ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV817

Design and Implementation of E-Bicycle

Abhirash Choudhary[1]; Aditya Tupkar[2]; Aryan Gedam[3]; Nayan Harbare[4]; Himanshu Sarode[5]
[1,2,3,4,5]Department of Electrical Engineering,G H Raisoni College of Engineering & Management Nagpur

Under the Guidance of
Kiran Raut
Department of Electrical Engineering,
G H Raisoni College of Engineering & Management Nagpur

Abstract:- E-bicycles combine traditional cycling with electric assistance, offering various models like pedal-assist, throttle-controlled, and speed pedelecs. They provide benefits such as reduced fatigue, longer commutes, and improved health, while also contributing to reduced traffic and emissions. However, challenges like high initial costs, battery life, limited range and theft concerns exist. In this paper implementation of dynamo systems incorporated with e-bicycle, which generate electricity from pedaling, can extend battery range and promote sustainability by reducing reliance on external power sources. This paper focus on the design of electric cycle with dynamo implementation in front wheel. In order to overcome the above problem proposed design incorporated with dynamo to the driving range up 58 km.

Keywords:- *E-Bicycle, Dynamo, Lithium-Ion Batteries, Range Extension, BLDC Motor.*

I. INTRODUCTION

Electric bicycles (e-bikes) have emerged as a popular and sustainable mode of urban transportation, offering a cleaner alternative to traditional gasoline-powered vehicles. With increasing concerns over environmental pollution, carbon emissions, and the rising number of automobiles globally, the need for eco-friendly alternatives has never been more urgent. E-bikes, equipped with Pedal Assist Systems (PAS), offer an innovative solution by combining human effort with electric assistance, making cycling more efficient and accessible. However, a significant challenge remains in improving the convenience of e-bikes, particularly in addressing long charging times and dependence on grid-based power sources.

This paper focuses on the design and development of an advanced e-bike system that incorporates a PAS for enhanced performance, along with an innovative charging solution. The project explores the integration of a brushless DC (BLDC) motor, regenerative power systems, and renewable energy sources such as solar, reducing reliance on external electrical supplies. Additionally, a key objective is to create a fast-charging system with an efficient design, cooling mechanisms, and safety features, aiming to significantly reduce charging time while maintaining battery longevity. The overall goal is to offer an energy-efficient, sustainable, and user-friendly transportation alternative to traditional vehicles, contributing to greener urban mobility.

II. LITERATURE REVIEW

The transition to eco-friendly transportation has spurred significant advancements in e-bicycle design, with recent studies exploring innovative ways to improve sustainability, efficiency, and adaptability for a wide range of users. The study by Sharma et al. addresses environmental concerns by proposing the conversion of traditional gasoline-powered bikes into electric models using BLDC motors. This approach cuts down on pollution and noise, reduces the dependence on fossil fuels, and offers a low-maintenance alternative. By repurposing existing gasoline bikes, this solution also promotes a circular economy, giving older bikes an extended life in an eco-friendly format and thus reducing the waste associated with outdated vehicles.

Silva’s study, meanwhile, places a strong emphasis on weight optimization and rider comfort, introducing a novel e-bicycle design with a minimized power pack that not only reduces the e-bike’s weight but also incorporates a monitoring system. This system tracks physiological metrics, such as heart rate, heart rate variability, and cadence, providing feedback that helps detect fatigue and assist the rider accordingly. This approach is particularly beneficial for riders undertaking longer journeys or those requiring tailored assistance based on physical exertion. Silva’s emphasis on weight reduction and health-focused features highlights an essential shift toward user-centered e-bicycle designs, making electric bikes more accessible and comfortable for riders with different fitness levels and physical needs [1].

Gandhi et al. target another gap in the e-bicycle market by designing an e-bike that achieves high speeds and features a strong starting torque. This design caters to consumers looking for efficient commuting options with better acceleration and high-speed capabilities. The researchers also incorporate a predictive model that advises riders on the optimal riding speed based on real-time battery levels, helping users conserve energy and extend the range of each charge. This predictive function enables the e-bike to maximize energy efficiency, allowing riders to travel longer distances while reducing the frequency of recharges, which

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV817

is particularly valuable for both daily commuters and longer-distance travelers [2].

Sutar et al. explore an alternative energy source by creating a hybrid solar-powered e-bicycle that integrates an auto-gear mechanism and multiple charging methods. This e-bicycle can be powered by solar panels or a dynamo, enhancing sustainability and functionality. The auto-gear system adapts to varying load conditions, allowing the bike to perform efficiently regardless of terrain, while GPS tracking adds an additional security layer. The solar-powered charging feature aligns with rising global interest in renewable energy, making this e-bike an ideal solution for individuals seeking cost-effective, sustainable, and versatile transportation in urban and rural areas alike [3].

Lastly, Mohandass et al. address the needs of children with disabilities by designing a three-wheeled electric cycle with unique safety and monitoring features. Aimed at providing accessible transportation for children with disabilities and autism, this e-cycle includes essential safety features such as seat belts, GPS tracking, a crash detection system, and obstacle sensors. These features enhance both rider safety and parental control, as a mobile app allows guardians to monitor the cycle's location, battery level, speed, and travel distance. This app also facilitates communication between the rider and guardian, ensuring that children with special needs can travel independently yet securely. Mohandass et al.'s focus on accessibility underscores the potential of e-bicycles to expand mobility for underserved groups, promoting social inclusion and independence [4].

Together, these studies demonstrate the versatility and adaptability of e-bicycles to meet the growing demand for sustainable transportation while addressing specific user needs, from general commuting to enhanced safety for vulnerable populations. By combining renewable energy sources, lightweight and health-conscious designs, performance-focused features, and adaptive technology, these innovations highlight e-bicycles as a viable alternative to traditional fuel-based vehicles, contributing significantly to the movement toward sustainable urban and suburban transportation solutions.

III. PROPOSED SYSTEM

Electric bicycle is a vehicle that is called as e bike. It is a bicycle which assist by the electric motor to set the vehicle in motion. The bicycle uses electric dc motor which is receiving power supply from rechargeable batteries. With the help of batteries. the power supply is given to the motor, the bicycle can travel up to 15 to 20 mph. but this range depends on the batteries and the motor power limit which each of the components has their own specifications and limitations .The electric bicycle is not restricted or tend to the motors vehicle law even though it is powered by motor. it still considered as bicycle which is the identity of Electric bicycle. It is a bicycle which is assist by the electric motor the bicycle is still fixed on it. The electric bicycle is free from pollution, this is because it using electric source, rather than gasoline. It will not cause pollution to environment, and it will be more similar to a motorcycle.

Hence, the using of motor that power supply from the batteries is used on the electric bicycle. The electric bicycle is still used pedal to for pedaling. it just adding the motor, batteries, electronic components and throttle for speed. This add up is for assist the rider in certain condition which is when pedaling away up the high slope. figure 1 shows ovweview of proposed system.

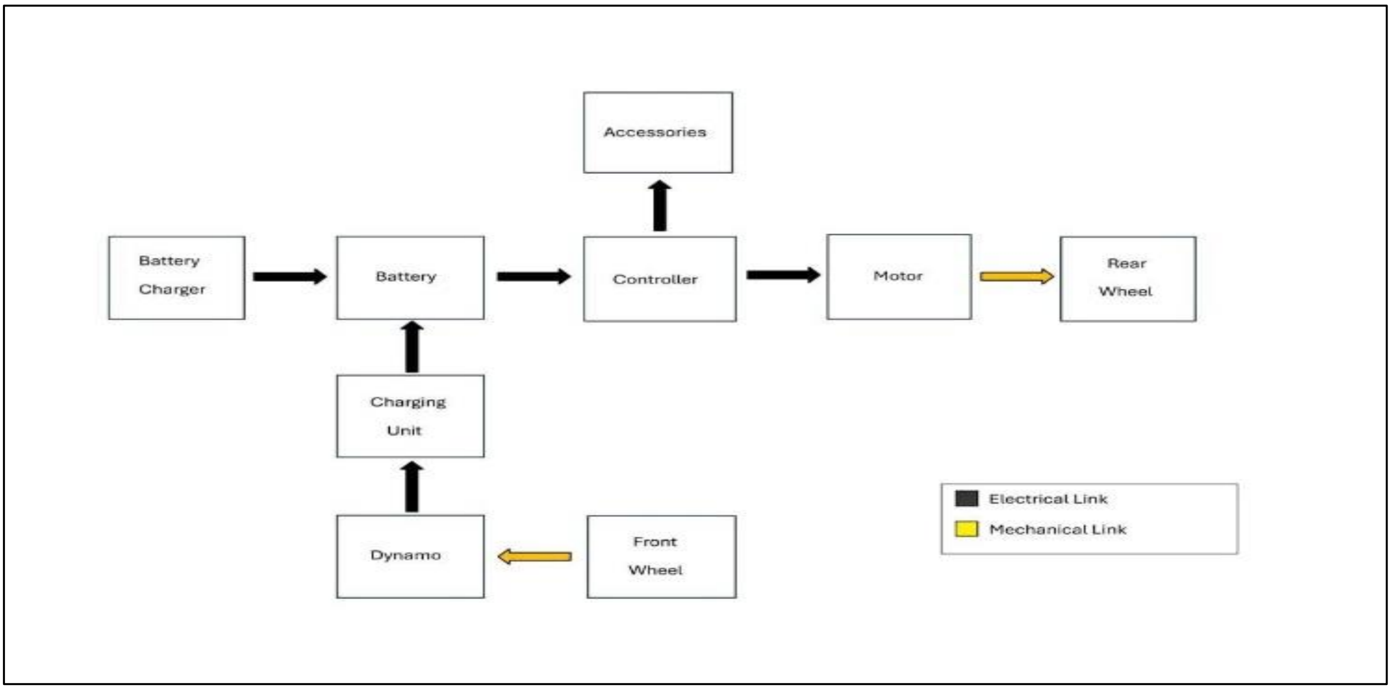

Fig 1: Overview of Proposede System

IV. HARDWARE AND IT'S IMPLICATION

Following are the components of proposed system like battery, BMS, motor, generator, boost converter, controller, etc. They are described in detail below.

A. Battery

A battery is a device that stores chemical energy and converts it into electrical energy to power electronic devices. It consists of one or more cells, each containing an anode, cathode, and electrolyte, which facilitate a chemical reaction that generates an electric current. Batteries come in various types, such as disposable (single-use) and rechargeable, and are used in everything from small gadgets to large vehicles. The battery pack shown below consist of total 28 Li-ion cells in each battery, one cell is of 3.7v 2600mAh, 7 blocks of 4 parallel cells are connected in series in order to make 24v 10.4Ah battery pack. Figure 2 shows battery pack.

Fig 2: Battery Pack

B. Battery Management System:

A Battery Management System (BMS) is an electronic system that manages and monitors the performance of a rechargeable battery pack. It ensures safe and efficient operation by balancing the charge across individual cells, monitoring temperature, voltage, and current, and protecting the battery from conditions like overcharging, deep discharge, overheating, and short circuits. The BMS also provides important data on the battery's health and state of charge, helping to extend the battery's lifespan and optimize its performance in applications such as electric vehicles and renewable energy storage systems. Figure 3 shows battery management system.

Fig 3: BMS (Battery Management System)

C. Motor

A Brushless DC (BLDC) motor is an electric motor that operates without the mechanical brushes used in traditional DC motors. Instead, it uses an electronic controller to switch the current in the motor windings, creating a rotating magnetic field that drives the rotor. BLDC motors are known for their high efficiency, durability, and quiet operation, making them popular in applications like electric vehicles, drones, and household appliances. Figure 4 represents DC Motor.

Fig 4: BLDC Motor

Motor used in proposed system comprises of various specifications they are shown in table no. 1

Table No.1: Motor specifications

Specifications	Details
Rated Voltage	24V DC
Rated Power	250 KW
RPM	400
Rated Current	10.41 A
Full Load Current	14.20A
Undervoltage Protection	20.50V
Current Limiting Protection	20.00A
Torque Constant	9 Nm(90kg-cm)
Sprocket	9 tooth only fits

D. DC Generator

A Direct Current (DC) generator is an electrical machine that converts mechanical energy into direct electrical energy. It works on the principle of electromagnetic induction, where a conductor moving in a magnetic field induces an electric current. DC generators consist of components like an armature, commutator, brushes, and a magnetic field, all working together to produce a steady flow of electricity in one direction. They are commonly used in applications requiring stable and controllable power such as in battery charging, small-scale power generation, and various industrial processes. The simplicity and reliability of DC generators make them a crucial component in many electrical systems, especially where direct current is needed. Figure 5 shows DC Generator.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV817


Fig 5: DC Generator

E. Boost Converter

A buck-boost converter is a type of DC-DC converter that can step up (boost) or step down (buck) the input voltage to a desired output voltage level. It combines the functionality of both buck and boost converters by using an inductor, a switch (usually a transistor), a diode, and a capacitor. The converter can produce an output voltage that is either higher or lower than the input voltage, depending on the duty cycle of the switch. This makes it versatile for applications where the input voltage may vary, but a stable output voltage is required. Figure 6 shows boost converter.

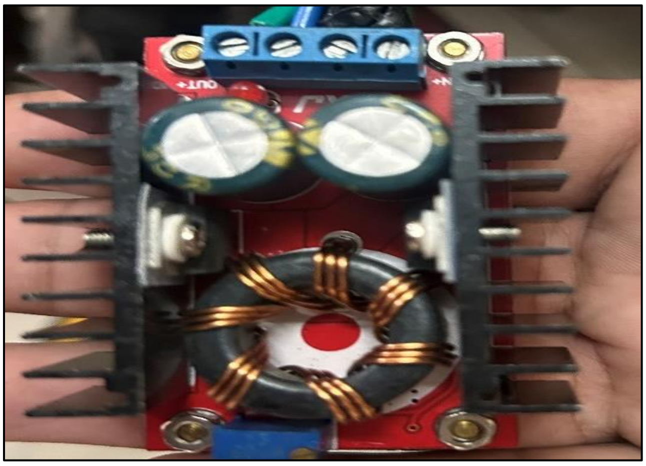
Fig 6: Boost Converter

F. Controller

It A motor controller is an electronic device that regulates the operation of an electric motor. It manages the motor's speed, torque, and direction by controlling the power supplied to it. Depending on the type of motor and application, the controller can vary from a simple on/off switch to a complex system that adjusts the motor's performance based on feedback and specific parameters. Controllers ensure that the motor operates efficiently and safely within its design limits. Figure 7 shows controller.

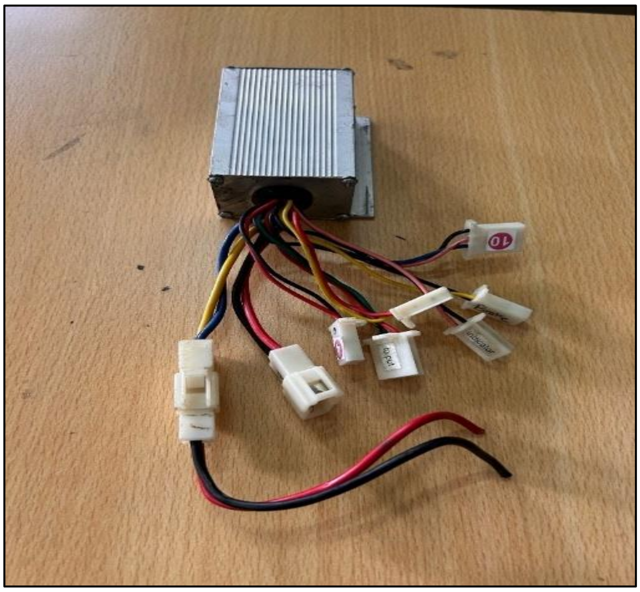
Fig 7: Controller

V. PRTOTYPE

The Prototype that we have made consists of a 250W motor and the rated operating voltage is 24V. Here we are using 2 battery in split mode and also alternate swapping mode. Each battery will be of 10.4Ah.the motor has a torque of about 90kg/cm which has a pull of about 85kgs.

Maximum speed attained by the e-bicycle will be 20km/hr. Without the dynamo connected, the range of the e-bicycle will be 55kms and after the dynamo is being connected , the range will be extended to about 58kms (approx 60kms).


Fig 8: E-Bicycle Prototype

VI. CALCULATIONS& OBSERVATIONS

During the testing phase of the e-bicycle the following results were observed and are shown in table no.2: Initially a single battery was charged at 100%.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV817

Table 2: Observed Range without Dynamo

Battery level drop(%)	Distance travelled(Km)
100-90	3
90-80	3
80-70	3
70-60	3
60-50	3
50-40	3
40-30	3
30-20	3
20-10	3
Below 10	**e-bicycle turned off**

Below 10% battery level, the e-bicycle will be turned off due to the undervoltage protection scheme which is set at 20.50V.

So, the total range given by a single battery will be about 27kms.

But, as we are using 2 battery in split system, The

Total range of the e-bicycle will come out at about 55Kms(total)

Hence, Toatl Range= 55Kms

Now, after connecting the dynamo to the front wheel of the e-bicycle. The observation are shown in table number 3.

Table 3: Observed Range with Dynamo

Battery level drop(%)	Distance travelled(Km)	Extra range generated by the dynamo(Km)
100-90	3	0.33
90-80	3	0.33
80-70	3	0.33
70-60	3	0.33
60-50	3	0.33
50-40	3	0.33
40-30	3	0.33
30-20	3	0.33
20-10	3	0.33
Below 10	**e-bicycle turned off**	**Turned off**

So, for one complete discharging cycle of the e-bicycle,the dynamo will be able to produce approx. 3kms additional range.(About 11% extra efficiency)

So, the effective range of the e-bicycle considering both the batteries and dynamo will come to be about 58Kms(approx. 60Kms).

VII. CONCLUSION

This project demonstrates the potential of integrating dynamo and split battery technology to enhance the range and efficiency of electric bicycles. Incorporating a dynamo into the system enables regenerative power generation during cycling, allowing batteries to recharge and sustain longer rides with minimal external charging requirements. This approach extends range and reduces dependency on frequent charging, making the bicycle both convenient and environmentally friendly.

This system provides a practical solution for urban commuting, recreational cycling, and eco-friendly transportation by offering a self-sustaining, energy-efficient alternative to conventional electric bicycles. Overall, the project extends range and supports sustainable energy usage, promoting an affordable and accessible green transportation solution for the future. The combined dynamo and split battery technology has the potential to redefine e-bike performance and reliability, marking a significant advancement in electric mobility.

FUTURE SCOPE

Future technology may resolve battery lifespan issues caused by today’s fast-charging modes, while advancements in battery design will allow for smaller, higher-capacity packs. On-wheel hub generators, similar to hub motors, could enable efficient energy generation within a compact setup. Additionally, as EV production scales, component availability will increase, and costs will decrease, making electric vehicles more accessible.. When all the industries started focusing on EV the spare parts should be available at local markets results in availability of components and reduced cost.

REFERENCES

[1]. S. Sharma, V. Kher, A. Singh, A. Sangam, S. Dhamini and R. Apoorva, "Design of Innovative and Eco-Friendly E-Bicycle," 2022 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), Chennai, India, 2022, pp. 1-5, doi: 10.1109/ACCAI53970.2022.9752618.

[2]. N. C. D. Silva et al., "An Experimental Study on Smart Electric Bicycle with Weight Minimized Power Pack," 2021 3rd International Conference on Electrical Engineering (EECon), Colombo, Sri Lanka, 2021, pp. 80-86, doi: 10.1109/EECon52960.2021.9580942.

[3]. Gandhi, S. R. Mistri and A. K. Gangrade, "Design and Performance Testing of an E-Bicycle," 2021 3rd International Conference on Sustainable Technologies for Industry 4.0 (STI), Dhaka, Bangladesh, 2021, pp. 1-6, doi: 10.1109/STI53101.2021.9732615.

[4]. Sutar, K. Rane, S. Mahamuni, T. Sarkar, M. Banerjee and B. L.Swamy, "Low-Cost, High-Speed Hybrid Solar Powered Auto Geared Electric Bicycle," 2024 International Conference on Inventive Computation Technologies (ICICT), Lalitpur, Nepal, 2024, pp. 2126-2129, doi:10.1109/ICICT60155.2024.10544479.

[5]. M. P. Mohandass, M. Mathesh, K. M. Haneef and K. Vaisali, "Smart E-Cycle for Abled/Disabled and Autistic Children - Fabrication and Validation," 2024 International Conference on Science Technology hesisi Engineering and Management (ICSTEM), Coimbatore, India, 2024, pp.1-4, doi: 10.1109/ICSTEM61137.2024.10560859.
[6]. Tadic, "Study on Automatic Electric Vehicle Charging Socket Detection Using ZED 2i Depth Sensor". Electronics 2023, 12, 912. https://doi.org/10.3390/ electronics12040912
[7]. International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON) | 978-1-6654- 5499-5/22/S31.00 ©2022 IEEE | DOI:10.1109/SMARTGENCON56628.2022.10084234
[8]. J. F. Cardoso, C. Chillet, L. Gerbaud and L. A. Belhaj, "Electrical Machine Design by optimization for E-motor Application: a Drive Cycle Approach," 2020 International Conference on Electrical Machines (ICEM), Gothenburg, Sweden, 2020, pp. 2514-2519, doi:10.1109/ICEM49940.2020.9270888
[9]. N. Yadav, D. Patil, S. P. Jadhav, D. Kanase and S. Prasad, "Electric Bicycle using Pedal Assist System (PAS)," 2024 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS), Bhopal, India, 2024, pp. 1-6, doi: 10.1109/SCEECS61402.2024.10482013.