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Hybrid E-Bicycle with Multi-features

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ABSTRACT: The increasing demand for eco-friendly transportation systems has led to the development of electric bicycles as an alternative mode of transport. The project “Hybrid E-Bicycle with Multi-features, is designed and research to provide an energy-efficient, economical, and environmentally friendly transportation solution. This prototype research combines pedal power and electric motor assistance to create a hybrid system capable of reducing fuel dependency and pollution. The bicycle is equipped with a rechargeable battery, BLDC motor, speed control system, mobile charging unit, lighting system, horn, and regenerative charging mechanism and demonstrates how renewable and electrical energy technologies can be integrated into daily transportation systems to achieve sustainability and energy conservation

KEYWORDS: Solar Energy, Electric Bicycle, Photovoltaic Effect, BLDC Motor, Charge Controller, Battery Storage System, Renewable Energy, Green Transportation, Sustainable Mobility, DC Power System, Energy Efficiency, Solar Powered Vehicle..

I. INTRODUCTION

The fuel prices especially the petrol is rising steadily day by day. The pollution due to vehicles in metro cities & urban areas is increasing continuously. To overcome these problems, an effort is being made to search some other alternative sources of energy for the vehicles. Again, it is also not affordable to purchase vehicles (mopeds, scooters or motorcycles) for all the class of society. Keeping this in mind, a search for some way to cater these economically poor people as well as to provide a solution for the environmental pollution was in progress. The solar assisted bicycle developed is driven by DC motor fitted in front or rear axle housing & operated by solar energy. The solar panels mounted on the carriage will charge the battery & which in turn drive the hub motor. When the bicycle is idle, the solar panel will charge the battery [1],[2].

This arrangement will replace the petrol engine, the gear box & the fuel tank in case of a two-wheeler or a chain sprocket, chain & gear shifting arrangement of a conventional bicycle being used by most common man. As a part of dissertation work, the solar assisted bicycle is fitted with a de hub motor on front axle of a bicycle with power rating of 250W and with a travelling speed of around 25-30 km/h. It is provided with a pair of lead acid batteries of 35 Ah each, a photovoltaic solar panel with capacity of 20 watt, a voltage regulator of 24v 10 Amp, accelerator and motor controller of 24v 25Amp. There is also a provision for charging of the battery with 220-240V, AC wall output supply, in case of poor solar supply due to cloudy weather[4],[5].

II. SYSTEM MODEL

The reserach system is a hybrid e-bicycle equipped with multiple advanced features. The bicycle uses a **BLDC motor powered by a rechargeable battery pack**. The rider can select between: Manual Pedal Mode, Electric Mode, Hybrid Mode.

In hybrid mode, both manual pedaling and electric motor assistance work together to reduce rider effort and improve efficiency, The bicycle also contains : LED headlight and tail light, Mobile charging unit, Digital speedometer, Battery status display, Horn system, Regenerative charging system, The system is designed to be lightweight, efficient, and economical.

The working of the solar-powered electric bicycle begins with the solar panel capturing sunlight and converting it into DC electrical energy. The generated electricity is regulated through the charge controller and stored in the battery. The stored energy is supplied to the motor controller, which controls the operation of the BLDC motor according to the throttle input. The motor then rotates the bicycle wheel, resulting in the forward movement of the bicycle

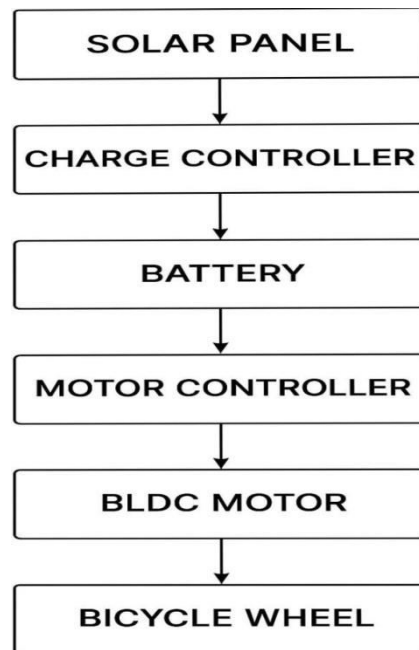


Figure 2.1 Block Diagram power generation System for The Bicycle

2.1 Solar Panel : The solar panel is the primary energy source of the system. It converts sunlight into electrical energy using the photovoltaic effect. The generated electrical power is in the form of direct current (DC), which is used for charging the battery and operating the motor system.

2.2 Charge Controller : The charge controller regulates the voltage and current generated from the solar panel before supplying it to the battery. It protects the battery from damage due to overcharging and deep discharge conditions.

2.3 Battery : The battery acts as an energy storage device in the system. It stores electrical energy generated by the solar panel and supplies power to the motor whenever required, especially during low sunlight conditions.

2.4 Motor Controller : The motor controller controls the operation, speed, and torque of the BLDC motor. It converts battery power into controlled electrical signals required for efficient motor performance.

2.5 BLDC Motor : The Brushless DC (BLDC) motor converts electrical energy into mechanical rotational energy. BLDC motors are preferred due to their high efficiency, low maintenance, and longer operational life.

2.6 Bicycle Wheel : The bicycle wheel receives rotational motion from the BLDC motor and converts it into forward movement of the bicycle.

III. SYSTEM MODEL SPECIFICATION & CALCULATIONS

The design involves the calculation of the power required to run a bicycle at a specified speed of 10 km/h and the development of a solar-powered system capable of supplying the required power. Since additional components such as the motor, batteries, and solar panel are mounted on the bicycle, a lightweight geared bicycle with suspension was selected. A 6-speed geared bicycle was used for the prototype model.

Design Calculations

✚ Normal Reaction

$$N_r = (100 \times 9.81) / 2 = 490.5 \text{ N}$$

✚ Friction Force

$$F = \mu N = 0.3 \times 490.5 = 147.15 \text{ N}$$

✚ Torque Required

$$T = F \times r = 147.15 \times 0.25 = 36.78 \text{ N-m}$$

✚ Speed Calculation

$$\omega = V/r = 11.11 \text{ rad/sec}$$

$$N = 106 \text{ RPM}$$

✚ Power Calculation

$$P = (2\pi NT)/60 = 408.2 \text{ W}$$



- ✚ Battery Specification : Three 12V, 12Ah batteries are connected in series to obtain 36V supply.
- ✚ Charging Time : Charging time = 3 hours.

Bicycle Data, Specifications and Performance Characteristics

Table: 3.1 Bicycle Data Specifications and Performance Characteristics.

Parameter	Specification
Rim Diameter	0.5 m
Wheel Radius	0.25 m
Bicycle Speed	10 km/h
Total Weight (Cycle + Rider)	100 kg
Coefficient of Friction	0.3

IV. RESULT & CONCLUSION

The design calculations for the solar-powered electric bicycle were carried out based on the bicycle specifications and operating conditions. The calculated results are summarized in Table 4.1.

Table: 4.1 Bicycle Data after Calculation result and Performance

Parameter	Calculated Value
Normal Reaction on Each Tyre	490.5 N
Frictional Force	147.15 N
Required Torque	36.78 N-m
Angular Velocity	11.11 rad/sec
Wheel Speed	106 RPM
Power Required	408.2 W
Selected Motor Rating	410 W
Battery Capacity Required	36 V, 12 Ah
Number of Batteries	2/3
Battery Charging Time	3 Hours

From the above calculations, it is observed that approximately 408.2 W power is required to operate the bicycle at a speed of 10 km/h. Therefore, a 410 W BLDC motor is selected for efficient operation. The required torque for driving the bicycle is found to be 36.78 N-m. A 36 V battery system consisting of three 12 V, 12 Ah batteries connected in series is selected to meet the motor power requirement. The calculated charging time of the battery system using AC supply is approximately 3 hours. The proposed system provides an efficient, eco-friendly, and economical transportation solution using solar energy. The developed hybrid e-bicycle successfully demonstrated dual-mode operation combining manual pedaling and electric propulsion : **Smooth electric propulsion Reduced rider effort, Effective regenerative charging, Stable speed control, Efficient battery utilization, Reliable performance under varying load conditions.** The LED lighting system and charging features operated effectively during testing. The prototype model demonstrated that hybrid e-bicycles are practical and efficient for short-distance transportation applications.



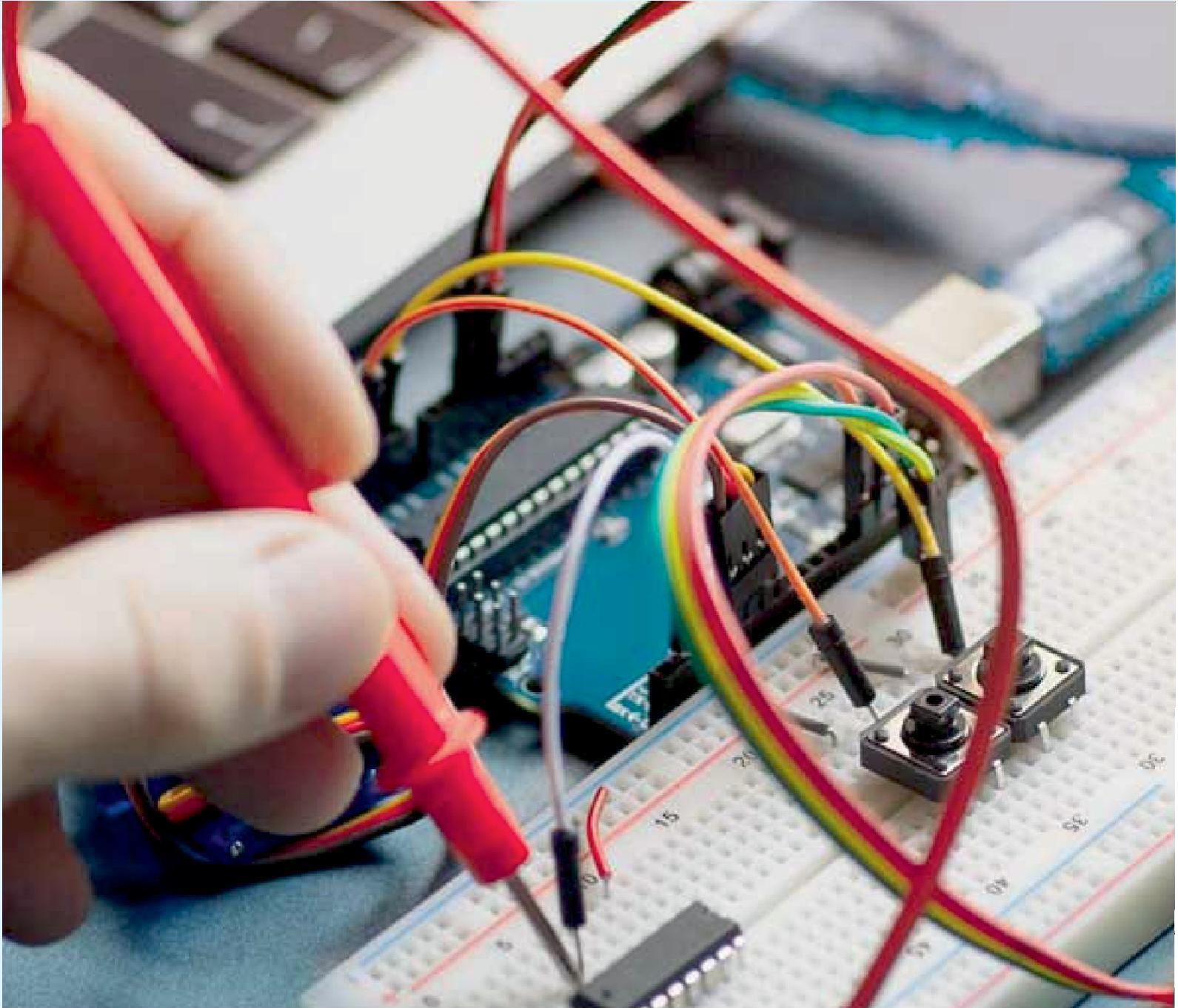
Figure.4.1. Real Time implementation of Front View Final Model of Development of Hybrid E-Bicycle with Multi-features

V. CONCLUSION

The Research on “Hybrid E-Bicycle with Multi-Features” was successfully designed and implemented. The system combines electric propulsion with manual pedalling to provide an economical, energy-efficient, and environmentally friendly transportation solution & demonstrated the practical application of electrical and mechanical engineering principles. Features such as regenerative charging, smart control systems, and energy-efficient components improved overall system performance. The hybrid e-bicycle reduces environmental pollution, minimizes fuel dependency, and supports sustainable transportation for short-distance travel.

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