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Telegram Application to Monitor and Control of Automatic Railway Crossing Prototype Using Automatic Transfer Switch

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ABSTRACT (10 PT)

A railroad crossing is a device that functions to close and open roads that limit or stop public traffic lanes so that vehicles stop temporarily and give priority to trains. Failure of a railroad crossing will have fatal consequences because it will cause accidents and cause fatalities, injuries, or other material losses. The accident occurred because there was no equipment or failure of officers when operating the railroad crossing. To overcome these obstacles, the railroad crossing was made automatically. This paper proposes a prototype control of an automatic railroad crossing using an automatic transfer switch (ATS) monitored by the Telegram application. The main power source of the railroad crossing prototype is a photovoltaic generator system consisting of solar modules, inverters, and batteries. ATS is proposed so that the system is able to automatically transfer the power supply from the solar power generator to PLN electricity if the battery voltage is not enough to drive the railroad crossing or vice versa. The results of the study show that the combination of a 50 Wp solar module and a VRLA battery (12V and 12Ah) is able to store and generate electricity to drive the railroad crossing. The INA219 sensor is able to measure the current, voltage, and power of the PV module and battery. Arduino Uno is able to process voltage and current sensor data, send and receive UART data (RX TX), and communicate with ESP8266. Data from ESP8266 can then be sent and monitored remotely by the Telegram application via Arduino-Uno. The results of DC current and DC voltage tests using the INA219 sensor between the Telegram application and Multimeter are able to produce errors below 5%. The Telegram application is also able to monitor the DC voltage and DC current of PV modules and batteries, as well as the DC adapter voltage and DC adapter current from PLN remotely, and the status of opening and closing the railway crossing gate based on the power supply selection by ATS.

1. INTRODUCTION

A railroad crossing is a tool that functions to close and open roads that limit or stop public traffic lanes so that vehicles stop temporarily and prioritize trains[1]–[3]. Failure to operate at a railroad crossing will have fatal consequences because it will cause accidents and cause fatalities, injuries, or other material losses[4]. The accident occurred due to the lack of equipment or due to the failure of officers when operating the railroad crossing[5]. To overcome these obstacles, an automatic railroad crossing was created.

A smart train opening and closing detection and warning system has been implemented in[2]. The proposed system uses sensors to detect trains and automatically open and close the train gates, capture images of detected obstacles and send them to the driver. An accident prevention system using an automatic level-crossing system has been observed in[3]. The system uses Arduino Uno as a platform with ATMEGA16U2 as a microcontroller, and ultrasonic sensors to detect passing trains and obstacles at the railroad crossing gates. A

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prototype of an automatic train gate control system using Arduino has been designed in[3]. The sensors function to detect the arrival of trains, send messages to Arduino, and turn on the bell so that users get information that the train is approaching. The system also drives the servo motor to close the gate and open it automatically after the train passes. A railroad safety system and smart crossing gates based on the Internet of Things (IoT) have been implemented[1]. The proposed system uses Force Sensitive Resistor (FSR) detectors, Light Dependent Resistor (LDR) detectors, laser detectors, Arduino Uno, and IoT. The automatic railway crossing gate control system based on the Arduino-Uno microcontroller has been introduced in[3]. A microcontroller unit called the Node Microcontroller Unit ESP 8266 series is used as a tool that sends information to the Telegram platform for notification when the ultrasonic sensor and vibration sensor detect the arrival of a train[6].

Automatic railway gate control to avoid accidents at level crossings has been designed in[7]. The system uses two IR sensors to drive a stepper motor that is remotely controlled by Arduino to open the gate and close the railway crossing gate again. LCDs and alarms are used as warning devices to drivers not to cross the gate when the train passes. Automatic rail gate control at level crossings has also been observed in[8]. The proposed system has a sensor near the crossing gate that is able to detect the arrival of a train. The test results show that the system has a shorter door-closing time and requires fewer workers compared to when manual doors were still used. An IoT-based prototype for automatic railway gate control for opening and closing railway crossing gates has been implemented[9]–[11]. The system operates using Arduino by receiving input signals from two sensors and sending information to the gate motor driver to open and close the gate remotely. Programmable railway entrance control using IR Sensors and Arduino has been designed[12]. The system is able to control and monitor regular traffic signals from the railway entrance automatically[13].

Automatic railway gate control to prevent accidents using Arduino and sensors has been implemented[12]. The system is equipped with RFID to collect data from the railway station, convey it to registered users, and emit infrared radiation to send train arrival information to Arduino. A prototype of an automatic railway gate system based on Arduino Uno to improve the efficiency and safety of road users at railway crossings has been proposed[14]. The system uses sensors to identify incoming trains and close the gates automatically. The system is able to monitor and control the integrated railway traffic system management robustly and intelligently using Arduino Uno. A gate control system with the ability to automatically recognize train arrivals supplied by solar energy has been designed[15]. The system uses servo motors to control the movement of the gate and infrared sensors to detect trains on the tracks equipped with bells and traffic signal lights[16]. The system uses solar panels and rechargeable batteries and is able to supply power independently so it is suitable for application in remote areas without an electric power supply[17]–[21].

Previous research on the control and monitoring system for crossing gates still uses PLN electricity[22]. This paper proposes a prototype of automatic railway crossing control using Arduino Nano and ESP8266 which is monitored by the Telegram application such as described in [23]–[32]. The main power source of the railway crossing prototype is a PV-generating system consisting of solar modules, solar charge controllers, and batteries, while PLN electricity functions as a backup source[33]. ATS functions as an automatic switch that transfers power from the solar module to PLN electricity if the battery voltage is not enough to drive the railway crossing or vice versa[34]–[42]. The Telegram application is used to monitor PLN voltage, PLN current, battery voltage, battery current, PV voltage, PV current, and the status of opening and closing the railway crossing gates via a smartphone screen[43]–[48]. The paper is structured in four parts. Section 2 discusses the description and flow materials of the proposed research method. Section 3 reveals the simulation results and discussions containing the results of the implementation of the tool, the results of the design of the current and voltage sensor validation testing software, battery voltage testing, testing the Telegram application working mechanism, and testing the tool under conditions supplied by solar modules and PLN. Finally, the conclusions and limitations of this paper are stated in Section 4.

2. METHOD

2.1. Proposed Method

Figure 1 shows a diagram of the working mechanism of the prototype monitor and control of the railway crossing using ATS. The equipment consists of three parts, namely input, microcontroller, and output. Each of the three parts has hardware and software. The input part consists of an INA219 sensor that functions to monitor the current and voltage values of the 50 Wp solar module. Furthermore, the current and voltage values are multiplied to obtain the existing power capacity generated from the solar module. The Solar Charge Controller (SCC) functions to regulate the charging current to the battery, avoid overcharging and overvoltage, and regulate the current taken from the battery so that the battery does not experience full discharge and overloading. A 12V VRLA-type battery with a capacity of 12Ah functions to store the electrical power generated by the solar module. In addition to being connected to the solar module battery, the ATS is also connected to the PLN source via a DC adapter. On the output part, there is also an INA219 sensor to monitor the current, voltage and power values on the battery side.

The software used is Arduino Nano developed by Arduino IDE 4. Arduino nano functions to process voltage and current sensor data and send and receive UART data (RX TX) with ESP8266. This component sends data to the telegram application and receives sensor data from Arduino. When a train passes, ultrasonic sensors 1 and 2 will send a signal to the ESP8266 to be processed, and order servo motors 1 and 2 to close the gate and reopen it after the train passes. The Telegram application functions as an interface to monitor several electrical parameter values. The parameters i.e. solar module voltage and current values, battery voltage and current, PLN source voltage and current, and the train gate opening and closing status. The ESP8266 sends a number of these values via a Wifi signal to be displayed on the user's smartphone screen using the Telegram application. Figure 2 shows a flowchart of the monitoring and control system. If the battery voltage is less than 11 V, the ATS will transfer the power supply from the solar module to the PLN source. On the other hand, if the PLN voltage is less than 11 V, the power supply will be transferred by the ATS from PLN to the solar module. Ultrasonic sensors 1 and 2 will detect the sound of a passing train by sending a signal to the ESP8266 and processing it to drive servo motors 1 and 2 so that they can close and open the train gates.

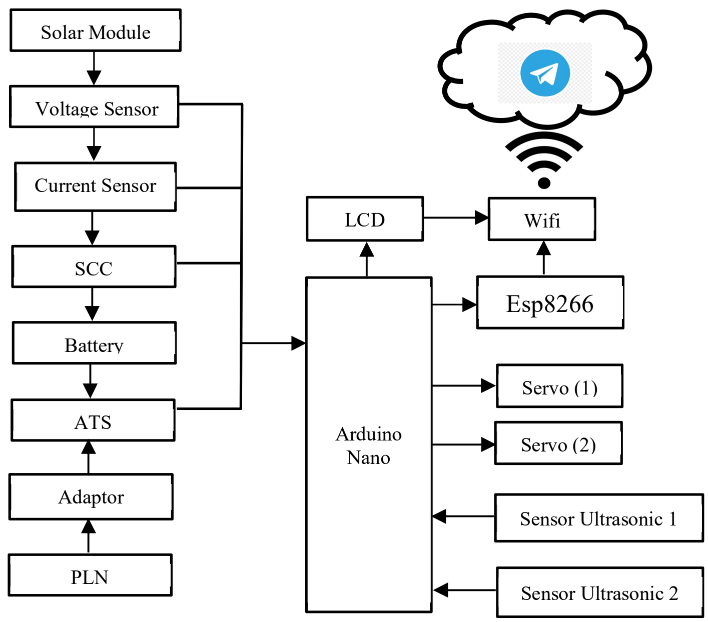


Figure 1. Flowchart of the Proposed Prototype Working Mechanism

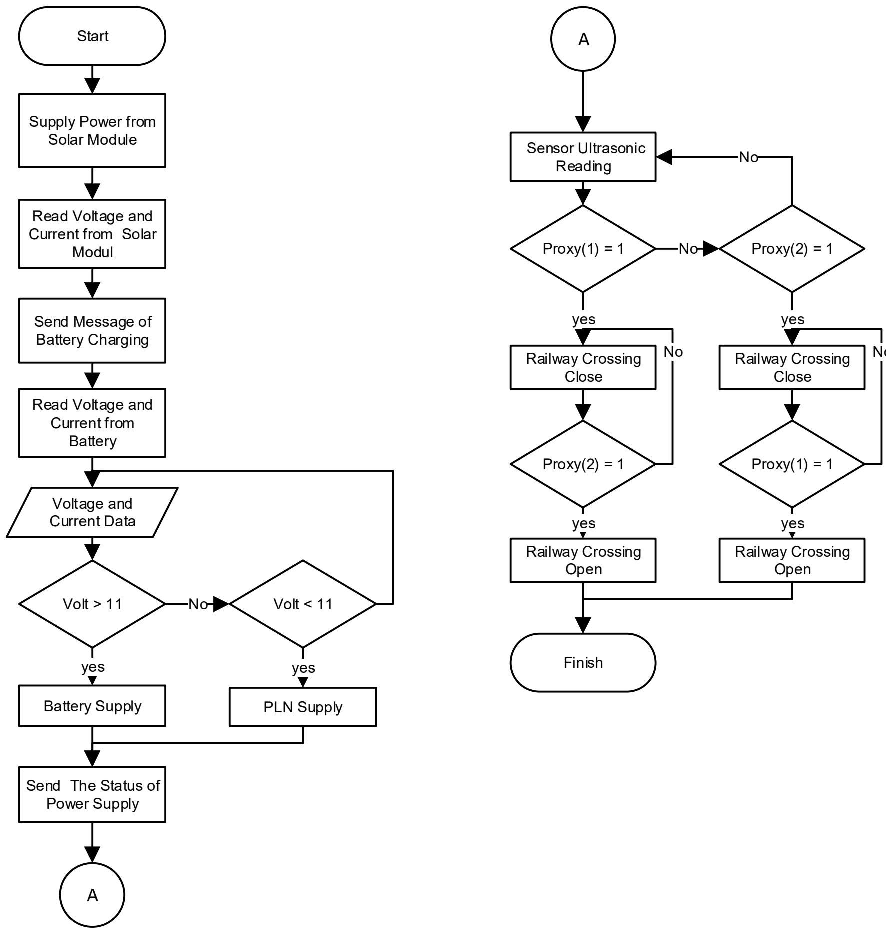


Figure 2. Flowchart of monitoring and controlling system

2.2. Sensor Validation Test

The study used two testing methods, namely using current and voltage sensors compared to measurements using a multimeter. To determine the measurement accuracy and performance of the prototype tool, the results of the sensor measurements must be compared with the results of the multimeter measurements. The results of the comparison of measurement data between sensor testing and multimeter measurements, produce a difference in the percentage of error in the current and voltage values formulated in the following Equation (1):

$$\text{Error (\%)} = \frac{\text{Multimeter Measurement} - \text{S} \qquad \text{Measurement}}{\text{Multimeter Measurement}} \times 100\% \tag{1}$$

3. RESULTS AND DISCUSSION

3.1. Prototype Implementation

Figure 3 shows the results of the hardware design of the prototype monitor and control of the railway crossing using ATS. The numbering in the figure indicates the parts used in the equipment. The parts include i.e. (1) Battery, (2) Solar Charger Control, (3) INA219 Sensor, (4) 5 Volt DC Relay, (5) ESP8266, (6) Arduino Nano, (7) 20x4 LCD, (8) Lamp load, (9) Ultrasonic sensor, (10) Railway crossing, (11) Train model, (12) Solar module, and (13) Adapter.

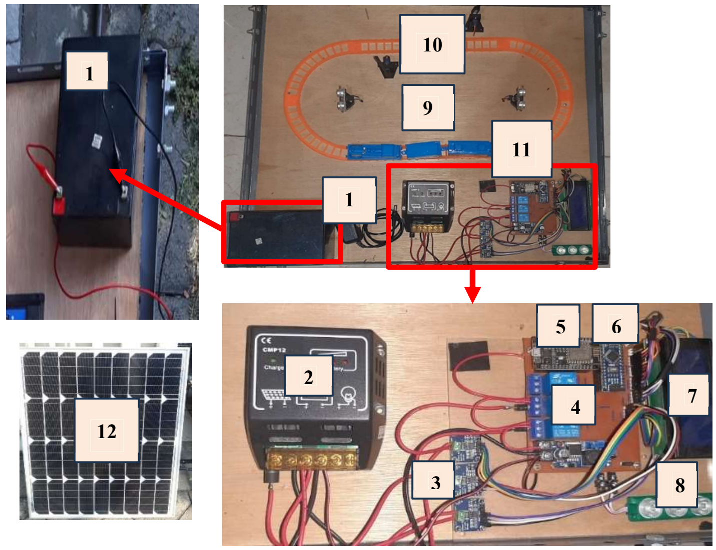


Figure 3. Prototype Monitor and Control of Railway Crossing Gate Using ATS

3.2. Software Design

Figure 4 shows the Telegram application screen display and the results of testing the railway crossing monitoring equipment on the smartphone screen in the ATS condition connected to the solar module source. The screen display shows that the prototype is able to monitor battery voltage, battery current, PV voltage, and PV current of 10.27 V, 0.21 A, and 11. 03 A, and 0.31 A, respectively. The screen display also shows the condition of the railway crossing in the open condition.

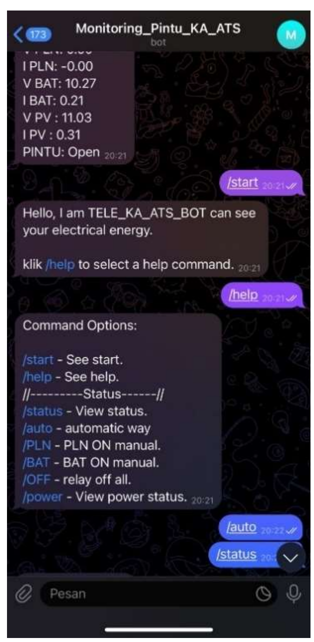


Figure 4. Display of parameters and status of the train gate using the Telegram application

3.3. Current and Voltage Sensor Validation Testing Using INA219 Sensor

The INA219 current sensor test was conducted to determine the performance of the INA219 current sensor and to test the program that had been designed by the authors. The INA219 current sensor test was conducted by comparing the results of the sensor readings and digital multimeter measurements. The results of the INA219 current sensor test are shown in Table 1. In addition to current, the INA219 sensor is also used to measure voltage parameters. Similar to the current sensor test, the voltage sensor test was conducted to determine the performance of the voltage sensor and to test the program that had been designed by the authors. The results of the voltage test using the INA219 Sensor are presented in Table 2. Using Equation 1, the current and voltage measurement errors between the sensor and the multimeter are then obtained and the results are presented in Tables 1 and 2.

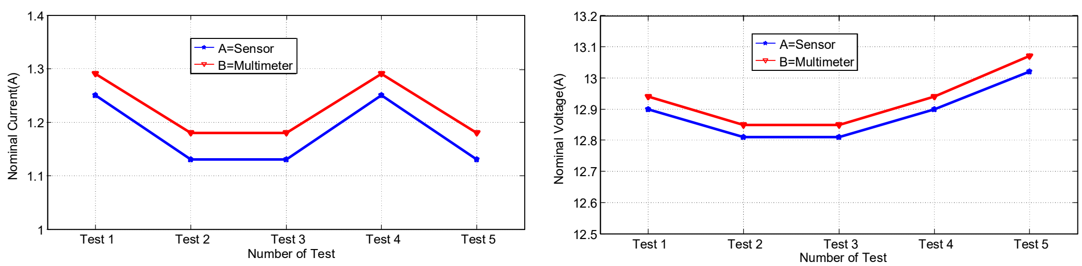
Table 1. Current Test Validation Results

No	Current Sensor (A)	Multimeter (A)	Deviation	Error Measurement
1.	1.25	1.29	0,04	3.10
2.	1.13	1.18	0.05	4.24
3.	1.13	1.18	0.05	4.24
4.	1.25	1.29	0.04	3.10
5.	1.13	1.18	0.05	4.24
			Average	3.80

Table 2. Voltage Test Validation Results

No	Voltage Sensor (V)	Multimeter (V)	Deviation	Error Measurement
1.	12.90	12.94	0,04	0,31
2.	12.81	12.85	0,04	0.31
3.	12.81	12.85	0,04	0.31
4.	12.90	12.94	0,04	0,31
5.	13.02	13.07	0,05	0,38
			Average	0.33

Figures 4.a and 4.b respectively show a comparison of current and voltage values when measured using a digital multimeter and the INA219 sensor.



(a) (b)

Figure 4. Comparison of measurement results using a digital multimeter and INA219 sensor for (a) current and (b) voltage.

Figure 4a shows that measurements using a digital multimeter and the INA219 Sensor are able to produce an average current measurement error of 3.80%. Figure 4b shows that using both tools is able to produce an average voltage measurement error of 0.33%. The test results show that the use of the INA2019 sensor is able to produce relatively good current and voltage measurement accuracy because the error value is still within the maximum limit of 5%.

3.4. Battery Voltage Testing

Testing the voltage value on the battery before and after charging can be seen in Table 3 below:

Table 3. Battery Voltage Testing

No	Voltage Before Charging (V)	Voltage After Charging (V)
1.	11,55	13.24
2.	11,67	13.33
3.	11.73	13.41
4.	11.83	13.49
5.	11.88	13.55
Average	11.74	13.41

Hasil pengujian tegangan baterai rata-rata sebelum pengisian adalah 11,74 V. Selanjutnya setelah proses pengisian, tegangan baterai rata-rata meningkat menjadi 13,41 V.

3.5. Testing How Telegram App Works

The design of the Telegram application menu is done to show status data on the tool. Figure 5 shows the performance of the tool displayed on the Telegram application status on the Smartphone screen.

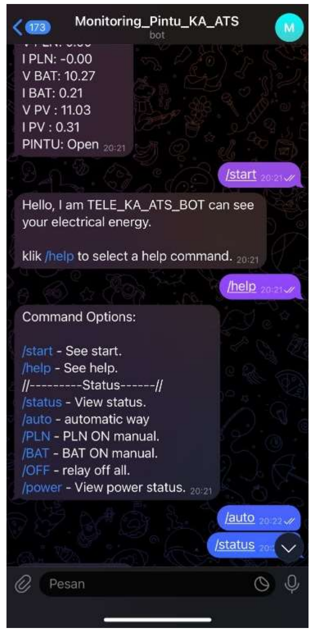
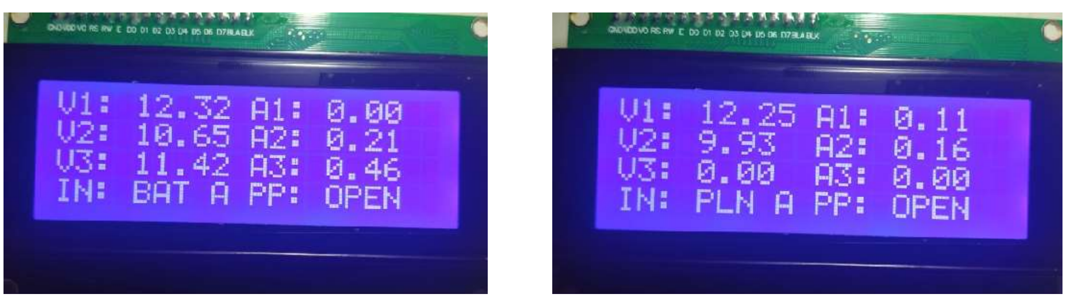


Figure 5. Telegram Status Display

Figure 5 shows the monitoring of the device's performance using the Telegram application. V PLN, I PLN, V Bat, A Bat, V PV, A PV, and train gate show i.e. DC adapter voltage, DC adapter current, Battery voltage, Battery current, Solar module voltage, Solar module current, and train gate status. The values of the battery voltage, battery current, solar module voltage, solar module current, and train gate status show i.e. 10.27 V, 0.21 A, 11. 03 V, 0.31 A, and Open status respectively.

3.6. Testing the Tool in Conditions Supplied by Solar Modules and PLN

Figures 6.a and 6.b show the results of monitoring the tool testing when the ATS is connected to the solar module and PLN power supplies respectively.



(a) (b)

Figure 6. Results of monitoring the tool testing when the ATS is connected to

(a) the solar panel power supply and (b) PLN

Figure 6 shows the monitoring of the device performance using LCD. V1 PLN, V2 Battery, V3 Solar Module, A1 PLN, A2 Battery, and A3 Solar Module each show: Adapter voltage, battery voltage, solar module voltage, adapter current, battery current, and solar module current. Figure 5a shows the values of adapter voltage, battery voltage, solar module voltage, adapter current, battery current, and solar module current. respectively 12.32 V, 10.65 V, 11.42 V, 0.00 A, 0.21 A, and 0.46 A. In this condition the ATS is automatically connected to the solar module source because the nominal battery voltage is above 11 V. Figure 5b shows the values of adapter voltage, battery voltage, solar module voltage, adapter current, battery current, and solar module current. each of 12.25 V, 9.93 V, 0 V, 0.11 A, 0.16 A, and 0.00 A. In this condition, the ATS is automatically connected to the PLN source because the nominal battery voltage is below 11 V.

4. CONCLUSION AND LIMITATION

The prototype of automatic railway crossing control using ATS monitored by Telegram application has been proposed. The main power source of the railway crossing prototype is a PV-generating system consisting of solar modules, a solar charge controller, and a battery. The ATS device is proposed so that the system is able to automatically transfer power supply from solar modules to PLN electricity if the battery voltage is not enough to drive the railway crossing or vice versa. The results of the study showed that the combination of 50 Wp solar modules and VRLA batteries (12V and 12Ah) is able to store and produce electrical energy to drive the railway crossing. The INA219 sensor is able to measure the current, voltage, and power of the solar module and battery. Arduino Nano is able to process voltage and current sensor data, send and receive UART data (RX TX), and communicate with ESP8266. Data from ESP8266 is then sent and monitored remotely by the Telegram application via Arduino-Nano. The results of current and voltage testing using the INA219 sensor with a multimeter are able to produce errors below 5%. The Telegram application is also able to monitor the voltage and current of solar modules and batteries, as well as the adapter voltage and adapter current from PLN remotely, as well as the opening and closing status of railroad crossing gates based on the nominal battery voltage by ATS. The more test data, the greater the sensor data recorded and transferred from the prototype monitoring system to the Telegram application. This condition causes data transmission from the ESP32 module to the Telegram application to result in an average time delay of between 5 and 7 seconds. A solution to increase the bandwidth capacity of the internet network signal for data transfer is needed by users to overcome these obstacles.

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