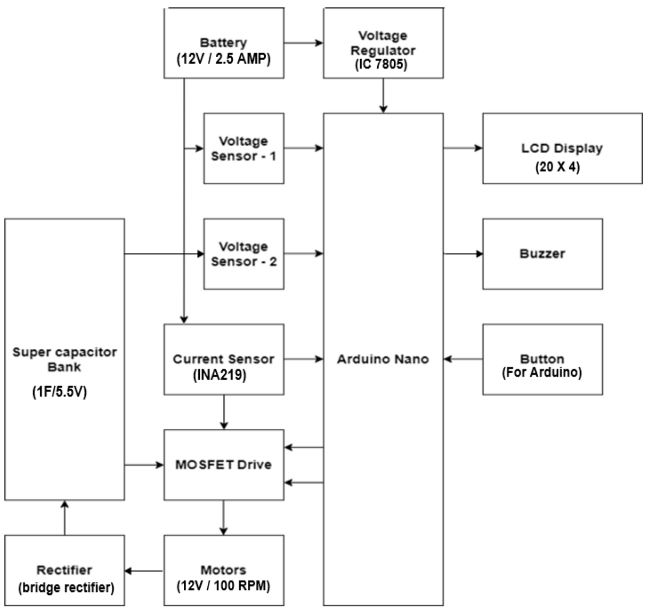

Figure 8. Block Diagram

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B. System Flow Chart

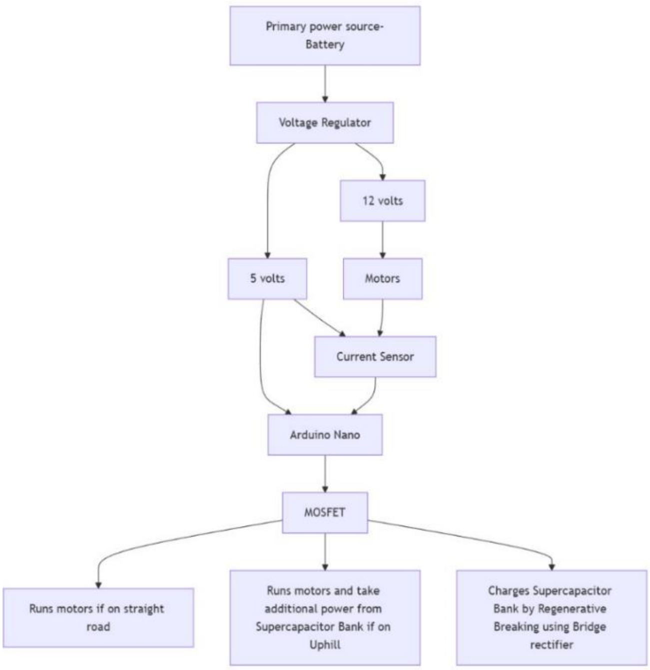

Figure 9. System Flow Chart

II. LITERATURE SURVEY

This literature survey provides an overview of key contributions and advancements in the field, highlighting seminal works and recent research that have shaped the hybrid vehicles and advancement in EV's and Super-Capacitor.

Eiman ElGhanam, Hazem Sharf [1] Performance Evaluation of Hybrid Battery Supercapacitor-Based Energy Storage Systems for Urban-Driven Electric Vehicles: This study proposes a hierarchical hybrid energy storage system (H-HESS) for electric vehicles (EVs), combining supercapacitors (SCs) and lithium-ion batteries (Li-ion). SCs handle peak currents during urban driving cycles, reducing battery stress and improving efficiency. Simulation shows a 55.7% peak current reduction and about 2% better battery capacity retention compared to a traditional battery-only system, highlighting potential benefits for EV range and longevity.

Rameez Pulapparambil Vallikkattil, Mohamed Ibrahim, and Dimiter Georgiev [2] Control strategy of fuel cell/supercapacitor hybrid propulsion system for an electric vehicle Supercapacitors are becoming an emerging energy storage technology as the improvements in electrode materials have been outstanding lately, which in turn has enhanced the performance of supercapacitors significantly.

Dhruba P. Chatterjee, Arun K. Nandi [3] A review on the recent advances in hybrid supercapacitors: Supercapacitors, known for their high-power density, are being improved through hybrid architectures to boost energy density, rate capability, and stability. Key advancements involve the nano-structuring of electrodes using materials like metal oxides, sulfides, and conducting polymers. The review highlights mechanisms of energy storage, the impact of component concentration, and electrochemical performance metrics. Future applications include robotics, renewable energy, wearables, and biotechnology.

Andari Wahib, Samir Ghozzi [4] Control strategy of fuel cell/supercapacitor hybrid propulsion system for an electric vehicle: The developed energy management approach (EMA) for a fuel cell vehicle successfully reduces fuel consumption by optimizing the energy flow between various sources. By integrating a storage device, the system ensures continuous energy production, significantly minimizing hydrogen consumption. Simulations demonstrate the effectiveness of the EMA, showing a nearly 51% reduction in hydrogen use.

III. OBJECTIVES

The objectives of proposed work are as follows: -

- In Hybrid electric vehicles, (HEVs)we combine supercapacitor and batteries so that it will help in utilizes benefits of both of them and simultaneously help in enhance overall performance and efficiency. Here are the following objectives of HEVs using supercapacitor bank.
- Improved Energy Efficiency: - Due to the combination of Supercapacitor and batteries, it helps in better power management of the system and which also helps in controlling higher efficiency and reduce energy losses in the system. During braking, the main advantage of supercapacitors is that it has ability to store energy, which can be reused. This process is known as regenerative braking, This energy can be reused to provide acceleration which helps in improving efficiency.
- High Power Density: Since, Supercapacitor have a higher power density than traditional lithium ion battery. which means they can deliver High bursts of power that will particularly help in providing quick acceleration and whenever sudden high Power is required in short time, which is essential for rapid acceleration and deceleration. This helps in providing quick bursts of energy whenever there is requirement of sudden acceleration.
- Extending battery Life: Due to Integration of supercapacitor and batteries in HEVs. Supercapacitor helps in reducing the strain on the battery while battery handling high Power demand. This helps in increasing the lifespan of the battery life and also helps in handling high Power events and maintaining its performance.
- Light-weight vehicle: Supercapacitor are generally lighter in weight and more compact than high capacity batteries which helps in reducing overall weight and space of the vehicle which helps in better handling the vehicles.
- Fast Charging and Longer vehicle mileage: Supercapacitor can be charged very quickly by regenerative braking which helps recover energy faster

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and continue providing necessary acceleration without long delays. This will help in increasing the mileage of electric vehicle when used along with the batteries as it can provide immediate power is needed.

- Environmentally friendly: In hybrid electric vehicle using supercapacitor produce lower emissions compared to traditional internal combustion engine (ICE) Vehicles. HEVS using supercapacitor eliminates the use fuel consumption which also helps in fuel saving and also contributing to Environmental conservation and Sustainability.

IV. EXPECTED RESULTS

- Enhance vehicle acceleration and regenerative braking capabilities through advanced power dynamics management: - The vehicle will have regenerative braking system which will charge the super-capacitor bank where the motors will generate AC current and a bridge rectifier will convert AC current to DC current for super-capacitor bank to store it.
- Optimize hybrid vehicle energy efficiency by integrating supercapacitors for rapid energy storage and release- The vehicle have main supply for 12V battery and secondary supply for the super-capacitor bank which makes our system an hybrid vehicle, Due to regenerative breaking the current produced by our motor is stored in super-capacitor bank, when in need of the extra current it, perform rapid charging and dis-charging in our system, when extra current is required to run the motors ex-while going uphill or sudden accelerative power
- Increase Battery life of the electric vehicle and its longevity: - Thus, by Optimizing the regenerative braking system on super-capacitor bank, the strain on our battery is significantly reduced which reduces the charging and dis-charging cycle of battery (500~1500 cycles) which in turn increase the life span of the battery. On the other hands the Super-capacitor bank can withstand millions of charging and dis-charging cycle with quick dis-charge. Making our system more reliable and stable with battery life increased.

V. CONCLUSION

In our project, we developed a hybrid system for electric vehicle that uses both a traditional battery system and a supercapacitor. This system improves the performance and efficiency of the vehicles, increases the lifespan and reduces the carbon footprint. The super capacitor can quickly store and release energy which makes it ideal for situation where sudden burst of power is required, such as during acceleration and regenerative braking. This technology has the potential to transform the electric vehicle industry, making it eco-friendly transportation.

The smart Hybrid system, we work on has great potential for future development. As technology advances the supercapacitor can become even more efficient and affordable. This system could be applied to public transports vehicles like buses and trains and heavy vehicles like trucks. Additionally, advancement in the energy storage could leads to even longer driving range and faster charging time, making EV more appealing to the general public. Through continuous research and development, we aim to overcome existing limitations and unlock the full potential of our project. By doing this, we will contribute to cleaner, greener and more sustainable transportation landscape, transforming the way we travel and interact with our environment.

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