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(Review Article)

EV battery soH, soC monitor on the edge of speed control and fire protection

P Jeevan Kumar Reddy [1,*], S Praveen Kumar [2], R Sai Rohith [2], B Satya [2], T Uma [2], P Nikitha [2] and V Niranjan [2]

[1] *Sri Venkateswara College of Engineering, Tirupati, Andhra Pradesh, India.*
[2] *Sri Venkateswara Engineering College, Tirupati, Andhra Pradesh, India.*

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Abstract

Lithium batteries are the most common energy storage devices in items such as electric vehicles, portable devices, and energy storage systems. However, if lithium batteries are not continuously monitored, their performance could degrade, their lifetime become shortened, or severe damage or explosion could be induced. To prevent such accidents, we propose a lithium battery state of health monitoring method and state of charge estimation algorithm based on the state of health results. And also speed control in electric vehicles is mandatory as it is used to influence the rotational speed of motors and machinery. This has a direct effect on the operation of the machine and is crucial for the quality and outcome of the work. Li-ion batteries have a lot of energy in them, and thermal runaway accelerates quicker the more power is in the battery itself. If a battery is fully charged and something happened inside it, then thermal runaway would happen really quickly. To overcome this, fire protection of electric vehicle is necessary.

Keywords: Battery; BMS; Fire Protection; SoC; SoH; Speed Control

1. Introduction

Battery monitoring is a critical aspect of electric vehicles (EVs) as the battery is the primary source of power for the vehicle. The battery pack in an EV is typically made up of several individual battery cells that work together to provide the necessary power to the vehicle. Monitoring the performance and health of these individual cells is important for ensuring the safety and reliability of the vehicle. Electric vehicles (EVs) are becoming increasingly popular due to their many benefits, such as lower emissions, lower operating costs, and quieter operation [1-5]. However, EVs also have unique safety concerns, such as the risk of battery fires, and require specific monitoring and control systems to ensure safe and efficient operation.

State of Charge (SoC) and State of Health (SoH) monitoring are two critical aspects of EV battery management. SoC refers to the amount of charge remaining in the battery, while SoH refers to the overall health and condition of the battery. Accurately monitoring these parameters is essential for optimizing battery performance, predicting remaining range, and preventing damage to the battery. Speed control is another important aspect of EV operation, as it helps to ensure safe and efficient driving. This can be achieved through a variety of systems, including electronic speed controllers and regenerative braking systems, which can help to improve energy efficiency and extend the vehicle's range. Fire protection is a critical safety concern in EVs, as battery fires can pose a significant risk to both the vehicle and its occupants [6-8].

To address this risk, EVs may include various safety features such as battery management systems, thermal management systems, and fire suppression systems. These systems work together to monitor battery temperature and prevent thermal runaway, detect and extinguish fires, and protect occupants in the event of a fire [9-11].

* Corresponding author: P Jeevan Kumar Reddy

Electric vehicles (EVs) have gained popularity in recent years due to their potential to reduce greenhouse gas emissions and dependence on fossil fuels. One of the key components of an EV is its battery pack, which stores the energy needed to power the vehicle. Monitoring the state of charge (SoC) and state of health (SoH) of the battery is crucial for the proper operation of an EV. Additionally, speed control and fire protection are important safety features that are incorporated into EVs [12-16].

1.1. State of Charge (SoC) and State of Health (SoH) Monitoring

SoC refers to the amount of energy that is currently stored in the battery pack. SoC monitoring is essential because it ensures that the battery pack is not overcharged or undercharged, which can lead to decreased performance or even damage to the battery. SoC can be monitored using a variety of methods, including voltage and current sensing, coulomb counting, and impedance spectroscopy [17-19]. SoH refers to the overall health of the battery pack, including its capacity and ability to hold a charge over time. SoH monitoring is important because it allows the vehicle owner to determine when the battery pack needs to be replaced or serviced. SoH can be monitored using methods such as capacity EV SoC AND SoH monitor and speed control with fire protection testing, impedance spectroscopy, and electrochemical impedance spectroscopy.

1.2. Speed Control

Speed control is another important feature of EVs. EVs are typically powered by electric motors, which require a controller to regulate their speed. The controller adjusts the amount of power that is supplied to the motor, which in turn controls the speed of the vehicle [20-24]. The controller receives input from various sensors, including the accelerator pedal and brake pedal. By adjusting the amount of power supplied to the motor, the controller can control the speed of the vehicle. Additionally, some EVs are equipped with regenerative braking systems, which can help to slow down the vehicle and recapture energy that would otherwise be lost during braking.

1.3. Fire Protection

Fire protection is a critical safety feature that is incorporated into EVs. Lithium-ion batteries, which are commonly used in EVs, have the potential to catch fire if they are damaged or overheated. In order to prevent fires, EVs are equipped with a variety of safety features, including thermal management systems, fuses, and disconnect switches. Thermal management systems are used to regulate the temperature of the battery pack. This can help to prevent overheating and reduce the risk of fire. Fuses and disconnect switches are used to protect the battery pack in the event of a short circuit or other electrical fault. Additionally, EVs are equipped with onboard fire suppression systems, which can quickly extinguish a fire in the event of an emergency.

2. Existing system

In existing system there are many problems involved such as petrol price queuing time & cost so all human needs is to reduce the travelling cost and time. In this system we could not monitoring the SoC level (battery voltage level) and SoH percentage (battery percentage) so that we can face many problems such as vehicle accident and battery failure. Here the major issue is costing of the fuel increasing day by day so we don't have any solution to resolve this issue.OCV refers to Open Circuit Voltage of the battery (battery no load condition). It is the simplest method for SOC estimation. With some battery chemistries, OCV voltage is linear function of SOC. Thus, measuring the OCV we can predict the SOC of the battery easily. While with other Li-ion chemistries, OCV vs SOC is a flat curve [25-27].

In such condition, usage of this method is limited. Other limitations using this method. It is an offline method. Battery should not be connected to any load for at least 2 hours to accurately measure the OCV. Also, OCV not only varies with SOC, but with a cell's internal resistance. Over-current protection is that protection in which the relay picks up when the magnitude of current exceeds the pickup level. The main element in over-current protection is an over-current relay [28-31]. The over-current relays are connected to the system, normally by means of CTs, for small power motors direct to supply line In the System three phase supply is given to the 4-pole contactor which is connected to Relay through Relay drivers [32-37]. The infeed contactors signal is fed to the SIMOCODE PRO V module. The contactors are connected to a switching block which is then connected to three phase Induction motor. The contactor control is fed to the SIMOCODE module from the switching block.

Disadvantages

- Dependent on people
- Required more time

- High in cost

3. Proposed System

A proposed system for monitoring electric vehicle state of charge (SOC) and state of health (SOH), as well as controlling the vehicle's speed and providing fire protection, could include the following components: Battery Management System (BMS): A BMS is responsible for monitoring the SOC and SOH of the battery pack. It can also manage the charging and discharging of the battery pack to prevent overcharging, over-discharging, and thermal runaway. The BMS can communicate with the vehicle's control system to provide information about the battery pack's health and charging status. Speed Control System: The speed control system can regulate the speed of the vehicle, preventing it EV SoC AND SoH MONITOR AND SPEED CONTROL WITH FIRE PROTECTION S.V College of Engineering, Dept of EEE 4 from exceeding a safe limit.

The speed control system can use sensors to detect the speed of the vehicle and adjust the acceleration and braking accordingly. Fire Protection System: The fire protection system can detect and suppress fires that may occur due to electrical faults or thermal runaway. The fire protection system can include sensors to detect temperature, smoke, and flames, as well as an automatic fire suppression system that uses chemicals or water to put out the fire. Communication System: The communication system can enable the BMS, speed control system, and fire protection system to communicate with each other and with the vehicle's control system. The communication system can also provide real-time information about the vehicle's SOC, SOH, speed, and potential fire hazards. The proposed system is designed to ensure the electric vehicle's safety, performance, and longevity. The BMS ensures the battery pack's health, while the speed control system ensures the vehicle operates safely. The fire protection system protects against thermal runaway events, and the communication system provides real-time updates and alerts to the driver and control centre. In summary, an EV system of SoH monitoring, SoC, and speed control with fire protection is essential for ensuring the safety and performance of electric vehicles. The proposed system incorporates all these features and is designed to provide a comprehensive solution to ensure the electric vehicle's longevity and safety.

3.1. Block Diagram of Proposed System

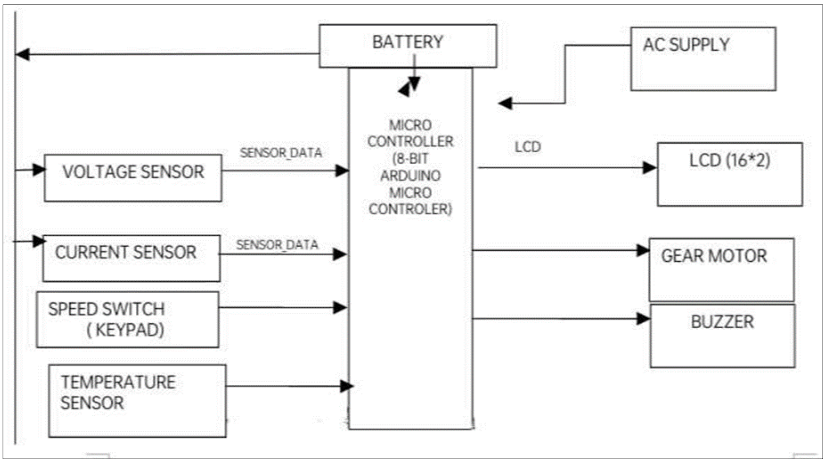

Figure 1 Proposed System

Fig. 1 shows the Arduino as a Prime controller and also the components like voltage sensor, Current sensor, battery, keypad, Temperature sensor, Gear Motor, Buzzer LCD etc. In this proposed technique we are using AC sources to recharge the battery and voltage and current sensors are used to monitor the battery level of the project also we can monitor the battery voltage in real time. We also implemented a smart switch (keypad) for MOTOR speed control in this method. Here temperature sensor is used to monitor the battery temperature if the temperature increases buzzer will be activated. Here LCD is used to display all the statuses.

3.2. Advantages

due to speeding or sudden braking. The fire protection system can detect and prevent fires from occurring in the battery system, reducing the risk of accidents.

- Longer battery life: The SOC and SOH monitors allow drivers to track the battery's charge level and health, making it easier to optimize charging and prevent overcharging or undercharging. This can extend the life of the battery and save costs on replacements.

- Better performance: Monitoring the SOC and SOH can also help drivers optimize their driving habits, such as avoiding aggressive acceleration or braking, to improve the battery's performance and range.
- Cost savings: By extending the battery life and improving performance, EV owners can save money on fuel and maintenance costs over the long run.
- Environmental benefits: Electric vehicles produce fewer emissions than gas-powered vehicles, so the use of EV SOC and SOH monitors and speed control with fire protection can help reduce overall carbon emissions and improve air quality.
- Improved safety: With a speed control system, drivers can maintain safe and consistent speeds, preventing accidents due to speeding or sudden braking. The fire protection system can detect and prevent fires from occurring in the battery system, reducing the risk of accidents.
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3.3. Applications

- Battery Management Systems (BMS): SOC and SOH monitoring can be used in BMS to track the battery charge level and its health status, respectively.
- Vehicle Diagnostics: EV SOC and SOH monitoring can be used to diagnose and identify potential problems with the battery, which can help in preventive maintenance and avoid expensive repairs.
- Energy Management: By monitoring SOC and SOH, EVs can optimize their energy usage and extend their range. This is particularly important for long-distance journeys.
- Speed Control: Speed control systems can be integrated with fire protection systems in EVs to prevent overheating and fires. For example, if the temperature of the battery pack rises beyond a certain level, the speed can be automatically reduced to minimize the risk of fire.
- Fleet Management: In large fleets of EVs, SOC and SOH monitoring can be used to track the performance of the batteries and optimize their usage. This can help reduce maintenance costs, extend the lifespan of the batteries, and improve overall fleet efficiency

4. Embedded system

As its name suggests, embedded means something that is attached to another thing. An embeddedsystem can be thought of as a computer hardware system having software embedded in it. An embeddedsystem can be an independent system or it can be a part of a large system. An embedded system is a microcontroller or microprocessor-based system which is designed to perform a specific task. For example, a fire alarm is an embedded smoke. So, we can define an embedded system as a Microcontroller based, software driven and reliable, real-time control system. Embedded systems are typically built around microcontrollers or microprocessors, which are small, low-power CPUs that can be integrated into a single chip. These chips often include other components, such as memory, input/output interfaces, and communication protocols, which are necessary for the system to function.

One of the key features of embedded systems is their real-time computing capabilities. This means that the system can respond to input and produce output in real-time, with minimal delay. This is essential inapplications such as medical devices and automotive systems, where a delay in processing input could have serious consequences. Another important feature of embedded systems is their low power consumption. Since these systems are often used in battery-powered devices, it is important that they aredesigned to operate efficiently and conserve power as much as possible. This often involves using low- power components, optimizing the system's software, and implementing power-saving features such as sleep modes and power gating.

Embedded systems can be programmed using a wide range of programming languages, includingC, C++, Java, and Python. However, the programming process for embedded systems is often more complex than for general-purpose computers, as the system's software must be designed to work with thespecific hardware components and real-time constraints of the system. One of the main challenges in developing embedded systems is ensuring that they are reliable and secure. Since these systems are oftenused in critical applications, it is essential that they are designed to be robust and resistant to failures. This requires careful testing and verification of the system's hardware and software, as well as implementing security features such as encryption and access control.

In conclusion, embedded systems are a critical component of modern computing, used in a wide range of applications. These systems are designed to perform specific functions with real-time constraints,and are built around low-power microcontrollers or microprocessors. Developing reliable and secure embedded systems requires careful design, testing, and verification of the system's hardware andsoftware, and implementing power-saving features, encryption, and access control.

4.1. Characteristics of an Embedded System:

- **Single-functioned** – An embedded system usually performs a specialized operation and does the same repeatedly as shown in Fig. 2. For example: A pager always functions as a pager.
- **Tightly constrained** – All computing systems have constraints on design metrics, but those on an embedded system can be especially tight. Design metrics is a measure of an implementation's features such as its cost, size, power, and performance. It must be of a size to fit on a single chip, must perform fast enough to process data in real time and consume minimum power to extend battery life.
- **Reactive and Real time** – Many embedded systems must continually react to changes in the system's environment and must compute certain results in real time without any delay. Consider an example of a car cruise controller; it continually monitors and reacts to speed and brake sensors. It must compute acceleration or de-accelerations repeatedly within a limited time; a delayed computation can result in failure to control of the car.
- **Microprocessors based** – It must be microprocessor or microcontroller based.
- **Memory** – It must have a memory, as its software usually embeds in ROM. It does not need any secondary memories in the computer.
- **Connected** – It must have connected peripherals to connect input and output devices.
- **HW-SW systems** – Software is used for more features and flexibility. Hardware is used for performanceand security.

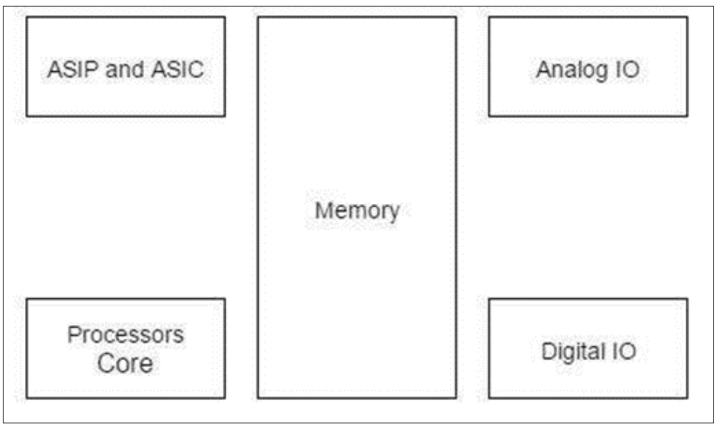

Figure 2 Memory

4.2. Basic structure of an embedded system

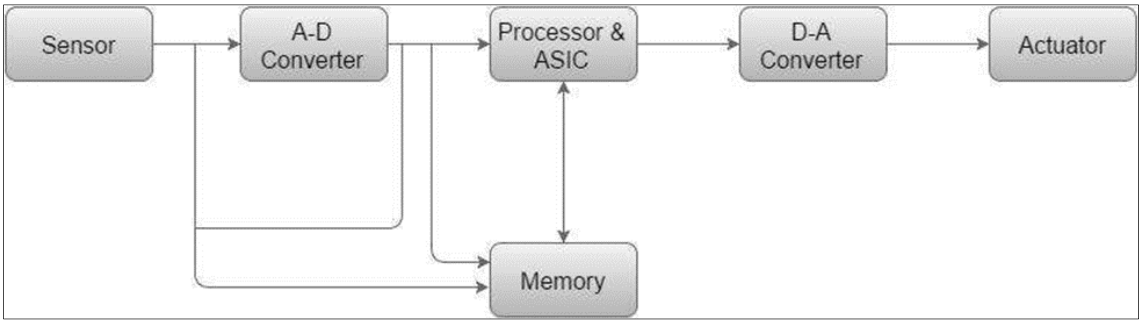

Figure 3 Structure of Embedded System

- Sensor − It measures the physical quantity and converts it to an electrical signal which can be read by an observer or by any electronic instrument like an A2D converter. A sensor stores the measured quantity to the memory.
- A-D Converter − An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.
- Processor & ASICs − Processors process the data to measure the output and store it to the memory.
- D-A Converter − A digital-to-analog converter converts the digital data fed by the processor to analog data.
- Actuator − An actuator compares the output given by the D-A Converter to the actual (expected) output stored in it and stores the approved output as shown in Fig. 3.

5. Embedded system software

A typical industrial microcontroller is quite unsophisticated compared to a typical enterprise desktop computer and generally depends on a simpler, less-memory-intensive program environment. The simplest devices run on bare metal and are programmed directly using the chip CPU's machine code language. Often, however, embedded systems use operating systems or language platforms tailored to embedded use, particularly where real-time operating environments must be served. At higher levels of chip capability, such as those found in SoCs, designers have increasingly decided that the systems are generally fast enough and tasks tolerant of slight variations in reaction time that "near-real-time" approaches are suitable. In these instances, stripped-down versions of the Linux operating system are commonly deployed, though there are also other operating systems that have been pared down to run on embedded systems, including Embedded Java and Windows IoT (formerly Windows Embedded). Generally, storage of programs and operating systems on embedded devices make use either of flash or rewritable flash memory

6. Results and discussion

Fig. 4 gives the hardware setup of proposed system with battery, motor, display and other electrical and electronics components.

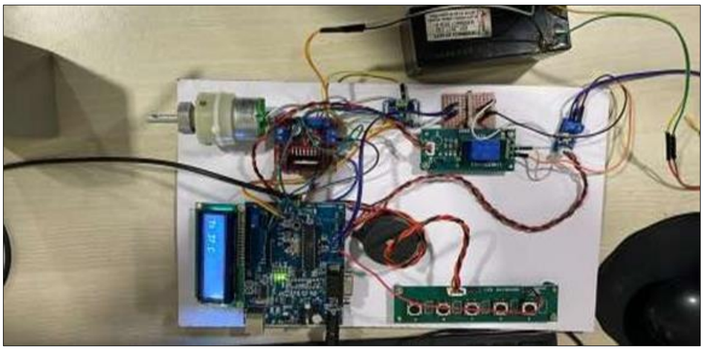

Figure 4 Kit

- STEP 1: Connecting AC Supply to the Arduino Board

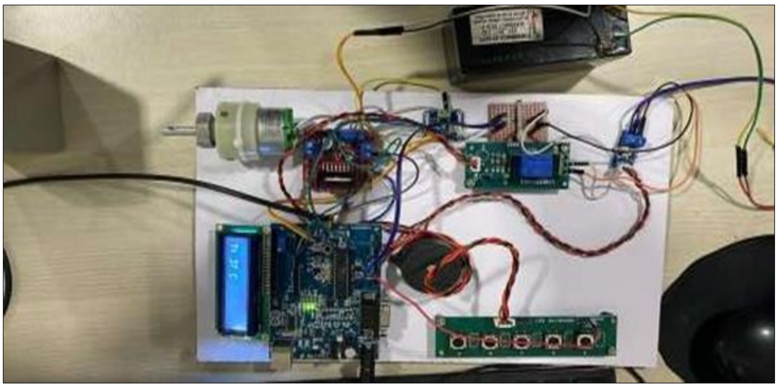

Figure 5 AC Supply to Arduino Board

By connecting the ac supply to the Arduino board, the board will turn ON and displayed the project title as shown in Fig. 5.

- STEP 2: After giving the supply the Arduino runs the code and monitors the SoC, SoH and it displays on LCD.

Figure 6 LCD displaying SoC and SoH when connected to AC Supply

When an power is provided to the Arduino board, it starts running code and monitoring the soc and soh and the values displayed on the lcd screen as shown in Fig. 6.

- STEP 3: Choose the speed of the motor as per your requirement with the help of keypad switches.

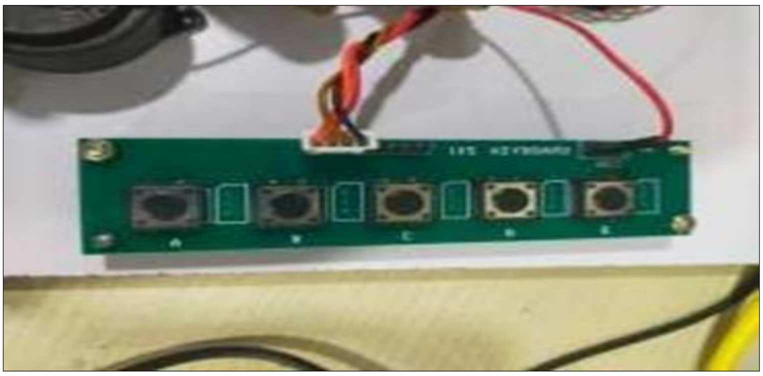

Figure 7 Keypad switches

With the help of 5x1 keypad switch we can adjust the speed of the motor. The keypad switch contains the slow speed and high speed options. You can select which option that you want to operate as shown in Fig. 7.

- STEP 4: The Gear Motor runs at desired speed which you were chosen.

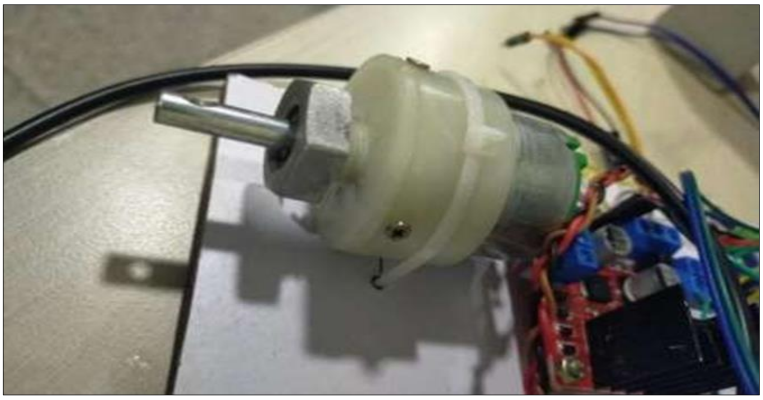

Figure 8 Motor running at desired speed

Therefore, the motor running at the desired speed with the help of the keypad switch as shown in Fig. 8.

- STEP 5: So, Buzzer rings when the temperature exceeds threshold value.

The temperature sensor set a minimum values and maximum values for the temperatures, when the temperature exceeds it will alarm the buzzer and notifies on the lcd display as shown in Fig. 9.

Figure 9 Sensing the Temperature

7. Conclusion

Based on the system, EV SOC (state of charge) and SOH (state of health) monitoring are important for electric vehicle battery management. These technologies can help extend the lifespan of thebattery by monitoring its performance and predicting when maintenance or replacement may be necessary. In addition, speed control and fire protection are also critical aspects of EV technology. Speedcontrol can improve the safety of drivers and passengers by ensuring that vehicles do not exceed safe speeds. Fire protection is crucial to preventing potential fires that can occur due to battery malfunctions or accidents. Overall, these technologies are important for the safe and efficient operation of electric vehicles. By utilizing advanced monitoring and safety features, EV manufacturers can provide a better driving experience for their customers while also ensuring their safety.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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