



## IOT - Based Flexy Fare Smart Charging System

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**Abstract:** *The Smart IoT Energy Meter (SIEM) for electric vehicles, utilizing WIFI cloud-based technology, will enable successful implementation in monitoring power consumption and billing for battery electric vehicles. Interaction between users and the SIEM via Wi-Fi using cloud intuitive applications has proven efficient, with response times within one minute. Customer data and billing info are also recorded in cloud for further analysis. The SIEM communication capabilities are enhanced with an Android- based application for Bluetooth communication and SMS monitoring by operators. Through operator intervention, voltage and current measurement errors have been significantly reduced. However, challenges remain, as evidenced by the high Total Harmonic Distortion (THD) of the current from the battery charger. Additionally, the Flexy Fare Smart Charging System complements this innovation by maximizing Electric Vehicle charging efficiency and minimizing environmental and hazard impact through real-time energy metering which allows application to truncate the charging after desired Kwh is consumed. Together, these advancements mark significant progress toward sustainable and efficient electric vehicle charging solutions.*

**Keywords:** *SIEM, electric vehicles, THD, WIFI, Cloud- based technologies.*

### 1. INTRODUCTION:

In recent years, there has been a considerable increase in the global adoption of electric vehicles (EVs), spurred by concerns about environmental sustainability and the need to cut carbon emissions. As the EV industry grows, there is an increasing desire for novel solutions to the difficulties of charging infrastructure and energy management. Electric vehicles energies are supplied by batteries which can store only limited amounts of electrical energy. These batteries are charged using an AC-DC converter that converts AC power from power lines to DC power. AC-DC converter is a non- linear electric device that can also produces high current harmonics. Conventional AC-DC converter can produce a current Total Harmonic Distortion (THD) of 77.9%. These high current harmonics can cause an increase in energy loss, a decrease in the quality of the electric network, an increase in the temperature of the transformer and also excessive load for high penetration of electric vehicles [1].

Wi-Fi technology is included into energy meters, enabling connection between the metering equipment and EVs with Wi- Fi - enabled on board systems. Wi-Fi connectivity also makes it easy to implement charging strategies such as load balancing and demand response, which assist energy and minimize grid congestion. Additionally, the use of EV owners and operators of charging stations can remotely monitor charging sessions, receive real-time notifications, and modify charging settings from any location with cellular service to Wi-Fi

connectivity. Smart energy system connected with Wi-Fi cloud-based technology have emerged as potential solutions for monitoring and managing the electric car charging process. In response to these issues, smart energy meters have been created with expanded functionality and connectivity possibilities, allowing for real-time monitoring and management of EV charging operations. The combination of Cloud-based and cloud technologies in energy meters provides a complete solution for optimizing EV infrastructure and energy management. Wireless meters provide for seamless communication, remote monitoring, and intelligent control of charging, permitting stakeholders to make educated decisions and optimize the benefits of electric mobility.

## 2. LITERATURE SURVEY:

- In 2011 C. Gao and M. A. Redfern [2] “A Review of Voltage Control Smart Metering Technologies on Distribution Networks” Smart metering can quickly transmit voltage information from all monitors to the master head end, allowing for near real-time control. This article examines the prospects for voltage control smart metering technology in distribution networks. The consequences and benefits of smart metering for voltage regulation are examined in order to better future power system development. The data transmission system may be used for on-load tap-changer (OLTC) voltage control strategies.
- In 2015 Darshan Iyer and Dr. K. A. Radhakrishna Rao [3], “IoT Based Electricity Energy Meter Reading. The growing generation need wireless enabled gadgets that include Bluetooth, Radio Frequency Identification, embedded sensors, and many more. In that regard, IOT technology has advanced from its inception to become widely used today. Electricity plays a crucial function in our lives. As the number of users grows fast, it has become increasingly to meet the demand for electricity is impossible to survive, and it is critical to conserve electricity. As the population grows, so do the needs of consumers, necessitating technological advancement. So, we created the system using faster and more advanced technologies like Wi- Fi and cloud-based technologies.
- In 2015 M. Patel Umang and M. Modi Mitul [4], Smart Energy Meter sends power/unit data to the cloud via SMS or Wi-Fi, allowing users to access data room module apps and websites. Using cutting-edge technology, smart energy meters will save money, labor, effort, and time while also successfully monitoring power consumption, use, and fraud. It is safe, easy to use, and user-friendly. The metering system incorporates low-cost components, making it more affordable.
- In 2015 Luigi Martirano Matteo Manganelli Danilo Sbordone [5] proposed the classification of the metering system has developed into a Smart Metering System (SMS). A distributed SMS is a metering system made up of a network of multiple meters installed in the electricity system at various levels of distribution.
- In 2017 Birendra kumar Sahani. Tejashree Ravi. Akib Javed Tamboli and Ranjeet Pisal [6] The meter’s LED blinks continually, indicating the current measurement. We count units based on kwh. In this project, we aim to create a system that uses Arduino Nano as the controller will continuously monitor an energy meter. Arduino measures unit consumption based on the blinking LED on the energy meter. Our created web page will continuously display the measured reading and cost calculation. Set a threshold value on a web page using Wi-Fi to meet needs of the consumer. When the consumer’s readings approach the defined threshold value, a notification will be sent.
- In 2017 Vidyashree M S [7], The suggested method enabled live monitoring of energy use. The Arduino Micro controller automatically measures electrical factors such as voltage, current, power, and energy consumption. In 2018 Muljono, I.M.A.Nratha, I.M.Ginarsa, dan I. M. B. Suksmadana [8] The purpose of energy meters is to monitor voltage and currents and calculate their product in order to provide an immediate answer to power consumption by home equipment. This power is united over a certain amount of time to provide the energy required.

- In 2018 D.V.N. Ananth, G. Joga Rao, Ch. Satish, J. Shyam, K. Santosh, U.V.V.S.S.V. Prasad, K. Ramya [9] For Wi-Fi module uses the network coverage of the SIM. Smart Energy Meter uses SMS or/and Wi-Fi to send the power/unit data to cloud, so that user can access the data room module Apps and websites. It is safe and easy to use and user friendly. The metering system uses cheap components which will decrease the overall cost of the equipment increasing its affordability and penetration in non-metered areas.
- In 2019 Pooja D Talwar<sup>1</sup>, Prof. S B Kulkarni,[10] Energy conscious awareness is built by displaying the SIEM works well as the information on maintenance are informed on our mobiles. The tariff strategy for linear and nonlinear loads is used to calculate the energy cost per-kWh. The details of load energy consumption are stored in a database.
- In 2019 S. Imran and Dr. K. Prahlada,[11] The Internet of Things refers to physical devices, vehicles (also known as “connected devices” and “smart devices”), buildings, and other items that are embedded with electronics, software, sensors, actuators, and network connectivity, allowing them to collect and exchange data. The suggested solution connects energy meters to the internet using the IoT idea.

### 3. METHODOLOGY:

SIEM uses microcontroller (Arduino NANO), voltage sensor (ZMPT101B), current sensor (ZMCT103C), NodeMCU ESP8266, TFT LCD 2.4inch, relay 1 module, buzzer, MCB, RFID sensor and cloud server. Fig 1 shows the block diagram of the SIEM for billing system of electric vehicles. Customer can request to use SIEM for batteries charging on electric vehicles via Wi-Fi. All interactions between customer and SIEM is monitored by operator via SMS from SIEM. SIEM can also be setup or calibrated by operator using android- based application. Electric vehicle supply equipment (EVSE), connectors connecting vehicle to EVSE and secure network connecting EV to the IoT cloud service to transmit data using secured wireless technology. The IoT cloud service offers applications that receive, analyze and manage data in real-time to assist EV users in making real time decision that would enhance the quality of EV charging. Here while tapping the RFID tag into the RFID reader [13] then the signal is given to the Arduino controller board. The Smart EV charging station is an innovative product developed for the growth of both two- wheeler and four-wheeler.

SIEM is divided into four sections. Part 1 describes the process of writing major files to storage medium. The major files take the form of text files. The main files contain default data, such as for the SIEM name, password, voltage sensor scale, current sensor scale, and energy price. Part 2 is the setup process for the Wi-Fi name and password in AT mode. Part 3 involves setting up or calibrating the SIEM process utilizing an Android-based application. Table I contains codes for SIEM setup and calibration. Part 4 describes the communication process between the consumer and SEM.

The techniques for determining voltage ( $V_{rms}$ ), current ( $I_{rms}$ ), power (Watt), Power Factor (PF), Distortion Factor (DF), and total harmonic distortion of current (THD).

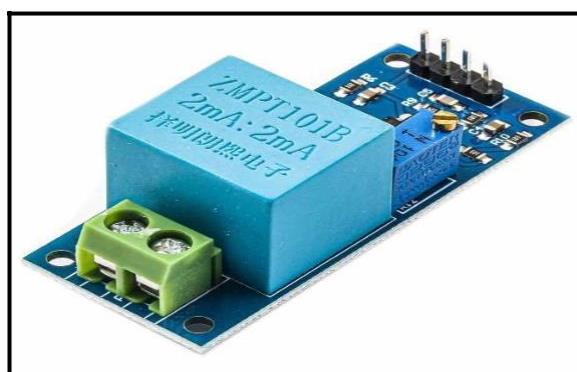
The current and voltage sensors depict the connection between the IOT GA6 Mini and the Arduino Nano. The IOT GA6 small receives electricity (+5 volts) from the Arduino Nano. The Arduino Mega uses pins 10 ( $R_x$ ) and 11 ( $T_x$ ) for serial communication with the IOT GA6 Mini. Fig.1 depicts the connection between the ESP8266 and the Micro Controller. As with the IOT GA6 small, the ESP 8266 is powered by electricity (+5 volts) from the Arduino Mega. To enter AT mode, pin 34 must be powered by a voltage (+3.3 volt). Pin 14 ( $T_x3$ ) and pin 15 ( $R_x3$ ) are utilized for serial communication with the ESP 8266 (Wi-Fi module).

## CODES FOR SETUP AND CALIBRATION

No.	Remarks	Codes
1.	To replace pswd	*010; old_pswd: new_pswd#
2.	To replace price	*301; pswd: new_price#
3.	To replace SIEM name	*303; pswd: new_name#
4.	Info @kWH price	*123#
5.	Voltage calibration	*701; pswd: $V_{ref}/V_{SEM}$
6.	Current calibration	*702; pswd: $I_{ref}/I_{SEM}$

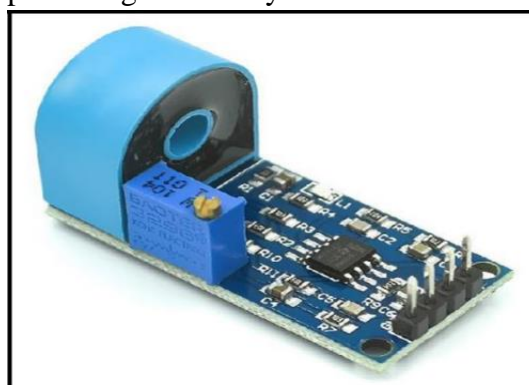
**TABLE I**

As shown in Fig.1 this module is equipped with the ZMPT101B series, which provides high-precision voltage transformation. Voltage sensor is used to check the EV battery's voltage levels while charging. This monitoring ensures that the charging voltage remains within acceptable limits, preventing overcharging, which can shorten battery life and pose safety issues.



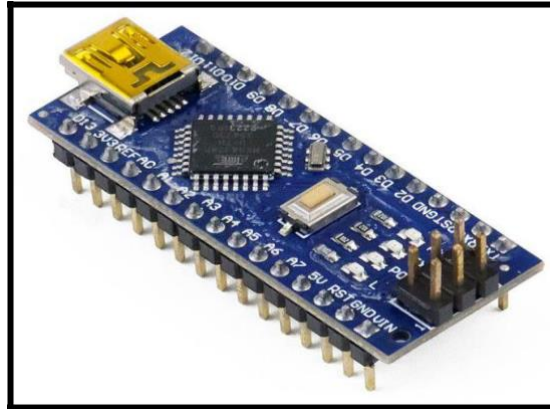
**Fig 1: ZMPT101B AC Voltage sensor**

As shown in fig.2 this ZMCT103C module comes with a unique donut-shaped IC design. To measure current, simply we pass the wire through this IC. Additionally, an onboard potentiometer allows users to adjust the amplification factor, offering flexibility in applications. This is used to measure the electric current that flows from the charging station to the EV's battery during the charging process. This measurement serves to monitor the charging rate and ensure that it stays within safe limits, preventing overloading of the charging infrastructure and protecting the battery from harm.



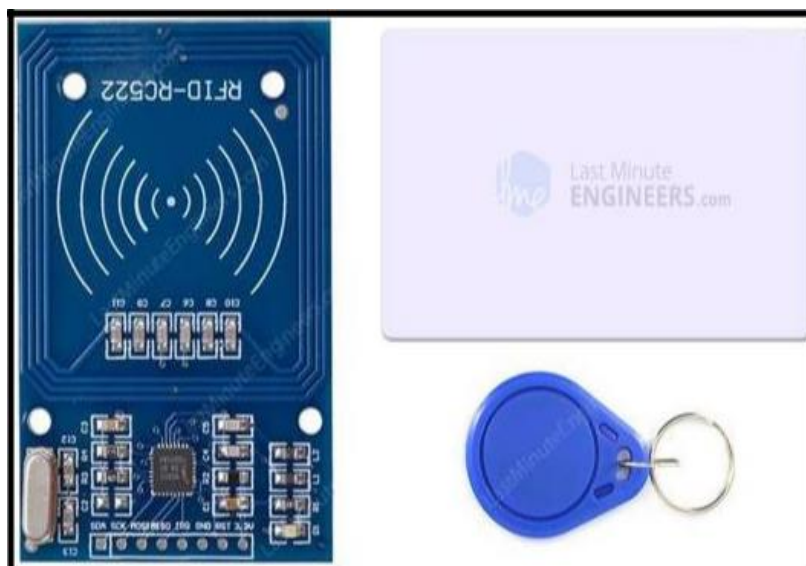
**Fig 2: ZMCT103C Current Sensor**

As shown in fig.3 the microcontroller that has been used is Arduino Nano it can provide a number of capabilities, including managing charging, regulating motor speed, keeping an eye on battery levels, and adding safety measures. You could use actuators to operate parts like the brakes or lights after using sensors to collect information on temperature, speed, and battery condition. Adding a wireless communication module may also make it possible to monitor and operate the car from a distance. Just make sure that the Arduino Nano's capabilities meet the needs of electric vehicle.



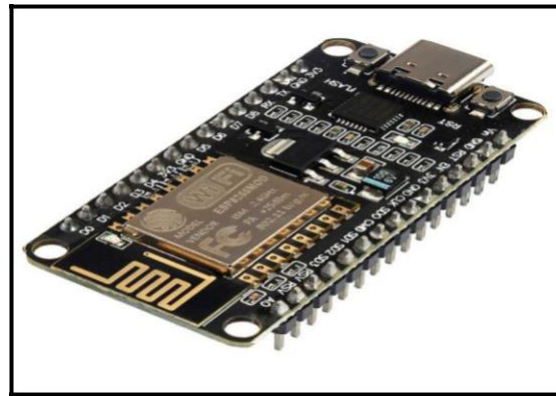
**Fig 3: Arduino Nano**

As shown in fig.4 RFID tags can replace traditional physical keys or key fobs, allowing users to access and start their EVs by simply presenting an RFID card or token. This keyless entry system improves convenience for EV owners and eliminates the need for carrying bulky keychains.



**Fig 4: RFID Tag and Reader**

As shown in fig.5 this ESP8266 NodeMCU will be incorporated into the EV charging infrastructure for smart charging capabilities. It can interface with charging stations and utility systems over Wi-Fi to plan charging sessions, optimize charging rates depending on renewable energy supply, and implement dynamic pricing schemes. Furthermore, NodeMCU supports user identification, payment processing, and data logging for billing and analytic. This data is stored in Thing Speak, an IoT platform that allows users to gather, analyze, and visualize data from internet-connected sensors and devices.



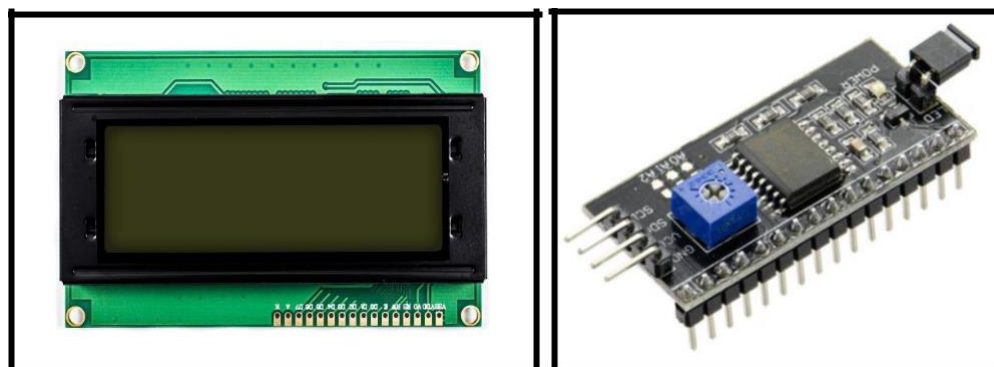
**Fig 5: NodeMCU ESP8266**

As shown in fig.6 DVM power adaptor is a 5V 2A SMPS charging system regulates and monitor stable voltage output, ensuring it remains within safe limits. It enhances safety of system by preventing overcharging or undercharging, optimizing battery life. The adaptor provides compatibility with various devices by optimizing power requirements accordingly.



**Fig 6: DVM Power Adaptor**

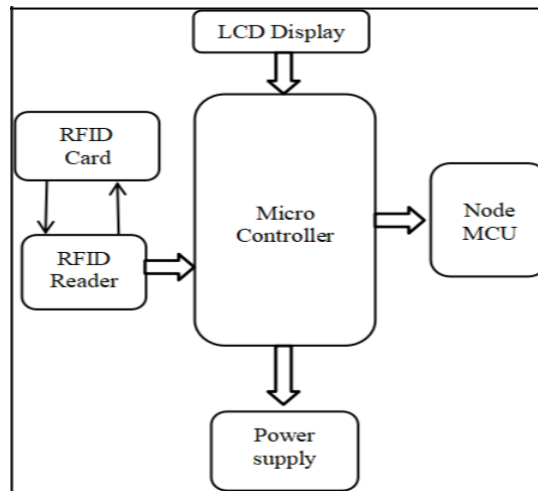
As shown in fig.7 LCD display in a smart charging system provides users with real-time charging information, including battery status, charging progress, and error messages. It enhances user experience by offering visual feedback and control options, such as setting charging parameters or selecting charging modes. Additionally, it can display system diagnostics and notifications, alerting users to any issues or maintenance requirements. The LCD display serves as an intuitive interface, improving usability and enabling efficient interaction with the charging system.



**Fig 7: LCD and I2C**

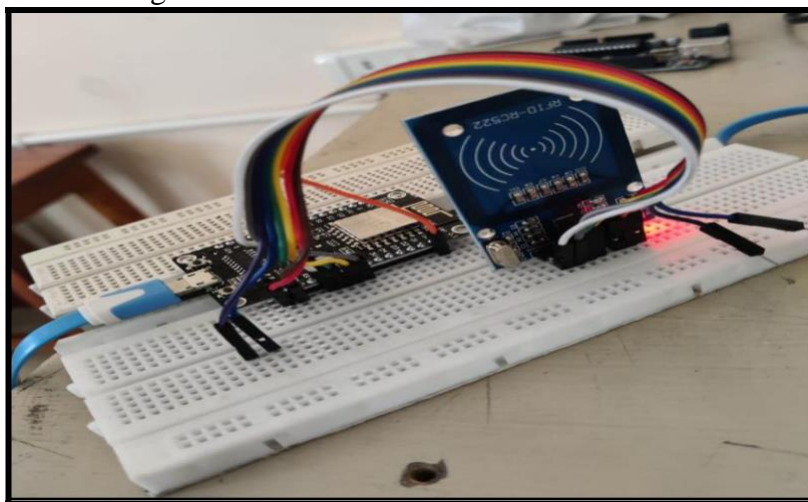
#### 4. FLOWCHART:

It depicts the operational flow of charging system in which all the metrics are met to deliver optimum performance in monitoring fair fare calculation and cut – off.



#### 5. RESULT AND DISCUSSION:

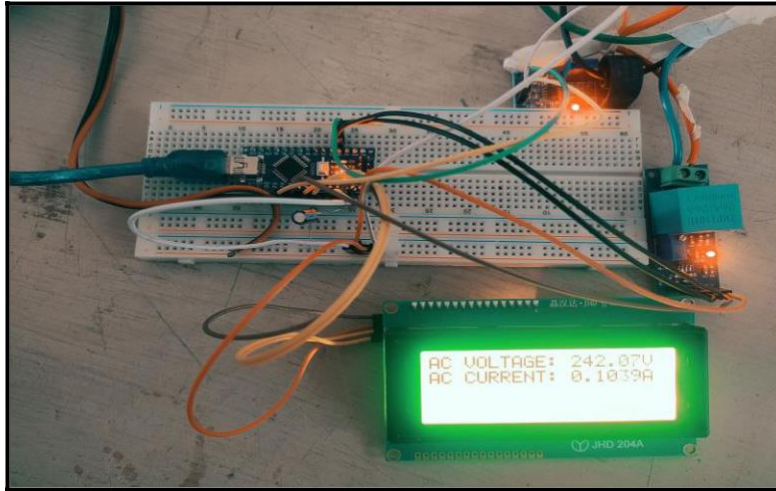
While tapping the RFID Tag into the RFID reader then the reader reads the specific value in the tag after that the signal passes through the Arduino controller then the controller switches the particular relay coil. Finally, the EV system is get charged for particular predetermined time duration. Wi-Fi module is connected with the Arduino controller while tapping the RFID tag the information has send to the owner and the total time of charging is stored in the cloud storage.



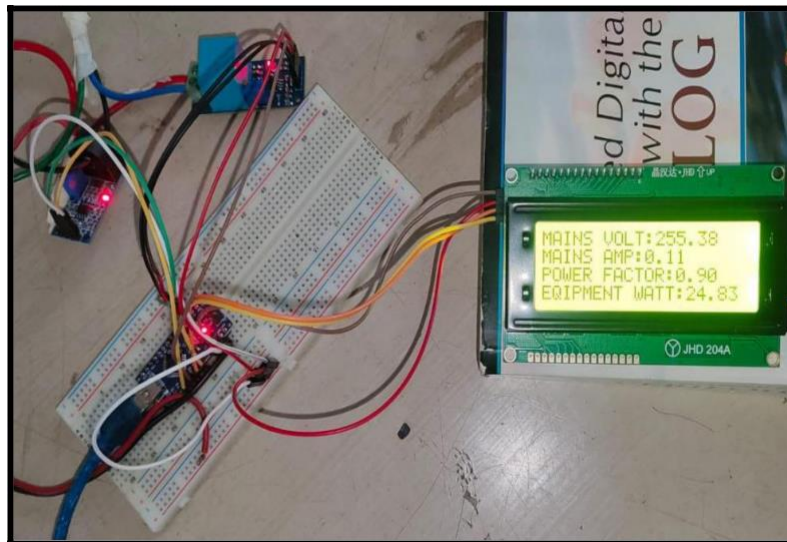
**Fig 8: Advanced RFID Charging Authentication**

The IoT-based flexy fare smart charging system combines IoT technology with dynamic pricing to optimize electric vehicle charging. By monitoring real-time data such as energy demand and grid congestion, the system adjusts charging rates dynamically. This encourages users to charge during off-peak hours, reducing strain on the grid and promoting renewable energy utilization users benefit from lower charging costs during non-peak hours, incentivizing behavior that aligns with grid sustainability goals. Additionally, the system enhances grid resilience by distributing charging load more evenly throughout the day.

## 6. SAMPLE OUTPUT:



**Fig 9: VI measurement and display**



**Fig.10. PF (power factor) and wattage of Load**

## 7. CONCLUSION:

The Flexy Fare Smart Charging System uses IoT technology to make electric vehicle charging better. It adjusts charging based on how many people need it at different times, which helps save energy and keeps the power grid stable. Charging prices change depending on demand, so people are encouraged to charge when fewer others are doing it. This helps balance the load on the grid and rewards people for charging in eco- friendly ways. The system also predicts future charging needs, making it more reliable and keeping users happy. Using this system helps cities become smarter and encourages cleaner ways to travel. Overall, it's a big step towards a cleaner and more efficient future for electric vehicles. Electrical Vehicle is the future trend for recent generations due to pollution free atmosphere which reduces global warming. Advancement of power electronics converters makes this as a feasible feature to charge our electrical vehicles from renewable sources.

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