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Modified E-Bike System with IoT-Based Diagnostics and Control

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Abstract: *This Paper aims to promote sustainable urban mobility by designing and developing an affordable, low-maintenance electric two-wheeler. This prototype emphasizes accessibility, affordability, and simplicity in response to the limits of current electric vehicle (EV) solutions—such as their high cost, complicated technology, and limited local manufacturability—and the growing need for environmentally friendly transportation. The electric bike was built with a rechargeable lithium-ion battery pack, brushless DC (BLDC) motor, and a specially made metal chassis. To reduce costs and promote repairability, locally sourced materials and components were used. In order to improve user experience without adding to system complexity, the architecture also permits the incorporation of fundamental IoT features like battery monitoring and anti-theft tracking. The prototype proved to be a feasible choice for everyday urban travel, particularly in underdeveloped nations, as initial testing revealed satisfactory performance in terms of speed, battery efficiency, and ease of use. Through practical innovation and economical engineering, our research advances the larger objective of democratizing electric mobility.*

Keywords: Electric Bike, Design of Bike, motor, Battery, Controller, IOT Module

I. INTRODUCTION

Overview of Electric Vehicles (EVs) Background A potential remedy for the escalating environmental issues brought on by the usage of fossil fuels and greenhouse gas emissions is the electric vehicle (EV). Electric motors that get their power from rechargeable batteries power EVs, in contrast to conventional cars with internal combustion engines. This change promises reduced running expenses, quieter operation, and increased energy efficiency in addition to lessening dependency on non-renewable resources. Government incentives, growing awareness of climate change, and battery technological breakthroughs have all contributed to the global shift toward electric mobility [1, 2].

Transportation's Need for Sustainability Cities are dealing with major issues like air pollution, traffic congestion, and growing fuel prices as a result of the fast urbanization and population expansion. Particularly in developing nations, traditional two-wheelers are a major source of urban air pollution. As a result, there is a pressing need to create ecologically friendly and reasonably priced sustainable transportation options for the typical commuter [3]. Because of their small size, convenience of use, and minimal environmental impact, electric two-wheelers offer the perfect option [4, 5].

Objective of the Project This project's main goal is to create a low-cost, simple electric two- wheeler that may be used as an environmentally friendly form of urban transportation. The prototype seeks to show that it is feasible to produce an effective electric car that satisfies users' daily travel demands utilizing locally accessible materials and simple production processes. This research emphasizes affordability, energy efficiency, and ease of maintenance to make EV adoption more accessible, especially in resource-constrained regions [6].

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II. SYSTEM COMPONENTS AND DESIGN

The EV bike is composed of several essential components that work in unison to optimize the use of battery energy sources:

- Scrab bike. For this project, we have used a four-stroke gasoline powered bike. And then we removed engine, gearbox and other components. As I replaced these components with motor, battery and controller.
- BLDC Motor. For getting high efficiency, speed, high initial torque and low maintenance a BLDC motor is preferred as it is good for the load carrying capacity, on considering the vehicle weight and the passenger weight this motor is selected. This BLDC motor is powered by lithium-ion battery pack and is controlled by a controller.
- Specification 48V & 1000W
- LI ION Battery: Lithium-ion (li-ion) batteries are a type of rechargeable battery commonly used in various electronic devices, including E-bikes. The selection of battery pack is an important part of an electric vehicle. WE have done several calculations then I selected battery pack. The lithium-ion battery has less weight compared to the lead acid battery.
- Specification: 48V & 24AMP
- Battery Charger: For lithium-ion battery pack we have selected 48 V and 6 Amp li-ion battery charger. Basically, a charger is a device that converts alternate current received through charge port to direct current and control the amount of current flowing into the battery pack
- Specification: 48V & 6Amp.
- Controller: While BLDC motors, they do require control electronics and regulated power supplies. Thus, a 48 V drive controller is selected which is required to control the BLDC motor. The controller choosing for the project must match up with the battery specifications as well as with the motor specifications.
- IOT : The Internet of Things (IoT) refers to a network of physical objects - "things" - that are embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. These "things" can range from everyday household items to sophisticated industrial tools.
- NEO6: Model u-box NEO-6M
- Type GPS receiver module
- Receiver Type 50-channel u-box 6 positioning engine
- Tracking Sensitivity-161 dBm
- Acquisition Sensitivity -147 dBm
- Cold Start Time ~27 seconds
- Warm Start Time ~25 seconds
- Hot Start Time ~1 second
- Position Accuracy 2.5 m CEP (typical)
- Velocity Accuracy 0.1 m/s
- Time Accuracy 1 µs
- ESP32: The ESP32 is a powerful and cost-effective microcontroller developed by Express if Systems. It is a dual-core 32-bit processor based on the Tensilica Xtensa LX6 architecture, capable of running at speeds up to 240 MHz. It is designed for high-performance embedded and IoT applications, providing a good balance of processing power and energy efficiency.
- HUMIDITY SENSOR: A humidity sensor, also known as a hygrometer, is an electronic device used to measure the amount of moisture (humidity) in the air. It is commonly used in weather monitoring, HVAC systems, greenhouses, and smart home or IoT applications.
- CURRET SENSOR: A current sensor is an electronic device used to detect, measure, and monitor the flow of electric current (AC or DC) in a circuit. It converts the current into a proportional electrical signal, which can be voltage or digital data for monitoring and control purposes.

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III. METHODOLOGY

Design of the Chassis The electric bike's chassis serves as its structural core, supporting the full weight and guaranteeing rider safety. Because mild steel tube frames are inexpensive, easy to fabricate, and have a good strength-to-weight ratio, they were chosen. The rectangular frame shape used in the design is optimized for weight distribution, stability, and electrical component mounting space. To stop deformation under dynamic loads, small reinforcements were inserted at stress-bearing joints. Additionally, the construction has mounting locations for the motor, control devices, battery pack, controller, IOT module ESP32.

Source of Power The 48V, 24Ah lithium-ion battery pack that powers the bike strikes an excellent mix between cost and energy density. Under typical working circumstances, the battery has a potential range of 40–50 km per full charge. The battery took about four to five hours to fully charge using a typical 230V AC charger. To preserve equilibrium and guarantee thermal safety, the battery was positioned in the center beneath the seat.

BLDC Motor Because of its small size, excellent efficiency, and low maintenance requirements, a brushless DC (BLDC) hub motor was selected. With a 1000W power rating, the motor can reach a maximum speed of 45 to 50 km/h. The hub motor, which is built into the back wheel, reduces noise and mechanical complexity by doing away with the need for chains or belts. Under varied load situations, the motor's torque, response time, and thermal characteristics were evaluated.

System of Control A digital speed controller, an Electronic Control Unit (ECU), and a twist- grip throttle are all part of the control system. The ECU controls how the battery, motor, and brake system interact, while the throttle controls power delivery in response to user input. Low- voltage protection and an automatic cut-off in the event of an overcurrent are examples of safety measures. Future integration of the system with simple IoT modules for GPS anti-theft tracking and battery monitoring is supported.

Body and Frame Mild steel tube, which provides toughness and bending resistance, is used to create the frame. ABS plastic is used to make body panels because it is lightweight and resistant to corrosion. For the comfort of the rider, the seat is ergonomically constructed with foam padding and synthetic leather. For practical use, extra features including side stands, a simple instrument cluster, and an LED headlight were include

3.1 Block Diagram

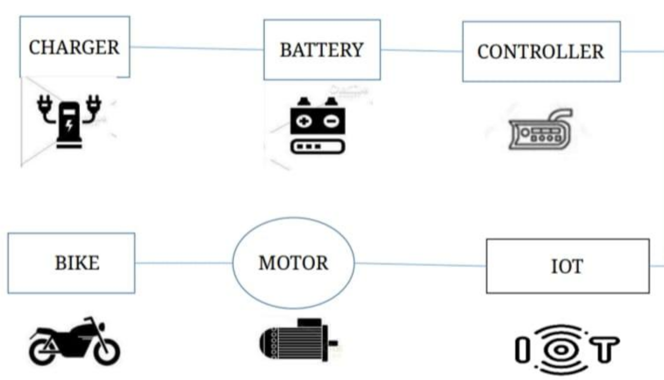

Figure no. 1 - Block Diagram

As shown in Figure 1. The Black Diagram shows the working of the Smart Electric Bike System begins with the charger supplying electrical energy to the battery, which stores and provides power to the entire system. The battery powers the controller, which acts as the central unit regulating the flow of electricity to the motor based on user inputs such as throttle and brake signals. The motor, in turn, converts this electrical energy into mechanical energy to drive the bike forward. Integrated IoT functionality enables real-time monitoring and data collection, such as battery status, speed, and location, which can be accessed remotely for diagnostics, tracking, and improved user experience.

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3.2. IoT Circuit

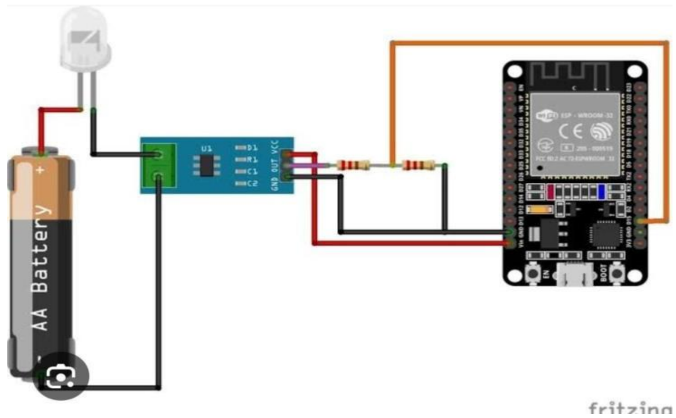

Figure no. 2 – IoT Circuit

As shown in Figure 2, An IoT EV bike system enhances connectivity, data collection, and management for electric bikes. It enables real-time tracking, monitoring, and control, and includes features like remote locking, theft protection, and performance data insights, all accessible via a smartphone app.

Sensing and Data Collection: Sensors continuously gather data (speed, location, battery status, etc.)

Data Processing

ESP32 processes the data locally and sends it via Wi-Fi to the cloud.

Cloud Communication

Real-time data is stored and displayed on a mobile app or web dashboard.

User Interface

User can view live tracking, battery status, speed, etc. Control features like locking/unlocking, motor ON/OFF from the app

3.3 BIKE CALCULATION

Load calculation

The total load applied to the BLDC motor is calculated based on the following weight of the vehicle and its accessories. Vehicle weight = 94 kg, Motor weight = 3 kg, Battery weight = 6 kg, Rider and accessories = 60 kg Total load = 163 kg.

Power calculation

Assuming the maximum velocity of 30 km/hr., the power required to pull the rated load is calculated by using the formula $P = F \times (V \div 3600)$ where, P = power in watts V = velocity 30 km/h = 30000 m/h

$P = 31.94 \times (30000 \div 3600) = 266$watts

Distance calculation

The distance that can be travelled using this battery is given by,

d= 1152/31.94 = 32 km

The road conditions may not be same during the whole journey,

So we can recalculate the distance that can be travelled by increasing the force that is required to run the vehicle:

$D = wh \div F = 1152 \div 40 = 28.8$km

Charging time calculation

The charging time of a lithium-ion battery varies depending upon the charger used for it.

The charging time of the battery is given by

$T = Ah / A$

Where, Ah = ampere hour rating of battery

A = current in amp (charger)

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T = 24 ÷ 6 = 4 hour

3.4 System Design

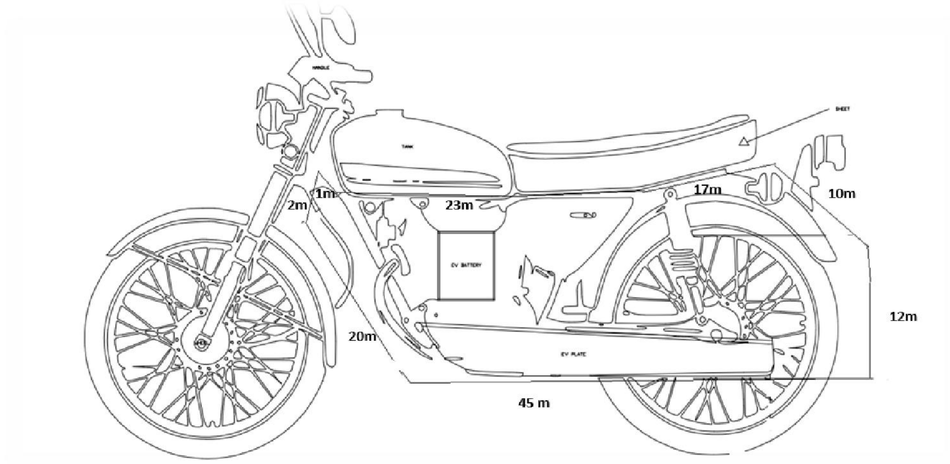

Figure no. 3 – Autocad Design of Bike

The system design of the electric bike illustrates the spatial arrangement and dimensions of key components to ensure balance, efficiency, and functionality. The EV battery is centrally placed within the frame for optimal weight distribution, supported by a 45m-long EV plate that provides structural stability and protection. The tank area serves as a design element or storage space, while the seat is positioned above the battery compartment for rider comfort. Front and rear suspension areas, marked with dimensions, contribute to ride stability and comfort. Additional components such as the rear panel sheet and wheelbase clearances are strategically designed to maintain ground clearance, aesthetics, and accessibility for maintenance, resulting in a well-balanced and efficient electric bike system.

3.5 Software Design:

The software design of the electric bike in AutoCAD involves creating precise 2D and 3D models of all mechanical and electrical components, including the chassis, battery casing, and motor housing, wiring paths, and mounting brackets. Using AutoCAD, designers can define accurate dimensions, geometries, and spatial arrangements to ensure proper fitting and alignment of parts. Layers and annotations are used to separate components such as the EV battery, motor, frame, and controller units for clarity and ease of modification. This digital design helps simulate the physical integration of components, facilitates manufacturing through detailed technical drawings, and enables early detection of design flaws, ultimately improving the efficiency and accuracy of the bike's development process.

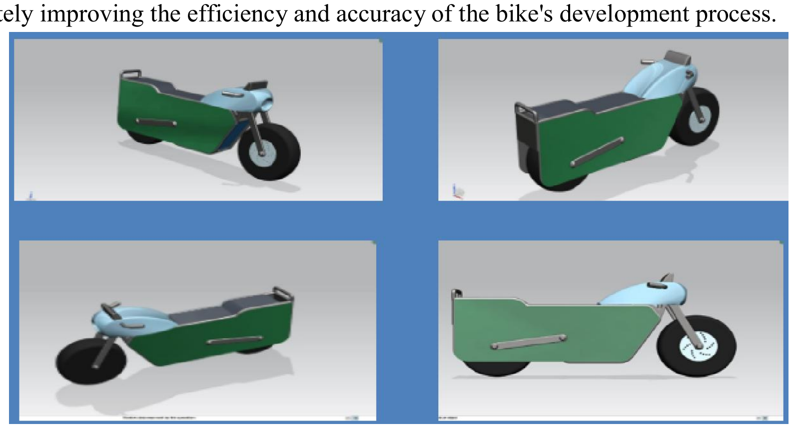

Figure NO 4 - CAD Module

3.5. System description

System Design" is a labelled technical layout of an electric bike (e-bike) system design. The measurements shown in millimetres (mm) indicate dimensions of various parts of the bike, which may be important for hardware integration, component placement or CAD modelling.

Here's a description of the main components and likely functions in the diagram:

- Dimensional Reference: Useful for 3D modelling or assembling the bike.
- Component Sizing: Helps in determining battery/motor/controller fitment.
- System Integration: Useful for layout planning during the design and manufacturing process.
- Battery Compartment (23mm): The large box likely houses the Li-ion battery pack.
- Controller/Microcontroller Unit: Likely mounted near or within the battery enclosure.
- Frame Chassis (45mm): Structural support to hold all components together.
- Motor Connection Cables: Not shown, but typically routed internally or along the frame.

3.6 Working of this Model:

Integration of IoT Modules A unique IoT module was added to the system to improve functioning, offering real-time monitoring and fundamental smart features: Sensors Real-time battery level monitoring using a voltage sensor Energy usage is monitored with a current sensor (ACS712 or similar). Temperature sensor for tracking motor/battery heat (DS18B20 or thermistor) ESP32 microcontroller for Bluetooth and Wi-Fi data processing Neo-6M GPS module for tracking location Dashboard view: A web dashboard or mobile app can be used to view data, showing: The voltage and remaining charge of the battery Temperature of the motor Present-day usage GPS and geofencing provide real-time location and anti-theft notifications. A 5V DC-DC converter that is attached to the primary battery powers the Internet of Things system. Because it is modular, future enhancements like fleet management integration and remote diagnostics are possible.

Figure no5– IMPLIMENTED MODEL

This fig describe the modification of old bike into new

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IV. RESULT & DISCUSSION

Figure no.6 – Web Dashboard

Control Panel (Left Side):

- Switch: A toggle button (currently ON) likely used to turn the system or a specific component on/off.
- Slider: Set to 8, this could adjust parameters like motor speed or power level.
- Number Input: Allows manual entry of values for system tuning or commands.

Monitoring Panel (Right Side):

- Current (V0): Shows the current flow, which is 22 units (likely in Amps or Volts).
- Temperature (V2): Displays temperature as 68°C, shown with a green circular gauge.
- Humidity (V1): Shows 84% humidity, indicated by a red gauge.
- Location Data:
- Latitude (V3): 5
- Longitude (V4): 159
  these values suggest GPS-based tracking functionality for the vehicle.
- Current Graph (bottom): A graphical plot shows variation in current over time.
- Time Range Tabs (Top of Graph):
- Users can select data views by time frame: 1 hour, 6 hours, 1 day, 1 week, etc., for trend analysis.

Buttons:

- Save and Apply: Confirms and applies any changes made to the dashboard.
- Cancel: Discards unsaved changes.

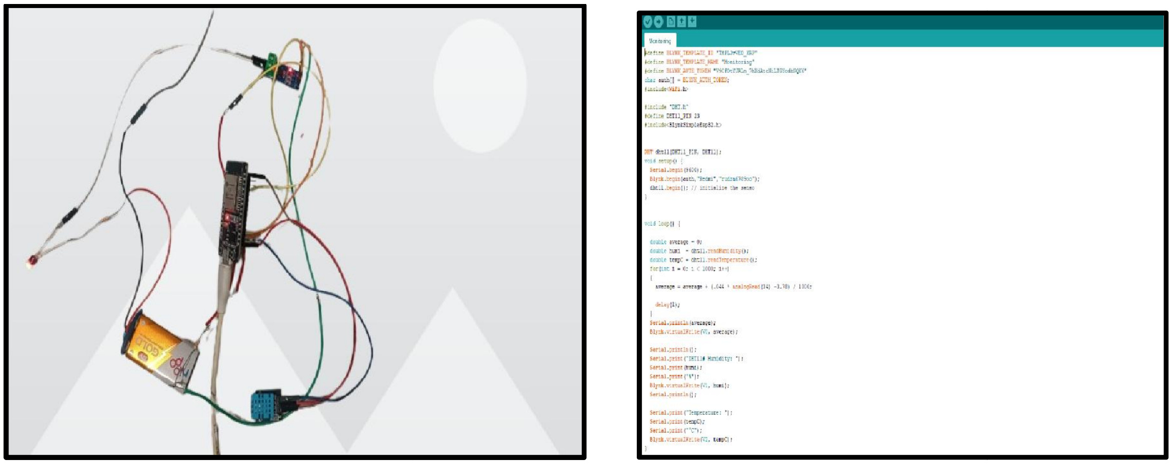

Figure no 7:- result in IoT Software

The IoT software's web dashboard displays real-time results collected from various sensors connected to an electric bike or similar smart system. These results provide crucial operational insights:

- Current (22 V or A): Indicates the live electrical current drawn by the system. This helps in assessing power consumption or detecting faults like overcurrent.
- Temperature (68°C): Shows the temperature around the motor or battery. Monitoring this helps prevent overheating and ensures safe operation.
- Humidity (84%): High humidity levels can affect electronic components; this data helps take preventive measures in moist environments.
- Latitude (5) & Longitude (159): These GPS coordinates provide the current location of the vehicle or device, enabling tracking and navigation.
- Control Widgets (Switch, Slider, and Number Input): These allow remote user control of specific parameters such as turning systems ON/OFF, adjusting speed, or setting values.
- Graphical Data (Current over time): Visual representation of current flow trends helps identify patterns, usage behavior, or detect issues like spikes or drops in performance.

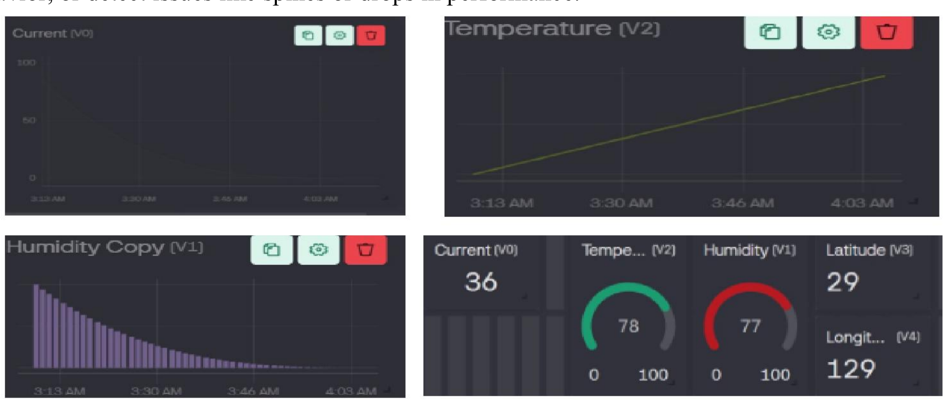

Figure no.8 - Graph of Current, Temperature, Humidity, Current of a Bike

As shown in Figure 8, the dashboard is used for monitoring and controlling an IoT-enabled system, possibly an electric bike or weather station. Below is a breakdown of its elements.

Control Panel (Left Side): Switch: ON/OFF toggle control – currently ON.

Slider: A slider set to value 8 – can be used to control speed, power, or another analog parameter.

Number Input: – for manually entering numeric values.

This graph represents the real-time variation of temperature over a selected time period on your IoT web dashboard.

Parameter Monitored: Temperature (V2): Time Range: From around 3:13 AM to 4:03 AM
Trend: The temperature is increasing gradually over time, as shown by the upward slope of the green line.
Purpose: This helps users monitor how temperature changes—potentially useful in
This graph shows the trend of humidity readings over time labelled as Humidity Copy (V1):
Parameter Tracked: Humidity (V1)
Time Period: From approximately 3:13 AM to 4:03 AM
Graph Type: Vertical bar chart
Humidity is decreasing steadily over time.

V. CONCLUSION

Future Extent Looking future, the project can be improved in a number of ways: Solar Integration: Using solar energy can improve sustainability and lessen reliance on traditional power sources. Features of IoT: By integrating IoT, real-time monitoring, remote control, data analytics, and predictive maintenance may be made possible, which will boost productivity and user involvement. Automation and AI: AI may be used in later iterations to make intelligent decisions and automatically modify the system in response to user behavior

or environmental data. Support for Mobile Apps: Creating a companion mobile application may provide notifications, enhanced usability, and remote access. The system's versatility, environmental friendliness, and user happiness will all be further enhanced by these developments.

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