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Pedal Assist and Mid-Drive Electric Bicycle

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Abstract: Transportation is very much important as it connects people from one place to another place. A mode of transport is a solution that makes use of a particular type of vehicle, with the increase in population the number of vehicles owned is also increasing. The environmental impact of transportation is significant because it is a major user of energy and burns most of the world's petroleum. This creates air pollution, including nitrous oxide and other particulates and is a significant contributor to global warming through emission of co2.Bicycles have always been a popular mode of transportation due to their low cost, ease of use, health benefits and mobility. Their drawbacks however include low practical range, increased efforts when compared to other vehicles and safety concerns in urban areas.

Keywords: Electric Bicycles, Mid-Drive, Pedal Assist, Throttle, Touch Display, Aurdino.

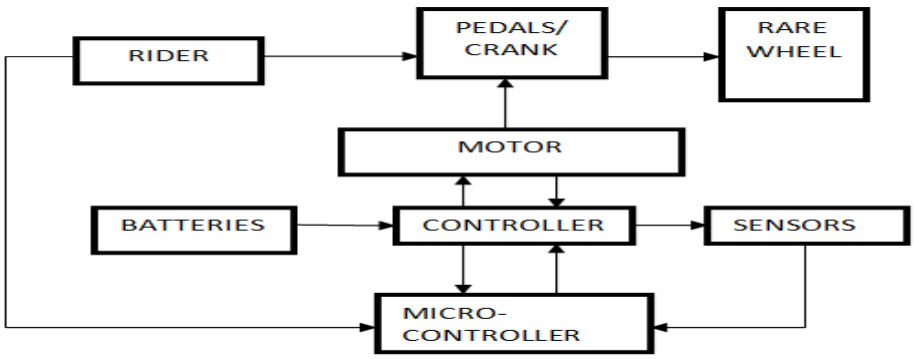
1. INTRODUCTION

The cost of fossil fuel is increasing day by day as well as government policy is also towards the minimization of atmospheric pollution. Bicycle is an economical and pollution free vehicle for controlling the atmospheric pollution, which is not depending on crude oil. Electric Bicycle is a bicycle which makes use of electric motor for propulsion. E-bikes use rechargeable batteries and the lighter varieties can travel up to 25 to 32 km/h , depending on the laws of the country in which they are sold, while the more high-powered varieties can often do in excess of 45 km/h. In some countries such as Germany, they are gaining in popularity and taking some market share away from conventional bicycles while in others, such as China, they are replacing fossil fuel-powered mopeds and small motorcycles. The first pedal-assisted bicycles appeared in India in 1993. In general, every electric vehicle in India has to get the Automotive Research Association of India (ARAI) approval. This is what is defined as electric bicycle and the safety requirements:

- One or more electric motor with power of less than 250W
- Maximum speed of 25 kilometre per hour

The Vehicles which comply with the above requirements are not categorized as motor vehicles. Hence transport rules are not applicable for those vehicles.

2. BASIC CONFIGURATIONS OF ELECTRIC BICYCLE



3. OVERVIEW OF COMPONENTS USED

BLDC motor: BLDC motor doesn't have brushes. The stator consists of windings in which exciting current flows and the rotor is made up of permanent magnet. The flux is created by the windings. The magnetic flux of the motor causes the motoring action. The advantages of a brushless motor over brushed motors are high speed, high power to weight ratio and electronic control. An electronic sensor detects the angle of the rotor, and controls semiconductor switches such as transistors which switch current through the windings, either reversing the direction of the current, or in some

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motors turning it off, at the correct time each 180° shaft rotation so the electromagnets create a torque in one direction. The elimination of the sliding contact allows brushless motors to have less friction and longer life. 250Watt, 36volt BLDC motor is used.

Gear Box: 10:1 Helical Inline Gear reduction box is used. The gear box reduces the higher motor speed to the slower wheel speed, increasing torque in the process. 3000RPM from the output of the motor is reduced to 300RPM by the Gear box.

BLDC Controller: Three Hall-effect sensors are embedded in the stator to indicate the relative positions of stator and rotor to the controller, so that it can energize the windings at the correct time and in the correct sequence. High (for one pole) or low (for the opposite pole) signal is generated when the rotor magnetic poles pass the Hall sensors. The sequence of commutation can be determined by combining the signals from the three sensors.

Li-Po Battery: When compared with Lead acid batteries, Li-Po batteries have the following advantages: **Weight:** Lead acid battery is pretty heavy. That means lead acid batteries are typically more than three times the weight of their lithium counterparts. **Efficiency**: Lithium Polymer batteries are more efficient than lead acid batteries. **Cycle life:** Lead batteries achieve just 300 or so lifetime cycles, while lithium batteries can achieve 700 to 800. Cycle life in lead acid batteries is highly dependent on the level of discharge, while lithium batteries are only slightly affected by discharge level.

Aurdino Micro-Controller: Aurdino Atmega2560 has 54 digital input/output pins out of which 15 can be used as PWM outputs, 16 analog inputs. It has 16 MHz crystal oscillator. It has flash memory 32k bytes out of which 0.5k is used for the boot loader. SRAM (static random access memory) is where the sketch creates and manipulates variables when it runs. It has SRAM of 2k bytes. EEPROM is memory space that programmers can use to store long-term information. Atmega2560 has 1k byte of EEPROM.

LCD touch display: Working voltage of 2.2 inch LCD touch display is 5V and has Resolution of 320 x 240.TFT Touch Shield is a resistive touch screen, compatible with Aurdino Mega platforms. It can be used as display device or sketch pad. This touch display is used by the rider to select different modes of riding the bicycle.

Battery Management system: A battery management system (BMS) is electronic system that manages a rechargeable battery, such as by protecting the battery from operating outside its Safe Operating Area, monitoring its state, controlling its environment, authenticating it. Additionally, a BMS may calculate values of Maximum charge current as a charge current limit (CCL) and Maximum discharge current as a discharge current limit (DCL).

Cadence sensor: The number of revolutions of the crank per minute is known as cadence or pedalling rate. This sensor sends signals to microcontroller when rider starts pedalling.

4. DESCRIPTION OF ELECTRIC BICYCLE

Pedal assist- Mid drive electric bicycle consists of a 250W BLDC shaft motor which can produce around 10Nm torque and 300RPM. This motor is mounted above the crank of bicycle which is powered by 36V, 10Ah Li-Po battery. This Motor is controlled by a BLDC Driver. The input to the BLDC Driver is given from throttle during throttle Mode. During Pedal Assistant mode, rider can select different modes of assistance through LCD console according to his requirement. From motor a chain drive is connected to the crank of the bicycle. A freewheel is fitted in between the crank and axel of bicycle in order to prevent pedals from rotating when motor is turned ON. Cadence sensor is used to detect the rotation of the pedal. Based on the cadence sensor output microcontroller will supply the power to BLDC motor. This Mid-Drive Electric bicycle can also be used as a normal bicycle.

5. DESCRIPTION OF LCD AND WORKING

LCD touch display is used by the rider to select different modes of bicycle riding according to his requirement. This is shown in Fig 2. Whenever the rider touches the button, the green button turns into red button for 1sec in order to confirm the rider what he has touched. When throttle button is touched, the rider can make use of throttle available in the right side of the handle to run the cycle as an E-Bike. In order to run the E-bicycle as a normal exercise bicycle, normal mode can be selected. If the rider wishes to have assistance, he can select low / medium / high assistance based on his requirement. PAS L refers to low mode of assistance, where low assistance is given only when the rider starts pedaling. Medium and High assistances are given if Pedal Assistant (PAS) medium and high modes are selected.

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Fig 1. Pedal Assist and mid-drive electric Bicycle

Fig 2. LCD Display

6. INVESTIGATION OF POWER DELIVERED V/S SPEED

Fig 3 shows graph of Power delivered by motor (in Watt) Vs Speed of the bicycle in KMPH in both flat road and road with 2.05% gradient. Throttle mode is used and the Weight of the rider is 60Kg. In Fig 4, Same rider is used to ride the bicycle in both Flat road and 2.05% gradient road using Pedal assistant high mode and the graph of Power delivered by motor (in Watt) Vs Speed of the bicycle in KMPH is plotted.

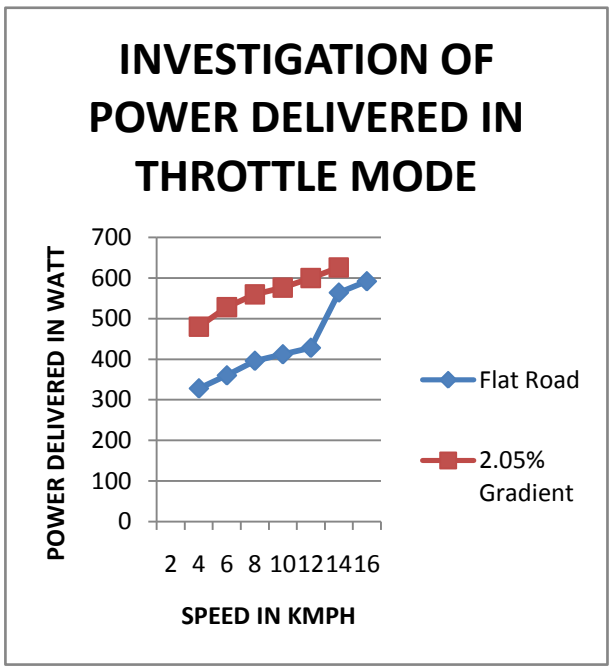

Fig 3. Power delivered in Throttle mode.

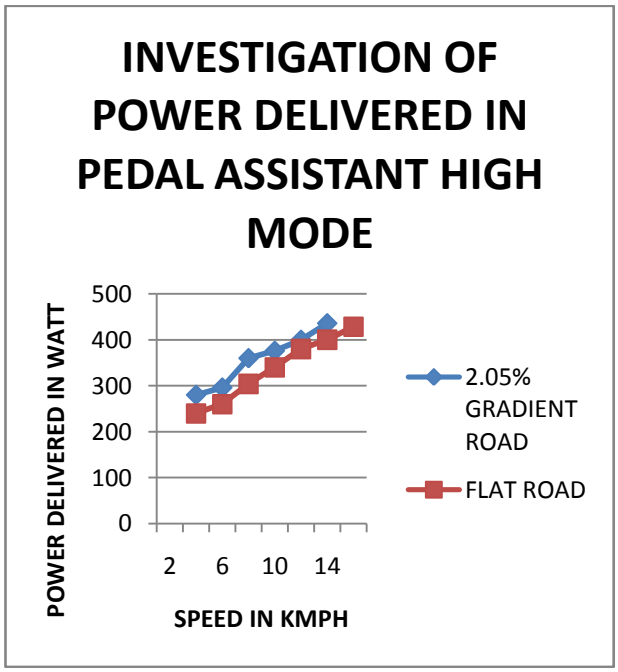

Fig 4. Power delivered in Pedal assistant High mode

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7. CONCLUSION

Pedal Assist and Mid-Drive electric bicycle can achieve a maximum speed of 40KMPH and if 25KMPH speed is maintained, then it can travel a distance around 20 - 25KM when the battery is fully charged considering the weight of the rider as 60kg.This pollution free Electric bicycle can be effectively used for short distance transportation in metropolitan cities. Also the LCD display helps the rider select various modes easily while riding as per his requirement.

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