Enhancing Bot Performance and Durability with Supercapacitor Backup in an Arduino Uno-Based Control System

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ABSTRACT

This paper proposes a supercapacitor-based bot control system that runs on an Arduino Uno and provides a motor driver with backup power. The technology is built to guarantee dependable and unbroken bot movement even in the event of a power outage or primary battery depletion. The supercapacitor used in the project, which offers high power density and quick charging and discharging capabilities, is switched between using a relay module. The suggested approach improves the bot's general functionality and longevity while offering effective energy management. The experiment shows the potential advantages of using supercapacitors in robotics applications, especially in circumstances where dependability and uninterrupted operation are crucial.

Keyword : *Supercapacitor, battery management systems, Electric Vehicle.*

1. INTRODUCTION

In modern vehicle design, efficient energy management is crucial for optimal performance, longer service life, and reduced environmental impact. One of the major challenges in vehicle design is to maintain reliable power supply while optimizing fuel economy and reducing emissions.

This paper presents a vehicle battery management system that utilizes a supercapacitor as a backup power source. Supercapacitors are energy storage devices that have high capacitance values and are capable of storing and delivering energy quickly. They are capable of storing energy in an electric field, unlike batteries that store energy in a chemical reaction. Supercapacitors offer several advantages over traditional batteries, including high power density, long cycle life, fast charging and discharging, and good performance at low temperatures.

The proposed system employs a switch to manually switch between the main supply and the supercapacitor. The main supply is used for normal operation, while the supercapacitor is utilized during acceleration, deceleration, or other high-power demand situations. The switch provides a convenient and reliable way to manage vehicle energy consumption, reducing the load on the primary battery and improving overall system efficiency.

The system is designed to ensure reliable power supply and uninterrupted vehicle operation even in challenging conditions. The supercapacitor is charged during normal operation and can provide additional power during high-power demand situations, reducing the load on the primary battery and extending its service life.

The project aims to demonstrate the potential benefits of utilizing supercapacitors in vehicle battery management systems, particularly in scenarios where reliable power supply and uninterrupted vehicle operation are critical. The proposed system offers an efficient and reliable way to manage vehicle energy consumption, reduce fuel consumption and emissions, and extend the service life of the primary battery.

2. EXISTING SYSTEM

Lead-acid batteries are commonly used in vehicles to provide electrical power for starting the engine and powering the vehicle's electrical systems. However, lead-acid batteries have several disadvantages, including low energy density, limited lifetime, and poor cold-weather performance.

Lead-acid batteries are heavy and have a low energy density, which limits the amount of energy that can be stored in a given volume or weight. This limits the range of electric vehicles that use lead-acid batteries and requires frequent recharging. Lead-acid batteries also have a limited lifetime and must be replaced periodically, which can be expensive and time-consuming.

In addition, lead-acid batteries are sensitive to temperature and have poor cold-weather performance, which can limit their usefulness in cold climates. They also require regular maintenance, including monitoring the electrolyte level and ensuring proper charging to prevent sulfation.

Overall, the use of lead-acid batteries in vehicles has several disadvantages that limit their performance and usefulness compared to newer technologies like supercapacitors.

2.1 MODULE EXPLANATION

LCD: -The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations.

ATMEGA328P: - The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts,serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed. The **ATmega328** is a single chip micro-controller created by Atmel and belongs to the megaAVR series.

ATmega328 in DIP package, pre-loaded with the Arduino Optiboot (Uno 16MHz) Bootloader. This will allow you to use Arduino code in your custom embedded project without having to use an actual Arduino board. To get this chip working with Arduino IDE, you will need an external 16MHz crystal or resonator, a 5V supply, and a serial connection. If you are not comfortable doing this, we recommend purchasing the Arduino Uno board that has all of these built into the board. Atmel's ATMega328 8-Bit Processor in 28 pin DIP package. It's like the ATmega168, with double the flash space. 32K of program space. 23 I/O lines, 6 of which are channels for the 10-bit ADC. Runs up to 20MHz with external crystal. Package can be programmed in circuit. 1.8V to 5V operating voltage!

L293D :- We start with the L293D. L293D is a popular motor driving IC. It is a 16 pin IC. The IC has 8 pins on both the sides. It has 2 enable pins, 1 V_{SS} pin, 1 V_S pin, 4 ground pins, 4 input pins and 4 output pins. Though not required here, but in case you wish to learn how to interface L293D with a microcontroller.

Enable – the enable pins, when are given **true,** (i.e. 1) then they enable the respective part of the IC. The enable 1 chip enables the Left part of the IC for inputs and outputs, and so does the Enable 2 does to the right part of the IC.

1. **V_{SS}** – this pin is to be given an input of 5 volts. This is used to power up the chip for its operations.

2. **V_S** – this pin is given the voltage that we have to supply to the motors. This voltage comes out through the output pins. Due to the gates used in the IC, the output is usually 1.8 to 2 volts less than the V_s.
3. **Input** – the input pin decides whether output has to be given to he respective output pin or not. When the Input is true, then output is also 1in the respective output pin. When input in the Input pin is 0, and then output in the respective output pin is also 0.
4. **Output** – the output pin is connected to the terminals of the motor. The input pins, as stated above, control its output.
5. **GND –** these pins are the ground pins, or, in other words, Zero.

The L293D IC can be used to control a maximum of 4 motors simultaneously. When 4 motors are connected to the IC, then for operation, -ve of each of the motors is connected to the **GND,** and the +ve terminal to the **output**s.

POWER SUPPLY BOARD: - Power Supply board is converting AC into DC Voltage.It will be converting Different Voltages Like 12v, 5v, 0v for various Application.

BLUETOOTH MODULE (HC-05) : - The HC-05 is a Bluetooth module that enables wireless communication between electronic devices. It uses Bluetooth protocol version 2.0 + EDR (Enhanced Data Rate) to provide secure and reliable communication over short distances. The module is designed to be easy to use and can be connected to an Arduino Uno microcontroller or other microcontrollers, allowing you to control and monitor the device using a smartphone, tablet, or other Bluetooth-enabled device. The HC-05 has a built-in antenna and can operate over a range of up to 10 meters (33 feet) in open space, depending on the environment and other factors.

The module supports a variety of Bluetooth profiles, including serial port profile (SPP) and AT command set. This makes it ideal for applications such as wireless data transfer, remote control, and Bluetooth-based IoT (Internet of Things) projects. The HC-05 module typically operates at a voltage of 3.3V and can be powered using a 3.3V or 5V power supply. It communicates with the Arduino using a serial UART interface and can be configured using AT commands sent via the serial port.

RELAY: - A relay module is an electronic component that allows you to control high-voltage and high-current devices using a low-voltage signal. It typically consists of a small electromechanical relay and a driver circuit that is used to switch the relay on or off using a digital signal from a microcontroller, such as an Arduino.The relay module provides electrical isolation between the low-voltage control signal and the high-voltage or high-current load, which can help protect the microcontroller and other circuit components from damage. Relay modules are commonly used in a variety of applications, such as home automation, robotics, and industrial control systems, where it is necessary to switch high-power devices such as motors, lights, heaters, or pumps. Some relay modules come with multiple relays, allowing you to control multiple devices independently using a single microcontroller. The number of relays and the maximum voltage and current ratings of the relays can vary depending on the specific module, so it's important to choose the right module for your particular application.

BATTERY CHARGER: -The rechargeable backup battery provides power to Finger Tec terminals when the primary source of power is unavailable. With the right backup battery, your system won't have to be interrupted during a power failure. 12V1.5Ah Backup Battery Access Control System: The external Rechargeable Backup Batteries are almost always used in an access control system. The backup battery prevents intruders from disabling the access control by turning off power to the building and continues locking the doors secured by the system. Time & Attendance System: For Time and Attendance System that records clocking-in and out data for employees, power failure might cause discrepancies in the payroll system. Thus, external rechargeable backup batteries are often used in Time & Attendance terminals as a backup power.

9.1 Input voltage: 120Vac 50/60Hz 0.4A Max. 9.2 Charging starting conditions: Battery not less than 5.5V 9.3 Rating output: 12Vdc 1.5A 9.4 Battery type: Lead-acid battery 9.5 Maximum charging voltage: 14.4V 9.6 Maintenance charging voltage: 13.2V~14.0V 9.7 Operating Environmental: -10~40℃, 90% RH Maximum 9.8 Weight: 0.62Lbs (0.28kg) approx. 9.9 Dimensions: L4.65" x W1.18" x H2.83" (L118 x W30 x H72mm)

GEARED DC MOTOR: - Geared DC motors can be defined as an extension of DC motor which already had its Insight details demystified here. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM.The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as

gear reduction. This Insight will explore all the minor and major details that make the gear head and hence the working of geared DC motor.

3. IMPLEMENTATION

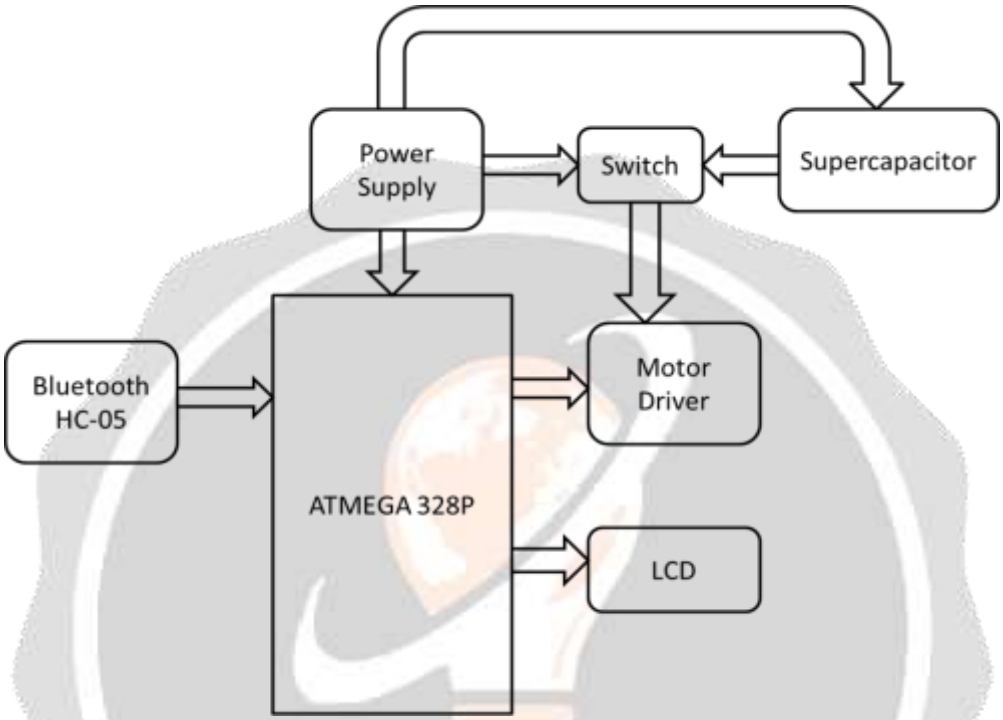

fig -1: Block diagram

The block diagram you described consists of a microcontroller, a motor driver, two motors, a Bluetooth module, and a relay. The microcontroller is the main control unit for the system and is responsible for processing input signals and sending output signals to the various components.The motor driver is used to control the speed and direction of the two motors. The driver receives commands from the microcontroller and translates them into signals that control the motors. The driver also protects the motors from overloading or overheating by monitoring the current and temperature levels.

The Bluetooth module is used to provide wireless communication between the microcontroller and a remote device, such as a smartphone or tablet. This allows the user to control the motor speed and direction from a distance.The relay is used to switch between the main supply and the supercapacitor supply to the motor driver. When the relay is in the main supply position, the motor driver is powered by a traditional power source, such as a battery or AC power. When the relay is in the supercapacitor supply position, the motor driver is powered by a supercapacitor, which provides fast charging and high energy density.

Overall, the block diagram represents a system that can be used to control the direction of two motors using a microcontroller, a motor driver, a Bluetooth module, and a relay. The system is designed to be flexible and efficient by using a supercapacitor as a power source, which provides fast charging and high energy density compared to traditional batteries.

4. CONCLUSIONS

In conclusion, the use of supercapacitors in vehicle electrical systems has several advantages over traditional battery-based systems. Supercapacitors offer fast charging, high power density, and a long lifetime compared to

traditional batteries. They also have a wide operating temperature range and can be easily integrated into existing electrical systems.

The implementation of a supercapacitor-based battery management system can result in improved vehicle performance, reduced fuel consumption, and lower maintenance costs. Supercapacitors can be used to provide power to the vehicle's electrical systems during acceleration and braking, which reduces the load on the traditional battery and improves fuel efficiency.

While there are some limitations to the use of supercapacitors, such as limited energy storage compared to traditional batteries, ongoing research and development is improving their performance and reducing costs. As the technology continues to evolve, it is likely that supercapacitors will become an increasingly important component in vehicle electrical systems, offering a more efficient and sustainable solution for powering vehicles.

5. REFERENCES

[1] "Design and implementation of an Arduino-based supercapacitor-powered vehicle" by A. K. Singh et al. in International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering.

[2] "Development of an Arduino-based supercapacitor charger for electric vehicles" by J. H. Kim et al. in Journal of Power Sources.

[3] "Design and simulation of an Arduino-based battery management system with a supercapacitor backup" by S. Ahmed and S. Islam in International Journal of Electrical and Computer Engineering.

[4] "Supercapacitor-based energy storage system for an Arduino-controlled electric vehicle" by G. Li et al. in International Journal of Power Electronics and Drive Systems.

[5] "Design and implementation of an Arduino-based solar-powered vehicle with a supercapacitor backup" by J. Xue et al. in Journal of Renewable and Sustainable Energy.

[6] "A study of supercapacitor-based energy storage system for an Arduino-controlled electric vehicle" by J. W. Choi et al. in International Journal of Automotive Technology.

[7] "Design and simulation of an Arduino-based supercapacitor management system for electric vehicles" by S. H. Jeon et al. in Energies.

[8] "A low-cost Arduino-based supercapacitor charger for electric vehicle applications" by J. M. Wang et al. in Journal of Power Sources.

[9] "Development of an Arduino-based vehicle power management system using a supercapacitor" by P. C. Singh et al. in International Journal of Scientific Research in Science, Engineering and Technology.

[10] "Design and simulation of a hybrid battery-supercapacitor power management system for Arduino-controlled electric vehicles" by H. Kim et al. in Journal of Power Sources.