Design and Implementation of Electric Bicycle with Speed controlling mechanism and Battery monitoring system

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Abstract - *The Era of the eco-friendly technologies is emerging rapidly; bicycles are the most dependent modes of transportation. The environmental factors and the increase in fuel price make it clear that it is far better to use a bicycle over a motor vehicle for traveling. This project, 'Design and implementation of Electric Bicycle with battery monitoring system and speed control mechanism,' is designed to provide two modes of travel, such as a power-on-demand mode for long distances and pedaling mode for short distances. This electric bicycle is provided with ease to switch between these two modes of operation. The electric vehicle depends on the battery for energy. Provision for monitoring the state of charge of the battery using IoT techniques is provided in the project. The speed controlling mechanism enables the user to ride the electric bicycle in different ranges of speed. IoT based speed monitoring system is provided. The monitored values of battery state of charge and the speed are displayed so that the rider gets the information about the status of the battery and the speed. Each circuit is designed separately and assembled to form an electric bicycle which can make the long distance cycling easier with many user-friendly features.*

Key Words: Electric bicycle, Speed Controlling, Speed Monitoring, Battery Monitoring

1. INTRODUCTION

A bicycle is common man's vehicle. Irrespective of the age, people love to ride it. But it is mainly used for joy riding nowadays. It is primarily because of the fatigue that is caused by pedalling the bicycle. Nowadays people don't develop enough stamina to ride bicycle for long distances. They want the machine to take the control whenever they want to. At this context, the electric bicycle come into a great help.

The fundamental motivation for the electric bicycle is to deal with the issues of pollution and those related with human nature of seeking comfort. Another purpose is about making a comfortable journey more economical. The electric bicycle is a battery-operated vehicle that is exceptionally affordable, with low upkeep cost and absolutely zero contamination. E-bicycles are an alluring option in contrast to ordinary bikes,

giving a naturally benevolent, fun, productive and advantageous approach to travel. In future E-bicycle will be the best-specialized application as an answer for the mobility issues, creating a better world for upcoming age.

Our electric vehicle can switch between the pedalling mode and the battery mode according to the rider's convenience. When the rider gets tired of pedalling, the operation can be shifted to the battery mode, with the help of a switch. The battery powered electric motor takes the control after that. When the bicycle is operated in the battery mode, the speed can be controlled by the rider. The state of charge of the battery is continuously monitored and displayed so that the rider can get the information about the balance charge in the battery and can plan for a recharge according to the nature of the drive. When the bicycle is running in battery, the speed is continuously monitored and displayed. The continuous monitoring, controlling and displaying of the speed and battery level help the rider to plan and enjoy his ride in a better way.

2. COMPONENTS USED

2.1 Components of Electric Bicycle

Main parts utilized in Electric bicycle are BLDC motor, battery, controller, throttle, chain set.

DC Motor:

The brushless DC motor is the best suited motor an electric bicycle. The motor used, is having rated power of 250W capacity with a rated speed of 400 rpm. Other specifications are as follows: The motor has a rated Operating Voltage of 36V, Rated Power: 250W. Max Torque: 32N.m. Rated Speed: 400RPM. Rated Current: 7A. Efficiency: 83%
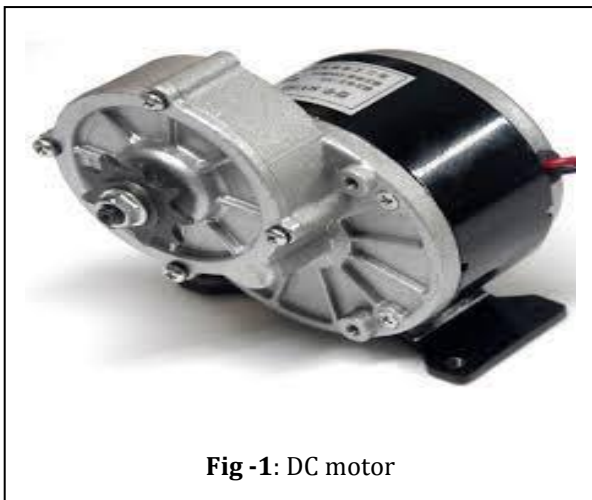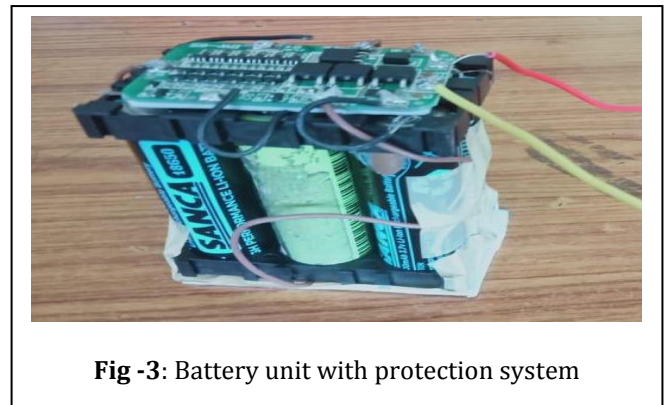
Fig -1: DC motor

Throttle:

Throttle for 24 V, 250W electric bicycle is a twist grip accelerator. It is connected to the motor controller. It is used as input to control motors. It is similar to the scooter accelerator available in the market.

Fig -2: Throttle

It features linear control over Electric bicycle motor and lets us to change the speed of the vehicle according to the requirement.

Battery Unit:

A lithium-ion battery is the rechargeable battery which is used in many electric vehicles. The lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. It is more efficient as it is less in weight, high speed, no pollution, more reliable. The battery unit is of rated voltage 24V and capacity is 2600mAh

Battery Protection System
6S 20A Li-ion Lithium Battery 24V 18650 Charger Protection Board Module is a small PCB mounted Li-Ion Lithium Battery charger protection module. This small battery charger protection module comes with various features like

Fig -3: Battery unit with protection system

Short circuit protection, Overcharge protection, Over-discharge protection, Overcurrent protection.

Chain set

It is more of a common type of chain drive which is used for transmission of mechanical power usually from the pedals to the drive wheel of the bicycle. In our case, we had to use 2 chains: one for transferring power from the pedal to the wheel and the other from the motor to the wheel. The operation is shifted from one wheel to the other with the help of a switch.

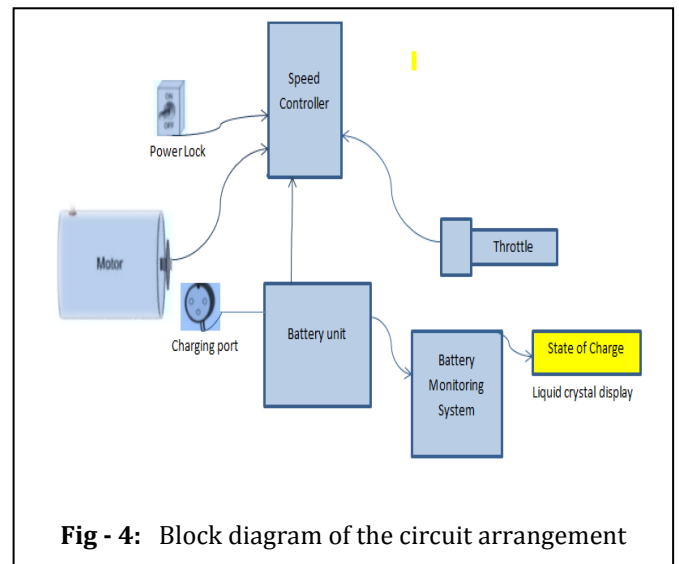**2.2 The block diagram**

Fig - 4: Block diagram of the circuit arrangement

The block diagram shows the arrangement of different components of the circuit. The battery powers the motor through the speed controlling unit. Battery monitoring system is connected with the battery and the state of charge is displayed in LCD. Speed controller block consists of the circuits for speed monitoring, displaying and controlling.

2.3 The control circuits

Battery Monitoring and displaying circuit (BMS):

BMS comprises an Arduino Uno board, resistors of value 100k and 10k, 9 V battery, breadboard, Liquid crystal display and connecting wires.

It is crucial to read battery voltage continuously to determine the state of charge of the battery unit. The voltage is read into Arduino using a voltage divider method to protect the Arduino from overvoltage.
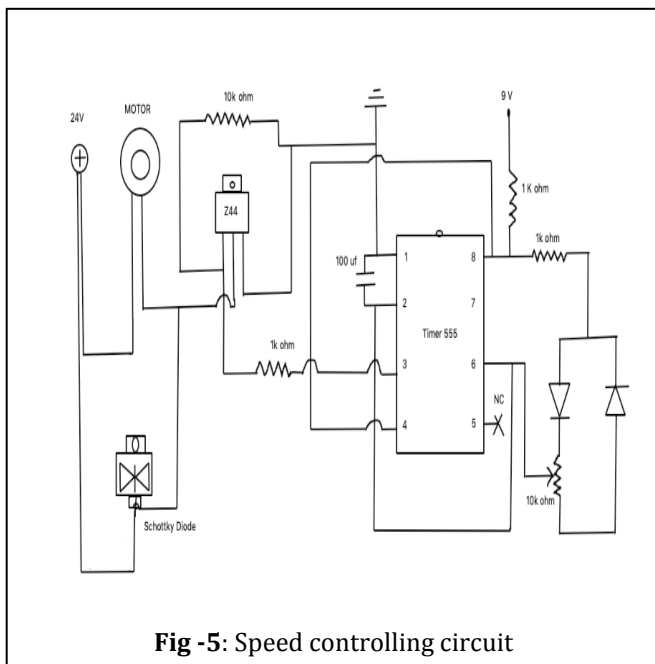
Fig -5: Speed controlling circuit

Arduino's analog inputs can be used to measure DC voltage between 0 and 5V (when using the standard 5V analog reference voltage) and this range can be increased by using two resistors to create a voltage divider. The voltage divider decreases the voltage being measured to within the range of the Arduino analog inputs.

The analog sensor on the Arduino board senses the voltage on the analog pin and converts it into a digital format that can be processed by the microcontroller. Here, we are feeding the input voltage to the analog pin (A0) using a simple voltage divider circuit comprising resistors R1 (100K) and R2 (10K). With the values used in the voltage divider it is possible to feed voltage from 0V to 55V into the Arduino board. The junction on the voltage divider network connected to the Arduino analog pin is equivalent to the input voltage divided by 11, so 55V ÷ 11 = 5V. In other words, when measuring 55V, the Arduino analog pin will be at its maximum voltage of 5V.

Speed Controlling of BLDC motor:

The speed controlling is carried out with IC 555 timer and a MOSFET as the main components. Resistors, capacitor and diode are the additional components used.

The speed controlling is carried out with IC 555 timer as the main component, it is used to create time delays and pulses in digital form. The throttle is connected to the 6th pin which is the threshold pin, this pin sets the threshold for the motor which in turn controls the speed of the motor. The IC is called 555 timer because the resistors used in the internal circuit of the IC are each 5k ohms. The capacitor of range 1000uf is connected across pins 1 and 2, the pin 1 is termed as ground pin and the voltages are measured with respect to this pin. The pin 2 is termed as trigger pin which is used to feed the trigger input, it is an inverting input of a comparator which is responsible for the transition of flip flop from set to reset. The 3rd pin is the output of the timer, here the output is connected between pin 3 and pin 8 which is the VCC this connection is known as normally on-load connection. This output pin produces digital output in the form of 0's and 1's this circuit is then connected to MOSFET Z44. The motor is connected across MOSFET and schottky diode. Thus, the speed is controlled.

An IR sensor is used to sense the speed at any moment. The IR module is interfaced between microcontroller and LCD. The sensor data is continuously logged to the LCD based on the code dumped in the Arduino UNO. This ensures the monitoring of the BLDC motor speed in RPM at different ranges of speeds.

The control circuit designed is then tested at different speed ranges. The typical values of voltages and speed at a different acceleration of throttle are as shown in table 1.

2.4 Mathematical calculations:

Calculations related with Battery Unit:

The battery unit provides an output voltage of 24 V when it is fully charged. It has a capacity of 2600mah.
The voltage of each battery is 3.7V
Number of batteries is 6.
Total voltage when connected in series is 3.7 * 6, i.e. 22.2v.
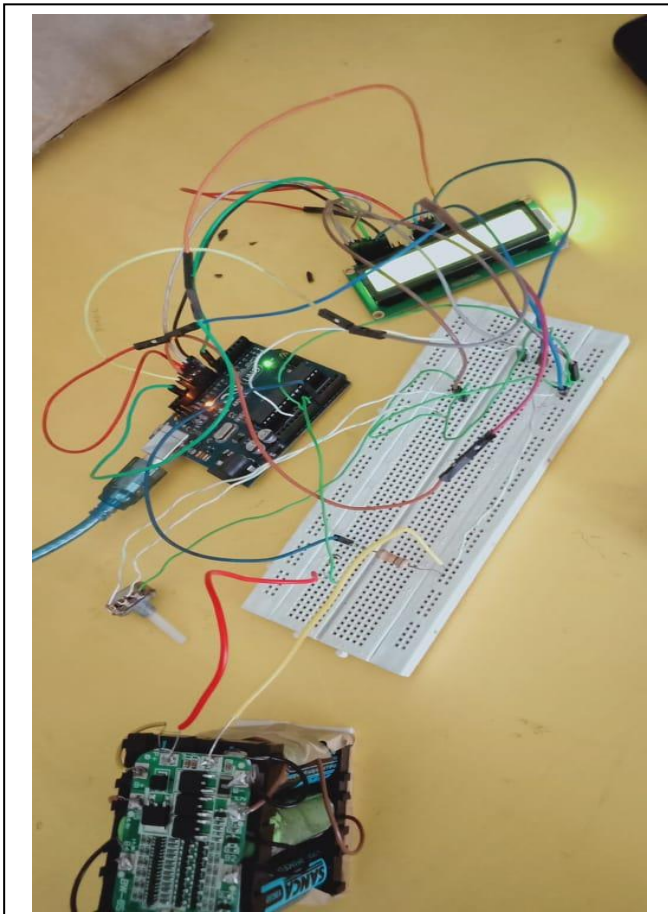
3. Hardware Results:

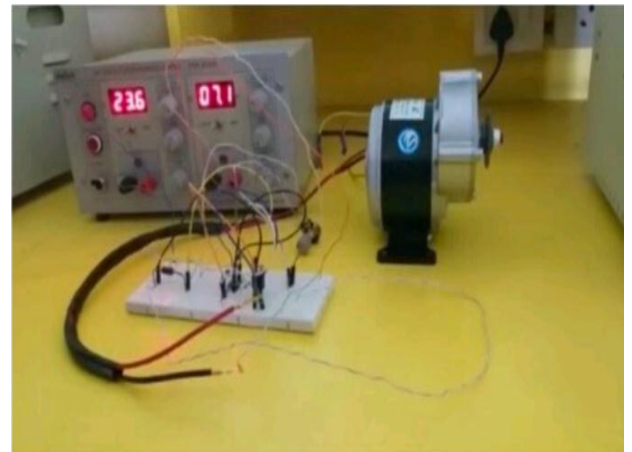**Fig -6**: Circuit arrangement for battery monitoring system

Fig -8: Testing of speed control circuit

Table -1: Voltage Vs Speed

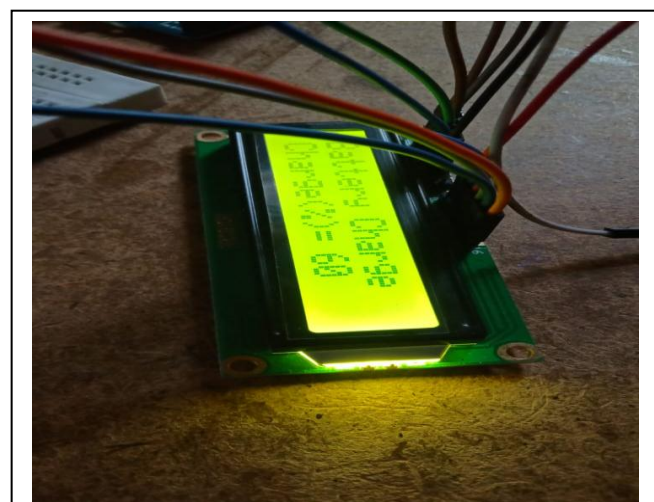| Voltage (V)	Speed (rpm)
3.7	40
7.4	92
11.1	145
14.8	200
18.5	245
22.2	301

Fig -7: Display of state of charge of the battery

Fig -9: Project Outlook Before Assembling

Fig -10: Electric bicycle after Assembling

Fig.6 shows the circuit arrangement for the battery monitoring system. The state of charge is displayed in the LCD as in fig.7. The speed control circuit is initially tested by taking input from a regulated power supply as shown in fig 8. Then it is connected with the battery and connected in the cycle. Values of Table 1 shows the speed at different voltages. It can be observed that the speed is increased as the voltage is increased. Fig.9 shows the arrangement where the battery supplies power for the motor operation. Fig.10 shows the complete assembled cycle ready to work as an electric vehicle.

4. CONCLUSIONS

The project "Design and Implementation of Electric Bicycle with Battery Monitoring system" based on electric vehicles and Arduino IoT for electric bicycle, which can not only meet the requirements of the conventional battery monitoring functions effectively but also facilitate easy monitoring of the state of the battery pack. The battery monitoring system with the display of the state of charge has been successfully applied in an electric bicycle. The main conclusions are as follows:

1. The battery monitoring system in the project can effectively manage the monitoring and displaying of the battery in the electric bicycle.
2. The electric bicycle made from a conventional bicycle is feasible and convenient to travel longer distances through power-on-demand mode.
3. The speed controlling system in the project can effectively control the speed of BLDC motor of electric bicycle
4. The speed of the electric bicycle at different speeds with respect to throttle acceleration, is monitored.

The project "Design and Implementation of Electric Bicycle with Speed and battery Monitoring Mechanism" is based on electric vehicles and Arduino IoT for electric bicycle, which meet the requirements of the Speed monitoring functions effectively and also facilitate monitoring of the speed. The speed monitoring system with the display of the speed in rpm has been successfully applied in an electric bicycle.

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