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Design and Development of a GPS-Based Vehicle Tracking System with Electric Vehicle Integration

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ABSTRACT:
This research presents the design and development of a GPS-based vehicle tracking system integrated into a two-wheeler electric vehicle (EV) for improved mobility and security. The objective is to create a cost-effective solution for tracking vehicle locations via Google Maps, ensuring accurate monitoring and enhanced transportation efficiency. The system utilizes an Arduino MEGA microcontroller as the main processing unit, coupled with a Ublox NEO-6m GPS module for coordinate tracking and a SIM 900A GSM module for communication with users. While the system performs reliably in outdoor environments, indoor performance is limited due to GPS signal obstruction. Future improvements may involve integrating a high-performance GPS module, such as the NEO-6P, to enhance signal strength and accuracy. To address transportation gaps in rural areas, the project extends to developing a two-wheeler EV with a top speed of 25 kmph. This EV reduces transportation costs compared to internal combustion engine (ICE) vehicles and supports environmental sustainability. By integrating GPS navigation and remote monitoring, the system ensures vehicle security, efficient route tracking, and real-time status updates. Additionally, an online payment system enhances the convenience of transportation services. If the vehicle crosses a defined radius without authorization, remote locking features enable security enforcement.

This integrated system employs minimal components such as batteries, motors, controllers, and converters, ensuring low-cost production and maintenance. The overall focus is on improving affordability, safety, and efficiency, particularly in rural areas.

Key Words - Electric vehicles (EVs), Battery, Brushless DC Motor (BLDC), DC-DC converters, Permanent Magnet (PM), Hub Motor, GPS Tracker, Miniature Circuit Breaker (MCB).

1. INTRODUCTION:

In recent years, the increasing reliance on traditional fuel-powered vehicles has raised significant environmental concerns. The pressing issues of air pollution, rising fuel costs, and the depletion of fossil fuels have driven the urgent need for alternative transportation solutions. Electric Vehicles (EVs) have emerged as a promising solution, offering zero-emission transportation while maintaining efficiency comparable to traditional internal combustion engine (ICE) vehicles. This growing shift toward EVs aligns with global efforts to reduce carbon footprints and achieve sustainable mobility. Among various EV designs, electric scooters have gained considerable attention due to their compactness, affordability, and practicality for short-distance travel. The core of an e-scooter's functionality lies in its electric system, which comprises key components such as the battery, motor, motor controller, and additional electronic equipment. These elements collectively provide power to the motor, enabling vehicle propulsion. The stored energy, whether in chemical or electrical form, is efficiently converted into mechanical energy to drive the wheels.

A pivotal component in this system is the brushless DC (BLDC) motor, mounted on the rear wheel hub. This motor is widely chosen for its compact size, high efficiency, and noiseless operation, ensuring a smooth and safe riding experience. Additionally, integrating GPS technology into EV systems has improved security features, allowing vehicle owners to track their vehicles' precise locations in real-time. As EV adoption continues to grow, innovations in tracking systems and electric power management will play a vital role in ensuring sustainable and secure transportation. Our primary objectives in designing and developing an e-scooter are outlined as follows. Cost Efficiencies. Emission Reduction. Overcoming Electric Vehicle Drawbacks. Enhancing Life Span and Efficiency. ELECTRIC VEHICLE COMPONENTS Key Components in Electric Scooter: Battery Charger, Battery, Motor Controller, BLDC HUB Motor, DC-DC Converter, Wiring harness.

2. METHODOLOGY:

Based on block diagram from Figure 1, Arduino MEGA is used to control the whole process between GPS module and GSM module. GPS module is used to get the coordinates of the vehicle while GSM module is used for sending coordinates to user by message. In order to track the vehicle location, first it needs to find the coordinates of vehicle. GPS module will connect with satellite continuously to get the coordinates. Then GPS will send the coordinates to Arduino UNO. Arduino MEGA will extract the required data that received by GPS. When GSM module receive command from user by massage, GSM module will cooperate with Arduino MEGA to reply the message and send it to user by using GSM module. The message contains the coordinates of vehicle location.

Figure 2 shows the flowchart of GPS Based Vehicle Tracking System. First, GPS will be connecting continuously with satellite to routing the coordinate. Once the LED at GPS module was blinking, it means the location was locked. Then, check the LED at GSM Module. It will be blinking after get the mobile communication line.

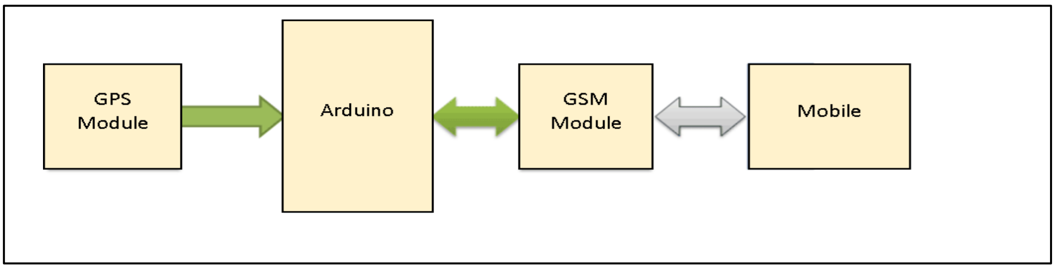

Figure 1: Block diagram of GPS

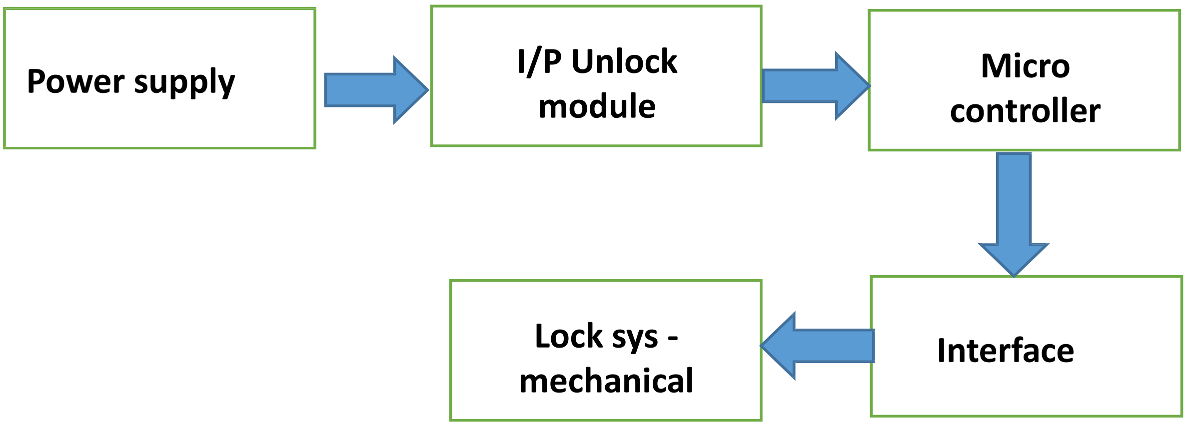

Figure 2: flowchart of power Based Vehicle Tracking System

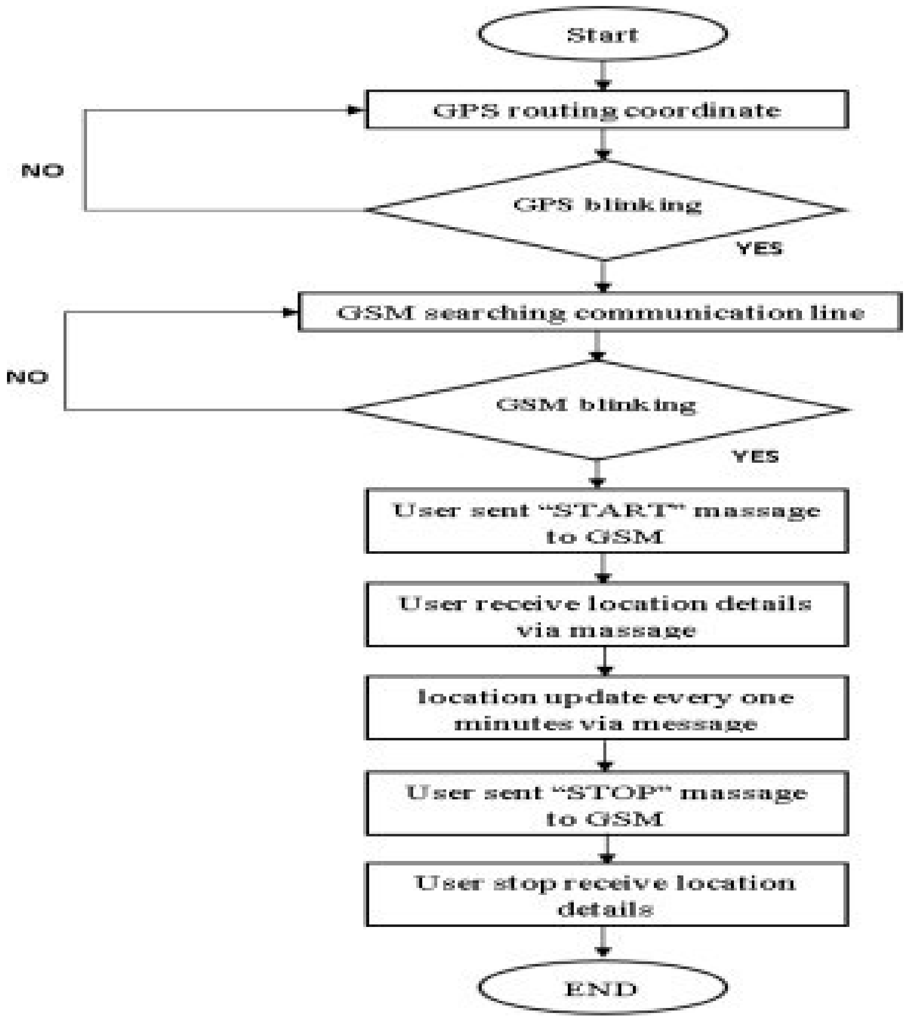

Figure 3: Algorithm for GPS Based Vehicle Tracking System

After all LED was blinking, user can send ―START‖ to GSM module via massage. GSM will reply the message it shows in figure 3 The message will contain location of vehicle detail and URL link to Google Maps. The location will be updated every one minute. In order to terminate the system, user just need to send ―STOP‖ to GSM. Then, the system will stop sending message to user's phone

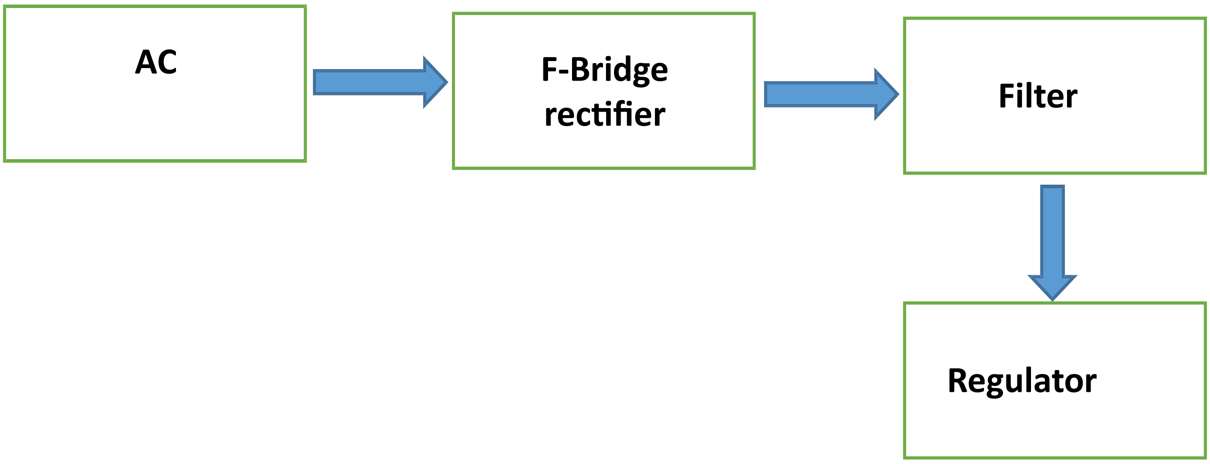

Figure 4: Block diagram for system module

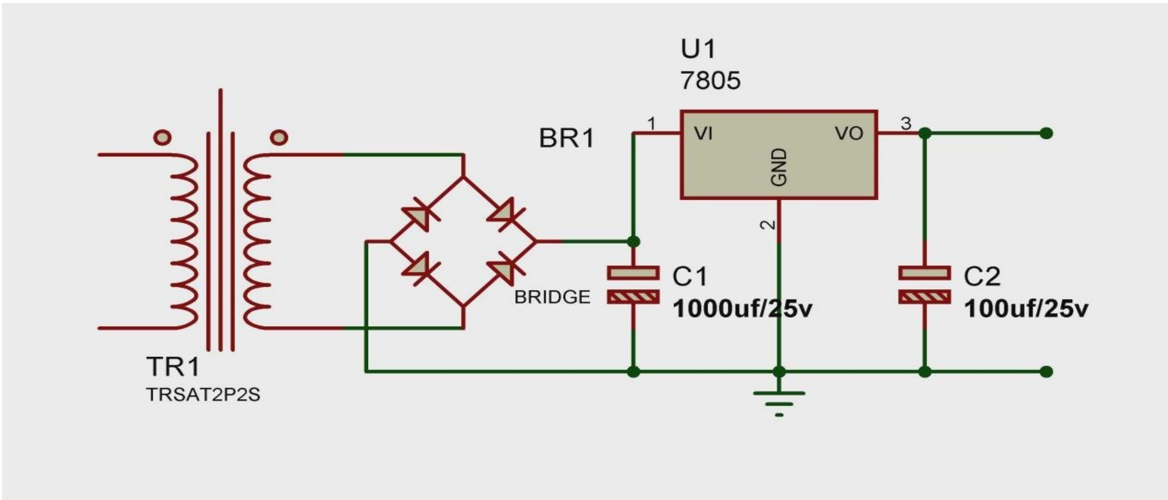

Figure 5: Block diagram

The battery charger is essential to making the most of the battery's capacity. Among a battery charger's noteworthy characteristics are its effectiveness and dependability, weight, and price, duration of charge, and power density. The charger's features are determined by its parts, switching techniques, algorithms for control. A microcontroller can be used to digitally implement this control method. There are two steps to the charger. The AC-DC is the first and it shows in Figure 5. converter with power factor correction, which ensures a high-power factor by converting the grid's AC voltage to DC. Depending on the method used for charging, the subsequent stage adjusts the battery's voltage and current. The charger can be either

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unidirectional, meaning it can only charge an EV battery from the grid, or bidirectional, meaning it can both charge the battery in charging mode and pump any extra energy from the battery back into the grid This is the 48-volt, 5-amp lithium-ion battery.

charger circuit for a 48-volt, 25-amp battery, as seen in. This circuit is for a current-limited lithium-ion battery charger, and it is based on the well-known IC LM 317 variable voltage regulator. The resistance of resistor R2 determines the charging current. The charging voltage is determined by POTR4 and resistor R3. Transformer T1 reduces the mains voltage, while bridge D1 corrects the imbalance. The filter capacitor is C1. When the charger is turned off or there is no mains power available, diode D1 stops the battery's current from flowing backward and it shows in Figure 6.

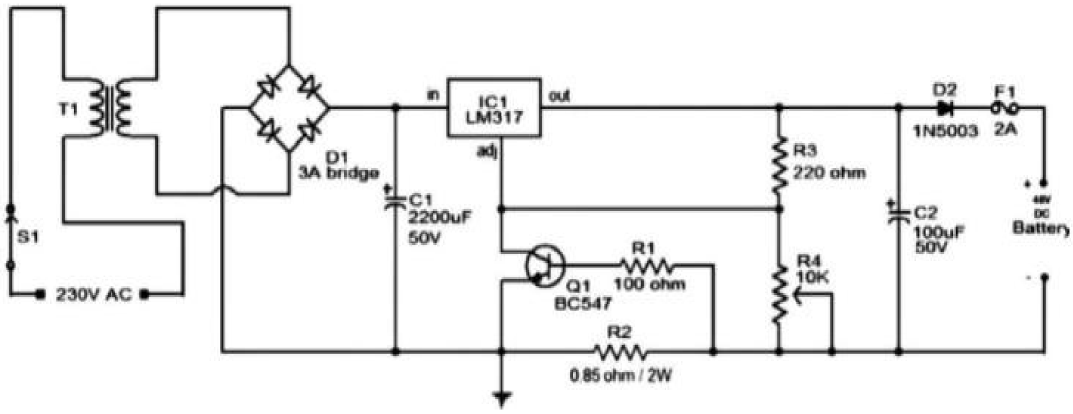

Figure 6: The circuit diagram of Battery charger

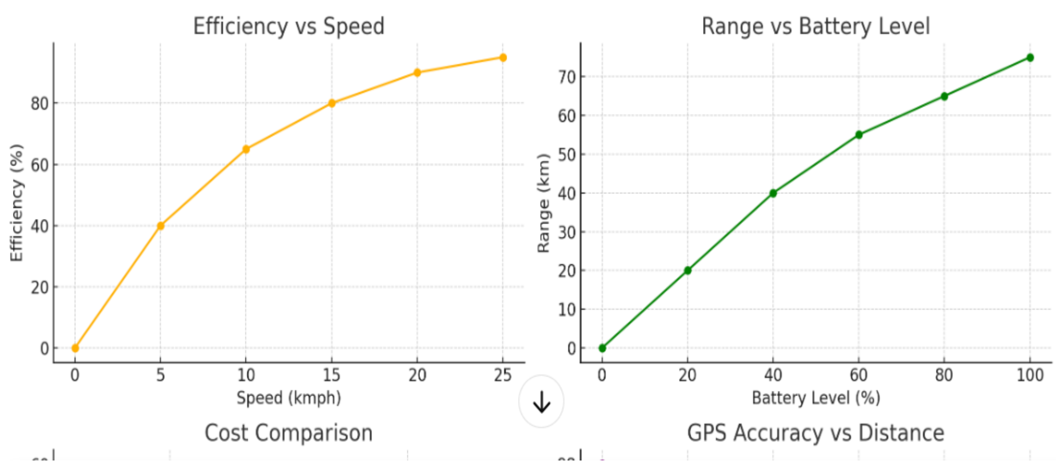

Figure 7: Comparison of Efficiency Vs Speed and Batter Vs Range

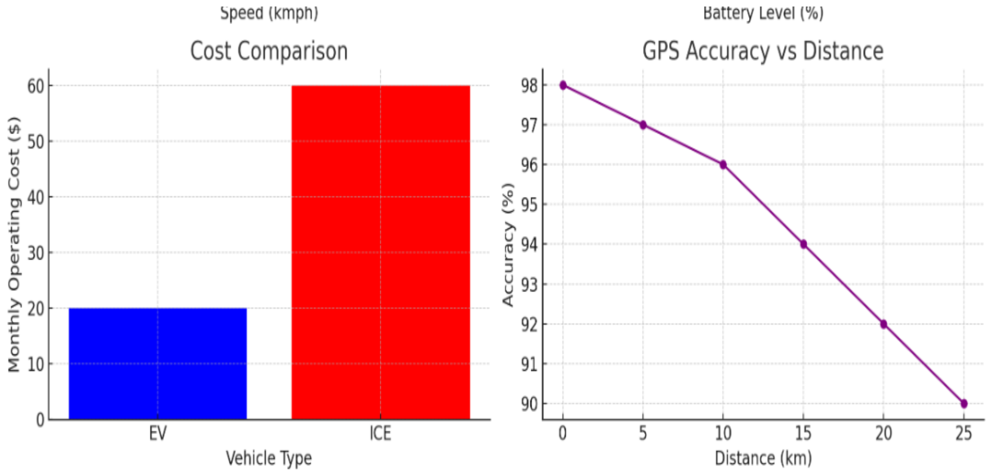

Figure 8: Comparison of Cost by Vehicle and GPS Vs Distance

Software Development:

Figure 3 shows the software that used to develop the program, namely IDE software. The software is an open-source Arduino Software, the code will be written on this software and it will be upload to Arduino board.

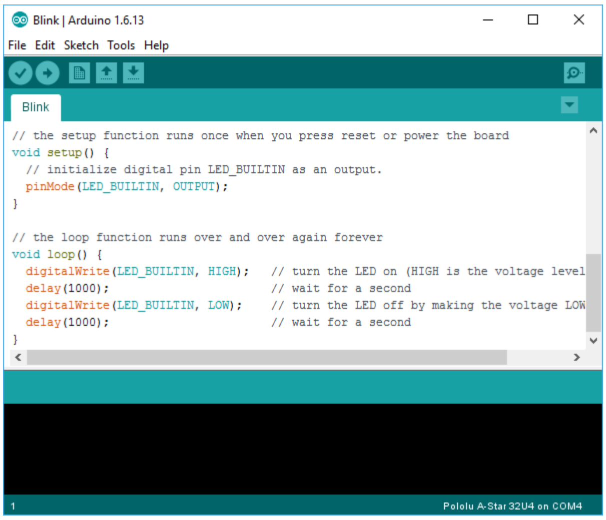

Figure 8: Arduino Data

Arduino Mega 2560 is a microcontroller board based on the ATmega2560. As shown in Figure 4, it has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller and simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started [3].

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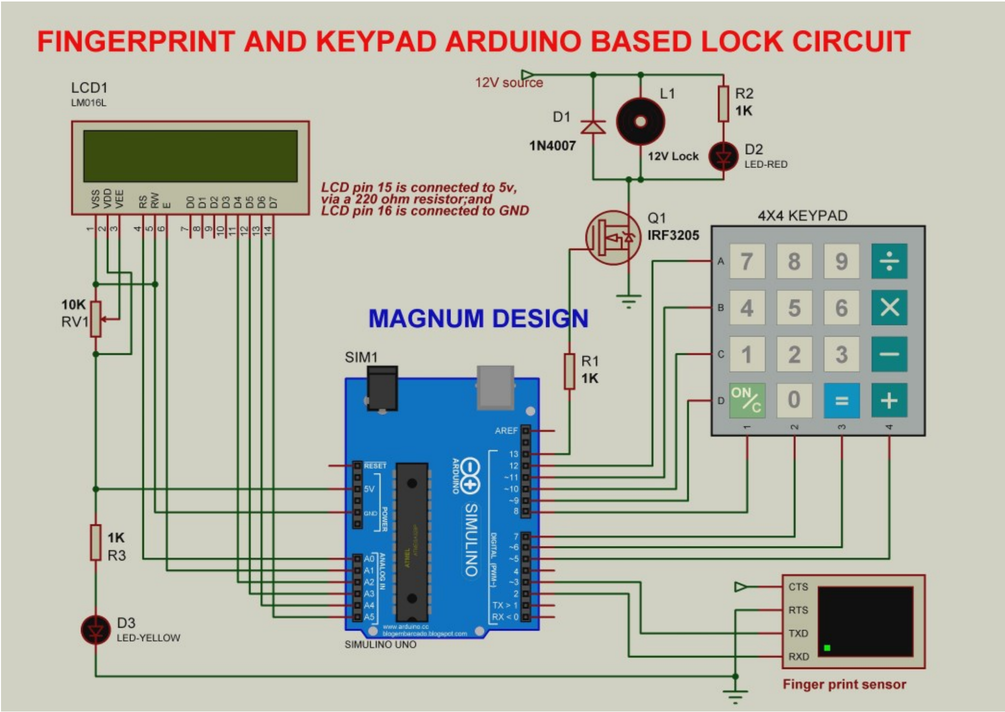

Figure 8: Software design of GPS system

Figure 9: SIM900A Module

Figure 9 shows SIM900A Module which is built with Dual Band GSM/GPRS based SIM900A module from SIMCOM. It works on frequencies 900/ 1800 MHz. SIM900A can search these two bands automatically. AT Commands can also set the frequency bands. The baud rate is configurable from 1200- 115200 through AT command. The GSM/GPRS module has internal TCP/IP stack to enable connection with internet via GPRS. SIM900A is an ultra-compact and reliable wireless module [5].

NEO-6 module is a series of family stand-alone GPS receivers featuring the high-performance UBLOX 6 positioning engines. These flexible and cost-effective receivers offer numerous connectivity options in a miniature 16 x 12.2 x 2.4 mm package. Their compact architecture and power and memory options make NEO-6 modules ideal for battery operated mobile devices with very strict cost and space constraints [4].

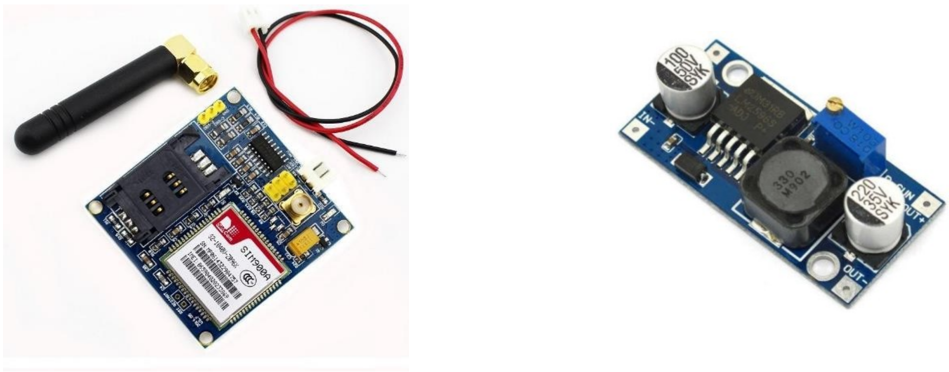

Figure 10: EEPROM

As can see on Figure 10, this module has an external antenna and built-in EEPROM. the project prototype, while Figure 10 shows the picture of component in the system.

Prototype:

A GPS Based Vehicle Tracking System prototype has been developed for the project. Figure 8 shows the general view of the project prototype, while Figure 11 shows the picture of component in the system

Figure 11: Vehicle Tracking System prototype

Asdasd:

The component in a blue box is DC-DC Stepdown, the yellow box is GSM Module while the green box is GPS Module and the red box is an Arduino Mega Figure 11 shows the view of the project while been test. Firstly, the program will be upload to Arduino MEGA. Then wait for the GPS for routing the coordinate and GSM for connecting a phone line. After get the coordinate, GPS will blink every 3-4 second. Same with GSM, after get the line, it will blink 3-4 second. In the figure, the LED for GPS and GSM indicators were blinking, which mean the coordinate was already locked. Then it ready to send an information if it received a command from user. The vehicle tracking system was test at outdoor and indoor. The result was depending at the surrounding location. Figure 11 shows the general view of the project. First the program will be upload to Arduino. Then wait for the GPS for routing the coordinate and GSM for getting a phone line. After get the coordinate, GPS will blink every 3-4 second. Same with GSM, after get the line, it will blink 3-4 second. In the Figure 11 the LED at GPS and GSM were blinking, which mean the coordinate was already lock and it was ready to send an information if receive a command from user. The data of coordinate also can be check at serial monitor at IDE program.

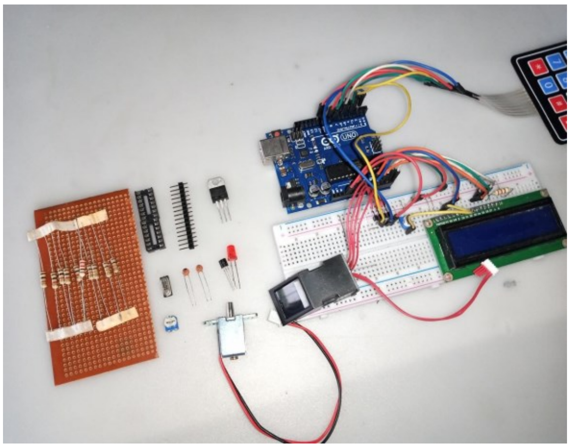
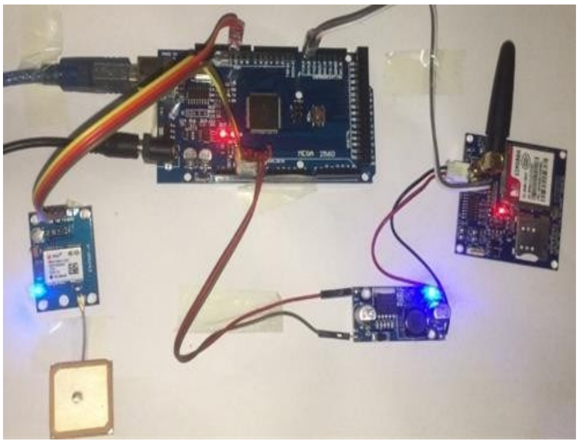


Figure 12: Working models

It will show the longitude, latitude and time taken. The user phone number will be exposed on the serial monitor. This program had been setup with own term to cooperate between user and the vehicle tracking system. In this program two term was used which is ―START‖ and ―STOP‖. The ―START‖ term is using to active the system, meanwhile term ―STOP‖ for terminate the system. Figure 12 shows serial monitor when receive ―START‖ command from user via massage from the user. After receive ―STOP‖ command, the system will terminate the connection with user but still routing the latest coordinate. Once the user sent ―START‖ to GSM module. GSM module will cooperate with Arduino and Arduino will extract data that received by GPS module.

Conclusion:

This study successfully demonstrates the development of a GPS-based vehicle tracking system integrated with electric vehicle (EV) technology to enhance security and transportation efficiency. By leveraging a GSM module, the system allows vehicle owners to track their stolen or lost vehicle via coordinates and a Google Maps link. The system's ability to provide real-time location updates every minute significantly aids in vehicle recovery.

Future improvements, such as integrating a high-performance GPS module like the NEO-6P for better accuracy and utilizing IoT technology for cloud-based data storage, can further enhance the system's reliability. The adoption of EVs, particularly electric scooters, addresses environmental concerns by reducing air pollution and offering a cost-effective transportation alternative. Their suitability for urban and rural areas, where fuel access may be limited, makes e-scooters a practical solution. By combining GPS tracking technology with electric vehicle innovation, this project contributes to improved security, reduced crime rates, and enhanced sustainability in modern transportation systems.

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