DESIGN AND DEVELOPMENT OF AN ELECTRIC HYBRID RICKSHAW

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ABSTRACT

The auto rickshaw is one of the important transport medium for end to end connectivity in many cities. A motor assisted battery driven Hybrid rickshaw can provide a relatively comfortable non-polluting and a silent transport system for urban and rural areas of India. The primary focus of this research was to develop an Electric Hybrid Rickshaw without requiring significant changes to the structure of widely popular existing rickshaws. The proposed model is a modified form of conventional electric rickshaw and combination of a battery operated motor driving system with the solar battery charge system for ideal time. The model was developed so as to save energy, limit overuse, and keeping the identity and driving mechanism of old rickshaws. An idea of battery charging infrastructure using Solar-Battery-Charging-Station is also mentioned. The performance test revealed that the hybrid vehicle provides satisfactory speed, easier motion control and good scope of manipulating the shares of human effort and motor power. Besides reducing air and sound pollution, such rickshaws demanding less physical effort, may provide large scale employment in urban and rural areas of India.

Keyword:-*BLDC motor, Lithium-ion battery, Controller, Differential, solar panel, LDR module, Uno Arduino R3..*

1. INTRODUCTION

E-rickshaws are small vehicles, with three wheels and use electric power from batteries to run. They use an electrical motor of 650-1400W as engine which draws the electric power from the rechargeable batteries installed in rickshaw body. These battery operated vehicles are perfect for small distance transport, both cargo and people; they are perfect for running on narrow streets because of their small size. But biggest reason for their popularity is operating cost and zero pollution. They are like normal rickshaws but operated by electric motor instead of petrol or diesel. They are best for pollution free, environmental friendly transport system in short distances.

E-rickshaw is a good option due to less human effort and cost of fuel if compared with auto rickshaw and human pulled rickshaw. The pollution coming out from E-rickshaw is immensely less and it provides last mile connectivity that means it provides door to door service. Recently in India battery operated E-rickshaw are in much demand. Its comfortable and economic mode of transport has gained E-rickshaw popularity in India[1].

A study of travelling and charging of E-rickshaw patterns revealed that till today a household socket is the only option for the vehicle owners to charge their vehicle. As electricity comes from thermal power plants which emit CO_2 the e-rickshaw cannot be considered as a zero emission vehicle unless it will operated fully with the help of solar panel. 1.281 kg of CO_2 per unit of electicity generated is emitted in Coal-fired thermal power plant. 1.52 kg per litre of CO_2 is emitted by combustion of LPG. In combustion of diesel 2.71 kg per litre of CO_2 is emitted. From the figures in the table 1 given below it can be analyzed that e-rickshaw is more efficient than other vehicle [6].

TABLE 1 CARBON DIOXIDE EMISSION OF VARIOUS THREE WHEELERS

Sr.No.	**Vehicles**	**Specific CO2 emissions (gm/passenger-km)**
1.	Auto-rickshaw(LPG)	23.556
2.	Auto-rickshaw(Diesel)	21.51
3.	E-rickshaw	19.129

E-rickshaws are now of the preferred modes of transport in streets because of its low maintenance cost, eco-friendliness, being non noise pollutant, easy to drive. The motor is brushless DC motor manufactured mostly in India and China. The electrical system used in Indian version is 48V DC can run 90 to 100 km/full charge. Basic capacity is driver plus 3 passengers.

The main objective is to develop a model of e-rickshaw and interfacing system with solar panel. E-rickshaw is a basically battery operated vehicle which is directly equipped with battery and solar panel. The main aim to develop the pollution free vehicle with use of hybrid mechanism (battery and solar panel).

- To construct rickshaw light in weight
- Use of good material for a long life.
- To developed rickshaw is easy to operate.
- Non-polluted

To fulfill this objective this experimental research work involved the following processes:

• Study the structure and driving features of the existing conventional rickshaws and electric auto-rickshaws.

• To find a cost effective, feasible design and fabrication of parts for transforming conventional rickshaw to a hybrid one.

• Performance test of the hybrid vehicle to evaluate its feasibility and effectiveness compared to conventional and electric motor assisted rickshaws.

2 DESIGN AND CALCULATION ON TECHNICAL ASPECTS

The basic components require for experimental setup to develop prototype are BLDC motor, controller, Lithium ion battery, solar panel, Speedometer, Differential, LDR module, Tyre, Uno Arduino, Servo motor, Ultrasonic sensor.

2.1 BLDC MOTOR

Electronically commutated motors (ECMs) popularly known as Brushless DC electric (BLDC) motor. These are synchronous motor operated on DC power supply. In order to control the torque and speed of the motor the controller must capable enough to provide current pulses for the windings of motor[4]. The rotor consists of permanent magnets in the traditional configuration. The rotor whereas surrounded by the three stator windings. One of the trending applications of BLDC includes electric transportation system.

Calculations is carried out for Total Mass of electric vehicle: 350kg including weight of chassis (90kg), battery (45kg), person weight(1+2 person of total weight 250kg), Other weight (50kg) and for standstill or Initial velocity of EV: 0 and max velocity: 35km/hrs.

Parameter for calculation:
I = 22A
V = 48v

P = 900w
N = 2700 RPM
Pole=8

Torque: $T = \frac{60*P}{2*\pi*N} = \frac{900*60}{2*\pi*2700}$ = 3.18 N/M

Output Power:

$W = \frac{2*\pi*N}{60}$ = 282 rad/sec

Pout = T x W = 899.12

Efficiency:

Pin = V x I = 48 x 22 = 1056

% $\eta = \frac{Pout}{Pin} = \frac{900}{1056}$ *100 = 85.22 %

Now based on efficiency motor power should be greater than 900 W.

The existing BLDC motor to propose the controller for the same and the specification for the existing motor as follow:

- Voltages : 48Vdc
- Rated power : 1000W
- Speed : 2700 rpm
- Rated torque: 10Nm
- Peak torque : 25Nm
- Efficiency : > 85%
- Cooling options : air or liquid cooling

Figure-1 BLDC motor

2.2 CONTROLLER

Motor controller usually supplied with AC power. The power that comes in to a controller is at a set frequency. The motor controller first turns that AC to DC then turns the DC back into AC at right frequency. It use device called rectified to make DC current. The speed of a BLDC motor controlled by controlling the input DC voltage/current. The higher the voltage more is the speed. Many different controller algorithms have been used to provide the control the BLDC motor speed. The motor voltage is controlled by using a power transistor operating as a linear voltage regulator

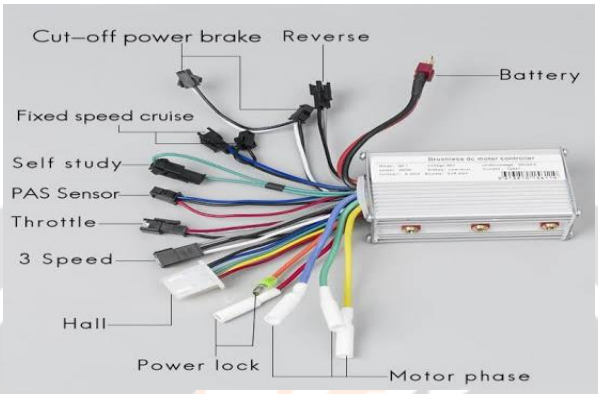

Figure-2 BLDC Motor controller

2.3 LITHIUM- ION BATTERY

The electrolyte carries positively charged lithium-ions from the anode to the cathode and vice versa through the separator. The movement of the lithium-ion creates free electrons in the anode which creates a charge at the positive current collector. The separator blocks the flow of electrons inside the battery.

Calculation of Lithium Ion Battery

P=VI
P=2400 watt
V=48 volt
2400=48×l
I=50 (50A for protection elements design)

Calculation of AH
2400watt×1hr=2400w-hrs.
Battery efficiency is around 85%
2400whr×1.15=2760
2760w-hr ÷ 48v =57.5 = 58 AH

Rated watt –hour capacity = Rated AH capacity x Rated battery voltage
= 58 x 48
= 2784 Watt – hour

Charging current 100rating / Charging current = 58 / 10 = 5.8 hrs.

To charge fully discharged battery Approx 5.8 hrs. is required. And for fast charging AH should be more which reduce charging time.

Specification

- Nominal voltage : 48 v
- Nominal capacity : 50A
- Weight : Approx 0.7kg
- Max. Charging current : 1.0C
- Max. Discharging current : 30-50A
- Cycle life : >500 times

Figure-3: Lithium-ion battery

2.4 DIFFERENTIAL

The axle is a part in e rickshaw which supports the differential and motor. We provide an axle designed to support motor weight and differential and also enhance performance of e-rickshaw. The quality of axle is important for safety and durability of the vehicle.

Figure-4: Differential

Specification:-

- Corrosion free
- Robust construction
- 1 ton load capacity
- Size 34 inches

2.5 SOLAR PANEL

Principle of solar panne : The photovoltaic effect, the photovoltaic effect is the conversation of sunlight energy into electricity. In pv system the pv cells exercise this effect.Semiconductor material in PV cells are dropped to from P-N structure as an internal electrical field[7].

Specifications:

- Maximum power : 330 W
- Maximum power voltage : 39V
- Maximum power current : 8.47A
- Short circuit current : 8.98A
- Open circuit voltage : 44.5V
- Maximum system voltage : 1000V

Figure-5: Solar panel

2.6 LDR MODULE

The automatic light used in E-RICKSHAW, it will provide a better solution for manual lighting of vehicle. It will sense the outside intensity of light and turns on the light automatically. The working principle of an LDR is photoconductivity, that is nothing but an optical phenomenon. When the light is absorbed by the material then the conductivity of the material reduces. When the light falls on the LDR, then the electrons in the valence band of the material are eager to the conduction band.

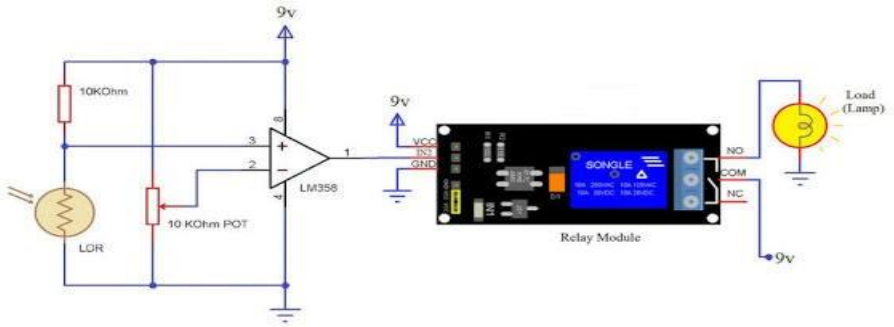

Figure-6 Automatic light controller using relays and LDR module

Specification:

- Operating Voltage : 3.3V to 5V DC
- Operating Current : 15milli amps
- LEDs indicating output and power
- Output Digital - 0V to 5V, Adjustable trigger level from preset

2.7 UNO ARDUINO R3

The automatic dustbin used in E-RICKSHAW. Which helps to create clean, safer, more hygienic environmental and enhanced operation efficiency while reducing Management costs , reduced, and rode side emissions.
The dustbin opens automatically when it receives the signal and closes it 'hatch. Also the dustbin consists of level sensing ultrasonic sensor that constantly measures the level of garbage in the dustbin and automatically detects if it is about the fill up.

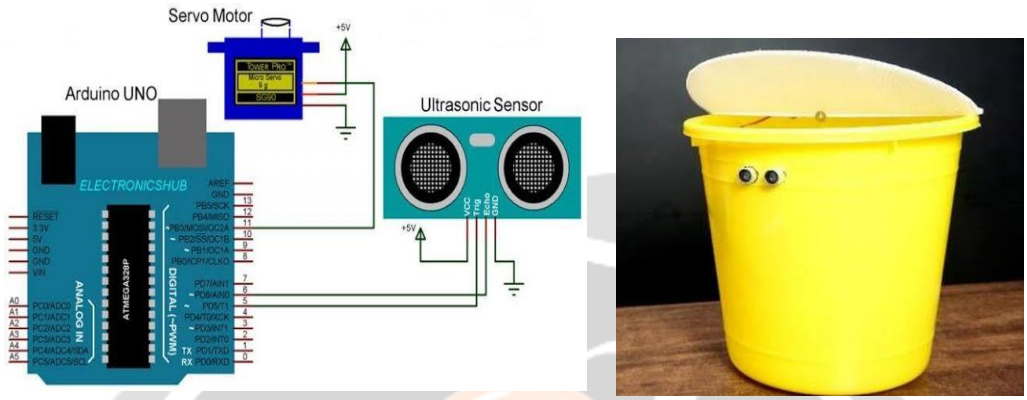

Figure-7: Circuit diagram smart dustbin using Uno Arduino R3

3 DESIGN METHODOLOGY

There are various factors and parts of the project that either had to be designed or selected. The major ones are given below with criteria for selection or design of each. In this e- rickshaw we have used a electric and mechanical controlling technology which is used to operate a mechanical & electrical equipment. The BLDC MOTOR controlled by controller using PWM technique having MOSFET. Motor controller usually supplied with AC power. The power that comes in to a controller is at a set frequency. The motor controller first turns that AC to DC then turns the DC back into AC at right frequency. It use device called rectified to make DC current. The speed of a BLDC motor controlled by controlling the input DC voltage/current. The higher the voltage more is the speed.
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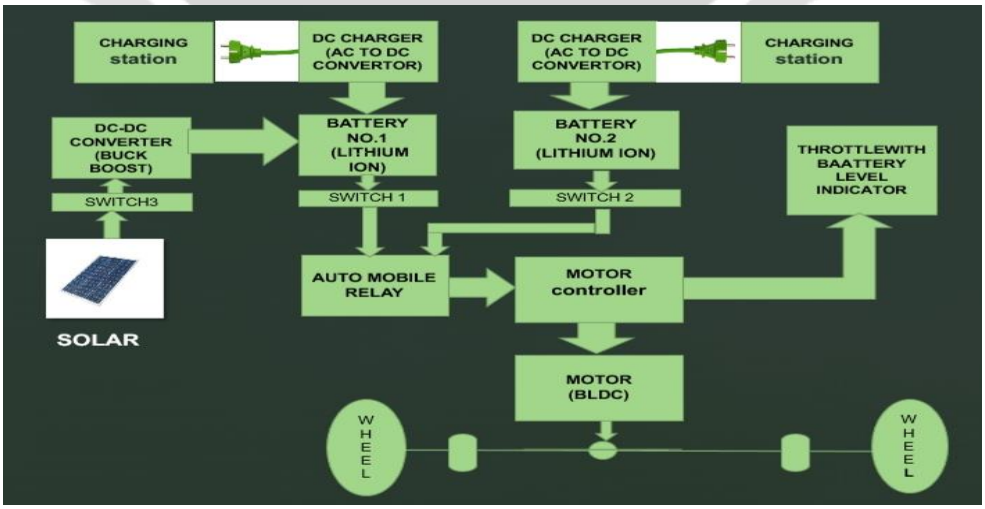

Figure-8 : Block Diagram of System

The block diagram gives whole process about the control system for vehicle. We are using two batteries connected through Automobile relay. The charged battery gives the supply for controller. The controller controls whole automated controlling devices. The controller gives respective commands to the motor, speedometer etc. Proper commands given from the input were further given to the controller and controller operates. Controller drives the motor which deal to move the vehicle. Automation controller controls the whole automation devices which are based on the user input.

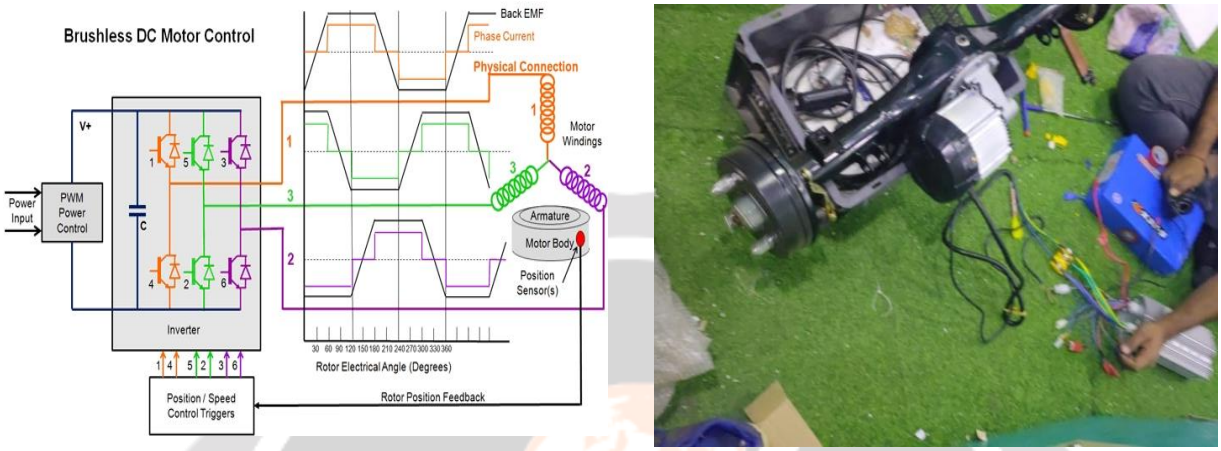

Figure-9 : Interfacing of BLDC motor with differential

Three Hall device embedded in the motor are usually used to provide digital signals which measure rotor position within 60 degree sectors and provide this information to the Motor controller. Because at any time ,the current in two of the winding are equal in magnitude and the third is zero.

This method can only produce current space vector having one of six different directions. As the Motor turns, the current to the motor terminals is electrically switched (commutated) ever 60 degree of rotation so that the current space vector is always within the nearest 30 degree of the quadrature direction.

Figure-10: Electrical and Mechanical testing

In the mechanical system such as in E-RICKSHAW, the brake shoes as actuated by a cum, which is attached to the brake linkage and pedal. When press the brake pedal, the cum turns. The friction between the brake linings and the drum causes the drum to stop rotating, there by stopping the wheel.

4 CONCLUSION

The study revealed that the e-rickshaws are energy efficient than other forms of motorized public road transport vehicles in the state. But the major challenges are required to be addressed for the proper implementation of these e-rickshaws. The paper shows the custom design of electric vehicle. While designing the vehicle there are different consideration and calculations. The one of main point is the selection of the motor and battery and its capacity. The design of chassis is also play the vital role in vehicle manufacturing. The points considered in this paper are the basic need of the designing of electric vehicle.

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