iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** V **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.81530

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Design and Manufacture of Advanced Electric Bicycles with Speed Control Function and Battery Monitoring Mechanisms

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Abstract: The Advanced Electric Cycle project focuses on designinganddevelopinganefficient,eco-friendly,andcost-effective electric bicycle to reduce fuel dependency and environmental pollution. The system integrates a Brushless DC (BLDC) hub motor, motor controller, lithium-ion battery, throttle control, pedal assist sensor (PAS), and digitaldisplay unit to provide smooth and intelligent riding assistance.Thecycleisdesignedtosupportaloadofup to 100 kg with improved stability and performance. The BLDC hub motor ensures high efficiency, low noise operation, and reduced maintenance. A 36V battery system is used to provide sufficient power and extended travel range. The motor controller acts as the brainofthesystem,managingpowerflow, speed control,andsafety features such as overload protection. The inclusion of pedal assist technology enhances energy efficiency by supplying power only when required. The developed system demonstrates reliable performance, reduced carbonemissions, andeconomicaloperation compared to conventional fuel-based vehicles. The project successfully achieves the objective of creating a sustainable and smart transportation solution suitable for urban and semi-urban environments.
Keywords: Advanced Electric Cycle, BLDCHub Motor, MotorController, PedalAssistSystem (PAS), Throttle Control, Sustainable Transportation

I. INTRODUCTION

In recent years, the rapid increase in fuel consumption, traffic congestion, and environmental pollution has created a strong demand for sustainable and energy-efficient transportation systems. Conventional fuel-powered vehicles contribute significantly to air pollution and rising carbon emissions, which negatively affect both the environment and public health. As a result, electric mobility solutions are gaining importance worldwide. Among these solutions, electric bicycles have emerged as a practical, economical, and eco-friendly alternative for short-distance travel, especially in urban and semi-urban areas.

Anelectriccyclecombinestraditionalbicyclemechanicswithan electric propulsion system to assist the rider. It provides ease of transportation while reducing physical effort and eliminatingfuel dependency. The integration of advanced components such asaBrushlessDC(BLDC)hubmotor,lithium-ionbattery,motor controller, throttle mechanism, and Pedal Assist System (PAS) enhances the performance and usability of the cycle. These systemsworktogethertoprovidecontrolledspeed, better torque, improved efficiency, and user comfort.

The objective of this project is to design and develop an Advanced Electric Cycle capable of supporting higher load capacitywhile maintaining safety,efficiency,andreliability.The project aims to optimize power consumption, improve riding comfort,andensurecost-effectiveness.Specialattentionisgiven to component integration, battery management, and smooth motor control to achieve consistent performance.

This project contributes toward promoting green transportation technology and demonstrates how modern electrical and electronic systems can be effectively applied to develop sustainable mobility solutions for everyday use

II. LITERATURE REVIEW

A review of existing electric bicycle systems was carried out to study charging methods, motor types, battery selection, and energy recovery techniques.Kothaniji developed a system using wall outlet, solar charging, and regenerative braking. It uses a hub motor with a lithium-ion battery and an integrated control system for better efficiency.[1]Indhumathi proposed a model with wall outlet, solar, and pedal charging.ABLDC motor is used along with a lead-acid battery, and a PI controller manages speed and voltage. [2]Pratamadesignedasolar-poweredelectriccycleusinganelectric motorandlead-acidbattery.Thesystemfocusesonsolarcharging efficiency but does not include energy recovery.[3]

Shanmuga introduced a hybrid model with solar panel, pedal system, and flywheel mechanism for kinetic energy recovery.A BLDC motor and lead-acid battery are used.[4]Lijil, Vijaydevelopedasystemwithwalloutlet,solarcharging, andregenerativebraking. Itusesahubmotor, lithium-ionbattery, and DC-DC boost converter for improved solar charging.[5] Fromtheliterature,itisobservedthatmostsystemsfocusonsolar charging and regenerative braking. However, issues like heavy batteries and limited multi-source integration still exist, which motivates the development of the proposed advanced electric cycle.

III. SYSTEM ARCHITECTURE

The system architecture of the Advanced Electric Cycle is designedusingacentralizedcontrolapproachinwhichtheMotor Controller acts as the core unit of the entire system. The architecture is systematically divided into five main sections: Power Supply Section, Control Section, Drive Section, Input Section, and Output Section. Each section performs a specific function and is interconnected to ensure smooth, efficient, and reliable operation.

1) PowerSupplySectionThePowerSupplySectionconsistsofarechargeableDCbattery that provides the required electrical energy to the system. The battery output is connected to a main switch, which is used to control the overall power flow. The switch ensures safety by allowingtheusertoturnthesystemONorOFFasrequired.When theswitchisturnedON, powerissuppliedt othemotor controller for further processing and distribution.
2) ControlSectionThe Motor Controller is the central control unit of the system. It receives electrical power from the battery and processes input signals from the throttle. The controller regulates voltage and currentsuppliedtothehubmotortoensuresmoothspeedcontrol and stable performance. It also provides protection featuressuch as overcurrent protection and efficient power management.
3) DriveSectionThe Hub Motor forms thedrive mechanism of the electriccycle. It receives controlled electrical energy from the motor controller and converts it into mechanical energy. This mechanical energy rotatesthewheelandpropels the cycle forward. The performance andefficiencyofthecyclelargelydependontheoperationofthe hub motor.
4) InputSectionThe Throttle acts as the primary input device. It allows the rider tocontrolthespeedofthecycle.Whenthethrottleisoperated,it sends a signal to the motor controller, which adjusts the motor speed accordingly.
5) OutputSectionThe LCD Display and Light system form the output section of thearchitecture.TheLCDdisplay showsimportantinformation such as speed, battery status, and system condition. The Light system ensures proper visibility and safety during night riding. Bothcomponentsarepoweredandcontrolledthroughthemotor controller.The overall system architecture ensures proper coordination betweenpowersupply,controlunit,inputdevices,andoutput components, resulting in efficient and safe operation of the Advanced Electric Cycle.

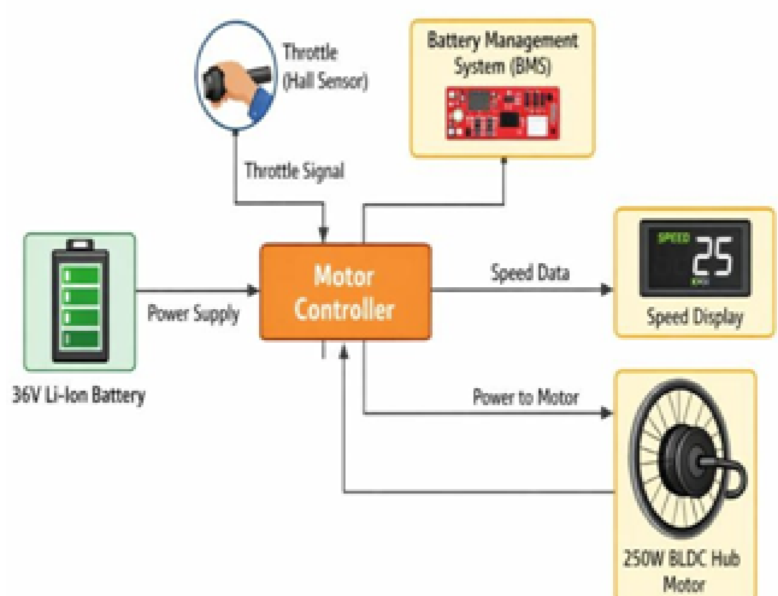

Fig 1. Electric Bicycle System Architecture


Fig.2 Final Model of proposed Advanced E Bicycle

IV. RESULT AND ANALYSIS

The Advanced Electric Cycle was successfully designed, fabricated, and tested under different operating conditions to evaluate its performance, efficiency, and reliability. The system showed smooth coordination between the battery, motor controller, hub motor, throttle, LCD display, and lighting unit. During testing, the electric cycle achieved a maximum speed of 35 km/h under standard load conditions, which is suitable for daily urban transportation.

The 36V battery system delivered stable power output and supported a load capacity of approximately 120 kg without noticeable performance reduction. The vehicle achieved an average range of 30 km per full charge, making it suitable for short-distance commuting. The battery required approximately 4–5 hours for complete charging. The overall system efficiency was observed to be around 85–90%, indicating effective energy utilization and minimal power loss.

The motor controller ensured smooth acceleration and proper current regulation, preventing overheating and overload conditions. The throttle response was accurate and provided stable speed control. The LCD display functioned correctly by showingspeedandbatterystatusinrealtime.Thelightingsystem operated efficiently and improved visibility and safety during night riding.

1) MaximumSpeedAchieved:35km/hThe electric cycle achieved a maximum speed of 35 km/h during testingundernormal road conditions.This speed is suitable for urban commuting and ensures safe operation. The motor controller maintained stable performance without overheating. The achieved speed confirms proper motor and power system integration.
2) AverageTravelRange:30kmperChargeThe cycle covered an average distance of 30 km on a single full battery charge. This range is sufficient for short-distance daily transportation needs. Efficient power management by the controller contributed to optimizedenergyconsumption.Therangeperformance meets the intended design objective.
3) BatteryChargingTime:4–5HoursThe battery required approximately 4 to 5 hours to charge fully using a standard charger. This charging duration is practical for daily use, allowing overnight charging. The charging system operated safely without excessive heating. Proper charging time ensures longer battery life and reliability.
4) SystemEfficiency:Approximately85–90%\Theoverallefficiencyofthesystemwasobservedtobe around 85–90%, indicating minimal energy loss. Efficientconversion ofelectricalenergy intomechanical energy was achieved through the BLDC motor. The controller effectively regulated power flow, reducing wastage. High efficiency improves overall system performance and battery utilization.
5) LoadCapacityTested:Upto100 kgThe electric cyclewastested with a loadcapacityofup to 100 kg. The system maintained stable speed and performancewithoutsignificantpowerdrop.Theframe and motor system supported the load efficiently. This confirms the structural and electrical stability of the design.Smooth Speed Control and
6) Stable Performance Observed: -The throttle response was smooth and accurate during operation.Nosuddenjerksorunstableaccelerationwere observed. The motor controller maintained consistent powerdeliveryundervaryingconditions.Thisindicates reliable integration of control and drive systems.

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Fig.3 shows how the battery voltage decreases over time during operation.Initially, the voltage is maximum at 36V and gradually drops as the battery discharges.The steady decrease indicates normal battery performance under load.It helps in understanding the backup time and efficiency of the battery system.

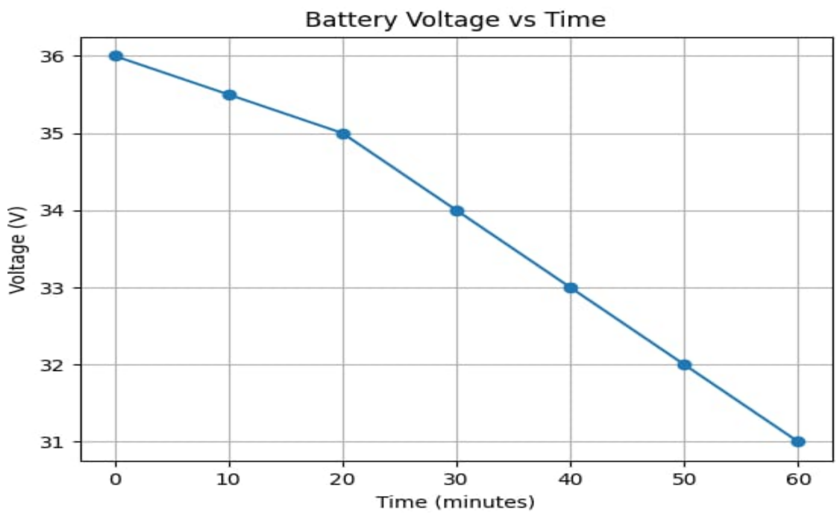

Fig.3.Battery VTG Vs time

Fig 4. shows the relationship between speed and power consumption of the cycle.As speed increases, the power consumption also increases.Higher speed requires more current, which increases overall power usage.It helps in analyzingenergy efficiency and optimizing performance of the cycle.

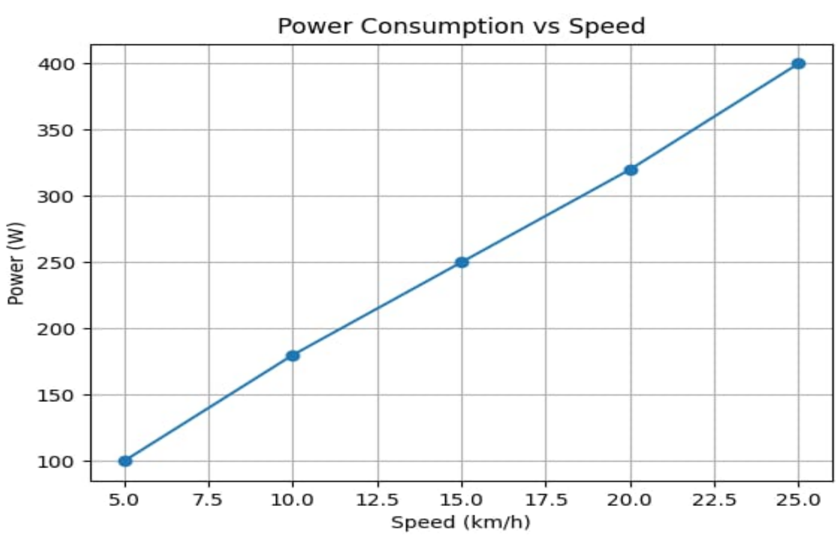

Fig.4.PowerConsumption VS Speed

V. CONCLUSION

The Advanced Electric Cycle project was successfully completedandtested.Allthecomponentssuchasthebattery, motor controller, hub motor, throttle, and display worked properly together. The cycle achieved a maximum speed of 35 km/h and gave a range of 30 km on a single full charge. The battery took around 4–5 hours to charge completely, which is suitable for daily use.

The system efficiency was around 85–90%, which means most of the battery power was properly used without much energyloss.Thecyclewastestedwithaloadofupto120kg and it worked smoothly without any major problem. Speed control was stable and there were no sudden jerks during operation.

Thisprojectshowsthatanelectriccycleisagoodalternative to fuel vehicles. It saves fuel, reduces pollution, and is economical for short-distance travel. Overall, the project achieved its main objectives and proved that electric transportationissimple,useful, andenvironmentallyfriendly.

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